

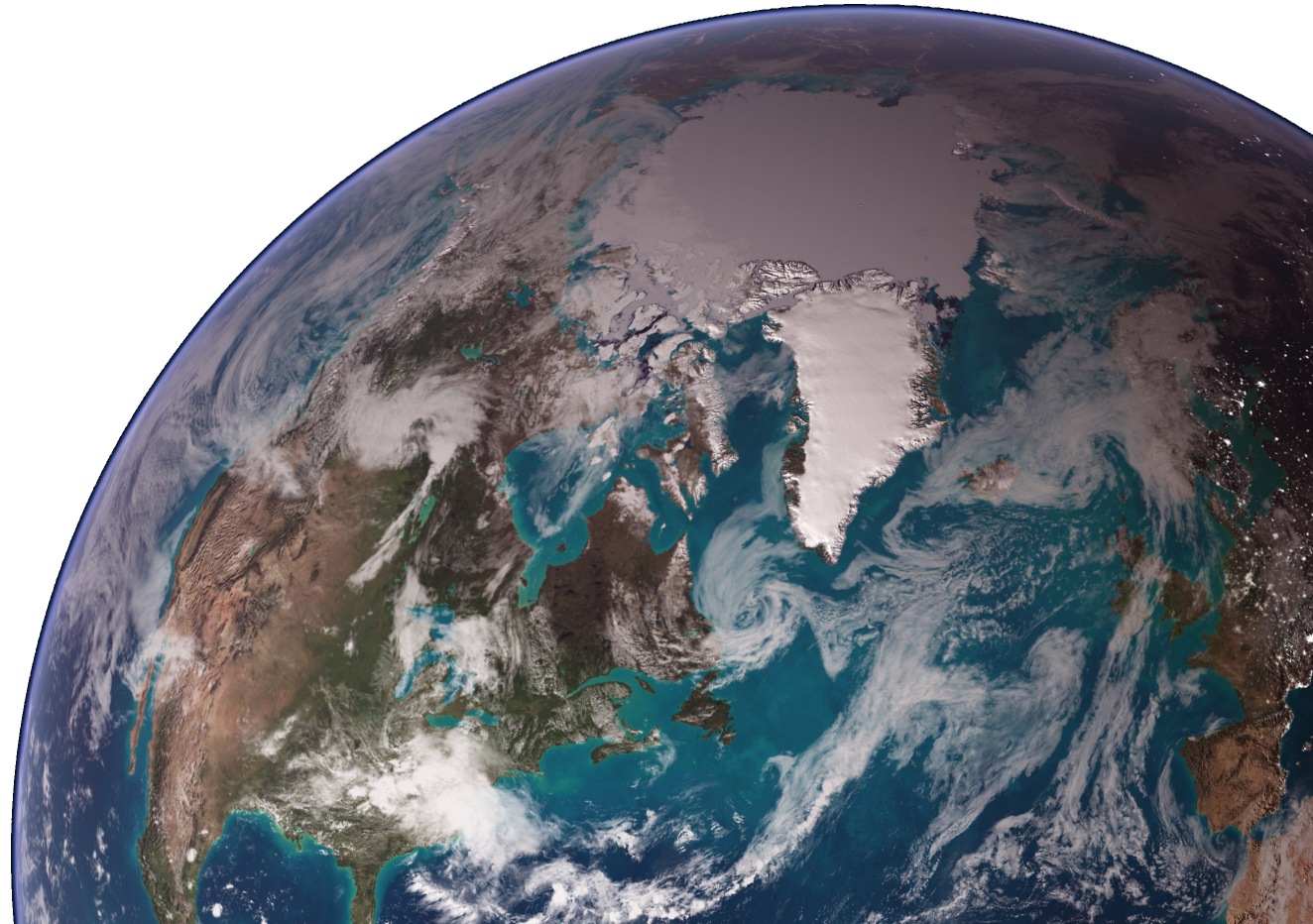


NOAA RESEARCH • ESRL • PHYSICAL SCIENCES DIVISION

Model Uncertainty Parameterization in Ensembles

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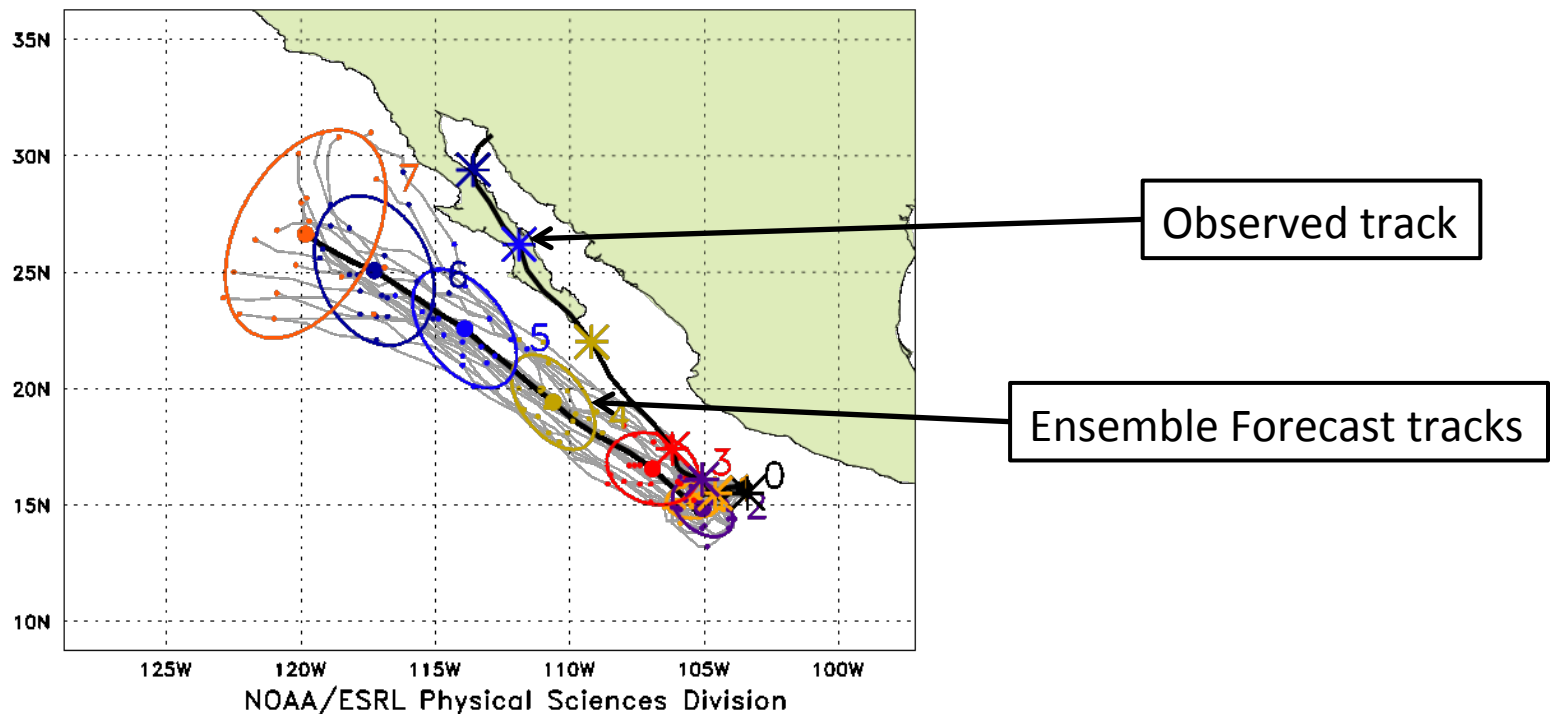
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The