ALADIN-HIRLAM Newsletter

No. 7, September 1st, 2016

Joint 26th ALADIN Workshop & HIRLAM All Staff Meeting 2016
04-07/04/2016, Lisbon, Portugal

ALADIN Programme, c/o P. Termonia, IRM, Avenue Circulaire 3, 1180 Bruxelles, Belgium

HIRLAM-C Programme, c/o J. Onvlee, KNMI, P.O. Box 201, 3730 AE De Bilt, The Netherlands

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Introduction

I am happy to provide you with the seventh edition of the combined Newsletter of the HIRLAM and ALADIN consortia.

This edition was supposed to be mainly dedicated to the "***26th ALADIN Workshop & HIRLAM All Staff Meeting 2016***" that took place on 4-7 April 2016 in Lisbon (Portugal).
But … not so many of those who presented something during the workshop have found time to write down an article around their slides or poster.
Thus, besides these articles, I have added the full list of talks and posters with a direct link to their pdf file. I remind you that the **sessions have been recorded and can be viewed on the stream broadcast system : http://www.ustream.tv/channel/ipma .**

In Lisbon, ALADIN celebrated its 25th anniversary. This was the opportunity to think back and share some ALADIN stories.

A special focus is also proposed on the recent Doctors and on articles recently published by ALADIN/HIRLAM colleagues in NWP specialised international journals.

Find information on the list of events planned for the second semester of 2016 and later on.

I hope you enjoy reading the seventh ALADIN-HIRLAM Newsletter, thank the authors for their contributions and hand it off first to the ALADIN HIRLAM Programme Manager who will introduce this anniversary edition.

Patricia

For additional information, please visit the ALADIN and HIRLAM websites, or simply ask the authors of the articles.

Editorial

Piet Termonia

In November, 1990 the Director of Météo-France, Mr. Lebeau sent a letter to the Directors of some Central European countries with an invitation to start a collaboration on Numerical Weather Prediction, with the aim to jointly develop a LAM version of the French ARPEGE model. The technical side of this endeavour would be in the hands of Jean-François Geleyn. In the next year *(exactly 25 years ago)* the ALADIN project got started.

In the decades after that there was a major transfer of knowledge. Many young people outside Météo-France in Europe and North Africa received their training in NWP through this program, particularly during many long stays in Toulouse. This led to a specific ALADIN culture, with a specific ALADIN slang. Since the code of the ALADIN System is shared with the one of ECMWF, the ALADIN program served for many of the ALADIN trainees as a springboard for a later career in the European Centre.

Unfortunately I did not take part in the early "golden years" but joined somewhere in 2000. But I was fortunate enough to work with many of the first-wave "ALADINists". Their company and the human atmosphere in the project were some of the main reasons I became really enthusiastic about the ALADIN program.

As an illustration, I had my first lectures in meteorology during the ALATNET training course, somewhere in the woods in a remote place called Radostovice in the Czech Repulbic in May 2000. The format of the lectures was ALADIN trademark: atypically intense, with lectures in the morning, in the early afternoon and late in the evening. But they were, at the same time, atypically relaxed. There were breaks in the late afternoon to do sports and most importantly, during the evening lectures we were allowed to drink Czech beer. But what struck me was the dedication of the teachers, in particular Jean-François. I remember that, at some point during his lecture, he was mentioning the IFS. Being a total ignorant newcomer at that point, I dared to ask the question: "what is IFS?" After being in a sort of state of shock that I didn't know this, Jean-François reacted: "You don't know what IFS is??? OK I will organize a special lecture about IFS this afternoon." So while the others were outside to relax and to do sports I stayed inside and listened to Jean-François' lecture about the IFS. In fact, this was the only time in my life that a question I asked during a lecture was answered by … an extra lecture.

The program has been running for 25 years now. Let us look at a few numbers. Since 1991, the ALADIN Partners contributed with 1375 full-time equivalents (an average 55 persons.year over 25 years), 600 persons, 2550 stays/visits by 300 persons (mean duration of the stays/visits: 1 month), 20 General Assemblies, 26 Workshops, 33 PhDs, 47 Newsletters, countless training courses, seminars, meetings. Recently, in 2015 the contributions were 88 full-time equivalents, carried out by 190 persons, running 36 operational configurations all around the world, running on a wide range of computing platforms. Of course, the ALADIN program gave each participating country a state-of-the-art NWP model, which allowed the Institutes to address their local operational NWP needs.

It was not at all straightforward to exchange such a specialized and a wide-ranging body of knowledge to develop and run a shared NWP system operationally in 16 countries. This became possible thanks to the efforts of all the people who contributed to it, from the early starters to the youngsters who joined lately, but mostly thanks to the exceptional efforts and skills of Jean-François Geleyn. Looking back at the result of Mr. Lebeau's invitation letter, one can say in the ALADIN slang that it turned out to be truly *better than expected*.

Events announced for 2016 (and later on)

1 Meetings

- 38th EWGLAM and 23rd SRNWP meetings, 3-6 October 2015, Rome, Italy
- HIRLAM Council, December 7, 2016, Darmstadt, Germany
- 21st ALADIN General Assembly and 2nd joint ALADIN GA and HIRLAM Council, December 8, 2016, Darmstadt, Germany

=> 2017
- Joint 27th ALADIN Workshop & HIRLAM All Staff Meeting 2017, 3-7 April 2017, Helsinki, Finland
- 14th PAC and 5th HAC/PAC meetings , 22 May 2017, Copenhagen, Denmark

=> 2018 !!
- Joint 28th ALADIN Workshop & HIRLAM All Staff Meeting 2018 , 16-20 April 2018, Toulouse, France

2 Working Weeks / Working Days

- September 12-14, 2016, Brussels (Be): 2016 ALARO-1 WD
- November 21-25, 2016, Helsinki : working week on HarmonEPS, GLAMEPS and calibration and verification of probabilistic forecasts : dedicated page on HIRLAM wiki

- more information on-line

3 Regular video meetings

Roger Randriamiampianina took the initiative to organize regular group video meetings on atmospheric Data Assimilation via google hangouts, for DA staff from both ALADIN and HIRLAM.

First technical tests with google hangouts showed very good quality communication and the first video meetings took place in February and March 2016. More information on hirlam wiki.

4 About the past events

Find on-line information about the past ALADIN-HIRLAM common events such as the joint ALADIN Workshops & HIRLAM All Staff Meetings, the minutes of the HMG/CSSI meetings, the joint HAC/PAC meetings, the joint ALADIN General Assemblies and HIRLAM Councils.

Happy 25th Birthday ALADIN!

ALADIN little story (first part) : the epic journey of the first decade

1 Back 25 years

As written by Andras (from the very 1st generation of ALADINers), the work on ALADIN begun exactly 25 years ago, on September 2, 1991, when the first "stagiaires" came to Toulouse but the genesis of ALADIN was in November 1990 when Météo-France ("La Météorologie Nationale" back then) proposed to the NMSs of Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia to jointly develop and maintain a LAM version of the ARPEGE system.

In January 1991, the so-called MICECO support (French Ministry of Foreign Affairs support for the visits of the Partners' specialists in Toulouse) was acquired and would remain the continuous and main source of financing for ALADIN at its beginnings.

In March 1991, three scientists from the NMSs of Czech Republic (Radmila), Hungary (Dezső) and Romania (Vlad) developed a feasibility study of the proposed common project.

In September 1991, the active phase of the project started in Toulouse: Slovakia declined the offer to participate but Austria, through what will be the RC-LACE endeavour, and Poland decided to join in. A "cahier des charges" (specifications) for the ALADIN project was established for the LAM-ARPEGE project that would be renamed ALADIN one month later by Sylvie, its god-mother.

2 The first decade : Pioneer days, golden years and MoU1 times

March 1992

Bulgaria became the 7th ALADIN Partner. 19 people (Au (Herbert, Klaus), Bg (Valery), Cz (Lubos, Martin, Michal, Radmila), Fr (Alain, Jean-François, Manu, Sylvie, Véronique), Hu (Andras, Dezső, Gabor), Pl (Marek), Ro (Elena, Vlad, Victor) from the 7 Partners had already worked on ALADIN when the first report on ALADIN current status and perspectives was produced:

August 1992

The French Ministry for Research accepted to finance four Ph.D grants in the framework of the ALADIN project. These would allow the scope of the project to be enlarged by studying basic questions related to its usefulness and further evolution.

October 1992

Based on ARPEGE cycle 9 and allowing the first full forecasting tests, Cycle 0 of the ALADIN library was declared.

January 1993

In a competitive context (1 over 35), the Commission of the European Communities selected the pre-operational work on ALADIN as one of the subjects financed (130000 ECU) under the so-called PECO action (see the 7 page application form).

October 1993

On request of the Informal Conference of Western European Directors (ICWED), Météo-France took the initiative to convene a meeting on the organisation at the European level of Short-Range NWP developments. SRNWP was born, organising a network of 20 countries (half being members of ALADIN).

November 1993

The NMSs of Morocco, Slovakia and Slovenia joined the project.

April 1995

The NMSs of Croatia and Spain (the latter would later leave) joined the project.

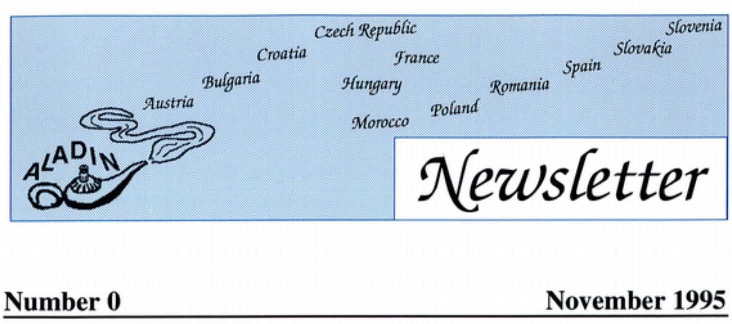
THE FIRST ALADIN CHART DISTRIBUTED VIA RETIM

May 1994

The work of the seven members of the PECO-financed pre-operational team (with the additional contributions of the Ph.D. students and an established team of Météo-France scientists) led to a successful conclusion. ALADIN became quasi-operational on Météo-France’s C98 computer on 31 May (see the ALADIN quasi-operational bulletin n°1 and a first ALADIN chart distributed via RETIM !)). Although the application was run only once a day (in sequential mode with respect to ARPEGE), up to 36 hours only and without a specific data-assimilation cycle, proof of the wisdom of the concept was nevertheless at hand. The scientific status of this first quasi-operational version of ALADIN was presented during the second meeting of the LACE steering committee (Bratislava, 29-30/06/94)

End of 1995

The ALADIN Newsletter n°0 was published and announced through the 1st ALADIN mailing list (aladin@cnrm.meteo.fr).



A workstation version was built (still in dead-branch mode with respect to the development cycles) by the SELAM group (NMSs of Bulgaria and Romania). This work also prepared the way for the distributed-memory version of ALADIN foreseen for cycles 6 and 7 of the library.

January 1996

RC-LACE and Météo-France signed an agreement to use the J916/12 computer in Toulouse as host for an ALADIN-LACE pre-operational application from 1 July 1996 to 31 December 1997 in order to provide a transition for the build-up of the Central European joint application of ALADIN between the six contributing NMSs. During more than two years, a LACE team (3-4 scientists simultaneously, from LACE Partners) took turns in Toulouse to develop, maintain and phase the ALADIN-LACE application.

February 1996

The success of the first Ph.D. phase (two theses had already defended and two were about to be defended) led the French Ministry for Research to renew the grant. Five new Ph.Ds were thus in the pipeline.

ALADIN-INCO & ALADIN-KIT

Beginning of 1996, a concerted action proposal (ALADIN-INCO) was submitted (150 page document, 15 partners, NMSs and environment agencies) to the INCO-COPERNICUS call in Brussels In February 1996: "Improved real time protection against short range diffusion of radio-nuclide pollutants through the co-operative development and operational use of an advanced numerical weather prediction system for Central Europe". It was rejected for non-conformity with the aims of the financing. We took the lesson that we should not any more try to twist a subject to fit in the pre-chosen work plan if the latter is too far away from our own aims.
We also applied to the same INCO-COPERNICUS call, under the Acronym "ALADIN-KIT" to get funds to "keep-in-touch" after the end of the successful 1993 PECO action. ALADIN-KIT was accepted and allowed participants to the former PECO to attend the EWGLAM/SRNWM meetings (and the evening ALADIN meetings – and diners – organised since then beside EWGLAM/SRNWP).

March-August 1996

In a form of cascade, four applications started their cycle of pre-operational to operational status: ALADIN-MAROC and ALADIN-FRANCE (in March), ALADIN-LACE in Toulouse (in July), ALADIN-ROMANIA (in August).

October 1996

The NMS of Belgium joined the project.

Distributed Manpower

The ALADIN people were no longer working exclusively in Toulouse (French people and Partners "stagiaires"), as local ALADIN teams begun working in the Partners NMSs) and a regular monitoring of the ALADIN manpower ("at home" and "during visits") was established and is still on-use, although new criteria had been added later on).
A public ftp was opened for exchanging information (postcript format only) with the ALADIN partners : newsletters, informations for Toulouse visitors, quasi-operational bulletins, manpower statistics, ...

ALADIN Workshops

With the ALADIN applications becoming (pre-)operational and developments/installations being done outside Toulouse, a need for exchanges between NWP people and forecasters, and among NWP developers, led to the organisation of the ALADIN Workshops (twice a year in 1996-2001, only once since 2002).

1st MoU : 1996 - 2000

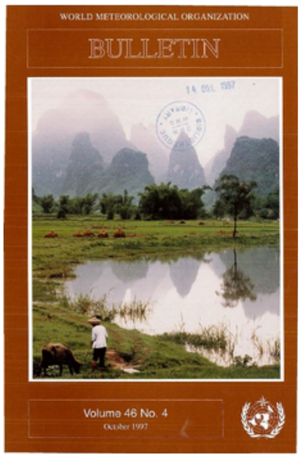
In 1996, the evolutions of the ALADIN project made it necessary to get a minimum of formalization around the project in order to keep it as successful as it had been during the first five years. The 1st MoU (Memorandum of Understanding) was born: it recalled the principles guiding research, development and maintenance of ALADIN (more precisely of ARPEGE/ALADIN, to recall the interdependency of the two systems), detailed the conditions of use of the ALADIN software and the membership rules, defined the governance (mainly through the Assembly of partners). It was signed in

November 1996 in Paris, during the 1st Assembly of ALADIN Partners, in the presence of the Secretary-General of WMO, Prof. G.O.P. Obasi, and the French Ministry of Transports, Mr. B. Pons. Of course, nobody told these personalities that the best seller of the day was not the MoU1 but ... the dark side of the Memorandum … !
In November 1998, a new version of the MoU was accepted during the 3rd Assembly of Partners that mainly regulated the access to the ALADIN code (in relation with the 1st agreement between ECMWF and Météo-France for the access and the use of ARPEGE/IFS).

New Partners

The NMWs of Portugal (April 1997) and Moldova (April 1998, but would withdraw during the 2nd MoU) joined.

International recognition: ALADIN in the WMO Bulletin, Oct. 1997



A complete presentation of the ALADIN project was published in the WMO Bulletin Vol. 46, n°4, pp 317-324, October 1997. The Bulletin advertised this article by : *"...a detailed description of the ALADIN project ..., written by some of the 110 members of the international scientific team. ALADIN has its roots in the firm belief that international cooperation between NMSs, whatever their technological capacities, is both essential and mutually beneficial"*.

(Pre-)Operational applications

Many pre-operational and fully operational versions of ALADIN started running on the Partners workstations (the Belgium team realizing the shortest time - between the beginning of the work with ALADIN and the operational statu s- within all partners, on MF supercomputer (Futjitsu VPP) and on the NEC supercomputer in Prague (ALADIN-LACE moved from Toulouse computer to the new LACE centre).

March 1998, ISBA

In March 1998, the former surface parametrization was replaced by a more realistic one ("ISBA"). Besides its scientific aspects, this change was a real challenge as it needed a simultaneous real-time switch in the ARPEGE suite and in all the operational or pre-operational ALADIN suites.

January 1999, ALADIN on the Internet

In January 1999, ALADIN website was born: http://www.cnrm.meteo.fr/aladin/ (the address is still valid today although the IT people have been regularly linking it to different aliases!). It was mostly in English, besides the home page that benefited from translation into the many languages used in our countries (Arabic, Bulgarian, Croatian, Czech, Dutch, French, German, Hungarian, Polish, Portuguese, Romanian, Russian, Slovak, Slovenian!) : part of this is still more or less readable on the "old website" (end of 2008 version).

Survive and thrive Y2K

End of 1999, ALADIN was preparing for surviving the Y2K transition (see page 3 of the Newsletter n°16) but the main event was when the ALATNET (see below) proposal that had been proposed to the 5th Program of the European Union was favourably evaluated by the Commission.

ALADIN Training NETwork (ALATNET) years : 2000-2004

The ALATNET project (1st March 2000 - 29 February 2004) was supported by the TMR/IHP Programme of the European Community. "It aimed at diversifying and widening the international research effort around the Numerical Weather Prediction Limited Area Model (ALADIN) with basic objective to build the ALADIN NWP system up to a state where it can treat the dynamics and physics of atmospheric phenomena at scales down to 10 km and where it can assimilate in a continuous and balanced mode all relevant data for the prediction of extreme weather events." ALATNET offered 9 Pre-Doc (Ph.D grants) and 3 post-Doc positions in 5 teams (Belgium, Czech Republic, France, Hungary and Slovenia).

Theoretical training courses, exploring the leading-edge topics of NWP (high-resolution modelling, data assimilation, numerical methods) opened to the whole European NWP community, were organized regularly and completed the local, practical training for newcomers. The organisation of the 1st ALATNET training course was a bold challenge that turned into a mere success: it went on very well for the 57 participants (40% of newcomers among the students, thus not knowing each other) gathered during 14 days (on a 24/7 basis) in the CHMI summer house (situated in a remote part of Czech Republic also known as the Czech Siberia) where, besides the cook's family we were there only inhabitants … Communication with the outside world was possible from time to time, but only with a few selected mobile phones, if you were lucky, on top of the hill and immune to giant mosquitoes.

ALATNET had really gave a new boost to ALADIN thanks to the many research achievements of ALATNET, but not only; ALATNET also helped improve networking, increase the mobility and, above all, on the human side; ALATNET gave the opportunity to train many newcomers from ALADIN partners and from other consortia, and to welcome in the "ALADIN family" a 2nd generation of ALADINers (see Mariska article). The practical conditions were not always that easy but it proved to be a great human adventure.

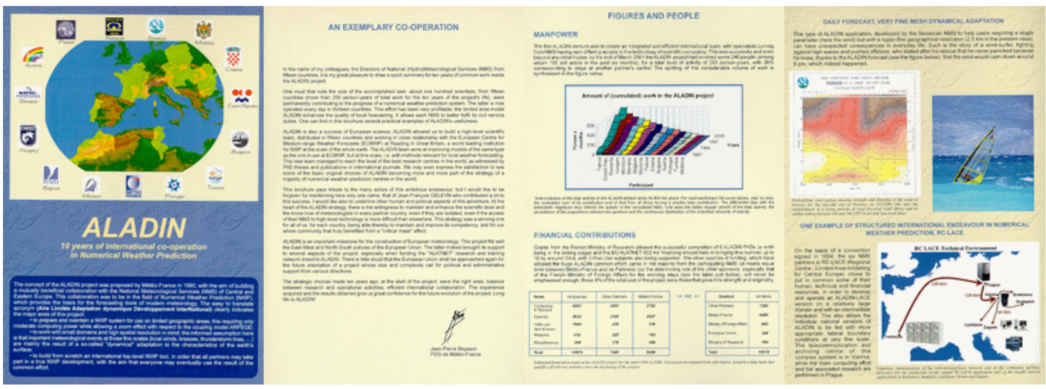
MoU2 : decentralisation and formalisation

The 2nd ALADIN Memorandum of Understanding was signed on May 31st 2001 by 15 Partners (Tunisia joined ALADIN, Moldova too but left soon after). It introduced:

- an enlarged definition of the ALADIN partnership, with three levels of "rights versus duties" : Full Member, Associated Member, User;
- more precise guidelines for the commercial use of ALADIN products;
- stricter rules for the registration of the manpower dedicated to ALADIN;
- the creation of a Technical Cooperation Standing Committee (TCSC) of four members (Météo-France representative, LACE representative, SELAM representative, and a representative of the other partners), in charge of the routine project coordination for technical issues.

10 year anniversary, booklet and so much more ...

Early morning, the members of the steering committee of ALATNET held their 3rd meeting in the Maison de l'Hôtel Polytechnique in Paris. Then, around a coffee break, they joined the ALADIN delegations (Directors of the NMSs, ALADINers, Météo-France Direction team). The anniversary began with some scientific presentations and a constructive round-table. After lunch, the 2nd MoU was signed by the Directors of the ALADIN NMSs in the presence of Mr. Gayssot (French Ministry of Transports); Mr Delsol (WMO) and the ambassadors of some ALADIN countries. The words "ALADINers" (in English) and "ALADINistes" (in French) were given an official and international recognition thanks to their use by Mr. Gayssot in his appreciative speech. Some ALADINers were nominated for their important contribution to ALADIN, in term of research, operational, technical or practical effort (i.e. *great specialists of desperate situations whatever …*): Claude, Doina, Dominique, Andras, Radmila, Luc, Jean-Daniel, Martin, Gabor, Manu, Jean-François, Mihaela and Patricia. Paper copies of the ALADIN booklet were distributed and the celebration ended after various additional addresses and a nice cocktail in the gardens of the Hôtel, adding to the successfulness of this perfect day …



Extract from the ALADIN booklet

Then, many of the nominated ALADINERs (and the Director of the Tunisian INM for his first visit to Toulouse Météopole) headed for the airport to fly to Toulouse where other meetings had been planned for the next morning and the following days/weeks.

At that point, the spirit of our ALADIN magic lamp proved to be a little tired (may be some side-effect of the champagne cocktail?) or may be he kept his information for the Boss (who, by chance ?, had decided to reach Toulouse by train). The planes for Toulouse were cancelled with no hope for a kick restart to fly (Bordeaux radar was out of order). The trains were full and the decision was taken to go back by car (better not to tell who among the ALADIN travellers got this stroke of genius). Of course, we were not the only ones to decide to rent a car (it was before a long bank holiday week-end). We succeeded to rent the last two cars available and split into two working groups for long and deep discussions during a long travel: huge traffic jams in Paris and later on, parts of the motorway closed due to some burning trucks (thus, we had the opportunity to visit by night Orléans and the French countryside) … One group reached the conclusion (Toulouse!) rather early (3 o'clock in the morning), taking advantage of better tools (car!) and more efficient participants (less tired drivers). The others returned the rented car in Toulouse airport 3 hours later, exactly when the first plane from Paris was landing! Then, *everything was under control* (of course, with specialists of the desperate situations), everybody was on-time at the 9 o'clock meeting with the Tunisian Director. More important, after a whole night brainstorming (what other mean to keep the drivers awake besides speaking to them all the time), everything was settled for the episodes, the ALADIN workshop in Toulouse the next week and the two-week ALATNET seminar in Gourdon that would follow. Everybody agreed that *it could have been worse*!.

3 ALADIN : the journey continues

… to be published in the next newsletter

Meanwhile, when reading Zied article (3rd generation of ALADINers), you will see that the ALADIN spirit is still the same these days …(not surprising from a colleague from Tunisia, considering how thrilling had been the Tunisian first steps in ALADIN … on May 31st, 2001!).

Happy 25th Birthday ALADIN!

A personal birthday message from ECMWF

I still have vivid memories about my train trip (yes, it was much cheaper than flying at that time) from Budapest to Toulouse (via Paris) and arriving at Gare de Matabiau on the 1st of September, 1991. Before my trip I had received careful hand-written instructions (yes, email was not used regularly at that time from Jean-François how to get to Toulouse and how to explain (in French!) if I am going to be late. At that time "I didn't guess" that this trip will have a significant influence on my career and will pave my path towards being at ECMWF today. I have to confess that I did not have a clear idea what I am supposed to do in Toulouse, it was just an adventure for me to learn more about NWP and explore uncharted territories. Retrospectively, now I know that this trip to Toulouse not only changed my professional career, but also my entire life too.

So Radmila, Jean-François, Victor and Vlad were waiting for me at the railway station and the ALADIN adventure had begun (in fact it had started half a year earlier when Radmila, Dezső and Vlad visited Météo France in Paris).

Vlad, Radmila, Jean-François and Dezső in front of Météo-France premises in Paris

The ALADIN development work therefore started at the same time, when Météo France moved from Paris to Toulouse as part of the French decentralisation. We had started to work with Sylvie, Veronique, Alain and Jean-François and soon more and more “stagiaires” joined the club.

I had been asked several times what is the secret of ALADIN, why is it so successful? I think, the answer is the fact that there was a special bond forged among the "stagiaires" in Toulouse. We were not only working together, but living together and sharing plenty of memorable events. Just to mention a few: Christmas party at the Batiment B, where every nation cooked their typical Christmas food (see also the story of "WaterKing") or excursions with CIES (where everything was in French though we did not really speak that language…) or questionnaires (quiz) about the ALADIN life (and the dark side of the Memorandum) or trips to the Pyrenees or marathon running along the Canal du Midi or simply gathering in Doina's pub in the morning for breakfast. We got lot of special friendships among us, which are with us forever. In normal working conditions you are just together with your colleagues in office hours and maybe you have some common activities outside the office work too, but you don't have such a living relation with your colleagues what we had in the golden ALADIN times in Toulouse.

I know that there was lot of scepticism about ALADIN at the beginning. I believe even Météo France considered ALADIN professionally as a backup solution if the hyper-stretched ARPEGE would not work properly. It was more a "political" move to endorse countries in Central and Eastern Europe and capitalise on the opening of the iron curtain and on their hunger for learning new things. Neither did the involved Meteorological Services have full faith in ALADIN at the beginning. I remember my director's words when visiting Toulouse after a year of development work: "I did not consider that you would really develop a tool, which can be used in the everyday forecasting practise". I am sure that Jean-François and others needed lot of perseverance to convince everybody that it was the right direction to move in. Does anybody question now that Météo France's decision to initiate the ALADIN cooperation was not a very wise one? The choice of HIRLAM to join forces with ALADIN also justifies this decision. Inevitably, now ALADIN/HIRLAM is the strongest NWP limited-area cooperation in Europe involving more than 25 countries.

I am really proud that I had been part of the ALADIN story from the very beginning and I feel myself very lucky to know so many people inside and outside ALADIN in the field of numerical weather prediction. I am sure that my experience is not a unique one. For instance now in Reading at ECMWF we have 18 scientists, who had direct ALADIN roots: Cornel, Cristina, Ervin, Fernando, Filip, Gábor, Gianpaolo, Marta, Martin, Miha, Mohamed, Raluca, Richard, Sándor, Sylvie, Thomas, Tomas and myself (and then we don't mention such people at ECMWF who were at least indirectly involved in ALADIN as Carla, Florence or Jean-Noël for instance).

So ALADIN is indeed a big family, which is growing year-by-year. Maybe after 25 years the ALADIN feeling is not the same any more than in the "nice old times" (and the ALADIN rookies are not taking the train to Toulouse any more), but I hope the special bond between "aladinists" and "hirlamists" will remain the same, which made this cooperation so successful and at the same time so enjoyable. I hope ALADIN/HIRLAM will continue to change the life of many young scientists in the next 25 years or so and the ALADIN family of models will continue to faithfully serve the forecasters of the participating meteorological services.

Long live ALADIN, best of luck for the next 25 years!

András Horányi

Reading, 29 July, 2016

Happy 25th Birthday ALADIN!

Short report from many years spent with ALADIN
(personal memories)

1 Introduction

I have joined the ALADIN team in Toulouse in early spring of 1997 - thus I am honoured to belong to the 2nd generation of ALADINists. Prior my first ALADIN stay I had got mental preparation from my already experienced Slovak colleagues on how to spend several months isolated in the Meteo-France site situated in the middle of nowhere on the suburb of Toulouse next to gypsy camp, where the only evening entertainment was the work in the office, and where the common stagiaires languages were *bad English* and FORTRAN90. And they did not forget to encourage me by reminding that the nickname given to the Slovak NWP team was the "*Department for the elimination of the wrong ways in the development of NWP models*"...

2 My life with ALADIN

I had to survive a 27 hours long journey in a bus from Bratislava to Toulouse enjoying reading my very first ALADIN documentation on CANARI - in French. Finally I arrived and became the ALADIN stagiaire - the newcomer. My very first ALADIN mentors were Hungarian duo *Elemer* and *Arpad*. You should easily understand that under such supervision I had to quickly adapt to the ALADIN working and living habits established by the pioneers of the golden times: to learn the ALADIN slang (who would *jeopardise* not to know *Why Apuka has no dog?*) and the nicknames of ALADINists (who remembers who are *Jenoferi or Danizoli*?), to memorize the *Dark side of Memorandum*, and to answer the famous ALADIN *questionnaire* - to name just few of them. On the other hand joining the ALADIN family meant to work among a group of smart, nice and enthusiastic colleagues who never refused to answer any question and were ready and happy to help finding a proper solution for any problem one might encounter; all that within warm and inspiring atmosphere of GMAP corridor where the ALADIN team spirit was supported and often even intensified by our French colleagues. Joining the ALADIN family also meant to experience and enjoy the stagiaires life full of unforgettable jokes, events or stories, parties in Batiment B or pizzas in GMAP cafeteria; the weekend trips all around the France, to the sea sides or to the Pyrenees, on foot or on skis.

When I have joined the ALADIN team, most of the research and development work as well as the training of newcomers has been carried out in Toulouse. Some of the ALADIN applications has reached their (pre-)operational status by that time, but all were running in the downscaling mode. My first stay was part of the 1997 ALADIN data assimilation workshop, where the baby steps to built a 3DVAR version of ALADIN were made. Those were the days when sometimes the table in Sodexho canteen was not large enough to accommodate all stagiaires at once, and *Budapest!* was commonly used.

Inseparable part of my ALADIN education and memories are the training schools, mostly in frame of the ALATNET project: Radostovice, Gourdon, Kranjska Gora. Those were organised on beautiful places but students were busy with the lectures from 8 a.m. till 10 p.m., where breaks were filled both witch chats and scientific discussions and free time with sports and excursions. I am sure everybody had enjoyed it a lot.

Another part of (my) ALADIN life are the numerous workshops and meetings. The very first one I have participated in was (by chance) the very 1st ALADIN Workshop on the Use of ALADIN/LACE in Forecasting Practice, hosted by SHMU in Bratislava in June 1996. I was freshly graduated from the University and I was hardly able to follow the talks. Since than I had the honour to co-organize in Slovakia quite few meetings linked to ALADIN. I had particularly enjoyed the EWGLAM in Bratislava, where during the meeting dinner after some local Slovak wine participants grouped by delegations were singing songs about Maria (and/or for Maria) in their language. Few others that could be considered as a kind of milestone thus are worth to mention: the 15th ALADIN workshop, June 2005, where the "QUO VADIS, ALADIN?" was the key topic for presentations and discussions; the 10th General Assembly of ALADIN Partners in October of the same year, where the 3rd ALADIN MoU was signed; or the very first meeting of ALADIN Local Team Managers (LTMs), October, 2006 when I have experienced its chairmanship that would become later my official ACNA duty.

EWGLAM/SRNWP, Bratislava, October 1999

15th ALADIN Wk http://www.cnrm-game-meteo.fr/aladin/spip.php?article138 *: Quo vadis, ALADIN ?*

Well, *even the nostalgy is not the same as it used to be*… Nowadays every Partner runs NWP system and wide range of operational applications based on it on his own resources. The research and development work is not conducted mostly in Toulouse any more, but in the “deported” mode. Long research stays were replaced by shorter working days. But the ALADIN spirit remains. It is rather obvious when a group of ALADINists meet - that happens at least twice per year during the ALADIN workshop and EWGLAM meeting. Again we share not only scientific ideas and operational experiences, but also the news about our personal lives and our families. There were colleagues that I have met only once, but with many others I am still in contacts - and not only in professional ones - after almost 20 years.

3 Conclusion

Not bad at all! And even *Better than expected*! All those experiences has influenced my future work and career so much. *It would be a pity to open discussion on that.* Happy Birthday, ALADIN, let’s your lamp lights and shines for new generations of ALADINists for at least next 25 years!

Maria Derkova (Mariska)

Bratislava, 18 August, 2016

Happy 25th Birthday ALADIN!

Sixteen countries, one team !

It's being almost six years already since my first visit to Meteo-France for the Maintenance Training. The idea was to prepare a new group of phasers so many participants joined from different countries, but what made this short experience so memorable, is that it was not just about getting familiar to Mitraillette or Clearcase, but offered a so spontaneous team building.
A particular friendship attitude made new comers integration so smooth, and besides the scientific discussions and getting lost in the third Merge exercise with Mihaly, I enjoyed discussing about Tunisian sweets with Tonda, also hearing some climbing adventure in Czech Republic with Patrick or a snow hiking story in Pyrénées with Olda.. The outcome of this training was just more than I could expect !

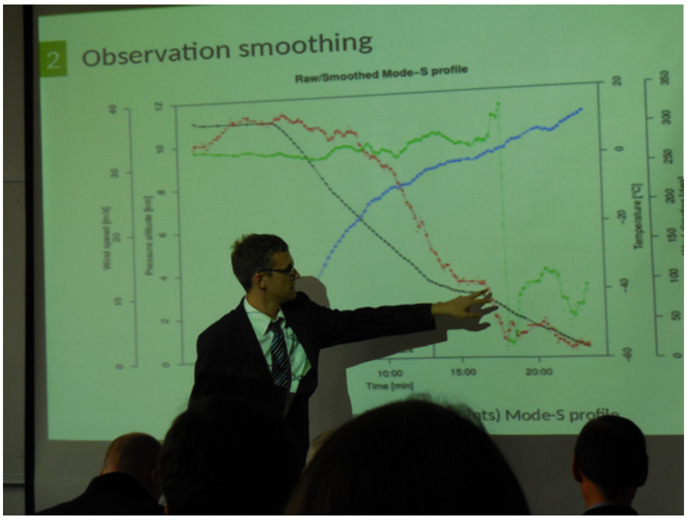
And this was just a beginning.. I still remember my first phasing stay, and how available Claude, André and Françoise were to answer my multiple questions, what a chance! That was a huge push in my career! I just realized that there are no borders in ALADIN, it's amazing how I could fix a binary linking issue with an advice from Bulgaria, and the famous "8" error with a recommendation from Slovakia, or step forward in Data Assimilation with help from Slovenia where I took a selfie at the highest point I could ever reach in Kamnik during a memorable hiking with Benedikt !

Every single contribution, stay or event was full of memories and motivation, and they were so intense that they had a great impact on me, either on personal or professional sides. This impact was so influent that it passed to all the team in my institute, pushing every member to work harder and contribute in improving ALADIN, the consortium of sixteen countries but only ONE team !

