Tropical Cyclone Prediction and Attribution

Presented by
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Developing a dynamical model that has skill in predicting hurricanes, especially intense hurricanes at seasonal time scale is central to NOAA’s mission and highly relevant to society.

**Experimental Real-Time Hurricane Seasonal Predictions**
- Sharing data with NHC and CPC

**Statistical-Dynamical Seasonal Prediction Models**
- Landfalling storms

**Attribution Study**
- Active hurricane season
- International collaboration

**Development of HiFLOR**
- Successful Seasonal Predictions for Major Hurricanes

**Future Projections**
- Regional change in hurricane activity
- Intensification Rate

**New Model Development**
- SPEAR
- Nested HiRAM

<table>
<thead>
<tr>
<th>Year</th>
<th># of SCI papers</th>
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<tbody>
<tr>
<td>2014</td>
<td>1</td>
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<td>2015</td>
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<td>2018</td>
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<td>2019</td>
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Seasonal Hurricane Predictions by FLOR

CM2.5: Fully coupled model with 50km-mesh atmosphere and 0.25° ocean/sea ice

FLOR: Fully coupled model with 50km-mesh atmosphere and 1° ocean/sea ice

FLOR has skill in predicting hurricanes a few months in advance

The real-time hurricane forecasts are shared with the experts in NHC and CPC to support their seasonal hurricane outlook.

Vecchi et al. (2014, J. Climate)
Zhang, G. et al. (2019, GRL)

Zhang, G. et al. (2019, GRL)

Initial Month

Zhang, G. et al. (2019, GRL)
Major Hurricane Seasonal Predictions by HiFLOR

FLOR: Fully coupled model with 50 km-mesh atmosphere and 1° ocean/sea ice
HiFLOR: Fully coupled model with 25 km-mesh atmosphere and 1° ocean/sea ice

HiFLOR shows skillful prediction for frequency of major hurricanes a few months in advance in the North Atlantic (r=0.72).

Murakami et al. (2015, 2017, *J. Climate*)
Landfalling Hurricane Seasonal Predictions over US

<table>
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<tr>
<th>Target</th>
<th>Paper</th>
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</thead>
<tbody>
<tr>
<td>Landfalling Typhoons in East Asia</td>
<td>Zhang W. et al. (2016, <em>JAMES, 2017, J. Climate</em>)</td>
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What caused the active major hurricanes in North Atlantic?

A. Moderate La Niña?
B. Warmer Tropical Atlantic?
C. Warmer off the coast of North America?
A. Moderate La Niña?
Pacific SST anomaly was removed. Major Hurricanes are still active.

B. Warmer Tropical Atlantic?
SSTa in the tropical Atlantic was removed. MHs reduced.

C. Warmer off the coast of North America?
SSTa off the coast of US was removed. Major Hurricanes are still active.

- Responded to 13 Media Interviews (e.g., The Washington Post, News Week, NHK)
- The same method was applied to the active 2018 typhoon season in the Western North Pacific under the International collaboration with JAMSTEC and MRI (Qian et al. 2019, GRL, in press).
Future Projections on Hurricanes

We conducted a number of climate simulations using FLOR and HiFLOR to address potential impact of anthropogenic forcing on hurricane activity.

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<tr>
<th>Projection Target</th>
<th>Result</th>
<th>Publication</th>
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| Central Pacific Hurricanes               | Projected to increase in the future              | Murakami et al. (2015, *BAMS*)
|                                          |                                                  | Murakami et al. (2017, *J. Climate*)               |
| Intensification Rate of Hurricanes       |                                                  | Bhatia et al. (2019, *Nat. Comm.*)                 |
| Mediterranean Hurricanes                 |                                                  | González-Alemán (2018, *GRL.*)                     |
| Landfalling Tropical Cyclone Rainfall    |                                                  | Liu et al. (2018, *J. Climate*)                    |

**Tropical Cyclone Density Change by Doubling CO₂**

- FLOR: -11%
- HiFLOR: +6%

HiFLOR projects an increase in frequency of global tropical storms, whereas FLOR projects a decrease in global frequency.

Vecchi et al. (2019, *Clim. Dyn.*)
SPEAR-Hi (C384, 25-km), a next generation seasonal prediction model, is under development. Preliminarily, we obtained reasonable storm intensity and global distribution of storms.

Global-to-regional two-way-nested Grid

Hurricane Inner-core Size Distribution


Hurricane structure is predictable using a fine-resolution nested global model.

Gao et al. (2019, *JAMES*)
Summary

1. Over the last 5 years, skill in seasonal predictions of hurricanes has been significantly improved by development of dynamical and statistical-dynamical models.

2. Under the great societal interests in ongoing increases in extreme events like hurricanes, we developed a new real-time attribution method to identify the key SST precursors.

3. Projected future changes were investigated by taking advantage of the realistic simulations of hurricanes and major hurricanes by the GFDL dynamical models.

4. Development of next generation seasonal hurricane forecast models is work in progress. Our new challenge will be improving prediction skill of storm structure, intense hurricanes, and landfalling storms at seamless time scales.