need to properly represent forecast uncertainty in predicting weather and extremes

Hurricane Odile: Initialized Sept. 11, 2014 at 00Z

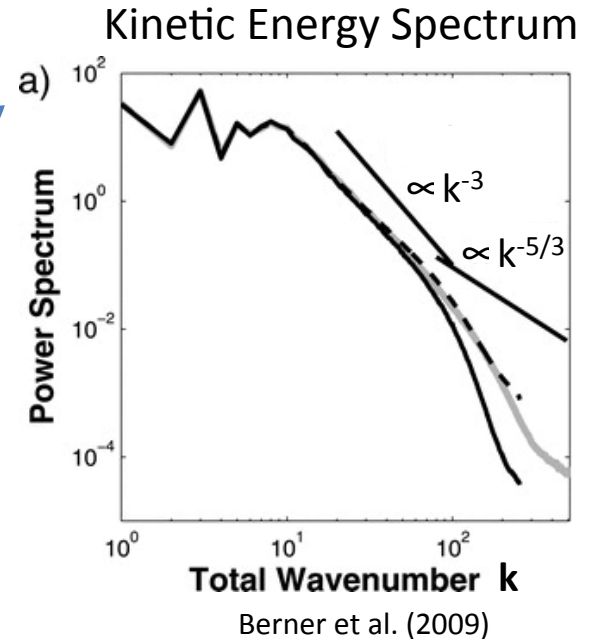
GEFS operational ensemble



NOAA/NCEP/GFS ensemble was confident that the hurricane would stay off shore.

