

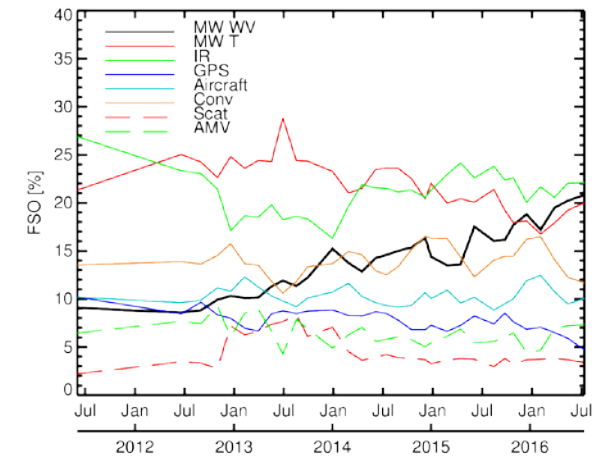
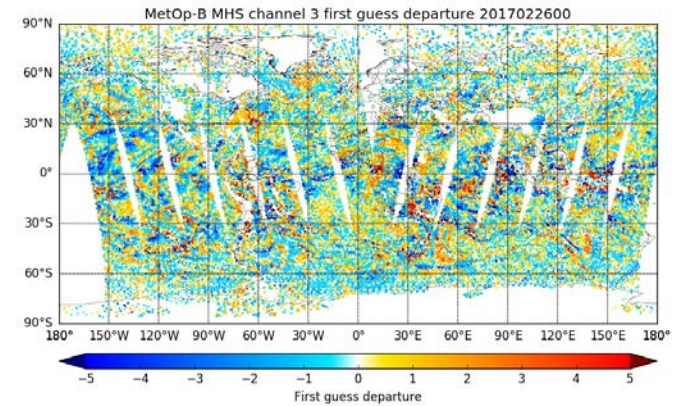
Assimilation of AMSU-A in the presence of cloud and precipitation

Peter Weston, Niels Bormann and Alan Geer

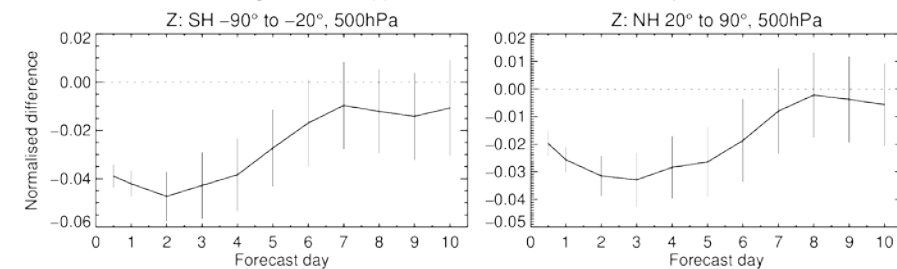
ITSC-21, Darmstadt – Thursday 30th November 2017

Brief introduction to all sky assimilation at ECMWF

- All sky assimilation of MW satellite data since 2009
- No cloud screening
- Radiative transfer takes cloud and precipitation into account
- Variable observation error model inflates errors in presence of cloud and precipitation
- Instruments currently assimilated:
 - MW imagers: SSMIS, GMI, AMSR2
 - MW humidity sounders: MHS, MWHS2, SAPHIR
- Importance of all sky data has increased steadily in recent years
- Currently all sky assimilation results in up to 4% reduction in Z500 forecast errors out to day 5/6



