Norwegian Meteorological Institute

Atmospheric data assimilation in HIRLAM: Recent progress and plan

Roger Randriamampianina & HIRLAM DA group

EWGLAM & SRNWP meeting 3-6 Oct. 2016, Rome

outline

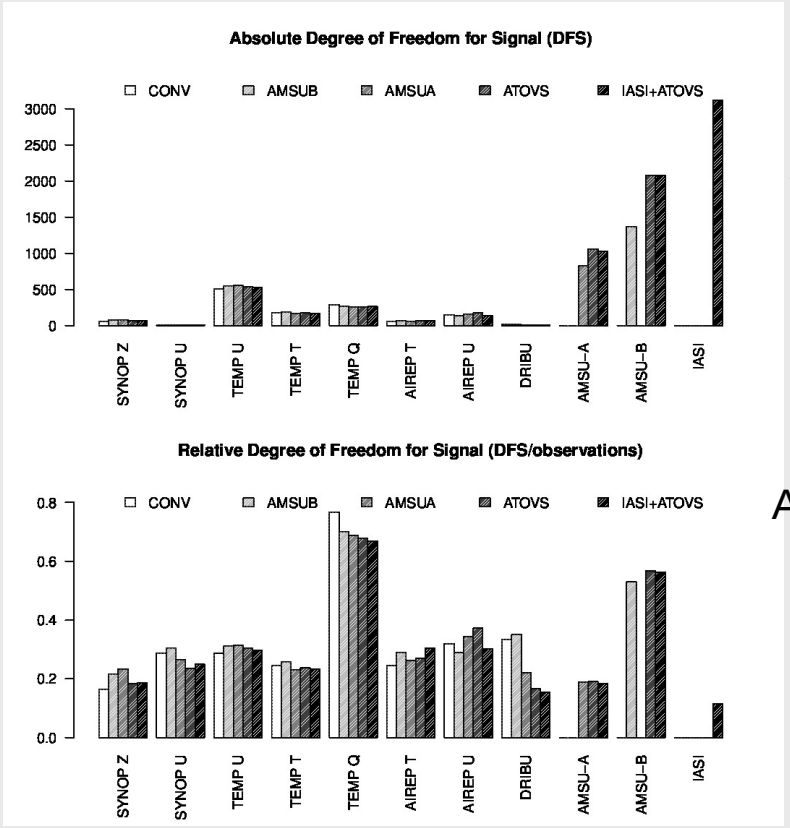
- Operational upper air data assimilation (UA-DA) systems in HIRLAM;

- Highlight of the progress in UA-DA;

- Short and long term plans.

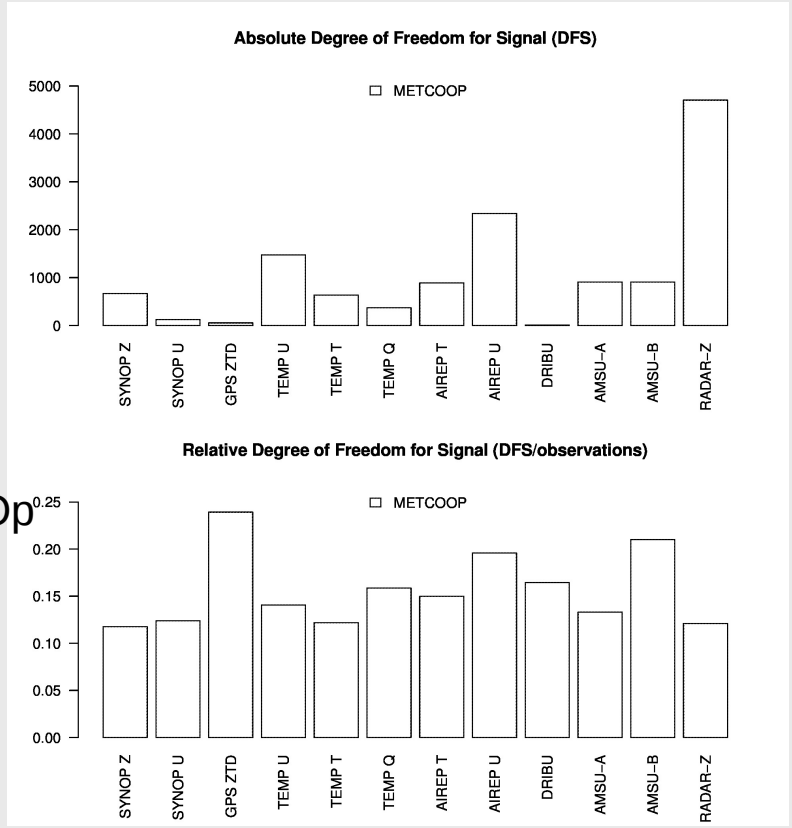
Operational upper air data assimilation (UA-DA) systems

- **Assimilation scheme:** 3D-VAR;
- **Cycling Strategy:** 3 hourly;
- **Conventional observations:** SYNOP, SHIP, BUOY, AMDAR, AIREP, ACARS, ModeS EHS, Pilots, TEMP;
- **Satellite radiances:** AMSU-A/B/MHS, IASI. obs from NOAA, and Metop satellites;
- **Satellite retrievals:** Scatterometer, GNSS ZTD, (geo)AMV;
- **Radar observations:** Reflectivity;
- **Bias correction scheme:** Variational (VarBC) applied to radiances and GNSS data.



AROME-Arctic (left) old results on four different days

AROME-MetCoOp (right) old results on one case



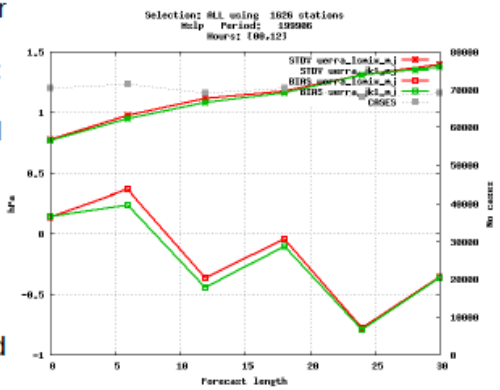
Highlight of the progress – initialisation

