Integrated Observations and Applications with the SSEC Portable Atmosphere Research Center

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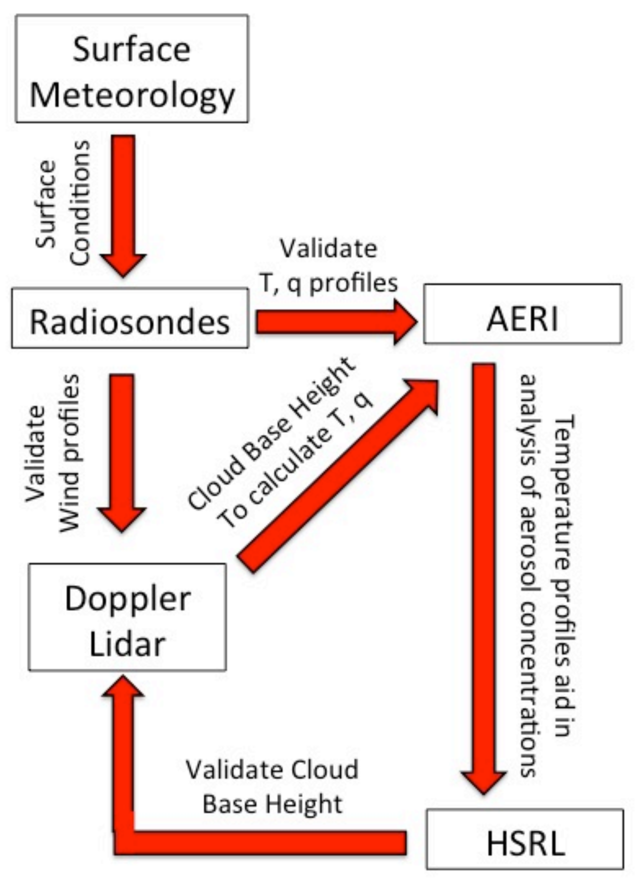
SPARC Overview

The SSEC Portable Atmosphere Research Center (SPARC) enables the deployment of instruments with which to perform targeted measurements of the atmosphere in order to advance our understanding of weather and climate systems. The SPARC consists of three remote sensing instruments, along with a surface meteorology station and radiosonde launching capabilities.

SPARC trailer deployed in McCracken, KS on 9 June 2015 for a low-level jet mission during PECAN.

The combination of instruments on the SPARC allows for high-temporal resolution retrievals of thermodynamic variables (temperature, water vapor mixing ratio, wind speed and direction) in the boundary layer in addition to retrievals of aerosol layers and vertical velocities. Each instrument featured on the SPARC is essential to both produce and validate products of other instruments, forming a integrated instrumentation suite aboard a single mobile vehicle.



FRAPPÉ

The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ) took place from 16 July to 16 August 2014 along the Front Range of Colorado. FRAPPÉ aimed to better understand summertime air quality in Front Range of Colorado. Complex local meteorology and a diverse set of pollution sources, create unique conditions and problems to monitor and forecast air quality. SPARC was stationed at the Boulder Atmospheric Observatory (BAO) tower site in Erie, CO.

Science Objectives:

1. **Characterize Front Range air quality**
2. **Better model and forecast Front Range air quality**

PECAN Overview

The Plains Elevated Convection at Night (PECAN) field campaign took place from 1 June to 15 July 2015 in the Central Plains of the United States. This campaign was designed to provide intensive observation periods of nocturnal convection in the Plains. Missions focused on nocturnal convection in the presence of a stable boundary layer, nocturnal low-level jet, and elevated instability.

