CPTEC and NCEP Model Forecast Drift and South America during the Southern Hemisphere Summer

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Introduction

The complexities of the processes leading to the onset of precipitation over the tropical area of South America range from remotely controlled effects, such as the changes in the positioning of convective areas in the Pacific and Atlantic Oceans, in response to the sun position, to locally controlled processes which are highly dependent on surface processes, also responding to the seasonally varying solar forcing. Modeling the onset of the rainy season in several parts of South America as well as its interanual and intraseasonal variability during the rainy season has been a challenge in the operational and research centers. This report deals with some of the model deficiencies in modeling the heat sources over the tropical sector of South America during the summer season based on the observed model forecast drift. The forecast drift is defined as the differences between the model forecast and the corresponding verifying analysis. A brief report is made of the forecast drift of the NCEP model in December 1993 at a time when its physics was quite similar to the system used for the NCEP reanalysis. A description of the more recent forecast drift at NCEP and at CPTEC (the Brazilian Center for Weather Forecasting and Climate Research) is also provided in this report. CPTEC runs a version of the COLA model both for weather forecasting and season outlook (up to 3 months) since 1995.

MRF Forecast Drift in December 1993

The Bolivian High (Silva Dias et al. 1983) shows a regular westward displacement and zonal elongation as the forecasting proceeds in December 1983. Table 1 shows the average position of the Bolivian High center at 24, 48 and 72 hours, compared to the observed mean position.

Table 1 - Mean position of the observed Bolivian High center and the forecasted position after 24, 48 and 72 hours.

	Observed	24 hour forecast	48 hour forecast	72 hour forecast
Latitude	11 S	10 S	9 S	9 S
Longitude	62 W	65 W	68 W	71 W

The upper tropospheric cyclonic vortex off the NE coast of Brazil also shows substantial changes in the forecast compared to analysis. In general, the upper low is weakened in the forecast.

The weakening of the upper anticyclonic circulation over the central part of Brazil and the enhancement of the upper negative anomalies in the forecast (i.e., more anticyclonic) to the west of South America is observed in the NCEP forecast drift at 150 hPa (figure not shown). The negative anomalies of the NE coast of Brazil are also consistent with the daily analysis of the position and intensity of this important feature of the regional summer circulation.

Several other patterns of the streamfunction drift are already well established in the 24 hour forecast, such as the anticyclonic model drift off the coast of southeast North America, in the Caribbean region, over Arabia, and off the east coast of Asia. Cyclonic anomalies are also present in the central portion of North America, in the North Atlantic just north of the equator and western China. Significant anomalies are also found in the Southern Hemisphere. The intensity of the upper level trough, off the NE coast of Brazil decreases with time but is clearly shown at the 24 hr forecast (Figure not shown). Other interesting features are: the enhanced upper cyclonic anomaly over the South Atlantic, with anticyclonic anomalies over most of southeastern Africa and cyclonic model drift over southern Australia.

The forecast drift of the divergence at 24, 72 and 96 hours have also been computed (figures not shown). In areas where the analysis is divergent and the divergence drift is negative, the model tends to produce less upper level divergence than the analysis. The difference between the forecasted upper level divergence and the analysis over tropical South America, in the eastern Amazon extending southeastward (approximately in the location of the South Atlantic Convergence Zone/SACZ) is quite substantial: by day 3 of the forecast the maximum upper level divergence drops to about 50 % of the verifying analysis. The forecast tends to decrease the upper level convergence as compared to the analysis (e.g., in the central Pacific Ocean between 170^o E and 150^o W along 5 to 10^o N) Positive model drift in areas where the analysis shows convergence means that the forecast is less convergent at upper levels, suggesting weakening of the subsidence. In fact, in the particular case of northern Argentina/Bolivia, the model divergence drift is so positive that mean upper level divergence is forecasted in this area while the analysis shows mean convergence. Direct comparison between model precipitation and raingauge data indicates that the MRF model predicts excessive rainfall over northern Argentina. There are also indications that the MRF model overpredicted the rainfall in the highlands of Bolivia, based on the indirect indications from satellite imagery. The observed precipitation analysis over Central Brazil and along the SACZ indicated that the MRF forecast underpredicted the precipitation.