– Jk against large scale mixing (LSM) with the Aladin model

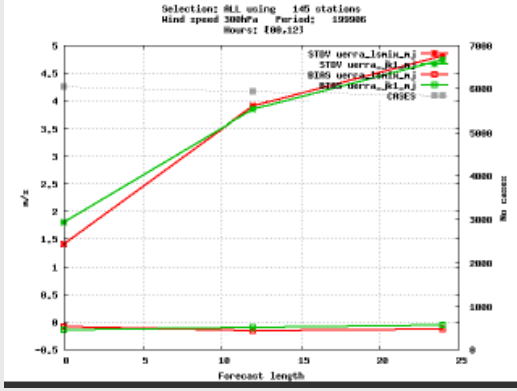
Jelena Bojarova (SMHI) study performed in frame of UERRA project

As one could expect, neither LSM nor Jk constraint are able to correct ALADIN model for systematic deficiencies which became more and more pronounced during longer forecasts : a too low pressure with too warm air in the lower troposphere over land. Both Jk term and particularly LSM overshoots surface pressure (positive bias) trying to resist this systematic deficiency. One can see that Jk term keeps model state further away from observations at analysis time, improving forecast quality for longer forecast lengths. The possible overfit of observations in a standard configuration should be considered.

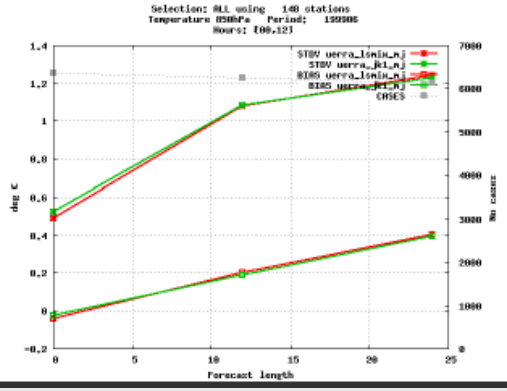
Surface pressure



Wind Speed 300hPa



Temperature 850hPa



See link below for more details

https://hirlam.org/trac/attachment/wiki/HarmonieVideoMeetings/etkf_4dvar_3dvar_oops_meeting/Jk_LSM.pdf

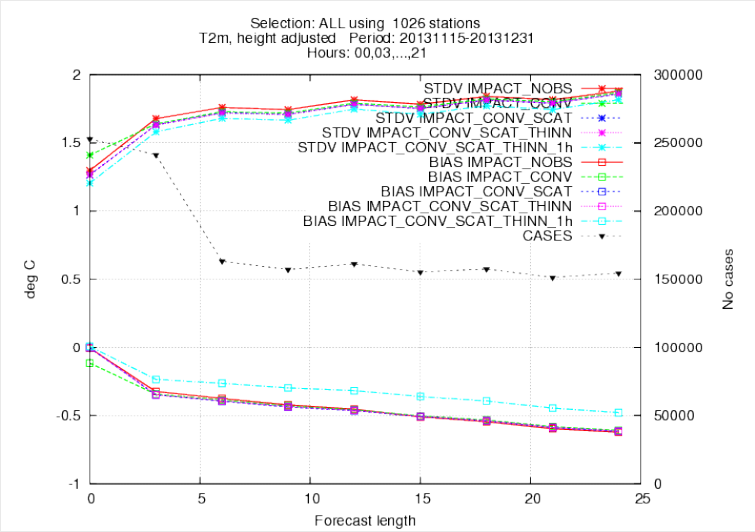
– Cloud initialisation: flexible solution ready for operational implementation by M. Lindskog(SMHI) & Toon Moene(KNMI) in CY38h1.2

Highlight of the progress – 3D-VAR studies

– 1h versus 3h cycling with ASCAT data

Gert-Jan Marseille, Jan Barkmeijer, Siebren de Haan and Wim Verkley (KNMI);

1h cycling is better



https://hirlam.org/portal/validation/38h1/IMPACT5

– Accounting for observation footprint in model space – "supermoding"

u/v (m^2s^{-2})	variance (o-b)	variance (o-<b>$|_{footprint}$)
ASCAT	2.75/3.31	2.46/2.99
OSCAT	1.93/2.86	1.51/2.31

averaging in model domain improves (o-b) statistics substantially (10-20%)

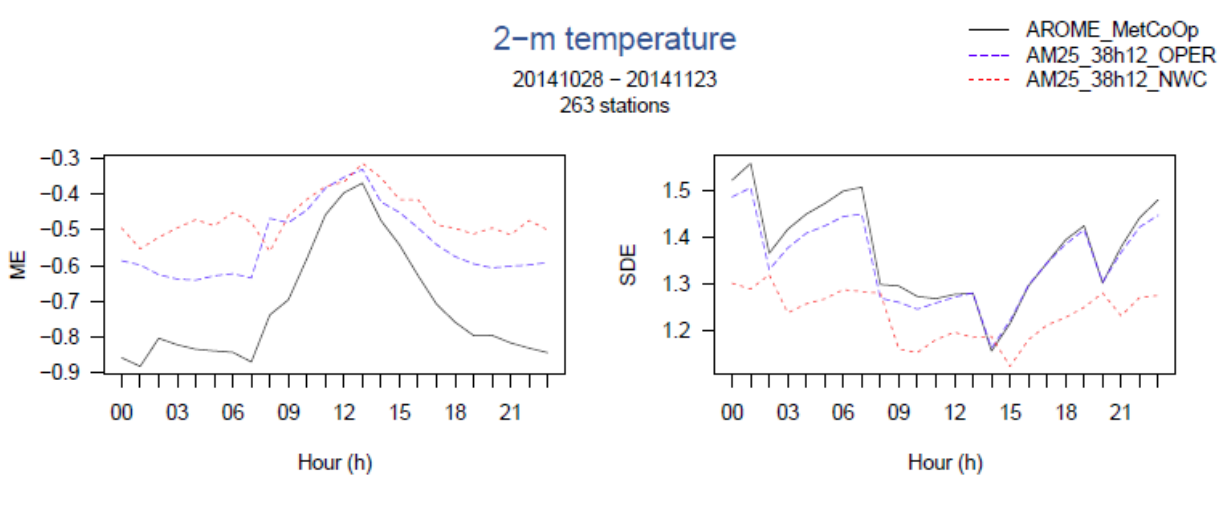
Recommendation: HARMONIE observation operator to take into account observations footprint

Highlight of the progress – RUC, nowcasting

– 1h 3D-VAR rapid refresh using MetCoOp model, conventional and ATOVS data
Lise Graff, R. Randriamampianina, M. Müller (MET Norway)

