EXTENDED RANGE FORECASTS OVER SOUTH AMERICA USING THE REGIONAL ETA MODEL

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Abstract

An 80 km NCEP Eta model was configured to run over South American continent. This limited area model has 38 layers in the atmosphere and its domain includes part of the adjoining Atlantic and Pacific Oceans. The model was setup to perform one month forecasts. Results obtained from a dry season month and a rainy season month over South America in 1997 showed that the re-initialization of model at short range forecasts is not necessary. Diagnostics showed good mass conservation and no drying tendency, suggesting model stability for longer integrations. Both cases (dry and wet) reproduced the climatological signal of the forecasted months. The monthly accumulated total precipitation agrees well with the observations. These long-term runs using the Eta model over South America show satisfactory regional climate forecasts for this continent.

1. Introduction

The present resolution limitation of Atmospheric General Circulation Models (AGCMs) and Coupled General Circulation Models (CGCMs), which are dependent on the computer capability, to simulate smaller scale features of meteorological fields, makes the Regional Models very attractive in climate prediction. In many cases, small to synoptic features contribute to the precipitation fields which are not detected in GCMs and the prediction of precipitation led only by large scale features generally result in erroneous predictions.

A Regional Model, with higher resolution, can resolve the orography better than GCMs. For South America the model response to synoptic and subsynoptic systems is crucial, particularly for the South and Southeast regions which are frequently swept by frontal and convective systems

In an atempt to improve the climate prediction over South America, this study is carried out to evaluate the regional model performance for extended range forecasts. In this preliminary study, the regional Eta model was used to produce 1-month forecasts over South America under dry and wet conditions.

2. General characteristics of the model

The model was configured with 80 km resolution and 38 layers in the vertical. The domain covers most of South America, from about 13^o N up to about 55^o S, and part of the adjacent oceans. The prognostic variables are temperature, specific humidity, winds, surface pressure, turbulent kinetic energy and cloud water. The equations are solved on the E-grid and integrated through a split-explicit scheme based on a forward-backward and a Euler-backward schemes, both modified by Janjic' (1979). The finite space differences uses Janjic' method (1984). The convective parametrization uses a modified Betts-Miller Scheme (Janjic', 1994), turbulence is represented by Mellor-Yamada 2.5 scheme in the free atmosphere and Mellor-Yamada 2.0 in the surface layer. Further details on the model are given in Black, 1994, and Chou, 1996.

3. Experiments description

Two extended runs were performed: one in August 1997, a dry month for Central and Southeast South America , and another in November 1997, which is spring in Southern Hemisphere and a rainy month in those regions of the continent. The model was integrated from 1 August, 1997, 12 UTC, and from 1 November, 1997, 00 UTC using NCEP analyses as initial conditions. Forecasts from CPTEC/COLA GCM were taken as lateral boundary conditions. The global model input data used truncation T62 and 28 layer resolution. The boundaries were updated every 6 hours and the tendencies distributed linearly within this time interval. Initial lower boundary conditions used annual climatology of soil moisture. Sea surface temperature was taken from the weekly mean observations on the day 1 of the forecast and kept “frozen” during the one month integrations. Albedo was taken from seasonal climatology.

The regional Eta model has been used previously to describe summer circulation over South America (Tanajura, 1996). That climatology was built from short range forecasts. However, in the current work, the model performed continuous 30-day integrations, without being restarted. This allows the model to develop its own climate with less influence of the initial conditions, which originated from a coarser and different physics model. This continuous integration showed that the regional model was well configured, and conserving the necessary properties for stability.

4. Forecast verification

Verification shown here is based on the monthly total precipitation and on the equitable threat score for both months. Monthly total precipitation was prepared by the Brazilian Meteorological Institute (INMET), while the Equitable Threat Score (*ETS*) was based on daily surface observations from GTS plus automatic weather stations.

