Updates on all-sky radiance assimilation at ECMWF

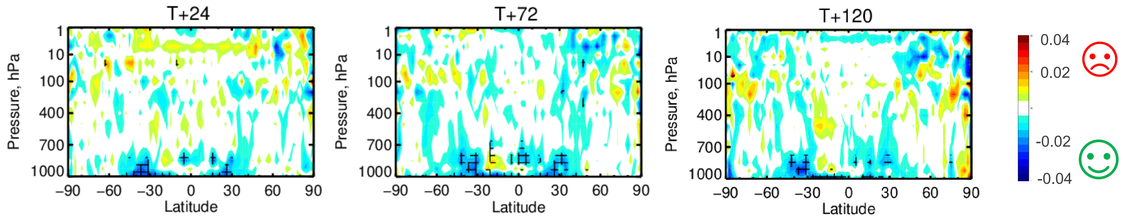
Alan J. Geer[1], Katrin Lonitz[1], Peter Weston[1], Niels Bormann[1]

(1) European Centre for Medium-Range Weather Forecasts (ECMWF)

katrin.lonitz@ecmwf.int

1. Extension to 150 GHz and 166 GHz channels

The all-sky assimilation of microwave radiances has been extended to 150 GHz, h-polarised from SSMIS-F17 and 166 GHz, v/h-polarised from GMI between 45ºS and 45ºN for the current operational IFS cycle 46R1. Besides reducing a dry bias in the lower atmosphere, wind and humidity forecast scores have been improved up to day 5.



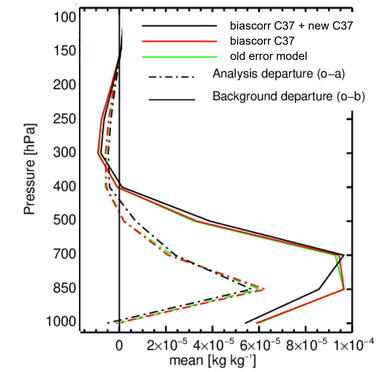
Normalised difference in RMSE of 24, 72 and 120 h relative humidity forecasts resulting from the all-sky assimilation of 150/166 GHz channels. 45R1 experimentation covered 6 months over two seasons.

2. Water vapour correction to all-sky observation error model

The IFS shows a mean drying of the lower atmosphere. About 17% of the drying is caused by the all-sky assimilation of microwave radiances (MW drying effect), which could be reduced by various updates in the past, e.g. the additional assimilation of 150/166 GHz or an update of the humidity background error model in IFS cycle 43R3. Part of the MW drying effect has been attributed to an asymmetry inside the all-sky observation error model for microwave radiances over ocean. Here, the assigned observation errors depend on the calculation of cloud amount (C37), which seemed to assign smaller errors under dry conditions compared to under moist conditions.

This asymmetry can be improved through:

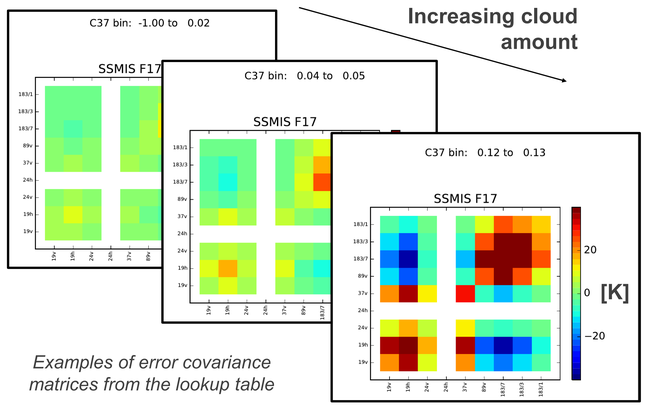
- Using bias-corrected values for the calculation of C37 (biascorr C37)
- Taking into account differences in the water vapour field between modelled and observed values of C37 under almost cloud-free conditions (new C37)



Vertical profile of mean values of first guess departures and analysis departures for specific humidity observations from radiosonde of 45R1 experiments with assimilating SSMIS-F17 only. Results are shown for the time period between 1 July and 31 August 2017 between 20ºN and 60ºN.

3. Adaptive inter-channel observation error covariances for all-sky microwave

Since Bormann et al. (2011, doi:10.1002/qj.833) we have known that interchannel error correlations are much larger in cloudy situations than in clear-skies, but all-sky assimilation has not yet taken this into account. To combine all-sky observation error inflation with inter-channel error correlations, a bin approach is proposed. An error covariance matrix is fitted to the background departure covariances in a large number of bins defined by the symmetric cloud amount ("C37") and the total column water vapour amount (to provide higher representation errors in tropical convection compared to midlatitude frontal systems). This approach is currently in testing.



