Norwegian Meteorological Institute

HIRLAM upper-air data assimilation Progress report

Roger Randriamampianina
with contribution from HIRLAM colleagues

EWGLAM, 28 Sept - 2 Oct. 2020, Virtual meeting

outline

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

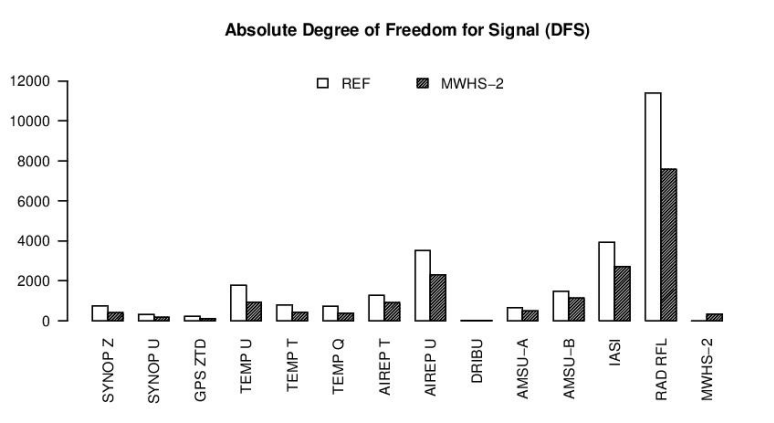
- Improving the use of observations

- Algorithmic development

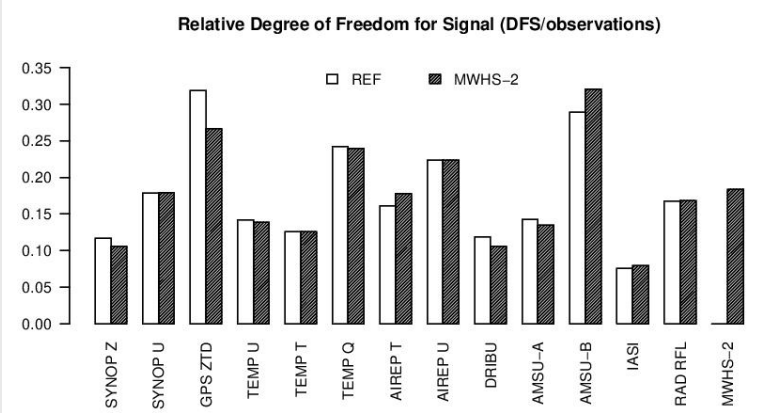
- Concluding remarks and further plan

Operational upper air data assimilation (UA-DA) systems

- **Assimilation scheme:** 3D-VAR;
- **Cycling Strategy:** 1 / 3 hourly;
- **Conventional observations:** SYNOP, SHIP, BUOY, AMDAR,TAMDAR, AIREP, ACARS, ModeS EHS/EMADDC, Pilots, TEMP;
- **Satellite radiances:** AMSU-A, AMSU-B/MHS, ATMS, IASI;
- **Satellite retrievals:** Scatterometer, GNSS ZTD, GPS RO, AMV;
- **Radar observations:** Reflectivity;
- **Bias correction scheme:** Variational (VarBC)
- **Blacklisting of conventional observations:** IFS decision



DFS impact of observations in METCOOP



Use of more observations in operational DA

Observations added since last EWGLAM meeting:

– *Met Éireann*: AFIRS AMDAR; TAMDAR
– *AEMET*: REFL, T2m, RH2m, Metop-C ASCAT, ATOVS and IASI.
– *MetCoOp*: Mode-S EHS; Metop-C ATOVS
– *DMI-IMO*: Mode-S EMADDC; GPS RO (Metop-C & FY-3)

Observations under test:

Met Éireann (E Whelan, E Harney, R Darcy):
Mode-S EMADDC, ATMS, MWHS2, REFL

AEMET (J Sanchez, P Escriba, M Diez, J Campins, B Navascués):
SEVIRI and Doppler winds

KNMI (J Barkmeijer, G-J Marseille, S de Haan):
Mode-S EMADDC, REFL, ATOVS, IASI, GNSS STD

MetCoOp (O Vignes & Co):
Mode-S EMADDC; Metop-C ASCAT/IASI, MWHS2

DMI-IMO (X Yang, M Dahlbom, B Amstrup, S Thorsteinsson):
Metop-C ATOVS/IASI/ASCAT, Polar winds

