DERA

BNSC

ENVISAT EXPLOITATION PROGRAMME

Meeting Report

USING ENVISAT DATA FOR ATMOSPHERIC APPLICATIONS

Friday June 18, 1999, DERA, Farnborough

DERA

DERA is an Agency of the UK Ministry of Defence

DERA BNSC

ENVISAT EXPLOITATION PROGRAMME

CONTENTS

USING ENVISAT DATA FOR ATMOSPHERIC APPLICATIONS

The UK Envisat Exploitation Programme is a BNSC Programme managed by DERA to exploit the use of data that will be available from Envisat. It aims to encourage those in the EO community concerned with policy, research, applications development and operations to work together to stimulate the use of Earth observation data and the supply of information products to grow the market.

During 1998 the programme concentrated on the four instruments that measure reflectance and backscatter from the land and oceans. This year the Programme is being extended to the instruments that measure atmospheric variables.

The Workshop 'Using Envisat Data for Atmospheric Applications' is the first stage in this new phase of work. This will be followed by an analysis of the requirements for data and products. (A short questionnaire is enclosed in this report). Further information will be made available and the actions that arose from the meeting will be acted on as appropriate.

This report provides a summary of the issues raised at the Workshop, copies of the presentations and some background information on Envisat and the instruments that will provide data on the atmosphere.

Summary of discussions

Role of ESA

There will be a second Announcement of Opportunity for PIs in 2001.
There are links between the instrument team teams and users in that there are data users on the instrument teams.
ESA will make contact with the PIs to aid the use of the data
But ESA does not have plans for programmes to develop use beyond the PIs
ESA does not have many plans for a 'Help' facility. The British Atmospheric Data Centre Centre at RAL could provide some of this information. It could also *provide* the link between SuperJanet and the PAC.

Data Policy

ESA does not currently have a policy to make data freely available over the Web in a way similar to NASA.
There are currently no plans to use the high band width links of SuperJanet to transfer data. If the academic community want to take advantage of this, they would need to put a link into the UK PAC.
There will be a waive of costs for all PIs, for some National Programmes and for projects approved by the ESA PBEO.

Near Real Time Data

NRT data will be available within 3hours of its transmission to a ground station.
Collection of global coverage depends on the instrument but will usually take 3 days.
Off line data will be available in a minimum of 3 days.

Cal/Val

Neither NERC nor BNSC have any programmes or funding for Cal/Val. Cal/Val is usually part of the instrument programme and undertaken by the country building the instrument. The UK therefore will be funding cal/Val for AATSR.
There is a need though to validate the geophysical products. The atmospheric chemistry team is setting up a facility at NILU for validation of products. This should be extended/promoted in the UK.

Actions arising from meeting

- Meeting with industry users of products to discuss proposals for funding
- Discussion with NERC regarding an Envisat Thematic programme
- Liaison with other European countries
- Provide information on EO LINK
- Meeting of PIs
- Validation of products

Programme

Background to EnviSat Exploitation Programme	BNSC/DERA
The EnviSat Mission AATSR MERIS	C Reading, ESA-ESTEC
GOMOS	Dr H Roscoe, BAS
SCHIAMACHY	Dr B Kerridge, RAL
MIPAS	Dr A Dudhia, University of Oxford
EnviSat data policy Data availability and ordering Pricing policy	Dr W Cudlip, DERA
NERC policy	Dr S Wilson, NERC Lesley Grey, RAL
Applications	led by Prof. A O'Neil University of Reading
Atmospheric modelling using spaceborne data	Prof. A O'Neil
Global monitoring of stratospheric chemistry using spaceborne data	Dr M Chipperfield University of Cambridge
Operational products for NWP, nowcasting and climate modelling	Prof J-P Muller UCL
Discussion Requirements for data Review of objectives Current issues	

Attendees

Atmospheric Processes, DERA	David Lee
Atmospheric Research Airborne Support Facility, DERA	Andrew Kaye
BAS	Howard Roscoe
BNSC	Roger Robinson
Environment Agency	Jon Baker Paul Williams
ESA	Chris Readings
ITE	Steve Wilson
Met Office	DR Pick Jonathon Taylor
RAL BADC	Lesley Gray Anne de Rudder Sam Pepler
Space Department, DERA	Dawn Williamson Wyn Cudlip
Space Science Dept, RAL	John Ballard Brian Kerridge
UMIST	Alan Gadian
University College London	Jan-Peter Muller
University of Cambridge	Martyn Chipperfield Adrian Lee
University of Edinburgh	R Harwood
University of Leicester	Gary Corlett
University of Liverpool	Mark Cresswell
University of Oxford	A Dudhia
University of Reading	Alan O'Neil
University of Southampton	Reno Choi Andrew Ford Toby Wicks Valeria Salvatori Gary Llewellyn

Vu foil presentations

THE ENVISAT MISSION

C.J. Readings

Earth Sciences Division
Estec, Noordwijk, The Netherlands

ENVISAT - General Mission Characteristics

Broad mission objectives:

- **Continuity of ERS observations for monitoring coastal zones, open oceans, ice and land surface**
- **Enhanced oceanic, atmospheric and land suface missions**

General mission characteristics:

- **ENVISAT will be launched in 2000 in a polar orbit; nominal altitude 800 kms**
- **Nominal five year lifetime; equator crossing time 10:00 hrs (local)**

See "Envisat Mission: Opportunities for Science and Applications", ESA SP-1218 and <http://envisat.estec.esa.nl>

ENVISAT - The Atmospheric Mission

Includes three atmospheric chemistry instruments:

- **GOMOS - Global Ozone Monitoring by Occultation of Stars**
- **MIPAS - Michelson Interferometer for Passive Atmospheric Sounding**
- **SCIAMACHY - SCanning Imaging Absorption spectrometer for AtMospheric ChartographY**

plus two other instruments also designed to be used to observe the atmosphere:

- **AATSR - Advanced Along Track Scanning Radiometer**
- **MERIS - MEdium Resolution Imaging Spectrometer**

However, others also can be used to observe atmospheric features i.e. ASAR and RA-2

GOMOS - General Characteristics

- Prime target is the monitoring of trends in stratospheric ozone and the study of the chemistry and dynamics of the stratosphere;

- Exploits stellar occultation to achieve high accuray concentration profiles with good geographic coverage;

- In addition to O_3 will measure NO_2 and NO_3 plus aerosols, PSCs, water vapour and temperature;

- Covers UV/VIS (250 to 675 nm; 1.2 nm resolution), IR (756 to 773 nm at 0.2 nm resolution and 926 to 952 nm at 0.2 nm resolution)

- Measures temperature scintillations using two broad band photometers (650 to700 nm and 470 to 520 nm)

- Mass of 163 kg; power consumption 146 watts

MIPAS - General Characteristics

- Chemistry of the stratospheric chemistry, the polar winter and the upper atmosphere upper troposphere;

- Diurnal changes, atmospheric dynamics and non-LTE (local thermal equilibrium) processes; stratospheric/tropospheric exchange;

- High resolution limb viewing Fourier transform interferometer operating up to mid-infrared (4μm to 15μm; < 0.035 $cm^{-1)}$;

- Very flexible viewing geometry

- Mass of 320 kg; power consumption 195 W

SCIAMACHY - General Characacteristics

- Limb/nadir viewing spectrometer operating in the ultraviolet, visible and near infrared regions of the spectrum;

- Global observation of various trace gases in the troposphere and the stratosphere; concentration profiles as well as column amounts

- In the troposphere - biomass burning, industrial pollution, arctic haze, forest fires, dust storms etc. In the stratosphere - ozone chemistry and volcanic events;

- Very flexible viewing geometry; nadir and limb viewing; Sun and Moon tracking; 198 kg mass; 122 watts power consumption;

- Combines wide spectral coverage (0.24μ tp 2.4 μm) with high spectral resolution (basically 0.24 μm to 0.55 μm)

Data - General Points

- Generally data stored on tape recorders and then relayed to ground;
- High resolution MERIS data transmitted directly to ground:
- "Near real time" products not always as good as "off-line" products;
- Official Products listed in *Envisat Mission: Product Summary Overview*, ESA SP-1221

Data Policy

- **ESA has an unique data policy covering its two major Earth Observation Programmes i.e. ERS and ENVISAT**

- **Open and non-discriminatory policy for data distribution**

- **Aim is to maximise the beneficial use of the data and stimulate balanced development of science, public utility and commercial appications**

- **Conditions for distribution depends on use of data**

- **Two categories of user recognised:**

  Category I - research and application development
  Category II use - all other uses including operational and commercial use

- **For Category I use ESA sets price and is responsible for distribution of data**

MERIS - General Characteristics:

Primary mission goals:

- Biooptical oceanography: Assessment of ocean surface optical properties and water constituents, leading to phytoplankton biomass and productivity estimates via measurements of various pigment concentrations.

Secondary mission goals:

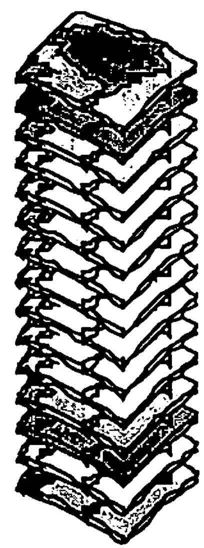
- Atmospheric monitoring: Investigations of cloud and aerosol parameters namely cloud top height, water vapour column content, aerosol load.
- Land surface processes: Global scale monitoring of vegetation, assessment of distribution, and condition.

The MERIS bands:

No.	Band centre (nm)	Band width(nm)	Potential Application
1	412.5	10	Yellow substance and turbidity
2	442.5	10	Chlorophyll absorption (maximum)
3	490	10	Chlorophyll and other pigment concentrations
4	510	10	Suspended sediment, red tides
5	560	10	Chlorophyll baseline (absorption minimum)
6	620	10	Suspended sediments, scattering
7	665	10	Chlorophyll absorption (maximum)
8	681.25	7.5	Chlorophyll fluorescence, red edge
9	705	10	Aerosol type, (Red/NIR boundary), atmos corr.
10	753.75	7.5	Oxygen absorption reference band, Vegetation
11	760	2.5	Oxygen absorption R-branch
12	775	15	Aerosols over ocean (thickn./type), Vegetation
13	865	20	Aerosols opt. thickn. -type, Vegetation
14	890	10	Water Vapour over land
15	900	10	Water Vapour, Vegetation

The MERIS Observation Principle

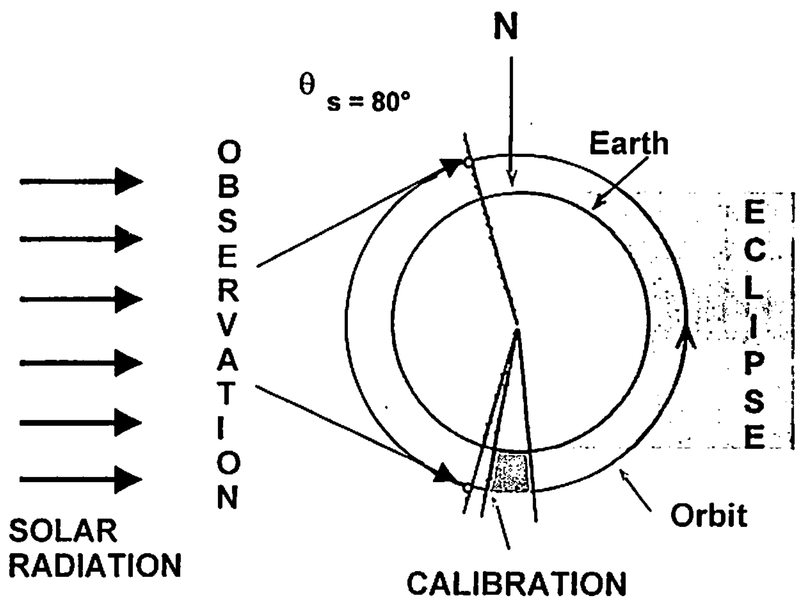
MERIS measures the radiance backscattered by the Earth in the Visible - Near-Infrared part of the spectrum



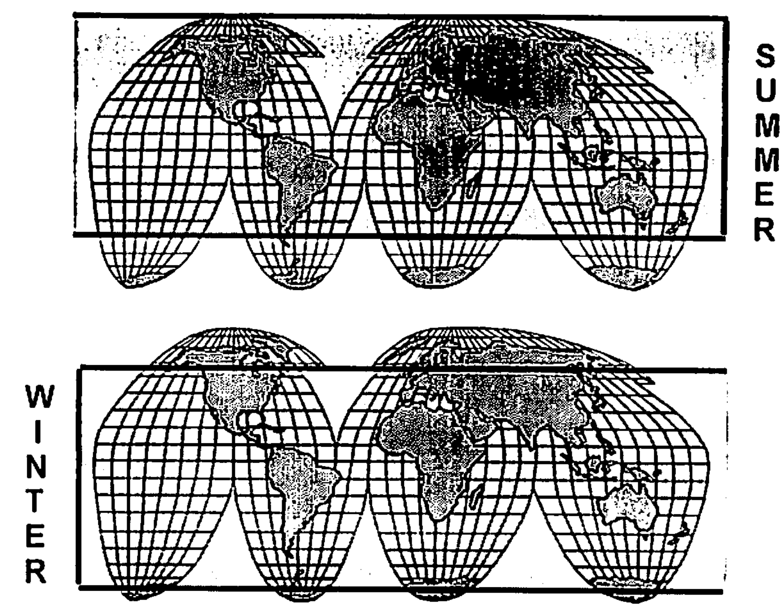
- PUSHBROOM IMAGER,
- SWATH WIDTH: 1150 km,
- FULL RESOLUTION: 300m
- REDUCED RESOLUTION: 1200m

- VIS-NIR SPECTROMETER
- BANDS: 15, PROGRAMMABLE IN WIDTH AND POSITION

Mission Operation



• OBSERVATION WITH A SOLAR ELEVATION ANGLE > 10°



• FULL COVERAGE OF OBSERVATION AREA WITHIN 3 DAYS

MERIS Data products (1)

In both spatial resolution modes from MERIS alone:

- Rayleigh radiance components.
- Aerosol (maritime and land types) radiance components.
- Surface leaving radiance components.

Using external data sources:

- Ocean primary production
- Phytoplankton, suspended sediments, yellow substance
- Cloud height/distribution and statistics
- Vegetation indices, state and condition
- Land Primary production

MERIS Data products (2)

Level 2 products:

Cloud processing:

- cloud top pressure determination,
- cloud type determination
- optical thickness determination
- albedo determination
- surface anisotropic reflectance determination

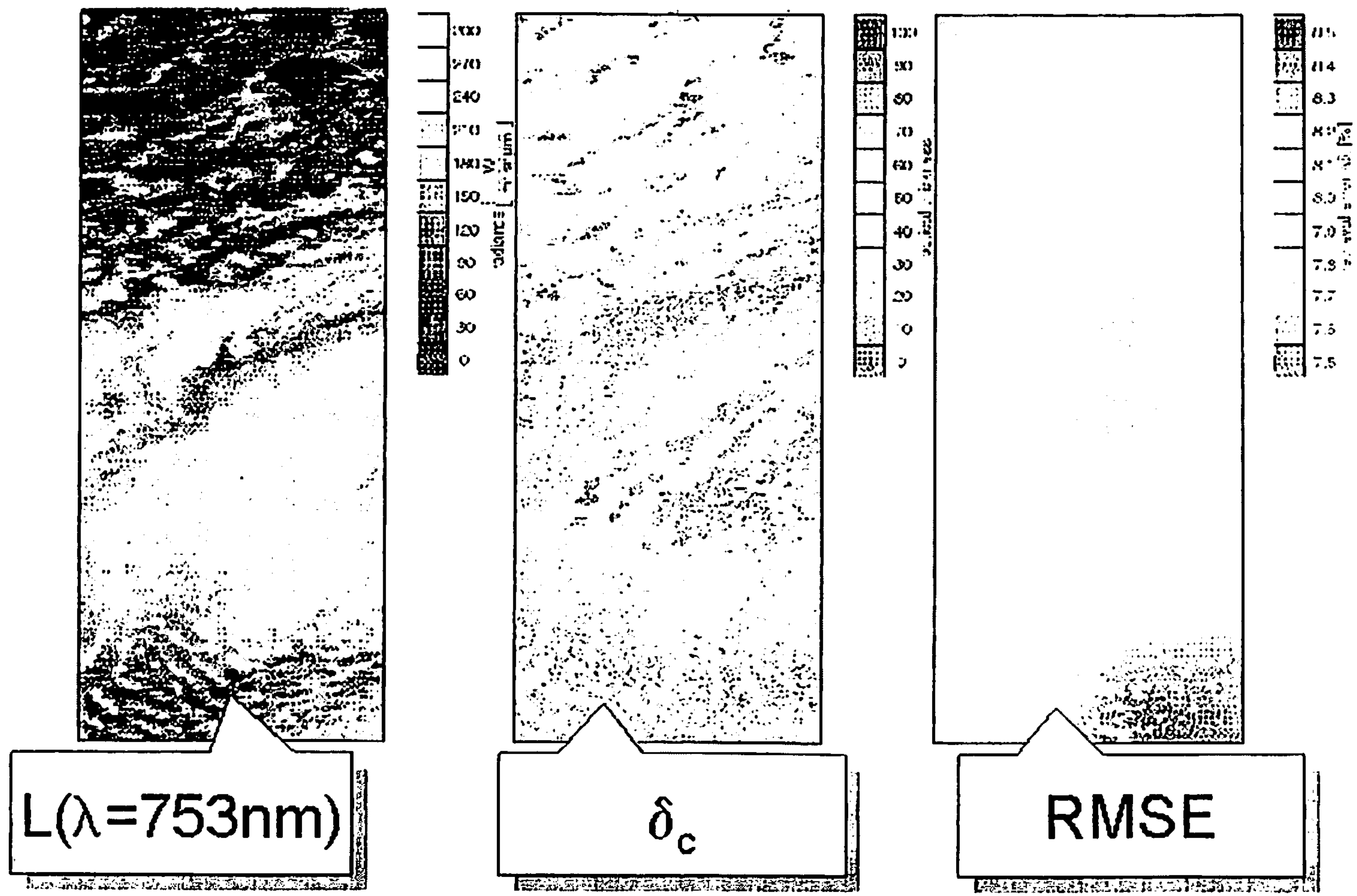
Water Vapour processing:

- total column content determination including:
  altitude correction over land,aerosol correction over ocean

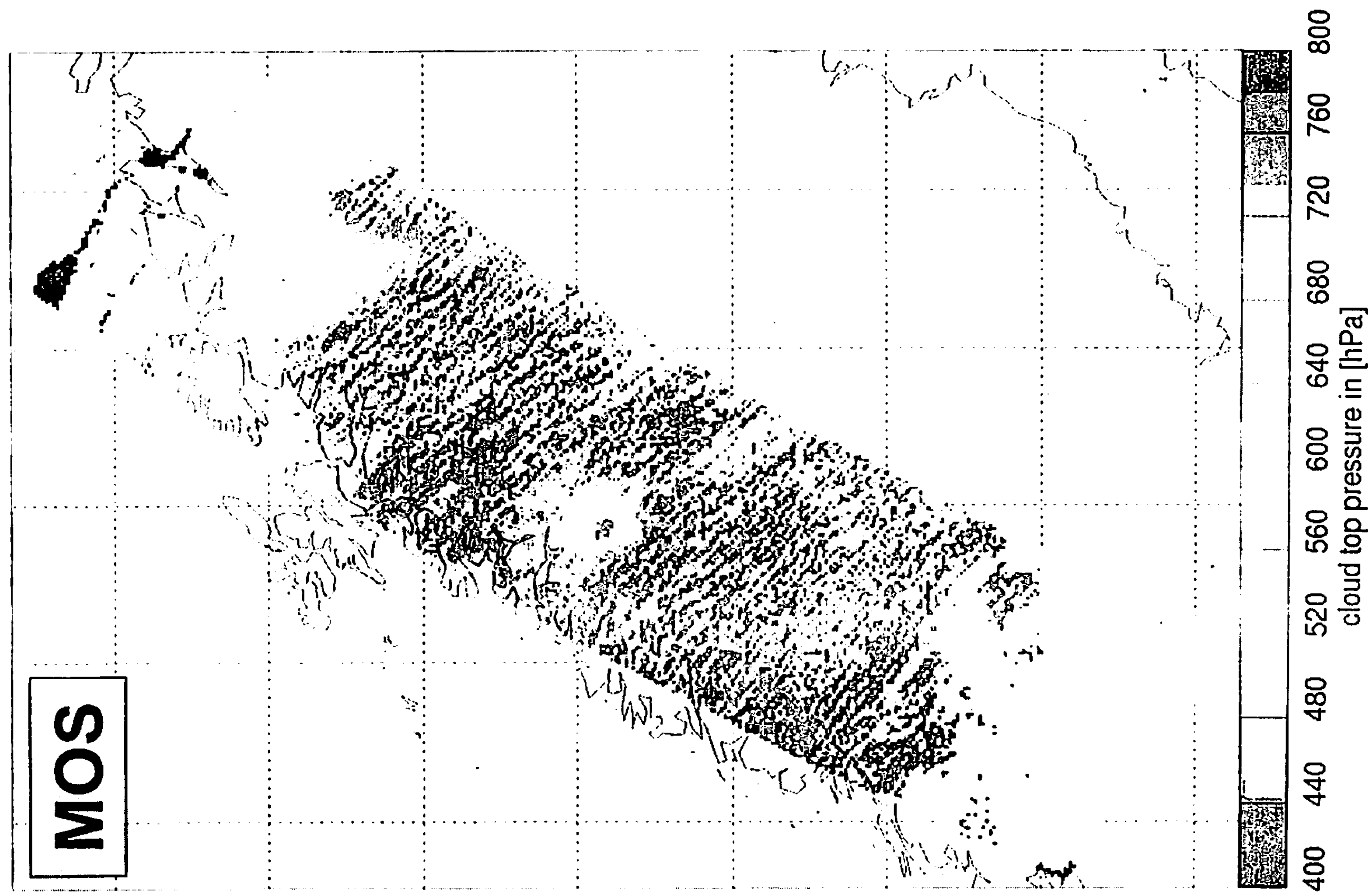
Land processing:

- land surface lambertian reflectance determination
- top of the atmosphere vegetation index determination
- atmospherically corrected vegetation index determination

MERIS: cloud parameters: application to MOS



MERIS Atmospheric Parameters



AATSR - General Characteristics:

Mission objectives: global sea surface temperature, cloud parameters and experimental vegetation products

Heritage: ATSR-1 on ERS-1, ATSR-2 on ERS-2

Instrument: AATSR on Envisat: dual view imaging radiometer (nadir and 55 deg. forward of nadir)

Spectral bands: 0.55 μm, 0.67 μm, 0.87 μm, 1.6μm, 3.7 μm, 10.7 μm, 12 μm

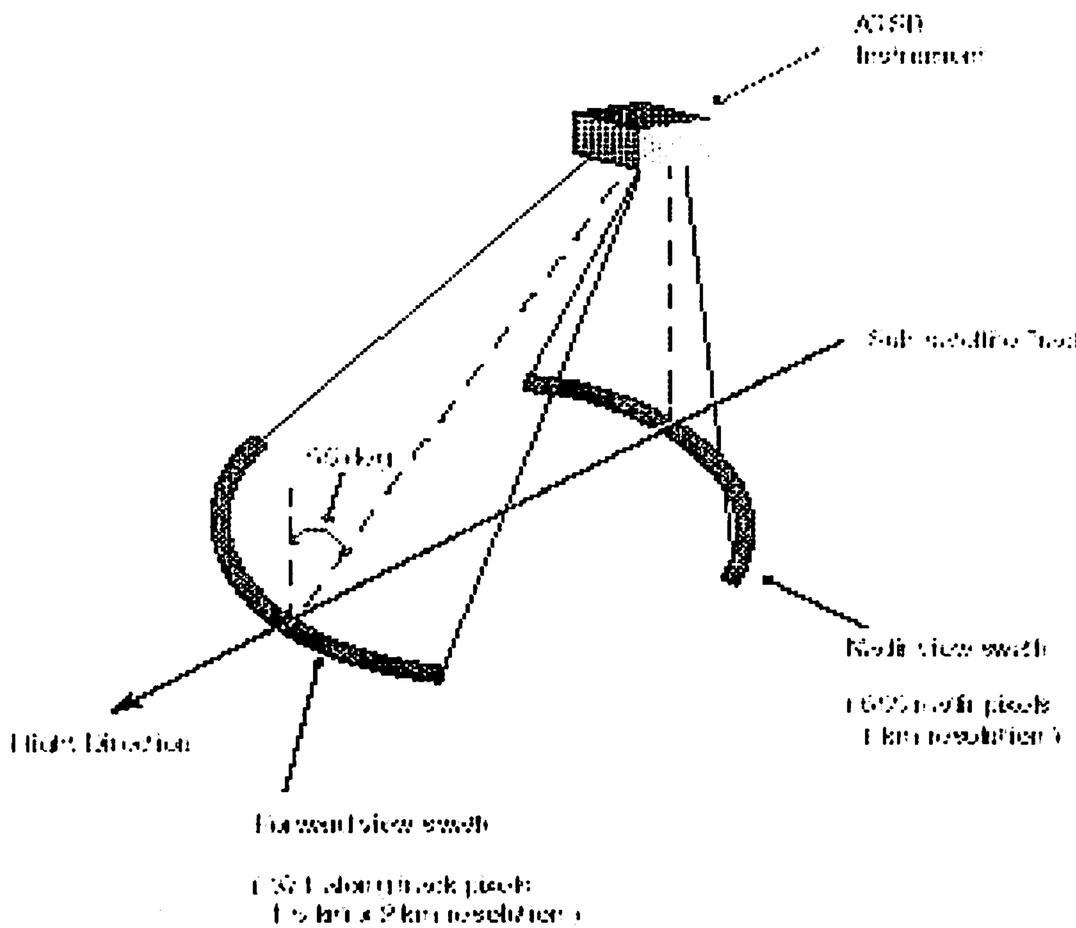
Geometry: 1 km spatial resolution over 500 km swath width

Variables: SST with an absolute accuracy of 0.5 K

Land surface temperature and experimental land products such as vegetation quantity and state

Cloud parameters such as cloud temperature, -height and -cover

ATSR Viewing Geometry

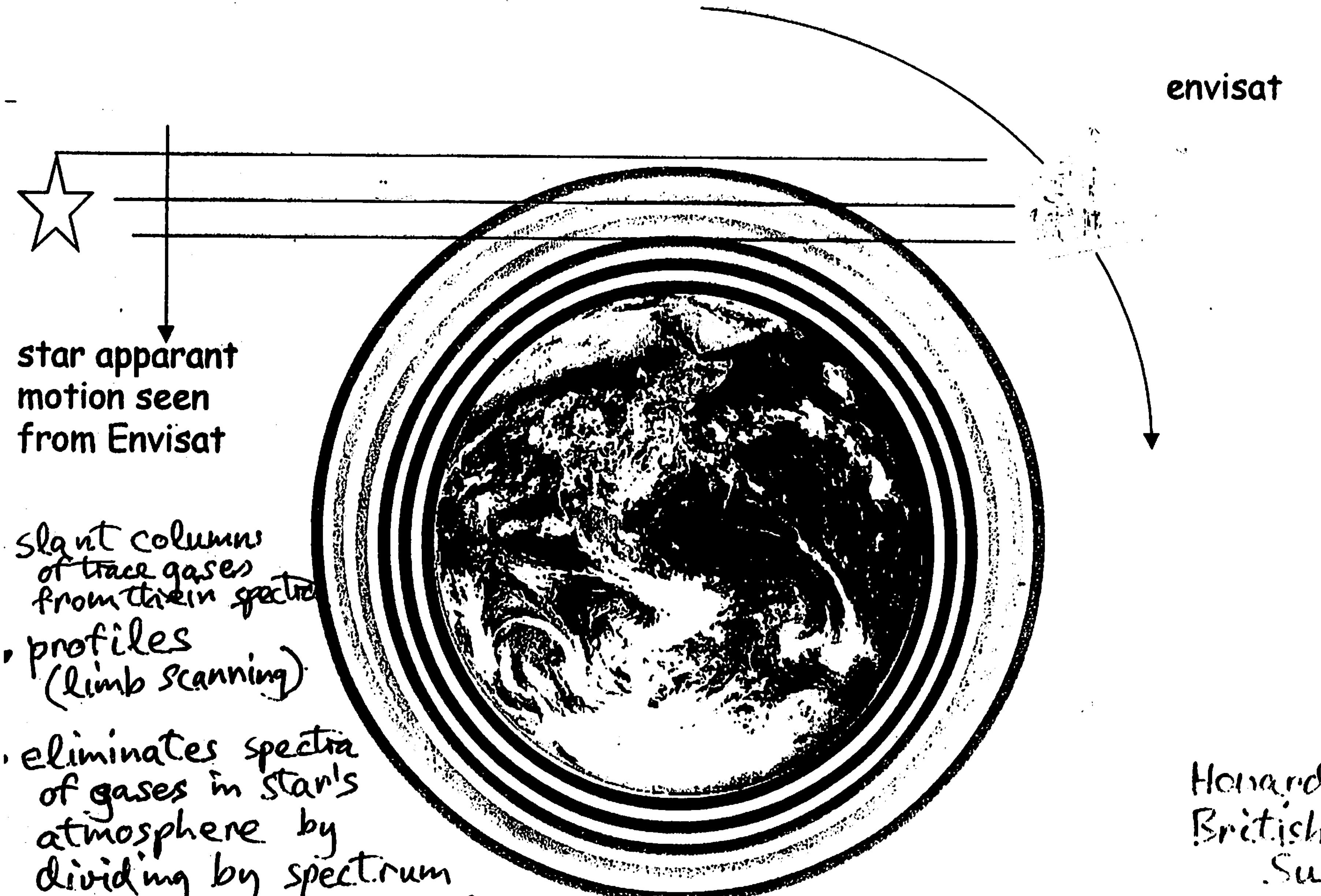


Active convection centres are indicated by the arrows. The tops of the clouds in these regions are flat; caused by the tropopause temperature inversion which stops the convective rising. Nevertheless, structure can be seen in the cloud tops showing the convective activity is strong. The rising air in these areas is forced to exit the column and does so laterally, forming an anvil.

GOMOS

Dr H Roscoe, BAS

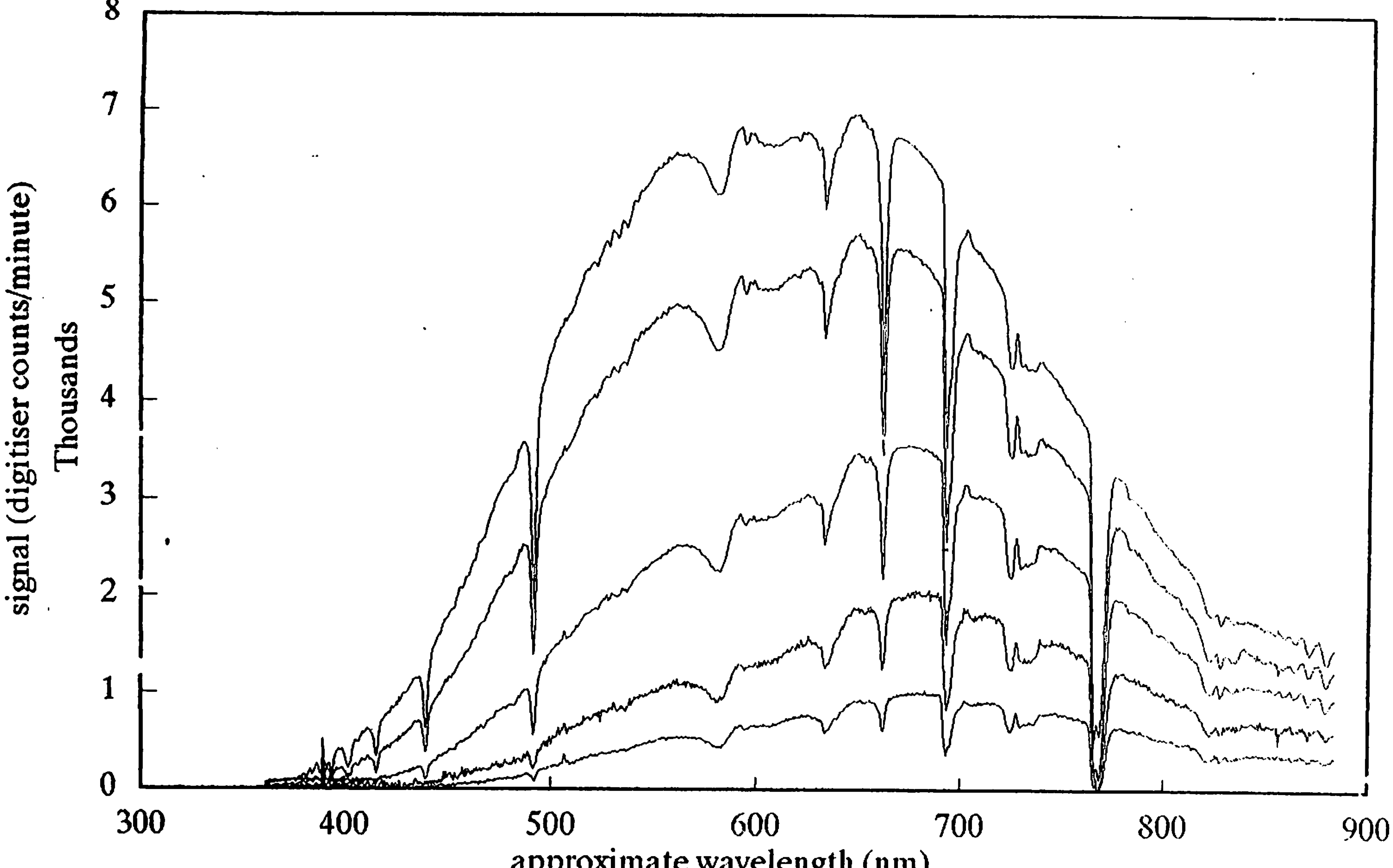
GOMOS: Global Ozone Monitoring by Occultation of Stars



- slant columns of trace gases from their spectra
- profiles (limb scanning)
- eliminates spectra of gases in star's atmosphere by dividing by spectrum above Earth's atmosphere

Howard R...
British Antarctic Survey
Member, G... Sci. Advisory Group

Day 214 (2 August 1995). These are 5 of 13 spectra measured that night



Elevation angles are from 2.4 degrees (lowest trace) to 11 degrees.
Integration time of each spectrum is 20 minutes, 1 digitiser count is 22 electrons

• position of star known very accurately
– tgt height known very accurately (unlike solar ... occultation)
– except refraction & scintillation

Geographical coverage: Simulations have shown that the occultation of 25 to 45 stars can be observed in one single orbit, distributed over all latitudes. It can be noted that when a star is occulted at one orbit, it will also be occulted at the following almost at the same latitude (figure 5). The star is fixed in an inertial system, the orbital plane has moved only by a small fraction of a degree (≅1/15°) and the Earth has rotated by 25 degrees. Therefore, the succession of points of occultation of the same star are aligned along a constant latitude circle, regularly spaced in longitude. In addition, because of the number of orbits per day (14 and 11/35), nearly the same longitude sampling apply three days later, and sampling of day 2 and day 3 are interlaced with the ones of day 1. Since the correlation time of ozone is more than 3 days (Frederik, 1984), it will be of great interest to regroup 3 days of orbit for a more complete global coverage.

• lots of occultations of stars each orbit.
– continuous global coverage (unlike solar occ.)

