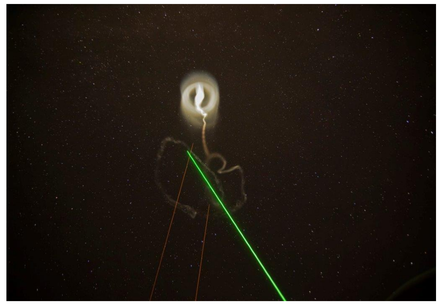


MLTL-01: New Sodium Resonance Wind-Temperature Lidar at Poker Flat Research Range: Initial Observations During SuperSoaker

Jennifer H. Alspach[1] <jalspach@alaska.edu>, Bifford P. Williams[2] , Jintai Li[1] , Richard L. Collins[1]
1. Geophysical Institute and Department of Atmospheric Sciences, University of Alaska Fairbanks, Fairbanks, Alaska, USA
2. G & A Technical Software Incorporated (GATS), Boulder, Colorado, USA

Abstract
A new sodium resonance wind-temperature lidar (SRWTL) system was installed in Fall 2017 at the University of Alaska Fairbanks Poker Flat Research Range in Chatanika, Alaska (65° N, 147° W). This lidar system incorporates a solid state CW seed laser (TA-SHG Pro, Toptica Photonics Inc.). The SRWTL was used to conduct observations during the winter. In this poster we highlight observations made during the SuperSoaker rocket investigation on the night of January 25-26, 2018. During the SuperSoaker mission, the SRWTL system was operated simultaneously with a Rayleigh lidar and an iron resonance density lidar. We present scientific analysis of these initial observations.

Sodium Resonance Wind-Temperature Lidar
The Sodium Resonance Wind Temperature Lidar (SRWTL) system was installed at Poker Flat Research Range (PFRR) in the fall of 2017. The lidar previously operated at the Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR) in Andoya, Norway.

The SRWTL uses precision atomic resonance spectroscopy to measure wind and temperature in the mesospheric sodium layer (~80-100 km). Wind and temperature measurements are derived from the Doppler shift and broadening of the sodium absorption spectrum. The lidar uses a three-frequency technique to characterize the sodium absorption spectrum and hence estimate the wind and temperature in the mesosphere.

The SRWTL has three major subsystems: a high-precision tunable continuous wave (CW) laser, a precision frequency shifter, and a pulsed amplifier. The tunable CW laser is composed of a CW seed laser and Doppler-free spectroscopy. The precision frequency shifter is an acousto-optic modulation system. The pulsed amplifier is composed of a pulsed dye amplifier (PDA) pumped by an Nd:YAG seeded laser.

