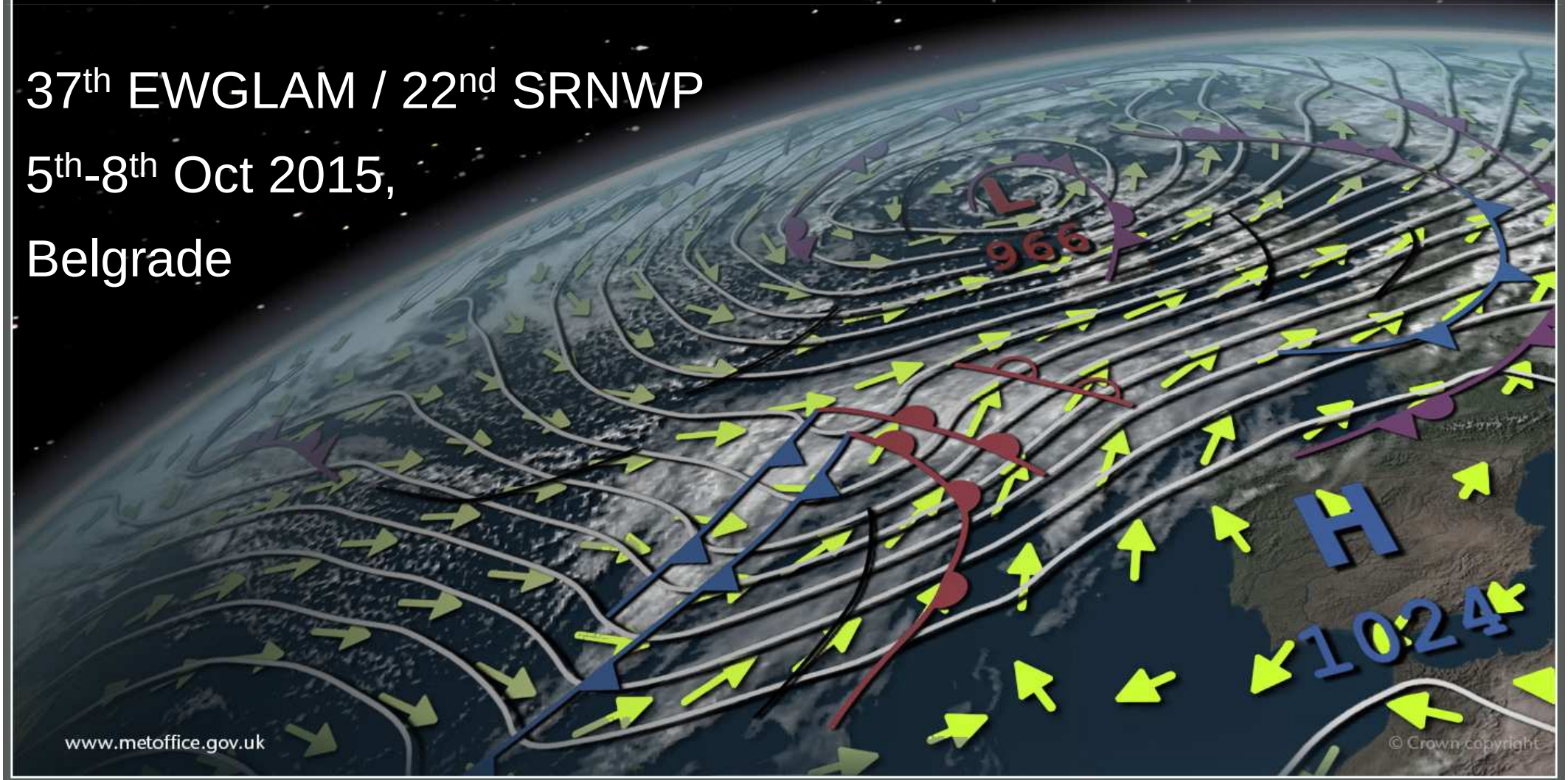
Developments in convective scale assimilation at the UK Met Office

Bruce Macpherson

37th EWGLAM / 22nd SRNWP

5th-8th Oct 2015,

Belgrade



Contents

This presentation covers the following areas

- Description of UK 1.5km DA system
- Recent & next upgrades
- Current projects (hourly 4DVAR)

UK 1.5km DA

- 8 three-hour assimilation cycles per day
- Forecasts to t+36 every 3 hours
  - Observation cut-off hh+ 75min
  - Lateral boundaries from hh-3hr run of 17km Global model at DT 03, 09, 15, 21 UTC
  - Lateral boundaries from hh-6hr run of 17km Global model at DT 00, 06, 12, 18 UTC
- 3DVAR (with FGAT) + IAU for all observations, *except* Latent Heat Nudging for radar-derived surface rain rate

UK 1.5km – extra observations *not* assimilated in global model

- radar-derived surface rain rate (hourly, 5km resolution)
- visibility from SYNOPs (hourly)
- T_{2m} & RH_{2m} from roadside sensors (hourly)
- Doppler radial winds (3-hourly)
- SEVIRI Channel 5 radiances above low cloud
- high-resolution AMVs from MSG
- GeoCloud cloud fraction profiles (3-hourly, 5km resolution)
  - zero cloud down to cloud top, missing data below
- cloud fraction profiles from SYNOPs (3-hourly)
  - zero cloud up to cloud base, missing data above

Recent Upgrades

February ‘15 Upgrade (PS35)

- Introduce IASI
- Migrate to Metop A/B coastal scatterometer products
- For insertion of GeoCloud data, use model climatology of cloud thickness to decide cloud ‘thickness’

Peter Francis

Next Upgrade

Upgrade candidates

❑ Covariances

- ➢ ‘Swapped Transform Order’ with improved representation of spectrum in training data (shorter wind length scales)

❑ Cloud

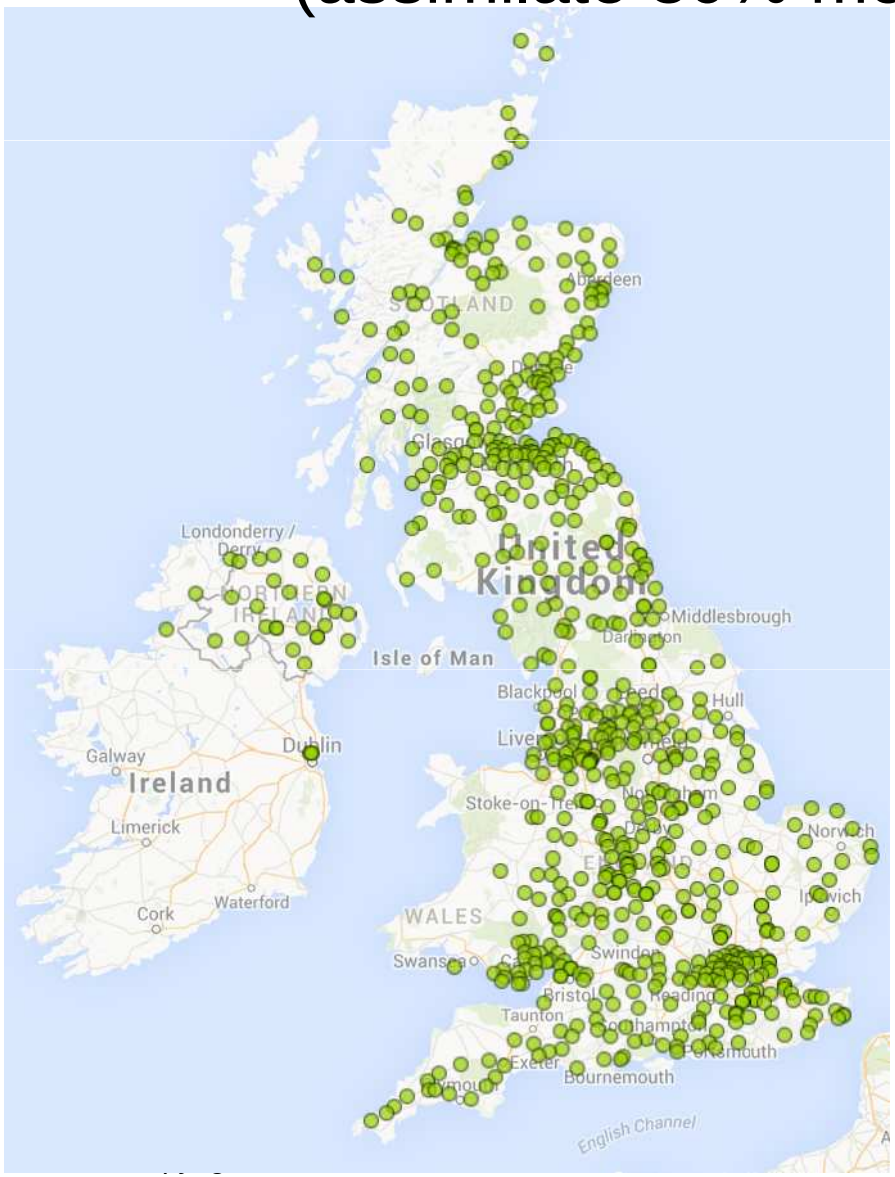
- ➢ Creation of ‘GeoCloud’ cloud fraction data within OPS (instead of within offline AUTOSAT)
- ➢ Enable insertion of thicker cloud obs from SYNOP (instead of single layer - cf GeoCloud at PS35)
- ➢ Revise model cloud thickness climatology from PS35 data

