Preliminary observational investigation of the variability of nighttime equatorial thermospheric winds over Nigeria, West Africa

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Outline

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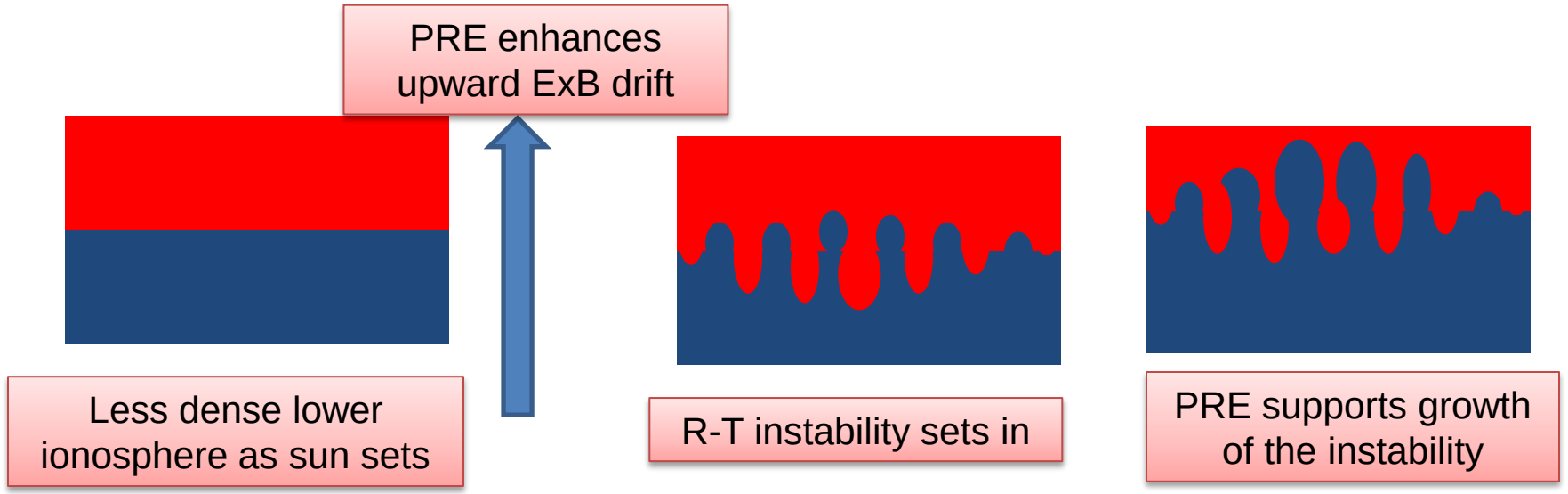
Introduction & Review of Previous Research

Equatorial plasma bubbles are evening/night time ionospheric phenomena usually occurring at the low and equatorial latitudes

EPBs are known to be caused by a combination of the Rayleigh-Taylor (R-T) Instability and the Pre-Reversal Enhancement (PRE)



Introduction & Review of Previous Research

The structure of the low-latitude ionosphere-thermosphere system is established to be partly a consequence of the mutual interactions between the plasma, electrodynamics, and the neutral atmosphere [e.g., Rishbeth, 2000; Chapagain et al., 2012].

Data & Methods - FPI

Thermospheric neutral wind speeds were obtained from a Fabry-Perot interferometer (FPI) installed at the Space Environment Research Laboratory, Abuja, Nigeria (Geographic: 8.99°N, 7.38°E; Geomagnetic: 1.6°S)

The FPI is installed as a result of collaboration between the National Center for Atmospheric Research (NCAR), USA, and the Centre for Atmospheric Research (CAR), Nigeria.

It measures the Doppler shift in the O 630 nm airglow emission induced by the neutral wind at altitude of about 250 km.
The error in the wind speed is about 2-6 m/s

Data & Methods - FPI

The instrument has a rotating stage (with a mirror) for viewing at 45 degree elevation angle.
The rotating stage will direct the instrument to view at 45^{o}, 135^{o}, -45^{o}, and -135^{o} angles relative to a fixed calibration lamp. The instrument is oriented in such a way that at 135^{o} it is viewing north, 45^{o} is west, -135^{o} is east, and -45^{o} is south.

Under the rotating stage, there is a CCD camera which is maintained at a temperature of -8.5^{o}C. The instrument is connected to a cloud detector for sky condition monitoring. The sky cloud condition is recorded to the data header to be used during data selection.

