

WHY STUDY THE AURORA?

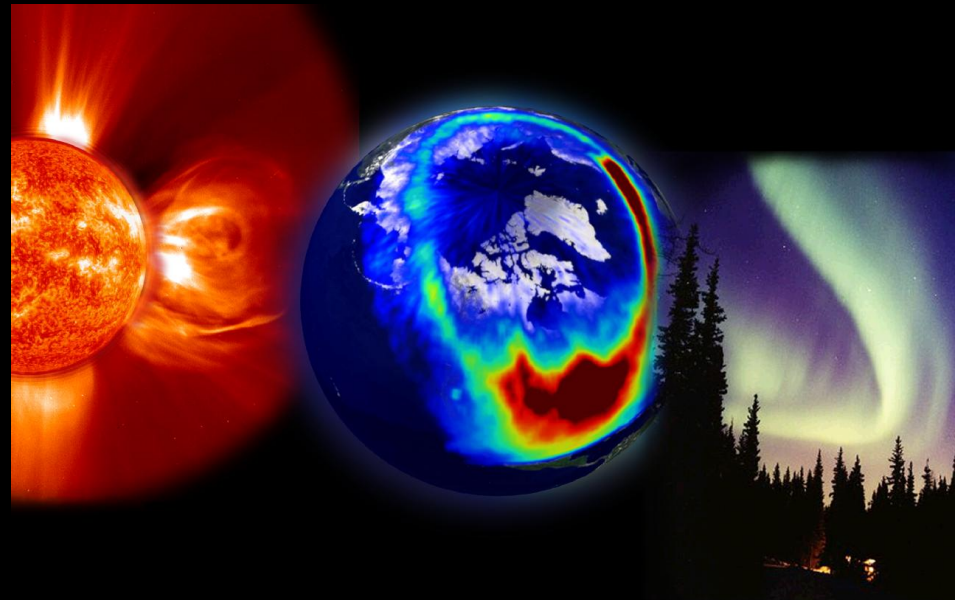
F. Sigernes

The Kjell Henriksen Observatory (KHO)
The Birkeland Centre for Space Science
(BCSS)

Prof. II NTNU - AMOS
University Centre on Svalbard - UNIS
N-9170 LONGYEARBYEN
NORWAY

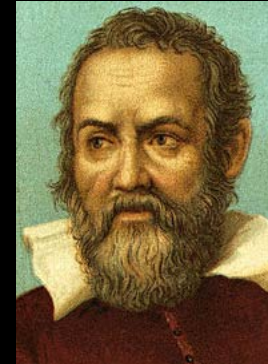
OUTLINE

- HISTORICAL FACTS
- THE MOTHER OF THE AURORA: THE SUN!
- THE SOLAR WIND AND THE MAGNETOSPHERE
- IMPACTS ON EARTH
- WHY SVALBARD?
- THE KJELL HENRIKSEN OBSERVATORY AT BREINOSA



In the early days ...

- Galileo Galilei (1564-1642) – who observed sunspots, suggested that aurora was caused by air rising out of the Earth's shadow to where it can be sunlit.
- De Mairan (1678-1771) French Philosopher revived the old theory that aurora was reflection of polar ice crystals and snow
- Edmund Halley (1656-1742) – The aurora is ordered by the Earth's magnetic field



The emergence of solar terrestrial physics



George Graham



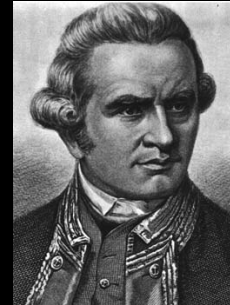
Anders Celcius



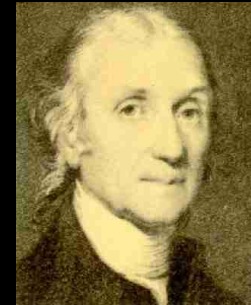
Olaf Hiorter



J.C. Wilcke

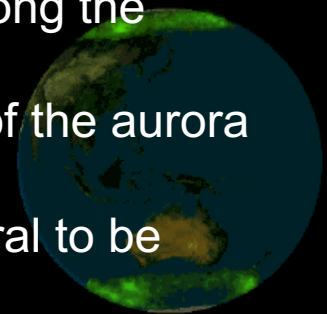


James Cook

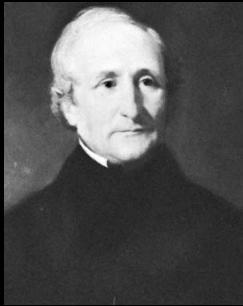


Henry Cavendish

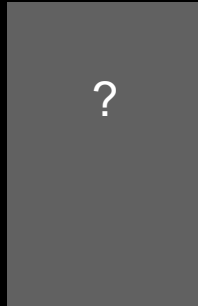
- 1722: George Graham noticed that the compass is always in motion.
- 1740 : Anders Celcius confirmed Graham's observation.
- 1741: Olaf Hiorter observed a relationship between auroral activity and geomagnetic activity.
- 1770: J. C. Wilcke noted that rays extended upward along the direction of the magnetic field.
- 1770: James Cook reported the southern counterpart of the aurora borealis – aurora australis.
- 1790: Henry Cavendish triangulated the height of auroral to be between 52 and 71 miles (80 -112 km).



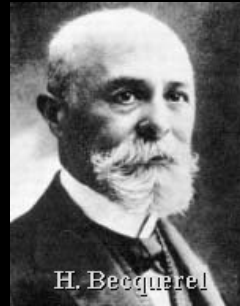
First ideas on Sun-Earth Connection



Edward Sabine

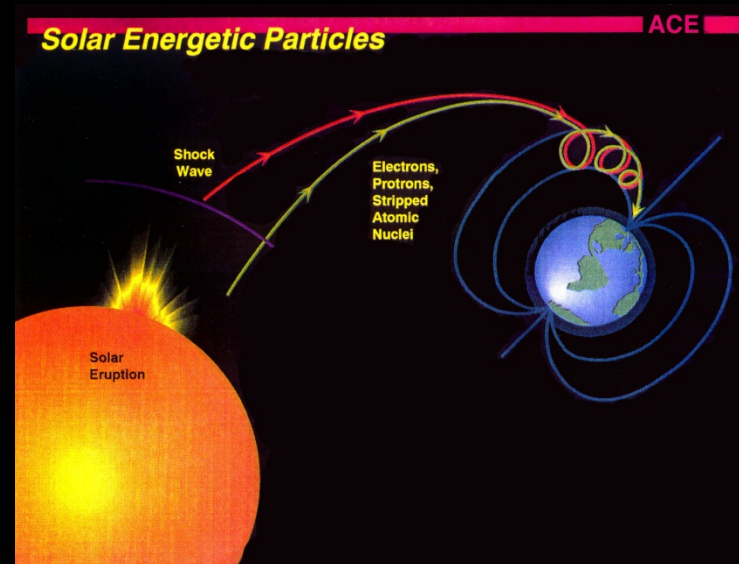
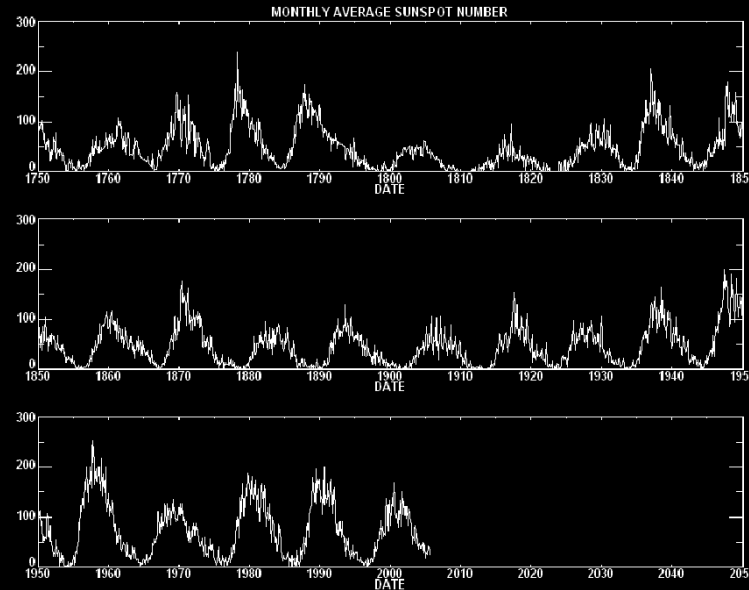


Richard
Carrington

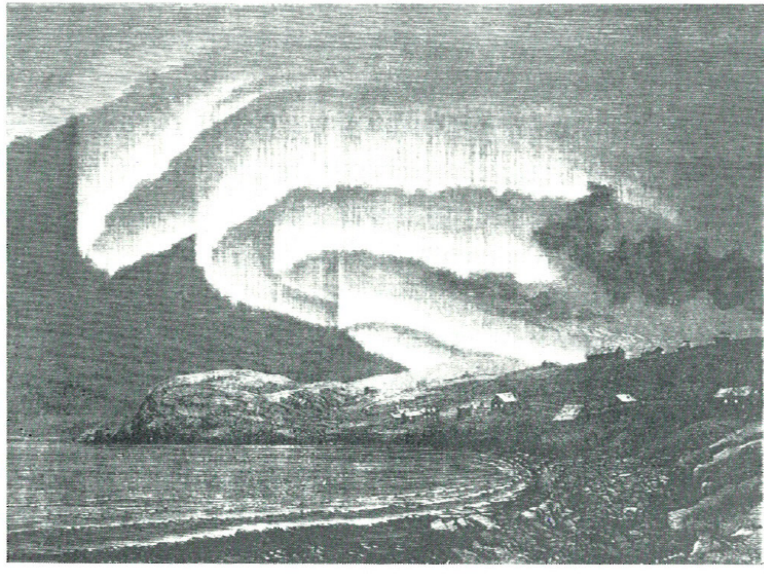
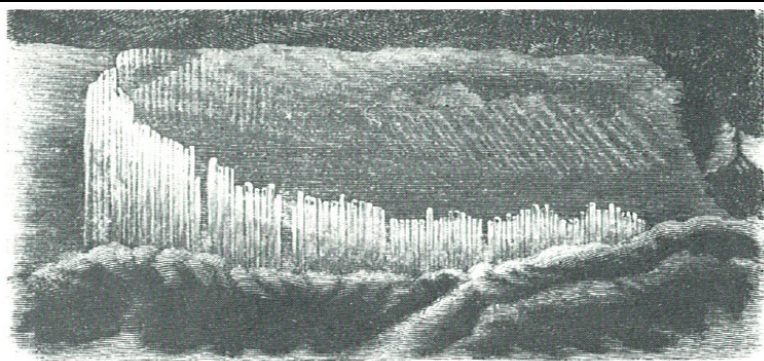


Henry
Becquerel

- 1851: Edward Sabine was able to show that the intensity of geomagnetic activity varied in concert with solar activity (~10 year)
- 1859 : Richard Carrington identified the connection between a solar flare and geomagnetic activity
- 1878 : H. Becquerel suggested that protons shot off from the Sun were guided by the Earth's magnetic field to the auroral zone.



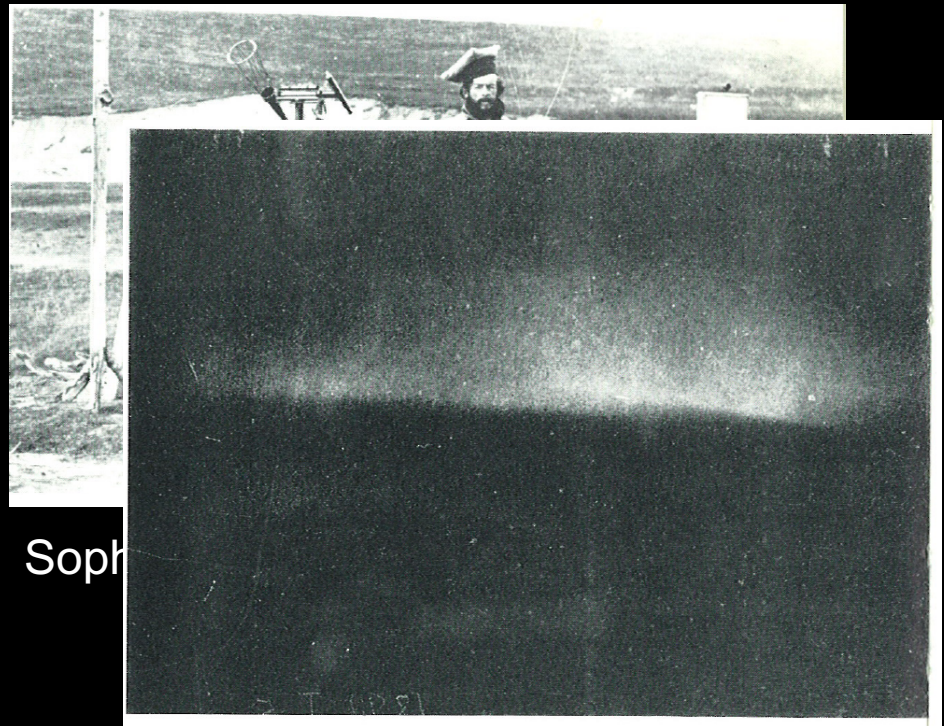
The Finnmark expeditions



French expedition to Bossekop
lead by Bravias (1838 -39)

First international polar year (1882 -83)
Purpose was to find the auroral altitude
from 2 sites:

Bossekop and Kautokeino



Soph

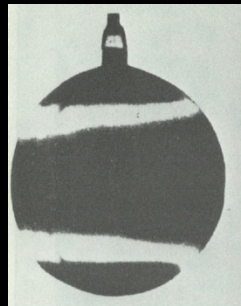
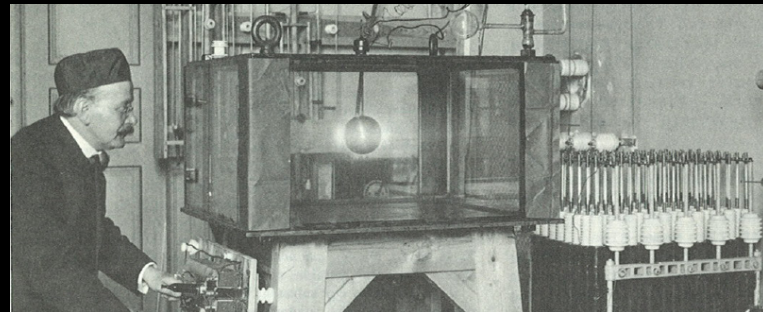
First image of aurora. Bossekop
by Brendel (1892) – 7 sec exp.