❑ Satellite radiances

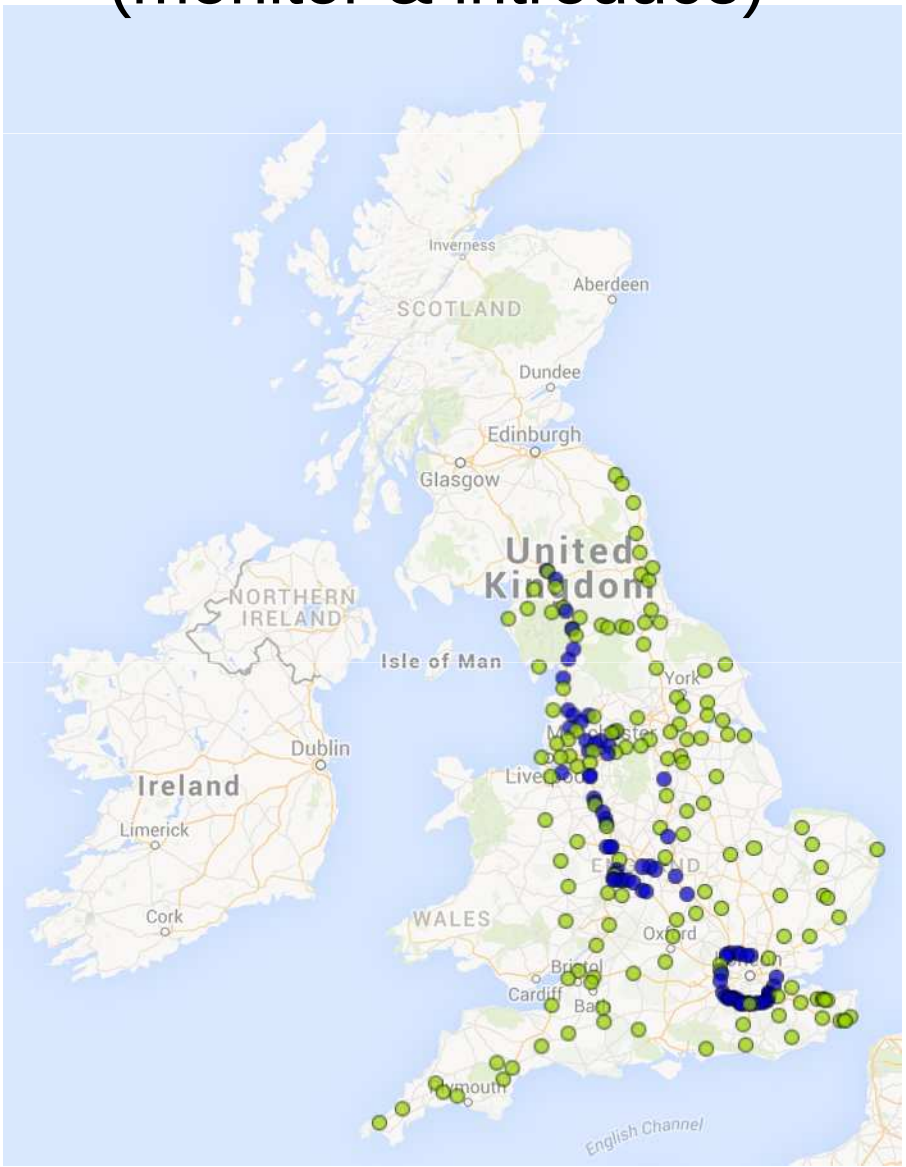
- ➢ add CrIS and AIRS (to supplement IASI)
- ➢ add ATMS humidity channels

+ Roadside sensor network

T / rh
(assimilate 30% more)



Visibility
(monitor & introduce)



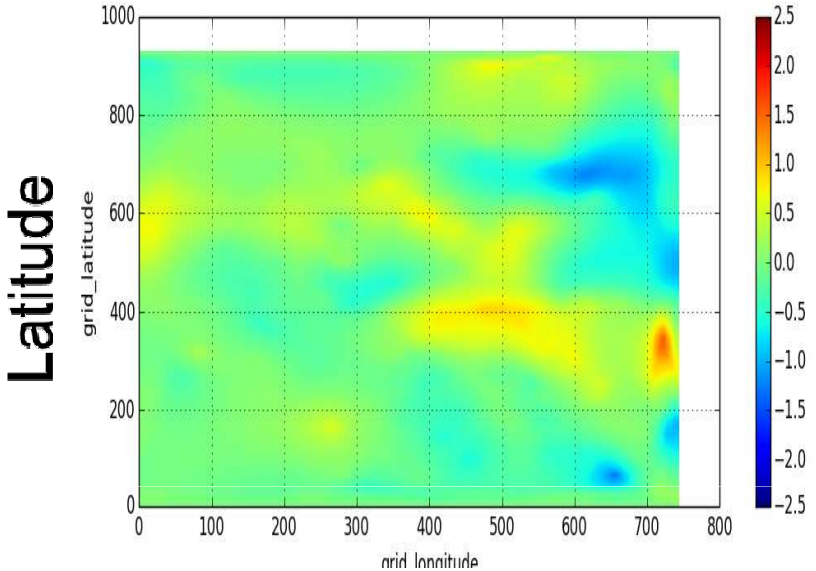
New ‘Swapped Transform Order’ Covariances

- Currently apply vertical transform before horizontal transform when calibrating UKV covariances
- Horizontal transform models correlations by a SOAR function with a single characteristic lengthscale for each vertical mode (*currently 150-200km for Ψ and X*)
- Reversing transform order allows horizontal correlations to vary with height and vertical correlations to vary with horizontal scale
- Full vertical correlation matrices available for each total wavenumber
- Wind increments now exhibit smaller-scale structure

