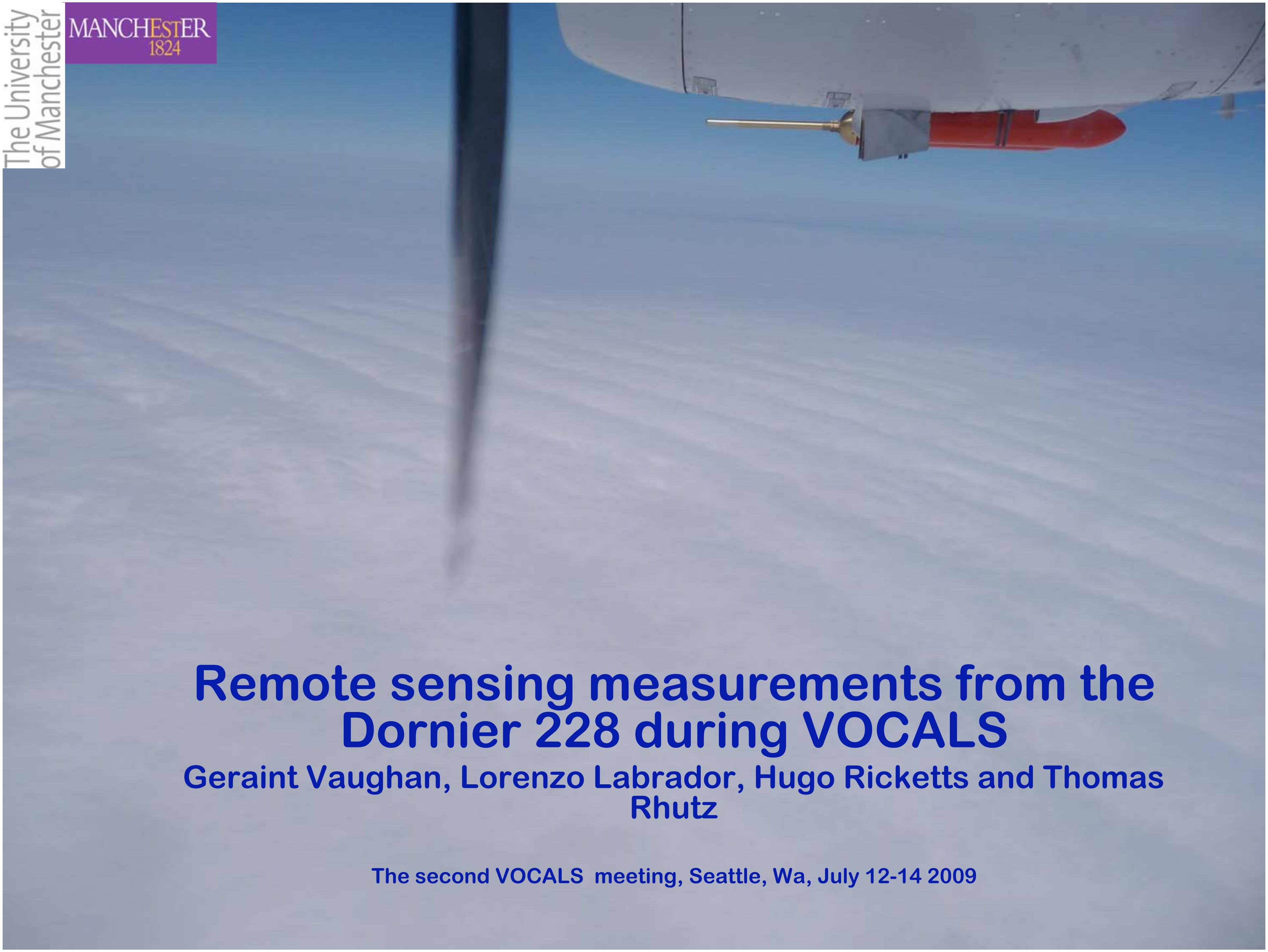


Remote sensing measurements from the Dornier 228 during VOCALS

Geraint Vaughan, Lorenzo Labrador, Hugo Ricketts and Thomas Rhutz

The second VOCALS meeting, Seattle, Wa, July 12-14 2009

Overall aim of WP4

Compare remotely-sensed cloud property measurements to similar retrievals from satellites (e.g. MODIS) and in-situ measurements on board the BAE-146 and C-130 aircraft.

Objectives

- To use the spectrally-resolved reflectivity measurements to derive cloud effective radius and optical depth (where thin)

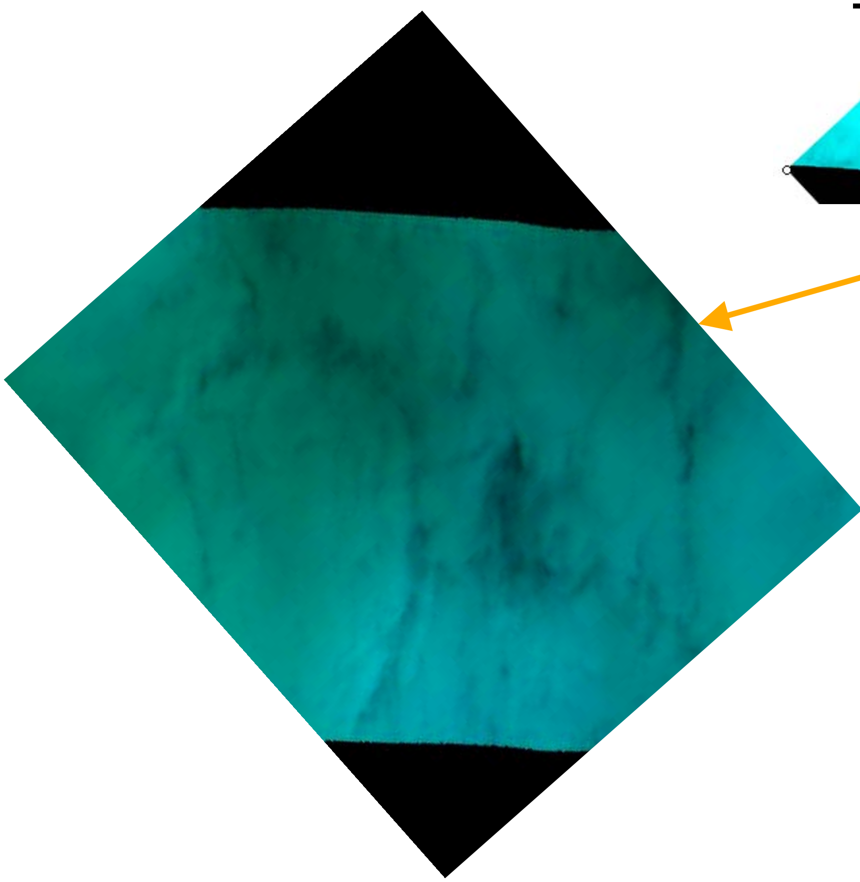
- To derive the scale structure of reflectivity from the hyperspectral imagers, for comparison with the LES model