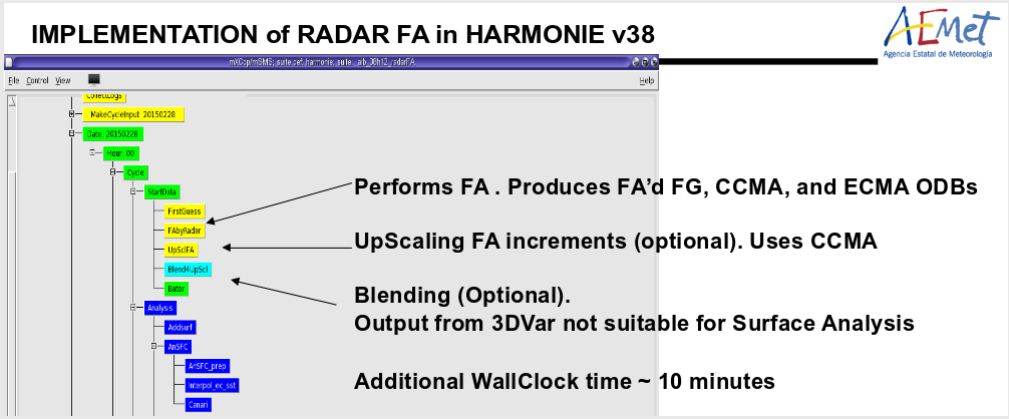
Cut-off time: 15 min

We succeed to reduce the production of real-time very short-range forecast to 2-7 hours



– Carlos Geijo: Field alignment with radar winds (see Carlos' talk)

Almost ready for operational implementation



Highlight of the progress – High-resolution observations

– Magnus Lindskog (SMHI): Assimilation of **Seviri radiances** in frame of DNICAST. Implementation based on LACE data pre-processing, but **small difference in handling in VarBC**.

3D-VAR, conv+ATOVS

And

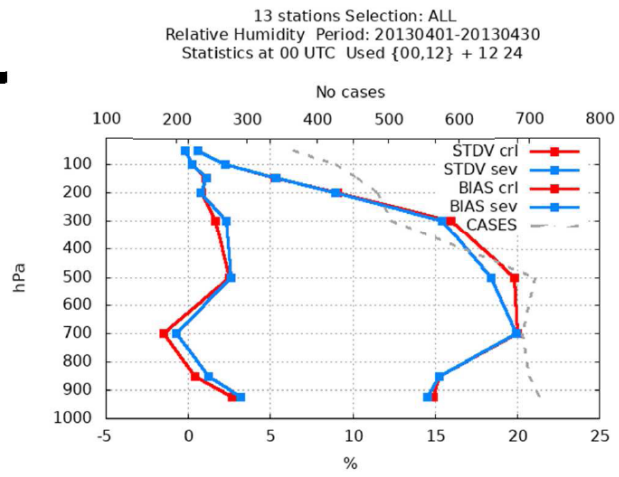
Seviri

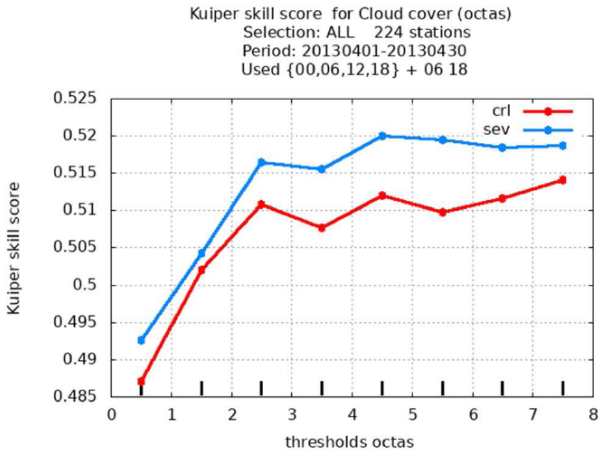
Use of SEVIRI radiances

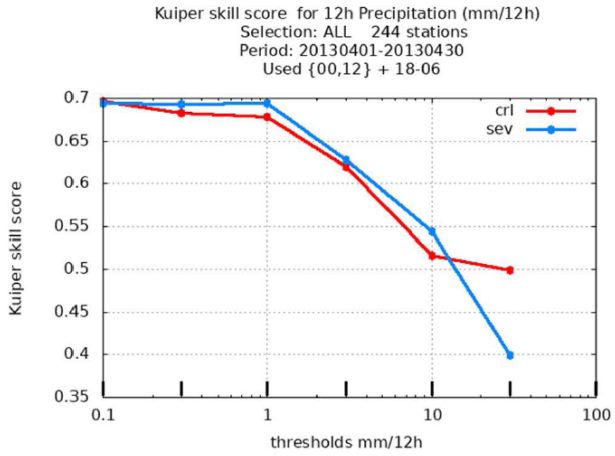
Scores for verification against observations (April, 2013)

