Sensitivity of Simulated Great Salt Lake Effect Precipitation to the Parameterization of Microphysical Processes

John D. McMillen and W. James Steenburgh

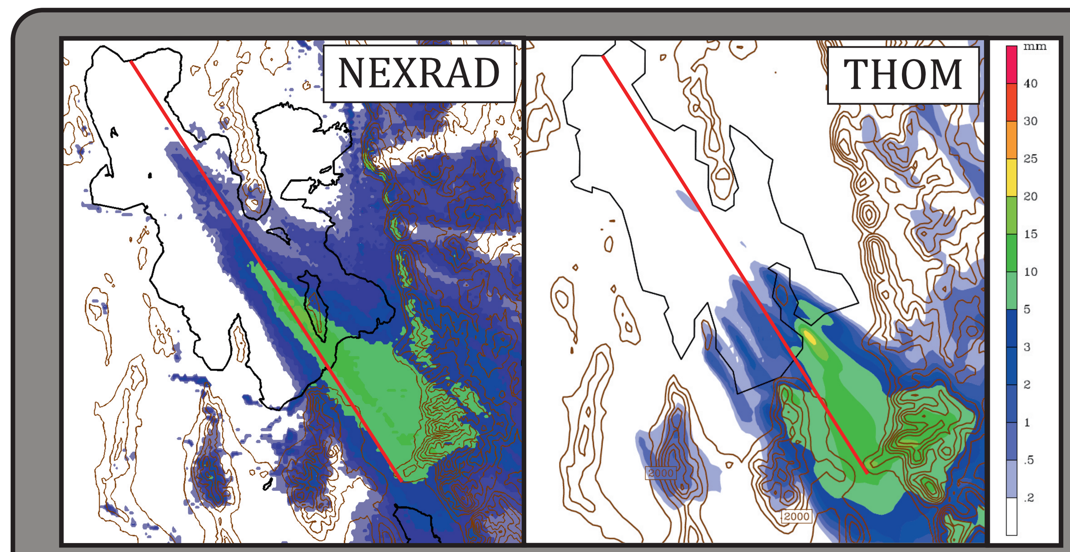
Department of Atmospheric Sciences, University of Utah, Salt Lake City, Utah

Introduction

- Great Salt Lake-Effect (GSLE) snow is a significant forecast challenge for forecasters and NWP during the cool season.
- Alcott and Steenburgh (2013) showed via simulation the GSLE event of 27 October 2010 required synergistic interaction of orography and land-lake surface contrasts to produce precipitation comparable to observations.
- GSLE precipitation is sensitive to moisture flux from the lake and moisture in the incident airmass as shown by Onton and Steenburgh (2001).
- We found GSLE precipitation distribution and amount was also sensitive to the choice of microphysics parameterization (MP) in the Weather Research and Forecasting (WRF) Advanced Research WRF (ARW) system.

Methods

- We simulated the 27 Oct 2010 GSLE event with the WRF-ARW V3.4.
- The GSLE event occurred following the passage of a precipitation band associated with a baroclinic trough.
- Our control simulation (THOM) used the Thompson MP scheme and produced a similar precipitation distribution and amount to that derived from NEXRAD observations.
- Additional simulations used the same configuration as THOM, except for the choice of Goddard (GODD), Morrison (MORR), and WRF double moment six class (WDM6) MP schemes.



Total GSLE precipitation 0230-1700 UTC 27 Oct 2010.
Red line included for reference on this and following plots.

Simulation Configuration

3 one-way nested domains	Thompson MP
1.33 km grid spacing inner domain	Kain-Fritsch cumulus (outer domains only)
35 vertical levels	YSU PBL
8 sec integration time step	NOAH LSM
NAM initial and boundary conditions	RRTMG SW and LW radiation
	Simple second order diffusion
	2D Smagorinsky eddy coefficient

- All simulations generated similar moisture fields after a few hours of model run time, indicating consistent synoptic situations.
- Consistency of synoptic conditions imply that GSLE precipitation distribution and amount differences between simulations were primarily caused by the choice of MP scheme.

