



Covariance modelling developments for convective-scale data assimilation at the Met Office

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- Acknowledge: Kerry Day, Gareth Dow, Chiara Piccolo, Marek Wlasak

Current transform order

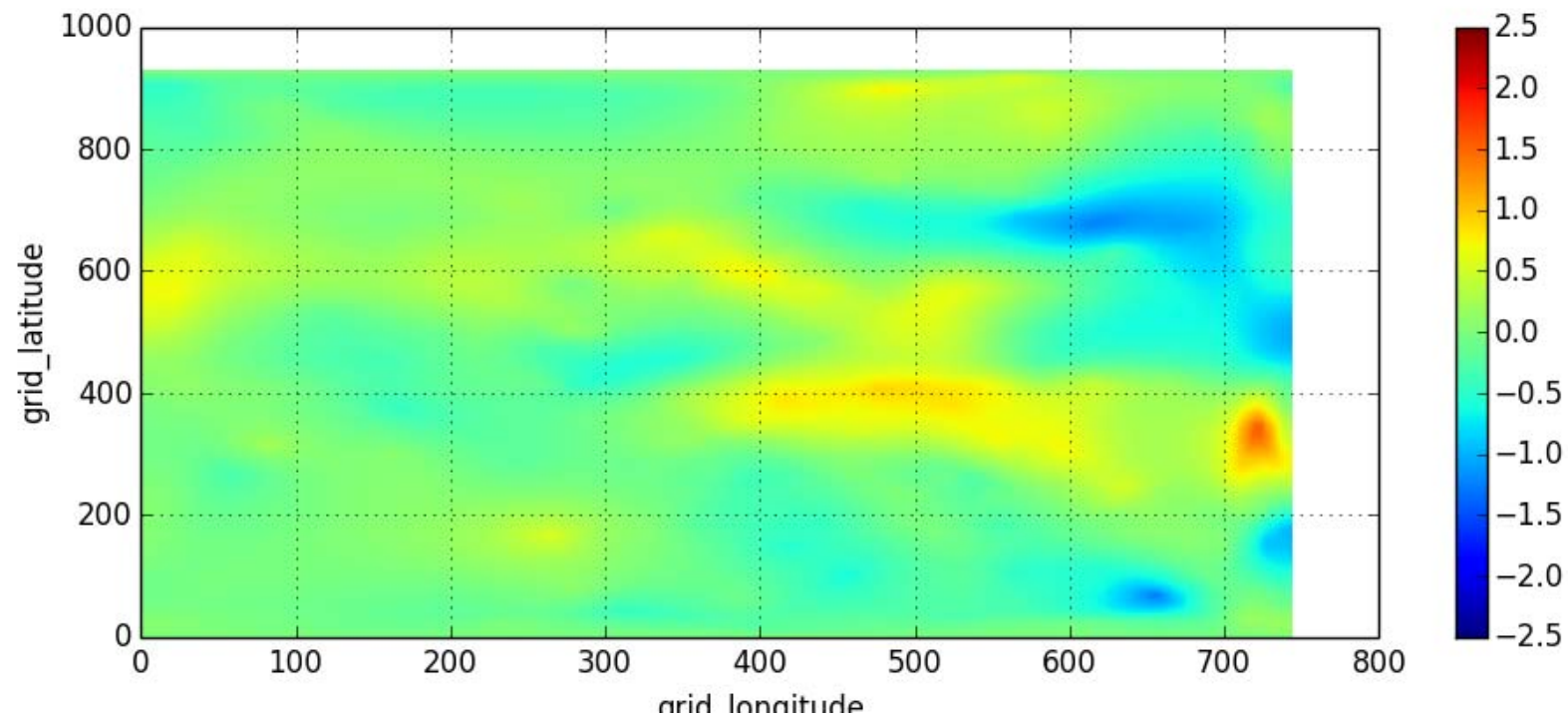
$$\mathbf{v} = \mathbf{T}_h \mathbf{T}_v \mathbf{T}_a \mathbf{T}_p \delta \mathbf{x}, \quad \delta \mathbf{x} = \mathbf{U}_p \mathbf{U}_a \mathbf{U}_v \mathbf{U}_h \mathbf{v}$$

- Vertical transform convolves surface to top of atmosphere data to form vertical modes
- Horizontal transform models correlations as second-order autoregressive function with single characteristic length scale for each mode

Control variable	Leading mode scale (km)
Streamfunction	150
Velocity potential	190
Unbalanced pressure	70
Moisture	30
Log ₁₀ aerosol	60



v analysis increment (current)





