Unified Global and Regional Weather Prediction at Medium- and Short-Range Timescales

Presented by Jan-Huey Chen

Geophysical Fluid Dynamics Laboratory Review
October 29-31, 2019
## Development Path of SHiELD

**System for High-resolution prediction on Earth-to-Local Domain**

<table>
<thead>
<tr>
<th>Version</th>
<th>NGGPS Phase II submission</th>
<th>fvGFS_v2016</th>
<th>fvGFS_v2018</th>
<th>SHiELD_v2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of code release/ online real-time forecasts</td>
<td>March 2016</td>
<td>August 2016</td>
<td>June 2018</td>
<td>July 2019</td>
</tr>
</tbody>
</table>

### Features/Updates:

- **Version 1** — fvGFS_v2016
  - FV3 dycore
  - NOAH land model
  - 2015 GFS Physics

- **Version 2** — fvGFS_v2018
  - Zhao-Carr MP → GFDL MP
  - Major bug fixes: energy conservation, surface cycle, surface albedo, surface emission

- **Version 3** — SHiELD_v2019
  - Vertical levels: 63 → 91
  - SAS → Scale-aware SAS
  - YSU PBL
  - Inline GFDL MP
  - Mixed Layer Ocean Model
  - Higher land resolution
  - PD tracer advection

### Bug fixes:
- Radiation, YSU

### Updates:
- Cloud-radiation interaction, GFDL MP, ocean surface roughness

### Global SHiELD at 13 km resolution:
- Weather and hurricane forecasts

### Two-way nested C-SHiELD at 3 km resolution:
- Severe weather forecasts
Weather Forecast at Global Scale

- The prediction skill of 500-hPa geopotential height -- the most important metric to measure the capability of a system to provide short and medium-range forecasts.

**Annual Mean NH 500hPa HGT Day-5 AC**

<table>
<thead>
<tr>
<th>Model</th>
<th>ACC</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFS</td>
<td>0.887</td>
</tr>
<tr>
<td>CMC</td>
<td>0.881</td>
</tr>
<tr>
<td>UKMO</td>
<td>0.898</td>
</tr>
<tr>
<td>ECMWF</td>
<td>0.918</td>
</tr>
</tbody>
</table>

Year of 2017

Historical Performance of Global NWP Models
Provided by Fanglin Yang, NCEP/EMC

(https://www.emc.ncep.noaa.gov/gmb/S TATS_vsdb/longterm/)
Improvements of H500 ACC in GFDL SHiELD

NCEP/GFS v14
Legacy operational forecasts

NGGPS Phase II submission
• FV3 dycore
• NOAH land model
• 2015 GFS Physics

Without optimizations

Impacts of updated physics

fvGFS_v2016
• Zhao-Carr MP → GFDL MP

fvGFS_v2018
• YSU PBL
• Inline GFDL MP
• Mixed Layer Ocean Model

SHiELD_v2019
• Cloud-radiation Interaction
• Other bug fixes
Impacts of Using Different Initial Conditions

<table>
<thead>
<tr>
<th>Model</th>
<th>Initial Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCEP/GFS v14</td>
<td>NCEP/GFS v14</td>
</tr>
<tr>
<td>GFDL fvGFS_v2018</td>
<td>fvGFS_GFSIC</td>
</tr>
<tr>
<td>ECMWF/IFS (CY41R2)</td>
<td>fvGFS_IFSIC</td>
</tr>
</tbody>
</table>

Based on 2017 NH hurricane season; Aug-Oct 2017

General forecast skill

TC track forecast error

Chen et al. 2019, GRL
Impacts of Using Different Initial Conditions

• Intensity forecasts: Do the ICs or the model itself play a bigger role?

The improvement of TC intensity forecasts and P-W relationship with fvGFS is primarily due to the capabilities of the model itself and not the ICs.

Chen et al. 2019, GRL
Forecasts with Variable Resolution SHiELD

- Improved TC intensity and structure (nested grid)
  - Zhou et al. 2019, BAMS

- Improved terrain induced precipitation (stretched grid)
  - Hazelton et al. 2018, WAF
  - Zhou et al. 2019, BAMS

4-day total accumulated precipitation
Hurricane Harvey (2017)

Hazelton et al. 2018, WAF
Convective Scale Prediction

• Severe weather event forecasts

Multiple derechos predicted 5-6 days in advance

SPC observed severe weather reports
Valid 12Z 27 May to 12Z 28 May

fvGFS Severe Weather Proxy
12Z 27 May to 12Z 28 May
Future Plans & Challenges

- Increasing model resolution to 6.5km or higher with corresponding dynamical core and physics developments.

- Development of atmospheric data assimilation for model initialization and verification

- Keep contributing model developments into the broader community, e.g., EMC

**GFDL contribution:**
Cold bias correction in the GFS V15

Provided by Linjong Zhou (March 2019)