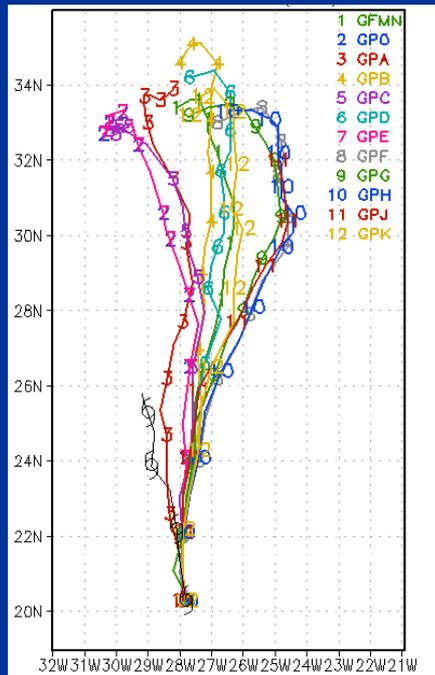
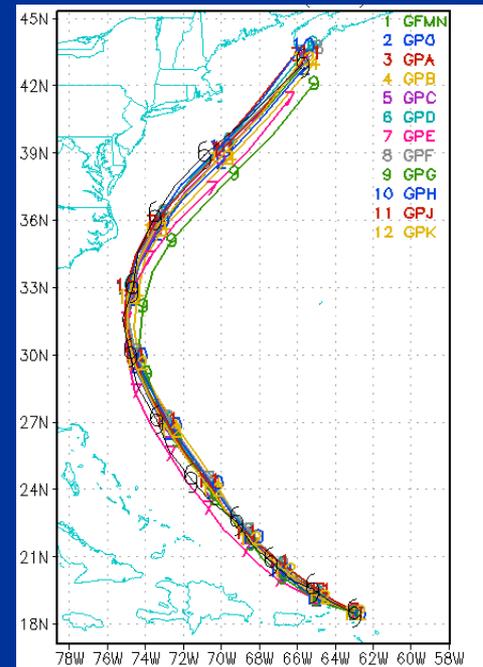


# GFDL Hurricane Model Ensemble



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NOAA / GFDL



October 3, 2011

# Design of the system

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- Focus on intensity
- Several members created by modifying the structure-related data from the NHC storm warning message in order to perturb the axisymmetric vortex



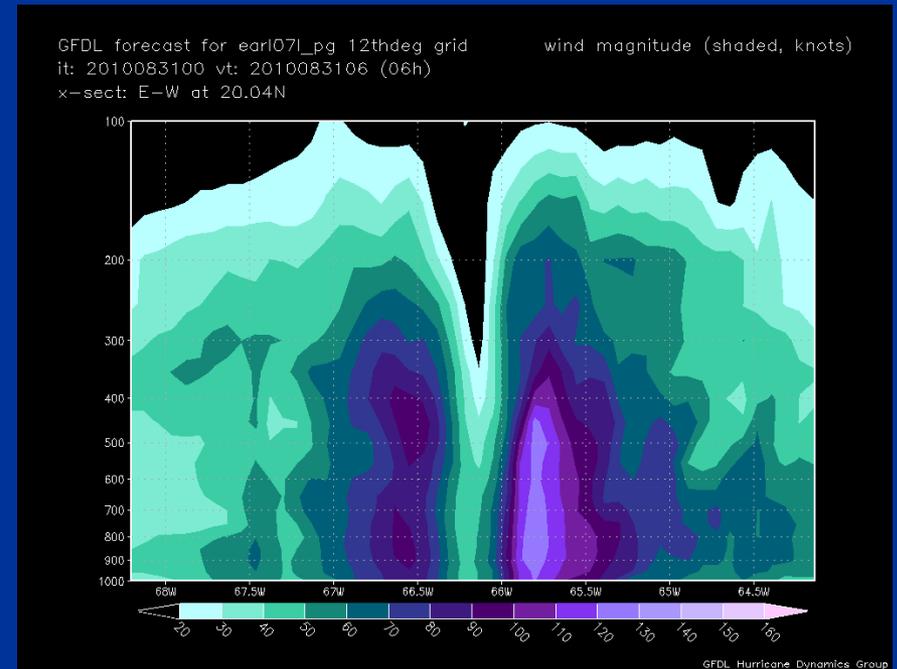
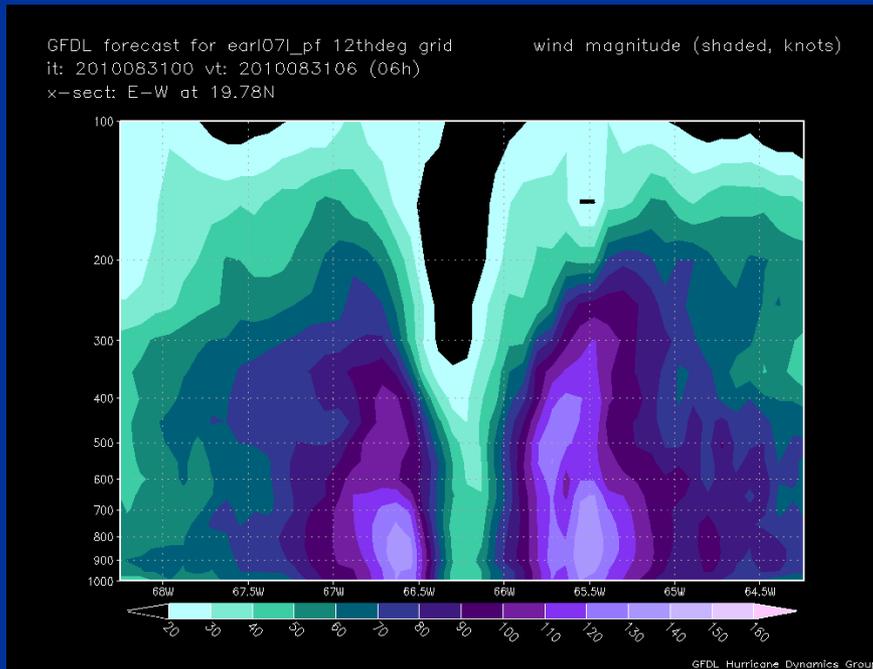
# Defining the ensemble members

