Assimilation of ocean surface wind vectors into global and regional models of tropical cyclones: Present and future.

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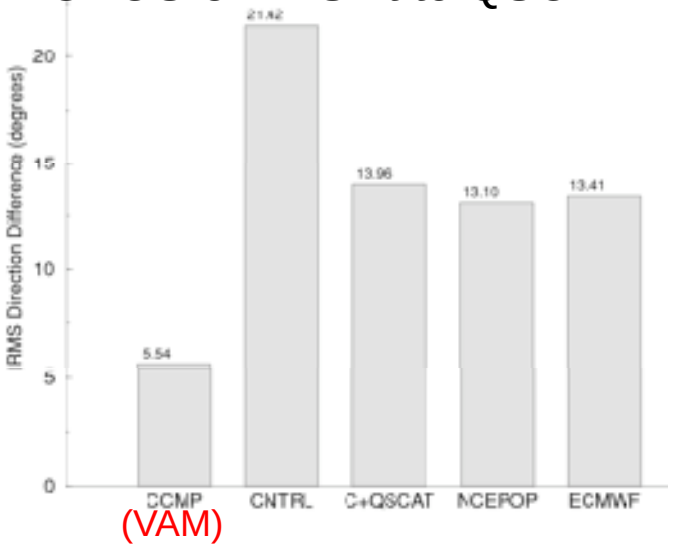
Outline

1. Ongoing activities
    a. Generation of the Cross-Calibrated MultiPlatform (CCMP) Ocean surface wind data set.
    b. Evaluate (and enhance) the impact of each type of satellite surface winds on ocean surface wind analyses and NWP.

2. Numerical modeling and data assimilation experiments for tropical cyclones
    a. Real data (QuikSCAT) in NCEP GSI
    b. Synthetic data in NCEP GSI
    c. Varying vertical error covariance in NCEP GSI
    d. Ensemble Kalman Filter (EnKF)

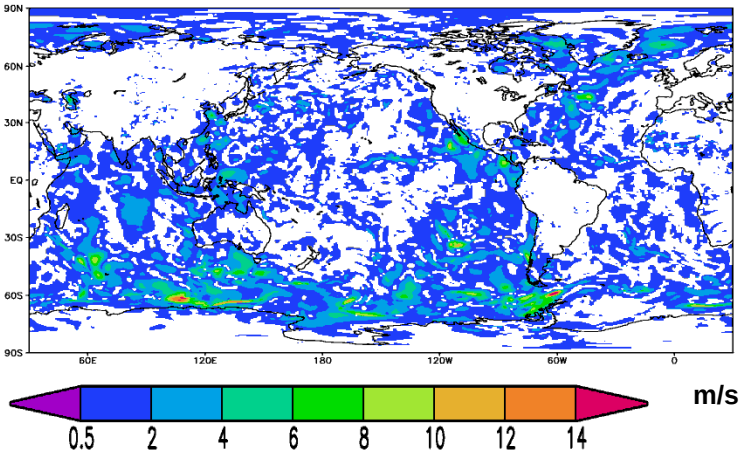
Ongoing activities

GEOS-5 RMS fit to QSCAT

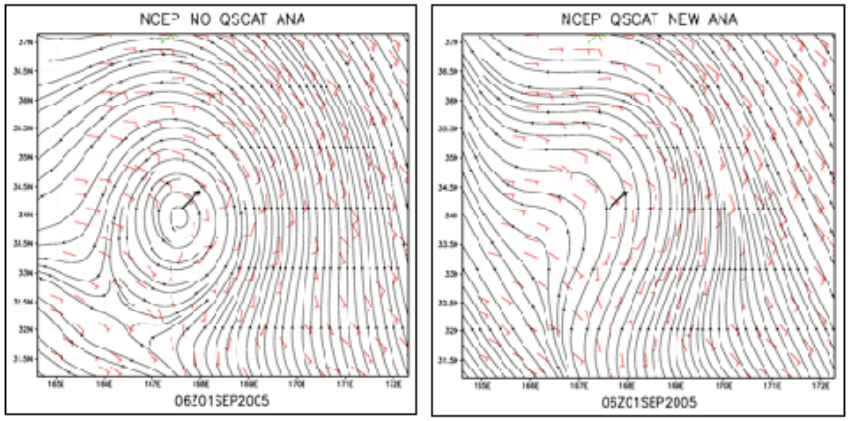


(VAM)

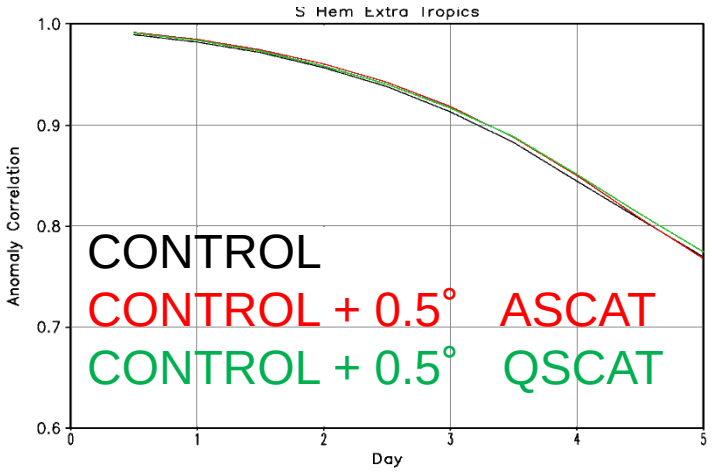
Impact of QSCAT on GEOS-5 surface wind analysis: 1 week



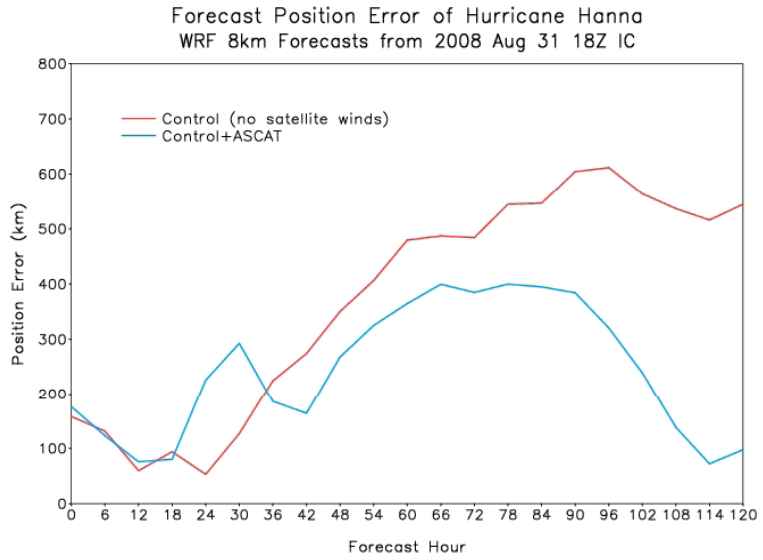
Removal of spurious cyclones via QSCAT

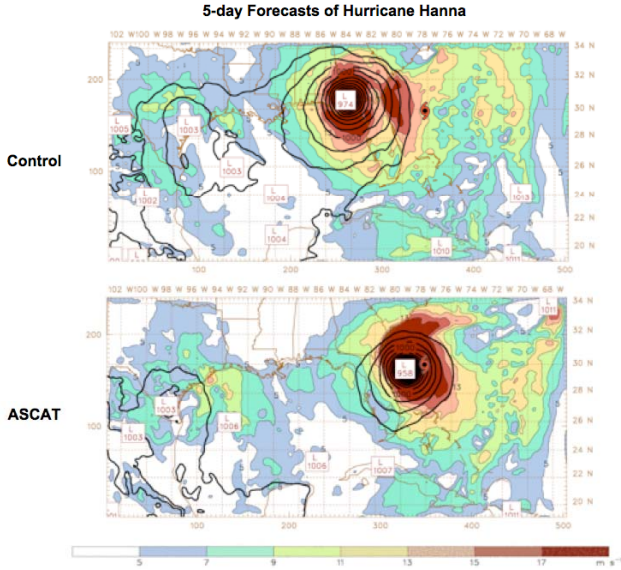


GEOS-5: QSCAT and ASCAT



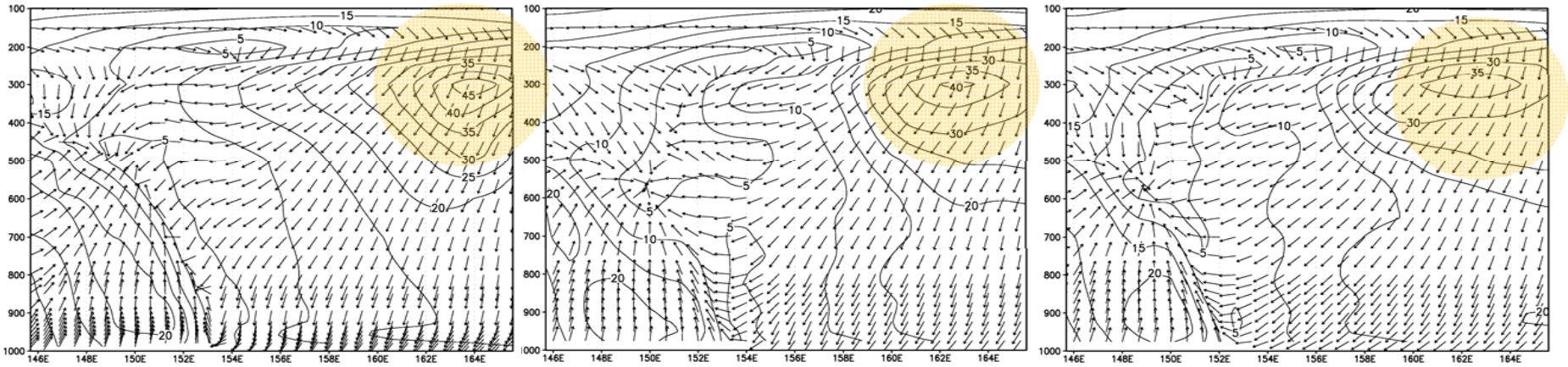
Ongoing activities





Assimilation of ASCAT winds into GEOS-5: Beneficial impact on WRF track and intensity forecasts of Hurricane Hanna (2008)

OSSE: Assimilation of synthetic QSCAT winds in GSI can degrade analysis of jet stream



"Truth" Control Control + Winds

Summary 1

(i) CCMP

- Generated 20+ years of 6-hourly CCMP OSVW data at 25 km resolution.
- Close fit to data, significant improvements in meteorological features.
- Infrastructure to rapidly reprocess based on recommendations from OVW community.

(ii) Impact Studies

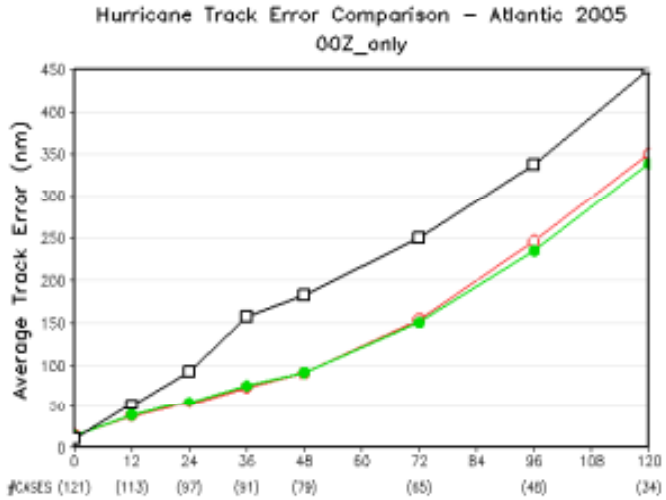
- Assimilation of QuikSCAT winds generally improves NASA and NCEP model analyses of ocean surface winds.
- Impact on forecasts is positive but smaller than that previously obtained. Impact limited by competing data, super-obbing, aspects of GSI analysis.

- QuikSCAT and ASCAT winds, derived sea level pressure and gradient level winds are being assimilated using the GEOS-5, NCEP and WRF models to assess the potential for increased beneficial impact of OVW-derived mass and wind data.

