Centre For Earth Observation Instrumentation

EMERGING TECHNOLOGIES WORKSHOP

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Spaceborne Global Wind Measurements for Meteorology – A Combined Package of Lidar & Passive Instruments :

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Spaceborne Global Wind Measurements

During the past 2 ½ years, the ESA Aeolus Mission has provided the first regular global-scale measurements of atmospheric winds from ground level to 30 km.

Despite its undoubted technological and scientific successes, there remains the issue of providing long-term global coverage for winds, probably with a mini-constellation of 4 satellite in suitable near-polar orbits to provide the high-quality wind data required by the assimilative numerical weather forecasting models.

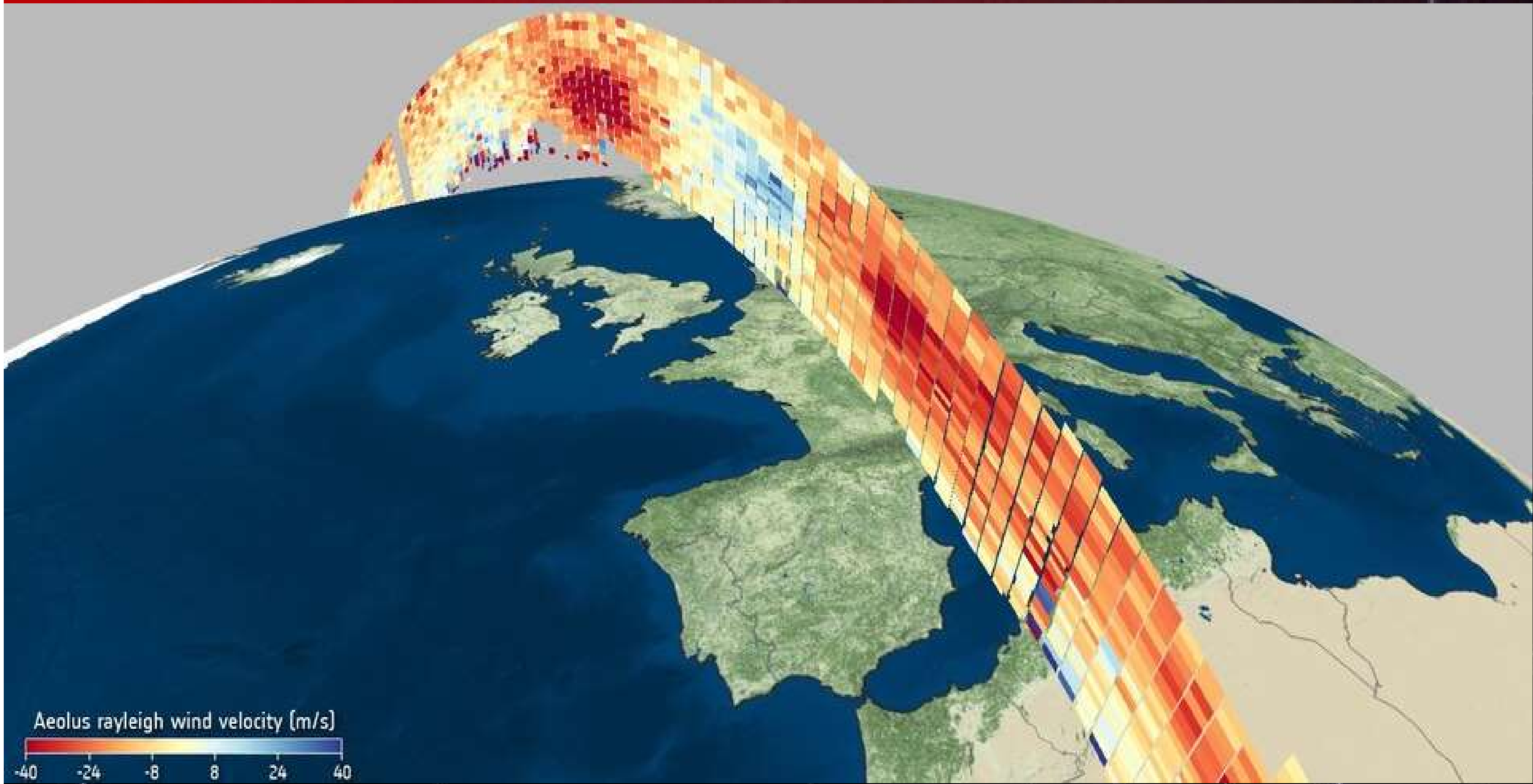
Using the Aeolus laser and technologies, this is both expensive and technically highly demanding.

We have thus been investigating the possibility to exploit many recent technical advances, using a Correlation Wind Lidar and an Advanced High-Resolution Doppler Interferometer.

SPACEBORNE GLOBAL WIND MEASUREMENTS

ESA's Aeolus Mission

SPACEBORNE GLOBAL WIND MEASUREMENTS



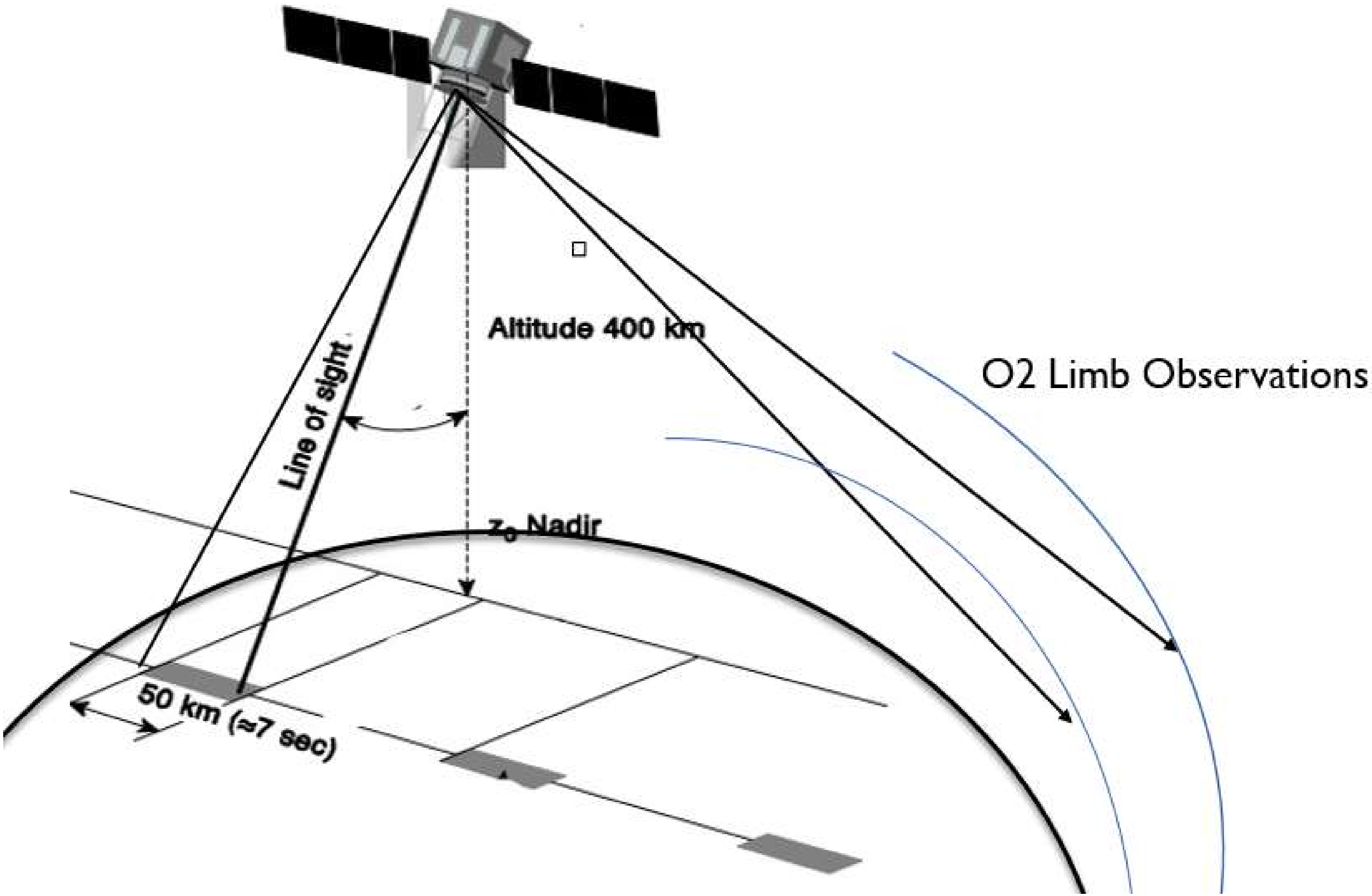
ESA's Aeolus mission has already been demonstrated to be a major success, providing regular wind data (such as that above) into ECMWF assimilative weather forecast modelling and thus improving forecast skill.

