

Variability of Moisture and Convection over the South American Altiplano during SALLJEX: An Exploratory Study

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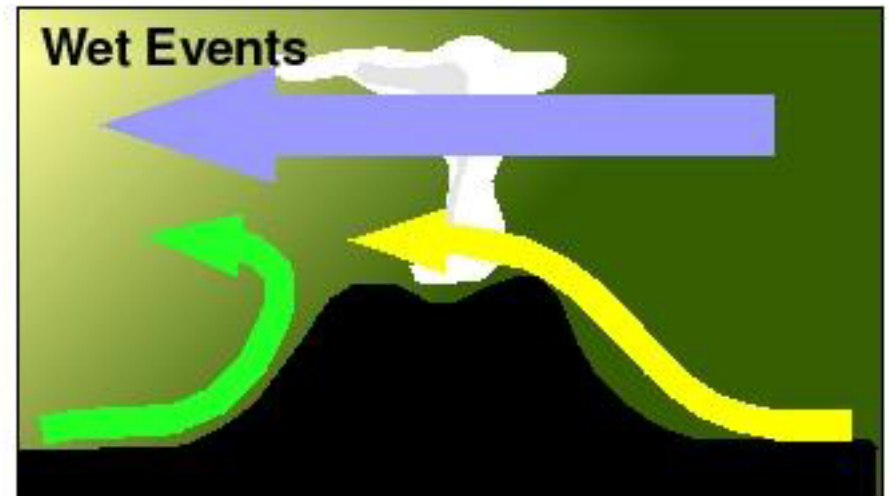
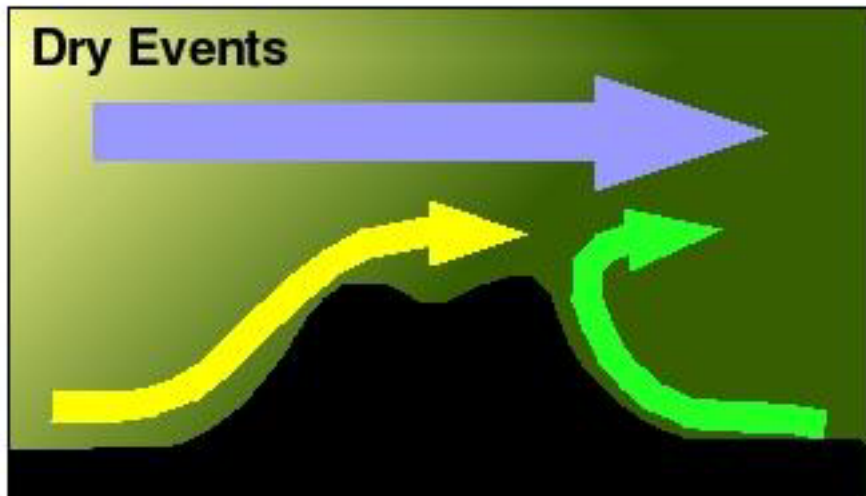
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Background

Afternoon summertime convection over the South American Altiplano exhibits a pronounced intraseasonal variability. Past observational and modelling studies (i.e., Garreaud 1999, 2000), have led to the following conclusions relating to the occurrence of :

- The availability of wide-spread moisture in the boundary layer of the Altiplano is the key factor controlling the occurrence basin-wide convection and rainfall.
- The summertime climate of the Altiplano alternates between distinct wet and dry periods (5 -10 days long) which are generally coherent across the entire basin.
- This variability is in turn controlled by synoptic variations of zonal mid- and upper- level winds, which act to modulate the relative intensity of daytime upslope flow on the western (dry) and eastern (wet) sides of the Andes.



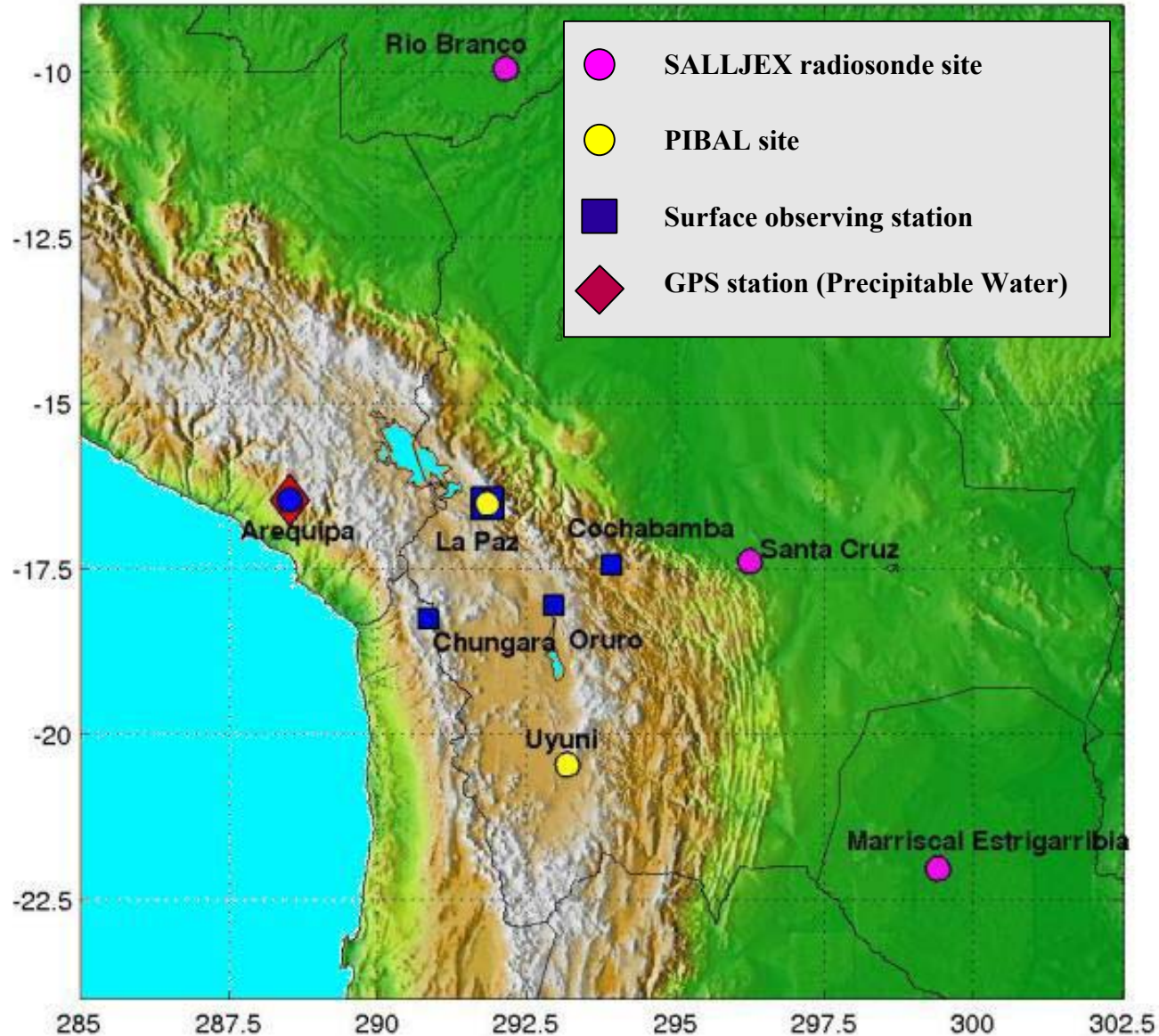
Objectives

In this exploratory study we examine the key elements of this conceptual model using SALLJEX data collected during the period 15 November 2002 – 15 March 2003. We examine in particular:

- The intraseasonal, spatial and diurnal variations of moisture and convection during the SALLJEX summer.
- The associations between moisture, convective cloudiness and rainfall
- Aspects of the moisture transportation process

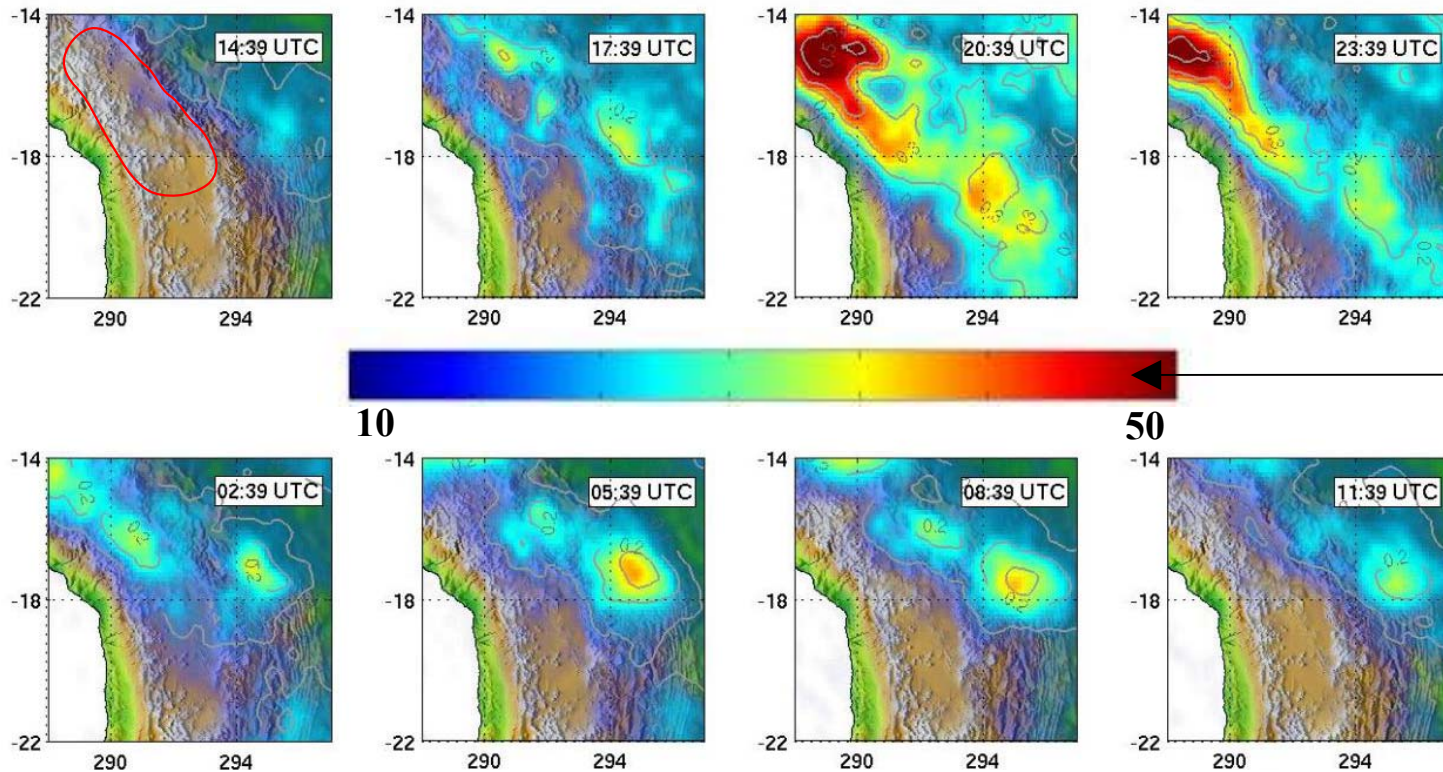
Study Area and Instrumentation

- Most datasets obtained from the SALLJEX data management website
- GPS data were obtained from the IGS (International GPS Service) global network



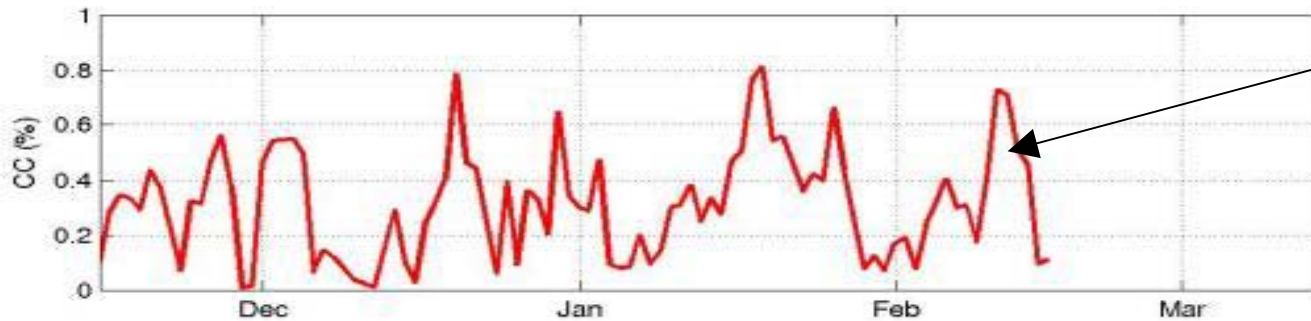
Patterns of Convective Cloudiness during SALLJEX Season

Diurnal cycle:



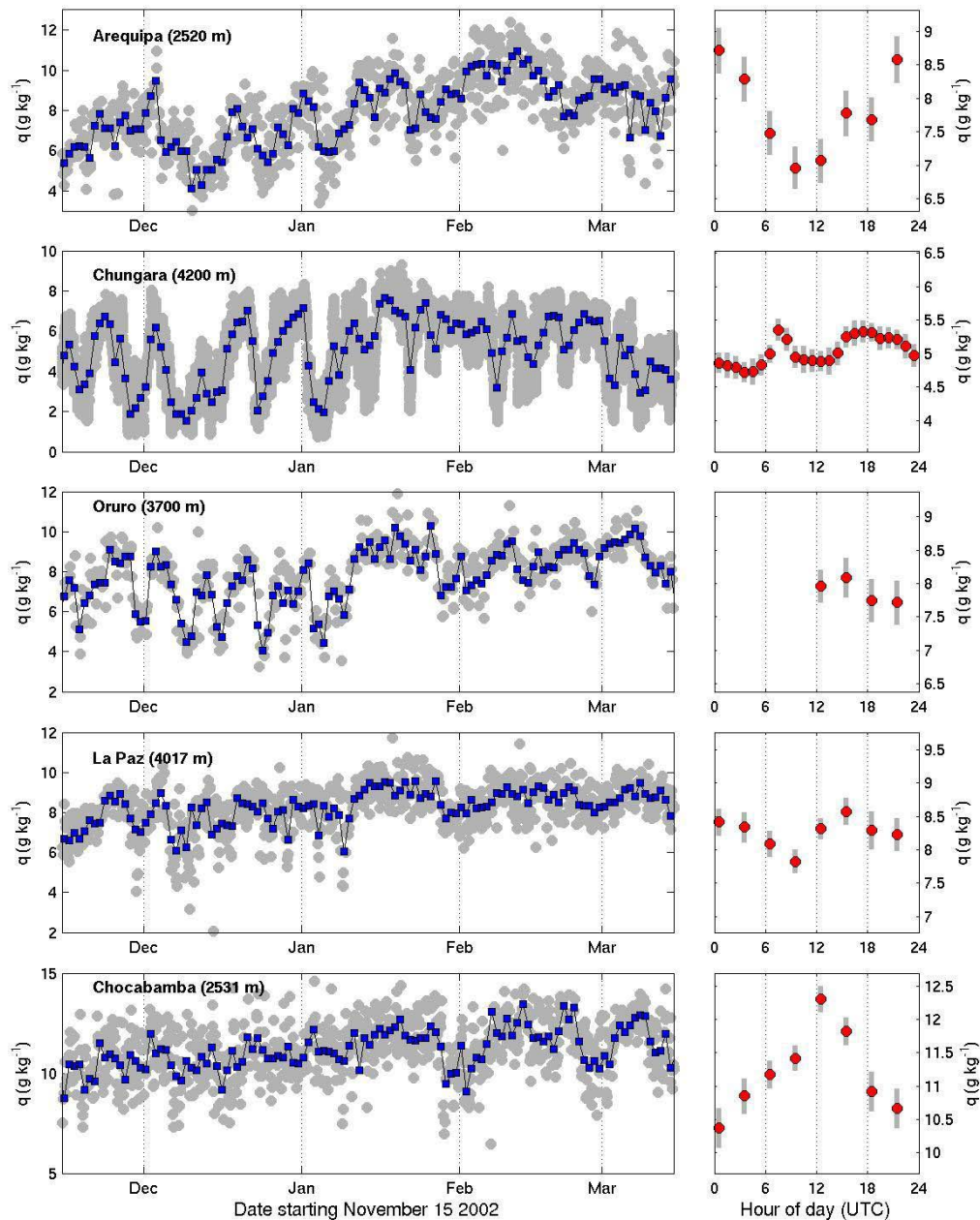
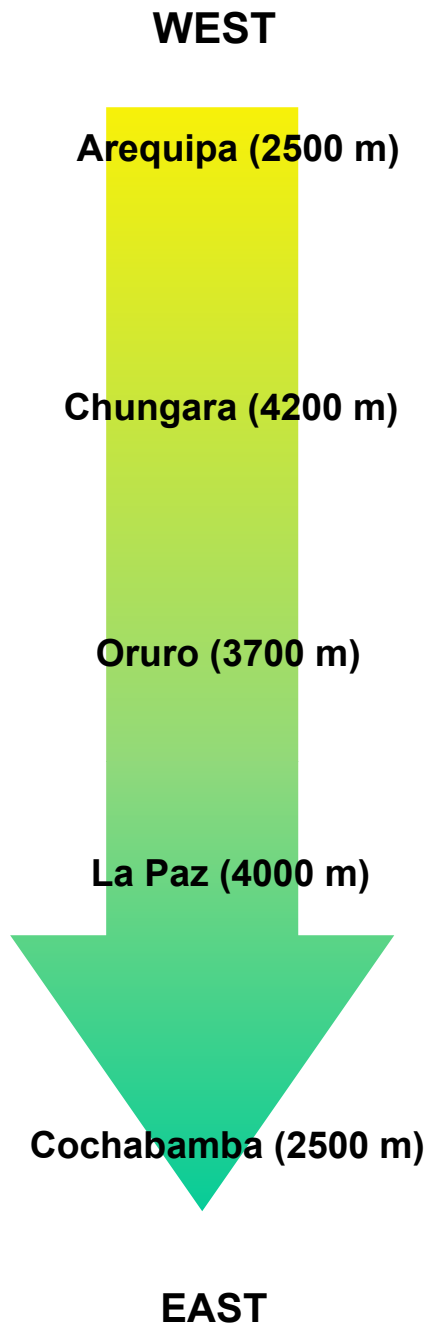
% occurrence of days with afternoon cloud top temperatures < 235 K during SALLJEX season.

Intra-seasonal variation:



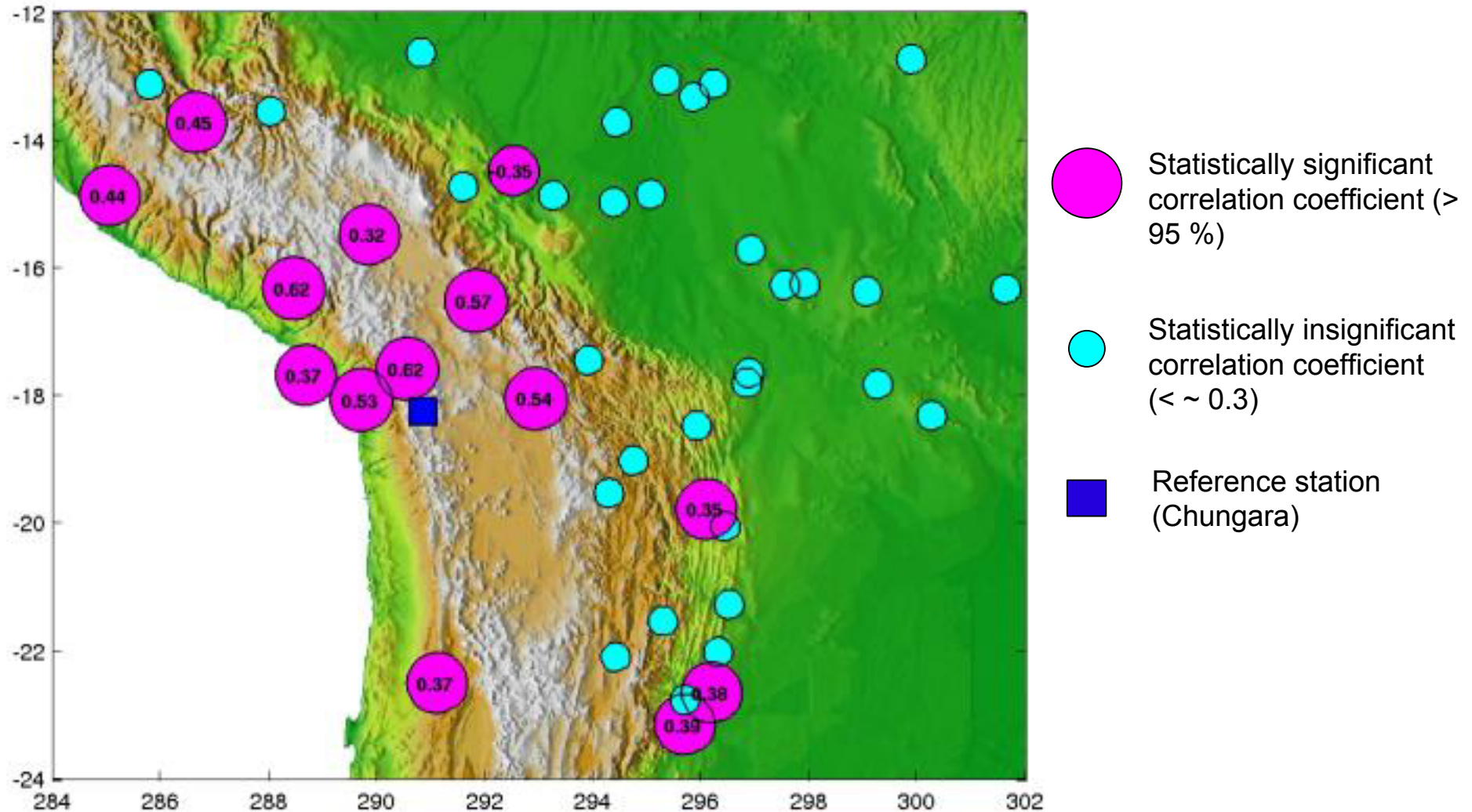
Fraction of the north-western Altiplano covered by convective clouds (T_b < 235K)