2a. NCEP/EMC Study

Data denial experiments 2005/6:

- No QuikSCAT
- QuikSCAT wind vectors processed by NESDIS



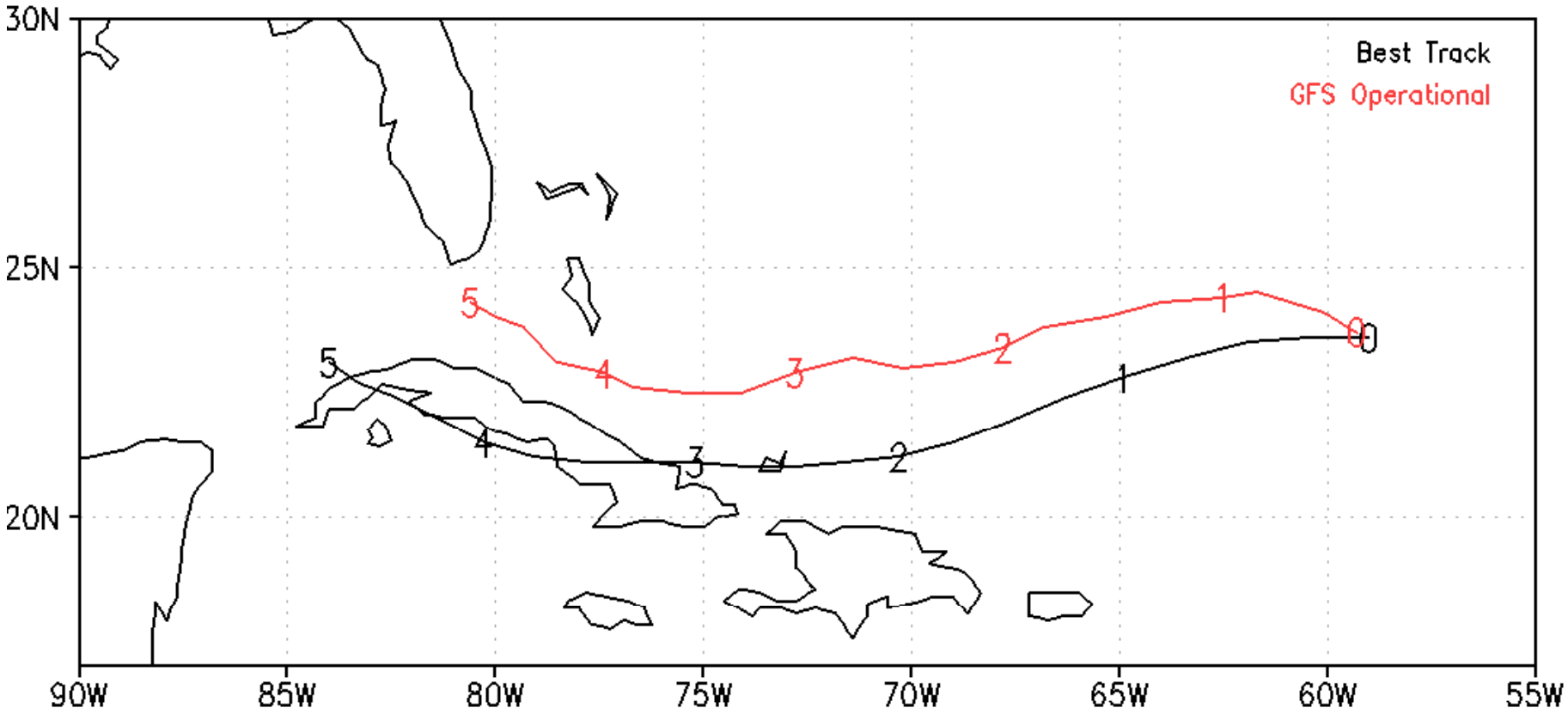
Overall conclusion: Assimilating QuikSCAT data had little impact on NCEP GFS hurricane track errors

- Conservative QC; observation error (3.5 m/s)
- Super-obs: obs averaged in 1º x 1º boxes
  - Significant wind vectors (>20 m/s) are compromised
- Short vertical error correlation lengthscale, appropriate for tropical cyclone?

2b. GSI Assimilation experiments

- One assimilation time: 00 UTC, Sept 5th 2008
  - Hurricane Ike in western Atlantic
- Operational NCEP GSI as of 2008-9
  - ~ 35 km resolution
- Current capability:
  - Assimilating operational observations
  - Synthetic-observation experiments

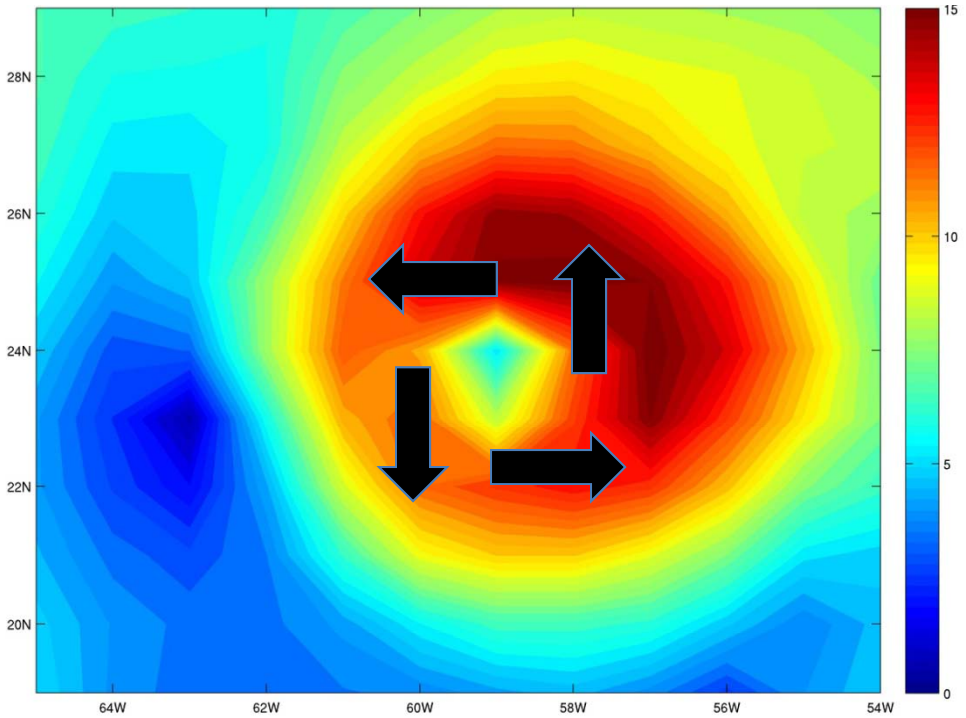
Operational GFS forecast

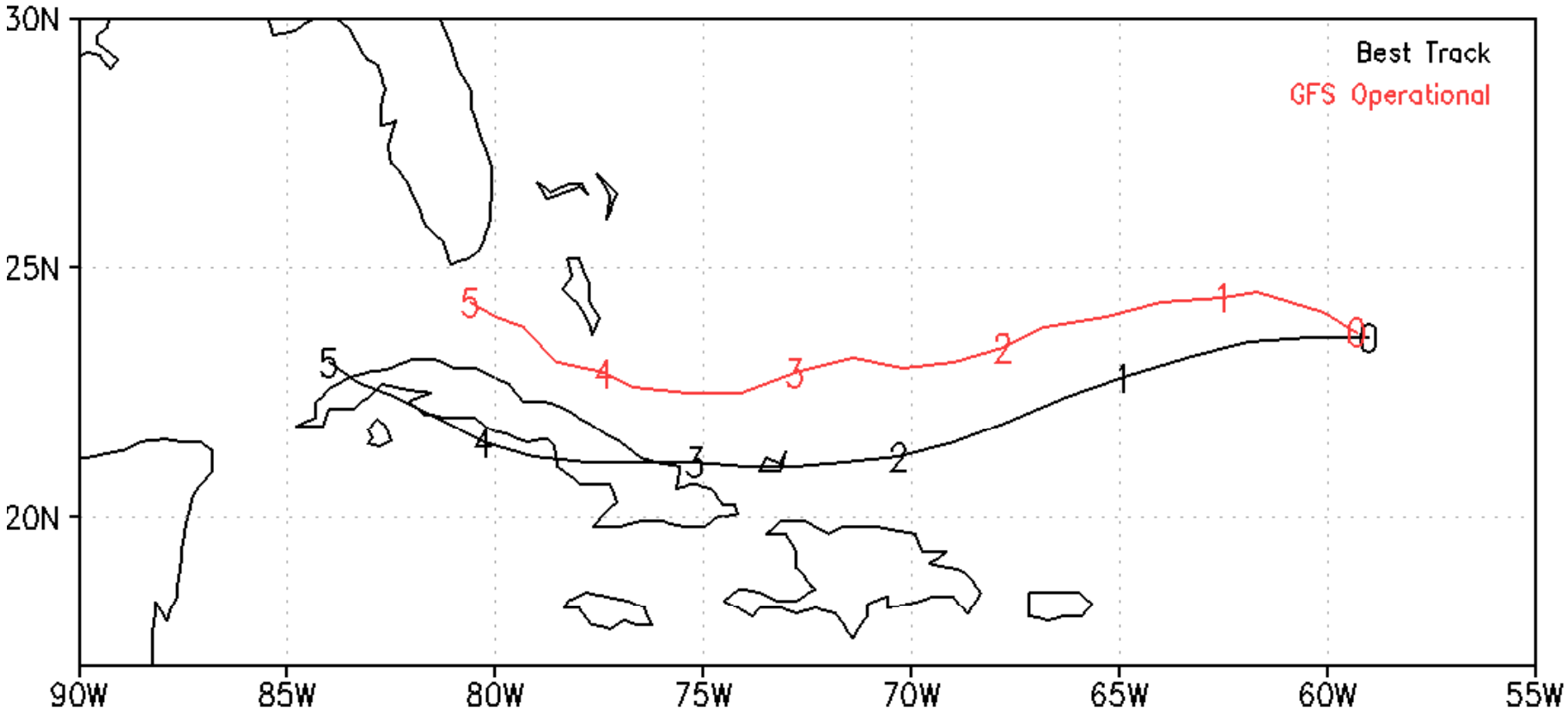


Synthetic observations of u, v

Suppose that there were 4 new, near-perfect wind observations, reporting wind speeds 10 m/s higher than the analysis.

What would be their impact on the analysis?