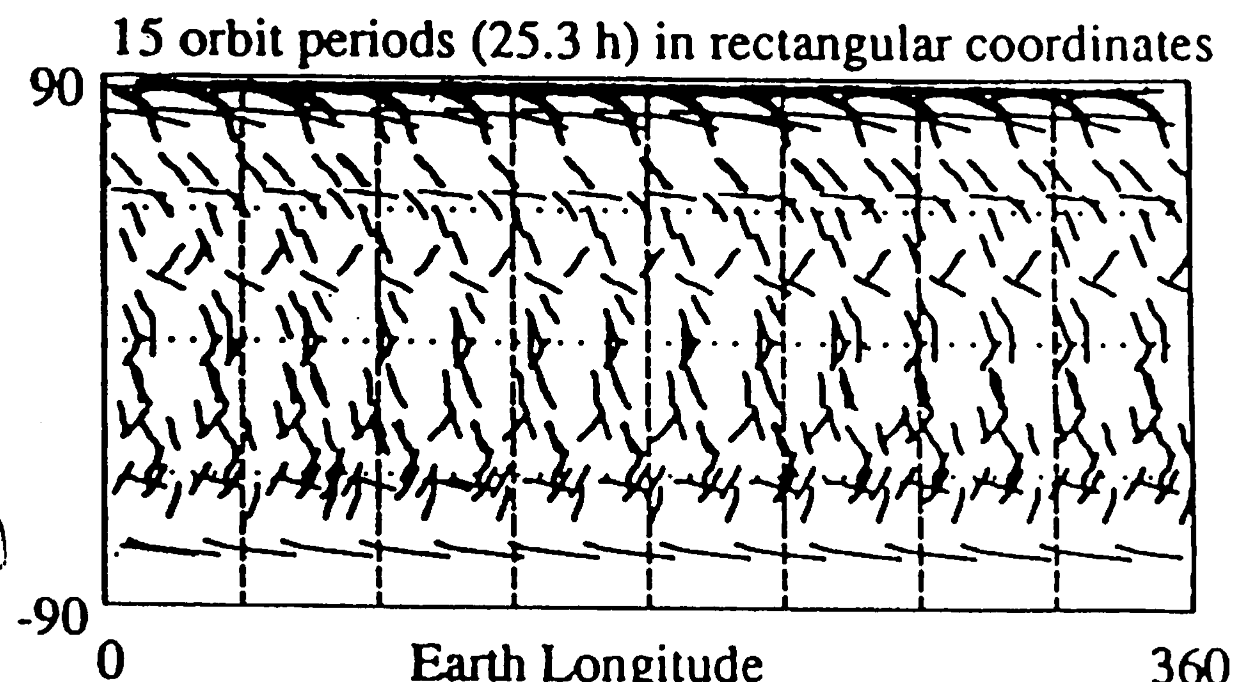
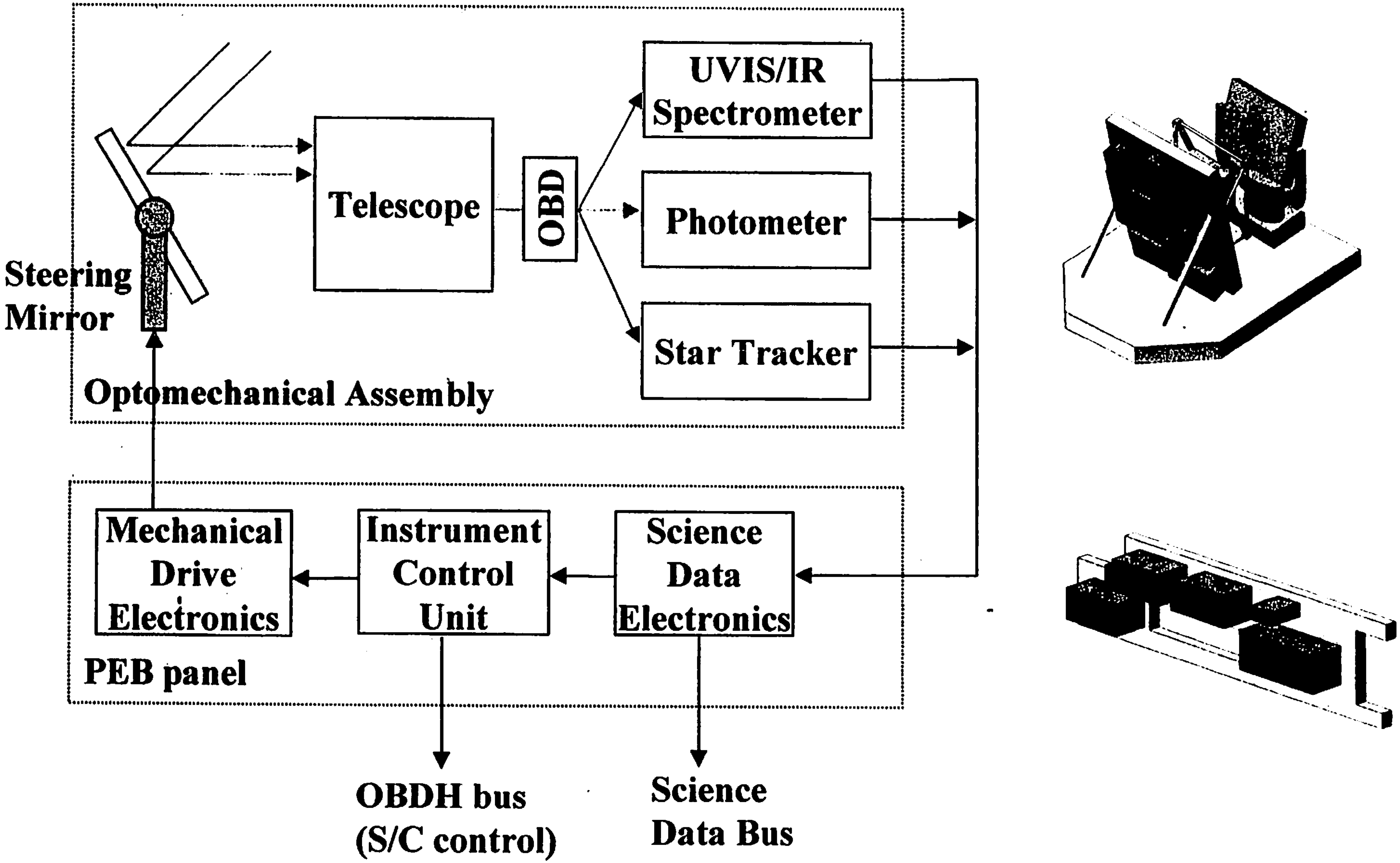
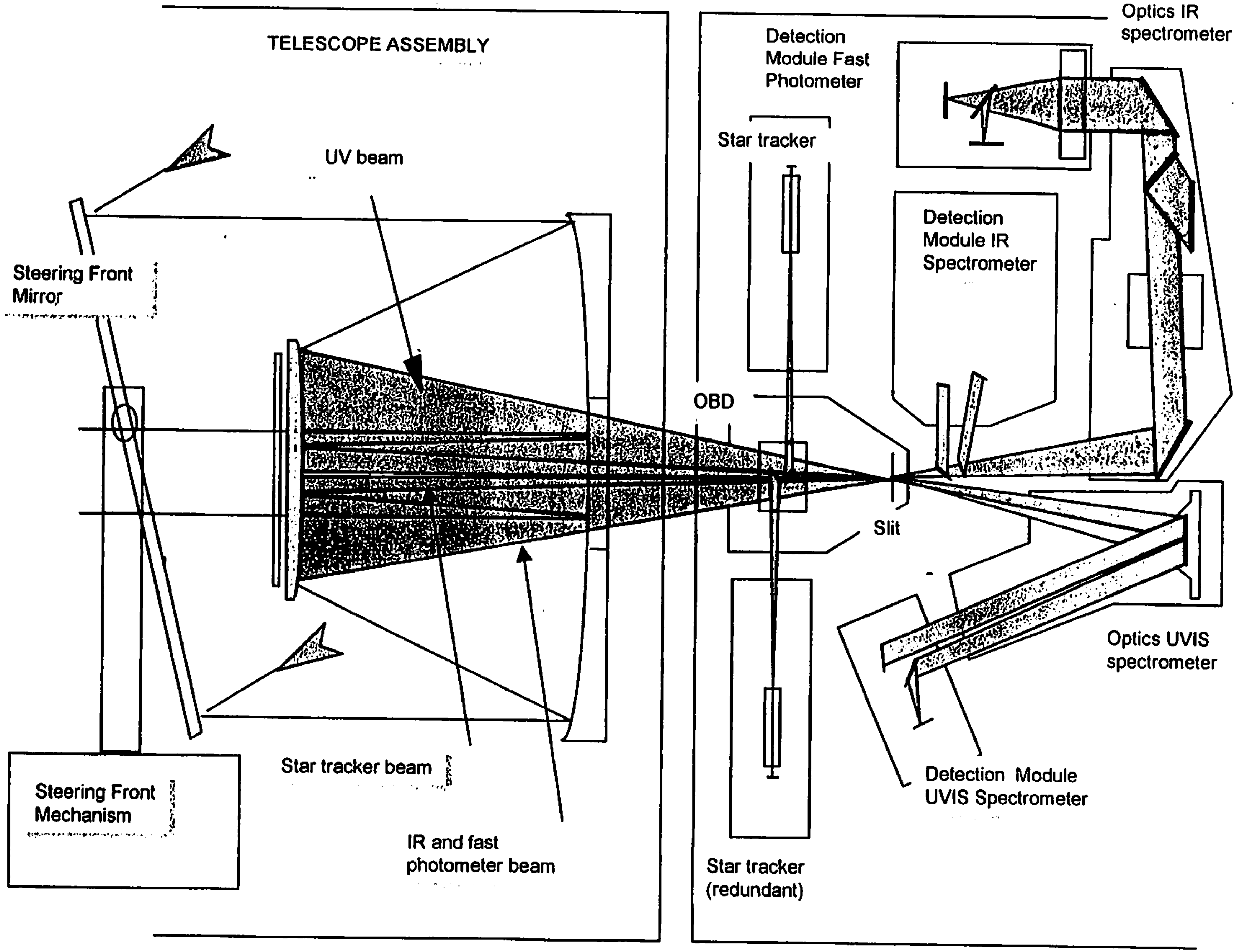


Figure 5. Global coverage obtained with GOMOS in 25. 3 hours (15 orbits)(after Korpela, 1991)

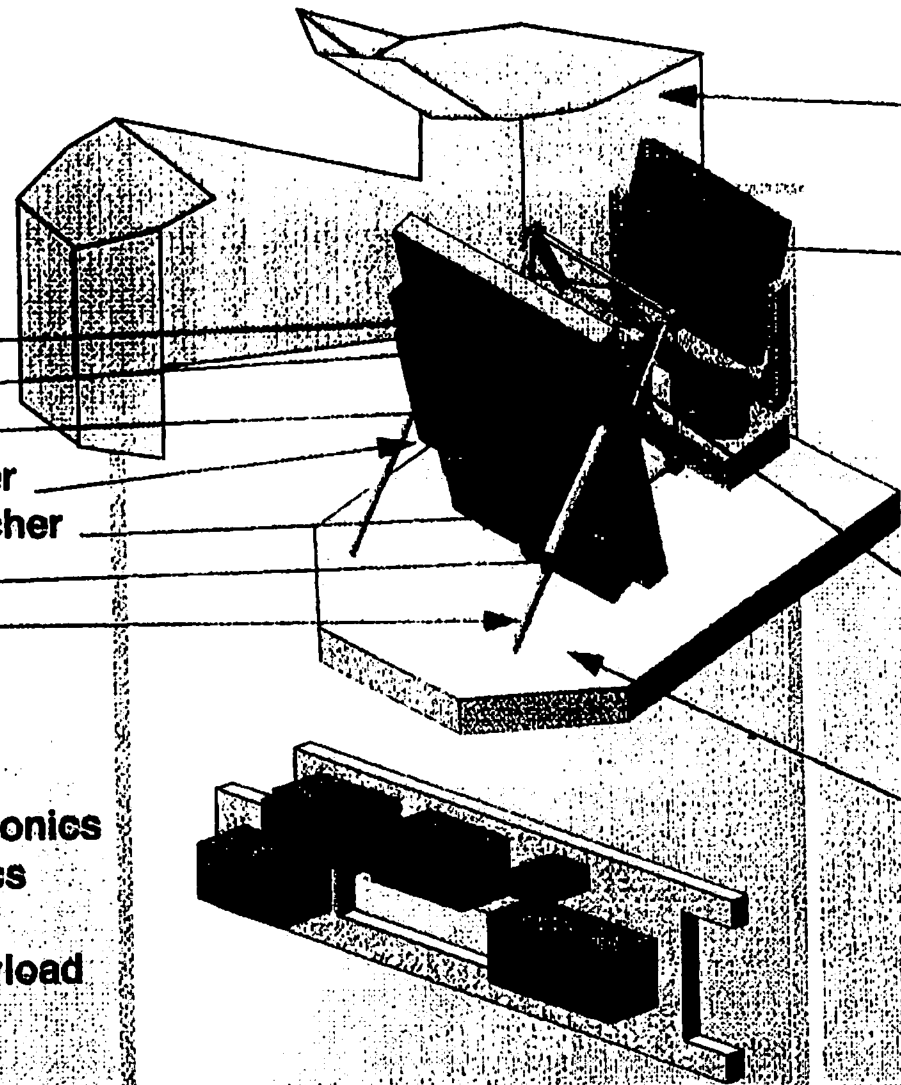
Ozone accuracy retrieval and trend capability:
The brightest stars are giving the best ozone retrievals. Also the color of the star is important, hot stars being favored for the UV and ozone at high altitudes, while cool stars are preferred for H_2O at 936 nm. Along a typical orbit, the number of stars that can be occulted with their brightness and corresponding ozone local density retrieval accuracy δ[O3] are listed below:

	star magnitude	δ[O3]
1 Sirius	mv = -1.44	<1%
3 stars	mv <0	<1%
3 stars	0 < mv<1	1-3%
7 stars	1<mv<2	3-10%
12 stars	2<mv<3	10-30%


UVIS/IR Spectrometer
Telescope
OBD
Photometer
Steering Mirror
Star Tracker
Optomechanical Assembly
Mechanical Drive Electronics
Instrument Control Unit
Science Data Electronics
PEB panel
OBDH bus (S/C control)
Science Data Bus

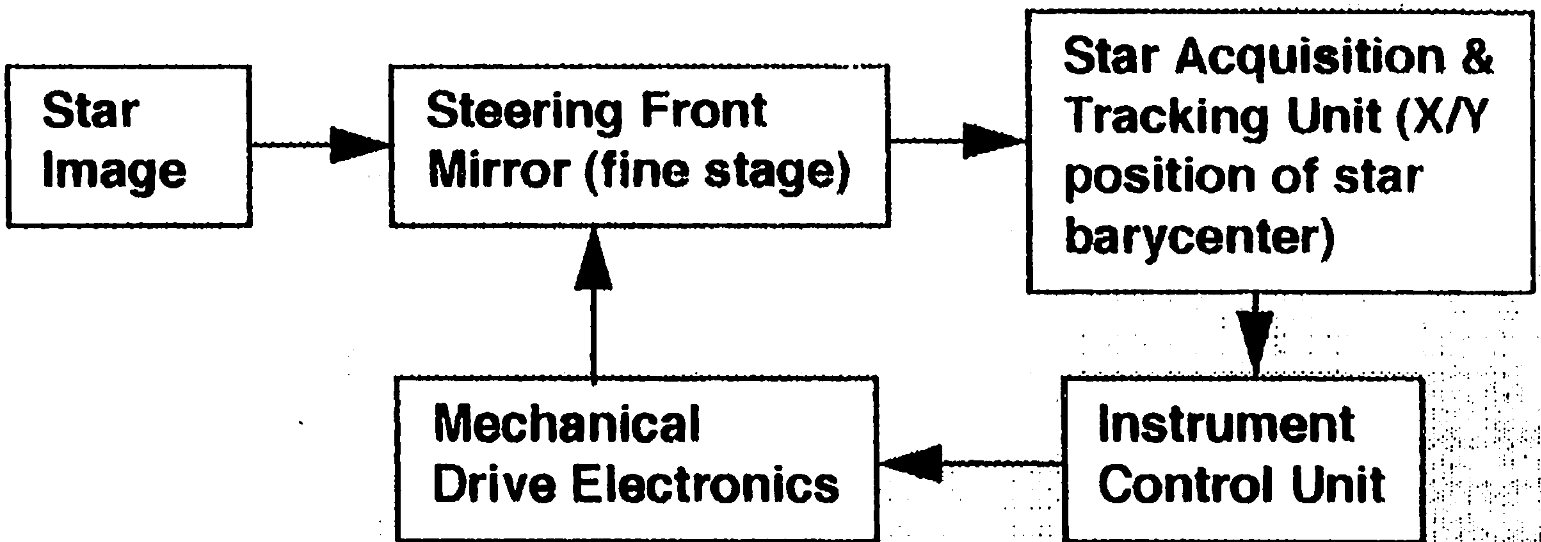

TELESCOPE ASSEMBLY
UV beam
Steering Front Mirror
Star tracker beam
Steering Front Mechanism
IR and fast photometer beam
Detection Module Fast Photometer
Star tracker
OBD
Slit
Star tracker (redundant)
Optics IR spectrometer
Detection Module IR Spectrometer
Optics UVIS spectrometer
Detection Module UVIS Spectrometer

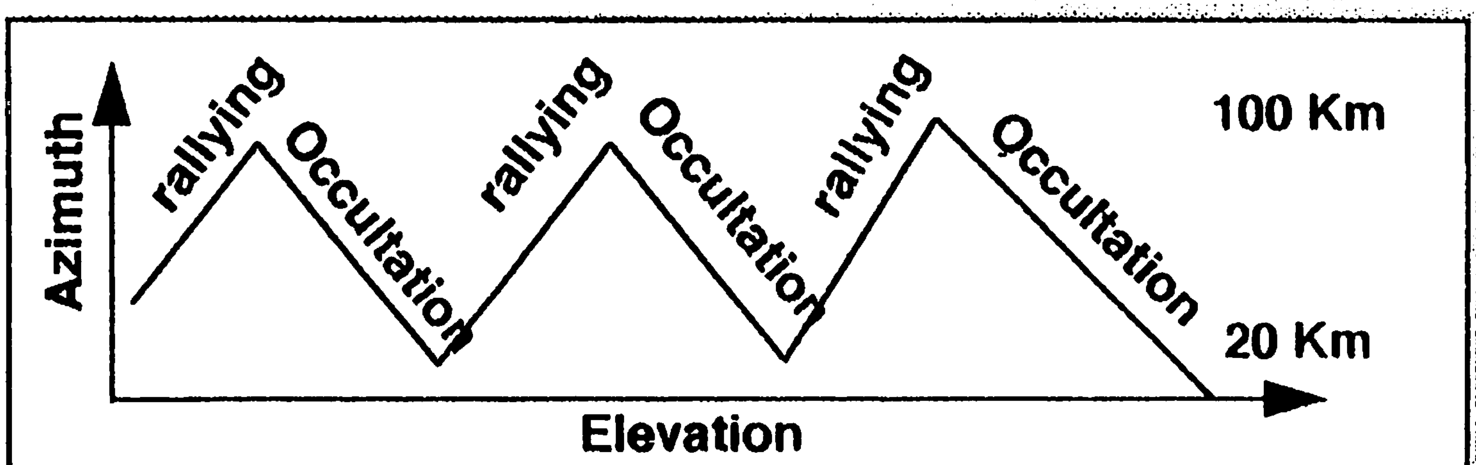
Instrument Layout



For more information, please contact : A. Popescu (apopescu@estec.esa.nl) or T. Paulsen (tpaulsen@estec.esa.nl) at ESA/ESTEC

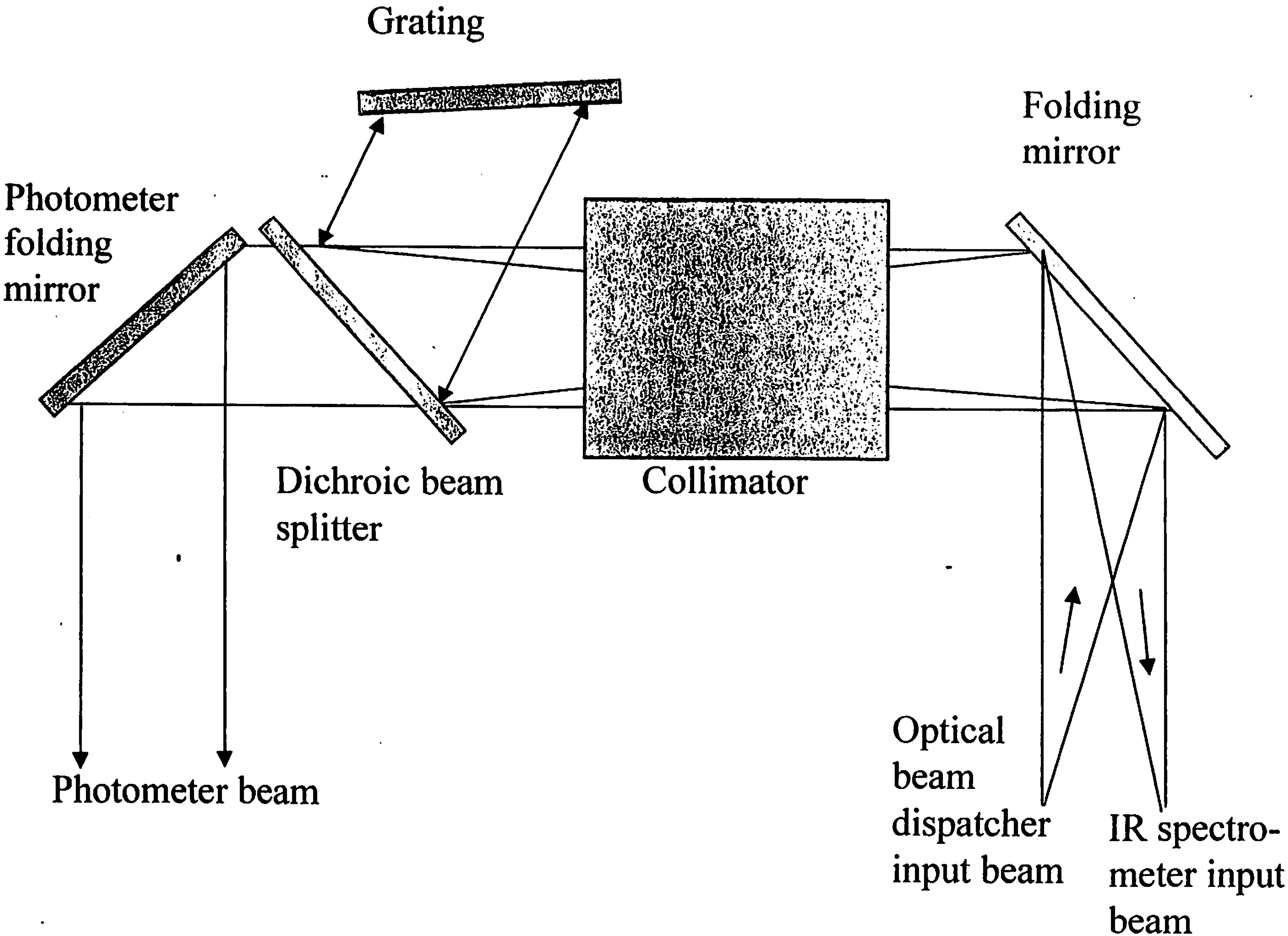
Star Tracking Operation

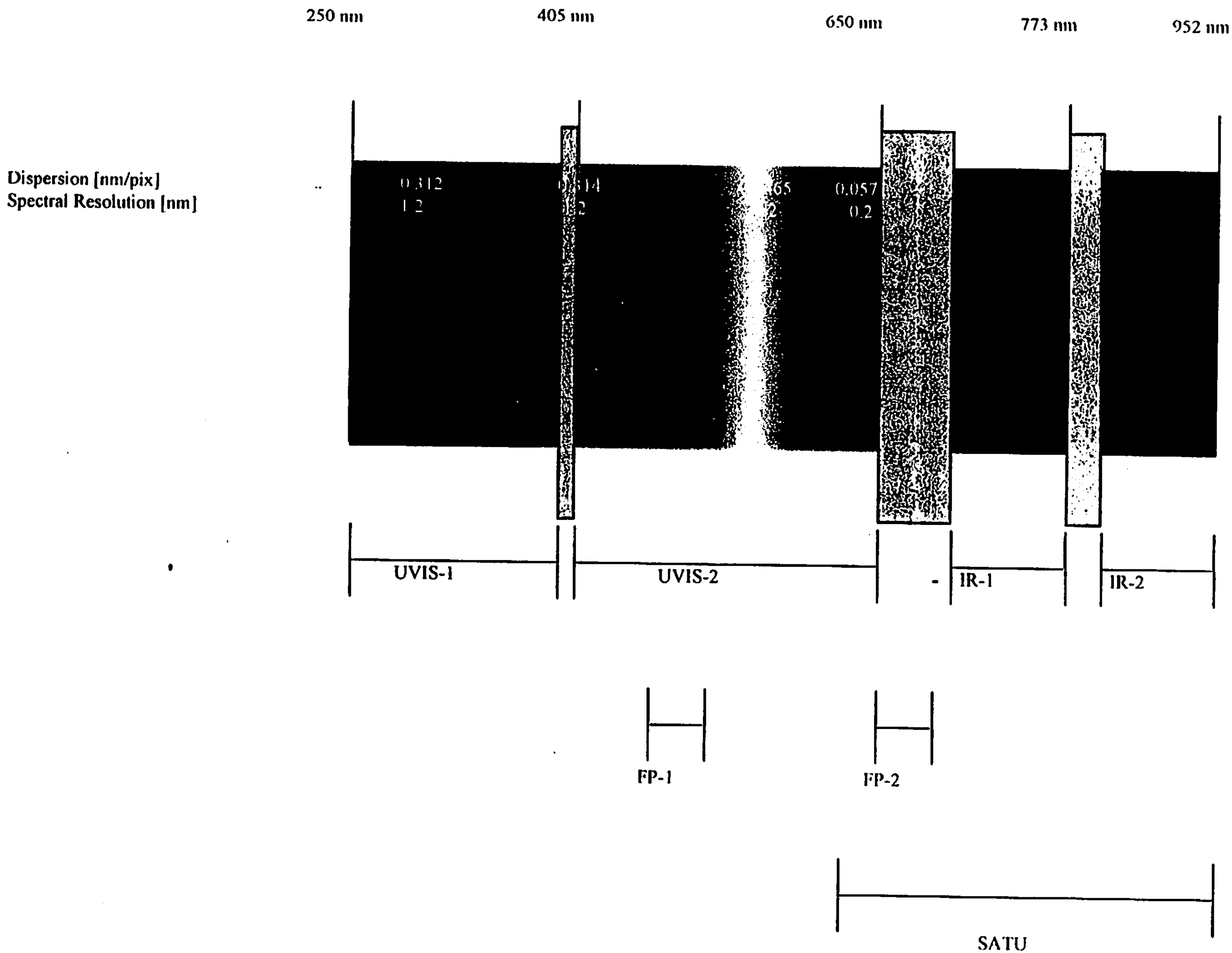




Mass:	163 Kg
Power Consumption:	146 W
Datarate:	222 Kbit/s
Operation:	Day/night

Key Performan


Grating
Folding mirror
Photometer folding mirror
Dichroic beam splitter
Collimator
Photometer beam
Optical beam dispatcher input beam
IR spectro-meter input beam


250 nm
405 nm
650 nm
773 nm
952 nm
Dispersion [nm/pix]
Spectral Resolution [nm]
0.057
0.2
UVIS-1
UVIS-2
IR-1
IR-2
FP-1
FP-2
SATU

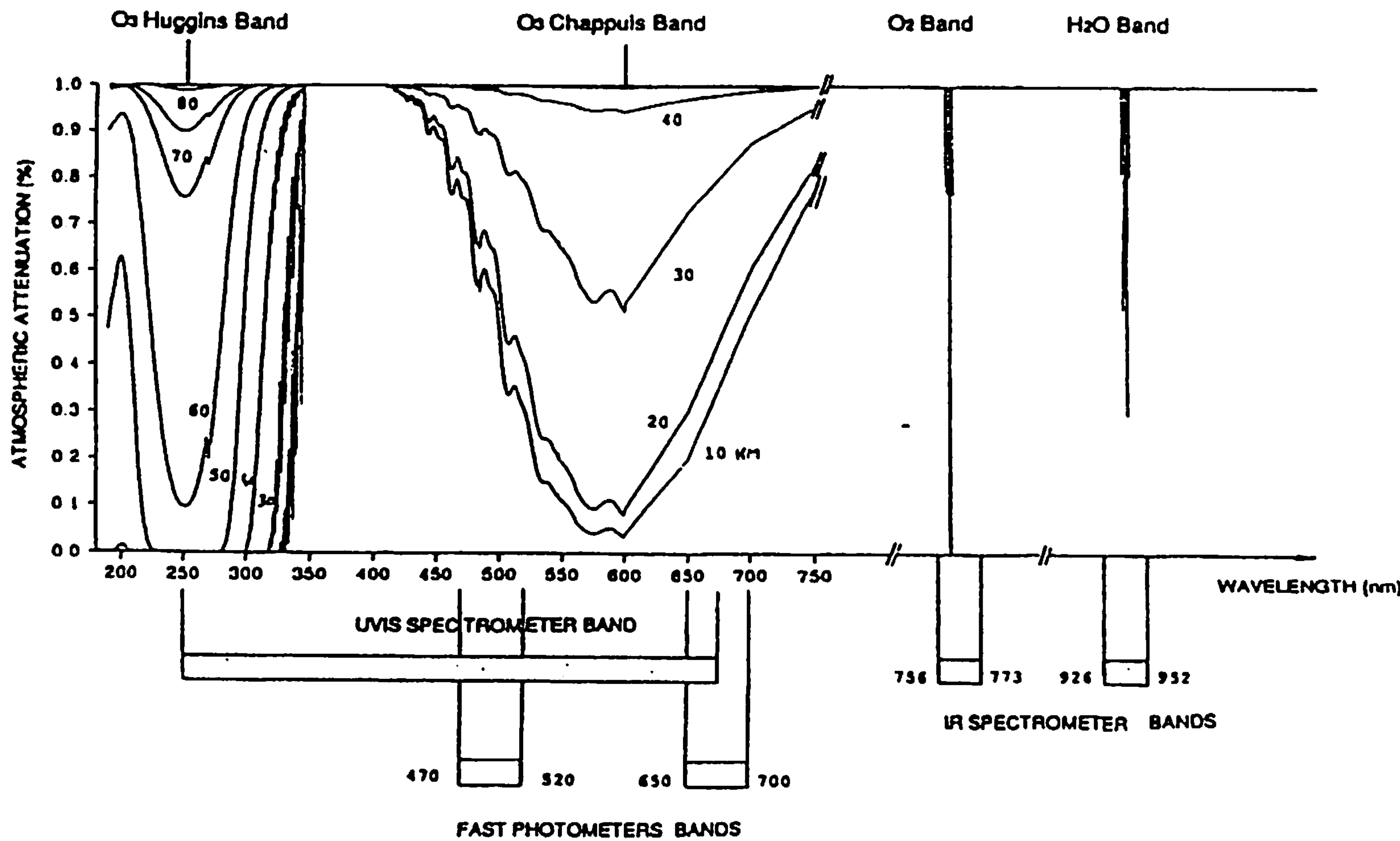
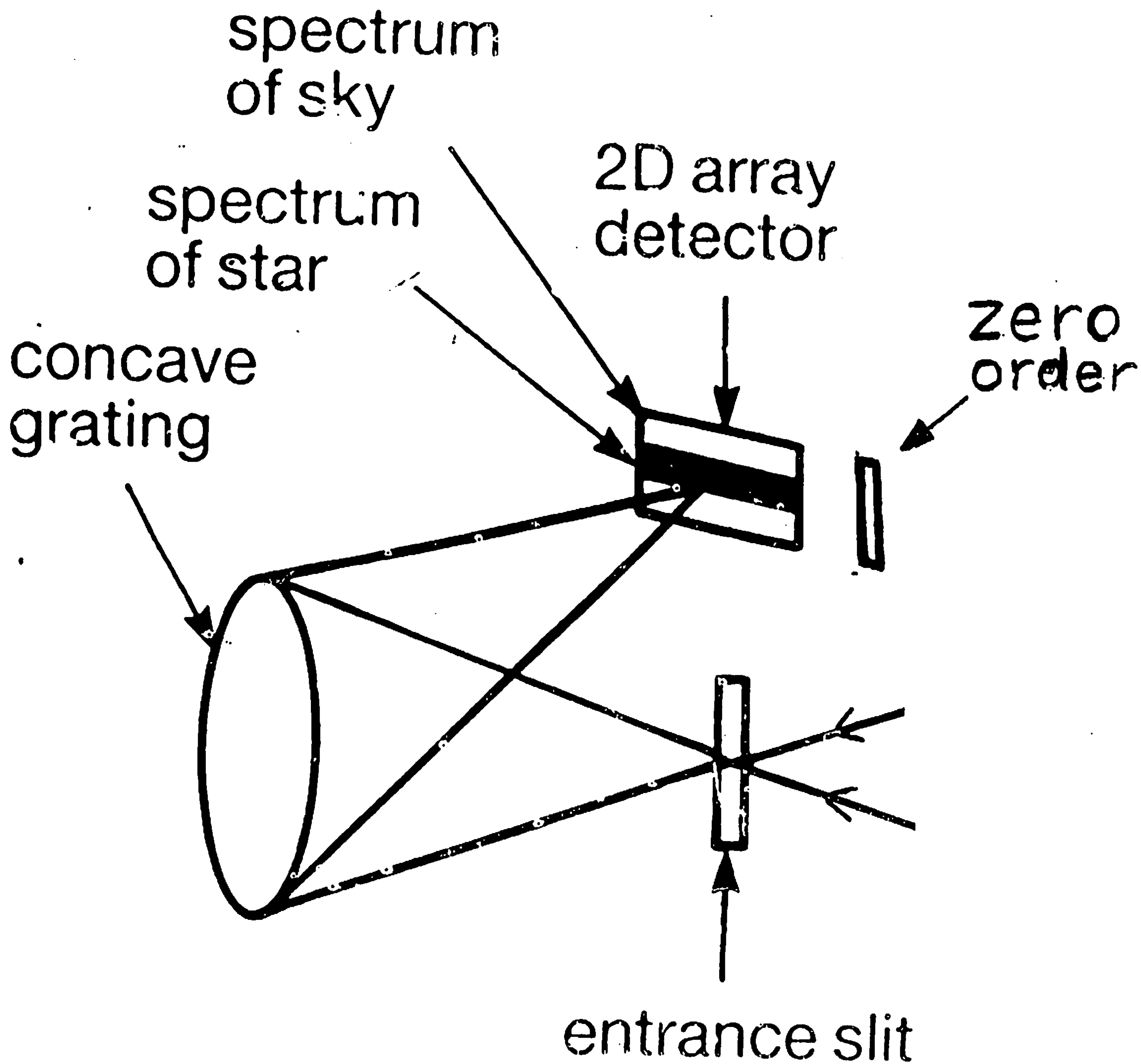


Figure 3. Atmospheric ozone transmission simulated at various altitudes (10-80 km) as a function of Wavelength and domaines of GOMOS spectrometers and fast photometers.


spectrum of sky
spectrum of star
2D array detector
zero order
concave grating
entrance slit

transmission at tgl height 20 km

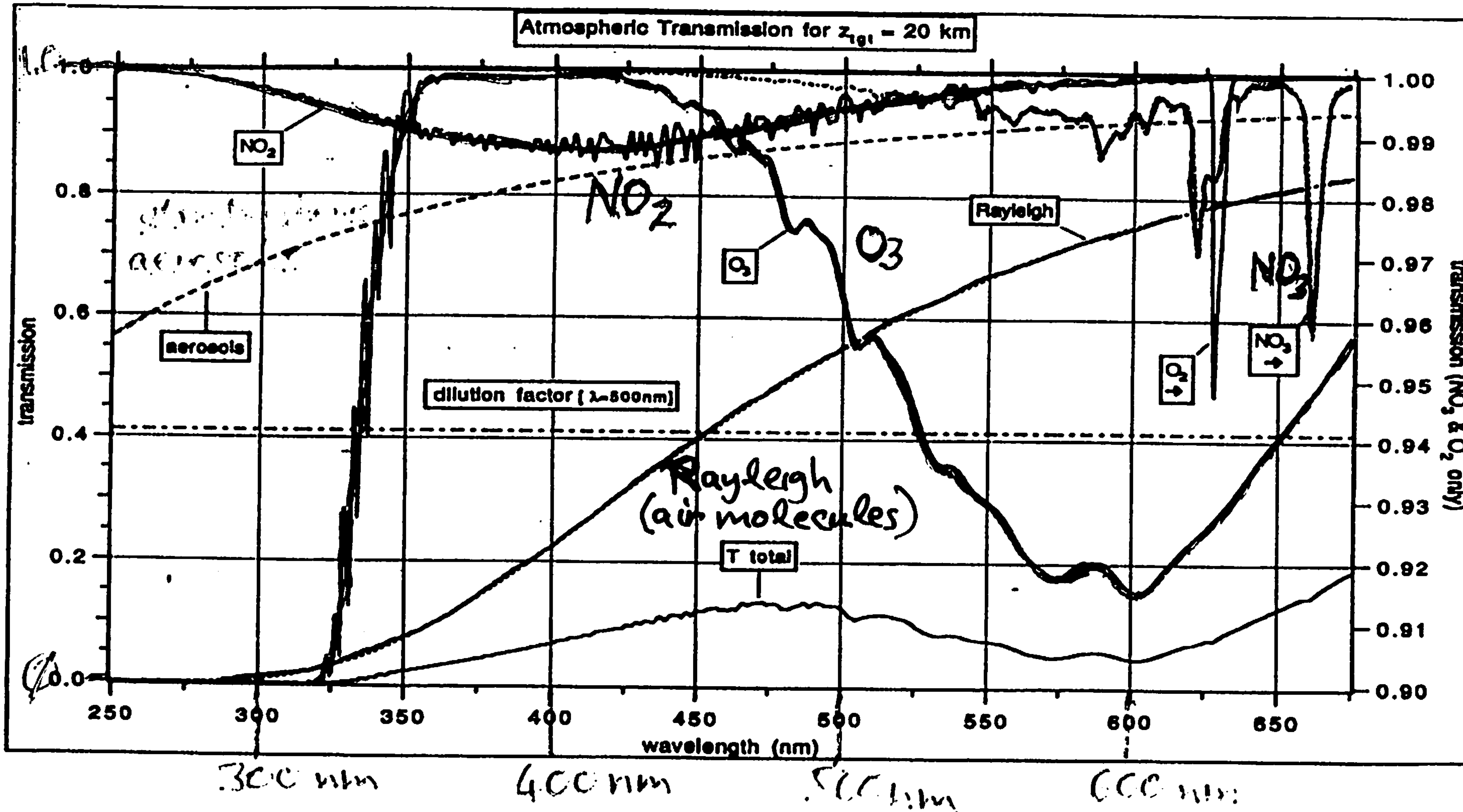
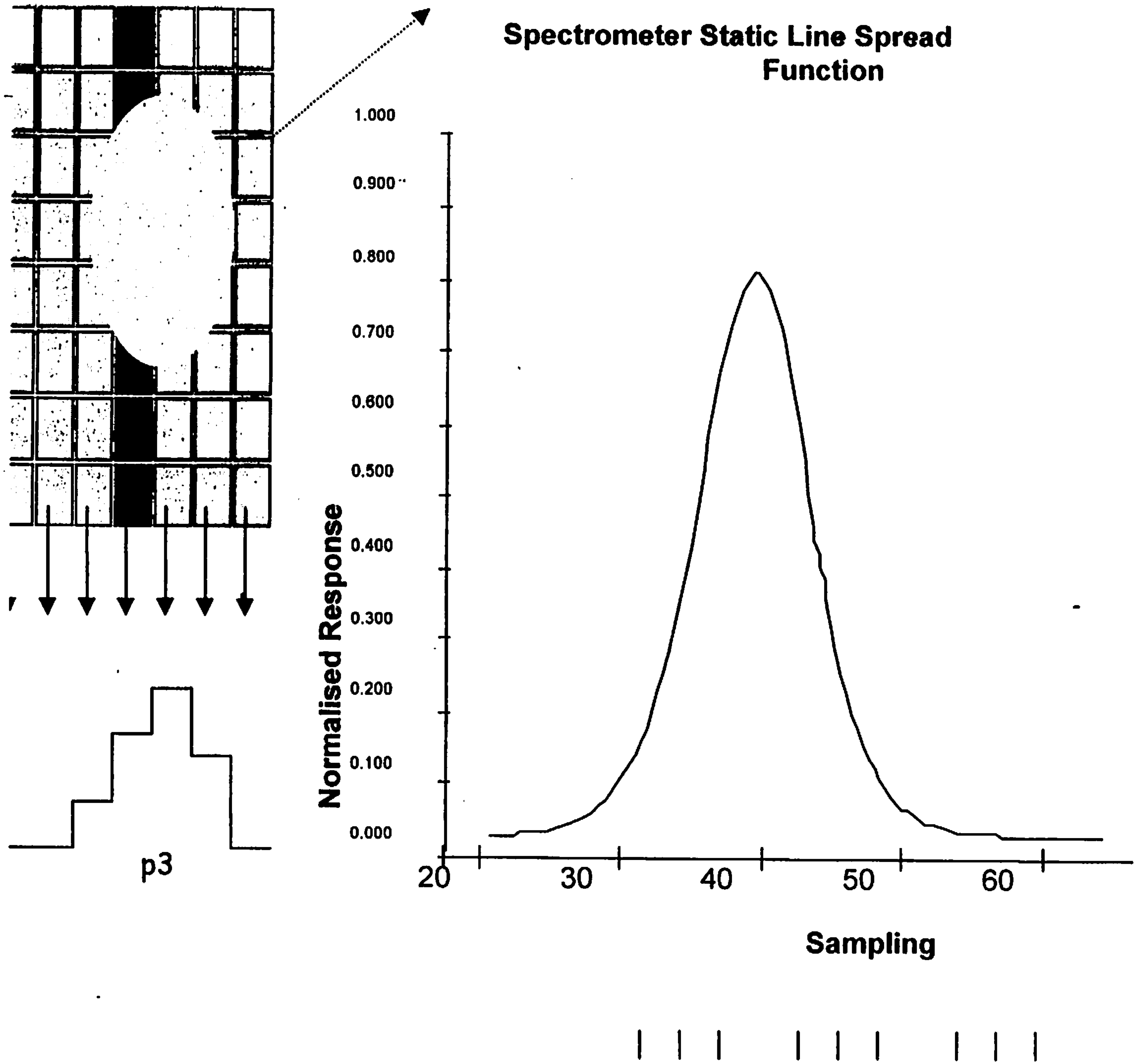


Figure 4. Forward simulation of the atmospheric transmission. The contribution of various absorbers at p = 20 km are indicated as well as the total transmission.The dilution factor is due to atmospheric refraction.


Spectrometer Static Line Spread Function
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Normalised Response
20
30
40
50
60
Sampling
p3

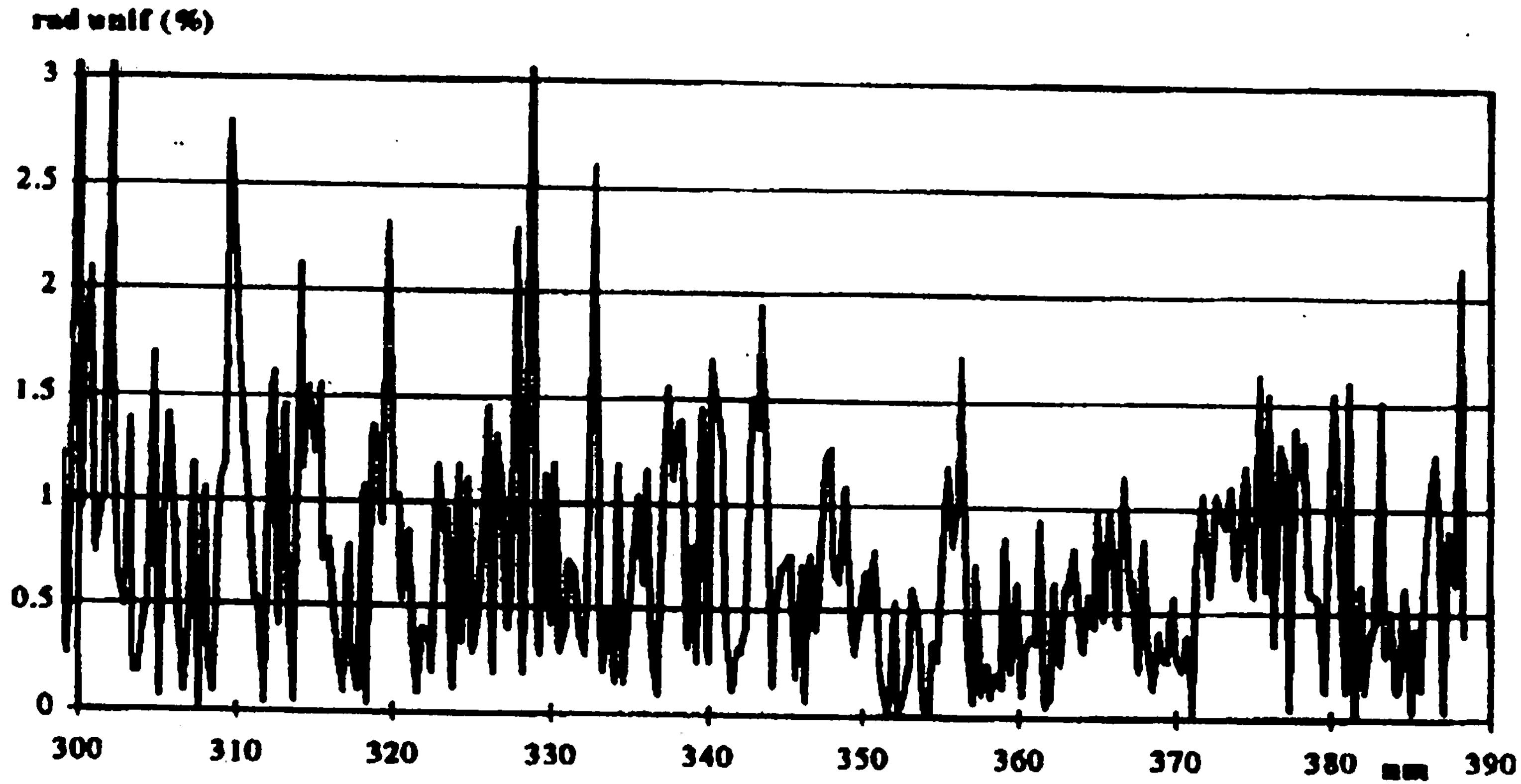


Figure 4 Radiometric uniformity in the visible band processed from pixel map in uniformity mode. The advantage of using the uniformity mode and perform the binning in software is that this mode allows for much longer integration times and hence smaller signal-to-noise contribution.