std and bias for relative humidity →

Kuiper skill score for Cloud Cover and 12h precipitation





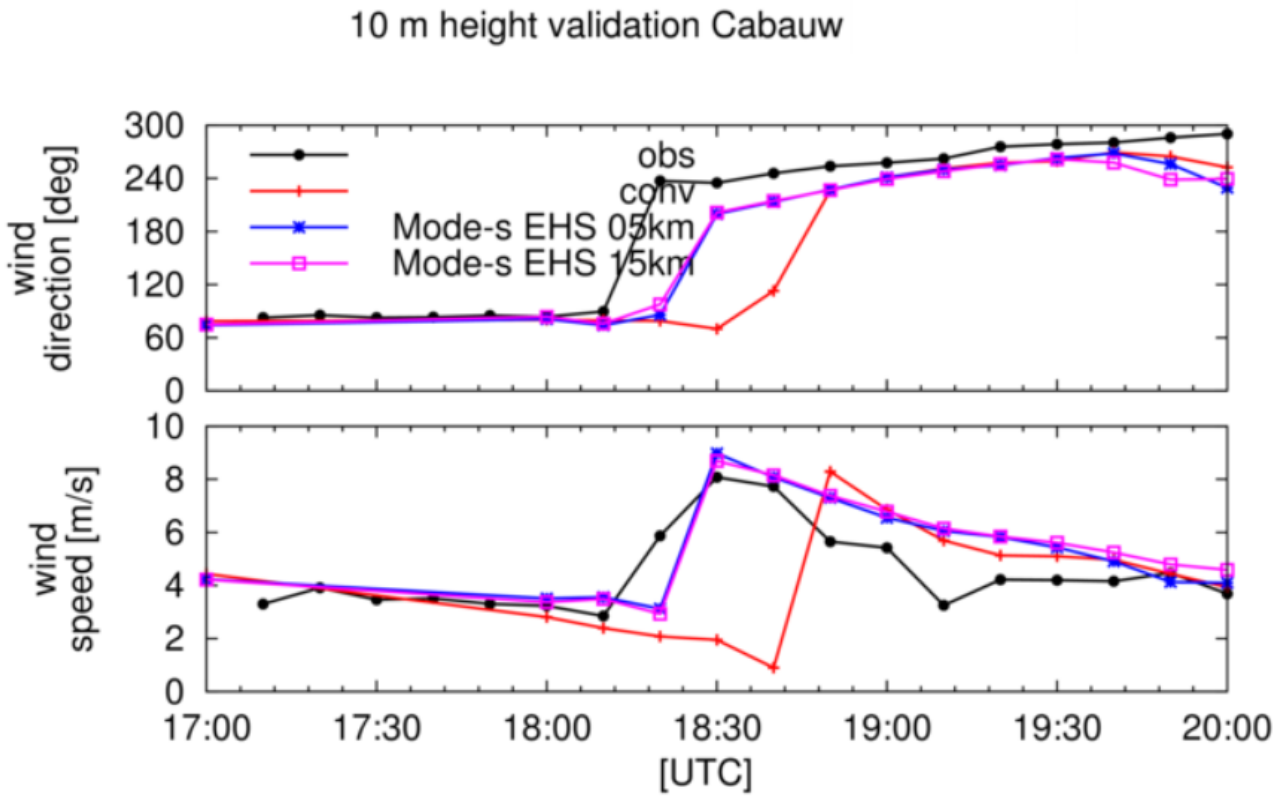


Highlight of the progress – High-resolution observations

– Aircraft derived data (ADD): **Mode-S EHS** tested with 4D-VAR at KNMI with good results.
Jan Barkmeijer (KNMI)

Royal Netherlands Meteorological Institute
Ministry of Transport, Public Works and Water Management

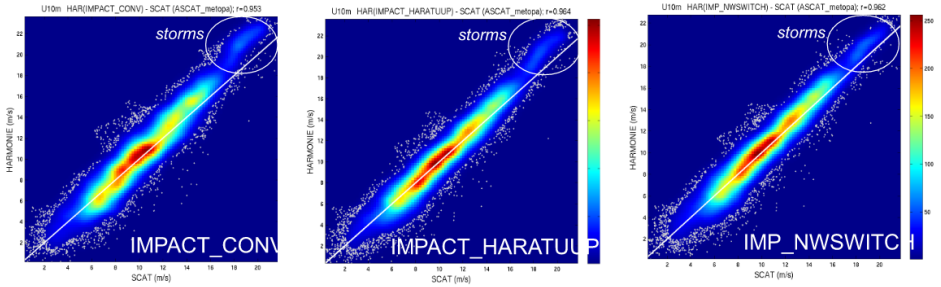
MODE-S EHS: improved 3DVAR timing of a passing front



Highlight of the progress – High-resolution observations

– ASCAT data: **ASCAT data** tested with HARATU scheme at KNMI with good results.

Harmonie (T+3) vs. ASCAT-Metop-A

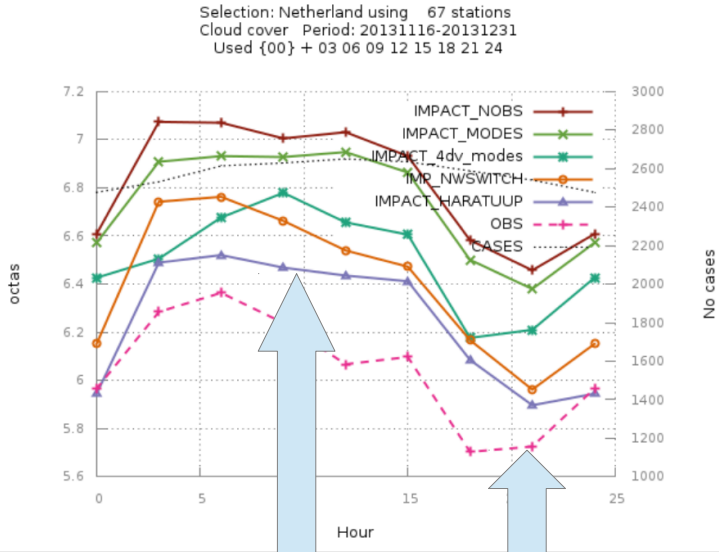


- Harmonie exaggerates strong wind (over sea)
- Better match (closer to diagonal/less broad) for HARATU (over sea)
- Performance for wind speed >18m/s probably related to drag relation

Promising combi:

Harmonie (ASCAT) data assimilation + HARATU

IMPACT on cloud cover



3D-VAR (ASCAT + HARATU)

Observation

Highlight of the progress – High-resolution observations

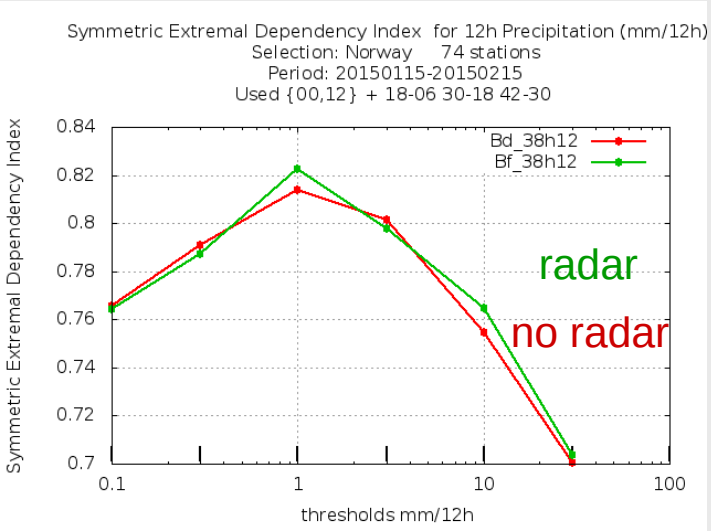
– **Prep-opera toolbox**: Mats Dahlbom(DMI) built a pre-processing tool that reads and process OPERA radar data. He tested this tool with data of 70 radars from 10 European countries.

