Development of surface physics and assimilation in HIRLAM

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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Land		
Patches	1	1-3 (incl. expl. canopy)
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)
Physiog.	ECOCLIMAP	FAO

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Glacier	-	soil with ice properties	Explicit snow as glacier
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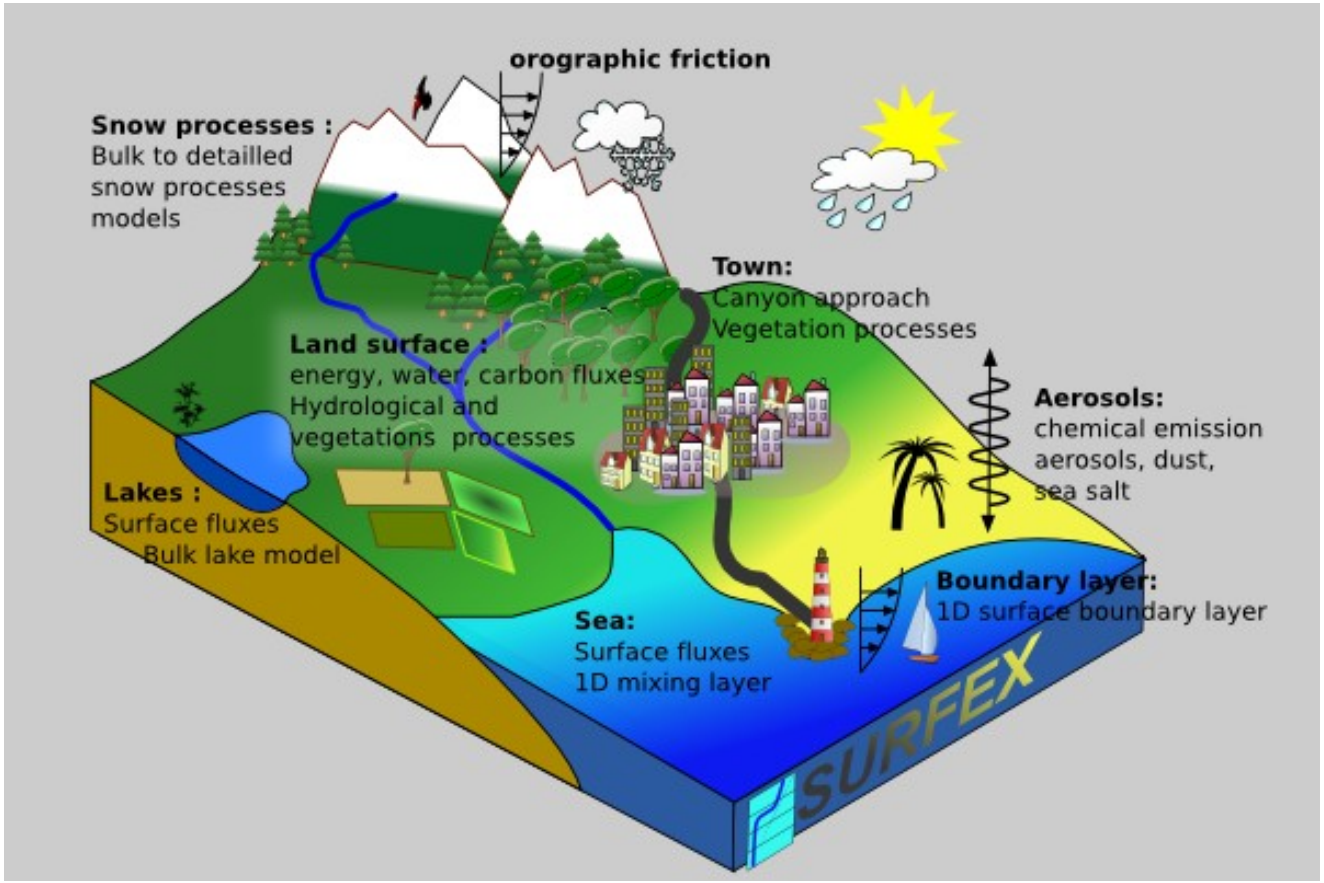
Lake, Sea, Town, Nature

