Overview of HIRLAM surface activities

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SMHI

with contributions as acknowledged

but special thanks to HIRLAM system colleagues who are always involved!

Summary of Tuesday side meeting on Surface processes and data assimilation

- We took the opportunity to discuss in more details the surface related presentations already given in plenum.
- A **SODA_V8 branch** exists in the SURFEX Git repository with the main purpose to share development and test setups for EKF and EnKF applications. See this wiki for more info: https://hirlam.org/trac/wiki/HirlamMeetings/Surface201610/SODA_development
- Balazs Szintai presented a development plan: **Use satellite LAI product in combination with SURFEX offline simulations with A-gs** (prognostic LAI) to estimate LAI fields which are then used as input for the operational model LAI.
- **Concern about vegetation roughness in SURFEX**: z0_veg = 0.13 * h_veg. No dependence yet on displacement height. Efforts will be made to reformulate this.
- **Moving towards EKF**: (i) Efforts are needed to understand under which circumstances we see strange behaviour of Jacobians. (ii) When this is known we should e.g. turn off soil moisture assimilation during rain events. (iii) We should account for realistic limits of control variables before we solve for the Kalman Gain. Not correct the increments afterwards as we do now.

See this wiki for details:
https://hirlam.org/trac/wiki/Meetings/Surface/Surface_side_meeting_Toulouse_201804

Surface related presentations at the Workshop from HIRLAM institutes

Oral

- **Trygve Aspelien** (MetNorway): On the use of amateur weather observations in an operational nowcasting and NWP framework (testing gridpp as a parallel solution to CANARI for spatialisation of observations for surface data assimilation)
- **Sander Tijm** (KNMI): HARMONIE-AROME forecast model developments (LAI and soil moisture assimilation problems)
- **Kristian Pagh Nielsen** (DMI): Testing the snow albedo sensitivity in HARMONIE-AROME
- **Ekaterina Kurzeneva** (FMI): Performance of FLake in HARMONIE
- **Laura Rontu** (FMI): Status of subgrid-scale orography parametrizations ororad and orotur in HARMONIE-AROME

Posters:

- **Ulf Andrae** (SMHI): MetCoOp activities (test of new clay/sand data base)
- **Teresa Valkonen** (MetNorway) : Physiographic data sets in AROME-Arctic

Examples in this presentation

- Moving towards more advanced surface physics in cy43/SURFEXv8.1
- Impact on Rh2m and U10m when moving from 1 (all vegetation types averaged) to 2 (separation of forest and open land) patches (includes turning off Surface-layer scheme).
- Moving towards EKF and satellite observations for surface data assimilation.
- Wave coupling in cy43 (HARMONIE-AROME, SURFEX – OASIS – WW3).

Examples of activities not mention much today:

- Simple ICE (SICE) model by Yurii Batrak (MetNorway): On its way into SURFEXv9. Prognostic ice thickness is now running in pre-operational mode.
- Parameter sensitivity studies: Currently, given a new release of a HARMONIE-AROME cycle there are still a number of parameters in SURFEX which, if they are tuned, may give yet a bit better performance of a certain setup (domain). John de Vries (KNMI) is working on this.
- Glacier development: Bolli Palmason et al. are looking into how the Explicit snow scheme (12 layers) in SURFEXv8 can be used as glacier model.
- Looking into LAI from ECOCLIMAP 2nd generation as an alternative in cy40h.

General surface comments

cy40h1.1 is our latest official **meteorological** release of the ALADIN-HIRLAM NWP system with the HARMONIE-AROME model configuration.
cy40h1.1.1 is our latest official **technical** release.
cyxxh represents our future ambitions.

	c**y40h1.1**	**cy40h1.1.1**	**cy43h? and beyond**
Land			
Patches	1	**1 or 2 (no SBL model)**	3 patches with expl. canopy
Soil	Force-restore	Force-restore	Diffusion (14 layers)
Snow	D95	D95	Explicit snow (12 layers)
Glacier	“Pile of snow”	“Pile of snow”	Explicit snow as glacier
Assimilation	CANARI-OI	CANARI-OI	MESCAN/gridpp-EKF/EnKF
Sea	SICE	SICE	SICE
Lake	Deep soil temp	**FLake (optional)**	FLake (later with EKF)
Town	TEB	TEB	TEB (more options)
Physiog.	ECOCLIMAP	**ECOCLIMAP (modified)**	Utilize high res. data

Now we head for cy43h including SURFEXv8

Great! As illustrated by Patrick Le Moigne SURFEXv8 opens up the possibility to utilize more physically based processes for vegetation, snow, soil, hydrology.

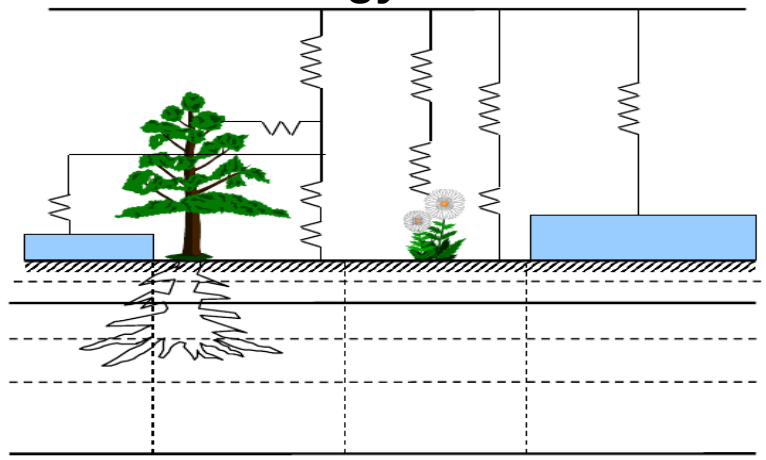
Why is that great?

