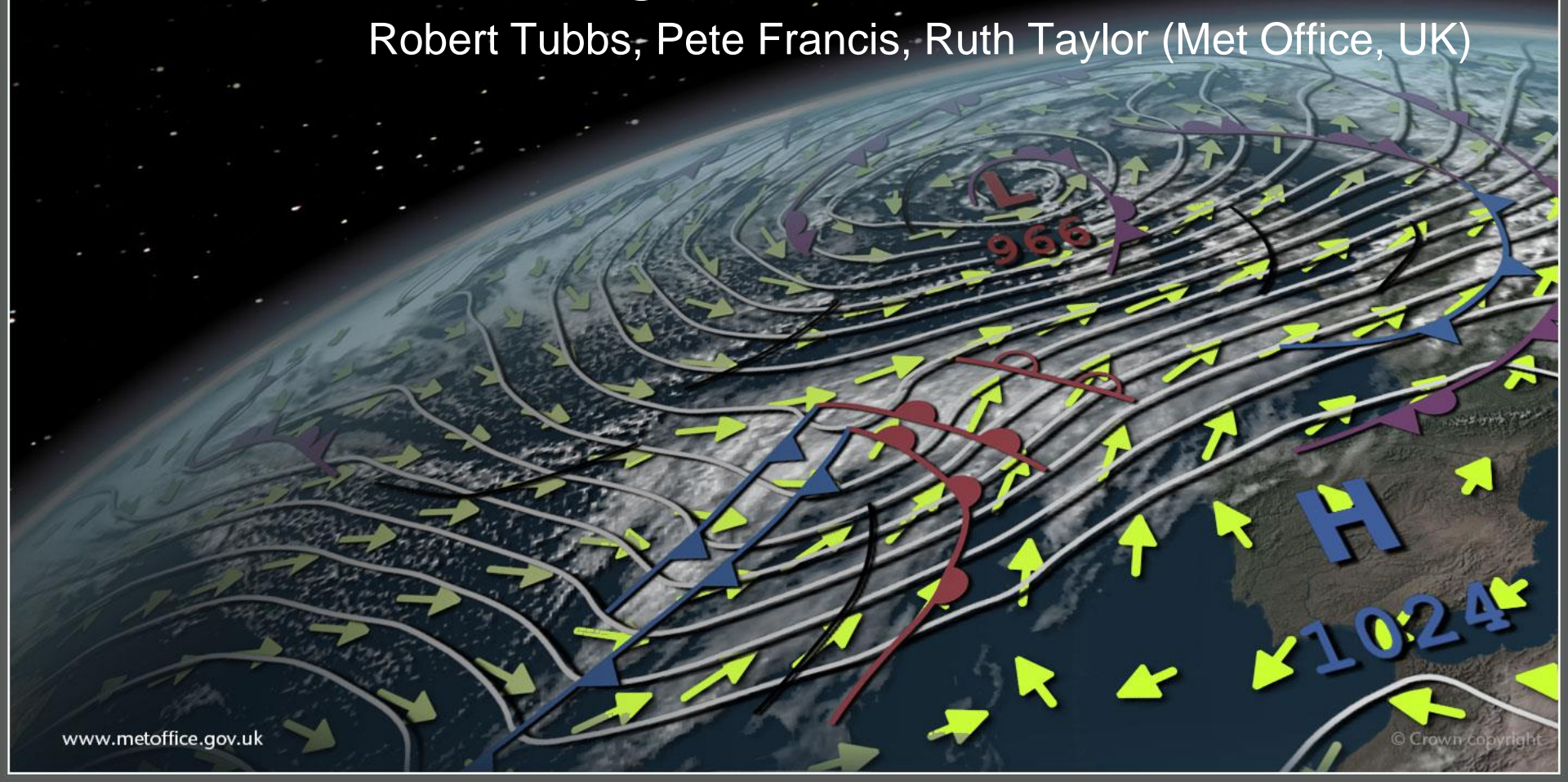


# Improvements to the Use of Infrared Data from Geostationary Satellites in Met Office Global and Regional Models

Robert Tubbs, Pete Francis, Ruth Taylor (Met Office, UK)



