# Satellite Data Assimilation in Met Office Regional models

Recent Improvements and Assessment of Performance

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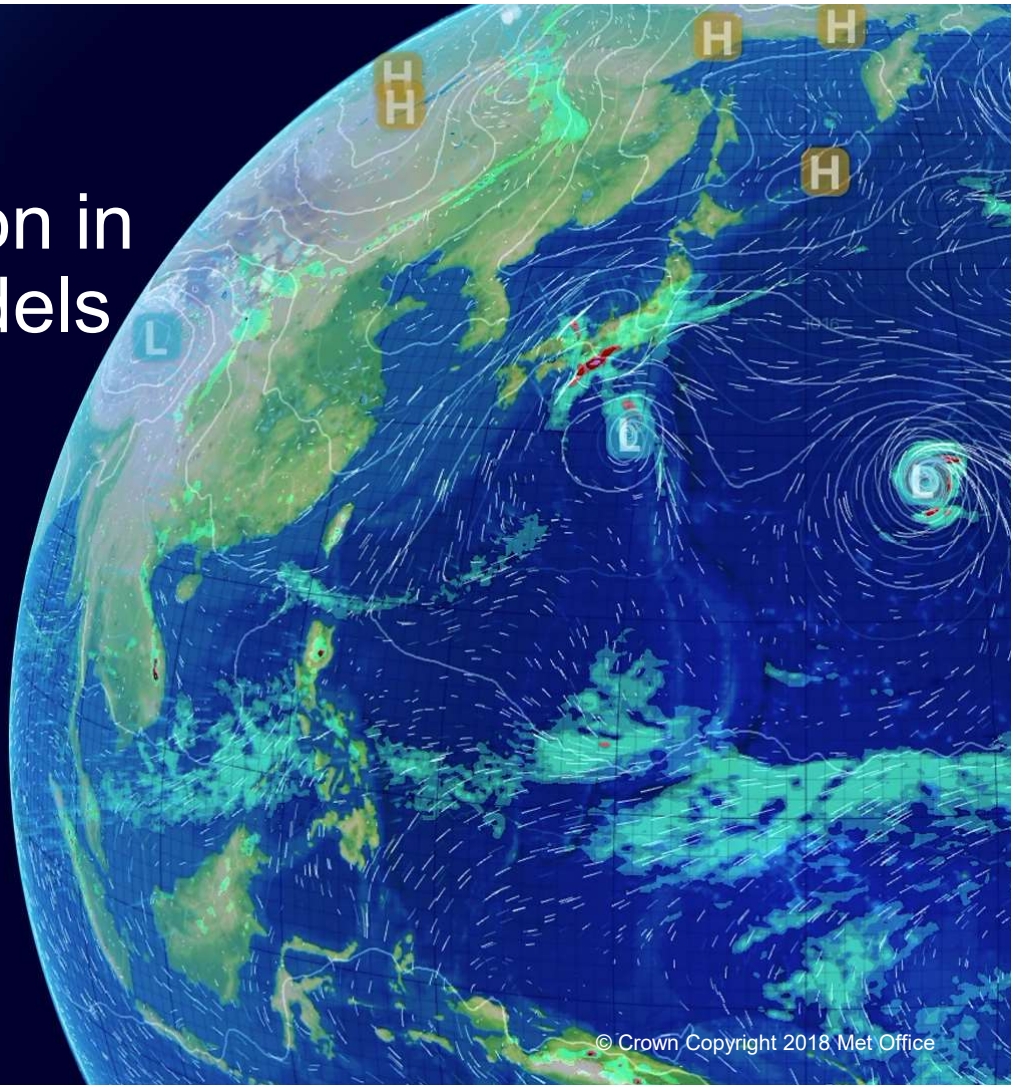
With the support of the Convective Scale NWP Team



