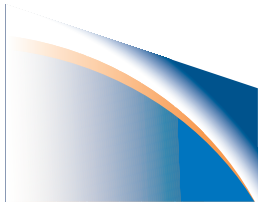

NCAR

Background error modelling: climatological flow-dependence

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Background error modelling: climatological flow-dependence

Spectral formulations of the B matrix allow:

- three-dimensional grid point background error σ_b;
- good representation the average spatial structure of analysis increments.

But they are restricted to

- homogeneous isotropic horizontal analysis increments (for CV);
- homogeneous structure of vertical correlation (for CV).

Gridpoint formulations

They allow to relax those assumptions:

- EOF decomposition can be local;
- recursive filters can be applied with varying lengthscales.

Background error modelling: climatological flow-dependence

However currently `gen_be/WRF-Var` do not make benefit of this!

We end up with the worse covariances of both worlds!

- homogeneous and isotropic structure of horizontal analysis increments (for CV), that have a bad power spectrum (Gaussian assumption)
- homogeneous structure of vertical correlation (for CV)
- homogeneous σ_b (they are the sqrt of EOF eigenvalues)

Moreover, the horizontal analysis increments looks not so good (c.f. PSOT results of `gen_be_stage4_regional` without tuning of lengthscales).

A new estimate of lengthscales

The Wu, Purser and Parrish (2002) formula

The correlation lengthscale can be estimated through the ration of the variance of the field to the variance of its Laplacian:

$$L = \left(8 \frac{\boldsymbol{V}_\psi}{\boldsymbol{V}_\zeta} \right)^{1/4}$$

gen_be_stage4_regional_from_variances

```
* for each member (date or ensemble)
    + for each vertical level or EOF mode
        - perform spatial laplacian computation with fft
        - accumulate variance for projected field
        - accumulate variance for projected Laplacian field
    + end
* end
* Compute lengthscales
```

A new estimate of lengthscales: results for CONUS 200

We obtain *local* lengthscales which noise seems in agreement with Pannekoucke *et al* (2008) and choose to use the median over the domain.

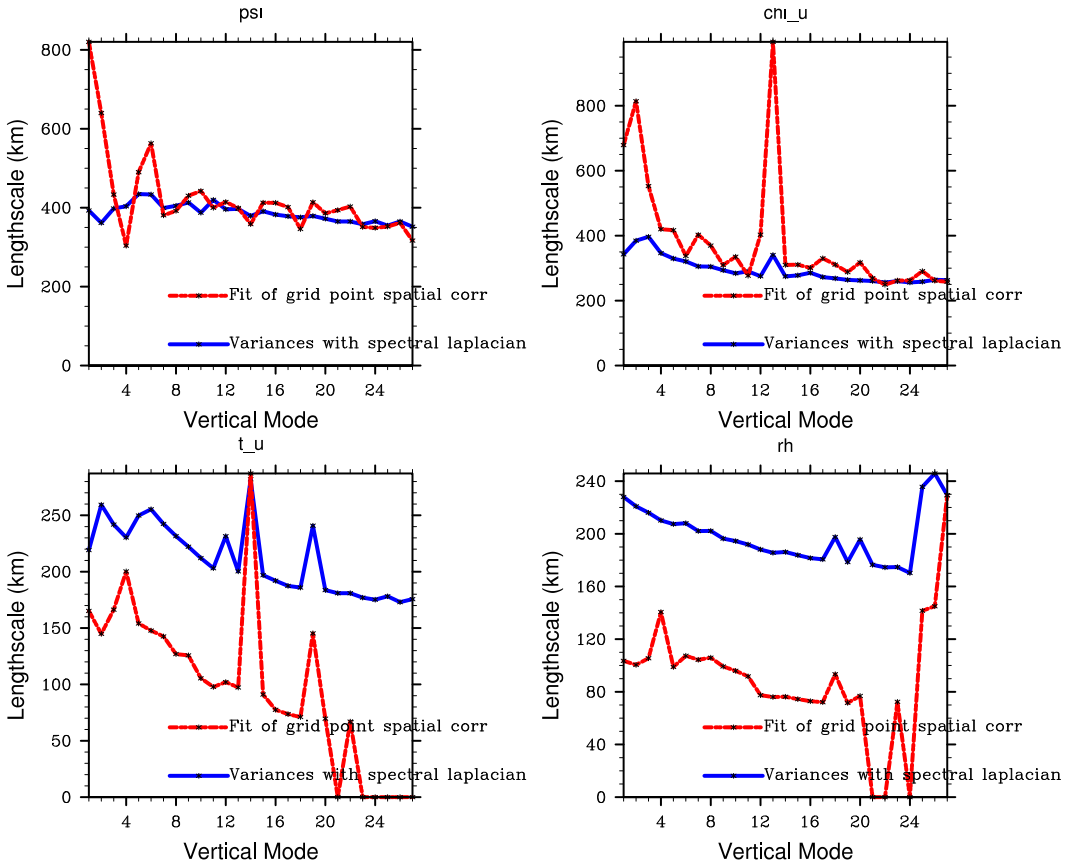


Figure: Comparison of raw lengthscales obtained over the CONUS domain (200 km resolution) for the fit of spatial correlation (`gen_be_stage4_regional`) and the new estimate from the variances (`gen_be_stage4_regional_from_variances`)

Comparison

- Smoother results over the EOF mode (more robust).
- Shorter lengthscales for ψ, χ_u and larger for t_u, rh.