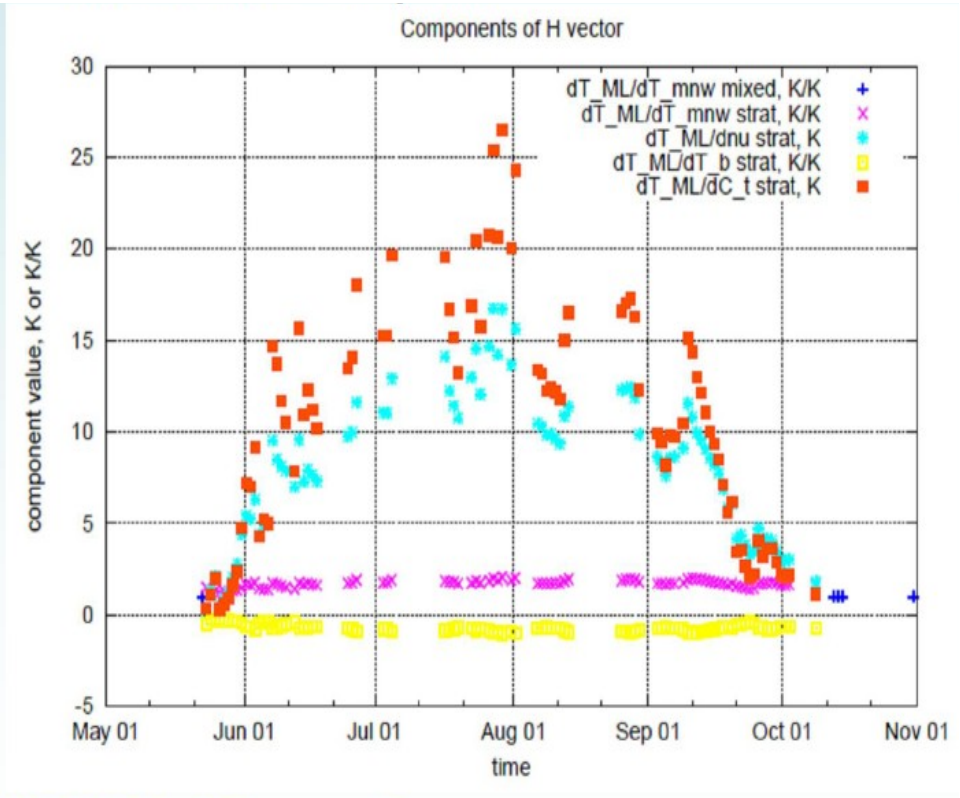


Lakes – FLake modelling and DA

FLake is already used operationally in NWP by e.g. HIRLAM/FMI, COSMO and ECMWF and in climate applications of the ALADIN-HIRLAM system using the HARMONIE-Climate configuration.

Currently we are working on making the lake model FLake operational in cy40h. It will run in so called “peaceful coexistence” without data assimilation.

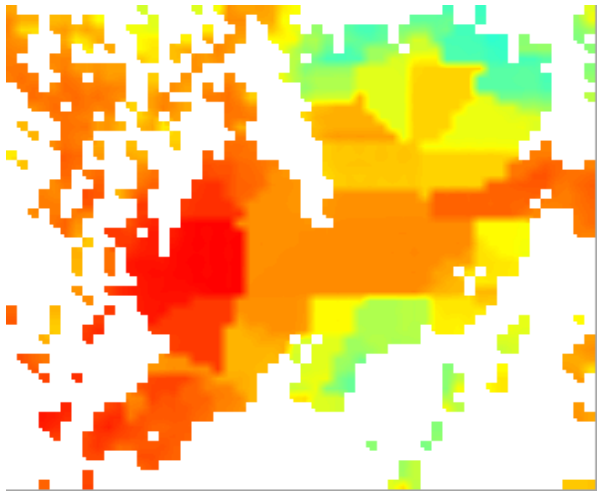
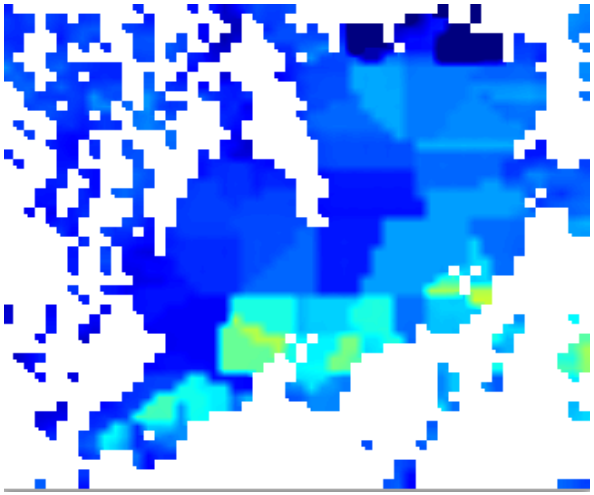
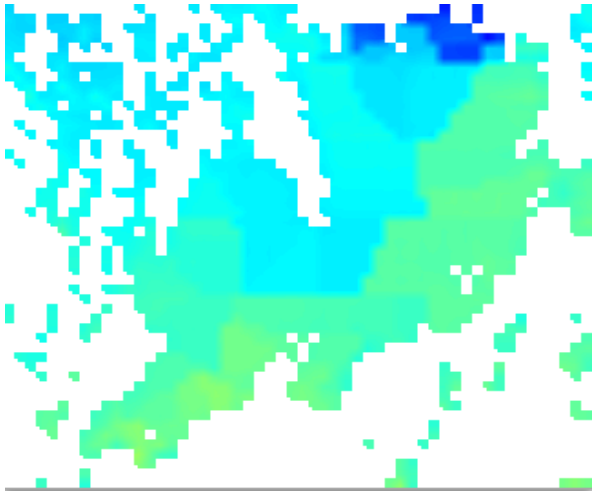
In parallel Ekaterina Kourzeneva (FMI) is working on EKF assimilation methods for lakes.
Studies are done of EKF Jacobian behaviour and of structure functions for lake surface temperature from observations.
Radius of influence is in the order of 1000 km!
See FMI poster!



