SMHI NWP modelling – operations, development and research

Main Operational runs

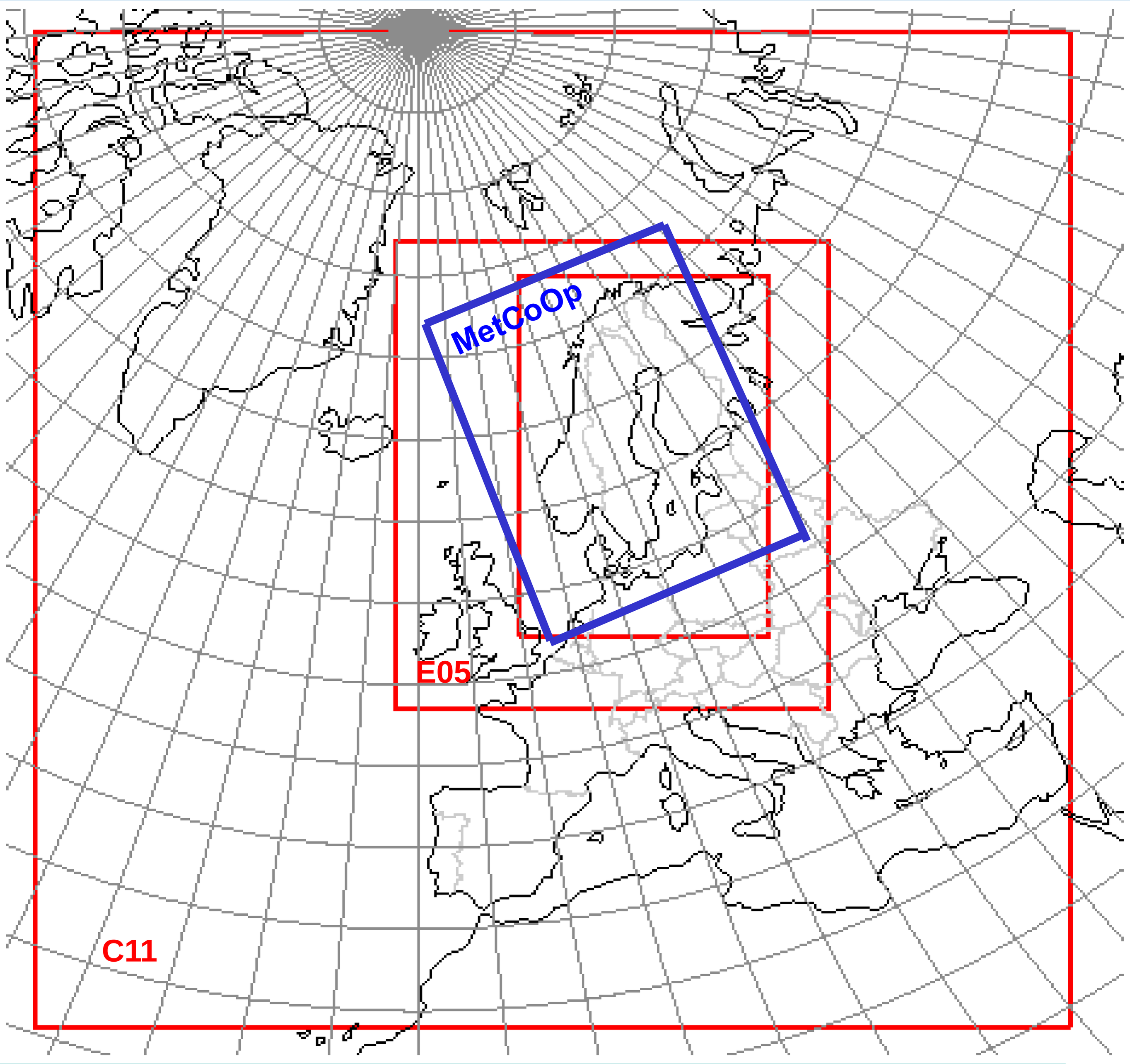
4 analyses and forecasts per day. 00, 06, 12, 18

