Poster Session I # 711

The National Center for Atmospheric Research eye-safe high spectral resolution lidar: a facility for airborne and ground based measurements of the optical properties of atmospheric aerosols and clouds

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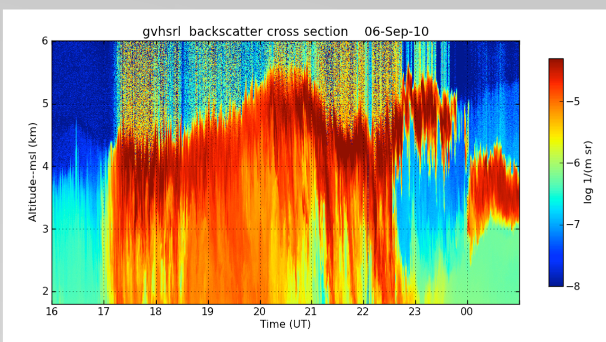
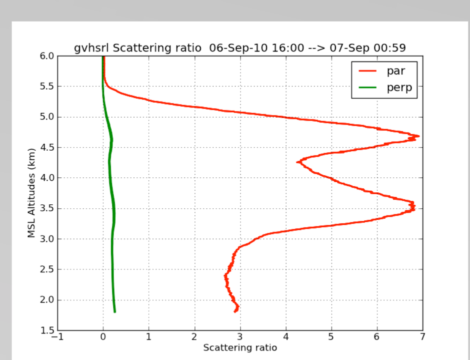
background

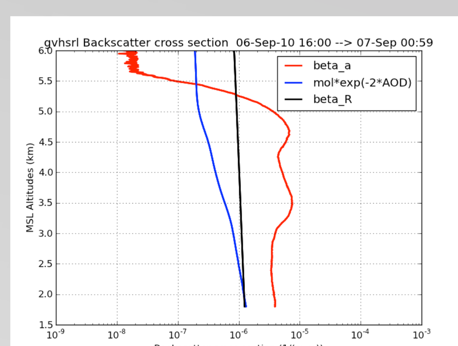
A high spectral resolution lidar (HSRL) was operated aboard the National Science Foundation's (NSF) Gulfstream V (GV) aircraft as part of the **T**ropical **O**cean t**R**oposphere **E**xchange of **R**eactive halogen species and **O**xygenated VOC (TORERO) field program. The HSRL makes calibrated measurements of the optical properties of atmospheric aerosols and clouds: backscatter cross section, depolarization ratio, extinction, and integrated optical depth Calibrated measurements of atmospheric aerosols and clouds can be made at distances up to 20 km from the aircraft. Examples of data products available from the lidar are shown below.

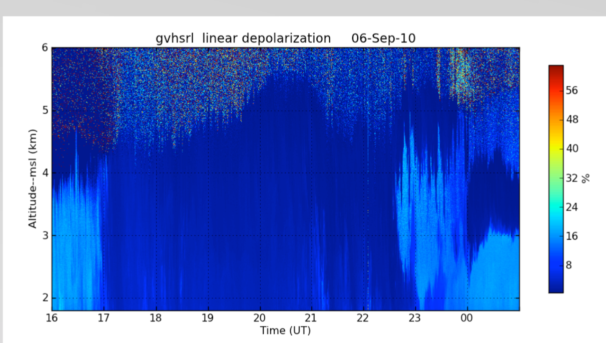
High Spectral Resolution Lidar Calibrated Data Products



