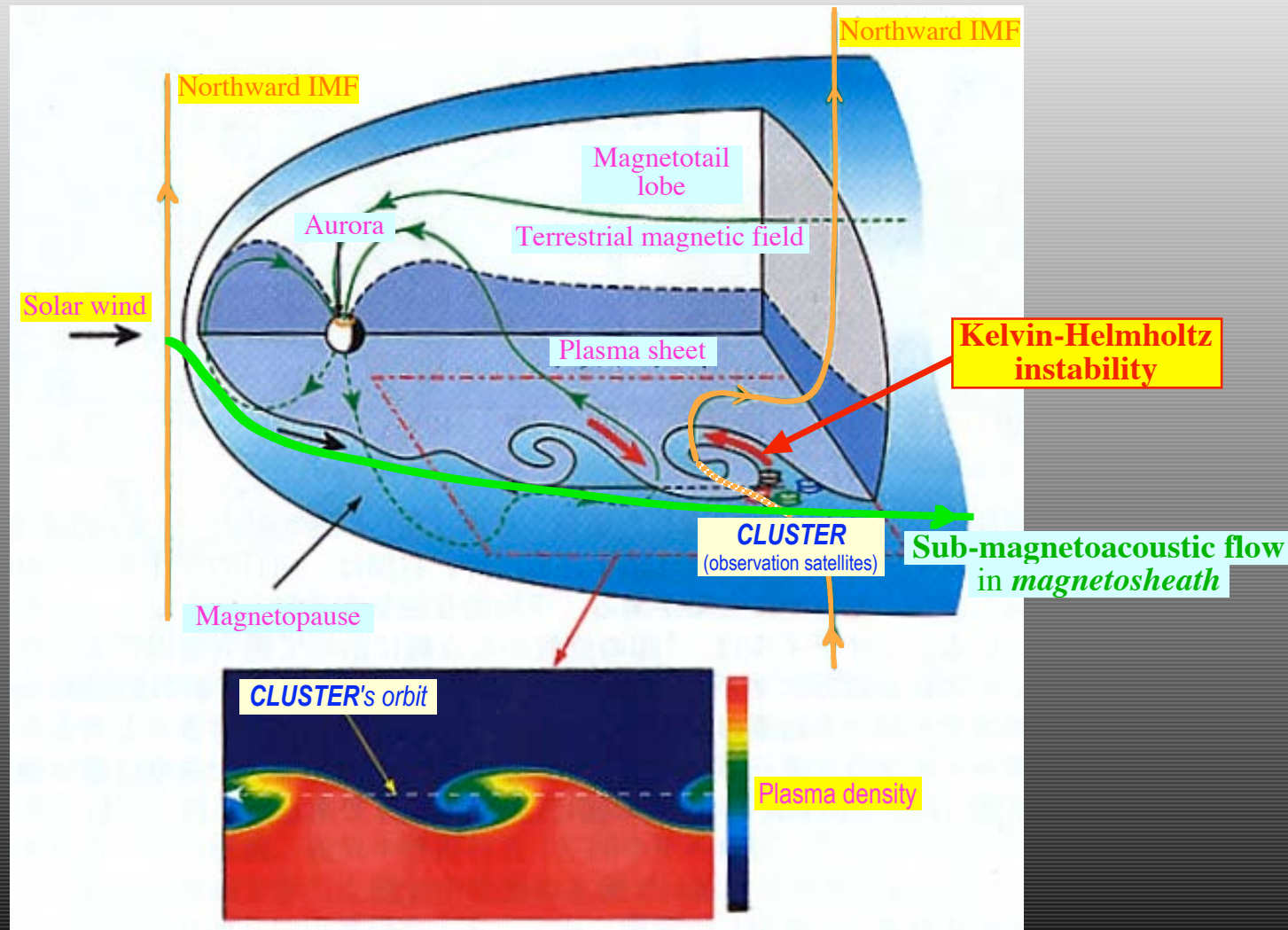
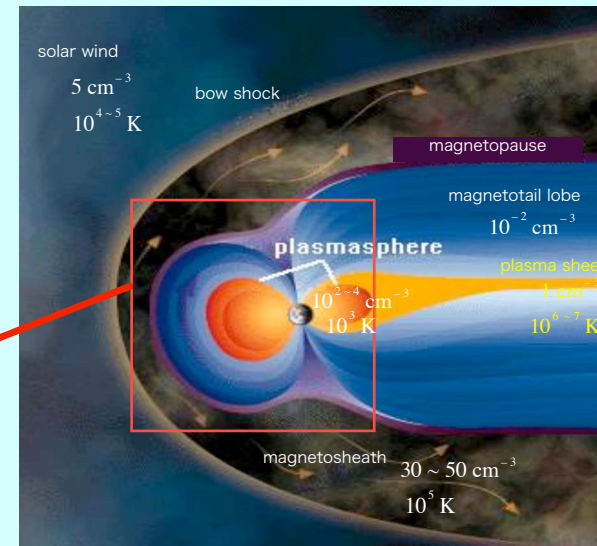


