Updates on all-sky radiance assimilation at ECMWF

Katrin Lonitz and Alan J. Geer
Research Department, ECMWF, Reading, United Kingdom

1. Extension to 150 GHz and 166 GHz channels

The all-sky assimilation of microwave radiances has been extended to 150 GHz, v-polarised from SSMIS-F17 and 166 GHz, h-polarised from GMI between 49°S and 45°N 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.

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. A correction 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 oceans. 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.

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 inter-channel 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.

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 for assimilating 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).

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 Baudo, 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 hydrometer-weighted cloud overlap over land as well as ocean
- Using DDA dendrite rather than Mie sphere for cloud ice

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.

6. Liquid Water Permittivity

The effect of different liquid water permittivity models are studied using the all-sky assimilation framework of the IFS. Overall, the permittivity model by Rosenkranz (2015) has been chosen to replace Liebe (1989). Six dev. in FG dep. for samples with no frozen hydrometers but containing some cloud from SSMIS-F17 normalised by the std. dev. of results from Liebe (1989). Horizontal bars indicate a 95% confidence range. Results cover the time period for August 2016 between 20ºS & 90ºS.

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 reduction. 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. Work continues on revised macrophysical and microphysical assumptions, with the aim to update both the IFS in a future operational cycle, and the default settings for RTTOV-SCATT v13.