SURFEX for ALADIN/ALARO

Rafiq Hamdi
with input from ALADIN colleagues

1. Experiences with SURFEX within ALADIN consortium

2. Surface data assimilation using EKF

3. Coupling SURFEXv7.2 to ALARO-1

4. Other applications & Future work

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Austria

- SURFEX + AROME + DA is Optimal Interpolation OIMAIN offline (cy37t1op1)
- Cy38t1 is also technically OK and sooner or later we will switch to this newer cycle
- One problem is the soil ice melting in spring where the soil ice did not melt in time, when it became warmer
- This leads to significant (4K) T2m cold biases in flat terrain.
- There was also a bug in OIMAIN leading to wrong surface increments, because 10m wind was corrupted in case of using CANOPY and lowest model level below 10m.

Austria

- From cy38t1 on, 10m wind is taken from atmospheric file in OIMAIN automatically

- Clemens Wastl included during a MF stay (cooperation with Yann Seity and Laura Rontu) last year orographic shadowing into AROME-SURFEX (cy41 and backphased cy38t1 export).

- Another problematic issue is, that SURFEX LFI/FA files from later cycles (for example cy40) cannot be used in older cycles.

- Finally Nauman did some tests with new orography (SRTM) and ECOCLIMAP II in AROME-SURFEX (online cy38t1 AROME1km). Technically, it was OK but the improvement in the forecast is rather small.

Austria

- If anybody is running FLAKE regularly, it would be nice to spread some informations on that (files needed, bugs, namelist settings)

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Geosci. Model Dev., 8, 845–863, 2015
www.geosci-model-dev.net/8/845/2015/
doi:10.5194/gmd-8-845-2015

Geoscientific Model Development
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Study of the Jacobian of an extended Kalman filter for soil analysis in SURFEXv5

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Received: 5 September 2014 – Published in Geosci. Model Dev. Discuss.: 28 October 2014
Revised: 9 February 2015 – Accepted: 3 March 2015 – Published: 27 March 2015

Abstract. An externalised surface scheme like SURFEX allows computationally cheap offline runs. This is a major advantage for surface assimilation techniques such as the extended Kalman filter (EKF), where the offline runs allow a cheaper numerical estimation of the observation operator Jacobian. In the recent past an EKF has been developed within SURFEX for the initialisation of soil water content and soil temperature based on screen-level temperature and relative humidity observations. In this paper we make a comparison of the Jacobian calculated with offline SURFEX runs and with runs coupled to the atmospheric ALARO model. Comparisons are made with respect to spatial structure and average value of the Jacobian, gain values and increments. We determine the optimal perturbation size of the Jacobian for the offline and coupled approaches and compare the linearity of the Jacobian for these cases. Results show that the offline Jacobian approach gives similar results to the coupled approach and that it allows for smaller perturbation sizes that better approximate this linearity assumption. We document a new case of non-linearities that can hamper this linearity assumption and cause spurious $2\Delta t$ oscillations in small parts of the domain for the coupled as well as offline runs. While these oscillations do not have a detrimental effect on the model run, they can introduce some noise in the Jacobian at the affected locations. The oscillations influence both the surface fluxes and the screen-level variables. The oscillations occur in the late afternoon in summer when a stable boundary layer starts to form near the surface. We propose a filter to remove the oscillations and show that this filter works accordingly.

1 Introduction

Externalising surface schemes from upper-air atmospheric models has many advantages. If the interface between the different parts is defined in a flexible manner (see Best et al., 2004, for an example), then it provides the possibility to plug one scheme into different models, even targeting different applications, ranging from climate to high-impact weather. Another major advantage is that the scheme can also be used in an offline mode, allowing for cheap solutions in specific applications. An example of this is studied in the present paper: the implementation of an extended Kalman filter (EKF) for surface assimilation (Mahfouf et al., 2009), where cheap offline runs with the SURFEX external land surface model (Masson et al., 2013; Hamdi et al., 2014a) allow one to numerically estimate the observation operator Jacobian.

Surface assimilation techniques, like this EKF, can improve the boundary layer forecasts of a numerical weather prediction (NWP) model considerably (Douville et al., 2000; Hess, 2001; Drusch and Viterbo, 2007). The surface serves as a lower boundary condition for the NWP model and has an important impact on the lower atmosphere. Land surface models (LSMs) determine the partitioning of the energy into latent and sensible heat fluxes (e.g. by means of evapotranspiration processes) and these fluxes provide the main link between the surface and the atmosphere. In the past two decades LSMs have been improved considerably. Still, there are a lot of uncertainties and errors in model parameterisations, model resolution and observation measurements of soil variables. In order to provide an optimal initial surface state for an NWP forecast, the assimilation of surface observations into the land surface model is necessary. The amount and fre-

