Testing and Evaluation of the GSI-Hybrid 3DVAR for basin scale HWRF

Chunhua Zhou[1,3], Hui Shao[1,3], Ligia Bernardet[2,3], Mrinal Biswas[1,3] and Brian Etherton[2,3]

[1] National Center for Atmospheric Research (NCAR)
[2] NOAA/ESRL/GSD
[3] Developmental Testbed Center (DTC)

What is GSI-Hybrid 3DVAR?

GSI-3DVAR (static BE)

$$J(x) = \frac{1}{2}(x - x_b)^T B^{-1}(x - x_b) + \frac{1}{2}[y - H(x)]^T R^{-1}[y - H(x)]$$

GSI-Hybrid 3DVAR

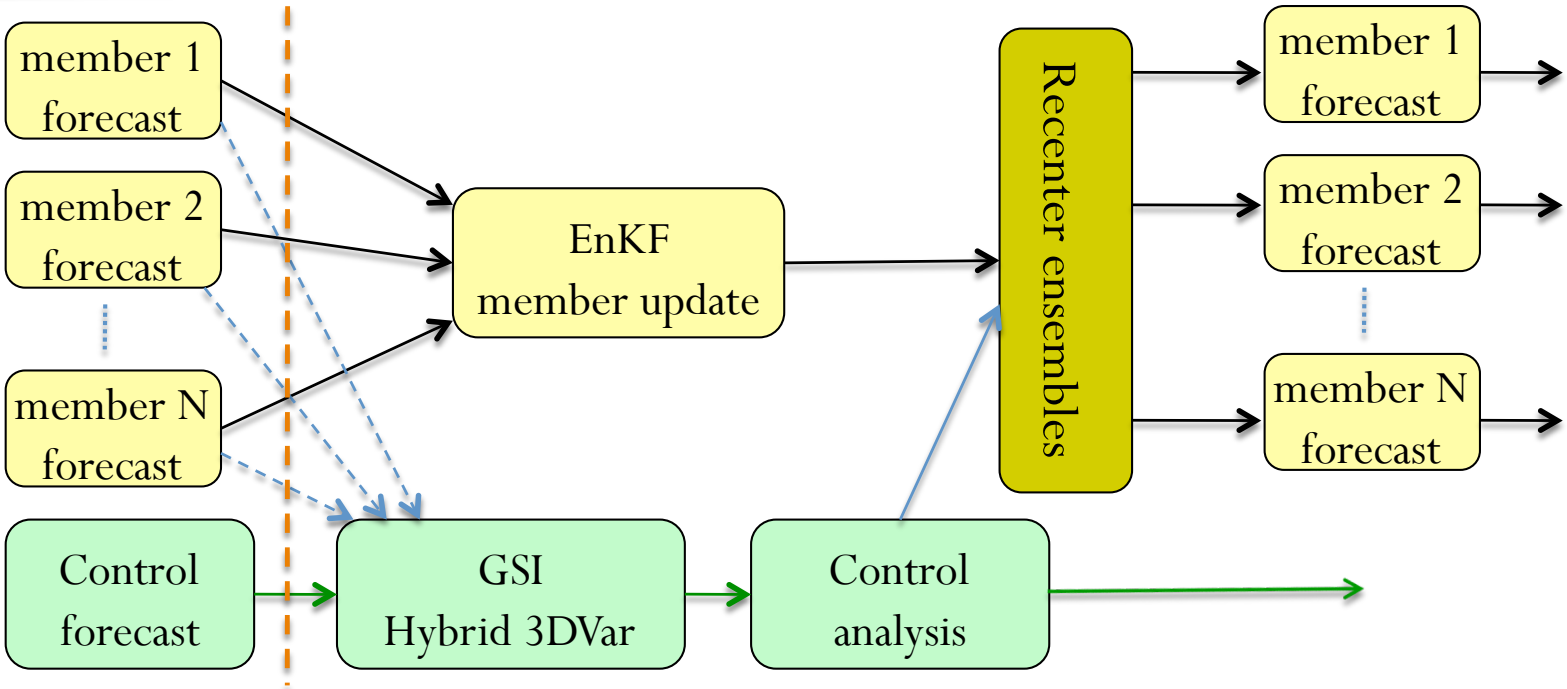
$$J(x,\alpha) = \beta_1 J_b + \beta_2 J_e + J_o$$

3DVAR

ensembles

extended control variables

$$= \beta_1 \frac{1}{2}(x - x_b)^T B^{-1}(x - x_b) + \beta_2 \frac{1}{2}\alpha^T A^{-1}\alpha + \frac{1}{2}[y - H(x + x_e)]^T R^{-1}[y - H(x + x_e)]$$



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- **GSI-Hybrid 3DVAR**

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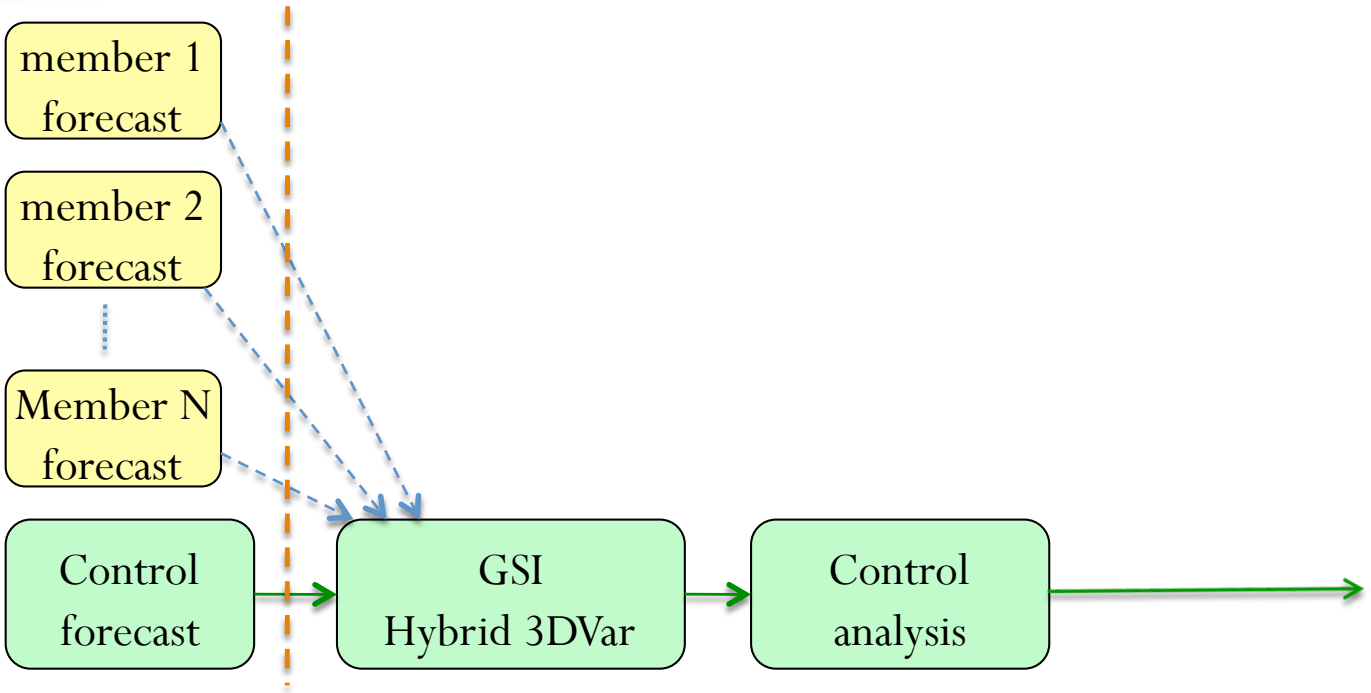
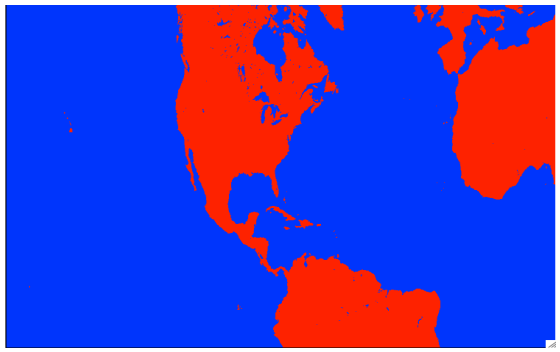


Model configuration

- HWRF: basin scale branch from EMC, 61 vertical levels, model top at 2mb, horizontal grid spacing=27km, on basin scale domain
- GSI: basin scale branch from EMC
- Background: GFS

