Odin: ten times the lifetime - ten times the science?

ETON rocket campaign
23rd March 1982

Swedish Space Corporation

Odin

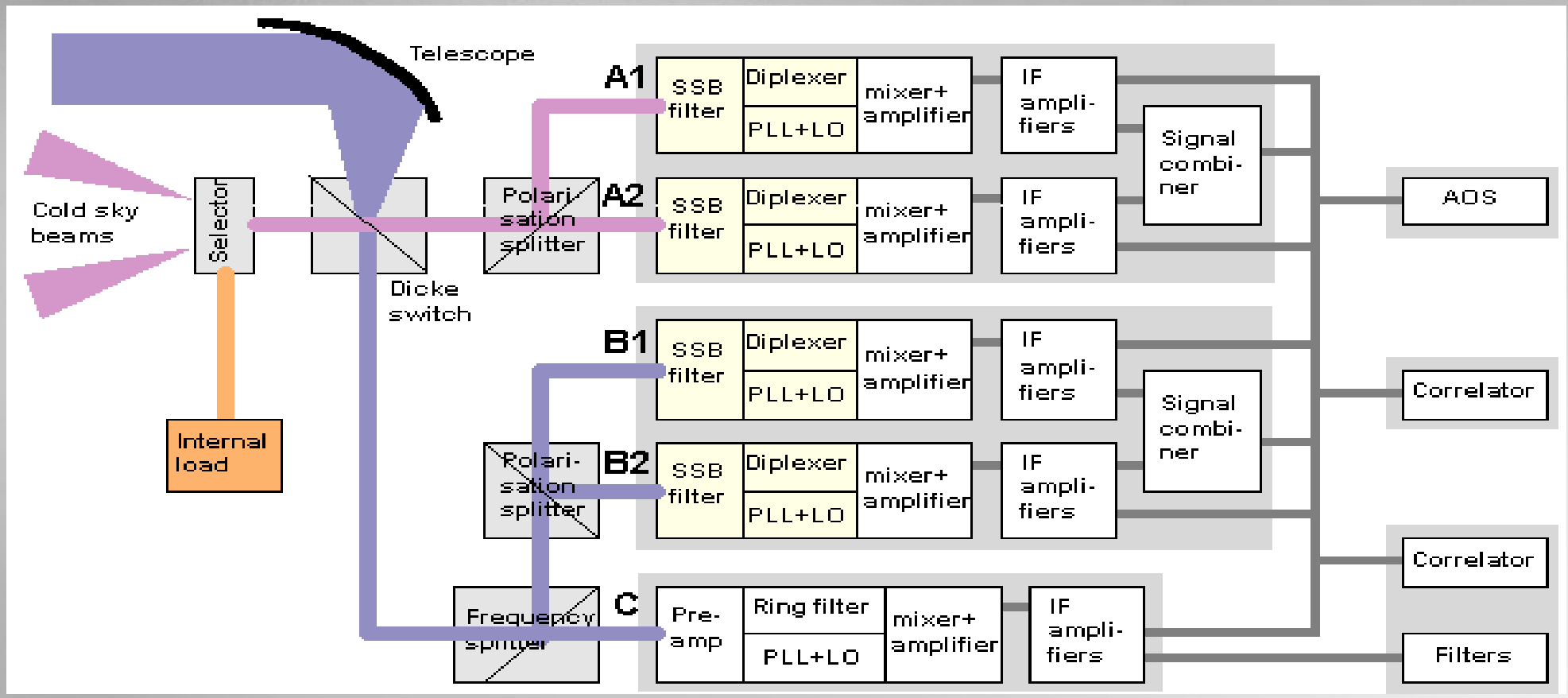
MINUTES OF MEETING	Date: **22 May 1992**	Ref: RWB5-295
Subject: **Odin Science Team, meeting 2**	Place: **Swedish Space Corporation**	

Attendance			
Participants	Organisation	Participants	Organisation
Åke Hjalmarson	OSO	Erik Ordell	OSO
Urban Frisk	SSC	Fredrik Sjöberg	SSC
Jacek Stegman	MISU	Donal Murtagh	MISU
Lennart Nordh	SOS	Fredrik von Schéele	SSC
Georg Witt	MISU		
Invited, but could not attend:			
Roy Booth	OSO	Göran Pilbratt	ESA-SSD

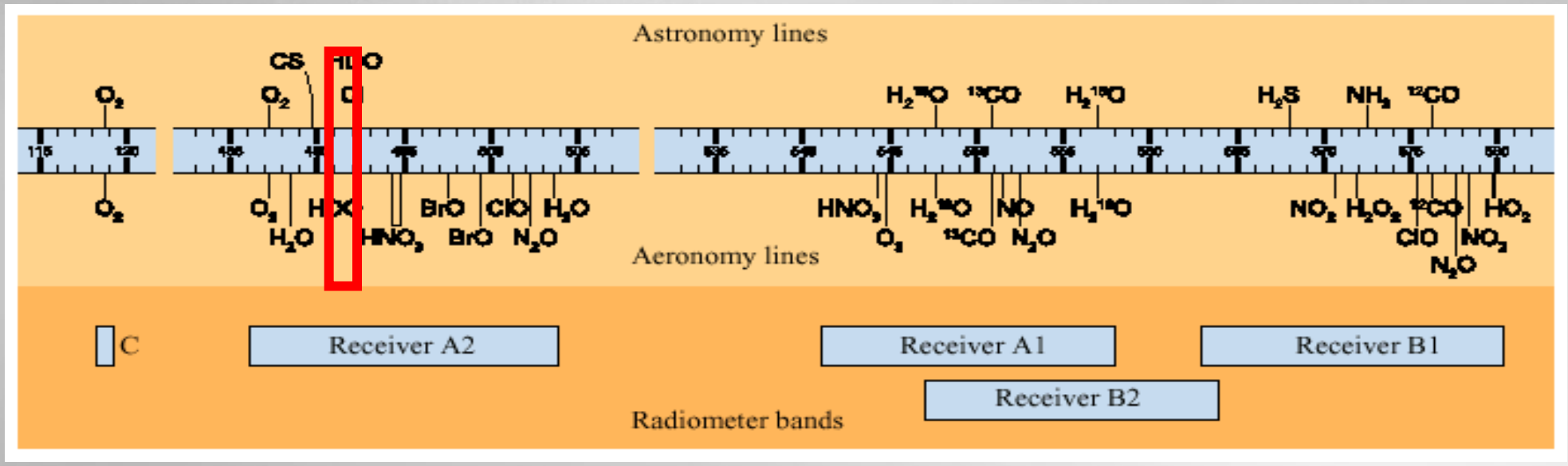
Odin

- Launched 20 Feb 2001
- Joint Astronomy/Aeronomy mission
- Carries two instruments
  - SMR
  - OSIRIS
- Sun synchronous orbit 18:00 hour ascending node
- Two year design life

