Use of microwave radiances in the MetCoOp operational HARMONIE-AROME limited-area data assimilation

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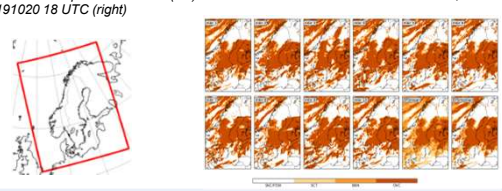
Operational

MetCoOp

MetCoOp is an operational cooperation between the three Nordic countries Finland, Norway and Sweden. We use the HARMONIE-AROME non-hydrostatic, km-scale forecasting system (Bengtsson *et al*., 2017), which is 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 an ensemble with ten members run with an horizontal grid distance of 2.5 km and with 65 vertical levels over a domain illustrated by the red frame in Fig 1. The model top is located at 10 hPa. The ensemble system is run with a 3h data assimilation cycle up to a forecast range of 66h and with an observation cut-off time of 1h and 15 min for main cycles (00, 06, 12 and 18 UTC) and 3h and 20 min for intermediate cycles (03, 09, 15 and 21 UTC). As an example, Fig. 1 shows an ensemble of +6h cloud cover forecasts, valid at 201901020 18 UTC.

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



Current use of satellite-based microwave radiances

The present use of satellite-based microwave radiances in the operational upper-air 3D-Var is illustrated in Fig 2. The observation operator for microwave radiances is utilizing the RTTOV radiative transfer model version 10.1.0. Only cloud-non affected radiances are used and to account for observation biases a variational bias correction (Dee and Uppala, 2009) is applied. We use a horizontal thinning distance of 80 km. Satellites, instruments and channels from which satellite microwave data are used are summarized in Fig. 2. Fraction of MetCoOp model domain covered by operationally used satellite Passive MicroWave (PMW) data are also shown in Fig. 2, for different assimilation cycles, for a latency of 10 min. In Fig. 3 the absolute Degree of Freedom of Signal (DFS) measure (Chapnik *et al*., 2006; Randriamampianina *et al*., 2011) is used to estimate the impact of microwave radiances on the analyses, as compared with other sources of observations used in the analysis. Examples are shown for 20190824 12 and 15 UTC. Also used in the MetCoOp analysis but not included in these DFS scores are Advanced Scatterometer data (ASCAT).

Fig. 2. Operational use of satellite Passive MicroWave (PMW) radiances (left) and fraction of MetCoOp domain covered by microwave radiances for different assimilation cycles (right).

Satellite	Instruments (channels)
NOAA-18	AMSU-A (6,7,8,9)
NOAA-19	AMSU-A (6,9), MHS (4,5)
METOP-A	AMSU-A (6,9), MHS (3,4,5)
METOP-B	AMSU-A (6,8,9), MHS (3,4,5)

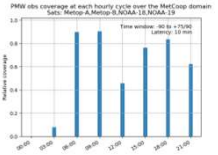
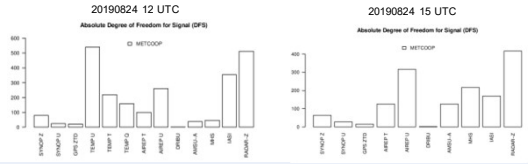


Fig. 3. Absolute Degree of Freedom of Signal (DFS) estimated for MetCoOp upper-air analyses at 20190824 12 UTC (left) and 15 UTC (right).



On-going work and plans for future enhancements

On-going work and plans for near-future

On-going work is concerned with introduction of satellite-based microwave radiances from the AMSU-A/MHS instruments onboard METOP-C and from the MWHS-2 instrument onboard FY-3C and FY-3D. Final channel selection will be based on monitoring statistics, but the aimed near-future operational use of cloud non-affected microwave radiance use is shown in Fig. 4. Fraction of MetCoOp model domain covered by near-future aimed operational use of satellite Passive MicroWave (PMW) data are also shown in Fig. 4, for different assimilation cycles, for a latency of 10 min. The aimed near-future use will result in an enhanced coverage and also a more evenly distributed coverage between data assimilation cycles. In particular, note increase of available data at 00 and 03 UTC cycles. A horizontal thinning distance of 80 km will be used for METOP-C AMSU–A and initially also for FY-3C/FY-3D MWHS-2. The updated observation operator will be using RTTOV version 11.2.0. Variational bias correction has been adopted to the newly introduced observations types and the particular characteristics (such as height of model top) of the MetCoOp HARMONIE-AROME configuration, as illustrated in Fig. 5 for one particular channel of MWHS-2 at FY-3C and FY-3D. A next step should be to introduce also NOAA-20 ATMS microwave radiances.

Fig. 4. Aimed near-future operational use of satellite Passive MicroWave (PMW) radiances (left) and fraction of MetCoOp domain covered by microwave radiances for different assimilation cycles (right).

Satellite	Instruments (channels)
NOAA-18	AMSU-A (6,7,8,9)
NOAA-19	AMSU-A (6,9), MHS (4,5)
METOP-A	AMSU-A (6,9), MHS (3,4,5)
METOP-B	AMSU-A (6,8,9), MHS (3,4,5)
METOP-C	AMSU-A (6,7,8,9), MHS (3,4,5)
FY-3C	MWHS-2 (4,5,6,11,12,13,14,15)
FY-3D	MWHS-2 (4,5,6,11,12,13,14,15)

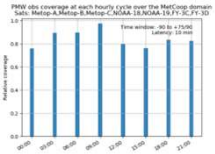
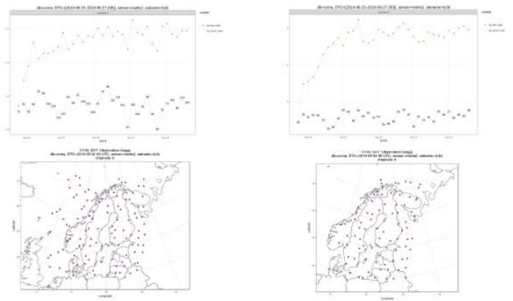


Fig. 5. Illustration of spin-up procedure for variational bias correction for MWHS-2 channel 6 from 24 August to 25 September 2019. Left column is for FY-3C 09 UTC cycles and right column for FY-3D 00 UTC cycles. (Upper: time-series: Lower: typical data coverage for that particular cycle and satellite/instrument).



Medium and longer term plans

Medium term work include an improved handling of surface sensitive channels, for example through application of surface emissivity atlases. We are furthermore aiming at assimilating also cloud affected radiances, possibly within the HARMONIE-AROME limited-area 4D-Var system that is under development. On the longer term it is planned to investigate the assimilation of microwave radiances from future small micro-satellites through carrying out Observation System Simulation Experiments (OSSE). Furthermore, it is in our long term plans to explore the use of microwave radiances around 200 GHz, to be provided by the Ice Cloud Imager (ICI), planned on-board EUMETSAT next generation polar satellites.

References

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