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 → *better linkage with observations*
- fewer prognostic variables → *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 → 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)

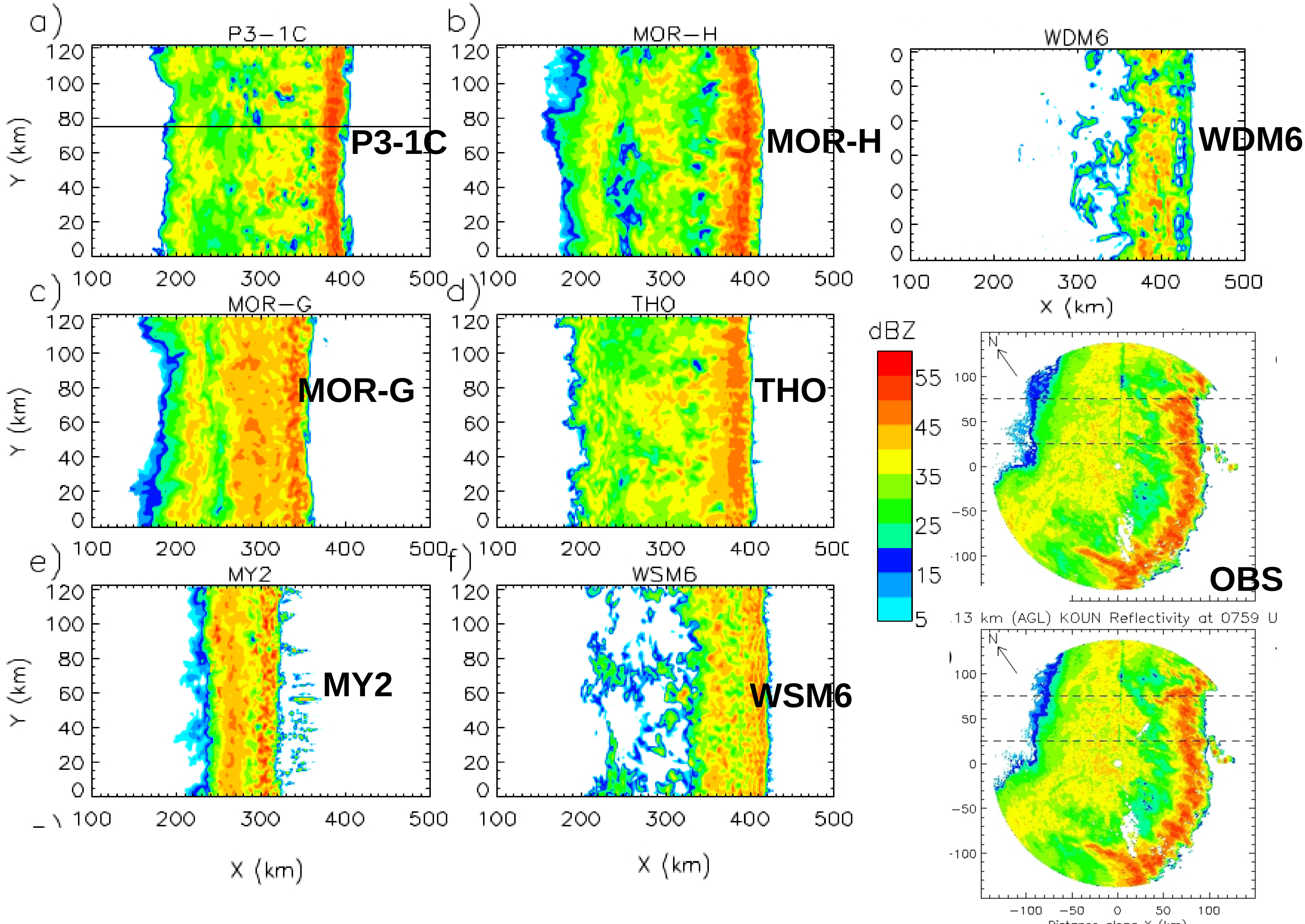
WRF SINGLE-MOMENT (WSM6)

WRF DOUBLE-MOMENT (WDM6)

