Spatio-temporal variability of WRF precipitation associated with the regional and local circulation in the Tropical Andes (Rio Santa Basin, Peru)

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ABSTRACT

The estimation of precipitation in Tropical Andes is challenging for the low temporal scale of satellite data and the limited number of in-situ measurements. The precipitation patterns in the Tropical Andes region are important especially in the Santa Basin where the agriculture, hydrology, and glacier formation are strongly influenced by precipitation. Satellite (product 3B42 of Tropical Rainfall Measuring Mission with grid size of 27km), in-situ observations and atmospheric model outputs (WRF-Weather Research and Forecasting) are compared for March 2013 to evaluate the atmospheric processes associated with the temporal and spatial distribution of precipitation. ERA5 reanalysis data is used to drive one domain with a horizontal grid size of 5km. Sensitivity experiments in WRF model demonstrate that the combination of Goddard (microphysics), Betts-Miller-Janjic (cumulus parameterization) and Mellor–Yamada–Nakanishi–Niino Level 2(planetary boundary layer) improve considerably the simulated diurnal cycle of precipitation. Over eastern side of the basin, northwestern winds parallel to the Andes is associated with precipitation formation in the mountains, while the western Pacific flow is the main mechanism transporting humidity to produce rainfall in the western side of the basin.

INTRODUCTION

The processes that take place on the Andes are influenced by circulation in the tropics. This circulation is dominated by the easterly winds, which carry moisture that controls precipitation (Garreaud, 2009). An important area located in this part of the tropical Andes is the Rio Santa Basin, composed of the Cordillera Negra and the Cordillera Blanca, contains the largest chain of glacial mountains in the tropics (Mourre et al., 2016) and the Cordillera Blanca represents 35% of the total area of Peruvian glaciers (Zapata et al., 2008). In this area the temperature and precipitation influence strongly the long-term evolution of the water balance and the prediction of these variables is associated to the future of the glaciers and water resources (Mourrre et al., 2016). However, using climate models to simulate properly the regional processes over the Andes topography have limitations (Giovannettone and Barros, 2009). For that, the study proposes the use of regional climate models (RCM) such as Weather Research Forecasting (WRF) model to simulate of the period of March 2013 comparing with TRMM 3B42 and in situ precipitation data.

EXPERIMENTAL SETTINGS

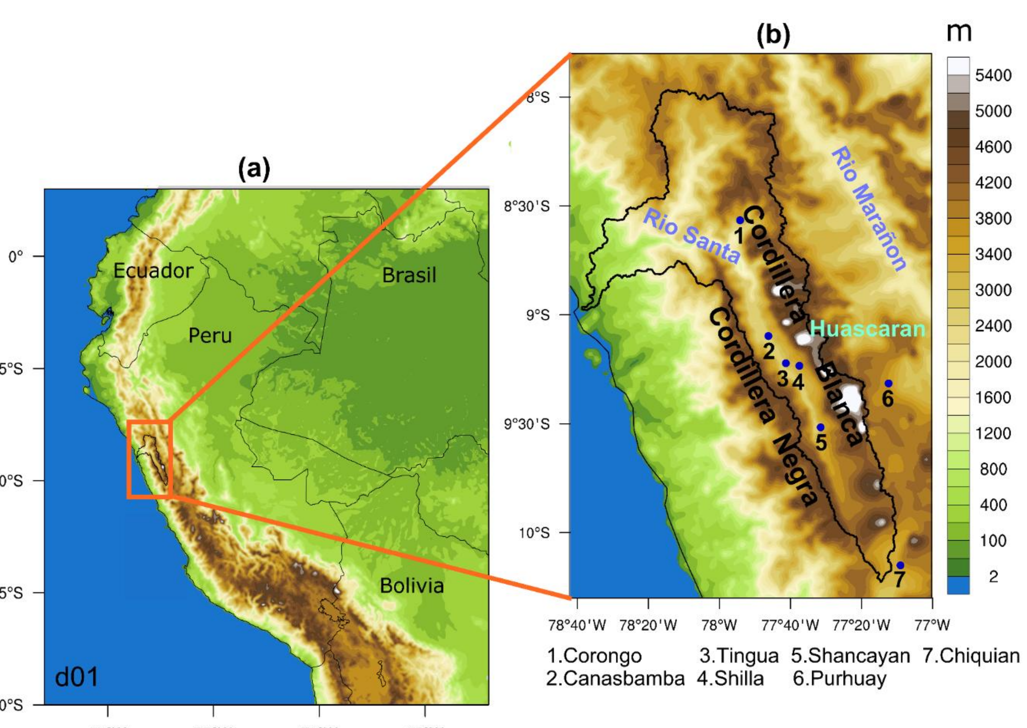

Figure 1. Simulation Domain (a) and Study Zone (b).

