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Recent Measurements of Thermospheric Winds over South Africa and Comparison with Horizontal Wind Model

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Abstract

Being able to understand trends and better specify the thermospheric winds is a critical step in improving our ability to model and predict the state of the upper atmosphere. Much effort has gone into providing measurements of the global thermospheric wind system, however measurements from the African sector are historically lacking. To address this, a new Fabry-Perot Interferometer (FPI) has recently been deployed to the South African Astronomical Observatory (SAAO), located at (32.38° S, 20.81° E). Here, we present the first observations from this site and compare the data collected from SAAO with the output of the Horizontal Wind Model (HWM14). This site is far removed from the locations of ground-based measurements used in the specification of HWM14. Thus, this data-model comparison serves as an independent validation of HWM14.

South African Astronomical Observatory

- In January 2018, a new FPI was installed at the South African Astronomical Observatory (SAAO) in Sutherland, South Africa (located at 32.38° S, 20.81° E) to study thermospheric winds and temperatures.
- This is one of four long term FPIs in Africa, but the first located in Southern Africa. The other three are located in Nigeria, Morocco and Ethiopia.
- Due to potential contamination of the dark skies at this astronomical site from our standard laser calibration chamber, the data presented here were obtained without a laser calibration source. For the wind measurements, this means that the zero reference was obtained assuming zero vertical wind.

