HIRLAM surface data assimilation

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SMHI

with contributions as acknowledged

From SURFEX Steering Committee March 23

The SURFEX team would like to stop maintenance of OI_MAIN and VARASSIM since all surface assimilation needs are now fulfilled by SODA (Surfex Offline Data Assimilation)! Thus, all of us are expected to base our development and systems on SODA.

A SODA specific contact person in the SURFEX team has been appointed: Clément Albergel

General surface thoughts and comments

Surface physics in SURFEX is in many aspects well beyond the needs in NWP applications but plenty of non-utilized potential exist!

Our current operational cy38h1.2/40h1 HARMONIE (AROME-SURFEX) system is less “advanced” over land than latest HIRLAM (still running at some centres):

	cy38h1.2/40h1	**HIRLAM**	**cyxxh**
Land			
Patches	1	1-3 (incl. “MEB” patch)	2 patches
Soil	Force-restore	Diffusion	Diffusion (14 layers)
Snow	Composite	Bulk-1L	Explicit snow (12 layers)
Assimilation	OI	OI	EKF
Sea	SICE (MetCoOp)	2-layer ice scheme	Sea ice
Lake	Deep soil temp	Deep soil temp/Flake	FLake (later with EKF)
Town	TEB	No (open land)	TEB (more options)
Physiog.	ECOCLIMAP	FAO	Utilize high res. data

HIRLAM contributions as activity/priority list

2 patches!

Explicit snow scheme and force-restore soil in combination with EKF (based on a cy40h mix with ISBAv8). Operational until next winter season... Later in combination with diffusion soil scheme.

Make FLake operational, first in peaceful coexistence and later in combination with EKF as under development by Ekaterina Kourzeneva.

In externally funded projects we have activities in EKF in combination with force-restore (Magnus Lindskog et al.) and EnKF methods (Tomas Landelius et al.).

A Master thesis student at MetNorway will work on diffusion soil scheme and EKF in the SURFEXv8 context from August 2016. We may invite Clément Albergel to visit MetNorway for this.

There are plans to have a PhD thesis project at KNMI partly with focus on surface assimilation aspects.

However, at the moment we have no direct HIRLAM activities in EKF aspects. But in a big consortia, ALADIN/LACE/HIRLAM we can rely on each other :-)

How to reach progress

- Next week (April 11-14 in Oslo) HIRLAM arranges a HARMONIE Surface Working Week on surface assimilation. See this wiki for more information: https://hirlam.org/trac/wiki/HarmonieWorkingWeek/Surface201604
  The agenda includes an 1-hour Google Hangouts session for those who are interested to follow WW progress and have interest in surface assimilation:
  Wednesday April 13, 10:00-11:00 (CET)
  Please let Patrick know if you wish to attend!

HARMONIE Surface Working Week on surface assimilation

https://hirlam.org/trac/wiki/HarmonieWorkingWeek/Surface201604/Satellite_list

List of satellite products relevant for surface assimilation

Last modified 2016-04-01 14:30

Information is primarily based on the WMO web-page Space-based Capabilities (OSCAR/Space) http://www.wmo-sat.info/oscar/spacecapabilities

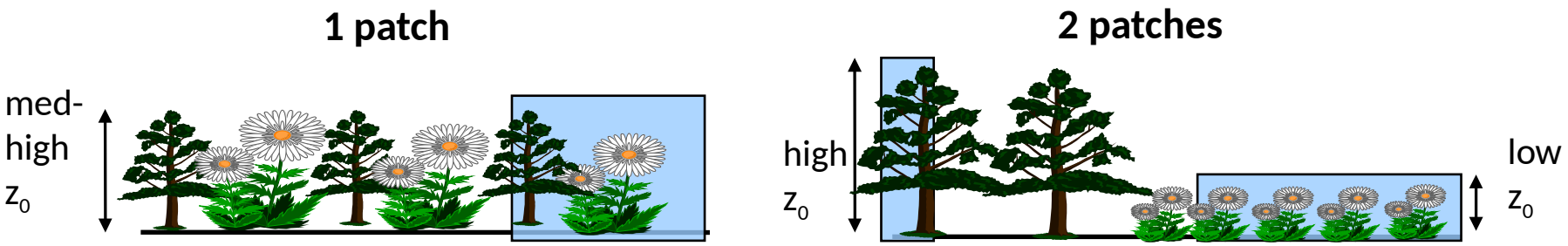
Instrument	Satellite	Period	Variable	Relevance	Limitations	Processing maturity	Observation operator	Comment
AMSR-2	GCOM-W1	2012-2017						
			Soil moisture at surface (7 Ghz)	2-very high	Vegetation dependent	Consolidated methodology	FASTEM + RTTOV?	
			Snow status (wet/dry)	2-very high	Snow-depth dependent	Consolidated methodology		
			Snow water equivalent	2-very high	Snow-depth dependent	Heavily dependent on external info		

