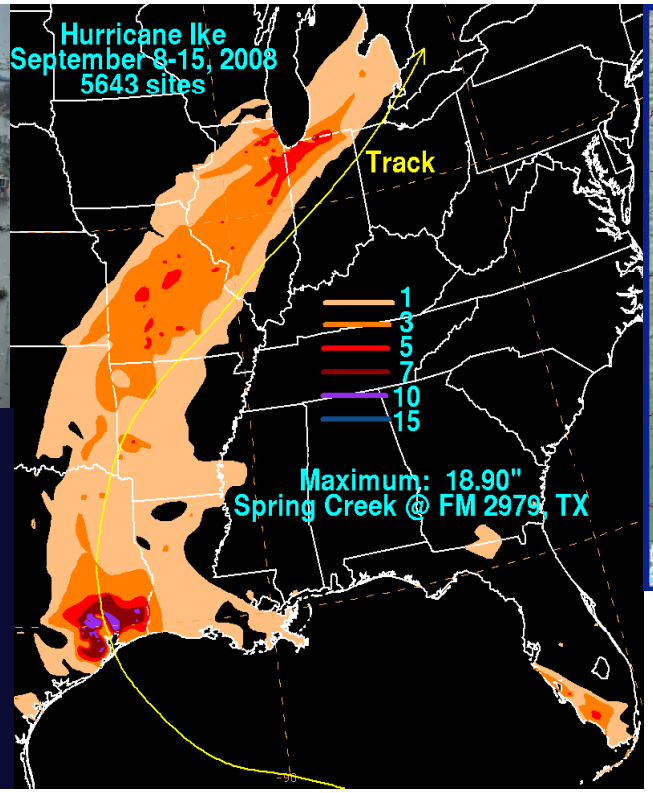
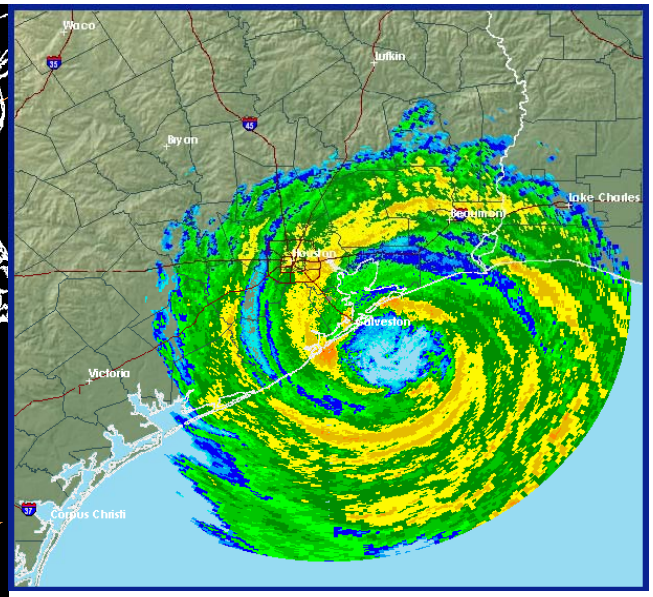
Ensemble Kalman Filter Assimilation of WSR 88D Radar Data and Forecasting for Hurricane Ike (2008)

Jili Dong and Ming Xue
CAPS/OU

Hurricane Ike (2008)



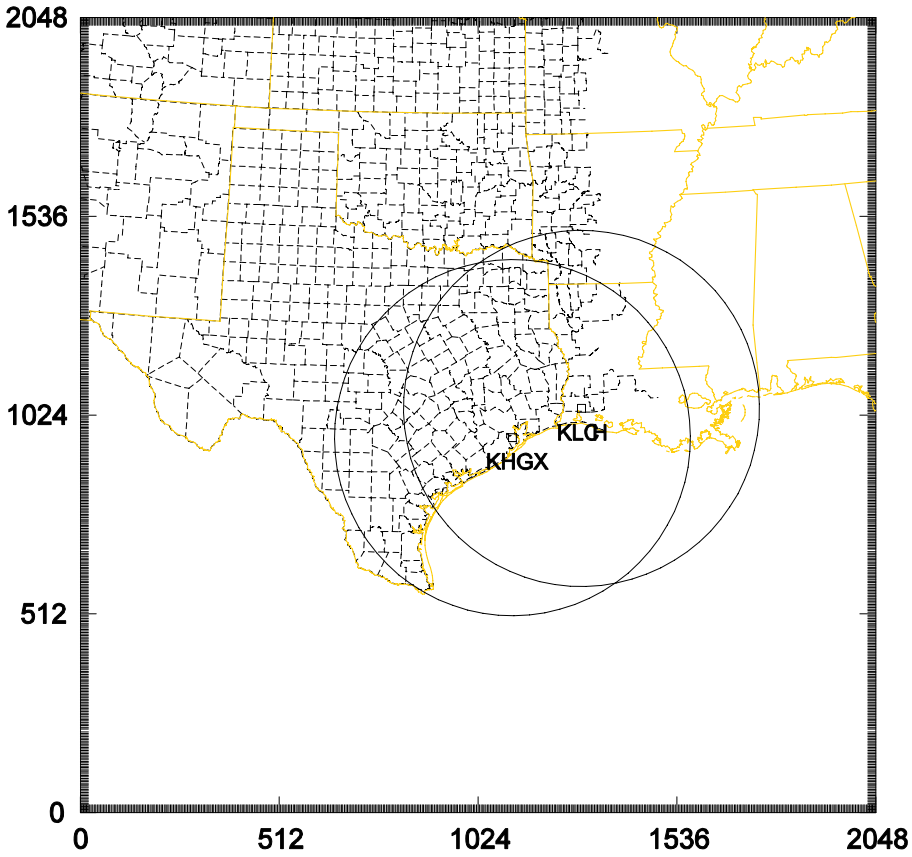


Before landfall
6:07 am 0913 GMT

- Landfall at 7:10 GMT 0913 on Gavelston, TX
- In Texas, 37 deaths; hundreds missing; 100,000 homes flooded
- $32 billion (2008 USD) loss; the third costliest in US history

Model Setup

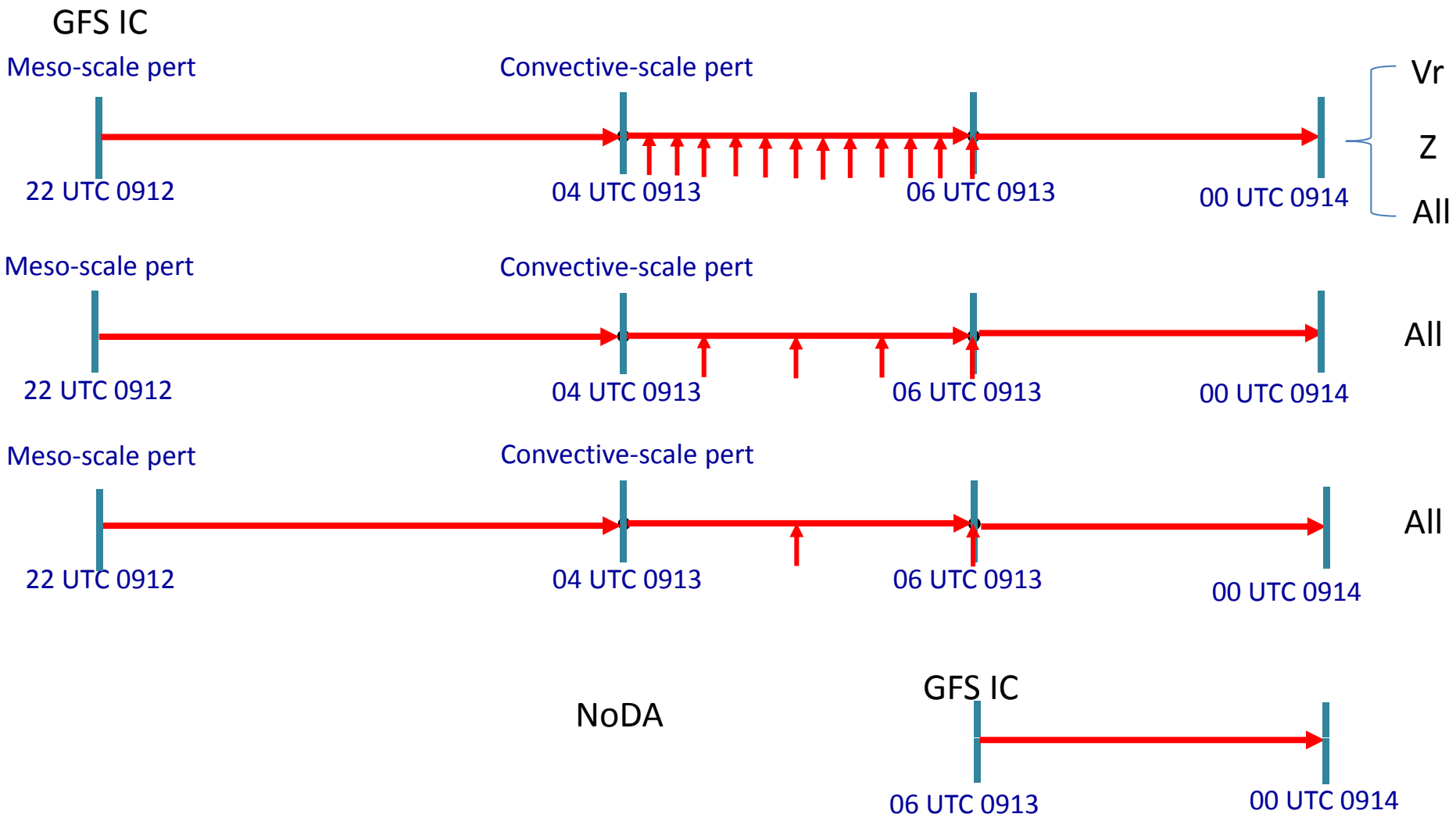
- ARPS model
- 515x515x53
- dx=dy=4km
- dzmin=50m;dz=625m
- Lin microphysical scheme



EnKF setup

- 32 member ensemble
- EnSRF (Whitaker and Hamill 2002)
- EnKF IC
  - Perturbed mesoscale environment with recursive filter of horizontal scale 100km
  - Perturbed LBC
  - Storm-scale perturbation: hor. scale 12km
- Inflation
  - 5% prior multiplicative inflation
  - Posterior additive error on wind components and potential temperature