# Contents

- Introduction
- Trials (3 sections including UKV and Global Model trials)
- Conclusions and future work



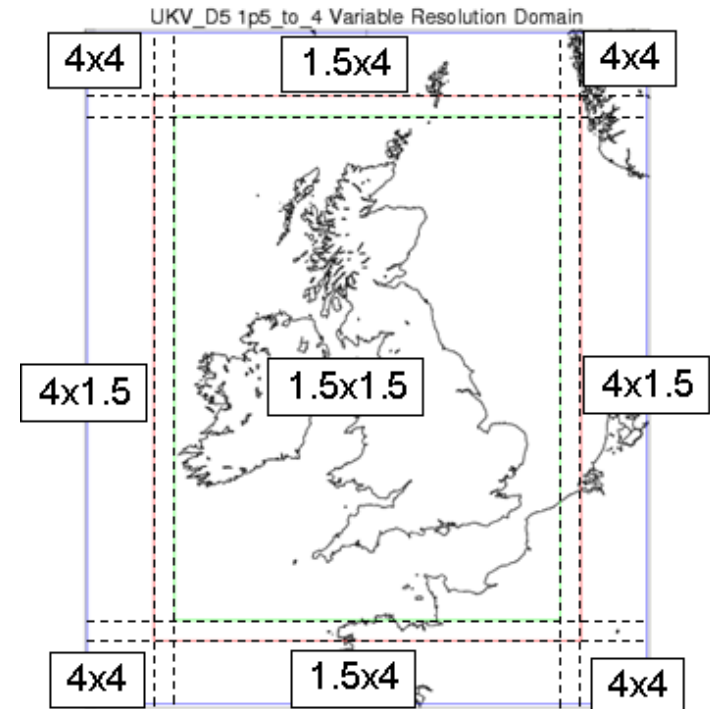
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# Introduction

- UKV model
- Use of SEVIRI IR observations
- CTP determination in OPS

# UKV NWP model

- UKV – Met Office regional model
- 1.5km grid spacing over the UK
- Stretched grid cells at the boundaries
- Lateral boundaries constrained by global model
- UKV system uses 3-hourly FGAT 3D-Var data assimilation of surface, sonde, aircraft, Doppler radar, satellite radiance and satellite cloud observations; and latent heat nudging of radar-derived rain rates.



