Towards activation of all-sky AMSU-A at ECMWF

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1) Introduction

In recent years a number of NWP centres have found significant positive impact from assimilating microwave radiances in all-sky conditions (Geer et al., 2017, Zhu et al., 2016, Migliorini and Candy, 2019). The clear-sky assimilation of AMSU-A at ECMWF has been fine-tuned over the past two decades, but the cloud detection still rejects up to 25% of data from the tropospheric temperature sounding channels. Assimilating the additional cloud- and precipitation-affected data should allow some positive forecast impact. At ECMWF two different systems and code paths are used for clear-sky and all-sky assimilation. Many of the differences have now been eliminated, but matching the performance of the existing clear-sky assimilation of AMSU-A in the all-sky system has proved challenging. This poster highlights remaining differences between the clear- and all-sky systems, compares performance of AMSU-A clear- and all-sky assimilation and suggests potential future enhancements. For more details see Weston et al. (2019).

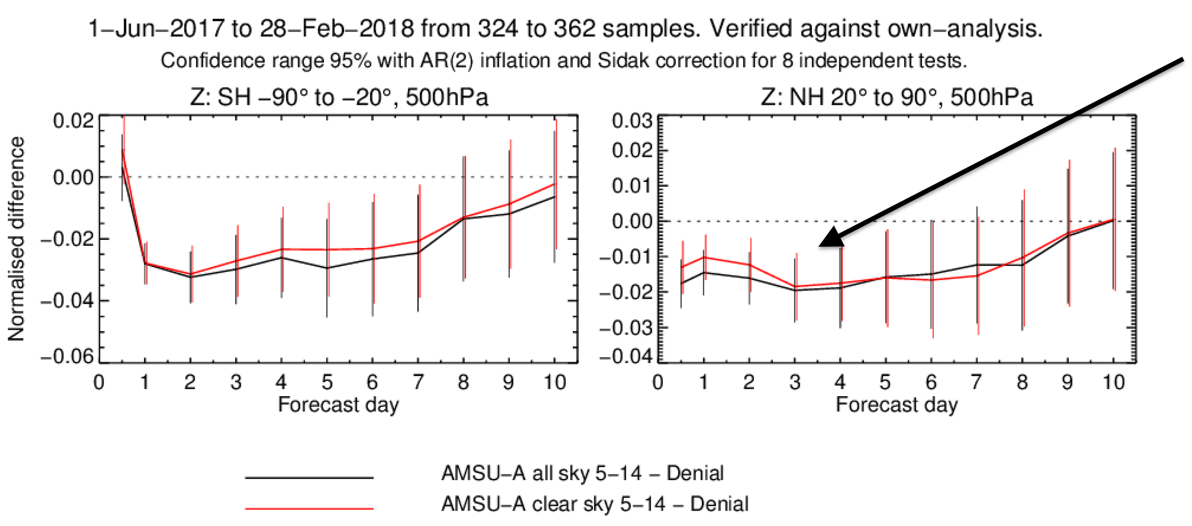
2) All-sky vs. clear-sky differences

Aspect	Clear-sky	All-sky
Radiative transfer	RTTOV	RTTOV-SCATT
Cloud detection	On	Off
Observation errors	Noise, cloud and surface dependent	Noise and cloud dependent
Thinning	125km x 125km boxes	Alternate points of a T_L255 reduced Gaussian grid, threshold on distance from grid point
Skin temperature sink variable	On	Off
Quality control	Basic, fg_depar, VarQC	Additional snow/sea-ice screening

Table 1: Differences between clear- and all-sky assimilation configurations. Aspects not covered such as bias correction, surface emissivity treatment etc. are the same in clear- and all-sky systems.

The following assimilation choices were important to achieve the current performance: thinning all AMSU-As from different satellites together rather than separately; additional snow/sea-ice screening due to residual biases; matching up the bias predictors and initial coefficients; changing the interpolation method from nearest neighbour to bi-linear in all-sky. These changes led to improved first guess fits to observations, especially ATMS, and improved forecast scores, particularly at high latitudes.

3) Results vs. denial



AMSU-A all-sky and clear-sky result in similar (large) improvements to extra-tropical geopotential height forecasts against an AMSU-A denial.

