Aurora Forecast 3D

A Global Adventure

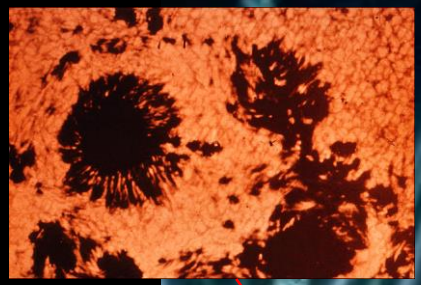
F. Sigernes [1,2,3,4]

[1] The University Centre in Svalbard (UNIS), N-9171 Longyearbyen, Norway
[2] The Birkeland Centre for Space Science (BCSS)
[3] The Kjell Henriksen Observatory (KHO)
[4] Centre for Autonomous Marine Operations and Systems (AMOS) NTNU

SNOW18, Arctic 365, Alta 14 -15 May, 2018

The Sun Earth Space environment

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



Sunspot close up!

= Space Weather

<u>Varying</u>

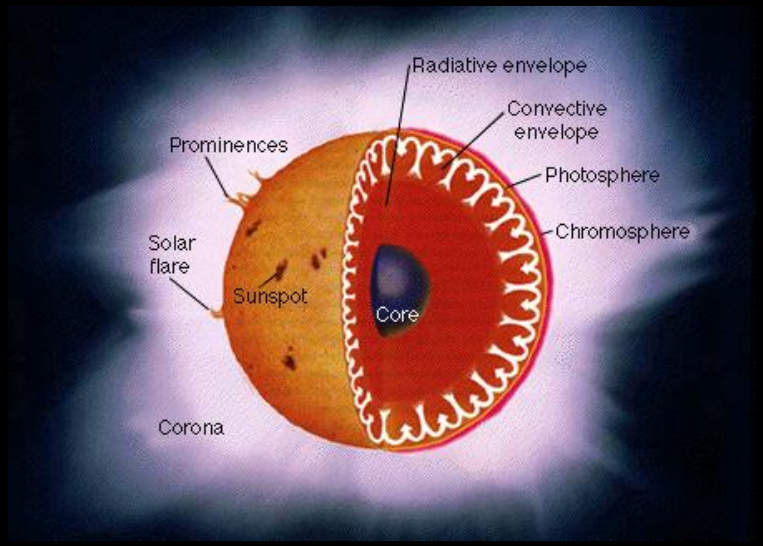
1) Radiation

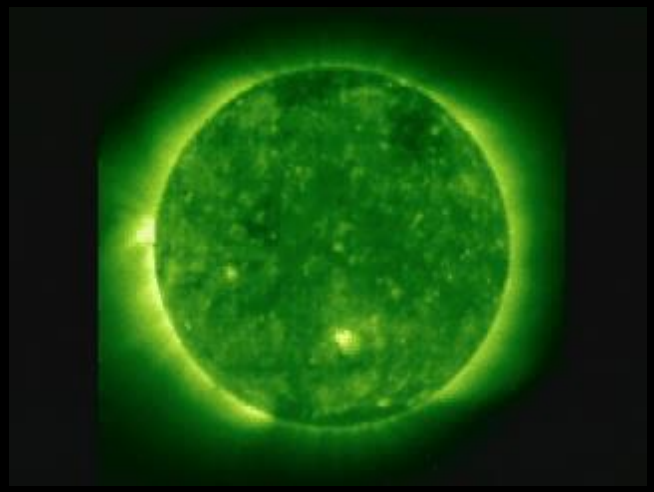
2) Solar Wind

Energetic Particles

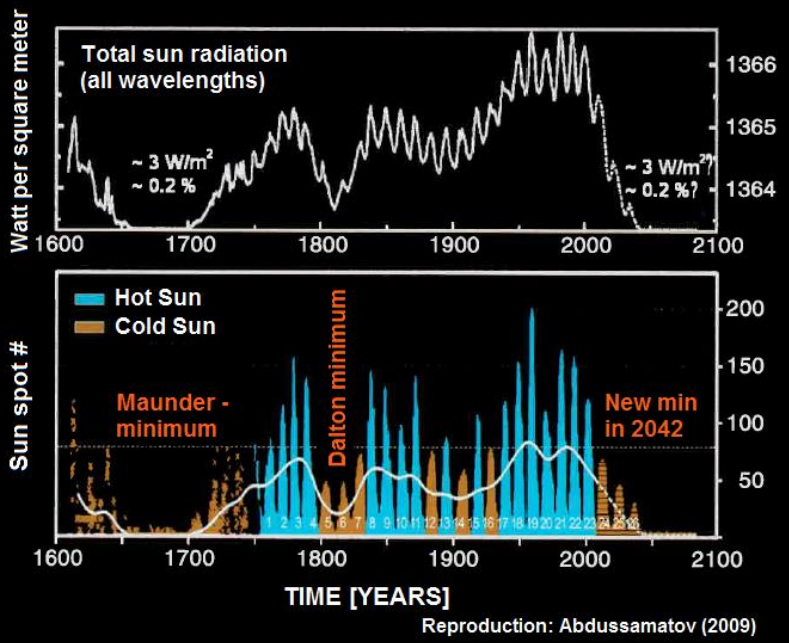
(Proton & electrons)

THE SUN IS A VARIABLE STAR

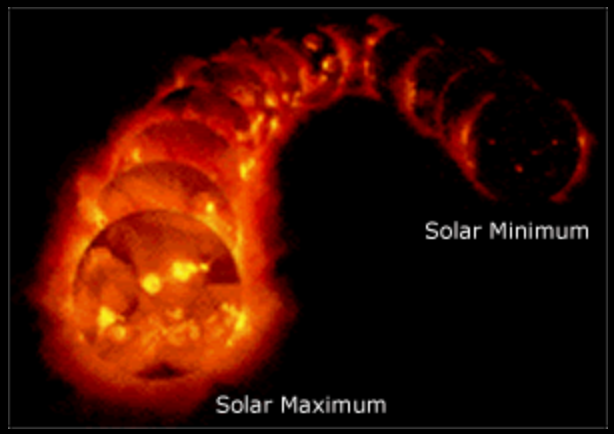




X-ray film of sun activity :