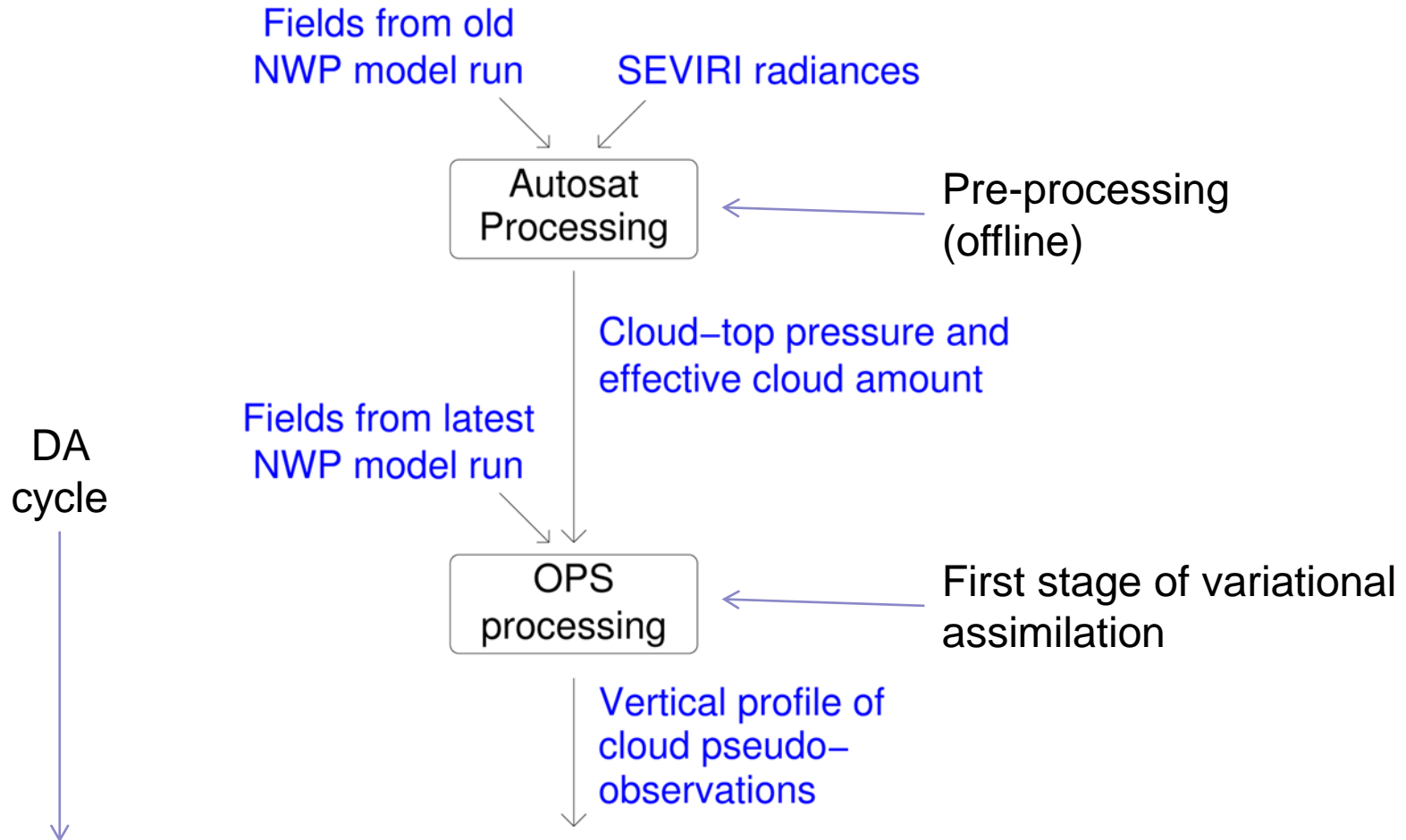
# Infra-red radiances from Geostationary satellites (1)

- GeoIR radiances used at Met Office when the cloud contamination is insignificant (clear-sky assimilation)
  - Global Model: radiances currently only used from clear-sky locations
  - UKV: SEVIRI channel 5 water vapour radiances are also used above low cloud (QC based on derived cloud top)
- Previously, cloud parameters (such as CTP) were calculated “offline”
- Now calculated within OPS as part of the DA cycle (more portable, easier to test changes)
- In the UKV these cloud parameters are used to select SEVIRI WV observations over low cloud