Zied Sassi

Tunis, 28 August, 2016

18th ALADIN General Assembly in Tunis, 14-15 November 2013

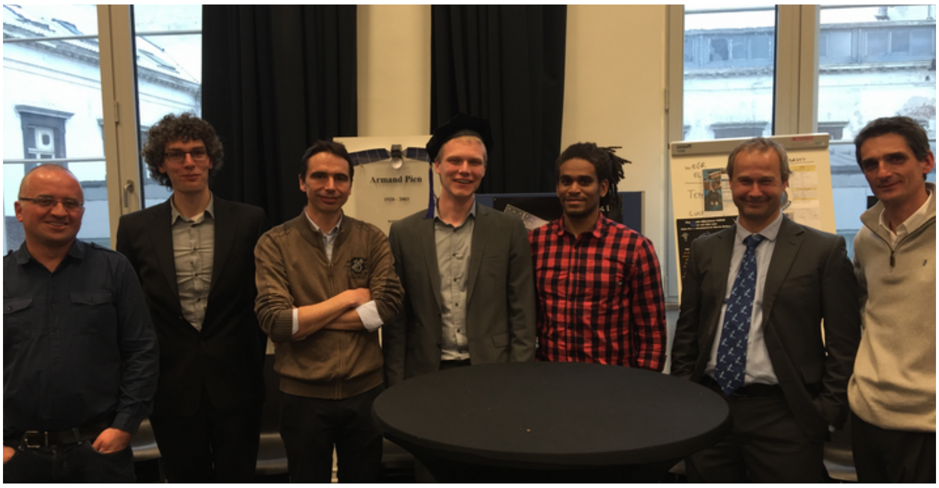


13 November 2015, Ljubljana University
Benedikt STRAJNAR

December 2015
Annelies DUERINCKX
University Gent, Faculty of Physics and Astronomy

16 April 2016
Rachida EL OUARAINI
Cotutelle between :
Institut National Polytechnique, Toulouse (France) &
Hassan II University, Casablanca (Morocco)

May 2016
Rozemien DE TROCH
University Gent,
Faculty of Physics and Astronomy



April 2016
Steven CALUWAERTS
University Gent, Faculty of Physics and Astronomy

More information on the previous ALADIN PhDs on the aladin website :
http://www.cnrm-game-meteo.fr/aladin/spip.php?article88

Click on the picture for more information on the PhD

Four-dimensional data assimilation of aircraft observations of the atmosphere in complex terrain

Abstract of the doctoral thesis, 13 November 2015

Benedikt Strajnar, Ljubljana University
Adviser: prof. dr. Nedjeljka Žagar & Coadviser: dr. Loïk Berre

1 Abstract

By increasing the resolution of numerical weather prediction (NWP) models the lack of high resolution measurements of the atmosphere is becoming more and more critical. The quality of the initial conditions for numerical weather forecast provided by data assimilation is highly dependent on the amount of available observations. The number of observations in the limited area mesoscale models with horizontal resolution of a few kilometers is a few orders of magnitude less than of the model points.

One of the main sources of observations for NWP is air traffic. Aircraft are equipped with instruments to measure temperatures and winds with aim to improve flight safety and efficiency. The development of meteorological system AMDAR (Aircraft Meteorological Data Relay) which has provided aircraft measurements for many years is coordinated by the World Meteorological Organization. The system requires the installation of additional communication equipment on the aircraft and the maintenance of data stream. Consequently, a very small, almost negligible proportion of all potentially available observations can then be collected. This thesis introduces an new approach for the delivery of wind and temperature data provided through air traffic control system. This data, known as Mode-S MRAR (Meteorological Routine Air Report), was acquired by Slovenia Control and was made available to the Slovenian meteorological office for the validation and application in NWP. Because the applied data transfer requires minimal additional costs, Mode-S MRAR is a very inexpensive source of meteorological measurements compared to other observing systems.

The usefulness of Mode-S MRAR data for numerical weather prediction is investigated with a limited area model ALADIN (in French Aire Limitée Adaptation dynamique Développement INternational), which is used for operational weather forecasting in Slovenia. An important prerequisite for successful application of new measurements is their quality control. An inter comparison study of Mode-S MRAR data against radiosondes and AMDAR observations over the common area is performed. It is found that Mode-S MRAR are of the same quality as AMDAR and that differences with respect to radiosondes are not greater than in the other similar studies. A more complete insight to the quality of the measurements is possible by the comparison with the short-term model forecasts. This validation reveals that some sensors are considerably biased, mainly on smaller aircraft. This provides basis for a list of aircraft with high-quality measurements to be used for assimilation.

Impact of the new data on analyses and forecasts is investigated by twoseparate assimilation cycles, one of them assimilating Mode-S MRAR observations in addition to all the other measurements. Since the impact on forecast is expected mainly over Slovenia due to the geographical limitations of the data coverage, the verification of forecast is possible only with the local measurements. With the exception of a single radiosonde measurement per day there is no high-quality observations in the lower troposphere, so the impact on the forecast has to be mainly checked against Mode-S MRAR observations.

Data assimilation experiments include the summer and the winter period. A significant impact of new measurements on the local analysis is detected. In the winter period, a positive impact is observed on the local temperature profile of the atmosphere and also the overall positive impact on the first few hours of temperature and wind forecasts. During a stable anticyclonic situations, the impact is even longer close to the ground, up to 24 hours in the forecast. In summer, the impact on forecast is much

more mixed. In addition to a general positive impact on very short-term forecast (2-3 hours), a negative impact on the temperature forecast is observed in the planetary boundary layer. It is found that the experiment with assimilated Mode-S MRAR observations is systematically too warm and too dry. Because humidity is not available through Mode-S, the influence on humidity caused by multivariate couplings with other observed variables is studied. When the impact of the observations of other atmospheric variables on the humidity through multivariate couplings in the background error covariances is not allowed, the systematic errors in temperature field disappear. This illustrates the importance of direct humidity information and its consistency in the analysis with the other variables in the mesoscale data assimilation, possibly by application flow-dependent background error covariances. On the case of the strong freezing rain in the beginning of 2014 it is demonstated how Mode-S MRAR observations improve the initial temperature profile and thus enable a better diagnosis of freezing rain.
The presented results have contributed the wide European initiative for a broader application of Mode-S data in the meteorological practice in Europe. With a groving network of such observations, a considerable impact on mesoscale numeric weather prediction can be expected.

2 References

An extensive article "Collection and assimilation of Mode-S MRAR aircraft observations in Slovenia", by Benedikt Strajnar was published in the ALADIN-HIRLAM Newsletter n°3, pages 9-15. This work was also presented during the Joint 24th ALADIN Workshop & HIRLAM All Staff Meeting 2014.

The potential of an Extended Kalman Filter for Soil Analysis in conjunction with a 3D-var system in a Limited Area NWP Model.

Extended abstract of the doctoral thesis, December 2015

Annelies Duerinckx, University Gent, Faculty of Physics and Astronomy
Promotors: Prof. dr. Piet Termonia and dr. Rafiq Hamdi

1 Introduction

The surface exerts an important influence on numerical weather predictions (NWP), especially for the planetary boundary layer (PBL). A good initialisation of the surface can therefore improve the short and medium-range forecast scores considerably. The link between the surface and the atmosphere is made by fluxes that transport energy and momentum between the surface and the atmosphere. The fluxes are regulated by the soil temperature and soil moisture content, that regulate the partitioning in sensible and latent heat flux. To initialise the surface, data assimilation techniques can be used. Those techniques combine observations with model data to estimate the real state of the system, or in our case the surface. Due to a lack of direct observations of soil temperature and soil moisture content, the assimilation process uses indirect observations of screen-level temperature and relative humidity. These screen-level observations are influenced by the surface fluxes and thus contain information about the state of the soil. A commonly used data assimilation technique for the surface is Optimal Interpolation (OI). Despite its operational usage in numerous NWP-centers, it has a few important shortcomings. The OI coefficients are pre-calculated and so they do not depend on the specific location or weather situation. Moreover, these pre-calculated coefficients make it cumbersome to include new observation types, like satellite observations. Recently an EKF has been developed for surface assimilation in the surface model SURFEX that meets these shortcomings. In the EKF the coefficients are calculated in an ad hoc manner, so their values are dependent on the specific location and weather situation. Moreover, the more general and ad hoc manner of calculating these coefficients allows the EKF to be more easily extended towards new observation types.

In this research the EKF is validated for the Numerical Weather Prediction (NWP) model ALARO coupled to the surface model SURFEX. The EKF is combined with a three dimensional variational (3D-var) assimilation for the upper-air and the added value of this combination, with respect to surface or upper-air assimilation separately, is investigated. The combination of the EKF with 3D-var for a limited area model is a new one that, to our knowledge, has not been tested before. The purpose of this thesis is to find an optimal set-up for the initialisation of the operational NWP-model of the Royal Meteorological Institute (RMI) of Belgium, that is currently initialised using an interpolation of the global ARPEGE data assimilation analyses for both the surface and the atmosphere.

The research is build up in in four stages. First, the importance of the surface for the planetary boundary layer and the upper atmosphere is described and the surface model SURFEX coupled to ALARO is validated above Belgium within this context. Next, data assimilation theory is discussed, with special attention for OI and the EKF as candidate assimilation techniques for the surface and 3D-var as a technique for the upper-air. The third stage is a thorough validation of the EKF, including a search for the optimal perturbation sizes for the finite differences calculation of the Jacobian of the observation operator. A comparison is made of the offline and coupled finite differences approach of calculation the Jacobian. In a fourth and final stage, the EKF is combined with a 3D-var upper-air assimilation and this combination is compared to a number of other set-ups. The comparison is made with regards to increments and validated with observation of the soil, the screen-level temperature, screen-level relative humidity, atmospheric soundings and precipitation observations.

2 Results

The validation of SURFEX

The validation of SURFEX show that SURFEX improves the forecast scores compared to the current operational ISBA surface scheme. The results over Belgium show that the introduction of SURFEX either shows improvement for or has a neutral impact on the 2m temperature (cfr. Figure 1), 2m relative humidity and 10m wind. However, it seems that SURFEX has a tendency to produce a too high maximum temperature at a high-elevation station during winter daytime, which degrades the scores. In addition, surface radiative and energy fluxes improve compared to observations from the Cabauw tower. It was found that the use of SURFEX has a neutral impact on the precipitation scores. Overall, it can be stated that forecast performance can be improved on average when using SURFEX in ALARO.

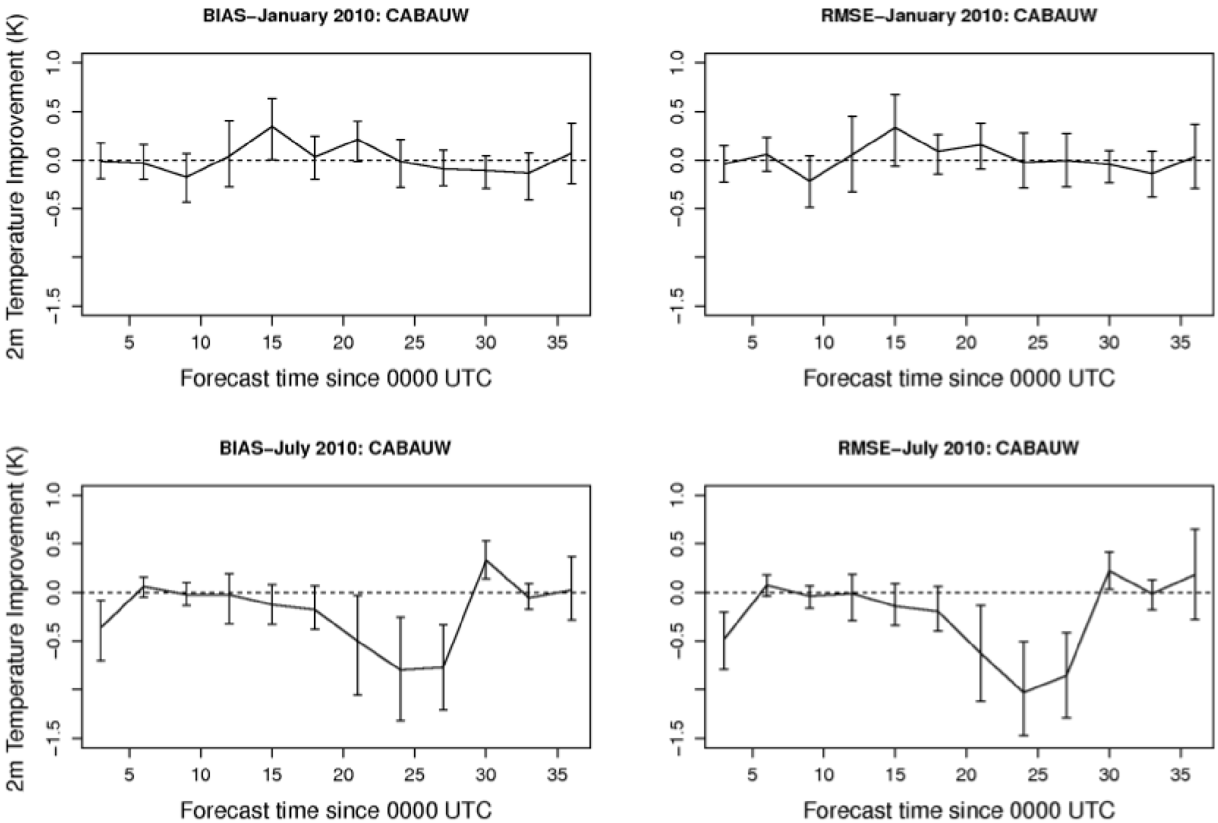


Illustration 1:The improvement in bias (left) and rmse (right) of the 2m temperature obtained when using SURFEX for January (top) and July (bottom). The 95 % confidence intervals for | biasOPER + SFX | − |biasOPER | and rmseOPER + SFX − rmseOPER were calculated with the bootstrap method.

The Jacobian of the observation operator of the EKF

The study of the observation operator Jacobian of the EKF shows that the offline and coupled approach have similar spatial patterns and values. Still, the offline approach has a few advantages over the coupled one. Firstly, the offline approach allows for smaller perturbation sizes due to which there is a better validity of the linearity assumption of the finite differences approach (see figure 2). Moreover, the offline approach is computationally much cheaper, allowing it to be used in an operational setting. A case of spurious 2-delta-t oscillations is documented. The oscillations arise in the late afternoon in Summer when a stable boundary layer sets in. It can be linked to an oscillation in the Richardson number (see figure 3) that is reflected in a number of surface related variables, amongst which 2m temperature (see figure 4) and 2m relative humidity, used to calculate the Jacobians. Test ware made with different perturbation sizes, time steps, values of the critical Richardson number and SURFEX coupling methods (implicit vs. explicit), but none of the different settings were able to remove or reduce the oscillation. Although the oscillation disappears again after a while and does not have a detrimental effect on the forecast scores, it introduces considerable noise in the Jacobian of the EKF (see figure 5) and thus in the increments. For this reason a filter was proposed to deal with these oscillations and it is shown that the filter works accordingly (see figure 6). Results show that the coupled, filtered approach gives the best forecast scores. Still our preference goes out to the offline, filtered approach that also improves the non-filtered EKF but is computationally much cheaper and thus more feasible for operational usage.

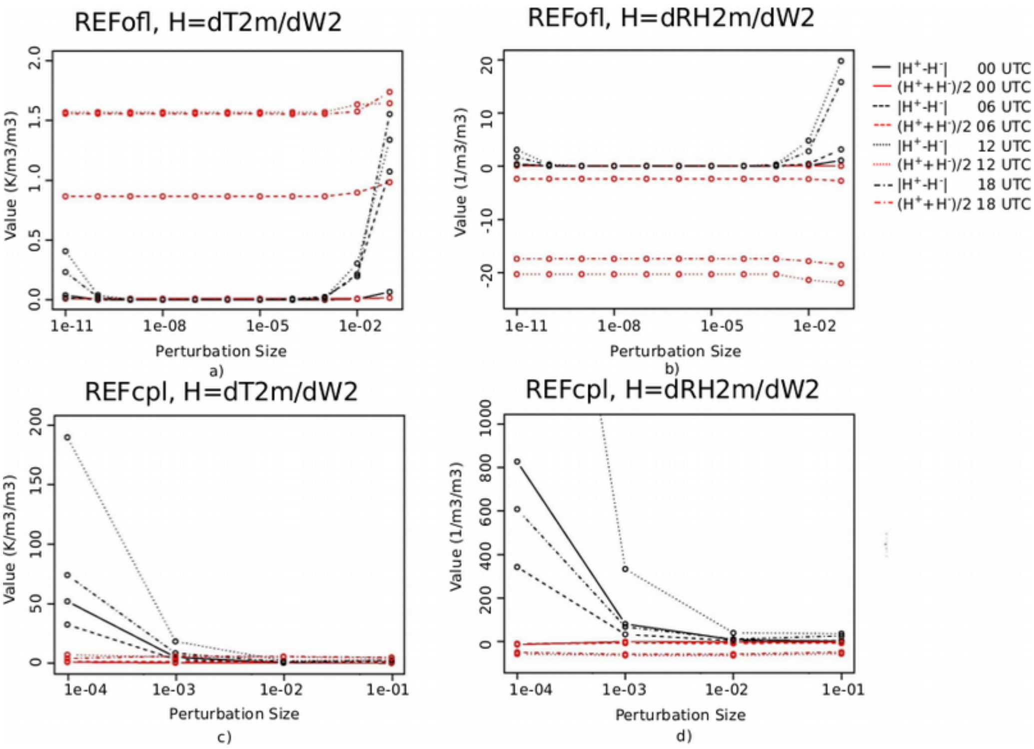


Illustration 2: Comparison of the optimal perturbation size for the offline (top) and coupled(bottom) approach. $|H+ - H-|$ (black) and $H+ + H- /2$ (red) for different perturbation sizes on 2 July 2010 at 00:00, 06:00, 12:00 and 18:00 UTC averaged over the whole domain with $H = \delta T2m / \delta Wg2$ (left) and $H = \delta RH2m / \delta Wg2$ (right).

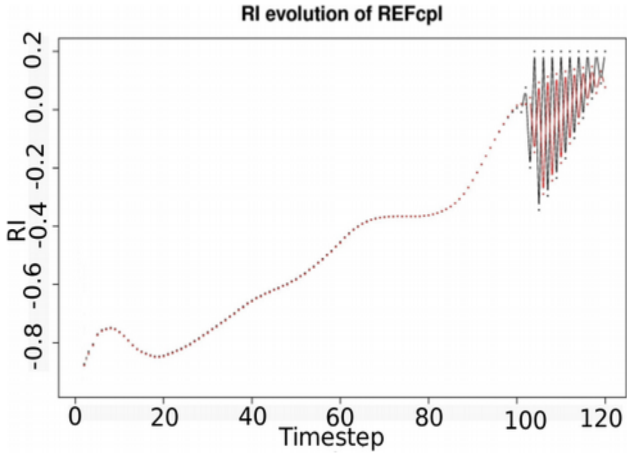


Illustration 3: Evolution of the Richardson number (RI) during a 6h coupled run for 2 July 2010 from 12:00 until 18:00 UTC as it

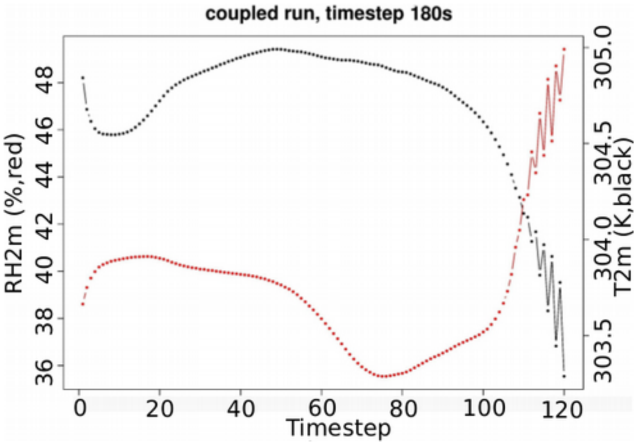


Illustration 4: Evolution of T2m (black) and RH2m (red) during a 6h coupled SURFEX run for 2 July 2010 from 12:00 to 18:00 UTC

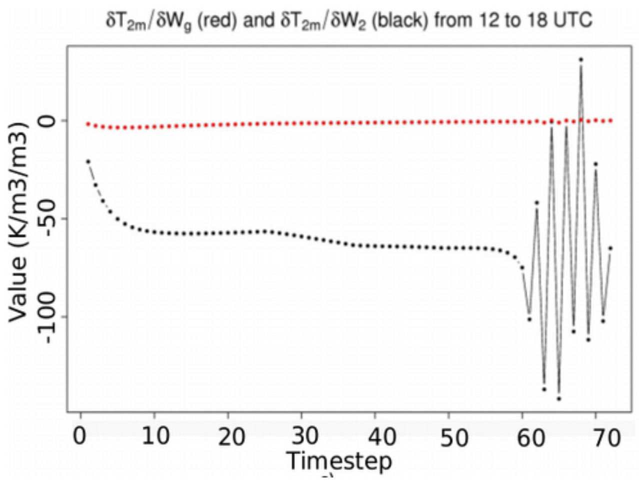


Illustration 5: δT2m /δWg1(red) and δT2m /δWg2 (black) from 12:00 to 18:00 UTC for an offline SURFEX run on 2July 2010.

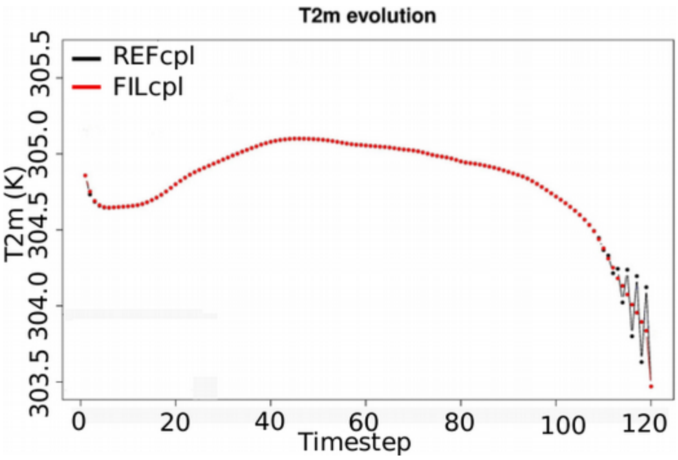


Illustration 6: Evolution of T2m for the coupled reference run (REF, black) and the filtered run (FIL, red).

Validation of the combination of the EKF with a 3D-var assimilation for the upper-air

In the final stage the EKF is combined with a 3D-var upper-air assimilation and this set-up is compared to a number of other initialisation set-ups. Experiments were performed for 1 year and for eight different set-ups. The goal of the verification is to get similar scores as the Open Loop, that uses the interpolated ARPEGE analysis as initial conditions for the surface and the atmosphere as it is done in the correct operational set-up at the RMI. Results show that the planetary boundary layer in the model is in general too cold and too wet, except during summer. The surface assimilation is capable of partly eliminating this bias. The importance of the surface assimilation is confirmed by the much larger bias and root mean square error of the free run , in which the surface is not reinitialised after each assimilation cycle but is allowed to run freely during the whole year. The combination of surface and upper-air assimilation provides better scores for soil moisture content and screen-level humidity (see figure 7) compared to the Open Loop, especially during the first twelve hours of the forecast. Comparisons of the model values with atmospheric soundings and precipitation observations show that the 3D-var assimilation experiments are not able to reproduce the scores of the Open Loop for the upper layers of the atmosphere. This is probably due to a lack of observations, since only conventional observations are used in the assimilation so far. Only during Autumn, the 3D-var assimilation is able to improve the Open Loop scores for precipitation. The scores also show the positive effect of surface assimilation on the precipitation forecasts.

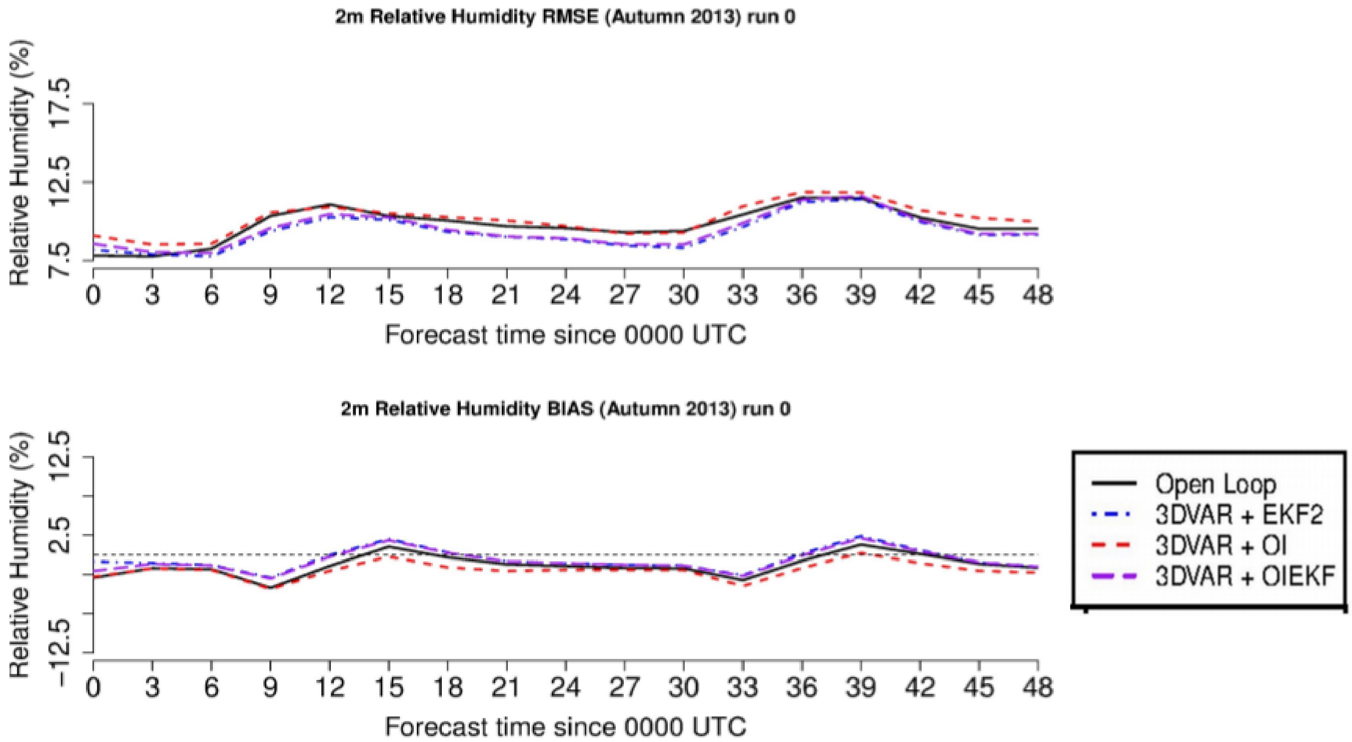


Illustration 7: creen-level relative humidity RMSE and BIAS scores for OL, 3D-Var+OI,3D-Var+EKF and 3D-Var+OIEKF averaged over 13 stations in Belgium for Autumn 2013

3 Conclusion

In general it can be concluded that the surface assimilation, and in particular the EKF, improves the surface and boundary layer humidity compared to the Open Loop. For temperature the results are more mixed, but also in this case the surface In general it can be concluded that the surface assimilation, and in particular assimilation experiments are able to achieve similar results as the Open Loop in most cases. The 3D-Var upper-air assimilation should be improved by a better B-matrix and adding satellite data, GNSS ZTD data and radar data. The advantages of the combination of surface and upper-air assimilation are clear from the improved scores for soil moisture content and relative humidity in the lower parts of the atmosphere, compared to the runs with only surface or upper-air assimilation. As a conclusion for the operational set-up of the RMI it can be said that the surface assimilation runs, and particularly the EKF, are able to get similar or improved scores compared to the current operational initialisation set-up. The 3D-var upper-air assimilation however, should first be improved by using satellite, GNSS and/or radar observations and a better B-matrix before it can be considered for operational usage.

Sensitivity of global and regional ensemble assimilation to initial conditions and lateral boundary conditions

Extended abstract of the doctoral thesis, April 2016

Rachida EL OUARAINI, INP de Toulouse and Hassan II University of Casablanca
Promoters: Dr. Claude FISCHER, Prof. El Hassan SAYOUTY and Dr. Loïk BERRE

1 Introduction

Ensemble assimilation is a method increasingly used to estimate flow-dependent spatial covariances of forecast errors for data assimilation systems, and to provide initial perturbations to ensemble prediction systems.
Such approach is used for both global and regional systems through the specification of suitable lateral boundary conditions in the second case.

The success of an ensemble assimilation is largely based on the realism of associated perturbations that simulate the system errors. By carefully designing perturbations, the ensemble spread can be shown to be representative of background error. The estimation of background error statistics and the production of initial states of a numerical weather prediction model are then improved. Consequently, the choice of ensemble perturbations should be studied carefully.

Ensemble perturbations may be implemented in different ways. In practice, observation perturbations are provided by random draws of the observation error covariance matrix $\mathbf{R}$. Lateral boundary condition perturbations in a regional ensemble come generally from ensemble forecasts on a larger area. Background perturbations may be created firstly through the perturbation evolution from the previous analysis step, and secondly via the addition of model perturbations that are representative of modeling errors. The ability to generate initial background perturbations (at the very start of the ensemble cycling period), as well as lateral boundary condition perturbations, as random draws of a covariance model is another approach that has been explored in this research.

This research is built up in two stages mainly. In the first stage, the sensitivity of a global ensemble assimilation system to its initial condition perturbations is examined. This is conducted by comparing a "cold" initialization technique (initial perturbations equal to zero) with a method using initial perturbations which are randomly drawn from a covariance model. In the second stage, the sensitivity of a regional ensemble assimilation to its lateral boundary condition perturbations is considered. In this context, a comparison between different techniques producing lateral boundaries is achieved. It involves comparing approaches using lateral boundary perturbations which are either equal to zero, or drawn from a global ensemble, or generated using a covariance model.

2 Results

Sensitivity of a global ensemble assimilation to initial conditions

The sensitivity of ensemble data assimilation spread to initial background perturbations has been investigated in this study formally and experimentally. The formal analysis of error and perturbation equations shows that error variances are likely to converge in time whatever the ensemble initiation is, for instance even if they are expected to be underestimated during the first analysis/forecast steps when using initial background perturbations equal to zero. This has been confirmed experimentally, by comparing variance estimates provided with different initiation strategies. A reference ensemble (REF) has been started 6 days before the start of the experimental period to obtain stable background perturbations. This has been compared with a cold-start ensemble (COLDS), using initial background perturbations equal to zero, and with another experimental ensemble, initiated by random draws of a specified background error covariance matrix $\mathbf{B}$ (RANDB). It appears that the convergence of variance estimates is reached after 3-4 days of cycling of the ensemble assimilation system (see Figure 1). Moreover, the initiation by random draws of $\mathbf{B}$ provides variance structures that are more consistent (see Figure 2), and better correlated (Figure 3) with the reference ensemble. Finally, an impact study indicates that using initial random draws of $\mathbf{B}$ is beneficial for the forecast quality at the beginning of the period, while the impact is neutral once variance estimates have converged toward similar values (see Figure 4).

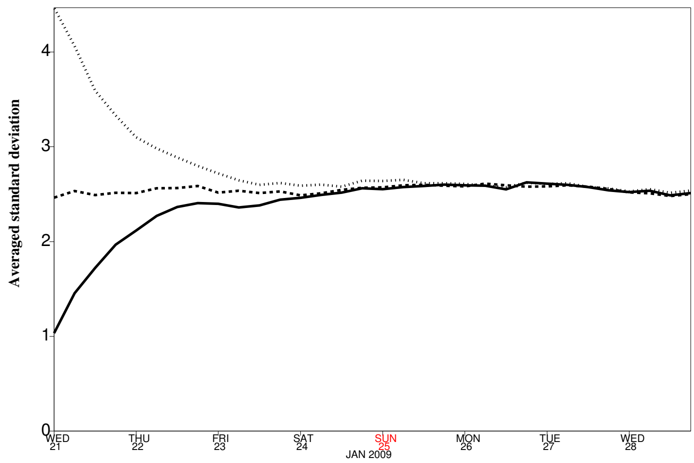


Figure 1: Temporal evolution of horizontally averaged standard deviations of vorticity near 500 hPa for experiments REF (dashed line), COLDS (solid line) and RANDB (dotted line).

Sensitivity of a regional ensemble assimilation to lateral boundary conditions

In this research, the ensemble data assimilation spread of the regional ALADIN-France system has been studied with different choices of LBC perturbations for 3- and 6-h forecast ranges, while observations and initial LBCs are perturbed in all experiments. A first ensemble configuration (GLBC), considered as a reference, is based on the use of the operational global ensemble data assimilation system of Météo-France, in order to provide perturbed 3- and 6-h LBCs. A second ensemble configuration (ULBC) uses the global deterministic forecasts of ARPEGE, in order to provide 3- and 6-h LBCs to each member of the ensemble; this amounts to using zero-valued LBC perturbations for these forecast ranges. A third ensemble (PLBC) uses 3- and 6-h LBC perturbations, which are provided by random draws of an error covariance model which is assumed to be representative of LBC errors.

A formal analysis of error and perturbation equations has been carried out in order to provide an insight of the relative effect of 3- and 6-h LBC perturbations, compared to observation and initial LBC perturbations. Due for instance to the contribution of observation perturbations to forecast perturbations, it has been noticed that the relative effect of LBC perturbations is likely to depend on the spatial coverage and quality of the observation network. In addition to this formal analysis, experimental studies of ensemble spread sensitivities to LBC perturbations have been carried out. Time-averaged horizontal maps of spread indicate that the use of unperturbed 3- and 6-h LBCs leads to an underestimation of the ensemble spread that affects about a third of the ALADIN-France domain, due to advection (see Figure 5). Conversely, this is much less pronounced in the central and North-East parts of the LAM domain, due to the predominant contribution of observation and initial LBC perturbations in these regions. The spread underestimation is avoided when using LBC perturbations which are randomly drawn from an error covariance model, leading to spread maps which are similar to those of the reference regional ensemble coupled to the global ensemble (Figure 5). An additional experiment indicates also that the spread maps are sensitive to the amplitude scaling of these drawn LBC perturbations (not shown). Furthermore, the time evolution of ensemble analysis spread over the period of study indicates that the spread spin-up period is relatively short (1 day), the spread increases towards stable values within a few data assimilation cycles (Figure 6). This can be seen as resulting partly from the influence of LBC perturbations, but also from the contribution of observation perturbations and of associated cycled background perturbations. Correlations of spread maps, computed over the whole domain and test period, indicate that the spread obtained with the PLBC method is better correlated with the reference case (GLBC) than the spread obtained with ULBC (see Figure 7).