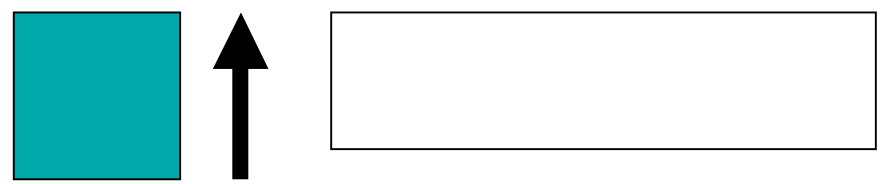
Remote sensing suite onboard the Dornier DO-228

3 remote sensing instruments:

- SPECIM's Eagle & Hawk hyperspectral imagers
- Leosphere LIDAR
- Airborne Multispectral Sunphoto- and Polarimeter

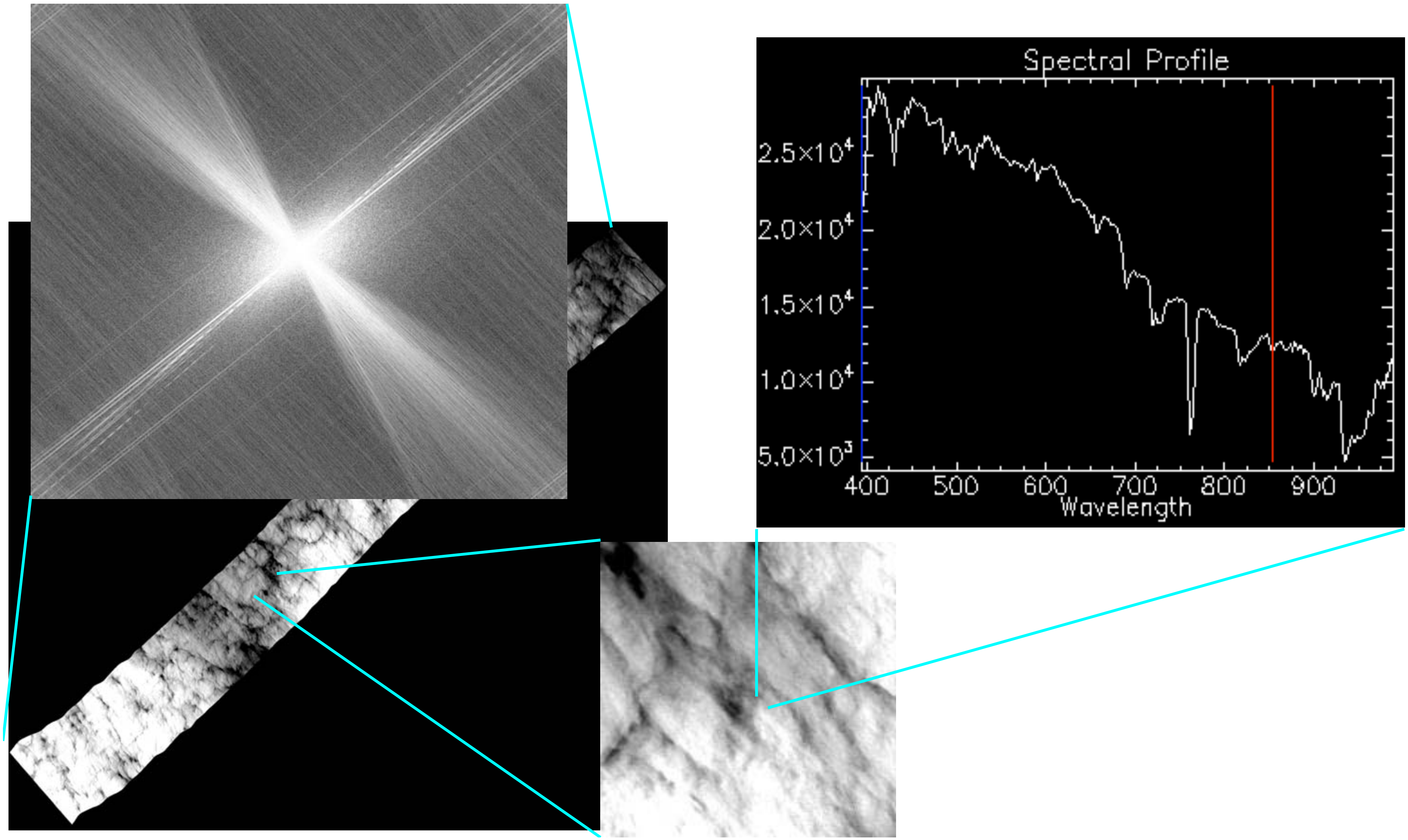
Eagle and Hawk sample data, VA02_081028





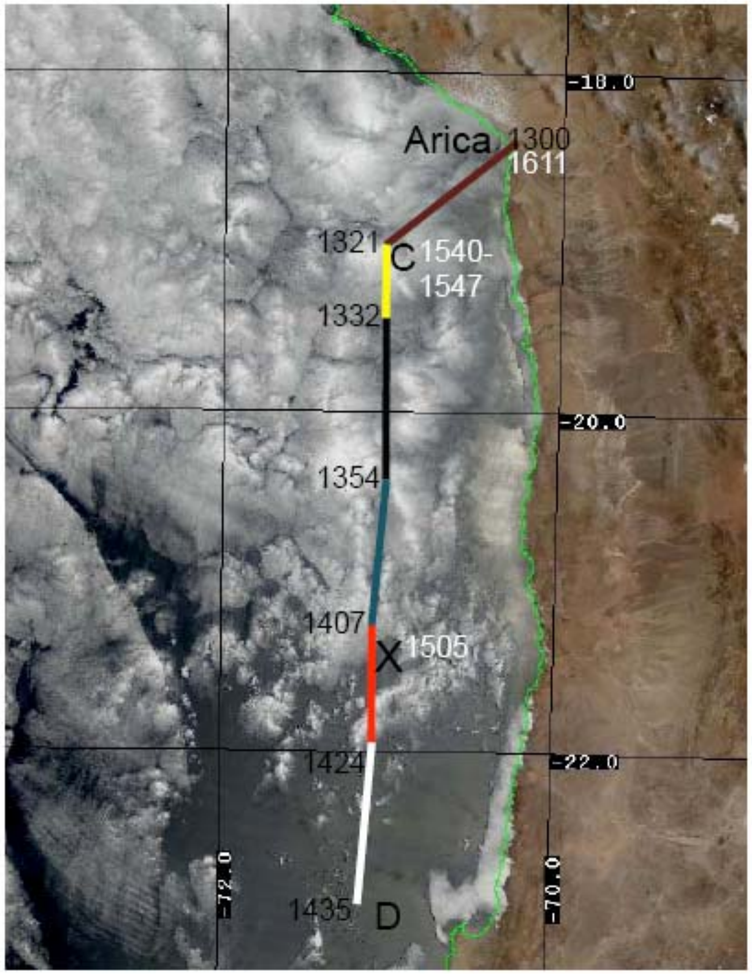
Eagle pixel	Hawk pixel
2.8 x 2.4 m	1.6 x 4.6 m
1024 pixels	320 pixels
400-970 nm	1000 - 2400 nm
Δλ = 2.9 nm	Δλ = 8 nm

