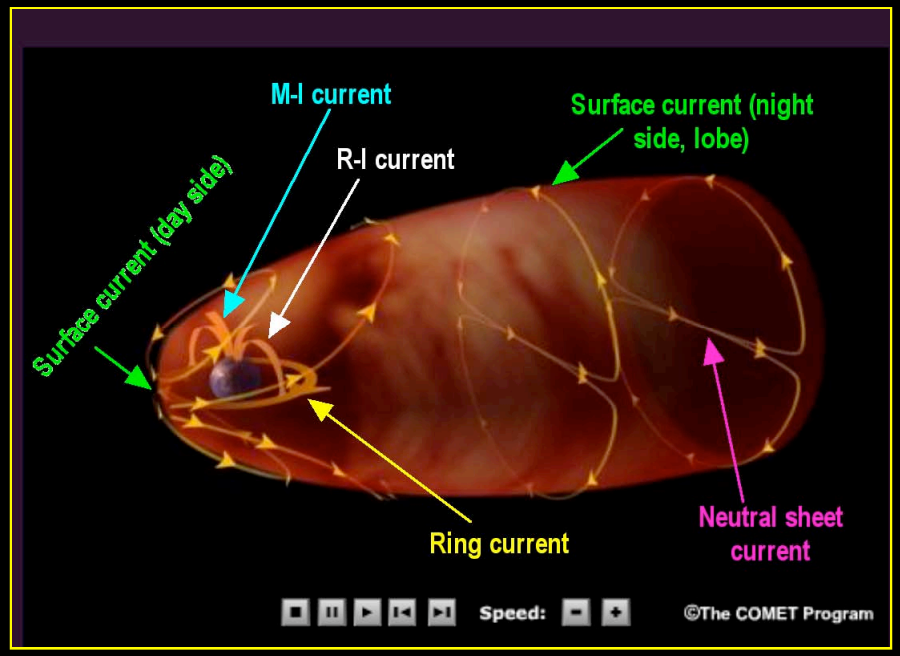
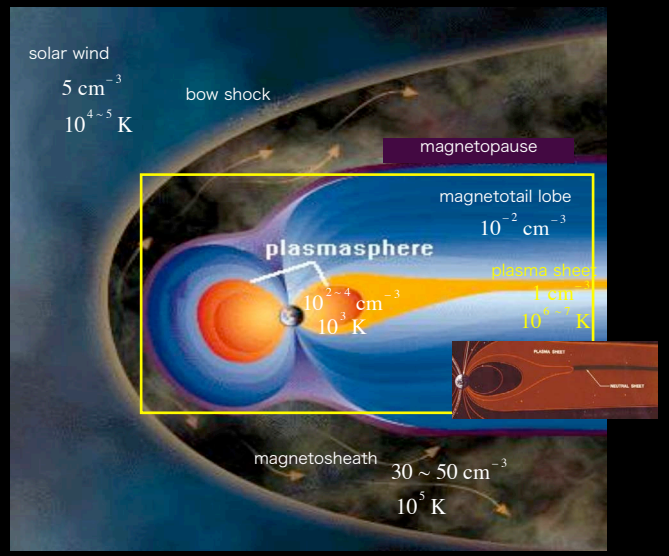
Non-steady phenomena in magnetosphere