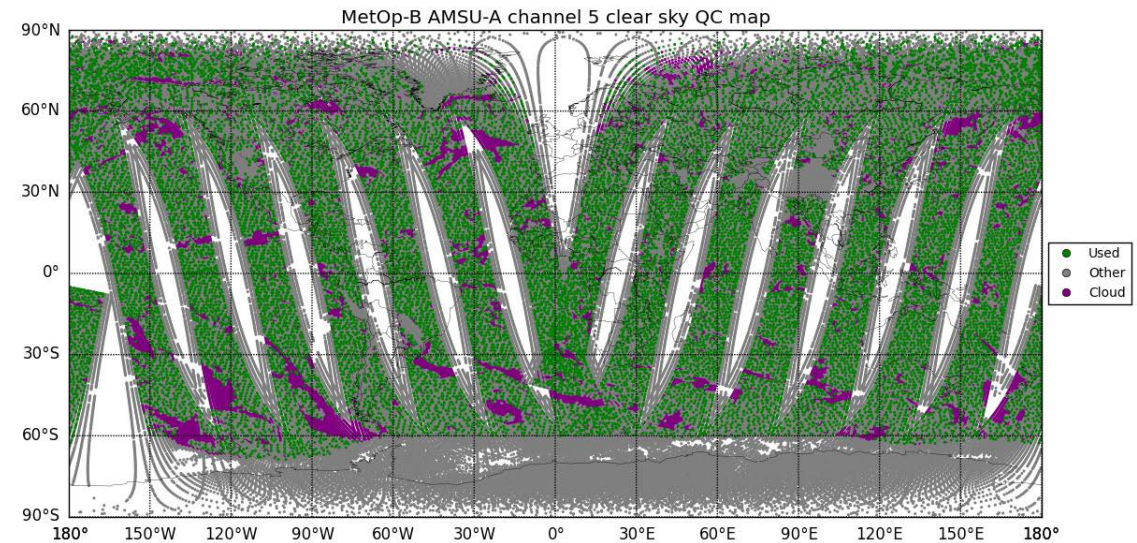
26-Feb-2015 to 13-Sep-2015 from 380 to 399 samples. Verified against own-analysis.
Confidence range 95% with AR(2) inflation and Sidak correction for 4 independent tests



— All-sky GMI, AMSR2, MHS and SSMIS – No allsky control

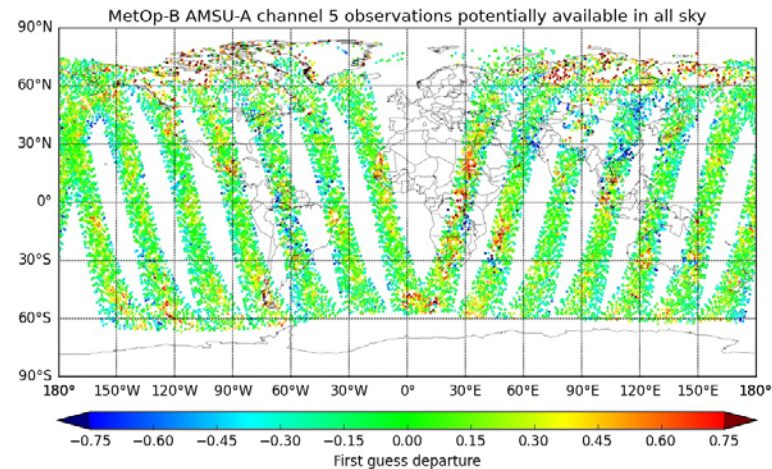
Motivation for moving AMSU-A to all sky assimilation

- The impact of MW humidity sounding data is ~doubled in all sky compared to clear sky
- Allows the use of extra data in meteorologically active areas:
 - We generally care more about where clouds and precipitation are than where they aren't! e.g. tropical and extra-tropical storms, convection etc.
 - Up to 25% of AMSU-A channels 5-8 data is currently screened out due to cloud
- Lower peaking channel 4 has strong sensitivity to cloud liquid water and is not currently assimilated
- Technically easier to maintain one system rather than two (clear sky and all sky systems)



