

# The northern lights

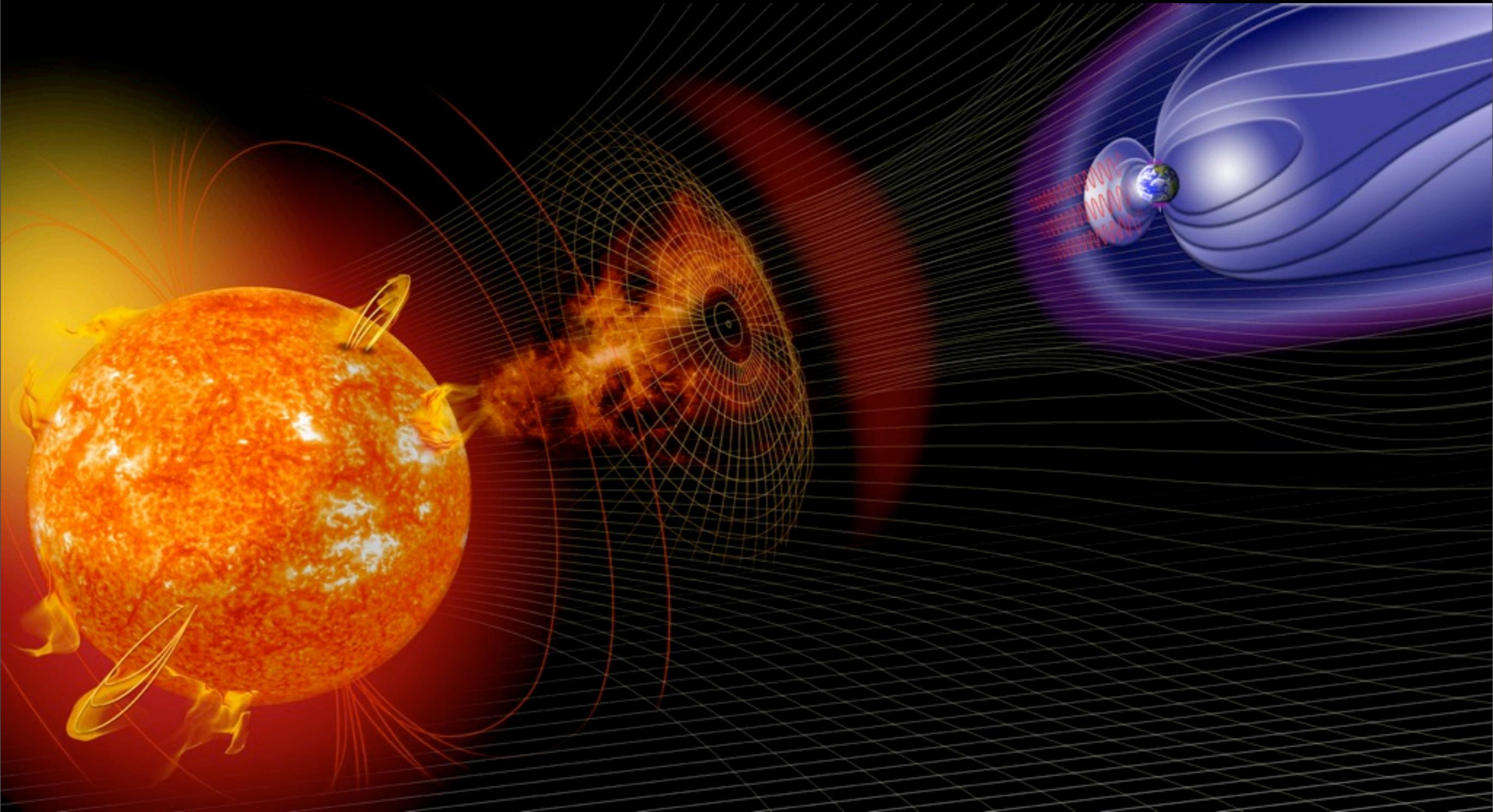
## A message from the Sun

*Pål Brekke*

*Norwegian Space Centre*

EISCAT (Njål Gulbrandsen)

# The Sun the the Northern Lights



NASA

# *The Northern Lights*



Pål Brekke

# The Northern Lights

*"No pencil can draw it, no colours can paint it,  
and no words can describe it in all its  
magnificence."*

Austrian explorer Julius von Payer

Pål Brekke

# A vengeful force

- In ancient times, most people were afraid of the lights.
- Children would be brought inside
- Northern lights were a vengeful force which killed those who mocked it. DO NOT WHISTLE TO IT!!!
- Many believed it was a message from the creator.
- An old tale from the Nordic countries said that, "God is angry when the aurora flames".
- An omen of war, or disasters or plagues



Aurora over Nurnberg 5 October 1591



# Beliefs of Indigenous Peoples

- The Eskimos in the northernmost parts of Canada believe that the northern lights were created by spirits, which, dressed in the mystical light, are having fun because the Sun is missing.
- Rapidly moving aurora were called the dance of death.
- The Sami people calls it “guovssahas” - the light you can hear



# Finnish Folklore



# Danish Folklore



I. Sandahl

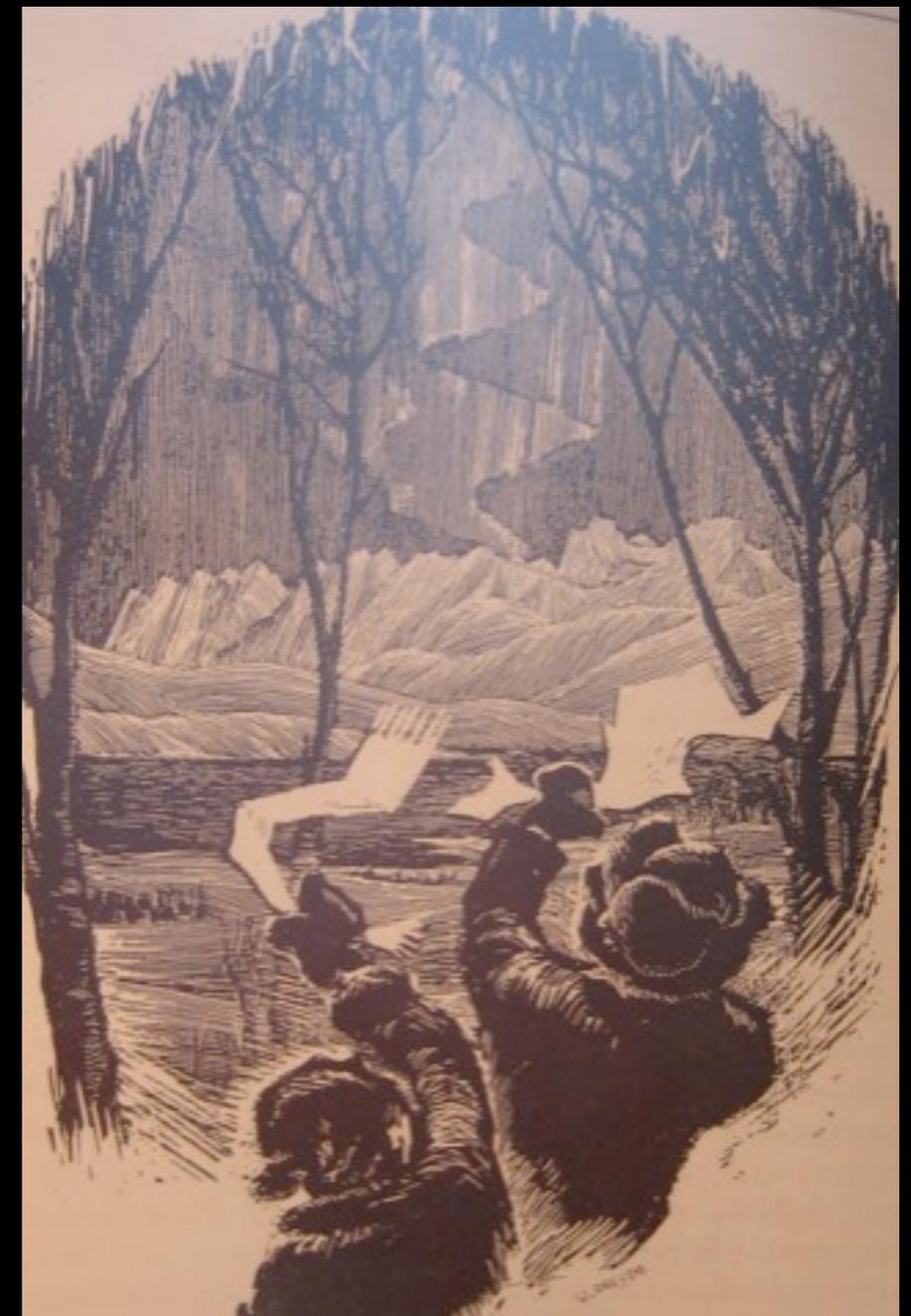


# Beliefs of Indigenous Peoples

- The Mandan Indians (North Dakota) explained the northern lights as fires over which the great medicine men and warriors of northern nations simmered their dead enemies in enormous pots.



# Myths



Ulf Dreyer

Children waving with white clothing - intensity of waving increased the motion of the aurora!

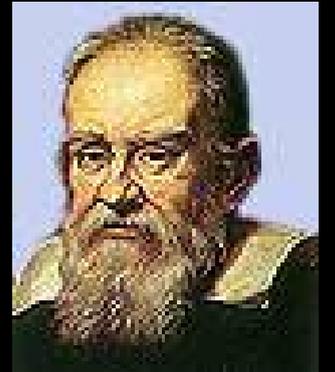
# The Name - Aurora Borealis

**What does the name mean?**



# The Name - Aurora Borealis

- The scientific name for the phenomena is Aurora Borealis, which is Latin and translates into “the red dawn of the north”.
- It was the Italian scientist Galileo Galilei (1564-1642) who first used the expression. On the latitude where Galileo was living, northern lights consist of mainly red colour.



Galileo Galilei (1564-1642), Italian mathematician, philosopher and astronomer. Among his discoveries are the four Galilean moons around Jupiter. Although he wasn't the first to see northern lights, he gave it its scientific name.



# The Name - if Galileo lived in Norway?



Lux Viridis Borealis - the green light in the North

# "The Sky's on fire"

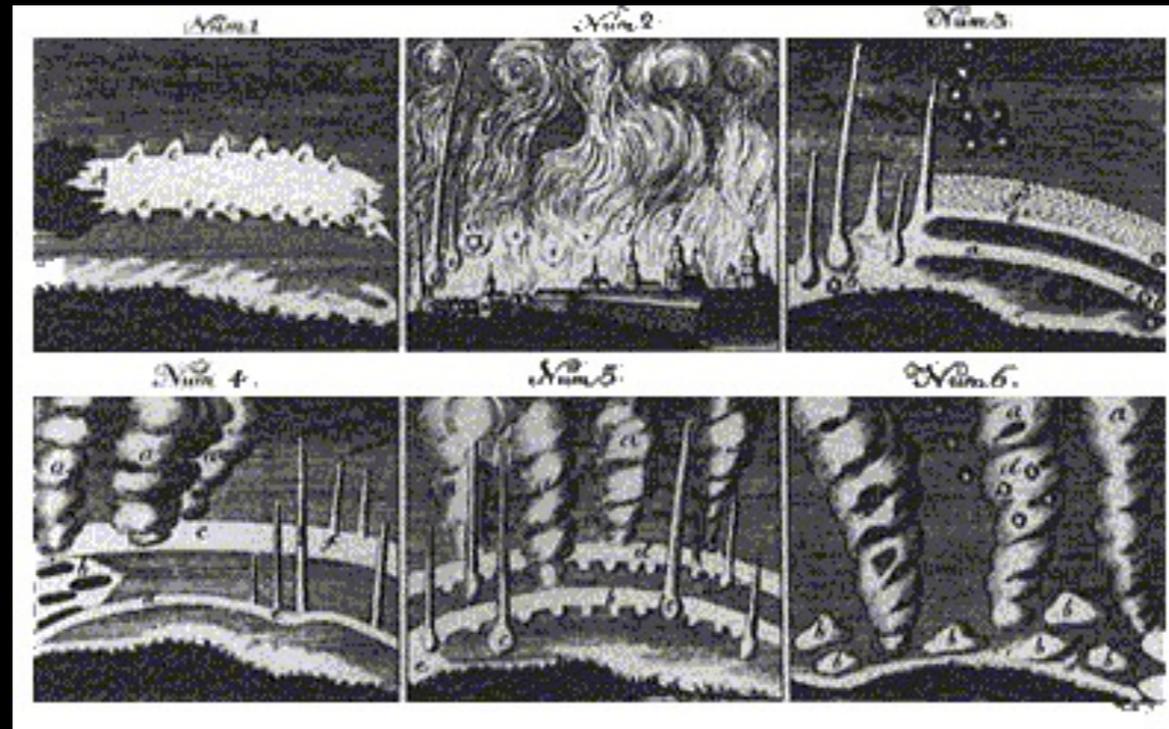
The Roman emperor Tiberius in 34AD was tricked into thinking the port of Ostia was on fire and he sent troops to deal with it. In fact, he was witnessing a red aurora.



© Copyright 2003, [Chris L Peterson](#).

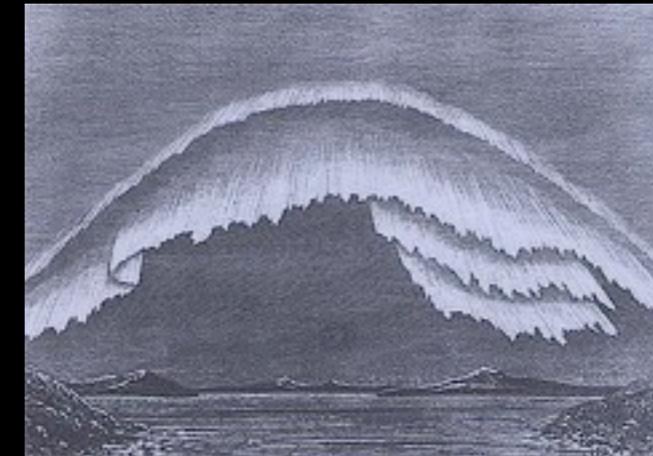
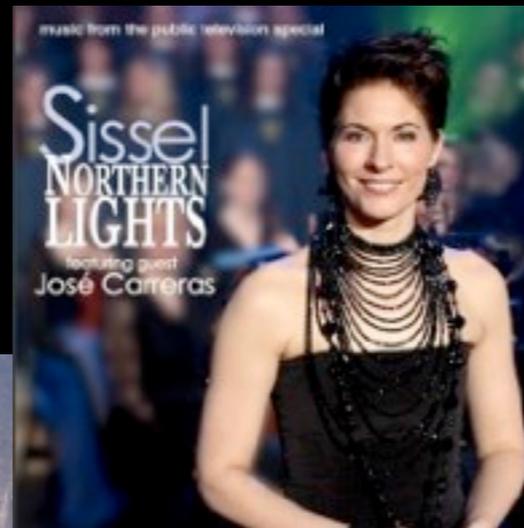
# Early Aurora Science

The strong aurora on 6 March 1716 could be observed in large parts of Europe and gave birth to more modern science.

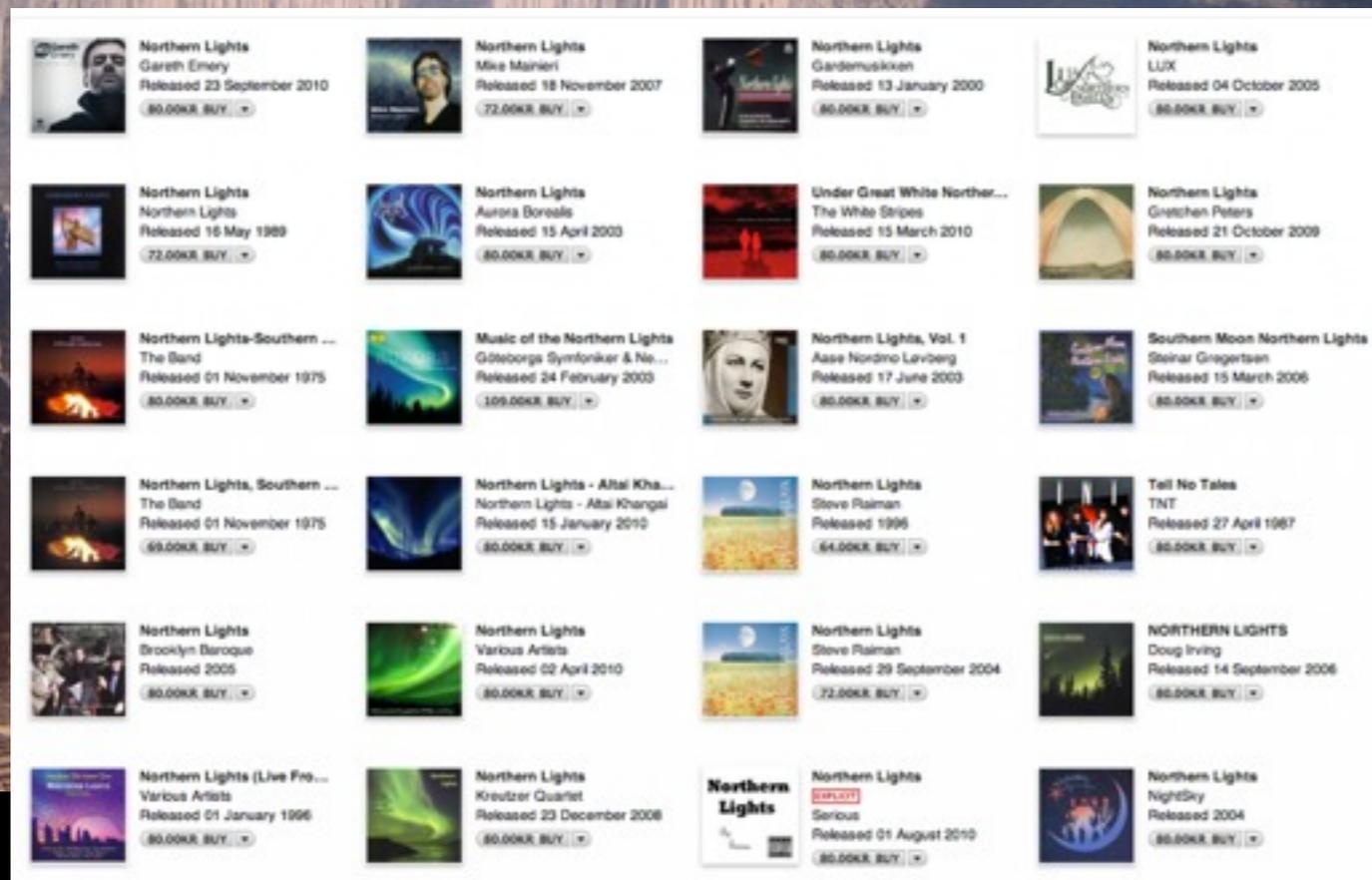


- Sir Edmund Halley published the first detailed description of the aurora in 1716.
  - He expressed that at an age of 60 years he had give up on experiencing this amazing phenomenon.
  - Argued that the top of the aurora arc did not point towards the North pole, but towards the magnetic pole
  - "Auroral rays are due to the particles, which are affected by the magnetic field; the rays are parallel to Earth's magnetic field"

# Inspiration in arts and music



A drawing of northern lights made during a French expedition to Alta in 1838-39.



Aurora as depicted by Fridtjof Nansen.

# Kristian Birkeland (1867 - 1917)

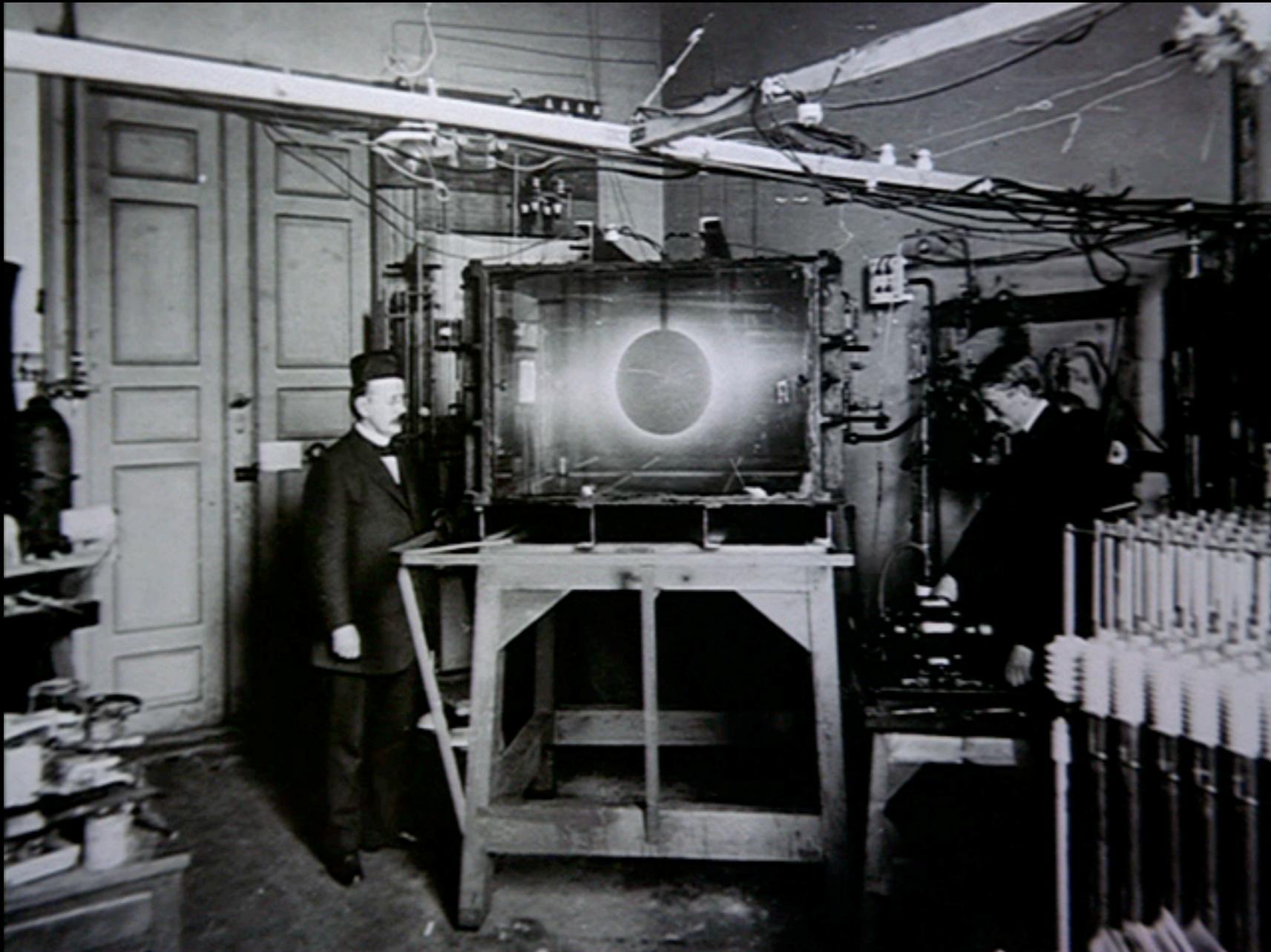
- It was known since 1747 that rapid movements of a compass needle was related to high auroa activity.
- Established a series of magnetic observatories in the Arctic and subsequently determined that the aurora was linked to solar activity.



German documentary about Kristian Birkeland

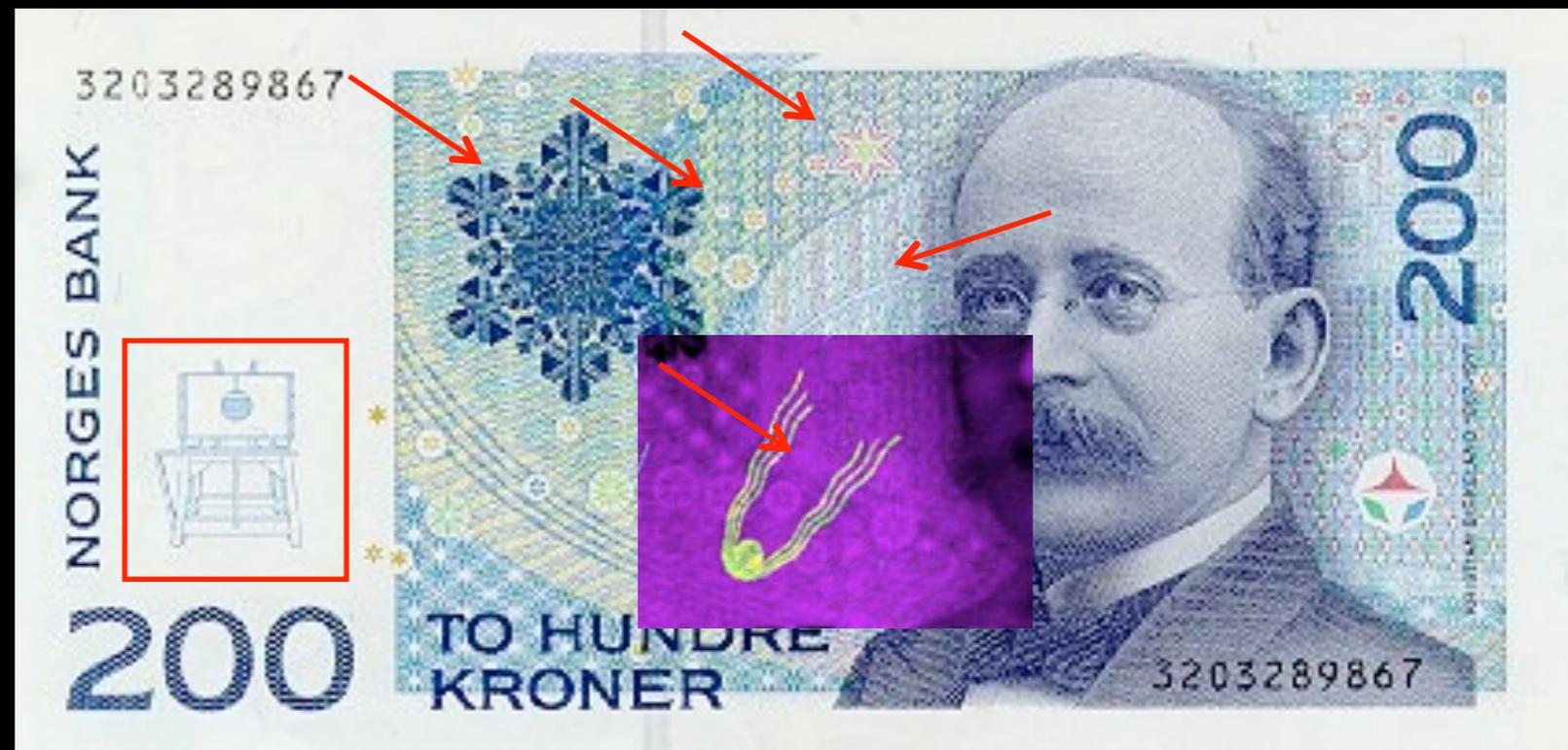
# Kristian Birkeland (1867 - 1917)

- The first realistic theory of the aurora: Electrical charged particles travelling with large velocities from sunspots. These were captured by the Earth's magnetic fields and channelled down towards the polar regions.
- He supported his theory by creating artificial aurora in his laboratory in 1896.



