

The benefits of assimilating HIWRAP radial velocity with an ensemble Kalman filter

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Summary from Yesterday:

- HIWRAP data apparently useful for hurricane analyses and forecasts
- Focusing flight track on the inner core allows for more accurate inner-core analysis, but at the expense of analysis accuracy at larger radii
- There is NO meaningful difference in forecasts initialized from analyses with aforementioned different flight tracks
- Assimilating simulated HIRAD + HIWRAP simultaneously appears to benefit analysis accuracy more than for HIWRAP alone

Objectives Review

1. Generate 48-h ensemble and deterministic forecasts without data assimilation
2. Select 'truth' realizations for simulated data experiments
3. Assimilate simulated HIWRAP observations with an ensemble Kalman filter (EnKF)
4. Assess quality of analyses and forecasts as a function of first-guess quality

WRF-EnKF system

- EnKF from Zhang et al. (2009)
- WRF-ARW V3.1.1, 27/9/3 km
- 30-member ensemble, IC/BCs from WRF-VAR + GFS
- Ensemble integrated 12 h to generate mesoscale covariance
- WSM-6 mp for assimilation; GSFC for truth (model error)



Model domains

Selecting ‘truth’ realizations

Realizations selected to test EnKF performance in face of:

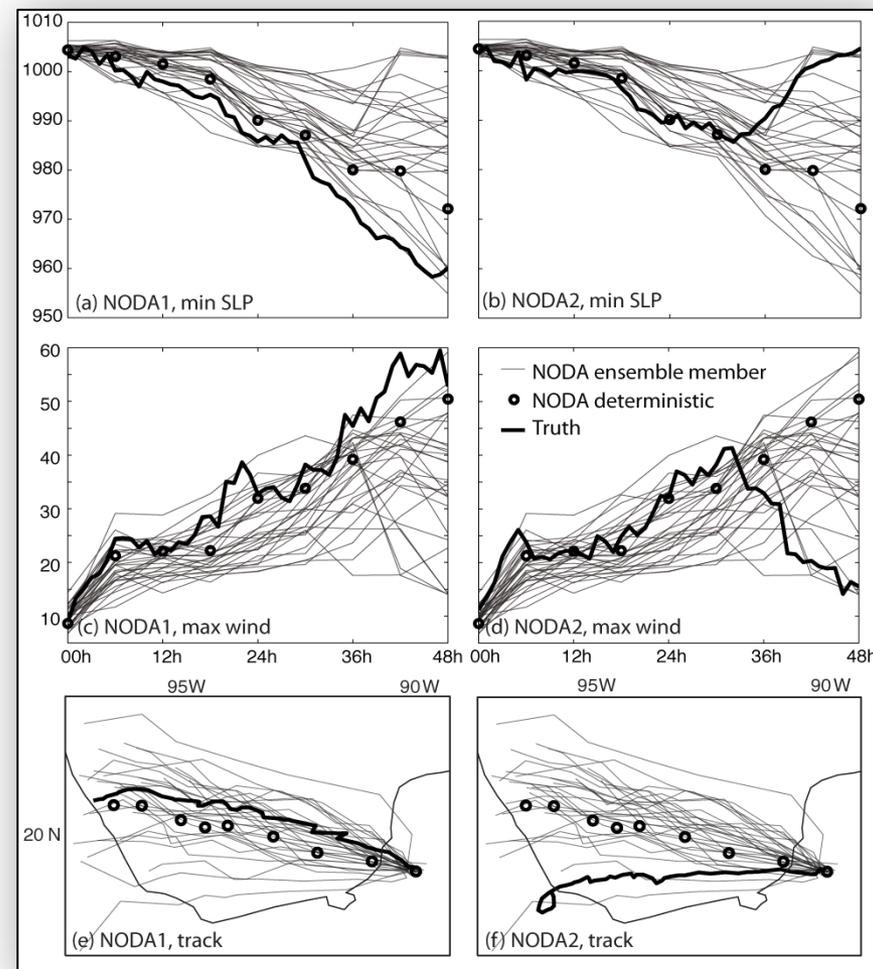
- Small error of the prior

How much improvement does the EnKF offer when the forecast is already pretty good? (NODA1)

