Multivariate Covariance

- Current analysis variable in MPAS-JEDI
  - Temperature, (3d) pressure, specific humidity, zonal & meridional wind @ Cell Center

- (prototype?) Multivariate relationship by using ..
  - psi, chi_u, T_u, ps_u, q

Multivariate Covariance

- Work in progress

- psichi_to_uv & its adjoint
  - Operate on MPAS mesh (cell center) during minimization
  - two methods following Bill Skamarock's note
  - Not tested through C++

- uv_to_psichi (e.g., inverse of psichi_to_uv)
  - Tested two offline packages: NCL & FEniCS

NCL

$u_r = -\frac{\partial \psi}{\partial y}, \quad v_r = \frac{\partial \psi}{\partial x}$: Rotational component

$u_i = \frac{\partial \phi}{\partial x}, \quad v_i = \frac{\partial \phi}{\partial y}$: Divergent component

- edge normal wind @ Edge

→ zonal & meridional wind @ Center with radial basis function reconstruction

→ interpolate into fixed* lat/lon grid

→ Get **psi & chi @ lat/lon grid** via NCL routine "uv2sfvpf"

* There is also other choices: such as Gaussian grid.

FEniCS

From Bill's note (& what is implemented in MPAS-JEDI)

$u_r = -\frac{\partial \psi}{\partial y}, \quad v_r = \frac{\partial \psi}{\partial x}$: Rotational component

$u_i = -\frac{\partial \emptyset}{\partial x}, \quad v_i = -\frac{\partial \emptyset}{\partial y}$: Divergent component**

- edge normal wind @ Edge

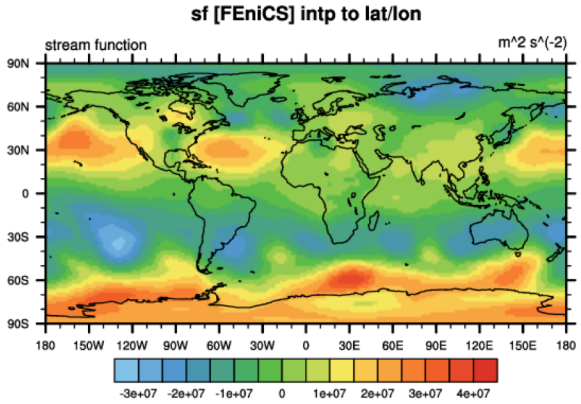
→ vorticity & divergence @ Center

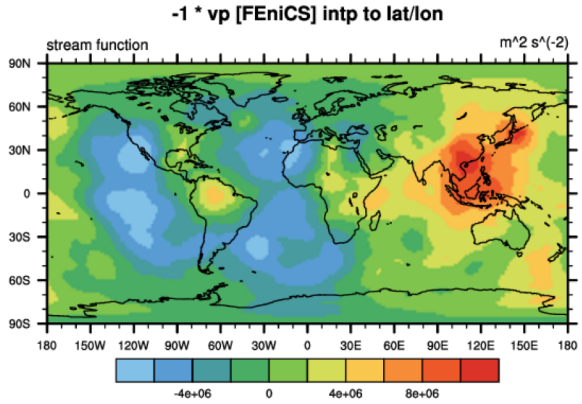
→ Get **psi & chi @ Center** by solving Poisson's equation via Python interface of FEniCS

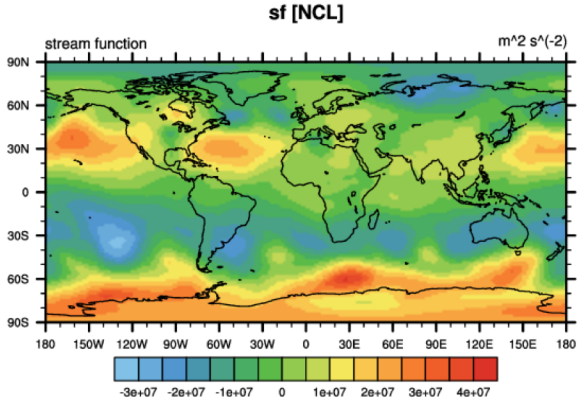
$$-\nabla^2 \psi = -\zeta$$
$$-\nabla^2 \emptyset = \delta$$

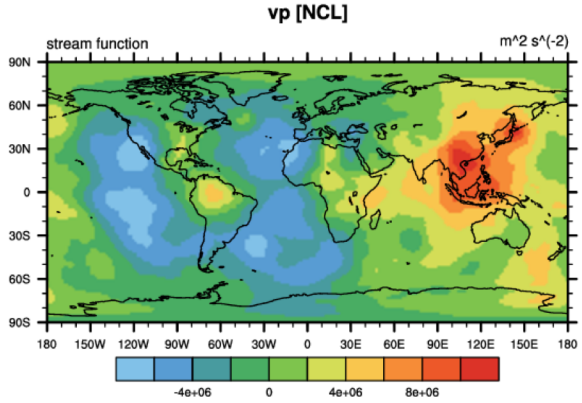
** The phase of velocity potential between NCL and FEniCS is in opposite by definition.

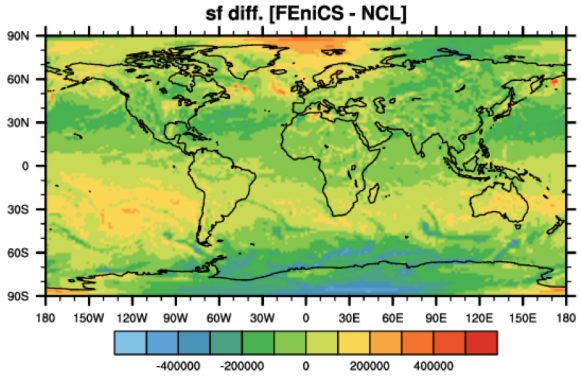
lev=11

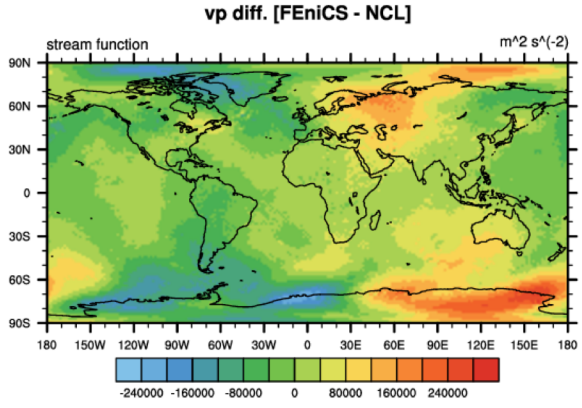












- Qualitatively similar
- Difference is in one-order smaller magnitude.

Short term steps

- With some amount of statistics [psi, chi, T, Ps, q], we want to get the regression coeff. with BUMP.
  - Can BUMP handle a level-by-level regression ?
  - Can BUMP handle a regression between ps & psi ?
  - Can we estimate a reasonable regression coeff. ?
  - Have anyone explorered the BUMP regression capability ?
- Will start the simplest one: < psi, T >, when ready.