Impacts of Surface Fluxes on Cloud-Permitting Hurricane Analysis and Prediction

Lessons learned from PSU stream-1.5 retro runs

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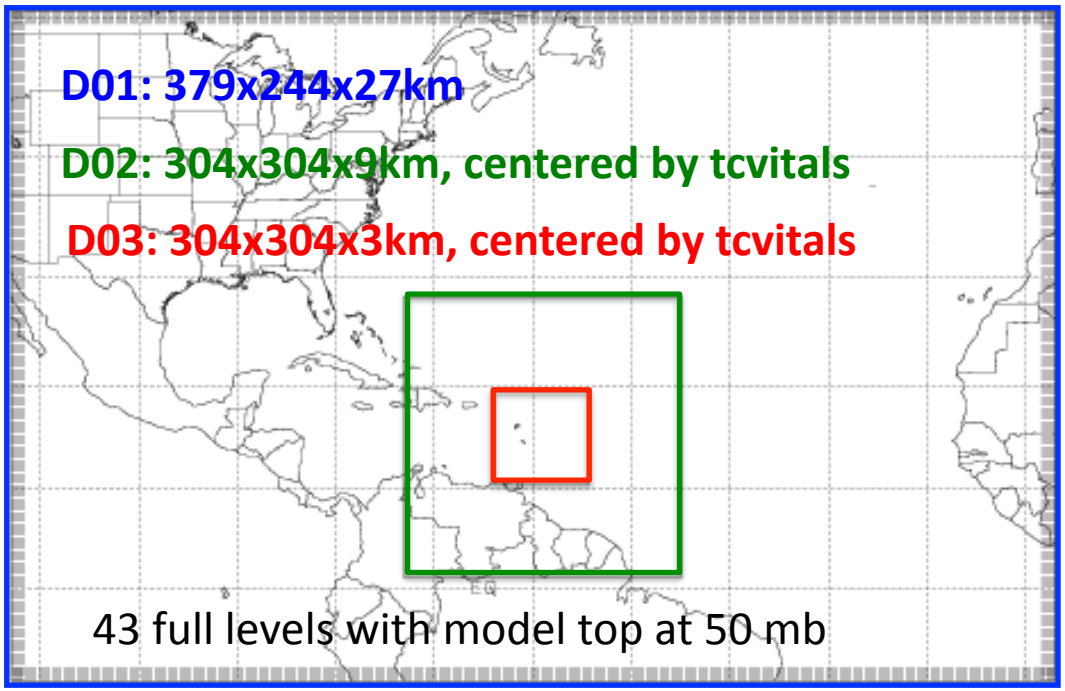
APSU (2012) Configurations

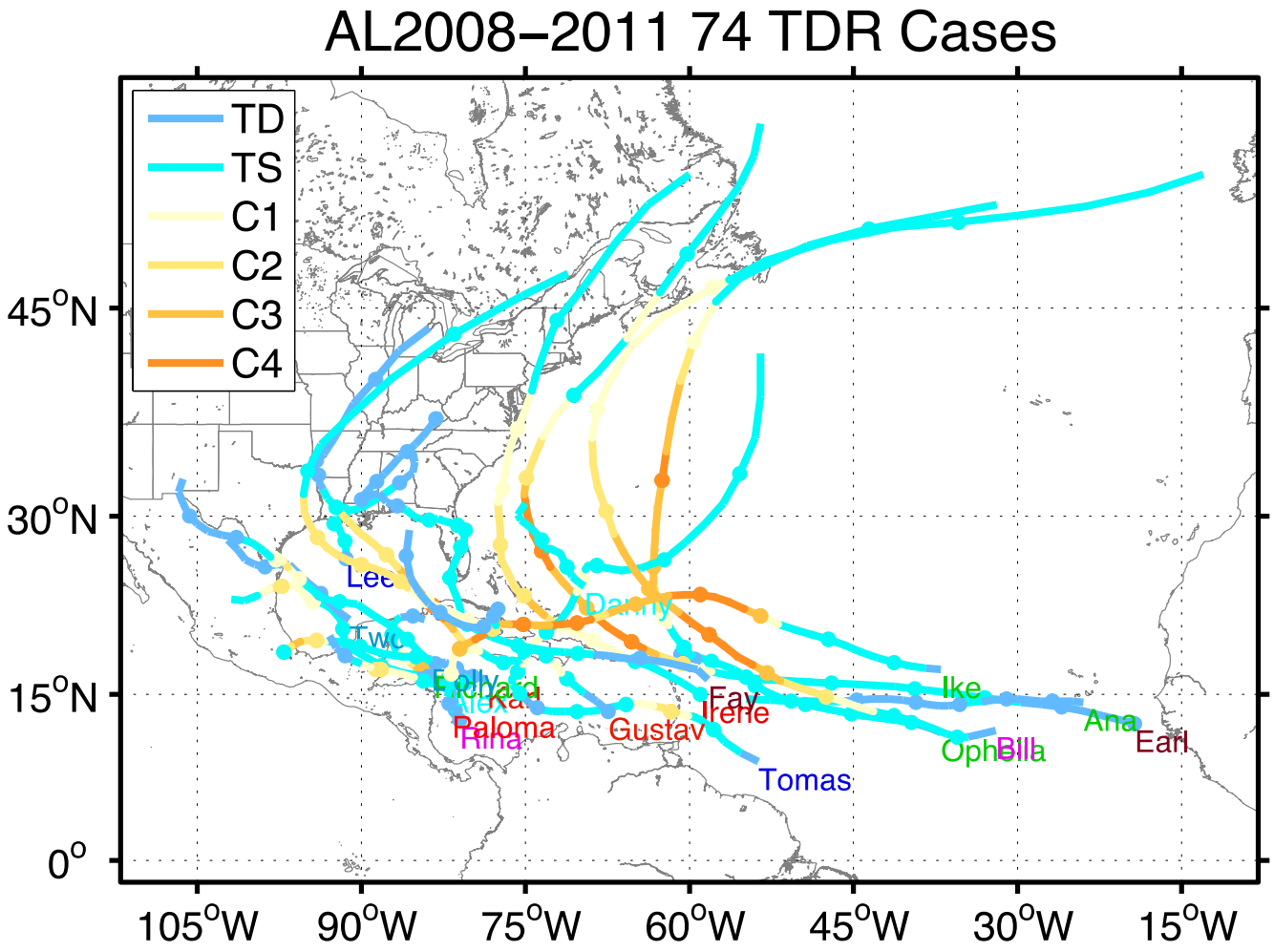


- WRF V3.3.1
- Grell-Devenyi ensemble (D01)
- YSU PBL
- Monin-Obukov Surface Layer
- thermal diffusion Land Surface
- Rrtm for longwave
- Dudhia for shortwave
- Garratt Ck, Cd formulation