Data & Methods - FPI

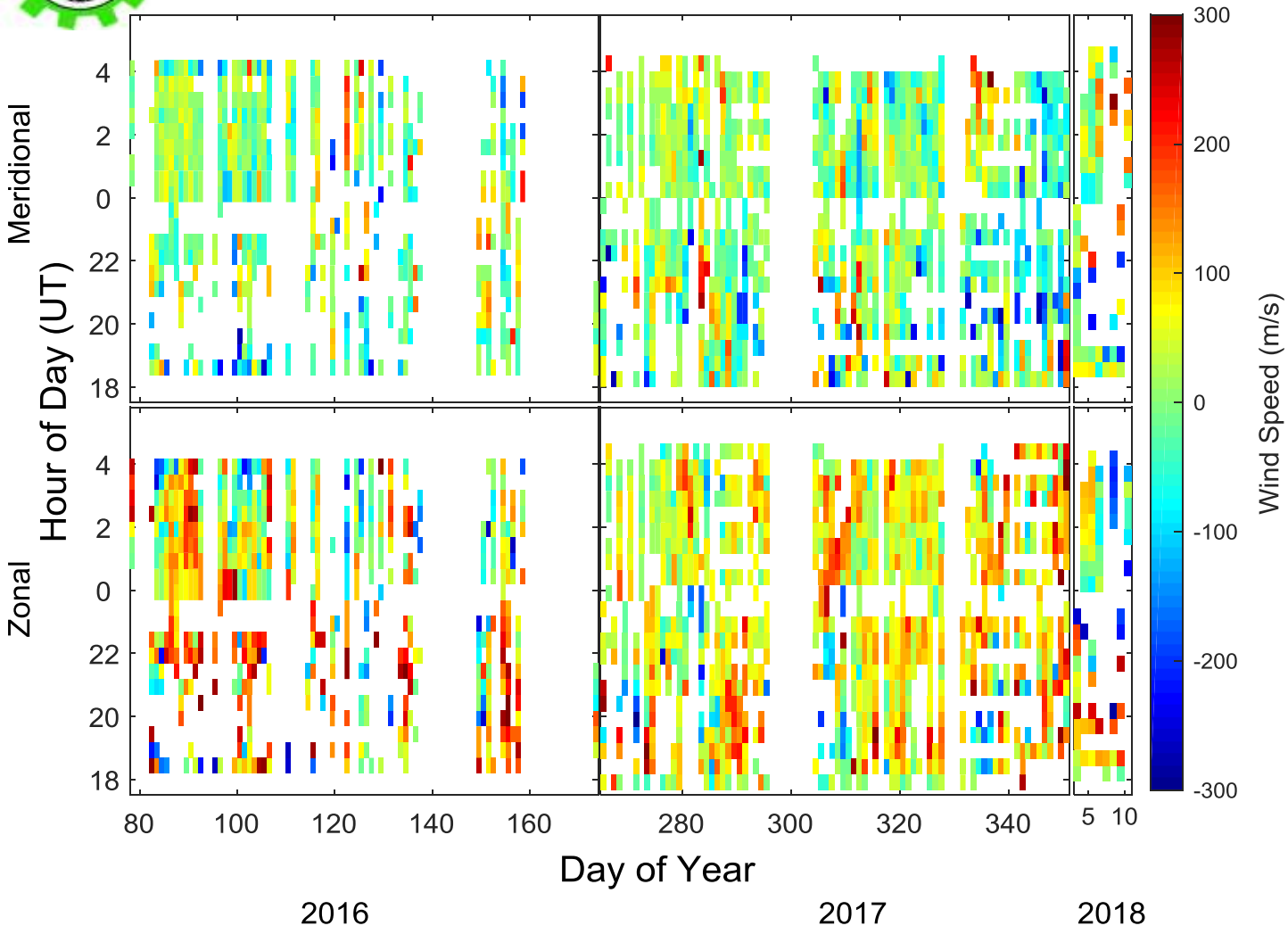
Data from the FPI instrument are obtained and stored as images.
Each image is stored as a file with a 2-byte integer header. The image size is 346x258 (2-byte unsigned integer).

The image data are processed into wind speed information using software developed at NCAR.

Data Availability

2016: March through June
2017: September to December
2018: January

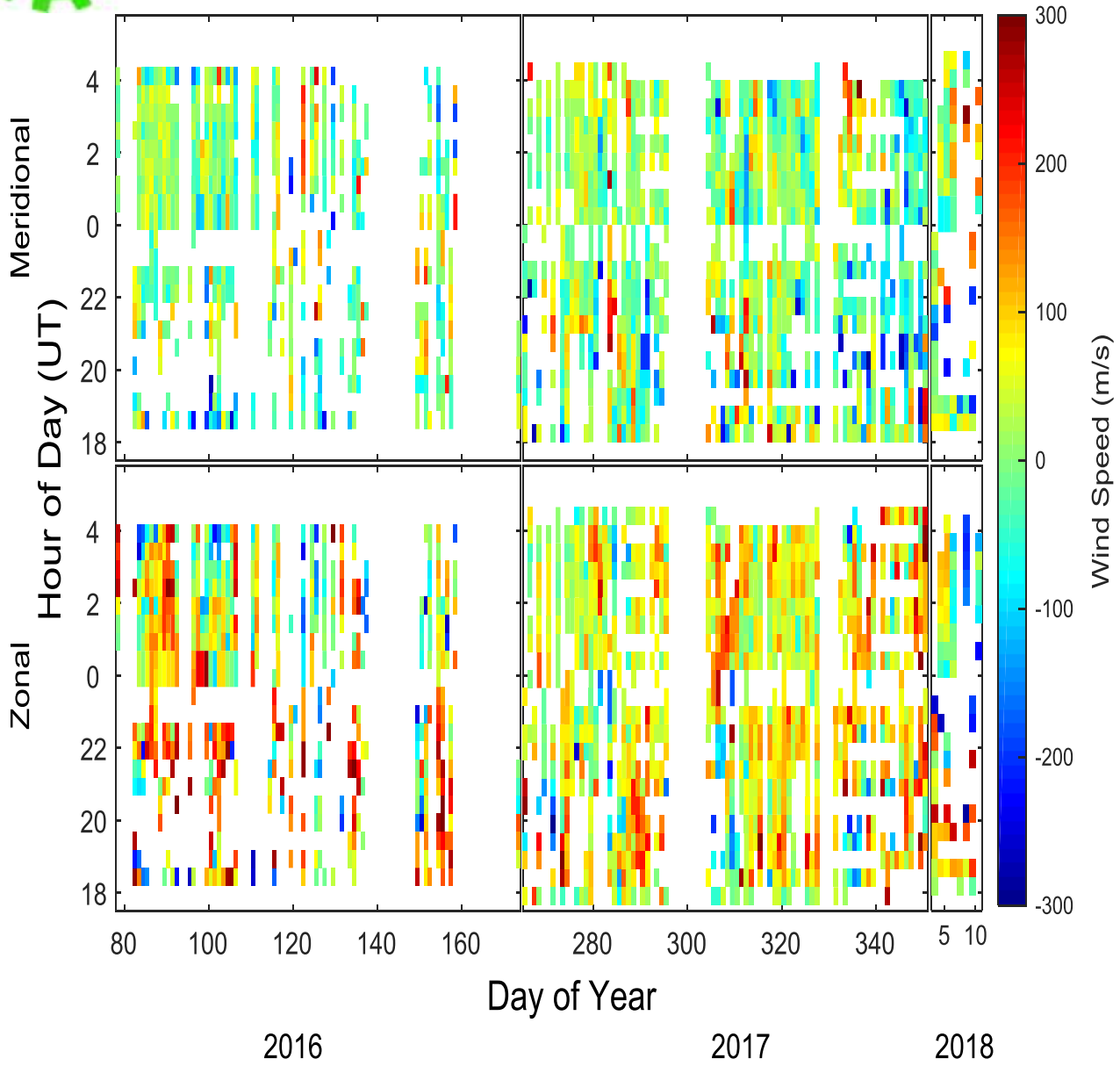
Night time variation of meridional & zonal winds



The direction of the zonal wind is predominantly eastward with magnitude about 250 ms^{-1} just before midnight through the predawn period.