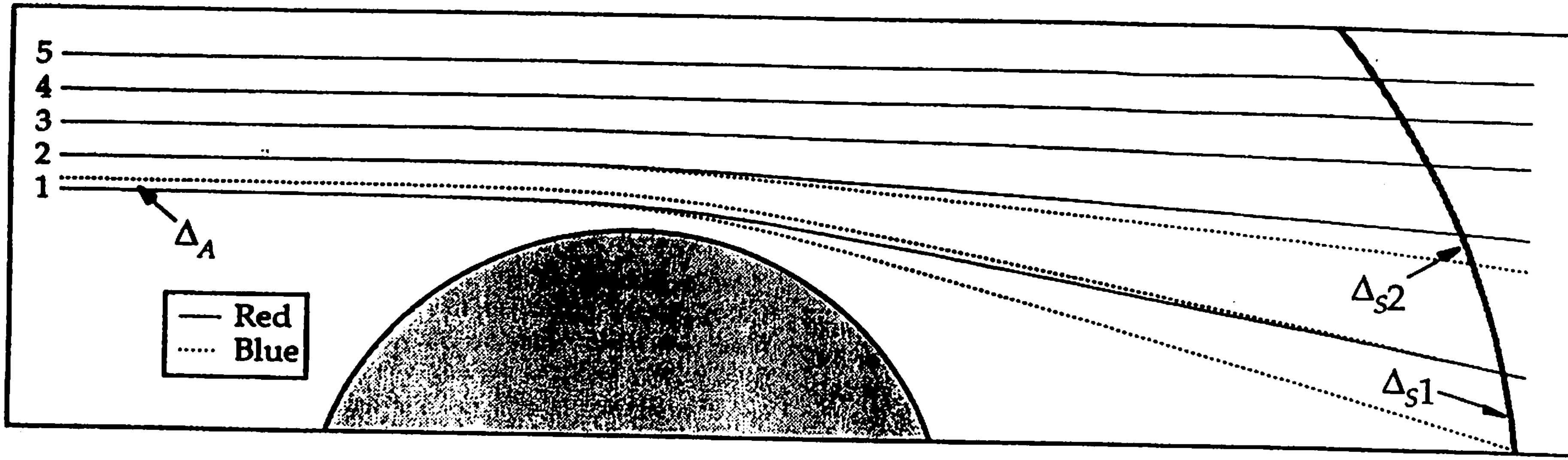


Figure 6 . Schematic representation of the trajectories of rays with various tangent altitudes showing the increasing divergence of the ray tubes after crossing of the atmosphere. Refractive dilution is a consequence of energy conservation within ray tubes. Chromatic effects are illustrated with an exaggerated refractivity ratio m = 1.50. The chromatic lag Δ_S at the satellite level is proportional to the refraction angle while the chromatic shift Δ_A saturates for low altitudes (dilution q smaller than 0.5)(from Dalaudier, 1999)

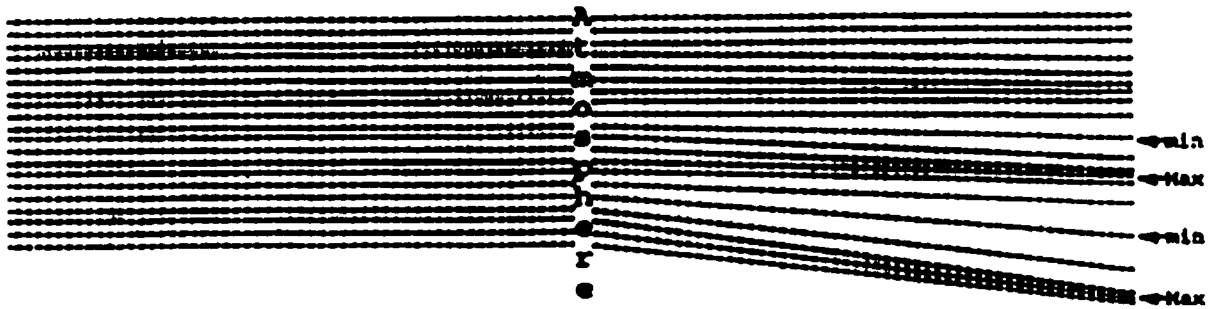


Fig. 7 : Schematic of variable bending of atmospheric rays. Regions marked min and max indicates variations of intensities producing the scintillation effect (after Dalaudier)

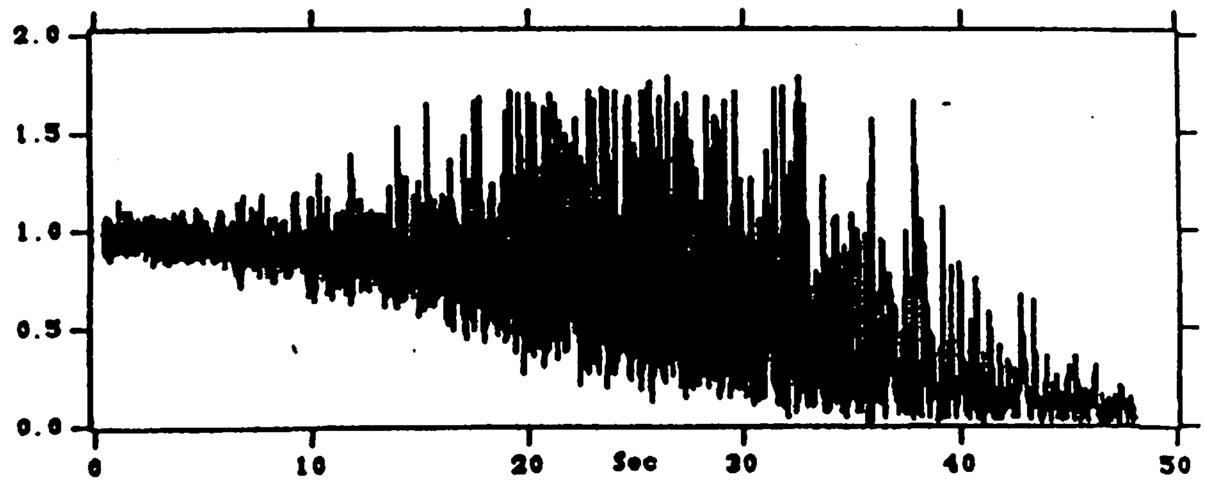


Fig. 8 Stellar scintillations observed from space.

- the tangent point (VWP) latitude when the Moon occurs in the window.

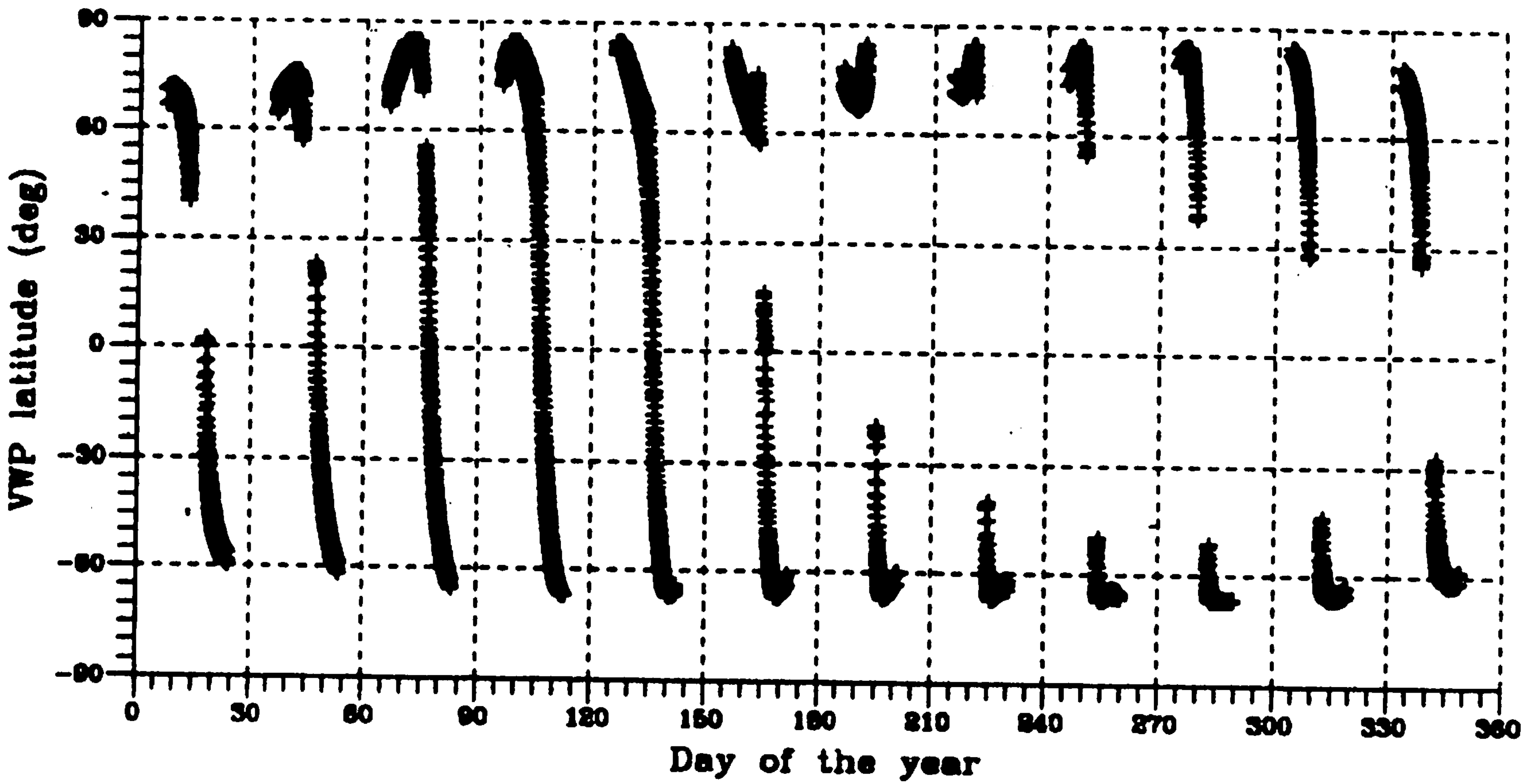
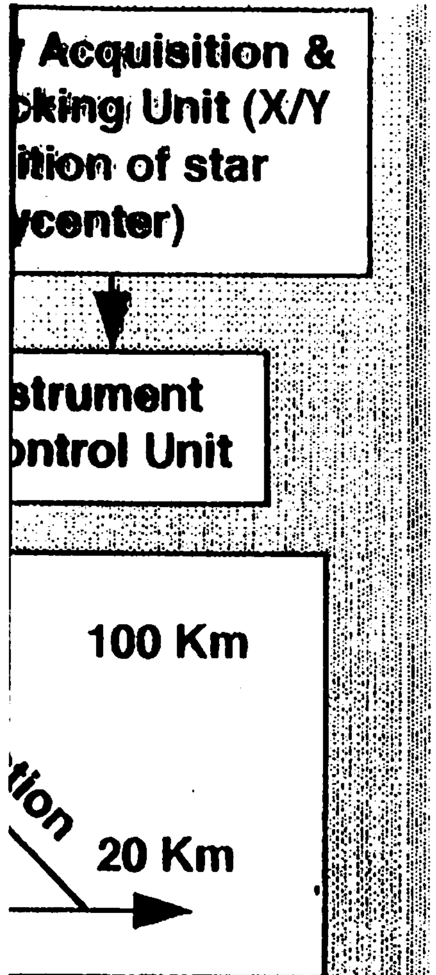
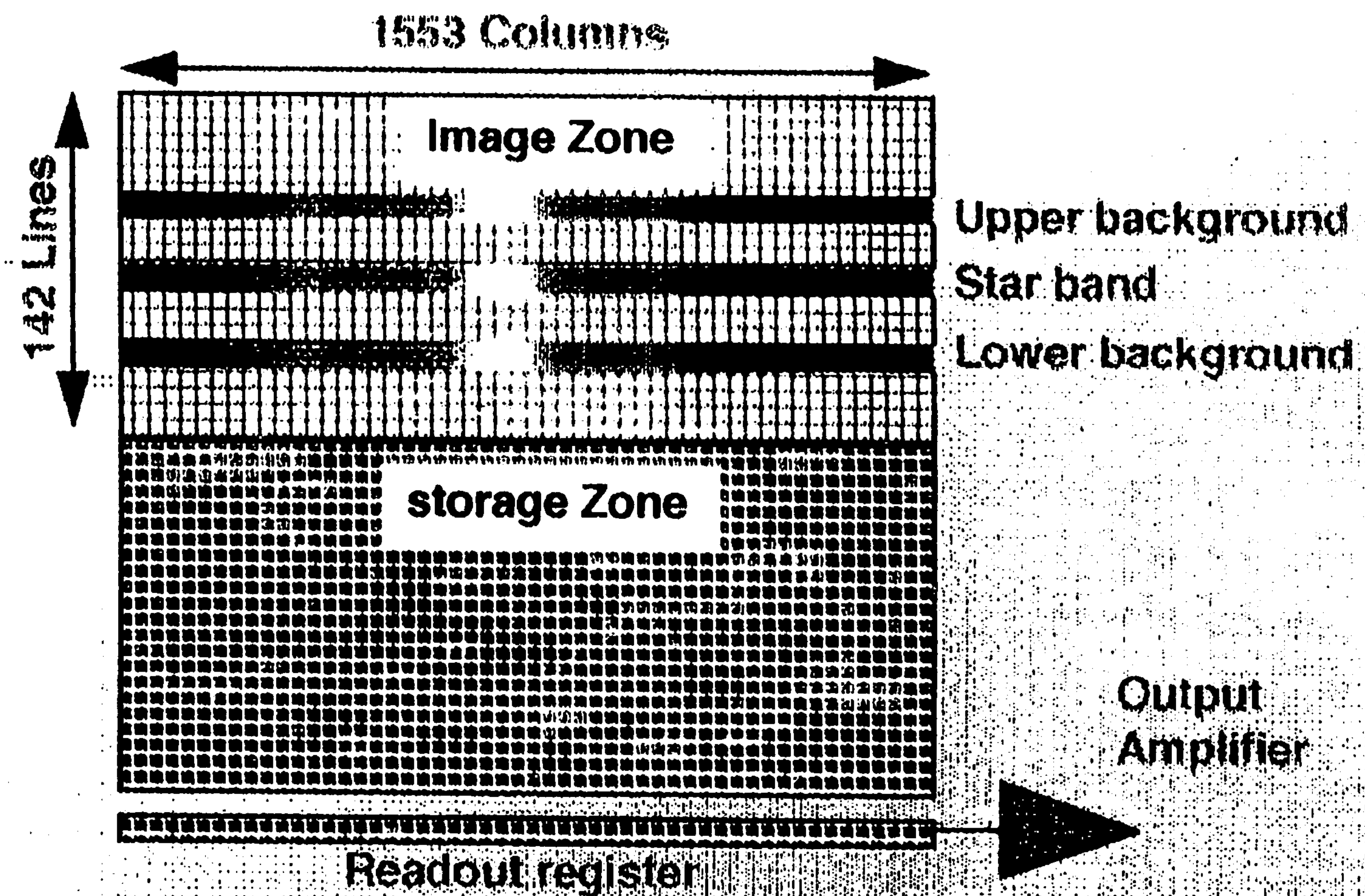


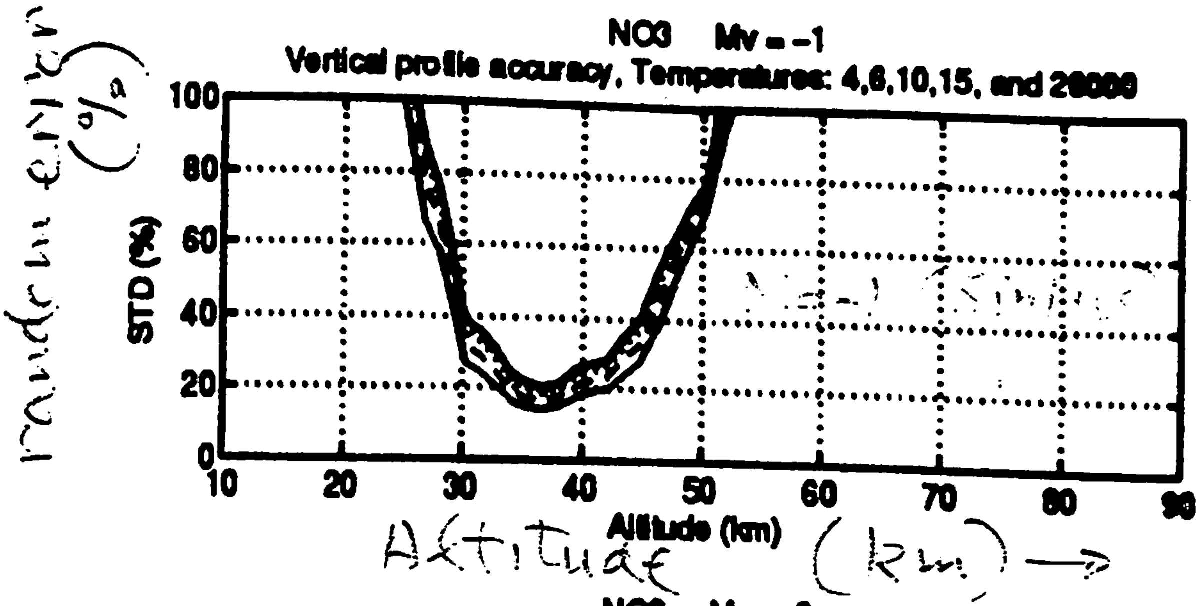
Figure 3.4.2.2-1 - Whole GOMOS field of view : -10° ... 80°

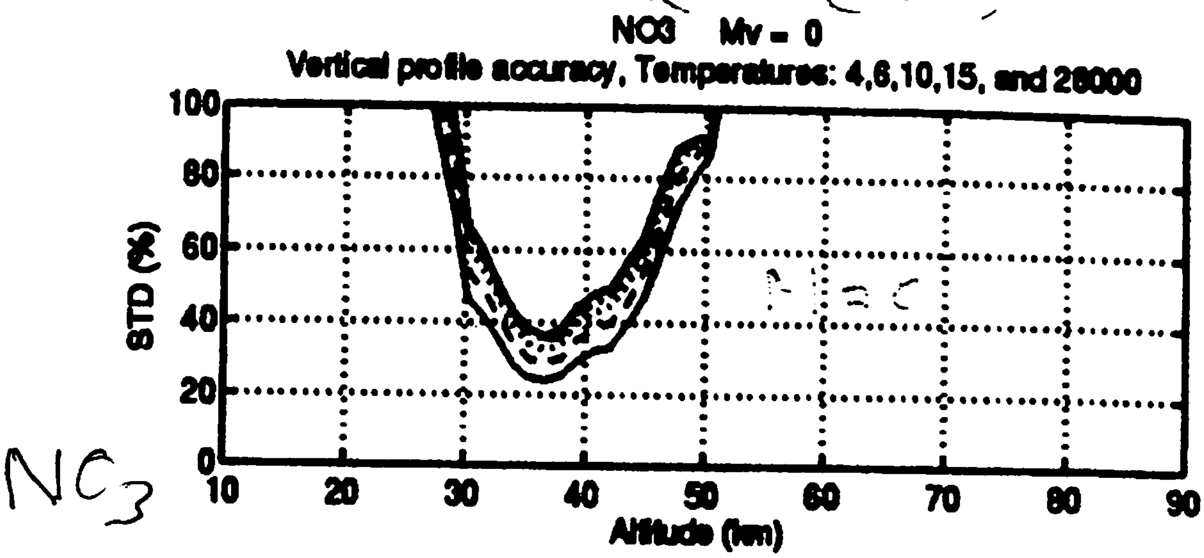


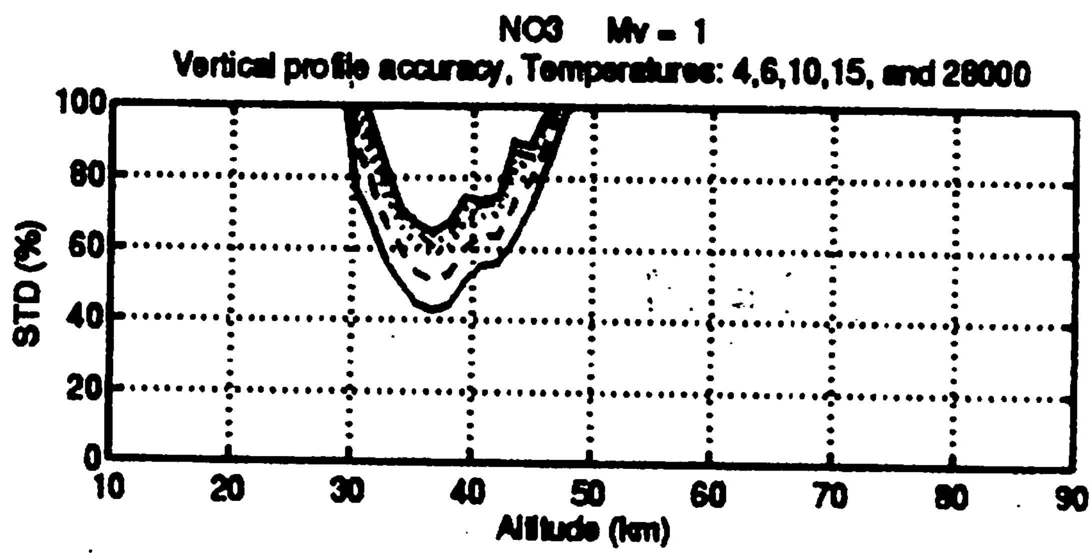


Key Performances

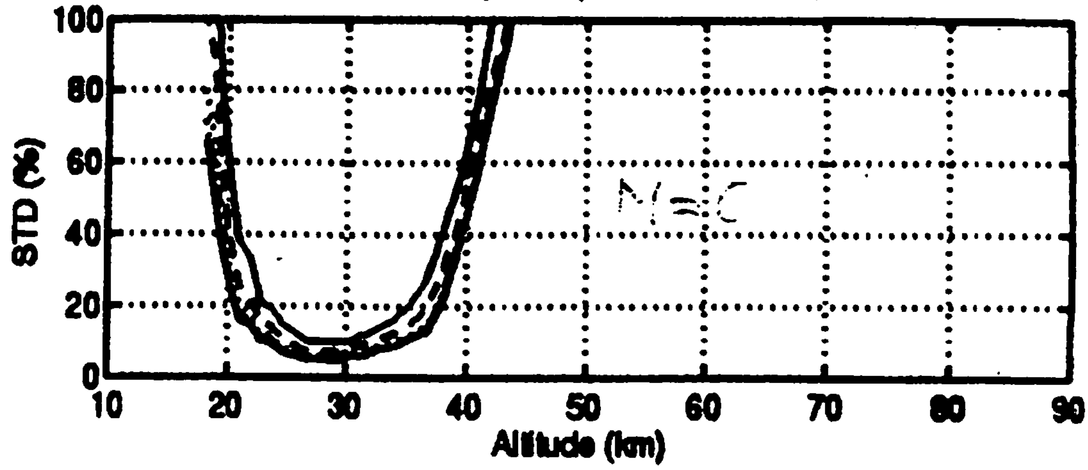
Spectral Resolution	1.2 nm (250-650 nm) 0.2 nm (753-952 nm)
Integration time	0.5 sec
Vertical resolution	1.7 Km
Photometer- Integration time	1 ms


NO3 Mv = -1
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000
STD (%)
Altitude (km)
random error (%)
Altitude (km) →

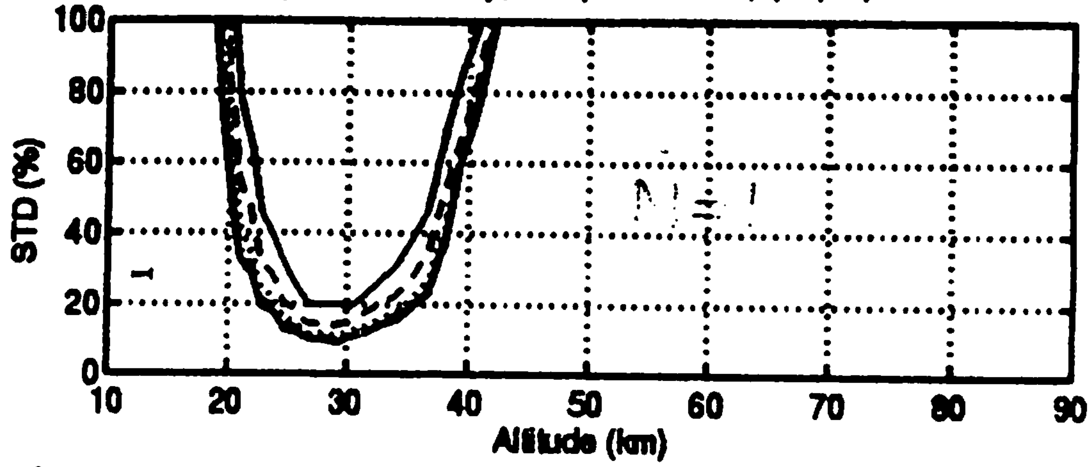

NO3 Mv = 0
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000
STD (%)
Altitude (km)
NC3


NO3 Mv = 1
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000
STD (%)
Altitude (km)

NO2 Mv = 0
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000

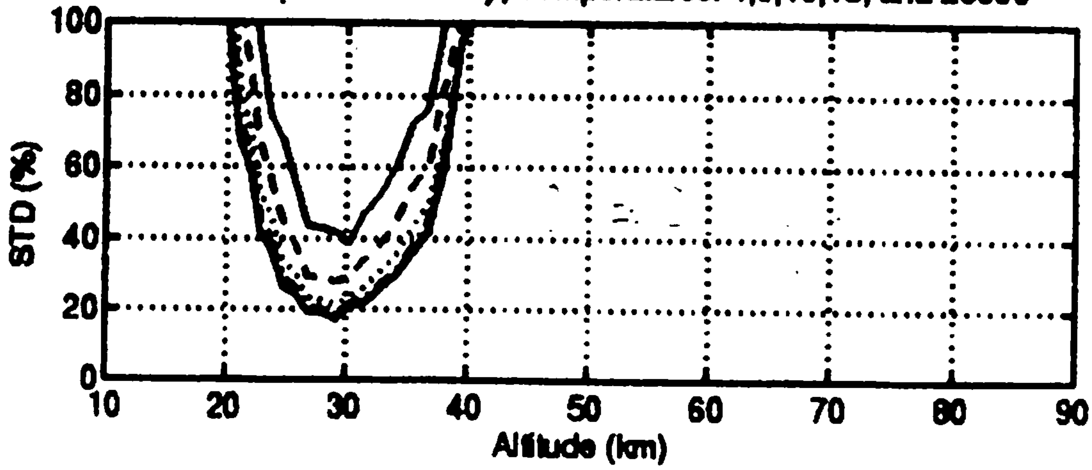


NO2 Mv = 1
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000

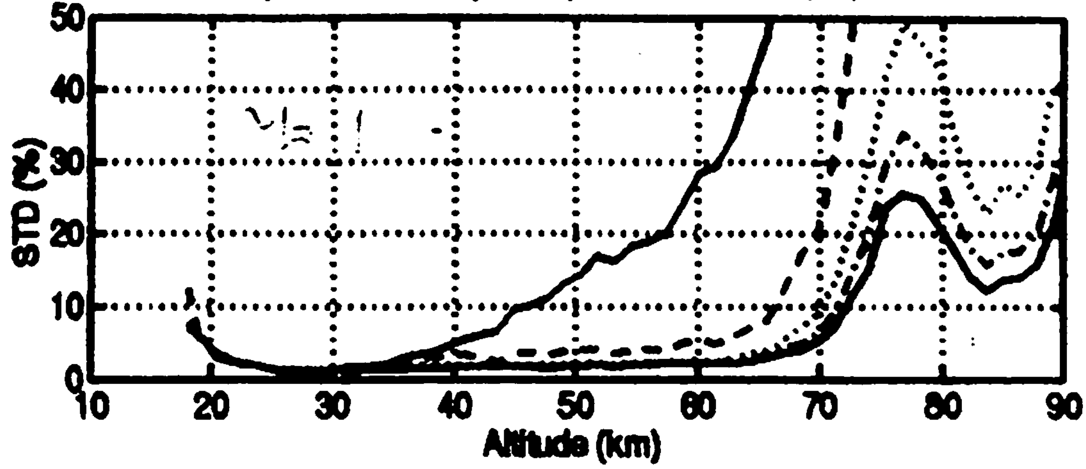


NO_2

NO2 Mv = 2
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000

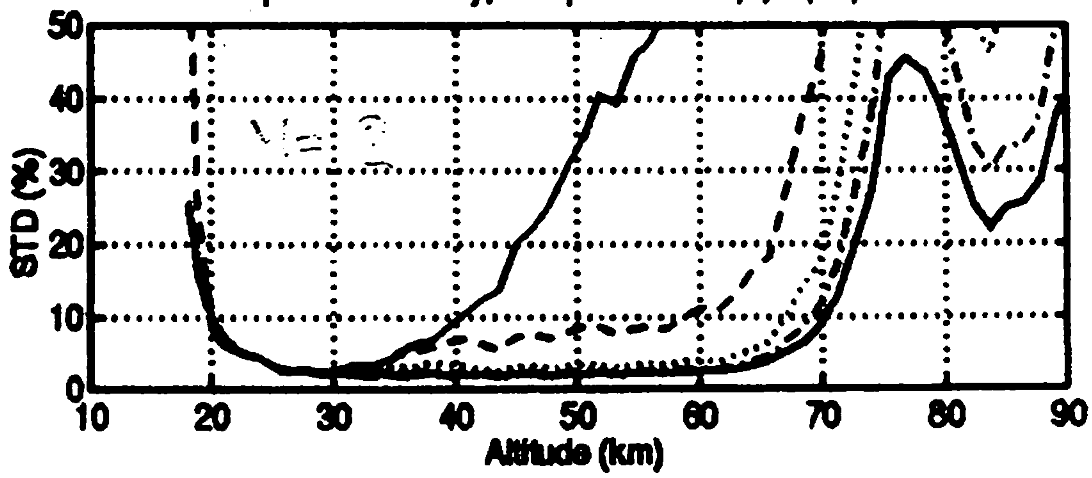


O3 Mv = 1
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000

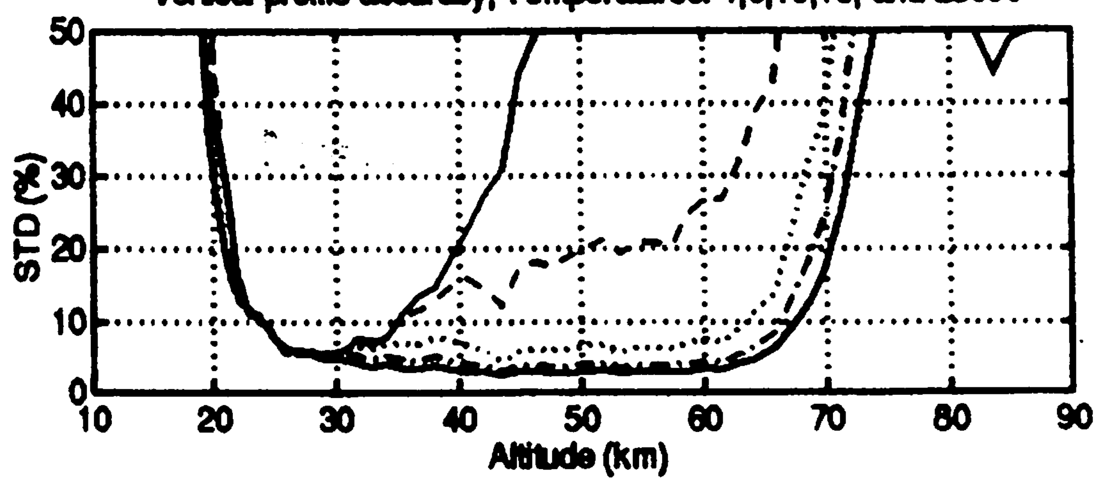


O_3

O3 Mv = 2
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000

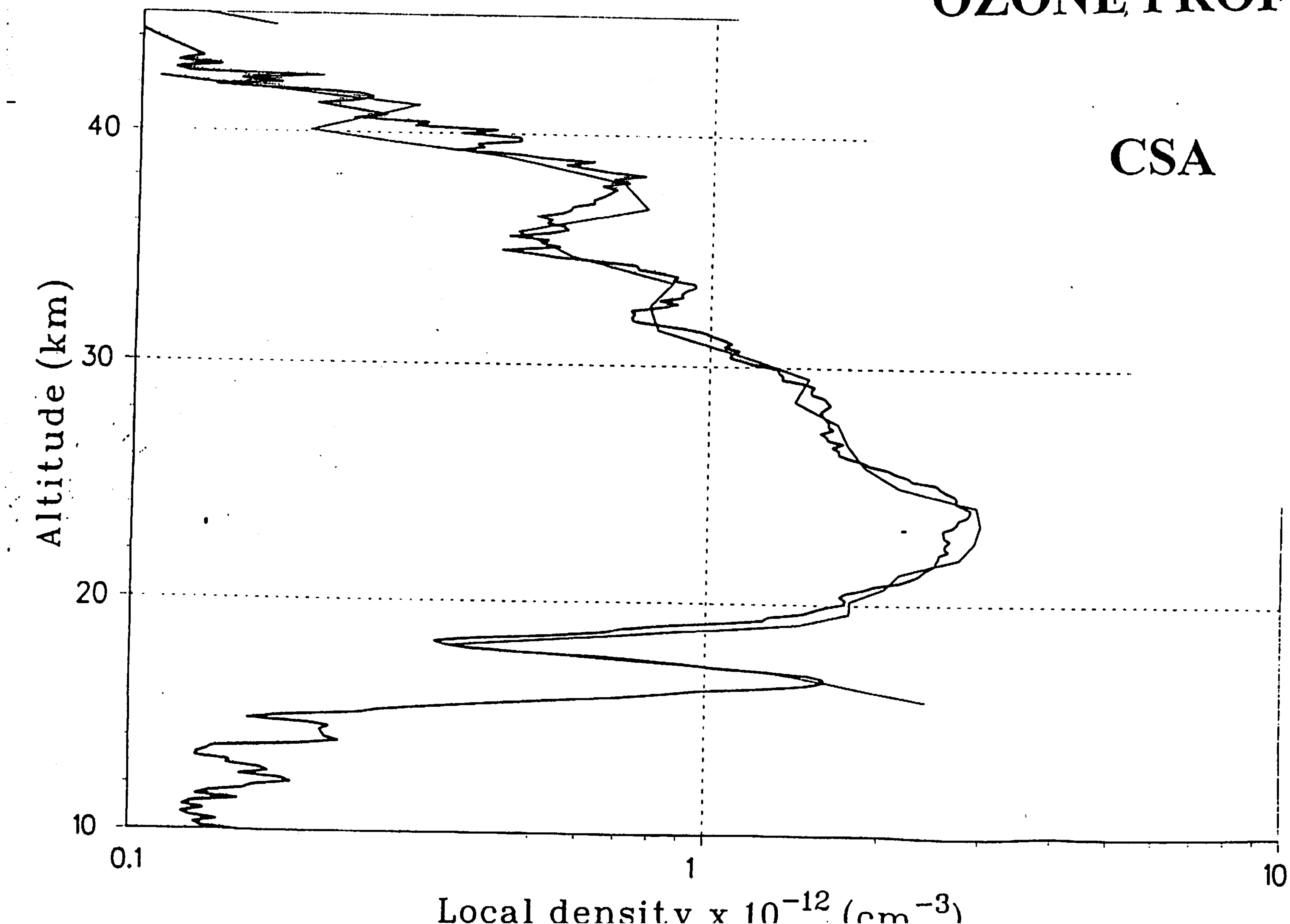


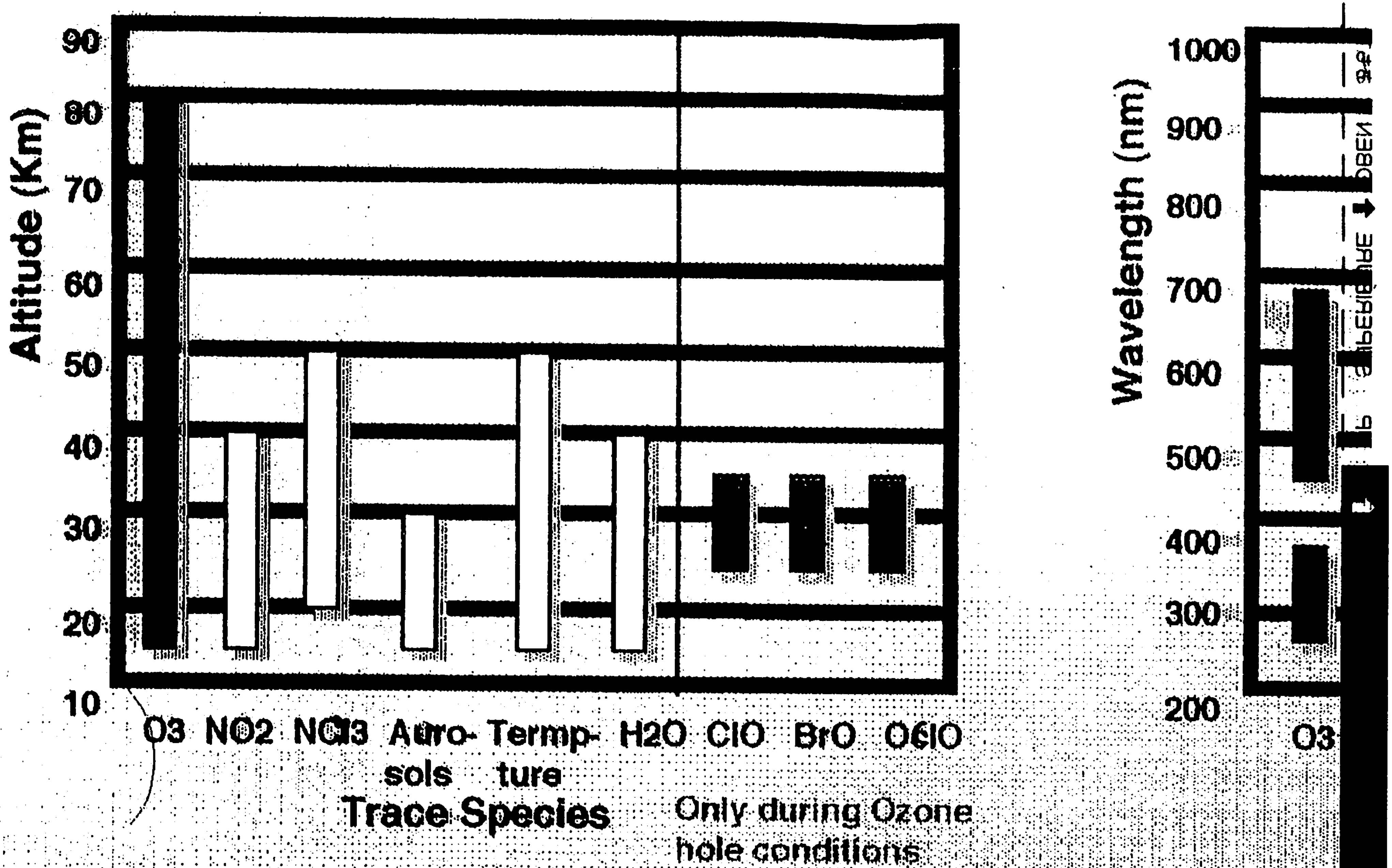
O3 Mv = 3
Vertical profile accuracy, Temperatures: 4,6,10,15, and 28000



OZONE PROFILE

CSA





Altitude (Km)
90
80
70
60
50
40
30
20
10
O3
NO2
NO3
Aero-
sols
Temp-
ture
H2O
ClO
BrO
OClO
Trace Species
Only during Ozone
hole conditions
Wavelength (nm)
1000
900
800
700
600
500
400
300
200
O3

CLRC

Envisat Atmospheric Data Workshop

DERA, Farnborough
18 June 1999

SCIAMACHY Presentation

B J Kerridge, RAL

1. Objectives
2. Instrument
3. Data Products

CLRC

1. Objectives

Primary: Global measurements of trace gases in the troposphere and stratosphere for investigations of, eg:

- Biomass burning, biogenic emissions and pollution events in the troposphere
- Ozone chemistry in the stratosphere

Secondary: Measurements of:

- Atmospheric aerosol
- Clouds
- Atmospheric temperature
- Surface spectral reflectance (0.35 - 2.5μm)