ALTITUDE = 113 KM (Tromholt)

Kristian Birkeland (1867-1917)



- The "First Auroral Physicist"!
- Professor – 31 years old.
- In 1896 he postulated a new theory that aurora are associated with currents floating along magnetic field lines
 - The Birkeland currents.
- Experiment + Theory = Innovation (60 patents).
- Fixation of Nitrogen – gave birth to Norsk Hydro / Yara - a world leading fertilizer company



The terrella-laboratory (1905)
His assistants were Karl and Olav Devik!



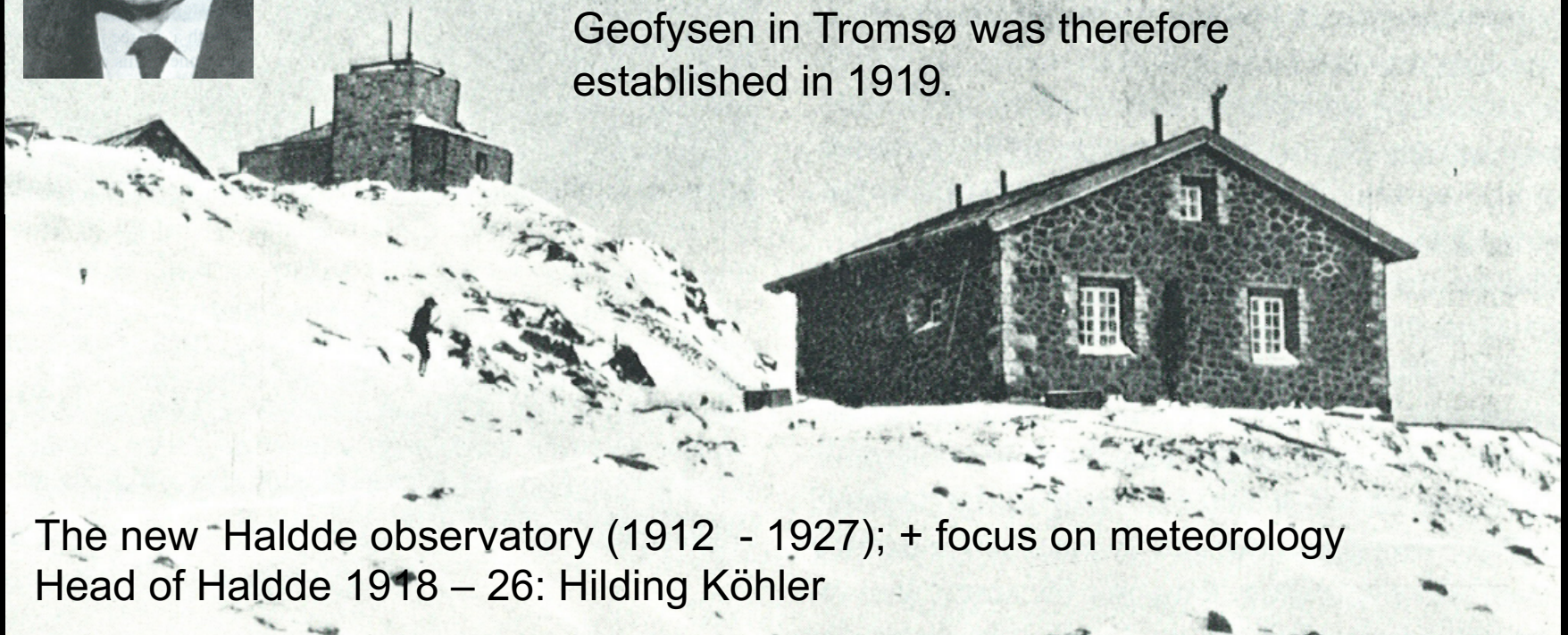
Kristian Birkeland start field observations to prove his theory of the aurora



Olav Devik
Halddde: 1915-1918
(1886-1986)

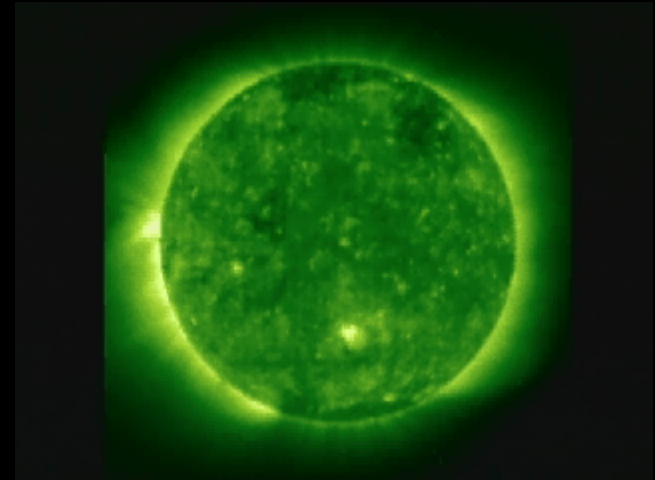
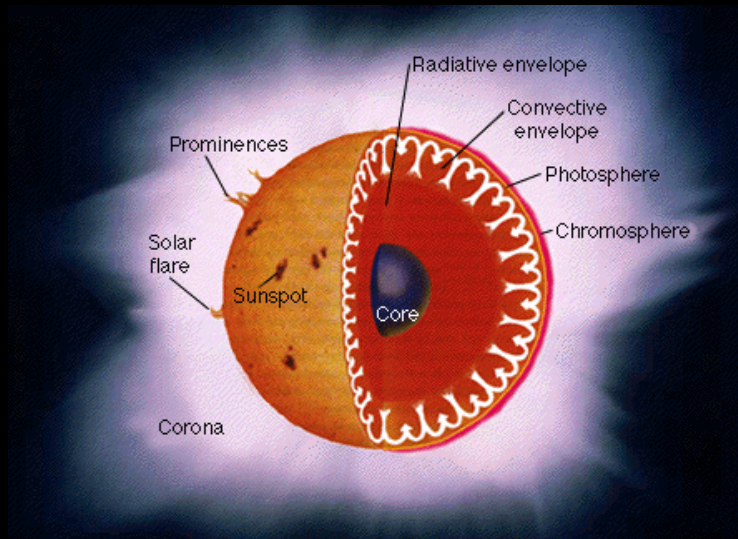
Krogness and Devik realized that Halddde was too isolated in order to attract scientists and develop the fields of meteorology and auroral physics.

Geofysen in Tromsø was therefore established in 1919.

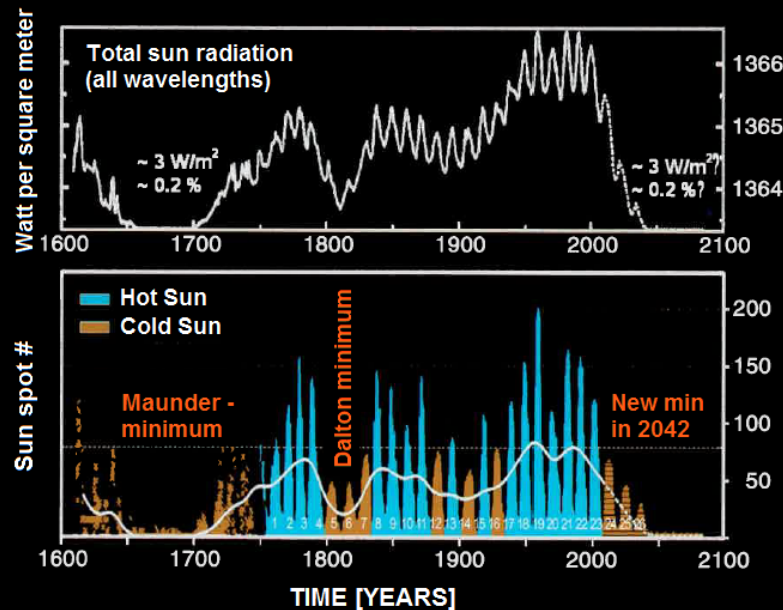


The new Halddde observatory (1912 - 1927); + focus on meteorology
Head of Halddde 1918 – 26: Hilding Köhler

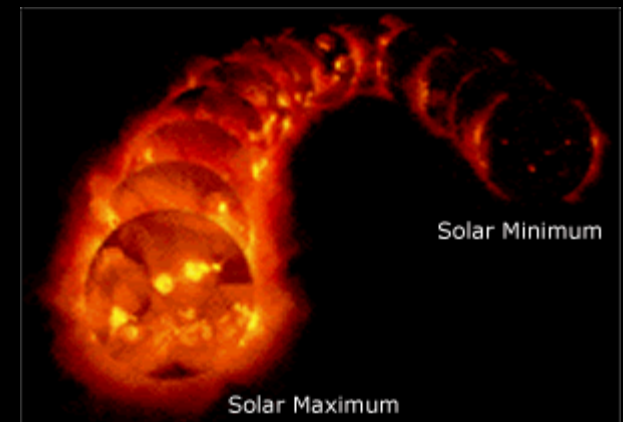
THE SUN IS A FUSION REACTOR



X-ray film of sun activity :



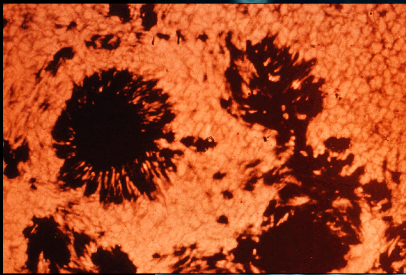
Reproduction: Abdussamatov (2009)



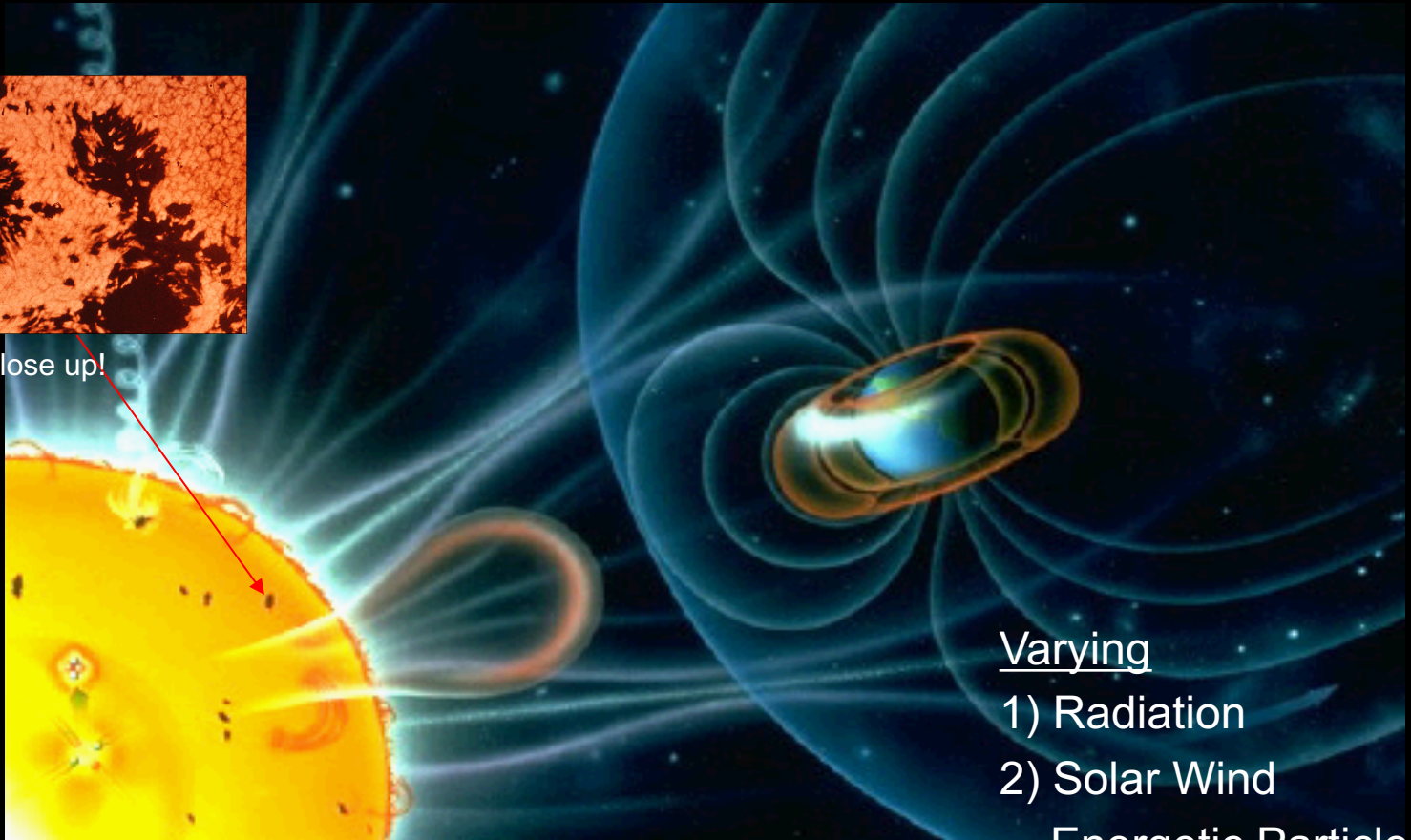
Animations @ NASA

The Sun Earth Space environment

We live in the extended atmosphere of a variable star – The Sun



Sunspot close up!