Currently, we believe/know that some of the near-surface related forecasting problems are caused by too simplified surface processes, e.g. too short soil-energy memory, only one surface-energy balance for everything (snow, vegetation, upper soil).

HIRLAM – cy40 SURFEXv7.3 – cy43 SURFEXv8

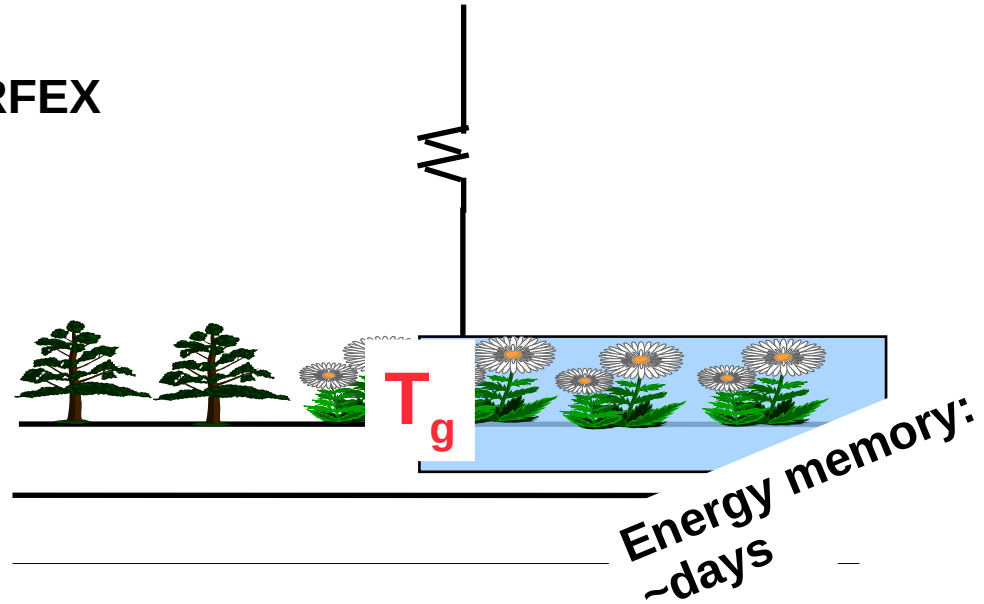
HIRLAM

Multi level/energy with OI

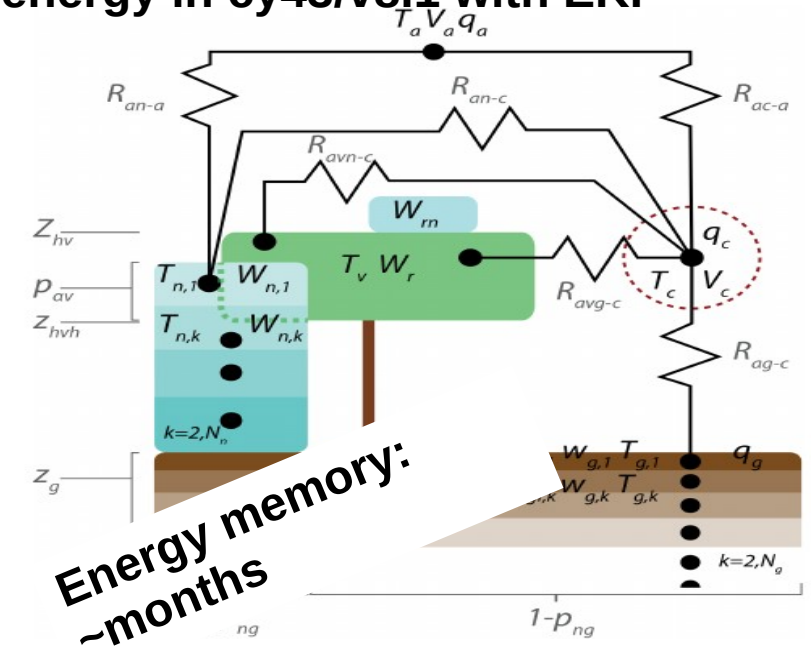


SURFEX

Force-restore in cy40/v7.3 with OI



Multi level/energy in cy43/v8.1 with EKF



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With a longer soil memory we can run the system in climate mode (down-scaling, say ~3 years without data assimilation, utilizing spectral nudging) to identify systematic biases and hopefully reduce them before we activate data assimilation.

Problem?
Hmhm, the soil memory with respect to both water/ice and energy is O(years). Thus, a well balanced initial state is needed to avoid long spin-up period, although soil-data assimilation will partly compensate for this. Lakes, modelled by lake model FLake, introduce a similar need of spin-up. We have no data assimilation for lakes yet but, at least, lakes represent a smaller area.

Climate version of cy43t2 for NWP – current status

In HIRLAM we currently work with three branches of cy43t2:

- **A NWP branch where we focus on getting data assimilation working.**
- **A climate version where SURFEXv8.0 (2 years old) is used (default in cy43t2). Used for firsts tests of our SURFEXv8 options wish list. Samuel Viana (AEMET) and Emily Gleeson (Met Eiren) are working on this.**
  This setup crashes after a month or so. Seem to be related to snow and/or soil water….
- **A climate version where SURFEXv8.0 is replaced by SURFEXv8.1. Here the SURFEX code is kept under version control in the SURFEX Git repository to keep us close to latest development by the SURFEX team. Patrick with help from Yann Seity and Stéphanie Faroux is working on this.**
  This setup crashes immediately. Seem to be related to initialisation (PREP) from ECMWF grib files...