Figure 1 (above): Change in RMSE of extra-tropical 500hPa geopotential height forecasts for AMSU-A all-sky (black) and clear-sky (red) against an AMSU-A denial baseline

All-sky improves fits to wind observations slightly more than clear-sky in the extra-tropics.

All-sky improves fits to humidity sensitive observations (AMSR2 and ATMS channels 18-22) more than clear-sky in the extra-tropics.

All-sky and clear-sky have similar impacts to fits to temperature sensitive observations (ATMS channels 6-15 and GPSRO).

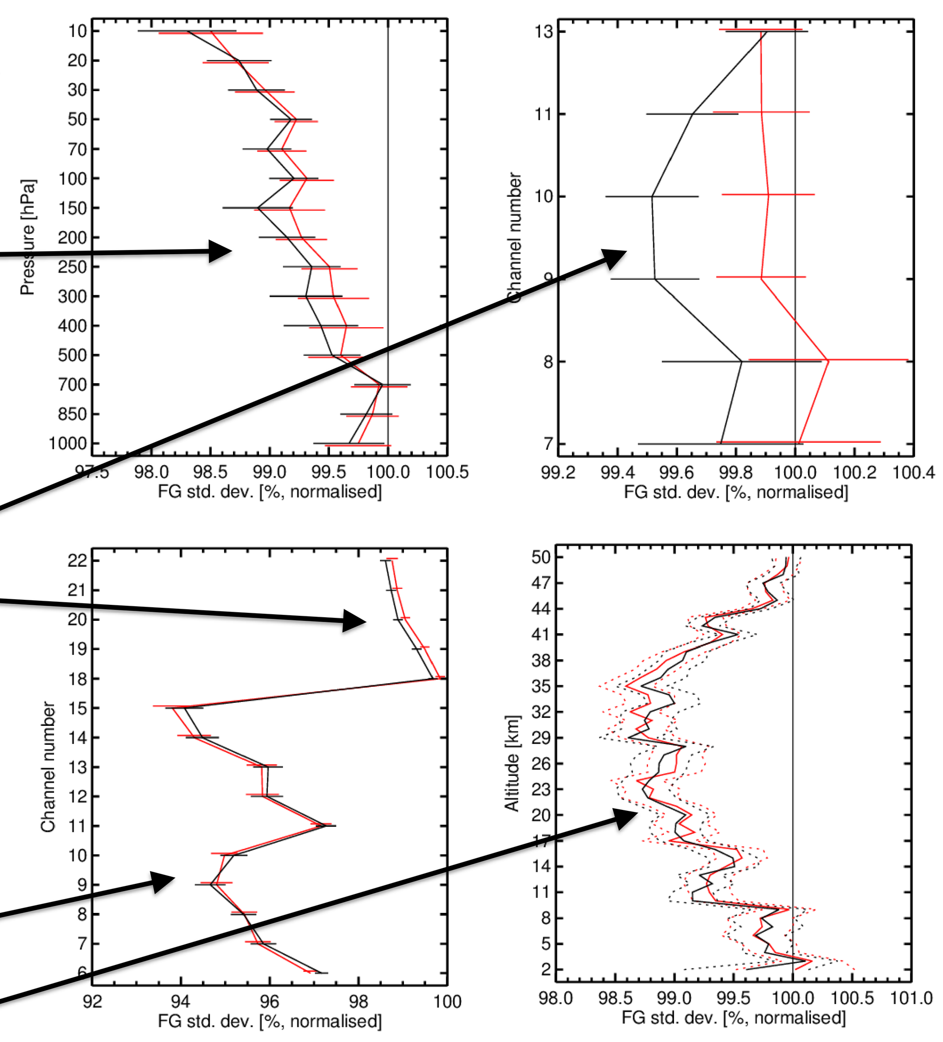
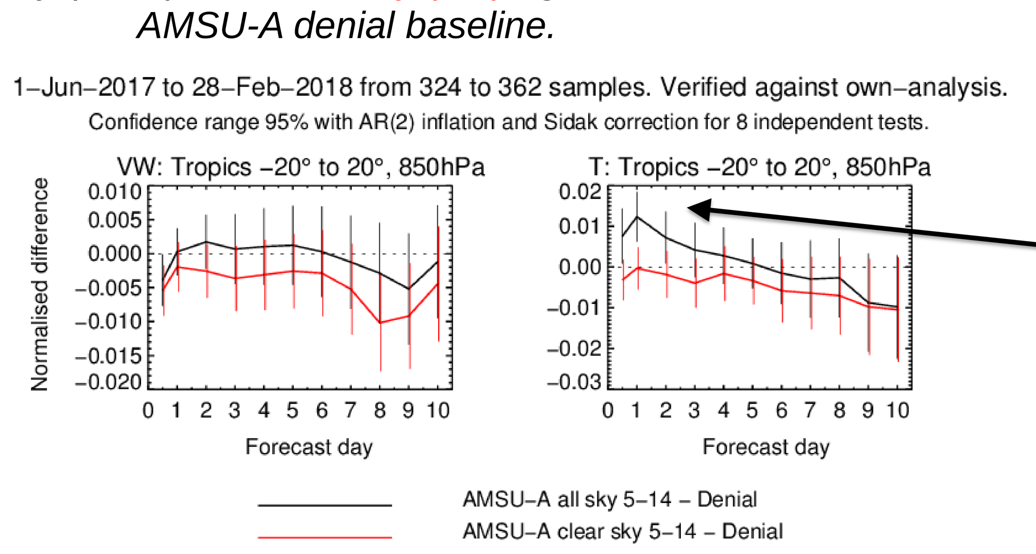


