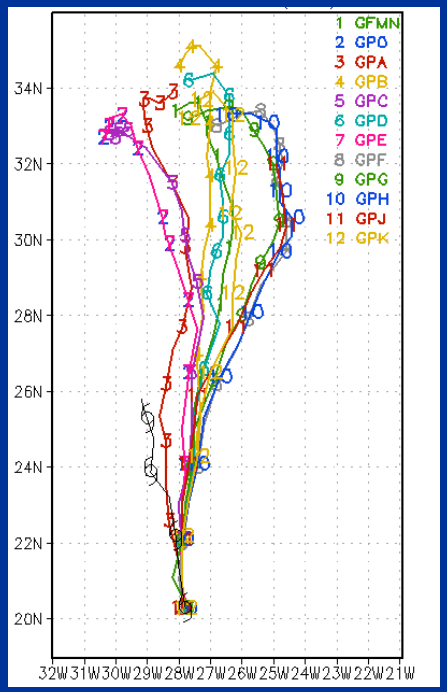
GFDL Hurricane Model Ensemble Performance during 2011 Atlantic Season



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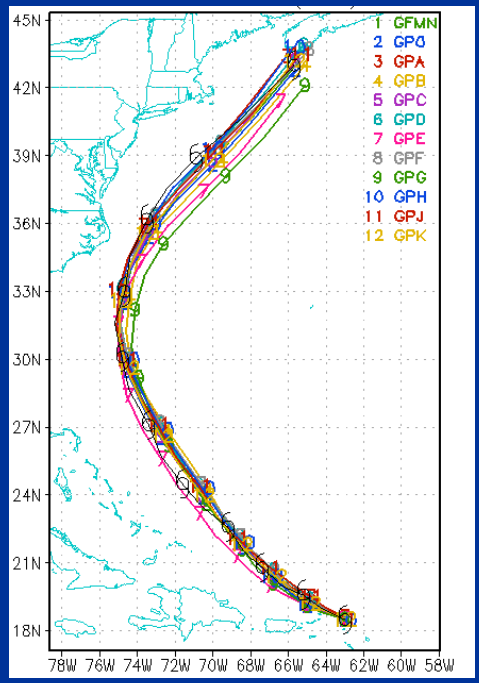
HFIP Team Meeting
Miami, FL
09 November 2011



GFDL Ensemble

- Goal: Design and run a simple ensemble based on the operational GFDL model to provide additional, useful guidance on track and intensity.

- Method: Run at same resolution as operational GFDL model (3 nests: 1/2^{o}, 1/6^{o}, 1/12^{o}). Apply perturbations by either modifying the vortex structure / moisture fields in the core region or by running with modifications to the convective parameterization scheme.

- Membership: 16 perturbed members, 1 control forecast.

GFDL ensemble membership for 2011

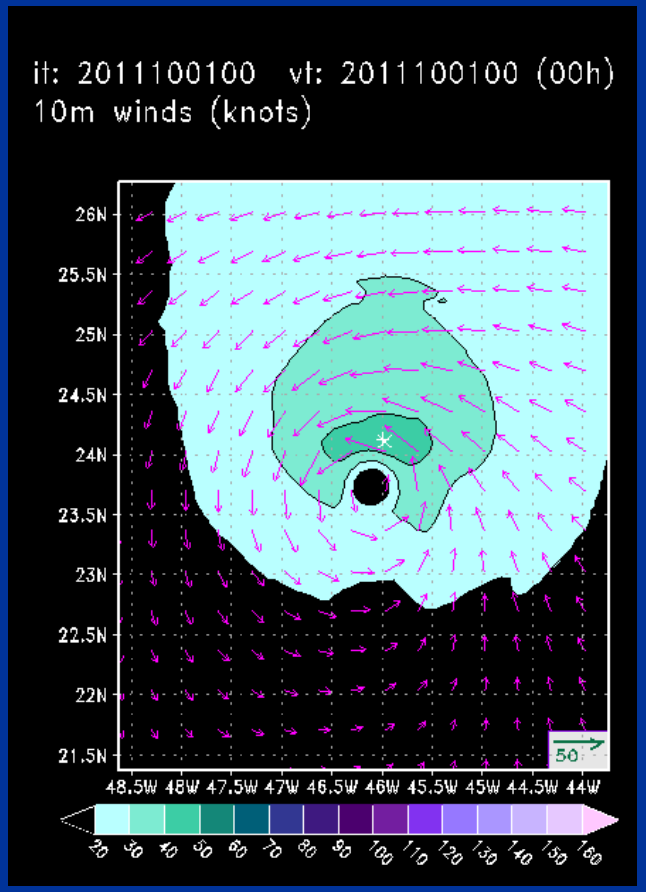
- 17-member ensemble: 16 perturbed members + control fcst
  - P00: Control forecast (2011 operational GFDL)
  - P01: Unbogussed forecast
  - P02: Increase $Vmax_{(0)}$ +10%
  - P03: Decrease $Vmax_{(0)}$ -10%
  - P04: Increase 34R (+25%), 50R (+40%), ROCI (+25%)
  - P05: Decrease 34R (-25%), 50R (-40%), ROCI (-25%)
  - P06: Increase Rmax +25%
  - P07: Decrease Rmax -25%
  - P08: GFDL operational model 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