Aurora, Substorm, Magnetic storm

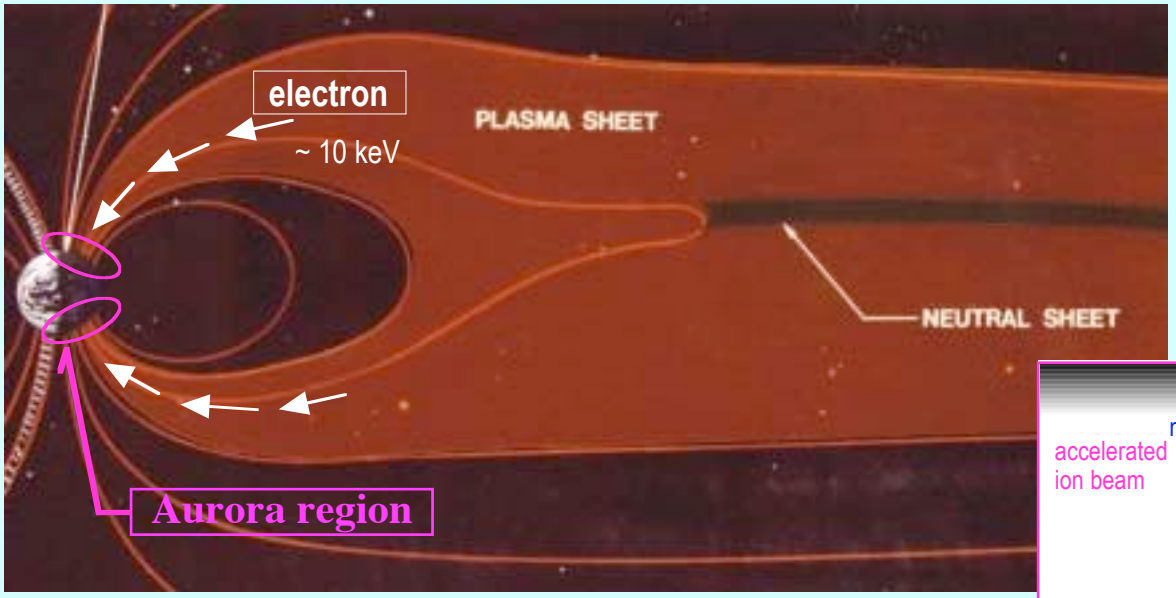
Steady state

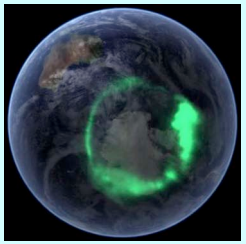


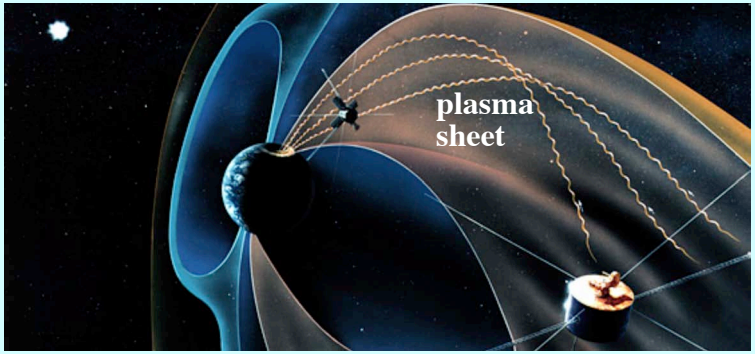


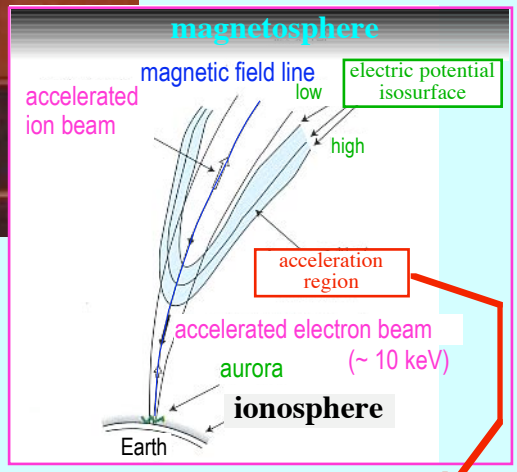
Aurora

Efficient injection of high-energy electrons from **plasma sheet**









Electric potential is not constant along a field line (via kinematic Alfvén wave?)