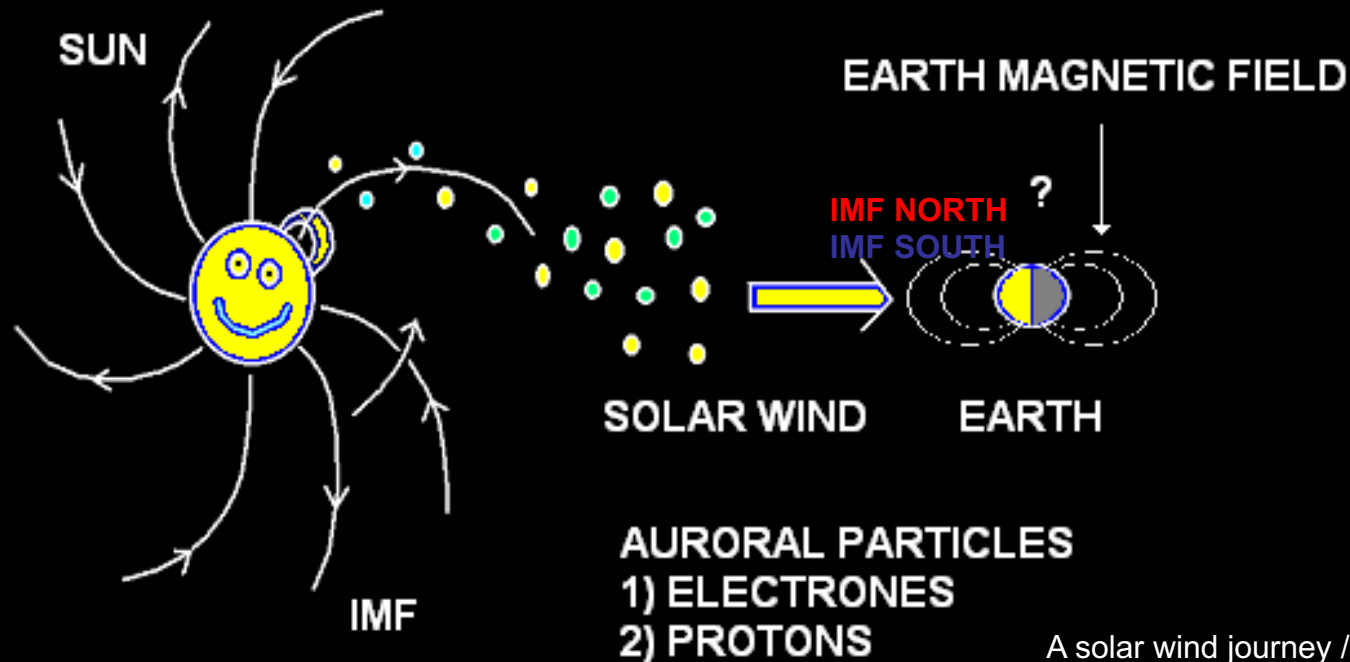
= Space Weather

Varying

- 1) Radiation
- 2) Solar Wind

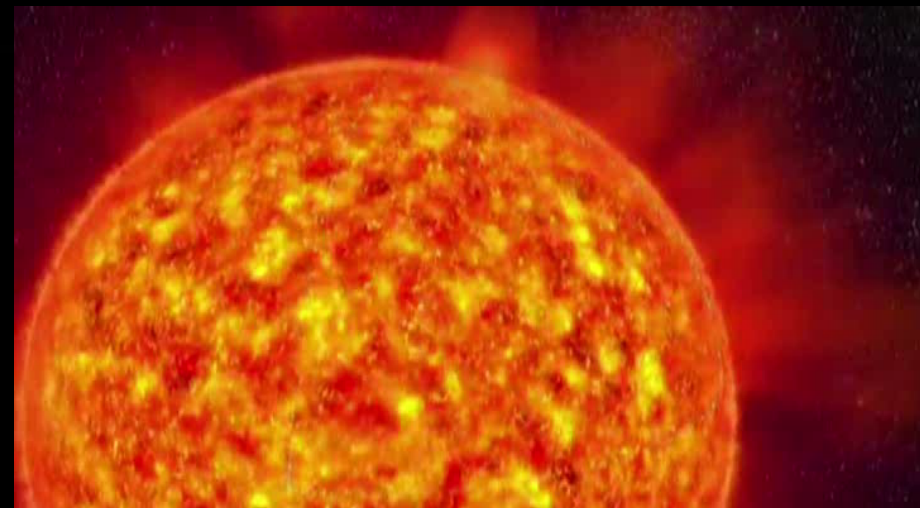
Energetic Particles
(Proton & electrons)

There is wind in space: Solar wind!



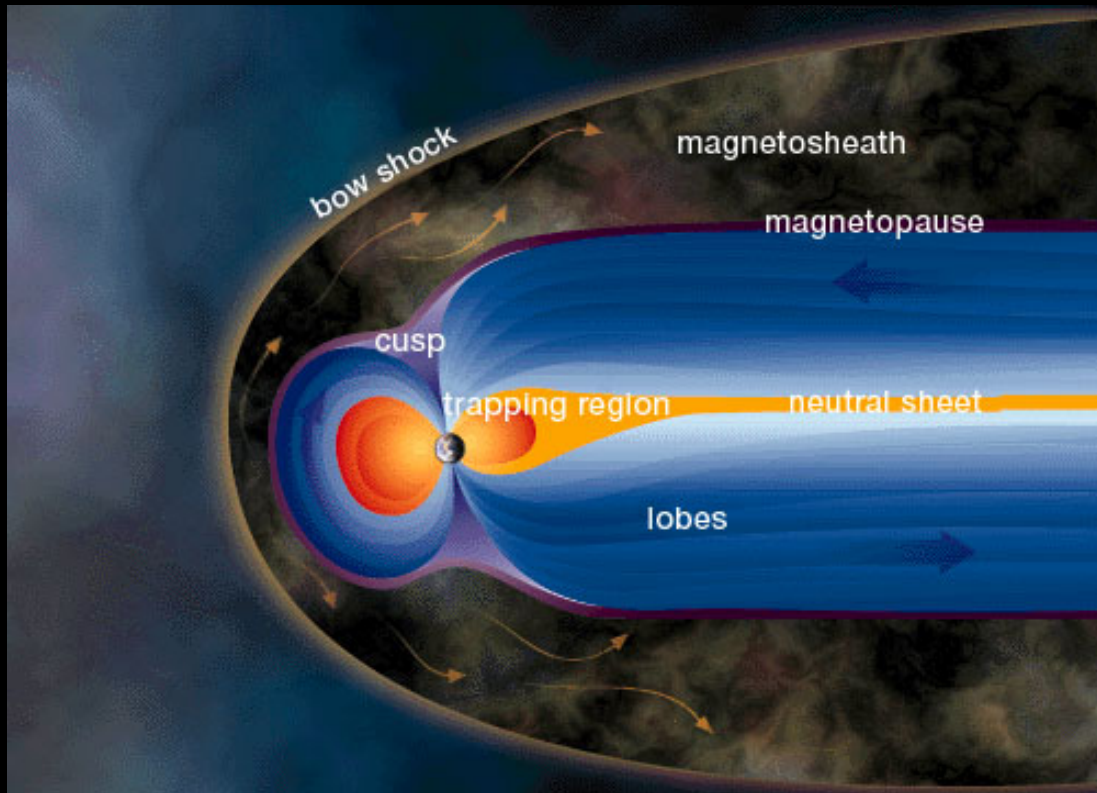
A solar wind journey / animation :

Sun: 26 days rotation; $D = 100 \times D_E$



A MORE DETAILED VIEW OF THE MAGNETOSPHERE

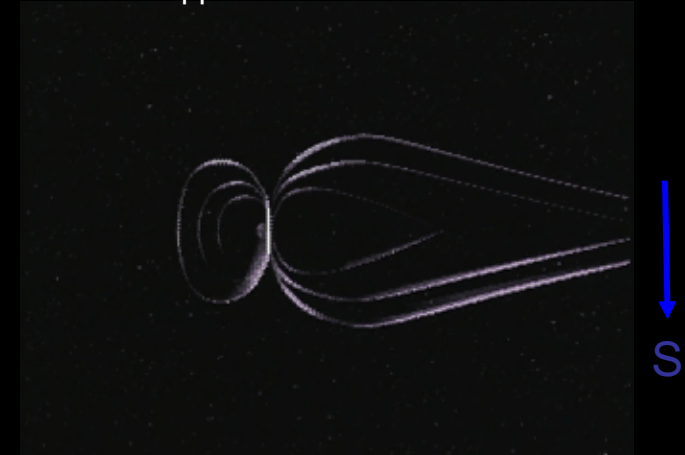
EARTH'S FIRST DEFENCE



The Earth has a magnetic field :



What happens active sun conditions ?



NB! MAGNETIC SHIELD IS **ON** FOR IMF POINTING NORTH & **OFF** FOR IMF SOUTH

The Auroal Oval on the 200 kr note



Terrella – a magnetized sphere placed in a vacuum chamber



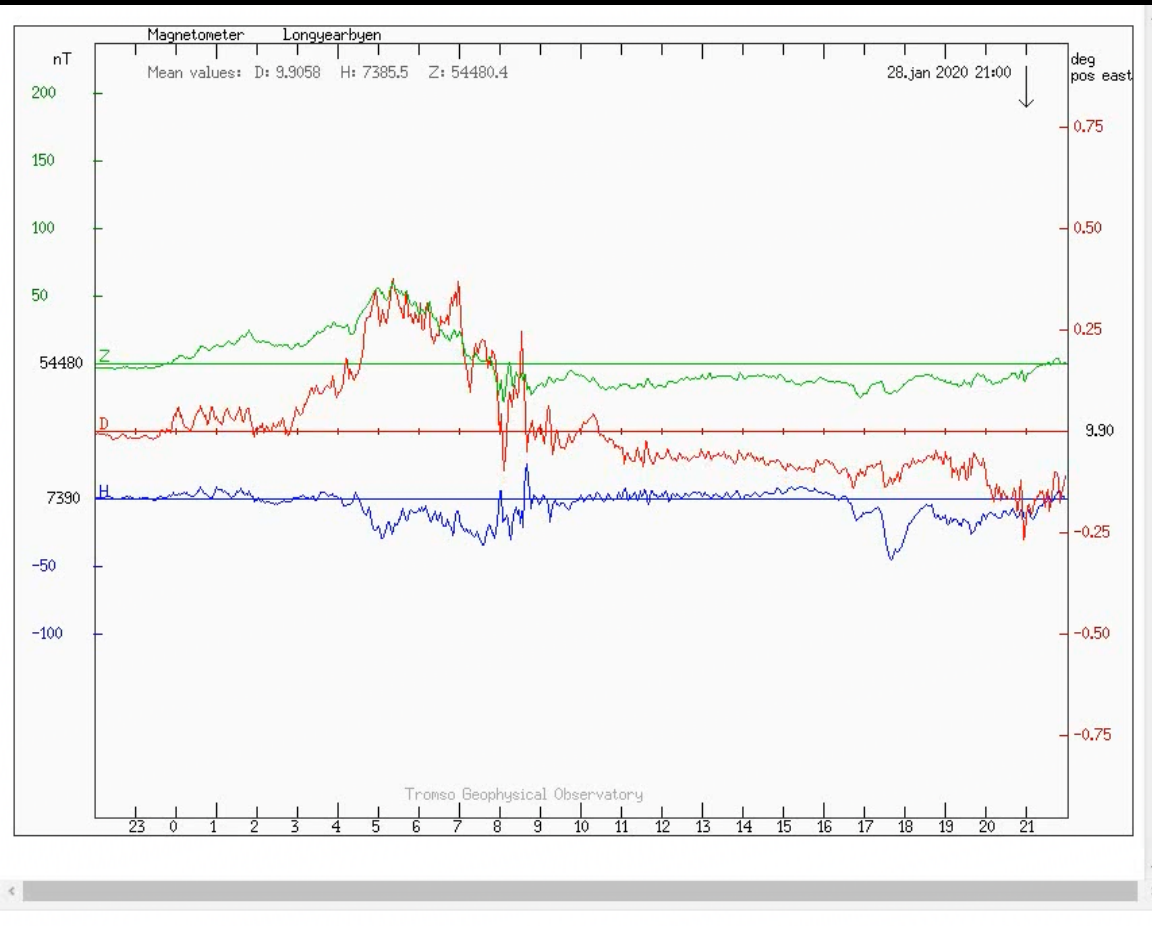
KHO

“A breakthrough with the Terrella Experiment in 1901”

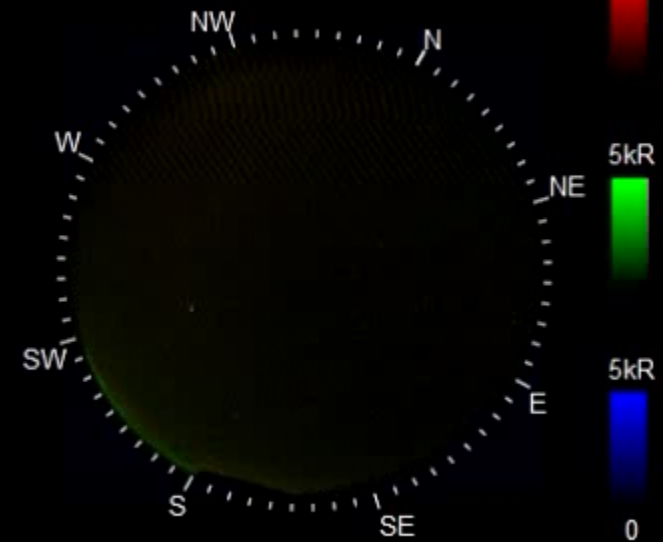
Birkeland currents

The Kjell Henriksen Observatory (KHO)