- 2010 ensemble composition: 11-member ensemble: 10 perturbed members and a control forecast
  - GP0: Control forecast (GFD5 run on Jet)
  - GPA: Unbogussed forecast
  - GPB: Control, but with no asymmetries included
  - GPC: Control, but with the use of old environmental filter
  - GPD: **Increase** storm size (ROCI-based) by 25%
  - GPE: **Decrease** storm size (ROCI-based) by 25%
  - GPF: **Increase** wind radii 25%, **increase** storm size 25%
  - GPG: **Decrease** wind radii 25%, **decrease** storm size 25%
  - GPH: Old filter (GPC), plus both size **increases** from GPF
  - GPJ: Old filter (GPC), plus both size **decreases** from GPG
  - GPK: Set Rmax minimum to 45 km (GFD5 control uses 25 km)

Size  
Members

# Earl 2010083100

Modifications to the observed storm size data that are input into the axisymmetric spinup lead to noticeable changes in the model storm structure

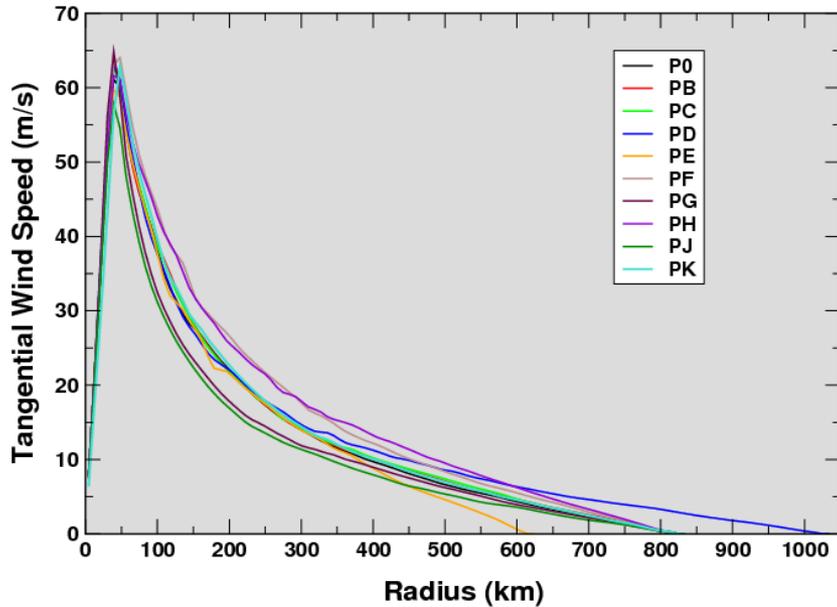


GPF: **Increase** all wind radii and storm size (ROCI) by 25%

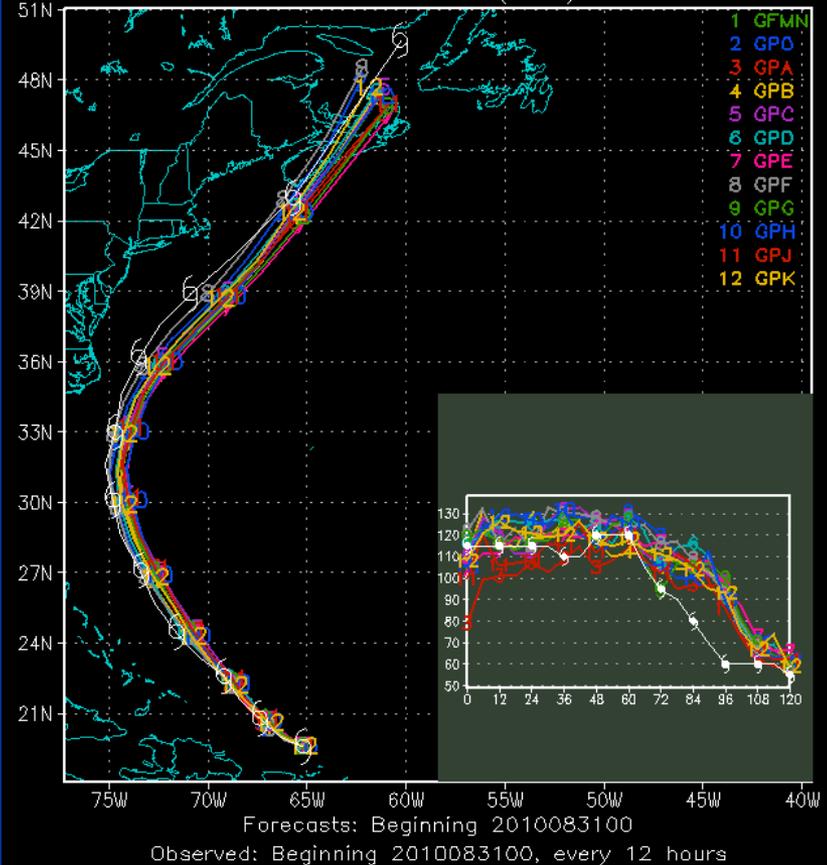
GPG: **Decrease** all wind radii and storm size (ROCI) by 25%

# Earl 2010083100

Initial Axisymmetric Profiles of  $V_t$  for GFDL Ensemble Members  
Earl 2010083100 (Observed: 59 m/s)