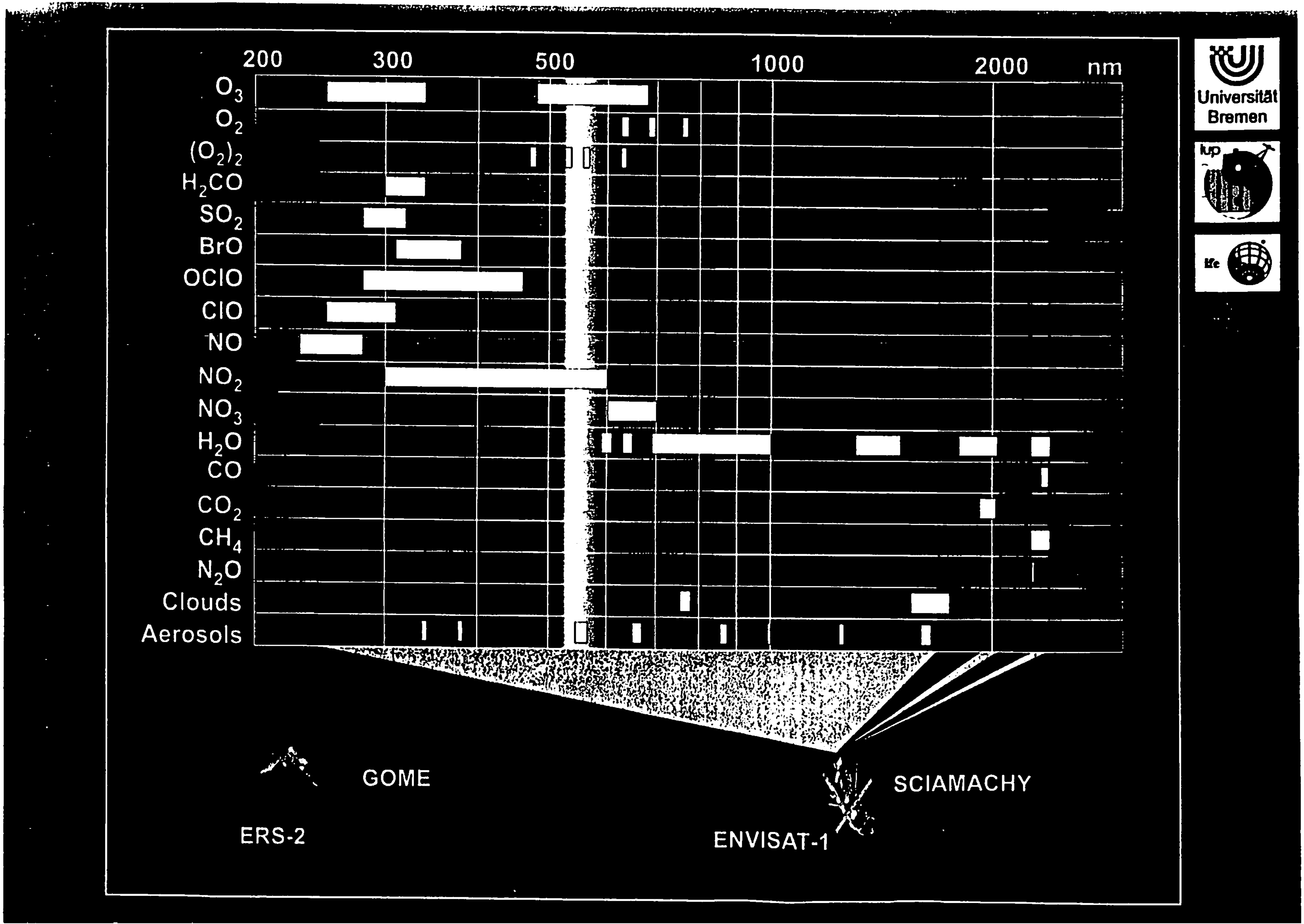
Troposphere	Stratosphere	
O_3, O_4,NO_2,N_2O, CO,CO_2,H_2O,CH_4	O_3,O_2,O_2^*,O_4,NO,NO_2, BrO,N_2O,CO,CO_2,H_2O,CH_4	
Polluted condition HCHO,SO_2	Volcanic eruption SO_2	Ozone hole conditions OClO,ClO

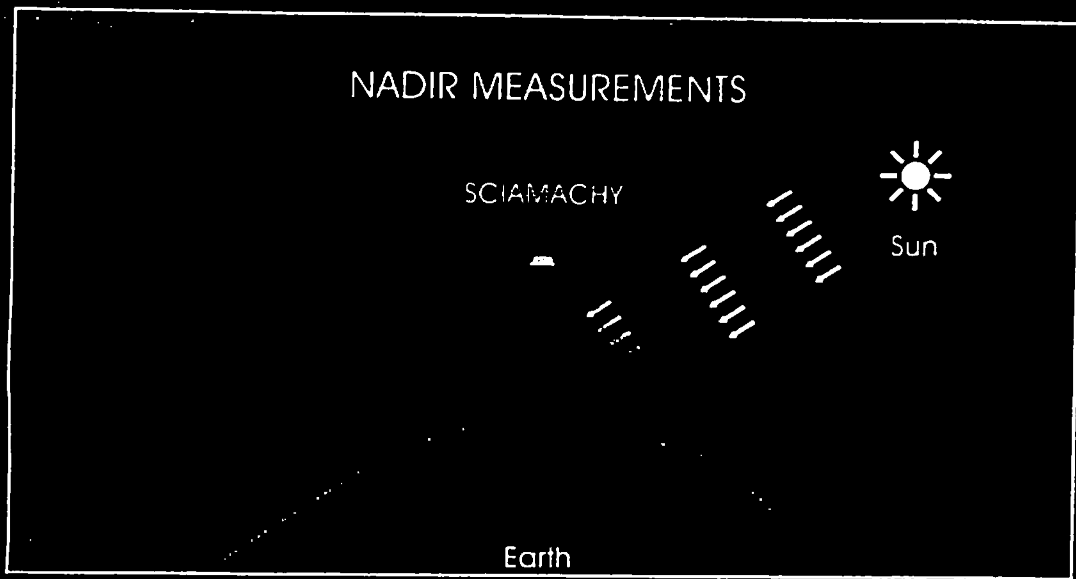
CLRC

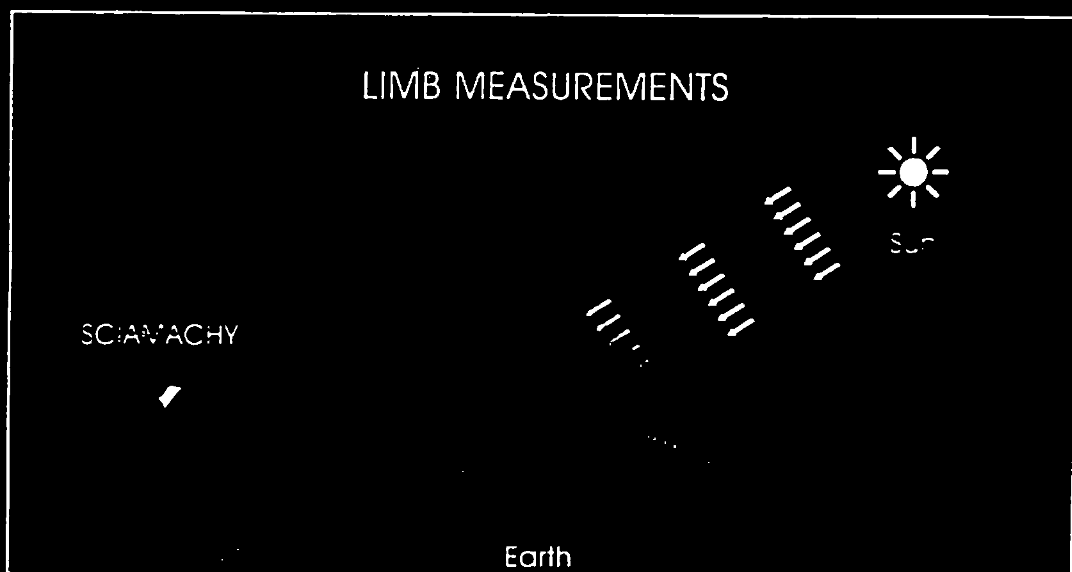
2. Instrument

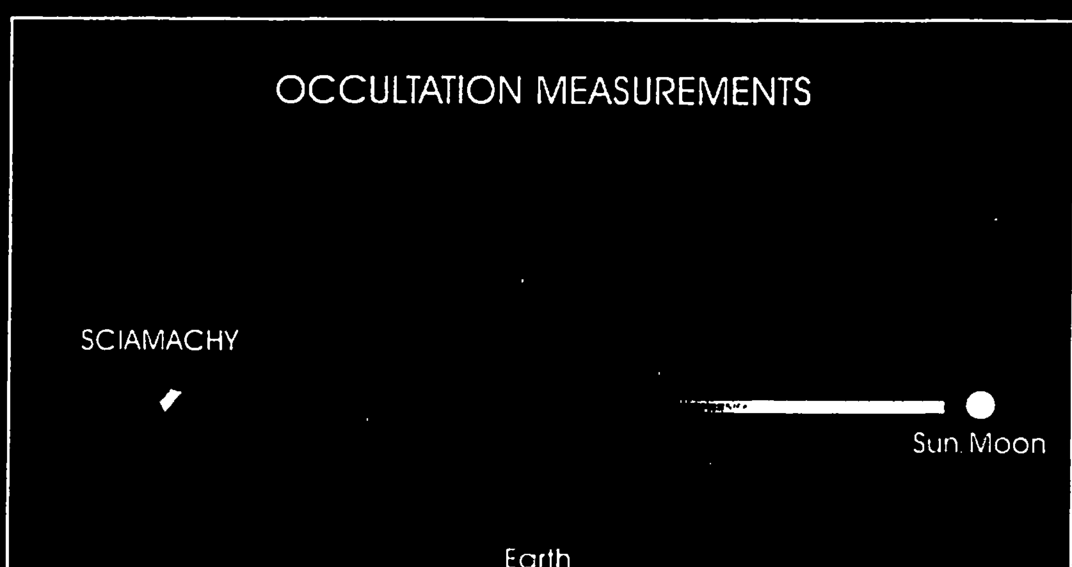
- 8-channel grating spectrometer
- Contiguous measurements from 240 - 1700mm and in two selected bands between 2.0 and 2.4μm
- Spectra sampled by 1024 element detector arrays
  - Bands 1 -5: Si (cf GOME)
  - Bands 6 - 8: InGaAs
- Two single-axis scanning mirrors
- Measurement of trace gas absorption signatures in three modes:
  1. Nadir backscatter → total columns (cf GOME)
  2. Limb backscatter → stratospheric profiles
  3. Occultation → stratospheric profiles
- Spectra also contain aerosol, cloud and surface information
- **Direct heritage in nadir from GOME (240 - 790nm)**

Channel	Spectral range (nm)	Spectral Resolution (nm)
1	240-314	0.24
2	309-405	0.26
3	394-620	0.44
4	604-805	0.48
5	785-1050	0.54
6	1000-1750	1.48
7	1940-2040	0.22
8	2265-2380	0.28


200
300
500
1000
2000
nm
O_3
O_2
$(O_2)_2$
H_2CO
SO_2
BrO
OClO
ClO
NO
NO_2
NO_3
H_2O
CO
CO_2
CH_4
N_2O
Clouds
Aerosols
Universität
Bremen
GOME
ERS-2
SCIAMACHY
ENVISAT-1







Universität Bremen

CLRC

Nadir

- 960km (max) swath → full coverage at equator after 3 days
- Nominal pixel size:

  30km (along-track) x 30km (across-track) for 0_3, $N0_2$ and 0_2

  30km (along-track) x 240km (across-track) for others

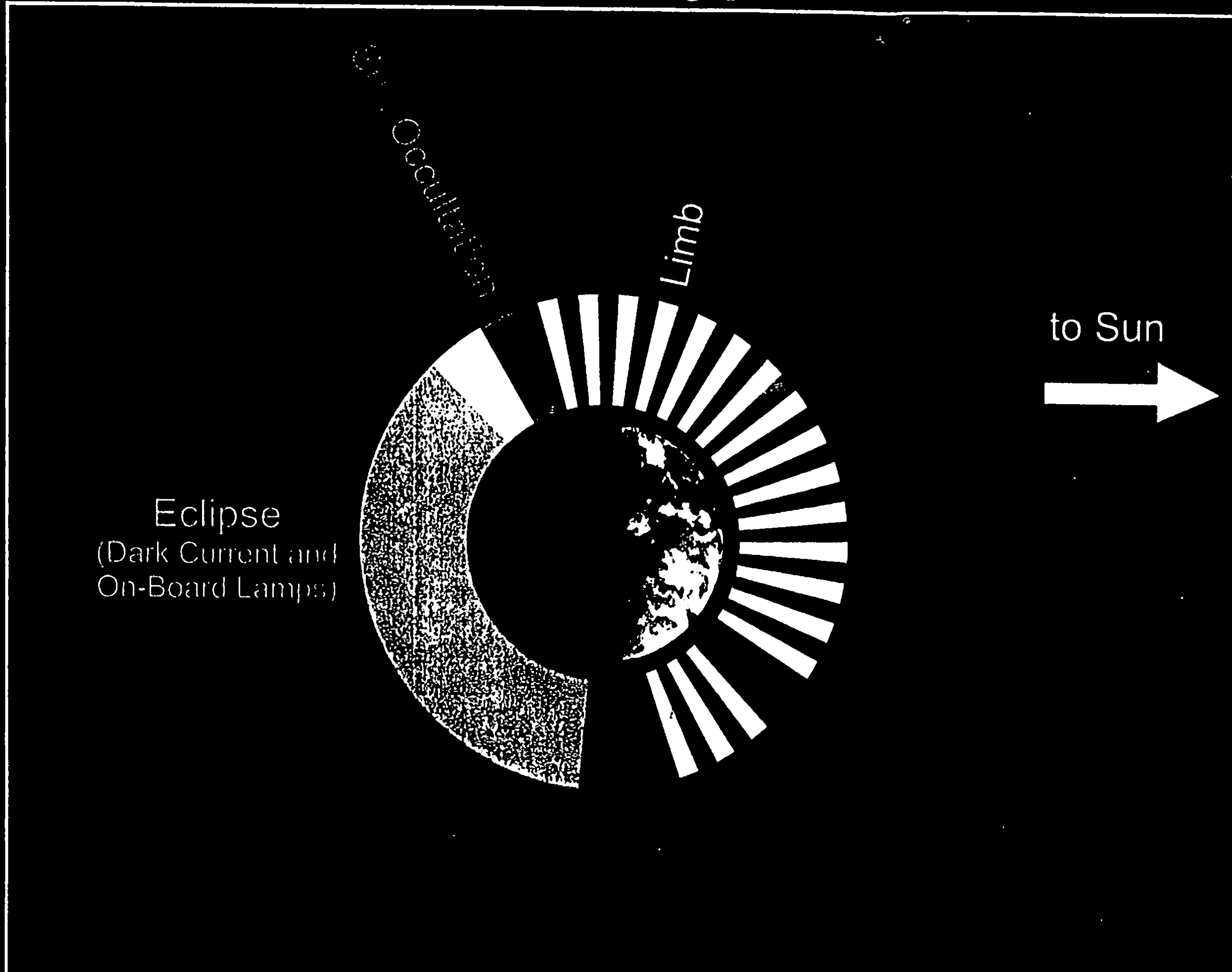
Limb

- 960km wide azimuth scan at each tangent-height (4 samples of 240km width)
- Nominal scan 0 - 100km @ 3km steps
- Optionally 0 - 45km @ 1.5km step

Occultation

- Larger vertical measurement range than limb (due to higher radiometric precision)
- Solar: once per orbit in N hem
- Lunar: once per orbit in ≈ 5 - days/28 days

SCIAMACHY Typical Orbit



CLRC

Inflight Calibration

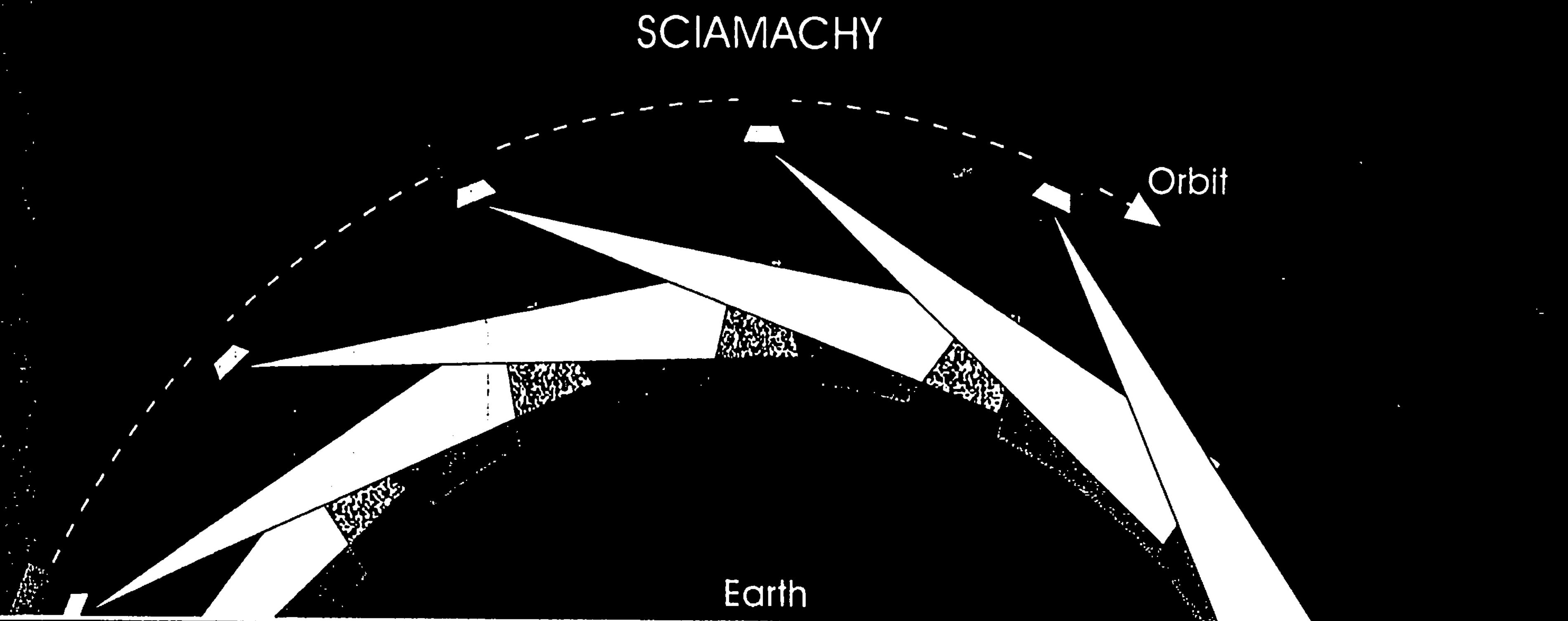
– Polarisation monitoring devices	-	continuously
– White lamp (tungsten halogen)	-	monthly
– Spectral lamp (PtCrNe)	-	monthly
– Sun via diffuser (solar reference spectra)	-	daily

– Dark-current (top of limb-scans and night-side)

– Direct sun/moon (top of occultation scans)

LIMB/NADIR MATCHING

= - Limb Column



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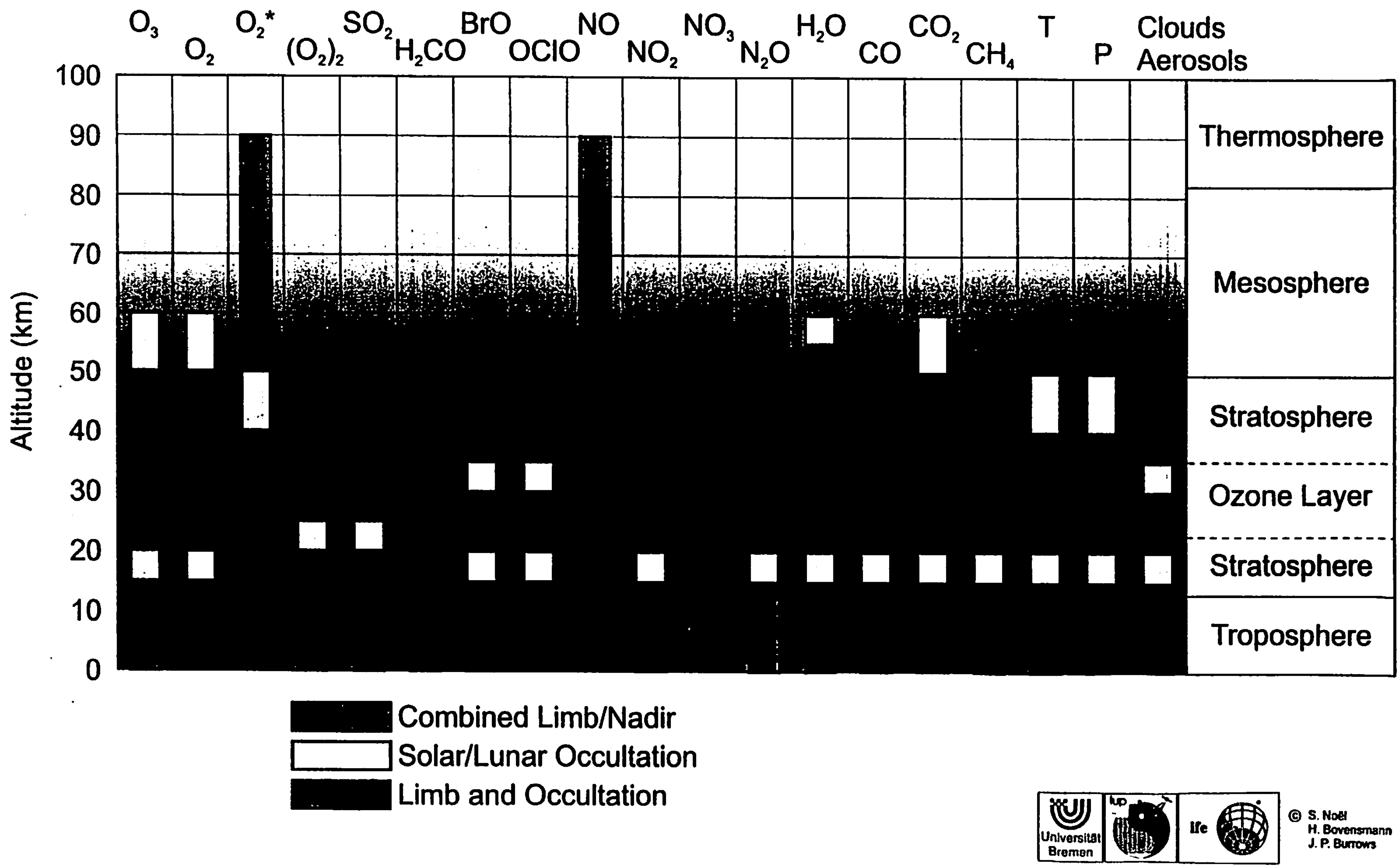
SCIAMACHY Altitude Coverage



3. Data Products

CLRC

Level 0	-	Raw data
Level 1	-	Geolocated/calibrated spectra
Level 2	-	Retrieved geophysical parameters

(a) <u>Near-real time</u> (Nadir only)

UV/Vis

- Total columns from DOAS
- Cloud fractional cover and height from O_2 A-band and PMDs
- Aerosol absorption index

→ Algorithms derived directly from GOME

Near-IR

- Total columns from BIAS

→ New algorithms under development

NRT Meteo

– Ozone column only in BUFR format

(b) **Off-Line**

– Total columns of additional gases
– Stratospheric profiles from limb and occultation

→ New algorithms under development

SCIAMACHY Operational Level 2 Products

	Nadir Total Column Amount			Limb Stratospheric Profile		
	UV/Vis	IR	UV to IR	UV/Vis	IR	UV to IR
Near Real-Time	O_3 NO_2 OClO * SO_2 * H_2CO * BrO **	H_2O N_2O CO CH_4	Clouds Aerosol			
Off-Line	O_3 NO_2 BrO OClO * SO_2 * H_2CO * UV Index**	H_2O N_2O CO CO_2 CH_4 Pressure Temp.	Clouds Aerosol	O_3 NO_2 BrO**	H_2O CO_2 CH_4 Pressure Temp. N_2O** CO**	Aerosol

*observed under special condition
(volcanic eruption, ozone hole, heavy tropospheric pollution)

#reduced quality at CO fitting window

**recommended by Science Advisory Group, implementation under negotiation with agencies

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Potential for Further Product Development

- Advanced algorithm development proposed by several groups (Envisat AO

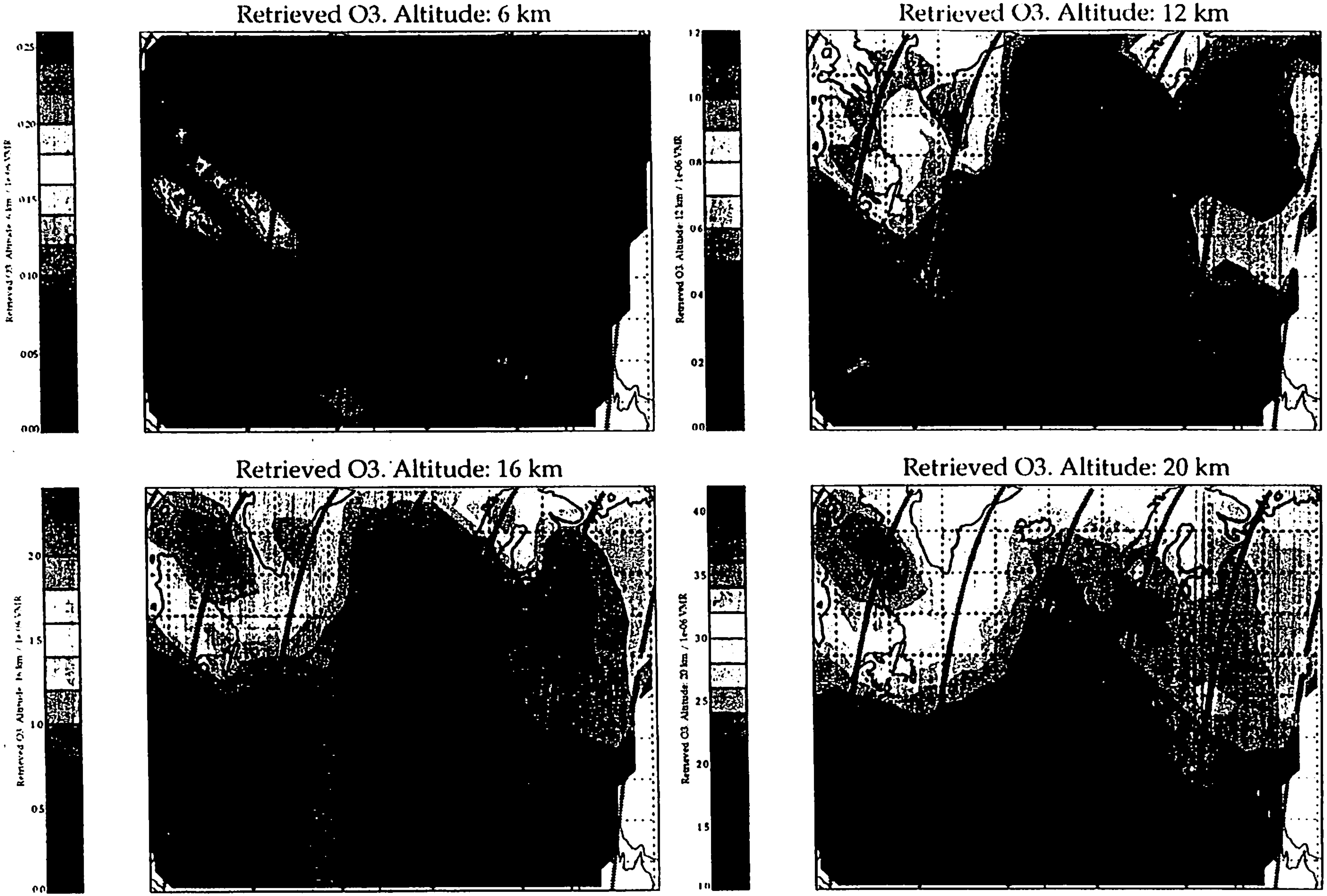
→ Additional and improved products, eg

  - Height-resolved O_3 retrieval from nadir (cf GOME)
  - Tropospheric column from limb/nadir combination

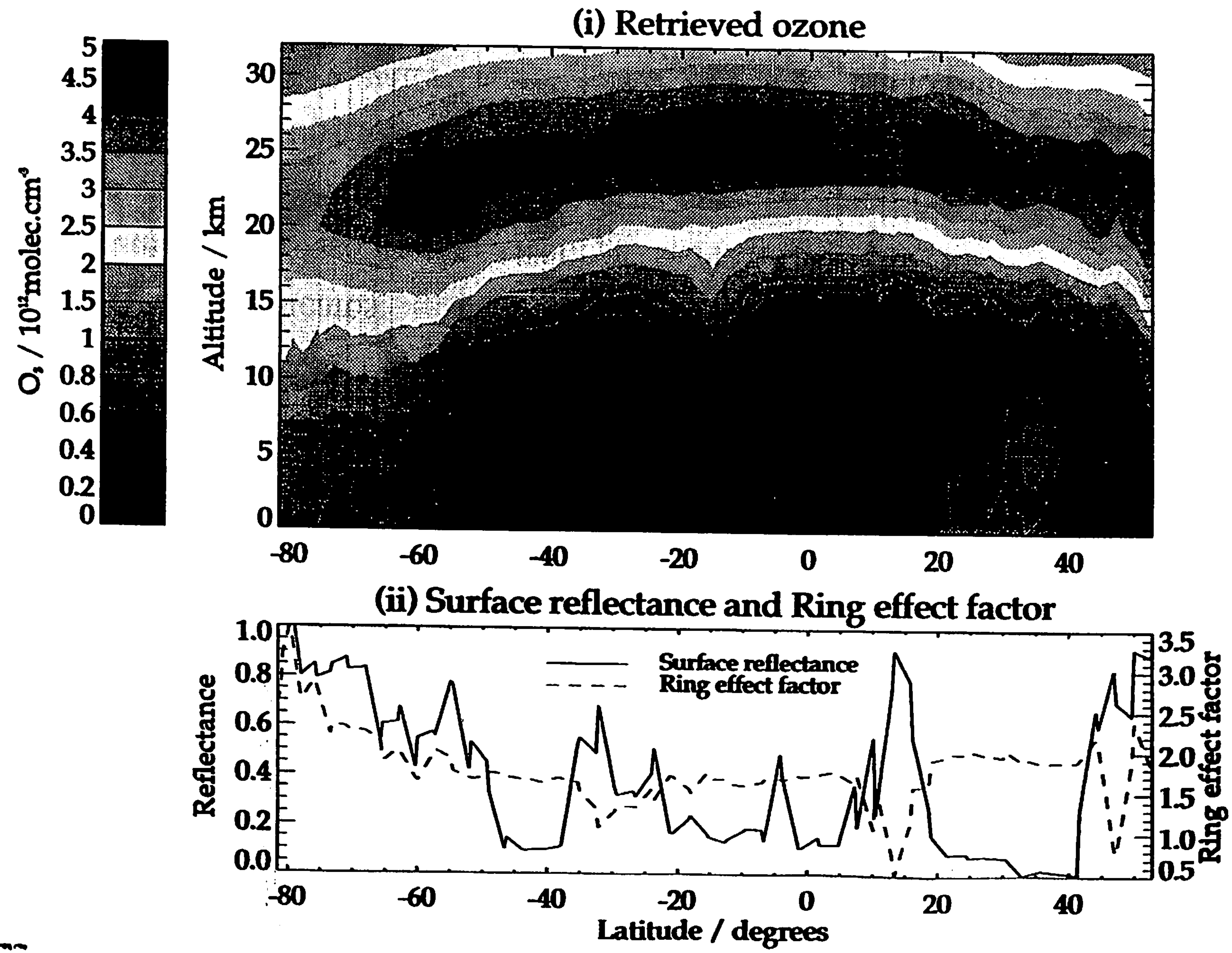
Potential for Synergy with Other Sensors

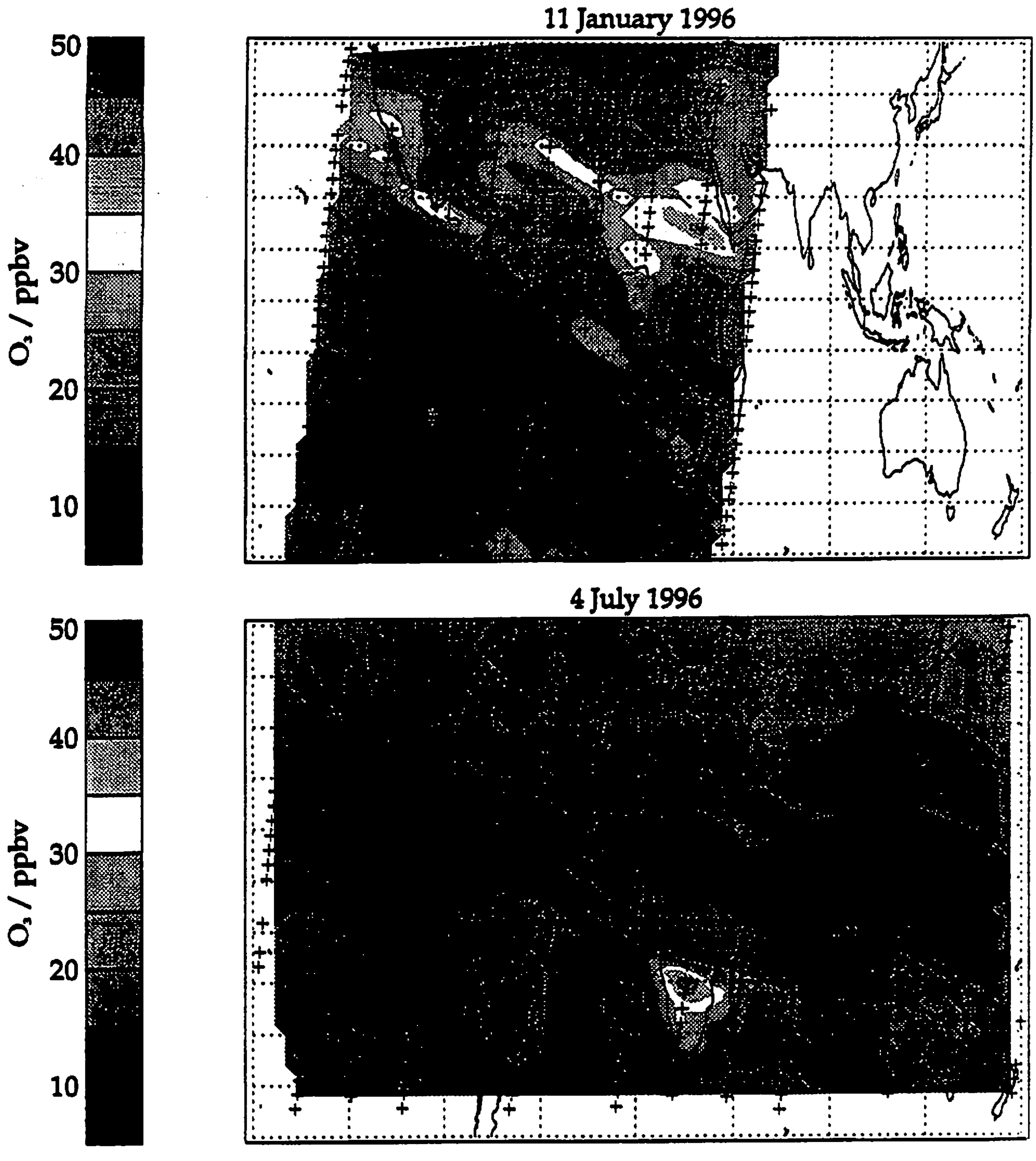
- Cloud information derived from (1 x 1km) ATSR-2 data for GOME
- Similar synergy of AATSR and SCIAMACHY
- Synergy with stratospheric profile information from MIPAS (0_3, H_20 and $N0_2$)

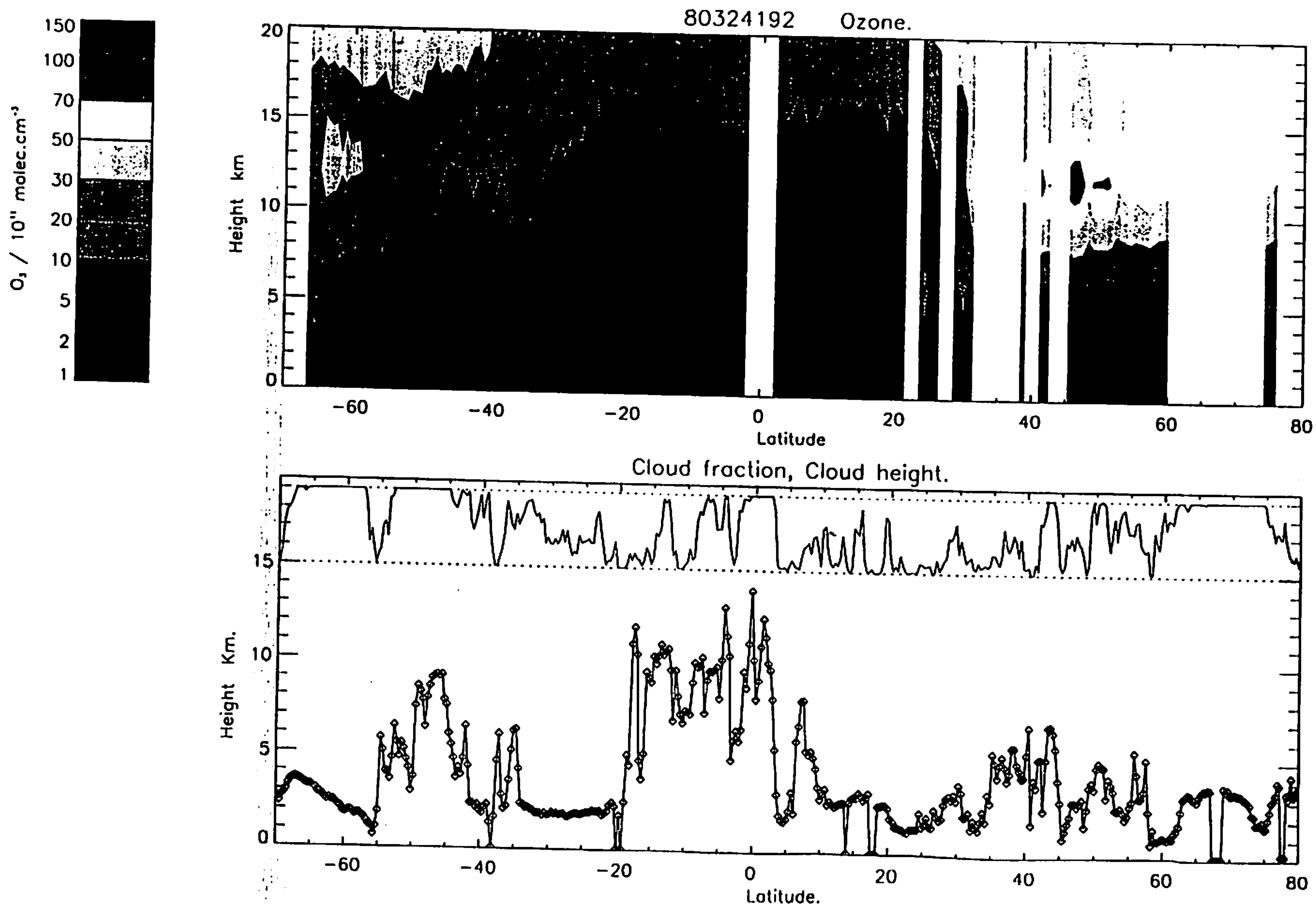
GOME O_3 Retrievals for 8 March 1997



ALL PROD 70308_1


(i) Retrieved ozone
O_3 / 10^{12}molec.cm^{-3}
Altitude / km
(ii) Surface reflectance and Ring effect factor
Surface reflectance
Ring effect factor
Reflectance
Latitude / degrees


11 January 1996
4 July 1996
50
40
30
20
10
O3 / ppbv



R.S. 10:23 18/06/99.