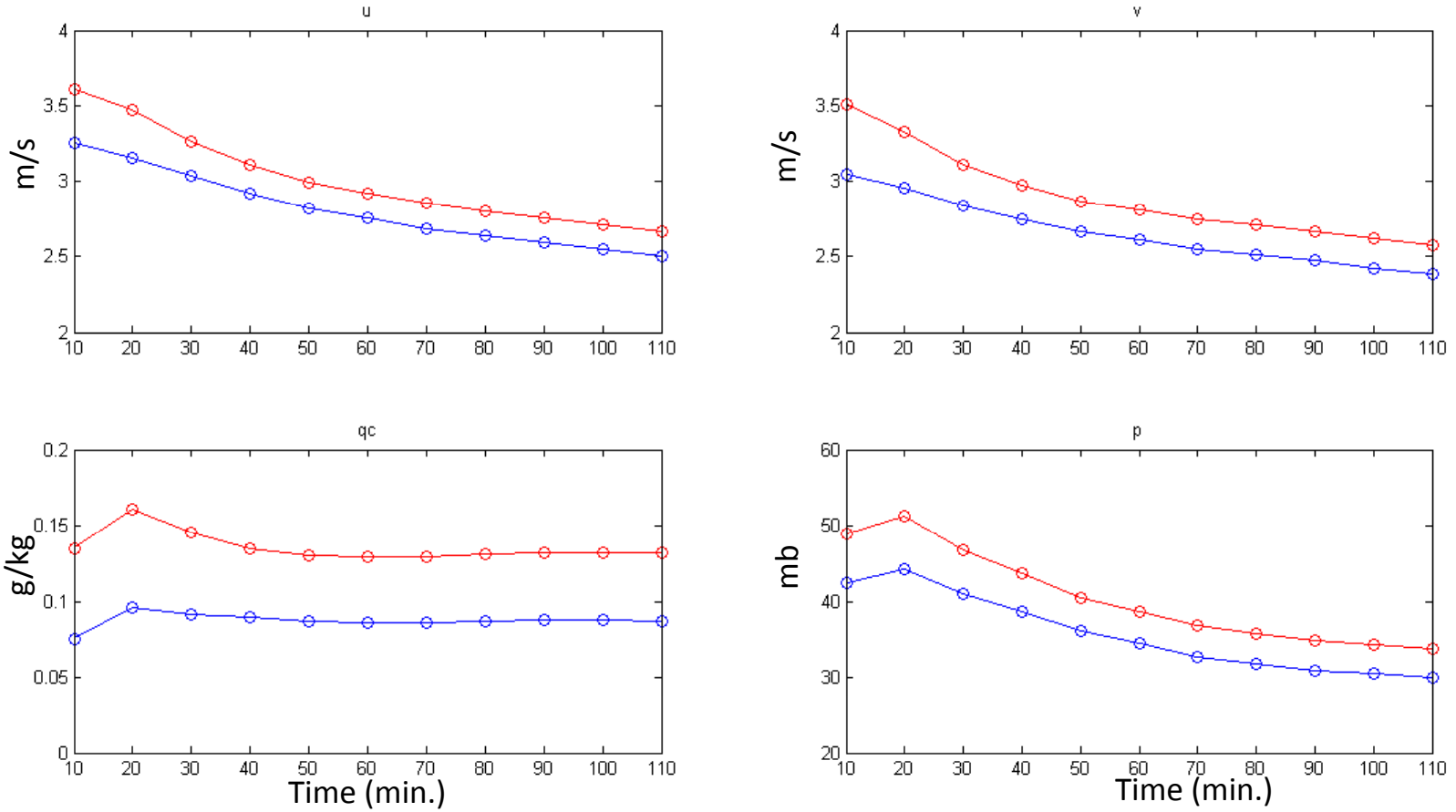
Assimilation Scheme



Radar Observation

- Vr and Z on elevation level vertically
- σ_{vr} =1m/s; σ_z = 2dbz
- Vr manually quality-controlled with SOLO and only in echo region used
- 0 reflectivity included to suppress spurious cell
- Z only update microphysical variables and p
- Covariance localization: 12km horiz. and 4km ver.

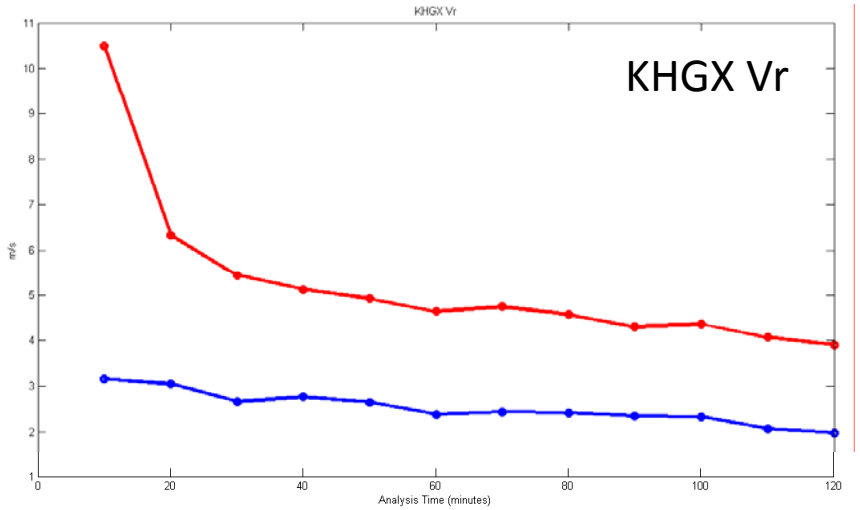
Spread of state variables

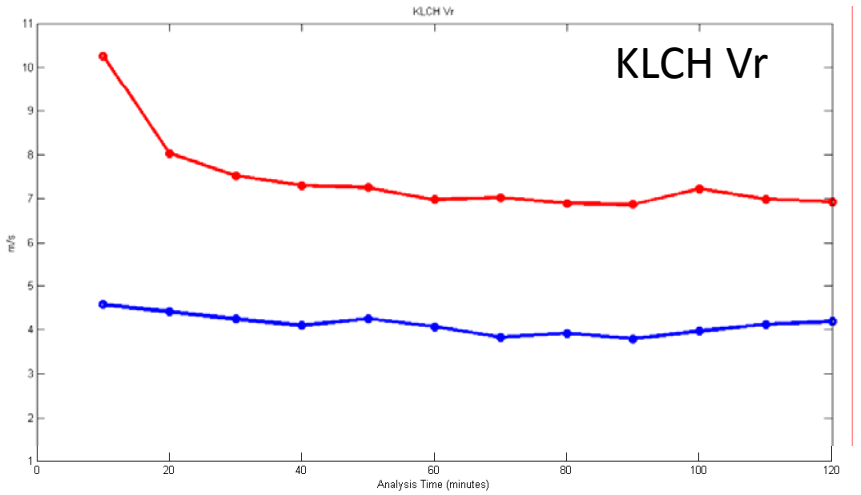


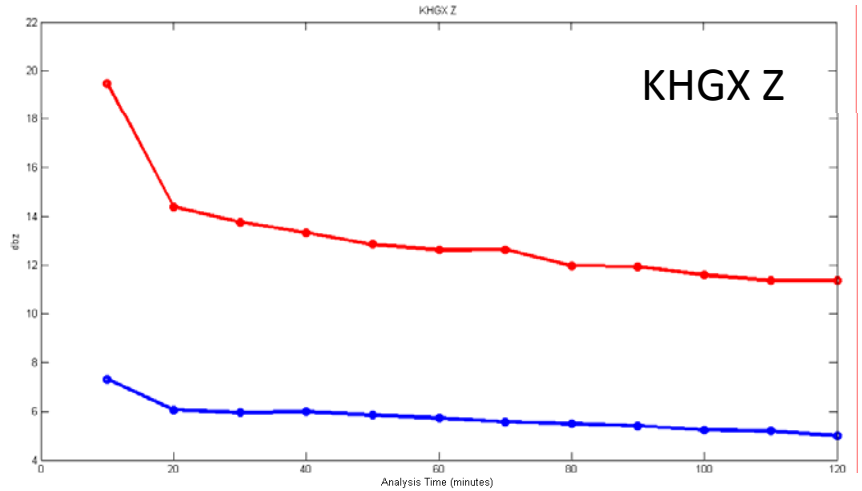
--- Forecast

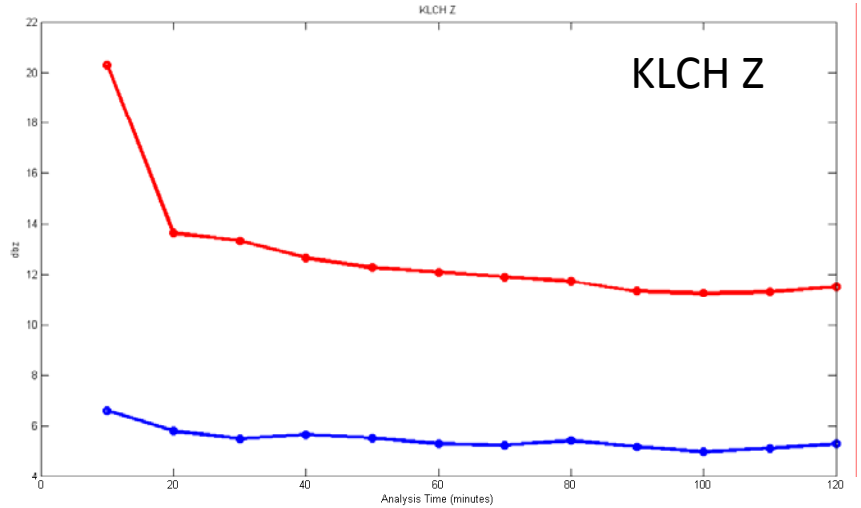
--- Analysis

RMS Innovation (y-Hx)