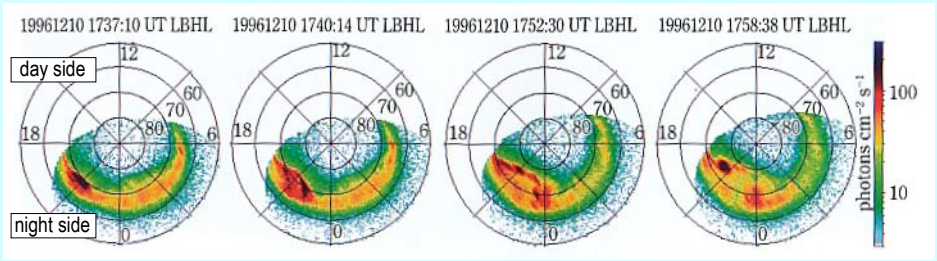
=> produces **strong field-aligned electric current (FAC)**

Substorm (time scale: 1 - 2 hr)

Explosive phenomenon in magnetosphere followed by **aurora breakup**

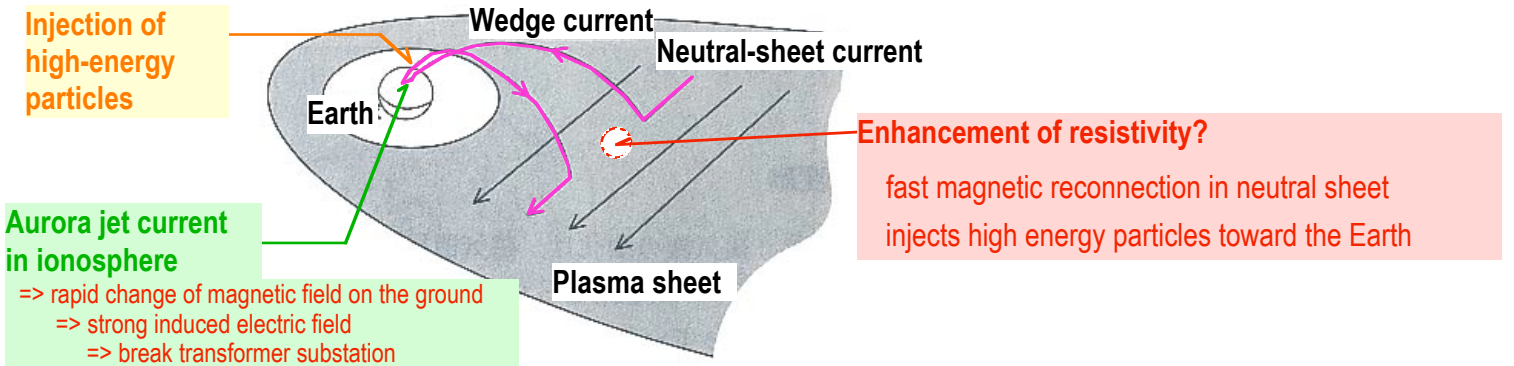
=> rapid release of free magnetic energy accumulated in magnetotail lobe

... observed from the ground



... observed from a satellite

Aurora jet current: change of the current system during a substorm

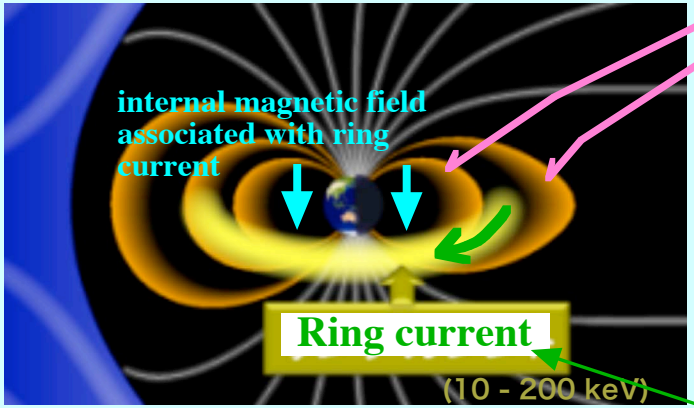


Magnetic storm (time scale: several days)