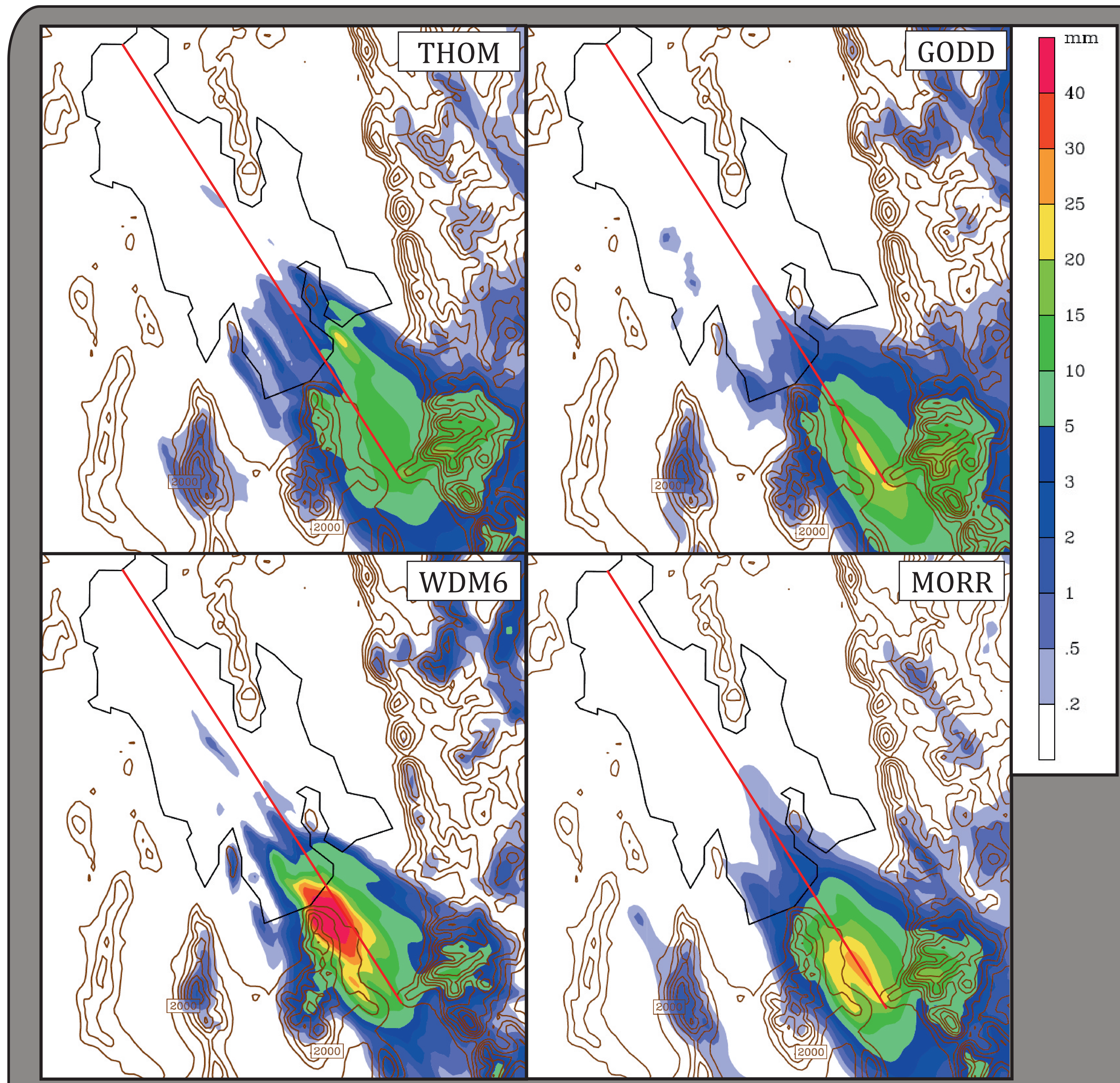
Results

- The GODD, MORR, and WDM6 simulations all produced more mean precipitation and larger areal distributions of precipitation than the THOM simulation.