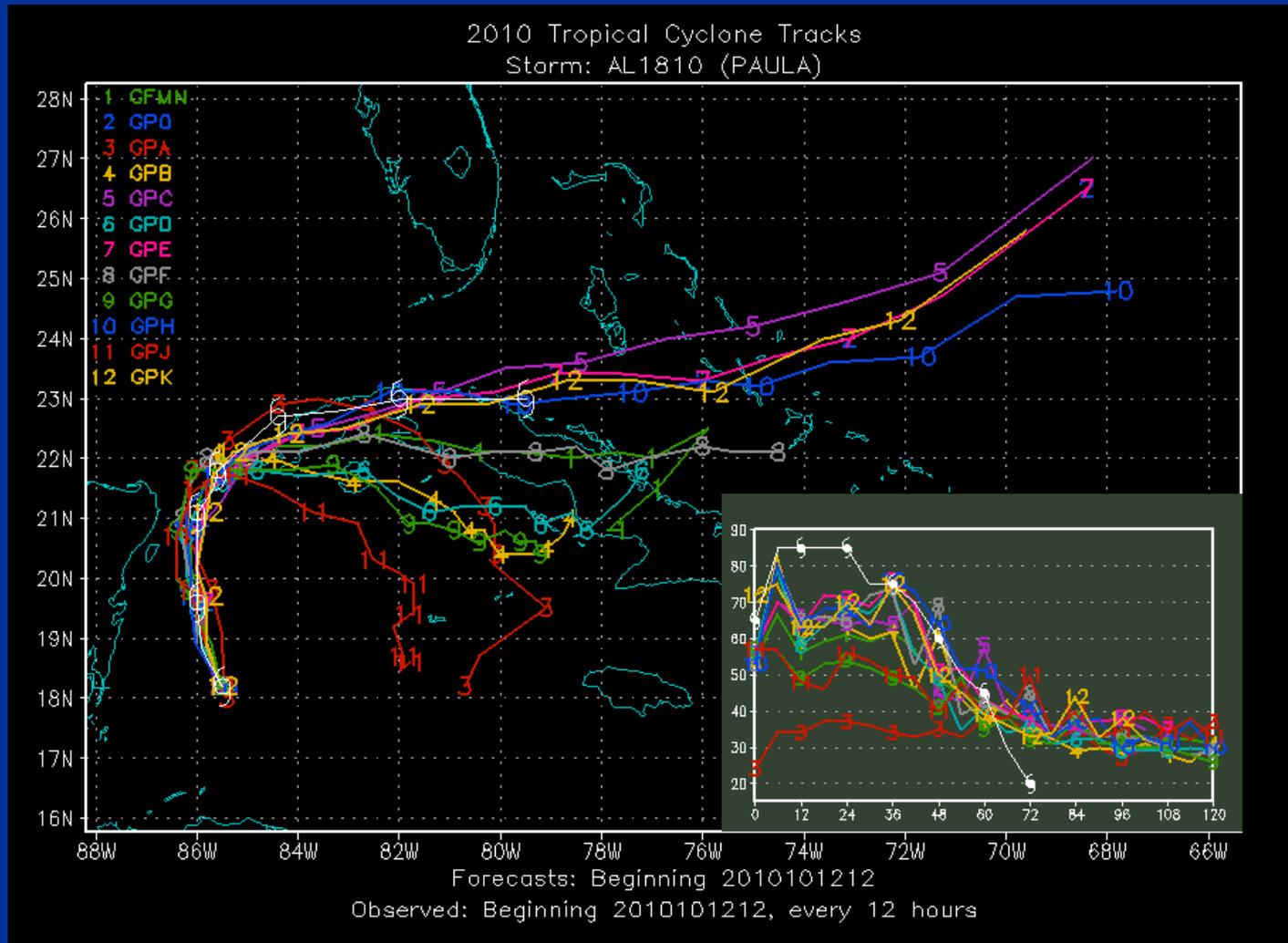


2010 Tropical Cyclone Tracks  
Storm: ALD710 (EARL)



Spread evident in the  $V_T$  profiles from the vortex spinup leads to noticeable spread in the  $V_{max}$  forecast, but very little spread in the tracks.