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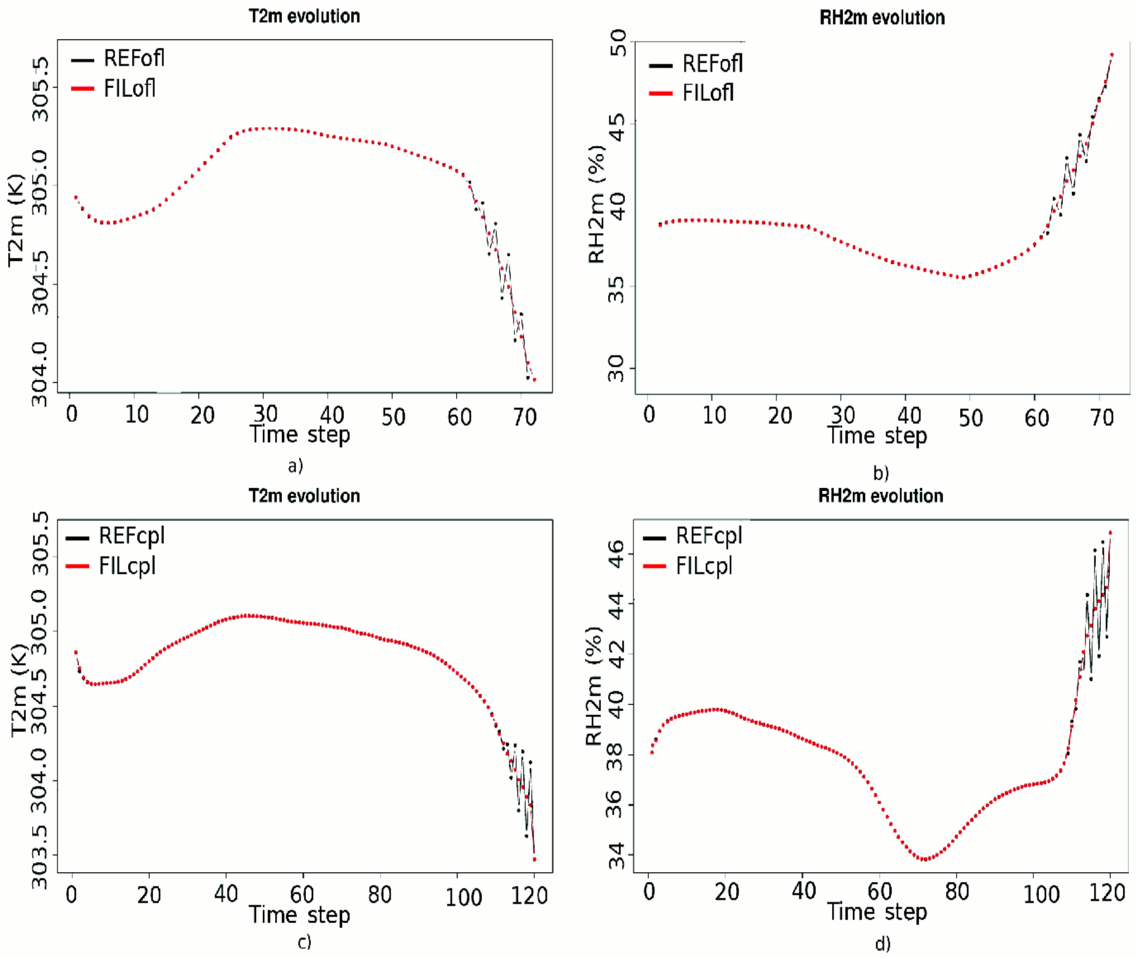

Figure 7. Evolution of $T_{2\,\mathrm{m}}$ (left) and $\mathrm{RH}_{2\,\mathrm{m}}$ (right) at location A for the offline (top) and coupled (bottom) reference runs (REF, black) and the filtered run (FIL, red).

We document a new case of non-linearities that can hamper this linearity assumption and cause spurious 2 Delta t oscillations in small parts of the domain for the coupled as well as offline runs.

The oscillations occur in the late afternoon in summer when a stable boundary layer starts to form near the surface. We propose a filter to remove the oscillations and show that this filter works accordingly.

