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SEASONAL TEMPERATURES FROM THE UPPER MESOSPHERE TO THE LOWER THERMOSPHERE OBTAINED WITH THE LARGE, ALO-USU, RAYLEIGH LIDAR

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Abstract: Observations have been made with the large, Rayleigh-scatter lidar at the Atmospheric Lidar Observatory at Utah State University (ALO-USU; 41.74° N, 111.81° W) from summer 2014 to summer 2015. During this first operational year the lidar acquired nearly 100 nights of observations between 70 and 115 km altitude, i.e., from the upper mesosphere, through the mesopause, and into the lower thermosphere. This was possible because of the large 4.9 m2 collecting area of the mirrors and the 42 W of 532 nm emission at 30 Hz. These two factors produce a figure of merit, the power-aperture-product, of 206 W m2, making this one of the two most sensitive Rayleigh lidars in the world. The all-night data have been reduced to obtain relative densities and absolute temperatures. The temperatures are divided into three-month seasons, which are used to determine variations in altitude and in time. They clearly show significant and complex patterns. Additionally, they are compared to the original ALO-USU temperature climatology, which extends from 45 to 90 km, from 11 years of data from the original lidar, and they are compared to the temperatures from the NRL-MSISE00 empirical model.

RESULTS

The large Rayleigh Lidar at ALO-USU has extended observations from 90 km into the lower thermosphere at 115 km. (Close to our 120 km goal.)

Individual nights show waves with long vertical wavelengths (10–20 km) growing in amplitude from 10 to 30 K with increasing altitude.

Big temperature spikes occur, but are unexplained.

A 1st temperature min. occurs at 80–85 km in spring, summer, & fall.

- Grows from 178 K (summer mesopause) to rel. min. of 200 K (fall).
- In contrast, MSIS only has a minimum in this region in summer.

A 2nd temperature min. appears at 100–110 km in fall, winter, & spring.

- Grows from 190 K (winter mesopause) to 200 K in fall & spring.
- In contrast, MSIS has this minimum ~10 km lower & 10 K colder.

From 80–105 km the fall profiles is “almost” constant at ~200 K.

- MSIS has positive slope above ~100 km in fall, winter, & spring.
- MSIS has negative slope below ~95 km in fall, winter, & spring.

Below 90 km, compare these new observations to ALO-USU climatology.

- Summer, fall (& spring) show remarkably good agreement.
- Winter has significant differences. (Because of the small number of nights, this may arise from geophysical variability.)
- Good agreement between the two at 90 km supports agreement of Rayleigh and Na temperatures.

The new results are good since they start at least 20 km higher.

- Climatological results are based on Na temps. from CSU [4].
- In fall and spring, temperatures are less than MSIS below 85 km.

THE FUTURE

Increase Altitude Range

- Raise the top altitude (Goal is 120 km):
  - Improve alignment
  - Detector with greater QE
- A new telescope and detector system has just been added to the lidar system to lower the bottom altitude to ~35 km.

Independent Initial Temperature — New Analysis Method

Create a Global Network with a Simplified Telescope System

- Other countries can afford
- One large mirror
- More sensitive detector

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Currently, the Rayleigh scattering lidar is operated by the Rayleigh LIDAR team at Utah State University, which includes students and faculty. In addition, Patrick Emerick, David Hocking, and Nick Hobbs, USU, and Brian Haggard, Patrick Sharp, are也 contributing students and faculty. The equipment and support were obtained through grants from NASA (NNX10AI54G), USU, and others.

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