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MATH: Monitoring Atmosphere Turbulence and Humidity

Per Høeg
Aalborg University
hoeg@kom.aau.dk

MATH

Monitoring Atmosphere Turbulence and Humidity

Per Høeg
Aalborg University

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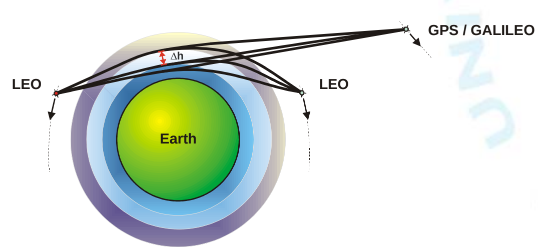
esa

Call for ESA Earth Core Explorers

Earth Explorers

Related mission proposals (pre-qualified proposals: 27)

- **MATH** [LEO-LEO (CALL), Water vapor lidar (DIAL)]
  - **AWC-NDSA** [LEO-LEO]
    - **ACCURATE** [LEO-LEO, GPS + IR laser occ.]



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Objectives

- Establishing unbiased observations of global **water vapor**, **temperature**, **pressure**, **aerosols, particles** and **clouds** throughout the troposphere.
- Establishing observations of global troposphere **turbulence**. Determine the role of turbulence in the dynamic and thermodynamic microphysical processes, leading to cloud formation from the initiation of water vapor phase transition.
  - Accurate (< 0.2 K) and vertically resolved (0.5 - 1 km) global vertical temperature profiles in the troposphere and the stratosphere
  - Accurate (< 10 % in relative humidity) and vertically resolved (0.5 km) global water vapor profiles in the troposphere
  - Systematic observations of troposphere turbulence strength, extent and spectral characteristics
  - Clouds and cloud boundaries (top and bottom)
  - Aerosols and lower troposphere particles (city-heating, smog)

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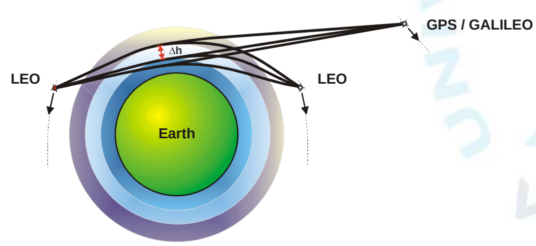
Constellation

- Two satellites in a sun-synchronous, dawn-dusk orbital plane. The satellites are flying in opposite directions, having an inclination of 90°- 100°.
- The larger satellite, carrying both the lidar and the LEO-LEO instrument, orbits in an altitude of 450 km. The mass of the satellite is 1200 kg.
- The smaller satellite, carrying only the LEO-LEO instrument, orbits in an altitude of 600 km. The satellite mass is 150 kg.



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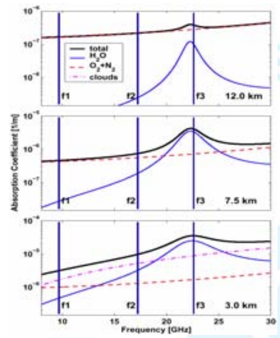
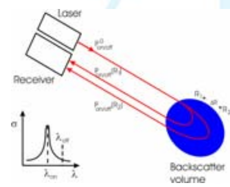
Measuring Methods

LEO-LEO
Horizontal occultations at three frequencies in the X/K band (10, 17 and 23 GHz).
High accuracy amplitude measurements paired with a time sampling of 1000 Hz determine vertical profiles of water vapor, temperature and pressure, as well as the refractive index structure constant C_n^2 of troposphere turbulence.

Lidar
Nadir-viewing water vapor lidar measurements at four frequencies in the wavelength band 925-940 nm.
The absorption lines characterize regions in the troposphere and lower stratosphere with differential optical thicknesses in the range 0.02-0.1.
Combination of different absorption cross sections for the probing frequencies and the differential absorption of the laser radiation represents the atmospheric humidity profile from the surface of the Earth up to altitudes of 16 km.