3 Conclusion

The first part of this work [El Ouaraini and Berre, 2011] has focused on the study of the sensitivity of a global ensemble assimilation spread to initial background perturbations. A formal review of perturbation evolution equations allowed highlighting three properties. First, the damping properties of perturbations that are associated with the analysis step. Next, the underestimation of spread during the first steps of cycling in the case of a cold start. The third property highlights the temporal convergence of the spread. The experimental study was then used to show that the ensemble spread is similar after about 3 days of cycling, regardless of the used initial background perturbations. The use of zero initial background perturbations (cold start), however, generates underestimated ensemble spread and less well distributed geographically in the early steps of the assimilation cycle. The implementation of initial perturbations from random draws of an error covariance model however provides a realistic ensemble spread similar to that of the control ensemble.
The question of initializing an ensemble assimilation system can thus be important in an operational context if, for some reason, the assimilation cycle was interrupted. In fact, a restart from random perturbations improves the ensemble spread compared with a cold start, for which several cycles of assimilation would be needed (spin-up time) to be able to find realistic spread values.

In the second and final stage of this research [El Ouaraini et al., 2015], the sensitivity of a regional ensemble assimilation spread to lateral boundary condition perturbations has been considered. To study the contribution of different perturbations in the assimilation system, a formal analysis of error and perturbation equations has been implemented. It has been shown that the contribution of lateral boundary condition perturbations depends on the spatial coverage and quality of the observation network. Experimentally, three sets of lateral boundary condition perturbations were compared: perturbations obtained from a global ensemble, zero perturbations and perturbations constructed from random draws of a specified error covariance matrix $\mathbf{P}$, which is assumed to be representative of lateral boundary condition errors. It was shown that under-dispersion associated with the non-perturbation of lateral boundary conditions affects about a third of the ALADIN-France domain, due to advection during the data assimilation cycling. The use of lateral boundary conditions perturbations which are drawn from an error covariance model provides realistic ensemble spread that is fairly well correlated with the control ensemble spread coupled to a global ensemble.

This approach is a practical alternative for regional NWP centers that do not have a global ensemble system and that would like to avoid dependency and cost constraints of distant transfers of coupling files from another center of NWP. Random draws method offers also the opportunity to enhance a regional ensemble by increasing the number of its members.

In general, it can be concluded that initial and lateral boundary perturbations constructed from random draws of an error covariance model provide realistic ensemble spread with a reasonable cost.

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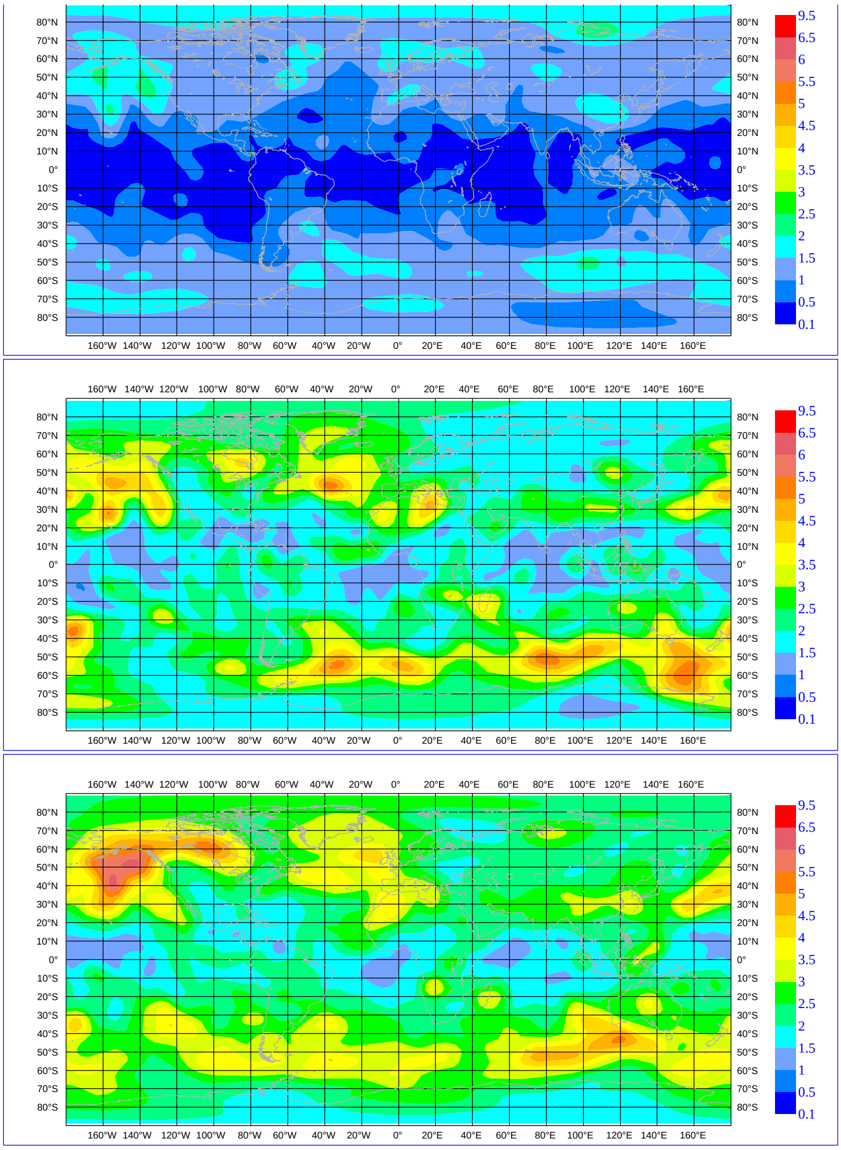

Figure 2: Standard deviations of vorticity near 500 hPa produced by the first analysis/forecast step (on 21 January 00 UTC) for experiments COLDS (top), REF (middle) and RANDB (bottom). Unit: $10^{-5}s^{-1}$

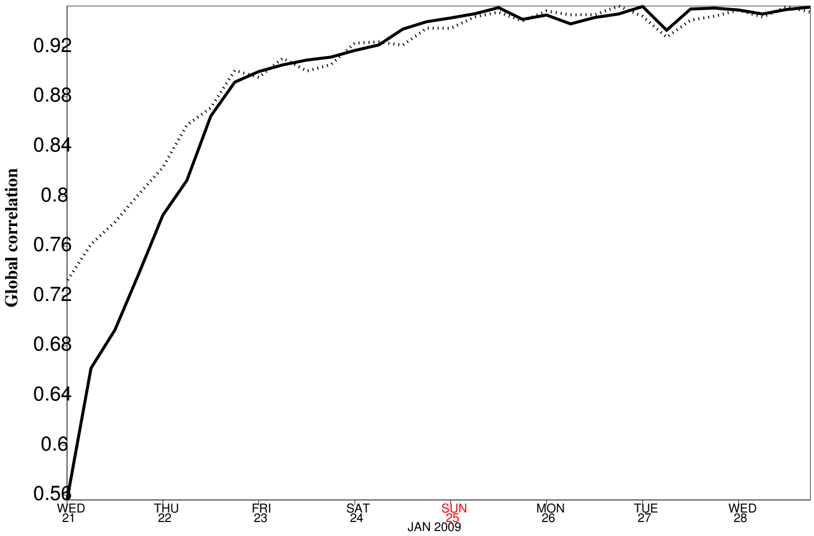

Figure 3: Temporal evolution of global correlations between respective standard deviation maps of vorticity near 500 hPa of RANDB and of REF (dotted line), and between respective maps of COLDS and of REF (solid line)

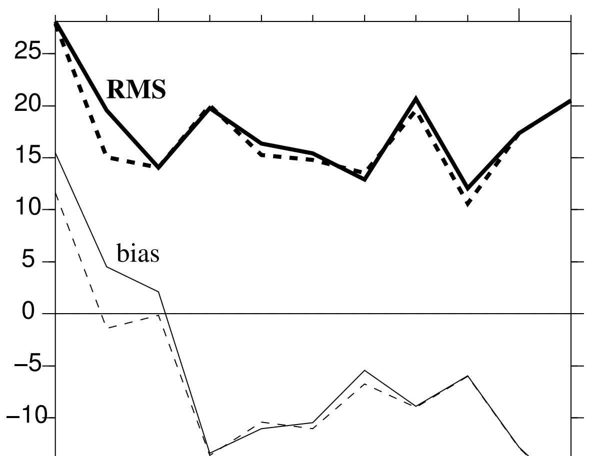

Figure 4: Temporal evolution of RMS and bias over Europe of 48h forecasts of geopotential (unit: m) at 850 hPa calculated against radiosonde observations, for experiments using variances provided by RANDB (dashed line) and COLDS (solid line) respectively.

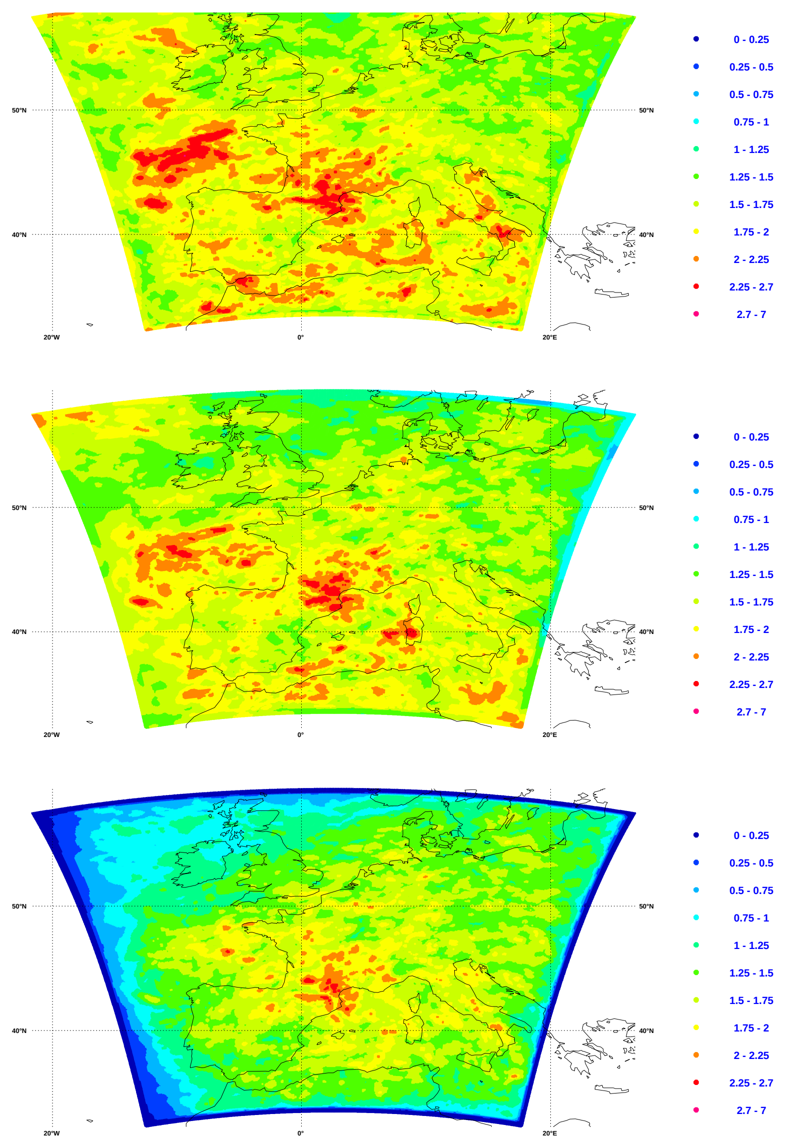

Figure 5: Horizontal maps of time-averaged spread of 6h zonal wind forecasts valid at 06 UTC, near level 500 hPa for : PLBC (Top), GLBC (Middle) and ULBC (Bottom)

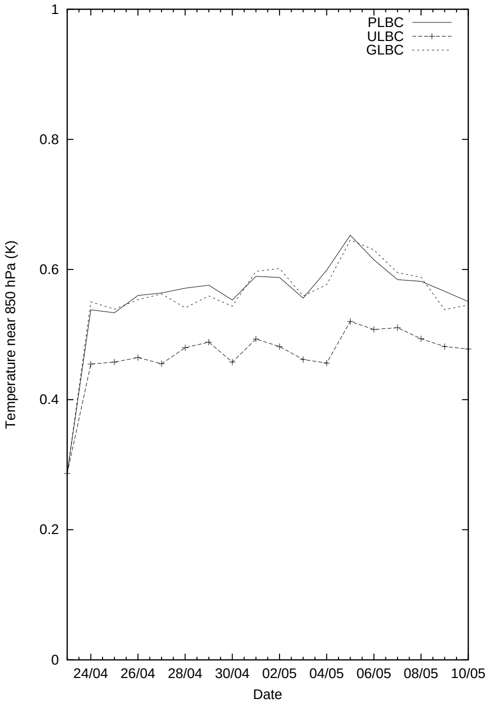

Figure 6: Temporal evolution of horizontally-averaged analysis spread maps valid at 00 UTC of Temperature near 850 hPa

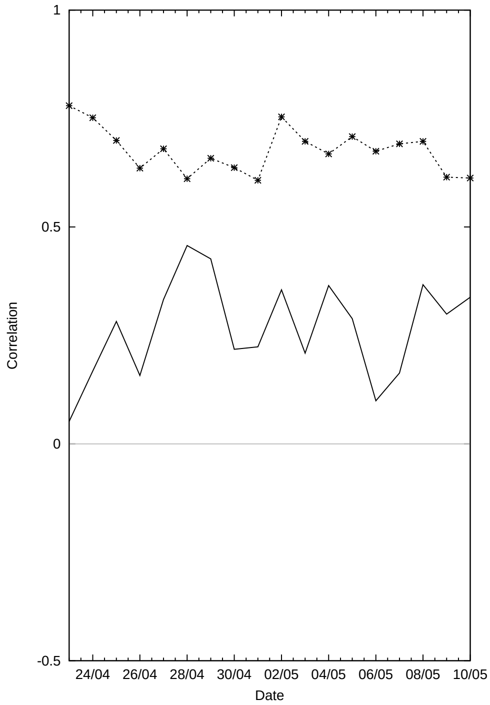

Figure 7: Temporal evolution of domain-averaged correlations between respective spread maps $6h$ *forecasts valid at 06 UTC of ULBC and of GLBC (solid line), and of PLBC and GLBC (dotted line) for Temperature near 850 hPa*

Horizontal spatial discretization modularity within the spectral semi-implicit semi-Lagrangian ALADIN framework

Extended summary of the doctoral thesis, 18 April 2016

i.r. Steven Caluwaerts, University Gent, Faculty of Physics and Astronomy
Promotors: prof. dr. P. Termonia, dr. ir. D. Degrauwe, prof. dr. H. Dejong

1 Summary

Modeling the evolution of our atmosphere accurately is beneficial for society. The groundbreaking work of Vilhelm Bjerkness and Lewis Fry Richardson laid the foundations of numerical weather forecasting. Last decades, the accuracy of the forecasts has been improved strongly, mainly by the increase in available computing power and high-quality observations, the improvements in data assimilation, and a better understanding of the atmospheric processes and numerical methods. The ambition for the modeling consortia consists of further improving the quality of the forecasts by using the resources optimally. With this study we hope to add a small contribution to the achievement of this huge challenge.

Chapter 1 presented a historical introduction on numerical weather prediction (NWP) and a non-exhaustive overview of the different continuous equations systems and discretization schemes that are used in today's NWP models. It was explained that choices made in a NWP model should be seen within the context where the model is developed in; this framework imposes constraints that are beyond the control of the model developer.
This study is situated within the context of the ALADIN model, which is used operationally in 16 countries. The ALADIN numerics combine the highly accurate spectral horizontal spatial discretization with a semi-implicit semi-Lagrangian (SISL) time discretization, which permits the use of long timesteps while staying stable. Due to the diagonal character of derivative operations in spectral space, the Helmholtz problem that results from the SI discretization is solved trivially in spectral space. Because some of the computations, for example the subgrid physics parameterizations, are evaluated in grid points, transforms between spectral and grid point space are needed every timestep. The global character of the spectral basis functions makes that these transforms need global communication. Combined with the trend towards massively parallel supercomputing, where communication seems to become a bottleneck, this could undermine the scalability of the spectral approach. Apart from its potential scalability problem, there is a second disadvantage: a spectral method can not include horizontally inhomogeneous terms in the Helmholtz equation. Therefore, the nonlinear residual terms, which are treated with an explicit timestepping scheme, are substantial and this may pose problems for the stability of the scheme.
As local spatial discretization methods fit within the two previous limitations, this thesis investigated whether and how one could implement local methods, for example a finite difference (FD) scheme, within the current ALADIN numerics.

Model developments need to obey external constraints that are imposed on the NWP model. Therefore, chapter 2 gave an overview of three constraints that are relevant for the ALADIN numerics:

1. The goal of the ALADIN model is to deliver timely high-resolution mesoscale forecasts on limited area domains.
2. Code is developed in a modular way such that the impact on the engineering applications and products of the model, on other parts of the model, and on the users is minimal. For this thesis the modularity constraint is translated into two recommendations: maintain the timestep organization and stay on a collocation or unstaggered grid, where all variables are defined in the same grid points.
3. The model must exploit the increased computing power.

Atmospheric motion can be decomposed into different sorts of waves. Some, for instance Rossby waves, have large meteorological relevance, whereas others, such as acoustic waves, are not of any meteorological interest. Inertia-gravity waves (IGWs) have a position in between. They are of direct importance for some mesoscale meteorological phenomena. However, at synoptic scales they only have an indirect relevance. At these scales the atmosphere is always striving towards a geostrophic balance between the geopotential and velocity fields. Imbalances to this geostrophic adjustment are restored by radiating away IGWs.

As illustrated in chapter 3, discretization in space and time causes the numerical atmospheric waves to be different from their analytical counterparts. By its high order of accuracy, the spectral discretization method does represent all waves accurately. However, a local discretization method on an unstaggered grid (A-grid) results in inappropriate geostrophic adjustment for the shortest scale IGWs. Therefore, many models make use of a staggered grid where different variables are defined in different grid points. Another solution proposed in literature, called the Z-grid method, consists of reformulating the equations from wind components to divergence and vorticity. In this way, one can recover appropriate IGW propagation while staying on an unstaggered grid, which is one of the constraints for the model. Therefore, chapter 4 presented a more detailed study of the Z-grid method within the SISL ALADIN framework.

The detailed SISL Z-grid study in chapter 4 revealed two important points of attention:

- Combining the Z-grid approach with a SI time discretization results in a scheme containing asymmetries between spatial operators in the explicit and implicit part of the computations. Analysis and toy model tests based on the linear SWE show that these asymmetries result in unphysical IGW dispersion that annihilates the appropriate Z-grid properties. Local SISL Z-grid schemes that were proposed in literature suffer from this problem.
- The eigenvector decomposition of a Z-grid scheme is incorrect for the shortest scale part of the spectrum, independent of the time discretization. Short scale noise in the wind fields for Z-grid geostrophic adjustment tests confirm this analysis.

By modifying some of the operators in the explicit part of the SISL computations, symmetry can be restored. However, the eigenvector decomposition is inherent to the Z-grid method and can not be solved easily by tweaking the scheme or its operators. Adding non-linear terms, such as advection, or truncation to the SWE toy model makes that the inappropriate wave behavior becomes less obvious. Therefore, one could wonder how relevant dispersion properties are within the context of a complete
NWP model.

Finally, chapter 4 illustrated the possibility of local schemes to include inhomogeneous terms in the Helmholtz solver. By doing so, the non-linear residuals, which are a source of potential instabilities and are treated in an explicit way, are reduced.

Chapter 5 explained that introducing a SISL scheme based on a local spatial discretization method fits well within the current ALADIN timestep organization. The main change would be the introduction of a sparse matrix solver for the Helmholtz problem to replace the current diagonal problem in spectral space. For the development of such a solver one could make use of the extensive experience in different branches of science about iterative solvers for large, sparse matrix systems on massively parallel machines.

Despite the fact that the implementation of such a solver falls out of the scope of this thesis, chapter 5 presented results of FD runs undertaken with the ALADIN model. Adding the FD wave responses to the current spectral code is sufficient to mimic the use of FD schemes in ALADIN. This methodology provides a powerful testbed to investigate the scientific impact of different spatial discretization methods.

One high-resolution LAM forecast with quadratic truncation was repeated for different spatial discretization schemes. The standard spectral run was considered as the reference. Some conclusions:

- The FD schemes based on the asymmetric Z-grid approach had larger differences with the reference run than the A-grid based schemes. A detailed look clearly showed the fingerprint of the distorted projection of the eigenvectors by the Z-grid scheme. As the decomposition is crucial during the first timesteps, a proper initialization (e.g., DFI) may weaken or remove this problem.
- There was no fingerprint found of the negative group velocity of the A-grid schemes.
- By increasing the order of accuracy of the FD scheme, the local schemes converged toward the reference run.

These conclusions were valid for ALADIN tests both in adiabatic and ALARO mode.
Let us come back to the question that formed the basis of this thesis: *Can we use within the current spectral SISL ALADIN model a local horizontal spatial discretization scheme and how to do this?*.
This thesis provides arguments that a local solver can be added to the ALADIN framework while retaining most of the current code organization. FD spatial discretization methods based on the Z-grid approach suffer from an eigenmode decomposition problem, which mainly manifests itself during the first timesteps. Similar FD tests were undertaken within an A-grid approach and no fingerprint of the spurious waves that are diagnosed in analytical A-grid tests was found. The A-grid approach combined with fourth- or higher-order FD spatial discretization yields results close to the spectral experiments for ALARO tests. Therefore, higher-order A-grid methods are a promising candidate for a modular implementation of local schemes within ALADIN.

2 Outlook

The full thesis can be downloaded on the aladin webpage dedicated to PhDs.

The application of the ALARO-0 model for regional climate modeling in Belgium:
extreme precipitation and unfavorable conditions for the dispersion of air pollutants under present and future climate conditions

Extended abstract of the doctoral thesis, May 2016

Rozemien De Troch, University of Ghent, Department of Physics and Astronomy
Supervisors: Prof. Dr. Piet Termonia and Dr. Rafiq Hamdi

1 Introduction

Climate models, and in particular regional climate models (RCMs) find their origin in Numerical Weather Prediction (NWP) models. Important developments in NWP models have in the mid 1950's led to the first applications of Global Climate Models (GCMs). The current GCMs have a spatial resolution of around $100-200$ km, and are an essential tool to determine and correctly understand the large-scale mechanisms and phenomena in our climate system, such as the general atmospheric circulation. However, the coarse spatial resolution of the GCMs falls short to take into account many key regional and local aspects and underlying subgrid scale processes, such as for example extreme precipitation. To account for this scale difference between the large-scale information from the GCMs on the one hand, and the small-scale and local information which is extremely relevant for impact studies on the other, the downscaling technique has been introduced.

A frequently used downscaling technique, is the dynamical downscaling, and more specifically the nesting approach. In this approach large-scale meteorological fields from either a GCM or from analyses of observations are used to provide the initial and time-dependent meteorological Lateral Boundary Conditions (LBCs) for the high-resolution Limited Area Model (LAM) or RCM. Over the last decades, RCMs have undergone enormous improvements in their development, characterized by important advancements in their representation of landscape and surface features, in their description of subgrid-scale physical effects, and in their spatial resolution (down to 10 km). Nowadays, the RCMs have become a popular tool for regional climate modeling, in which multiyear simulations are carried out to study important regional and local climate processes, such as extreme events.

In this research it is studied in detail to what extent the operational NWP model of the Royal Meteorological Institute of Belgium (RMI) (i.e. ALARO-0) can be used for regional climate modeling in Belgium of (i) extreme precipitation, and of (ii) the unfavorable meteorological conditions for the dispersion of air pollution. Precipitation is one of the most important climate variables. Furthermore, the underlying precipitation processes play a crucial role in the state of the atmosphere and the regional and global climate. Hence, a correct description of the precipitation processes in the climate models is crucial. However, deficiencies in the parameterizations for precipitation, and in particular for deep convection, prevent the climate models to correctly simulate spatial and temporal variations, as well as the frequency and intensity of precipitation. The new physics parameterizations for deep convection and clouds in the ALARO-0 model were specifically designed in the context of NWP, and aimed to be used for the mesoscale to the convection-permitting scales (i.e. so-called "gray-zone" scales). The multiscale aspect of the physics parameterizations, called Modular Multiscale Microphysics and Transport (3MT), has indeed been demonstrated through consistent and realistic weather forecasts at spatial resolutions ranging from 10 km up to high resolutions of 4 km (Gerard et al., 2009).

In the research department of the RMI, the ALARO-0 model, which is a new version of the ALADIN model, is since 2010 used for regional climate simulations. Although, a detailed regional climate modeling study for Belgium is since then not carried out. Therefore in a first step, the Belgian ALARO-0 NWP model and its new physics parameterizations is validated for climatological time scales, by driving the model with "perfect boundary conditions" coming from global reanalyses. For precipitation, and more specifically extreme precipitation, the validation of the downscaling results is executed for a wide range of spatial and temporal resolutions. In a following step, the model is applied for a climate projection under the A1B scenario as described by the Intergovernmental Panel on Climate Change (IPCC), in which a global climate change simulation is dynamically downscaled using the ALARO-0 model. In this research, the ALARO-0 simulations with a vertical resolution of 46 model levels, are carried out up to high spatial resolutions of 4 km, corresponding to the finest atmospheric (micro)scales. Furthermore, this horizontal and vertical resolution is much higher than the state-of-the-art GCM and RCM resolutions of roughly $100-200$ km and 12 km as used in international initiatives such as the Model Intercomparison Project Phase 5 (CMIP5) and the EURO-CORDEX project.

2 Results

2.1 Validation of the ALARO-0 model for simulating extreme precipitation climatology in Belgium

As a first goal, the main feature of the ALARO-0 model, i.e. the new 3MT physics parameterization package and its multiscale characteristic, is validated for precipitation in a climate context. For this the ERA-40 reanalysis is dynamically downscaled using the ALADIN model and the ALARO-0 model on a horizontal resolution of 40 km, followed by a one-way nesting on high spatial resolutions of 10 and 4 km. This setup allowed us to explore the relative importance of spatial resolution versus parameterization formulation on the model skill to correctly simulate extreme daily precipitation. The relative frequencies, shown in Fig. 1, are calculated for 30-yr (1961-90) daily summer precipitation amounts of the observations and model data, which are binned into bins of 1 mm day^{-1}. To provide a reference for regional climate modeling, relative frequencies from the ERA-40 driven ALADIN-Climate/CNRM simulations are also calculated. It can be seen that for the low precipitation rates all models manage to reproduce the observed frequencies relatively well. Once the 0.95^{th} quantile (q0.95) of the observations (indicated by the vertical black line) is exceeded, CNRM shows an increasing departure from the observations with frequencies left shifted from the observations. ALARO-0 and ALADIN at 40-km horizontal resolution (ALR40 and ALD40) reveal a similar result, while for the higher 10-km resolution a clear difference between both models is apparent. The small overestimation of ALADIN at 10 km resolution (ALD10) for the low precipitation rates persists and becomes larger for the higher rates. The model clearly rains too often, both with very small and very high quantities of rainfall. On the other hand, the frequencies of ALARO-0 at 4 km and 10 km resolution (ALR04 and ALR10) nicely follow the observations, showing their ability to capture the occurrence of extreme and rare precipitation events, with values around 100 mm, quite well (De Troch et al., 2013).

As a measure for similarity between the observed and modeled frequencies the Perkins Skill Scores (PSS) are also given in Fig. 1. The overall PSS, as well as PSS for precipitation amounts below and above the 0.95^{th} quantile of the observations, is higher for ALARO-0 than for ALADIN and CNRM. This result demonstrates that the new 3MT parameterization, and its multiscale character, are responsible for a correct simulation of extreme summer precipitation at multiple horizontal resolutions, ranging from 40 km to 4 km resolution (De Troch et al., 2013).

Subsequently it is investigated to what extent the ALARO-0 model is able to simulate several subdaily precipitation characteristics at different temporal as well as spatial resolutions. The result of the diurnal cycle for Uccle (Fig. 2) shows for the high-resolution simulations at 4 and 10 km resolution (ERA40-ALR04, ERAINT-ALR04, ERA40-ALR10) an improvement in the onset and peak of convective activity w.r.t. the observations

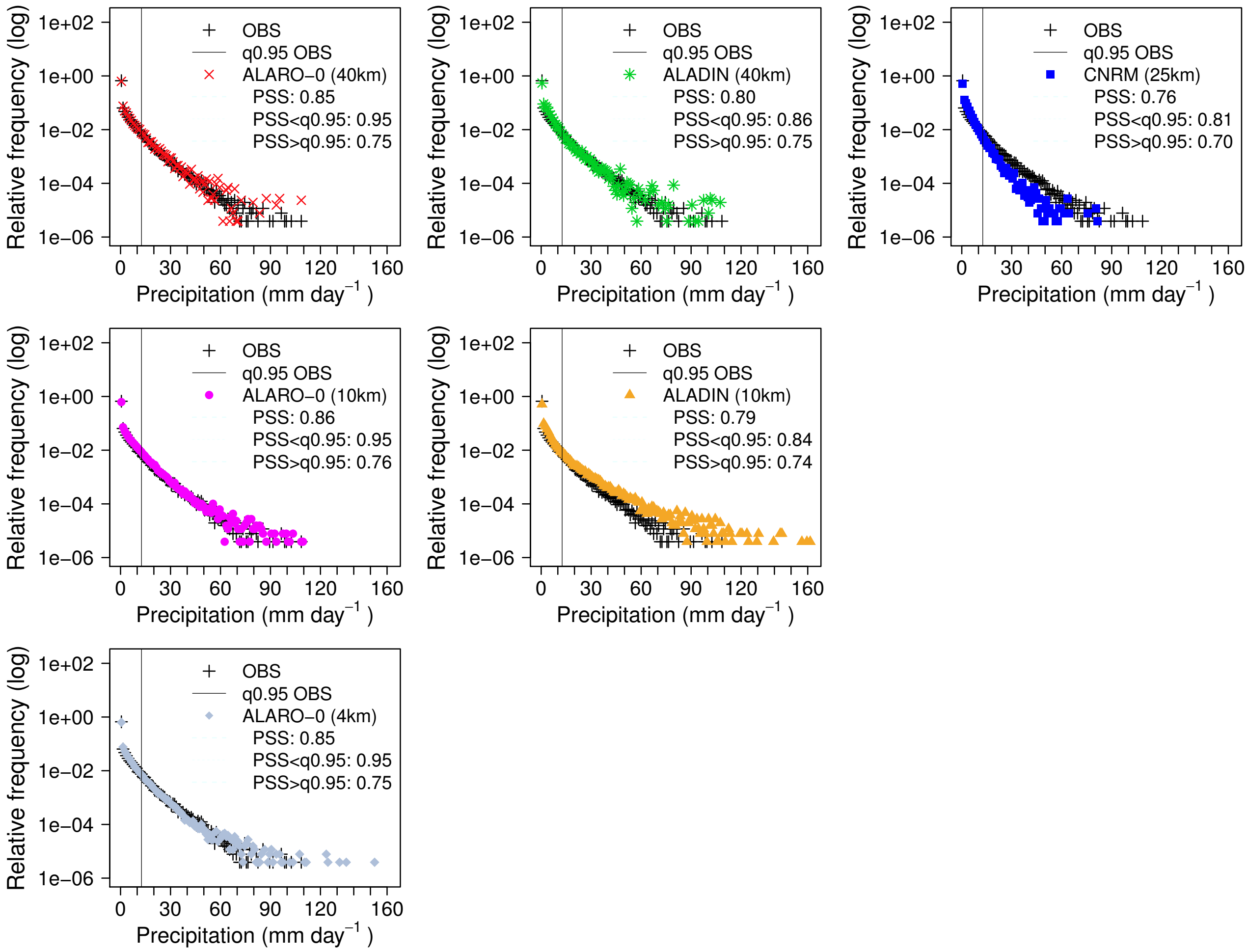

Figure 1: Relative frequencies of observations and model simulations: (left) ALARO-0 at 40-, 10-, and 4-km spatial resolution; (center) ALADIN at 40-, and 10-km spatial resolution; (right) CNRM. Frequencies are computed with the 30-yr (1961-90) daily cumulated summer precipitation given for each station separately and are displayed on a logarithmic scale. Numbers for PSS correspond to the average of the Perkins Skill Score calculated for precipitation amounts below and above the 0.95th quantile of the observations (PSS $<$ q0.95 and PSS $>$ q0.95). The black line indicates the 0.95th quantile of the observations.

(OBS). The low resolution ALARO-0 40-km run (ERA40-ALR40) on the other hand, is not able to reproduce the observed diurnal cycle both in magnitude and phase.

Furthermore, to estimate return level estimates, the Generalized Extreme Value (GEV) distribution is fitted to the summer annual maxima intensities in Uccle for different aggregation times. For a fixed duration d and return period T, Intensity-Duration-Frequency (IDF) relationships are then derived (Fig. 3). An important rainfall feature of particular interest for extremes is that, to a first approximation, the IDF curves display a power law dependence on averaging duration d and return period T. This scaling property of rainfall can be related to the fact that the estimated GEV parameters such as the location parameter μ and scale parameter σ, have a power law of the aggregation times (Willems, 2000). This means that if the parameter values are known for one particular aggregation time, they are also known for all other aggregation times only by applying a scaling factor. Hence, intensities in the IDF-relation plots are calculated by using (i) the parameters estimated from the GEV fit (circles), and (ii) the location- and scale parameter derived from a power law (solid lines). Intensities are plotted on log-log graphs, with the different panels representing different durations (1, 2, 3, 6, 12, and 24 h). First of all, it can be seen from Fig. 3 that the use of the power law values for the location- and

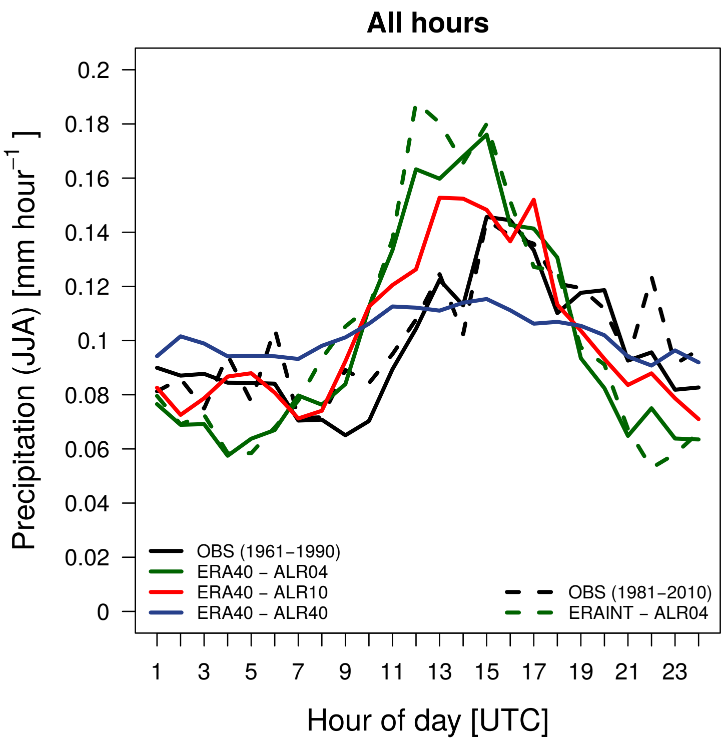

Figure 2: Observed (black) and modeled (green for ERA40-ALR04 and ERAINT-ALR04, red for ERA40-ALR10, and blue for ERA40-ALR40) 30-yr mean diurnal cycle of June-July-August (JJA) for all days in Uccle, Belgium.

scale parameter, is a valid method for the derivation of IDF-relationships.

