USE OF MICROWAVE RADIANCES FROM METOP-C, FY-3C AND FY-3D SATELLITES IN METCOOP DATA ASSIMILATION

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Structure

- The limited area forecasting system
- Use of microwave radiances
- Design of experiment
- Results
- Sensitivity study and outlook
- Concluding remarks

The limited-area forecasting system

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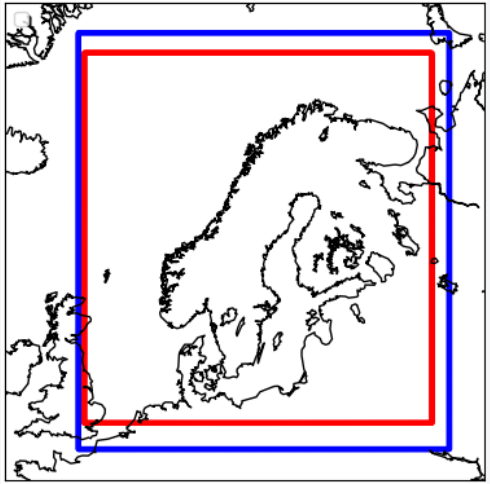
- MetCoOp NWP operational collaboration over northern European model domain.
- EDA-based ensemble forecasting system.
- HARMONIE-AROME modelling framework.
- 2.5 km grid distance and 65 vertical level.
- 3D-VAR upper-air data assimilation with 3 h data assimilation cycle.
- Conventional types of in-situ measurements, radar-based humidity, GB GNSS ZTD, MODE-S winds, satellite-based ASCAT winds, and satellite based microwave (MW) (MHS, AMSU-A) and IR (IASI) radiances assimilated.

MetCoOp **C** and **D** modelling domains



High Resolution Limited Area Model Hirlam

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Use of microwave radiances

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Microwave radiance observation usage	
Instrument	Satellites
AMSU-A	Metop-A, Metop-B, Metop-C, NOAA-18, NOAA-19
MHS	Metop-A, Metop-B, Metop-C, NOAA-19
MWHS-2	FY-3C, FY-3D

- Channel selection taking into account model top, influence by surface and monitoring experiences.
- Clear-air radiances only.
- Observation operator based on RTTOV (Radiative Transfer for TOVS) version 11.2.0.
- Observation handling including cloud detection, data selection, quality control, bias correction, error specification.

Use of microwave radiances

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MW radiance instruments/channels assimilated

Channel number			Channel Frequency (GHz)		
AMSU-A	MWHS-2	MHS	AMSU-A	MWHS-2	MHS
6			54.400(H)		
7			54.940(V)		
8			55.500(H)		
9			57.290344(H)		
	5			118.75 ± 0.8(H)	
	6			118.75 ± 1.1(H)	
	11	3		183 ± 1.0(H)	183 ± 1.0(H)
	12			183 ± 1.8(H)	
	13	4		183 ± 3.0(H)	183 ± 3.0(H)
	14			183 ± 4.5(H)	
	15	5		183 ± 7.0 (H)	190.31(V)

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Design of experiment

A parallel data assimilation and forecast experiment was run for the period extending from 27 Sep to 27 Oct 2019. There were two parallel runs designed as follows:

- **REF**-With system and observation usage as in a pre-operational model version (no ASCAT and MODES).

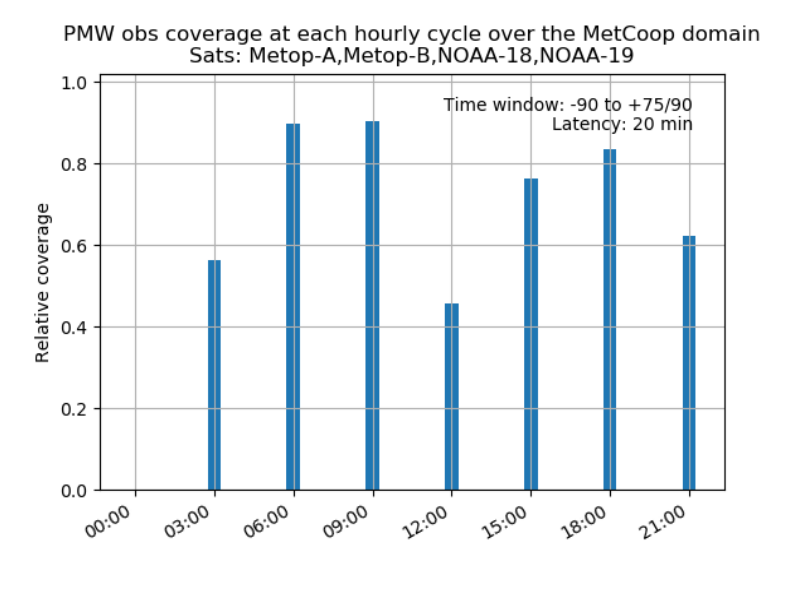
- **SAT**- As REF but with additional MW radiances in the form of Metop-C (AMSU-A, MHS) and FY-3C, FY-3D (MWHS-2)