30N
25N
20N
90W
85W
80W
75W
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55W
Best Track
GFS Operational
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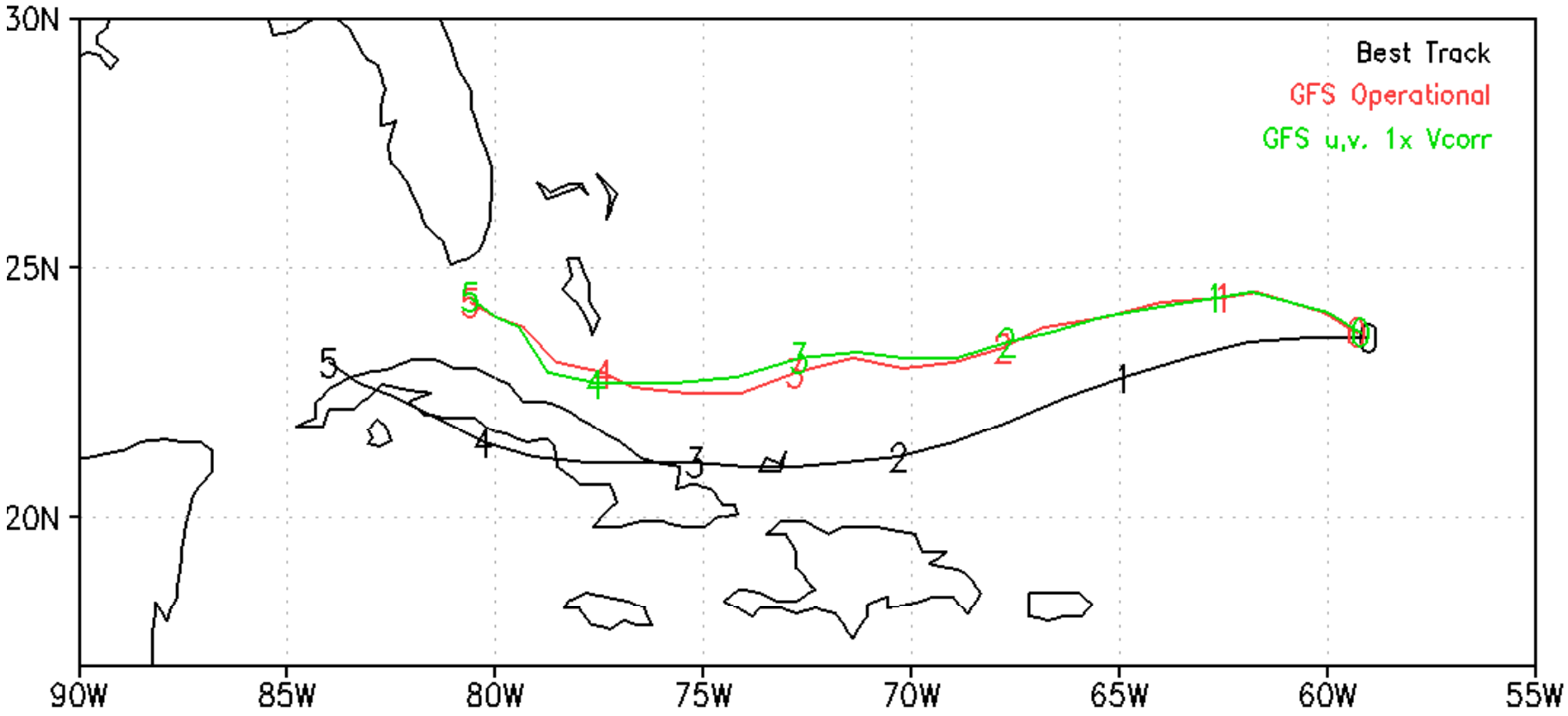
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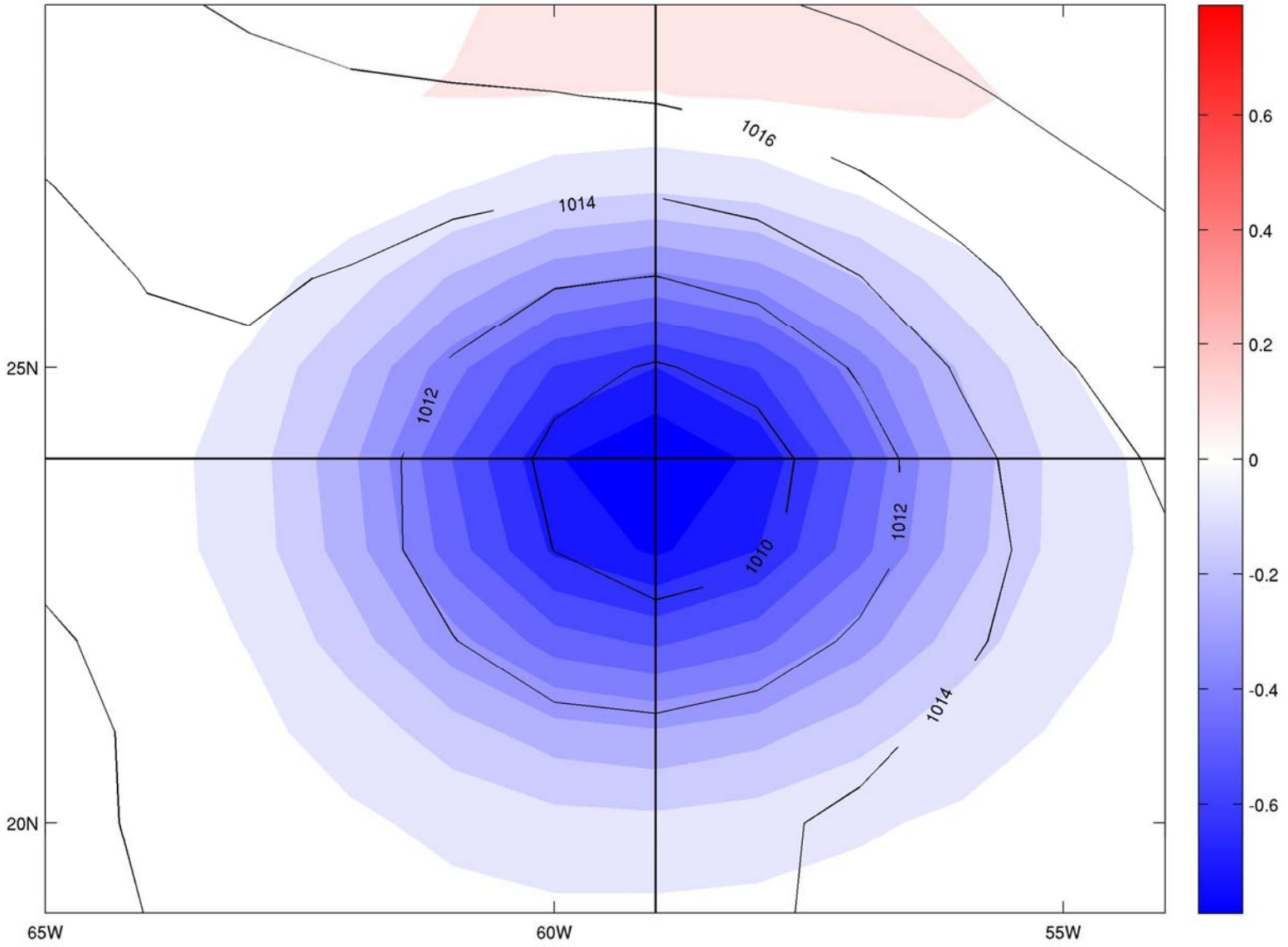
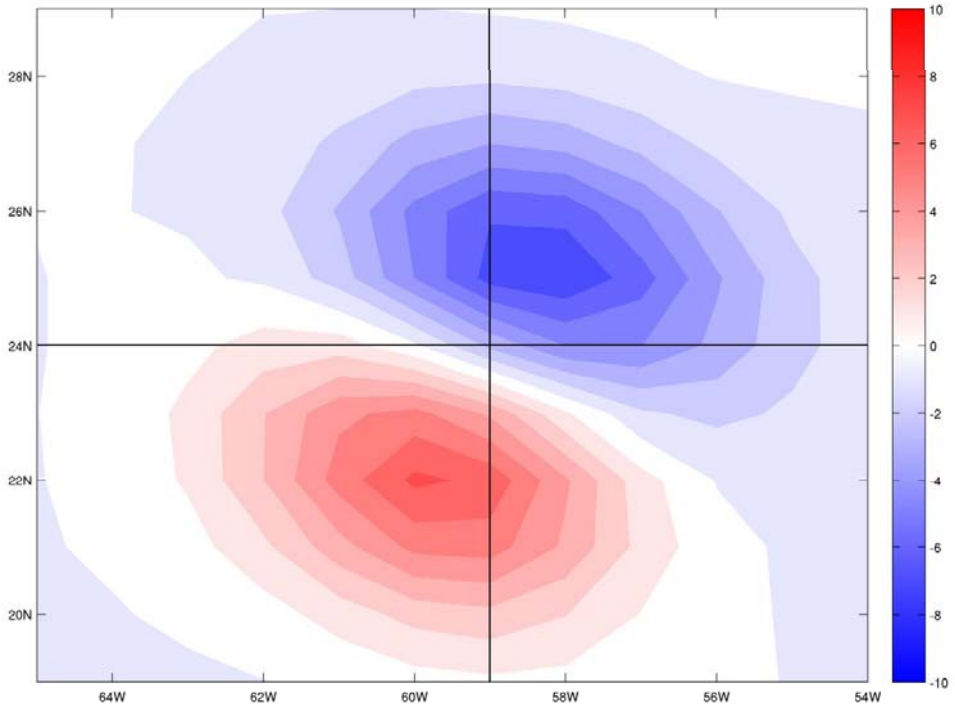
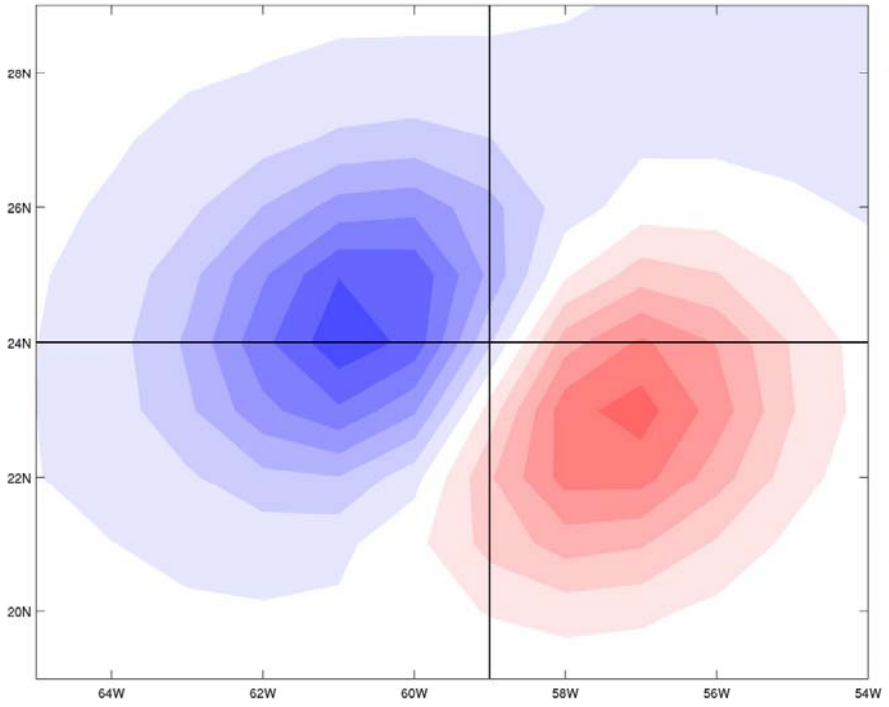
Analysis increment (analysis – f.guess) in MSLP



