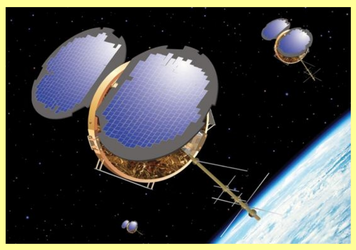
Comparison of GPS local and non-local operators with the GSI system: An OSSE study



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1. Introduction

After deployment to their final orbits, COSMIC is expected provide ~2,500 RO soundings per day uniformly distributed around the globe in near real time to support operational numerical weather prediction. A simple local refractivity operator (1D) has been implemented successfully in the NCEP GSI system. However, in the presence of significant horizontal gradients (strong convection, atmospheric front), the modeling of GPS RO refractivity by the local operator at ray tangent point may result in significant errors. To reduce these errors, a non-local excess phase operator (2D) has been implemented and tested in the GSI system. Using the non-local operator, the along-track refractivity and refractivity horizontal gradient information can be taken into consideration without significantly increasing the computational cost. An OSSE is performed to evaluate the performance of local and non-local operators for a GPS RO sounding that passes through the eye of Hurricane Katrina, where there are significant horizontal refractivity gradients.

2. Non-local approach

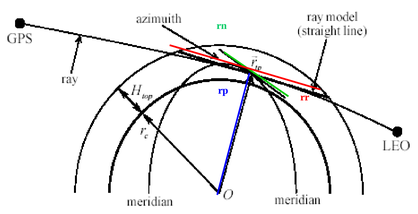


Fig.1: layout of ray trajectories for modeling of non-local observables

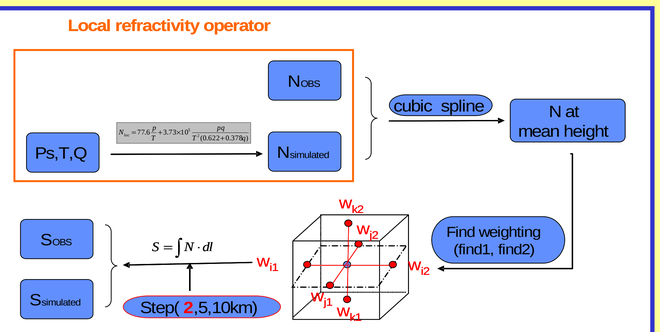


Fig.2: The Non-local code —— General Flow

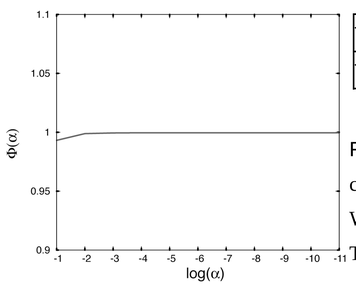
Sokolovskiy et al.(2005) developed an non-local operator to account for the effect of horizontal gradient, and showed it may reduce the representiveness error than local.

3. Implementing Non-local into the GSI system

The basic analysis problem of the GSI system with increment approach is to minimize the cost function:

$$J(x) = J_B + J_N + J_{others}$$

After Implanting Forward operator, its Tangent Linear and Adjoint, the system is tested successfully. Observation error statistics



<dy,dy>	0.2168395953702E+01
<dx,dx*>	0.2168395953702E+01

Fig.3: Non-local operator tangent linear check. The variation of $\phi(\alpha) = \frac{F(X+\alpha X) - F(X)}{\alpha X^T \; g\_F(X,\alpha X)}$ With respect of $\log(\alpha)$

Tab.1: shows Adjoint check.

4. Design of OSSE

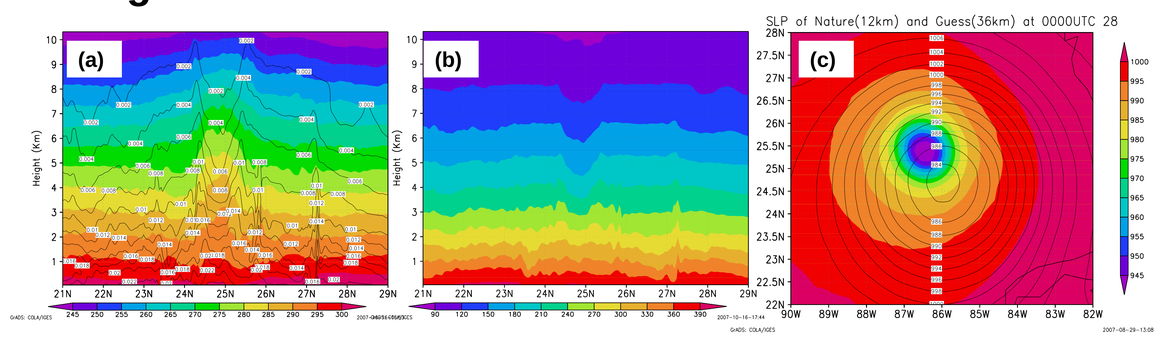


Fig. 4: (a) Vertical distribution of T (K) and Q (kg/kg), and (b) refractivity (N) crossing the "eye" of Katrina (24.8° N) along south-north cross section; (c) sea-level pressure (hPa) of "nature" run (contour) and first guess (line) at 0000 UTC 28 August 2005.

