Recent developments with SURFEX coupled to ALARO

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- **SURFEX: A NEW LAND SURFACE SCHEME FOR ALARO NWP**
- **SURFEX/EKF: A NEW DATA ASSIMILATION METHOD**
- **SURFEX: A NEW LAND SURFACE SCHEME FOR REGIONAL CLIMATE APPLICATIONS**

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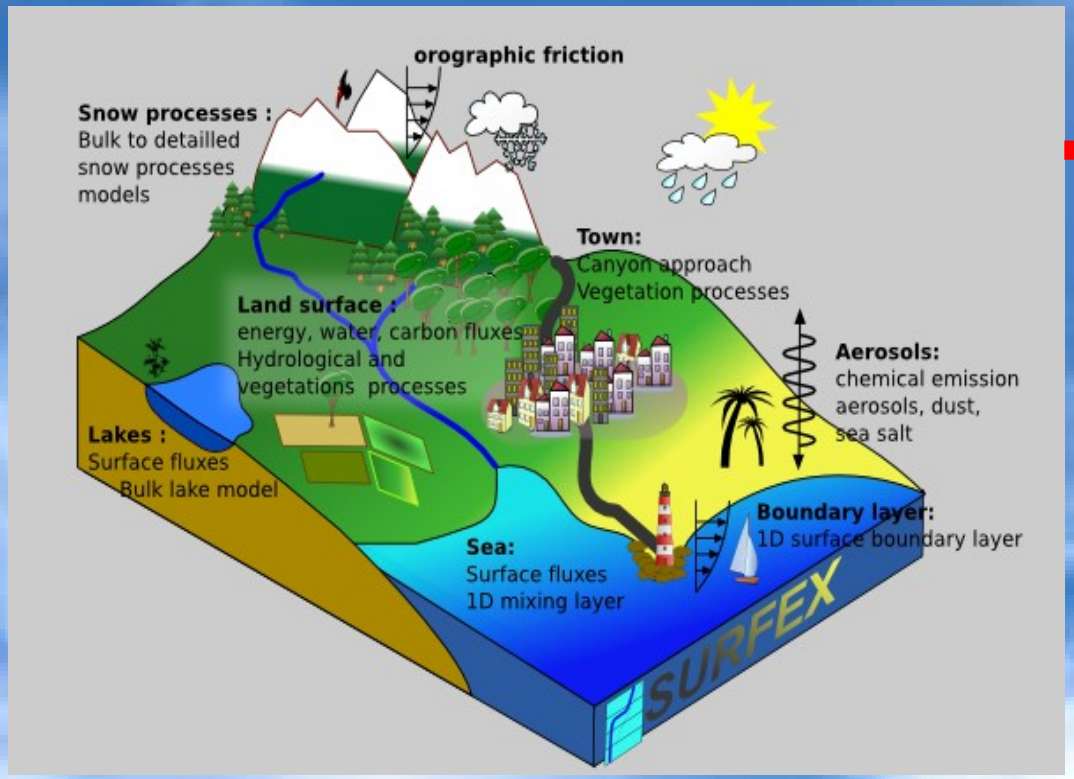
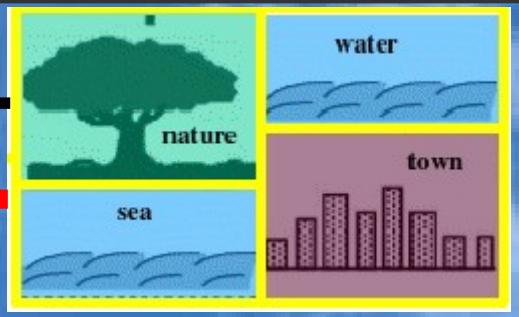
Tiling

One important feature of the externalized surface:
each grid cell is divided into 4 elementary units called tiles according to the fraction of covers in the grid cell





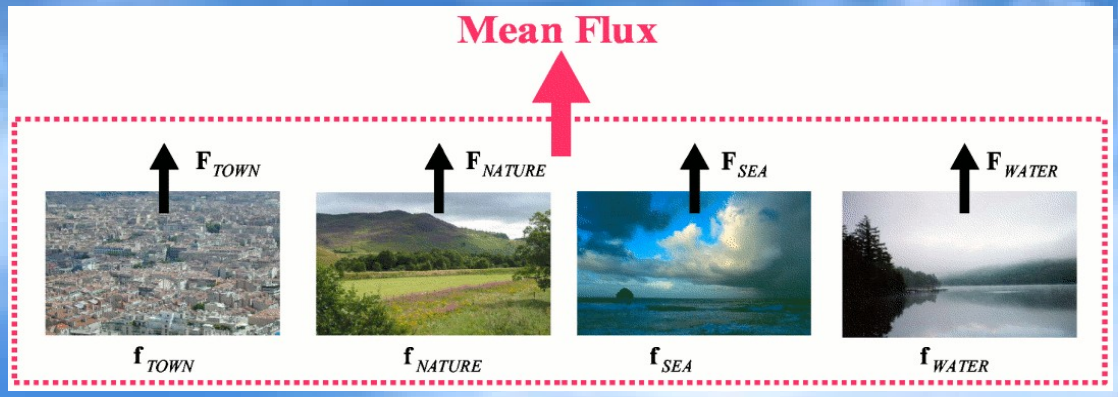
1: bare ground
2: rocks
3: permanent snow
4: deciduous forest
5: conifer forest
6: evergreen broadleaf trees
7: C3 crops
8: C4 crops
9: irrigated crops
10: grassland
11: tropical grassland
12: garden and parks

ECOCLIMAP database

OFFLINE MODE

- albedo
- emissivity
- radiative temperature
- momentum flux
- sensible heat flux
- latent heat flux
- CO_2 flux
- chemical flux

Atmospheric forcing
Sun position
Downward radiative flux



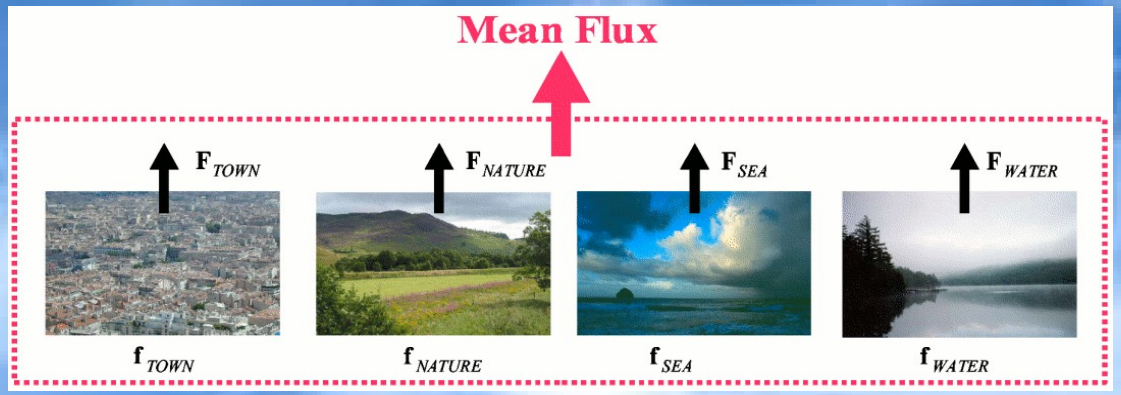
INLINE MODE

Surfex output as surface boundary conditions for atmospheric radiation and turbulent scheme.

