Hurricane Ensemble Panel Discussion

- How can we create more skillful EPSs?
  - Better physics perturbation or Multi-model ensemble (or SKEBS)

- What are the best methods of taking advantage of these EPS?
  - Ensemble mean and ensemble spread (3D fields); Issue warning when spread from dynamic model is larger than some threshold

- How do we better deal with model error? Ocean uncertainty?
  - Model physics pert. related to storm scale;

- What kinds of products would justify the computational cost, especially over the current non-dynamical ensemble products
  - Statistical ensemble can not predict extreme event or large uncertainty

- What products are missing?
  - Ensemble spread along with ensemble mean

- What kinds of scientific experiments could answer these questions?
 - More physics scheme perturbations that hurricane track/intensity sensitive to, convection, surface physics

> **Improving ensemble spread is essential**

 • Besides ensemble mean track/intensity, ensemble spread is the most important variable that can used by forecasters (Debby, Sandy2012, Sandy, Joaquin 2015,…)

 • Current HWRF EPS is under-dispersed, especially for intensity spread;
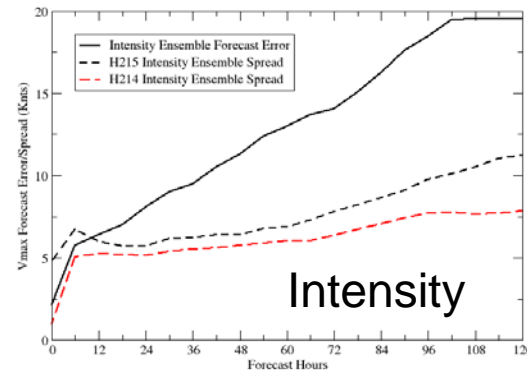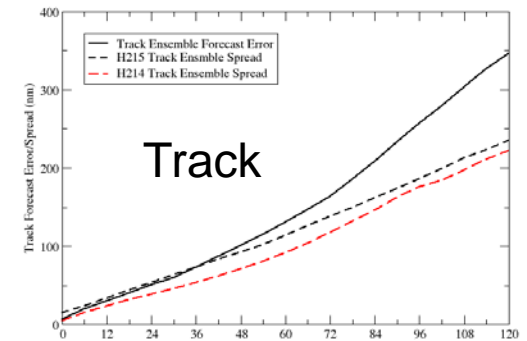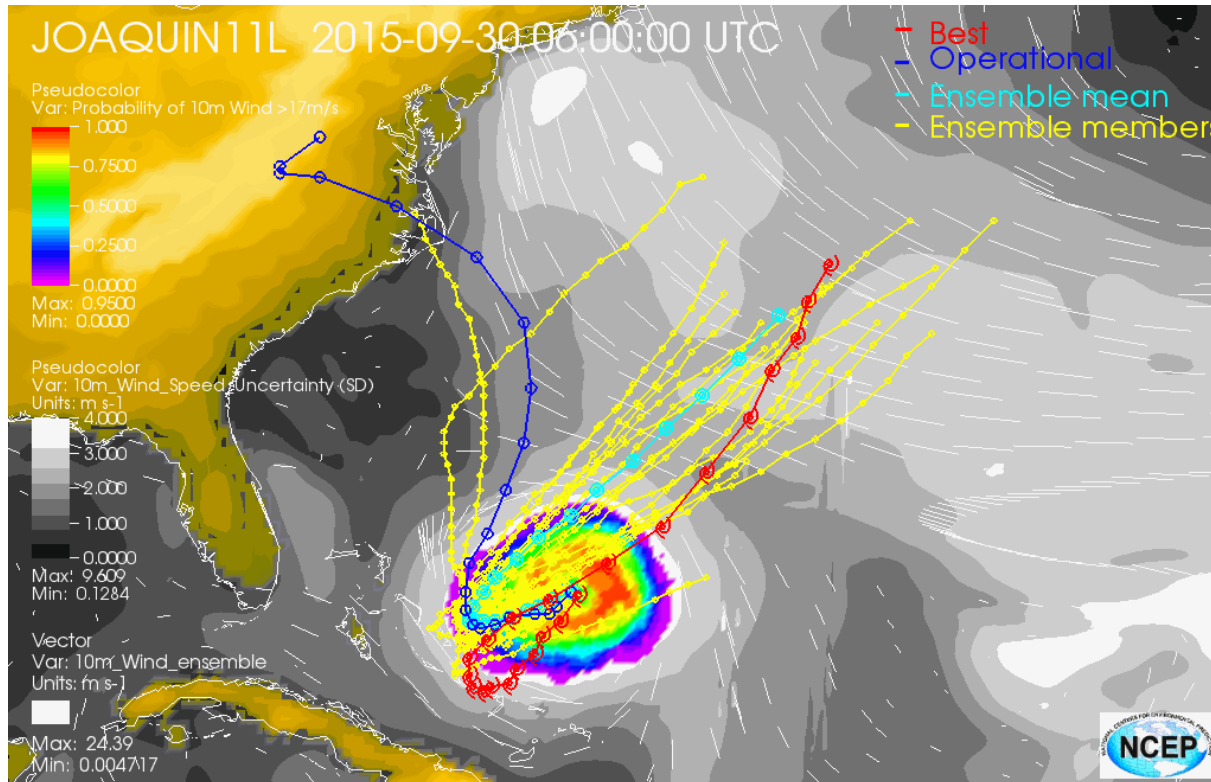
Issues and challenges in Operational Ensemble Prediction System