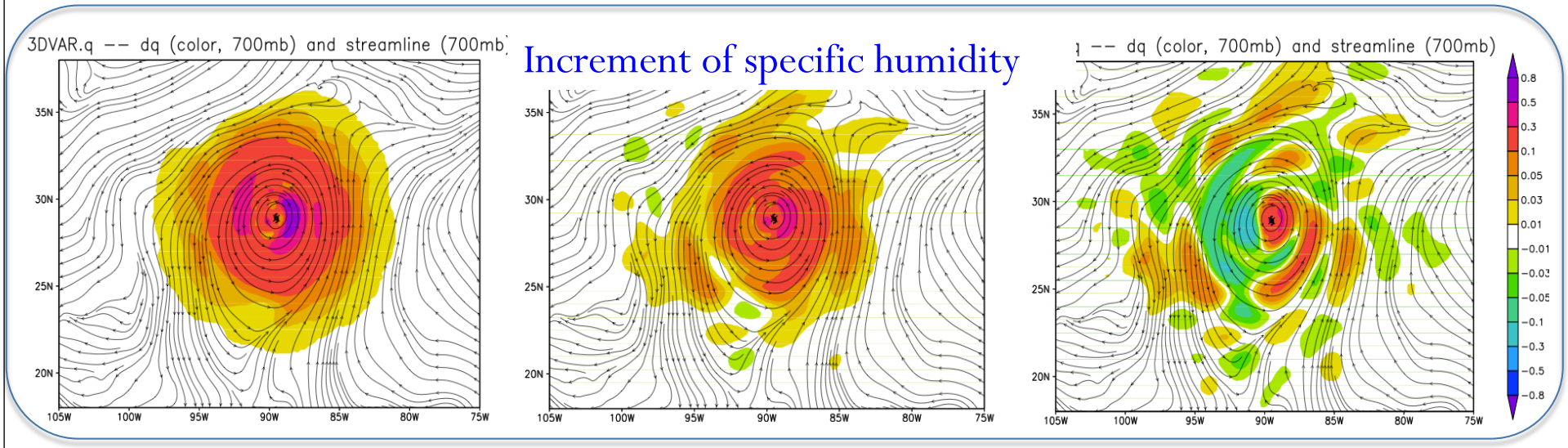


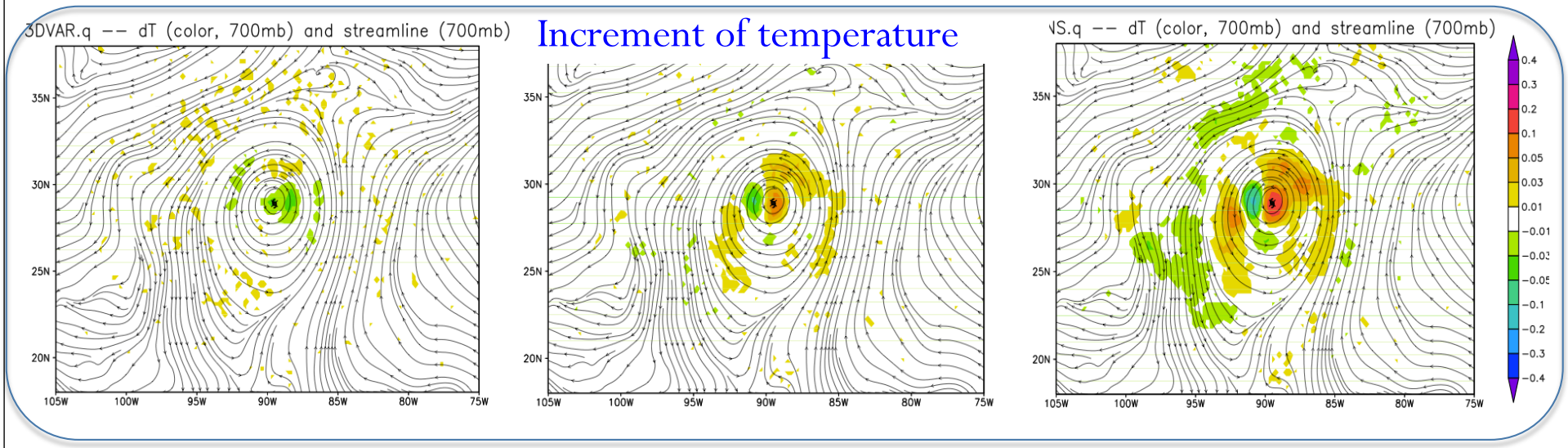
Cross-covariance investigation

- 3DVAR: $\beta_1=1.0,\ \beta_2=0.0$
- HYB: $\beta_1=0.25,\ \beta_2=0.75$
- **ENS**: $\beta_1=0.0,\ \beta_2=1.0$

- 80 global ensembles
- The single observation is at or around storm center of Isaac (Hurricane) or Kirk (tropical storm)
- Background: 2012082900

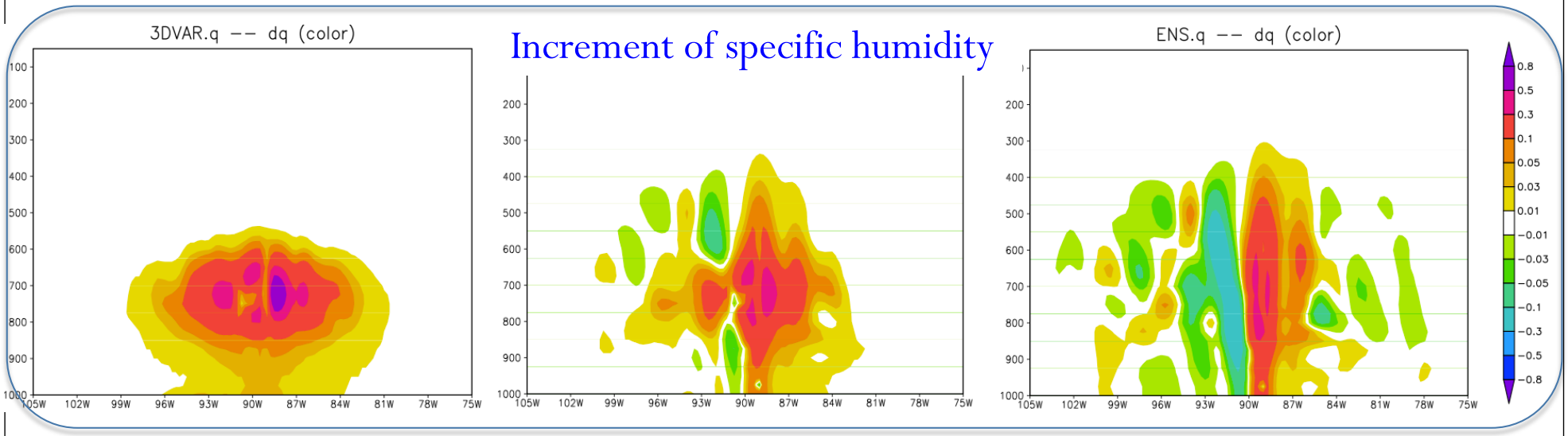
- Obs: q=1g/kg at 700mb at 28.9N, 270.5E (Isaac center)

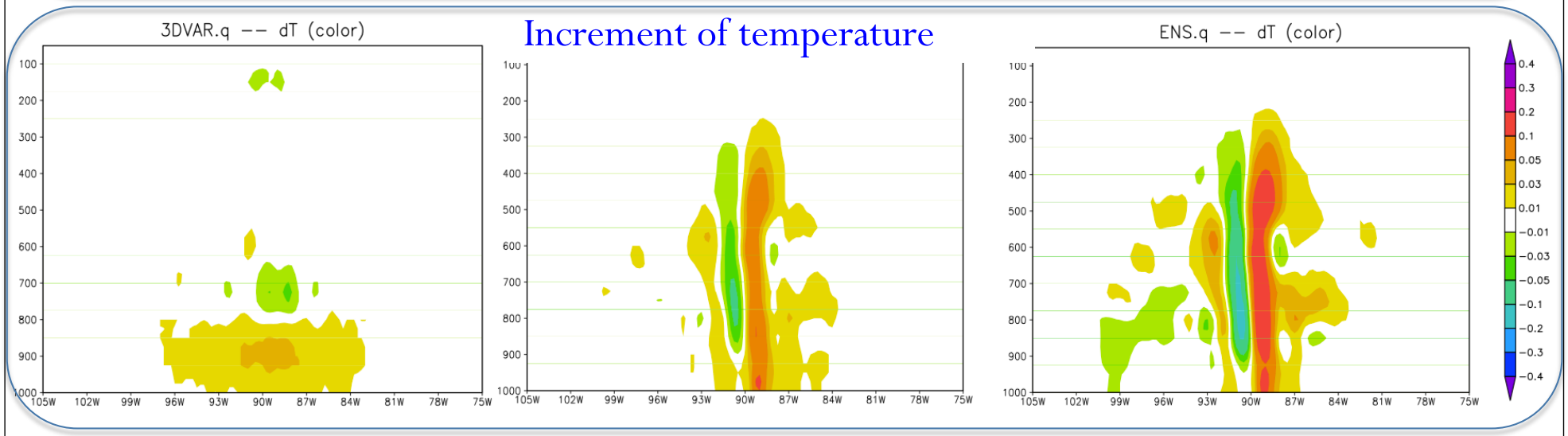




3DVAR Hybrid Ensemble

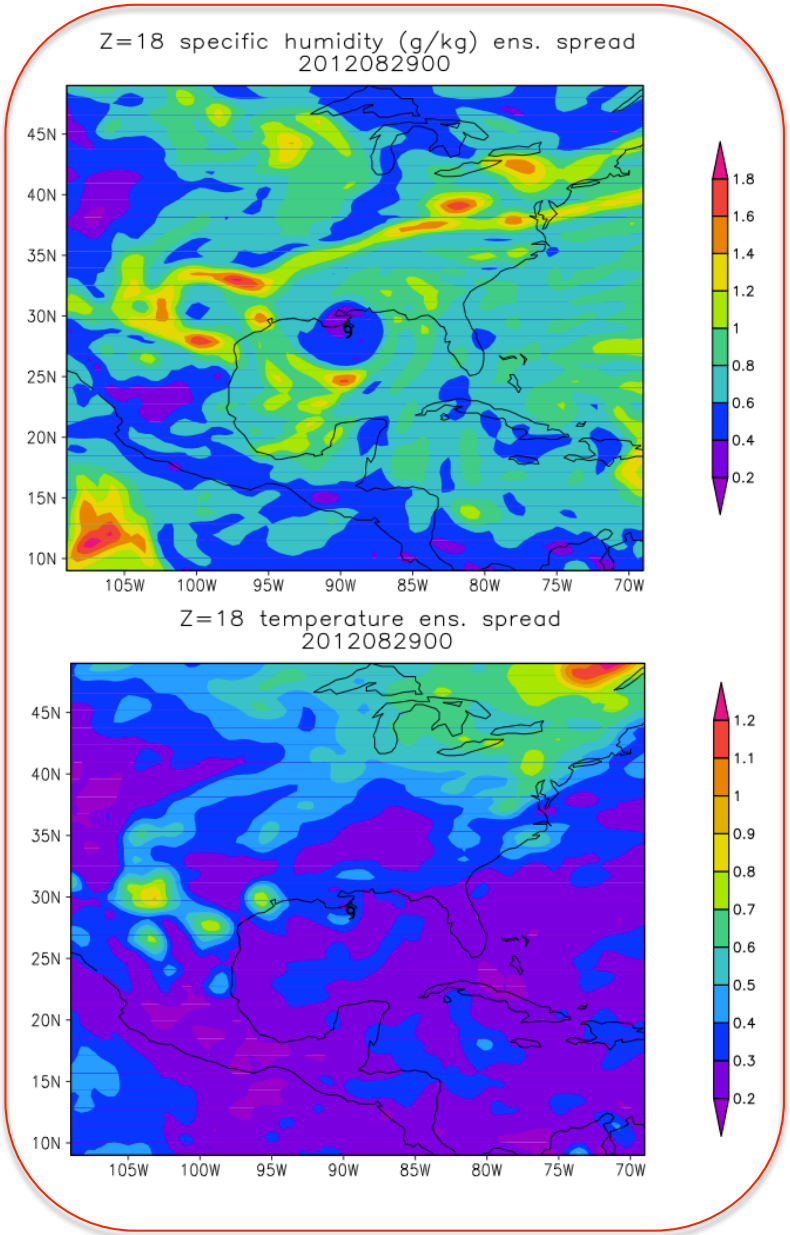
- Obs: q=1g/kg at 700mb at 28.9N, 270.5E (Isaac center)