- Large error of the prior

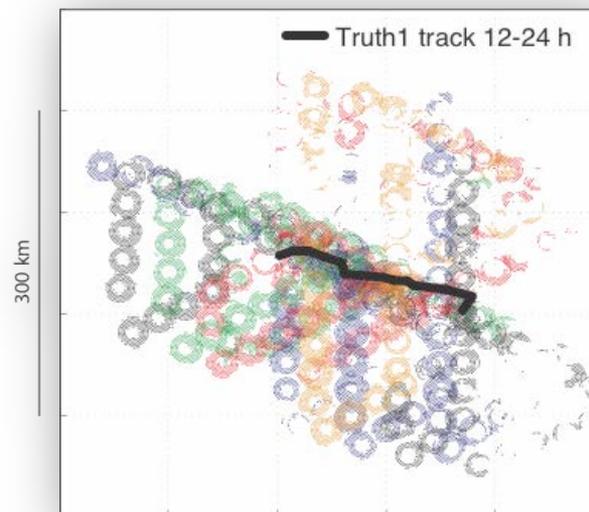
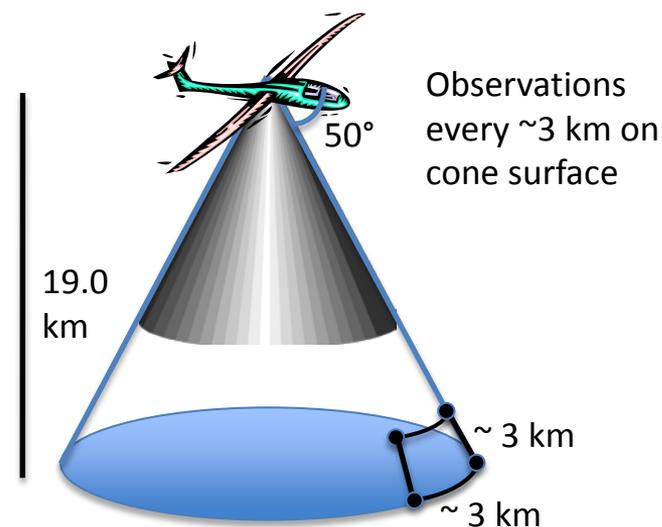
How well can the EnKF correct when the truth is unlike most of the prior? (NODA2)