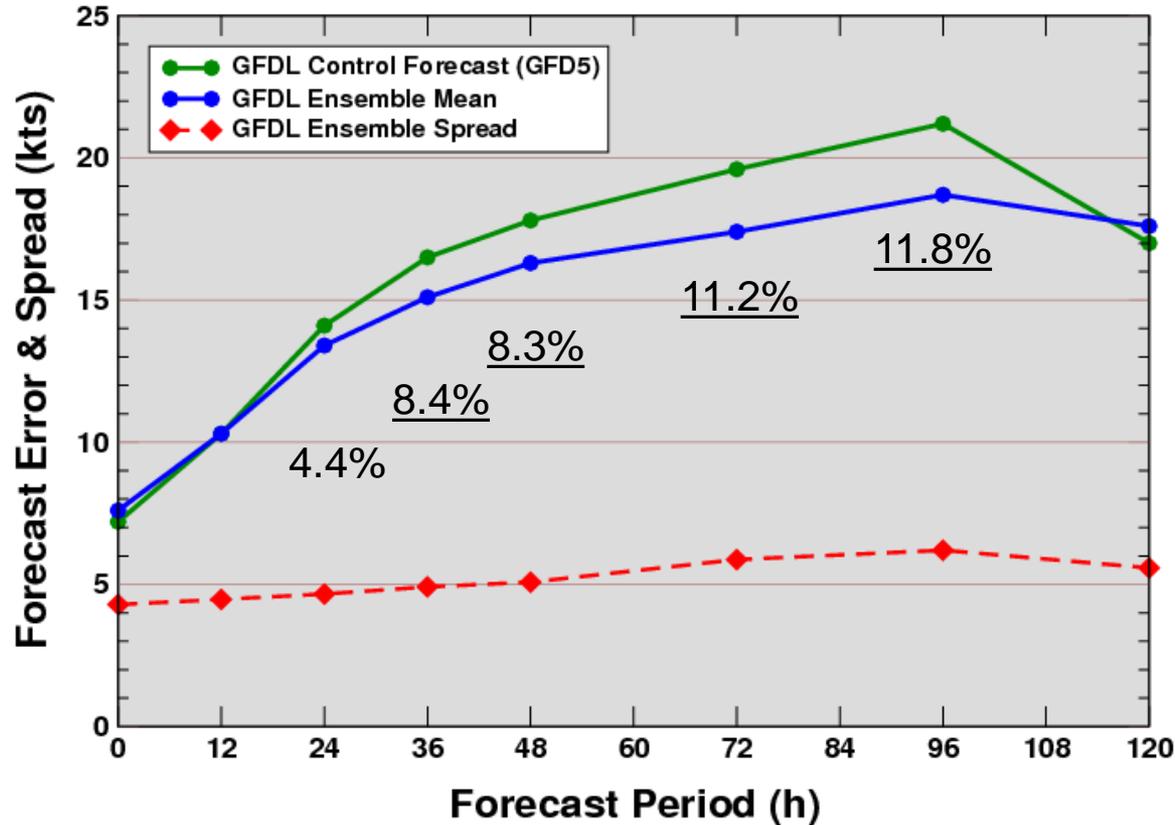
# Paula



Cases of Paula exhibited some of the most spread for track forecasts

# Intensity Results

**GFDL Ensemble Intensity Forecast Errors and Spread  
2010 Atlantic Basin**

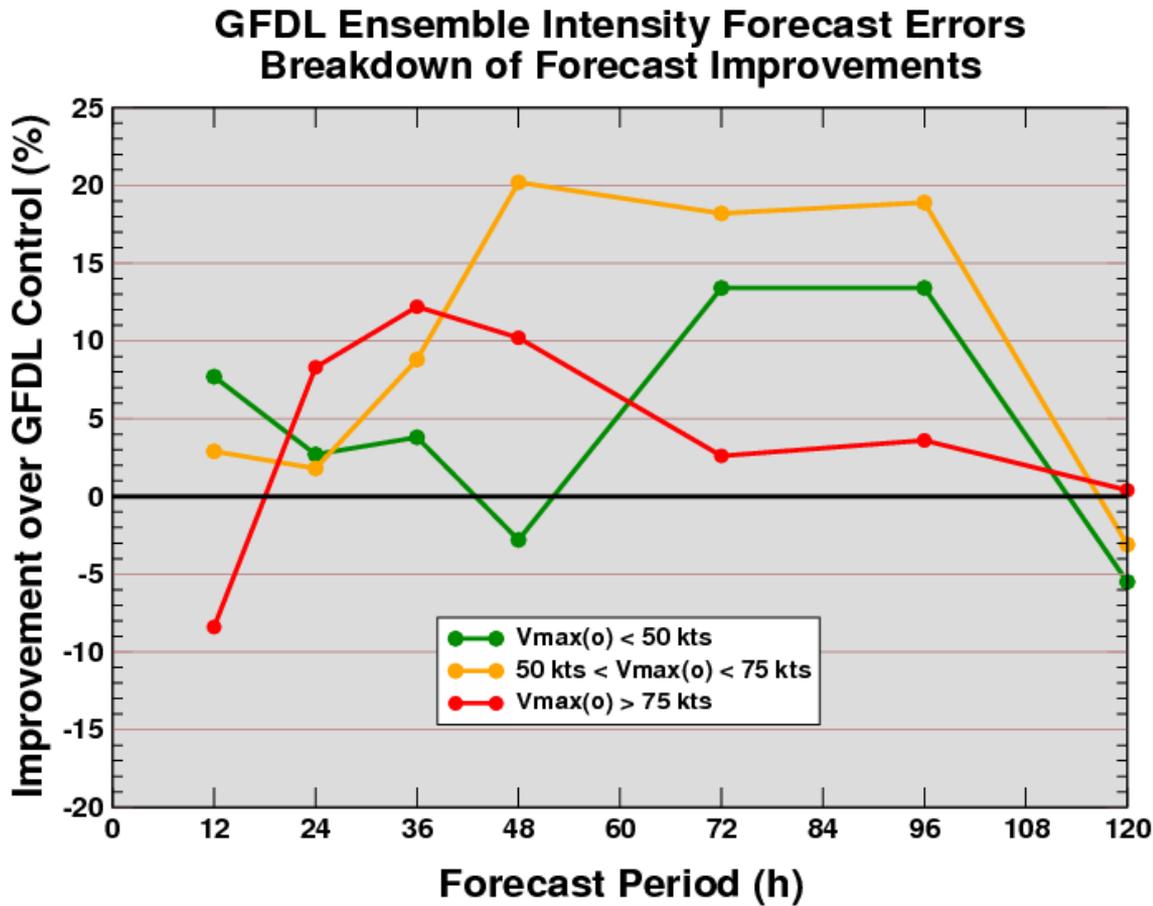


#CASES: 189 171 156 139 123 92 70 56

Statistically significant improvements of the ensemble mean over the control are seen through the middle of the forecast period.

