Exchanges

- Scientific Contributions -

Modeling Studies Related to SALLJEX*

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Introduction

Prediction of weather and short-range climate evolution over South America is characterized by different observation problems than those found in North America. The SALLJEX project focused upon special problems posed by observation gaps in the Southern Hemisphere. In addition to observation issues, the steep Andes orography and the low latitude of most of the continent provide new concerns relative to forecast problems for North America. Remote sensing is particularly important in the Southern Hemisphere, where the forecast skill now approaches levels found in the Northern Hemisphere. This has been accomplished through better and more efficient use of vast amounts of satellite data, primarily over the oceans. The impact of an enhanced observing network in the SALLJEX area is a major challenge that may lead to improvement of models, data assimilation procedures, and better use of remote sensing products over continents.

There remains a question whether data-deficient regions of the oceans or of the continents most strongly limit the southern observing system. This is being addressed within CPTEC, INPE, and the University of Sao Paulo in Brazil, in the University of Buenos Aires, CIMA, and the Servicio Meteorologico in Argentina, at the University of Chile, and also by investigators in North America using SALLJEX observations to study the value of regional surface-based observations. The field experiment was supported by regional, real-time model simulations provided by researchers within these organizations. Real-time comparison between model results and observations was routinely made at the operations center of SALLJEX in Santa Cruz de la Sierra in Bolivia. Model forecasts were used for guidance in planning special observing and intensive observing periods, and were at times found to be quite accurate for planning purposes, but were less adequate at other times, and the experiment has led to systematic intercomparisons of models designed to prioritize observational and modeling enhancements required for improved numerical guidance.

Dynamical perspectives

Past research by Silva Dias and collaborators has shown that basic features of low-level summer circulations in tropical regions are often well-described by linear models that include the effect of observed heat sources. These and other studies also point out significant discrepancies over South America that cannot be resolved in models lacking the topographic effect. A number of studies confirm that the lower tropospheric flow is most affected by the steep mountains, while the upper level flow is barely influenced.

While most past studies have emphasized topographic modifications of Amazon Basin wind systems and the effect of heating east of the Andes, some investigators emphasize correlation of the East Andes LLJ with El Nino events of the Pacific Ocean, and with the strength of the upper westerlies. Cyclonic circulation surrounds the Andes in the lower-troposphere in both summer and winter, and this supports a poleward east Andes LLJ in

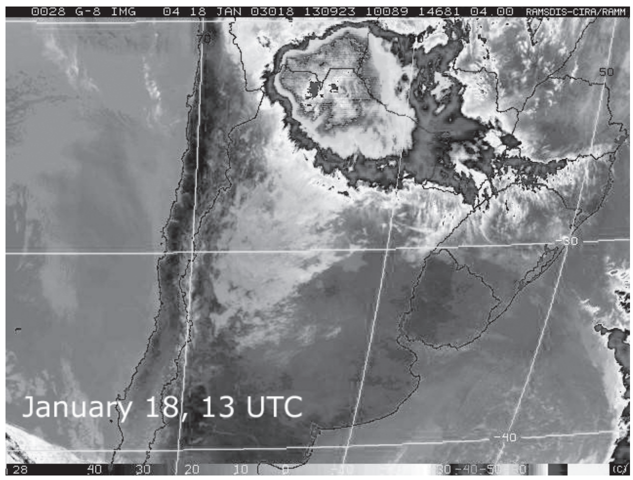

Fig. 1: Mesoscale Convective System as observed over the SALLJEX area on January 18, 2003 at 13 UTC by the GOES-8? satellite.

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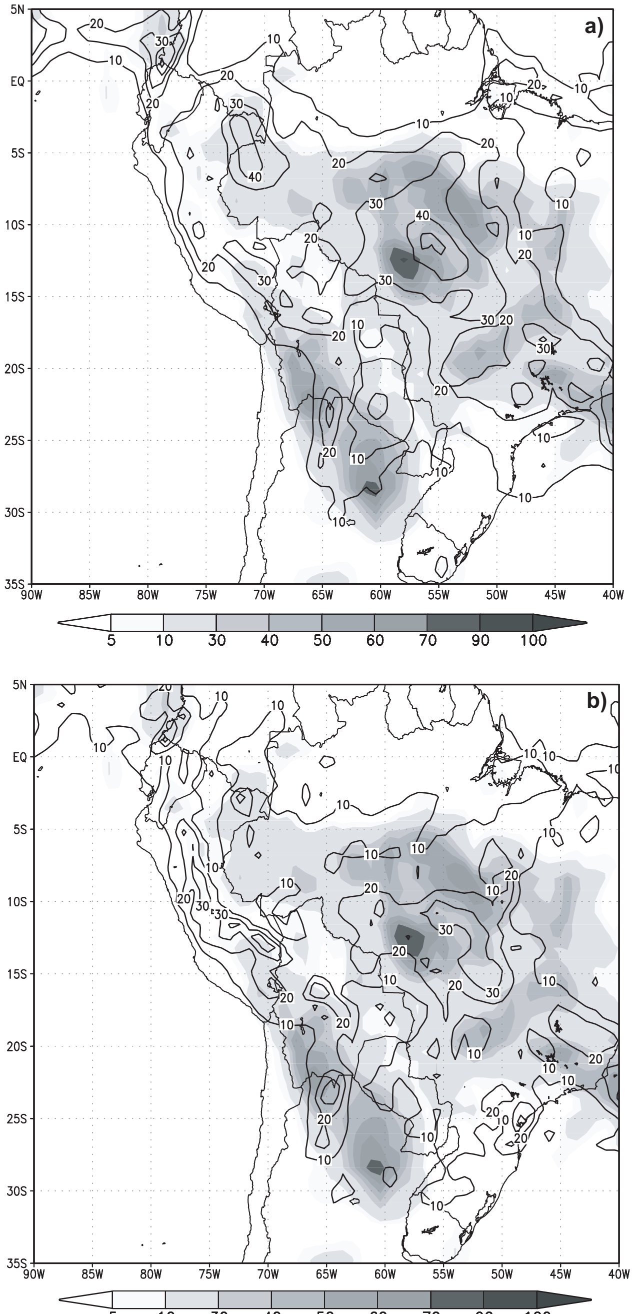

