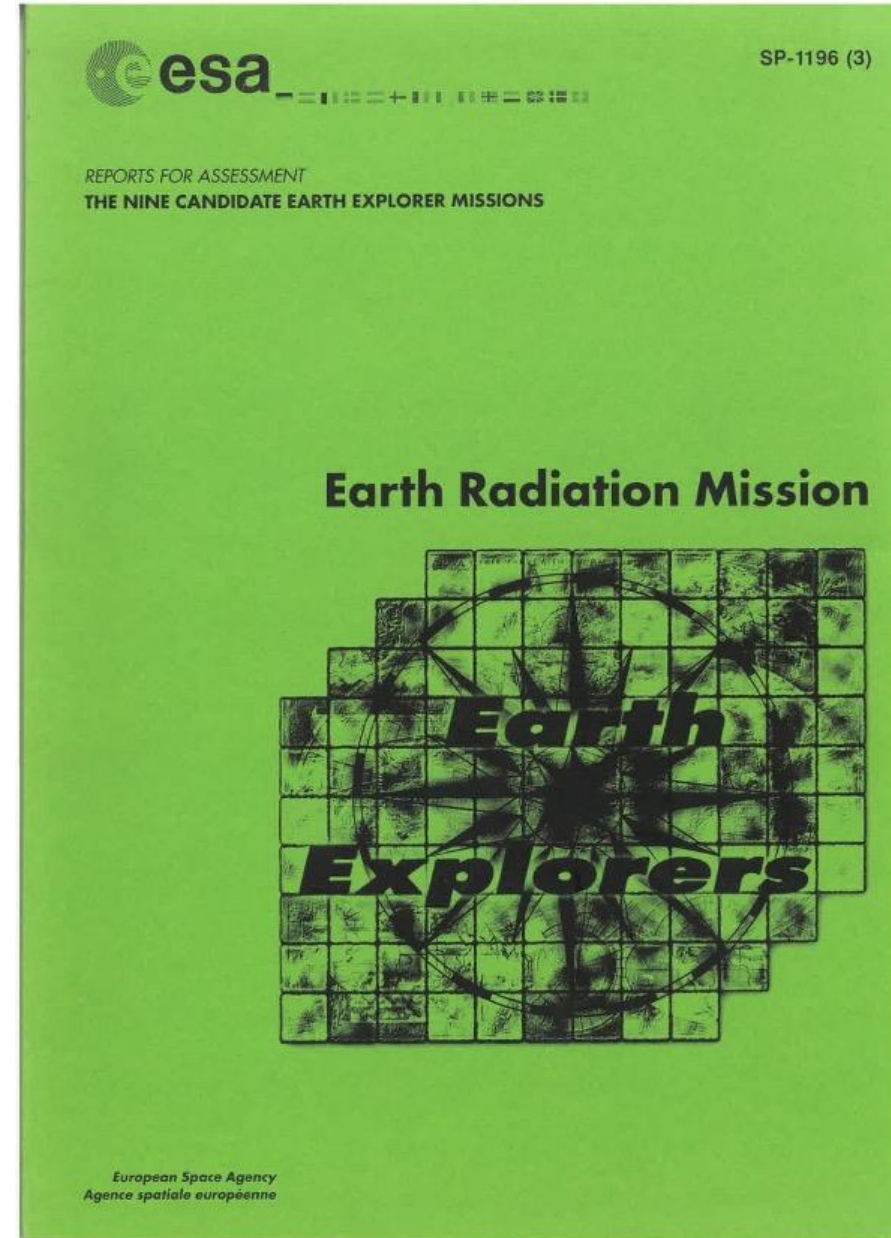


EarthCARE: The story so far – The First 30 years

Anthony Illingworth, Univ of Reading

First proposed July 1996
(black and white apart from the cover)

ESA-JAXA Pre-Launch EarthCARE Science and
Validation Workshop
ESA-ESRIN Frascati
13-17 November 2023



#1: MAY 1996 GRANADA; NINE CANDIDATES FOR PHASE A STUDIES

“EARTH RADIATION MISSION” “RADIATION”?