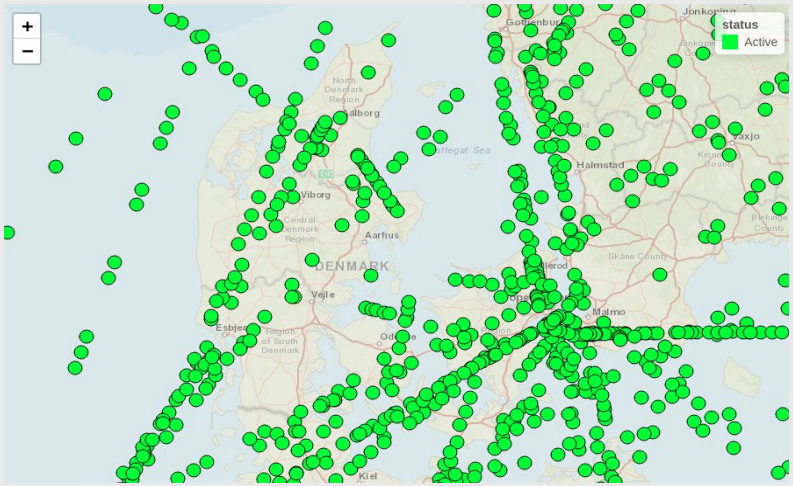
Danmarks Meteorologiske Institut

Use of observations in DA

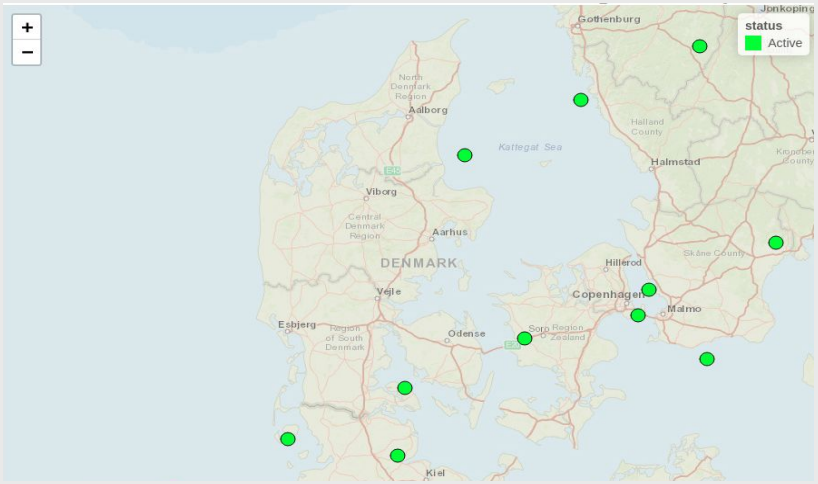
Reduced Airborne Observation (AO) during COVID-19 causes less accurate weather forecast

Xiaohua Yang, DMI

12 UTC, Feb 6, 2020



12 UTC May 21, 2020



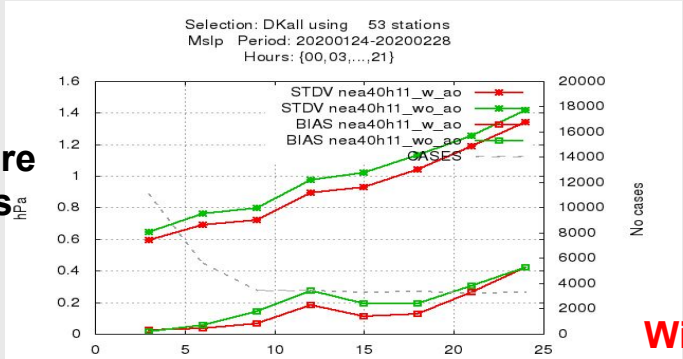
COVID-19 causes severe loss in airborne meteorological measurement data available to weather forecast models. Green dots in the above plot denote typical situation with aircraft observation (AO) available to the weather prediction model DMI-HARMONIE before (left) and during (right) COVID-19. Loss of AO data is estimated to affect quality of weather forecast to a non-negligible degree.

Use of observations in DA

Xiaohua Yang, DMI

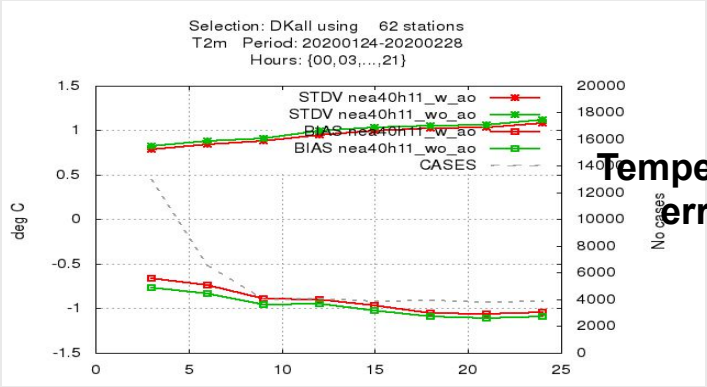
Impact of Aircraft data to forecast accuracy

Pressure errors



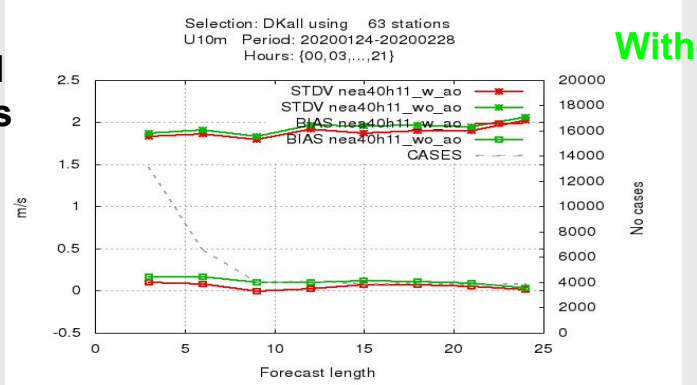
With AO

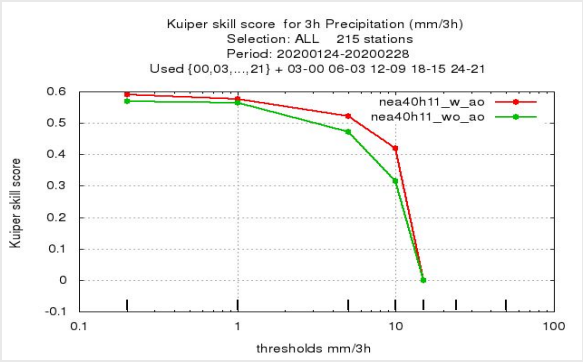
Without AO



Temperature errors

Wind errors





Rain Skill level

Simulation experiments comparing DMI-HARMONIE forecast during Feb 2020 **with** and without aircraft data. The model quality is defined as averaged forecast fit to surface observations in Denmark. X-axis are forecast lead-time, Y-axis the errors in standard deviation and average offset for pressure, temperature and wind, skill level for rainfall. It is shown that loss of aircraft observation data causes noticeably larger errors in 1-day forecast for key weather parameters and degrade forecast skill.

Assimilation of radial Doppler wind

Jana Sánchez-Arriola & Beatriz Navascués , AEMET

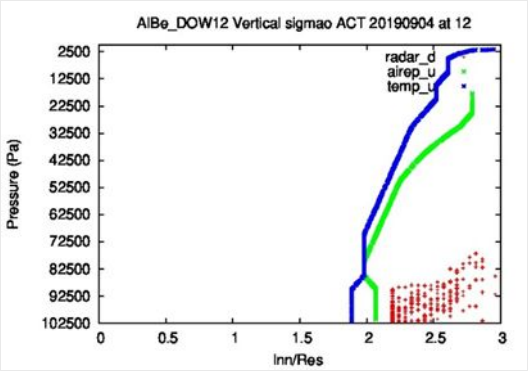
Impact studies based on cy40 including Doppler winds and reflectivities from BALTRAD preprocessing centre.