Injection of ions into **ring current** via **a series of substorms**

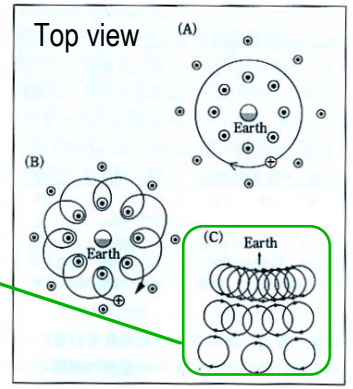
Van Allen radiation belts

inner... 2000 - 5000 km above the surface,
proton dominant (> 50 Mev)
outer... 10,000 - 20,000 km above the surface,
electron dominant (> 1 MeV)



Gyration of ions around terrestrial magnetic field
(depends on ion's gyroradius)

Ring current... case (c)
(diamagnetic current
based on nonuniform
distribution of particles)



Enhancement of **ring current**

Disturbance Storm Time Index (Dst index):
The Dst index is an index of magnetic activity derived from a network of near-equatorial geomagnetic observatories that measures the intensity of the globally symmetrical equatorial electrojet (the "ring current").

Reduction of **terrestrial magnetic field** in **low - middle latitudes (magnetic storm)**

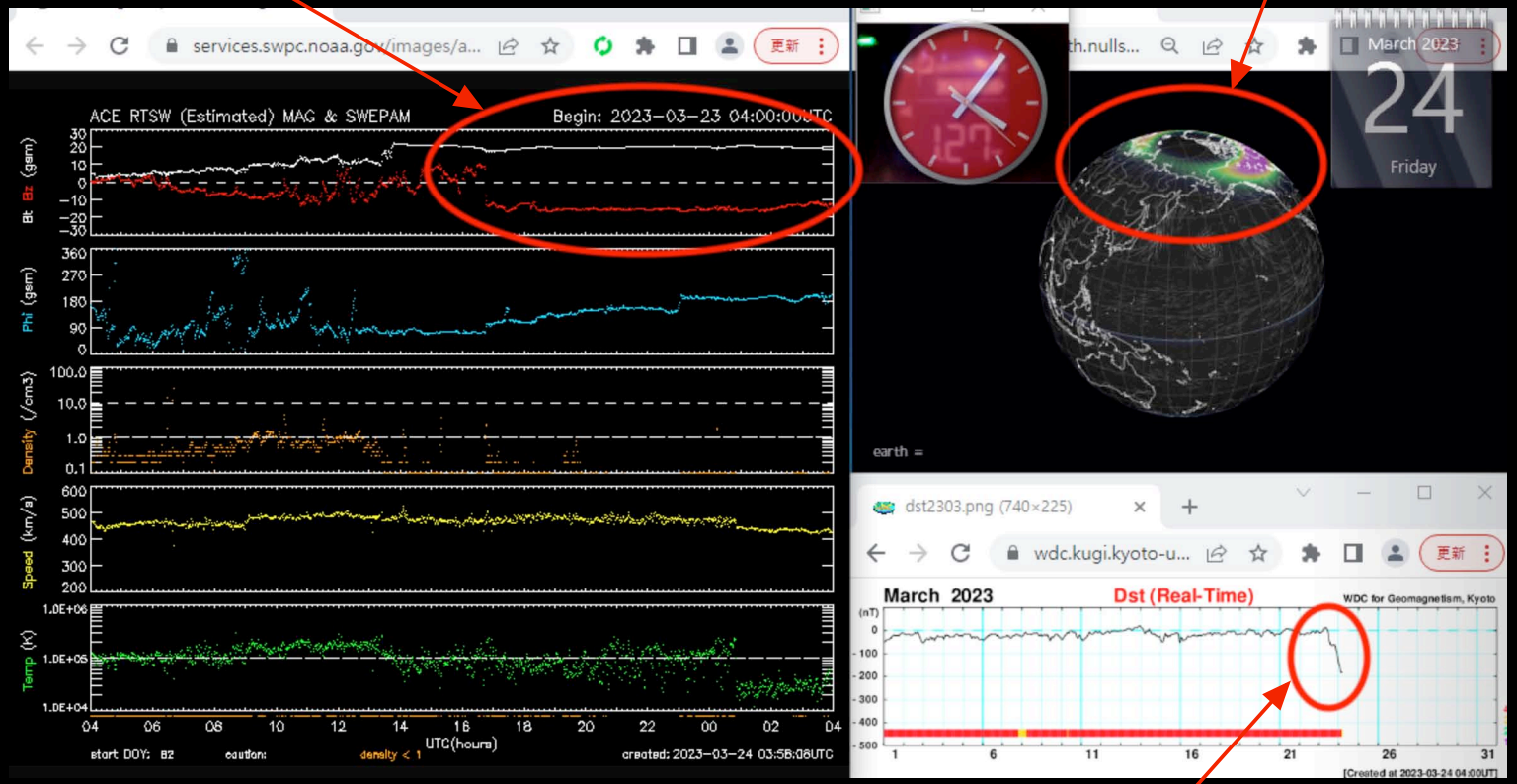
Influences human life...