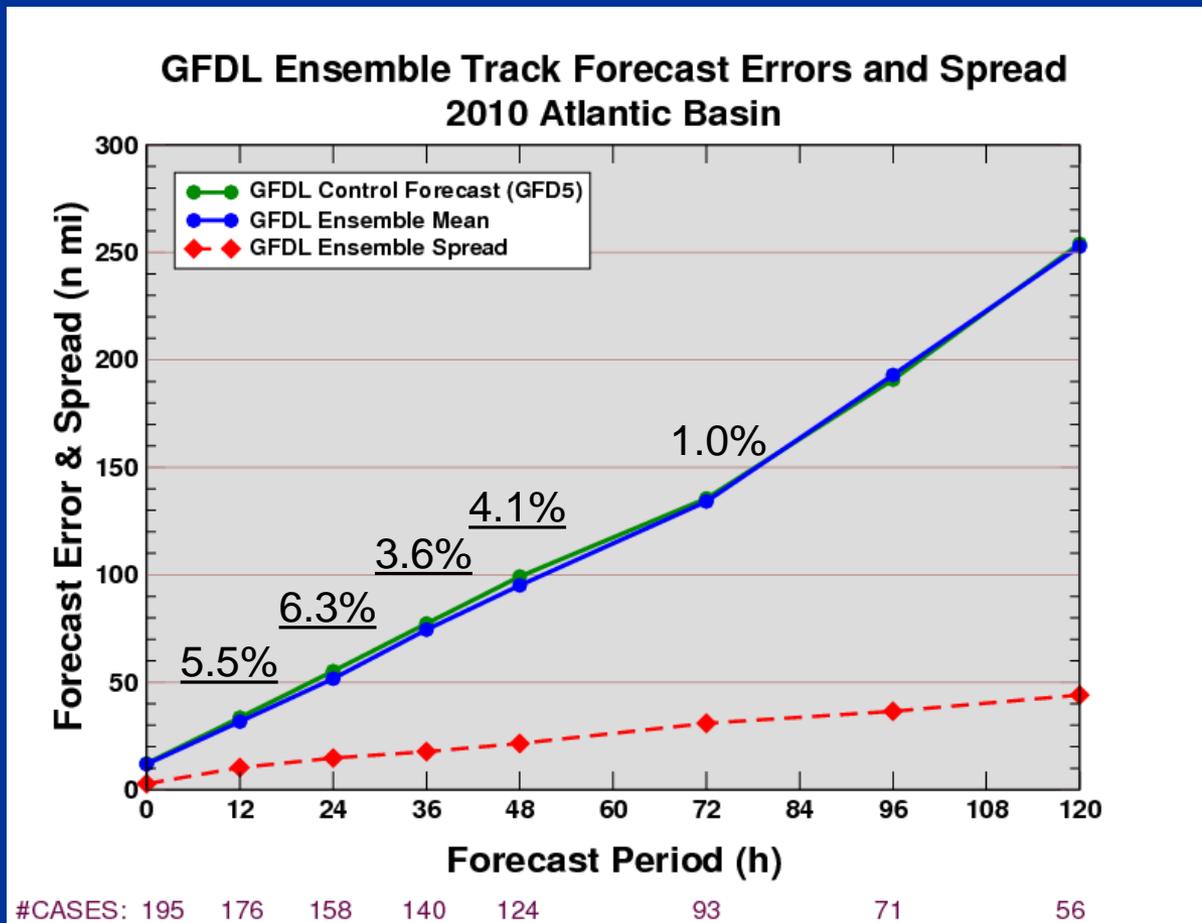
However, the spread results indicate an underdispersive ensemble

# Intensity Improvement Stratified by $V_{max(0)}$



Forecasts for weak storms saw very little improvement from the 2010 GFDL ensemble mean until 3 days, while stronger storms saw improvements at earlier lead times.

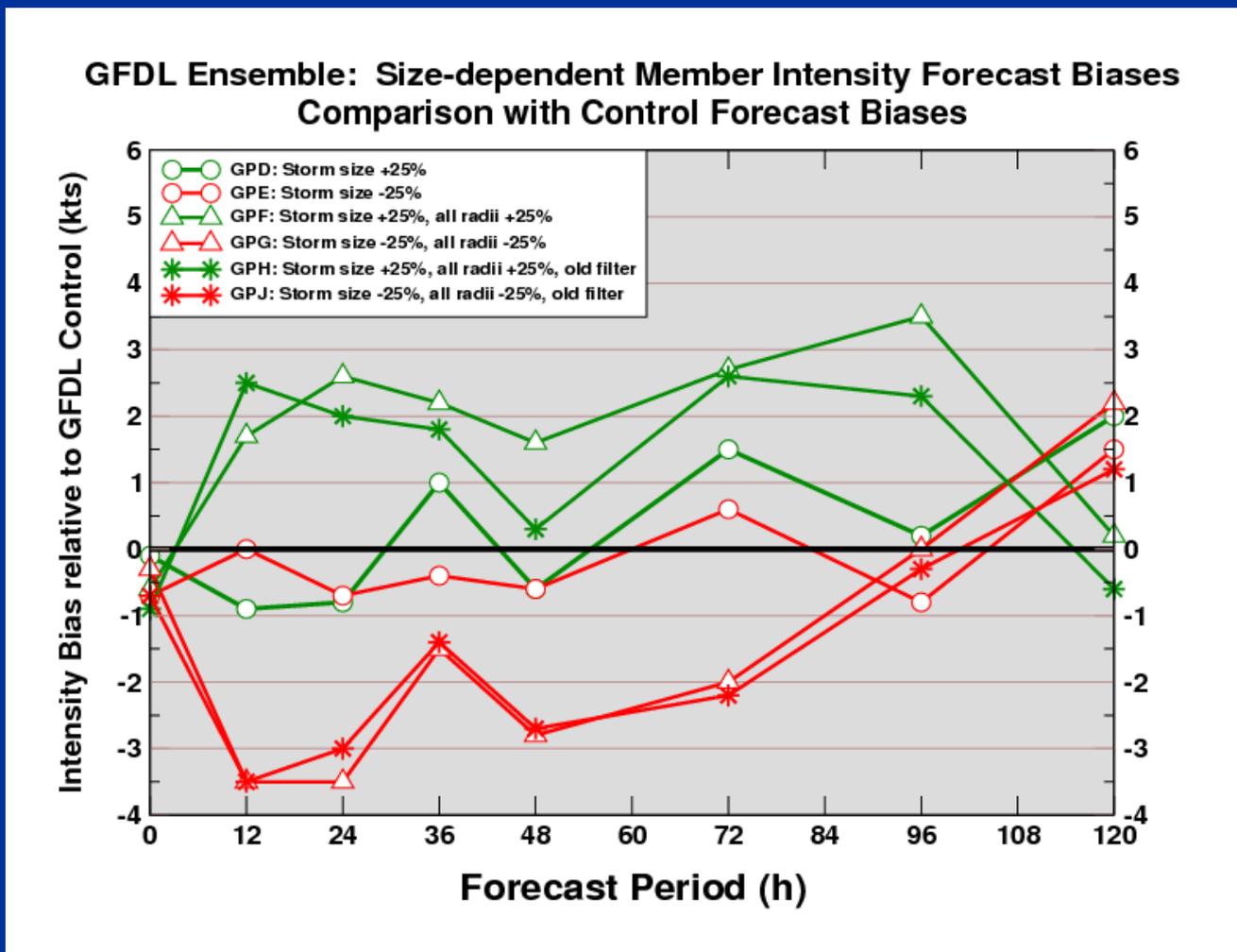
# Track Results: 2010 Atlantic Basin



Improvements for track are smaller than for intensity, but still significant from 12-48h .

