Satellite OSEs in the UKV 4D-Var system

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Abstract

Results are presented from a series of Observing System Experiments (OSEs), with each trial denying a different set of satellite observations. These trials were based on controls using a setup approximating that used operationally in the UKV for OS43. The controls were run for a winter and a summer period. The trials show that GeoCloud observations give significant improvements to surface forecasts. In the winter trial, radiance observations were found to improve the fits to sonde observations. Denial of sub-groups of radiance observations worsened the background fits to other radiance observations. Denial of radiance observations did not significantly degrade the forecasts of surface variables. Satellite observations appeared to have a smaller impact in the summer trial than in the winter trial period.

Introduction

The UKV NWP model is a regional model covering the UK and surrounding areas, utilising the Met Office Unified Model NWP system with hourly Data Assimilation (DA). The grid boxes are rectangular, ranging in size from 1.5×1.5km at the centre of the domain to 4km×4km at the corners (see Figure 1), with all gridlines on a rotated lat-lon grid (the UK is positioned over the equator in the rotated grid). A wide range of conventional and satellite observations are assimilated in the 4D-Var DA, as shown in Figure 2. RTTOV v12 is used on vertical profiles interpolated to the 44 RTTOV pressure levels. The model is also adjusted via latent heat nudging in response to radar reflectivity observations (these are not shown in Figure 2).

In order to assess the relative contributions of different satellite observations, a series of denial trials were performed for two periods: 01/12/2018 - 31/01/2019 (labelled “Winter”) and 15/07/2018 - 14/09/2018 (labelled “Summer”). The control used was very similar to the OS43 setup of the UKV (used operationally in 2020). For the winter period, additional trials were performed denying different subgroups of radiance observations (e.g. microwave sounders or hyperspectral IR sounders).

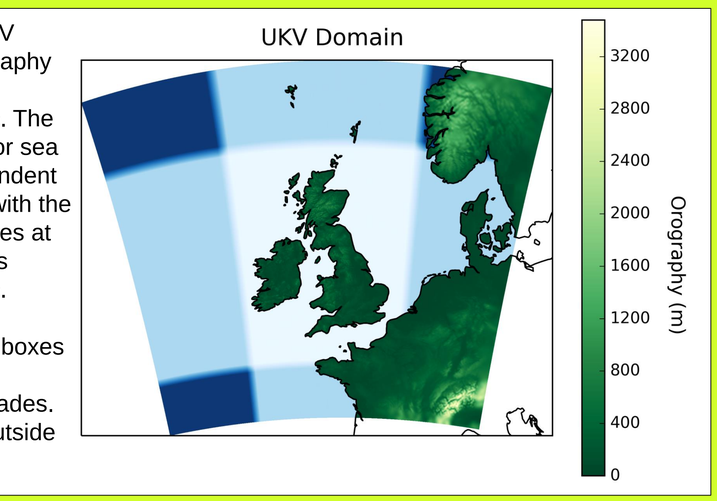

Figure 1 – The UKV domain, with orography plotted in the green/yellow scale. The blue shade used for sea grid boxes is dependent on grid box area, with the 4km×4km grid boxes at the domain corners coloured dark blue. 1.5km×4km and 1.5km×1.5km grid boxes make up the two principle lighter shades. White areas are outside the domain.

Results

Full details of the denial trials can be seen in *Data Assimilation and Ensembles Science Report 35: Satellite denial trials in the UKV*, available from the author of this poster. I provide here a summary of the denial trials which had the most significant impact on forecast performance.

In the winter trials, denial of all radiance observations and of GeoCloud pseudo-observations of cloud (derived from SEVIRI radiances) gave the largest impact on the UKV Index surface observation verification score, with a change of -0.47% (a negative score indicates that the denial of observations degraded the forecast performance). By denying different subgroups of these observation types it was found that GeoCloud had the greatest impact on surface forecasts (-0.42% UK Index change), and this was confirmed by the Hinton plots from the new HiRA verification system (see Figure 3). The next largest impact came from denial of all microwave sounders (-0.23% change) and then hyperspectral IR sounders (-0.11% change). The small impact of IR sounders may indicate that these instruments are no-longer well-tuned in the UKV system (when they were introduced, the UKV was very different, with a smaller domain and 3-hourly 3D-Var DA). The denial of all radiance observations gave detrimental impact to the lower and mid tropospheric verification against sondes (see Figure 4). Denial of any one subgroup of radiance observations led to poorer background fits to most other radiance observation types.

In the summer trials, only the denial of GeoCloud observations gave significant degradation to surface verification scores (see Figure 3). Denial of radiance observations in the summer trial gave slight degradation of the upper air verification against sondes, but at certain lead times surface temperature verification was slightly *improved* by the radiance denial (although other surface variables were generally degraded). Trials denying different subgroups of radiances were not performed for the summer period.

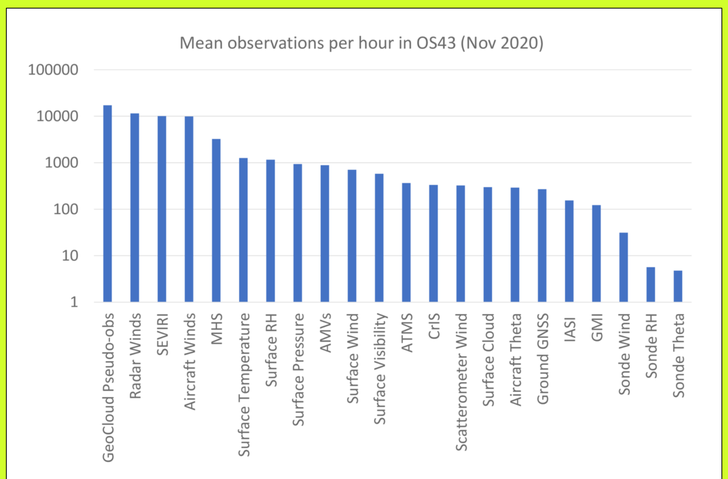

Figure 2 – Average number of observations assimilated in 4D-Var per hourly cycle in the operational (OS43) UKV for an example week in early November 2020. The total number of observations is dominated by satellite, radar Doppler wind, aircraft winds (including Mode-S) and surface observations. Observations with many channels or many vertical levels may have a larger relative impact.