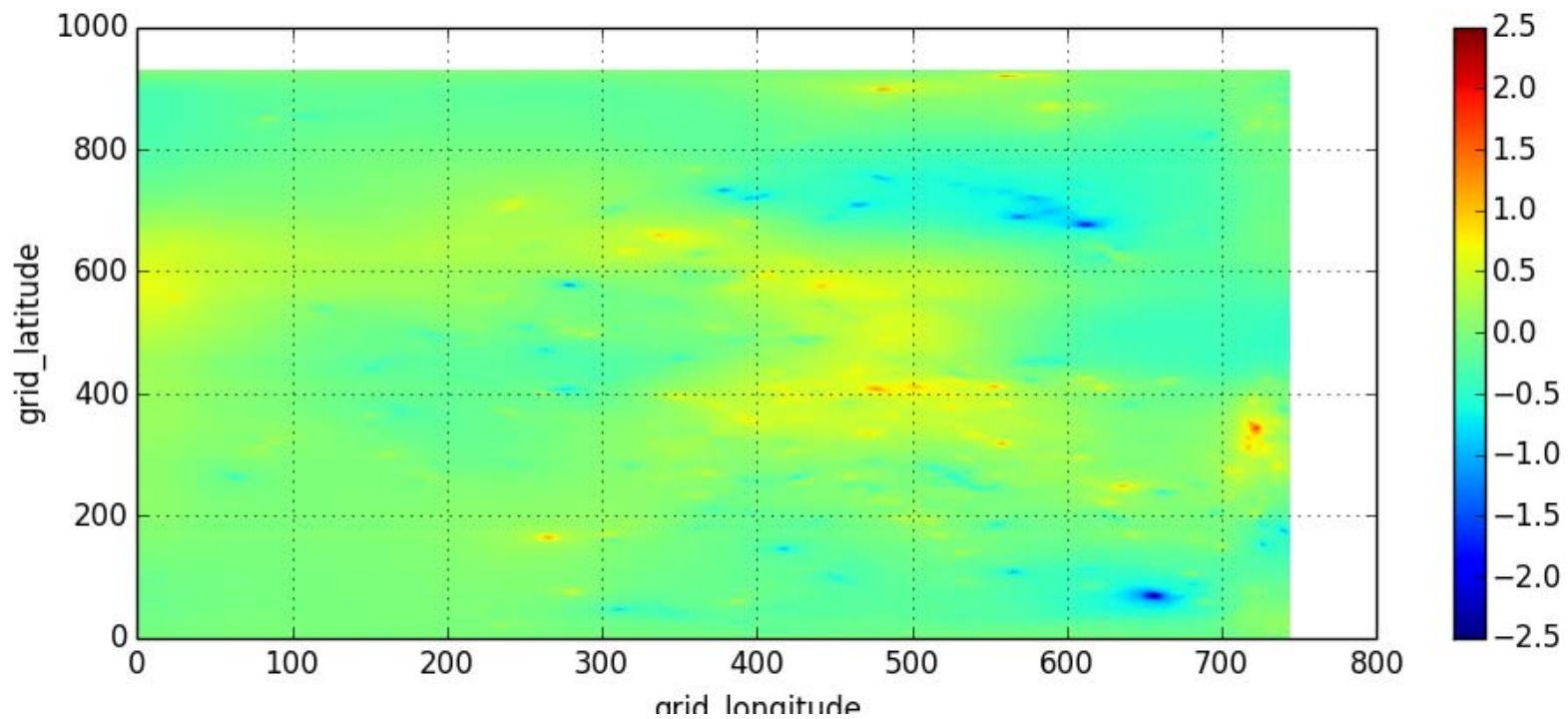
Proposed transform order

$$\mathbf{v} = \mathbf{T}_v \mathbf{T}_h \mathbf{T}_a \mathbf{T}_p \delta \mathbf{x}, \quad \delta \mathbf{x} = \mathbf{U}_p \mathbf{U}_a \mathbf{U}_h \mathbf{U}_v \mathbf{v}$$

- Follows Météo-France and HIRLAM
- Vertical correlations vary with horizontal scale
- Horizontal transform spans a range of length scales
- Vertical covariance matrix for each horizontal waveband



v analysis increment (swap)





