Laboratoire de Mécanique des Fluides et d'Acoustique

Stratified Turbulence in the Mesosphere and Lower Thermosphere

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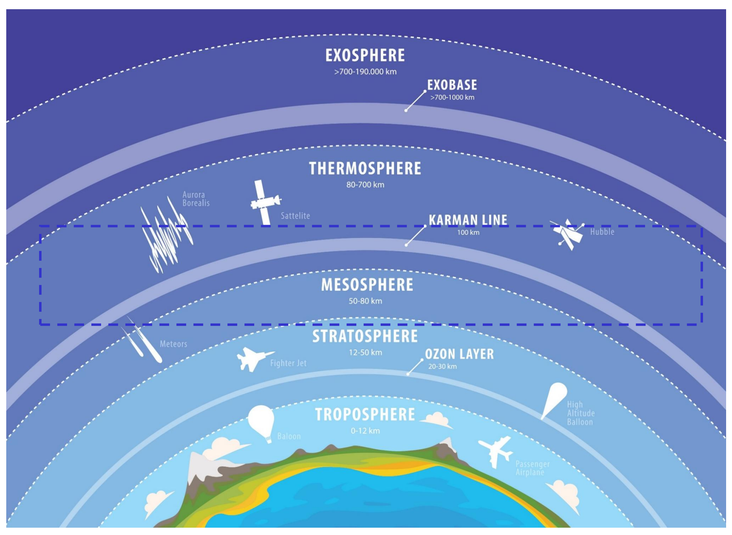
What is interesting about MLT?

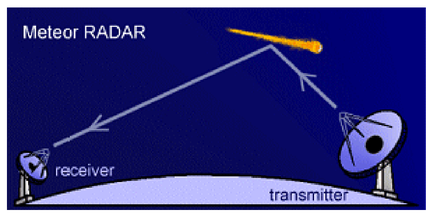
- The Mesosphere and lower thermosphere [MLT] is an extremely dynamic region of the atmosphere where gravity waves break and turbulent structures create.
- It is located at an altitude between ~ 60km and ~120km, it is stratified and is colder in summer and warmer in winter.

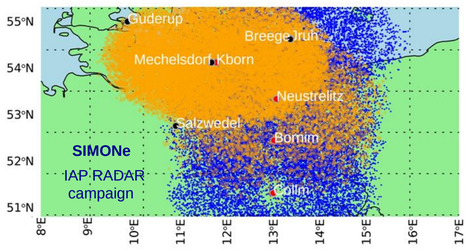


- Weather balloons and aircraft cannot fly as high enough to reach MLT with in-situ instruments. Satellites orbit above the MLT and cannot make direct measurements.
- Instruments on sounding rockets can be used to investigate this region of the upper atmosphere; however, they are brief, infrequent, and expensive.
- So, ground-based instruments like Radar, Lidar, passive optical imagers are among the best options to study MLT.

Meteor Radar Observations

- Meteor radar uses radio reflections from meteor trails to estimate the MLT winds.
- The winds are obtained after averaging all meteor detections at a given altitude during a time interval, assuming that the horizontal wind is homogeneous inside the observed volume.





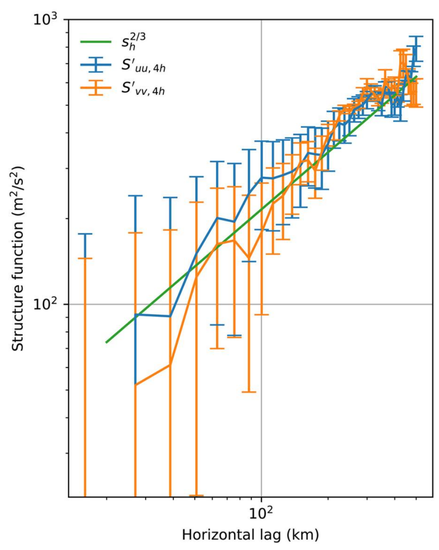
(Top): Schematic diagram of a bi-static meteor radar.; (Bottom): Locations of transmitting and receiving stations operated during a multi-network meteor radar 2018 campaign [SIMONE] and positions of meteor detections during a 24-hr interval are shown in the figure. [2].

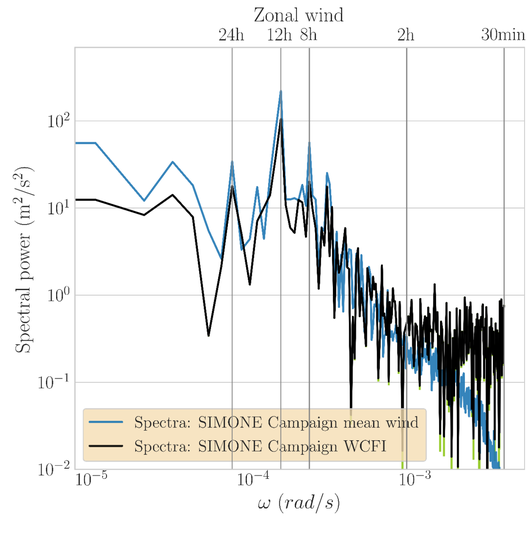
Wind Field Correlation Function Inversion

- Each measurement from meteor radar is a one-dimensional projection of the wind velocity vector sampled randomly in space and time. Vierinen et al. 2019 describe Wind field Correlation Function Inversion (WCFI) as a method to investigate stratified turbulence, which allows estimating the second-order structure functions of the real three-dimensional wind field using such sparse observations.
- In WCFI, we utilize pairs of Doppler measurements observed at different times and positions to obtain terms that contain information about the wind field correlations. The expected values of the products of the random variables can be expressed as a correlation function which is a function of temporal and spatial displacement.

Turbulent Spectra

- From the autocorrelation and cross-correlation functions of the wind velocity field in the MLT, we obtain reliable estimates of the kinetic energy spectra and structure-function.





(Left): The figure shows the structure-functions of the horizontal wind derived from the correlation functions [2].; (Right) The figure portrays the comparison between the spectra obtained from the estimated velocities and the WCFI method using the Simone Campaign data from Nov 2 to Nov 9, 2018. In the WCFI method, a 100km horizontal scale has been used, and it was averaged over 20km. [3]

References

1. G. Stober and J. L. Chau (2015), Radio Sci., 50, 431–442
2. J. Vierinen, et al. (2019). Earth and Space Science, 6, 1171–1195.
3. Charuvil Asokan et al (2020) , in preparation