Magnetic versus auroral activity



Longyearbyen 28.01.20 22:00:00UT
RGB=[6300,5577,4861]Å Intensity=[5,5,5]kR



78.15°N 16.04°E Luna(-12.8,296.2)°14.7% Sun(-29.4,341.3)°

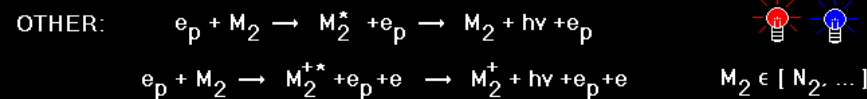
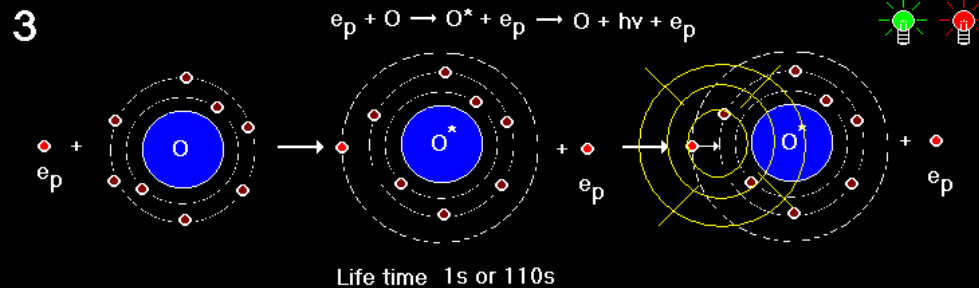
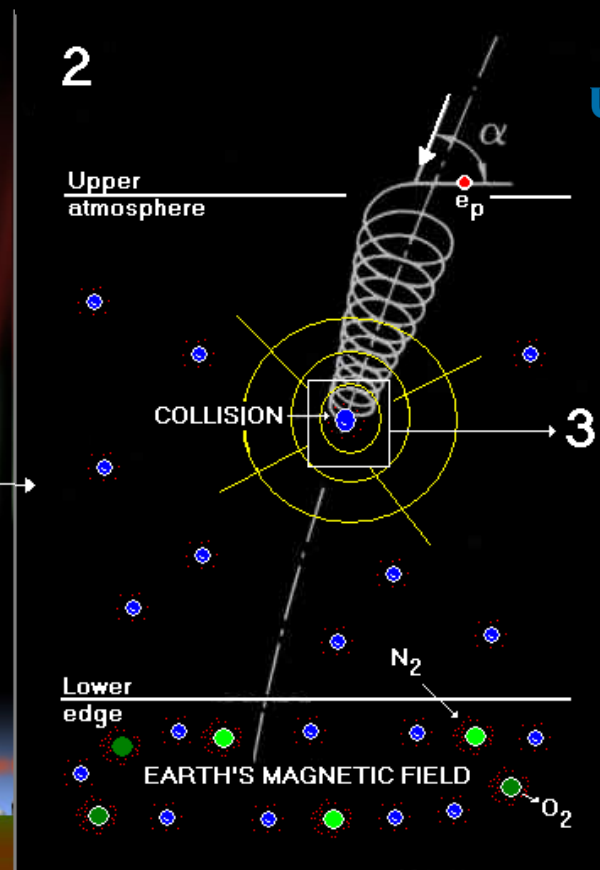
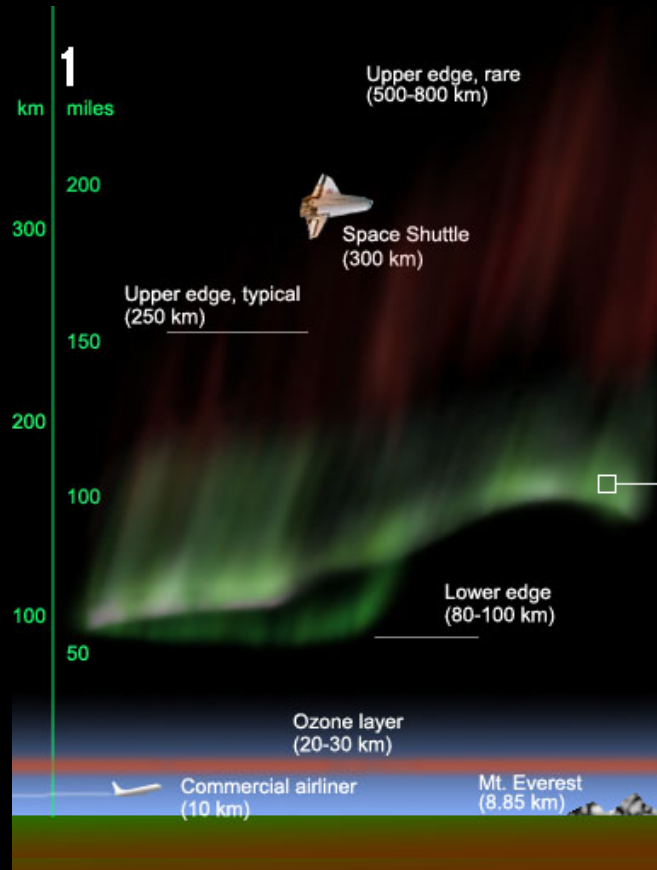
NORUSCA All-Sky camera (UNIS)

Fluxgate magnetometer (TGO)

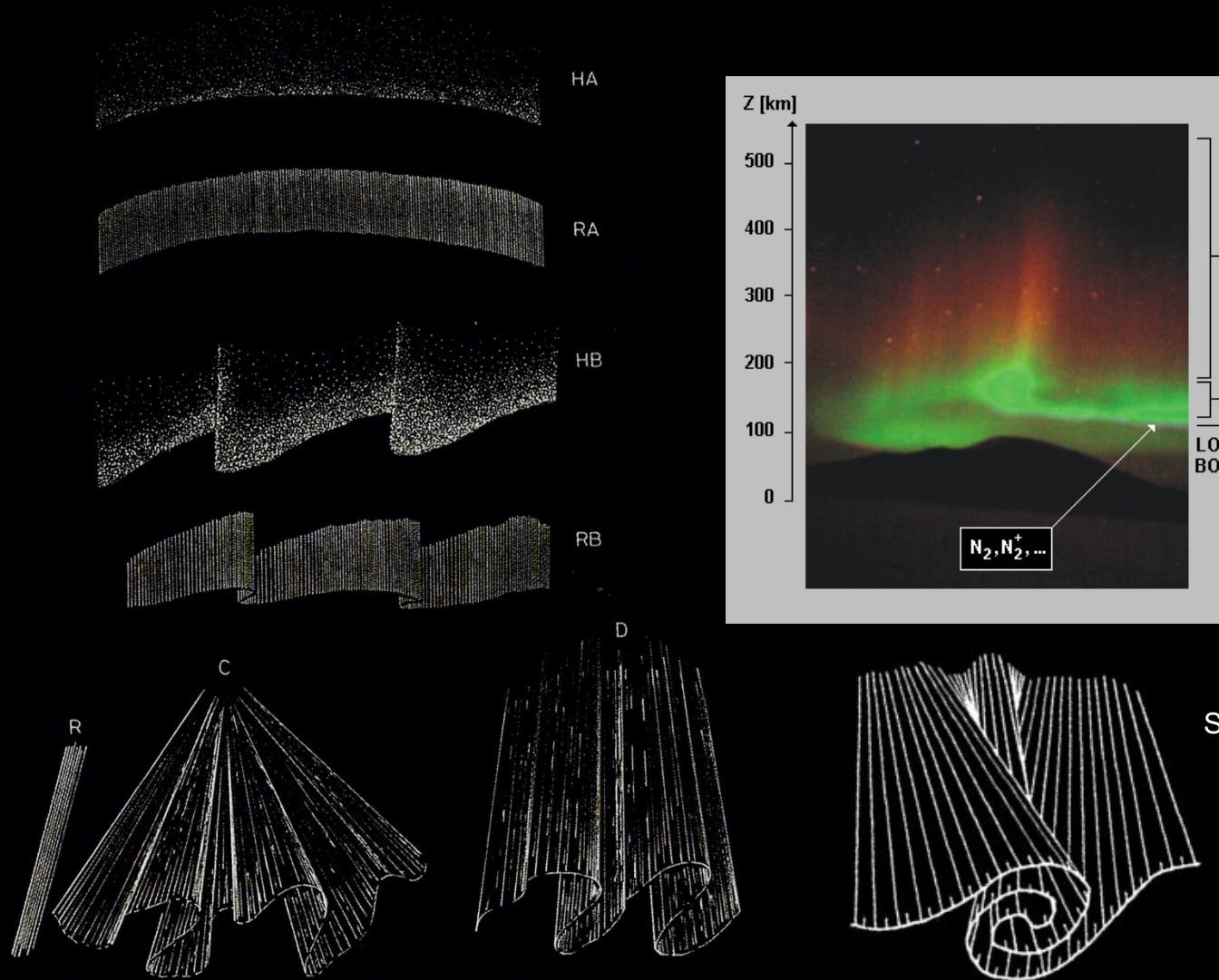
F. Sigernes (2020)

AURORA

THE EARTH'S
ATMOSPHERE
IS THE LAST
DEFENCE



The Auroral forms

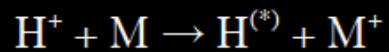


HA – homogeneous arc
 RA – arc with ray structure
 HB – homogeneous band
 RB – bands with ray structure

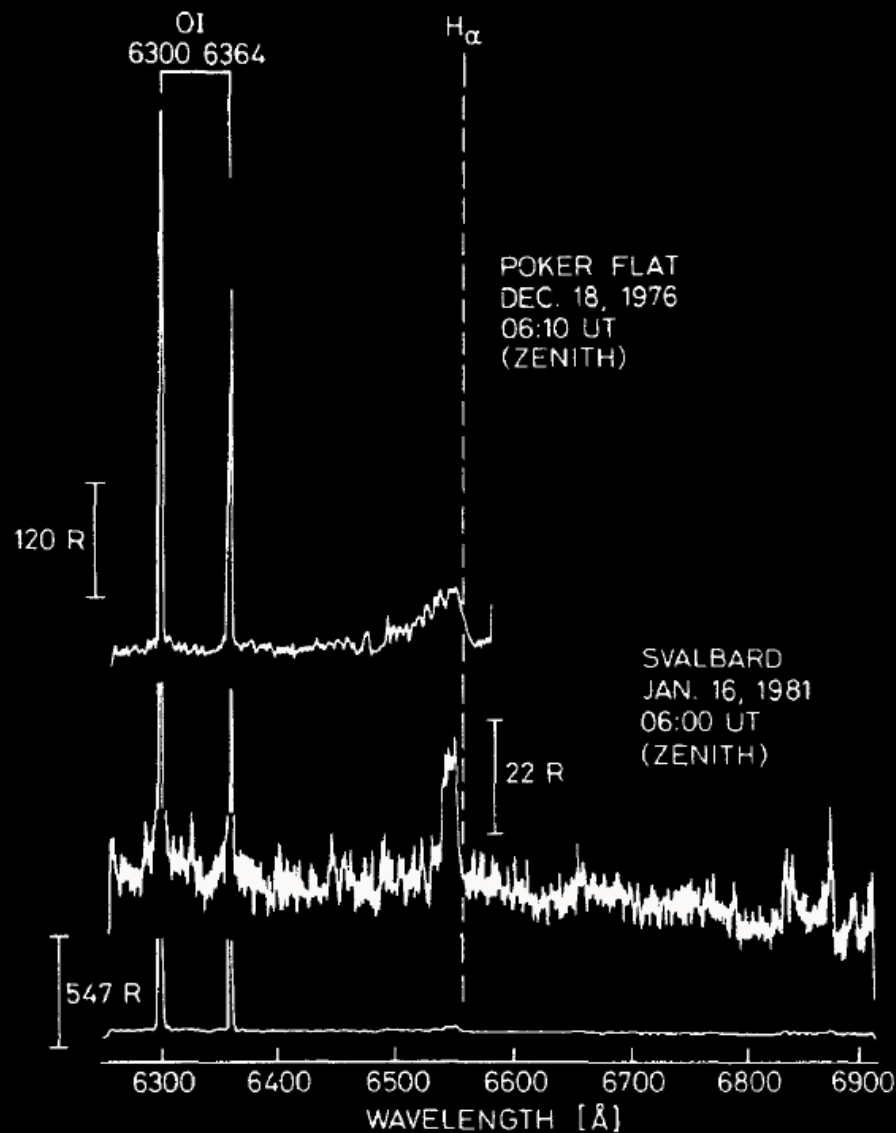
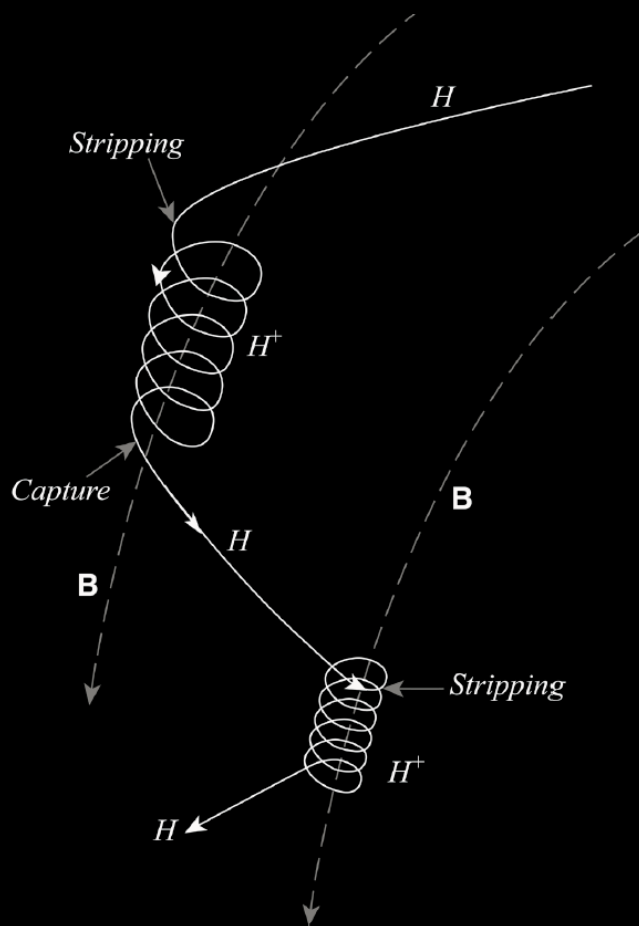
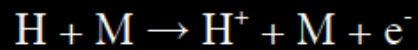
R – rays,
 C – corona
 D – drapes (curtains)
 S – Spirals

