P1.72 EXTREME PRECIPITATION EVENTS OVER SOUTHERN MEXICO: SENSITIVITY OF WRF SIMULATIONS TO CLOUD MICROPHYSICS PARAMETERIZATIONS.

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1. INTRODUCTION

Mexico is characterized by a variety of climates, from extreme desert conditions in the Northwest region to tropical jungle in the Southeast (between 15º N and 18º N). The state of Oaxaca is located between 15.65º and 18.65º north latitude, and between 93.86º and 98.53º west longitude, southwest of the Tehuantepec Istmus. This region that receives over 2000 mm annual average of accumulated precipitation, is characterized by a very complex topography, with mountain ranges reaching 3000m above mean sea level less than 100Km from the coasts, enhances the potential of orographic precipitation (Fig 1).

The purpose of this investigation is to evaluate the role that WRF-model microphysics parameterizations have in the development of extreme precipitation events in the southern state of Oaxaca, Mexico, a region that by the characteristics mentioned above, is very susceptible to flooding and landslides.

Considering only the rainy summer season in Mexico (from May to October), gamma PDF's were constructed at each climatology station of selected coastal regions in Oaxaca. Daily accumulated precipitation values over the 95th percentile of the gamma PDF were selected to identify extrema. This study concentrates mainly on three cases.

The first one (0600 GMT 04 June 2008) was produced by the remnants of the tropical storm Arthur (31 May 2008 through 01 June 2008) that induced instabilities in the region of the Gulf of Tehuantepec. Later, an easterly wave by 1200 GMT 03 June 2008 originated a cyclonic system that was not documented by the National Hurricane Center. On June 4 2008, 180 mm of daily accumulated precipitation fell at the location of Union Hidalgo. Figure 2a shows the UV satellite image at the time of event.

The second case (0600 GMT 07 July 2008) originated from the remnants of the tropical depression 5E in the Pacific Ocean (5 -7 July 2008), an eastward propagating disturbance from the Pacific and a northwestward flow from the Caribbean Sea, resulting in strong confluence in the Isthmus of Tehuantepec. Puerto Angel recorded 115.3 mm of precipitation on 7 July 2008 (Fig 2b).

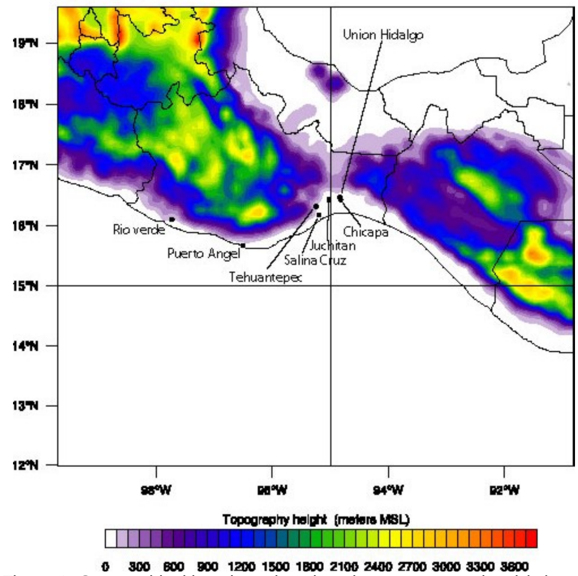

Figure 1. Geographical location, elevation above mean sea level (m) and station points used.

Finally, the third case (2300 GMT 23 September 2008) is linked to easterly waves that produced deep convection in the Isthmus of Tehuantepec and along the coast of the state of Oaxaca. Satellite images (Fig 2c) show that it was a moderate size convective system the one responsible for the 215 mm of precipitation recorded at Rio Verde in only one day.

The three cases selected for this study exceeded by far the 95th percentile values of 90, 90 and 50 mm of daily accumulated precipitation, respectively. We only present here the simulation results corresponding to the first two cases.