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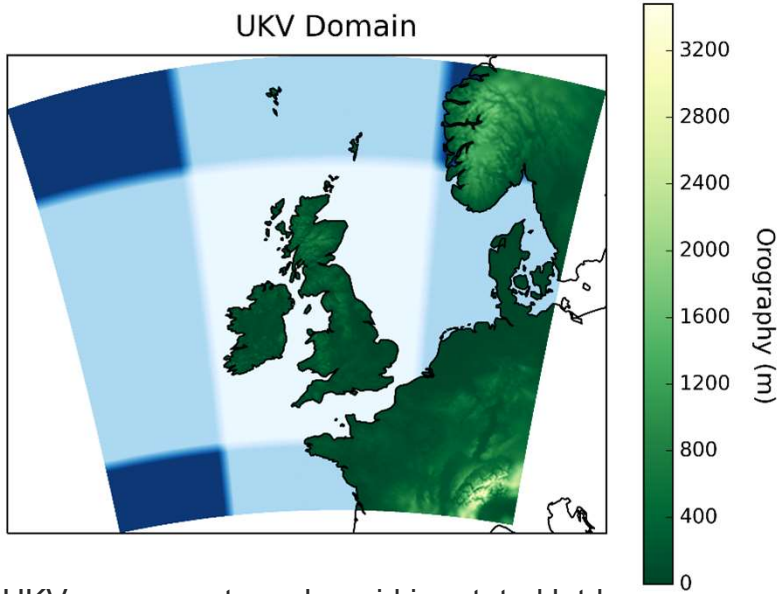
# UKV introduction

- The UKV has hourly-cycling 4D-Var data assimilation using climatological covariances
- Grid is 1.5x1.5km over the central region, with spacing increasing smoothly to 4km
- Mode-S aircraft winds, radar Doppler winds, satellite-derived pseudo-obs of cloud top, satellite radiances and surface temperature are biggest sources of obs in 4D-Var
- Aircraft temperature, sonde obs and other surface obs have a very beneficial impact
- The model also has latent-heat nudging based on radar rain rates




The UKV uses a rectangular grid in rotated lat-lon coordinates with variable spacing. The sea is coloured according to grid box area (with 4x4km boxes dark blue)

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# Observing System Experiments in the UKV

- A series of observation denial experiments were run for two trial periods of two months each
  - December 2018 and January 2019
  - Mid-July 2019 to mid-September 2019

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# Denial of GeoCloud observations

- GeoCloud observations are pseudo-observations of cloud and clear sky (at and above the cloud top), generated from SEVIRI radiances and UKV model background fields
- GeoCloud observations adjust the humidity in the UKV model, but only where the model humidity is not consistent with the satellite observations (e.g. model cloud in a location observed to be above any cloud, or clear where the cloud-top height observations indicate that cloud is present)

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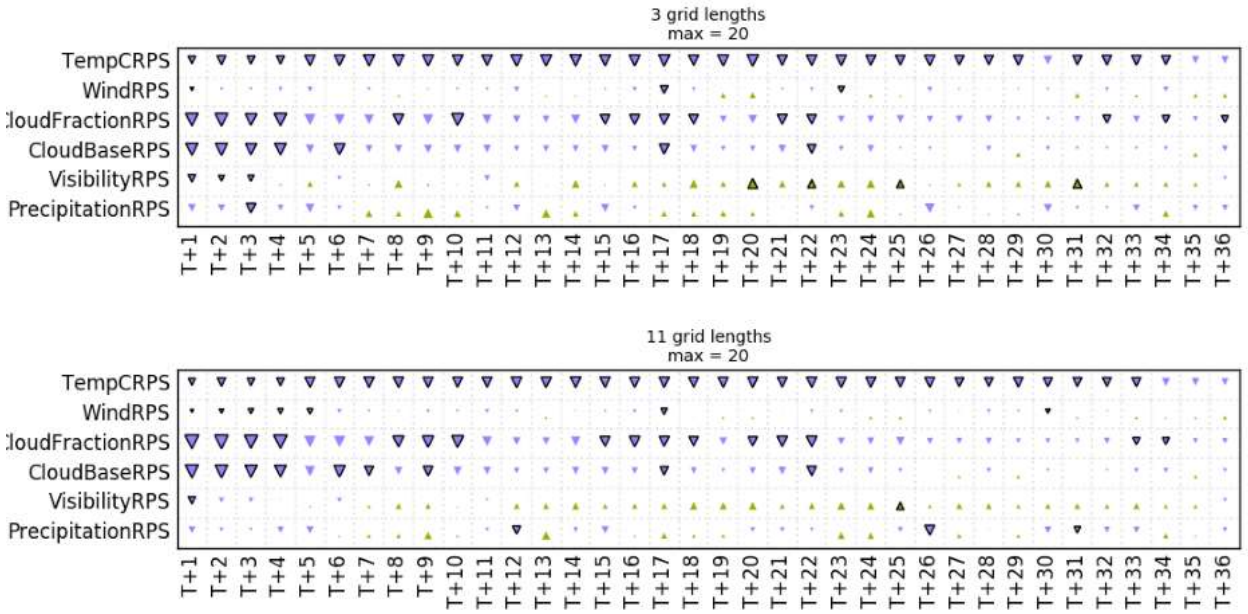
# Denial of GeoCloud – Dec/Jan 2018-2019