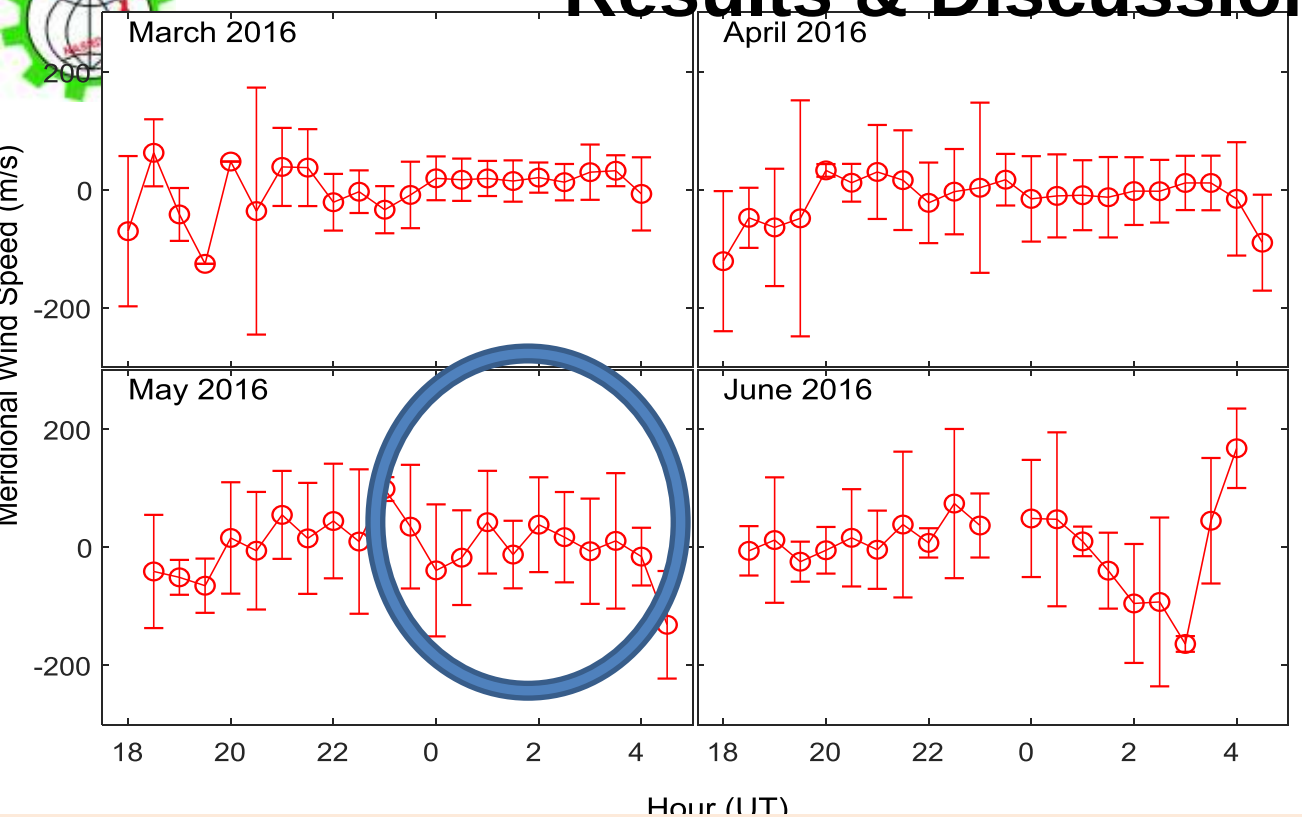
The zonal wind exhibits a generally weak magnitude in most of the nights but a few nights that recorded a magnitude of about 150 ms^{-1}

Night time variation of meridional & zonal winds



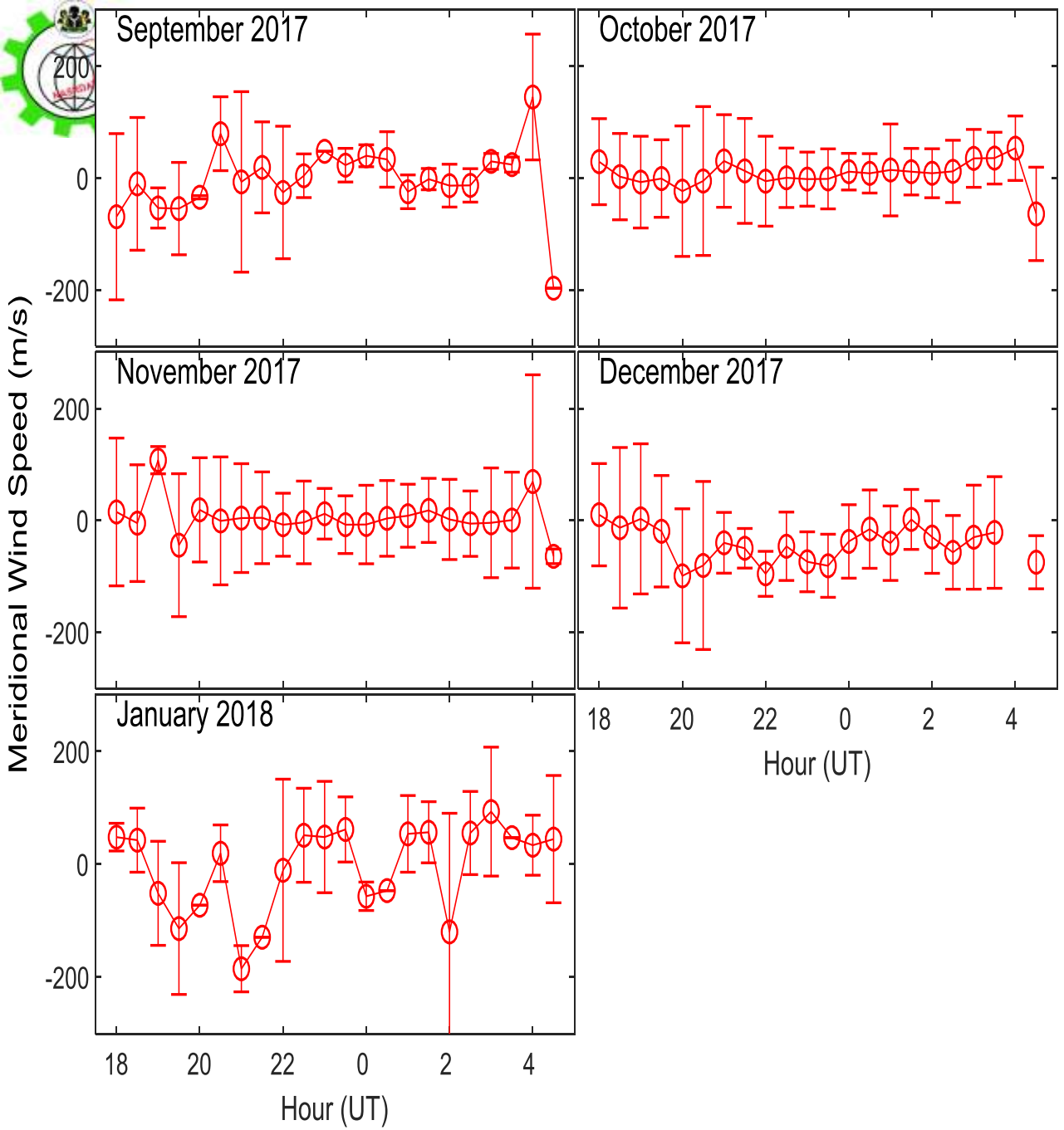
For the meridional wind speed, the magnitudes of the post-midnight monthly mean values are generally less than those of the pre-midnight for all the months considered, except for March 2016, May 2016, June 2016, and October 2017.

