Numerical Simulations of the Andes LLJ: Sensitivity to Model Resolution and Physics

Pedro L. Silva Dias

Department of Atmospheric Sciences
Institute of Astronomy and Geophysics
University of São Paulo
São Paulo SP
Brazil

The Low Level Jet (LLJ) along the eastern slopes of the Andes is a local circulation, thermally driven, generated by the large scale topographical structure or a large/synoptic scale circulation enhanced by the topographical barrier and with a significant influence of the intrusion of the Atlantic Subtropical High and enhanced Chaco low. The East Andes LLJ (EALLJ) plays a major role in the moisture transport from the Amazon Basin to northern Argentina, Paraguay and Southern/Southern Brazil during the summer season and presents a large variability on daily, intraseasonal and interannual time scales. The EALLJ also plays an important role in the genesis of severe weather systems.

There are several aspects of EALLJ which are consistent with idealized models but others are not: (a) observational evidence of late afternoon/early evening maximum rather than a shallow nocturnal/early morning maximum, (b) enhanced nocturnal cloudiness and rainfall at the foothills (Santa Cruz).

The objectives of this presentations are: (a) What is the role of latent heat release in the phase of the Andean N/NW LLJ?, (b) Can we infer from the downscaling what is the spatial scale of the LLJ?, (c) Through downscaling of the NCEP analysis, what is the behavior of the N/NW LLJ during the WETAMC/LBA in January 1999 compared to January 1998? The Regional Atmospheric Modeling System – RAMS has been extensively used at the University of São Paulo to explore the above questions.

Atmospheric Mesoscale Models can be used as interpolators of the course meteorological analysis produced by the global data assimilation systems to produce higher resolution analysis. The more appropriate physics for higher resolution (non-hydrostatic, parameterization of moist processes, resolution of atmospheric systems such as squall lines, MCC etc.) and the higher resolution lower boundary condition in general lead to significant improvement in the reproduction of meteorological observations. RAMS is sufficiently flexible to explore the impact of downscaling of a global coarse analysis such as the NCEP.

Two dimensional simulations of the local circulation associated with the Andes were performed in two modes: a totally dry run (moisture is a passive tracer which only influences the radiation) and a wet simulation with latent heat release associated with convective clouds (Dappozzo 1996 – MSc Dissertation at the Institute of Astronomy and Geophysics, University of São Paulo). The horizontal grid resolution is 10 km and the vertical spacing is based on a telescopic grid with minimum resolution of 200m near the surface increasing at a rate of 1.2. The 2D simulations are performed at approximately 15S. An example of the simulations is shown in Fig. 1 (meridional wind speed at 577m above the surface at the Andes foothills). The maximum northerly jet east of the Andes is reached at approximately 12 UTC (07 LT). Latent heat release shifts the maximum intensity of the LLJ to later time (between 00 and 06 UTC or 19 and 01 LT) along the foothills. Most of the convection develops along the eastern slopes of the mountains during the early afternoon and the low level pressure drop leads to the intensification of the northerly flow as a result of geostrophic adjustment of the wind field. Douglas et al. (1999) reported stronger 18 LT LLJ than early in the morning although the pilot balloon data was more scarce in the late afternoon thus requiring more observational evidences.