– Good progress with testing **OPERA data**
Wim Verkleij (KNMI), Martin Ridal (SMHI) and Mats Dahlbom (DMI), Jana Sanchez (AEMET)

– **Clear echoes and blocked radar data** at MET Norway
(R Azad, C Elo and R Randriamampianina).

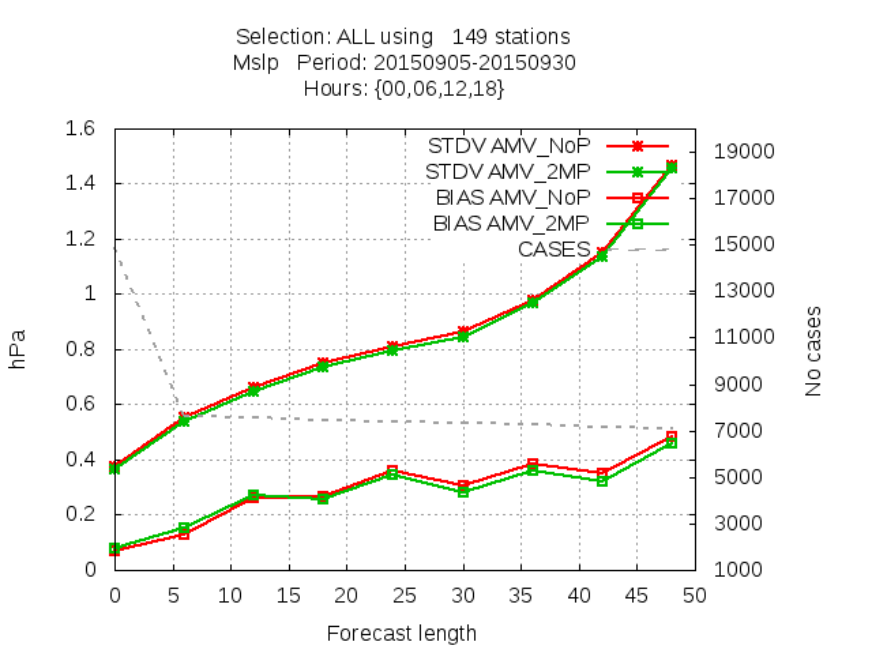
–Test on avoiding the use of detected clear echoes shows promising results on humidity and precipitation forecasts;

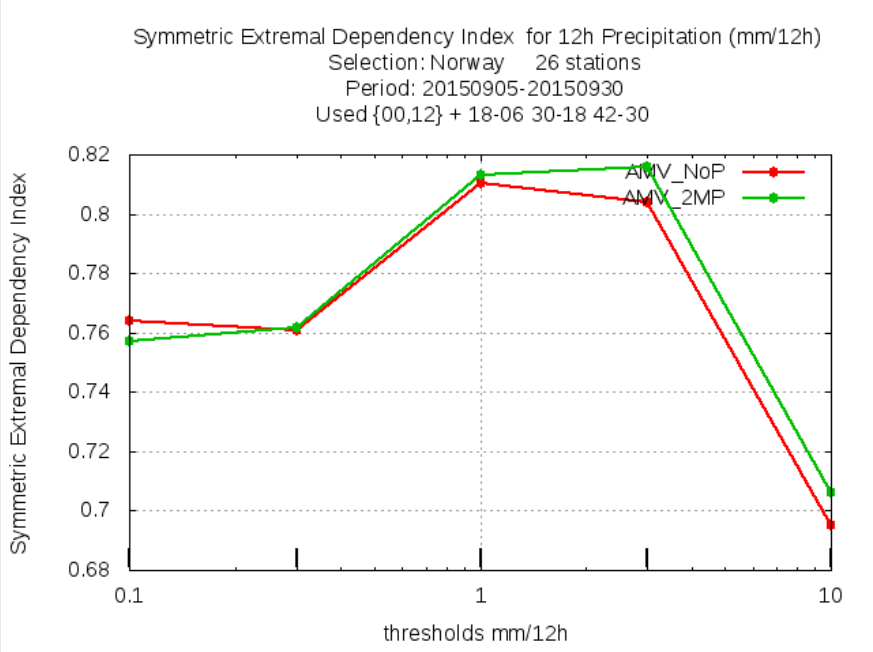
– Properly handling blocked data also showed promising results.



Highlight of the progress – High-resolution observations

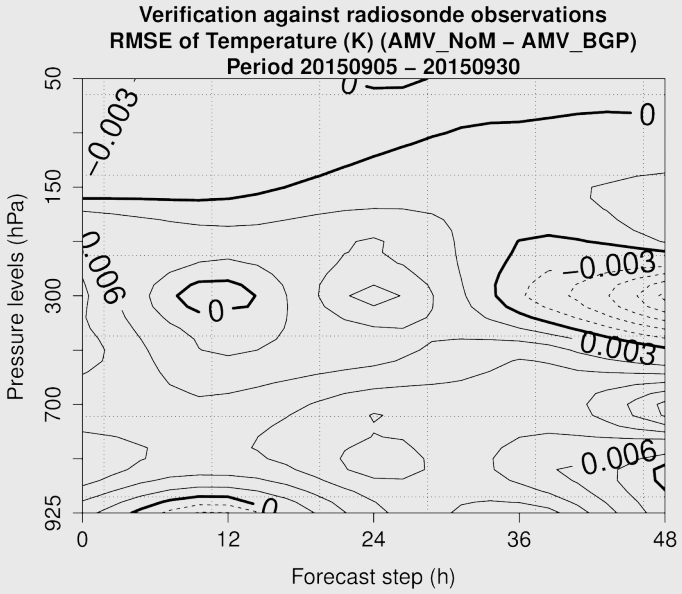
– **High-resolution atmospheric motion vectors** (HRW) from geostationary satellite and **polar winds**: R Randriamampianina, M Mile, Trygve Aspenes, Harald Schyberg.
In frame of SAWIRA-2 project and OMSZ-MET Norway cooperation,