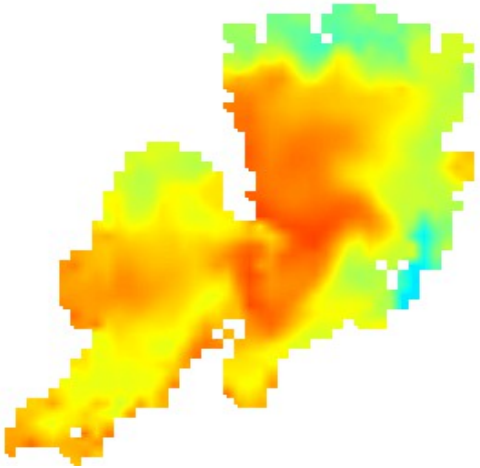
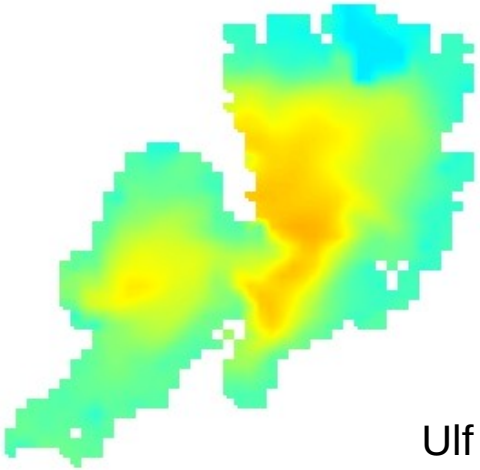
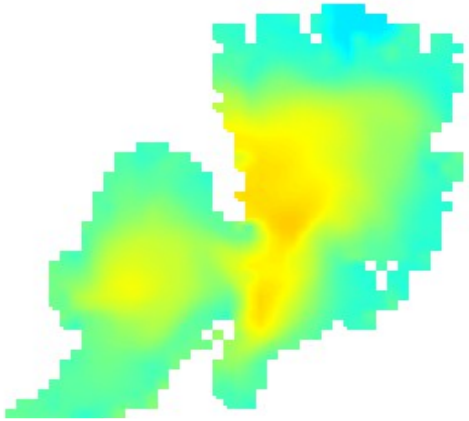
Ocean model for big lakes (Vänern, Sweden, 5650 km^2)

Feb 10 2016 **Feb 25 2016** **March 5 2016**

Former: Extrapolate 2nd layer soil temperature to lake surface temp

Current: Running ocean model HIROMB (soon NEMO)