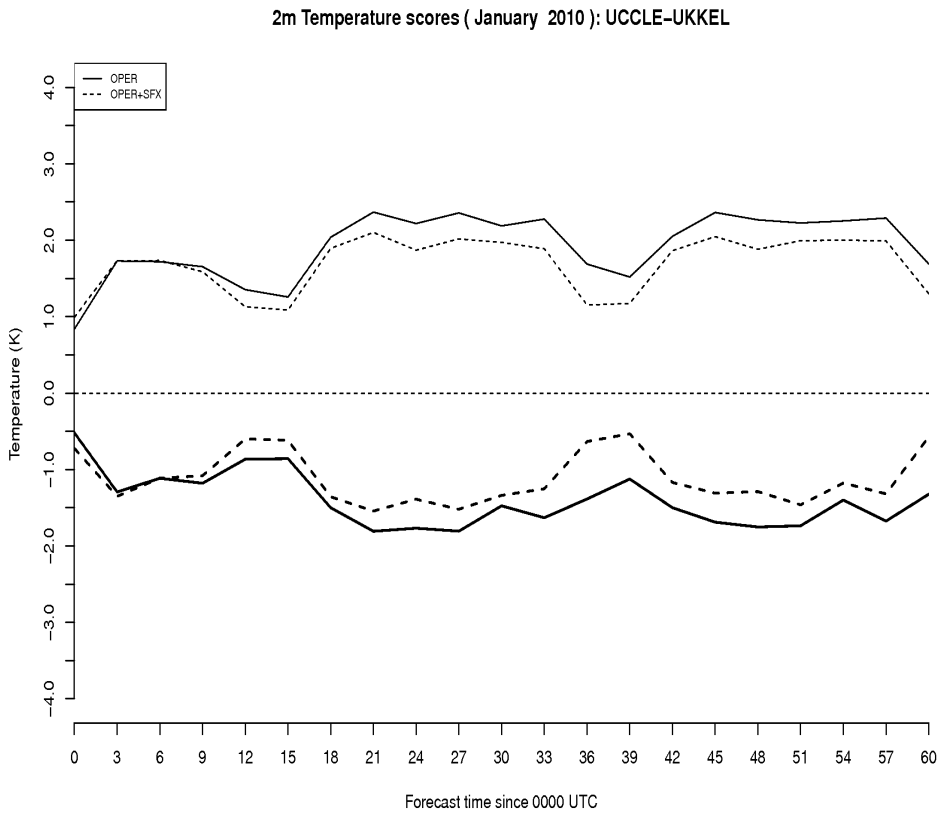
- albedo
- emissivity
- radiative temperature
- momentum flux
- sensible heat flux
- latent heat flux
- CO_2 flux
- chemical flux

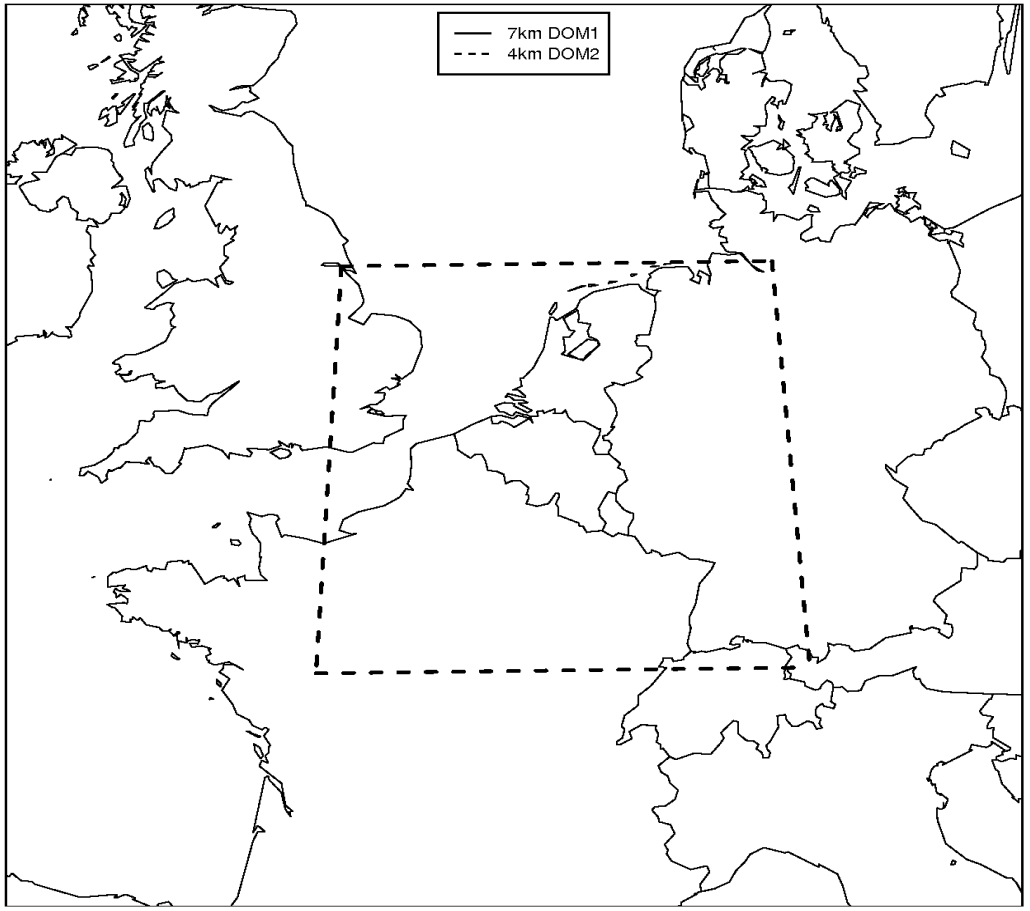
ALARO model

- Atmospheric forcing
- Sun position
- Downward radiative flux



ALARO-OPER # ALARO-SURFEX 7km run over Belgium





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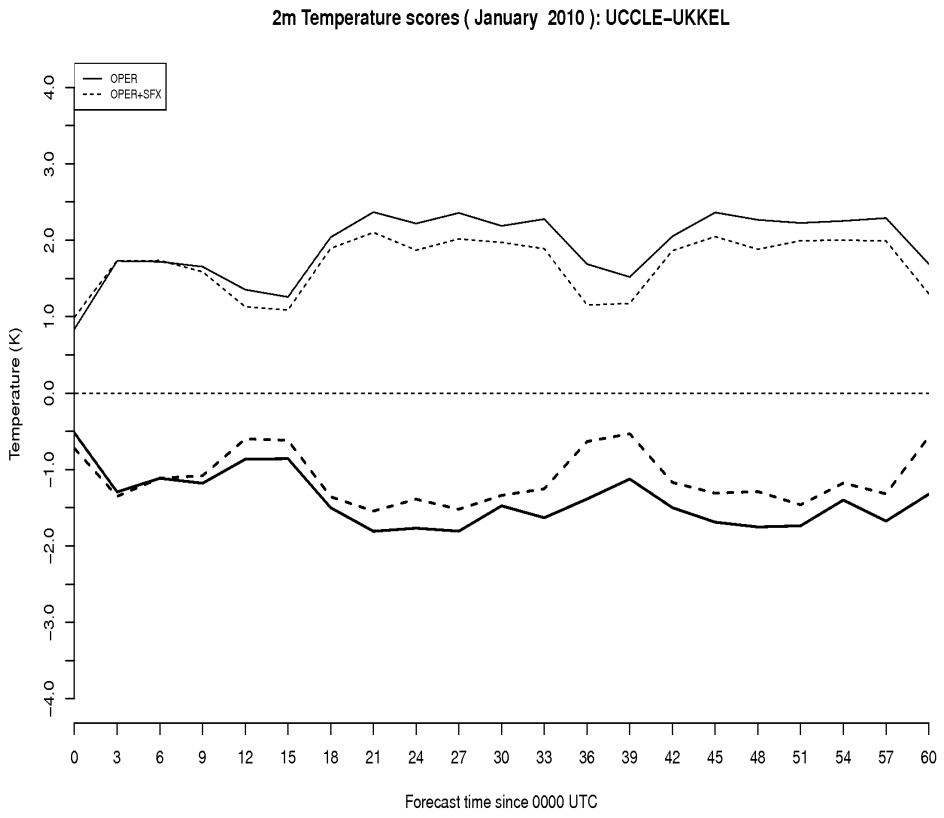