Results & Discussion



The early hours of the nights during the equinox in year 2016 shows a dominant poleward wind with magnitude varying between 150 & 200m/s. This is followed by a sharp decrease just before the midnight and an equatorward shift till the predawn period.

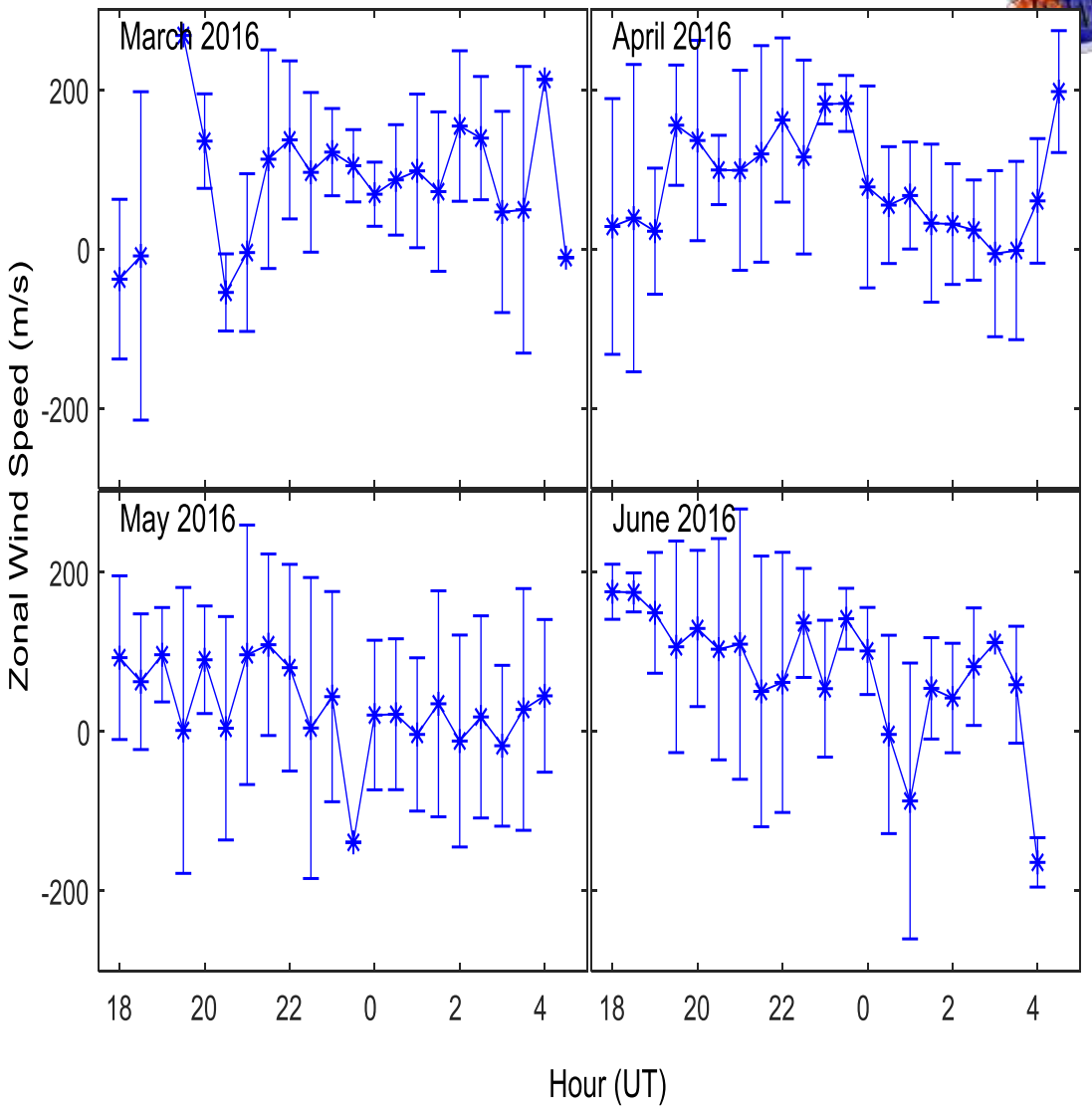
- The meridional wind is majorly poleward in the months of March 2016, June 2016; and equatorwards in the other months.
- While the meridional winds remains equatorwards before and after midnights in April 2016 it is noted to change directions either from Poleward to equatorwards or vice versa in the month of May 2016



- The solstice months in 2017 show a weak magnitude in the early hours of the night and a nearly constant magnitude just after post sunset period through the night.
- lower magnitude was observed in 2017 than other years considered.

The monthly variation in zonal wind show a predominantly eastward wind till just after twilight followed by a sudden reduction till midnight before picking up again and increase the predawn period.

