Multivariate static covariance in MPAS-JEDI

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at JEDI Discussing Meeting on June 4th 2020

B design: overview

$$B = K_1 K_2 \Sigma C \Sigma^T K_2^T K_1^T$$

- The multivariate B is designed to follow that of WRFDA and GSI
- K_1 : linear variable change, psichi to uv in mpas-jedi
- K_2 : linear variable change, vertical regression in BUMP VBAL
- $\Sigma C \Sigma^T$: univariate covariance matrix, in BUMP
  - Σ : a diagonal matrix with standard deviation, also linear variable change, BUMP VAR
  - C : a spatial correlation matrix, BUMP NICAS

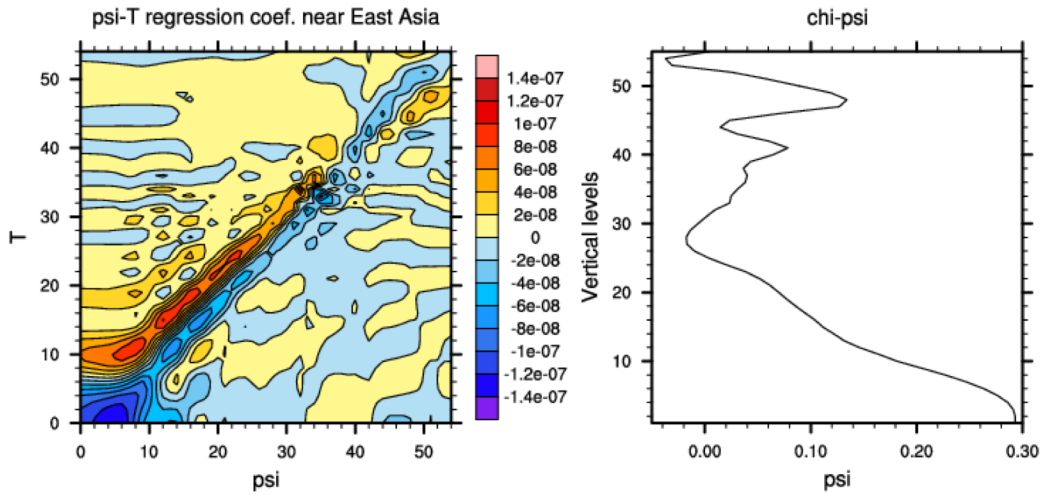
$$K_1 : \begin{bmatrix} \delta u \\ \delta v \\ \delta T \\ \delta sh \\ \delta p_s \end{bmatrix} = \begin{bmatrix} -\partial_y & -\partial_x & 0 & 0 & 0 \\ \partial_x & -\partial_y & 0 & 0 & 0 \\ 0 & 0 & I & 0 & 0 \\ 0 & 0 & 0 & I & 0 \\ 0 & 0 & 0 & 0 & I \end{bmatrix} \begin{bmatrix} \delta \psi \\ \delta \chi \\ \delta T \\ \delta sh \\ \delta p_s \end{bmatrix} \quad K_2 : \begin{bmatrix} \delta \psi \\ \delta \chi \\ \delta T \\ \delta sh \\ \delta p_s \end{bmatrix} = \begin{bmatrix} I & 0 & 0 & 0 & 0 \\ L & I & 0 & 0 & 0 \\ M & 0 & I & 0 & 0 \\ 0 & 0 & 0 & I & 0 \\ N & 0 & 0 & 0 & I \end{bmatrix} \begin{bmatrix} \delta \psi \\ \delta \chi_u \\ \delta T_u \\ \delta sh \\ \delta p_{s,u} \end{bmatrix}$$