Intraseasonal and Diurnal variation of Specific Humidity



Correlation Map of Specific Humidity

- The intra seasonal variations of specific humidity are (weakly, but significantly) correlated with those at other sites along the Altiplano and its western slopes, but are not significantly correlated with variations at sites in the Bolivian lowlands.



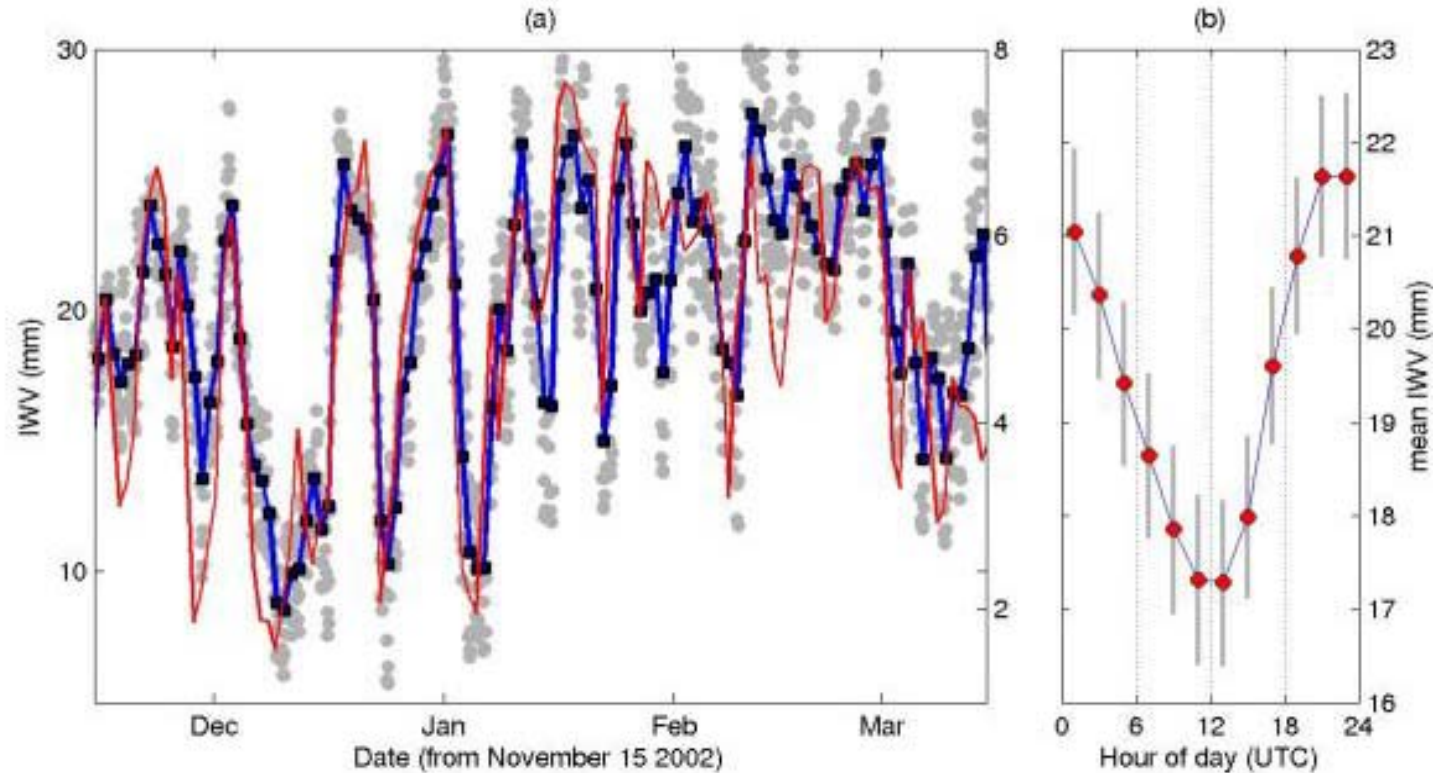
GPS-PW at Arequipa

Intra seasonal variation

Diurnal variation

PW at Arequipa

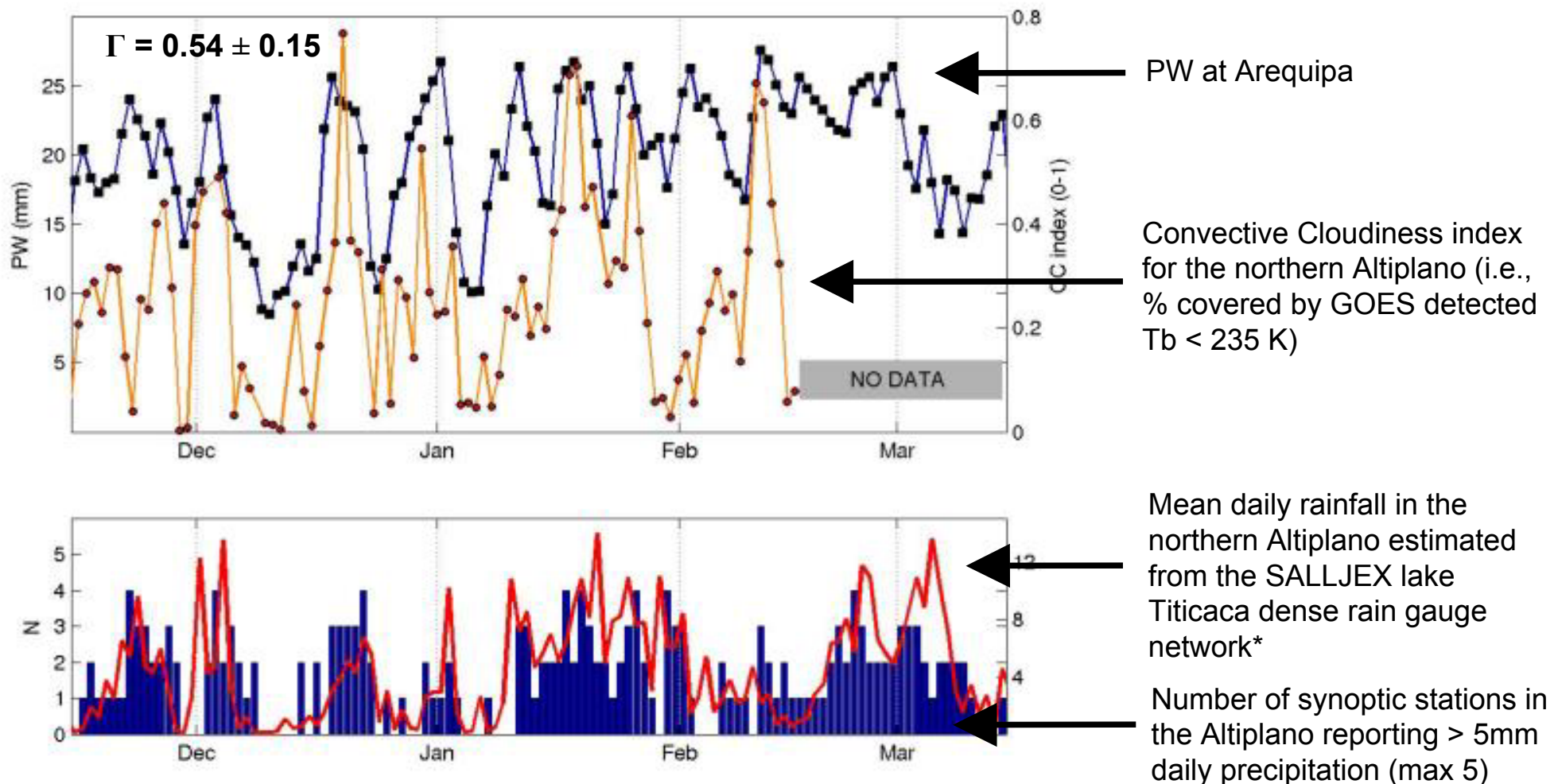
Qv at Chungara



- GPS estimates of total Precipitable Water (PW) at a permanent station near Arequipa provide an alternative (and perhaps more robust) estimate of water vapor variation over the northern Altiplano.