Eagle sensor (400-988 nm) , VA09, sample flight transect 06/11/2008



VOCALS Nov 5 2008 – VA08

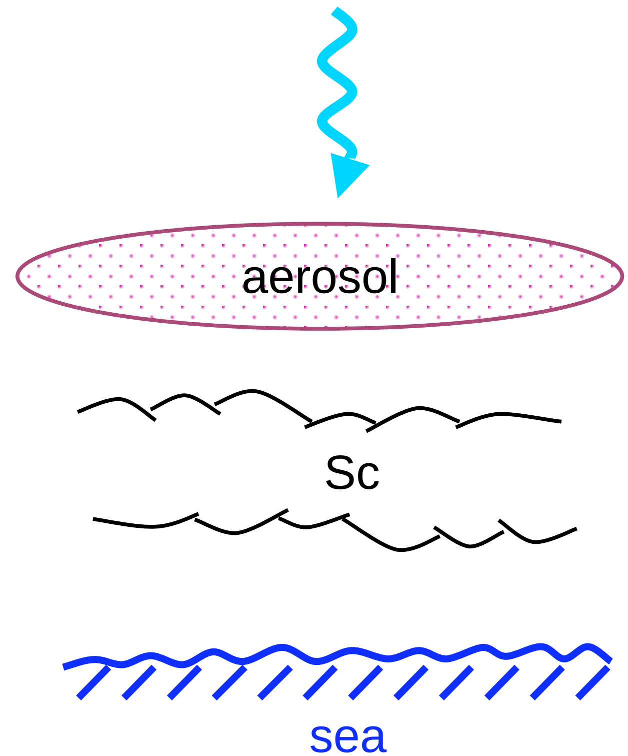
Terra MODIS overpass at 1505 UTC



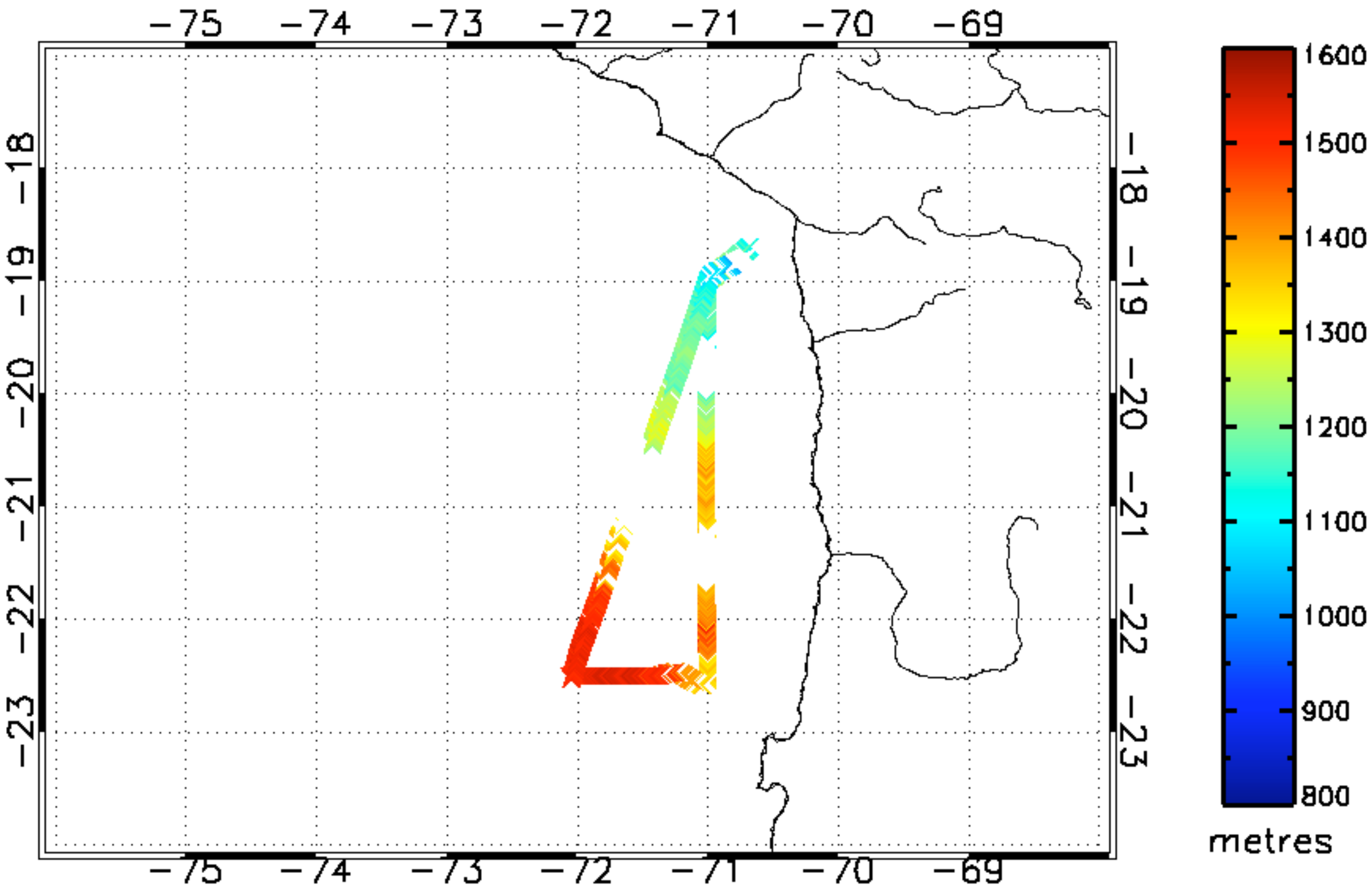
Return leg along the same line reaching Point X at 1505 UTC and Point C at 1540 UTC; spiral down at Point C and return to Arica at 1611 UTC