- Consistently degraded performance in surface verification when GeoCloud removed
- Improved layer cloud gives improved shortwave radiation and improved surface temperatures



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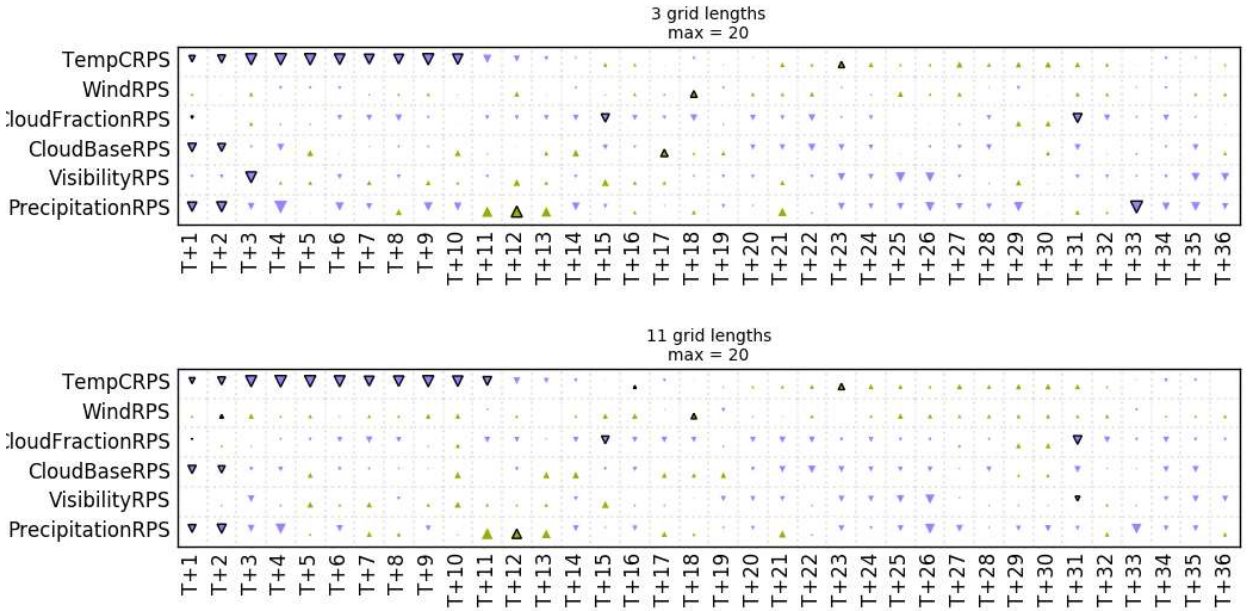
# Denial of GeoCloud – mid-Jul to mid-Sep 2019

- Consistently degraded performance in surface verification when GeoCloud removed
- Benefits smaller in summer



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# Denial of radiance observations

- In OS43, radiance observations were assimilated from:
  - SEVIRI, MHS, ATMS, CrIS, AIRS, IASI and GMI
  - IR radiances only used if they had little or no cloud-contamination
- Denial of all radiances did *not* degrade the surface verification (in fact surface temperatures were possibly marginally better in summer!)
- Denying all radiances degraded verification against sondes (both periods)
- For the winter 2018-19 period, individual groups of radiances were denied (microwave, IR sounder or SEVIRI)
  - Denial of any one group of radiances degraded the average model background fit to all other radiance types (in following cycles)