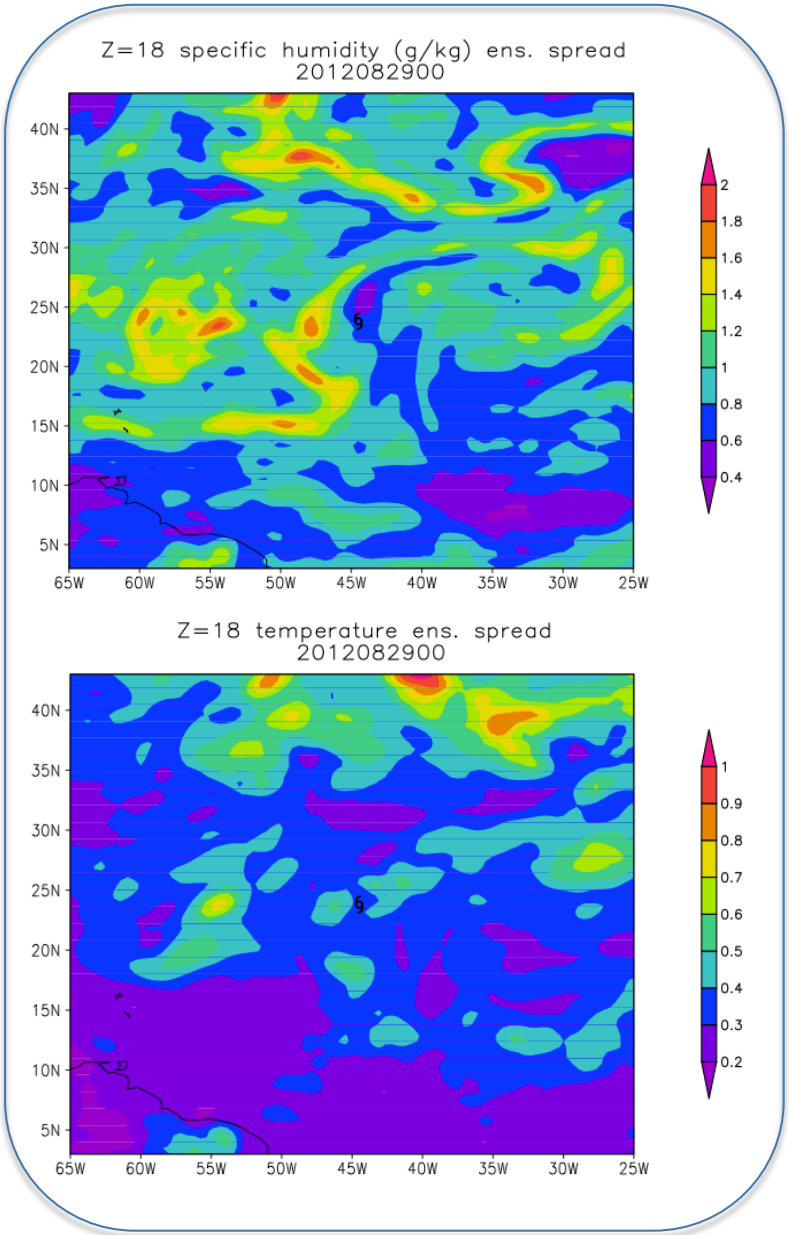




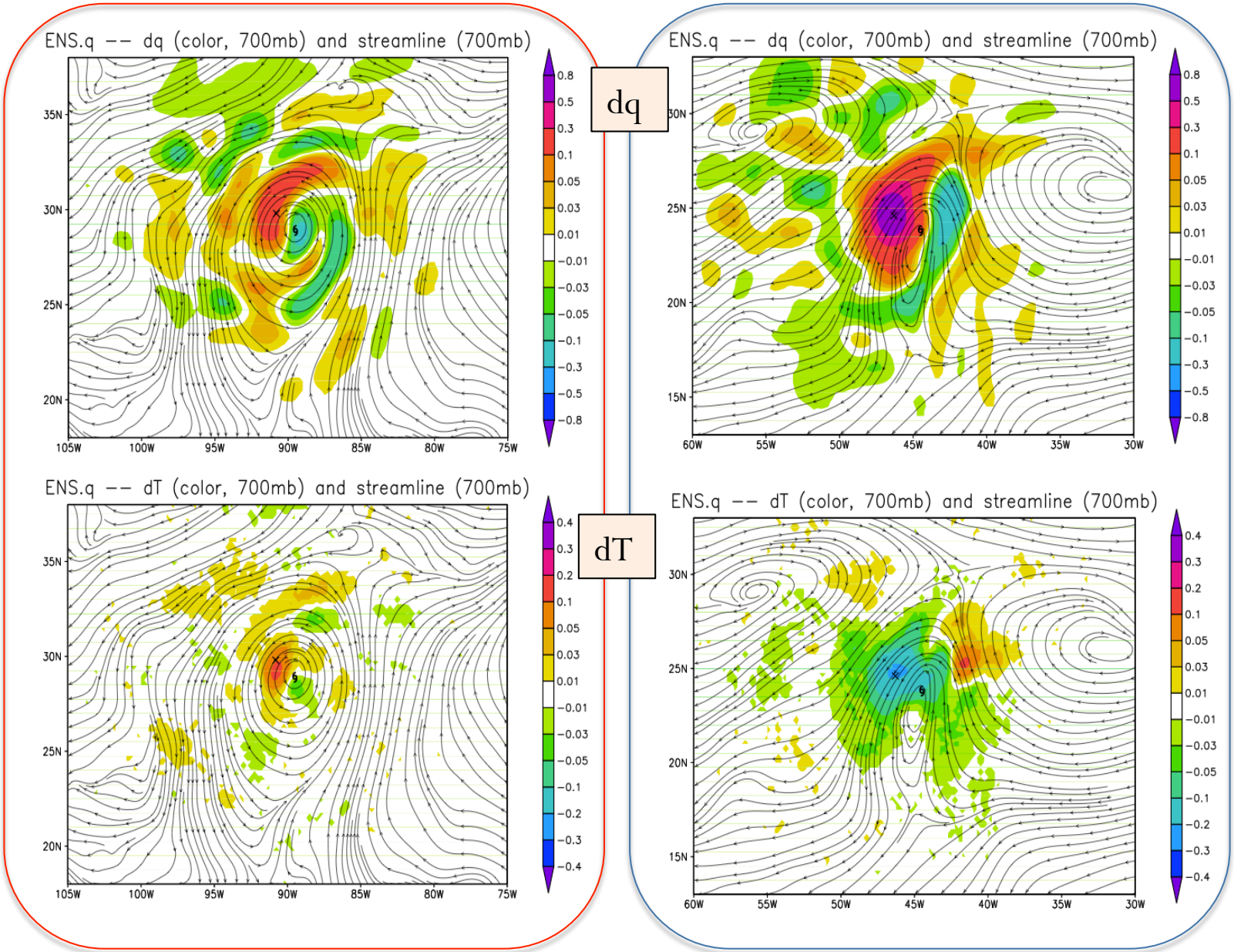
3DVAR Hybrid Ensemble

Ensemble spread of q (top) and T (bottom) around Isaac (left) and Kirk (right) at 2012082900