‘Truth’ realizations and NODA forecasts



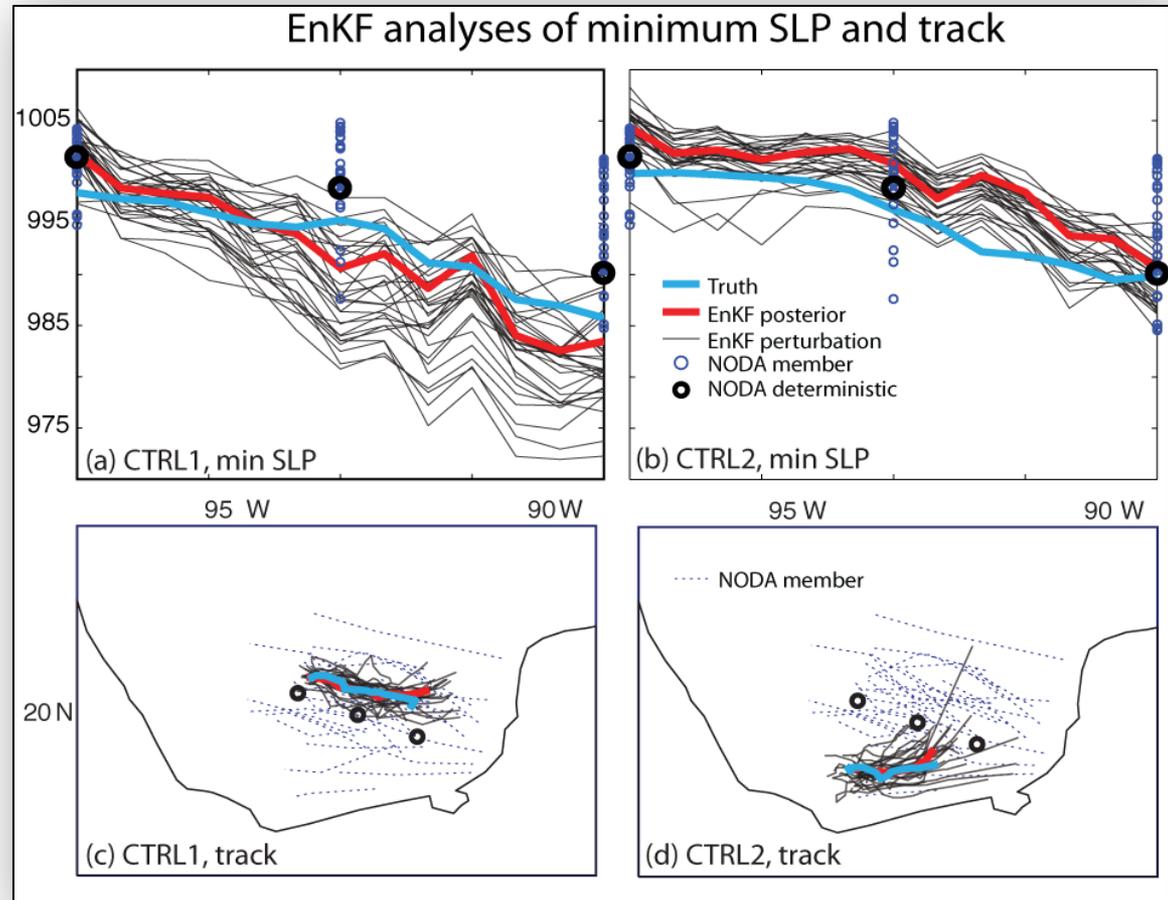
'Truth' simulation flight tracks

- Instantaneous scans every ~ 28 km; observation cones slightly overlap at surface
- Data grouped into 1-h flight segments from same output time; ~ 1900 obs/hr
- Add 3 m/s random error, only assimilate when attenuated dBZ > 10