Figure 2 (above): Change in first guess fits to AMSR2 (upper left), conventional wind (upper right), ATMS (lower left), and GPSRO (lower right) observations in the Southern hemisphere for AMSU-A all-sky (black) and clear-sky (red) against an AMSU-A denial baseline.

Figure 3 (below): Change in RMSE of tropical 850hPa vector wind (left) and temperature (right) forecasts for AMSU-A all-sky (black) and clear-sky (red) against an AMSU-A denial baseline.



All-sky degrades short-range wind and temperature forecasts in the tropics compared to clear-sky.

4) Possible future enhancements

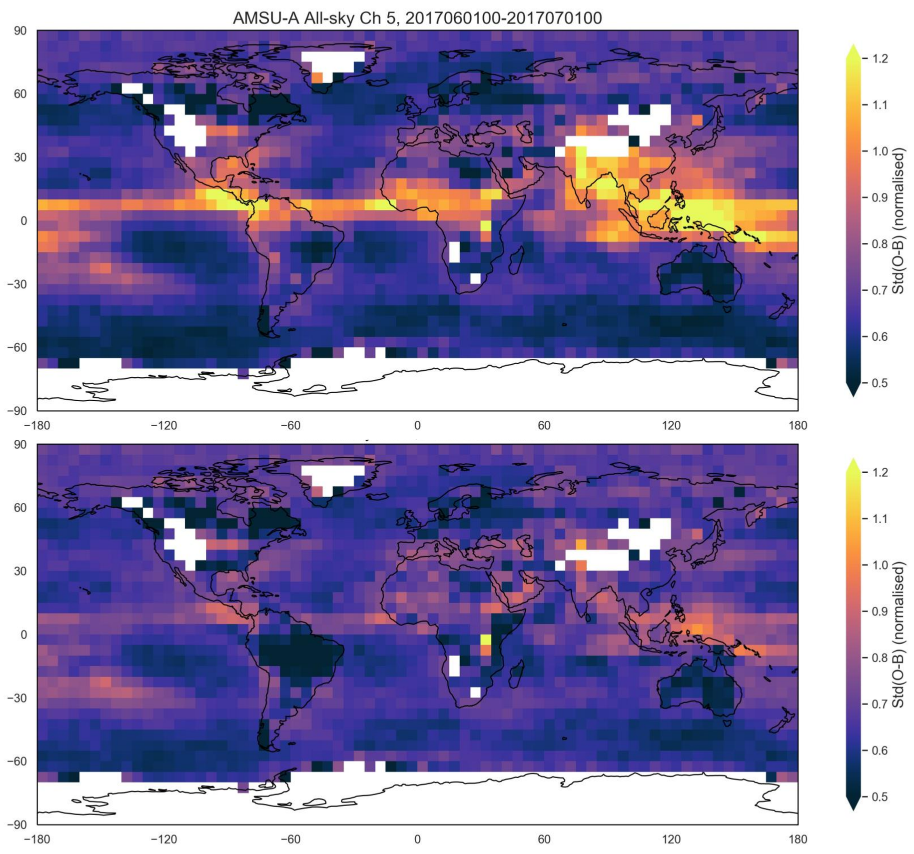


Figure 4: Standard deviation of first guess departures for AMSU-A ch. 5 normalised by observation errors, shown for Control (top) and TCWV-inflated errors experiment (bottom).