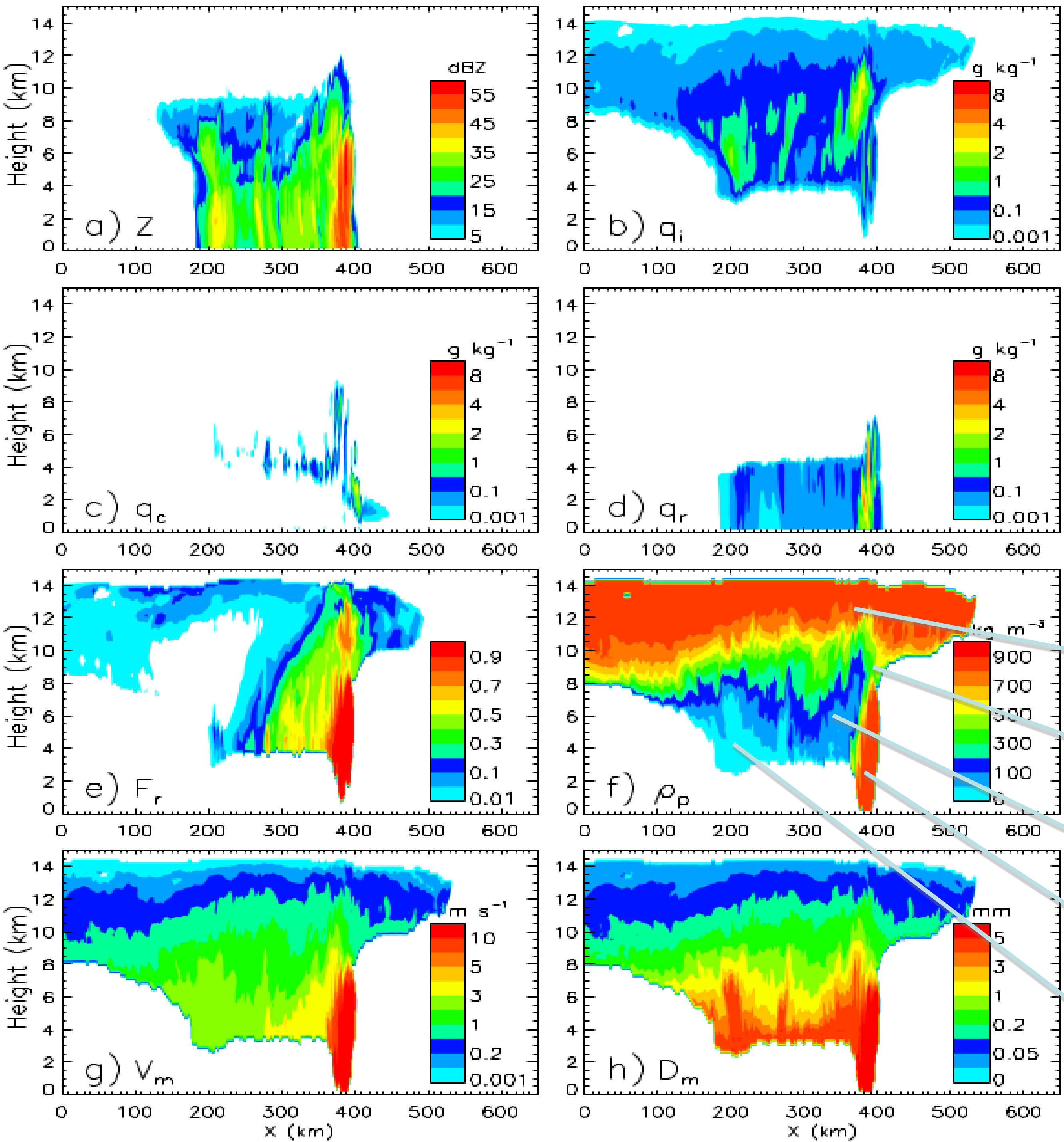
Squall line results

- WRFv3.4.1, $\Delta x = 1$km, 3D quasi-idealized setup

WRF Results: Reflectivity at 1 km height, t = 6 h

