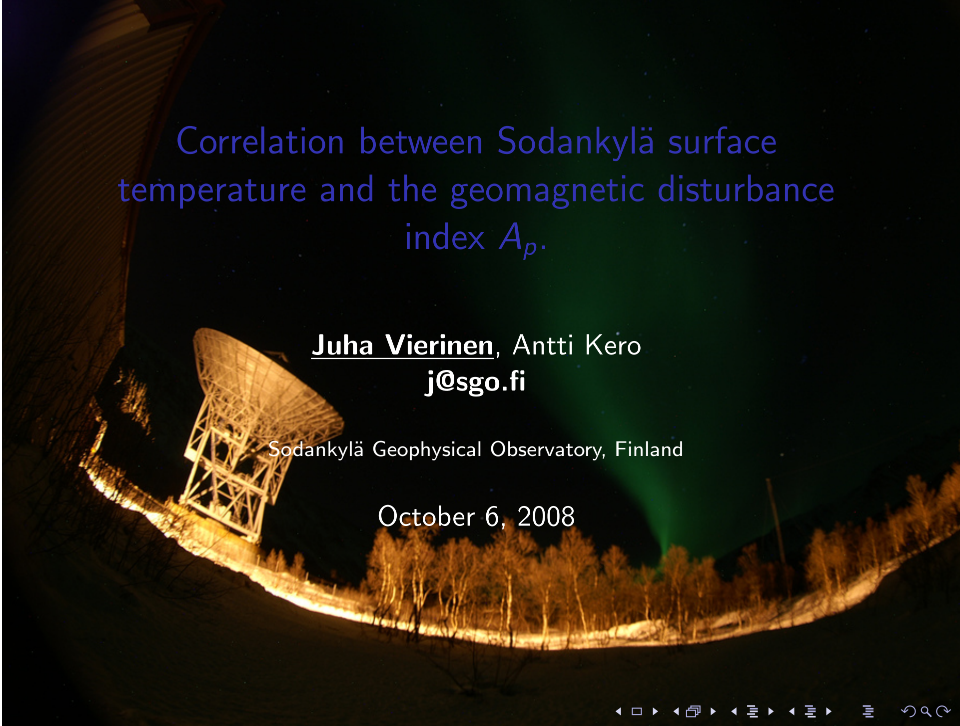


Correlation between Sodankylä surface temperature and the geomagnetic disturbance index A_p.

Juha Vierinen, Antti Kero
j@sgo.fi

Sodankylä Geophysical Observatory, Finland

October 6, 2008

Geomagnetic disturbance indices

- A_k is a *heuristically* formed measure of the largest magnetic field variation within three hours (in nT scale).
- A_p index is a global equivalent, averaged over different stations around the world.
- A proxy of high energetic particle precipitation.

(E. Kataja, *Magneettisen aktiivisuuden mittaamisesta*)

Geomagnetic disturbance indices

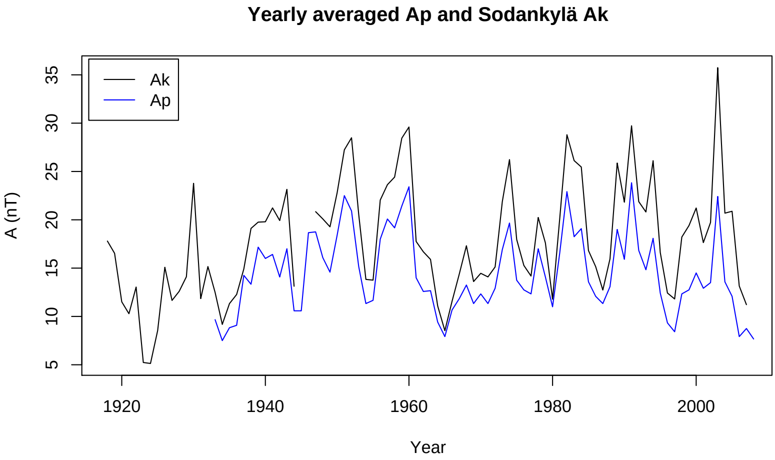


Figure: Yearly averaged Sodankylä A_k and planetary A_p.