- Produce "nature" run comes from WRF ARW 24-h forecast (0000 UTC 28 August 2005) with a high-resolution grid (4 km, 361 x 361x 38);
- Simulate GPS RO sounding from a north-south cross section cutting through the "eye" of Hurricane Katrina with a 2D ray-tracing method;
- Assimilate this single sounding with local and non-local respectively in the GSI;
- Make the comparison of analysis from local and nonlocal.

5.1 Comparison —— Difference

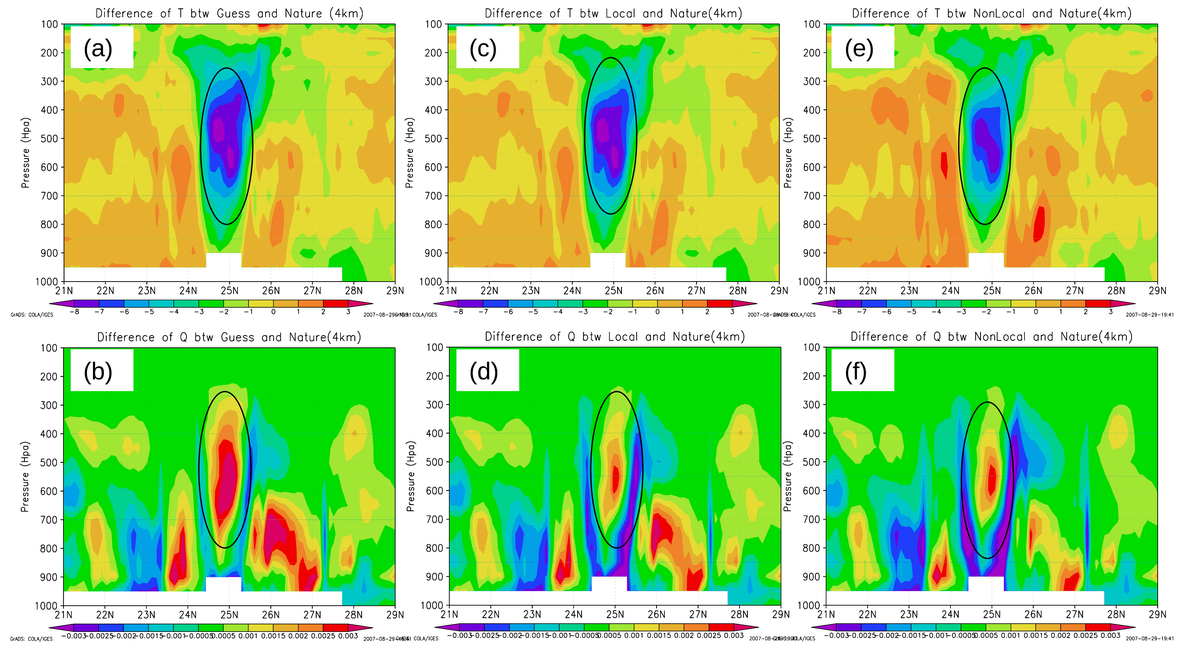


Fig.5: The vertical differences between the assimilation experiments and nature run along the ray path. They are the background (a,b), GPS local (c,d) and GPS non-local (e,f) minus the "Truth" for Temperature (up panels) and Moisture (below ones).

5.3 Comparison —— Bias and STD

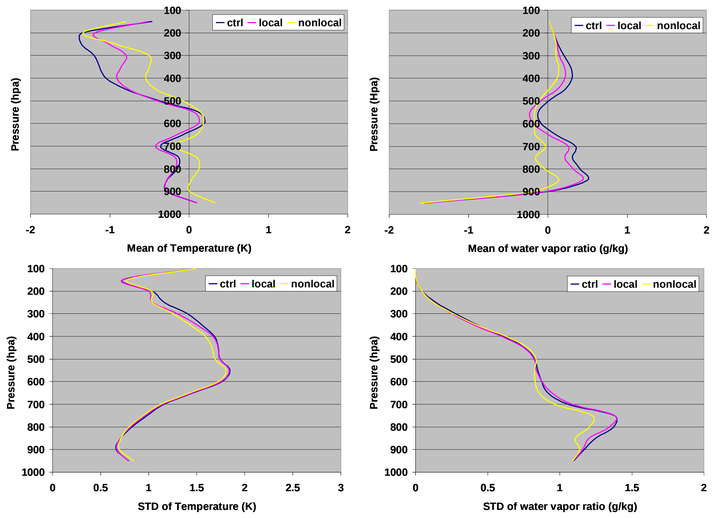


Fig.8: The bias (up) and standard deviation (below) of difference for temperature (left) and water vapor mixing ratio (right) btw assimilation experiments and "truth" within 250x250 km of GPS simulated sounding.