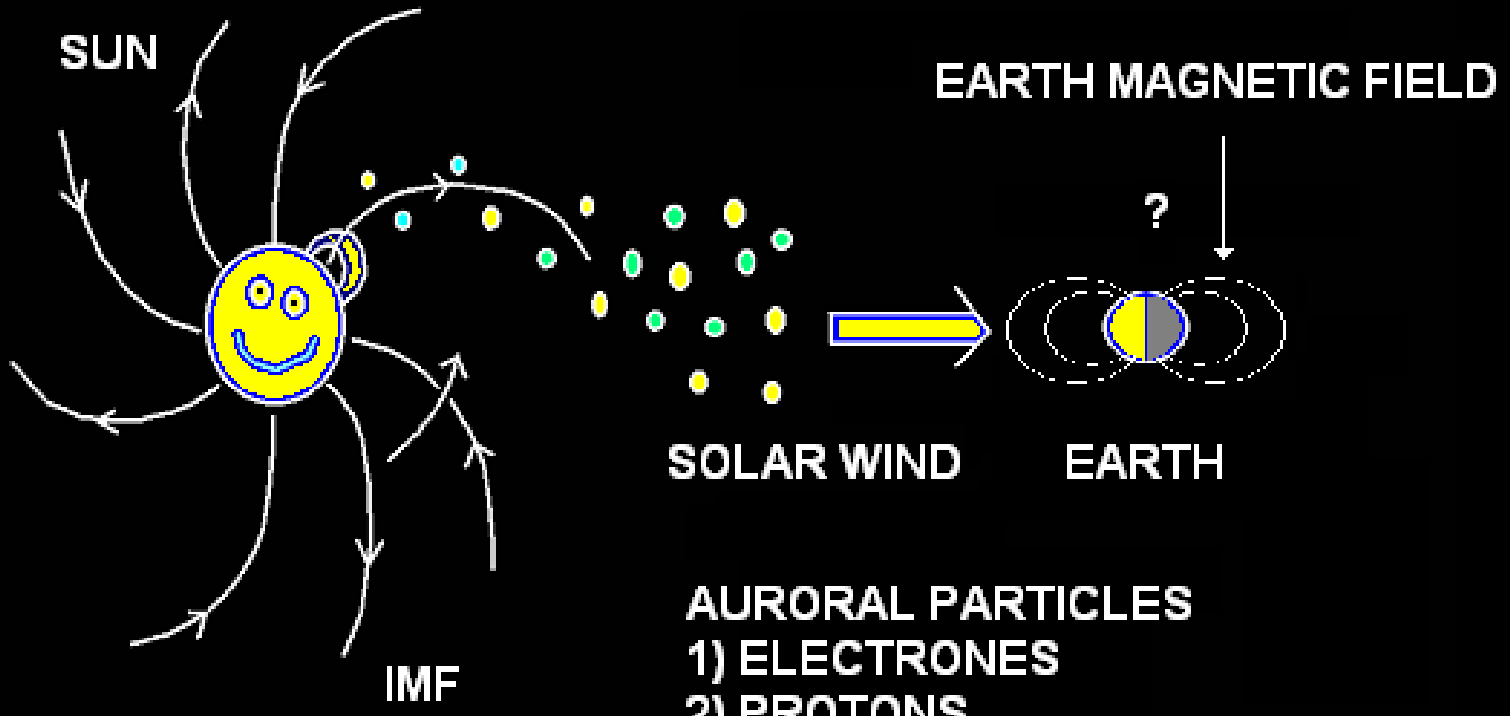


Reproduction: Abdussamatov (2009)



Animations @ NASA

There is wind in space: Solar wind!



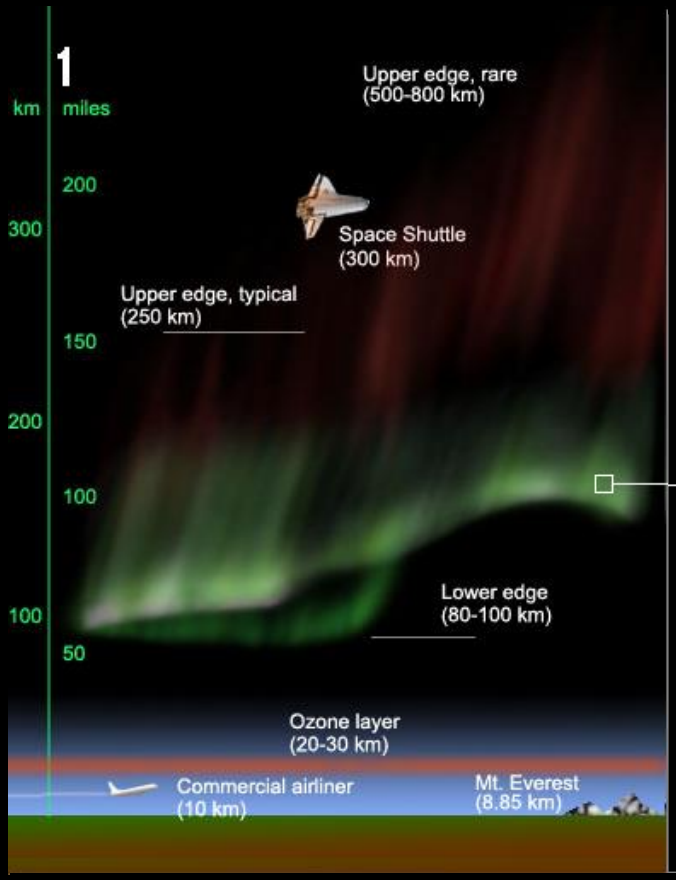
Sun: 26 days rotation; $D = 100 \times D_E$

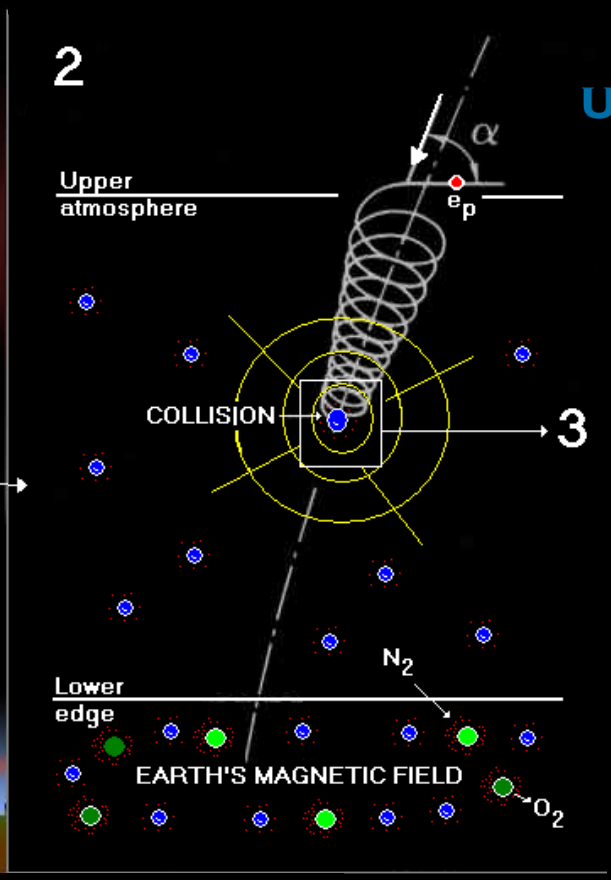
Solar journey

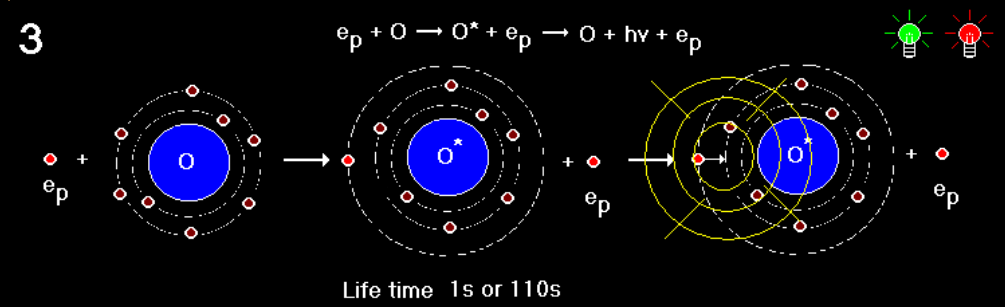
Animations @ UiO

AURORA

THE EARTH' s ATMOSPHERE IS THE LAST DEFENCE







OTHER: $e_p + M_2 \rightarrow M_2^* + e_p \rightarrow M_2 + h\nu + e_p$

$e_p + M_2 \rightarrow M_2^{+*} + e_p + e \rightarrow M_2^+ + h\nu + e_p + e$

$M_2 \in [N_2, \ldots]$

FUTURE: PLASMA FUSION REACTORS?

