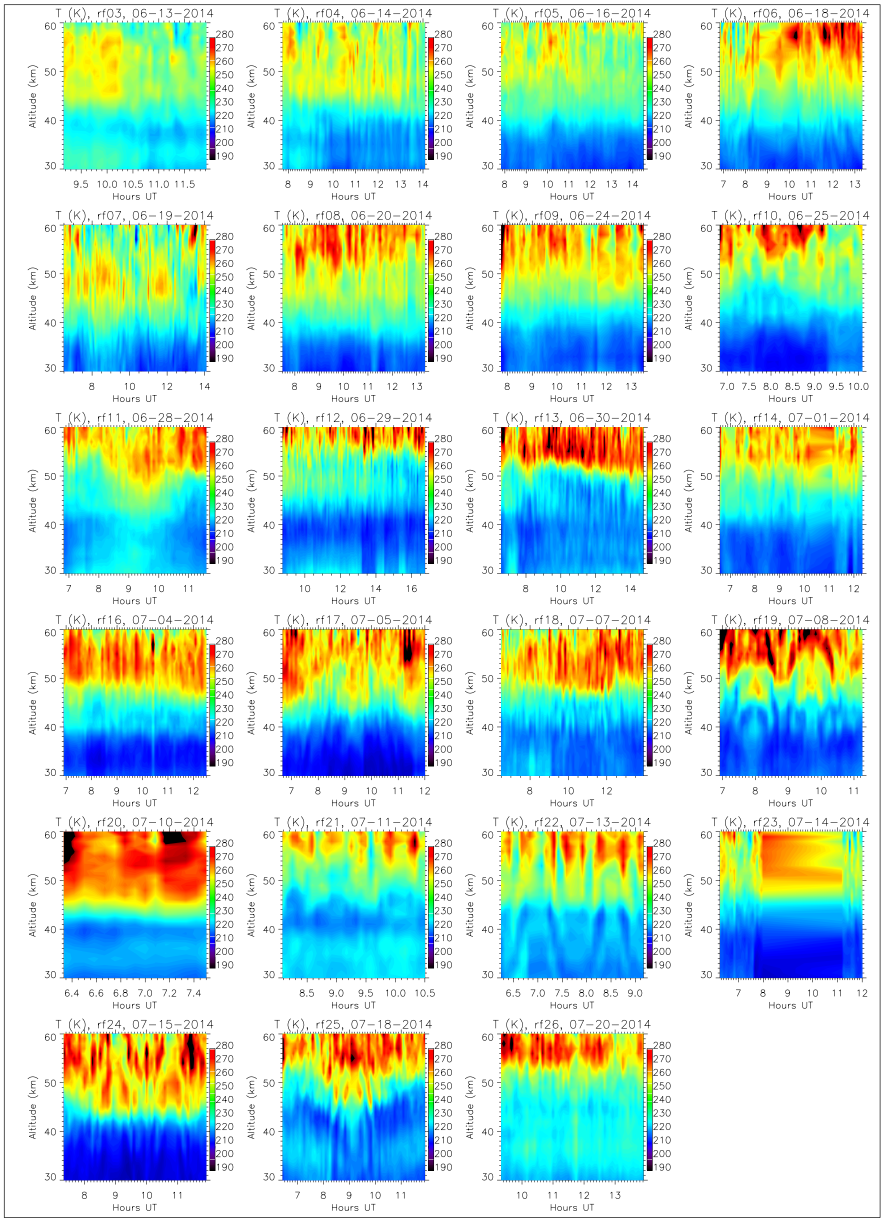

GV Rayleigh Lidar Data Quality Report

Project: DEEPWAVE

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Version: February 13, 2015, Preliminary Data

1.0 Data Set Overview

The GV Rayleigh lidar measures the change in density with altitude and infers the temperature profile from 30 to 60km altitude. This method assumes scattering only from molecules and not aerosols, so generally used above 30km. Data from 22 to 30km can be provided on request, with caveats.

- The Rayleigh lidar operated on 23 flights: rf03 to rf26, except for the daytime flight (rf15).
- 32 degrees in latitude and 40 degrees in longitude
- Latitude from 31.2S to 63.4S
- Longitude from 144.4E to 184.2
- 130 hours of lidar operation - most in database, some with lower signal may be uploaded later

2.0 Instrument Description

The Rayleigh lidar is a new facility instrument built at GATs, Inc. for the NCAR Gulfstream V. This lidar and the GV sodium lidar are contained in two standard GV instrument racks in the L1 and L2 position. The laser is a diode-pumped Nd:YLF Photonics DS20-351 generating 5W at a 351nm wavelength and a 1 kHz pulse repetition rate. This laser is small, robust and power efficient and it operated with no issues throughout the 6-week campaign. We expand the beam to 20mm diameter and 0.4mrad divergence, so that it is eye-safe at the aircraft exit for 0.25 sec exposures when it exits the double-pane laser windows on the top of the aircraft. The telescope is a 305mm diameter f/4 Newtonian design supported under the aircraft vertical viewport by a plate between the two lidar racks. The fiber-coupled detector is a 50% quantum efficiency, low noise photomultiplier tube with a 0.5nm FWHM interference filter. The returned signal profiles are recorded at 1 sec temporal and 37.5m altitude resolution.