The estimated extreme precipitation intensities are for the highest-resolution simulation (ALARO-0 at 4 km resolution, ERA40-ALR04) and for all durations in close agreement to the observed estimated intensities. For the highest return periods (i.e. $T = 50$ years or $T = 100$ years) the modeled intensities deviate slightly from the observations. Since the intensity estimates are based upon summer annual maxima precipitation intensities for a period of only 30 years (1961-90), one should keep in mind that estimates for such large return periods are relatively uncertain. The 40-km low-resolution intensities (ERA40-ALR40) strongly deviate from the observations, and consistently underestimate the observed intensities for all return periods. However, from the 6-hour durations onwards, ERA40-ALR40 starts to approach very closely the observations.

The results of this validation suggest that the multiscale character of the ALARO-0 model as apparent in the simulation of the daily precipitation climatology (Fig. 1), is not valid for the simulation of subdaily precipitation. Compared to the low-resolution simulations, the high 4-km model results demonstrate a significant added value in the description of the daily precipitation cycle (Fig. 2), very high precipitation amounts (Fig. 1), and important scaling properties such as the linear behavior of the GEV parameters (Fig. 3).

2.2 Application of ALARO-0 for present and future climate impacts on extreme precipitation and the unfavorable meteorological conditions for the dispersion of air pollution

The positive results from the validation allowed us to apply the model in a next step for the calculation of a climate projection. The future changes in extreme precipitation and the meteorological conditions which are unfavorable for winter smog episodes, as a consequence of increased greenhouse gas (GHG) concentrations described by the A1B scenario of the IPCC, are investigated. The validation of the control simulation reveal

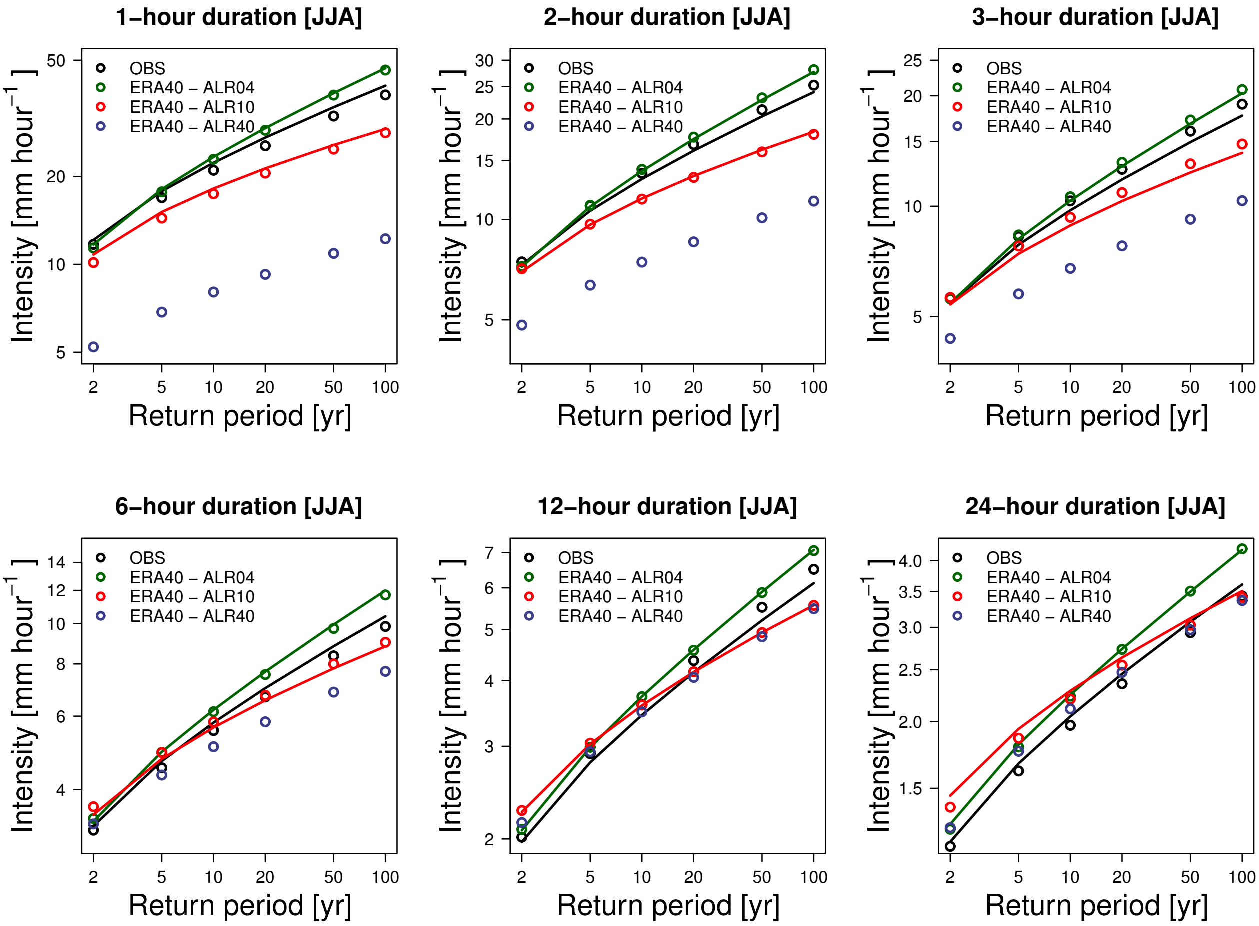

Figure 3: JJA IDF-relationships with the intensities (return levels) calculated by using (i) the GEV-estimated parameters (circles), and (ii) the location- and scale parameter (i.e. μ and σ) derived from the power law (solid lines). For both intensity calculations (i) and (ii) one and the same mean value over all durations for the shape parameter (γ) has been used. Intensities are given as a function of return period (T) for observations (black) and models (green for ERA4O-ALR04, red for ERA40-ALR10, and blue for ERA40-ALR40), plotted on log-log graphs, and computed for the station of Uccle and its nearest model grid box values. The different panels represent different durations (1, 2, 3, 6, 12, and 24 h).

significant biases, which can be attributed to model errors that are present in the driving GCM CNRM-CM3. The future changes are explored through a sensitivity of the model for changes in the climate forcing, in which the differences between the future scenario (SCN, 2071-2100) and the control simulation (CTL, 1961-90) are quantified.

When it comes to the extreme winter precipitation, Fig. 4 shows that we can expect to some level of confidence a future increase in the hourly precipitation amounts (taking into account the model biases and the projection results from other modeling studies). However, for summer precipitation the negative changes in extreme and hourly precipitation are more uncertain. The negative changes are not significant and smaller than their respectively biases, and the negative response is in disagreement with the modeling results for western- and central Europe from previous studies. These disagreements can be attributed to the transition zone in which Belgium is located, and the strong dependency of the parameterizations, and in particular the parameterizations for deep convection, which are an important source of uncertainty in the projection of extreme summer precipitation.

To study the climate change impact on winter smog episodes in Brussels, two different stability indices are analyzed. As an illustration, Fig. 5 shows results for both indices, the transport index and the Pasquill stability

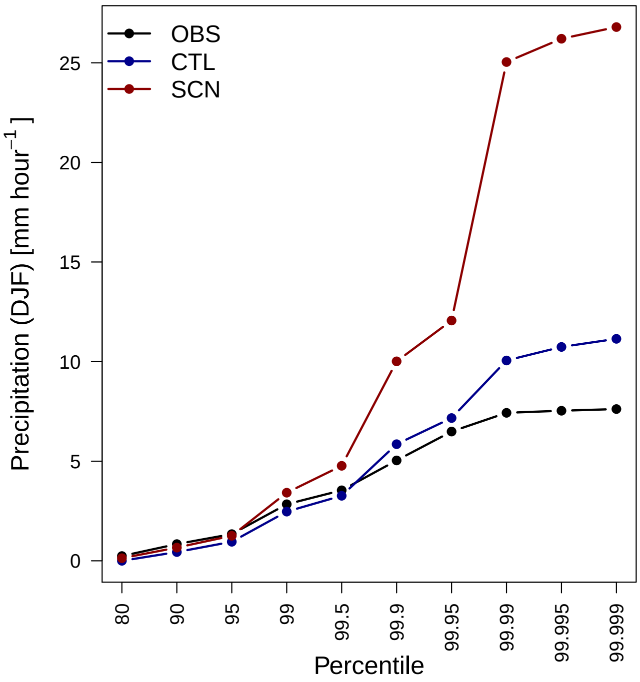

Figure 4: Percentiles of 1-hour winter precipitation (December-January-February DJF, 1962-1990 and 2072-2100) for the observations (OBS), the control simulation (CTL), and the scenario simulation (SCN) in Uccle.

classes, which are based on meteorological conditions determining the dispersion of air pollution. Figure 5 (left) shows that a stable layer near the surface, characterized by low transport length values, is built up over the course of the day. Such low transport length values in the lower part of the boundary layer during an extended period of several hours, characterize calm situations with a weak horizontal wind and a very stable atmosphere and hence conditions that are unfavorable for the dispersion of air pollution. Furthermore, for the Pasquill classes during the winter the stable E and F classes are mostly relevant, as they also reflect stagnant conditions with few dispersion of potentially present air pollutants. It can be seen from Fig. 5 (right) that for the relevant E and F indices the modeled frequencies from the ERA-Interim driven ALARO-0 simulation (ERAINT) are only slightly under- and overestimated.

These results demonstrate that stability indices obtained from the downscaled ERA-Interim reanalysis with the ALARO-0 model are a useful tool to infer meteorological conditions that are unfavorable for extreme pollution peaks.

Before future changes in occurrences of the transport- and Pasquill indices corresponding to such unfavorable meteorological conditions are assessed, it is investigated how well the stability indices derived from present-day downscaled GCM CNRM-CM3 fields (CTL) are reproduced by ALARO-0 w.r.t. the reference datasets. When one replaces the reanalysis data providing the boundary fields for the RCM with driving fields from a coupled GCM, it is well known that additional model biases coming from the GCM are often introduced. Comparison of frequency statistics of the transport- and Pasquill indices obtained from the control simulation (CTL) with the observed frequencies indeed revealed significant biases, and in particular for the transport index. To account for these model imperfections, a linear Q-Q bias correction has been applied directly on the transport length values. After correction, the present-day frequencies are significantly improved, with remaining deviations from the observations that fall within an acceptable range of 10%.

In order to quantify the uncertainty on the future changes, the same linear correction method as used to correct present-day transport length values, has been applied to correct the future transport lengths. Our results suggest

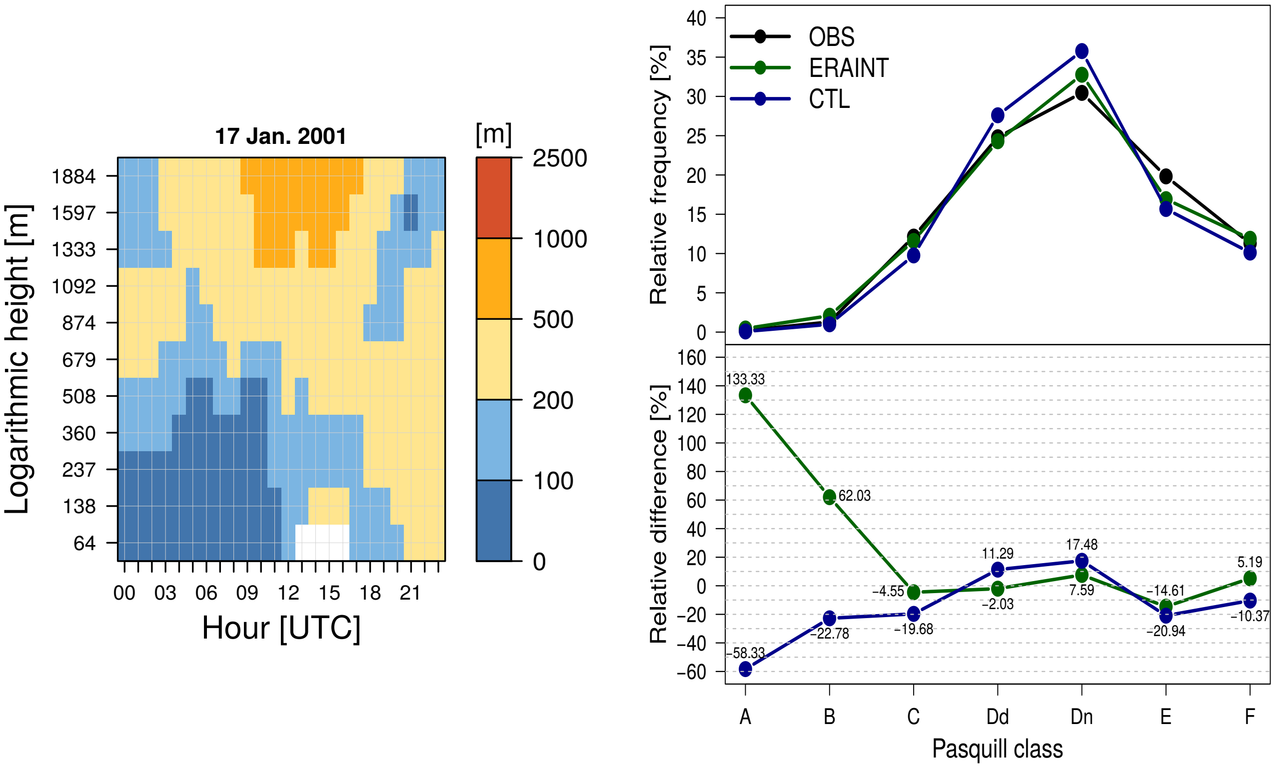

Figure 5: (left) Transport length values for 17 January 2001 when an extreme pollution peak has been recorded. The transport index is calculated for the closest model grid point to Uccle. The white areas indicate unstable parts of the atmosphere where the Brunt-Väisälä frequency is not defined; (right) Relative frequencies and differences of observed (OBS, black) and modeled (green for ALARO-0 driven by the ERA-Interim reanalysis, ERAINT, and blue for CTL) Pasquill indices in Uccle and its closest model grid point for DJF 1990/91-1998/99. The numbers indicate relative differences between ERAINT and CTL w.r.t. OBS.

a consistent increase in frequencies of low transport length values (Fig. 6) as well as stable Pasquill classes under future A1B climate conditions, reflecting a tendency towards more stable conditions and a possible degradation of air quality during winter smog episodes in Brussels.

3 Conclusion

Overall, the results of the validation of extreme precipitation at the daily and subdaily timescale demonstrated that the ALARO-0 model is able to consistently capture the relevant precipitation characteristics at a wide range of atmospheric and corresponding temporal scales, varying from the micro- to the mesoscales.

Based upon these results we conclude that the ALARO-0 model of the RMI can be used for regional climate modeling in Belgium, and in particular for the application of extreme precipitation and the meteorological conditions which are unfavorable for the dispersion of air pollution during winter smog episodes. This general conclusion allows us to state that the great potential of the high horizontal and vertical resolution of the downscaled model results provide relevant climate information that can be used as a forcing for impact studies on for example the Urban Heat Island effect (UHI), extreme precipitation, and the meteorological conditions which are unfavorable for the dispersion of air pollution.

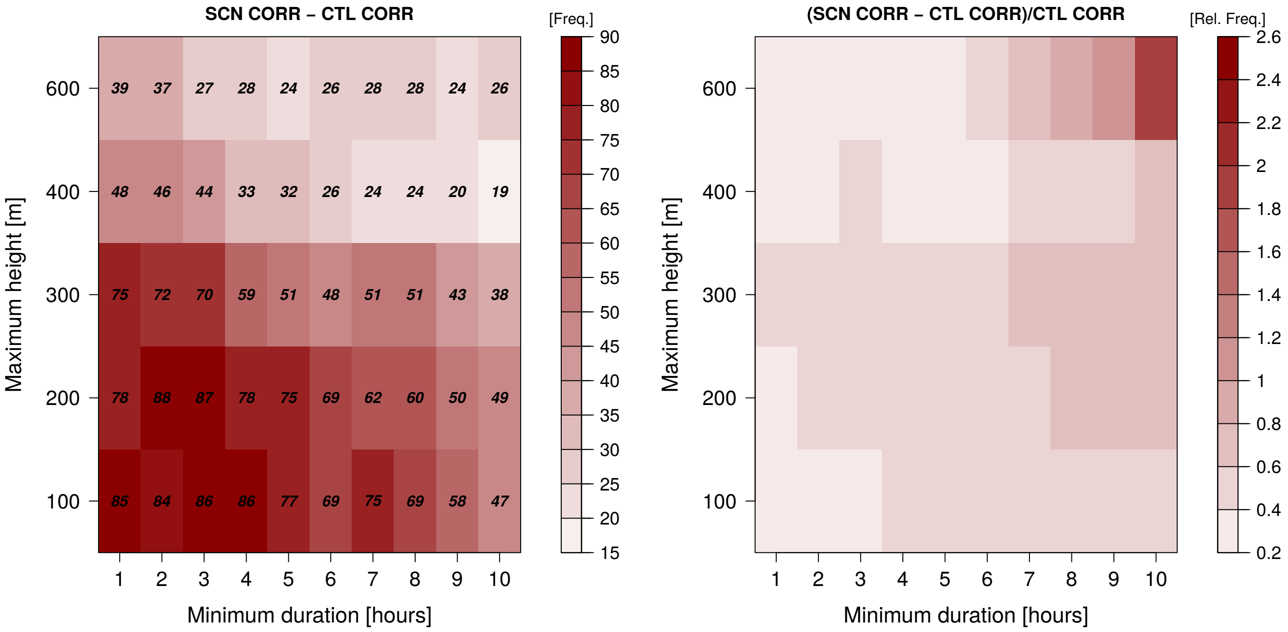

Figure 6: Absolute (left) and relative (right) differences in frequencies of transport length values $l < 200$ m between the bias corrected scenario simulation (SCN CORR) and the bias corrected control simulation (CTL CORR). The frequencies are calculated for the 9-yr DJF CTL climate and future SCN climate period 1990/91-1998/99 and 2046/47-2054/55 for the closest model grid point to Uccle, respectively, and they are shown for maximum heights ranging between 0 and 600 m, and minimum durations ranging between 1 and 10 h.

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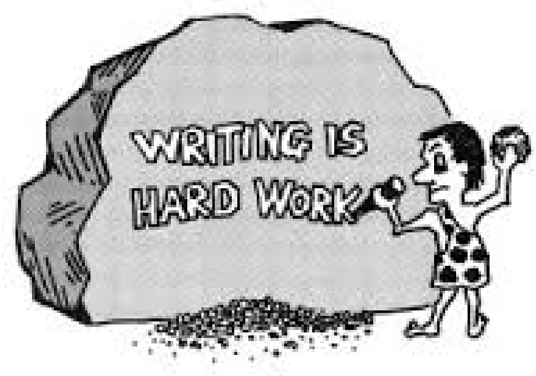

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Research Article

Single interval shortwave radiation scheme with parameterized optical saturation and spectral overlaps

J. Mašek, J.-F. Geleyn, R. Brožková, O. Giot, H. O. Achom, P. Kuma

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Featured Research Article

Improvement of the forecast of convective activity from the AROME-France system

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Geoscientific Model Development — Open Access — EGU

Generalization and application of the flux-conservative thermodynamic equations in the AROME model of the ALADIN system

Daan Degrauwe[1], Yann Seity[2], François Bouyssel[2], and Piet Termonia[1,3]

[1]RMI Belgium, Ringlaan 3, Ukkel, Belgium
[2]CNRM, Météo-France, Avenue Coriolis 42, Toulouse, France
[3]Department of Physics and Astronomy, Ghent University, Proeftuinstraat 86, Ghent, Belgium

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Geoscientific Model Development — Open Access — EGU

Validation of the ALARO-0 model within the EURO-CORDEX framework

Olivier Giot[1,2], Piet Termonia[1,3], Daan Degrauwe[1], Rozemien De Troch[1,3], Steven Caluwaerts[3], Geert Smet[1], Julie Berckmans[1,2], Alex Deckmyn[1], Lesley De Cruz[1], Pieter De Meutter[1,3], Annelies Duerinckx[1,3], Luc Gerard[1], Rafiq Hamdi[1], Joris Van den Bergh[1], Michiel Van Ginderachter[1,3], and Bert Van Schaeybroeck[1]

[1]Royal Meteorological Institute, Brussels, Belgium
[2]Centre of Excellence PLECO (Plant and Vegetation Ecology), Department of Biology, University of Antwerp, Wilrijk, Belgium
[3]Department of Physics and Astronomy, Ghent University, Ghent, Belgium

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Single interval shortwave radiation scheme with parameterized optical saturation and spectral overlaps

Jan Mašek[ab], Jean-François Geleyn[cd], Radmila Brožková[ab], Olivier Giot[ef], Haliima Okodel Achom[d] and Peter Kuma[g]

Article published in-QJRMS, on-line in October 2015 and in Vol 142, January 2016

1 Abstract

Spectral integration is the most time consuming part of solar radiative transfer codes used in numerical weather prediction. Routinely used approaches usually incline to one of two extremes – expensive and very accurate correlated k-distribution method made affordable by doing radiative transfer calculations with reduced temporal and/or spatial resolution, or cheaper but less accurate broadband approach affordable at every grid-point and time-step. Both approaches have their pros and cons, but hybrid solutions do not seem very promising. The presented work improves accuracy of full spectrum broadband approach by parameterizing secondary saturation of gaseous absorption, optical saturation of Rayleigh scattering and of cloud absorption as well as non-random gas-cloud spectral overlap. In order to isolate the problem of spectral integration from other approximations, one builds a narrowband reference using the same delta-two stream framework as the broadband scheme. Using this reference reveals the surprising fact that saturation effect of cloud absorption for one single layer and for the whole solar spectrum can be parameterized in a rather compact way, with one simple formula for liquid clouds and one for ice clouds. One then introduces the concept of effective cloud optical depth, which extends the applicability of parameterized cloud optical saturation to multi-layer cases, accommodating also effects of gas-cloud spectral overlap in the near-infrared. A scheme with all the above parameterizations indeed pushes accuracy limits of broadband approach to the level where a single shortwave interval can be used. This opens the possibility to reduce costs by using selective intermittency, where slowly evolving gaseous transmissions are updated on the timescale of hours, while quickly varying cloud optical properties are recomputed at every model time-step. In a companion article it will be demonstrated that the above core strategy is applicable also to thermal radiative transfer, with perhaps even better cost effectiveness there.

2 The full article

Mašek, J., Geleyn, J.-F., Brožková, R., Giot, O., Achom, H. O. and Kuma, P. (2016), Single interval shortwave radiation scheme with parameterized optical saturation and spectral overlaps. Q.J.R. Meteorol. Soc., 142: 304–326. doi:10.1002/qj.2653.

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a Department of Meteorology and Climatology, Czech Hydrometeorological Institute, Prague, Czech Republic
b Global Change Research Centre, Academy of Sciences of the Czech Republic, Brno, Czech Republic
c CNRM-GAME, Météo-France/CNRS UMR 3589, Toulouse, France
d Department of Physics and Astronomy, Ghent University, Belgium
e Department of Meteorological and Climatological Research, Royal Meteorological Institute, Brussels, Belgium
f Department of Biology, Centre of Excellence PLECO, University of Antwerp, Belgium
g Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovakia

Improvement of the forecast of convective activity from the AROME-France system

Pierre Brousseau, Yann Seity, Didier Ricard, Julien Léger
CNRM-GAME, CNRS and Météo-France, Toulouse, France

Article published in June 2016 as a Featured Research Article in QJRMS

1 Abstract

AROME-France is a convective-scale numerical weather prediction system which has been running operationally at Météo-France since the end of 2008. In order to determine its initial conditions, it uses a 3D-Var assimilation scheme at the same resolution as the model in a continuous data assimilation cycle. In addition to conventional and satellite observations used in global data assimilation systems, dedicated observations for the mesoscale such as surface observations and radar measurements (radial winds and reflectivities) are assimilated. A major update of this system occurred in April 2015 with, among several improvements, (i) an increase of both horizontal and vertical resolutions (1.3 km and 90 vertical levels versus 2.5 km and 60 levels), and (ii) the reduction of the period of the data assimilation cycle from 3 to 1 h (as a result of the model spin-up reduction and the tuning of the background-error covariances). This study presents the preparatory work to these modifications and explores the main impact expected on convective activity forecasts. (i) appears to result in more realistic convective cells and better rainfall and wind gust scores and (ii) allows assimilation of more observations with information at the mesoscale which provides more accurate initial conditions and hence better subsequent rainfall forecasts. The benefits of using both (i) and (ii) in a pre-operational configuration are shown using objective precipitation scores and illustrated by a case-study.

2 The full article

Brousseau, P., Seity, Y., Ricard, D. and Léger, J. (2016), Improvement of the forecast of convective activity from the AROME-France system. Q.J.R. Meteorol. Soc.. doi:10.1002/qj.2822

Available on-line : http://onlinelibrary.wiley.com/doi/10.1002/qj.2822/full

Generalization and application of the flux-conservative thermodynamic equations in the AROME model of the ALADIN system

Daan Degrauwe[1], Yann Seity[2], François Bouyssel[2], and Piet Termonia[1 3]

Article published in June 2016 in GMD

1 Abstract

General yet compact equations are presented to express the thermodynamic impact of physical parameterizations in a NWP or climate model. By expressing the equations in a flux-conservative formulation, the conservation of mass and energy by the physics parameterizations is a built-in feature of the system. Moreover, the centralization of all thermodynamic calculations guarantees a consistent thermodynamical treatment of the different processes. The generality of this physics–dynamics interface is illustrated by applying it in the AROME NWP model. The physics–dynamics interface of this model currently makes some approximations, which typically consist of neglecting some terms in the total energy budget, such as the transport of heat by falling precipitation, or the effect of diffusive moisture transport. Although these terms are usually quite small, omitting them from the energy budget breaks the constraint of energy conservation. The presented set of equations provides the opportunity to get rid of these approximations, in order to arrive at a consistent and energy-conservative model. A verification in an operational setting shows that the impact on monthly-averaged, domain-wide meteorological scores is quite neutral. However, under specific circumstances, the supposedly small terms may turn out not to be entirely negligible. A detailed study of a case with heavy precipitation shows that the heat transport by precipitation contributes to the formation of a region of relatively cold air near the surface, the so-called cold pool. Given the importance of this cold pool mechanism in the life cycle of convective events, it is advisable not to neglect phenomena that may enhance it.

2 The full article

Degrauwe, D., Seity, Y., Bouyssel, F., and Termonia, P.: Generalization and application of the flux-conservative thermodynamic equations in the AROME model of the ALADIN system, Geosci. Model Dev., 9, 2129-2142, doi:10.5194/gmd-9-2129-2016, 2016.

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1 RMI Belgium, Ringlaan 3, Ukkel, Belgium

2 CNRM, Météo-France, Avenue Coriolis 42, Toulouse, France

3 Department of Physics and Astronomy, Ghent University, Proeftuinstraat 86, Ghent, Belgium

Validation of the ALARO-0 model within the EURO-CORDEX framwork

Olivier Giot et al. [1], [2], [3]

Article published in March 2016 in GMD

1 Abstract

Using the regional climate model ALARO-0, the Royal Meteorological Institute of Belgium and Ghent University have performed two simulations of the past observed climate within the framework of the Coordinated Regional Climate Downscaling Experiment (CORDEX). The ERA-Interim reanalysis was used to drive the model for the period 1979–2010 on the EURO-CORDEX domain with two horizontal resolutions, 0.11 and 0.44°. ALARO-0 is characterised by the new microphysics scheme 3MT, which allows for a better representation of convective precipitation. In Kotlarski et al. (2014) several metrics assessing the performance in representing seasonal mean near-surface air temperature and precipitation are defined and the corresponding scores are calculated for an ensemble of models for different regions and seasons for the period 1989–2008. Of special interest within this ensemble is the ARPEGE model by the Centre National de Recherches Météorologiques (CNRM), which shares a large amount of core code with ALARO-0.
Results show that ALARO-0 is capable of representing the European climate in an acceptable way as most of the ALARO-0 scores lie within the existing ensemble. However, for near-surface air temperature, some large biases, which are often also found in the ARPEGE results, persist. For precipitation, on the other hand, the ALARO-0 model produces some of the best scores within the ensemble and no clear resemblance to ARPEGE is found, which is attributed to the inclusion of 3MT.
Additionally, a jackknife procedure is applied to the ALARO-0 results in order to test whether the scores are robust, meaning independent of the period used to calculate them. Periods of 20 years are sampled from the 32-year simulation and used to construct the 95 % confidence interval for each score. For most scores, these intervals are very small compared to the total ensemble spread, implying that model differences in the scores are significant.

2 The full article

Giot, O., Termonia, P., Degrauwe, D., De Troch, R., Caluwaerts, S., Smet, G., Berckmans, J., Deckmyn, A., De Cruz, L., De Meutter, P., Duerinckx, A., Gerard, L., Hamdi, R., Van den Bergh, J., Van Ginderachter, M., and Van Schaeybroeck, B.: Validation of the ALARO-0 model within the EURO-CORDEX framework, Geosci. Model Dev., 9, 1143-1152, doi:10.5194/gmd-9-1143-2016, 2016.

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1 RMI Belgium, Ringlaan 3, Ukkel, Belgium
2 Centre of Excellence PLECO (Plant and Vegetation Ecology), Department of Biology, University of Antwerp, Wilrijk, Belgium
3 Department of Physics and Astronomy, Ghent University, Proeftuinstraat 86, Ghent, Belgium

Around the joint 26th ALADIN Wk & HIRLAM ASM 2016

26th ALADIN Wk & HIRLAM 2016 ASM

Hostel by the Instituto Português do Mar e da Atmosfera (Portugal)
April 4-8, 2016 in Lisbon

Not so many of those who presented something at the last Wk&ASM have found time to write down an article around their slides/posters.
The pdf files of the presentations and posters are available through the below links.
The sessions have been recorded and can be viewed using the link on the stream broadcast system : http://www.ustream.tv/channel/ipma .
In case you would like to know more about a presentation, don't hesitate to contact directly its author !

1 Presentations

Plenary opening session

- Piet Termonia : ALADIN status overview
- Jeanette Onvlee : HIRLAM highlights of the past year and challenges for HIRLAM-C
- Balazs Szintai : Status of the EUMETNET C-SRNWP project

Plenary session 1: Data Assimilation

- Claude Fischer : Data assimilation aspects at Meteo-France
- Mate Mile : Highlights of latest LACE data assimilation activities
- Roger Randriamampianina : Hirlam upper-air data assimilation: progress and plans
- Jan Barkmeijer : The observations IMPACT experiment
- Eoin Whelan : Use of observations in HARMONIE (including WMO BUFR and COPE)
- Roohollah Azad : Assimilation of Norwegian radar reflectivity in Harmonie: Quality control strategies
- Magnus Lindskog : Data assimilation for improving short-range DNI forecasting
- Florian Meier : AROME-Nowcasting in Austria

Plenary session 2: Surface

- Patrick Samuelsson : HIRLAM plans for surface physics and data assimilation development
- **Helga Toth : Biomass and Soil Moisture Assimilation over Hungary in the framework of IMAGINES project** **article in this Newsletter**
- Rafiq Hamdi : Combining the EKF soil analysis with a three dimensional variational upper-air assimilation for ALARO
- Sander Tijm : SURFEX fluxes in Spring and Summer
- Yurii Batrak SICE : simple sea ice scheme
- Carl Fortelius : Urban heat fluxes from Arome-Harmonie compared to eddy-covariance data
- **Martina Tudor : Fields in ISBA clim files** **article in this Newsletter**

Plenary session 3: Forecast model

- Petra Smolikova : RC LACE dynamics activities
- Yann Seity : Recent MF developments in AROME physics
- Neva Pristov : Alaro status overview
- Eric Bazile : What’s up for the physics in the coming months ....
- Lisa Bengtsson : Recent HIRLAM developments in HARMONIE-AROME physics/dynamics

- Radmila Brozkova : New shallow convection parameterization in ALARO-1
- Wim de Rooy : HARATU update
- Eric Bazile : Preliminary results for the GABLS4 intercomparison
- **Laura Rontu: HARMONIE radiation studies 2012-2016** **article in this Newsletter**
- **Karl-Ivar Ivarsson : Latest updates of the cloud- and condensation parametrizations in HARMONIE/AROME** **article in this Newsletter**

Plenary session 4: EPS

- Martin Bellus : LAM-EPS activities in LACE
- Inger-Lise Frogner : Developments in GLAMEPS and HarmonEPS
- Andrew Singleton : Perturbation experiments with MetCoOp EPS (MEPS)
- Garcia-Moya Jose A : gSREPS: Mesoscale EPS in AEMET. Status
- Xiaohua Yang : COMEPS, a mesoscale-EPS RUC system
- Mihaly Szucs : Test of the SPPT scheme
- Johansson Åke : Issues in the verification of EPS

Plenary session 5: System

- Daniel Santos-Munoz : HIRLAM-C plans for system
- Claude Fischer : Cycles and code changes
- **Ryad El Khatib : Toward Fullpos in OOPS** **article in this Newsletter**
- Roel Stappers : Matrix free linear algebra in OOPS
- Daan Degrauwe : The way out of the scalability gridlock: ESCAPing dwarfs
- **Alexandre Mary : The EPyGrAM tool: a Python library for handling model fields** **article in this Newsletter**
- General discussion (announcement of the system side meeting)

Plenary session 6: Quality, user and climate aspects

- Piet Termonia : Feedback from ALADIN Forecasters meeting
- Bent Sass : Quality Assurance of Harmonie during HIRLAM-C
- Hylke de Vries : Harmonie-Climate, first results and future plans
- Jure Cedilnik : Two-way coupling of ALADIN and POM ocean model for Adriatic sea
- Lesley De Cruz : Validation and climate projections of the ALARO-0 model on the EURO-CORDEX domain

2 Posters

- Christoph Wittmann : NWP related activities in Austria
- Rafiq Hamdi : Belgian National Poster
- Boryana Tsenova : NWP in Bulgaria
- **Martina Tudor : Operational suite in Croatian Meteorological and Hydrological Service - status and plans** **article in this Newsletter**
- Alena Trojakova : The NWP activities at CHMI
- Alena Trojakova : Assimilation of aircraft Mode-S observations in ALADIN/CHMI
- Nielsen Kristian Pagh, Alexander Mahura and Xiaohua Yang : Aerosol effects over China investigated with a high resolution convection permitting weather model
- Xiaohua Yang : IGA and operational collaboration between IMO and DMI (preliminary)
- Ekaterina Kurzeneva : Status of lake developments in HARMONIE
- Patricia Pottier : The NWP systems at Meteo-France
- **Patricia Pottier : ALADIN 25th Anniversary** **article in this Newsletter**

- Claude Fischer : Sensitivity of regional ensemble data assimilation spread to perturbations of lateral boundary conditions (El Ouaraini, Berre, Fischer, Sayouty)
- Balazs Szintai : NWP at the Hungarian Meteorological Service
- Emily Gleeson : Radiation Experiments using the ALADIN-HIRLAM system
- Ruth Mottram : Glaciers in HARMONIE
- Eoin Whelan : Operational NWP in Met Eireann
- Hanneke Luijting, Trygve Aspelien, Yurii Batrak, Mariken Homleid, Jørn Kristiansen, Teresa Valkonen and Dagrun Vikhamar Schuler : Surface modelling and assimilation at MET Norway
- Hassan Haddouch : Numerical weather prediction in Morocco
- Randriamampianina Roger : Use of geostationary and polar atmospheric motion vectors
- Randriamampianina Roger : OSE and OSSE with the AROME model over the Arctic
- Marek Jerczynski : Polish national poster
- Maria Monteiro : ALADIN - Portuguese Technical and Scientific Activities
- Alexandra Craciun : Aladin activities in Romania
- Maria Derkova : ALADIN related activities @SHMU
- Benedikt Strajnar : ALADIN in Slovenia - 2016
- Jana Sanchez Arriola : Use of observations in Aemet Harmonie suite
- Javier Calvo : Operational NWP systems in AEMET
- Alvaro Subias : Vertical finite elements - some test
- Ulf Andrae : MEPS, Ensemble forecasting in MetCoOp
- Per Unden : UERRA - Regional Reanalyses and Uncertainties
- Bjorn Stensen : Experience with HarmonEPS in multi-physics mode
- Alper Guser : ALADIN Related activities in TURKEY
- Bin Cheng, Yurii Batrak, Jiechen Zhao, Zhongxiang Tian and Marcel Nicolaus: Observed and modelled snow and ice thickness in the Arctic Ocean

3 Working groups, side-meetings, LTM meeting, HMG/CSSI meeting, ...

More information on the 26th Wk&ASM 2016 (full agenda and participants, photos) and the side events (WG discussions, LTM meeting, HMG/CSSI meeting) are available on the dedicated page on the aladin website.