Fig. 2a (upper panel): 48-hour mean total presipitation between Januar 17, 00 UTC and January 19, 00UTC and GPCP precipitation estimates (shaded)
Fig 2b (lower panel): 48-hour total precipitation dispersion (contour) and GPCP precipitation estimates (shaded for January 19, 00 UTC.

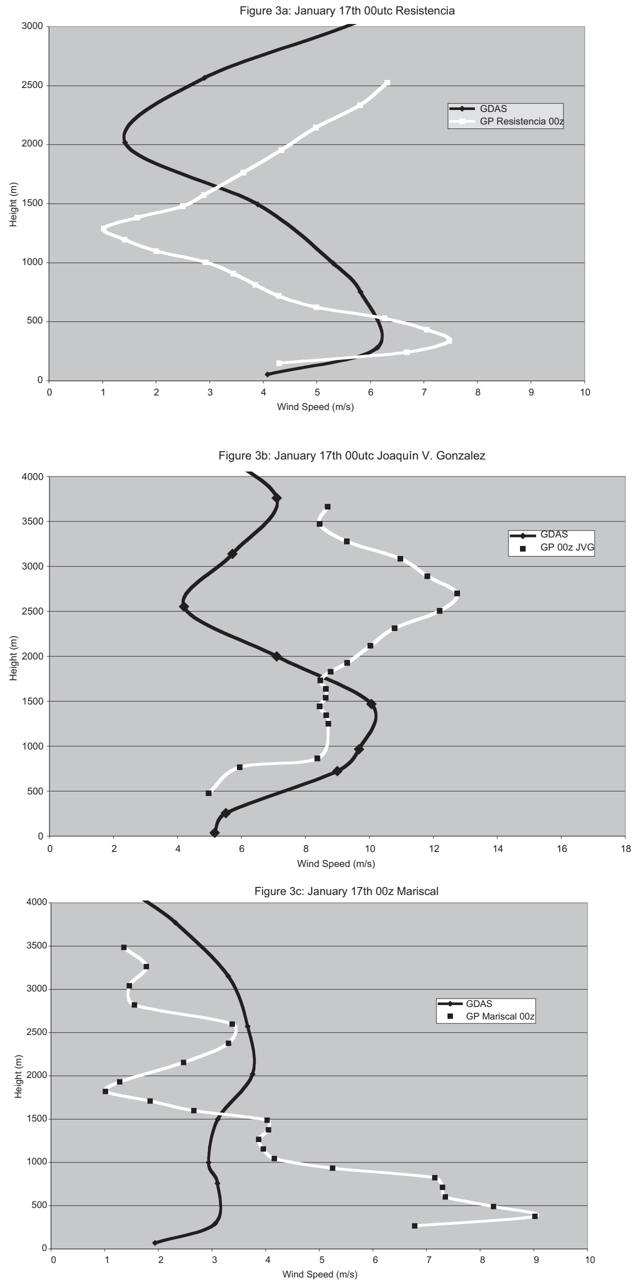

Fig. 3: Differences between selected SALLJEX wind speed profiles and those obtained reanalysis gridded fields at 3 different locations on January 17th.

both seasons. This contrasts with observations for the Great Plains LLJ of North America, which reverses from winter to summer. Lau and collaborators suggest that the South American monsoon system has more similarities with the South Asian monsoon.

Regional models

The inability of global models to capture important details of regional circulations has prompted many regional model simulations over South America. Only a sample of recent studies focused upon the SALLJEX domain is summarized here. Silva Dias and collaborators have demonstrated that the structure of the simulated LLJ is highly dependent upon horizontal resolution, and suggest that accurate moisture transport along the eastern slopes of the Andes may require grid sizes as small as 20 km. Nicolini and collaborators demonstrate the important role of initial surface conditions for prediction of rainfall associated with Chaco jet events (particular cases of the LLJ characterized by augmented southward penetration of the jet, and associated with enhanced precipitation over the La Plata basin.) The long memory of surface conditions reflects the prominent role of land surface processes in South American rainforests.

