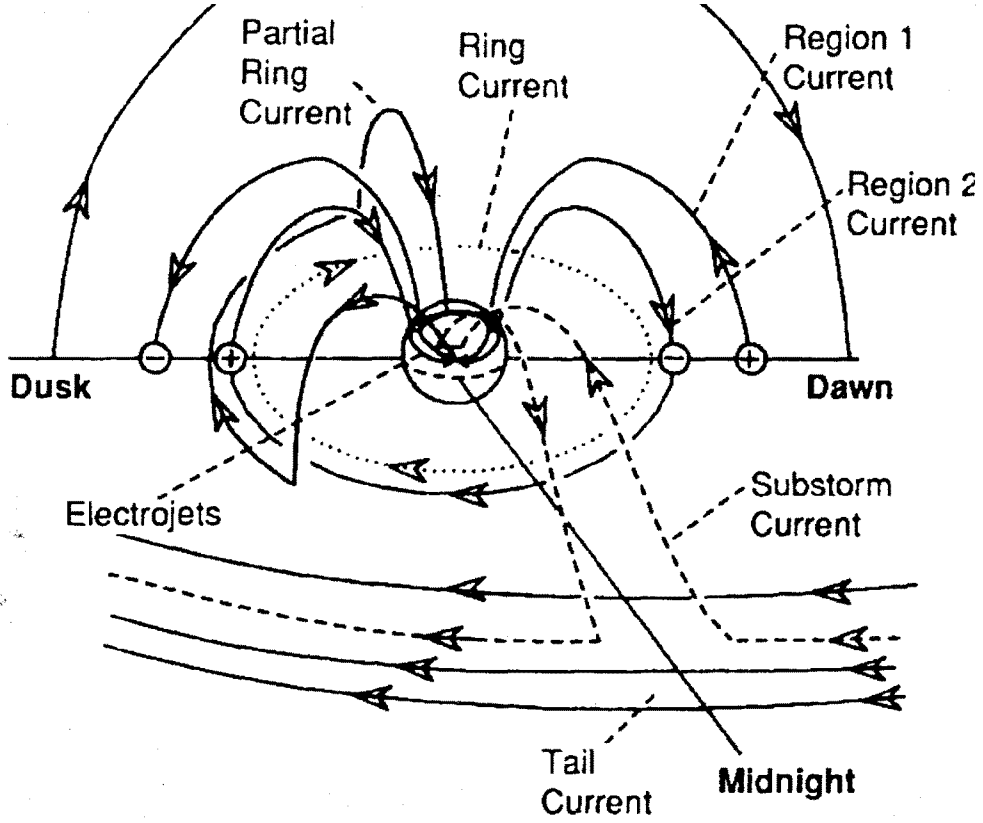
Ring current ~ few MA

Tail current ~0.5 mV/m

~ 40 nT/1R_e
= 5 x 10^{-9} A m^{-2}

Ionosphere ~1μA m^{-2} to get
instabilities and
potential drops (~ 1-10 kV)



Growth Phase : Energy is extracted from the solar wind and stored in the magnetosphere