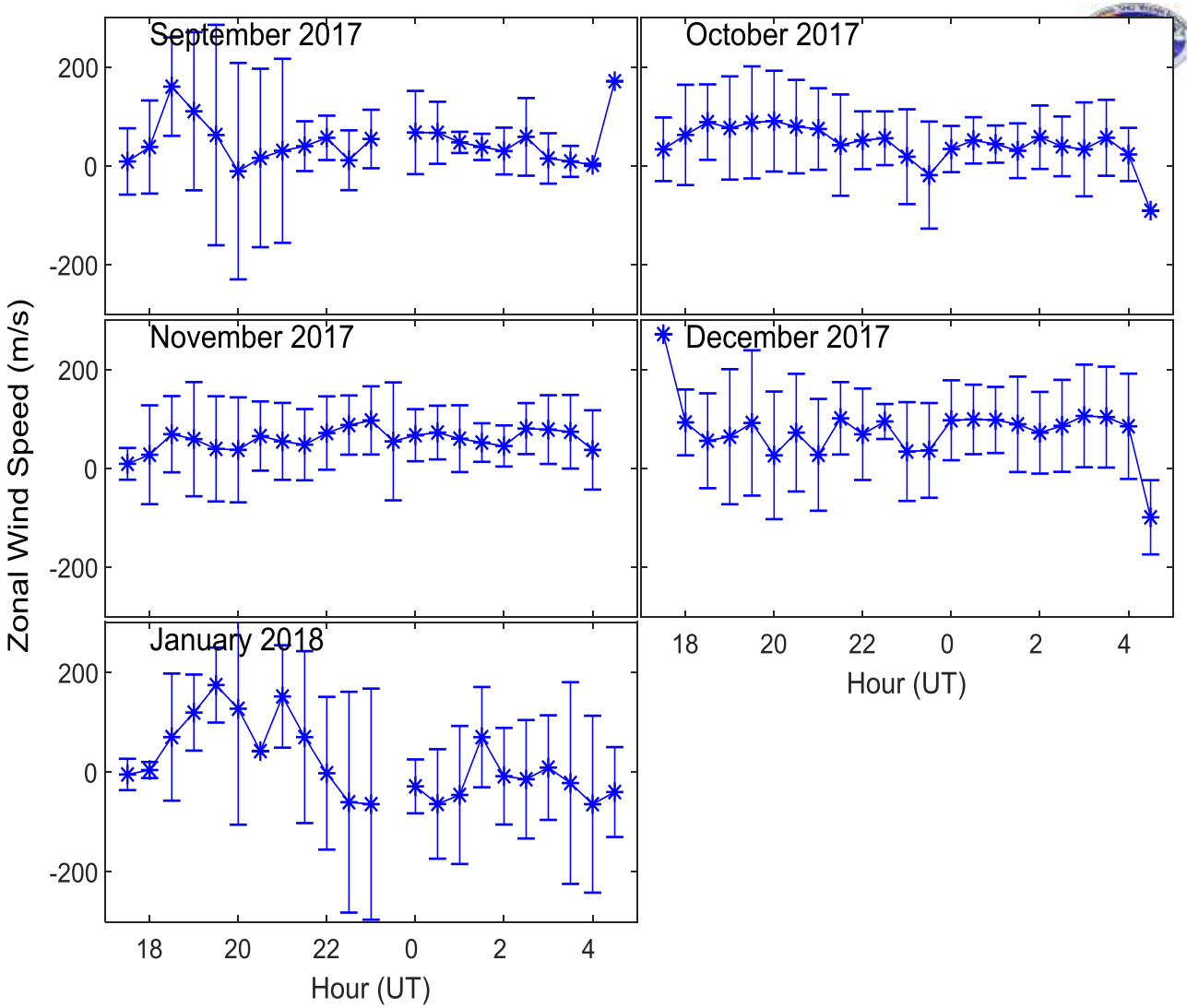
The early hours of the solstice months recorded higher magnitude of between 50 and 180m/s than the equinox months though these values reduced around the midnight.



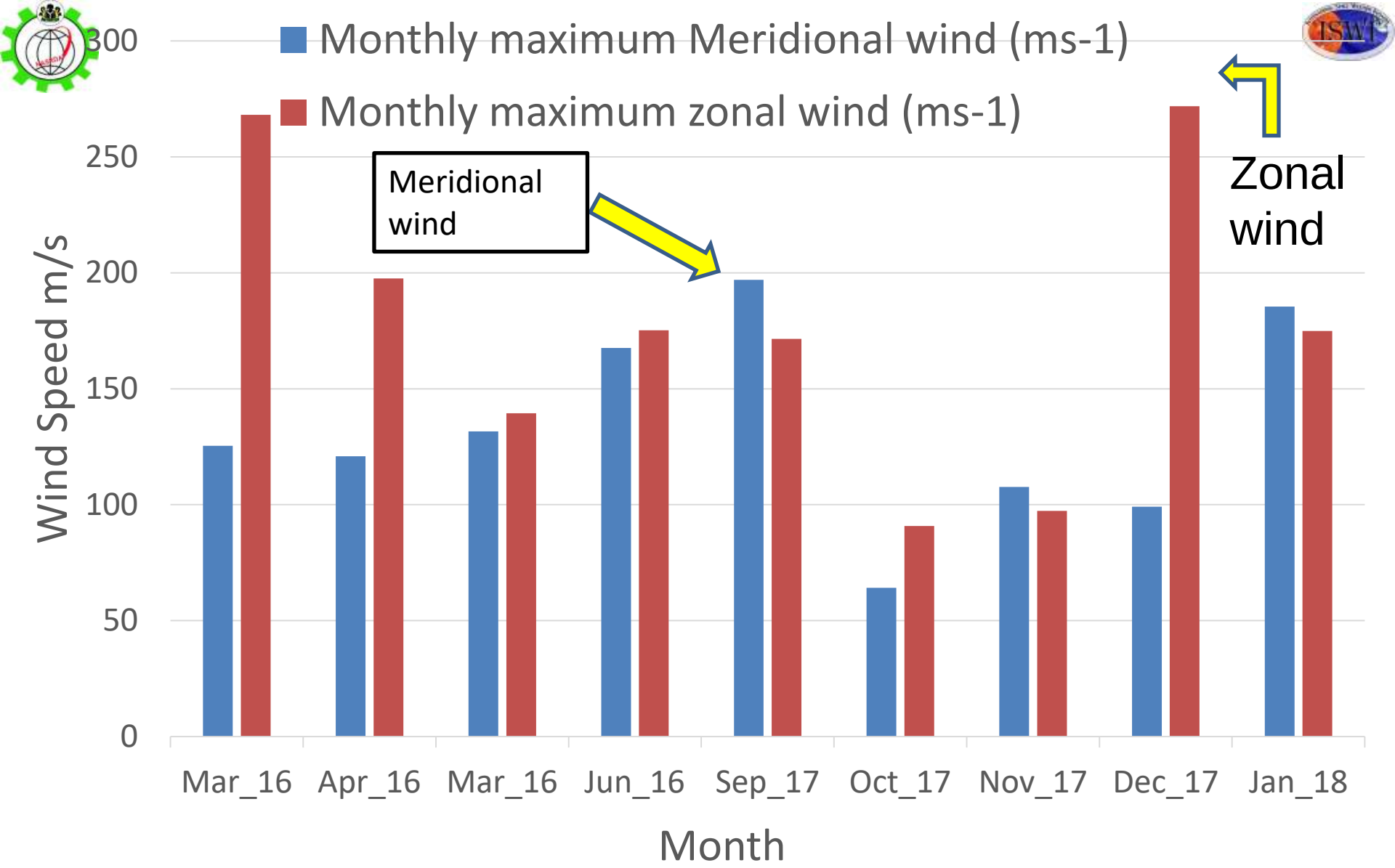
The zonal wind is majorly eastwards at all months except in December when a mean westwards speed of -19.72 was observed.