2. INPUT DATA AND CHARACTERISTICS OF THE SIMULATIONS

WRF-ARW was selected to simulate the cases described above. Three one-way nested domains were used, with 8km grid spacing and explicit convection in the innermost, to compare with CMORPH precipitation estimates. FNL analysis provided the initial and lateral boundary conditions

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for simulations every six hours. The Mellor-Yamada-Janjic parameterization was selected for boundary layer processes and Eta model for those in surface layer. The Kain-Fritsch cumulus parameterization was used for the two coarser domains.

As for the microphysics, only single moment parameterizations such as three and five class (WSM3 and WSM5 respectively), Lin et al. and Thompson et al. were considered. Additional runs without orography but with Thompson microphysics were considered to evaluate differences in storm intensification and development.

Simulations of each case were initiated 8 hours before the beginning of the extreme precipitation event (according to satellite images) plus 6 hours of spin up time, hence, the initial times were 1200 GMT 03 June 2008, 0600 GMT 06 July 2008 and 0600 GMT 23 September 2008 for each event respectively.

Streamfunction at 700 hPa, hourly precipitation tendency and daily total accumulated precipitation in stations near the observation stations are analyzed. To locate accurately station points, bilinear interpolations from WRF grid points were done.

3. RESULTS

3.1 Simulations for 0600 GMT 04 June 2008.

The evolution of the streamfunction at 700hPa (Fig. 3) does not show a significant difference between simulations with the different microphysical schemes. However, the one with no microphysics shows a slower temporal evolution of the circulating system inland (ie, it is producing a rotational and translational effect).

All simulations with or without different microphysical schemes developed a cyclonic mesoscale system that lived and persisted over land. In reality, the cyclonic system made landfall on 2315 GMT 03 June 2008 and dissipated over the mountains of western Chiapas. Hence, none of these simulations could properly resolve the real mesoscale situation and therefore the spatial precipitation pattern neither, as shown in figure 4 when comparing with CMORPH image.

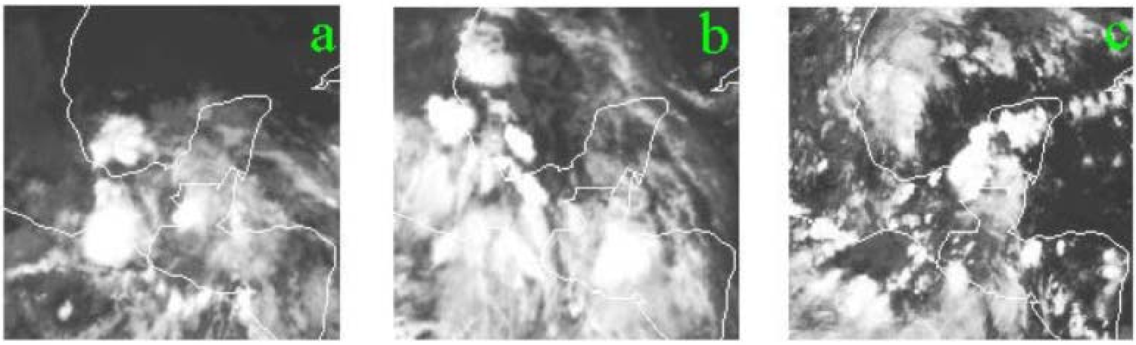

Figure 2. IR images from GOES showing time of precipitation. a. For the first case at 0600 GMT June 4 2008. b. For the second case at 0630 GMT July 7 2008. c. For the third case at 2215 GMT September 23 2008.

An important aspect to consider is the fact that at the zone of the Gulf of Mexico, precipitation patterns are not explicitly solved at all.

Observed precipitation values at station points where maxima occurred varied significantly (figure 5), indicative of the very small scale of convection. Comparing these values with those simulated at observation points, different totals were obtained and none of the simulations can accurately reproduce precipitation from convective systems.

3.2. Simulations for 0600 GMT 07 July 2008.

The confluence zone generated by the synoptic situation is simulated accurately, at 700 hPa level (figure 6), there is no significant difference among microphysics simulations even taking into account the one with no microphysics parameterization, at least for the time of interest. Hence, at a first sight, this is telling us that the mesoscale system dominated over convection.

