10.3

EVALUATION OF OLAM PERFORMANCE IN TWP-ICE AND WINTER OROGRAPHIC PRECIPITATION IN COLORADO

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1. INTRODUCTION

The Ocean–Land–Atmosphere Model (OLAM; Walko 2008*a* and *b*) extends the capabilities of the Regional Atmospheric Modeling System (RAMS) to a global model coupled to an ocean model. OLAM has several unique attributes that clearly depart from the norm of general circulation models. Among them, an unstructured adaptive grid that enables local mesh refinement to any degree and a representation of complex terrain uses a form of volume-fraction or cut-cell method in which model levels are strictly horizontal. State-of-the-art components of RAMS@CSU microphysics (e.g., explicit activation of aerosols and several bin-emulating approaches) complement the capability of explicitly resolving convection of this global modeling system. In order to evaluate these recent OLAM improvements that are especially relevant in the cloud-resolving scale, we chose two cases that differ in nature: monsoonal tropical convection over the north of Australia and orographic precipitation in Colorado. This first test corresponds to the Tropical Warm Pool-International Cloud Experiment (TWP-ICE) field experiment that took place over and around Darwin, Australia, from January 20 through February 13, 2006. A wide variety of observations from different platforms documented during TWP-ICE represent an almost ideal framework to evaluate the ability of this global model to simulate the evolution of tropical convection during a period governed by different regimes.

The second test corresponds to a wintertime orographic mixed-phase cloud, studied by our group, occurred in February 2007 over north-central Colorado. Both cases are simulated using a nearly identical model configuration, a global grid with seven degrees of refinement. Cell size is slightly above 1km within the regions of interest that cover approximately 30000 km^2. Comparisons between OLAM and observations for the TWP-ICE tropical case are given in section 2.

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Section 3 compares OLAM against some observations and RAMS outputs for a wintertime precipitation case from which RAMS performed a notably well.

2. TROPICAL TWP-ICE CASE

2.1 Simulation conditions

The simulations were initialized on January 18 2006 00:00Z and, for the result presented in this abstract, covered the first 7 days of the TWP-ICE field campaign. A time step of 10s, and the two-moment microphysical module were used in OLAM, recently migrated from RAMS@CSU. We used a global grid with 7 grid refinements; figures 1 and 2 show the global mesh and the region with the finest refinement, respectively The latter is centered in Darwin and has a "grid spacing" slightly above 1km over the field experiment area (Fig. 3). The polygonal in this figure delimits the area used to compute averaged quantities and maximum values, used for comparisons against quantities derived from observations. .

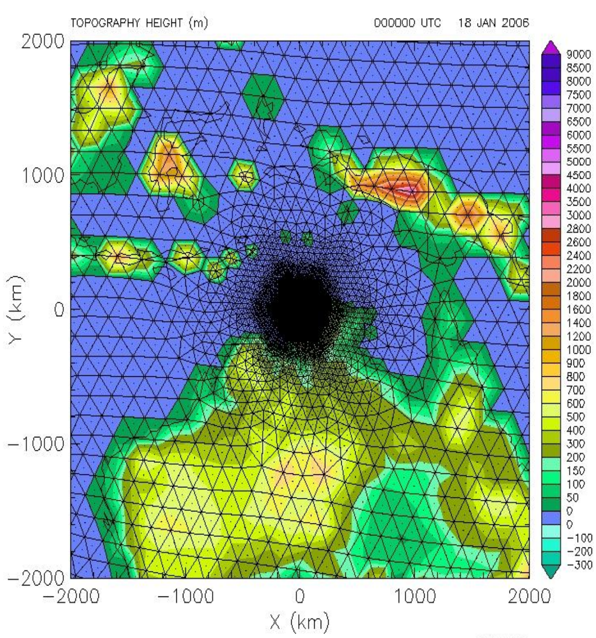

Figure 1 OLAM grid

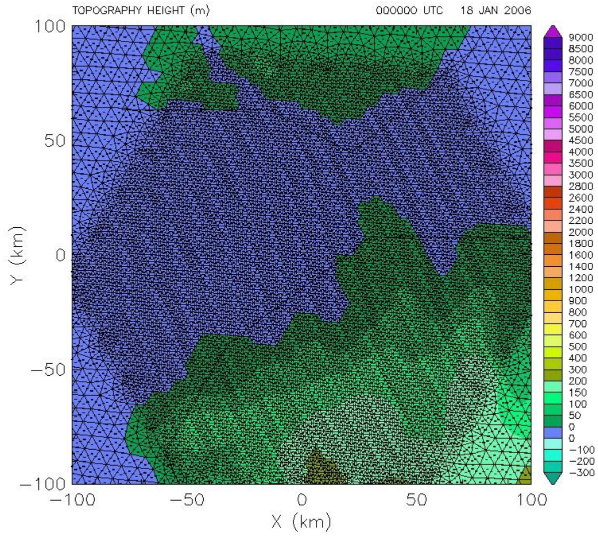

Figure 2 OLAM grid detail near Darwin.

