Space Weather effects on Earths Climate
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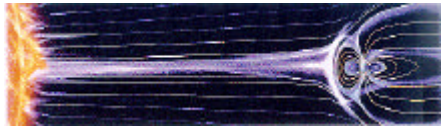

Space Weather Effects

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- High-Energy Particle Radiation Studies

SWWT Meeting 30 September 2002

Does Space Weather Affect Earth's Climate ????

Solar Activity and Climate

Yes !!!

George Reid [1987, 2000]

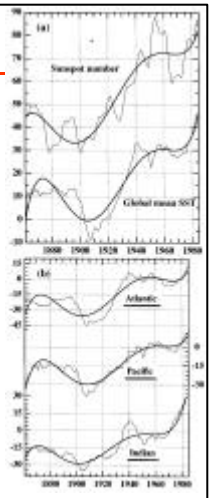

Figure 1. (a) Eleven-year running means of the annual sunspot numbers (upper light curve) and of the annual mean global sea-surface temperature shown as departures from the 1951–80 average in units of 0.01K (lower light curve). Heavy curves are least-squares 7th degree polynomial fits to the data. (b) Same as (a) for the three major ocean basins.

FP6 Expression of Interest

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Space Weather effects on Earth's Climate

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Space Weather Effects on Climate

A number of Space Weather parameters have been observed to vary in a concerted way with solar activity, which is most easily spotted in the 11-year solar cycle. There is also evidence for longer term variability. Important Space Weather parameters directly related to the varying solar activity are the following:

- ***varying total solar irradiance intensity and spectrum***
- ***the varying solar UV, EUV and X-ray emissions***
- ***solar high-energy particle radiation events***
- ***solar energetic particle emission, i.e. solar wind***
- ***solar magnetic field embedded in the solar wind***

and also parameters that represent indirect effects of solar activity like

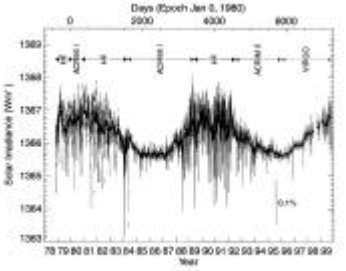
- ***solar cycle variations in high-energy cosmic ray particle radiation intensities***
- ***high-energy particle precipitation from Earth's radiation belt***

There is strong support for the view that these varying parameters influences the Earth's climate. However, the processes which connect Space Weather with climate are still subject to considerable debate. Several mechanisms have been proposed. Among the most prominent are the following:

Space Weather Effects on Climate

- **Cyclic changes in total solar irradiance.**

The intensity of solar radiation has been recorded reliably from satellites only since 1978. The variations over a solar cycle appear to be of the order of 0.1% corresponding to a change of around 0.24 W/m^2 in average power input to the Earth. Modelling the effects of such changes on the sea surface temperature (SST) results in anticipated variations of the order of a few tenths of a degree. Attempts have been made to trace such variations back to the little ice age. The indications are that the Sun's total irradiance may have varied by 0.2% to 0.6% during these 300 years. This variation would then correspond to mean temperature changes on the order of 0.5 to 1 degree.



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- **Variations in solar UV irradiance.**

The solar cycle variations in the irradiation at ultraviolet wavelengths is one to two orders of magnitude larger than the variations in total irradiance. Most of the UV radiation is absorbed in the stratosphere and can not directly influence the troposphere or ground temperatures. The UV radiation contributes to producing ozone which acts as a greenhouse gas assisting to enhance the effect of solar irradiance on Earth's temperatures. Some model calculations, in addition, indicate that dynamic coupling between the stratosphere and the troposphere could cause effects in tropospheric winds and storm tracks from variations in solar ultraviolet fluxes and changes in stratospheric ozone.

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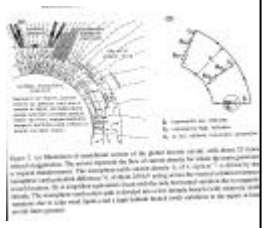
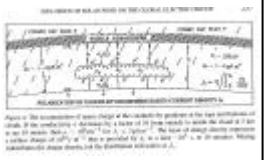
Variations in troposphere temperatures and cloud physics by global electric circuit changes.

The global electric circuit is powered by thunderstorm activity mainly in the tropic regions and by the polar cap electric potentials generated by the solar wind. The global electric circuit is strongly influenced by the conductivity of the atmosphere.

The global conductivity properties may have considerable solar wind modulation due to the ionising effect from the variable cosmic radiation, from precipitation of high-energy electrons from the radiation belts and from occasional solar proton events both of which relate to the solar activity cycle. The electric field is assumed to affect cloud formation through droplet charging and ice nucleation processes.

Various sources suggest that the above sources of radiative forcing from natural variations are comparable in magnitude to the radiative forcing by anthropogenic greenhouse gases.

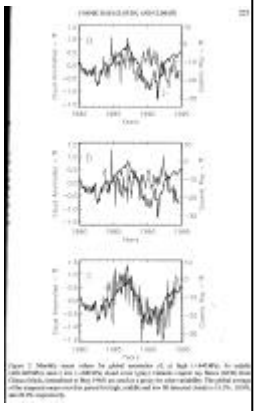




Space Weather Effects on Climate

- **Variations in Earth's cloud cover related to changes in cosmic radiation.**

The heliosphere is shielded from the high-energy cosmic particle radiation by the Sun's magnetic field. The solar magnetic fields are transported by the solar wind to distances far beyond the orbit of the Earth. The shielding against the cosmic radiation by the interplanetary magnetic field is strongest at solar maximum. Thus the intensity of galactic cosmic radiation is coarsely in anti-phase with solar activity. A fraction of the cosmic radiation can penetrate to the stratosphere and upper troposphere and may cause substantial ionisation at these altitudes. The enhanced concentration of ions is expected to increase the formation of cloud condensation nuclei. From examination of the cloud cover on a global scale and the cosmic ray intensity variations as deduced from ground-based neutron monitors an apparent relation between cloud cover and galactic cosmic ray intensities has been found.



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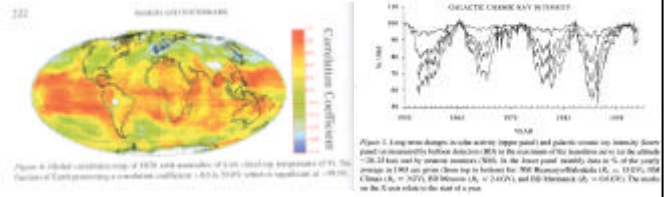
The Cosmic Ray Cloud Theory has been debated in several tens of publications. No consensus has been reached yet. The theory has severe problems which are now recognised by the authors.



Space Weather Effects on Climate

Expected Results from the Proposed Work

The project strives to identify and quantify those space weather effects which are prime contributors to variations of the Earth's climate. We aim at reaching consensus among scientists on the mechanism and the extent to which space weather phenomena entail climate changes. A well-founded and widely accepted view on these issues will provide guidance to national and EU authorities when making far-reaching, economically straining and occasionally unpopular decisions to protect the environment and avoid undesirable climatic development.

Experience has shown that disagreement between scientists can have a paralysing effect on decision makers.

The reporting of results from the proposed work will serve to inform the public in the European countries in a scientifically well-founded way on natural variations of environmental and climate conditions. Such information is expected to enhance the public awareness of environmental and climatic issues and to create support for necessary actions to protect the life on planet Earth.