- 60 members
- Radius of Influence: SCL
- Mixing: 0.6

- Ics & BCs: GFS analysis and its forecasts

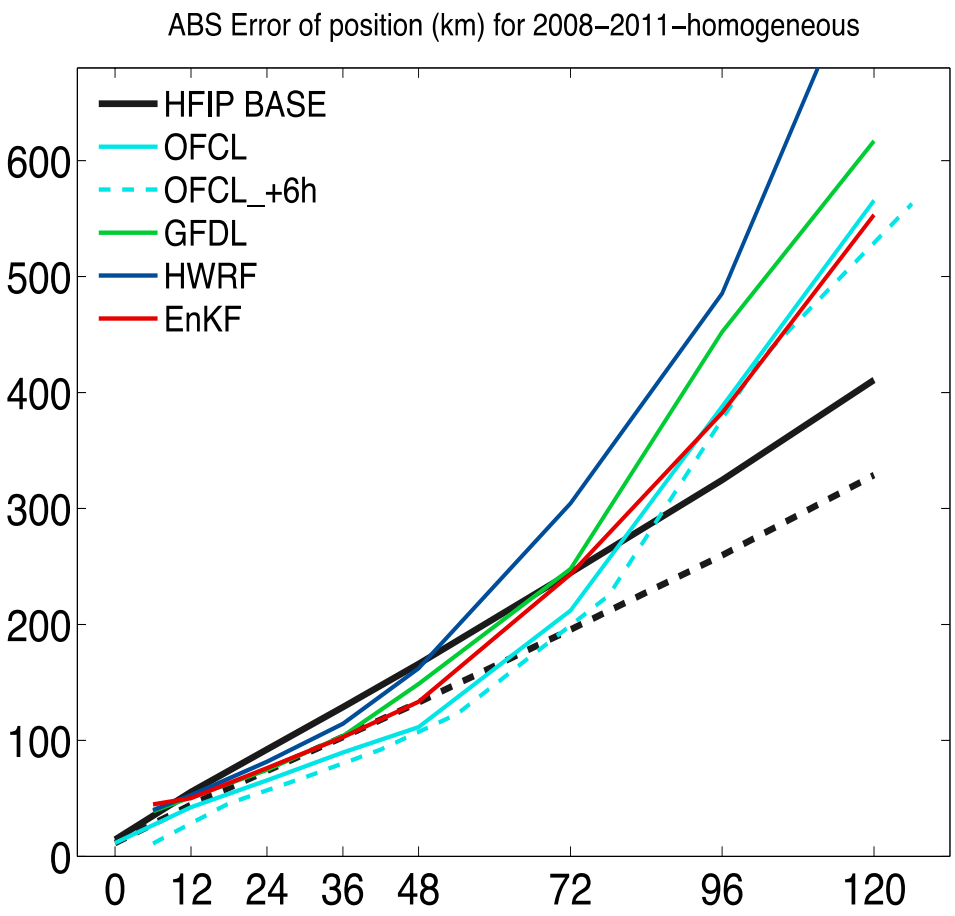
Retro Runs for Storms with TDR



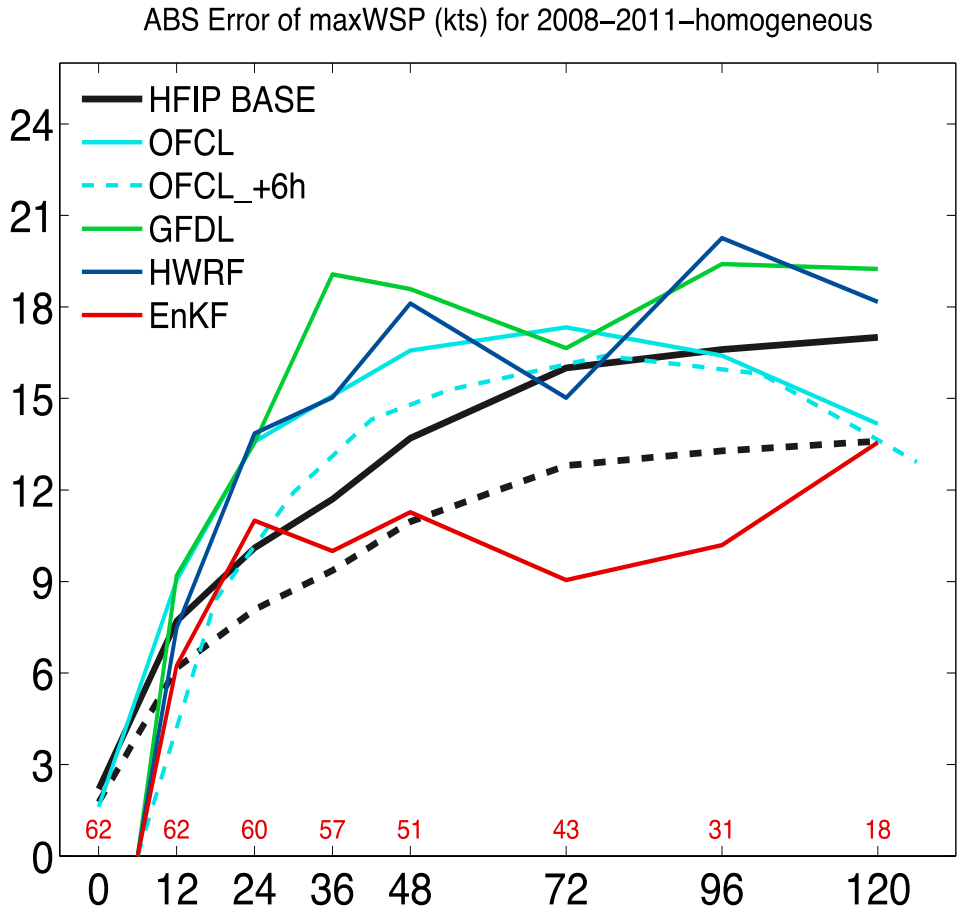
2008	26	Dolly, Fay, Gustav, Ike Paloma
2009	10	Ana, Bill, Danny
2010	25	Alex, Two, Earl, Karl, Richard, Tomas
2011	13	Irene, Lee, Ophelia, Rina

EnKF Performance Assimilating Airborne Radar OBS

Mean Absolute Error for 74 P3 TDR missions during 2008-2011



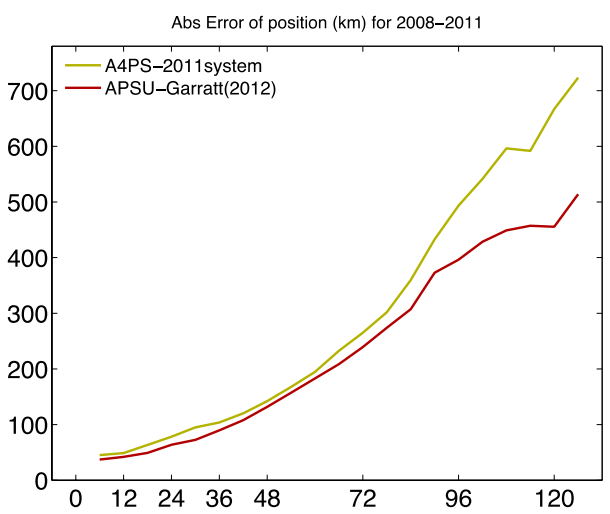
Position Error (km)

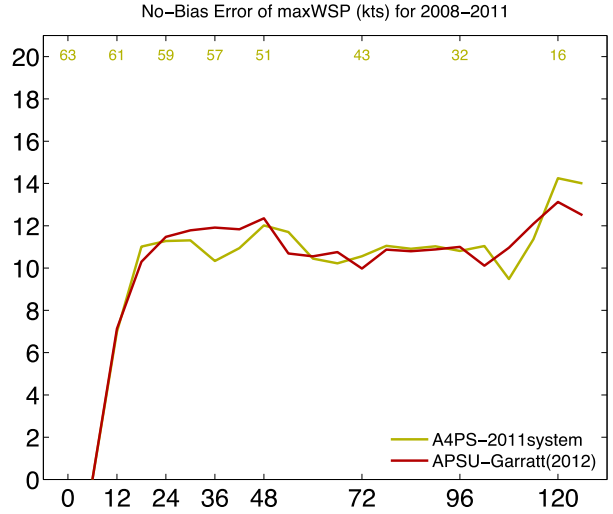


Intensity Error with Bias-correction (kt)

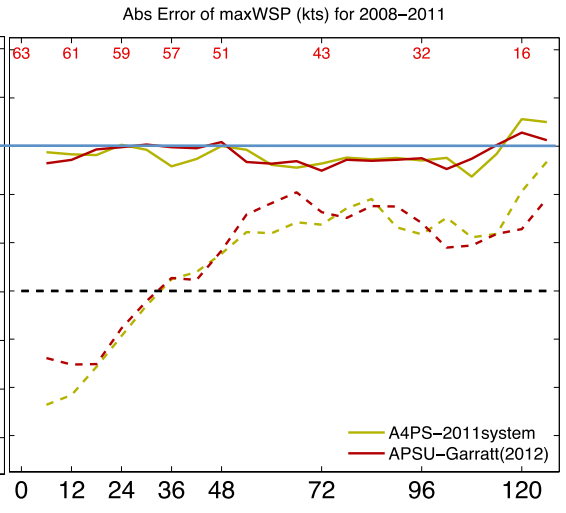
$$Corrected\ \mathrm{Vmax} = \mathrm{Vmax} - \left(\frac{30\mathrm{h} - \mathrm{t}}{30\mathrm{h}} \times Bias\_at\_initial\_time\right)$$