The influence functions (Grimm and Silva Dias 1995) of the barotropic vorticity equation linearized about a climatological basic state (zonally and meridionally variable) can be used to associate the rotational to the divergent drift. The weakening of the subtropical jet in northern Argentina and the strengthening of the upper westerlies to the south is compatible with the excessive upper level divergence in the Bolivian region. The weakening of the upper cyclonic flow off the NE coast of Brazil is also compatible with the decrease of the upper divergence in the eastern Amazon, Central Brazil and along the SACZ as the forecasting time increases.

CPTEC and NCEP Forecast Drift in 1997/1998

The CPTEC operational model in the Southern Hemisphere summer of 1997/98 used the Kuo scheme for deep convection and the Sib model for the surface processes. The operational experience at CPTEC has indicated that the diurnal temperature cycle with the CPTEC model is better captured, compared to the NCEP model (which uses a simpler surface module). Experience at CPTEC indicated that the Sib parameterization is able to sustain significant evapotranspiration in the forest area even after relatively long dry periods in view of the capability of removing water from the deeper layers of the soil by the deeper roots of the forest trees. Thus, besides the differences in model resolution, compared to the NCEP operational model, there are significant differences in the physics formulation.

The forecast drift of the 200 hPa wind in January 1998 of the CPTEC operational model at 24, 72 and 120 hours is shown in Figures 1 a, b and c, respectively. The divergence drift is shown in shading. The observed upper level wind drift is suggestive of weak upper level divergence (i.e., weak convective forcing). As time increases, the cyclonic drift over South America shows a slow westward displacement as well as a increasing anticyclonic drift off the NE coast of Brazil. Another feature of interest is the strong upper level anticyclonic drift west of Chile. According to the influence function analysis, it may be related to the forecast drift in the divergent component in the equatorial Pacific. The CPTEC specific humidity drift at 500 hPa as well as other vertical levels tend to indicate that the model is excessively humid (figure not shown). This has also been observed in the daily analysis which tend to show excessive cloudiness.

The NCEP forecast drift in January 1998 of the 200 hPa wind at 24, 72 and 120 hours (Figure 2a,b and c) differs considerably from the CPTEC pattern. The NCEP drift at 120 hours is considerably smaller over South America. However, the upper level anticyclonic drift off the NE coast of Brazil is present in the beginning of the forecast but decreases as the forecast time increases. There are indications of excessive upper level divergence over the tropical continental area of South America suggesting that the NCEP model has intensified the land convective forcing (this is supported by the analysis of other Southern Hemisphere summer months, not shown as well as the forecasting experience at CPTEC). The development of an anticyclonic drift at approximately 20^o S over South America and the decrease of the anticyclonic drift off the NE coast of Brazil indicates that the model tends to increase the convective forcing in the SACZ region as the forecast time increases. This observation is also supported by the operational forecasting experience in the last summer at CPTEC which indicated that the NCEP forecast was able to sustain the SACZ, in general over-intensifying the convective activity in the region in the extended range forecast. The development of a cyclonic drift in NW South America is also indicative of excessive upper level divergence over the tropical continental area. Further work is necessary in order to explain the wind drift in the Pacific region.

Summary

In summary, the analysis of the forecast drift of the NCEP model suggests a significant change in the pattern when comparing the older version, operationally used in Southern Hemisphere summer of 1993/94, with the operational version in 1997/98. The analysis of the CPTEC forecast drift, on the other hand, indicates that the model is not able to sustain enough convective forcing over the tropical sector of the continent.