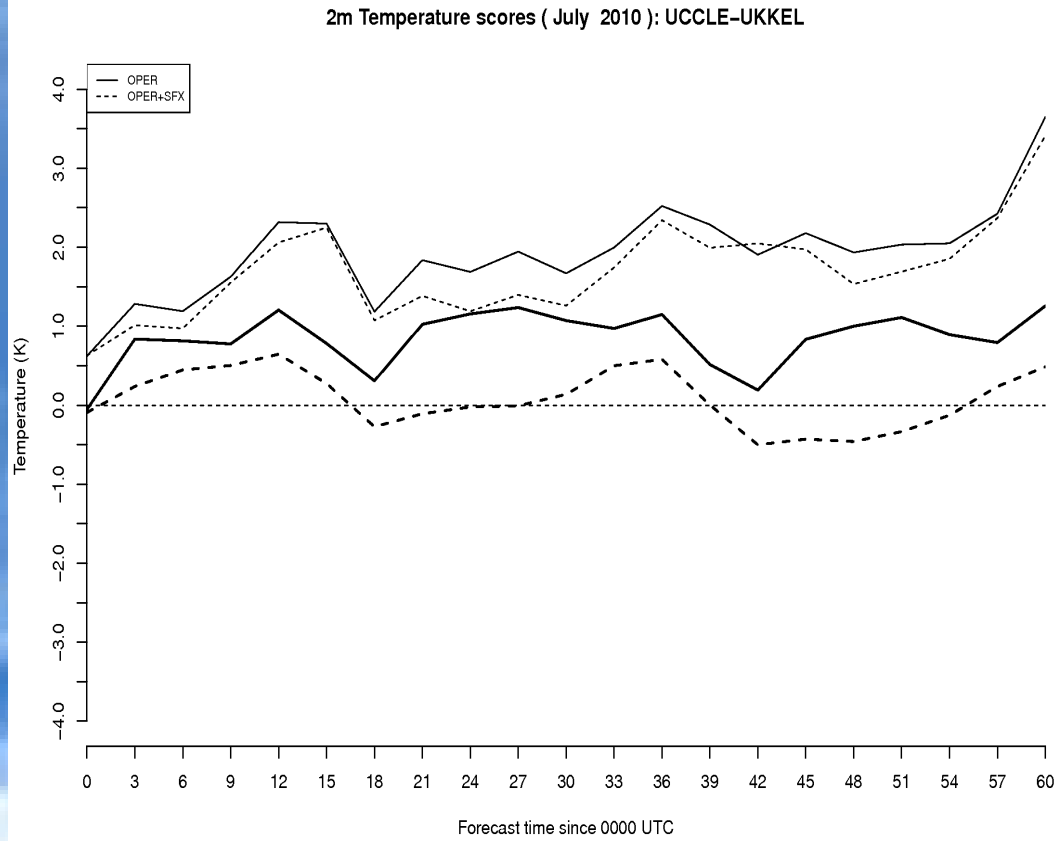

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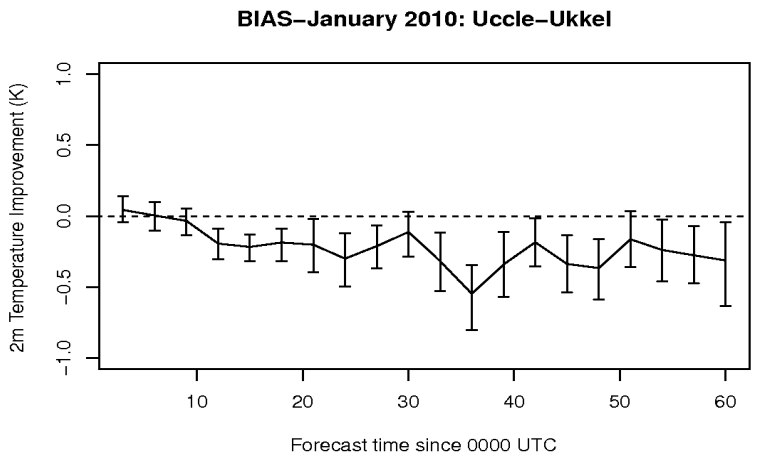
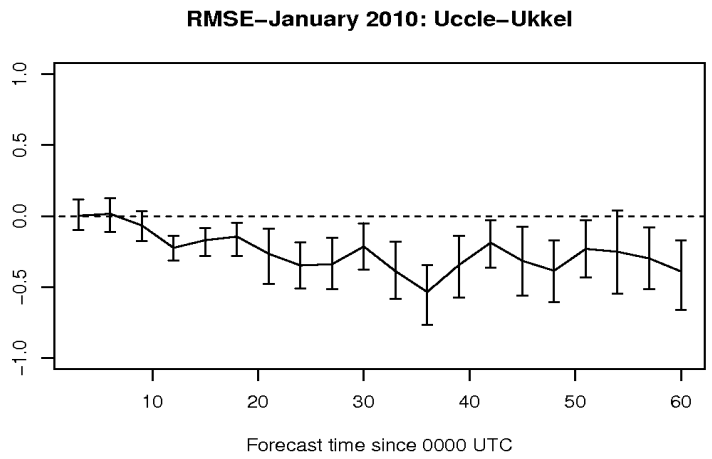
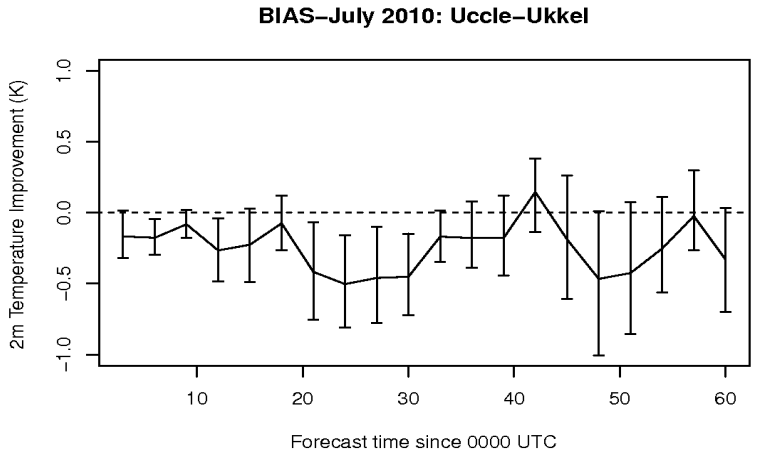
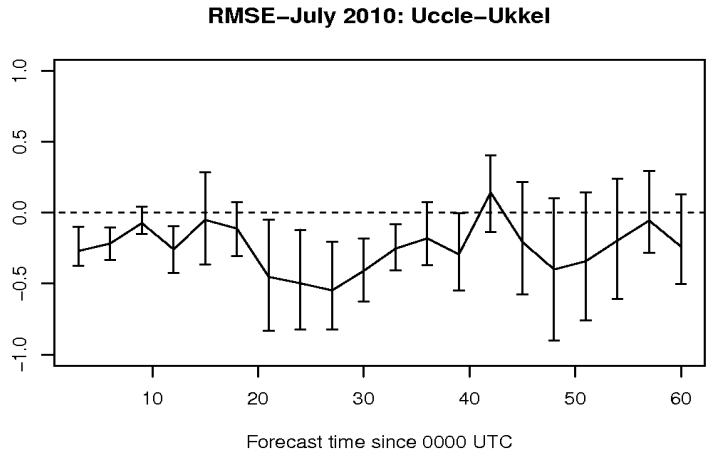






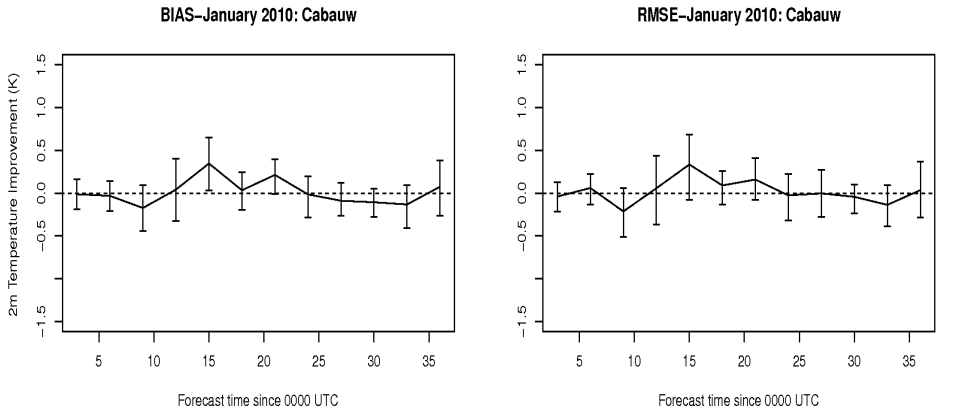


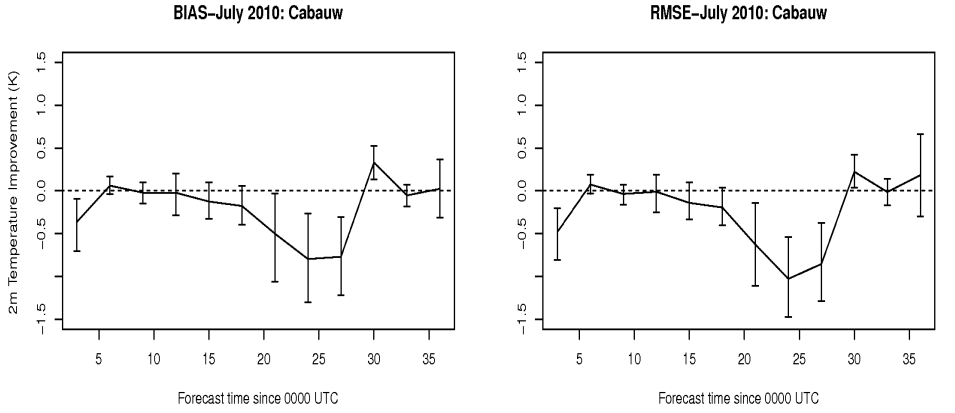
ALARO-OPER # ALARO-SURFEX 7km run over Belgium

Table 2. The average daytime/nighttime scores for the flat/high elevation and coastal synoptic stations, sign (+) means improvement, sign (0) means neutral effect, and sign (-) means degradation of the scores.