HARMONIE Arome, 2.5km –
3D-VAR 3h-RUC +60h
HARMONIE-RCR for cy38h1

HIRLAM C 11km –
4D-VAR 2 loop LSMIX +60 h
2 hours data cut-off

HIRLAM E 5 km –
3D-VAR no LSMIX+48 hours
1 hour 20 min data cut-off

1 hourly ECMWF boundaries
ECMWF GTS -> BUFR obs preprocessing
SYNOP,SHIP,TEMP,PILOT,
BUOY,AIREP,AMDAR
BUFR AMDAR
ATOVS AMSU-A radiances – EARS
Radar reflectivities and winds passive in HARMONIE



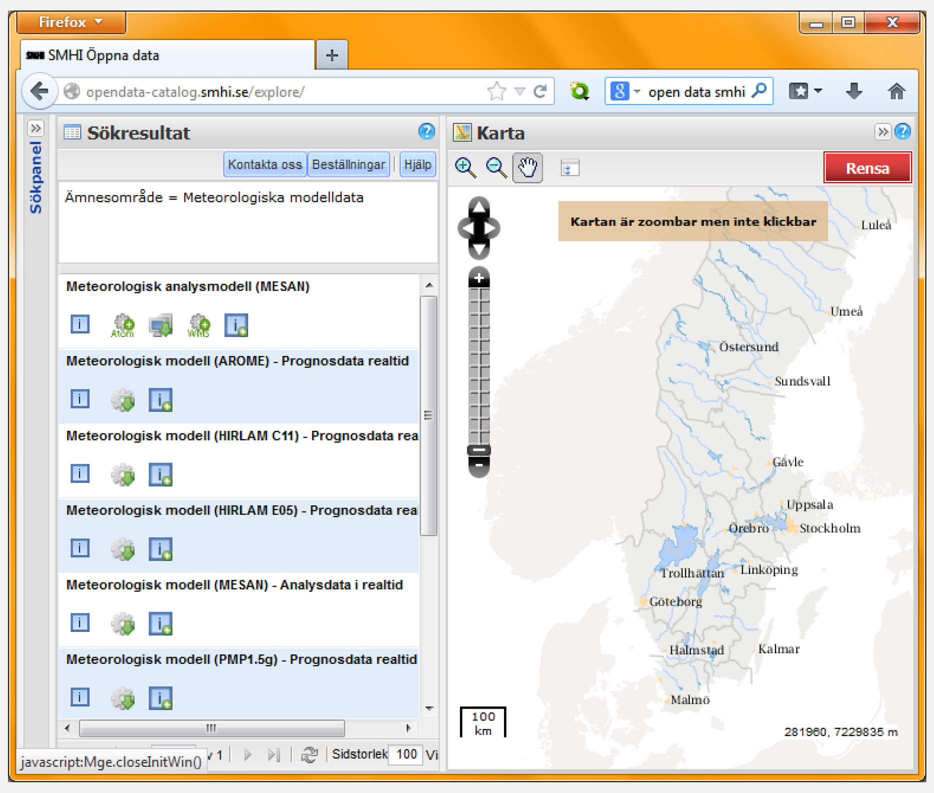
Name	Model	gridpoints	levels	timestep	Assimilation	Boundaries
C11	Hirlam 7.1.2	606x606	60	300 s	4D-Var	ECMWF
E05	Hirlam 7.3	506x574	65	150 s	3D-Var	HIRLAM
MetCoOp AM25	HARMONIE y38h1.1	750x960	65	60 s	3D-Var 3h-RUC	ECMWF

MetCoOp - A joint Swedish-Norwegian NWP production

- RCR (Regular cycle with the reference) -centre for HARMONIE Arome cy38
- Shared HPC resource
  - Currently **Vilje at NTNU in Trondheim** (place 68 in TOP500 in June 2013)
  - Next HPC resource will be procured by SMHI for production from 2015.
- **MetCoOp Technical Memorandum Series: http://metcoop.org/memo**
- **Plans**:
  - Setting Radar observations to active in data assimilation
  - HarmonEPS on new HPC from 2015

Open Data and the Inspire directive

- opendata-catalog.smhi.se/
- Since January 2014 online
- Meteorol. and oceanogr. Observations:
  - One graphical user interface for historical data (GUI)
  - Atom feeds for realtime and historical data (API)
- Graphical user interface for archive of meteorological and oceanographical model data
- Weather forecast data
- Search interface
- Webservice for other realtime data, delivery fee



