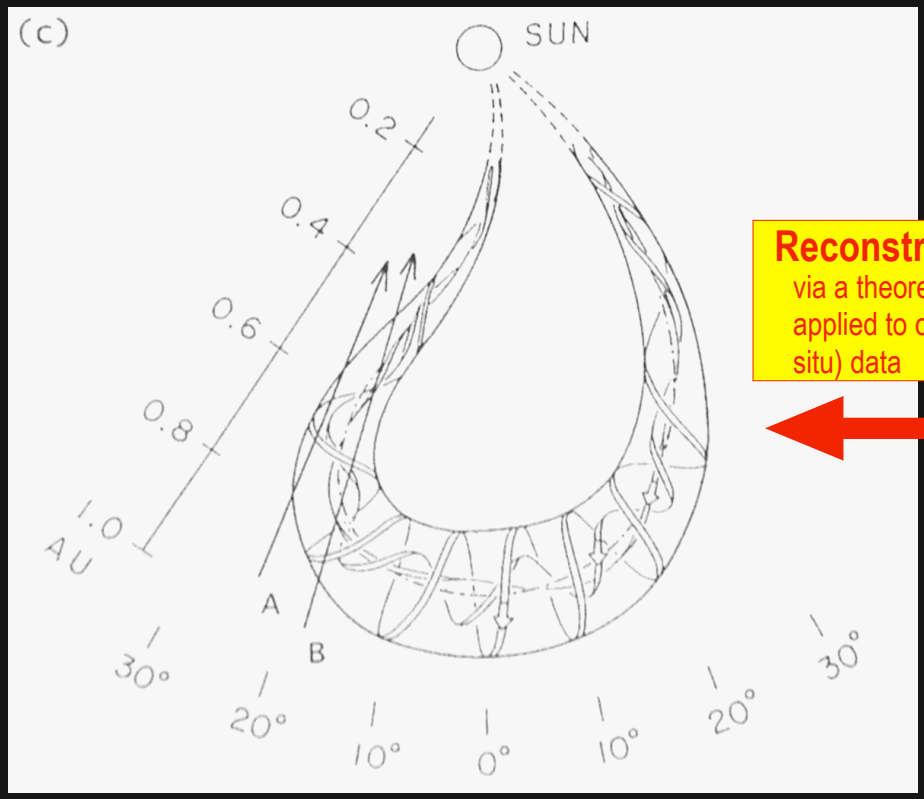
Interplanetary CME (ICME)

CME traveling through the interplanetary space



Expected helical magnetic structure of an ICME

Marubashi (2000)

Reconstruction
via a theoretical model applied to observed (in-situ) data

In-situ observation data

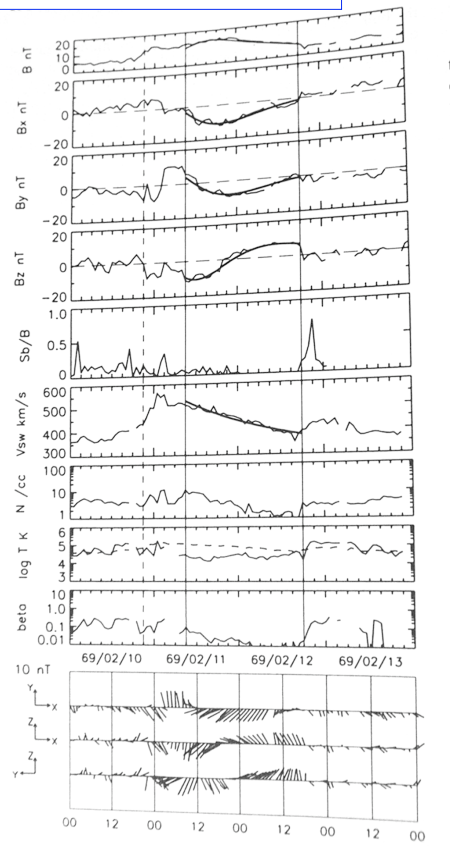
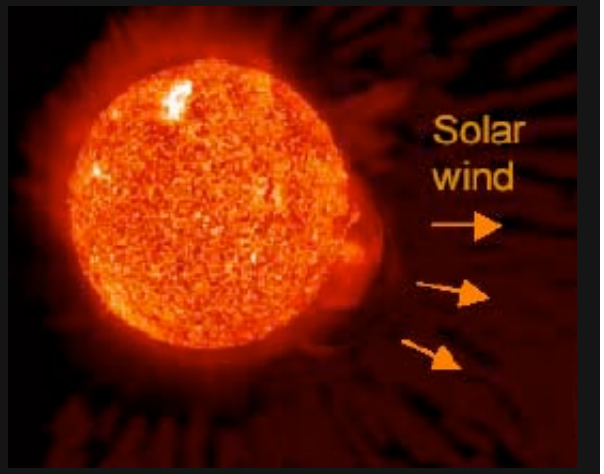