3.0 Data Collection and Processing:

We calculate the atmospheric density profile from the lidar signal profile taking into account the geometric factors and then integrate the density down from an assumed top starting temperature to obtain a temperature profile. For the start temperature, we used the ECMWF model temperature at 71km interpolated to the aircraft time and position. The temperature profile becomes independent of the assumed starting temperature at 1-2 scale heights below 71km. This calculation assumes that there is no aerosol scatter, so we show results starting from 20-25 km up to ~60km. At 40km altitude, we have a temperature error of ~1K in a 5 min, 3km integration. At 60km, the error is ~5K.

We account for aircraft altitude and attitude. Data is discriminated for:

1. zenith angles greater than 1.5 degrees (turns, altitude changes)
2. Signal <50% of typical.
3. Signal varies more than 30% from profile to profile

VALIDATION:

1. Pre-flight (Boulder, Colorado): Comparison with radiosondes (Figure 1).

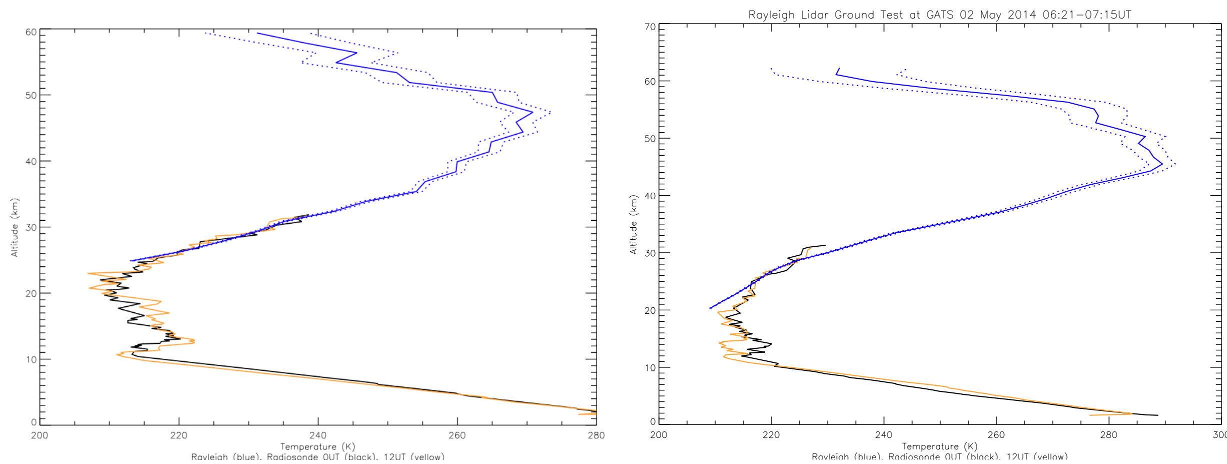

Figure 1: Radiosonde-Lidar comparisons: left: March 17, 2014, right, May 02, 2014

2. Comparison with Lauder, New Zealand Rayleigh lidar (Figure 2).

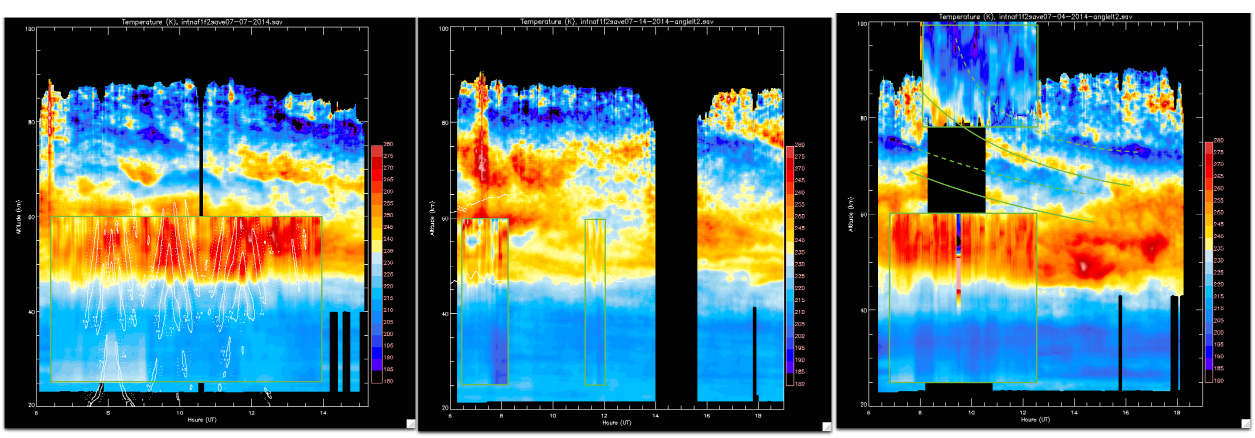

Figure 2: Rayleigh lidar comparison: GV (inside green boxes) vs ground-based (Lauder): left: rf18, middle: rf23, right: rf16.