Non-explosive injection of solar wind plasma into magnetosphere via *Kelvin-Helmholtz instability* at magnetopause



Polar cap & polar cusp



plasmasphere... inner magnetosphere where reconnected magnetic fields are distributed

plasma sheet... magnetotail lobe compressed via MS-convection

Polar cap

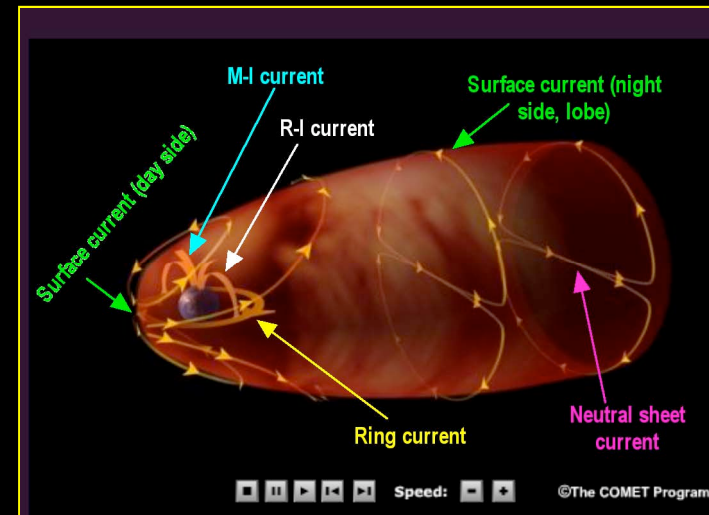
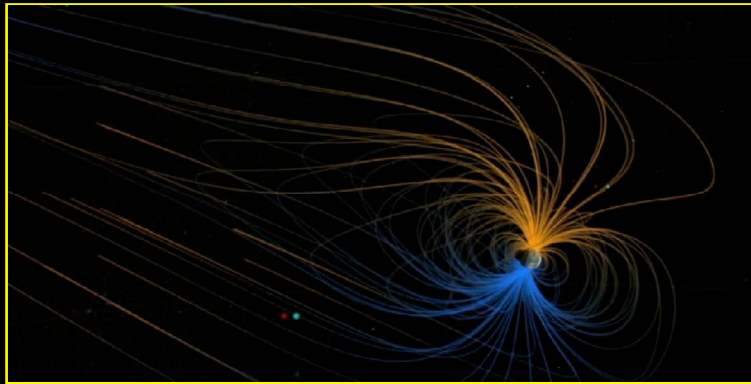
Terrestrial magnetic field lines connected to IMF lines

Polar cusp

Neutral point =>
magnetosheath (SW) plasma can make a direct access to **ionosphere**