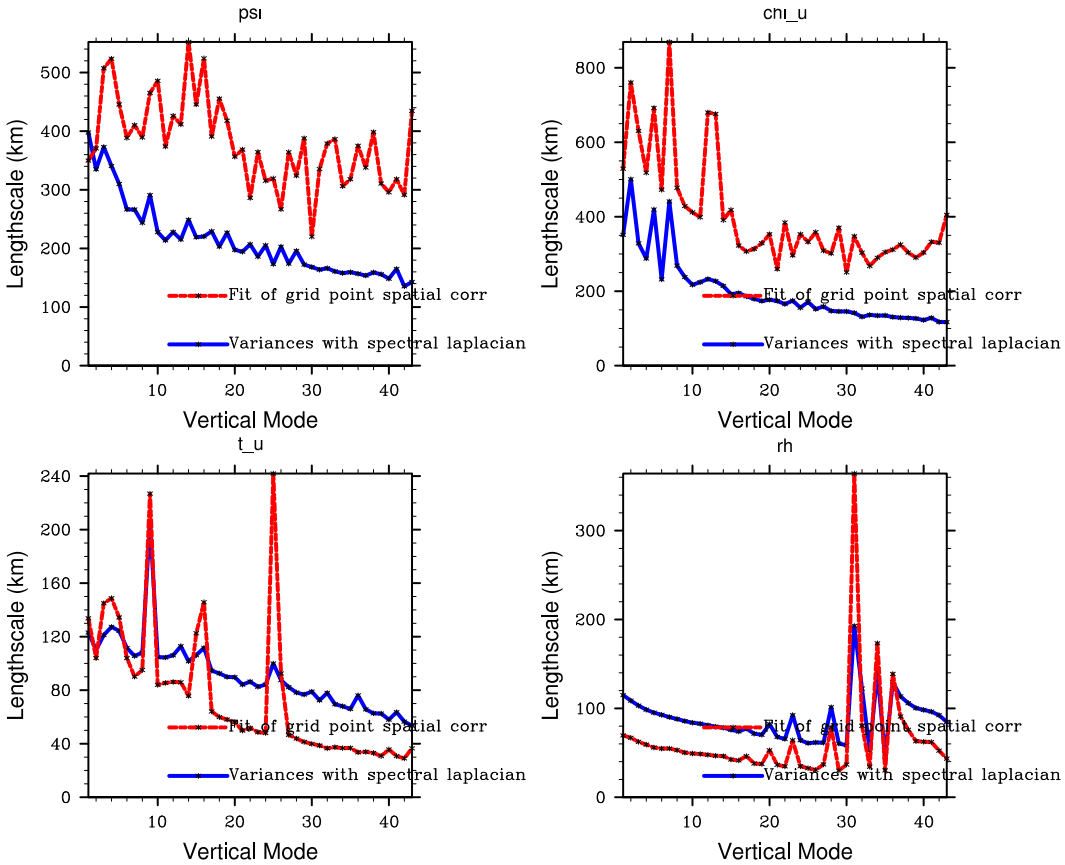


Figure: Same comparison over the AMPSRT domain (45 km resolution)

Single observation experiments (PSOT)