Proton Aurora

Charge capture



Charge stripping



IMPACTS ON EARTH

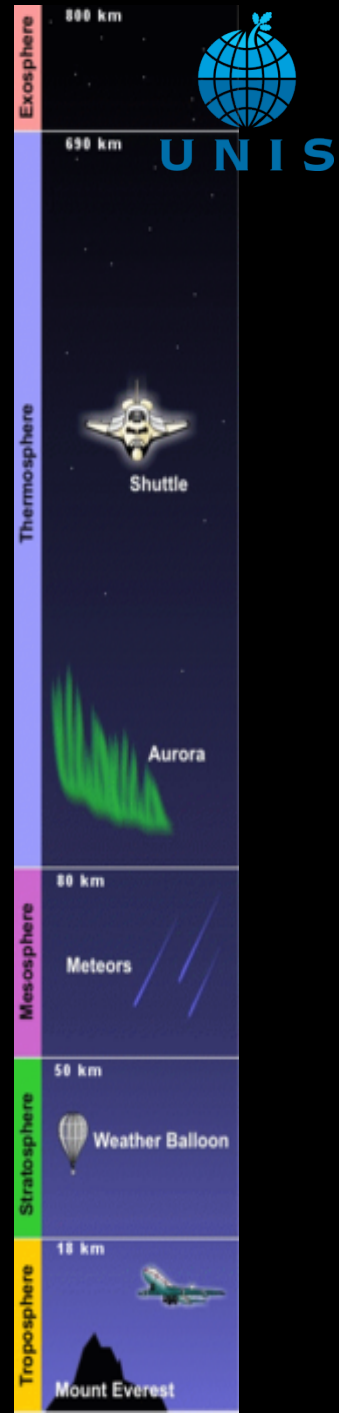
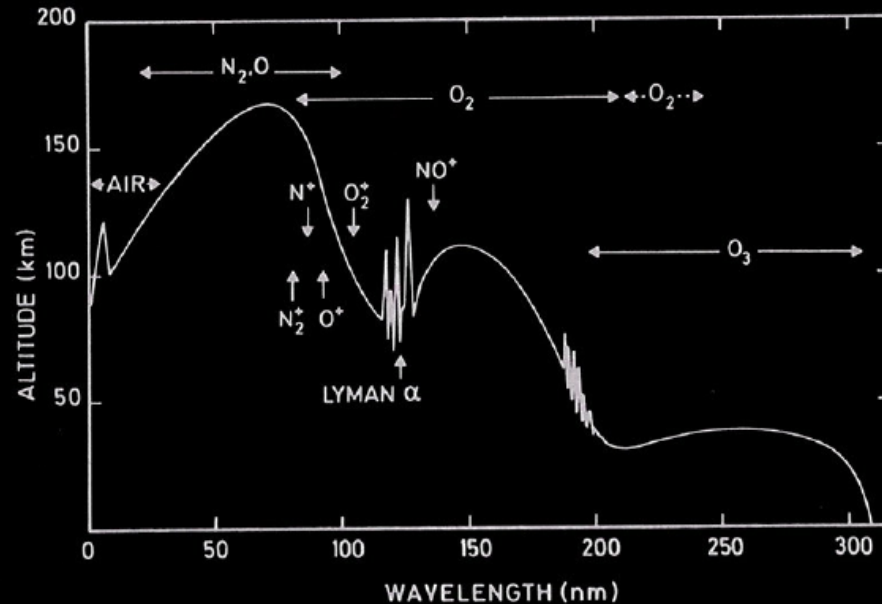
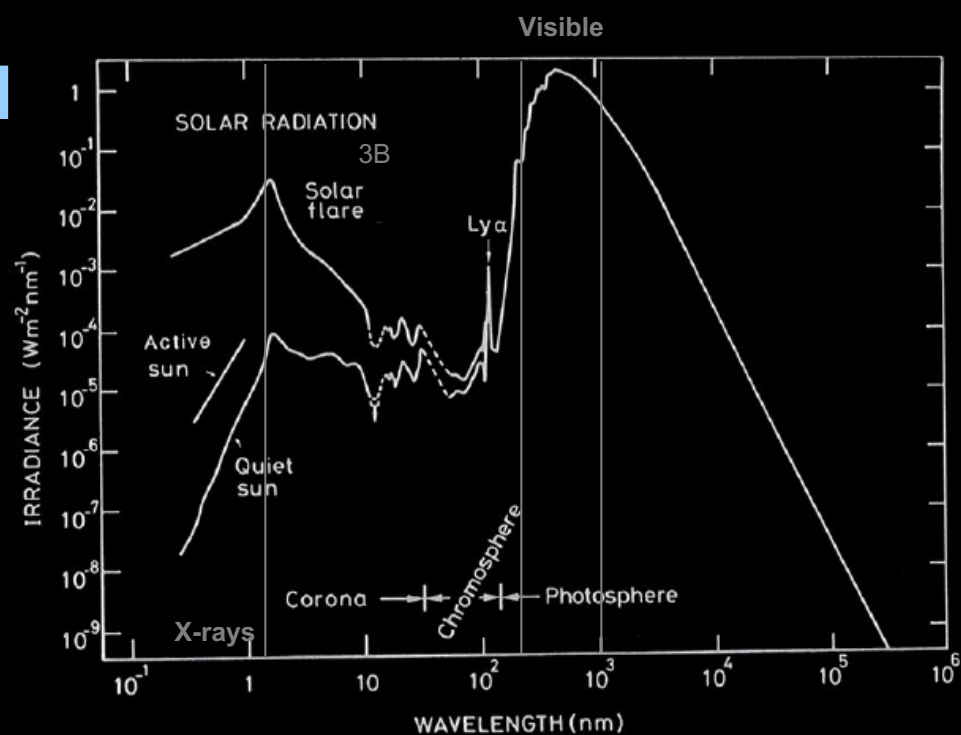
Radiation

Flares are classified according to peak intensity X-ray :

B, C, M & X.

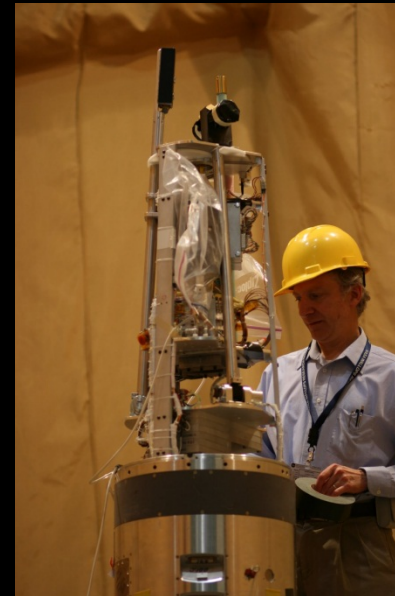
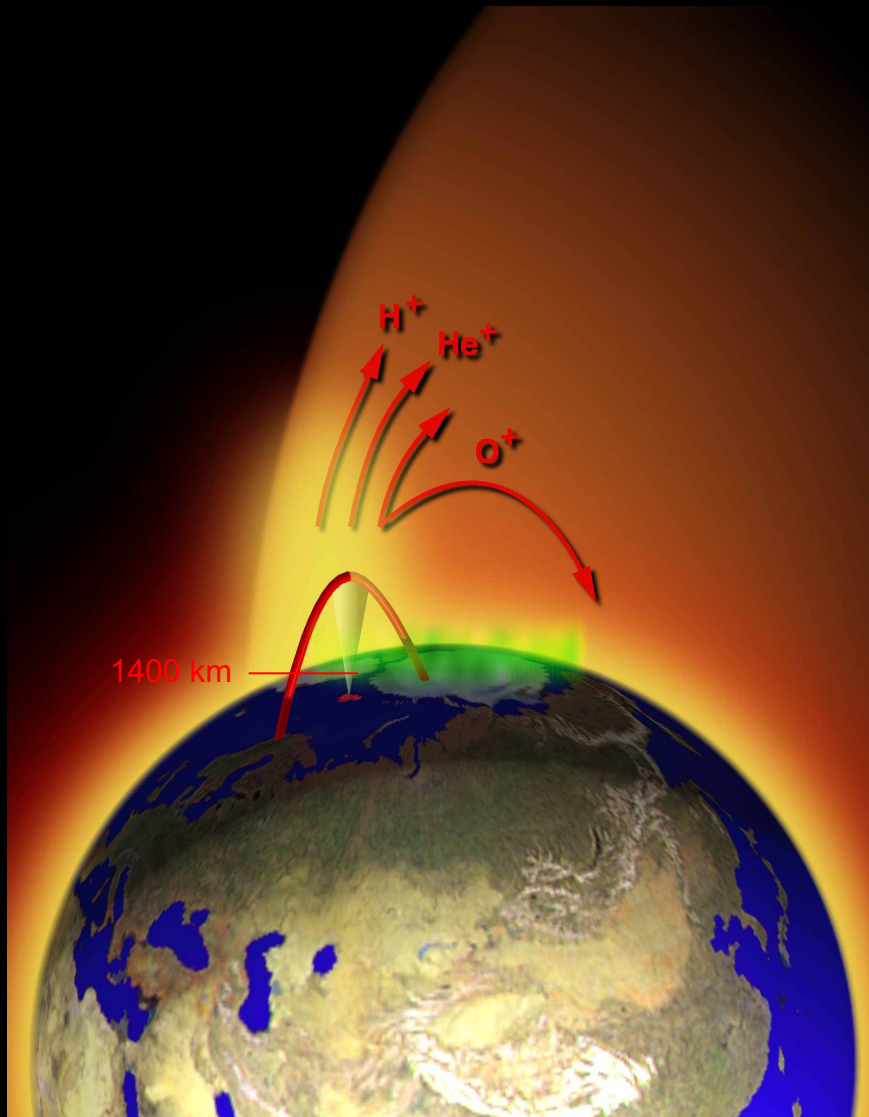
Each with 9 subdivisions.