Spaceborne Global Wind Measurements

The Correlation Wind Lidar (CWL). incorporates several enhancements compared with the previous generation of CWL instruments, including a means of high-resolution spectral separation of the Mie from the Rayleigh Signal. This improves the SNR for wind measurements using the Mie signal from aerosols and clouds.

Spaceborne Global Wind Measurements

SPACEBORNE GLOBAL WIND MEASUREMENTS



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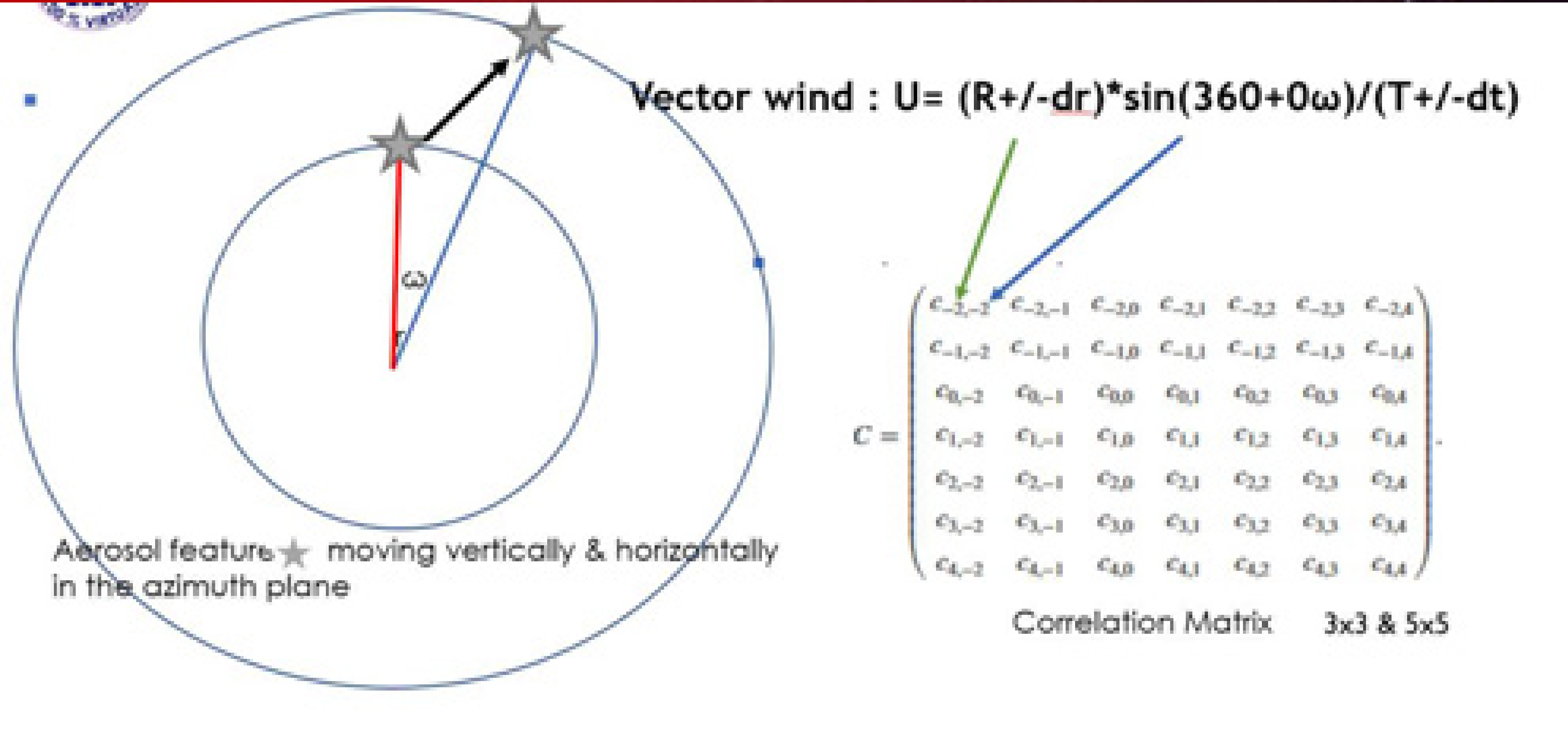
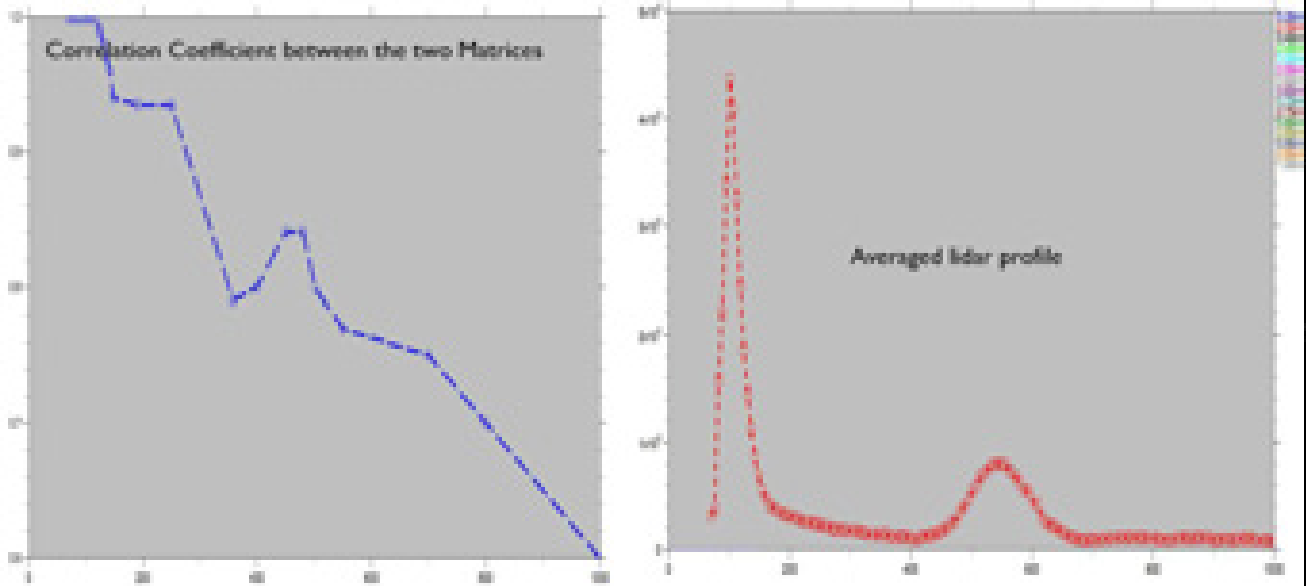
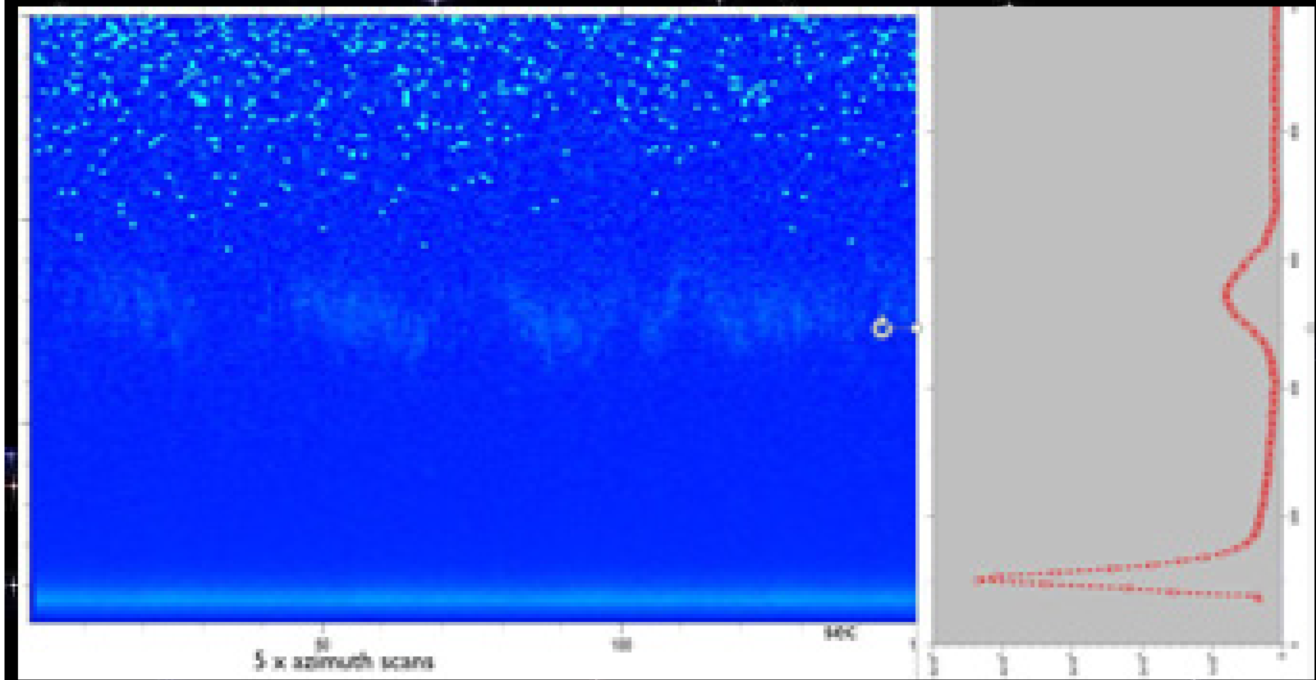


Wind vector calculation in CWL in polar coordinates. The aerosol feature moves with the wind during the scan. The resulting cross-correlation Matrix is shown on the right. The coefficient indexes provide the new coordinate position of a feature – scan by scan.

