MM5 model validation under different cumulus parameterizations

René Lobato[1], C. Cario[2], N. Hernández[2], and R.E. Morales[3]
(1) Mexican Institute of Water Technology, (2) Mexican Weather Service, (3) University of Veracruz.

I. Introduction

The Mexican Weather Service (MWS) has been running the MM5 model in an operational basis, and during nearly two years the model has provided useful information to forecasters. Though a daily subjective evaluation is performed, we have started a objective validation primarily based on case event studies carry on statistical analysis, and moving ahead with systematic supervision of the model outputs we are setting up an automatic procedure for reviewing the model's abilities to represent the physics of the basic variables such as rainfall and surface temperature, these are the main concerns for an operational facility. Unfortunately rainfall is the most difficult variable to predict from the short to the long ranges. Though many efforts are dedicated to improve the knowledge on the physics of this process, still a long way to go for understanding the basic stages, making it even harder to predict for convective systems linked to highly irregular terrains (Wang and Seaman, 1996), such is the case for Mexico.

This paper shows the results of two case studies, one for the summer time and the other for winter and for each case, four different cumulus parameterizations were considered for this study: Betts-Miller, Grell, Kain-Fritsch and Kuo, and one ensemble of the former ones (mean areal average of the four parameterizations), all these outputs simply correlated with recorded rainfall data from climatic stations.

Corresponding author address: René Lobato. Mexican Institute of Water Technology. Paseo Cuauhnahuac 8532, Jiutepec, Morelos, 62490, México. Tel. (777) 319-3001. e-mail: rlobato@tlaloc.imta.mx

During summer months Mexico is under the occurrence of mesoscale systems and some being defined as complex, even that they occur at lower latitudes (Madox, 1980), these systems basically are originated by the strong vertical unstability and the moisture advected from both the Gulf of Mexico and the Pacific Ocean, it is very common to experience an intense and short duration rainfall which in a few kilometers away may have not noticed. Though explicitly resolved rainfall is important, for Mexican conditions we find that it is more important the parameterized cumulus convective rainfall.
In a more general context the skill for prediction rely much on the initial conditions. To run the model we take the outputs from the AVN model but this model indeed takes global data both from surface and atmosphere. In the region we are focusing there are a few upper air stations and surface synoptic observatories, therefore the AVN must be considered with care since sparse data may bring unreliable results.

II. Model concerns

There have been some attempts for intercomparisson in mesoscale models, from integrated models (Cox et al, 1998; Colle et al. 2000) up to single modules representing one physical process such as cumulus convection (Alapaty et al. 1994). It is complex to establish a system with all the variants used especially for operational purposes, even tough that costs of computational resources are reduced; the handling of massive data turns out to be very difficult.

In many occasions the skill of a model output to represent the process involved is validated against true rainfall (Giorgi, 1991), unfortunately the matching of these two results is not simple, model outputs show regular spaced grids but real data does not, and sometimes the representation of the process is unrealistic since the sparseness may not capture the temporal variability.

For our study we accumulated the modeled rainfall outputs in a daily basis trying to match the schedule when true data is collected at 8:00am local times. At the same time, explicitly resolved rainfall was added to the cumulus parameterized, at this stage it is really complex to discern the amount of rainfall that comes from either process.

III. Spatial representation

Mexico´s geography is quite diverse, from the arid and desert regions on the north to the humid semitropical lands in the southeastern part. Under such scenarios, it is expected that different atmospheric circulations prevail for each climatic region. For such reason, it was necessary to separate these regions so that each one is evaluated accordingly. Grid cells of approximately 2^0x2^0 were adapted and within each cell all the modeled grid points were matched with the interpolated real data fitting in this case 16 points, Figure 1, for each cell and with these points carry on with the basic statistical analysis (mean, variance and r^2).

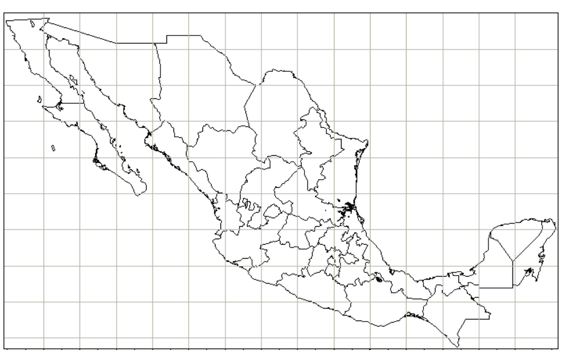

Figure 1. Grid cell domain for statistical validation.

IV. Case studies

a) Winter case

The winter case described here occurred from February 12-19, 2001. A cold front affected the Norwest Mexican region while in the central part a ridge stayed stationary while in the southern part light rains occurred. The Jet Stream was located over Sonora and Chihuahua. During the last days, moisture from the Gulf of Mexico, Figure 2, due to the passage of the front cold left moderate rains over the states along the Gulf.