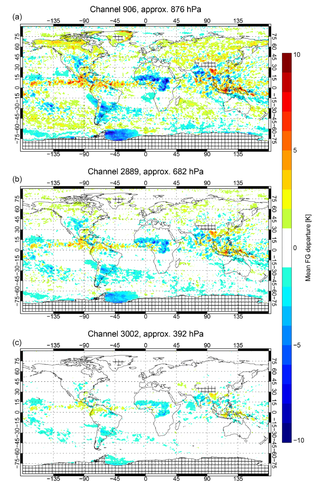
Examples of error covariance matrices from the lookup table

4. All-sky infrared water vapour sounding channels on IASI

All-sky infrared assimilation is now a viable operational possibility. The quality of agreement between simulated and observed all-sky IASI radiances is now very good, making use of RTTOV with the Chou-scaling scattering approximation, multiple independent columns (the "streams" approach) and the recently updated Baran ice cloud optical properties. Experiments assimilating 7 IASI upper-tropospheric water vapour sounding channels in all-sky conditions showed similar NWP performance to clear-sky assimilation in the midlatitudes but improved performance in the tropics. A major part of getting this to work was a new observation error model combining inter-channel error correlation, error inflation in the presence of cloud, and variational quality control (VarQC).

Geer, A.J., Migliorini, S. and Matricardi, M., 2019. All-sky assimilation of infrared radiances sensitive to mid- and upper-tropospheric moisture and cloud. Atmospheric Measurement Techniques, 12(9), pp.4903-4929.

Geer, A.J., 2019. Correlated observation error models for assimilating all-sky infrared radiances. Atmospheric Measurement Techniques, 12(7), pp.3629-3657.



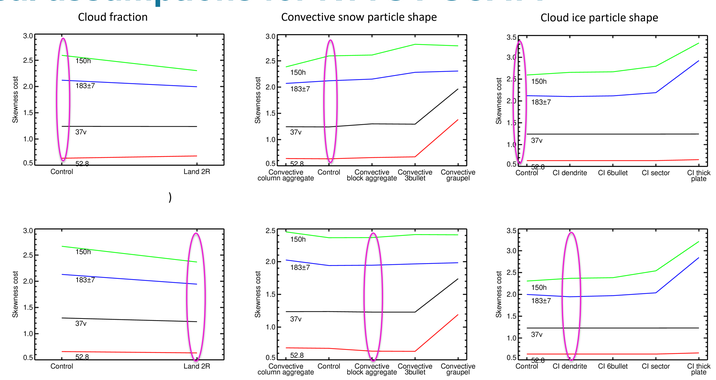
Mean all-sky background departures from Metop-A (using operational bias correction) sampled over 1–20 June 2017 in three IASI channels. Cross-hatching indicates excluded areas.

5. Improved macro- and micro-physical assumptions for RTTOV-SCATT

Key to getting a good fit between simulated and observed all-sky microwave radiances is to choose appropriate microphysical and macrophysical assumptions (Geer and Baordo, 2014, doi:10.5194/amt-7-1839-2014). Recently, 3360 new combinations of micro- and macro-physical assumptions have been explored. The skewness of the FG departures provides a cost function by which to measure the misfit to observations.

The fit to observations can be improved by:

- Using the hydrometeor-weighted cloud overlap over land as well as ocean
- Using DDA dendrite rather than Mie sphere for cloud ice
- Using ARTS database (doi:10.5194/essd-10-1301-2018) DDA large-block aggregate rather than sector snowflake for convective snow



Micro and macro-physics costfunction at first guess (pink ovals, top row) and analysis (pink ovals, bottom row). Coloured lines indicate the skewness cost for four representative channels of SSMIS over land and ocean

6. All-sky AMSU-A (5p.02)

Moving the assimilation of AMSU-A from the clear-sky system to the all-sky system has been investigated. The latest results show that the all-sky AMSU-A assimilation performs slightly better than clear-sky in the extra-tropics but worse than clear-sky in the tropics. It is hoped that, with a few more improvements, all-sky AMSU-A will soon be suitable for operational implementation.

7. Liquid Water Permittivity (5p.08)

The effect of different liquid water permittivity models are studied by using the all-sky assimilation framework of the IFS. Overall, the permittivity model by Rosenkranz (2015) has been chosen to replace Liebe (1989).

Conclusions and status

1. 150 GHz and 166 GHz channels have been operational assimilated in all-sky conditions since June 2019
2. The water vapour correction reduces the drying effect by about 10%, but it requires maintenance of a TCWV retrieval. We need to decide if the maintenance overhead is worthwhile.
3. All-sky microwave error covariance modelling brings small benefits to medium-range scores but slight degradations in background fits to other observations.
4. Operational implementation of all-sky IR assimilation is worthwhile but it awaits a decision on whether we will assimilate reconstructed radiances in future.
5. Improved microphysical and macrophysical assumptions will be submitted for the next available operational cycle
6. AMSU-A all-sky is close to being operationally viable.
7. Liquid water permittivity model by Rosenkranz (2015) used operationally since June 2019 and part of RTTOV 12.2.