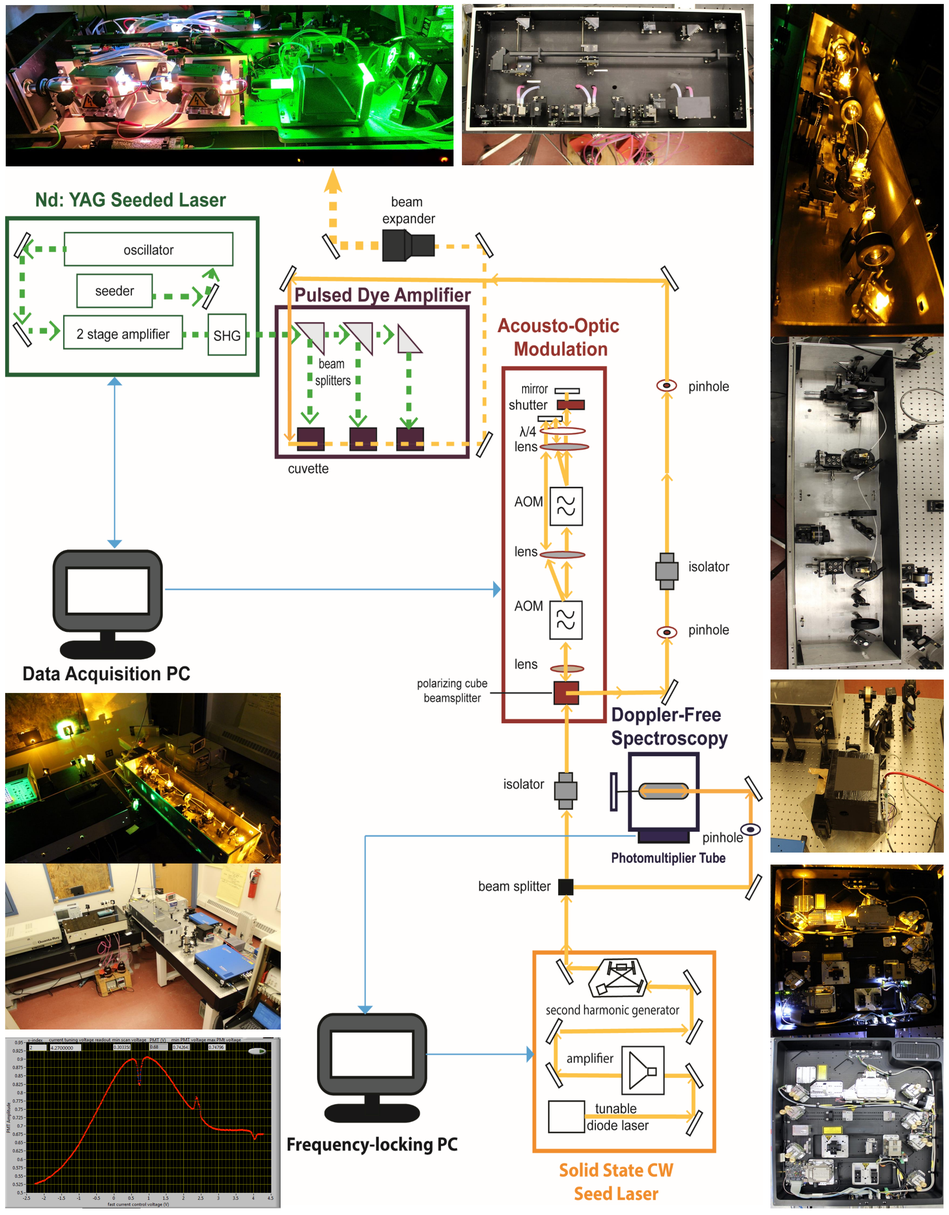
The CW seed laser is locked at the Na D2a line, and then two Acousto-Optic Modulators (AOM) are used to create two shifted frequencies (+630MHz, -630MHz). The beam is then pulsed and amplified through the PDA.

During installation at PFRR, the CW seed laser was upgraded. The sum-frequency generator (SFG) was replaced with a precision solid-state continuous wave (CW) tunable laser (DLC TA-SHG Pro, Toptica Photonics Inc.). The CW tunable laser has a maximum output power of 1 W and incorporates a tunable diode laser, tapered amplifier, and intra-cavity second harmonic generator. This CW tunable laser is of a class of precision lasers characterized by stable CW light, mode-hop-free tuning, narrow lidewidth, and high output power. These characteristics enable measurements with exceptional accuracy.

CW Seed Laser Specifications	
Wavelength	589 nm
Coarse tuning range	+/- 2 nm
MHF Tuning range	>20 GHz
SHG Output Power	<1000 mW

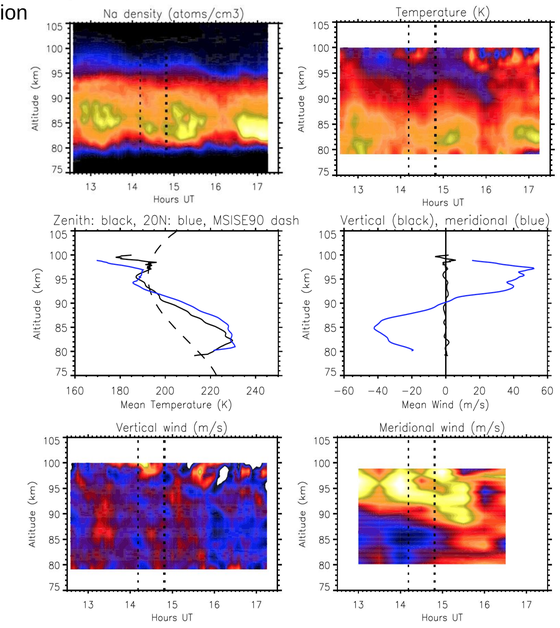
SRWTL system specifications for SuperSoaker	
Transmitter	
CW laser	
Wavelength	589 nm
SHG Output Power	620 mW
PDA Output	
Laser	Nd:YAG
Wavelength	532 nm
Pulse energy	12 mJ
Repetition rate	30 Hz
Receivers	
0.6 m telescope	vertical-pointing
0.9 m telescope	pointing N 20° off-vertical
Raw resolution	5 sec, 150 m