Enhancement of **current in ionosphere** => **ionospheric storm** => damages telecommunication

Strong disturbance in the space (24 March, 2023)

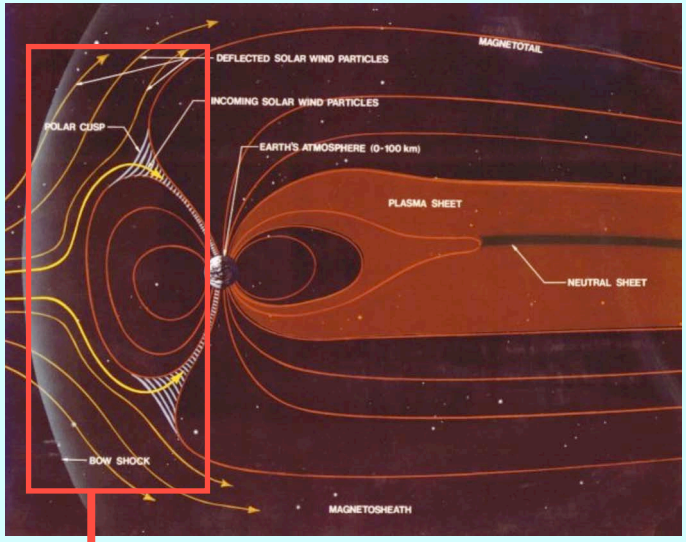
Negative B_Z (=> southward IMF)

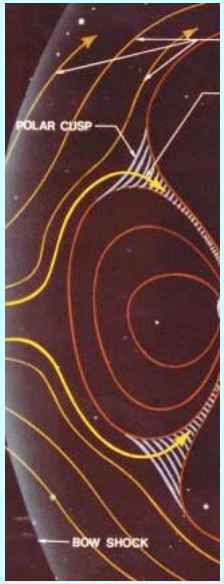
Aurora



Sharp fall in Dst

Fast stream in solar wind





Compression of magnetosphere

$$\rho_{SW}\, v_{SW}^2 > \frac{B_E^2}{2\,\mu}$$

Because of **fast stream**, magnetopause is **compressed up to the inside of geo-synchronous orbit** (~ 6.6 R_E).

Satellites in geosynchronous orbit are **exposed to dense & hot plasma flows in magnetosheath**.

Key issues in space weather...