➢ **Improving ensemble spread is essential**
  - Possible cause: physics schemes are generally closely correlated, so that perturbations generated by perturbing parameters in one physics or using different physics schemes are correlated;
  - Possible solution: multi-model ensemble, or improve current physics perturbations

➢ **Large scale initial condition perturbation**

➢ **High resolution EPS can improve hurricane intensity forecasts**
  - Computationally expensive
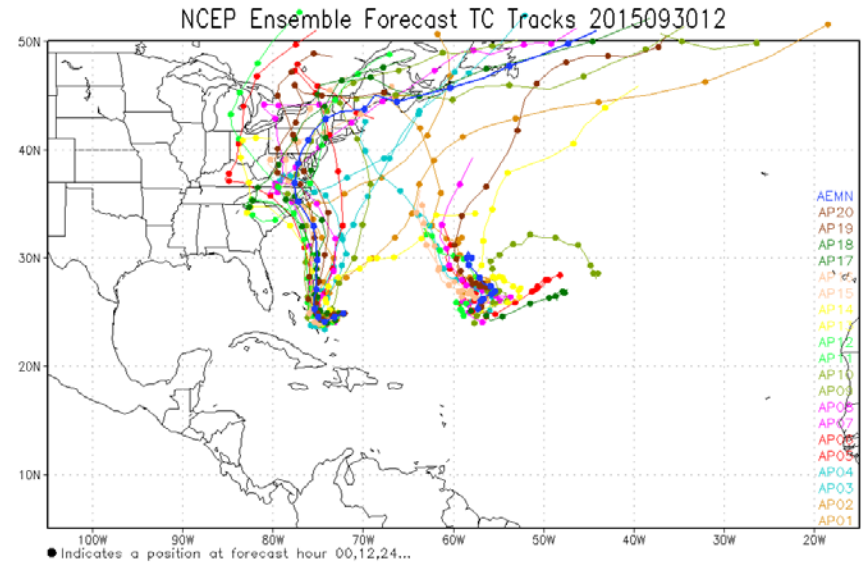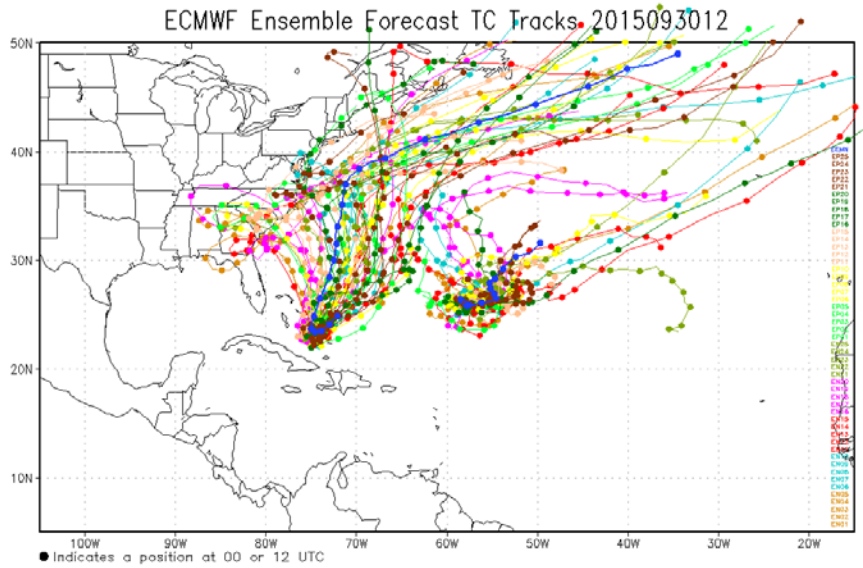
➢ **Better representation of model ensemble results**
  - Multimodal, cluster analysis
  - Identify un-reliable forecast, cycles that have predictability issues