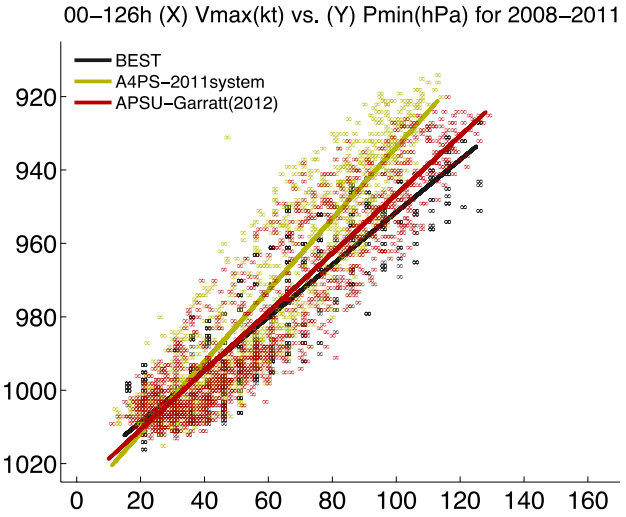
PSU 2011 vs. 2012 system



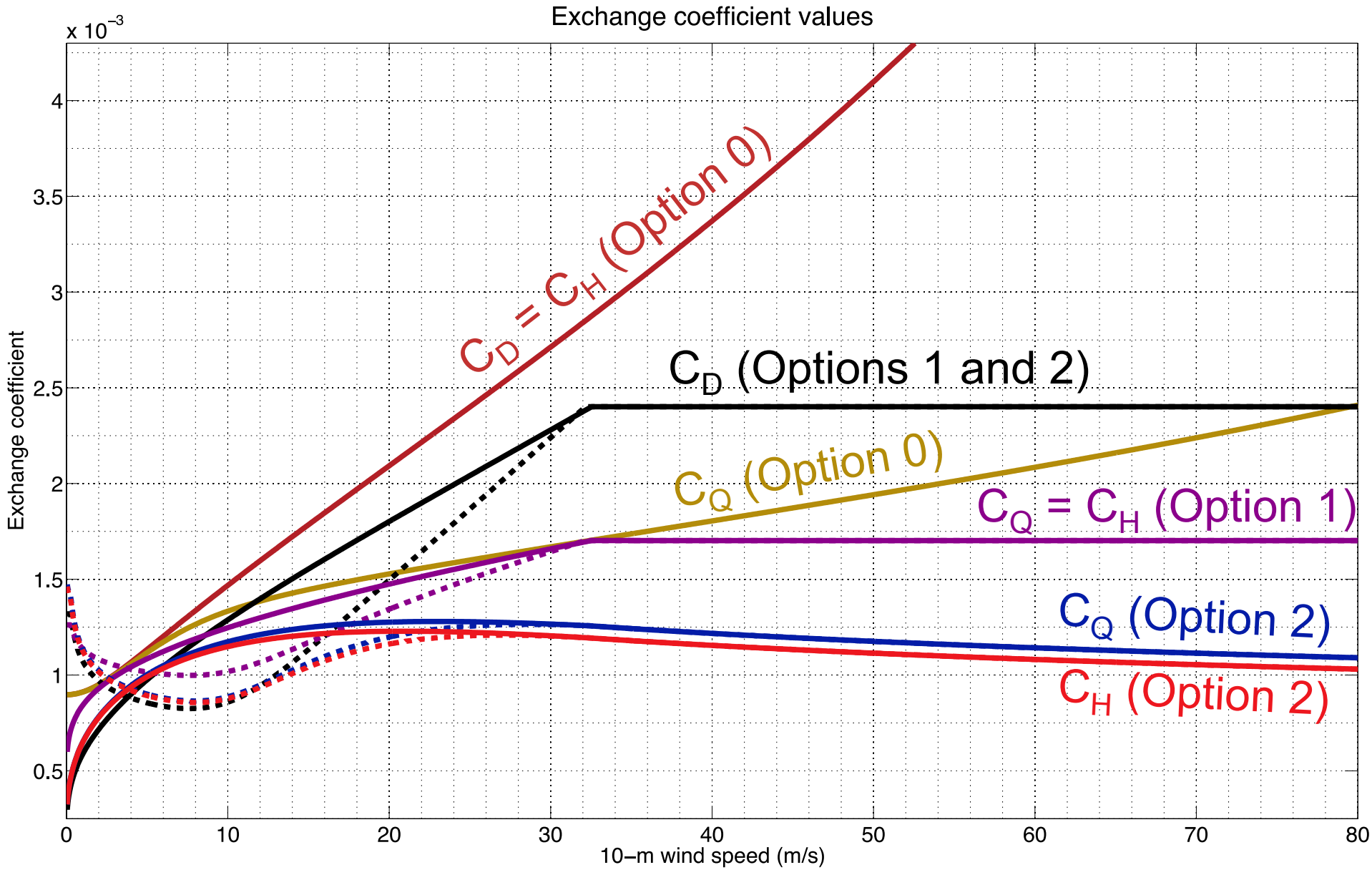


Bias-correction: applies the full adjustment at 6h to the time-lagged forecast out to 18 h, applies a linearly decreasing adjustment from 18 to 30 h, and then no adjustment for the remainder of the forecast.



