Rayleigh Lidar Observations of the Mid-Latitude Mesosphere During Stratospheric Warming Events and a New Rayleigh-Mie-Raman Lidar at USU

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Rayleigh Lidar Observations of the Mid-Latitude Mesosphere During Stratospheric Warming Events and a New Rayleigh-Mie-Raman Lidar at USU

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USU Physics Colloquium
September 10, 2013
The Atmosphere

Altitude [km]

Temperature [K]

0 10 20 30 40 50 60 70 80 90 100 110 120

0 100 200 300 400

The Atmosphere

Thermosphere

Mesosphere

Noctilucent Clouds

Aurora

Meteors

Airglow

Mesopause

Stratopause

Stratosphere

Jet Stream

Raman, N₂

Rayleigh

LIDAR

Resonance
K, Na, Mg, Fe, Ca⁺

Radar

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Global Aeronomy Terms-Regions

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Global Aeronomy Terms-Directions

- **Vertical**
- **Zonal**
- **Meridional**

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The Polar Vortex

Winter → Eastward

Westward ← Summer

http://eesc.columbia.edu/courses/v1003/lectures/ozone/

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Sudden Stratospheric Warmings

- Caused by wintertime increase in planetary waves (periods ≥ 2 days), which results in a slowing or even reversal of the polar vortex

- Minor SSW: temperature increase (60°-90°N; 10 hPa≈32 km)

- Major SSW: temperature increase (60°-90°N; 10 hPa) + mean zonal wind reversal (60°N; 10 hPa)

- Nearly all of the major SSWs have occurred in the Northern Hemisphere

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Previous SSW Studies


- Virtually NO change in temperature at mid latitudes (Liu and Roble, 2002).

- Yuan et al. (2012), reported coolings of ~20 K from 80-90 km at mid-latitudes.
Located at the Atmospheric Lidar Observatory (ALO; 42°N, 112° W)

- 45-90 km attitude range

- 5000 hours of temperature data taken over 11 years in climatology (Herron, 2007)

- Climatological composite year averaged 31 days across and 11 years deep
Mid-Latitude Mesospheric Temperatures - 1 of 2

ALO Temperatures Jan 2001 to Feb 2001 (01/01/01 = Day 0)

Altitude [km]

Event Day Number

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Mid-Latitude Mesospheric Temperatures – 2 of 2

Temperature at 40N, 120 W

ALO Temperatures Jan 2003 to Feb 2003 (01/01/03 = Day 0)

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Results

- Coolings and warmings defined by the difference between nightly averaged temperatures and climatological temperatures for that day of the year.
- Coolings between -15 and -45 K.
- Coolings start at about 70-80 km before peak day, rise to 80-90 km during peak and lower again to 70-90 km afterward.
- Warmings between 15 and 25 K.
- Warmings stationed in lower mesosphere from 50-70 km.
Results-1 of 3

Temperature Difference (in K) for 02/99-03/99

Temperature Difference (in K) for 03/00-04/00
Results - 2 of 3

Temperature Difference (in K) for 01/01-02/01

Temperature Difference (in K) for 02/02-03/02
Results-3 of 3

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Conclusions

- A general cooling pattern was found in the upper mesosphere using mid-latitude rayleigh lidar data acquired during six major, Northern Hemisphere SSWs.
- The coolings had magnitudes of 15-45 K.
- The temporal evolution of this phenomena showed coolings at altitudes of 70-90 km that then rise to 80-90 km while becoming colder near the peak of the SSW and finally descend back to 70-90 km while lessening in strength as the SSW descends from its peak.
- Similar coolings were shown at high latitudes previously, whereas these coolings happened at mid-latitude.
- Similar cooling magnitudes and altitudes to previous mid-latitude study.
New Rayleigh-Mie-Raman Scatter Lidar

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System Upgrades

* Original ALO Rayleigh lidar system
  - Laser power ~21 W at 532 nm & 0.15 m² collecting area—PAP ≈ 3.1 Wm²
  - Good data from 45 to ~90 km for 1993 – 2004

* New ALO Rayleigh-Mie-Raman lidar system
  - Laser power 42 W at 532 nm, ~4.9 m² collecting area—PAP ≈ 206 Wm²
  - Data altitude range from 15 to 120 km
  - This dynamic range will be achieved by using 4 PMT detector channels: 2 Rayleigh scatter channels, 1 Rayleigh-Mie scatter channel and 1 Raman scatter channel
System Upgrades
June-July 2012 Campaign

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Temp Profile from May 2013

05/15/2013 Nightly Temperature (Seed Temp = 235.000, Hmax = 109.000 km)

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Scientific Applications

- Temperature Climatology
- Noctilucent Clouds
- Thin Aerosol Layers
- Mesospheric Inversion Layers
- Characterization of Mesospheric Gravity Waves
- Upward Propagation of Gravity Waves-Growth and Energy Loss
- Climatological Trends in Temperatures from 11 Years of Data
- Solar Cycle Effects on Temperatures
- Sudden Stratospheric Warmings
What’s Next for the RMR Lidar

- Installing all of the detector optics and hardware
- Implementing new data reduction methods to increase altitude range higher (Khanna 2012)
- Making continuous observations!
- Preparing the telescope cage for rotating and scanning functionality
Interested in Working with Us?

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References


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