Analysis increment of 1000 hPa u, v

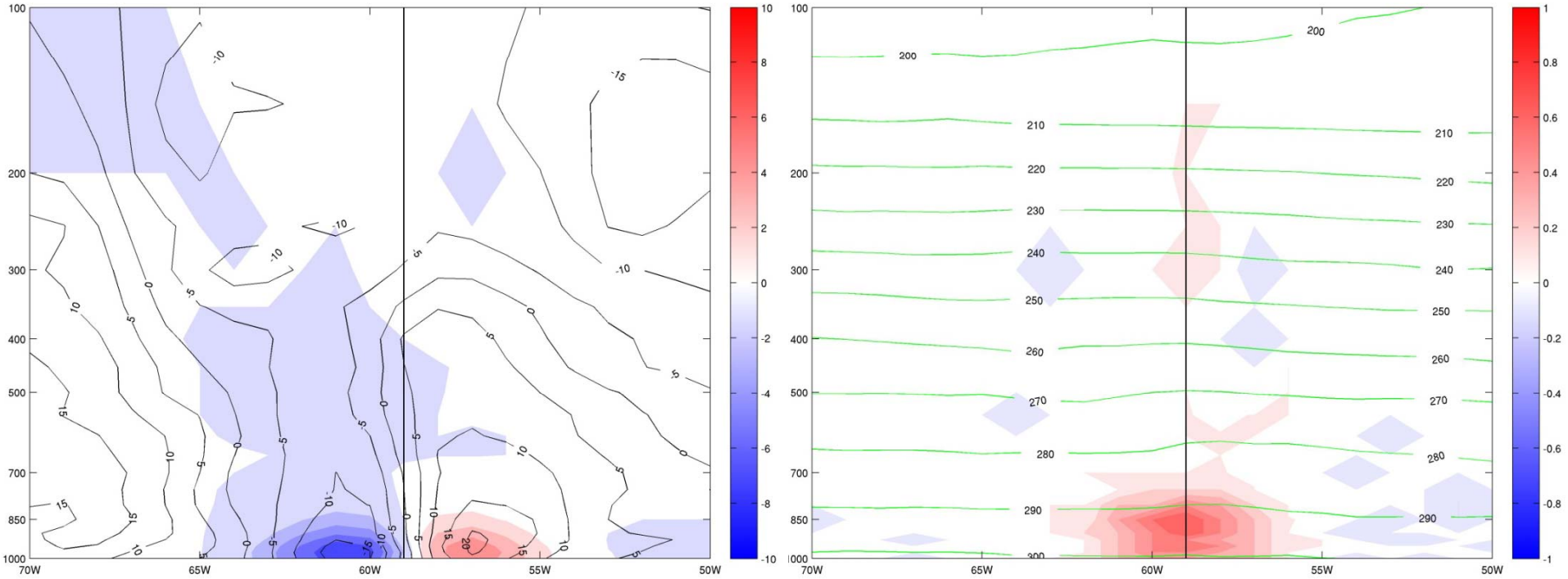


u



v

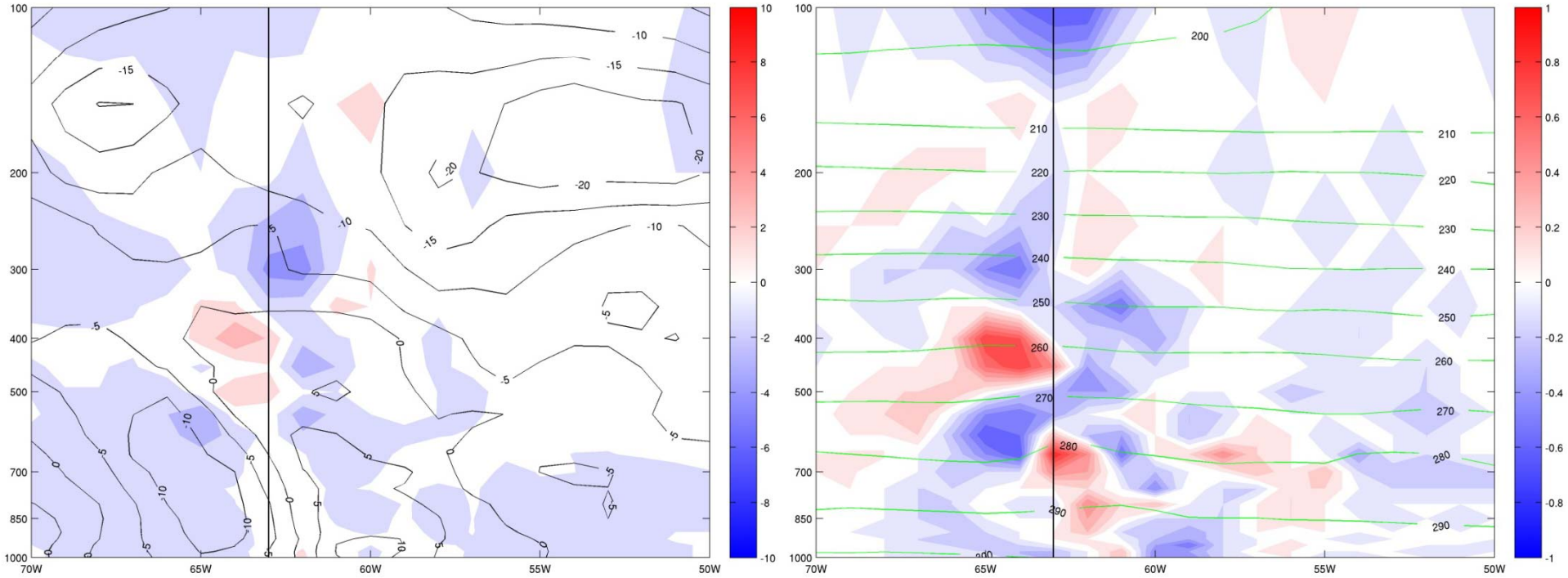
Vertical E-W cross-section through Ike: Analysis increment



v

T

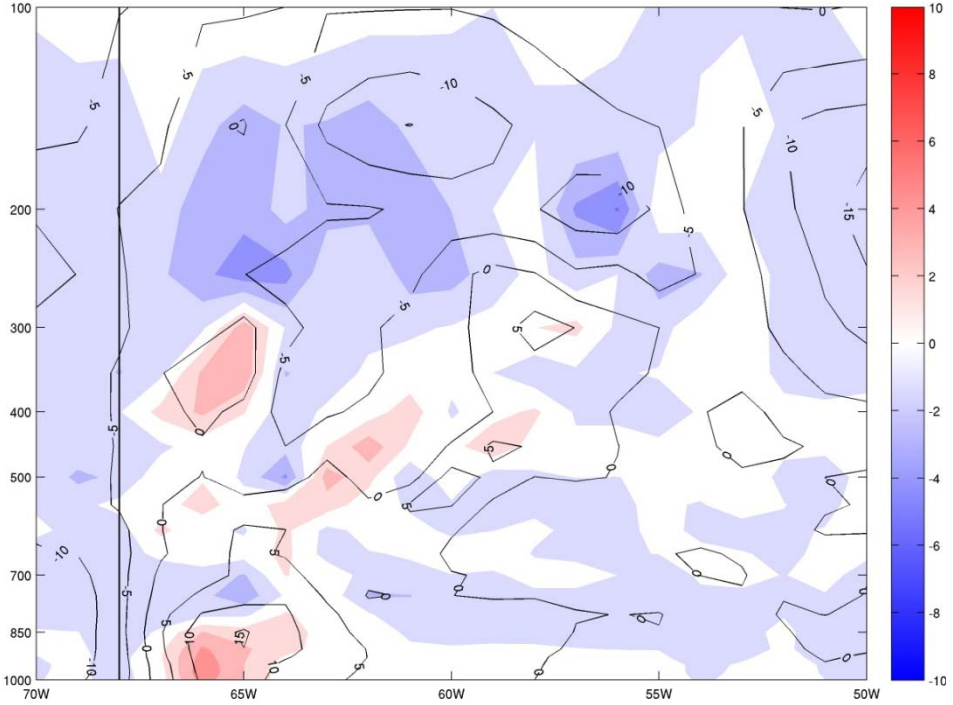
Vertical E-W cross-section through Ike: Forecast increment through +24h



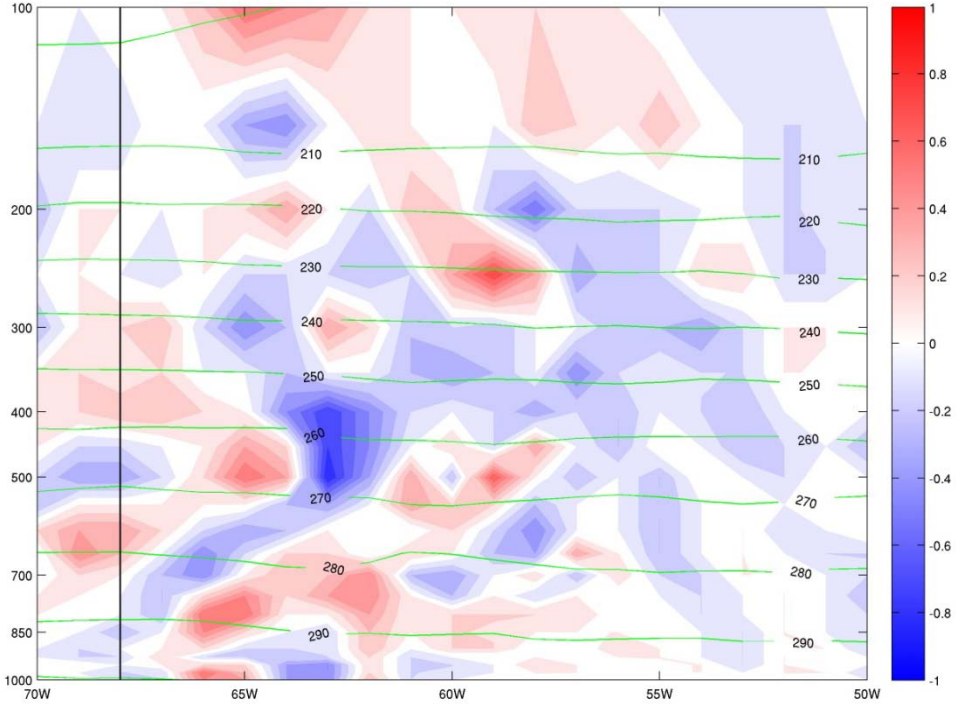
v

T

Vertical E-W cross-section through Ike: Forecast increment through +48h



v

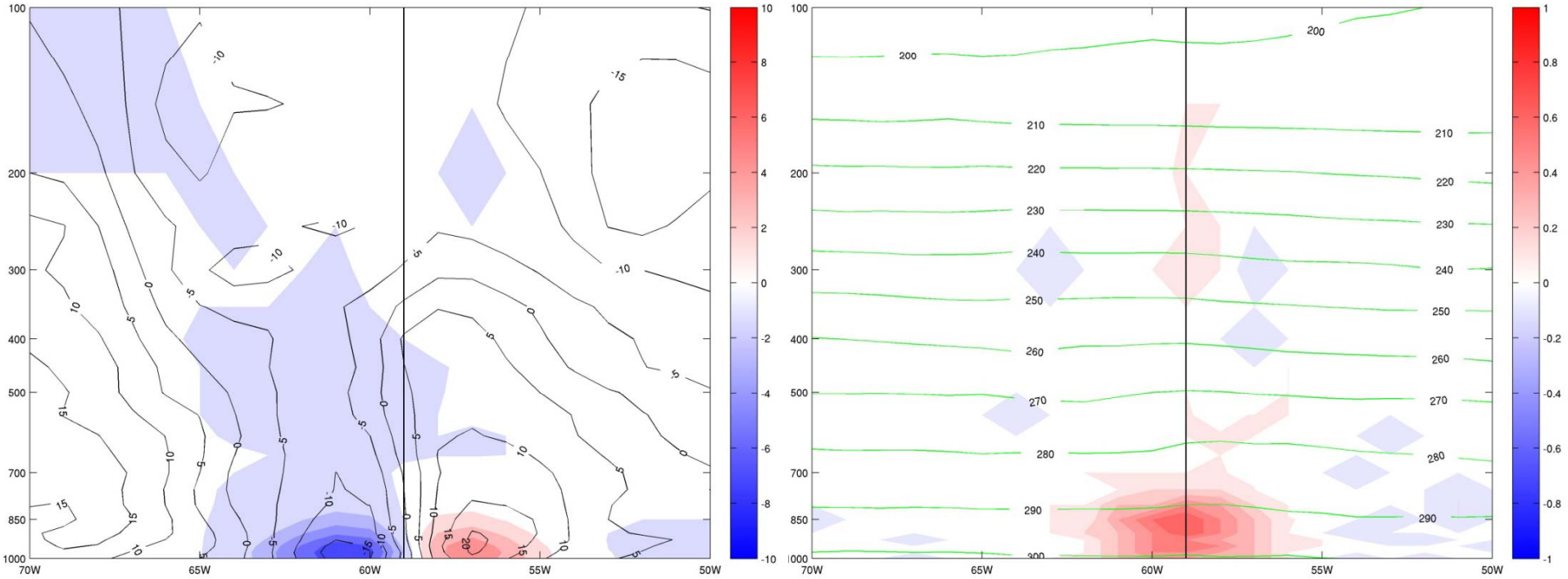


T

2c. Vertical error correlation lengthscale L_z

- Minimal modification to the track of Ike due to assimilation of the 4 wind vectors.
- Influence of ‘observations’ on the analysis only extended through the boundary layer.
- This influence possessed no clear signal at later forecast times.
- Any improvement if L_z is increased?