Expansion Phase : Unloading energy from magnetosphere into ionosphere

Recovery Phase : Returning to ground state

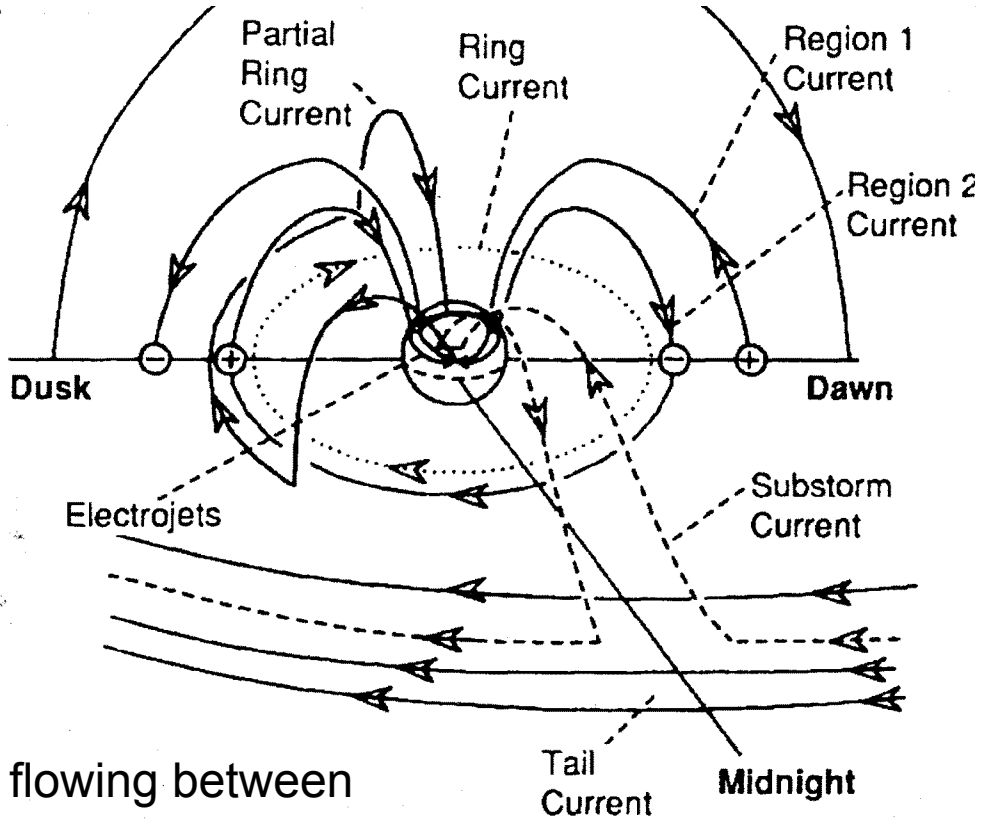
No activity without southward IMF

Particles accelerated from plasma sheet

Tail field collapse