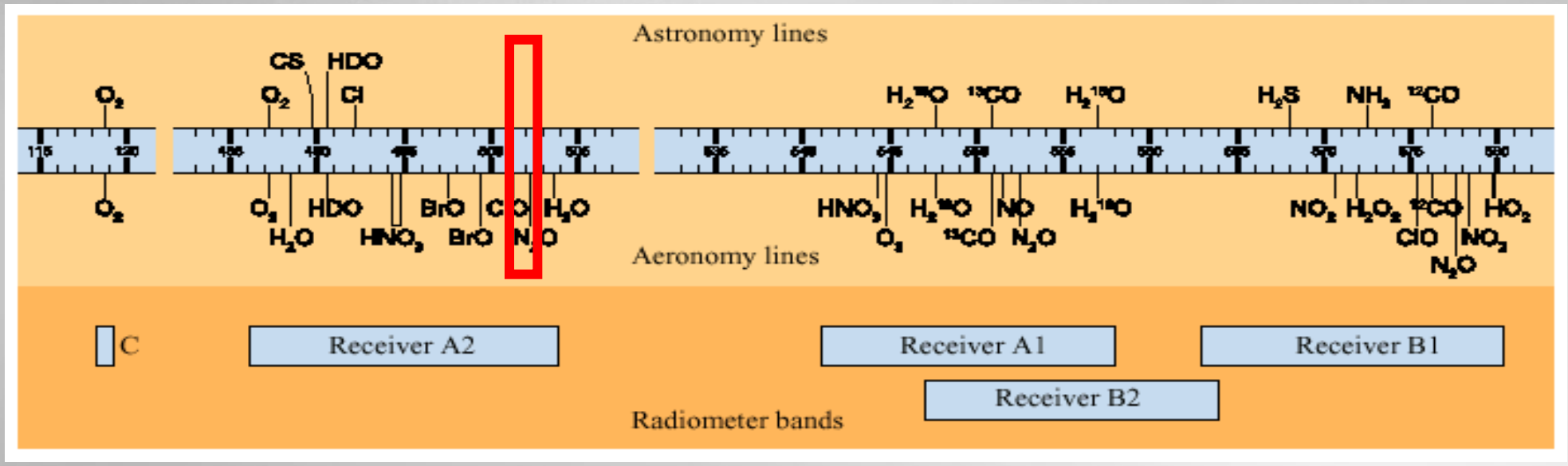
The Radiometer SMR



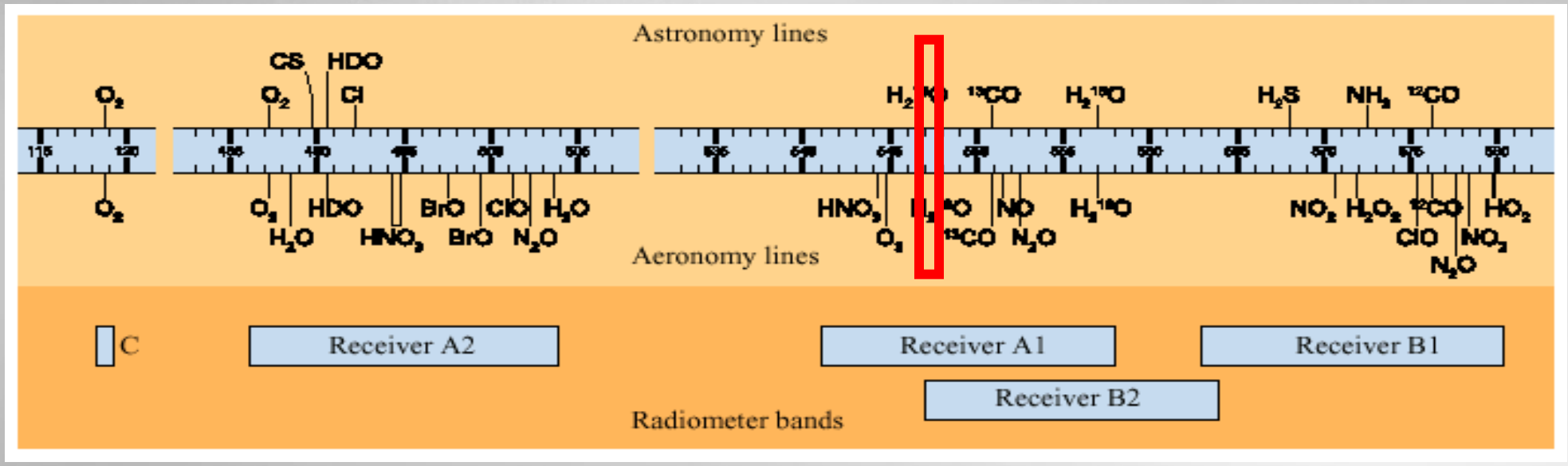
Frequency coverage and species



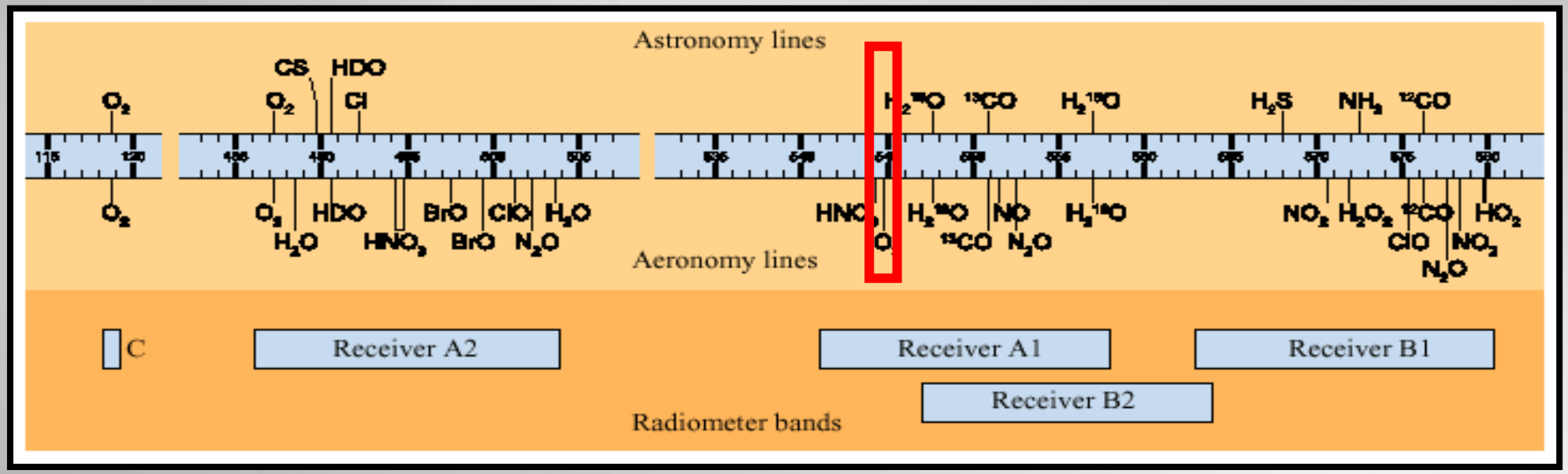
Frequency coverage and species



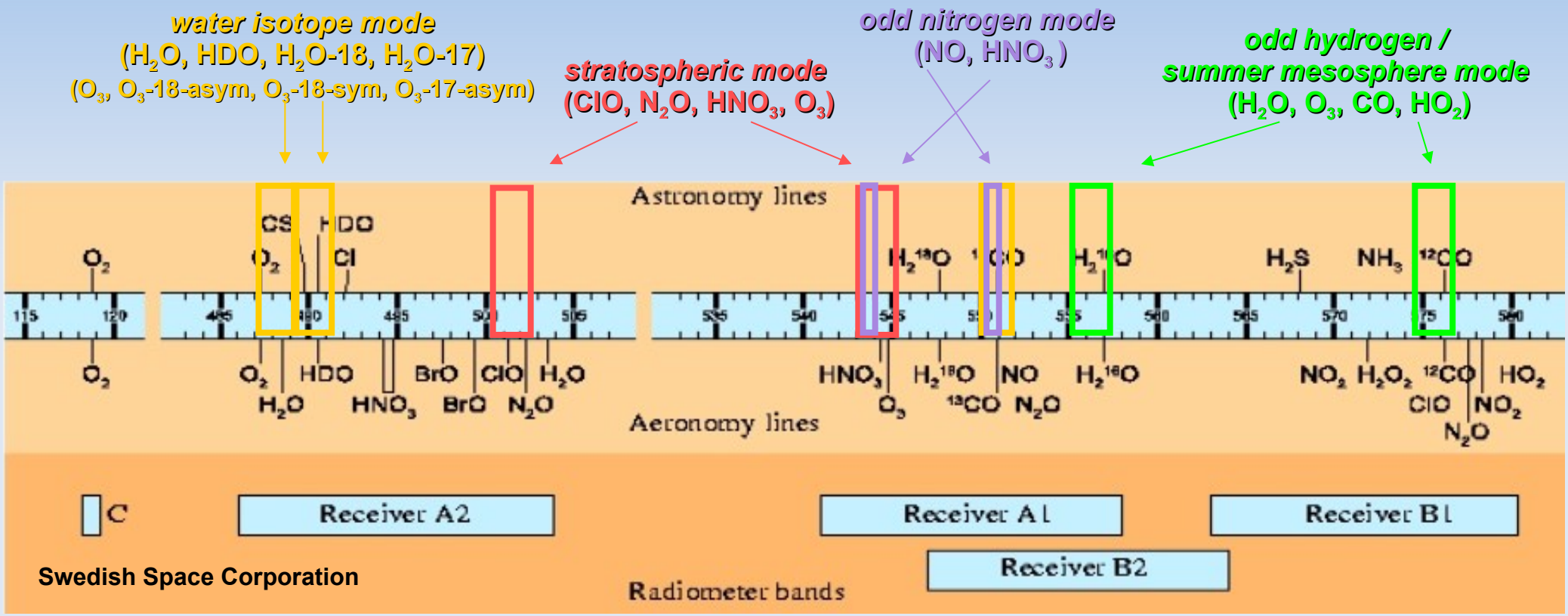
Frequency coverage and species



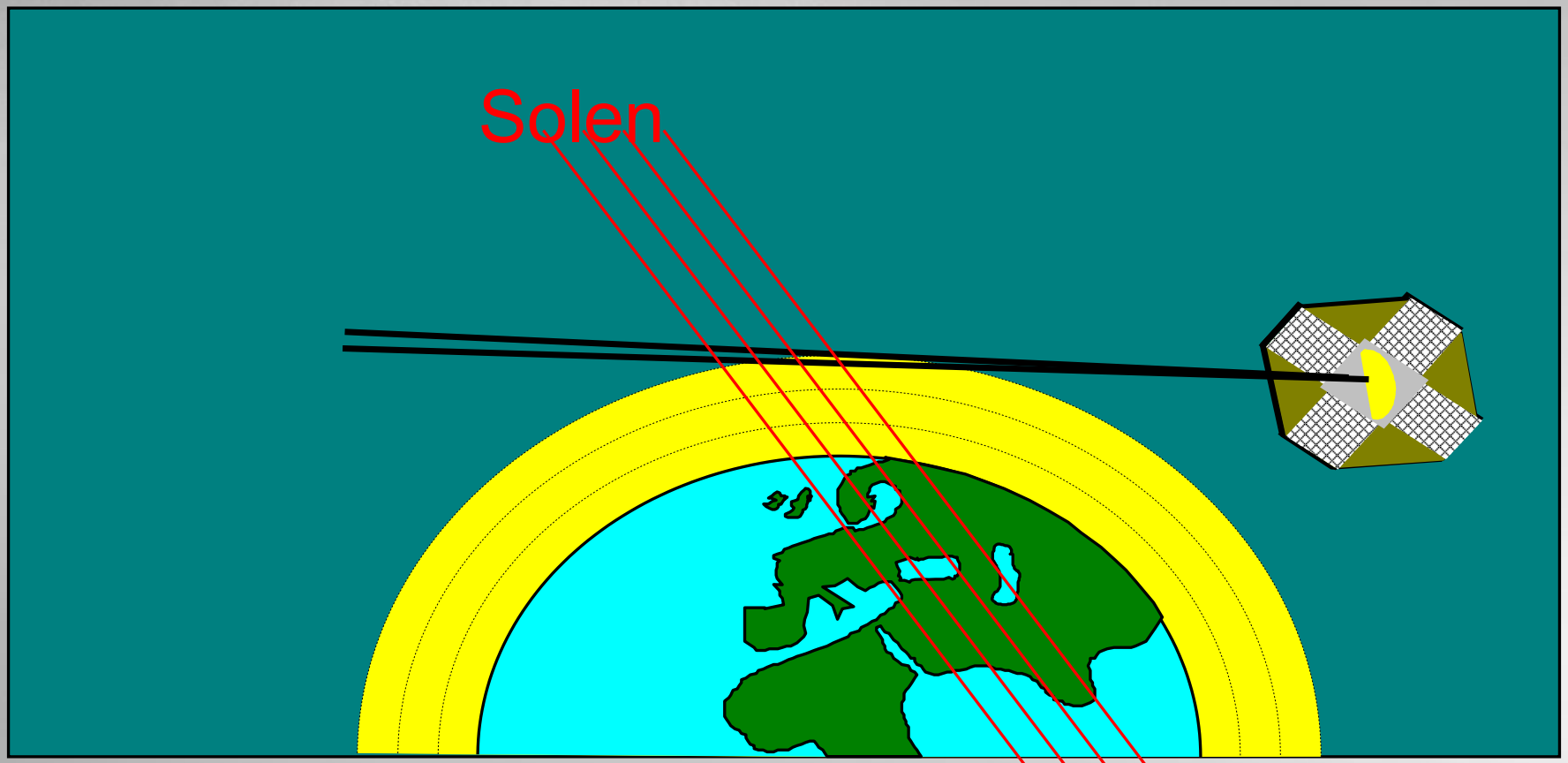
Frequency coverage and species



Odin/SMR frequency coverage

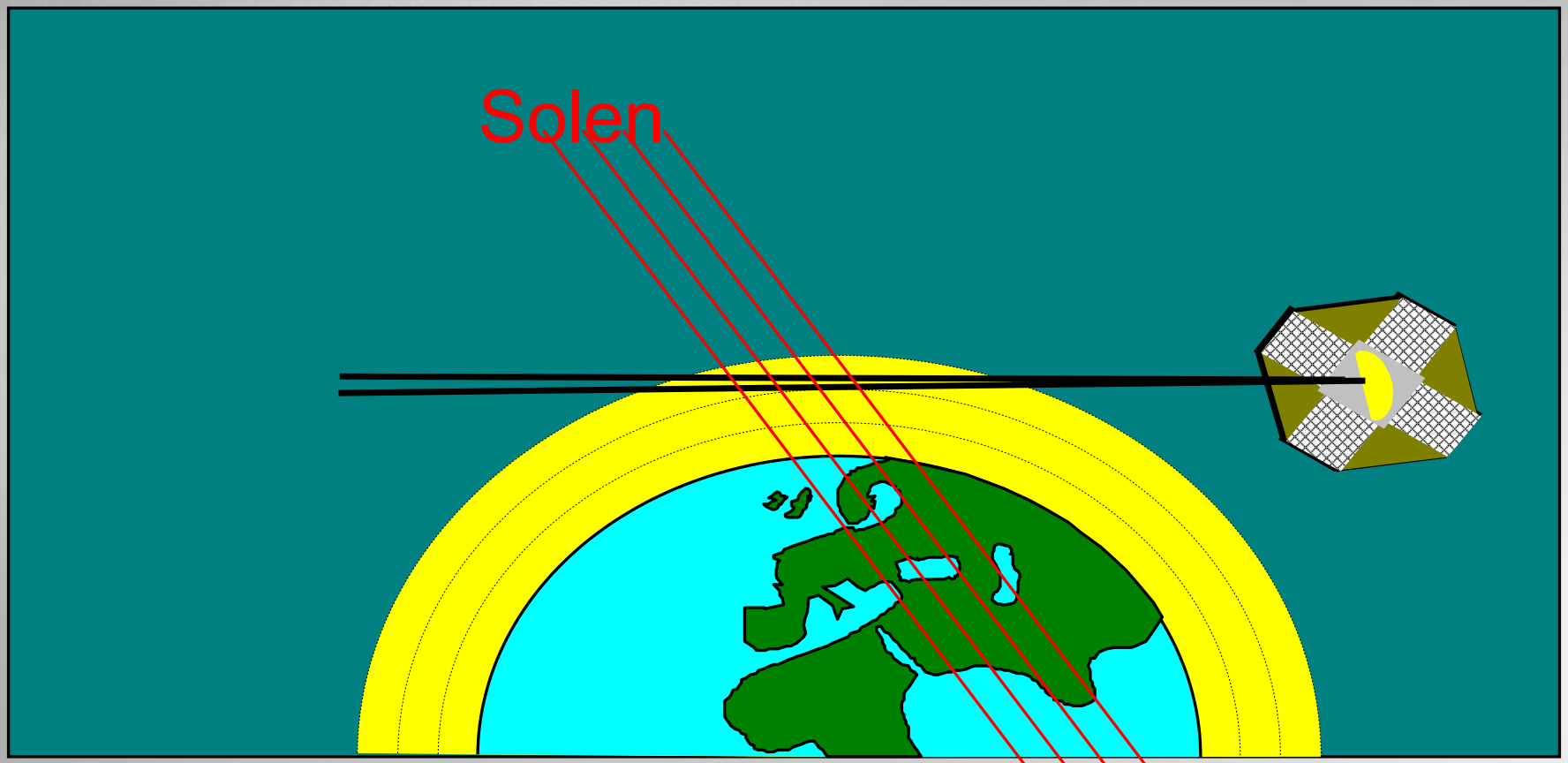


Odin limb scanning

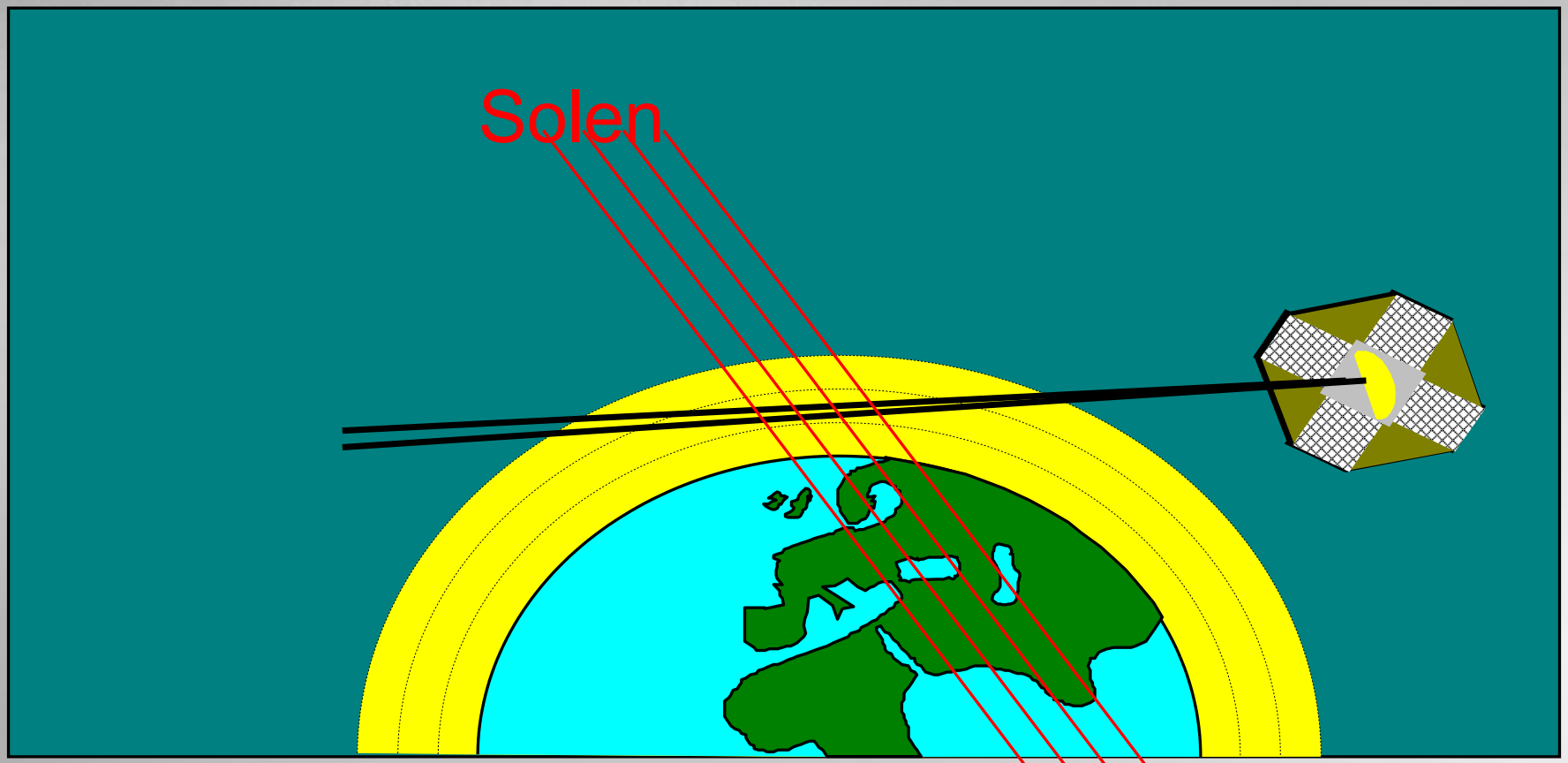


Först

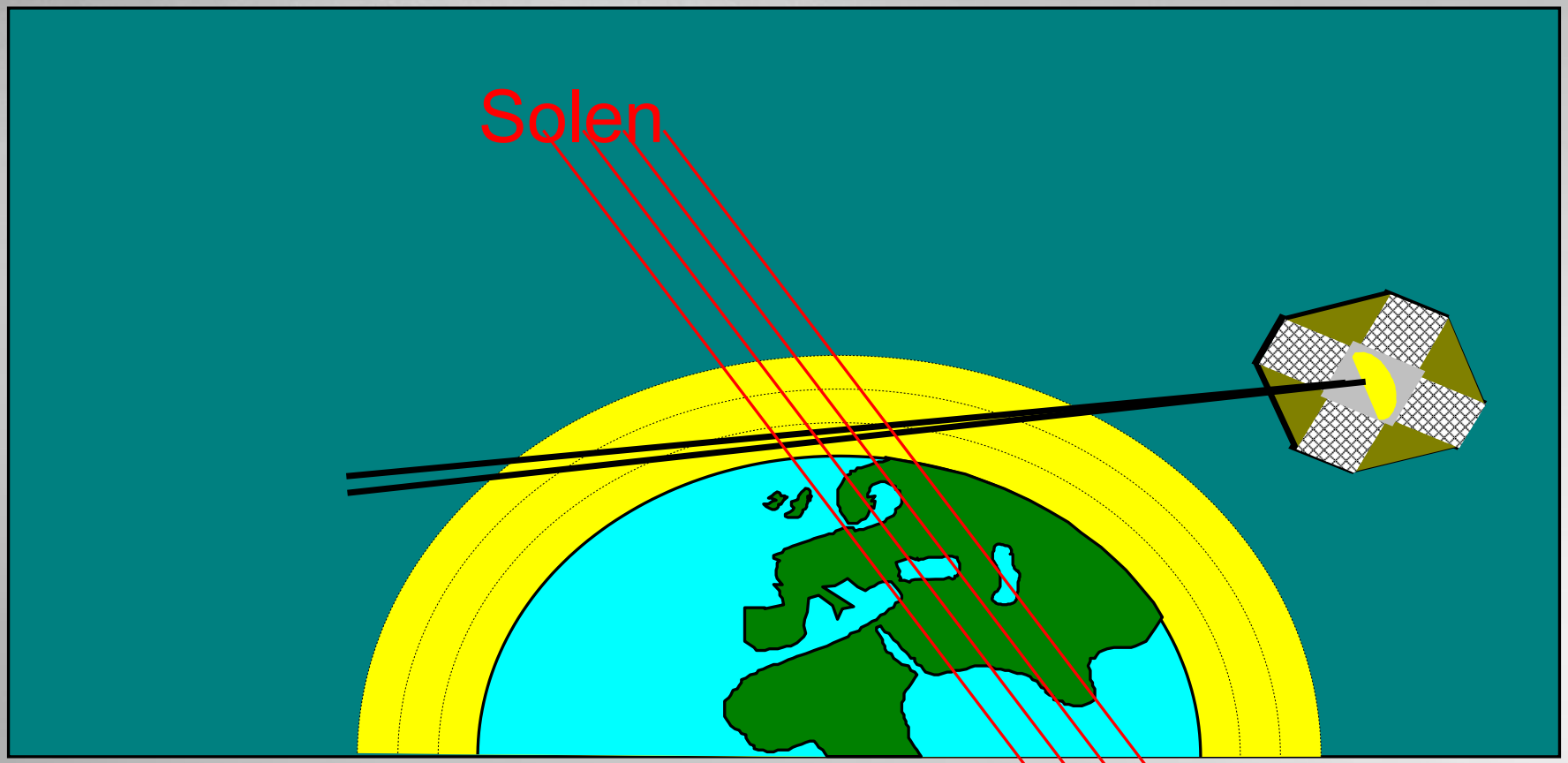
Odin limb scanning



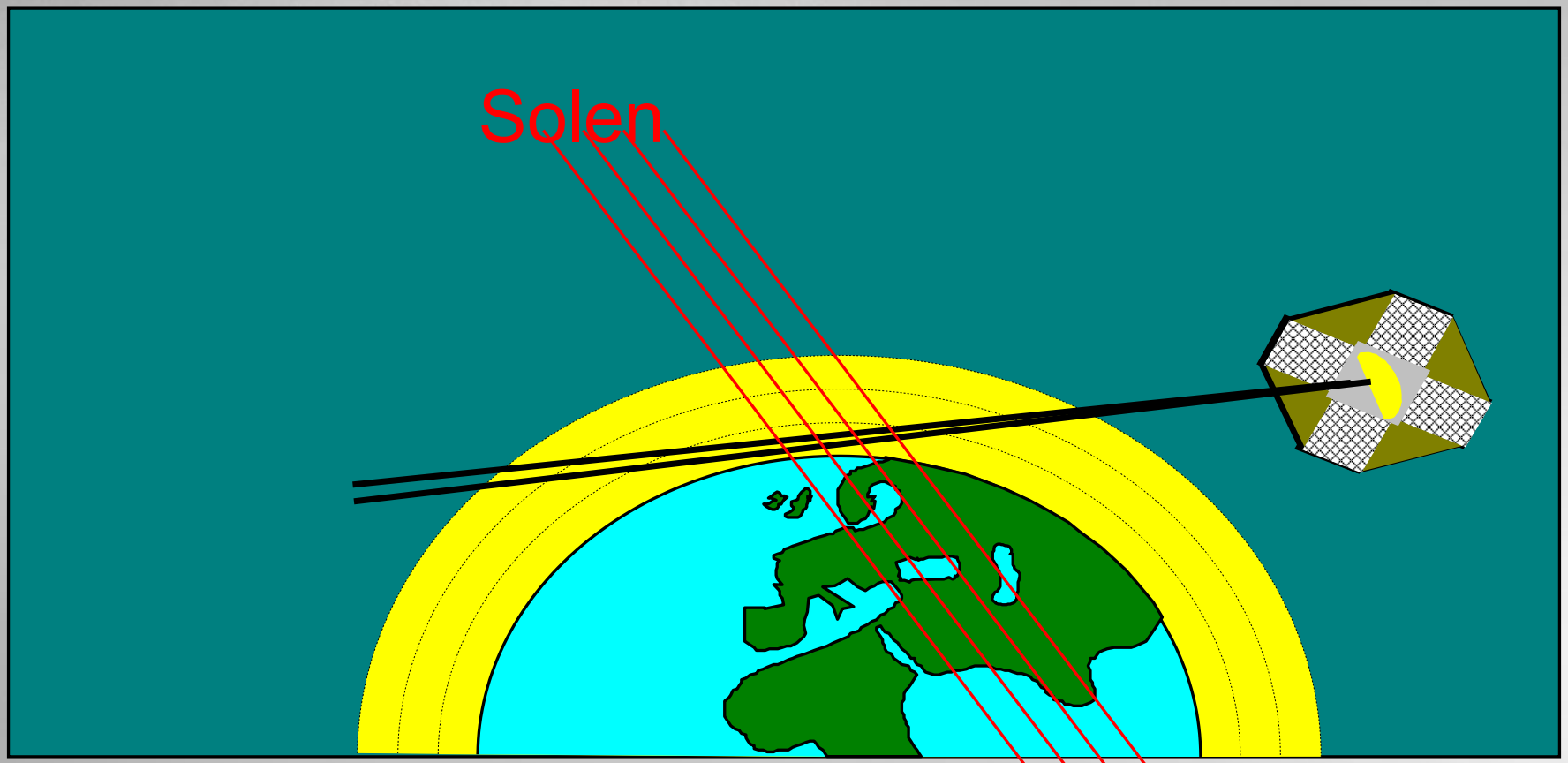
Odin limb scanning



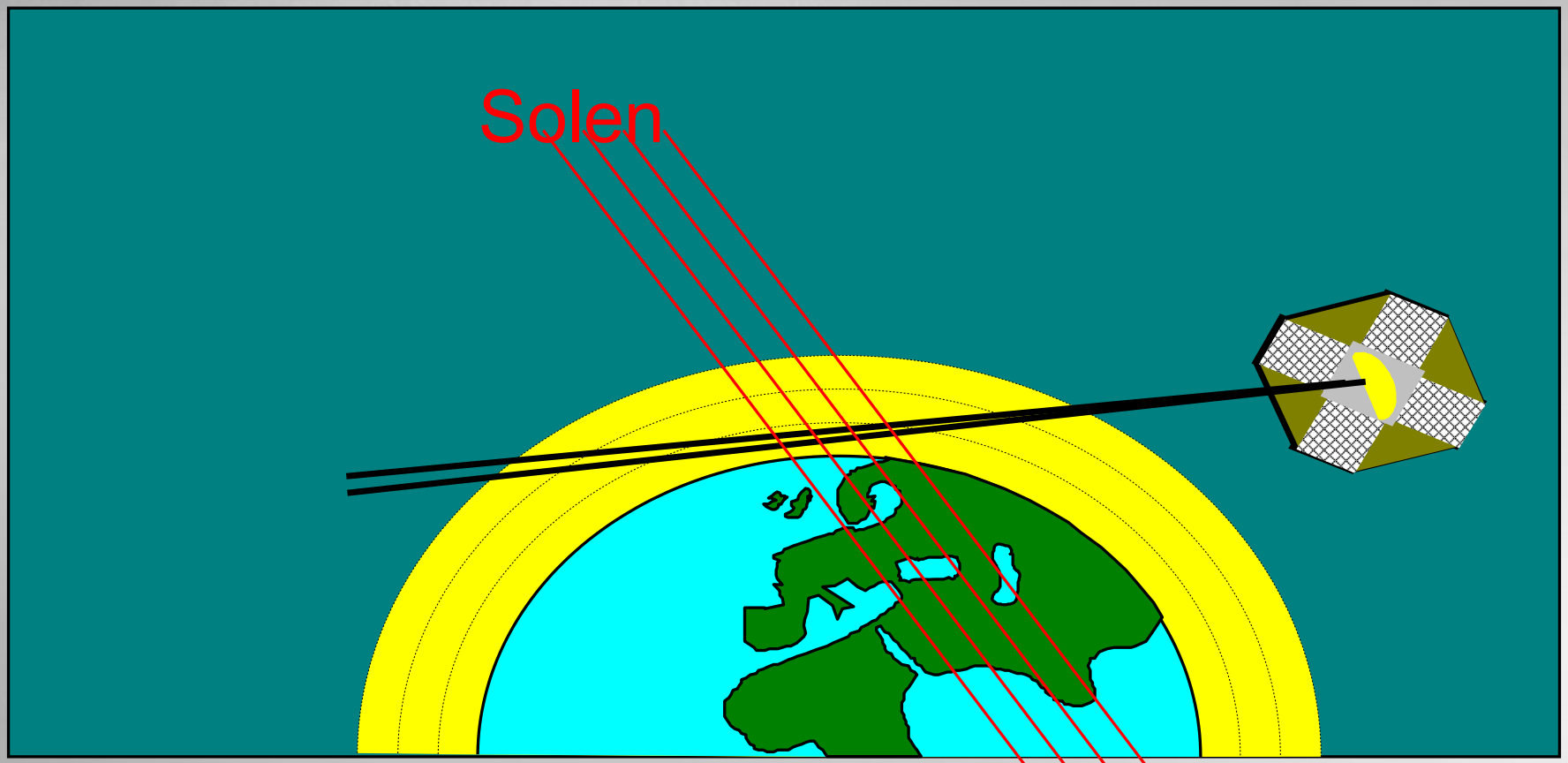
Odin limb scanning



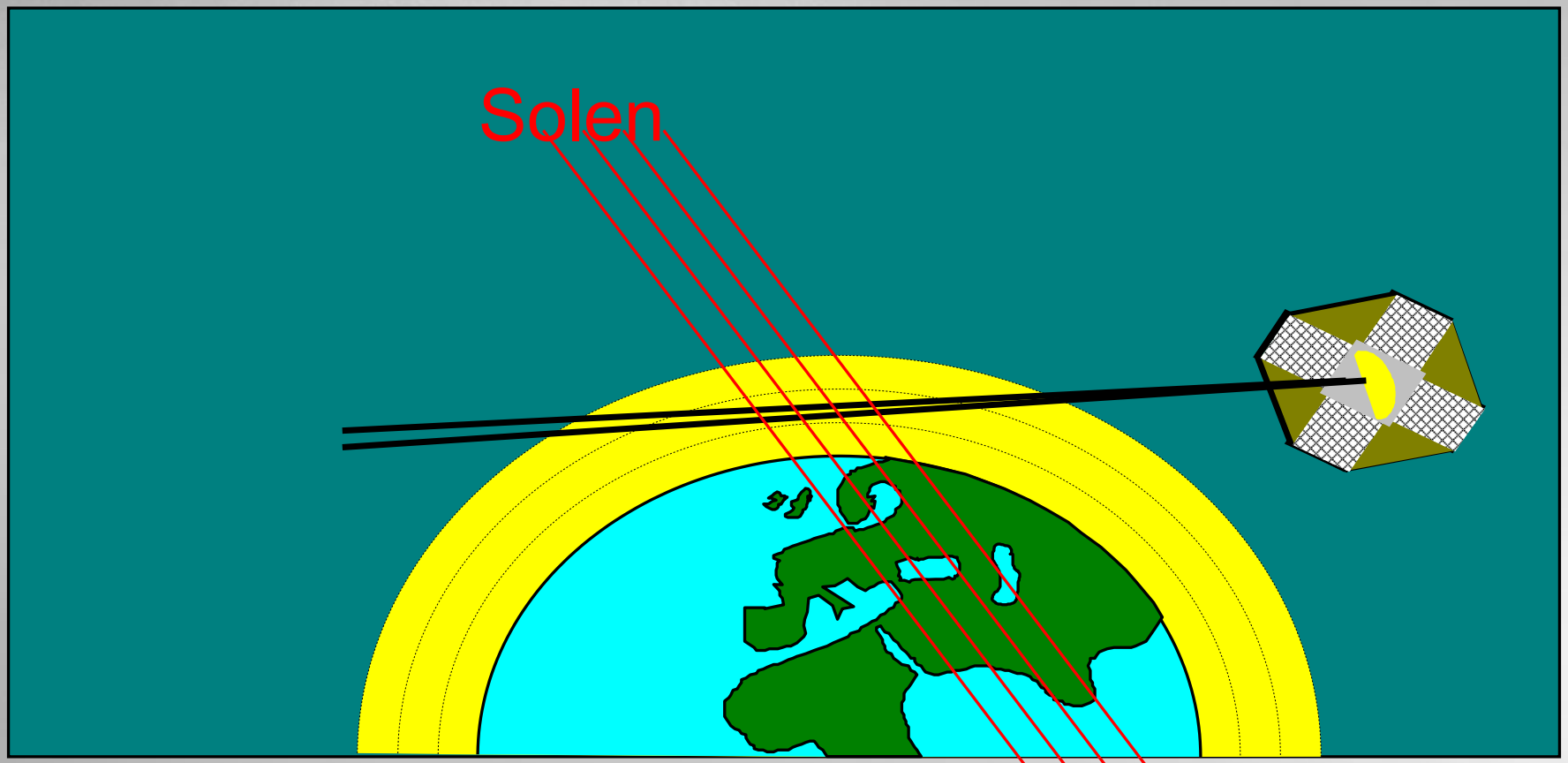
Odin limb scanning



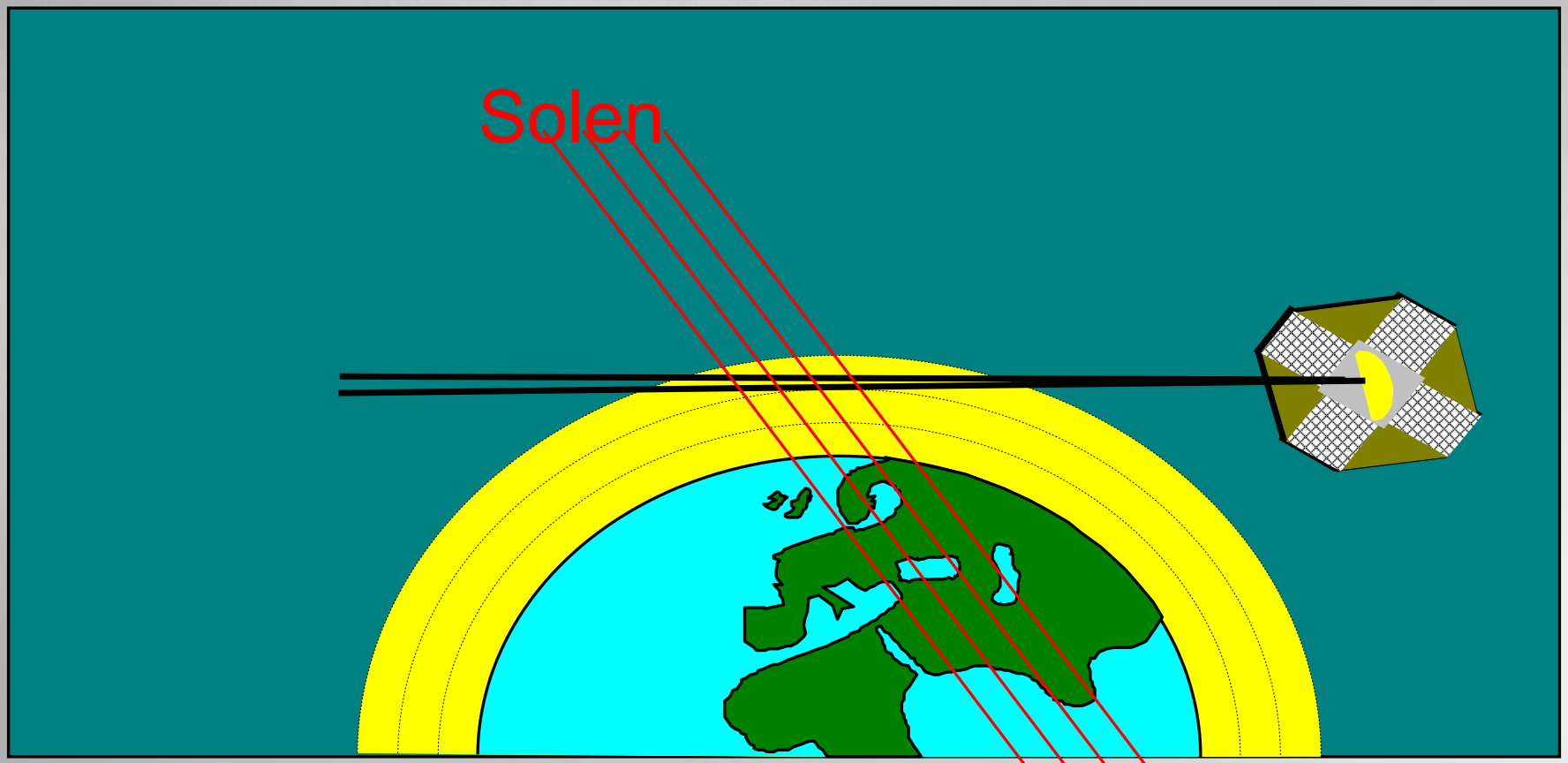