Biomass and Soil Moisture simulation and assimilation over Hungary in the framework of ImagineS project

Helga Tóth, Balázs Szintai and László Kullmann

1 Introduction

The IMAGINES (Implementation of Multi-scale AGricultural INdicators Exploiting Sentinels) project, as continuation of Geoland2 project, is a program funded by the European Union's 7th Framework Programme, which has been realized between 2012 and 2016 with 8 partners.One of the aims of ImagineS is to develop and run the land data assimilation system (LDAS) which is capable of simulating the main processes of the above the ground biomass and to describe the carbon and water fluxes in the soil and on the surface. This LDAS is based on the SURFEX V7.3 (SURFace EXternalisée) model which is a suitable tool to simulate these processes (Le Moigne, 2012). In our experiments the model was run on regular lat-lon grid with 8x8 km resolution over a domain covering Hungary. Cycling mode was applied and the 24-hour forecast was produced with 6h output frequency. Evaluated model outputs are the LAI (Leaf Area Index), the WG2 (Root-zone volumetric soil moisture content), the GPP (Gross Primary Product) and the NEE (Net Ecosystem Exchange).

SURFEX was run in offline mode, this means that the surface fluxes have no influence on the atmospheric fields, but the model needs meteorological data (air temperature, humidity, wind speed, precipitation, long and short wave radiation). These information come from the ALADIN (Aire Limitée Adaptation dynamique Développement InterNational) numerical weather prediction model (Horányi at al., 2006) except for the radiation, which is derived from LandSAF (Land Surface Analysis Satellite Applications Facility) observation. The reason for this choice is that radiation influences to a great extent the photosynthesis and the NWP model's fields are not as accurate as satellite observations.

In the report some results are showed, one- and two-dimensional evaluations of the model runs, which are compared to satellite and in-situ measurements. The added value of the assimilation of satellite products on vegetation biomass simulations is evaluated over Hungary using reference agricultural yearly statistics of straw cereal yields.

2 Models and methods

Surfex model

In the SURFEX system each surface grid point is separated into 4 different tiles: nature, sea, lake and town. The model handles each tile independently. In our work only the nature tile was treated. The nature tile is further divided into 12 patches according to the vegetation or surface types: bare soil, rock, permanent snow, deciduous tree, coniferous tree, broadleaf evergreen tree, C3 crops, C4 crops, irrigated crops, grassland, tropical grassland, parks and gardens. The model solves the prognostic equations and calculates the surface fluxes separately for the different patches. Each patch uses the same atmospheric forcing (air temperature, humidity, wind speed, long and shortwave radiation, pressure, precipitation), but the parameterizations are different and independent of each other. The resulting surface fluxes (momentum, sensible- and latent heat) are averaged according to the area fraction of the patches and returned to the atmosphere. Surface parameters are determined by physiographic databases: GTOPO30 for orography, ECOCLIMAP-II for surface covers (Faroux et al., 2013), and FAO for soil texture.

The nature tile is simulated with the ISBA (Interaction between Soil, Biosphere and Atmosphere) scheme (Noilhan and Planton, 1989), which computes the exchanges of energy and water between the continuum soil-vegetation-snow and the atmosphere above. A more recent version of the model named Isba-A-gs (Calvet et al., 1998, Gibelin et al., 2006) accounts for a simplified photosynthesis model where the evaporation is controlled by the aperture of the stomatas, the component of the leaves that regulates the balance between the transpiration and the assimilation of CO_2. This model is suitable for describing the evolution of the vegetation. Biomass is a prognostic variable. Growing of vegetation is due to photosynthesis (CO_2 assimilation) while the decline can be due to soil moisture stress or senescence. The model takes into account the soil moisture stress in the photosynthesis (Calvet, 2000). Plants can have two strategies to the stress: draught avoiding and draught tolerant strategy.

One of the carbon-fluxes, GPP (Gross Primary Product) is calculated as the sum of net assimilation and the dark respiration of leaves. NEE (Net ecosystem exchange) is determined as a difference of Re (ecosystem Respiration) and GPP. In ISBA-A-gs this is parametrized by a simple method depending on surface water content and the surface temperature.

Land Data Assimilation System

To improve the accuracy of the initial fields, data assimilation is used. The analyzed variables are LAI and WG2. These variables have long memory (slow variability in time) and furthermore LAI and soil moisture influence to a high extent the evaluation of photosynthesis and through this the value of carbon fluxes. Observations for LAI are derived from SPOT-VGT (till May, 2014) and PROBA-V (from June, 2014) satellite data. The SPOT/VGT LAI Version 1 (GEOV1) is derived from the SPOT/VGT Top of Atmosphere (TOA) reflectances provided by the SPOT/VEGETATION program (Baret et al., 2013), while the PROBA-V LAI Version 1 is derived from the SPOT/VGT-like Top of Atmosphere (TOA) PROBA-V reflectences generated by the PROBA2VGT module. Both products are provided at a spatial resolution of 1 km and 10 days sampling time in regular latitude/longitude grid. To analyze the root-zone soil moisture, surface soil moisture (SSM) needs to be assimilated which is derived from SWI (Soil Wetness Index) product. SWI is calculated from MetOp. ASCAT observations using a recursive exponential filter. SWI is provided at 10 km spatial resolution with daily sampling (Albergel et al., 2009). From SWI information to get SSM value we have to use the following relationship: $SSM=SWI^*(w_{max}-w_{min})+w_{min}$, where w_{min} and w_{max} are the minimal and maximal SSM values that the model can take at a given grid point. The derived SSM data are bias corrected with respect to the model climatology by using a seasonal-based CDF (Cumulative Distribution Function) matching technique described in Scipal et al. (2008). In Figure 1 the model simulation is compared with the raw ASCAT and the CDF rescaled ASCAT time series at Hegyhatsal (located at western part of Hungary). The CDF matching with seasonal correction improves the temporal correlations between the data and the model.

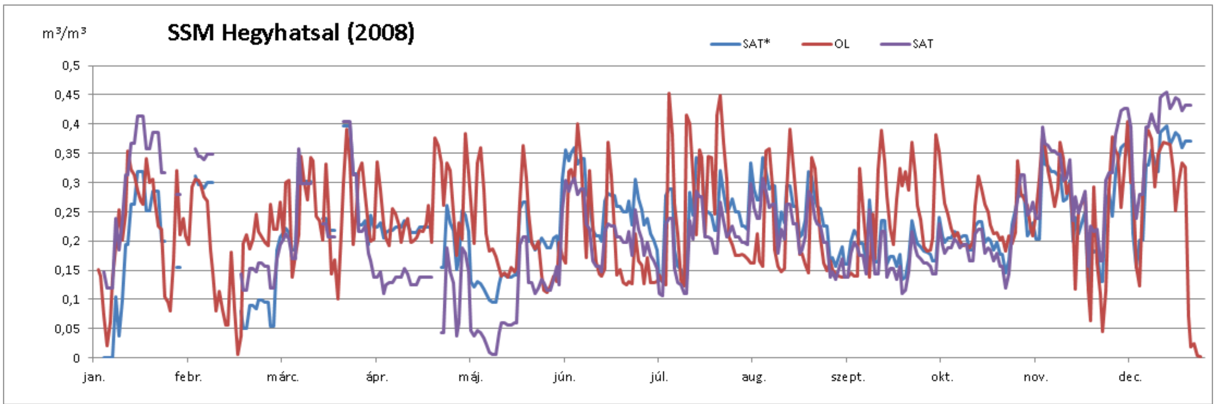

Figure 1: Surface soil moisture evolutions for 2008 at Hegyhatsal (West-Hungary) for model (red), raw ASCAT satellite observations (purple) and ASCAT seasonal CDF rescaled (blue) observations.

Extended Kalman Filter (EKF) assimilation method was performed to analyze LAI and SSM (Bouttier and Courtier, 1999, Mahfouf, 2010). To determine these values, observations and background (model forecast starting from a previous cycle) information need to be taken into account. The theory of Kalman Filter assumes that the analysis can be obtained by the following equation:

$$x_a=x_f+\mathbf{K}(y_o-H(x_f)) \qquad (1)$$

Where **x** is the model state vector (a means analysis, f means forecast), **y** is the observation vector, *H* is the non-linear observation operator, **K** is the Kalman gain.
The analysis equation is solved at each grid point independently, as we assume that, there is no correlation between the neighbouring grid points.

3 Results

2D Validation, Anomalies

Open-loop (with no assimilation) and assimilation runs were performed and compared with satellite observations for period 2008-2015. The observation error was set to 0.2 m^2/m^2 for LAI and 0.04 m^3/m^3 for SSM. The model error was set to 0.2 m^2/m^2 for LAI, 0.5 m^3/m^3 for SSM and 0.2 m^3/m^3 for WG2.

The ability of the modeling system to simulate inter-annual variability has been validated in 2D over Hungary. Eight years (2008-2015) have been simulated using LAI and SSM assimilation and open-loop runs. These eight years were used as a baseline to calculate monthly anomalies for the year 2012, when an extremely strong drought affected Hungary. The normalized anomaly was calculated as:

$$AnoX = \frac{X - \langle X \rangle}{stdev(X)} \qquad (2)$$

where <*X*> stand for the long year monthly average and *stdev(X)* indicates the standard deviation of *X*. *X* can be variables such as LAI or root-zone soil moisture (WG2). *AnoX* could be calculated for either monthly or 10-day periods for the simulations and also for the satellite data. Figure 2 shows the monthly *AnoLAI* values calculated from satellite products and from the simulations (open-loop and assimilations). Both models are able to reproduce the extremely low LAI anomalies in 2012 for the whole country.

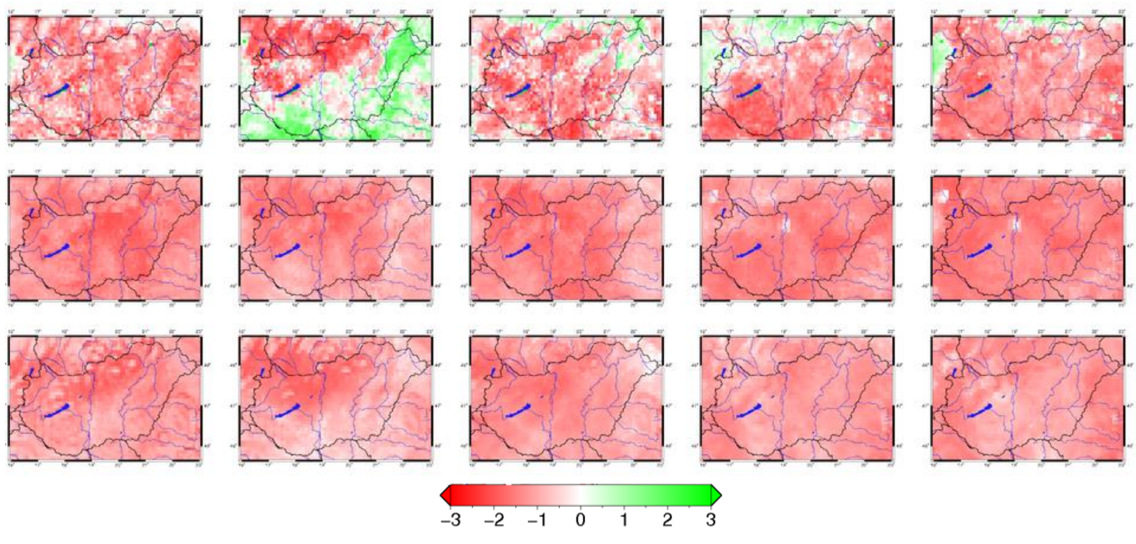

Figure 2: Monthly anomalies for the year 2012 from May to September: SPOT/VGT GEOV1 LAI product (first row), assimilated LAI (second row) and open-loop LAI (third row)

Standard statistics such as correlation, bias and RMSE were calculated against the satellite information for both kinds of simulations. Monthly area-mean LAI scores are illustrated in Figure 3 and Figure 4. The open-loop experiment produces low correlation for LAI at every spring time repeatedly, especially in May, and these weak correlations disappear in the summer or autumn period. In the assimilation, these wrong correlations do not appear, the extended Kalman filter works properly (Fig. 3). LAI is underestimated by the models (negative bias) especially for the summer months, except for 2010, when the amount of biomass was overestimated for the whole year (Fig. 4).

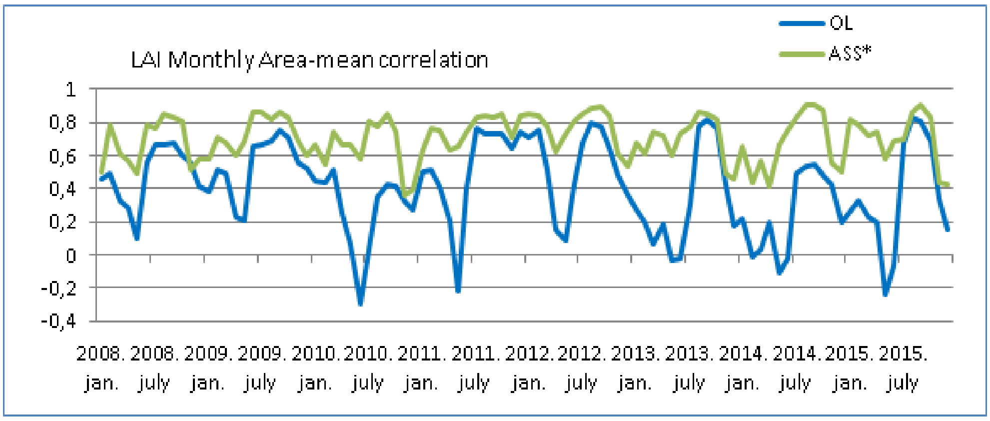

Figure 3: LAI area-mean correlation (open-loop: blue, assimilation: green)

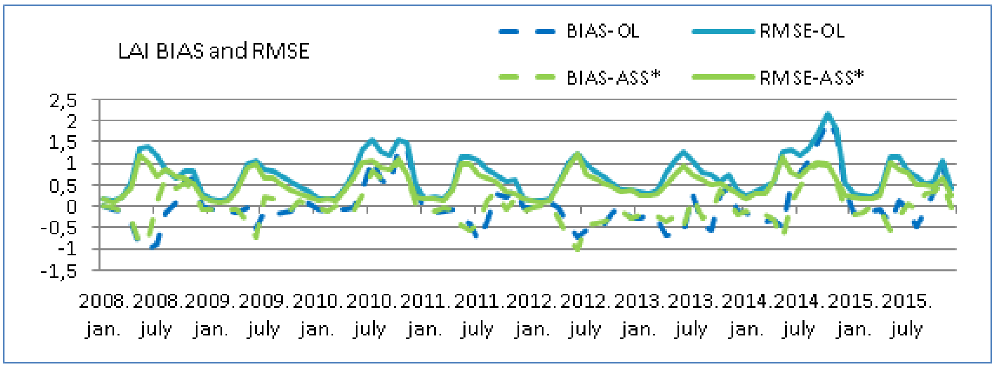

Figure 4: LAI bias (dashed line) and RMSE (full line))
for LAI for open-loop (blue) and assimilation (green) runs.

1D Validation

Experiment outputs were validated against in-situ measurements of Hegyhátsál (located in the Western part of Hungary lat.: 46° 57′ 34″, lon.: 16° 38′ 30″). Data are available from two levels:

- 3 m height from a grassland area (valid for only the grassland patch):
  - LAI (weekly, only in the growing season)
  - Soil Moisture (daily) (derived from 10-30 cm depth)
  - Carbon fluxes: GPP, Reco and NEE (daily)
  - Water flux: Latent Heat (LE) (daily)
- 82 m height (valid for the whole grid-point, consisting mainly of agricultural area):
  - Carbon fluxes: GPP and NEE (daily)
  - Water flux: LE (daily)

The latent heat flux is well represented by the simulations (Fig. 5, on the left), while carbon flux is underestimated by both runs (Fig. 5, on the right).

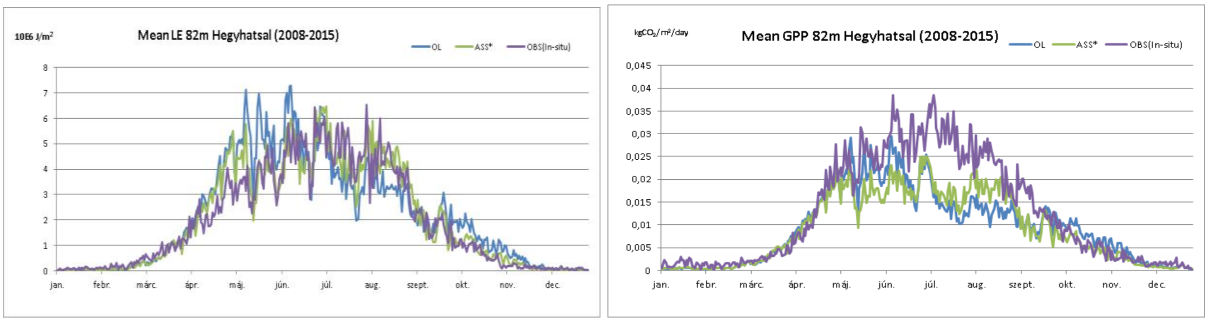

Figure 5: Mean Laten heat flux at 82 m (on the right) and Mean Gross Primary Product at 82m (on the left) in Hegyhatsal site open-loop (blue), assimilation (green), observation (purple)

Validation of agricultural yield

Biomass is a prognostic variable and is directly affected by the LDAS systems and used for agricultural validation. The above-ground biomass simulated by ISBA-A-gs over croplands and grasslands relates to agricultural yields (Calvet et al., 2012). Agricultural observations such as straw cereal yield measurements are used for this validation over Hungary. A comparison with crop model-based results is also performed. The validation is done for the 9 straw cereal locations in Hungary.

WOFOST (WOrld FOod STudies) is a crop growth model (Boogaard et al, 1998) that allows the estimation of yields quantitatively and it was developed by the Center for World Food Studies (CWFS) in cooperation with the Wageningen Agricultural University, Department of Theoretical Production Ecology (WAU-TPE) and the DLO-Center for Agrobiological Research and Soil Fertility (AB-DLO), Wageningen, the Netherlands. The simulations were provided by Joint Research Center which is maintining the model. They are done at soil unit level and multiple times for each of the soil types within a soil polygon. Then they are aggregated according to the provided information about the coverage of the soil types within the soil unit polygon intersected by the grid of 25 by 25 km. The WOFOST grid points corresponding to 9 straw cereal locations in Hungary were used for this validation. Data for soft wheat were extracted from 2008 to 2013 in 10 daily steps for water limited above-ground biomass (kg/ha).

The WOFOST data were compared with the ISBA-A-gs outputs for straw cereals before (open loop) and after data assimilation, as well as with the in situ yield data provided by the Centre Office for Statistics in Hungary. Results are illustrated in a scatter-plot (Fig. 6) shows the summarized information coming from the estimations. The most accurate biomass estimate is given by the assimilation run compared to the in-situ yield. WOFOST and the open-loop runs overestimate the wheat biomass production for all sites. The assimilated above-ground biomass correlates with the in-situ yield: $R = 0.25$ (without the outlier data from 2010, $R = 0.56$), while the open-loop simulation is uncorrelated with in-situ $R = -0.13$ (without 2010, $R = 0.28$), WOFOST estimation has also a poor correlation: $R = 0.15$ (without 2010, $R = 0.32$).

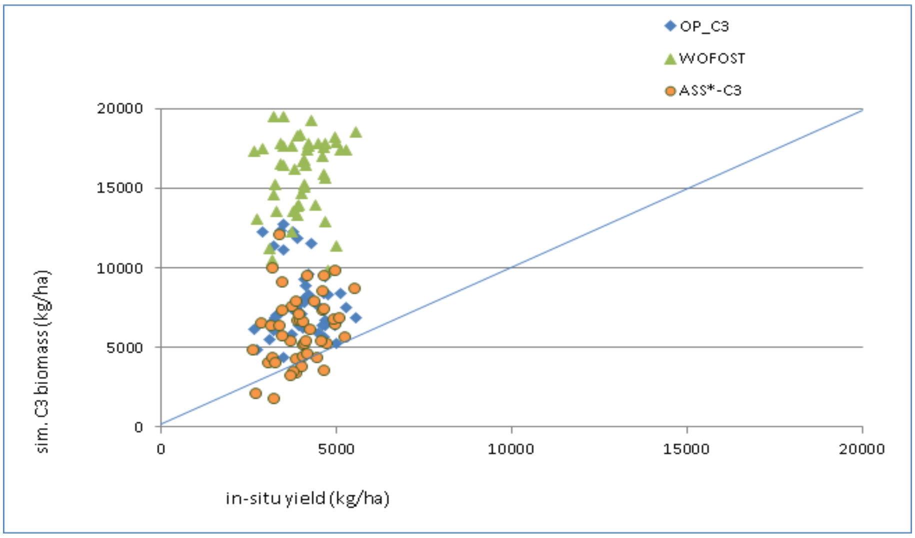

Figure 6: Scatter plot: Simulated above-ground biomass of straw cereals (open-loop (blue diamond), assimilation (oragne circles) and WOFOST estimation (green triangles)) vs. observed yield, over 8 administrative units in Hungary for the period of 2008-2013

4 Conclusion

In the framework of the IMAGINES project a Land Data Assimilation System was applied at the Hungarian Meteorological Service to monitor the above ground biomass, surface fluxes (carbon and water) and the associated root-zone soil moisture at the regional scale (spatial resolution of 8km x 8km) in quasi real time. In this system, the SURFEX V7.3 model was used, which applies the ISBA-A-gs photosynthesis scheme to describe the evolution of vegetation. SURFEX was forced using the outputs of the ALADIN numerical weather prediction model run operationally at OMSZ. First, SURFEX was run in open-loop (i.e. no assimilation) mode for period 2008-2015. Secondly, the Extend Kalman Filter (EKF) method was used to assimilate SPOT/VGT LAI and SWI ASCAT/Metop satellite measurements. The EKF run (with assimilation) was compared to the open-loop simulation and to observations (LAI and Soil Moisture satellite products) over the whole country and also to a selected site in West-Hungary (Hegyhatsal). It was shown that a significant improvement is obtained by using the LDAS chain. The LDAS system was able to describe the exchanges of the water vapor and CO_2 between the vegetation the soil and the atmosphere.

It has been shown that the above-ground biomass simulated by ISBA-A-gs over wheat relates very well to agricultural yields if the assimilation of both satellite observations (LAI and SWI) is performed.

The ImagineS project was finished at the end of June 2016. The products of the project as crop estimations, droght indicators and time series will be promoted to the potential end-users (experts from Ministry of Agriculture and Agricultural Directorate).

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Fields in the clim files for ISBA (in combination with PGD)

Martina Tudor, Stjepan Ivatek-Šahdan and Antonio Stanešić

1 Introduction

Configuration e923 is used to create fields that contain so called climatological or constant fields. Some of these fields vary during the year and other are constant. The result are 12 monthly climatological files. The configuration e923 is executed in 8 steps, numbered 1 to 9, while the step number 7 is omitted in the standard procedure (it is related to the aqua planet simulations). A climatological file is created in the following 8 steps:

step 1 - definition of numerous fields describing orography and land-sea mask, depending on the namelist, few fields that describe topography can be created from a PGD file (using one database - the same as for SURFEX) while other fields are computed from the usual database (another one), creates one output file

step 2 - definition of surface, soil and vegetation characteristics without annual cycle, creates one output file, uses fields computed in the previous step and input,

step 3 - definition of monthly climatological values of soil temperature and moisture, modification of albedo and emissivity according to the climatology sea-ice limit, creates 12 output files, uses fields computed in the first two steps and input,

step 4 - definition of the vegetation characteristics and modification of several surface characteristics, uses fields computed in the first three steps and input,

step 5 - modification of fields created by step 2 or 4 over land from high resolution datasets for each month, uses fields computed in steps 1, 2 and 4 and input,

step 6 - modification of climatological values for soil temperature and moisture using "new" climatology, uses fields computed in steps 1 and 3 and input,

step 7 - modification of fields over the water surfaces (not run for usual e923)

step 8 - computes monthly fields of A, B and C coefficients for profiles of ozone

step 9 - computes monthly fields of aerosols (sea, land, soot, desert).

Steps 4 to 9 have to be run separately for each monthly file. Each step (except the first one) uses some of the fields created in previous steps as input. Additionally, there is Step 10, that is also run for the aqua planet and not used for common clim files.

2 Layout

Each step of the configuration e923 uses a number of input files (possibly more than 15 years old?) that contain different fields in different resolutions, some of the input files cover the whole globe, while other cover a smaller area and most of them use the output fields from the previous step. The default values for the covered area and resolution of the input files are set in incli0.F90, these default values are listed in Table 1, but can be changed in the namelist NAMCLI. Each step requires input files named in a prescribed way (the names are hardcoded

Table 1: Parameters change according to N923 value (step of 923). Finally, the values for NGLOBX/Y are set equal to NDATX/Y, and the resolution of input data EDLON/LAT is computed from NDATX/Y for datasets 1-4, 6, 8 and 9. The values for step 6 are modified in the namelist. The rest are using these default values.

N923	1	2	3	4	5	6	8	9
LIEEE	T	T	T	T	T	T	F	F
NDATX	8640	360	432	360	860	240	144	72
NDATY	4320	180	216	180	420	120	73	45
coverage	global	global	global	global	SW(-25,30)	global	global	global
Resolution (degrees)	0.042	1	0.83	1	0.1	1.5	2.5	5

in the subroutines) so the input files are copied from the source directories to the working directory with the required name before executing computations. Some steps would work (well, execute something) even without the input files (using only output from the previous step) and write the output file. Such steps simply check for the existence of the input files and execute particular computations only if the input file exists. The only indication of the missing input files would be in the NODE file. So some variables change and others do not, depending on the existence of the input files. Currently there are several high resolution files missing/not used in different steps. The computations related to all steps can be done using a single script. The only thing that changes is the namelist and mostly in a minimum way since each step requires different N923 in the namelist. The only exception is Step 6, where an alternative data set is used for input and the resolution of the input increased from 1.5 to 1 degree (longitude and latitude).

2.1 Step1 - topography

The novelty in e923 is the usage of PGD (fields from the SURFEX file). This allows using new topography from the new database. A PGD file is created using a separate script that has to be run before the step 1. Using the topography and land sea mask from the new file is invoked by setting LNORO=T in the namelist NAMCLA. If one wants to use new (alternative) land sea mask (LNLSM=T), one also needs to use the new topography file. If PGD topography is imported (LIPGD=T) in the Step 1 of e923, envelope is added to the topography using multiplication factor FENVN and the topography variance from the old database (topography variance is used from the different database than the database used for the topography in the PGD file).

The resulting clim files are created as a combinationi of topographies from several databases. As a consequence land-sea mask and height of topography are taken from one database (used for SURFEX), but proportion of land, standard deviation of orography and other parameters describing topography are taken from another database.

SURFIND.TERREMER is the land sea mask, can have only 2 values, values over land are fixed to 1, and 0 for water surfaces if the percentage of water surface over the area of the grid cell is greater than the SMASK parameter that can be controlled via namelist NAMCLI, and was set to 0.5. The "old" land sea mask is applied to correct the roughness length and compute the fraction of land, and the new percentage of water is read from the new file afterwards and used to compute the new land sea mask. But the contents of this new file is not used for the field describing the percentage of water (or land) in the grid cell nor to correct the fields that should have certain default values above the sea surface.

SURFPROP.TERRE is the field that describes the fraction of land in the gridbox. It is equal to 1 for purely land points, 0 for the sea points, and varies from 0 to 1 over the coastlines, land with small lakes and rivers. It should match the land sea mask field, but in the Step 1 it is taken from the old database, even if the land sea mask is taken from the new one. This field can have substantially different values. The proportion of land is used in the subsequent steps of the configuration e923. The values should be computed from the new database and put into the clim file before the subsequent steps of the configuration e923.

SURFGEOPOTENTIEL - terrain height as geopotential (height in meters multiplied by 9.81 m/s2) as a grid-point field and SPECSURFGEOPOTEN as its spectral counterpart. This field can include the effect of envelope, controlled by the parameter FENVN in namelist NAMCLA, and the height of surface H_s is computed according to:

$$H_s = H_{mean} + FENVN * H_{stdev} * (1 - P_{water}) \quad (1)$$

where P_{water} is the percentage of water in the grid cell (from the old database!) and H_{stdev} is standard deviation of topography described below, H_{mean} is the mean topography in the grid cell.

SURFET.GEOPOTENT is the standard deviation of sub-grid topography multiplied by g=9.81m/s2. This field is taken from the old database by the standard Step 1 of the configuration e923. It is computed as:

$$H_{stdev} = \sqrt{\sigma_H^2 + \sigma_h^2 + \frac{(H_{max} - H)(H - H_{min})}{4}} \quad (2)$$

where σ_H s the terrain variance resolved in the input file but not in the output topography (rather questionable what this is once the output resolution approaches the resolution of the input file), σ_h is the unresolved variance read from the Sigma input file, and $\frac{(H_{max}-H)(H-H_{min})}{4}$ is simly contents of the file Hmax-HxH-Hmin_ov4.

SURFVAR.GEOP.ANI is the anisotropy coefficient, it is equal to 1 for isotropic surfaces (sea) and varies from 0 to 1, where lower values mean that the terrain is particularly varying in one direction, but not in another. This field is computed using the fields taken from the old database by the standard Step 1 of the configuration e923. The output of eganiso is the square of the anisotropy coefficient. But in acdrag it is used as anisotropy (not the square value). The anisotropy γ and direction θ are computed as

$$\gamma^2 = \frac{P_1 + P_2 - \sqrt{(P_1 - P_2)^2 + 4P_3^2}}{P_1 + P_2 + \sqrt{(P_1 - P_2)^2 + 4P_3^2}} \quad (3)$$

$$\theta = atan\left(\frac{-(P_1 - P_2) + \sqrt{(P_1 - P_2)^2 + 4P_3^2}}{-2P_3}\right) - atan(\frac{gnordl}{gnordm}) \quad (4)$$

where

$$P_1 = \frac{\left(\frac{\partial H}{\partial x}\right)^2 \sigma_H^2}{\left(\frac{\partial H}{\partial x}\right)^2 + \left(\frac{\partial H}{\partial y}\right)^2} + \frac{\left(\frac{\partial h}{\partial x}\right)^2 \sigma_h^2}{\left(\frac{\partial h}{\partial x}\right)^2 + \left(\frac{\partial h}{\partial y}\right)^2} \quad (5)$$

$$P_2 = \frac{\left(\frac{\partial H}{\partial y}\right)^2 \sigma_H^2}{\left(\frac{\partial H}{\partial x}\right)^2 + \left(\frac{\partial H}{\partial y}\right)^2} + \frac{\left(\frac{\partial h}{\partial y}\right)^2 \sigma_h^2}{\left(\frac{\partial h}{\partial x}\right)^2 + \left(\frac{\partial h}{\partial y}\right)^2} \quad (6)$$

$$P_3 = \frac{\frac{\partial H}{\partial x}\frac{\partial H}{\partial y}\sigma_H^2}{\left(\frac{\partial H}{\partial x}\right)^2 + \left(\frac{\partial H}{\partial y}\right)^2} + \frac{\frac{\partial h}{\partial x}\frac{\partial h}{\partial y}\sigma_h^2}{\left(\frac{\partial h}{\partial x}\right)^2 + \left(\frac{\partial h}{\partial y}\right)^2} \quad (7)$$

SURFVAR.GEOP.DIR is the direction of the principal axis of topography (in radian). This field is computed using the fields taken from the old database by the standard Step 1 of the configuration e923. The angle of topography is computed from the components of the tensor and then the angle of the grid orientation is added so the final angle θ is not restricted to the range from $-\pi/2$ to $\pi/2$.

SURFZ0REL.FOIS.G is the roughness length of the bare surface multiplied by g=9.81m/s2, it can be scaled using an arbitrary parameter FACZ0 in the namelist NAMCLA, the experiments shown here used FACZ0=1. This field is computed using the fields taken from the old database by the standard Step 1 of the configuration e923. In e923, the surface roughness is computed as a combination of standard deviation and square root of the density of the number of peaks from both resolved and unresolved topography:

$$Z_{0ter} = \sigma_H\sqrt{\frac{N}{S}} + \sigma_h\sqrt{\frac{n}{S}} \quad (8)$$

where N is the number of resolved peaks (in the topography file), n is the number of peaks in the NB_peaks input file, and S is the surface of the grid cell.

2.2 Inserting fields from the new database to the clim file (after Step 1 is finished)

As mentioned before, only two of the fields describing topography are taken from the new database, and other fields are taken from the old one. Since the proportion of land had several strange features over the Adriatic after the Step 1 and not corrected in the subsequent steps so these features remained in the final clim files (Figure 1a, not-existent peninsulas along Italian coastline, rather messy Croatian coastline).