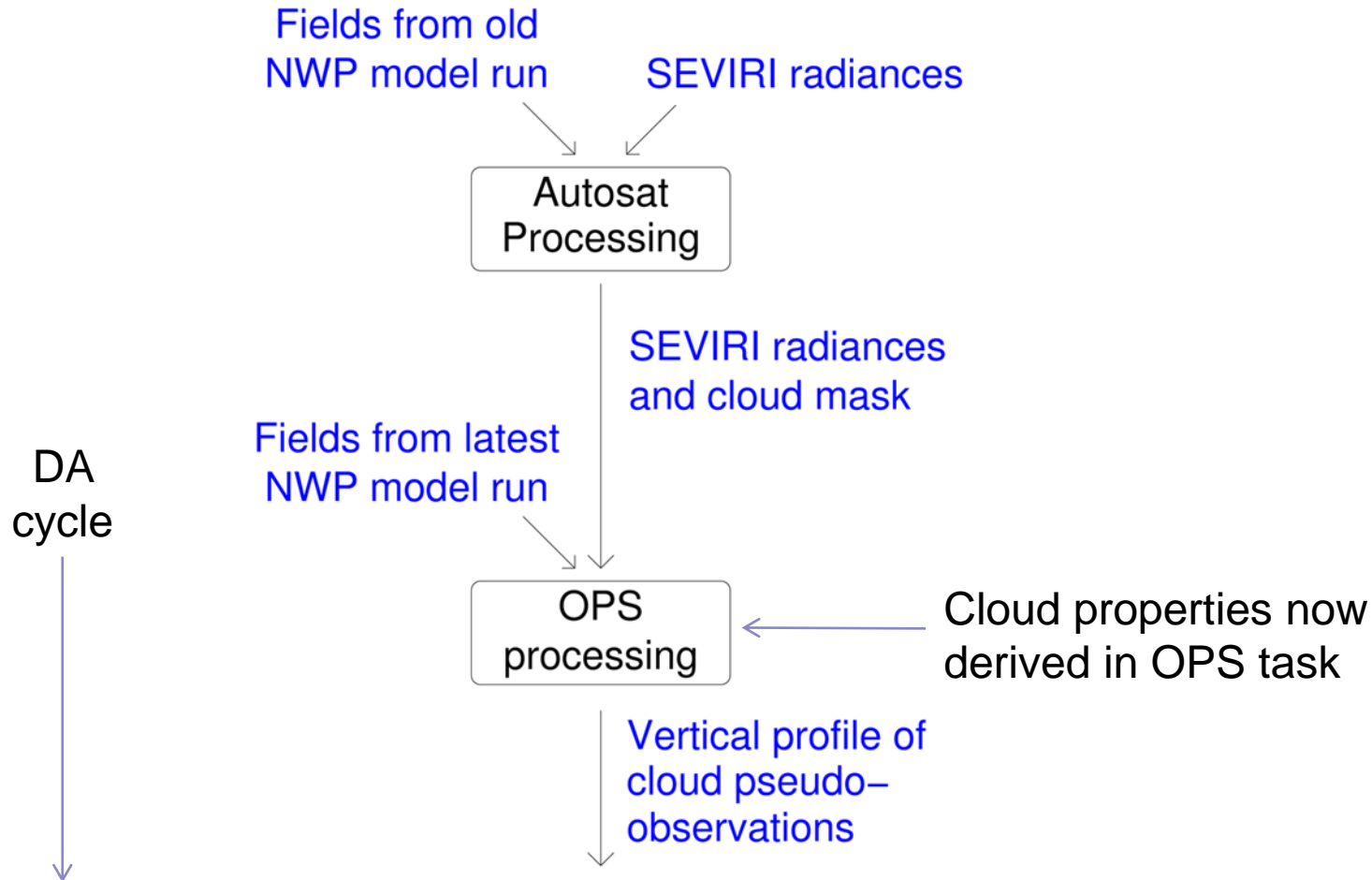
# Infra-red radiances from Geostationary satellites (2)

- CTP information from SEVIRI is also converted into GeoCloud pseudo-observations of cloud (at the cloud top) and pseudo-observations of clear air (above the cloud)
- These are assimilated in Var as moisture increments in the model at and above the cloud top (GeoCloud assimilation)
- GeoCloud pseudo-observations can also be generated in OPS from AHI radiances

# Previous CTP derivation



# New CTP derivation





# OPS CTP derivation

If observation is cloudy, then:

- 1D-Var used to calculate CTP using approximation of single grey cloud layer with RTTOV v9 (1D-Var first guess CTP derived using minimum residual technique)
- If large uncertainty in CTP or cloud top is at low altitude then cloud top is set to the most stable layer in the model background (assuming suitably stable layer exists) – brightness temperature constraint is also used



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## Trial results – for 3 sets of trials

- Use of CTP from OPS for UKV GeoCloud assimilation
- Using these CTPs to select water vapour radiances over low cloud in the UKV
- WV radiances over cloud in the Global Model