Land

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 (MetNo), Patrick Samuelsson (SMHI), Mariken Homleid (MetNo), Karl-Ivar Ivarsson (SMHI)

A cy40h branch with 2 patches

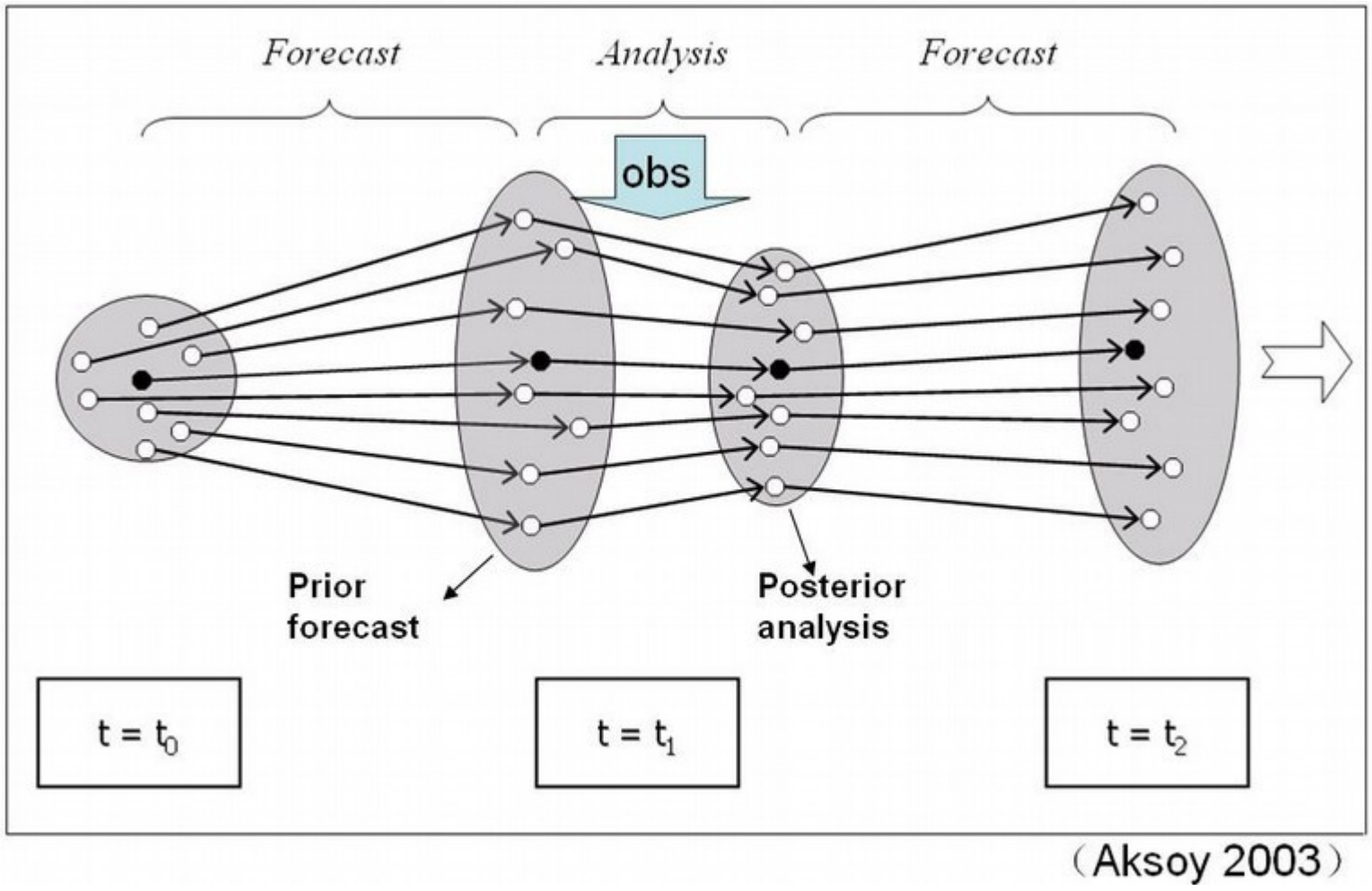
https://svn.hirlam.org/branches/harmonie-40h1_patchy_assim