Non-steady phenomena in magnetosphere

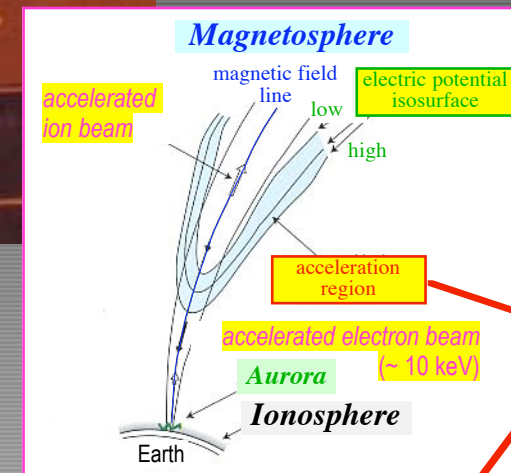
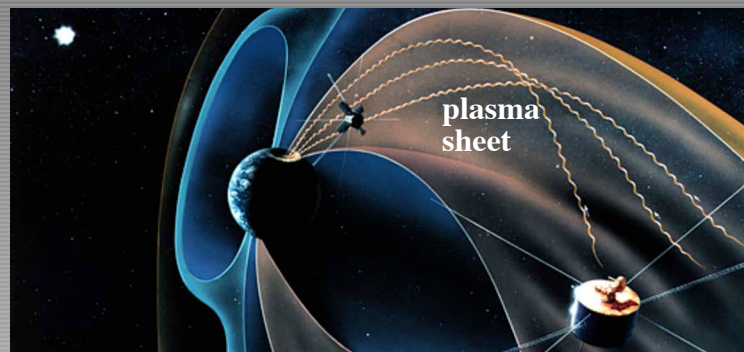
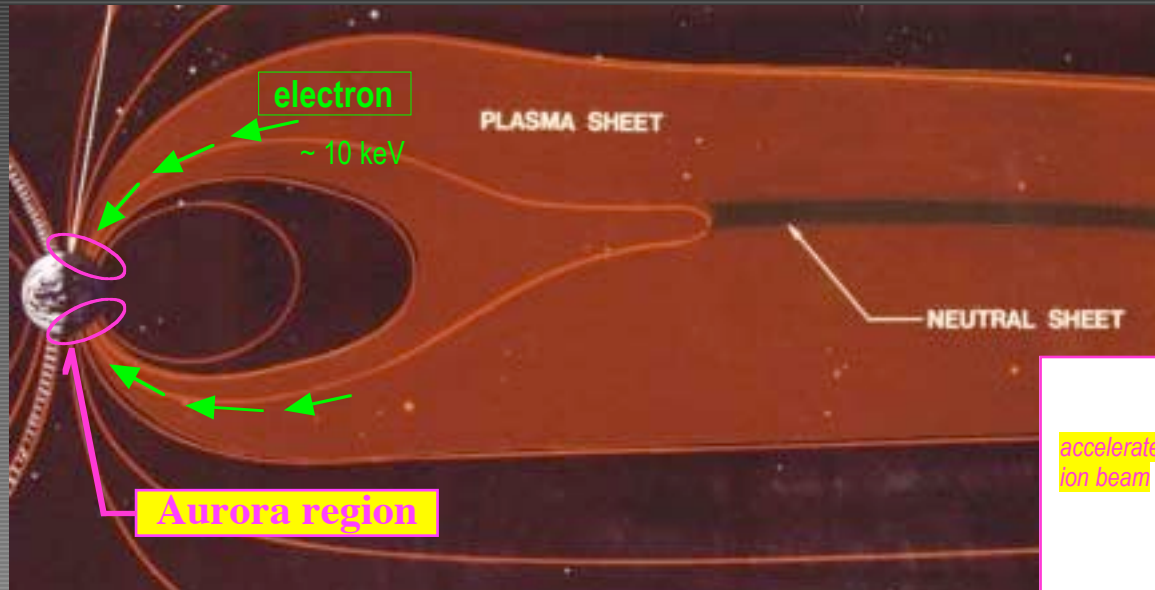
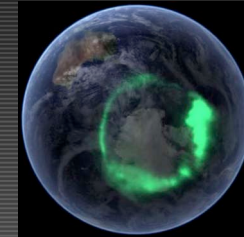
Aurora, Substorm, Magnetic storm