Marek Wlasak & Gordon Inverarity

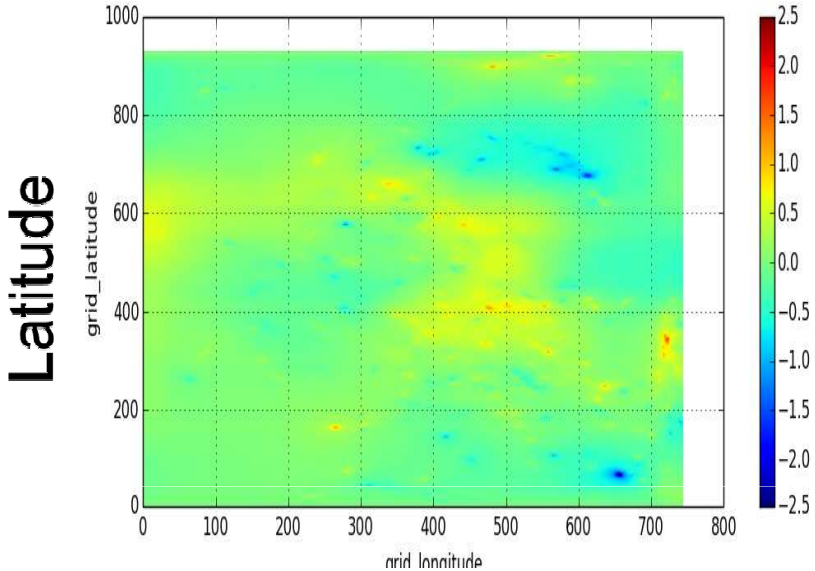
v analysis increment

Current



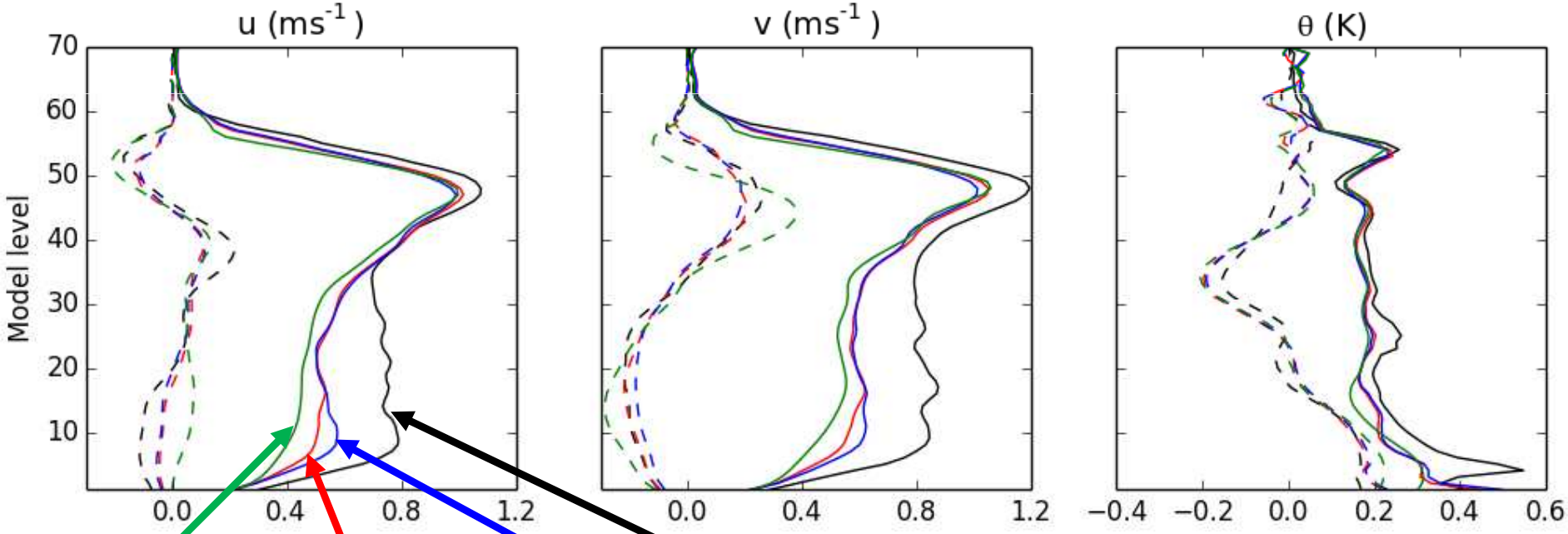
Longitude

Swapped Transform Order



Longitude

Analysis increments



STO cov + noAG

STO cov + AG

OP cov + AG

STO cov + retuned AG

GeoCloud

- Derive GeoCloud data within UK OPS step, using *latest* high resolution UK model profiles
  - replace creation in external AUTOSAT system, using (*older*) global model profiles
  - Prepare for GeoCloud assimilation anywhere

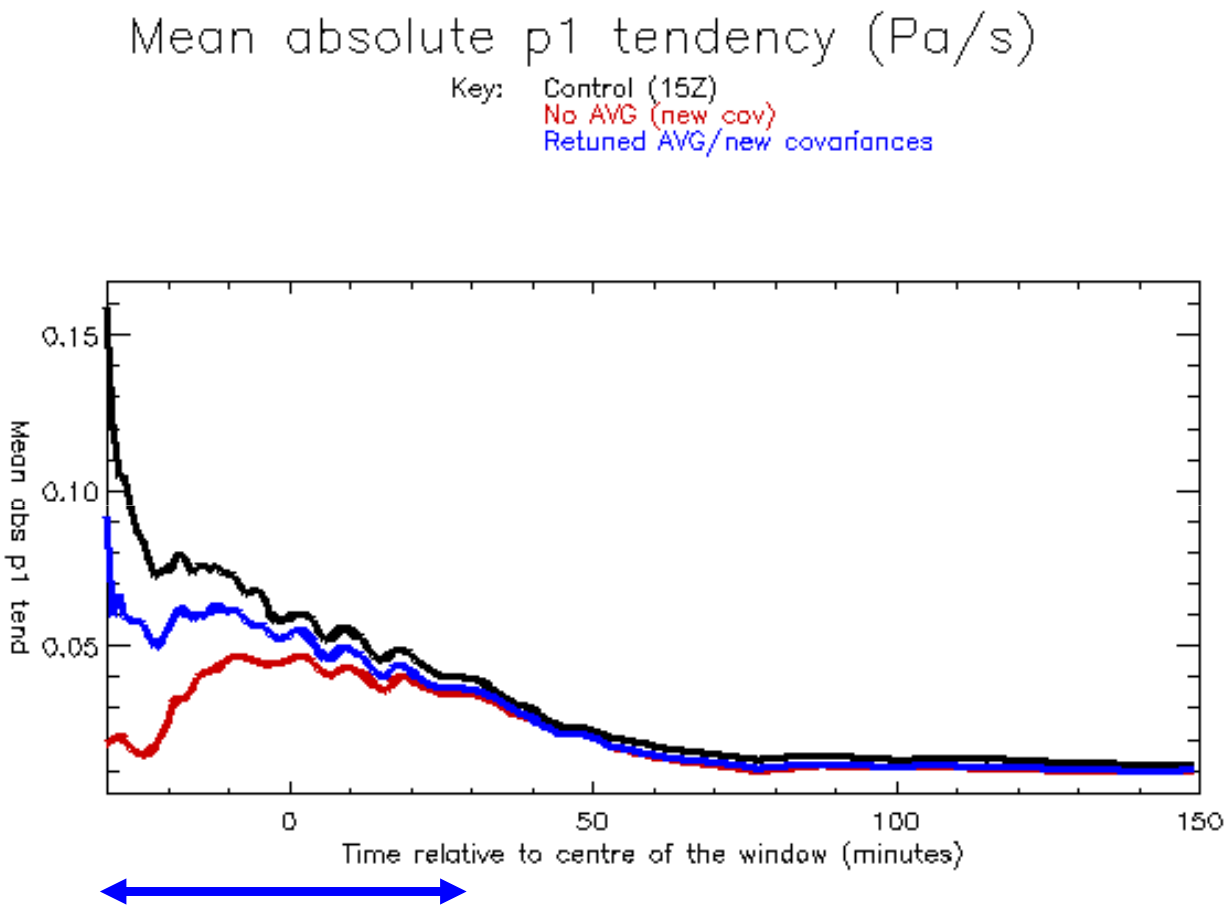
Bob Tubbs

Current Projects

Hourly UK-wide 4DVAR

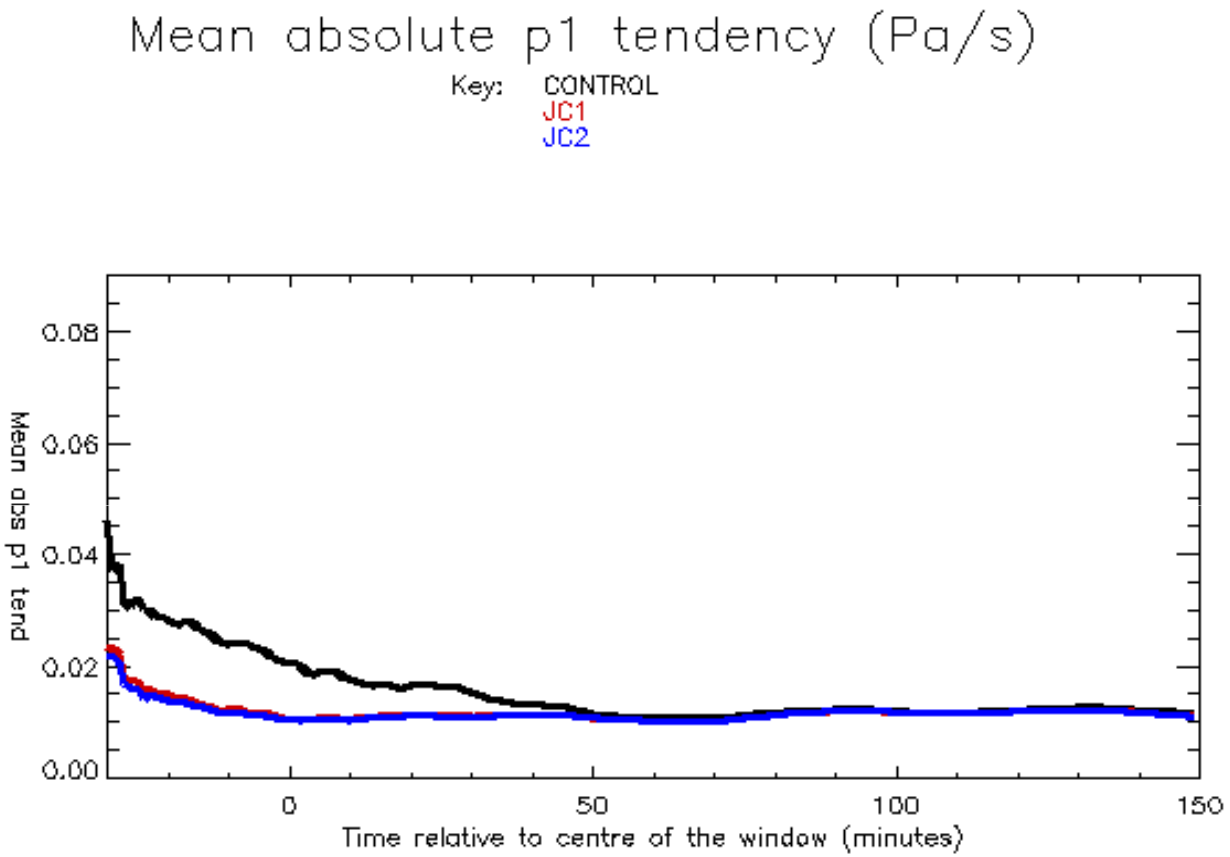
- Build on Nowcasting Demonstration Project run for 2012 Olympics
- Improve post-processing products in 0-6hr period
- Hourly updates to t+12 – potential benefit in severe weather

Gravity wave activity in 4DVAR – impact of covariances, adaptive grid and new lateral boundary data