Acknowledgements
The SRWTL relocation and deployment at PFRR was funded by the NSF grant AGS-1734852. The authors thank the staff at PFRR for their support of SuperSoaker and ongoing lidar observations. PFRR is operated by the Geophysical Institute of the University of Alaska Fairbanks with support from NASA.



SuperSoaker Investigation
The SuperSoaker rocket investigation was focused on understanding the energetics and chemical response of the atmosphere to a water release in the mesosphere. The investigation was conducted on the night of January 25-26, 2018 at PFRR. The SRWTL was operated during the mission and provided observation on both the night of the launch and during the two-week campaign period as weather permitted. The lidar receiver telescopes were pointed in the vertical and 20° off-vertical to the north. The 20° off-vertical beam was chosen to point toward the location of the SuperSoaker water release.

These SRWTL observations were taken with a raw resolution of 150 m in altitude and 5 sec in time. The observations yielded measurements of the sodium density, temperature, vertical and meridional wind at 1 km and 5 min resolution



The vertical dotted lines in the contour plots show the times of the rocket launches. The sodium density, wind, and temperature from the night shows a variety of wave activity, including the presence of waves with periods of 2 hours and less. The meridional winds show evidence of a longer period wave, possibly the semidiurnal tide.

The SRWTL operated during the investigation along with a Rayleigh density lidar and an iron resonance density lidar. These multiple lidar measurements are being analyzed.

Next Steps
In summer 2018 the NSF awarded funding for conducting new studies with the SRWTL over the next three years. SRWTL measurements will focus on wave activity, driving of circulation, and ion-neutral coupling in the middle and upper atmosphere. The SRWTL will be operated in conjunction with an all-sky imager and three other lidars at PFRR, the Rayleigh density-temperature lidar, the metal resonance density lidar, and the Volume Imaging Sodium Lidar (VISL). Coordinated Rayleigh lidar and SRWTL observations will yield temperature (30-110 km) and wind (80-110 km) profiles. The SRWTL will also operate in collaboration with two radars, the Poker Flat Meteor Wind Radar (PFMWR) and the Poker Flat Incoherent Scatter Radar (PFISR). The SRWTL and the listed suite of instruments at PFRR will support collaborated studies of small-scale waves, Arctic weather and climate, and aerosol-plasma coupling.

The NSF award also supports technical improvements to the SRWTL. In June 2018 the seed laser for the pulsed Nd:YAG pump laser was replaced. An iodine-based spectral monitoring system will be implemented. This monitoring system will enable spectral characterization of the transmitted sodium light on an individual pulse basis. The receiving system will also be extended to three channels through the installation of a new 36 inch telescope. The three telescope receivers will be configured to yield measurements in the vertical, meridional, and zonal directions.

Further Reading
Chu, X., and G.C. Papen (2005), Resonance Fluorescence Lidar. In: *Laser Remote Sensing,* eds. T. Fujii, and T. Fukuchi, Taylor and Francis Group, Boca Raton, pp 179-432.
Krueger, D.A., C.-Y. She, and T. Yuan (2015), Retrieving mesopause temperature and line-of-sight wind from full-diurnal-cycle Na lidar observations, *Appl. Opt.*, 54, 9469-9489.

For discussion on PFMWR, see Klemm, J., SKiYMET Meteor Radar System at Poker Flat Research Range, ITMA-04
For discussion on PFISR, see Li, J., Turbulence measurements with Poker Flat Incoherent Scatter Radar (PFISR)- A hypothesis test approach, ITIT-12