However, the spread in the track forecasts is extremely low.

# Comparison of 2010 Intensity Forecast Biases



Modifying the wind radii and storm size together has more of an impact on intensity bias than just modifying storm size alone.

# GFDL ensemble membership for 2011

- 17-member ensemble: 16 perturbed members + control fcst

➤ P00: Control forecast (New 2011 operational GFDL)

➤ P01: Unbogussed forecast

➤ P02: Increase  $V_{max(0)}$  +10%

➤ P03: Decrease  $V_{max(0)}$  -10%

➤ P04: Increase 34R (+25%), 50R (+40%), ROCI (+25%)

➤ P05: Decrease 34R (-25%), 50R (-40%), ROCI (-25%)

➤ P06: Increase  $R_{max}$  +25%

➤ P07: Decrease  $R_{max}$  -25%

➤ P08: GFDL ensemble control from 2010

➤ P09: 20% (max) modification to axisymmetric moisture perturbation

➤ P10: 10% increase to initial mixing ratio in full field

➤ P11: 10% decrease to initial mixing ratio in full field

➤ P12: Asymmetries from previous forecast NOT included

➤ P13: Allow greater % of frictional dissipation to go into heating

➤ P14: Decrease the amount of vertical momentum transport

➤ P15: Reduce the penetration of downdrafts into the boundary layer

➤ P16: Shallow convection turned on

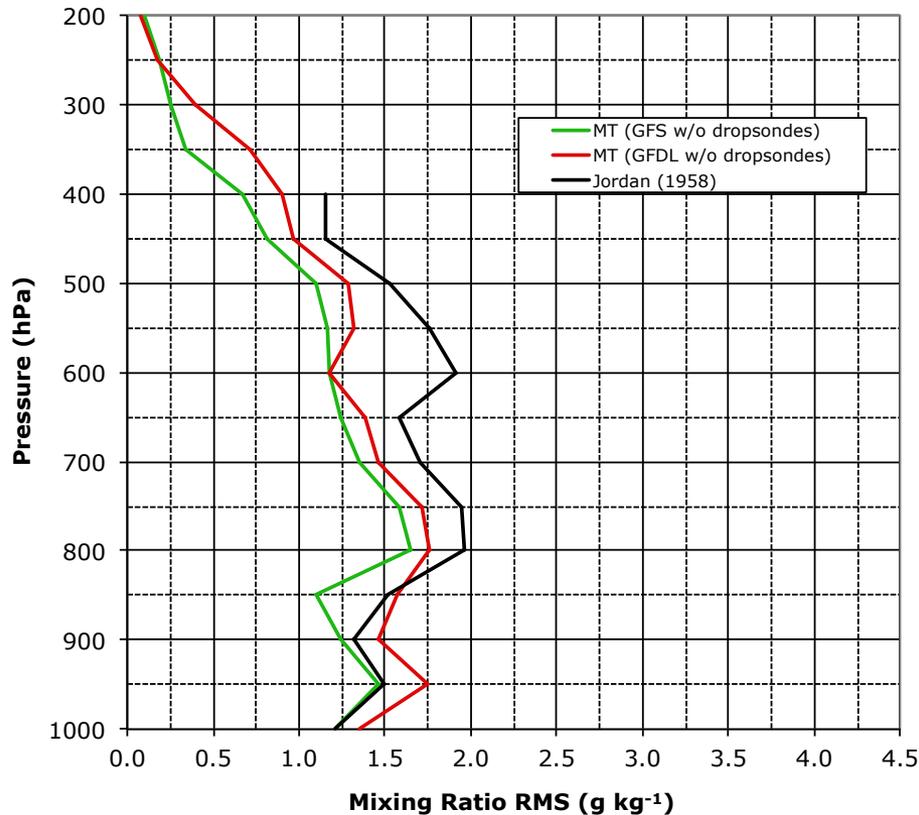
Size  
Members

Moisture  
Pert.  
Members

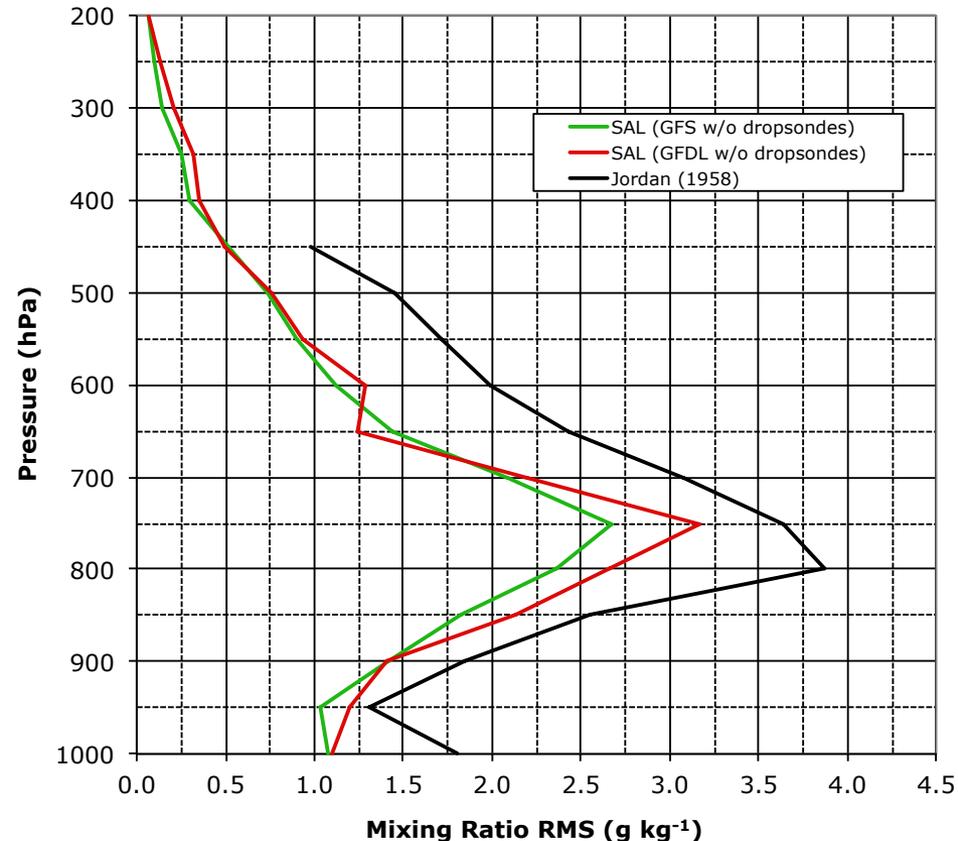
Convective  
Param  
Members

# Moisture modification: Motivation

## Moist Tropical RMS MR differences



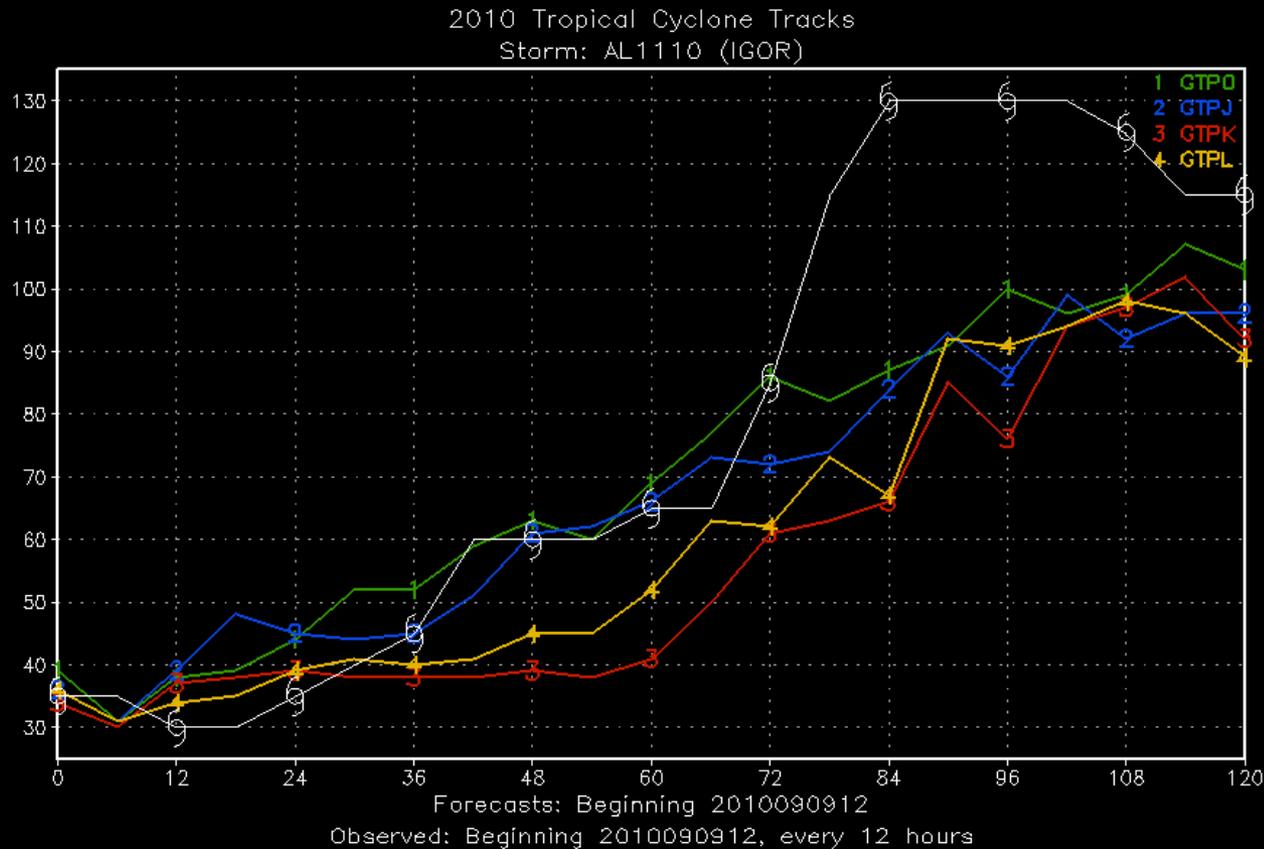
## SAL RMS MR differences



(Source: Jason Dunion)

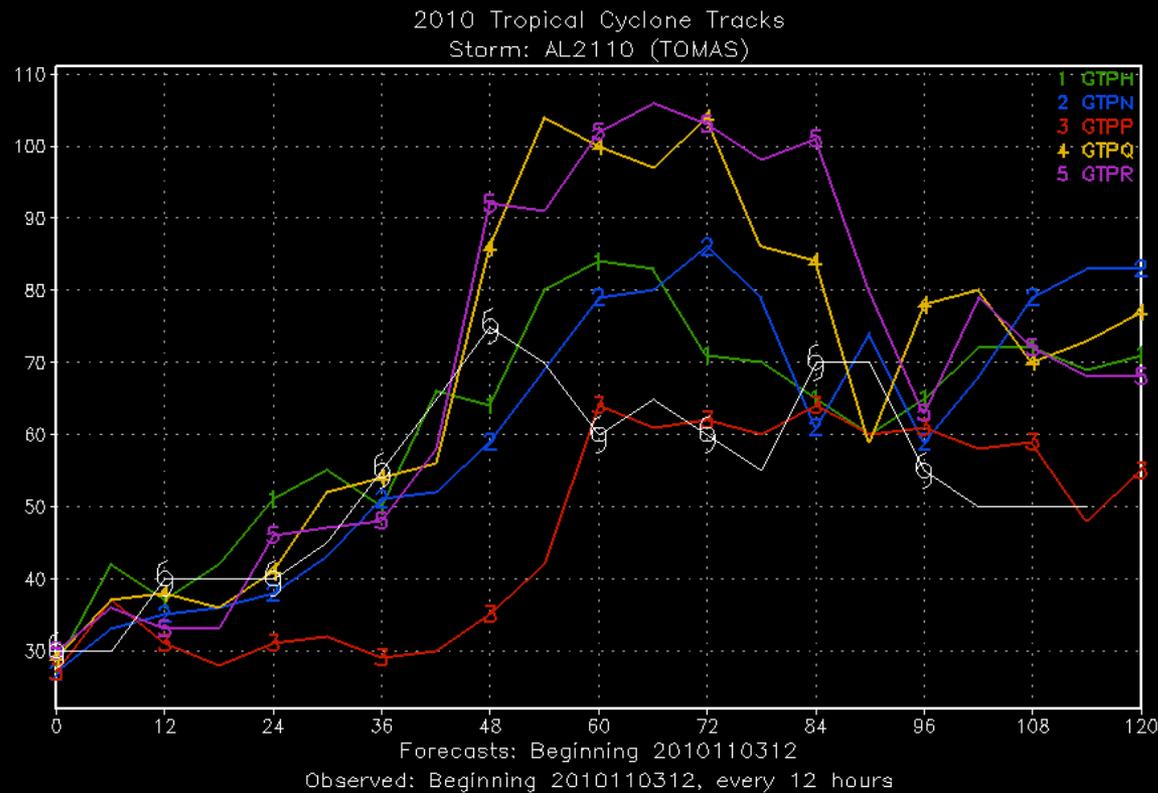
- G-IV drops reveal difficulty with moisture initialization in models (Dunion)
- Kimball (2006) found large sensitivity to different initial moisture profiles