Steady state

Aurora

Efficient injection of high-energy electrons from plasma sheet



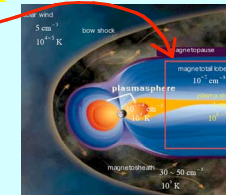
Electric potential is not constant along a field line (via kinematic Alfvén wave?)

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

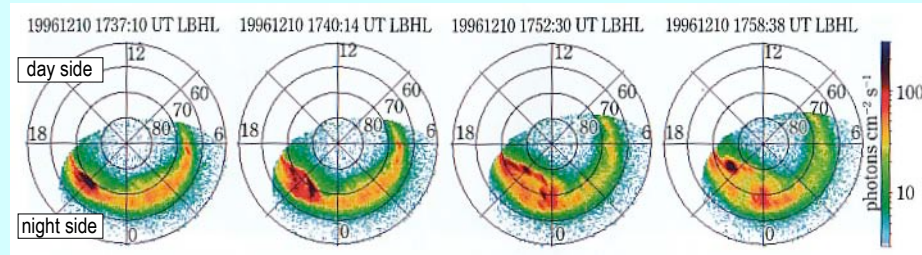
Substorm (time scale: 1 – 2 hr)

Explosive phenomenon in magnetosphere followed by aurora breakup

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



... observed from the ground



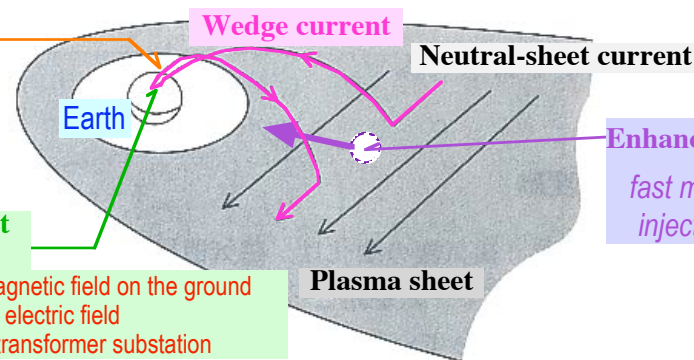
... observed from a satellite

Aurora jet current... change of the steady-state current system during a substorm

Injection of high-energy particles

Aurora jet current in ionosphere

=> rapid change of magnetic field on the ground
=> strong induced electric field
=> may break transformer substation

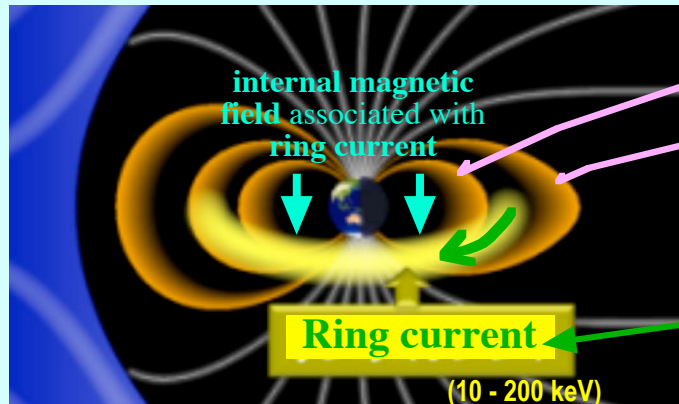


Enhancement of effective resistivity?

fast magnetic reconnection in neutral sheet may inject hot plasma blobs toward the Earth

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

Ring current... 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 (ring current).