First changes to run assimilation (OI) with two patches: CANARI and OI have been modified. First guess in CANARI is now based on open land T2m (if it exist). The same increment is given to open land and forest patches.

nam/surfex_namelists.pm
scr/obsmon_stat
src/mse/externals/aroini_surfc.F90
src/surfex/ASSIM/assim_inland_watern.F90
src/surfex/ASSIM/assim_isba_update_snow.F90
src/surfex/ASSIM/assim_isban.F90
src/surfex/ASSIM/assim_nature_isba_ekf.F90
src/surfex/ASSIM/assim_nature_isba_oi.F90
src/surfex/ASSIM/oi_cavegi.F90
src/surfex/SURFEX/read_isban.F90

Long term goal: EnKF including the hydrological time scale

Ensemble Kalman Filter (EnKF)



(meteorologists are on shorter-term also working with an Extended Kalman Filter (EKF))

Satellite based surface measurements

Satellite radiances

AMSR2 (GCOM-W1)

MIRAS (SMOS)

SAR (Sentinel-1)

(provides information of soil moisture, surface temperatures and snow: but advanced observation operators needed)

Processed products

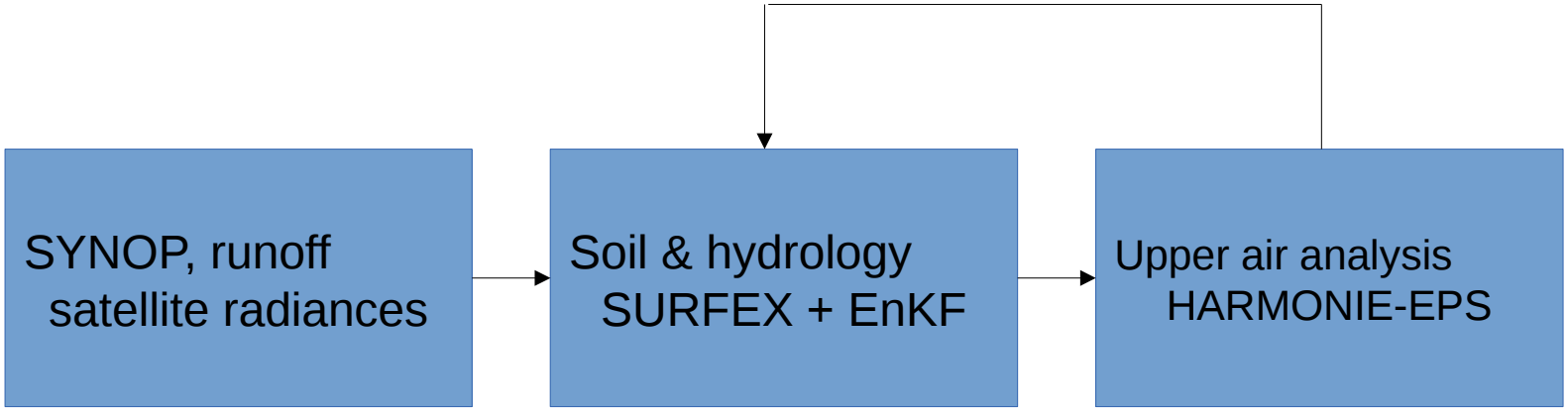
such as ASCAT soil moisture and GLOBSNOW SWE