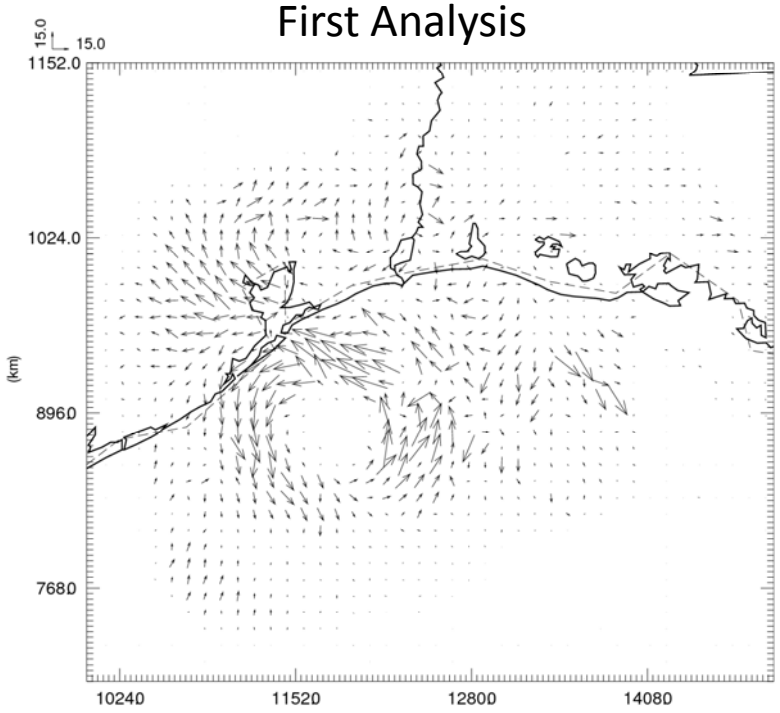


--- Forecast

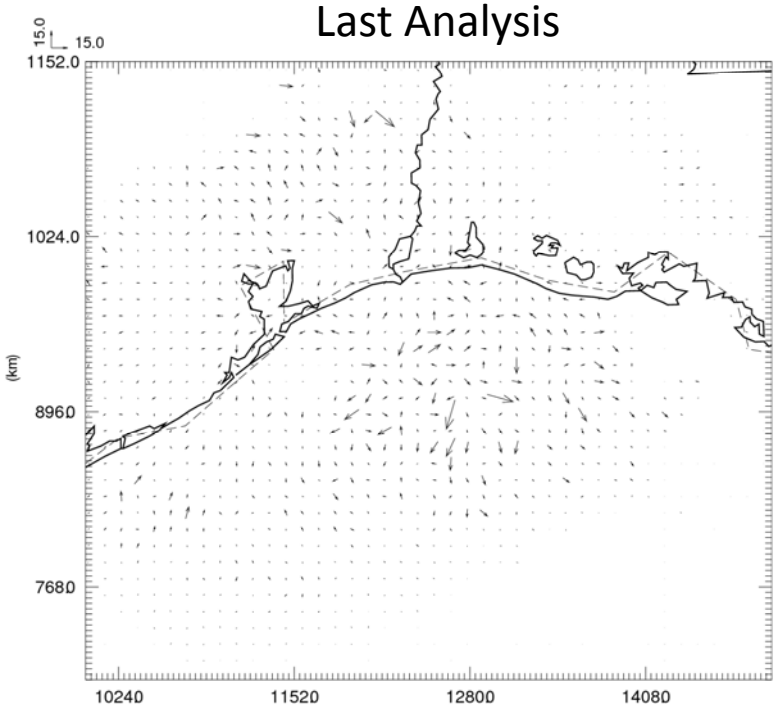
--- Analysis

Analysis Increment of wind component at z=3km

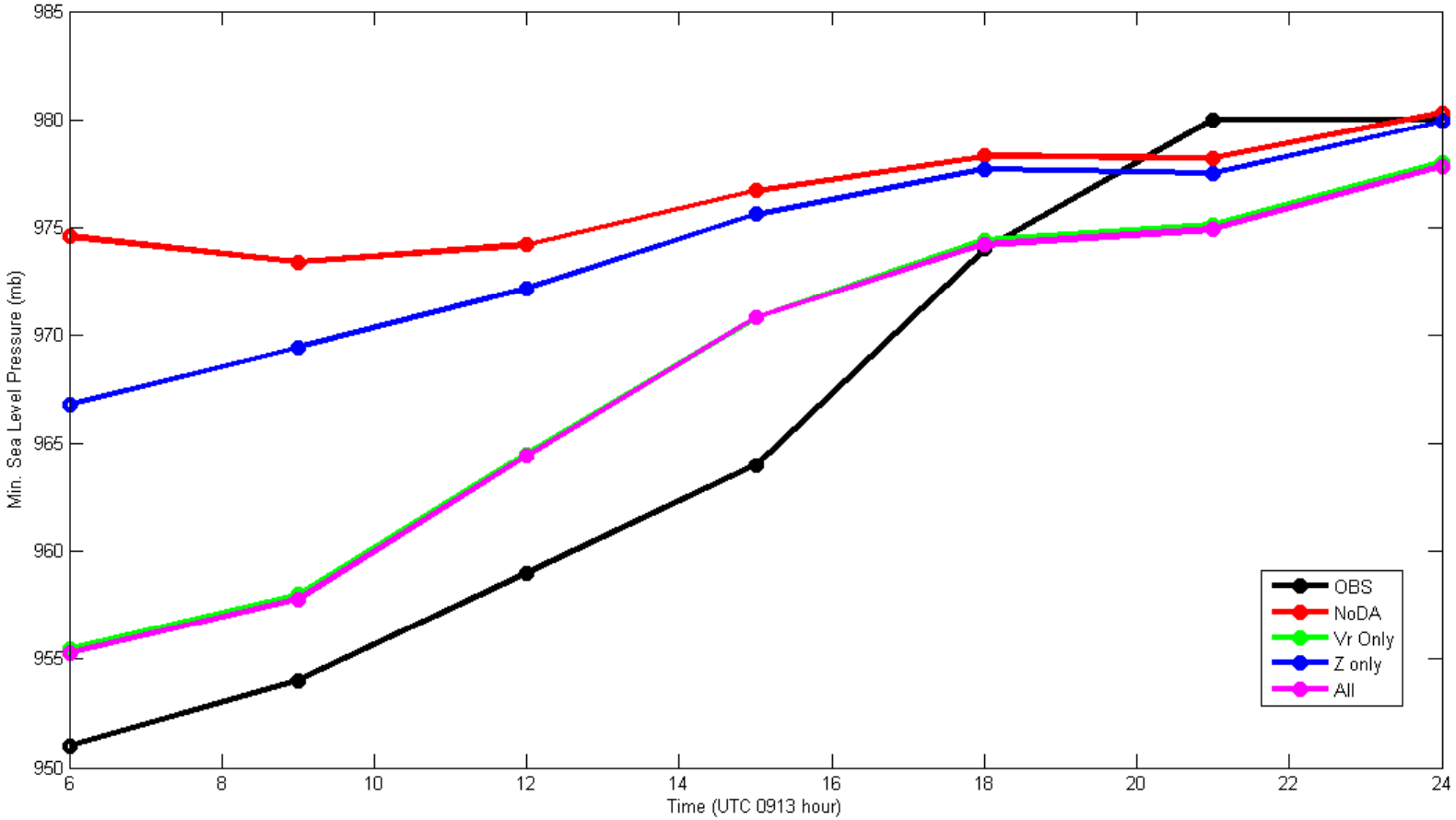
First Analysis



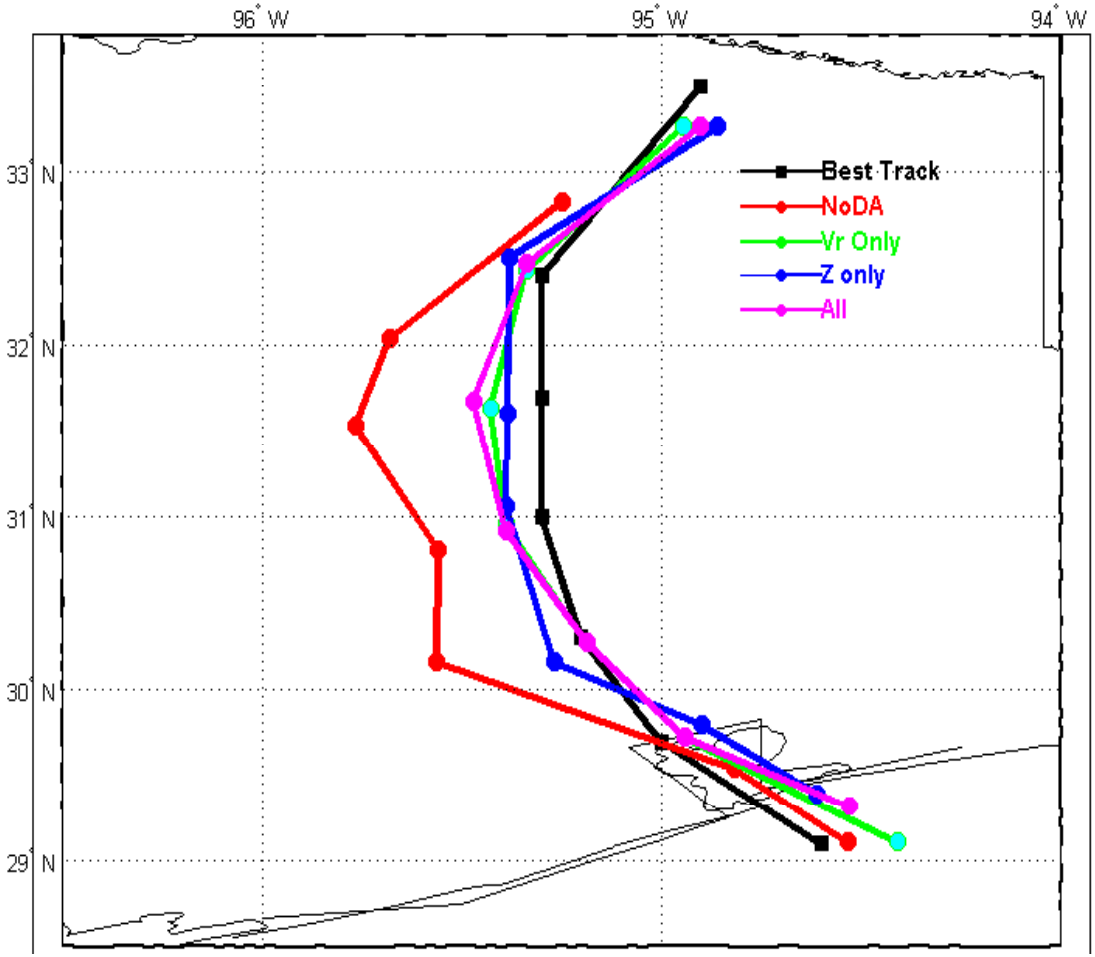
Last Analysis

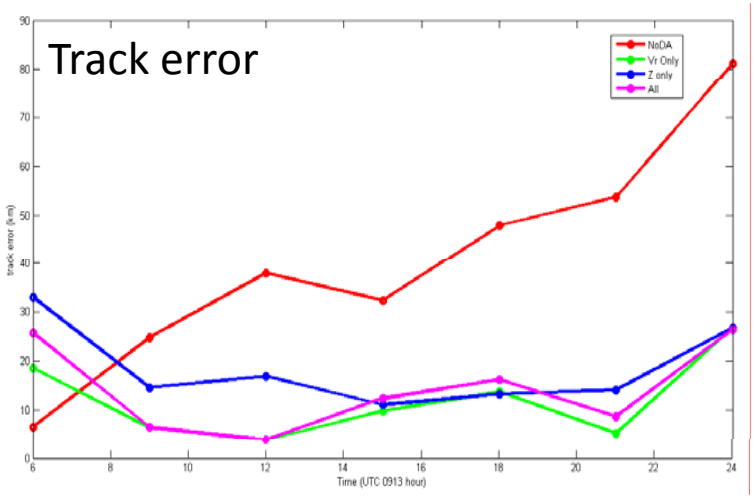


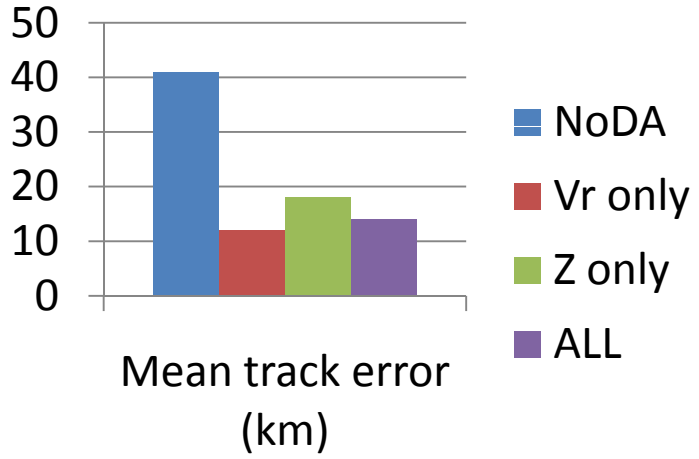
Intensity Forecast