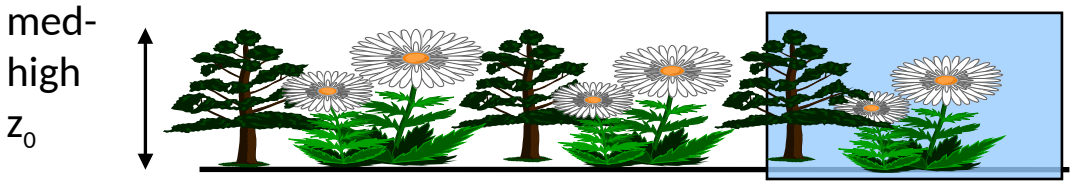
People involved: Samuel Viana (AEMET), Emily Gleeson (Met Éireann), Patrick Samuelsson (SMHI)
But not least,we lean upon Météo-France colleagues and HIRLAM system colleagues.

Problem with too cold/moist spring conditions in cy40h1.1

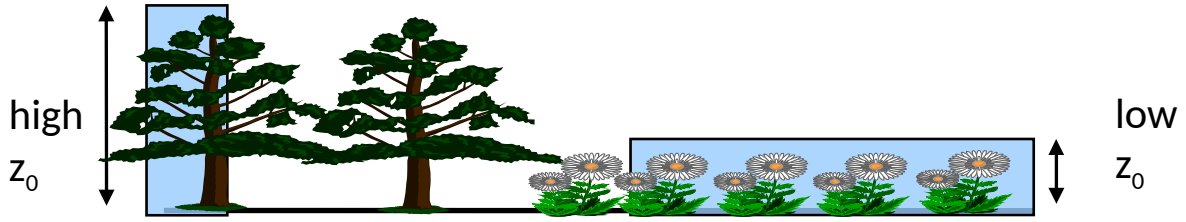
In Helsinki last year I stated:

One hypothesis is that using 2 patches in SURFEX instead of 1 can help this problem .

1 patch



2 patches



Note: The atmospheric surface-boundary layer (SBL) (also known as the Canopy model) needs to be switched off when 2 patches are used.

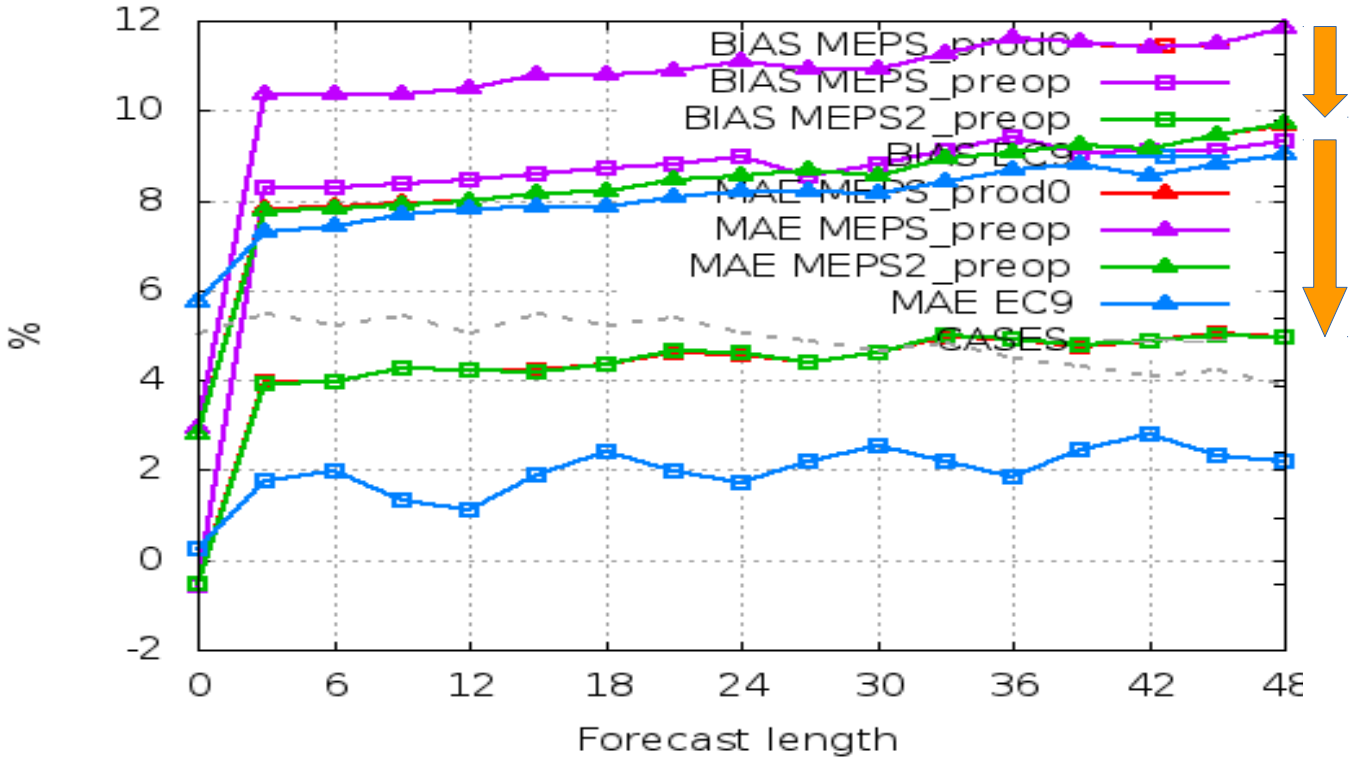
Using 2 patches show beneficial results over MetCoOp, Iberia and KNMI domains.

Okay, so how does it look? We take a look at behaviour over the MetCoOp domain where 2 patches are now running operational (also include SBL off and lake model FLake). This NWP setup is now availbale in cy40h1.1.1...

People involved: Patrick Samuelsson, Mariken Homleid, Trygve Aspelien, Ulf Andrae, Matti Horttanainen (FMI).