→field-aligned currents

Move closer to Earth following fieldlines

Some mechanism has to prevent particles from mirroring



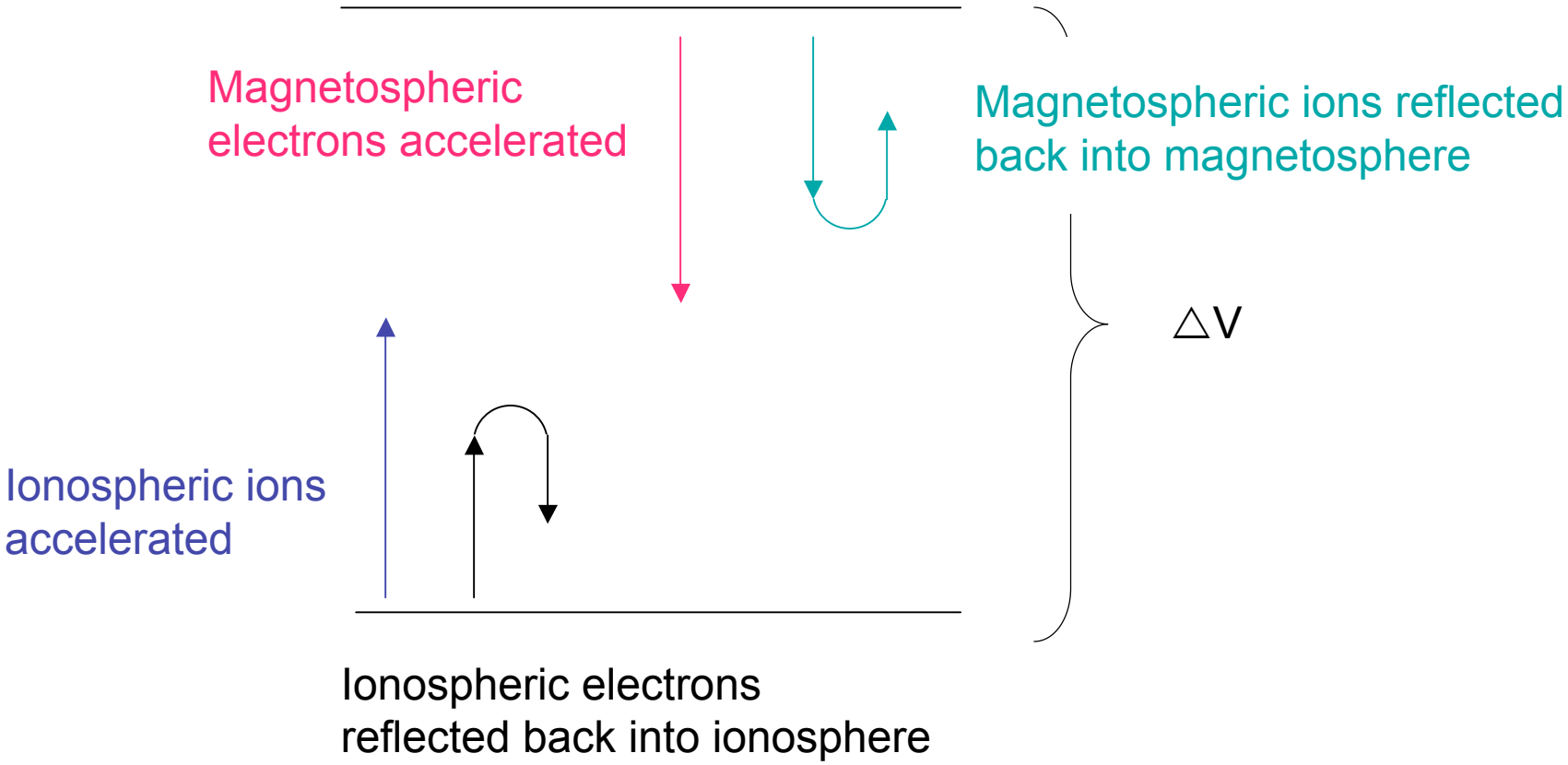
Potential drop develops at altitude ~ 1000 km with positive potential at lower altitudes

