J3.2 PHYSICAL INITIALIZATION FOR THE REGIONAL SPECTRAL MODEL

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1. INTRODUCTION

Although atmospheric analyses and reanalyses are now providing physical realistic fields for many variables, precipitation remains problematic. Physical initialization (PI) has been proposed as a technique for improving precipitation and related hydroclimatological simulation skill. For this reason, the Scripps Experimental Climate Prediction Center (ECPC) is now implementing a PI procedure in the Regional Spectral Model (RSM).

We summarize here some of the improvements obtained for climate simulations over two distinct domains: (1) U. S. and Mexico during a Southwest-Mexico monsoon season; and (2) South America during the rainfall season of the Amazon region and increased activity of the South Atlantic Convergence Zone (SACZ).

2. MODEL

The ECPC RSM, which was previously described by Juang and Kanamitsu (1994); Anderson et al. (2001); and Roads (2003), used for these experiments had 60-km resolution and 28 levels in the vertical. A Mercator projection was used for the projection of the regional grid. The RSM is a primitive equation model, with similar physics as the driving NCEP-DOE AMIP-II reanalysis (R-2) Global Spectral Model as reported in Kanamitsu et al. (2002).

3. DATA SET

The ECPC RSM initial and boundary conditions were obtained from the coarser-scale R-2 (1.875° resolution) and 28 vertical levels.

Daily rain rates were provided by the Climate Prediction Center (CPC) precipitation analysis (see Higgins et al., 2000) over the U. S. domain. R-2 precipitation fields were used for the rest of the model domain, including Mexico. The CPC precipitation was provided on a regular grid of 0.25º.

SSM/I-OLR precipitation estimates were used in the simulations over South America. The SSM/I-OLR estimate was provided on a Gaussian grid of 0.7º. The NOAA/NESDIS SSM/I algorithm (Ferraro and Marks, 1995) was used to estimate the rain rates.

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All rainfall fields were bi-linearly interpolated to the regional model's grid.

The sea surface temperature (1 degree resolution) was taken from the PIRCS data set.

4. PI PROCEDURE

This scheme basically adjusts the humidity profile using the difference between the "observed" and predicted rain rates as factor of this adjustment. In order to provide consistent temperature profiles, the cumulus and large-scale precipitation parameterizations are then immediately called. This methodology differs from the procedure used by the FSU Nested Regional Spectral Model (Nunes and Cocke, 2003), where a modified Kuo parameterization is the convection scheme, however the general PI procedure follows the same structure, as shown in Fig. 1.

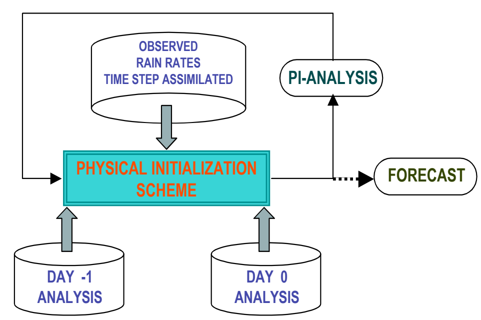


Fig. 1 – General overview of a PI procedure considering a data assimilation system.

5. RSM 60-km EXPERIMENTS

The experiments were performed during summer over the U. S. and Mexico, for July-August-September, starting on July 1st, 1999 at 0 UTC; and South America, during January, starting on January 1st, 1999 at 0 UTC.

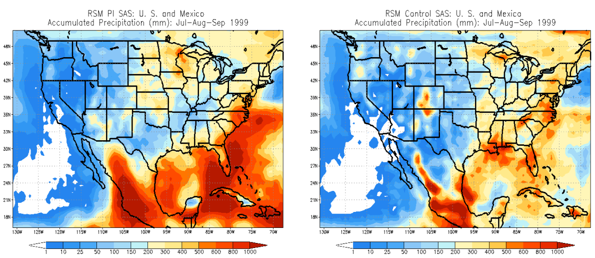
The control simulations were not initialized. In the PI simulations, the rain rates were updated every 24 hours, and the moisture adjustment took place every time-step, which was 3 min. The boundary conditions were updated every 6 hours.