DA window

Gravity wave activity in 4DVAR – impact of digital filter (Jc penalty term)



DA window

Plans

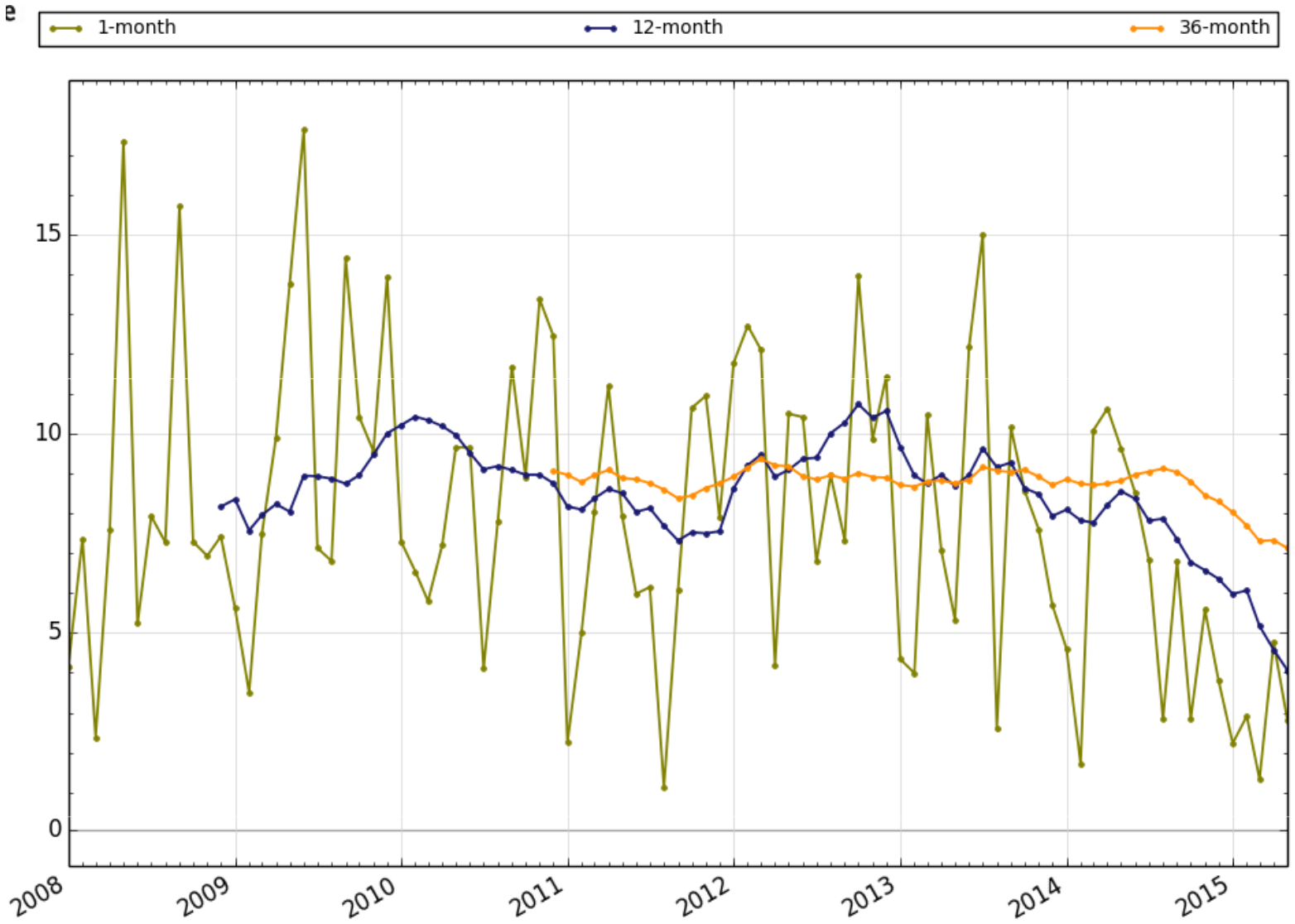
- Compare latest hourly 4DVAR system with 3-hourly 3DVAR
  - Measure separate signals from hourly cycling & 4DVAR
- Assess initialisation by ‘Jc term’
- Optimise frequency of observation input
- Measure impact of short observation cut-off and assess need for update runs
- Report on longer trials (Spring ‘16)
- Move to larger UKV domain (review cost of 4DVAR)
- Prepare for full pre-operational trials
- **Implement: by Spring 2017**

Later developments

- Reflectivity assimilation (initial trials Spring ‘16)
- Outer loop
- Improve computational efficiency of 4DVAR

Sensitivity to age of global lateral boundary data

- Boundary data are important even for short-period UKV forecasts
- CONTROL – standard set up, where 00, 06, 12, 18 UTC UKV runs use t-6 global lbcs
- TEST – t+0 global lbcs replace t-6 lbcs
- IMPACT – UK NWP Index 1-1.5% better with 'fresh' lbcs (1 month trial) cf UKV model ~5% better than global model
- Conclude -
  - more frequent global runs may improve 0-12hr UK forecast



%

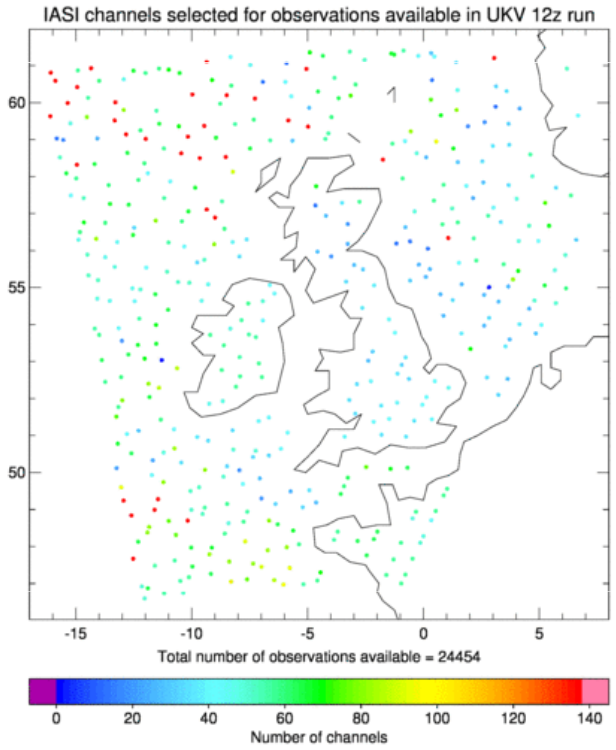
(‘Added Value’ of UKV relative to Global model)

Questions?

Additional slides

Introducing IASI

- Configuration:
  - All 4 IASI FOVs
  - 60km thinning
  - 132 of 138 channels used in global (reject high peaking water vapour channels due to residual bias)
  - AAPP coast threshold reduced to 50km
  - All other aspects of configuration same as global model
  - *Small benefit to T_{2m} and rainfall*



IASI observations for single12Z cycle

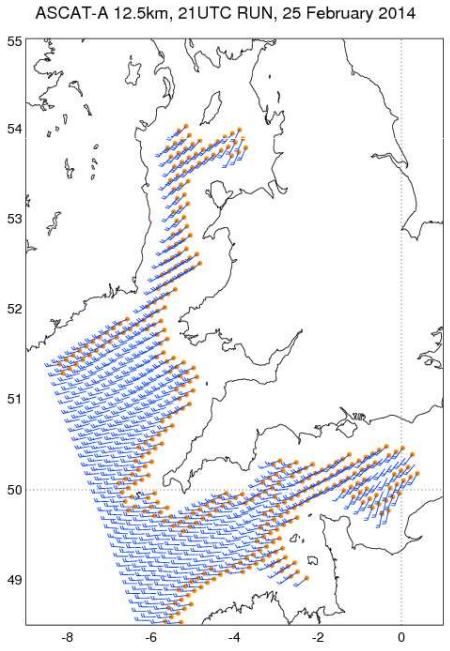
(total no = 24454)

Peter Weston

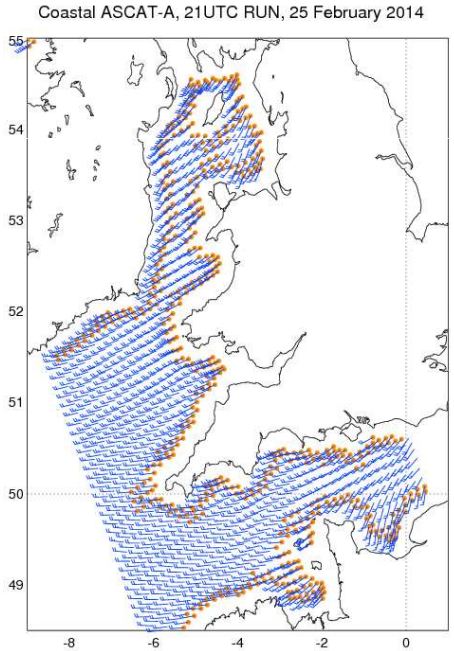
Scatterometers

- Currently using 12.5 km ASCAT-A only (no equivalent Metop-B product)
- Migrate to coastal wind products from Metop-A and Metop-B
- Addition of Metop-B improves coverage