Leosphere aerosol lidar

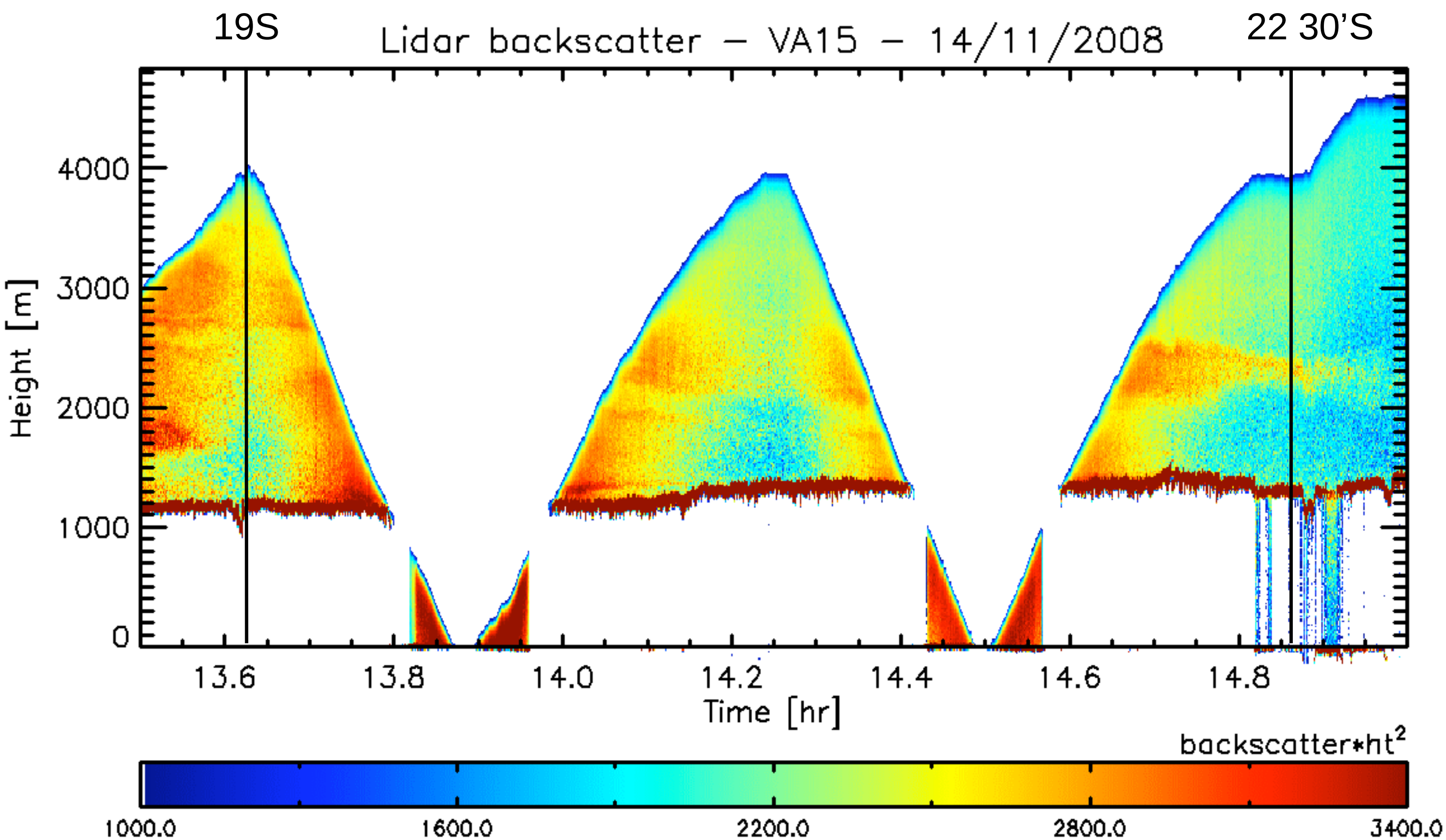
- Wavelength: 355nm
- Max. range: 5000m
- Spatial resolution: 1.5m
- Temporal resolution: 1s
  => 100m @ 200kt
- Real-time aerosol processing
- Cloud top height
- Aerosol backscatter coeff.