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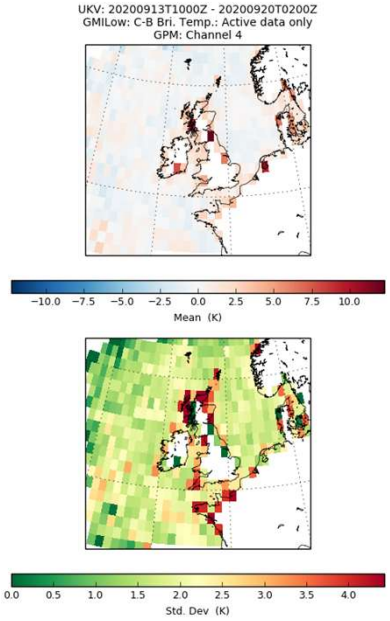
# Improved radiance assimilation

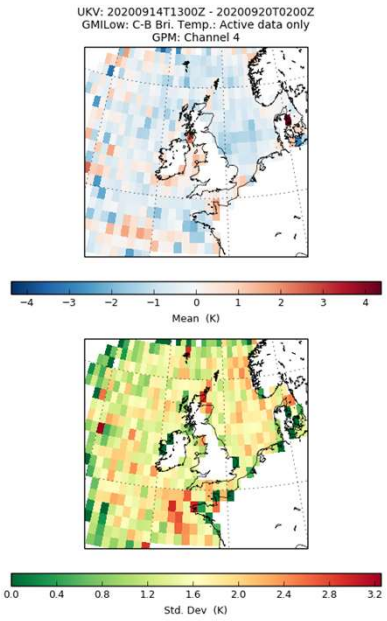
- The radiance denial trials suggested that the impact of radiance assimilation has reduced somewhat since initial implementation
- Statistical analysis of the radiance assimilation highlighted a number of minor issues:
  - The biases for a small number of IASI channels are not updated actively by VarBC – some of these biases needed updating slightly (of order ~0.1K)
  - O-B fits were found to be worse for ATMS around precipitation – the Bennartz quality control test is likely to be updated to exclude more of these observations at the next parallel suite
  - O-B fits were found to be worse around coastlines for GPM/GMI and for SEVIRI window channels – in the current parallel suite observations near* to coastlines are being omitted using a new quality control algorithm