Vertical adaptive grid

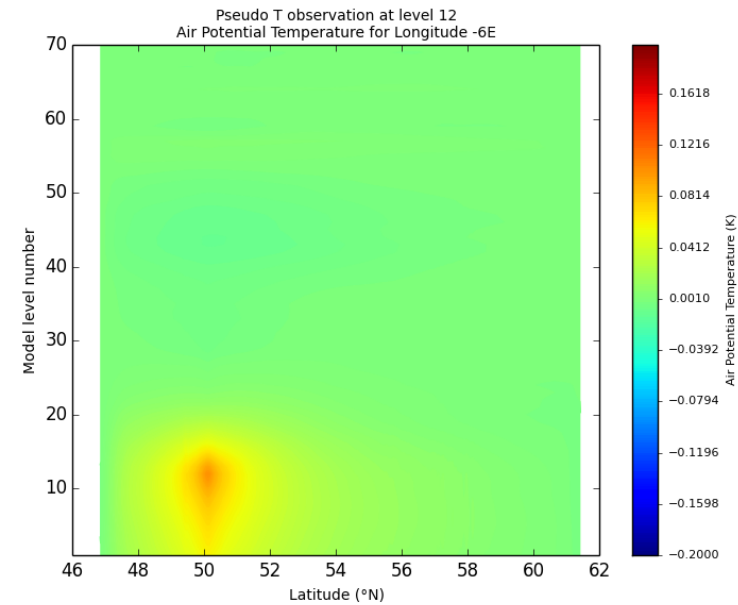
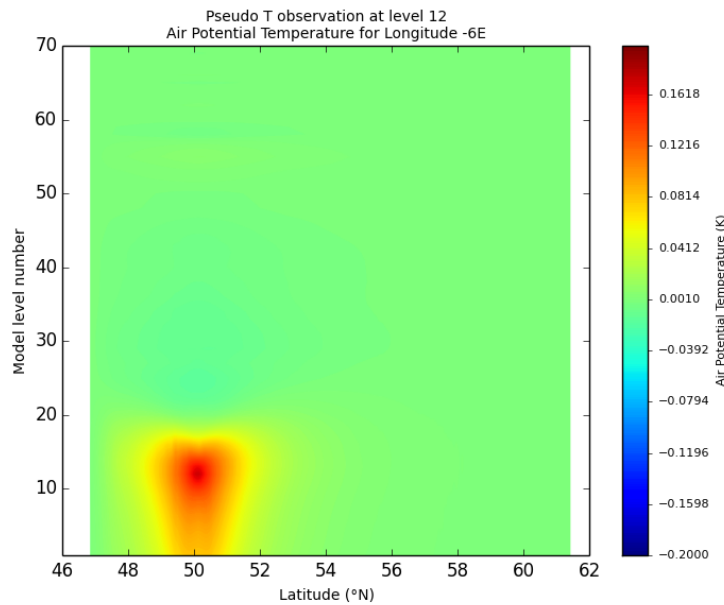
- Adjust spacing between vertical levels to concentrate levels around temperature inversions based on monitor function
- Improves correlation representation
- Introduces some flow dependence to otherwise stationary covariances
- C. Piccolo and M. Cullen, Q. J. R. Meteorol. Soc., 2011 and 2012
- Retuned parameters for proposed transform order



θ response to T level 12 pseudo-observation (No AG)

Current

Swap

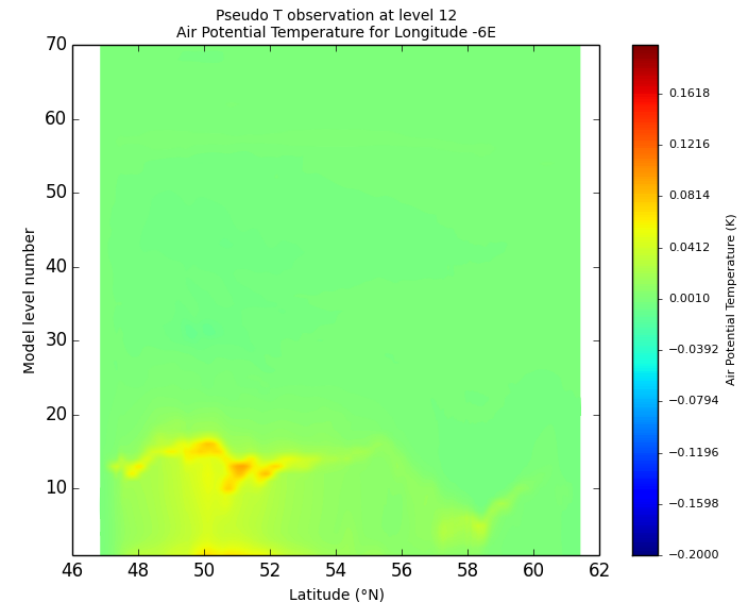
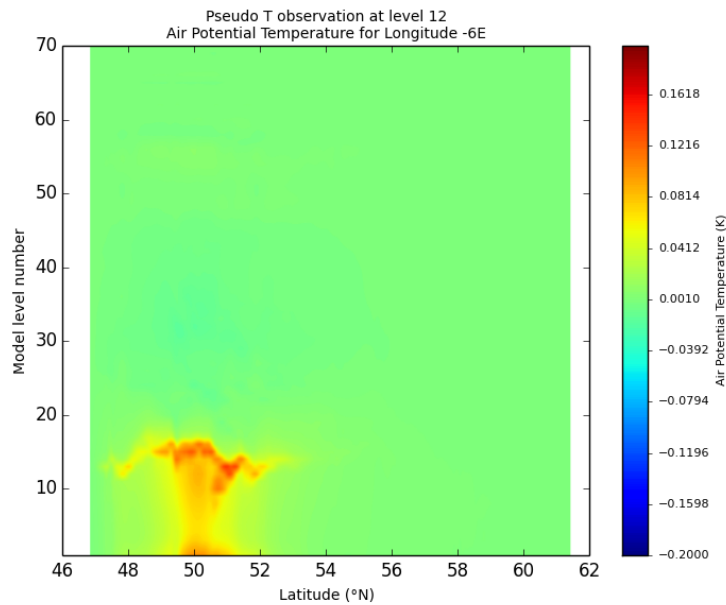




θ response to T level 12 pseudo-observation (AG)