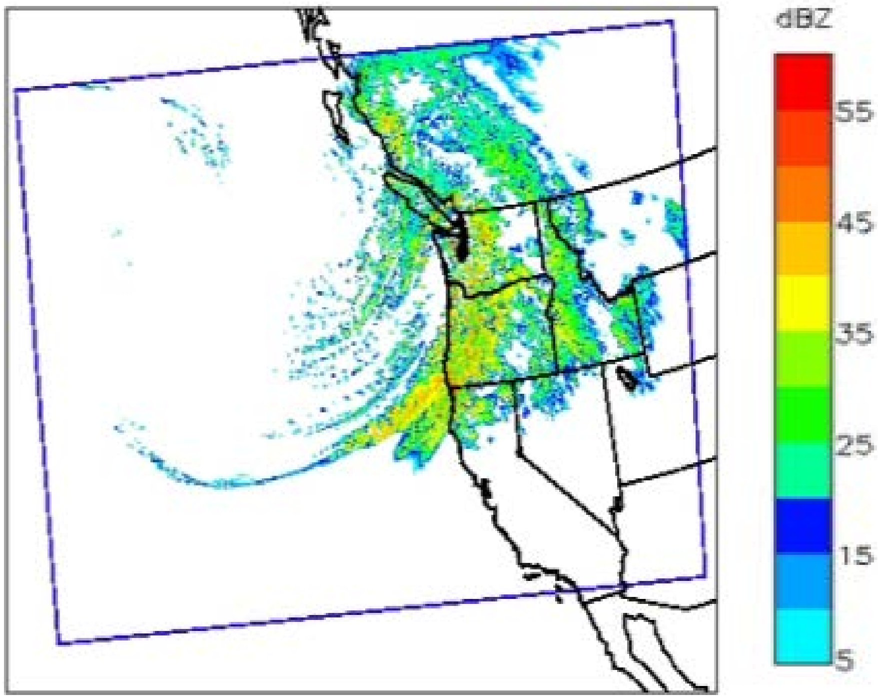


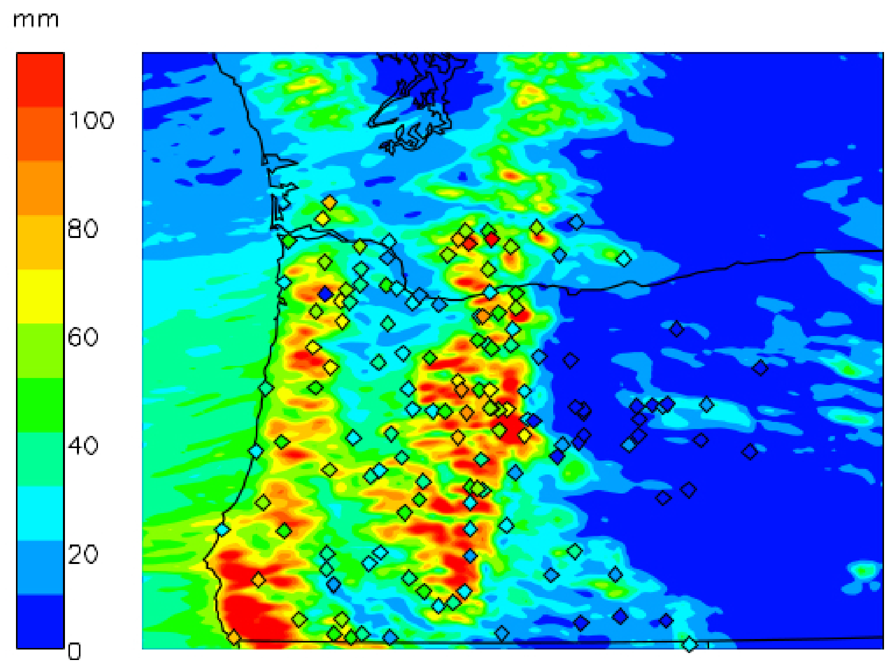
Vertical cross section of model fields at 6 hours