Science Objectives:

1. **Initiation and early evolution of elevated convection**
2. **MCS internal structure and microphysics**
3. **Bores and wave-like features**
4. **Storm- and MCS-scale numerical weather prediction**

Acknowledgements

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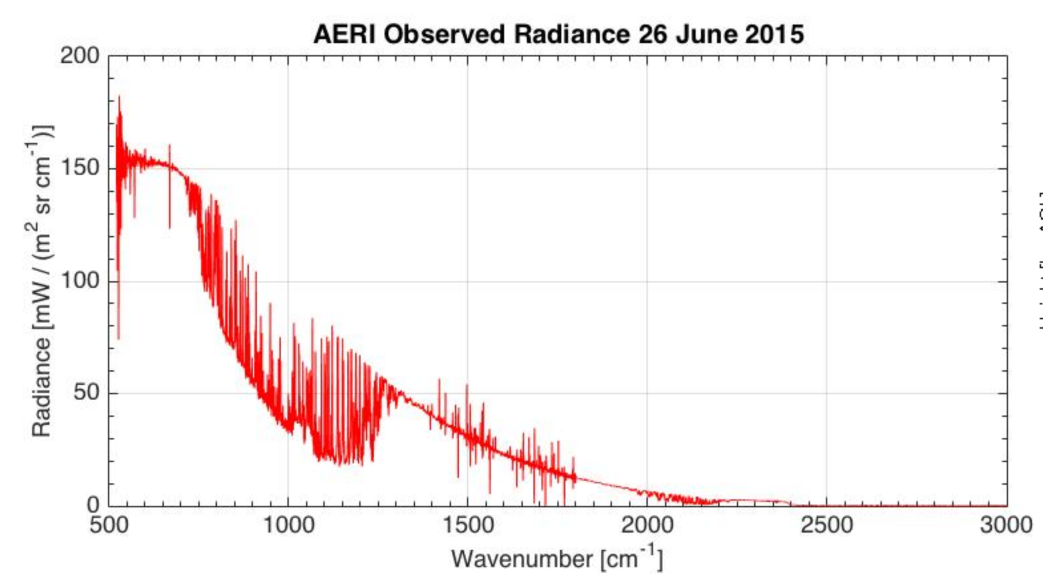
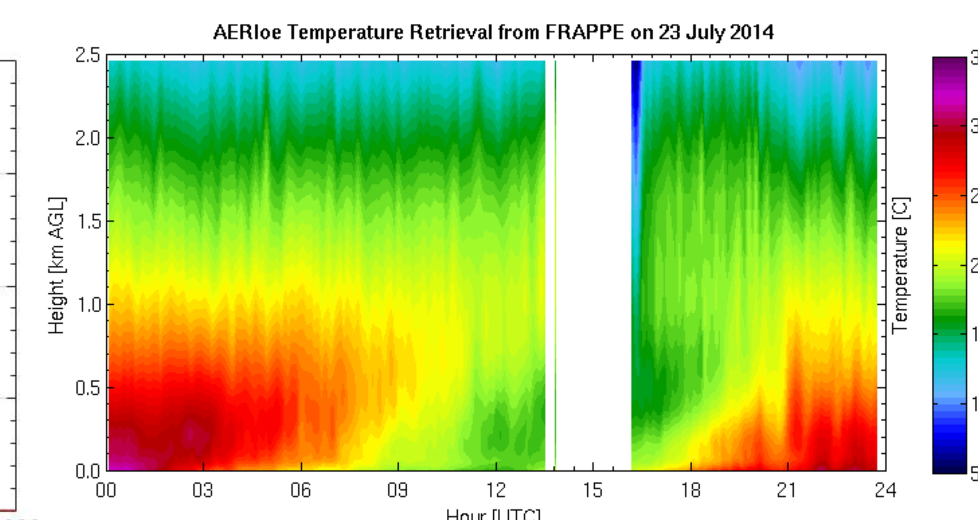
Instrumentation

Three different remote sensing instruments are onboard the SPARC: atmospheric emitted radiance interferometer (AERI), HALO-Streamline Doppler lidar, and High-Spectral Resolution Lidar. Combined, these instruments are able to produce high-temporal resolution observations of thermodynamic and dynamic atmospheric variables in the boundary layer.

Atmospheric Emitted Radiance Interferometer (AERI):

AERI measures downwelling radiation emitted from the atmosphere between 520 and 3000 cm^{-1} (19.2 and 3.3 μm) with a resolution of about 1 cm^{-1} every 20 seconds. Nearly continuous retrievals of thermodynamic variables (temperature and water vapor mixing ratio) and trace gas concentrations, that emit and absorb in the range of wavelengths that the instrument covers (eg: CH_4, CO_2, CO, O_3), can be derived. Turner and Löhnert (*J. Appl. Meteor. Climatol.*, 2014) developed the AERIoe algorithm (iterative optimal estimation inversion scheme) using LBLRTM as forward model and a radiosonde climatology as a first guess, to produce temperature and water vapor mixing ratio profiles from AERI observed radiances.



