Use of Aircraft Weather Observations in the MetCoOp HARMONIE-AROME Forecasting system

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MetCoOp Observation Usage

MetCoOp

MetCoOp is an operational cooperation between Estonia, Finland, Norway and Sweden. We use the HARMONIE-AROME non-hydrostatic, km-scale forecasting system (Bengtsson *et a*l., 2017), which is a configuration of the ALADIN-HIRLAM Numerical Weather Prediction (NWP) system (Seity *et al*., 2011). The MetCoOp operational NWP setup (Müller *et al.,* 2017) is comprised of a data assimilation system for the surface (OI) and upper-air (3D-Var) together with a forecast model. The system is a continuous ensemble data assimilation based ensemble with 5 members per hour with using a horizontal grid distance of 2.5 km and with 65 vertical levels over a domain illustrated by the area in Fig. 1. The ensemble system is run with 3 independent 3 h data assimilation cycles covering: (1) 00, 03, 06, 09, 12, 15, 21 UTC, (2) 01, 04, 07, 10, 13, 16, 19, 22 UTC and (3) 02, 05, 06, 11, 14, 17, 20, 23 UTC, respectively. So that over 6 h 30 ensemble members can be obtained (Andræ *et al.,* 2020) . Forecasts are run up to a range of +66 h. As an example, Fig. 1 shows an ensemble of ten +6h cloud cover forecasts, valid at 201901020 18 UTC.

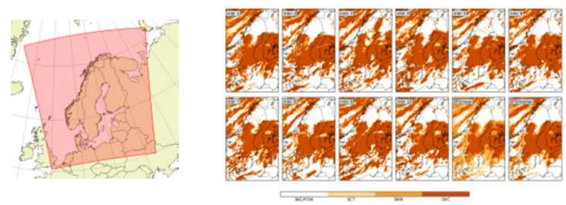

Fig. 1. MetCoOp model domain (left) and ensemble of ten +6 h cloud cover forecasts, valid at 20191020 18 UTC (right)

Observation Usage

Operational MetCoOp observation usage in the upper-air data assimilation include conventional types of in-situ measurements in the form of radiosonde, pilot-balloon wind, SYNOP, ship, and aircraft measurements. In addition radiances from the AMSU-A, MHS and IASI instruments onboard polar-orbiting satellites are operationally used, as well as surface winds from the Advanced Scatterometer (ASCAT) instrument. Furthermore, humidity observations from networks of ground-based weather radars and GNSS receiver stations are used within the operational configuration. Observation cut-off time of 1 h and 15 min. On-going research regarding a future extended observation usage include assimilation of radar radial winds, satellite-based Aeolus HLOS winds (Fig. 2), satellite-based MWHS-2 instrument radiances as well as Mode-S winds and temperatures.

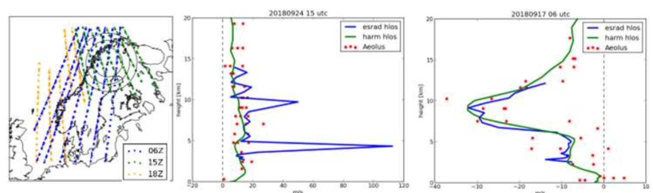

Fig. 2. Aeolus HLOS data coverage for various data assimilation cycles over the MetCoOp domain and the location of Kiruna ESRAD wind-profiler as indicated by centre of circles (left Fig.). Examples (middle and right Figs.) of comparisons of Aeolus observations (red dots) with ESRAD (blue line) and a research version of HARMONIE-AROME forecasts over the MetCoOp domain (green lines).

Mode-S

Data Amounts and Handling

A processing chain has recently been established (Fig. 3, left) to retrieve Mode-S data from the EMADDC processing hub. Data retrieved within the MetCoOp area are mainly originating from Denmark (EnHanced Surveillance (EHS) and Meteorological Routine Air Report (MRAR)) and Norway (EHS). Due to data policy reasons, the processing chain for Swedish data is for the time being disrupted.