Frontal/orographic case:
December 13-14, 2001, IMPROVE-2

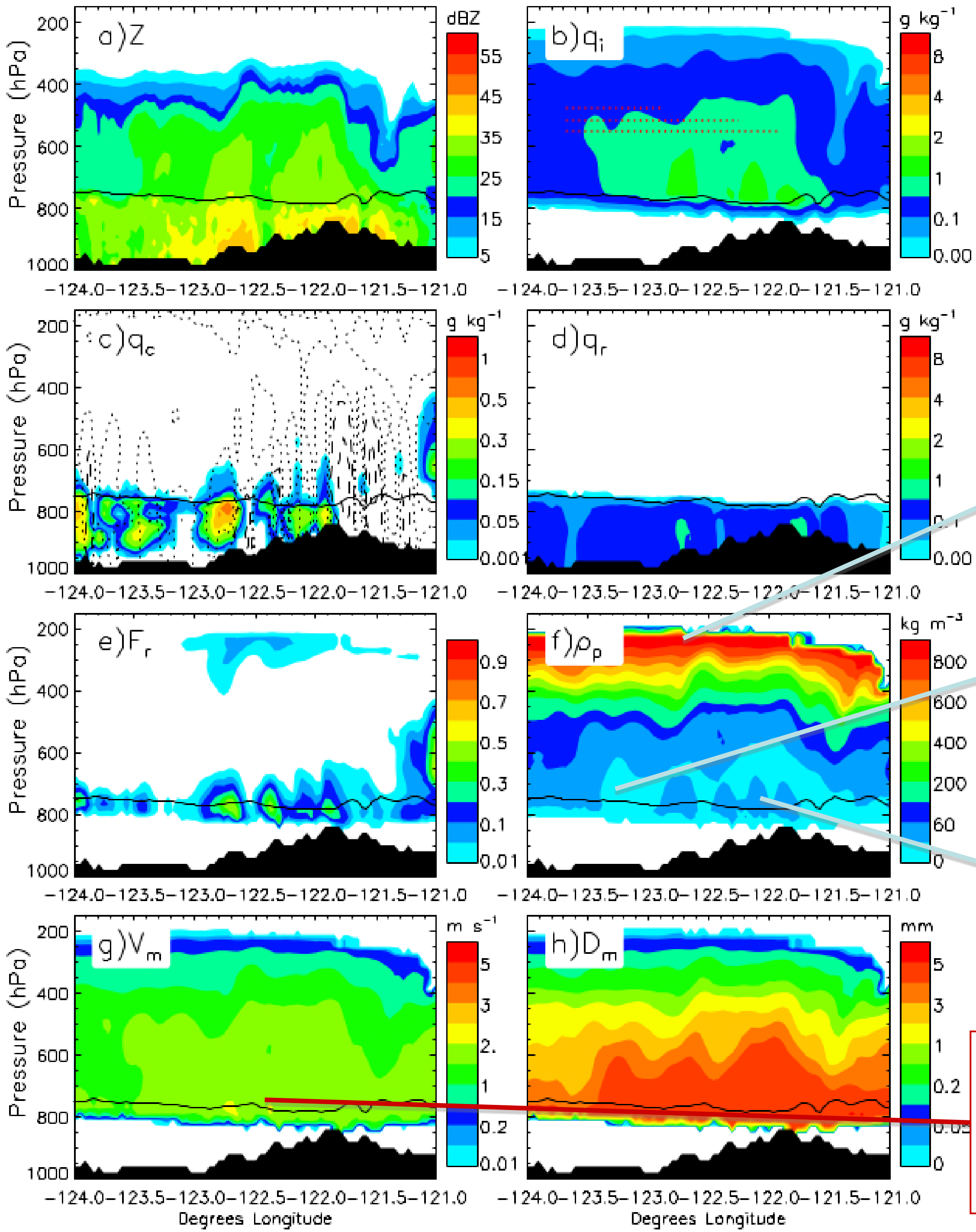
- WRFv3.4.1, Δx = 3km, 72 stretched vertical levels