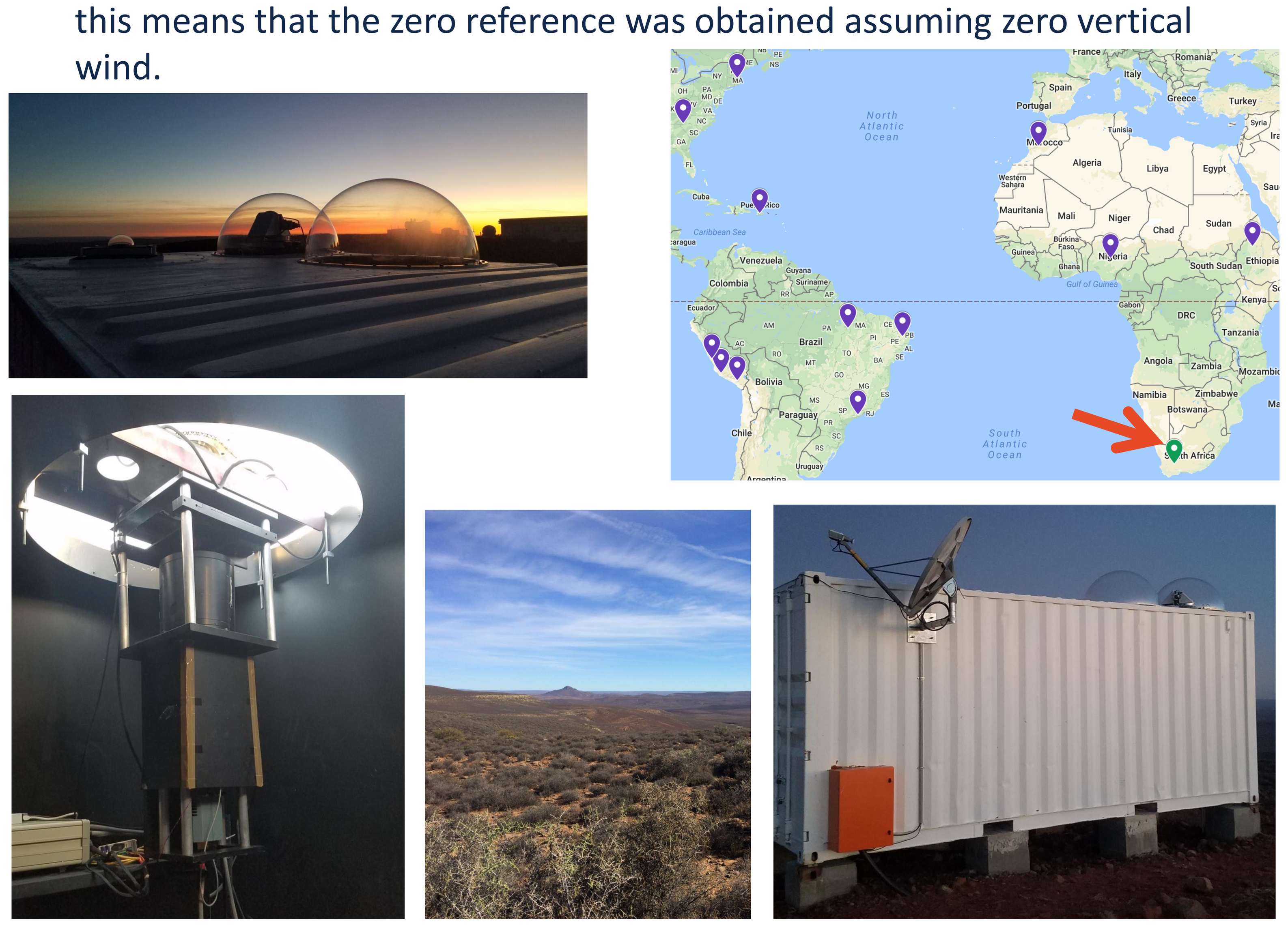

Figure 1: Images of the site of the new FPI in Sutherland, South Africa.

Night to Night Variability

- Significant variation in amplitude of zonal wind after reversing westward.
- Time at which the zonal wind reverses varies by ~2 hours (1:00 LT - 3:00 LT) over these three nights.
- In the meridional wind, there appears to be more variation before the wind turns poleward, where sometimes a double peak feature arises. This feature gets averaged out when looking at data over the month.