		$Winter_{NIGHT}$	$Winter_{DAY}$	$Summer_{NIGHT}$	$Summer_{DAY}$
2m Temperature	Flat	+	+	+	0
	High	0	-	0	+
	Coast	0	0	+	0
Wind speed at 10m	Flat	+	0	+	0
	High	0	0	0	0
	Coast	+	0	+	0
Wind direction at 10m	Flat	0	0	0	0
	High	0	0	0	0
	Coast	0	0	0	0
2m Relative humidity	Flat	+	+	+	0

ALARO-OPER # ALARO-SURFEX 4km run at CABAUW



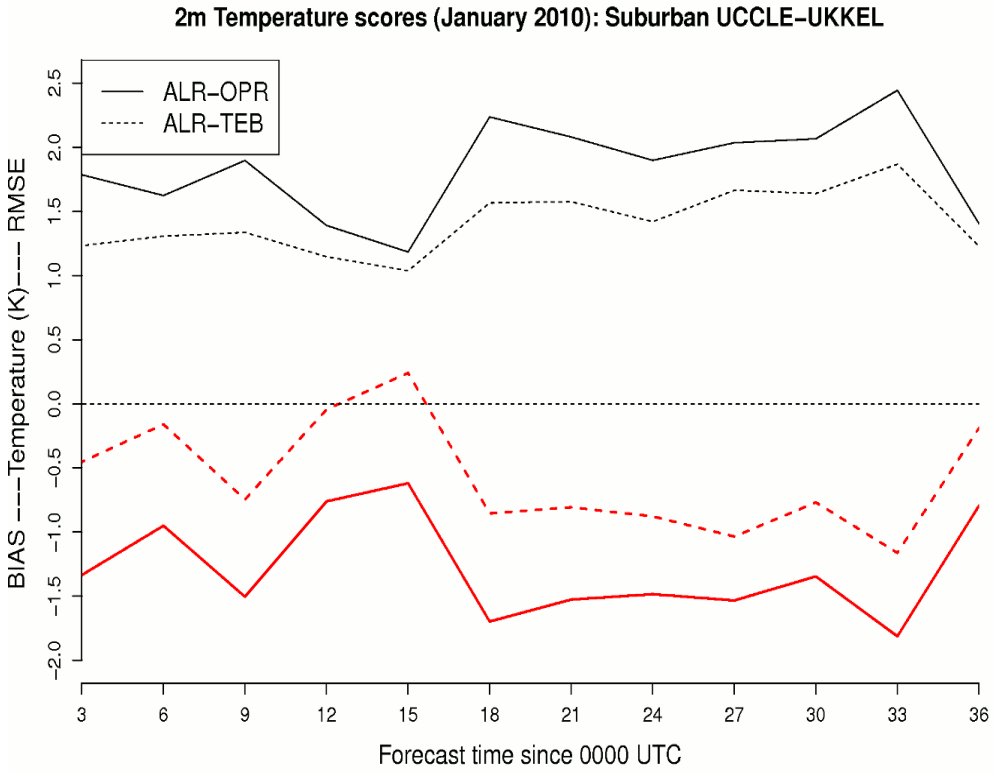


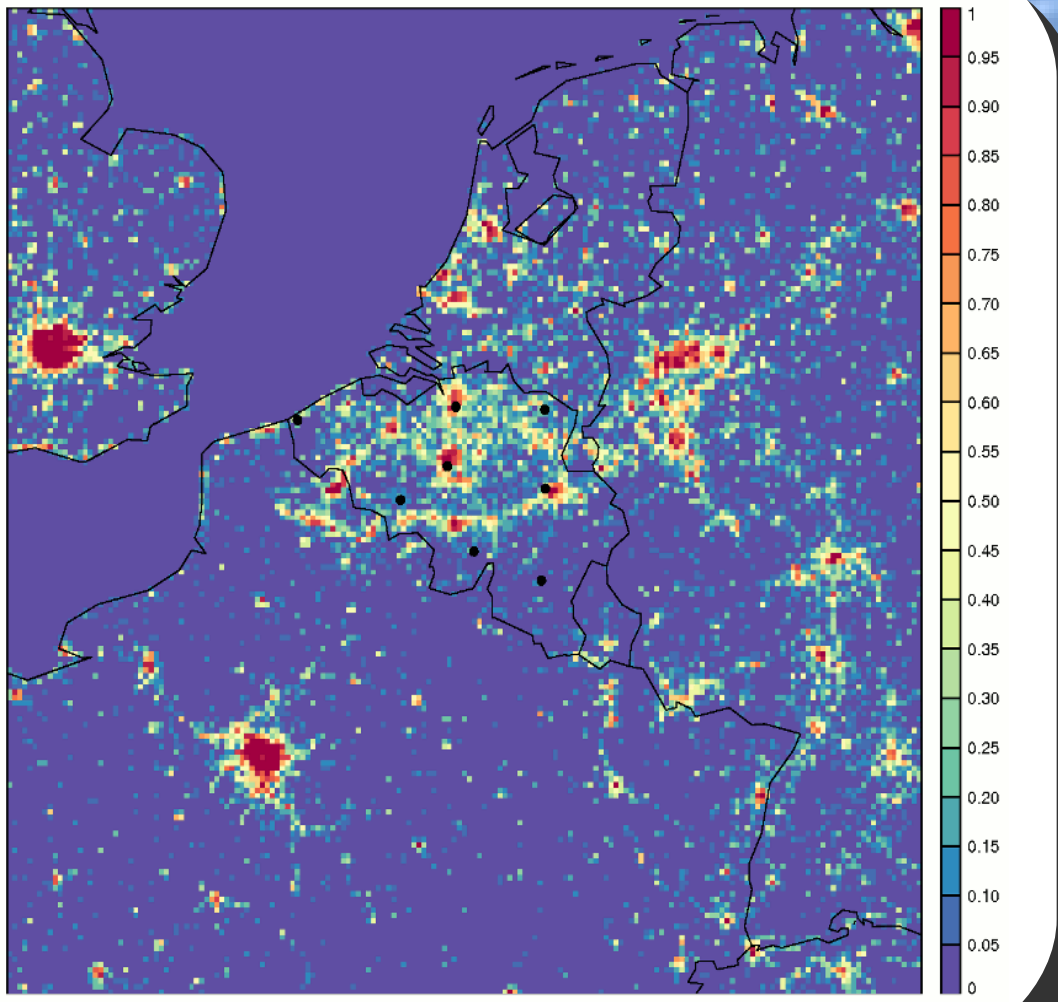
ALARO-OPER # ALARO-SURFEX 4km run at CABAUW

Table 5. The average daytime/nighttime scores for the radiative balance, energy balance at the Cabauw tower station, sign (+) means improvement, sign (0) means neutral effect, and sign (-) means degradation of the scores.