Atmospheric Response



UNIS

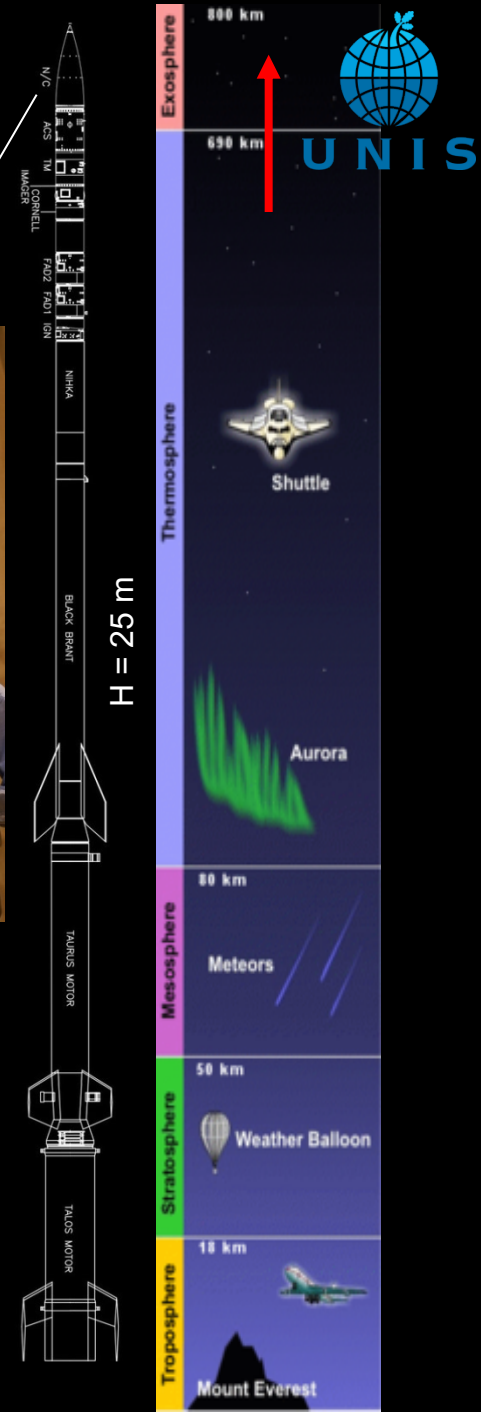
Impacts: Magnetospheric Ion Outflow



The SCIFER 2 Payload



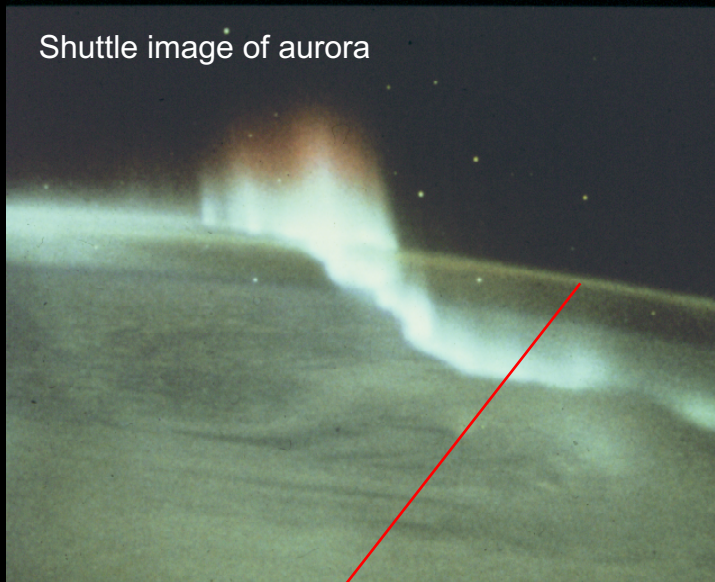
Rocket assembled on launcher, Andøya



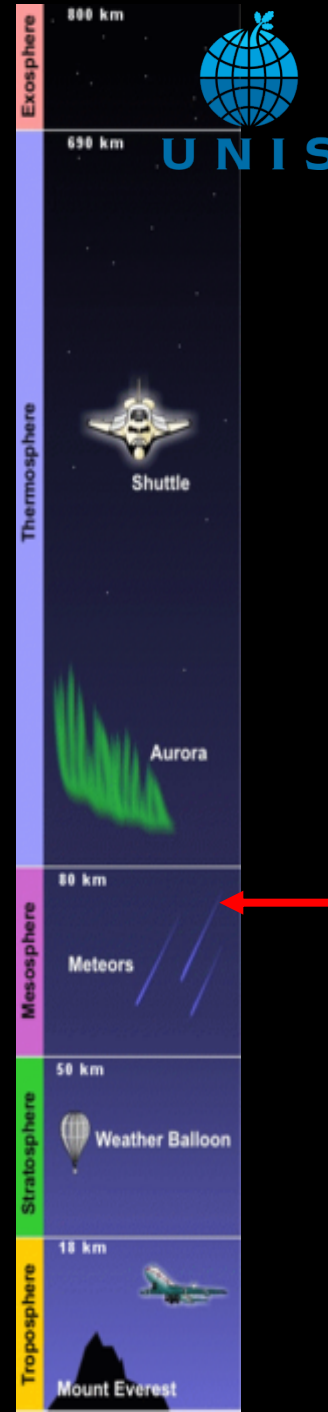
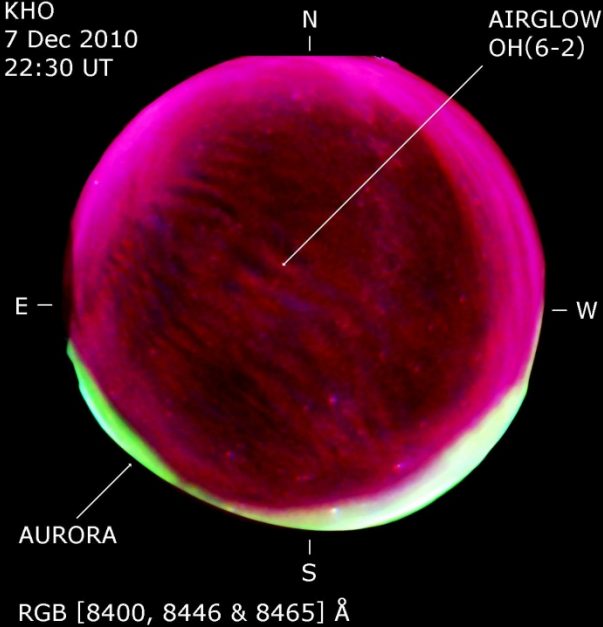
Impact on the Mesosphere ?



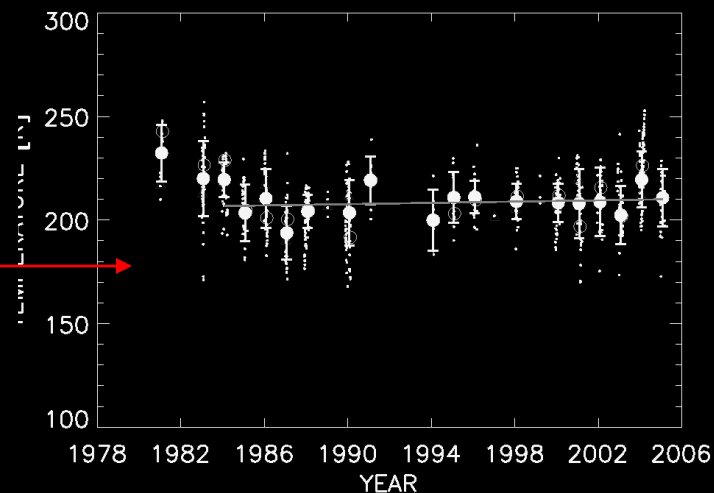
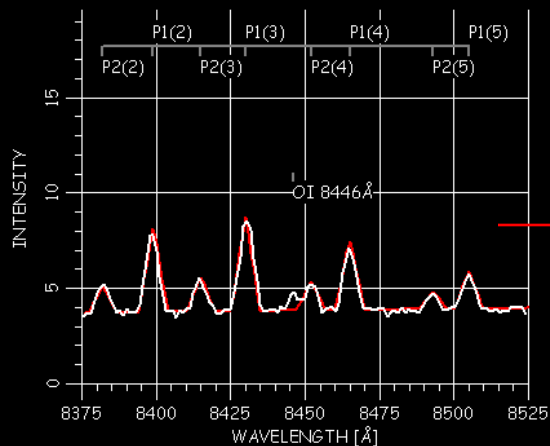
UNIS



KHO
7 Dec 2010
22:30 UT

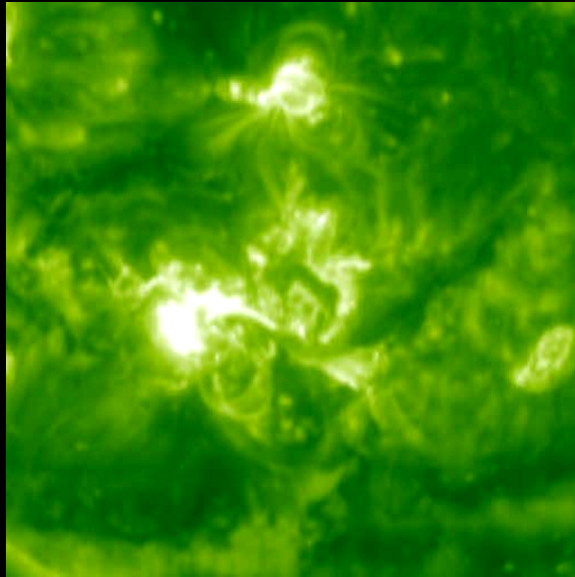


D:\SyntheticOH\src\OH62sample1.dat
SYNTHETIC OH(6-2) SPECTRUM T = 199 K

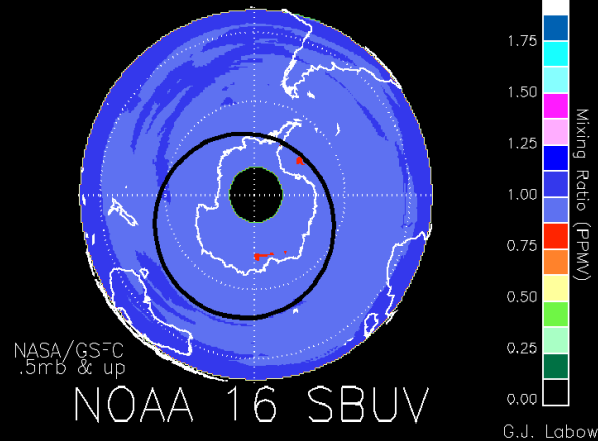


Stratospheric impact: the Ozone Layer ?

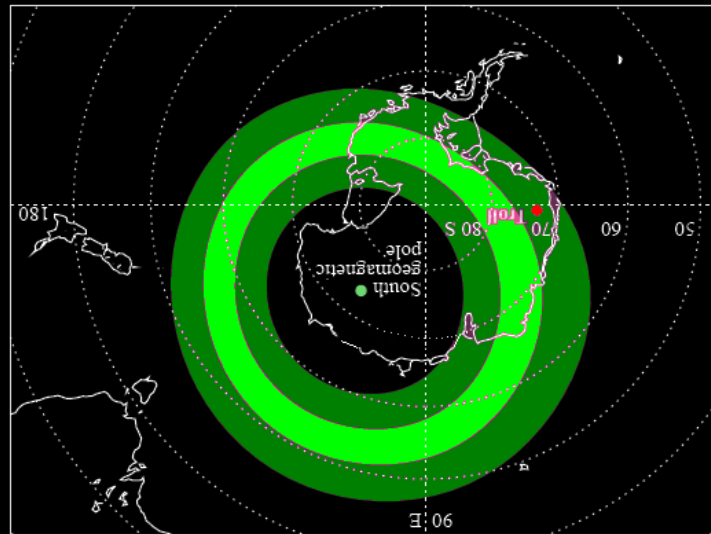
SOHO



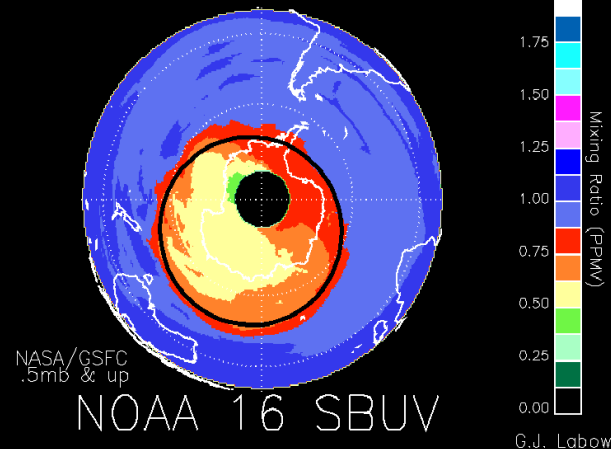
October 27, 2003



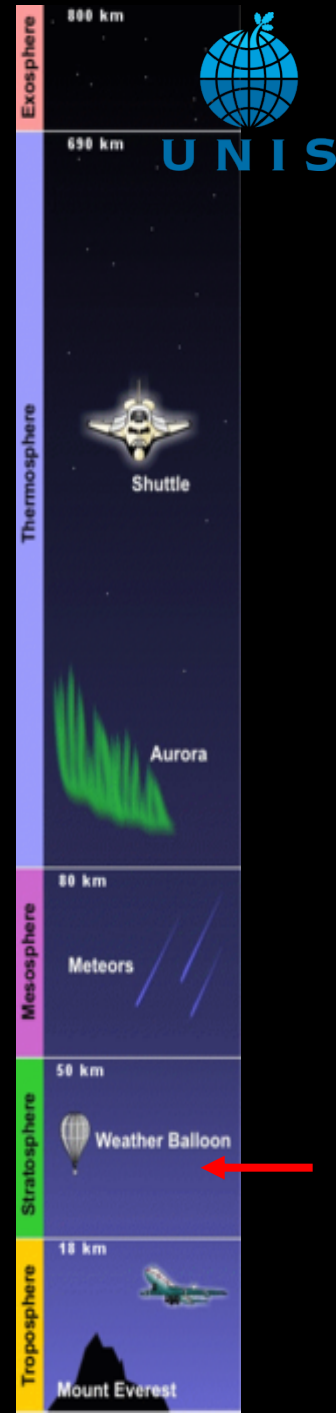
Proton Impact zone 28 October, 2003



October 29, 2003



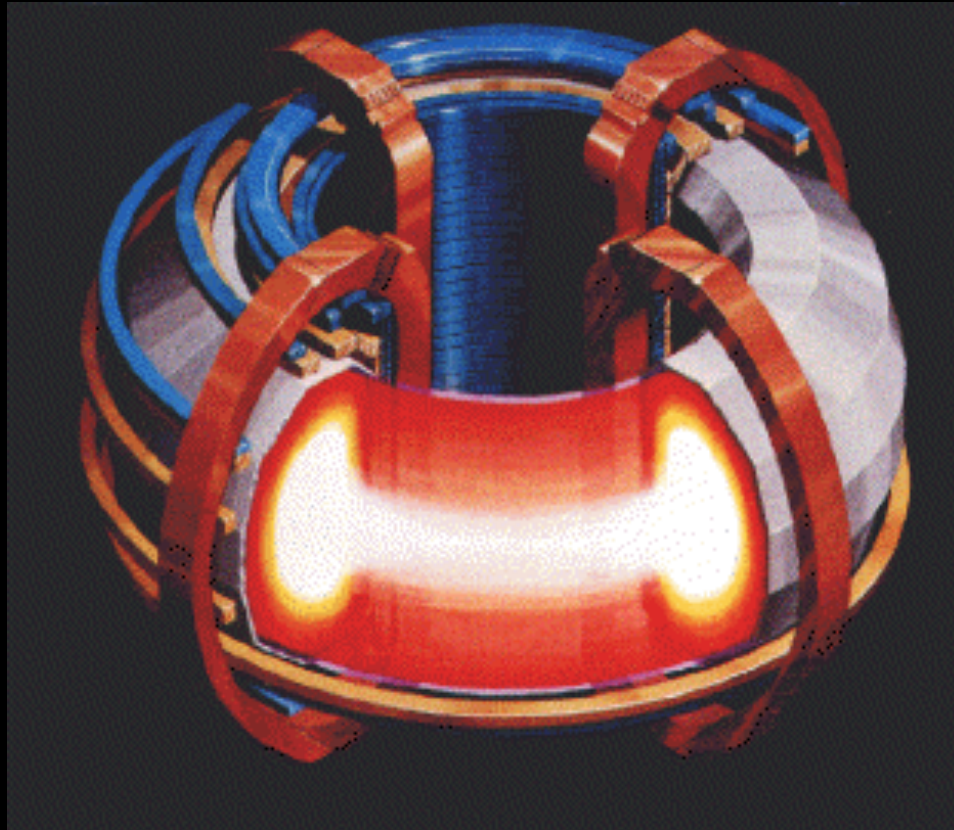
Large proton events deplete the upper level ozone for weeks to month (Jackman et al. GRL 28, 2883, 2001). These short term effects can destroy up to 70% of the ozone in the middle stratosphere.