Current

Swap

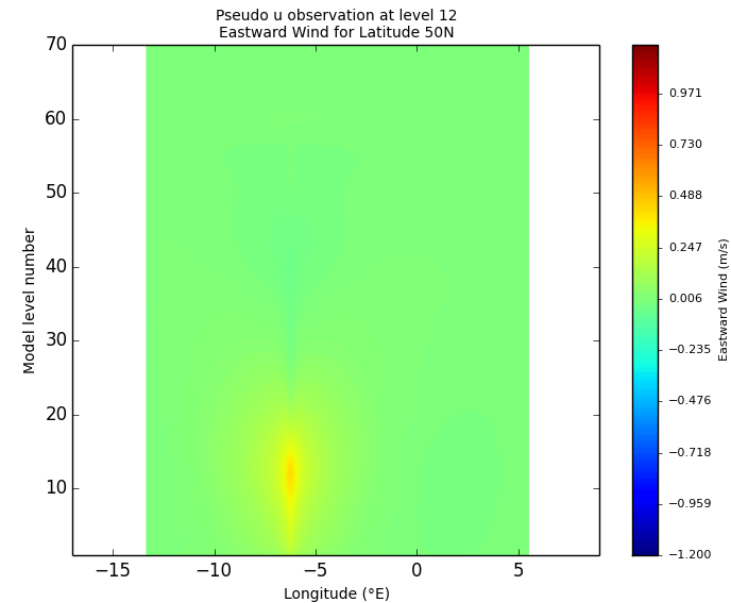
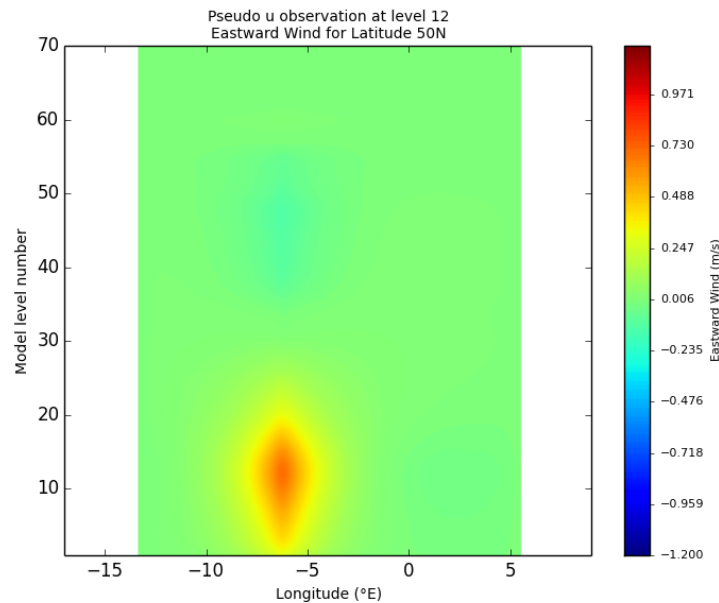




u response to u level 12 pseudo-observation (No AG)

Current

Swap

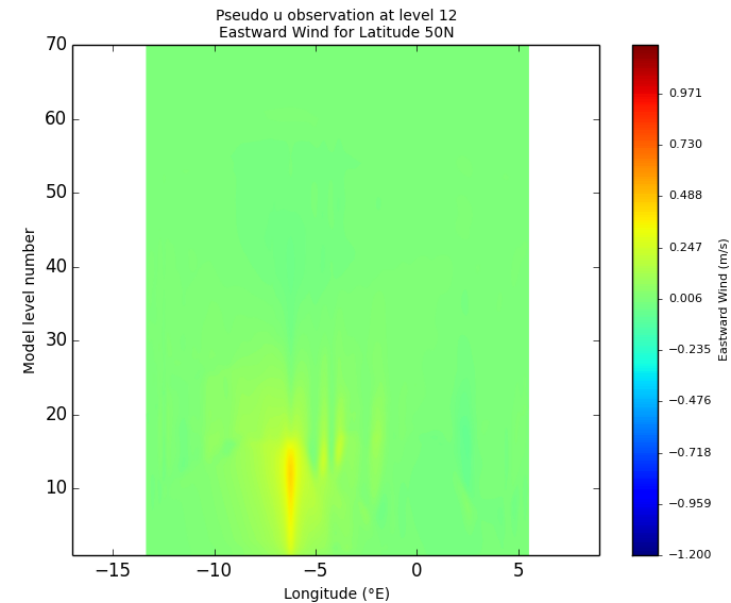
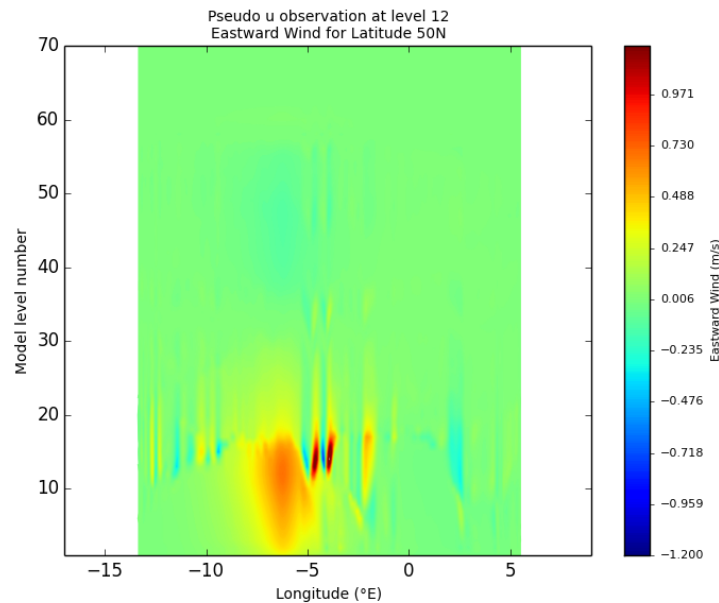




u response to u level 12 pseudo-observation (AG)