Externally funded projects

Swedish National Space Board 2015-2017

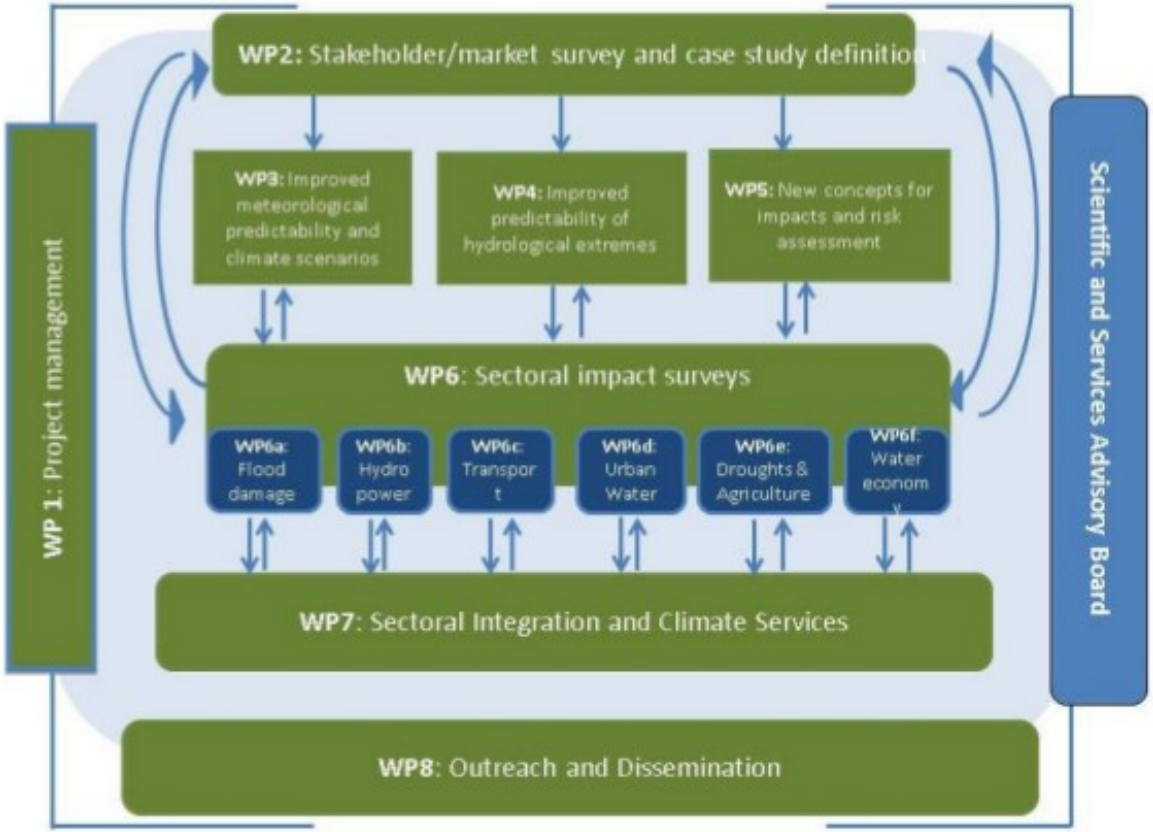
Assimilation of satellite-based measurements of the hydrosphere - towards a combined meteorological-hydrological forecasting system (2015-2017)

Graphical illustration of project components



Externally funded projects

IMPREX: IMproving PRedictions and management of hydrological Extremes (2015-2018)