Figure 1. Solar wind parameters surrounding the February 11, 1969 flux rope event. An associated shock is indicated by a dashed line. Thick curves present the results of nonlinear least squares fitting (see text).

Solar wind (SW)...

Continuous outflow of a solar magnetized atmospheric plasma



Brief history:

1859... R. Carrington found a flare on the Sun (he supposed an energy flow from the Sun).

1913... K. Birkeland predicted flows of electrons and positive ions from the Sun.

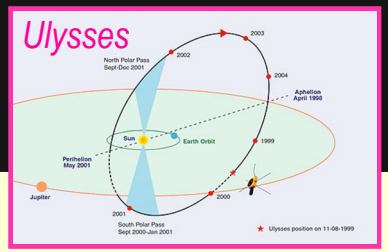
1919... F. Lindemann suggested that both electrons and protons come from the Sun.

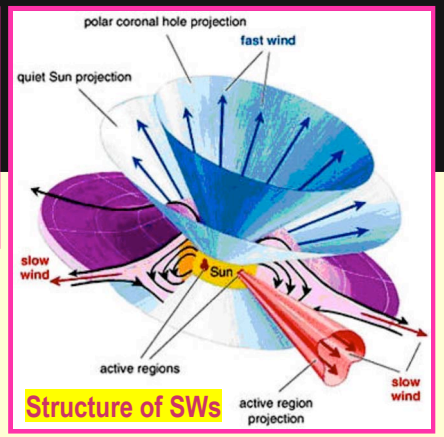
1950s... S. Chapman suggested that a coronal plasma should extend over the orbit of the Earth.

1951... L. Biermann investigated tails of comets and postulated that the Sun emits a steady stream of particles pushing the tails away from the Sun.

1958... E. Parker developed a hydrodynamic model of solar wind.

Statistical properties of SWs





Components: **electrons, protons**

Energy: **10 ~ 100 ev** (1 ev ~ 10^4 K for **thermal plasma**)

Speed (near the Earth): **400 km/s** (*slow wind* $1.5\times10^{6}\ K$, coronal composition)

750 km/s (*fast wind* $8\times10^{5}\ K$, photospheric composition)

(c.f. escape velocity: 618 km/s, coronal thermal velocity: 150 km/s)

Source region: **low latitude, from closed-field region** (*slow wind*)

high latitude, from open-field region (*fast wind*)

Mass flux (loss rate of mass): $\dot{M} \sim 10^{12}$ g/s ($\sim 10^{-14}\ M_\odot$ / yr)

$M_\odot \sim 2\times10^{33}$ g

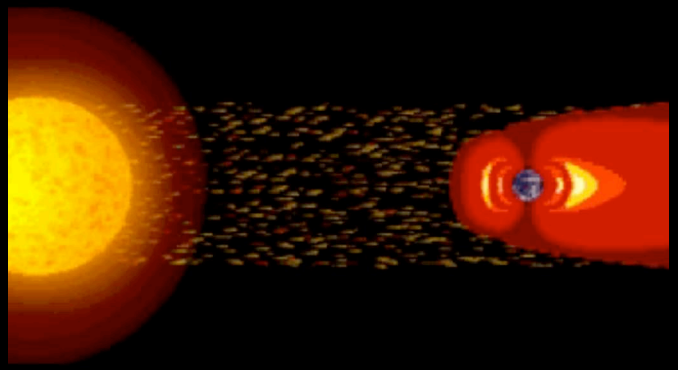
Angular momentum flux (loss rate of angular momentum):