*within 6km for SEVIRI, 16km for GMI

# Removal of observations near coasts – O-B

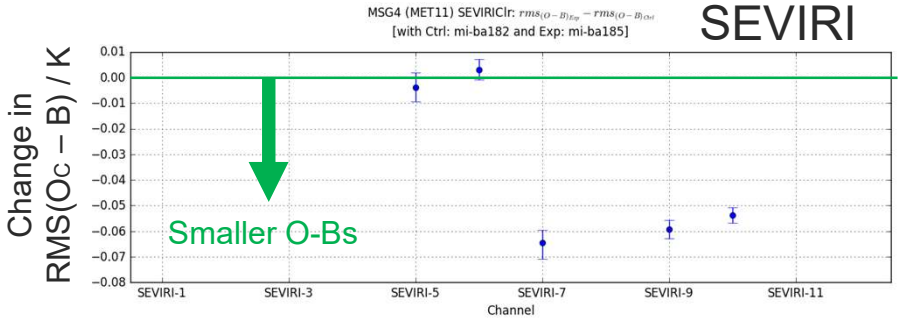



GMI Ch4 Control

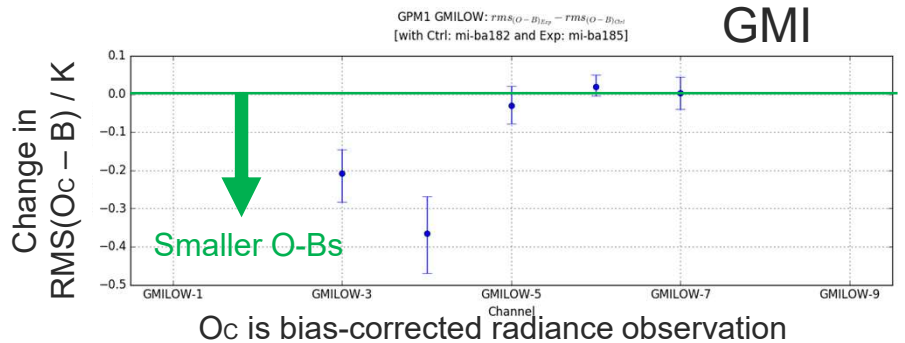



Coastal filter trial

SEVIRI



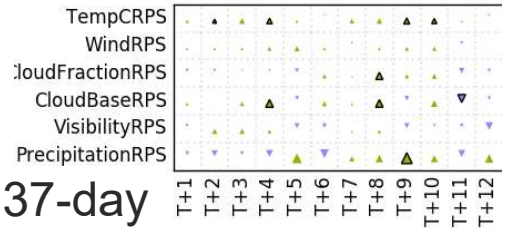

GMI



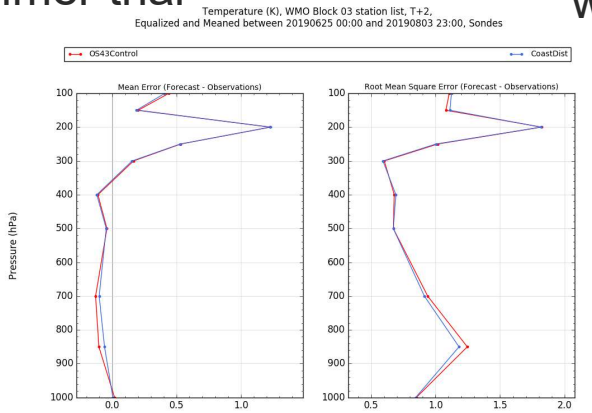

Oc is bias-corrected radiance observation

# Verification results

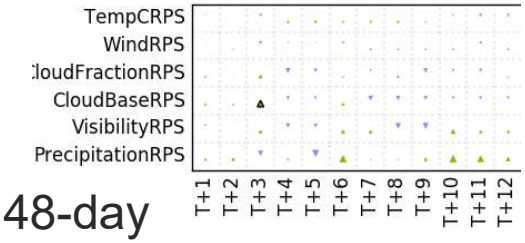
Small improvement to surface verification in summer



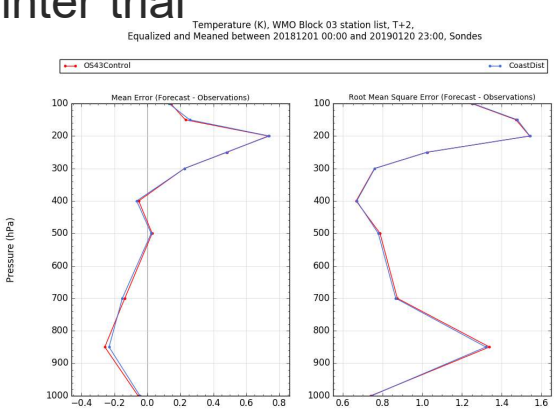

37-day summer trial




Larger improvement to upper-air verification in summer, and small improvement in winter




48-day winter trial



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# Conclusions

- Observation denial experiments in OS43 suggest that:
  - GeoCloud pseudo-observations of cloud improve UKV forecasts of surface temperature and cloud
  - Satellite radiances improve the upper air forecasts, but have little impact on surface verification
  - I would like to reduce statistical noise in upper-air verification (use more than just sondes)
- Analysis of the performance of satellite radiance assimilation indicated several areas of potential improvement:
  - Exclusion of observations near to coastlines was found to improve forecast performance (particularly in the lower troposphere), and is being implemented in the current parallel suite (PS44)
  - Reductions to rain contamination of microwave observations (updates to the Bennartz test) will be tested in the next parallel suite (PS45)
  - Biases for channels which are not updated by VarBC will be adjusted more regularly
  - Use of VarBC for a larger fraction of satellite channels will be tested in PS45

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# Future work

- The Met Office is planning a “Next Generation” DA system over the next few years
  - The new system is likely to be JEDI-based (see Mike Bush’s talk)
  - There will be little further development of current systems after this year
  - Updates such as the capability to model slant paths from the satellite will wait for the new system