A_k and EUVB flux

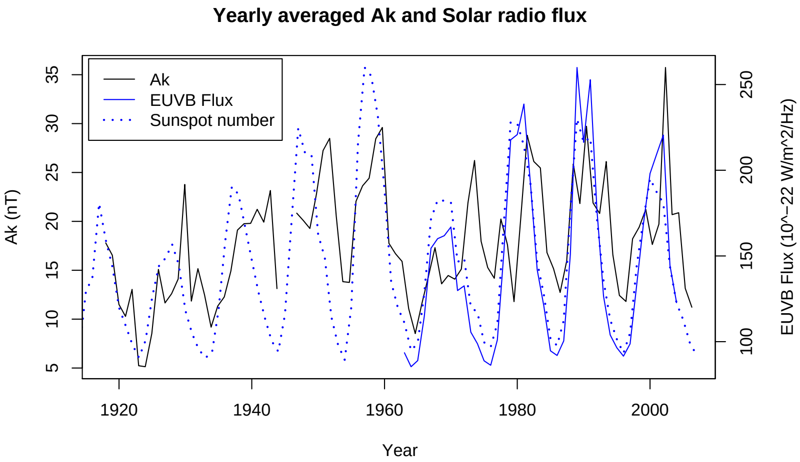
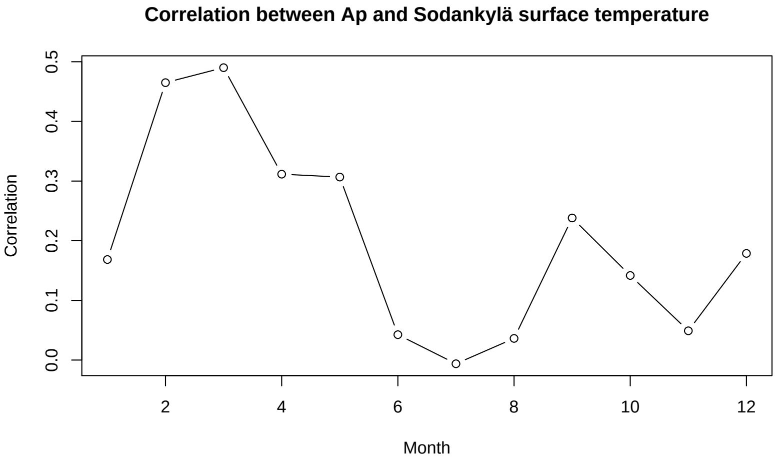


Figure: Yearly averaged Sodankylä A_k and Solar EUVB flux (Tobiska et.al. 2000). A_k and EUVB flux correlated, with a certain lag.

Polar surface temperature T and the A_k index

- There are several reports of the correlation between northern hemisphere polar spring-time surface temperature and the geomagnetic disturbance indices (Bucha 2002, Palamara 2003).
- Recently, work by Seppälä (2004, 2008), Rosanov (2005), and Lu (2008) have renewed interest in the topic, by suggesting a new mechanism for the effect.
- Sodankylä has a long time-series of temperature with no urban heat-island effect – what does the data look like?

The strongest correlation is in the Spring



Sodankylä February surface temperature and A_p

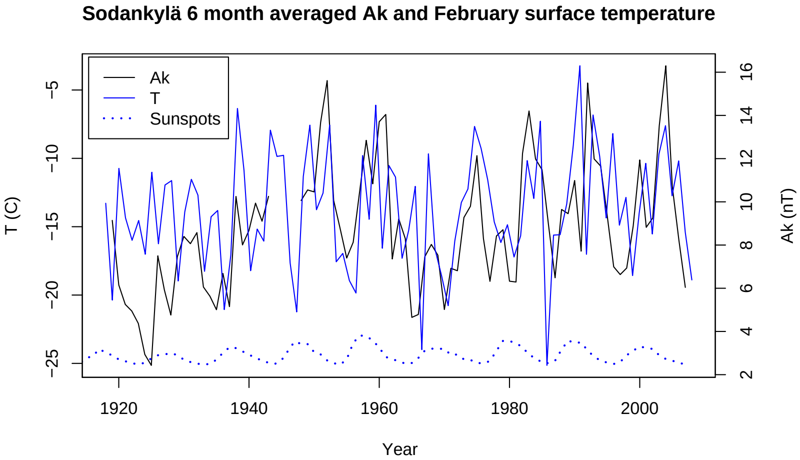


Figure: Sodankylä averaged A_k over September-February, and preceding surface temperature in February.

