URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Observations of Kilometer-Scale Instabilities in the Polar Summer Mesosphere Resembling Varicose Mode Flows

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The Mesosphere and Lower Thermosphere (MLT) is a fascinating yet difficult-to-study region that represents the boundary layer between the Earth's atmosphere and outer space. This high-altitude region, situated between 60-120 km, is the site of dynamic processes driven by wave breaking and the accompanying turbulence. Remote sensing devices, such as radars, have proven to be invaluable tools in exploring the secrets of the MLT.
The Middle Atmosphere Alomar Radar System (MAARSY), situated in northern Norway, uses Polar Mesospheric Summer Echoes (PMSE) as tracers to investigate dynamics at various scales. Chau et al. (2021) recently documented the occurrence of an exceptional event, characterized by extreme radial velocities that were strongly localized in both space and time. The discovery of this event was serendipitous, as the conventional data processing method was unable to detect these high values. This occurrence has initiated a new study aimed at uncovering if such remarkable events, or events with a comparable structure, are more widespread and have been overlooked due to previous data filtering methods and erroneous interpretations.
The study conducted an examination of 623 measurement days, leading to the identification of 234 instances of varicose mode events. The first half of the PMSE season saw the highest number of varicose mode events, with most of them taking place in June. On average, each event had a duration of 20 minutes and was marked by an increased average layer thickness, almost doubled, resulting from the formation of the varicose structure. The study determined that the maximum wind velocities in the upward and downward directions were primarily around ±10 m/s, with a few exceptional cases reaching velocities as high as 25 m/s in downdrafts and 35 m/s in updrafts. These findings are summarized in Figure 1. This new understanding of the MLT holds tremendous potential for future research and advancements in atmospheric science.

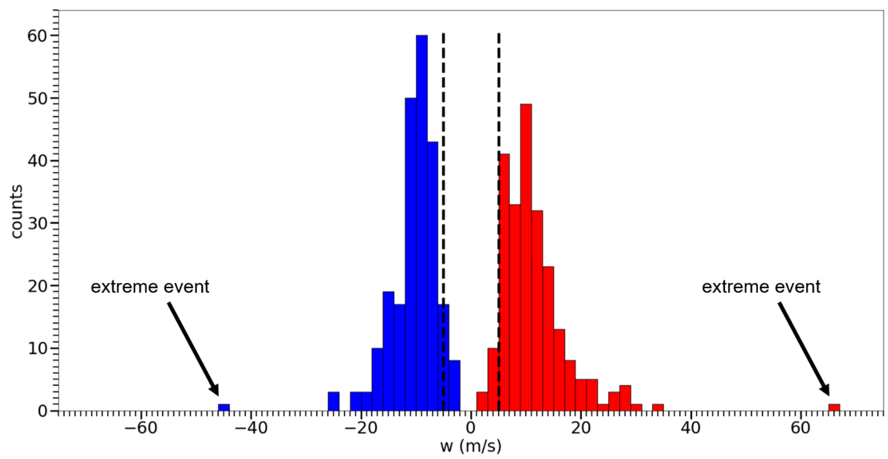

Figure 1. Distribution of the maximum radial velocities of the events from 2015-2017 and 2019-2021, separately for the updrafts (red) and downdrafts (blue). The up draft and down draft velocities reported by [1] are indicated with arrows. The thick dashed lines show the expected radial velocity values in the MLT region ($\approx \pm$ 5 m/s).

References

[1] J. L. Chau, R. Marino, F. Feraco, J. M. Urco, G. Baumgarten, F.-J. Lübken, W. K. Hocking, C. Schult, T. Renkwitz, and R. Latteck, "Radar Observation of Extreme Vertical Drafts in the Polar Summer Mesosphere," *American Geophysical Union (AGU)*, **48**, 16, August 2021, doi: 10.1029/2021GL094918.