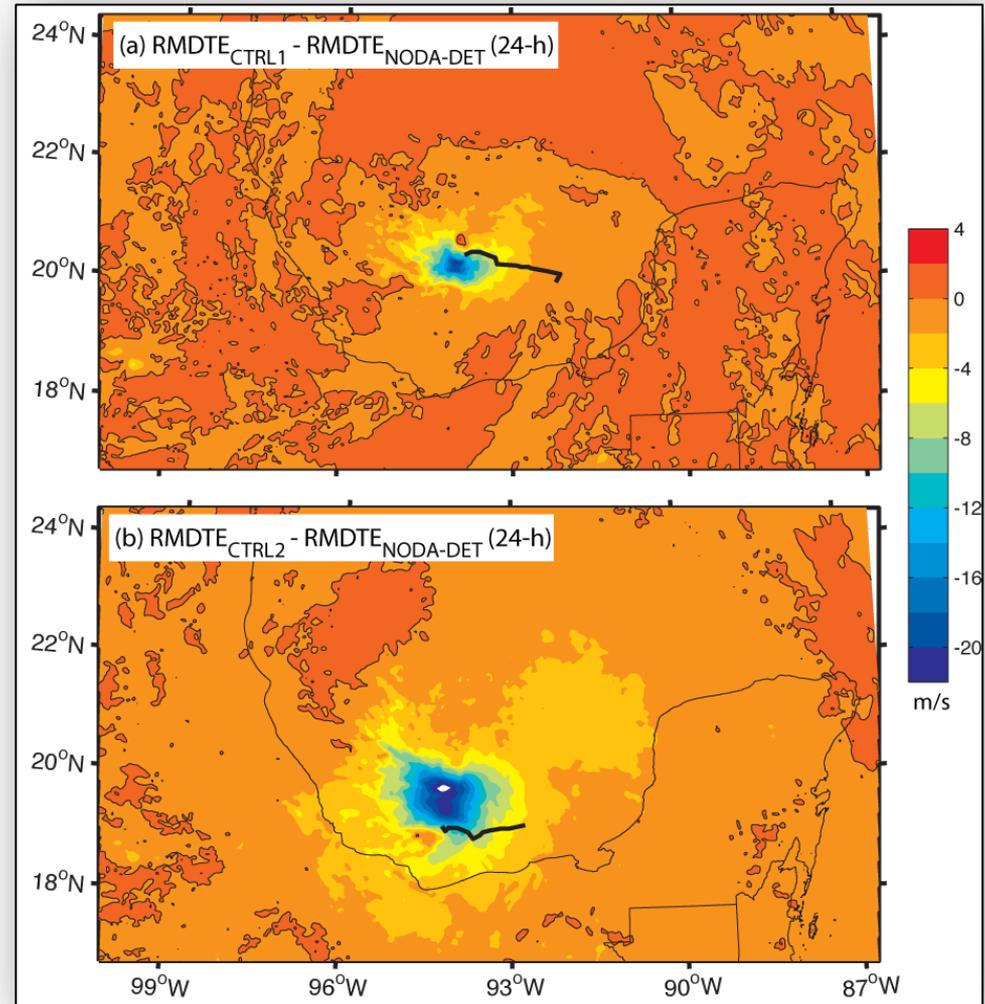
Results: Analysis evolution

- Intensity metrics:
Generally small corrections due to small initial error in NODA
- Position: more noticeable correction, particularly for CTRL2



Results: Analysis error after 12 h

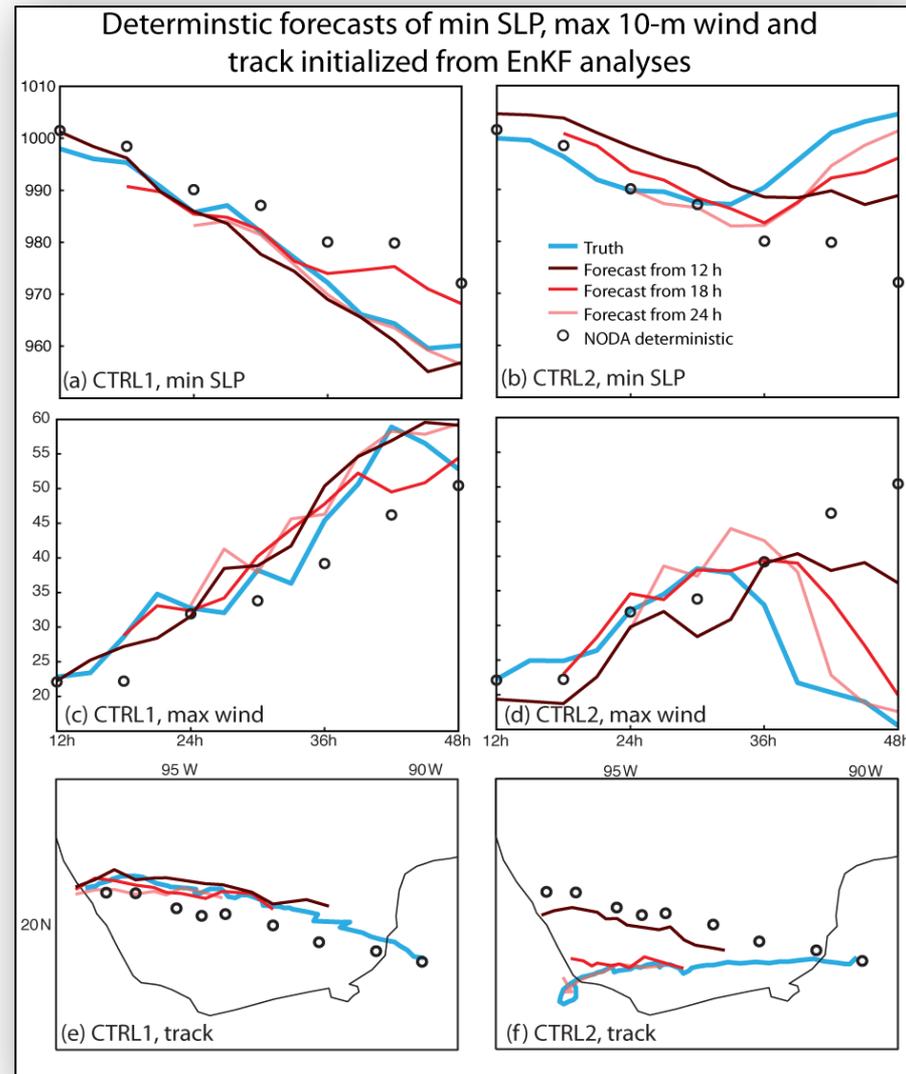
- EnKF reduce RM-DTE > 80% after 13 cycles in both cases [DTE = $0.5 \times (u'u' + v'v' + Cp/Tr \times T'T')$, prime is difference from truth]
- CTRL2 has larger and more widespread error reduction than CTRL1