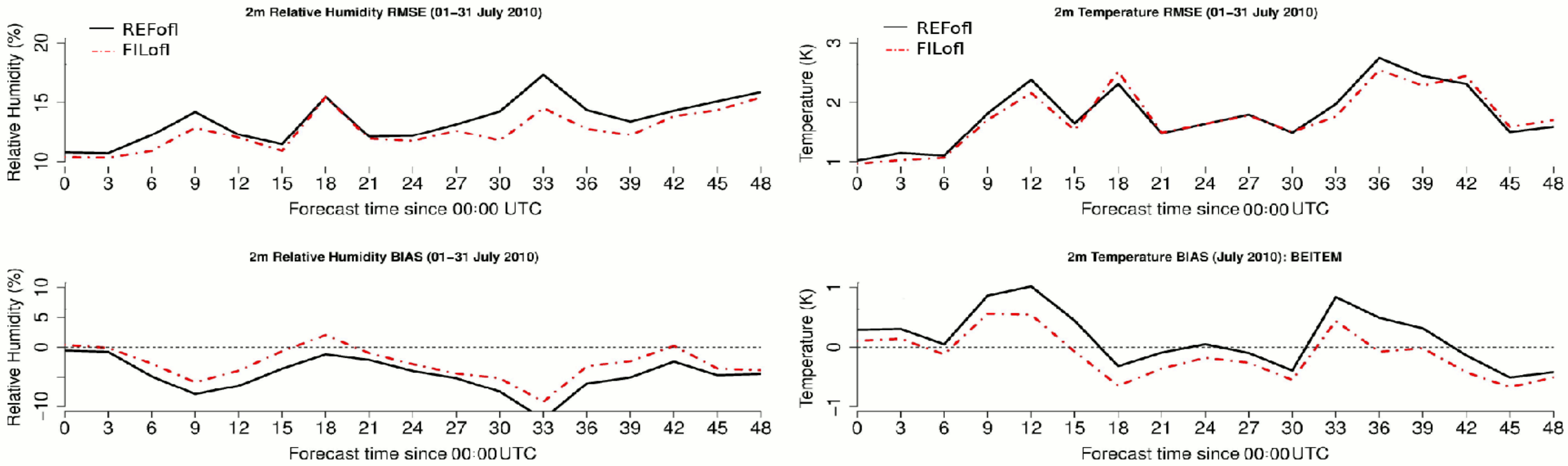

Figure 15. Forecast scores (BIAS and RMSE) for $RH_{2\,m}$ and $T_{2\,m}$ for all forecast ranges of the runs at 00:00 UTC averaged over July 2010 in Beitem (Belgium) for REFofl (black) and FIL1ofl (red).

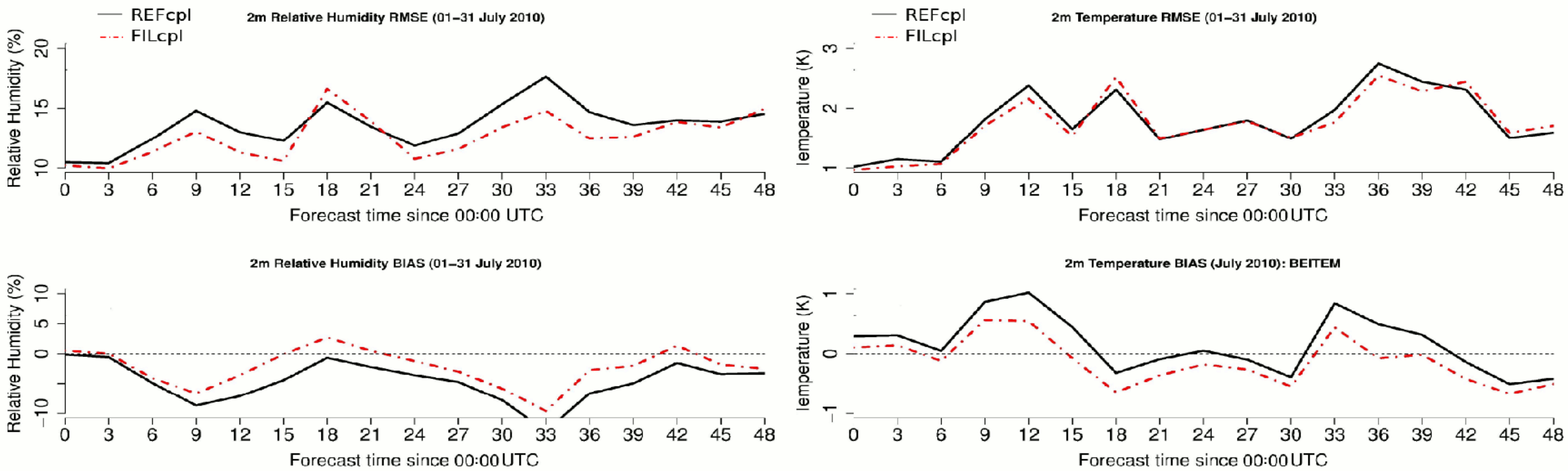

Figure 16. Forecast scores (BIAS and RMSE) for $RH_{2\,m}$ and $T_{2\,m}$ for all forecast ranges of the runs at 00:00 UTC averaged over July 2010 in Beitem (Belgium) for REFcpl (black) and FILcpl (red).

- **Running 1-year assimilation cycle with SURFEX EKF and 3dVar atmospheric assimilation. To be submitted to QJ**

- **STAEKF scheme is introduced in Cy36t1 but still to solve some final technical difficulties due to the new derivative computation of the B matrix.**

- **Some surface parameters are not initialized correctly (XCT & XRS) to be fixed.**

- **Testing SODA within Cy38 technically work but with problem for the offline runs to be fixed.**

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- **To run ALARO-1 with TOUCANS and SURFEX the issue of the exchange coefficient should be solved.**

- **The solution that was proposed for CY36T1 is now introduced in CY38T1OP3 interfacing the average drag coefficient PCD & PCDN calculated from SURFEX and to initialize its value for the first time step.**

- **The TOUCANS stability function are now introduced in SURFEXv7.2 under the LDRAG_COEF_ARP key.**