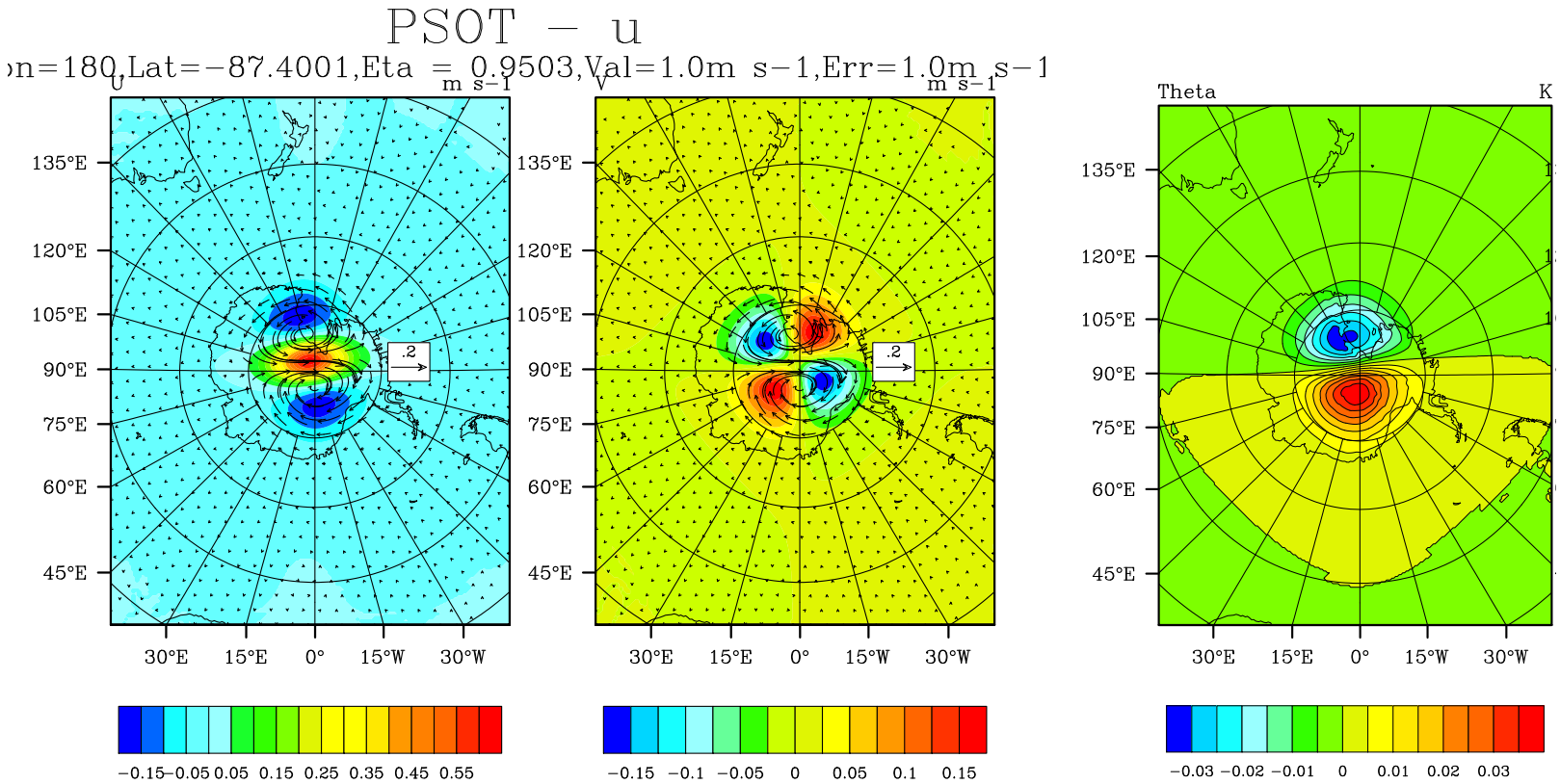


Figure: PSOT over the AMPSRT domain (45 km resolution) for a u observation

Single observation experiments (PSOT)

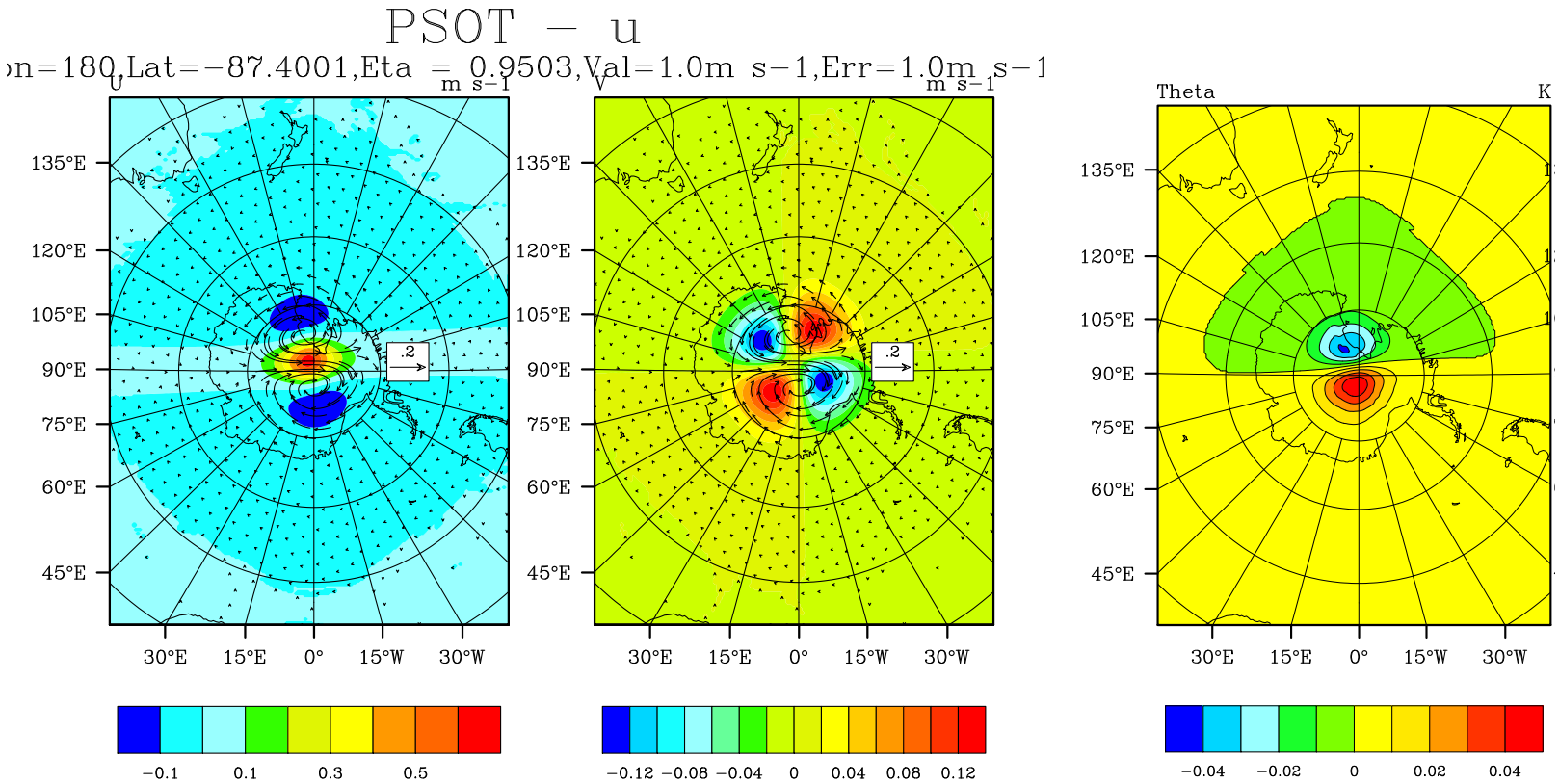


Figure: PSOT over the AMPSRT domain (45 km resolution) for a u observation

Single observation experiments (PSOT)

