Study of laser frequency stability from the observed vertical wind velocity by the Na lidar at Tromsø

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We have been continuing wintertime wind/temperature lidar observations of the MLT region (upper mesosphere and lower thermosphere) since October 2012 at Tromsø (69.6N, 19.2E), Norway [Nozawa *et al*., 2014]. With the highly advanced lidar technique, wind velocity in the range of 80-115 km can be measured by detecting the frequency difference between the laser and the returned photon frequency in an accuracy of ~1 MHz [Kawahara *et al*., 2017]. The frequency difference of 1 MHz corresponds to ~0.6 m/s. During the observation, the laser frequency is hourly tuned to the frequency-offset at $\nu_a = -651$ MHz with a Doppler-free technique, and the frequency is stabilized with a wavemeter (WSU-30, HighFinesse) until the next Doppler-free spectrum scan begins. The observed nightly-averaged vertical wind velocity is expected to be 0 m/s. However, the data seems unexpected systematic wind offset of 5-12 m/s. Conversely, the velocity offset reflects the frequency locking stability or something to be considered either in observation or data analysis. Example of the nightly averaged wind velocities between Oct. 2012 and Mar. 2013 are shown in Figure 1. The wind offset is around 12 m/s (20 MHz off-frequency from ν_a) in this winter season, however, diverse daily offset should suggest daily or hourly laser frequency locking stability.
We examined

(1) the nightly averaged wind profiles in each season, and the time change of the nightly velocity offset of 85-95 km
(2) the hourly averaged wind profiles in a day and the time change of the velocity offset of 85-95 km
(3) time change of 10-minute averaged wind profiles to examine the frequency drift

In this presentation, we discuss the above topics and possible causes in laser system.

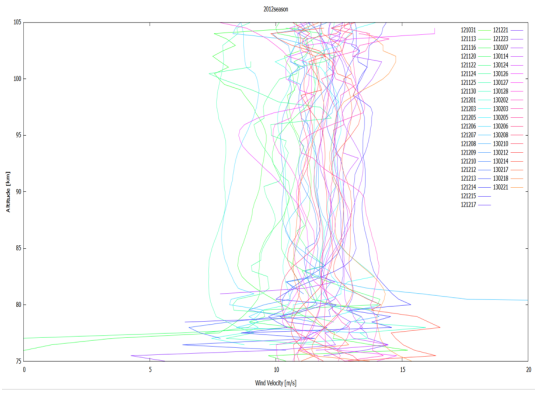

Figure 1. Nightly averaged vertical wind velocity measured by the Na lidar between Oct. 2012 and Mar. 2013.

References

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