Equator crossing time 1400. Orbit 600km

Comprising two elements

i) A set of instruments to be deployed on a satellite

GRACE “Global Radiation Aerosol and Cloud explorer”

ii) A set of auxiliary measurements, utilizing observations made by satellites missions, from the ground and elsewhere.

GRACE four instruments:

Nadir pointing cloud radar at 78 or 94GHz

Backscatter lidar at 1064nm.

Cloud Imager 0.55, 0.66, 1.6, 3.7, 11, and 12 μm

Broad-band radiometer for SW and LW fluxes at TOA

(0.2 μm – 4 μm and 4 μm to 50 μm)

FINAL VERSION 2023

– SAME APART FROM EXTRA 2.2 μm CHANNEL

IN 1994 RECEIVED COPIES OF TWO LETTERS QUESTIONING THE WISDOM OF LAUNCHING A 94GHz RADAR AND RECOMMENDING THE PROJECT BE DISCONTINUED: ONE LETTER TO ESA AND ONE TO THE DIRECTOR GENERAL OF THE UK MET OFFICE

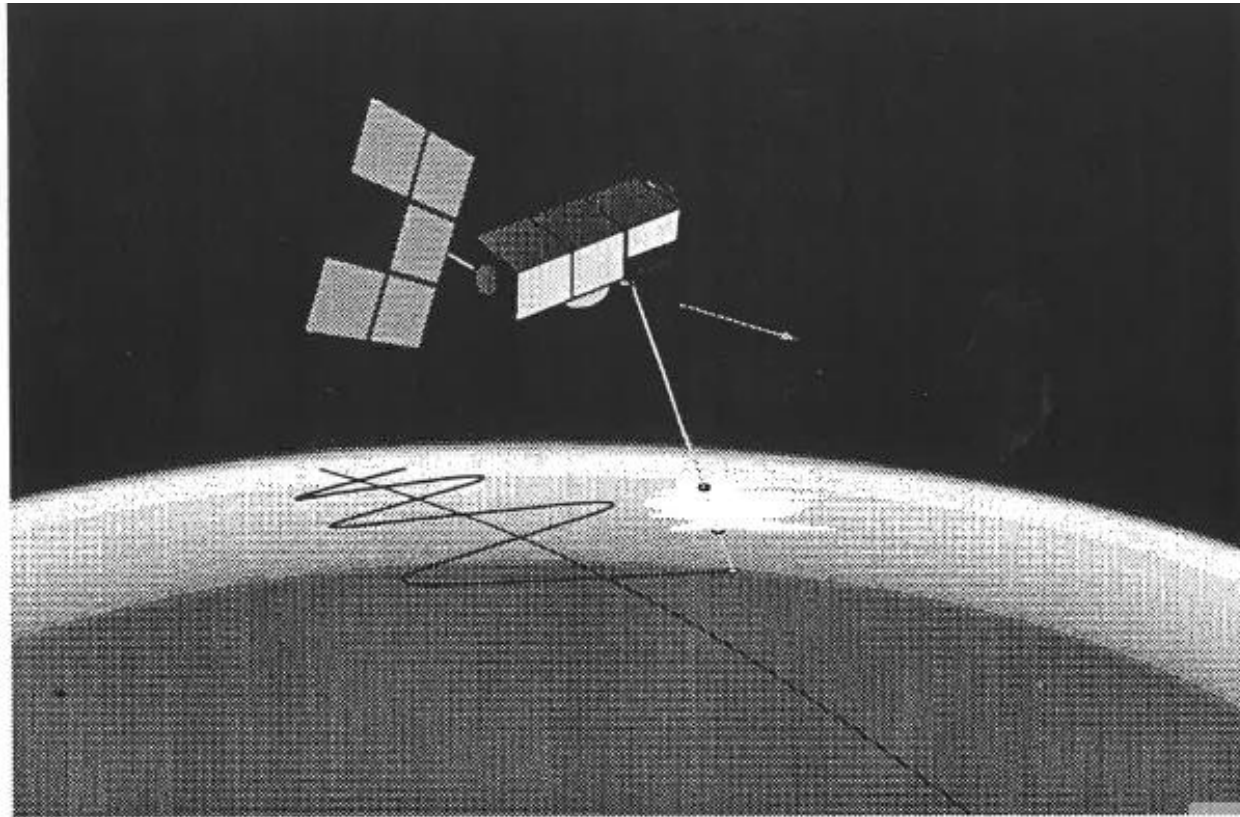
i) SENSITIVITY INSUFFICIENT TO DETECT FAIR WEATHER CUMULUS.

ii) IWC FROM Z IMPOSSIBLE – just need one large ice particle for enormous errors.