Deep convection parameterization using cellular automata

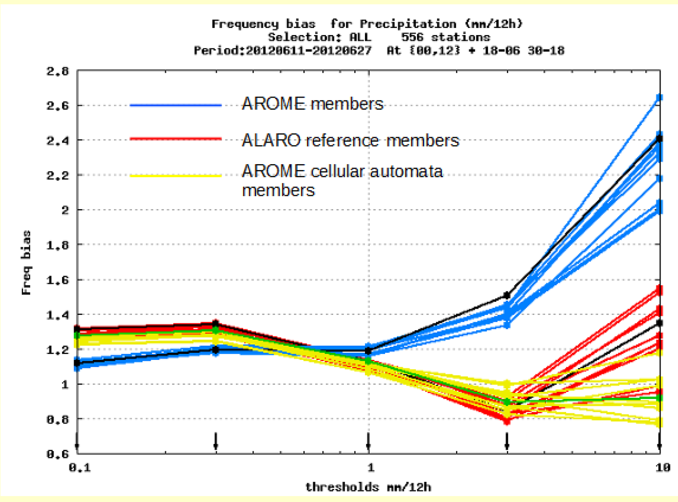


Figure 1: Example how the cellular automata can improve the forecast skill of precipitation in regions with high amount of CAPE.

Lisa Bengtsson
*A large contribution to model construction error uncertainty stems from the statistical representation of deep convection.
*Impact of a stochastic deep convection parameterization using cellular automata described in Bengtsson et al. (2013), as implemented in the high resolution HarmonEPS.
*The cellular automata stochastic scheme is coupled to the deep convection parameterization in the ALARO model, and we can thus in the same EPS system compare deterministic skill of each ensemble member using AROME physics, ALARO physics and ALARO with a stochastic parameterization. We can also study probabilistic behaviour of the EPS.