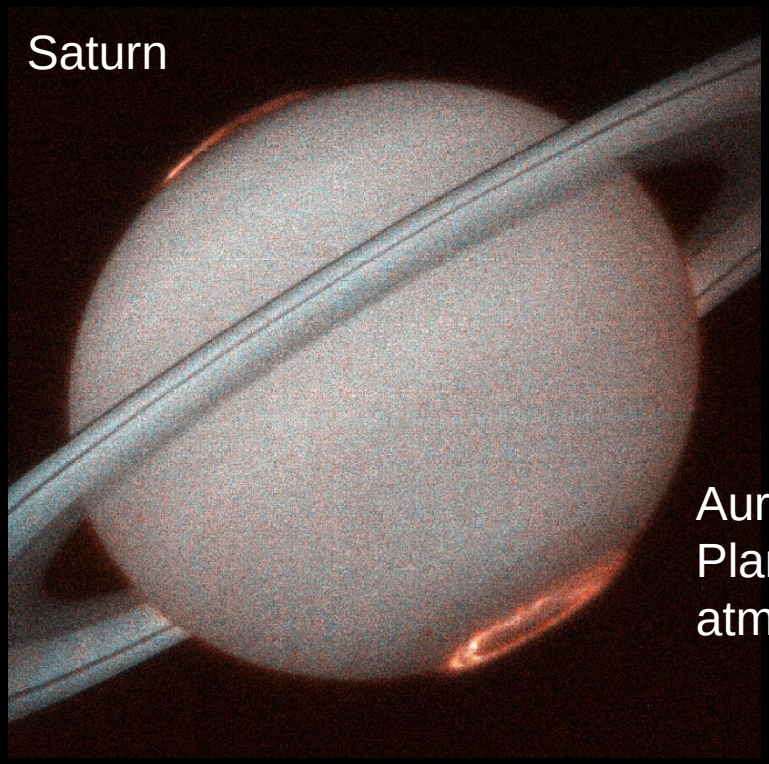
Leakage of diffusion across the magnetic field is the main problem to be successful with controlled fusion of Hydrogen atoms.

We study the same things in nature!

Planetary Auroras

UV Images from the Hubble Telescope

Saturn



Jupiter

Auroras reveal existence of Planetary magnetic fields and atmospheric composition!

The Auroal Oval on the 200 kr note

KHO

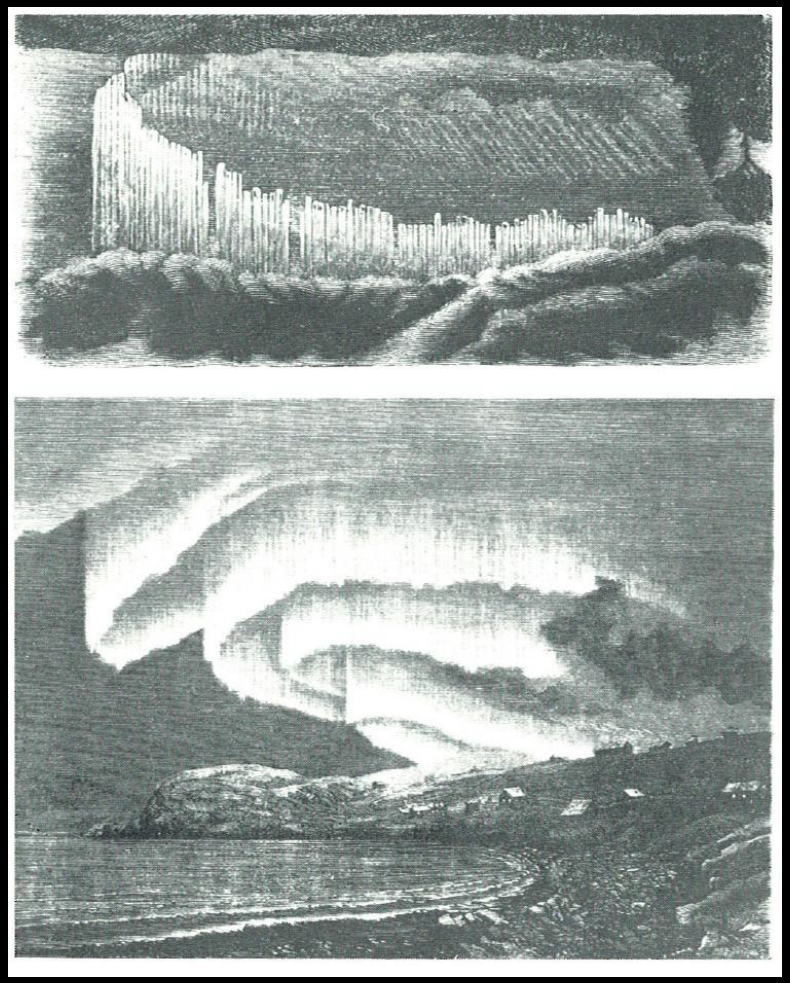
Terrella – a magnetized sphere placed in a vacuum chamber

The aurora ovals are Norwegian!

"A breakthrough with the Terrella Experiment in 1901"