Odin limb scanning



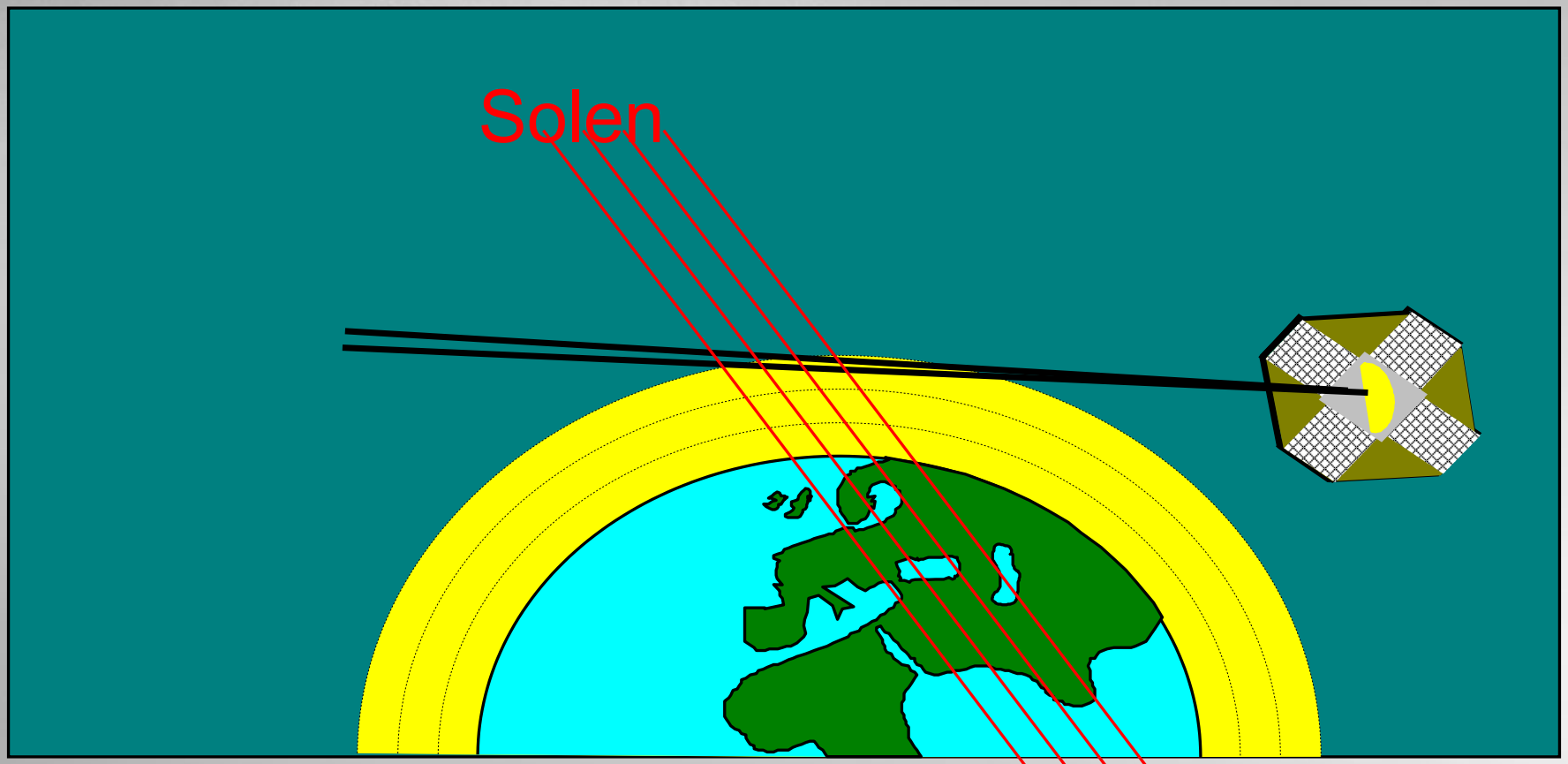
Odin limb scanning



Odin limb scanning

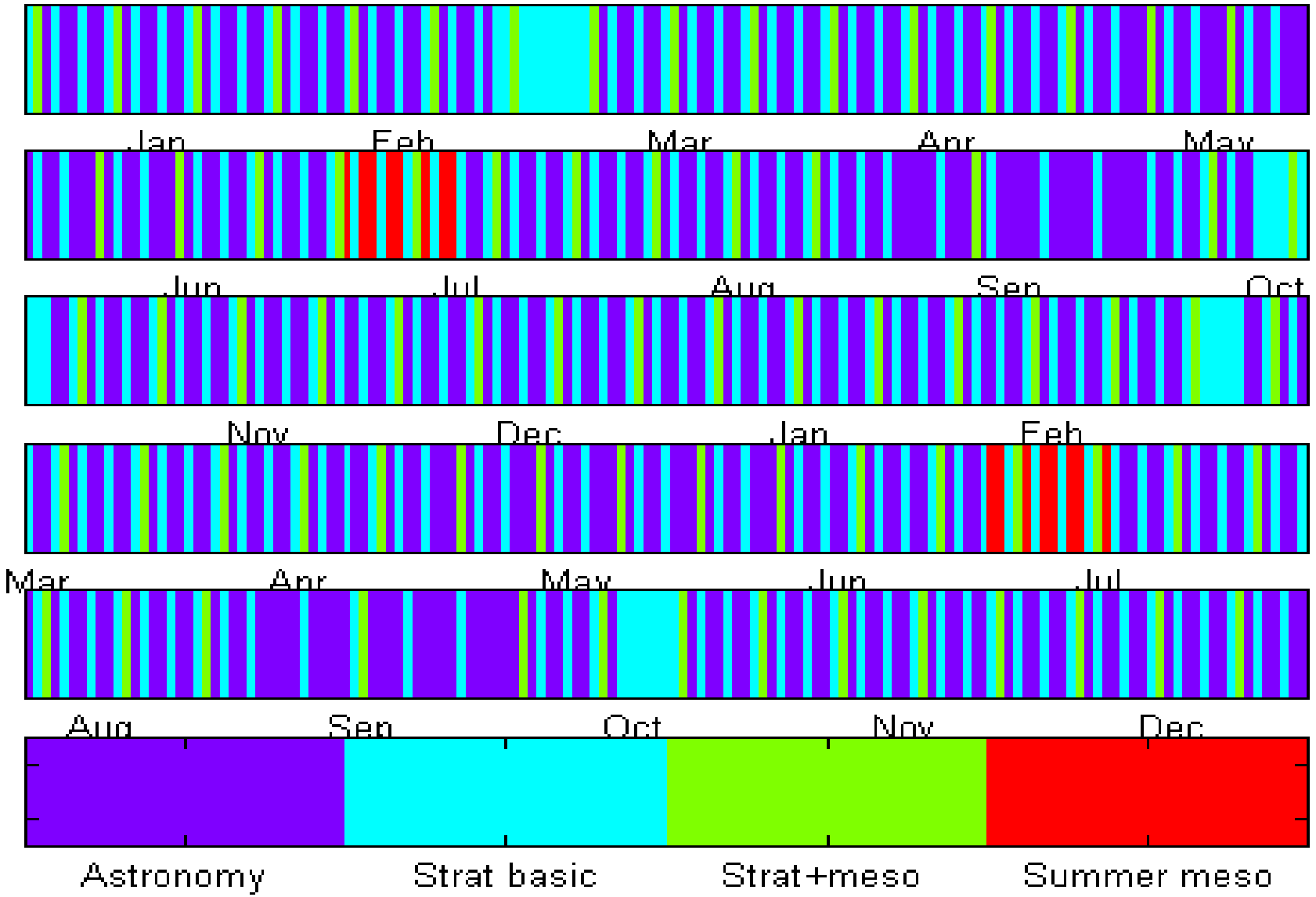


Odin limb scanning



Division of time with Astronomy (First 7 years)

- 50 – 50 principle
- Basic stratospheric mode every 3rd day
- Extra day for other modes every 3rd basic day
- Special programmes for validation campaigns and geophysically interesting periods

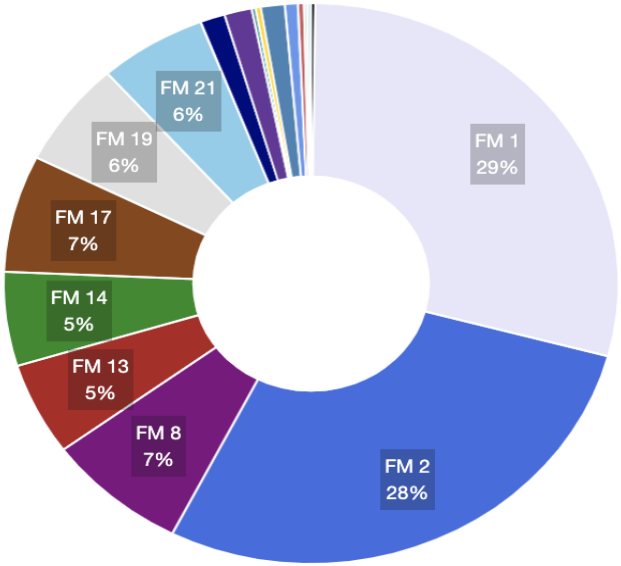

Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Astronomy
Strat basic
Strat+meso
Summer meso

Current status of database

This page displays the statistics for the Odin/SMR altitude scans for each frequency modes as defined in the table below. Click on a year to see detailed statistics for that year.

