HAFS Physics Priorities

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Outline

- **Step 1**: Implement HWRF physics suite into **Common Community Physics Package (CCPP)**.
- **Step 2**: Compare with other available physics suites in CCPP.
- **Step 3**: Compare with other available surface layer, PBL and microphysics schemes in CCPP.
- **Step 4**: Develop new physics schemes, such as surface layer and PBL schemes in CCPP.

**GOAL**: Build a physics suite that is best for HAFS
Interactions among physics schemes

Cumulus (SH, DP, MID) → Microphysics (1-m, 2-m, 3-m)

Cloud Detrainment → Closure

Convective Cloud Fraction → Non-Convective PBL Cloud Fraction

PBL (Stable, Unstable) → Surface (land, water, ice)

Surface Fluxes → Convective Rain

Radiation (LW, SW) → Closure

Cloud Effects

Downward SW/LW → Upward SW/LW

OGWD → CGWD

Closure
## HWRF and HMON Physics Suite

<table>
<thead>
<tr>
<th>Scheme/Suite</th>
<th>HWRF</th>
<th>HMON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convection</td>
<td>Scale-aware SAS</td>
<td>Scale-aware SAS</td>
</tr>
<tr>
<td>PBL</td>
<td>Hybrid-EDMF(^{(2)})</td>
<td>Hybrid-EDMF(^{(2)})</td>
</tr>
<tr>
<td>Surface layer</td>
<td>GFDL(^{(1)})</td>
<td>GFDL(^{(1)})</td>
</tr>
<tr>
<td>Land surface model</td>
<td>NOAH</td>
<td>NOAH</td>
</tr>
<tr>
<td>Radiation (LW/SW)</td>
<td>RRTMG</td>
<td>RRTM</td>
</tr>
<tr>
<td>Microphysics</td>
<td>Ferrier-Aligo</td>
<td>Ferrier-Aligo</td>
</tr>
<tr>
<td>Gravity wave drag</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

\(^{1}\) Observation-based surface roughness length over ocean  
\(^{2}\) Eddy-diffusivity adjustment in PBL scheme under strong wind conditions over ocean
HWRF Physics Suite in CCPP

- Collaboration between GSD, NCAR and EMC.
- The F-A scheme with ‘separate water species advection’ is now working in CCPP.
- The F-A scheme with ‘total condensate advection’ is difficult to implement due to the limit support of water loading and air mass calculation for ‘total condensate water species’ in dyn-core.
- Work is still on going.
**Ferrier-Aligo Microphysics**

Update: \( qt, f_{\text{ice}}, f_{\text{rain}}, f_{\text{rime}} \)

Call main subroutine

Update: \( qc, qr, qi, qrimef \)

\( qi \) is total frozen water

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**F-A SCHEME**

Update: \( qt, f_{\text{ice}}, f_{\text{rain}}, f_{\text{rime}} \)

Call main subroutine

Update: \( qc, qr, qi, qrimef \)

\( qi \) is total frozen water

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**Dyn-core**

(advection, horizontal diffusion)

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**Radiation**

(cloud fraction, effective radii)

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**Land surface model**

(precipitation, snow)

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**PBL scheme**

(vertical diffusion all F-A tracers)

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**cumulus**

(detrained cloud liquid and ice to F-A)

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**Separate Water Species In Dyn-core**
GFDL
Surface layer

Surface Layer scheme

Exchange coefficients for
Momentum and heat
Over land

Friction stress over
Land and water, and
Fluxes of Heat and moisture
Over water

NOAH
Land surface model

Fluxes of heat and moisture

PBL scheme
**Control:** GFS surface layer scheme  
**New:** YSU-ECMWF-like surface layer scheme

The **new** scheme reduced the near surface turbulent diffusion in stable conditions.