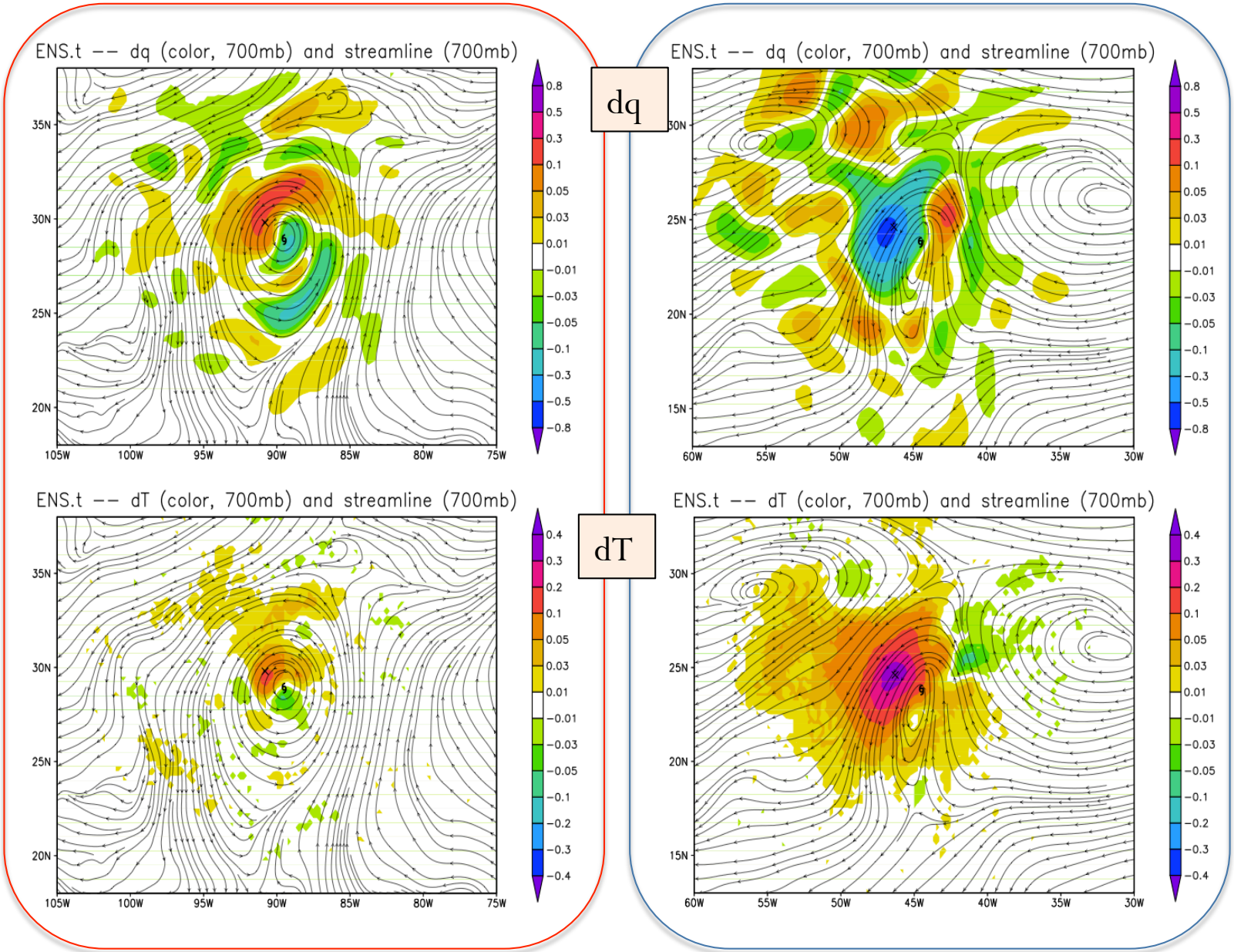




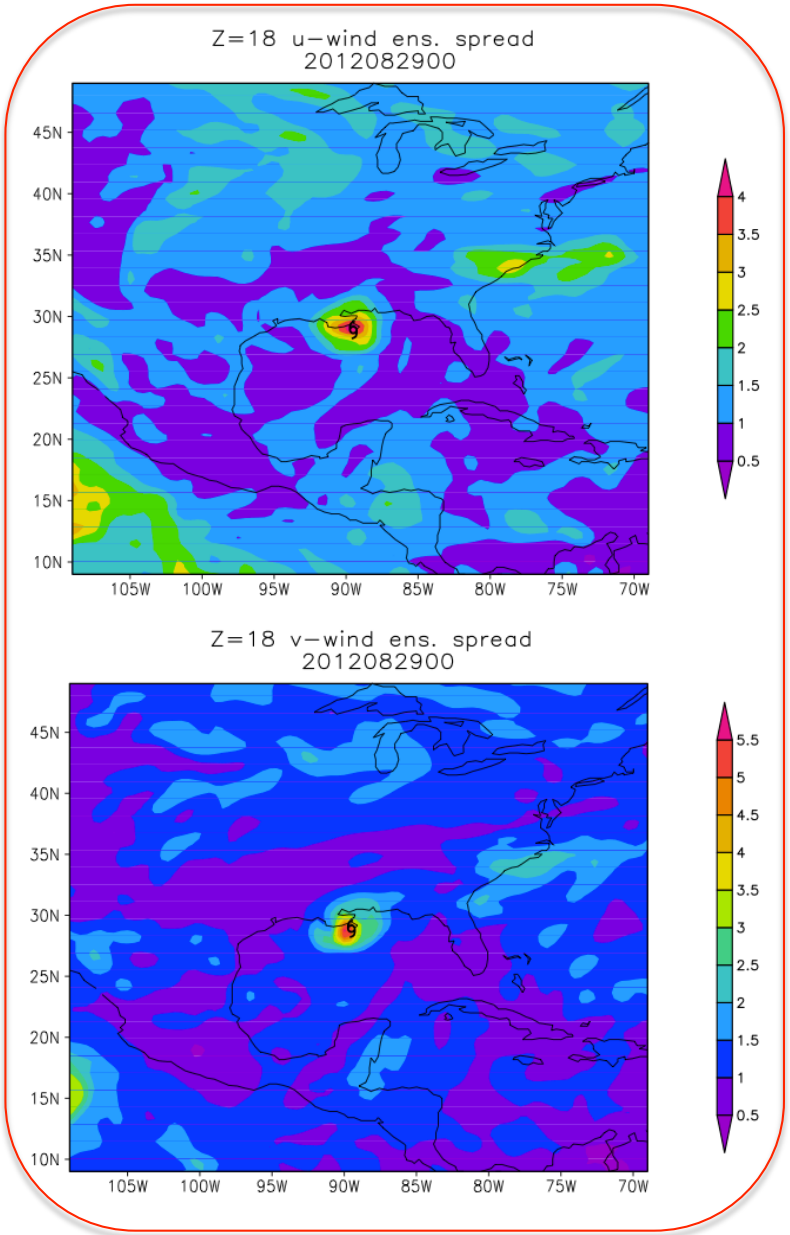
- Obs: q=1g/kg at 700mb - NW of the storm center Isaac (left) and Kirk (right)

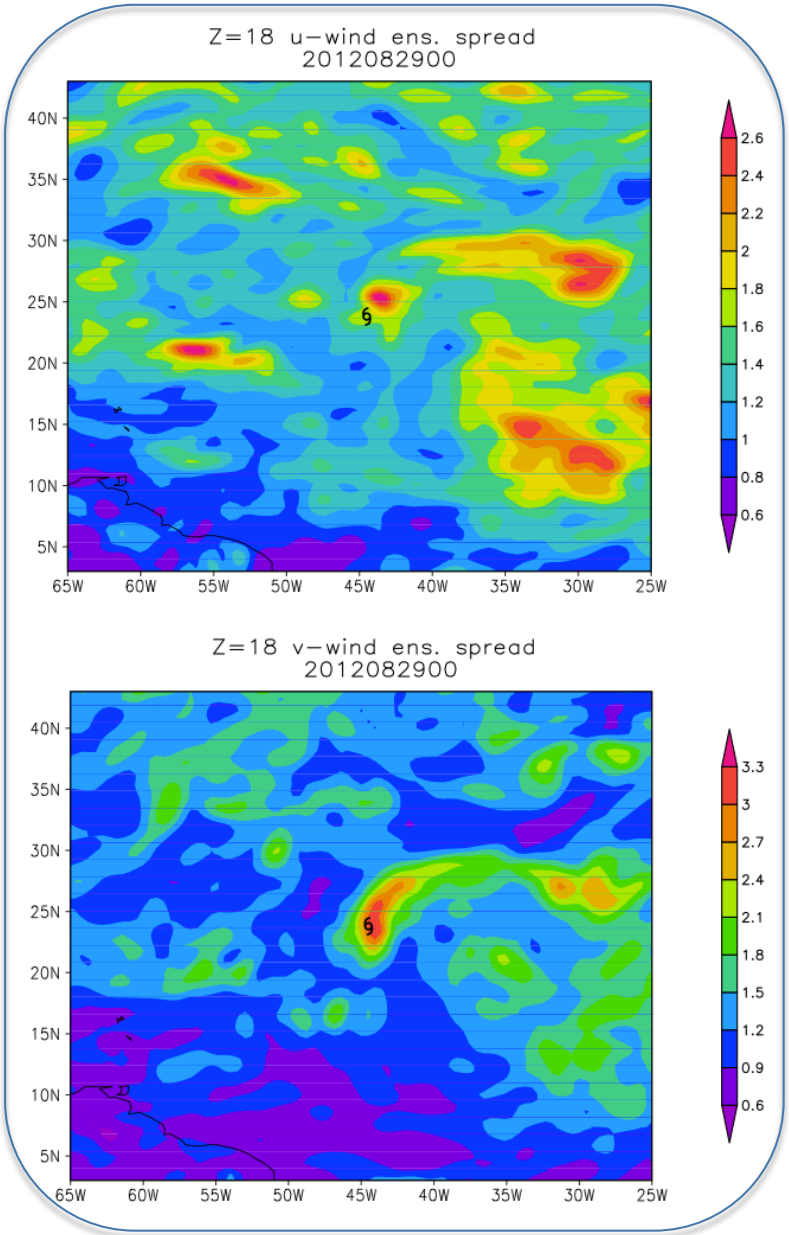


- Obs: T=1K at 700mb - NW of the storm center Isaac (left) and Kirk (right)



Ensemble spread of u (top) and v (bottom) around Isaac (left) and Kirk (right) at 2012082900