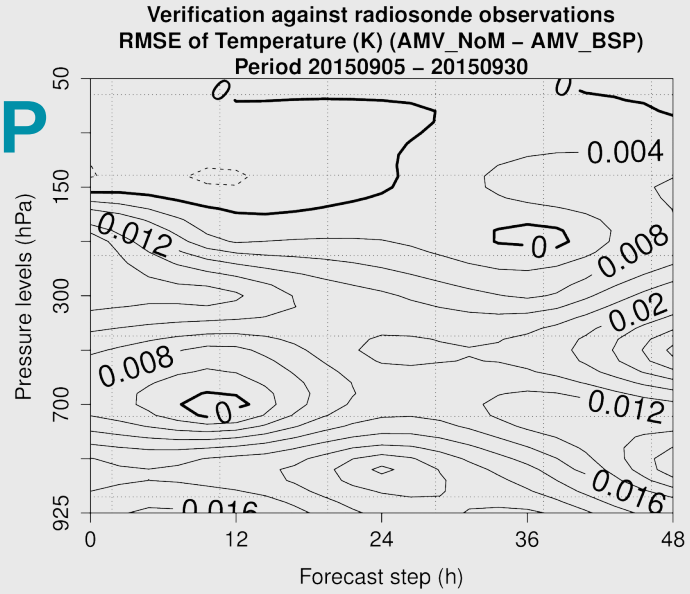




Promising impact of Polar winds on AROME-Arctic forecasts

Impact of Geo winds on forecasts: 00 and 12 UTC runs on METCOOP

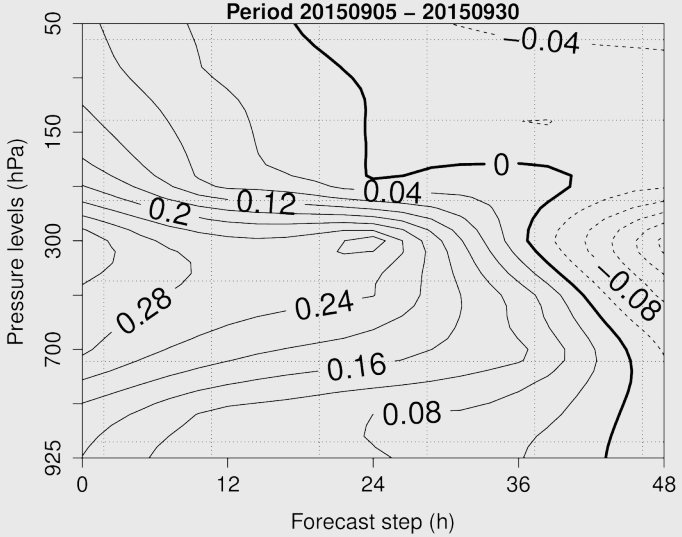


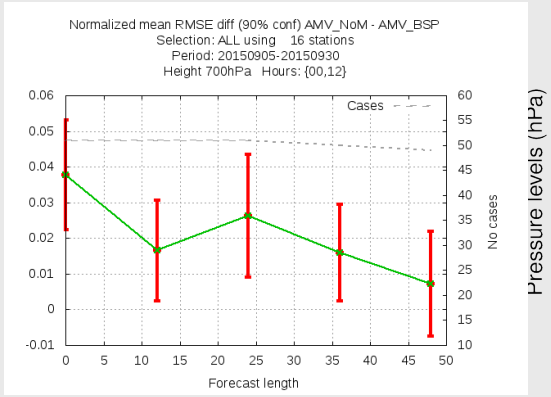


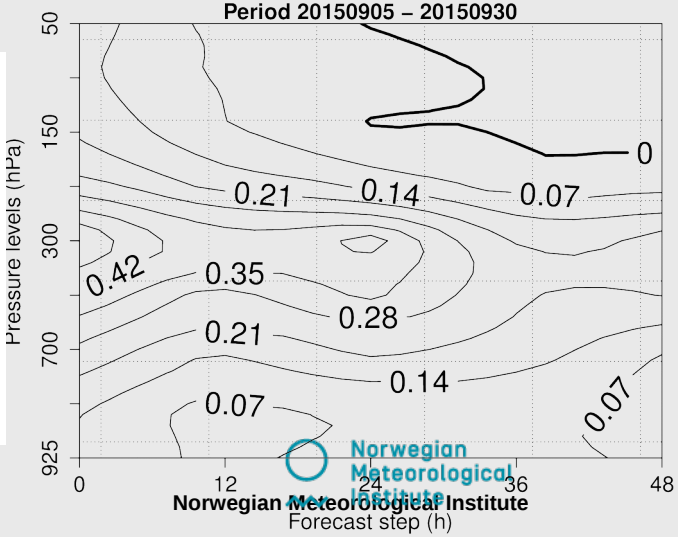
MPEF + Polar winds

against
16 Radiosondes

HRW + Polar winds







Highlight of the progress – High-resolution observations

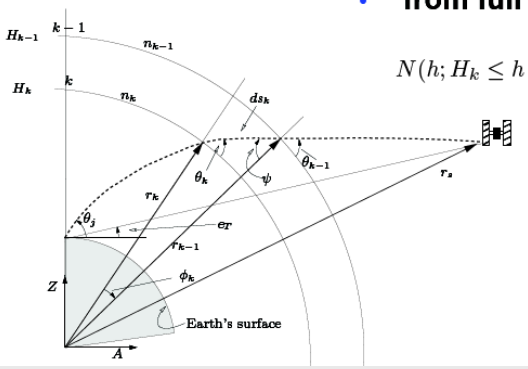
– Siebren de Haan(KNMI): Observation operator for **GNSS slant total delay (GPS STD)** in Harmonie. The implementation was done with cycle 38h1.2 and was done similarly to the GPS RO, but it is a new and separate operator.

Implementation

Royal Netherlands Meteorological Institute
Ministry of Transport, Public Works and Water Management

- **Obs operator**
  - **coordinate along signal path in x-z-plane**
  - **from full level to full level:**

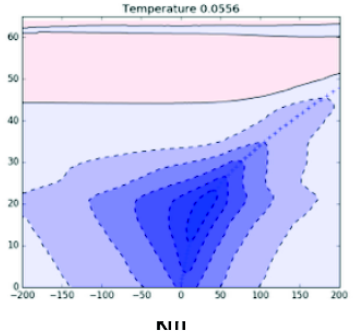
$$N(h; H_k \le h < H_{k-1}) = N_k \left(\frac{N_{k-1}}{N_k} \right)^{\frac{h-H_k}{H_{k-1}-H_k}}$$