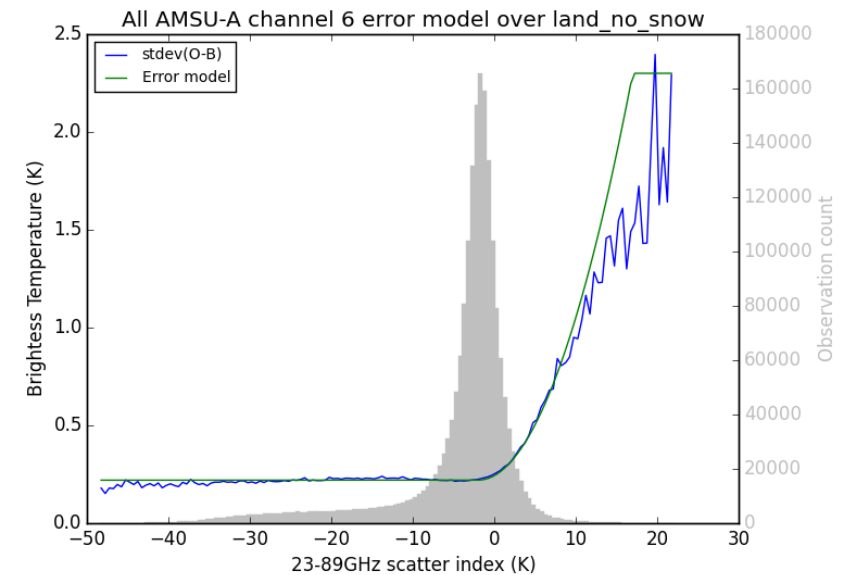
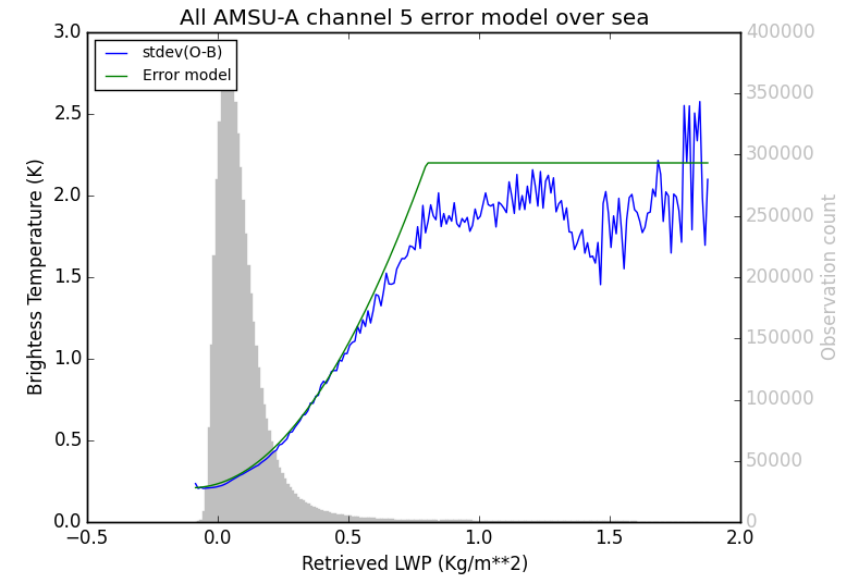
All sky and clear sky systems

- All sky and clear sky systems are fundamentally different in how observations are pre-processed and assimilated, therefore the plan is to:
 1. Remove or reduce any differences as much as possible e.g. match up quality control and thinning
 2. Isolate performance difference (if any) between clear sky treatment of AMSU-A in clear sky system v all sky system
 3. Then measure benefit (or degradation) of additionally assimilating cloud affected data