12.5-km Hamming window



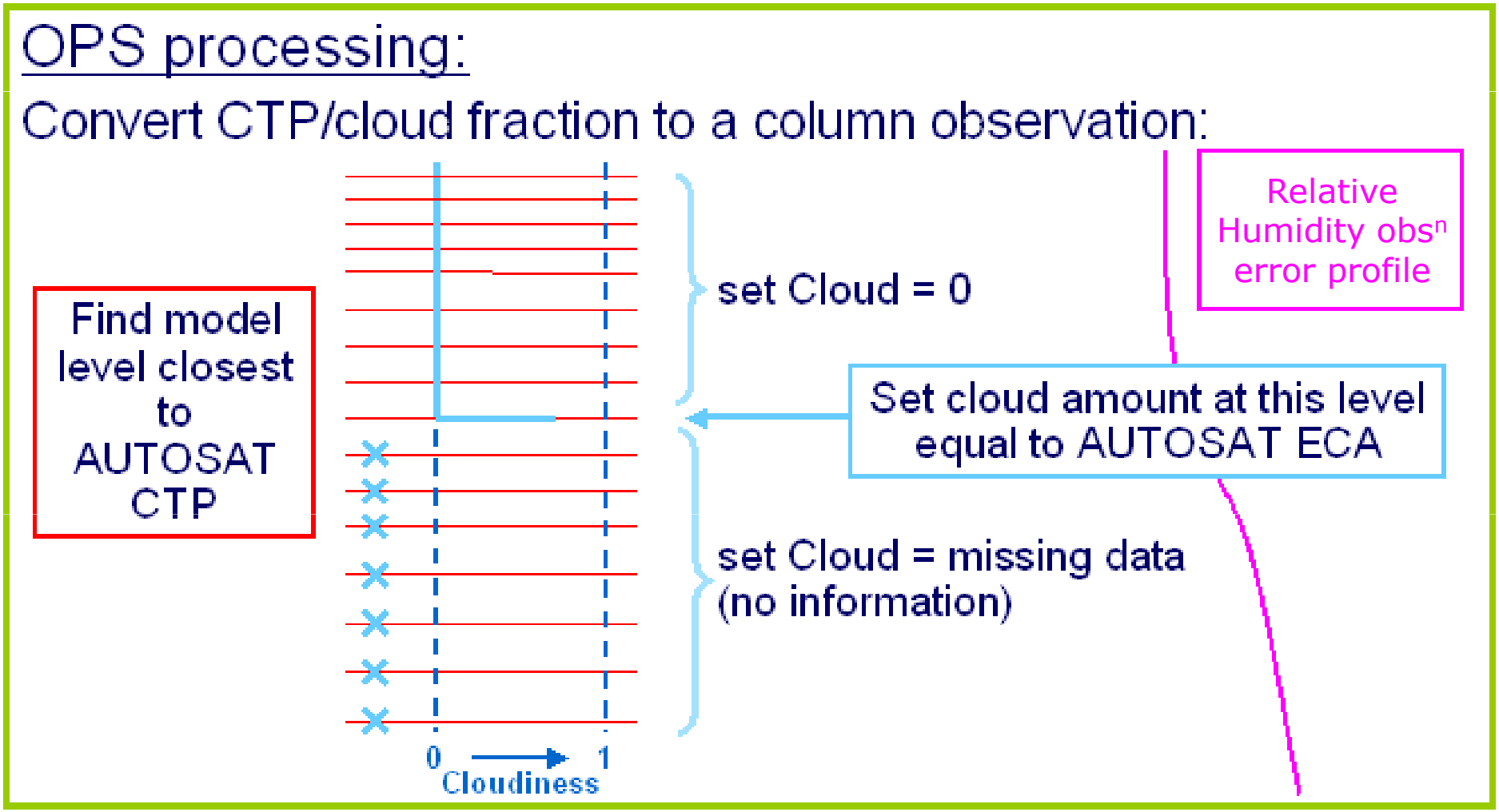
Coastal



● Land flag set

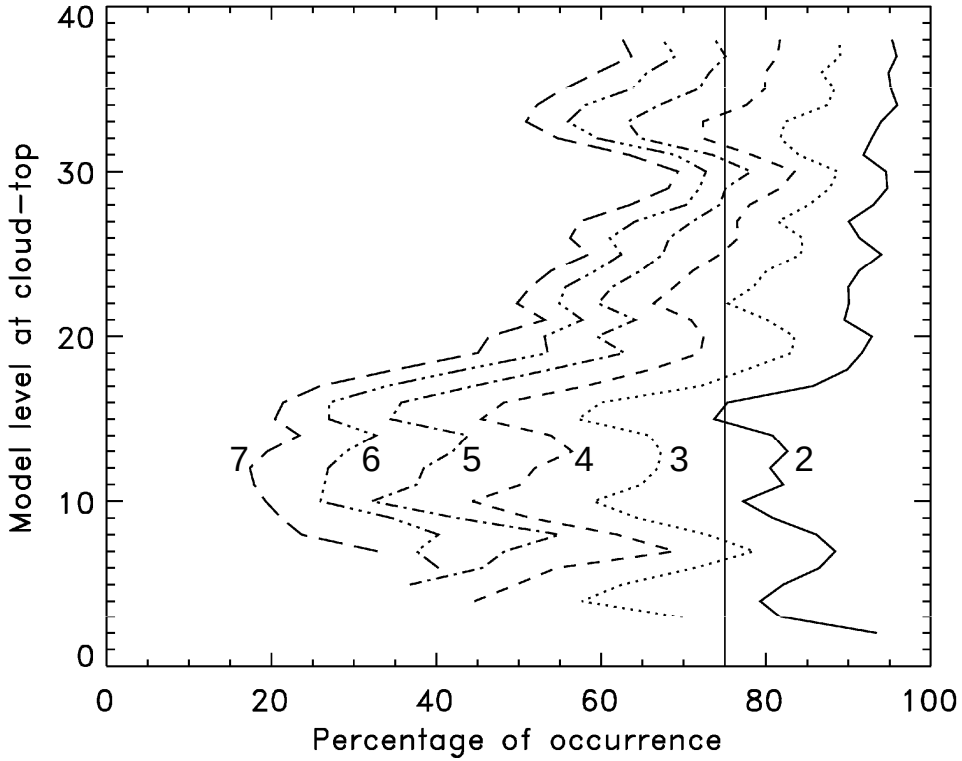
James Cotton

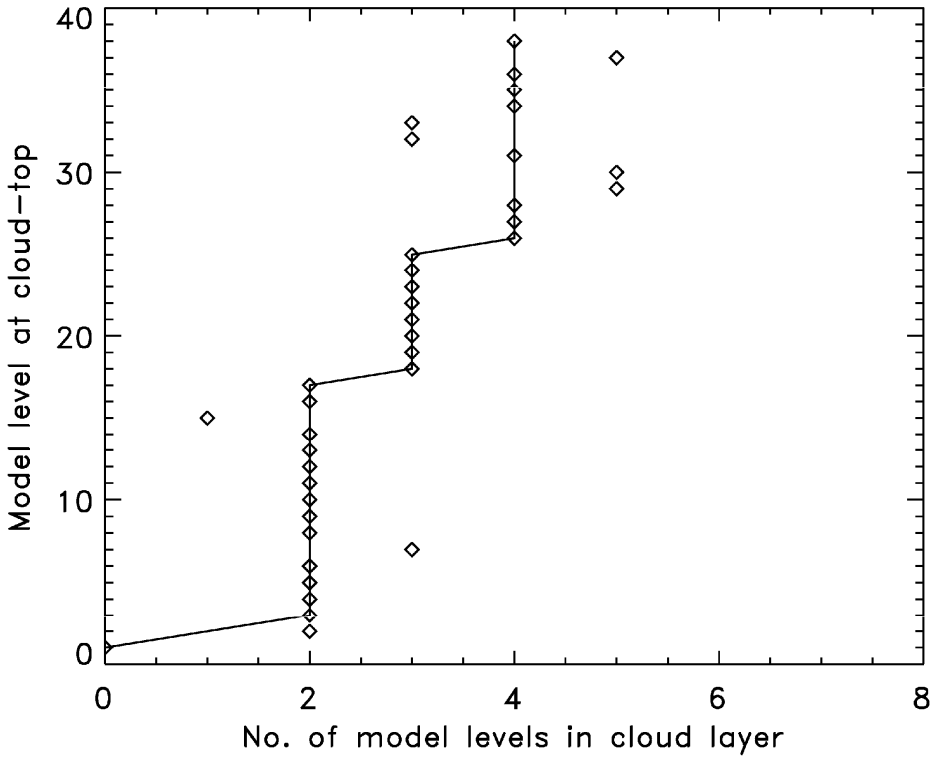
GeoCloud assimilation



Peter Francis

UKV cloud layer thickness climatology





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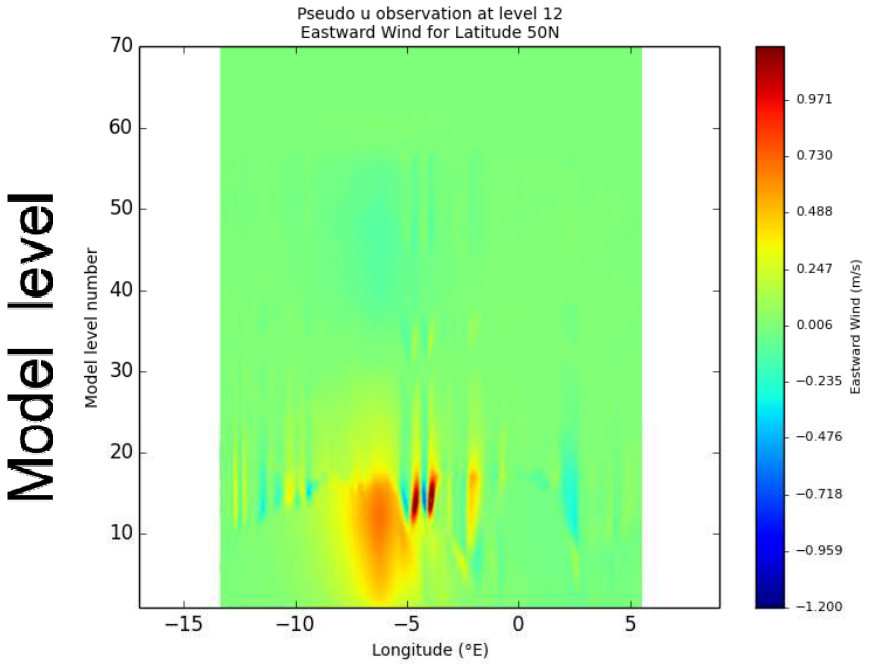
u response to u level 12 pseudo-observation (with AG)