SPACEBORNE GLOBAL WIND MEASUREMENTS

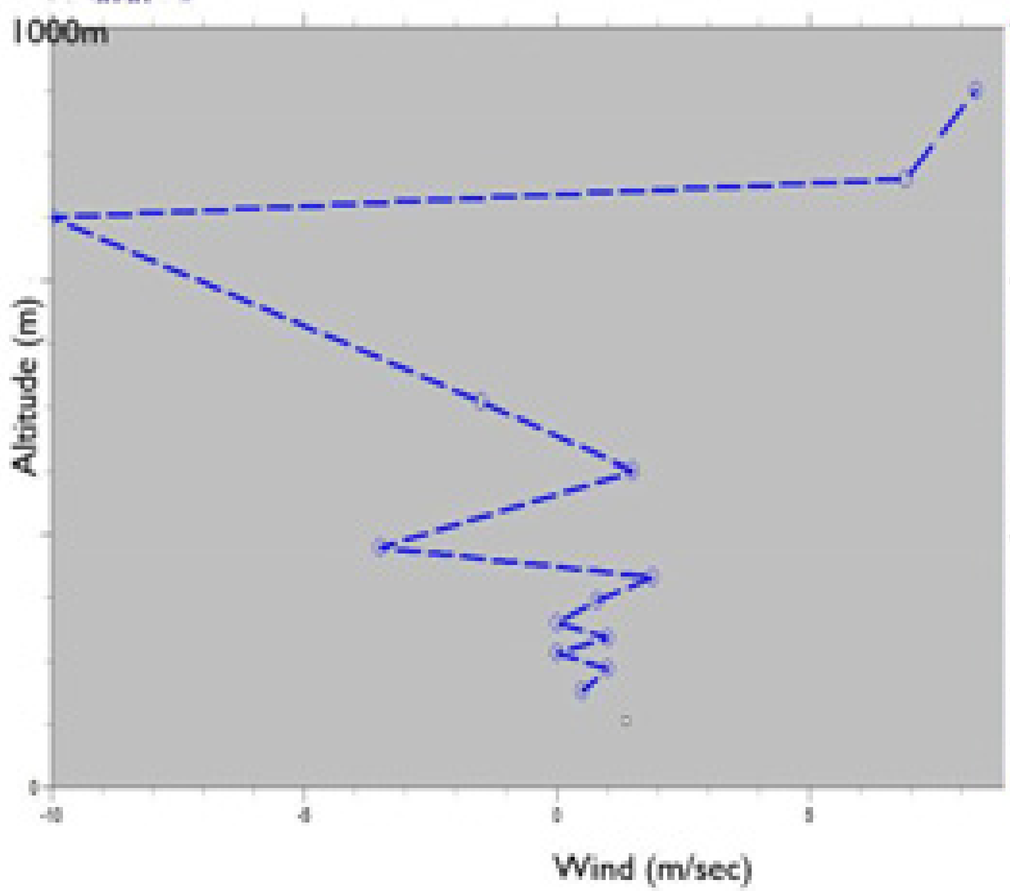


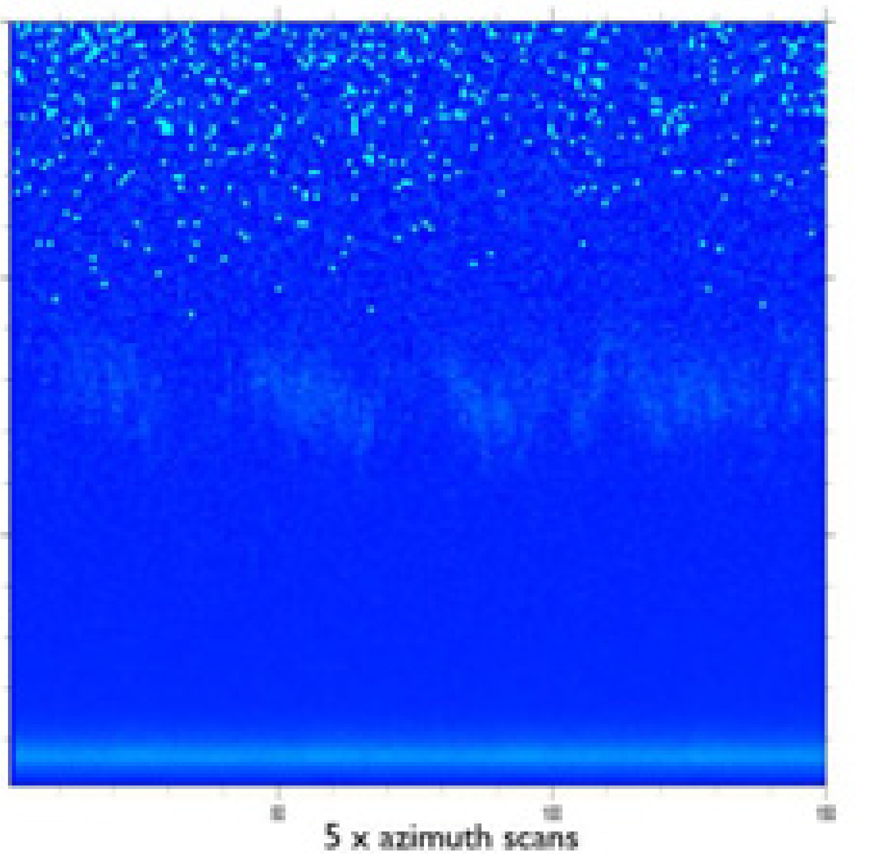
- The Picture shows the magnitude of the correlation coefficient (blue curve) corresponding to the lidar profile (red curve).



The Point Cloud Image corresponding to above

SPACEBORNE GLOBAL WIND MEASUREMENTS





The picture above shows the deduced wind profile

The corresponding Point Cloud Image.

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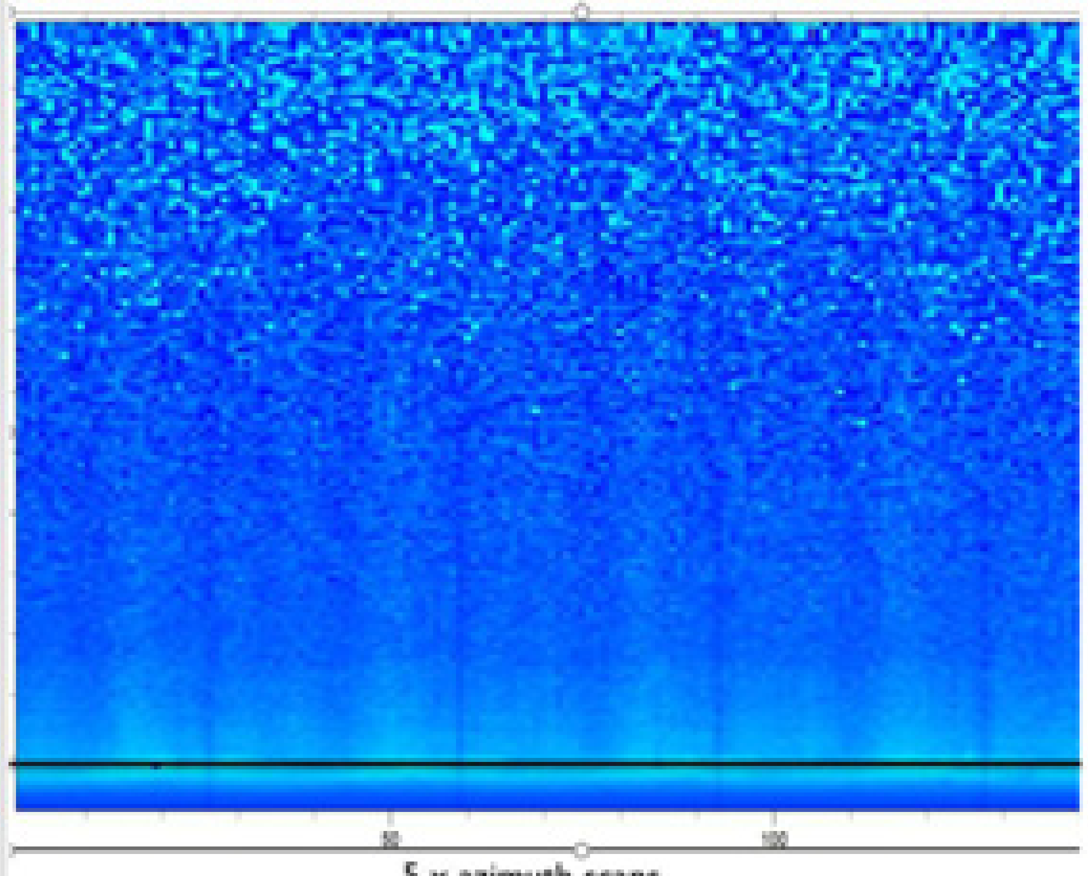