Downscaling of the NCEP analysis (2.5^o resolution) to a 80 km and to a 20 km grid centered over Santa Cruz de La Sierra – Bolivia (18S, 68^o W) indicates that the low level jet temporal and spatial scales vary significantly between January 1998 and January 1999. The pilot balloon data was available during both periods at the Santa Cruz airport. The WETAMC/LBA campaign provided additional data coverage during January/February 1999. Figure 2 shows at vertical cross section during the mean diurnal cycle of the wind and potential temperature at Santa Cruz taken from the 20 km downscaling. The spatial structure and phase of the NW LLJ presented significant sensitivity to the downscaling resolution (both horizontal and vertical), although the 20 km seems to be barely sufficient to capture the basic features. The NW LLJ was much stronger during the 1998 period compared to the WETAMC results. The NW LLJ in the mean diurnal cycle during January 1998 (January 1999) is of the order of 14 m/s (4m/s) at 1.200 m (600m) above the surface. The 20 km downscaling indicates the presence of stratiform cloudiness in the early morning over the Santa Cruz area with enhanced subsidence. Early morning maximum wind speed is observed to the east of Santa Cruz in the downscaling. The maximum wind speed associated with the NW LLJ reached about 18 ms-1 in the 1998 period against 12 ms-1 in January 1999. While several episodes of strong NW LLJ were reproduced by the downscaling of January 1998, only a few cases were produced in 1999. Observations support these differences.

In summary, there are model indications that the phase of the NW LLJ along the eastern slopes of the Andes is dependent on the latent heat release associated with convection along the eastern slopes of the mountains. Away from the mountains the maximum wind speed is attained in the early morning. However, the early evening maximum seems to be reproduced in the model simulations only with latent heat release. The 20 km downscaling produces a LLJ closer to the mountains. Much more data is needed to validate the model results.