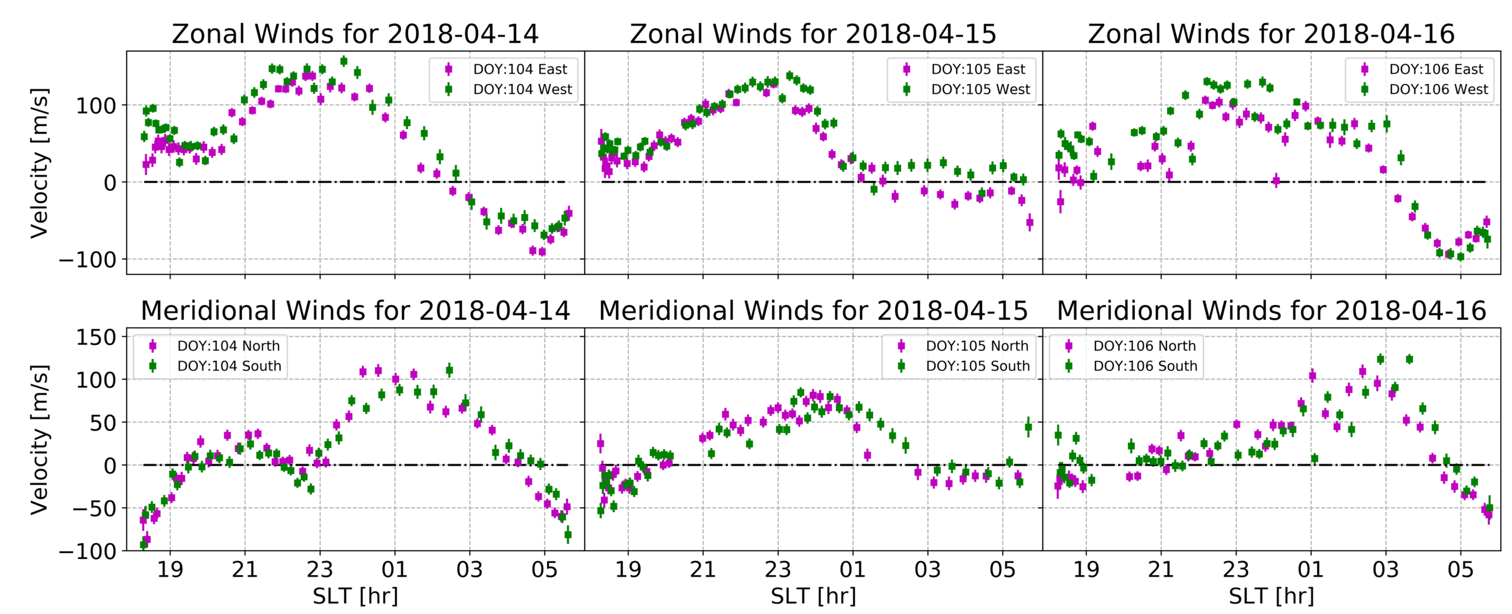

Figure 2: Data from three consecutive nights (|Dst|<20 nT). The top panel shows the zonal wind and the bottom panel shows the meridional wind.

Climatological Model Comparison

- Wind data is binned by 30 minutes for each day in the month and then averaged over the month.