One pulse is emitted at the centre of the water vapor line (λ_{on}) and another pulse is transmitted on the line wing (λ_{off}). The backscattered energy from different altitudes is defined by the travel time of the laser pulse and the laser pulse length, defining the scattering volume.





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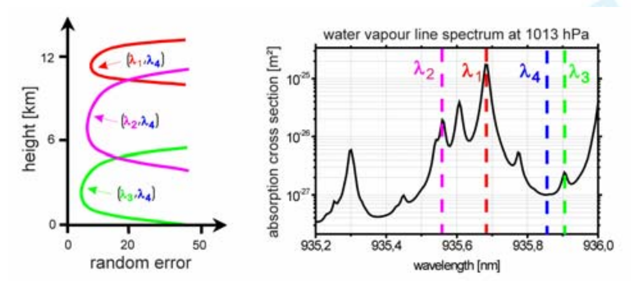
Measuring Method (Lidar)



The transmitter of the lidar instrument will operate at four different wavelengths with different absorption cross sections (right panel).
The corresponding lidar signals experience different water vapor optical thicknesses, resulting in different penetration depths. Three combinations of signals using three wavelength pairs, respectively, result in a composite water vapor profile from ground to the upper troposphere.

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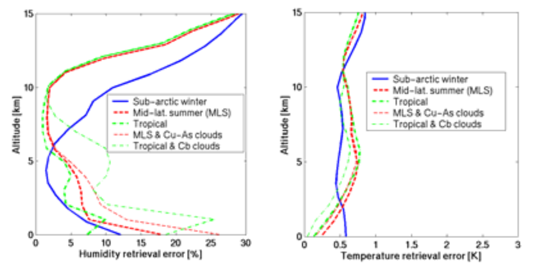
Measurements (LEO-LEO)



Retrieval errors of specific humidity (left) and temperature (right). The results cover three different standard profiles (based on FASCODE transmission cloud models). One is in clear air (heavy line), while the rest is for typical cloudy cases

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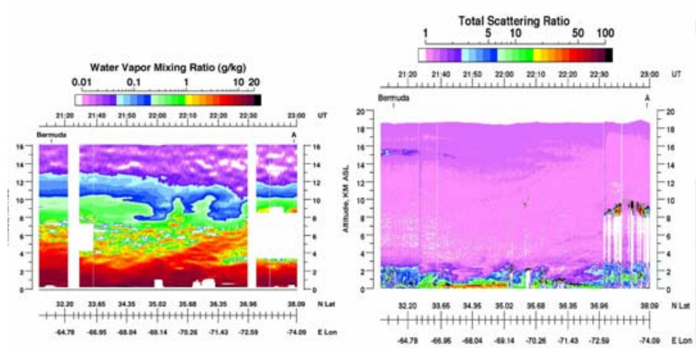
Measurements (Lidar)



Atmospheric cross sections of water vapor (left) and aerosols/clouds (right) obtained by H_2O lidar measurements. Two interleaved pairs of wavelengths were used with vertical resolution of 330 m and a horizontal resolution of about 25 km.
A stratospheric intrusion of dry air can be seen in the water vapor cross section along with a rising moist layer associated with a front.
The aerosol/cloud scattering is defined by the total atmospheric scattering ratio, obtained by normalizing the off-line lidar return by that from a aerosol-free atmosphere.
The aerosol/cloud data have a vertical resolution of 30 m and a horizontal resolution of 200 m, showing the capability to infer spatial and optical characteristics of cloud and aerosol layers as well as the height of the boundary layer.

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Next Steps

- Full proposal – in preparation for the deadline: August, 2005
- ESA issues science studies for the 3-6 selected missions (Phase A; 2006)
- Selection of mission to proceed to full implementation (2007/2008)

Interested companies and scientists
can contact me for further information and cooperation

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