Static B in MPAS-JEDI

$$\boldsymbol{B = K_1 K_2 \Sigma C \Sigma^T K_2^T K_1^T}$$

- Analyzed variables
  - zonal wind
  - meridional wind
  - temperature
  - specific humidity
  - surface pressure
- Variables inside B
  - stream function
  - unbalanced velocity potential
  - unbalanced temperature
  - specific humidity (or pseudo RH)
  - unbalanced surface pressure

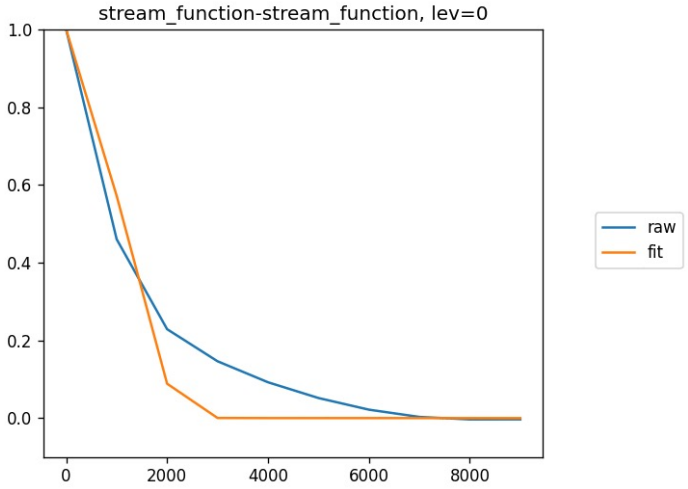
C : Spatial correlation matrix for “unbalanced” variables (BUMP NICAS)
Σ : Multiplying the error standard deviation for “unbalanced” variables (BUMP VARiance)
K_2 : Adding cross-variable balanced parts to unbalanced variables (BUMP Vertical BALance)
K_1 : Converting $\{\psi, \chi\}$ to {u, v} either with MPAS’s own routine or with SABER’s generic routine

Estimating the statistics

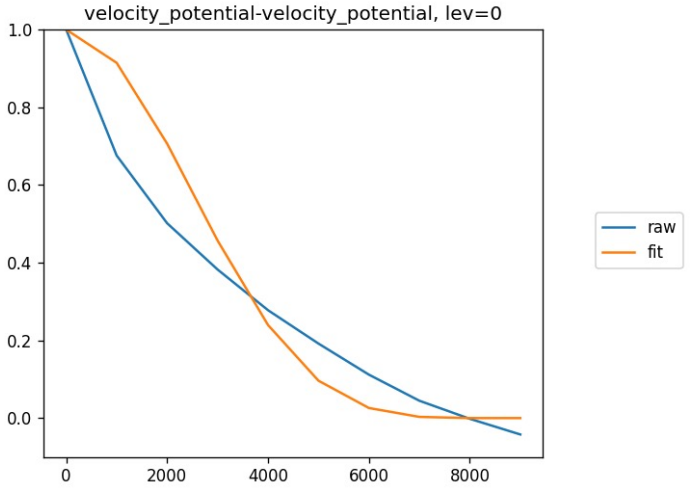
- From 366 samples (3 months) of NCEP GFS 24 hour and 12 hour forecast difference valid at the same time, the **multivariate B** statistics were diagnosed at 120 km mesh.
- Cross-variable regression coefficients, error standard deviations, horizontal and vertical correlation length scales
- Because the inverse of psichi_to_uv is not available on the native mesh, the u/v fields are interpolated to intermediate lat/lon grid, then spectral harmonic transform is used to get the psi &chi. Finally, psi & chi on the lat/lon grid are interpolated back to the native grid.