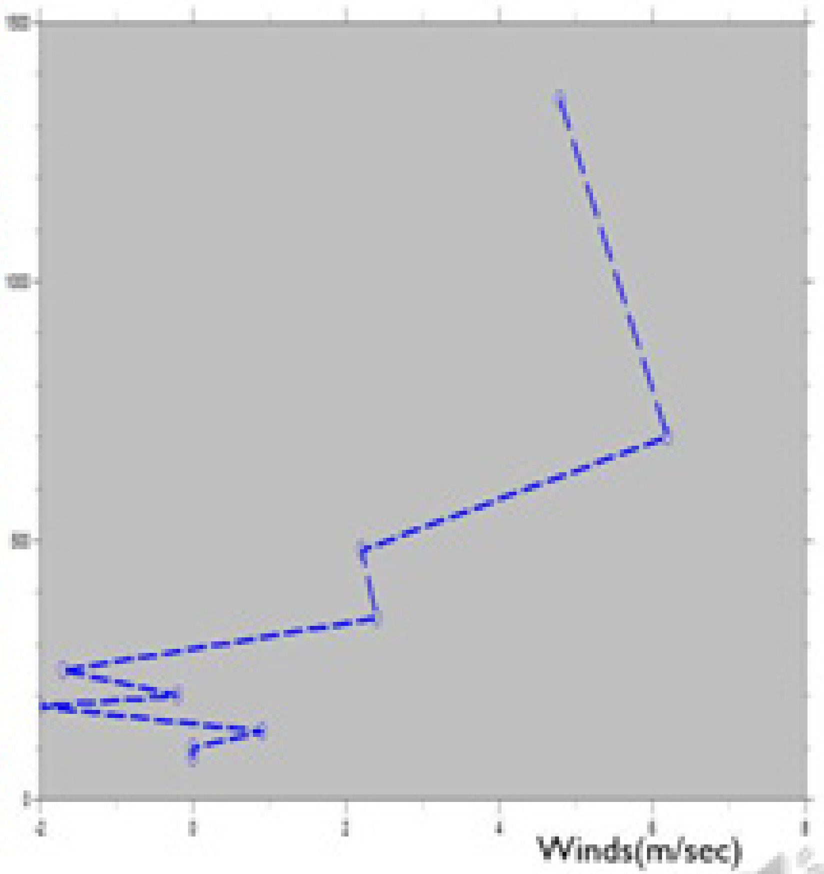

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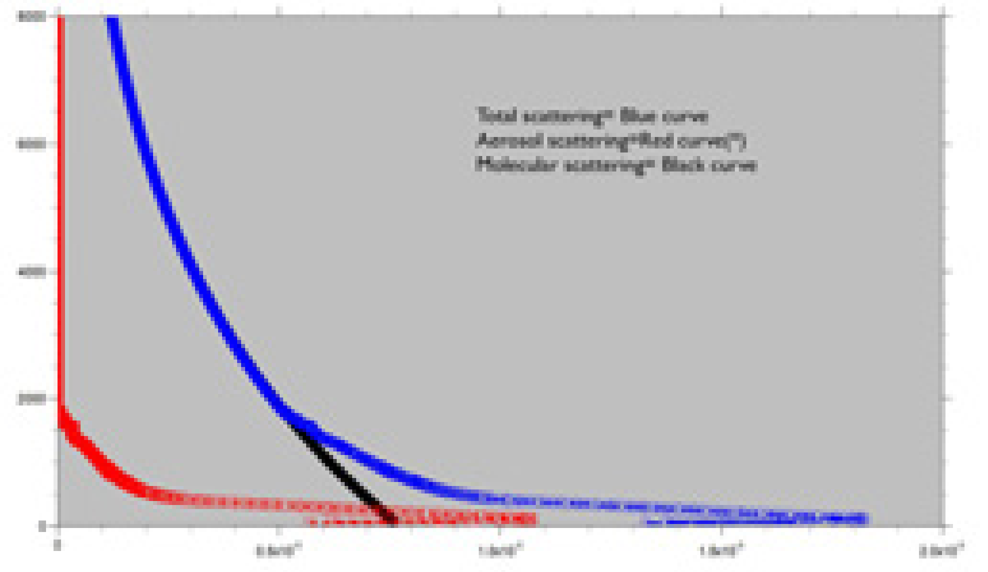
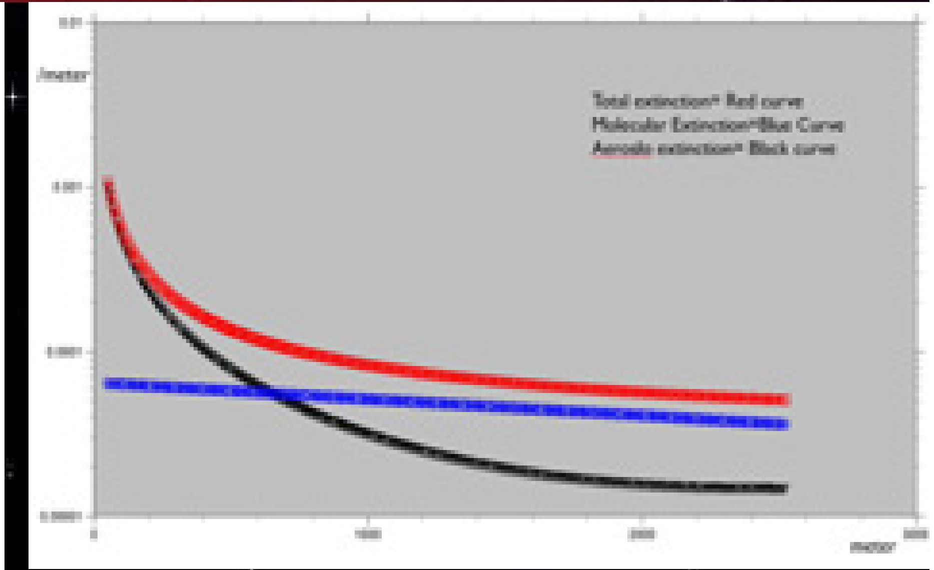
SPACEBORNE GLOBAL WIND MEASUREMENTS



