Lower Atmospheric Thermodynamics & Turbulence Experiment (LATTE)

Participating Institutions:

National Center for Atmospheric Research (NCAR)
University of Oklahoma (OU)
University of Colorado (CU)
Lawrence Livermore National Laboratory (LLNL)
National Oceanic and Atmospheric Administration (NOAA)
Colorado Research Associates (CORA)

Project Description

Background

The purpose of this document is to briefly outline and discuss the upcoming Lower Atmospheric Thermodynamics & Turbulence Experiment (LATTE) to be conducted at the Boulder Atmospheric Observatory (BAO) in February of 2014. A primary motivation behind the experiment has been the testing and validation of the NCAR 449-MHz spaced antenna, multiple-frequency wind profiler, which is to be further developed into an adaptive Modular Profiler Network (MPN). Whereas the testing and validation remains a major objective, the experiment has expanded in scope as described below. The primary goals of the experiment are provided below. Types of instruments included in the experiment (so far) are 449-MHz wind profiler, instrumented tower (BAO), Doppler lidars, optical image-motion anemometers, surface flux station, instrumented unmanned aerial systems (UAS), and sodar.

Objectives

The three primary objectives of the experiment are:

- Validate both wind and reflectivity measurements from the NCAR 449-MHz wind profiling radar (WPR) using sonic anemometers, lidars, and UAS: The NCAR WPR operates in a spaced antenna mode and recently has been upgraded to allow range imaging (RIM) operations as a means of improving its range resolution. Observations from the lidar will be used to validate the 3-D wind estimates produced by the radar. Wind observations from the tower-mounted sonic anemometers can also be used for comparison. Moreover, flights from the UAS will be used to generate estimates of C_n^2 (which is related to the radar reflectivity when dealing with Bragg scatter) and the UAS-derived winds will be compared with the tower and wind profiler.
- Determine the extent to which Doppler lidars can be used to measure atmospheric turbulence: Methods will be explored using single- and multiple-lidar configurations to retrieve estimates of the 3-D atmospheric turbulence and wind fields. Such data sets can, among other applications, be used in wind energy applications. Wind and turbulence estimates from the lidars will be compared against observations from tower-mounted 3-D sonic anemometers, optical anemometers, UAS, and radar.
- Compare Bragg scatter from S-Pol with scatter from wind profiler and C_n^2 from UAS: S-band weather radar can detect true clear air scatter (Bragg scatter) produced by gradients in the refractive index. When turbulence in homogeneous, isotropic, volume-filling, and within the inertial subrange, then the backscattered power detected by the radar can be related to C_n^2. RHI scans using S-Pol will be made along a radial corresponding to the location of the BAO. Signals from S-Pol indicative of Bragg scatter (enhanced reflectivity, low ZDR, relatively high correlation coefficients) can be used to compare retrieved values of C_n^2 from those estimated using the 449-MHz WPR and UAS.

Logistics

The experiment is scheduled to take place during February 10-28, 2014. Tim Bonin and Jennifer Newman from OU will be present during that time. They will bring the OU Doppler lidar and the OU UAS. The month of February was selected for the experiment because i) this is when the 449-MHz radar and the lidars are available and ii) it is less likely that S-Pol will detect biological scatter. Some instruments such as the NOAA sodar and lidar are already in place at the BAO site. Other instruments will need to be brought in. Instruments to be specially deployed at the BAO for the experiment are listed below.

- The 449-MHz radar: It will likely be set up at the BAO during the period of February 3-7, although this could be completed earlier.
- OU Halo Doppler lidar: To be brought and set up by Bonin and Newman
- LLNL ZephIR and WindCube lidar: Logistics still need to be determined. Newman will set up the lidars with assistance from Bonin.
- Sonic anemometers: These will be provided by OU and possibly NCAR. Alternatively, they may be provided by Muschinski. The instruments will be deployed on the BAO tower by Muschinski and his students. They will also provide data loggers.
- UAS: OU will bring its SMARTSonde platform. Brian Argrow (CU) is working on acquiring a CoA to allow operation of the UAS at the site. CU may also bring a DataHawk. All UAS flights and operation will be coordinated through CU.
- NCAR Tram System: Steve Oncley will set up and operate this instrument