3. Comparison with ECMWF: (Figure 3) Lidar slightly hotter than ECMWF from 50-60km. Mean temperature profiles quite close from 30-50km. Model and lidar report similar mesoscale temperature changes during the flights as well as showing waves at similar locations with similar vertical structure.

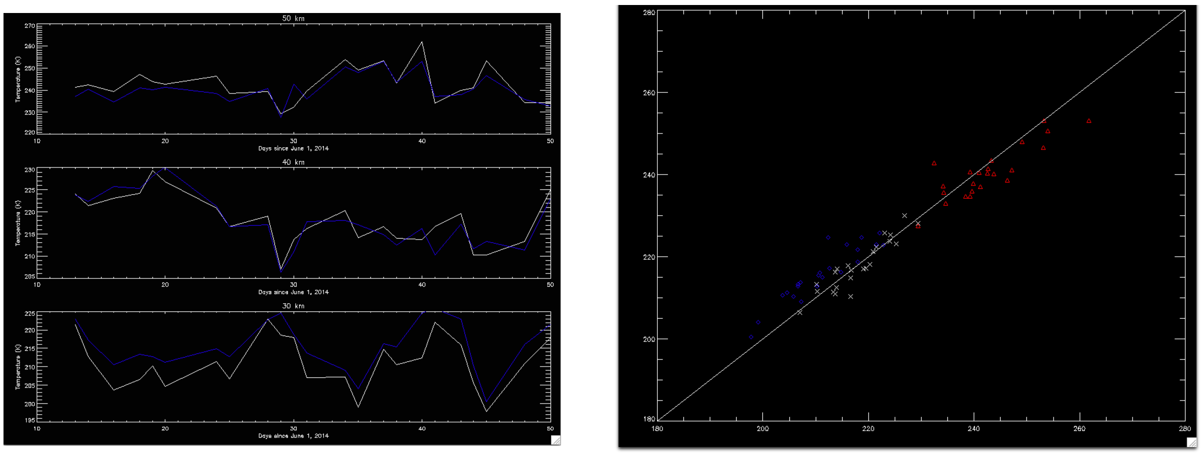

Figure 3: ECMWF-GV Lidar comparisons: left: Flight mean temperatures for Lidar vs ECMWF (blue) at 30km, 40km, 50km, right: Lidar (x-axis) vs ECMWF (y-axis) temperatures for 30km (blue), 40km (white), 50km (red).

4. Comparison with satellite: SABER (in progress). Generally good agreement 30-50km.

5. Comparison with New Zealand radiosondes 20-30km (TBD).

4.0 Data Format:

- netCDF file for each flight:
- **filename:** example: aircraft.NSF_NCAR_GV_Rayleigh_Lidar.201406130910.Temperature_rf03_3km_5min.nc
  - aircraft.NSF_NCAR_GV_Rayleigh_Lidar.YYYMMDDHHmm.Temperature_rf[FlightNumber]_[VerticalResolution]_[TimeResolution].nc
- netCDF Global Attributes:
  - "**Title**" (string), "**Month**" (int), "**DayOfMonth**" (int), "**Year**" (int), "**NumTimes**" (int), "**NumAlt**" (int)
- netCDF Variables:
  - **Hour** [Hours UT] 1D float array (NumTimes): Mean time for each measurement

- **Altitude** [km ASL] 1D float array (NumAlt): Altitudes for temperature profile typically at 30-60km at 1km separation. See filename for actual vertical resolution (typically 1 or 3km) of measurement.
- **Latitude** [Degrees North] 1D float array (NumTimes): Mean aircraft latitude for each measurement
- **Longitude** [Degrees East] 1D float array (NumTimes): Mean aircraft longitude for each measurement
- **GValt** [km ASL] 1D float array (NumTimes): Mean aircraft altitude for each measurement
- **Temperature**, [Degrees (K)] 2D float array (NumTimes x NumAlt)
- **TempErr** [Degrees (K)] 2D float array (NumTimes x NumAlt): Random error in temperature (photon noise)

- Variable Attributes:
  - Each variable has two attributes: "**long_name"** (string) and "**units" (string)**.
- example IDL procedure provided: **readRayleighLidarNetcdf.pro**
  - **Pro readRayleighLidarNetcdf, file, title, numt, numz, month, day, year, hour, z, gvlat, gvlon, gvalt, temperature, temperr**
  - send it file= path + filename and it returns the rest

5.0 Data Remarks:

1. rf20 (10 July 2014) needs work. 2nd half of dataset (not shown) has low signal.
2. rf12 (29 June 2014) may have aerosol contamination 30-35km from 13-17UT.
3. Most of the missing data is due to turns or descents to lower altitudes.
4. Temperatures from ~22km to 30km can be produced on request.