How we account for model uncertainty.

- **Dynamics:** Due to the model's finite resolution, energy at non-resolved scales cannot cascade to larger scales.
 - Approach: Estimate energy lost each time step, and inject this energy in the resolved scales. a.k.a stochastic energy backscatter (SKEB; Berner et al. 2009)
- **Physics:** Subgrid variability in physical processes, along with errors in the parameterizations result in an under spread and biased model.
 - Approach: perturb the results from the physical parameterizations, and boundary layer humidity (Palmer et al. 2009), and inspired by Tompkins and Berner 2008.



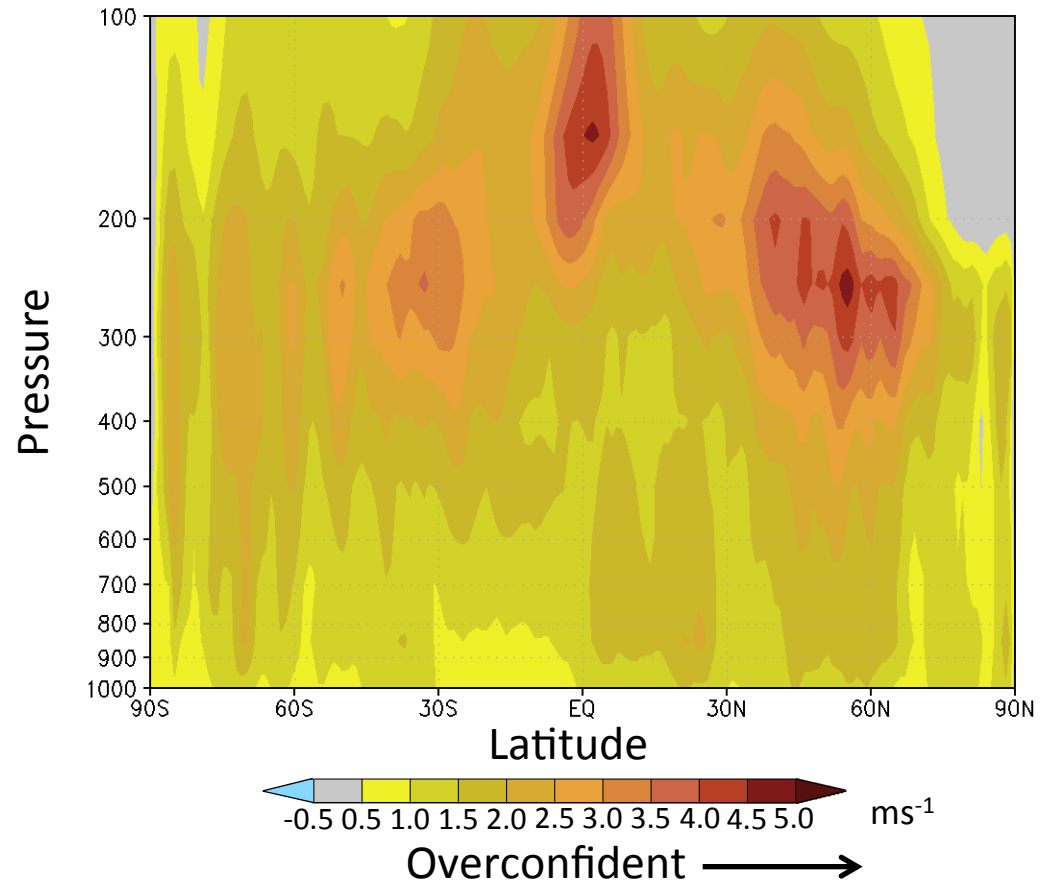
Kinetic Energy spectrum of the rotational component of wind. Gray line is for a high resolution analysis. Solid black line is low-resolution model. Black dashed line is low resolution model run with SKEB.