Ulf Andrae (SMHI) & ocean colleagues

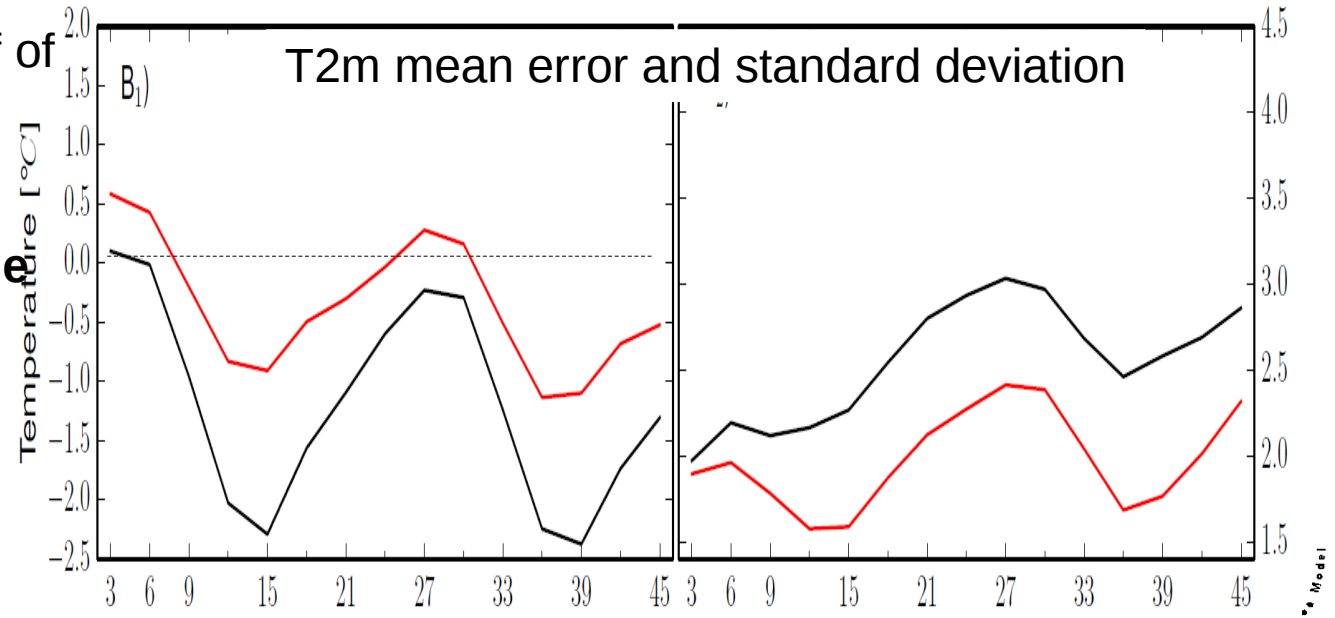
Sea, sea-ice modelling and DA

Since cy38h1.2 the “Simple Ice” model (SICE) by Yurii Batrak (MetNorway) is running operationally in the HARMONIE-AROME configuration. SICE uses the SURFEX diffusion soil scheme with ice characteristics. The HIRLAM intention is to make SICE an official contribution to SURFEXv9.

However, there is no assimilation available for sea-ice conditions yet...

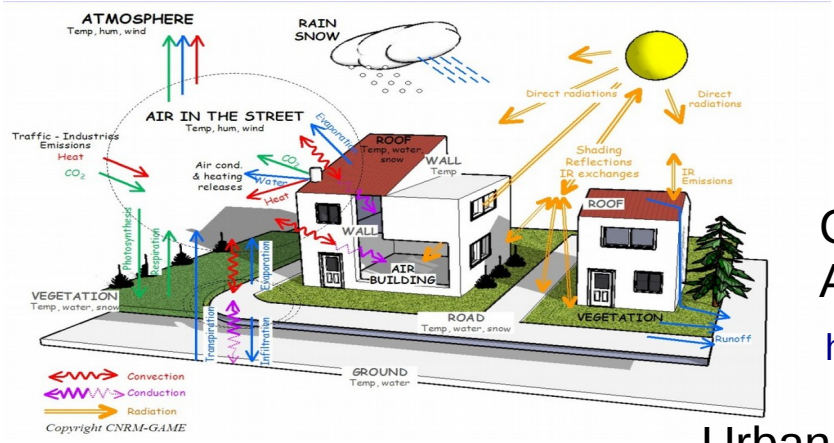
Currently, SST is initialised in SURFEX PREP and kept constant during the forecast. Next step: (i) update SST during forecast if such SST fields exist (from an operational ocean model), (ii) Use e.g. SURFEX 1D oceanic mixing layer model. (iii) ...

Seven stations in the Gulf of Bothnia for March 2013.
HARMONIE-AROME configuration
without the SICE scheme
with the SICE scheme



Town

The Town-Energy Balance (TEB) model of SURFEX is used operationally in cy40h1.1 & in HARMOINIE-AROME config applied over Stockholm with 1 km res.



SMHI

Copernicus
Europe's eyes on Earth

Urban SIS

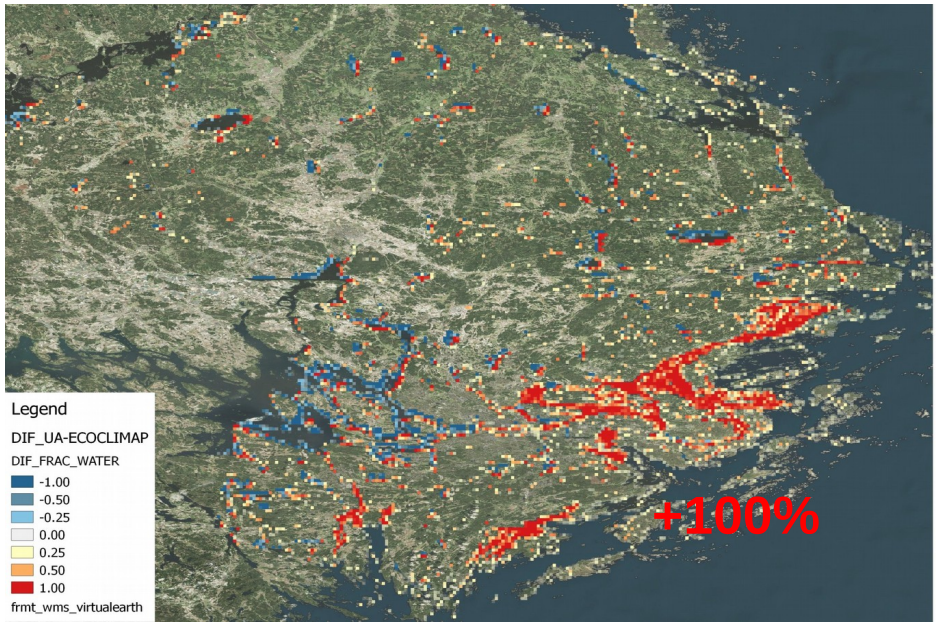
Jorge H. Amorim et al.