Vertical E-W cross-section through Ike. Analysis increment: operational L_z



v

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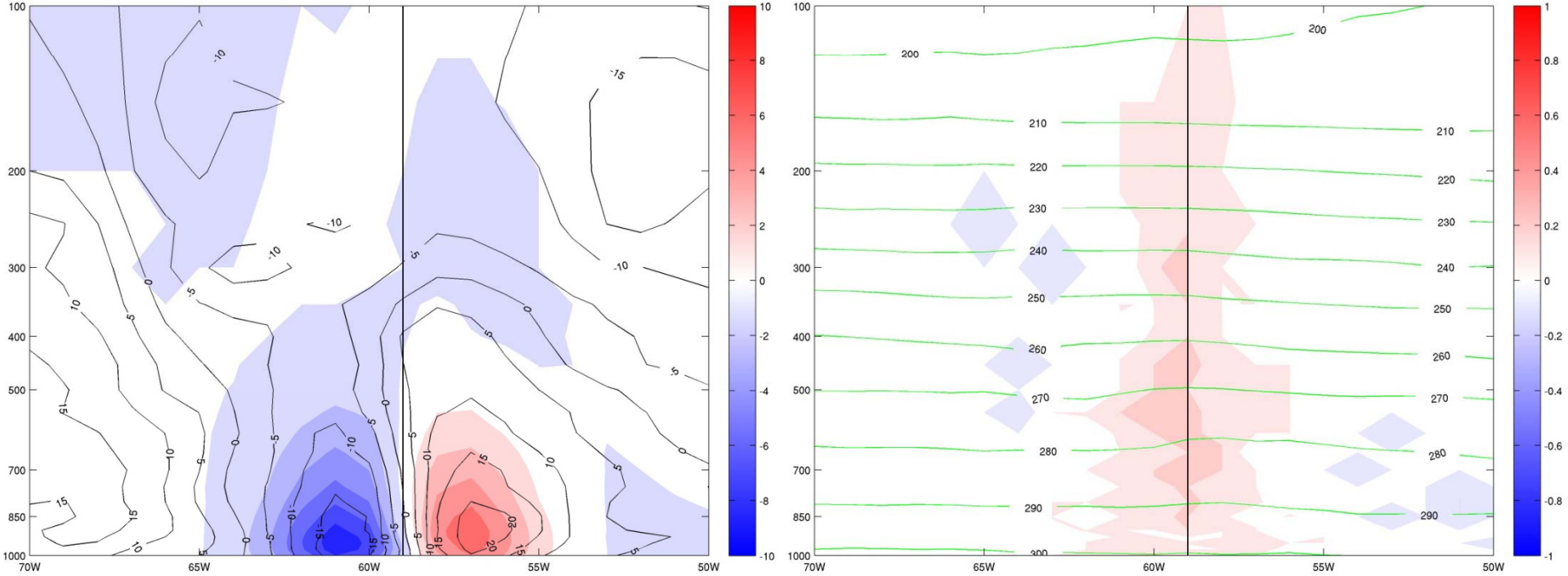
Vertical E-W cross-section through Ike.
Analysis increment: 2 x L_z



v

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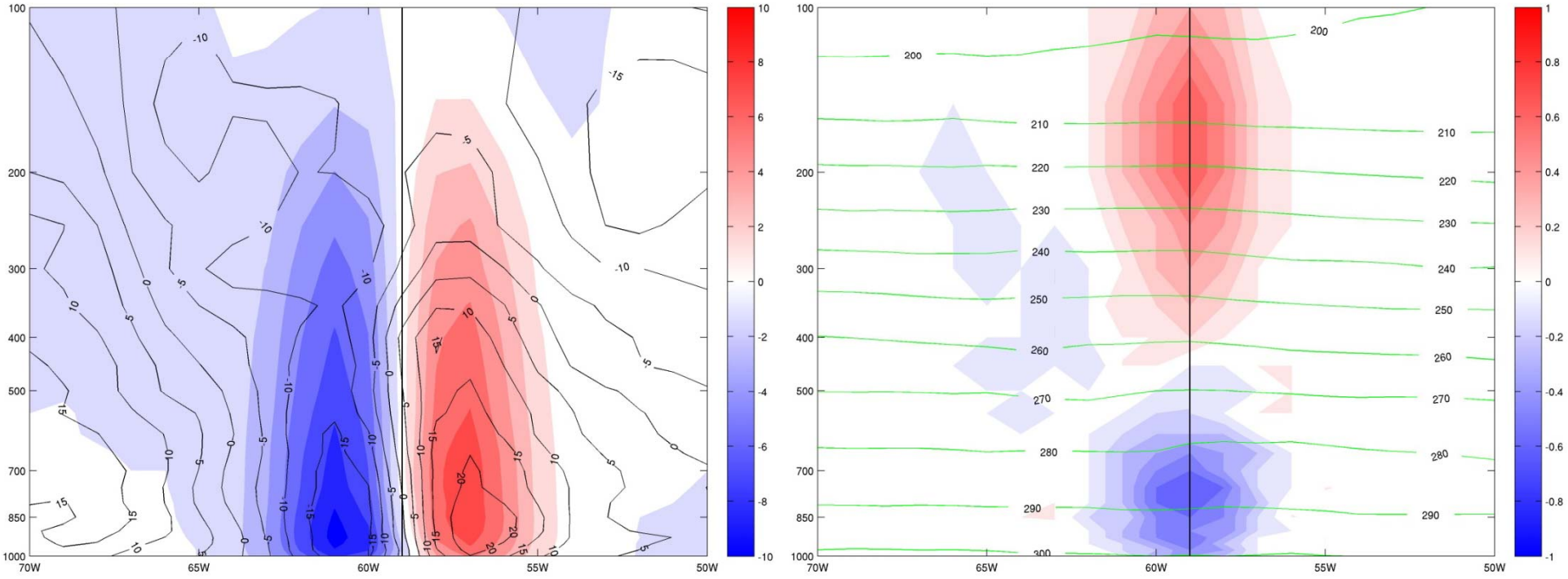
Vertical E-W cross-section through Ike.
Analysis increment: 4 x L_z