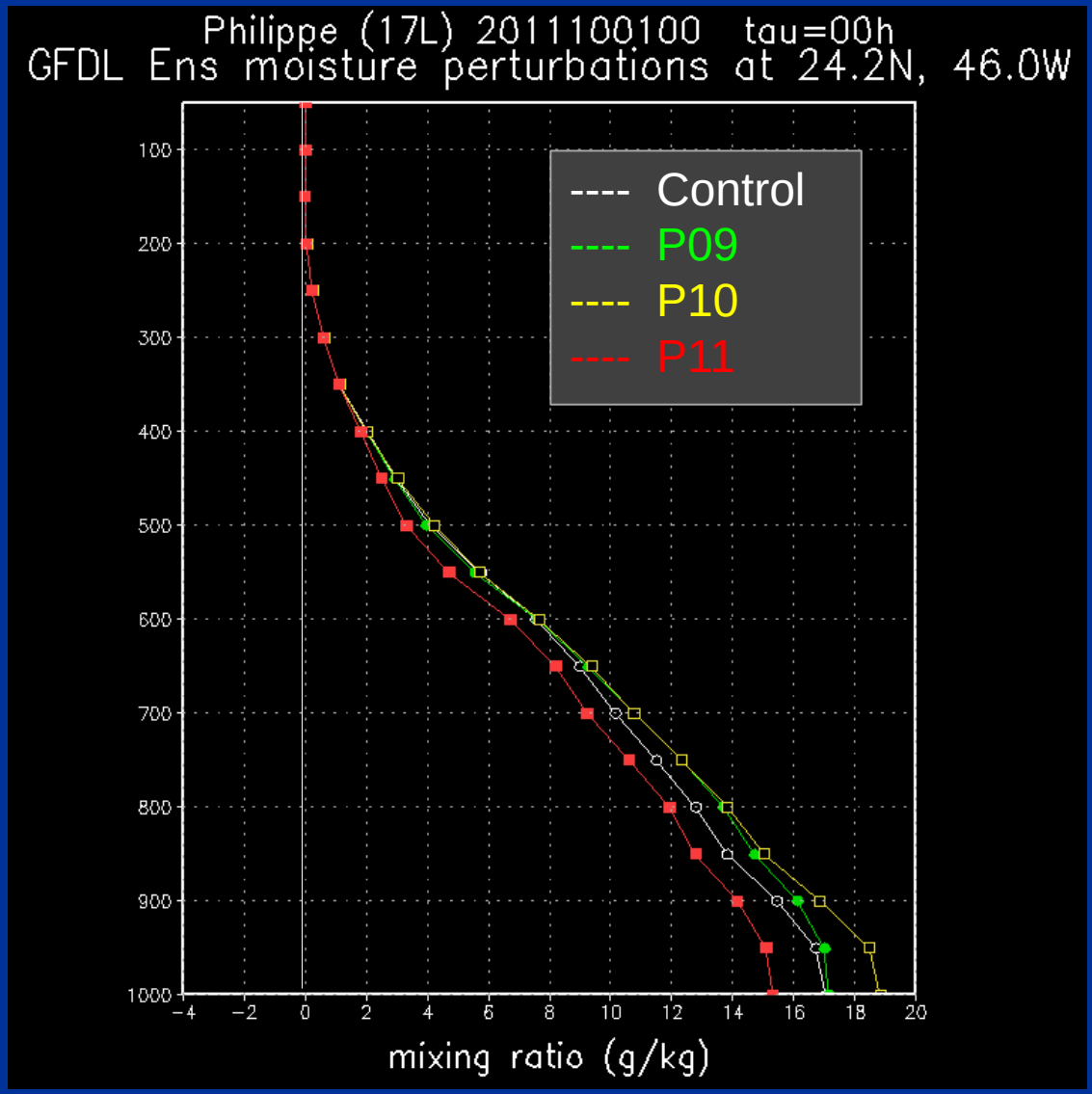
Size Members

Moisture Pert. Members

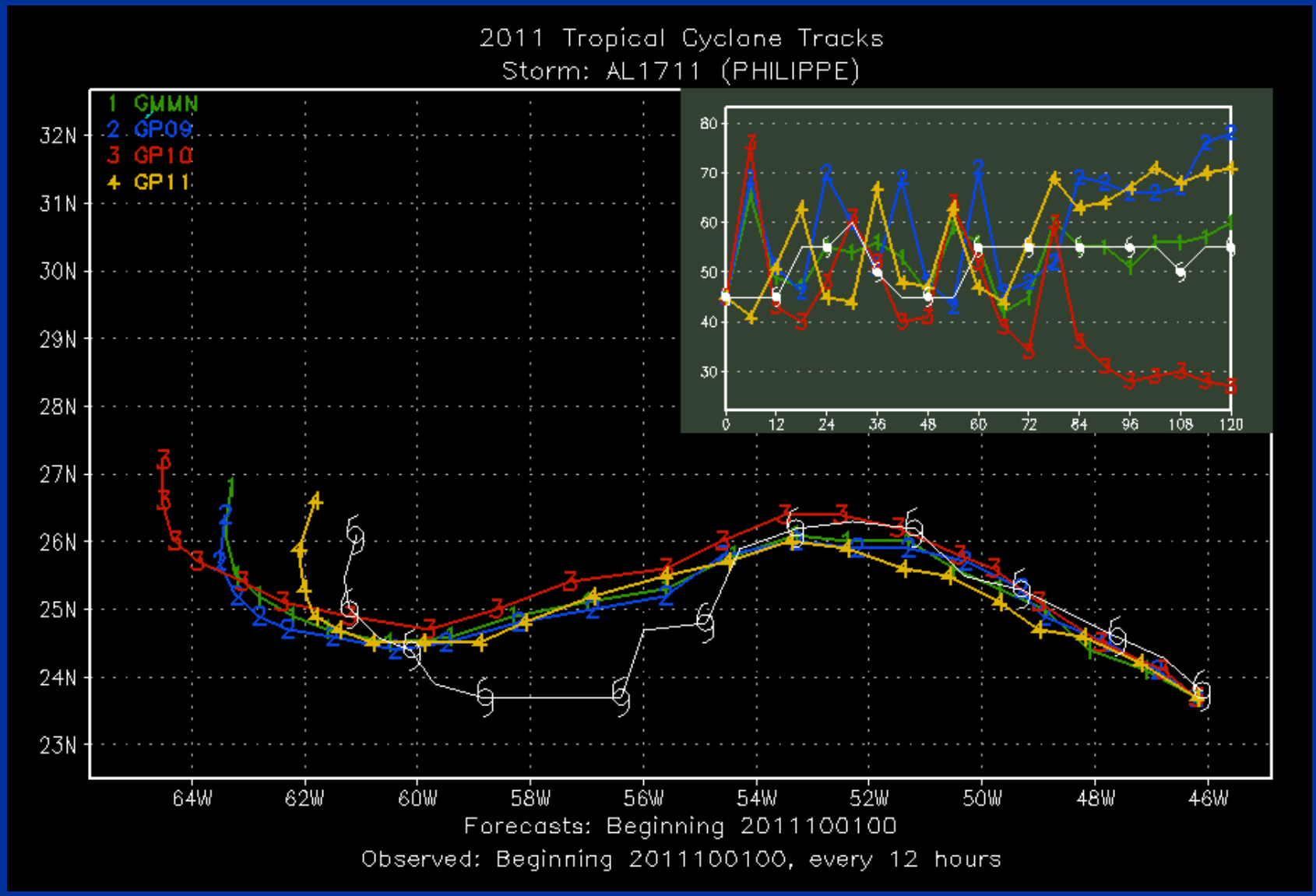
Convective Param Members

Example of initial moisture perturbations: Philippe 2011100100

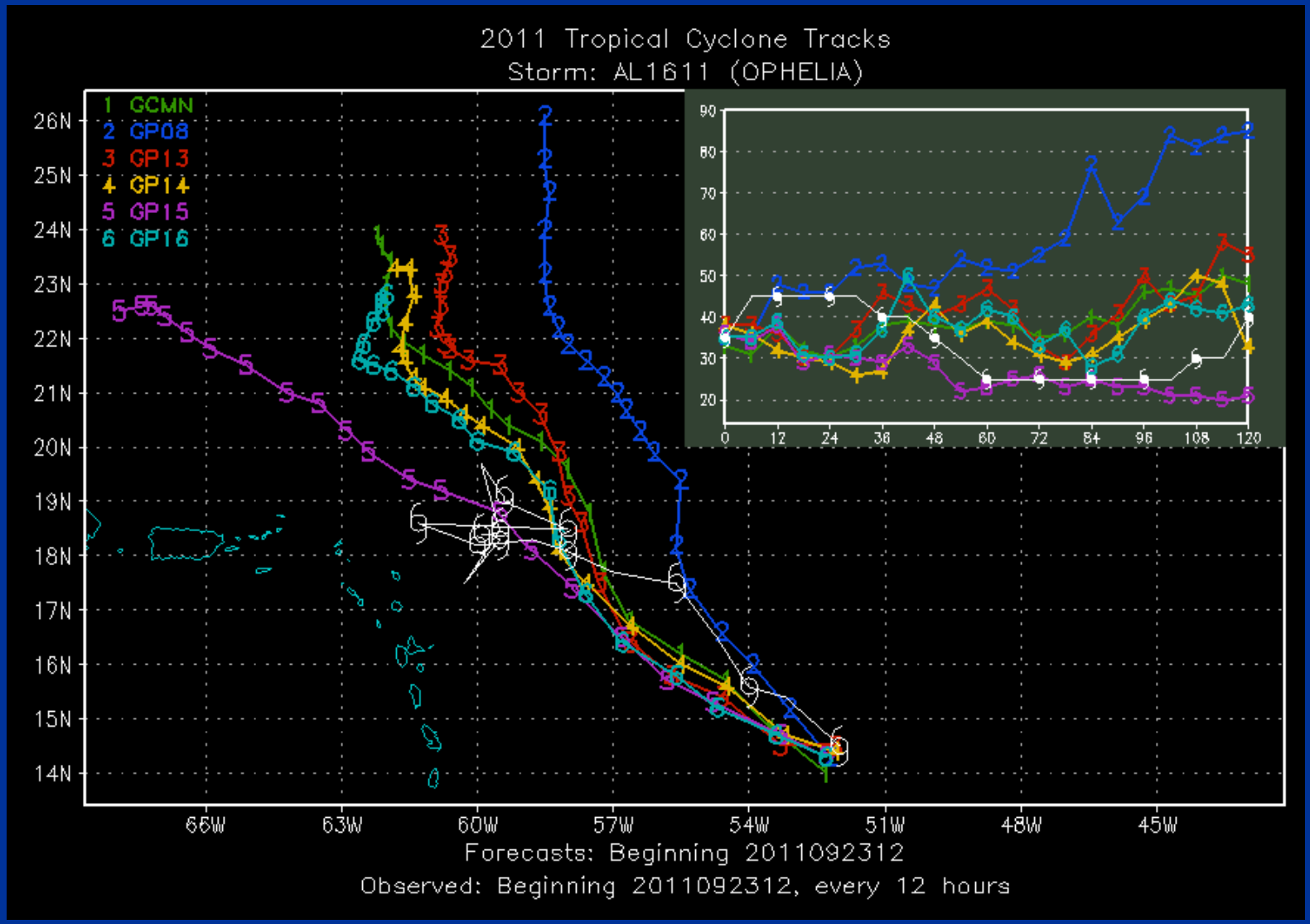




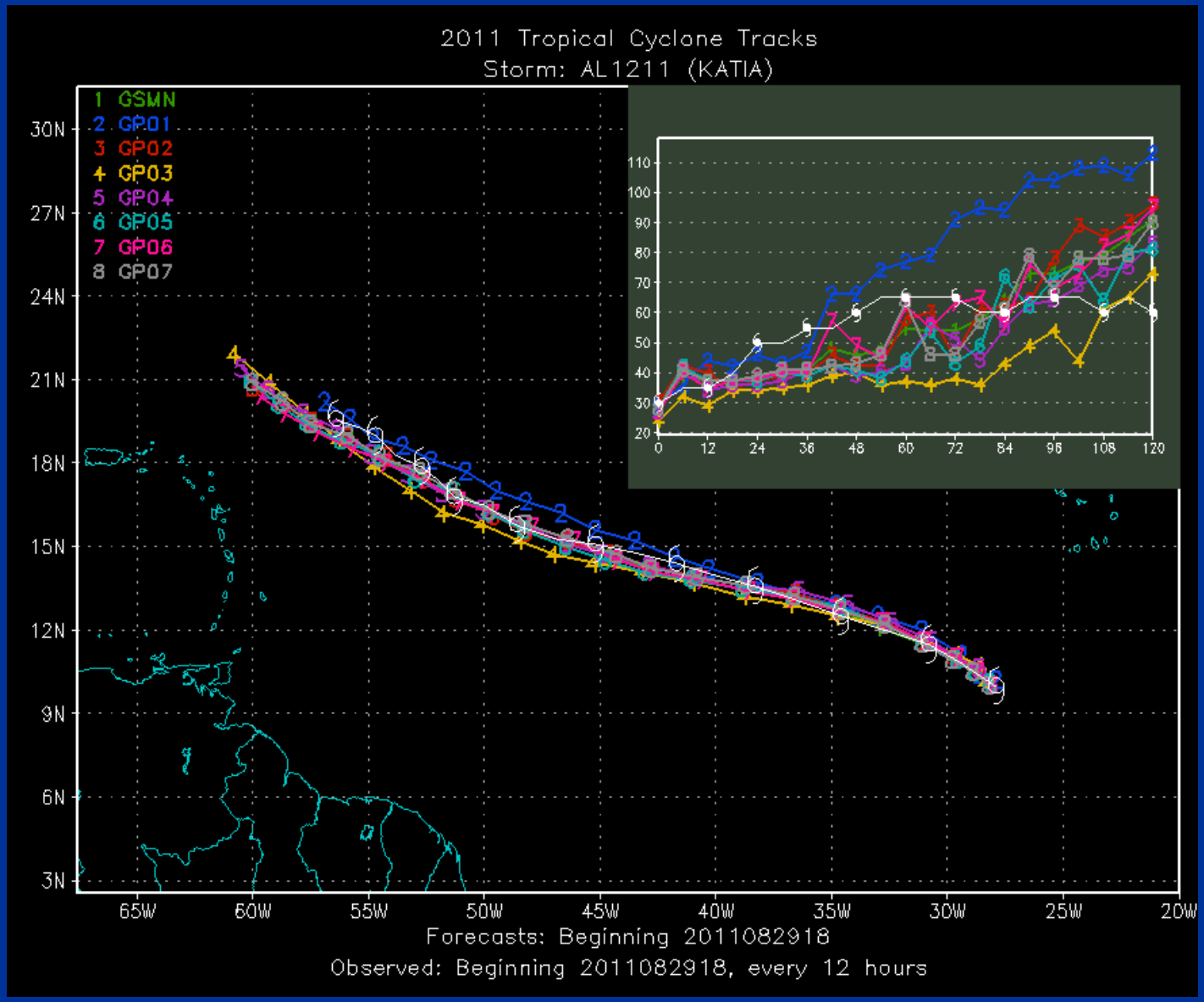
Example of initial moisture perturbations: Philippe 2011100100