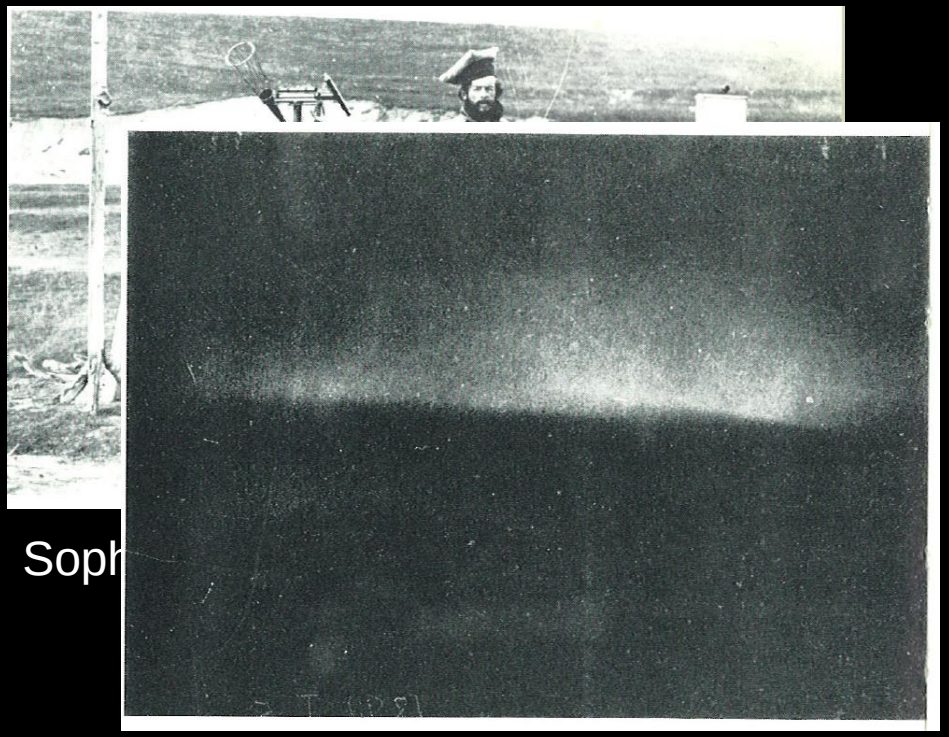
Birkeland currents

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

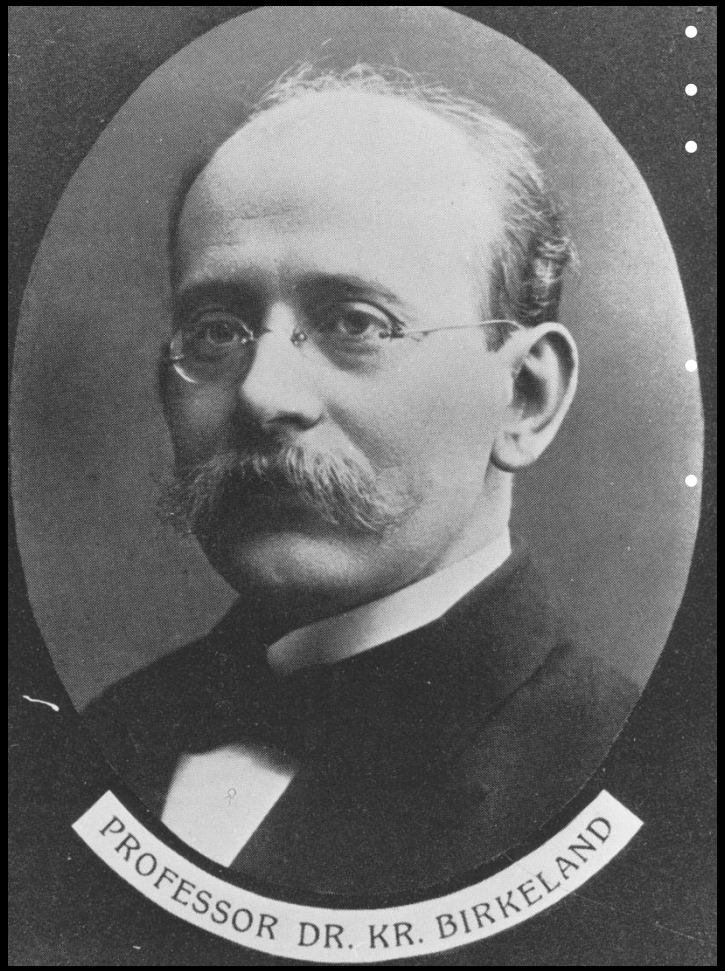


Soph

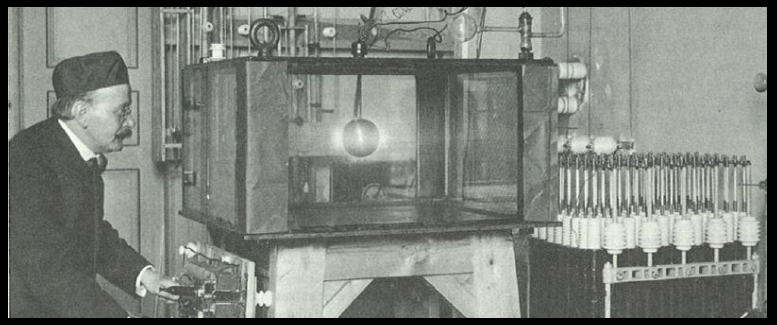
First image of aurora. Bossekop by Brendel (1892) – 7 sec exp.

ALTITUDE = 113 KM (Tromholt)

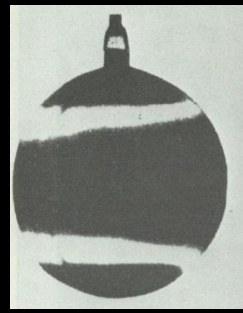
Kristian Birkeland (1867-1917)



- 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
Haldde: 1915-1918
(1886-1986)

.

Krogness and Devik realized that Haldde was to 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 Haldde observatory (1912 - 1927); + focus on meteorology
Head of Haldde 1918 – 26: Hilding Köhler

13.35

GLOBE | SKYVIEW | SETUP | ?

Longyearbyen
27.04.13 22:25:39 UT

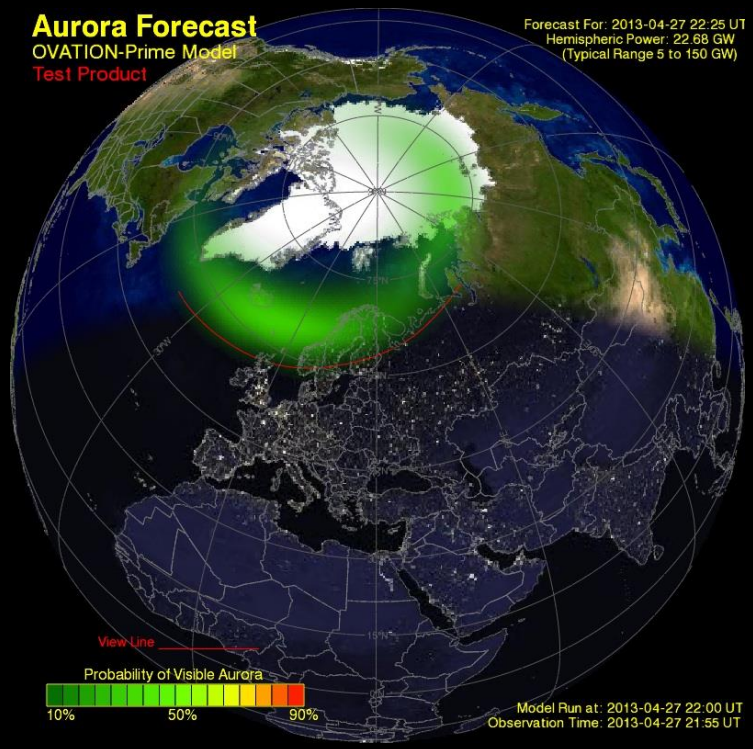
0%

N
W
15%
E
S

+0
+1
+4

Kp = 3.5
Manual Override
Mars RA 33.4° DEC 13.1° 2.44AU

NEXT Details Aurora Forecast 3D



Also popular: The WEB based server snapshots from NOAA SWPC

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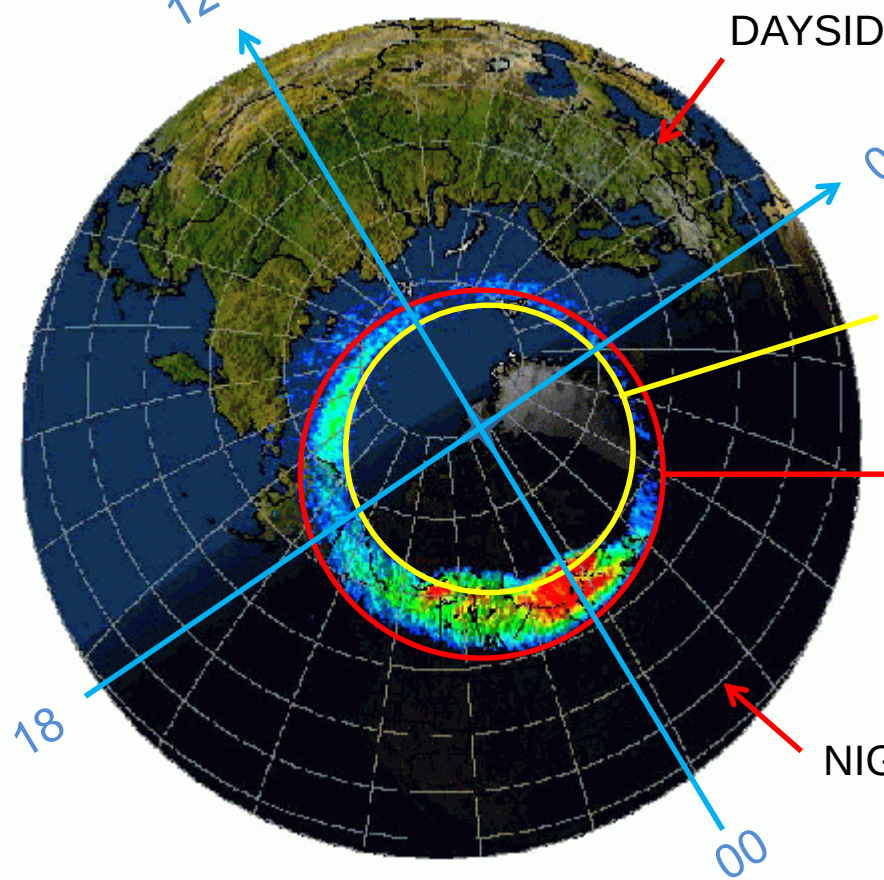
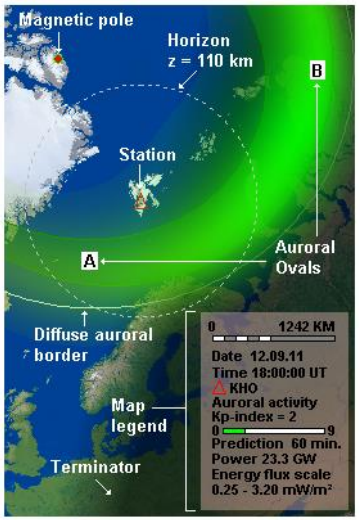
SNOW18, Arctic 365, Alta 14 -15 May, 2018

