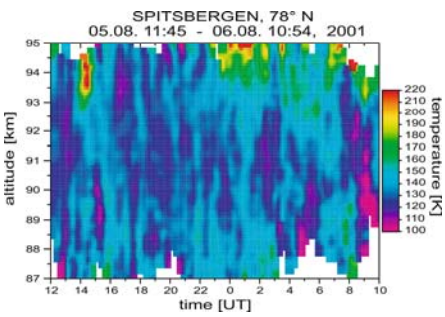
Temperature Measurements above the Arctic

DL 100 as a seed laser in rough conditions

Rudolf Neuhaus, Ph.D.
TOPTICA Photonics AG

The measurement of atmospheric temperatures in the mesopause region, 80 – 105 km above sea level, is a challenging but important task in the quest to analyze the dynamics and chemistry of the atmosphere.
Measurements were carried out by the world's only mobile temperature-LIDAR, built by the Leibniz-Institut für Atmosphärenphysik (IAP) in Kühlungsborn, Germany. From 1999 to 2000 it was placed on the Canary island Tenerife, 2400 m above sea level, and from 2001 to 2003 in the Arctic region at Spitsbergen (78° N). An ultra-low drift version of TOPTICA's DL 100 was used to seed a pulsed alexandrite ring laser, that fired up into the sky. Atmospheric temperature profiles were determined from the temporal and spectral analysis of the back-scattered light by analyzing the Doppler width of the Potassium D1 line at 770 nm as a function of delay time. In order to assess the temperature with an accuracy of 1 K, the Doppler width of typically 1000 MHz has to be determined with 1 MHz resolution. To maintain the required frequency stability during several days of measurements in rough conditions, the laser was actively locked to a Potassium transition. With this ground-based LIDAR system, it was possible to measure temperatures as high as 100 km in the atmosphere at full daylight, with a sensitivity of one single Potassium atom per cm³. In the Arctic the unit enabled the first mesopause temperature measurements ever performed at daylight conditions and values down to 100 K and below were recorded. In contrast to the troposphere, the coldest mesopause temperatures at these altitudes occur during the summer months, even though the sun remains above the horizon 24 hours per day. At mesopause

Mobile LIDAR system at Spitsbergen, 78°N.



Time dependence of temperature distribution above Spitsbergen.

altitudes the temperature is mainly controlled by the dynamics and chemistry of the atmosphere rather than direct heating by the sun.

Because of the low temperatures ice clouds can form at approximately 84 km height. At latitudes between 50° and 60°, these noctilucent clouds can be observed by eye during the summer months. However, since observation by eye is only possible in the dark, it was unknown whether these clouds also exist in the polar region. Measurements with the Potassium LIDAR have shown that such clouds are indeed common in the Arctic mesopause region, occurring 75 % of the time during summer.

The IAP is currently working on a new unit that will operate at an Iron resonance line at 386 nm. Again, it will depend on a DL 100 as seed laser, this time at 722 nm. In addition, a second DL 100, stabilized to the 780 nm Rubidium line with TOPTICA's CoSy unit, will serve as a frequency standard. The researchers' goal is to also measure the vertical wind with an accuracy of 0.5 m/s.