First try with:

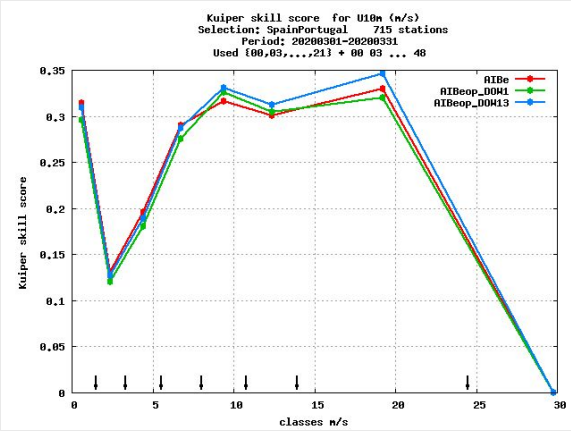
1) Tuning of sigmao value depending on the distance from the radar, increasing its value.

2) Innovation rejection limit decreased 4 times

Good impact on pcp, a neutral impact on T and neutral to negative on 10m winds have been found



New Obs err values for wind from AIREP, TEMP and radar DOW

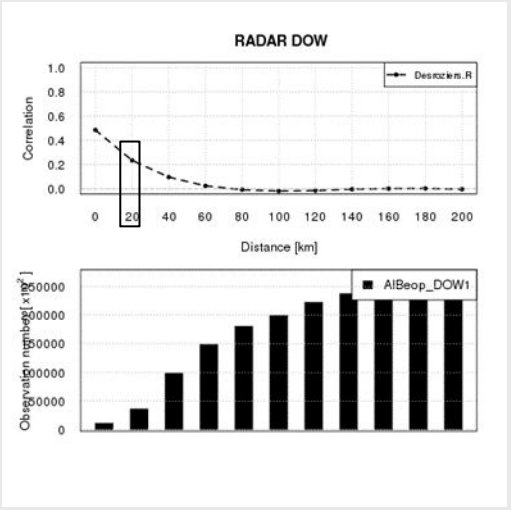


KSS of 3h acc pcp, the red is control, Green by default and blue with the first try of the tuning.

Now working on:

1) Tuning of the thinning distance.

2) Tuning again the sigmao error according to Desroziers et al 2005.



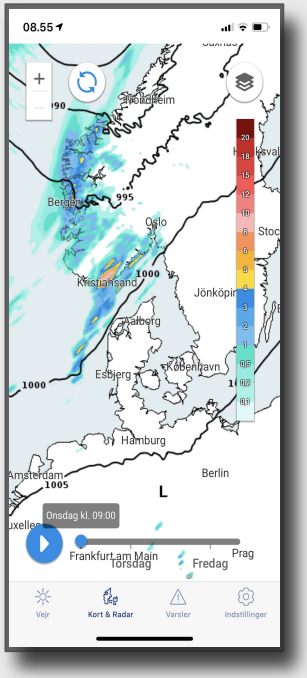
Liu and Rabier (2003) Thinning distance between DOW obs should be 20 km for this experiment

Enhanced use of crowdsourced observations

Danmarks Meteorologiske Institut

Smartphone Pressure System (SMAPS) (Kasper S Hintz, DMI)

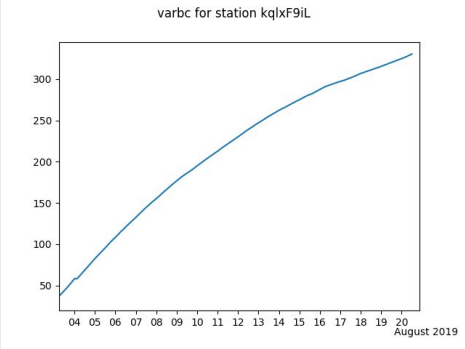
DMI has collected smartphone pressure observations (SPOs) through third-party apps.
Recently the framework collecting such observations was installed in the DMI-app, doubling our data amount to about 250.000 observations per day.
We have updated the framework to use a less accurate position estimate, and **we have deleted the unique smartphone identifier**, thus, the data is not categorized as personal data anymore.
Bias-correction becomes more difficult - but we expect “numbers to beat accuracy”.
An experiment with cy43h and a resolution of 750m is currently being set up, with assimilation of these observations, to be run for an extended period.
Observations will enter the model through ODB.

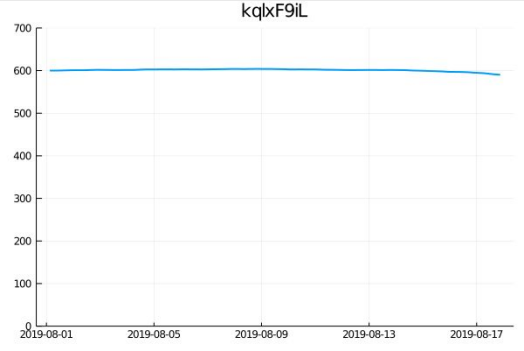


The framework measures and computes the pressure observation in the background while the app is open.

Surface Pressure from Netatmo (R Stappers (MET Norway), J Bojarova, P Madeiros (SMHI))

Assimilation of hourly Netatmo surface pressure using variational bias correction technique was developed. Machine learning for QC. Testing of the different components of the scheme is needed. For example application of the hourly bias coefficients update together with the daily radiance aggregations.