The spatial precipitation pattern (figure 7) using Lin and Thompson parameterization schemes fit better to satellite image in the area of the Gulf of Tehuantepec (figure 2b) in comparison with the rest. Accordingly to station points, observed values are in better agreement with the results obtained with the Thompson microphysics excepting the one from Tehuantepec station (figure 8). It is worth to remark that CMORPH values are sub-estimated in this geographic area, as we have already seen in the previous case. Because in this case, the CMORPH value is greater than the one reported, we speculate that this value cannot be trusted.

Clearly, the assumptions made in the different microphysical schemes are important for the precipitation from mesoscale systems. A comparison between GOES IR satellite imagery and

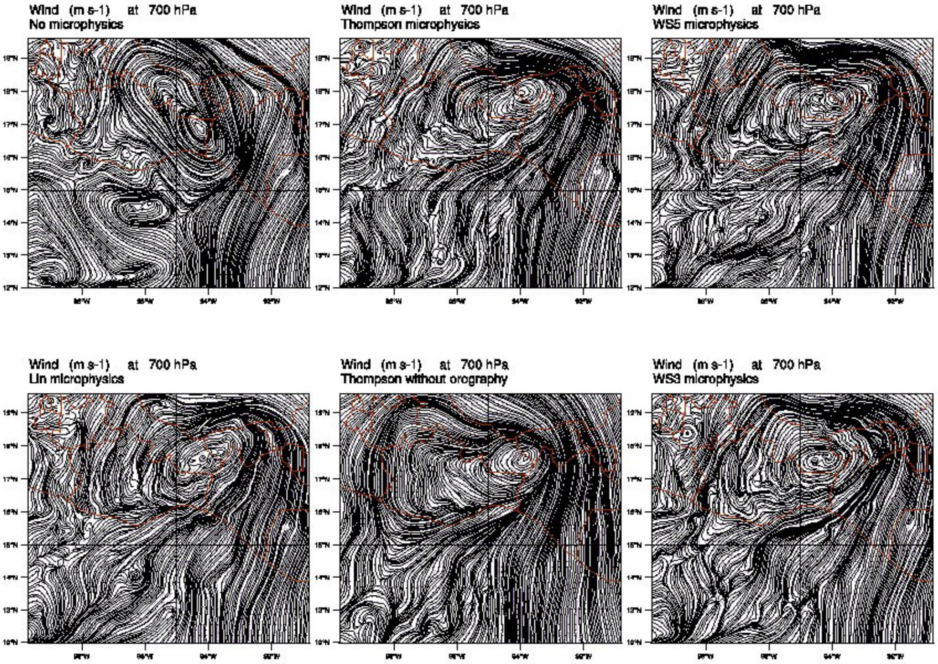

Figure 3. Stream function panel at 0600 GMT 4 June 2008. Upper left: No microphysics. Upper center: Thompson scheme. Upper right: WSM5 scheme. Bottom left: Lin scheme. Botton center: No orography and Thompson scheme. Bottom right WSM3 scheme.