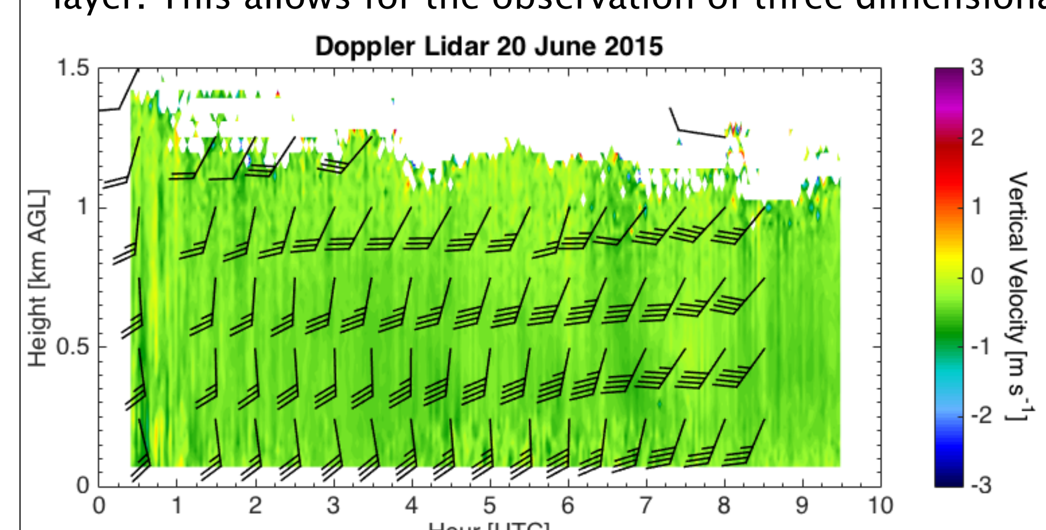


SPARC AERIoe retrieval from FRAPPÉ on 23 July 2014 in Erie, CO.

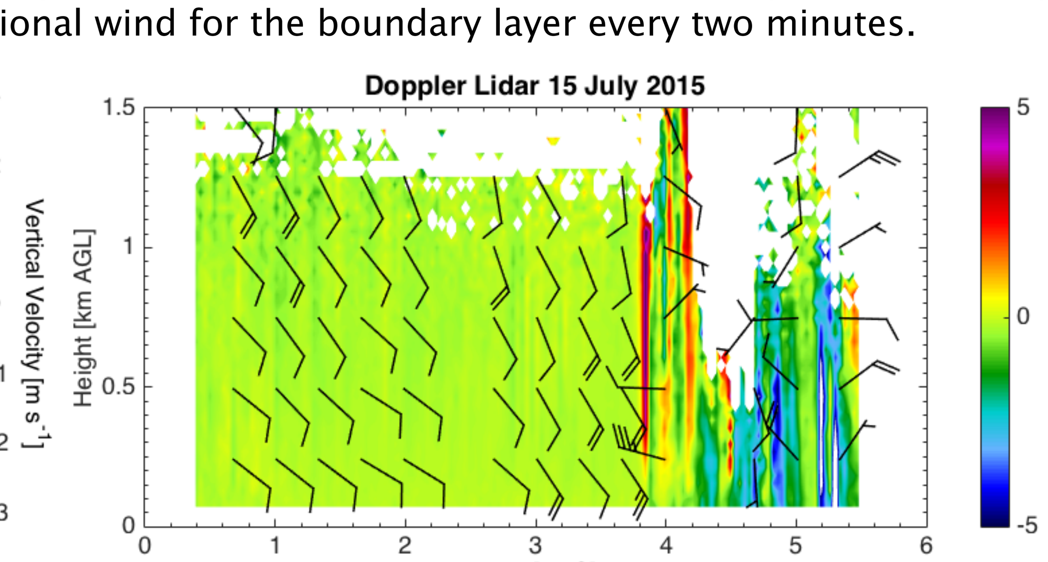
Current work from PECAN is focused on deriving cloud base height from Doppler Lidar backscatter observations. This will be used to run the AERIoe algorithm for all AERIs used during PECAN.