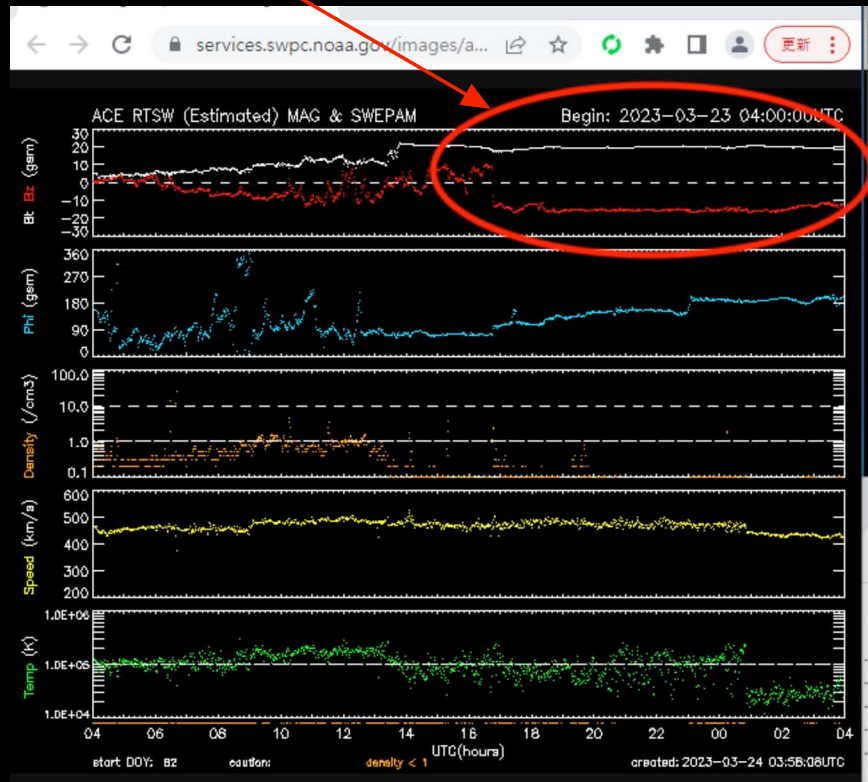
Reduction of terrestrial magnetic field in low-middle latitudes (magnetic storm)

Influences human life...

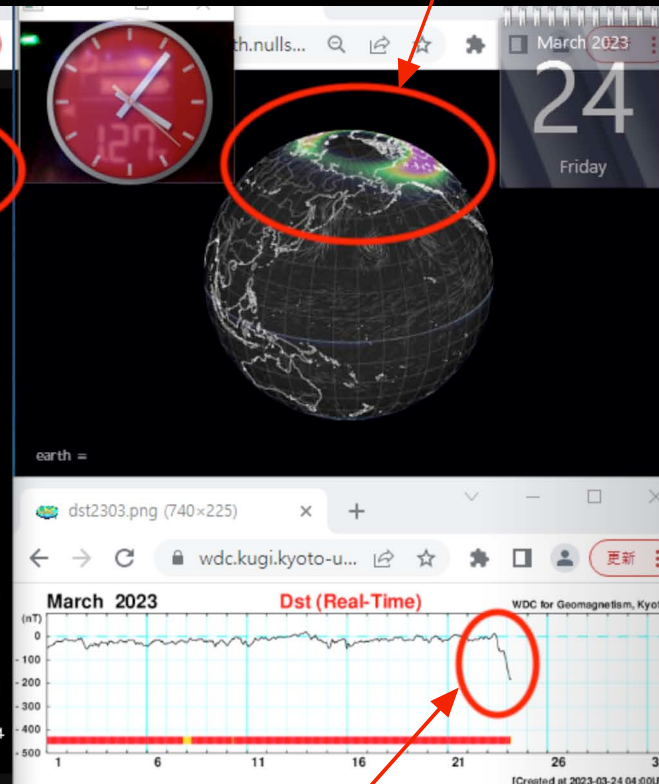
Enhancement of current in ionosphere => ionospheric storm => may damage telecommunication

