Situation-dependent estimates of background errors in radiance space

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Introduction

In recent years ECMWF has moved to a hybrid 4DVAR system, in which the spread of an Ensemble of Data Assimilations (EDA) provides situation-dependent aspects of the background error. Here we present an analysis of this spread in radiance space for AMSU-A, and evaluate it through departures between observations and short-range forecasts. More details can be found in *Bormann and Bonavita* (2013).

Ensemble of data assimilations (EDA)

The EDA run operationally at ECMWF consists of a number of separate lower-resolution 4DVAR systems which use perturbed input parameters. The ensemble spread is generated by perturbing the observations, the model parameterisations, and other input fields such as SST, all according to their error characteristics. This is illustrated schematically in Fig. 1.

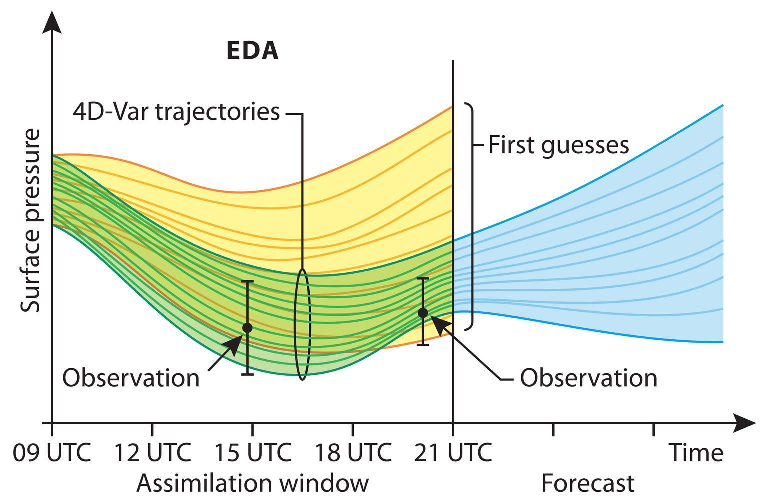

Figure 1 Schematic illustration of the EDA: each member performs 12-hour cycling 4DVAR, but assimilates differently perturbed observations, and uses differently perturbed model parameterisations and other input fields. This generates spread as an estimate of the combined uncertainty.

Skill of the EDA in radiance space

The EDA is routinely evaluated and calibrated using analysis fields to generate the background errors for the high-resolution deterministic forecast.

Here, we evaluate the ensemble spread instead with AMSU-A observations. To do so, we first map all ensemble members to radiance space to calculate the ensemble spread in radiance space, as described in *Bormann and Bonavita* (2013). An example is shown in Figure 2.

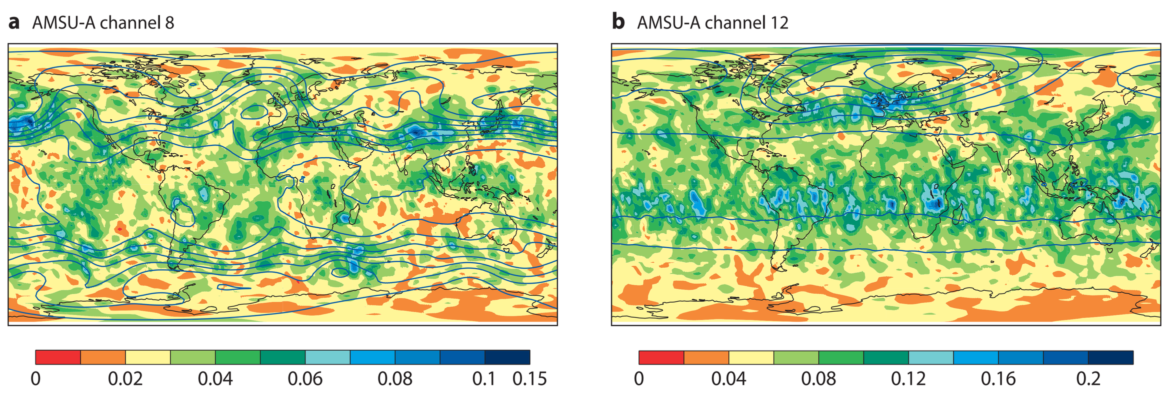

Figure 2 Examples of the EDA spread in radiance space for AMSU-A channel 8 (left) and channel 12 (right), valid on 15 February 2012 at 9Z. Also shown are contours for the 200 hPa and 10 hPa geopotential, respectively.