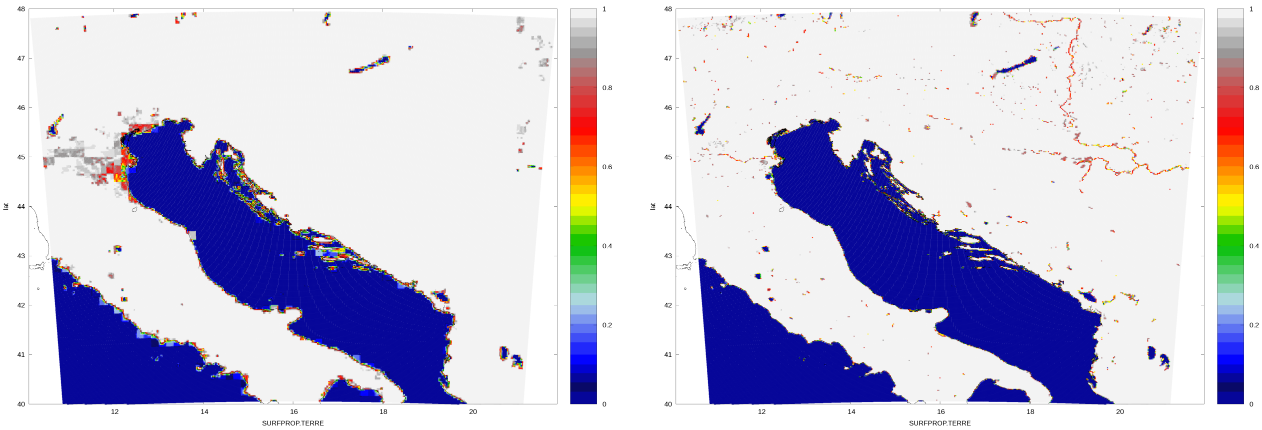

Figure 1: Proportion of land after the Step1 (a) and computed from the SURFEX PGD file (b). These figures show data for 2 km resolution domain.

Therefore an FA file was created from the SURFEX PGD file that had the same geometry as the Const.clim file and then the percentage of land was computed as:

$$P_{land} = 1 - P_{sea} - P_{water} \tag{9}$$

where P_{sea} and P_{water} are SFX.FRAC_SEA and SFX.FRAC_WATER. This field was inserted into the Const.clim file overwriting the old SURFPROP.TERRE field.

Furthermore, surface roughness for the bare land exhibited a chessboard pattern over the Alps and other mountains (Figure 2a, this feature became apparent only when the value of the roughness length was plotted as a small square on the position of the grid point), this was considered unnatural and could affect the forecast quality there.

As a first guess, this parameter was taken from the new database as the square root of the standard deviation of topography times g and the resulting field is shown in Figure 2b. One can immediately see much higher values above the mountains such as the Alps, but even more so above the mountains along the Croatian coastline that were rather smooth in the old clim files. The z0 field can be tuned together with the turbulence scheme. The Figures 2a and 2b show the roughness length in the clim file from the old database and the new field, the range of values in the new file is the same as the range in the old files.

Fields describing the anisotropy of topography and angle to the main axis were taken from the SURFEX PGD file. The anisotropy γ and the angle θ are computed in SURFEX as:

$$K = \frac{1}{2}\left(\left(\frac{\partial h}{\partial x}\right)^2 + \left(\frac{\partial h}{\partial y}\right)^2\right) \qquad L = \frac{1}{2}\left(\left(\frac{\partial h}{\partial x}\right)^2 - \left(\frac{\partial h}{\partial y}\right)^2\right) \qquad M = \frac{\partial h}{\partial x}\frac{\partial h}{\partial y} \tag{10}$$

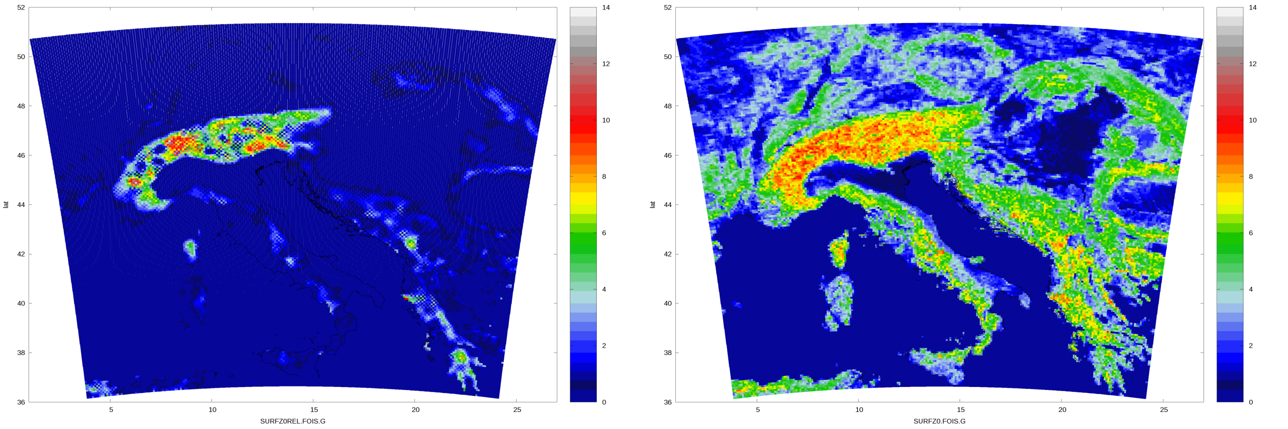

Figure 2: Surface roughness (a) and corrected field (b) in 8 km resolution (the values in the figures were divided by 9.81).

$$\theta = \frac{1}{2} atan \left(\frac{M}{L} \right) \qquad \gamma = \sqrt{\frac{K - \sqrt{L^2 + M^2}}{K + \sqrt{L^2 + M^2}}} \tag{11}$$

One can immediately see that the output is γ, not γ^2 as in e923. The anisotropy from e923 is shown in Figure 3a and from SURFEX in Figure 3b. Larger values means that the unresolved topography is more isotropic. Low values indicate that terrain is changing dominantly in one direction and the values above the sea should be 1 (isotropic surface). Since γ varies from 0 to 1, square of this field should yield lower values. This is why γ has higher values in Figure 3b than in 3a.

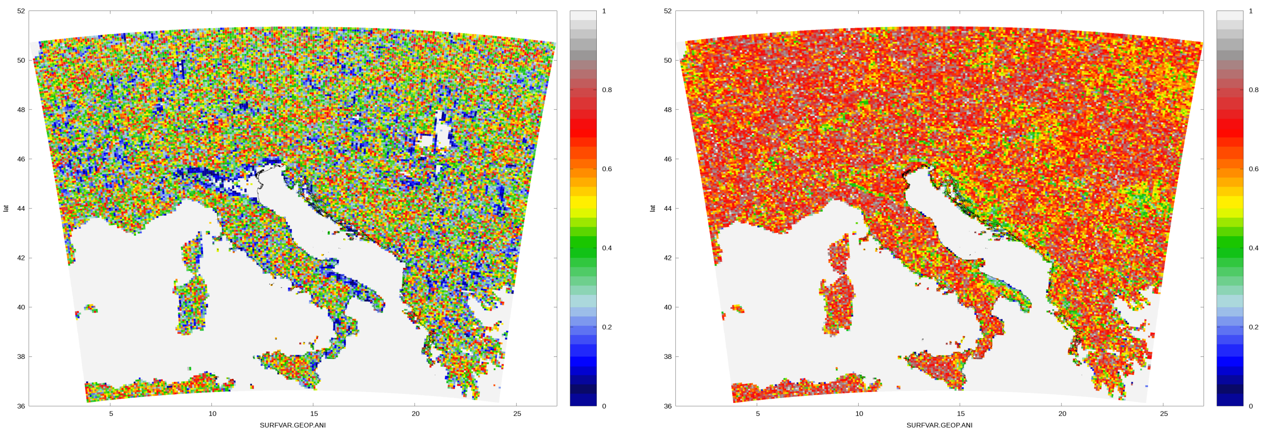

Figure 3: Anisotropy of unresolved topography in 8 km resolution, when computed by e923 from the old database (a) and taken from SURFEX (b).

In SURFEX θ is (according to the available documentation) defined as an angle to the x axis, positive northward and varies from -90 to 90. In code, θ is multiplied by 180/pi. Depending on the sign of L, the above θ is modified so that 90 degrees are added if L is negative and in the end, if the resulting angle is larger than 90 degrees, θ is reduced by 180 degrees. The link between the two θs (the one from e923 and another from SURFEX) is less transparent. Let's assume that one can identify the following:

$$K = \frac{1}{2}(P_1 + P_2) \qquad L = \frac{1}{2}(P_1 - P_2) \qquad M = P_3 \tag{12}$$

Then we start from the computations of θ in e923, how it is computed in eganiso, and insert the relations as defined above.

$$\theta = atan(\frac{-(P_1 - P_2) + \sqrt{(P_1 - P_2)^2 + 4P_3^2}}{-2P_3}) \tag{13}$$

$$\theta = atan(\frac{-2L + \sqrt{4L^2 + 4M^2}}{-2M}) = atan(\frac{L - \sqrt{L^2 + M^2}}{M}) \tag{14}$$

Since in SURFEX the angle θ is defined as one half of the arcus tangens function, one has to go to some basic trigonometic transformations. It is valid that:

$$atan(x) = \frac{1}{2}atan\frac{2x}{1 - x^2} \qquad for \qquad |x| < 1 \tag{15}$$

$$atan(x) = \frac{\pi}{2} + \frac{1}{2}atan\frac{2x}{1 - x^2} \qquad for \qquad x > 1 \tag{16}$$

$$atan(x) = -\frac{\pi}{2} + \frac{1}{2}atan\frac{2x}{1 - x^2} \qquad for \qquad x < -1 \tag{17}$$

inserting this property (well the first line) into the above formula for θ, one gets:

$$\theta = \frac{1}{2}atan\frac{2\frac{L-\sqrt{L^2+M^2}}{M}}{1 - \left(\frac{L-\sqrt{L^2+M^2}}{M}\right)^2} = \frac{1}{2}atan\frac{2\frac{L-\sqrt{L^2+M^2}}{M}}{\frac{M^2-(L^2-2L\sqrt{L^2+M^2}+L^2+M^2)}{M^2}} \tag{18}$$

$$\theta = \frac{1}{2}atan\frac{2M(L - \sqrt{L^2 + M^2})}{-2L^2 + 2L\sqrt{L^2 + M^2}} = \frac{1}{2}atan\frac{2M(L - \sqrt{L^2 + M^2})}{-2L(L - \sqrt{L^2 + M^2})} \tag{19}$$

$$\theta = -\frac{1}{2}atan\frac{M}{L} \tag{20}$$

Apparently the two angles are not defined the same way (the above derivation is valid if the absolute value of the argument of the arcus tangens function is less than unity). Let's see if it is possible to start from the SURFEX definition of θ and try to go back:

$$\theta = \frac{1}{2}atan\frac{M}{L} \qquad means \qquad \frac{M}{L} = \frac{2x}{1 - x^2} \tag{21}$$

$$M - Mx^2 = 2Lx \qquad Mx^2 + 2Lx - M = 0 \tag{22}$$

$$x_{1,2} = \frac{-2L + -\sqrt{4L^2 + 4M^2}}{2M} = \frac{-L \pm \sqrt{L^2 + M^2}}{M} \tag{23}$$

The quadratic equation has two solutions. The one with a plus sign would correspond to the minus of the argument of the arcus tangens function got when starting from e923. Finally

$$\theta_{e923} = \theta_{surfex} \tag{24}$$

2.3 Step 2: Sand and Clay

This step calculates the following fields: dominant land use type, bare ground albedo (used in 3 fields), emissivity, maximum and useful depth of the soil column, percentages of clay and sand and maximum vegetation fraction.

SURFPROP.ARGILE - percentage of clay, varies from 3 (above the sea surface!) to 58, the field appears unnatural (Figure 5a).

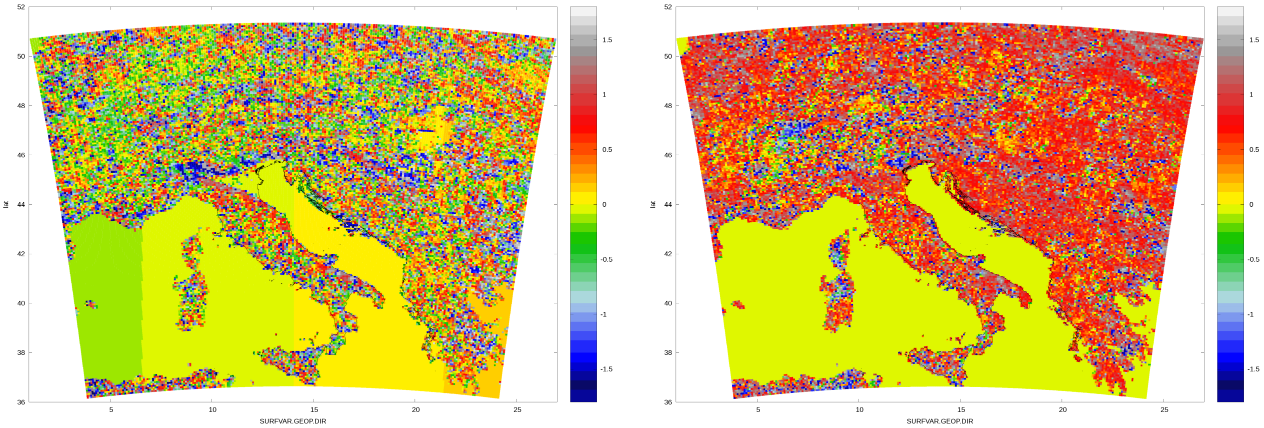

Figure 4: The angle of the main axis of topography with the x axis, θ in ISBA (a) and in SURFEX (b) recomputed to be in radians (but not multiplied by -1).

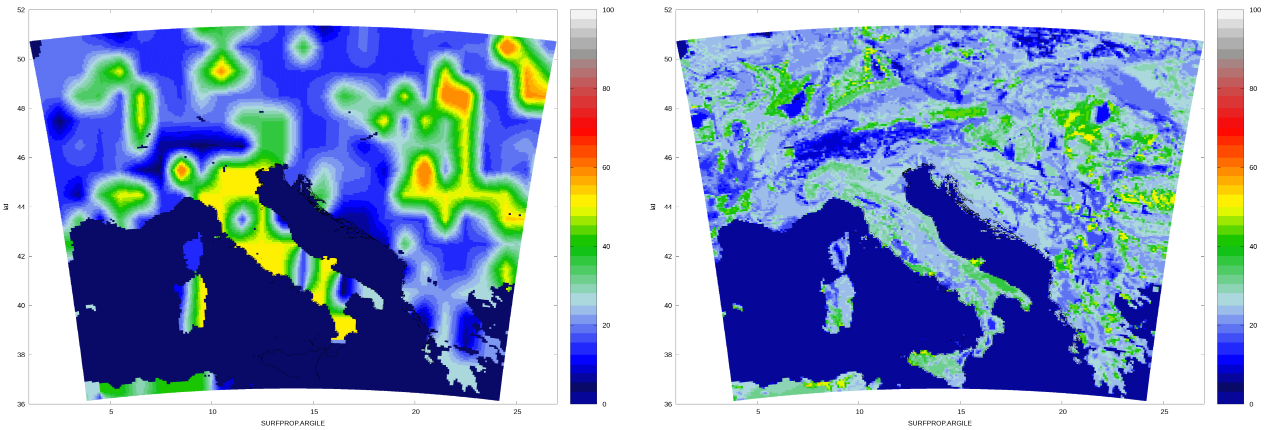

Figure 5: Proportion of clay in the clim file (a) and after the correction using data from the SURFEX PGD file (b).

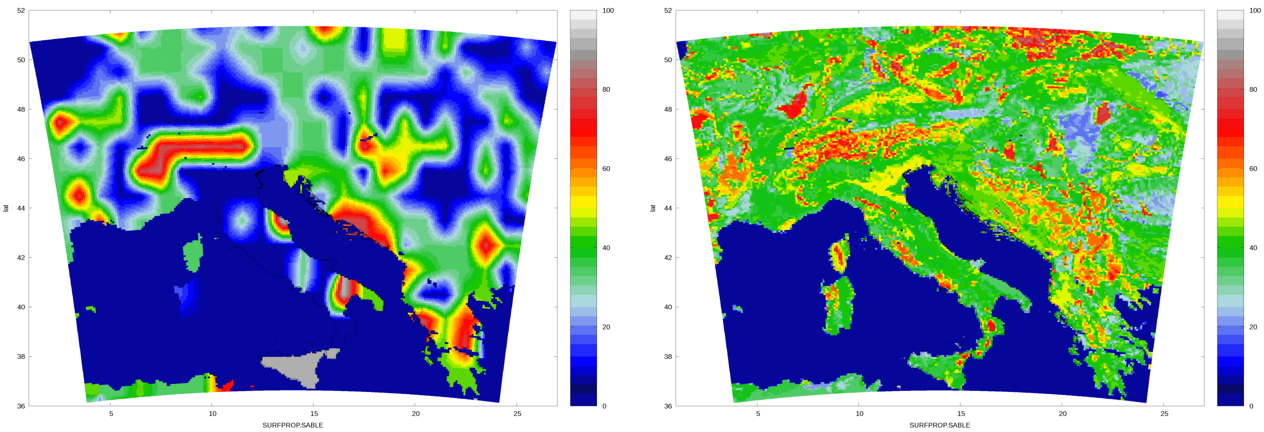

Figure 6: Proportion of sand in the clim file (a) and after the correction using data from the SURFEX PGD file (b).

SURFPROP.SABLE - percentage of sand, varies from 6 (above the sea surface!) to 92, the field appears unnatural (Figure 6a).

Both can be computed from the percentages of clay and sand from the SURFEX PGD file after correcting for the values above the sea (from 10^{20} to 0), limiting with the proportion of land and scaling with 100, the resulting fields are shown in Figureis 5b and 6b. These field could be modified by high resolution data in Step 5, but there are no input files.

3 Testing

The impact of modified roungness length was tested by running 31 forecasts in 8 and 2 km resolutions starting from 00 UTC for March 2016. The forecast of wind at 10m above fround depends on the roughness length. The introduction of new, rougher surface reduced the wind speed in cases with strong to severe bura wind (that blows fron northeast therefore from land to sea). The reduction in wind speed varies from place to place.

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HARMONIE-AROME radiation studies 2011-2016

Laura Rontu, Emily Gleeson, Kristian Pagh Nielsen, Velle Toll, Jan Mašek

1 Introduction

The idea for a HARMONIE-AROME radiation comparison was presented five years ago at the annual EWGLAM /SRNWP meeting (Rontu, 2011). It was suggested that the best radiation parametrizations for a meso-scale NWP model are those which can optimally and consistently use information about cloud microphysical properties, cloud extent, surface radiation properties and aerosol data available in the model; this information varies rapidly in both time and space. There was a need to create a platform for the comparison of radiation parametrizations of varying complexity in a unified environment. Consequently, such a platform has been built within the AROME physics subroutine (apl_arome), where the IFS (from here onwards: IFSRADIA; ECMWF, 2006), ALARO (ACRANEB2; Mašek et al., 2016) and HIRLAM (HLRADIA, Savijärvi, 1990; Wyser et al., 1999) radiation schemes can now be called using the same input fields. In addition, each scheme generates the same output parameters. To date, nine radiation working weeks have been arranged between 2012 and 2016 in order to make comparisons of and improvements to the schemes available in HARMONIE-AROME. A summary of some of this work and outcomes is presented in this article.

The aim of the radiation parametrizations in an NWP model is to estimate the radiative heating in the atmosphere due to the vertical divergence of the net longwave (LW) and net shortwave (SW) radiation fluxes. This is a source term in the thermodynamics equation in the model. The radiation parametrizations also provide the model with the surface-level downward (LWDN, SWDN) and upward (LWUP, SWUP) radiation fluxes, which are part of the surface energy balance and a lower boundary condition for the calculation of atmospheric radiation transfer.

The variables and processes inluded in the parametrization of the SW and LW radiative transfer in HARMONIE-AROME are illustrated schematically in Figure 1. Parametrizations of the optical properties (optical thickness, single-scattering albedo and asymmetry factor) of liquid clouds, ice clouds and six aerosol types are used in the SW part of the spectrum. These optical properties are also used in the LW calculations in the ACRANEB2 scheme. However, in IFSRADIA and HLRADIA LW scattering is neglected and therefore only the layer optical thicknesses are used for the corresponding LW calculations in these schemes. The optical properties are calculated as a function of the layer mass load, the effective sizes of the cloud particles and the aerosol type. The effective sizes of the cloud particles depend on the concentrations of cloud liquid, cloud ice and on temperature.

It is important to note that using (part of) the grid-scale mass of snow and graupel precipitating particles in the radiation parametrizations but assuming that these have the same inherent optical properties as cloud ice crystals, may lead to unexpected results. The entire chain of parametrizations needs to be considered in order to improve the atmospheric radiative transfer calculations.

The radiative properties of the surface (i.e. surface temperature, albedo and emissivity in addition to variables for orographic radiation parametrizations such as slope angles and local horizon) depend on surface properties (e.g. surface type, vegetation etc.) and elevation. These are provided by the physiography, climatology and analysis (e.g. snow cover) or are derived in other parametrizations (e.g. soil surface temperature).

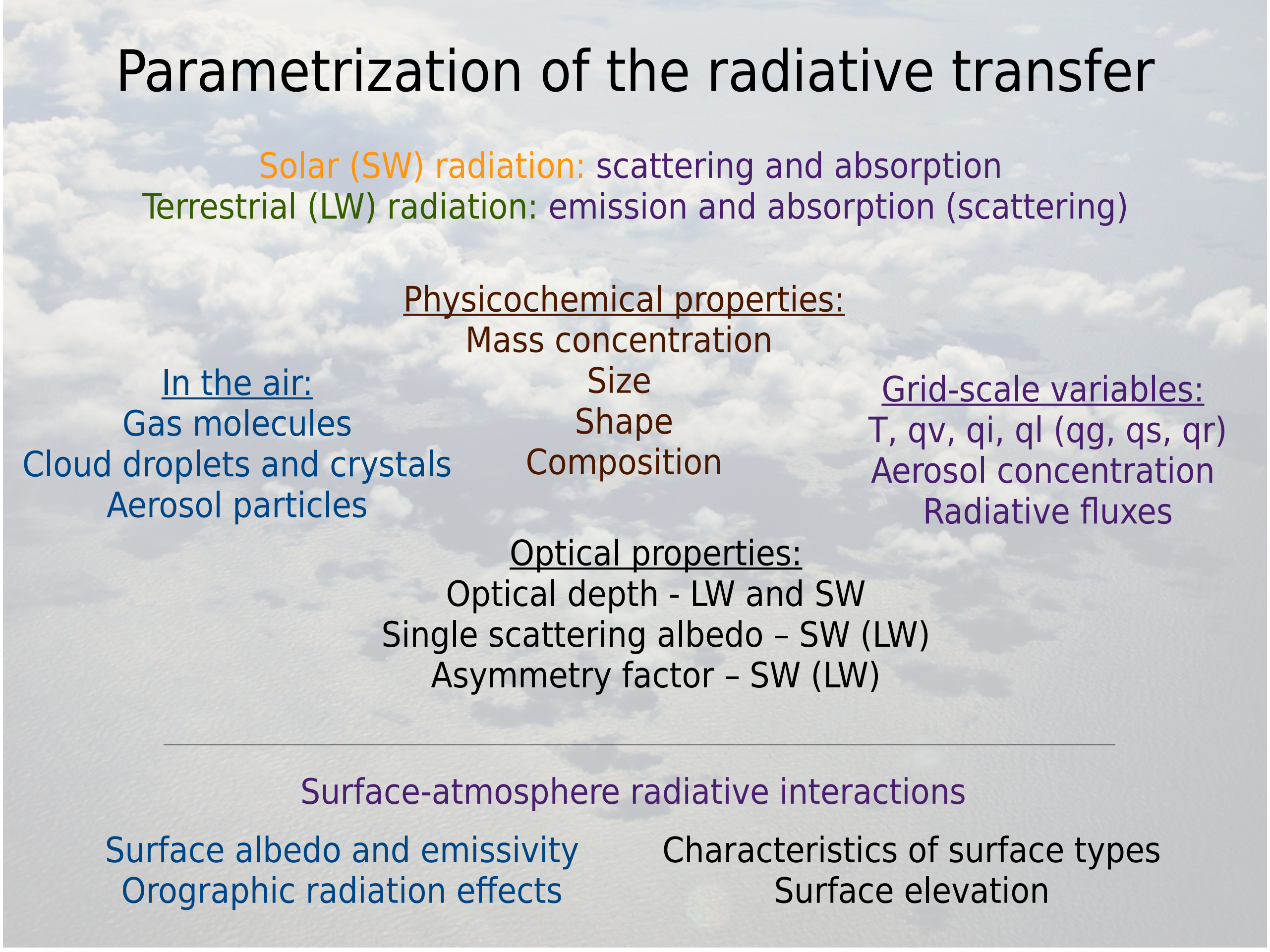

Figure 1: *Variables and processes inluded in the parametrization of the SW and LW radiative transfer in HARMONIE-AROME. Notation of the grid-scale variables: T = temperature, qv = specific humidity, qi = specific cloud ice water content (cloud crystals), ql = specific cloud liquid water content (cloud droplets), qg = specific precipitating graupel content, qs = specific precipitating snow content, qr = specific rain content (rain drops). qg, qs and qr as well as LW scattering are in brackets because their inclusion in the radiative transfer calculations is optional.*

Within the HARMONIE-AROME framework, it is possible to address the questions posed in the 2011 EWGLAM / SRNWP presentation (quotation rephrased):

"The aim of the model comparison experiment is to compare and validate HIRLAM-ALARO-AROME radiation parametrizations over complex terrain. The experiment should provide the information needed to understand the relative importance of the following in mesoscale models:

1. Advanced multi-band clear-sky radiative transfer parametrizations (provided by the ECMWF radiation scheme within AROME)
2. Accurate handling of cloud-radiation interactions, necessary due to the improved time resolution of radiation calculations
3. Improved treatment of radiation-surface-interactions, including sloping surface parametrizations."

The hypothesis was that in the mesoscale models the fast interactions between clouds and radiation and the surface and radiation could be of greater importance than accounting for the spectral details of the clear-sky radiation. Thus, computationally affordable single-band schemes like HLRADIA and ACRANEB2, which can be run at high temporal and spatial resolution at the expense of high spectral resolution, could be more suitable for this type of model than schemes like IFSRADIA which are developed for large-scale models.

2 Atmospheric comparisons

SW radiation fluxes from the IFSRADIA and HLRADIA schemes were tested by Nielsen et al. (2014) and compared to DISORT (Stamnes et al., 1988, 2000) benchmark results in single-column MUSC experiments, based on code from the harmonie-37h1.radiation branch. In this study, a diagnostic MUSC framework without integrations in time, was applied in clear and cloudy sky aerosol-free test cases. The cloud condensate content (liquid and ice) and the effective particle sizes were prescribed; no observations were used in the comparisons. It was found that the results of the experiments using the simple broadband HLRADIA scheme are as good as those from the spectral IFSRADIA scheme, especially in cases involving liquid clouds. A new parametrization of cloud liquid optical properties for IFSRADIA (the Nielsen cloud liquid optical property scheme) was suggested and found to perform better than the default Fouquart scheme (Fouquart, 1987) for a range of sensitivity tests.

The current status of the actions related to SW radiation, suggested by Nielsen et al. (2014), is summarized below:

- The current choice of six SW spectral bands in HARMONIE-AROME/IFS should be re-assessed, as the first spectral band is irrelevant for NWP modelling. *Status: task found to be of low priority, not done.*
- The effect of changing the SW cloud inhomogeneity factor from 0.7 in IFSRADIA (0.8 in HLRADIA) to 1.0 should be tested against observations of global radiation in the framework of 3D HARMONIE-AROME experiments. *Status: tested using IFSRADIA, update accepted in HARMONIE cycle 40h1 (Gleeson et al., 2015).*
- The effects of using the Nielsen cloud liquid optical property parametrization within the IFS scheme on the general 3D NWP results should be tested against observations of global radiation. *Status: tested over the Irish operational domain, update accepted in HARMONIE cycle 40h1 (Gleeson et al., 2015).*
- In order to improve the delta-Eddington radiative transfer calculations, the possibility of using a variable average zenith angle for diffuse irradiances (as outlined in Räisänen, 2002) should be investigated. *Status: not done.*
- The HLRADIA gaseous transmission coefficients should be tuned to the Kato-DISORT clear sky results presented in Nielsen et al. (2014) and repeated for the other AFGL atmospheric profiles. *Status: done, coefficients updated (Gleeson et al., 2015).*
- The impact of aerosols needs to be investigated. *Status: done, results published in Gleeson et al. (2016); Toll et al. (2016, 2015)*

The direct radiative effect of aerosols on SW radiation fluxes under clear-sky conditions in HARMONIE-AROME was studied by Gleeson et al. (2016). Diagnostic single-column MUSC experiments were performed in this case also, but observational data from the Tõravere observatory in Estonia were used to define the aerosol load and to estimate the inherent optical properties of the aerosols. A case study involving Russian forest fires during the summer of 2010 was selected for the experiments. In this case the aerosol was assigned to the land aerosol category in MUSC. The simulated SWDN fluxes were compared to observations of global radiation. The initial atmospheric state (temperature, humidity etc.) was extracted from 3D HARMONIE-AROME experiments at each hour for which a diagnostic MUSC experiment was run.

We found that the optical properties of the aerosols and their spectral distribution, and not only the mass concentration, are important. Compared to observations, the broadband radiation schemes (HLRADIA, ACRANEB2) were found to provide similar global radiation fluxes to the six-band IFSRADIA scheme. We also found that the simulated global radiation shows better agreement with the measurements when the broadband aerosol optical depth (AOD) and the corresponding single-scattering albedo and asymmetry factor, derived from observations, were used instead of the climatological or parameterized aerosol optical properties (Tegen et al., 1997; Hess et al., 1998).

Aerosol-radiation interactions were also discussed in the synoptic-scale studies by Toll et al. (2016) and Toll et al. (2015). In these studies, 3D model experiments using ALARO physics, as opposed to AROME physics, and the IFSRADIA radiation scheme were performed over Europe for a time period where the aerosol distribution was close to the climatological average and separately for the summer 2010 Russian wildfire case study. For the period where the aerosol distribution was close to the climatological average, accounting for the direct radiative effect of aerosols using the more realistic time-varying aerosol data from the Monitoring Atmospheric Composition and Climate (MACC) reanalysis (Inness et al., 2013) rather than the default climatology of (Tegen et al., 1997) improved the accuracy of the simulated radiative fluxes. Improvements in the temperature and humidity forecasts in the lower troposphere were also found compared to the case where the direct radiative effect of aerosols was not included. Although the dependency of forecast synoptic conditions on the aerosol dataset was found to be weak, it is important to at least account for the climatological average of the direct radiative effect of aerosols over Europe. On the other hand, for the wildfire period in Russia and Eastern Europe during the summer of 2010 where aerosol concentrations were very high, near-real-time aerosol distributions rather than climatological averages, were needed to account for the direct radiative effect of the aerosols. Including aerosols from the MACC reanalysis rather than the default Tegen climatology considerably improved the forecast of near surface temperatures, global radiation and the vertical profile of temperature.

3 Surface interactions

Surface albedo is needed by the atmospheric SW radiation parametrizations and possibly as output from the forecast model. It is an important parameter which affects radiation-surface interactions. The derivation of the grid-scale albedo for the radiation parametrizatons in HARMONIE-AROME is complicated and may still contain inconsistencies. In the future, it may be possible to use albedo climatologies, e.g. Blanc et al. (2014) or analysed albedos based on near-real-time satellite observations.

There are three aspects to surface albedo: spectral, surface and time dependance. The albedo of bare land and vegetation for the UV, visible and near-IR wavelength bands is provided by SURFEX (PGD). From these, the value for each of the six spectral bands of IFSRADIA, and a broadband value for ACRANEB2 and HLRADIA, is derived using the assumed spectral distribution of SW radiation in the lower troposphere. Currently, the albedo of snow is a prognostic variable in the default snow parametrization scheme in HARMONIE-AROME (applied for seasonal snow, but not for glaciers!). Sea and lake surface albedos are modified by corresponding parametrizations. Separate albedos are defined for the direct solar beam and for diffuse radiation. A simple formula, dependent on the solar zenith angle (SZA), $albedo_{dir} = albedo_{dif} + 0.2/(1 + cos(SZA)) - 0.12$, is suggested for the calculation of the direct beam albedo.

Another example of radiation-surface interactions are the effects of orography on radiation. Recently, parametrizations developed for the HIRLAM model (Senkova et al., 2007) have been imported to SURFEX (Wastl et al., 2015; Rontu et al., 2016) and are available via the apl_arome and aplpar interfaces in HARMONIE-AROME. In these parametrizations the surface slope, sky view and shadow factors are used to modify the surface SWDN and LWDN radiation fluxes calculated by any of the available atmospheric radiation parametrization schemes. The factors are derived from the high-resolution source orography data for each gridpoint in the model domain. Detailed sensitivity studies, over the Sochi Olympics area, using 3D and single-column experiments, showed that substantial, and physically realistic, changes in SWDN and LWDN radiation fluxes take place locally.

However, their influence on the simulated screen-level temperatures was small (Rontu et al., 2016). A conclusion from the Sochi study was that a comparison of the simulated and observed radiation fluxes would offer a more reliable alternative to screen-level temperatures for model validation. This is dicsussed in more detail in Section 4.

It is recommended that the output albedo, possibly requested by users of HARMONIE forecasts, is derived from the accumulated surface SWDN and SWUP radiation fluxes. Using this method, additional effects due to urban or orographic radiation parametrizations, which can be implicitly included in the atmospheric radiative transfer calculations as described in the previous paragraph, can be taken into account.

4 Validation by radiation

Observed radiation fluxes provided by surface stations and satellites offer an interesting possibility for validating NWP models:

- Observed and predicted fluxes have a greater correspondence to each other than observed and predicted cloud cover or screen-level temperatures for example.
- More ground-based and satellite SW observations are becoming available – how should we use these for systematic monitoring and validation of NWP models?
- Reliable SW radiation fluxes are increasingly required for the solar energy industry.

An example of using surface-based downwelling and upwelling SW and LW fluxes for intercomparison of the IFSRADIA, ACRANEB2 and HLRADIA radiation schemes within HARMONIE-AROME was shown by Kangas et al. (2016), who described the mast verification system maintained by FMI *http://fminwp.fmi.fi/mastverif*. It was found that the three radiation schemes produced somewhat different LWDN radiation fluxes under cloudy conditions. However, this did not change the overall cold bias in the predicted screen-level temperature compared to observations recorded at the FMI-ARC Sodankylä observatory.