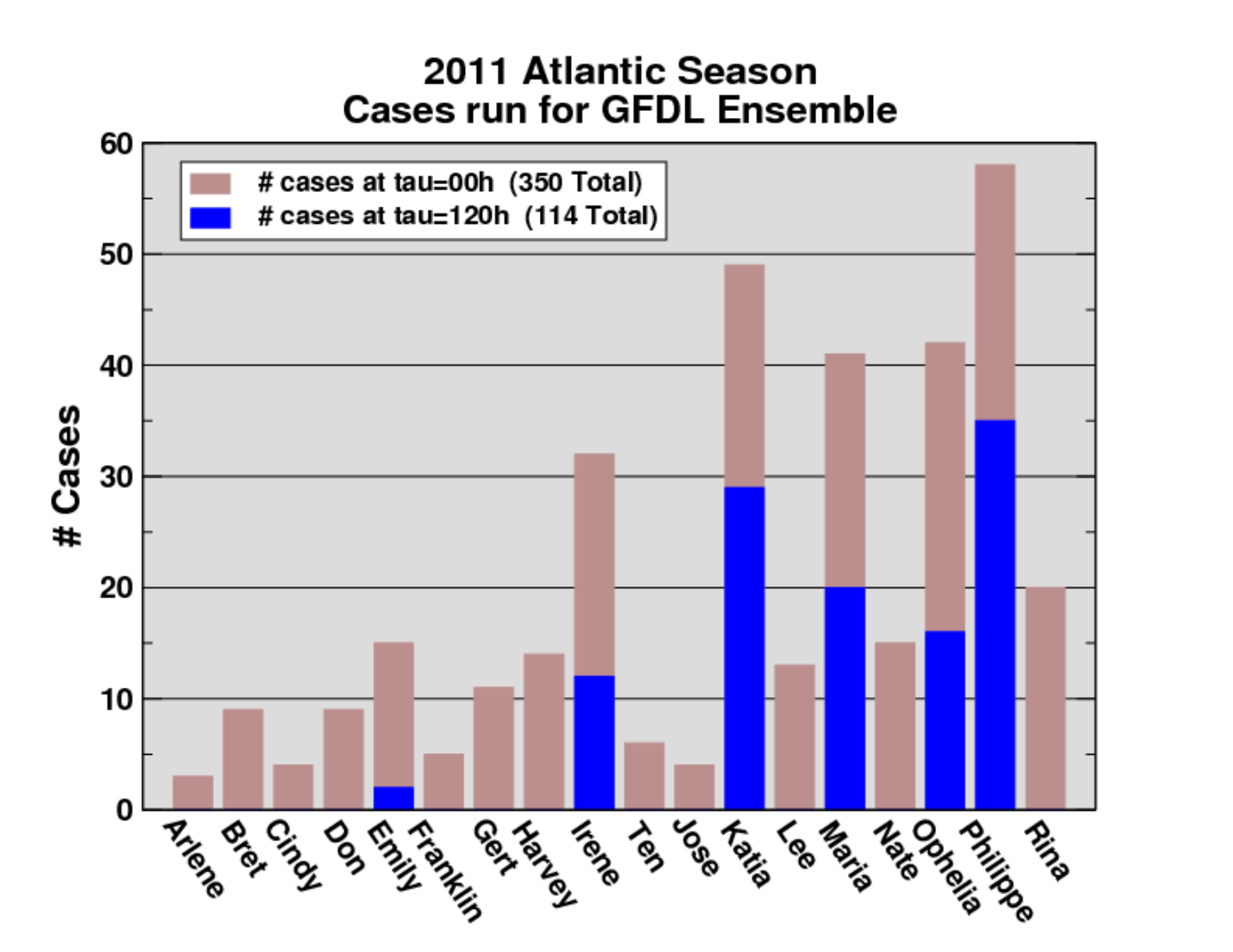
Example of convective perturbations: Ophelia 2011092312