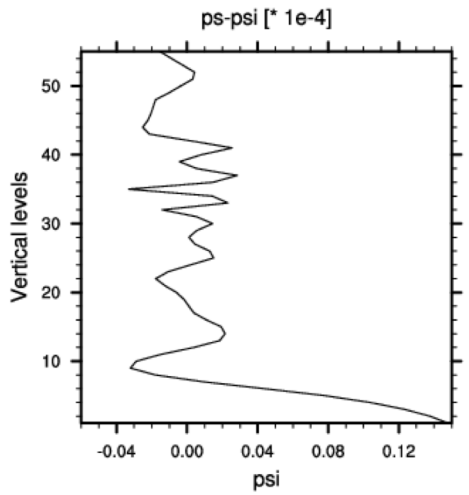
K_2 : Vertical regression

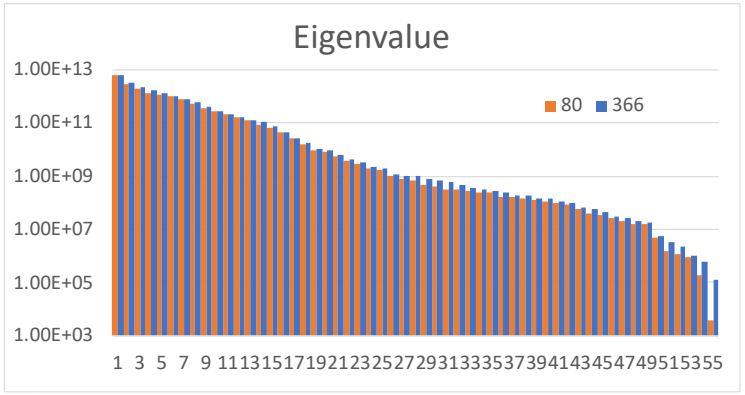
$$K_2 : \begin{bmatrix} \delta\psi \\ \delta\chi \\ \delta T \\ \delta sh \\ \delta p_s \end{bmatrix} = \begin{bmatrix} I & 0 & 0 & 0 & 0 \\ L & I & 0 & 0 & 0 \\ M & 0 & I & 0 & 0 \\ 0 & 0 & 0 & I & 0 \\ N & 0 & 0 & 0 & I \end{bmatrix} \begin{bmatrix} \delta\psi \\ \delta\chi_u \\ \delta T_u \\ \delta sh \\ \delta p_{s,u} \end{bmatrix}$$

- ψ is a predictor for the balanced part of χ , T , and p_s.
- Full matrix for M & N, diagonal matrix for L
- 366 perturbations (over 3 months) of GFS 24 hour and 12 hour forecast differences are used to estimate the regression coefficients.
  - PTBs for $\{\psi\ \chi\ T\ \ sh\ p_s\}$ are calculated off-line.
  - Auto- and cross-covariance matrices are then computed and averaged over latitude bands of +/- 10 degrees.
  - A Cholesky decomposition method is used for inverse of auto-covariance matrix $< \psi', \psi' >$.
  - Pseudo inverse was implemented with EVD.

366 members, Pseudo inverse (20 modes)