➢ **Diagnostic tools and visualization**

HWMN Parallel: TC intensity Vmax
Storm: RAYMOND (17E) INIT 2013102400
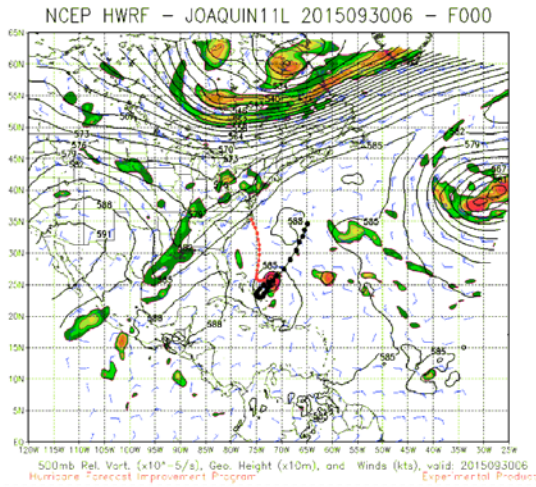Mean — Member
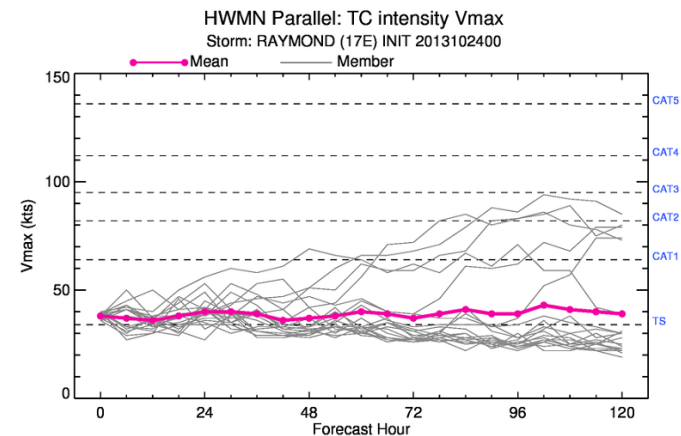
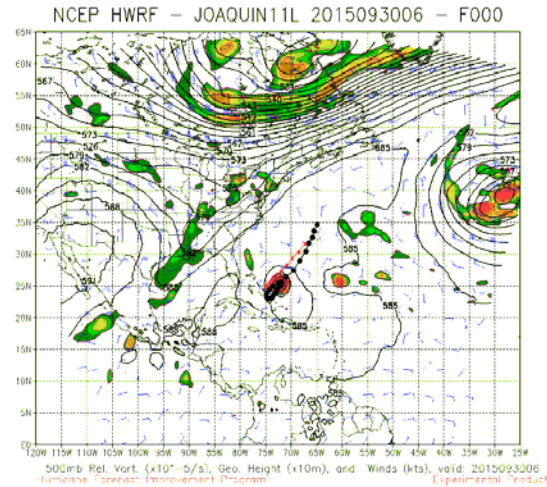# ECMWF EPS vs GEFS, 12Z, 20150930