SWUP (reflected SW radiation at the surface) is related to the surface albedo. Observations of this parameter represent local conditions, especially over snow covered areas. LWUP is related to surface temperature and again represents local conditions over open and, possibly snow-covered, land for example. The grid-average values of SWUP and LWUP in an NWP model, even a very fine resolution model, represent a bird's-eye view of the parameter. In Sodankylä during spring this is analagous to flying high over the tree tops and seeing dark trees in addition to the white snow-covered surface. For this reason, modelled and observed SWUP is generally not comparable. More studies are needed in order to understand the statistical dependency between surface temperature and LWUP.

Simulated and observed LWDN fluxes are related to the cloud condensate content (liquid and ice), cloud cover, cloud bottom temperature and, in clear-sky cases, to the near-surface air temperature and humidity. SWDN is related to cloud condensate content, cloud particle size and cloud cover. Under clear sky conditions aerosol content and specific humidity play the most significant roles. Real-time SWDN flux measurements are available at SYNOP stations in many countries and thus offer the potential of including such observations in the standard verification of HARMONIE-AROME.

Gleeson et al. (2015) introduced validation of SWDN radiation using the clear sky index (CSI). This is a useful parameter for comparing SW radiation because it also acts as a proxy for cloud cover and cloud condensate amounts. The index is the ratio of global SWDN divided by the maximum possible global SWDN for a given location, date and time. A reliable estimate of the maximum clear-sky SW radiation flux can be obtained from the model. However, in this study, it was calculated by applying the HLRADIA clear-sky formulation off-line.

Using CSI as a proxy for cloudiness highlights the binary (on/off) nature of cloud cover in HARMONIE-AROME. This is indicated by the U-shape of the model curves in Figure 2 which shows the CSI calculated for

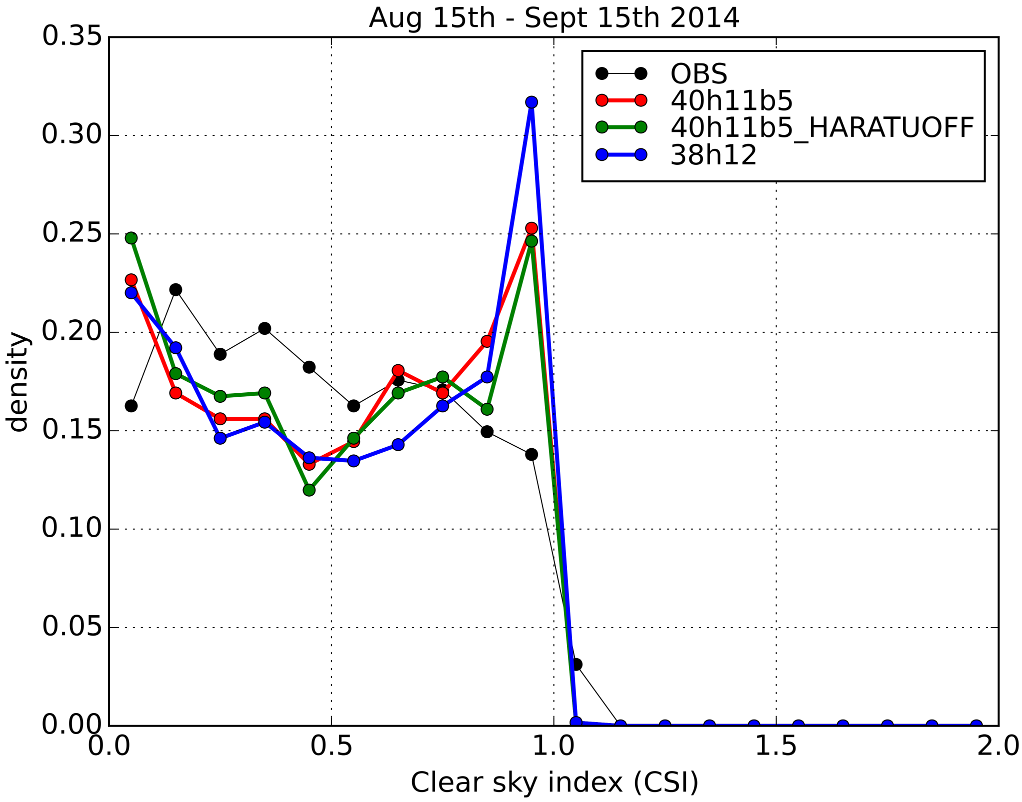

Figure 2: *Probability distribution function of the Clear Sky Index (CSI) based on observations (at 6 synoptic stations in Ireland; black dotted continuous line) and HARMONIE-AROME 6-hour forecasts (for 3 configurations of the model (red, green, blue dotted continuous lines) - see inserted legend for details) for the period August 15th to September 15th 2014. In general the CSI is close to 1 under clear sky conditions. However, the CSI may also be high for cases with total cover when the clouds are thin.*

Irish stations in August/September 2014 using observations and 3 configurations of HARMONIE-AROME: 1) cycle 38h1.2, 2) cycle 40h1.1.beta.2 (using the Nielsen SW cloud liquid optical property scheme, a cloud inhomogeneity of 1.0 and updated atmospheric turbulence scheme HARATU (HARMONIE-RACMO TUrbulence), 3) same as 2) but without HARATU.

5 System aspects

Three radiation schemes (IFSRADIA, ACRANEB2 and HLRADIA) have been configured in the HARMONIE-AROME radiation development branch and in several MUSC experiments using the HARMONIE-AROME framework up to cycle 40. It is planned to make these available and to carry out further testing using the harmonie-43h1 cycle. In cycle 43, SURFEX v.8 will be available. Within this framework it will also be possible to implement the orographic radiation parametrizations for further testing and possible operational use.

It is planned to introduce more up-to-date aerosol data into the forecast system. The work will start with a renewal of the climatological aerosol data, with the eventual goal of using the near-real-time aerosol data available at ECMWF. The radiation schemes in HARMONIE-AROME have already been shown to be capable of using this aerosol data. However, work needs to be done on the indirect (cloud-related) effects of aerosols.

We have suggested introducing surface-based global radiation observations into the standard validation of the operational HARMONIE-AROME system. An inventory of available observations and an implementation plan are needed for this.

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Latest updates of the cloud- and condensation parametrizations in HARMONIE-AROME

Karl-Ivar Ivarsson

1 Introduction

HARMONIE-AROME has been running operationally within the bi-lateral cooperation MetCoOp between the Norwegian Meteorological Institute and the Swedish Meteorological Institute since March 2014. This HARMONIE-AROME set-up is named AROME-MetCoOP in this paper and has a horizontal resolution of 2.5 km, the number of model levels is 65 and the model domain consist of 739x949 grid-points covering north-western Europe. The model operates with three hourly update cycling, but forecasts used for general purpose are produced every six hour only. The forecasts of 2m temperature and 10m wind speed are (in a broad sense) better than any other comparable models. This is also true for precipitation forecasts if one consider 24-hours precipitation verified by fractions skill score. But there are also some remaining issues which are presented in the next section. Only the ones that are dealing with cloud- and condensation will be discussed in some more detail. A short summary is given in the last section.

2 Some deficiencies seen with AROME-MetCoOP and possible solutions

Too much of graupel compared to ordinary snow

According to meteorological definitions, graupels are small (1mm or less) white balls of ice which may fall out of a stratus layer and not bouncing when hitting the ground (ww code 77) or a little larger white icy balls (1-5mm) often falling from convective clouds in winter or early spring (ww code 87). Those graupels are often bouncing when hitting the ground. Also hail is included in the graupel category in the present set-up of the ice micro-physical scheme ICE3. Apparently, there seems to be too much of graupel compared to ordinary snow, since graupel is present also in large scale precipitation, where normally only snow is observed.

One reason for the over-prediction of graupel is that small graupels growing in an ice-supersaturated environment still becomes graupels in the model, instead of being transformed to snow crystals, which is more in agreement with observations and theoretical considerations.

This over-prediction of graupel is reduced in the following way:

- If the supersaturation with respect to ice is at least 15% and the graupel mixing ration is near zero, turn all new graupel into snow.
- If the graupel mixing ratio is 10e-7 or more or if there is no ice-supersaturation, do not convert between snow and graupel.
- A bilinear transition for different supersaturation's and mixing-ratios is used. This means that if for example the supersaturation with respect to ice is 7.5% and the mixing-ratio is 0.5x10e-7 then ¼ of the graupel deposition becomes snow and the remaining ¾ becomes graupel.

This parametrization is activated by a logical switch called LGRSN.

An example of the effect of switching on LGRSN is seen in figure 1:

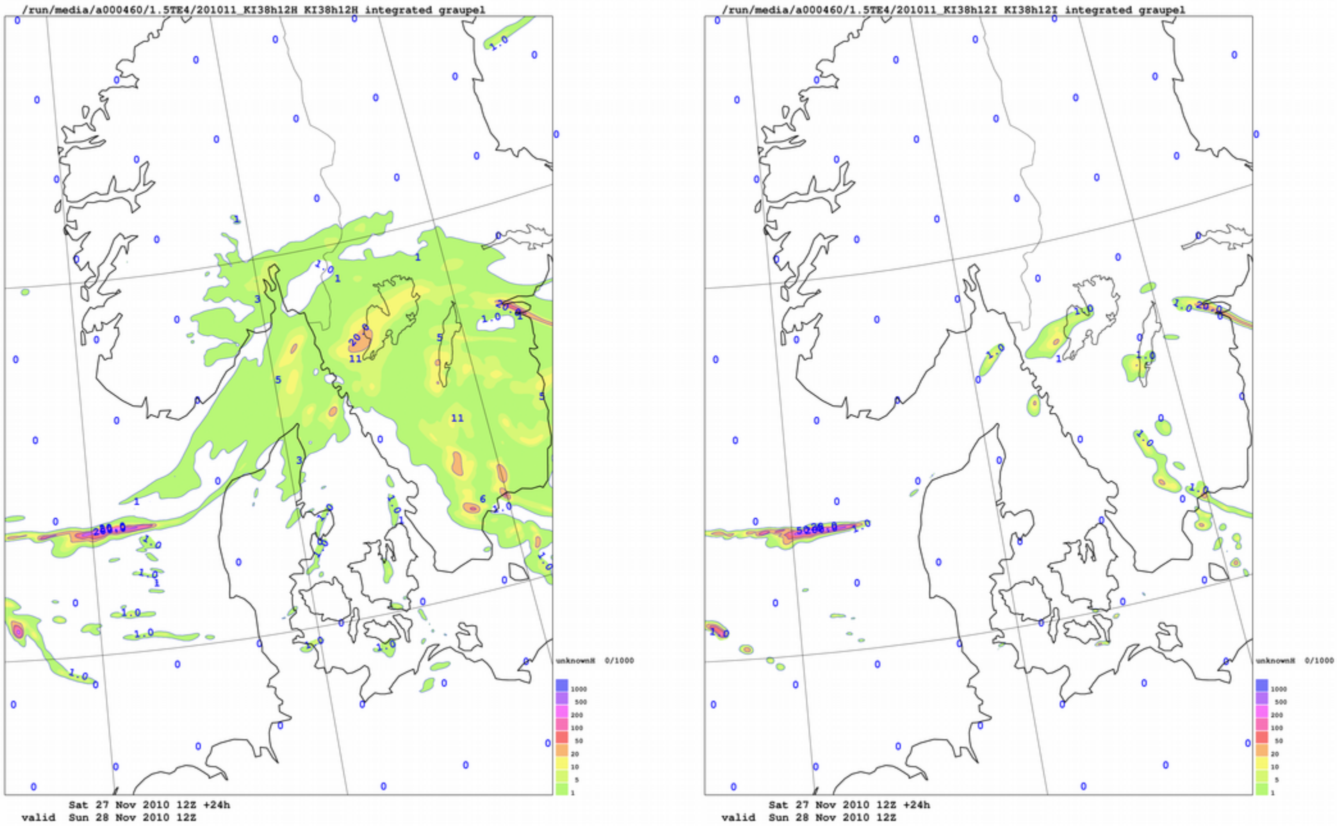


Figure 1: Integrated graupel. (kg/m^2 x 100) To the left without LGRSN and with LGRSN to the right.

The figure shows a forecast of a heavy snowfall in late November 2010. The amount of graupel is strongly reduced when LGRSN is switched on, but in convective areas there are hardy any difference. With LGRSN, the ordinary snow is increased in such way that the total precipitation amount is fairly the same (not shown). The verification shows very small effects. The moisture in the lower troposphere is marginally increased in winter and thus also the amount of low clouds.

Super-cooled rain is not forecast properly

Forecasts of supercooled rain are strongly suppressed by a too fast refreezing of rain falling trough a layer with a temperature below freezing point. In order to slow down the refreezing the following modifications are made:

- When there is only small amounts of cloud ice and ice nucleolus (IN), do not refreeze.
- When the mixing-ratio of snow is less than 0.1g/kg do not any raindrop accretion into graupel. This is suggested by Rutlegde and Hobbs (1984), and (partly) by Thompson et al (2004).
- Freezing rain should normally be converted into graupel/hail and not into snow.

This modifications makes it possible to avoid most refreezing when there a shallow layer of air with temperatures down to at least -5 Celsius. The verification shows a very small impact, except a more accurate prediction of freezing rain. There exists slightly different ways to improve the forecasts of freezing rain, see the article “Improvement of microphysical processes in HARMONIE” by Pleun Bonekamp and Sander Tijm in this newsletter. Rutlegde and Hobbs (1984) also suggested anther criteria (not yet tested) to avoid too much graupel: The cloud liquid ratio should exceed 0.5 g/kg before turning on the riming growth.

Too much fog, especially in late winter and in spring.

The main reason is probably the handling of patches in the SURFEX scheme, which leads to too much latent heat flux from the surface compared to the sensible heat flux. Thus, the lowest model levels become too moist and too cold. Tests with using two patches instead of one shows so far encouraging results.

Several experiments also show that using the HARATU switch for turbulence (default in cycle-40) reduces the over-prediction of fog.

But one also have to consider that the amount of active cloud condensation nucleus (CCN) is probably less in a persistent stable stratified fog layer than what is generally the case. The reason is that sedimentation of cloud liquid also leads to sedimentation of CCN. Since the fog layer is stable, very little new CCN is transported into the layer by turbulence. Less CCN concentration leads to fewer but larger cloud droplets. This increases both the speed of the droplet sedimentation and rate of auto conversion of liquid to rain. This leads to a positive feedback with both faster fog decay and faster CCN reduction. This process could be properly forecast with a two-moment scheme, but with present scheme it is easiest just to assume that the CCN concentration should be less in a stable fog layer.

The method suggested here is just to reduce the CCN amount at the lowest model level and the second lowest model level. Using the a reduction of CCN to 15% of the original value for the lowest model level and to 40 % for the second lowest model level decreases the over-prediction of fog without have any other notable effects in the verification result. This reduction is rather modest (Frequency bias for cloud base below 70m goes down from 2.8 to 2.4 in one of our tests) so other modifications, e.g. in surface scheme seems necessary.

Bug fix in rain_ice.F90 with OCND2

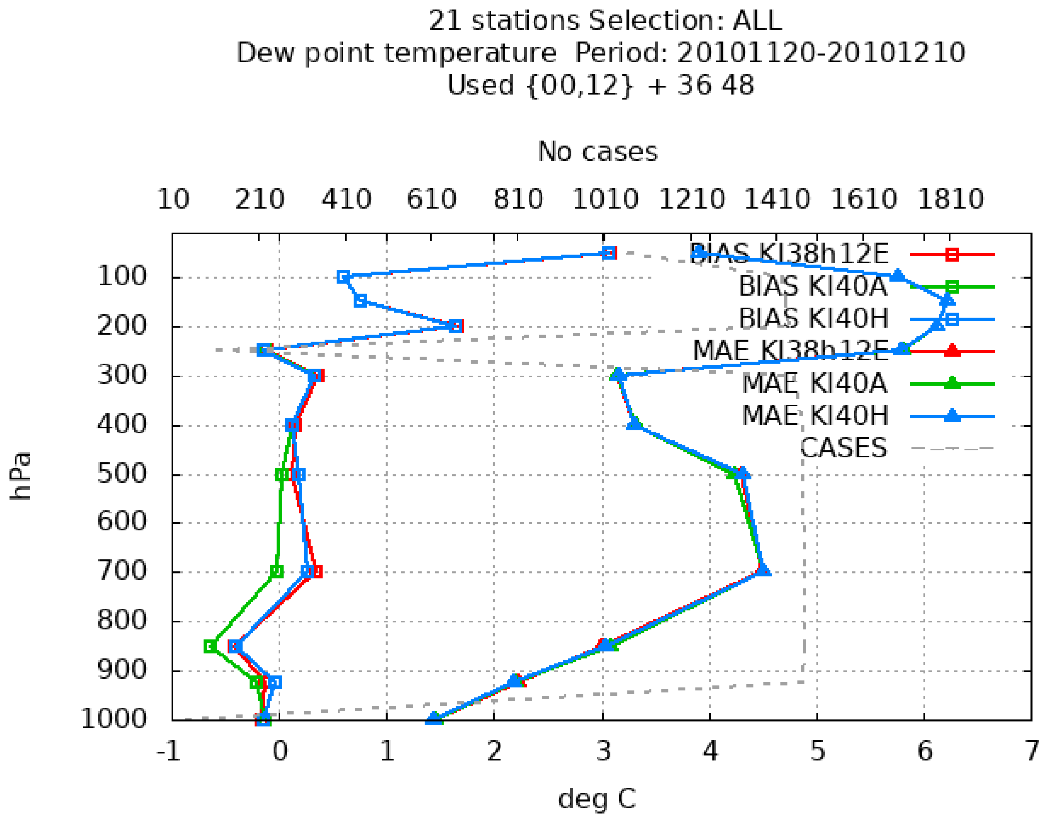


Figure 2: Mean error (bias) and mean absolute error of dew point temperature for different pressure levels. Red lines refers to cycle 38, Green to uncorrected cycle 40 and blue to corrected cycle 40. The forecast domain is that of MeCoOp and covers north-western Europe. The forecast length are 36 and 48 hours . HARATU=F in all three experiments.

Cycle 40 has been found to considerable drier than cycle 38 in lower and middle troposphere in case of temperatures below freezing, also if all other know differences such as the use of the HARATU scheme are taken into account. The reason for this have been tracked down to a bug in the implementation of the OCND2- switch in cycle 40. An example of one of the tests are seen in figure 2.

The correction concerns the handling of model thickness and model height only. From Figure 2, it is obvious that the differences between cycle 40 and -38 becomes much less after the correction. Unfortunately, one had to set the HARATU-flag to false in those comparisons due to technical reasons.

Crashes in AROME-Arctic

AROME-Arctic is running operationally in fairly the same way as AROME-MetCoOp, but the model domain is far north compared to the MetCoOp domain and covers northernmost Scandinavia and a part of the Arctic Ocean including Svalbard.

A model crash happened almost a the same time at March 5 2016, regardless of the starting time of the model. The reason was a “sudden stratospheric warming” event. The combination of the low pressure at the highest model level and a fairly high air temperature made it possible to get an infinite saturation mixing ratio of humility. The reason is that the vapour pressure became higher than the air pressure. The solution is to avoid any calculation of saturation mixing ratio when vapour pressure is near or higher than the air pressure. Condensation is not possible anyway in those conditions so such calculations are meaningless.

The modifications needed have a very small impact of the model result and is of no practical importance.

Spurious very large precipitation amounts in a few grid-points in case of moist unstable air and weak wind

This has been an issue for the working group of cloud- and condensation in resent years, and the introduction of OCND2 has reduced this problem somewhat. In March 20 2016 over northern Swedish mountain range, an extreme event of spurious high precipitation occurred. It was mostly graupel since it was a small and extremely intense convection cell in the model. The precipitation amount reached 175 mm in 12 hours. This extreme amount was seen in just one or two grid points. After discussions during- and after the all-staff meeting in Lisbon 2016 it became clear that this may not necessarily due to the cloud- and condensation calculations. It may instead be related to the model dynamics. The recently developed modified semi-Lagrangian scheme called COMAD was tested for this case. With COMAD, the spurious precipitation completely disappeared. (see Malardel and Didier ,2015 for more details of this scheme)

Also longer experiments with COMAD show satisfactory result. The frequency bias of the highest precipitation amounts decrease and the fraction skill score of 24-hours precipitation increases a little.

Other effects are small.

Plans

There are other work for improving clouds- and condensation. One is to have different CCN- and IN concentration in the planetary boundary layer than above. Other work concerns having similar treatment of subgrid-scale fraction of liquid and ice in radiation as in cloud physics and also similar size distribution of ice crystals for sedimentation as for the rest of cloud micro-physics. Using similar CCN distribution in radiation as in micro-physics is another issue.

3 Summary

There are several cloud-and condensation updates that are ready (or ready in a near future) for implementation. There are also updates that affects cloud-and condensation in the model but are not really changes in the cloud-and condensation parametrizations. This is summarized in the following table :

Table : Current updates concerning clouds and precipitation

Update	**Description**
More realistic graupel content	Small graupels become snow in case of high ice supersaturation by the switch LGRSN
Better forecasts of supercooled rain	Increase the lower limit for the conversion of ice, liquid, and snow into graupel.
Reducing fog	Assume lower CCN concentration near ground. Improve surface scheme by using two patches (not ready yet). Use HARATU switch for turbulence.
Bug fix	Pure technical change in rain_ice.F90
Avoid crash in case of sudden stratospheric warming	Avoid calculation of saturation mixing ratio when vapour pressure is near or higher than the air pressure.
Avoid spurious large precipitation	Use COMAD option in semi-Lagrangian dynamics

4 Acknowledgements

The author wishes to thank Yann Seity at Meteo-France for the help with the namelist settings for the COMAD semi-Lagrangian dynamics. Also thanks to Lisa Bengtsson at the Swedish meteorological- and hydrological Institute for introducing the logical switch LGRSN and Sander Tijm at Royal Netherlands Meteorological Institute (KNMI) for fruitful discussions regrading many of the issues mentioned here.

5 References

Rutledge, S. A. and P. V. Hobbs 1984: The mesoscale and microscale structure and organisation of clouds and precipitation in midlatitude cyclones X11: A diagnostic modelling study of precipitation developments in narrow cold-frontal rainbands J.Atmos. Sci. 41, 2949-2972

Maradel, S. and R. Didier 2015 : An alternative cell-averaged departure point reconstruction for pointwise semi-Lagrangian transport schemes Q. J. R. Meteorl. Soc. 141 2114-2126

Thompson, G. , R. M. Rasmussen , and K. Manning, 2004: Explicit forecasts of winter precipitation using an improved bulk microphysics scheme. Part 1: Description and sensitivity analysis. Mon. Wea. Rev., 132 519-542

Toward Fullpos in OOPS

Ryad El Khatib

1 Introduction

The so-called « OOPSification » of the post-processing package FULLPOS aims to execute the 4DVAR assimilation inside a single binary file (Figure 1).

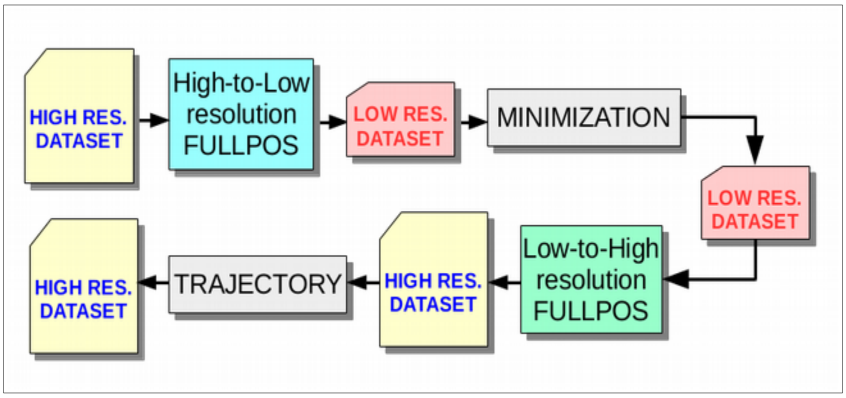


Figure 1 : 4D-Var single binary file (simplified !)

The proposed strategy is to progress via intermediate steps where the code refactoring enables inovations in the post-processing package to the benefit of flexibility and performance.

2 The configuration 903

The new configuration 903 of the software is developped to serve, among other purposes, as a testbed for Fullpos in OOPS. It is nothing but a configuration of Fullpos "off-line", meaning that it makes a straight call to Fullpos without going through the 4DVar control subroutines (CNT1-CNT2-CNT3) nor the model temporal loop (CNT4), as shown in figure 2.

The configuration 903 can be used as a post processing server, where an internal loop over input files is inserted, saving the cost of the configuration setup.
It should also be used for interoperability purposes, replacing the configuration 901 which is parallel but not distributed. In that context, the post-processing would be run as an IFS Fullpos call (reading a set of GRIB files), where eventually the output file would be written out in FA format.

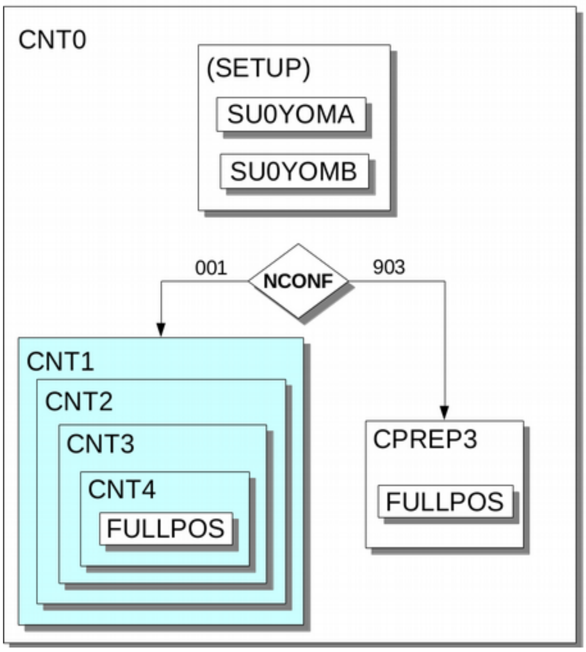


Figure 2 : The configuration 903

3 Progressive externalization of Fullpos

Refactoring of the code for object orientation will progress together with a progressing externalization of the post-processing package. The major steps will be a move of the setup of the post-processing out of the general setup (SU0YOMA and SU0YOMB) ; and the reading and writing of data files out of the post-processing computational core. (figure 3).

A major difficulty for OOPS is that the output data layout should fit the model state layout.

With the possibility to use more than one unique setup for output post-processing datasets, one can imagine running two kinds of post-processing in the in forecasting model : a first one for low frequency outputs on various output grids ; and a second one for hight frequency outputs on the model grid.

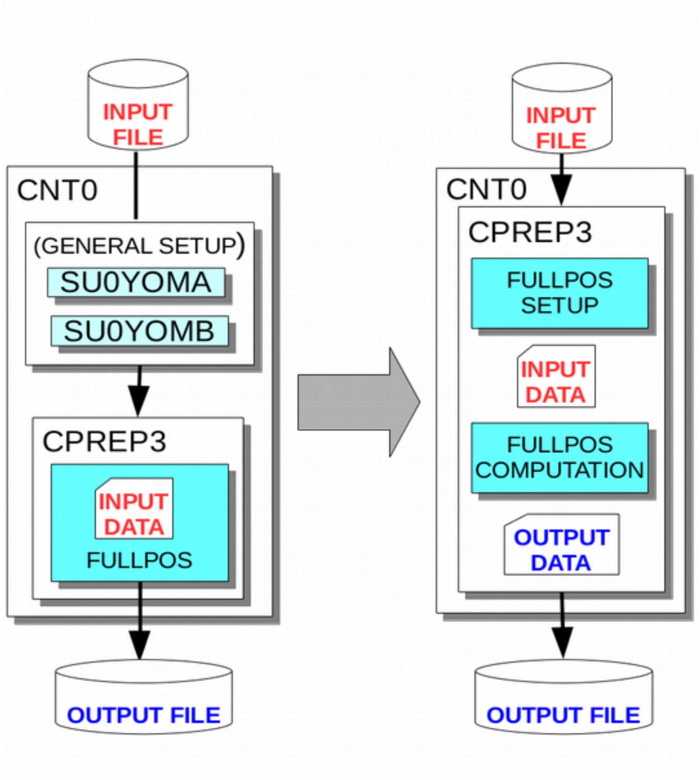


Figure 3 : progressive externalization of Fullpos

4 Second generation post-processing servers

The forecasting model is already using a software server for its I/Os.

We can image in the future that the configuration 903 itself could be turned into a general post-processing server. But unlike the 4DVar in a single binary file, this post-processing server may need less computing resources than its host program ; therefore its input data would need to be reshuffled from the model MPI distribution to the post-processing MPI distribution (figure 4).

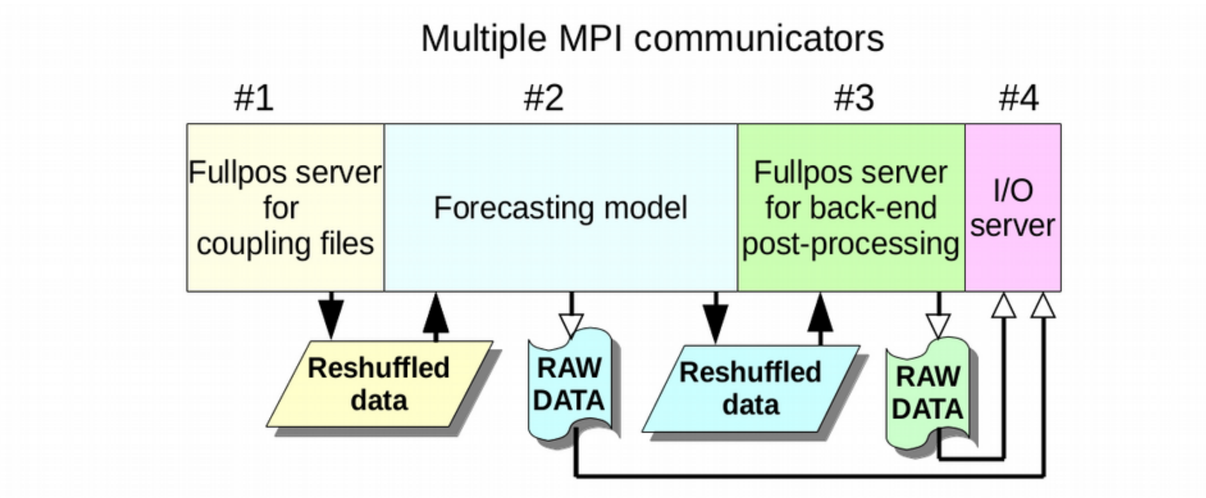


Figure 4 : Second generation post-processing servers

Release of EPyGrAM v1.0

Alexandre Mary

The EPyGrAM library is a toolbox designed to handle meteorological fields from model outputs in various formats (FA, GRIB...) in Python. It is also provided with a set of command-line applicative tools enabling fast insight into model output files.
For more details, please refer to the Lisbon 2016 ALADIN/HIRLAM Wk/ASM presentation : EPyGrAM (on ALADIN website); or the EPyGrAM v1.0 documentation (on GMAPDOC).

The library is open-source, distributed under CeCILL-C licence. Its development is managed on the Redmine platform : https://opensource.cnrm-game-meteo.fr/projects/epygram and the source code management is done under a GIT repository therein. Partners are encouraged to propose improvements through these Redmine/GIT.

Installation and assistance within partners of ALADIN/HIRLAM are supposed to rely on a number of contact points, still to be confirmed.

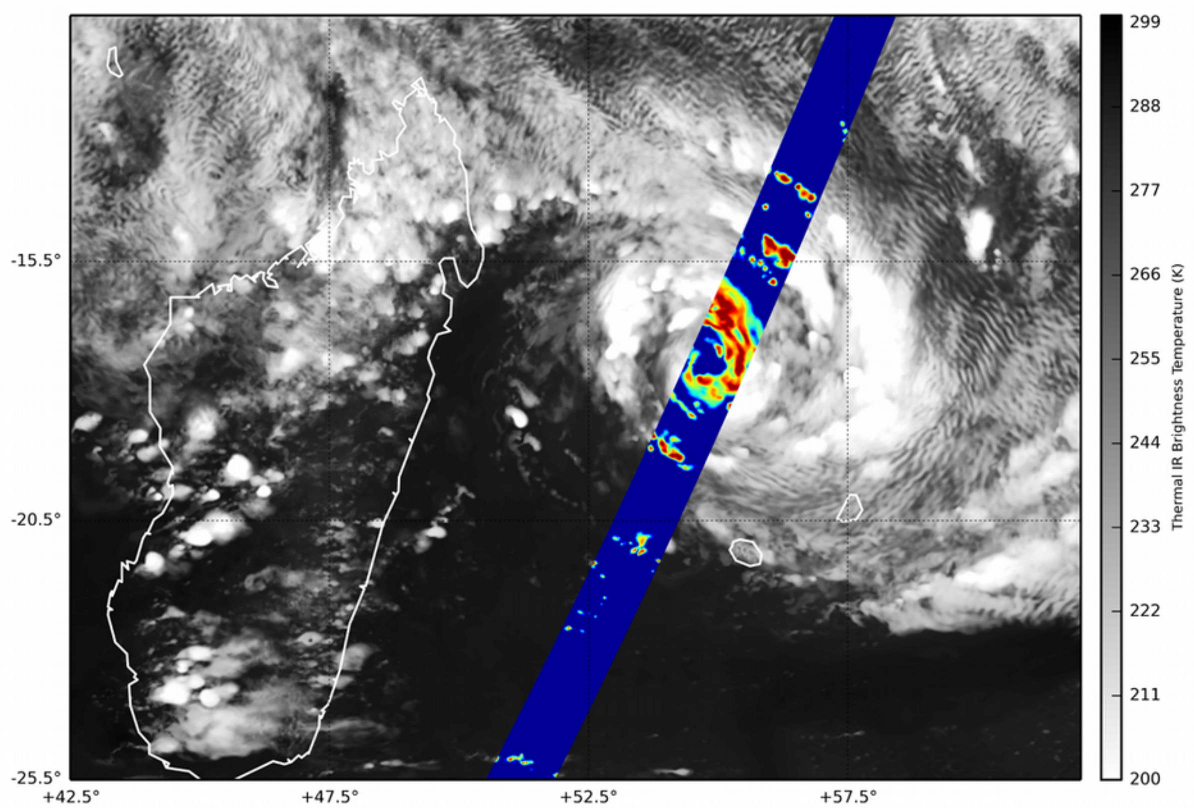


Figure 1: Example of plot realized using **epygram** *(plus some more post-processing): AROME simulated brightness temperatures superposed with AROME simulated GPM Core reflectivities. Image courtesy of P. Chambon.*

NWP at Meteorological and Hydrological Service of Croatia - 2016

Martina Tudor, Stjepan Ivatek-Šahdan, Antonio Stanešić, Alica Bajić, Kristian Horvath, Iris Odak Plenković, Mario Hrastinski

1 Introduction

The operational model version used is AL38T1 with ALARO0 physics for 8, 4 and 2 km resolution forecasts. Operational forecasts run for:
- 8 km res, 360 sec, 4 times per day, 3D var and surface OI, 6 h cycling, to 72 hours, LBCs: IFS, 37 levs.
- 4 km res, 180 sec, hydrostatic and nonhydrostatic in parallel, both only from 00 UTC up to 72 hours, surface OI, 6h cycling, LBCs: IFS, 73 levs, (still!) to do: 3D var.
- 2 km dynamical adaptation, 60 sec timestep, hourly, up to 72 hours,
- 2 km non-hydrostatic run, 60 sec timestep, using AL36T1 with available ALARO0 developments, from 06 UTC up to 24 hours.

