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Thermospheric Neutral Winds Above the Oukaimeden Observatory: Effects of Geomagnetic Activit.

A.Loutfi^{1,2}, A.Bounhir¹, F.Pitout², Z.Benkhaloun¹, and J.J.Makela³

¹ Laboratory of High Energy Physics and Astrophysics

² IRAP-Research Institute in Astrophysics and Planetology

³ Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, USA

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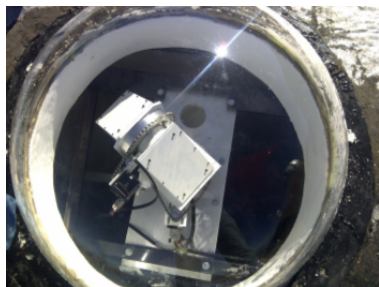
- Study the response of the thermosphere winds during the quiet and disturbed days above the Oukaimeden Observatory in Morocco (geographic coordinates : 31.206° N, 7.866° W ; magnetic latitude : 22.77° N) over 3 years (2014-2016) using instrument and digital means.



Fabry-Perot interferometer

Fabry-Perot interferometer

- Measures the atmospheric emission "airglow" at 630 nm to determine its intensity.
- Estimate the speed and temperature of neutral winds at **250 km**.



Classification of days	SYM-H	Kp	Number of days
Calm days	≥ -20	≤ 2	504
Moderate days	$-50 \leq \text{dst} \leq -20$	$2 \leq \text{kp} \leq 5$	245
Disturbed days	≤ -50	≥ 5	41

TABLE – The classification of days according to the two geomagnetic indices Kp and SYM-H.

Thermospheric Wind Variability with the solar cycle

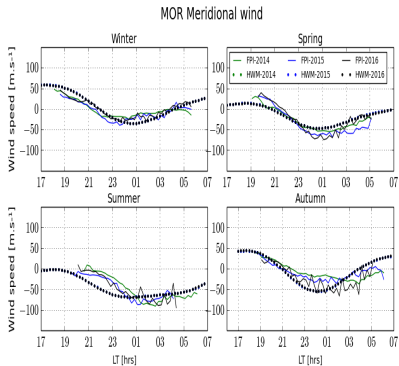


FIGURE – Seasonal variability with the solar cycle meridional winds over three years 2014,2015 and 2016.

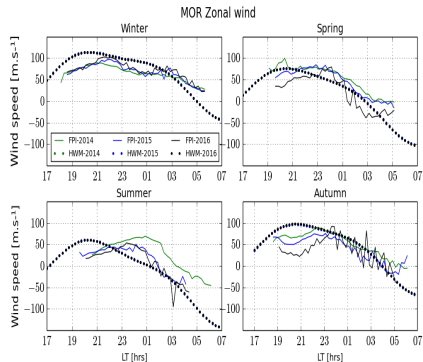


FIGURE – Seasonal variability with the solar cycle zonal winds over three years 2014,2015 and 2016.

Annual variability

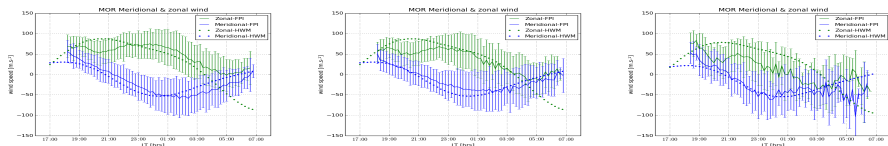
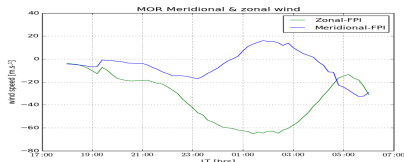
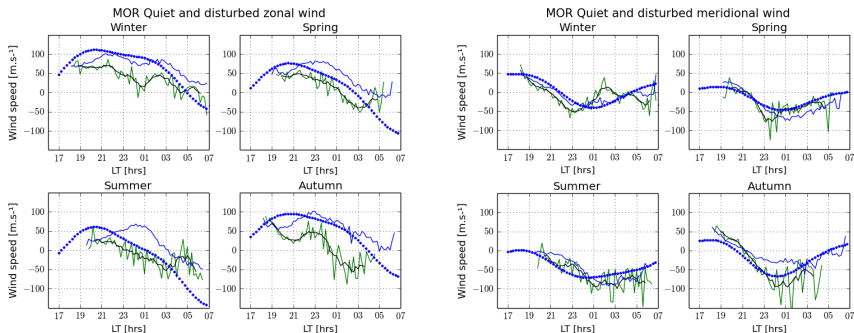


Figure : Average speed of meridional (blue) and zonal (green) neutral winds as a function of universal time, of three years measurements, from 2014 to 2016 of FPI data (solid lines) and HWM14 model (dotted lines). Quiet nights (left panel), moderate (middle panel) and disturbed (right panel) are represented. Positive values are eastward for zonal winds and northward for meridional ones.



- During all hours of the night \Rightarrow the zonal winds are heading to **westward**.
- Between [19 : 00.01 : 00] \Rightarrow southerly winds head for **south** [01h00,04h00] \Rightarrow southerly winds head for **north**.