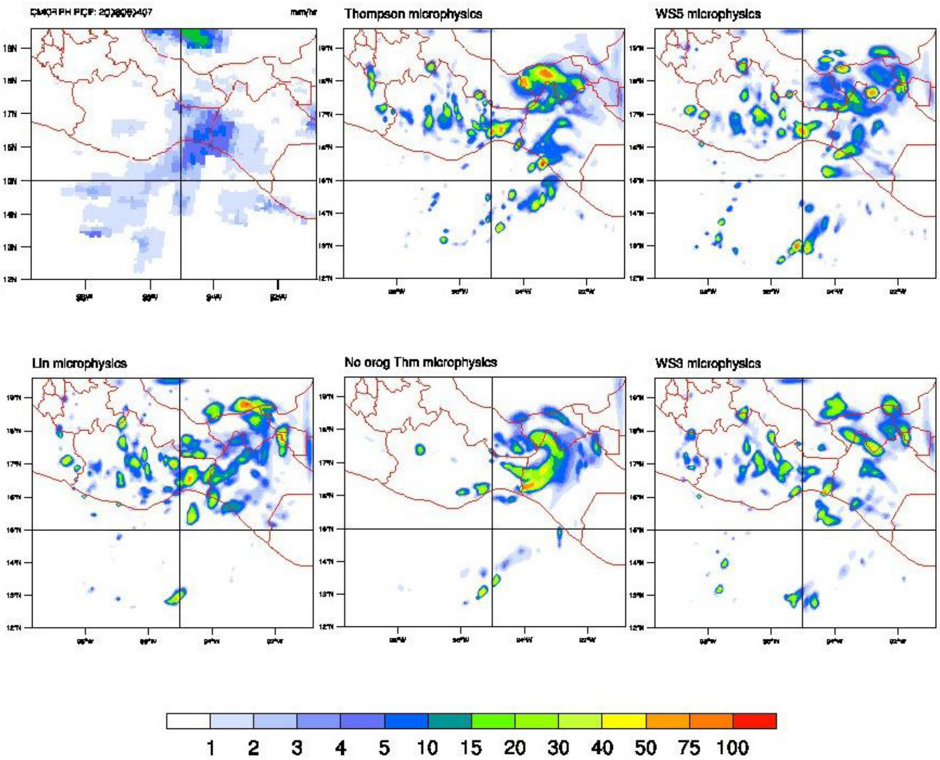

Figure 4. Precipitation tendency since 0500 GMT 4 June 2008 to 0600 GMT 4 June 2008 (mm). Upper left: CMORPH estimate, upper center Thompson scheme, upper right WSM5 scheme. Bottom left: Lin scheme, bottom center: No orography with Thompson scheme, bottom right: WSM3 scheme

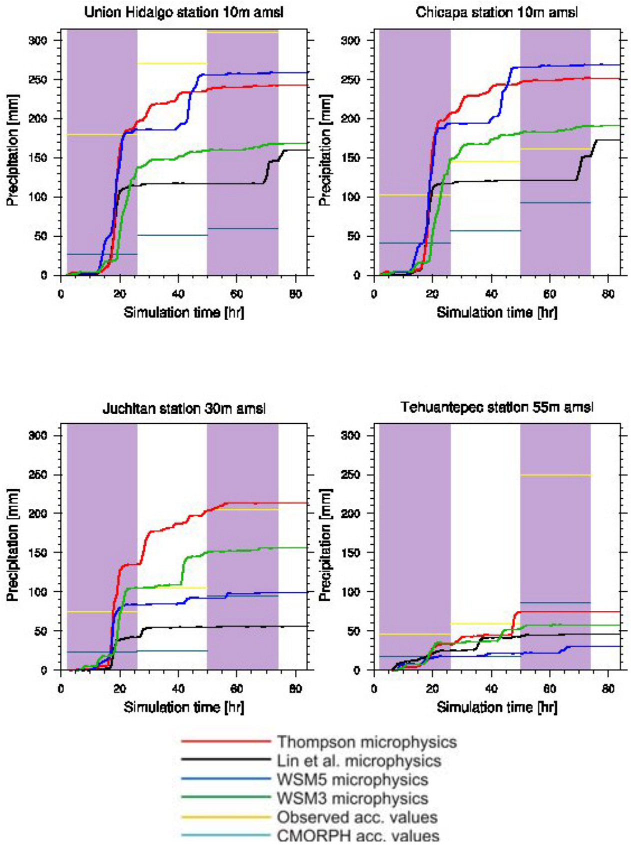

Figure 5. Total accumulated precipitation at station points for Case 1 under different microphysics parameterization schemes. Upper left, Union Hidalgo station. Upper right, Chicapa station. Bottom left, Juchitan station and bottom right, Tehuantepec station. Purple and white sectors show the 24 hours of observation time whose values are denoted by the yellow line. Cyan lines indicate CMORPH accumulated values at the same interval.

CMORPH estimates, indicates that the simulated precipitation pattern is slightly shifted to the left at 1300 GMT 07 July 2008. It is also noteworthy that the pattern of the streamfunction without microphysics does not show the cyclonic system generated at a later time 1200 GMT 07 July 2008 south of Puerto Angel (15.5N, 96.5W).

Again we must mention that in the region of the Southern Gulf of Mexico, precipitation is not explicitly solved as can be seen in figure 7.