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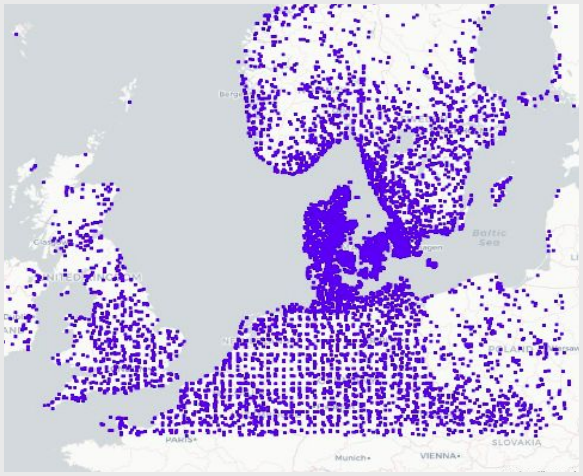
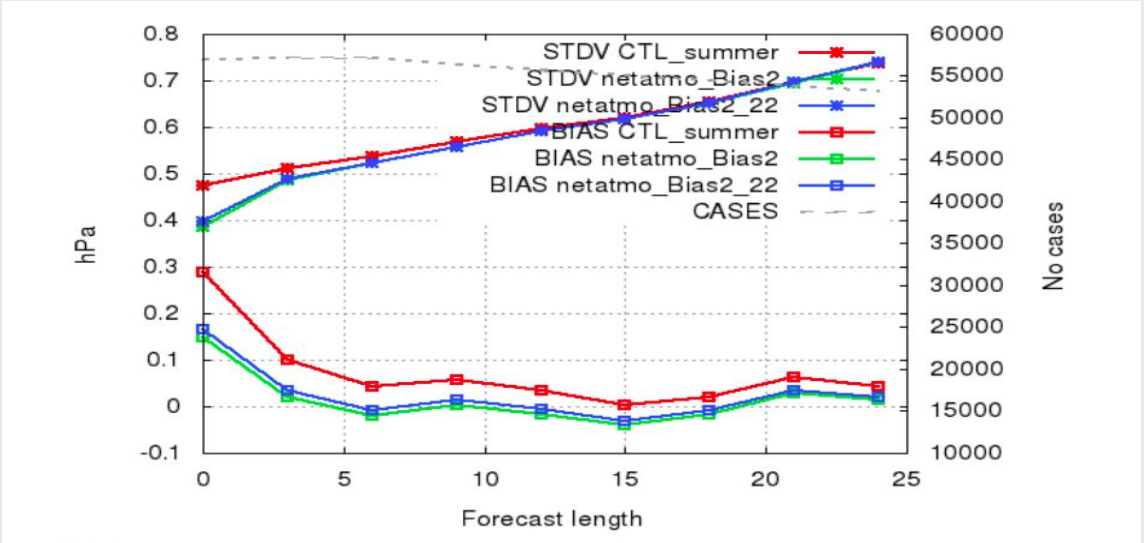
Experimental use of crowdsource data

Alessandro Falcione, Xiaohua Yang and Eigil Kaas

A study of preprocessing and assimilation of NETATMO data in a NWP system,
(Master thesis project at Copenhagen University & DMI)





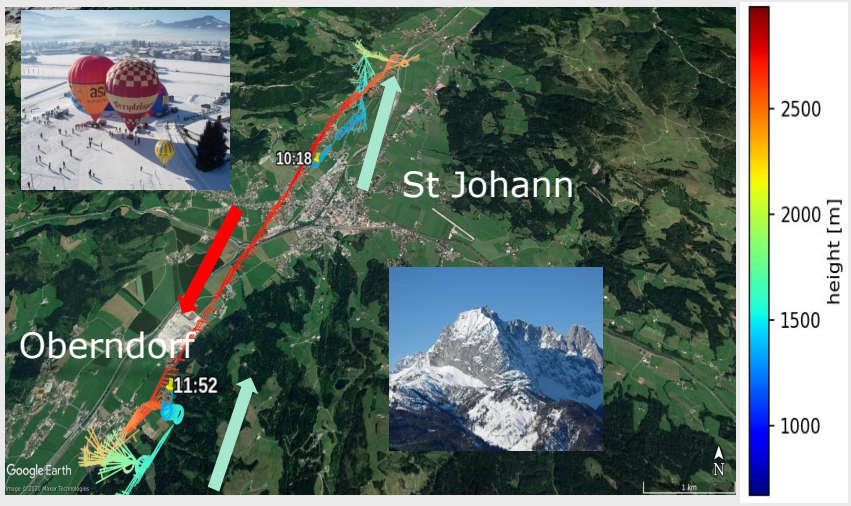
(Source of test data: private weather station "NETATMO")

-- CTL **-- ading netatmo pressure data**
-- with thinning

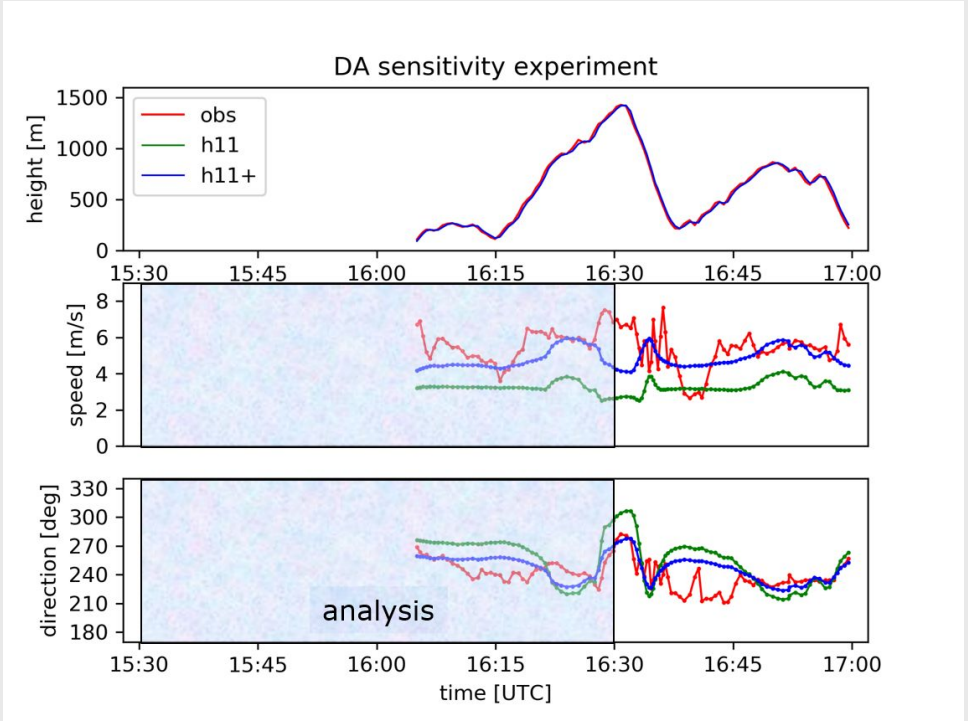
Tested also for winter period and showing similar promising good impact on MSLP and T2m

Assimilation of Hot-Air Balloon observations

Cisco de Bruijn, KNMI



16 January 2005 10:18-11:52 UTC, Mountain Hot-Air Balloon flight near Sankt Johann (Tyrol, Austria), in the valley the winds are opposite to the winds above the inversion. The left and right subplots show respectively the take-off and a screenshot during the flight



15 September 2012 16:02-17:03 UTC, Transect of a Hot-Air Balloon (HAB) flight (red), NWP model (green), NWP model with assimilated HAB data (blue), the light blue box is the assimilation time window, the analysis time is at 16:00 UTC.