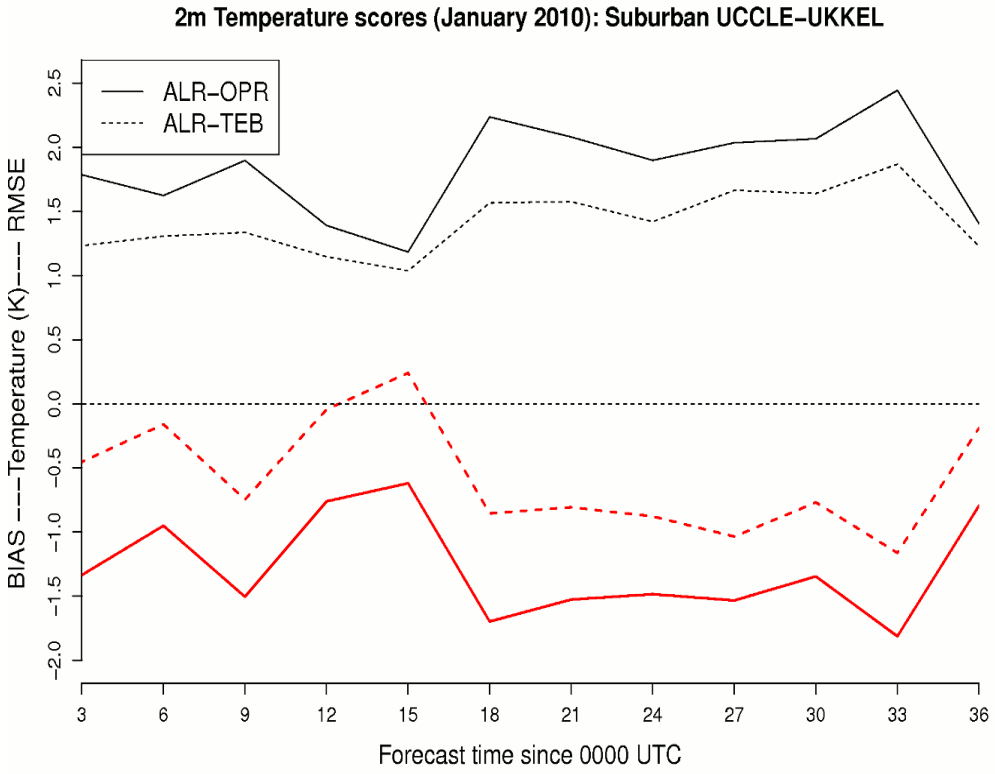
	$Winter_{NIGHT}$	$Winter_{DAY}$	$Summer_{NIGHT}$	$Summer_{DAY}$
Radiative Balance				
Long wave ↓	0	0	0	0
Long wave ↑	0	0	+	0
Short wave ↓	0	0	0	0
Short wave ↑	0	0	0	+
Energy Balance				
Latent heat flux	0	+	0	+
Sensible heat flux	0	0	0	+
Storage heat flux	+	+	+	+