LOCATION: AURORA OVAL TERMS



Download Android forecast with Q-Code scanner



(A) Auroral oval by Starkov (1994)
(B) Electron energy flux Zhang & Paxton (2008)

F.Sigernes, 2011

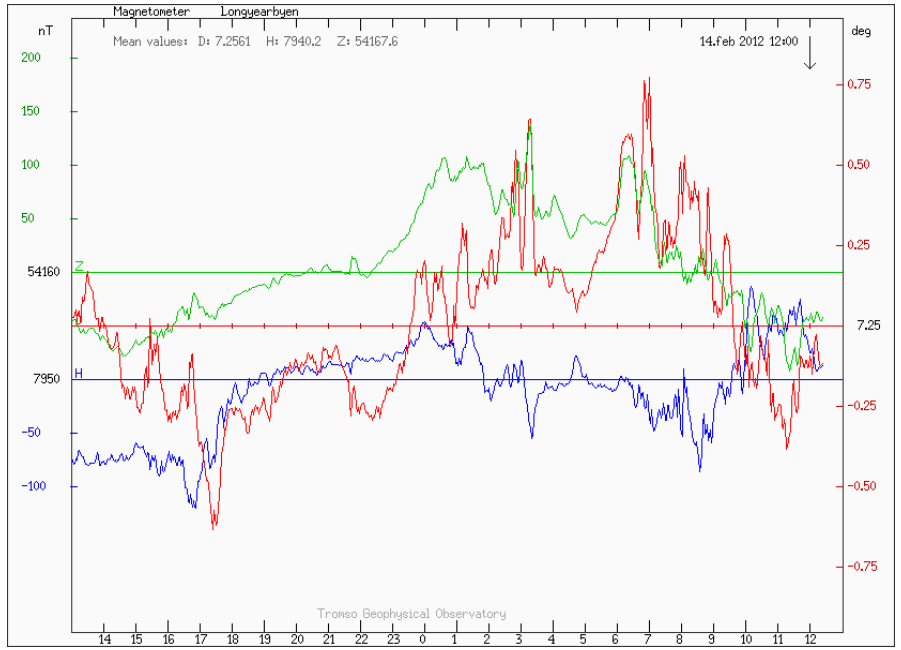
Note: Size and location depends magnetic activity or **Kp index**

GEOMAGNETIC ACTIVITY

K-index	Boulder, CO observatory measurement (nT)
0	0 - 5
1	5 - 10
2	10 - 20
3	20 - 40
4	40 - 70
5	70 - 120
6	120 - 200
7	200 - 330
8	330 - 500
9	>500

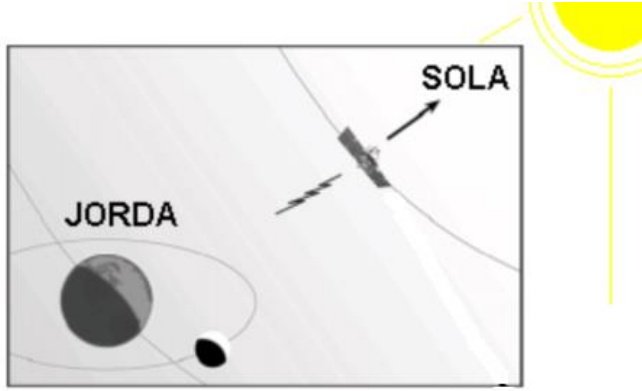
The **K-index** quantifies max disturbances in the horizontal component of earth's magnetic field during a 3 hour period.

Planetary estimated **Kp index** is derived by calculating a weighted average of K-indices from a network of geomagnetic observatories (US Air Force) and NOAA



Using data from solar satellites, located 1 hour upstream in the solar wind, we get the **predicted Kp index**.

Prediction time ~ 60 minutes



MATEMATICAL REPRESENTATIONS OF THE AURORAL OVALS

The Feldstein-Starkov ovals

Poleward and equatorward boundaries of auroral oval in geomagnetic co-latitude:

$$\theta_p \text{ or } \theta_e = A_0 + A_1 \cos\left[15\left(t+\alpha_1\right)\right] + A_2 \cos\left[15\left(2t+\alpha_2\right)\right] + A_3 \cos\left[15\left(3t+\alpha_3\right)\right],$$

where amplitudes A_i and phases α_i is given by

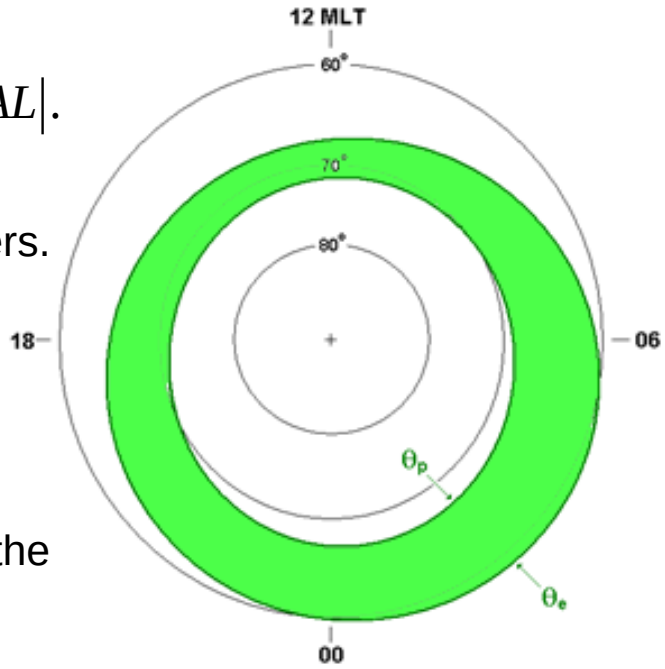
$$A_i \text{ or } \alpha_i = b_{0i} + b_{1i} \log_{10}|AL| + b_{2i} \log_{10}^2|AL| + b_{3i} \log_{10}^3|AL|.$$

The AL index is the max negative excursion of the H component from several ground based magnetometers.

