# HIRLAM NWP activities connected to use and development of SURFEX

**Patrick Samuelsson**
**SMHI**

**with contributions as acknowledged**

# General surface comments

Surface physics in SURFEX is in many aspects well beyond the needs in NWP applications but plenty of non-utilized potential exist! SURFEX includes more processes, implemented in a more consistent way, than HIRLAM surface ever did.

At the same time, our latest operational version, cy40h1.1, of the ALADIN-HIRLAM NWP system (HARMONIE-AROME model configuration) is in some important aspects less “advanced” over land than latest HIRLAM (still running at some centres):

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| Soil | Force-restore | Diffusion |
| Snow | Composite | Bulk-1L |
| Glacier | - | soil with ice properties |
| Assimilation | CANARI-OI | OI |
| | | |
| **Sea** | SICE | 2-layer ice scheme |
| **Lake** | Deep soil temp | Deep soil temp/FLake |
| **Town** | TEB | No (open land) |
| | | |
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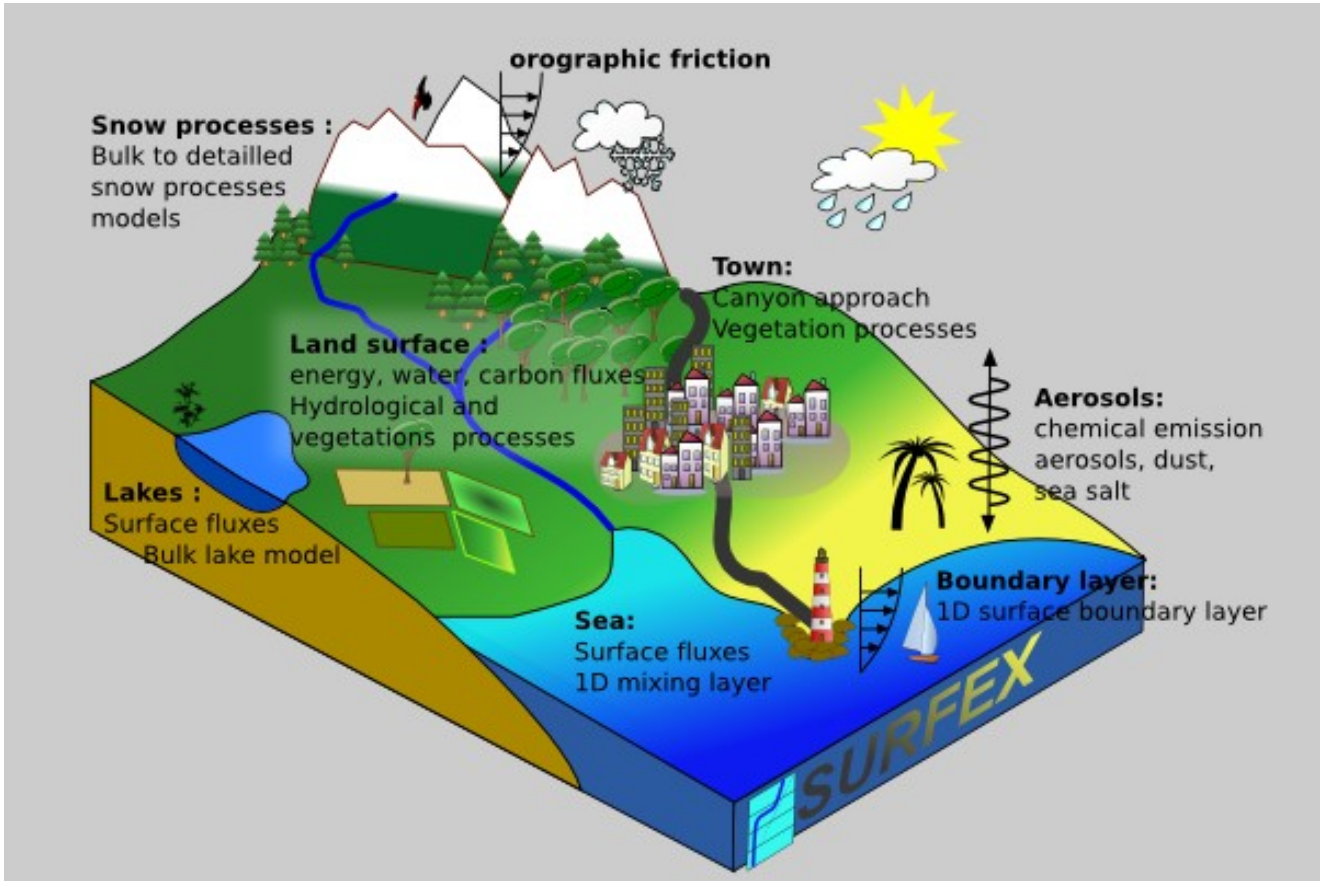
# Lake, Sea, Town, Nature



# Presentations at the Workshop from HIRLAM institutes

- Ekaterina Kurzeneva (FMI): Details around lake model FLake in SURFEX and HARMONIE
- Yurii Batrak (MetNorway): SICE: simple sea ice scheme. Possibilities and limitations
- Hanneke Luijting (MetNorway): Regional Snow Modeling in Norway with SURFEX/Crocus
- Mariken Homleid and Trygve Aspelien (MetNorway): From D95 to Explicit snow scheme- experiences from offline and plans for NWP
- Emily Gleeson (Met Éireann): Modelling Glaciers in the ALADIN-HIRLAM NWP System.
- Juan Carlos Sanchez Perrino (AEMET): Implementation of water table dynamics in SURFEX based on explicit diffusion equations.