# Science on a bill

- Aurora seen from below and the Polar star
- Big dipper and Little dipper
- Snow crystal - cold climate
- The Terella-experiment



- Map of the Arctic and the magnetic pole
- Aurora-oval
- Birkeland Current
- “Invisible” comet

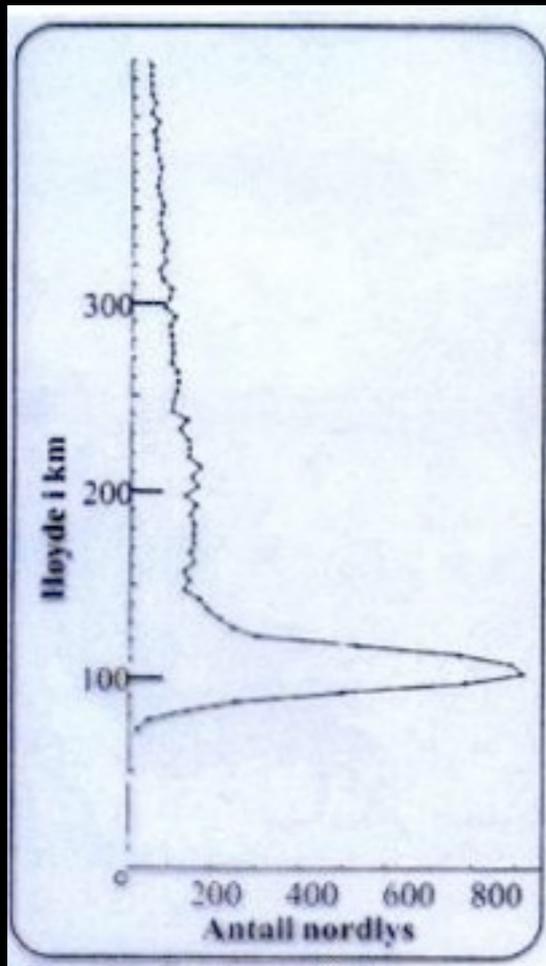


# The glowing comet

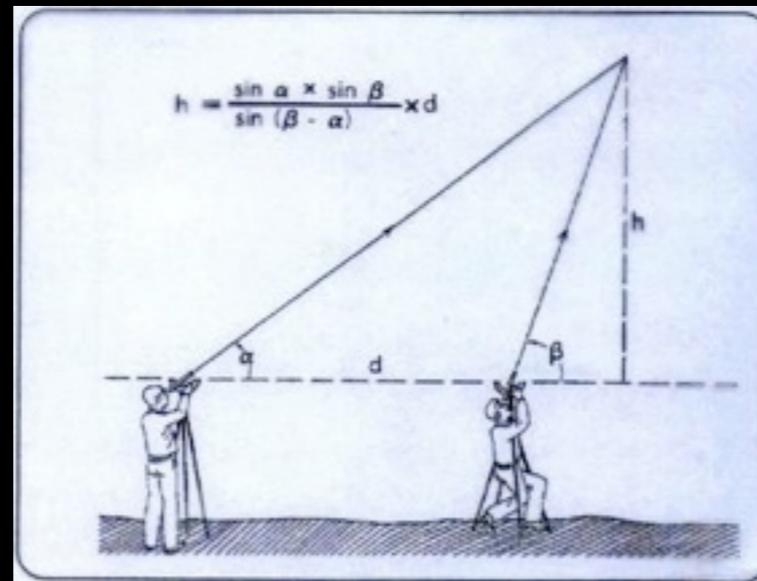


# Carl Störmers (1874 – 1957)

- Height of the aurora
- First aurora atlas (40,000 pictures)

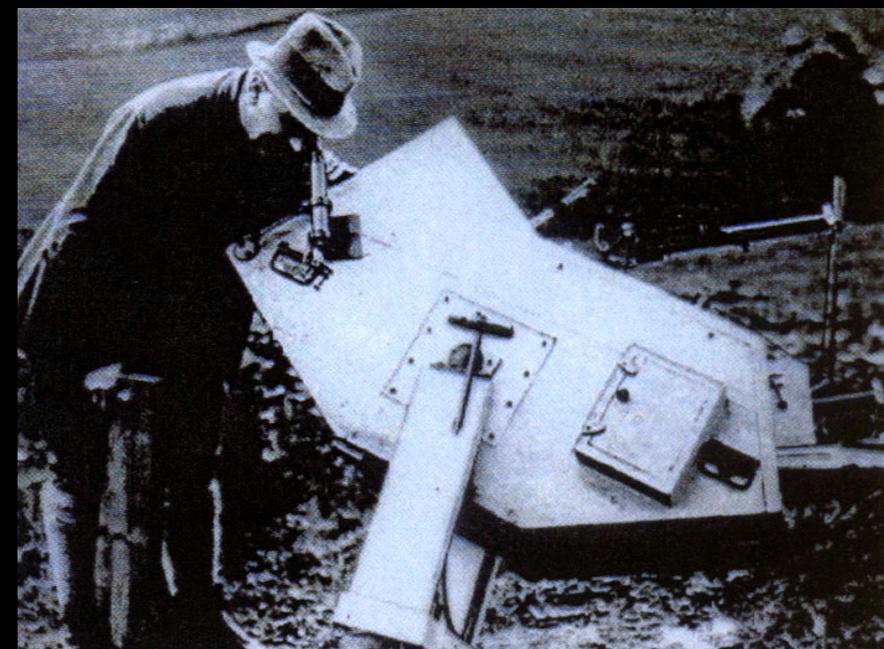
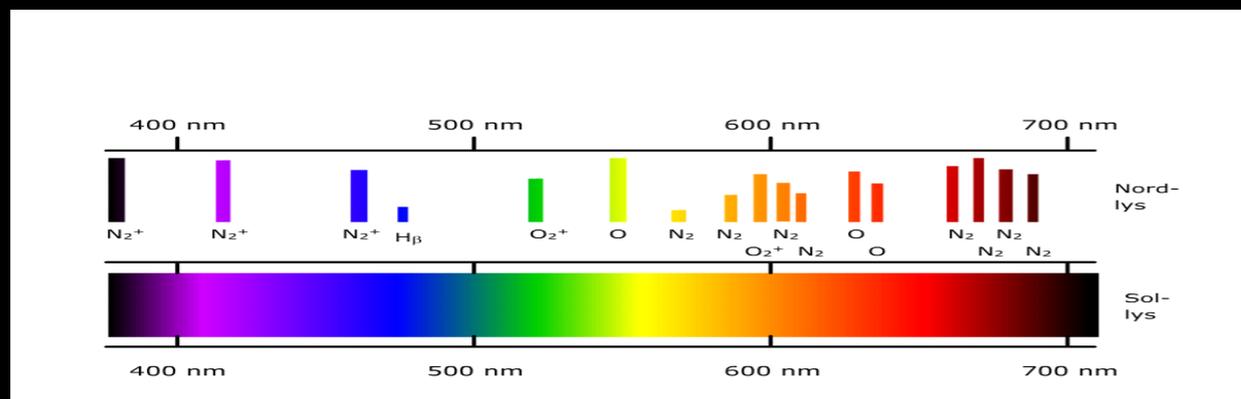
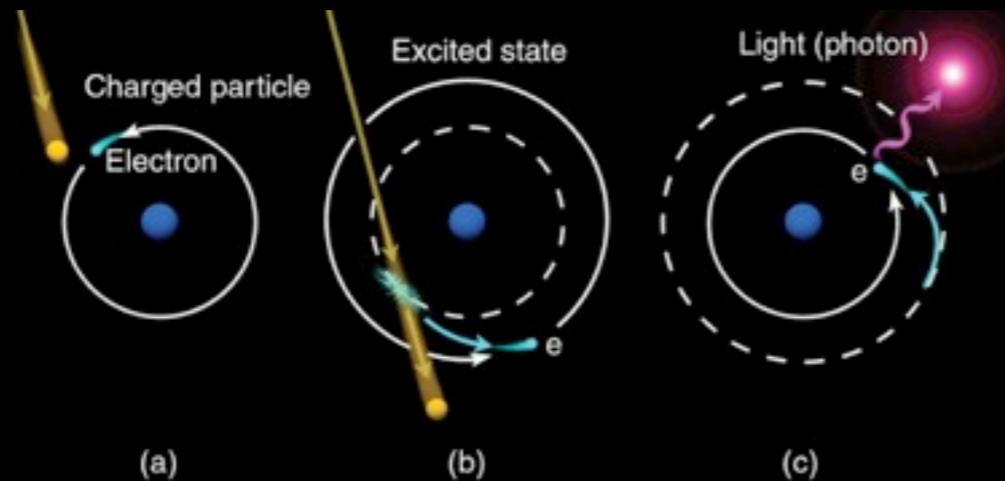


Professor C. Störmer and his assistant outdoors taking parallax auroral pictures to calculate the altitude of auroras.



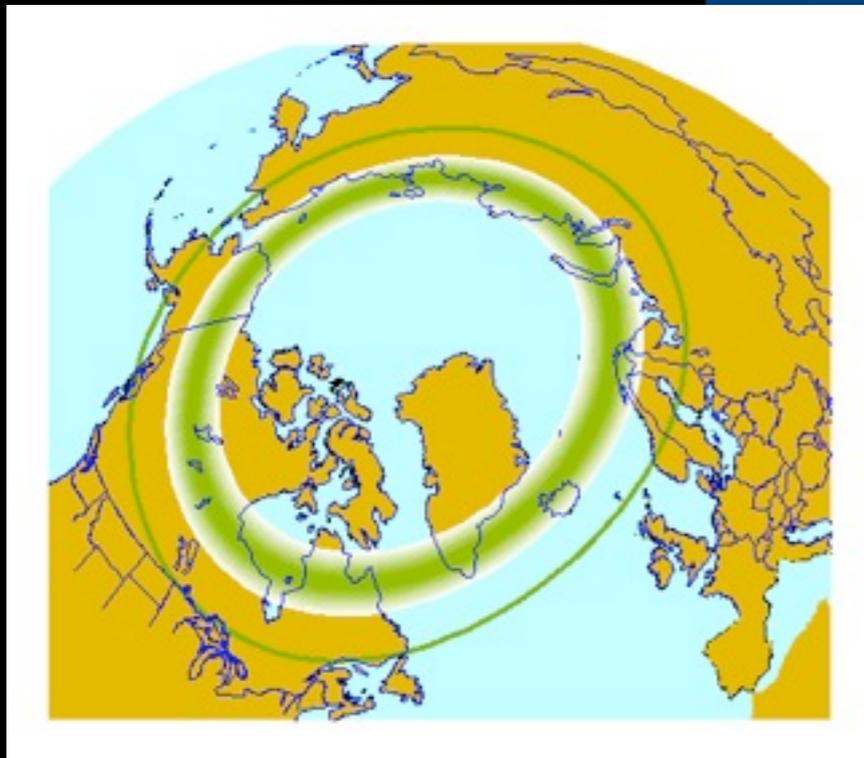
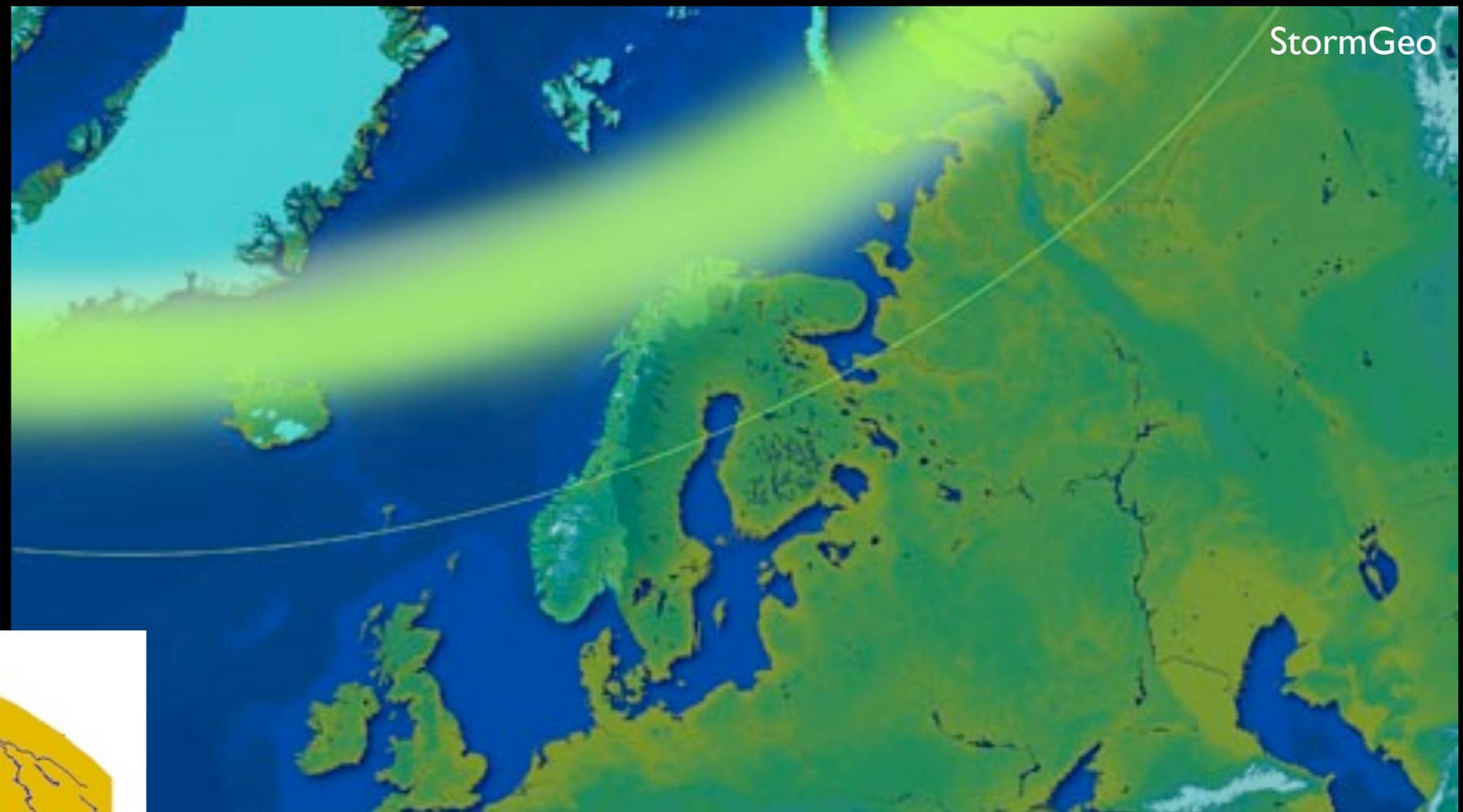
# Lars Vegard (1880 - 1963)

- The spectra of the aurora - the colors - the fingerprints
- First to observe the proton-aurora
- Composition of our atmosphere

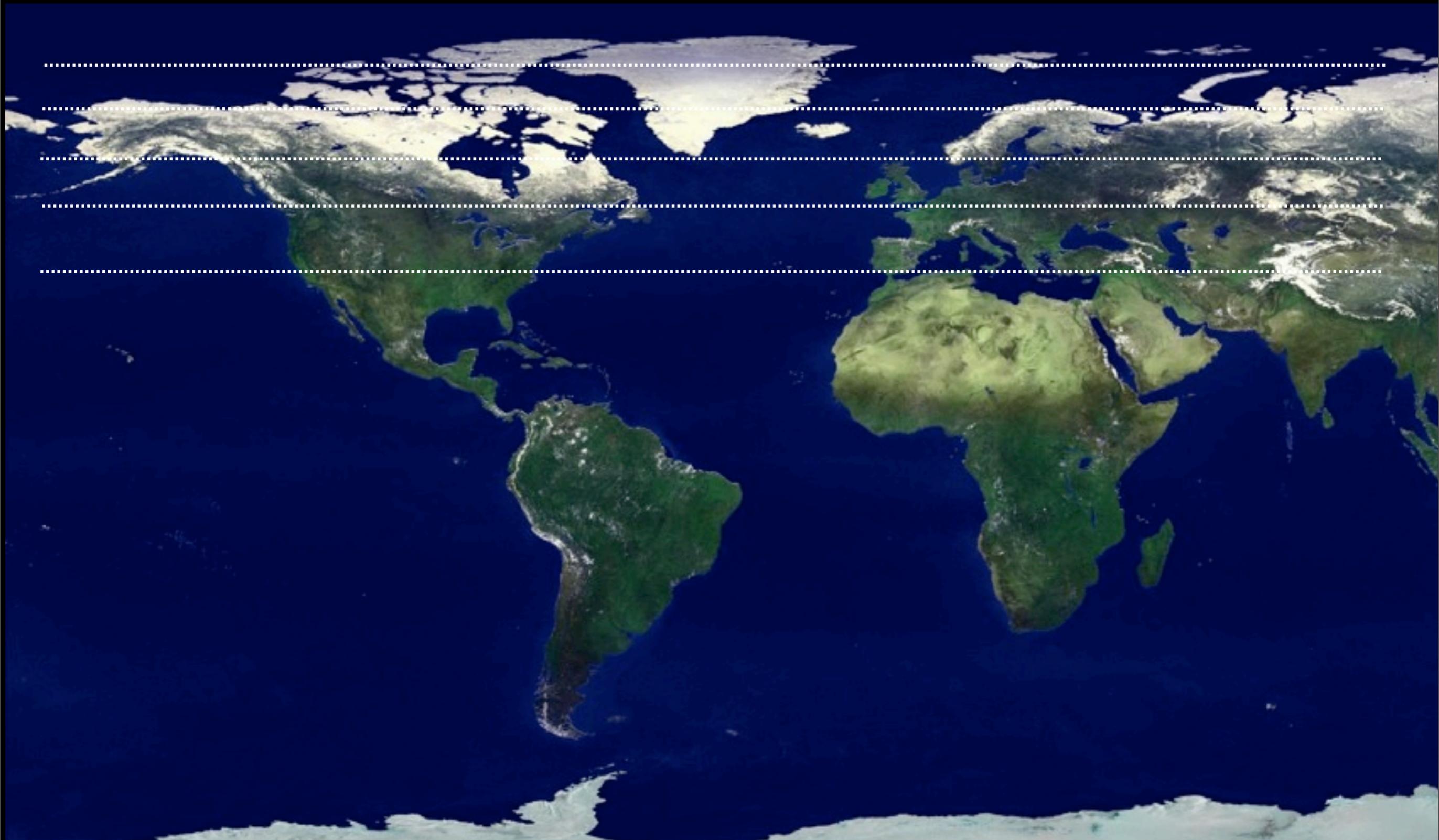


Professor Lars Vegard with this aurora-spectrograph

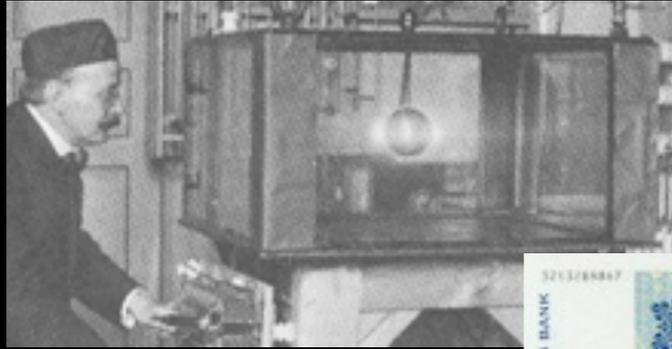
# Norway tailor-made for Aurora Science



# Where is Norway and Svalbard?



# Historic traditions



Long traditions within space research due to our location far north :

- Scientific observations of the aurora before 1900
- Birkeland's innovative experiment in 1896
- National solar observatory in 1957
- First rocket launch in 1962



# Solar Physics in Norway



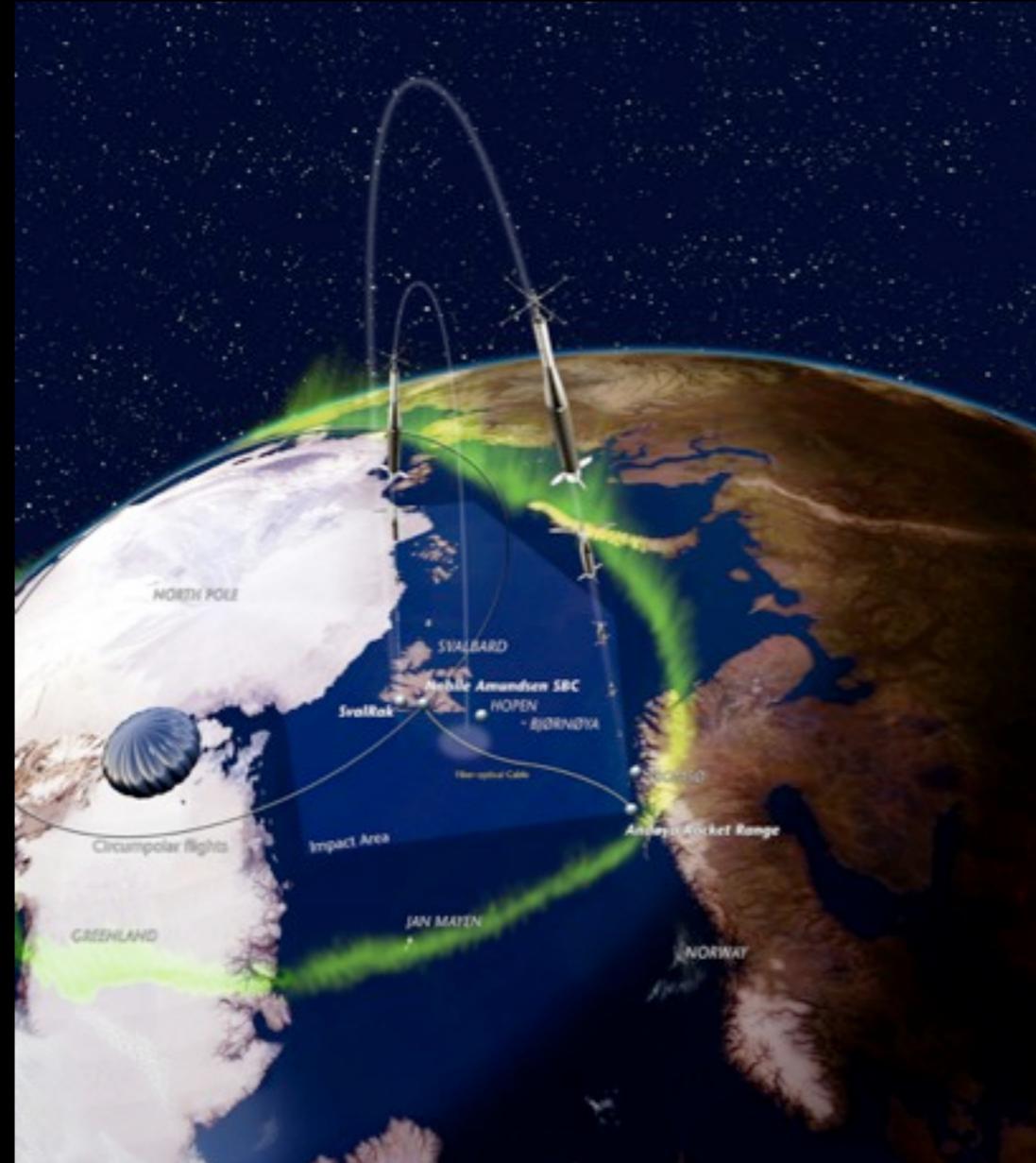
Institute of theoretical astrophysics was established by Professor Rosseland in 1934 and built with help from the Rockefeller Foundation.



The National Solar Observatory was opened in 1957. Provided satellite tracking for US Airforce in the 50s and 60s.

# The very start of space research. Andøya Rocket Range

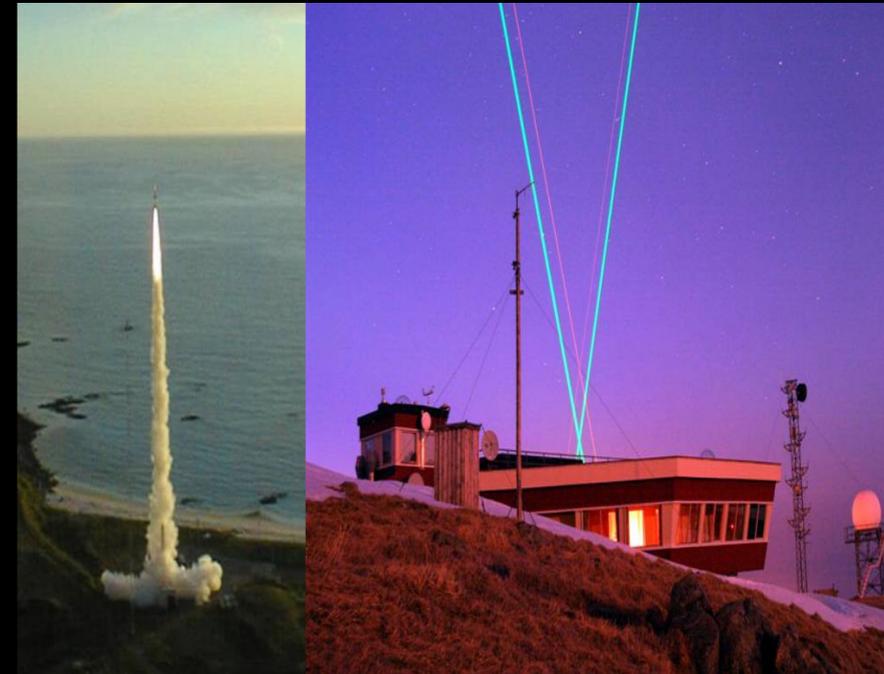
Ferdinand from Oksebåsen, Andøya 18 august 1962



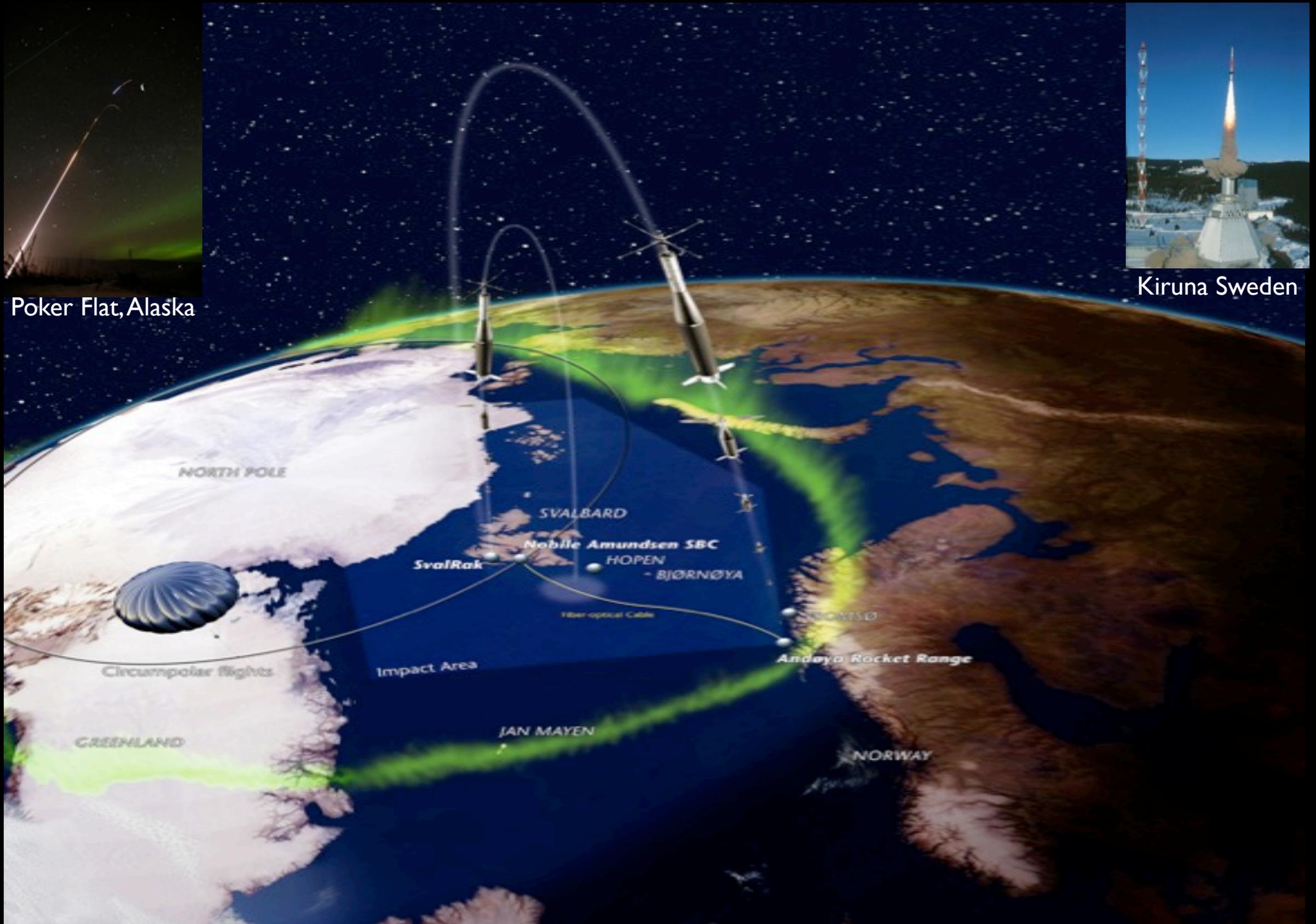
# Clean rooms - now and then!