Observation error model

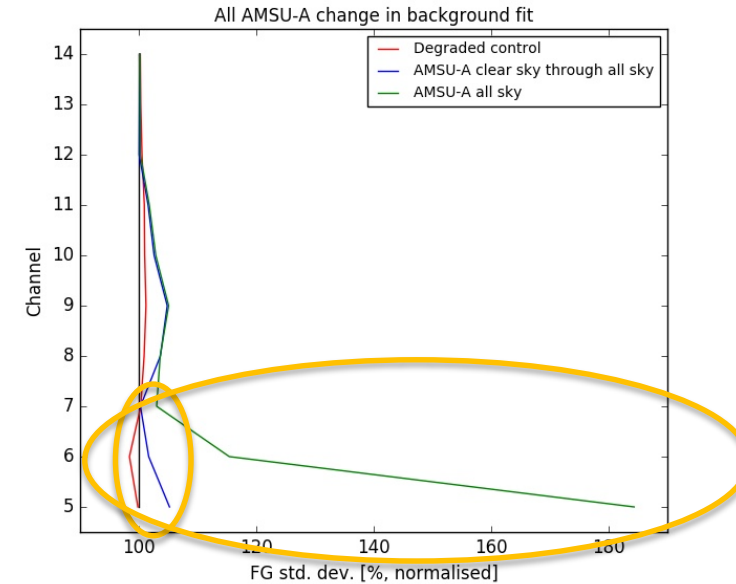
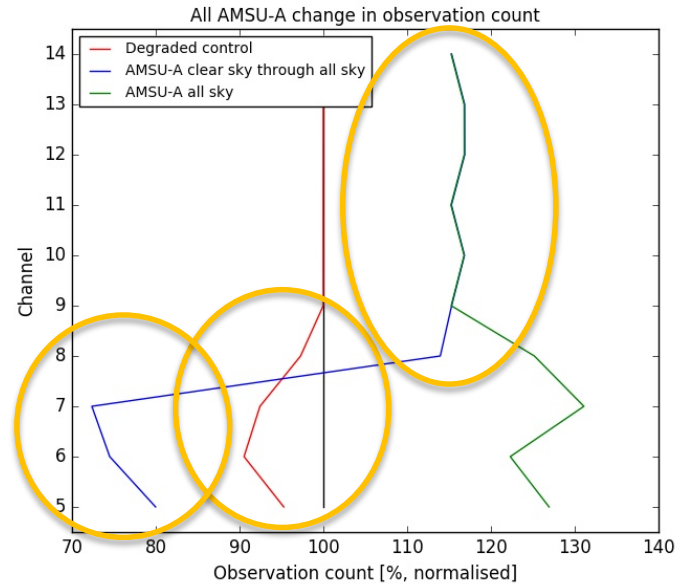
- Variable observation error model is used to make normalized first guess departures more Gaussian and let cloud affected observations past quality control
- Over sea the retrieved cloud liquid water path from window channels 1 (23.8GHz) and 2 (31.0GHz) is used as a cloud predictor (Grody et al, 2001)
- Over land the 23-89GHz scattering index (difference in radiances between channels 1 and 15 (89.0GHz)) is used as a cloud predictor
- The standard deviation of first guess departures is then binned against the symmetric cloud predictors
- An error model is fitted to these histograms so less weight is given to radiances that are affected by cloud



Experiment summary

- Baseline control:
 - Full observing system
 - Cycle 43r1 (operational Nov 2016 – Jul 2017)
- Three flavours of experiments:
 - Degraded control – without slant path radiative transfer, simplified cloud screening, orography screening
 - Clear sky through all sky – channels 5 to 14, same observation errors as clear sky control
 - All sky – channels 5 to 14, same clear sky errors, all sky errors calculated from O-B statistics
- Experiments were run for 2 periods of 4 months each and all results are merged

Normalised changes in AMSU-A counts and first guess fits

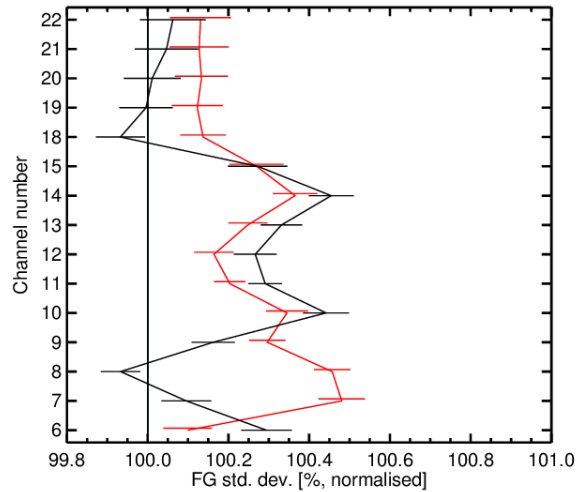


- Degraded control has more conservative cloud detection => fewer lower peaking channels are deemed cloud free
- All sky thinning results in more observations overall due to remaining thinning differences
- Clear sky thinning selects observations with lowest channel 4 departure => lower fg dep for other channels (esp lower peaking channels) and more lower peaking channels cloud screened in clear sky through all sky
- Background departures larger in all sky due to cloud effects