Doppler Lidar:

The Streamline Doppler lidar (HALO Photonics, Great Britain; Pearson et al., *J. Atmos. Oceanic Technol.*, 2009) utilizes a 1.5 μm laser to measure along-beam wind speeds, in any direction, within the atmospheric boundary layer. This allows for the observation of three dimensional wind for the boundary layer every two minutes.

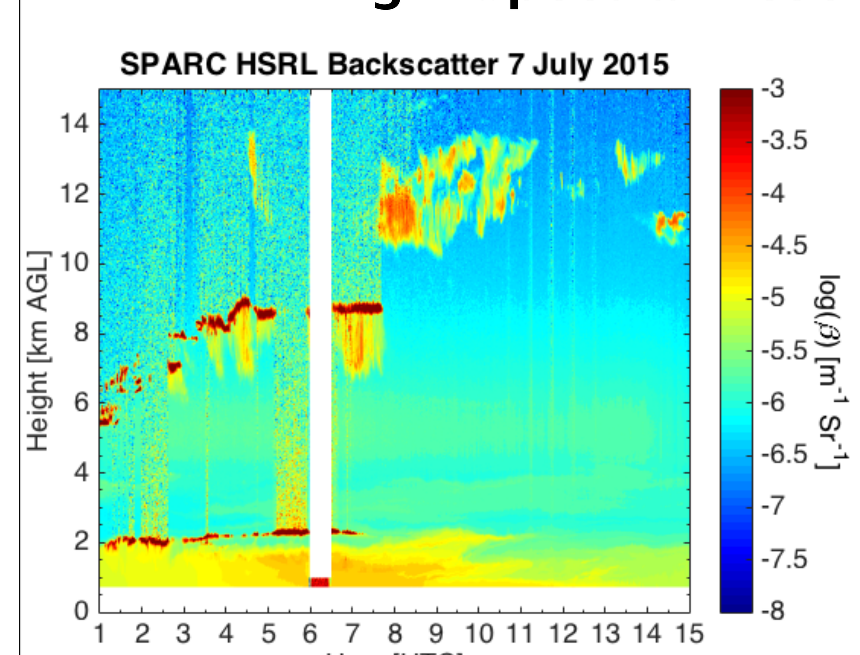


SPARC Doppler lidar retrievals for 20 June 2015 in McCracken, KS for a LLJ mission during PECAN.



SPARC Doppler lidar retrievals for 15 July 2015 in Scott City, KS for a CI mission during PECAN.

High-Spectral Resolution Lidar:



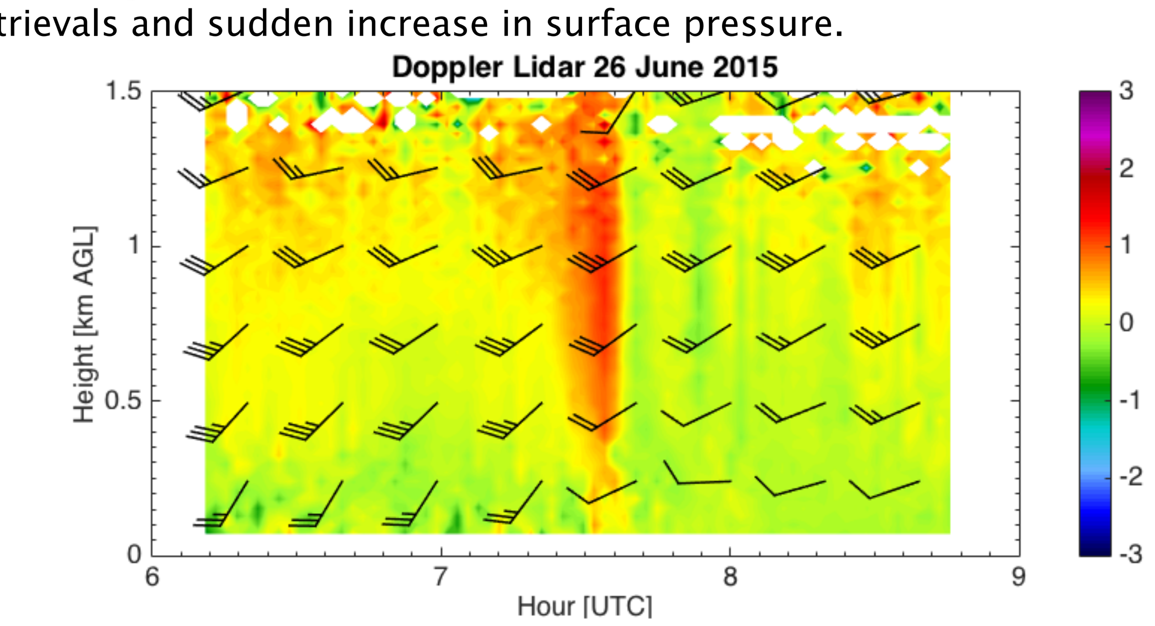
SPARC HSRL backscatter retrievals for 7 July 2015 in Hays, KS during PECAN.