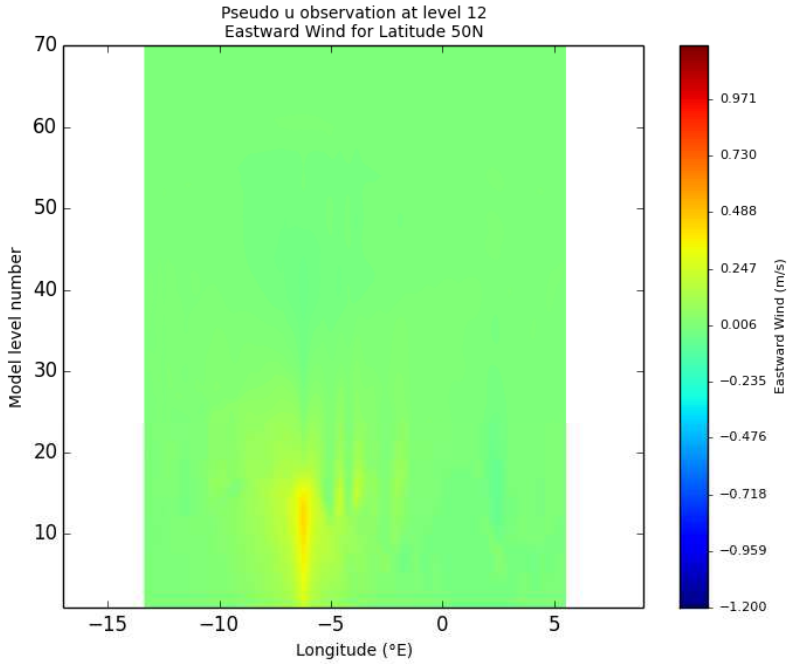
Current



Model level

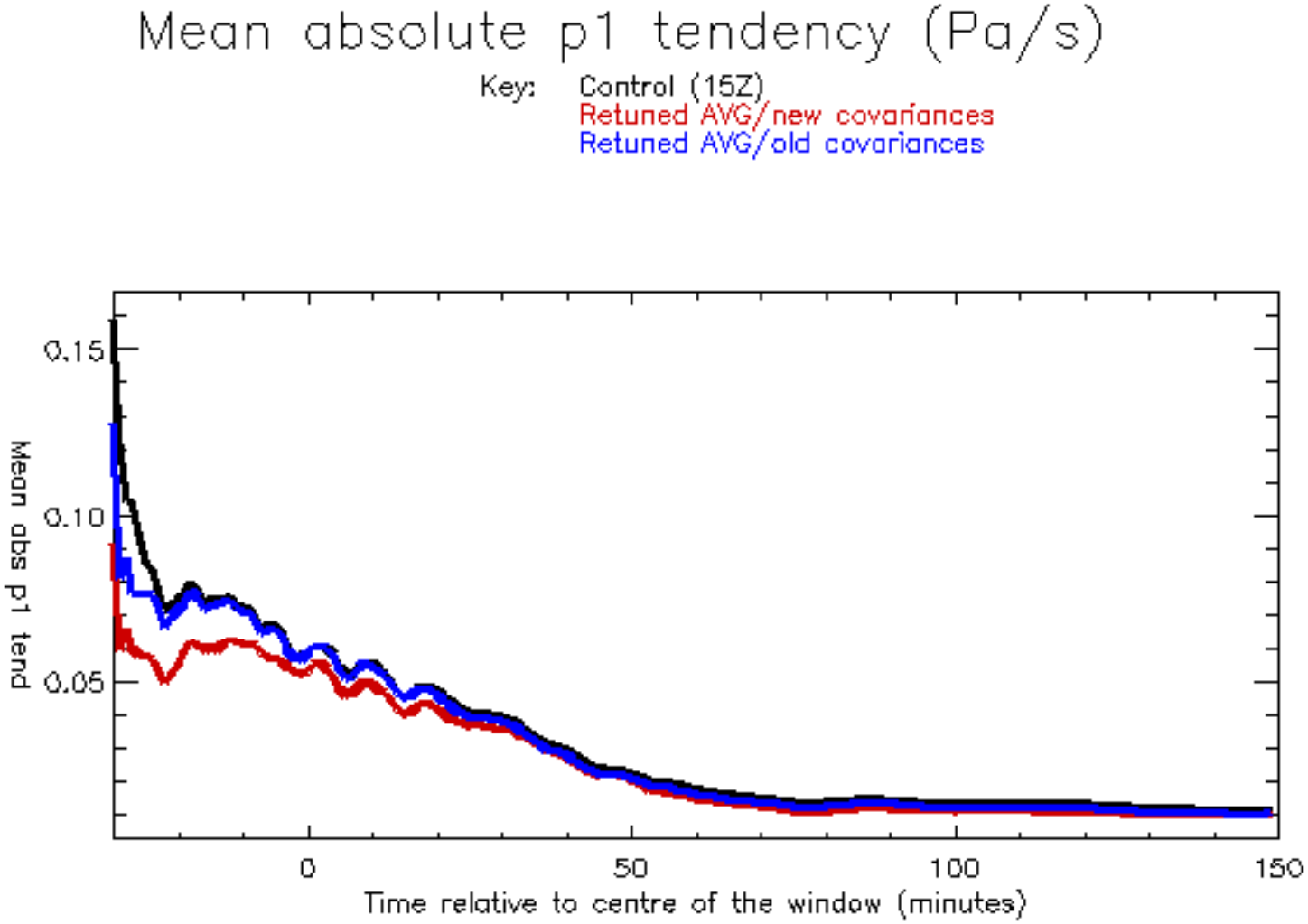
Longitude

Swapped Transform Order

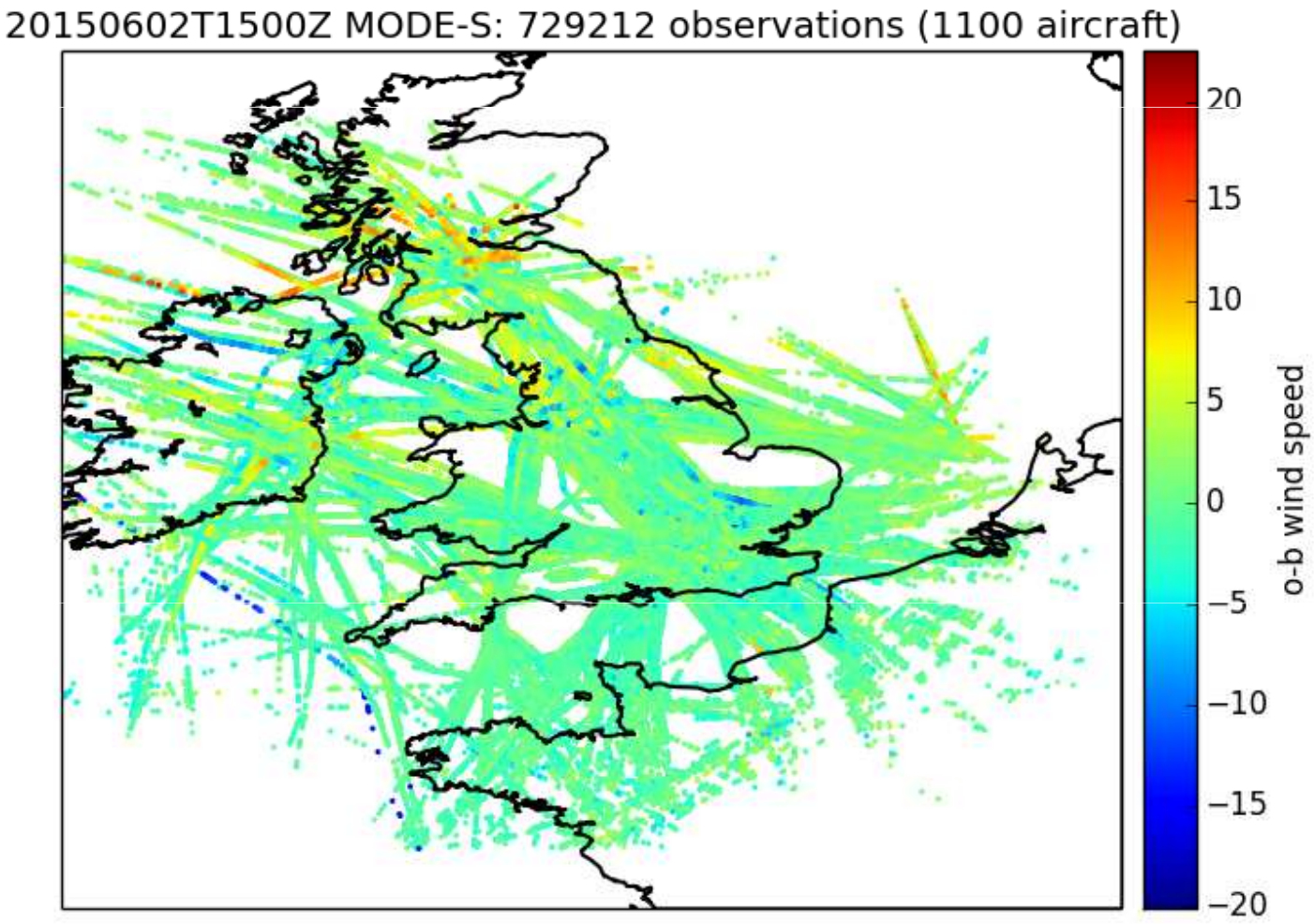


Longitude

Gravity wave activity