Results

- Both clear sky through all sky and all sky AMSU-A experiments show significant degradations in the stratosphere
- Clear sky through all sky also degrades the troposphere
- All sky is better in the troposphere but only returns to neutral at best against the control

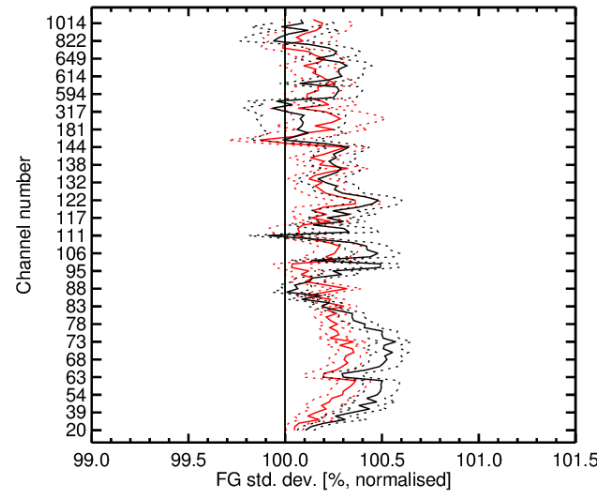
Instrument(s): NPP ATMS Tb Area(s): N.Hemis S.Hemis Tropics
From 00Z 1-Jan-2016 to 12Z 31-Oct-2016



— All sky AMSU-A
— Clear sky through all sky AMSU-A



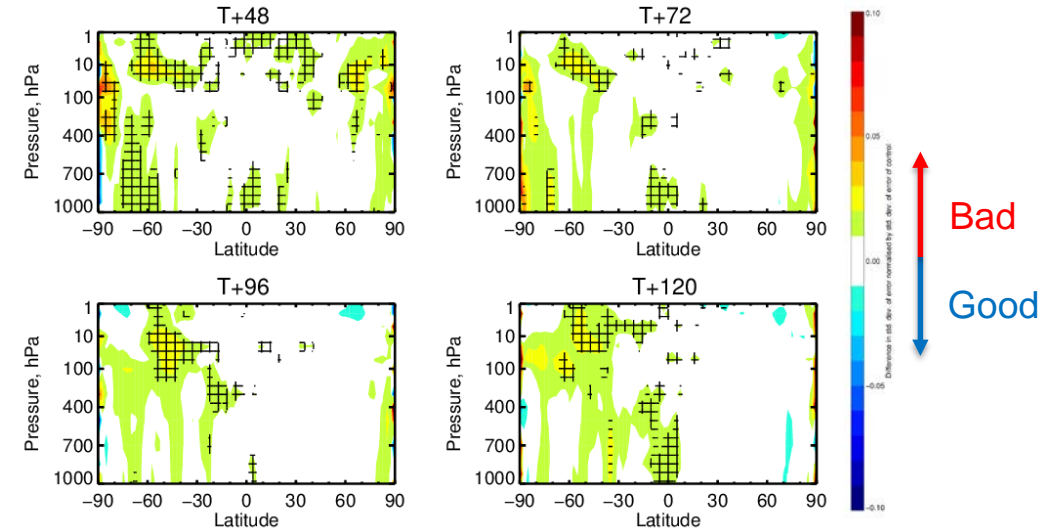
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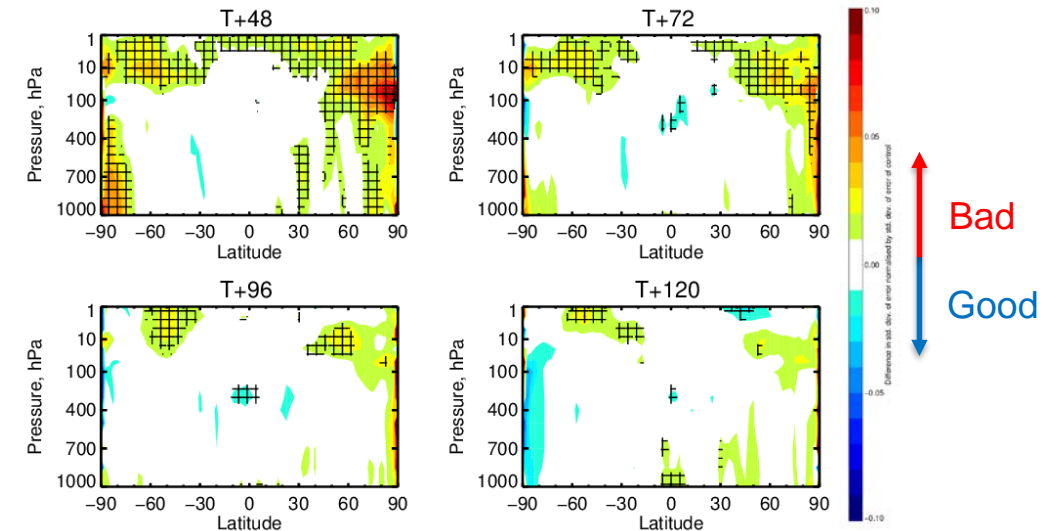
— All sky AMSU-A
— Clear sky through all sky AMSU-A