Equitable Threat Score can be calculated by the expression:

$$ETS = \frac{H - CH}{F + O - H - CH}$$

where $CH = (F \times O) / N$, F is the number of forecast precipitation events above a certain threshold, O is the number of observed events above the threshold, H is the number of hits, and N is the number of grid-points. The *BIAS* Score is defined as: $Bias = F/O$.   *ETS* and *Bias* scores are used together, and a perfect forecast is equivalent to $ETS=1$ and $Bias=1$. The amounts of precipitation were divided into 8 categories: 9, 30, 80, 150, 250, 400, 600, 800 mm.

4.1 Monthly Total Precipitation

a. Dry month run

The central part of the country was dry and no precipitation occurred during this month, as seen in the observational field (Figure 1a). The no-precipitation borderline was well captured by the regional model, however it was overdried in some parts of Northeast Brazil (NE) (Figure 1b). In the Amazon region and also in the South, where precipitation occurred regularly, the model forecasted closely the observed amounts. The model predicted values between 100 and 200 mm along the eastern coast of NE. These values were reported by INMET inland of NE and over the northern coast of Bahia. In addition to this standard observation network, automatic surface stations also reported a total precipitation of the order of 100 mm to the southern coast of Bahia, which was predicted by the regional model.

A comparison with the precipitation amounts produced by the global model showed that the regional model can create a climate of its own. The general pattern of the precipitation contours from the GCM forecasts are very similar to the observations, however, precipitation was forecasted for the observed no-precipitation regions (Figure 1c). Precipitation over South and Northeast Brazil are reasonably captured by both GCM and regional models.

b. Rainy month run

In November rains have resumed over the central part of the continent (Figure 2a). The general pattern of the forecast precipitation compares reasonably with observations, however a tendency for underestimating precipitation inland of NE repeats in this run. Isolated observed maxima of precipitation in the central states of Brazil are also missing from the forecasts, although the general amounts over 100 mm were forecasted. In November 1997, the El Nino event was well established with warm sea surface temperatures over the Pacific Ocean. During typical El-Nino years, negative anomalies of precipitation are observed over the Amazon. Over this region, the largest amounts in the regional model (Figure 2b) and in the observations ranged between 200 and 300 mm, which is close to climatology. The GCM forecast (Figure 2c) produced in general more rain than the regional model, over some parts of the country.

4.2 Threat and Bias Scores

a. Dry month run

Only grid points which contained at least one observation was included in the computation of Equitable Threat Score and Bias Score. The ETS and Bias curves show four different colors, which refer to the whole domain (SA, dark blue): North (NO, green), Northeast (NE, red) and Center-South (CS, light blue) regions. NO is located within the corner points [11° N, 90° W] and [15° S, 45°W], NE is within [11° N, 45°W], [15° S, 25° W], and CS, [15° S, 90° W], [50° S, 25° W]. The scores were based on the daily precipitation observation received at CPTEC, which include automatic weather stations, in addition to GTS data.

The Equitable Threat Score (Figure 3a) shows that the regional model produces good forecasts of precipitation at low amounts. For larger amounts, the number of observations are very small, and the significance of the result also becomes less reliable. The score drops sharply from the first category to the others. CS shows the best score among the three regions. NE shows the worst due to small number of observed precipitation events.

The Bias score corroborates part of the results from section 4.1.a. Precipitation values over Northeast of Brazil were underestimated as are indicated with Bias values smaller than 1. In NO, some countries, such as Colombia, reported only very few number of observations, the total monthly precipitation was therefore smaller than the forecasted amounts. These results are indicated by Bias score greater than 1 (Figure 3a). Over CS, the precipitation at low amounts is well forecasted by the regional model, however at higher amounts, the model overestimates it. The smaller number of rain observations in this period results in smaller score, as less number of events are counted.

b. Rainy month run

Very high values of ETS (Figure 3b) in the small rain categories show that the model captures well the precipitation region, the score drops sharply for categories of rain over 150 mm. Similar to the dry period, the Center-South region produces the best scores, followed by North, and the smallest are in Northeast. During this month, the Bias score are closer to 1 in the Center-South indicating good forecasts. In the North, there is still some overestimate of precipitation larger than 80 mm. In the Northeast, the underestimated precipitation is shown with Bias score smaller than 1 (Figure 3b).