***Simulations forced by reanalysis ERA5**
***WRF-ARW version 3.7.1**
***Simulation period: March 2013**
***Simulation grid size: 5km**

PARAMETERIZATION	SCHEMES	REFERENCE
Planetary Boundary layer	(1,3):Yonsei University with wind topographic correction (option 1)	Hong et al. (2006)
	(2,4):Mellor-Yamada Nakanishi and Niino Level 2.5 (MYNN2)	Nakanishi and Niino(2006)
Surface layer	(1,3):MM5 similarity	Paulson (1970)
	(2,4):MYNN	
Land Surface	(1,2,3,4):Noah-MP with precipitation partitioning between snow and rain (option 2)	Niu et al.(2011)
Cumulus parameterization	(1):Grell-Devenyi	Grell and Devenyi (2002, GRL)
	(2):Betts-Miller-Janjic	Janjic (1994, MWR; 2000, JAS)
	(3,4):Grell-Freitas	Grell et al. (2013)
Microphysics	(1,3):Thompson	Thompson et al. (2008)
	(2,4):Goddard	McCumber (1989, MWR)
Radiation	(1,2,3,4):Longwave:Rapid Radiative Transfer Model (RRTM)	Iacono et al. (2008)
	(1,2,3,4):Shortwave: Duhia scheme	Dudhia (1989)

Table 1. Physical parameterizations used in the WRF simulations.

RESULTS

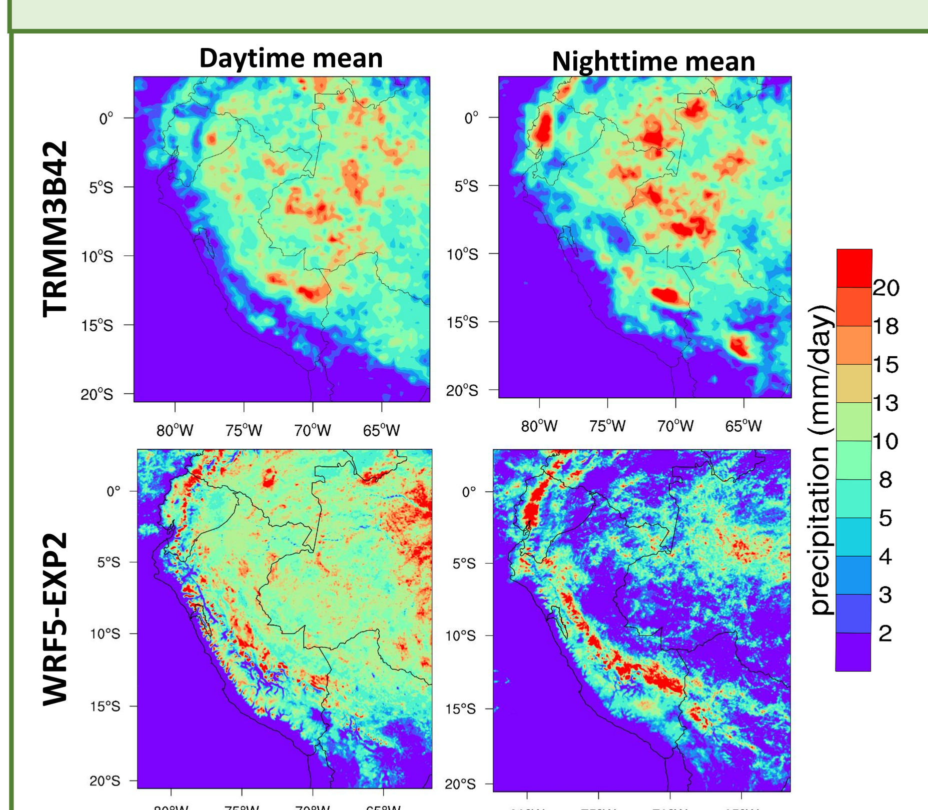

Figure 2. Precipitation mean from TRMM3B42 (March 2013) and WRF5-EXP2 corresponding to daytime (7-18hr) and nighttime (19-6hr).