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Trial 1

UKV

GeoCloud

# GeoCloud using OPS CTPs

Changes to GeoCloud pseudo-observations of cloud

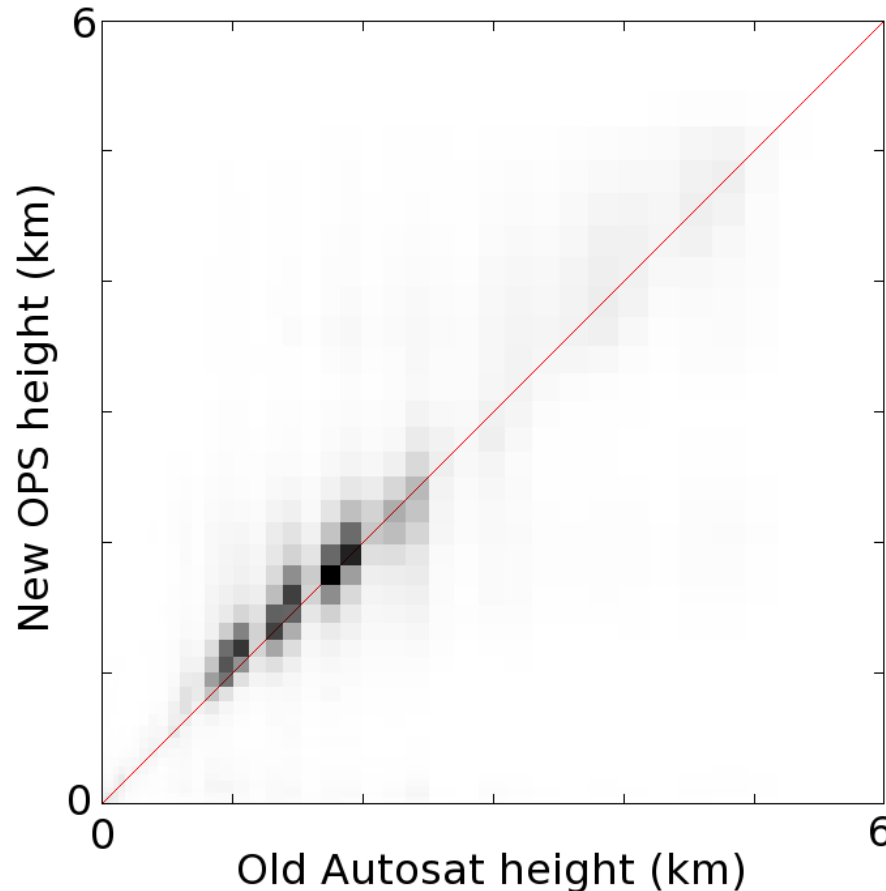
For 1-month trial in summer 2013 new OPS CTPs gave:

- Small (0.5%) improvement in Met Office “UK Index” over the old CTPs for surface weather
- Significant ( $>1\%$ ) improvement over a trial with no CTP assimilation)

OPS CTPs also gave some improvements in upper-air temperature and humidity (not in UK Index)

# PS37/OS36 UKV comparison

Comparison of NWP level of derived cloud top over UK between 11 Feb 2016 and 4 Mar 2016. NWP level plotted as function of height above sea level points. Correlation coefficient for cloud-top heights is 0.73.





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Trial 1

UKV

GeoCloud

## PS37 GeoCloud

- PS37 went operational at the Met Office (as OS37) on 15 March 2016, including these UKV GeoCloud changes



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## Trial 2

UKV WV  
radiance  
over low  
cloud

# UKV WV over low cloud results

I have also trialled OPS-derived CTP values for selecting SEVIRI water vapour observations over low cloud:

- 26-day trial in Summer 2014;
- 29-day trial in Winter 2015

Neutral impact (+0.2% in 2014, -0.2% in 2015) compared to a control using Autosat-derived CTP values for selecting observations over cloud

Changes are expected to go into PS38, removing the dependence of the UKV on offline CTP determination (and expected to go operational in autumn 2016)



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## Trial 2

UKV WV  
radiance  
over low  
cloud

# Future UKV trialling

Perhaps the greatest benefits of these changes are that:

- Future changes to GeoCloud CTP and WV over low cloud can be included in NWP trials, and resulting NWP performance can be verified independently (this was not straightforward before)
- GeoCloud and WV over low cloud can now be used with satellite data which does not include CTPs from a pre-processor
- GeoCloud CTPs are no-longer dependent on the height of inversions in the NWP model used to drive the pre-processor



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## Trial 2

UKV WV  
radiance  
over low  
cloud

# Future UKV trialling

- Very little tuning has been done yet of OPS-CTP performance – we plan to reduce CTP bias and improve quality control
- Improvements to the partitioning of  $q$  increments may also help GeoCloud performance (Stefano Migliorini)