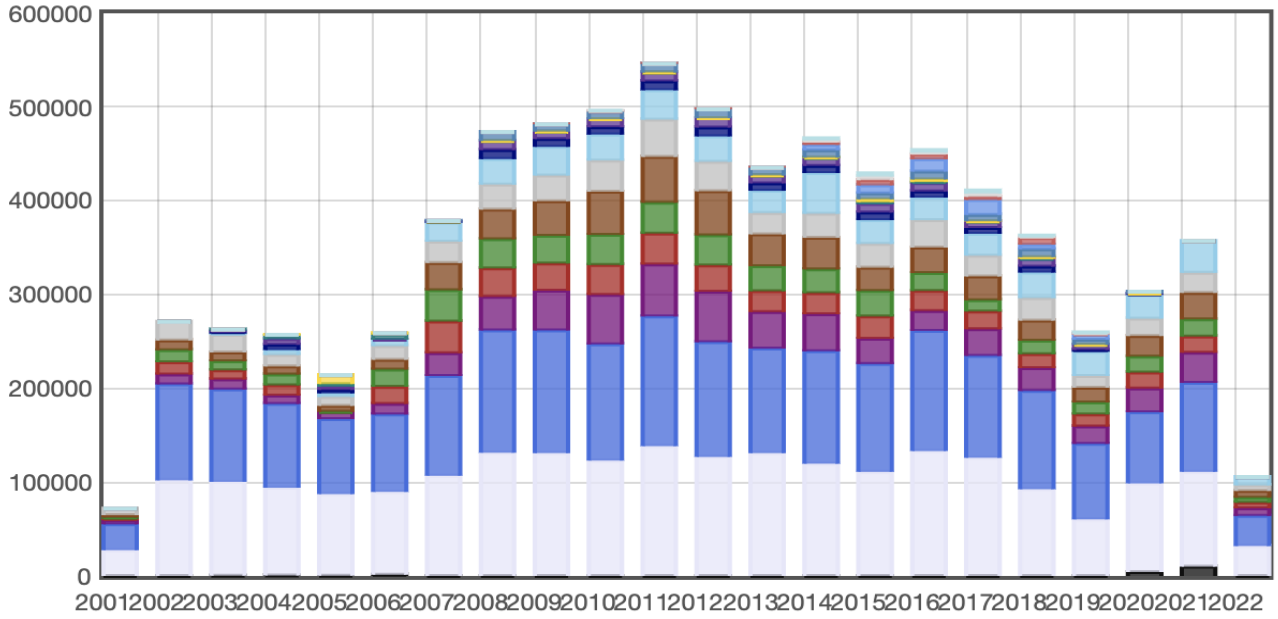
The database contains a total of 7794356 scans

Total number of scans by frequency mode:



Total number of scans: 7794356

Number of scans and frequency mode distribution per :

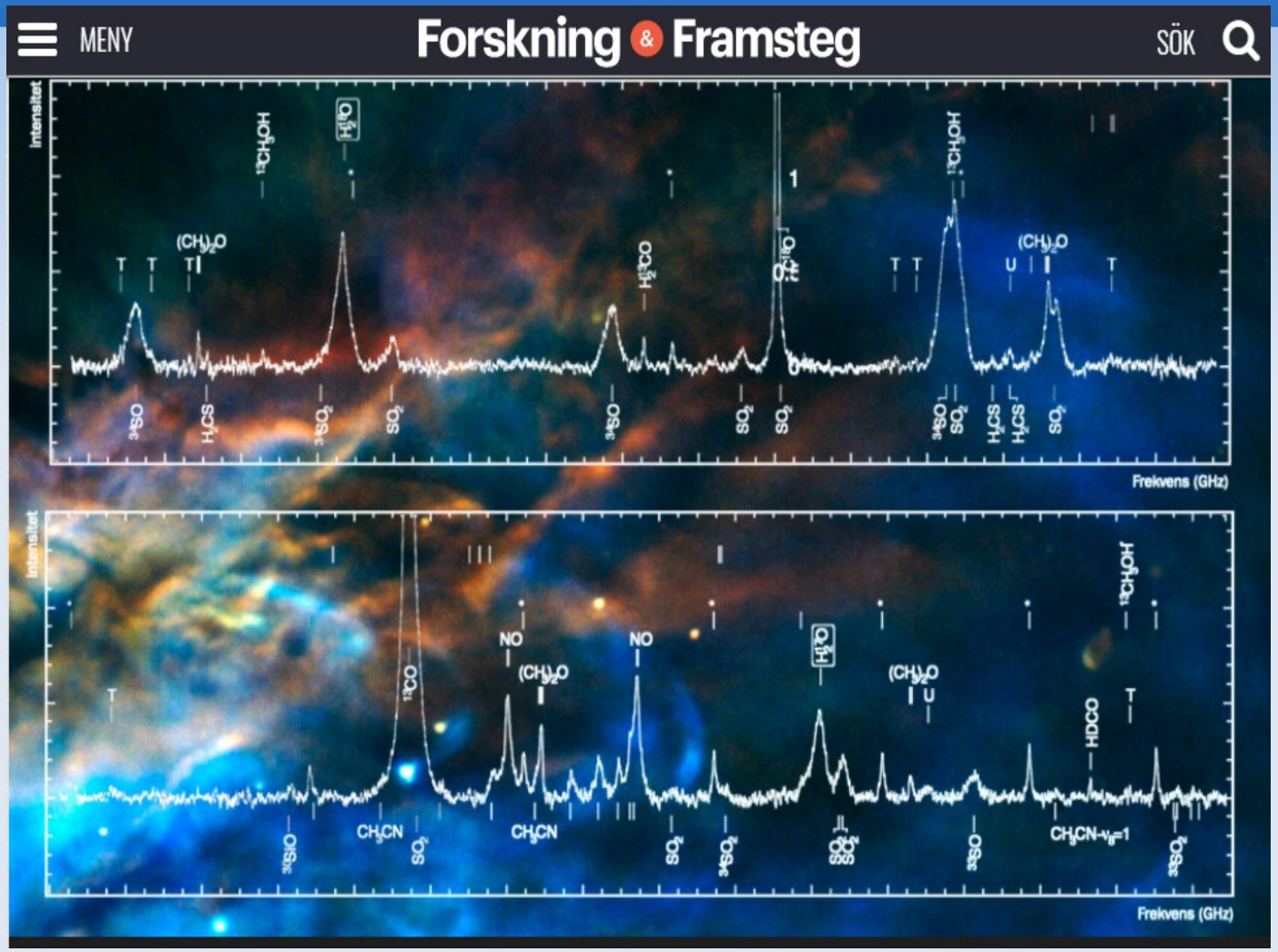


Total number of scans: 7794356

Astronomy -2008 +++

- Goals : O_2 , H_2O, line surveys in preparation for Herschel
- O_2 turned out to be much less abundant than expected
- H_2O in Galactic centre, comets, planetary atmospheres
- Extended lifetime
  - More comets
  - Follow changes in water injected into Jupiter's atmosphere by Comet Shoemaker-Levy 9

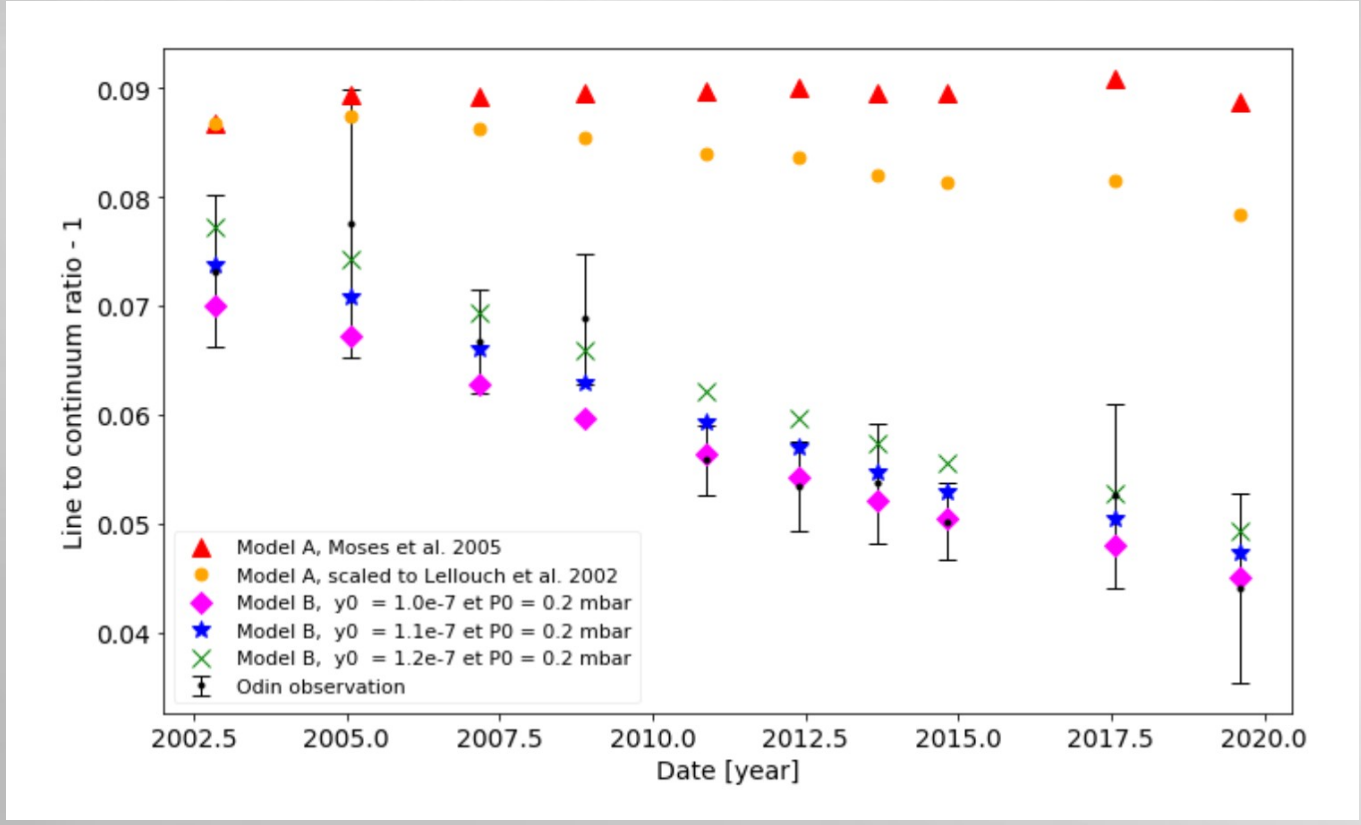
- Molekyler i stjärnbilden Orion



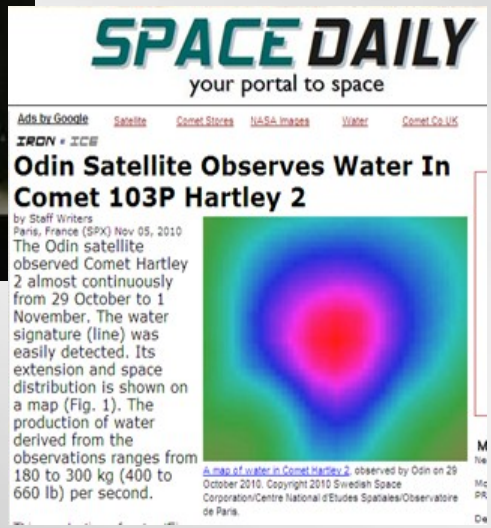
18-year long monitoring of the evolution of H_2O vapor in the stratosphere of Jupiter with the Odin space telescope

B. Benmahi[1], T. Cavalié[1,2], M. Dobrijevic[1], N. Biver[2], K. Bermudez-Diaz[2,3], Aa. Sandqvist[4], E. Lellouch[2], R. Moreno[2], T. Fouchet[2], V. Hue[5], P. Hartogh[6], F. Billebaud[1], A. Lecacheux[2], Å. Hjalmarson[7], U. Frisk[8], M. Olberg[9], and The Odin Team

Astronomy and Astrophysics 2020



- Odin erkänt duktig på att detektera vatten.
- Så ibland ber NASA om hjälp.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IRON • ICE

Odin Satellite Observes Water In Comet 103P Hartley 2

by Staff Writers
Paris, France (SPX) Nov 05, 2010

The Odin satellite observed Comet Hartley 2 almost continuously from 29 October to 1 November. The water signature (line) was easily detected. Its extension and space distribution is shown on a map (Fig. 1). The production of water derived from the observations ranges from 180 to 300 kg (400 to 660 lb) per second.

A map of water in Comet Hartley 2, observed by Odin on 29 October 2010. Copyright 2010 Swedish Space Corporation/Centre National d'Etudes Spatiales/Observatoire de Paris.

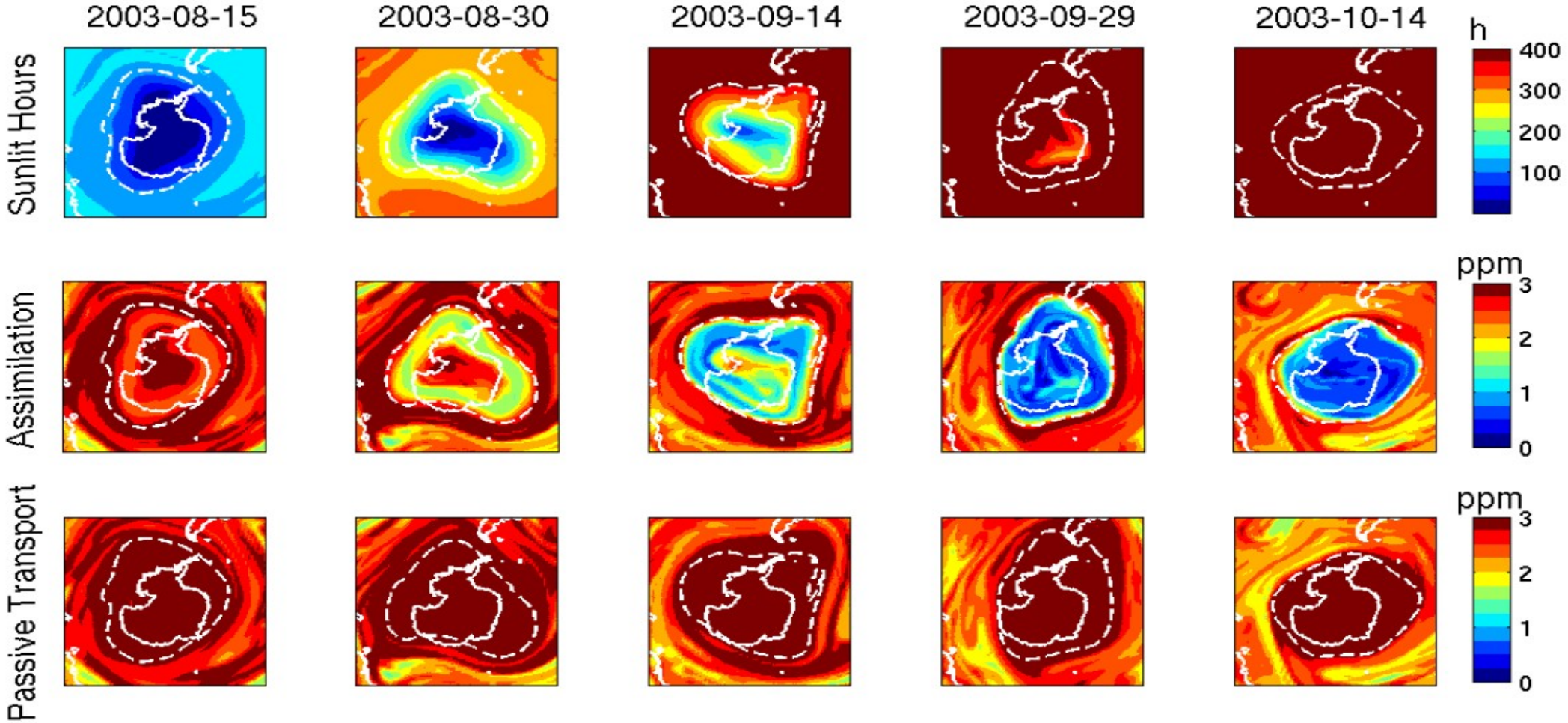
DEEP IMPACT MED TEMPLE 1, 2005
LCROSS, 2009
HARTLEY 2, 2010