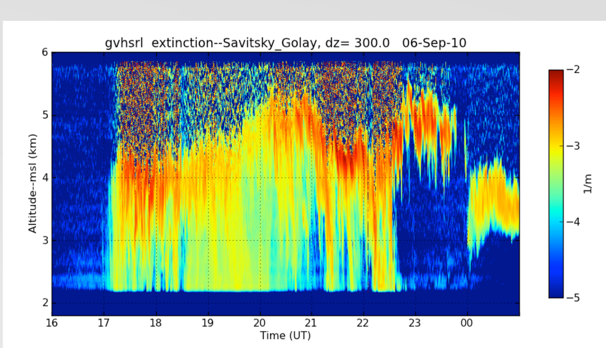


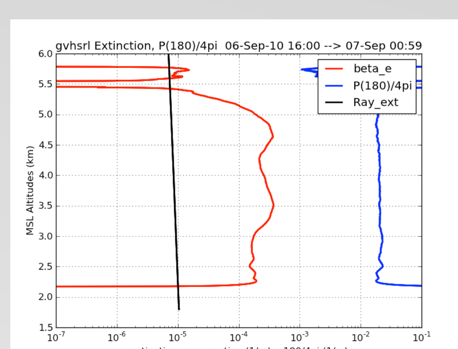
Aerosol Backscatter Cross Section



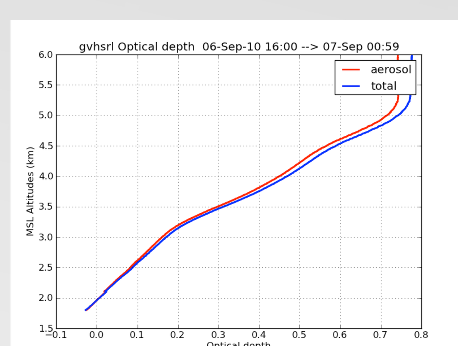


Linear Depolarization



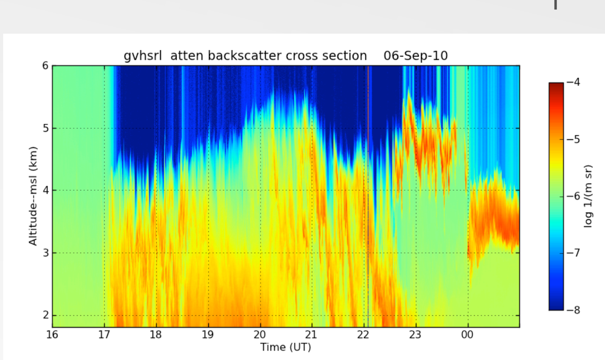


Extinction Cross Section



Data images and average profiles available to the scientist in real-time.

Conventional Lidar Data Display



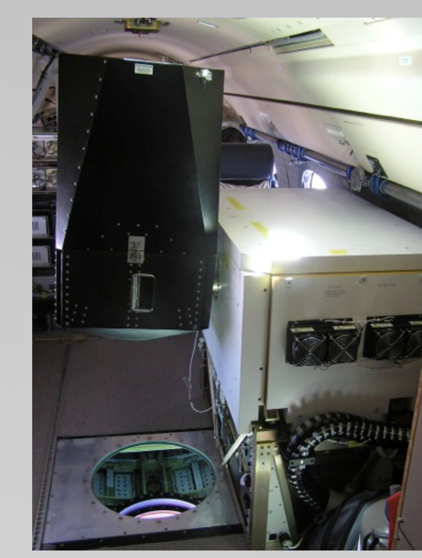
A conventional lidar return (shown above) contains signal from both aerosol and molecular backscatter. The HSRL technique separates these backscatter signals. Compare this image with the those above to see how the HSRL image reveals more detailed aerosol information.

