Medium Complexity Aerosol Treatment Coupled with Clouds/Precipitation/Radiation in a USA Operational NWP Model

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Aerosol-aware microphysics

Microphysics in WRF, RAP, HRRR, etc.

• Aerosol-aware scheme operational in HRRR/RAP since 23Aug2016

Fundamental, 1st order aerosol treatment (NWP)

• activation of CCN & IN
• depletion of aerosols – precip scavenging
• simplistic aerosol replenishment (surface emissions)
  o now including surface dust parameterization (GOCART)
• ensure physics consistency between prior scheme and new one
• directly couple with radiation for direct/indirect effects
Dust Emission Scheme

Originally from WRF-Chem GOCART

- Enhanced “erodibility” using MODIS visible satellite climatological albedo
Dust Emission Example Simulation (10-day)

0-hour forecast valid 00:00:00 UTC 10 Mar 2012

initial time: 00z 10Mar
Aerosol Optical Depth (AOD) Included into RRTMG-SW scheme

- 50-day simulation, comparison of 2 AERONET sites in China
Dust Storm in India

MCS moves across Indo-Gangetic Plain (IGP)
Ship Tracks

2012Jul14

GOES-visible

MODIS albedo

MODIS droplet#

derived effective radius
Aerosol impacts on landfalling tropical cyclones in China

**Storms:** 4 currently (at least 4 more)
WRF-model simulations
5-km spacing with 1-km vortex following nest

**Aerosols:** urban increase of 4X, 8X, 16X, 32X, 64X

**Evaluations**
- Track & Intensity
- Radial and Tangential Winds
- Updraft strength
- Precipitation (regional & quadrants)
- Cloud and rain profiles (mass/number)

Contributions by Lin Deng
Typhoon Nida (2016Aug01)

Contributions by Lin Deng
Updrafts

experiment differences
more – less aerosols
within 150km of center
Aerosol-aware microphysics

13-year WRF simulation CONUS 4-km spacing

- WRF icing (Temp, LWC, MVD) versus FAA Tech. Ctr. icing database
Stochastic Parameter Perturbations

Within microphysics alter CCN & IN activation

- Addressing known single-parameter uncertainties


**Experiment list**

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Control</td>
</tr>
<tr>
<td>WN</td>
<td>White noise</td>
</tr>
<tr>
<td>P1-G</td>
<td>Graupel</td>
</tr>
<tr>
<td>P2-W</td>
<td>Water (mu)</td>
</tr>
<tr>
<td>P3-GW</td>
<td>Graupel + Water</td>
</tr>
<tr>
<td>P4-A</td>
<td>Aerosol (CCN+IN)</td>
</tr>
<tr>
<td>P5-GA</td>
<td>Graupel + Aerosol</td>
</tr>
<tr>
<td>P6-WA</td>
<td>Water + Aerosol</td>
</tr>
<tr>
<td>P7-GWA</td>
<td>Graupel + Water + Aerosol</td>
</tr>
<tr>
<td>P8-HDF</td>
<td>Higher Diffusion</td>
</tr>
</tbody>
</table>
Stochastic Parameter Perturbations
Very clear signals of 1\textsuperscript{st} and 2\textsuperscript{nd} aerosol indirect effects

Difference in Cloud drop number (vert integ.)
Difference in Shortwave radiation (at surface)
Stochastic Parameter Perturbations

Very clear signals of 1\textsuperscript{st} and 2\textsuperscript{nd} aerosol indirect effects

Rain content (by altitude)
Acknowledgements

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