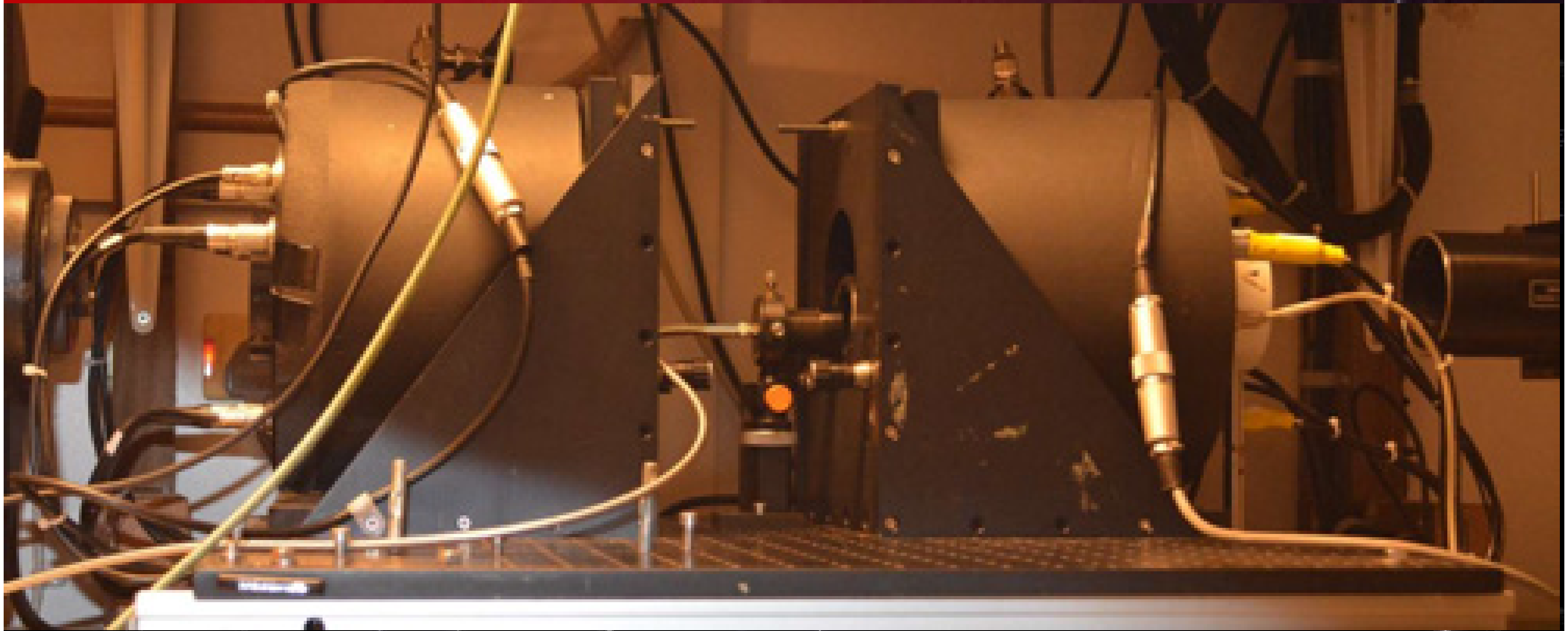


The calculated scattering & extinction coefficients corresponding to the figure shown previously.

A substantial further gain of performance can be obtained by measuring ONLY the Aerosol signal and eliminating the (often stronger) Rayleigh return (Mie Signal) from Aerosols.

The "ALFA" high-resolution system developed for ATLID has been adapted for this purpose and is currently on test.

SPACEBORNE GLOBAL WIND MEASUREMENTS



High Resolution Etalon and Low Resolution Etalons of the "ALFA" System during Etalon Alignment.

In combination, these transmit the narrow Mie Signal from Aerosols and eliminate the Rayleigh Signal

Spaceborne Global Wind Measurements

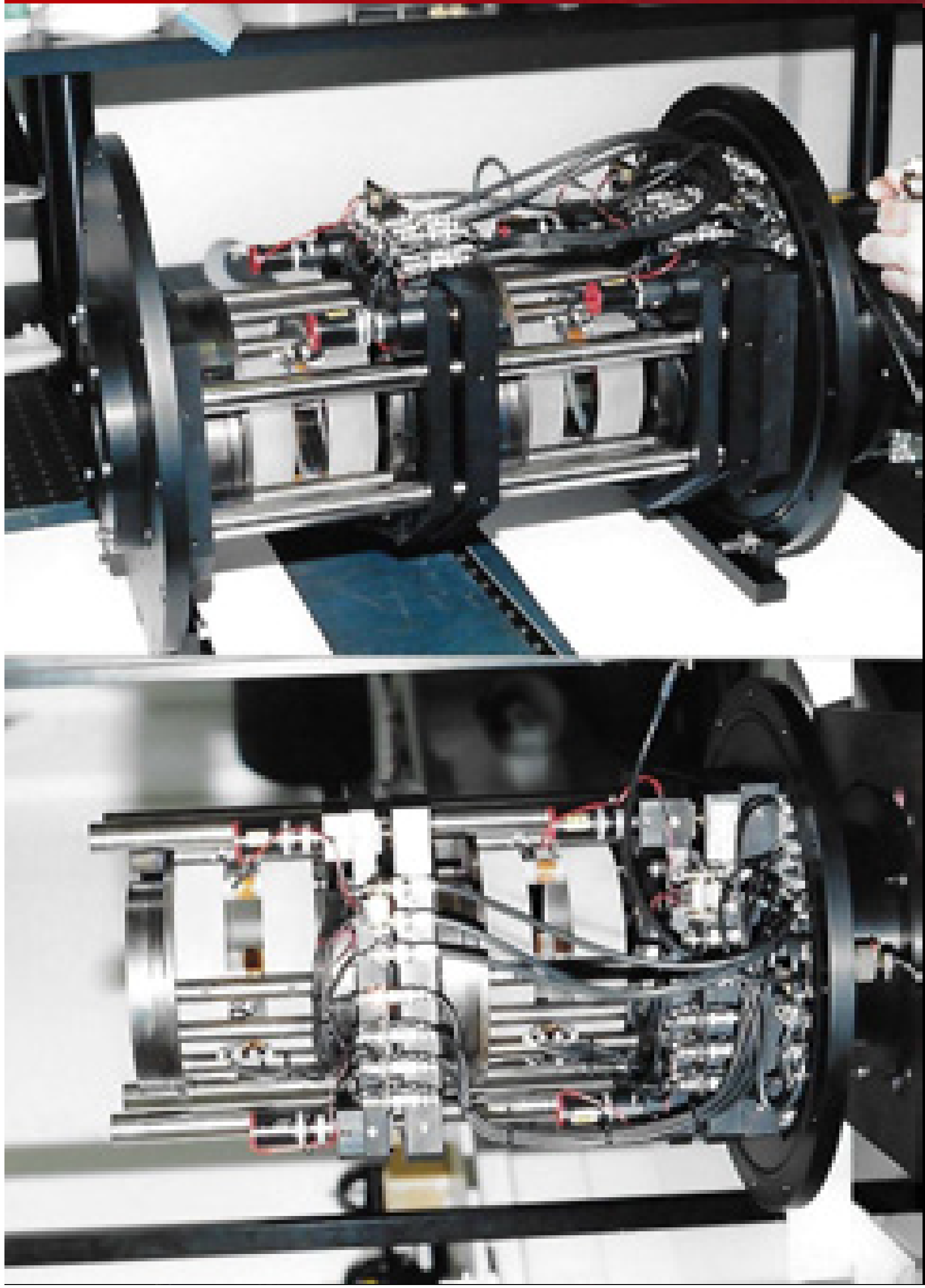
Our expectation is that the Advanced Correlation Wind Lidar can provide most of the high-quality wind data currently provided by Aeolus for the altitude region up to the tropopause.