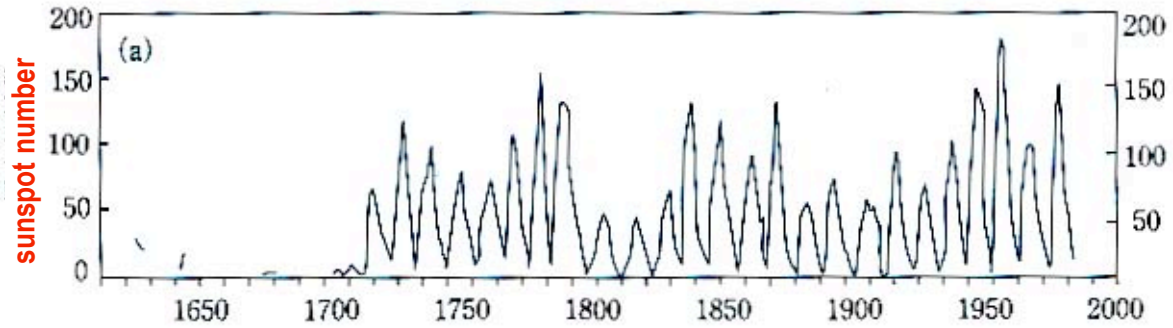
- Prediction of energetic phenomena on the Sun
- Mechanism for producing high energy particles
- Realistic behavior of IMF (quiet & disturbed states)
- Physical processes in magnetosphere responding to solar wind with IMF

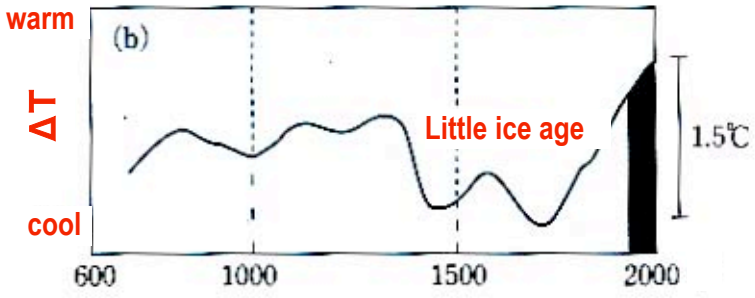
...

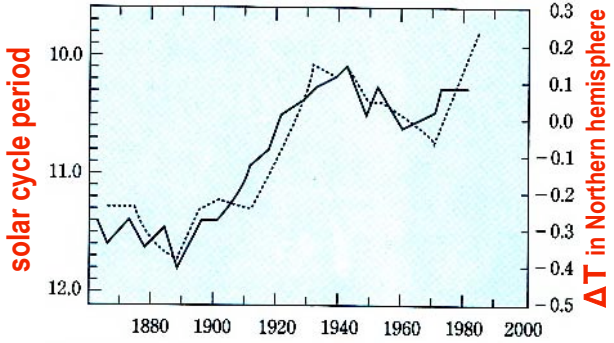
Space climate

long-term variation

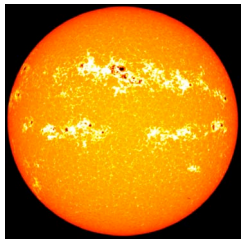
Relation between solar activity and terrestrial environment

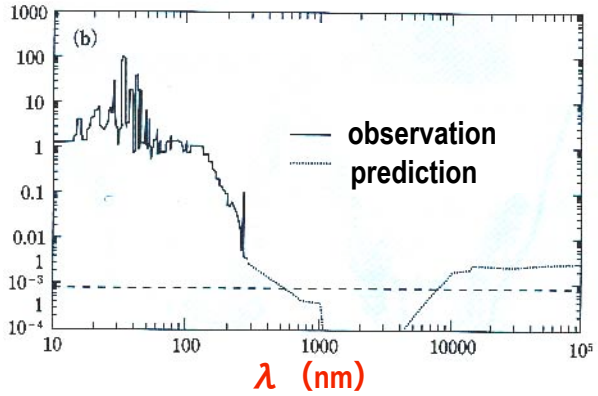


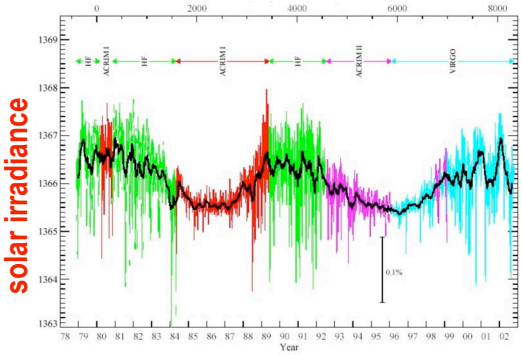




Intensity change ratio between solar maximum and minimum







Key issues in space climate...