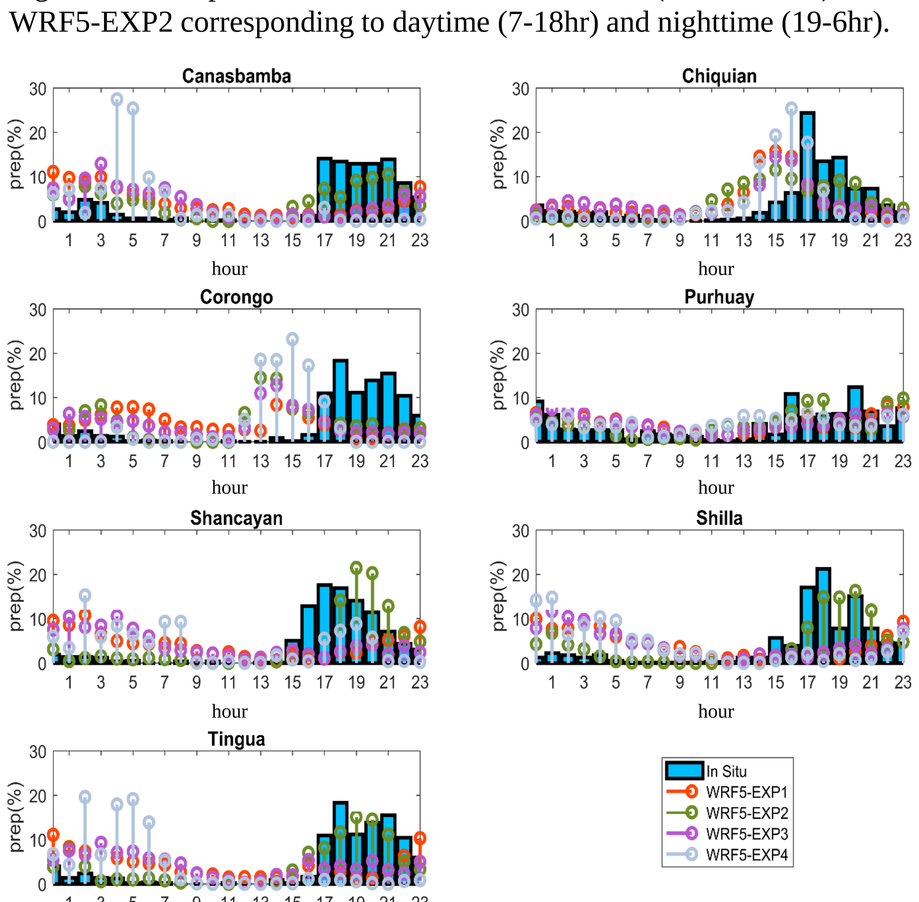

Figure 3. Precipitation diurnal cycle mean from observations (blue bar) and WRF experiments (color lines).