Clear sky through all sky change in geopotential height forecast error days 2-5

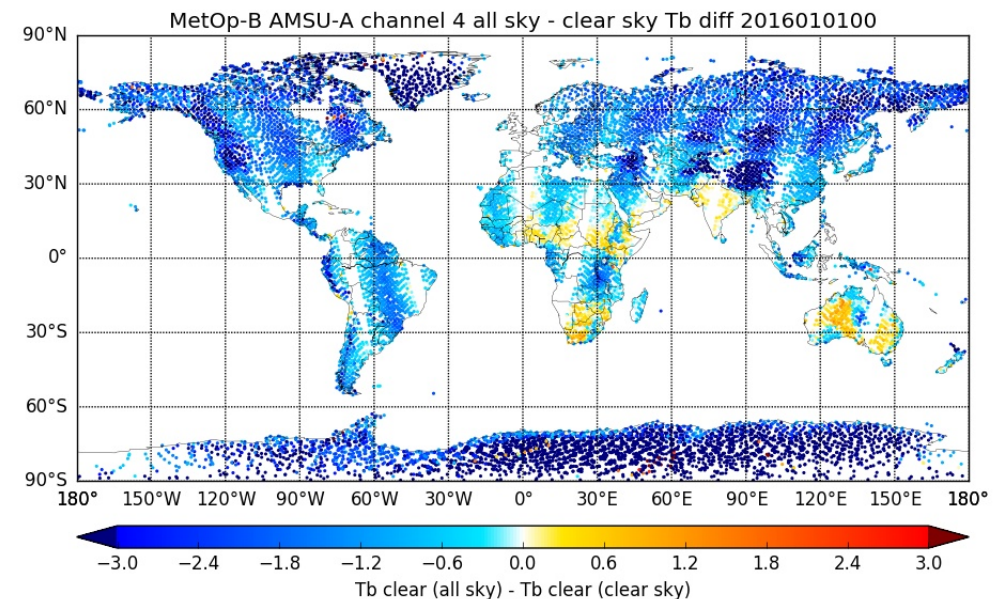
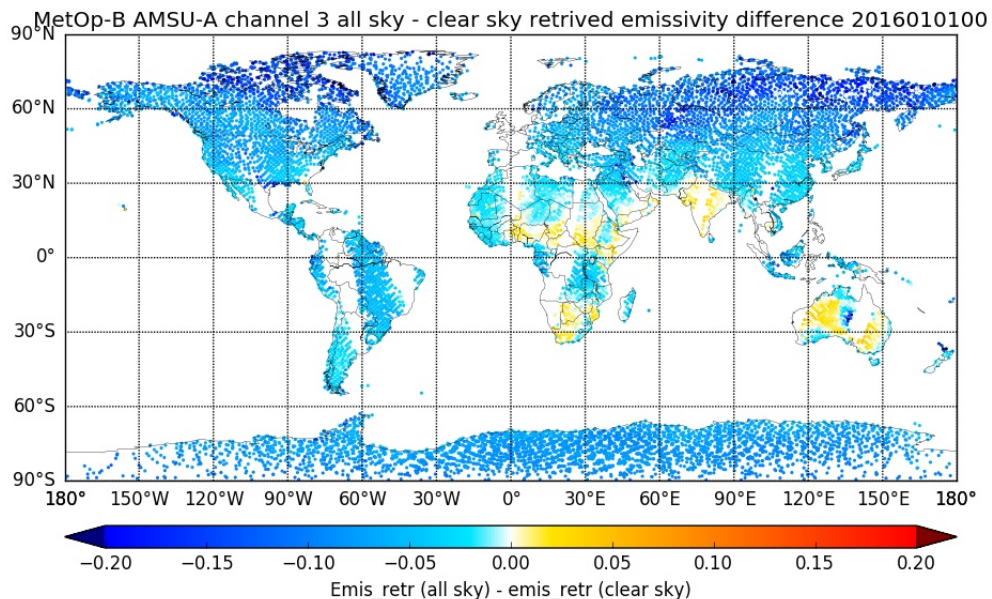


