



Airborne Lidar Measurements of Atmospheric Pressure using the Oxygen A-Band



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Laser Sounder Approach for ASCENDS Mission

Simultaneous laser measurements:

- CO₂ lower tropospheric column (One line near 1572 nm)
- O₂ total column (surface pressure) (Measure 2 lines near 765 nm)

Altimetry & atmospheric backscatterer profile from CO₂ signal.

Measurements use:

- Pulsed lasers
- 100 kHz pulse rates
- 8 laser wavelengths for CO₂ line
- Time resolved photon counting receiver

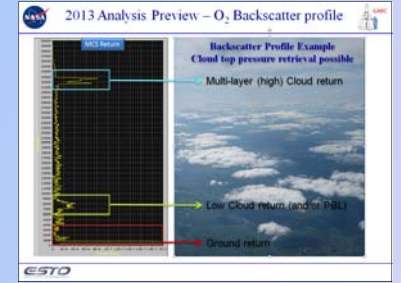
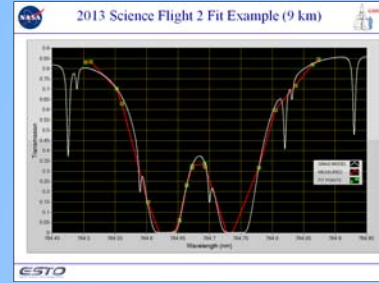
Measurements:

- CO₂ & O₂ column measurements
- Pulsed signal approach
- Isolate full column signal from surface
- Reduce noise from detector & solar background
- Time of flight provides column length

Height ~ 1000 m in 100 ns
Along track length
Need ~ 2% measurements of CO₂ & O₂ columns in ~10 sec

2013 ASCENDS Flights

1 st Eng. Flight	Local flight - aborted due to engine trouble
2 nd Eng. Flight	Winter and Southern Sierra
3 rd Science Flight	Sierra Nevada, CA
4 th Science Flight	Central Valley, CA
5 th Science Flight	Northern CA
6 th Science Flight	Sierra Nevada, CA
7 th Science Flight	Sierra Nevada, CA



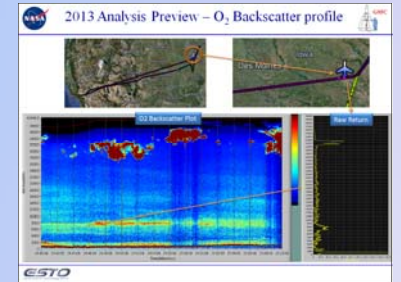
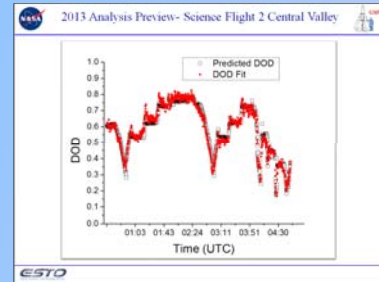
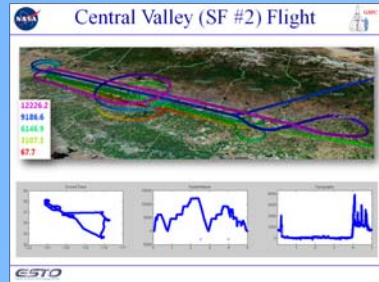
Need for O₂ Measurements

We need surface pressure for "the denominator" of the dry mixing ratio of CO₂

$$X(\text{CO}_2) = \frac{N(\text{CO}_2)}{(1 - X(\text{H}_2\text{O})) \times N(\text{Air})}$$

- X(H₂O) is the CO₂-dry air mixing ratio, N(CO₂) is the CO₂ number density measured by the CO₂ Sounder, and N(Air) is the air number density = surface pressure.
- Meteorological models can provide surface pressure, but there are uncertainties about their localization and global coverage.
- O₂ absorption measurements are a proven and demonstrated approach for pressure measurements.

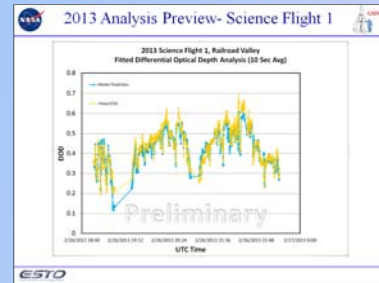
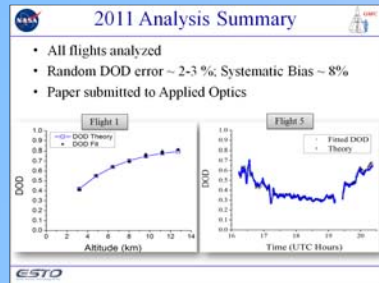
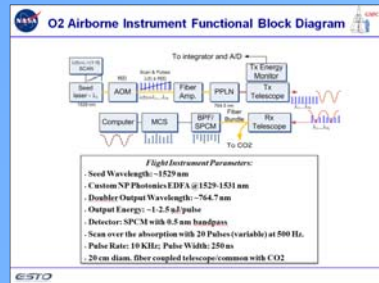
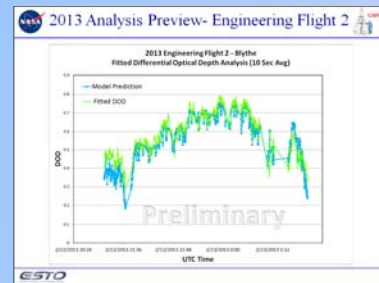
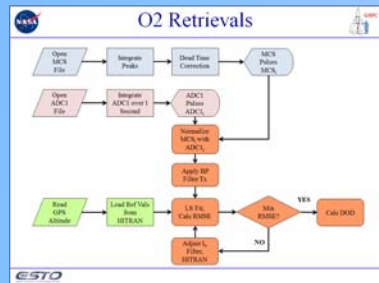
1 m spots separated by ~ 2 cm



O₂ Airborne Instrument with IPDA

2013 Wavelength Scan

2013 Wavelength Scan



- ### Summary and future plans
- Finished 2011 flight analysis and submitted paper to Applied Optics
 - Improved O₂ lidar performance (SNR, wavelength distribution)
 - Started 2013 analysis
 - Backscatterer analysis and layered retrievals - Cloud top pressure
 - Did step wavelength scanning improve results?
 - Did higher SNR improve results?
 - Investigate bias sources
 - Optimize bandpass filter and wavelength correction algorithms
 - Assess energy monitor and signal stability (filter Variance)
 - Identify additional metrics to evaluate lidar performance
 - Improve laser energy and optical characteristics
 - Test next generation optical (power) amplifier with second harmonic generator (SHG)
 - Implement 8 SPCM receiver
 - Demonstrate high dynamic range