References

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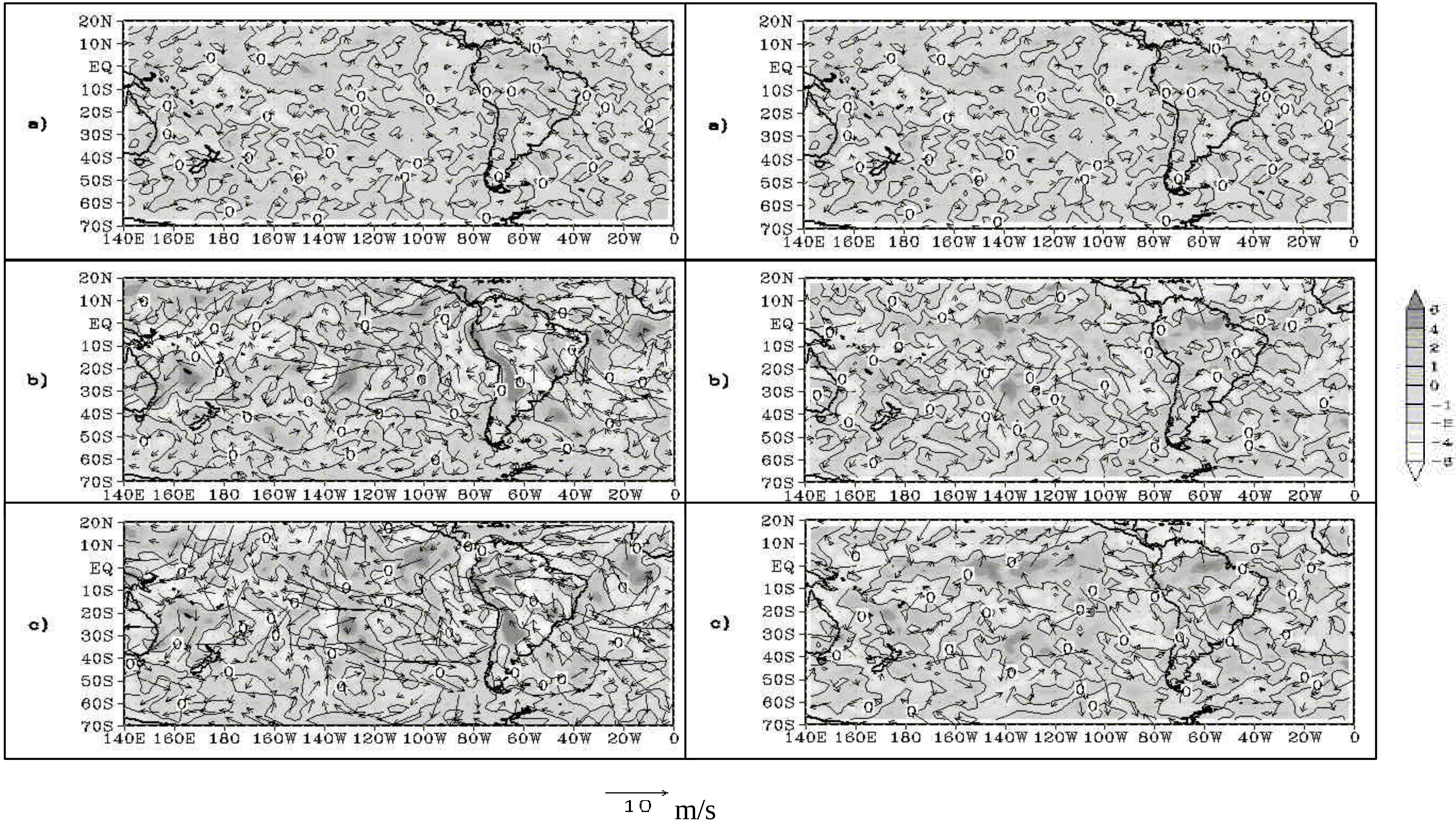

Figure 1 CPTEC wind (vectors) and divergence (shading unit in 10-6s^{-1} at 24,72 and 120 hours during January 1998.

Figure 2 NCEP wind (vectors) and divergence (shading unit in 10-6s^{-1} at 24,72 and 120 hours during January 1998.