**Caused by Decoupling**

Reference: Sandu et al. (2013)
## Currently Available Physics Suites in CCPP

<table>
<thead>
<tr>
<th>Suite/Scheme</th>
<th>GFS_v15</th>
<th>GFS_v16</th>
<th>CPT_v0</th>
<th>GSD_v0</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBL</td>
<td>HEDMF</td>
<td>sa-TKE-EDMF</td>
<td>HEDMF</td>
<td>sa-MYNN</td>
</tr>
<tr>
<td>Surface Layer</td>
<td>GFS</td>
<td>GFS</td>
<td>GFS</td>
<td>MYNN</td>
</tr>
<tr>
<td>LSM</td>
<td>NOAH</td>
<td>NOAH</td>
<td>NOAH</td>
<td>RUC</td>
</tr>
<tr>
<td>Radiation</td>
<td>RRTMG</td>
<td>RRTMG</td>
<td>RRTMG</td>
<td>RRTMG</td>
</tr>
<tr>
<td>Microphysics</td>
<td>GFDL-MP</td>
<td>GFDL_MP</td>
<td>aa-MG3</td>
<td>aa-Thompson</td>
</tr>
<tr>
<td>GWD</td>
<td>OGWD/CGWD</td>
<td>Unified-GWD</td>
<td>OGWD/CGWD</td>
<td>*OGWD/CGWD</td>
</tr>
</tbody>
</table>

HAFS.v0A: convection is turned off, no CGWD  
HAFS.v0B: convection and CGWD is in global domain only

sa: scale-aware  
aa: aerosol-aware

*GSD suite uses OGWD from WRF
Florence 2018 (initialized at 2018/09/10/00Z)

- **HAFS with ogwd on**
- **HAFS with ogwd off**
- **HWRF**
- **Best track**

OGWD-off closer to best track
OGWD-off closer to best track
The performance of HAFS.v0A and v0B 2019 over AL basin

![Graph showing track error, along track error, and cross track error for different models over forecast lead times.](image)

- **Track error**
  - HAFS.v0A
  - HAFS.v0B

- **Along track error**
  - HWRF Oper.
  - HMON Oper.
  - GFS Oper.
  - HAFS - Stand Alone Regional 3km
  - HAFB - Global Nest 3km

- **Cross track error**
  - HWRF Oper.
  - HMON Oper.
  - GFS Oper.
  - HAFS - Stand Alone Regional 3km
  - HAFB - Global Nest 3km
How to select other physics schemes?

- The schemes that can improve the track forecast through the improvement of large-scale circulation forecast
- The schemes that can improve the intensity forecast through the improvement of air-sea interaction and better representation of convective cells and clouds.

1) surface layer: YSU (in CCPP)
2) PBL: saYSU (in CCPP)
3) microphysics: WSM6 (in CCPP)
4) RRTMG: cloud overlap (not yet implemented in CCPP)
Strong Hurricane case

**HWRF**

HEDMF vs. MYNN

**Irma Track Error**

- **Shading (grey):**
  - Difference is insignificant
  - At the 99% confidence level

- **Shading (pink and light blue):**
  - The 25% and 75% percentiles

**Number of Cases**

**Forecast Lead Time (hr)**

**Track Error (km)**
Strong Hurricane case

HWRF
HEDMF vs. MYNN

Hurricane Irma (2017090706)

Hurricane Irma (2017090800)
Strong Hurricane case

HWRF
HEDMF vs. MYNN

Irma Vmax Error

Shading (grey):
Difference is insignificant
At the 99% confidence level

Irma Vmax Bias

Shading (pink and light blue):
The 25% and 75% percentiles
Weak Hurricane case

Hurricane Isaac (Sep. 08 – Sep. 15, 2018)

Hurricane Isaac

20N

15N

60W

40W

BEST
HEDMF
MYNN
Weak Hurricane case

HWRF

HEDMF vs. MYNN

Isaac Track Error

Number of Cases

Track Error (km)

Forecast Lead Time (hr)

Shading (grey):
Difference is insignificant
At the 99% confidence level

Shading (pink and light blue):
The 25% and 75% percentiles
Weak Hurricane case

**HWRF**

HEDMF vs. MYNN

**Isaac Vmax Error**

**Isaac Vmax Bias**

Shading (grey):
Difference is insignificant
At the 99% confidence level

Shading (pink and light blue)
The 25% and 75% percentiles
Challenges

1) Some schemes might improve *track forecast* but deteriorate *intensity forecast*; and vice versa.

2) For HAFS.v0B, are there possibilities to use other cumulus scheme to improve large-scale circulation forecast?

3) Computing resources are limited.
Thanks!