- There is a close relationship ($r = 0.84$) between the PW and the surface specific humidity at Chungara (~500 km distant), providing further evidence that incursions of moisture that reach the western Altiplano have a considerable spatial and vertical extent.

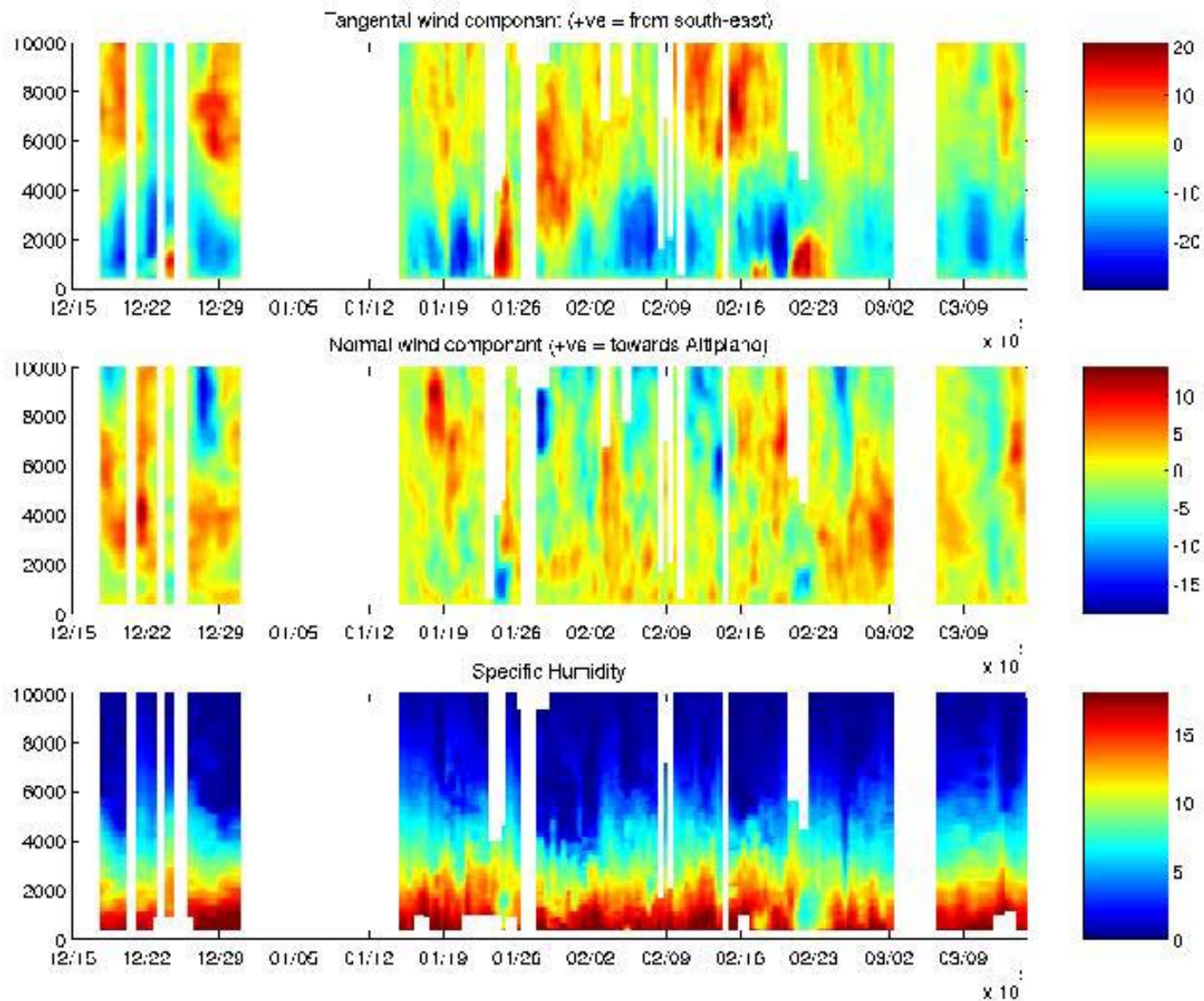
Moisture, Convective Cloudiness and Precipitation

- A good correspondence between the presence of moisture and both convective cloudiness ($r = 0.54$) and precipitation ($r = 0.38$) is seen during the SALLJEX season, in agreement with past studies.
- However we do note a few periods (i.e., 1 Feb – 6 Feb; 14 – 17 Feb) during which moisture over the Altiplano was not associated with precipitation or convection. These may warrant more detailed examination in a future study.