Use of Aeolus satellite observations

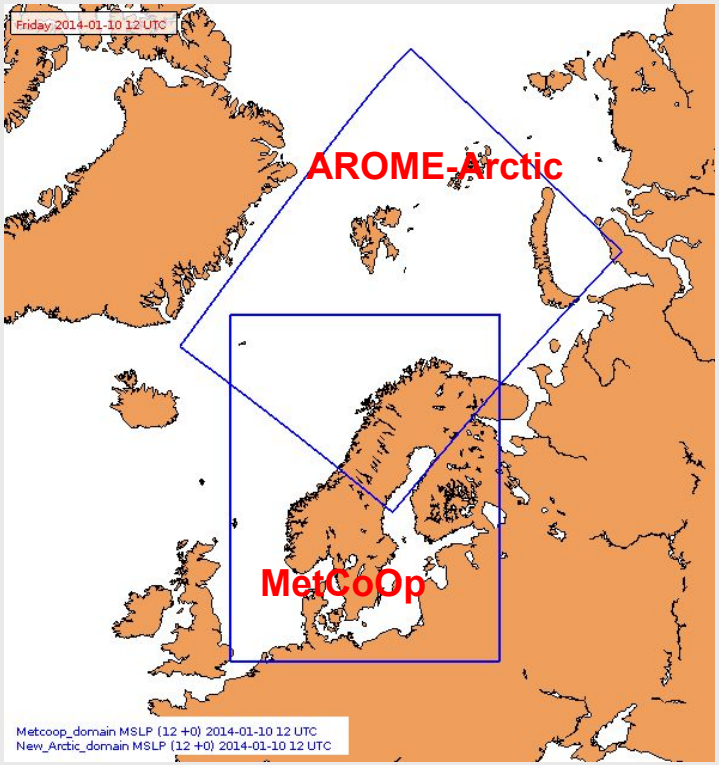
S. Hagelin, R. Azad, M. Lindskog, H. Schyberg, H. Körnich

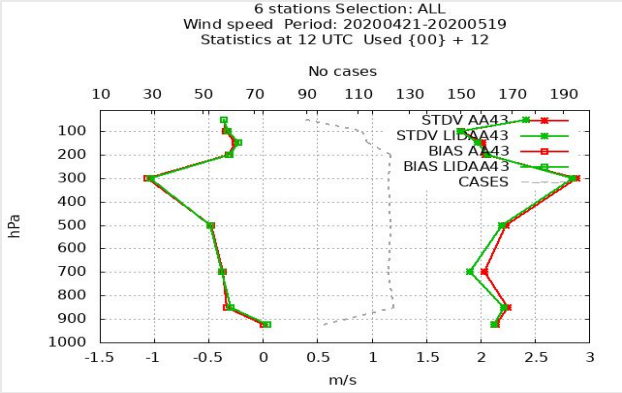
Satellite measures HLOS (Horizontal Line Of Sight) winds, ≈ east-west wind component
- Rayleigh winds: lower resolution, more data, measured in clear skies
- Mie winds: higher resolution and quality, but only available when cloudy

Data from Aeolus tested in MetCoOp domain in two four week periods using 3 hourly 3DVar
- Sept-Oct 2018, when satellite was new (laser A)
- Apr-May 2020, a more recent period (laser B)

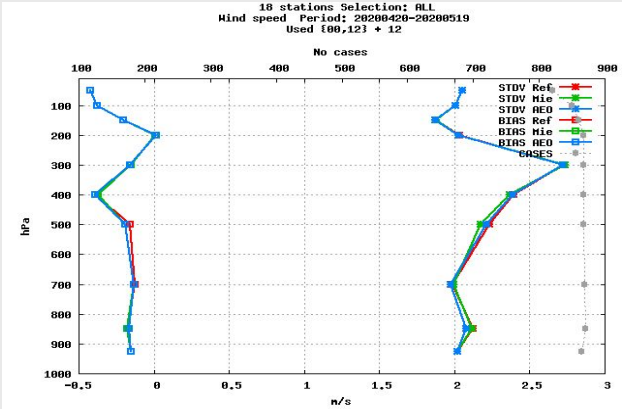
Satellite overpass possible for MetCoOp domain at 03, 06, 15 and 18 UTC

Aeolus data is ~14 % of total upper air wind data used in the data assimilation for laser A experiment.





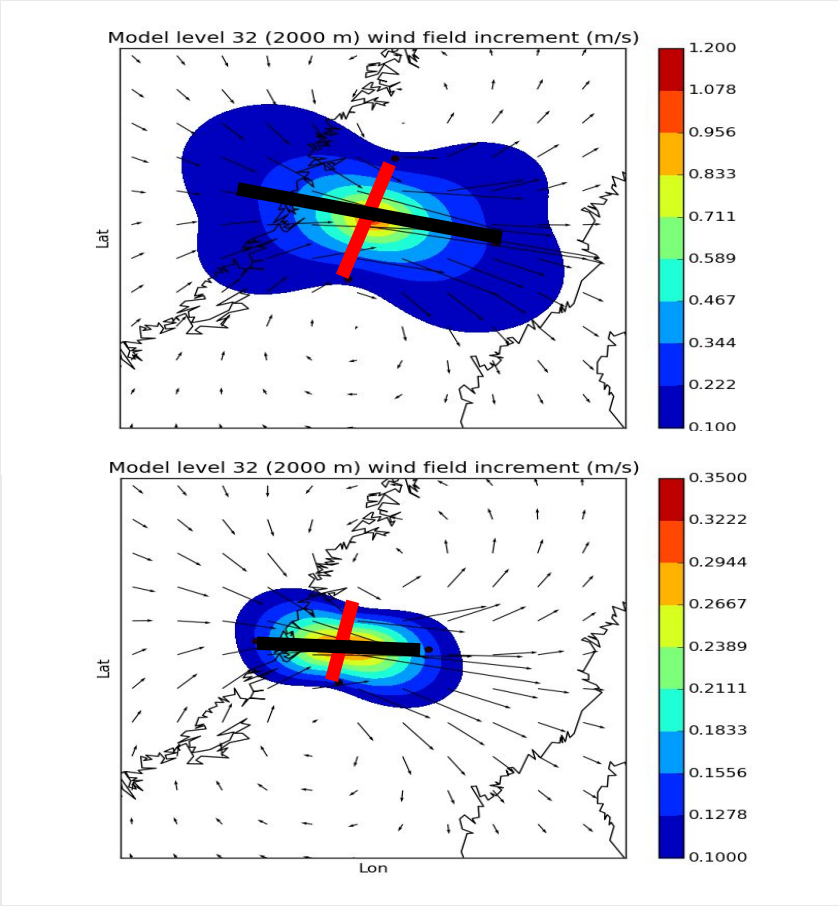
Impact of Aeolus data
on AROME-Arctic 12h forecasts
Green - with Aeolus data
Red - without Aeolus data



