GFDL's contributions to the North American Multi-Model Ensemble (NMME)

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The North American Multi-Model Ensemble (NMME)

GFDL is one of several different centers over North America (in addition to NCEP, NASA, NCAR/U. Miami, Environment Canada) that produces real-time seasonal predictions every month. GFDL has been officially participating since August 2015.
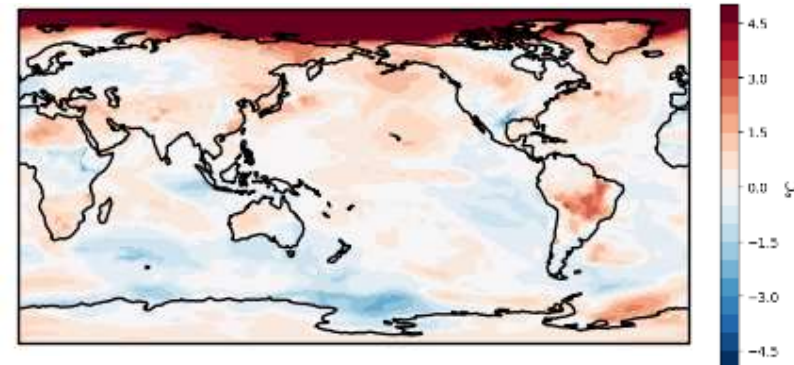
Starting the 1st of each month, GFDL scientists:
- gather observational data
- run assimilation system to produce initial conditions
- run forecasts using CM2.1 and two versions of FLOR
- quality control output
- transmit to NCEP

Argo float locations 1 Oct 2019 initialization
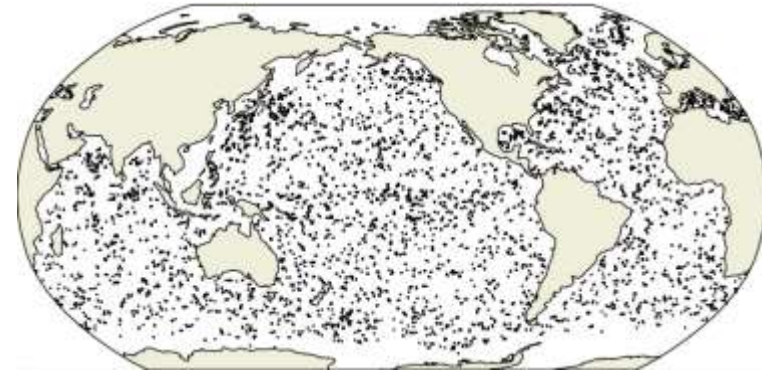

Oct 2019 FLOR T2m forecast

# GFDL's NMME forecasts contribute to NOAA's operational products.

- The GFDL NMME forecasts provide guidance for NOAA's seasonal outlooks

  - ➢ ENSO Outlook
  - ➢ Seasonal Temperature and Precipitation Outlooks
  - ➢ Atlantic Hurricane Season Outlook

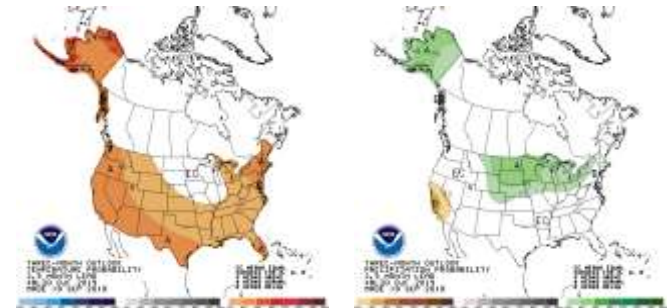- Ocean reanalysis provided to NCEP for the Multiple Ocean Reanalysis Intercomparison