# Differences with moisture perts: Igor example



In this case, the member with a moisture reduction (K) remains weaker than the member with a moisture increase (L). All members miss the RI.

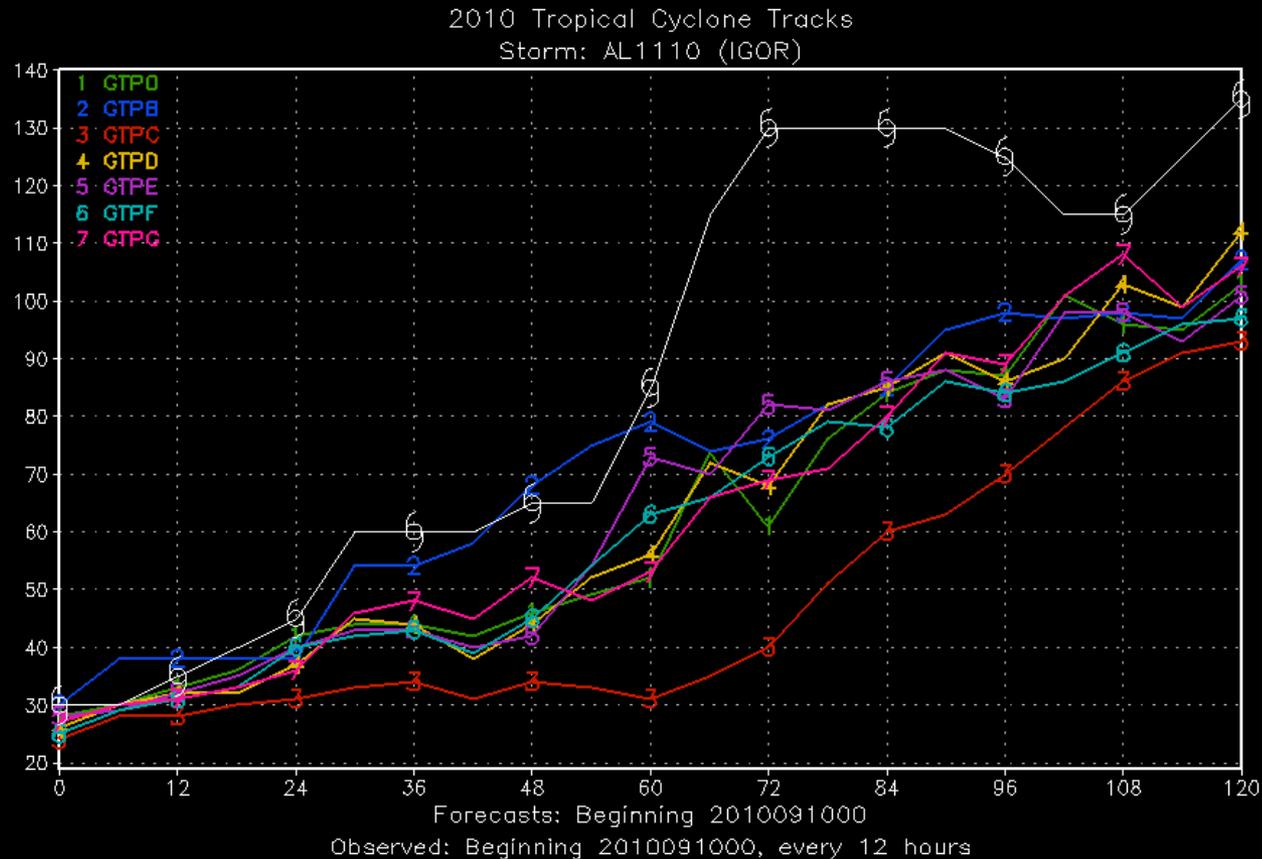
# Differences with convective perts: Tomas example



Considerable spread in the intensity forecast is seen from the 5 convective parameterization members for this case of Tomas.

The member with changes to the momentum mixing (P) remains the weakest throughout.

# Differences with size perts: Igor example



In this case, the size members that modify the initial Vmax +/- 10% (B = +10%, C = -10%) have the greatest impact throughout most of the forecast.

None of the members predicted the RI.

# Potential applications

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- Probabilistic guidance for:
  - Maximum wind speed
  - Wind threshold exceedance
  - Cyclone phase determination
  - Surface wind structure

# Summary

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- Modifying the vortex structure (via wind & moisture) shows promise for perturbing forecasts.
- Modest improvements over control run seen for 2010 ensemble mean intensity forecasts, somewhat less for track.
- The ensemble shows low dispersion for intensity and especially track, and it may benefit from increased spread.
- Potential applications can be coordinated with other HFIP groups.