Impact of Aeolus data
on MetCoOp 12h forecasts
Mie - with Mie Aeolus data
Blue- with Aeolus data
Red - without Aeolus data

Single Aeolus observation assimilation

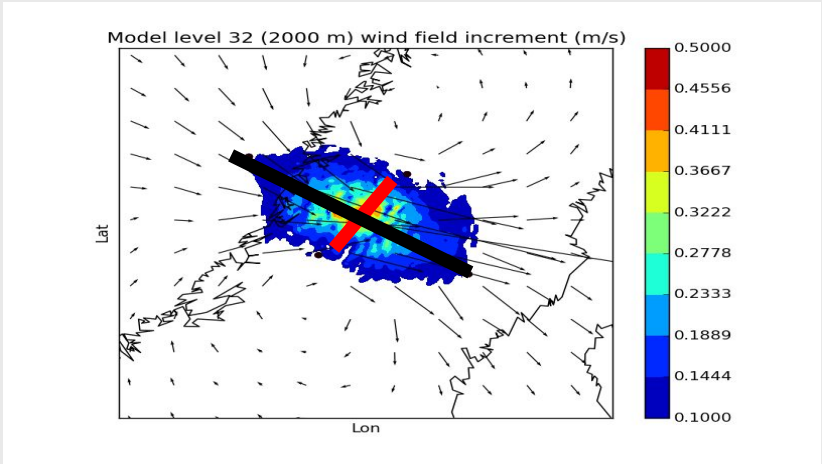
S. Hagelin, R. Azad, M. Lindskog, H. Schyberg, H. Körnich



4D-Var beginning of assimilation window

3D-Var increment

Illustration of horizontal tilt of increments. 4D-var (lower plots) tilt changes between beginning and middle of assimilation window in accordance with flow situation.



4D-Var middle of assimilation window

Improving the nowcasting system

Erik Gregow & David Schönach (FMI)

The MetCoOp HARMONIE-AROME-Nowcasting (MNWC)

The MNWC system produce hourly updated short-range forecast (+9h lead time),

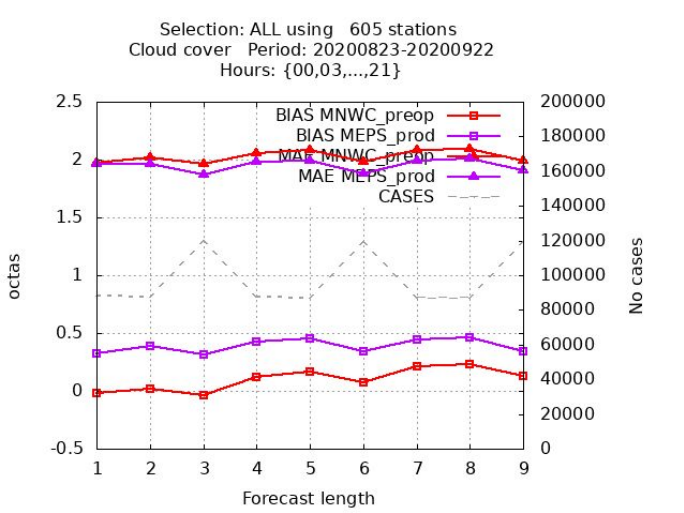
- with a 25 minute observation cutoff
- rapid refresh approach (first-guess from the MEPS control member).

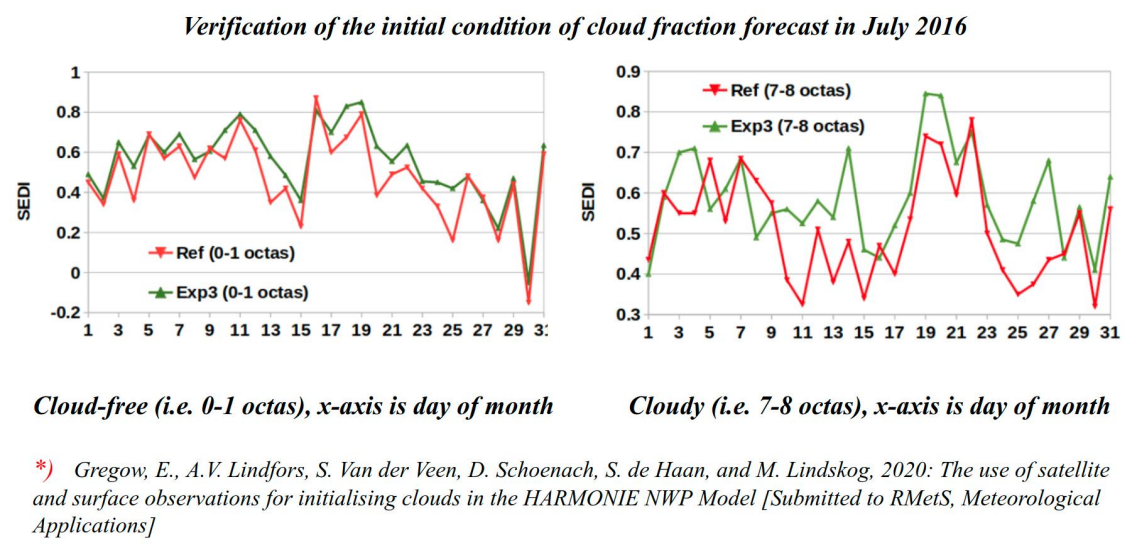
The short cutoff-time of data-assimilation results in a decrease in the number of observations