Anomalous depth of 20°C isotherm in Niño 3 region
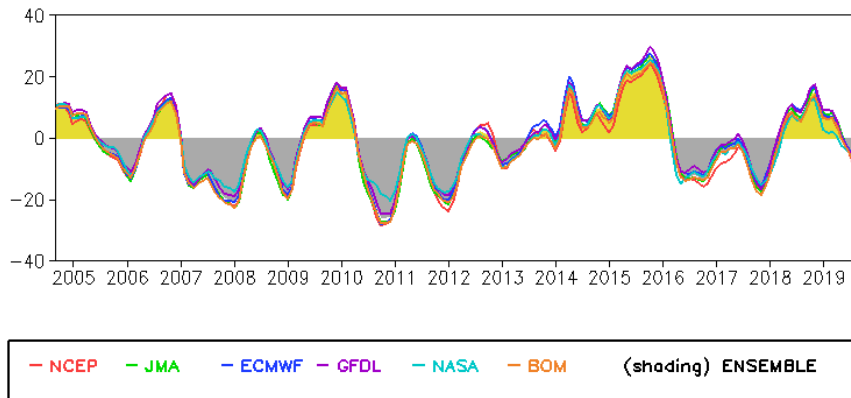
ENSO Outlook
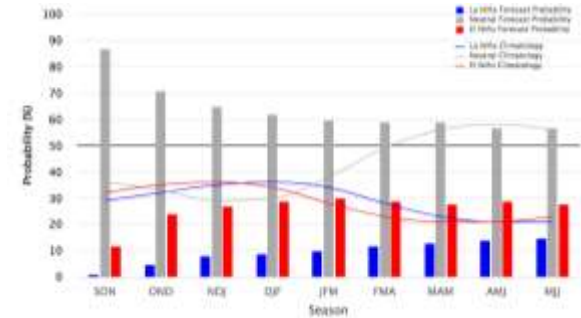
Seasonal T&P Outlooks
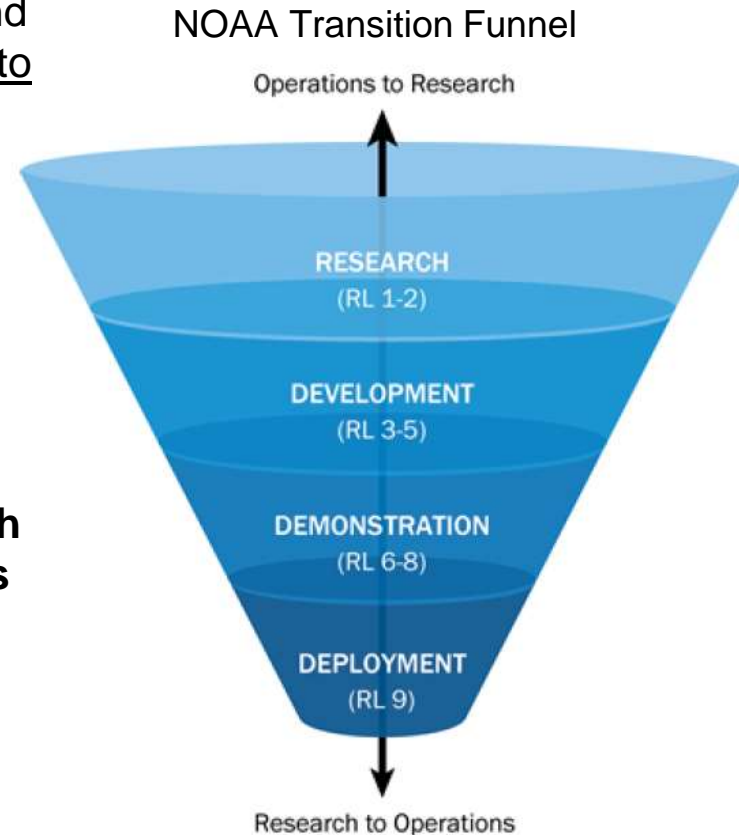

Atlantic Hurricane Outlook

Why should GFDL be engaged in real-time predictions?

- **Promotes the OAR mission:**
"Conduct research to understand and <u>predict</u> the Earth system; develop technology to improve NOAA science, service and stewardship; and transition the results so they are <u>useful to society</u>."

- **Value of diversity within a community of forecast models**

- **Scientific benefits of moving toward a seamless modeling system - hours to centuries**

- **Benefits to making climate change projections with systems that were developed as prediction models**

NOAA Transition Funnel

Operations to Research

RESEARCH
(RL 1-2)

DEVELOPMENT
(RL 3-5)

DEMONSTRATION
(RL 6-8)

DEPLOYMENT
(RL 9)