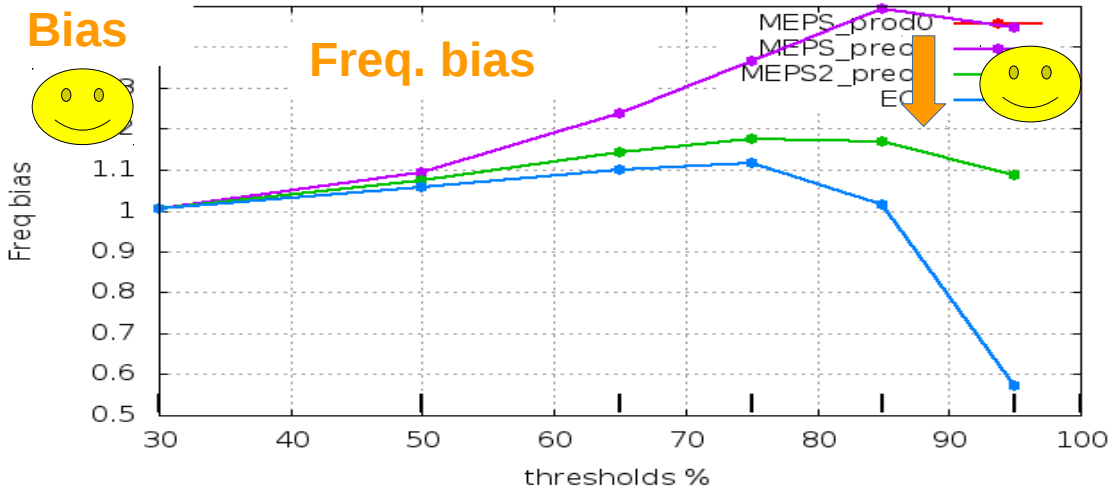
Problem with too cold/moist spring conditions in cy40h1.1

Rh2m: 7 days statistics from last week over the MetCoOp domain



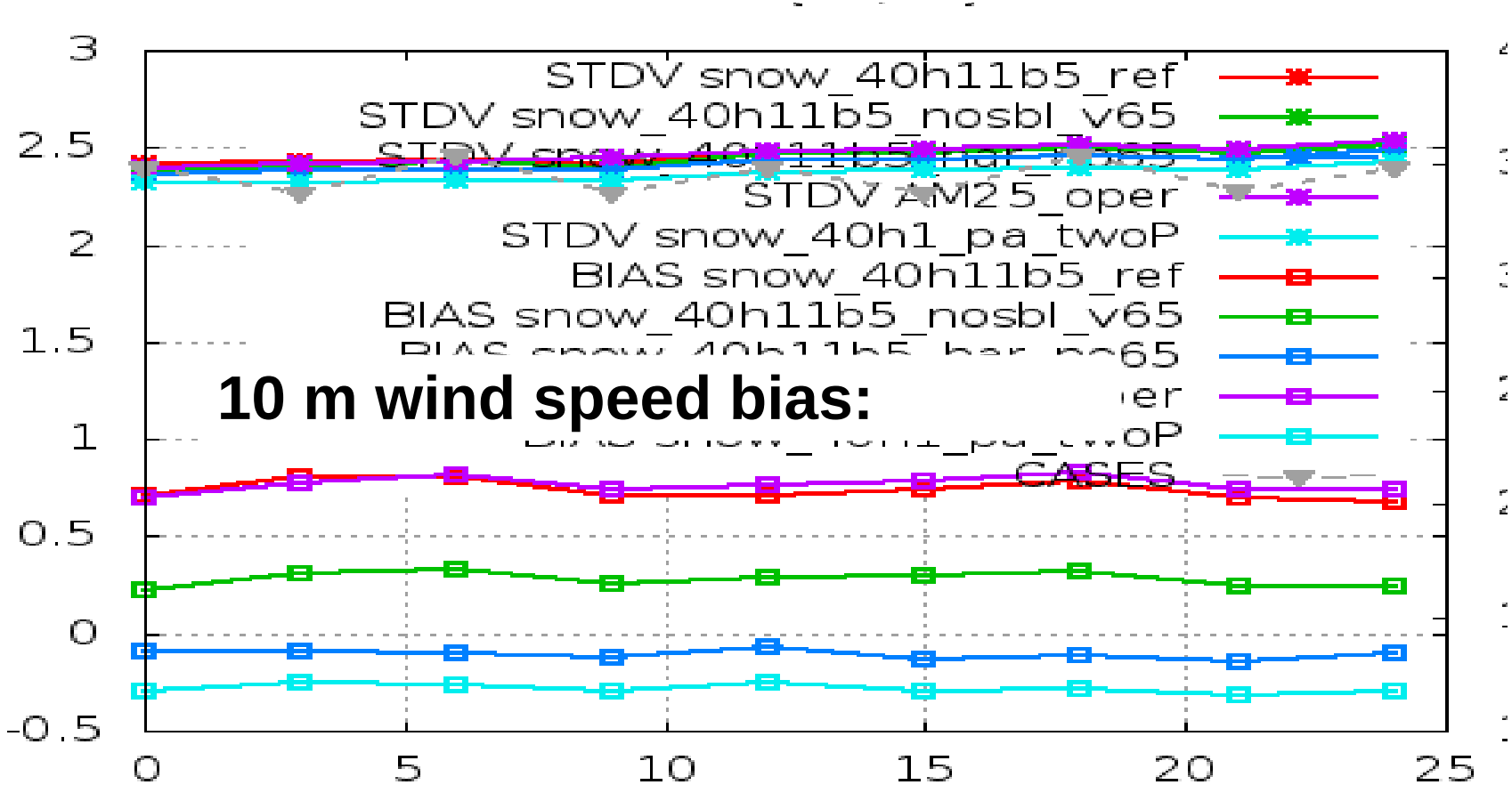
MAE

Bias



Operational (cy40h1.1.1): No SBL, 2 patches, FLake
Previous version: SBL, 1 patch, TG2 for lake water
ECMWF

