Climatology of tides and Q2D PW in the MLT region over the central coast of Peru and comparison with WACCM-X model

J. Suclupe[1,2] J.L. Chau[3], M. Milla[4], N. Pedatella[5], K. Kuyeng[1], D. Scipión[1]

[1]Radio Observatorio de Jicamarca, Instituto Geosfísico del Perú, Lima, Perú [2]Sección de Física Aplicada, Pontificia Universidad Católica del Perú, Lima, Perú [3]Leibniz Institute of Atmospheric Physics at the University of Rostock, Kühlungsborn, Germany [4]Sección de Electricidad y Electrónica, Pontificia Universidad Católica del Perú, Lima, Perú [5]High Altitude Observatory, NCAR, Boulder, CO, USA.

Abstract

This work show results of the climatology of solar tides (8, 12 and 24 hours) and quasi-two-day (Q2D) planetary waves obtained from the analysis of zonal and meridional mean winds that have been estimated at heights between 80-100 km over the central coast of Peru. We are considering in this analysis two years and half of wind data (Nov 2019- Apr 2022) measured with the multi-static specular meteor radar deployed around the Jicamarca Radio Observatory (11.95°S, 76.87°W) (SIMONe Jicamarca). Furthermore, this observational climatology is compared to a climatology obtained with the WACCM-X model. Based on the observations, we can conclude that, in general, the diurnal tide is more intense than the semidiurnal tide, and that the meridional components are more intense than the zonal ones. Moreover, the observations show higher amplitudes than the model does. The observations show that the Q2D PW has the maximum module in local summer months (mainly January) while the model shows maximum amplitudes in local summer months (January) and also in local winter months (June and July). Observations show that the 24h tide has the main maximum intensity between August and September, and a second peak in April, but the model shows two similar maximum peaks, the first one between August and September and the second one between February and April. Further details will be described in this work.

1. Location

Figure 1: Current simone stations.
Tx station: JRO
Rx stations: Alcacoto-Alto, Ancón, Pachacamác, Azpitia and Huancayo.

2. Objectives, data and methodology

- **Objectives: Obtain the climatology** of the background winds, solar tides (8, 12 and 24 hours) and Q2D planetary wave (48h) in the MLT region from the winds measured with the SIMONe Peru radar network (Jicamarca) and **compare this observational climatology** with a climatology obtained with the **WACCM-X** general circulation model.
- **Observational (SIMONe Peru) data:** Half-hourly zonal and meridional mean winds (Nov 2019 - Apr 2022).
- **Model (WACCM-X) data:** Three-hourly zonal and meridional mean winds (2010 - 2019).
- **Least square method** was applied.

