Investigating the Radiative Impact of Saharan Dust Aerosols on Medium Range Forecasts for African Easterly Waves in the Unified Forecast System

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OUTLINE

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4 DISCUSSION AND FUTURE WORK
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1. BACKGROUND AND MOTIVATION

African Easterly Waves (AEWs) are synoptic-scale disturbances that form over sub-Saharan Africa during the West African Monsoon season and are the primary precursor for Atlantic tropical cyclones (Russel et al., 2017).

Li and Sokolik (2018) point out that dust (a natural aerosol with average diameter between 0.1-100μm) is one of the most abundant aerosols on the Earth, which main source is the Sahara Desert (Bullard and Livingstone, 2009).

In addition, during the boreal summer, the dusty Saharan air layer is vertically extended from 850 to about 500 hPa, and more westward propagation of dust is enhanced. This behavior is mainly due to atmospheric features, such as low-level jets (LLJs), African easterly waves (AEWs), etc. (Grogan et al., 2017; Pu and Jin, 2021; Yu et al., 2021).
1. BACKGROUND AND MOTIVATION

- African Easterly Waves (AEWs) are an **essential part of the dynamics of northwestern Africa** and plays an **important role in the development of precipitation** over Western Africa, the Tropical Atlantic region, and the Caribbean.

- **Our main goal is to evaluate how the increase of dust content in the atmosphere can affect the characteristic and properties of the AEWs.**
2. UFS EXPERIENCE and EXPERIMENTAL DESIGN

EPIC CODEFEST JUNE 2023:
Unit Testing Framework for the UFS
JUNE 19-23, 2023

UFS Short-Range Weather App Users Guide
release/public/v2.1.0

1. Introduction
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      3.3.1. Activate the Regional Workflow
      3.3.2. Configure the Workflow
      3.3.3. Generate the Workflow
2. UFS EXPERIENCE and EXPERIMENTAL DESIGN

setup

Period:
2020-07-24T00:00 to 2020-07-30T00:00

Initialization data source:

GFS (0.5°x0.5°) / every 6 hrs

MERRA-2 CLIM. AEROSOL (0.625°x0.5°)
(iaer from 5111 to 1111)

Domain and grid spacing:

LatLon Projection scheme
Resolution of 25 km
328 x 120 points, centered at 10°W and 15°N

GRID_GEN_METHOD: ESGgrid

<table>
<thead>
<tr>
<th>* Dust</th>
</tr>
</thead>
</table>
| Dust aerosol is represented with 5 bins that correspond to dry size ranges (in μ) and densities (kg/m³):
| bin | 1 | 2 | 3 | 4 | 5 |
| radius | 0.73 | 1.4 | 2.4 | 4.5 | 8.0 |
| radius lower | 0.1 | 1.0 | 1.8 | 3.0 | 6.0 |
| density | 2500 | 2650 | 2650 | 2650 | 2650 |

WRTCP: Writes groups: 1
WRTCP: write_tasks_per_group: 32
WRTCP: output grid: "regional_latlon"
WRTCP: con_lon: -10.0
WRTCP: con_lat: 15.0
WRTCP: lon_lwr_left: -48.5
WRTCP: lat_lwr_left: 1.5
WRTCP: lon_upr_right: 28.5
WRTCP: lat_upr_right: 28.5
WRTCP: dlon: 0.25
WRTCP: dlat: 0.25
## 2. UFS EXPERIENCE and EXPERIMENTAL DESIGN

**Physic Suite: GFS_v16**

<table>
<thead>
<tr>
<th>Component</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation (SW/LW)</td>
<td>RRTMG</td>
</tr>
<tr>
<td>Microphysics (MP)</td>
<td>GFDL</td>
</tr>
<tr>
<td>Boundary Layer (PBL)</td>
<td>TKE-EDMF</td>
</tr>
<tr>
<td>Surface Layer (SL)</td>
<td>GFS</td>
</tr>
<tr>
<td>Gravity Wave Drag (GWD)</td>
<td>None</td>
</tr>
<tr>
<td>Land Surface Model (LSM)</td>
<td>Noah</td>
</tr>
<tr>
<td>Deep Convection (DCU)</td>
<td>Sa-SAS</td>
</tr>
<tr>
<td>Shallow Convection (SCU)</td>
<td>sa-MF</td>
</tr>
<tr>
<td>Lake Model (LM)</td>
<td>NSST</td>
</tr>
</tbody>
</table>

### Two Simulations

1. **CONTROL (CTRL):** UFS experiment with the original aerosols (dust) concentration from MERRA-2.