Example of size perturbations: Katia 2011082918

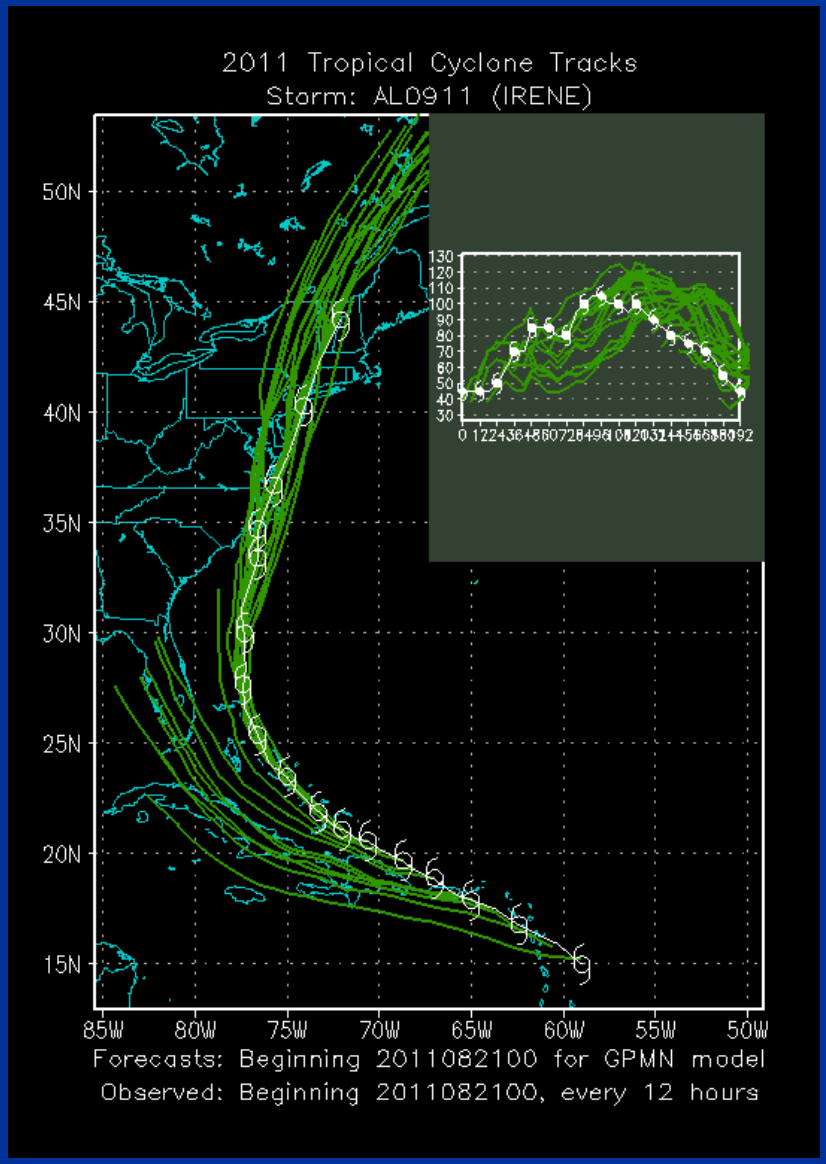


350 cases run for 2011 Atlantic season…



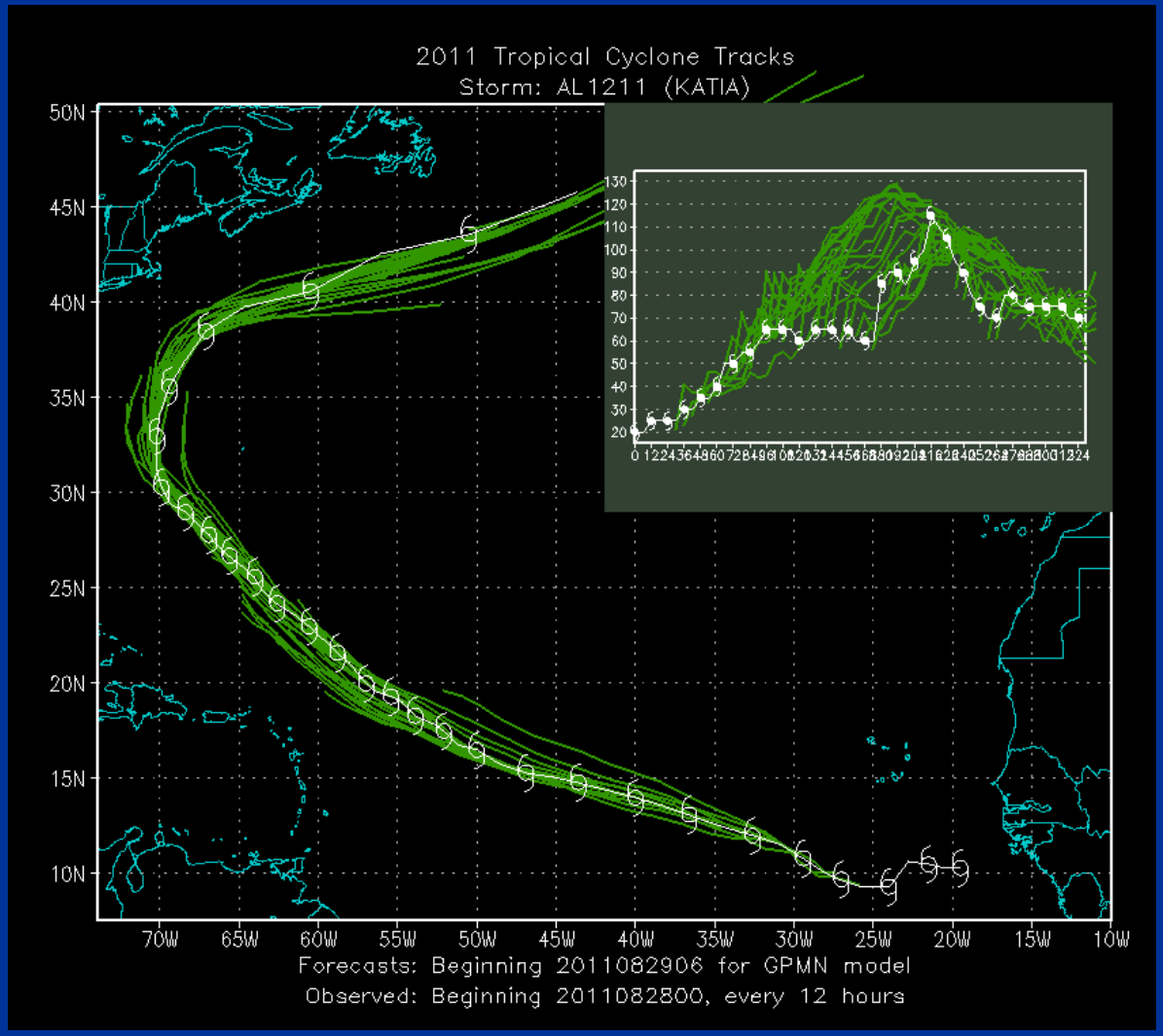
Hurricane Irene

- Left bias in the operational GFDL model track forecasts is also evident in the ensemble mean.



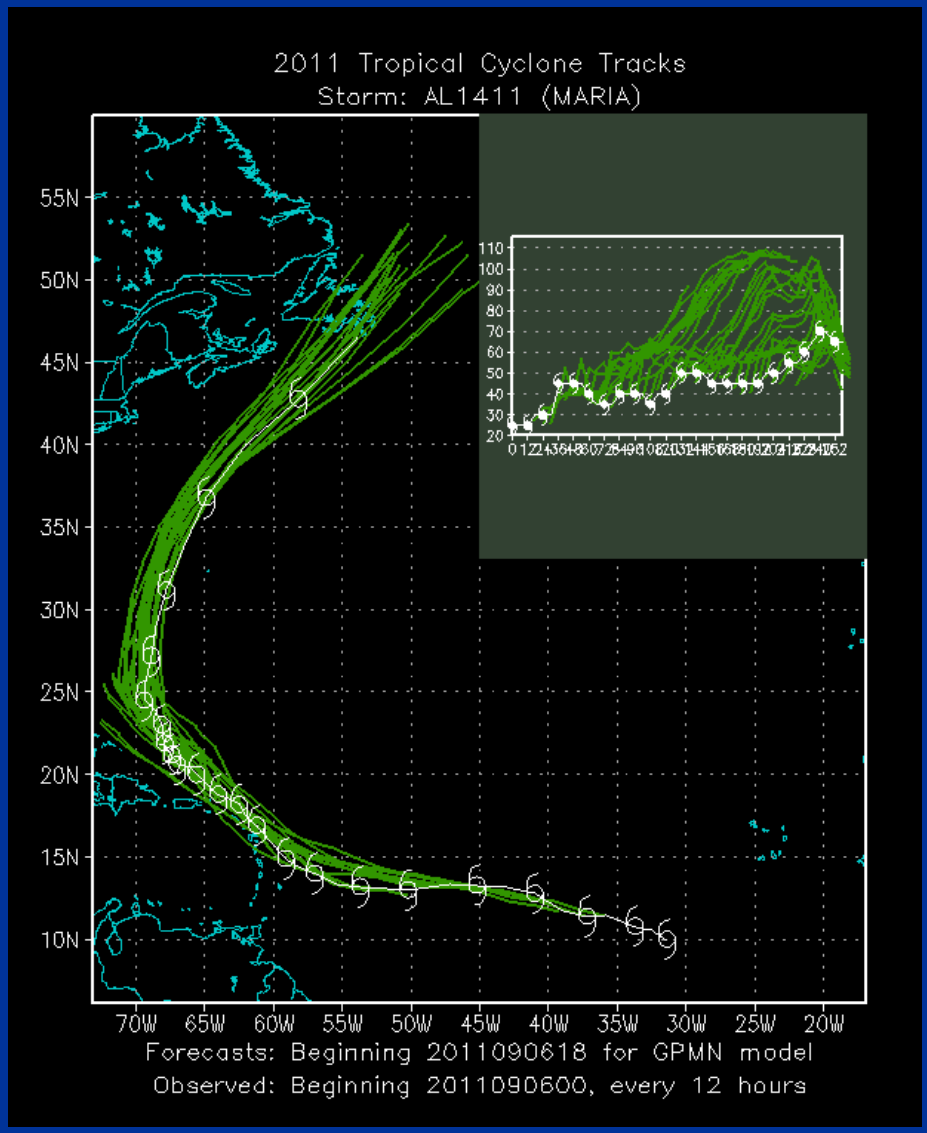
Hurricane Katia

- Katia's track was well forecast by the ensemble, with a mean error at 120h of 128 n mi.



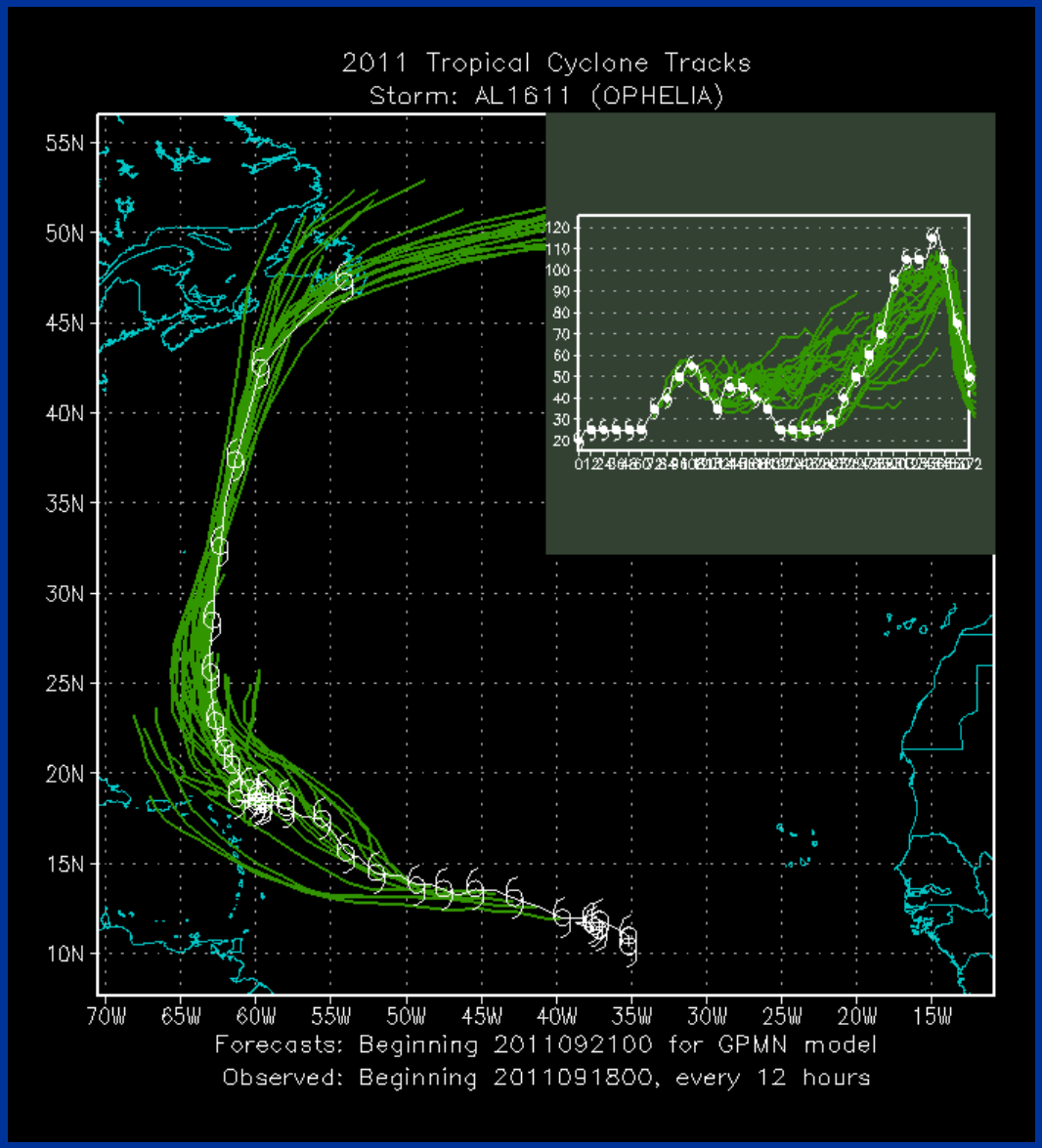
Hurricane Maria

- Cross-track errors were small for the ensemble mean, but the ensemble suffered from a large fast speed bias here.
- Also, intensity forecasts had a large positive bias throughout Maria's lifecycle.



