# Long-term Study of the Summer Wind Variability in the Mesosphere and Lower Thermosphere over Nearly Two Decades at Middle and High Latitudes

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## Motivation

The mesosphere and lower thermosphere (MLT) is a dynamically active region. The winds have been measured by partial reflection radars (PRR) and specular meteor radars (SMR) for almost two decades (2004-2022) over Germany and Norway (i.e., middle and high latitudes, respectively). These observations are the key to understand the long-term variability of the atmosphere between 60 and 110 km.

**Objective:** Long-term study of wind variability and possible trends.

**Focus:** MLT summer winds amplitudes. The summer is a calm atmospheric season due to the absence of planetary wave activity, allowing us to search for possible connections to external forcing (El Niño-Southern Oscillation, and quasi-biennial oscillation and solar activity and geomagnetic activity).

## Mean Winds Climatologies

Middle Latitudes | High Latitudes

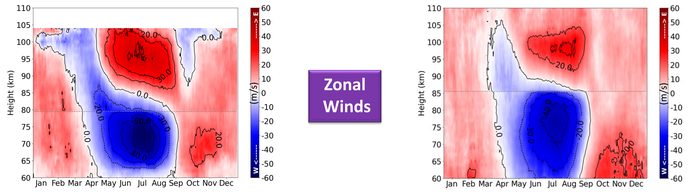



**Figure 1:** Mean zonal wind climatologies (2004-2021) product of the combination of SMRs (Juliusruh (54°N, 13°E) - Collm (51°N, 13°E), middle latitudes, between 80-104km (left figure) and PRR (Juliusruh) between 60-79km. On the right, is the climatology for high latitudes (SMRs Andenes (69°N, 16°E) - Tromsø (69°, 19°E)) at 86-110km and Saura PRR (60-85km). More details of the time series are in Jaen et al., 2022.

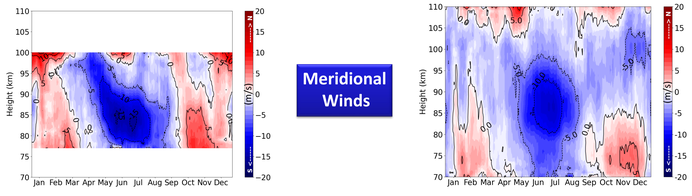


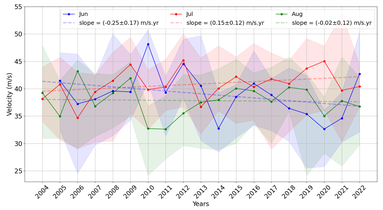

**Figure 2:** Mean meridional wind climatologies obtained from the combination of SMRs Juliusruh–Collm at middle latitudes and Andenes–Tromsø at high latitudes. The northward wind is indicated with red and solid contour lines, while the southward wind is in blue with dashed lines for the intensities.

## Long-Term variability of the MLT Summer Winds

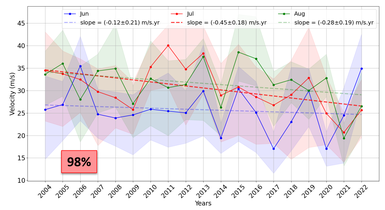
The time series are the result of the maximum amplitude of the wind velocity, per month and year. Neglecting the altitude for the maximum. June (blue), July (red) and August (green) are depicted with the linear function associated to them. The slopes were tested with Student t-test and the significance of a trend is indicated in a square with the color of the month.

Middle Latitudes | High Latitudes

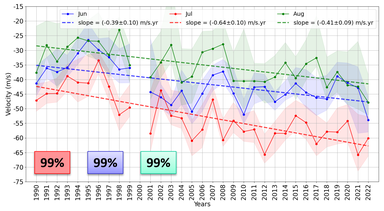
### Zonal wind component: Eastward Jet



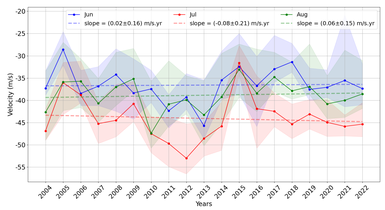

The eastward jet presents a significant trend only during July at high latitudes.