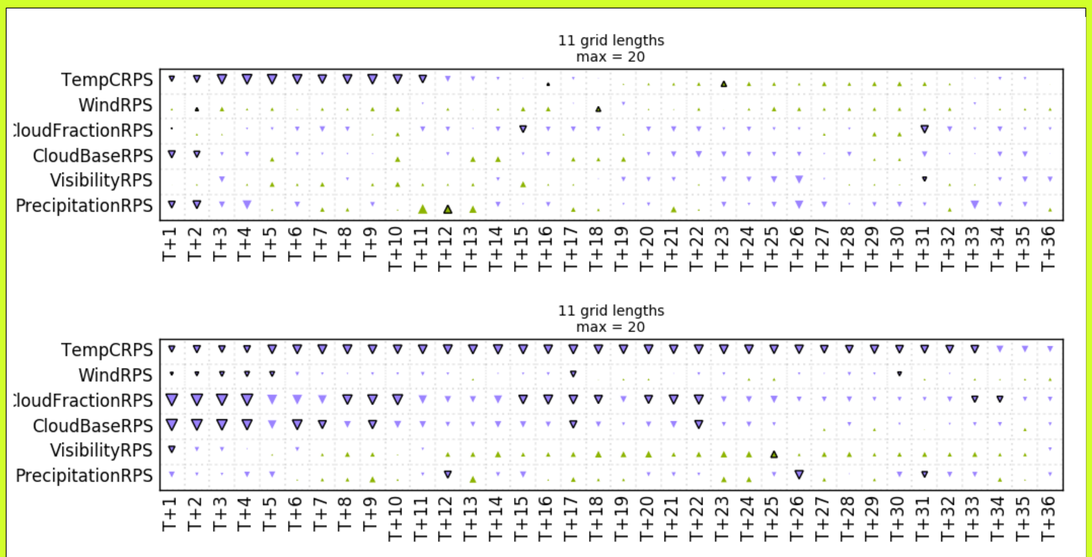

Figure 3 – Verification against surface observations for summer (upper plot) and winter (lower plot) trials with denial of GeoCloud observations. This shows clear benefit for GeoCloud observations.

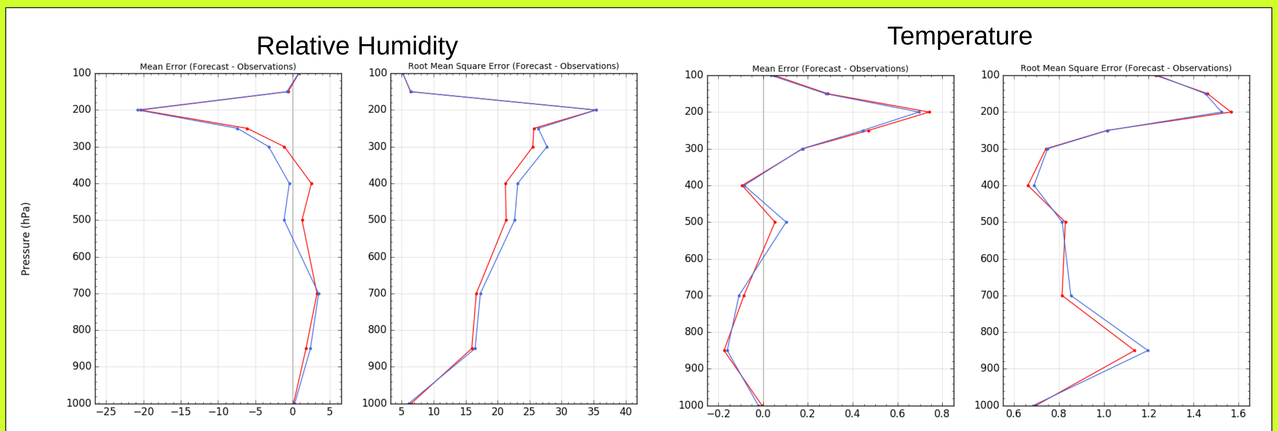

Figure 4 – Verification of T+1 forecasts against sonde observations for winter trials with denial of all radiances. The red line includes radiances, whilst radiances were denied for the blue trial line. The left panels show Relative Humidity (RH) and temperature verification is on the right. For this example, neither the control nor the trial included GeoCloud (but the control was otherwise similar to the OS43 setup). In the lower to mid troposphere, the radiance observations give a clear reduction to the RMS deviations of the forecast from the sonde observations. In the upper troposphere the results are more mixed, with e.g. the radiance assimilation giving larger RH bias at 400 hPa.

Conclusions and Further Work

Assimilation of satellite radiance observations and GeoCloud pseudo-observations (derived from SEVIRI radiances) gives a modest beneficial impact on OS43 UKV forecasts, particularly lower and mid tropospheric variables and (for GeoCloud) surface temperature and cloud cover. Quality control and bias correction changes have been developed since OS43 which further improve the average background fit to radiances in the UKV. Further development of UKV satellite DA will take place once the next generation JEDI DA system becomes available.

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