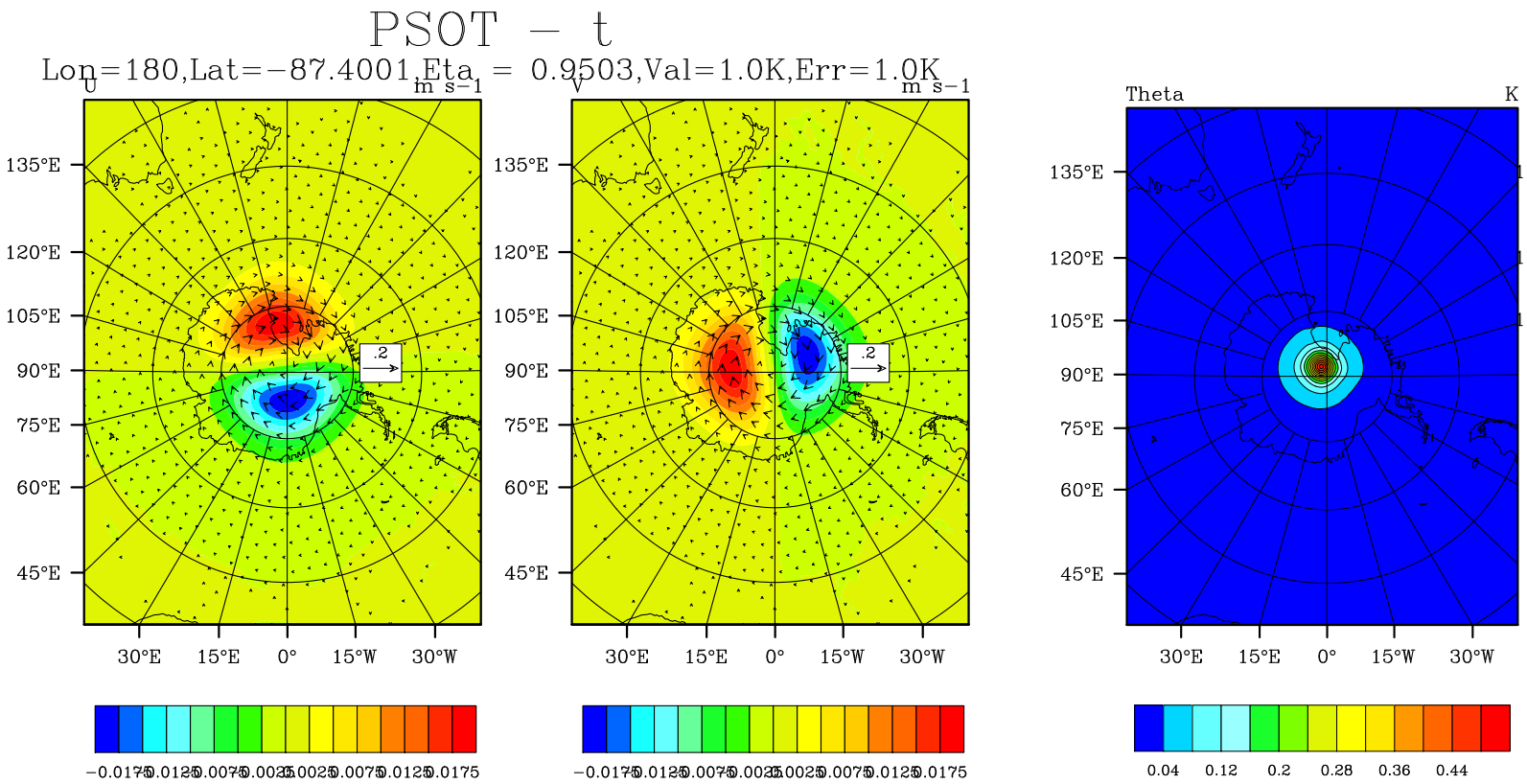


Figure: PSOT over the AMPSRT domain (45 km resolution) for a t observation

Single observation experiments (PSOT)