2 Overview of acivities

20 years of ALADIN project in Croatia

In 2015 we also celebrated 15 years of running operational forecast using ALADIN model.
These anniversary is celebrated by a special issue of Croatian Meteorological Journal (Vol. 50, also a nice round number) featuring introductory notes from Piet Termonia and Yong Wang as well as a number of articles describing several features from the past, the current status of the operational suite and recent developments. The articles are available online at http://hrcak.srce.hr/hmc.

Figure 1. The old (left) and new (right) interface to graphic outputs and tables.

New interface to the model products

The web interfaces on the internet (password protected) and intranet as well as the scripts that generate plots and tables there have been severely modified in order to produce plots of higher quality for the operational visualization products and simplify future changes (maintained by local Aladin staff, lot of work, no science).

More verification scores

There are VERAL and HARMONIE verification packages available, however there are also local tools developed that enable operational (automatic) model validation.

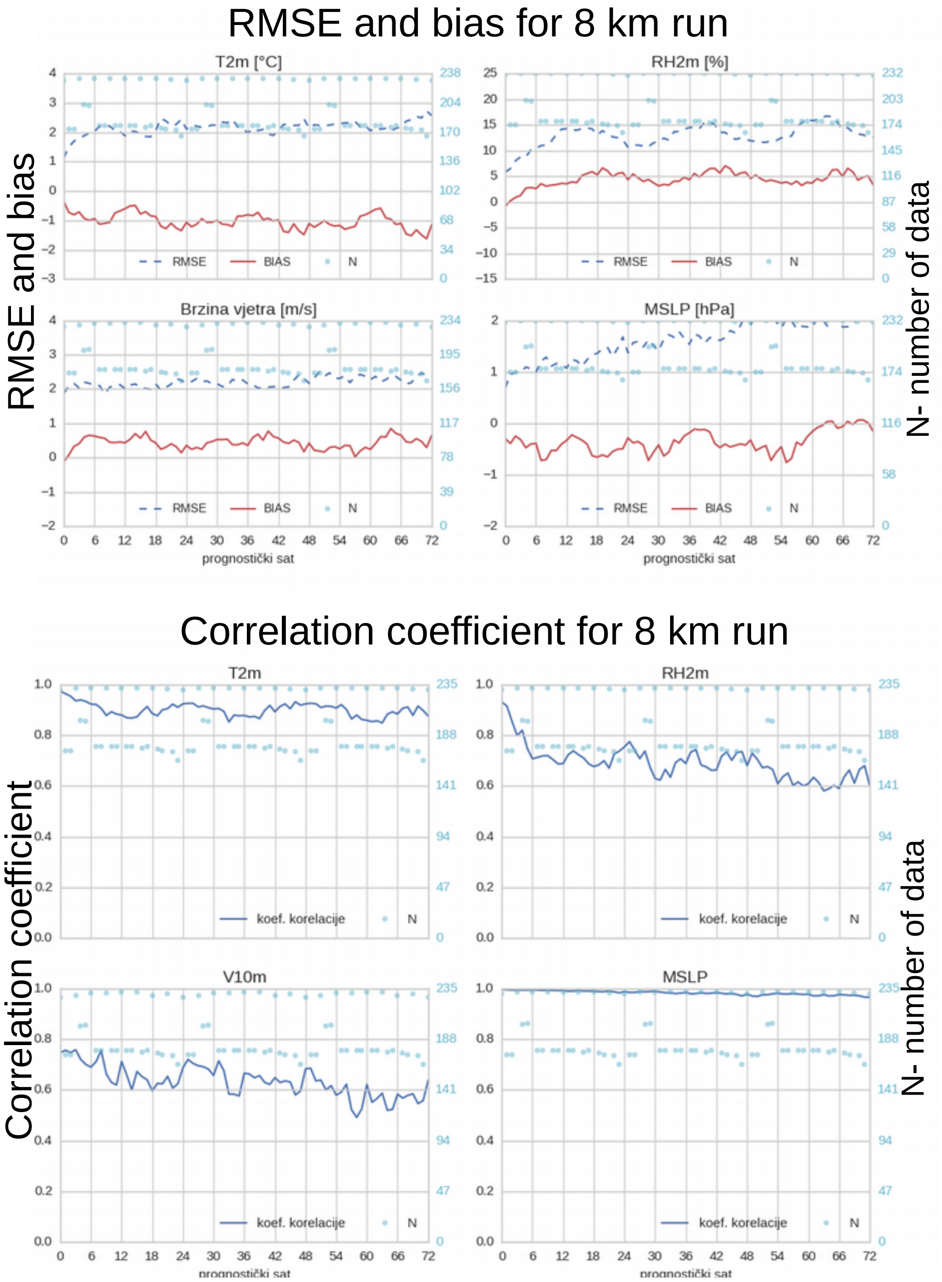


Figure 2. RMSE and bias (top and correlation coefficient (bottom row) for 8 km operational forecasts in Feb 2016 (the above plots are for only 7 Croatian stations).

When is the non-hydrostatic (NH) forecast better?

Severe events of bura wind can be missed by hydrostatic run but correctly predicted by non-hydrostatic forecast. These events are relatively short and/or localized (several hours up to one day long and affecting an area covered by several stations). This has been noticed first for the 2 km resolution NH forecast when compared to the 2km resolution dynamical adaptation (see report in the previous newsletter as well as Tudor and Ivatek-Šahdan, 2010). In 2016, there were hydrostatic and NH runs in 4 km resolution running in parallel and several such cases have been identified. The 2km resolution run is sitll superiour to both 4km runs due to better resolution of the coastal mountains that control the spatial variability of the wind field.

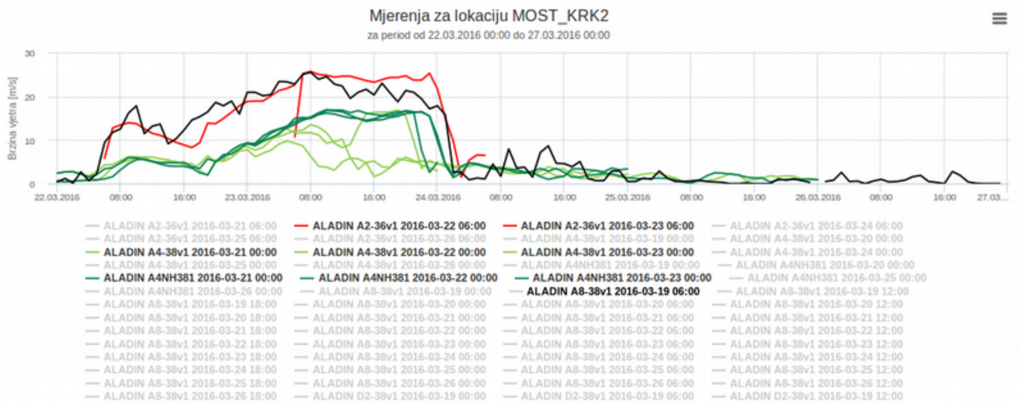


Figure 3. 10 m wind speed at Krk bridge: measured (black) and forecasts from 4 km hydrostatic runs (light green), 4km NH run (dark green) and 2km NH run (red).

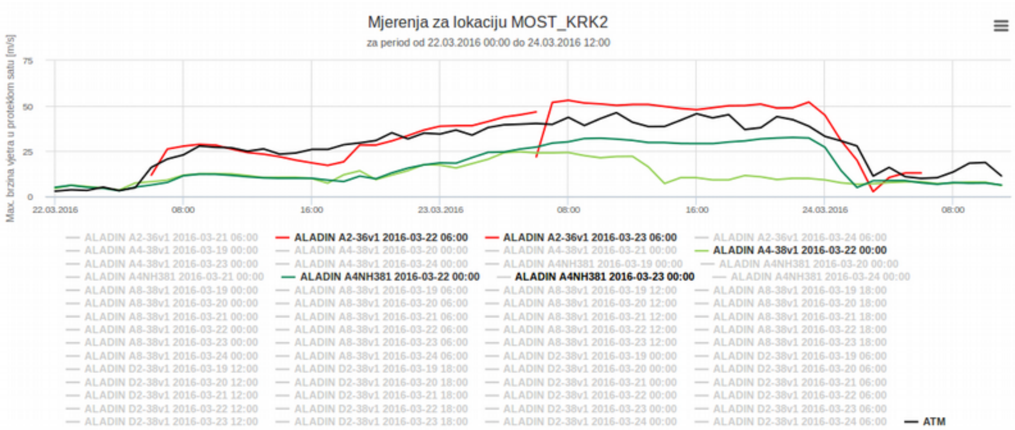


Figure 4. 10 m wind speed at Krk bridge: measured (black) and forecasts from 4 km hydrostatic runs (light green), 4km NH run (dark green) and 2km NH run (red).

Sea surface temperature (SST) in the coupling files from ARPEGE and IFS

SST is taken from initial file and remains constant during the model forecast. There are two sets of SST fields provided in the coupling files, from operational forecasts of IFS and ARPEGE. We compared the SST from the coupling files with the values measured on stations and found significant differences, up to 10K. There are large discrepancies in model SST (from IFS LBCs) and SST from OSTIA in certain regions, suggesting IFS SST is not entirely from OSTIA but modified, at least for the Mediterranean and Adriatic Seas.

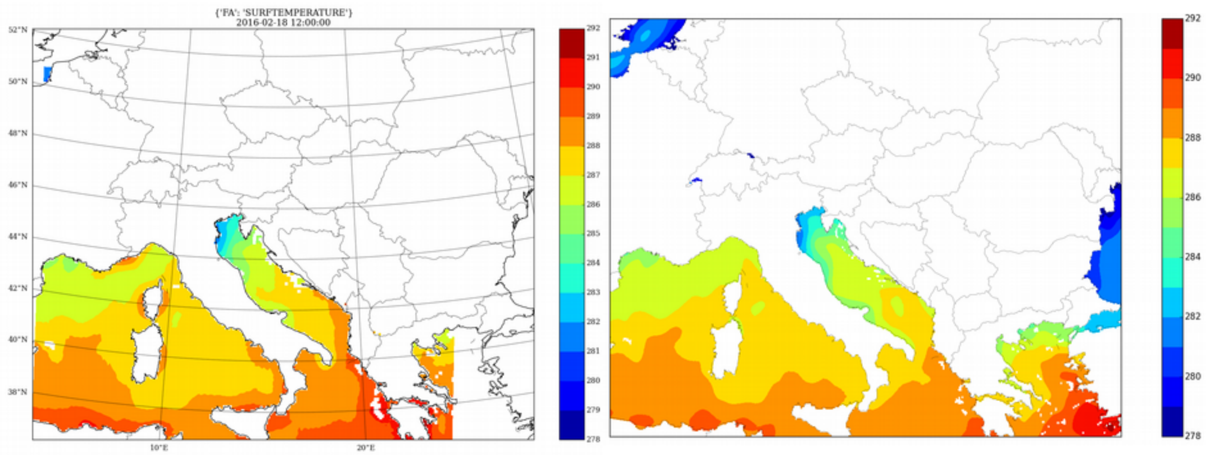


Figure 5. SST in ALADIN 8km resolution taken from IFS coupling file (left) and SST OSTIA analysis 6 km resolution (right) 2016 Feb 18 12 UTC.

3 References

Longer report on SST in coupling files: http://radar.dhz.hr/~tudor/sst/sst_coupl_files2.pdf

Tudor, M. and Ivatek-Šahdan, S. (2010): The case study of bura of 1 and 3 February 2007, Meteorol. Z., 19, 453-466.

A Mesoscale Regional Reanalysis for Ireland

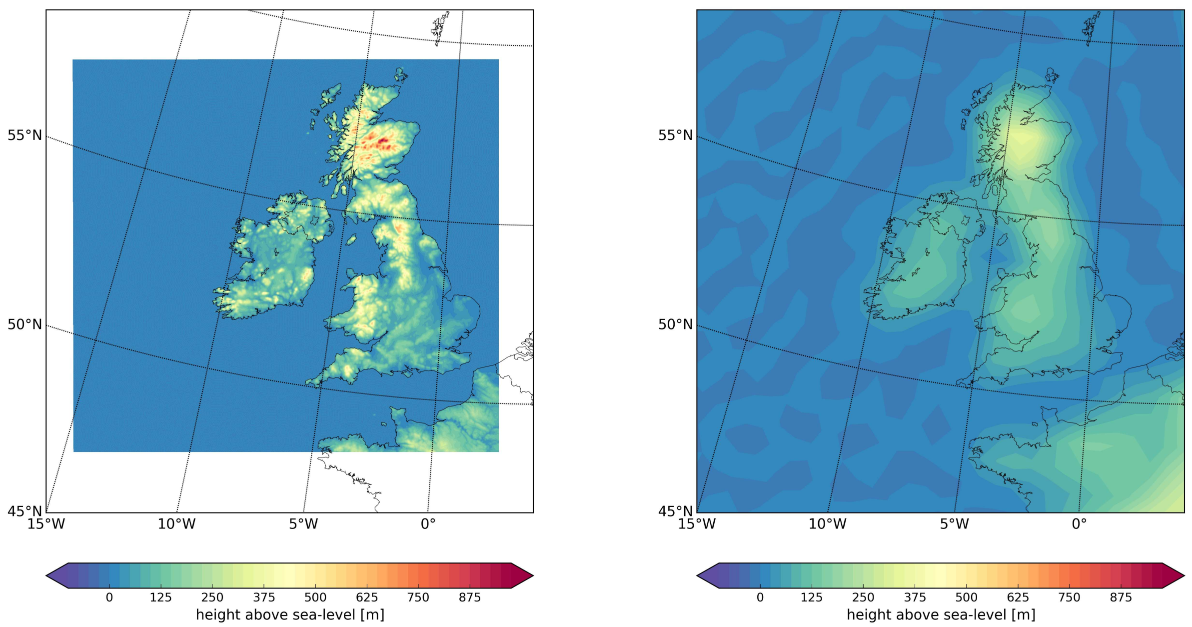
Eoin Whelan, Emily Gleeson

1 Introduction

Climate reanalyses are an important source of information for monitoring climate as well as for the validation and calibration of numerical weather prediction models.

MÉRA (Met Éireann ReAnalysis) is a 35-year reanalysis project being undertaken by Met Éireann staff. The HARMONIE-AROME canonical configuration of the HIRLAM-ALADIN system is being used to produce a high resolution gridded dataset of atmospheric, near surface and surface parameters for the period 1981 to 2015. The data assimilation component of HARMONIE-AROME is described in Brousseau et al. (2011) and the forecast component is described in Seity et al. (2011) with updates included in Bengtsson et al. (2016). HARMONIE-AROME uses the SURFEX externalised surface scheme (Masson et al., 2013) for surface data assimilation and the modelling of surface processes. The harmonie-38h1.2 tagged version of HARMONIE-AROME is being used to carry out the atmospheric simulations. The MÉRA dataset will extend the knowledge gained from observations as the model grid is much finer than observational coverage over Ireland and will include many parameters that are not routinely observed. It will be completed in spring 2017 with data being made available soon after.

This article provides an overview of the HARMONIE-AROME implementation used for the MÉRA project as well as a preliminary analysis of the final ten years of data.



(a) MÉRA (2.5 km grid spacing)

(b) ERA-Interim (79 km grid spacing)

Figure 1: MÉRA and ERA-Interim orographies

2 MÉRA Overview

This section summarises the HARMONIE-AROME configuration used for MÉRA and the production implementation. The use of ERA-Interim (Dee et al., 2011) data to provide lateral boundary conditions is discussed and details of an adjustment made to the surface drag coefficient are outlined. Finally, a brief summary of the MÉRA outputs is also provided.

2.1 Model configuration

HARMONIE-AROME is configured to run on a horizontal grid of 2.5 km, using 65 vertical levels and a model top of 10 hPa. The model domain is centred over the Island of Ireland and covers Ireland, the United Kingdom and an area of northern France, see Figure 1(a). The extra topographical information gained by using the 2.5 km grid is clear to see when compared with the ERA-Interim grid, Figure 1(b). The domain being used is the same as is used operationally by Met Éireann since 2011. Only conventional observations are assimilated in MÉRA. These observations are the same as those used by the ERA-Interim reanalysis project with Irish SYNOP observations replaced by locally stored observations. The local SYNOP observations are used to fill gaps in the ERA-Interim SYNOP observation archive and to add observations that were not made available outside of Met Éireann. A three-hour forecast cycle with surface and upper-air data assimilation is used. Three-hour forecasts are produced for each cycle except the midnight (00 Z) cycle which produces a 33-hour forecast. A summary of the model details is presented in Table 1.

Model version	HARMONIE-AROME 38h1.2
Domain	540 x 50 grid points (Δx =2.5 km)
Vertical levels	65 levels up to 10 hPa, first level at 12 m
Forecast cycle	3 hours
Data assimilation	Optimal interpolation for surface parameters 3DVAR assimilation for upper air parameters
Observations	Pressure from SYNOP, SHIP and DRIBU Temperature and winds from AIREP and AMDAR Winds from PILOT Temperature,winds and humidity from TEMP
Forecast	3 hour forecasts, but a 33-hour forecast at 00 Z

Table 1: HARMONIE-AROME configuration used for MÉRA

2.2 Lateral boundary conditions

ERA-Interim reanalysis data are used for the HARMONIE-AROME lateral boundary conditions (LBC). The ERA-Interim IFS configuration uses a T255 spherical-harmonic representation for dynamical fields, a reduced Gaussian grid with a horizontal grid spacing of approximately 79 km for surface fields and 60 vertical levels with a model top at 0.1 hPa.

Information from the ERA-Interim LBCs are read by the HARMONIE-AROME forecast model every three hours using one-way nesting. The downscaling ratio, the ratio of the driving model grid spacing to the limited area model (LAM) grid spacing, is approximately 32:1. The resolution of the LBC grid spacing and the LAM grid spacing should be as close as possible (Warner et al., 1997). Idealised studies have described the problem of reflections at outflow boundaries when there is a mismatch in grid spacings, e.g. (Harris and Durran, 2010). Davies (2013) showed that errors are small and confined to the boundaries for downscaling ratios of up to 4:1. However, downscaling of global climate simulations have successfully used a downscaling factor of 17 (Hollweg et al., 2008). Recent projects to produce an extreme wind climatology for The Netherlands

(Burgers et al., 2013) and a wind/wave climatology for Ireland (Gallagher et al., 2016) using ERA-Interim and HARMONIE-AROME have shown that the approach taken in this study, i.e. nesting HARMONIE-AROME directly with ERA-Interim LBCs, is effective.

2.3 Model changes

No significant changes were applied to the default HARMONIE-AROME data assimilation or forecast configurations used by the MÉRA project. However, some tuning of the surface drag coefficient, C_D, used by SURFEX was carried out following correspondence with Xiaohua Yang (Yang, 2014). Based on verification results from month long sensitivity tests, C_D was changed from a value of 0.01 to 0.025. C_D is set using the variable XCDRAG in the NAM_ISBAn namelist.

2.4 Practical details

Seven separate simulations were set up to run for five years at a time, with a one year spin-up period for each simulation. Each simulation is running on ECMWF's Cray XC30 system, cca. The output data are, temporarily, stored in ECMWF's data handling system, ECFS. The MÉRA project will produce approximately 150 TB of forecast and observation feedback data. The forecast data are being stored as GRIB files and the observation feedback as ODB2 files.

Three-hourly analysis output will be made available. Forecast model output will be made available for each forecast hour up to 33 hours for the 00 Z forecast and to three hours otherwise. A small subset of the surface model (SURFEX) output will be made available at analysis times and for each three hour forecast. Upper-air data will be made available on pressure levels as well as a selection of near surface levels. Analysis and forecast output data are summarised in Table 2.

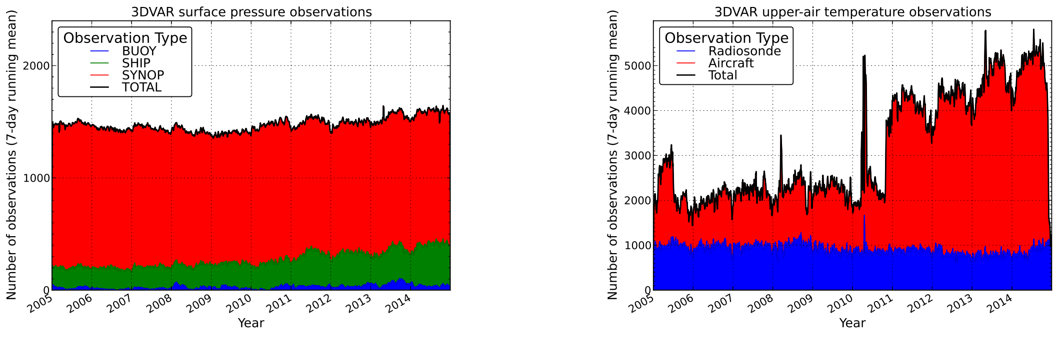
Level type	**Parameters**	**Levels**
Pressure	Temperature, wind, cloud, relative humidity, geopotential	100, 200, 300, 400, 500, 600, 700, 800, 850, 900, 925, 950, 1000 hPa
Height above ground	Temperature, wind, relative humidity	30, 50, 60, 70, 80, 90, 100, 125 150, 200, 300, 400 m
Sub-surface	Temperature, moisture, ice	0, 20, 300 cm (below the surface)
Surface	Radiative and non-radiative fluxes	Surface
Top of atmosphere	Radiative and non-radiative fluxes	Nominal top of atmosphere
Surface	Precipitation diagnostics	Surface
Diagnostic	Screen level parameters	-
Diagnostic	Other model diagnostic parameters	-

Table 2: Summary of output available on pressure, height and sub-surface levels

3 Data assimilation validation

Conventional observations are assimilated using the HARMONIE-AROME three dimensional variational (3DVAR) data assimilation system. Three-hour cycling with a 3DVAR minimisation followed by blending is utilised by MÉRA. Figures 2(a) and 2(b) show data counts of the number of surface pressure observations and upper-air temperature observations used by 3DVAR for the years 2005 up to the end of 2014. During this period there is a notable increase in the number of aircraft observations available.

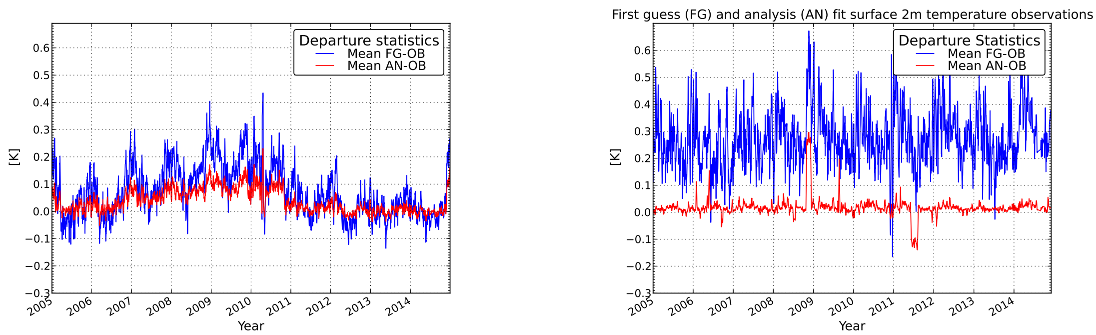
The difference between observation values (OB) and the equivalent first-guess (short-range forecast) values (FG) used by 3DVAR (i.e. the first-guess departures) are used to monitor and assess the quality of the MÉRA



(a) (b)

Figure 2: Time-series of the number of (a) surface pressure and (b) upper-air temperature observations used by the 3DVAR data assimilation in HARMONIE-AROME. A seven day running average is used.

data assimilation. The 3DVAR minimization process should produce an analysis (AN) which is closer to the observations than the model background. The departures for aircraft observations are shown in Figure 3(a) for the same period as the data count plots in Figure 2. The departures for 2 m temperature observations assimilated by the surface data assimilation are shown in Figure 3(b). An improvement in the average upper-air temperature departures is noticeable from 2011 onwards due to the significant increase in the number of aircraft observations available for assimilation.



(a) Upper-air FG-OB and AN-OB time-series (b) Surface FG-OB and AN-OB time-series

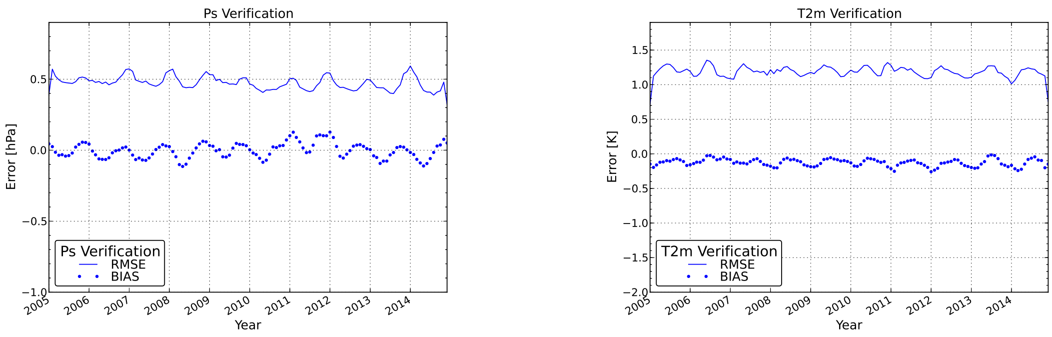
Figure 3: Time-series of FG-OB and AN-OB statistics for (a) aircraft temperature observations and (b) 2 m temperature observations assimilated (2005-2014). Mean first-guess departures are shown in blue and mean analysis departures are shown in red. A seven day running average is used.

4 Forecast validation

4.1 Verification using SYNOP observations

MÉRA 3-hour forecasts were compared with SYNOP observations using the *monitor* software available in the HIRLAM-ALADIN system. All of the SYNOP observations available in the MÉRA domain were used to validate 3-hour HARMONIE-AROME forecasts. Figure 4 shows verification results for the years 2005-2014.

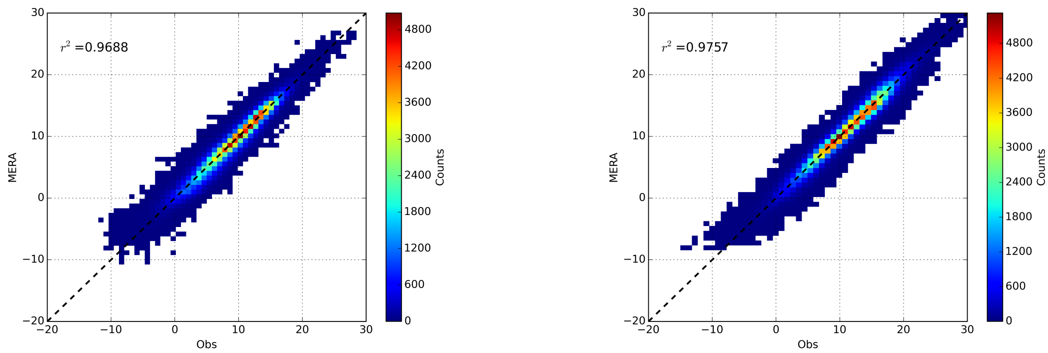
The results for surface pressure and 2 m temperature indicate consistent model performance for the time period.



(a) (b)

Figure 4: Time-series (2005-2014) of monthly verification scores for (a) HARMONIE-AROME 3-hour forecasts of surface pressure compared with SYNOP observations and (b) HARMONIE-AROME 3-hour forecasts of 2 m temperature compared with SYNOP observations. The average error, or bias, is plotted using dots and the root mean square error (RMSE) is plotted using a solid line. A 3-month running average is applied to the data.

Scatter plots of day and night time one, two and three-hour forecasts for the years 2005-2014 for a selection of Irish SYNOP stations (Dublin Airport, Casement Aerodrome, Cork Airport, Shannon Airport and Valentia Observatory) also indicate good agreement between observed and modelled 2 m temperatures. The five Irish SYNOP stations were selected as they provided a continuous, consistent observations dataset to compare with for the period.



(a) (b)

Figure 5: Scatter plots of forecasts compared with observations for (a) night time hours (19 Z - 06 Z) and (b) day time hours (07 Z - 18 Z). Observations of 2 m temperature from five Irish synoptic stations (Dublin Airport, Casement Aerodrome, Cork Airport, Shannon Airport and Valentia Observatory) were compared with MÉRA forecasts. The observations from these stations were selected as they all provided a near-continuous observation dataset for the validation period.

4.2 Verification using gridded temperature observations

Average values of daily minimum 2 m temperatures produced by MÉRA have also been compared with gridded observation datasets produced by Met Éireann. A brief description of climate averages for Ireland is available in

Walsh (2012). The average minimum 2 m temperatures compare well with the gridded observations. The most significant differences seen over higher elevations can be explained by the differences in the two topographies used. A complete validation of MÉRA will make use of gridded maximum 2 m temperature observations and gridded observations of rainfall accumulations as well as comparisons with climatological means.

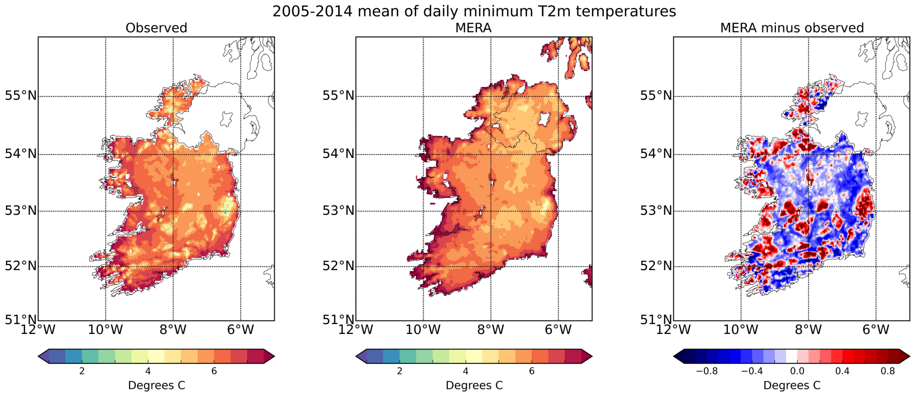


Figure 6: Average daily minimum temperature at 2 m produced by MÉRA (2005-2014) compared with gridded observations

5 Discussion and outlook

In this article we have described how HARMONIE-AROME has been used to produce a climate reanalyses dataset for Ireland. We have carried out a preliminary evaluation of the 2005-2014 data produced by MÉRA and have shown that the HARMONIE-AROME data assimilation system and forecast model perform well and consistently when compared with point observations. A more thorough validation of the entire dataset is underway. It is hoped that this work will quantify any model biases in the dataset.

This dataset will have uses in climatological research and applications including food and agriculture, renewable energy, ecology, economics, hydrology and planning. We plan to make it available to external users following a thorough validation.

We hope to be able build on the experience gained by developing the MÉRA project and analysing its output. A future regional reanalysis for Ireland would gain from using the latest version of HARMONIE-AROME, a larger domain, the assimilation of more observations and the generation of an ensemble of reanalyses.

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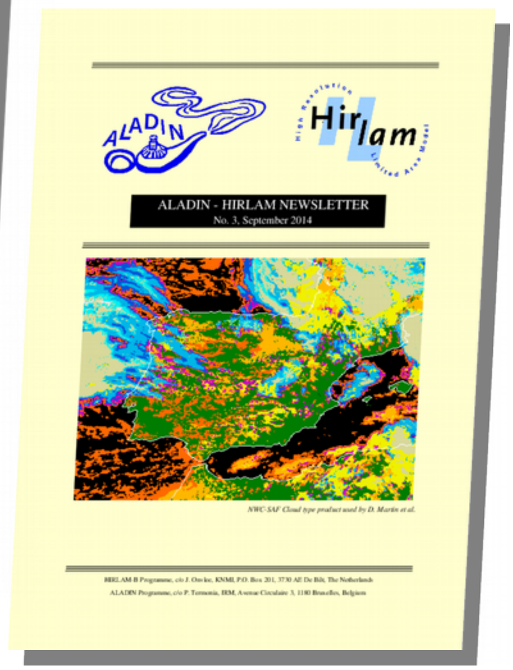

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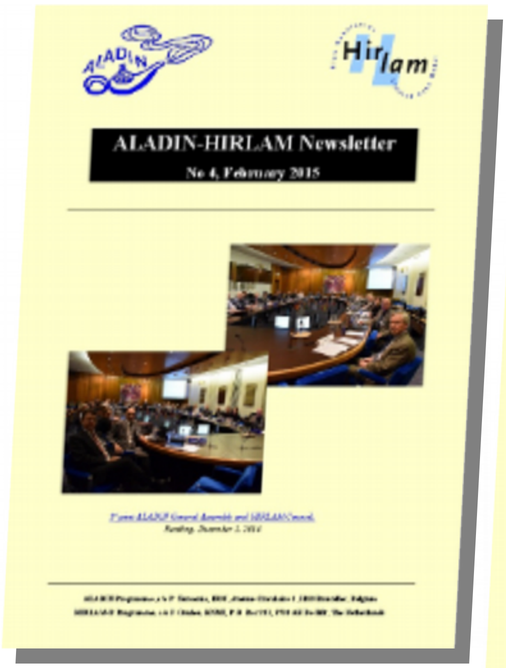

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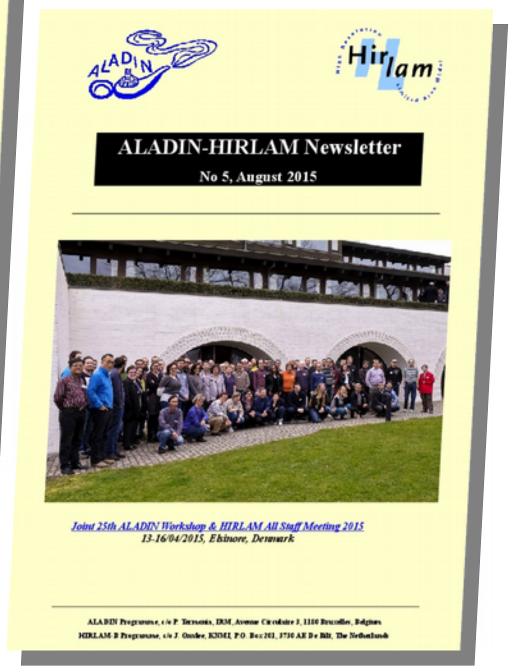

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