5-day forecast Zonal Wind RMS error minus Spread

zonal average from 1 month of forecasts: August 2012

RMS error: ensemble mean error with respect to verifying analyses

Ensemble Spread: standard deviation among ensemble members

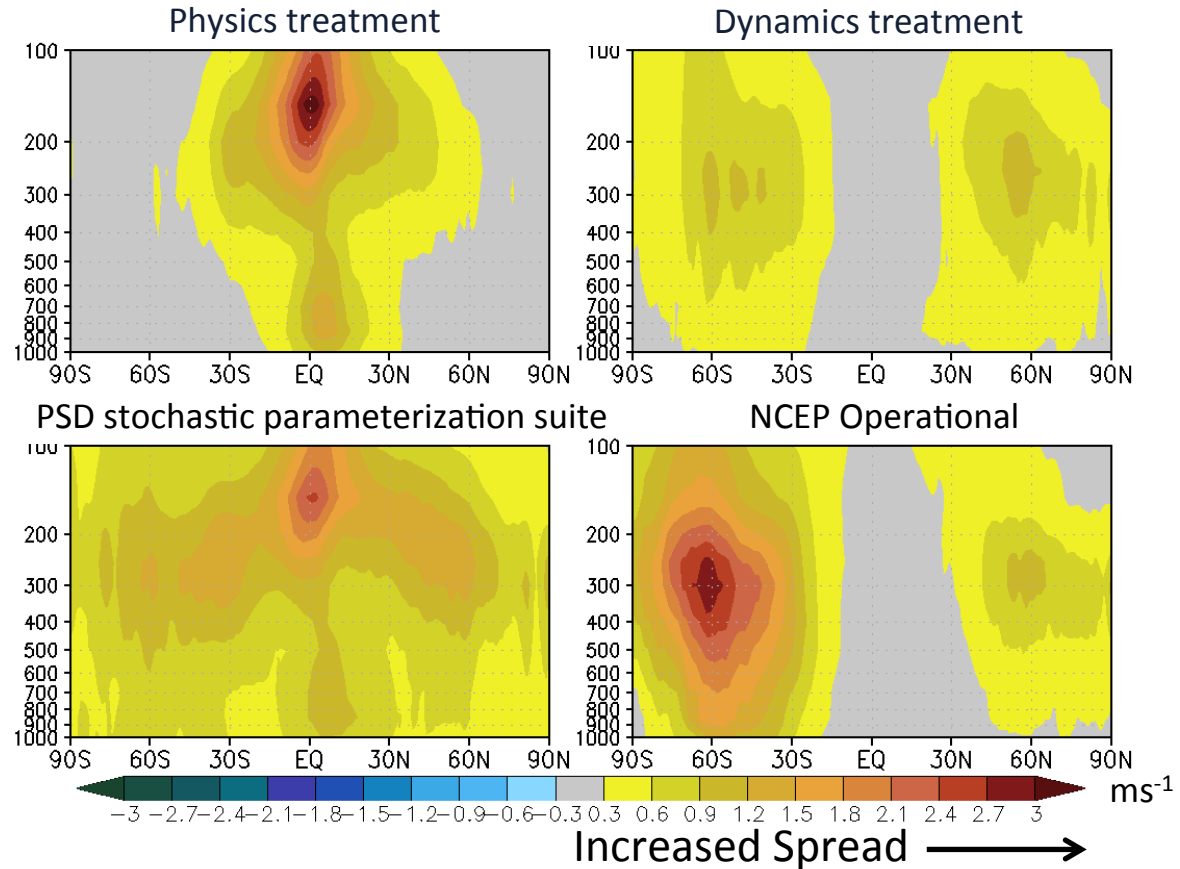


NOAA/NCEP/GFS ensemble, no treatment for model error “baseline”