# Andøya Rocket Range today



# Modern Science Infrastructure



# Kjell Henriksen Observatory



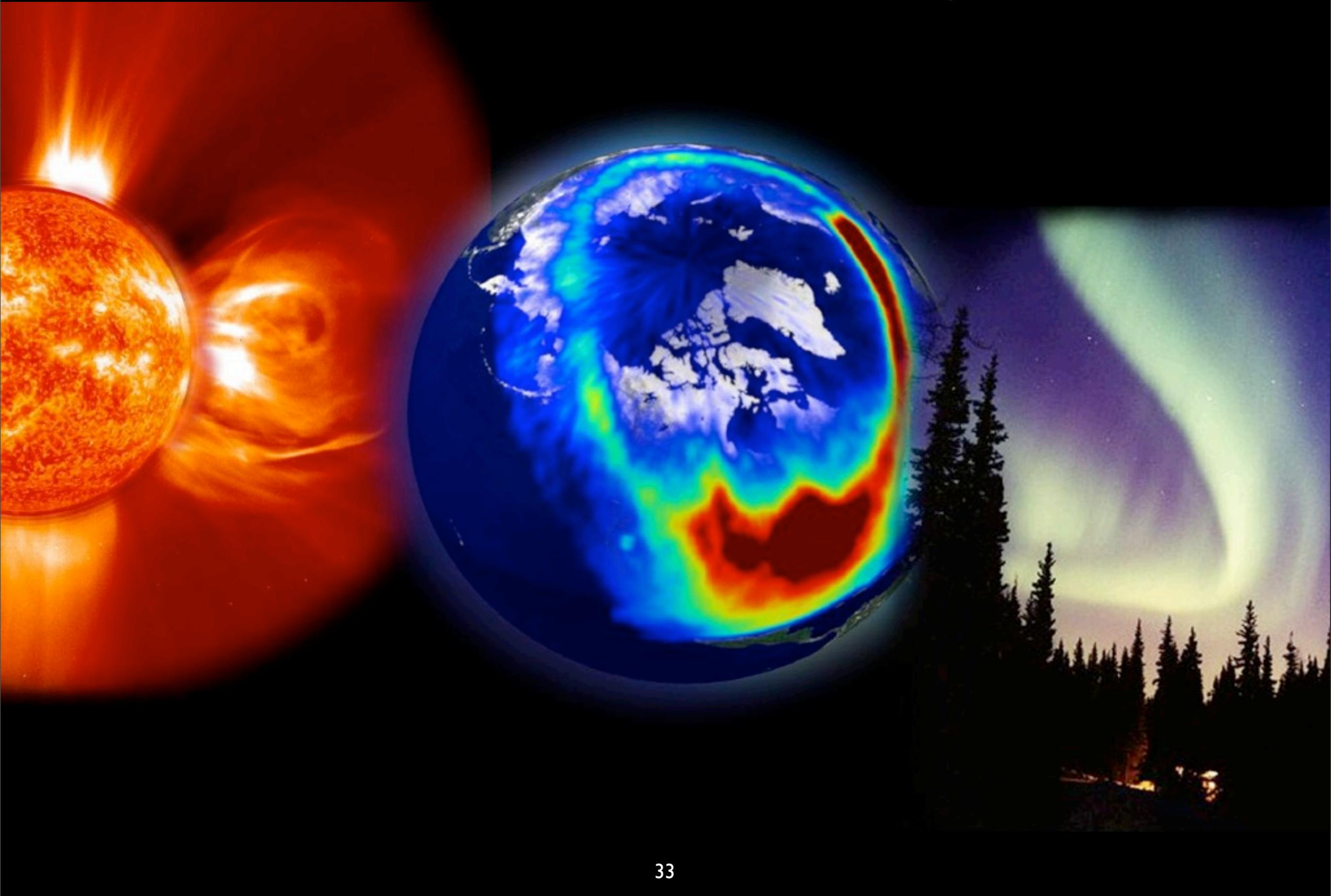
The Minister of Research and Higher education, Tora Aasland, officially opened the observatory, in minus 35 degrees Celsius

# EISCAT Svalbard



32 Meter dish

# The Sun - The Aurora Engine

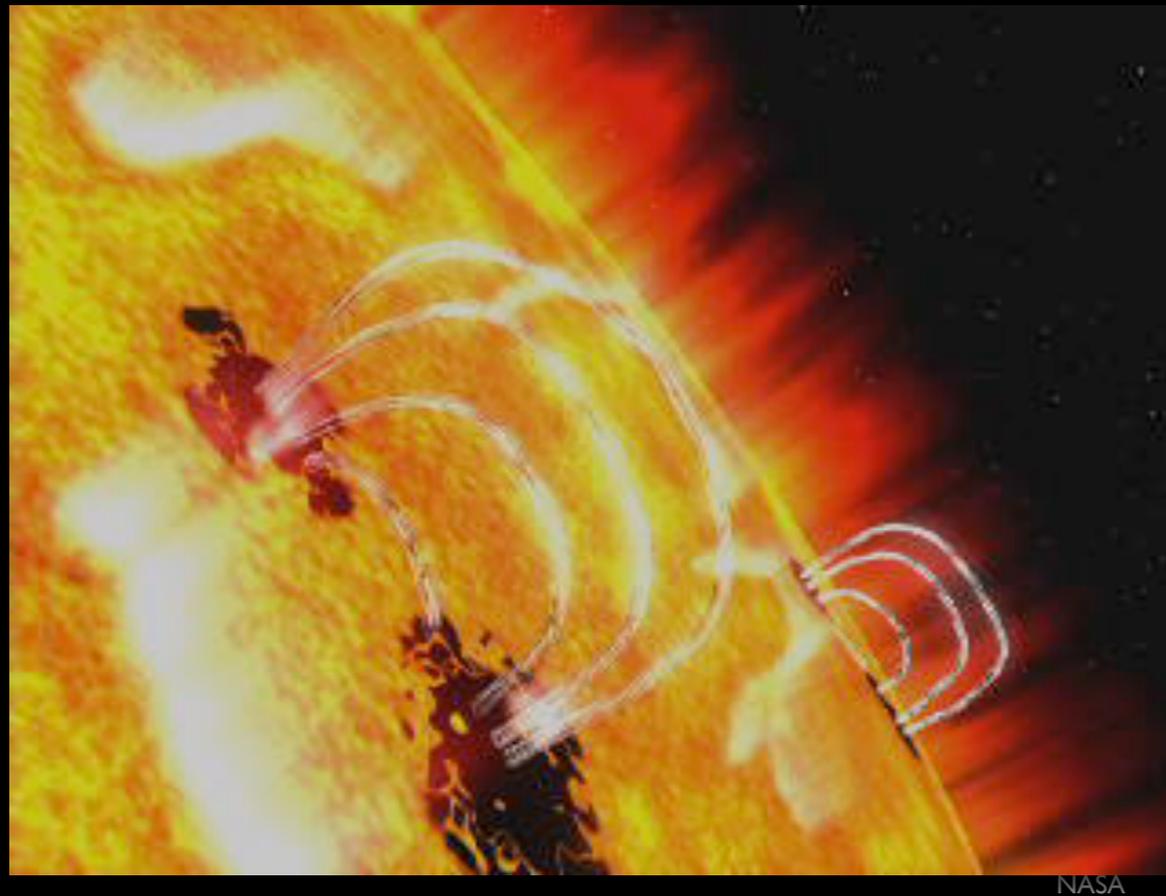


# SUNSPOTS

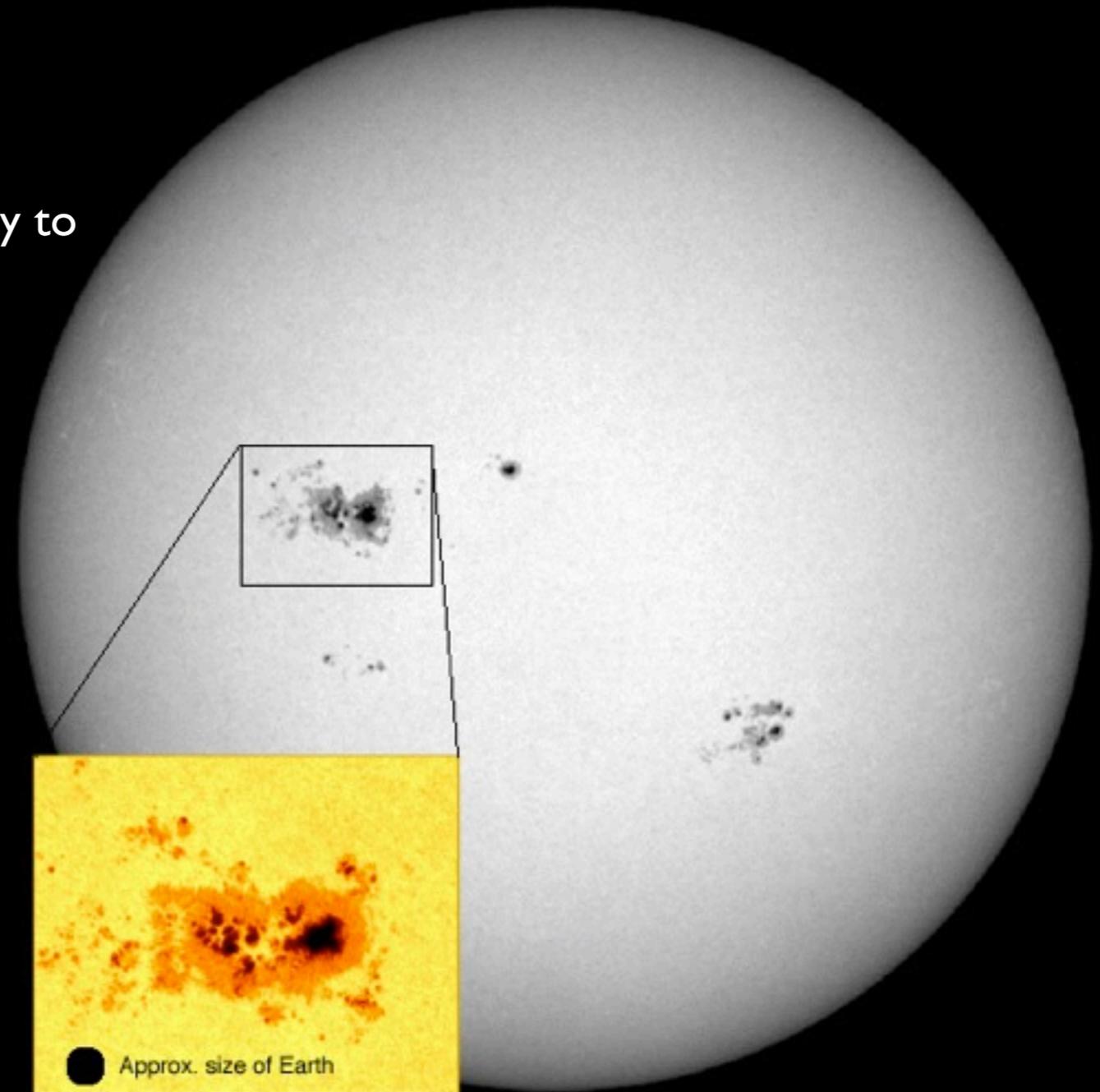
Dark features on the solar surface

Casued by strong magnetic fields emerging from the solar interior.

The strong magnetic fields blocks some of the energy to emerge from these regions.



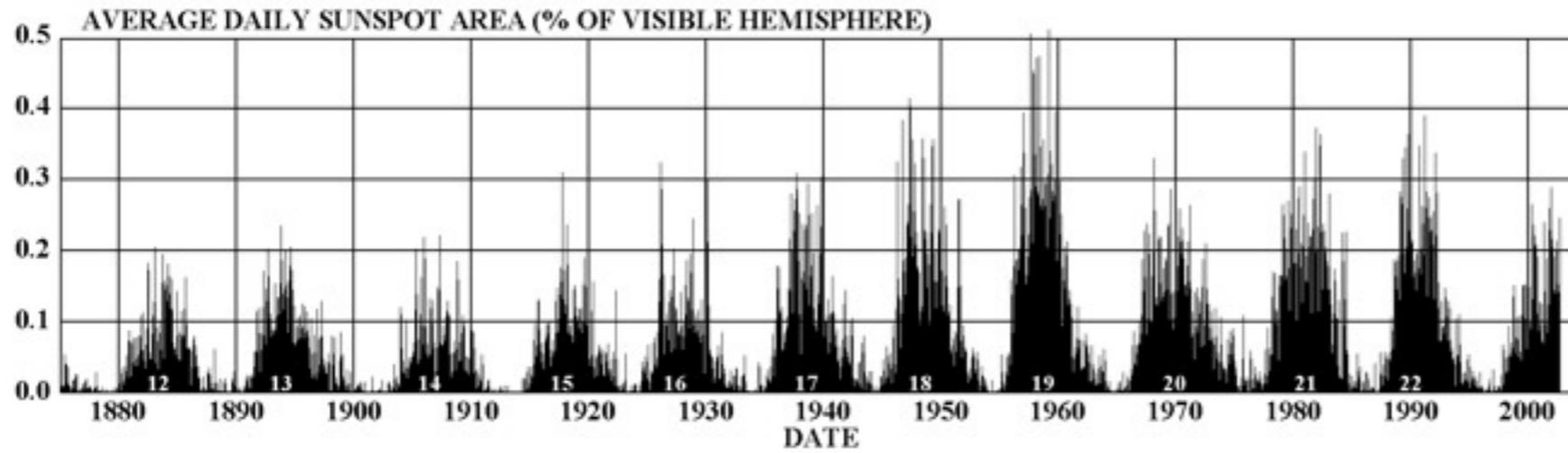
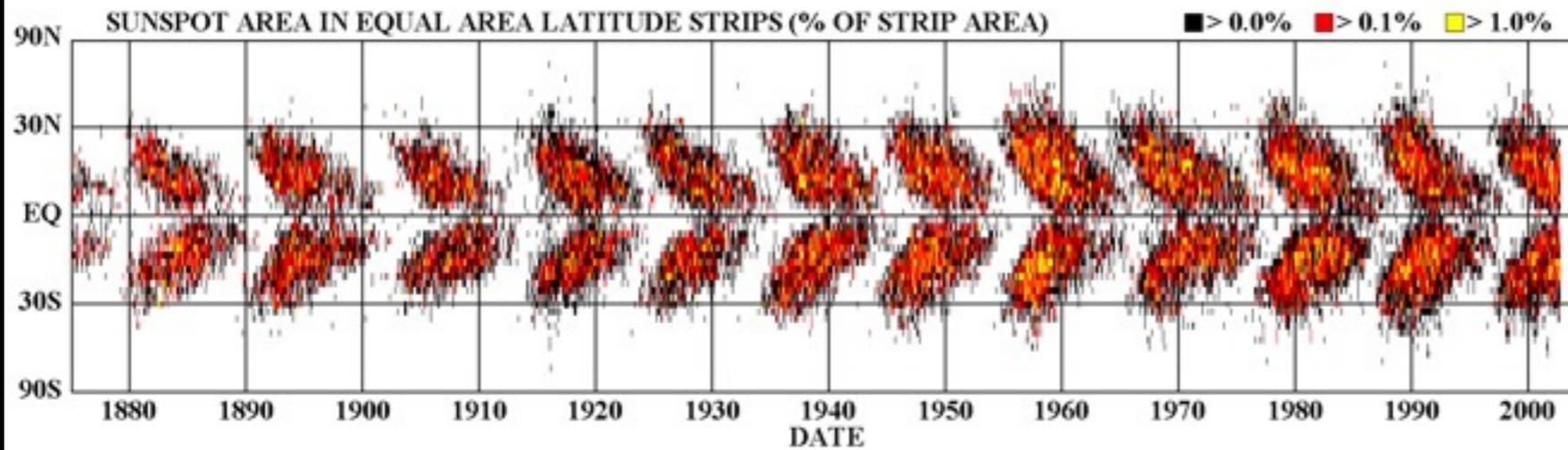
NASA



NASA/ESA/S. Hill

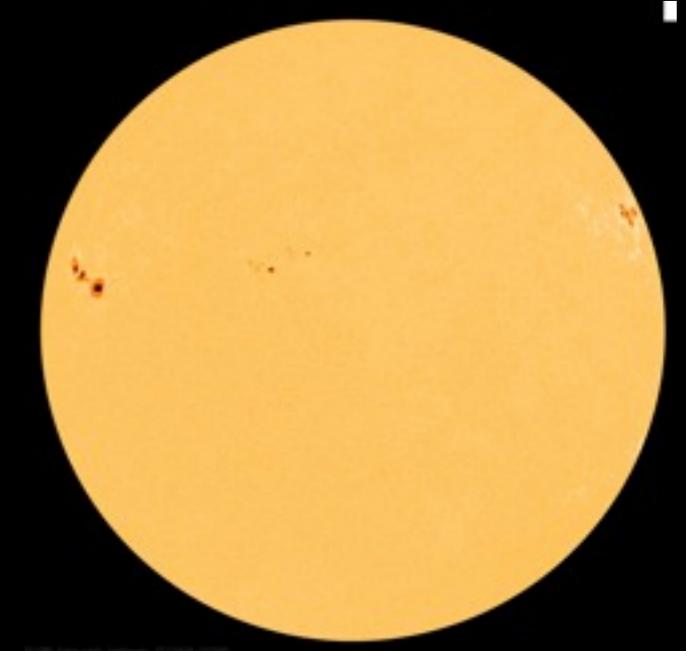
# Butterfly Diagram

## DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS



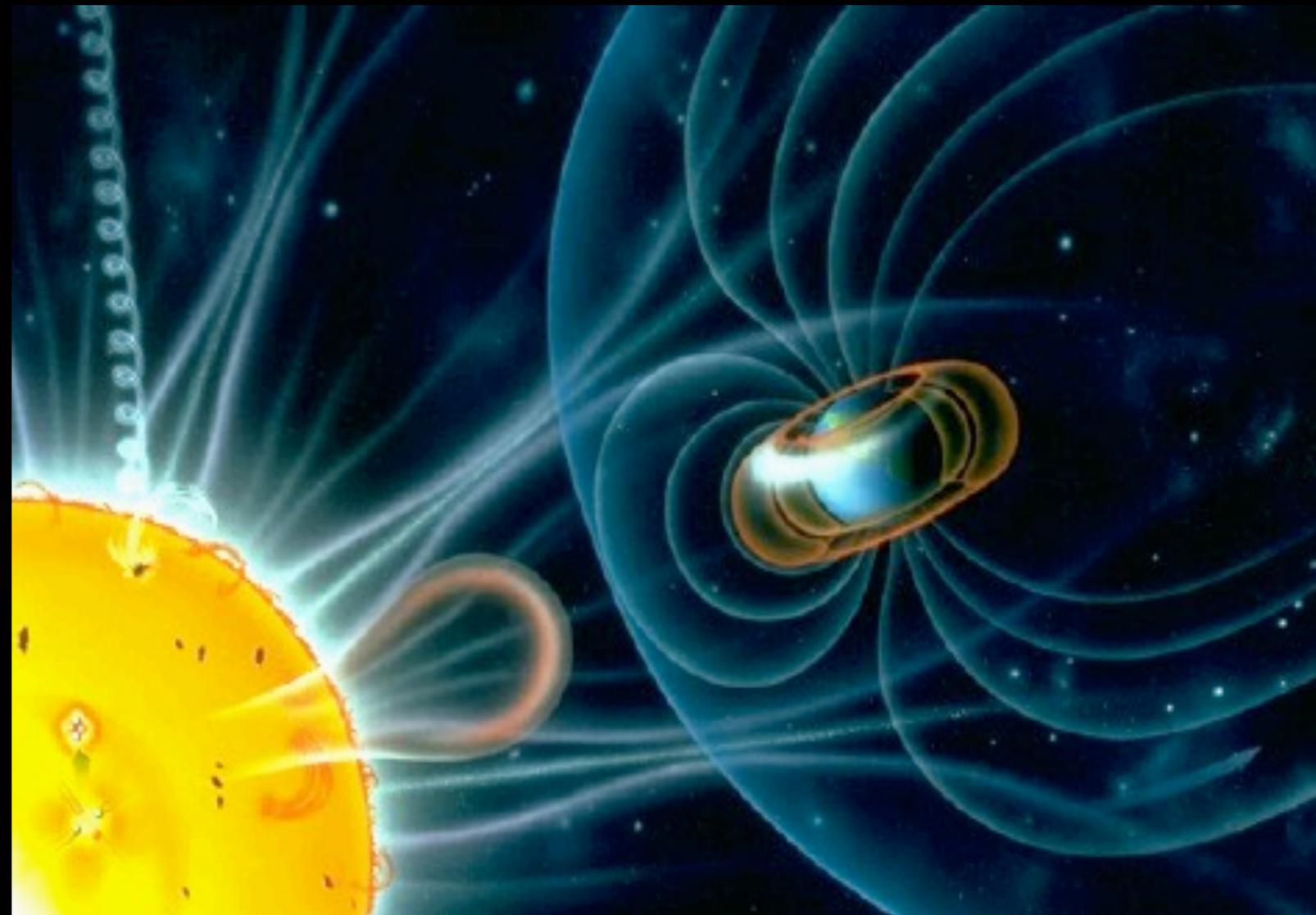
<http://science.msfc.nasa.gov/ssl/pad/solar/images/bfly.gif>

NASA/NSSTC/HATHAWAY 09/2002



# The Solar Wind also Creates Northern Lights

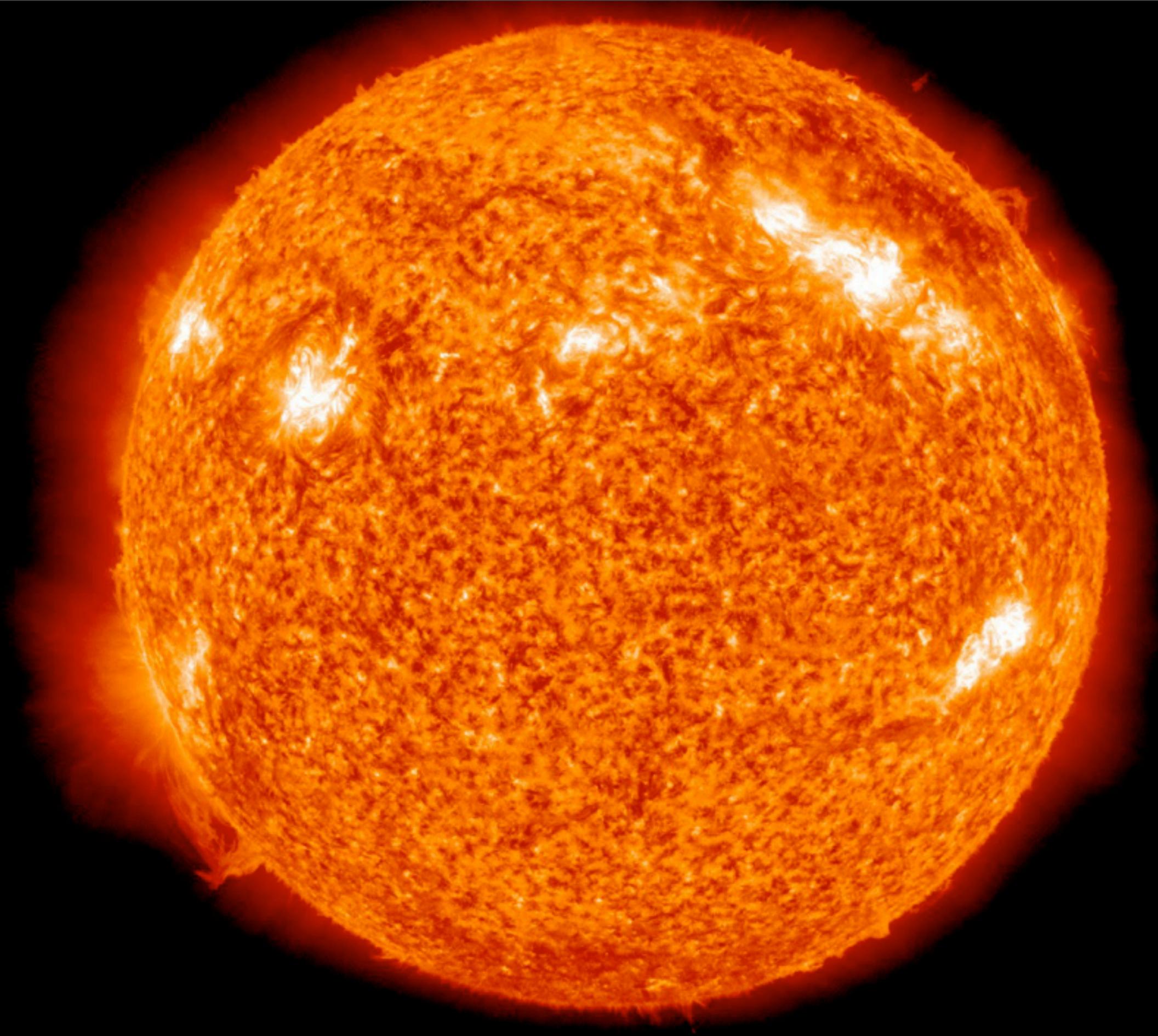
- A constant stream of particles flows from the Sun's corona, with a temperature of about a million degrees and with a velocity of about 1.5 million km/h.
- Gusts in the solar wind will buffet our magnetosphere and lead to a geomagnetic storm.