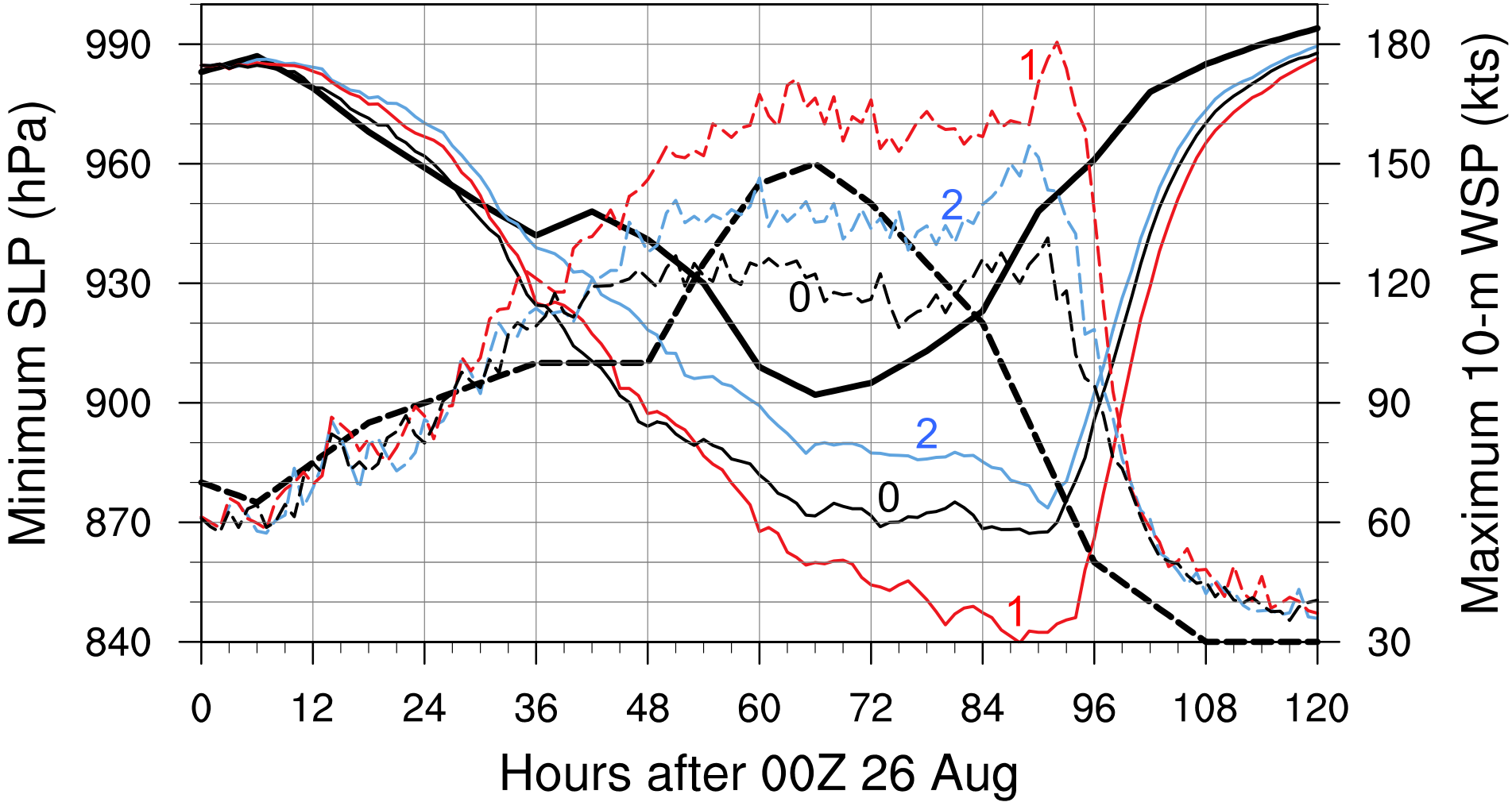


Two key differences: grid resolution and surface flux schemes



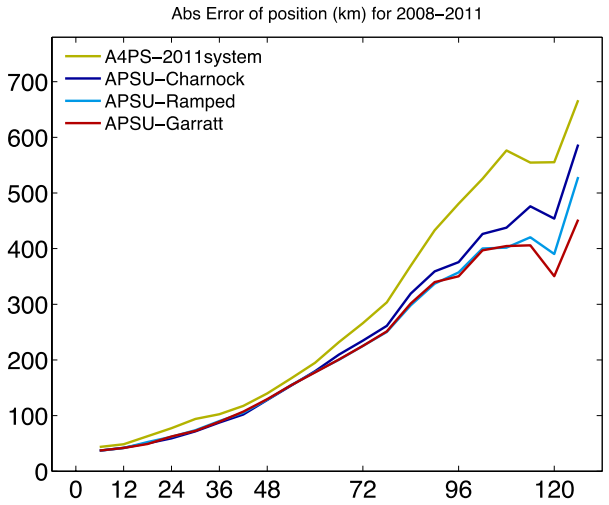
Solid (dashed) lines: Formulas in V3.4 (V3.3.1) of WRF

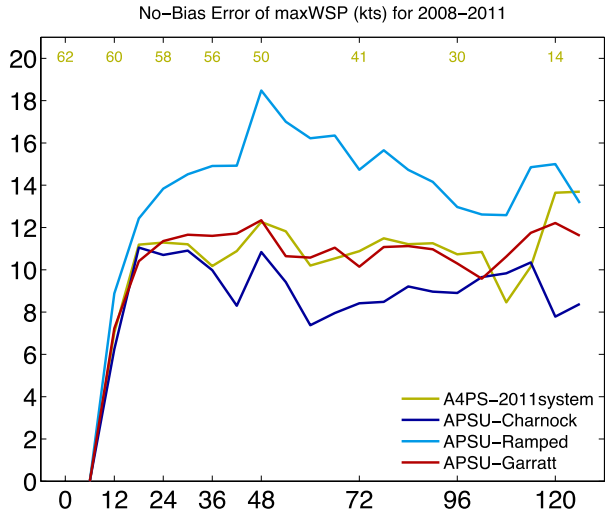
Sensitivity to WRF3.4 Options: Katrina'05

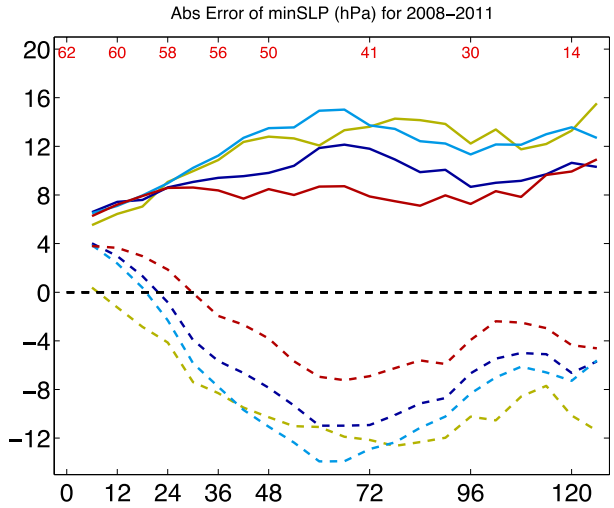


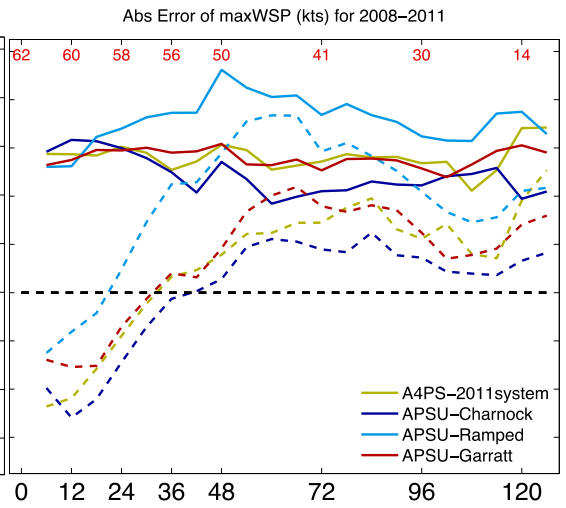
Intensity (SLP and wind speed) is *very* sensitive to isftcflx option