	Maximum Precipitation (mm)	Mean Precipitation (mm)	Percent Change In Mean Precipitation	Area ≥ 10 mm Precipitation (km^2)	Area ≥ 15 mm Precipitation (km^2)	Area ≥ 20 mm Precipitation (km^2)
CTL	24.43	1.23	N/A	739	63	11
GODD	20.95	1.35	9.39	1023	359	33
MORR	28.08	1.32	6.99	950	530	238
WDM6	52.50	1.50	22.25	905	583	391

Statistics from GSLE event total precipitation over the domain depicted in column 2.

Results

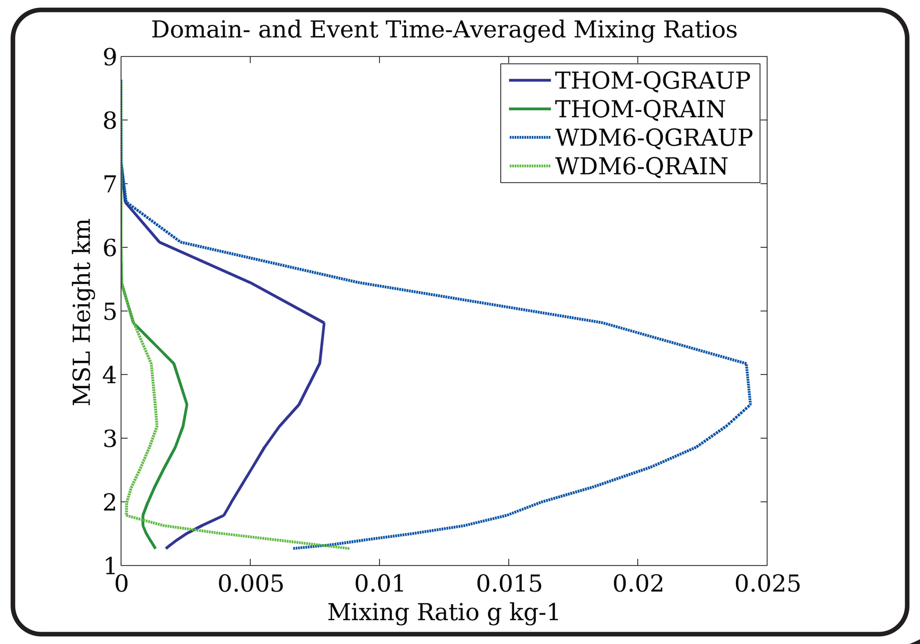


GSLE event total precipitation 0230-1700 UTC 27 Oct 2010.

- The choice of MP scheme causes differences in GSLE precipitation distribution and amount in two ways:
  1) differing amounts of graupel production
  2) and displacement of the convergence zone due to pre-GSLE event precipitation.

Graupel Production

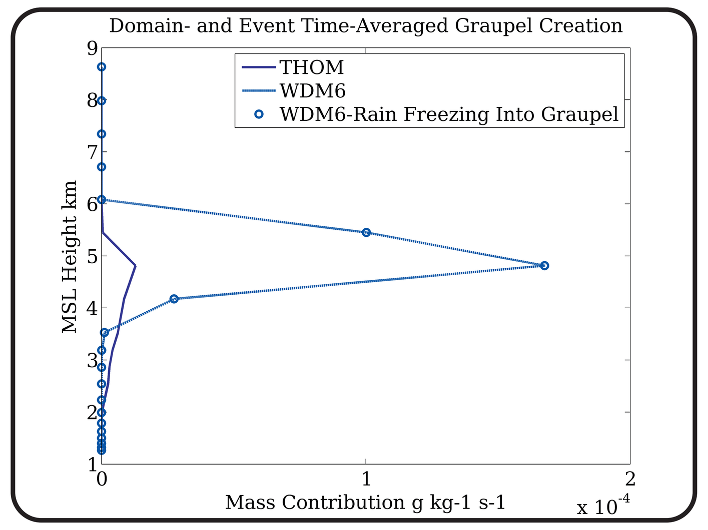
- WDM6 produced far more graupel and the maximum graupel mixing ratio was lower in altitude by roughly 1 km than THOM.
- Above 1.8 km MSL THOM produced slightly more rain, but below 1.8 km MSL WDM6 produced much more rain.
- The rain mixing ratio is important to consider because of its role in producing graupel.



