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METEOROLOGY

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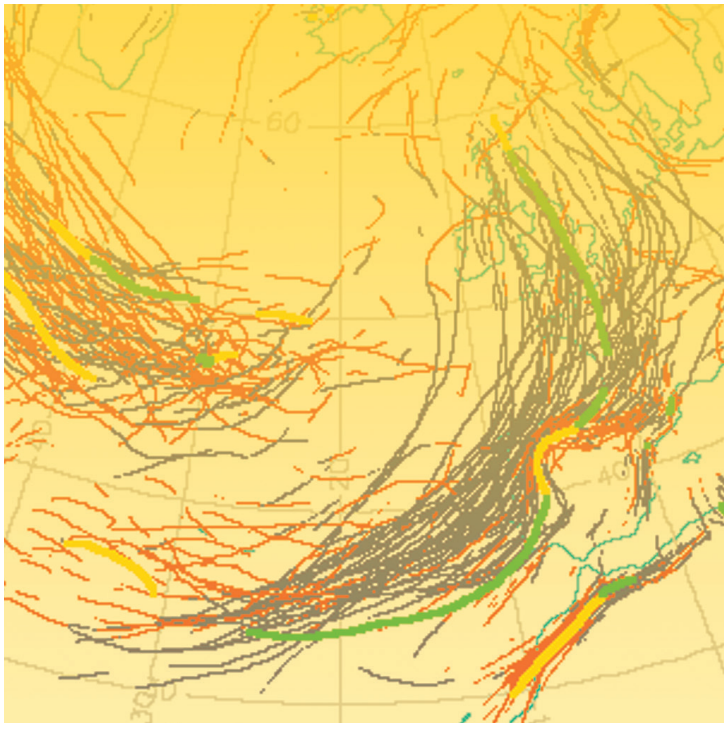

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The new all-sky assimilation system for passive microwave satellite imager observations

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With the operational implementation of IFS cycle 35r2 (Cy35r2) on 10 March 2009, a new system for the assimilation of passive microwave imager radiances was introduced. The microwave imager radiances are sensitive not just to atmospheric moisture and surface wind speed, but also to clouds and precipitation. Most of the data is contributed by the Special Sensor Microwave Imagers (SSM/I onboard DMSP satellites; available since 1987) and the Advanced Microwave Scanning Radiometer (AMSR-E onboard the Aqua satellite, available since 2003), and will be complemented by further satellite instruments in the future.

The all-sky system represents the first framework in which satellite radiances are not separated into clear-sky and cloud-affected streams. All radiances are treated with the same observation operator, which produces increments for all the above physical fields and actively drives the moist physics parametrizations. Most other satellite observations are used in cloud-free areas and the cloud screening is performed on the basis of observational information only. This may produce a sub-optimal sampling in situations where observations are clear but the model forecasts clouds; a disadvantage that is overcome with the all-sky system.

Substantial effort has been spent on the improvement of the observation operator, channel selection, the definition of observation errors and bias correction. The system also required the activation of the moist physics parametrizations in the first minimization of the 4D-Var assimilation process. As a result of all these changes, more microwave imager observations are used than before.