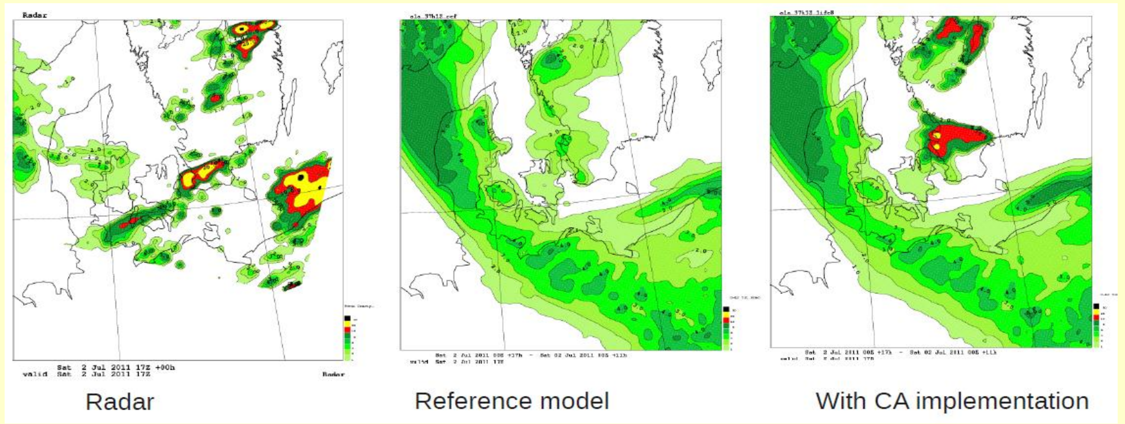
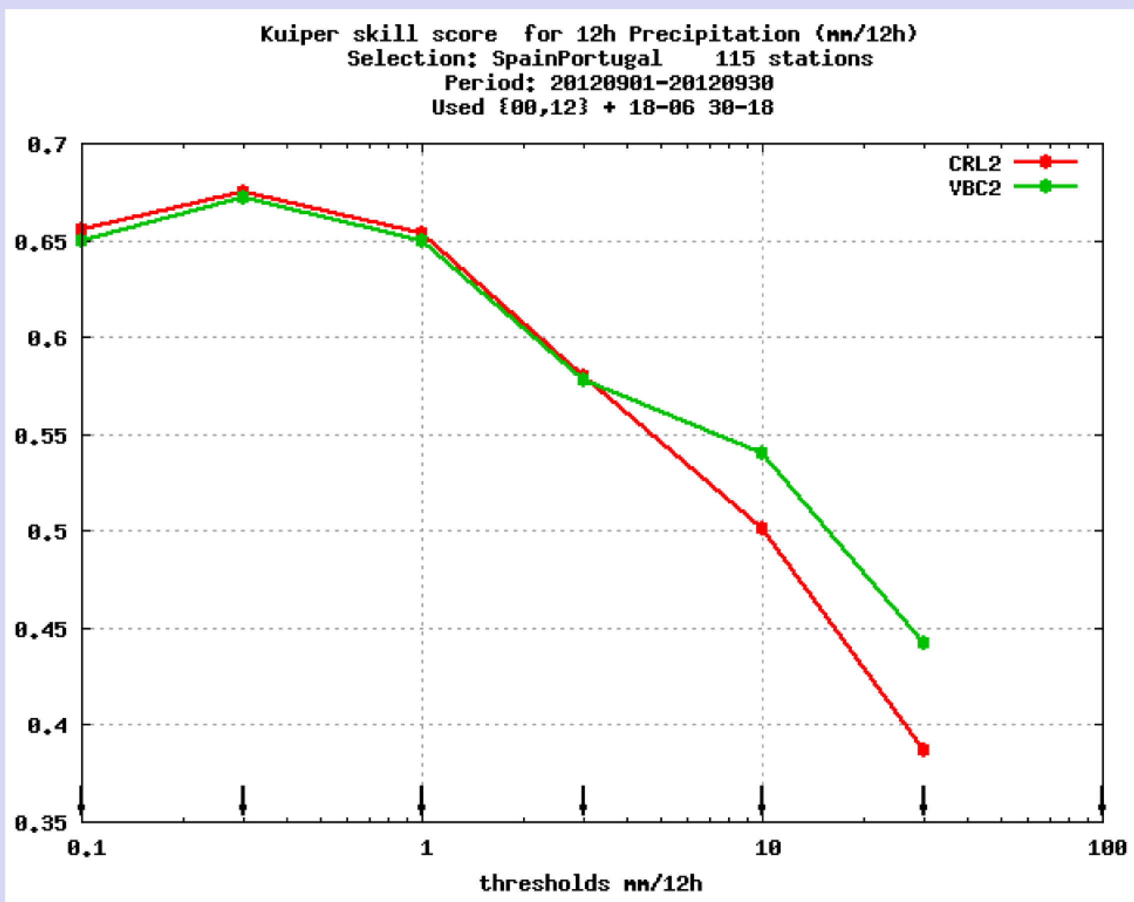


Figure 2 show the Frequency bias of 12 hour accumulated precipitation for all members AROME (blue)+ALARO (red) of HarmonEPS, and the ALARO members using the cellular automata scheme (yellow). The cellular automata scheme improves the frequency bias across all thresholds.
Presently, the cellular automata scheme reduces the ensemble spread (not shown) due to the reduction of the overestimation of high amounts of precipitation.

Assimilation of GNSS ZTD with HARMONIE



Kuiper skill score for 12h precipitation. Control experiment CRL2 (only conv obs) and experiment VBC2 (with additional GNSS obs).

M. Lindskog (SMHI), J. Sánchez (AEMET), S. Thorsteinsson (IMO), J. Bojarova (MET)
Aim: Impact of GNSS data on HARMONIE NWP forecasts.

Experiment: Arome with domain over Iberia and with 2.5 km horizontal resolution and 65 vertical levels.

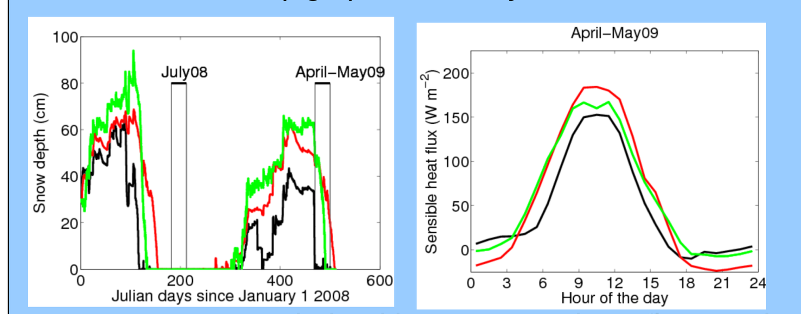
The GNSS run has been optimized with respect to bias correction, error statistics and thinning distances.