**Activities I include but not mentioned by others at the Workshop:**

- David Segersson & Jorge H. Amorim (SMHI): Urban SIS: high resolution climate data for cities
- Magnus Lindskog & Patrick Samuelsson (SMHI): Replacing OI with EKF for Force-restore/D95 snow setup.
- FMI group: Snow analysis by the
- Mariken: Moving from CANARI to MESCAN
- Patrick, Trygve, Mariken et al.: 2 patches
- Bolli (IMO): Improvements over Iceland with new physiography

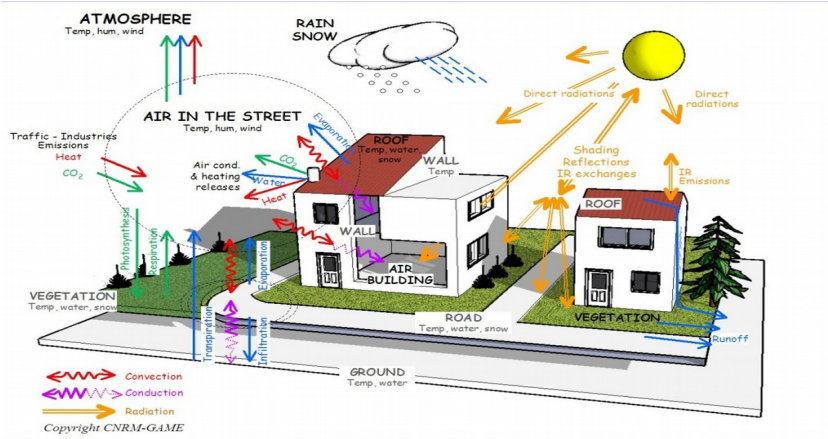



2006-2007
2012-2014

# Urban SIS:

# high resolution climate data for cities

A database for end-users working with infrastructure & health in the urban environment




**David Segersson & Jorge H. Amorim**

On behalf of ECMWF for the European Commission

SMHI

Copernicus
Europe's eyes on Earth

# UrbanSIS - Refining the urban surface

| Data category | Product | Spatial resolution (m) | Source data type | Webpage |
|---|---|---|---|---|
| **European physiography** | **ECOCLIMAP II (default HARMONIE)** | 1000 | ECOCLIMAP-I, GLC2000, MODIS | https://opensource.cnrm-game-meteo.fr/ |
| ***Enriched with:*** | | | | |
| **Spatial coverage of land cover types** | Copernicus Land Monitoring Services: Urban Atlas 2012 | 100 | Satellite data PROBAV v1.4 | http://land.copernicus.eu/local/urban-atlas |
| **Building polygons** | OpenStreetMap | nd | Various sources | https://www.openstreetmap.org |
| **Time-series of LAI** | Copernicus Global Land Service | 1000 | Satellite data | http://land.copernicus.eu/global/themes/vegetation |
| **Building+tree heights** (exclusively for Stockholm case) | Swedish Forest Agency | 12.5 | Lidar measurements | http://www.skogsstyrelsen.se/Myndigheten/Om-oss/Oppna-data |