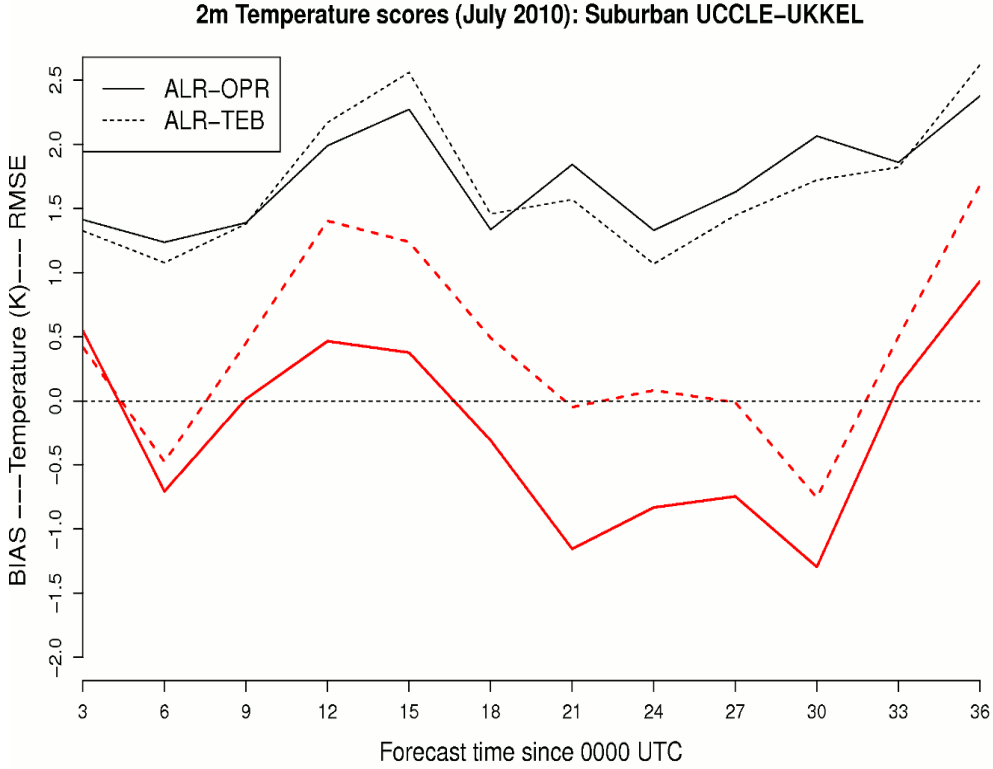
ALARO-SURFEX # ALARO-SURFEX-TEB 4km run



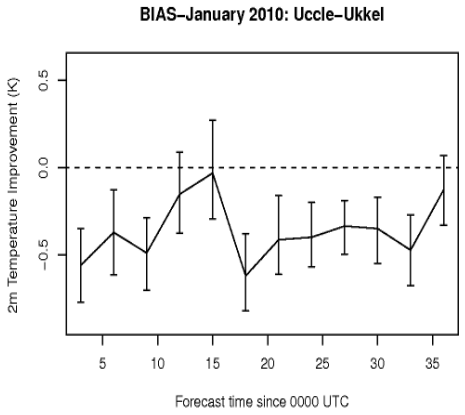


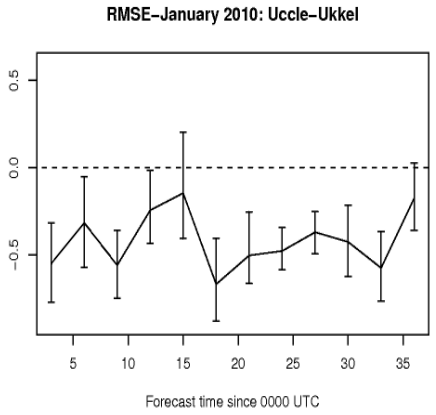
ALARO-SURFEX # ALARO-SURFEX-TEB 4km run

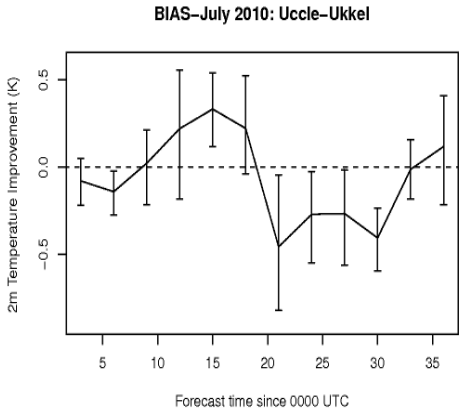


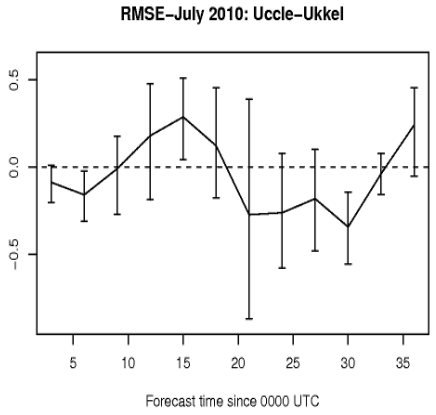


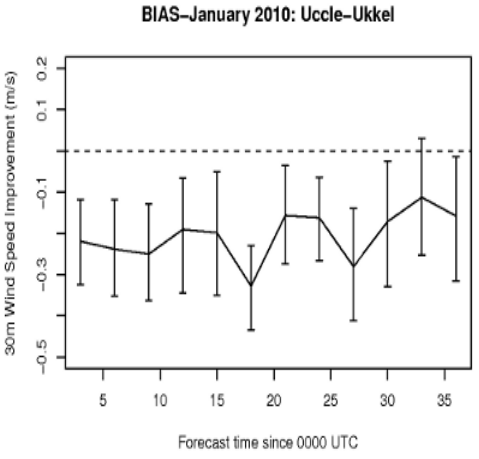
ALARO-SURFEX # ALARO-SURFEX-TEB 4km run

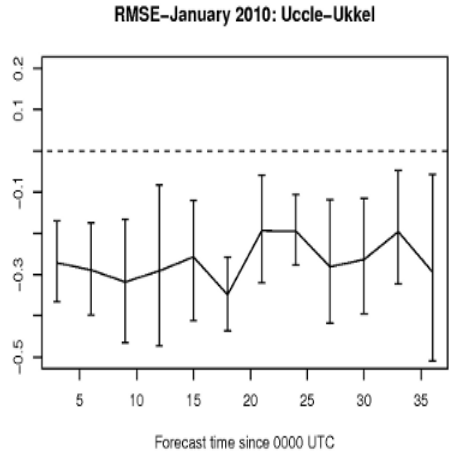


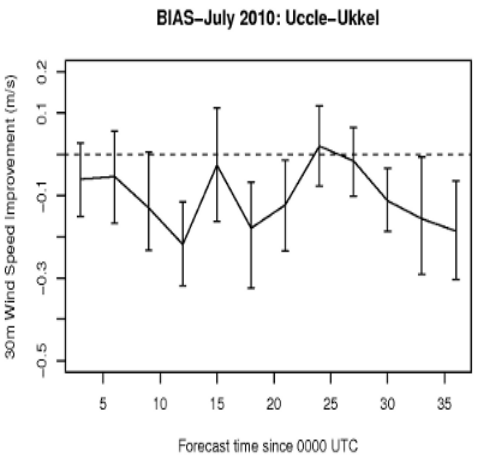


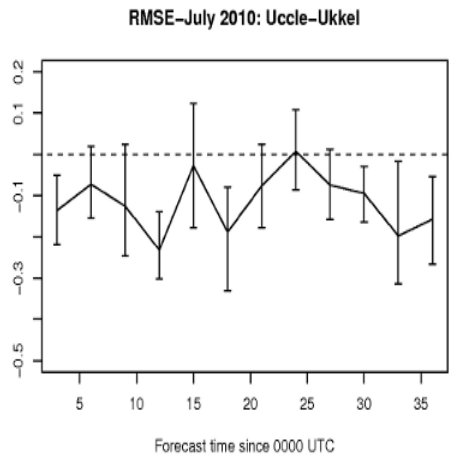












SURFEX: A NEW LAND SURFACE SCHEME FOR ALARO NWP

- **SURFEX/EKF: A NEW DATA ASSIMILATION METHOD**

SURFEX: A NEW LAND SURFACE SCHEME FOR REGIONAL CLIMATE APPLICATIONS

The EKF equation:

$$\mathbf{x}_t^a = \boldsymbol{x}_t^b + \mathbf{B}\mathbf{H}^T(\mathbf{H}\mathbf{B}\mathbf{H}^T + \mathbf{R})^{-1}[\boldsymbol{y}_t^o - \mathcal{H}(\boldsymbol{x}_o^b)]$$

The observation operator (includes a model propagation):

$$\mathcal{H}(.) \sim \mathbb{H}(\mathbb{M}(.))$$

The Jacobian of the observation operator:
(calculated with finite differences)

$$\mathbf{H} = \frac{\delta y^t}{\delta x^{t0}} = \frac{y_i^t(x^{t0} + \delta x_j) - y_i^t(x^{t0})}{\delta x_j}$$

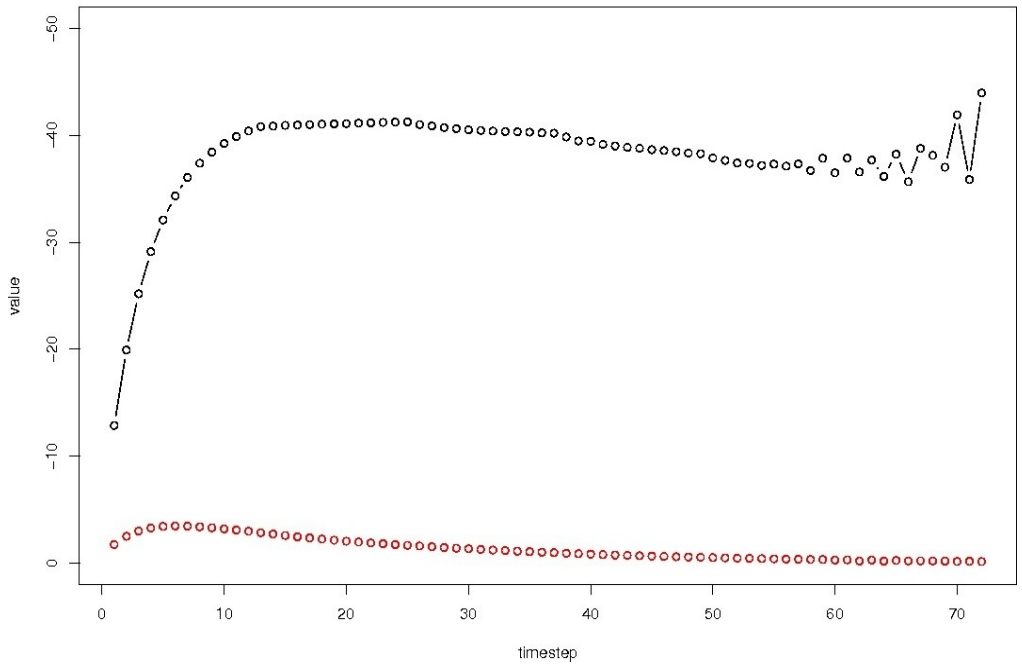
$$\mathbf{H} = \frac{\delta y^t}{\delta x^{t0}} = \frac{y_i^t(x^{t0} + \delta x_j) - y_i^t(x^{t0})}{\delta x_j}$$

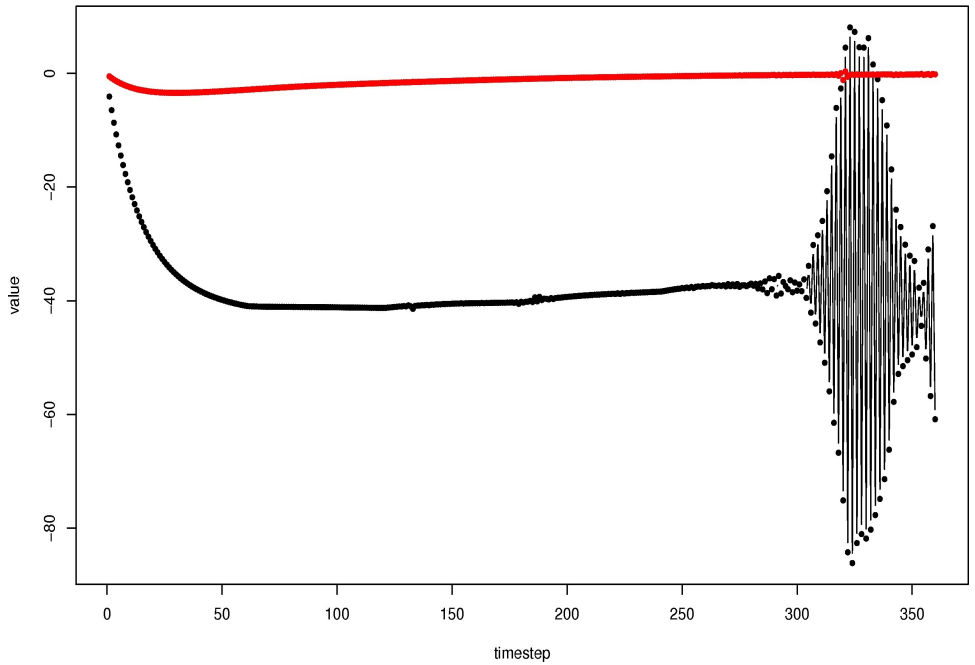
Calculation of the Jacobian:

- Perturb a component x_j of the control vector at time t_0
- Make a forecast to time t with the perturbed state
- Use the corresponding y_i at time t