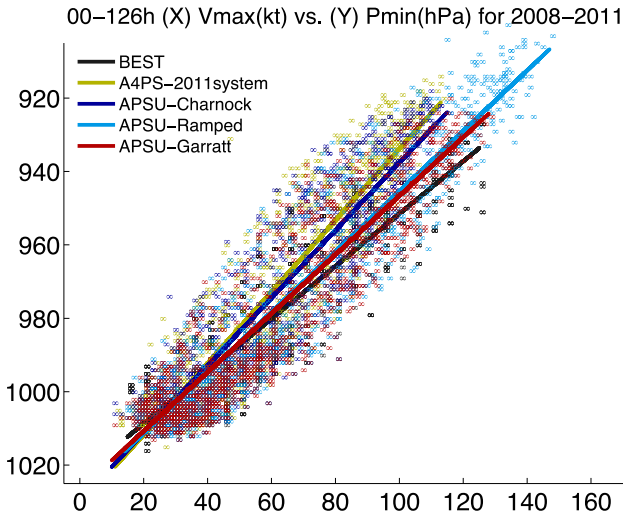
Tests w/ Cd/Ck in WRF V3.3 schemes



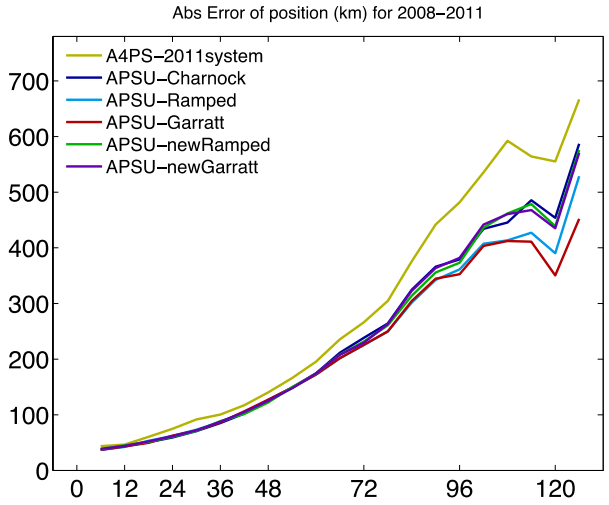


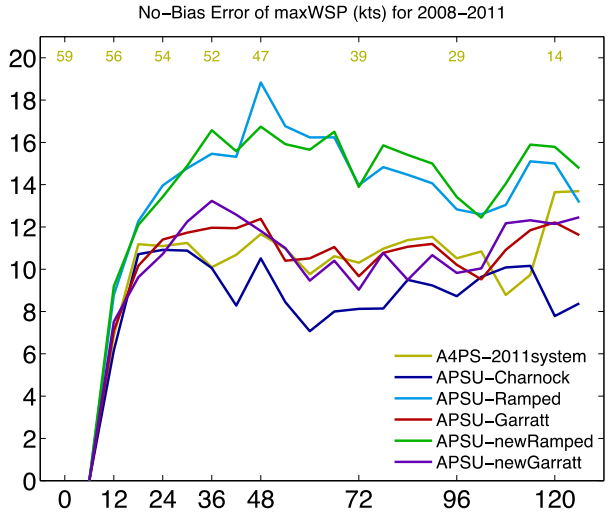


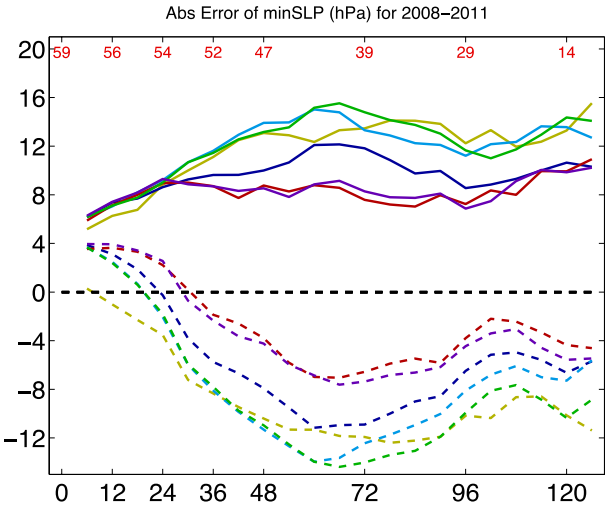


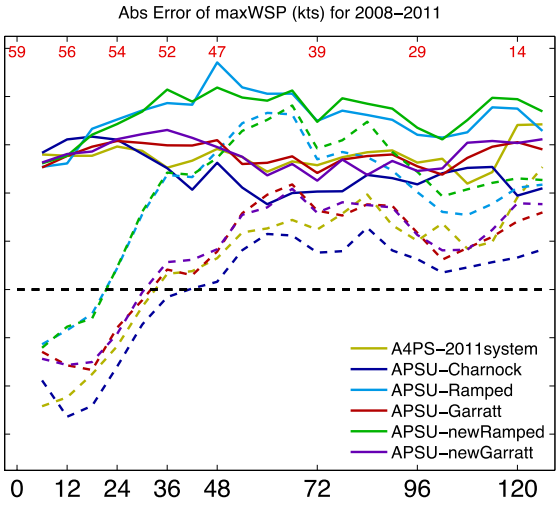


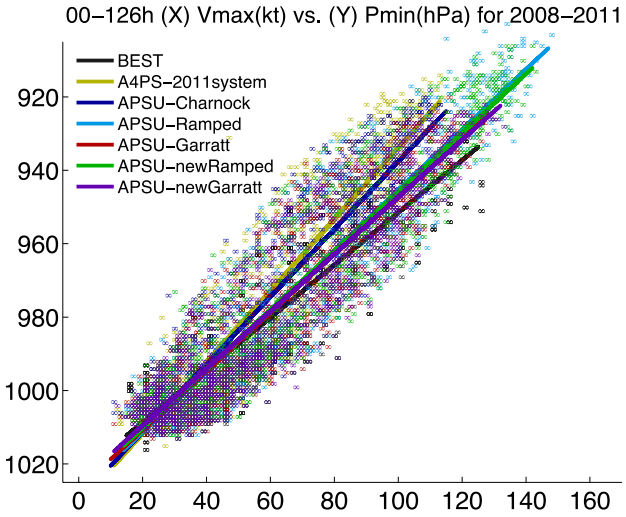
Tests w/ Cd/Ck in WRF V3.4 schemes



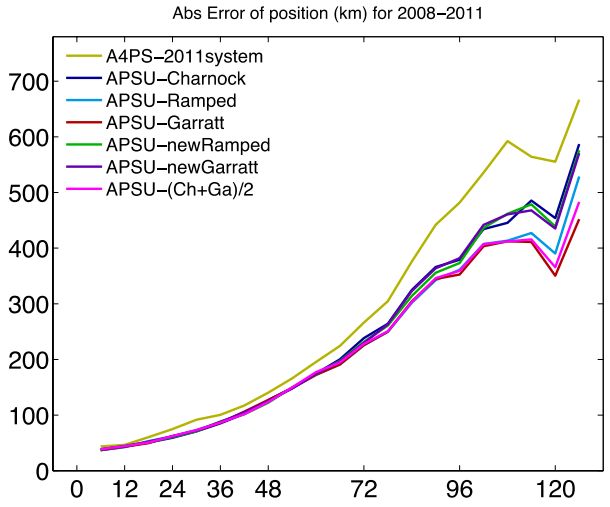


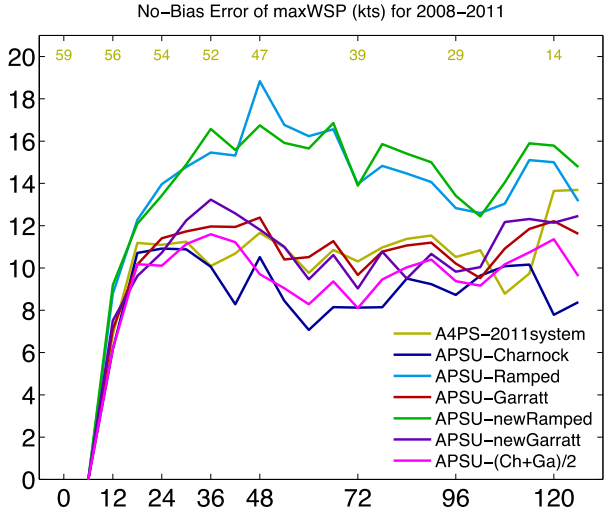


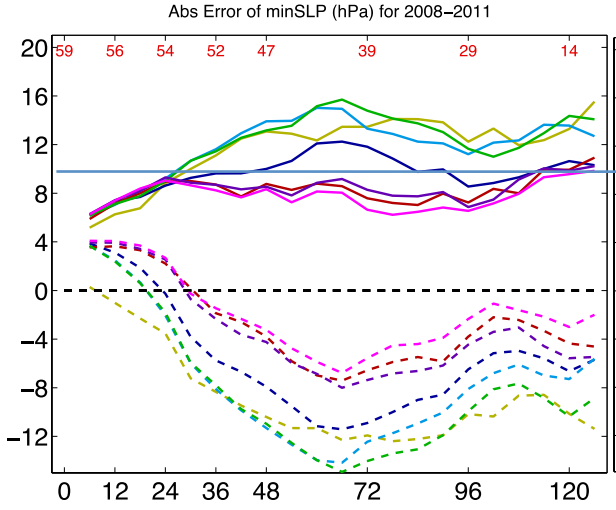


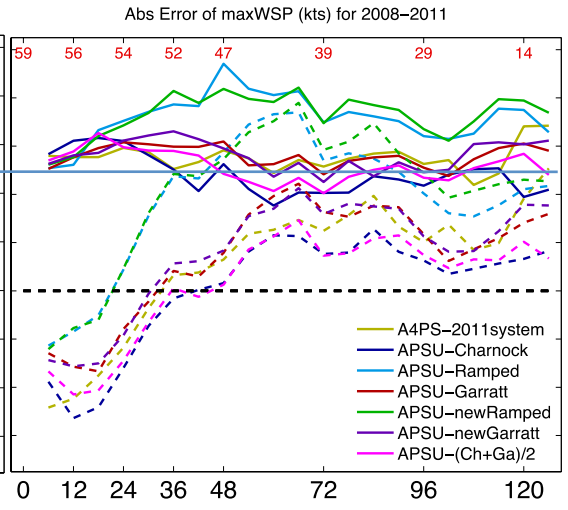


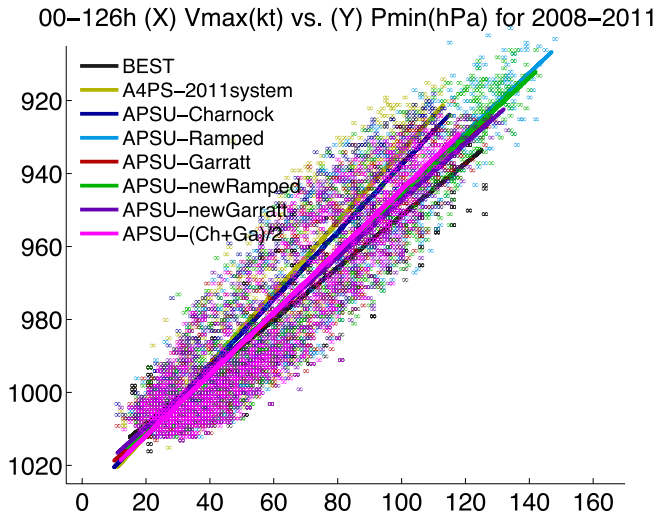
Test with an ad-hoc PSU scheme

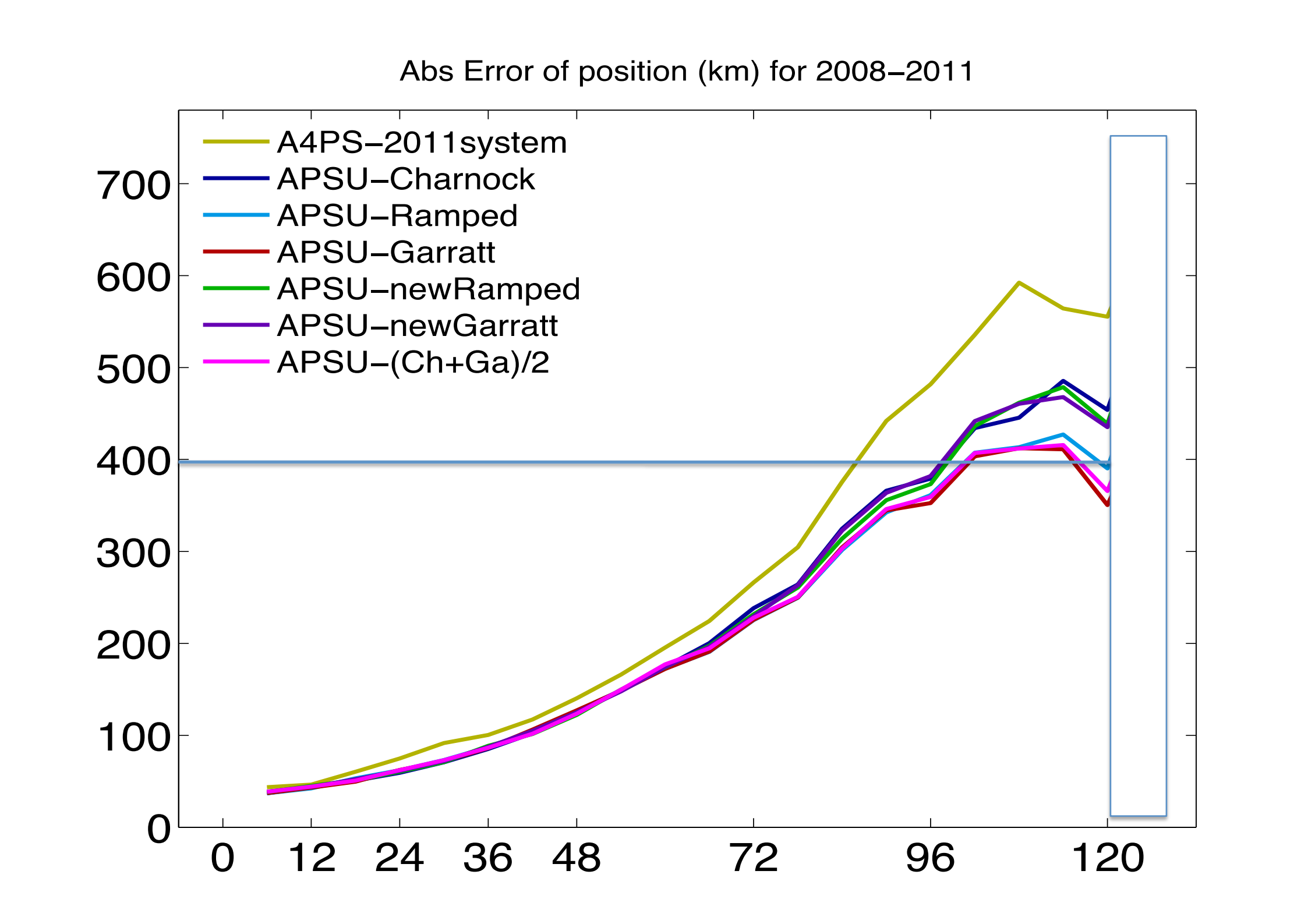