Aeronomy goals

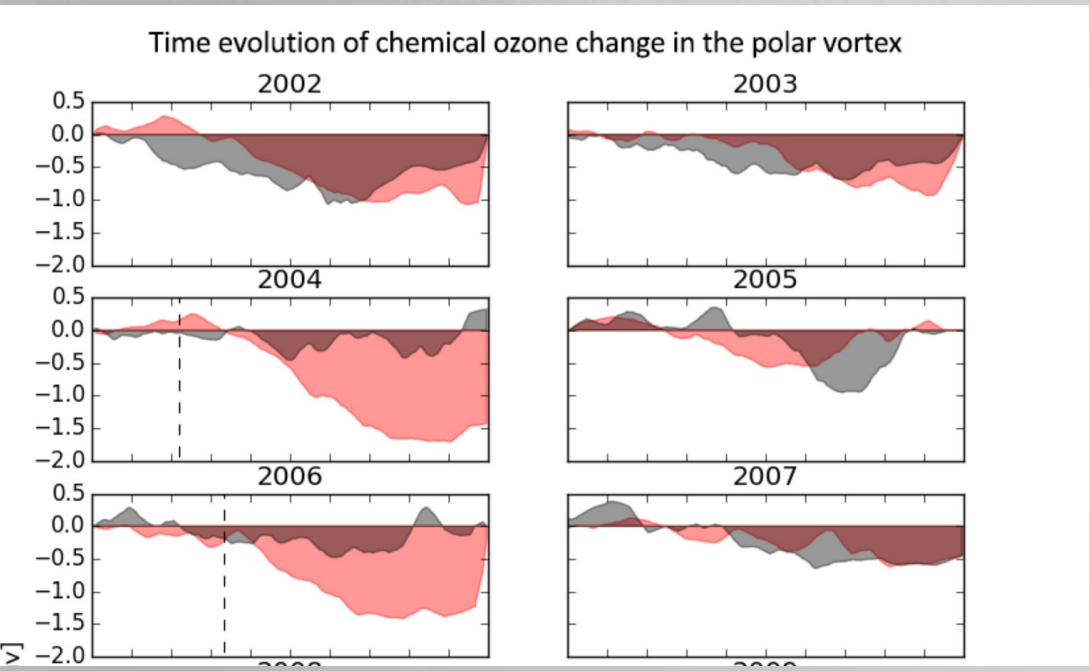
- Ozone loss
- Coupling between atmospheric regions
- Mesospheric small scale layers – NLC etc

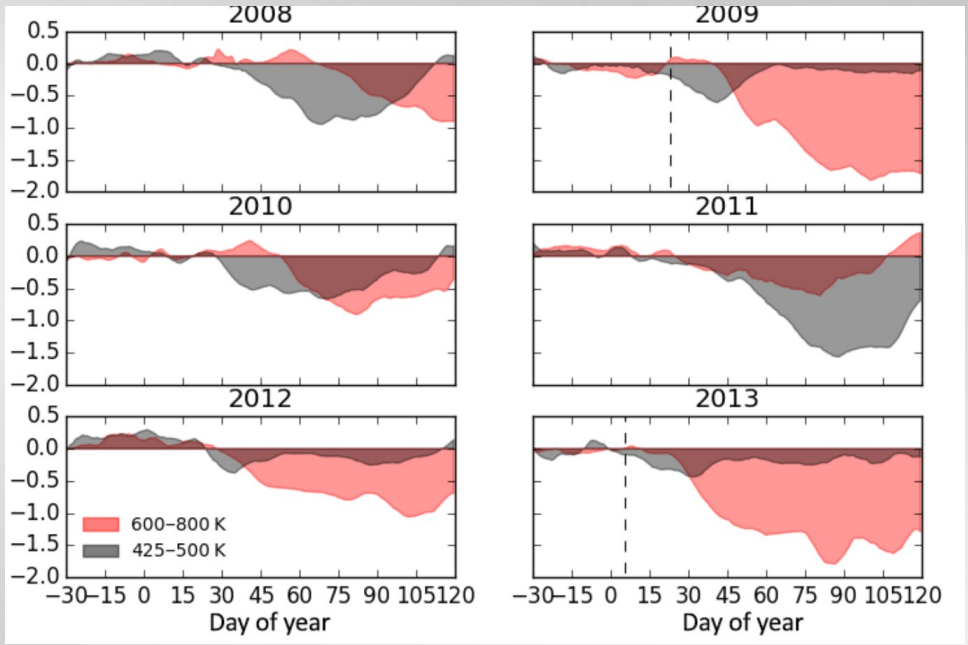
Ozone loss

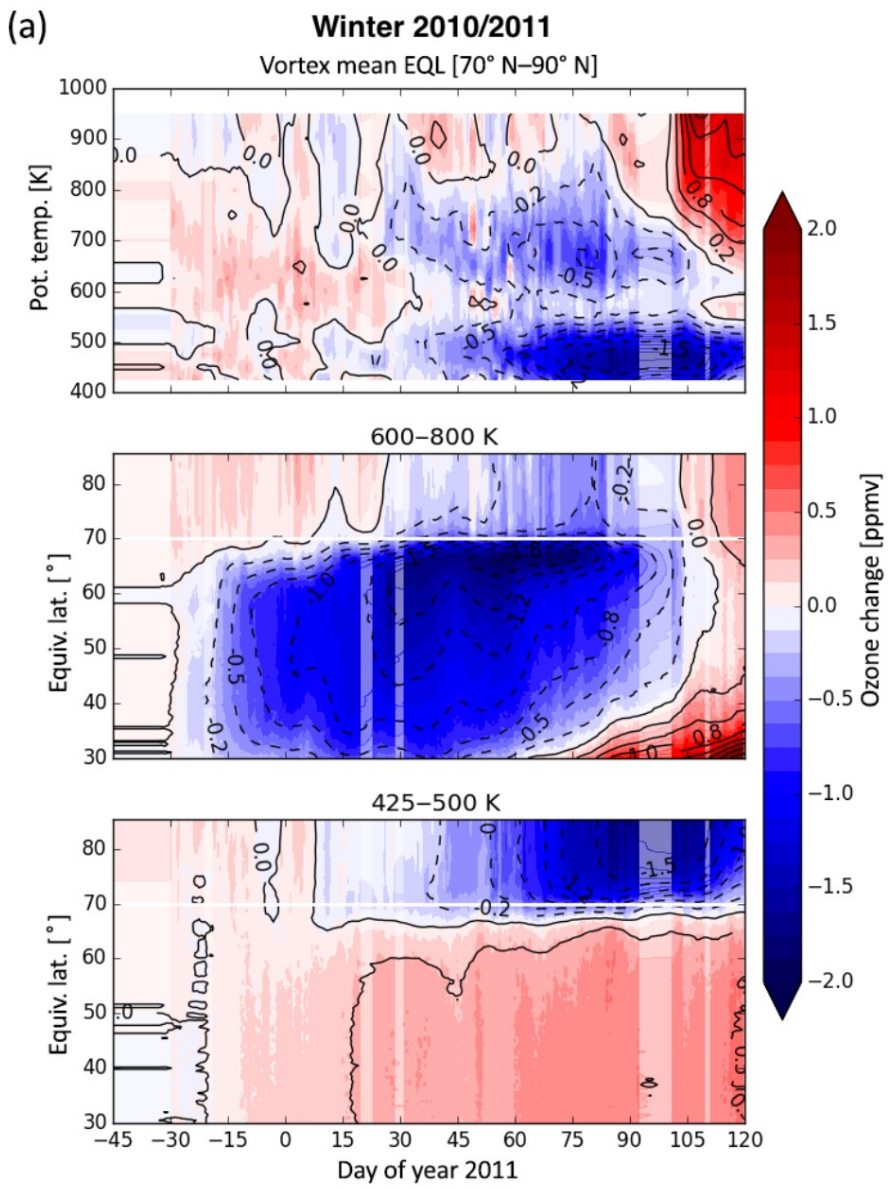
Ozone loss SH 2003

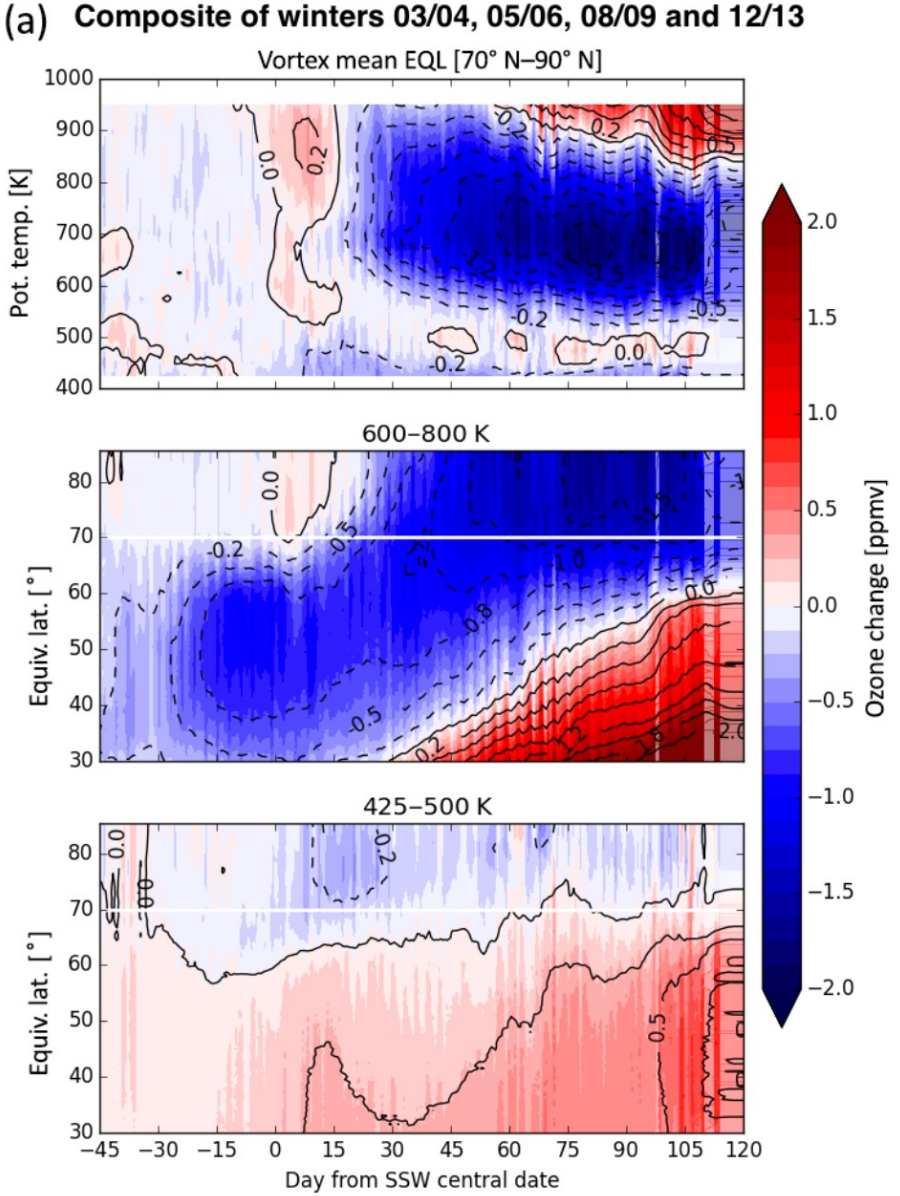


Two ozone loss mechanisms
Sagi et al. 2016





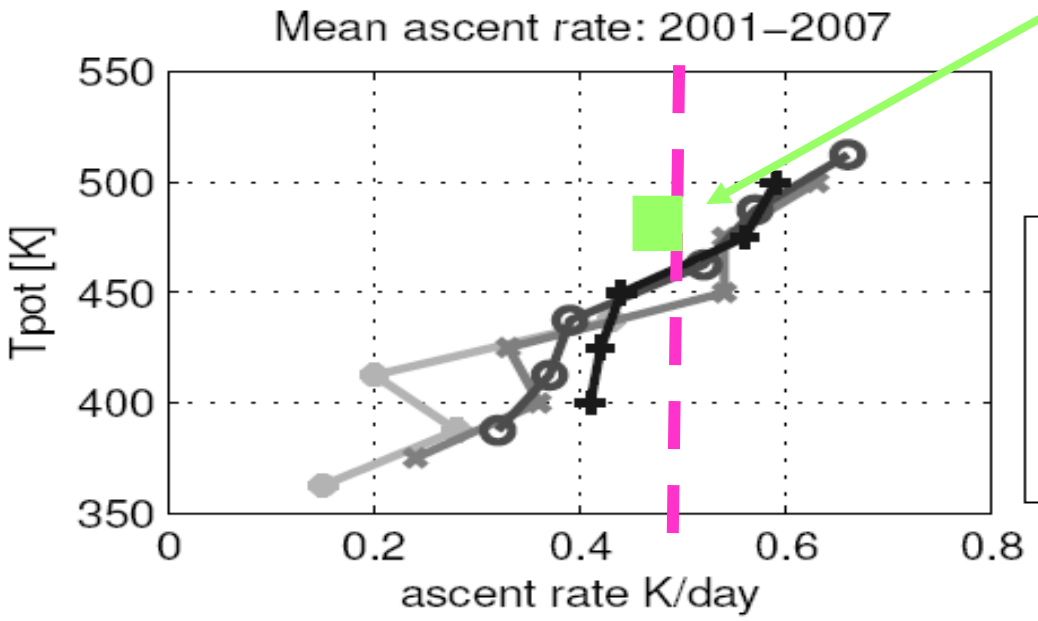

(a)
Winter 2010/2011
Vortex mean EQL [70° N–90° N]
Pot. temp. [K]
600–800 K
Equiv. lat. [°]
425–500 K
Equiv. lat. [°]
Day of year 2011
Ozone change [ppmv]


(a)
Composite of winters 03/04, 05/06, 08/09 and 12/13
Vortex mean EQL [70° N–90° N]
Pot. temp. [K]
600–800 K
Equiv. lat. [°]
425–500 K
Equiv. lat. [°]
Day from SSW central date
Ozone change [ppmv]

Stratospheric Dynamics

Tropical ascent rates

heating rates, trajectories
[Wohltmann & Rex ACPD, 2007]



Odin/SMR H2O@544.6GHZ

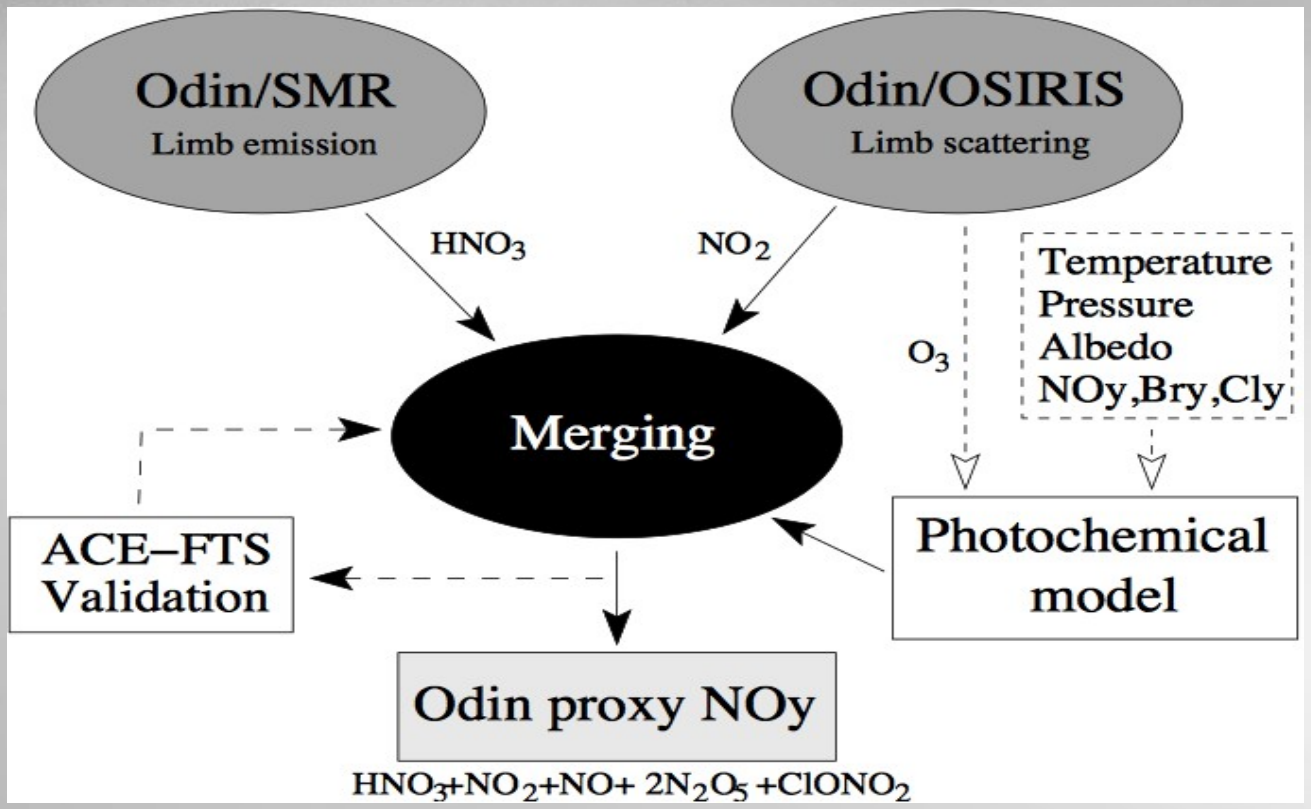
	375 to 550K	375 to 450K	450 to 550K
ΔT_{pot}=25K:	–	(0.30	–) K/day
ΔT_{pot}=50K:	0.48	(0.34, 0.58)	K/day
ΔT_{pot}=75K:	0.50	(0.37, 0.61)	K/day
ΔT_{pot}=100K:	0.50	(0.41, 0.59)	K/day

HALOE: 2[CH4]+[H2O]
[Hall & Waugh JGR, 1997]