Comparison of RM-DTE differences

Results: Deterministic forecasts

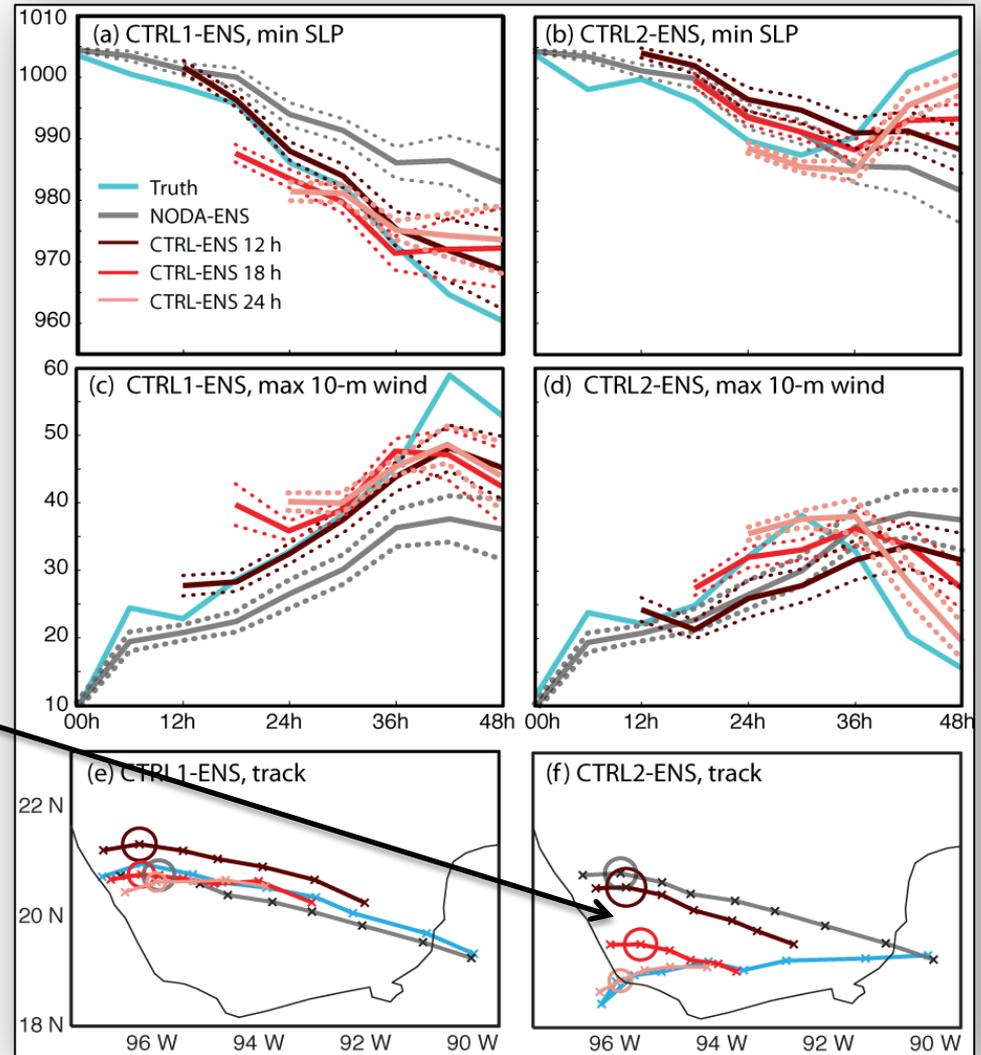
- Forecast error is reduced relative to NODA in both cases, particularly from 36-48 h
- NODA2 needs more time to produce better analyses (i.e., that produce 'good' forecasts)



Results: Ensemble forecasts

Similar to deterministic
forecast results...