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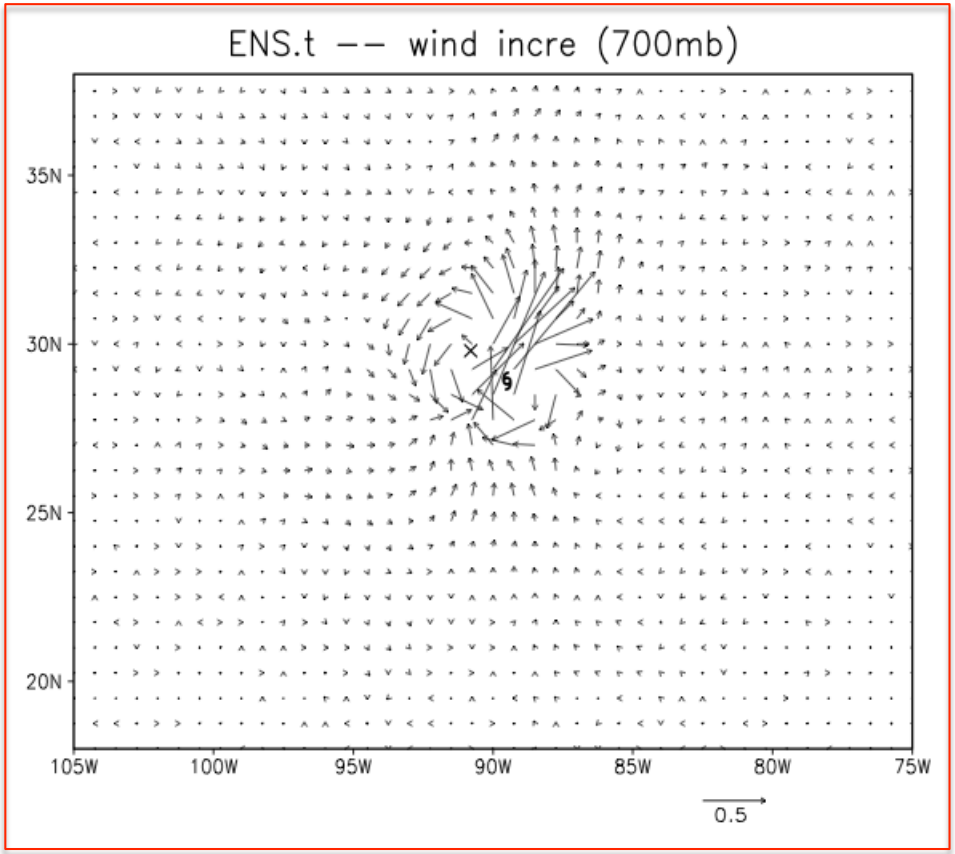
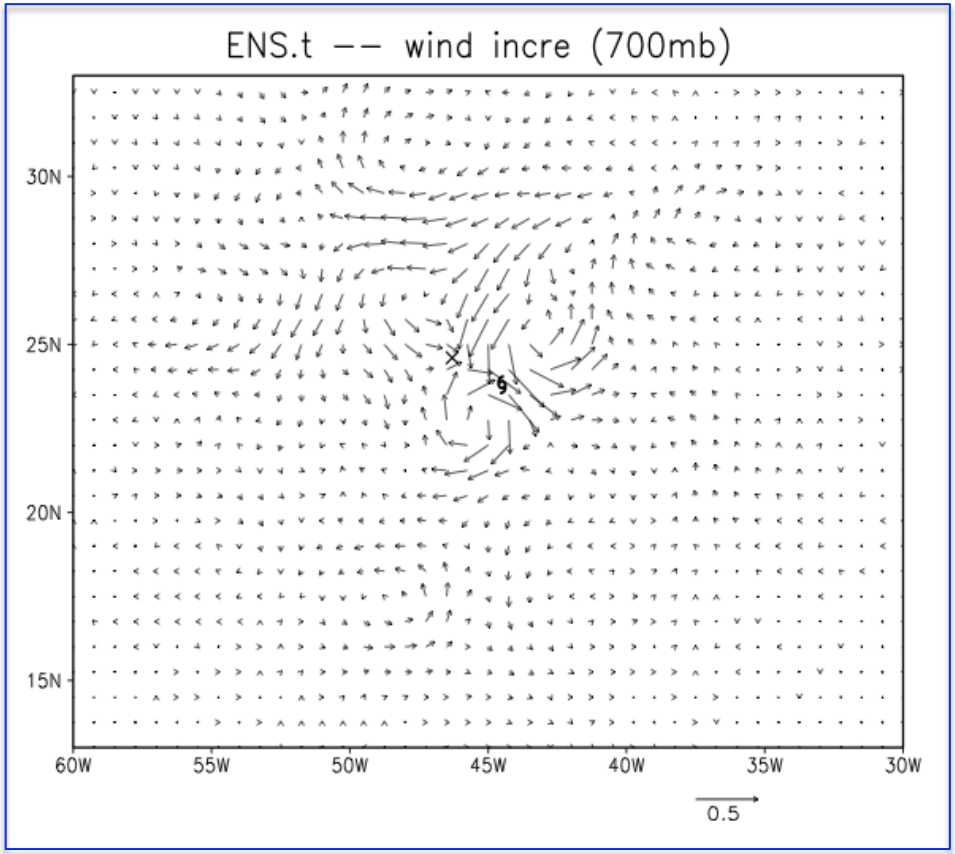
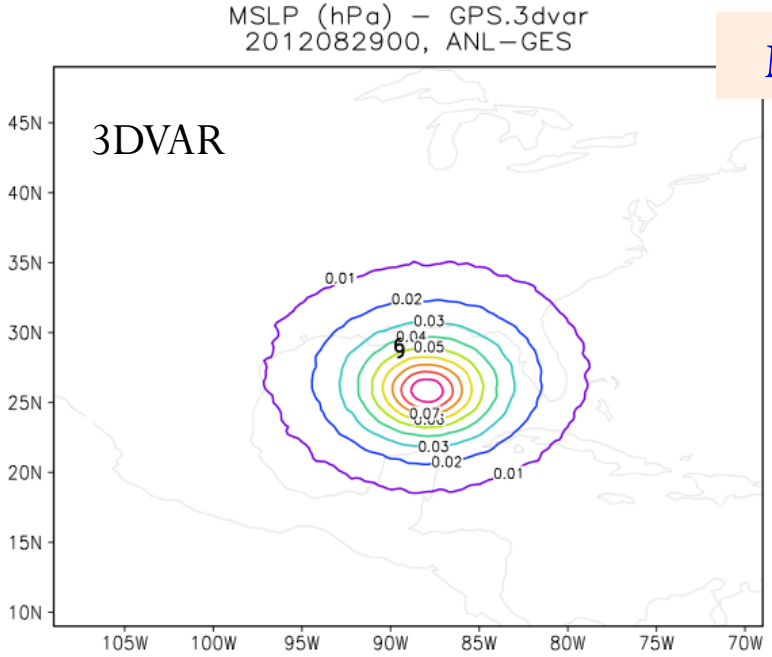
Wind increment at 700mb