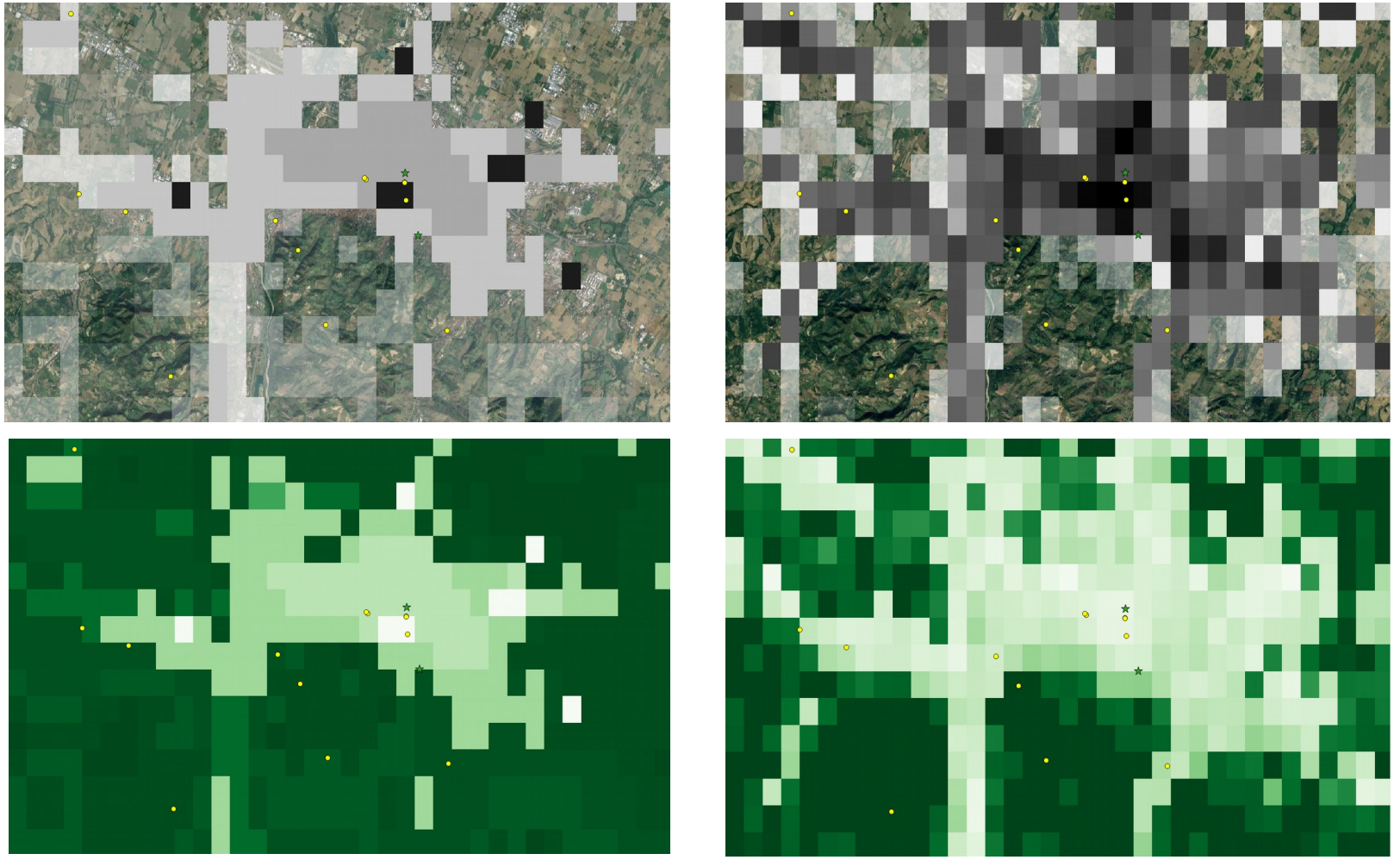
## Selection criteria for data sources:

*Accuracy/reliability *Spatial (& time) resolution *Availability

# UrbanSIS - Refining the urban surface for Bologna

## Default ECOCLIMAPII:

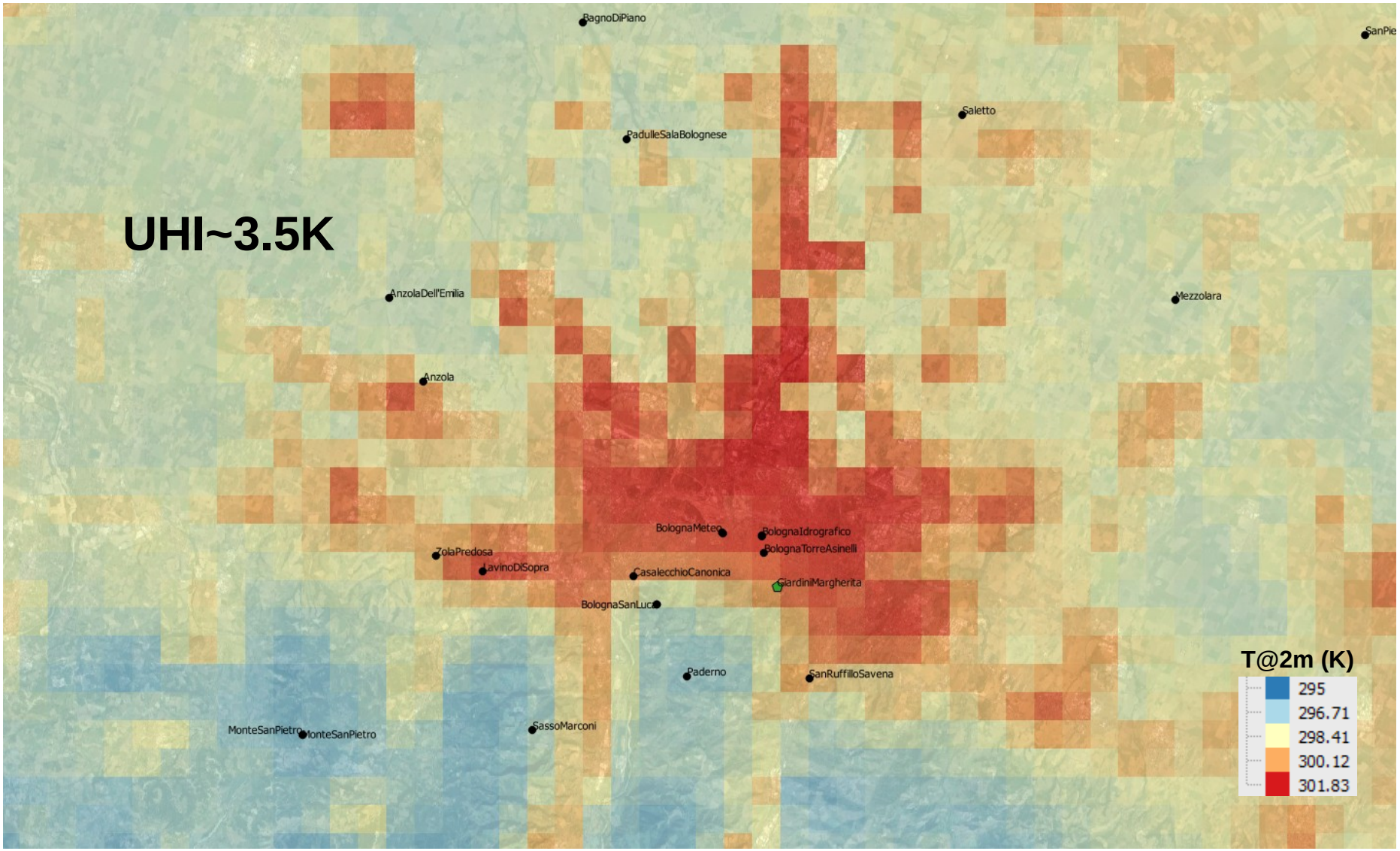
## New refined physiography:




The intra-city gradients of building density and vegetation fraction are more refined with inclusio of the enriched data sets.

# UrbanSIS - Urban Heat Island (UHI) effect over Bologna

## Monthly mean temperature@2m - July 2012



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# Is it necessary to increase the land process complexity?

**Yes!**

With current Force-restore scheme we have a memory in the soil energy/ temperature of roughly 1 day. This is not enough to give reasonable conditions for e.g. evapotranspiration.

The current composite soil/snow/vegetation (one single energy budget) gives e.g. wrong Bowen ratio (= SHF/LHF) and wrong ground heat flux.

Thus, these simplified parametrisations cause biases (in e.g. T2m, Rh2m) which we now try to correct for with surface data assimilation. But, we should not rely (so much) on data assimilation to fix biases.

We have plenty of examples where duty forecasters complain on the performance of the current operational system for near-surface conditions (supported by continuous verification) and where some of these complains can be attributed to lack of proper process descriptions. E.g. excess Rh2m over Scandinavia in spring time.

Utilisation of satellite radiances (in combination with observation operators) in surface data assimilation requires more relevant model variables (e.g. snow surface conditions).

# Surface data assimilation

Two main reasons why we must leave current OI (Optimal Interpolation) behind:

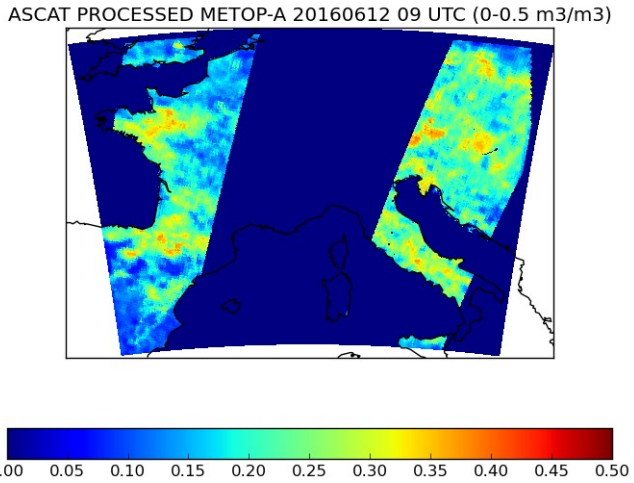
- Increased process complexity (increase in prognostic variables from ~10 to ~100).
- Utilisation of remote sensing products/radiances.

In near future the current OI (Optimal Interpolation) will be replaced by EKF (Extended Kalman Filter) methods but the longer term plan is to go for EnKF (Ensemble Kalman Filter) methods.

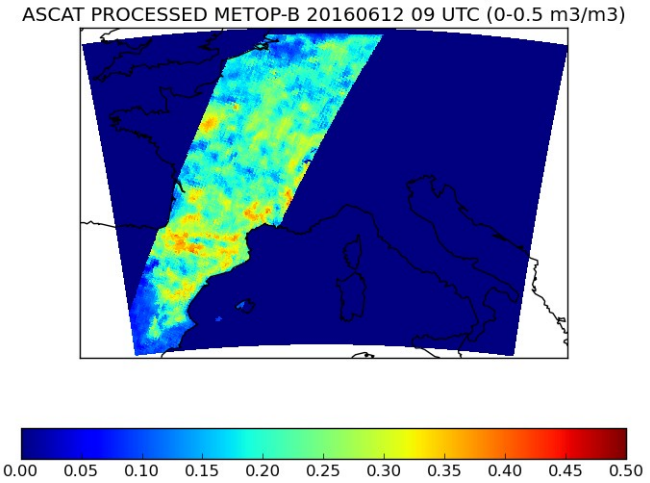
Two main reasons why EnKF should be better than EKF:

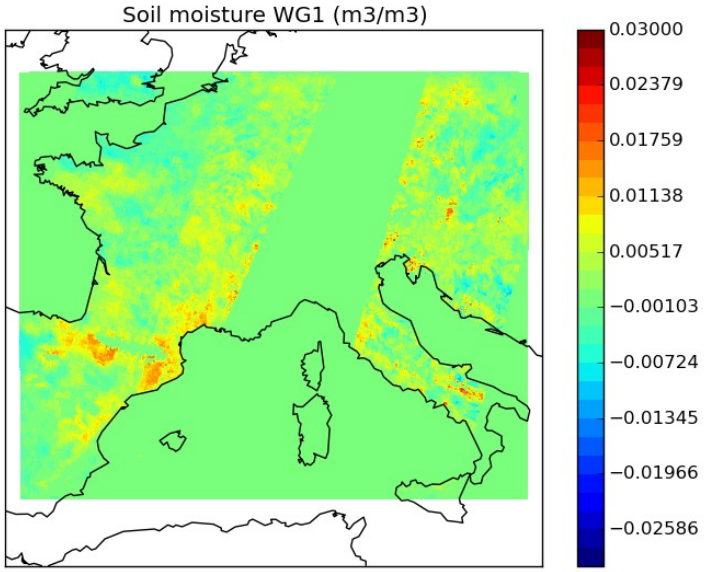
- Easier because one avoids the assumption that the system is required to behave linearly and one avoids the sensitive choice of size of perturbations.
- Fits better with EPS activities where atmosphere and surface can be perturbed simultaneously in a consistent way.

# Surface Data Assimilation of ASCAT data using EKF




**ASCAT A & B**
**2016-06-12**
**09 UTC**




**EKF based surface data assimilation WG1 increments 2016-06-12 09 UTC**

EU-IMPREX work by Magnus Lindskog (SMHI)

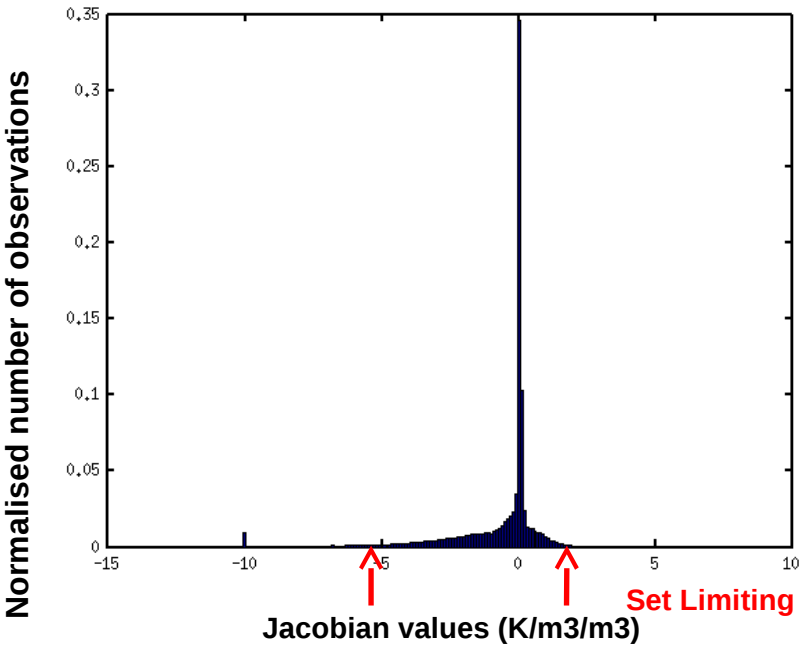
# Surface Data Assimilation of ASCAT data using EKF

## Tuning of the EKF system needed

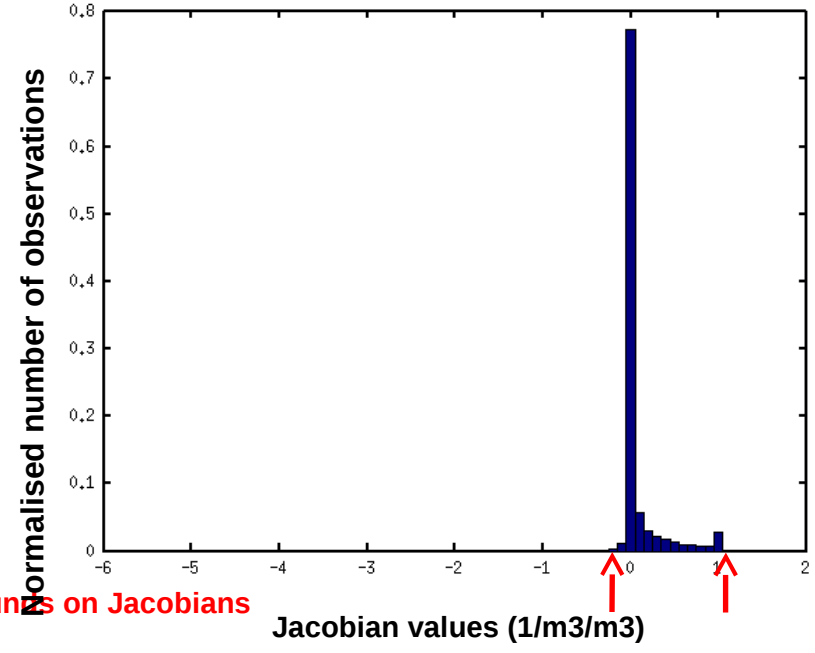
- Error specification
- Handling of large and noisy Jacobians

$$\mathbf{H}_{ij} \simeq \frac{\mathbf{y}_i(\mathbf{x} + \delta x_j) - \mathbf{y}_i(\mathbf{x})}{\delta x_j}$$

**dT2m/dT1**




**dRH2m/dwg1**




Set Limiting bounds on Jacobians

Consider the treatment of oscillations discussed by Annelies Duerinckx: oscillations occurring at critical values of the Richardson number when changing from an unstable to a stable boundary layer. She shows that the impact of these oscillations can easily be cured with a simple numerical temporal filter.