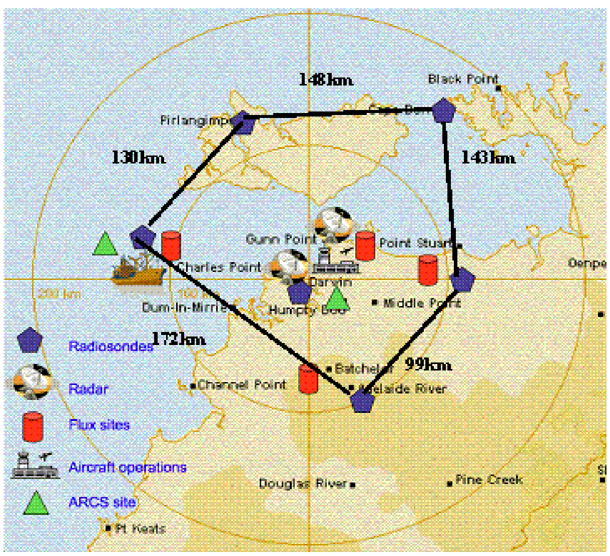

Figure 3 TWP-ICE experimental domain (figure from TWP-ICE website).

2.2 Results

These initial tests focused on the first monsoon event that occurred approximately between January 19 12:00Z and January 25 12:00Z. Figure 4 compares simulated and retrieved precipitation for this time period. There is a good agreement between simulated and retrieved precipitation rates for averaged as well as for maximum values. However, peak simulated values are approximately 10 and 15% higher for averaged and maximum values, respectively. Figure 5 compares liquid water content (LWC) vertical profiles for the same period.

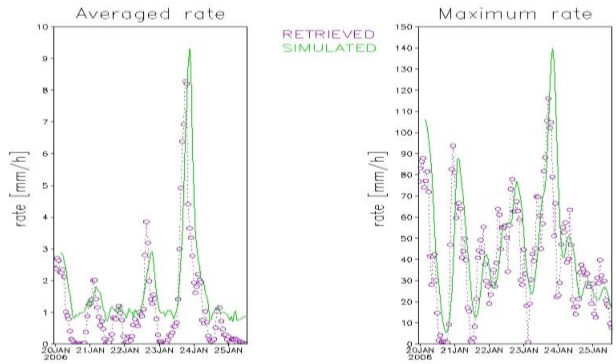

Figure 4 Comparison between simulated and retrieved precipitation rates, Averaged and maximum values correspond to the region in Fig 3.

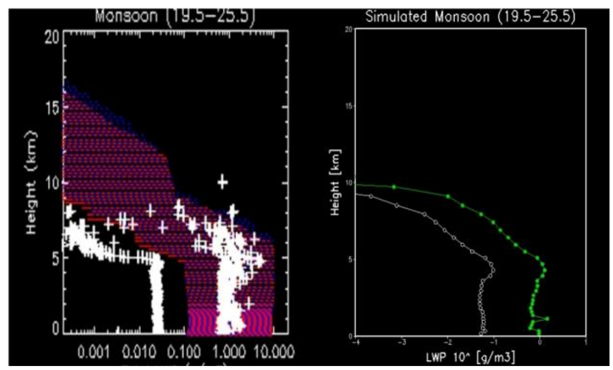

Figure 5 Comparison LWC vertical profiles for the first monsoon event (left panel adapted form figure in TWP-ICE website).