v

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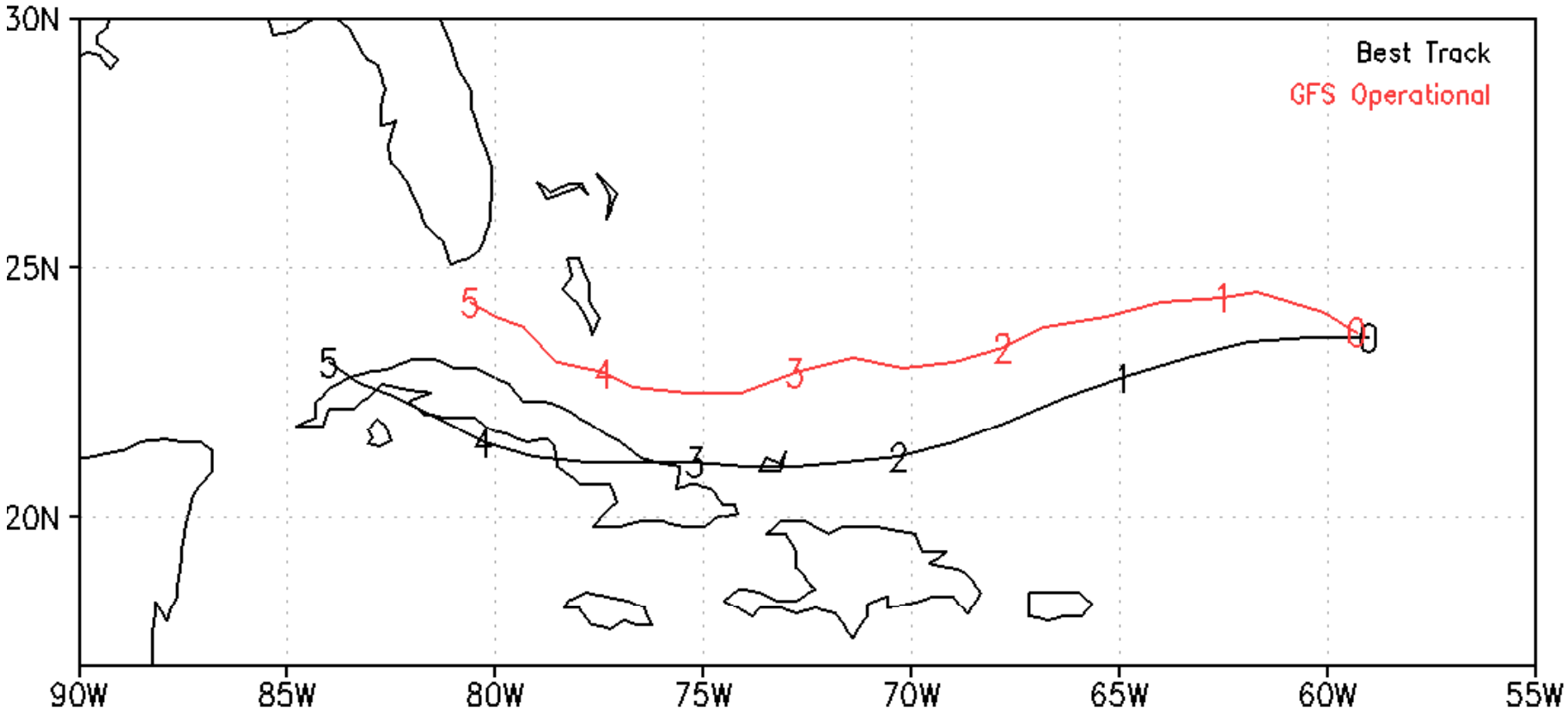
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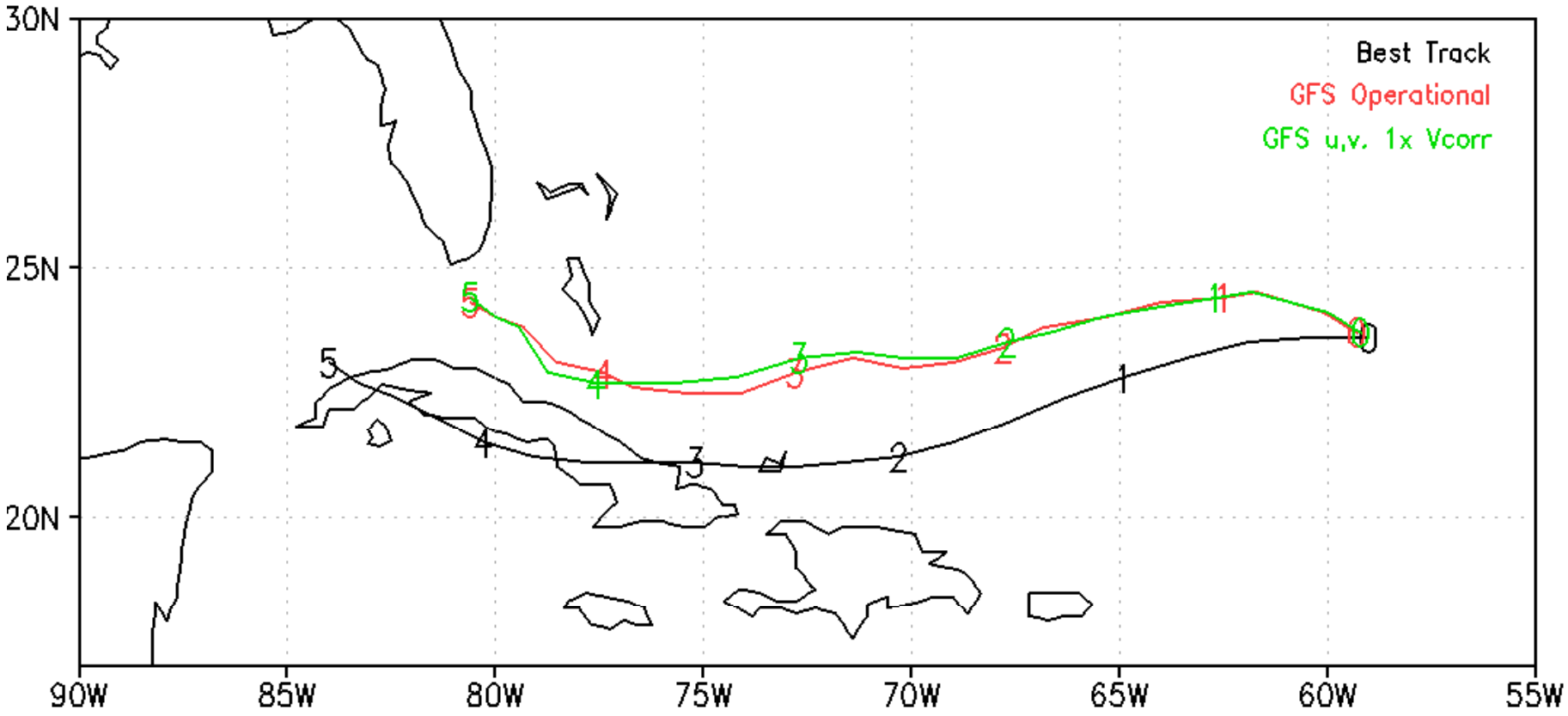
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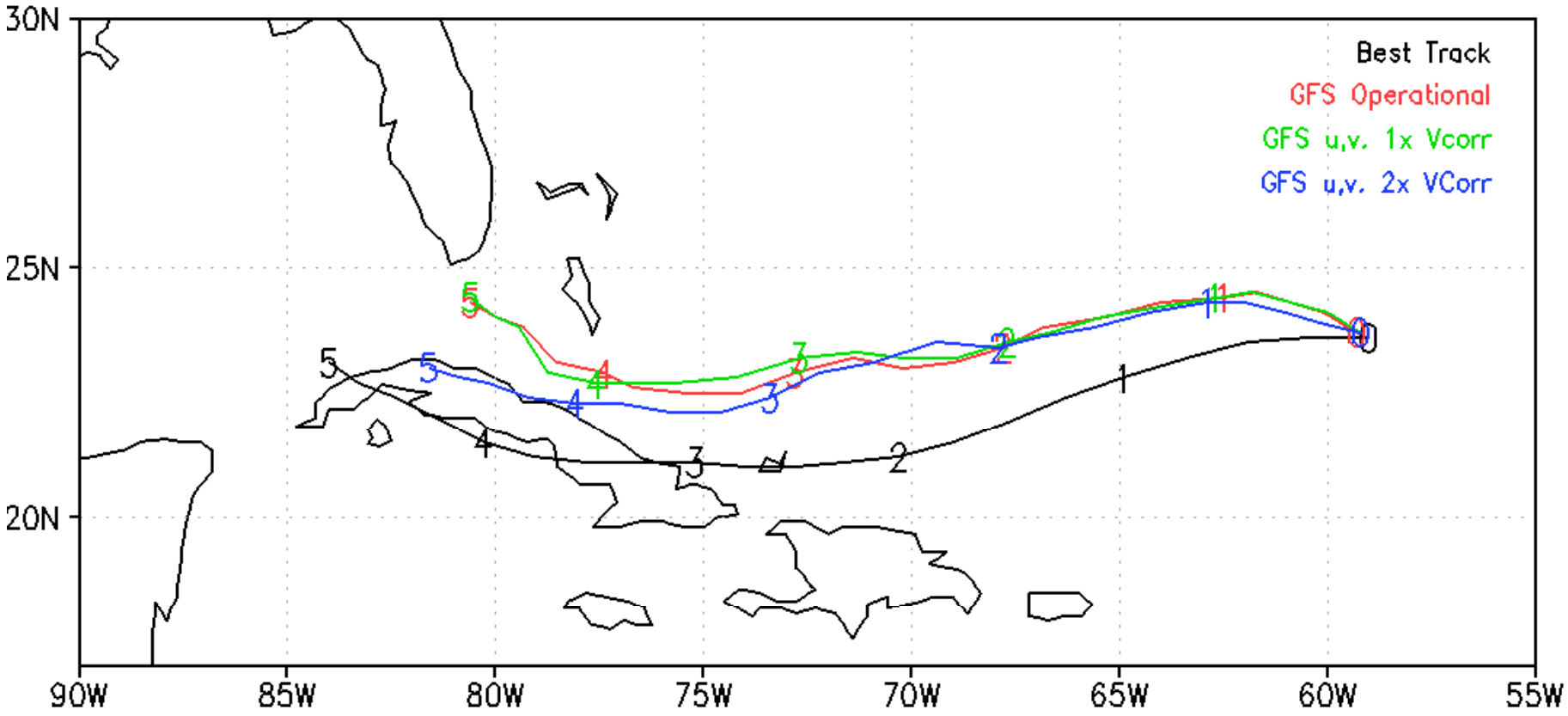
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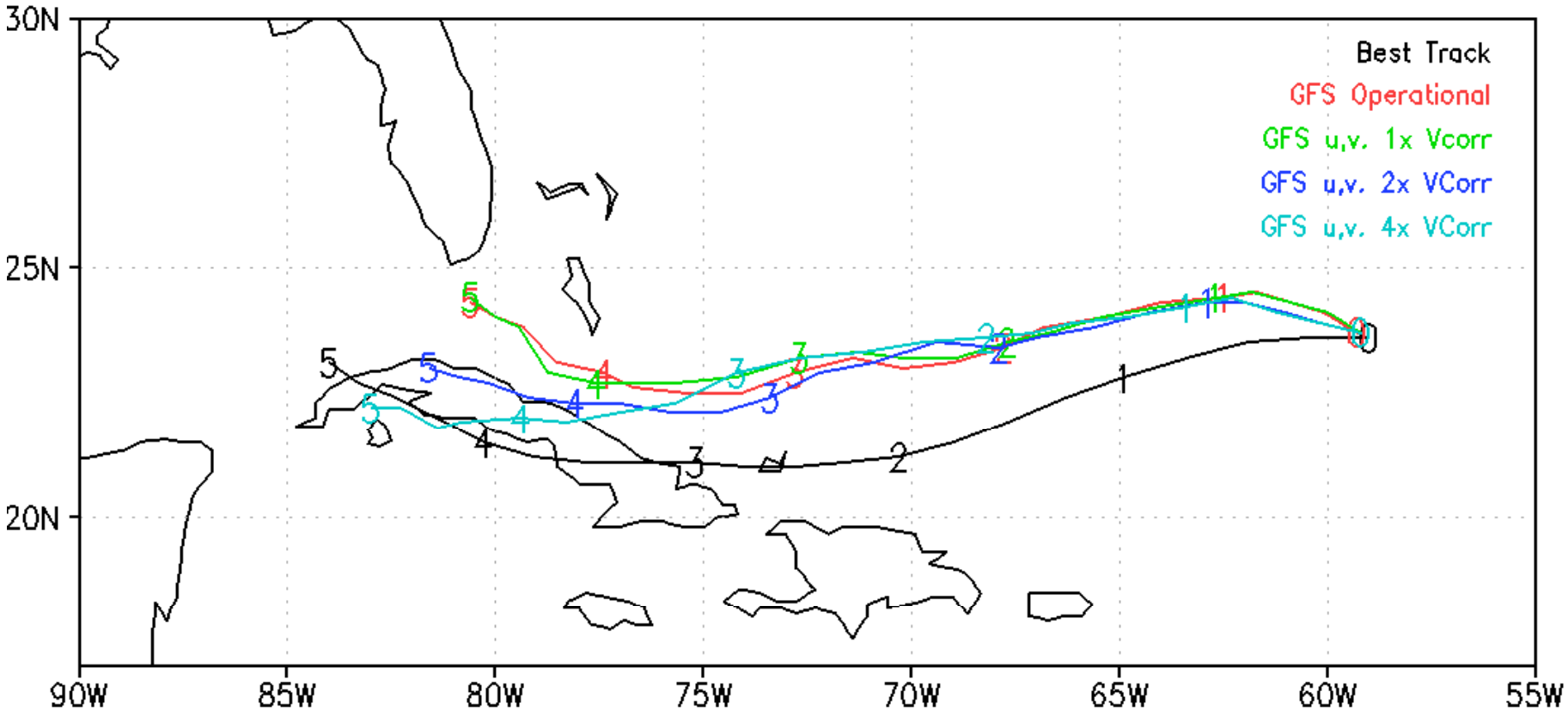
Best Track
GFS Operational
GFS u,v. 1x Vcorr
GFS u,v. 2x VCorr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65W
60W
55W
Best Track
GFS Operational
GFS u,v. 1x Vcorr
GFS u,v. 2x VCorr
GFS u,v. 4x VCorr