$\dot{J} \sim 7\times10^{29}$ g cm^2/s^2 ($\sim 10^{-11}\ J_\odot$ / yr)

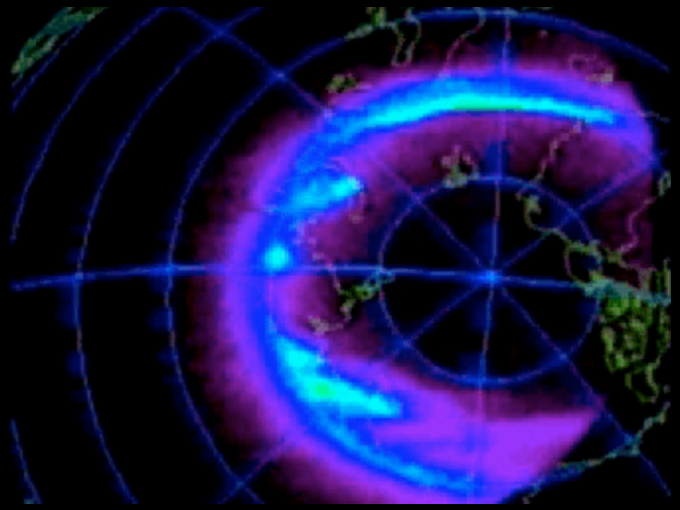
$J_\odot \sim 2\times10^{48}$ g cm^2/s

Interactions between solar magnetic fields and terrestrial magnetic fields

Solar wind (schematic model)