Results:
- Good impact of GNSS ZTD on humidity under 500 hPa, and 12h precipitation for high precip. rates.

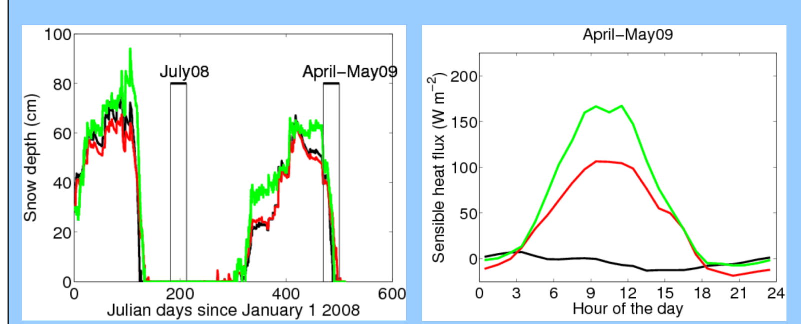
Plan:
- EGVAP preprocessing in collaboration with Swedish Land Survey Administration.
- Comparison of GIPSY and Bernese
- Operational from Jan 2015

Multi-Energy Balance in SURFEX

Observations and SURFEX simulations using **MEB** and **ISBA**, respectively, for snow depth (left) and sensible heat flux (right) in Sodankylä, northern Finland:



Parameters are optimised in respect to heat fluxes. The classical ISBA snow depth is heavily underestimated.



Parameters are optimised in respect to the timing of vanishing snow. The classical ISBA sensible heat gets wrong sign!

Patrik Samuelsson
Problem:
Interaction between vegetation and snow is usually modelled in a simple manner manner in NWP and climate models, which may have consequences. Two of them are:
Wrong timing in spring snow melt and river discharge peaks (usually too early in forest dominated regions).
Wrong energy flux exchange between surface and atmosphere (radiation and sensible and latent heat fluxes).

Action:
Introduce explicit canopy energy balance in SURFEX where turbulent and radiation fluxes within the canopy layer are parameterised. The snow accumulation is related to the height of the canopy (forest, shrubs, grass,…).
This Multi-Energy Balance (**MEB**) parameterisation will be available in upcoming SURFEXv8.

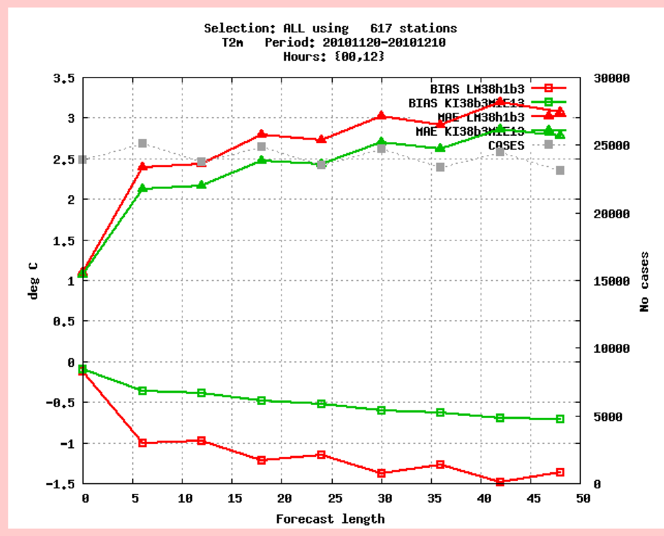
Modification of Arome ICE3 cloud physics

Karl-Ivar Ivarsson

Problem: Low clouds disappear too quickly around 0 to -10 C. Too much low clouds when below ~ -20 C. Also some over-prediction of cirrus.

Changes to ICE3: Stronger separation of fast cloud liquid water related processes from slower ice water processes. Introduction of ice cloud fraction used for post-processing and in radiation.

Prel. Results:
Winter: Better T2m, clouds, cloud base and more realistic upper air relative humidity.
Summer: Mainly neutral impact. The over-forecasting of strong precipitation is reduced with the modified scheme.