* source: www.nssl.noaa.gov/projects/pacs/web/html/s_rainfallresults02.html

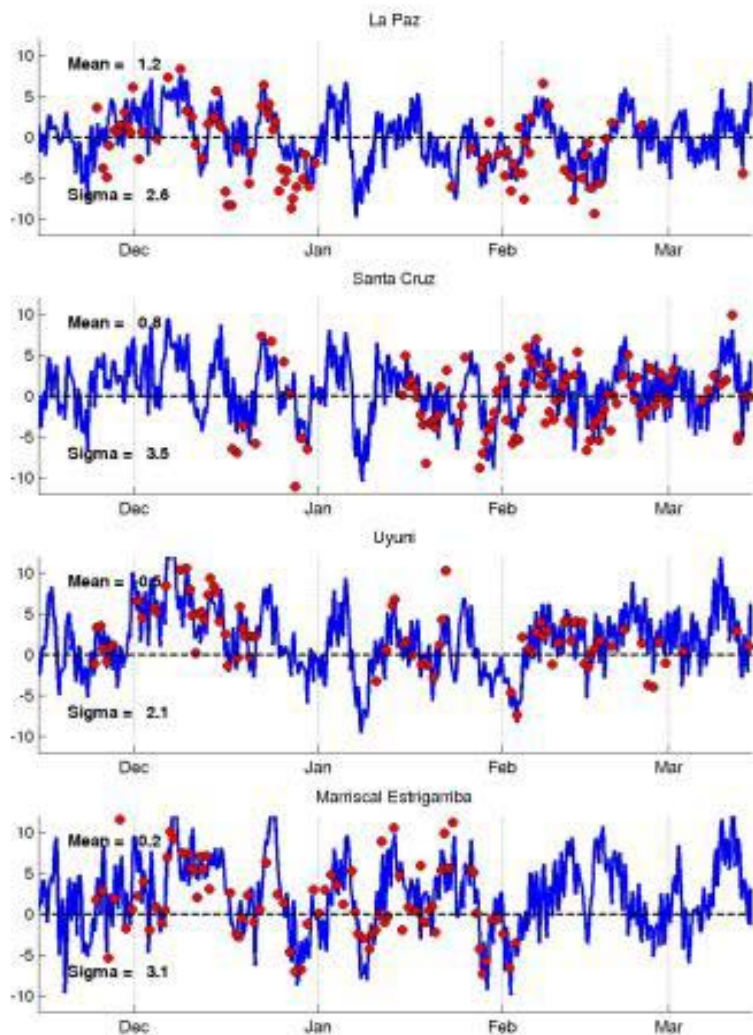
Winds and Moisture at Santa Cruz



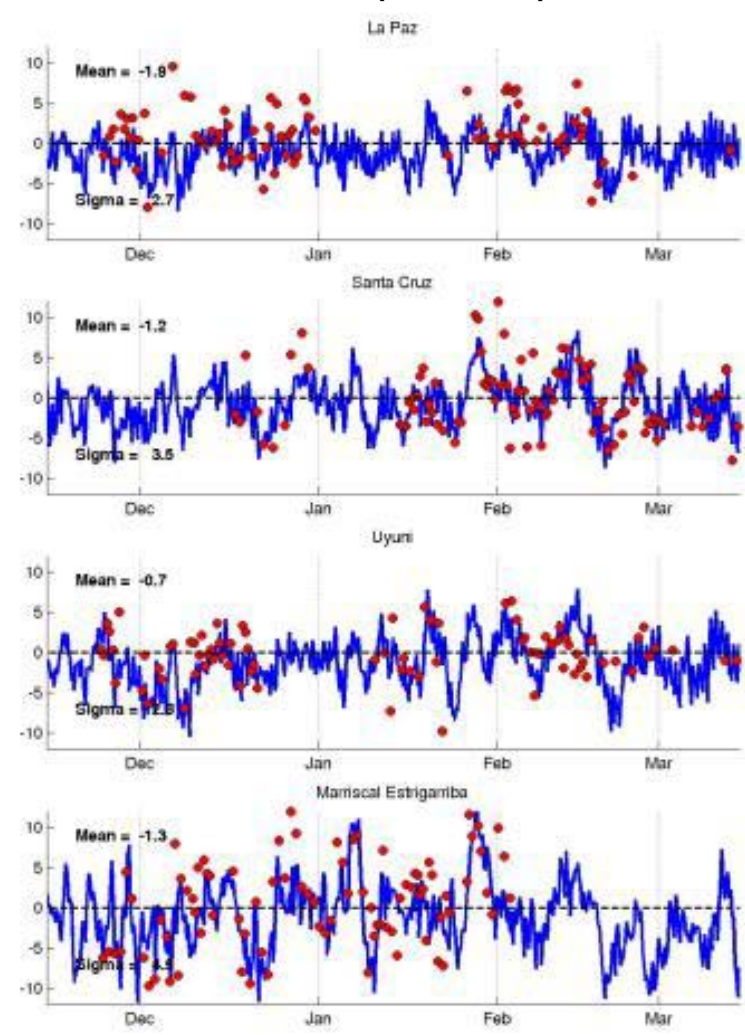
Example Comparison of Reanalyzed and Observed Winds (500 hPa)

- There is insufficient upper-air wind data near to the altiplano for a complete characterization of the SALLJEX summer season on the basis of observations alone.
- Comparison of observations with reanalysis suggest that the reanalysis data can describe synoptic fluctuations in upper air winds with reasonable accuracy ($r \sim 0.62$)

U-wind (500 hPa)