Research to Operations

GFDL Experimental Coupled Seasonal Prediction System
Predictions initialized Oct 1, 2019
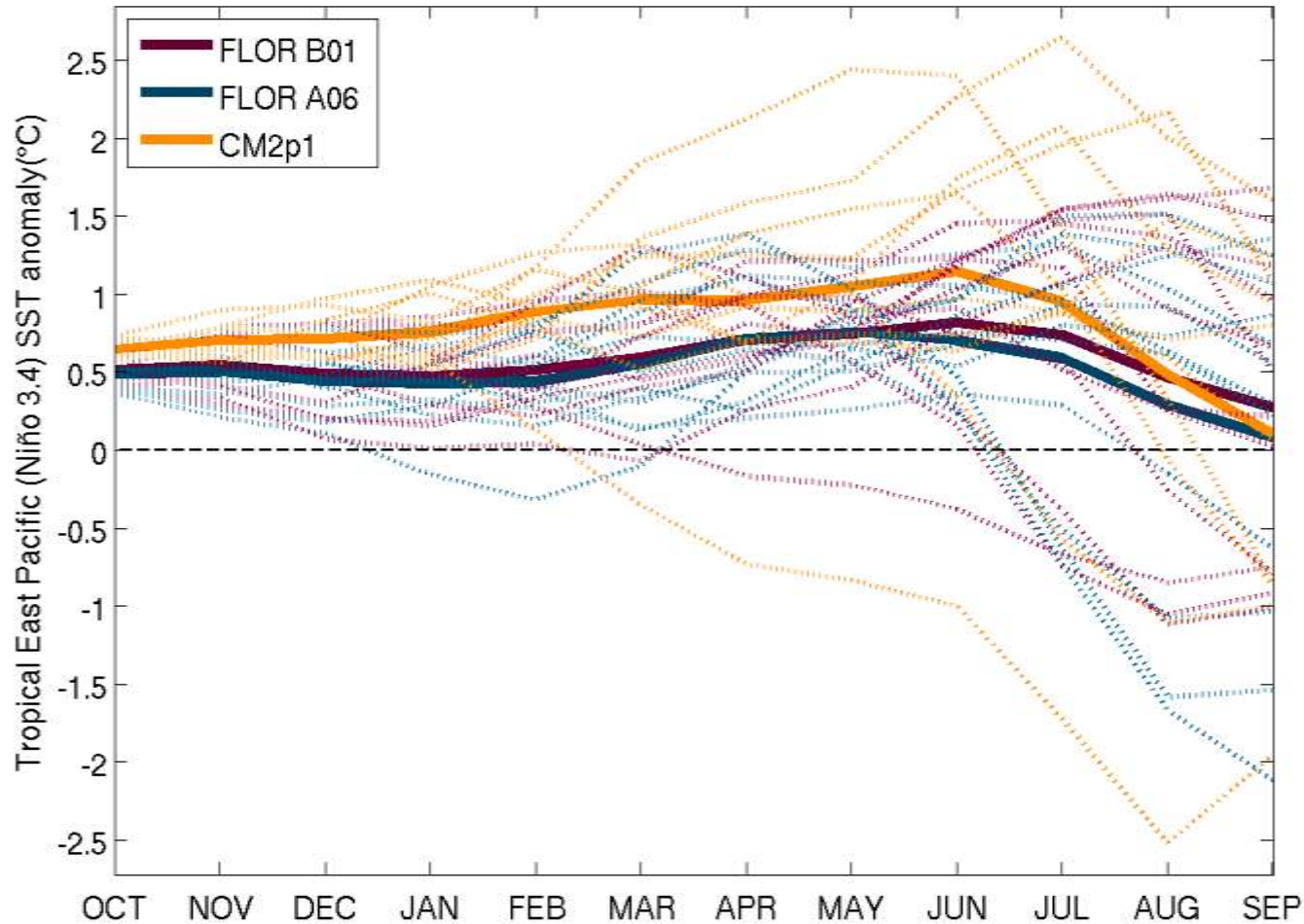
GFDL's seasonal forecasts: ENSO

ENSO Correlation skill

- Significant ENSO forecast skill out to 12 months, with FLOR outperforming CM2.1

- Superior performance of FLOR in simulating ENSO teleconnection patterns (*Jia et al. 2015, J. Clim.*)
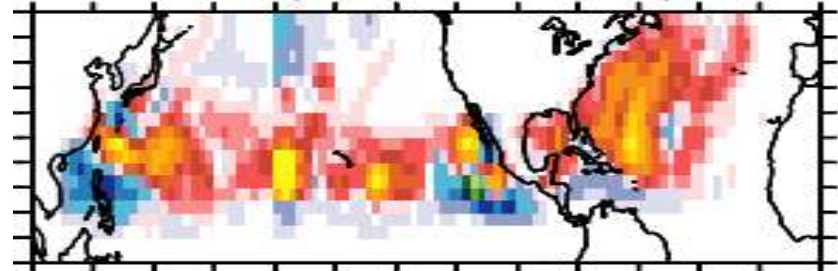
CM2.1