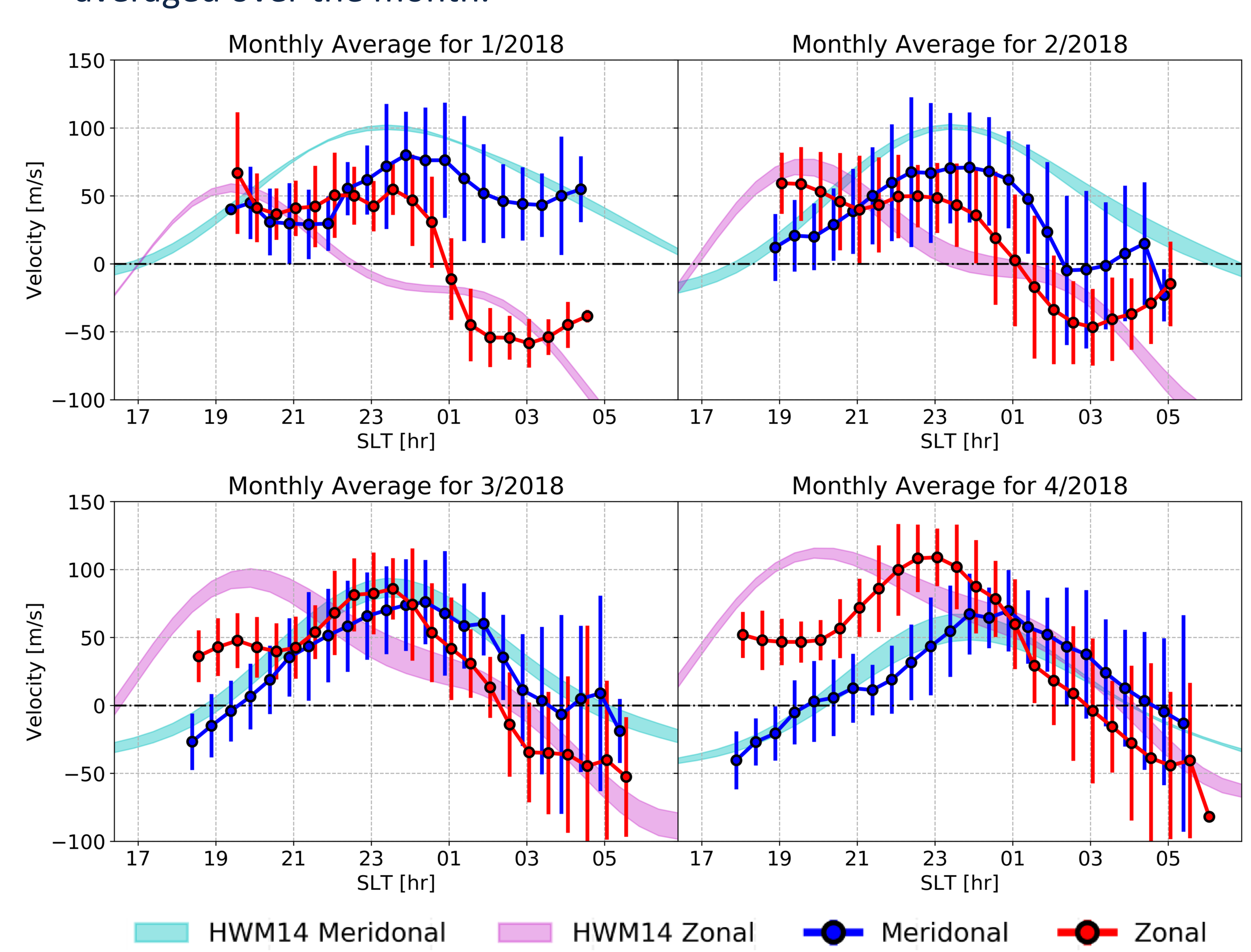

Figure 3: Monthly averages for the first 4 months of wind data from SAAO. Errorbars on each point represent the 1-sigma variability within each monthly bin.

Climatological Model Comparison (cont.)

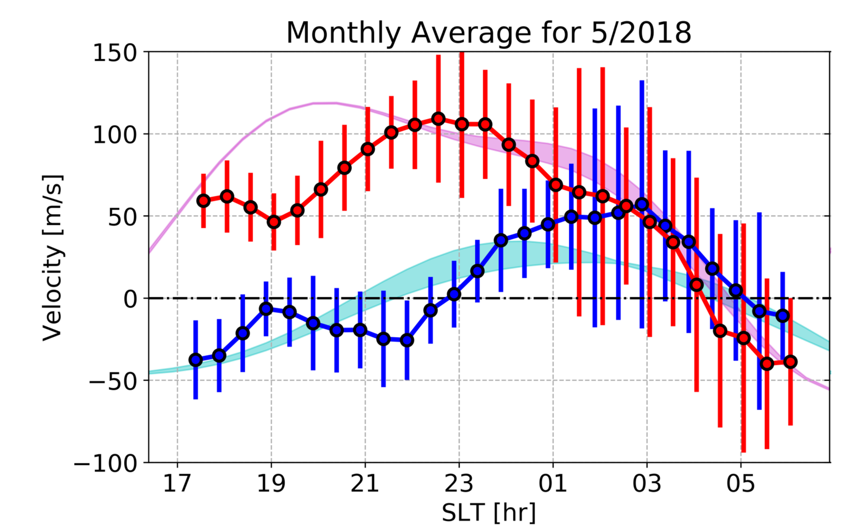

Figure 4: Monthly averages for the fifth month of wind data from SAAO. Errorbars on each point represent the 1-sigma variability within each monthly bin.

- Phase shift of the maximum in the zonal wind is not captured by HWM for all months of data. This is consistent with findings in Morocco in June and July (*Fisher et al., 2015*).
- Zonal wind data presents an initial local minima at the beginning of the night that is not shown in HWM. This trend is most noticeable in the summer months (January and February).
- In May, the timing of the maximum meridional wind and the presence of the initial local maxima are both not properly captured by HWM.

Conclusions

- There is significant night-to-night variability in both meridional and zonal wind measurements, particularly in the 2:00 LT - 5:00 LT time frame.
- The meridional component of the Horizontal Wind Model agrees fairly well with the data for January through April.
- The zonal wind data is offset from the Horizontal Wind Model by what appears to be a phase shift. This discrepancy is prevalent in all months of data thus far.
- Future work will continue comparison with HWM and will investigate longitudinal variability using data from instruments at similar geographic and geomagnetic latitudes.

Acknowledgements:

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Fisher, D. J., Makela, J. J., Meriwether, J. W., Buriti, R. A., Benkhaldoun, Z., Kaab, M., & Lagheryeb, A. (2015). Climatologies of nighttime thermospheric winds and temperatures from Fabry Perot interferometer measurements: From solar minimum to solar maximum. *Journal of Geophysical Research: Space Physics*, *120*(8), 6679-6693.