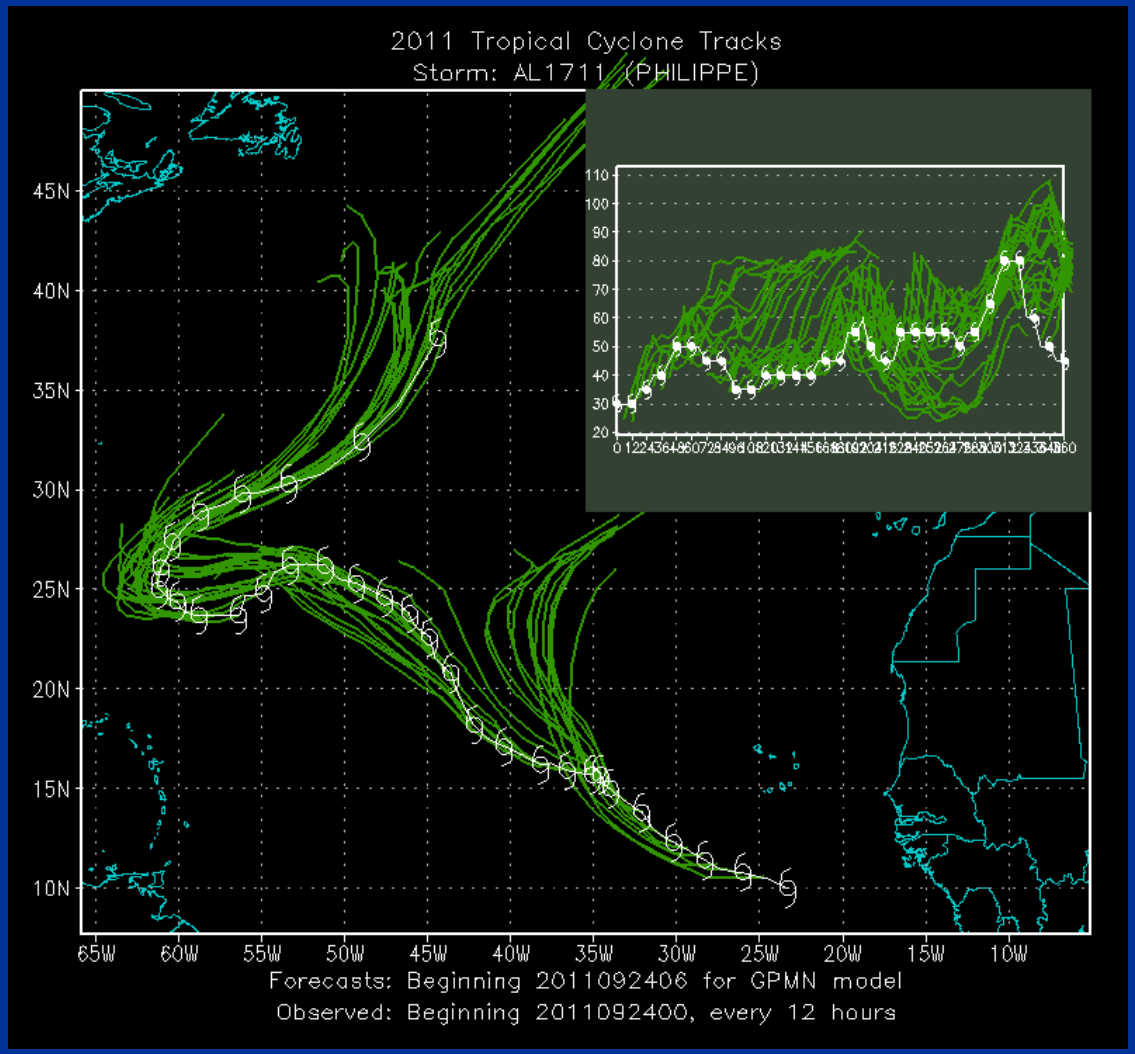
Hurricane Ophelia

- The largest track forecast spread was seen for forecasts of Ophelia and Rina.
- Ophelia track forecasts at 3-5 days were significantly better than the operational GFDL.



Hurricane Philippe

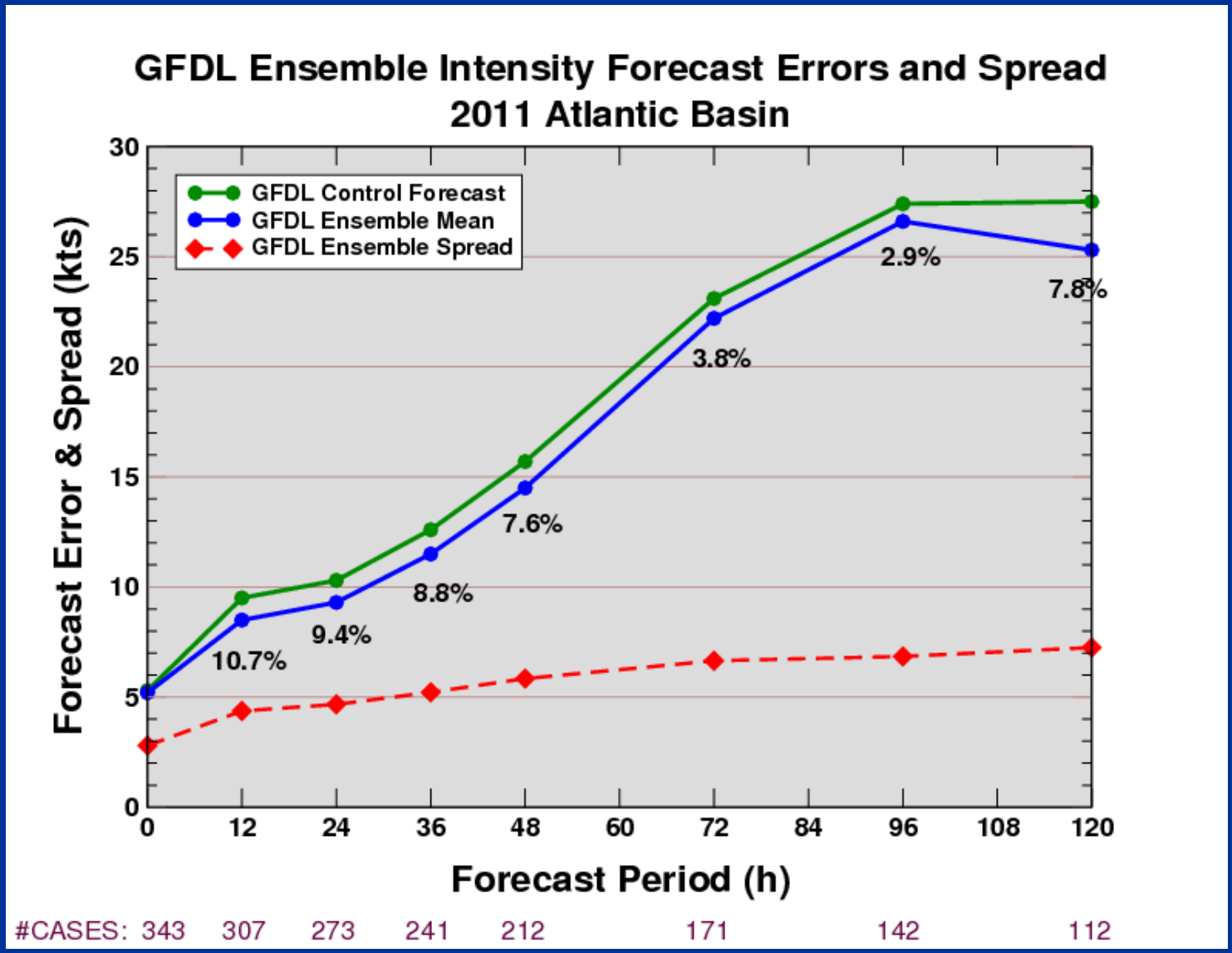
- Ensemble mean track errors for Philippe were comparable to the TVCN consensus at 3-5 days, but not as good as the GFS.
- For intensity, a problem again with a persistent positive bias.