Copernicus Land Monitoring Services: Urban Atlas 2012, 100 m resolution

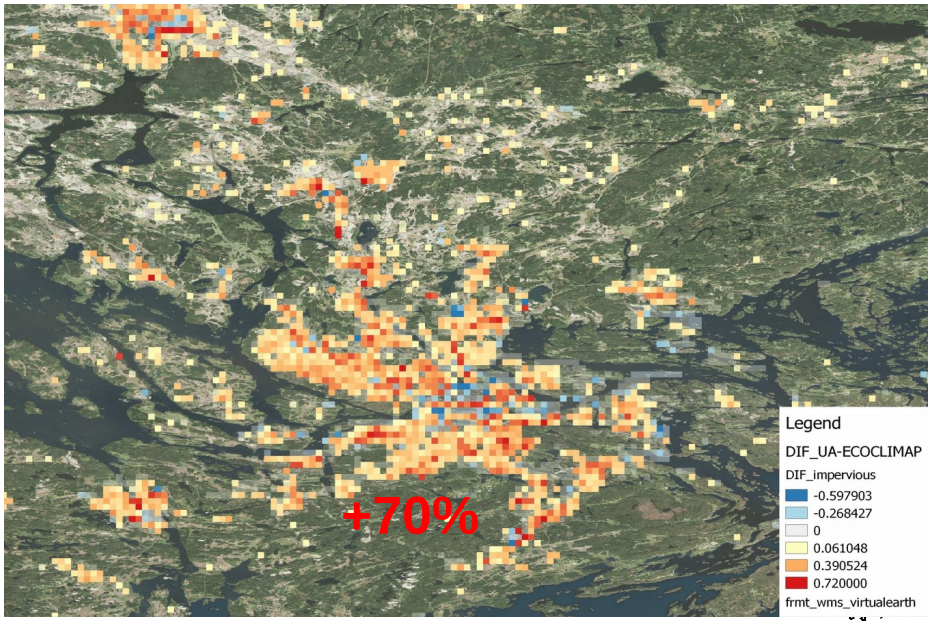
http://land.copernicus.eu/local/urban-atlas

Urban Atlas – ECOCLIMAP

Fraction of lakes



Fraction of sealed surfaces



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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.

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.

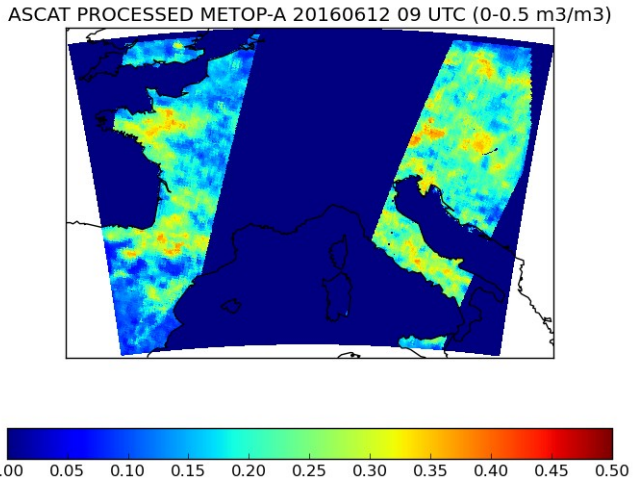
In near future the current OI (Optimal Interpolation) will be replaced by EKF (Extended Kalman Filter) methods.

Later we plan for EnKF (Ensemble Kalman Filter) methods.