UNIS

FUTURE: PLASMA FUSION REACTORS?

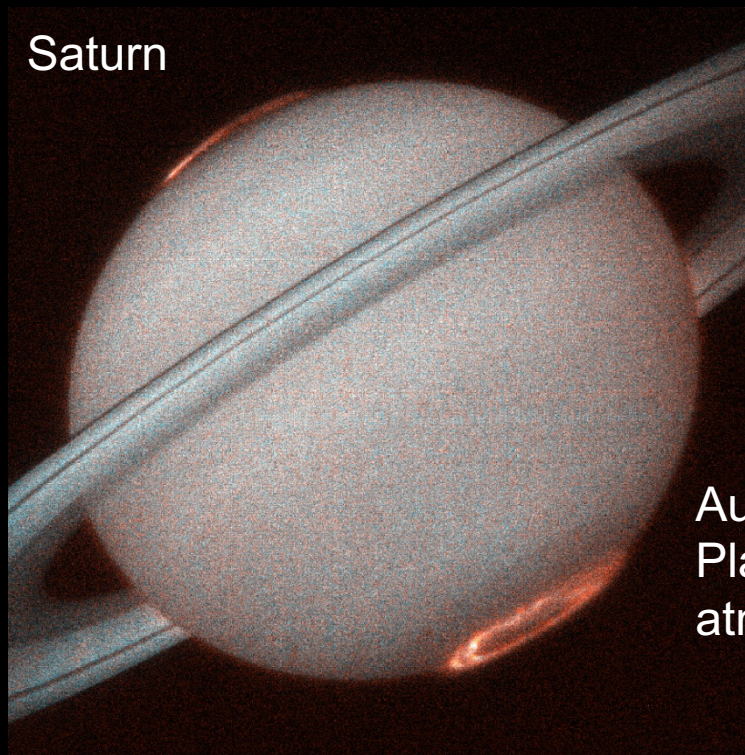


Leakage of diffusion across the magnetic field is the main problem to be successful with controlled fusion of Hydrogen atoms.

We study the same things in nature!

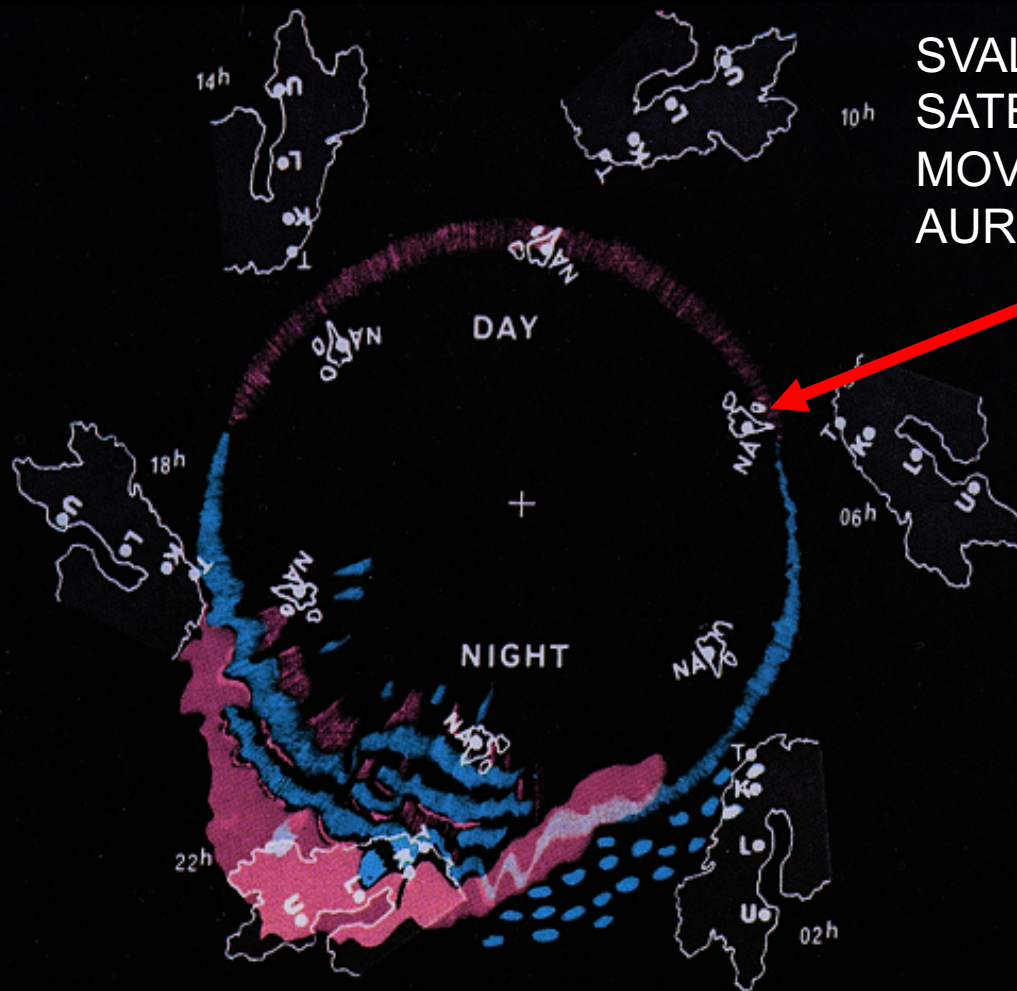
Planetary Auroras

UV Images from the Hubble Telescope



Auroras reveal existence of
Planetary magnetic fields and
atmospheric composition!

The Auroral oval vs. Svalbard



SVALBARD IS LIKE A SLOW SATELLITE WITH AN ORBIT MOVING IN AND OUT OF THE AURORAL OVAL!



+ IT IS DARK IN THE DAYTIME DURING WINTER (DAYSIDE AURORA)

The Auroral Station in Adventdalen



The dedicated scientists - pioneers



The University of Oslo – Physics Dept./ Norwegian Institute for Cosmic Physics Observatory (Omholt / Egeland) on Breinosa, October, 1970.



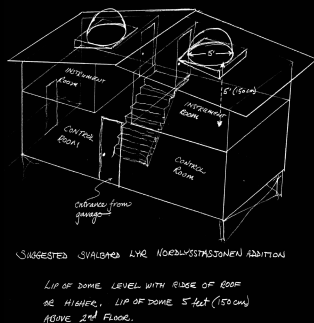
The Auroral Station in Endalen (1978)



The Auroral Station in Endalen stamp (1978 - 1983)



The Auroral Station in Adventdalen (1984)



Expansion in 1988



Platform Expansion 2002

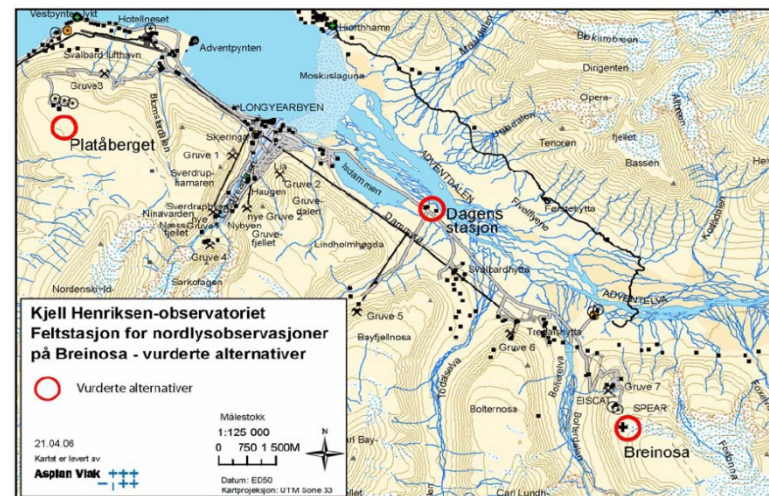


The current shape of the Auroral Station in **Adventdalen** (2005)