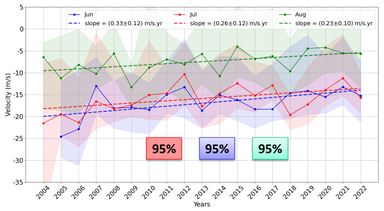

### Zonal wind component: Westward Jet



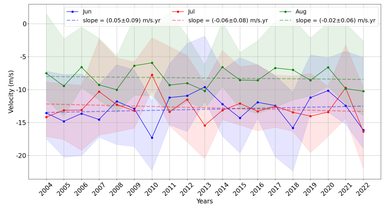

There are significant trends at middle latitudes: The westward jet velocity is intensifying.




### Meridional wind component: Southward Wind




At middle latitudes the southward wind is weakening.

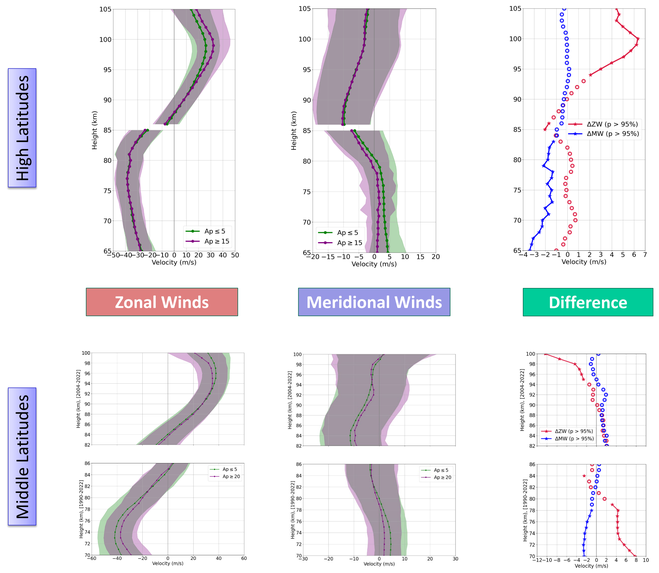



## Influences of the Gomagnetic Activity over the Winds

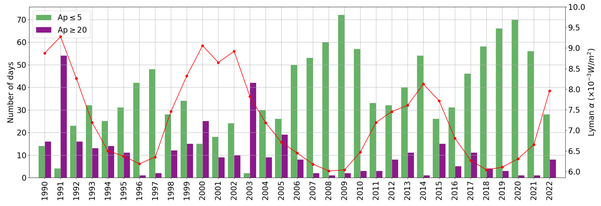
Mean velocity profiles for low (green) and high (purple) geomagnetic activity for the summer median zonal (a, d) and meridional (b,e) mean winds. The difference between both geomagnetic activities (c, f) for the zonal component (red) and the meridional (blue). The stars depict the values with more than 95% significance.

High Latitudes | Middle Latitudes

Zonal Winds | Meridional Winds | Difference




Total amount of days per year with low (green) and high (purple) geomagnetic activity, and the Lyman-α line (red).




- **High Latitudes:** stronger eastward winds above 94km and weaker northward wind below 84km.
- **Middle latitudes:** weaker zonal winds above 95km and below 79km. The meridional behaves similar to high latitudes with weaker northward wind below 78km. These result are similar to the ones found by Jacobi et al. (2021).

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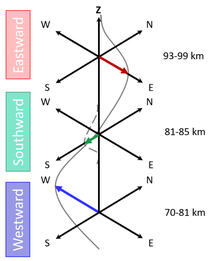
## Summary and Future Work

➢ **Trends:**
- At high latitudes the eastward wind in July shows a significant velocity decrease.
- At middle latitudes, the westward wind is increasing the maximum amplitude of the wind velocity, while the southward wind has the opposite tendency.

➢ **Influences of the geomagnetic signatures:**
- The eastward wind at high latitudes increases the velocity under high geomagnetic activity, while the meridional component becomes more disturbed.
- The zonal component at middle latitudes is deaccelerated under high geomagnetic activity.

❖ Study the gravity waves and the long-term behavior for further understanding of the trends identified.




Sketch of the summer vertical distribution of the velocity wind maxima.

## References & contact information


- Jacobi et al. 2021: Influence of geomagnetic disturbances on mean winds and tides in the mesosphere/lower thermosphere at midlatitudes, ARS. https://doi.org/10.5194/ars-19-185-2021.
- Jaen et al. 2022: Long-term studies of mesosphere and lower-thermosphere summer length definitions based on mean zonal wind features observed for more than one solar cycle at middle and high latitudes in the Northern Hemisphere, ANGEO. https://doi.org/10.5194/angeo-40-23-2022.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