Sodankylä February surface temperature and A_p

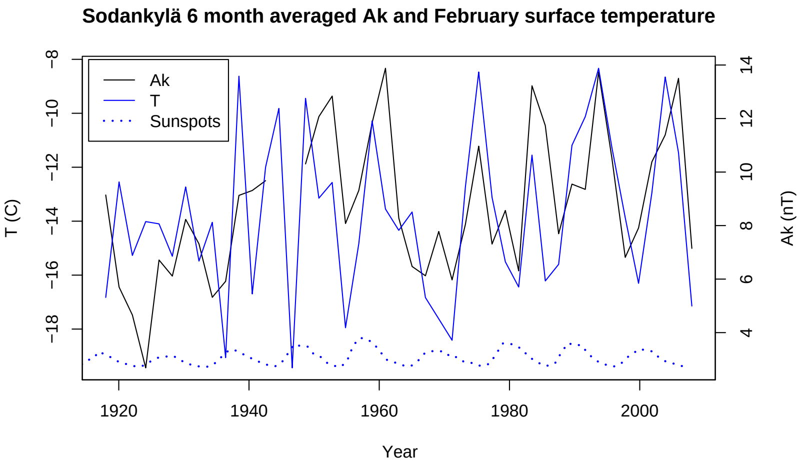


Figure: Sodankylä averaged A_k over September-February, and preceding surface temperature in February. Two-year average.

Sodankylä February surface temperature and A_p

Figure: Sodankylä averaged A_k over September-February, and preceding surface temperature in February.

Possible explanations

- Stratospheric ozone is affected by ultraviolet radiation flux, that depends on the solar cycle (*Humphreys 1910*). Correlation with A_p is a side-effect of the fact that A_p is also somewhat correlated with EUVB flux.
- Correlation between A_p and surface temperature is indirectly caused by changes in wave ducting condtions. *(Lu, H., M. A. Clilverd, A. Seppälä, and L. L. Hood, 2008)*
- The magnetometer measurement is temperature dependent (e.g., 0.7 nT/K, Kataja). However, A_p is global index and measurement stations are kept at nearly constant temperature.
- Reactive radicals (NOx) produced by auroral activity are transported to the stratosphere, where they interact with ozone, causing changes in global circulation. *(Rosanov et.al. 2005, Sinnhuber et.al. 2007)*

Detected NO_2 enhancements and O_3 depletions

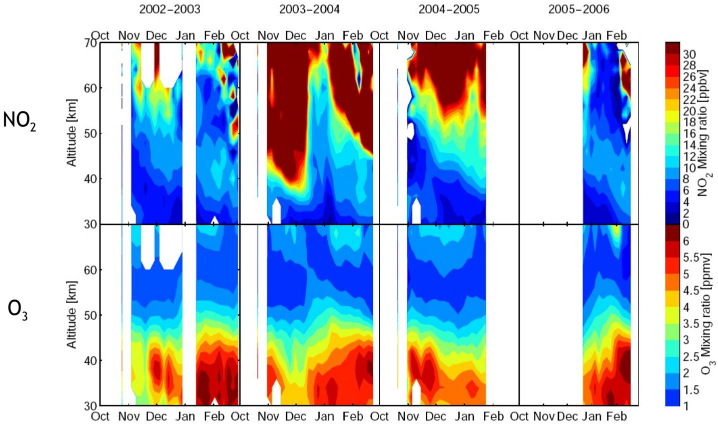


Figure: Detection of NO_2 enhancements and O_3 depletions during the polar winter *(A. Seppälä 2004)*.