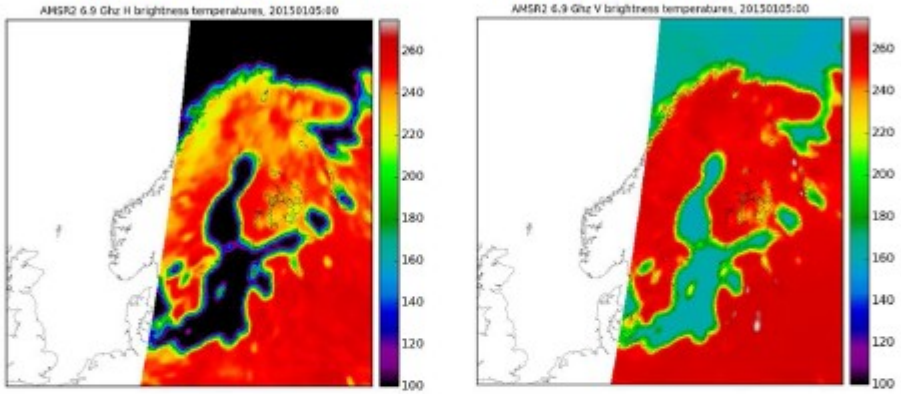


Observation operator for Radiances
AMSR2 level 1C, 6.9 GHz

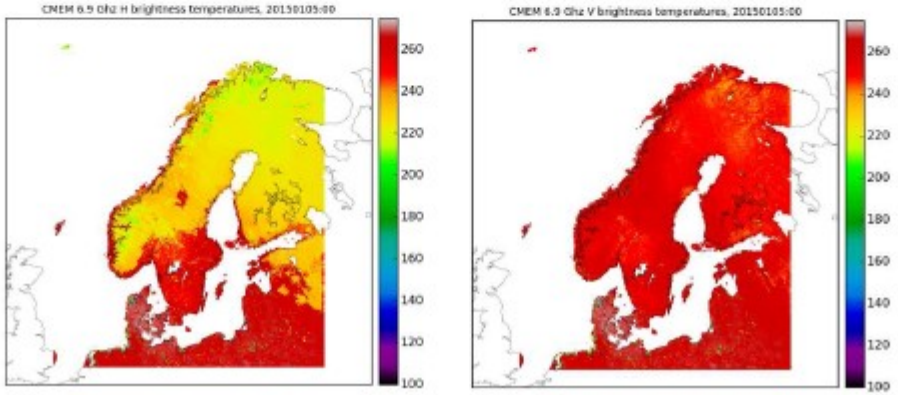
H brightness temperatures

V brightness temperatures

Observed radiances

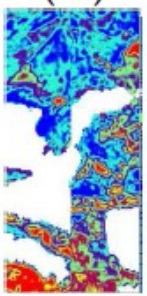


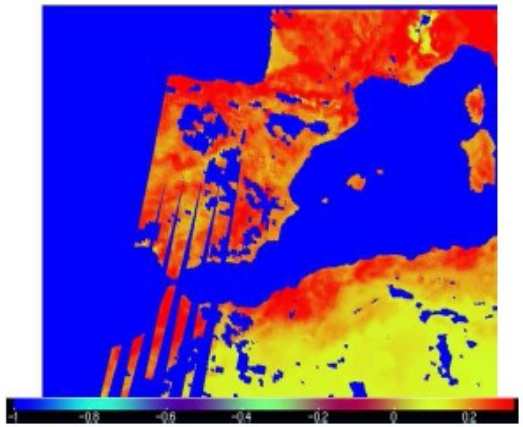
model counterparts derived with observation operator



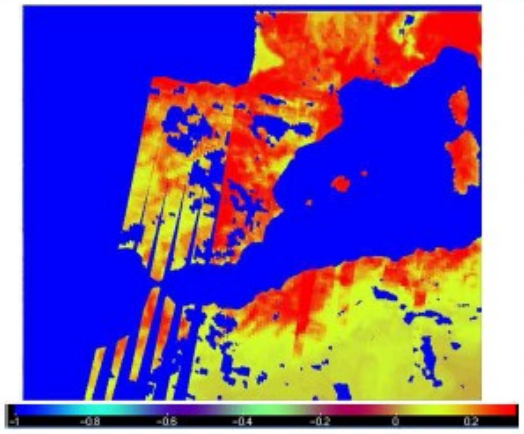
Processing and conversion of ASCAT derived soil moisture product

Derived Product (%)



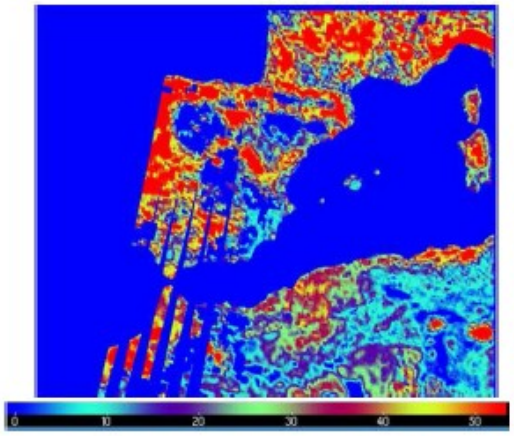


Modmin (0-0.2 m3/m3)