Simulated lowest level radar reflectivity at 0Z December 14

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



Vertical cross section of model fields at 0000 14 Dec in the IMPROVE-2 domain

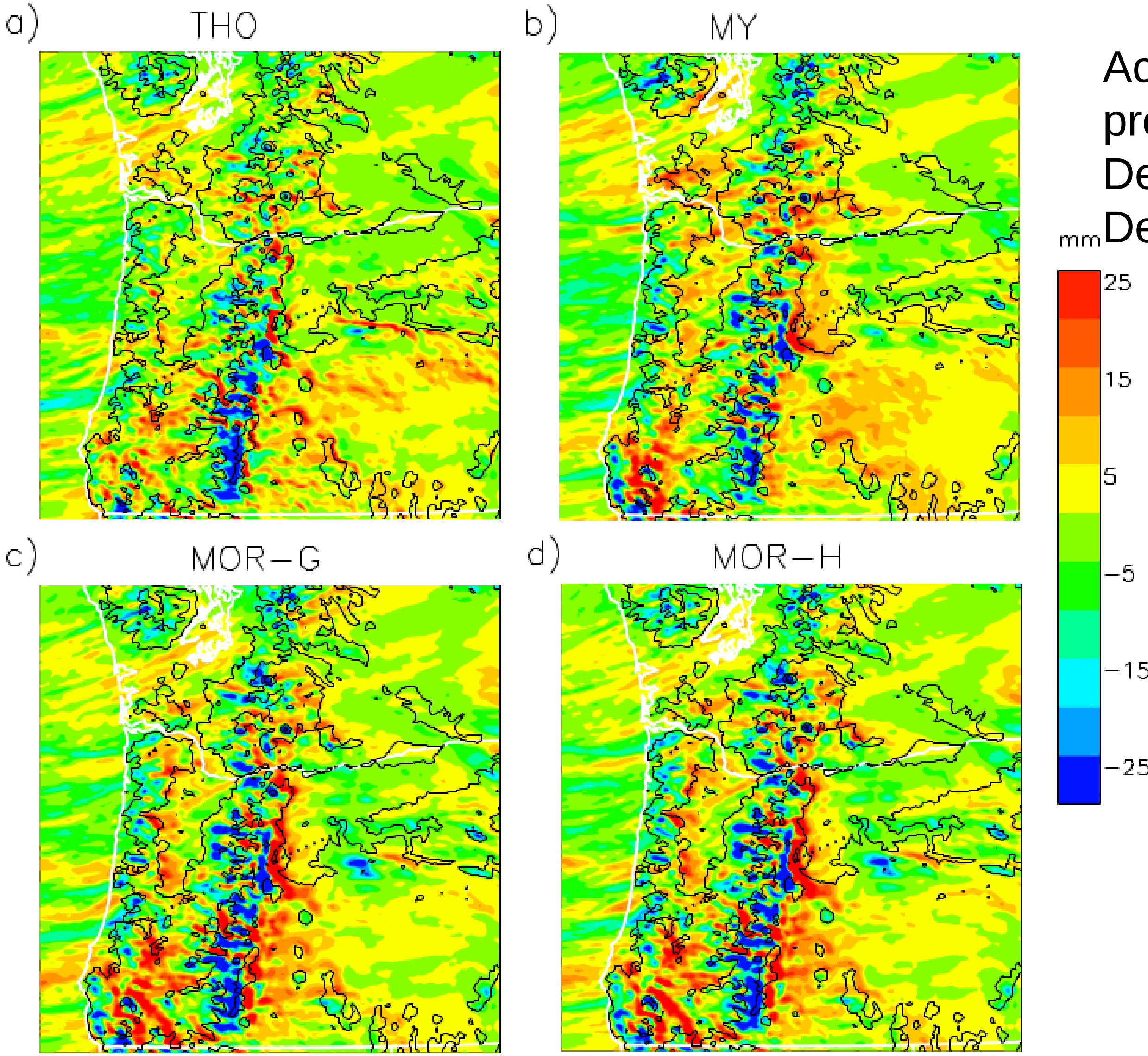
Small dense ice

Large unrimed ice (aggregates)

Rimed snow/low-density graupel

Increased fallspeed from rimed snow to > 2 m/s

Precip differences relative to P3-1C



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

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

Timing tests

	Squall line case	Orographic case	Number of prognostic variables
P3-1C	0.436	0.686	7
MY2	0.621	1.012	12
MOR-H	0.503	0.813	9
THO	0.477	0.795	7
WSM6	0.418	0.677	5
WDM6	0.489	0.777	8

*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.