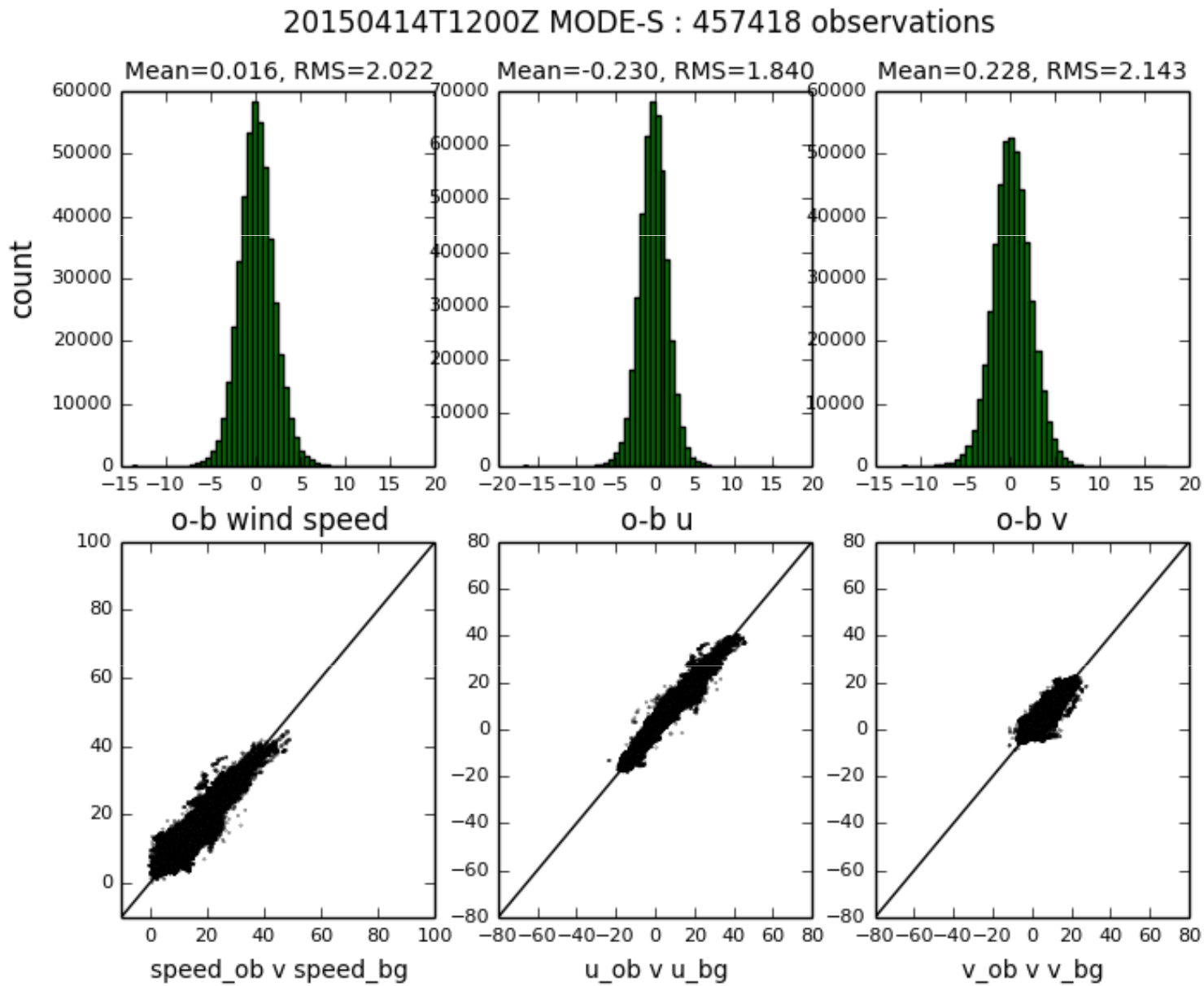
MODE-S monitoring



5 receivers

Adam Maycock

MODE-S monitoring - wind



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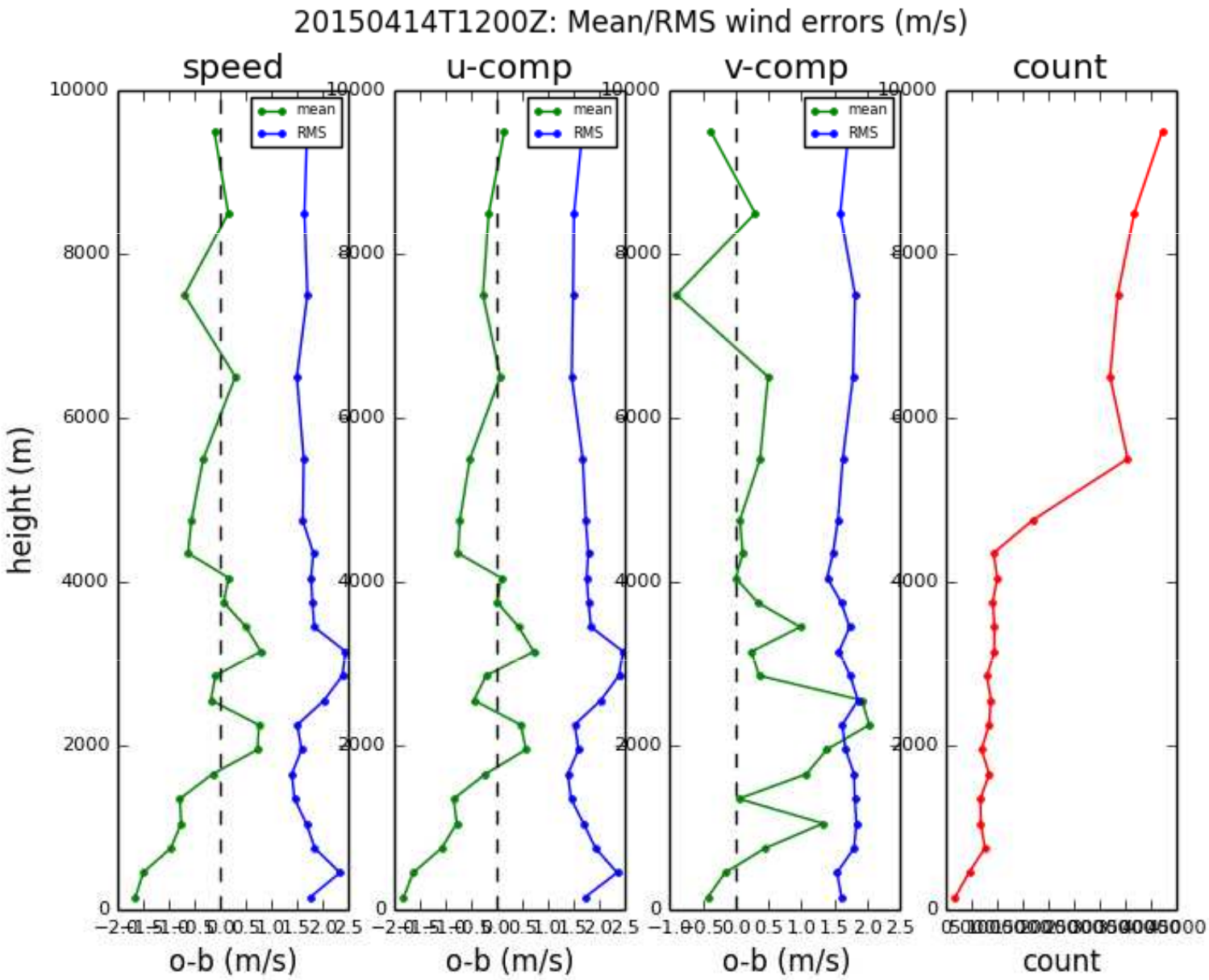
MODE-S monitoring - wind