Figures 6 and 7 compare simulated and retrieved LWPs for areas with no precipitation (precipitation rate lower than 0.02mm/h)

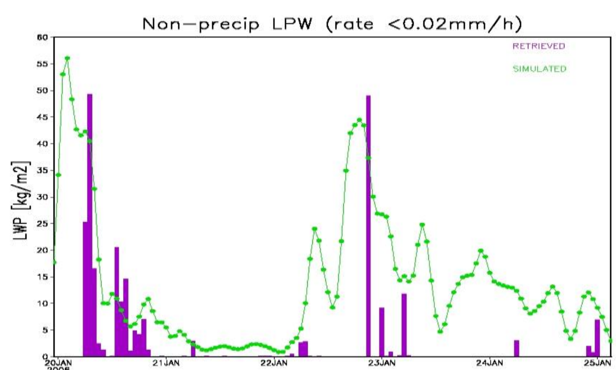

Figure 6 Comparison between simulated and retrieved LWPs averaged over areas with no precipitation.

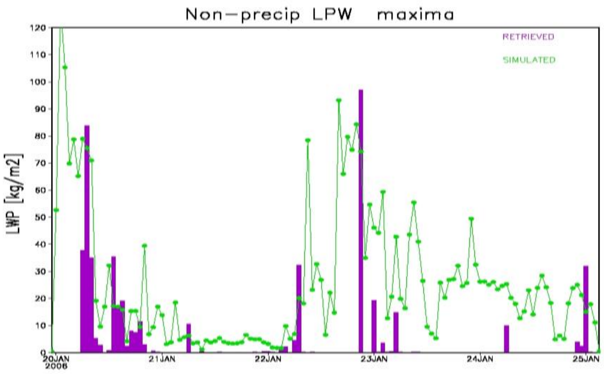

Figure 7 Idem, Fig. but for maximum values of LWP..

Figure 8 compares simulated and retrieved ice water paths (IWPs) averaged over areas with no precipitation (precipitation rate lower than 0.02mm/h). In this case, even though the times at which relative maxima occur almost coincide, simulated values are significantly larger than those derived from observations. This overprediction of IWPs also occurred with RAMS (not shown) and may be linked to a rather arbitrary choice for ice forming nuclei initial profiles.

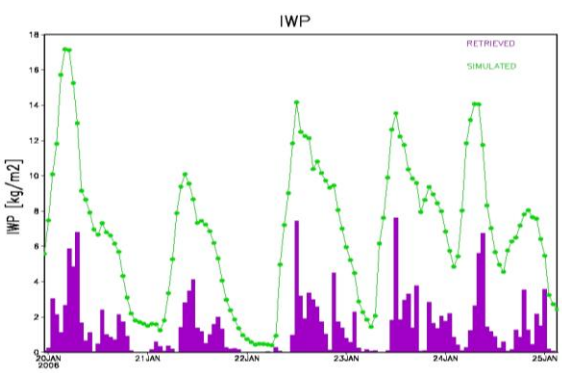

Figure 8 Comparison between simulated and retrieved IWPs averaged over areas with no precipitation.

3. COLORADO WINTERTIME CASE

3.1 Case description and RAMS simulation

This snowfall event occurred 11-12 Feb 2007 was dominated by high-density, heavily-rimed snow with an observed snow depth (325mm) to snow water equivalent (SWE) (44mm) ratio of ~7:1 at Storm Peak Lab (SPL). SPL is a high altitude atmospheric science lab located at the top of Mt. Werner (3200m above MSL) within the Park Range just west of Steamboat Springs, Colorado. Simulations of this snowfall event using the RAMS model were described by Saleeby et al. (2009). Simulated winds with RAMS at the SPL location agreed reasonably well with the observations indicating iprimarily westerly flow impinging upon the north/south mountain barrier with winds increasing over time from the 11th to 12th of February. Modeled temperature time series were within 1°C for the duration of the event and the temperature decreased from -2°C to -7°C over time. Following the onset of snowfall at 0600Z on the 11th, both the observations and OLAM indicated sustained relative humidity in excess of 100% through the 12th. With increasing westerly winds and decreasing temperature over the course of the event, there was increased orographic convergence and supersaturated conditions; as such, the supercooled liquid water content (LWC) increased with observed, time-averaged liquid water content increasing from ~0.1 g/kg to ~0.3 g/kg and a maximum of 0.7 g/kg. Model simulations also indicated an increase in the cloud LWC over time with a maximum of around 0.8 g/kg at SPL. With such high LWC in the observations and model, there was a substantial amount of rime on observed snow crystals and graupel and a large amount of riming occurring in the model as indicated by the production of rimed snow and graupel. ***what Time series of snow water equivalent(SWE) from RAMS and surrounding SNOw TELemetry (SNOTEL) sites all provide similar snowfall rates. RAMS accumulated SWE agrees within 2-3mm of observed, manual snowfall measurements at SPL at two particular times. Furthermore, the SNOTEL sites toward the north of the Park Range indicated greater accumulation than sites to the south. The RAMS figure of total surface accumulated SWE from Saleeby et al. (2009) also indicate greater snowfall to the north of SPL near the Towers SNOTEL site. In general, this was a well simulated event with regards to the flow dynamics, thermodynamics, microphysics, and precipitation. **section above is confusing as it is hard to tell when you are talking about OLAM, RAMS and obs