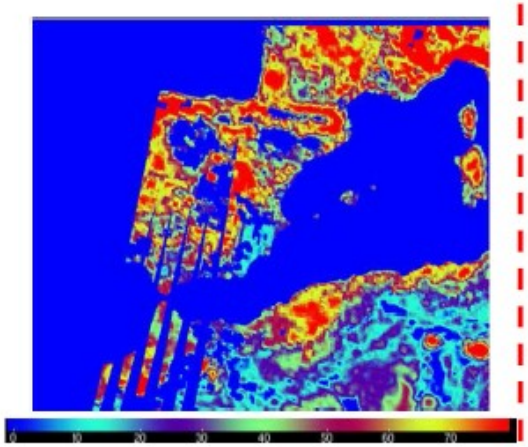


Modmax (0-0.28 m3/m3)

$$Ascatout = Modmin * \frac{Modmax - Modmin}{Ascatmax - Ascatmin} * (\text{Ascatraw-Ascatmin})$$

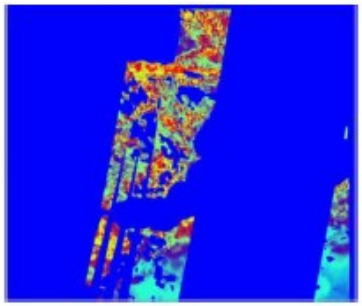


Ascatmax (0-80%)



Ascatmin (0-80%)

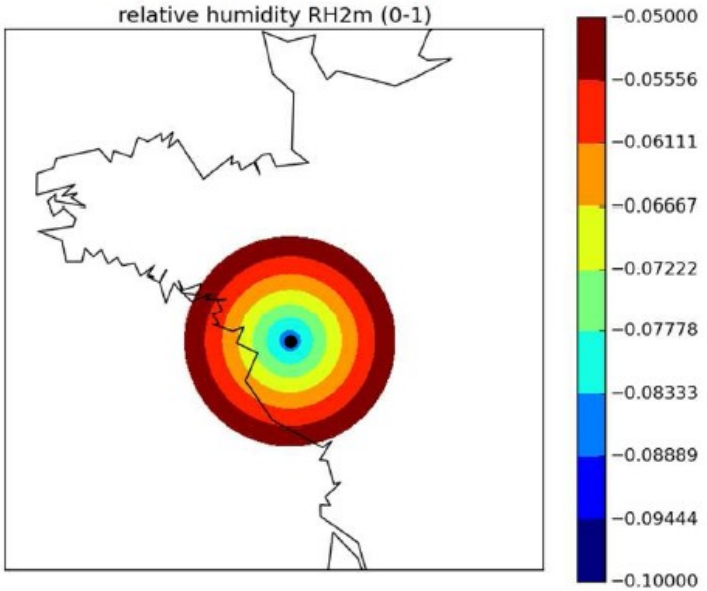
Processed Product (m3/m3)



Horizontally varying background error statistics

Impact of one single SYNOP Relative Humidity observation at the 2 meters height unit (%). The observation is located close to the west coast of France and the observed relative humidity is approximately 15 % less than the corresponding model value.