Function fitting issue

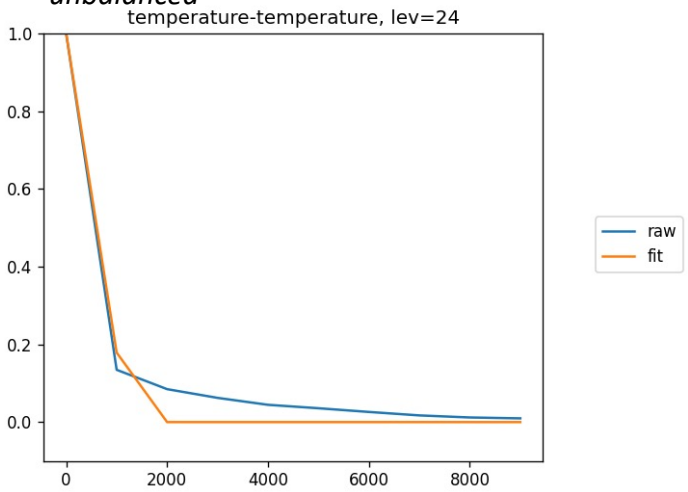
The lengthscale diagnostic in BUMP is based on the Gaspari and Cohn (1999)'s 5th-order function.



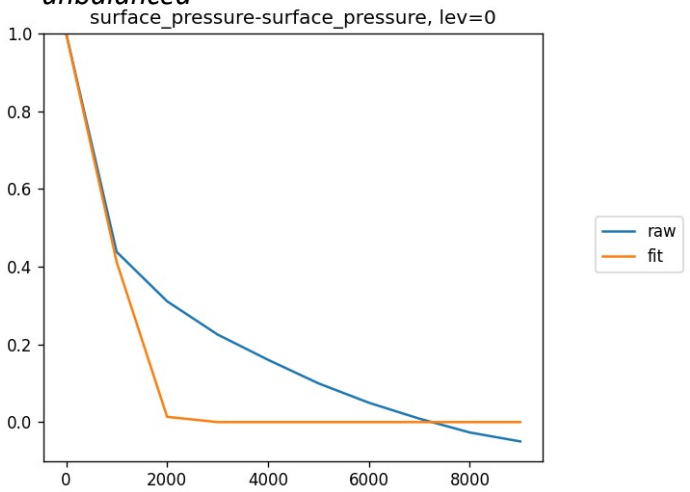
unbalanced



unbalanced



unbalanced



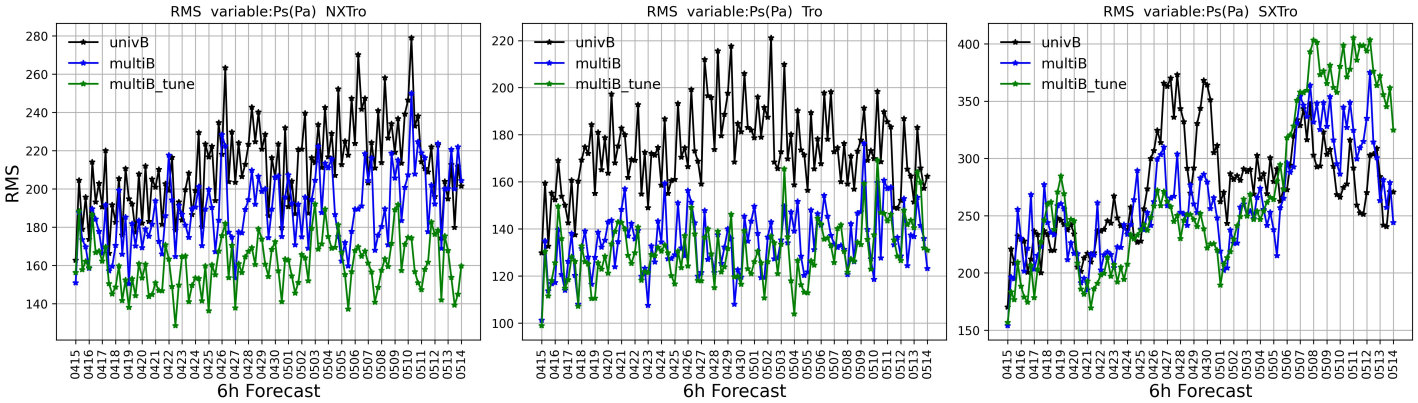
1916.81 km @~400hPa

2621.52 km

Tuned B and cycling test

- A series of single observation tests were performed.
- Based on the horizontal structure and fit-to-obs statistics, we have reduced the horizontal length scales for \psi and \chi_u as half of diagnosed values.