Results

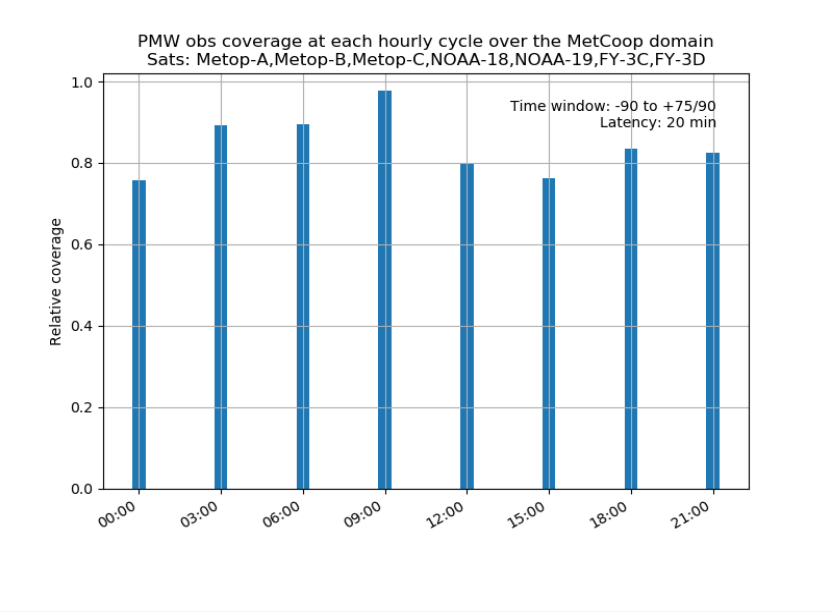
Data coverage

(20 min latency for MW radiances, observation cut-off is 75 min)

Availability with Current MW use in MEPS



Availability with Enhanced MW use in MEPS

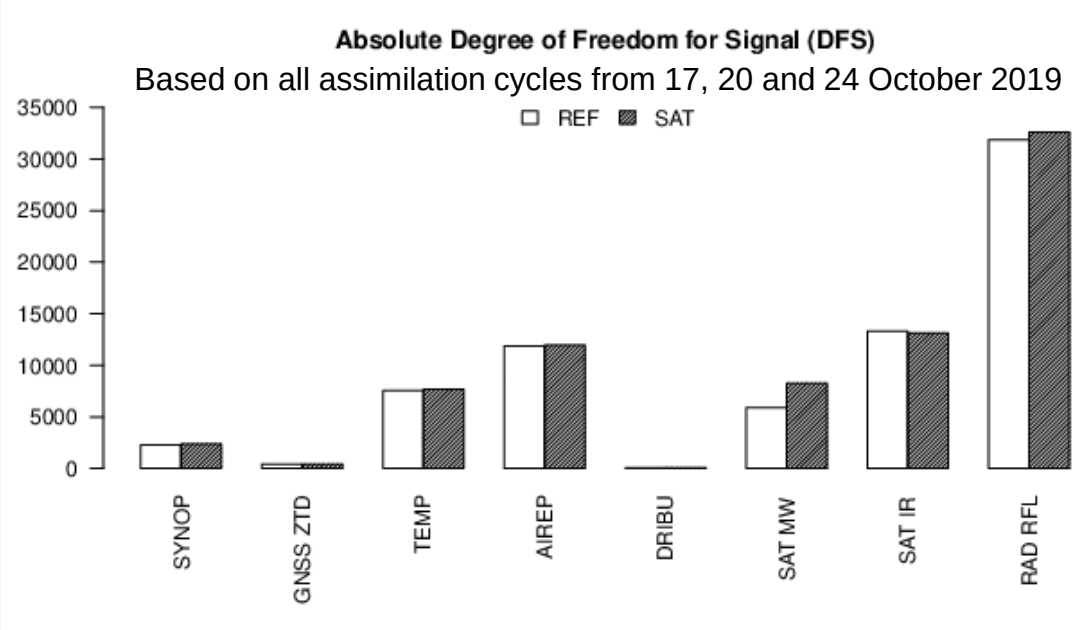


With an enhanced use of MW radiances there are MW radiances in the 00 UTC data assimilation cycle and there is also a more uniform distribution of MW radiances in between cycles.