5. Discussion and Conclusions

Extended runs of one-month length period were carried out with the Regional Eta model over South America. These runs were performed for a dry and a rainy month of South America regime in order to evaluate the model ability to produce regional climate forecasts for this continent.

Regional Eta model proved to be able to produce one month climate prediction for South America in a continuous run. The results were compared to the GCM forecasts in order to evaluate the positive contribution of the regional runs. The regional forecasts showed that the higher resolution could provide more detail to the forecasts, particularly for the surface fields (not shown). The magnitude of forecasted variables were in general closer to observations. It should be reminded that part of the quality of regional forecasts has dependence on the global model forecast quality.

The results from these preliminary tests are encouraging. The next steps of this work is to prepare the model for seasonal forecasting. The use of predicted sea surface temperatures are being considered, as well as an improved treatment of water transports in the soil and atmosphere that can presumably produce improved long-term forecasts with the Eta model over South America.

6. References

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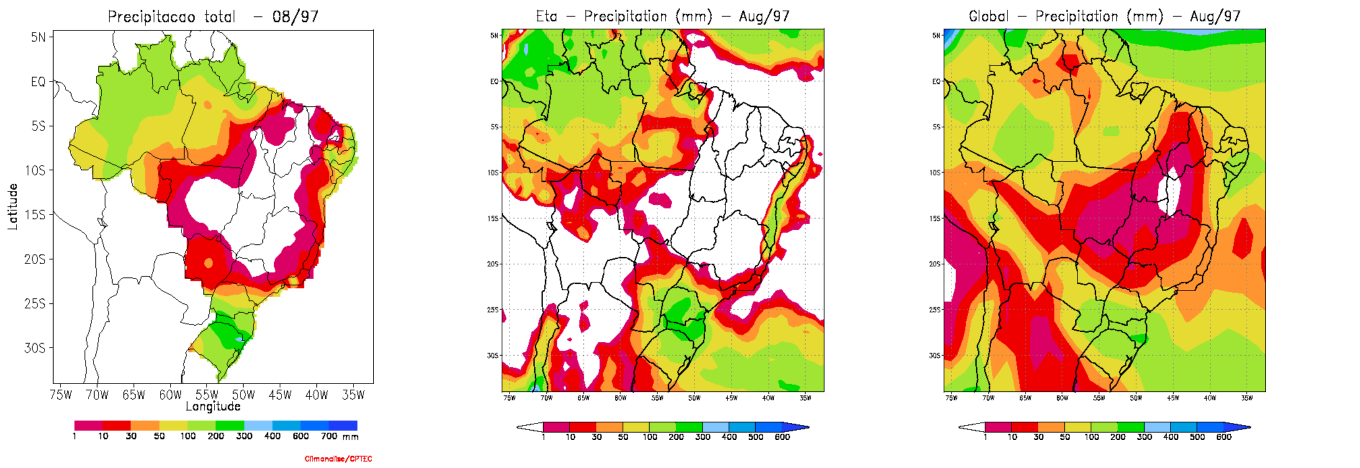
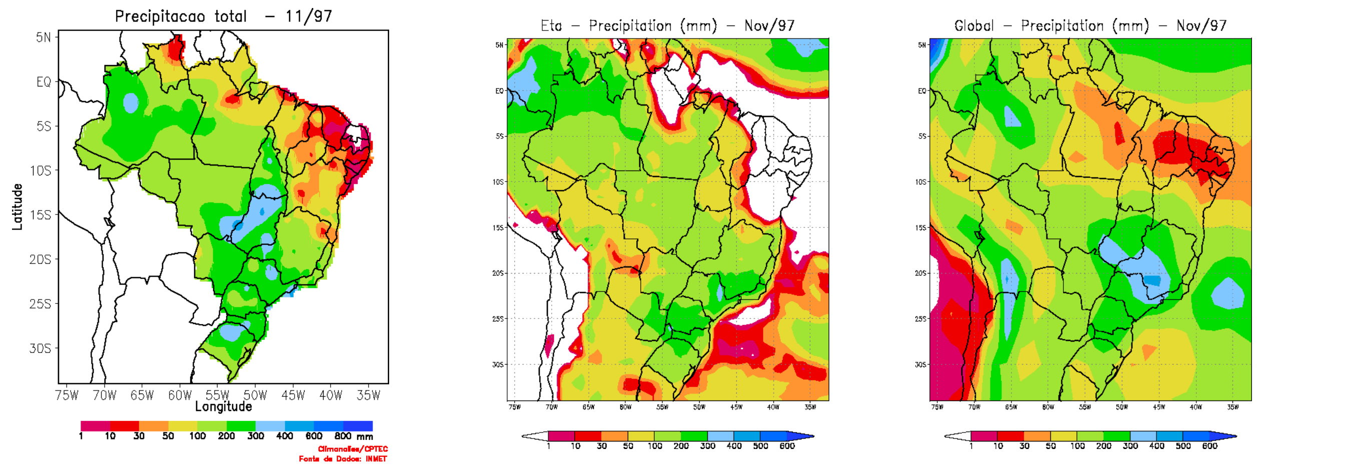