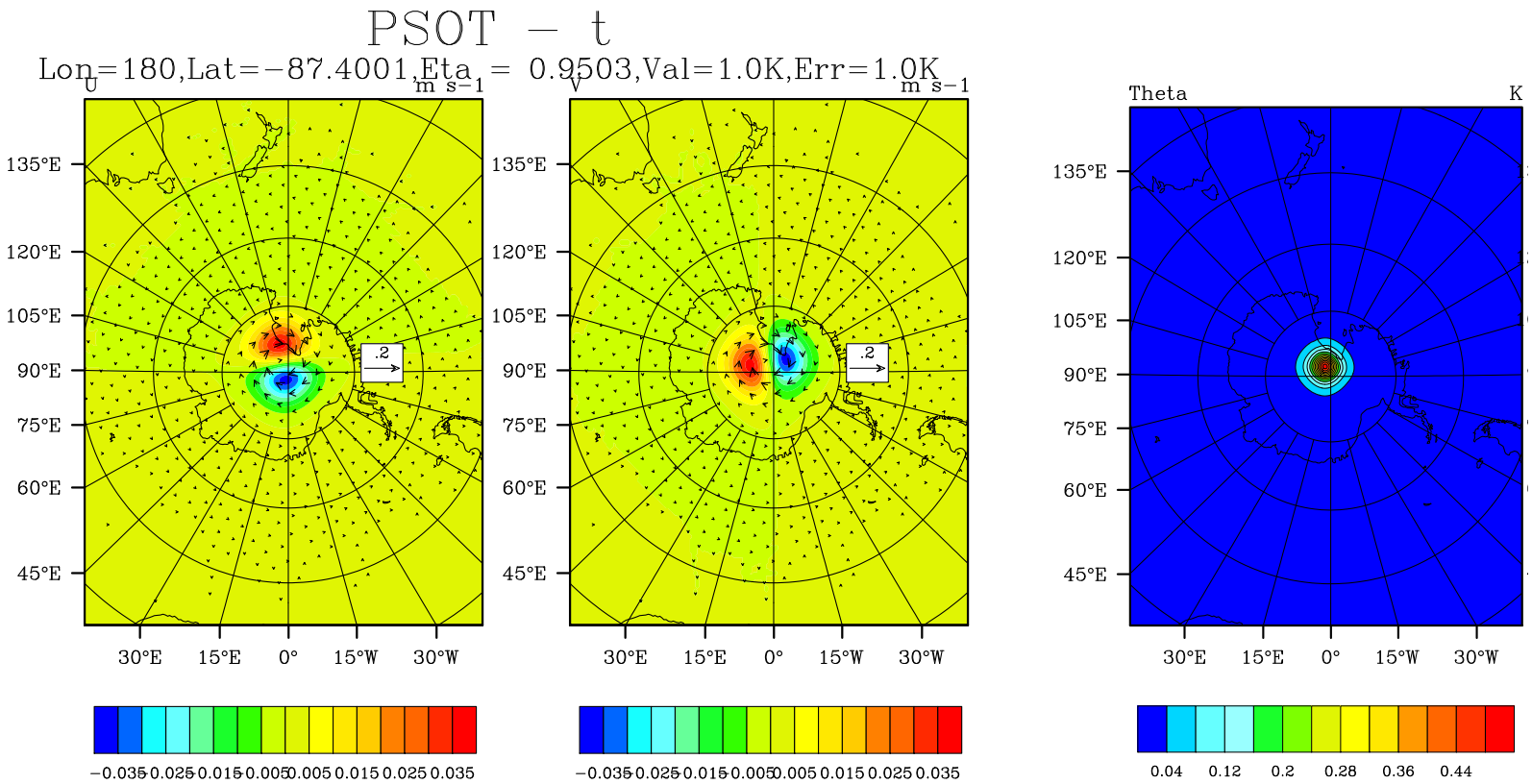


Figure: PSOT over the AMPSRT domain (45 km resolution) for a t observation

Single observation experiments (PSOT)

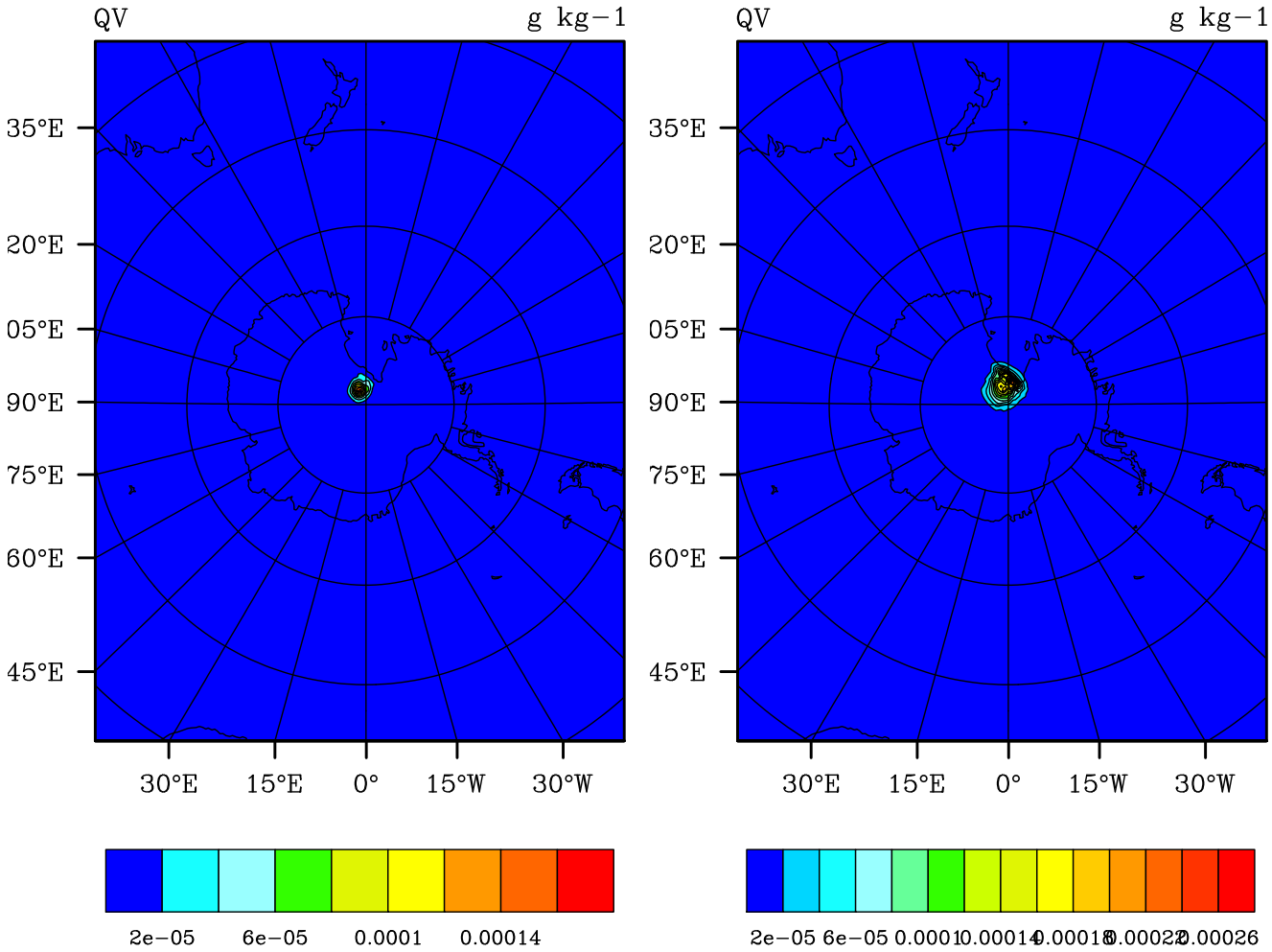


Figure: PSOT over the AMPSRT domain (45 km resolution) for a rh observation

Modelling the climatological flow-dependence

Currently, the `bin_type` in `gen_be` is an "on-off" way of specifying B. It allows j-dependence of