The Simplified and Relaxed Arakawa-Schubert cumulus convection parameterizations, respectively, SAS and RAS, were used during PI and control experiments.

5.1 *U. S. and Mexico*

The model's integration started on July 1st, 1999 at 0 UTC and ended on October 1st, 1999 at 0 UTC, from [131ºW; 16ºN] to [68°W; 51°N].

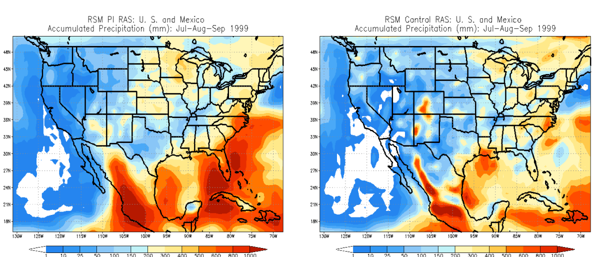
Fig. 2 shows the accumulated precipitation during PI (Fig. 2a) and control (Fig. 2b) simulations, where SAS was the convection scheme used.



(a) (b)

Fig. 2 – RSM 60 km accumulated precipitation (mm) over U. S. and Mexico, during July-August-September 1999 for: (a) PI and (b) control simulations, using SAS as the cumulus convection parameterization.

In Fig. 3, the accumulated precipitation for PI (Fig. 3a) and control (Fig. 3b) simulations are displayed, where RAS was the cumulus convection parameterization.



(a) (b)

Fig. 3 – Same as Fig. 2, except RAS was used as the cumulus convection parameterization.

Fig. 4 represents the verification field or merged precipitation analysis for the same domain and time period of the simulations. The verification data was used for assimilation as well.

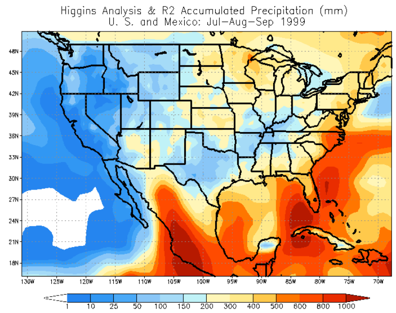


Fig. 4 – Merged accumulated precipitation analysis (mm) (Higgins data and R-2 precipitation fields) over U. S. and Mexico for July-August-September 1999.

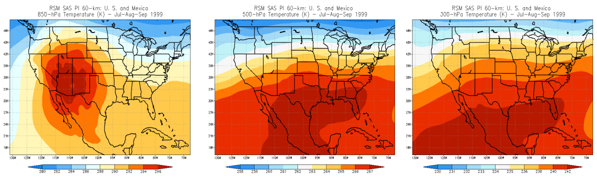
Table 1 shows the evaluation for the model's monthly accumulated precipitation in terms of spatial correlation coefficients and root mean square errors (RMSE).

Table 1 – Monthly Accumulated Precipitation Evaluation for U. S. and Mexico domain.

July 1999	**Corr. Coeff.**	**RMSE (mm)**
PI: SAS/RAS	**0.97/0.97**	**38.7/23.9**
Control: SAS/RAS	**0.65/0.66**	**79.6/77.5**
August 1999	**Corr. Coeff.**	**RMSE (mm)**
PI: SAS/RAS	**0.96/0.98**	**40.5/22.8**
Control: SAS/RAS	**0.52/0.58**	**90.9/85.3**
September 1999	**Corr. Coeff.**	**RMSE (mm)**
PI: SAS/RAS	**0.97/0.98**	**46.8/24.1**
Control: SAS/RAS	**0.74/0.76**	**89.9/86.3**

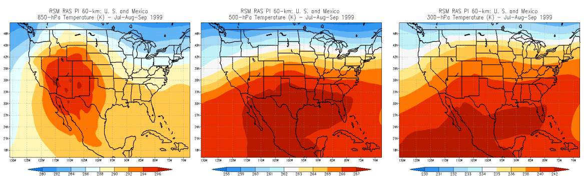
The PI simulations have successfully assimilated the "observed" rain rates as demonstrated by the high spatial correlation coefficients and the reduced RMSE. By the end of the first day of the simulation period, the correlation coefficient reaches values above 0.9. Then, this high correlation value is maintained or increased during all simulation intervals (not shown).