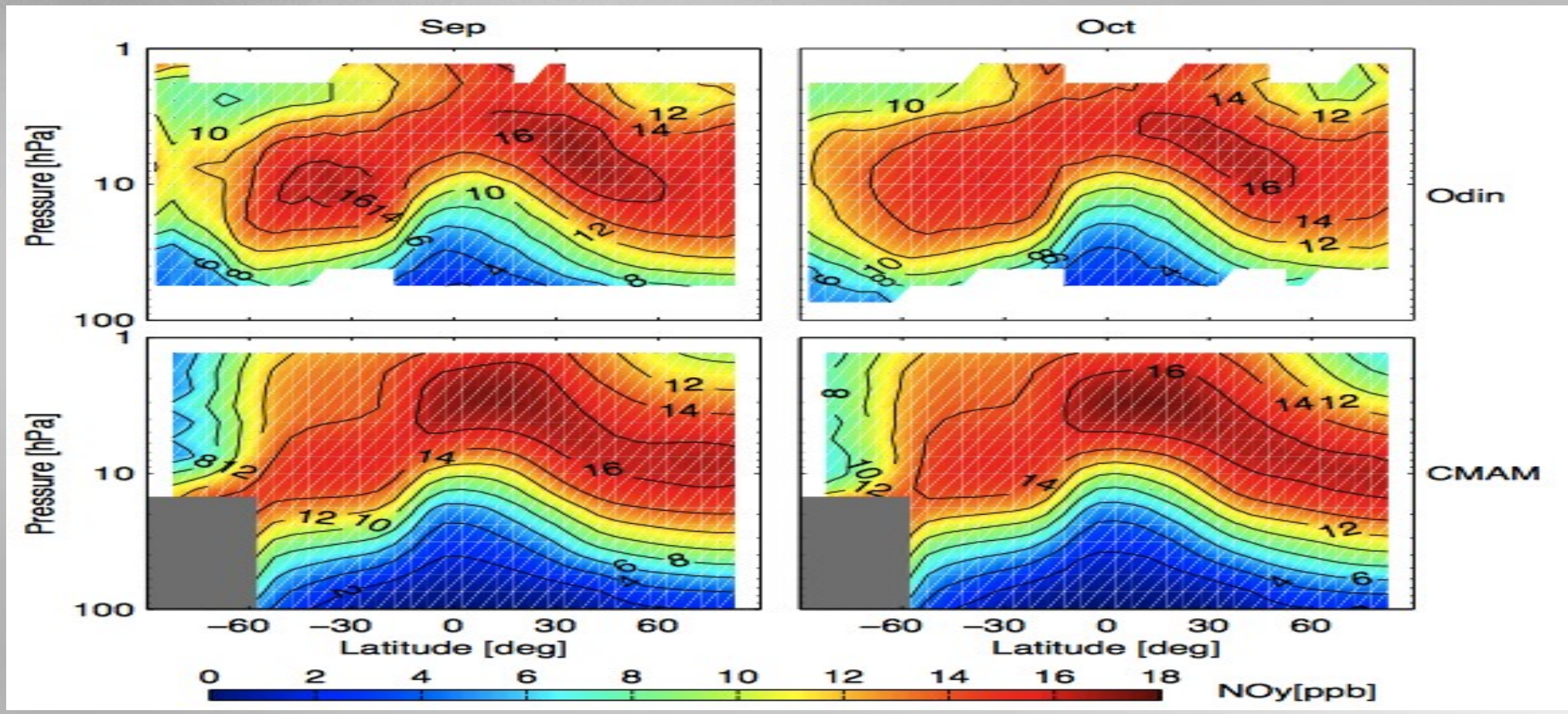
[J. Urban, Proc. Reunion Island Symp., 2007]

Climatologies and Model Comparisons

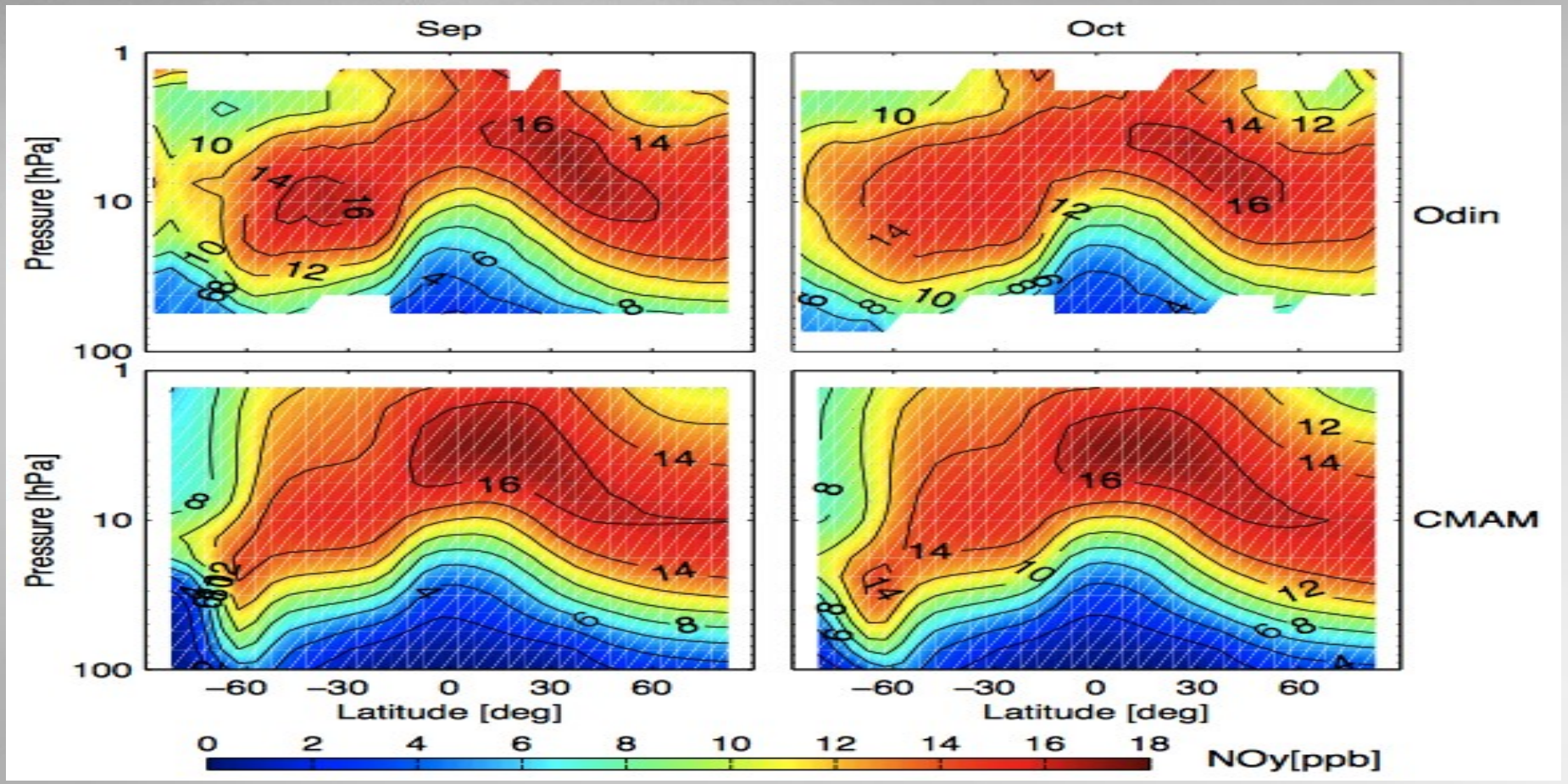
Odin NO_y


Odin/SMR
Limb emission
Odin/OSIRIS
Limb scattering
HNO3
NO2
O3
Temperature
Pressure
Albedo
NOy,Bry,Cly
Merging
ACE–FTS
Validation
Photochemical
model
Odin proxy NOy
HNO3+NO2+NO+ 2N2O5 +ClONO2

Comparison Odin CMAM

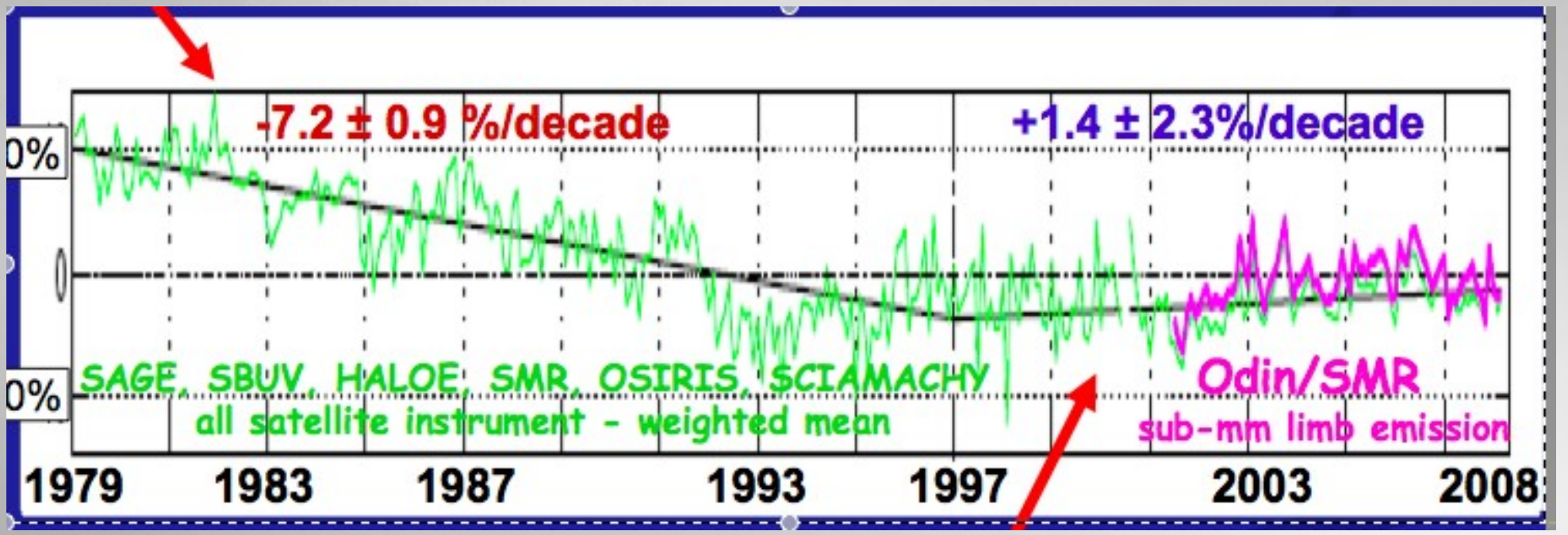


Corrected model



Trends

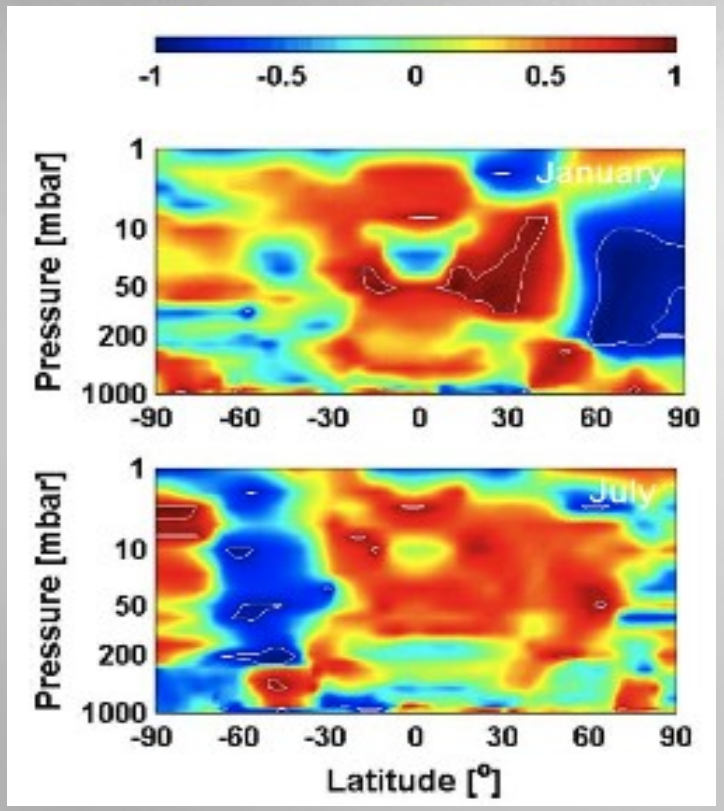
Upper stratospheric ozone recovery ?



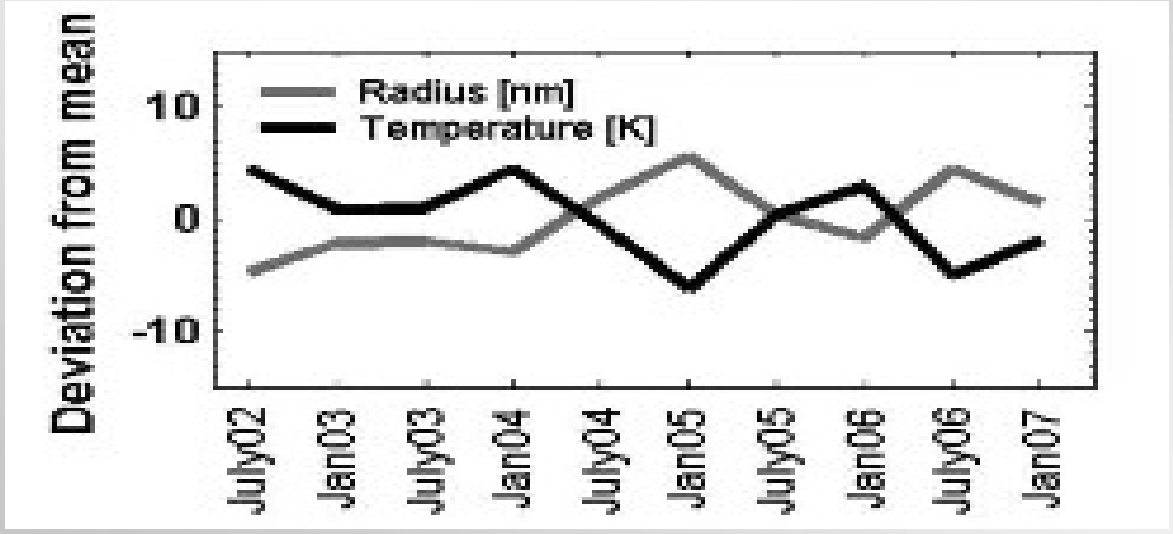
Trend in ozone from multi-instrument time series, Odin SMR and OSIRIS from 2001 (Jones et al., 2009)

Noctilucent Clouds and Global dynamics

Anti-correlation between winter hemisphere temperatures and NLC particle size



Karlsson et al. 2007



Odin - Tomography Results

- White contours show ice mass density ($2.5\,\mathrm{ng/m^3}$)
- Precision $\sim 3\,\mathrm{ng/m^3}$
- Dependent on particle size distribution
- Coloured contours are Temp.
- Precision 2 K
- Resolution 2.5x200 km

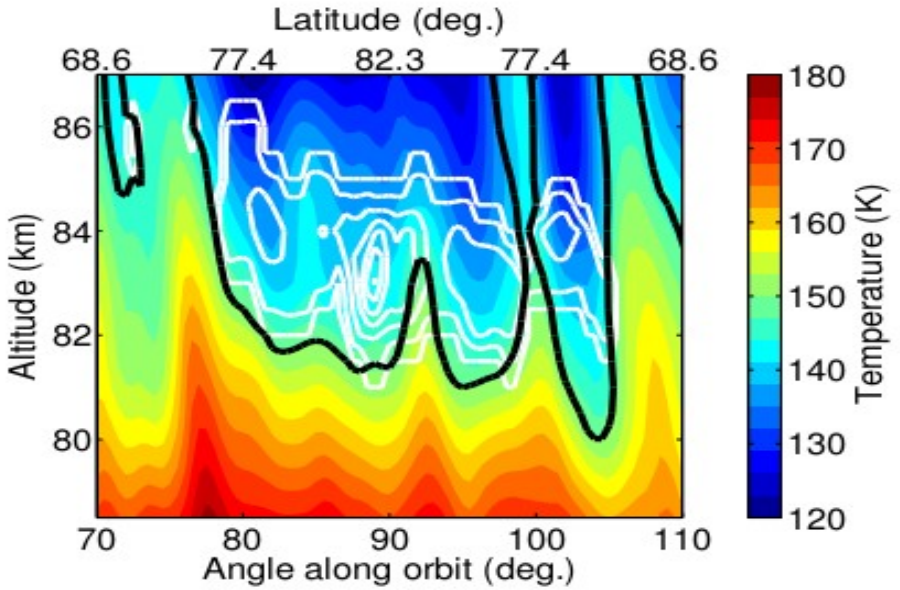


Figure: Temperature and Ice mass density from Odin.

Odin - Tomography Results

- White contours show ice mass density ($2.5\,\mathrm{ng/m^3}$)
- Precision $\sim 3\,\mathrm{ng/m^3}$
- Dependent on particle size distribution

- Coloured contours are Temp.
- Precision 2 K
- Resolution 2.5x200 km

- Coloured contours are Water vapour.
- Precision 0.2 ppmv.
- Accuracy limited by pressure info. (3 ppmv)