3. Results and discussion

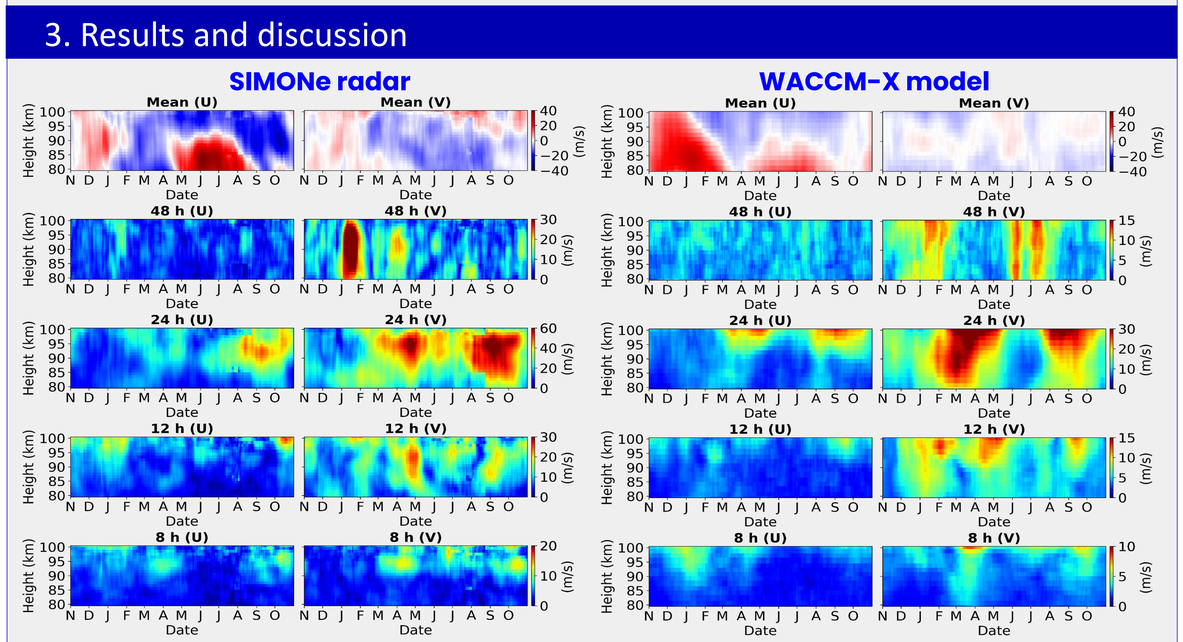

Figure 2. Composite year of amplitudes. Background winds and amplitudes of tides (24, 12 and 8 h) and Q2D Planetary wave. They were obtained by fitting to specific periods. The window size for the fitting was 21 days. Note the difference in scale between amplitudes of observations and the model.

SIMONe Climatology

- **In general**
  - The 24-hour tide is the most intense.
  - The meridional component is stronger than the zonal component.
- **Quasi-two-day PW**
  - It reaches maximum intensity in the local summer months, mainly January (80 - 100 km).
  - It reached a second intensity peak from March 15 to April 15 between (86 - 96 km).
- **24h tide**
  - For the zonal and meridional component, the maximum intensity is reached between August and September (83 - 99 km), and there was a second peak in April between (85 - 99 km). During the last days of August and the first days of October there is a high value of variability (see figure 3).
  - The minimum occurs in November and December.
- **12h tide**
  - For the meridional component, the maximum amplitude occurs from the first days of April to the first days of May (85 - 97 km).
  - For the zonal component, an increase of amplitudes (90 - 100 km) is observed in January. In addition, another increase is observed in October (95 - 100 km). In this last increase, the zonal component is greater than the meridional.
- **8h tide**
  - For the zonal and meridional component, amplitude increases above 90 km were observed.
  - The maximum values reached in the meridional component occur between March and April, as well as in October. These maxima possibly related to the fall (March 20) and spring (September 22) equinoxes.

3. Results and discussion

SIMONe Climatology

- **Zonal background wind**
  - A quasi-semi annual (quasi-annual) period is observed below (above) 90km.
  - The winds from May to August (80 - 90 km) are mainly eastward, and for this same period, between 90-100 km are mainly westward.
  - The winds in November and December (80 - 100 km) are mainly eastward. Also, in February and March for this same range of heights, the winds are westward.
  - In September and October, between (80 - 100 km), the winds are mainly westward, however, for regions less than 85 km there is a region of easterly winds. This region, in the observed time, has presented considerable variability (between September 15 and October 15) (see figure 3).
- **Meridional background wind**
  - A quasi-annual period is observed.
  - From November to January between 80-100 km, and from July to October between 92-100 km, the winds were mainly northward. For the rest of the months and heights, the winds were mainly southward.