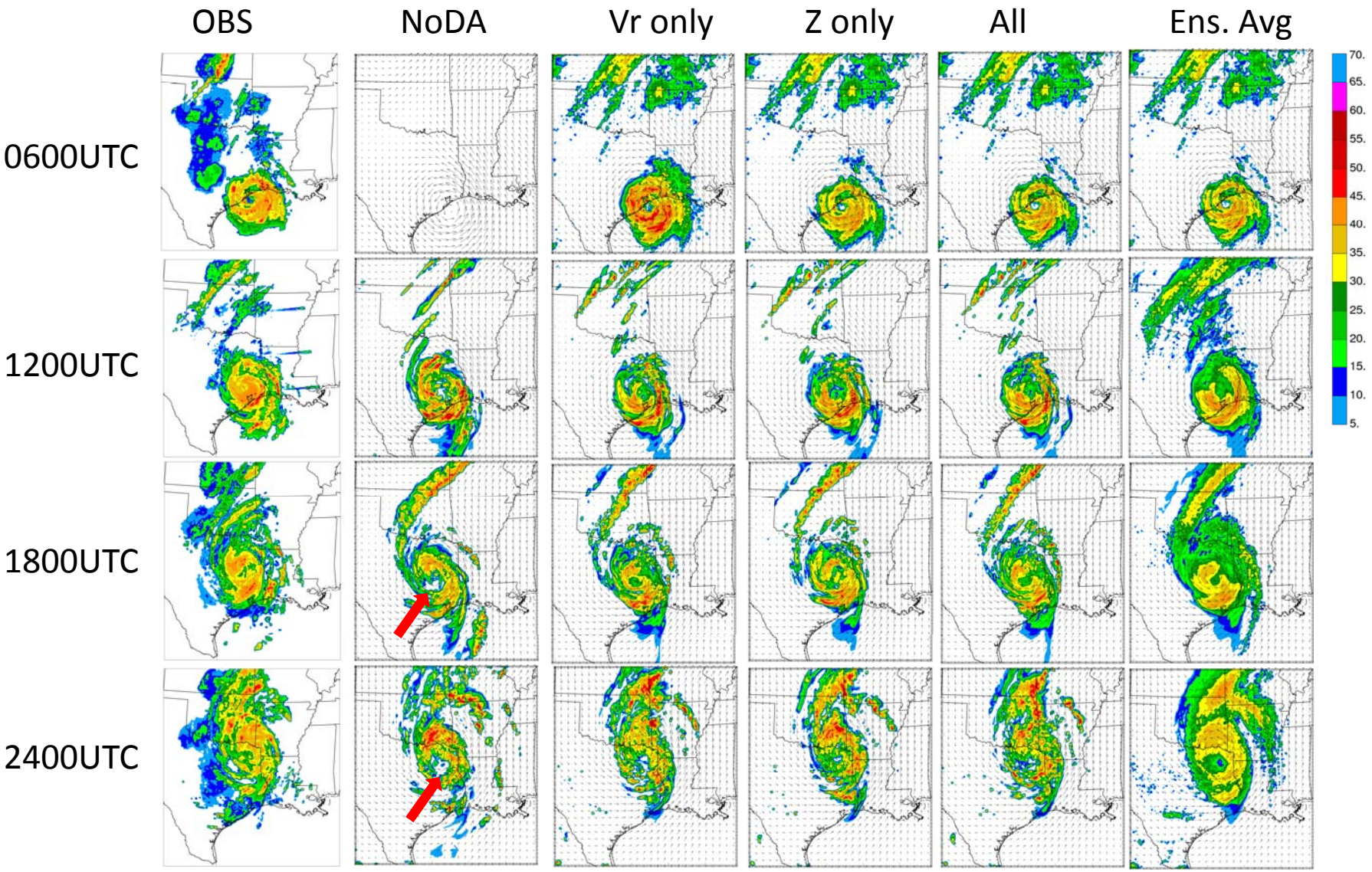
Track Forecast



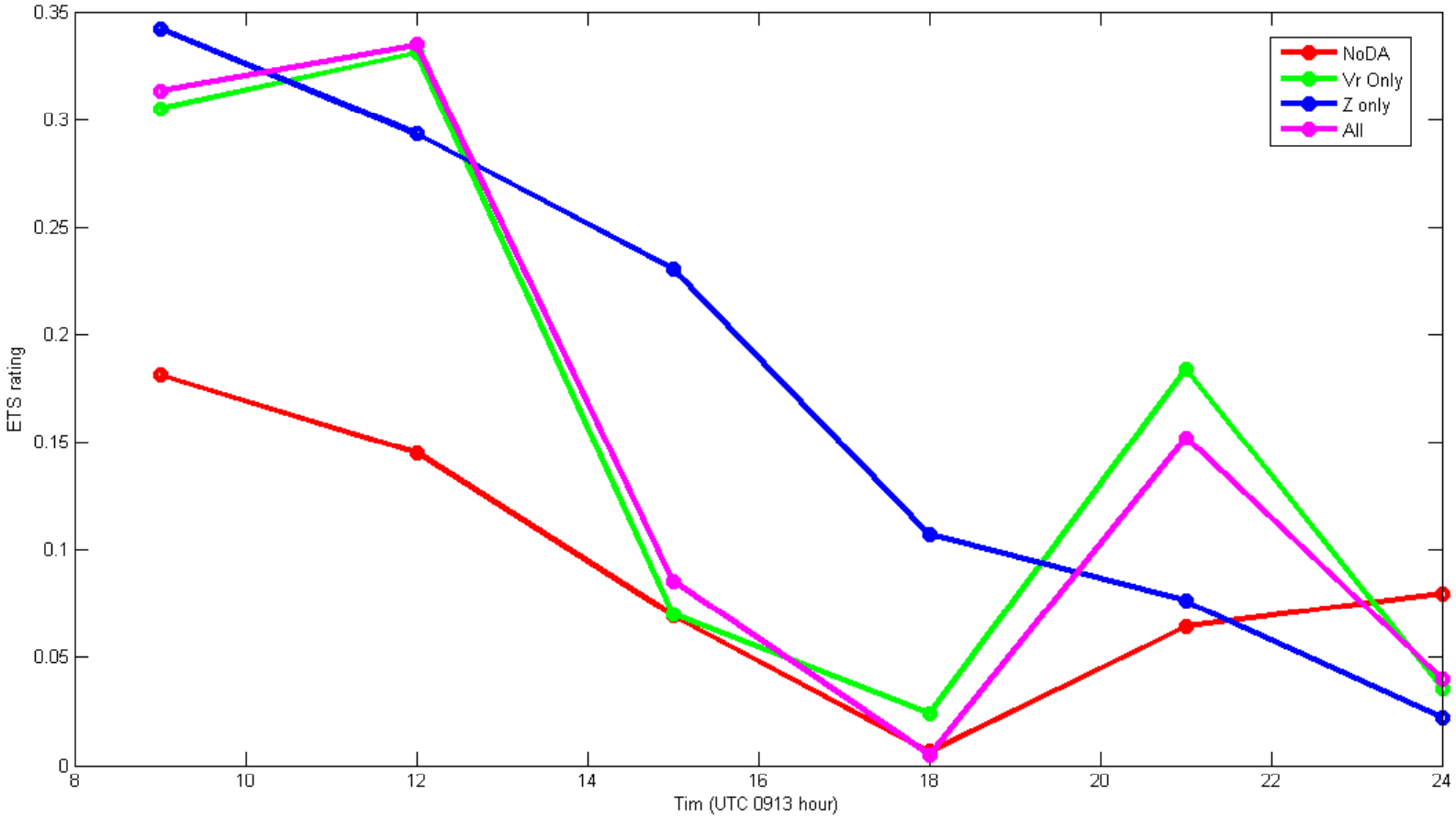




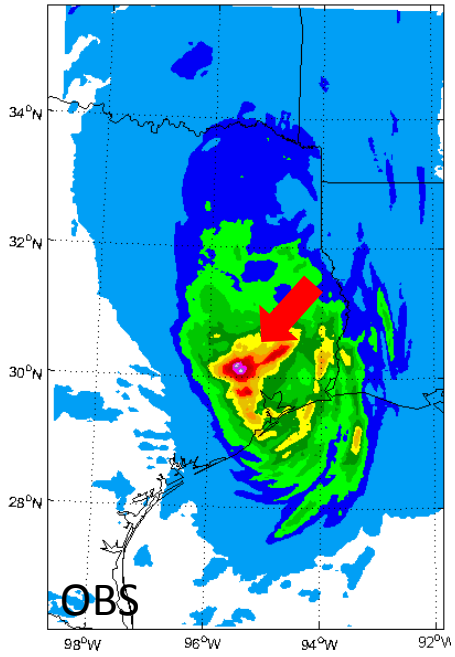
Composite Reflectivity

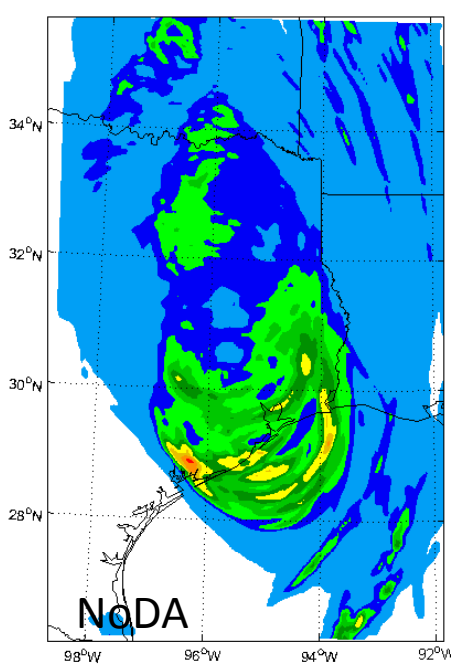


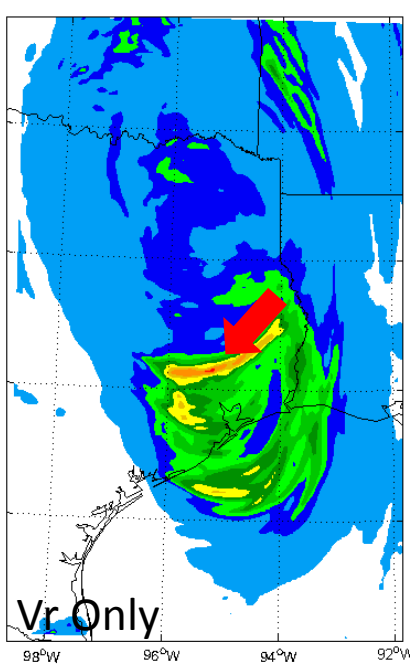
3hr. Accu. Prec. ETS rating (30mm threshold)

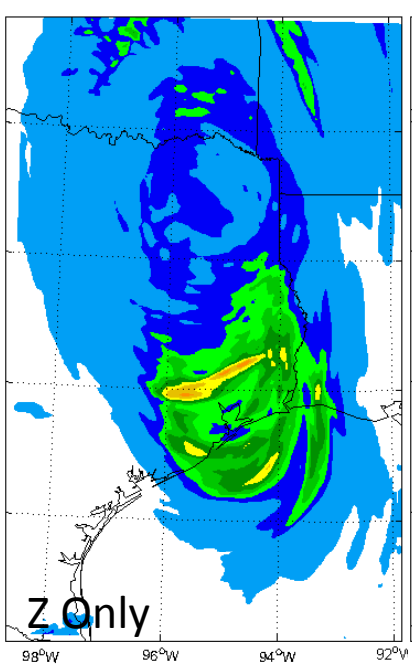


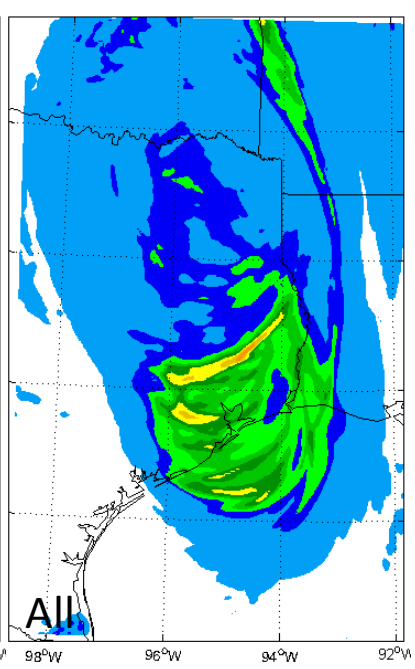
18 hr accu. prec.