HSRL uses a laser at 532nm to measure atmospheric extinction and backscatter to make aerosol concentration retrievals. Identifying the location of aerosols could be used in weather observation to identify mixed layers and inversions. Aerosols can also be used as a tracer, allowing of the detection of turbulence. Backscatter retrievals can be used to identify cloud features, as well, which can have applications to the PECAN science objectives.

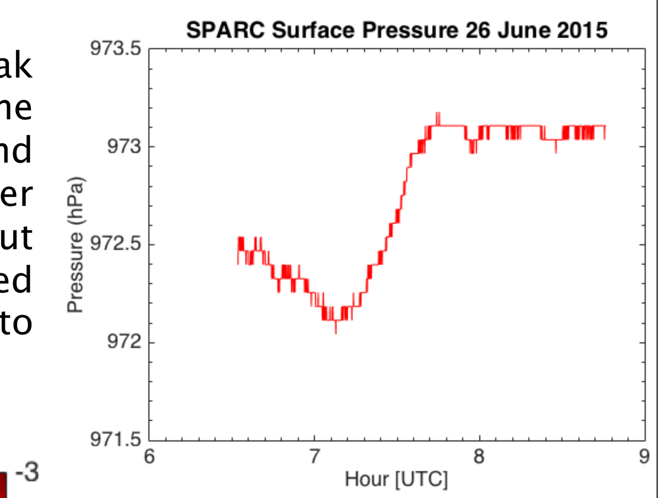
An example of HSRL applications can be seen by considering backscatter measurements from 7 July 2015 in Hays, KS. The nocturnal boundary layer is observed as a high concentration of aerosols, seen here below 2 km until 11 UTC, when it begins to break down as the sun rises and diabatic heating begins. Low-level clouds are identified at the top of the nocturnal boundary layer between 1 UTC and 7 UTC. Higher clouds are also observed between 3 UTC and 8 UTC, with intermittent virga being observed.