In addition to the primary objectives of the experiment, several other measurements and comparisons will be made. For example, it will be possible to compare sensible heat flux measurements from the tram with those estimated using the UAS. Under appropriate conditions when various assumptions can be made, estimates of the latent and sensible heat flux can be obtained using a small UAS. The surface flux values can be directly measured using the tram system. The experiment will provide an opportunity to validate the UAS-based method of retrieving fluxes. Additionally, it is planned to make comparisons of C_T^2 measurements using Taylor hypothesis and temperature differences along the path. Values of C_T^2 values are often retrieved from sonic anemometers by assuming that the Taylor hypothesis applies and transforming temperature distances in time to temperature differences in space and thereby generating C_T^2. The tram system could be used to add an actual spatial component to the C_T^2 calculations.

Site locations

BAO (40° 3' 0.10"N, 105° 0' 13.81"W) 1580 m
S-Pol (40° 7' 24.00"N, 104° 53' 28.80"W) 1530 m
KFTG (39.787, -104.546) 1680 m

Instrument components

UAS:
- OU SMARTSonde
- Possibly CU DataHawk

Radar:
- NCAR 449-MHz Wind Profiling Radar
- NCAR S-POL Weather Radar

Sodar:
- NOAA Sodar (not Doppler)

Celiometer:
- NOAA Vaisala CL31

Lidar:

- OU Halo Lidar
- LLNL ZEPHIR Lidar
- LLNL WindCube Lidar

Sonics:
- NCAR Tram System
- OU 3D sonics on the tower

Optical Anemometer:
- CORA optical image-motion anemometer

Tower:
- NOAA cup & vane anemometer @ 10m & 100m
- NOAA 2D sonic @ 300m
- 3-D sonic anemometers to be placed at 8 levels (10, 27, 50, 100, 150, 200, 250, & 300 m)

Modeling
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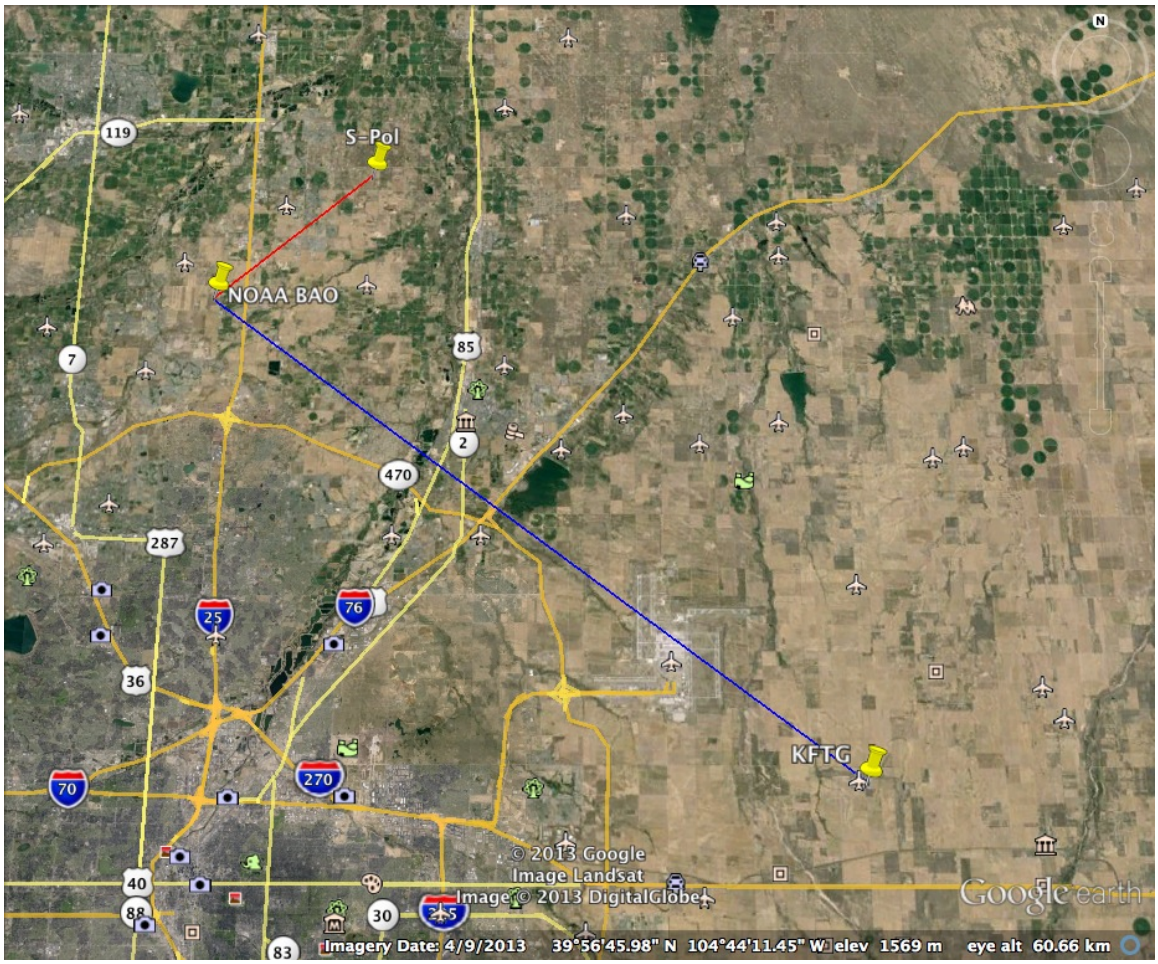