Current

Swap

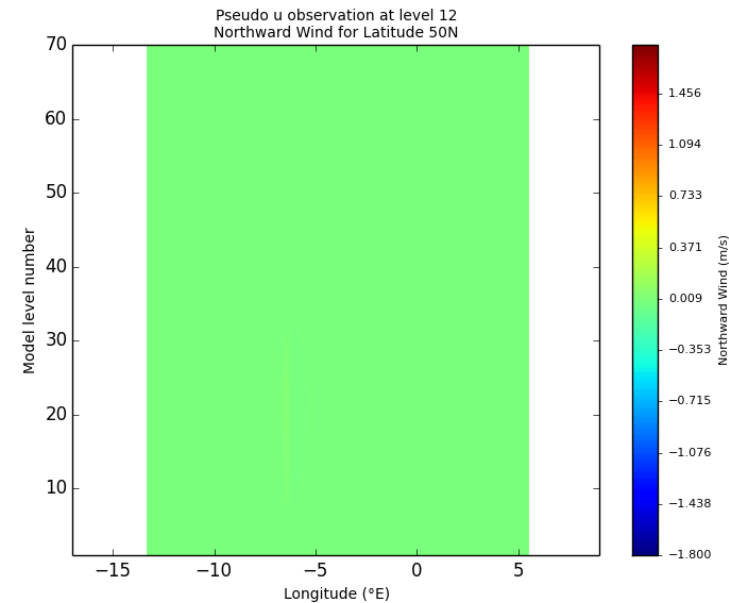
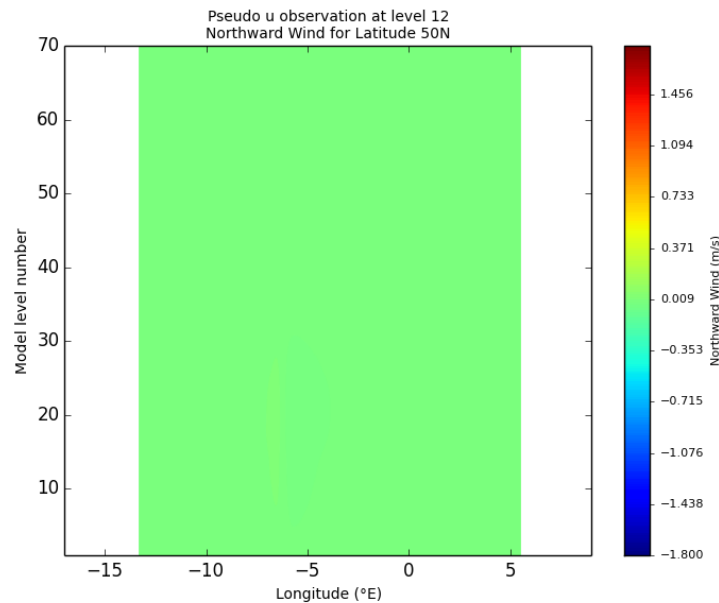




v response to u level 12 pseudo-observation (No AG)