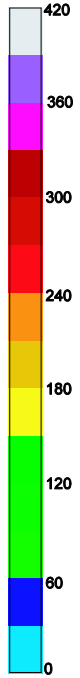




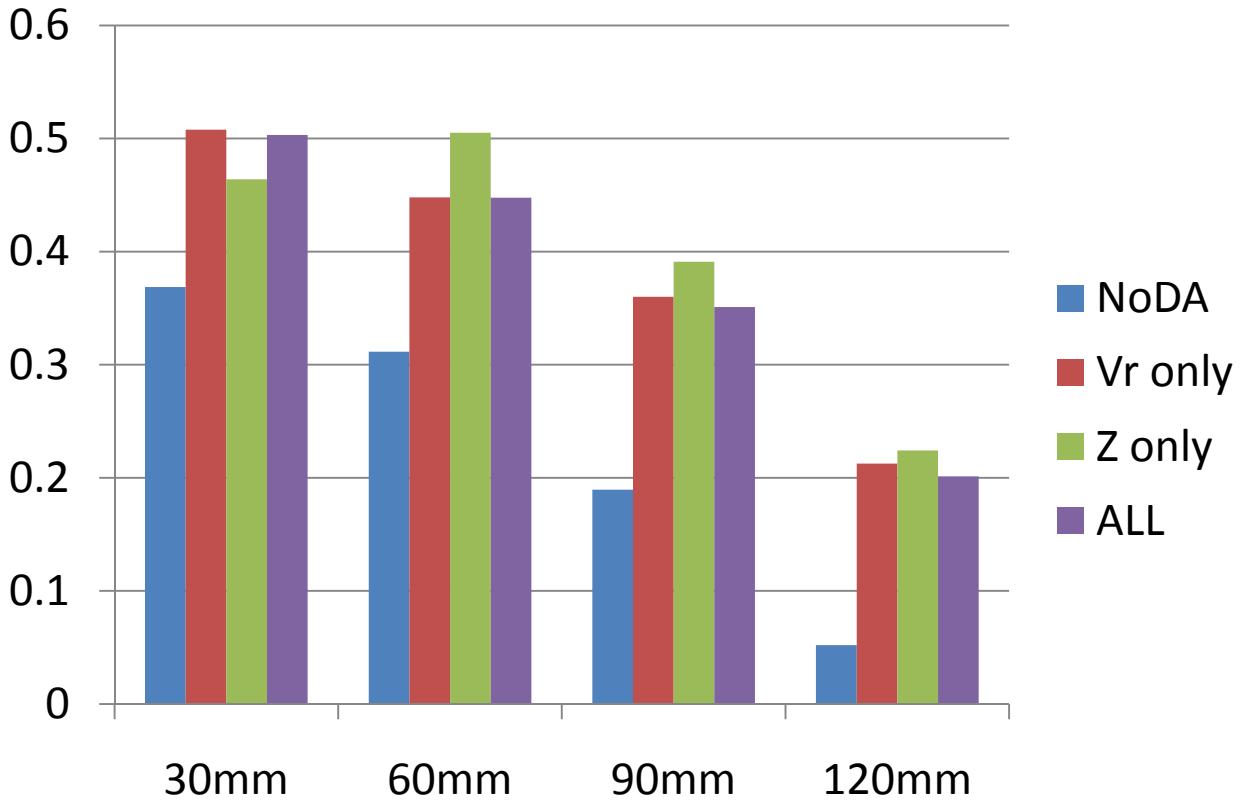




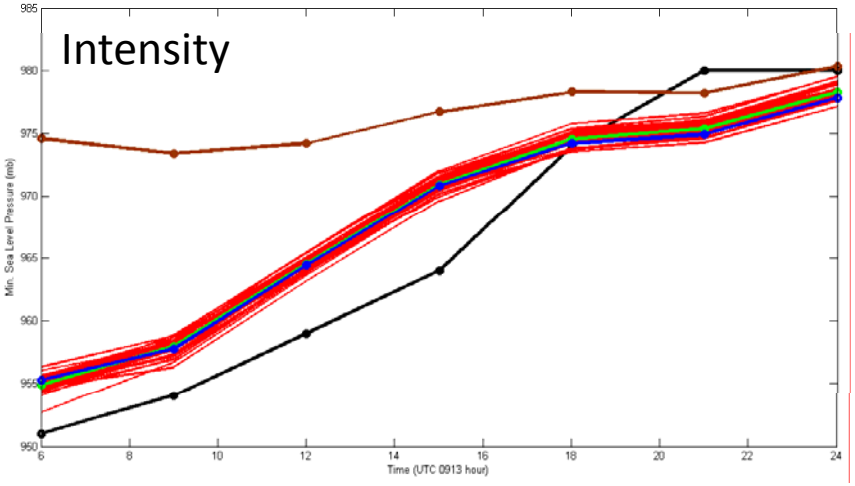


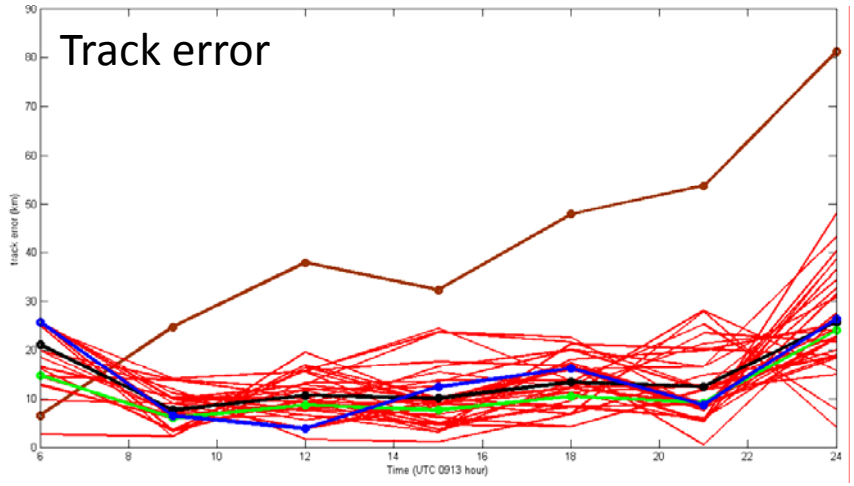


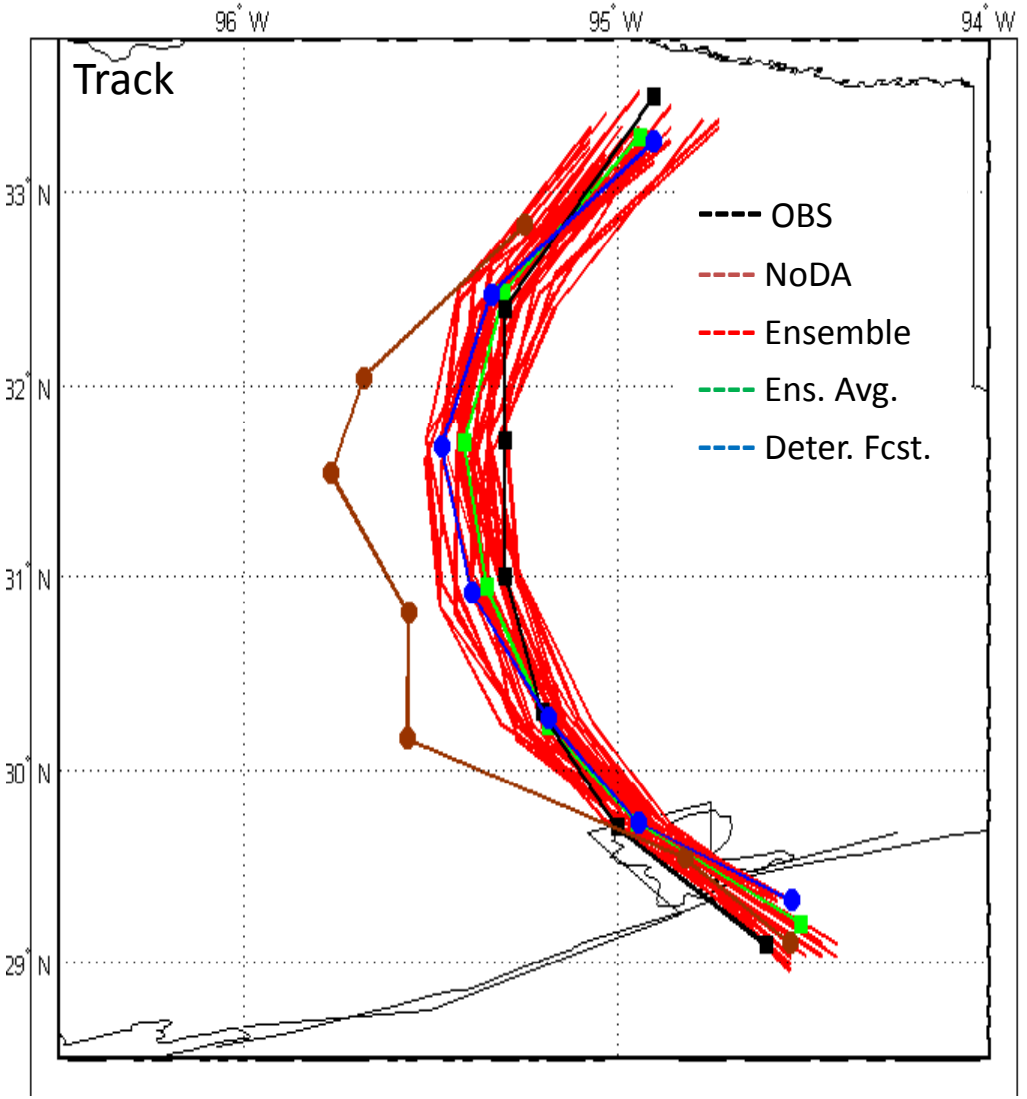
18 hr accu. prec. ETS rating



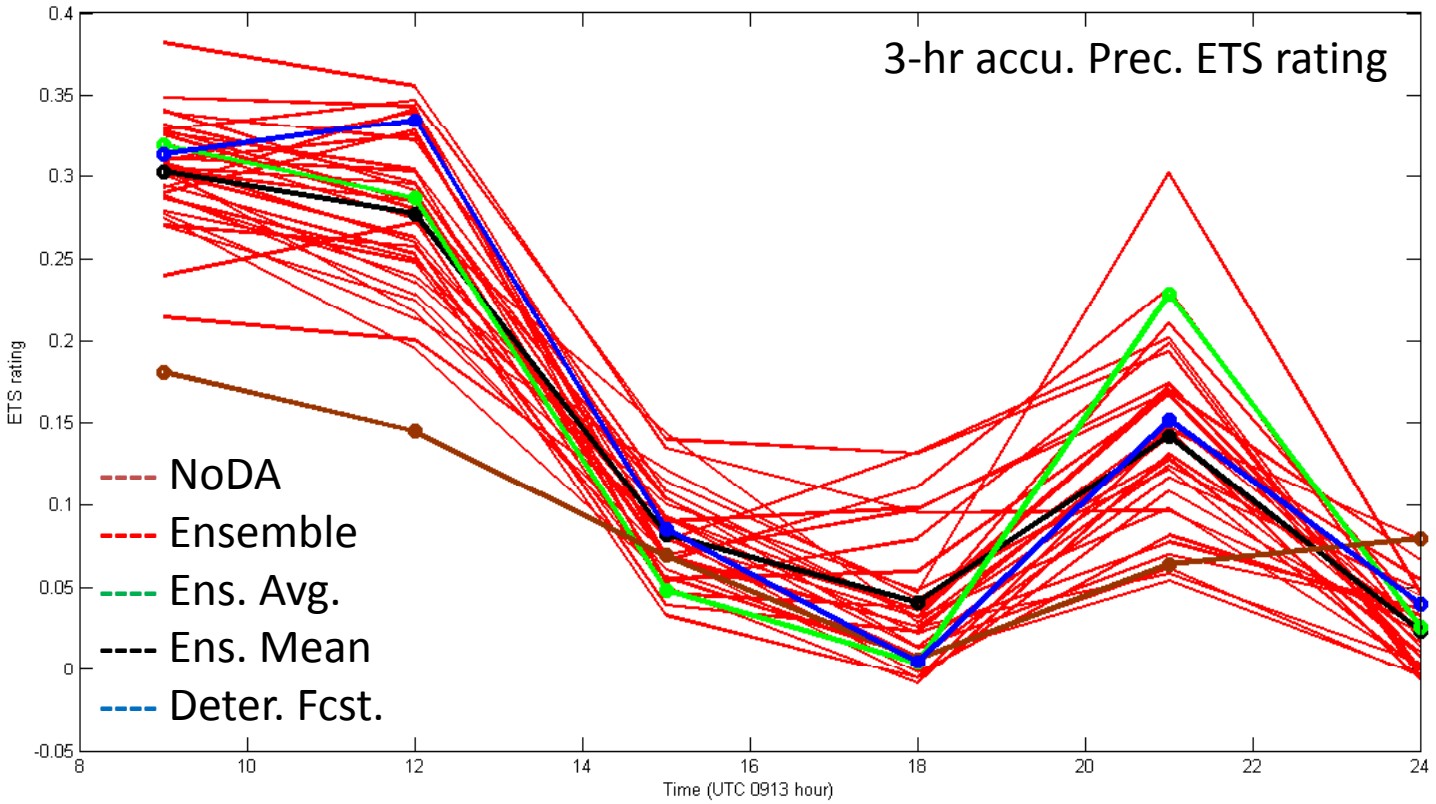
Ensemble forecast



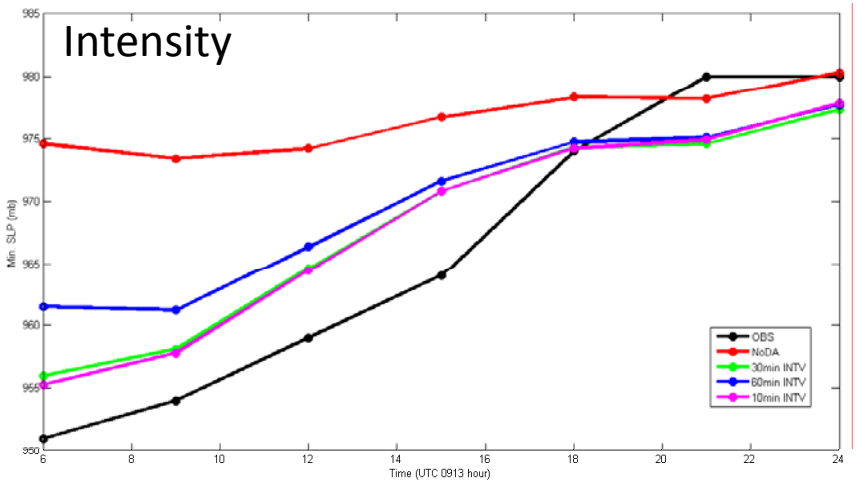