# Snow analysis

A visiting student at FMI, Maxime Quenon, has published a report on “Visual and Statistical Analysis of Snow Cover” where snow extent (SE) and Snow-Water Equivalent (SWE) simulated by cy38h1.2 HARMONIE-AROME-SURFEX has been compared with SYNOP snow depth, MetOp and MSG SE and Globsnow SWE. Report available via hirlam.org.

Next step is to utilize the satellite SE product H-SAF. Other possible sources of satellite snow-related information are H-SAF SWE, based on microwave data (similar to Globsnow), and L-SAF albedo.

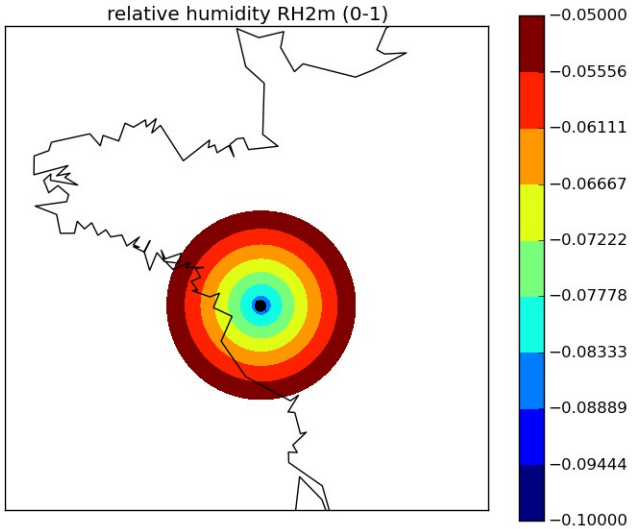
Please talk to Ekaterina Kourzeneva (FMI) if you are interested in details and plans.

# Move from CANARI to MESCAN

Horizontally varying background error statistics in MESCAN.

Impact of one single SYNOP Relative Humidity observation at Rh2m (%). The observation is located close to the west coast of France and the observed Rh2m is approximately 15 % less than the corresponding model value.

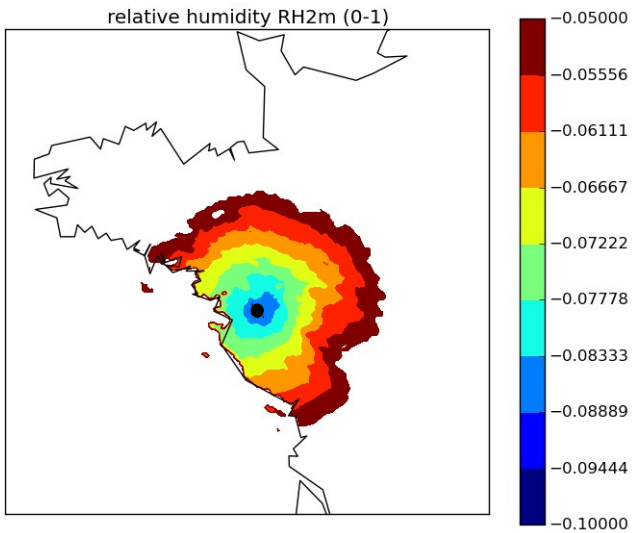
Current Method in CANARI




$$ro12=exp(-r/2a)$$

a – 85 km

Improved Method in MESCAN




$$Corr(r_{ij}, d_p, d_z) = 0.5\left[e^{-\frac{r_{ij}}{L}} + \left(1 + \frac{2r_{ij}}{L}\right)e^{-\frac{2r_{ij}}{L}}\right] \cdot F_p(d_p)F_z(d_z)$$

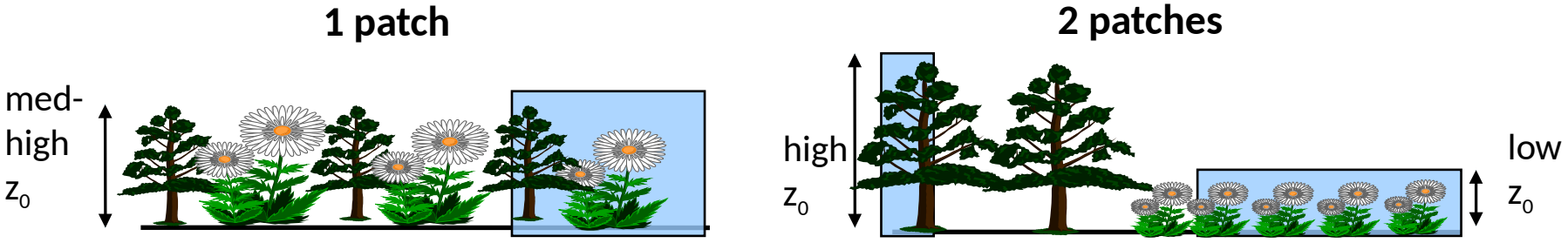
L – 195 km
(vertical correlation scale ~500m)