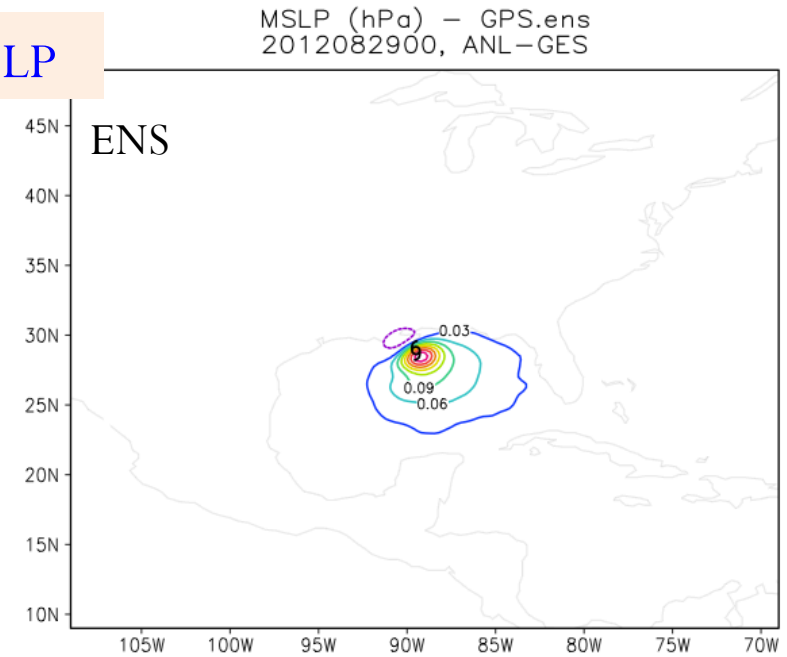


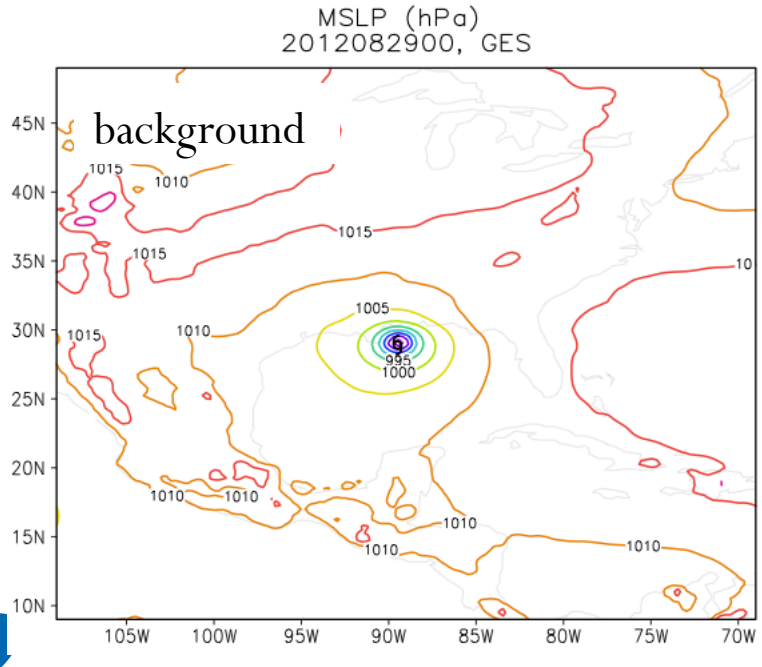


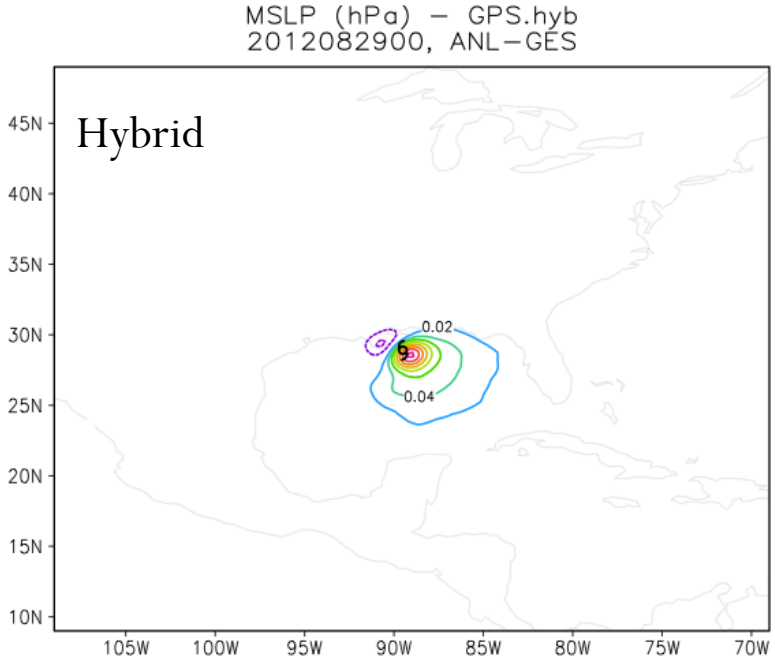
- Obs: one GPS profile at around 271.46E-272.64E, 25.2N-26.4N

MSLP









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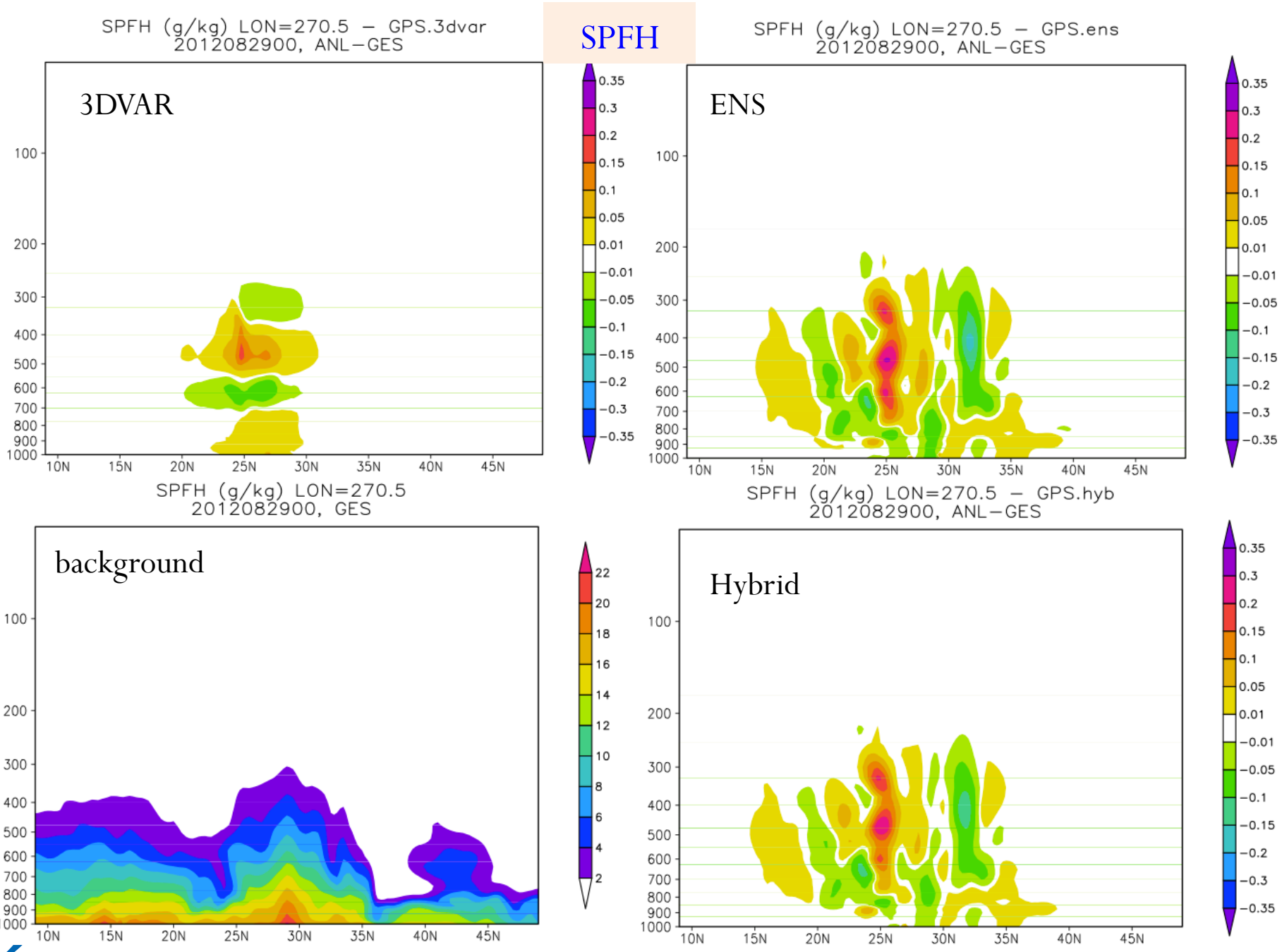

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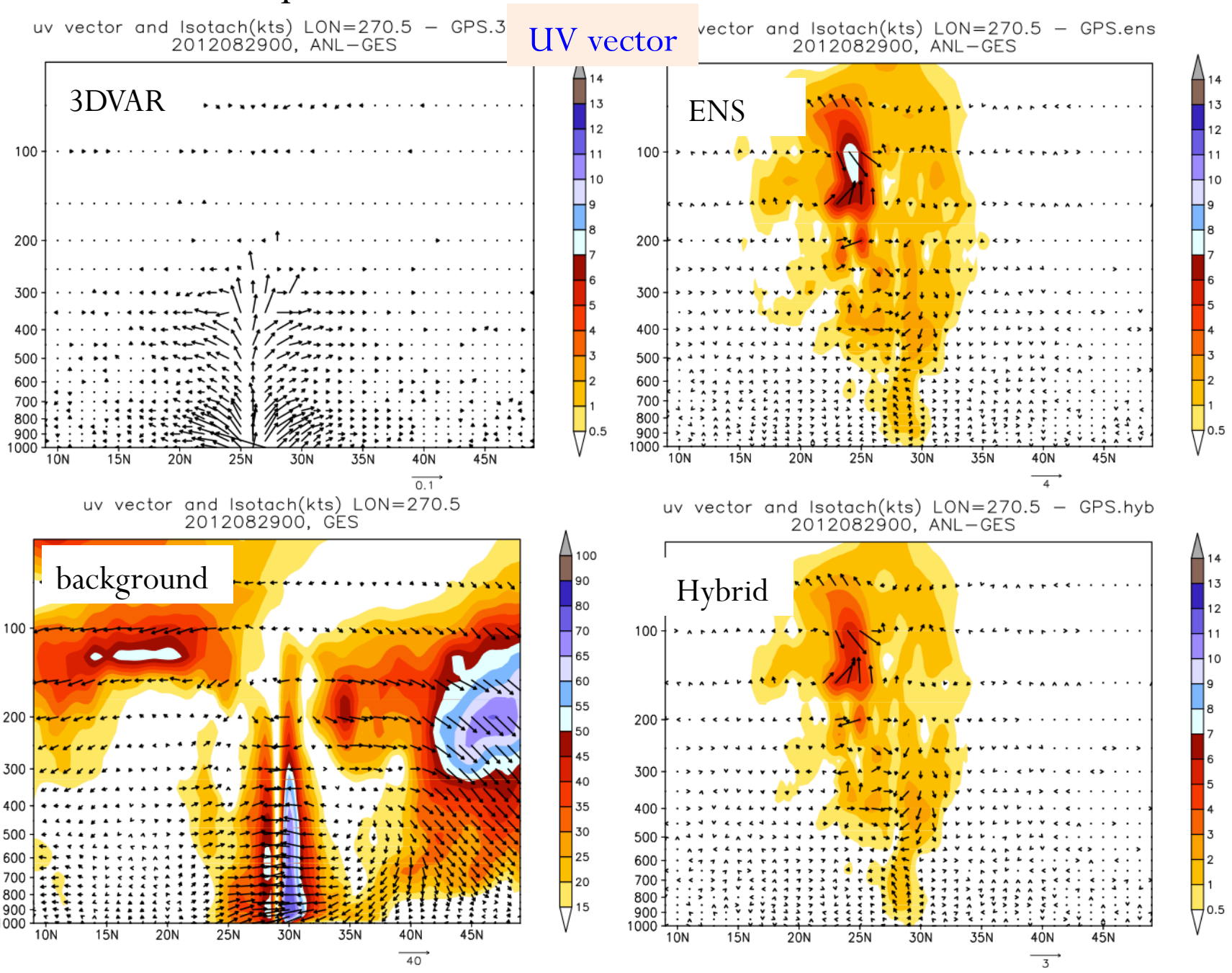
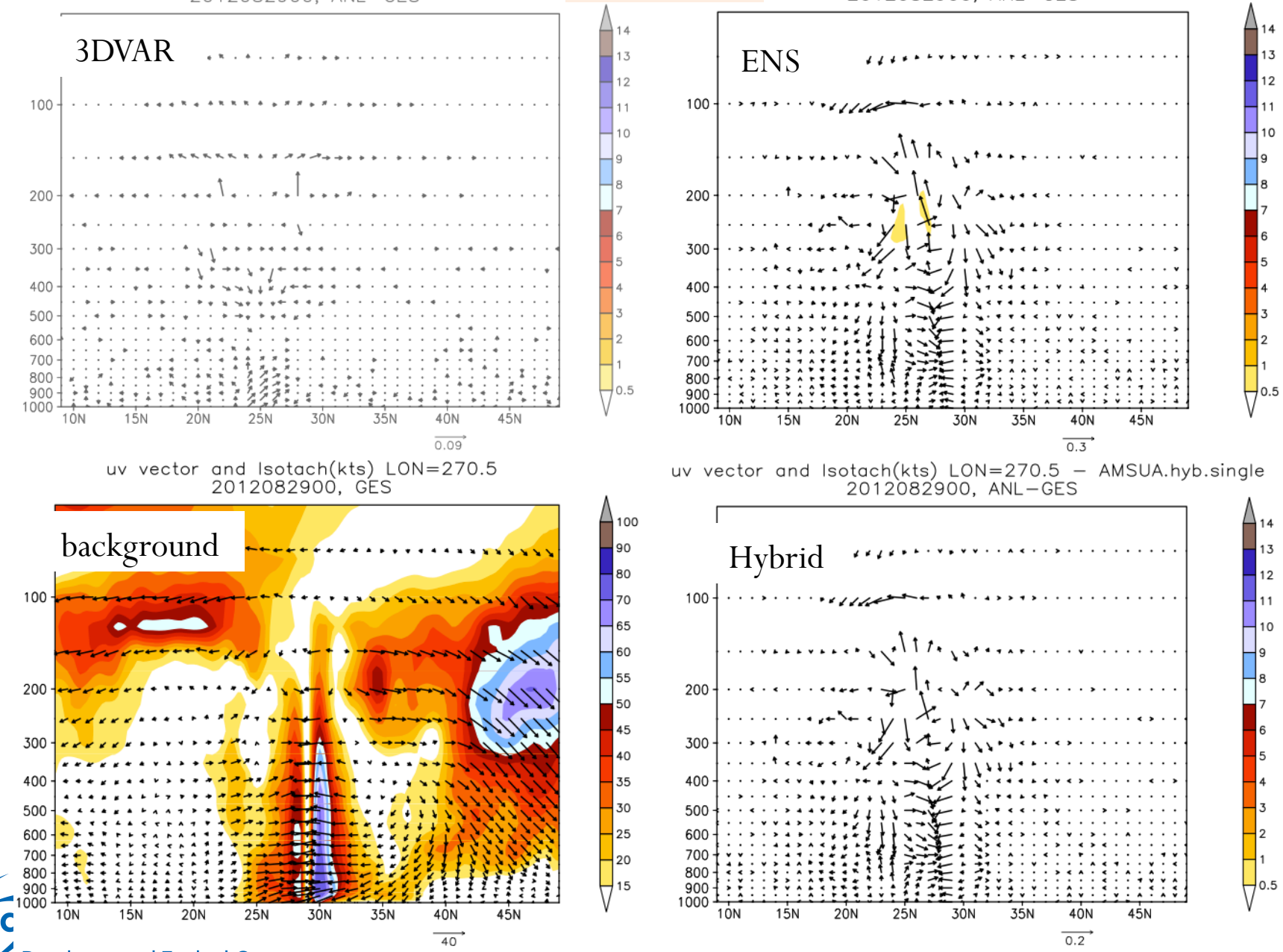