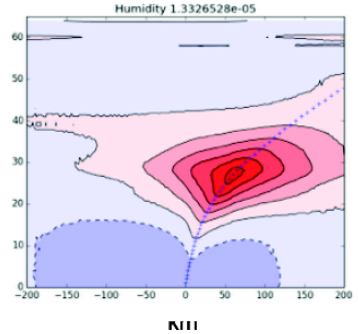


1st result

Royal Netherlands Meteorological Institute
Ministry of Transport, Public Works and Water Management

- **Single Observation:**
  - **azimuth = 0,elevation = 1**
- **Increments (AN-BG) in x-z-plane**

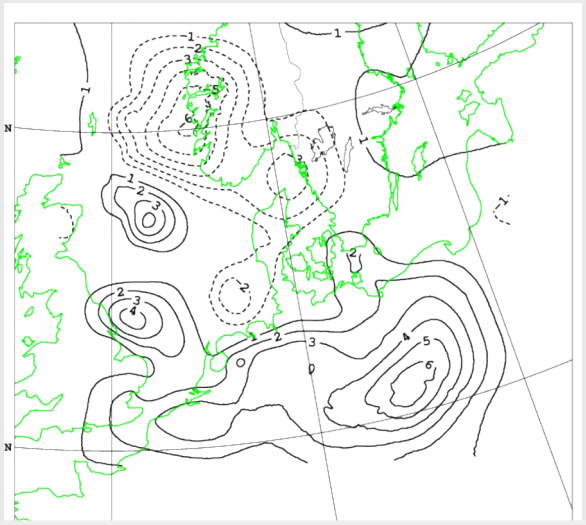




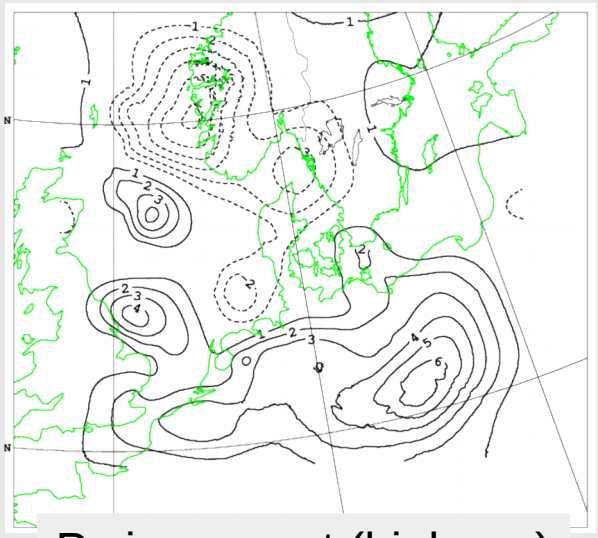
Highlight of the progress – algorithm development

–Nils Gustafsson(SMHI): **4D-VAR** development

1) Jc-DFI implementation;
2) better handling of change of resolution in spectral space;
3) run outer loop with update in ODB;



low resolution Ps increment



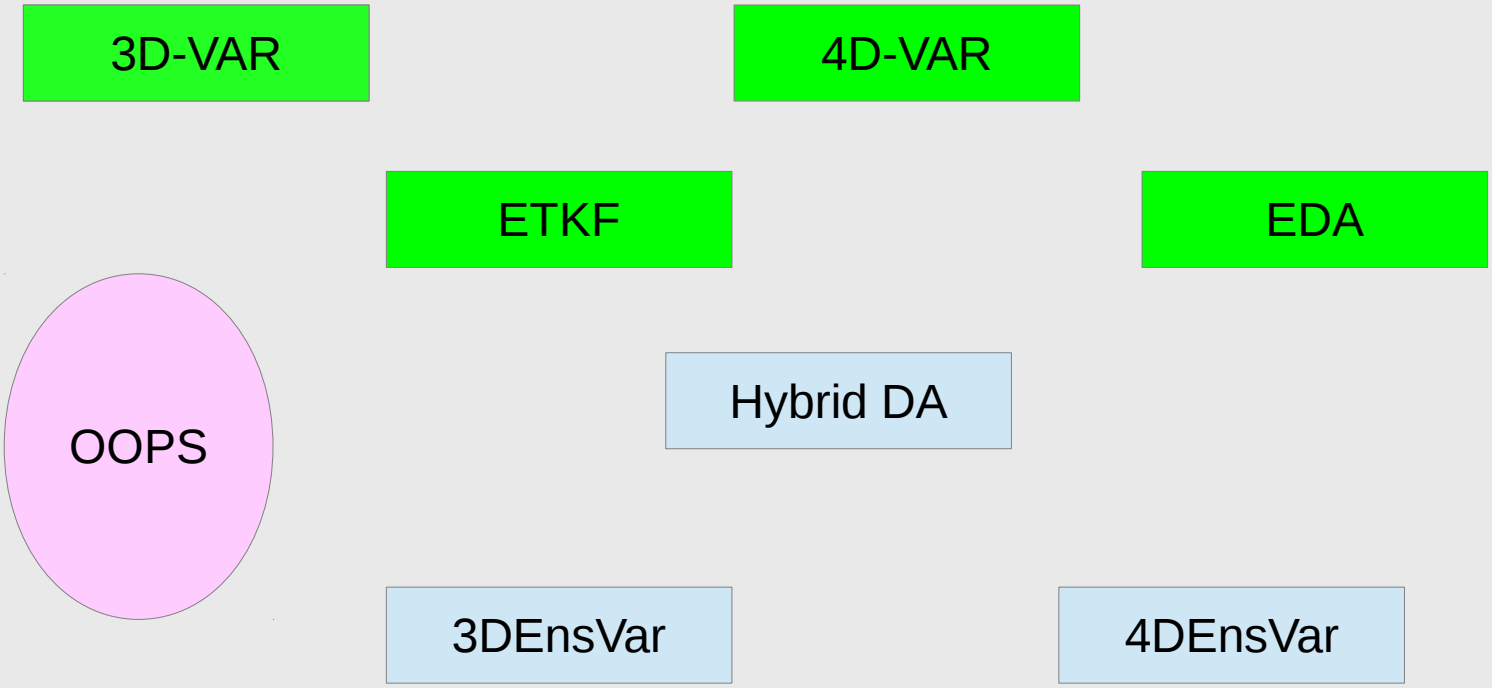
Ps increment (high res)

– Pau Escriba(AEMET): **LETKF** is proven to be better than 3D-VAR (38h1.2) for Spanish domain. We are now working with Harmonie CY40;

– Roel Stappers(MET Norway): Developed a matrix free linear algebra (MFLA), which will simplify further the **OOPS** programming framework.