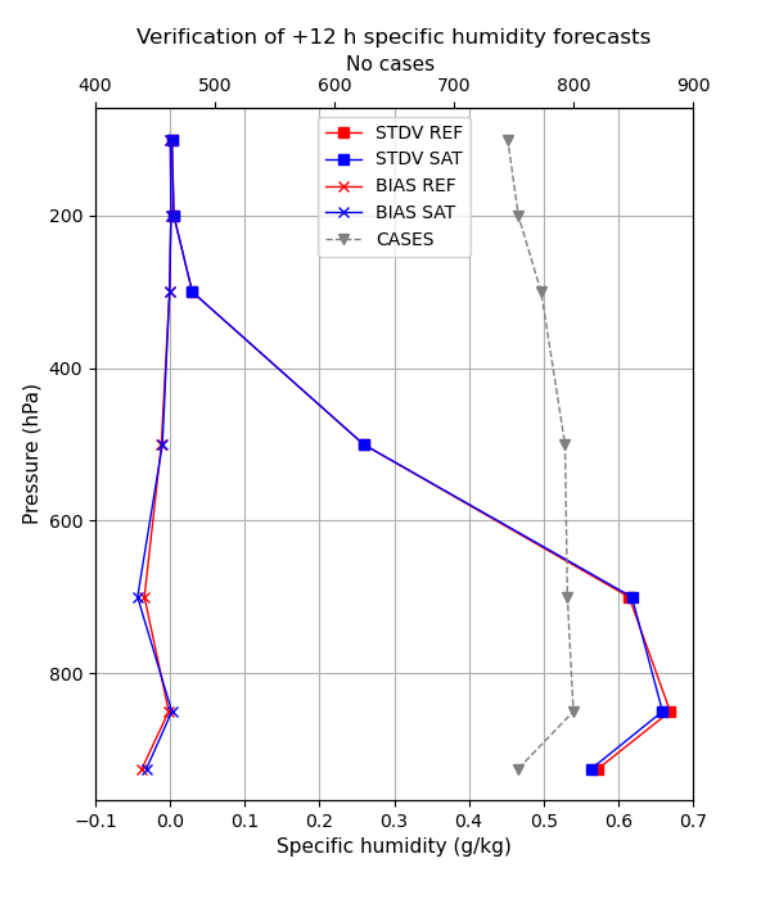
Results

Impact of on analyses

$$DFS = \frac{\partial H\boldsymbol{x}^a}{\partial \boldsymbol{y}} \approx (\tilde{\boldsymbol{y}} - \boldsymbol{y})\boldsymbol{R}^{-1}(\boldsymbol{H}\tilde{\boldsymbol{x}}^a - \boldsymbol{H}\boldsymbol{x}^b) - (\boldsymbol{H}\boldsymbol{x}^a - \boldsymbol{H}\boldsymbol{x}^b)$$



With an enhanced use of MW radiances there is increased impact of MW radiances on the analyses.