Current

Swap

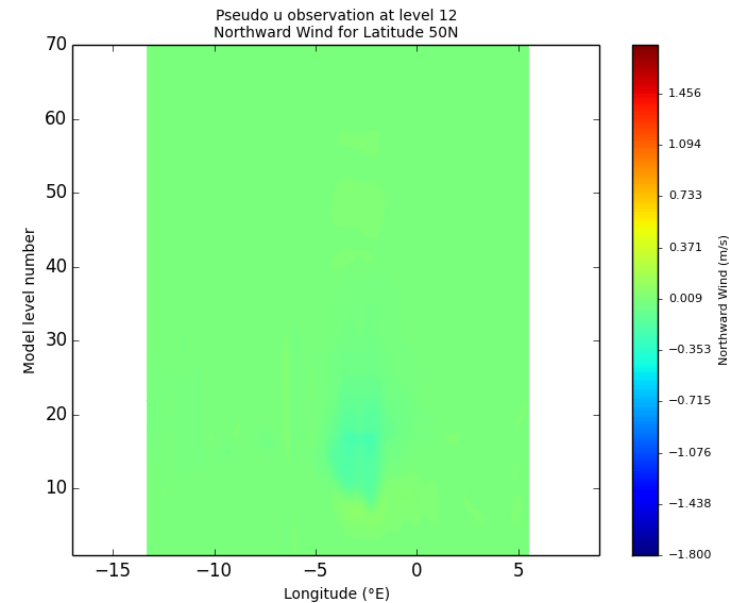
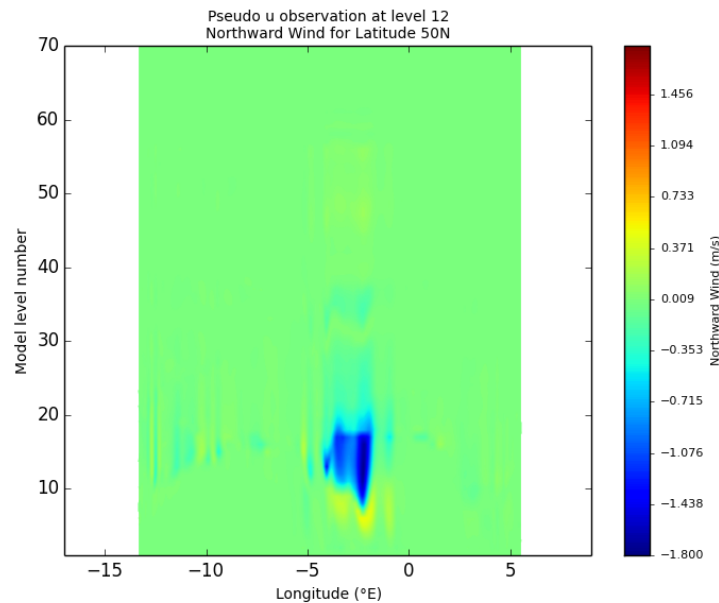




v response to u level 12 pseudo-observation (AG)

Current

Swap



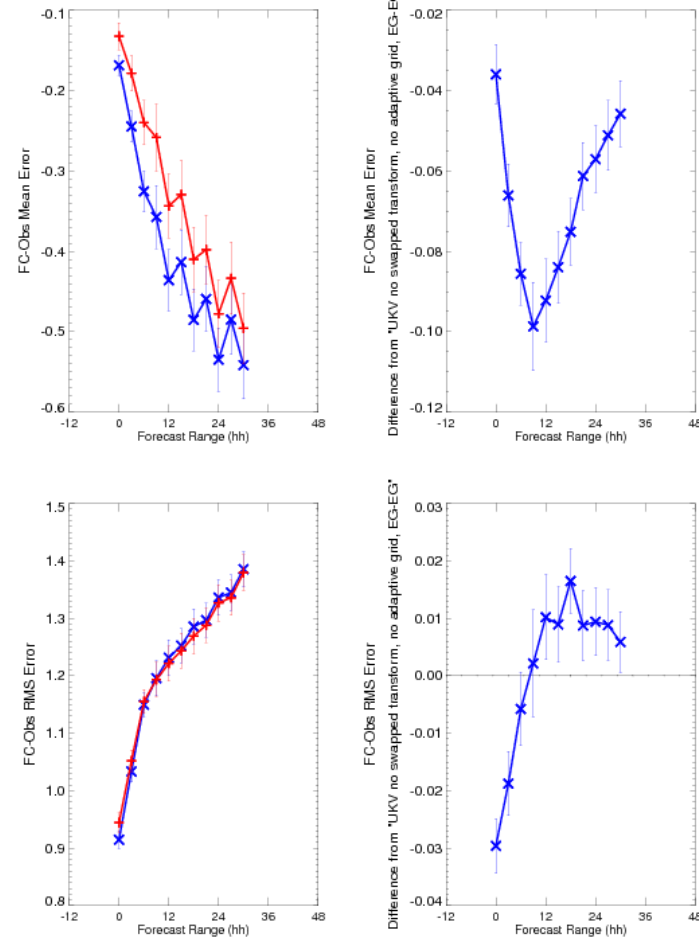


Trial results 22/01/13-07/03/13 (no AG)

Surface temperature

Temperature (Kelvin) at Station Height: Surface Obs
WMO Block 03 station list
Equalized and Meaned from 22/1/2013 00Z to 7/3/2013 23Z

Cases: + UKV no swapped transform, no adaptive grid, EG-EG
x UKV swapped transform, no adaptive grid, EG-EG