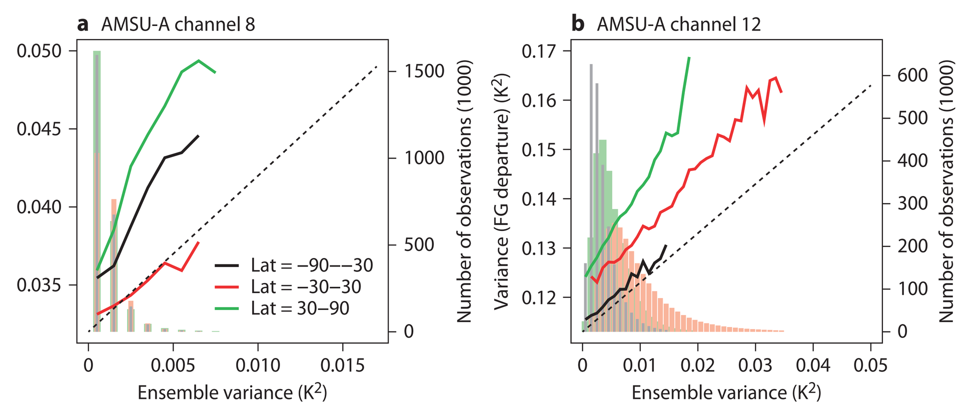

Figure 3 Variance of FG-departures for AMSU-A channels 8 (left) and 12 (right) as a function of the EDA variance for February 2012. The statistics are based on data after cloud screening and geophysical quality control. Also shown is the population of each bin as vertical bars (right axis; the bars use lighter versions of the colours indicating the three zonal bands shown in the legend).

Next we compare the ensemble spread to the variance of the differences between observations and short-range forecasts ("departures"). Binning the variance of these departures as a function of the ensemble spread results in Fig. 3. As expected, variances of the departures are larger where the EDA spread is larger, reflecting larger errors in the short-range forecasts. If observation and background errors are uncorrelated, and the EDA perfectly represents the background errors, we would expect the relationship to have a slope of one (dashed line), with the intercept given by the error in the observations. In contrast, over the extra-tropics the slope is steeper in the examples shown, suggesting that the EDA is under-dispersive.

The temporal evolution of the ensemble spread also suggests that the errors are growing more slowly in the EDA than suggested by observation departures, see Fig. 4. Most likely, this reflects short-coming in the perturbations of the model parameterisations, contributing to the under-dispersiveness of the EDA.

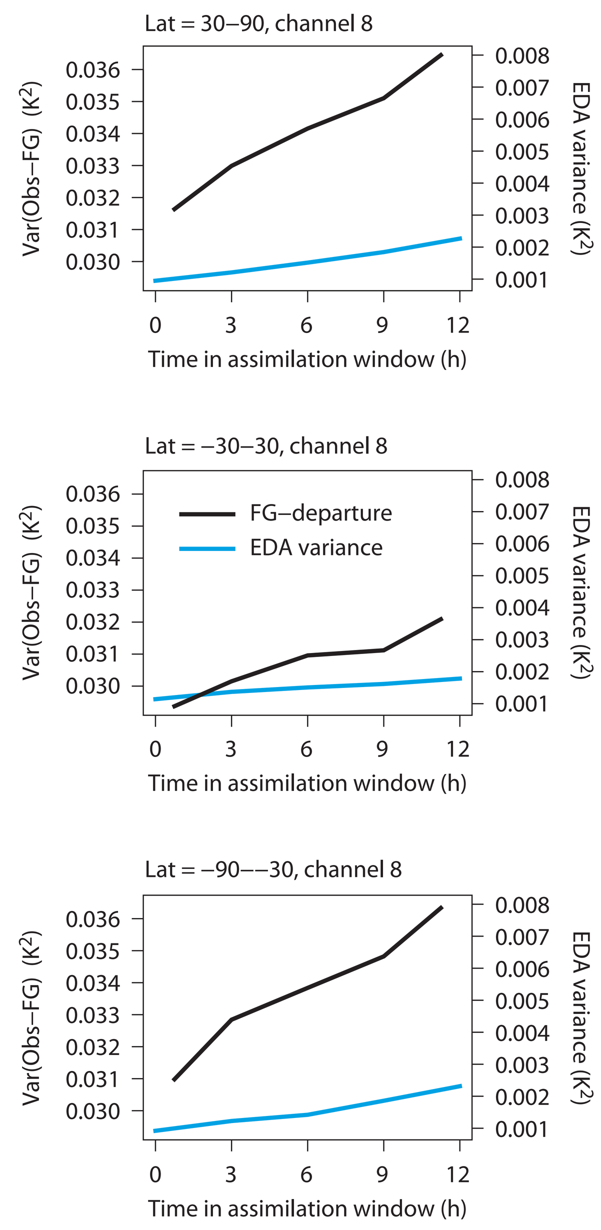

Figure 4 Variances of FG-departures (black, left y-axis) and uncalibrated EDA variances (blue, right y-axis) as a function of the position in the 12-hour assimilation interval of the high-resolution 4DVAR for AMSU-A channel 8. The departure statistics are based on data from all AMSU-A instruments combined, for February 2012, after geophysical quality control.