VA15 – pollution profiling 14/11/2008

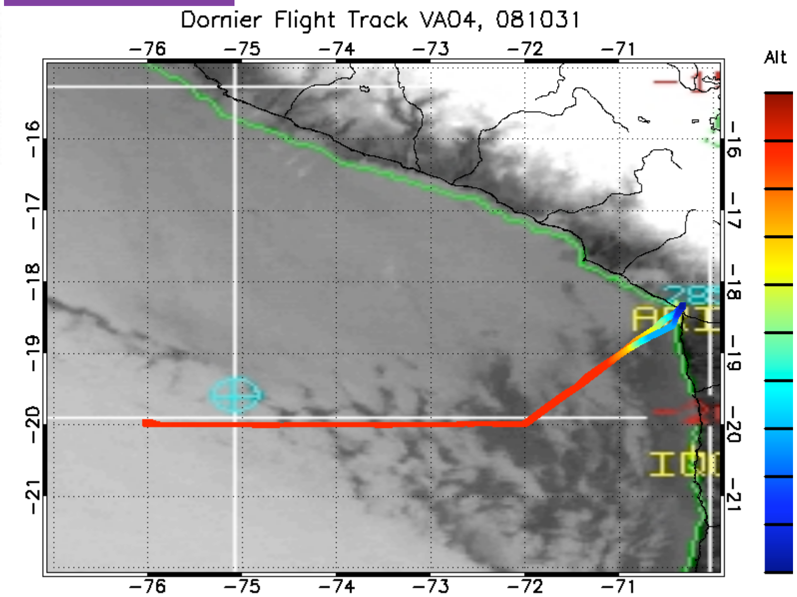


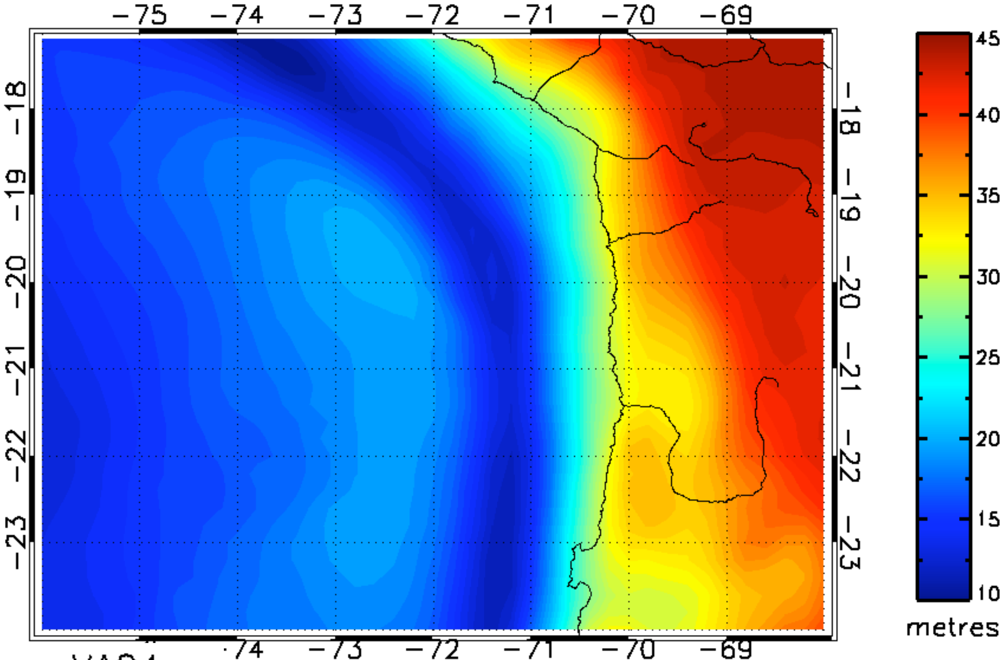
Dornier aerosol lidar – coastal pollution profiling along 71W

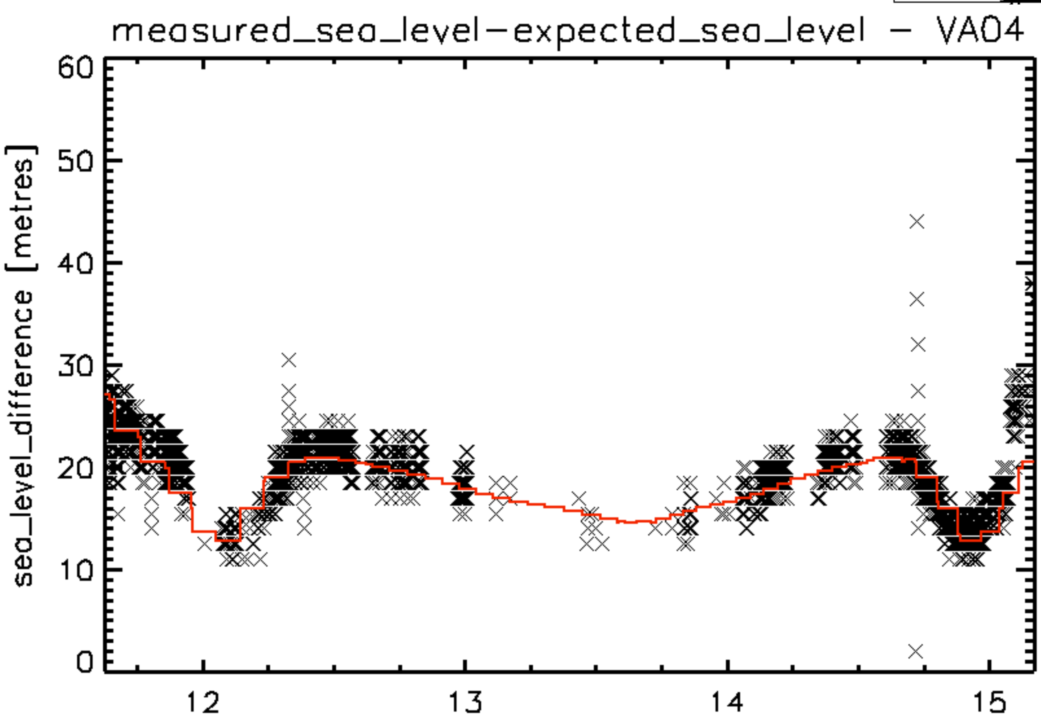


The University of Manchester

MANCHESTER 1824







Difference between WGS84 spheroid used by GPS and actual seal level

Freie Universität Berlin

Institute for Space Sciences

AMSSP-EM

Airborne Multispectral Sunphoto- and Polarimeter Engineering Model

AMSSP-EM Specifications during Vocals

Option: Pointing polarimeter

Status: System under development (during Vocals nadir look direction)

spectral range: 450 – 750 nm

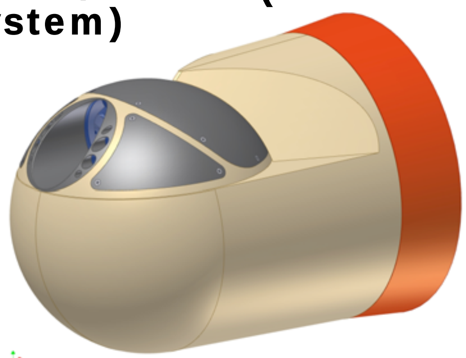
spectral channels: 150 (256)

spectral resolution: ~8nm

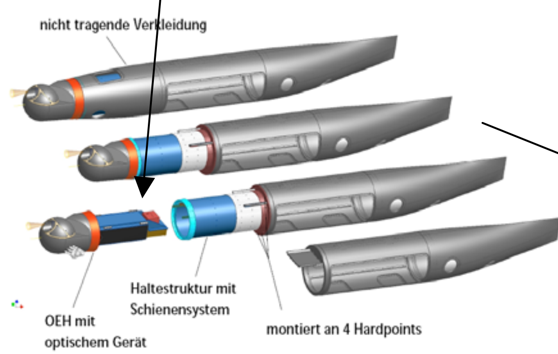
Option: Sunphotometer

Status: System under development (not used during Vocals)