But all these changes had negative impact on the U10m wind



cy40h without HARATU

- canopy scheme

+ HARATU turbulence

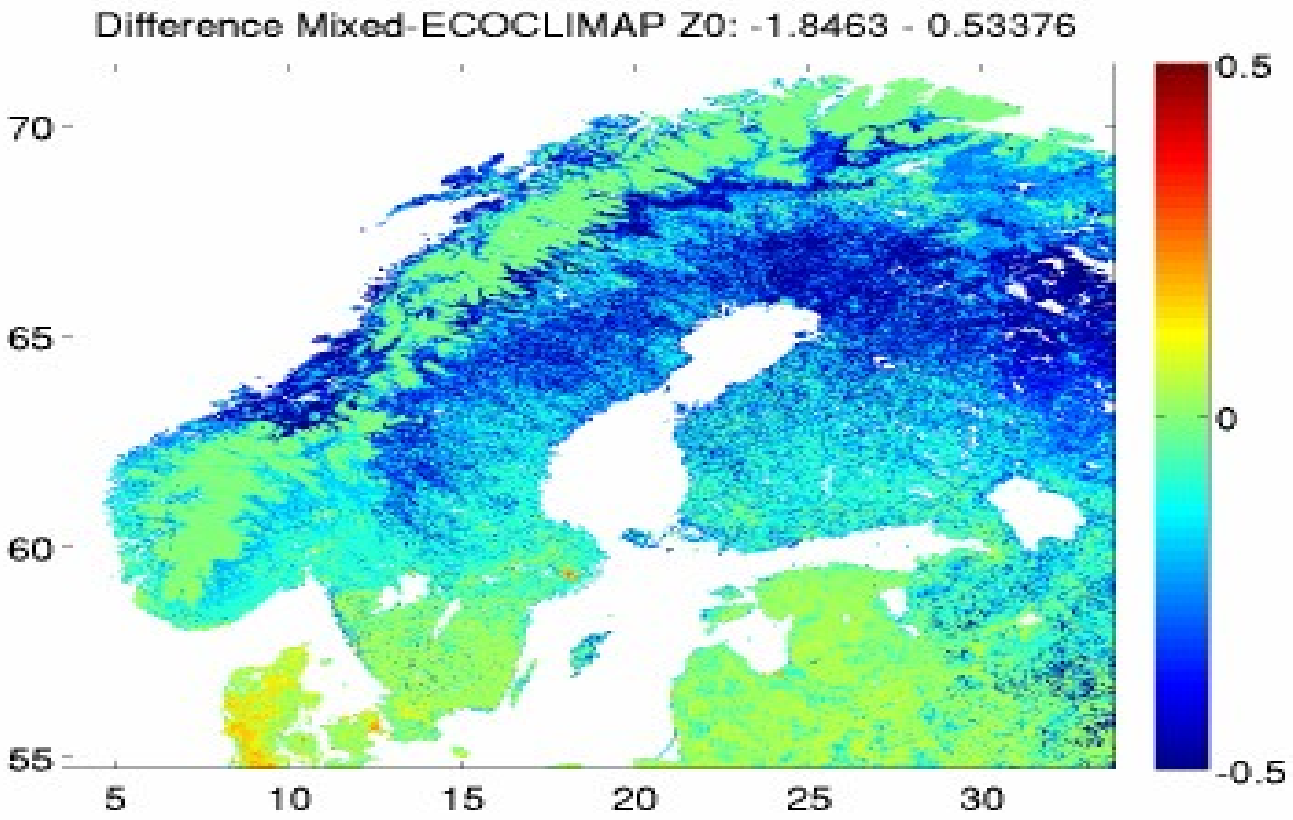
+ 2 pathces

Ohoh, we go from positive bias to negative bias...

Critical investigation of roughness length...

So, we looked into the surface roughness and concluded that the ECOCLIMAP tree height (roughness) seems to be overestimated in the northern half of the domain. Therefore, ECOCLIMAP tree height has been replaced by laser estimated tree height. See article in last ALADIN/HIRLAM Newsletter.
Also, we limit the maximum roughness length to 1.6 m.