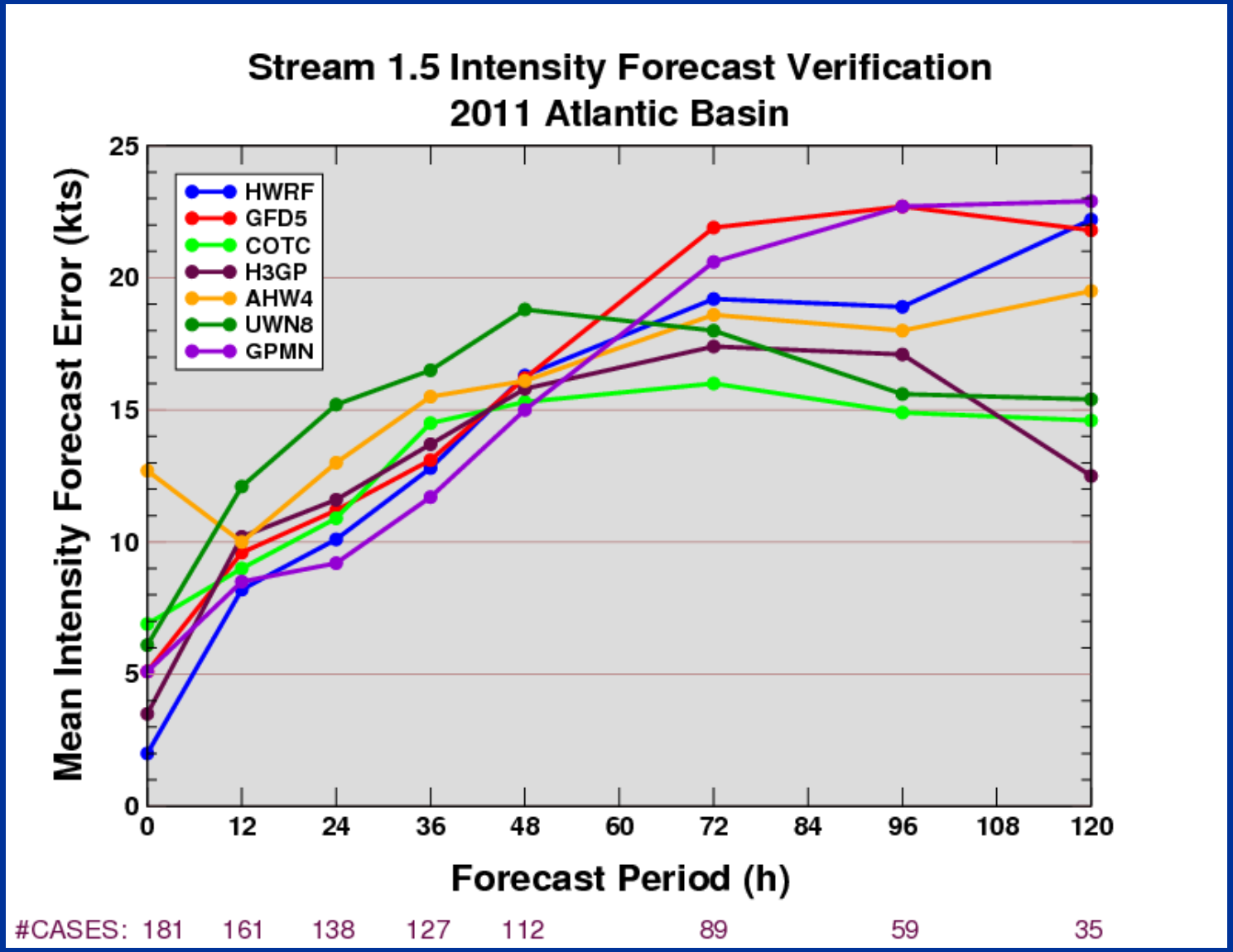
Some challenges this season...

- Timing-out of 1 or 2 member forecasts per cycle, preventing them from being included in mean.
- Switch from alpha to numeric member IDs introduced bug that prevented moisture members from being perturbed from early August through the end of September.
- Fix of a convective bug introduced another bug that prevented convective members from being perturbed for a 3-week period in September.
- We were only able to run the ensemble for 1 storm per cycle. In 2010, we were able to run up to 3 storms per cycle.

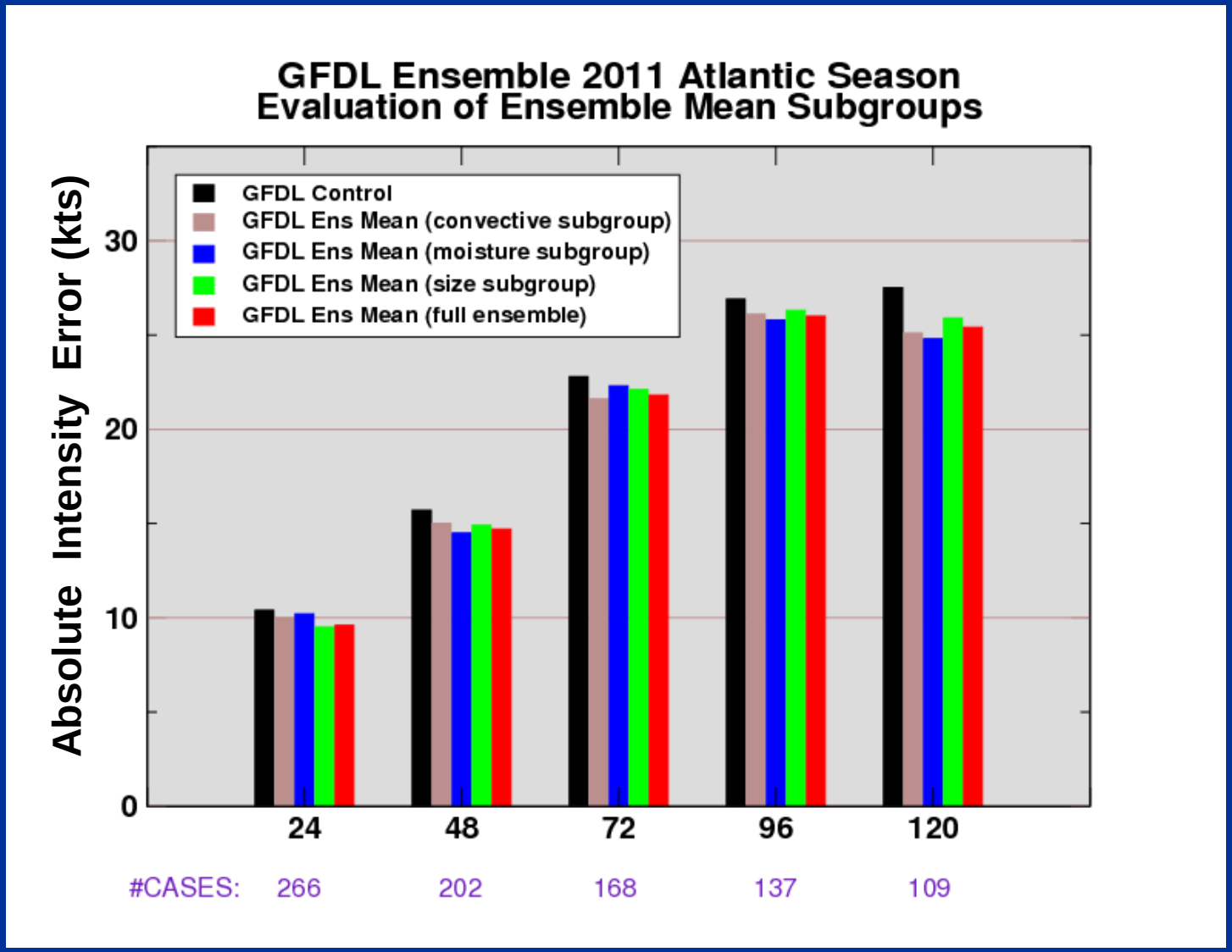
Intensity verification for 2011 Atlantic season



Comparison against other Stream 1.5 regional models



Intensity verification: Breakdown by GFDL ensemble member subgroup



Verification Rank Table for Intensity

- Table shows the verification rank (1 = Best, 17 = Worst) of ensemble members for intensity forecasts. Rank is based on the mean intensity forecast errors over the 72-120h period for all cases for each storm.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Emily	P08	P05	P11	P10	P03	P15	P01	P14	P09	P06	P00	P12	P07	P13	P16	P04	P02
Irene	P04	P08	P12	P10	P02	P09	P14	P01	P07	P06	P00	P11	P03	P16	P13	P15	P05
Katia	P08	P10	P04	P15	P03	P00	P05	P12	P14	P16	P06	P11	P07	P09	P02	P13	P01
Maria	P14	P08	P10	P15	P05	P09	P06	P03	P16	P02	P12	P04	P11	P01	P07	P13	P00
Ophelia	P01	P05	P12	P10	P00	P04	P09	P15	P02	P06	P07	P16	P03	P14	P13	P11	P08
Philippe	P08	P03	P14	P00	P15	P10	P11	P02	P16	P07	P13	P12	P05	P01	P06	P09	P04

Verification Rank Table for Intensity

- The 2010 version of the model control forecast (P08) ranked 1st or 2nd for 5 out of 6 storms, but last for Ophelia.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Emily	P08	P05	P11	P10	P03	P15	P01	P14	P09	P06	P00	P12	P07	P13	P16	P04	P02
Irene	P04	P08	P12	P10	P02	P09	P14	P01	P07	P06	P00	P11	P03	P16	P13	P15	P05
Katia	P08	P10	P04	P15	P03	P00	P05	P12	P14	P16	P06	P11	P07	P09	P02	P13	P01
Maria	P14	P08	P10	P15	P05	P09	P06	P03	P16	P02	P12	P04	P11	P01	P07	P13	P00
Ophelia	P01	P05	P12	P10	P00	P04	P09	P15	P02	P06	P07	P16	P03	P14	P13	P11	P08
Philippe	P08	P03	P14	P00	P15	P10	P11	P02	P16	P07	P13	P12	P05	P01	P06	P09	P04

Verification Rank Table for Intensity

- The member which bumped up total moisture by 10% (P10) ranked highly for all 6 storms.