#1 MAY 1996

GRANADA: NINE CANDIDATES FOR PHASE A STUDIES

GRACE LIDAR 1064um Sinusoidal scan - amplitude 25km. RADAR NADIR POINTING



**EARTH RADIATION MISSION
NOT SELECTED**

Subsequent discussions:
Five radar beams
to sample same 25km swath?

Figure 6.2. ATLID Scan Pattern

#2 JULY 1999

GRANADA: FOUR CANDIDATES FOR PHASE A STUDIES

EARTH RADIATION MISSION

NOW A SINGLE SATELLITE
WITH **FOUR** INSTRUMENTS:

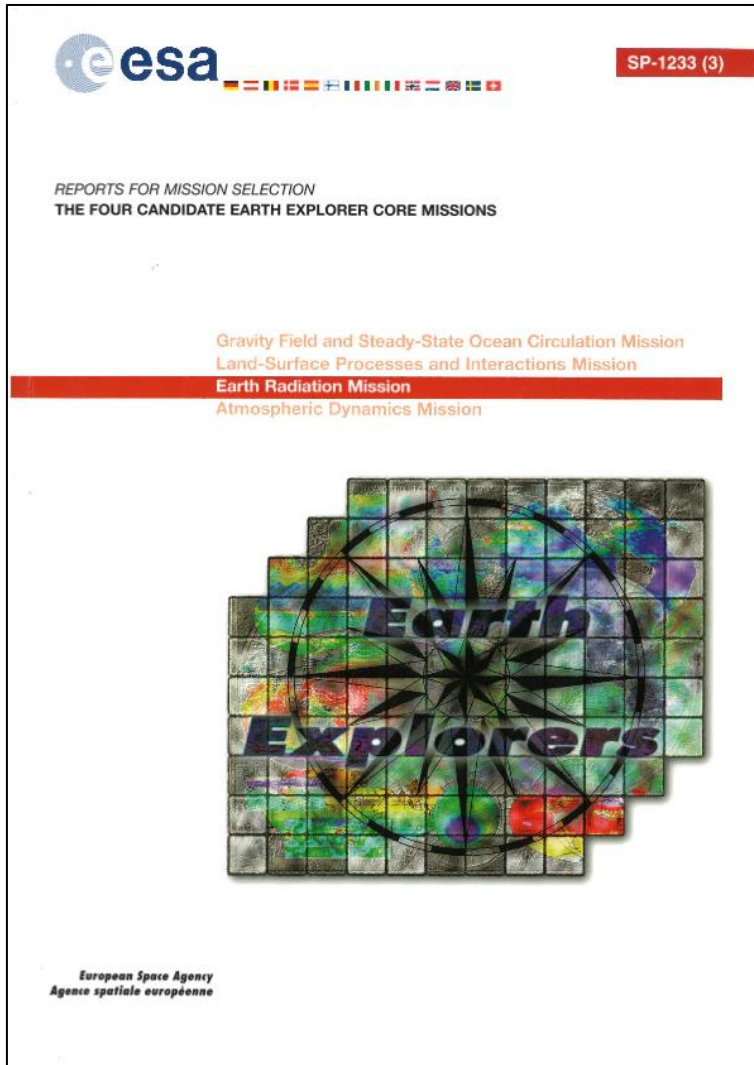
RADAR

LIDAR

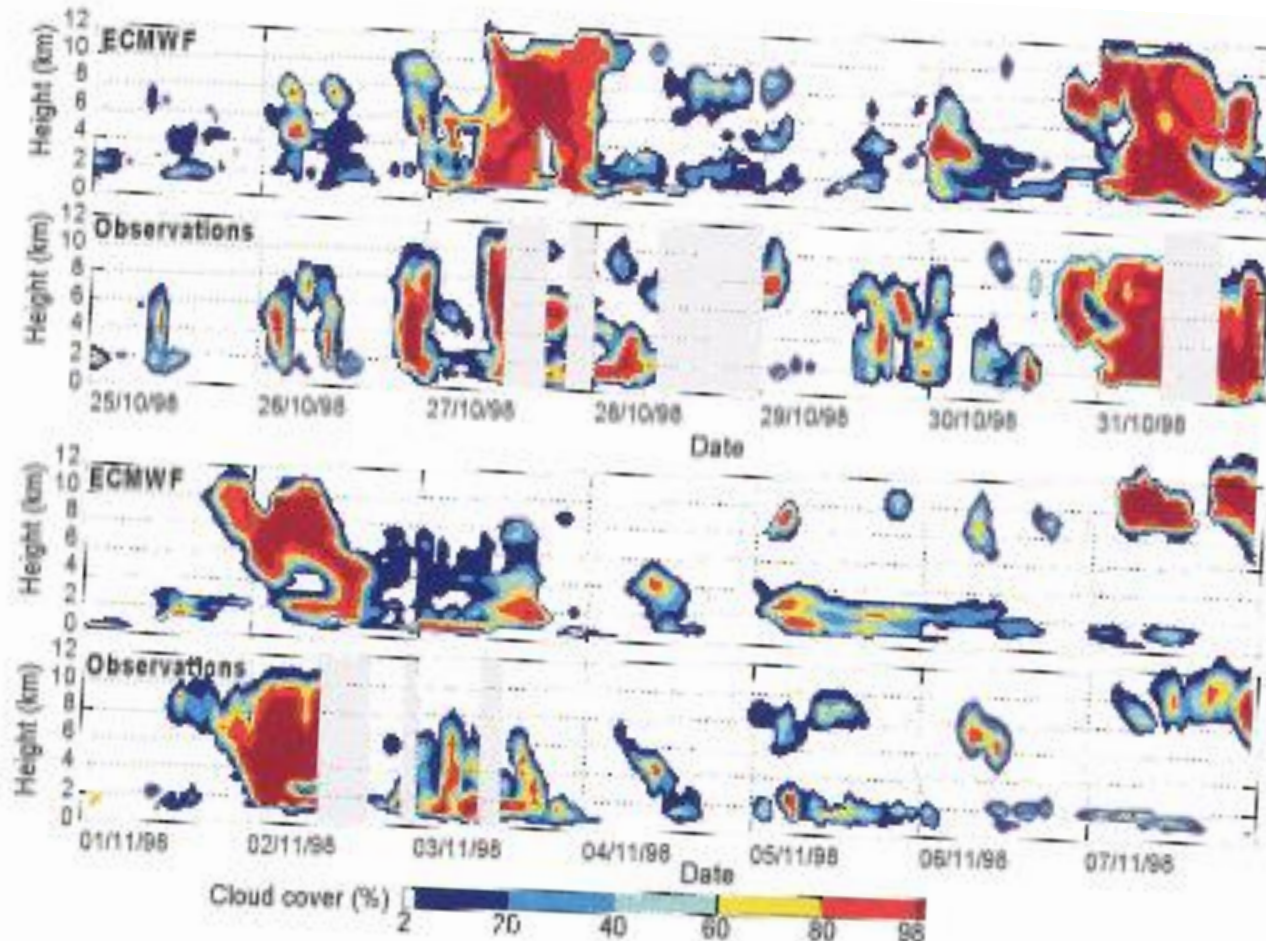
MSI - MULTI-SPECTRAL IMAGER

BBR - BROAD BAND RADIOMETER

~~ii) A set of auxiliary measurements,
utilizing observations made by
satellites missions,
from the ground and elsewhere.~~



NOW HAVE RADAR OBSERVATIONS OF CLOUD COVER FROM GROUND BASED RADAR
TO BE COMPARED WITH ECMWF CLOUD COVER (Robin Hogan)



25 OCT -31 OCT 1998

1 NOV - 7 NOV 1998

SURPRISE:
ECMWF MODEL DOES A GOOD JOB!
MOSTLY GETS CLOUDS IN THE RIGHT
PLACE AT THE RIGHT TIME

Figure 2.8. Observations of fractional cloud cover from ground-based radar at Chilbolton in the UK compared with predictions of fractional cloud cover (from ECMWF) over the same site.