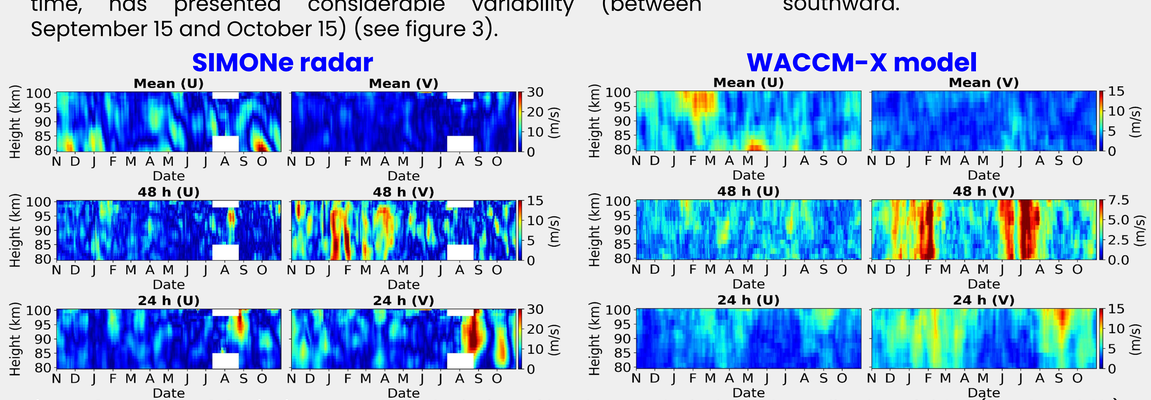

Figure 3. Standard deviation. Standard deviation of background winds and amplitudes of tides (24, 12 and 8h) and Q2D Planetary waves (48h). Note the difference in scale between amplitudes of observations and the model.

	Zonal		Meridional	
	correlation	ratio	correlation	ratio
Mean	0.44 (h = 0 km)	1.4	0.16 (h = 1km)	6.7
Q2D PW	0.26 (h = 8 km)	1.7	0.33 (h = 12km)	2.4
24h tides	0.67 (h = 8 km)	1.9	0.61 (h = 10km)	1.5
12h tides	>0.24 (h > 14km)	1.2	>0.54 (h > 14km)	1.3
8h tides	>0.71 (h > 14km)	0.8	0.48 (h = 3km)	1.6

Table 1. Average of height - correlations and ratios of maximum amplitudes between SIMOne observations and WACCM-X model. 'h' indicates the shift in altitude used to get the highest correlation.

Comparison with WACCM-X model

- The observations show larger amplitudes than the model.
- The observations show that the **Q2D PW** has the maximum module in the local summer months (mainly in January), while the model shows maximum amplitudes in the local summer months (January) and also in the local winter months (first days of June and July).
- Observations show that the **24h tide** has its main maximum intensity between August and September, and a second peak in April, but the model shows two similar maximum peaks, the first between August and September and the second between February and April.
- Observations and the model show that meridional **12h tide** has a peak in April-May, and meridional **8h tide** has one peak in March-April and other in September-October.
- As average, correlations (ratio of maximum amplitudes) between the observations and the model are 0.46 (1.4) for the zonal component and 0.42 (2.7) for the meridional component. See table 1 for further details.

4. Future Work

- Obtaining the climatology of MLT winds at other latitude (e.g. using SIMONe Piura radar network).

5. Acknowledgments

- Thanks to PROCIENCIA for the financial support through agreement N° 075-2021-FONDECYT.
- Thanks to Leibniz-Institute of Atmospheric Physics and Jicamarca Radio Observatory staff.
- Thanks to Dr. Pedatella for provide us the WACCM-X data.

6. References

[1] Chau, J. L., Urco, J. M., Vierinen, J., Harding, B. J., Clahsen, M., Pfeffer, N., ... & Erickson, P. J. (2020). Multistatic specular meteor radar network in Peru: System description and initial results.
[2] Lima, L. M., Paulino, A. R. S., Medeiros, A. F., Buriti, R. A., Batista, P. P., Clemesha, B. R., & Takahashi, H. (2007). First observation of the diurnal and semidiurnal oscillation in the mesospheric winds over São João do Cariri-PB, Brazil. Revista Brasileira de Geofísica, 25, 35-41.
[3] Dempsey, S. M., Hindley, N. P., Moffat-Griffin, T., Wright, C. J., Smith, A. K., Du, J., & Mitchell, N. J. (2021). Winds and tides of the Antarctic mesosphere and lower thermosphere: One year of meteor-radar observations over Rothera (68° S, 68° W) and comparisons with WACCM and eCMAM. Journal of Atmospheric and Solar-Terrestrial Physics, 212, 105510.

email: jsuclupe@igp.gob.pe