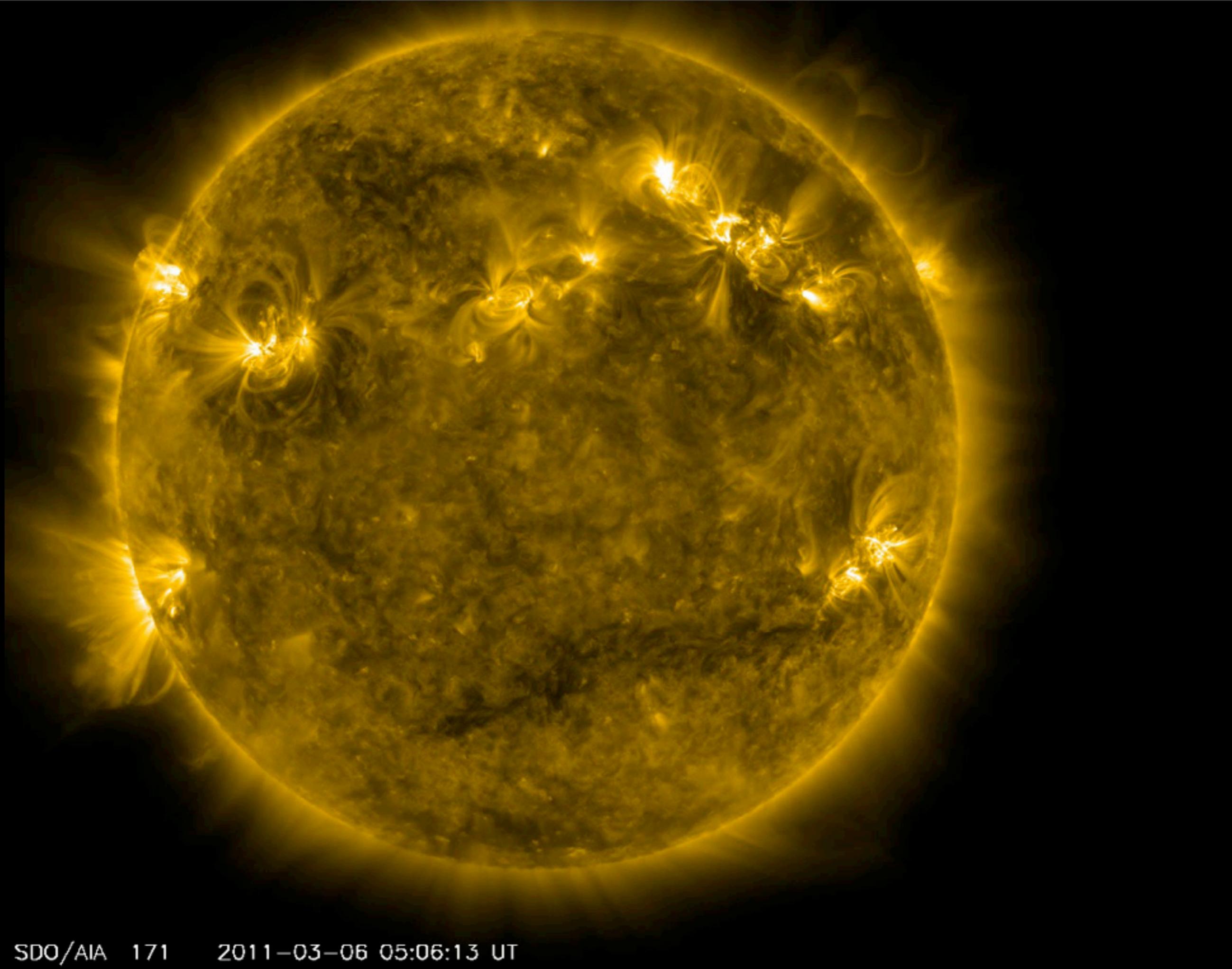
SDO/AIA 4500 2011-03-06 05:00:08 UT

torsdag 19. april 12



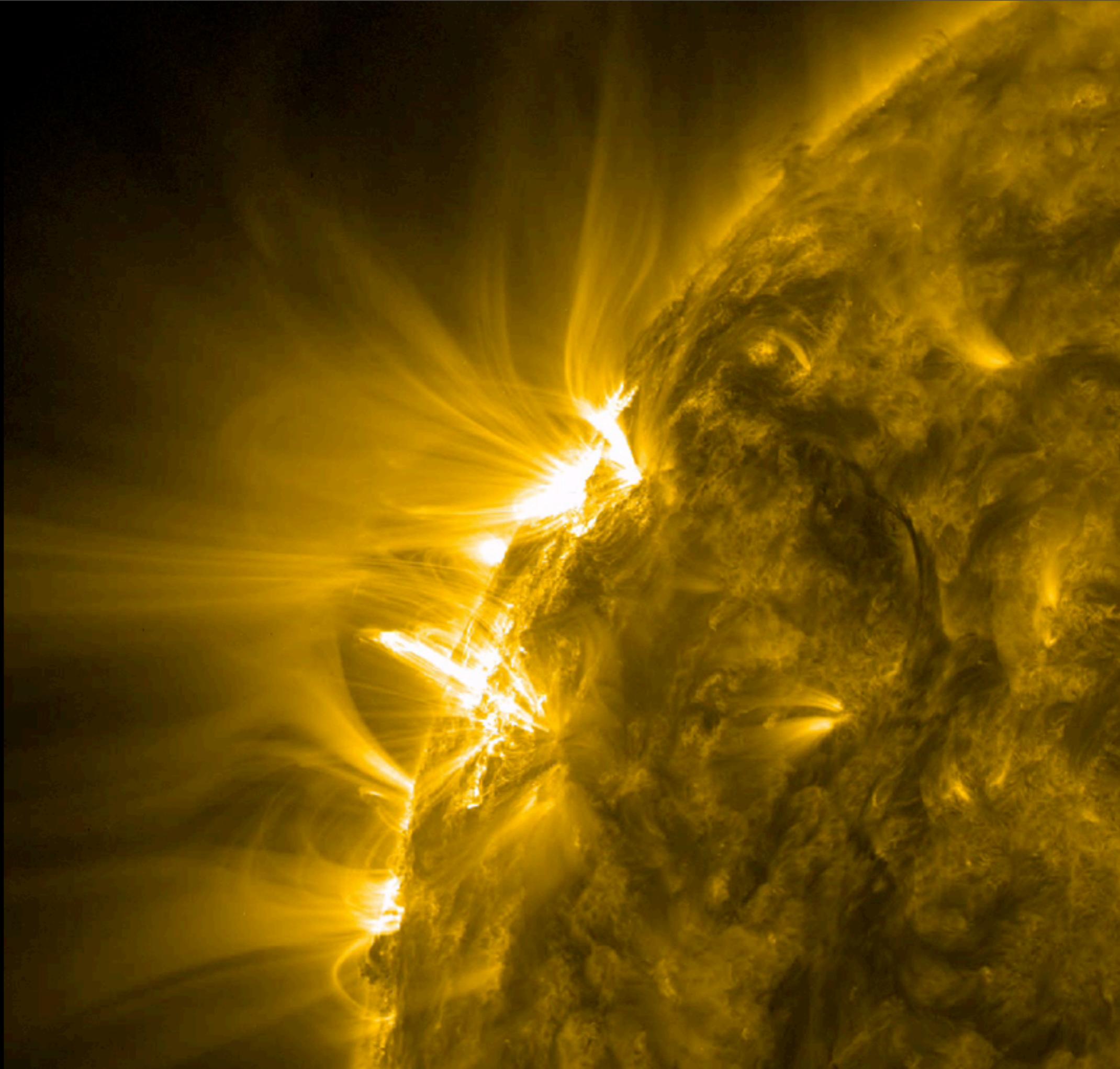
SDO/AIA 304 2011-03-06 05:06:09 UT

torsdag 19. april 12



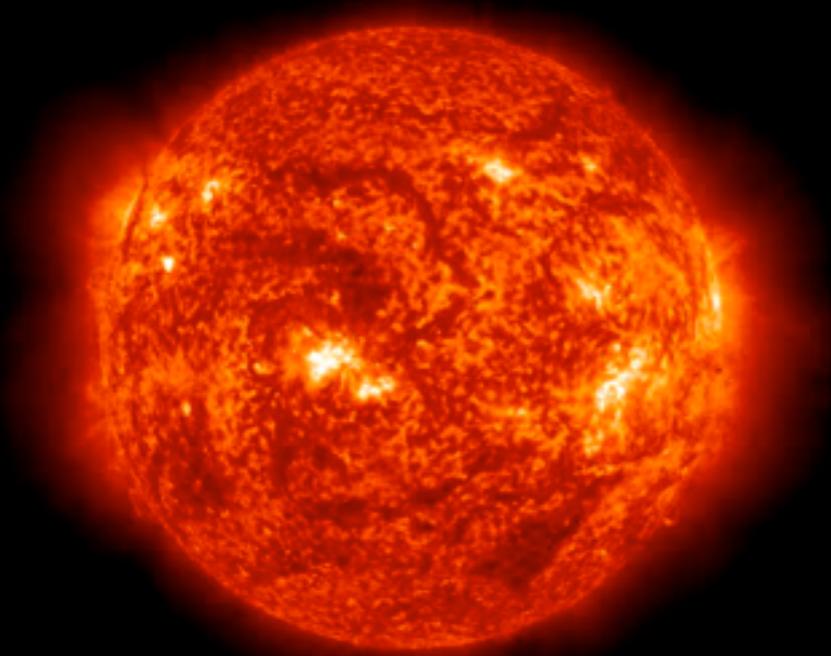
SDO/AIA 171 2011-03-06 05:06:13 UT

torsdag 19. april 12



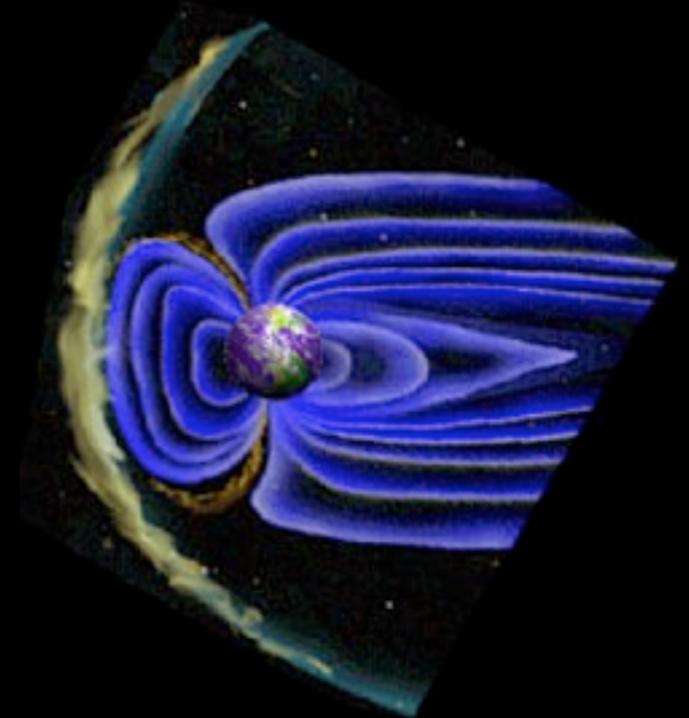
# The Sun-Earth Connected System

We live in the extended atmosphere of a variable star



## Varying

- **Radiation**
- **Solar Wind**
- **Energetic Particles**



2001 01/01 01:19

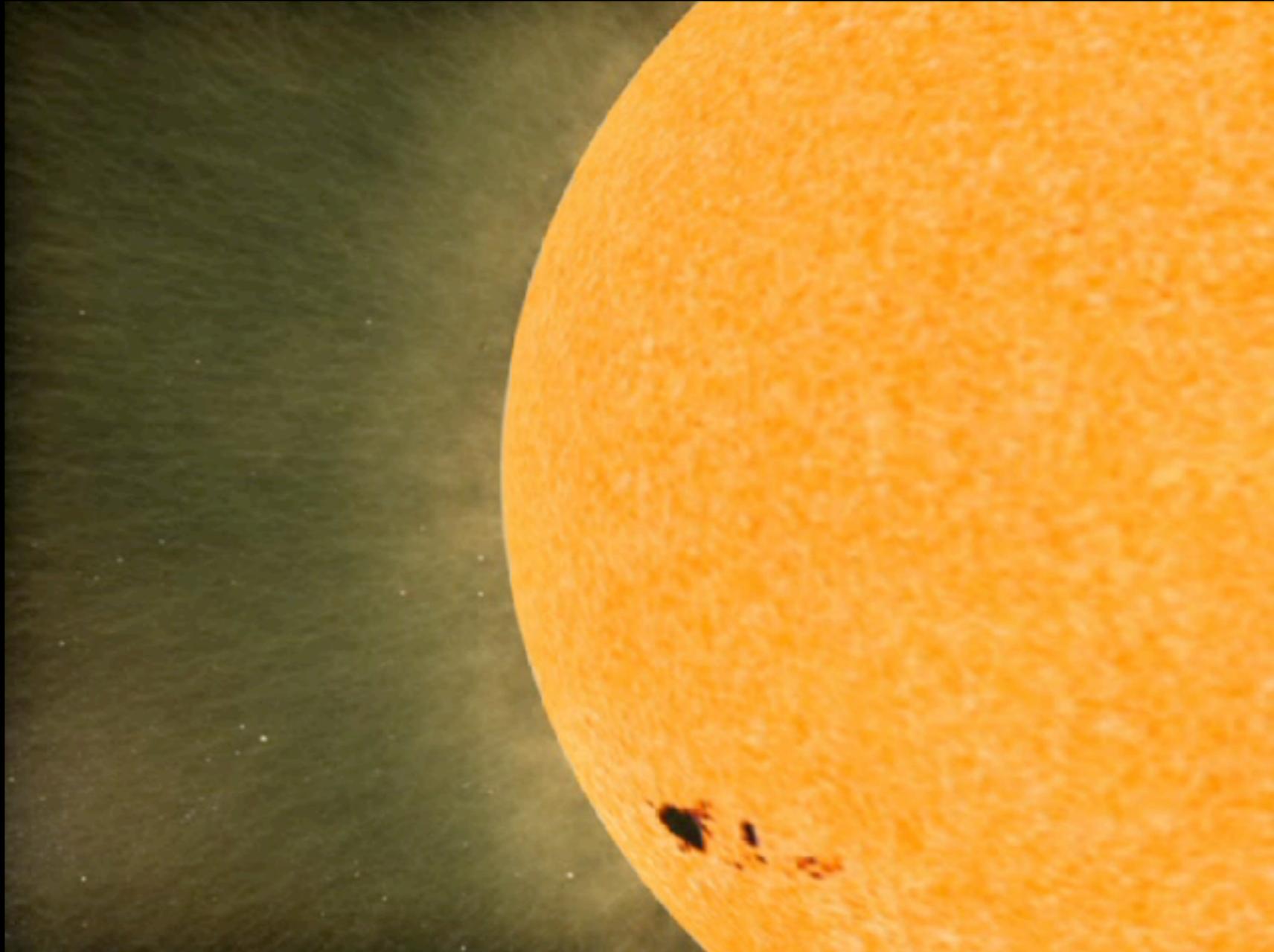
## Questions:

- How and why does the Sun vary?
- How does the Earth Respond?
- What are the impacts on humanity

# Space Weather



# What causes the Northern Lights



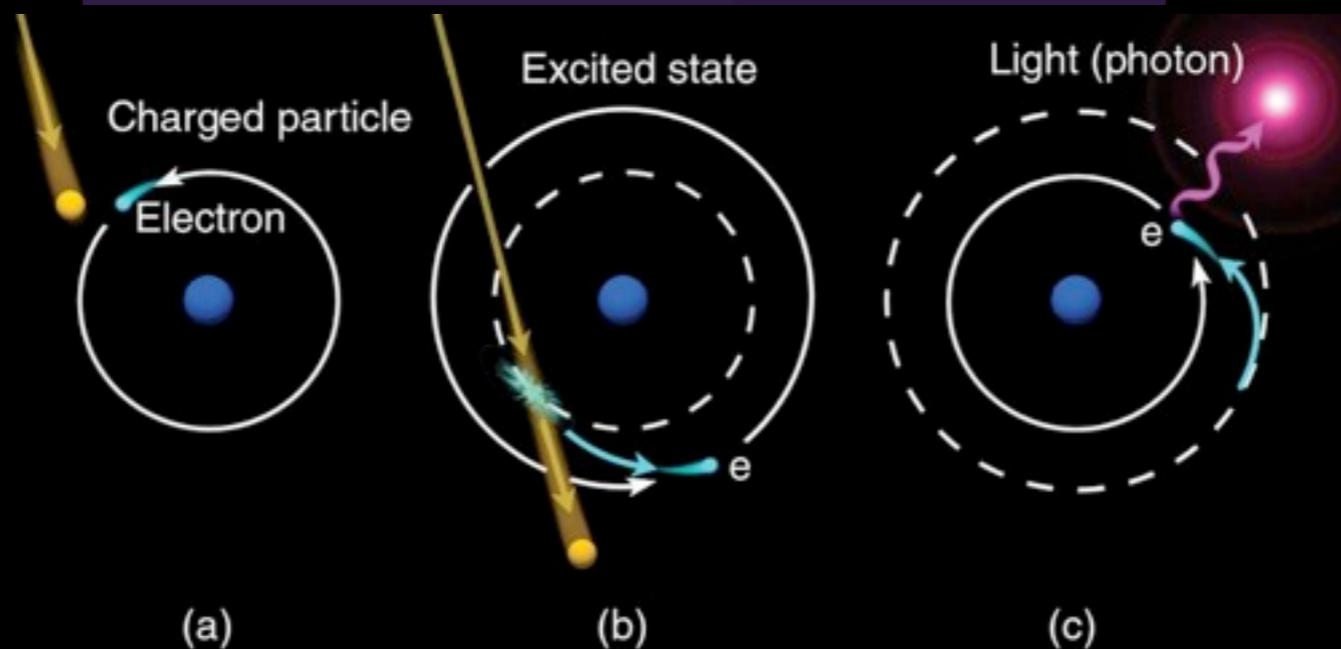
# What causes the Northern Lights



From the documentary «Hunting the Lights» - Hurtigruten (by P. Brekke) /Forskning.no

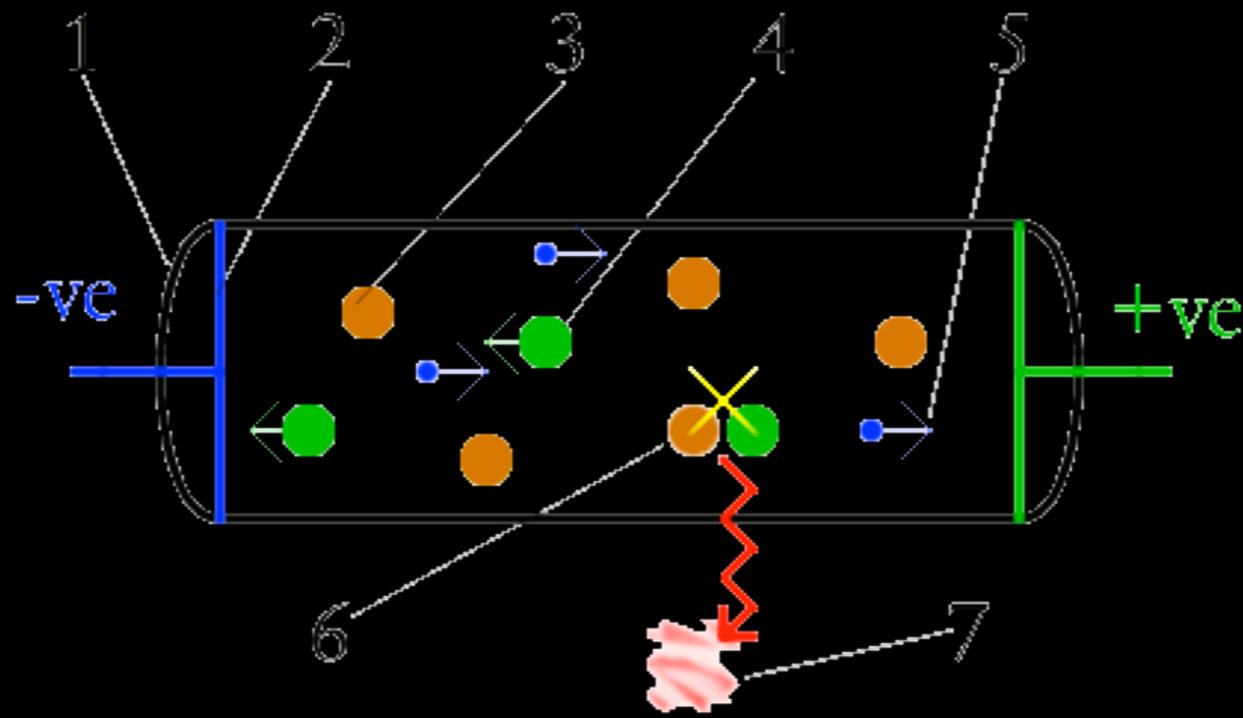
# The Colors of the Aurora

- The light from the Sun appears white but consist of all colors (e.g rainbow)
- The aurora light is composed of distinct colors that comes from certain gases in the Earths atmosphere.
- The colour composition of the aurora is the atmosphere's fingerprint.



# The aurora - A gigantic neon sign

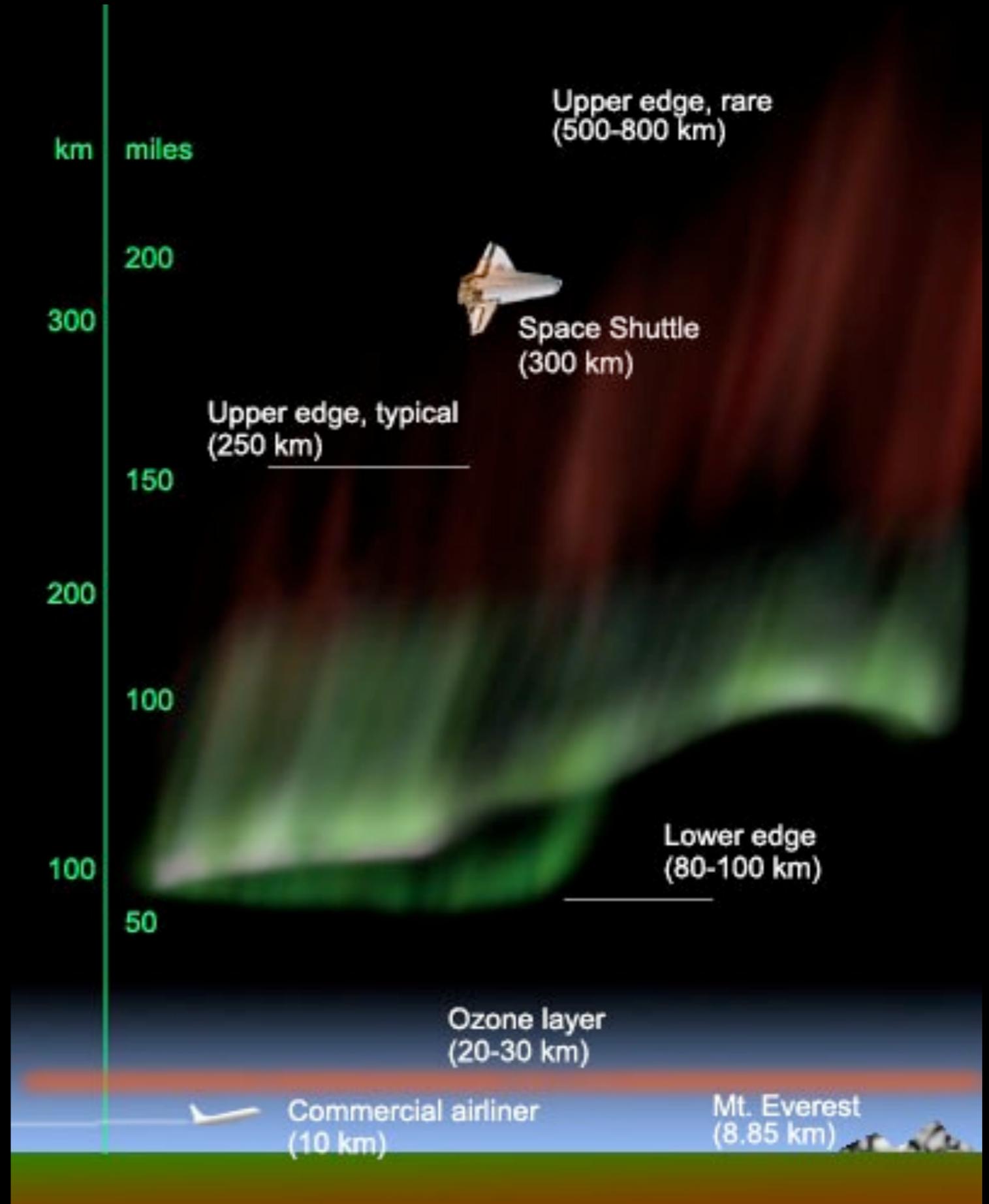
- Same effects as in a neon sign



© ExplainsTheUniverse.com 2008  
Some rights reserved.

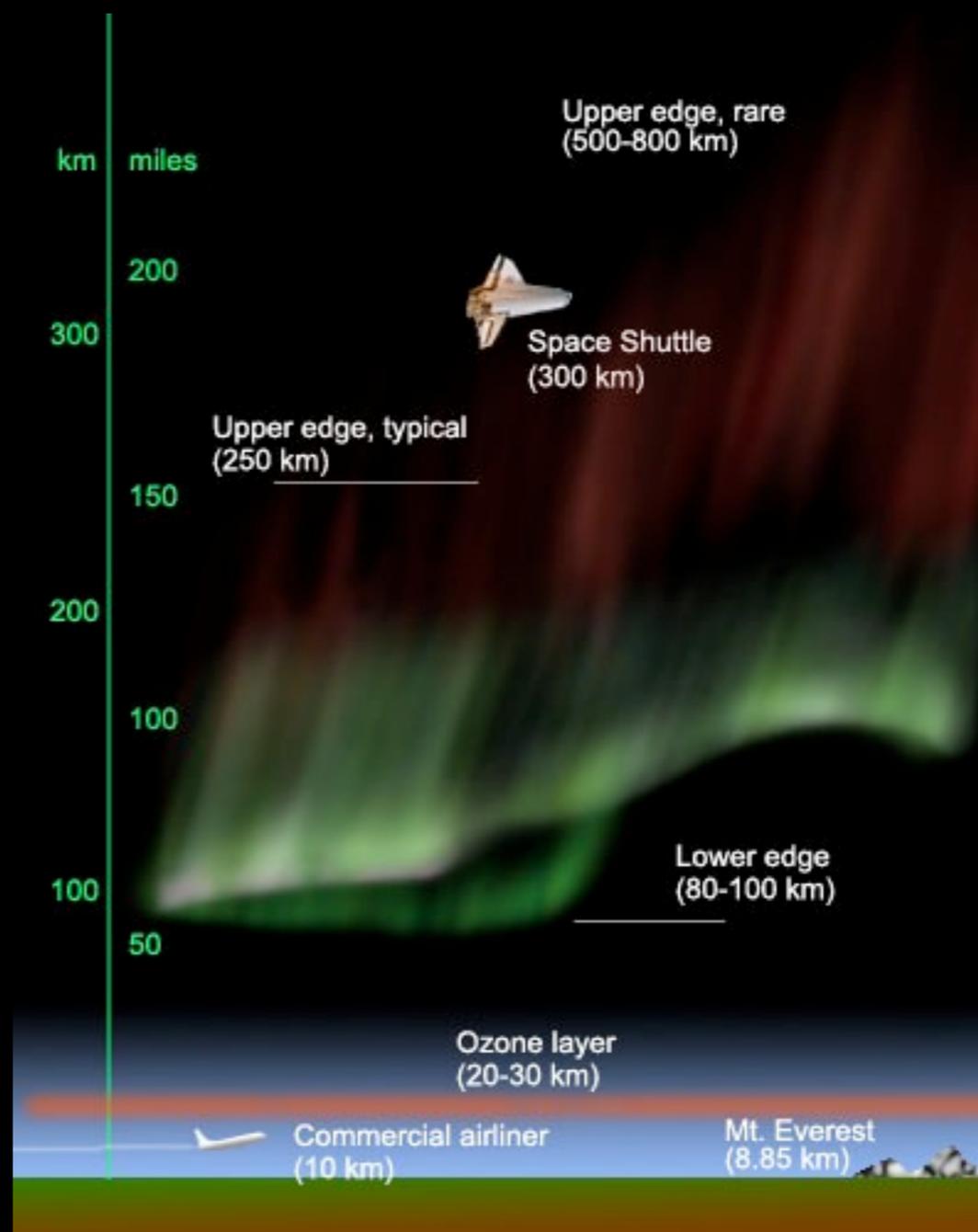
# The Height of the Aurora

- The Aurora extends from about 80 km to about 250 km and sometimes up to over 500
- Thus, the aurora is not a weather phenomenon



# Can you hear the Aurora?

Sound waves are pressure waves which travel about 340 metres per second in air at ground level. At altitudes between 80 and 500 kilometres, where the aurora occurs, we have a near-vacuum, so it is not possible for sound waves to propagate.



# Can you hear the Aurora?



The sound presented here, however, is not directly from the northern lights, but from a magnetometer hooked up to an audio recorder at Andøya Rocket Range. The variation in sound is the temporary variation in the magnetic field caused by the incoming solar particles.

Fredrik Broms

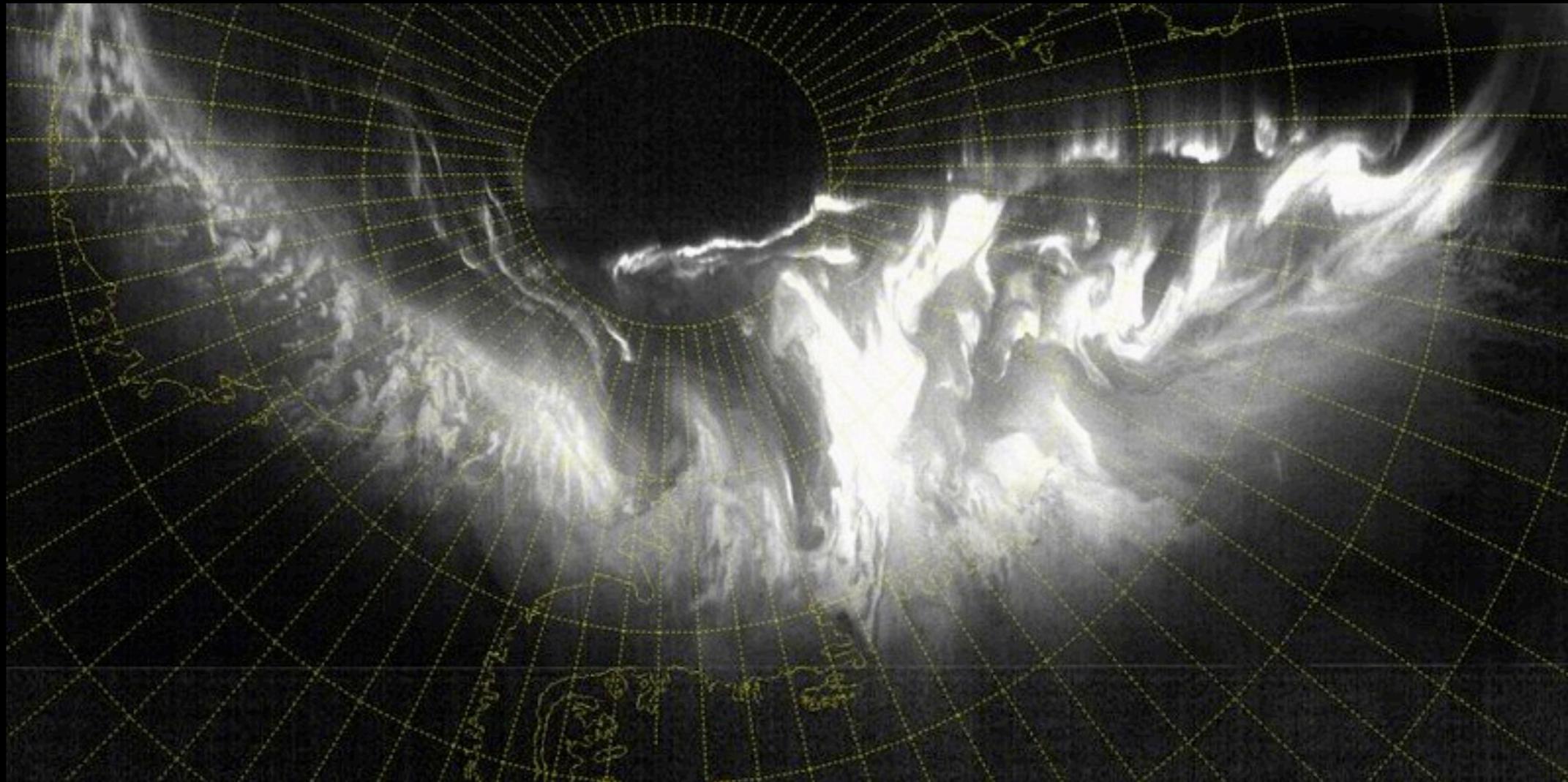
# Auroras from ISS



# Auroras from ISS



# Aurora from satellites

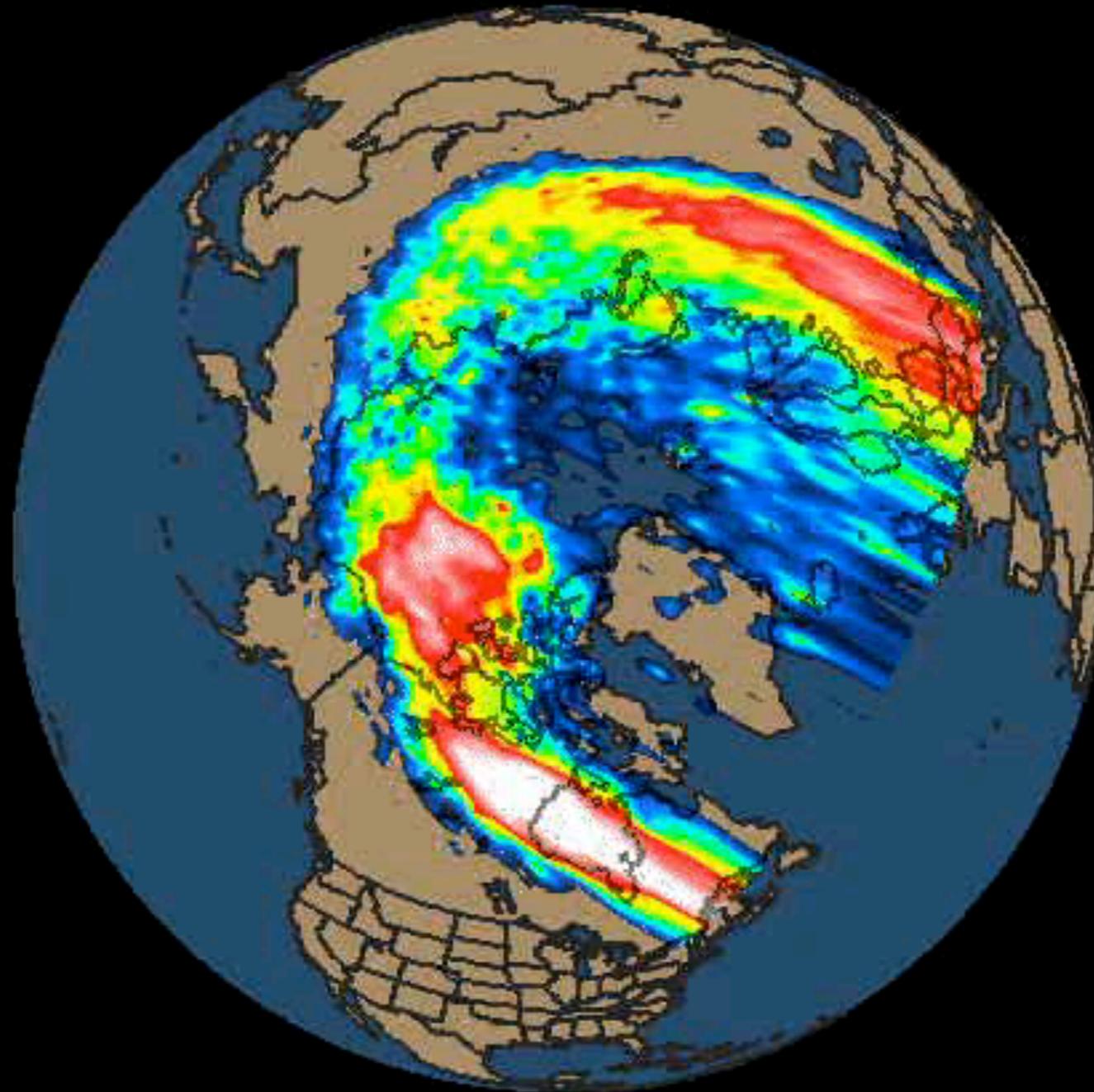


# Aurora from satellites



IMAGE-FUV-2000/07/15-14:00:39.U1

# Aurora from satellites



**15 JUL 2000, 19:06**

NASA

# Aurora on Saturn

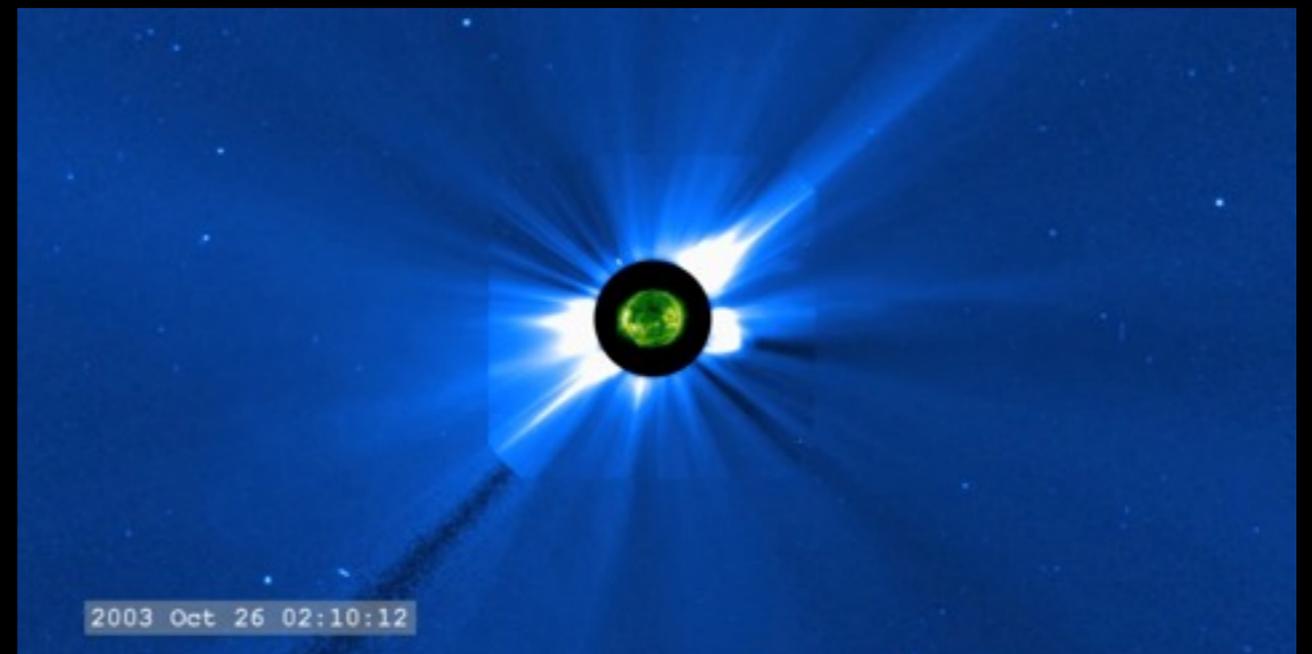
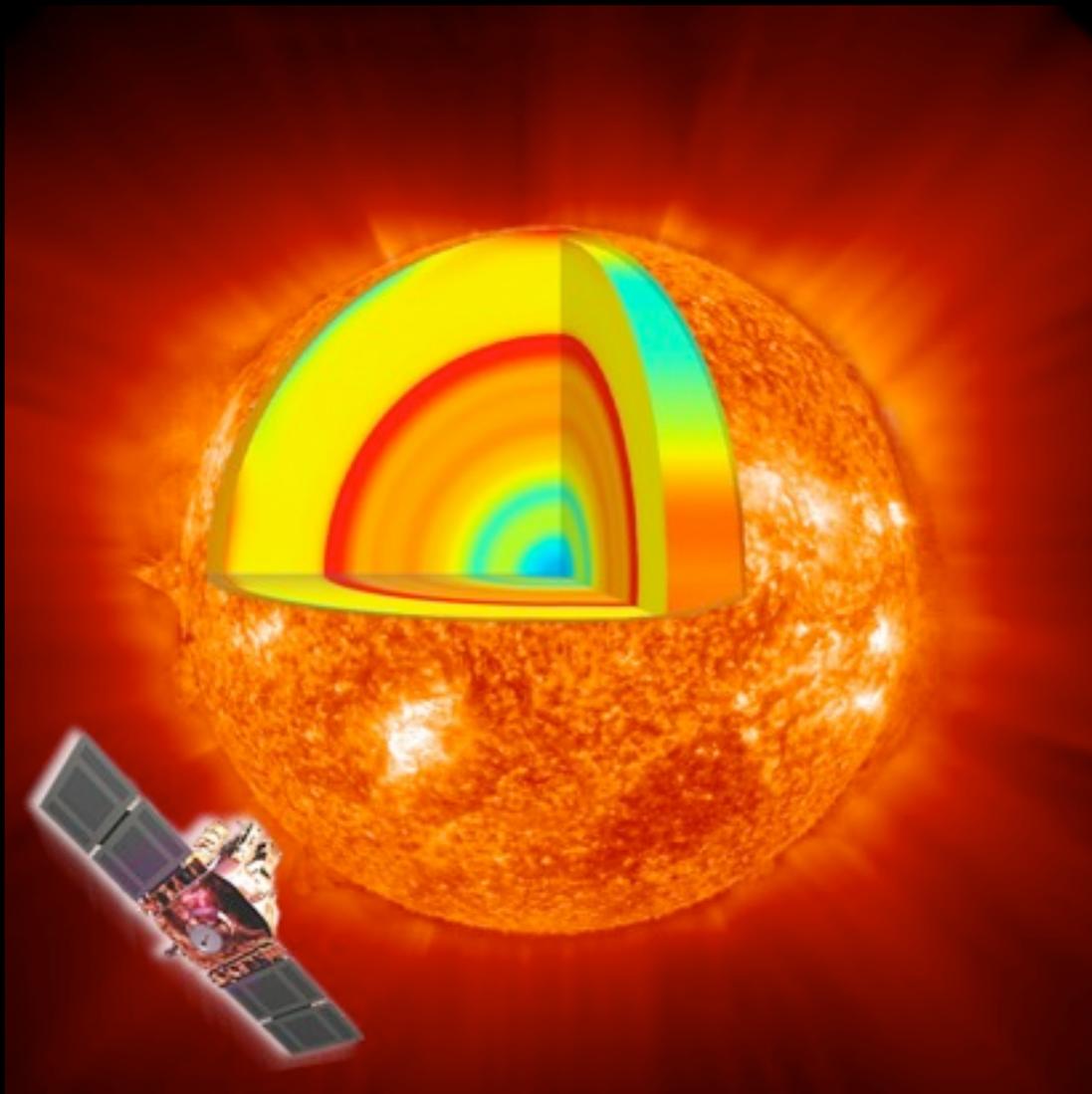