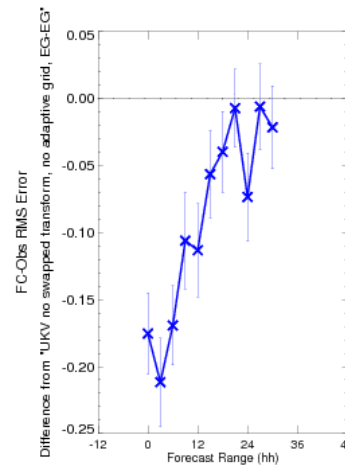
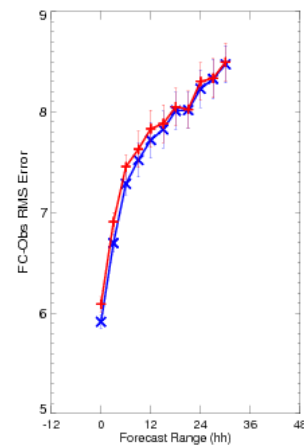
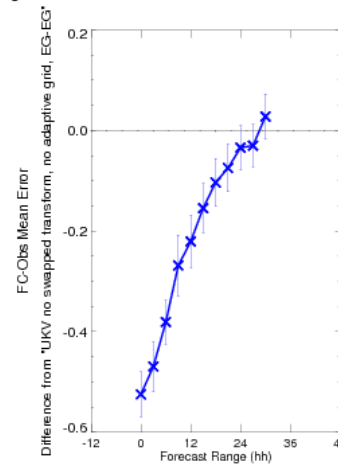
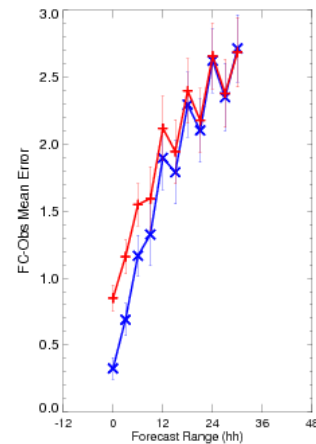


68% error bars calculated using $S/(n-1)^{1/2}$

Surface relative humidity

Relative humidity (%) at Station Height: Surface Obs
WMO Block 03 station list
Equalized and Meaned from 22/1/2013 00Z to 7/3/2013 23Z

Cases: + UKV no swapped transform, no adaptive grid, EG-EG
x UKV swapped transform, no adaptive grid, EG-EG

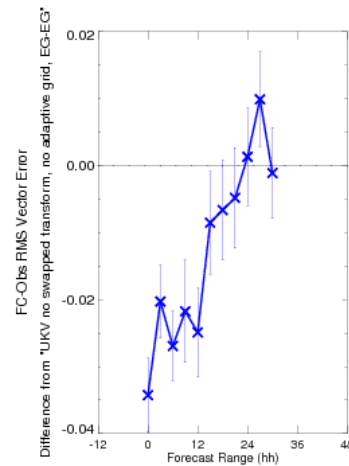
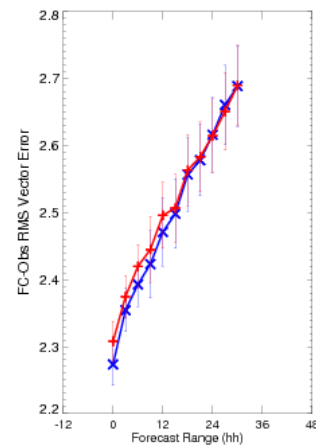
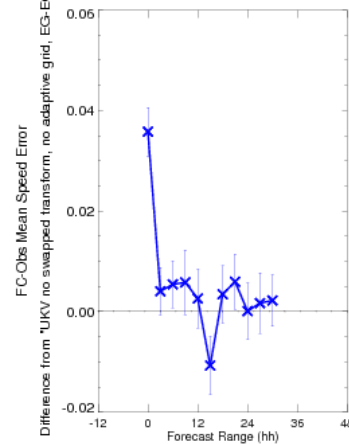
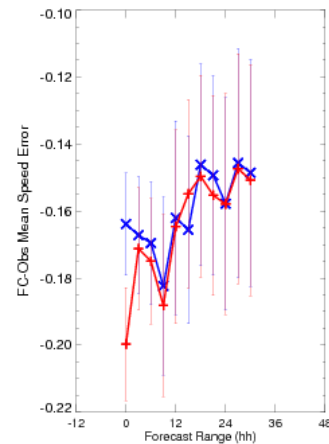