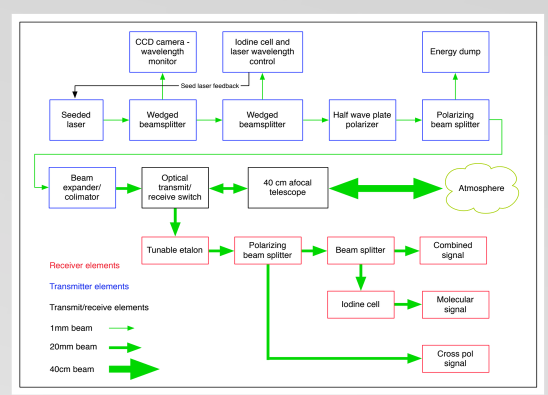
work performed

Flight operations for the TORERO field program were conducted from two locations: Anafagasta, Chile from January 19-29 and San Jose, Costa Rica from January 29 to February 26, 2012. Seventeen research flights were flown over remote regions of the Pacific Ocean. The map below shows seven proposed research flight plans for the Gulfstream V (GV) aircraft during TORERO. The altitudes flown varied widely from 0.1 km to over 15 km MSL. On some research flights the GV would rendezvous with the Japanese Research Vessel Hakuho Maru or the NOAA Research Vessel Kaimimoana that were servicing buoys along the 95 W longitude. The TORERO data examples next to the map were taken during Research Flight 4 (RF04) off the coast of Chile on January 27 and shows a typical profiling sequence. The lidar was used to determine atmospheric layers of interest and scientists then directed the GV to fly into these layers for in situ measurements. The GV starts at an altitude of over 7 km and descends to about 4 km for a short time, continues down to 100 m for marine boundary layer measurements. The calibrated backscatter cross section image, depolarization image, extinction image and average profiles of scattering ratio, extinction and backscatter cross section are available in real-time.

GVHSRL

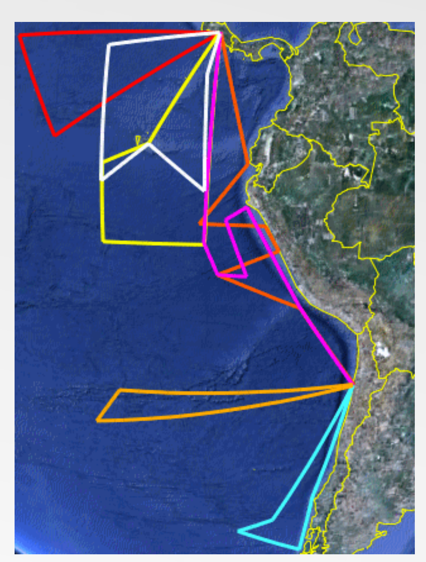
GVHSRL aircraft installation - the telescope can be rotated between up and down in a few seconds.

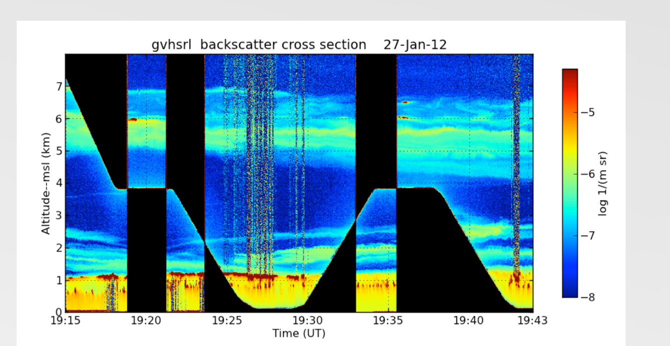


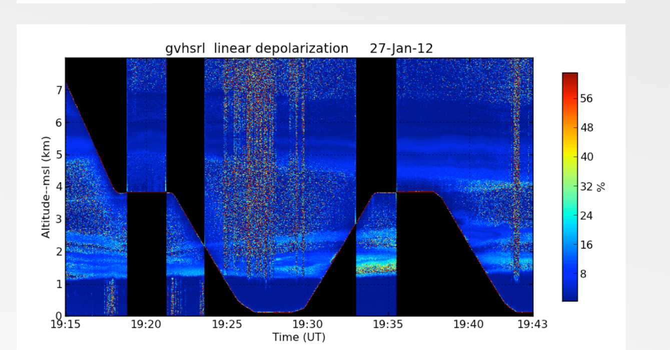


Laser Wavelength	0.532 μm
Laser Power	300 mW
Laser Pulse Rate	4000 Hz
Laser Pulse Width	50 ns
Laser Pulse Energy	75 μJ
Telescope Diameter	40 cm
Receiver	4 Channels
Detectors	Si:APD (photon counting)
Range Resolution	7.5 m

A simplified optical block diagram emphasizes the use of the telescope in both the transmitter and receiver. The transmit/receive telescope has excellent pointing stability. The expansion of the transmit beam to 40 cm is a major factor in making this lidar eye-safe at the telescope exit.