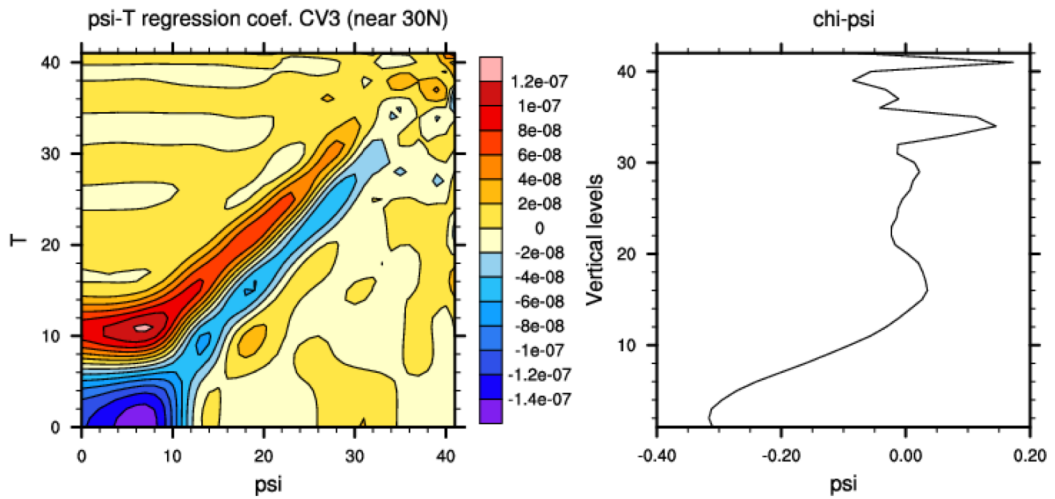


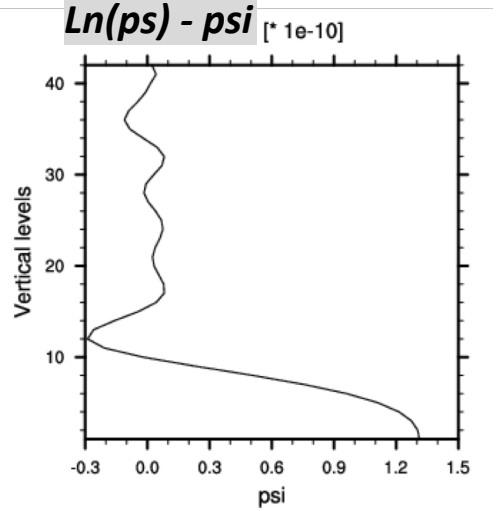




cond(A)	80	366
full	1.59E+09	5.09E+07
20	8.15E+02	7.30E+02

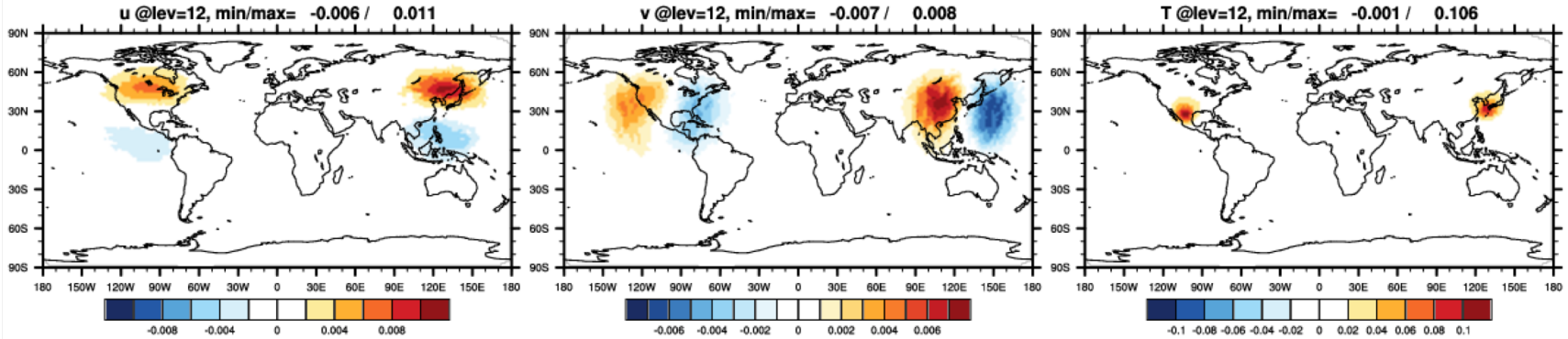
CV3 (Global GSI) from WRFDA

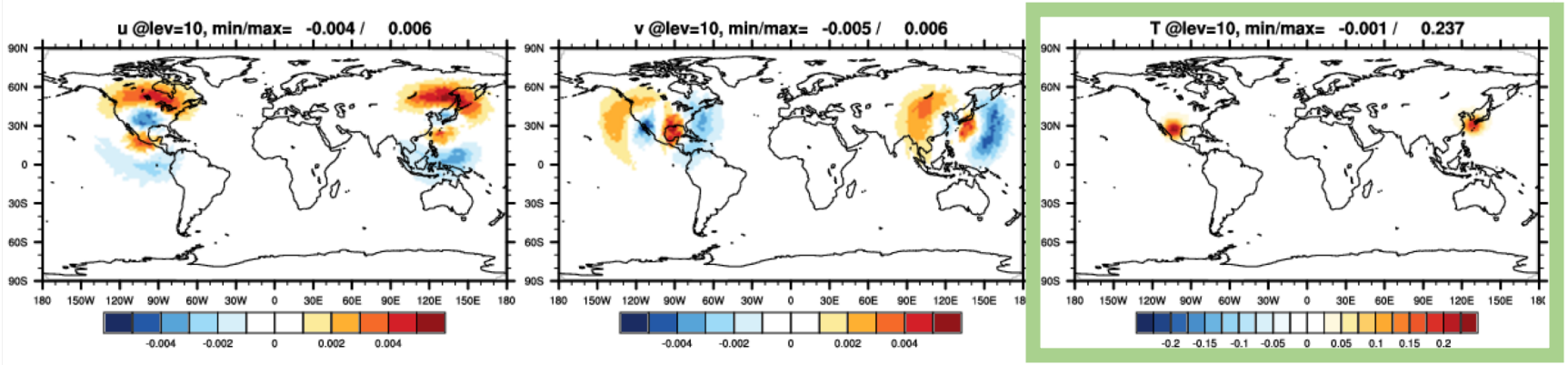