(Actual relative sizes)

# Aurora forecast: Monitoring the Sun

<http://soho.nascom.nasa.gov/data/realtime-images.html>

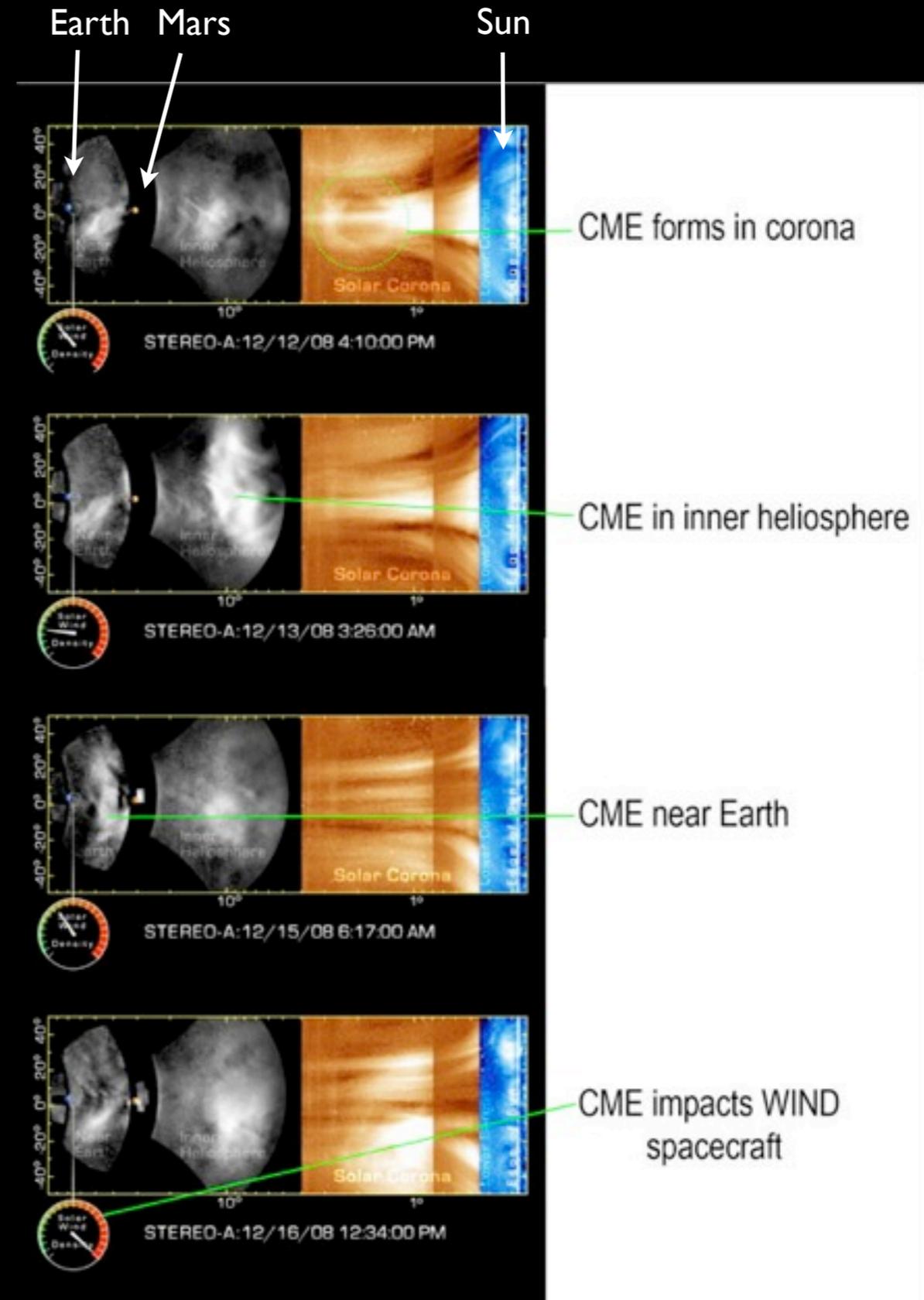
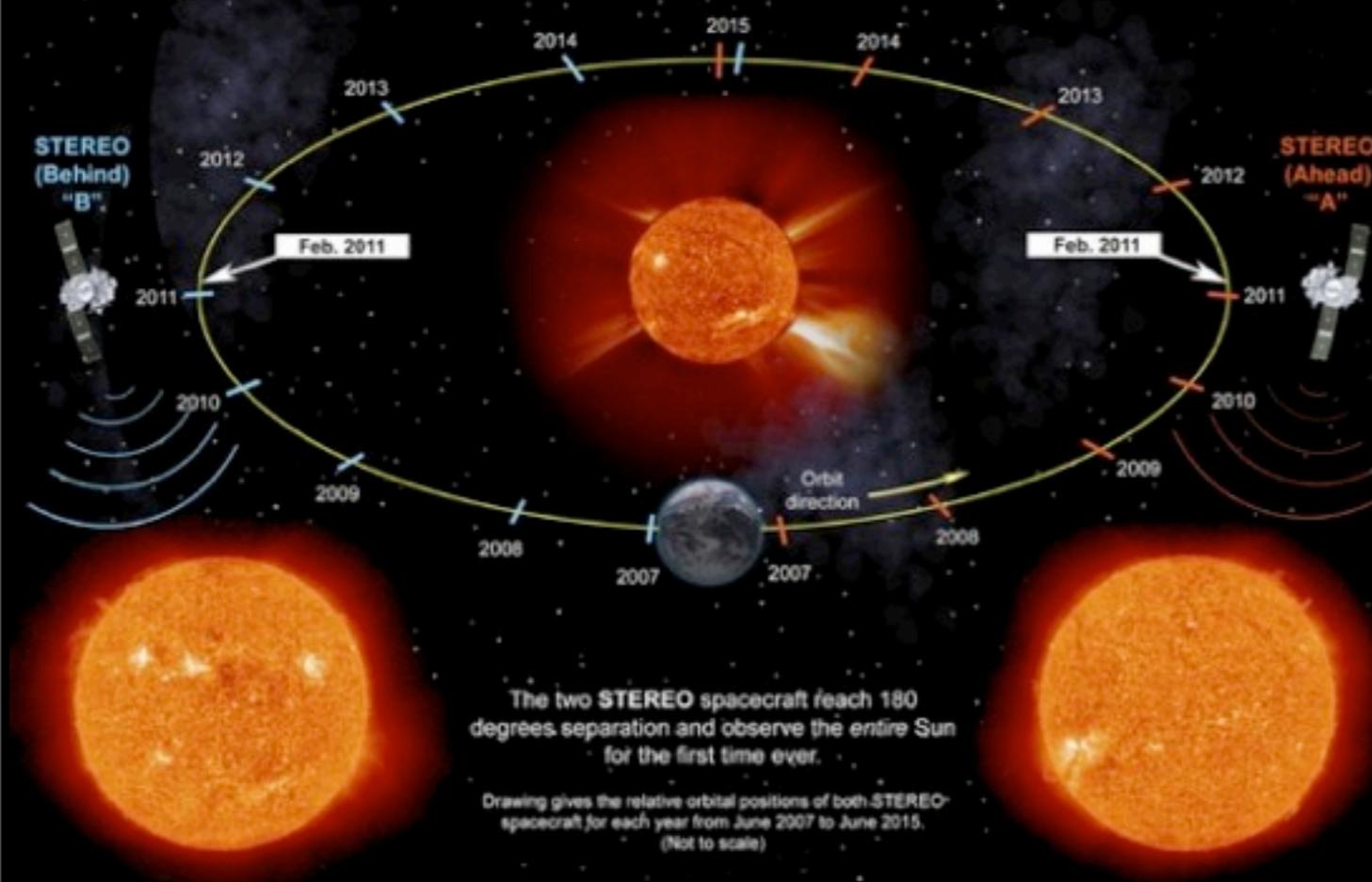
- SOHO can detect flares on the visible part of the Sun and also has a coronagraph that can detect CMEs. In particular it can see CMEs that are Earth directed.



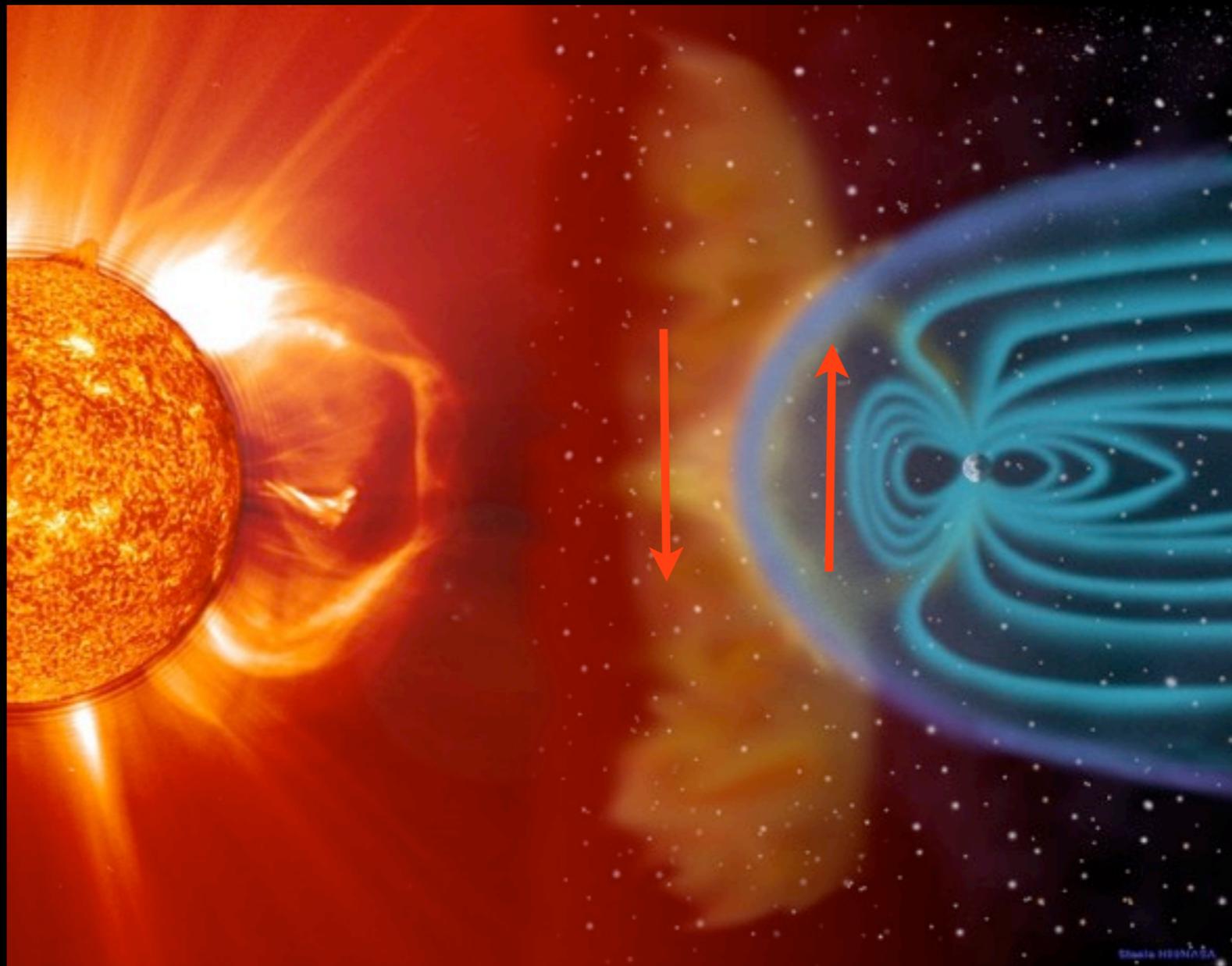
# STEREO

- Two satellites now observing the Sun from each «side». Thus, it can view the Earth directed CMEs from they leave the Sun - travelling towards the Earth. This gives a unique possibility to measure the speed and structure of the CME on its way.

## NASA's STEREO Sees the Entire Sun



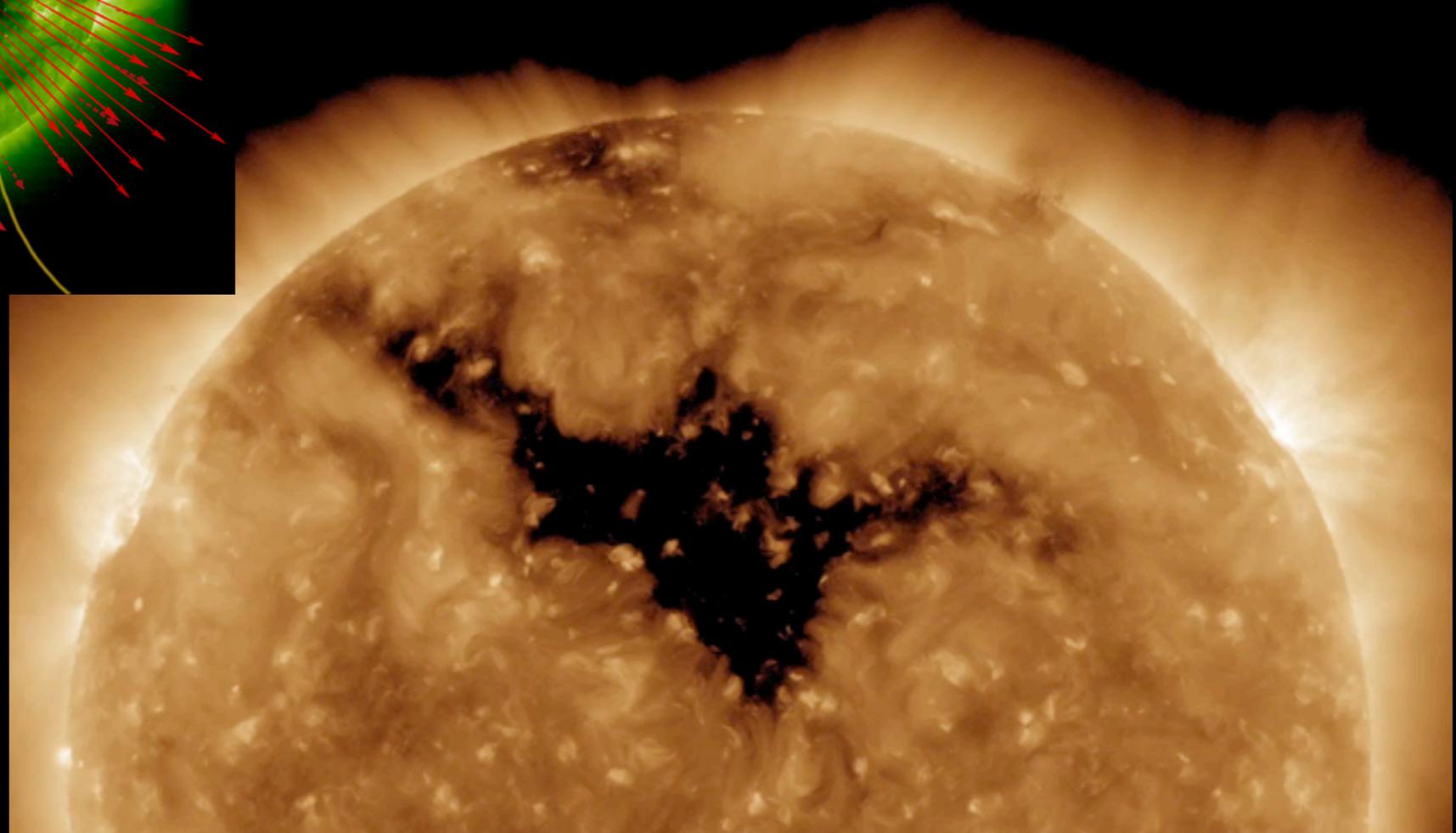
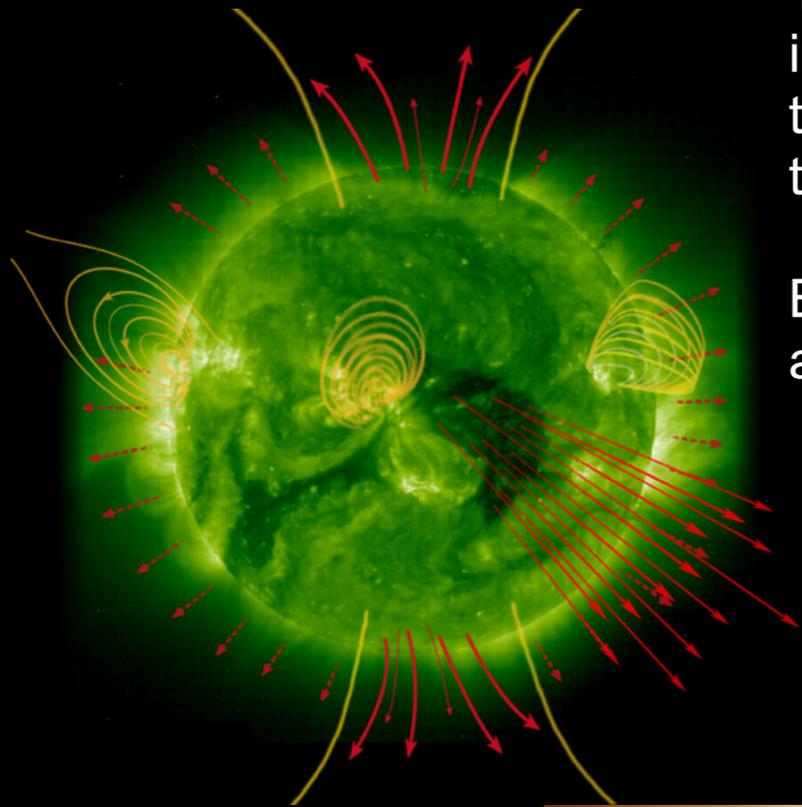
# How effective wil the storm be?



# Predicting Auroras - Coronal Holes

The fastest solar wind originates from the dark areas on the image, called coronal holes. Such holes often occur close to the polar regions, but can sometimes also be observed close to the equator.

By tracking coronal holes one can provide several days advanced forecasts



# Space weather warnings

[www.spaceweather.com](http://www.spaceweather.com)

The screenshot shows the homepage of spaceweather.com. The top navigation bar includes links for AURORA ALERTS, SUBMIT YOUR PHOTOS!, 3D SUN, CONTACT US, SUBSCRIBE, FLYBYS, and SCIENCE@NASA. The main content is divided into several sections:

- Current Conditions:** Displays solar wind speed (414.7 km/sec), density (0.3 protons/cm<sup>3</sup>), and X-ray Solar Flares (C1 0311 UT Nov28).
- What's up in space:** Features a "Meteorite!" advertisement and news articles about the Mars rover Curiosity and a radiation storm update.
- Sunspot Activity:** Shows a sunspot number of 123 and a "Spotless Days" counter.
- Solar Activity Forecast:** A large circular diagram showing the sun's surface with various activity levels and a color-coded forecast track.

Additional elements include a search bar, a "Subscribe to SpaceweatherNews" button, and several promotional banners for "Solar Telescope" and "Averted Imagination Astrophotography".

# The aurora over North-America

<http://www.gedds.alaska.edu/AuroraForecast/ShortTerm.asp>



## Geophysical Institute

HOME RESEARCH PEOPLE FACILITIES STUDENTS ADMIN

BUSINESS OFFICE DIRECTOR'S OFFICE HUMAN RESOURCES INFORMATION OFFICE OPERATIONS OFFICE COMPUTER RESOURCES DIGITAL DESIGN ELECTRONICS SHOP MACHINE SHOP MATHER LIBRARY PROPOSAL OFFICE

Advanced Search UNIVERSITY OF ALASKA FAIRBANKS UAF EMPLOYMENT FEEDBACK INTERNAL GI

Current view: North America



**Please Note:** The short term prediction presented here is based on the Planetary K (Kp) prediction of the [Costello Geomagnetic Activity Index model](#). You can find the actual Kp predictions [here](#), and more information on the Costello model [here](#).

Time of prediction: Monday, October 18, 2010 19:30 GMT\*  
Predicted Kp: 2.67  
Lead-time for prediction: 66.2 minutes

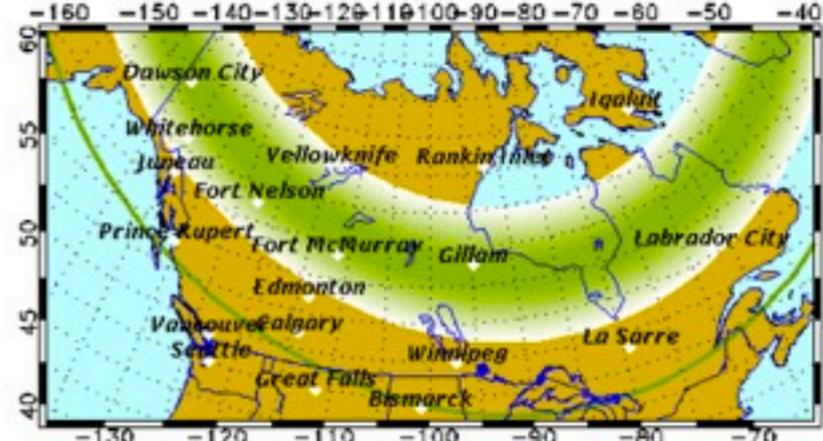
**Forecast:** Auroral activity will be moderate. Weather permitting, moderate displays will be visible overhead from Inuvik, Yellowknife, Rankin, and Iqaluit to as far south as Whitehorse, Ft. McMurray, James Bay and visible low on the horizon as far south as Prince Rupert, Calgary, Minot, Bemidji, Stevens Point, Traverse City and Quebec City, Canada.

\* Alaska Daylight Time (AKDT) is 8 hours behind Greenwich Mean Time (GMT) or Universal Time (UT).  
Alaska Standard Time (AKST) is 9 hours behind GMT or UT.

[Click here to return to the Geophysical Institute Auroral Forecast page](#)

### Short Term Aurora Forecast for Monday, October 18, 2010 20:36:15 GMT

**MODERATE Activity**



# Aurora forecaster in Norway

<http://www.storm.no/nordlys/>



## VÆRET

I samarbeid med 

Hvordan er været .

SØK

### Aurora Borealis - forecast for 10pm tonight

### Forecast for tonight - updated 11:00

Auroral activity will be quiet. Quiet displays will be visible directly overhead in northern Iceland and Norway, and visible low on the horizon as far south as Rovaniemi, Finland and Mo i Rana, Norway.

### What is really forecasted here?

Information about where the aurora will be located in the near future and from where one could observe it. The forecast is based on observations of solar and geophysical disturbances - what has happened on the Sun and what we expect will happen the next few days.