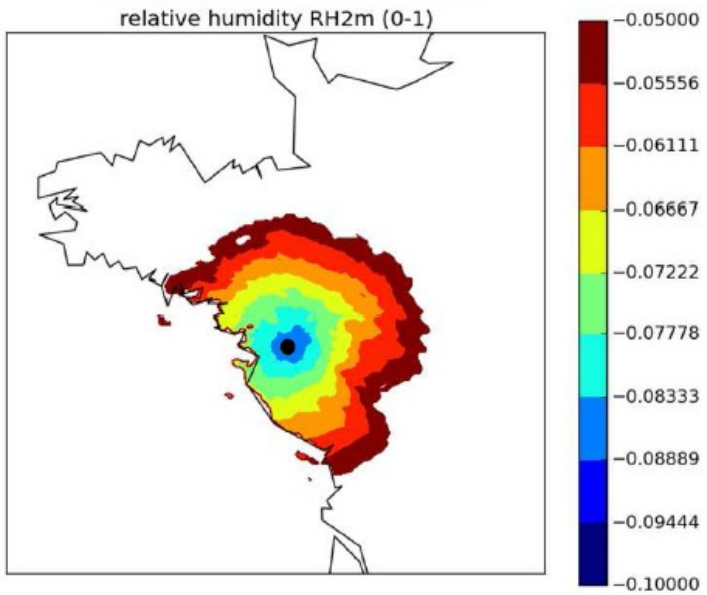
Current Method



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

a – 85 km

Improved Method



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

L – 195 km

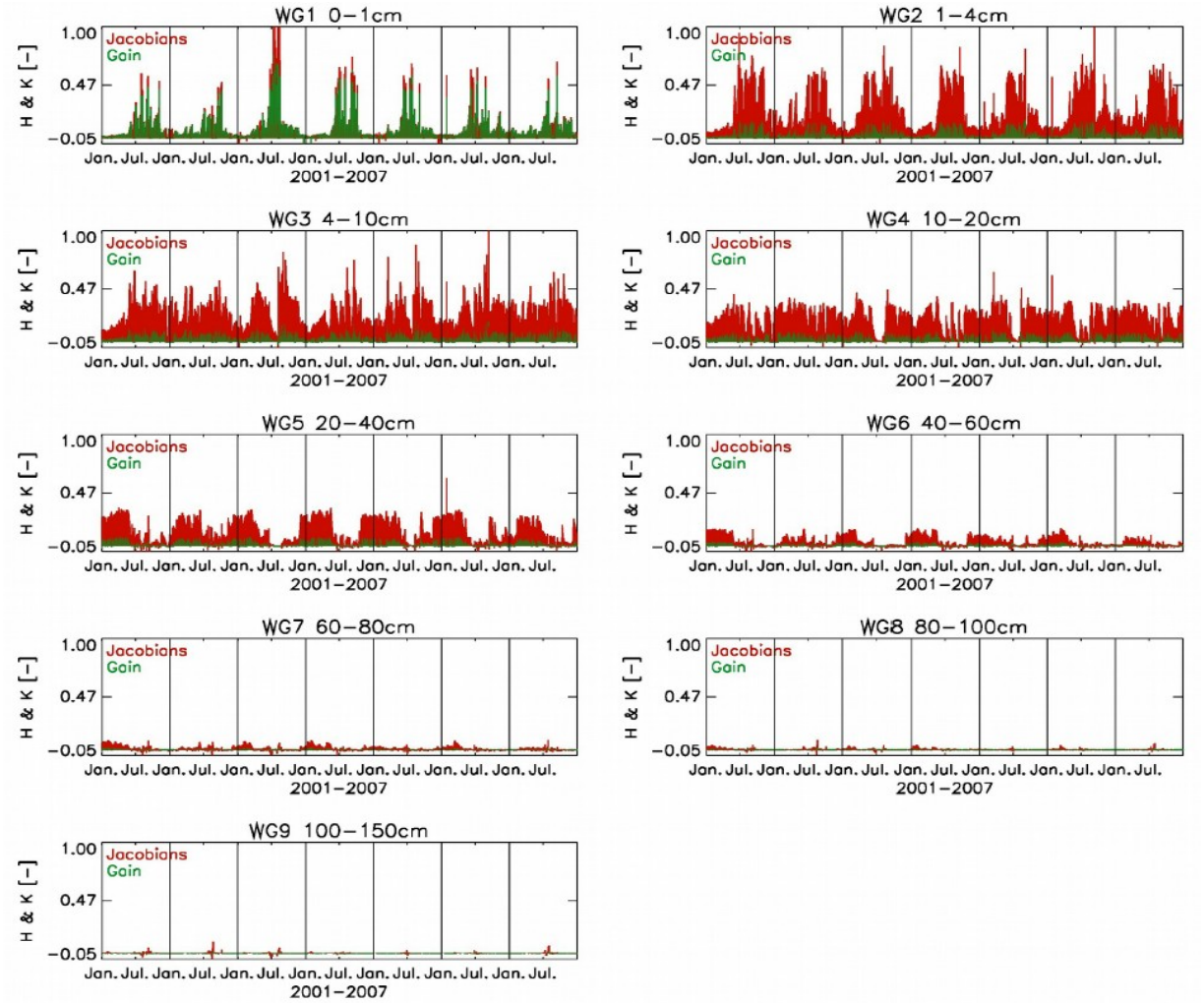
People involved: Magnus Lindskog (SMHI) and IMPREX colleagues

SURFEX and EKF

Magnus Lindskog (SMHI) is testing/developing EKF in combination with SURFEX fore-restore in HARMONIE context (similar to what has been done by Annelies Duerinckx (RMI) and what has been done in LACE). Experience problems in complex topography areas where the Jacobian of the observation operator gets unrealistically large values.... right Magnus??