- Regression coefficients (stage 2, U_p)
- Eigenvalues/vectors of vertical covariance (stage 3, U_v)
- Lengthscales (stage 4, U_h)

But when the grid is not j/latitude (as for AMPSRT), we are restricted to homogeneity (`bin_type` 5)

$$\boldsymbol{x} = U_p \; U_v \; U_h \boldsymbol{v} \tag{1}$$

Varying background error variances

`gen_be_stage4_regional_from_variances` provides gridpoint variances of fields on EOF modes that could be used to add climatological dependence of background error variances.

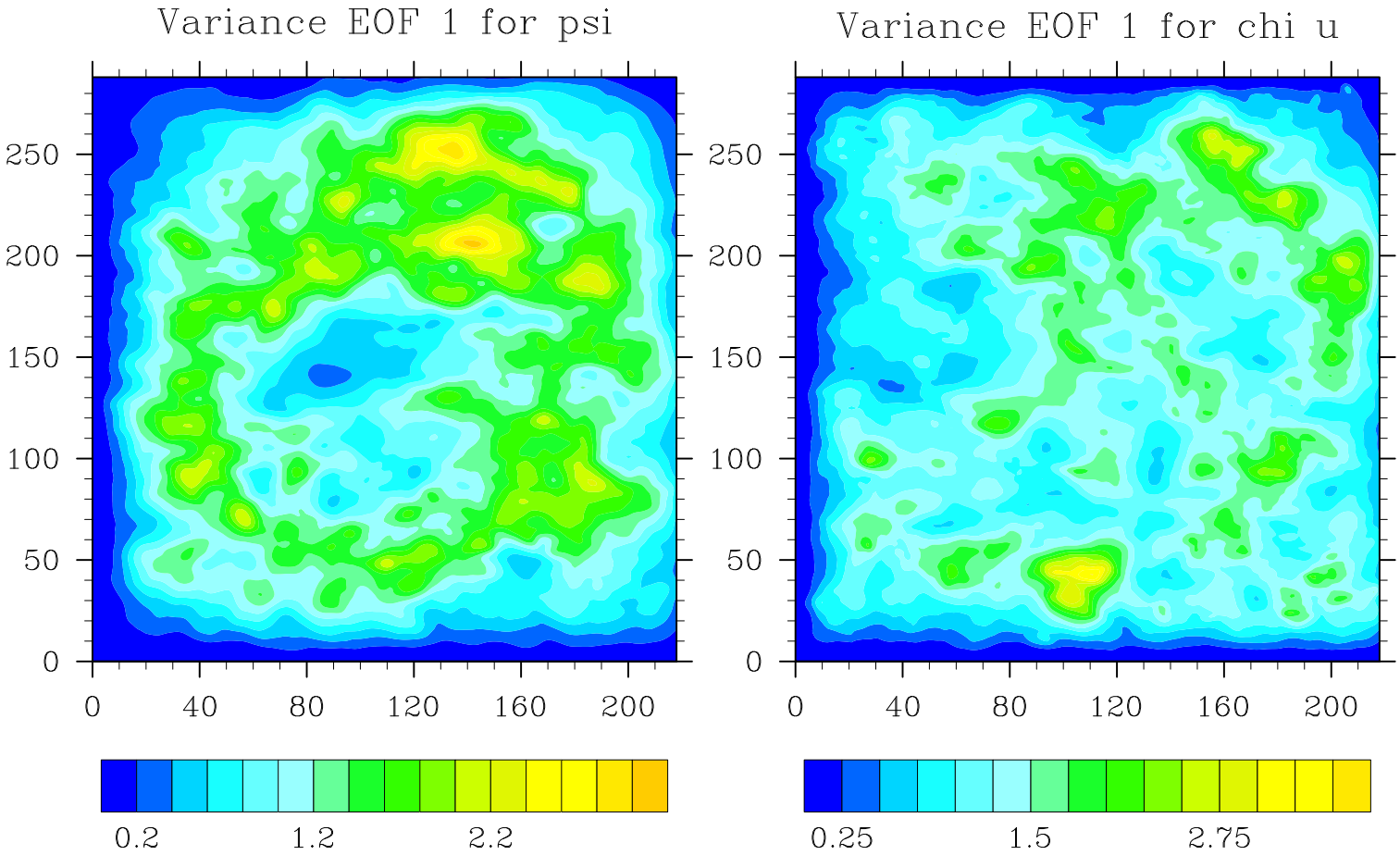


Figure: Variance for ψ and χ_u on EOF 1

Varying background error lengthscales

`gen_be_stage4_regional_from_variances` provides gridpoint lengthscales of fields on EOF modes