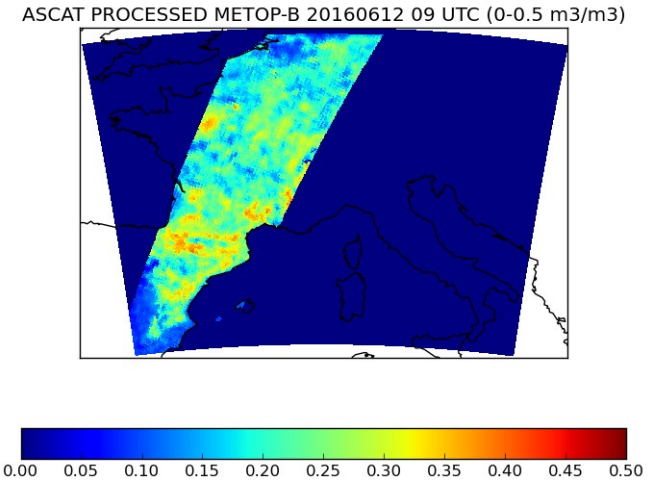
Two main reasons why EnKF should be better than EKF:

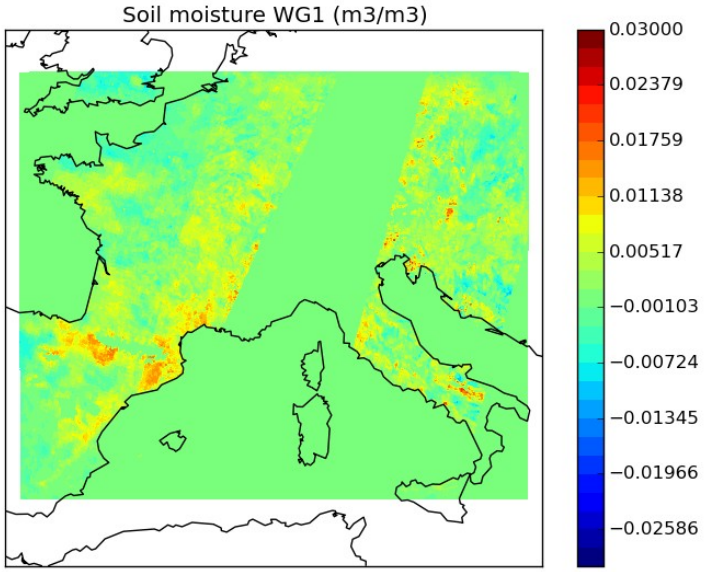
- Easier because one avoids the assumption that the system is required to behave linearly and one avoids the sensitive choice of size of perturbations.
- Fits better with EPS activities where atmosphere and surface can be perturbed simultaneously in a consistent way.

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

Handling of large and noisy Jacobians

EU-IMPREX work by Magnus Lindskog (SMHI)

Snow analysis

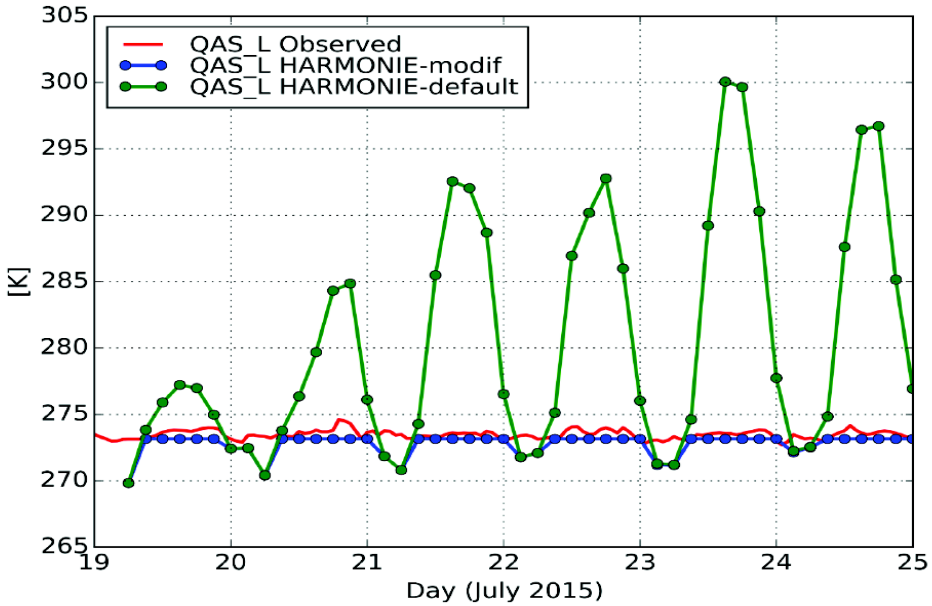
A visiting student at FMI, Maxime Quenon, has published a report on “Visual and Statistical Analysis of Snow Cover” where snow extent (SE) and Snow-Water Equivalent (SWE) simulated by cy38h1.2 HARMONIE-AROME-SURFEX has been compared with SYNOP snow depth, MetOp and MSG SE and Globsnow SWE. **See poster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

Ekaterina Kourzeneva (FMI) will summarize Maxime's work in a seminar so please let Ekaterina know if you wish to join (remotely).

