Space Weather: effects on technology, biosphere and society



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The root of all good and evil



The root of all good and evil



The root of all good and evil



Space Weather



The oldest known Space Weather effect: Aurora









Aurora Borealis

Aurora Australis

Space Weather: *effects*



Space Weather: *effects*





Space Weather: Schema huius præmiffæ diuifionis Sphærarum.



Spheres in modern science





Magnetosphere



A tale of two magnetospheres: the HOT: Radiation Belts



A tale of two magnetospheres the COLD: Plasmasphere



A tale of two magnetospheres why is it important?

- Density variations in *Plasmasphere*
- => wave-particle interaction with
- *Radiation Belts*' particles =>
- acceleration and precipitation
- of high (relativistic) energy
- particles =>
- damage of satellites' solar cell and electronics
- energy transfer into the neutral atmosphere



Relativistic electron precipitation & & surface charging

Temporary or permanent damage of satellite electronics:

- Telecommunication (Internet, TV, telephone)
- Navigation (GPS, GLONASS, Galileo)
- Remote sensing (Meteorology, natural hazards, disasters)

A tale of two three magnetospheres the WARM : Ring Current



ENA image on IMAGE

Magnetic storms











Meltdown of a transformer in South Africa due to the Halloween storm in October – November 2003.





Swedish pipeline data.



In 2006 oil was flowing out from the Alaska pipeline. Additional corrosion due to GIC's may have contributed to this accident. Here: Alaska pipeline near Fairbanks.



Space Weather effects on biosphere



Space Weather effects on biosphere



Space Weather effects on biosphere/climate



The Hunters in the Snow by Pieter Brueghel the Elder, 1565

Space Weather effects on biosphere/climate



View of River Thames in Winter (1660) by Aert can der Neer (1603-1677)

Space Weather effects on biosphere



Space Weather effects on biosphere People died Buosia (19)

2 = Sunspot or Wolf number

People died in cholera in Russia (1823-1923)

Occurrence of scarlet vs. latitude per 10000 inh.



Space Weather effects on biosphere





Occurrence of paralysis in Japan per 10000 inh.

Occurrence of dysentery in world per 10000 inh.

Occurrence of tetanus in Australia per 10000 inh.

Wave-particle interaction-



Wave-particle interactionprecipitating energy



Energetic particle precipitation and the atmosphere

Particle precipitation into the middle atmosphere (30 - 100 km) increases ionisation

lonisation leads to production of NO_x (and short-lived HO_x) through ion chemistry

NO_x (and HO_x) gases cause catalytic Ozone destruction

Ozone important to temperature and dynamics

Proton and electron precipitation, SPEs, REP, etc.

NO_x (NO + NO₂) chemical lifetime months during polar winter

 $2(\text{NO} + O_3) \rightarrow 2(\text{NO}_2 + O_2)$ $\text{NO}_2 + h\underline{v} \rightarrow \text{NO} + O$ $\text{NO}_2 + O \rightarrow \text{NO} + O_2$ $\text{NO}_2 + O \rightarrow \text{NO} + O_2$ $\text{Net: } 2O_3 \rightarrow 3O_2$

Link to surface temperature variability?

Music of the spheres How does it sound?

Music of the spheres How does it look like?

Dunedin, 2006-02-04 11:50:23UT



A brief history

 1886 Sonnblick High Altitude Observatory, Austria (cf. Hertz experiment, 1887): whistling noise on 22km long telephone line



A brief history II.

- Barkhausen, WWI: spy on enemy communications – or 'heard the grenades fly'
- 1953 L. R. O. Storey: origin and propagation of whistlers, *plasmasphere, short* and *long* whistlers
- 1956 R. Helliwell: nose whistlers
- 1963 D. Carpenter *plasmapause*

Origin of whistlers



0.9

What are the *whistlers* good for?

- 1. Nose frequency
- 2. Dispersion
- From 1. + 2. => where & what
- Where did it travel in *plasmasphere*
- What was the plasma density there

Automatic Whistler Detector and Analyzer (AWDA) system [Lichtenberger et al., JGR, 2008]:

Whistlers are searched in the broad-band VLF signal without human interaction

Automatic whistler analyses yields plasma and propagation parameters \rightarrow electron density distribution \rightarrow *Space Weather*

AWDANet

Extending network of AWDA systems covering low-, mid- and high (magnetic) latitudes since 2002 including conjugate locations ~50 000-10 000 000 (!) traces/year/station

Real time operation is in *experimental* phase

AWDANet -Europe



AWDANet - World



The AWDANet station – the first stand-alone Hungarian space experiment in Antrctica





SANAE, Antarctica, the advent of twelfth-night, 2006