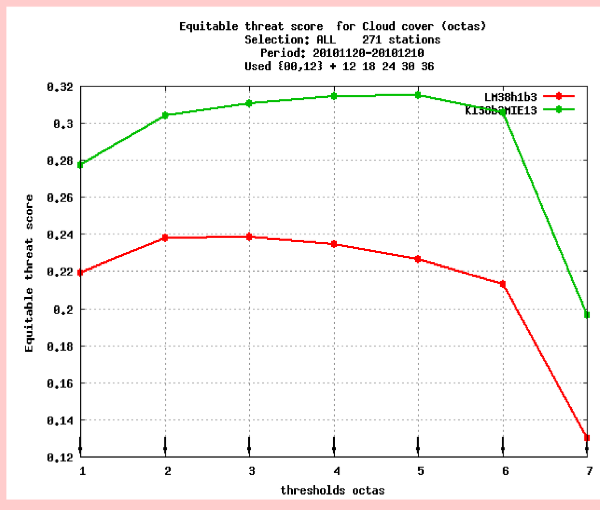


Figure: Verification of 2m-temperature (upper) and cloud cover (lower). The forecasts with the **reference** version is in red, the forecasts with the **modified** version is in green.

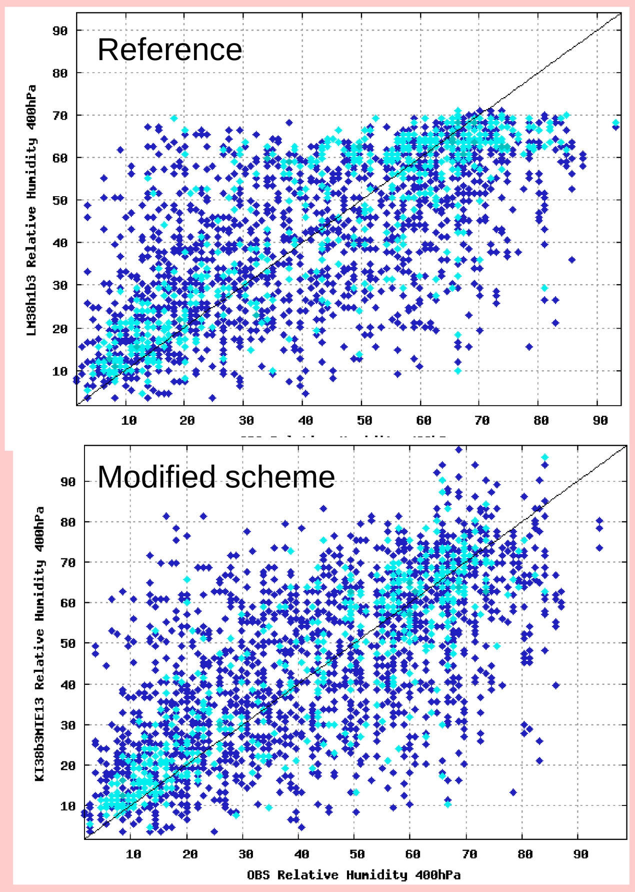


Figure: Verification against soundings of 400hPa-relative humidity with respect to water (Nov 18 to Dec 10, 2010).The reference scheme is unable to predict supersaturation with respect to ice for temperatures at this pressure level in winter. (about -30 to -55 C), so humidities roughly above 70% are missing, but are present with the modified scheme, as well as in the observations.