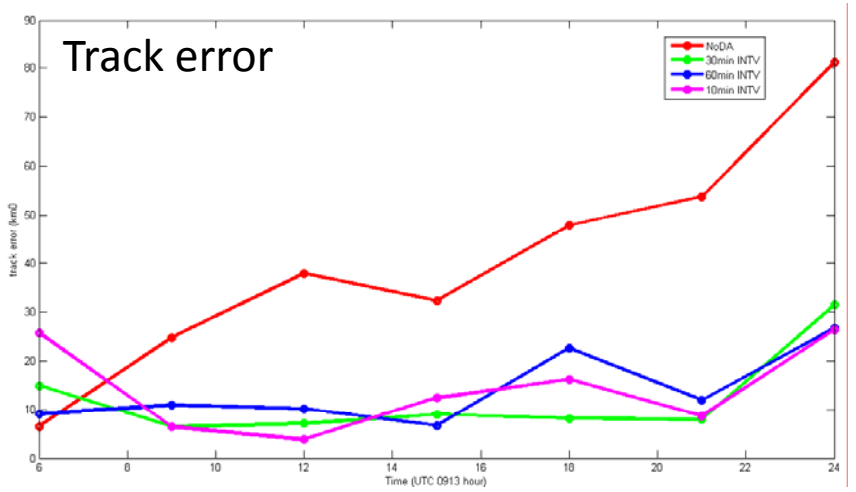


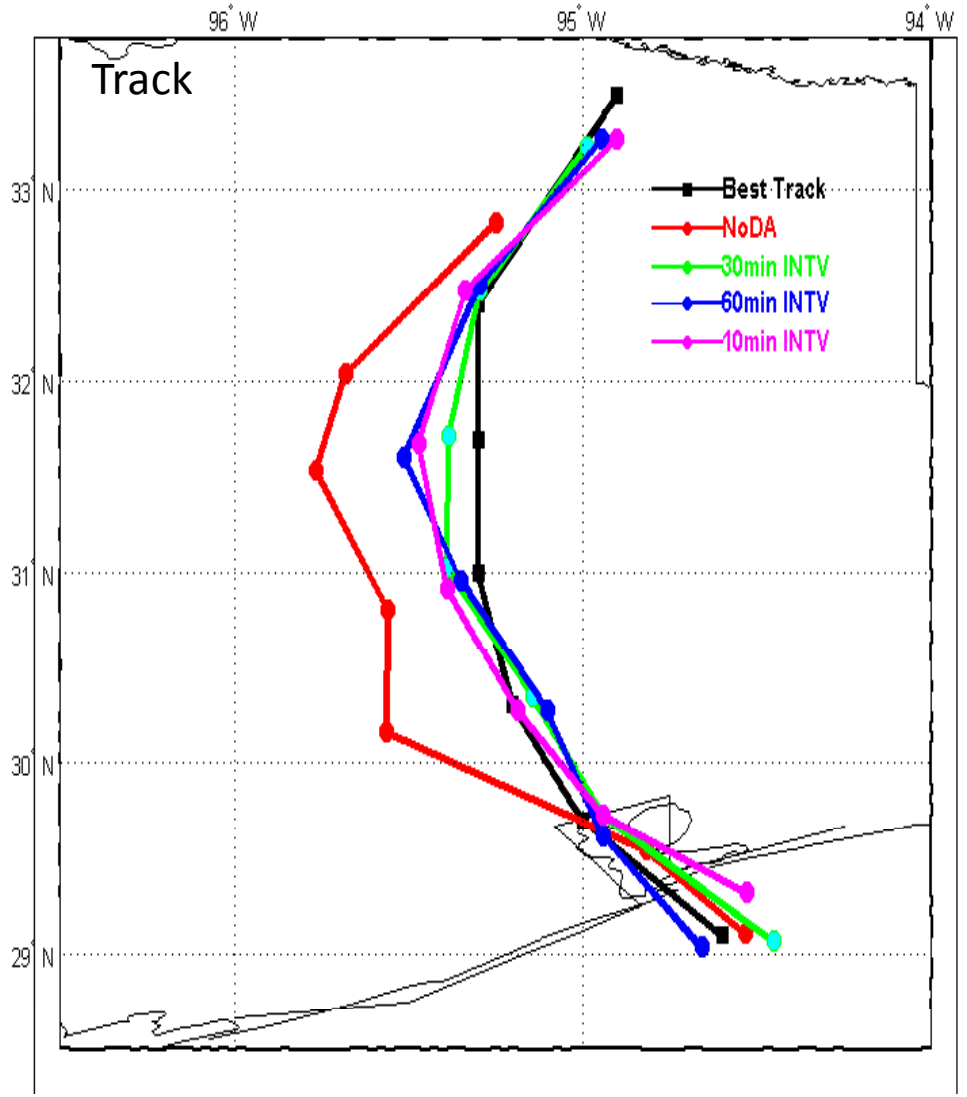
Ensemble Forecast



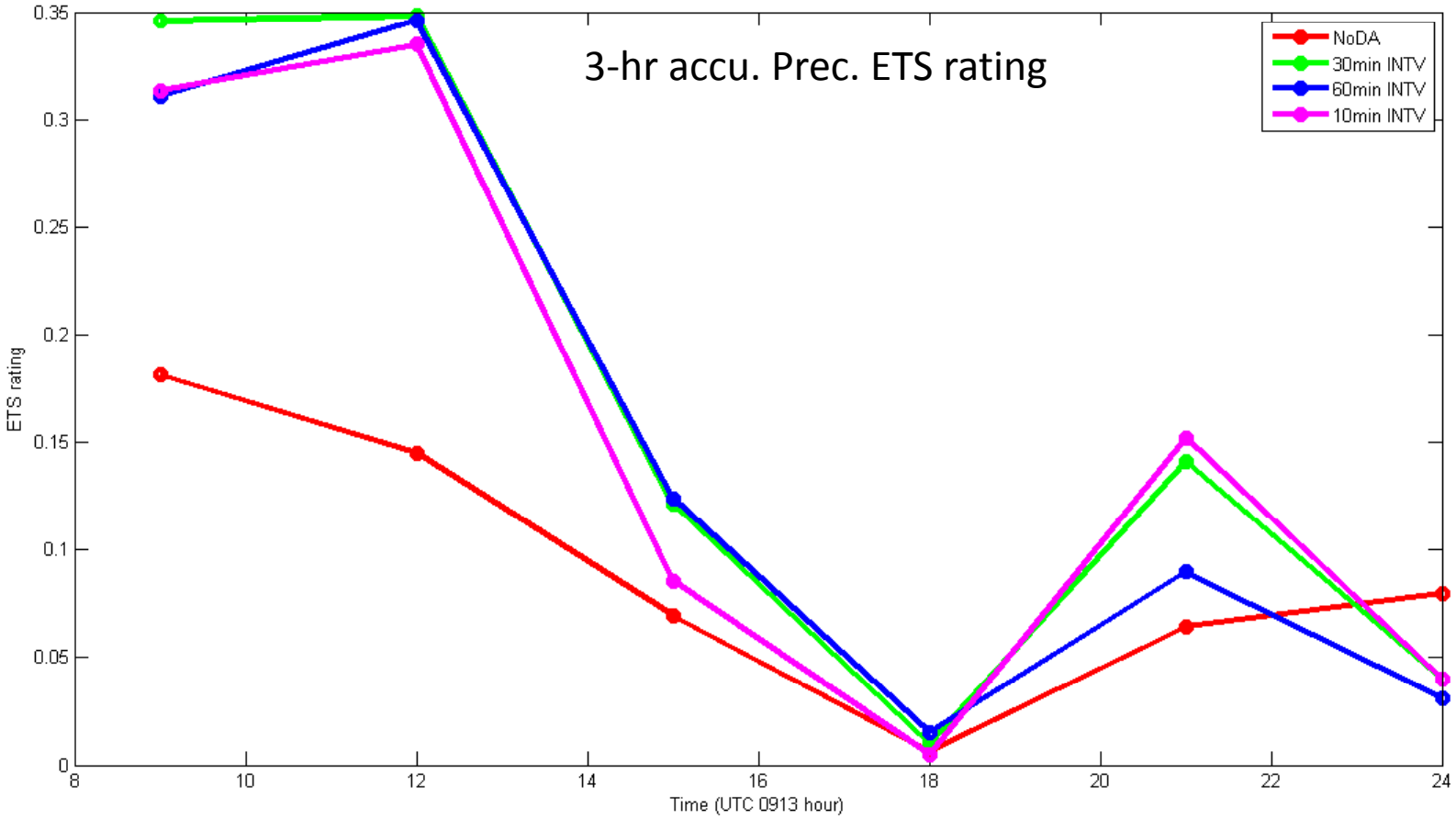
Assimilation Interval Experiments







Assimilation Interval Experiments



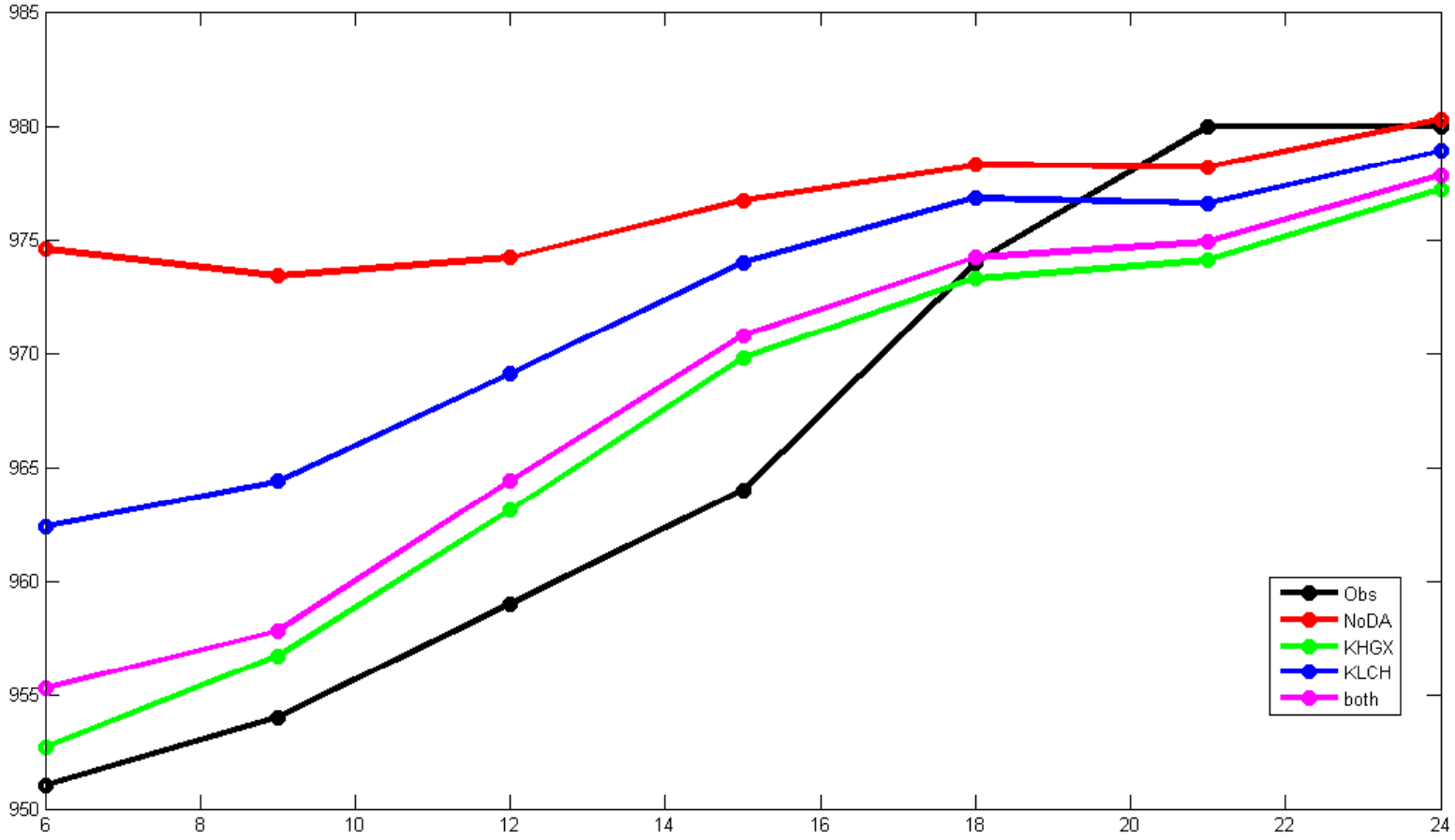
Summary

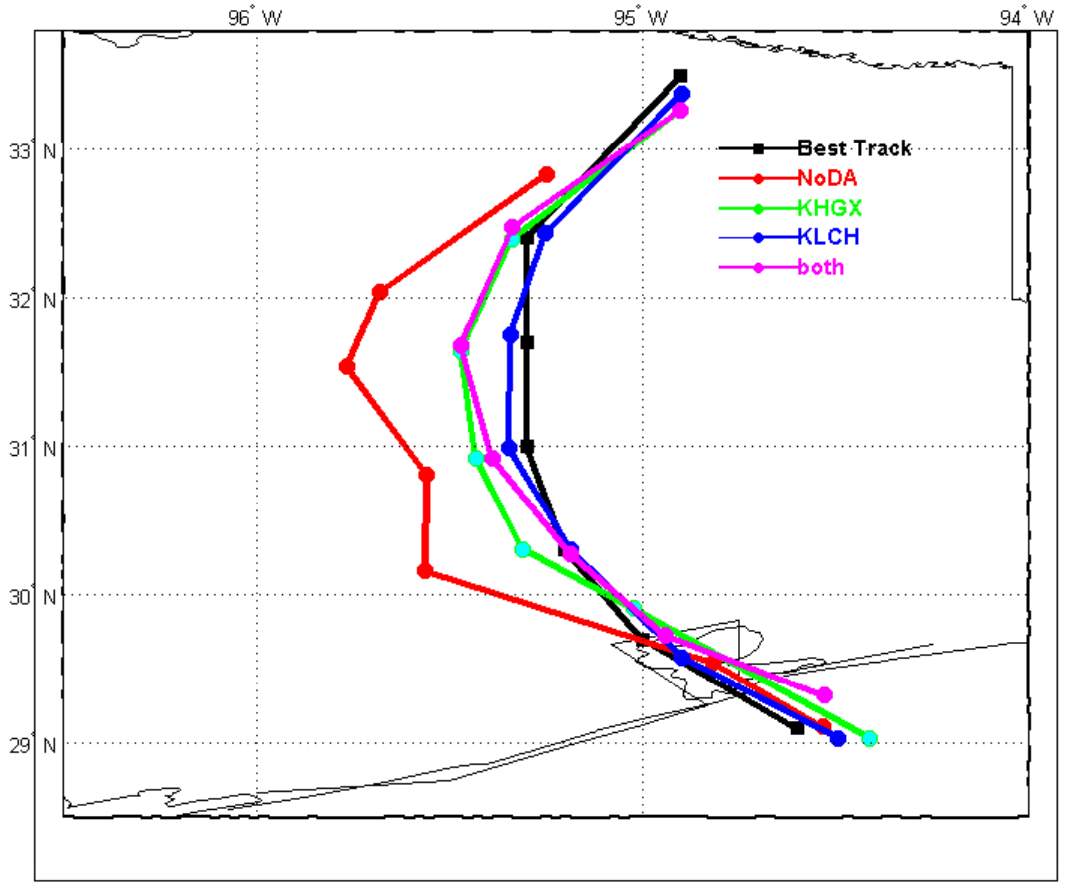
- Assimilation of radar radial velocity can improve track, intensity and precipitation forecast evidently
- Assimilation of radar reflectivity can improve track and precipitation forecast, but improvement to intensity is much smaller than Vr
- Assimilating both Vr and Z gives similar results as assimilating Vr only, suggesting more importance of Vr assimilation