the regions around the geomagnetic equator exhibits a very strong zonal wind in the early hours of the evening [Richmond et al, 1992]

Therefore the strong eastward wind could be attributed to the presence of a strong pre reversal enhancement just after sunset.



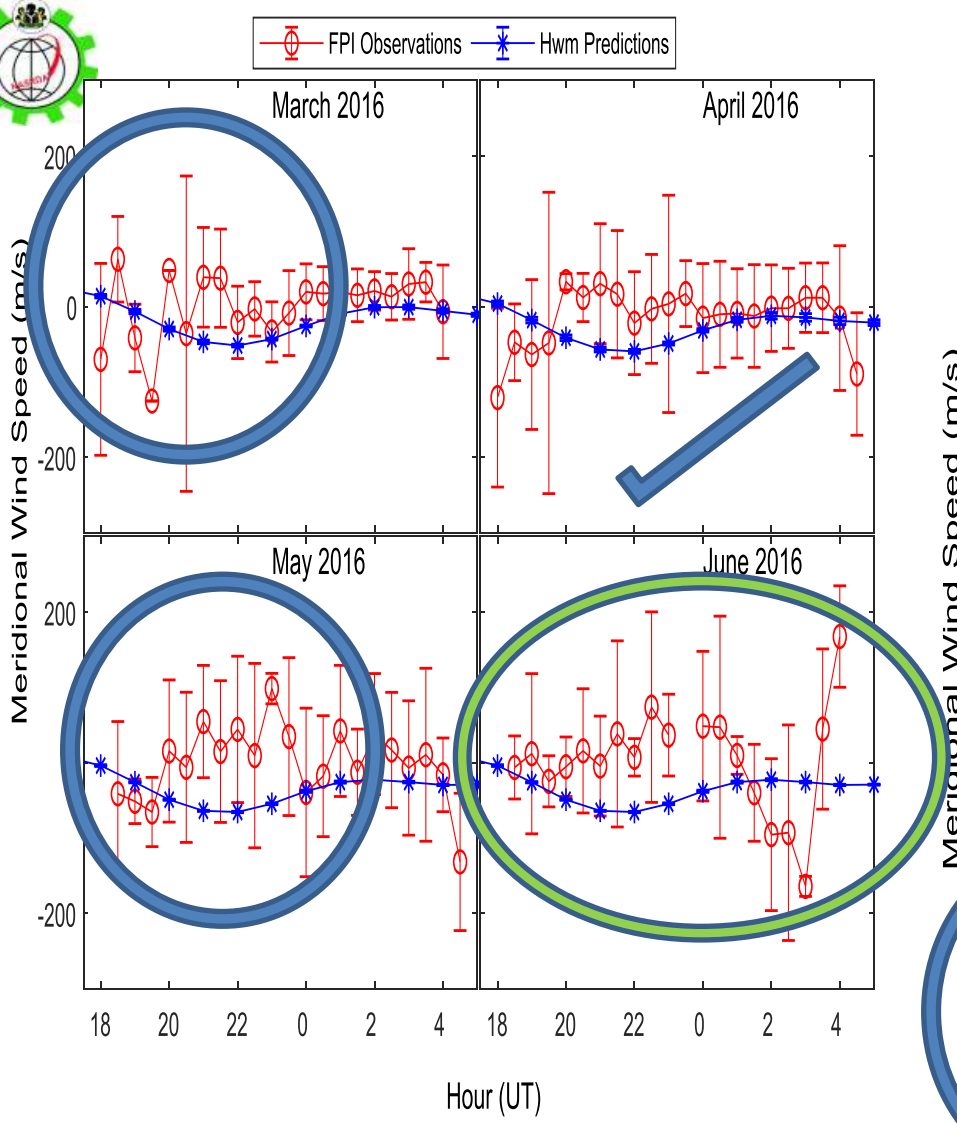
The equinoctial month of March 2016 recorded the greatest range variability of 322 ms^{-1}, while the month of November 2017 has the least range of 87.85 ms^{-1}.