Read more about aurora borealis: [www.northern-lights.no](http://www.northern-lights.no)

Samarbeidspartnere: [Norsk Romsenter](#) [UNIS](#) [University of Alaska](#)

Basert på data fra: [NASA/NOAA/SEC](#)

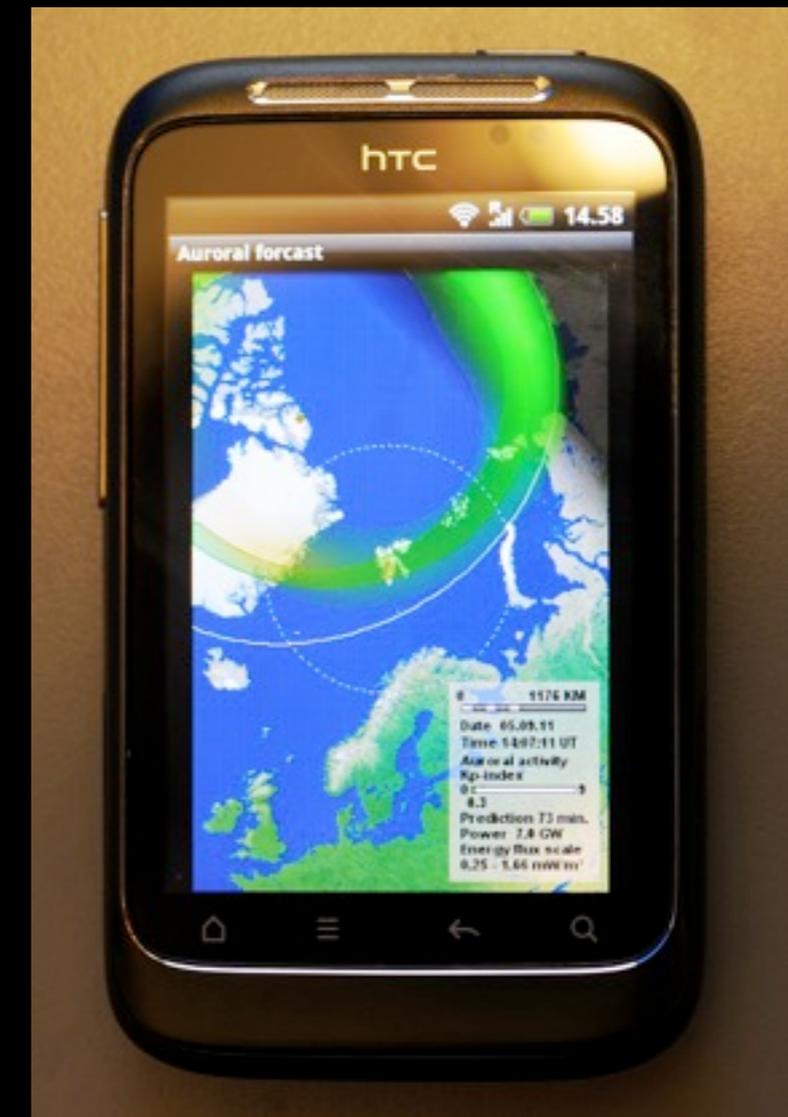
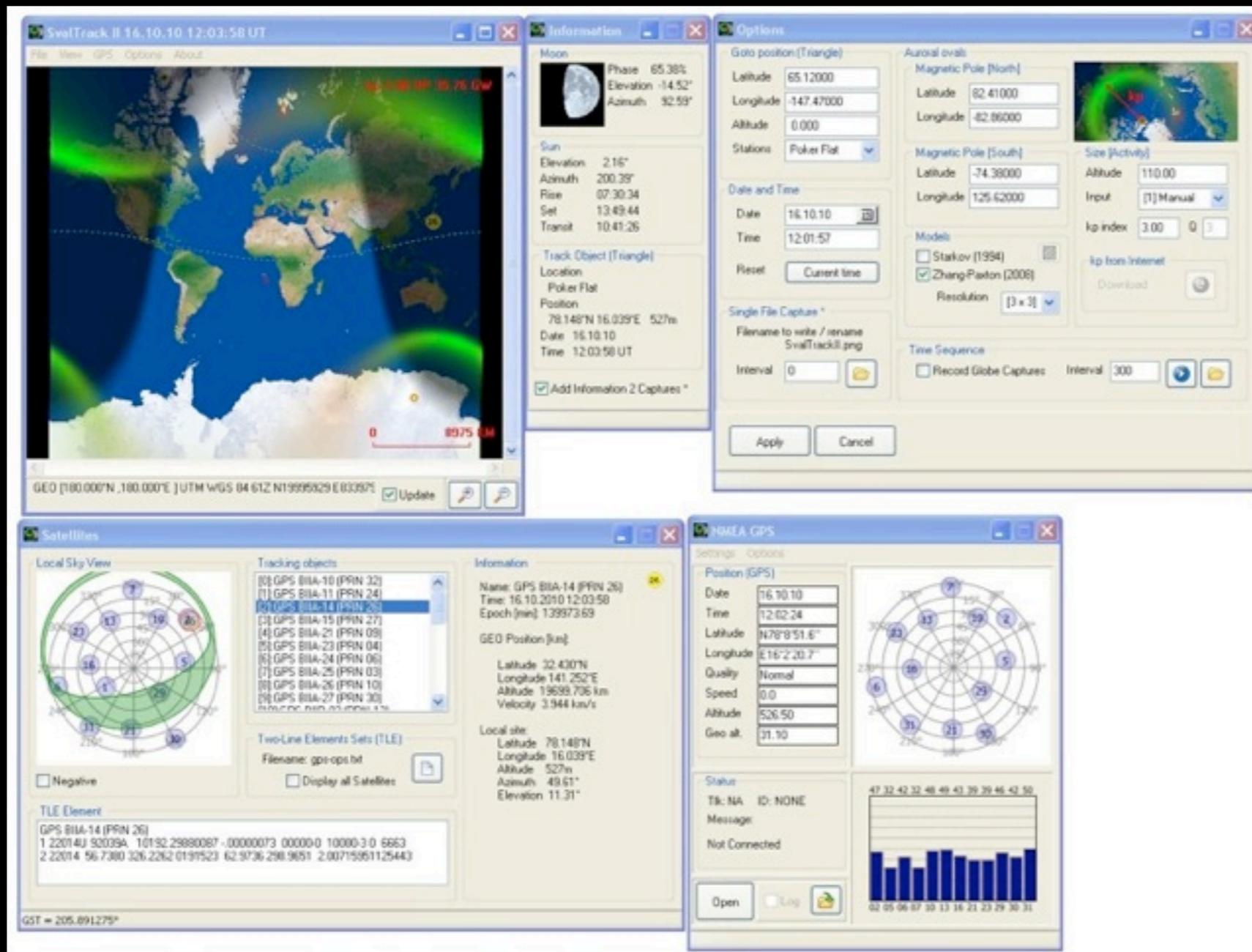
# The UNIS Aurora forecaster

Download at: <http://kho.unis.no/>

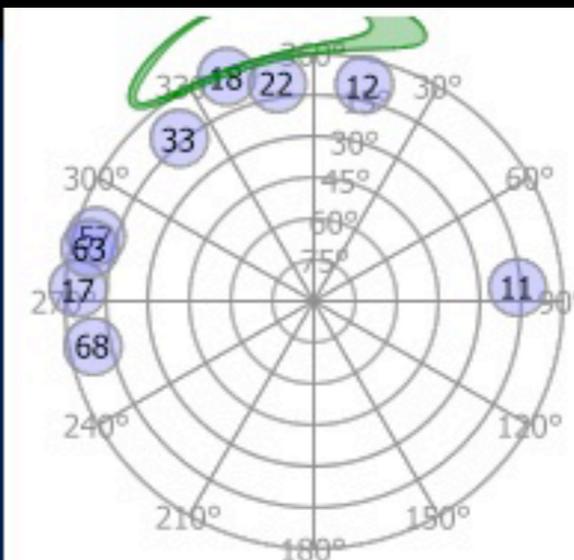
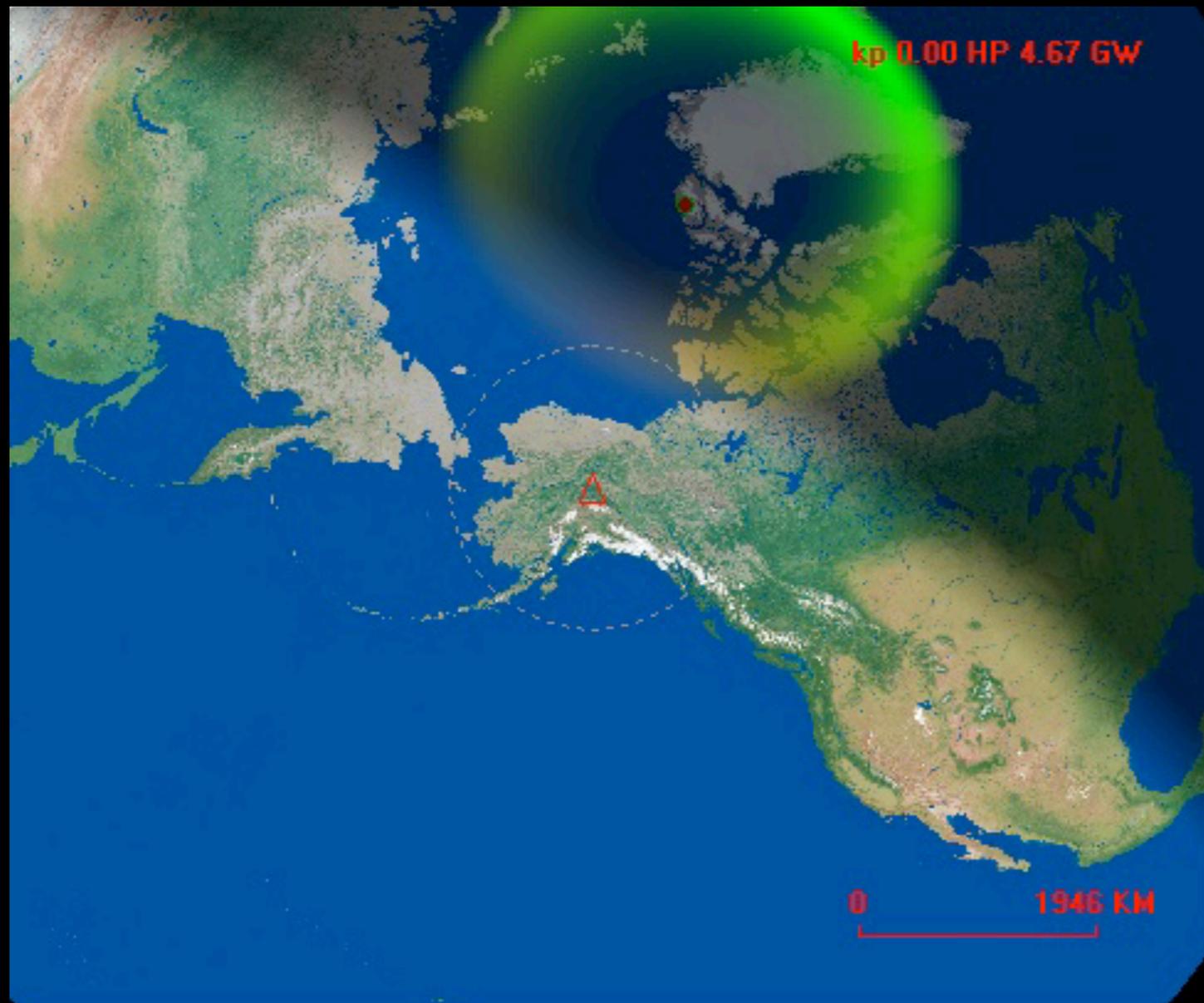
## Real time aurora oval forecasting - SvalTrackII

F. Sigernes <sup>(1)</sup>, M. Dyrland <sup>(1)</sup>, P. Brekke <sup>(2)</sup>, E. K. Gjengedal <sup>(3)</sup>, S. Chemouss <sup>(4)</sup>,  
D. A. Lorentzen <sup>(1)</sup>, K. Oksavik <sup>(1)</sup> and C. S. Deehr <sup>(5)</sup>

The 37th Annual European Meeting on Atmospheric by Optical Methods, Valladolid, Spain, 23 - 27 August 2010.



# The UNIS Aurora forecaster



- LOCAL ALL SKY VIEW**  
[11] TECHSAT 1B (GO-32)  
[12] LANDSAT 7  
[17] IKONOS 2  
[18] CBERS 1 (ZY 1A)  
[22] SAC C  
[33] HAIYANG-1A  
[57] WORLDVIEW-1 (WV-1)  
[63] JASON 2 (OSTM)  
[68] RAPIDEYE 4

**POSITION** 65.120°N 147.470°W



**MOON:**  
Phase 78.09%  
Elevation -6.56°  
Azimuth 95.27°

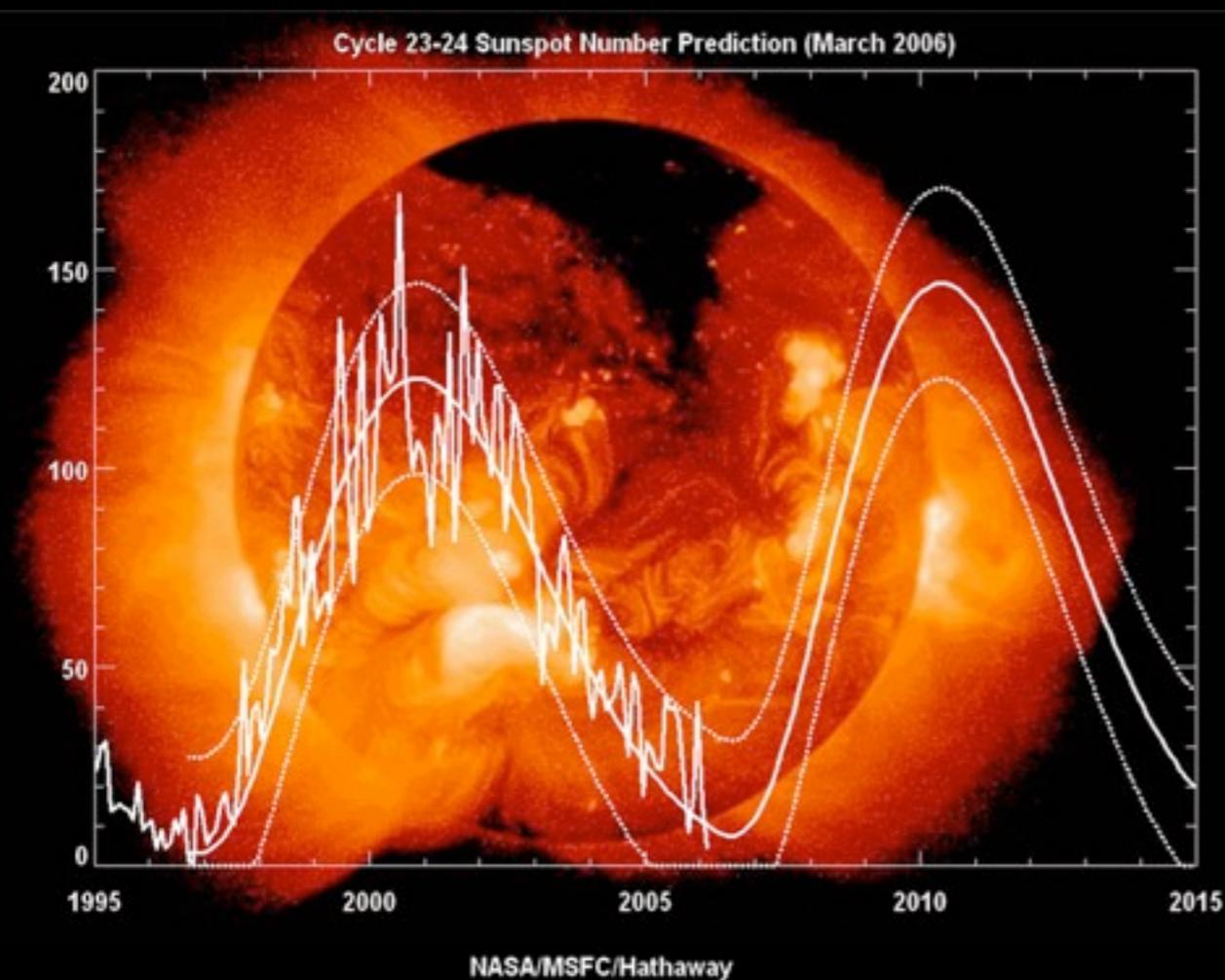
**DATE** 18.10.10

**TIME** 00:10:00 UT  
**SUN:**  
Elevation 10.02°  
Azimuth 218.78°

**kp = 0.00 HP=4.67GW**

# How often can we see it?

- **Northern lights can be observed this often on the following places during solar maximum:**
  - Andenes, Norway Almost every dark and clear night
  - **Fairbanks, Alaska** Five to ten times a month
  - **Oslo, Norway** Roughly three nights a month
  - **Northern Scotland, Great Britain** Roughly once a month
  - **US/Canadian border** Two to four times a year
  - **Mexico and Mediterranean countries** Once or twice a decade



P. Brekke

# Where best to view it in the high north

- Away from city lights
- On a summit or open country
- With a clear view of the horizon, especially to North
- Avoid the full moon
- Best time is before midnight.



P. Brekke

# Auroras over the EISCAT radar in Tromsø





Fredrik Broms

torsdag 19. april 12



Fredrik Broms



Fredrik Broms



Fredrik Broms



Fredrik Broms

# Auroras over Oslo 12 april 2010



Morten Ross

# Auroras over Scotland in 2003



Northern Lights from 21st Oct 2003 in Crooktree, NE Scotland. Photo courtesy of [Jim Henderson Photography](#)

# Auroras over Yorkshire in 2012



The Northern Lights glow over the Tan Hill Inn in Yorkshire. Photo: North News

# Auroras over Scotland in 2012



Peter Scott, Durness, Scotland 18 March 2012

# Auroras over Greece in 2003



Pluvia Sanguinea, from Athens, October 2003

# Auroras over USA



[aaronpeterson.net](http://aaronpeterson.net)  
Lake Superior - Upper Peninsula, MI 18 February  
2012

# Auroras over USA



**Bryen Larmay, Beecher Wisconsin, 18 February 2012**

# Auroras over USA



©Shawn Malone LakeSuperiorPhoto.com

Shawn Malone, Marquette, MI Feb. 19,  
2012

# Auroras over USA



Virginia, 24th October 2011



Alabama, 24th October 2011

# Auroras over USA



Chiefland FL, 20 November 2003

# How to take pictures of the Aurora



# How to take pictures of the Aurora

- DSLR camera (Manual mode)
- Tripod
- Fast wide angle lens 10-35mm (f/2.8, or lower)
- ISO ca 800
- exposure time 8-30 seconds



Fredrik Broms

# Aurora Cruise - Hunting the Lights

News | E-Newsletter Sign Up | Enquiry | Real time map | Travel Agents | 1893 Ambassador | Request a Brochure | Group Bookings  
Your country - GB  United Kingdom

 **HURTIGRUTEN**

**NORWAY**   **SPITSBERGEN**   **GREENLAND**   **ANTARCTICA**   **EUROPE**

**BOOK ONLINE**  
or Call 0844 272 8961

Start | In search of the Northern Lights | Northern Lights Cruises | Excursions | Ships | To Book

Start > In search of the Northern Lights > **Hurtigruten Winter**

What are the Northern Lights?

Arctic Norway and the Northern Lights

Arctic Norway and the Northern Lights Video

**Hurtigruten Winter**



## HURTIGRUTEN WINTER

# Aurora Cruise - Hunting the Lights



Photos: P. Brekke

# Working at the Norwegian Space Center



What my grandparents think I do



What my friends think I do



What my kids think I do



What my government think I do

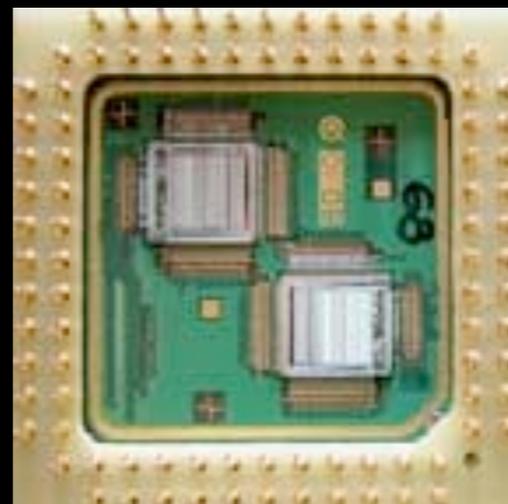
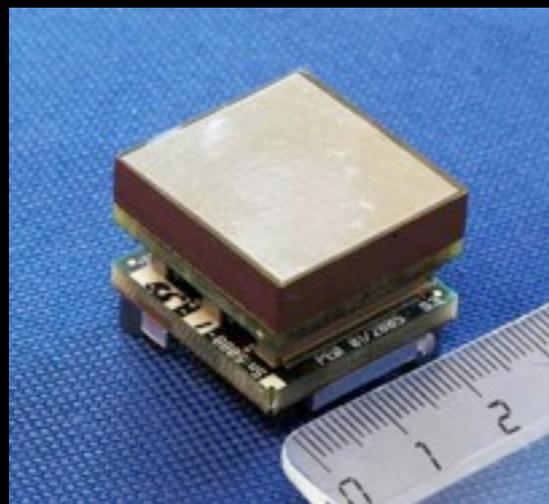
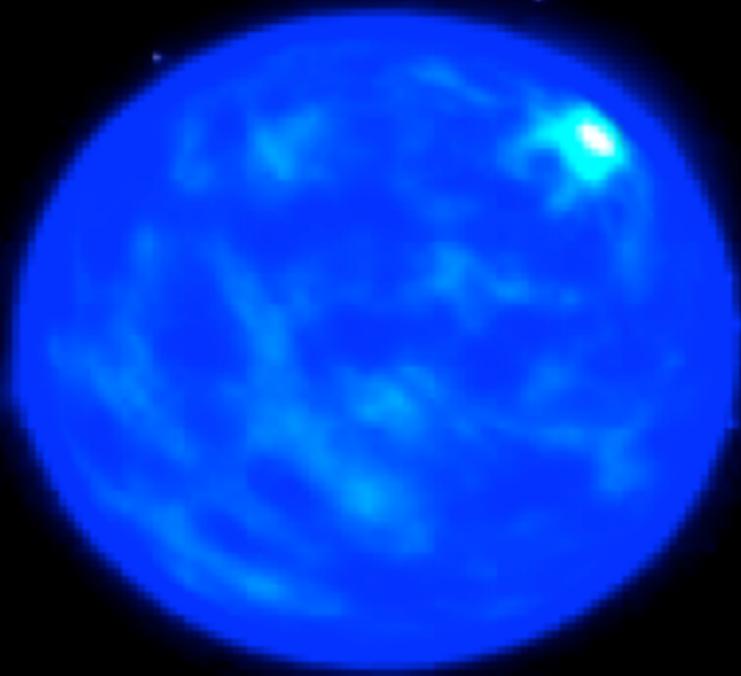


What I tell people I do



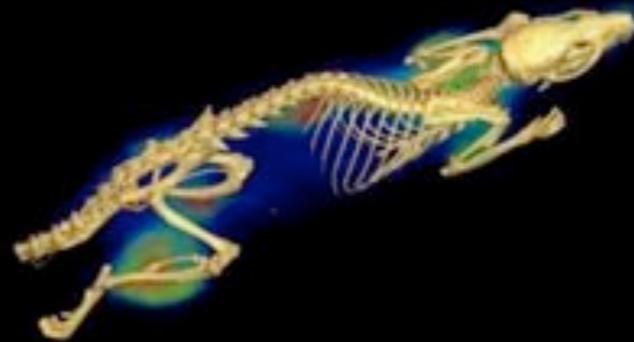
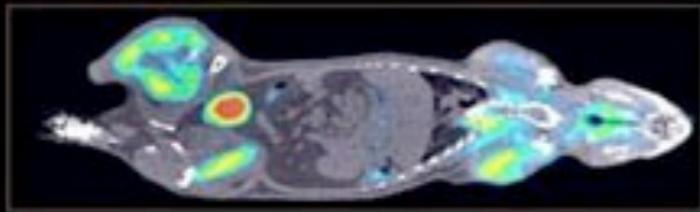
What I actually do

# Norwegian “camera” search for gamma burst



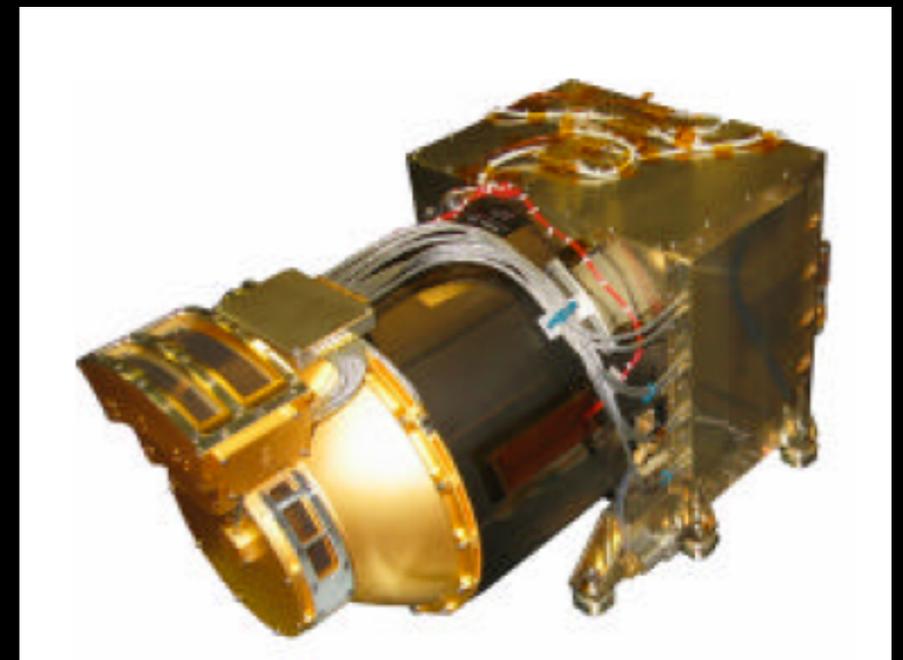
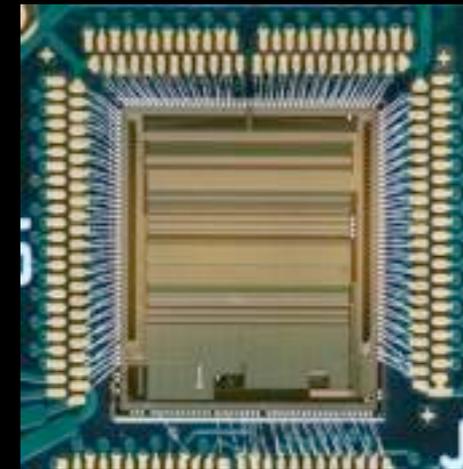
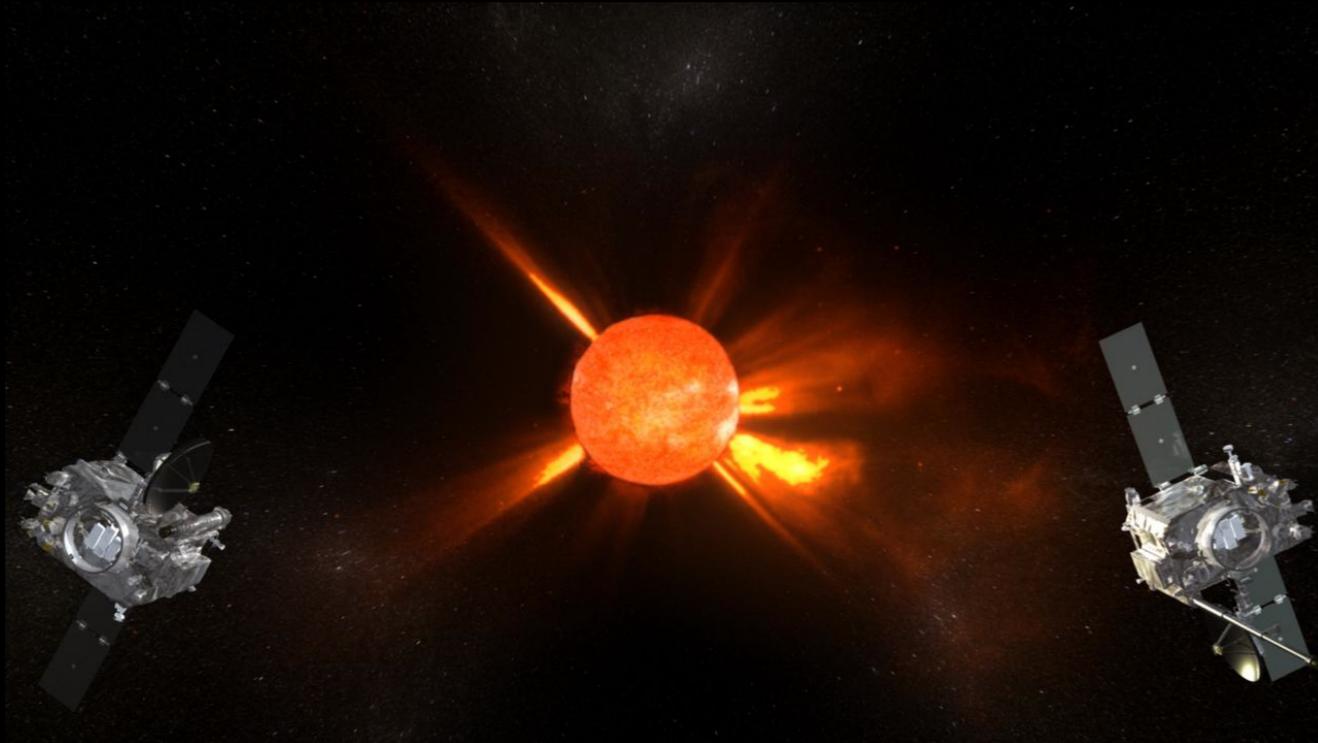
Gamma Medica IDEAS

The detector is used in “scanners” in medical research and developmen. This particular camera has imprived maoomgraphic imaging.. (Copyright: Gamma Medica IDEAS)



# GMI leverte ASIC til NASA's Stereo

GMI har levert ASICs (Application Specific Integrated Circuit) til solvind-instrumentet PLASTIC



# Svalbard - a test bed for future Mars missions

AMASE – Arctic Mars Analoge Svalbard Expedition is a Norwegian run cooperating project (ESA, NASA/JPL and Carnegie Institution of Washington) where future Mars rovers and instruments are being tested at Svalbard every summer.