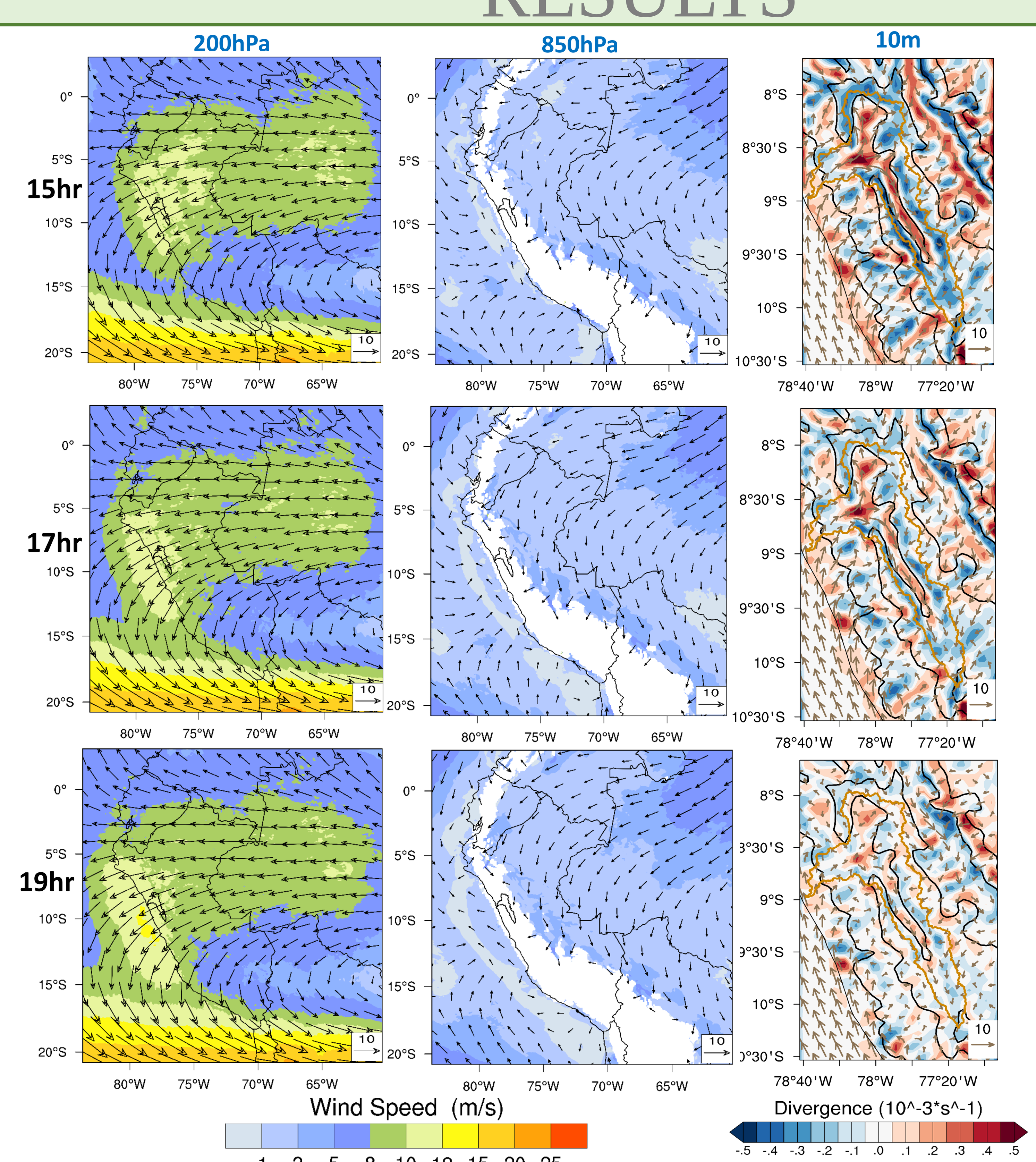

Figure 4. WRF5-EXP2 wind speed mean (color shaded, m s^{-1}) and wind direction mean (arrows, m s^{-1}) at 200 hPa for the first column in the left side and 850 hPa in the second column. In the third column the divergence (color shaded, 10^{-3} s^{-1}) and wind direction (arrows, m s^{-1}) at 10m. Each row indicates the conditions at 15, 17 and 19 hr.