To make a first evaluation of the quality, handling and impact of the Mode-S data a one month parallel data assimilation and forecast experiment has been carried out. A copy of the operational configuration (REF) was run in parallel with a version (MOD) where also Modes-S data were assimilated. The Modes-S data where mainly in the form of EHS, but also some MRAR from Denmark were used. Winds and temperatures from both Mode-S EHS and MRAR are assimilated. Mode-S observation error standard deviations have as a starting point been assigned similar values as AMDAR. Also similar quality control and thinning procedures as for AMDAR was applied. The number of EHS data used in the data assimilation of the MOD experiment is more than twice as high as the number of AMDAR observations used, but number of available MRAR is small (Fig. 3, middle). There is however a large daily variation of available Mode-S data (Fig. 3, middle), with many available observations during daytime (Fig. 3, right).

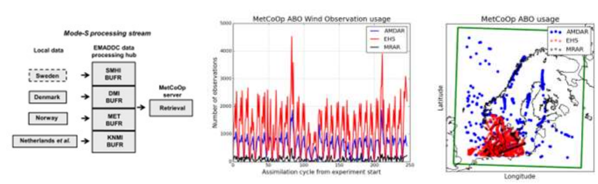

Fig. 3. MetCoOp Mode-S processing chain (left), variation of ABO usage in time for the assimilation experiments of the one month period (middle) and usage for 20191213 09 UTC (right). Blue colour represents AMDAR, red Mode-S EHS and black Mode-S MRAR.

Results and Plans

Observation minus background statistics for Aircraft Based Observations (ABO) are shown in Fig. 4 for winds (left) and temperatures (middle), in addition to statistics of observation minus analysis (right). For both winds and temperatures, Mode-S EHS observations are seen to have a quality slightly worse, but comparable with AMDAR. Mode-S MRAR observations as used here are of significantly worse quality than EHS and AMDAR. It can furthermore be noticed (Fig. 4, right) that rather similar weight is currently given to EHS and AMDAR in the data assimilation.

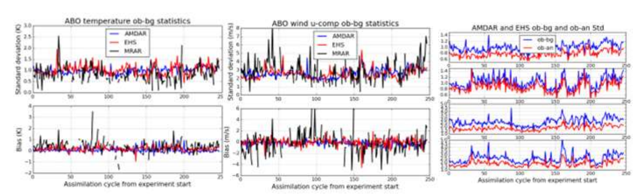

Fig. 4. Observation-background statistics for wind u-component (left Fig., unit: m/s) and temperature (middle Fig., unit: K). Upper panel is for standard deviations and lower for bias. Right Fig. shows observation fit statistics in the form standard deviations of observation minus background departures and observation minus analysis departures, for AMDAR and EHS respectively.

Verification of +12 h forecasts of the one month forecasts of REF and MOD against radiosonde observations (Fig. 5) reveal neutral to slightly negative scores on average, but there is significant day-to day variation.

On-going work concern studies using Mode-S EHS only (not MRAR) and with revised observation error statistics. Plans for the future include use of Swedish Mode-S data and further investigation of the potential need for application of bias-correction for Mode-S data. We also see a potential of future inter-comparisons of Mode-S and Aeolus HLOS observations.

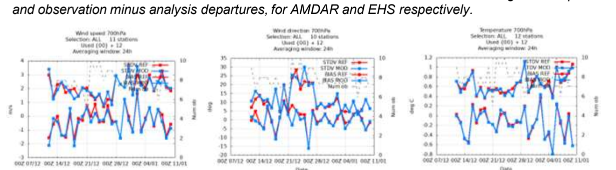

Fig. 5. One-month time-series of bias and standard deviation of +12 h forecasts of wind speed (left), wind direction (middle) and temperature (right) at the vertical level of 850 hPa. Verification is against radiosonde observations within the domain. Red curve is for the operational configuration (REF) and blue curve is for the version assimilating in addition Mode-S observations.

References

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