Glaciers in SURFEX

Current HARMONIE Ts over a snow-free part of a Greenland glacier



SURFEX currently does not include any glacier ice processes. Thus, when snow disappears a soil surface appears.

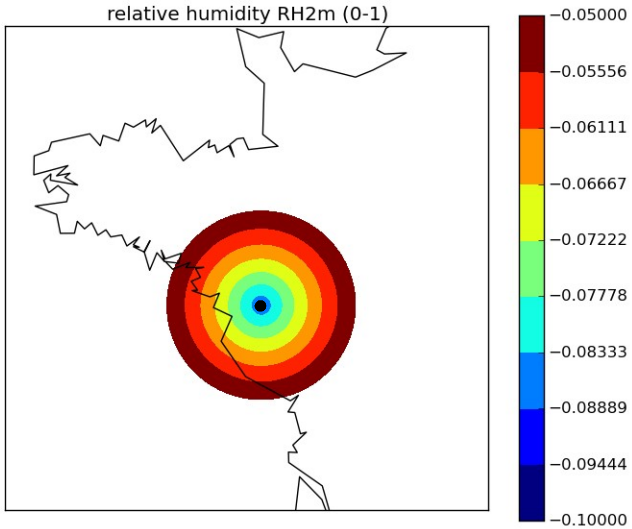
In collaboration with the Surfex team at Météo-France a few HIRLAM colleagues (Ruth Mottram, Emily Gleeson, Kristian Pagh Nielsen, Bolli Palmason) are currently involved in work where the Explicit snow scheme of SURFEXv8 will used as glacier model by defining a few of the bottom snow layers as ice (e.g. high density).

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.

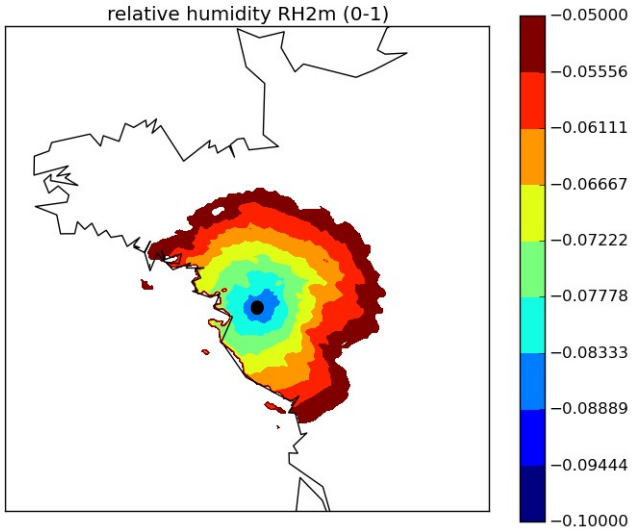
Current Method in CANARI



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

a – 85 km

Improved Method in MESCAN



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

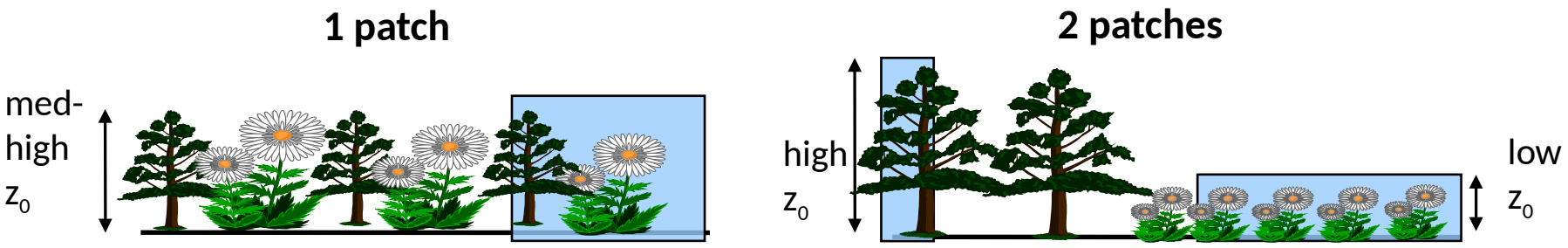
L – 195 km
(vertical correlation scale ~500m)

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

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

Over Scandinavia HARMONIE (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.