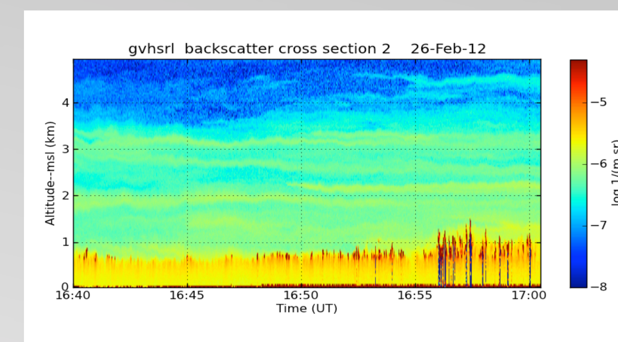


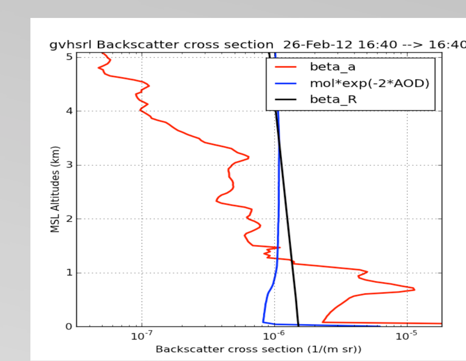


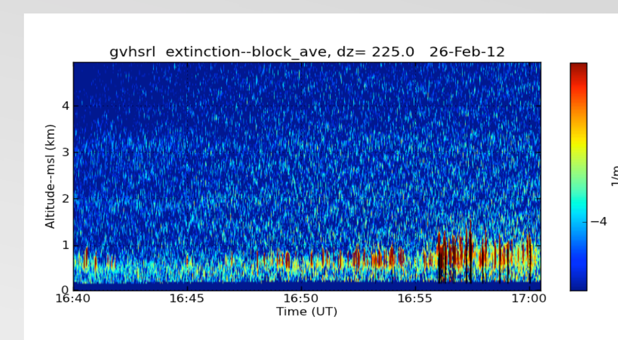


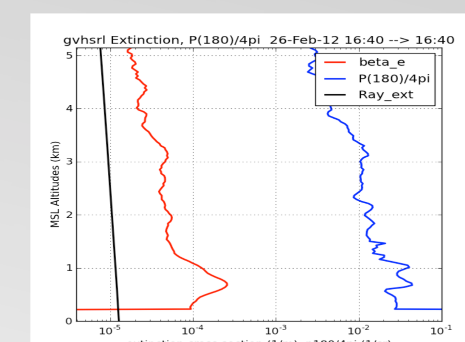
A map of proposed TORERO flight plans and an example of real-time backscatter cross section and depolarization data taken with the telescope alternating between zenith and nadir pointing.