That, however, would leave a major gap of knowledge about the state of winds in the stratosphere.

To overcome this short-fall, we have been reconsidering the High-Resolution Doppler Interferometer exploited to advantage for Stratospheric Winds with the NASA Upper Atmosphere Research Satellite.

Exploiting many of the technical and optical advances used in Aeolus, A-HRDI would measure vector dayside winds to 50 km – thus very largely eliminating the shortfall.

Spaceborne Global Wind Measurements



- Double Fabry-Perot Etalon (ground-based!).
- Two Fabry-Perot Etalons:
- Capacitance-Stabilised:
- Tuneable and with exact plate-parallelism;
- Aligned so that the plates are exactly parallel for both etalons.
- The etalons shown are for the Swedish Solar Telescope at La Palma!!

Spaceborne Global Wind Measurements

The image above shows the modulated fringe-pattern produced by two F-P etalons – when aligned + tuned. The "double-etalon" is the core of the HRDI instrument.

HRDI – UARS.

We were able to exploit single-etalon fixed-gap Fabry-Perot etalons for wind measurements from ground-based FPIs and also from Rockets and the Dynamics Explorer FP Interferometer.

Upper Atmosphere Research Satellite gave a new challenge:-

- Measure stratospheric winds!!

Use absorption lines of O_2, rather than emission lines of atomic O.

For this, three F-P etalons were required;

- **Two have to be tuneable!!**

Spaceborne Global Wind Measurements

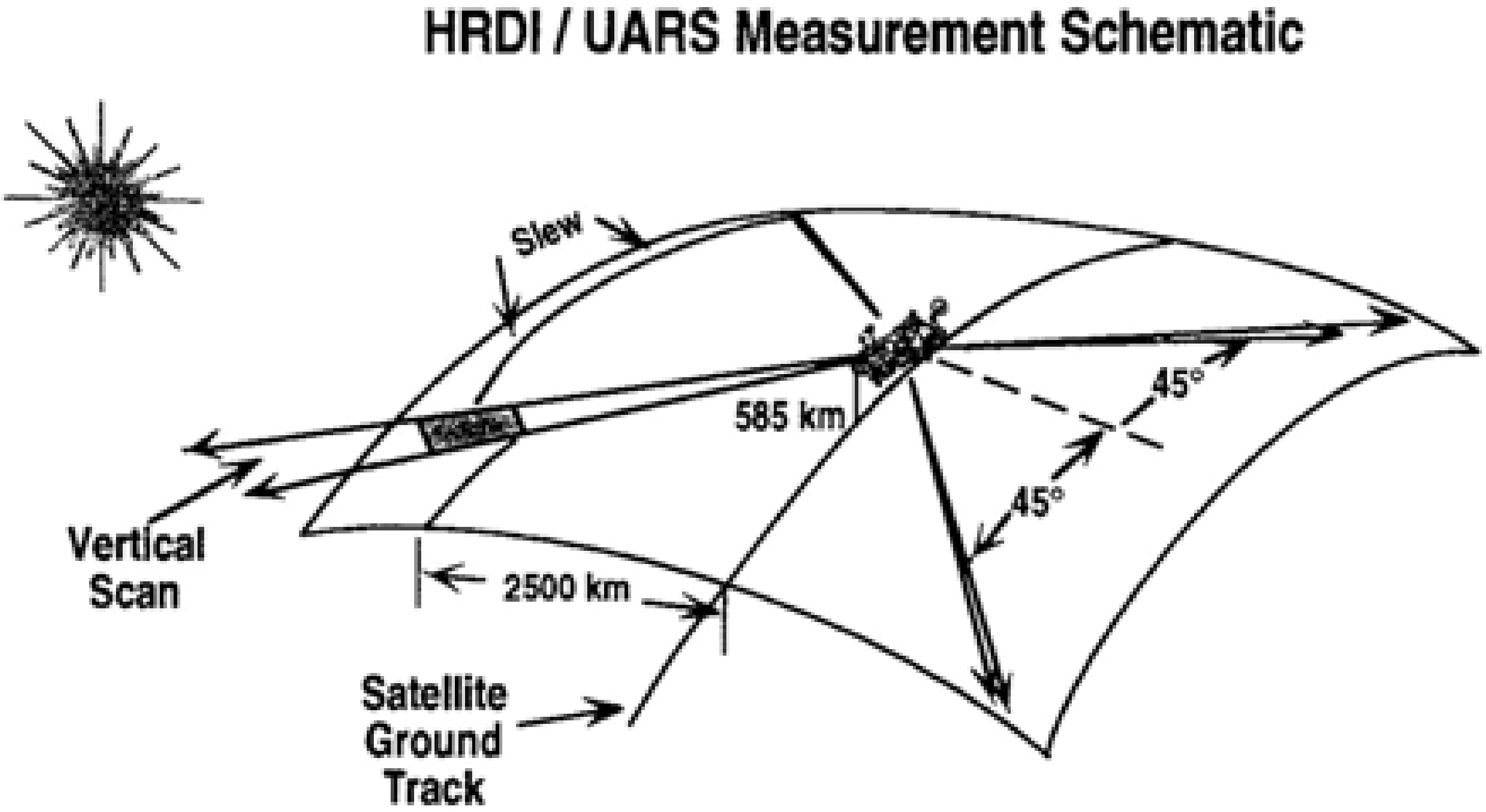
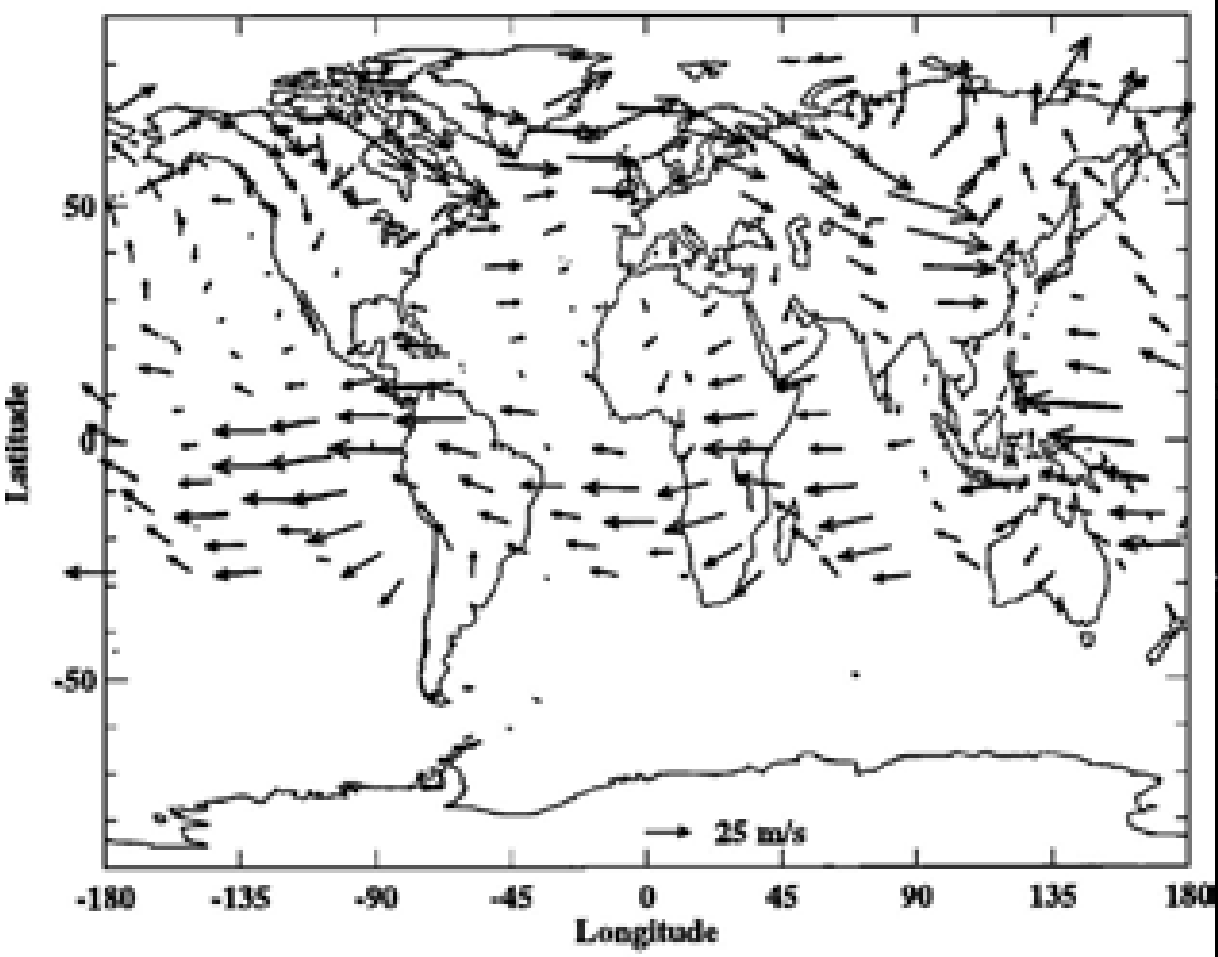