If infinitely conductive, couldn't develop a potential drop along fieldline

Can get potential drop if currents flowing between plasmas with different properties

2 different plasmas would be cold, dense ionospheric plasma and hot, rarified magnetospheric plasma

Field-aligned current would be the Birkeland currents



Substorm

1) IMF turns southward for 30-60 minutes

2) Ionospheric outflows and dayside magnetosphere eroded

3) Magnetic flux transported to the tail along with heavy ions (O+)

4) Plasma sheet thins and current moves earthward

5) Reconnection of the tail magnetic field

6) Plasma bubble forms near reconnection point and transported out of equatorial plane

7) Ion energized at reconnection point and injected into inner magnetosphere and ring current energizing from ~100 eV to > 10 keV (IMF turns back northward prior to this step)

8) Reconnection point moves tailward, ionospheric ions refilling tail

Storm

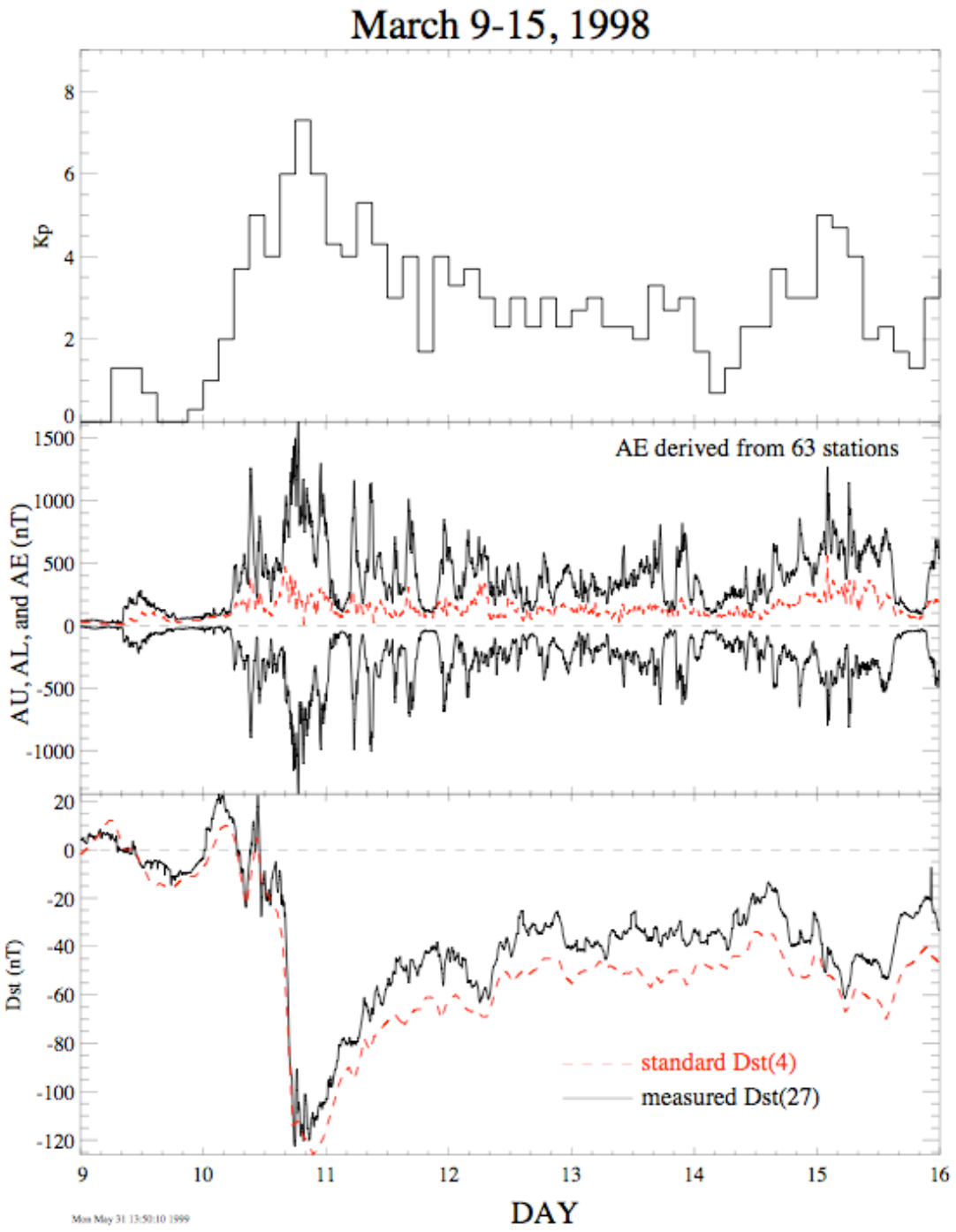
Ring current generates a magnetic field that can modify the Earth's magnetic field

Ring current reduces the horizontal component of the geomagnetic field is reduced; during a storm itis further reduced