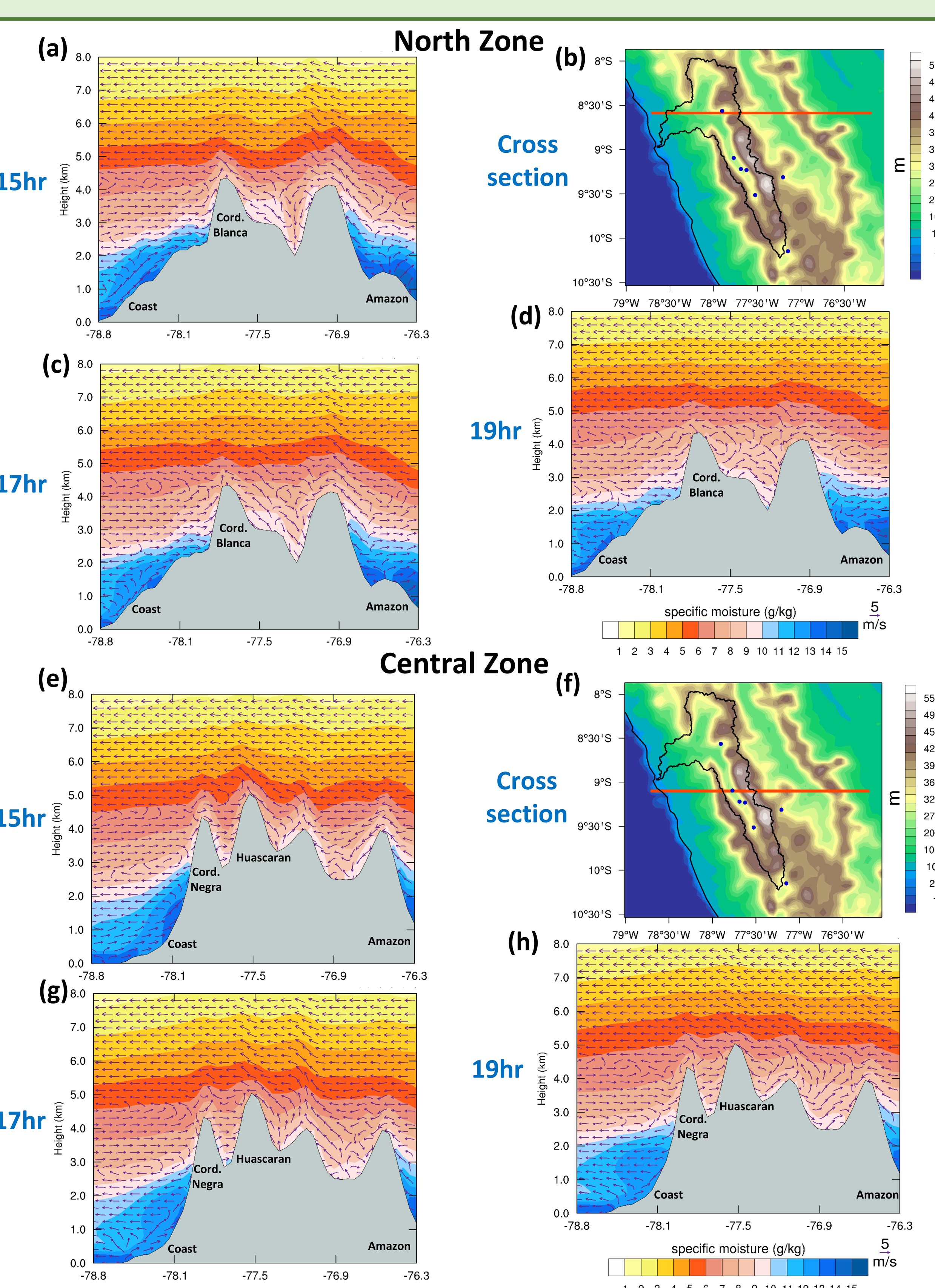

Figure 5. (a, c, d, e, g & h) Cross section composites of zonal wind mean (arrows, m s^{-1}) and specific moisture mean (color shaded, g kg^{-1}) in the (b) north and (f) central zone of the Rio Santa Basin.

CONCLUSIONS

- According to the evaluation of different WRF experiments, the best configuration was the WRF-EXP2.
- According to the hours chosen (15hr, 17hr, and 19hr), the high level circulation in the Pacific side doesn't affect the circulation at 850hPa. Otherwise, happen in the Amazon side where eastern flux in high level intensifies the humidity transport from Amazon to the Santa Basin.
- In the Pacific side during the early morning to late evening Pacific flow transports humidity to the basin and intensify the katabatic winds in the basin valley.
- The Pacific flow transport more humidity than the Amazon flow for precipitation of the Santa Valley. This result contrasts with the majority of research of Andes precipitation where the humidity is from the Amazon.

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