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## Trial 3

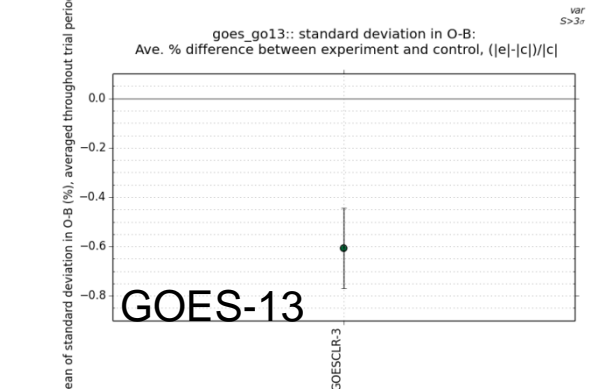
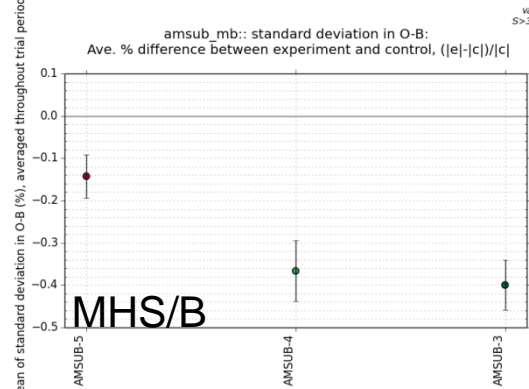
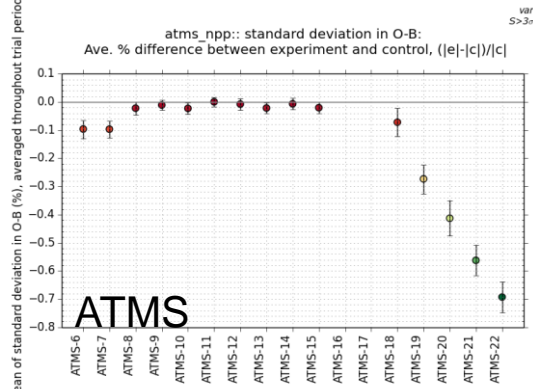
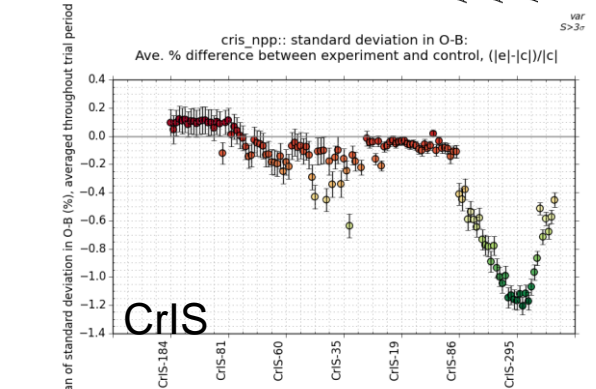
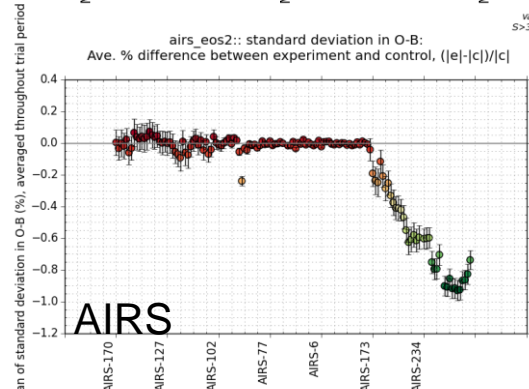
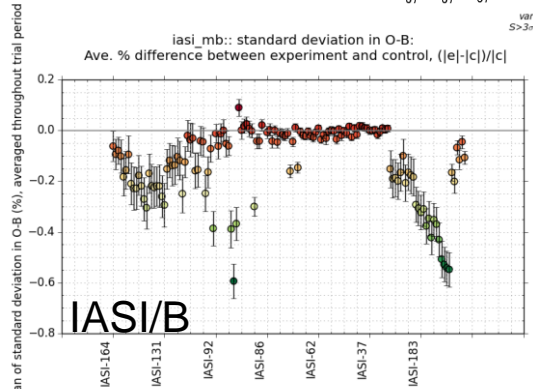
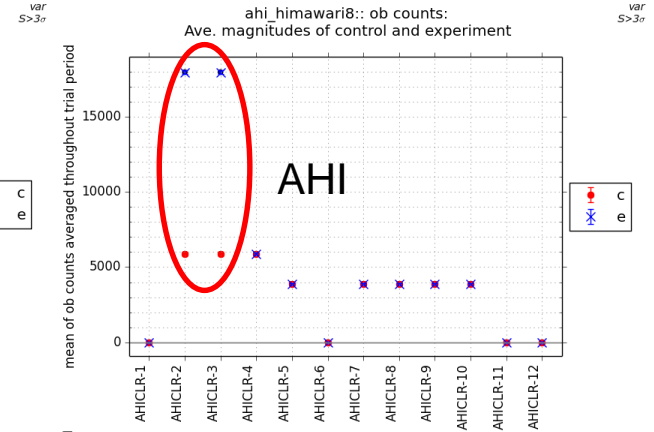
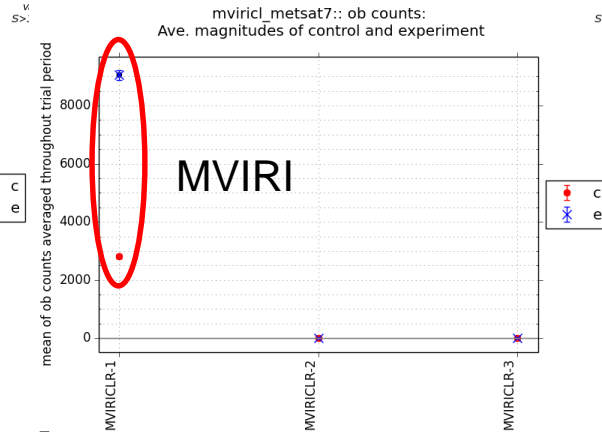
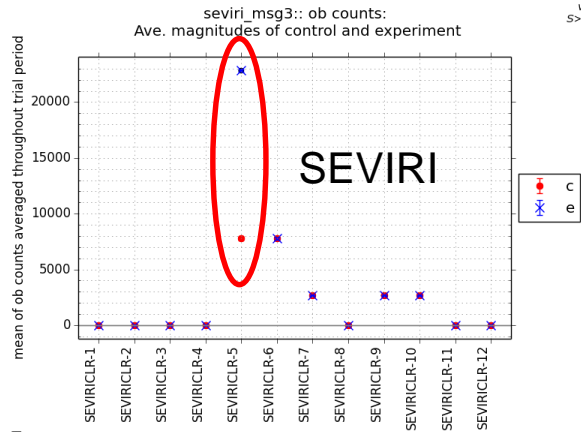
Global  
Model WV  
radiance  
over low  
cloud