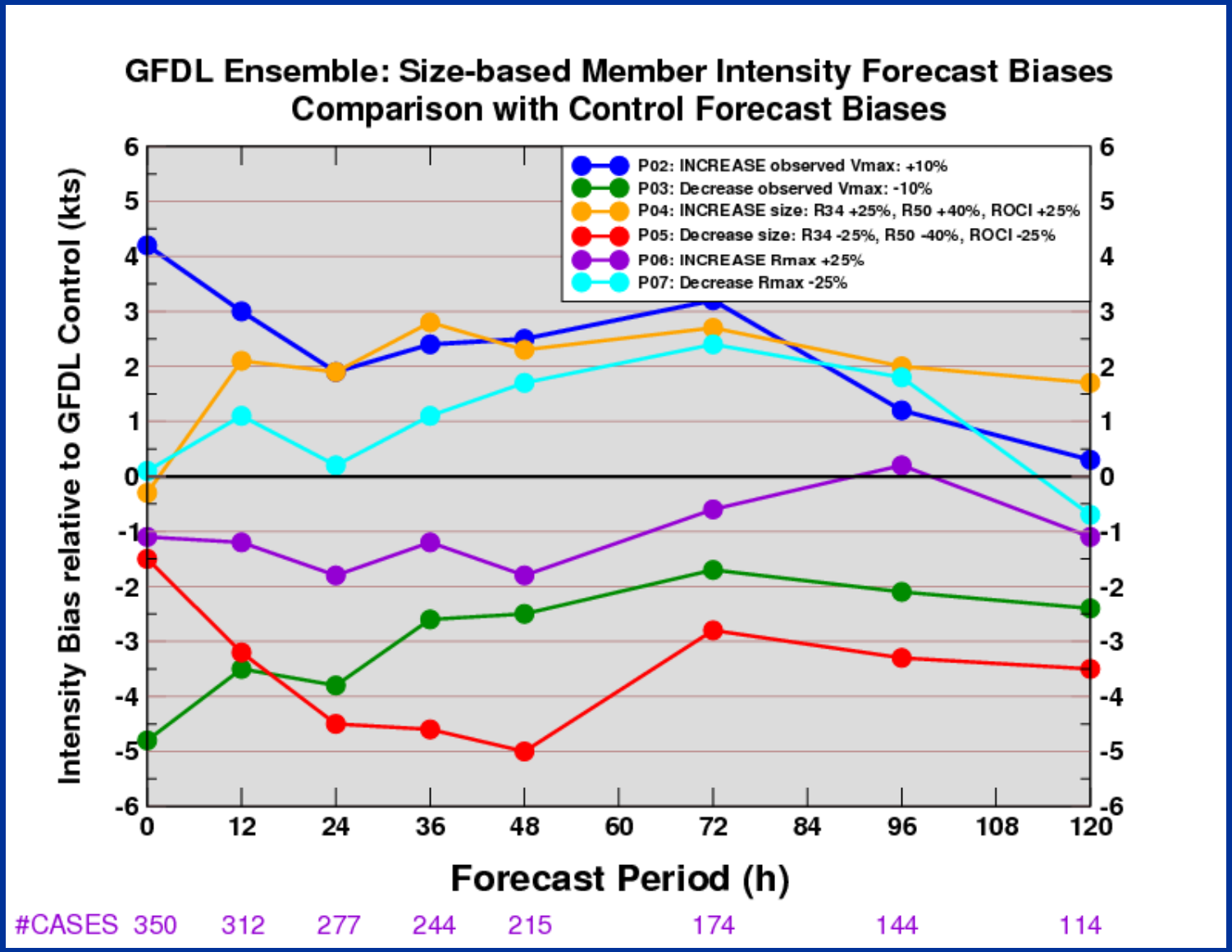
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Emily	P08	P05	P11	P10	P03	P15	P01	P14	P09	P06	P00	P12	P07	P13	P16	P04	P02
Irene	P04	P08	P12	P10	P02	P09	P14	P01	P07	P06	P00	P11	P03	P16	P13	P15	P05
Katia	P08	P10	P04	P15	P03	P00	P05	P12	P14	P16	P06	P11	P07	P09	P02	P13	P01
Maria	P14	P08	P10	P15	P05	P09	P06	P03	P16	P02	P12	P04	P11	P01	P07	P13	P00
Ophelia	P01	P05	P12	P10	P00	P04	P09	P15	P02	P06	P07	P16	P03	P14	P13	P11	P08
Philippe	P08	P03	P14	P00	P15	P10	P11	P02	P16	P07	P13	P12	P05	P01	P06	P09	P04

Verification Rank Table for Intensity

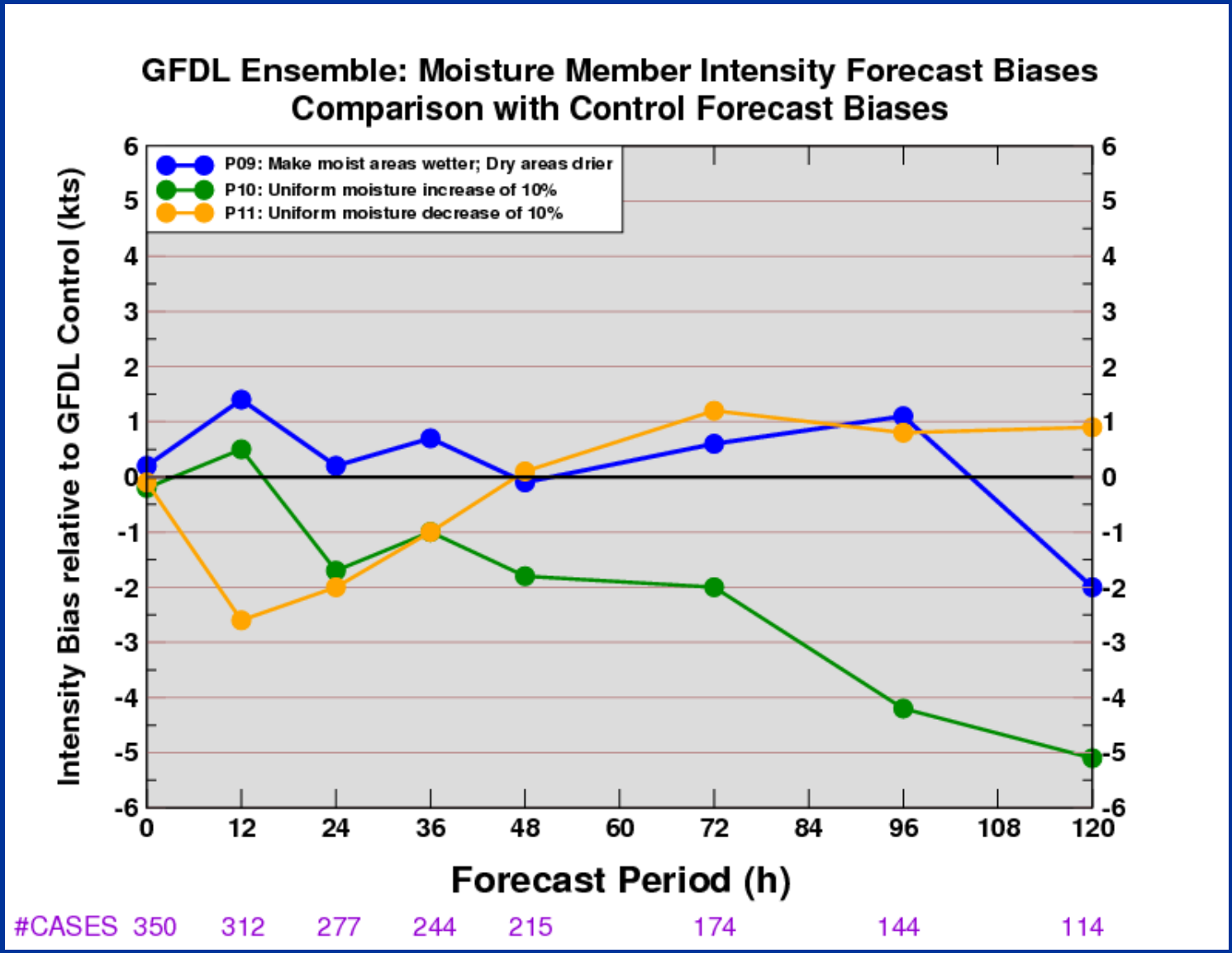
- The member which increased the impact of dissipative heating (P13) performed relatively poorly.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Emily	P08	P05	P11	P10	P03	P15	P01	P14	P09	P06	P00	P12	P07	P13	P16	P04	P02
Irene	P04	P08	P12	P10	P02	P09	P14	P01	P07	P06	P00	P11	P03	P16	P13	P15	P05
Katia	P08	P10	P04	P15	P03	P00	P05	P12	P14	P16	P06	P11	P07	P09	P02	P13	P01
Maria	P14	P08	P10	P15	P05	P09	P06	P03	P16	P02	P12	P04	P11	P01	P07	P13	P00
Ophelia	P01	P05	P12	P10	P00	P04	P09	P15	P02	P06	P07	P16	P03	P14	P13	P11	P08
Philippe	P08	P03	P14	P00	P15	P10	P11	P02	P16	P07	P13	P12	P05	P01	P06	P09	P04

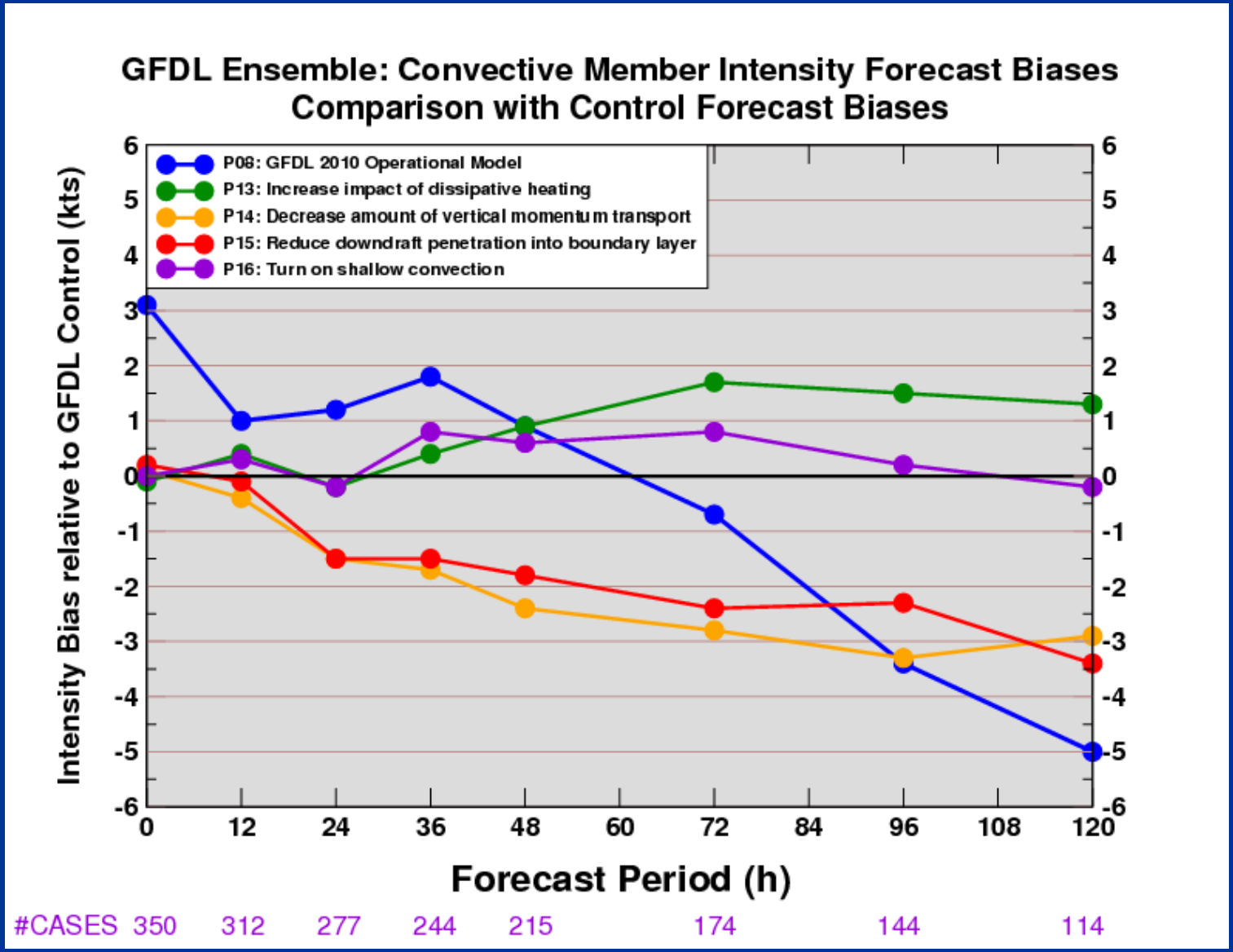
Comparison of Intensity Forecast Biases: Size members