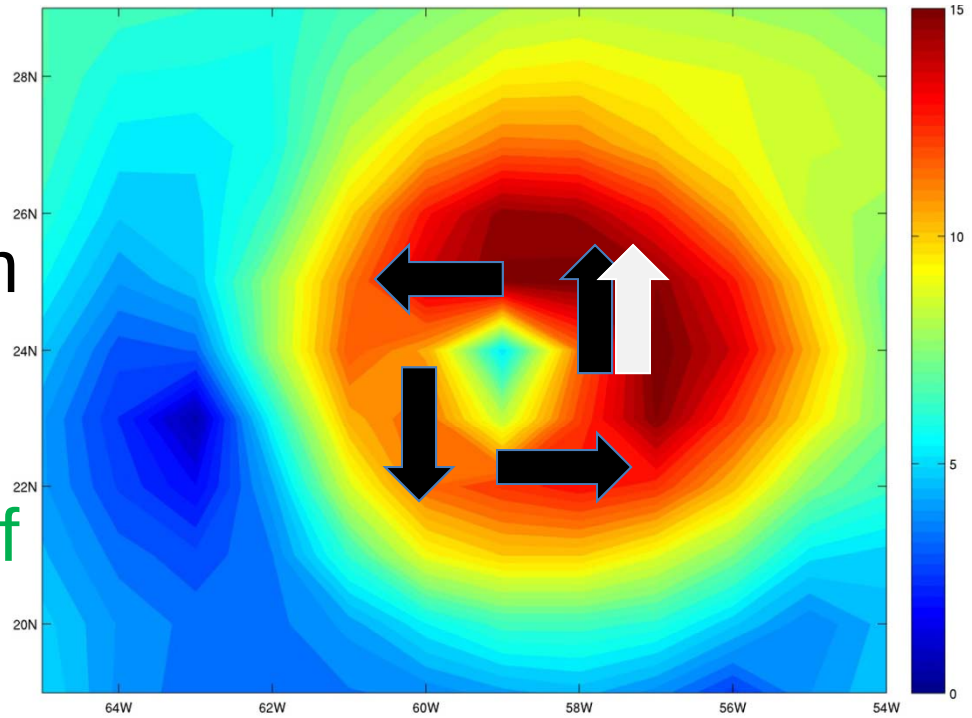
2d. GSI versus EnKF

Innovation 10 m/s
Ob error 0.1 m/s

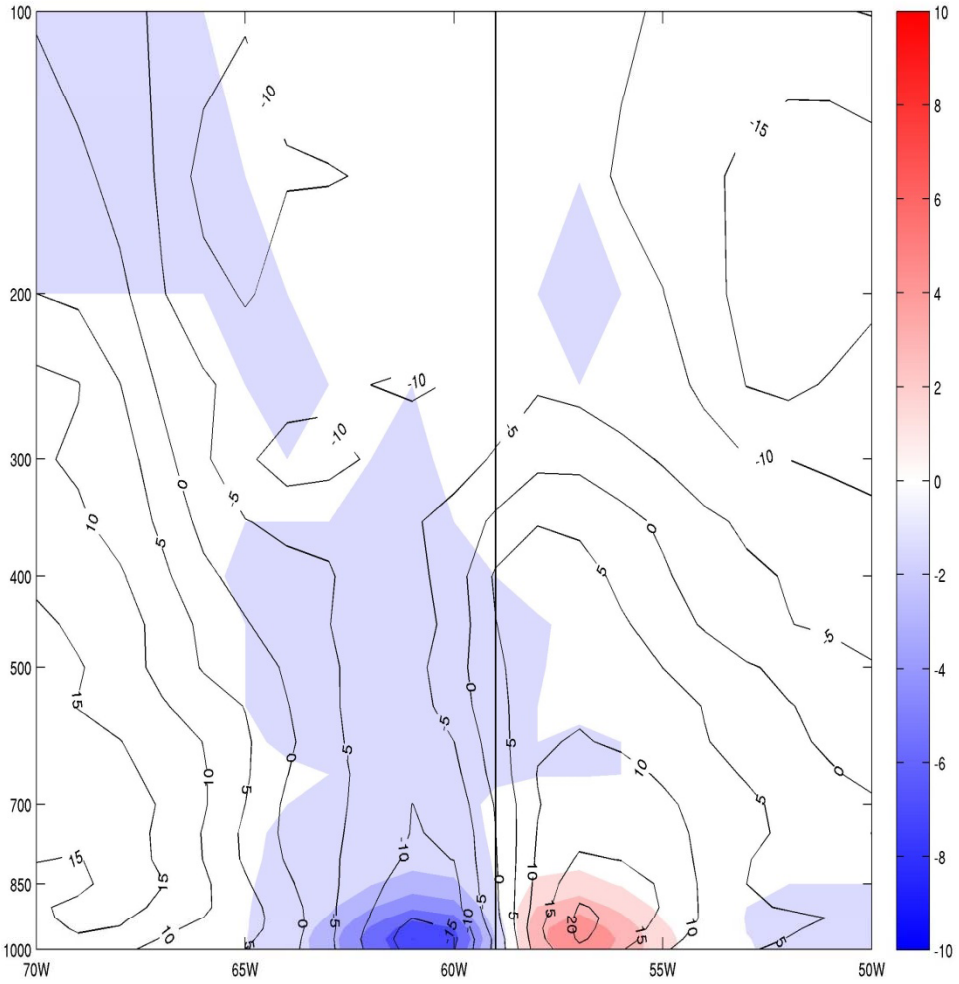
4 (u,v) obs 1 degree from center in GSI

1 v ob 150km east of center in WRF/EnKF.

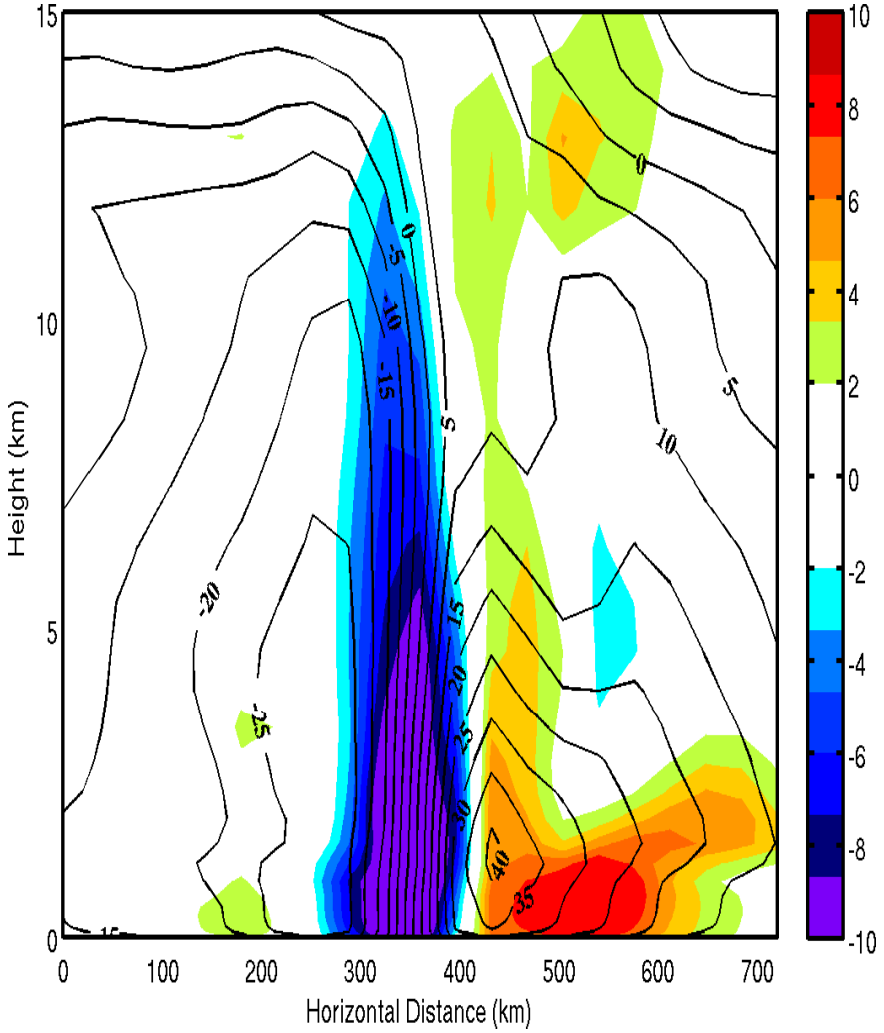
CAVEAT: Different Storms!



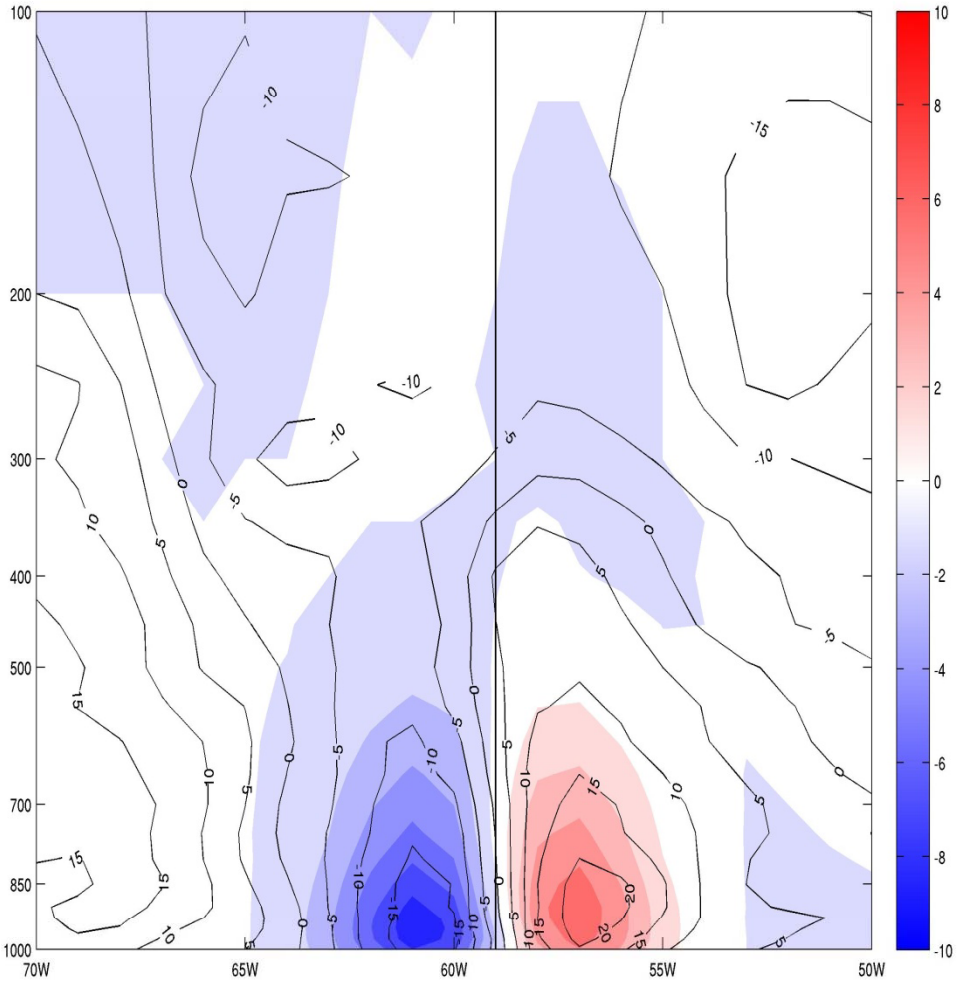
GSI Analysis Increment of v (m/s) Operational L_z



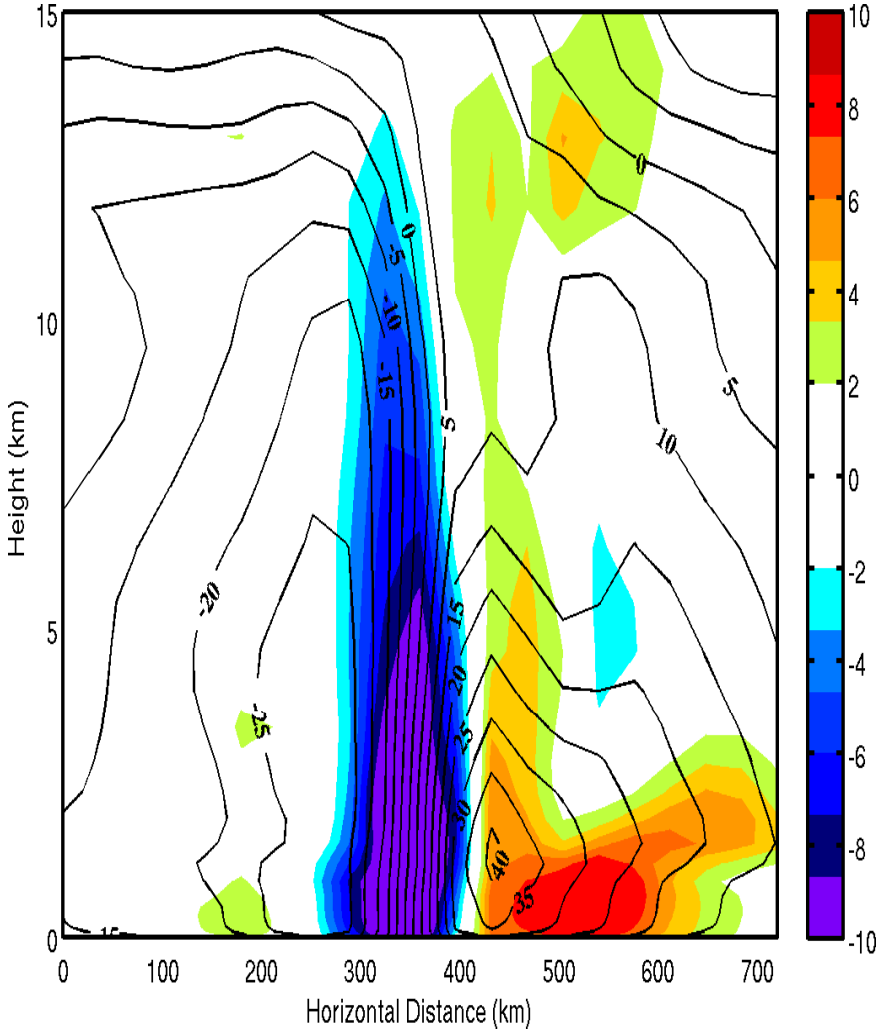
WRF/EnKF Analysis Increment of v (m/s)