68% error bars calculated using $S/(n-1)^{1/2}$

Surface wind speed

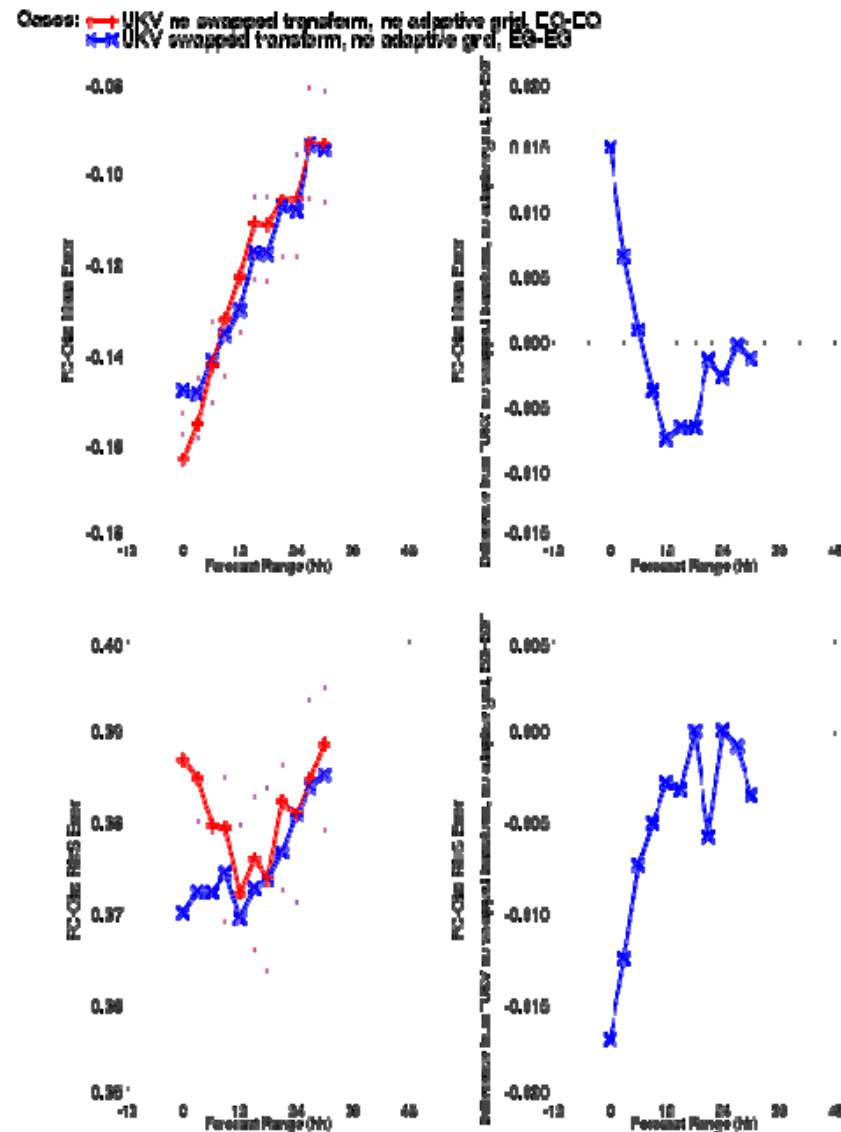
Wind (m/s) at Station Height: Surface Obs
WMO Block 03 station list
Equalized and Meaned from 22/1/2013 00Z to 7/3/2013 23Z

Cases: + UKV no swapped transform, no adaptive grid, EG-EG
x UKV swapped transform, no adaptive grid, EG-EG



68% error bars calculated using $S/(n-1)^{1/2}$

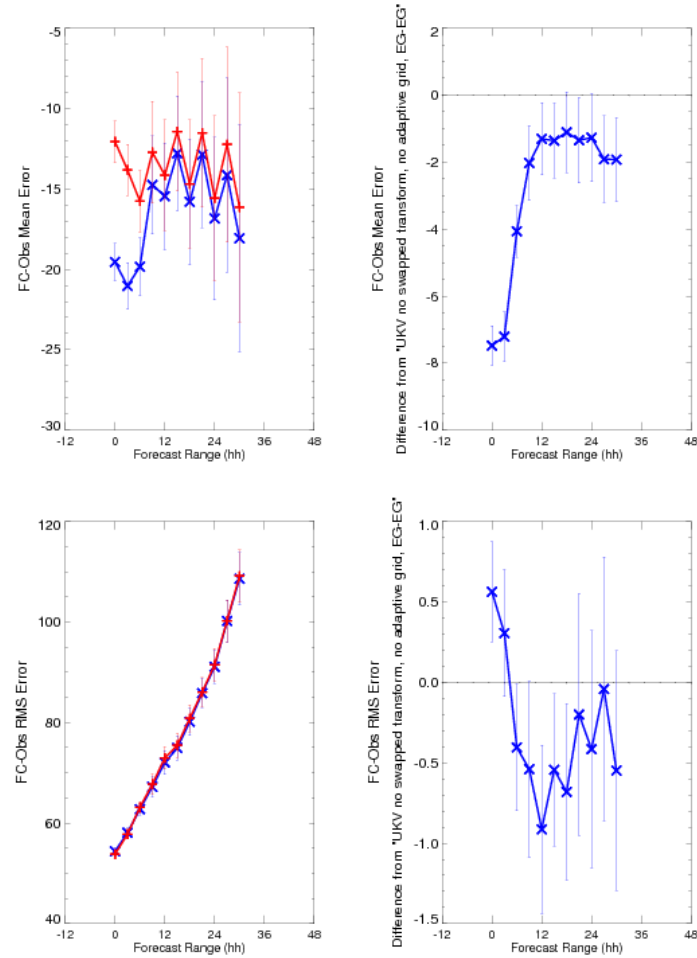
Fractional cloud cover



Surface pressure

Mean Sea Level Pressure (Pa): Surface Obs
WMO Block 03 station list
Equalized and Meaned from 22/1/2013 00Z to 7/3/2013 23Z

Cases: + UKV no swapped transform, no adaptive grid, EG-EG
x UKV swapped transform, no adaptive grid, EG-EG



68% error bars calculated using $S/(n-1)^{1/2}$



Conclusions

- Swapped transform order enables wind increments to span a range of scales
- Vertical adaptive grid better represents correlations across temperature inversions and introduces a degree of flow-dependence
- Favourable trial results from swapped transform order covariance statistics without vertical adaptive grid
- Aim to combine this work with hourly-cycling 4D-Var configuration under development



Questions and answers