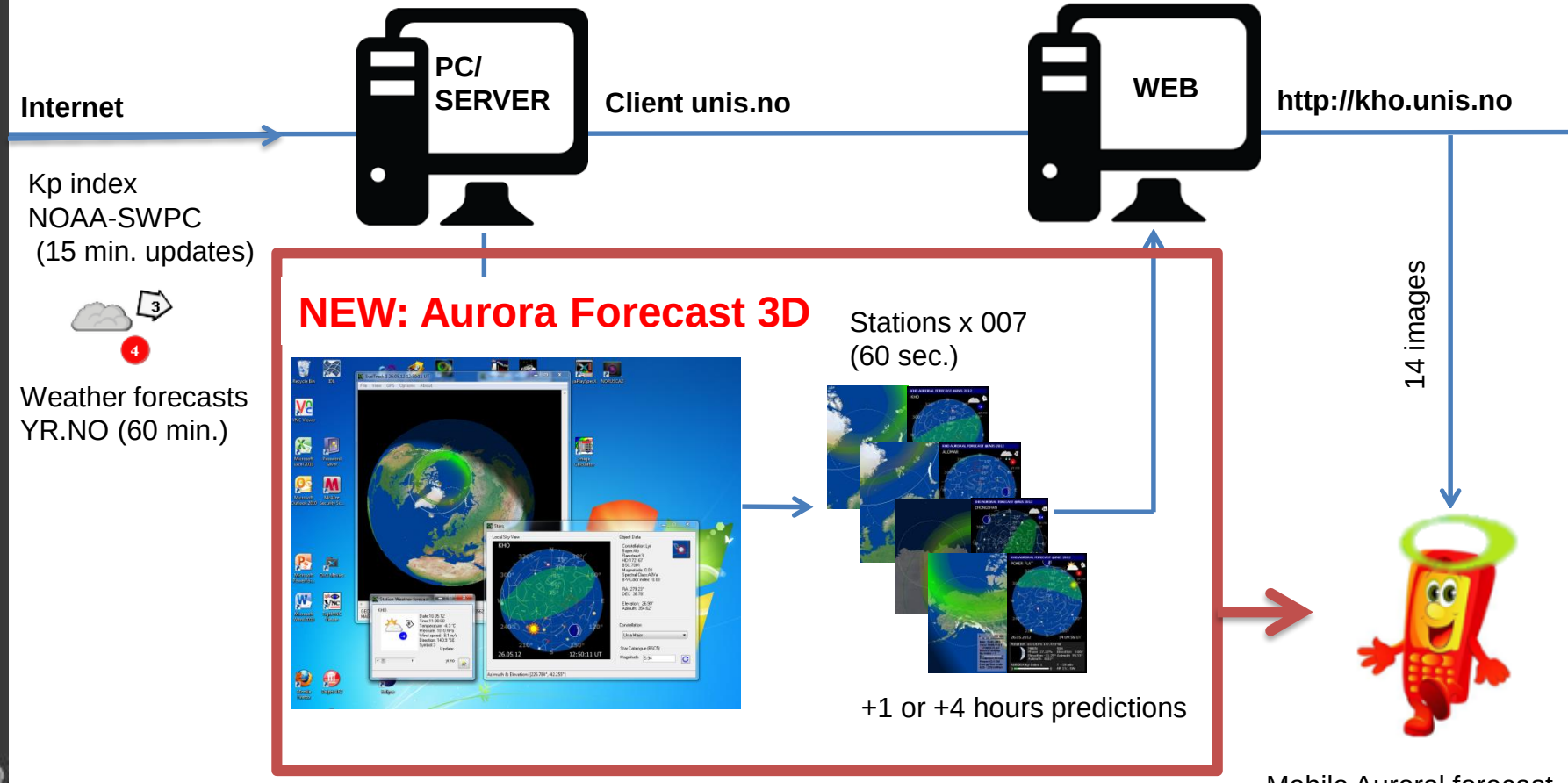
It relates to the planetary Kp index by

$$AL = 18 - 12.3 \cdot K_p + 27.2 \cdot K_p^2 - 2 \cdot K_p^3$$

The Kp is the predicted +1 and +4 hours index from the Wing Kp model at NOAA-SWPC



THE KHO AURORAL OVAL FORECAST SERVICE (2012 – 2018)



Limitations: Only a fixed number of stations available!

THE KHO AURORAL OVAL FORECAST 3D SERVICE (2018)

Internet

1) Kp index
NOAA-SWPC
(15 min. updates)

2) TLE files
- CSSi

(24 hours
updates)