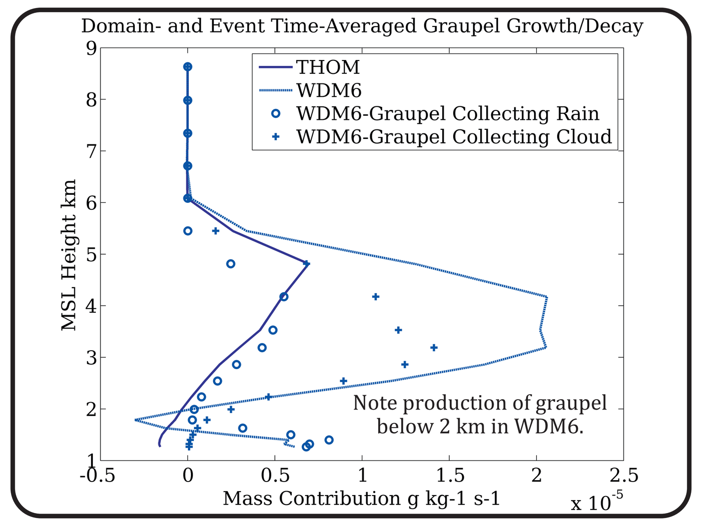
NSF Grants: AGS-0938611
AGS-1262090

Contact: john.mcmillen@utah.edu

Graupel Production

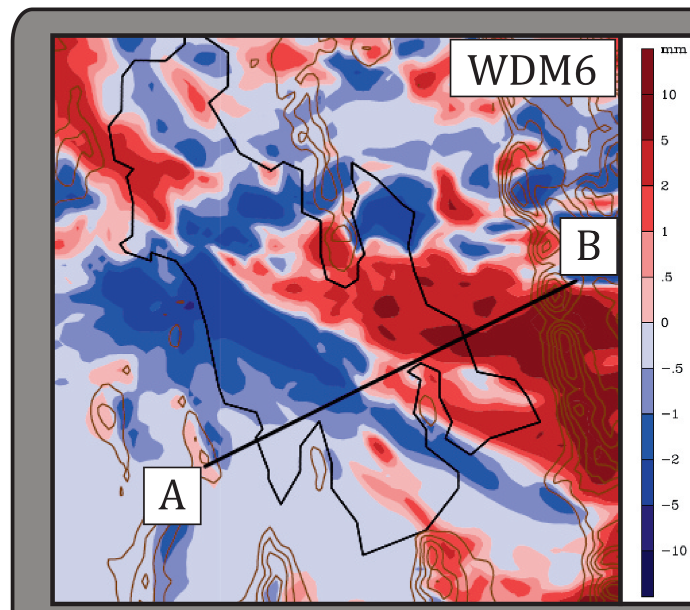


- WDM6 produced nearly ten times more graupel than THOM; the majority of WDM6 production was rain freezing into graupel.