3.2 Simulation conditions

The simulations were initialized on January 10 2007 18:00Z with a simulation time of 49h. The first 6 hours were considered as a model spin-up and were not used for comparisons. OLAM was used a time step of 10s, two-moment microphysics, and a global grid very similar to that used for the TWP-ICE case in that I has 7 grid refinements but centered in Colorado. Figures 9 and 10 show the global mesh and the region with the finest refinement, respectively The latter also has a “grid spacing” slightly above 1km; the rectangle indicates the boundaries of the third RAMS grid used for comparisons (contained within the hexagon with the finest resolution).

We performed several OLAM simulations varying the nudging timescales, the nudged variables, and including or not the θ_{il} factor (θ_{il}/θ ratio). In addition, this set of numerical experiments included 1-moment and 2-moment microphysics comparisons (see Fig 7), and one 2-moment simulation focused on the effect of enhancing CCN concentrations in OLAM (still in process).

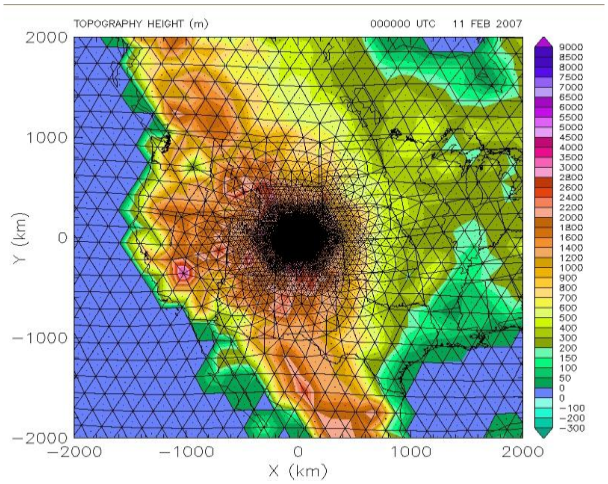

Figure 9 OLAM grid

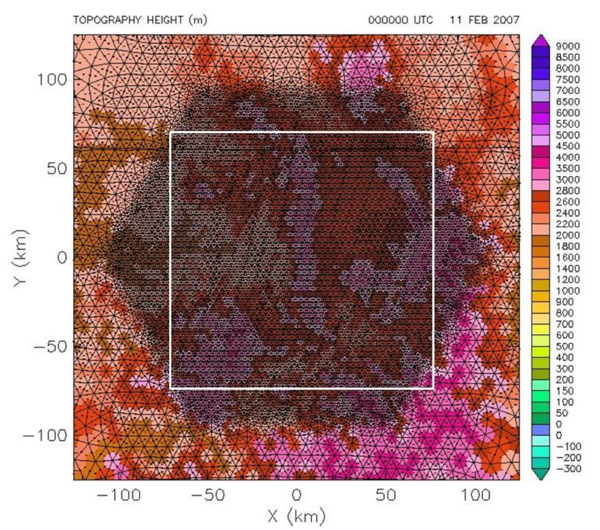

Figure 10 OLAM grid detail over Colorado

3.3 Results

Comparisons were made for the case occurred during a 43-h period beginning 11 February 00:00Z 2007. As mentioned in subsection 3.1, RAMS simulated well the flow dynamics, thermodynamics, microphysics, and precipitation of this case. For that reason, several comparisons were made between the two models. In particular, RAMS performed well in simulating the time evolution of the SWE for 3 of the 4 SNOWTEL sites, and differences between OLAM and RAMS were not large for these sites (Fig 11.) Observations indicate that precipitation ends slightly later than predicted by both OLAM and RAMS.