Magnus Lindskog, Tomas Landelius (SMHI) Mariken Homleid (MetNorway)

# Problem with too cold/moist spring conditions in cy38h1.2

Over Scandinavia HARMONIE-AROME (cy38h1.2) and HIRLAM (E05 at SMHI) differ in dividing available net radiation at surface into sensible and latent heat fluxes during spring situations leading to too cold/moist near-surface conditions in cy38h1.2.
Similar problem is reported over the Netherlands...

**One hypothesis is that using 2 patches in SURFEX instead of 1 can help this problem (similar to HIRLAM 7.4). A test branch of cy40h has been setup by MetCoOp with modified OI for 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.

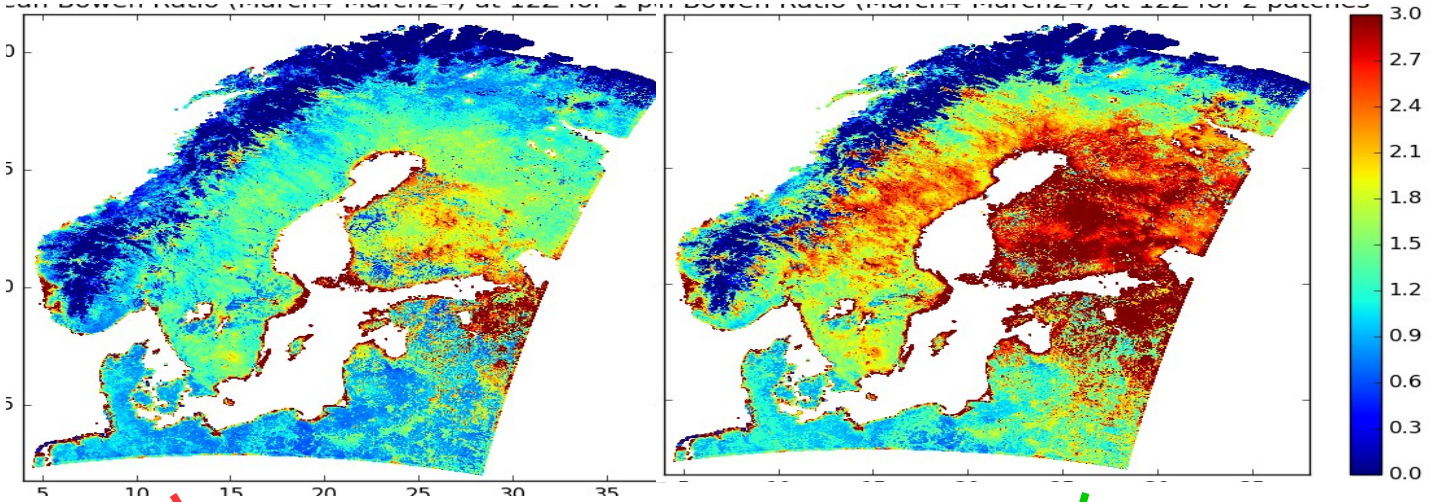
People involved: Trygve Aspelien, Patrick Samuelsson, Mariken Homleid, Karl-Ivar Ivarsson, Javier Calvo Sanchez