Results

Verification scores showing impact on forecasts

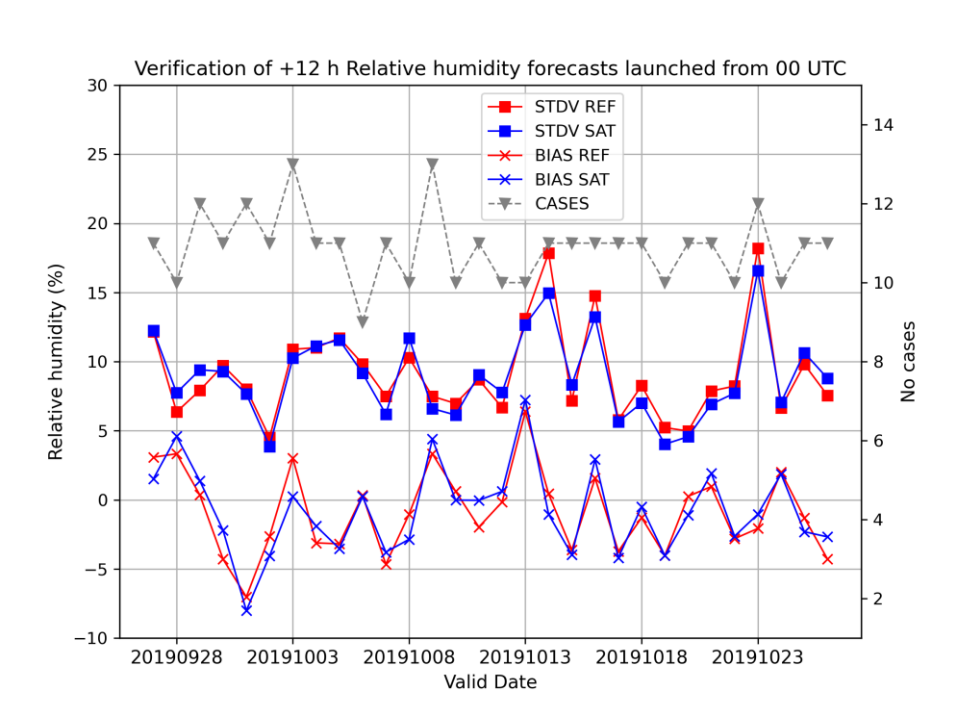
Vertical profile of bias and standard deviation of +12 h specific humidity forecasts of **REF** and **SAT**, for verification against radiosondes.

Verification period: 27 Sep - 27 Oct 2019.

With an enhanced use of MW radiances there is an improved quality of short-range low level moisture forecasts.

Results

Verification scores showing impact on forecasts



Time-series of bias and standard deviation of +12 h relative humidity forecasts that are launched from 00 UTC with **REF** and **SAT**, for verification against radiosondes.

Verification period: 27 Sep - 27 Oct 2019.

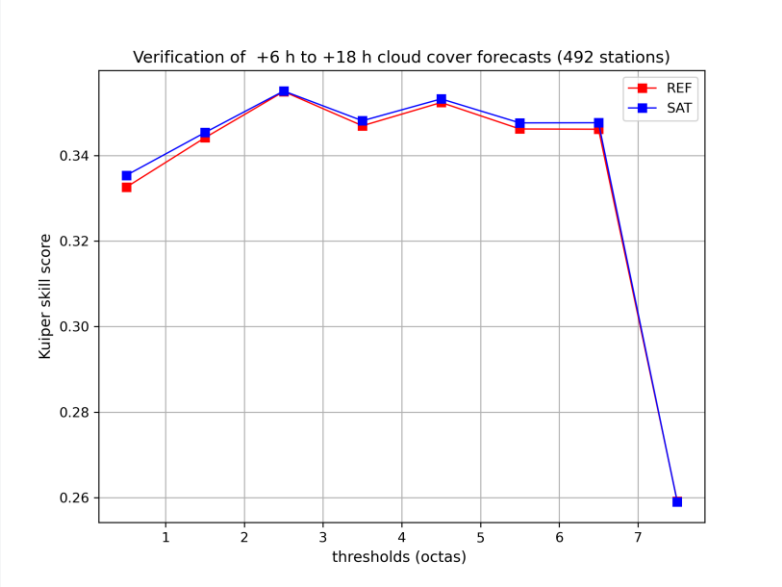
With an enhanced use of MW radiances +12 h SAT forecasts are in terms of standard deviation better than REF in 63% of the cases.

Results

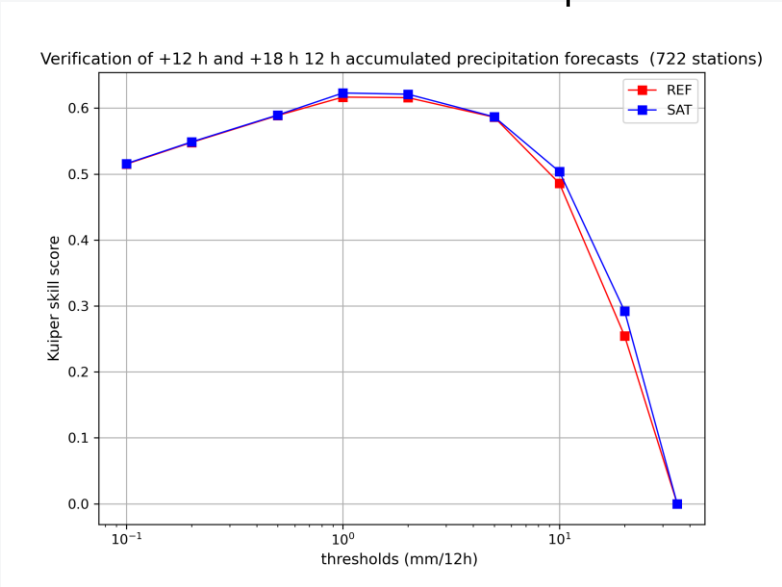
Verification scores showing impact on forecasts