#2 JULY 1999 GRANADA; FOUR CANDIDATES FOR PHASE A STUDIES

“EARTH RADIATION MISSION”

but the idea of two elements – SATELLITE called GRACE dropped

Lidar - 1064nm 70mJ - non scanning.

Better to have co-located lidar/radar profiles

“Very promising discussions with Japan – various meetings.

Similarities to Japanese ATMOS-B1 mission.

Possible scenario: NASDA (JAXA) contributes:

dual wavelength lidar, Fourier Transform Interferometer (FTIR) and a launcher.”

(too ambitious – not well defined?

ADM (Atmospheric Dynamics Mission)

“AEOLUS” selected...launched 2018.

#3 GRANADA SEPT 2001

FOUR CANDIDATES FOR PHASE A STUDIES

NEW NAME: “EarthCARE”

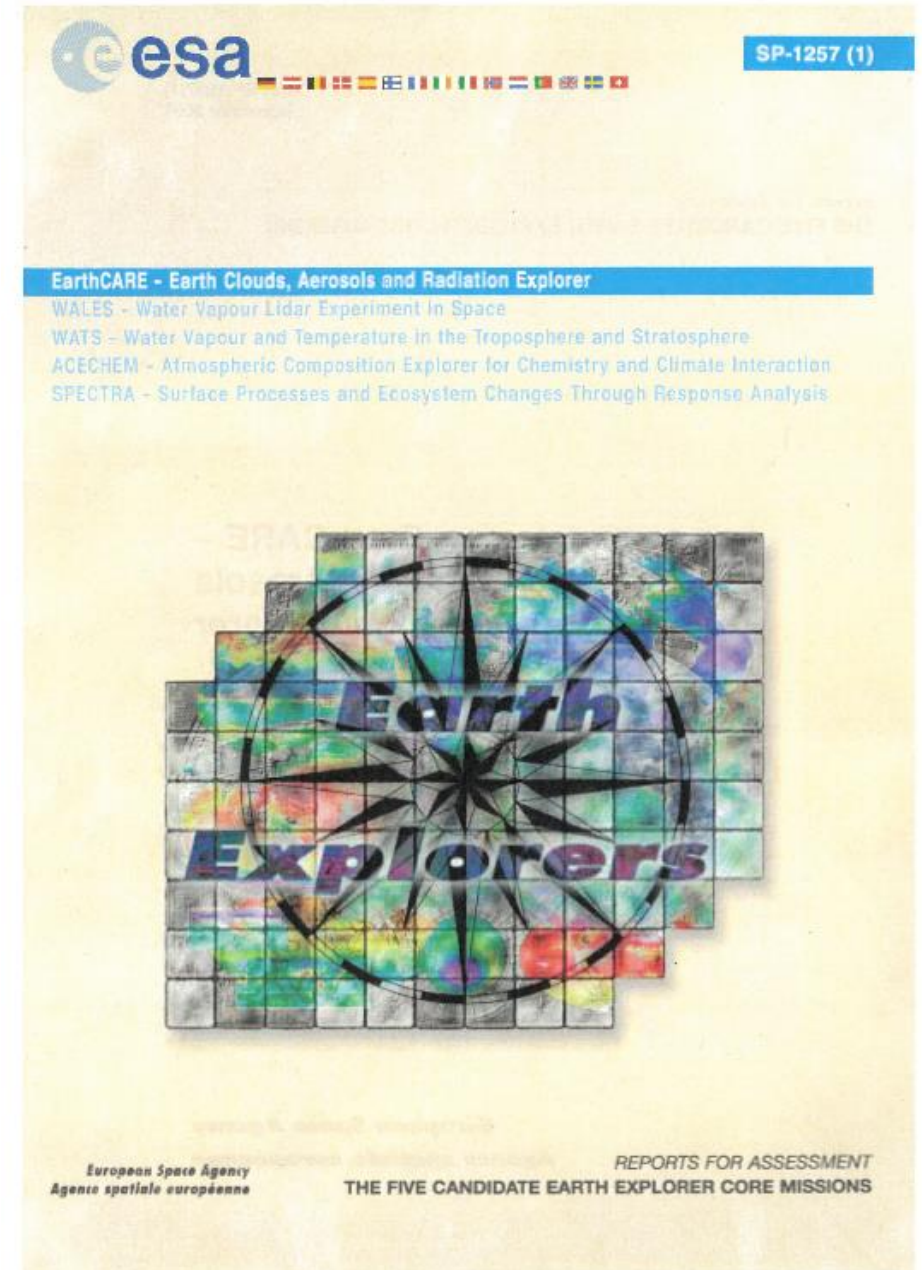
Earth Clouds, Aerosols and Radiation Explorer