2. **DUSTY_EXP (DU_EXP):** UFS experiment with eight times the original Dust concentration (“simulating an extreme event”).
3. RESULTS: Aerosol Optical Depth (AOD) 550nm

CTRL

DU_EXP

REFERENCE

AOD for the CTRL simulation (Average over the period July 24th – 28th of 2020)

AOD for the DU_EXP simulation (Average over the period July 24th – 28th of 2020)

A UFS Collaboration Powered by EPIC
Hovmoller Diagram for meridional wind at 700 hPa for both experiments. Average from 10°N-20°N.
3. RESULTS: RELATIVE VORTICITY AT 700hPa and OLR

Hovmoller Diagram (10°N-20°N) of cyclonic vorticity at 700hPa and Outgoing Longwave Radiation (OLR) for the CTRL experiment

Hovmoller Diagram (10°N-20°N) of cyclonic vorticity at 700hPa and Outgoing Longwave Radiation (OLR) for the DU_EXP experiment
3. **RESULTS:** WIND CIRCULATION AND CYCLONIC VORTICITY AT 700hPa

**CTRL**

DUx1 15Z27JUL2020

**DU_EXP**

DUx8 15Z27JUL2020
3. RESULTS: VERTICAL PROFILE OF TEMPERATURE

Average over 13°N-20°N and 15°W-0° for July 25th 15Z, 2020

Average over 11°N-18°N and 30°W-10°W for July 27th 15Z, 2020
3. **RESULTS:** MERIDIONAL DIFFERENCE OF TEMPERATURE (1000-850hPa) and WIND DIFFERENCES

**CTRL in Black and DU_EXP in Red**

- **ZONAL WIND DIFF. AT 700hPa (DU_EXP - CTRL)**
- **MERIDIONAL WIND DIFF. AT 700hPa (DU_EXP - DU_CTRL)**

Spatial distribution of the Temperature (°C) in the lower troposphere (average from 1000-850hPa) over tropical northwestern African region.

Temporal evolution of the meridional temperature gradient (difference between the north and south section) for the CTRL and DU_EXP experiments.
4. PRELIMINARY RESULTS AND FUTURE WORK

- Idealized UFS experiments were conducted. The dusty experiment exhibit the following features:
  - The wave structure looks “more defined” in the dusty experiment (DU_EXP), especially once the AEW is over the ocean.
  - More cyclonic vorticity along the AEW identified initially on July 24\textsuperscript{th}. However, it is not necessary the case for the wave initialized on July 26\textsuperscript{th}.
  - Generated less meridional temperature gradient in the lower troposphere, which led to less westward wind and a more meandering circulation.
  - Colder (warmer) temperatures are seen at the levels of 1000-850 hPa (850-550hPa). Once the wave is over the Atlantic ocean, there is no significant temperature differences in the lower troposphere.

- More realistic UFS simulations will be conducted in the future.
5. **UFS FEEDBACK**

- CODEFEST is a very effective way to spin-up. The EPIC team helped to solve technical issues via zoom virtual room.

- The Users Guide provides detailed information covering many specific aspects. However, the Quick Start section can be further improved. Tutorials are needed for compiling/working in the cloud (AWS).

- Some python and bash scripts could be improved or updated.

- It would be helpful to provide the guidance on how to speed up the run in the Frequently Asked Questions (FAQ) section. For instance, by changing the LAYOUT_X and LAYOUT_Y numbers.
THANK YOU