- **This solution could be available for the next version of SURFEX V8.**

```
&NAM_SURF_ATM
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  LRRGUST_ARP=.FALSE.,
!---------TOUCANS stability functions
 LDRAG_COEF_ARP=.FALSE.,
  LXCOEFKTKE=.FALSE.,
  LXCOEFK_F1=.FALSE.,
  CXGTURS='MD2',
  CX3TKEFREE=1.183,
  EXTKE_OLAM=0.29,
  NXUPTKE=0.5265,
  RXLOUIS_S0=0.136,
  PXLOUIS_S0=0.130,
  RXLOUIS_GU1=-2.67,
  RXLOUIS_GU2=-6.15,
  PXLOUIS_GU1=-1.13,
  PXLOUIS_GU2=-3.80,
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  RXLOUIS_GS3=1.0,
  RXLOUIS_GS4=2.7,
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  RXQNSE_GS3=20.0,
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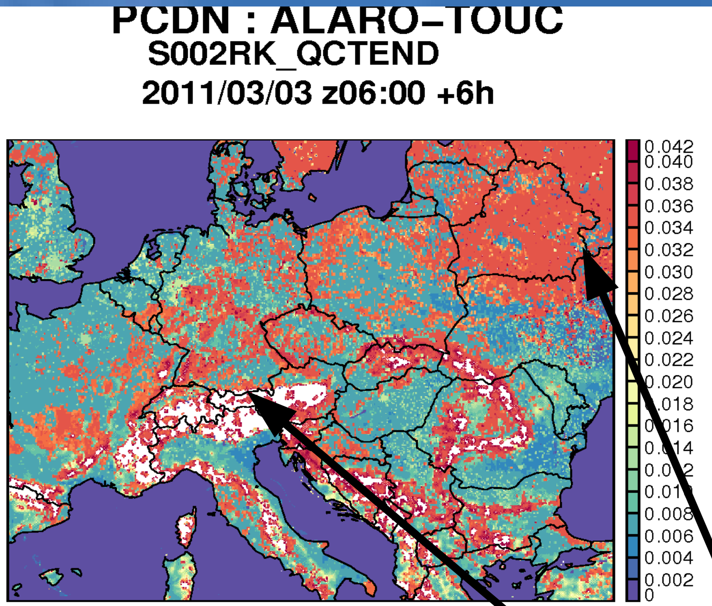
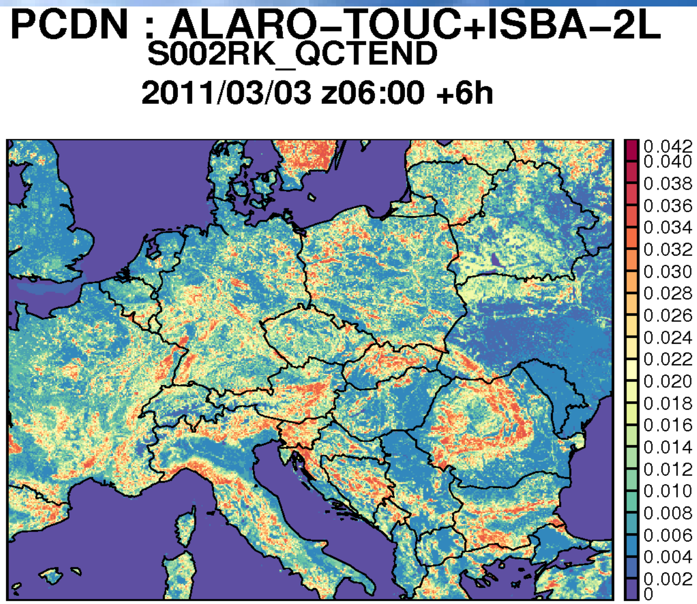
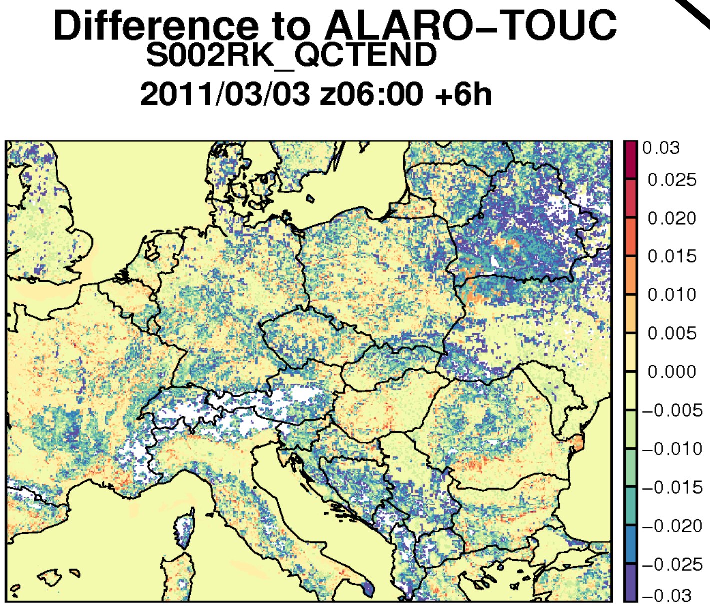
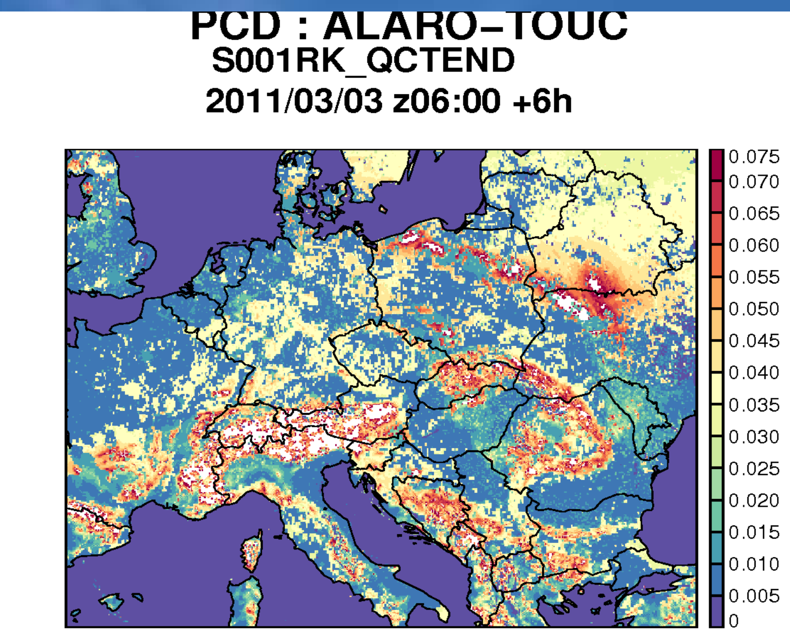
SURFEXv7.2







We can see that the drag coefficient over orographic ans snow covered areas is different, with and without SURFEX, were SURFEX seems to underestimate its values.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S001RK_QCTEND