# Kongsberg Satellite Services AS



- Owned 50% by the Norwegian Space Centre Properties AS og 50% by Kongsberg Defence & Aerospace AS
- Satellite stations in Tromsø, Grimstad, Svalbard (SvalSat) and in Antarctica (Troll station)

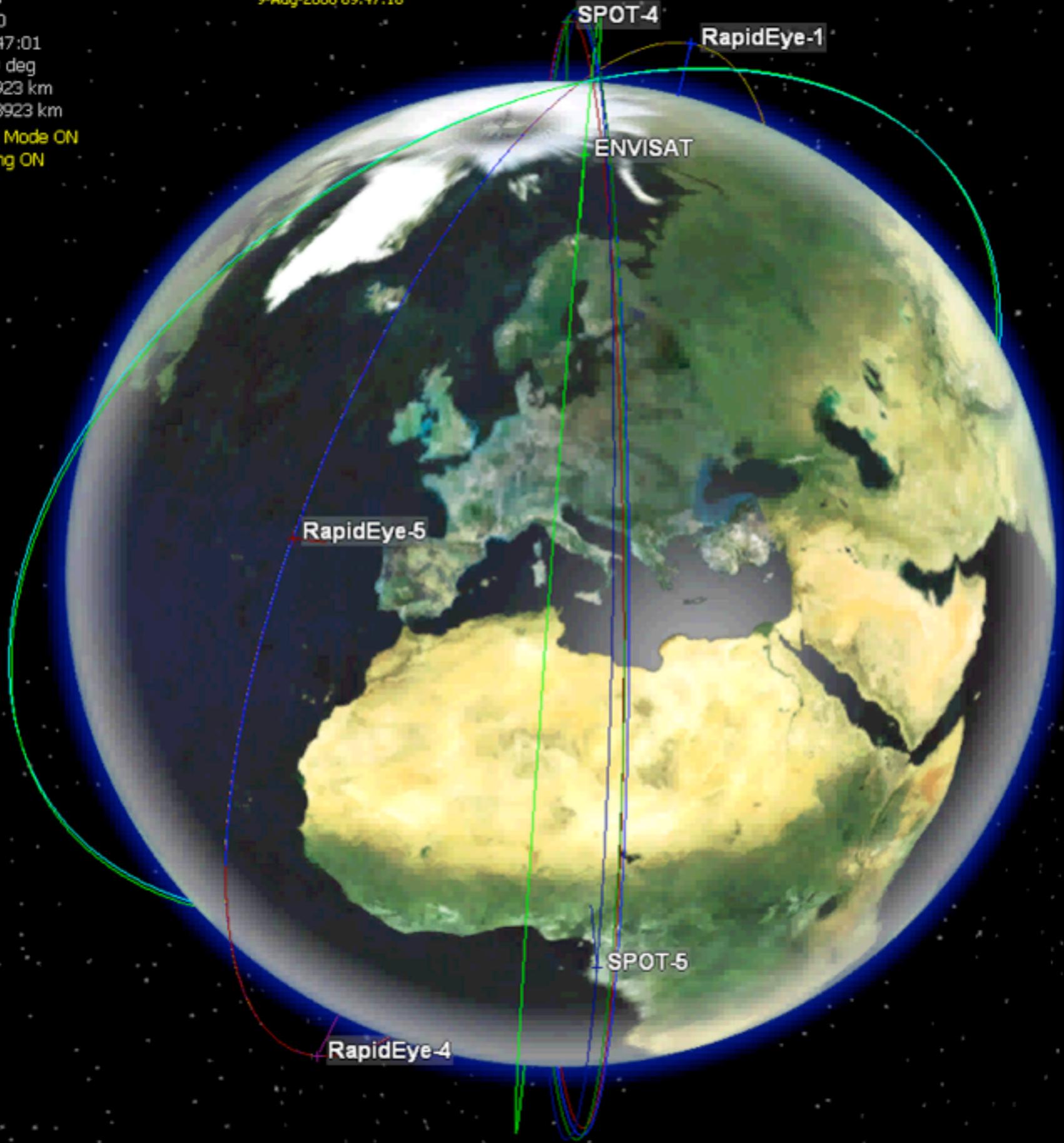


2008-Aug-09 09:47:01 UTC

Lat : 0.0000  
Lon : 0.0000  
MLST : 09:47:01  
SZA : 37.59 deg  
Range : 13923 km  
Altitude : 13923 km

Intersection Mode ON  
Auto Steering ON

w32 Aug-2008 w33 Aug-2008 w34 Aug-2008 w35 Sep-2008 w36 Sep-2008  
9-Aug-2008 09:47:10



SAVOIR - Swath Acquisition Viewer - © European Space Agency - Taitus Software

# World largest satellite station for polar satellites



## NASA/CSOC missions supported at SvalSat

LANDSAT-7  
QuickScat  
AM-1 (Terra)  
SAC-C  
ERS-2  
Acrimsat  
Champ  
Grace  
EO-1  
Kompsat  
Cobe  
Aqua  
Quicktoms

- **European TT&C Contracts with:**
  - NASA,
  - ESA,
  - EUMETSAT
  - METOP

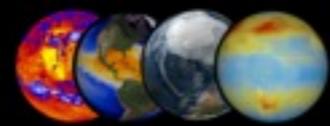
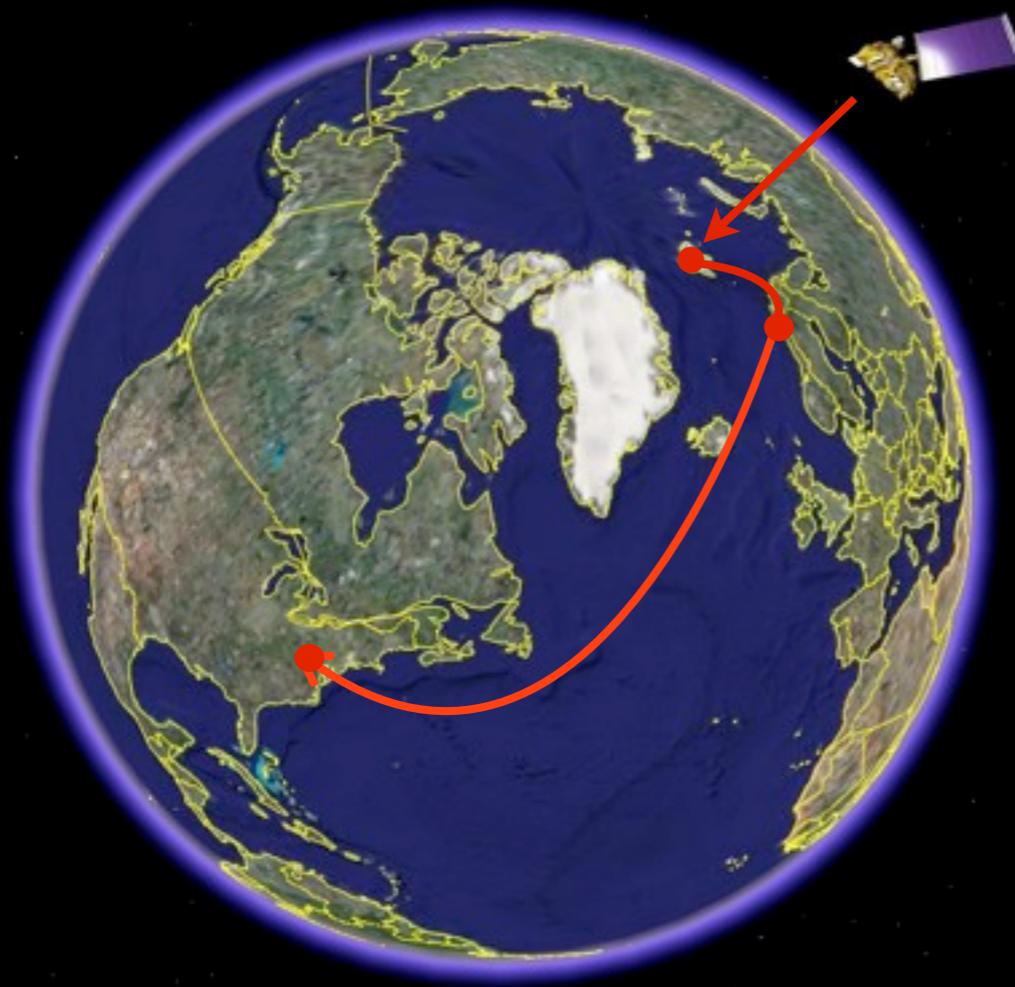


Svalbard - a cyberlink to USA

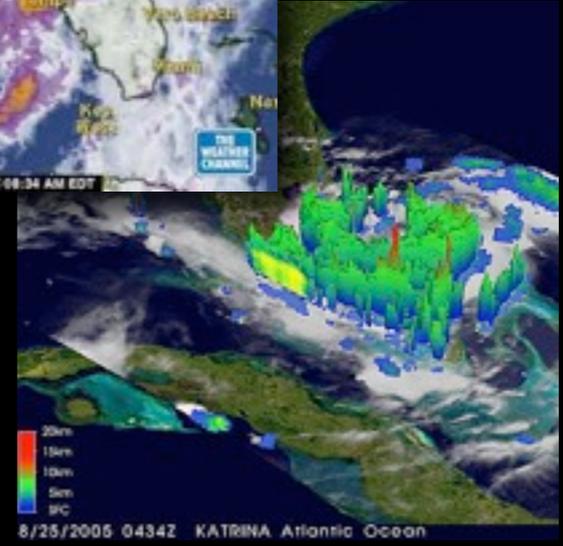
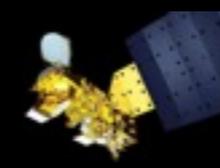


Satellite replaced by two fibre optic cables  
Length: 1,400 km, Price: USD 60 million  
Paid with external funds from NASA and NOAA/IPO

# Svalbard - A data-hub for USA's satellites



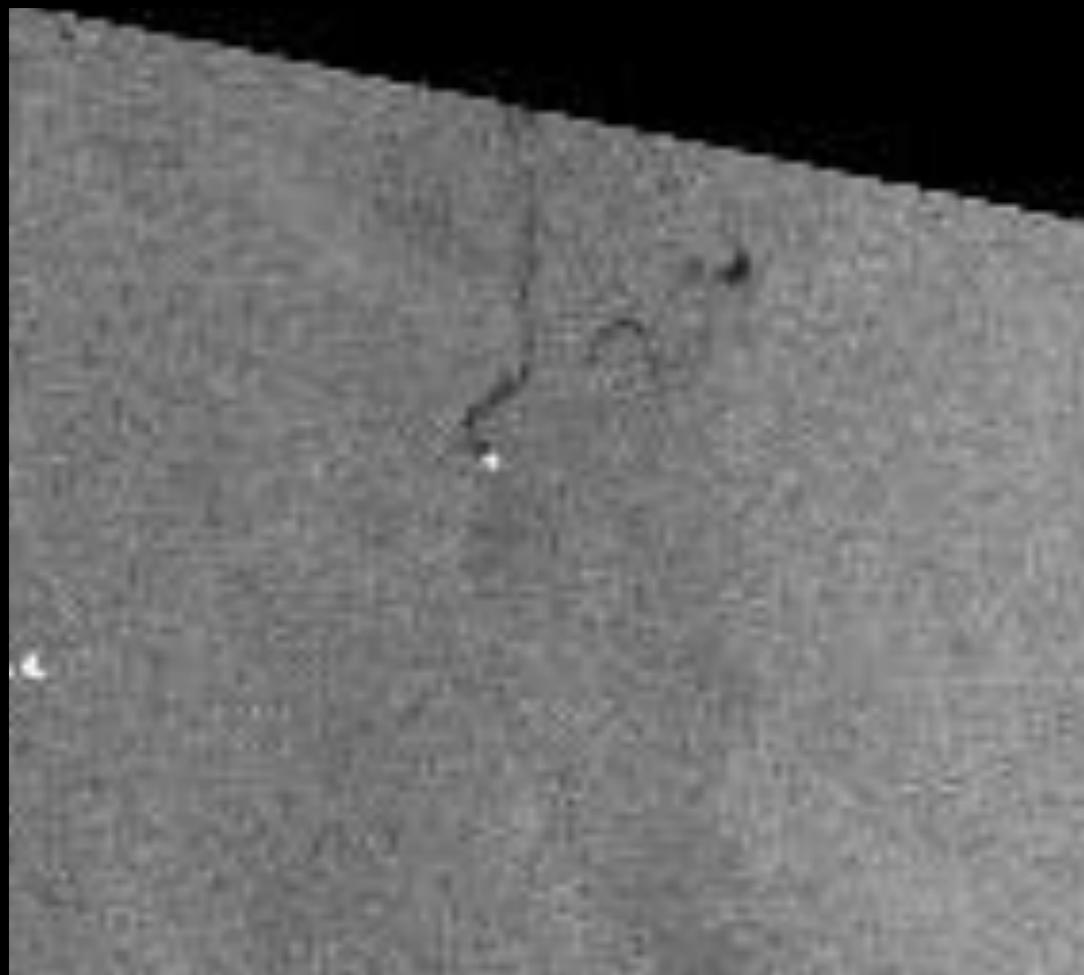
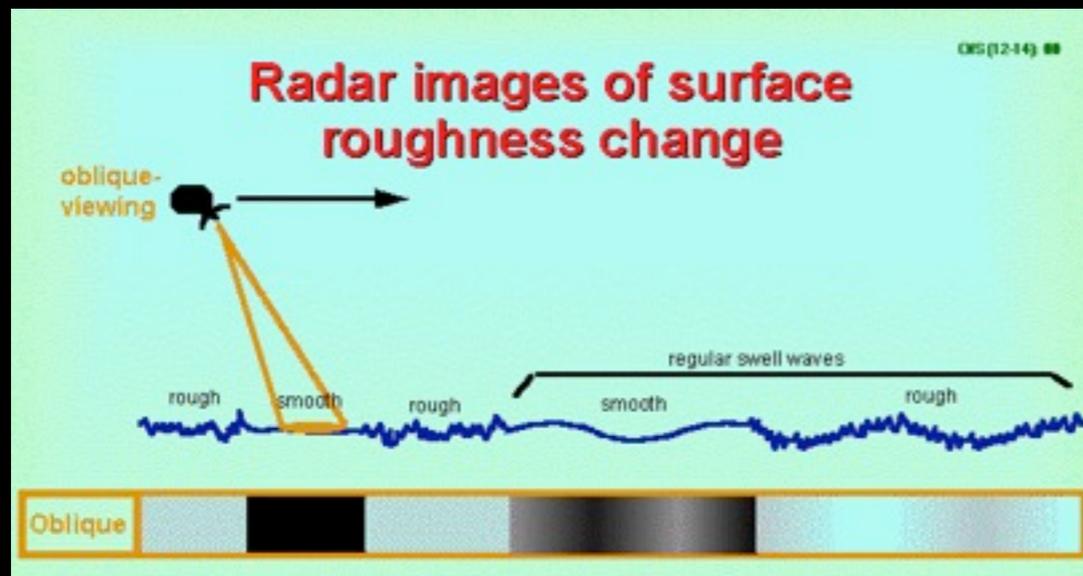
**Aqua**  
Project Science



Soumi NPP

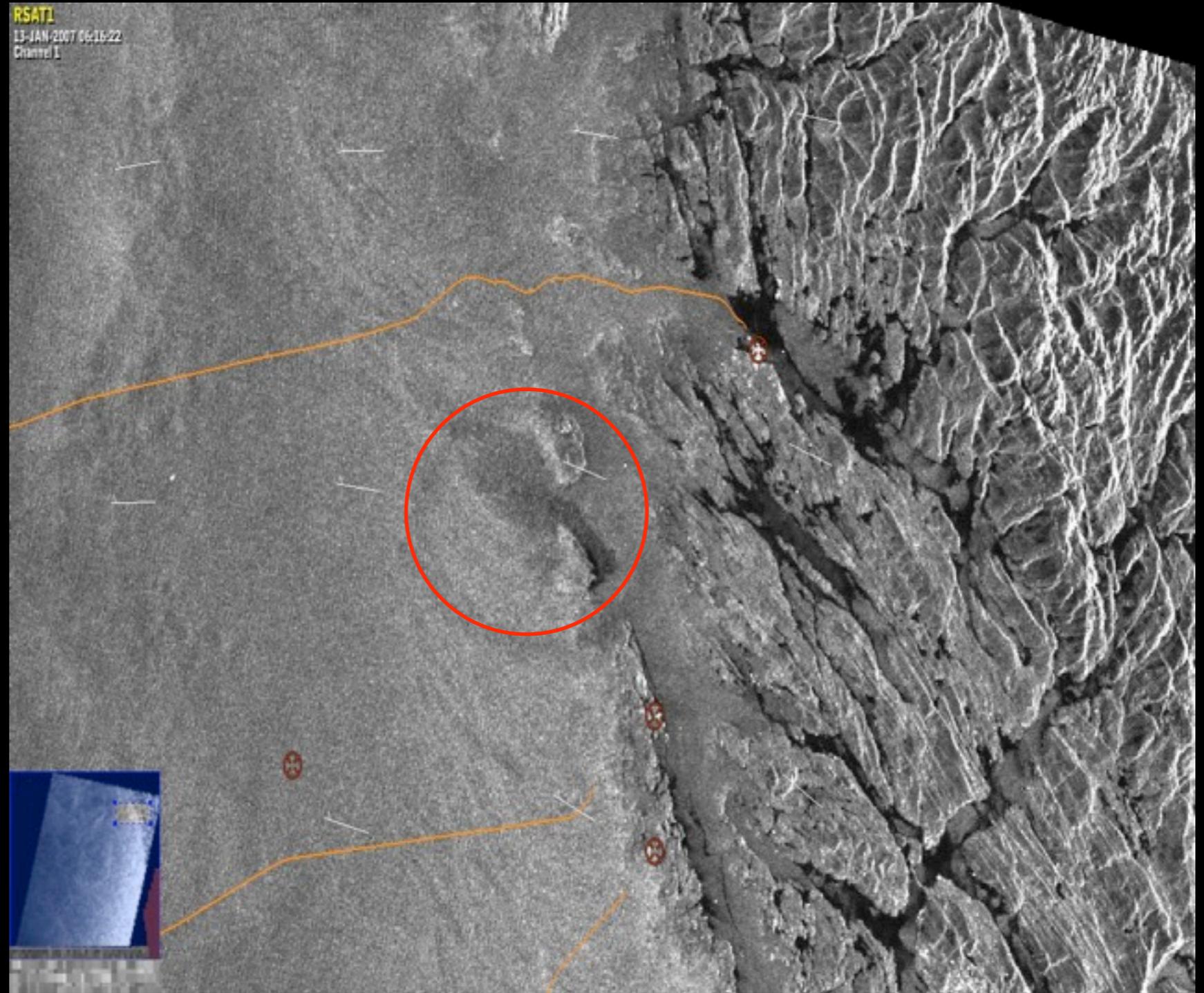
# First operational oil spill detection from satellites

Radar satellites can “see” oil spills day and night and through clouds



Oil spill from a Norwegian platform in 2004

# Recent ship wreck at Fedje, Norway



# Oil Spill in the British Channel

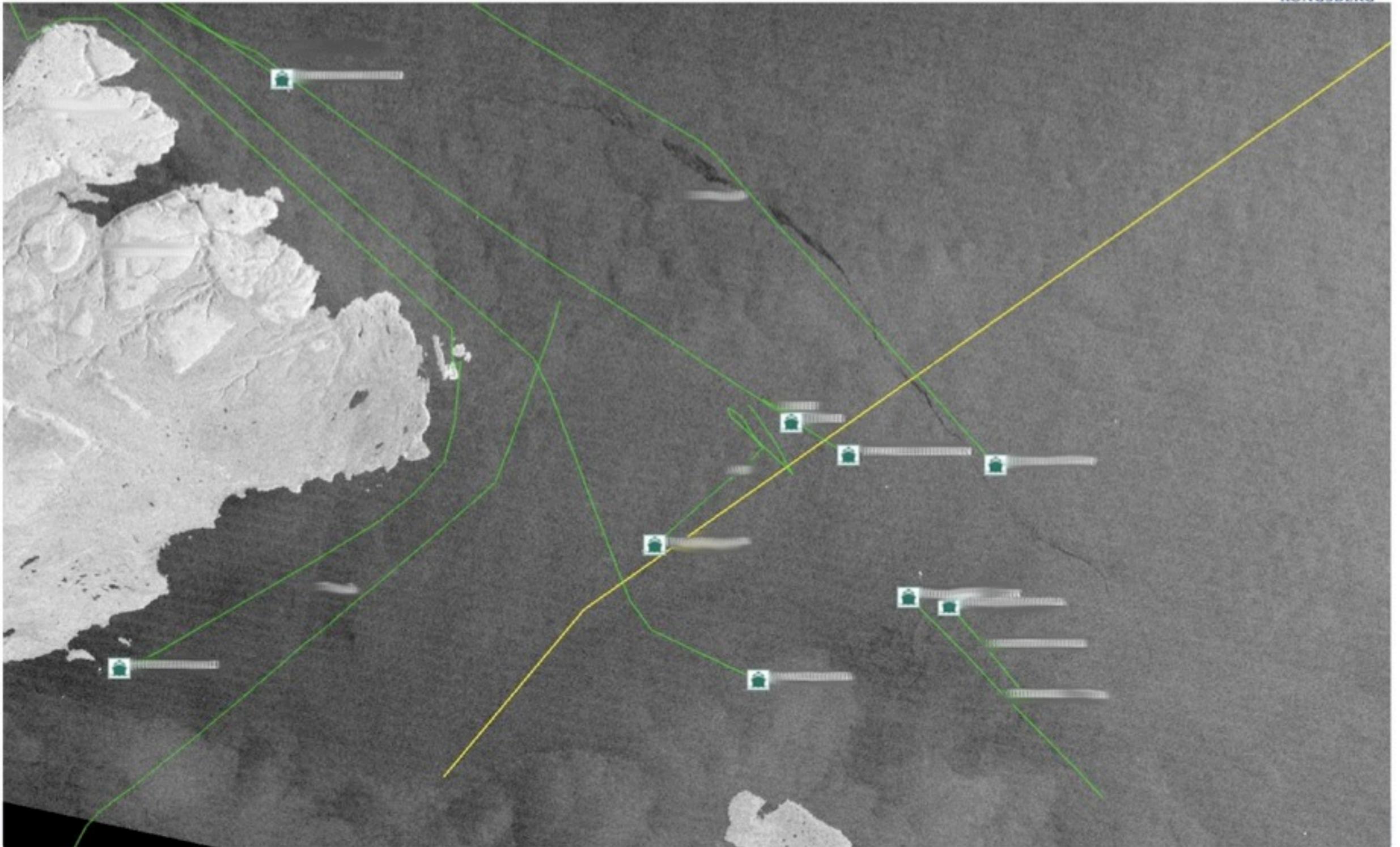


# Oilspill outside Nort-Norway

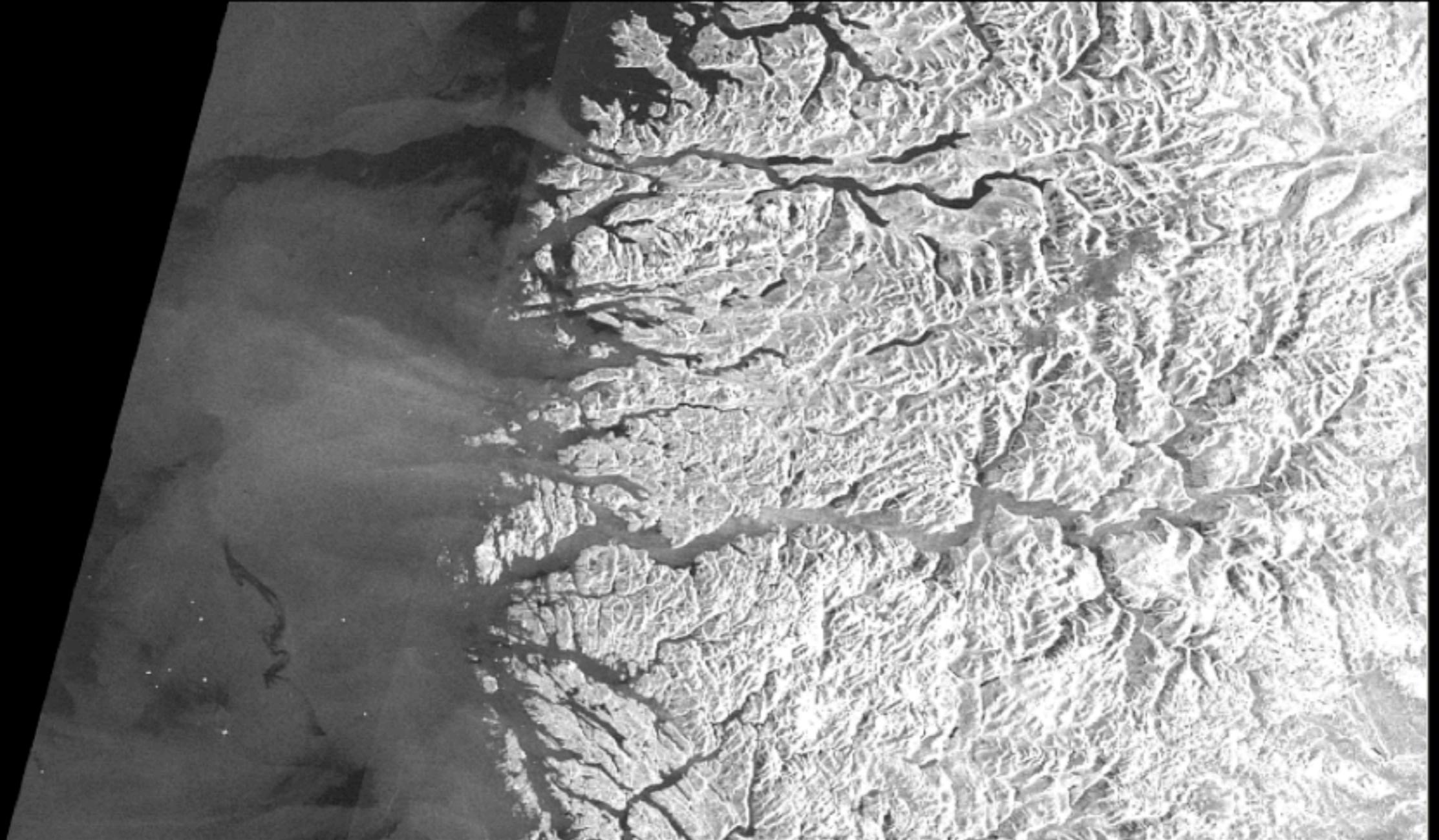
Service example: Extended Oil Spill Detection



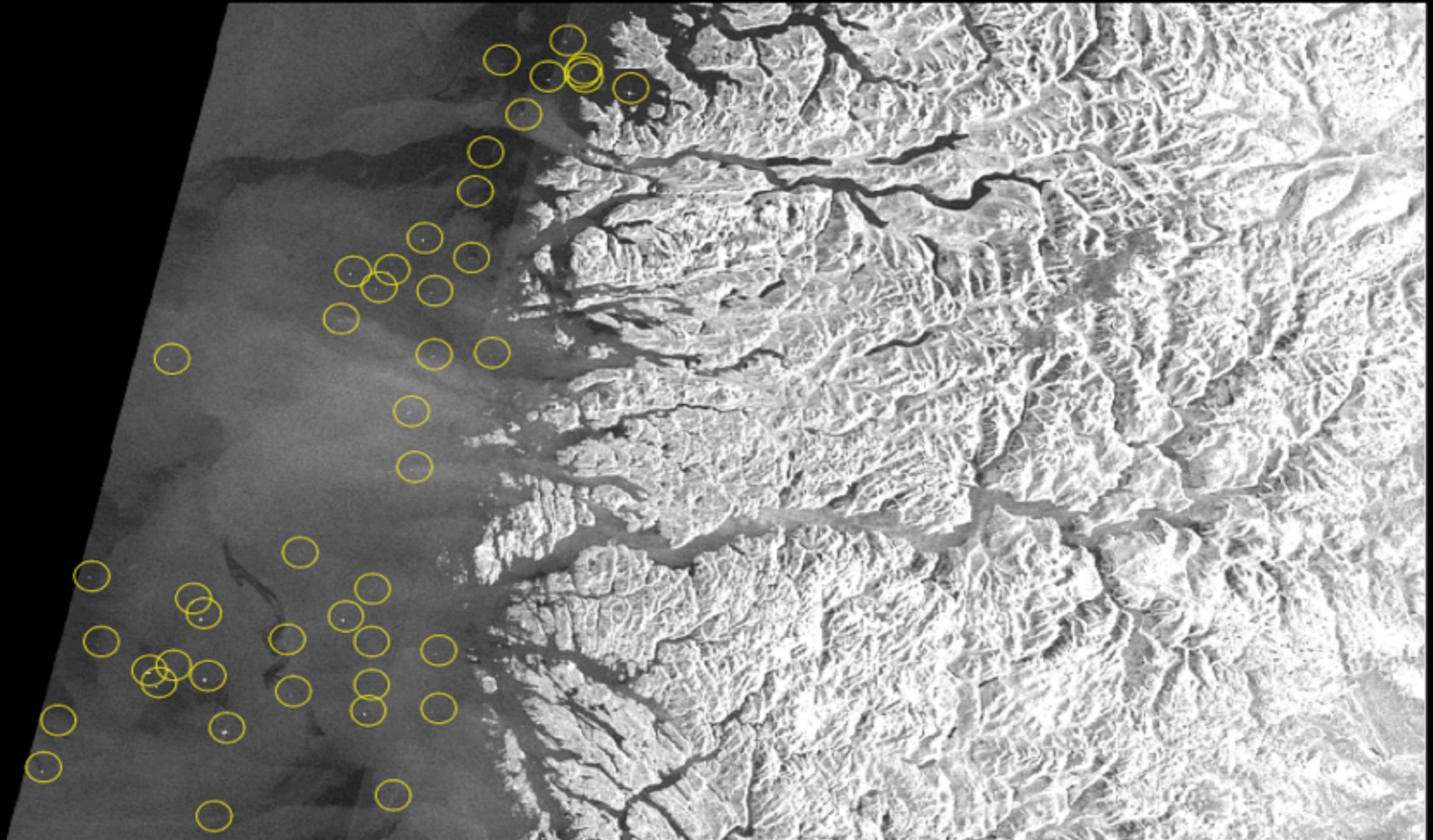
KONGSBERG



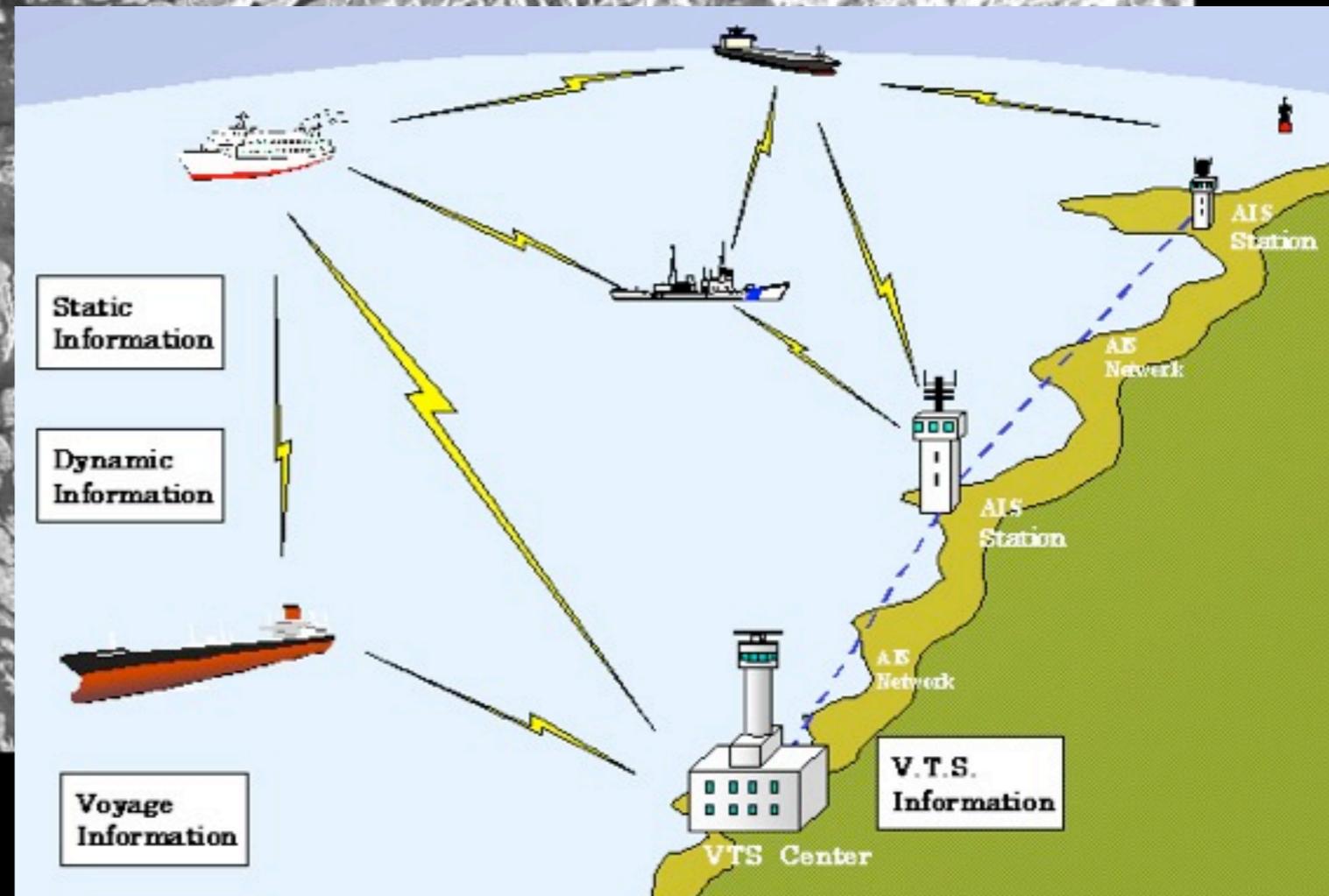
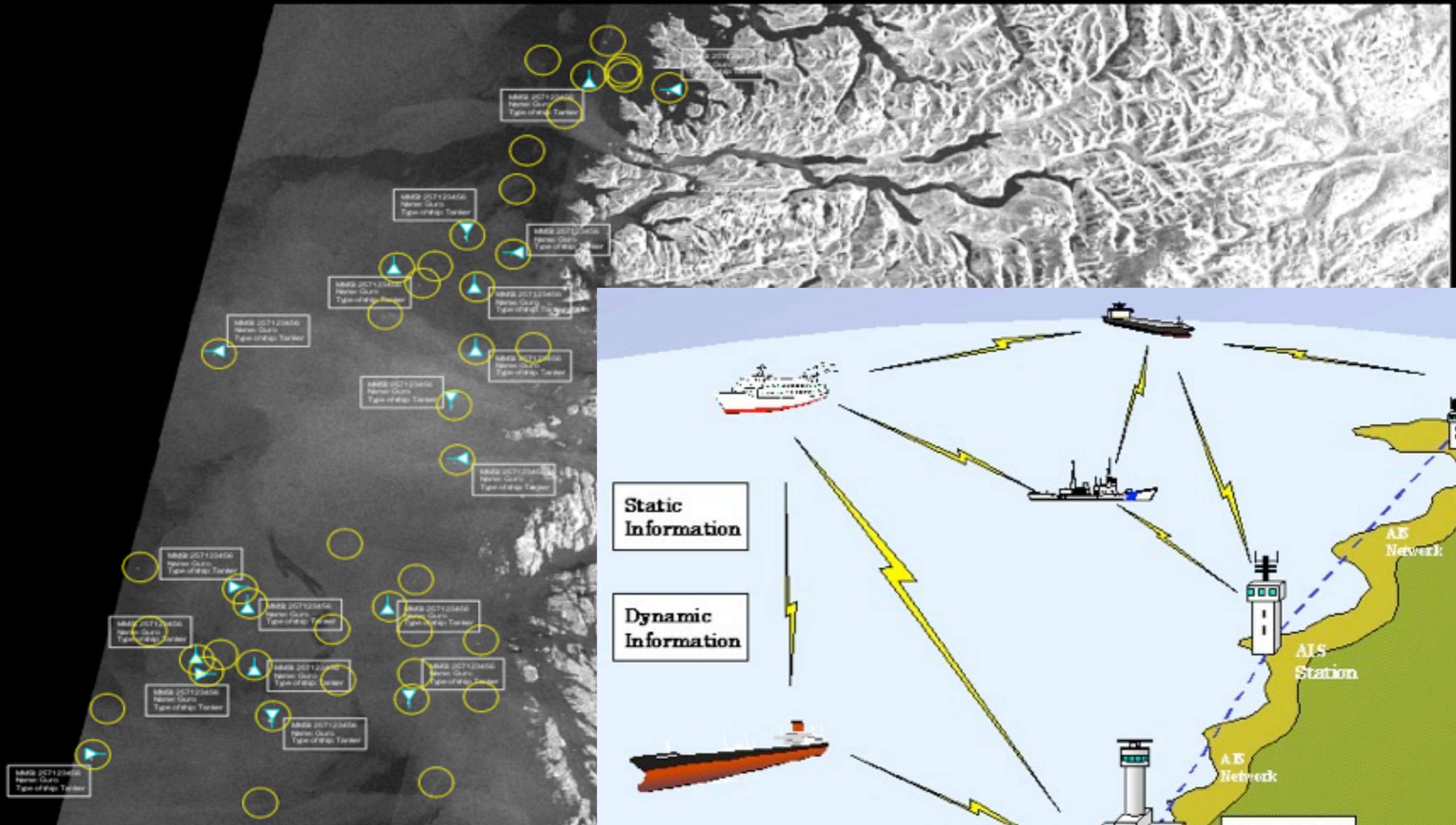
# RADARSAT images