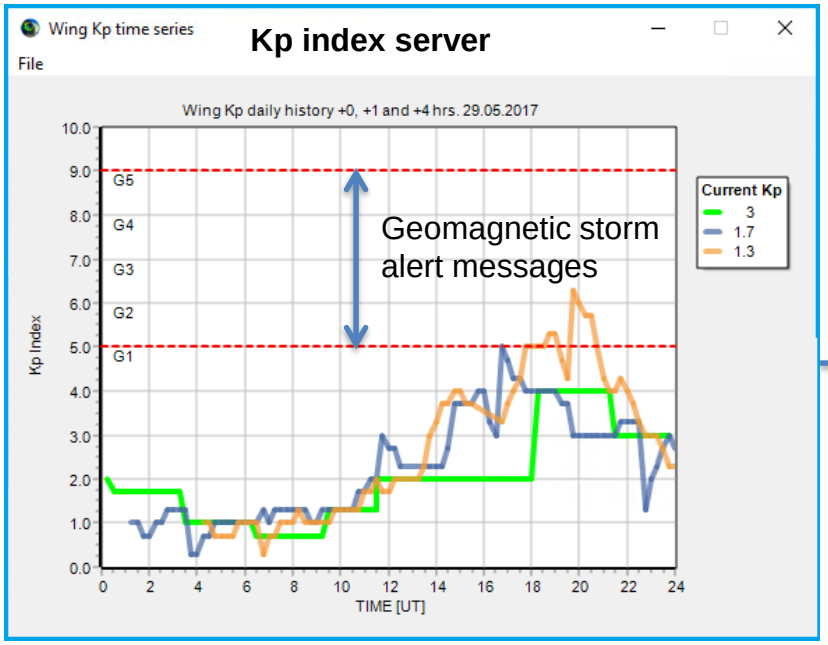
PC/
SERVER

Client unis.no

WEB

http://kho.unis.no

3 numbers
+ TLE file
+Alerts

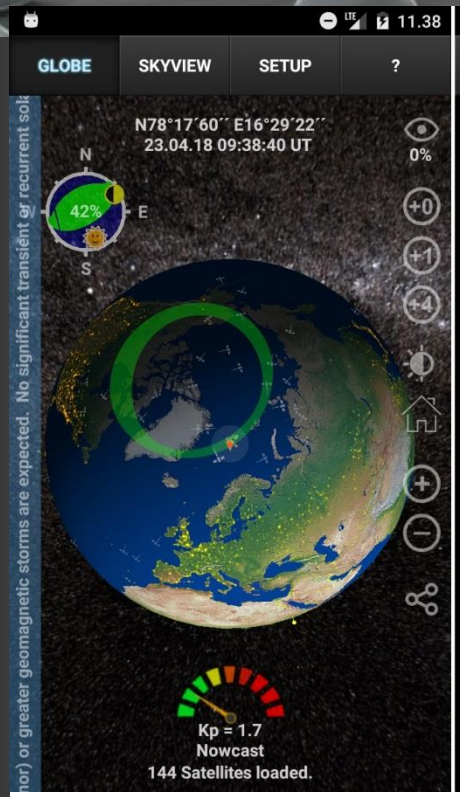


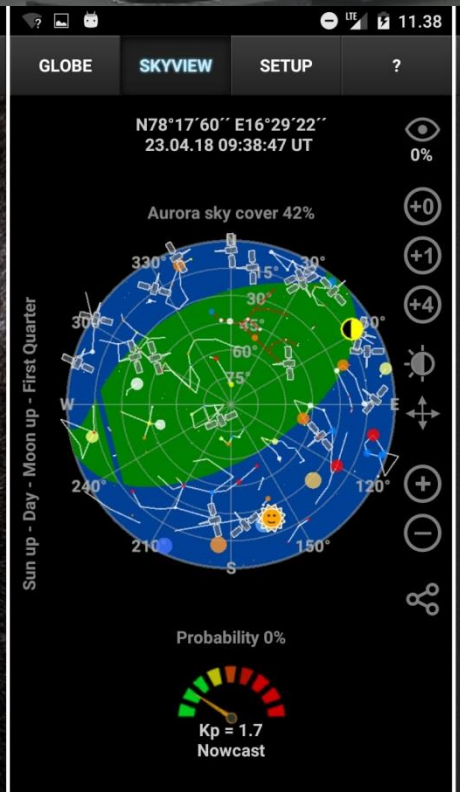
3 numbers

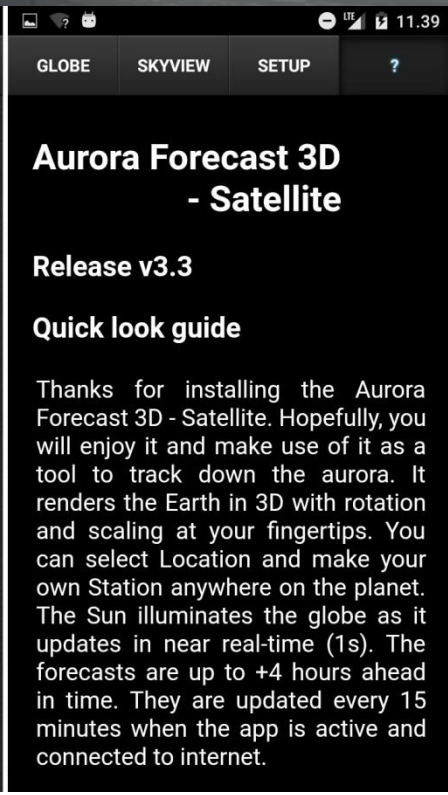
+41 TLE sets
+Alerts

The auroral forecast 3D

Aurora Forecast 3D - Snapshots



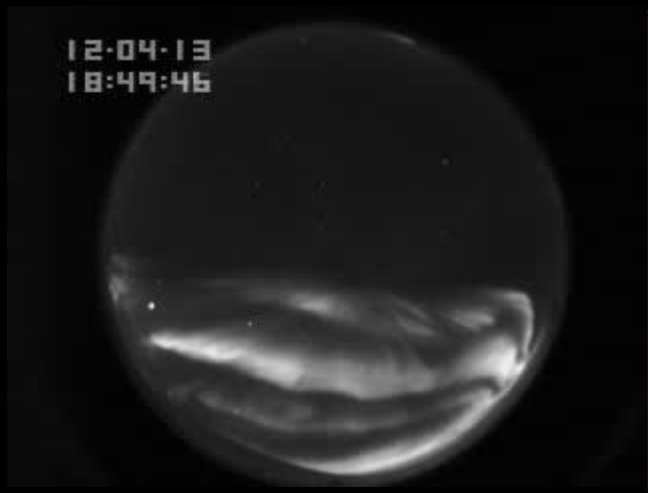


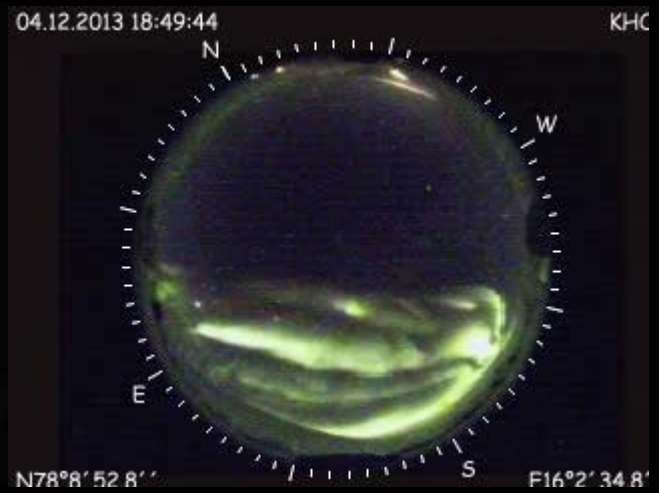


FEATURES

- 3D view port of Earth with zoom and rotation enabled.
- Solar illumination of the Earth and the Moon.
- Aurora oval size and location in real time. [1,2]
- Forecasts based on predicted NOAA-SWPC Kp index.
- Color scaled Kp speedometer.
- Aurora Compass sky view display.
- Editable station / location list.
- Go to animation.
- Right Ascension and Declination of planets. [3]
- Age of the Moon including the phase.
- Includes a 2.4 million star map. [4]
- City light texture. [5]
- Earth, Sun and Moon textures. [6,7]
- Skyview module to track planets and stars. [8]
- Geomagnetic storm alert messages.
- Satellites using TLE sets [9]

KHO
4th of December 2013



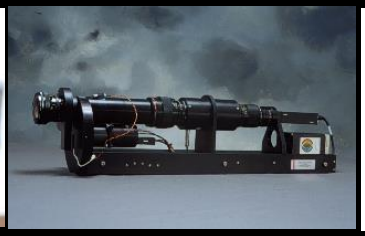


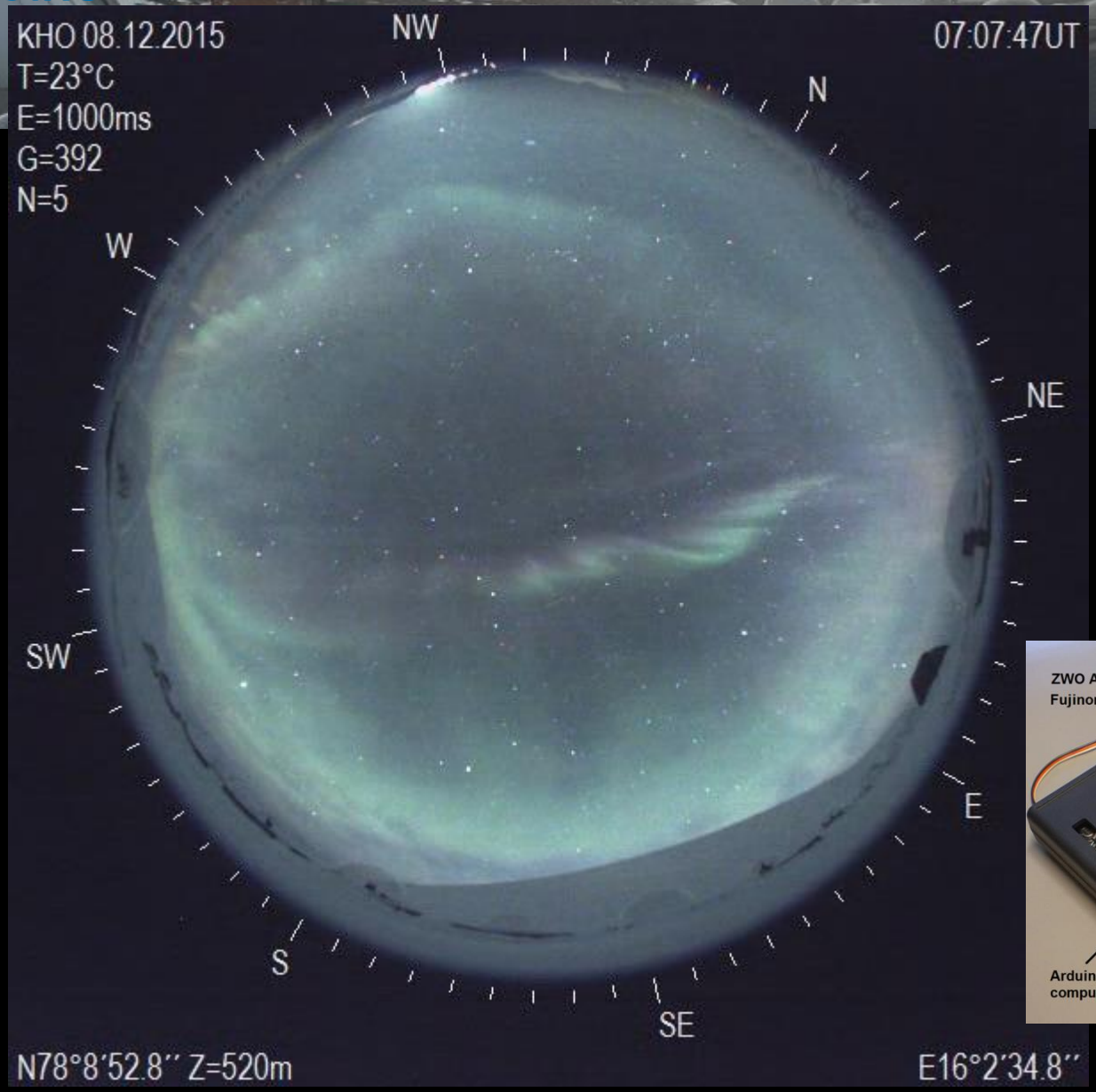
DSLR
Digital Single Lens Reflex
Circular Fisheye 180°
Time resolution: 5 - 30 s
Camera: Nikon D7000
Lens: Sigma 4.5mm f/2.8
Nikon D7000 -16M pixels
Color matrix: RGB