The impact of the precipitation assimilation on the temperature fields at 850 hPa, 500 hPa and 300 hPa can be seen by comparing Fig. 5 for SAS, and Fig. 6 for RAS with the reanalysis II (Fig. 7). RSM + PI + SAS has increased temperature values at low and upper levels than RSM + PI +RAS and R-2, which is in agreement with the slightly higher precipitation values observed in RSM + PI + SAS.



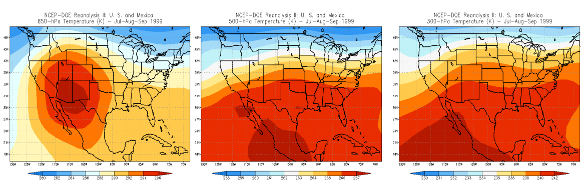
(a) (b) (c)

Fig. 5 – RSM + PI 60 km mean temperature (K) for July-August-September 1999 over U. S. and Mexico at (a) 850 hPa, (b) 500 hPa and (c) 300 hPa, where SAS was the cumulus convection parameterization.



(a) (b) (c)

Fig. 6 – Same as Fig. 5, except RAS was used as the cumulus convection parameterization.



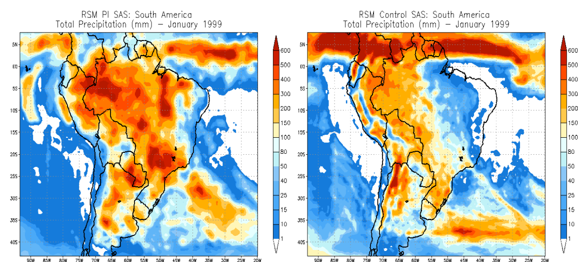
(a) (b) (c)

Fig. 7 – R-2 mean temperature (K) for July-August-September 1999 at (a) 850 hPa, (b) 500 hPa and (c) 300 hPa over U. S. and Mexico.

5.2 *South America*

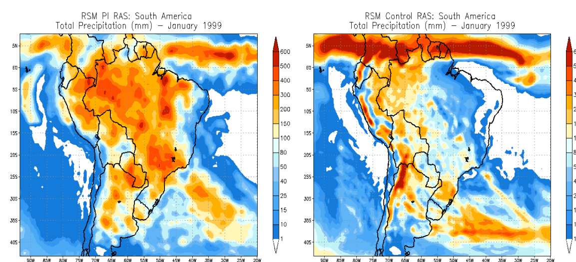
January 1999 was chosen due to the presence of intense convective patterns. The Amazon wet season had already started and the SACZ was active.

Fig. 8 represents the monthly accumulated precipitation for January 1999, for PI (Fig. 8a) and control (Fig. 8b) simulations, where SAS was the cumulus parameterization used. The accumulated precipitation for the simulations using RAS were displayed in Fig. 9a,b, respectively, PI and control experiments.



(a) (b)

Fig. 8 – RSM 60 km accumulated precipitation (mm) over South America, during January 1999 for: (a) PI and (b) control simulations, using SAS as the cumulus convection parameterization.



(a) (b)

Fig. 9 – Same as Fig. 5, except RAS was used as the cumulus convection parameterization.

In Fig. 10, the SSM/I-OLR rainfall estimate for January 1999 is shown over South America at the model's resolution.