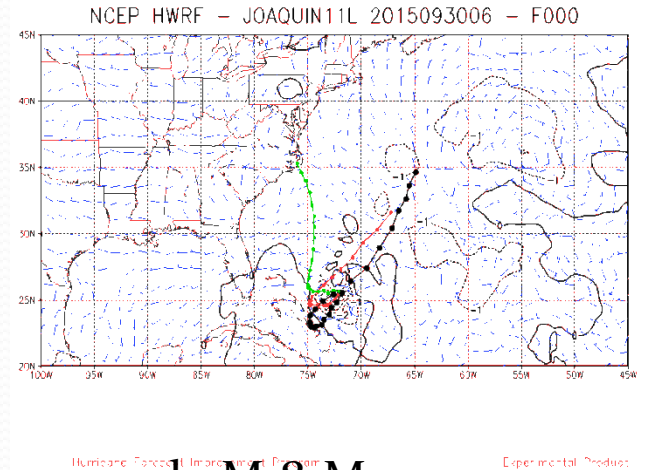

Track forecasts from ECMWF ensemble have large ensemble spread
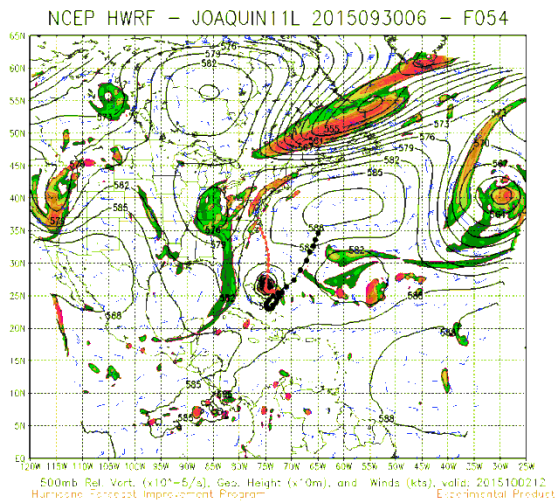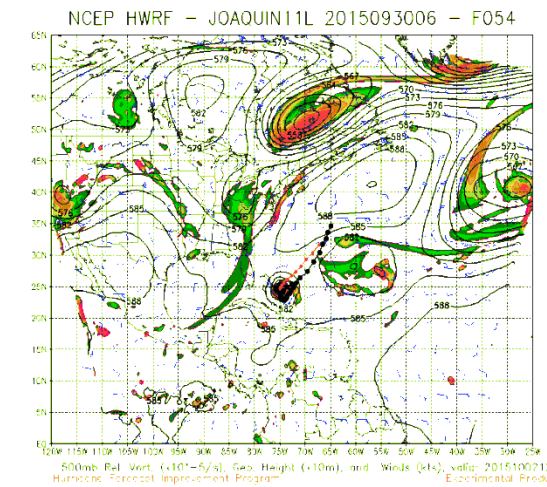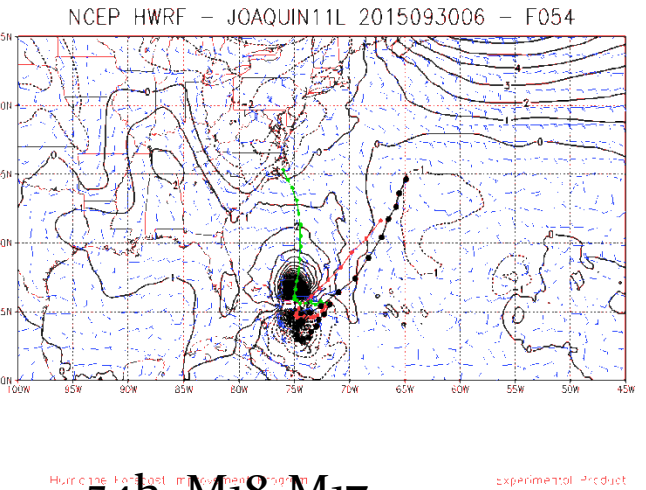
500hPa Height and Vorticity fields, 2015093006

00h, M17

00h, M18

00h, M18-M17

54h, M17

54h, M18

54h, M18-M17