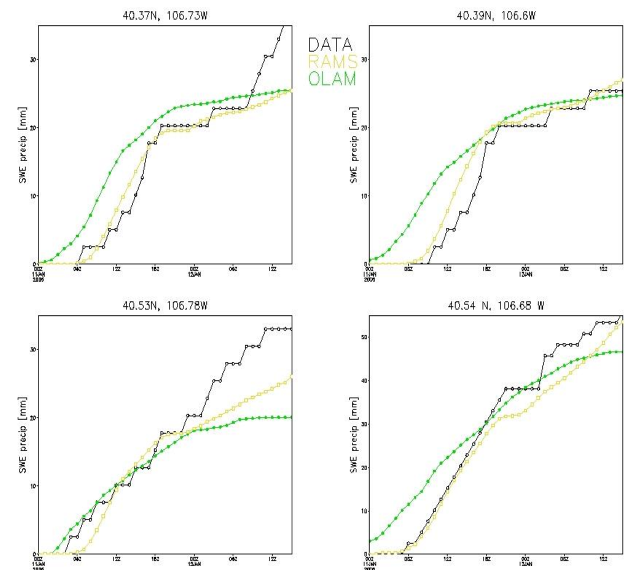

Figure 11 Comparison of SWE accumulated precipitation at four SNOWTEL sites and OLAM simulated amounts.

Figure 12 shows that OLAM reproduces well the accumulated precipitation spatial pattern, although it produces a less intense precipitation maximum (80mm vs 47mm) than observations. This underestimation is slightly more important when we do not nudge winds although the pattern is still very similar. However, when we compare the precipitation rate averaged over the area of the finest RAMS grid (Fig. 13), the maxima and the time evolution are comparable. OLAM more poorly represents the narrow maximum around 19 Jan 00:00Z suggested by the observations. Figure 14 is analogous to Fig. 13 but for the ice water path (IWP) that shows a similar behavior, but with again comparable maxima.

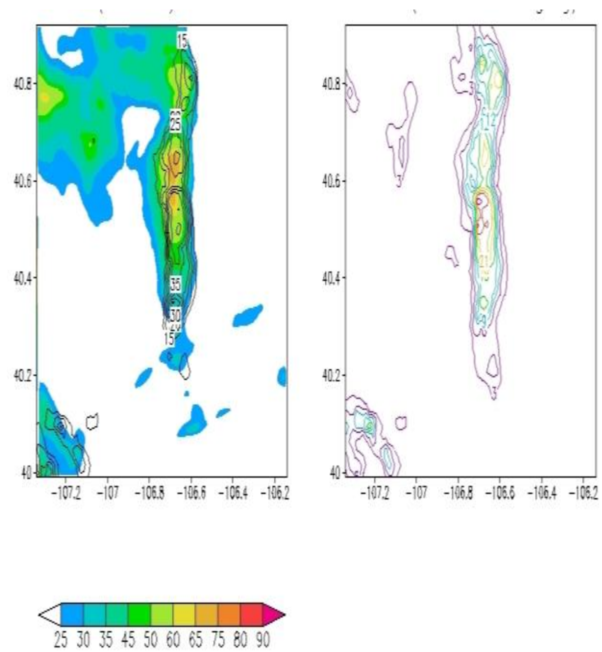

Figure 12 Comparison of accumulated precipitation simulated by RAMS and OLAM. Left panel compares RAMS and OLAM nudging both thermodynamics and mean winds (contours). Right panel shows the corresponding results obtained with OLAM with no wind nudging.

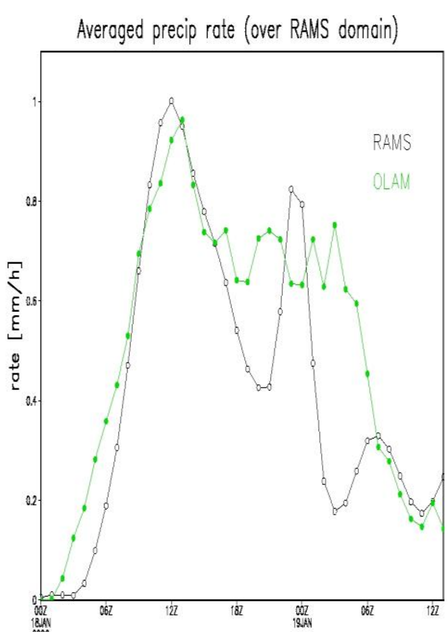

Figure 13 Time evolution of the averaged precipitation rate for RAMS and OLAM (2-moment microphysics and nudging winds).