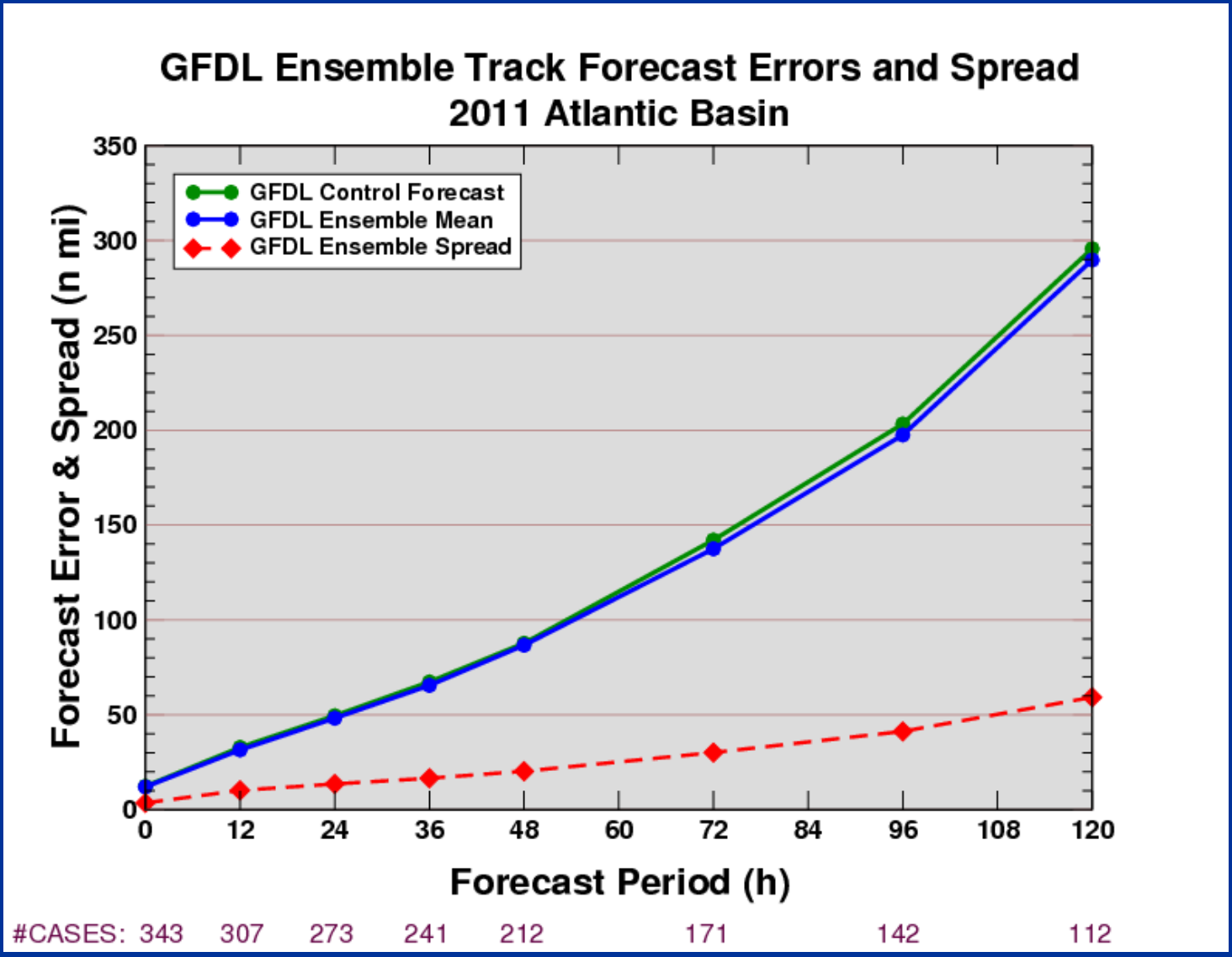
Comparison of Intensity Forecast Biases: Moisture modification members



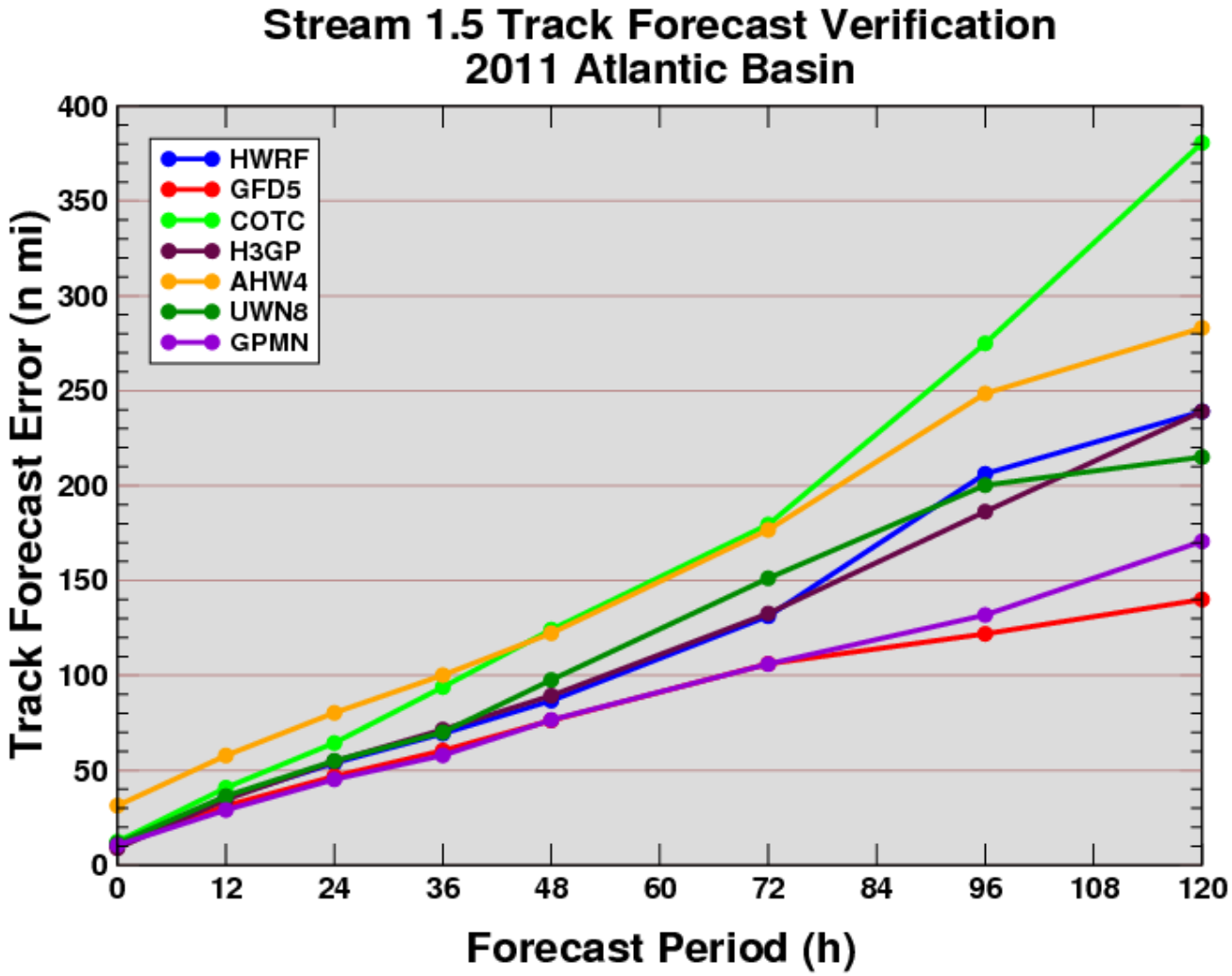
Comparison of Intensity Forecast Biases: Convection members



Track verification for 2011 Atlantic season



Track comparison against other Stream 1.5 regional models



Summary

- Ensemble mean shows an improvement over the control for intensity.
- For track, only marginal improvements are seen over the control, at 3 – 5 day lead time.
- Ensemble spread for both track and intensity was slightly larger than in 2010, but still too small.