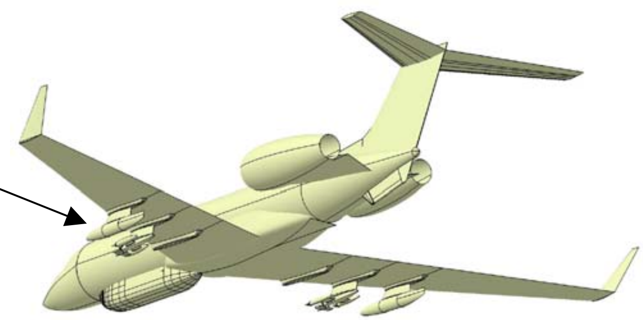
URMS/AMSSP (Universal Radiation Measurement System)



Optical Entrance Head



HALO Wing-Pod



Aircraft: HALO

Institute for Space Sciences

Freie Universität Berlin

Riedi 2007

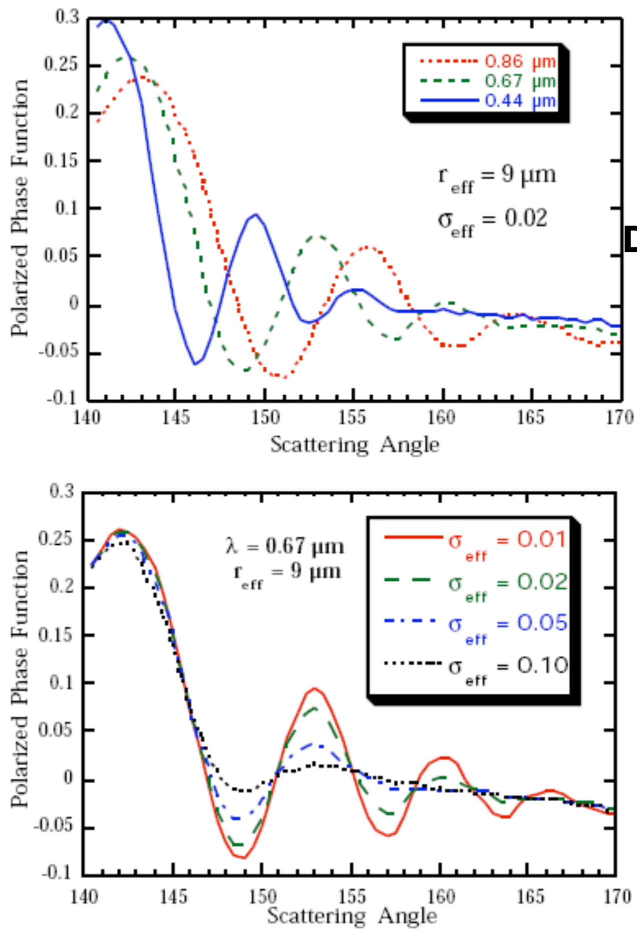


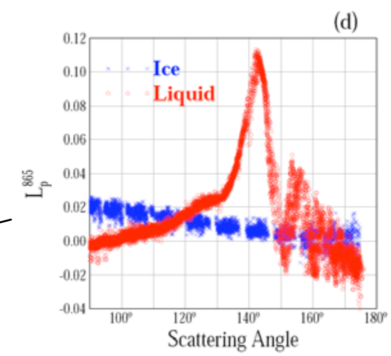
Figure 3. Polarized phase function $Pp(\gamma)$ as a function of scattering angle for cloud droplet size distributions as in eq. (3). In Fig. 3a, we show how $Pp(\gamma)$ varies with the wavelength. Fig. 3b illustrates the variation of $Pp(\gamma)$ with the size distribution variance.

AMSSP-EM:

Data analysis is an ongoing work

Degree of polarization depends on:

- **cloud droplet size**
- **cloud droplet size distribution**
- **cloud optical thickness**
- **cloud thermodynamic phase**
- **viewing geometry**
- **wavelength**



Riedi 2007

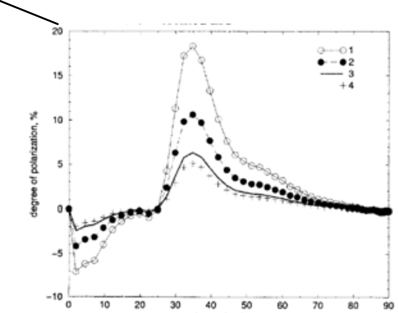
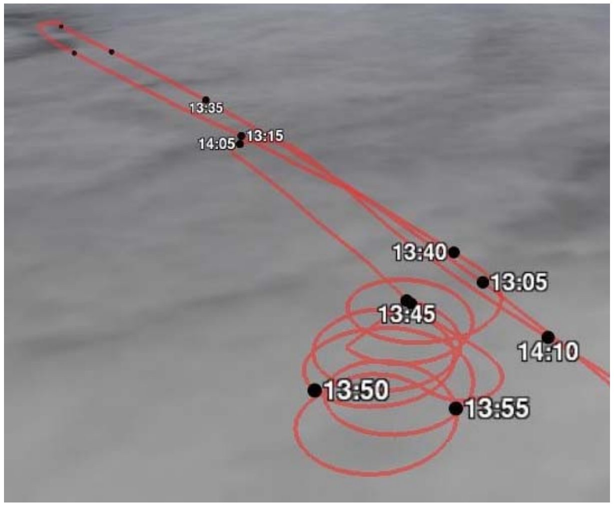


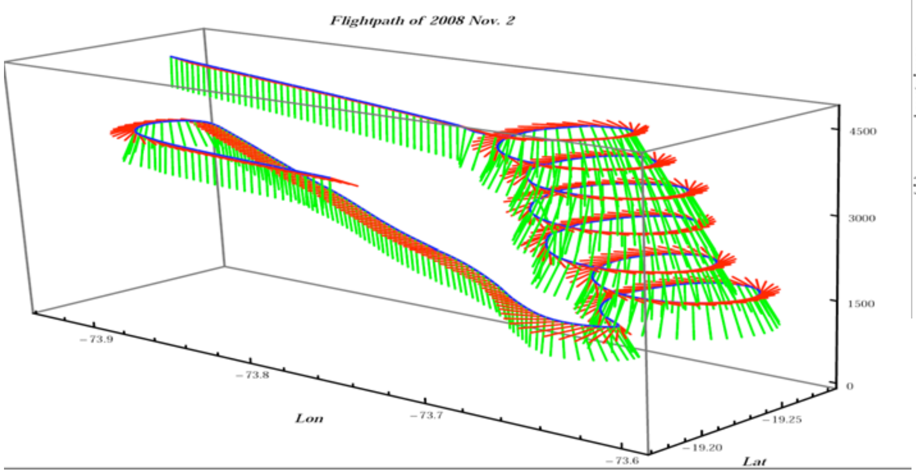
Fig. 1 The dependence of the degree of polarization of light reflected from water clouds on the incidence angle at $\lambda = 865$ nm, $\vartheta = 2^\circ$, $\varphi = 0^\circ$, $a_{ef} = 6$ μm, and $\tau = 5(1), 10(2), 30(3), 100(4)$.