4D-Ensemble Variational Data Assimilation for HIRLAM

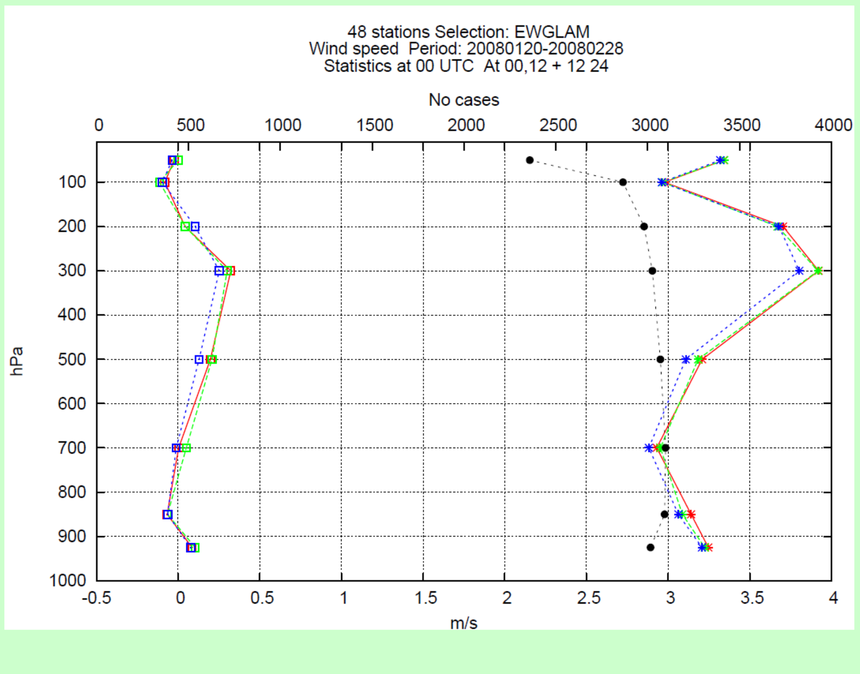


Figure: Standard deviation and bias verification of vertical profiles of wind speed against radiosondes. **4D-Var** (red), **4D-Var Hybrid** (green), **4D-En-Var Hybrid** (blue)

N. Gustafsson (SMHI), J. Bojarova (MET)

A 4D ensemble variational (4D-En-Var) data assimilation has been developed for a limited area model. The integration of tangent linear and adjoint models as in standard 4D-Var, is replaced through an ensemble of non-linear model states to estimate 4D background error covariances. The computational costs for 4D-En-Var are significantly reduced compared to 4D-Var and the scalability of the algorithm is improved. 4D-En-Var outperforms standard 4D-Var as well as Hybrid 4D-Var ensemble data assimilation with regard to forecast quality measured by forecast verification scores.

European regional reanalysis projects

URA Uncertainties in Ensembles of Regional ReAnalyses

EURO4M

EURO4M: finished.
- HIRLAM 22km, 1979-2014
- MESAN 5km, 1989-2010
- Will be published within CLIPC
- Hydrological application within UERRA
- Upcoming article (Dahlgren et al.)

UERRA, started, SMHI contribution:
- Coordinator Per Undén
- HARMONIE 11km, 1961-2010
- MESAN 5km cloud reanalysis

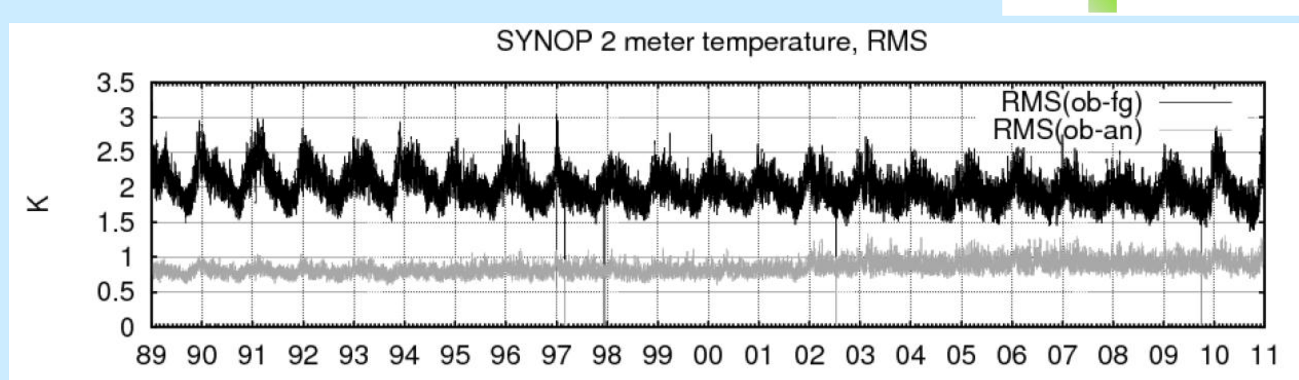


Figure: EURO4M-results
Upper: RMS for 2m-temperature between HIRLAM and SYNOP.
Right: Mean daily precipitation for JJA 1989-1994 from HIRLAM.