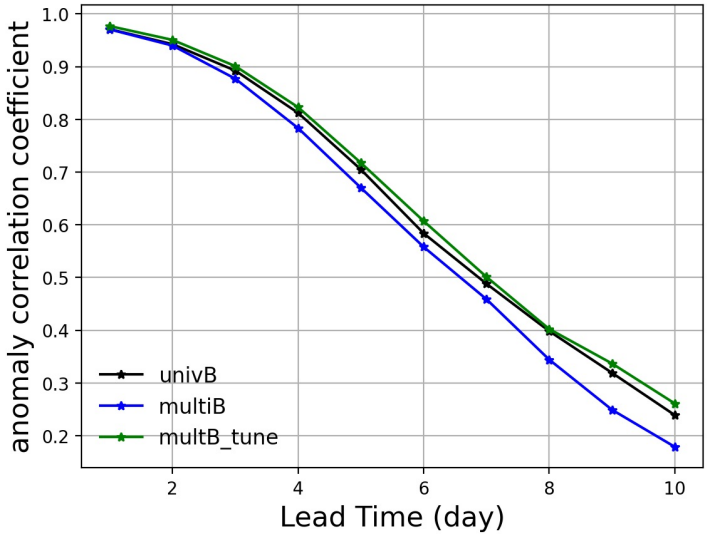
- Month-long cycling experiments, assimilating the conventional observations and clear-sky AMSU-A radiances at MPAS 120 km mesh.



univB
multiB
multiB_tune

Time-series of 6 hr forecase RMSE error for surface pressure

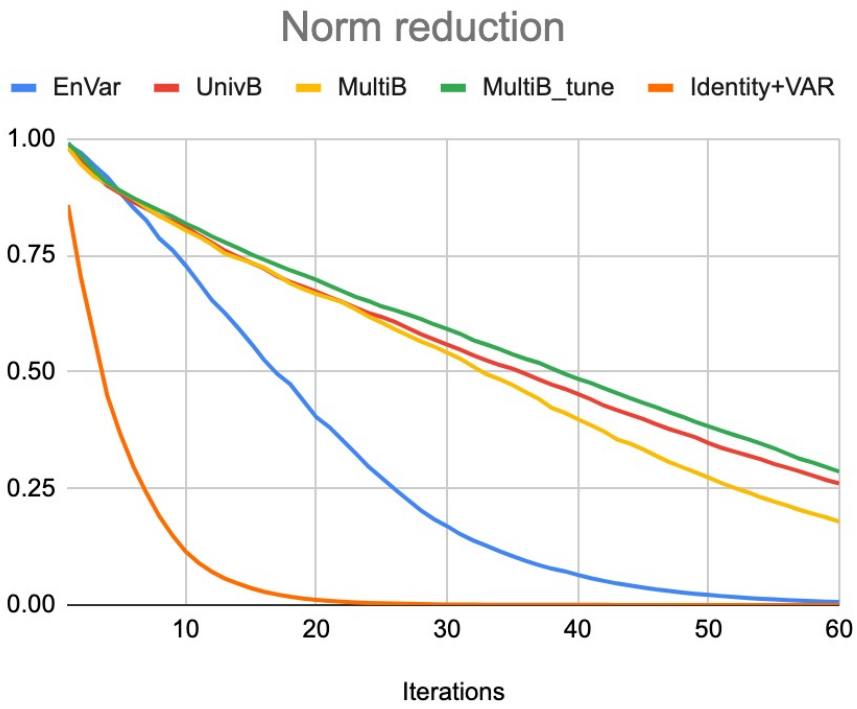
(smaller values are better)