Kokhanovsky 2000

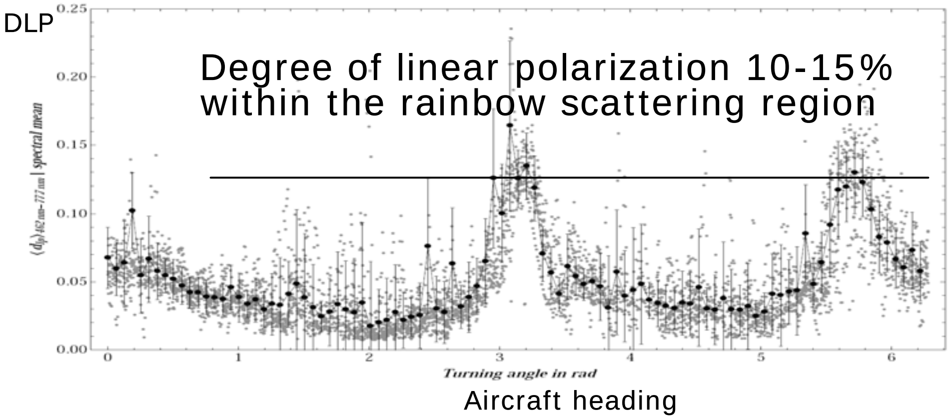
Institute for Space Sciences

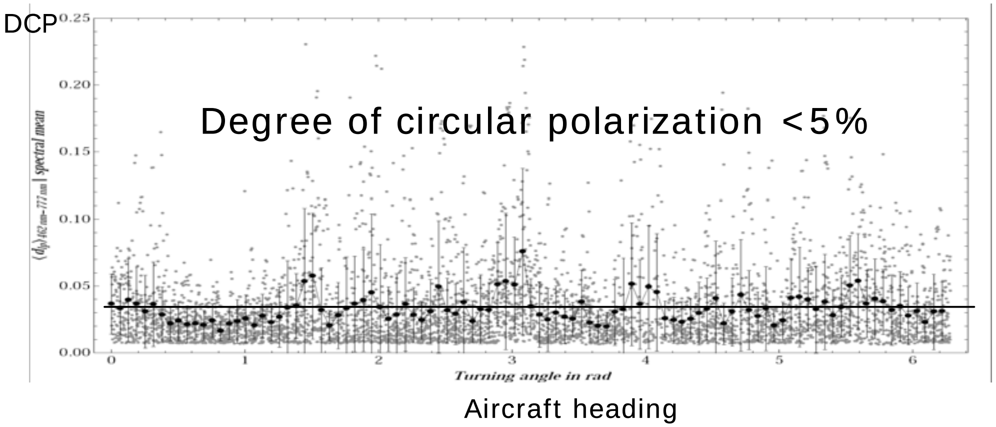
Nerc Dornier flight 2. Nov. 2008 during Vocals





AMSSP-EM measurements

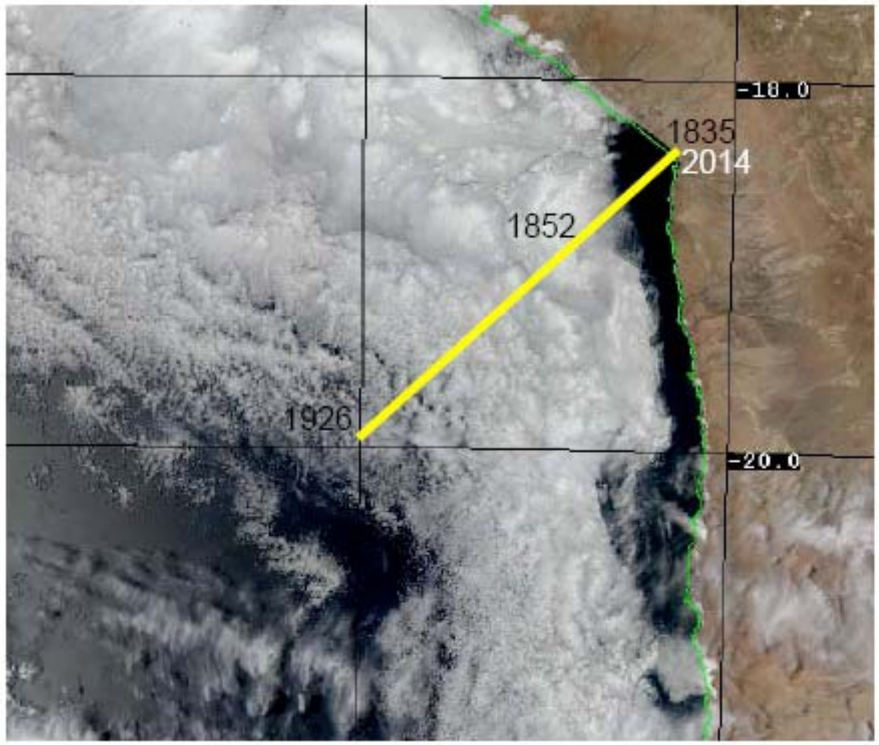




Eagle and Hawk hyperspectral imagers data status:

- Data available for 2 test flights: VA01 (26/10/08), VA02 (28/10/08) and 3 science flights: VA03 (30/10/08) VA09(06/11/08) and VA11(10/11/08)
- Data geo-referenced and geocorrected
- Four known Aqua/Terra (MODIS) overpasses during VOCALS-Dornier Flights, including 06/11/08