All sky change in geopotential height forecast error days 2-5



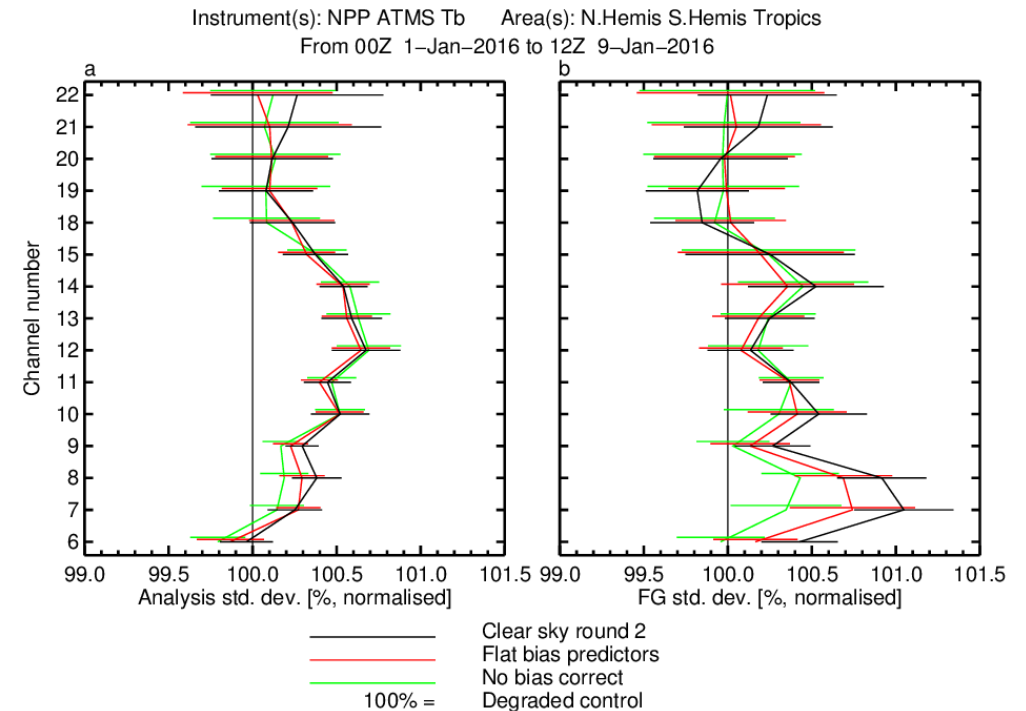
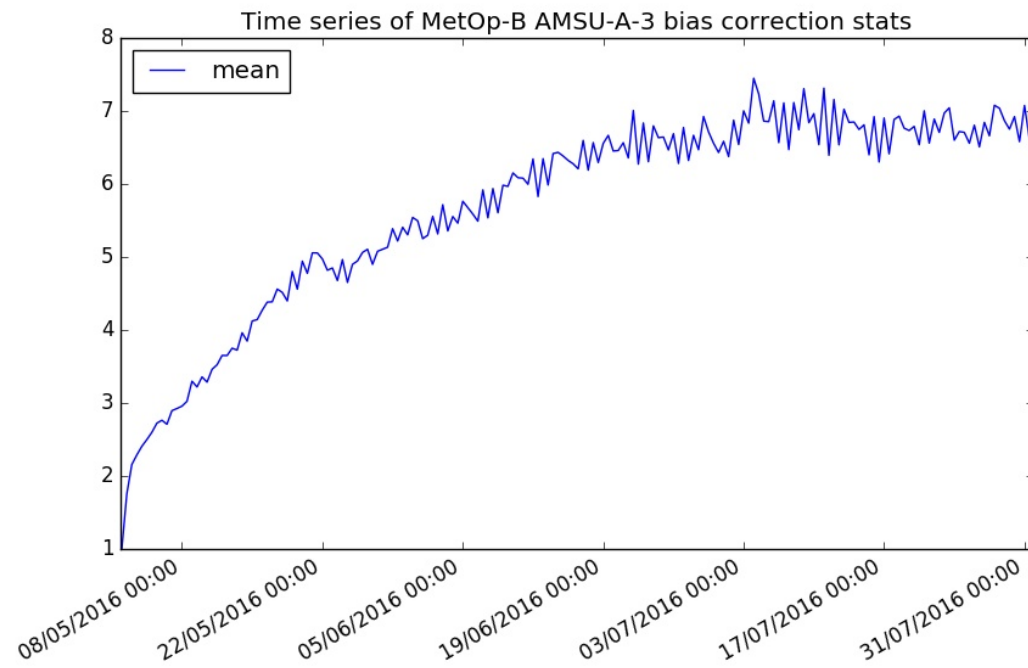
AMSU-A all sky - investigations

- Possible reasons for the stratospheric degradations:
 - Different distribution of observations
 - Unexpected differences between RTTOV and RTTOV-SCATT for stratospheric peaking channels
- Possible reasons for tropospheric degradations in clear sky through all sky:
 - Emissivity bias leading to larger biases in channel 4 and 5 in the all sky system
 - Channel 4 departures are used for cloud detection over land so the bias skews the cloud detection



AMSU-A all sky - investigations

- Bias predictors used for AMSU-A channel 3:
 - Original: T skin, TCWV, surface wind speed, third order polynomial scan angle, constant
 - Flat bias predictors & no bias correct: Third order polynomial scan angle, constant
- No bias correct: don't bias correct channel 3 brightness temperature for emissivity retrieval



Conclusions and future work

- The clear sky and all sky systems have been made more consistent with their treatment of observations
- The observation error model for AMSU-A has been refined
- Clear sky through all sky results remain slightly negative against clear sky AMSU-A baseline
- Move to all sky results in improved short to medium range forecasts in the troposphere but further degrades stratosphere
- Aspects to investigate further:
 - Degradations in stratosphere from clear sky through all sky and all sky experiments (clear/all sky RT differences, different distribution of observations)
 - Another set of experiments with fixes/improvements and updated IFS cycle
- Longer term:
 - Introduction of all sky assimilation of AMSU-A channel 4
 - Investigate the use of ATMS temperature and humidity sounding channels in the all sky system