Storms last 1-5 days

The more negative D_{st} the stronger the storm

D_{st} = worldwide average of the equatorial horizontal disturbance



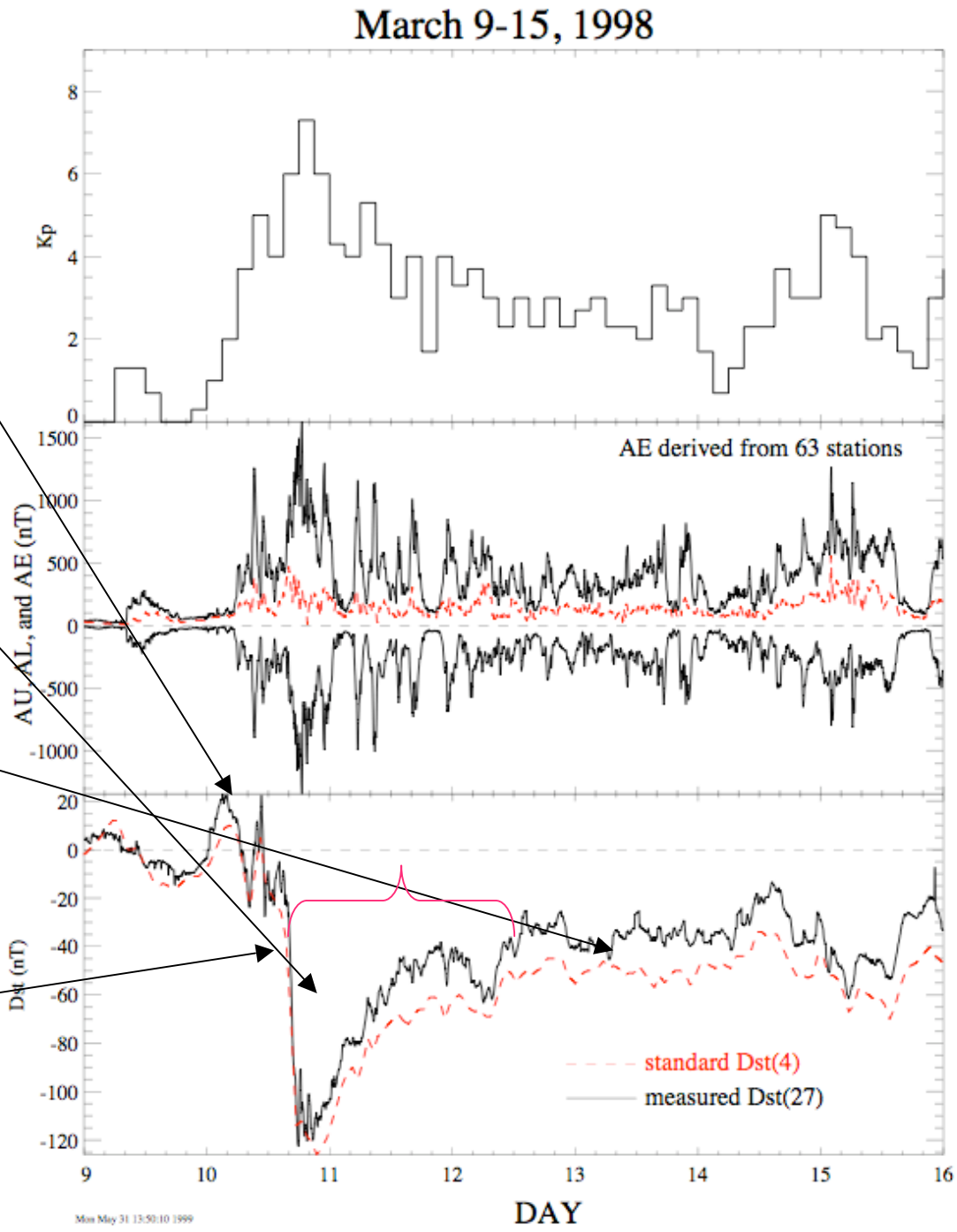
Sudden increase caused by magnetopause current
1-3 hours

Main phase (decrease) caused by ring current

Recovery caused by loss of ring current particles

0.5-25 hours

Slow phase 1-5 days



Storm (maybe?)

1) IMF turns southward for hour or more

2) Multiple substorms, ring current pumped up by addition of plasma and acceleration of plasma

3) Ionosphere ions accelerated out of ionosphere, filing tail and ring current with heavy ions like oxygen

4) Dissipation of ring current after IMF goes northward through
    1) Pitch angle scattering by waves
    2) Ring current close to surface charge exchange with cold neutrals

O^+ lost first (rapid), then H^+ (slow)

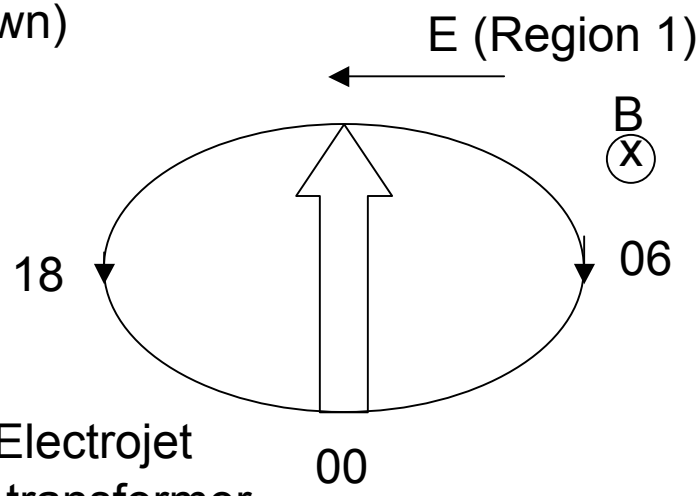
Conductivity

Increase in energy input → increase in field-aligned currents
→ field-aligned potential drops → acceleration of e- into ionosphere
→ discrete arcs and enhanced conductivity → more current drawn
→ larger potential drops → greater conductivity