- Obs: one AMSUA radiance profile at 272E, 25.12N

UV vector

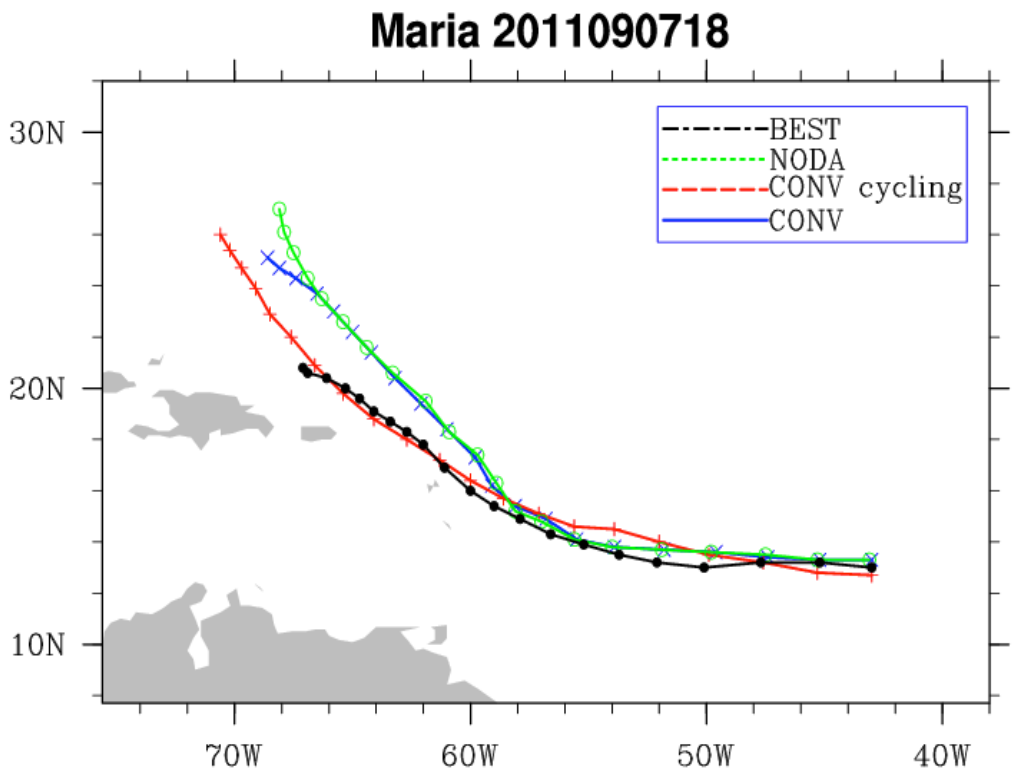


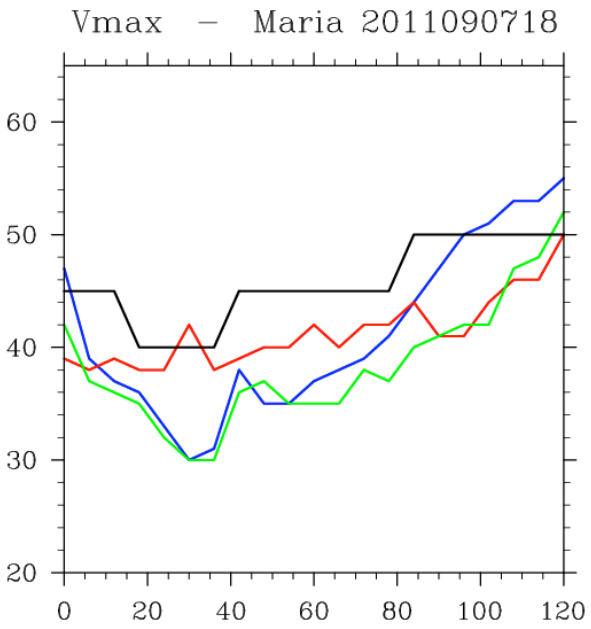
Configuration test: GSI Partial Cycling

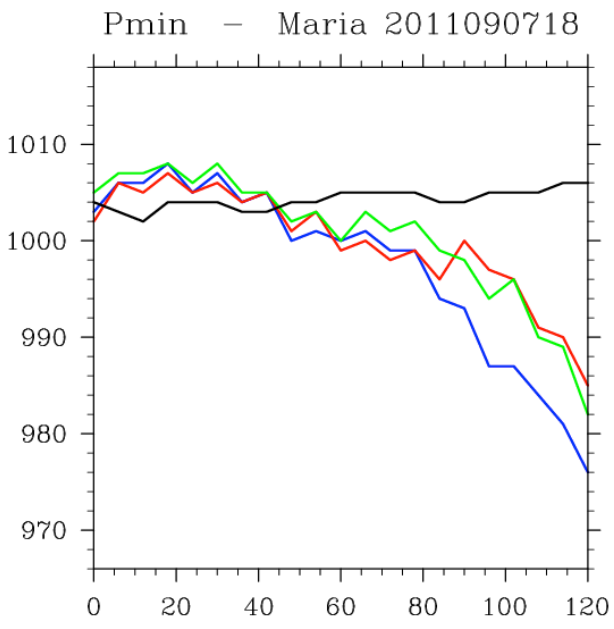
- ✓ CONV: conventional data, 1-time DA, no cycling
- ✓ CONV cycling: conventional data, 1-d DA cycling (6-hrly)