Strong disturbance in the space (24 March, 2023)

Negative B_z (southward IMF)

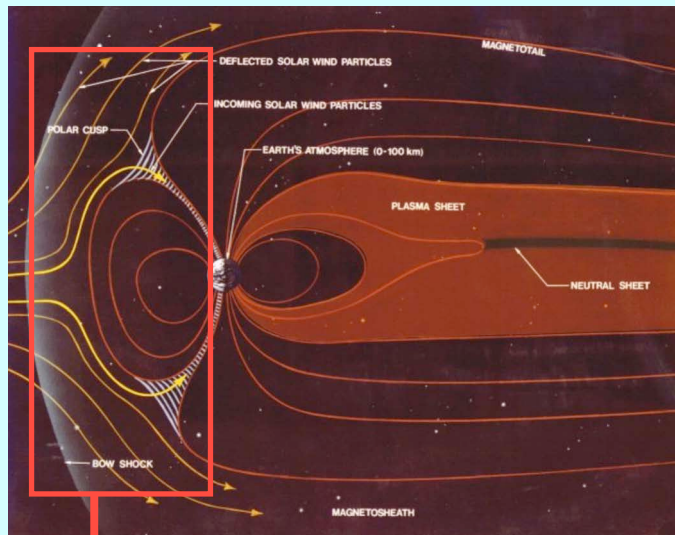


Aurora



Sharp fall in Dst

Fast stream in solar wind (strong dynamic pressure effect)