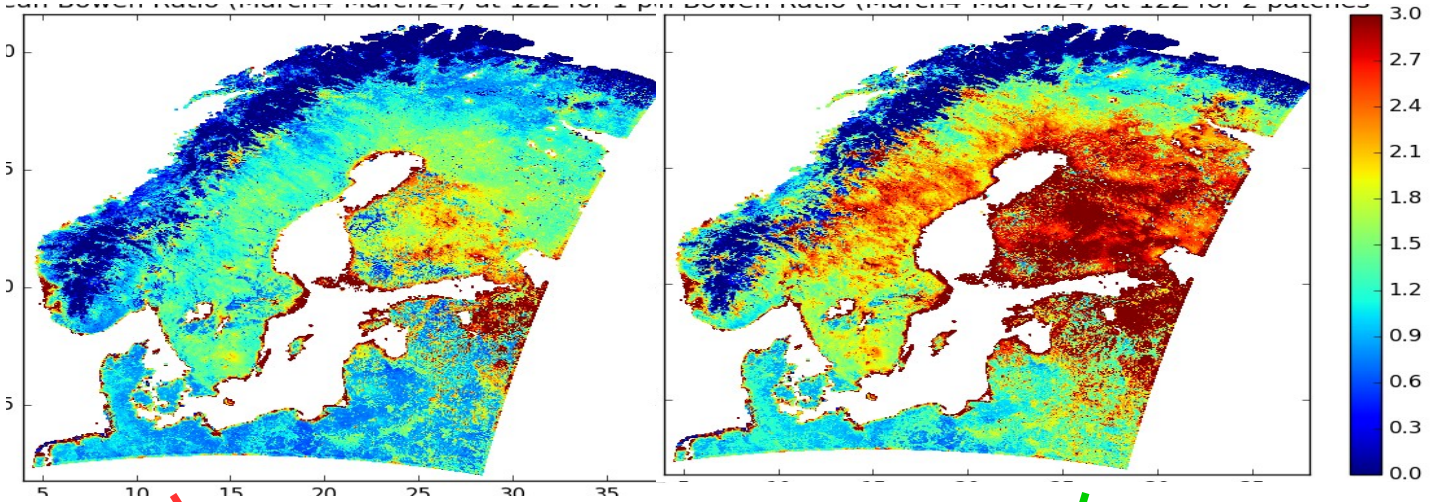
People involved: Trygve Aspelien, Patrick Samuelsson, Mariken Homleid, Karl-Ivar Ivarsson, Javier Calvo Sanchez

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

March 2016

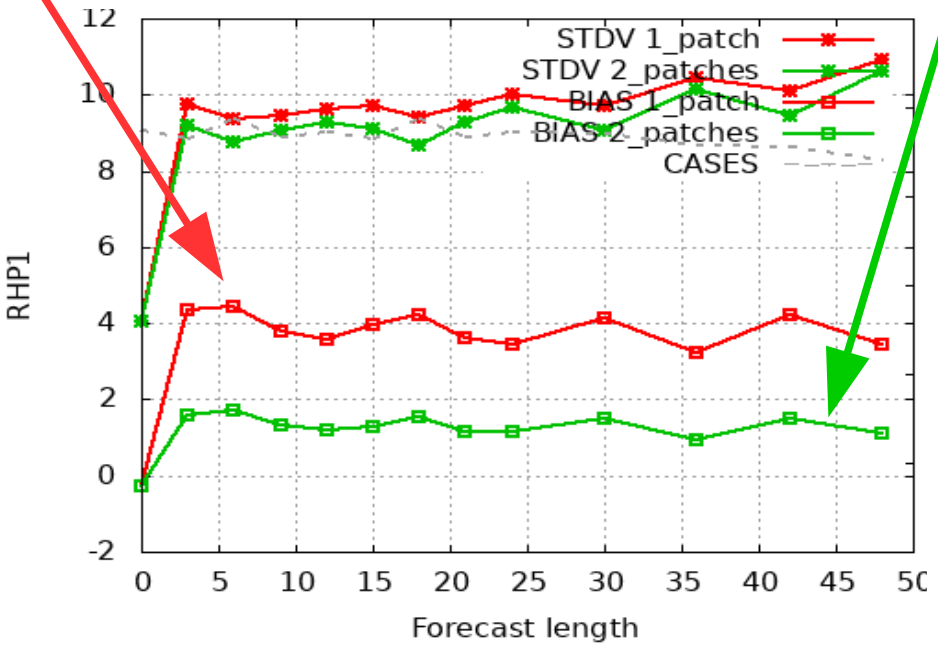
1 patch

2 patches



Bowen ratio = H/LE

Rh2m



Promising results: Plan is that 2 patches enter 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!

Also...

Physiography modificaions over Iceland and Greenland by IMO (Bolli Palmason et al.) reported by Jeanette Onvlee last Monday.

LAI-evapotranspiration sensitivity tests over the Dutch domain (Sander Tijm et al., KNMI).

Ororad (orography influence on radiation) by Laura Rontu (FMI) et al.