Highlight of some of high priority plans

Plan



Goal: to build mesoscale ensemble system with flow-dependent DA

Plan – improving schemes

– Testing different DA configurations (including new/modified balance) to detect the weak part of the system;

– When available testing the *incremental analysis update* (IAU, from CY41);

– The potential of *back and forth nudging* scheme (Auroux et al. 2005; Auroux and Blum 2008; Auroux et al. 2011; Kalnay et al. 2000) will be explored first with toy model, then in the Harmonie system;

Plan – more observations

– Wind observations (ModeS, Aeolus ADM data from next year);

– Cloud and cloudy observations: All-Sky, cloudy IASI and cloudy Seviri radiances;

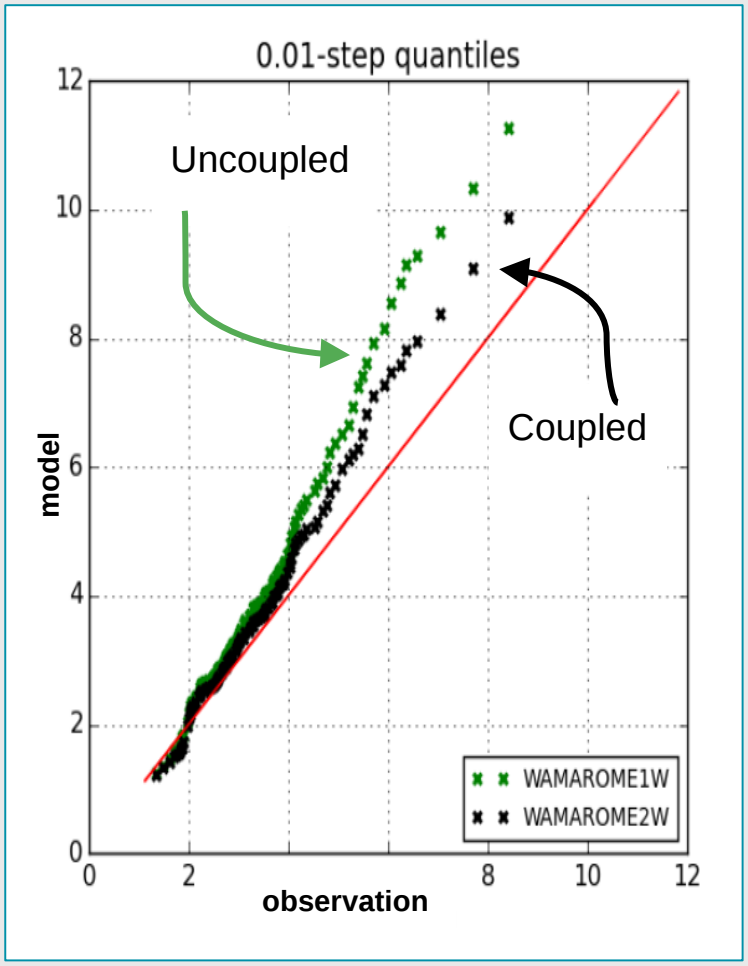
– Use of surface sensitive or low atmospheric peaking channels;

Use of ASCAT data with coupled system at MET Norway (Teresa Valkonen)

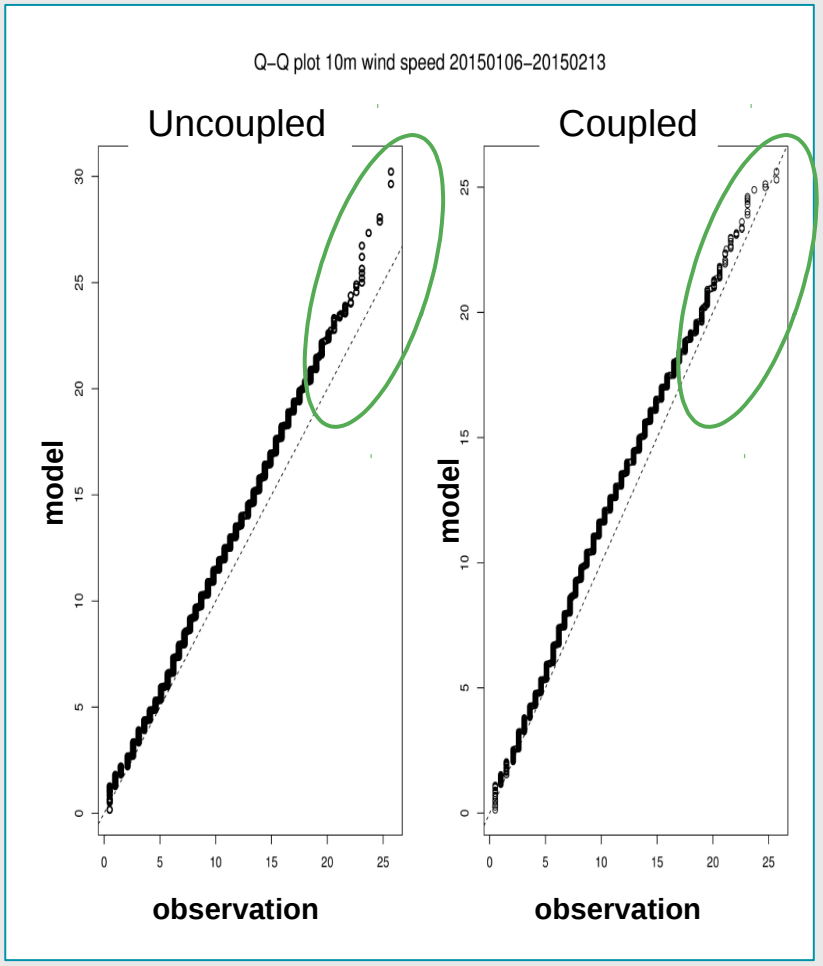
AROME-WAM coupling have shown to improve both wave and wind forecasts

Figures: Jakob Süld, MET Norway

Significant wave height in the North Sea



10-m wind speed at ocean stations



Working organisation

– Formation of groups working with the same or similar topics and have regular distant video meetings. Inviting Météo Fance, LACE and other Aladin colleagues;
→ we have 5 video meeting web-rooms on:
radar data processing, conventional data and COPE, Radiance data,
ETKF 3D-VAR 4D-VAR OOPS (algorithm) and retrieval data

– Face-to-face meetings are still needed and we will have min. twice per year.

Thank you