Compression of magnetosphere

$$\frac{\rho_{sw} v_{sw}^2}{2} \gg \frac{B_E^2}{2 \mu_0}$$

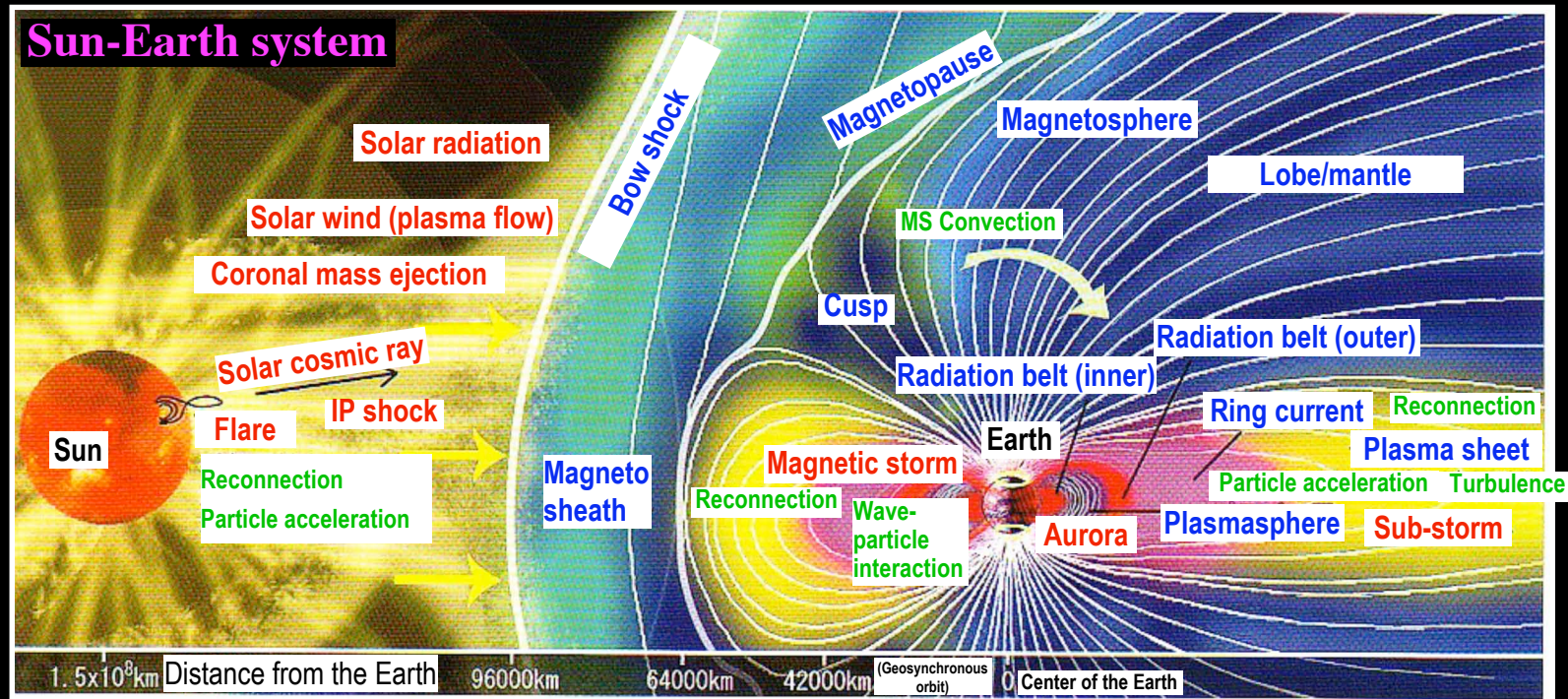


Because of fast stream, magnetopause is compressed into **geo-synchronous orbit** ($\sim 6.6 R_E$).



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

Phenomena, physical processes, and structure in Sun-Earth system



From T. Seki

Magnetic field & Plasma... main components of Sun-Earth system

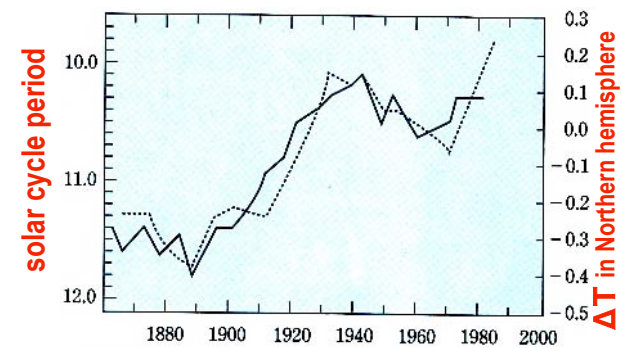
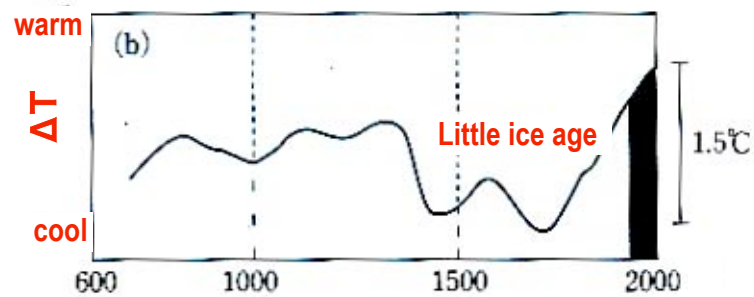
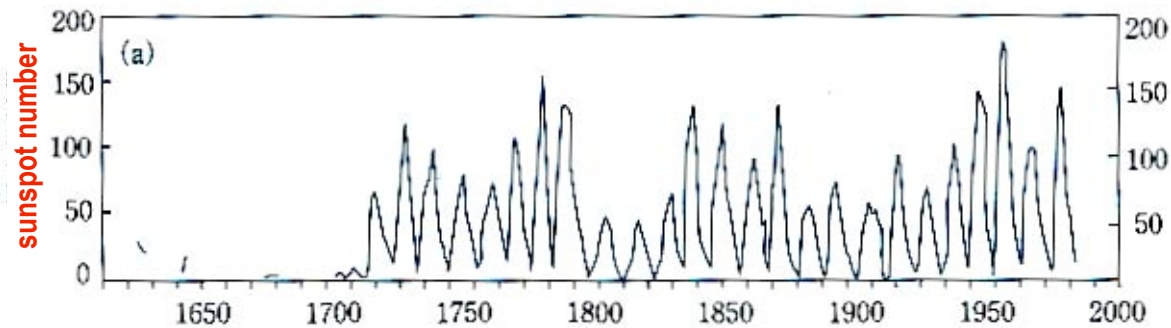
Key issues in space weather...