Current flows sunward across the polar cap

In auroral oval current concentrated by high conductivity into the eastward electrojet (dusk) and westward electrojet (dawn)

Hall current : caused by ExB drift
motion but collisions cause
ions to drift slower than electrons



Currents ~ 200 A measured at ground from Electrojet
only a few Amps needed to disrupt transformer

Escape

$$\frac{1}{2}mv^2 = \frac{GM_e m}{R_e}$$

$$v_{esc} = \left(\frac{2GM_e}{R_e}\right)^{\frac{1}{2}}$$

Only need 1/6th of distribution to be above escape velocity to get almost total loss

At Earth v_{esc} = 11200 m/s

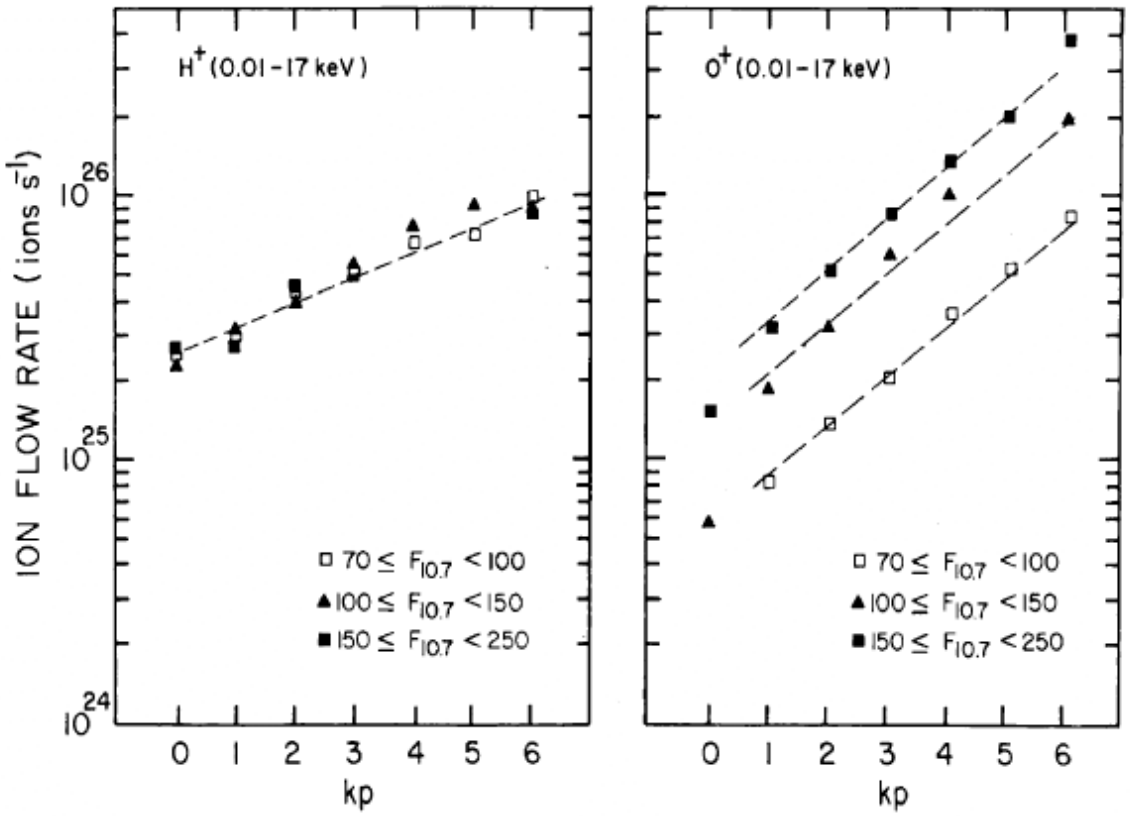
$$\frac{1}{2}mv^2 = kT$$

Thermal velocity (1500 K)