KHO 2008 -



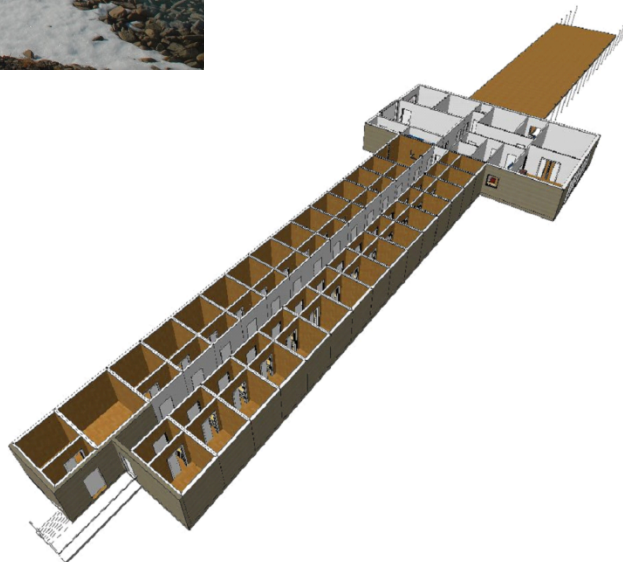
Summer view



Location

KHO

- 1) Instrumental module (30x)
- 2) Service Section
- 3) Platform



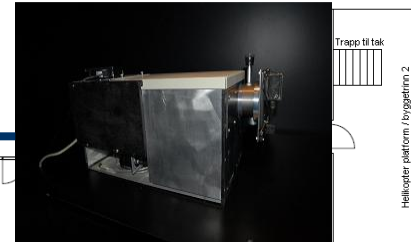
Prof. Dr² K. Henriksen



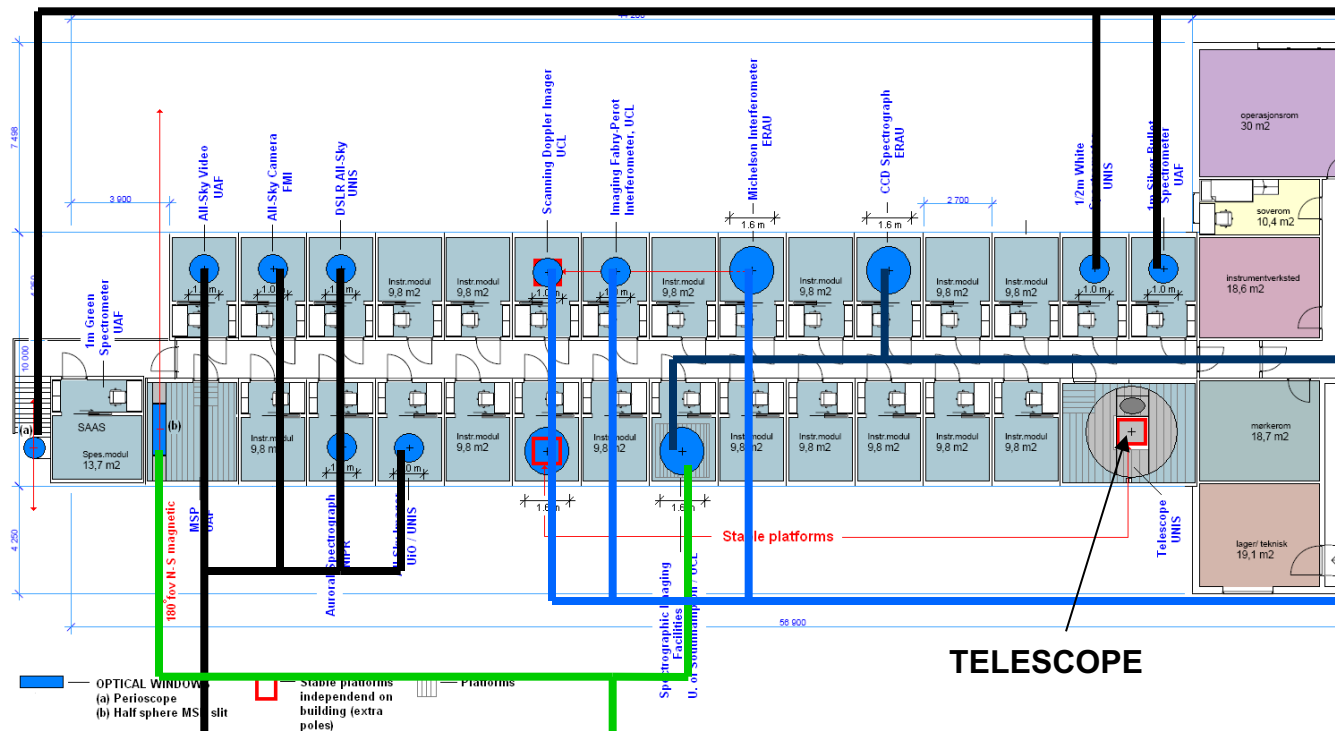
SPECTROMETERS



SPECTROGRAPHS

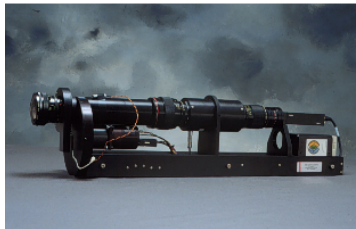


Interferometers

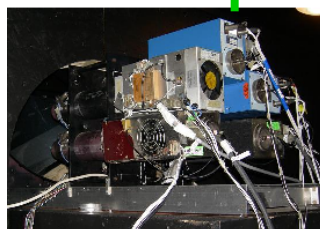


TELESCOPE

CAMERAS



PHOTOMETERS



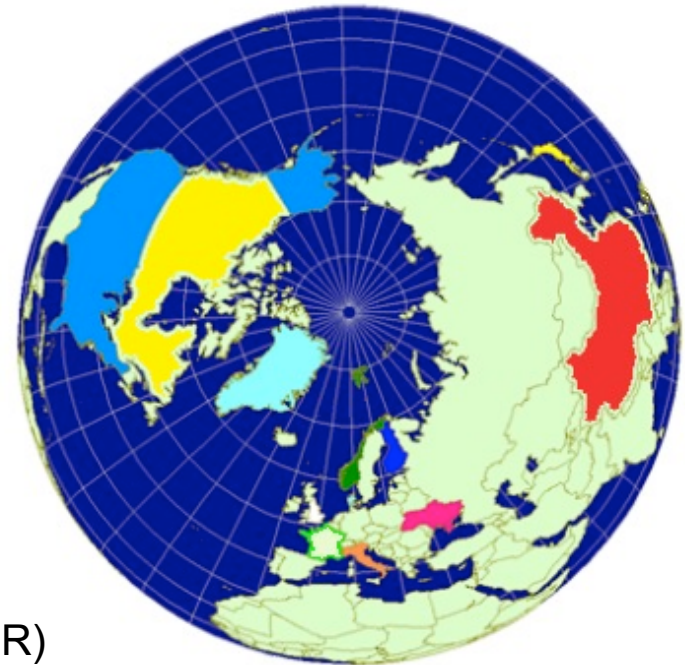
IN ADDITION

- a) Magnetometers
- b) Scintillation receivers (GPS)
- c) Riometer
- d) Weather station
- e) Web cameras

Institutions @ KHO



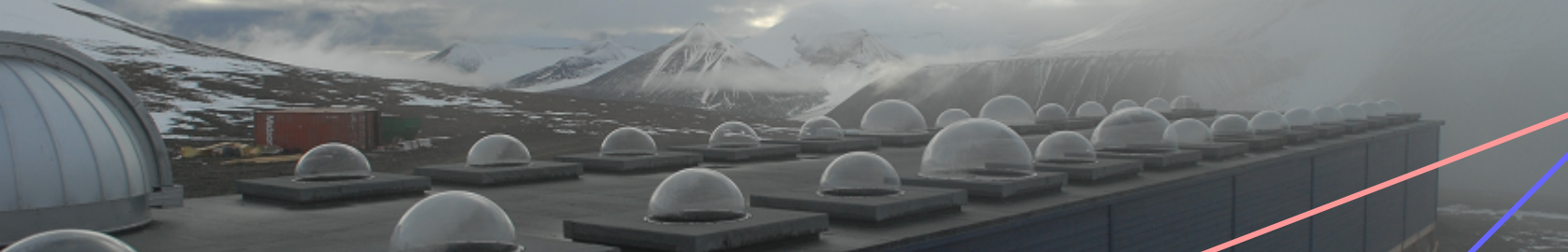
1. University Centre in Svalbard
2. University of Oslo
3. University of Tromsø
4. University of Bergen
5. University of Alaska, Fairbanks
6. University College London
7. University of Wales Aberystwyth
8. University of Southampton
9. University of New Hampshire
10. University of Rome
11. University of Calgary
12. Augsburg College
13. Tohoku University
14. National Institute of Polar Research Japan (NIPR)
15. Finnish Meteorological Institute (FMI)
16. Danish Meteorological Institute * (DMI)
17. Institute of Radio Astronomy (Ukraine)
18. The Polar Institute of China (PRIC)
19. NORSAR
20. National Institute for Aeronautics (LAPAN)
21. Technische Universität Berlin (TU)
22. Korea Polar Institute (KOPRI)



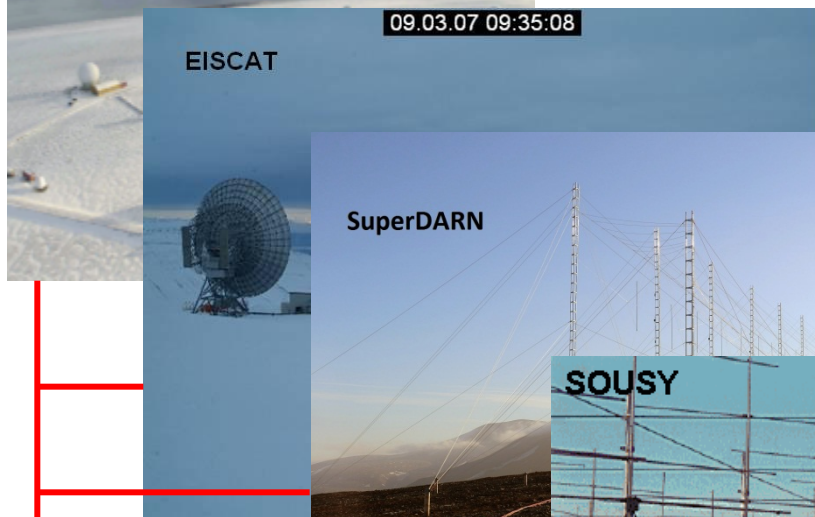
The 13 Nations @ KHO



... & excellent students!

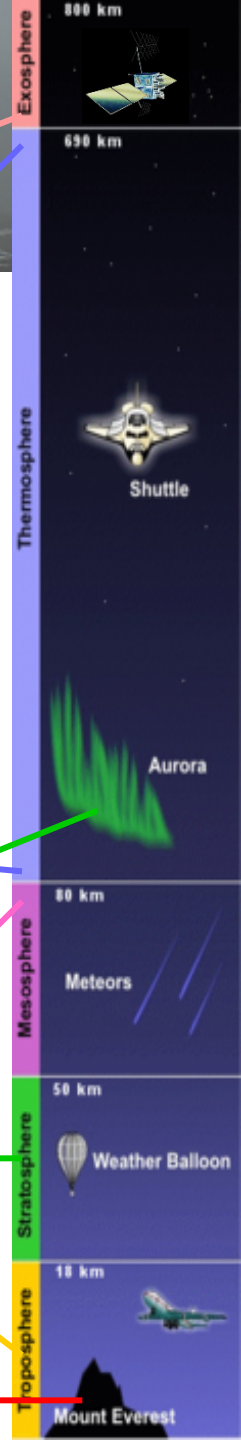


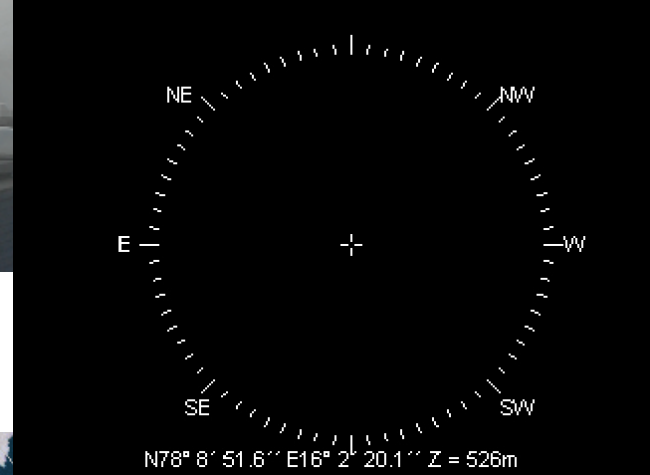
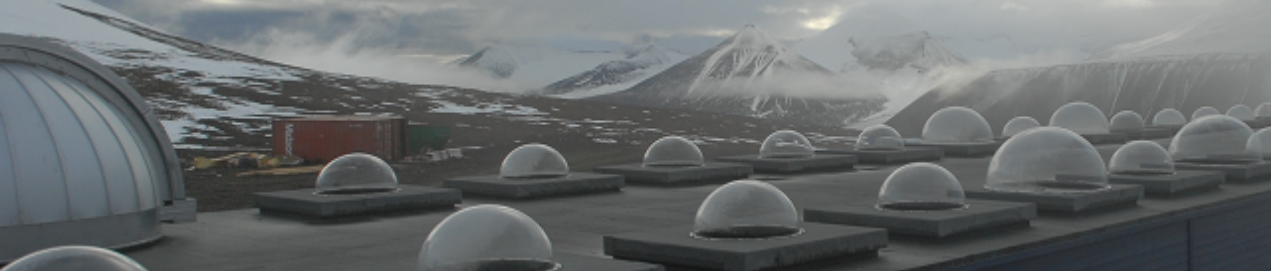
PARTNERS @ LYR



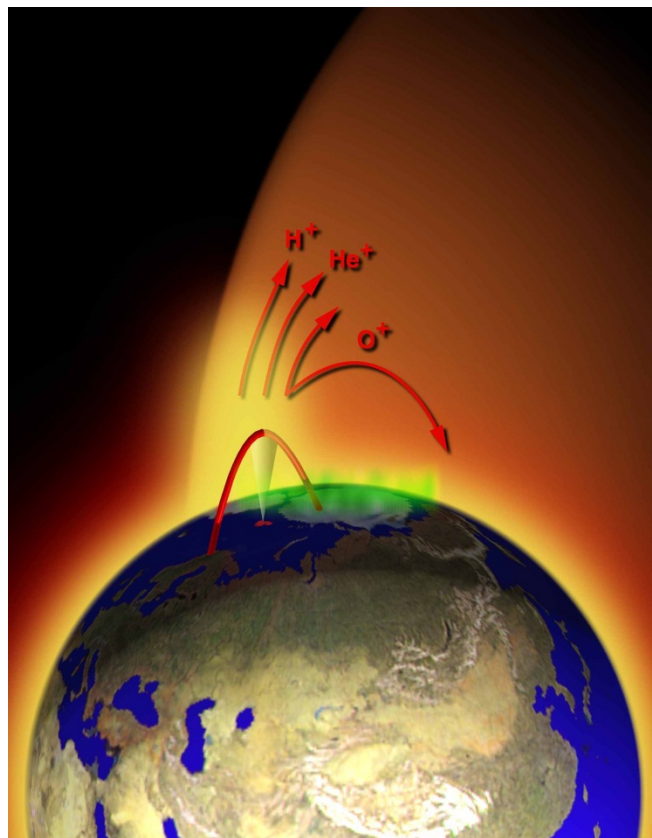
INTERNET

KHO - UNIS - ARS - MINE 7

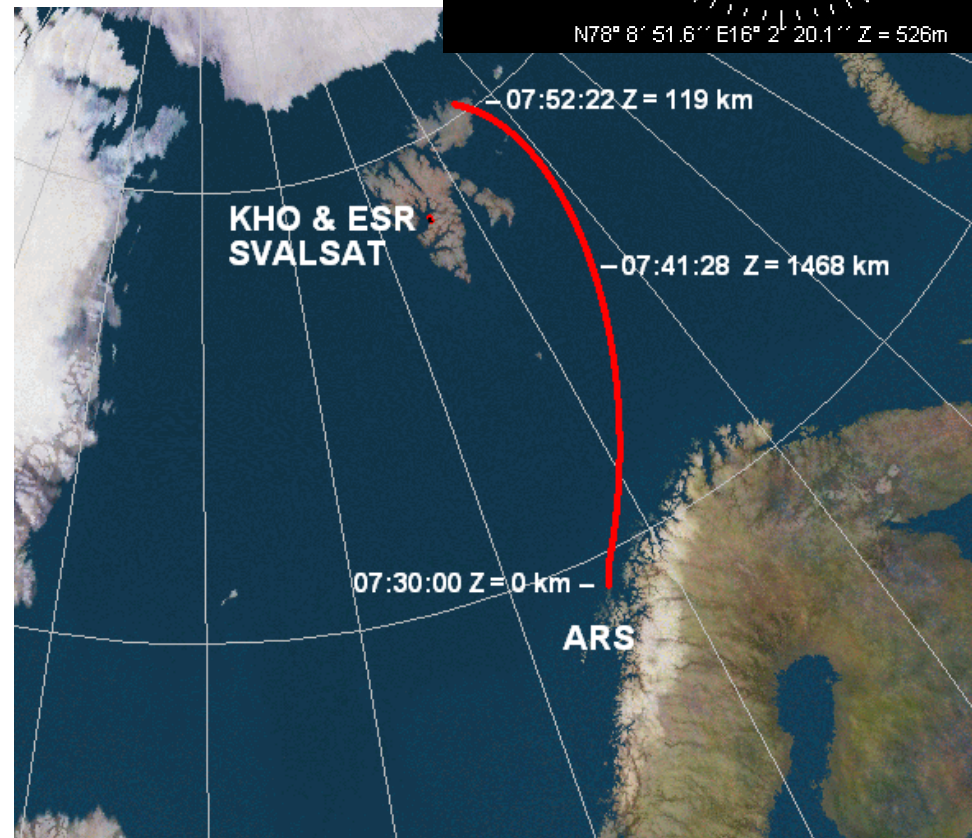




COOPERATION: SCIFER 2



Artistic view



THE SCIFER 2 ROCKET CAMPAIGN 18.01.2008 07:30 UT

SCIFER 2 = Sounding of the Cusp Ion Fountain Energization Region

More info at: <http://kho.unis.no>



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