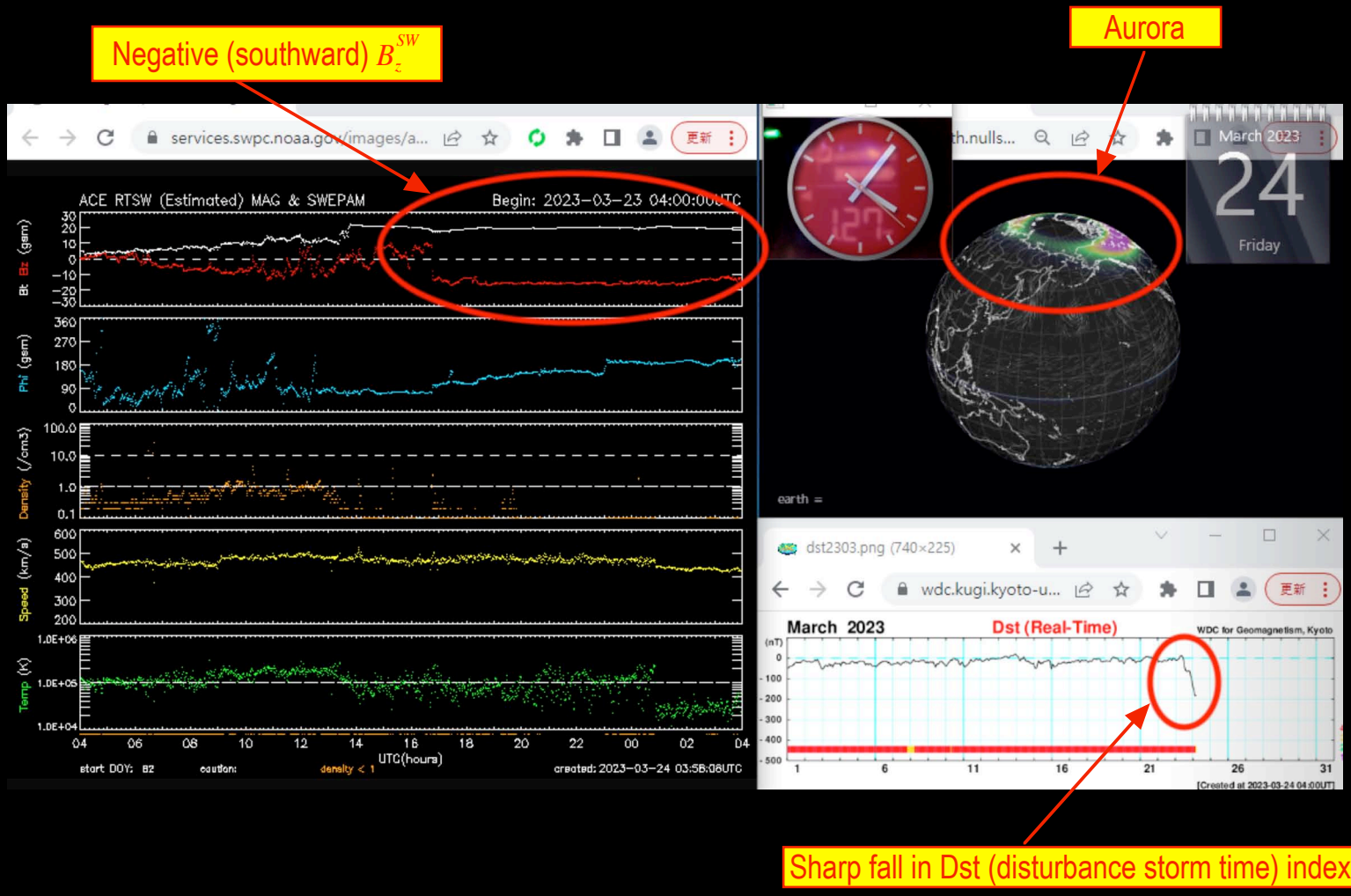


Aurora observed from the space

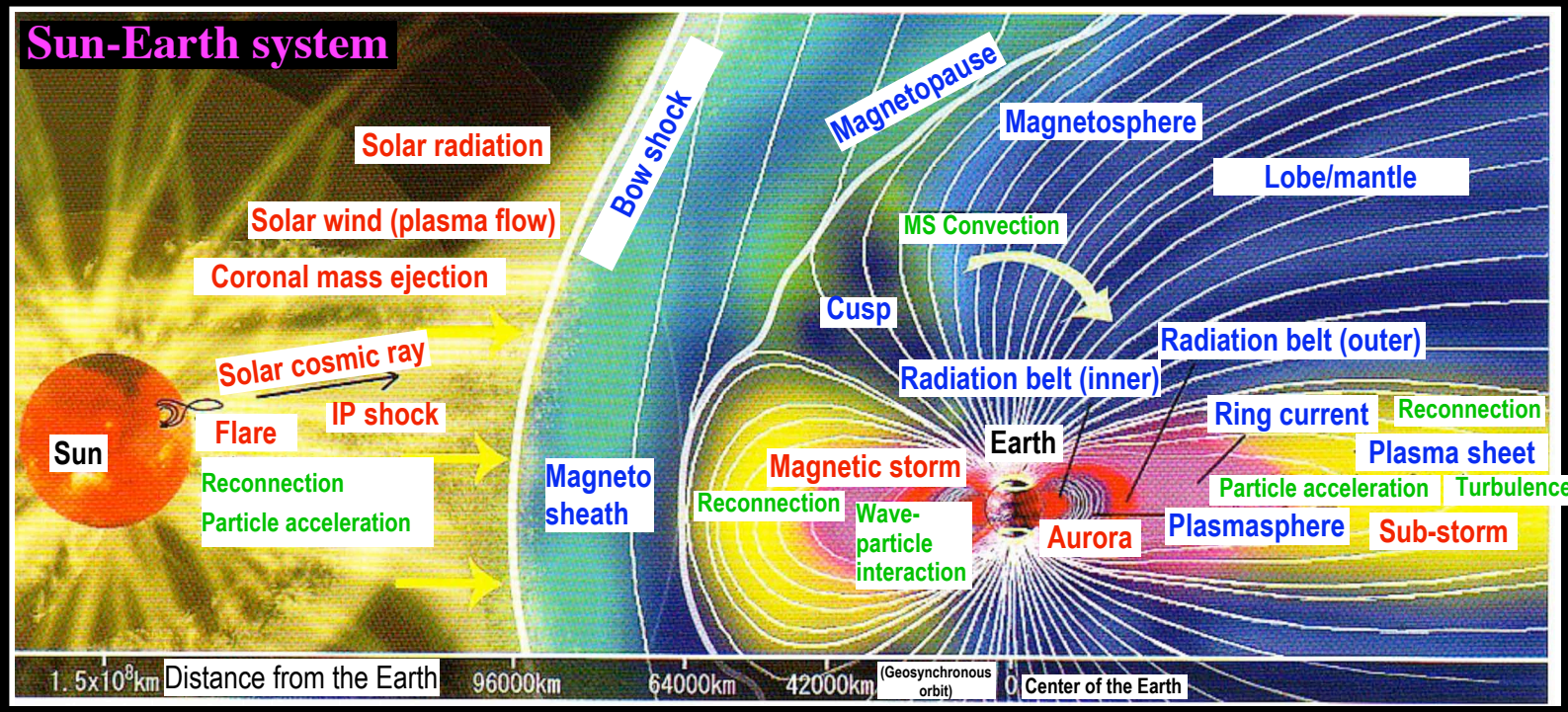


Aurora observed from the ground

An energetic event in the space (24 March, 2023)



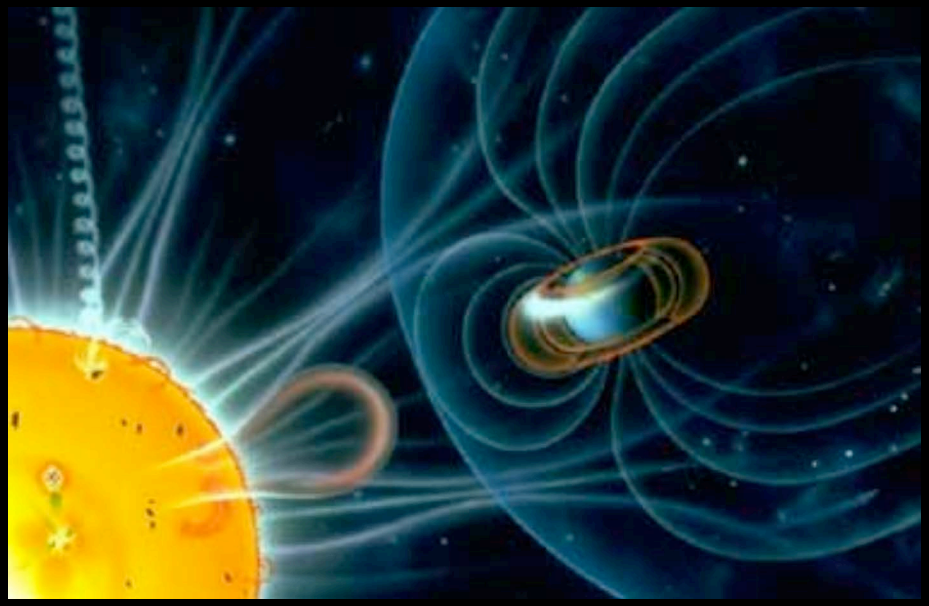
Phenomena, *physical processes*, and *structure* in *Sun-Earth system*



From T. Seki

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

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

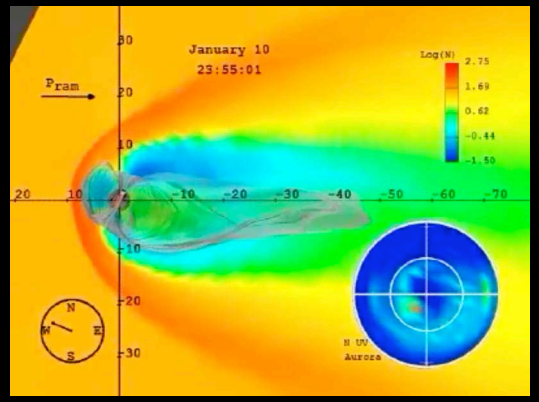


A view of ***the Earth inside the Sun****,*

or ***the Earth in the solar fields*** *is*

(solar gravitational field, solar radiative field, solar magnetic field)

important when we study the ***system****.*



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