Global circulation model, taking this into account

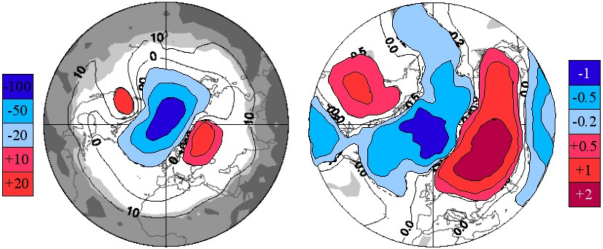


Figure 6. Changes in geopotential height at 50 hPa (m), and SAT (K) for boreal winter due to EEP. The light/dark/heavy shading shows the regions where the changes are judged statistically significant at or better than the 20%/10%/5%) levels.

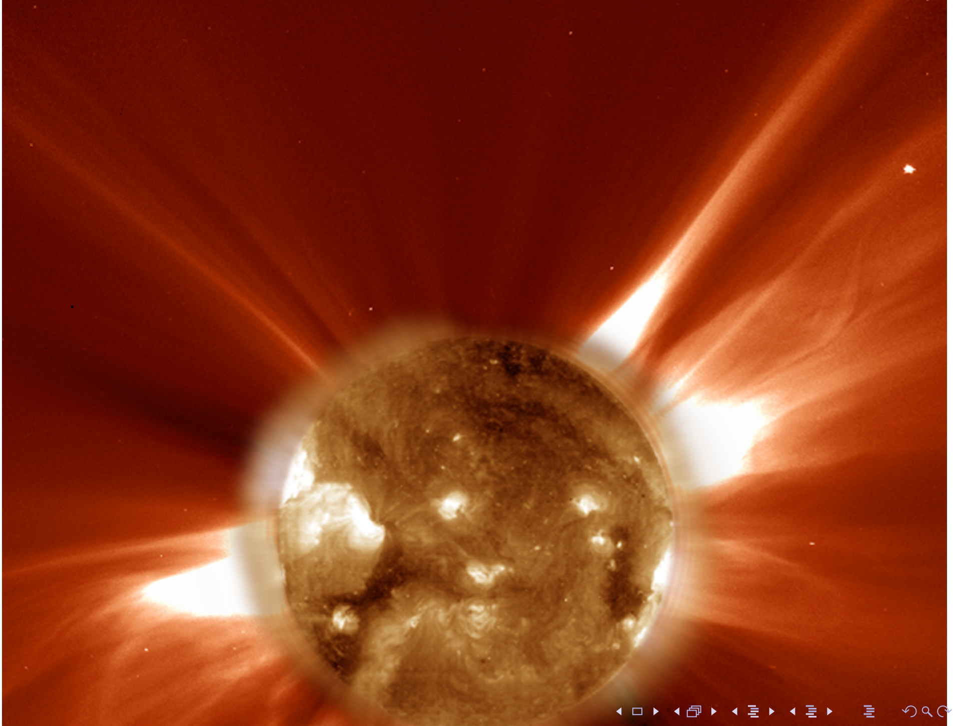
Figure: Modeled surface temperature changes, assuming *(Rosanov 2005)*.

Speculation

- Geomagnetic forcing drives ENSO and NAO (Bucha 2002, Palamara 2003).
- However, **no conclusive proof yet**.

Conclusions

- There is a strong Solar signal in polar spring-time surface temperature.
- Why is A_p and spring-time surface temperature T correlated? It is an open question.
- Does high energetic particle precipitation effect polar surface temperature, or does surface temperature effect the measurement of the geomagnetic disturbance index – or is the mechanism even more complicated?
- Correlation $\neq$ causality.



Sun Storm: A Coronal Mass Ejection

The Sun-orbiting SOHO spacecraft has imaged many erupting filaments lifting off the active solar surface and blasting enormous bubbles of magnetic plasma into space. Direct light from the sun is blocked in the inner part of the above image, taken in 2002, and replaced by a simultaneous image of the Sun in ultraviolet light. The field of view extends over two million kilometers from the solar surface. While hints of these explosive events, called coronal mass ejections or CMEs, were discovered by spacecraft in the early 70s, this dramatic image is part of a detailed record of this CME's development from the presently operating SOHO spacecraft. Near the minimum of the solar activity cycle CMEs occur about once a week, but near solar maximum rates of two or more per day are typical. Strong CMEs may profoundly influence space weather. Those directed toward our planet can have serious effects.
Credit: SOHO Consortium, ESA, NASA