3.3. Simulations for 2300 GMT 23 September 2008.

At 700 hPa level, the simulated confluence zone shows that even though the pattern is similar among all microphysics simulations, there is a notorious difference in the flow convergence located at 13.5N, 98.5ºW.

The convective areas, located left of these points, are responsible of such behavior. WS5 and Thompson, generate more precipitation than WSM3. In addition, the convergence is highly enhanced using the Lin and WSM3 schemes and smoothed with the Thompson and WSM5 schemes. Microphysics assumptions are again affecting this mesoscale system.

All simulations captured the small convective system located at Rio Verde Oaxaca and the features mentioned above at the Pacific. However, the values of precipitation are very low compared with the only available station in the area and none of the simulations could reproduce nor approximate the observation.

It is well known that the presence of an easterly wave enhances convection. However, any microphysics parameterization scheme could not reproduce at all this effect in

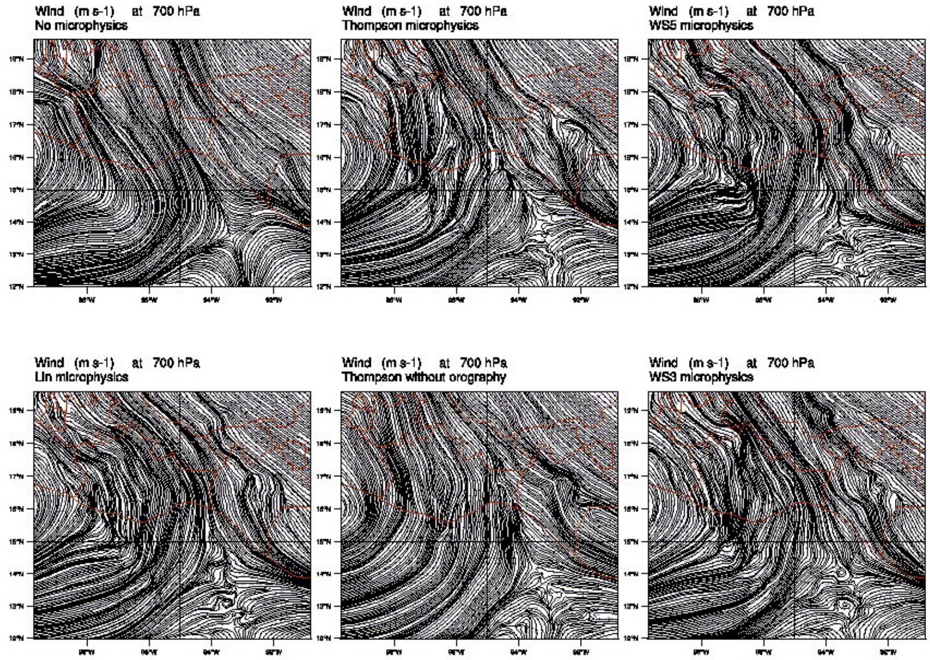

Figure 6. As in figure 3 but for case 2 at 0600 GMT 7 July 2008.