# Global model WV over low cloud

- Trials by Pete Francis and Ruth Taylor of water vapour channels over low cloud (using CSR product flags to select WV observations not contaminated by cloud)
- Significantly improved fits to water vapour channels on independent instruments (but statistically neutral in terms of standard Met Office verification scores)
- For the 2-month winter 2015/2016 trial, Himawari AHI instrument also included

# WV over low-cloud - Winter

From Pete Francis





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## Trial 3

Global  
Model WV  
radiance  
over low  
cloud

# Future of Global WV over cloud

- These changes have been included in the PS38 global model trial, and are expected to go operational in autumn 2016



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# Conclusions and future work

# Conclusions

- CTPs produced in the OPS part of the DA system found to be sufficiently good quality to replace CTPs calculated offline on Autosat for the UKV
- It is now possible to produce OPS CTPs for other LAMs and for global models, including using other satellites
- Assimilation of water vapour channel observations over low cloud in the Global Model was found to improve model fits to other observation types

# Future work

- We hope to improve the quality of UKV OPS CTPs using updated 1D-Var B-matrices and improved OPS quality control
- Cloud approximation could be improved if we switch to RTTOV v11
- In order to generate GeoCloud data in other regional or global models, 1D-Var B-matrices will be required for those models



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Any Questions?

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**New OPS CTP  
calculation**  
Only used for  
cloudy observations  
(still relies upon  
Autosat cloud  
mask)