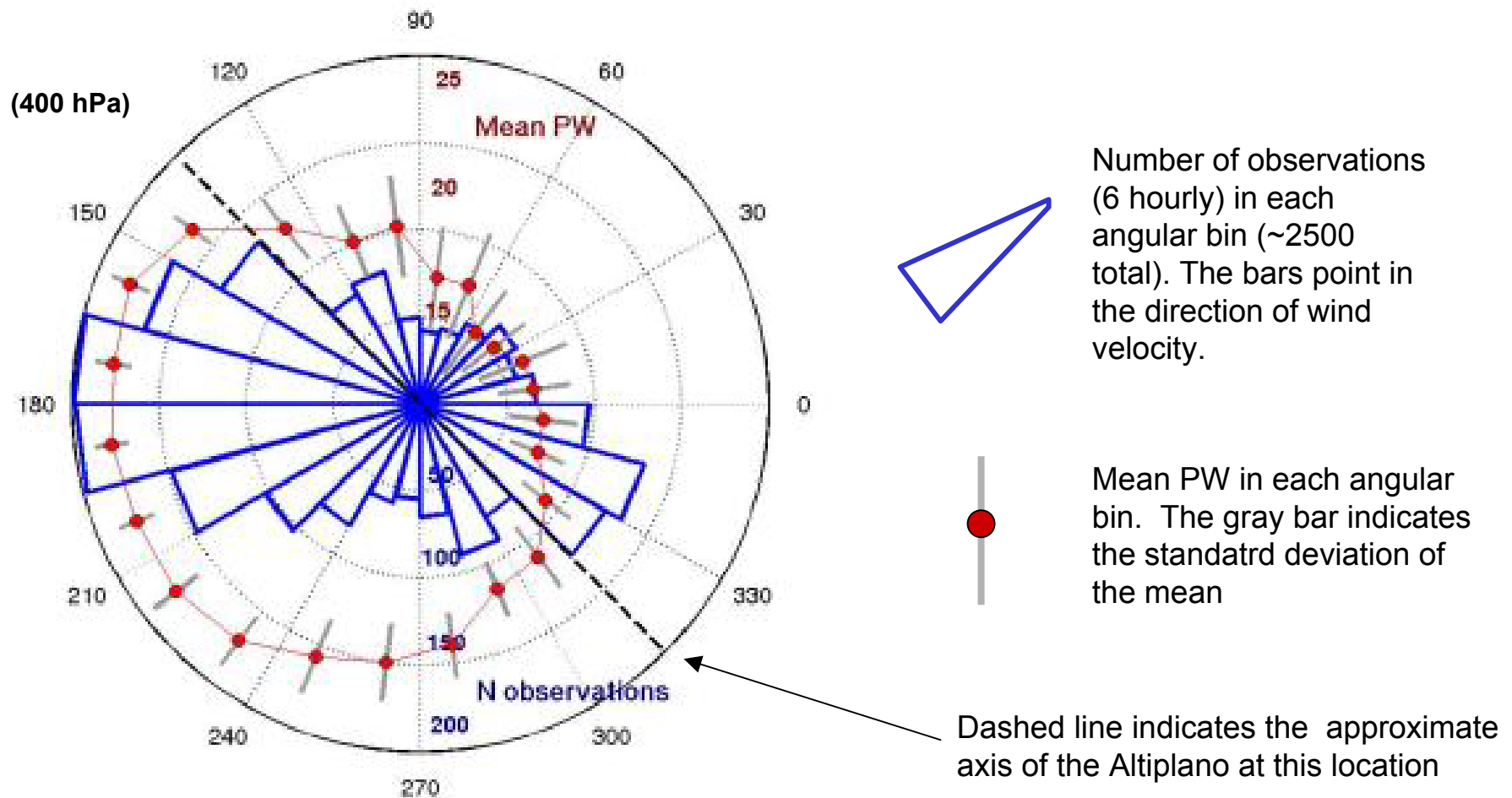


V-wind (500 hPa)



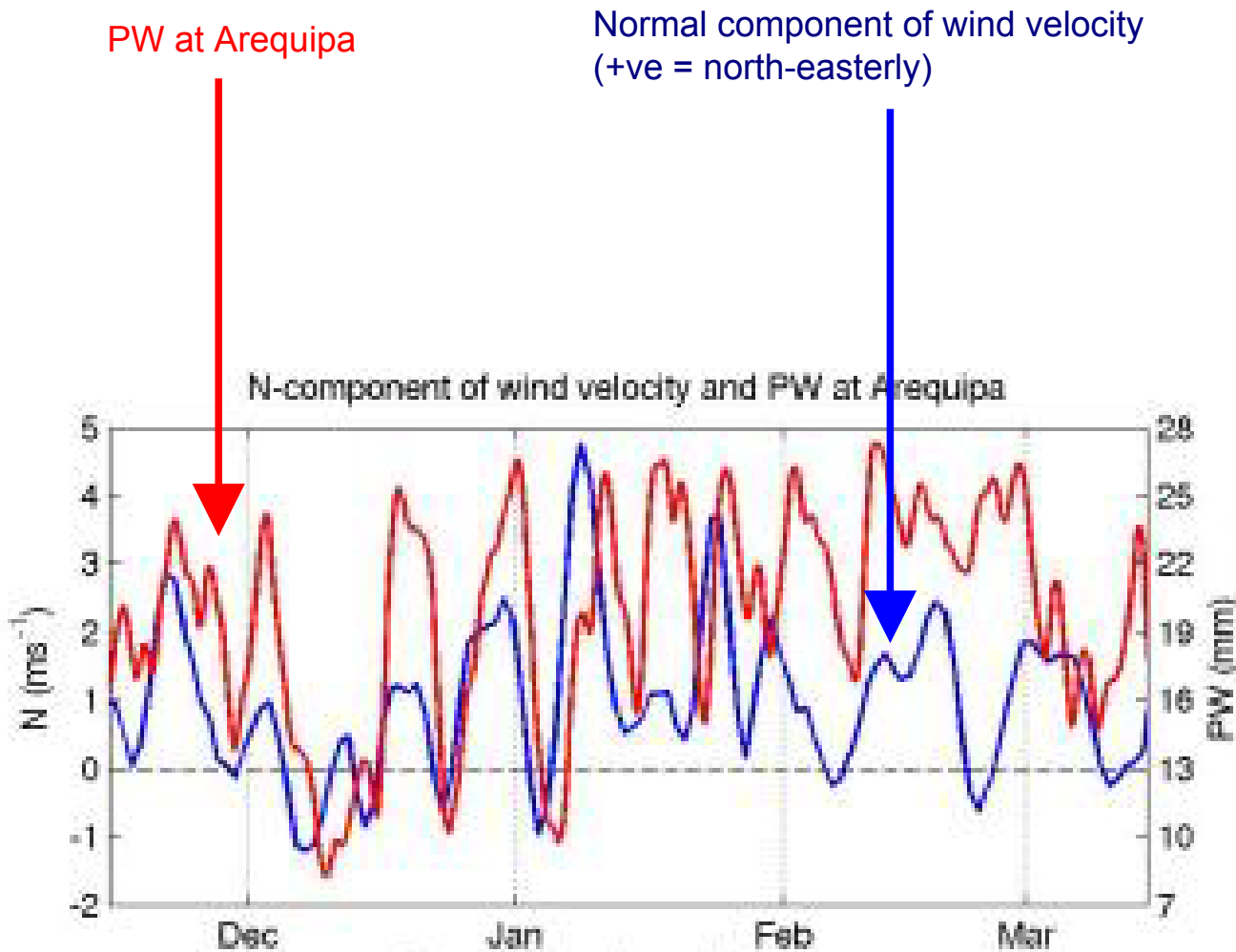
Dependance of Antiplanic Moisture on Upper Level Flow Direction

- 6 seasons 1997 – 2003 of GPS-PW and reanalyzed winds at are used to demonstrate the relationship between wind direction aloft and moisture content over the western Altiplano.
- PW appears most strongly related to the componant of flow normal to the Altiplano.