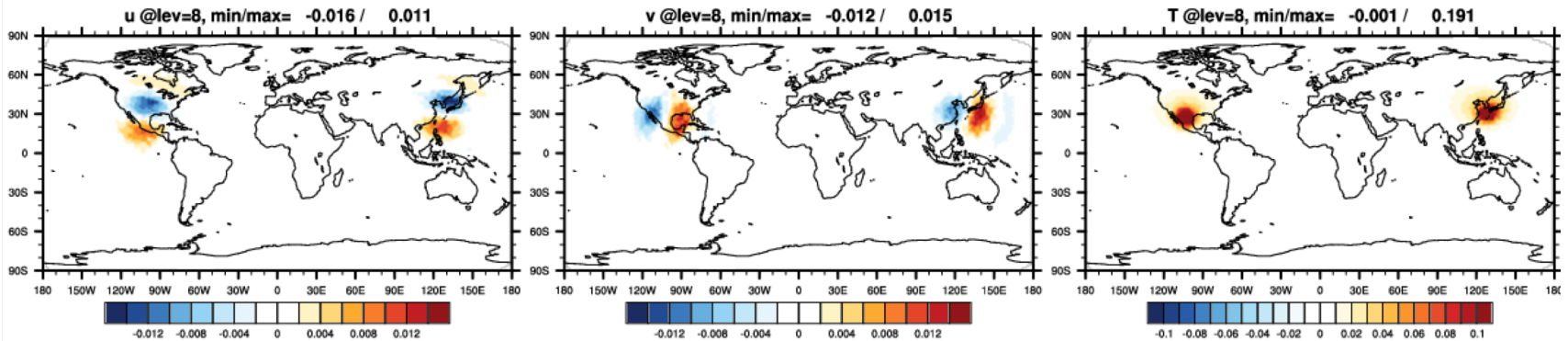


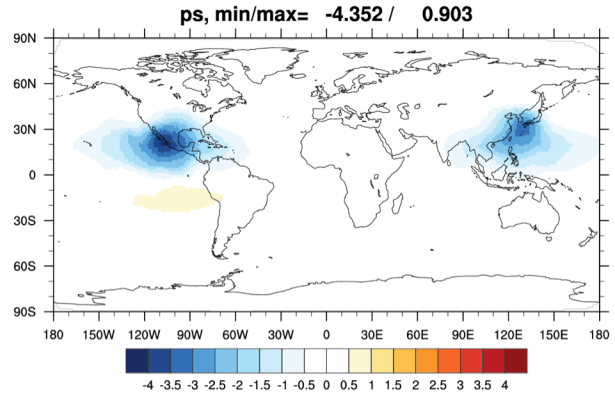
T obs : Both H&V length scales from HDIAG

1 K innov. @ lev=10









U obs : Both H&V length scales from HDIAG

1 m/s innov. @ lev=10