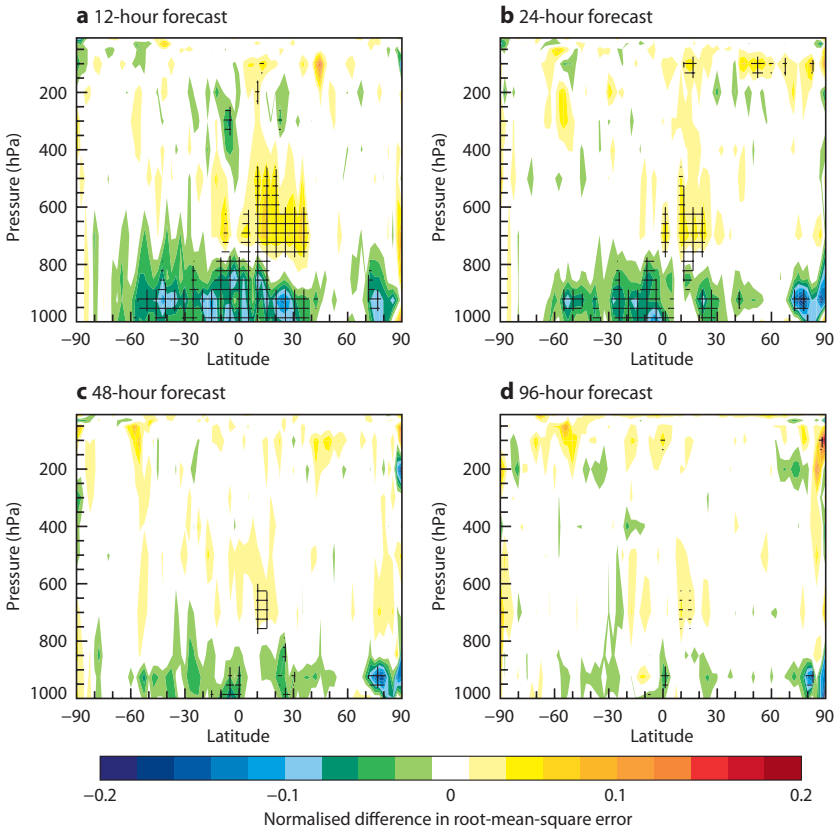

Figure 1 Normalised difference between All-Sky and Control experiments for the root-mean-square forecast error for relative humidity verified against own analyses for (a) 12-hour, (b) 24-hour, (c) 48-hour and (d) 96-hour forecasts. Blue colours indicate where the All-Sky experiment has smaller forecast errors than Control. Cross-hatching indicates differences significant at the 90% level.

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Figure 1 demonstrates the impact in terms of the normalized forecast error difference for relative humidity between the new system and a control experiment for five weeks in August–September 2008. The control experiment employed separate treatments of microwave imager observations in clear-sky and cloud-affected areas, the latter through the 1D+4D-Var assimilation system (*ECMWF Newsletter No. 110*, 12–19). The scores suggest a large improvement in the lower troposphere across all latitudes that is maintained until day-2 of the forecast. At mid-levels in the tropics a deterioration is found that is most likely related to larger variability due to a weaker constraint of observational humidity by the all-sky system compared to the 1D+4D-Var. Wind and temperature scores are rather neutral and the general fit to both satellite and radiosonde moisture observations in the analysis and short-range forecast is also largely unchanged. This means that the new assimilation of microwave imagers is producing similar forecast benefits to the previous one. These benefits are seen mainly in short-range tropical wind and moisture forecasts.

Figure 2 shows the time series of departure standard deviations between model analyses and independent total column water vapour observations obtained from the Microwave Radiometer (MWR) onboard Envisat. The Cy35r2 e-suite, in which the all-sky system has undergone pre-operational testing, constrains the moisture analysis less than the operational system, mostly due to a more rigorous quality control. This leads to generally larger analysis departure standard deviations when the all-sky system is used. In the period between April and May 2009, however, both active instruments (DSMP F-13 SSM/I and Aqua AMSR-E) had data outages so that the analysis departures increased by about 15% compared to the independent MWR observations. This trend is only reversed when the SSM/I and AMSR-E data returned in June 2009. This shows that, although the constraint of lower tropospheric moisture is slightly weaker than before, the new system still has quite a substantial positive benefit.

The all-sky system is the first operational 4D-Var assimilation system for clear, cloud and precipitation affected radiances and represents a significant step towards satellite usage in areas which have been largely unexploited until now. It is hoped that further updates will be made with Cy36r2 (due in spring 2010), based on improved bias correction, quality control and observation error definitions. With these it will be possible to increase the weight of the all-sky data in the analysis, thus substantially increasing the constraint of lower tropospheric moisture and cloud. In the future, the system will also be tested with microwave temperature (Advanced Microwave Sounding Unit, AMSU-A) and moisture (Microwave Humidity Sounder, MHS) sounder radiances aiming at a unified all-sky radiance assimilation for all sensors.

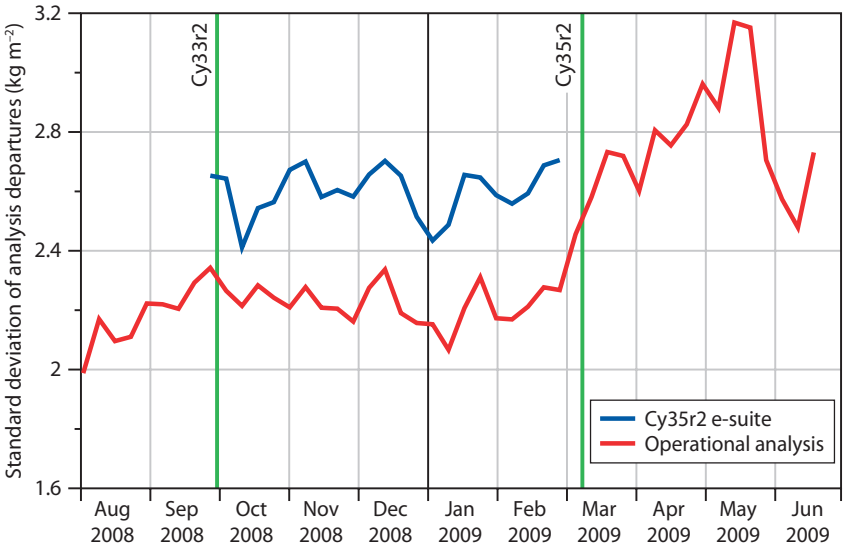

Figure 2 Standard deviation of analysis departures of total column water vapour from the Envisat Microwave Radiometer, calculated over the tropical region.

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