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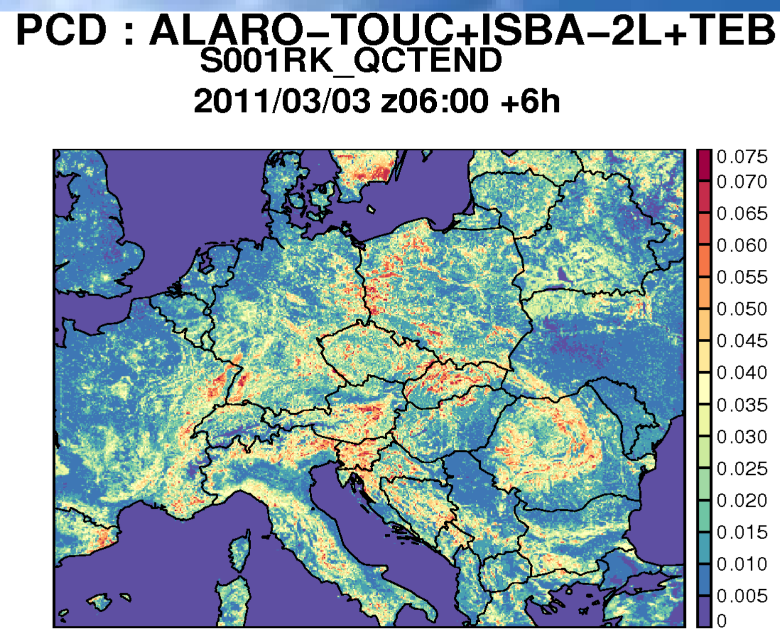
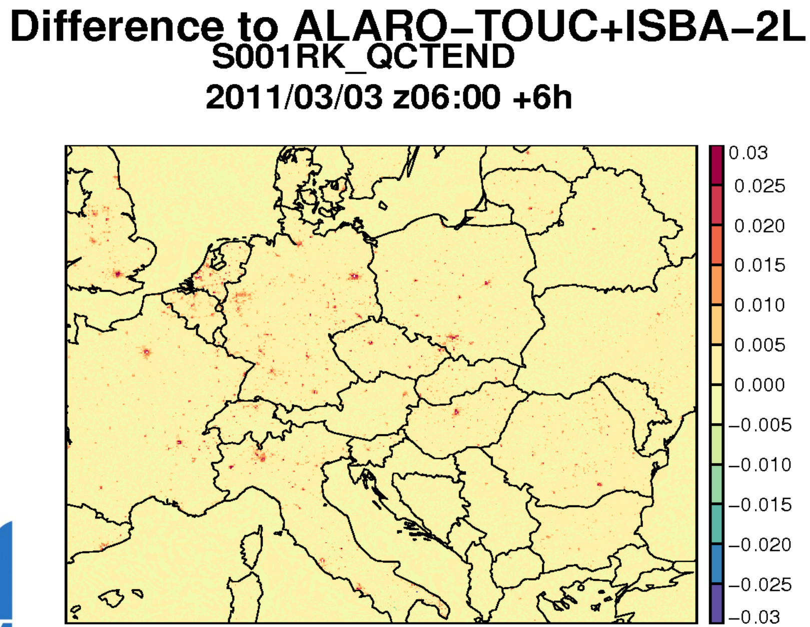
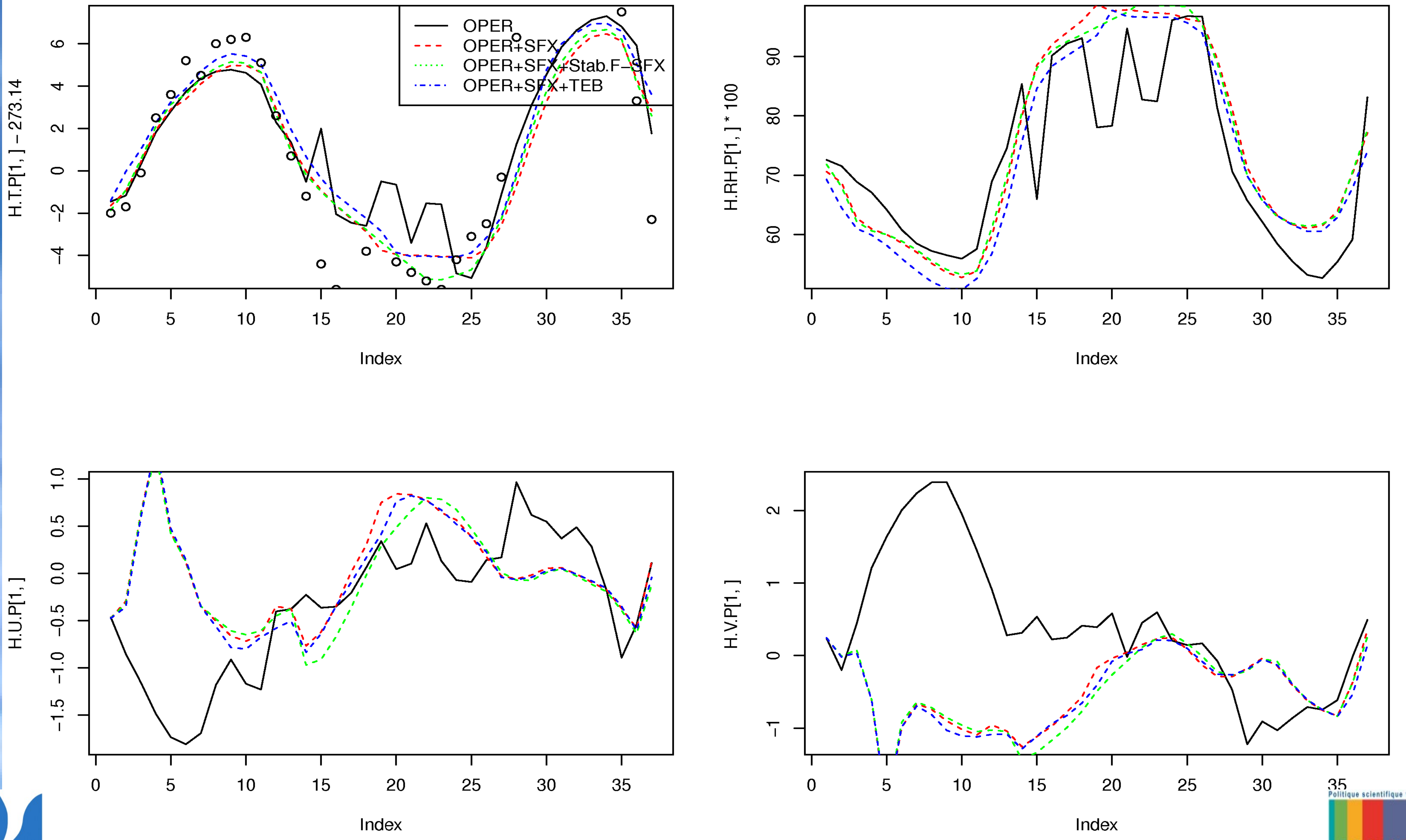
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0


PCD : ALARO–TOUC+ISBA–2L+TEB
S001RK_QCTEND
2011/03/03 z06:00 +6h
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0


Difference to ALARO–TOUC+ISBA–2L
S001RK_QCTEND
2011/03/03 z06:00 +6h
0.03
0.025
0.020
0.015
0.010
0.005
0.000