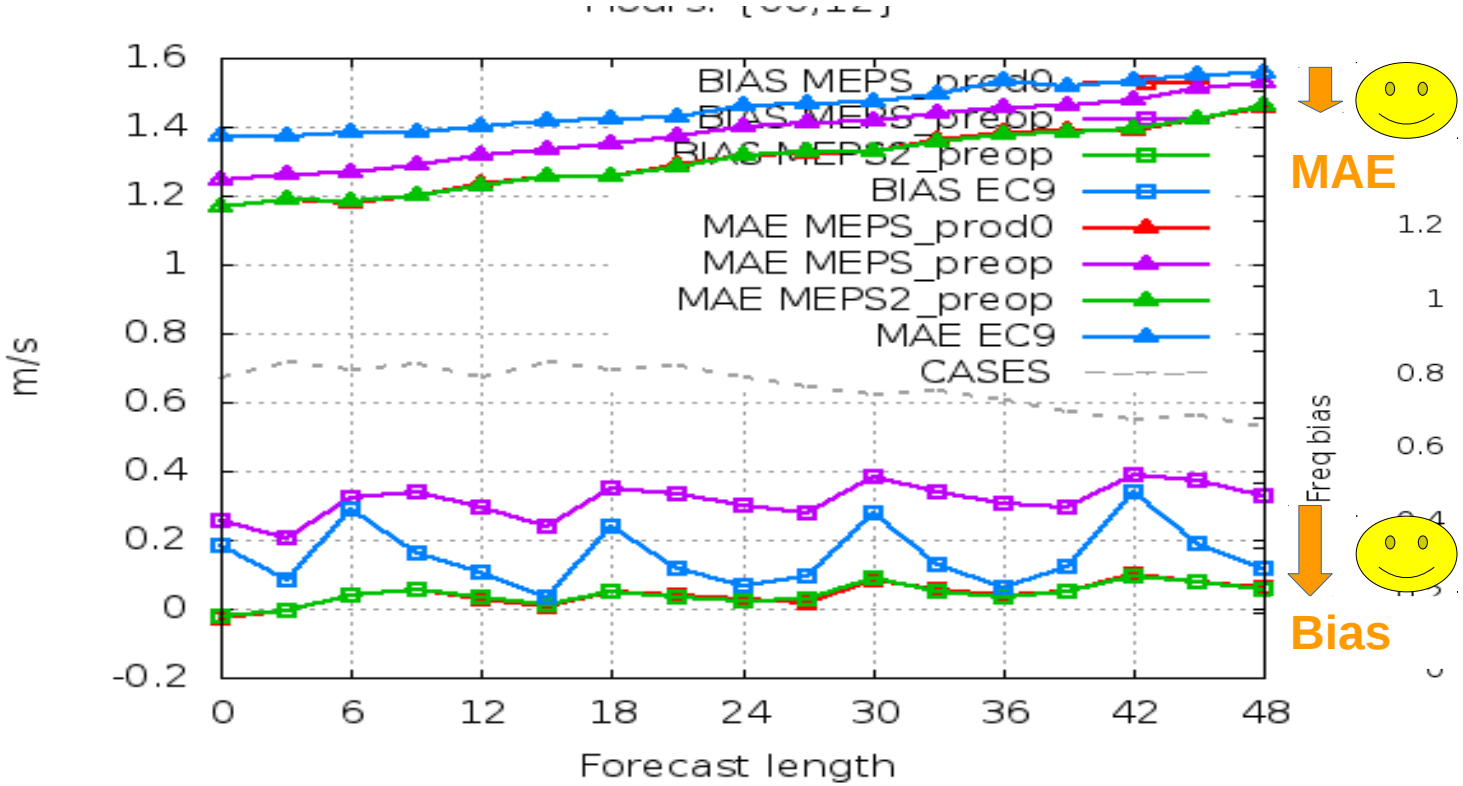
Difference (new – old) roughness :



We also increased snow roughness slightly (from 1 mm to 3 mm) to tackle too high wind speed over snowy mountain areas in winter time.

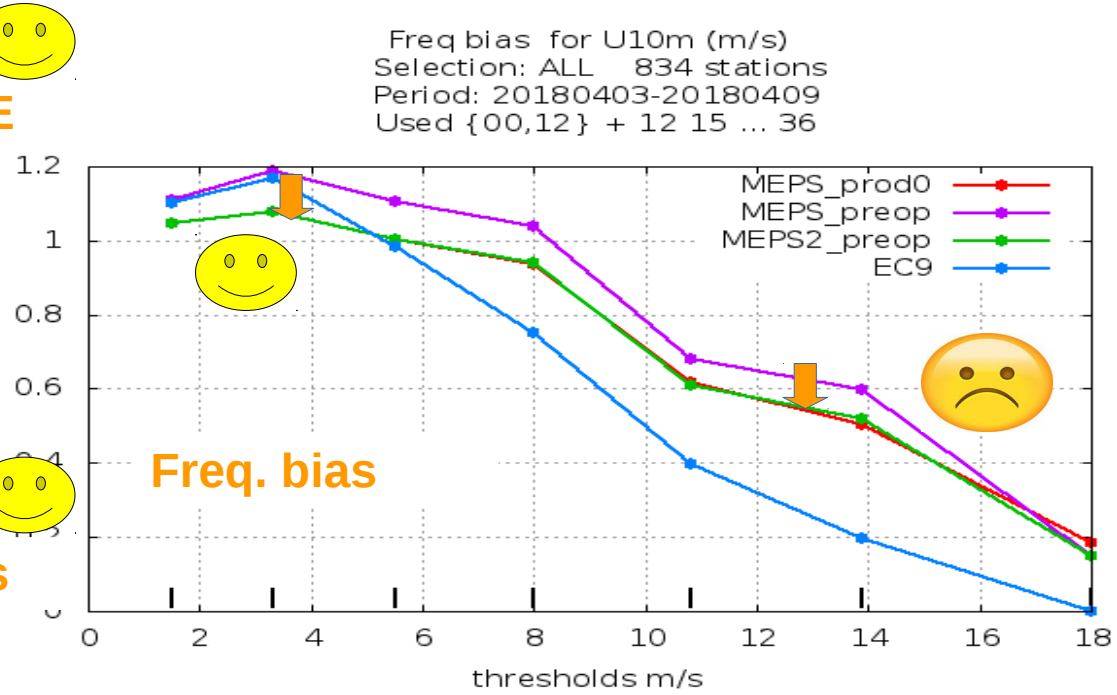
With modified tree height/roughness U10m improves

U10m: 7 days statistics from last week over the MetCoOp domain



MAE

Bias



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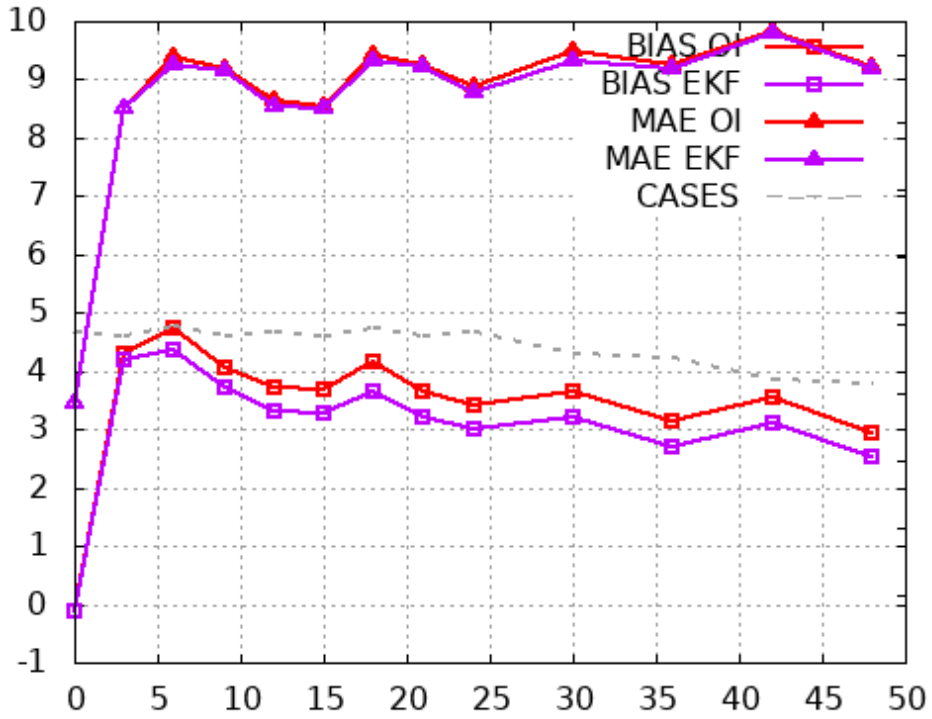
Moving towards EKF and satellite observations for surface data assimilation.