5.2 Comparison —— Increments

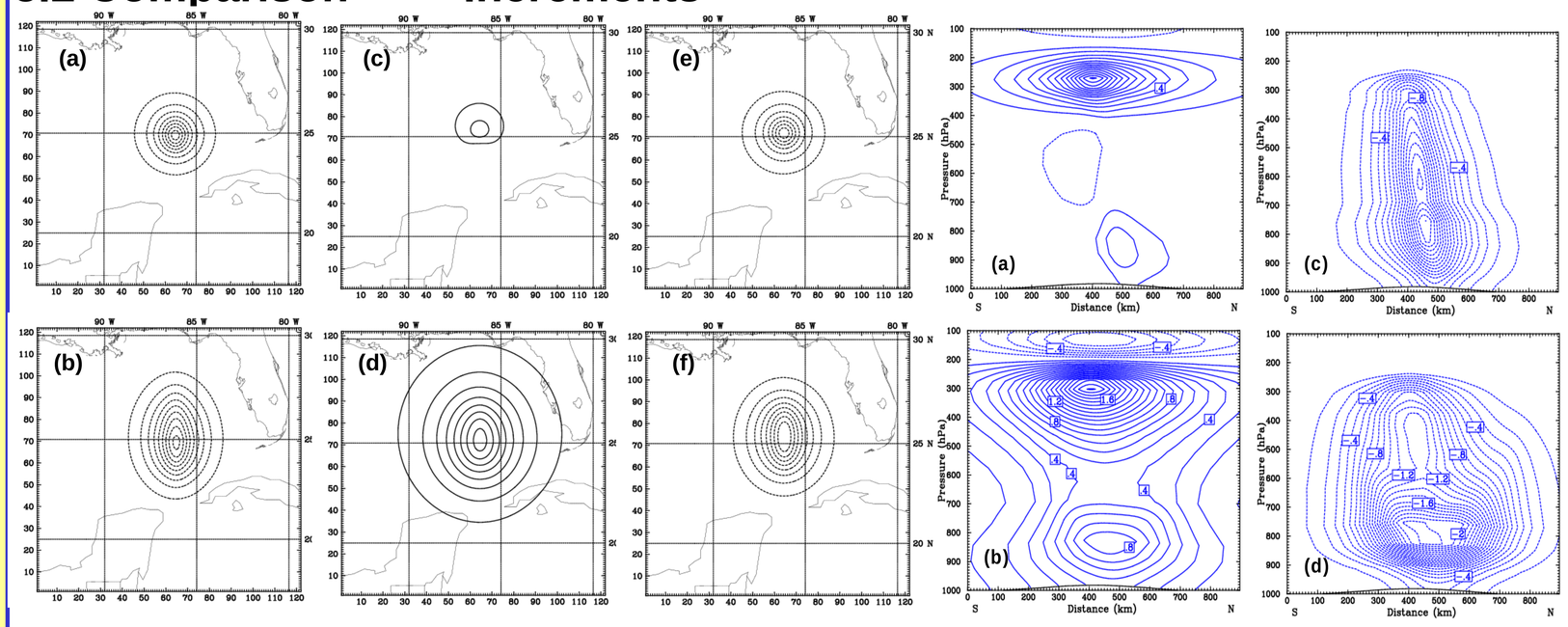


Fig. 6: the horizontal increment of (a,b) sea-level pressure, (c,d) T and (e,f) Q at 850 hPa; The up panels are local, the low ones are non-local.

Fig. 7: the Vertical increments of (a,b) T and (c,d) Q The up panels are local, the low is non-local

6. Conclusions and Discussion

The results show that shape and magnitude of the analysis increments for various model variables including, sea level pressure, temperature and water vapor mixing ratio, exhibit significant differences between local and non-local operators. The non-local operator produces more accurate analyses, when verified against the "truth" derived from the nature run. Another similar experiment (figure omitted) was performed over a region where there is little horizontal gradients. As expected, both non-local and local produce similar results over such area.

In the future, We will continue to working on the COSMIC follow-on with OSSE method.