- non-usage of certain observation-types; radiosondes and satellite wind-retrievals (i.e. ASCAT)

The ingestion of MSG-NWCSAF cloud information is used in the pre-operational MNWC runs

- it does improve the cloud fields and convection initialization, compared to MEPS
- but also causes spin-up in the precipitation field





*) Gregow, E., A.V. Lindfors, S. Van der Veen, D. Schoenach, S. de Haan, and M. Lindskog, 2020: The use of satellite and surface observations for initialising clouds in the HARMONIE NWP Model [Submitted to RMetS, Meteorological Applications]

Progress with 4D-Var

N Gustafsson, J Barkmeijer, M Lindskog, P Escriba, E Whelan, I Monteiro, R Azad

DOMAIN	SIZE	OBSERVATION SET
METCOOP25C	900x960	CONV
METCOOP25C	900x960	CONV + AMSUA/B/MHS + IASI
IBERIAxxm_2.5	800x648	CONV + ASCAT METOP A/B/C
IBERIAxxm_2.5	800x648	CONV + T2m/Hu2m
NETHERLANDS	800x800	CONV + EMADDC MODE-S + ASCAT METOP A/B/C

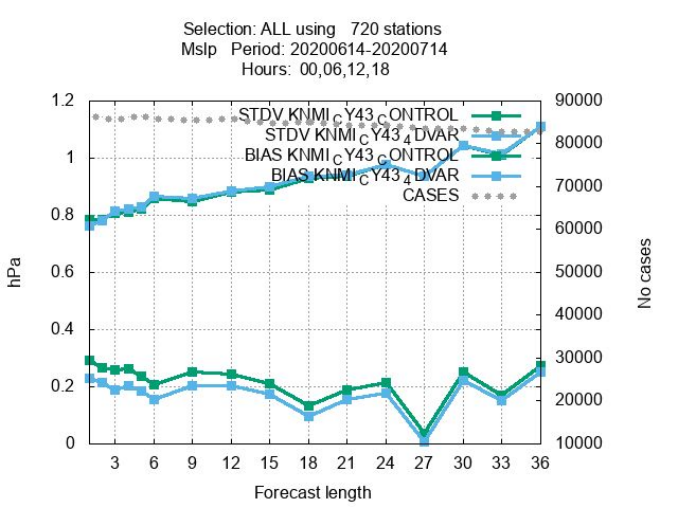
Common features:

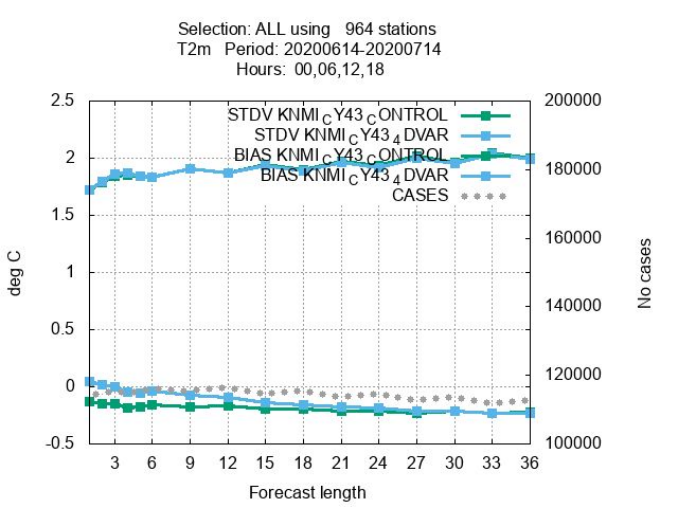
- 2 outer loops at 15 km and 7,5 km
- Obs window is 2 h with 7 subwindows
- Without large scale mixing of ECMWF data
- CONGRAD as minimizer