INTENSIFIED CCD
4th Gen Light intensified vacuum tube
Circular Fisheye 180°
Time resolution: 25 msec (real time)
Camera: Video CCD
NTSC: 30 frames /second
Monochrome
Frame accumulation ~1s (30 frames)

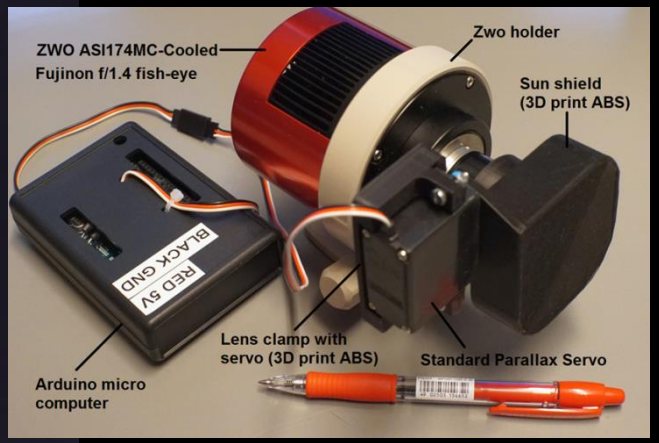
Color EMCCD camera
Electron Multiplying Charge Coupled Device
Circular Fisheye 185°
Time resolution: 25 msec (real time)
Camera: Raptor Hawk EM246
PAL: 25 frames / second
Color matrix: CYMG
Frame accumulation ~1s (25 frames)

Price (US $) : ~ 1K ~ 2K ~ 60K 60 - 90K ~9K

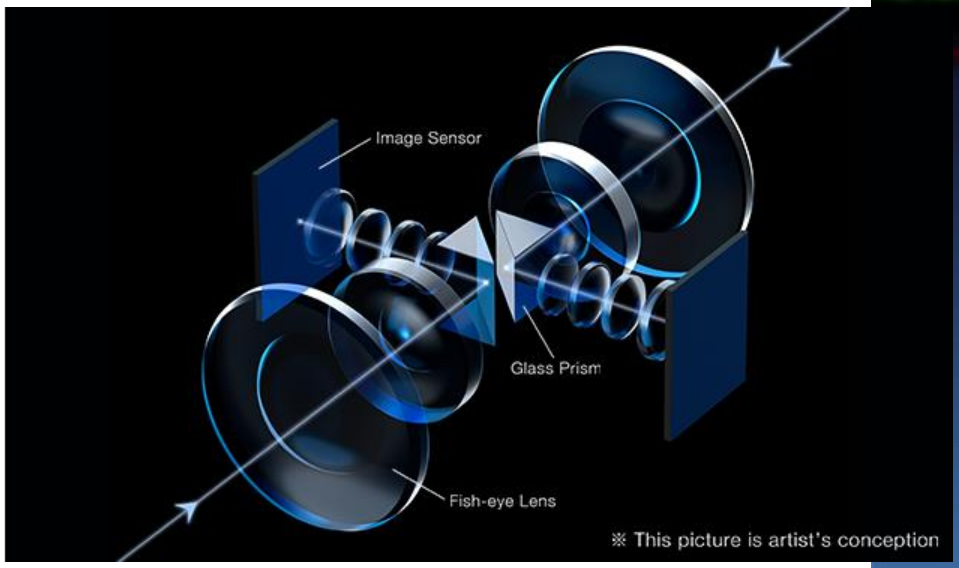




Pre noon
Dayside aurora



360 image of the aurora
The Ricoh Theta S



http://kho.unis.no/Gallery/2017/Aurora360/index.html

The exposure time is 3.5 second at ISO 1600.

Downloads

Platform	Where	Link / Search words	Rating/Users Aug 17
Android Mobile	Google Play Dec 16	"Aurora Forecast 3D"	4.0 / 6894
Apple iOS phone	Apple Store Aug 17	"Aurora Forecast 3D"	? / 679
Windows 32-bit PC	http://kho.unis.no	AuroraForecast3D_Win32.zip	-
Windows 64-bit PC	http://kho.unis.no	AuroraForecast32_Win64.zip	-
Apple OSX iMac	http://kho.unis.no	AuroraForecast32_OSX.zip	-

Acknowledgement

We wish to thank

The National Oceanic and Atmospheric Administration (NOAA) - Space Weather Prediction Centre for allowing us to download the predicted value of the K_p index every 15 minutes. The positions of the satellites are calculated by code [8] based on Two-Line Element (TLE) sets provided by the Center for Space Standards and Innovation (CSSi).

PS! The Aurora Forecast 3D is *fredware*….

References

[1] Sigernes F., M. Dyrland, P. Brekke, S. Chernouss, D.A. Lorentzen, K. Oksavik, and C.S. Deehr, Two methods to forecast auroral displays, Journal of Space Weather and Space Climate (SWSC), Vol. 1, No. 1, A03, DOI:10.1051/swsc/2011003, 2011.

[2] Starkov G. V., Mathematical model of the auroral boundaries, Geomagnetism and Aeronomy, 34 (3), 331-336, 1994.

[3] P. Schlyter, How to compute planetary positions, http://stjarnhimlen.se/ , Stockholm, Sweden.

[4] Bridgman, T. and Wright, E., The Tycho Catalog Sky map- Version 2.0, NASA/Goddard Space Flight Center Scientific Visualization Studio, http://svs.gsfc.nasa.gov/3572, 2009.

[5] The Visible Earth catalog, http://visibleearth.nasa.gov/, NASA/Goddard Space Flight Center, April-October, 2012.

[6] T. Patterson, Natural Earth III - Texture Maps, http://www.shadedrelief.com, 2016.

[7] Nexus - Planet Textures, http://www.solarsystemscope.com/nexus/, 2013.

[8] Hoffleit, D. and Warren, Jr., W.H., The Bright Star Catalog, 5th Revised Edition (Preliminary Version), Astronomical Data Center, NSSDC/ADC, 1991.

[9] Vallado, David A., Paul Crawford, Richard Hujsak, and T.S. Kelso, Revisiting Spacetrack Report #3, AIAA/AAS 2006-6753, https://celestrak.com, 2006.