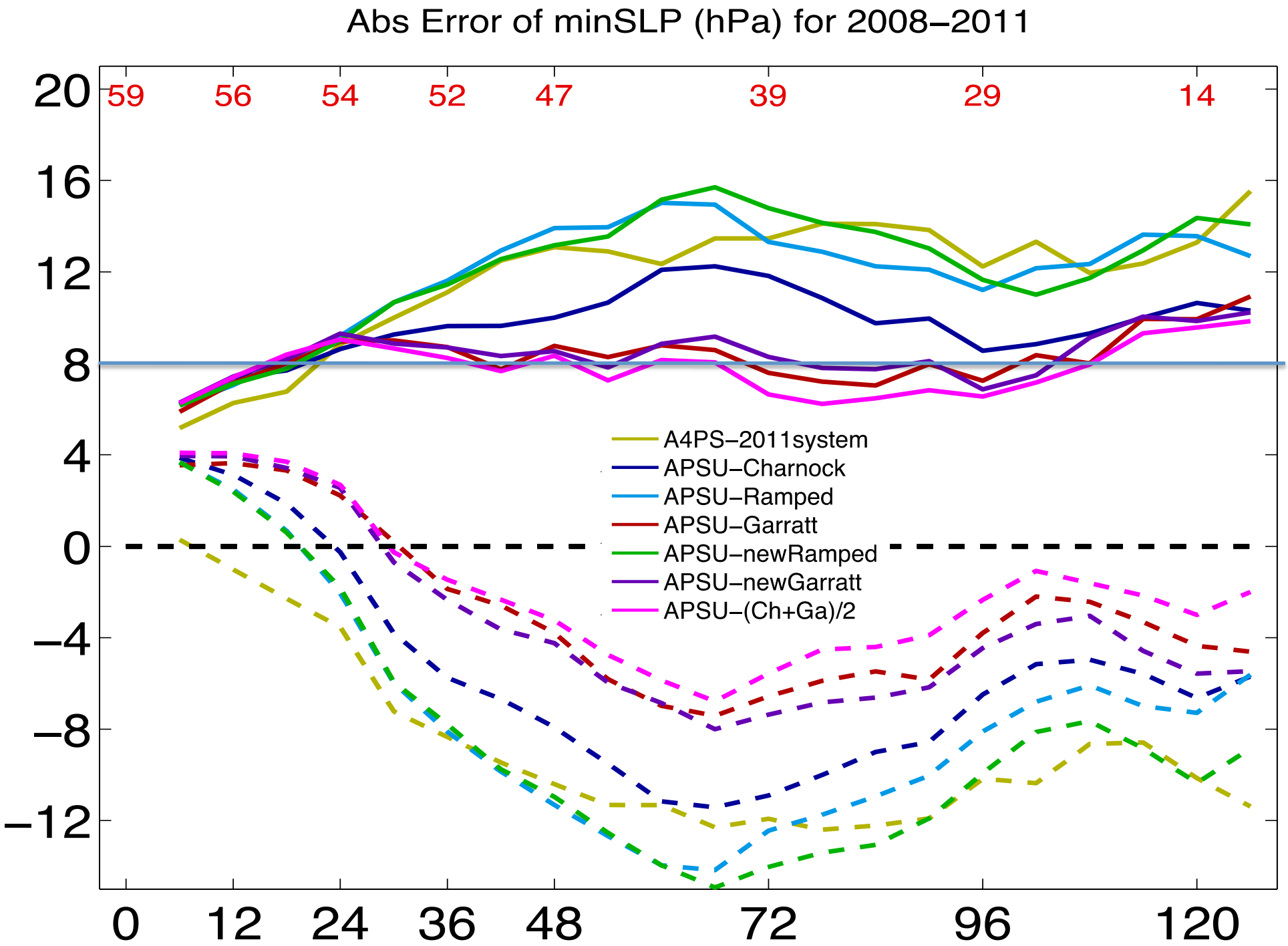


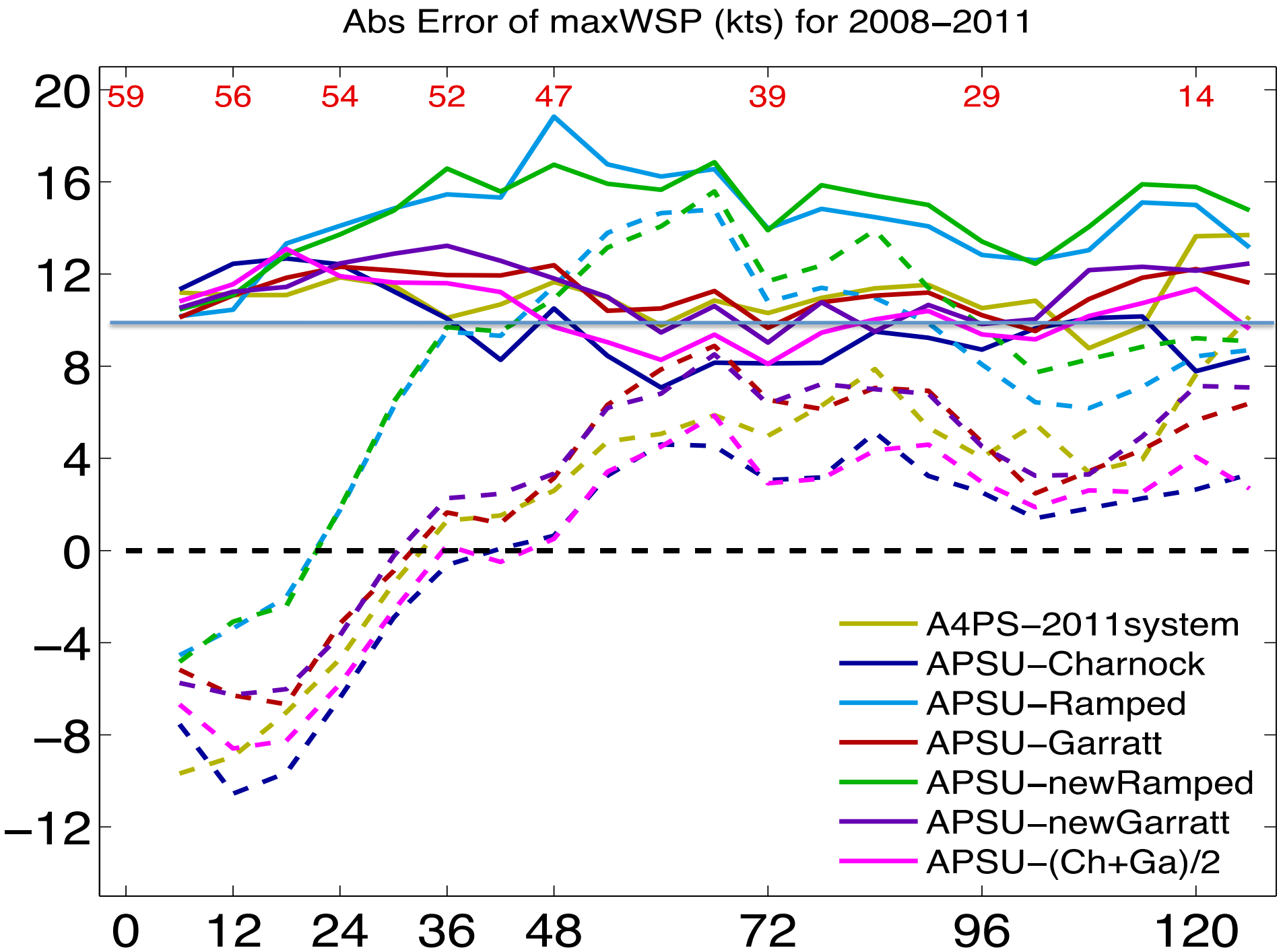


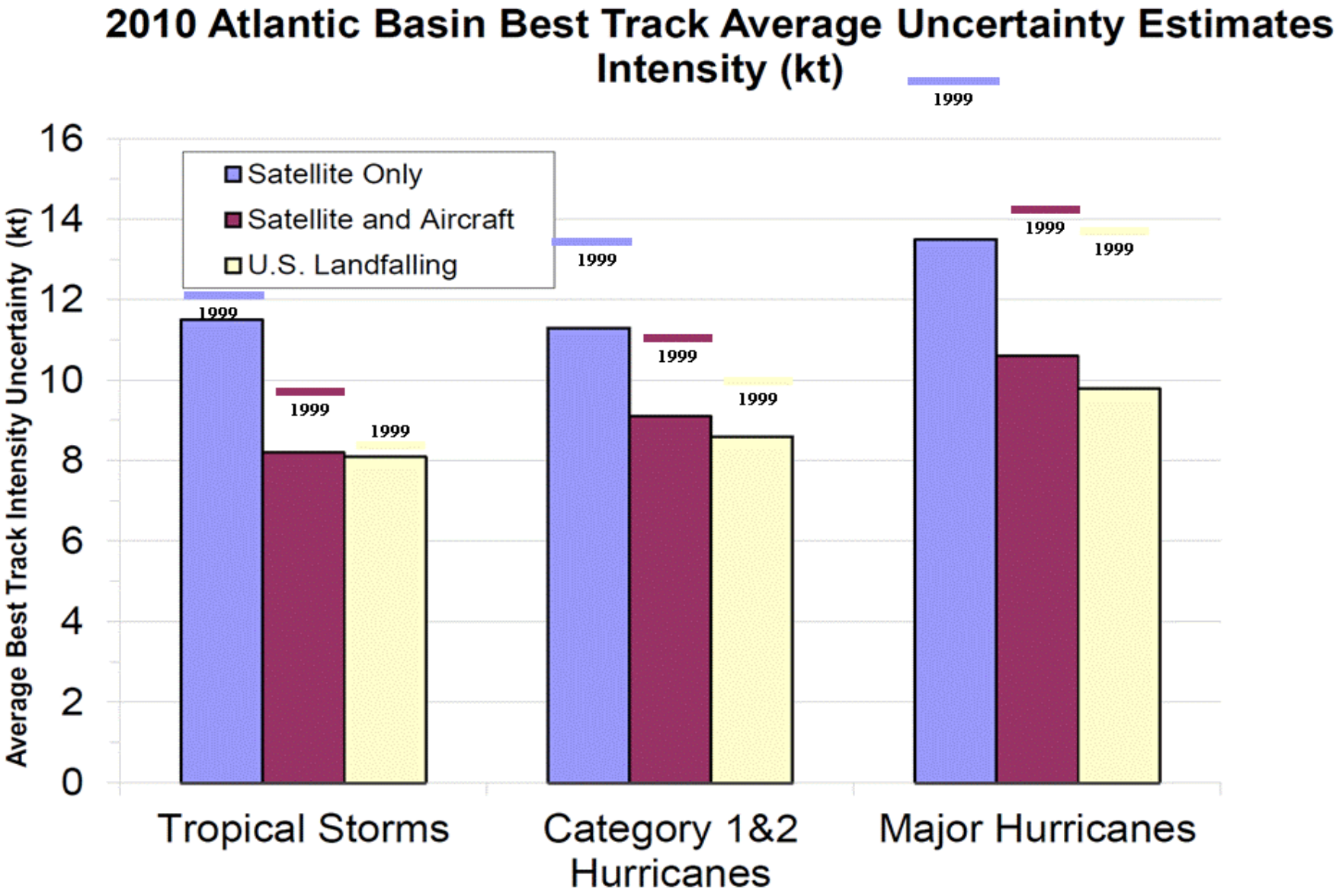




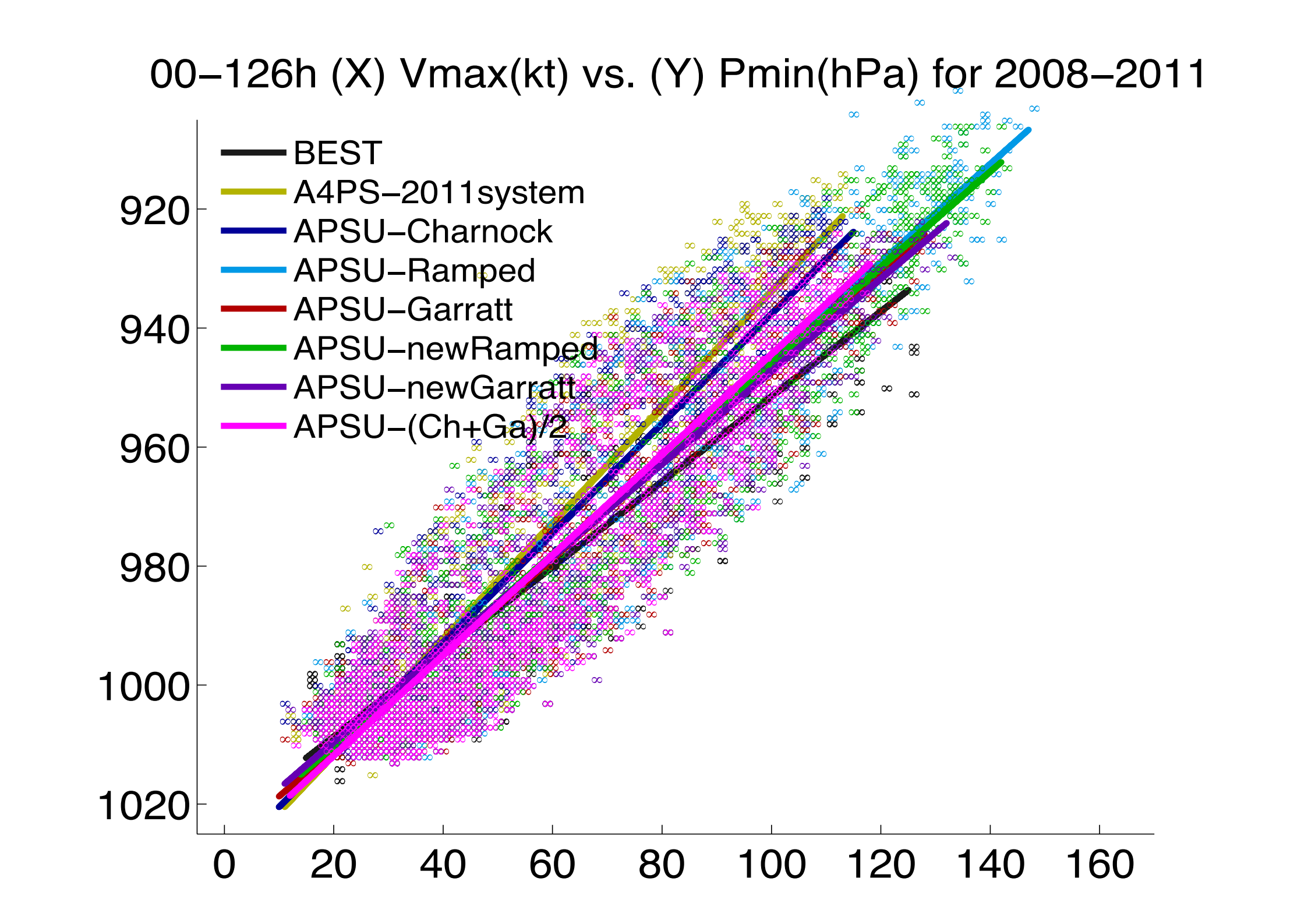

Abs Error of position (km) for 2008–2011
A4PS–2011system
APSU–Charnock
APSU–Ramped
APSU–Garratt
APSU–newRamped
APSU–newGarratt
APSU–(Ch+Ga)/2
0
100
200
300
400
500
600
700
0
12
24
36
48
72
96
120


Abs Error of minSLP (hPa) for 2008–2011
20
16
12
8
4
0
−4
−8
−12
59
56
54
52
47
39
29
14
0
12
24
36
48
72
96
120
A4PS–2011system
APSU–Charnock
APSU–Ramped
APSU–Garratt
APSU–newRamped
APSU–newGarratt
APSU–(Ch+Ga)/2


Abs Error of maxWSP (kts) for 2008–2011
59
56
54
52
47
39
29
14
20