--> one additional perturbed run for each component of the control vector

Jacobian of the EKF in SURFEX





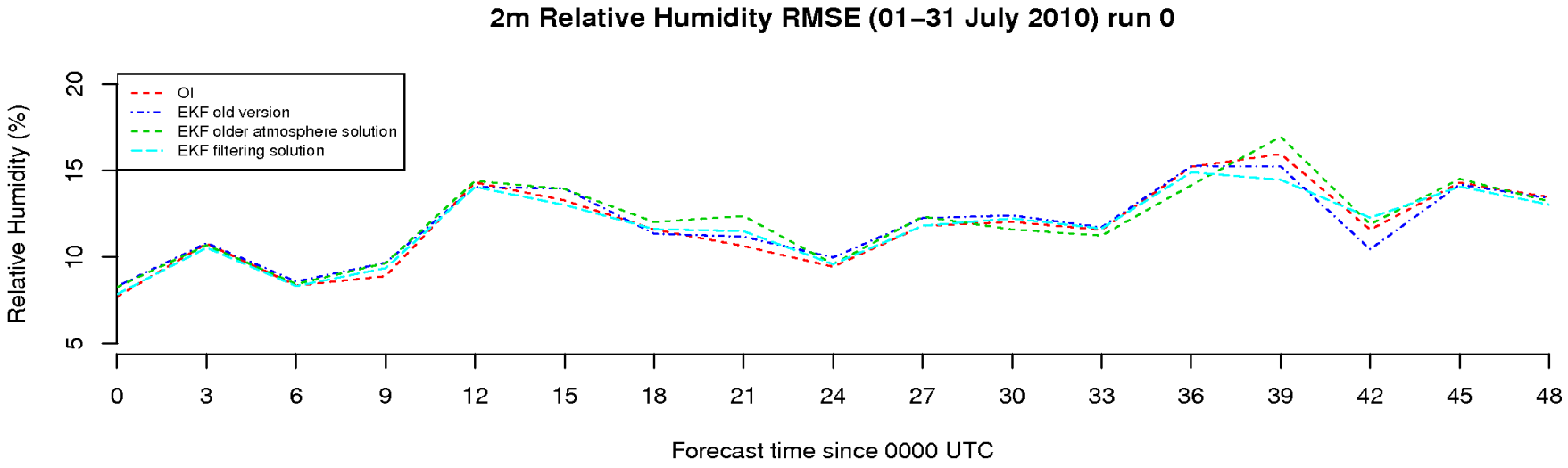
Evolution of dT2m/dWG1 (red) and dT2m/dWG2 (black) at 2 July 2010 from 12 UTC to 18 UTC with timestep 300s (left) and timestep 60s (right)

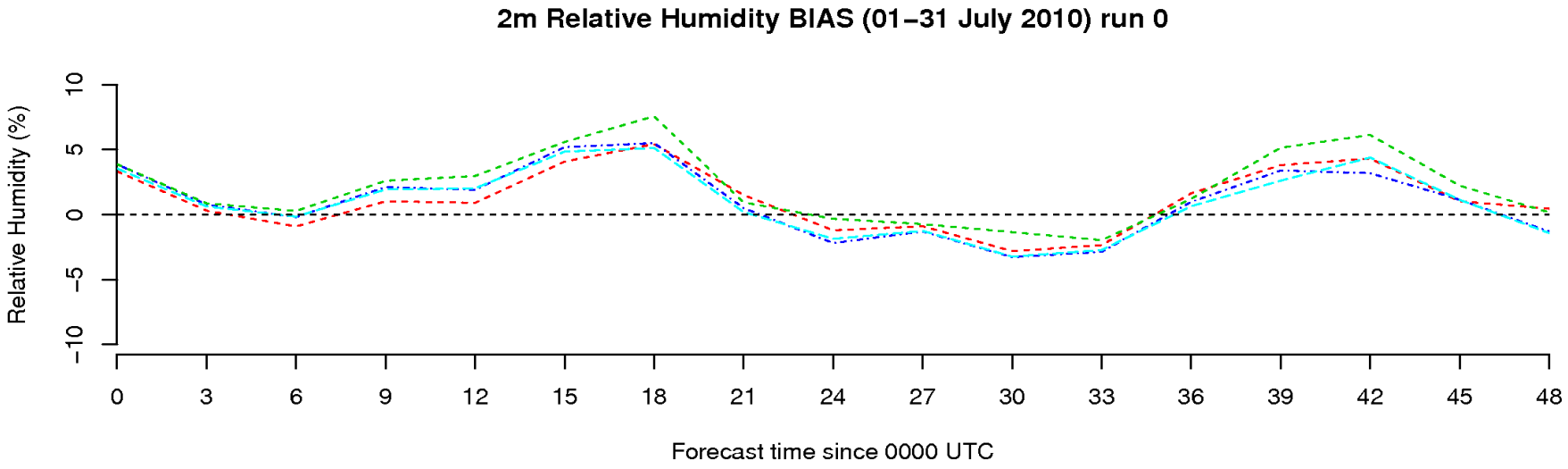
Problem:

- Decoupling of the surface and the atmosphere during sunset
- Creates very small oscillations in the fluxes BUT big oscillations in the Jacobian values

Solution:

- Filter the oscillation
- Use Canopy
- Use forcing files from an earlier run so the atmosphere has more time to adjust to the surface


2m Relative Humidity RMSE (01–31 July 2010) run 0
OI
EKF old version
EKF older atmosphere solution
EKF filtering solution
Relative Humidity (%)
5
10
15
20
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
Forecast time since 0000 UTC


2m Relative Humidity BIAS (01–31 July 2010) run 0
Relative Humidity (%)
−10
−5
0
5
10
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
Forecast time since 0000 UTC

SURFEX: A NEW LAND SURFACE SCHEME FOR ALARO NWP

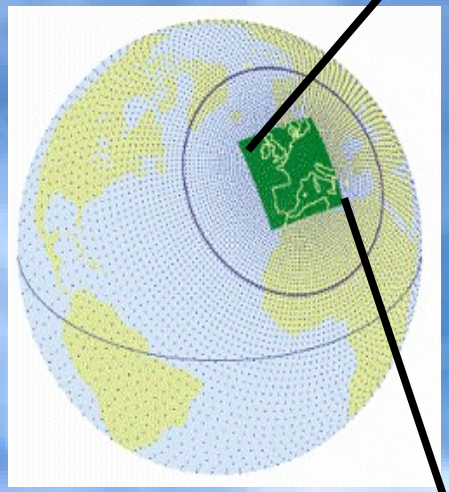
SURFEX/EKF: A NEW DATA ASSIMILATION METHOD

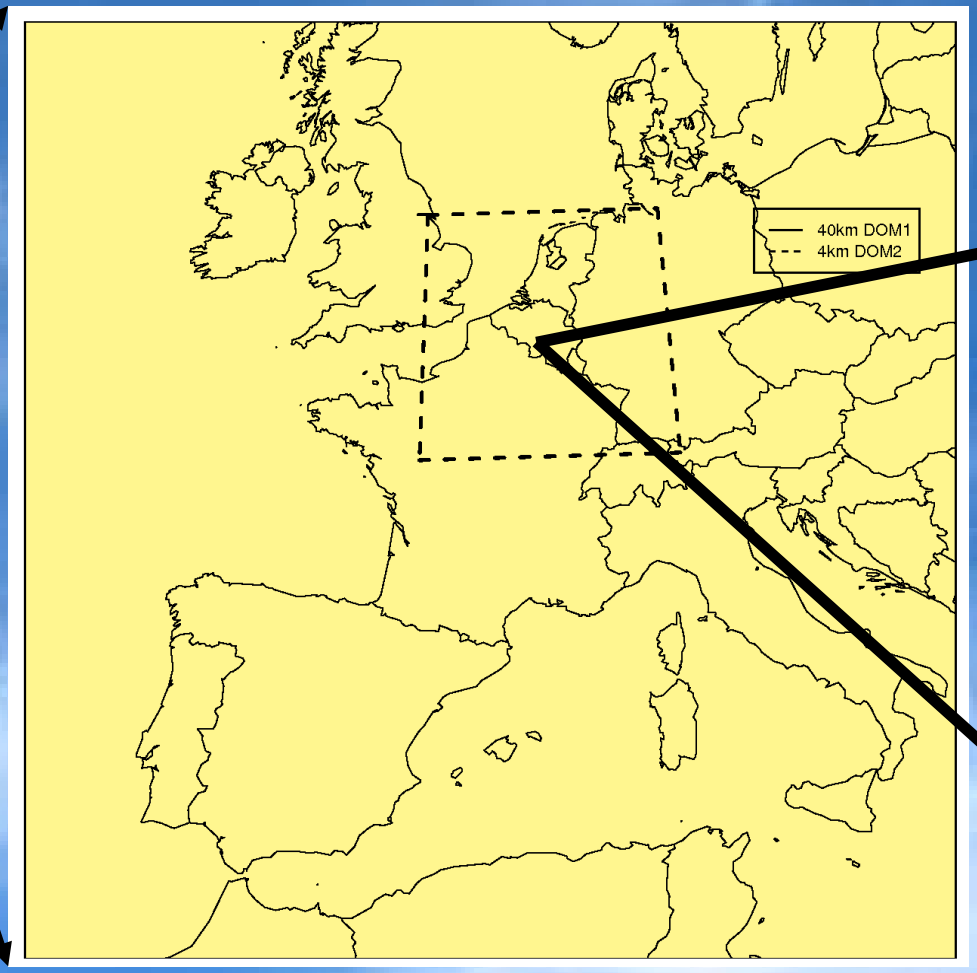
- **SURFEX: A NEW LAND SURFACE SCHEME FOR REGIONAL CLIMATE APPLICATIONS**

Dynamical downscaling using regional climate models (RCM)