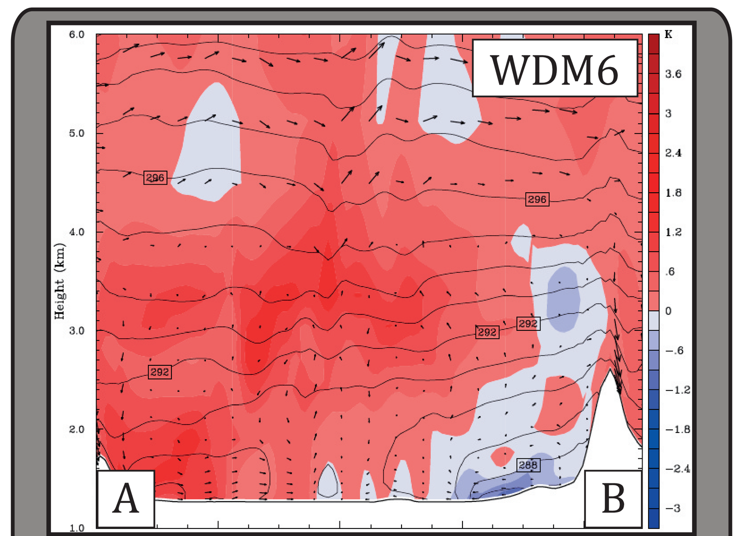


- WDM6 caused more graupel mass growth than THOM mostly by graupel collecting cloud water and rain.

Convergence Zone Displacement

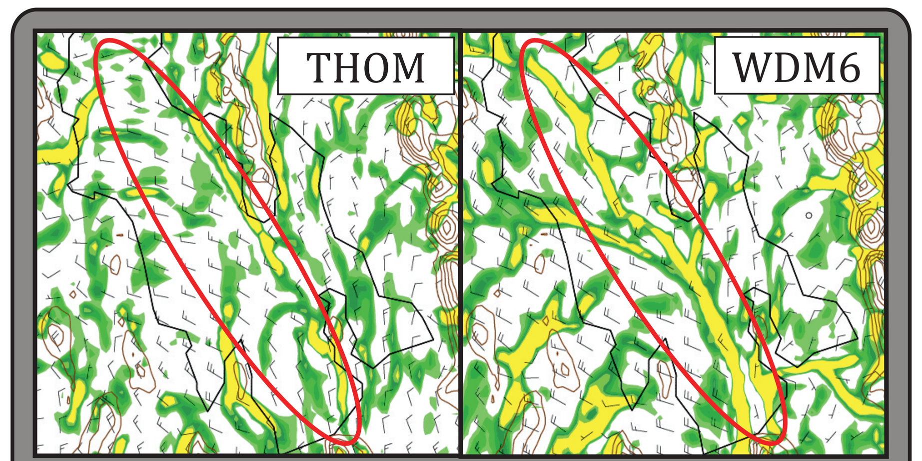


Total precipitation difference WDM6 minus THOM 1800 UTC 26 Oct 2010 - 0230 UTC 27 Oct 2010.



8 km horizontal average circulation and potential temperature over shaded potential temperature difference WDM6 minus THOM 0230 UTC 27 Oct 2010.

- WDM6 produced less(more) precipitation over the western (A)(eastern (B)) shore of the lake than THOM before the GSLE event.
- The diabatic cooling of the low level air over the eastern shore in WDM6 strengthened the land breeze from the eastern shore relative to THOM.
- The reduction in precipitation and diabatic cooling over the western shore in WDM6 caused the land breeze from the western shore to be weaker relative to THOM.



Divergence averaged through lowest 2 model levels (green < 0 s-1; yellow < -110 s-1; interval -30 s-1) and lowest model level winds (full barb = 5 ms^{-1}) 0230 UTC 27 Oct 2010.

- The difference in eastern and western shore land breezes between WDM6 and THOM resulted in displacement of the convergence zone west-southwestward in the WDM6 relative to THOM.
- This caused the west-southwestward shift in the precipitation maximum seen in the WDM6 GSLE total precipitation distribution.

Conclusions

- GSLE precipitation distribution and amount is sensitive to the choice of MP scheme.
- MP scheme choice affects GSLE precipitation distribution and amount by:
1) differing amounts of graupel production
2) and displacement of the convergence zone due to pre-GSLE precipitation.