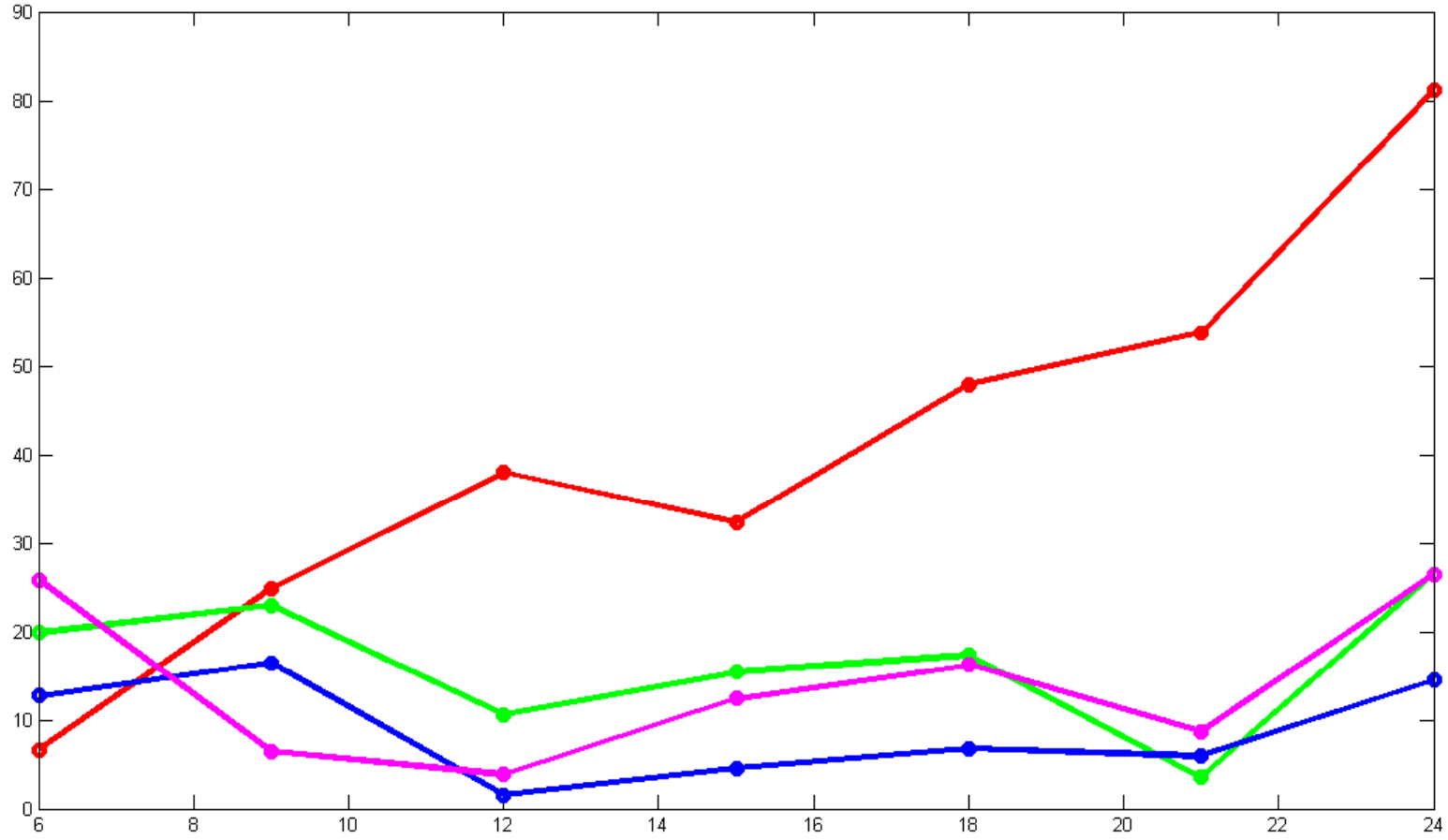
Summary

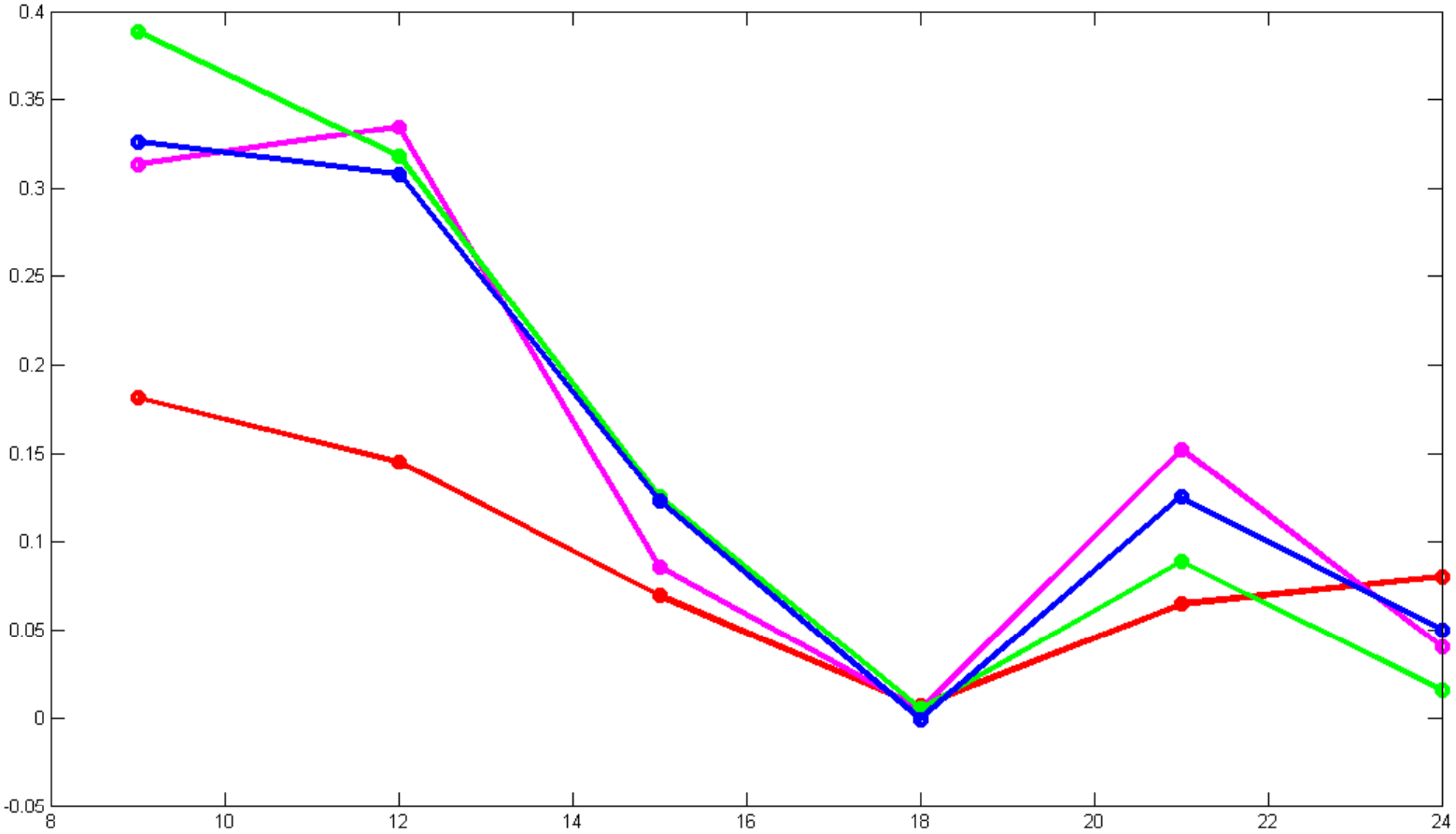
- Ensemble forecast shows uncertainty in track forecast but not much uncertainty growth in intensity
- 10min and 30min assimilation intervals show similar improvement in all aspects; 60min assimilation interval results in a weaker intensity

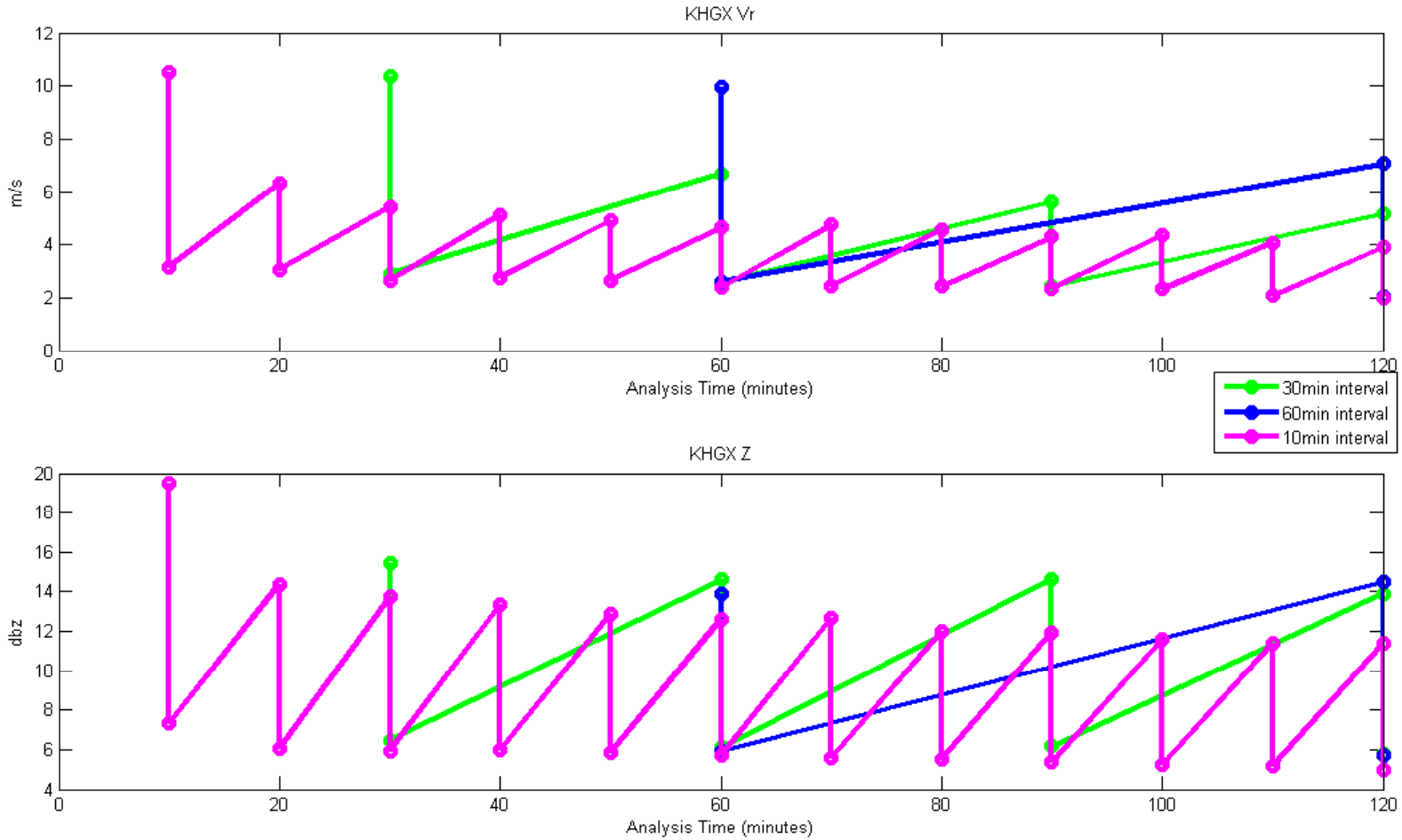
KHGX vs KLCH

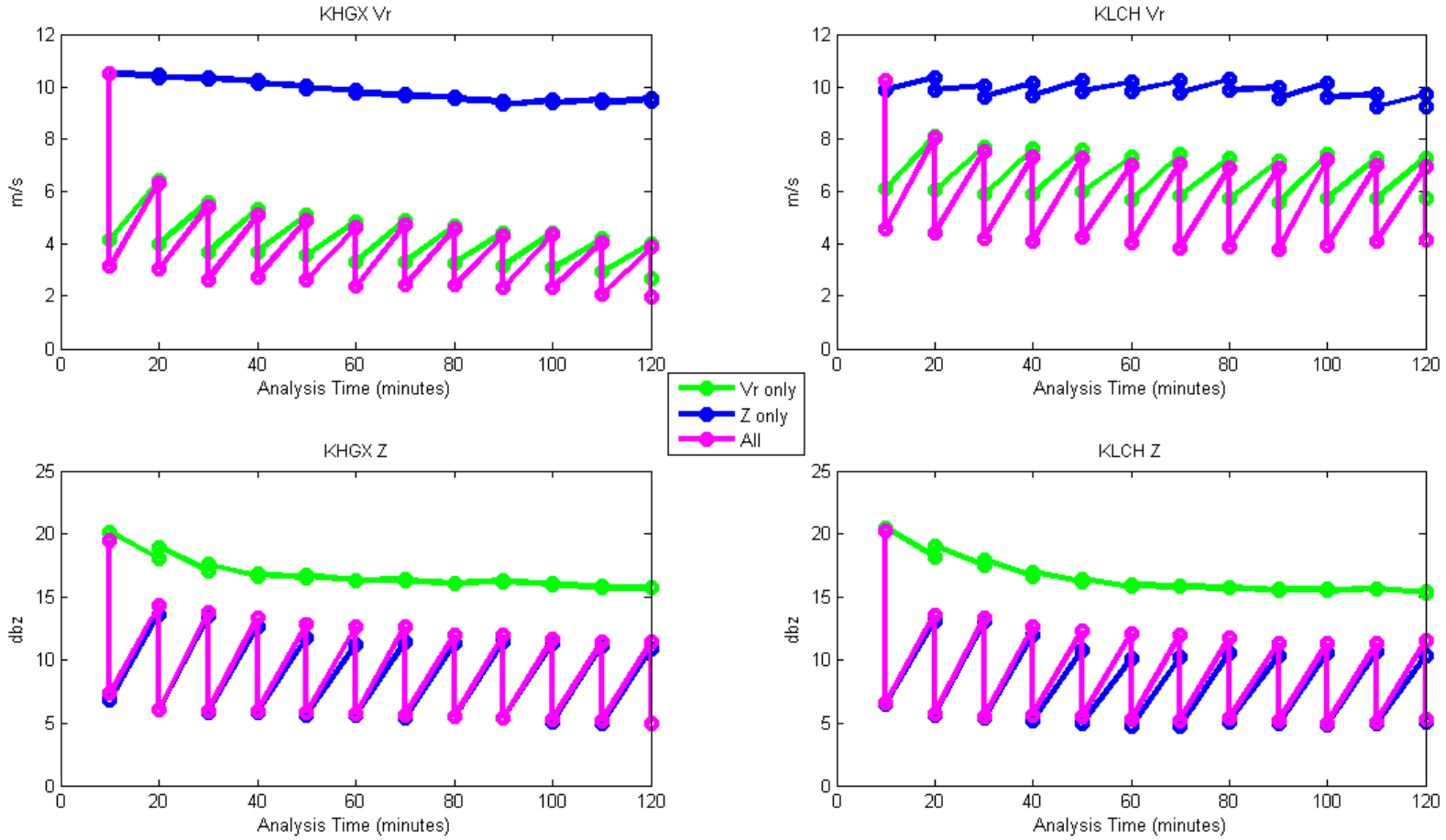

985
980
975
970
965
960
955
950
6
8
10
12
14
16
18
20
22
24
Obs
NoDA
KHGX
KLCH
both


96° W
95° W
94° W
33° N
32° N
31° N
30° N
29° N
Best Track
NoDA
KHGX
KLCH
both


90
80
70
60
50
40
30
20
10
0
6
8
10
12
14
16
18
20
22
24


0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
8
10
12
14
16
18
20
22
24


KHGX Vr
m/s
Analysis Time (minutes)
30min interval
60min interval
10min interval
KHGX Z
dbz
Analysis Time (minutes)


KHGX Vr
KLCH Vr
KHGX Z
KLCH Z
m/s
dbz
Analysis Time (minutes)
Vr only
Z only
All