Berbery and collaborators have used the Eta model to downscale the lower resolution analyses available over the region and to thereby obtain a higher resolution representation of the low-level flow that allows study of the processes that modulate the diurnal cycle.

A systematic intercomparison of regional models for a particularly active mesoscale convective system (MCS) has been initiated by Saulo and collaborators (http://www.salljex.at.fcen.uba.ar). This intercomparison is coordinated at the University of Buenos Aires, but includes participation by groups based at CPTEC, The University of Sao Paulo, the University of Chile, and the Universities of Maryland and of Utah in North America. The tested models include versions of the Eta, RAMS, MM5 models as well as the global CPTEC model.

A key aspect of the research is to assess the degree of dispersion of forecasts generated with identical initial and lateral boundary conditions, and very similar domain and horizontal resolution. Since a central forecast problem in this part of the world concerns mesoscale convective systems (MCSs) that are not routinely predicted by the operational global models, the research has thus far focused upon one such event that occurred during SALLJEX (Fig. 1). There are several hypothesized reasons for the poor model performance for this case, including inadequate boundary data, inadequate initial data, poor model parameterizations, and inherent predictability limits. Here we reproduce some of Saulo and collaborators' findings in regards to initial data quality and verification issues relevant to SALLJEX observations.

At the highest resolution (about 20 km) the models predict large amounts of precipitation (Fig. 2), but most do not adequately reflect the precipitation associated with the MCS of Fig. 1, and individual forecasts display high variability in areas of large precipitation. It is likely that much of the forecast variation reflects variability in model physical parameterizations, since all models use the same initial and lateral boundary conditions. The poorly predicted MCS may also be due to errors of the initial state specification, which did not have the benefit of SALLJEX observations. Fig. 3 illustrates differences between selected SALLJEX wind speed profiles and those obtained at the same locations from Reanalysis gridded fields. The observed vertical wind shears are poorly represented by the Reanalysis.

Fig. 4 displays predicted vertical profiles of wind speed at Resistencia. There is much inter-model variability, which is, however no larger than the difference between the SALLJEX radiosonde observation at this station and the Reanalysis estimate interpolated to the same point. Model initialization and validation in this case would clearly benefit from improved specification of the atmospheric state.

Future research

Future research will utilize the special SALLJEX observations in data assimilation systems. This effort has already begun at CPTEC and is planned in other research centers. Preliminary results indicate significant impact of SALLJEX observations upon a case study as well as improvement in the precipitation structure of an MCS in Northern Argentina.

Model experiments will focus upon the origin and maintenance of the East Andes LLJ, and study a variety of mechanisms, including: topographic impact on trade winds; orographic effect in the absence of latent heating; impact of latent heat release upon the LLJ; impact of surface thermal heating relative to upper level forcing associated with tran-

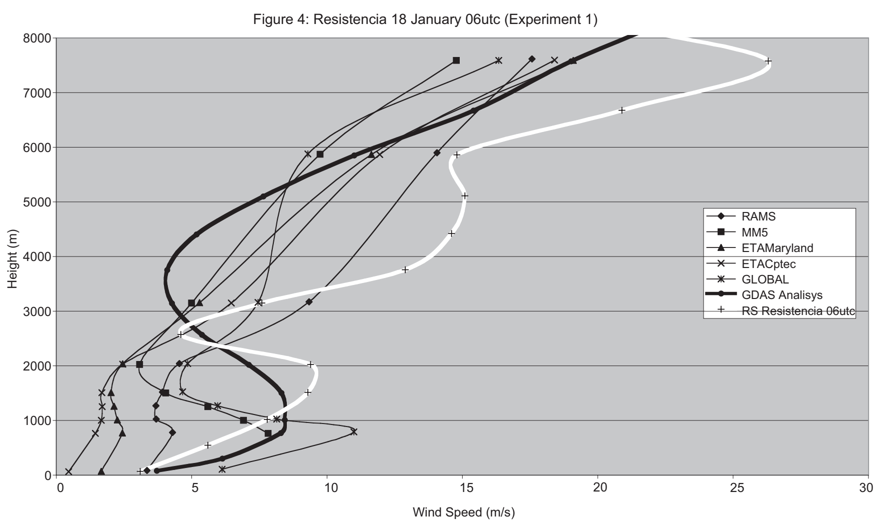

Fig. 4: Predicted vertical profiles of wind speed at Resistencia for January 18.

sient perturbations of the westerlies; propagation of low-level wind bursts from the North Atlantic towards the Plata Basin; cold surges (southerly case); and synergism among the previous mechanisms. The studies will be carried out with a variety of model techniques, and SALLJEX observations will provide an important test for different model methods, for predictability studies, and for future observing systems.

Acknowledgements

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