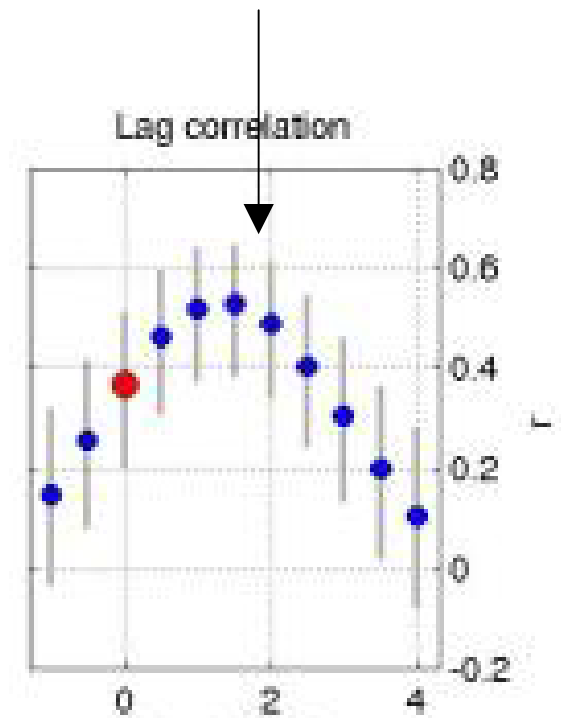


Relationship between Normal Wind Velocity (N) and PW

- This plot shows the relation between moisture over the western Altiplano and the mountain normal component of wind speed during the SALLJEX season.



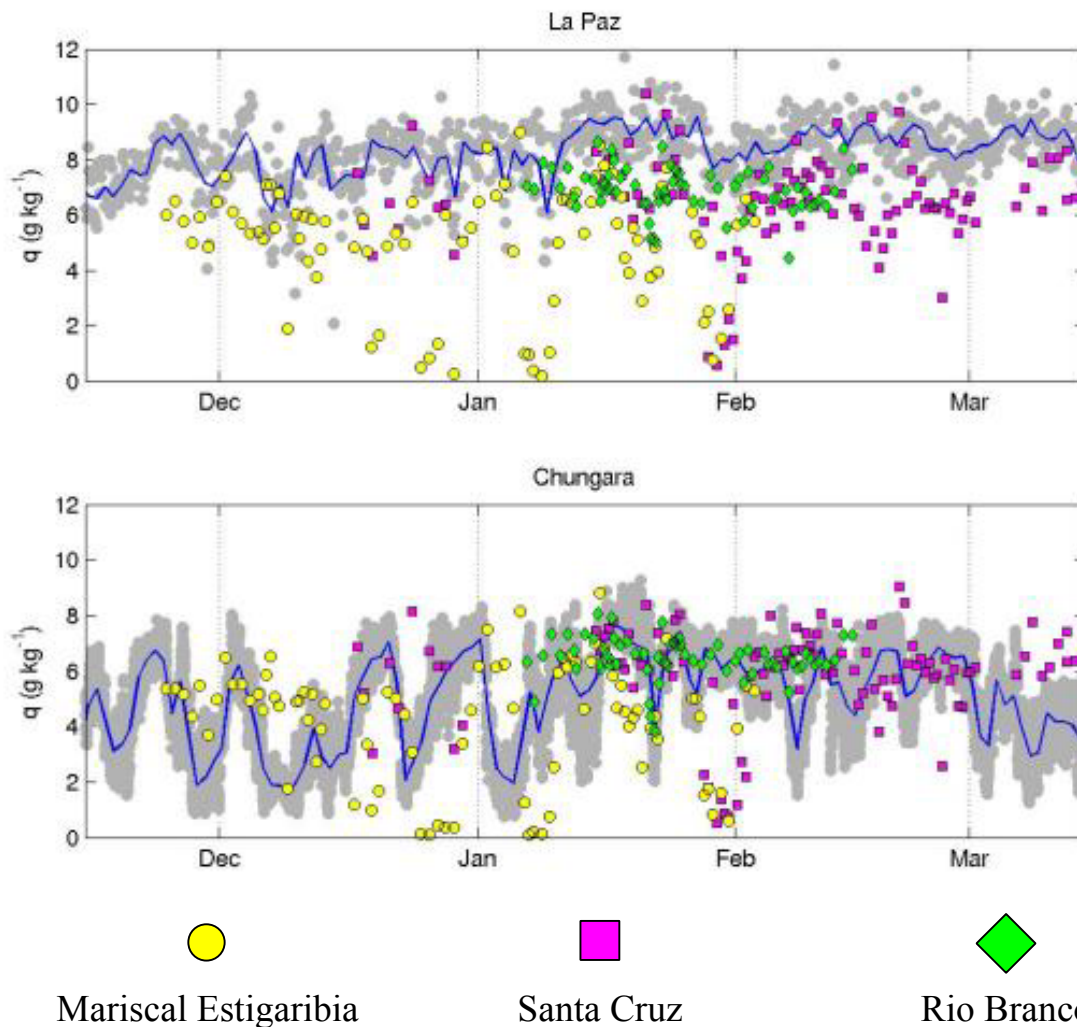
PW and N are most strongly correlated when the winds are shifted forward by 1.5 days, indicating a lag between changes in wind direction and the response of water vapor over the Altiplano



(A statistically significant lag of ~1 day is also evident in a 6 year comparison of GPS-PW and N-wind)

The origin of moisture over the Altiplano?

- Surface specific humidity at sites on the Altiplano is not substantially higher than that at the same height measured by radiosondes in the Amazon basin (particularly for surface stations in the western Altiplano, i.e Chungara, Oruro).
- This suggests that simple east-west advection can provide the bulk of the moisture observed over the Altiplano during wet events.



Summary

SALLJEX datasets have been used to examine the variation of moisture, convective cloudiness, rainfall and cross mountain flow during the period 15 November 2002 – 15 March 2003. The SALLJEX observations largely reaffirm the results of past studies and conceptual models of the summertime climate of the Altiplano. i.e.,

- Water vapour over the Altiplano exhibits marked intra seasonal seasonal fluctuations, most noticeably at points in the western Altiplano.
- Intra seasonal fluctuations of specific humidity are mostly local to the Altiplano, where they have considerable spatial and vertical extent.
- Periods of high moisture over the western Altiplano are associated with periods widespread convective cloudiness and rainfall.
- Periods of high specific humidity are significantly correlated with periods of synoptic scale north-easterly flow aloft.

In addition:

- Little mean difference is observed between the surface specific humidity over the Altiplano and the specific humidity at the same height above the Bolivian lowlands. This suggests that simple east-west advection can provide the bulk of the moisture observed over the Altiplano during wet events. i.e., the mechanism of upslope flow on the eastern slopes of the Andes may be less important than previously suspected.