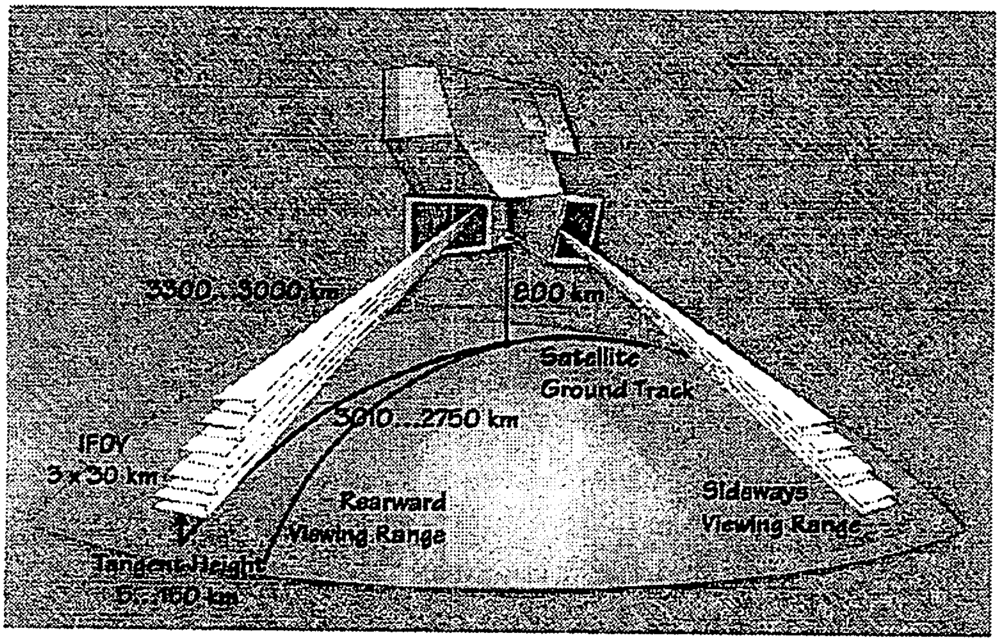
Michelson Interferometer for Passive Atmospheric Sounding

(MIPAS)

Anu Dudhia
Atmospheric, Oceanic and Planetary Physics
University of Oxford

dudhia@atm.ox.ac.uk

(& MIPAS Science Advisory Group)


3300...3000 km
800 km
Satellite
Ground Track
3010...2750 km
IFOY
3 x 30 km
Rearward
Viewing Range
Sideways
Viewing Range
Tangent Height
5...160 km

MIPAS — Measurement Characteristics

Infrared Interferometer

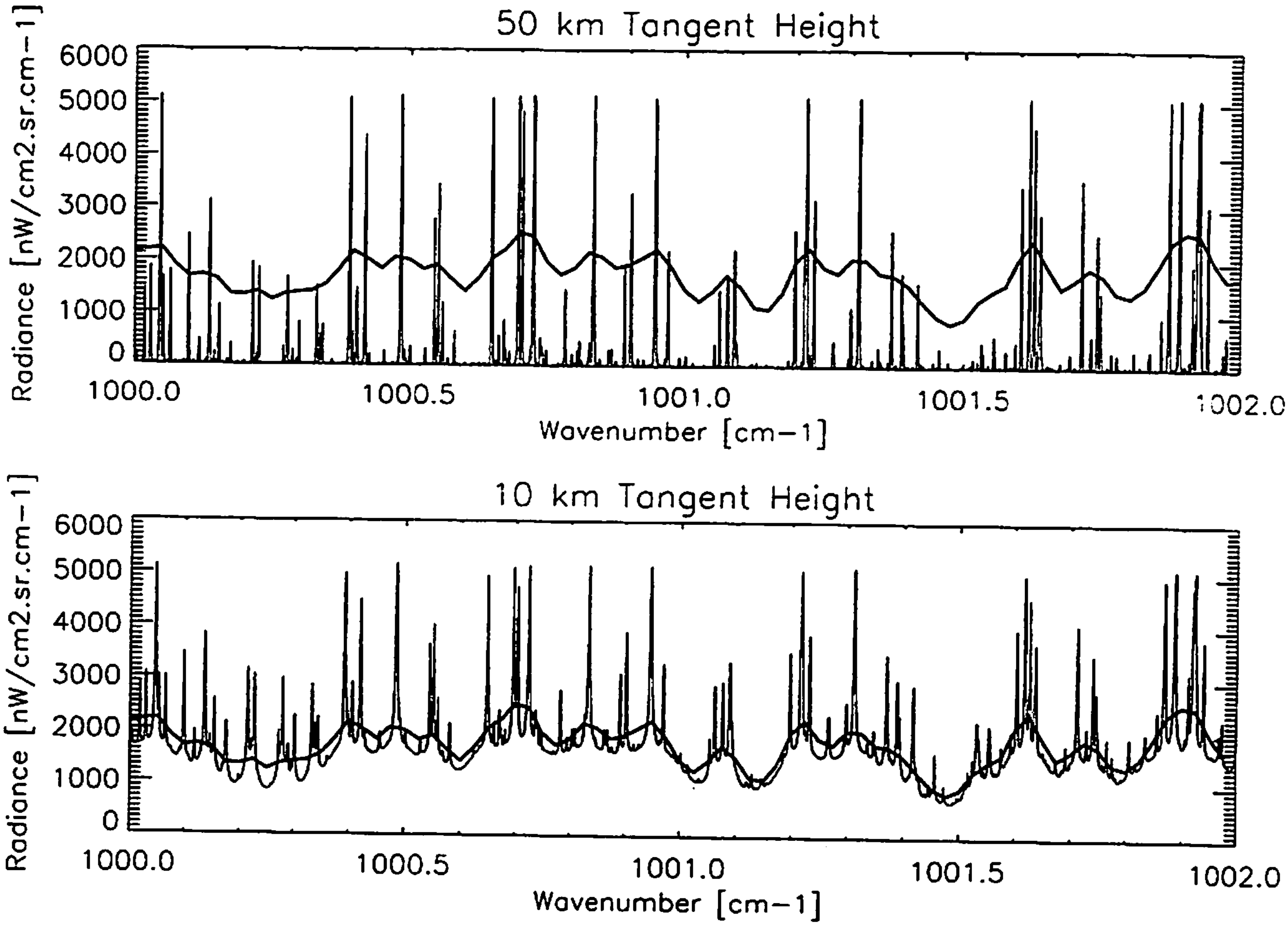
- Acquires spectrum every 4.6 s
- Spectral range 685–2410 cm^{-1} (14.5–4.1 μm), in 5 bands
- Spectral resolution 0.035 cm^{-1} (see plot)
  - ⇒ >50 000 points per spectrum
  - ⇒ Only a few percent of points can be used in operational retrieval (defined by 'microwindows').

Limb-Viewing

- Rear-viewing (nominal), or sideways
- Elevation Scan (Programmable)
  - ◦ Nominally 8–53 km in 16 steps of 3 km
  - ◦ 16 scan steps takes 75 s
  - ⇒ Profile spacing 500 km
- Azimuth scan
  - ⇒ extends coverage to poles

Global Coverage

- Sun-synchronous orbit (99° inclination, 800 km altitude)
- 100 minutes per orbit
  - ⇒ 75 profiles per orbit
  - ⇒ 5° latitude spacing
- 14 orbits/day
  - ⇒ 1100 profiles per day
  - ⇒ 12.5° longitude spacing ($\uparrow + \downarrow$ combined)



50 km Tangent Height
Radiance [nW/cm2.sr.cm−1]
6000
5000
4000
3000
2000
1000
0
1000.0
1000.5
1001.0
1001.5
1002.0
Wavenumber [cm−1]
10 km Tangent Height
Radiance [nW/cm2.sr.cm−1]
6000
5000
4000
3000
2000
1000
0
1000.0
1000.5
1001.0
1001.5
1002.0
Wavenumber [cm−1]

MIPAS — Retrieval Characteristics

Operational products (ESA)

- Near real time
  ⇒ Emphasis on robustness and speed
- Profiles of: T, CH_4, H_2O, HNO_3, N_2O, O_3, (NO_2?)
- 'Global Fit' Retrieval
  ⇒ no explicit *a-priori* profile
- Use of microwindows
  ⇒ random noise errors dominate
- Random error produced with each retrieved profile point
- Covariance matrices produced at intervals.

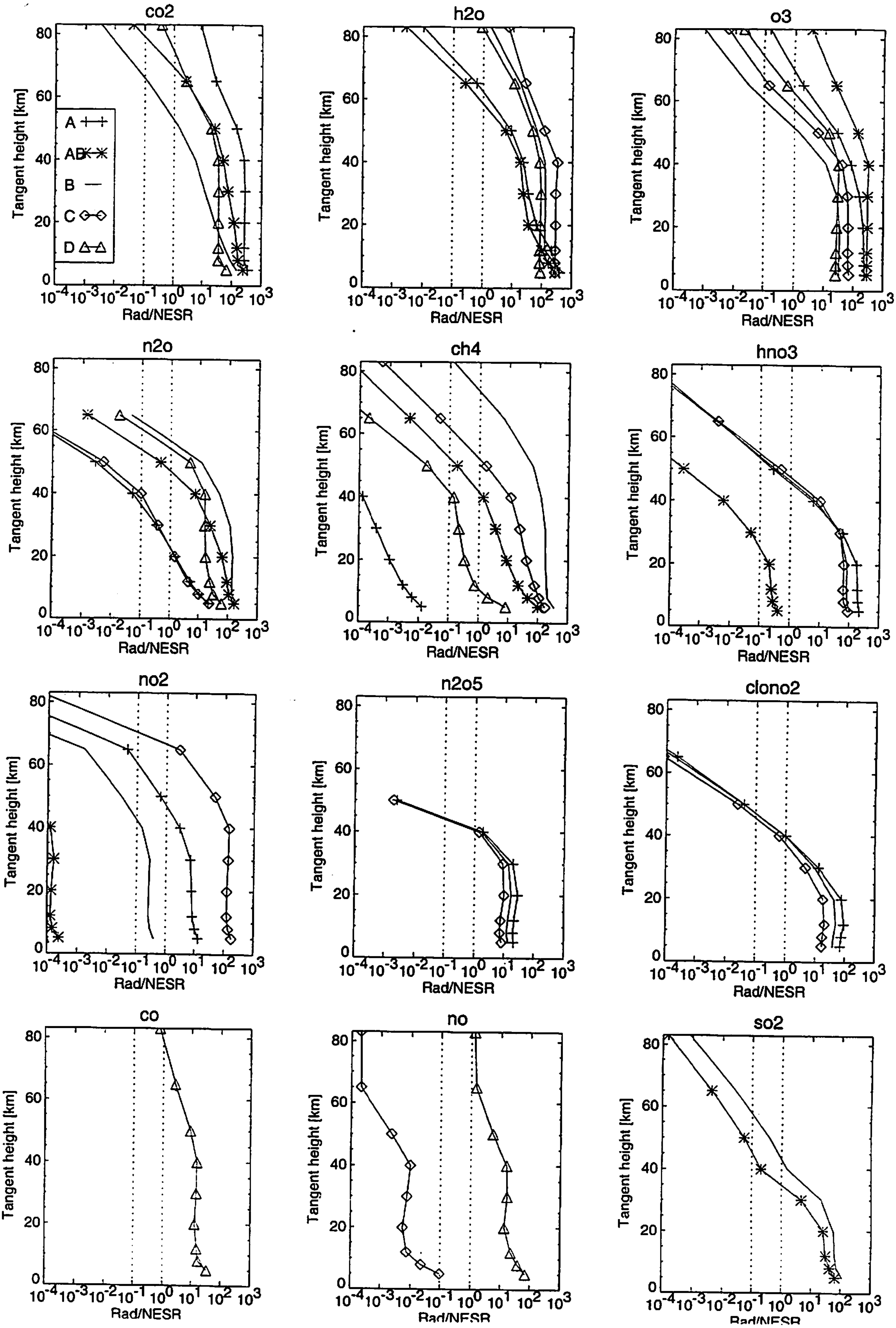
Off-line processor (DLR)

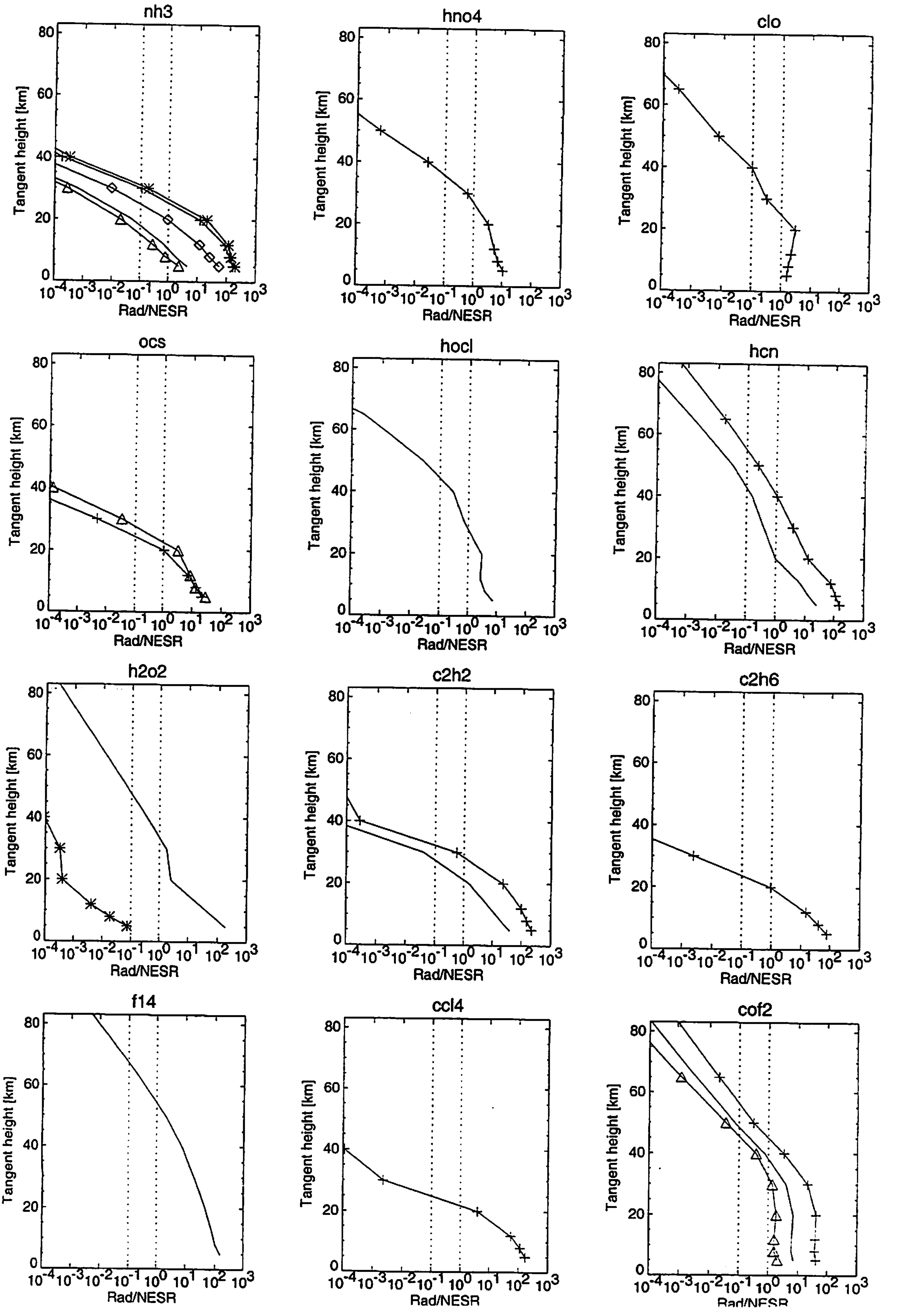
- Details not yet confirmed, probably similar list of products but different retrieval scheme.

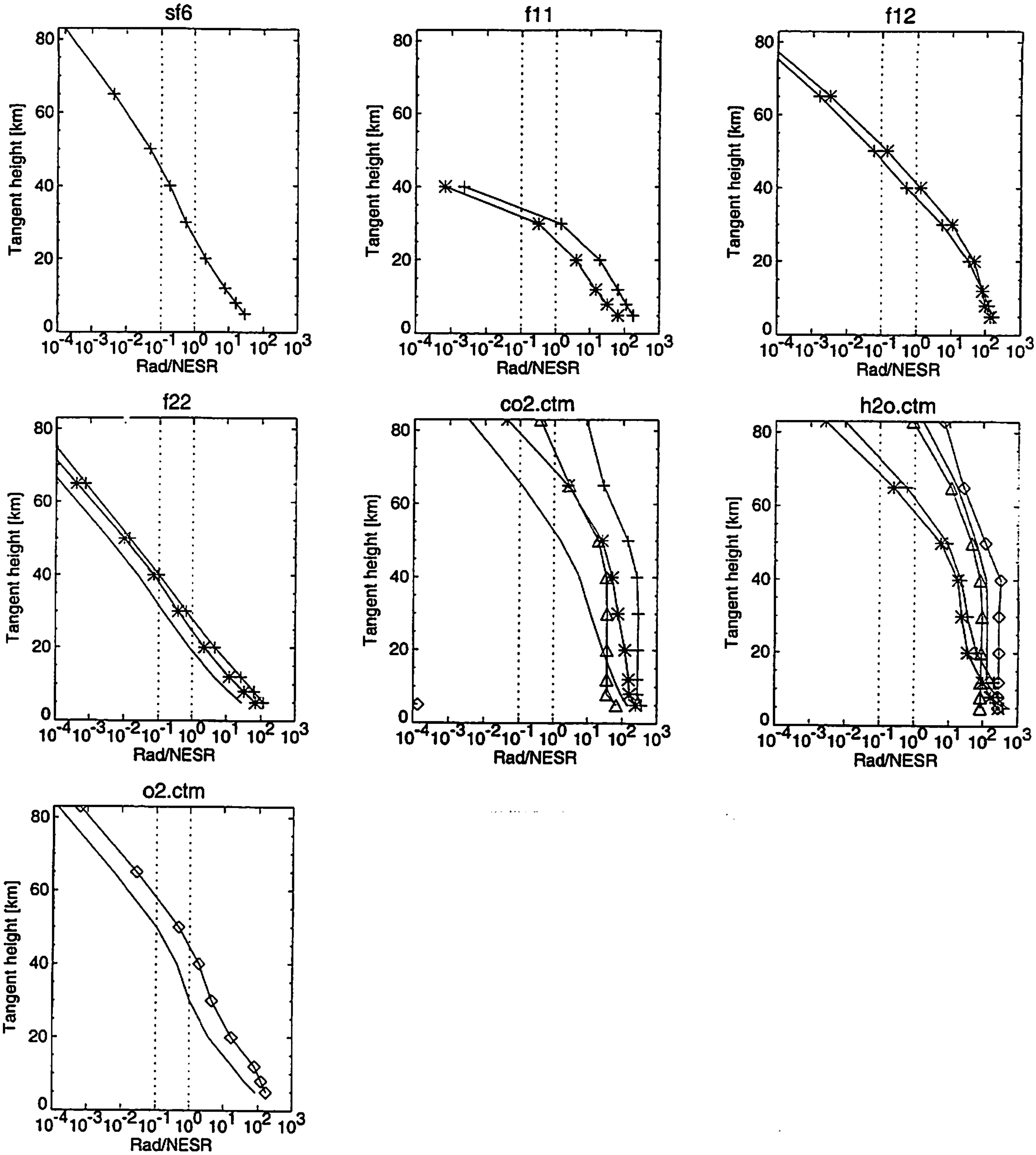
Other products

- 'Research' mode, undertaken by various institutes
- Extended list of species (see plots, by Paul Palmer):
  - Good S/N:
    C_2H_2, $ClONO_2$, CO, F11, F12, F14, HCN, N_2O_5, NH_3, NO
  - Marginal S/N:
    C_2H_6, CCl_4, ClO, F22, H_2O_2, HNO_4, HOCl, OCS, COF_2, SF_6, SO_2,

  NB: S/N is not the only limiting factor
- Use of more spectral information/physics (& cpu):
  - Extended altitude coverage
  - Increased precision
  - Increased vertical resolution (?)


co2
h2o
o3
n2o
ch4
hno3
no2
n2o5
clono2
co
no
so2
Tangent height [km]
Rad/NESR
A
AB
B
C
D


nh3
hno4
clo
ocs
hocl
hcn
h2o2
c2h2
c2h6
f14
ccl4
cof2
Tangent height [km]
Rad/NESR
0
20
40
60
80
10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}


sf6
f11
f12
f22
co2.ctm
h2o.ctm
o2.ctm
Tangent height [km]
Rad/NESR

Overview of ESA Data Policy & UK Envisat Ground Segment

by

Wyn Cudlip

DERA, Farnborough

DERA

Data Policy

- Data Policy is not about how much to charge for products.
- It is a tool to achieve the objectives of the mission.

- The objectives of the Envisat Data Policy are to maximise the beneficial use of Envisat data and to stimulate a balanced development of science, public utility and commercial applications.

Categories of use
(not Category of user!)

Category 1 use:

- Research and applications development use in support of the mission objectives, including research on long-term issues of Earth system science, research and development in preparation for future operational use, certification of receiving stations as part of the ESA functions, and ESA internal use.

  The identification of the Category 1 use is based on approval by PB-EO on the basis of appropriate peer review process.

Category 2 use:

- All other uses, which do not fall into Category 1 use, including operational and other commercial use.

DERA

Categories of use (contd.)

Mechanisms for identifying Category 1 use include:

- ESA announcements of opportunities
- National and European research and application development programmes, subject to agreement with ESA.
- Agreements with external organisations (e.g., international programmes)
- European training and education programmes
- Internal use by ESA, e.g., for calibration

Distribution Policy

- ESA will delegate to distributing entities the responsibility for the marketing and distribution of Envisat products and associated services for Category 2 use.

- ESA will retain overall policy and programmatic responsibility for distribution of Envisat data for Category 1 use and will be the direct provider of the service from its own facilities whenever feasible.

- Users of Category 1 data will obtain data directly from Envisat Processing and Archiving Centres (PACs) via the User Service Facility (USF) web interface

Price Policy

- ESA will fix the price for all Envisat data intended for Category 1 use. The price will be set at or near the cost of reproduction of the data.

- ESA will waive the Category 1 price for approved projects.

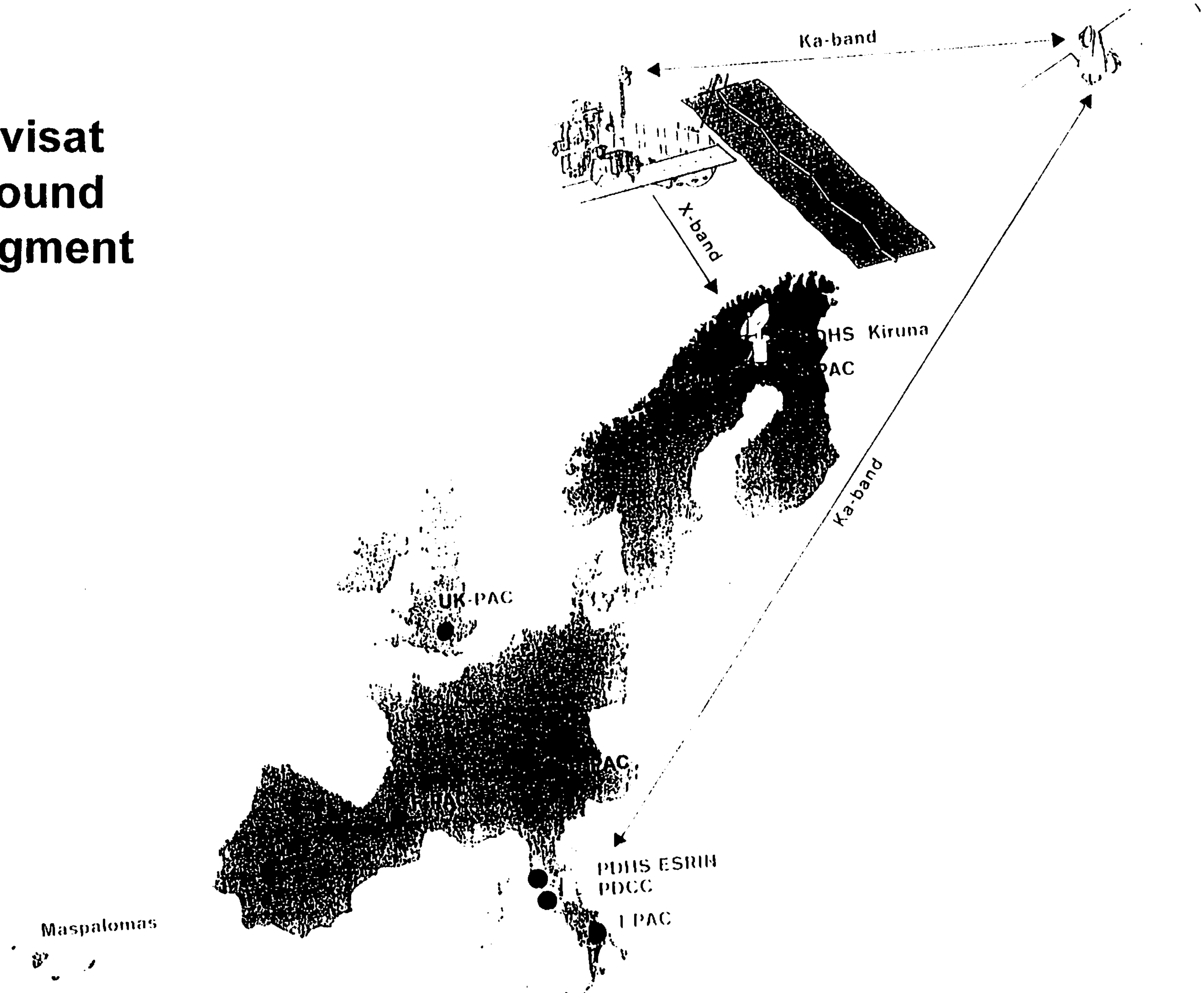
- For Category 2 use, distributing entities will be allowed to set their own prices (with certain limitations).

Envisat Processing and Archiving Centres (PACs)

- UK-PAC - Farnborough : ASAR, MERIS FR, AATSR
- D-PAC - Oberfaffenhofen : ASAR, MIPAS, Schiamachy
- F-PAC - Toulouse : ASAR Wave, RA, MWR
- I-PAC - Fucino : ASAR, MERIS FR
- E-PAC - Maspalomas : MERIS FR
- S-PAC - Kiruna-Salmijarvi : MERIS Reduced Resolution
- F-PAC - Finland : GOMOS (with D-PAC)

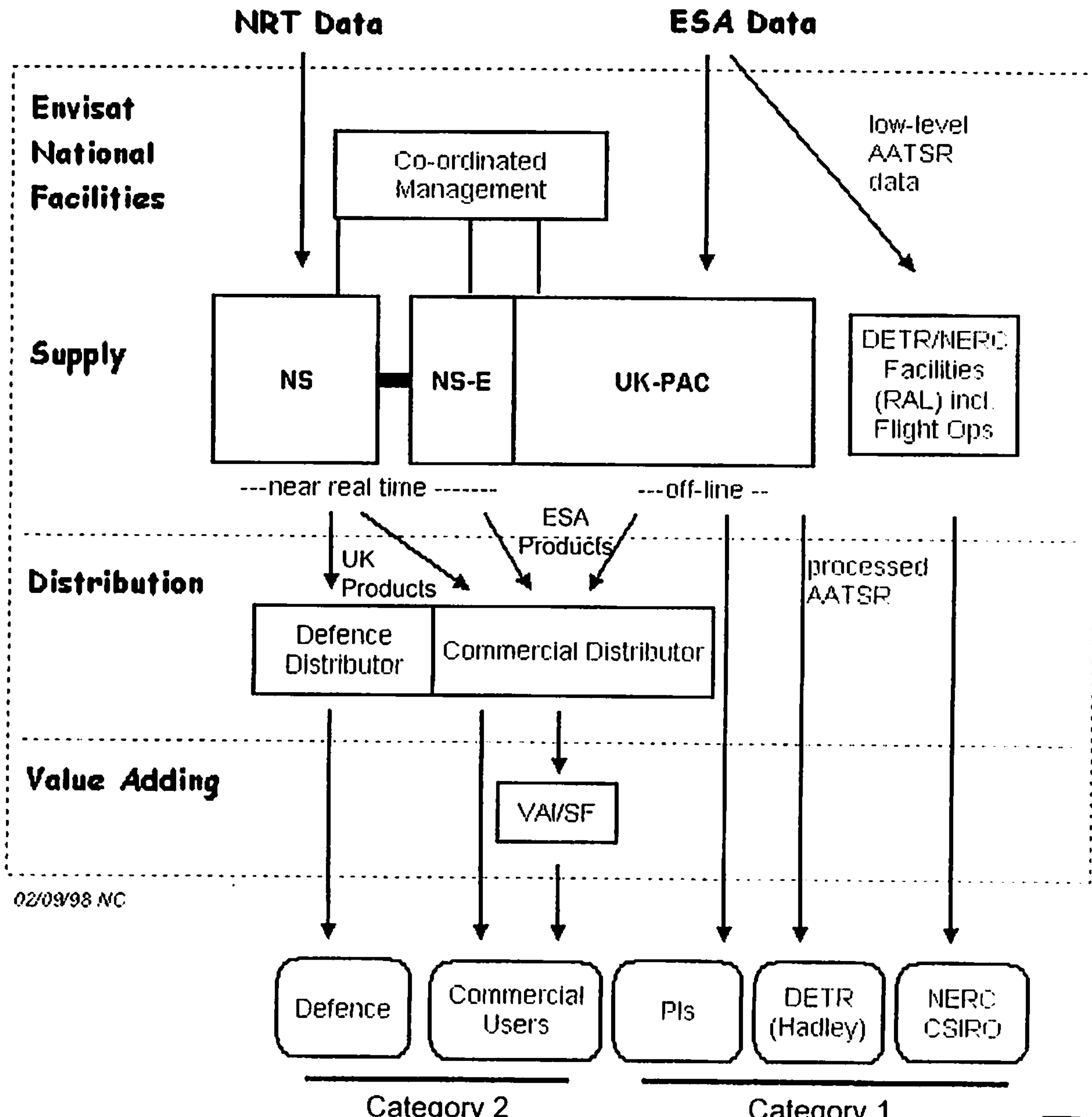
DERA

Envisat Ground Segment



DERA

UK Envisat Ground Segment Concept Model



DERA

Conclusion

- Data Policy is not just about price.

- ESA have defined 2 categories of use
  - Category 1 : "Scientific"
  - Category 2 : "Commercial"

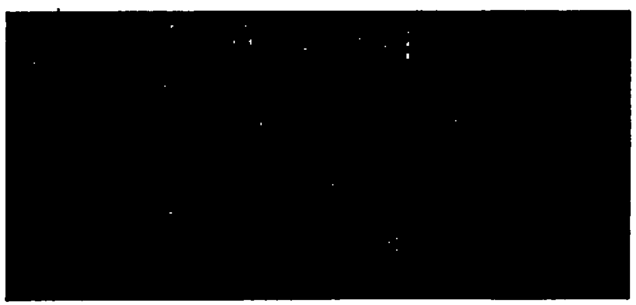
- Data for Category 1 use will be supplied by the PACs
- Data for Category 2 use will be supplied via Distributors

- Data for Category 1 use will be free of charge for approved projects

- NERC Policy -

Using Envisat data for atmospheric applications

Dr Steven Wilson
NERC Earth Observation Programme Manager



Natural Environment Research Council

- to promote and support, by any means, high quality basic, strategic and applied research, survey, long-term environmental monitoring and related postgraduate training in terrestrial, marine and freshwater biology and earth, atmospheric, hydrological, oceanographic and polar sciences and earth observation.

(First bullet of NERC mission statement)

Access to Envisat data by the NERC science community should be on optimal terms

- ESA announcements of opportunity
  - Data is ‘free of charge’
  - ESA requires confirmation of project funding
  - 1st Envisat AO closed June ‘98; next expected ~ 2 years after launch
- All data from GOMOS, SCIA and MIPAS will be made available by ESA under category 1 conditions

Mechanisms for identification of category 1 use (at or near the cost of reproduction)

- Important for instruments other than GOMOS, SCIA and MIPAS, e.g. MERIS, AATSR, ASAR ...
- R/D programmes of participating states (e.g. NERC) can qualify, but ...
  - NERC must demonstrate that it operates a peer review mechanism that is compatible with selection procedures used by ESA
- Large international research programmes
- Training and education

NERC procedure for access to data

- TBD!
- Possible model:
  - NERC initially clear peer review mechanism with ESA
  - Proposal includes ‘category 1’ costs
  - Data request accompanied by statement of peer review
  - Data held by scientist and associated with DDC
  - *Copy of data held by DDC for reuse ?*

Thematic programmes

- Upper troposphere / lower stratosphere ozone programme (UTLS - OZONE) - Open
- Forthcoming programmes:
  - Clouds Water Vapour and Climate (CWVC)
- Under development:
  - Polluted troposphere
  - Upper stratosphere/Mesosphere
- See http://www.nerc.ac.uk for further details

NERC Earth Observation activities

- NERC EO activities pre '94
  - Airborne Remote Sensing Facility (ARSF)
  - Dundee Satellite Receiving Service (DSRS)
  - Equipment Pool for Field Spectroscopy (EPFS)
  - Remote Sensing Applications Development Unit (RSADU)
  - NERC Unit for Thematic Information Systems (NUTIS) → ESSC
- Combined with SERC activities in 1994; EO Programme
  - Instrument build/Post launch support - ATSR, HIRDLS, GERB
  - Understanding observations; new techniques; RAL programme
  - EOSI (Fellowships, lectureships, infrastructure ...)
- New EO strategy and programme '98/'99
  - Greater emphasis on exploitation of data from EO missions and preparation for future mission
  - Cross-board strategy; integrate use of EO within the environmental science programme at NERC

Strategy

- NERC programme in EO will aim to:
  - Allow NERC scientists to take advantage of new observations throughout the world
  - Determine what observations are required, if necessary by contributing novel instrumentation for solving scientific problems
  - Strengthen the NERC community to do both of these effectively
- Maintain and grow relationship with DTI
  - BNSC EO programme has strong links to UK priorities in environmental research
  - DTI through BNSC have national responsibility for scientific space hardware
  - With DTI support, NERC have influenced key ESA programmes

Implementation

- Centres of excellence
  - To act as kernels in the development of the use of EO data
- New observing techniques
  - In preparation for future ESA 'opportunity missions'
- EOSI
  - Fellowships, short courses and special awards
- Developing the understanding of new observations
  - Through S&TB thematic programmes

BADC policy

Dr L Grey, RAL

British Atmospheric Data Centre

Who Are We?

NERC Designated Datacentres

- Antarctic Environmental Data Centre, BAS
- British Atmospheric Data Centre, RAL
- British Oceanographic Data, Birkenhead
- Environmental Information Centre, ITE
- National Geosciences Information Service, BGS
- National Water Archive, IH Wallingford
- NERC Earth Observation Data Centre, RAL

British Atmospheric Data Centre

What do we do?

NERC Review Recommendations

1. Support for NERC Field Programmes
2. Meteorological Data Supply
3. 'Data brokerage'
   - WWW links
   - CD-ROM collection
   - 3rd party satellite data

British Atmospheric Data Centre

Met. Data

UK Meteorological Office Data

- climate station data
  - 1959 onwards;1000 UK stations
- synoptic station data
  - UK + Europe; 220 stations; 1990 onwards
- radiosonde data
  - UK 1990 onwards; world-wide 1998 onwards
- model data : UKMO 'assimilated' data
  ECMWF Reanalysis + operational data

Trajectory service

British Atmospheric Data Centre www.badc.rl.ac.uk

Welcome to the World Wide Web server of the British Atmospheric Data Centre at the Rutherford Appleton Laboratory

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Help for the new user

The BADC and its Services

How to get data from the BADC?

Access to data and sources of information

→ BADC Datasets and Information

→ Extensive Links to other sites on the World Wide Web

Earlier News Items, Seminar Schedules, Conference Calendar, Acronyms and Abbreviations List

Latest News -*13th May 1999*: Searchable UKMO Met. Office Stations Catalogue now Available

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Keeping In Touch

Your feedback and comments

Who to contact for further information?

Last Modified : 4th February 1999
BADC Support Line, BADC@rl.ac.uk

UKMO - Global Radiosonde Data (1997 - Present)

Introduction

This dataset consists of radiosonde data from stations worldwide. Stations are categorised into 7 regions: Africa, Asia, South America, North and Central America, South-West Pacific, Europe, and Antarctica, respectively. A clickable world map is available to view worldwide radiosonde station lists. European radiosonde data for the period 1990 to June 1998 are also available.

The data comprise vertical profiles of temperature, dew-point temperature, wind speed and wind direction at standard and significant pressure levels. The standard pressure levels are 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20 and 10 mb. Significant pressure levels are calculated according to the Met. Office criteria and constitute levels at which significant events occur in the profile for example turning points.

The period of coverage is 1997 to present. Stations conduct ascents up to four times daily at the synoptic hours of 00, 06, 12, 18 GMT.

Restricted Data

The Met. Office wish to monitor the use of this data and require an acknowledgement of the data source if they are used in any publication. For these reasons we do not make the data available to anonymous users through these WWW pages.
In order to gain access to the data and accompanying software, please complete and sign the conditions of use form. You will then be given FTP access to the data directories from an account on a BADC computer. Please note that the UK Meteorological Office data sets are available **for *bona fide* academic research only**.

Access to Data

Your application for accessing the Radiosonde data will be processed within a day of receipt. *Provided your application is complete and fully meets the Met. Office conditions*, an account will be established and an email message inluding your account details will be sent to you.

You can then access the data via FTP using your account on tornado - the BADC file server. The data are located in the directory /badc/ukmo-rad/. There you will find a README file to guide you through the tree structure and the data directory.

The data held at the BADC, are stored in a simple ASCII format (plain text and "human" readable). A simple data file format has been adopted. Note that the data format for the UK and European radiosonde dataset is slightly different (see UK and European Radiosonde file format). Units are also different.

Documentation

The BADC provides a comprehensive help file which contains background information to help you use the UKMO radiosonde station data held at the BADC.

References

A list of other references is currently under construction.

Links to Further Information

Additional January and February 1997 Radiosonde data can be obtained from the FASTEX (Fronts and Atlantic Storm Track EXperiment) Central Data Archive via the web at http://www.cnrm.meteo.fr:8000/dbfastex/.

The UK Met. Office maintains web pages on EUMETNET (Rawinsonde Network Information, Operational problems and Research and Development) and individual member countries.

To Search for other data or information, visit our search facilities.

A list of other UK Met. Office datasets held at the BADC may be browsed.

Who to Contact

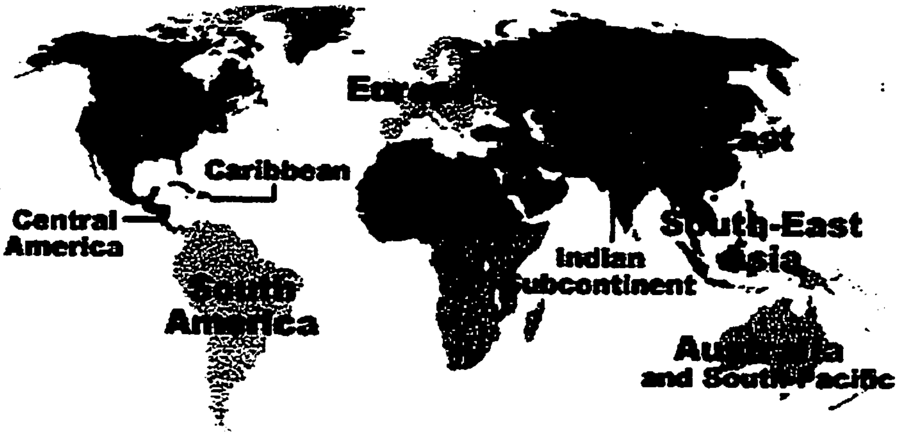
If you have queries about these pages or about obtaining the radiosonde station data from the BADC then you should contact BADC Support. Your query should be answered within one working day. When follow-up work is required, the BADC support will carry out the work as quickly and efficiently as possible, and in any case, the user will be kept informed of progress.

Last Modified: 6th October 1998

Global Radiosonde Map

British
Atmospheric
Data
Centre

Click on the geographical area of interest on the map (e.g. North America or Antarctica) to view the radiosonde station list in the selected region.



Antarctica

Last Modified: 6th October 1998
Anabelle Ménochet

Upper Air Station List in North and Central America

This file contains a master list of upper air stations in North America from which data is available. Please note that some north american upper air stations may also be found in the /unknown directory.

REGION 4: NORTH AND CENTRAL AMERICA

WMONO	STATION NAME	LAT.	LONG.	ALT.

BAHAMAS

/badc/ukmo-rad/data/standard/1997-now/bahamas/

WMONO	STATION NAME	LAT.	LONG.	ALT.
78073	Nassau intl airport	25.03N	7.728W	7m

BARBADOS

/badc/ukmo-rad/data/standard/1997-now/barbados/

WMONO	STATION NAME	LAT.	LONG.	ALT.
78954	Grantley Adams intl	13.04N	59.29W	56m

BELIZE

/badc/ukmo-rad/data/standard/1997-now/belize/

WMONO	STATION NAME	LAT.	LONG.	ALT.
78583	Belize intl airport	17.32N	88.18W	5m

Note: More stations also available in the unknown list (/badc/ukmo-rad/data/stand

BRITISH DEPENDENT TERRITORY - BERMUDA

/badc/ukmo-rad/data/standard/1997-now/bermuda/

WMONO	STATION NAME	LAT.	LONG.	ALT.
78016	Bermuda NAS/kindley	32.22N	64.41W	3m

BRITISH DEPENDENT TERRITORY - CAYMAN ISLANDS

/badc/ukmo-rad/data/standard/1997-now/cayman_islands/

WMONO	STATION NAME	LAT.	LONG.	ALT.
78384	Owen Roberts intl	19.17N	81.21W	3m

ECMWF Operational Analysis data

Introduction

Operational analyses from the European Centre for Medium-Range Weather Centre (ECMWF) are available through BADC for the period since March 1994. The data is updated monthly, two to three weeks after the end of the month, e.g data for June becomes available soon after mid July. Vorticity, divergence, temperature, surface pressure and vertical velocity data in T106 spectral form plus specific humidity on a gaussian N80 grid are available on the original model levels and also interpolated to standard pressure levels. Surface data such as temperature, soil wetness, snow depth etc are also available on the gaussian grid.

Although the ECMWF model is run at T213 (N160) resolution for this period the data available through the BADC are at T106 (N80) resolution for consistency with the ECMWF Reanalysis project (ERA) data and in order to reduce storage requirements. This dataset therefore complements and updates the ERA dataset, which is also available through the BADC.

Data on a lat-long grid is also available, see ECMWF gridded dataset

Restricted data

These data are for bona fide research purposes only and access is therefore restricted. *Note that the ECMWF data is only available via the meteorological organisation in your own country. The BADC distributes in the UK for the UK Meteorological Office.* For this reason, we do not make the data available to anonymous users through these WWW pages.

In order to gain access to the data, please complete and sign the conditions of use forms. You will then be given access to the data from an account on one of the BADC's computers.

Data Access

The data are held at RAL in their original GRIB format. Software to read the data is also available. The data can be accessed using an account on Tornado, the BADC's UNIX machine, or via the RAL Cray if you already have an account there.

An ECMWF picture gallery is available to view some sample data.

Documentation

When you register to use the ECMWF operational data we will send you a documentation pack including ECMWF documents such as the "User guide to ECMWF products" plus hardcopies of the BADC's online documentation on the structure and content of the data files and how to retrieve archived data etc. Registered users can also receive e-mail reports giving the latest status of the archived data and other services. Since the operational and ERA datasets are similar, the following help files will also be of interest:

- Description of the ERA data archived by the BADC
- References

Links to further information.

We maintain a set of links to ECMWF-related information on WWW, including the ECMWF welcome page. You may also find information from the BADC external links page. The BADC holds other ECMWF datasets: ECMWF Re-Analysis (ERA), ECMWF 2.5 degree gridded data, ECMWF derived products and ECMWF trajectory data.