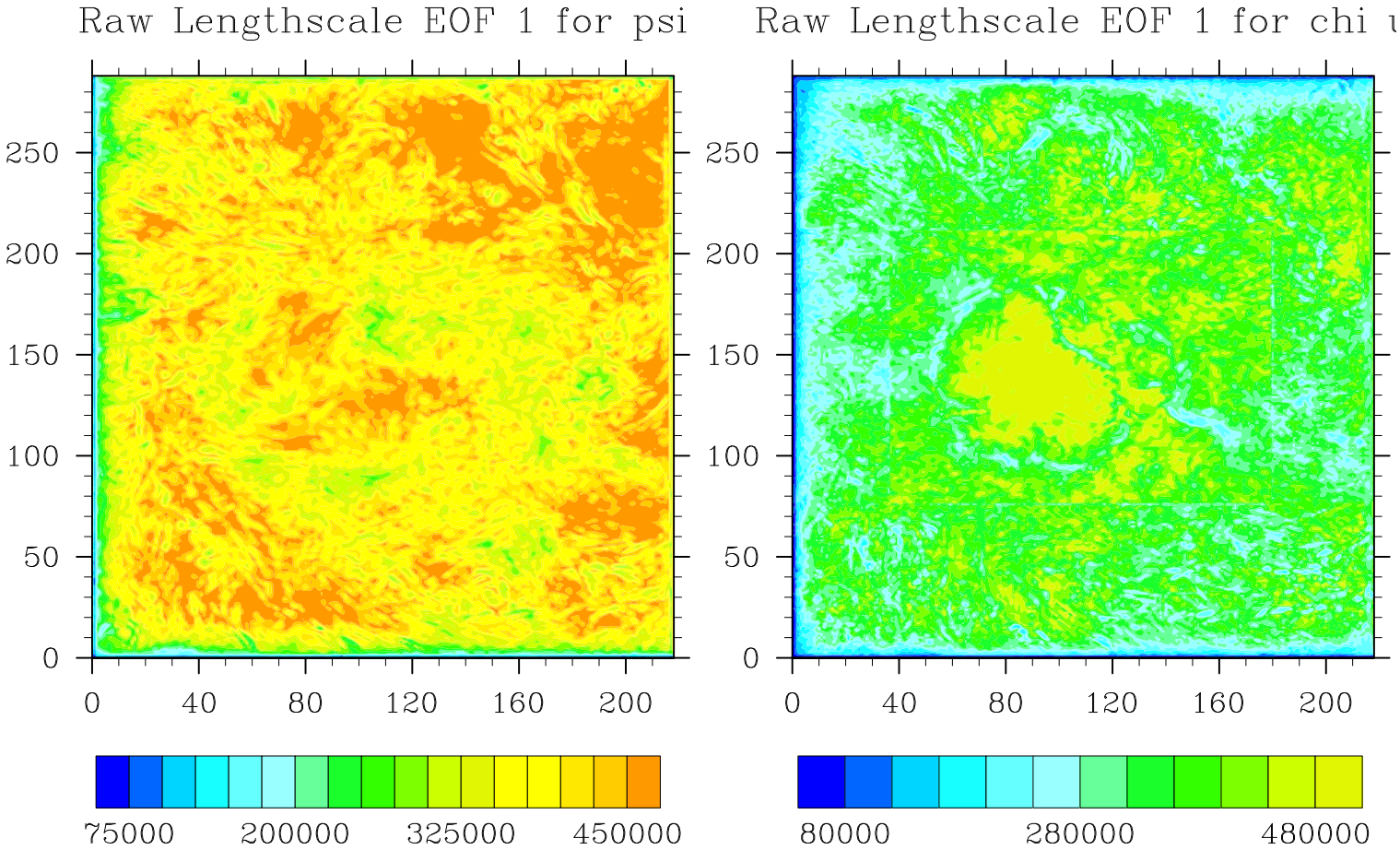


Figure: Lengthscale for ψ and χ_u on EOF 1

Varying background error lengthscales: recursive filters

Recursive filters can deal with smoothly varying lengthscales, but the amplitude of the filter has to be reconsidered (Purser *et.al*, 2003).
Basic equation of recursive filter of smoothing parameter α can easily be made grid-dependent.

$$A_i^{'} = \alpha A_{i-1}^{'} + (1-\alpha) A_i$$

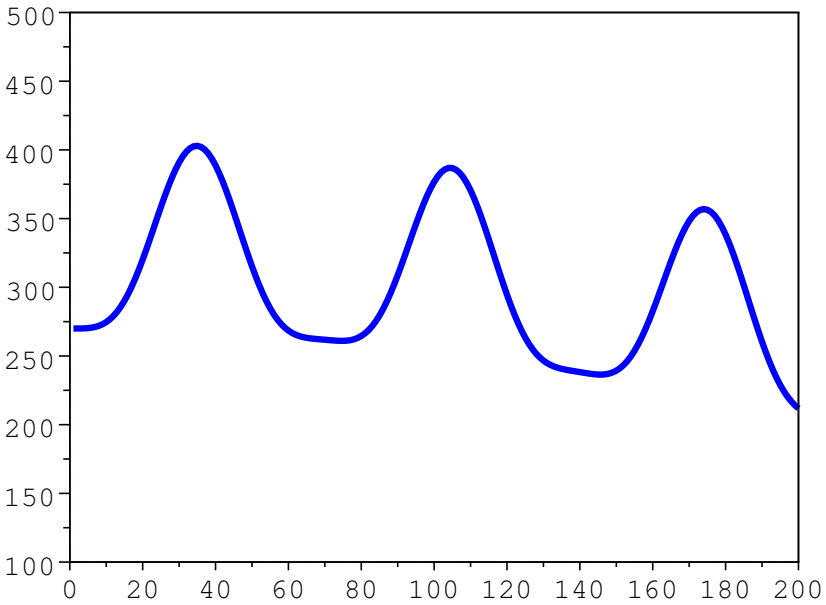


Figure: A varying lengthscale (km)