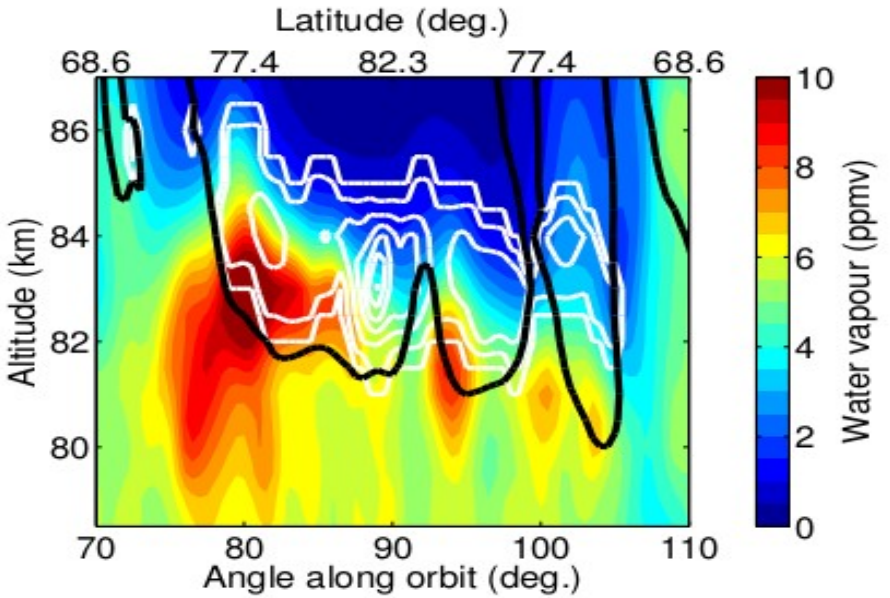
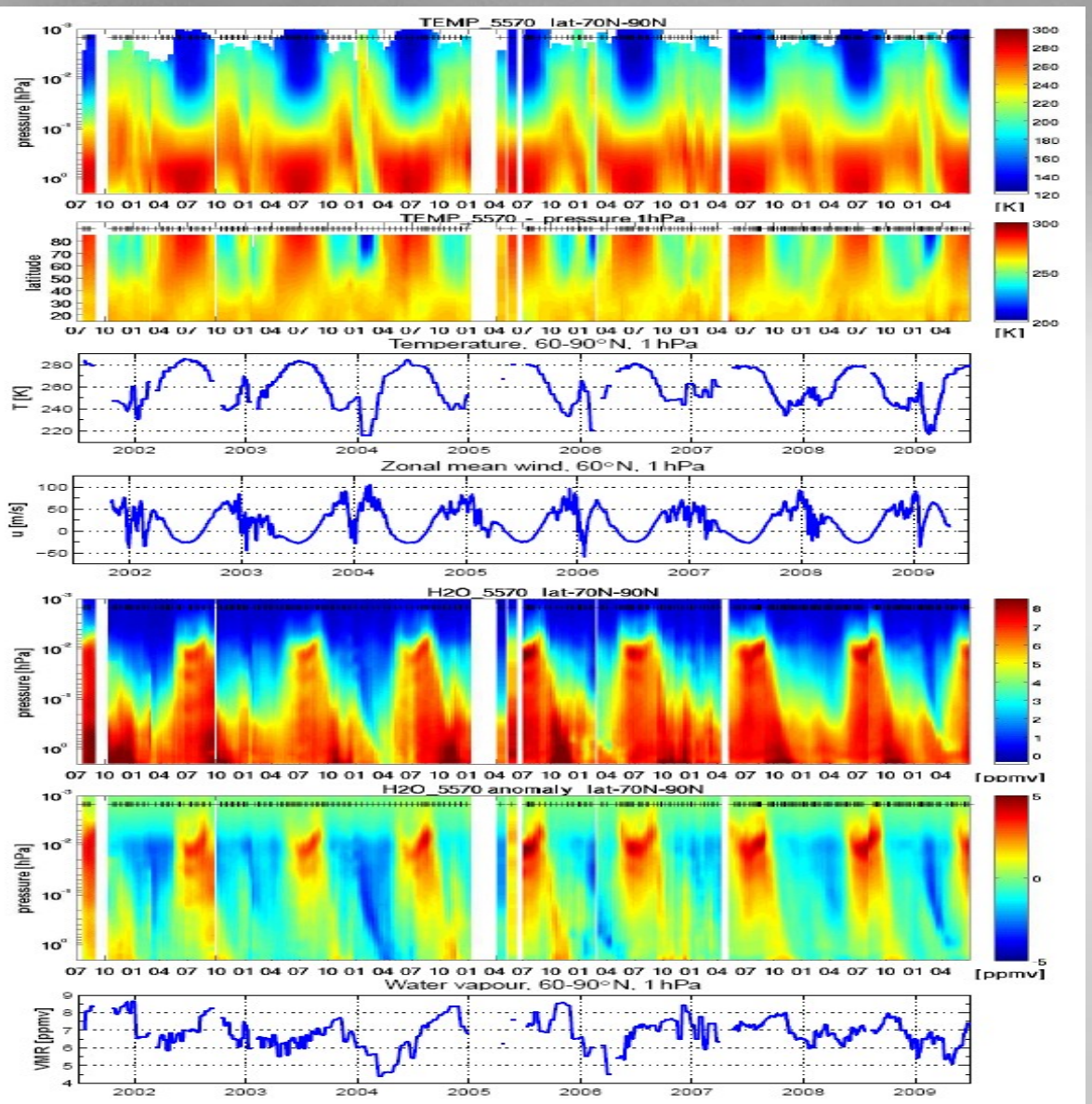
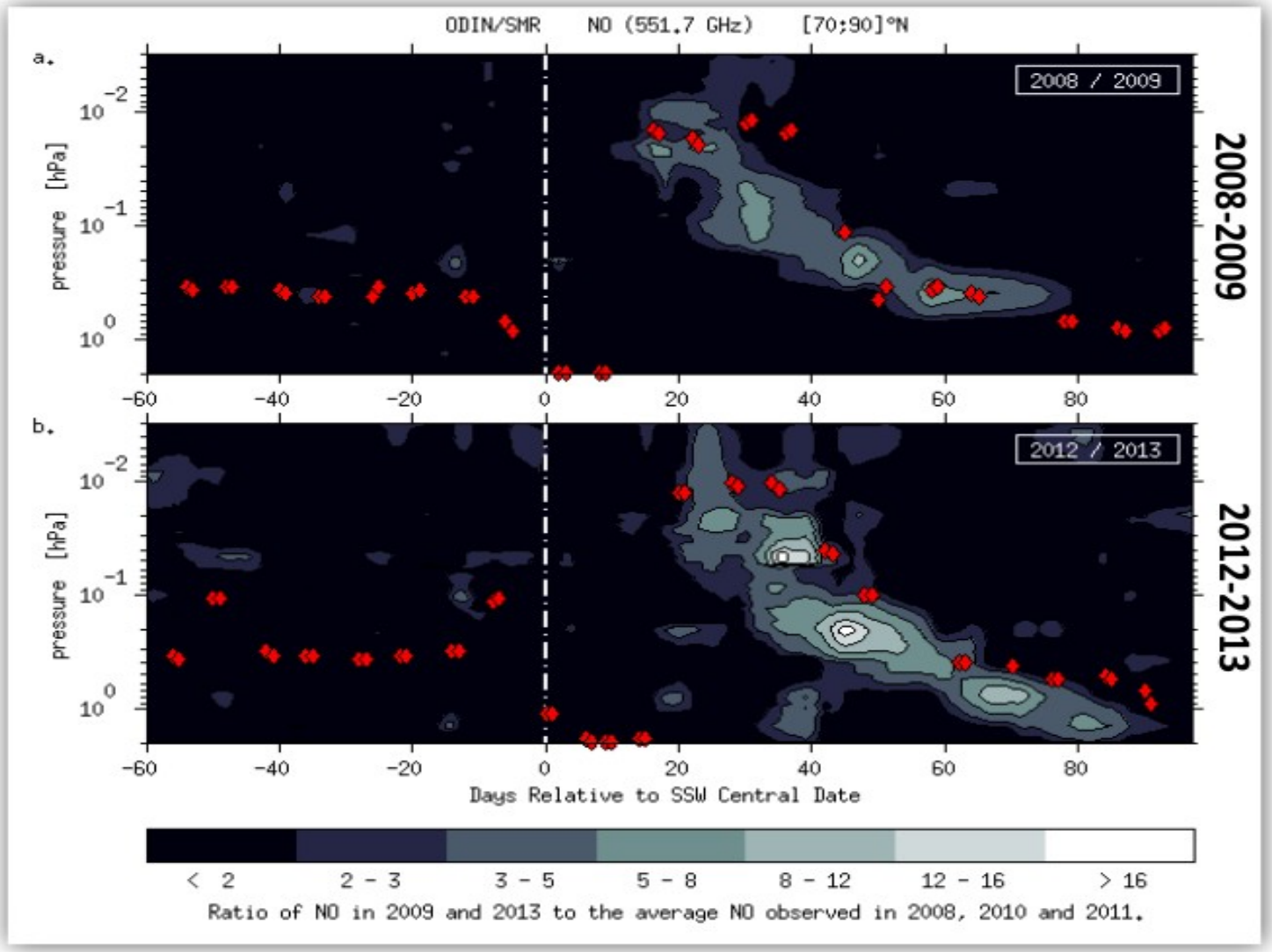


Figure: Water vapour and Ice mass density from Odin.



Anomalous decent from the mesosphere following Stratwarms

Orsolini et al. 2010



Pérot et al, ACP, 2014

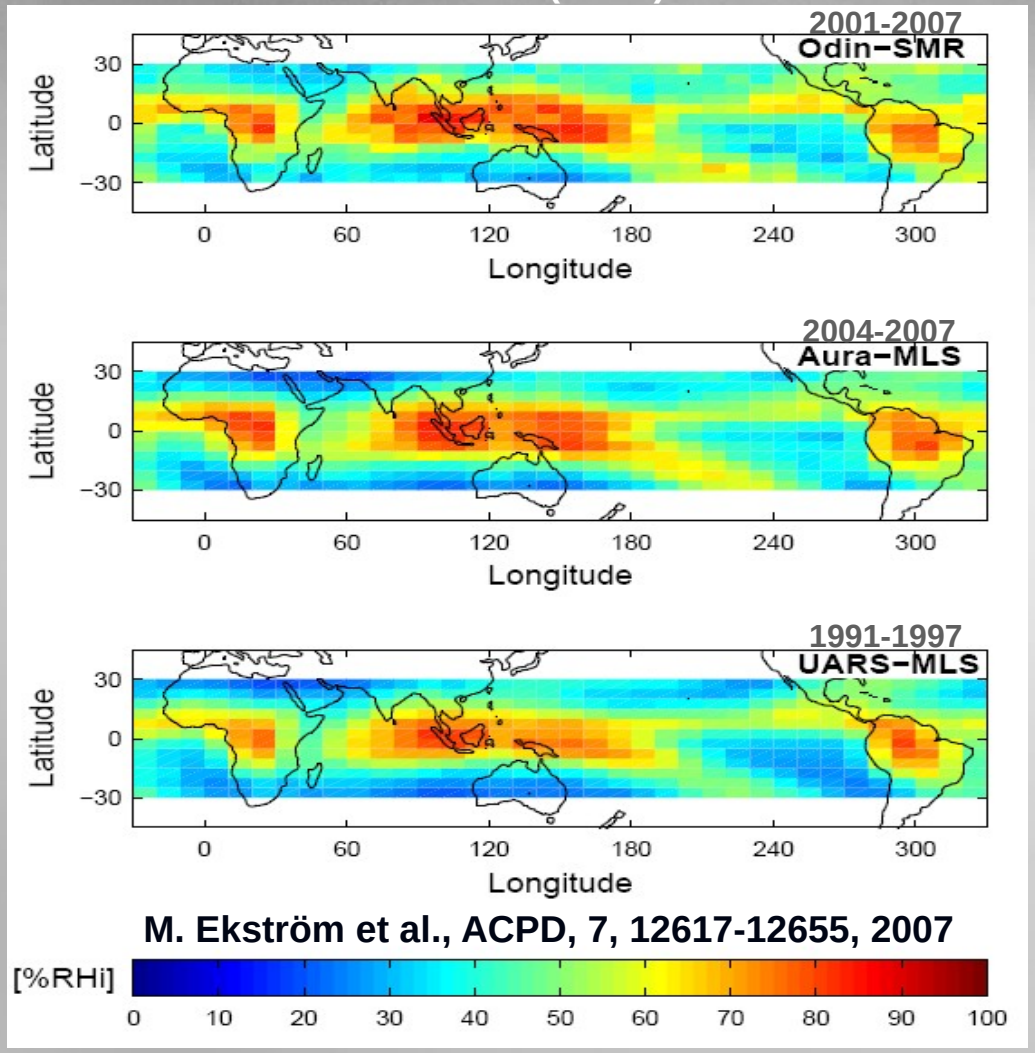
2013:

- **Larger enhancements** than in 2009 (up to 20 times more NO in the stratosphere than normal)
- Onset ≡ formation of the elevated stratopause. (recovery of the vortex)
- Tongue of EPP-NO: **More extended in time and in altitude**
- Higher potential to influence the middle atmospheric composition

Upper Troposphere and Cloud studies
Uses only spectra taken
below 9 km- quasi nadir mode

Upper tropospheric humidity

205 hPa (11km)



M. Ekström et al., ACPD, 7, 12617-12655, 2007

Ice water path

above ~12 km

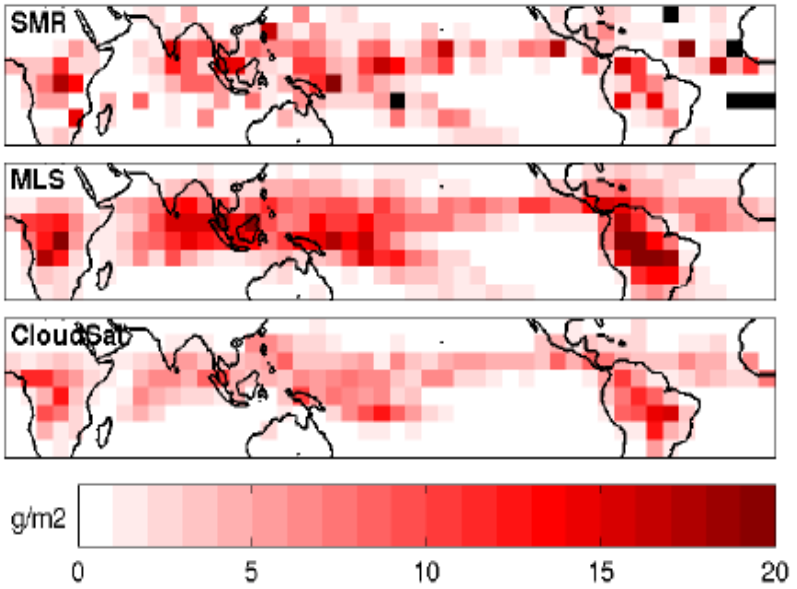
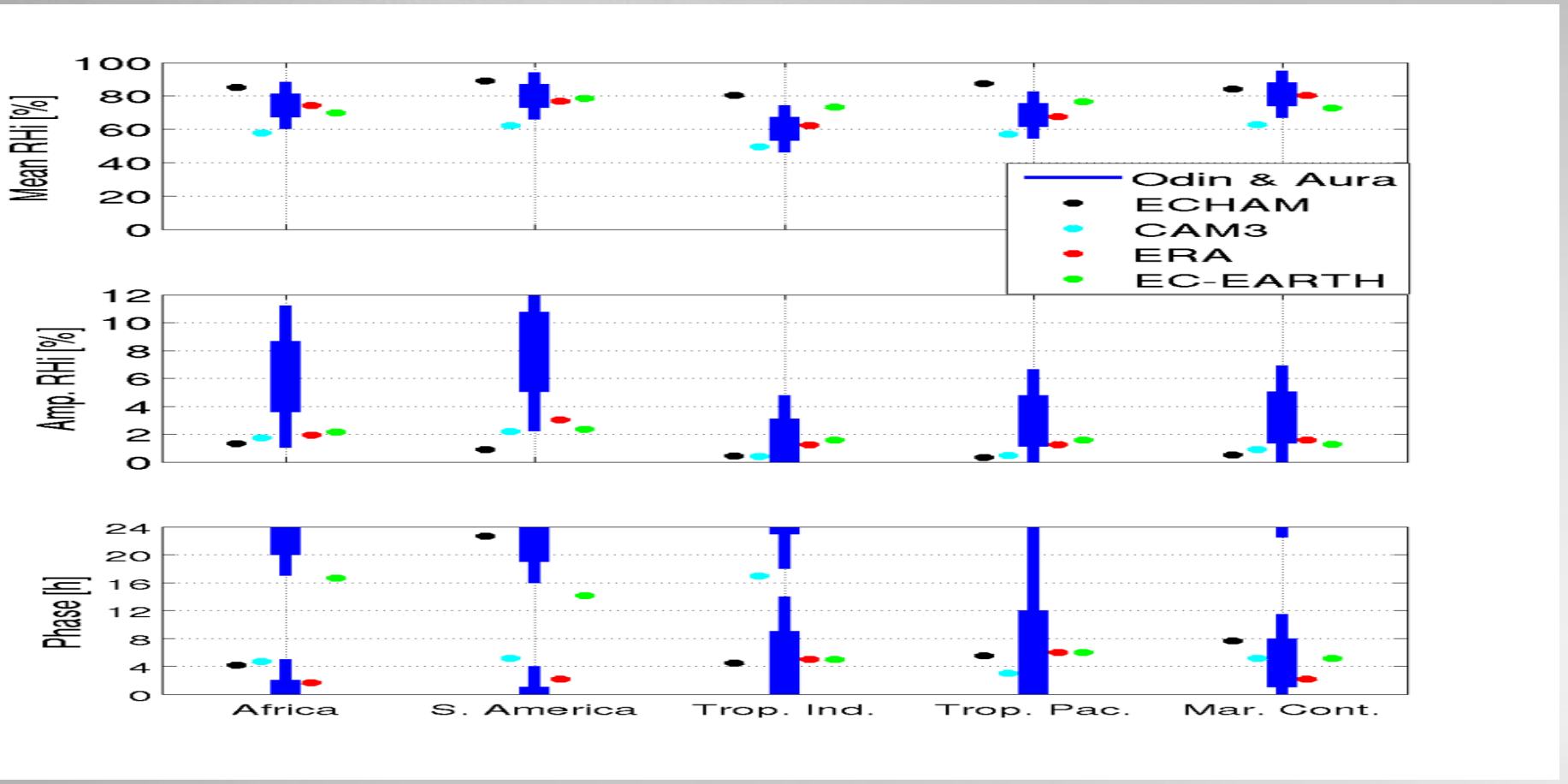


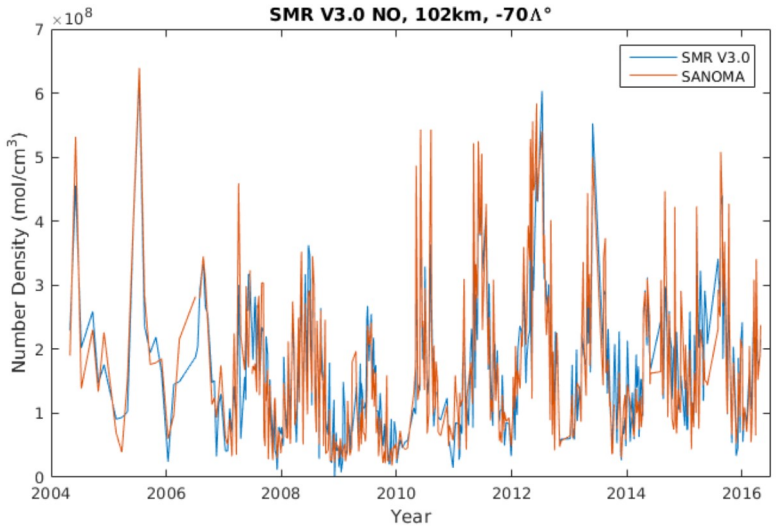
Fig. 4. Odin-SMR (top), Aura MLS (middle) and CloudSat (bottom) pIWP fields for data around 1 November . Data cover 15 October–15 November for Aura MLS (mean over 2004–2006) and CloudSat (2006), while for Odin-SMR the time period is 15 September–15 December (mean over 2001–2006). Black indicates less than 50 data points available for averaging and no IWP is given. Data averaged over 7.5° in both latitude and longitude.