–0.005
–0.010
–0.015
–0.020
–0.025
–0.03



OPER
OPER+SFX
OPER+SFX+Stab.F–SFX
OPER+SFX+TEB
H.T.P[1,] – 273.14
H.RH.P[1,] * 100
H.U.P[1,]
H.V.P[1,]
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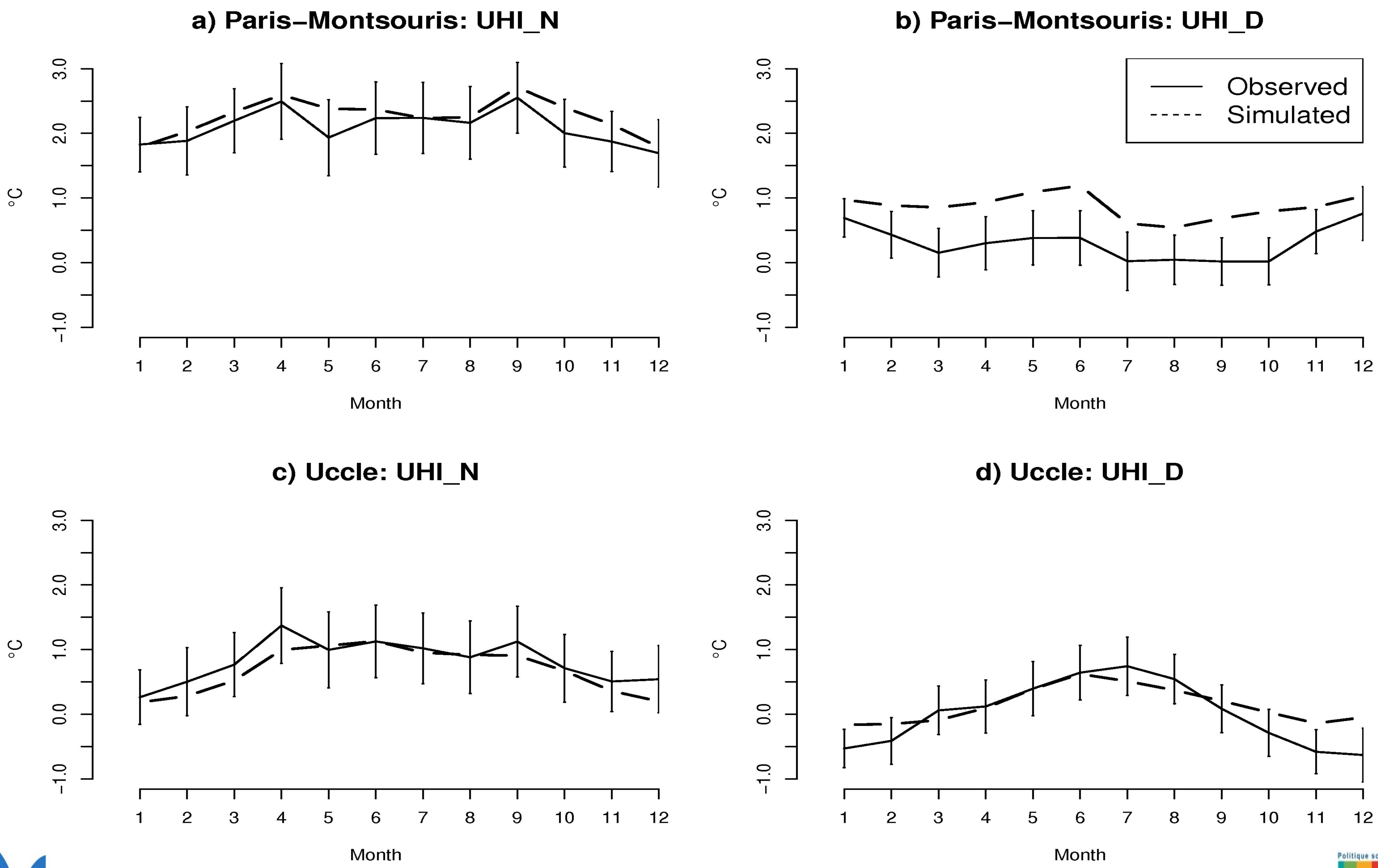
4. **Other applications & Future work**

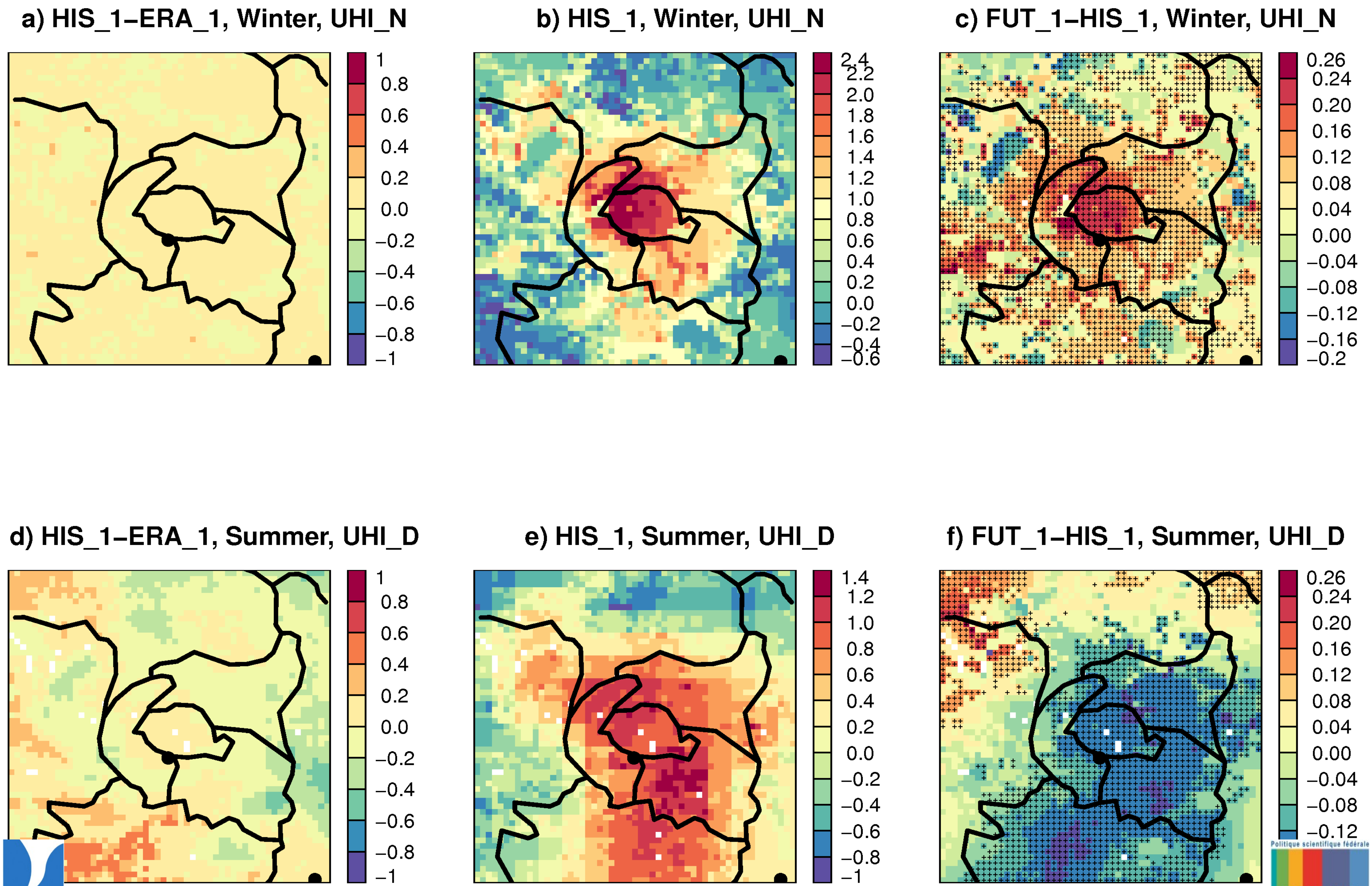
IRM depuis 100 1913

Politique scientifique fédérale belspo

Offline Urban climate simulations using SURFEX+TEB+SBL

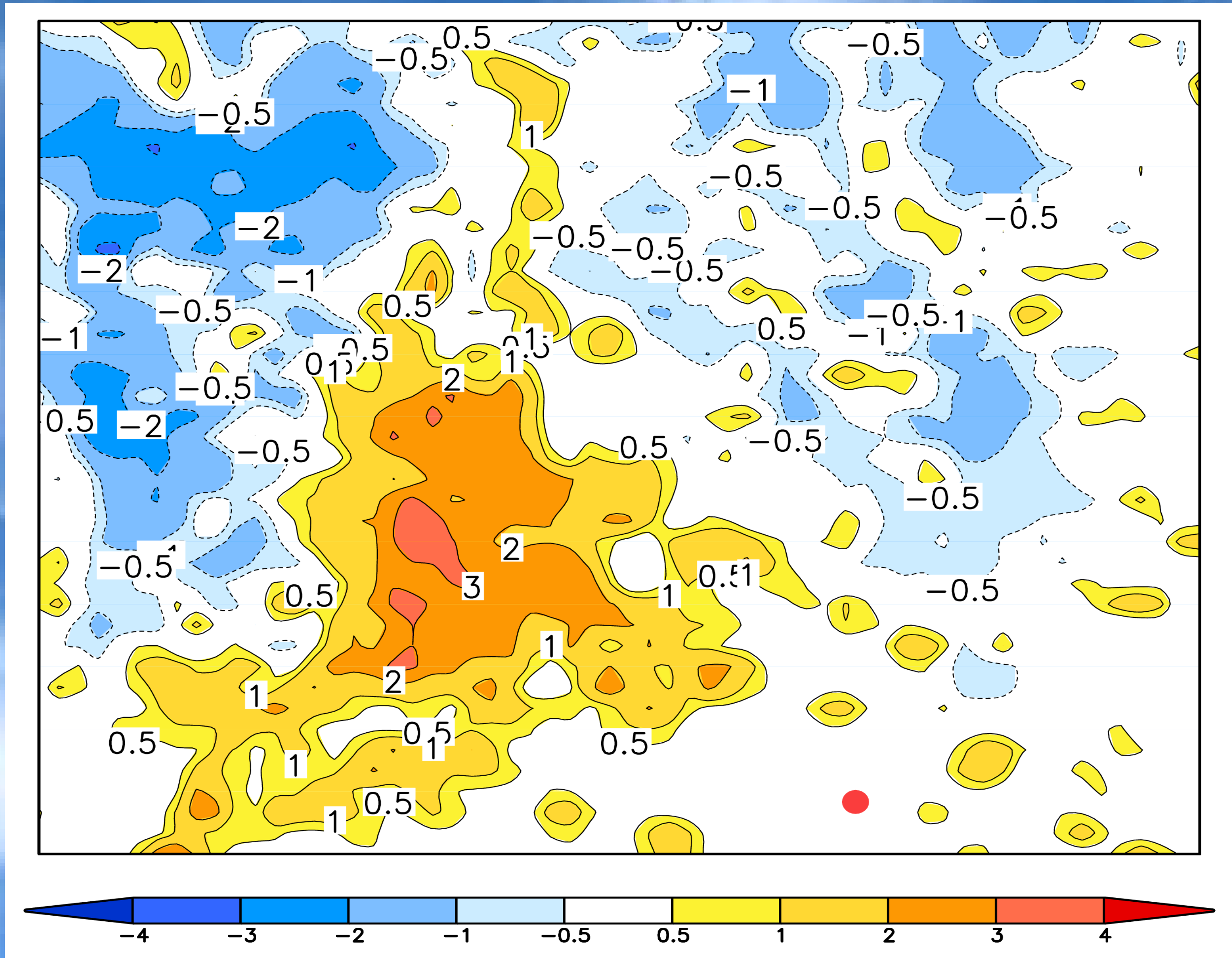


Hamdi et al., UC, 2015



Hamdi et al., UC, 2015

UHI map for Budapest. It is a mean UHI for spring at 03 UTC (at this time the UHI is high) for the period of 1991-2000.



- A scientific paper about the coupling 3DVAR + EKF for ALARO is in preparation (PhD of Annelies).

- Introduce the STAEKF within SODA and test it with 3-DVAR for ALARO.

- Continue the coupling between ALARO-1 and SURFEX

- Surfex WW to be announced for ALADIN partner.

- Writing a proposal for the assimilation of LAI & albedo from remote sensing observation with STAEKF within SURFEX.