Figure 1: Locations of radars. The 449-MHZ MPN is located at the BAO site. Separations between the BAO and S-POL (red line) and BAO and KFTG (blue line) are 12.9 km and 48.7 km, respectively.

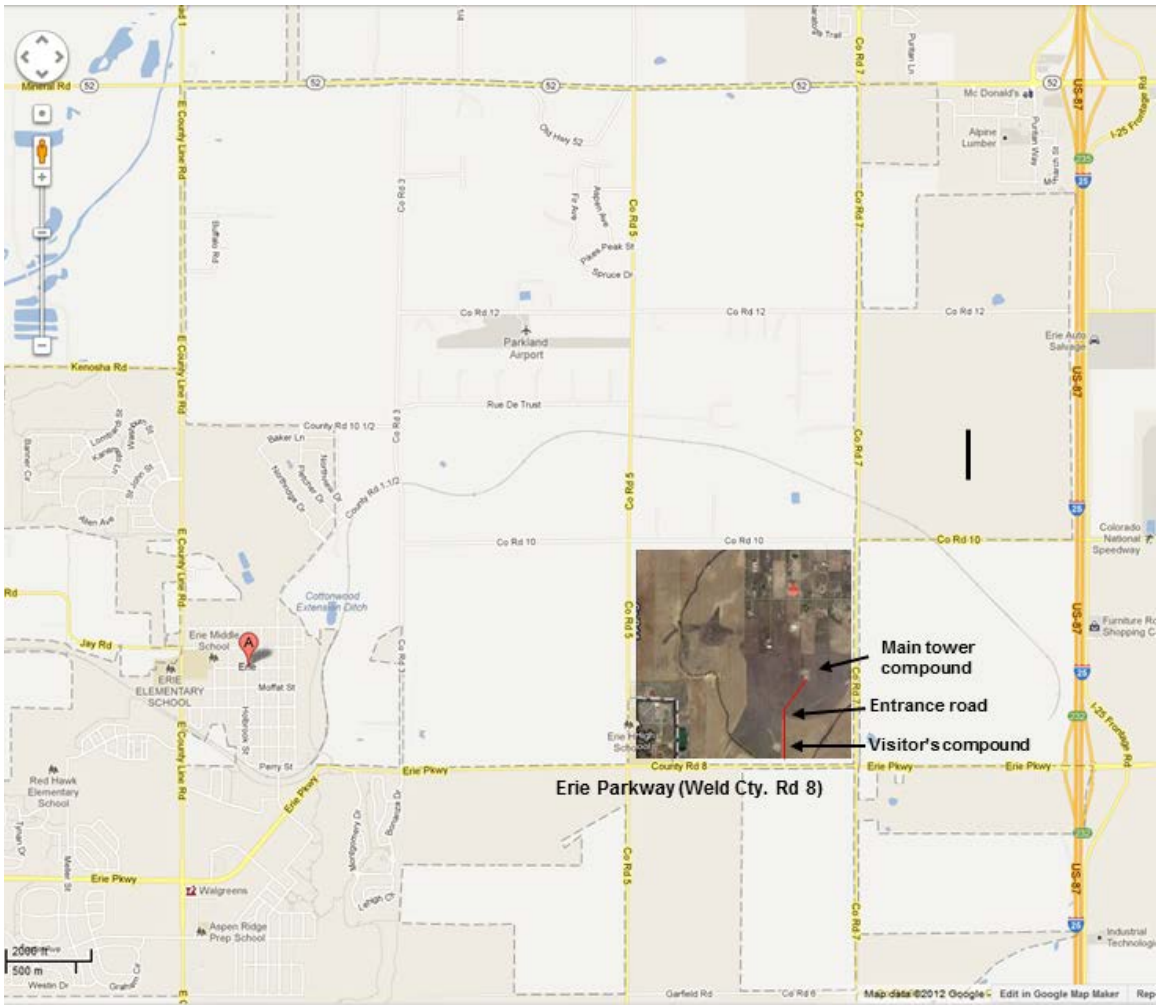

Figure 2: Large scale view of the BAO location

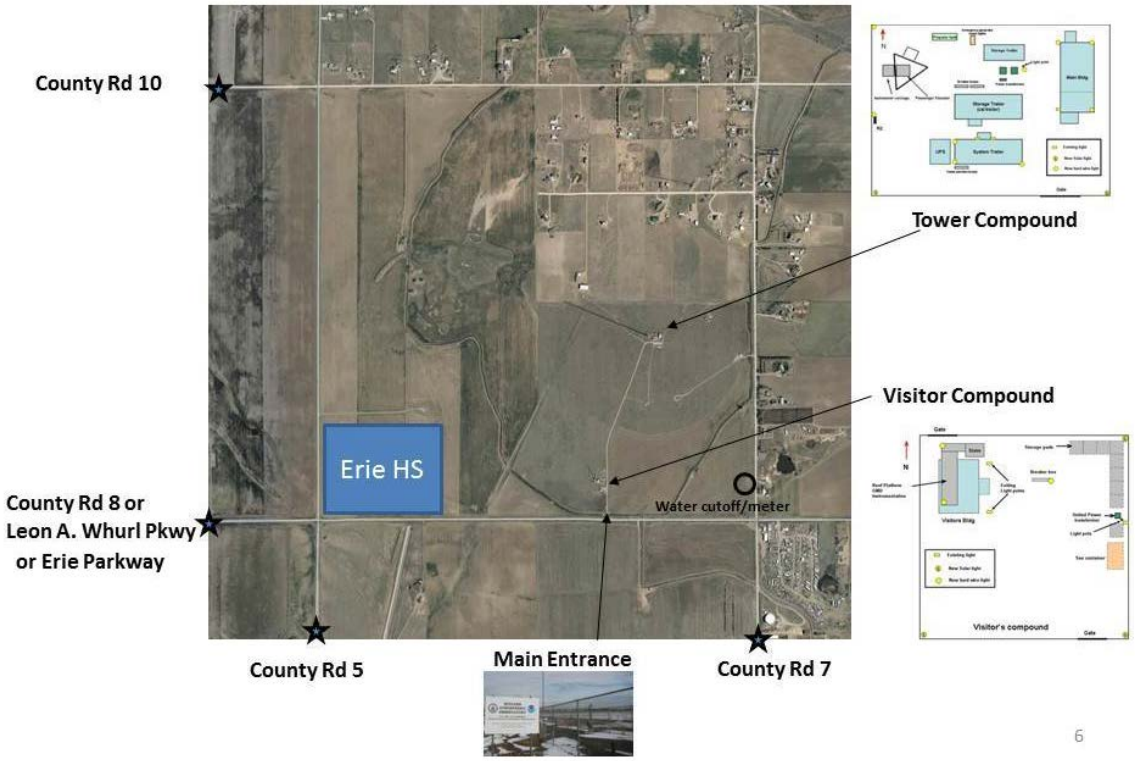

Figure 3: Zoomed in view of the BAO and infrastructure.