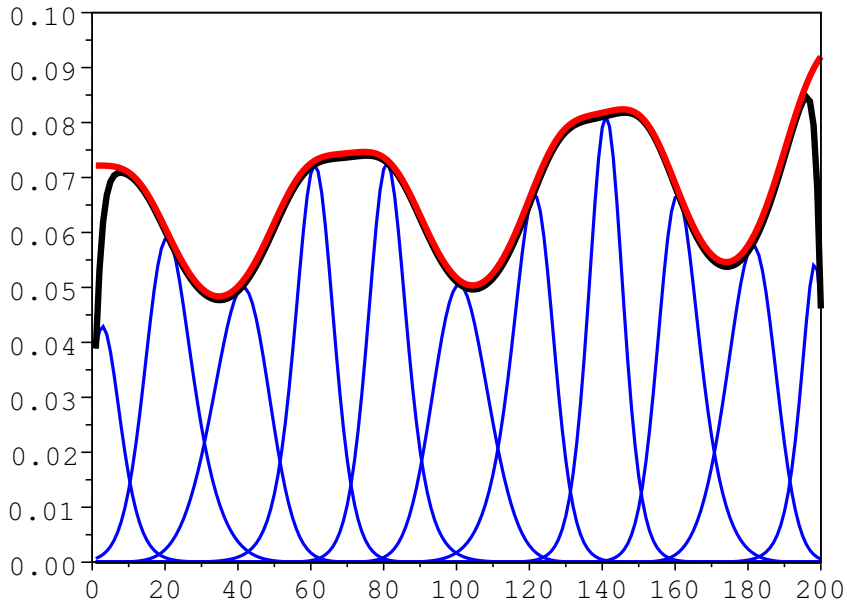
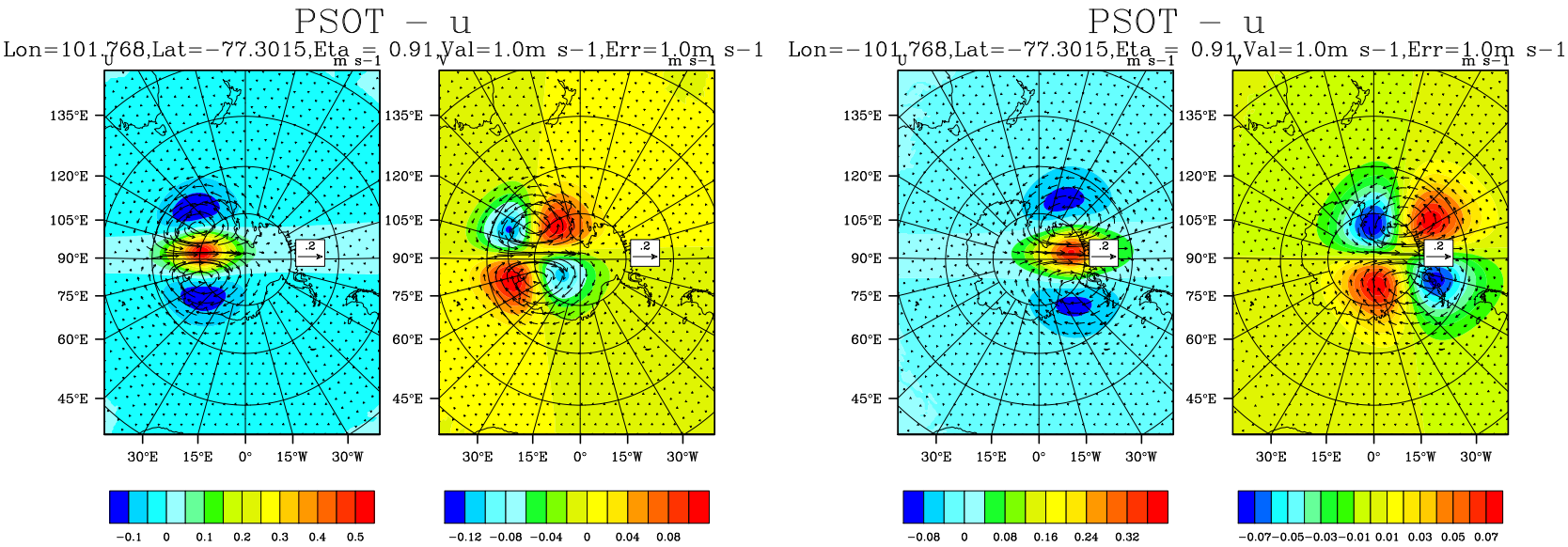


Figure: Impulse response of the 6-order recursive filter.

Varying background error lengthscales in WRFVAR

An academic test where the background error lengthscales are increasing by a factor of 2 from West to East.



Still some work to go to achieve proper normalization of the amplitude of the recursive filters.

Conclusion

Climatological flow-dependence

- New way of computing lengthscales, more efficient, looks better.
- On the way of specifying varying background error variances
- On the way of specifying varying background error lengthscales
- With `bin_type=0`, one can have varying regression coefficients (not shown)

Filtering

Variances, Lengthscales and Regression coefficients may need to be locally averaged (spatially and or temporally averaged).
The filter could be adaptive to the noise level and structure (Berre, Raynaud, Pannekoucke).

Flow-dependence of the day

This improvements could be used with the hybrid framework, but still a lot of work before.