Illustration of the Observing Scene of HRDI on-board UARS:
Four viewing directions at 90 degrees (horizontally) viewing the atmosphere between 10 and 40 km altitude, at the limb. Due to mass constraints, a single scanning telescope was used. A better arrangement would be to exploit four separate telescopes.

Spaceborne Global Wind Measurements



HRDI – UARS.

This is the global stratospheric wind field as measured by HRDI on the Upper Atmosphere Research Satellite.

Using the absorption lines of O_2 and H_2O, and the double F-P etalons of HRDI, the Doppler Shifts provided a novel means of global stratospheric wind

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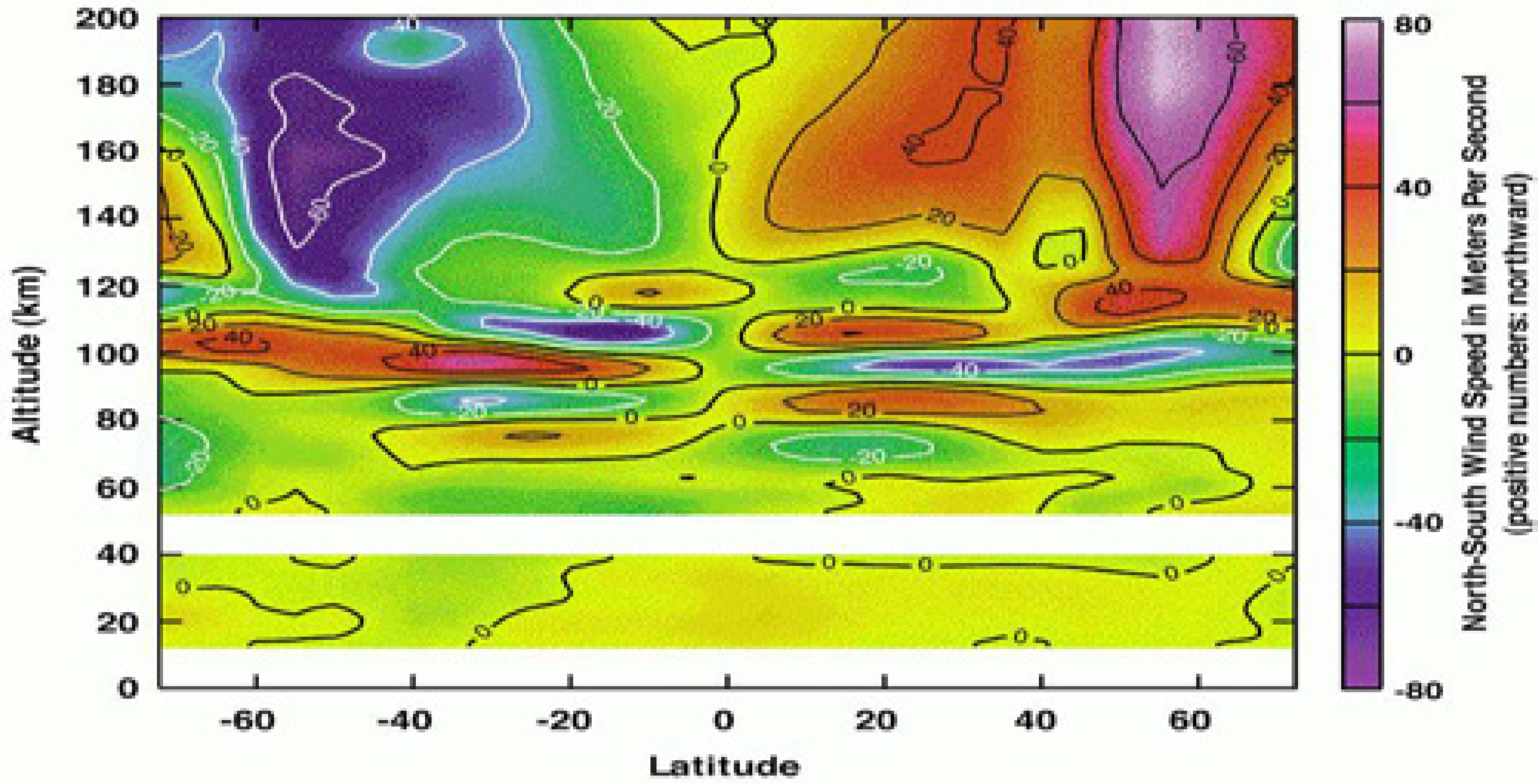

This is a composite image of atmospheric tidal measurements made by HRDI and WINDII for February 1993 to April 1994. The meridional (N-S) tidal wind is shown as a function of altitude and latitude at 12:00 non, local time. UARS observations are the most extensive global measurements of atmospheric tidal winds ever produced.