SURFEX and EKF

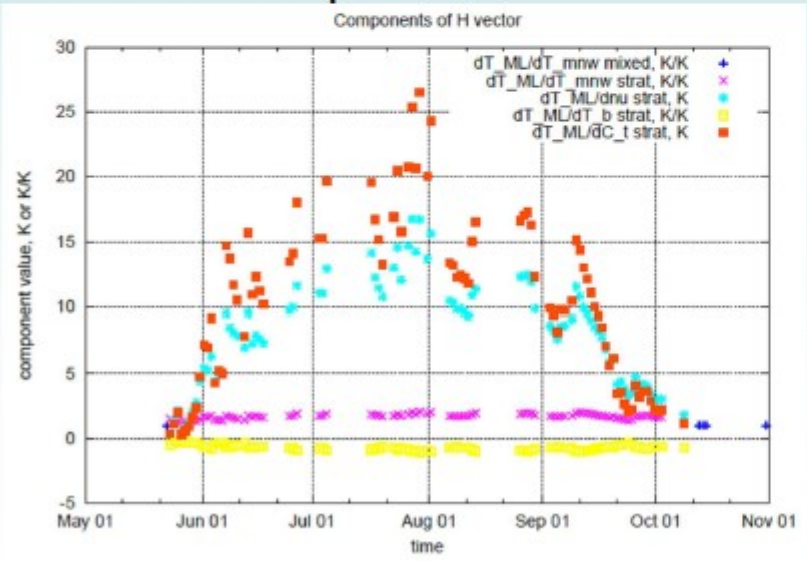
Clément Albergel, in SURFEX team, is applying SURFEX/SODA offline on diffusion soil scheme for satellite observed soil moisture: Results for Jacobian and Gain for 9 different layers:

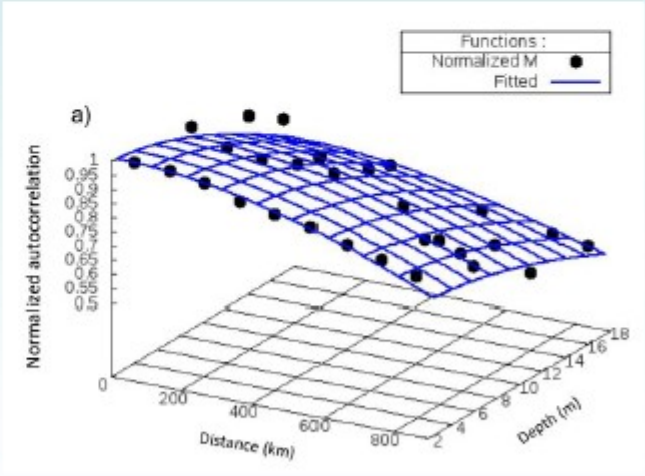


Lake

Lakes

- FLake in 2D, SURFEX7.3, HARMONIE cy40h –ongoing
- GLDBv3.1 included
- Tests in Antarctica
- Study of EKF Jacobians
- Structure functions for LST from obs (SYKE and MODIS), including dependency from the difference in the lake depth





SURFEX SC meeting
23 March, 2016

Lake Inarijärvi, 14.3 m

Sea

We are running SICE operationally now with prognostic sea-ice temperature but not yet with assimilation. Satellite products, e.g. sea ice concentration and surface temperature, do exist which can be used...

Bin Cheng et al. (FMI): Looking at the potential of using buoys (SIMBA units) deployed in the Arctic Ocean for assimilation of sea-ice characteristics in NWP.

Town

Currently we assimilate only one variable, XT_ROAD(:,3)

Carl Fortelius (FMI): “I believe forecasting the energy demand of HVAC-systems (Heating Ventilation Air Conditioning) to be one important application of TEB in the near future, and of course this raises the question of initializing not only the street temperature but also that of the building mass (walls and roofs). But where to get data?”

Future

Which people should be connected?

A consortia wide surface data assimilation workshop?

Update each other on our activities and plans. E.g. through Google Hangouts sessions a la the style of Roger for upper-air data assimilation...?