Who to contact

If you'd like to know more about ECWF Operational data and how to obtain it from the BADC, you should contact us via the BADC support line.

Last updated 23th Mar. 1998
by Sam Pepler.
http://www.badc.rl.ac.uk/data/ecmwf-op/

NDSC

NDSC: The Network for the Detection of Stratospheric Change

BADC = designated "mirror" datacentre.

Introduction

The BADC is the Official UK mirror site for the data of the Network for the Detection of Stratospheric Change (NDSC) - an international activity whose principal goal is to allow the earliest possible identification of long-term changes in the stratospheric ozone layer and to establish the causes of such change.

This aim is to be achieved by means of high quality measurements of a wide range of stratospheric chemical species and parameters derived from instruments operated at a number of ground stations around the world. At the moment there are five primary stations in the Arctic, Antarctica, Hawaii, New Zealand and Alpine Europe. With the exception of the New Zealand station, these are all composite stations which consist of more than one measurement site. In addition to the primary stations there are numerous complementary stations providing additional measurements.

The data held at the BADC consist of vertical column abundances and vertical profiles of stratospheric parameters. These data are held in the original NASA Ames format. In addition vertical profiles of geopotential height and temperature from the NCEP analyses are available above the NDSC measurement sites.

Restricted Data

The use of these data is currently restricted under the NDSC data protocol to NDSC investigators - Principal investigators (PIs), co-investigators and complementary investigators (CIs).

After the data have been validated it is expected that they will become publicly available.

Access to Data

The BADC holds NDSC data in "NASA Ames" format - an ASCII based file format which incorporates a number of self describing data formats. This file format, which has been used by a number of measurement campaigns is documented by Gaines and Hipskind.

The data can be retrieved by FTP from a named BADC computer account. If you would like access to the data, please contact the BADC support line.

We provide:

- help on acquiring and using the data files.

BADC Archive Directories

Directory: /badc/ndsc/data/stations

British Atmospheric Data Centre

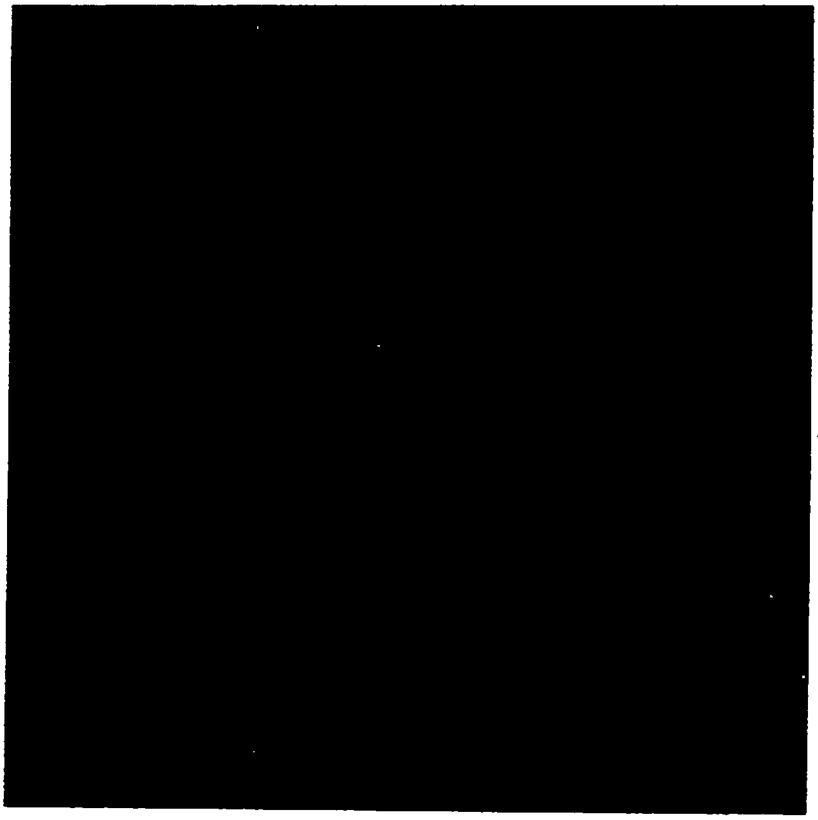
/badc/ndsc/data/stations

Parent directory (/badc/ndsc/data)

Current directory (/badc/ndsc/data/stations)

- aberdeen
- aberyst
- andoya
- arrival
- bandung
- bern
- bordeaux
- campbell
- dumont
- eureka
- faraday
- garmisch
- halley
- harestua
- jungfrau
- kiruna
- kiso
- lauder
- lerwick
- maunakea
- maunaloa
- mcmurdo
- moshiri
- nyalsund
- ohp
- pldebure
- reunion
- rikubets
- rothera
- scoresby

NDSC Arctic Stations



Station	Longitude	Latitude	Abbreviation
Eureka	-86.4	80.1	eu
Ny Aalesund	11.9	78.9	ny
Thule	-68.7	76.5	th
Sondre Stromfjord	-50.7	67.0	ss

Last Modified: Thu Aug 14 19:29:44 1997
Simon Williams

Query results

UARS

Searched for: 'uars' in: **all** New Query
Matching datasets: 6

Online cd-rom Tape/near-line tape vhs video

Not available anonymously; BADC account required

Cryogenic Limb Array Etalon Spectrometer (CLAES)
Catalogue record *Dataset web page* *Data directory*

An instrument on board the UARS satellite which measured global temperature, pressure, O3, H2O, CH4, N2O, NO, NO2, N2O5, HNO3, ClONO2, CFCl3, CF2Cl2 and aerosol extinction. Data are level 3A product (gridded in time and latitude along the satellite track) between 80N - 80S, 10-60Km, October 1991 - May 1993. Data are version 8. This dataset is public.

Halogen Occultation Experiment (HALOE)
Catalogue record *Dataset web page* *Data directory*

Instrument on board the UARS satellite which used solar occultation technique to measure global stratospheric and mesospheric profiles of pressure, temperature, O3, HCl, HF, CH4, H2O, NO, NO2 and aerosol extinction. Approx. 30 sunset and sunrise profiles per day between 80S and 80N. October 1991 - present. Data are level 2 products i.e. profiles at actual measurement location and not interpolated in horizontal. Data are version 18. Access permission required so that PI can monitor usage of data.

Improved Stratospheric and Mesospheric Sounder (ISAMS)
Catalogue record *Dataset web page* *Data directory*

Instrument on board the UARS satellite which measured global stratospheric and mesospheric temperature, CO, H2O, CH4, O3, HNO3, N2O5, NO, NO2, N2O and aerosol extinction. Gridded, global measurements between 80S and 80N, October 1991 - July 1992. Data include both level 2 product (profiles at actual measurement locations) and level 3A product (gridded in time or latitude along the satellite track). Data are version 9/10. ISAMS level 3 is public.

Microwave Limb Sounder (MLS)
Catalogue record *Dataset web page* *Data directory*

Instrument on board the UARS satellite which measured global ClO, O3, H2O, temperature and SO2. Data are level 3A product (gridded in time or latitude along the satellite track) between 80S - 80N, approx. 10-60 Km, October 1991 - present. Data are version 4 and public.

Microwave Limb Sounder (MLS) prototype H2O data
Catalogue record *Dataset web page* *Data directory*

Prototype water vapour profiles from the MLS data, retrieved at the University of Edinburgh. Data generally cover wider altitude range than "official" MLS version 4 retrievals and are available at a higher vertical resolution. Coverage is from September 1991 to April 1993.

UKMO - UARS Assimilated Data
Catalogue record *Dataset web page* *Data directory*

Sets of global meteorological analyses comprising 3-dimensional fields of temperature, geopotential height and wind components at 2.5 x 3.75 degree resolution from the ground to 0.3 hPa. Data are produced by the UK Meteorological office (UKMO) primarily to provide independent correlative data for instruments on the Upper Atmosphere Research Satellite (UARS) and are generated using data from operational meteorological observations. Timespan of dataset is October 1991 - present day. Software provided for deriving potential vorticity. CD-ROM set available containing whole dataset. GIF plot files of temperature, geopotential height and PV on standard levels also available. Access permission required so that PI can monitor usage of data.

Please report any problems with this page to:
Andrew Harwood

TOMS
SAGE
GOME (vertical profiles coming soon).

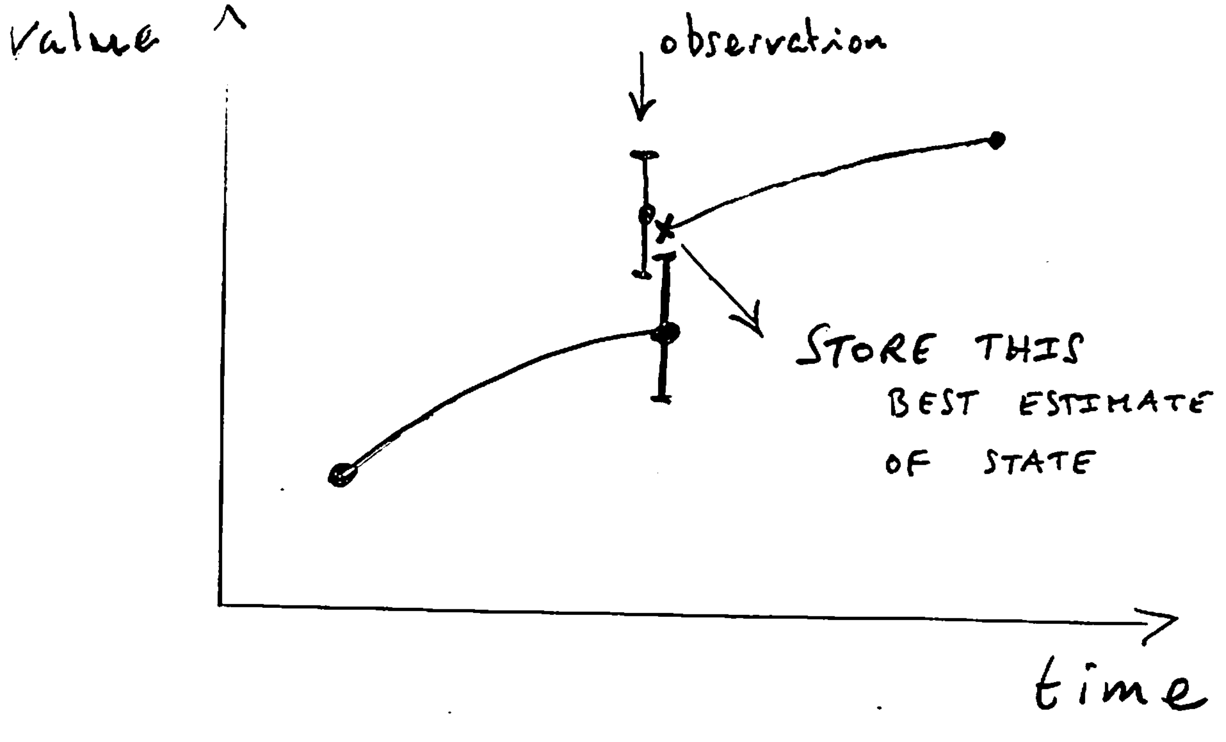
Use of the technique of data assimilation in Earth Observation and Climate Research

Alan O'Neill and William Lahoz

NERC Centre for Global
Atmospheric Modelling,
University of Reading, UK

What is Data Assimilation?

Data assimilation is the technique whereby observational data are combined with output (forecast fields) from a dynamical (i.e. ***evolving****) numerical model to produce an* ***optimal*** *representation of the* ***evolving*** *state of the atmosphere.*

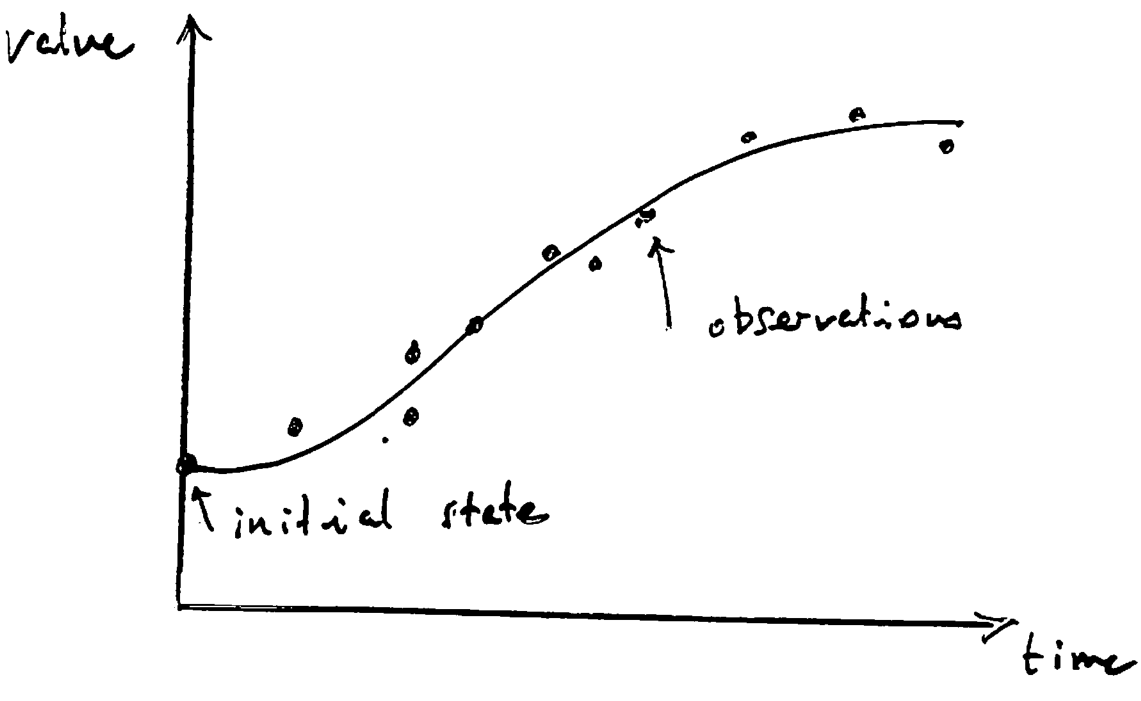


Benefits of Data Assimilation

- *Quality control*
- *Combination of data*
- *Errors in data and in model*
- *Filling in data-poor regions*
- *Designing observational systems and networks*
- *Maintaining physical and chemical consistency*
- *Estimating unobserved quantities*

Data Assimilation techniques

- *optimum interpolation (**OI**)*
- *three-dimensional variational assimilation (**3DVAR**)*
- *four-dimensional variational assimilation (**4DVAR**)*



- Kalman filter method

DARE: Data Assimilation in Readiness for Envisat

DARE is a EU-funded concerted action programme among whose objectives are:

- to co-ordinate the interaction between European groups in order to build a capability in data assimilation to process Envisat data for the atmosphere, and thereby to improve the quality and cost-effectiveness of the data.

- to identify data products that can be produced by data assimilation to facilitate the exploitation of Envisat data by a diverse user community

Co-ordinators

William Lahoz
Alan O'Neill

Partners

NERC Centre for Global Atmospheric Modelling, The University of Reading, UK

U.K. Meteorological Office, Bracknell, UK

Université Pierre-et-Marie Curie, Paris, France

Koninklijk Nederlands Meteorologisch Instituut, De Bilt, The Netherlands

Institut für Geophysik und Meteorologie der Universität zu Köln, Germany

Data Assimilation: The Future

- *Data assimilation is an essential tool for the full exploitation of research satellite data*

- *Ideally, research satellite data will be used in real time for operational use at some stage of the instrument lifetime*

Modelling of Stratospheric Chemistry Using Space-borne Data

Martyn Chipperfield

University of Leeds, U.K

- Atmospheric 3D Models
- Example from past satellite missions:
  - ClO in polar regions
  - Seasonal variations (e.g. O_3)
  - Long term trends/variability (e.g. O_3)
  - Filamentary structures
  -
- Studies for Envisat:
  - 3D modelling
  - Data assimilation

Three-Dimensional Chemical Models

3D Off-line chemical transport models:

- Dynamics constrained (forced by meteorological analyses (e.g. UKMO, ECMWF))
- Chemistry calculated.
- Detailed stratospheric chemistry scheme.
- Resolution variable: e.g.,
  - $7.5^o \times 7.5^o \times 2.5$ km for multiannual simulations.
  - $1.5^o \times 1.5^o \times 1.5$ km for a few weeks.

Example Datasets

Instrument	Platform	Dates	Species
TOMS	Nimbus 7	1979 - 1993	Column O_3
TOMS	Meteor-3	1993 - 1994	Column O_3
TOMS	Earth Probe	1997 -	Column O_3
MLS	UARS	1991 - now	O_3, H_2O, HNO_3, ClO, SO_2
HALOE	UARS	1991 - now	O_3, H_2O, CH_4, HF, HCl, NO
ISAMS	UARS	1991 - 1993	O_3, N_2O_5, HNO_3, ...
CLAES	UARS	1991 - 1993	O_3, N_2O_5, HNO_3, $ClONO_2$
GOME	ERS-2	1995 -	O_3, H_2O, NO_2, BrO
ILAS	ADEOS	1996 - 1997	O_3, N_2O, HNO_3, ...
ATMOS	Space Shuttle	5 day missions	O_3, (loads more)
CRISTA	Space Shuttle	5 day missions	O_3, HNO_3 ...(many)

ADEOS: Advanced Earth Observing Satellite

ATMOS: Atmospheric Trace Molecule Spectroscopy Experiment

CLAES: Cryogenic Limb Array Etalon Spectrometer

CRISTA: Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere

GOME: Global Ozone Monitoring Experiment

HALOE: Halogen Occultation Experiment

ILAS: Improved Limb Atmospheric Spectrometer

ISAMS: Improved Stratospheric and Mesospheric Sounder

MLS: Microwave Limb Sounder

TOMS: Total Ozone Mapping Spectrometer

UARS: Upper Atmosphere Research Satellite

ClO in Polar Lower Stratosphere

ClO destroys O_3 in polar spring through:

$$\begin{aligned}
\mathrm{ClO + ClO + M} &\rightarrow \mathrm{Cl_2O_2 + M} \\
\mathrm{Cl_2O_2 + h\nu} &\rightarrow \mathrm{ClO_2 + Cl} \\
\mathrm{ClO_2 + M} &\rightarrow \mathrm{Cl + O_2 + M} \\
\mathrm{2(Cl + O_3} &\rightarrow \mathrm{ClO + O_2)} \\
\mathrm{net: 2O_3} &\rightarrow \mathrm{3O_2}
\end{aligned}$$

ClO has a diurnal variation:

$$\text{ClO (day)} \leftrightarrow \text{Cl}_2\text{O}_2 \text{ (night)}$$

Microwave Limb Sounder (MLS) compared with 3D model:

- Model sampled at same 'local solar time'
- Good qualitative agreement
- Theoretical studies showed version 3 MLS ClO too large
- Version 5 ClO data now (independently) improved

MLS DATA

Lower Stratospheric ClO in 1992-93 NH Winter

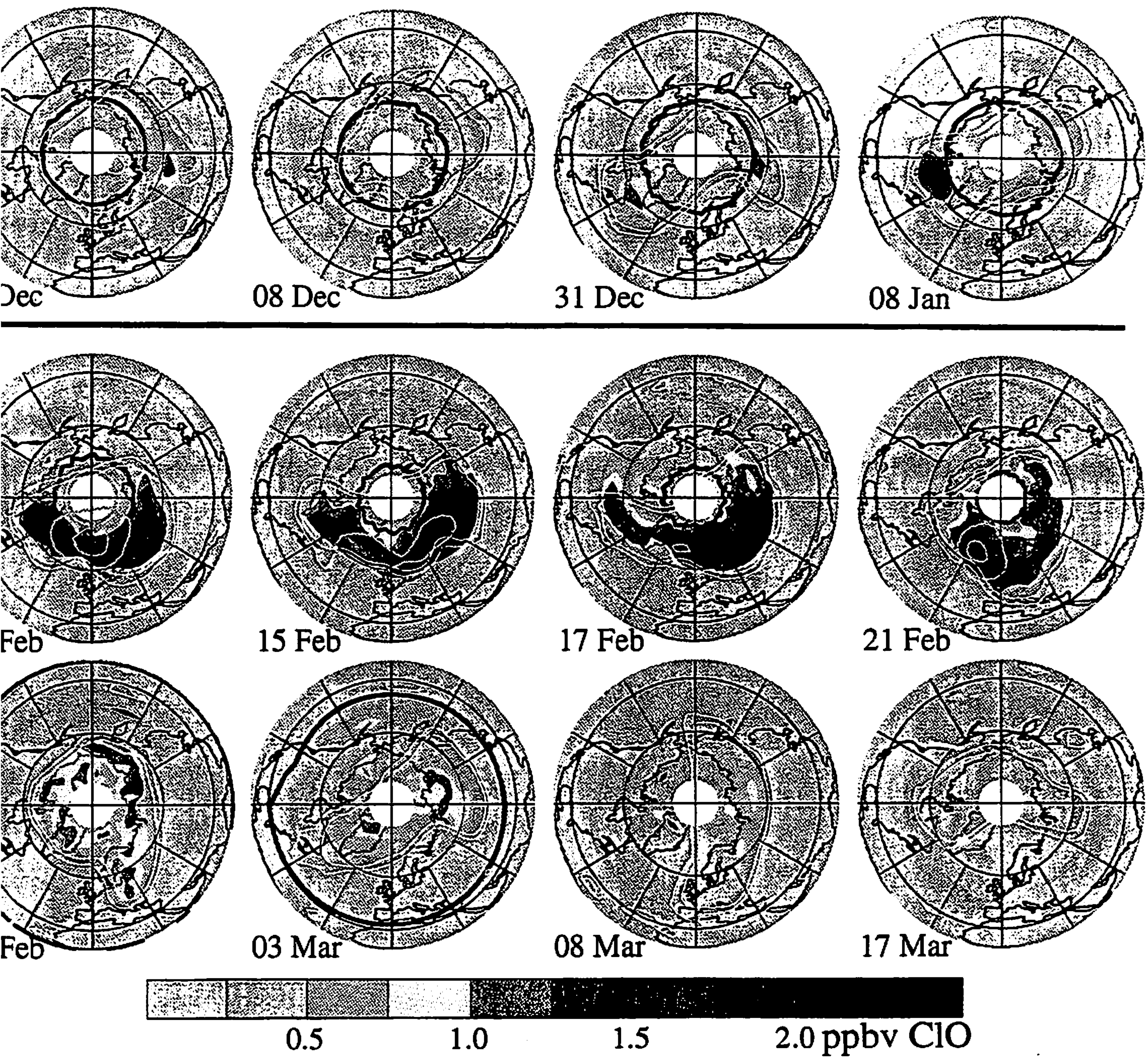
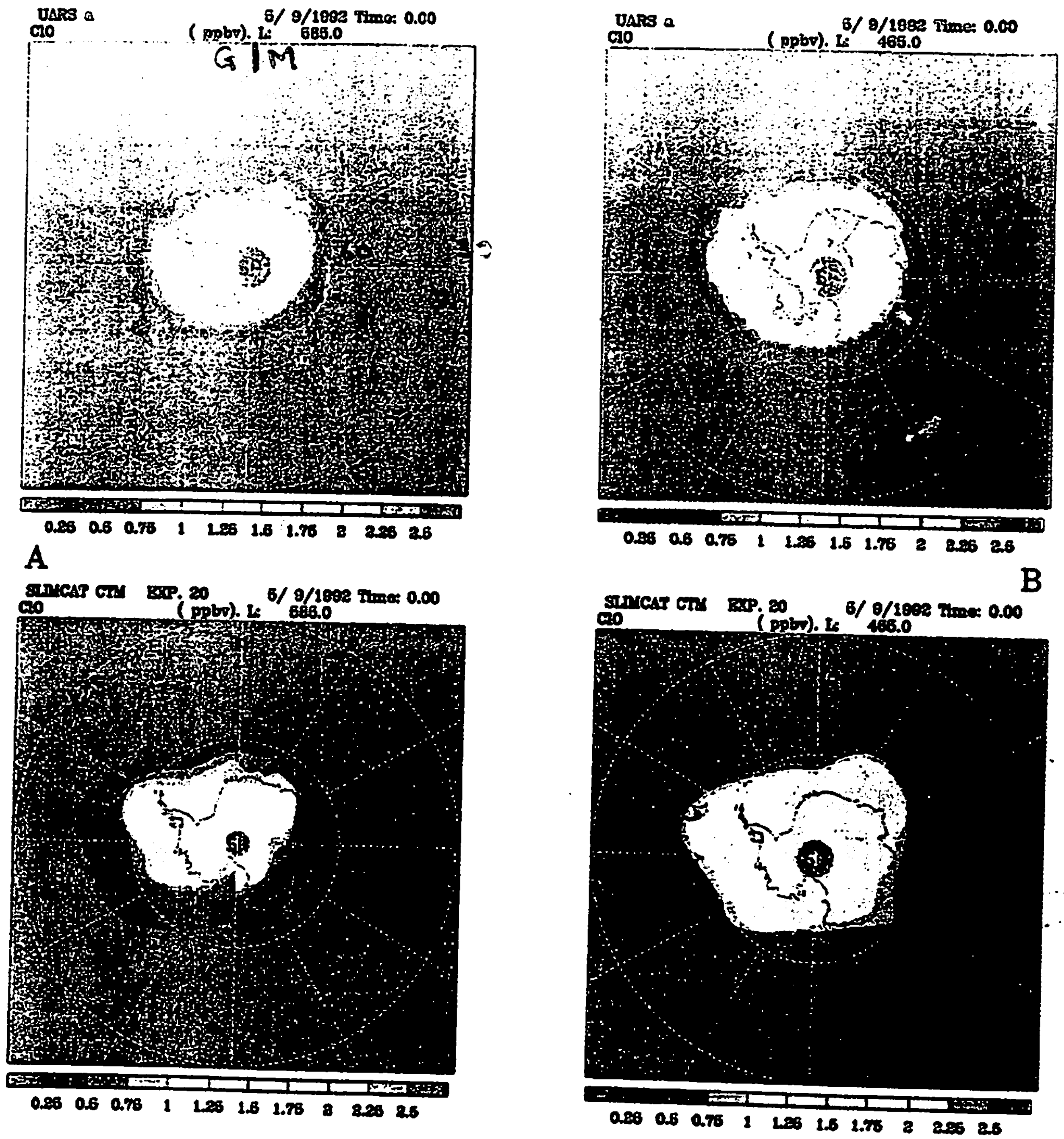


FIG. 2

5/9/1992 ClO Antarctic

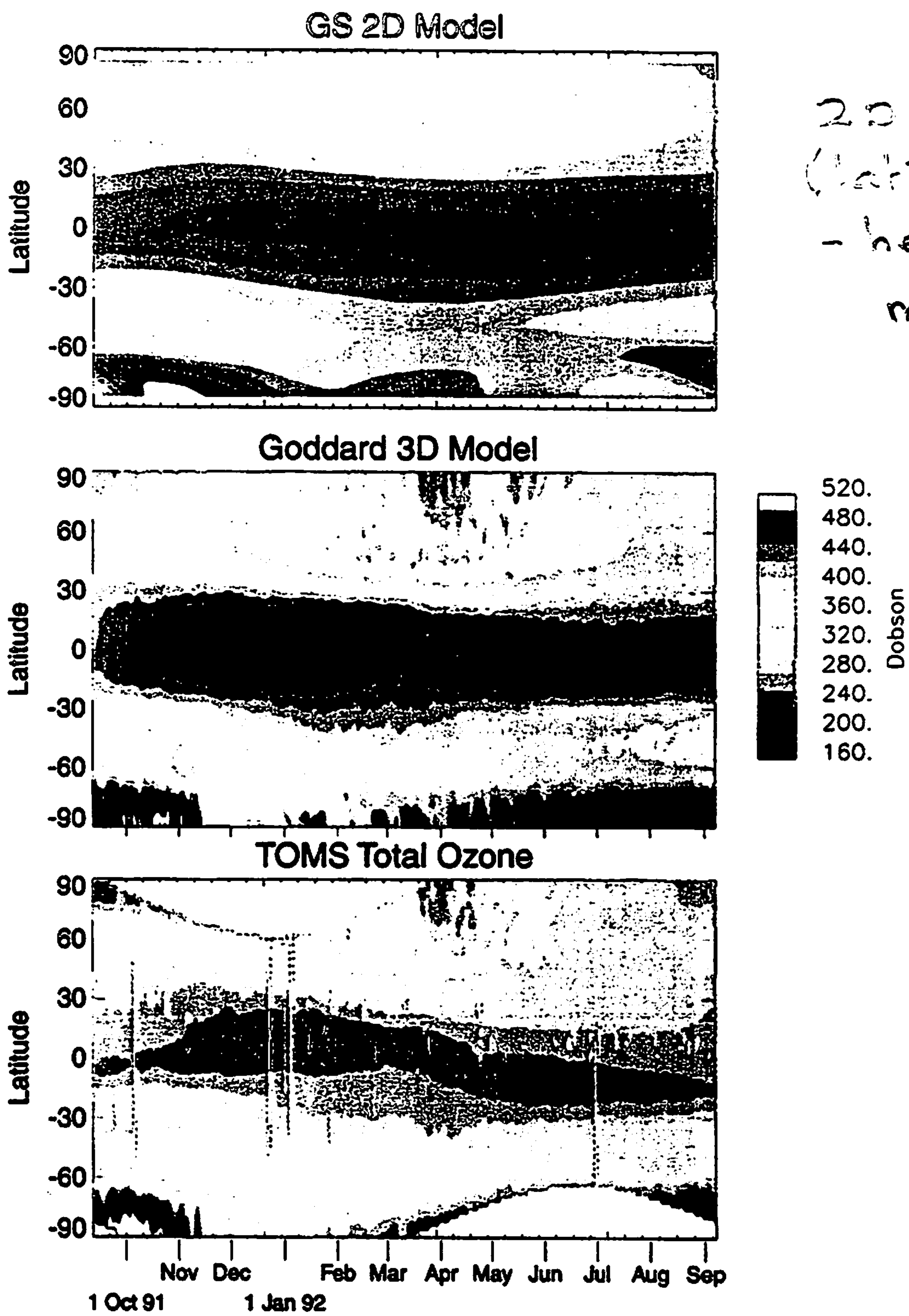
MLS

Model



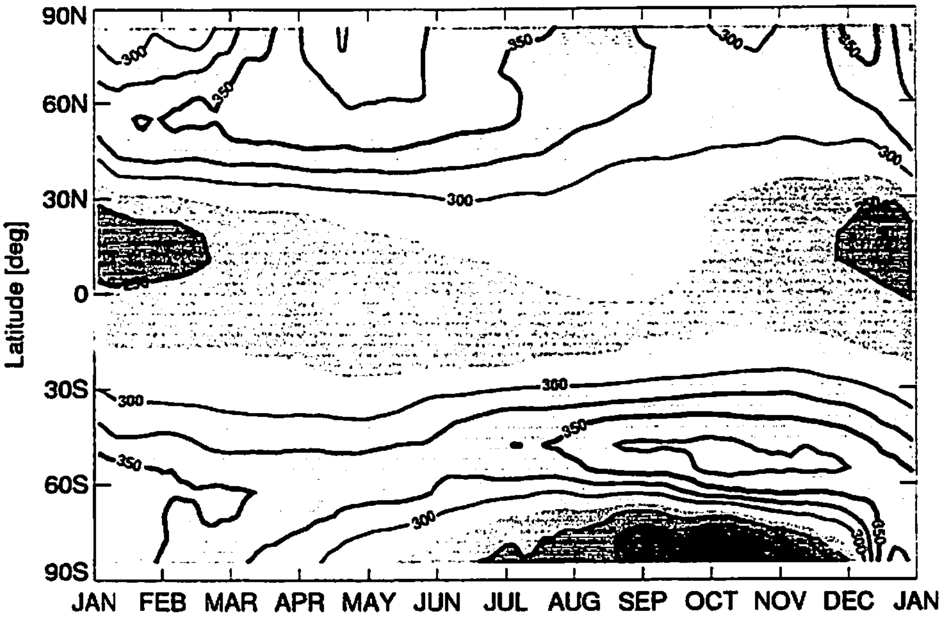
555 K (22 km)

465 K (19 km)

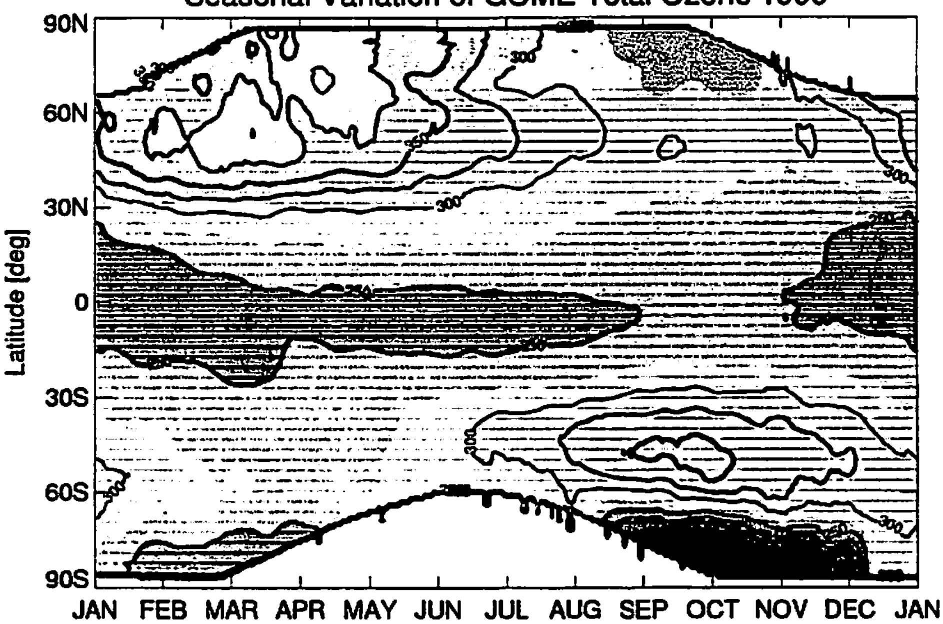


2D ('latitude - height') model.

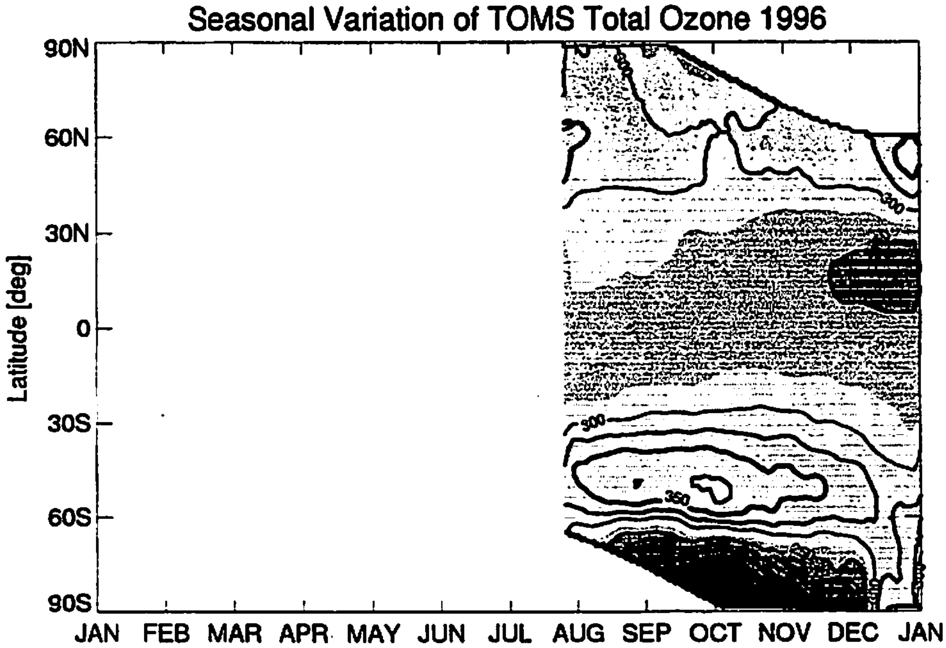
Seasonal Variation of SLIMCAT Total Ozone 1996



Seasonal Variation of GOME Total Ozone 1996



Seasonal Variation of TOMS Total Ozone 1996



CLAES N_2O

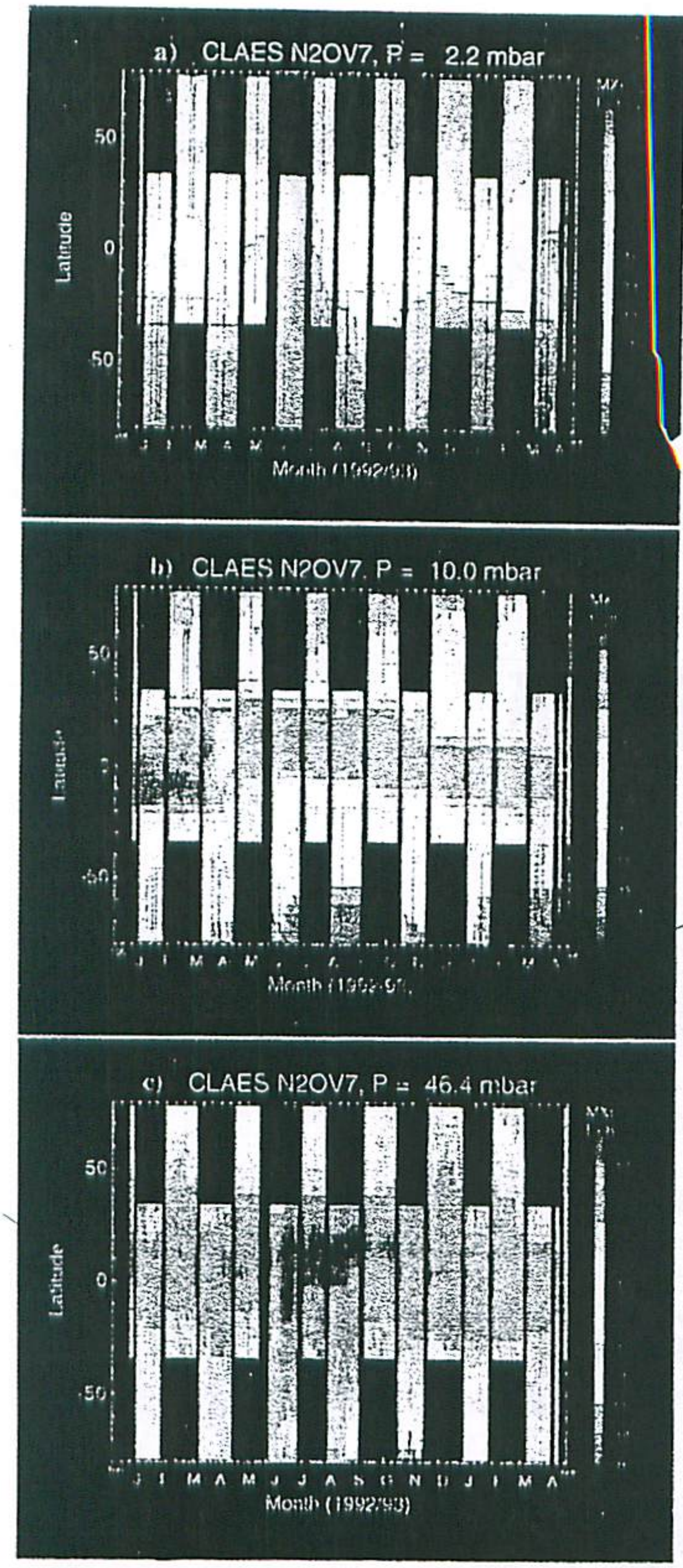


Plate 2. January 9, 1992, to April 24, 1993, time series of zonal-mean latitudinal distributions of CLAES N_2O mixing ratio (ppbv/10) at pressure surfaces near 2.2 mbar (43 km), 10 mbar (32 km), and 46 mbar (21 km). Note scale change between pressure levels. Data are gridded in intervals of 1 day and 4° of latitude. UARS day numbers are also indicated where January 9, 1992, is UARS day 120.