Larger cloudy first guess departures in tropics (e.g. from convection mis-location) could be accounted for using an additional TCWV predictor in the observation error model. We can tune these inflated errors for high TCWV values only, separately for ocean and land observations, as their error characteristics are distinct. With the new error model, regions of high normalised departures largely disappear.

More observations are assimilated at edge of scan in clear-sky. All-sky could better match the clear-sky distribution with updated data thinning.

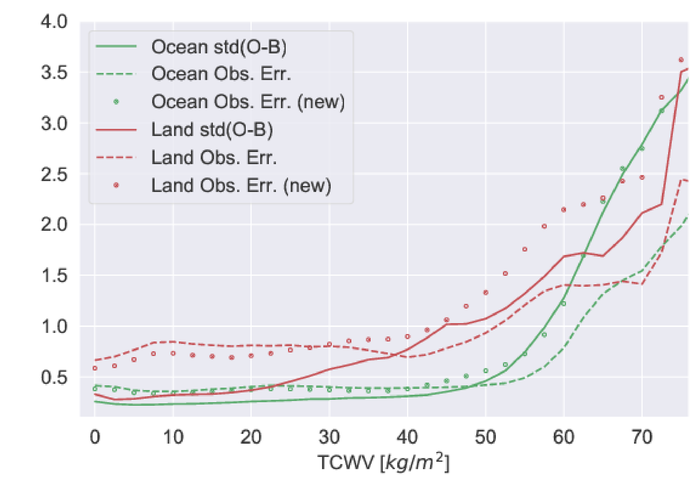


Figure 5: First guess departures and observation errors for ch. 5, plotted against columnar water vapour (TCWV).

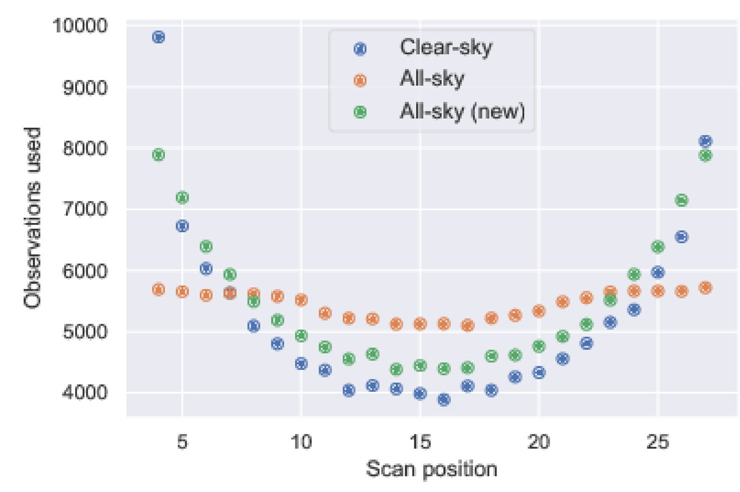


Figure 6: Number of assimilated observation across the scanline for AMSU-A all-sky and clear-sky over three days.

5) Conclusions

In the extra-tropics, AMSU-A all-sky is now comparable to the existing clear-sky assimilation. This involved bringing many aspects of the all-sky configuration into line with the clear-sky system: e.g. thinning, bias correction, quality control. Some of these aspects had surprisingly large impacts on forecast accuracy.

However, in the tropics, AMSU-A all-sky degrades forecasts when compared to clear-sky assimilation. Two hypotheses for this: larger first guess departures than assigned errors in areas of deep convection, and residual biases over deserts. The different distribution of observations across scan lines could also be suboptimal.

Ongoing experimentation aims to address these issues by inflating observation errors in regions of high TCWV, thinning the all-sky data to mimic the clear-sky stream, and adjusting variational quality control (VarQC) parameters for tropospheric AMSU-A channels. With these enhancements we aim to make the all-sky AMSU-A assimilation ready for operational implementation.

References

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