HARMONIE-AROME with surface OI replaced by EKF. Looks promising….



But, here limits are applied to the Jacobians to avoid crashes in the Kalman Gain calculation.

More careful approach:

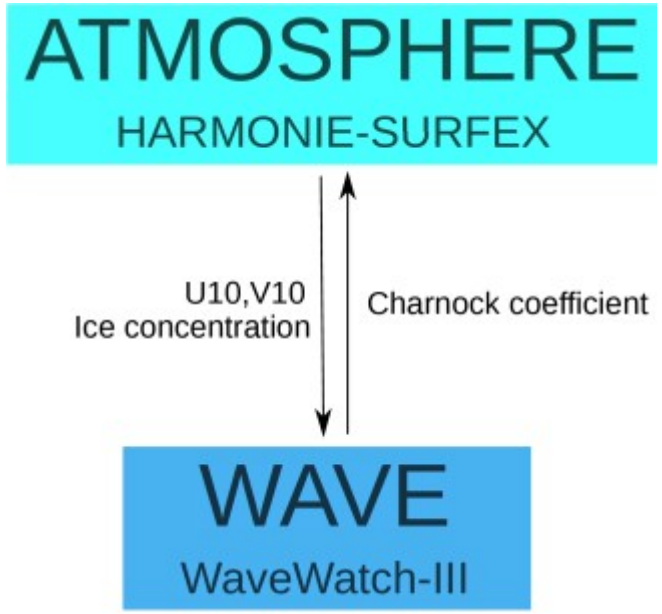
Non-linear situations:
How to deal with non-linear situations created by e.g. rain events: “Turn off” assimilation of soil moisture/ice but keep assimilation of soil temperature...

And what to do with soil water/ice in the presence of snow cover? In the Force-restore scheme, at 100% snow cover, there is no connection between 2m variables and soil moisture/ice variables. But in forest areas snow cover always <30%….!

Avoid EKF to force the control variables outside physical realistic limits:
E.g., soil moisture is not allowed to become negative or exceed the porosity of the soil. Currently, if this happens the increments are simply forced to zero. But this violates the EKF optimal solution. A better way would be to utilize lagrange multipliers. I.e. increase the cost for EKF to “force” control variables outside realistic constraints.

People involved: Jelena Bojarova, Magnus Lindskog, Åsmund Bakketun, Trygve Aspelien, Mariken Homleid, Ekaterina Kurzeneva, Tomas Landelius, Patrick Samuelsson

Sea wave modelling by Lichuan Wu, SMHI



cy43
SURFEXv8.0

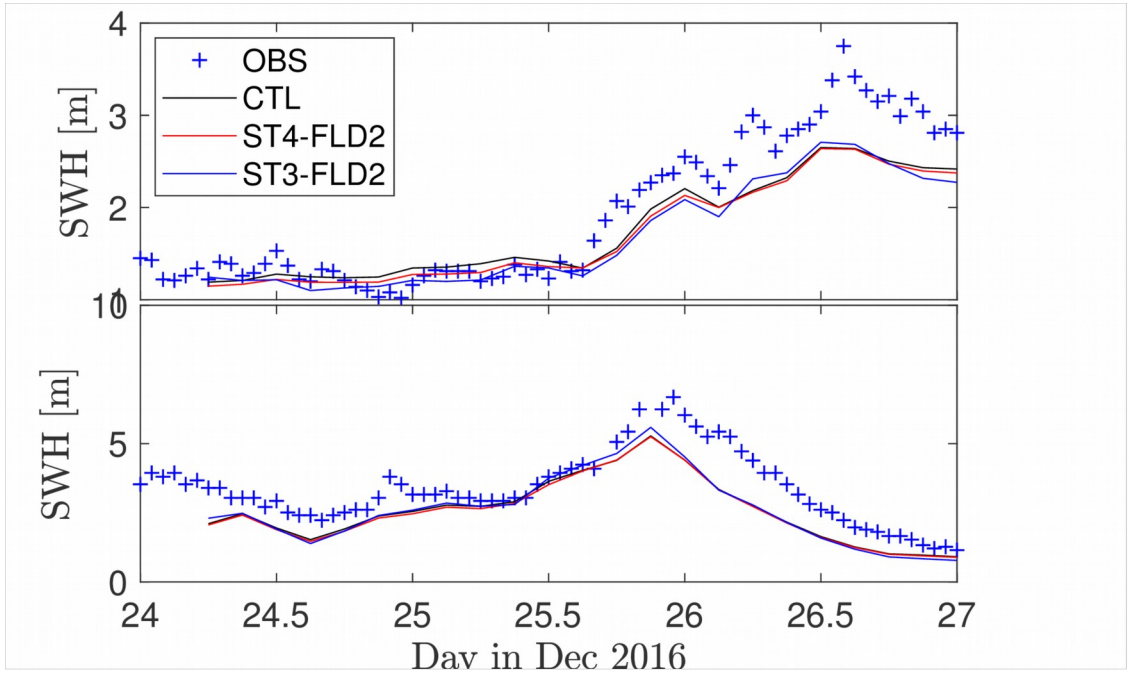
OASIS-MCT

WW3

- HARMONIE-AROME and WW3 has the same domain with same grid information. The boundary data for WW3 are from the WAM global run in ECMWF.
- HARMONIE-AROME and WW3 exchange information every 10 min through OASIS-MCT.