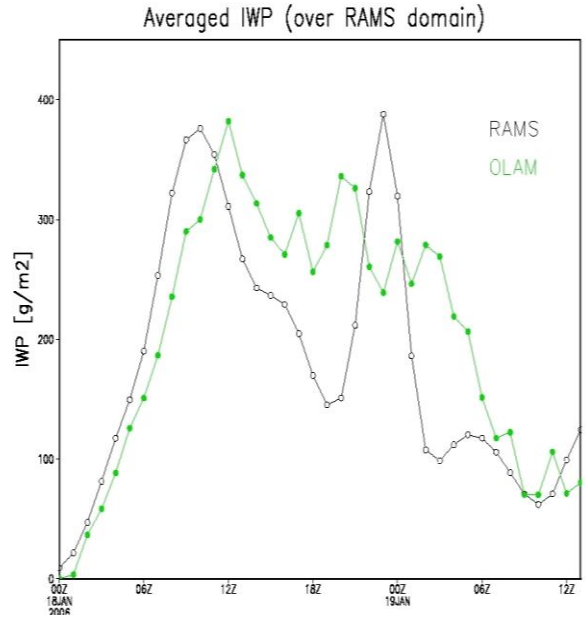

Figure 14 Idem Figure 13 but for simulated IWPs.

When we comparing 1-moment and 2-moment OLAM runs similar spatial patterns were simulated for accumulated precipitation (e.g., Fig.15) and for IWP (not shown). As mentioned above, we also compared simulations in which the θ_{il} factor (θ_{il}/θ ratio) was nudged or not. For those cases, differences were negligible as it can be seen in Fig. 16

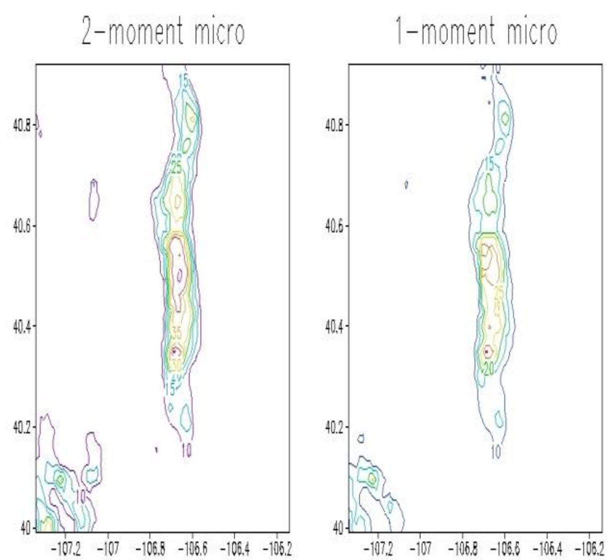

Figure 15 Comparison of simulated LWE accumulated precipitation for runs with different microphysical configurations.

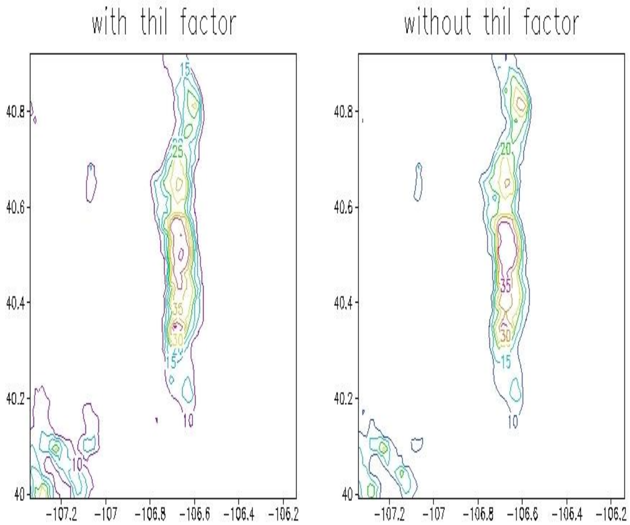

Figure 16. Idem Fig. 15 but comparing two nudging options.

4. DICUSSION

OLAM was evaluated for for two cases that differ significantly in nature: monsoonal tropical convection over the north of Australia and orographic precipitation in Colorado. The general performance of OLAM was good. We have several other runs in process to identify the optimal model configurations for these cases and time periods. In addition, we are performing simulations covering the entire 16 day-period of TWP-ICE field experiment, and a new series of OLAM tests is planned for another Colorado wintertime event for which RAMS performed poorly.

5. ACKNOWLEDGEMENTS

This research was funded by DOE Contract 66612P in which the University of Miami was prime contractor and CSU was a sub-contractor.
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6. REFERENCES

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