TORERO Data





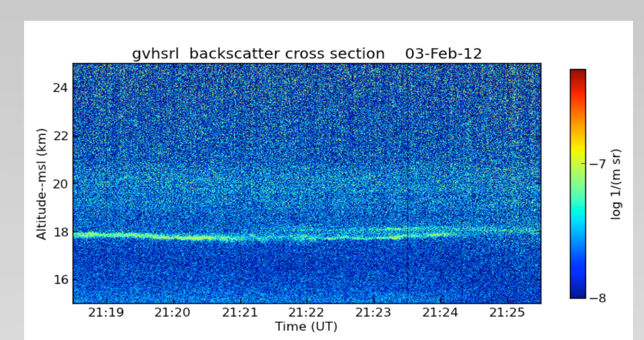


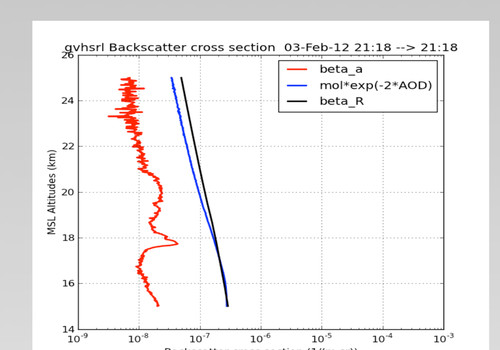


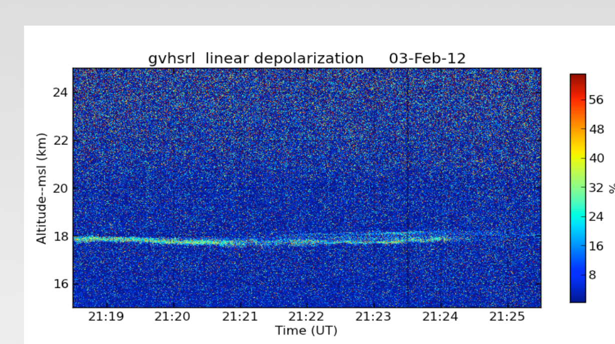
Marine Boundary Layer (MBL) GVHSRL real-time data products from RF17 taken of the coast of Costa Rica from an altitude of 7 to 10 km. The GV flight level for these data examples is 10 km. The images show data from the surface to 5km. The profiles show measurements from the MBL - up to 1 km above the ocean surface - and free tropospheric aerosols from the top of the MBL up to about 4 km.

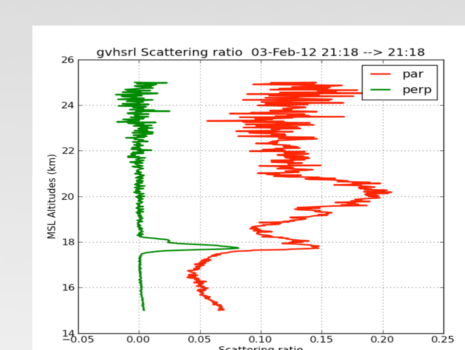
RF17 February 26, 2012

Sub-visible Cirrus Clouds







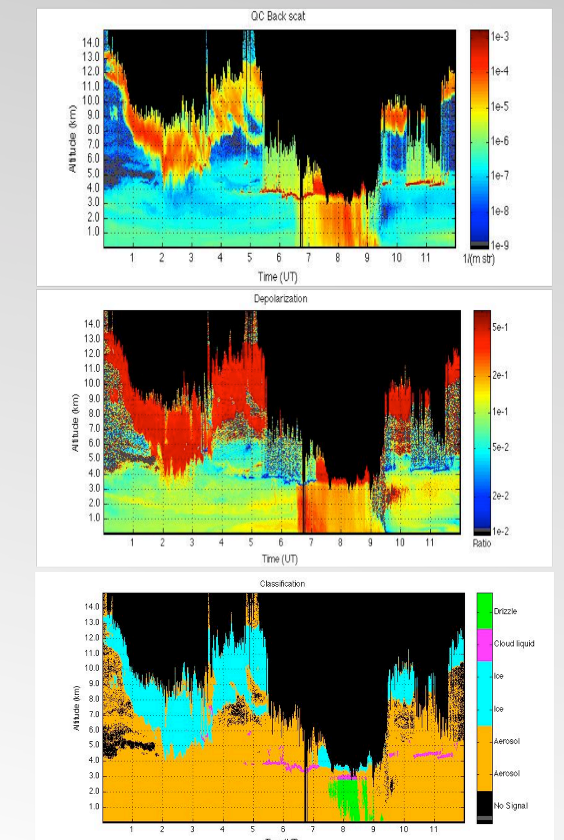


We are able to observe stratospheric aerosols and sub-visible cirrus clouds with the lidar. Shown above are the data from one approximately five minute zenith observation from a flight level above 13 km. We used depolarization to discriminate between the non-spherical ice crystals of the cirrus clouds and the spherical stratospheric aerosols.

data analysis

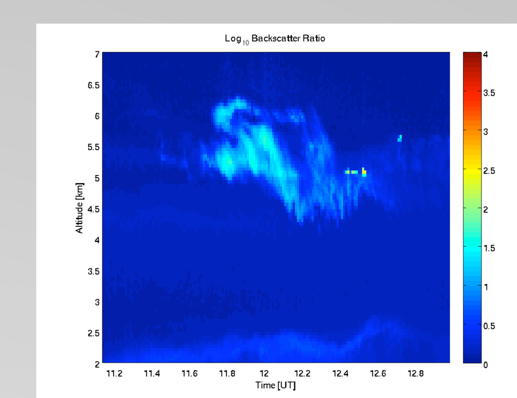
We are currently performing the data quality process on all the data taken during the TORERO field program. We are also developing an interactive web based data archive where the user can request any of the GVHSRL data products. The user will be able to select the time period, altitude range and both temporal and vertical range resolution on the final data product.