Kuiper skill score when verifying against synop land weather stations.

+6 h to +18 h cloud cover



+12 h an +18 h 12 h acc prec



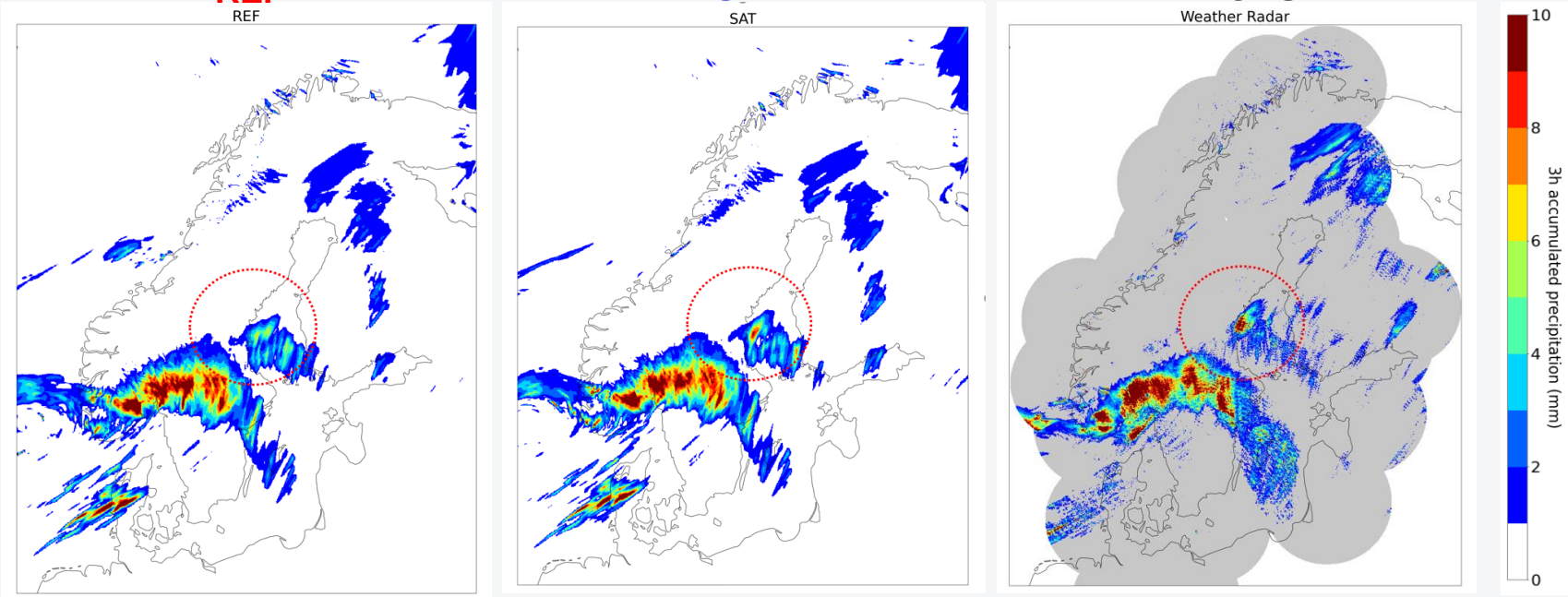
With an enhanced use of MW radiances short-range cloud cover and precipitation forecasts improve.

Results

Case study

3 h acc prec forecasts launched from 18 Oct 2019 00 UTC and valid at 19 Oct between 00 and 03 UTC (mm) and verifying radar product.