Change in Ensemble Spread

zonal average from 1 month of forecasts

120 hr zonal wind spread difference compared to baseline

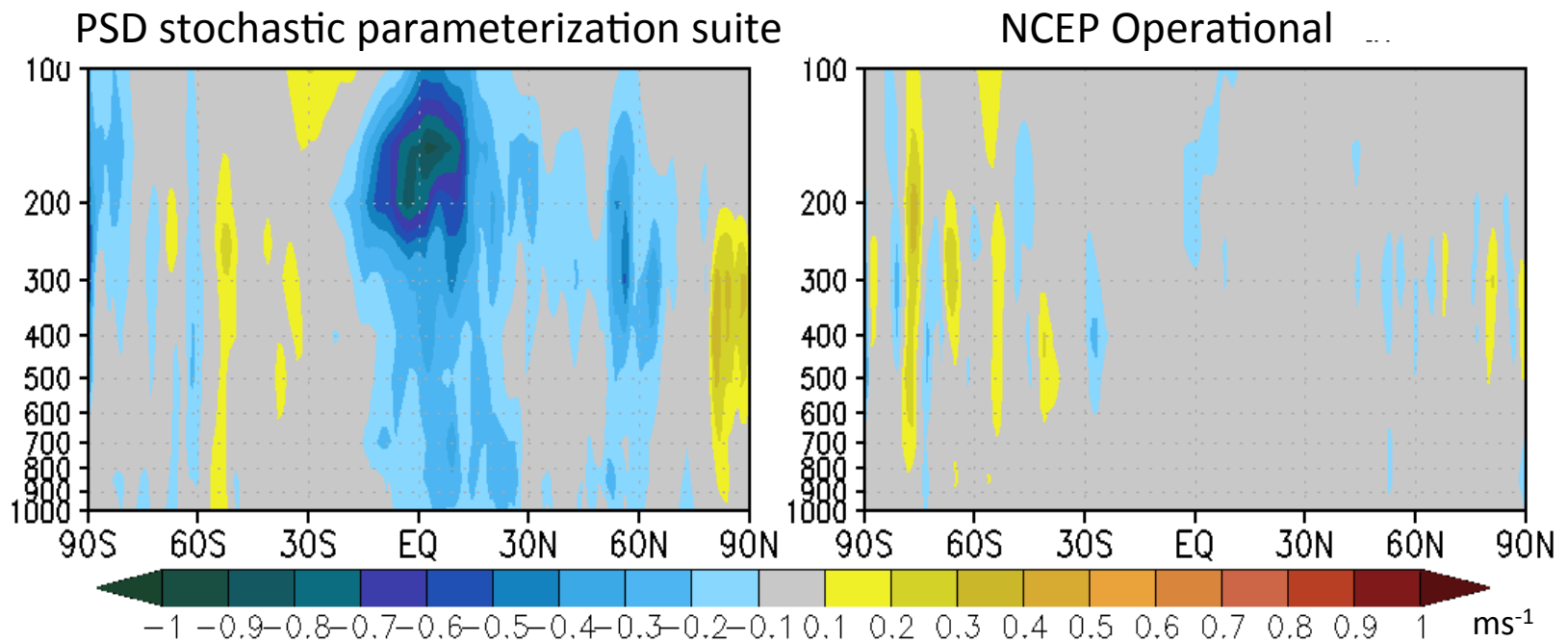


PSD stochastic parameterization suite is the inclusion of both the the physics and dynamics treatments.