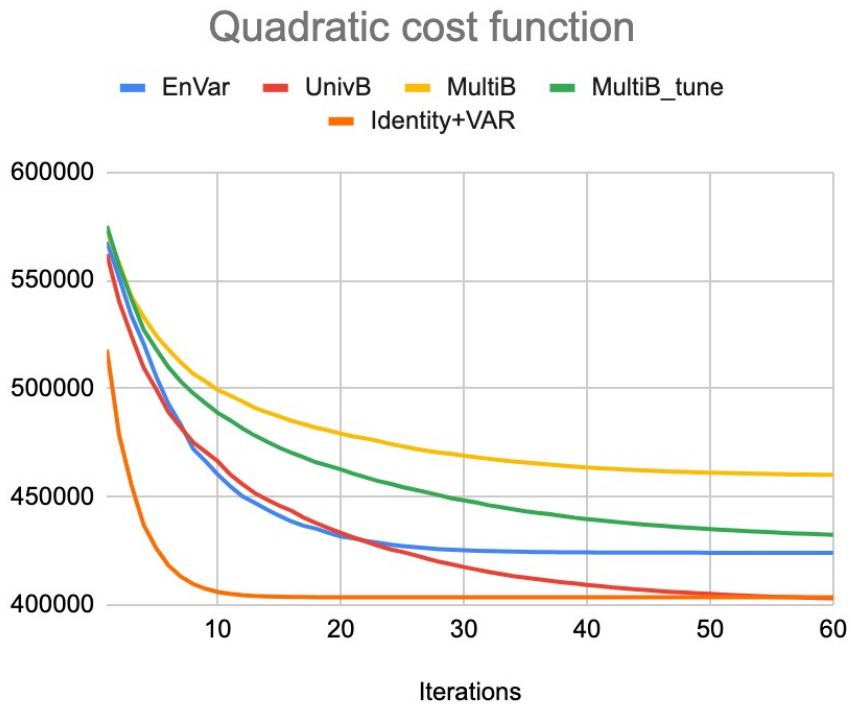


Anomaly Correlation Coefficient (ACC) of 500 hPa height, 10-day forecast initialized at each 00 UTC

(larger values are better)

Slow convergence issue





- DRIPCG Solver, 60 iterations, 120 km, assimilating Conv + clear AMSU-A
- Thefinal gradient norm reductions are…
  - EnVar : 0.006505417145735032
  - UnivB : 0.2626964499623243
  - MultiB : 0.1811678587232298
  - MultiB_tune : 0.2878865880452407
  - Identity+VAR : 0.00000062266194737105 2