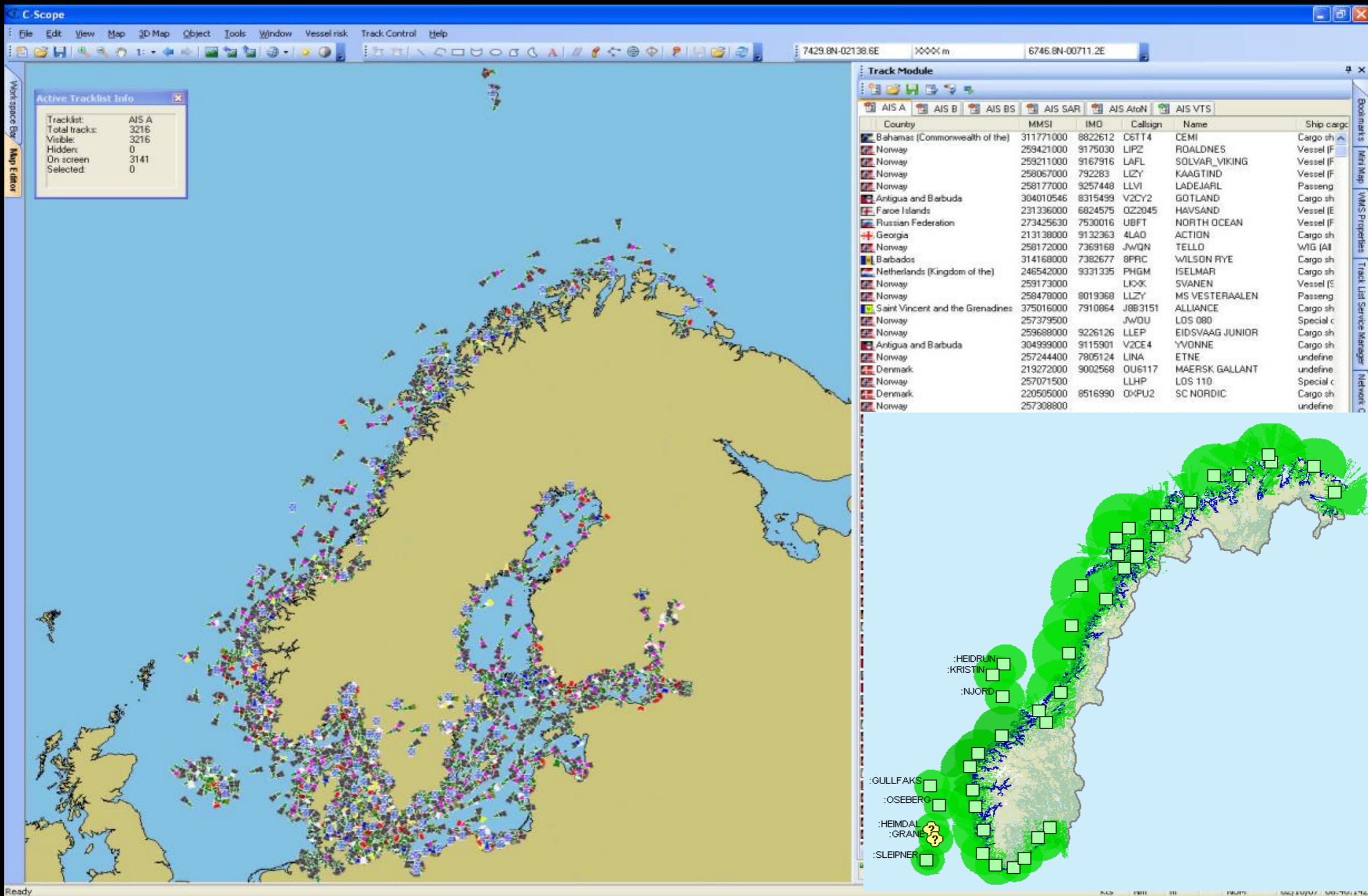
# Identifaction of ships - from RADARSAT



# Identification of ships - combining AIS information



# Norwegian Coastguard's AIS monitor

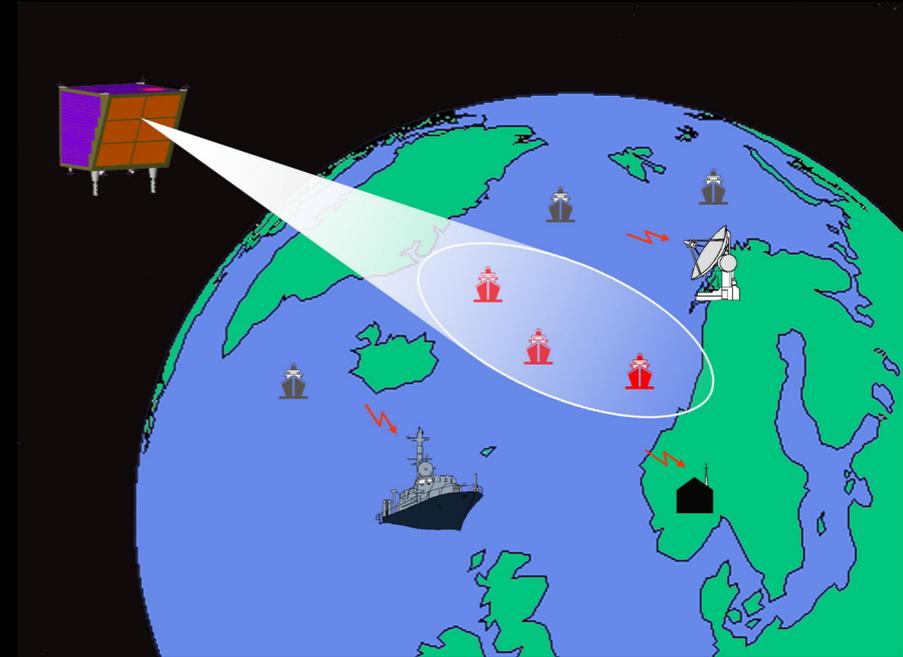


# Kystvaktens AIS monitor er ikke nok!



# Norsk AIS satellitt - AISSat-1

- Innmat bygget i Norge, satt sammen i Canada
- Totalkostnad på ca. 30 millioner NOK.
- Skutt opp sommeren 2010 på en Indisk bærerakett
- Koordineres av Norsk Romsenter, og inkluderer øremerkede midler fra NHD.
- Utviklingen skjer ved Forsvarets Forskningsinstitutt (FFI), med bidrag fra Kongsberg Defence & Aerospace og Kongsberg

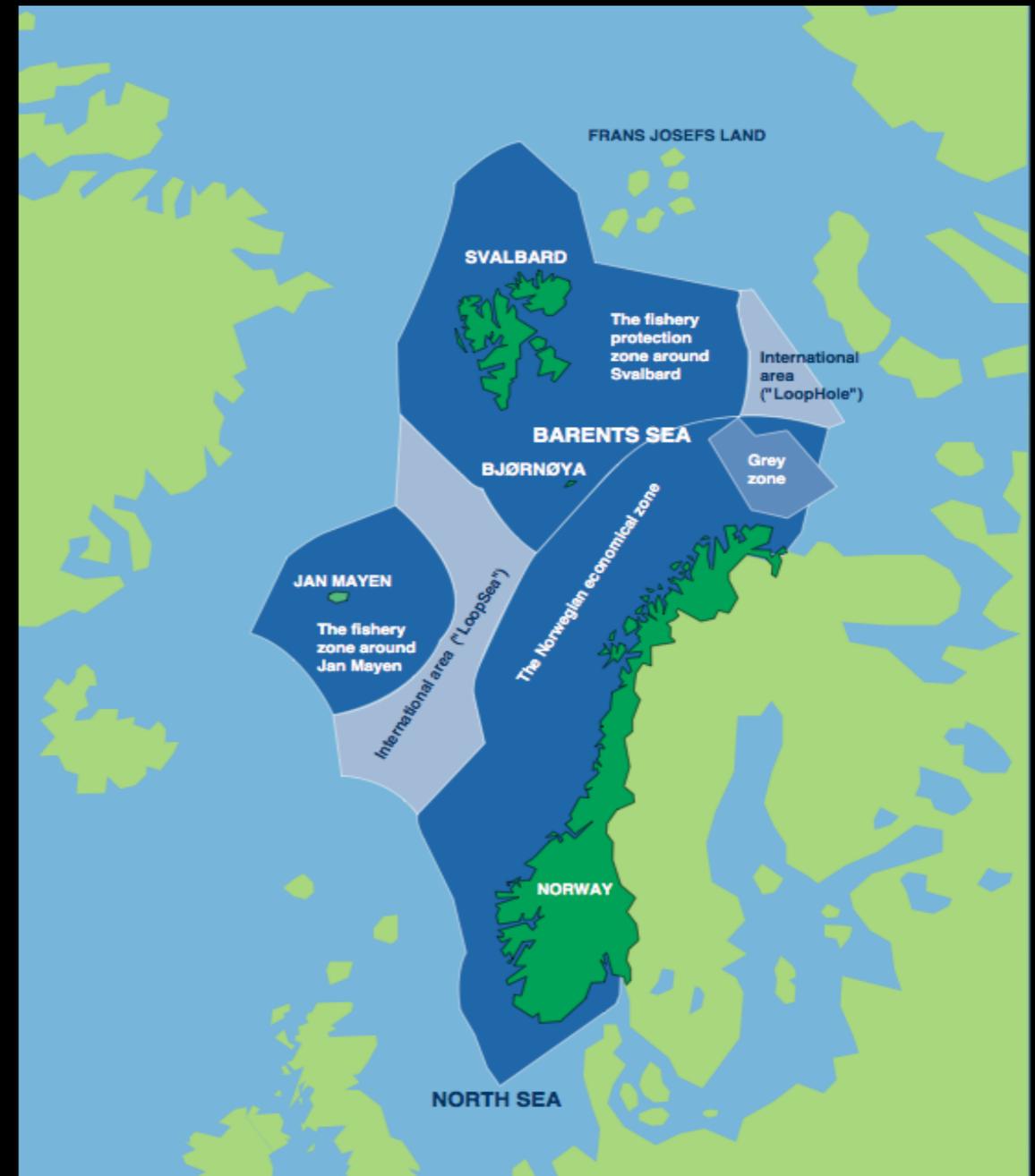
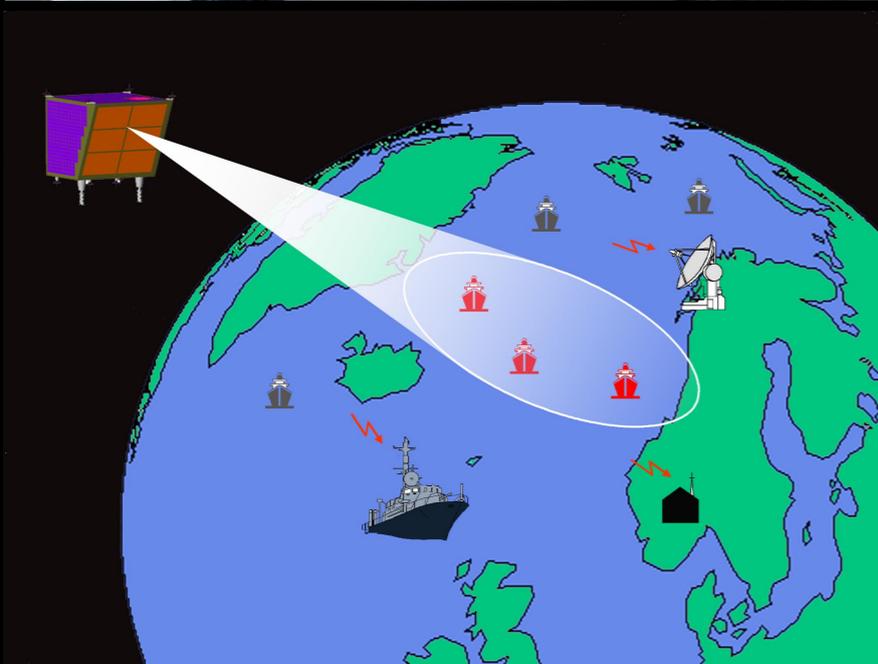


# Norwegian AISsat-1

National small AIS-satellite project was started 2 years ago

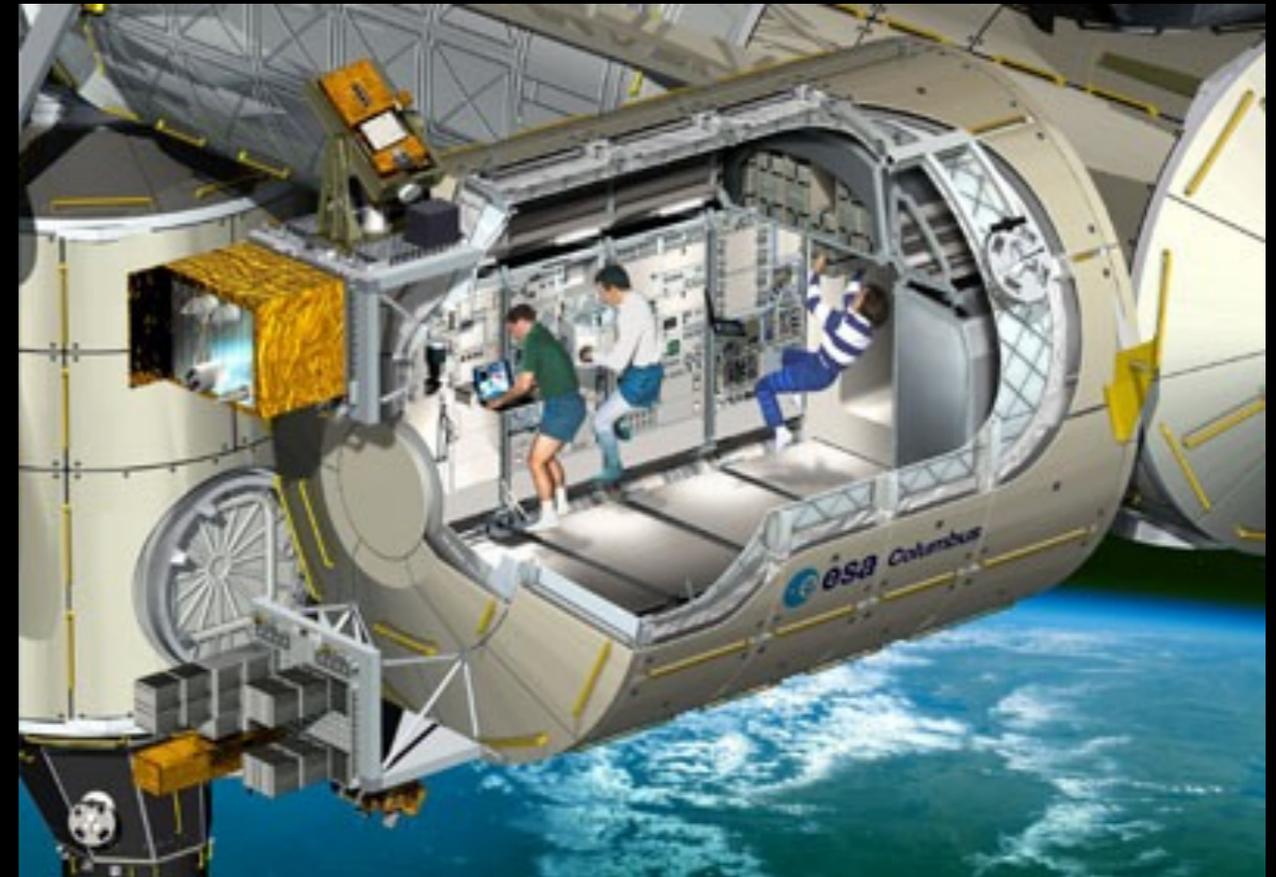
AISsat-1 has now been integrated in Toronto, Canada

Launch spring 2010 from India

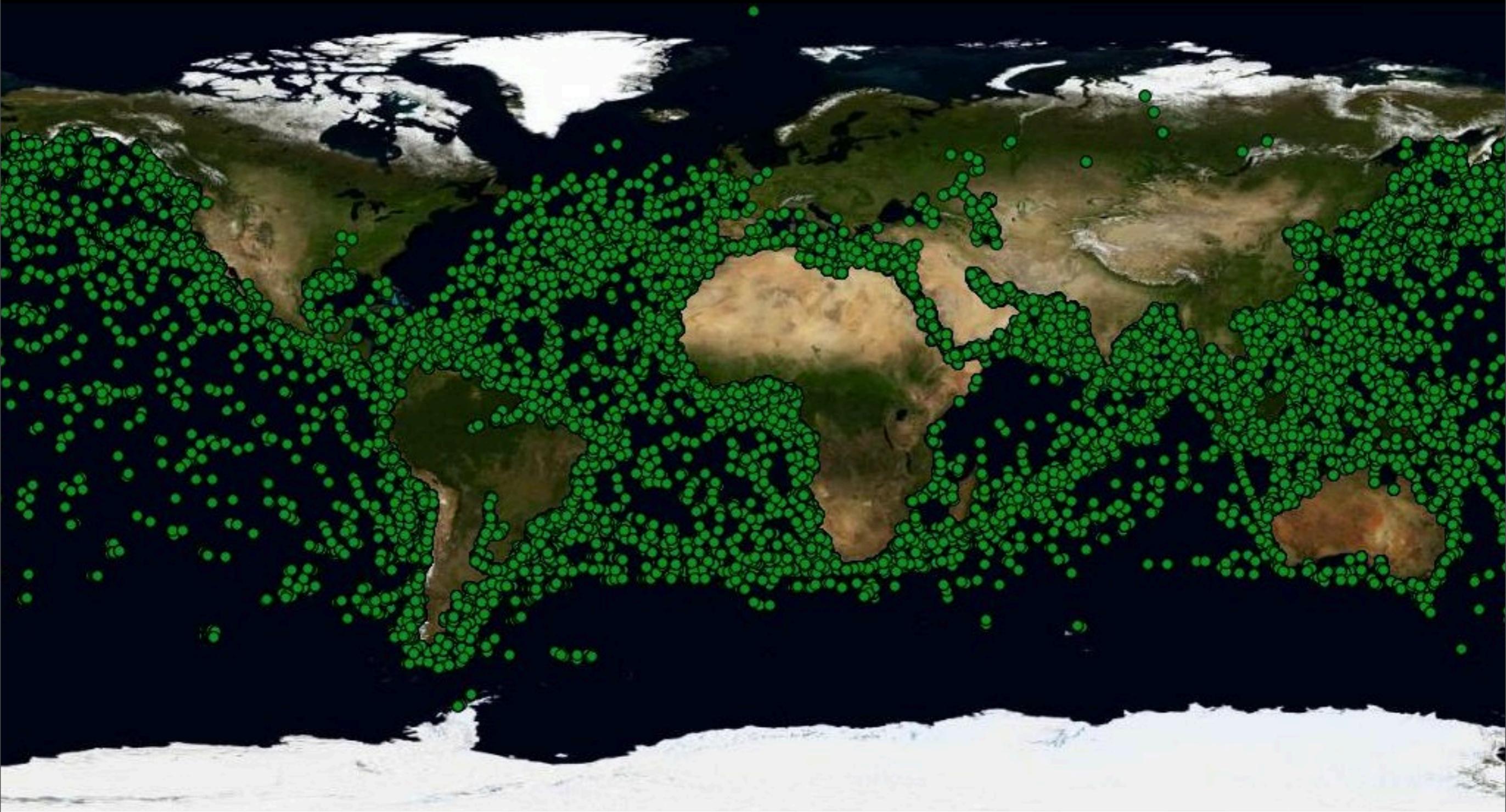


# Test version of AISsat (NORAIS) was installed at ISS

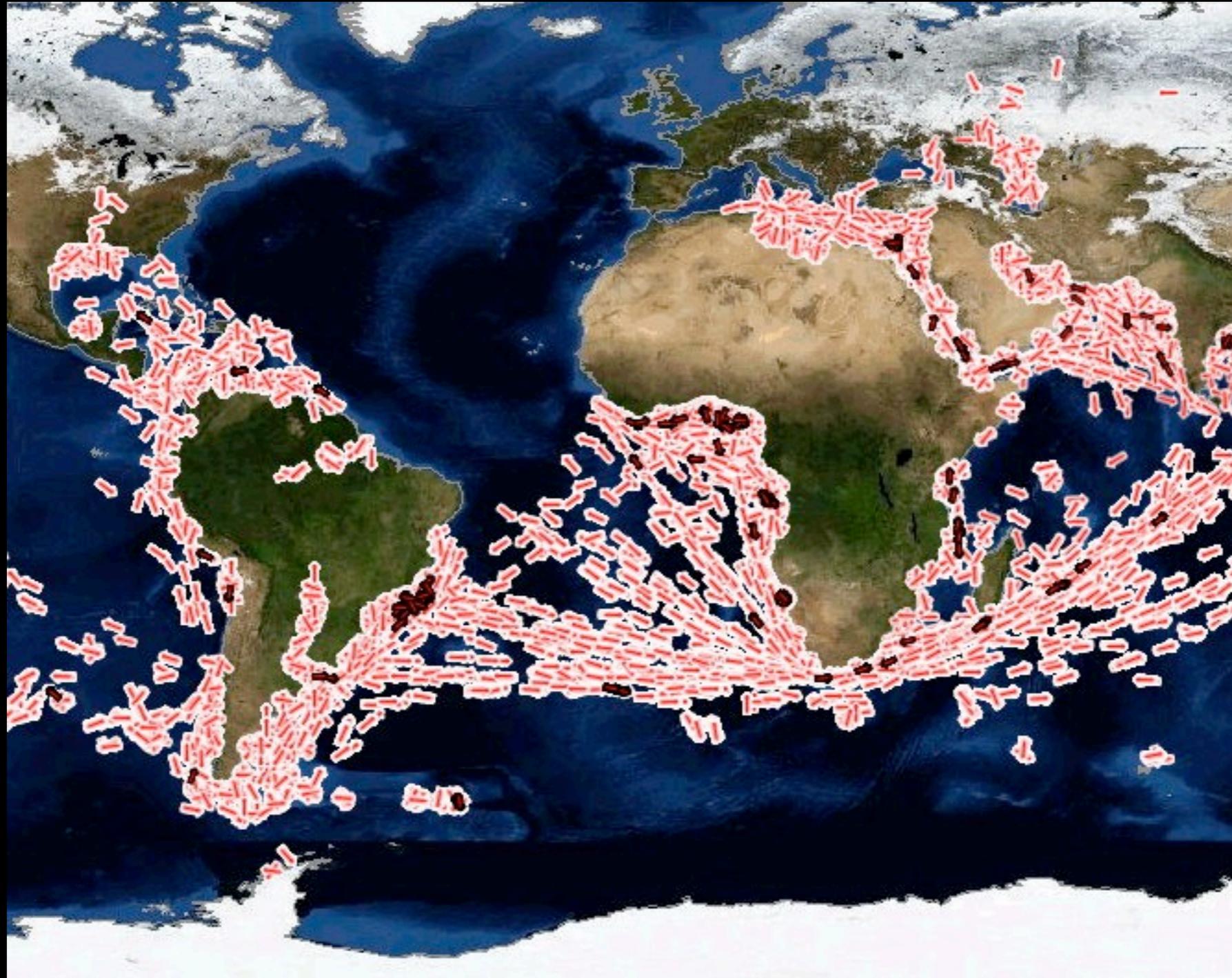
- Launch: NORAIS was launched in September, antenna late 2009
- EVA later this year for antenna deployment on Columbus
- Start of experiment: Early 2010
- Main goal: AIS signal tests in crowded areas



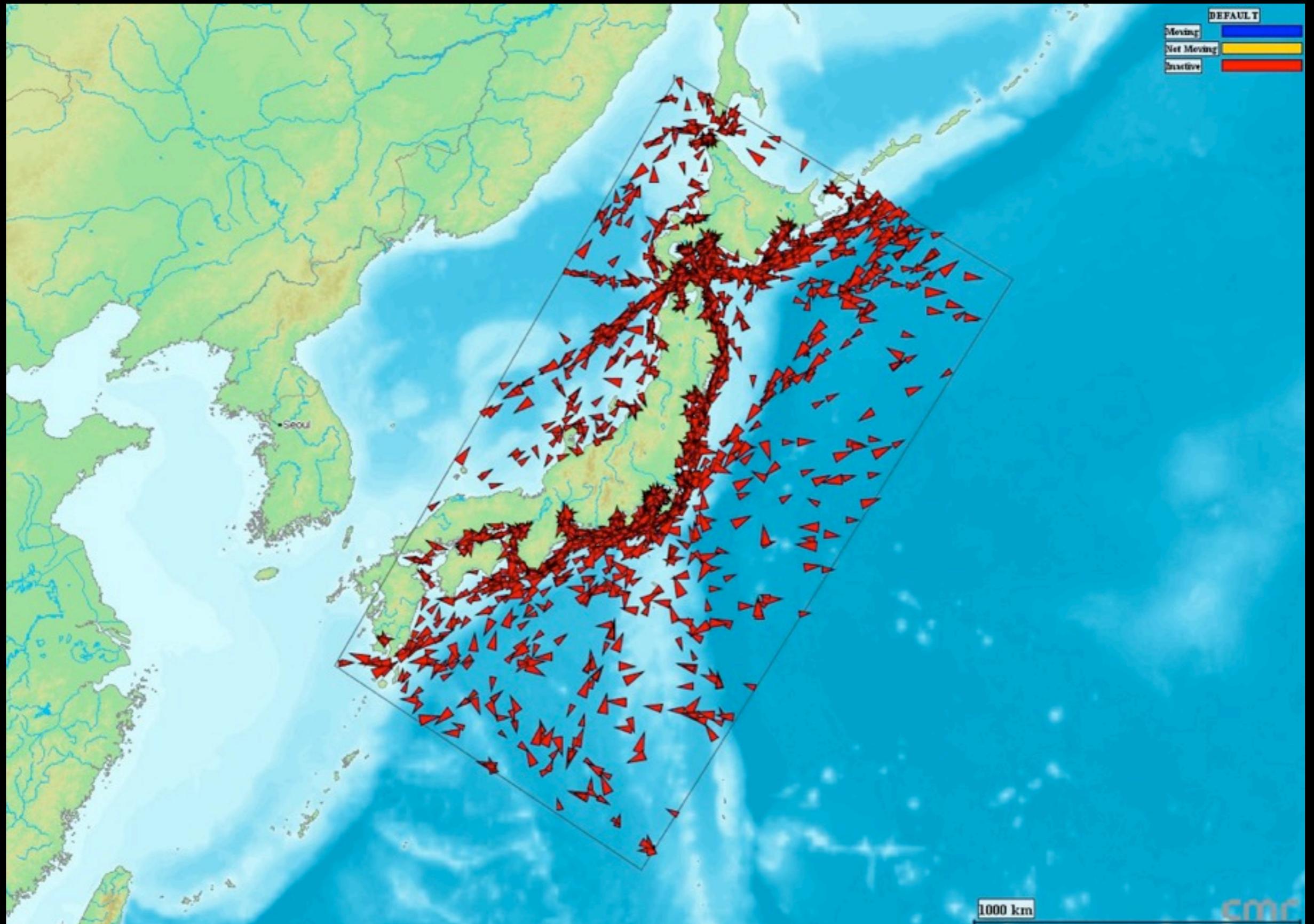
# Ship traffic detected from ISS



# Ship traffic detected from ISS



# AisSat-I hjelper Japan



# New book about the Sun and the Aurora



Info: [www.solarmax.no/Aurora/](http://www.solarmax.no/Aurora/)  
Paal@spacecentre.no

Fredrik Broms