Short-term forecast errors in radiance space

To estimate background errors we calibrate the EDA spread by scaling it with a factor derived from the relationships shown in Fig. 3. The scaling factors derived for February 2012 from AMSU-A data are shown in Fig. 5. To reduce sampling noise arising from the small size of the ensemble we filter the spread fields spatially. After scaling and filtering, we obtain a flow-dependent estimate of our errors in the background in radiance space, consistent with observation departures. An example is shown in Fig. 6

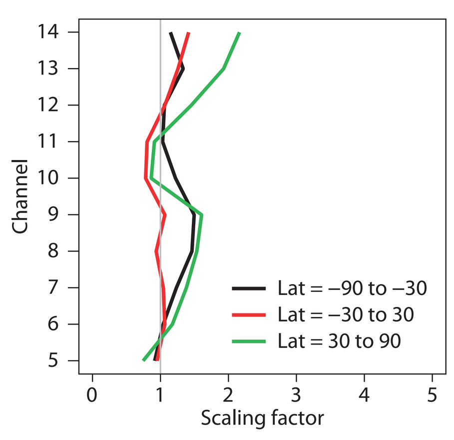

Figure 5 Scaling factors for the calibration of the EDA spread for AMSU-A channels for the indicated three zonal bands in February 2012.

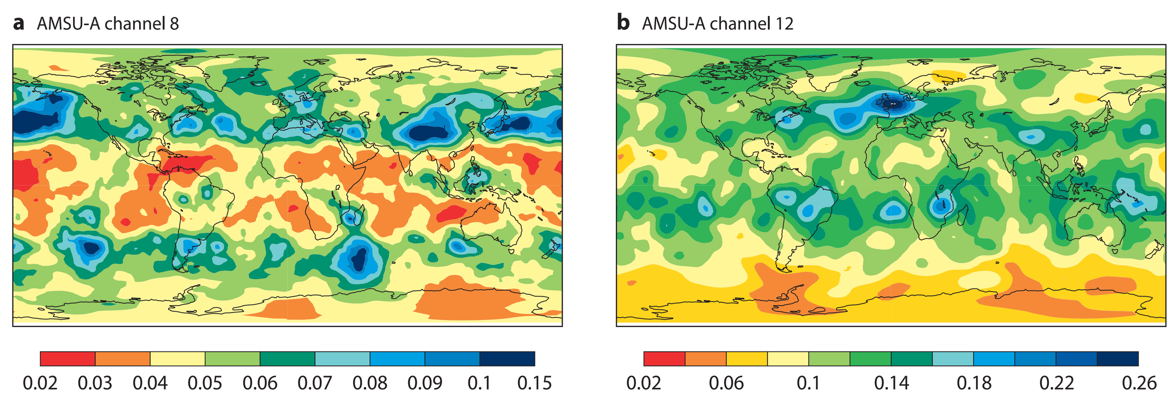

Figure 6 Examples of the calibrated and spatially filtered estimates of the background error in radiance space for AMSU-A channel 8 (left) and 12 (right) for 15 February 2012 at 9Z.

The small size of the estimated background errors in radiance space is striking: For AMSU-A channel 8, this estimate is less than 0.1 K for large regions of the globe. This compares to an instrument noise of 0.15 - 0.2 K for most of the AMSU-A instruments currently in orbit. This finding is typical for most tropospheric AMSU-A channels.

The flow-dependent estimates of background errors in radiance space are used at ECMWF as diagnostic, and also in the background quality control step to estimate the expected variance of the departures (together with the observation errors).

Conclusions

We present an analysis of the EDA spread against radiance observations. The results suggest that the ECMWF EDA is under-dispersive, particularly over the extra-tropics, consistent with results from analysis-based evaluations of the EDA. A calibration step is required to generate estimates of background errors. Related to this, we find that the temporal error growth in the EDA is smaller than suggested by observation departures.

The estimates suggest that the size of short-term forecast errors in radiance space in the ECMWF system is well below 0.1 K for large areas of the globe for the tropospheric AMSU-A sounding channels. This is relevant input to the specification of noise requirements for future atmospheric sounding instruments.

The background error estimates are used in the background quality control in the ECMWF system.

References

Bormann, N. and **M. Bonavita**, 2013: Spread of the ensemble of data assimilations in radiance space. *ECMWF Tech. Memo.* **708**, 29pp, available from: http://www.ecmwf.int/publications/library/do/references/list/14

Acknowledgements

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