Seasonal variability



Seasonal behavior of meridional winds(right set of panels) and zonal winds(left set of panels) for disturbed nights (solid green) and quiet nights (solid blue) as a function of local time, for three years measurements from 2014 to 2016. The solid black line is the sliding average of geomagnetically disturbed data. HWM model seasonal results (dotted lines) are also represented for quiet (blue) nights.

classification of zonal winds

- In 70 % of the cases, the flow reverses to the westward direction. The zonal thermosphere wind is stronger before midnight in 16 % of the cases and after midnight in 54 % of the cases, with a magnitude varying from 20 to 175 m/s.
- The second type seen in the database, accounting for the other 30% of cases, only a slight perturbation in the zonal wind is observed .
 ⇒ In general, perturbation of the zonal winds in early evening hours and before dawn is quiet small in 74 % of cases.

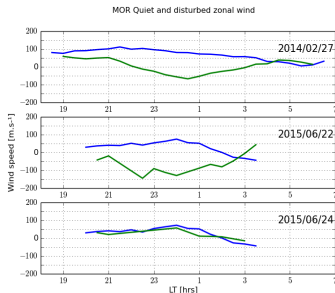


FIGURE – Example of zonal winds of disturbed (green) and quiet (blue) nights of types of the variation of the flow wind during a geomagnetic storm (from 41 storms occurring in the 2014-2015-2016 period). Positive values are eastward.

Meridional winds

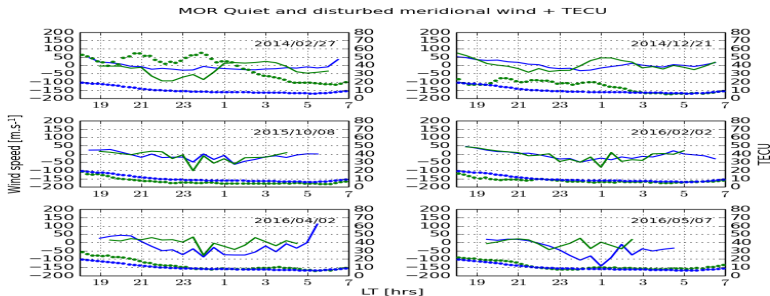


FIGURE – Examples of meridional winds (solid lines) and total electron content (TEC) measured over Oukaimden observatory (dotted lines) of disturbed (green) and quiet (blue) nights of types of the variation of the flow wind during geomagnetic storm (from 41 storms occurring in 2014–2015–2016 period). Quiet nighttime of FPI data are the median of 30 nights (15 nights before the storm and 15 nights after). Quiet nighttime of TEC data are the average of the quiet nighttime over 2015. The storms selected are the ones with $SYM-H \leq -50$ and $Kp \geq 5$. Positive values are northward.

Classification of storm data :

- **Type 1** : The first type is characterized by traveling atmospheric disturbances (TADs) induced circulation ; The storms of this first type characterized by TAD induced circulation account for 59 % of the cases.
- **Type 2** : In the second type, only a slight perturbation is seen. These cases of the second type are account for 33 % of the cases.
⇒ We notice that on some nights we can observe more than two TADs in the first type. However, we have observed in the two nights (02/04/2016 and 07/05/2016) the transequatorial wind whole the night. .

- Initial phase, the signature of the second transequatorial (northward) TAD is present with the maximum the speed 50 m/s after 6 hours of the beginning of the storm
- The main phase is characterized predominantly by the occurrence of the first TAD approximately 3 h after the storm main phase onset. The zonal winds tend to the maximum speed according to the minimum of the SYM-H.
- The recovery phase is mainly characterized by gentle storm flow. We can notice an eastward and equatorward storm flows approximately 18 h after the storm recovery phase onset.

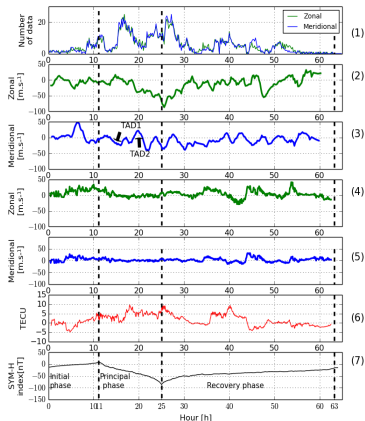


FIGURE – From top to bottom : number of data in each bin of zonal (green) and meridional (blue) neutral wind, Average of zonal, meridional neutral wind speed of 28 disturbed nights minus their correspondent quite time and Superposed SYM-H index of the same nights as a function of the time.

Conclusion

- Loutfi, A., Bounhir, A., Pitout, F., Benkhaldoun, Z., Makela, J. J. (2020). Thermospheric neutral winds above the oukaimeden observatory : Effects of geomagnetic activity. *Journal of Geophysical Research : Space Physics*, 125, 458e2019JA027383.
- Loutfi A., Pitout, F., Bounhir, A., Benkhaldoun, Z., Makela, J. J. Effects of meridional winds on the interhemispheric asymmetry of the equatorial ionization anomaly on the Africa sector over 3 years during both quiet and disturbed night, will be submitted in Jul 2021.