Change in RMS error

zonal average from 1 month of forecasts

120 hr zonal wind ensemble mean error compared to baseline



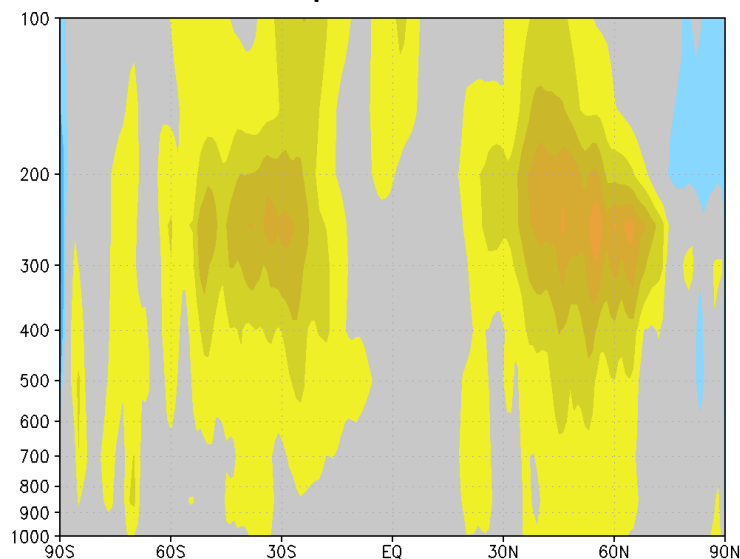
← Improved Forecast

Zonal wind RMS error minus Spread

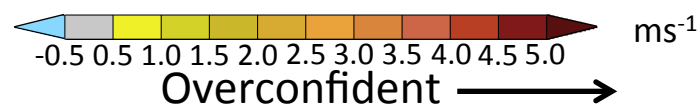
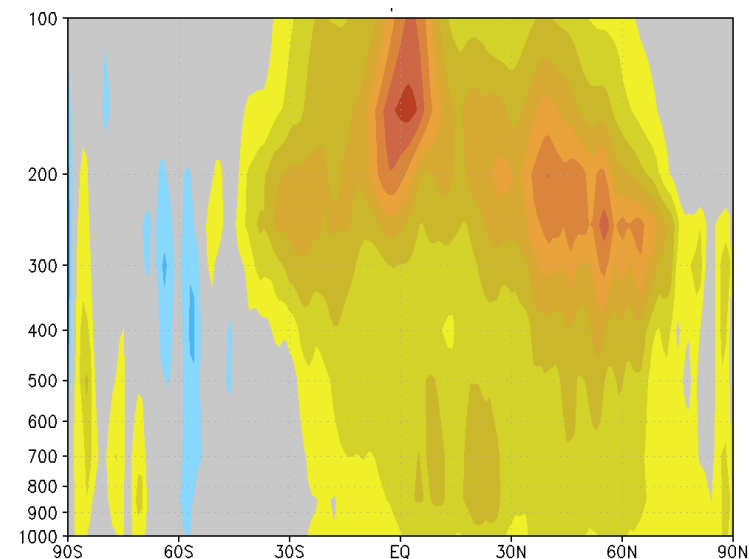
including treatment for model uncertainty

zonal average from 1 month of forecasts

PSD stochastic parameterization suite



NCEP Operational



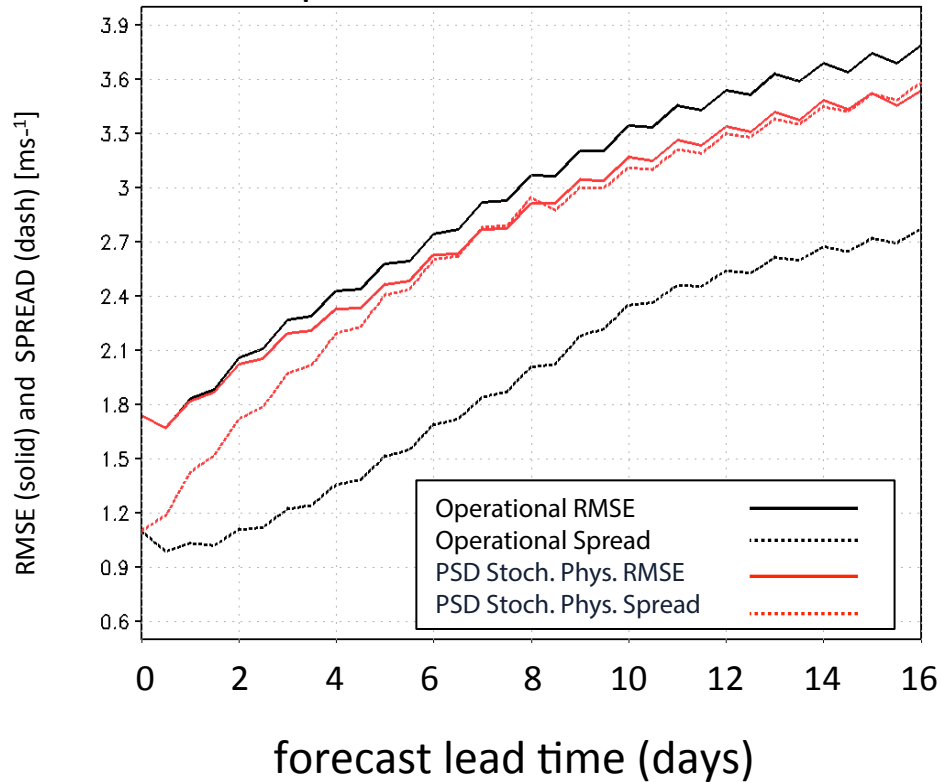
ESRL/PSD stochastic physics package greatly improves the spread/error relationship in the medium range forecast, but is still deficient in the jet stream regions.

Testing at NCEP/EMC

2 months in operational configuration

Global Ensemble Forecast System (GEFS)

Tropical 850 hPa Zonal winds



- The PSD stochastic physics suite substantially improves the ensemble spread.
- Forecast error is also reduced by over 10% in week-2.

Summary and Conclusions

- The parameterizations implemented by NOAA/ESRL/PSD produce a better calibrated forecast with the GEFS for most of the globe.
- Close collaboration with colleagues in NCEP/EMC has allowed for more extensive testing at different resolutions and longer leads.
- Target operational date is spring of 2016
- Already operational (January 2015) in the GFS data assimilation ensemble
- Although we improve the spread/error relationship in the upper air fields. Surface fields such as precipitation and 2 meter temperature are still poorly calibrated, thus requiring the need to calibrate the ensemble forecasts (next)