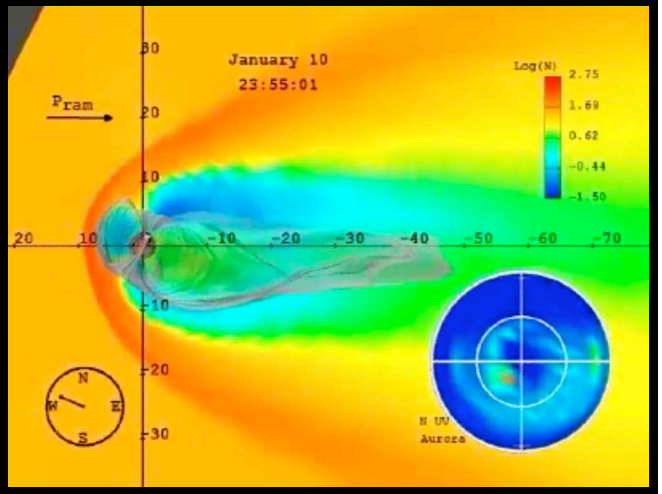
• Origins of climate variations are still unclear (although there are proposed several scenarios...).

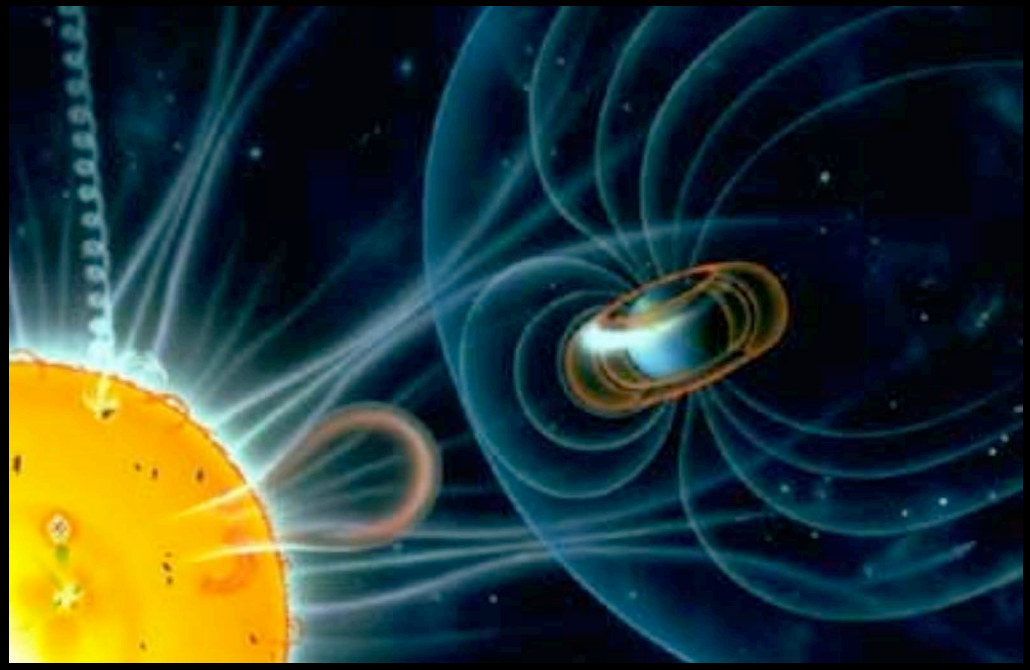
• Modeling of physical processes suggested by the scenarios

• Investigation of the mechanism for producing climate variations

...

The Sun & Earth forms an integrated system.





A view of 'the Earth inside the Sun' is important when we investigate the system.