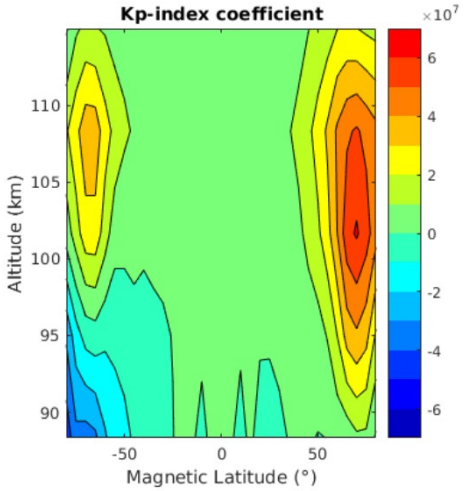
P. Eriksson et al., APCD, 7, 12035–12066, 2007

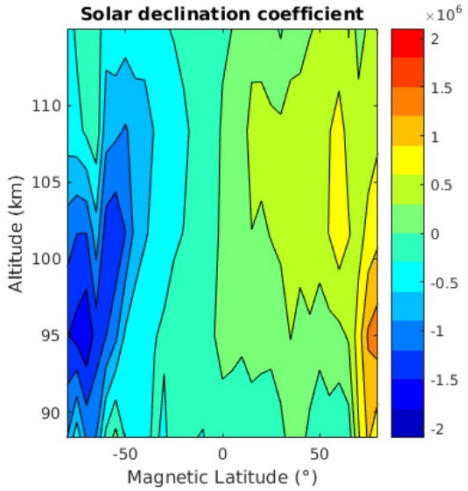
Diurnal variation of UT humidity combining Odin with other data – comparison to climate models

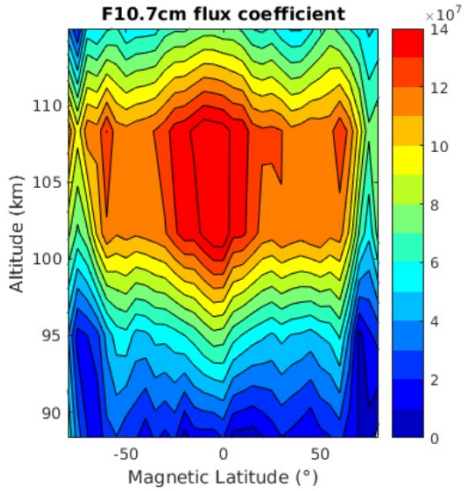


SANOMAT


SMR V3.0 NO, 102km, -70∧°
×10^8
SMR V3.0
SANOMA
Number Density (mol/cm^3)
Year
0
1
2
3
4
5
6
7
2004
2006
2008
2010
2012
2014
2016


Kp-index coefficient
×10^7
Altitude (km)
Magnetic Latitude (°)
90
95
100
105
110
-50
0
50
6
4
2
0
-2
-4
-6


Solar declination coefficient
×10^6
Altitude (km)
Magnetic Latitude (°)
90
95
100
105
110
-50
0
50
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2


F10.7cm flux coefficient
×10^7
Altitude (km)
Magnetic Latitude (°)
90
95
100
105
110
-50
0
50
14
12
10
8
6
4
2
0

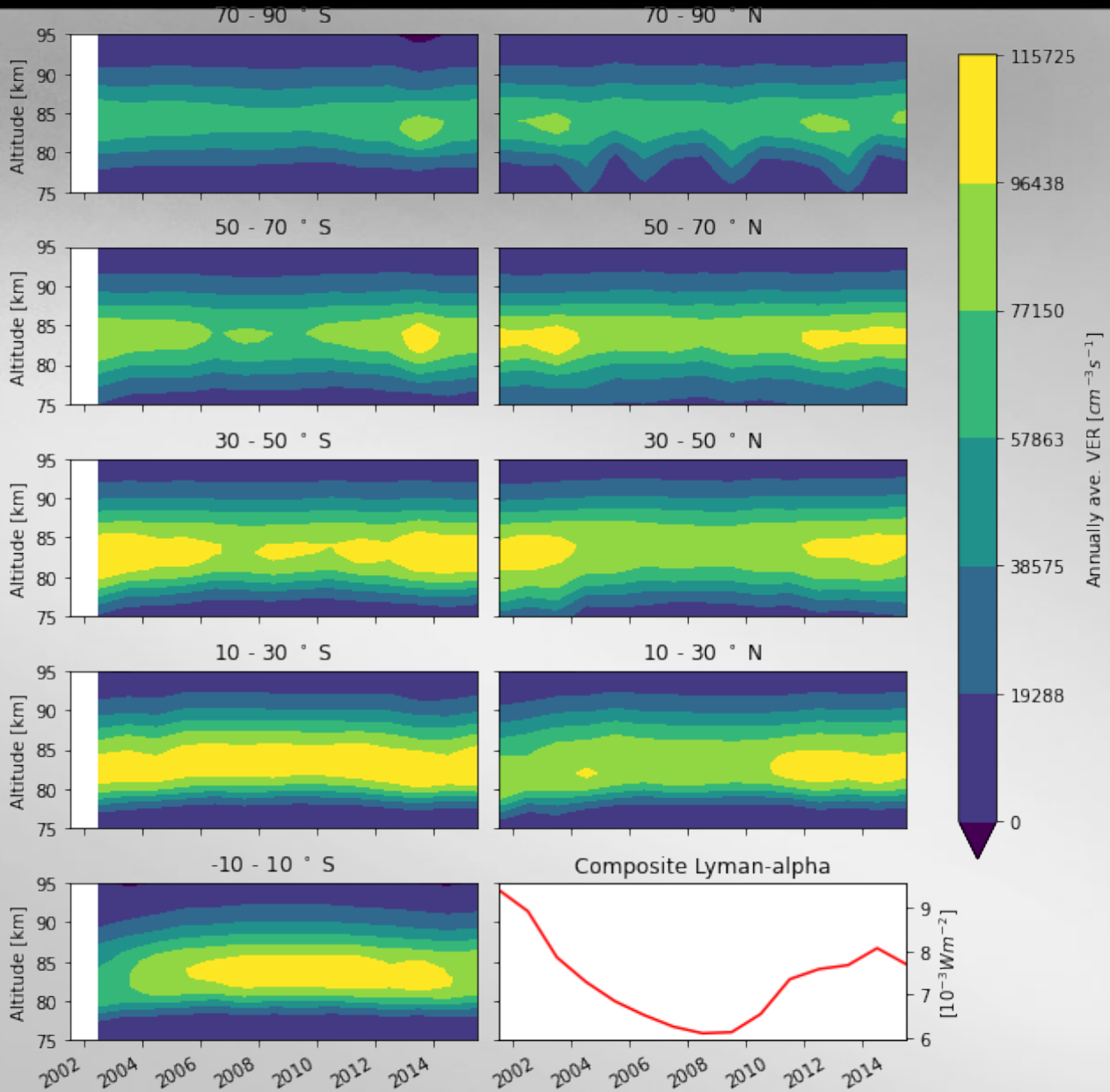
Current focus

- Using IR-imager in OSIRIS to prepare for MATS
- Quantifying the amount of Aurorally produced NO transported to the stratosphere
- Trends and solar cycle induced changes

OSIRIS I.53 um imager channel

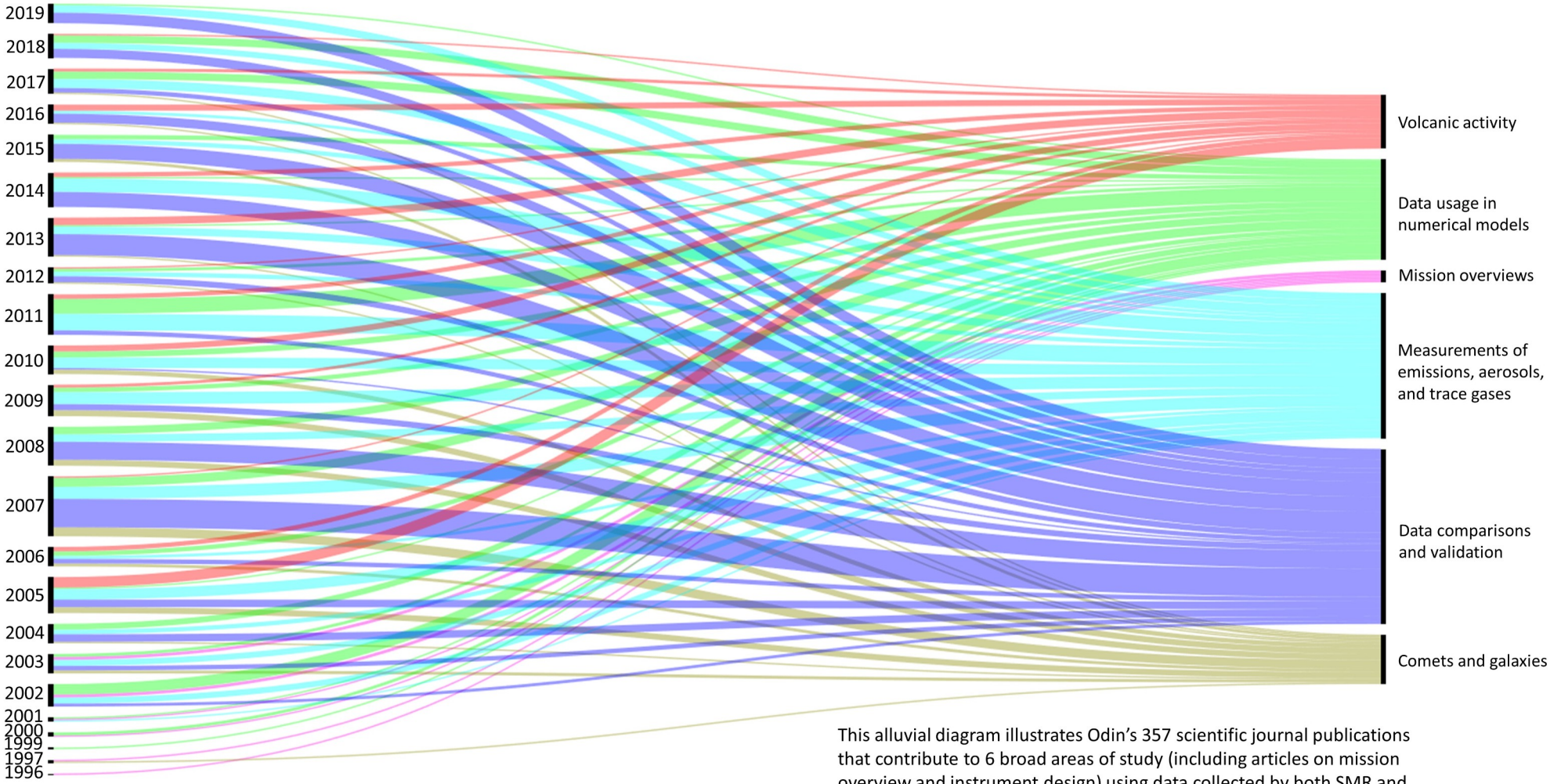
OH airglow emission over 16 years and the solar cycle

Li et al 2021



Rymdstyrelsen
Swedish National Space Agency

Publication History of the Odin Satellite



This alluvial diagram illustrates Odin's 357 scientific journal publications that contribute to 6 broad areas of study (including articles on mission overview and instrument design) using data collected by both SMR and OSIRIS instruments.

Canadian Space Agency | Agence spatiale canadienne

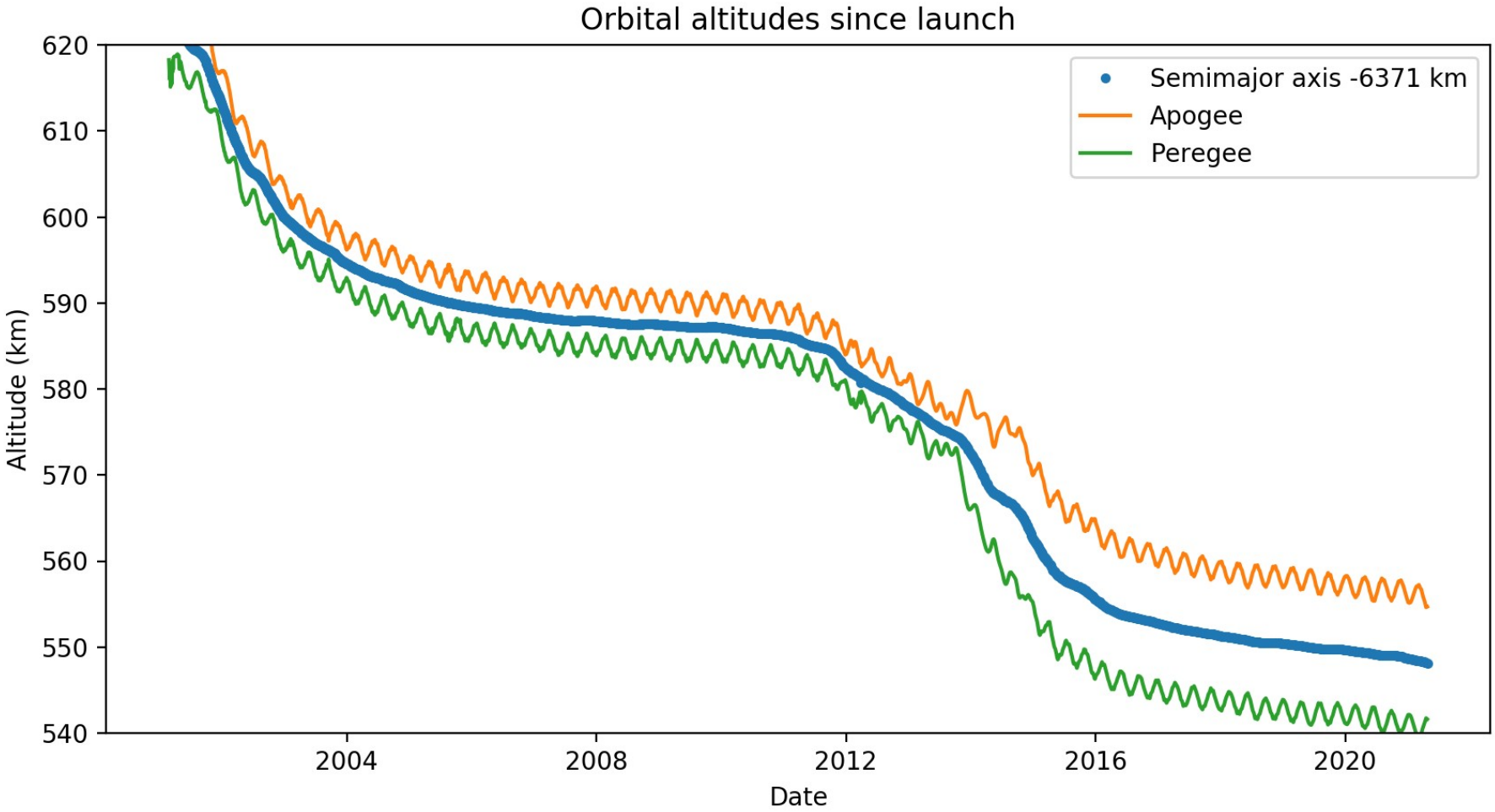
Canada

Conclusions

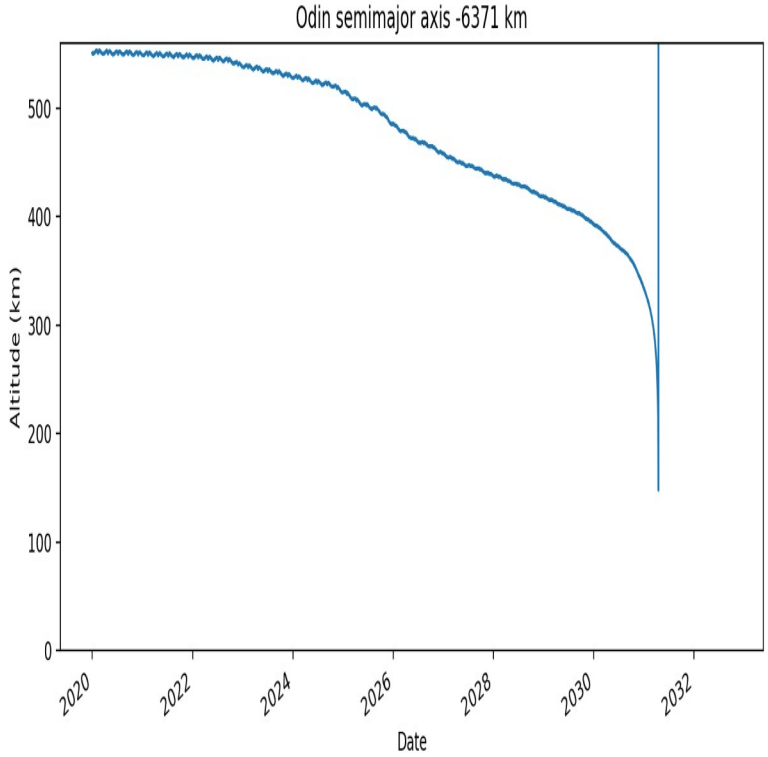
- Odin is still delivering after 21 years in space
- Flexibility in design has allowed new modes of operation leading to exciting results
- Unenvisaged products have been produced
- 10xlifetime = 10xScience - YES by a longchalk

“Leve Odin!” -See next 2 slides

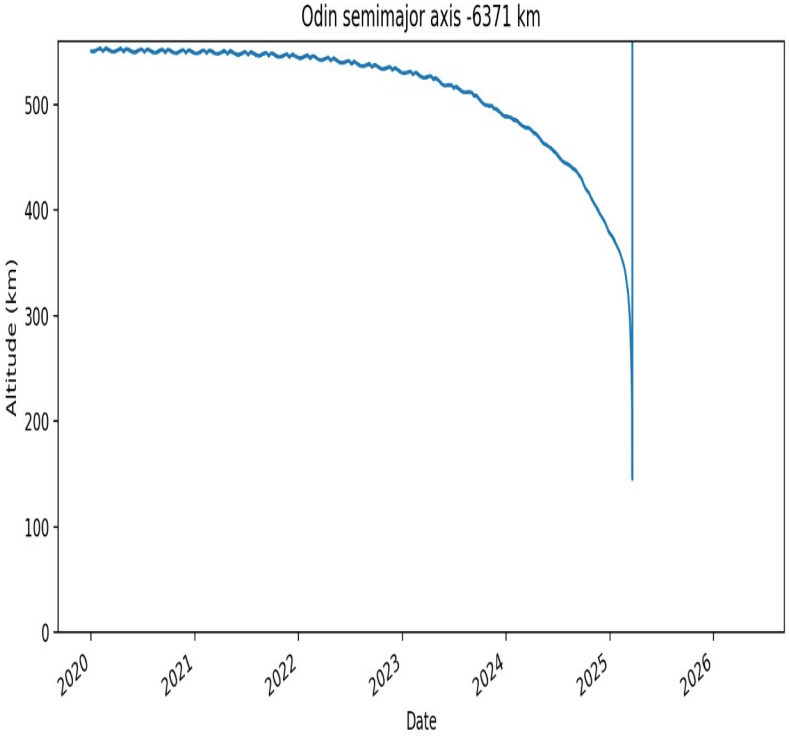
Odin’s orbit


Orbital altitudes since launch
Semimajor axis -6371 km
Apogee
Peregee
Altitude (km)
620
610
600
590
580
570
560
550
540
2004
2008
2012
2016
2020
Date

Odin’s fate ?



Solar cycle as per last one
Demise April 2031



Solar cycle as per penulitmate one
Demise March 2025