Coined by Jacques Testud

Non-native English speakers like this.

Native speakers –

Initially sounds a bit pretentious.



#3 SEPT 2001 GRANADA;
FOUR CANDIDATES FOR PHASE A STUDIES
NEW NAME: "EARTHCARE"

RADAR - **Doppler** – particle terminal velocities/convection/identify drizzle.

LIDAR: **355nm high spectral resolution**

- Rayleigh(molecular) channel and Mie (clouds) channel with cross-polar.

MSI **extra channel**: 0.66 0.865 1.6, **2.2** 8.7, 10.8 and 11.8 mm

BBR Broad band radiometer

Add another instrument. Fourier Transform Interferometer (FTIR) - retrieve profiles of water vapour and temperature profiles above cloud (flown on ADEOS)

"EarthCARE will be realised through extensive cooperation between ESA, NASDA (now JAXA).....ESA is expected to contribute to the platform, ground segment and three instruments ATLID, BBR and MSI while NASDA/CRL (JAXA) contribute two instruments namely CPR and FTS and launch"

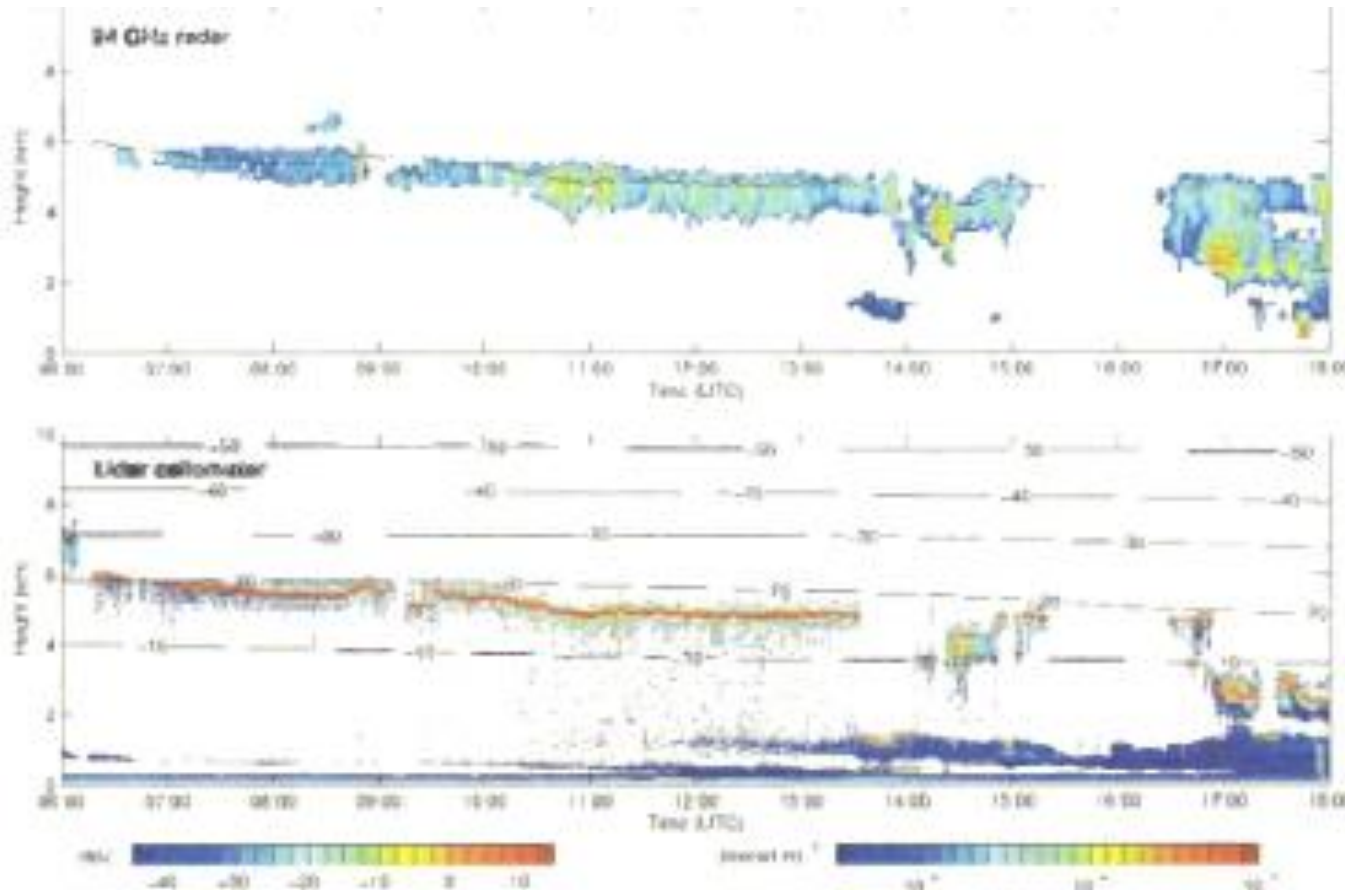


Figure 2.15: Synergy of ground-based radar and lidar reveals a layer of super-cooled droplets at a height of 5–6 km. The lidar return in the lower panel shows some aerosol in the lowest kilometre, and a highly reflecting and attenuating layer with $\beta > 5 \times 10^{-5} \text{ m}^{-1} \text{ sr}^{-1}$ from super-cooled liquid cloud droplets. The small super-cooled droplets give a negligible radar return, but the outline of the high b region embedded in the ice-cloud has been superposed in black on the radar picture.