psichi_to_uv

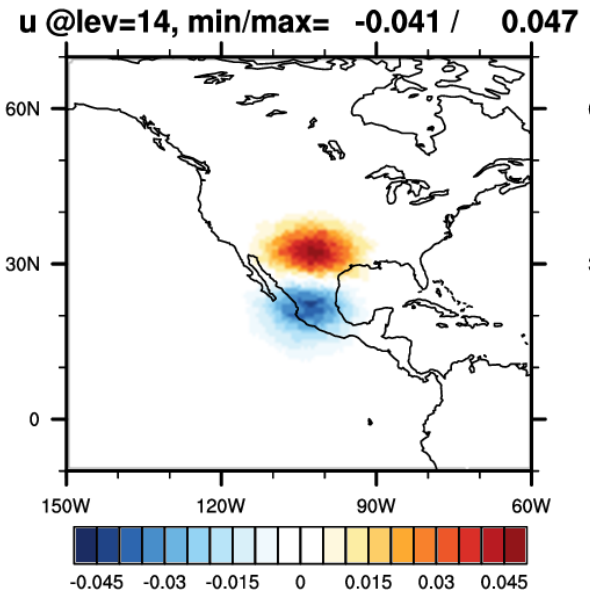
MPAS-JEDI's routine

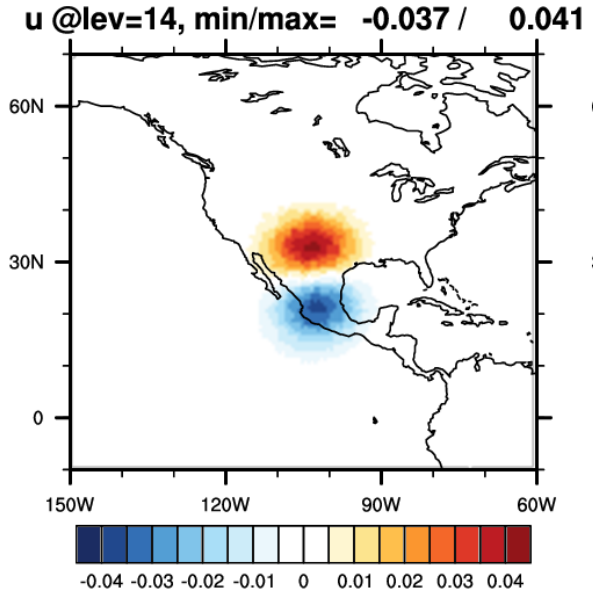
SABER's routine

intermediate 1 deg x 1 deg lat/lon grid

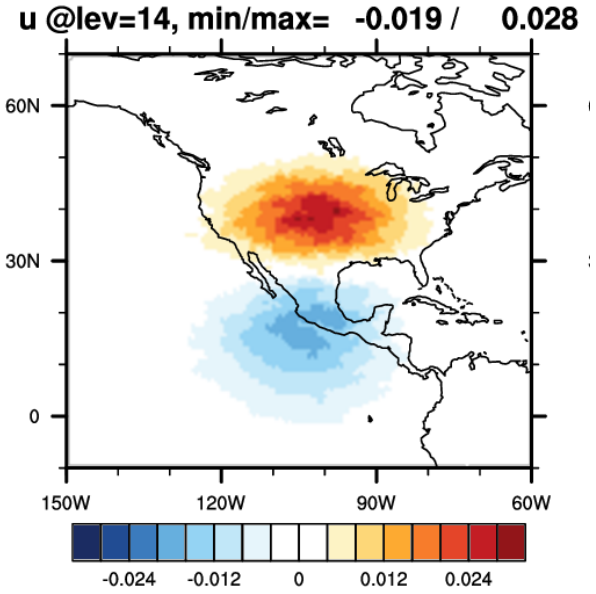
Quick summary

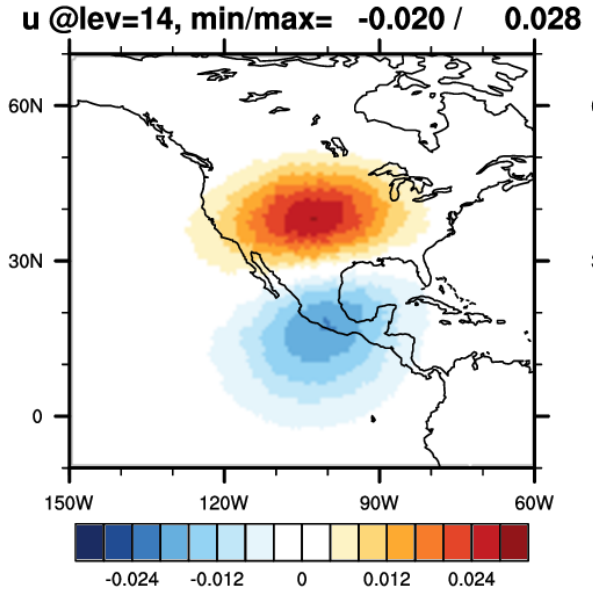
Tuned psi/chi length scale





Untuned psi/chi length scale





U increments from single temperature obs @lev=10 at the center of dipole

psichi_to_uv

- Using the saber's routine slightly improved the convergence.

- Cycling test with SABER's routine:
  - Smaller RMSE for 6 hr wind forecast in the mid-to-upper troposphere over Tro and SXTro.
  - Most surface 6 hr forecast RMSEs get worse.

- Note that…
  - there is a tunable parameter (wind_inflation) in the SABER's routine to compensate the smoothing effect in Savitzky-Golay filter .
  - Nearest neighbor interp. is used from native mesh to lat/lon.

Not part of static B, but related issue

- Connecting the analyzed variables and model variables.
- “surface pressure” is a diagnostic variable in MPAS.
- After analyzing “surface pressure” in DA,
  - the hydrostatic balance applied to update the “pressure”.
  - Then, “potential temperature” and “dry air density” are updated using the Poisson’s eq. and eq. of state.

- Analyzed variables
  - zonal wind
  - meridional wind
  - temperature
  - specific humidity
  - surface pressure

- **Model** variables
  - Edge normal wind
  - Potential temperature
  - Dry air density
  - Mixing ratio