Experiment	Physical package	Air-sea scheme	Wave feedback
CTL	ST4	NO	No
ST4-FLD2	ST4	FLD2	Yes
ST3-FLD2	ST3	FLD2	Yes

Comparison the measurements from two buoy sites in Baltic Sea with simulation results concerning SWH. 3 December days in 2016:



All three experiments give similar results since the sites represent coastal areas with limited wave-atmosphere feedback.

With support from Slovenia team, Météo-France team, Norwegian team

Sea wave modelling by Lichuan Wu, SMHI

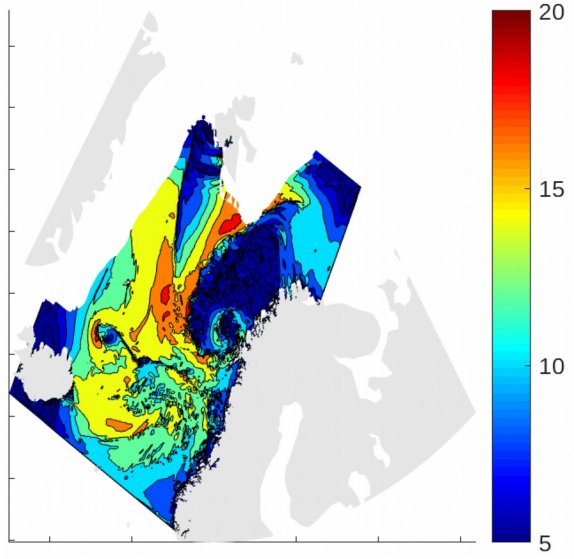
Polar Low in the North Sea, March 8, 2008, 20:00 UTC

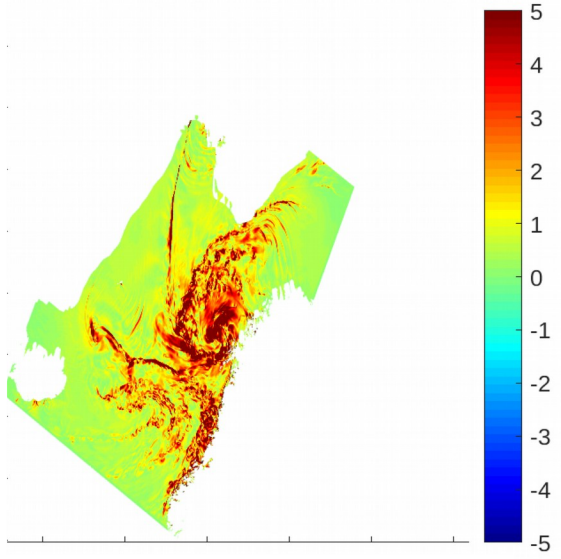
Note that U10m seems to increase due to wave – atmosphere coupling (or change of position of polar low) while wave height is not affected much.

CTL

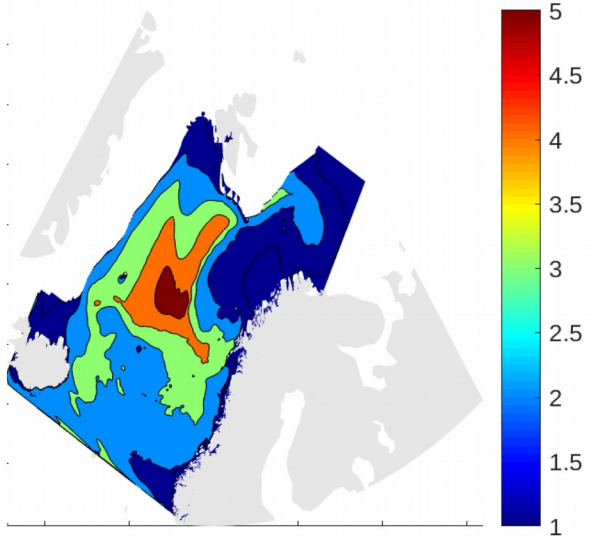
Difference ST3-FLD2 - CTL

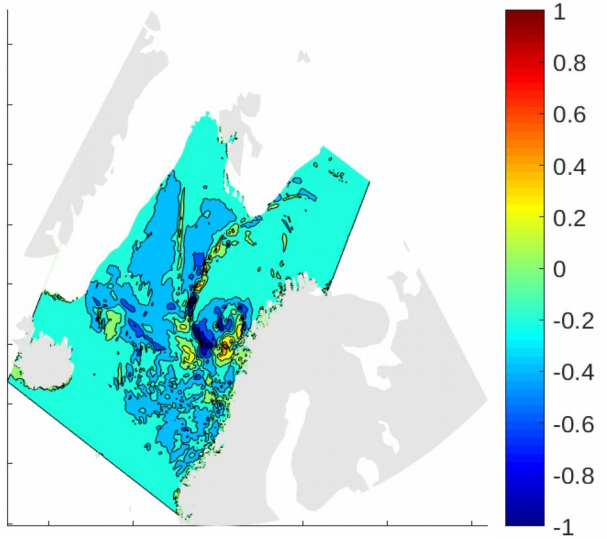
U10m





Wave height





Abiskojaure – Unna Allakas, Sweden
April 3, 2018

Albas, Occitanie, France
April 15, 2018