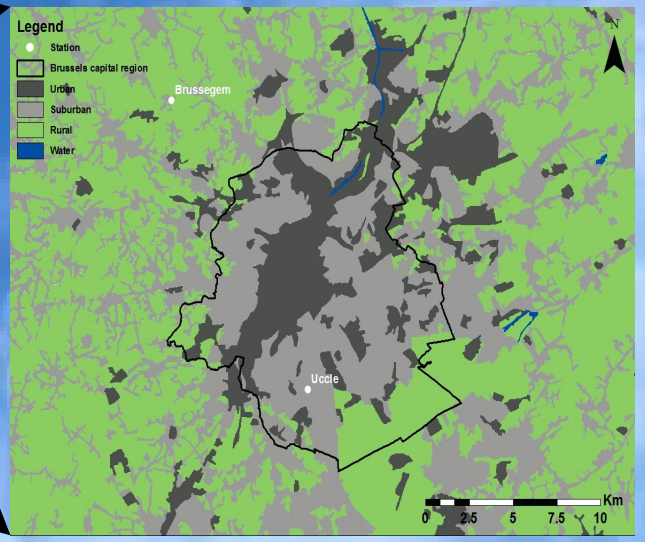
ALARO+SURFEX INLINE 40 km → 4km

GLOBAL





SURFEX OFFLINE 1 km



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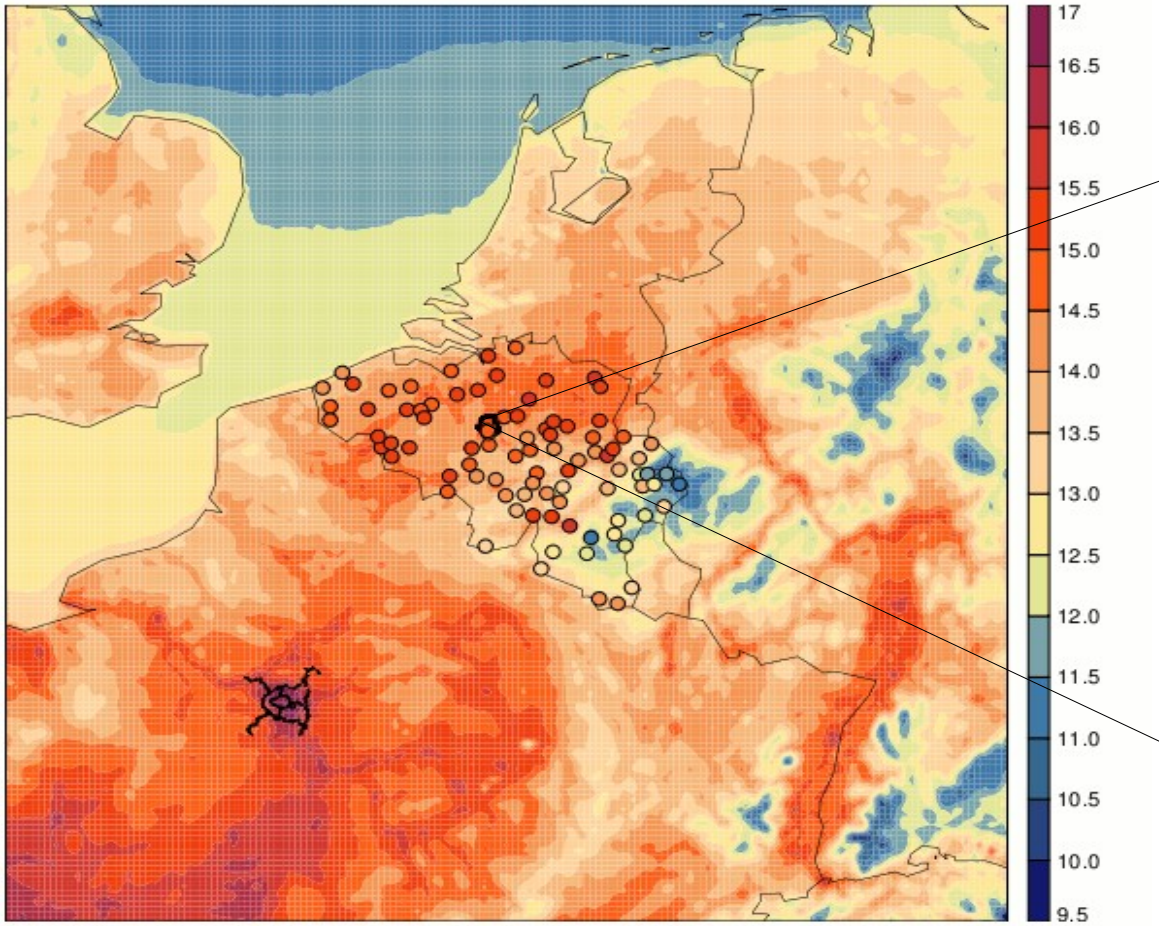
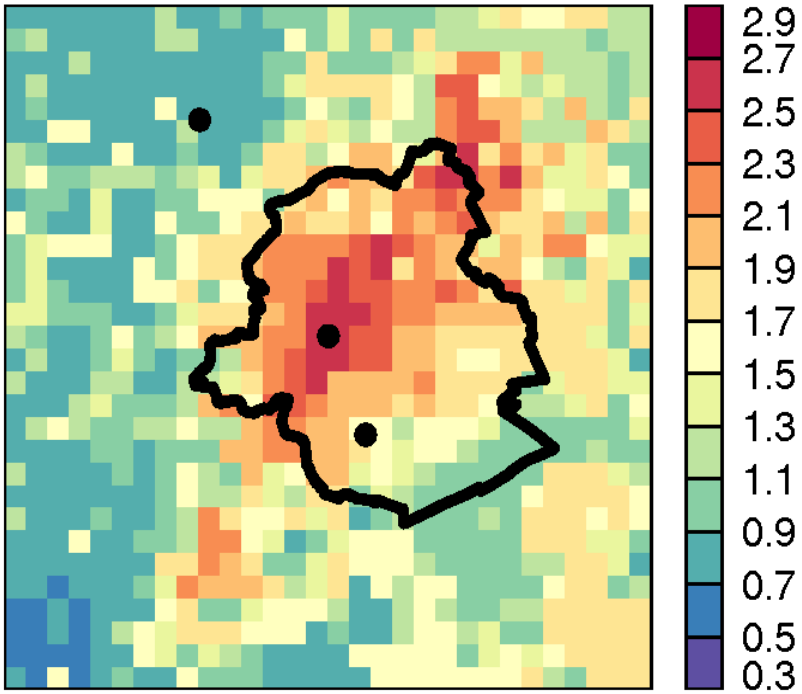


UHI of Brussels



1. Hamdi, R., Degrauwe, D., Duerinckx, A., Cedilnik, J., Costa, V., Dalkilic, T., Essaouini, K., Jerczynki, M., Kocaman, F., Kullmann, L., Mahfouf, J.-F., Meier, F., Sassi, M., Schneider, S., Váňa, F., and Termonia, P.: Evaluating the performance of SURFEXv5 as a new land surface scheme for the ALADINcy36 and ALARO-0 models, Geosci. Model Dev. Discuss., 6, 4053-4104, doi:10.5194/gmdd-6-4053-2013, 2013.

2. Combining an EKF soil analysis with a 3dVar atmospheric assimilation in a limited area NWP model. Duerincks et al. QJRMS to be submitted.