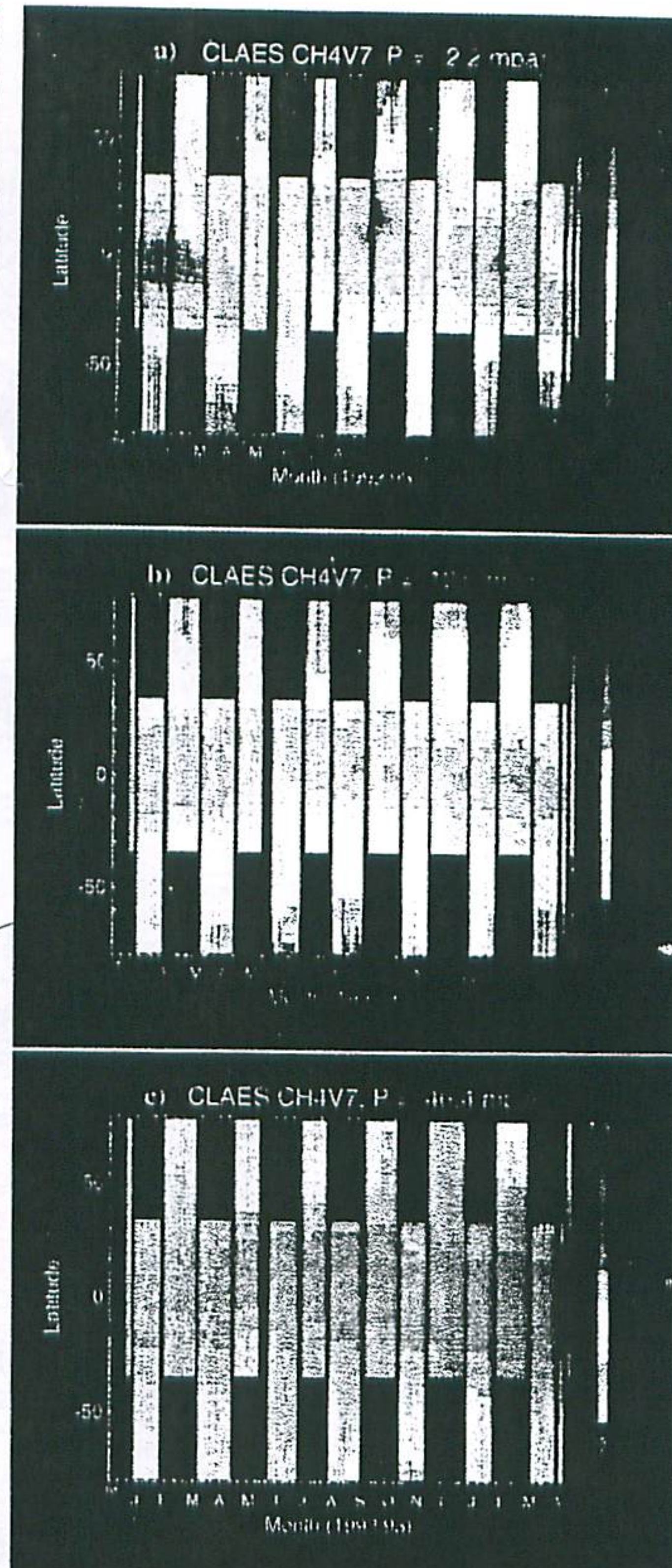


Plate 3. January 9, 1992, to April 24, 1993, time series of zonal-mean latitudinal distributions of CLAES CH_4 mixing ratio (ppbv/100) at pressure surfaces near 2.2 mbar (43 km), 10 mbar (32 km), and 46 mbar (21 km). Note scale change between pressure levels. Data gridding same as for Plate 2.

Roche et al (1996)

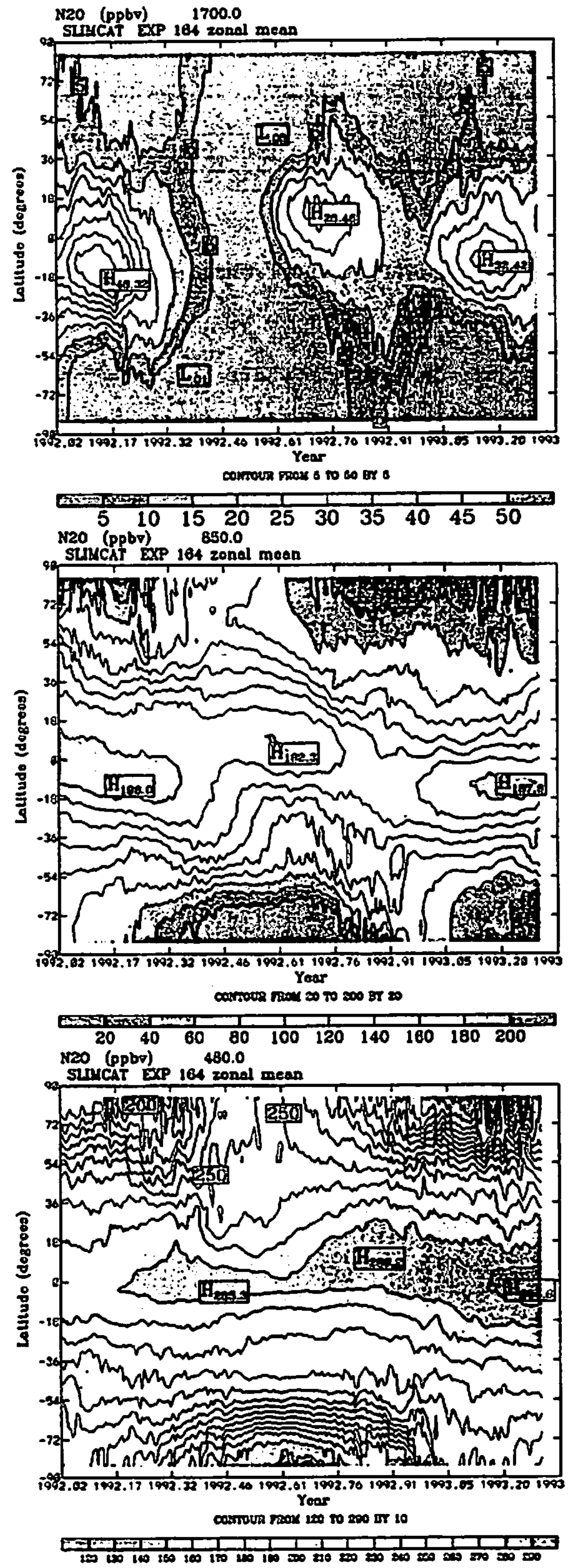


Figure 3. Time series of zonal mean N_2O at a) 1700 K, b) 850 K, and c) 480 K from January 1992 to April 1993 from run A. Note the different contour interval in each plot.

Observed monthly mean O_3 column

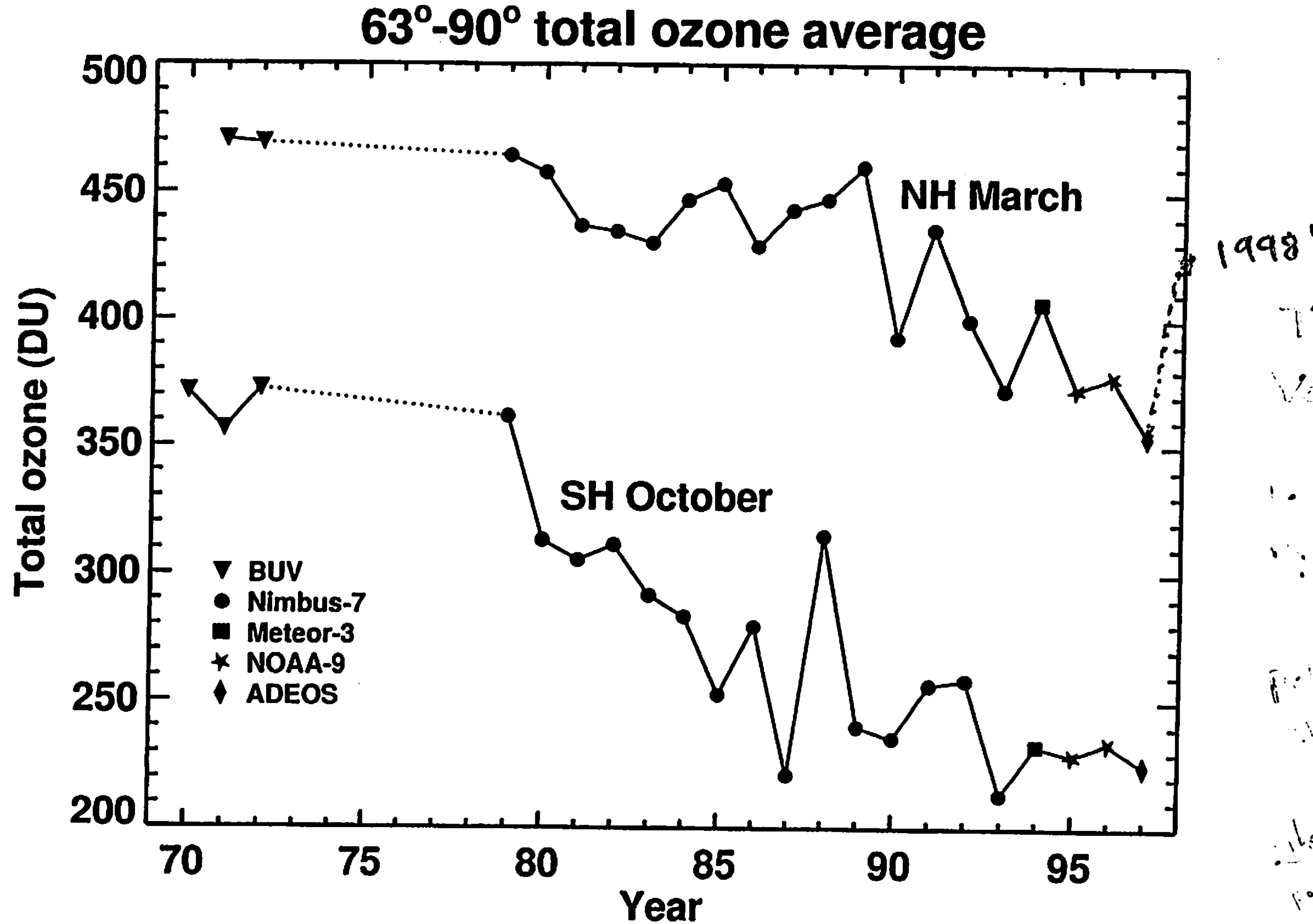
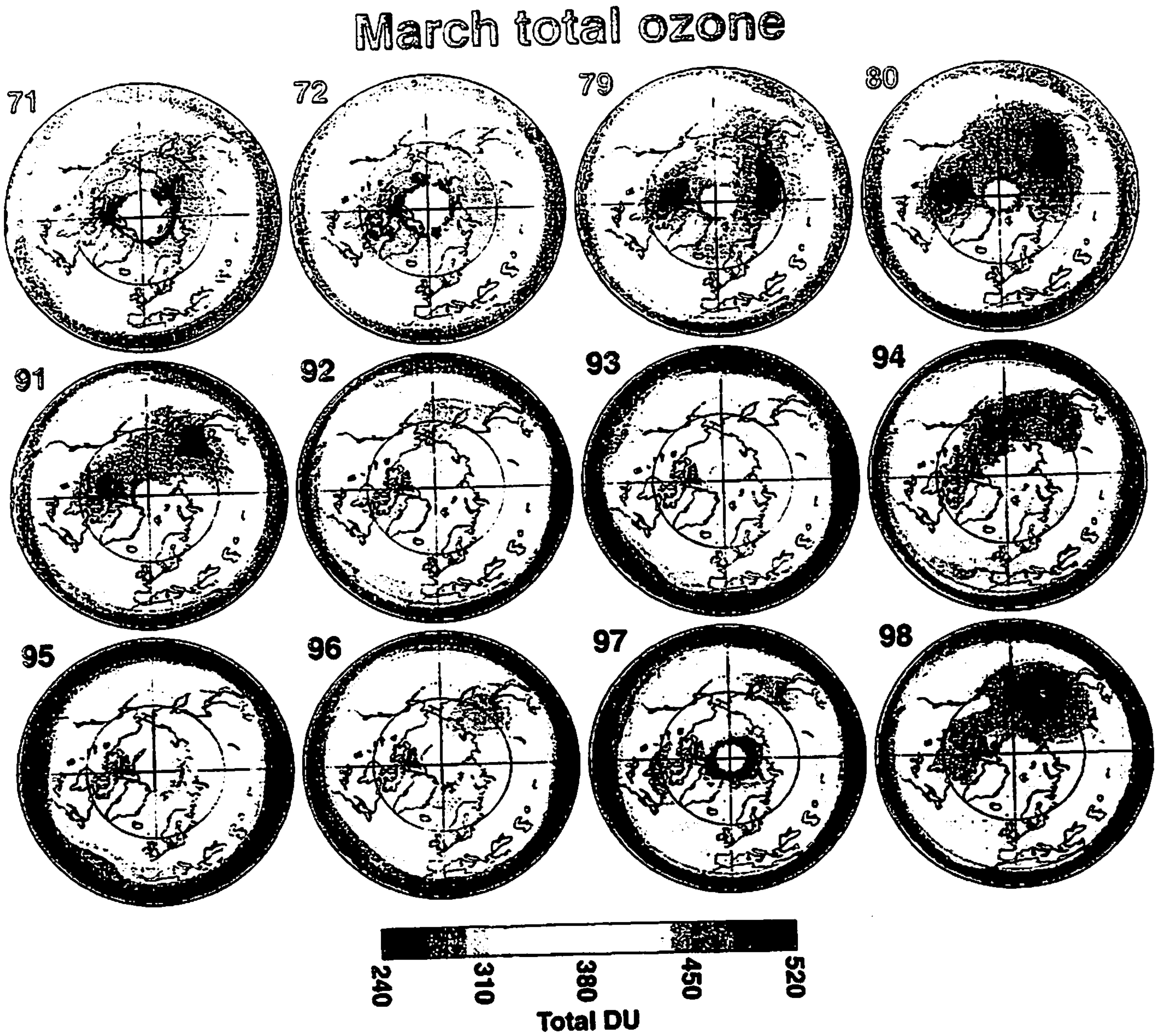
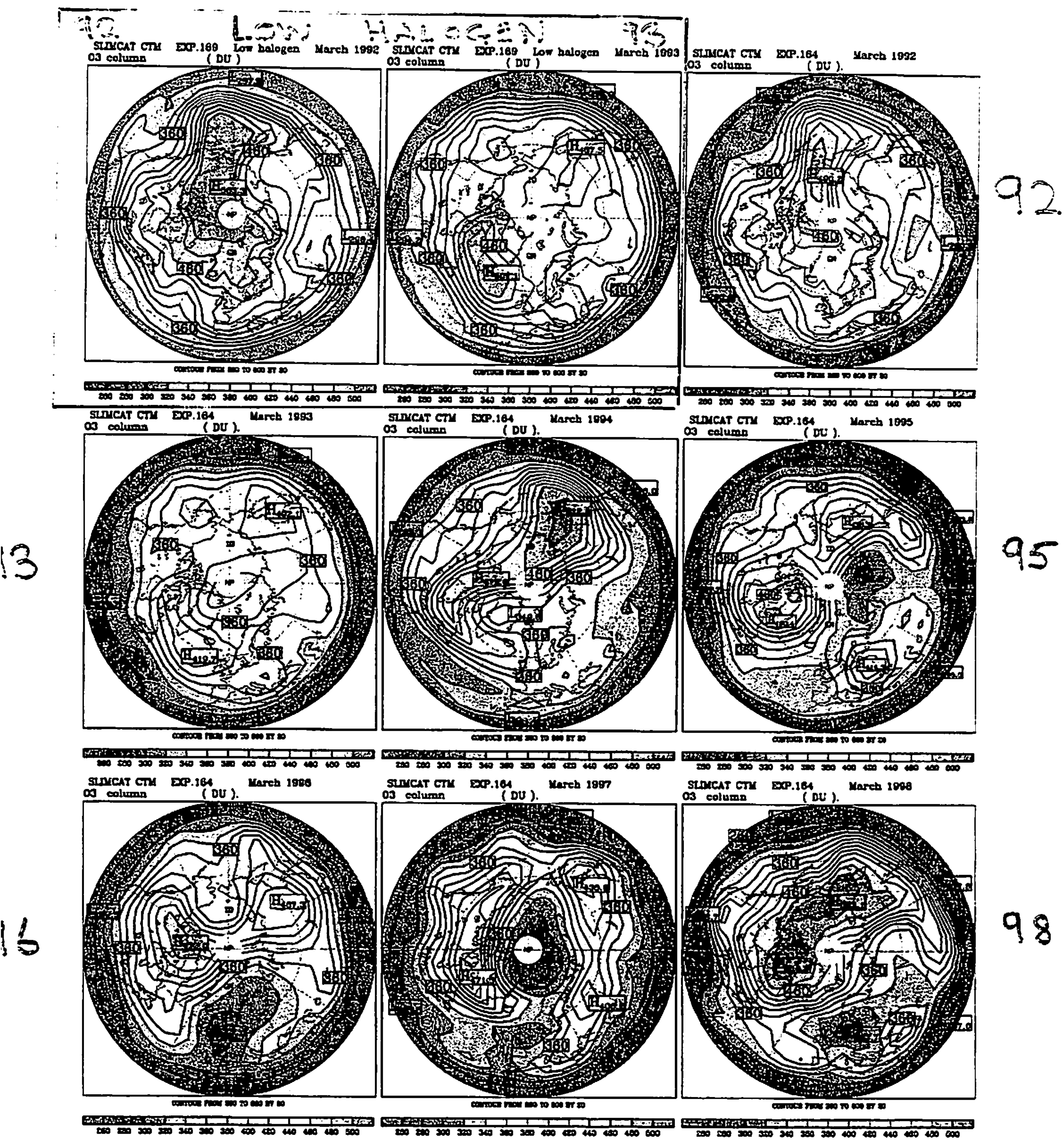


Figure <polar_1>. Average data for total ozone poleward of 63 deg. for March in the Northern hemisphere and October in the South. Adapted from Newman et al. [1997].

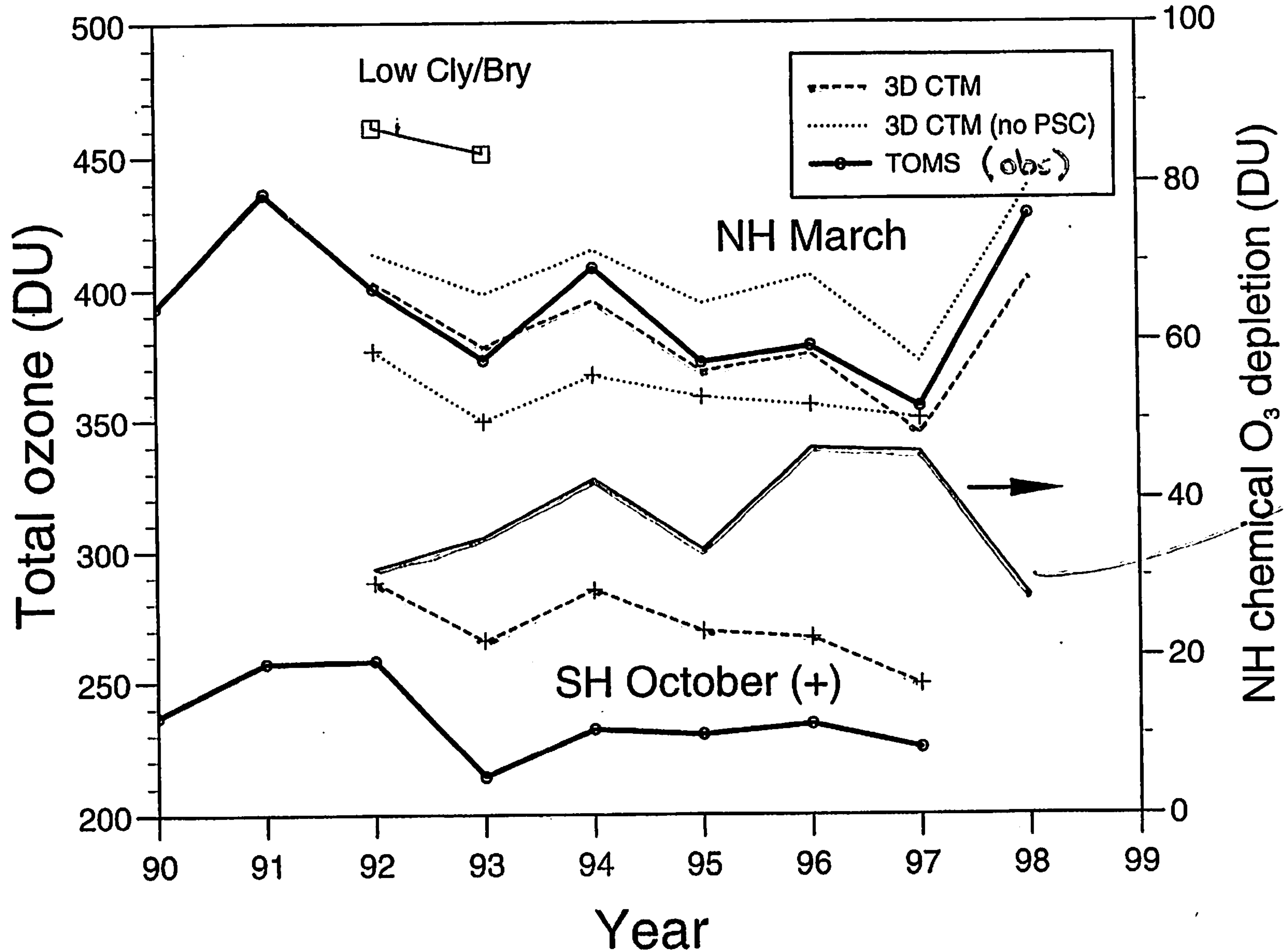

March total ozone
71
72
79
80
91
92
93
94
95
96
97
98
240
310
380
450
520
Total DU

3D Model: mean March O_3 column



3D model calculations

63°-90° Total Ozone Average

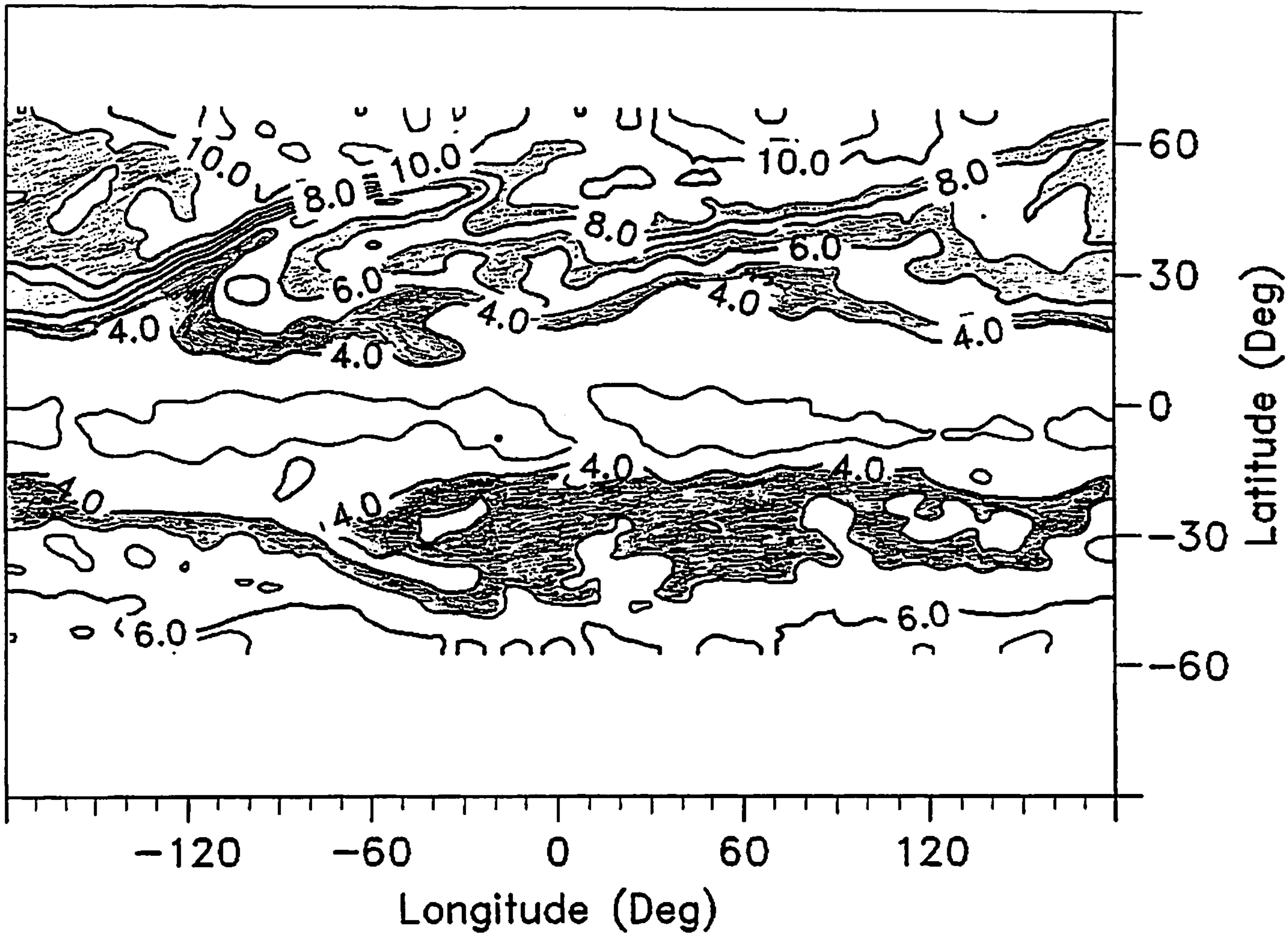


Seasonal chemical loss

(variability in chemical loss < overall variability).

CRISTA HNO3 6/11/94

27 km



14/2/1995 ClOx

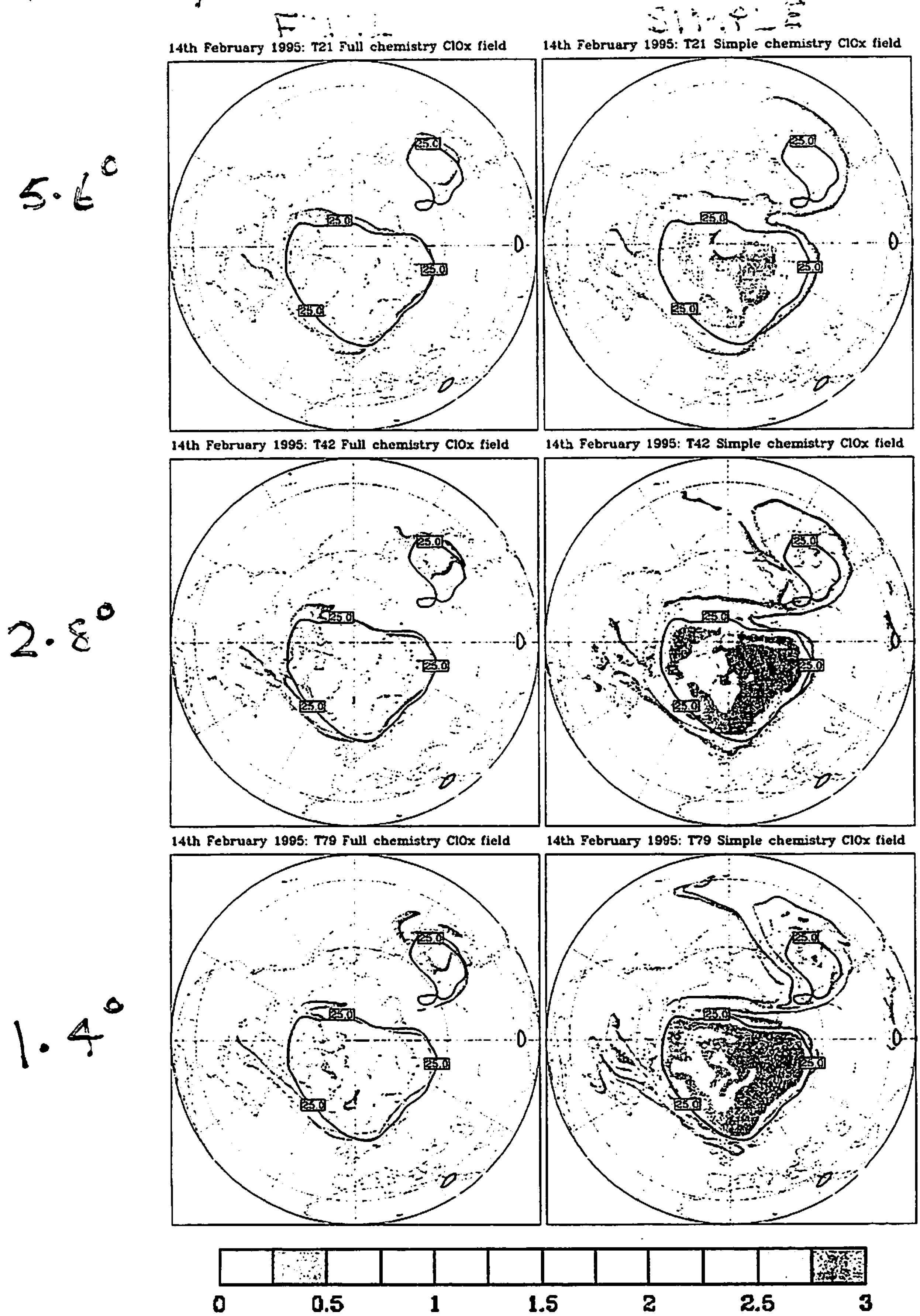
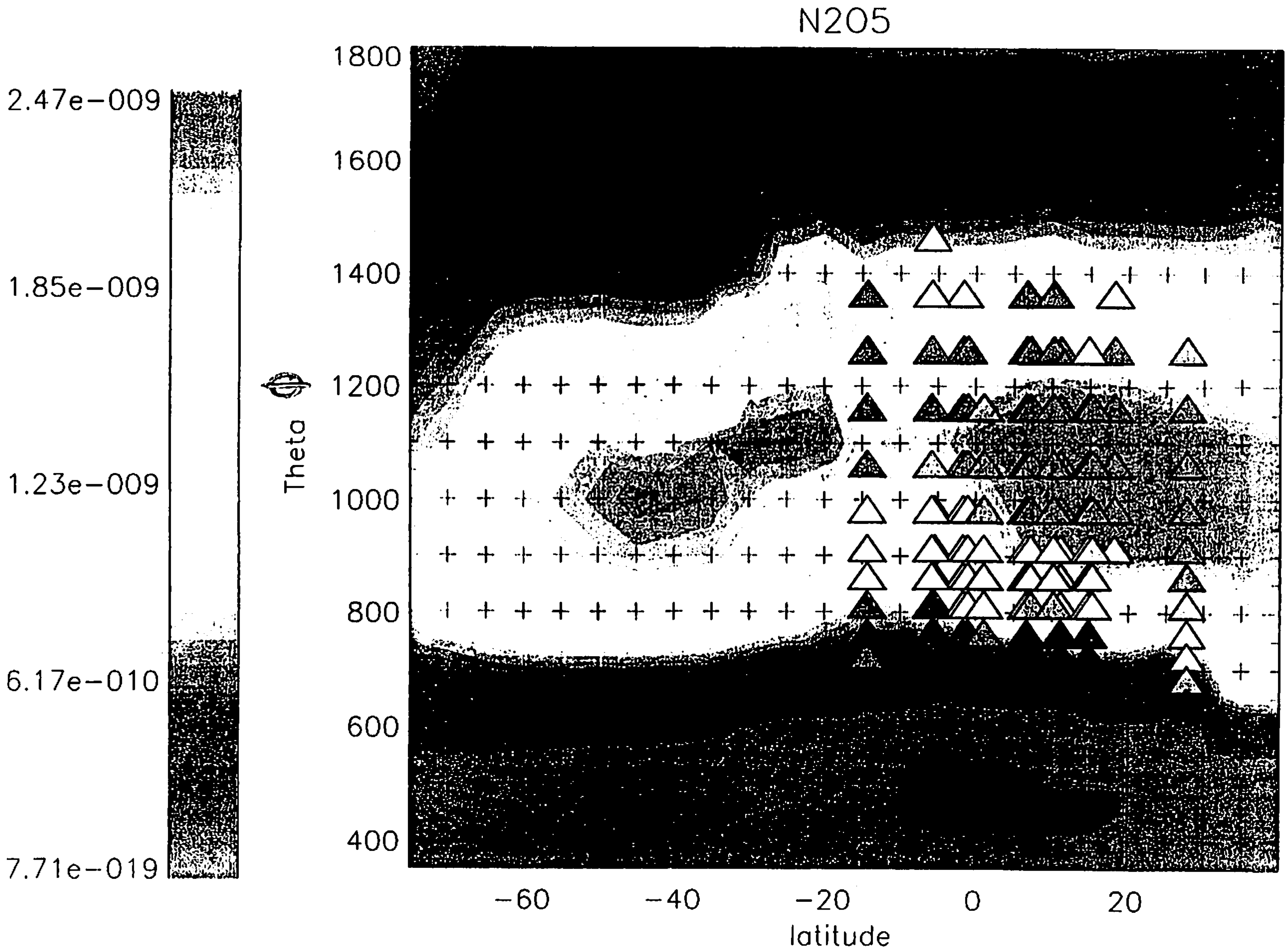


Figure 8. Model ClOx fields for February 14 at the 3 resolutions using the 2 different chemistry schemes.

4D-VAR CHEMICAL DATA ASSIMILATION



Operational applications in NWP, nowcasting and climate modelling using ENVISAT data: CLOUDMAP Project to evaluate new macroscopic and microphysical cloud parameters

Jan-Peter Muller, Rowan Dundas, Carolin Vogt
University College London
Jürgen Fischer, Lothar Schüler, Réne Preusker
Freie Universität Berlin
Hermann Manstein, Armin Drescher, Hartwig Hetzheim
DLR Institüts für Physik der Atmosphäre ,
Opto-electronik, Sensor Technik, Planetare Erkundung
Hans Roozekrans, Paul de Valk
KNMI
Armin Grün, Manos Baltsavias, Daniela Poli
ETH Zurich

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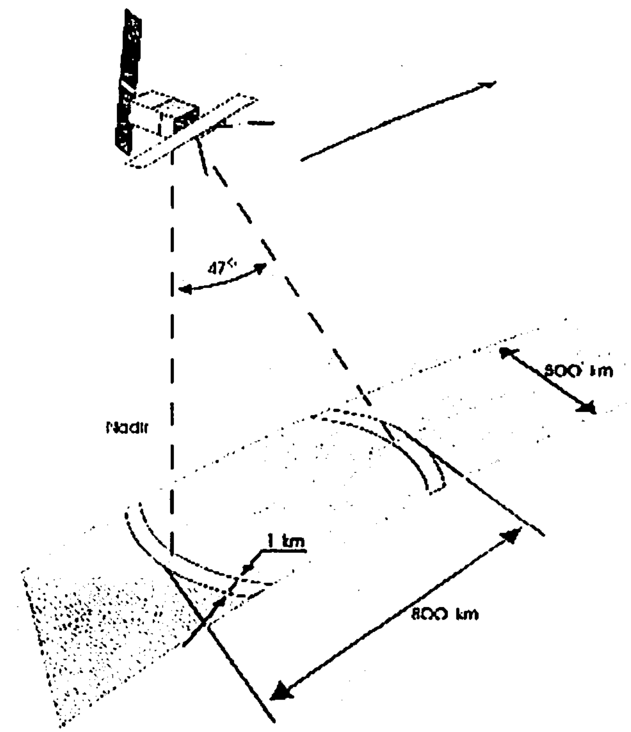
Sensors - (A)ATSR(2)

ATSR (ERS-1) 1991-96, ATSR2 (ERS-2) 1996-2001

AATSR (ENVISAT) 2000-2006

N.B. Conical scanner developed for atmospheric correction of Sea-Surface Temperatures. Excellent for Stereo acquisitions (B/H 1)
IFoVn 1km, IFoVf 1.7km
Swath 512km
Repeat time   8 days



Objectives

- Assess the potential of new instrument concepts to provide more accurate and reliable cloud-top products
- Evaluate the accuracy and reliability of cloud-top products using ground-based remote sensing instruments and develop a long-term validation strategy for cloud-top products
- Assess the potential of cloud-top products for numerical model verification within nowcasting, numerical weather forecasting and climate modelling

CLOUDMAP Project Overview

- Started in January 1998 for 36 months
- Aims
  - Assess new methods for cloud-top parameter extraction from existing and soon to be launched sensors particularly for cirrus and contrail clouds
  - Develop strategy for long-term automated validation of cloud-top parameters using ground-based remote sensing instruments
  - Quantitatively evaluate the impact of these new cloud-top parameters cf. existing data from AVHRR & METEOSAT on climate modelling, nowcasting and numerical weather prediction
- Cloud-Top Parameters
  - Cloud-top height/pressure (focus here)
  - Cloud-top wind
  - Cloud amount and contrail detection
  - Cloud microphysical parameters (e.g. optical depth, particle density)
- Underlying raîson d'etre
  - New methods are needed for cloud-top parameter retrieval which require a minimum amount of external information
  - Methods are required which do NOT need the use of objective analyses of temperature-pressure which have large errors, particularly within clouds

Scientific Justification - Nowcasting and NWP

- **Forecasts, especially short-term of cloud location, type and 3D distribution increasingly required for applications such as aviation**
- **AVHRR and METEOSAT currently employed for this purpose by national meteorological offices. These are limited by the use of objective analysis for the computation of cloud-top products, particularly height which is neither representative of local conditions or more particularly of T-P within clouds**
- **Interest in obtaining improved cloud-top parameters from ENVISAT, EOS and MSG. Focus here on ENVISAT**
- **ENVISAT-MERIS stereo will provide cloud-top parameters at 1km from MERIS (through Oxygen A-band) and AATSR (through stereo photogrammetry). MERIS CTPs dependent on radiative transfer calculations and surface albedo.**
- **EOS-MISR will provide stereo cloud-top heights over a narrow swath width (400km) but with 275m resolution..**
- **EOS-MODIS and MSG will provide split-window (CO2) cloud-top parameters but these are dependent on objective analyses.**

Scientific Justification - Climate Modelling

- One of the greatest current uncertainties in Global Climate Models is the role of clouds, particularly Cirrus and Marine StCu, in the Earth's radiation balance to determine whether clouds will enhance or decrease the effects of global warming
- Existing cloud climatologies, such as ISCCP or the HIRS/TOVS CO^2 split window do NOT provide the necessary accuracy either
  - to test the effects of clouds, particularly broken clouds, on GCM forecasts or
  - the consequences of "global warming" on changing Ci & MrStCu cloud amounts
- previous HIRS/TOVS data suggest that upper-level cloud amounts have increased since 1982. It has been hypothesized that contrails may contribute towards this increase.[Menzel & Wylie, 1995]
- need to help determine the uncertain role of clouds, particularly Cirrus and contrail clouds in providing a feedback (positive or negative) to the greenhouse effect.
- Cloud-top climatology provides one method for validating GCM climate hindcasts and cloud-radiative feedback
- assess the potential of new EO-derived cloud products to address needs for weather prediction as well as climate forecasting

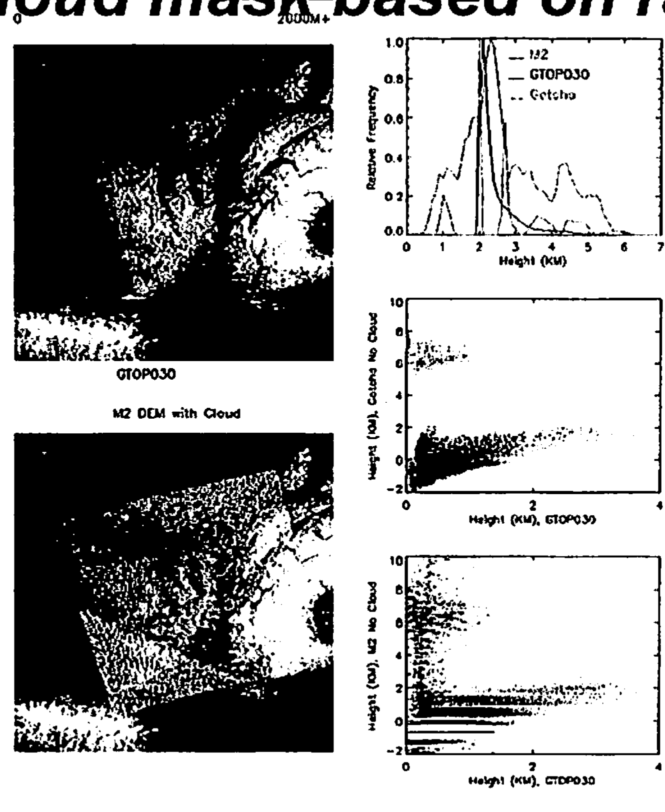
Roles of Project Partners

- **UCL provide co-ordination and research into the development, testing and validation of operational stereo photogrammetric methods for cloud-top height, cloud amount and cloud-tracked winds (ATSR(2),MISR)**
- **KNMI provide an end user evaluation and testing of cloud-top parameters both internally using hindcast predictions and externally through workshops and demonstration of CLOUDMAP products**
- **FUB provide research into the development of methods for the retrieval of cloud-top pressure using Oxygen A-band and cloud microphysics using spectral information in the visible and near-IR (MOS, MERIS)**
- **DLR provide research into [a] production of a long-term contrail coverage archive derived from AVHRR; [b] use of shadow for independent validation of stereo CTHs (MOMS); [c] automated contrail and cirrus detection using textural characteristics (MOS, ATSR(2), MISR, MOMS).**
- **ETH provide research into new sensor models and automated stereo matching algorithms for cloud images at very high resolution (MOMS)**

Stereo photogrammetric methods

- Cloud-top height and across-track wind-fields involve several steps:
  - Ingest of different data formats including extraction of sensor and orbital positional information
    - » SADIST2 for ATSR(2)
    - » New formats for ENVISAT AATSR
  - Automated stereo matching to compute correspondence fields
  - Transformation of matched disparities into geometric height and/or across-track wind-fields using sensor and orbital information and a suitable "photogrammetric camera model" [see Prata & Norman, 1997]
- Operational system has been developed with JPL and the University of Arizona for production of global height and wind-fields from EOS-MISR for a minimum of 5 years. IDL automated processing system now available for (A)ATSR(2)

Assessment of ATSR Cloud-top height (CTH) accuracy using land surface topography - comparison of ATSR stereo matchers (M2 & P-Gotcha) vs GTOPO30 DEMs with RAL ~~cloud mask~~ based on radiometry



GTOPO30 and Remapped M2 and Gotcha (Image 4).