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

March 2016

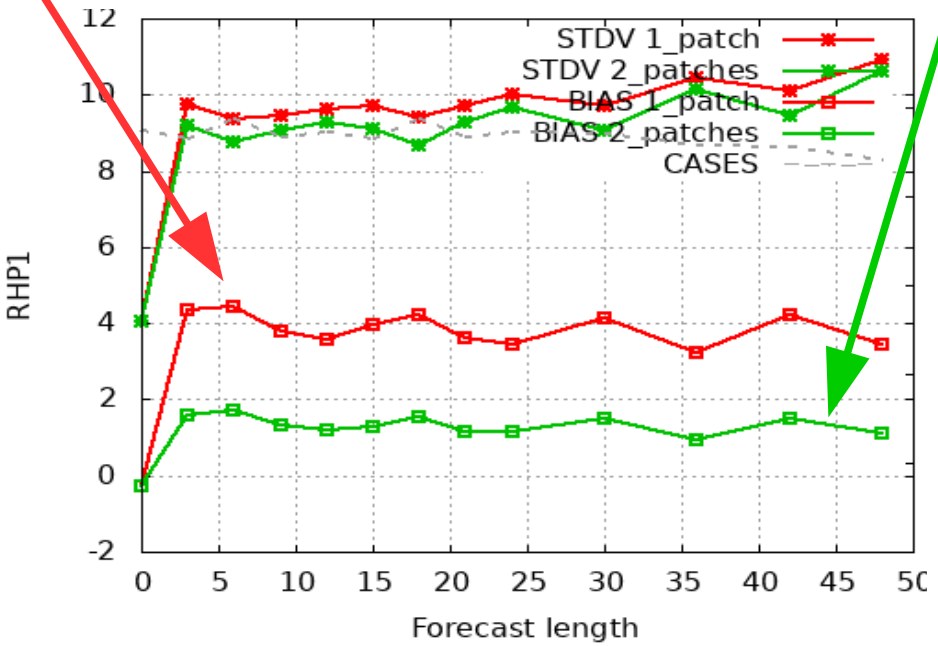
1 patch

2 patches




Bowen ratio = H/LE

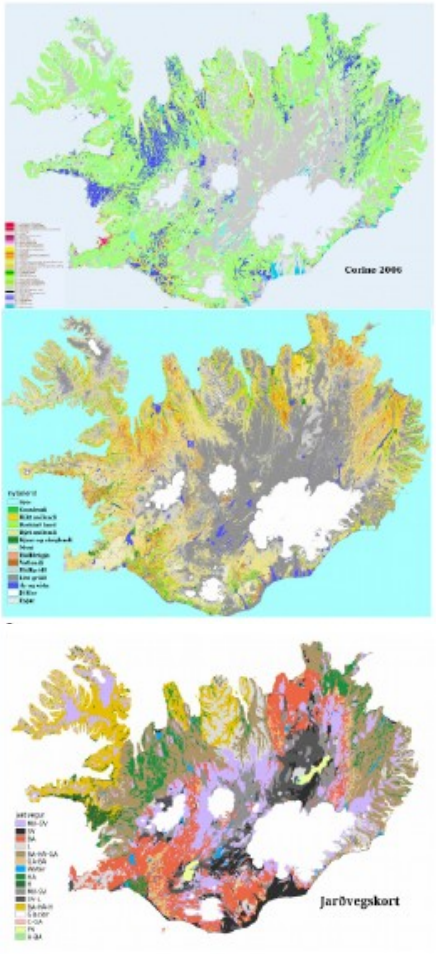
Rh2m




**Promising results:** 2 patches will be available in cy40h1.2.
**But**, still considerable bias in late spring.
**Hypothesis**: transpiration starts in the model while in reality it does not, due to still cold/frozen ground.
**Solution**: diffusion soil scheme!

# Improvements over Iceland with new physiography

Bolli Palmason et al (IMO, Icelandic Met Office)

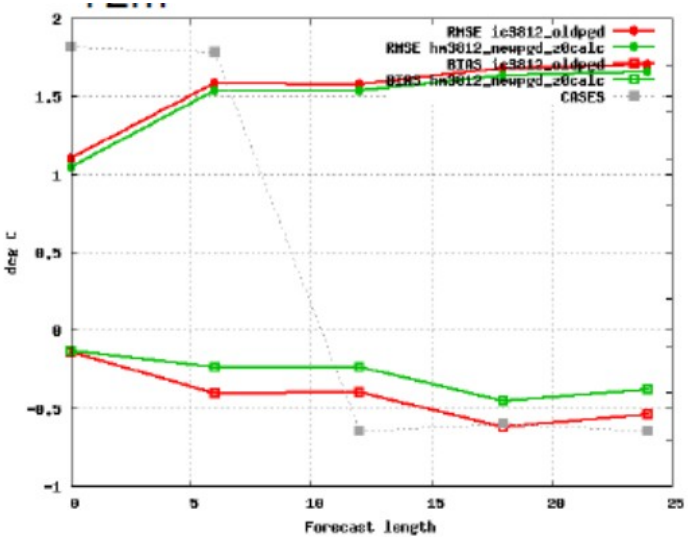



**Modified ECOCLIMAP for Iceland based on four databases:**

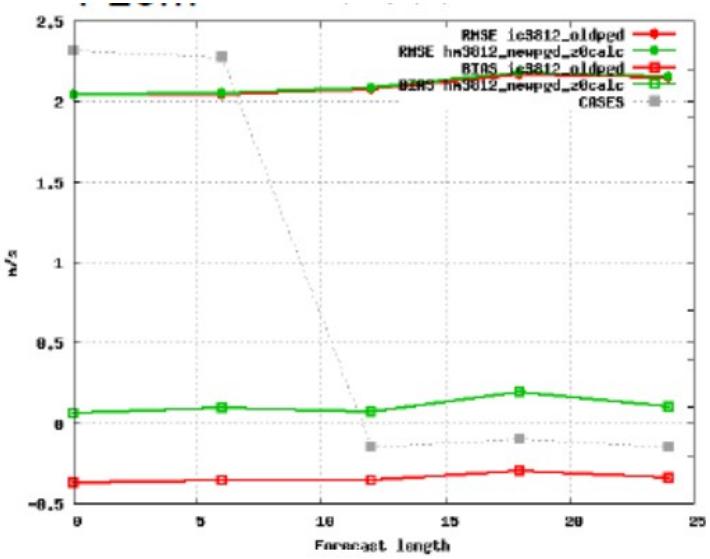
- Corine 2006
- Agricultural Univ. of Iceland (AUI) soil map
- AUI vegetation map
- MODIS LAI

Experiments for July 2012 with **OLD PGD** and **NEW PGD**
Biases decrease for

T2m




U10m




THANKS!