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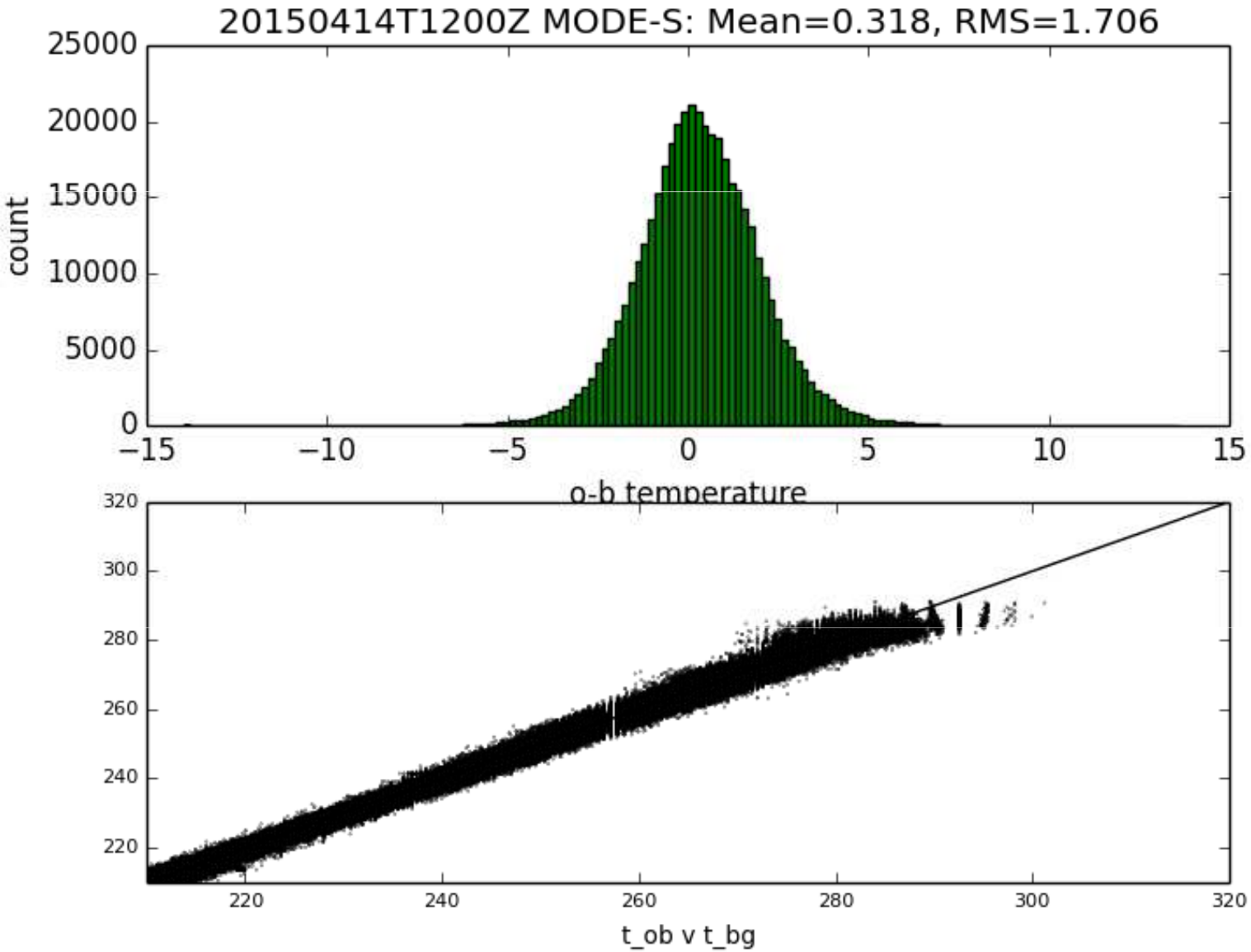
MODE-S monitoring - temperature



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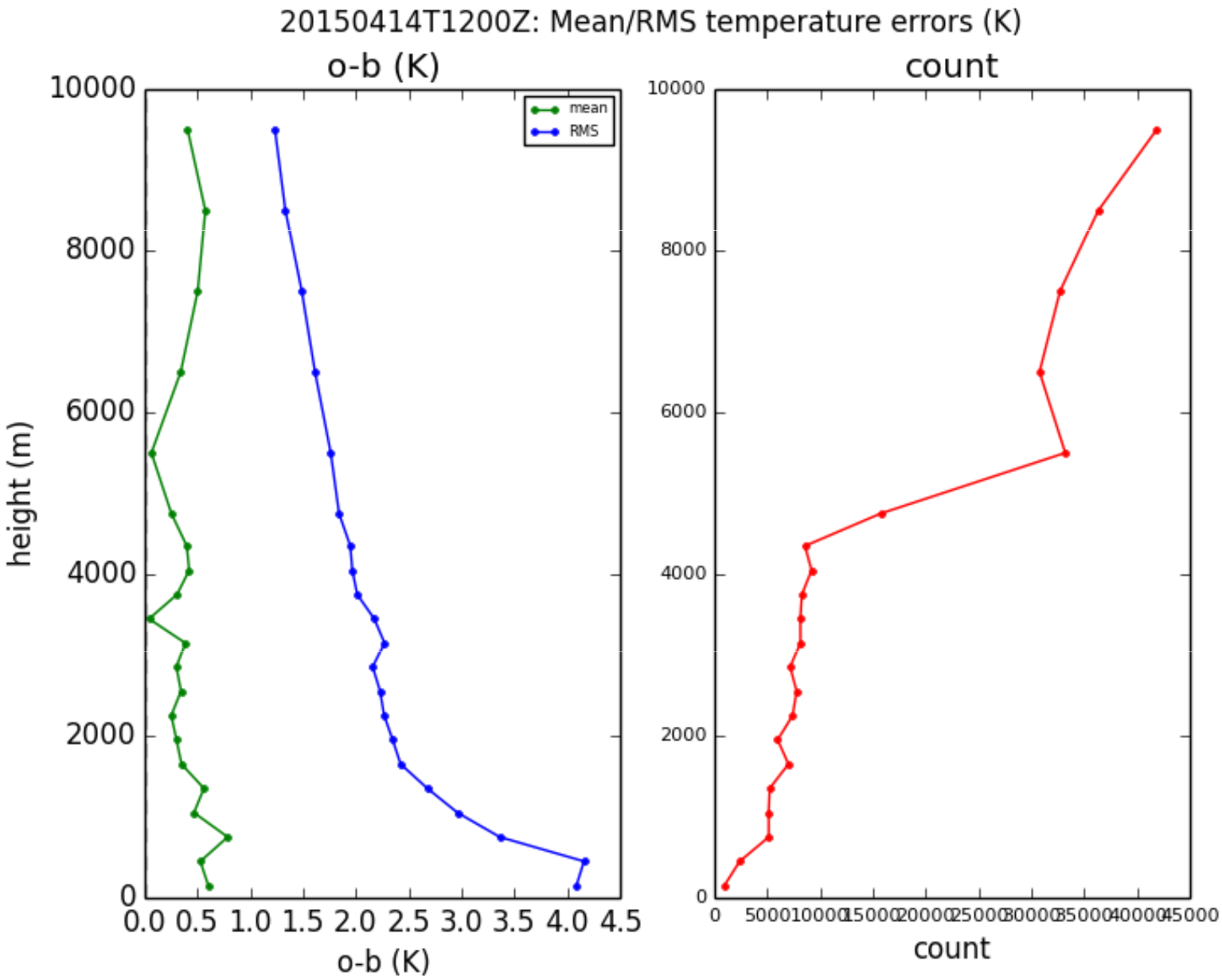
MODE-S monitoring - temperature



Adam Maycock

FSO at convective-scale

- Challenge of model non-linearities
- Linear Perturbation Forecast model and adjoint valid only for short forecast periods (~50% of 3-hr forecasts)
  - Work to reduce PF model instabilities
- Verifying analyses used within forecast error norm are assumed to be independent of the forecasts – not good assumption at t+3
- Error norm averaged through depth of troposphere not appropriate for model assessed for surface weather
- Test use of observation-based error norm at t+3
- Plan complementary use of OSEs to assess value at longer forecast times

Helen Buttery