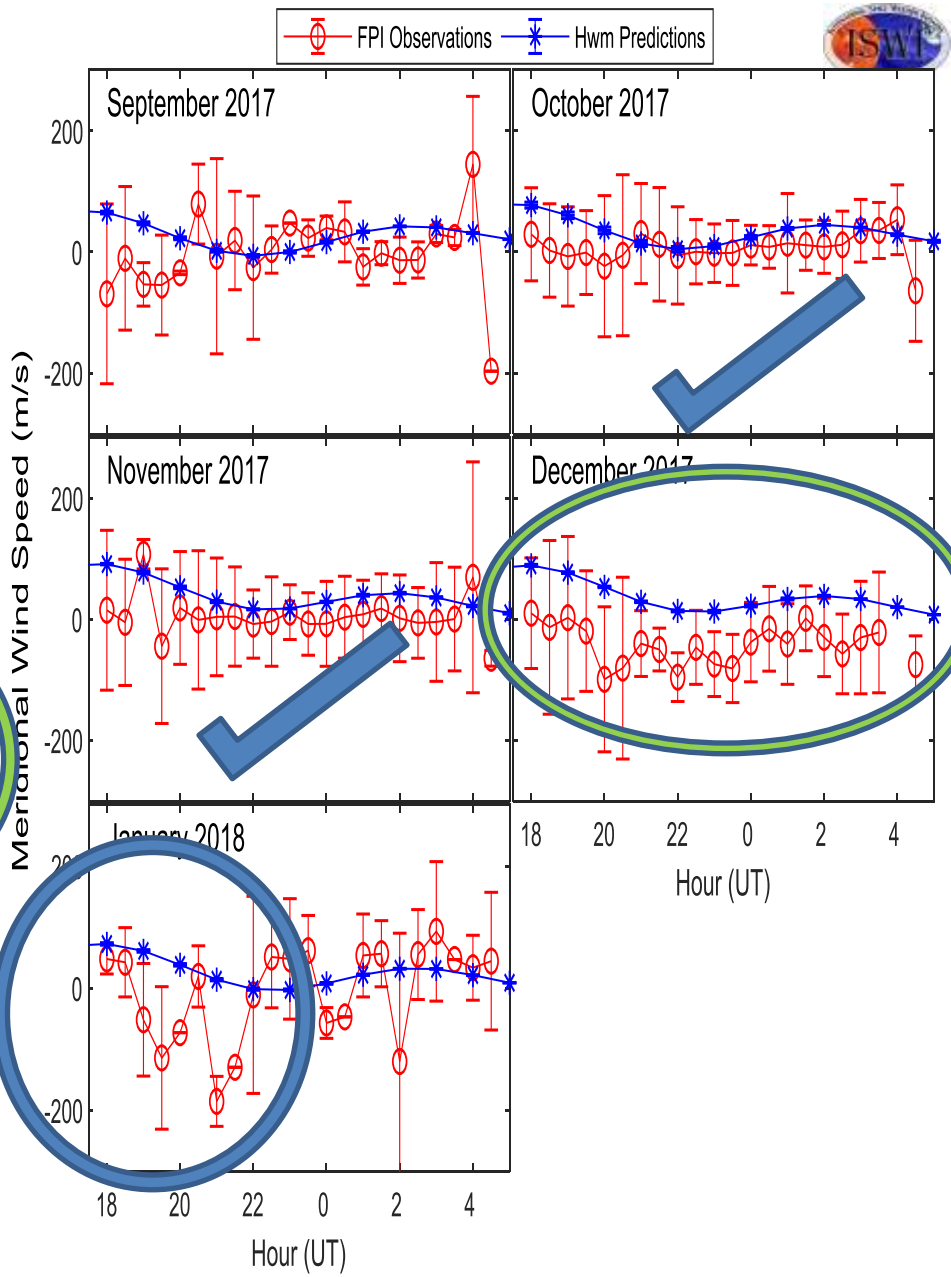


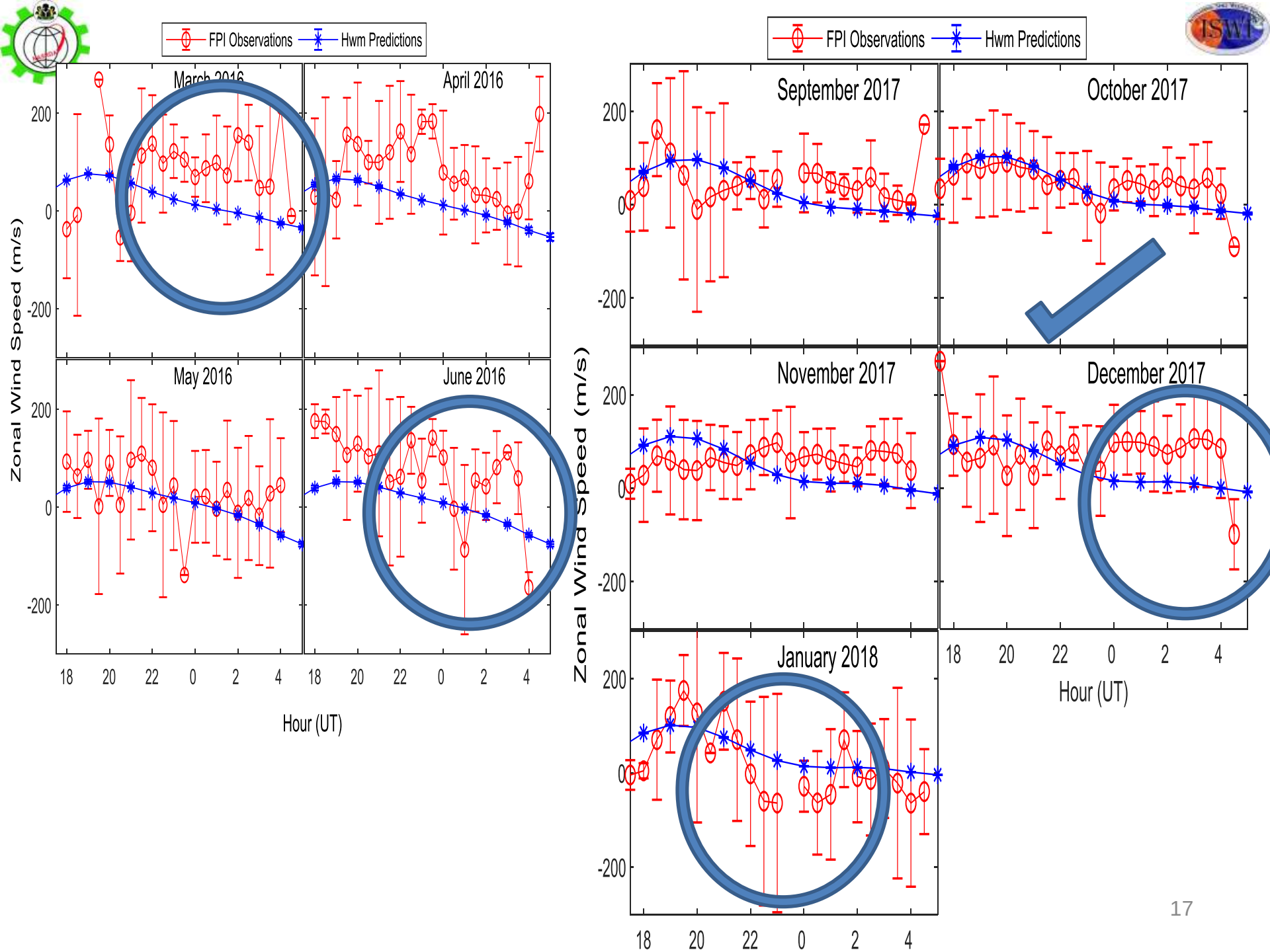
Variation of Monthly Maximum

Sector	Max zonal winds ms^{-1}	Max meridional wind ms^{-1}	References
West Africa*	271.83	196.99	This work
East Africa	90	50	Tesema et al., 2017
Peruvian	150		Martinis et al., 2001; Meriwether et al., 2011, 2012).
Brazilian	100		Meriwether et al., 2012; Makela et al., 2013