FLOR B01
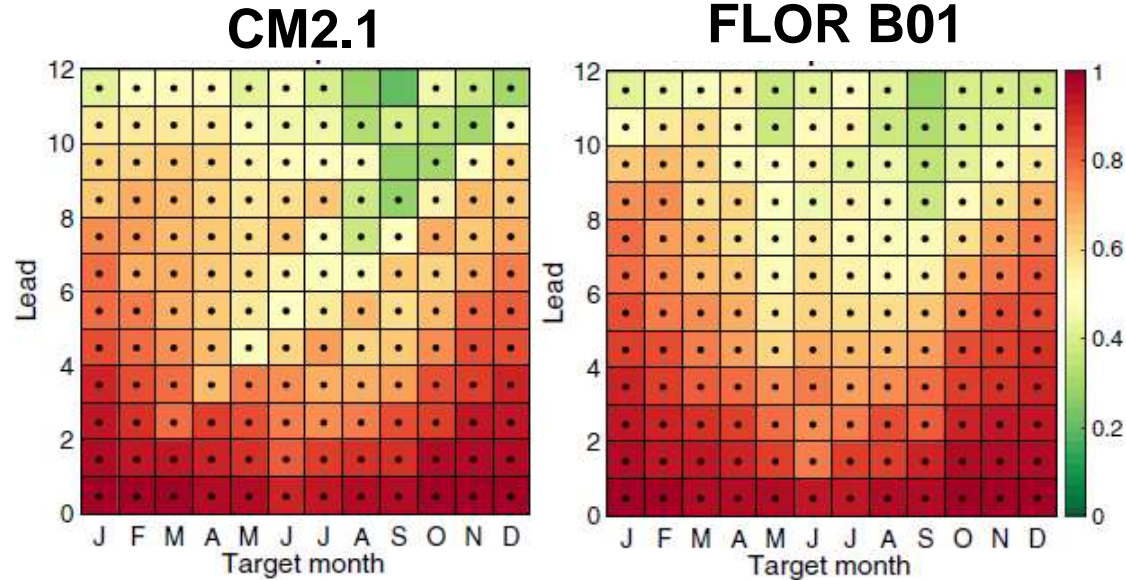
Source: Barnston et al. (2017, Clim. Dyn.)
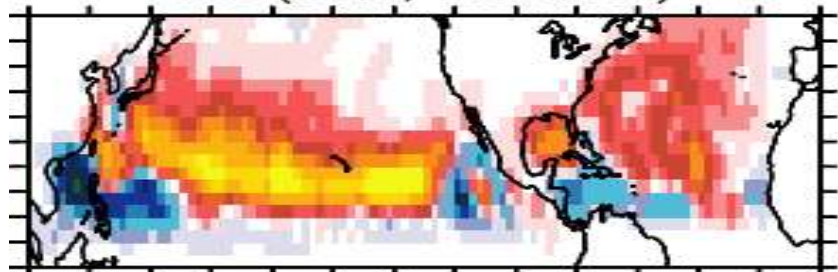
GFDL's seasonal forecasts: Tropical cyclones

- July – Nov 2019 predictions, initialized 1 July

- Ensemble means from FLOR and HiFLOR predictions (HiFLOR only for major hurricane predictions)
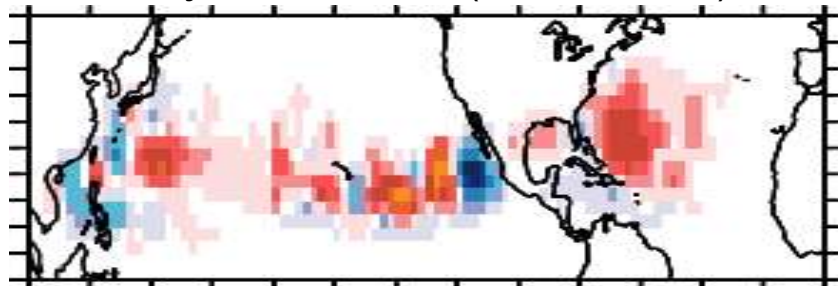
Tropical cyclone density anomaly forecasts