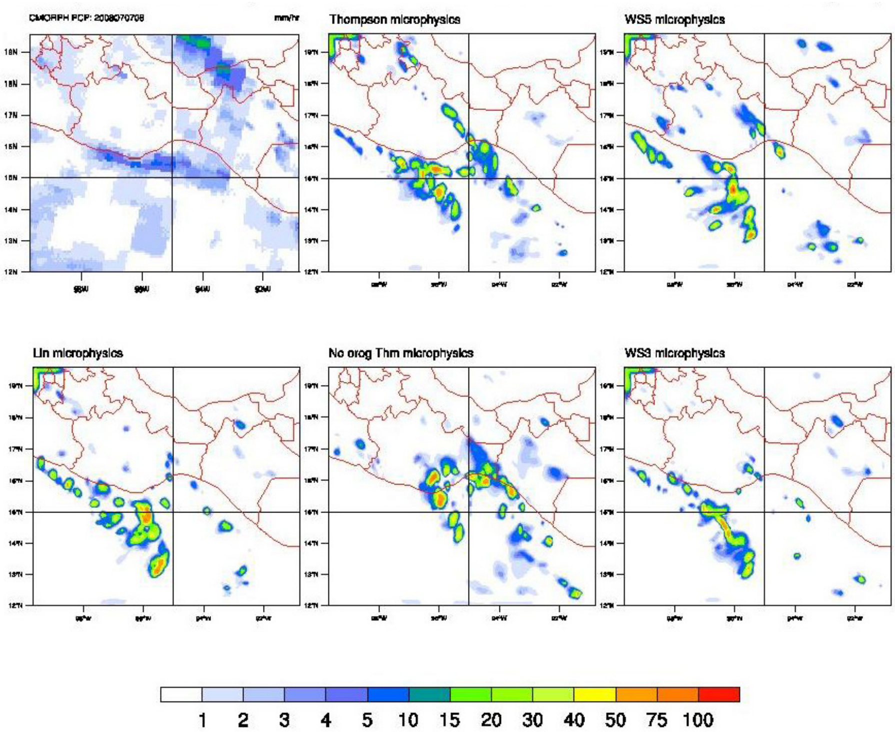

Figure 7. Precipitation tendency since 0700 GMT 7 July 2008 to 0800 GMT 7 July 2008 (mm) as in figure 4.

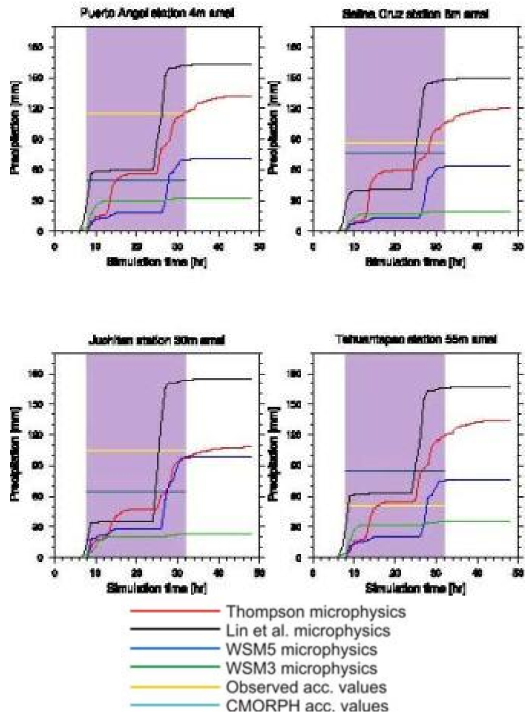

Figure 8. Total accumulated precipitation at station points for Case 2 as in figure 5. Upper left, Puerto Angel station. Upper right, Salina Cruz station. Bottom left, Juchitan station and bottom right, Tehuantepec station.

precipitation is grossly sub-estimated (not shown), implying that the moisture fields in the Gulf of Mexico and Isthmus of Tehuantepec are not well defined despite the fact that FNL analysis have all the information available.

4. CONCLUSIONS

Simulations of extreme precipitation events over southern Mexico considering explicit convection and microphysics were not able to capture and simulate local convection properly.

Being convection the main mechanism of storm development in the area, any microphysics parameterization scheme was not able to produce extreme precipitation.

The inclusion of the different microphysics schemes affected the mesoscale systems that originated such events leading to:

1. Change in the temporal evolution of cyclonic systems through rotational and translational effects.
2. Enhancement of confluences areas near convective zones.
3. Very different accumulated precipitation upon scheme in presence of convective activity.

However, for this geographic area, when the flow is coming from the Pacific (figure 6), it is possible to obtain very good results with the Thompson scheme (figure 8).

Finally, none of the simulations could capture the effects of enhancement of convection by easterly waves. This is because when comparing with CMORPH estimates, no precipitation was obtained, mainly at the Gulf of Mexico, suggesting that initial conditions in the area must be improved to get better forecasts in both basins. Hence, it is difficult to draw definite conclusions on the effects of microphysics in such systems.

Further research needs to be done in cumulus parameterization for tropical convective areas such as the Tehuantepec Gulf.

5. REFERENCES

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