*monthly means 105.20 45.93


FPI Observations
Hwm Predictions
March 2016
April 2016
May 2016
June 2016
Meridional Wind Speed (m/s)
200
0
-200
18
20
22
0
2
4
Hour (UT)


FPI Observations
Hwm Predictions
September 2017
October 2017
November 2017
December 2017
January 2018
Meridional Wind Speed (m/s)
200
0
-200
18
20
22
0
2
4
Hour (UT)


FPI Observations
Hwm Predictions
March 2016
April 2016
May 2016
June 2016
Zonal Wind Speed (m/s)
Hour (UT)
September 2017
October 2017
November 2017
December 2017
January 2018

Conclusions

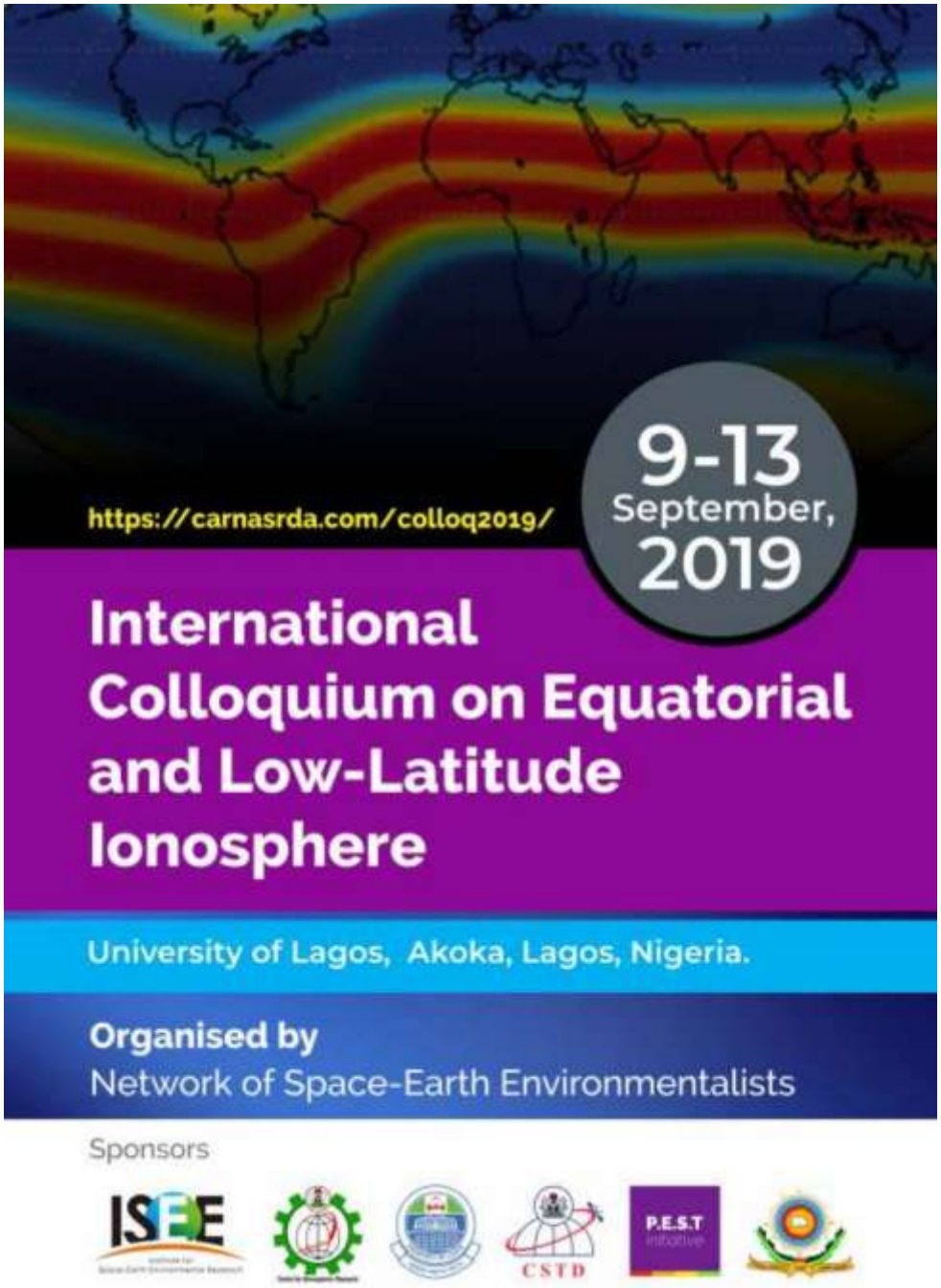
- The monthly means ranges between - 45.93 and 7.05 ms^{-1} for the Meridional wind speed
- the monthly means for the zonal wind speed range between 19.33 and 105.20 ms^{-1}.
- The meridional wind is majorly poleward (northwards) in the months of March 2016, June 2016, October 2017, and November 2017; and equatorwards (southwards) in the other months.
- The zonal wind is majorly eastwards at all months except in December

Conclusions

- Cumulatively, with the exception of March 2016, September 2017 and November 2017, the post-midnight monthly mean values of zonal wind speed are generally greater than those of the pre-midnight
- The equinoctial month of March 2016 recorded the greatest range variability of 322 ms^{-1}, while the month of November 2017 has the least range of 87.85 ms^{-1}
- For the meridional wind speed, the magnitudes of the post-midnight monthly mean values are generally less than those of the pre-midnight for most of the months
- March equinox has the highest mean zonal wind speed (89.48 ms^{-1}) and the lowest equatorward meridional wind speed (-0.85 ms^{-1})

Conclusions

- The zonal wind is more eastwards in March equinox.
- The season with the lowest mean zonal wind speed (47.60 ms^{-1}) is accompanied with the poleward mean meridional wind speed of 4.97 ms^{-1}.
- The Climatological model HWM14 mostly underestimates the post-midnight Meridional and zonal wind speeds, while at times over-estimates the thermospheric wind speeds during the hours 1800 - 2100 LT.
- There is a call for improvement of the HWM using newly observed data in African sector



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INTERNATIONAL WORKSHOP ON EQUATORIAL SUPERDARN

5th – 7th June 2019

Bowen University, Iwo, Nigeria

Theme: Prospects of Superdarn Radar System in Equatorial Region

https://carnasrda.com/superdarn-2/

Thank you

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