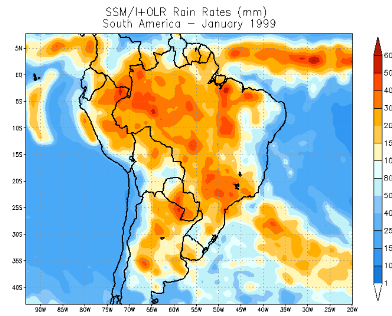


Fig. 10 – SSM/I-OLR rainfall estimate (mm) over South America for January 1999.

Table 2 displays corresponding evaluations for the South America domain and time period for all simulations (PI and control using SAS and RAS).

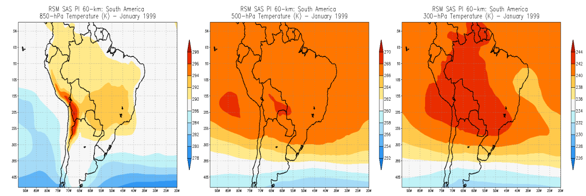
Table 2 – Monthly Accumulated Precipitation Evaluation for South America domain.

January 1999	Corr. Coeff.	RMSE (mm)
PI: SAS/RAS	**0.98/0.98**	**50.2/26.9**
Control: SAS/RAS	**0.37/0.31**	**196.0/189.8**

Over South America, the precipitation assimilation again surpasses 0.9, and the RMSE was dramatically decreased as shown in Table 2. This high correlation value was obtained by the end of the first day of simulation and kept for all period as same as U. S. and Mexico simulations (not shown).

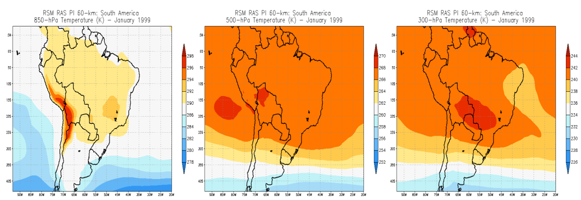
For the South America domain, the mean temperature, for January 1999, is displayed in Fig. 11, 12 and 13, respectively, for model's outputs using PI and SAS, PI and RAS, and R-2 at 850 hPa, 500 hPa and 300 hPa.

Systematically, the precipitation assimilation using SAS had slightly higher precipitation values as well as the temperature fields at upper levels. Nevertheless, as seen in U. S. and Mexico domain, the precipitation assimilation scheme did not degrade the temperature fields, and the SAS higher temperature values are consistent with the corresponding precipitation patterns.



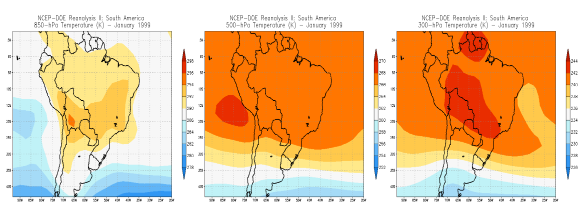
(a) (b) (c)

Fig. 11 – RSM + PI 60 km mean temperature (K) for January 1999 over South America at (a) 850 hPa, (b) 500 hPa and (c) 300 hPa, where SAS was the cumulus convection scheme.



(a) (b) (c)

Fig. 12 – Same as Fig. 11, except RAS was used as the cumulus convection scheme.



(a) (b) (c)

Fig. 13 – R-2 mean temperature (K) for January 1999 at (a) 850 hPa, (b) 500 hPa and (c) 300 hPa over South America.

6. CONCLUSIONS AND FUTURE WORK

Preliminary evaluations of the PI implementations indicate that the RSM was able to successfully assimilate the merged precipitation analyses and SSM/I estimates as well. The correlation coefficients exceeded 0.9 and the spin-up problem was noticeably reduced during the continuous assimilation period.

The rainfall nudging does not degrade the RSM temperature fields; in fact, they are well correlated with the R-2 fields.

We are now attempting to implement physically initialized analyses as part of our effort to develop useful downscaled reanalysis fields.

7. REFERENCES

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