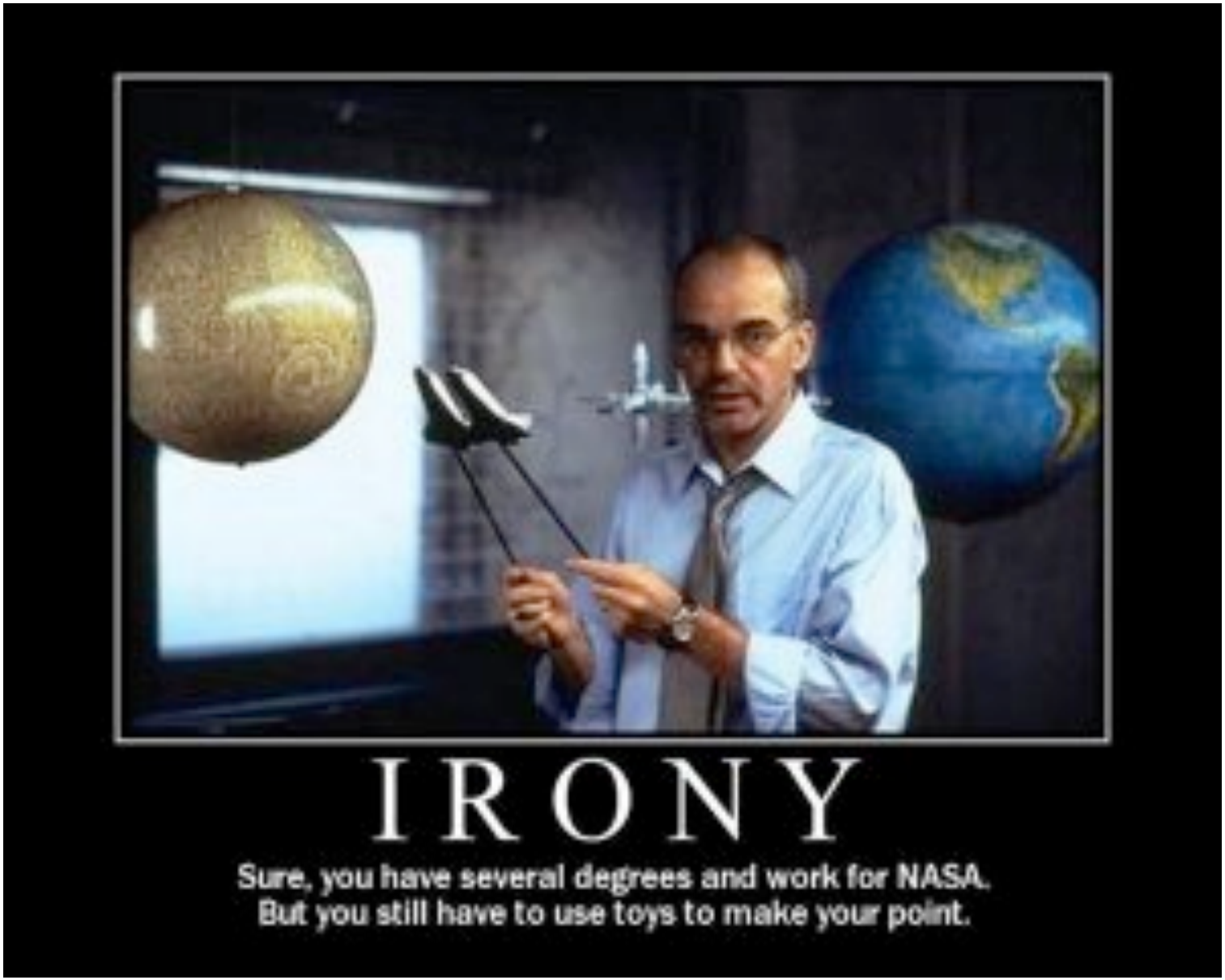
H^+ = 5000 m/s

O^+ = 1200 m/s

O_2^+ = 900 m/s



Magnitude of the ionospheric outflow as a function of Kp [from *Yau and André*, 1997.]


IRONY
Sure, you have several degrees and work for NASA.
But you still have to use toys to make your point.