- 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
- ...

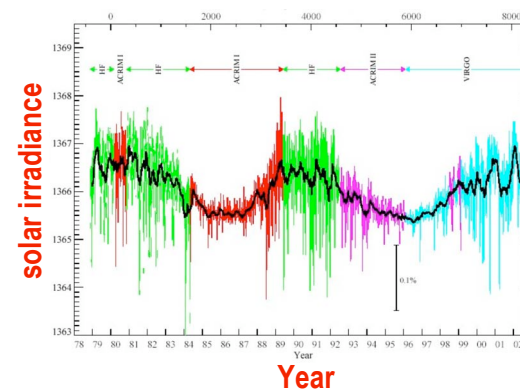
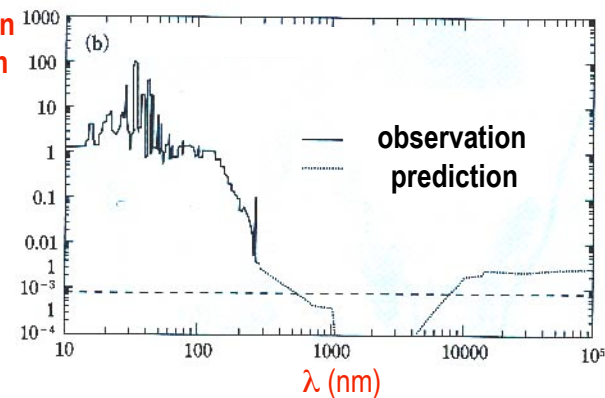
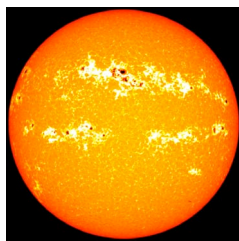
Space climate

long-term variation

Relation between long-term solar activity and terrestrial environment



Intensity change ratio between solar maximum and minimum



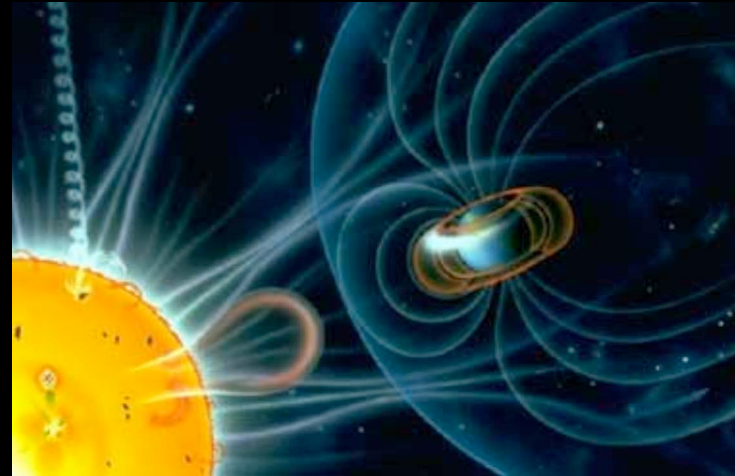
Key issues in space climate...

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 and Earth forms
an integrated system
composed of magnetic field
& plasma...*



The physical state of the Earth where we are living
depends on short and long-term solar activity.

*A view of the Earth inside the Sun, or
the Earth in the solar fields is important
(solar gravitational field, solar radiative field, solar magnetic field)
when we study the system.*