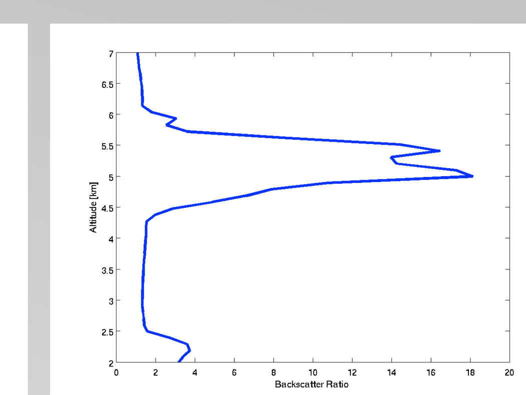
Particle Identification

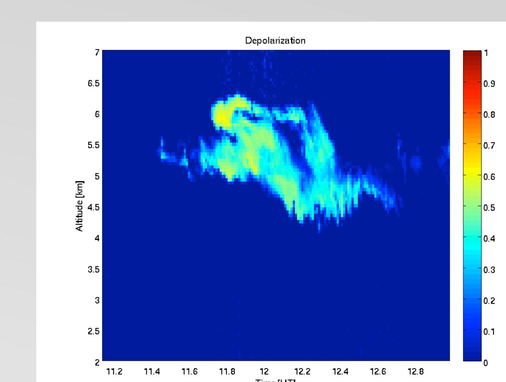


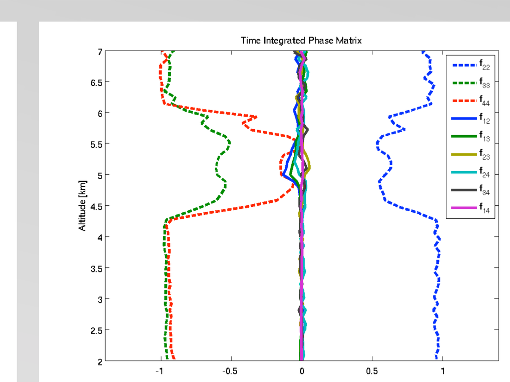
We are currently developing particle identification software using the backscatter cross section, depolarization, extinction, scattering ratio and backscatter phase function. These values are passed to membership functions to determine the degree to which each observation belongs to a particle type. Fuzzy logic processes that remove sharp thresholds between particle types are used to minimize misclassification of particles. The first results of this process using backscatter cross section and depolarization are shown in these plots.

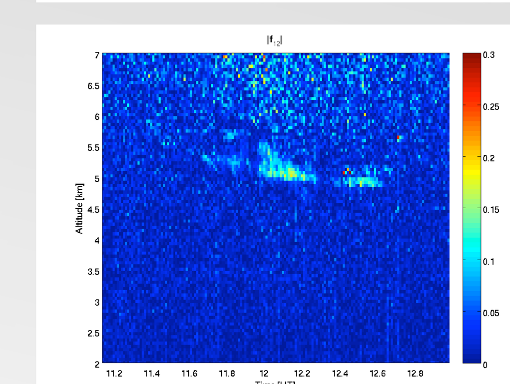
Oriented Scatterers

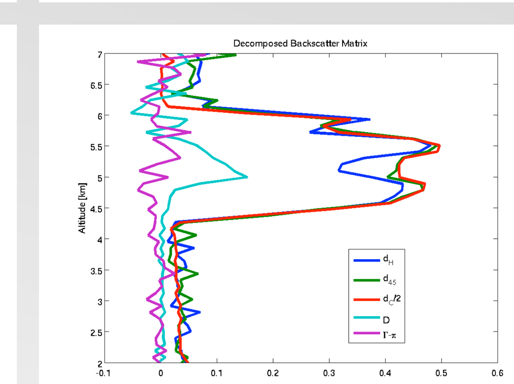












Conventional backscatter ratio (top right and left) and depolarization (middle left) observations of a cloud containing horizontally oriented ice crystals are shown. The full scattering matrix is detected (middle right) where off diagonal terms are solid lines, and diagonal terms are dashed lines. One off diagonal term is plotted to show where oriented ice crystals are present (bottom left). The scattering matrix can also be decomposed into physical polarization effects that also indicate the presence of oriented ice crystals (bottom right).