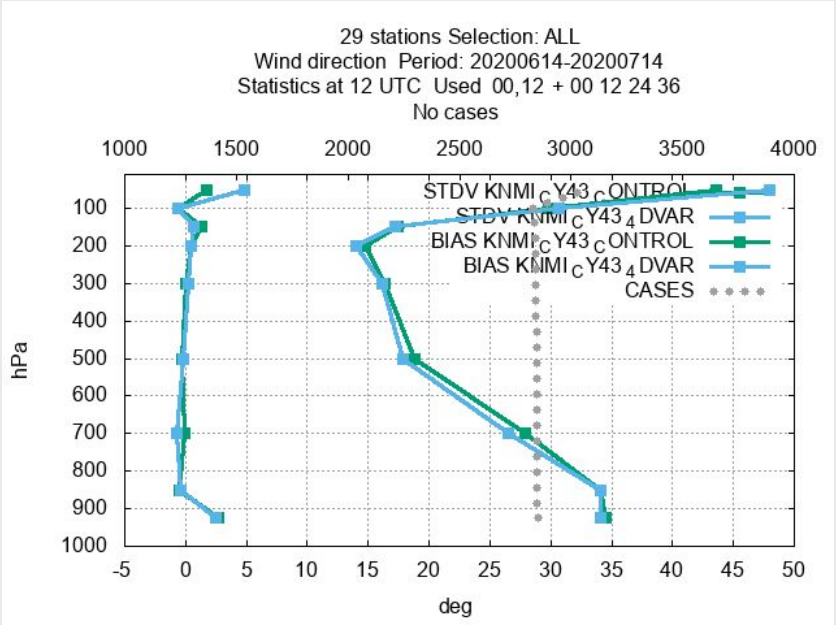
Harmonie-AROME: 2.5km resolution

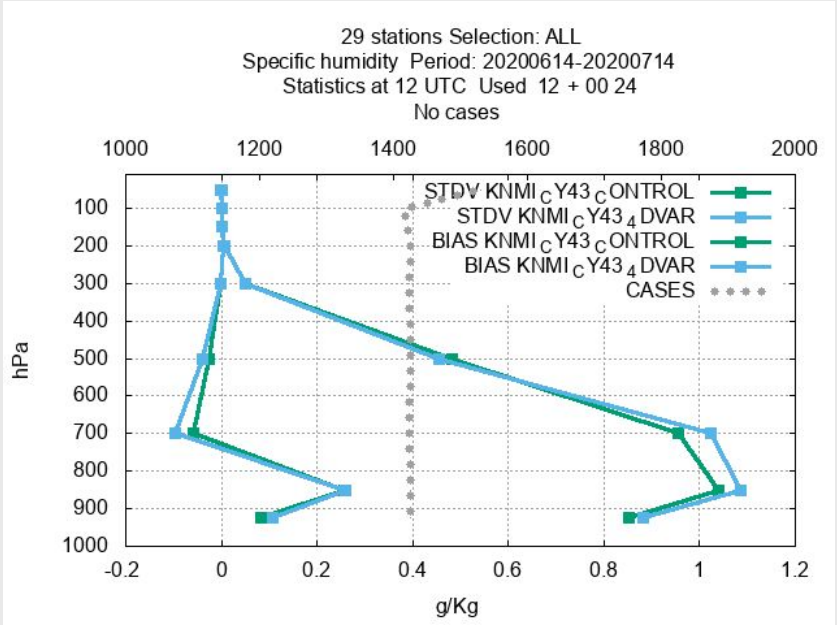
Progress with 4D-Var

N Gustafsson, J Barkmeijer, M Lindskog, P Escriba, E Whelan, I Monteiro, R Azad









Progress with 4D-Var

N Gustafsson, J Barkmeijer, M Lindskog, P Escriba, E Whelan, I Monteiro, R Azad

Very preliminary conclusion:

- For nearly all parameters
  4D-Var
  performs better/equal to 3D-Var

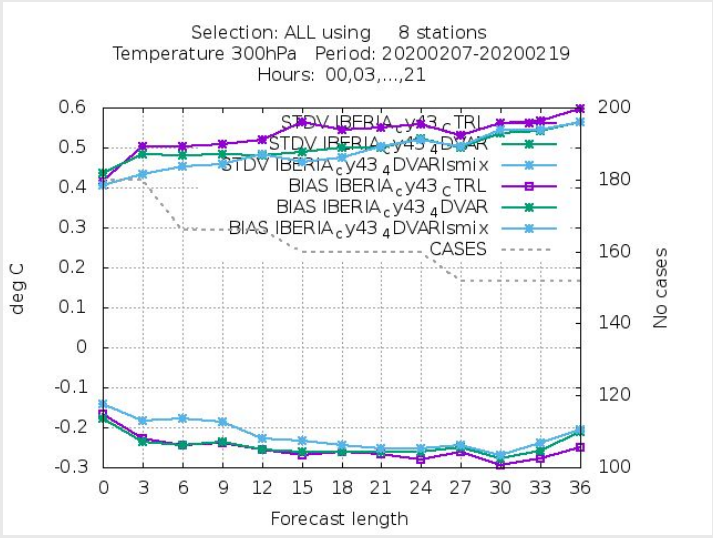
- Specific humidity profiles are
  worse for 4D-Var

Experiments not finished yet:

- Large scale mixing of ECMWF data
- AMSUA/B and IASI
- T2m and Hu2m

Near future

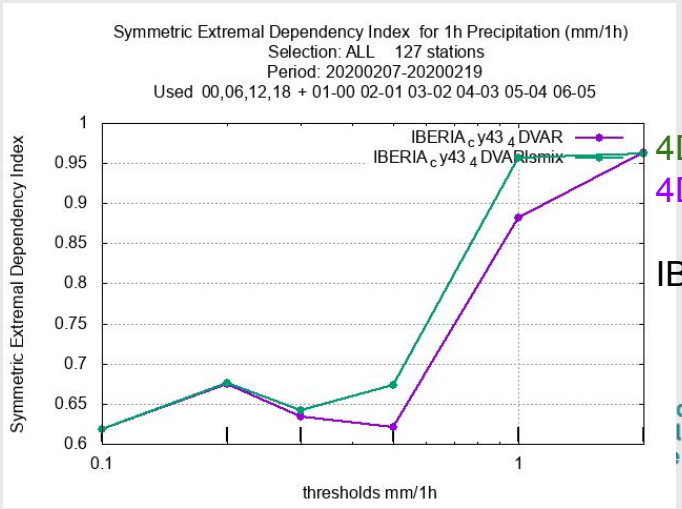
- Radar (RFL and DOW)
- (slant) GNSS
- Large extension zone
- Control of lateral boundary conditions



4D-Var +LSMIX
4D-Var
3D-Var

IBERIAN domain

Preliminary results from ongoing experiments



4D-Var +LSMIX
4D-Var

IBERIAN domain

Other ongoing development ...

LETKF (*P. Escriba, J. Bojarova*)**:** Further tuning of the scheme showed very promising results.

Hybrid and EnVar scheme (*J. Bojarova*)**:**
Tested with observation and Brand perturbation techniques. Further testing and tuning of scheme is needed while larger size ensemble is known to be required.

Field alignment (*C. Geijo*)**:**
The scheme was demonstrated through OSSE to be efficient with a successive hourly application up to 3 hours.

Supermodding/footprint operator development (*M. Mile*)**:**
Good progress with scatterometer and radiance data.

All-sky radiance assimilation (*R Azad, R Randriamampianina*):

Nowcasting-related dev: From development to operational implementation and testing (MetCoOp and DMI).
R. Azad (MET Norway), *E. Gregow, D. Schönach* (FMI), *X. Yang* (DMI)

Concluding remarks and outlook

– Continue to add more observations in local operational systems.
-- Aircraft EMADDC products, more satellite observations (ex. GPS RO, MWHS2, ATMS, AMV)

– Further explore the assimilation of crowdsourced observations in nowcasting and high resolution NWP applications

– We hope to have 4D-VAR in operational soon

– Continue developing the different components of our ensemble system (FA, nowcasting, LETKF and hybrid EnVar schemes)

Thank you