All tropical cyclones (winds ≥ 34kt)
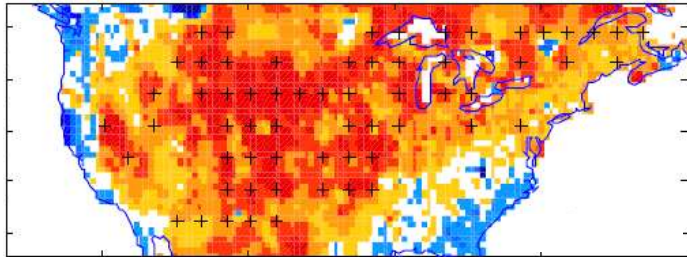
Hurricanes (winds ≥ 64kt)
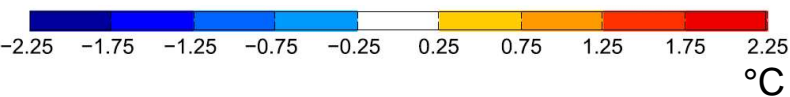
Major Hurricanes (winds ≥ 96kt)

yr^{-1} (2.5° grid)$^{-1}$

2012 June – August US heatwave

Observed T2m anomaly

FLOR forecast initialized 1 Jun

Targeted experiments to determine the role of radiative forcing and regional SST anomalies

Large-ensemble FLOR simulations to determine probabilistic projections

% of ensemble members exceeding JJA 2012 US T2m
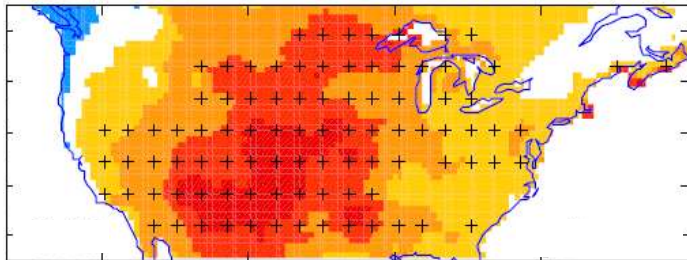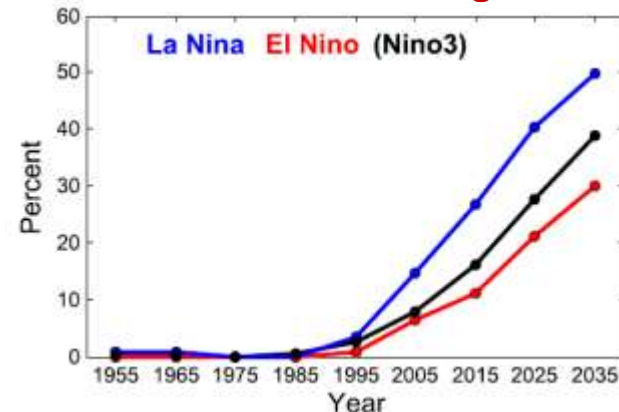
Source: Jia et al. (2016, J. Clim.)

	Atmosphere res	Ocean res	Status of Development
SPEAR_LO	100 km	1º	**Completed**
SPEAR_MED	50 km	1º	**Completed**
SPEAR_HI	25 km	1º	**In development**

Key Advances

- Moves prediction system development more in line with lab's main model development efforts (AM4, MOM6, LM4, SIS2), enhancing seamless prediction capabilities

- Improved data assimilation and model initialization system (see **Feiyu Lu's talk**)

- Better-resolved stratosphere in SPEAR_MED (65 vertical levels) indicates the potential for new prediction capabilities rooted in stratosphere-troposphere coupling (see **Liwei Jia's poster**)

Future Plans

- SPEAR_LO initialization refinements and reforecast simulations (ongoing)

- SPEAR_MED reforecast simulations (in coming months)

- SPEAR_HI physics finetuning for tropical cyclones (ongoing) and very limited set of reforecasts

- Transition SPEAR_MED as GFDL's real-time NMME prediction system (2020)

- Limited SPEAR_HI real-time seasonal forecasts targeting high-impact phenomena (e.g., Atlantic hurricanes)

Key Takeaways

- GFDL's NMME activities align with OAR mission "to understand and predict the Earth system" and to "transition the results so they are useful to society."

- GFDL's real-time seasonal forecasts serve as guidance for NCEP's operational outlooks while informing prediction-related research at GFDL.

- Our next generation seasonal-to-decadal forecast system: **SPEAR**

  ➢ Aligns real-time prediction activities with lab's main model development pathway
  ➢ Capitalizes on recent advances in model physics and initialization
  ➢ Promotes seamless prediction across timescales

- SPEAR_MED expected to transition into GFDL's real-time NMME prediction system; SPEAR_HI will be run in a limited capacity to target specific high-impact phenomena.