REF **SAT** **OBS**



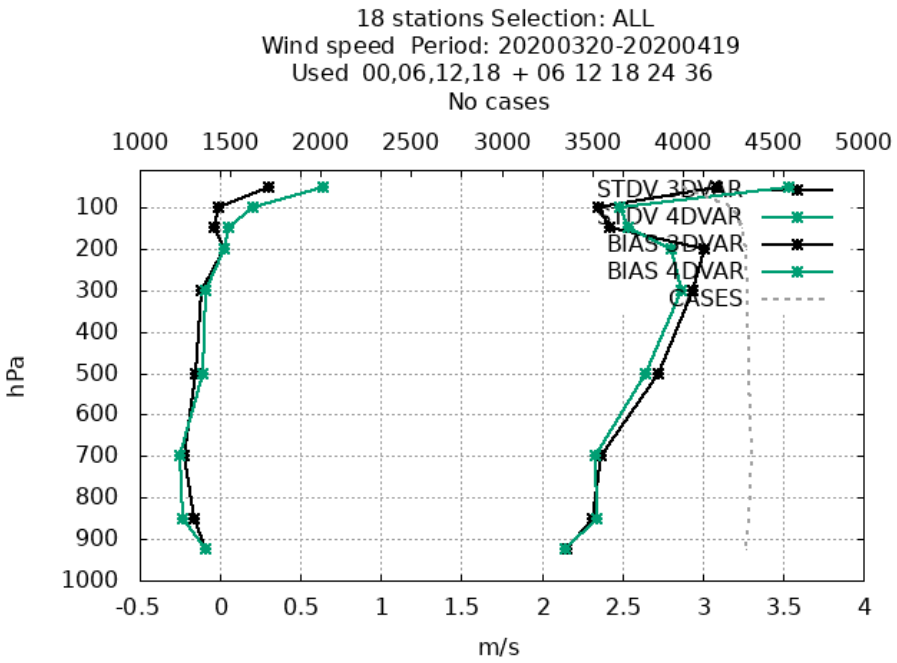
Both REF and SAT forecasts predicted well large scale precipitation patterns. For this particular case, a rather small scale intense precipitation event at the east coast of Sweden was better predicted with forecast from SAT.

Sensitivity study and outlook

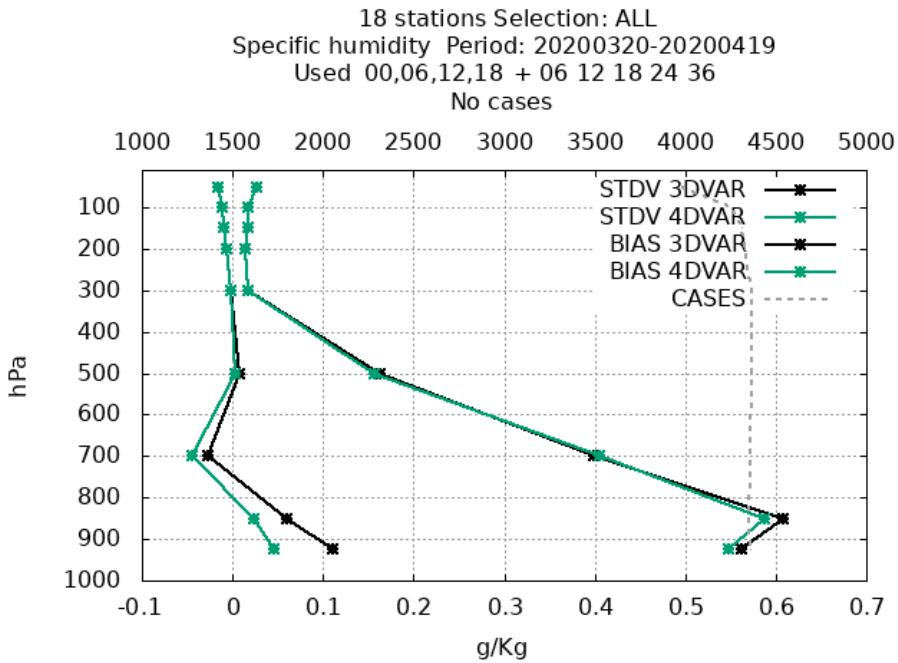
3D-Var versus 4D-Var parallel experiment 20200320-20200419

(conv ob, AMSU-A ,MHS, IASI, GB GNSS ZTD)

Wind speed



Specific humidity



With a refined data assimilation technique we will have the potential to get even further improvement from the enhanced MW usage.