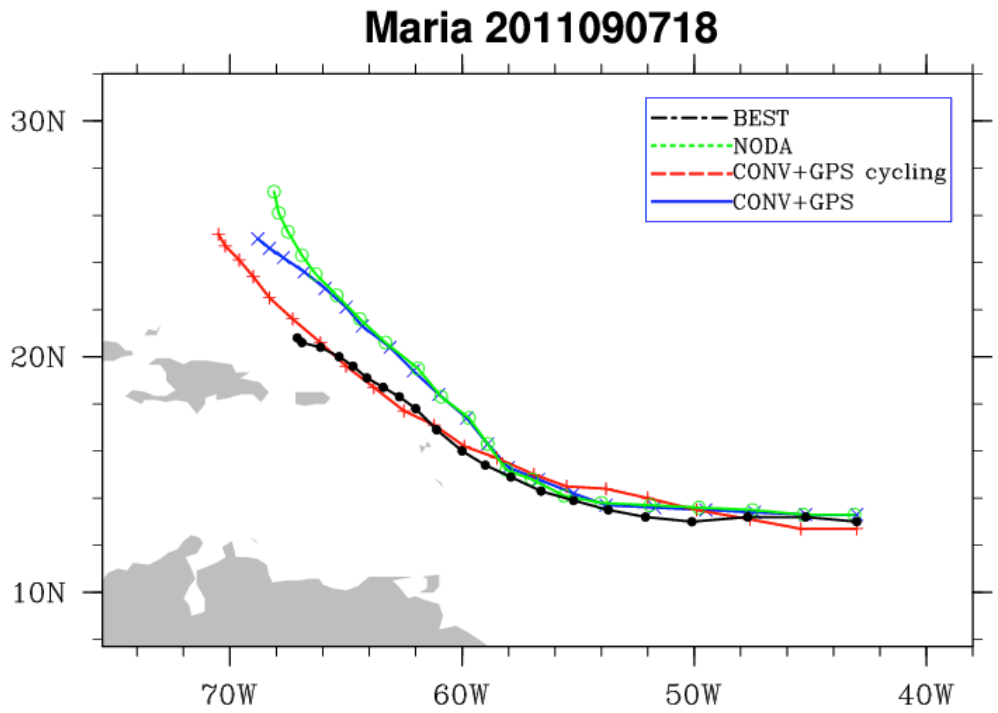
- ✓ GPS+CONV: conventional data + GPS RO, 1-time DA, no cycling
- ✓ GPS+CONV cycling: conventional data + GPS RO, 1-d DA cycling

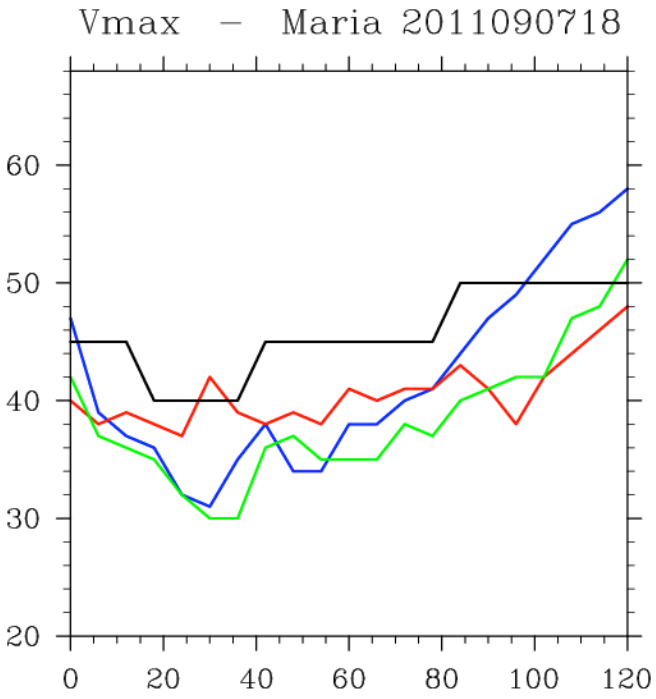
- ✓ NODA: cold start at analysis time, no regional DA


Maria 2011090718
BEST
NODA
CONV cycling
CONV
30N
20N
10N
70W
60W
50W
40W


Vmax – Maria 2011090718
60
50
40
30
20
0
20
40
60
80
100
120


Pmin – Maria 2011090718
1010
1000
990
980
970
0
20
40
60
80
100
120


Maria 2011090718
BEST
NODA
CONV+GPS cycling
CONV+GPS
30N
20N
10N
70W
60W
50W
40W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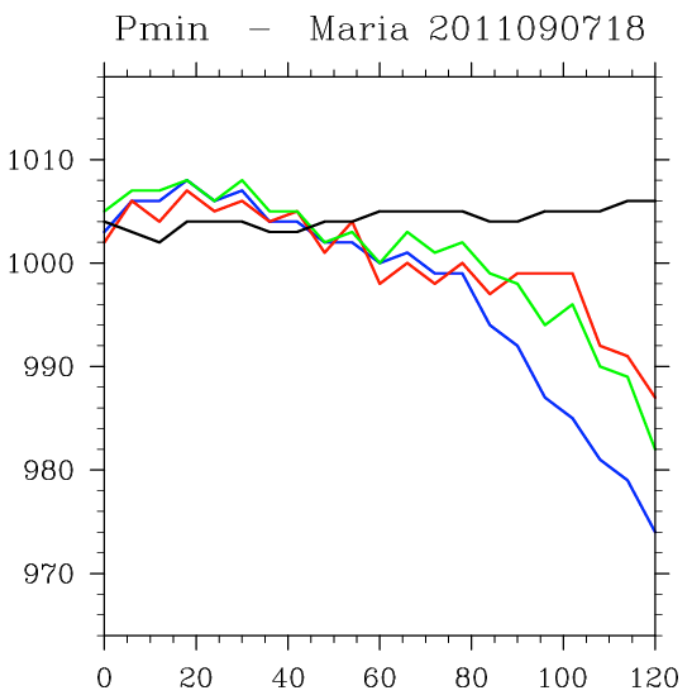
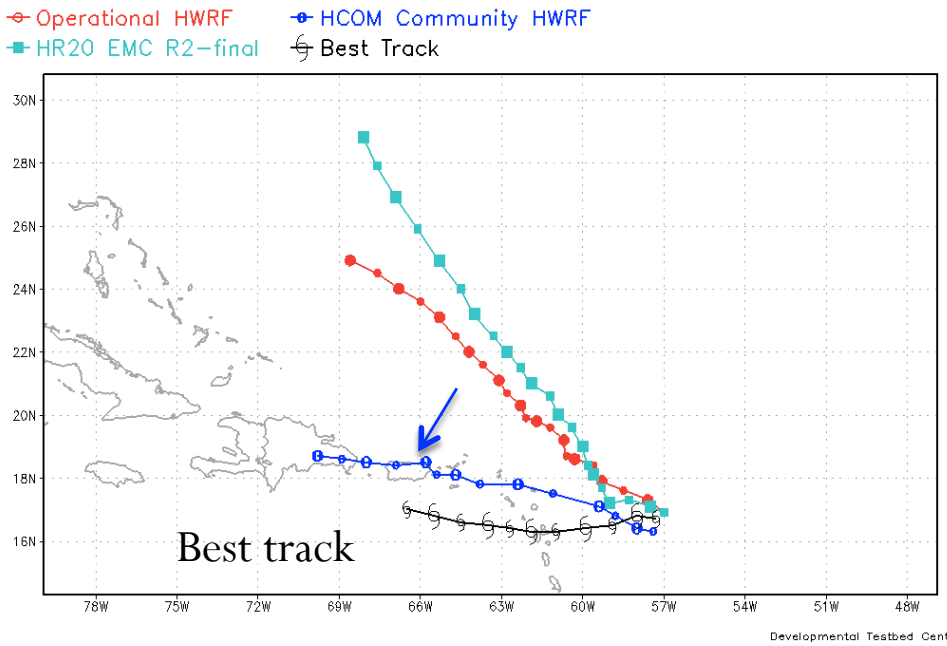

Pmin – Maria 2011090718
1010
1000
990
980
970
0
20
40
60
80
100
120

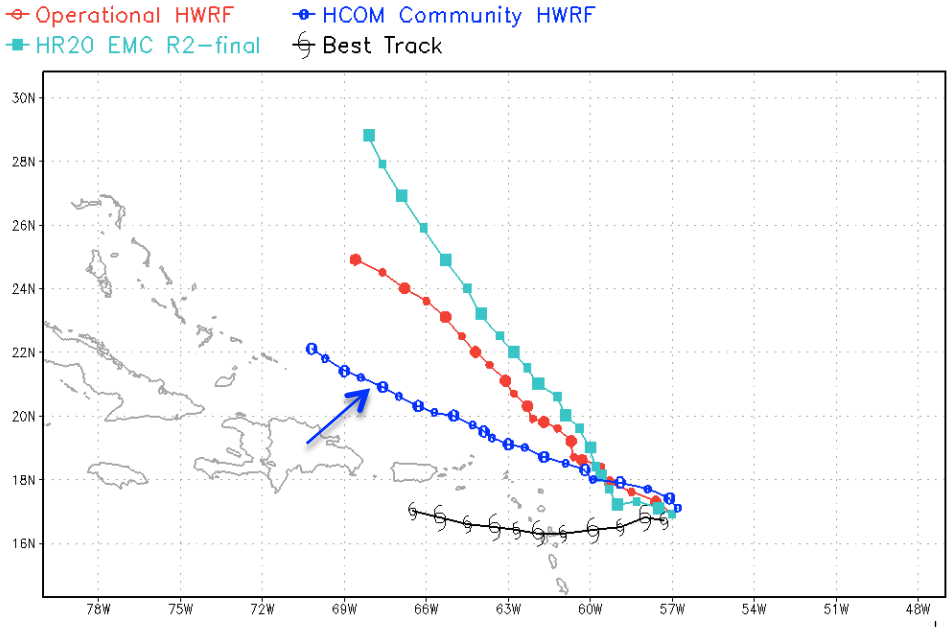
GFS vs Partial Cycling

Track Forecast

18 hr Cycling



No GSI (GFS cold start)



(This run is Erika (2009) on HWRF 2011 operational domain)

Summary and Future work:

- ✓ Single observation tests are done for investigating the cross co-variances around tropical cyclone and show reasonable flow dependent responses compared to isotropic response from the 3DVAR using static BE.

  ----- More tests and in-depth diagnostics: cloud variables?

  ----- Best combination of the static BE and the ensembles?

- ✓ Case studies show benefit in track and intensity forecast by cycling GSI data assimilation

  ----- More cases and extended runs - ongoing

  ----- Partial cycling with HWRF ensembles