SIMULTANEOUS LIDAR/RADAR
OBSERVATIONS FROM THE GROUND
IDENTIFY PERSISTENT THIN LAYERS OF
SUPERCOOLED DROPLETS WITH
ICE CRYSTALS FALLING OUT

PERSISTING FOR HOURS.....

THIN LAYERS OF SUPERCOOLED DROPLETS
HAVE A LARGE EFFECT ON THEIR
RADIATION

In the models, the clouds were glaciating
rapidly, but observations show they persisted..

This led to a COLD BIAS OVER NE EUROPE
In the winter time

#3 SEPT 2001 GRANADA;

EarthCARE not selected. No official feedback
Too complex – with five instruments???

#4 SEPT 2004 FRASCATI

EarthCARE Report for Assessment
Drop the FTIR

EARTHCARE SELECTED.

2010 BUDGET TOO HIGH!

EXPERT COMMITTEE SET UP TO EXAMINE DESCOPING OPTIONS.

“The overall objective of this assessment, to be conducted by independent experts, is to provide to PB-EO a report, summarizing the outcome of the assessment, documenting which viable options exist regarding the continuation of the EarthCARE satellite development.

In particular, the report shall address the current baseline together with viable de-scoping options as well as the run-down cost of a possible cancellation.”

7 Feb 2011 - Committee reports.

The Science Board reaffirms the high scientific value of the EarthCARE mission. There has been no change to the EarthCARE requirements since it was approved in 2004.