16
12
8
4
0
−4
−8
−12
0
12
24
36
48
72
96
120
A4PS–2011system
APSU–Charnock
APSU–Ramped
APSU–Garratt
APSU–newRamped
APSU–newGarratt
APSU–(Ch+Ga)/2



Courtesy of Chris Landsea and James Franklin


00–126h (X) Vmax(kt) vs. (Y) Pmin(hPa) for 2008–2011
BEST
A4PS–2011system
APSU–Charnock
APSU–Ramped
APSU–Garratt
APSU–newRamped
APSU–newGarratt
APSU–(Ch+Ga)/2
920
940
960
980
1000
1020
0
20
40
60
80
100
120
140
160

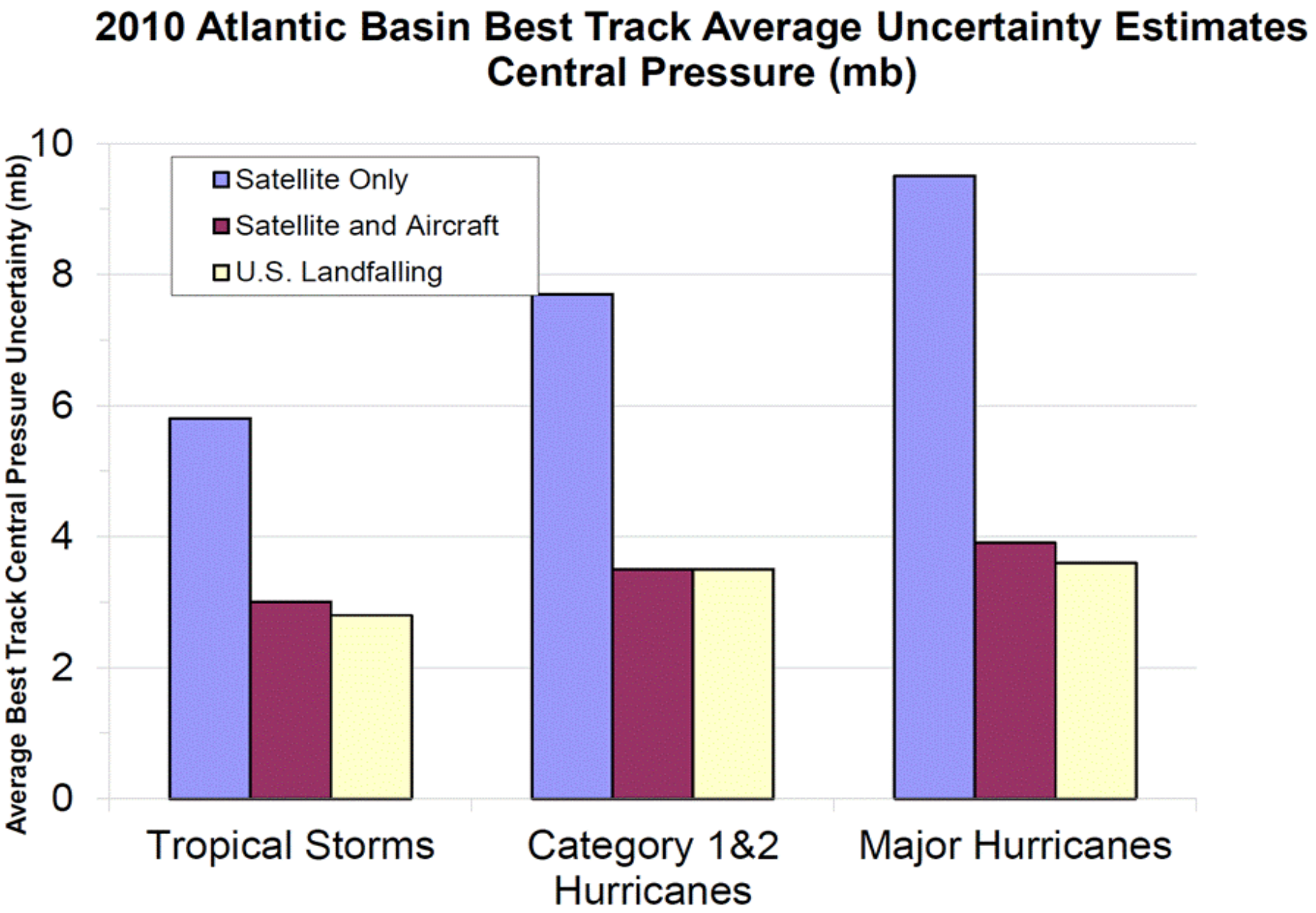
Lessons Learned:

1. With higher resolution and newer surface schemes, 2012 stream-1.5 runs (APSU) perform considerably better than the 2011 real-time system A4PS.

2. Hurricane intensity forecasts and pressure-wind relationship depend strongly on surface flux parameterizations. More work needs to be done on Cd/Ck.

3. It appears that with high-resolution convection-permitting ensemble analysis assimilating high-resolution inner-core observations, the intensity forecast error in terms of maximum 10-m wind speed is approaching the NHC-forecasters' perceived observational uncertainty in day 1-5 averaged for all the cases with TDR data during 2008-2011. What does this imply?

4. What is the intrinsic limit of hurricane intensity predictability?



Courtesy of Chris Landsea and James Franklin

Cd/Ck for AHW scheme