Note huge benefit of
cycling

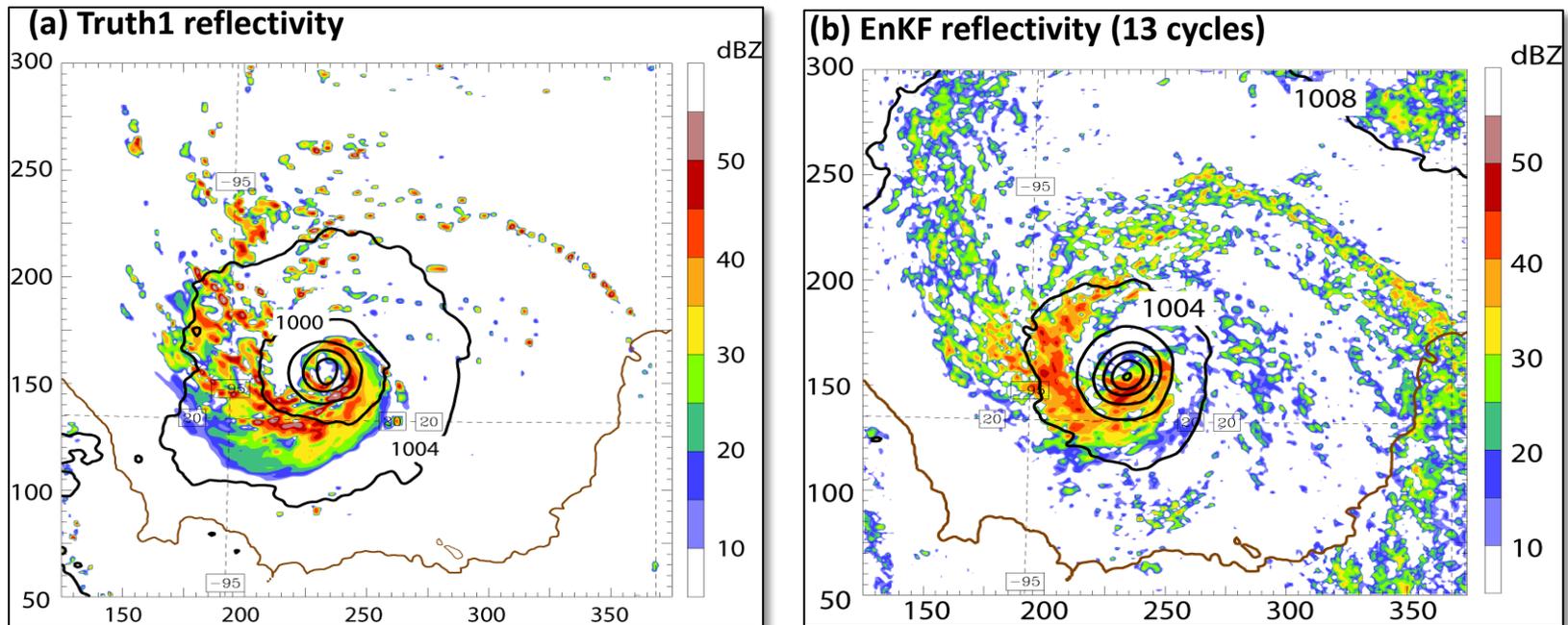


Summary

HIWRAP data appears to be useful for EnKF analyses and subsequent forecasts of a hurricane, particularly when the first guess is poor

- Strongest analysis error reduction for a poor first guess
- Notable forecast improvements after just one assimilation cycle in CTRL1
- A longer assimilation window (i.e., Global Hawk time scale) appears to benefit forecast more when the first guess is poor

Results: CTRL1 after 13 cycles



EnKF is able to produce good analysis of storm structure