Update on a New Approach for Parameterizing Microphysics by Predicting Multiple Ice Particle Properties

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A new microphysics scheme has been developed that predicts particle properties (mean density, size, rime fraction, etc.) for a single ice “category”:

- Predicted Particle Properties – One Category (P3-1C)

This contrasts with current schemes that partition different types of using pre-defined categories like cloud ice, snow, graupel, etc.
Some conceptual advantages:

- smooth evolution of ice particle characteristics
- avoids unphysical/poorly constrained thresholds for conversion between pre-defined ice-phase classes
- more consistent application of microphysical processes
- particle properties are real physical quantities that can be observed, conversion thresholds are not \( \rightarrow \) better linkage with observations
- fewer prognostic variables \( \rightarrow \) fast code!
Bulk ice particle properties are predicted with four degrees of freedom

- Prognostic variables: \( q_c, q_r, N_r, q_i^*, N_i, q_{rim}, B_{rim} \)

- The four prognostic ice variables can capture evolution from all modes of ice growth (deposition, aggregation, riming \( \rightarrow \) dry and wet growth)

\[ *q_i = q_{dep} + q_{rim} \]

Details of the scheme and simulation results are in Morrison and Milbrandt (2014) and Morrison et al. (2014), submitted to JAS
Two cases tested using WRF-ARW:

- June 20, 2007 Oklahoma squall line
- December 12-13, 2001 frontal/orographic precipitation in Washington/Oregon (IMPROVE-2)
Microphysics schemes tested:

P3-SINGLE CATEGORY (P3-1C)
MILBRANDT-YAU (MY2)
MORRISON-HAIL (MOR-H)
MORRISON-GRAUPEL (MOR-G)
THOMPSON (THO)
WRF SINGLE-MOMENT (WSM6)
WRF DOUBLE-MOMENT (WDM6)
Squall line results

- WRFv3.4.1, $\Delta x = 1$km, 3D quasi-idealized setup
WRF Results: Reflectivity at 1 km height, $t = 6$ h
Vertical cross section of model fields at 6 hours

- Small dense ice
- Medium-density graupel
- Low-density graupel
- Hail
- Large unrimed ice (aggregates)
Frontal/orographic case: December 13-14, 2001, IMPROVE-2

- WRFv3.4.1, $\Delta x = 3\text{km}$, 72 stretched vertical levels

Simulated lowest level radar reflectivity at 0Z December 14

Accumulated surface precip from 14Z December 13 to 8Z December 14
Rimed snow/low-density graupel

Large unrimed ice (aggregates)

Small dense ice

Increased fallspeed from rimed snow to > 2 m/s

Vertical cross section of model fields at 0000 14 Dec in the IMPROVE-2 domain
Precip differences relative to P3-1C

- P3-1C produces the smallest RMSE relative to surface precip observations among all schemes.

Accumulated surface precip from 14Z December 13 to 8Z December 14
Timing tests

<table>
<thead>
<tr>
<th></th>
<th>Squall line case</th>
<th>Orographic case</th>
<th>Number of prognostic variables</th>
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<tbody>
<tr>
<td>P3-1C</td>
<td>0.436</td>
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<tr>
<td>MY2</td>
<td>0.621</td>
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<td>MOR-H</td>
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<tr>
<td>WDM6</td>
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<td>0.777</td>
<td>8</td>
</tr>
</tbody>
</table>

*Total time step run time (sec), averaged from 4-7 h for the squall line and 12-36 h for IMPROVE-2.
Summary

• A new approach for parameterizing microphysics has been proposed that predicts ice particle properties for a single “category” instead of separating ice into different pre-defined categories like cloud ice, snow, graupel.

• Initial testing of P3-1C for squall line and orographic precipitation cases is promising → good results relative to observations and computationally efficient.

• Significantly more testing is needed → P3-1C will be included in the 2014 spring OU CAPS ensemble.

• Testing of the scheme for MC3E cases will begin shortly. We plan to couple the predicted properties directly with a polarimetric radar simulator.