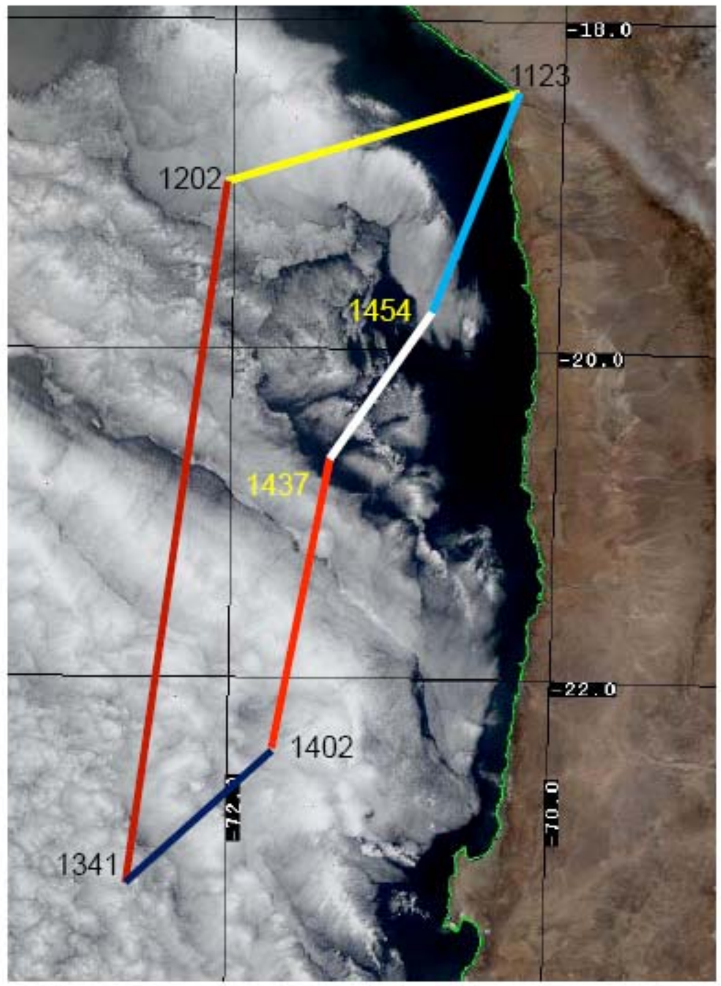
VOCALS Nov 6 2008 – VA09



Aqua MODIS overpass at
1835 UTC

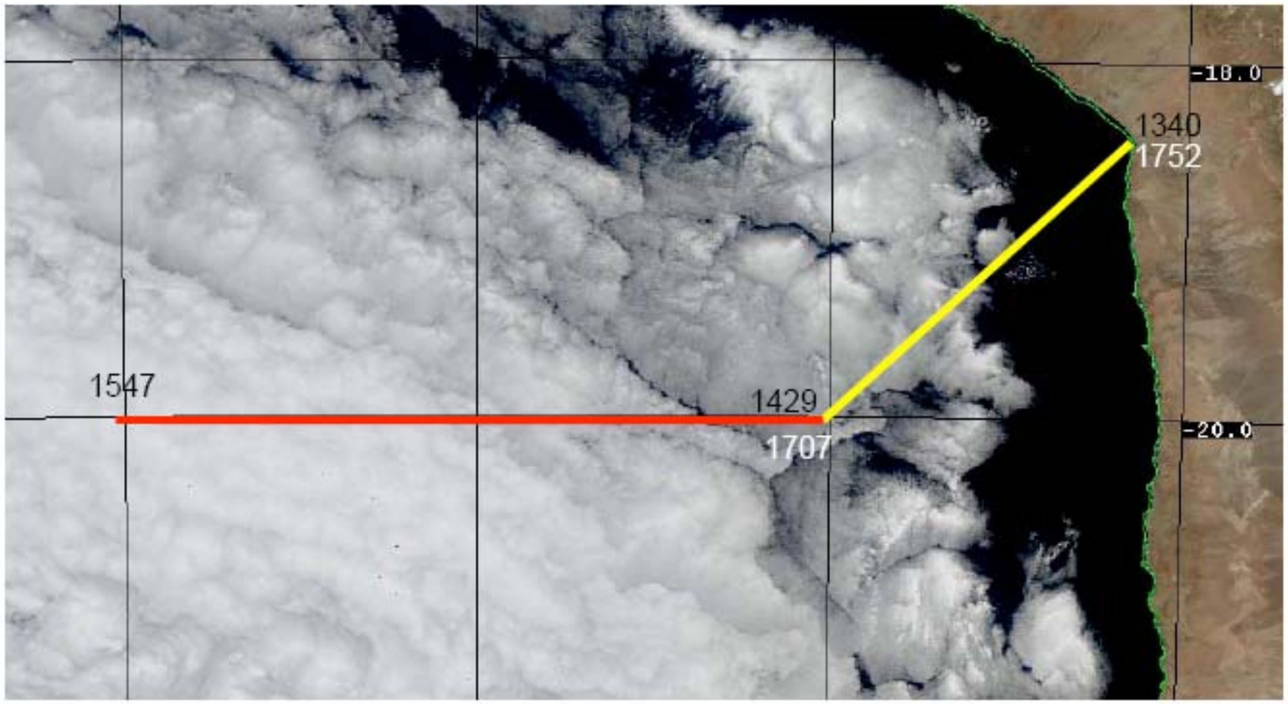
VOCALS Nov 10 2008 – VA11

Terra MODIS overpass at 1520 UTC



Two underflights by BAe146 – position not clear from report

VOCALS Nov 9 2008 – VA10



Terra MODIS overpass at 1440 UTC

Rendezvous with BAe146 west of 20S 72W during the outbound leg

WP4.2

Task WP 4.2 Determination of cloud properties from airborne radiation measurements.

- Retrieval of cloud effective radius and liquid water path from hyperspectral imager
- Validation by the in-situ measurements, from FAAM and C130 aircraft.
- High resolution mapping of the effective radius and liquid water content of polluted/unpolluted clouds
- Comparison made against satellite retrievals.
- In addition, the effects of aerosol overlying cloud will be investigated using lidar; this has been shown to exert significant biases in effective radius and cloud liquid water retrievals leading to an artifact known as the 'apparent indirect effect' (Haywood et al., 2004).

WP 4.1

Task WP 4.1 Assessment of the heteorogeneity of cloud properties on a wide range of spatial scales.

This task will use hyperspectral imager and lidar to provide cloud top height variability.

Spectral analysis techniques (Fourier and fractal analysis) will be used to determine the scale distribution of structures across the region.

This information will be used in two ways:

- to assess whether the scale distribution varies in a systematic way across the region, possibly correlated with the aerosol;
- to compare with simulations by the LES model and WRF.

Initial analysis of E+H - Lorenzo

- Learn to read the data!
- Calculate scale sizes of cloud features.
- Investigate regions of aerosol gradient (measured by FAAM/C130) for cloud brightness features
- Compare measured cloud reflectivity to satellites
- Pay particular attention to overpasses of FAAM/C130

Plan of attack

- Run data through MODIS algorithm and compare with MODIS retrievals – collaboration with Purdue Uni, NASA
- Use polarimeter data of Thomas Ruhtz – they will derive cloud properties also
- In the longer term, develop expertise in the group to do this ourselves