P-Gotcha-GTOPO30
0.09±1.38 km

M2-GTOPO30
0.22±1.81 km

Note :good correspondence of mountains for stereo DEM cf. GTOPO30 for Massif Central & Alps

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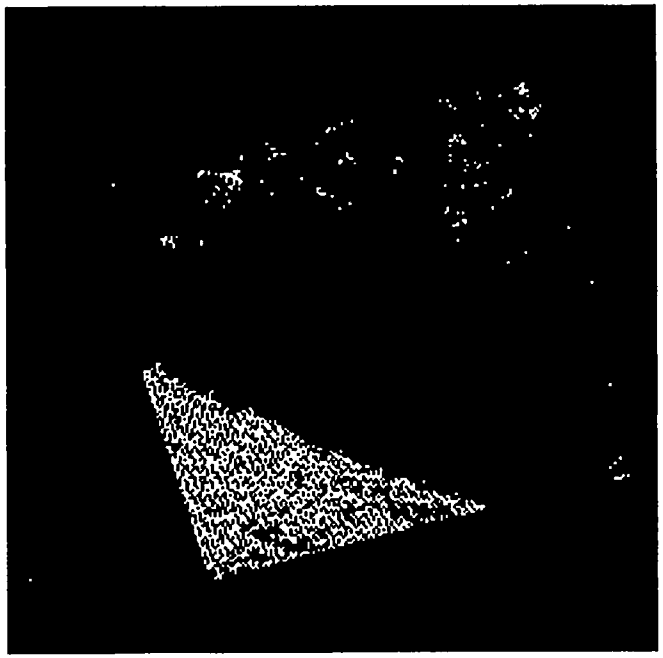
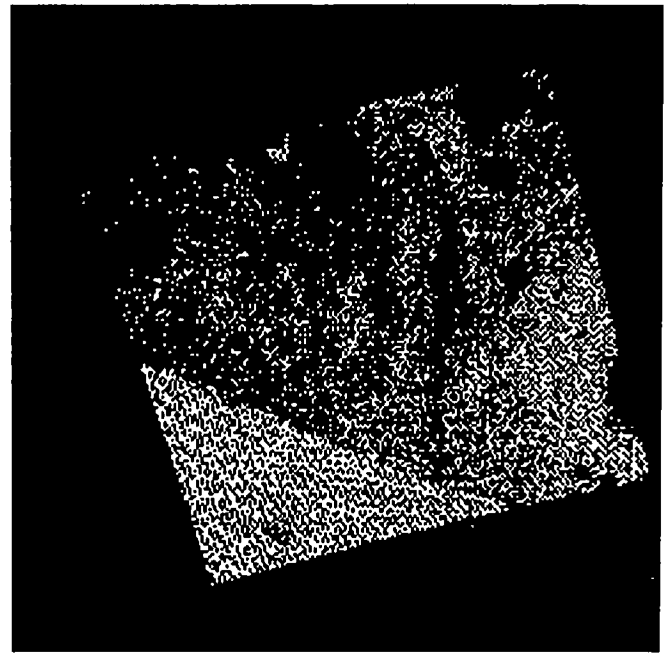
Assessment of the use of stereo-ATSR derived elevations to improve cloud masking (1)

- Initial tests using ATSR2 images over Greenland indicate that cloud masks may be produced by subtracting a ground DEM for the output of a stereo-matched ATSR2 data. However, due to the lack of any independent measurements of cloud cover it has not possible to validate the stereo cloud mask over Greenland
- Using a ground DEM and the stereo-derived cloud mask, it has been possible to quantify the accuracy changes due to the use of a stereo mask cf. radiometric mask from RAL
- Stereo cloud mask shows much higher accuracy than a radiometrically defined cloud mask from RAL

Assessment of the use of stereo-ATSR derived elevations to improve cloud masking (2) : Alps - Note the higher GROUND accuracy of the stereo cloud mask



M2-GTOPO30
0.22±1.81km

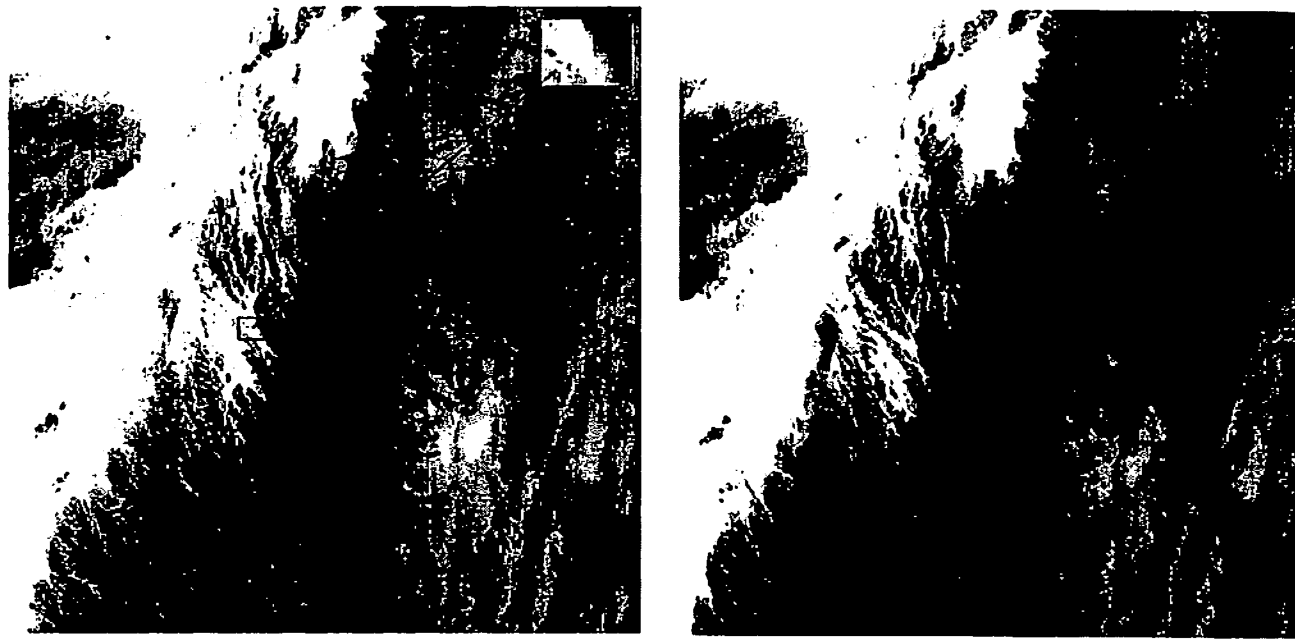


M2-GTOPO30
0.14±1.03km

Initial assessment of the use of ground-based mm-radar for validating Cloud-top Heights derived from ATSR2 during CLARE98 (1)

- ATSR2 data collected for every daytime and most night-time passes when ground-based mm-radar and laser ceilometer data collected from 1/8/98-31/12/99
- Selected ATSR2 stereo-pair on 23/10/98 during the ESA CLARE98 campaign when 35Ghz & 94Ghz data was being collected as well as ground-based stereo wide-angle camera images
- Stereo-matched heights show CTHs at the same cirrus-top but at different mid-levels as the radar reflectivity. This is due to the very broken nature of the cloud-tops observed at 1-1.7km by ATSR

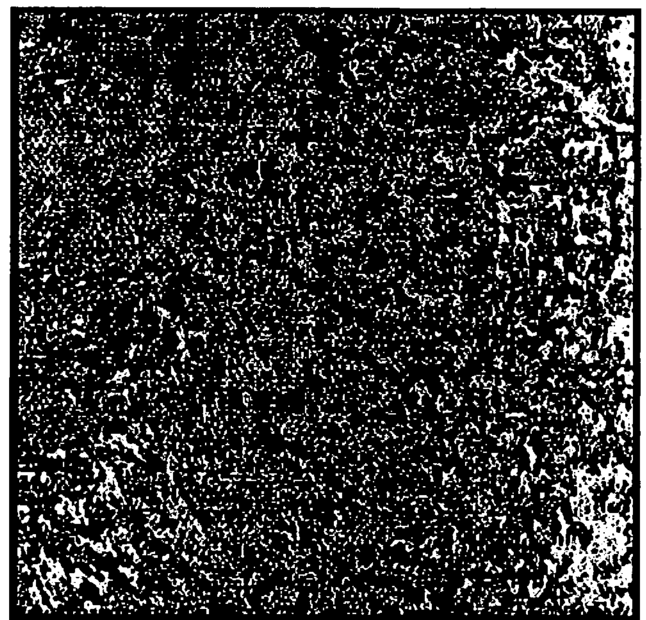
Initial assessment of the use of ground-based mm-radar for validating Cloud-top Heights derived from ATSR2 during CLARE98 (2)

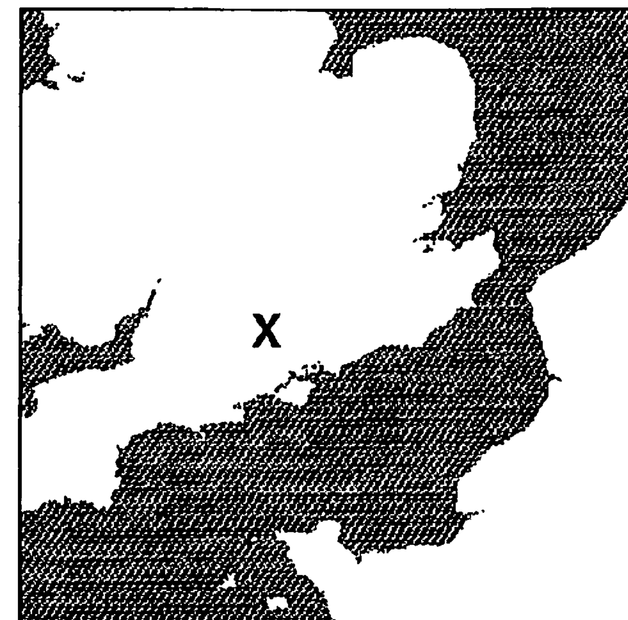


Box centred on CRF shows detail of Bt

ATSR2 11µm Brightness Temperatures (23.10.98). Left (nadir), Right (forward)

Initial assessment of the use of ground-based mm-radar for validating Cloud-top Heights derived from ATSR2 during CLARE98 (3)





X marks location of CRF

ATSR Cloud-top height field (left) and location (right)

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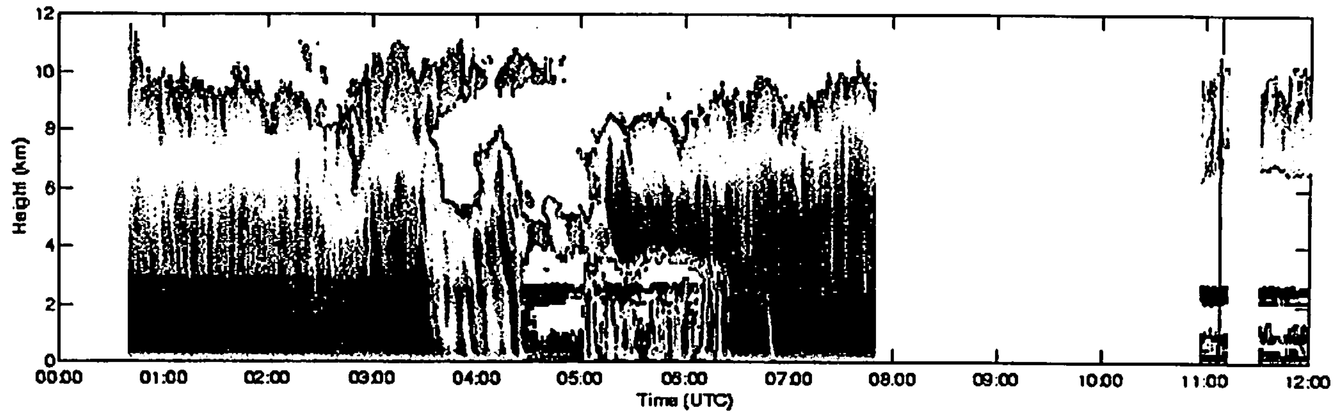
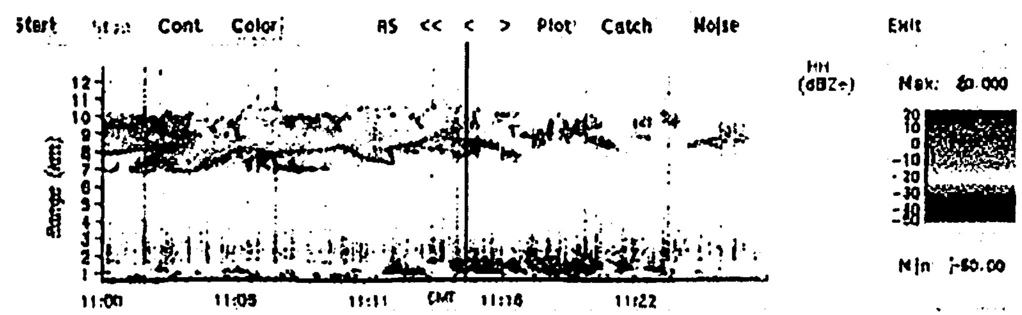
Initial assessment of the use of ground-based mm-radar for validating Cloud-top Heights derived from ATSR2 during CLARE98 (4)

Cirrus detected At 9km in both but lower CTH at 3-4km from ATSR cf. 2-3km from radar



GKSS 94GHz



Radar reflectivity at Chilbolton, UK from 35GHz & 94GHz (GKSS)

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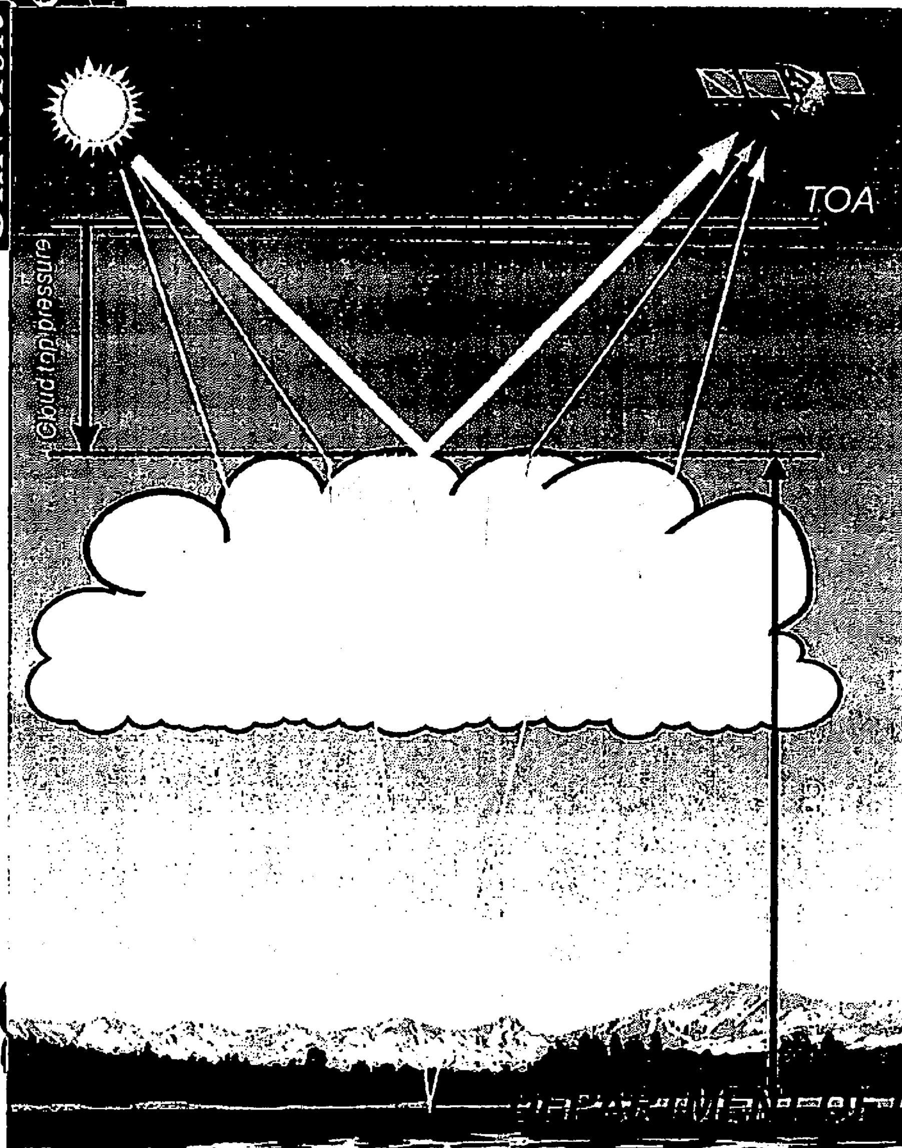
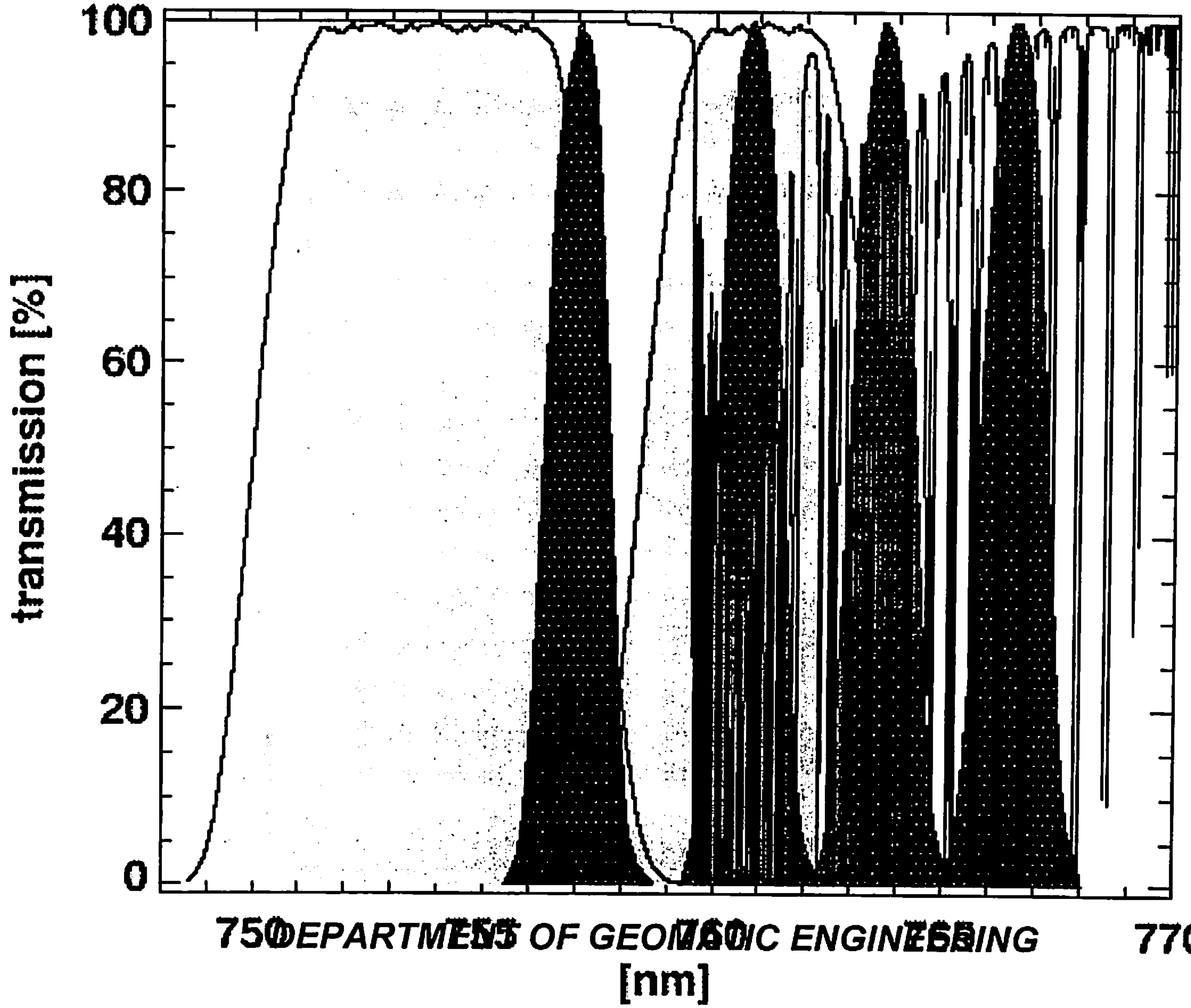
Cloud top pressure



First proposed by Yamamoto and Wark 1961

- radiance ratio between an absorbing and a window channel depends on photon path length
- photon path length is mainly determined by *air-mass above the cloud = cloud top pressure*
- algorithm has to account for:
  - *multiple scattering*
  - *surface reflection*
  - *multi-layer cloud system*

Channel setting of MOS A and MERIS



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Radiative transfer simulations

- Matrix Operator Model (Plass *et al.* 1973, Fischer 1983)
- horizontally homogeneous layers
- k-distribution to incorporate gaseous absorption
- discrete Solar- and viewing zenith angles

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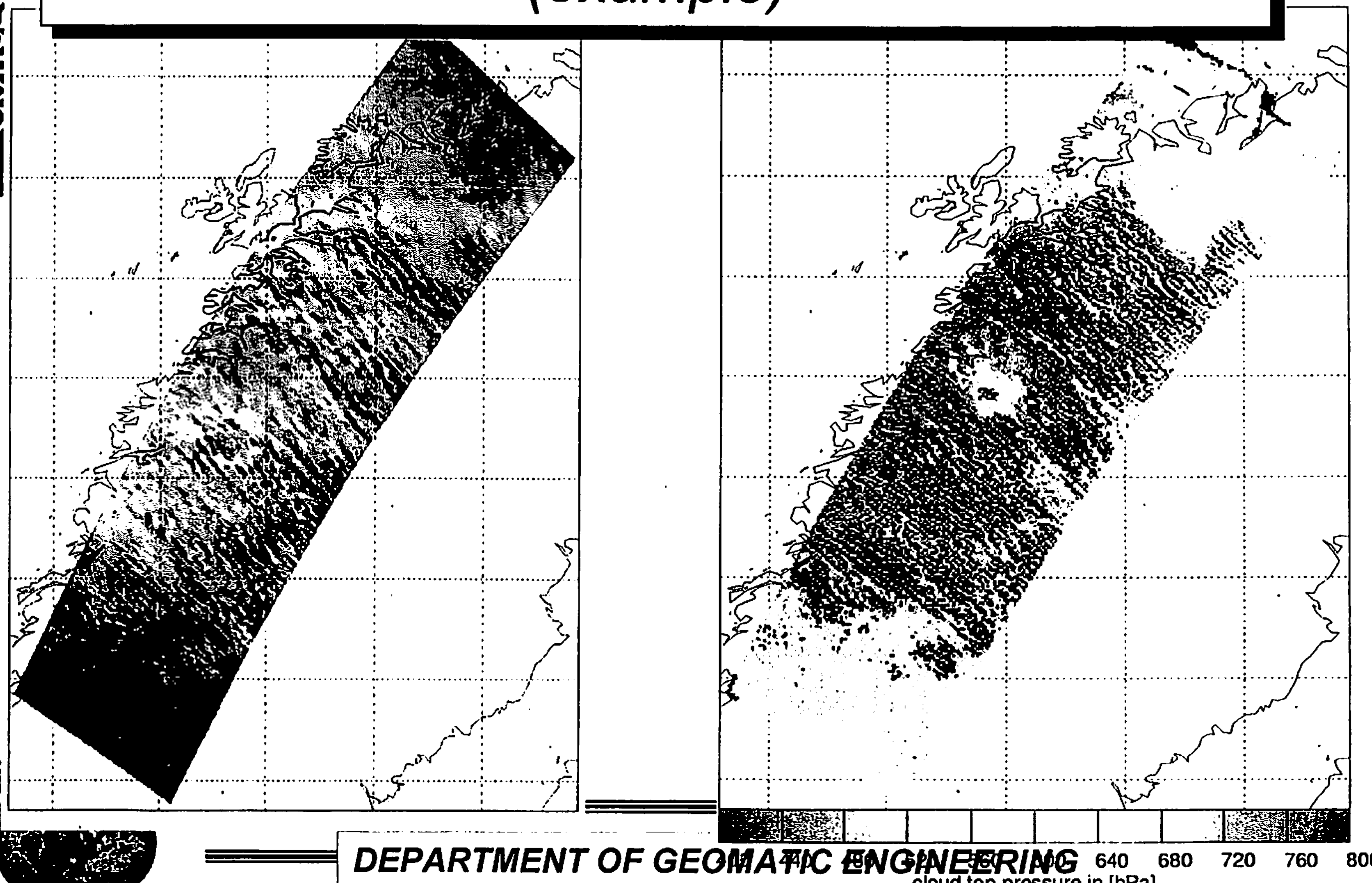
Radiative transfer simulations

Database for algorithm development

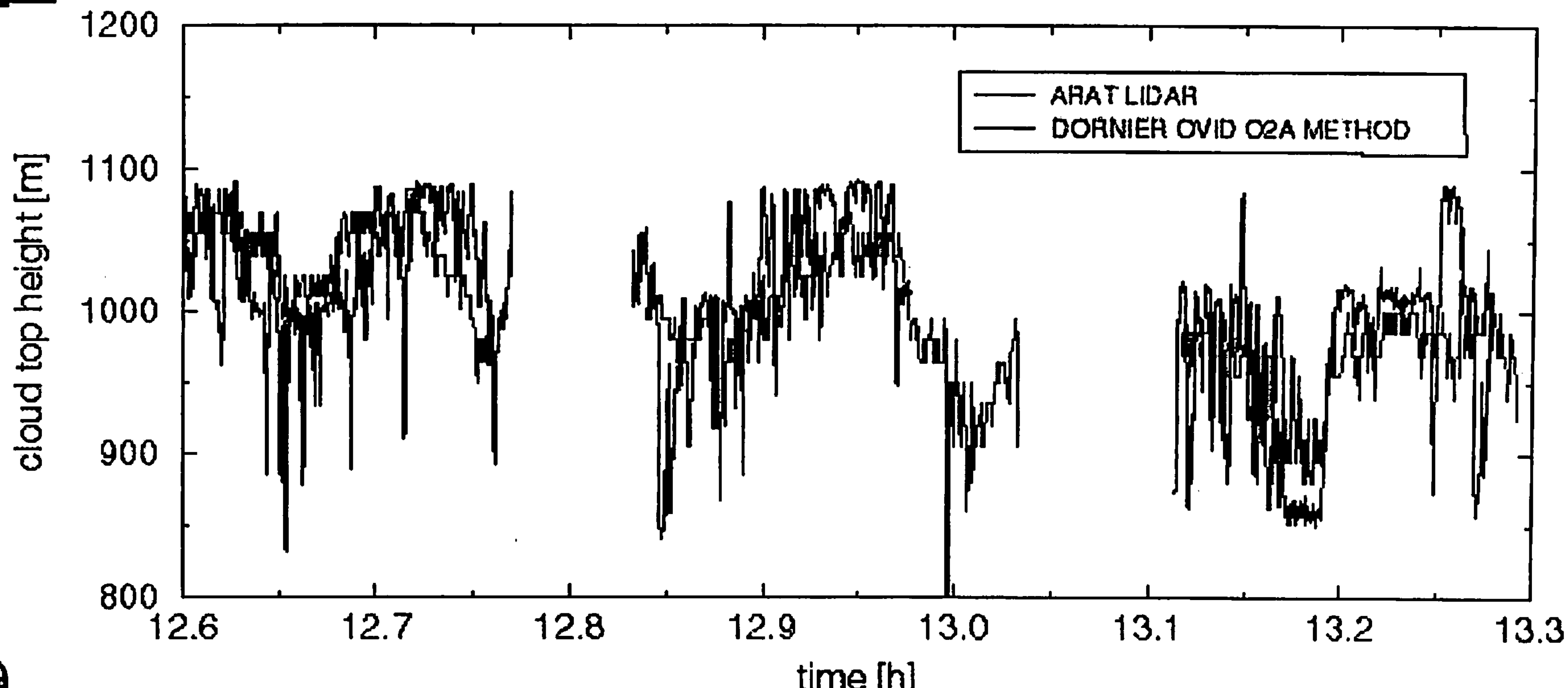
Database for algorithm testing

Sensitivity tests of retrieval algorithm

Cloud top pressure: application to MOS (example)



Cloud top pressure: Assessment using airborne OVID spectroscopic profiler - Comparison with LIDAR (ACE 2)



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Current Status of CLOUDMAP Project

- ATSR2 & MOS CLOUDMAP products have been produced
- Comparative analysis being performed with ground-based measurements for CLARE98 (Chilbolton multi-frequency mm-radar) and CLARA96 (NL network of 12 laser ceilometers and 2 mm-radars)
- Comparative analysis with AVHRR, METEOSAT and operational forecasts (mainly nowcasting) being performed at KNMI

Conclusions and Future Work

- Stereo-matched and Oxygen A-band cloud-top heights demonstrated and initial validation strategy developed using mm-radar and laser ceilometer data
- Further evaluation is being performed by KNMI and partners for
  - Validation of climate model and nowcasting outputs
  - Comparison with existing products during CLARA96
- (A)ATSR(2) although poorer in CT height accuracy can provide a long-term (15 year) cloud climatology
- MERIS will provide higher accuracy but for a much shorter time period (5 years)
- More information, including sample products, validation results and assessments from KNMI www.ge.ucl.ac.uk/research/CLOUDMAP.html

Background to Envisat Mission

Mission profile

The EnviSat satellite is the latest and most capable of ESA's missions. It will supply information to virtually all research areas involved in the environment and global climate change and is designed to provide measurements of the ocean, atmosphere, land and ice cover over a five year period. It is due to be launched in November 2000.

EnviSat profile

The EnviSat payload instruments consist of a group of ESA developed instruments (EDI) and a group of Announcement of Opportunity (AO) instruments funded nationally by the participating states. It will operate at an altitude of 800 km with a 10.00 am southwards overpass. The repeat period for data collection will vary from 3 days to 35 days depending on the characteristics of each instrument.

EDI Instruments

Medium Resolution Imaging Spectrometer (MERIS)
Michelson Interferometric Passive Atmospheric Sounder (MIPAS)
Advanced Radar Altimeter (RA-2)
Advance Synthetic Aperture Radar (ASAR)
Global Ozone Monitoring by Occultation of Stars (GOMOS)
Microwave Radiometer (MWR).
AO Instruments
Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY)
Advanced Along-track Scanning Radiometer (AATSR)
Scanner for Radiation Budget (SCARAB)
Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS).

AO Instruments

Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY)
Advanced Along-track Scanning Radiometer (AATSR)
Scanner for Radiation Budget (SCARAB)
Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS).

Details of instruments from which data on the atmosphere will be available

GOMOS
This instrument enables simultaneous monitoring of ozone and other trace gases as well as temperature distributions on the 20-100km altitude range. The instrument has an UV-visible and a NIR spectrometer fed by a telescope which has a line of sight

orientated towards the target star by means of a steerable mirror. The instrument then tracks the star and observes it setting behind the atmosphere

SCIAMACHY
The primary objective of this instrument is the global measurement of various trace gases in the troposphere and stratosphere. These are retrieved by the observation of the transmitted, backscattered and reflected radiation from the atmosphere on the 0.24-2.4μm range. The large wavelength range allows the determination of aerosols and clouds. The nadir and limb viewing strategy yields total column values and profiles for trace gases and aerosols in the stratosphere.
The measurements obtained will provide information
In the troposphere: biomass burning, pollution, arctic haze, forest fires, dust storms, industrial plumes
In the stratosphere: ozone chemistry, volcanic events, solar proton events.

MIPAS
MIPAS is a high resolution Fourier transform infrared spectrometer designed to measure concentration profiles of various atmospheric constituents on a global scale. It will observe the atmospheric emissions from the Earth horizon (limb) in the mid infrared region (4.15-14.6μm) providing global observations of photochemically interrelated trace gases in the middle atmosphere, in the troposphere and in the upper troposphere. These data will contribute to the development of a better understanding in the following areas:
Stratospheric chemistry: global ozone, polar stratospheric chemistry
Global climatology: global distribution of climate relevant constituents
Atmospheric dynamics: transport exchange between troposphere and stratosphere
Upper Tropospheric chemistry: correlation of gas distribution with human activities.
It will allow simultaneous measurement of more than 20 relevant trace gases, including the complete NOy family and several CFCs, atmospheric temperature, the distribution of aerosol particles, tropospheric cirrus clods and stratospheric ice clouds.

AATSR
This instrument provides a continuity from ARST-1 and ATSR-2 on ERSI has three visible/NIR channels and also middle and infrared channels. It has a spatial resolution of 1km at nadir and scans across a 500 km swath. The main products to be derived from the AATSR are Sea Surface Temperature products at an accuracy of 0.3K or better. The two angle viewing system will also provide information on cloud type and height, water vapour, water/ ice discrimination, particle size distribution and aerosol distribution.

MERIS
MERIS operates in the visible and near-infrared in 15 programmable channels at a spatial resolution of either 300 or 1200 m with a swath width of 1150km. Its main products are of ocean colour but it will also provide information on water vapour column abundance, cloud reflectance, cloud top height and aerosol optical thickness and type.

ASAR

The SAR will provide information on land cover and sea state, but recent research has shown its effectiveness at providing information on thunderstorms through the pattern the rainfall makes on the oceans and the phase data provides information on atmospheric structure.

RA-2

The radar altimeter provides some information on rainfall.

ENVISAT EXPLOITATION PROGRAMME

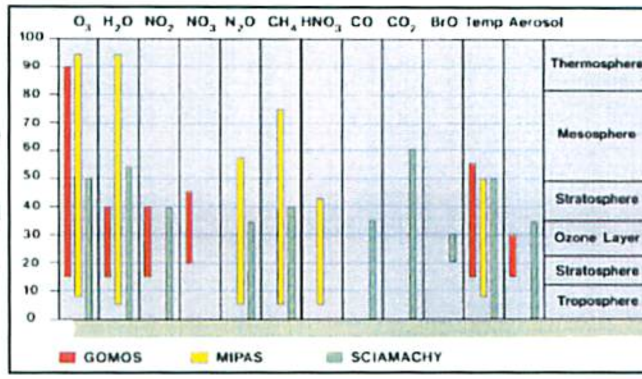
Atmospheric Applications

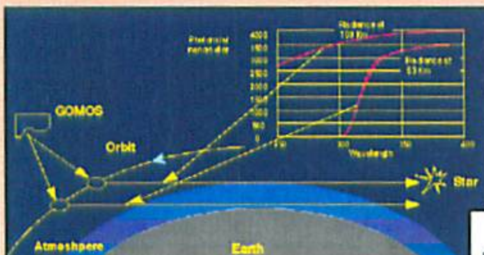
During the last decades it has become increasingly apparent that the chemical composition of the atmosphere is changing on a global scale, and that human activity is partly responsible for this change.

There is a clear need to increase our understanding of the central processes involved in atmospheric chemistry, and it is vitally important to monitor and investigate global budgets of ozone and other chemically important gases.

ENVISAT is an advanced Earth Observation satellite due to be launched in the year 2000. It will continue the global monitoring programmes started by the ERS series of satellites and carry a suite of 9 instruments. Five of the instruments (including 4 new instruments) are particularly useful for atmospheric applications:

GOMOS MIPAS SCIAMACHY MERIS AATSR

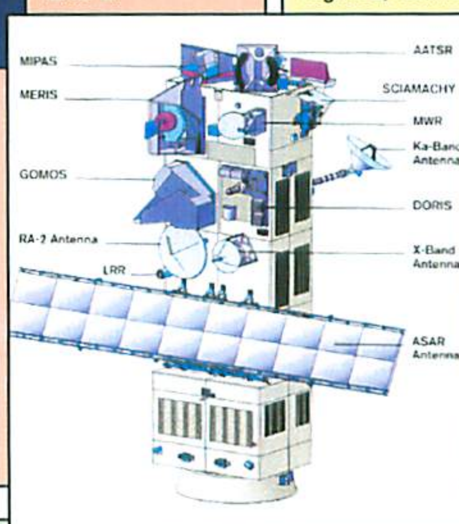




GOMOS : Ozone plays a central role in atmospheric chemistry. The first European ozone monitoring instrument was flown onboard ERS-2.

It provides valuable data for the understanding of ozone chemistry and for model validation. ENVISAT will carry GOMOS, a new instrument, to provide altitude-resolved global ozone mapping and trend monitoring with very high accuracy.

GOMOS uses a method of occultation by stars to obtain ozone measurements. As a preselected star sets through the atmosphere, its spectrum becomes more and more attenuated by the absorption of the various gases in the atmosphere. This measurement is then compared with the unattenuated stellar spectrum measured a few tens of seconds earlier, outside the atmosphere.



MIPAS : The **M**ichelson **I**nterferometer for **P**assive **A**tmospheric **S**ounding (MIPAS) is designed to measure concentrations of various atmospheric gases on a global scale. It operates in the near to mid infrared where many of the atmospheric trace-gases playing a major role in atmospheric chemistry have important emission features. MIPAS views the earth's horizon in either of two pointing regimes, rearwards and sideways.

The objectives of MIPAS include:

- Simultaneous and global measurements of geophysical parameters in the middle atmosphere, ie **Stratospheric chemistry:** O_3, H_2O, CH_4, N_2O, HNO_3; **Climatology:** Temperature, CH_4, N_2O, O_3
- Study of chemical composition dynamics, and radiation budget of the middle atmosphere
- Monitoring of stratospheric O_3, CFC's.

SCIAMACHY : The **SC**anning **I**maging **A**bsorption Spectro**M**eter for **A**tmospheric **C**artograp**HY** (SCIAMACHY) is one of the Announcement of Opportunity payload instruments who's primary mission is to perform global measurements of trace gases in the troposphere and in the stratosphere. It is a development of ERS-2 GOME instrument with additional wavebands extending to the near IR region. It also operates with new viewing geometries such as limb, including sun and moon occultations. Data will be used to investigate:

- Biomass burning, biogenic emissions, pollution episodes over populated regions, lightning production of oxides of nitrogen, Arctic haze, forest fires, dust storms, industrial plumes.
- Ozone chemistry including a special emphasis on the "ozone hole," volcanic events, and solar protons events
- Aerosol measurements
- Cloud measurements
- Land and ocean measurements
- Earth radiation budget
- Pressure and temperature measurements

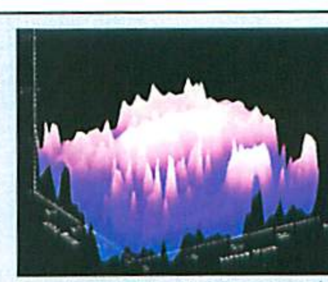
Total column ozone map (GOME), credit DLR.

Although **MERIS** is a sensor specifically designed for the investigation of marine and ocean processes, it will contribute to atmospheric investigations through the understanding of ocean processes as major drivers in climate. Also parameters such as the global coverage of clouds, cloud top heights, type and optical thickness of atmospheric aerosols will be measured to an accuracy never before realised with satellite observations. Data will aid in the generation of large scale maps, for:

- Ocean pigment concentrations, suspended sediments, dissolved organic matter;
- Clouds, aerosols, and water vapour content
- Measurements of pollution-derived aerosols over industrial zones, airports, and cities; to determine the sources of, and temporal trends in, pollution.

The prime scientific objective of the **A**dvanced **A**long **T**rack **S**canning **R**adiometer (AATSR) is to establish continuity of the ATSR-1 & 2 data sets of precise sea surface temperature (SST). Thus ensuring the production of a 10 year near-continuous data set especially useful for climate research.

This passive instrument takes measurements in the thermal infrared and visible channels. A two-angle viewing geometry can achieve a global accuracy in SST of better than 0.5 K by removing the distortions caused by the atmosphere. The visible channels will also be used to measure cloud parameters, for example; water/ice discrimination, temperatures and particle size distribution,



Isometric plot of cloud heights generated from ATSR data, credit RAL.

Further Information From: Dawn Williamson, DERA, tel: 01252 394663, fax: 01252 394663, email dwilliamson@scs.dera.gov.uk, http://www.eoboard.co.uk

DERA BNSC

ENVISAT EXPLOITATION PROGRAMME

Sources of information on the Envisat mission.

Available from ESA Publications, ESTEC
Earth Observation Quarterly.
EOQ 55 August 1997 (includes polar ozone, GOME< ATSR)
EOQ 58 March 1998 GOME Special (includes Ozone column, Ozone Profile, Minor Trace Gases, Applications, Validation and Development)
EOQ 59 June 1998 Wind Field Retrievals from SAR
EOQ 60 October 1998 Envisat instruments, products and applications
EOQ 61 Feb 1999 (includes the Data user programme and atmospheric applications)

Envisat Mission – Opportunities for Science and Applications SP-1218. January 1998
Envisat Mission – Product Summary Overview SP-1221. March 1998

Envisat Mission and System Summary. March 1997

Internet
ESA Envisat web site. Provides details on mission and instruments
www.
UK Envisat site. Provides information on UK initiatives and programmes of work. Please add information on your own interests, projects and organisations, post messages and ask questions.
www.eoboard.co.uk

DERA

BNSC

ENVISAT EXPLOITATION PROGRAMME

USING ENVISAT DATA FOR ATMOSPHERIC APPLICATIONS

Requirements for Envisat Data

Please complete form and return to Dawn Williamson. (Room 1058, A8 Bldg. DERA, Farnborough GU14 0LX, fax 01252 396310)

What is your main area of research?

Which instruments might provide useful data for your work?

MERIS
AATSR
GOMOS
SCIAMACHY
MIPAS

Other

Do you require data?

In near real time for operational work
Within 3/ 6 months for research

Will you do your own processing of the data or
Will you want processed data in a format that can be directly input into models?

Will you be receiving data

As a PI
Through NERC
As a researcher but through another mechanism
Purchase from ESA or a distributor

What further information would you like about instruments on Envisat

What would you like BNSC to do in increase the atmospheric science communities ability/capacity to use data from spaceborne instruments