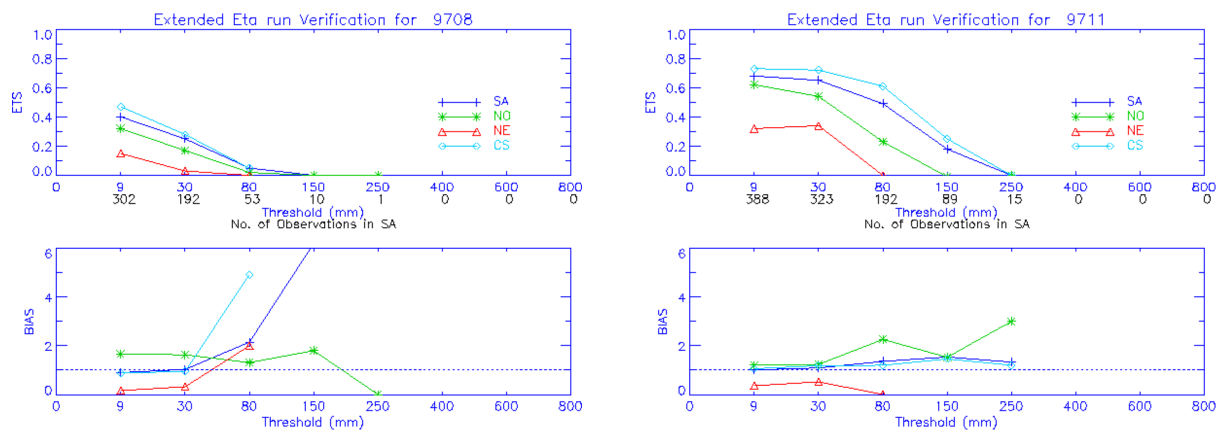
(a) (b) (c)

Figure 1 – Monthly total precipitation (mm) for the dry month, August, 1997: (a) observations provided by INMET; (b) predicted by Eta-model; (c) predicted by CPTEC/COLA GCM.



(a) (b) (c)

Figure 2 – Monthly total precipitation (mm) for the rainy month, November, 1997: (a) observations provided by INMET; (b) predicted by Eta-model; (c) predicted by CPTEC/COLA GCM.



(a) (b)

Figure 3 – Equitable Threat Score (*ETS*), and *BIAS* Score for Eta run verification: (a) dry month, August, 1997 (b) rainy month, November, 1997. (SA: South America; NO: Northwest; NE: Northeast; CS: Center-South.)