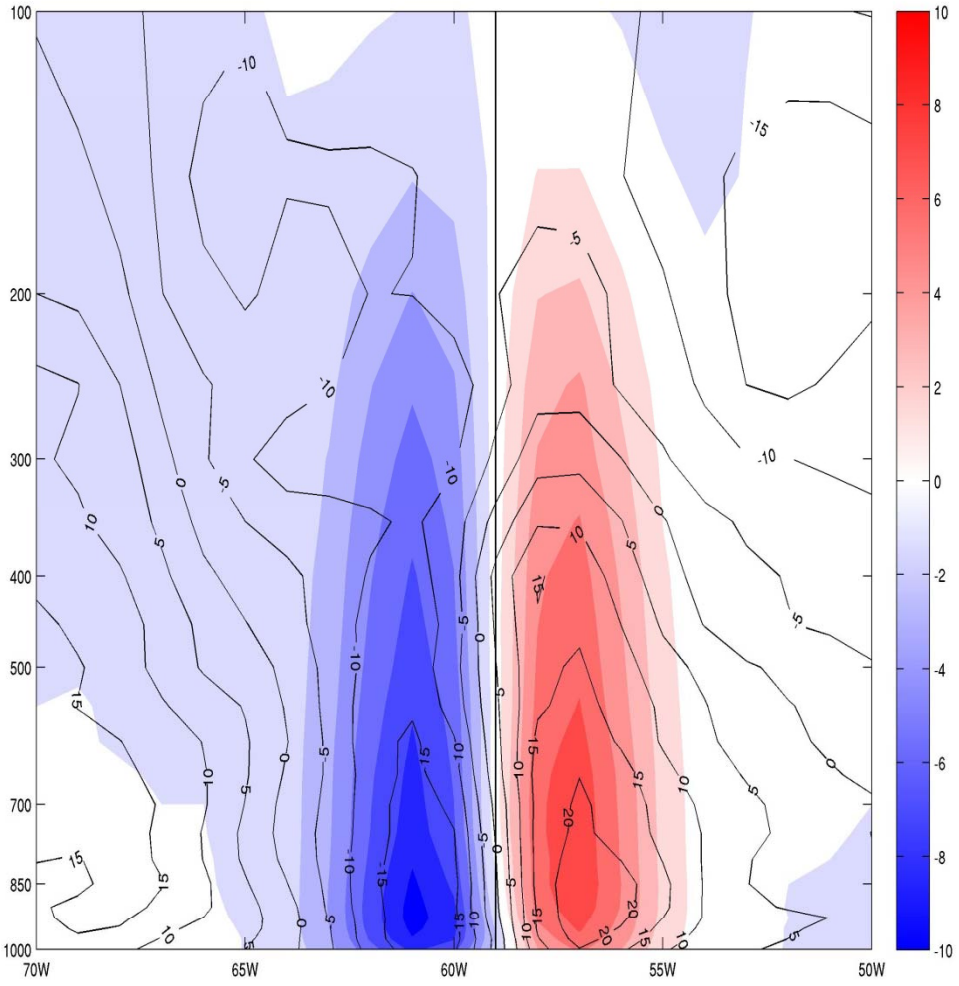
GSI Analysis Increment of v (m/s)
$2 \times L_z$



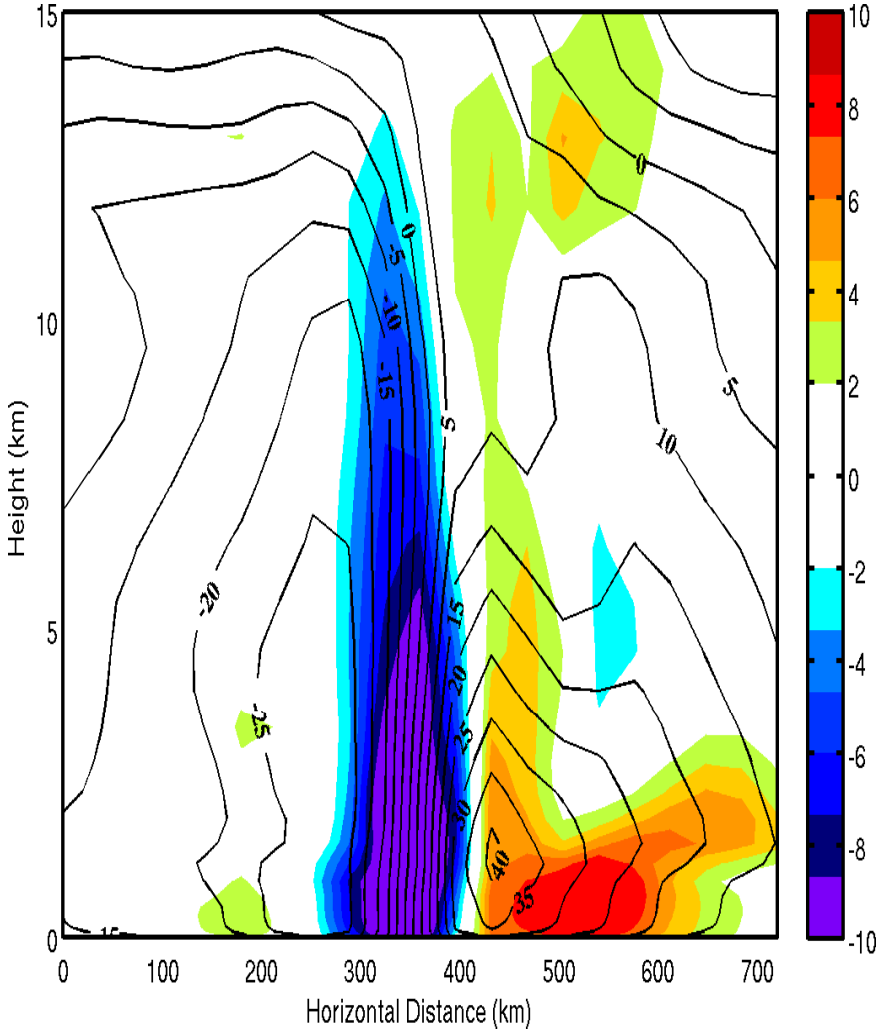
WRF/EnKF Analysis Increment of v (m/s)



GSI Analysis Increment of v (m/s)
$4 \times L_z$



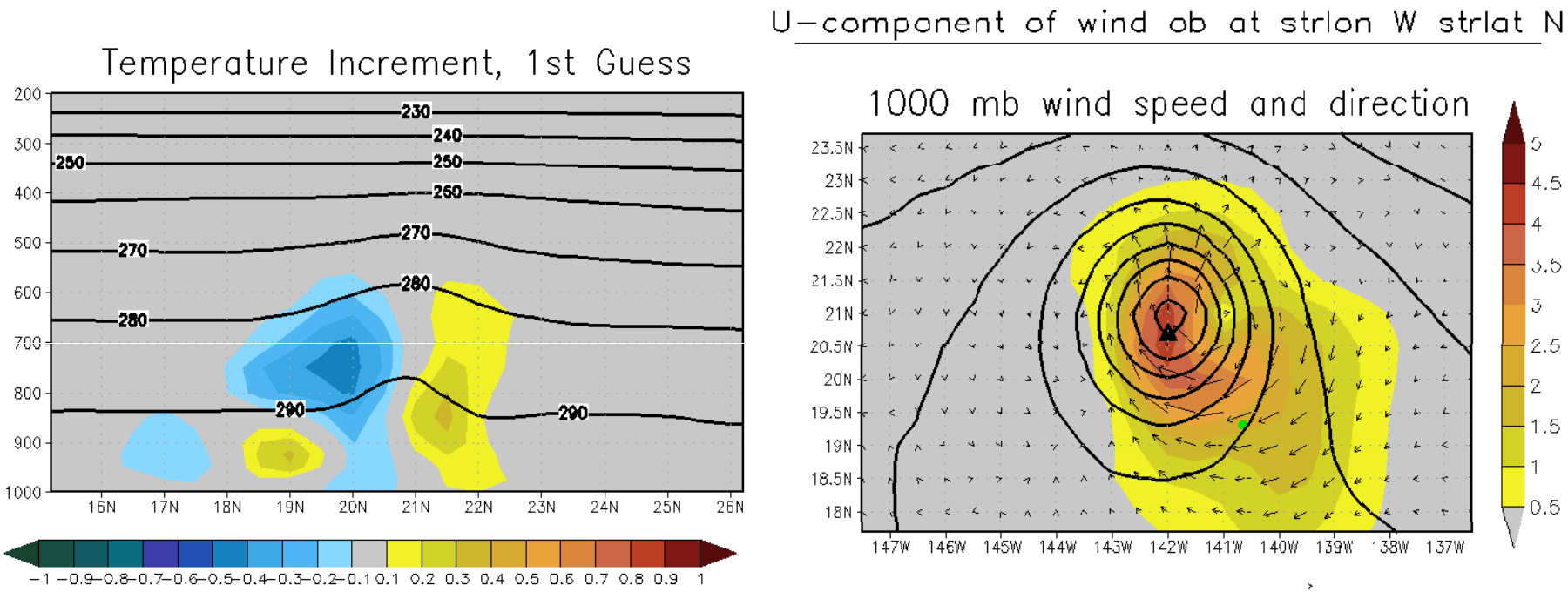
WRF/EnKF Analysis Increment of v (m/s)

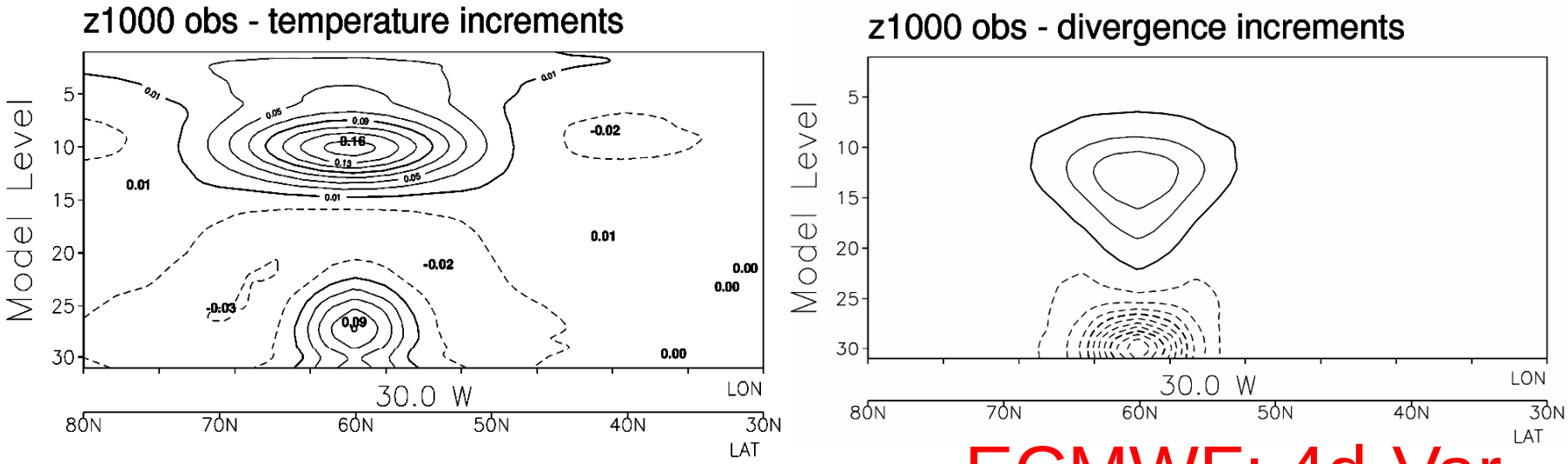


Summary 2

- **GSI**
  - Geostrophic & hydrostatic correction (needed 4 “obs”).
  - Local horizontal correction.
  - Significant increment only through boundary layer.
  - Increasing L_z improved storm structure and track forecast.

- **EnKF**
  - Gradient wind correction (used only 1 “obs”).
  - Stronger winds associated with shifting the storm further east and increasing intensity of winds.
  - Troposphere-deep increment: vertical error correlation lengthscale equivalent to 4x of GSI.


U−component of wind ob at strlon W strlat N
Temperature Increment, 1st Guess
1000 mb wind speed and direction
NOAA/ESRL: EnKF with GFS


z1000 obs - temperature increments
z1000 obs - divergence increments
Model Level
LON
LAT
ECMWF: 4d-Var

Conclusions and Future Work

- Effectiveness of assimilating OSVW data depends on the data assimilation scheme.
- Potentially significant benefits to NWP with novel flow-dependent data assimilation that incorporates meteorological features in the error structures.
- **Assimilate satellite surface winds using multiple data assimilation schemes:**
  - **EnKF (with GFS/FIM and WRF)**
  - **GEOS-5**
- **OSSEs to evaluate potential for new satellite surface wind observing systems (DFS).**