****

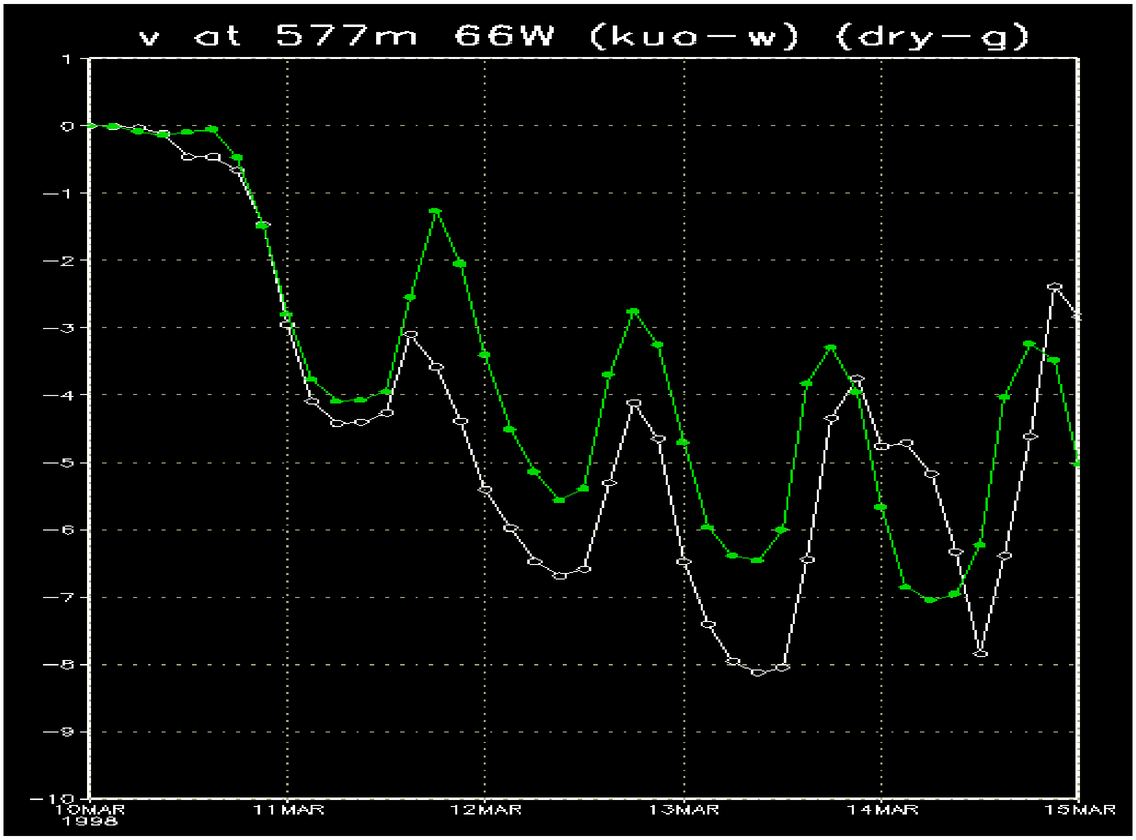

Fig. 1 Diurnal cycle of the meridional wind (m/s) at 577m above the surface during 5 cycles of the 2D simulation at the foothills of the Andes at 15^{o} S. Note that the maximum northerly jet reaches maximum values earlier when moist convection is included in the model.

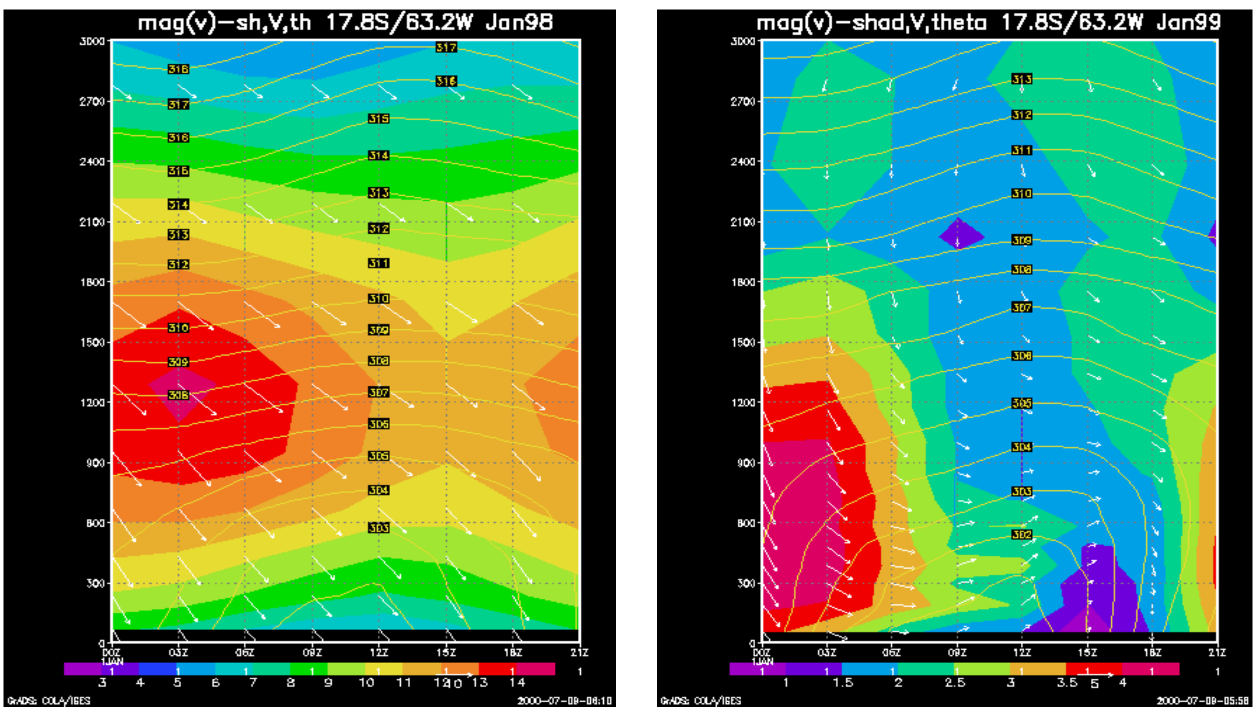

Fig.2 Mean diurnal change of the wind (arrows), wind speed (shaded) and potential temperature (contours) at Santa Cruz de la Sierra (Bolivia) repoduced by the 20 km RAMS downscalling of the NCEP global analysis during January 1998 (a) and January 1999 (b).