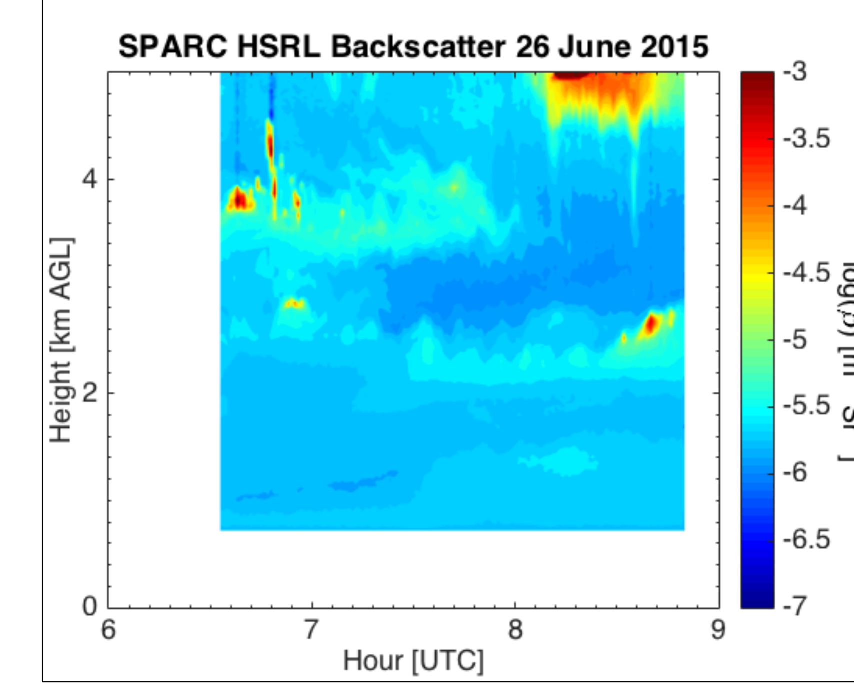
Case Study: 26 June 2015 Bore

On 26 June 2015, SPARC took observations from 6 UTC until 9 UTC in Eureka, KS. Nearby convection in eastern KS produced a bore that propagated over the SPARC around 730 UTC. The bore displays itself as the hydraulic jump, seen as the spike in vertical velocities in the Doppler lidar retrievals and sudden increase in surface pressure.



The Doppler lidar retrievals show peak vertical velocities exceeded 1 ms^{-1} at the onset of the bore. Horizontal wind retrievals provide evidence of layer lifting, as the layer of 35 knot winds out of the southeast (a proxy for a mixed layer) move from a height of 0.5 km to 1.0 km above ground level.

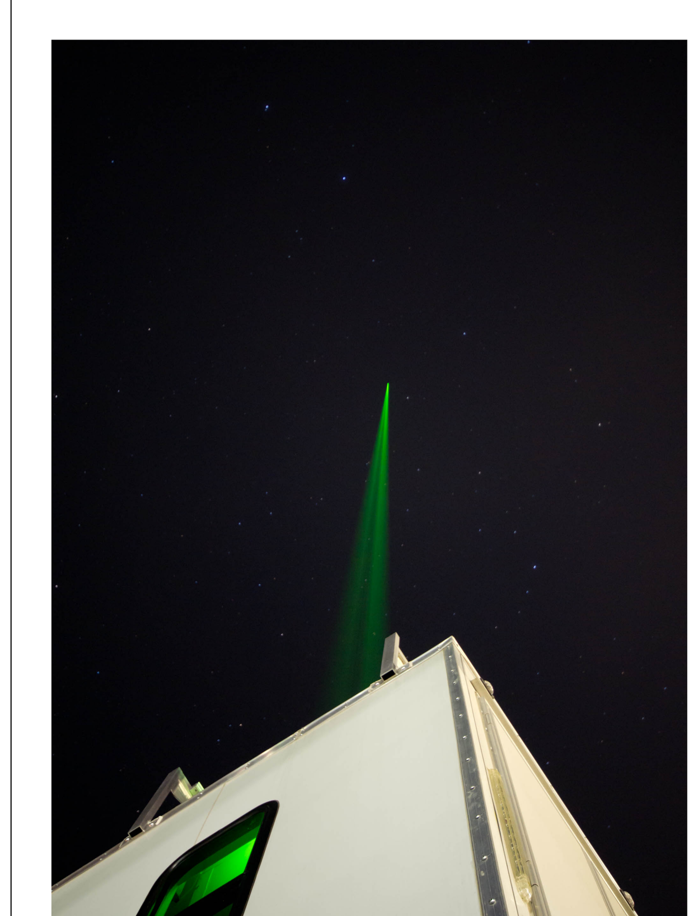




Surface pressure increases hydrostatically as the depth of the surface layer is increased by the bore. HSRL backscatter retrievals show some indication of layer lifting as well, as we observe the formation of a cloud around 845 UTC at 2 km above ground level.

Future Work

Future work will utilize the SPARC observing systems to monitor environmental conditions into the future. The instrumentation suite allows high-temporal resolution measurements ideal for a range of atmospheric research including air quality, convection, and boundary layer studies.



HSRL beam from the SPARC in Hays, KS. Credit: Tim Wagner

SPARC with a thunderstorm in the distance in Hill City, KS.