Sensitivity study and outlook

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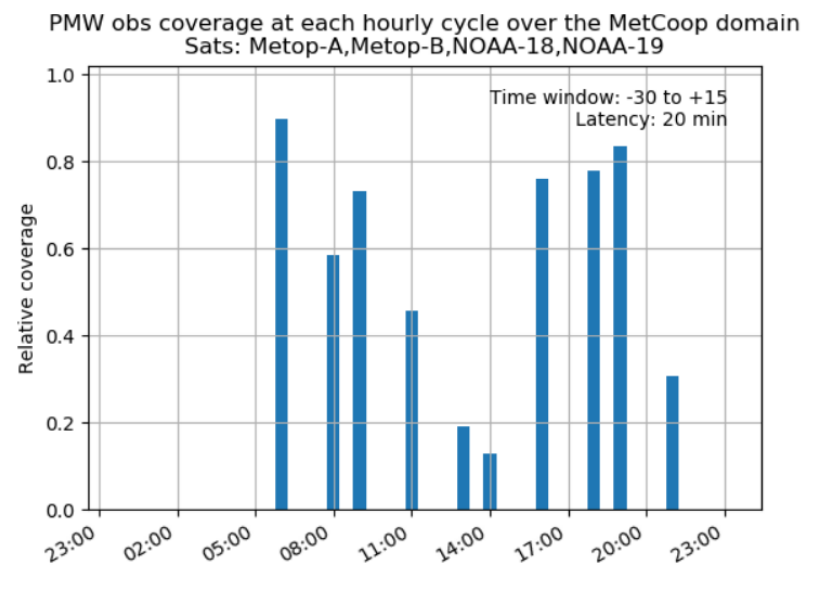
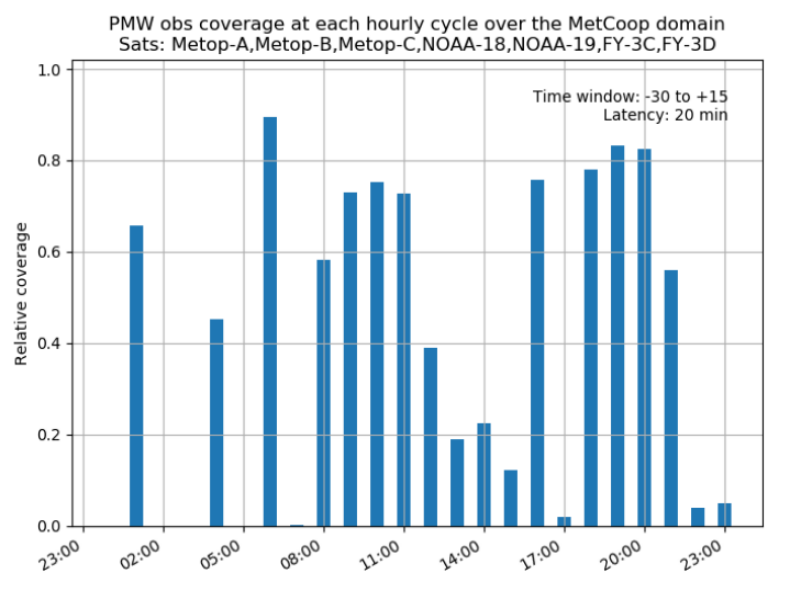
Data coverage in MetCoOp nowcasting suite

(20 min latency for MW radiances, forecasts each hour with observation cut-off 15 min)

Availability with Current use in nowcasting suite



Availability with Enhanced use in nowcasting suite



With an enhanced use of MW radiances we will get an improved MW data coverage in a nowcasting suite using a 15 min observation cut-off. There are however substantial remaining data gaps. A system of many small polar satellites equipped with a MW instrument would be sufficient for filling these many remaining gaps.

Conclusions

- The use microwave radiances from Metop-C as well as from FY-3C and FY-3D satellites has been demonstrated to be beneficial for a northern European limited-area modelling system.
- A sensitivity study indicates that with a refined data assimilation technique we will have the potential to get even further improvements from the enhanced MW usage.
- There is room for several enhancements regarding MW observation usage and handling. These include use of ATMS, refined data selection, improved observation operators for low-peaking channels and all-sky data assimilation.
- A Nordic team is currently together with ESA and EUMETSAT making preparations for handling of data from a prototype of a small Arctic Weather Satellite.