The considered event was chosen because this is the typical system which regularly appears during the season, in the winter case a cold front from the North Pole advected a massive cold air, which reached a warm front coming from the Atlantic Ocean, the occlusion brought a band convective rainfall that eventually crossed the entire country. Figure 3, shows the correlation coefficients of the accumulated modeled rain for the whole event. The satellite image is just a snapshot but en reality the Jet traveled southeastward reaching at later times the Yucatan Peninsula, this figure shows also this passage.

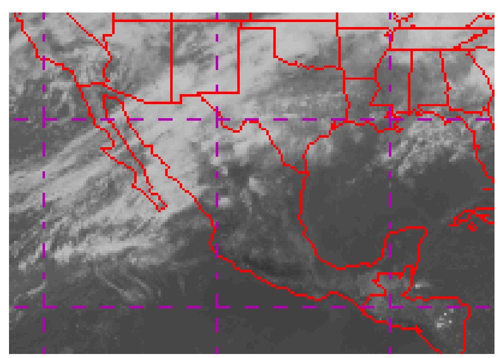

Figure 2.- Satellite image showing winter prevailing conditions for Mexico.

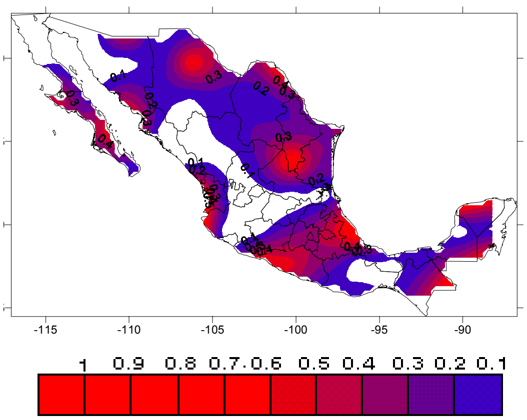

Figure 3. Ensembled cumulus parameterization outputs correlated with raingauge data.

b) Summer case

Summer months is when most of the rain falls in Mexico, being surrounded by two mayor mountain chains (Sierra Madre Occidental and Sierra Madre Oriental) moistuire fluxes arrive from both the Pacific and the Atlantic Oceans with a strong orographic forcing when interacting with these topographic elevations. Indeed this is the most difficult time for forecasters trying to predict such weather events. The event we are describing lasted approximately 10 days (13-18 September, 2000), figure 4 shows one satellite image showing the prevailing synoptic features, low level moisture crossing in the middle of the country, the active ITCZ in its northern most position and convergence along both sierras. Figure 5 shows the statistical correlation analysis of the ensemble modeled outputs (Betts-Miller, Grell, Kain-Fritsch and Kuo) with real raingauge data. Accumulated along the entire weather event.

IV. Conclusions

When comparing or correlating data careful consideration must be taken due to the representativeness, especially when the true data is sparse or the source does not match the scale of the phenomenon we want to diagnose.

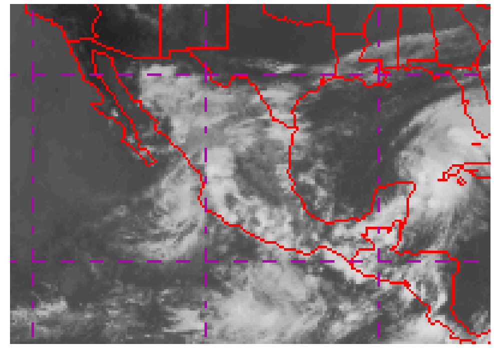

Figure 4. Satellite image showing prevailing synoptic weather conditions.

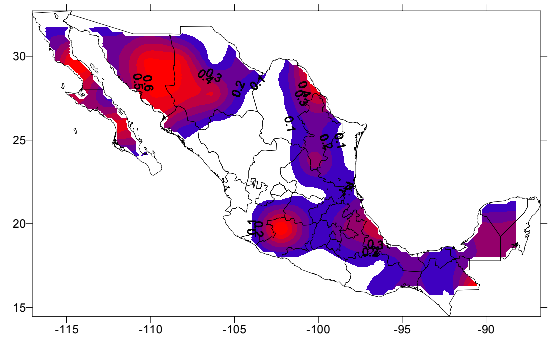

Figure 5. Correlation analysis (r^2) for the ensembled parameterizations (same color bar as Fig. 3).

For future model validations it is required to use data from denser networks. Unfortunately in Mexico the number of climatic stations is declining dramatically. A solution to overcome this problem will be addressed by requesting the assistance of the general public though a Mexican cooperative climate network.

For summer rainfall, in general the four parameterizations are closely correlated, we see that convective rainfall is more important that the explicitly resolved rainfall. On the other hand, for winter rainfall it is Grell the less correlated parameterization. Actual model validation is conducting a daily analysis in which for each cell, as described in this paper, is being correlated. The values are recorded as time series data bringing more detail to the regional validation.

V. References

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