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Lecture supporting the Ruohoniemi and Greenwald, JGR, 2005 paper

- The solar wind driven ionospheric flow in the polar cap is basically a twin-cell system. Anti-sunward flow a cross the polar cap (connected to the solar wind), and a sunward return flow equatorward of that.

- Cross-polar cap voltage:
  Cf- Figure 6.6 in the compendium $\Phi_{PC} = E_{PC} L$
  L refers the distance/diameter across the polar cap.
  See Chapter 9.4.2 in K&R

- The Open Closed Boundary (OCB) is the boundary between open and closed magnetic field lines. The open field lines are connected to the solar wind IMF. The Polar Cap Boundary (PCB) and OCB has the same meaning in this course.

- IMF B_Y introduces an asymmetry of a circular cell + a crescent shaped cell. This is explained as the effect of magnetic tension (K&R Fig 9.24)

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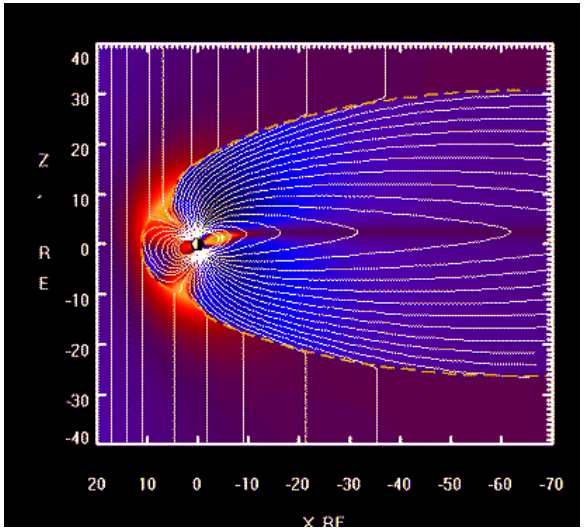
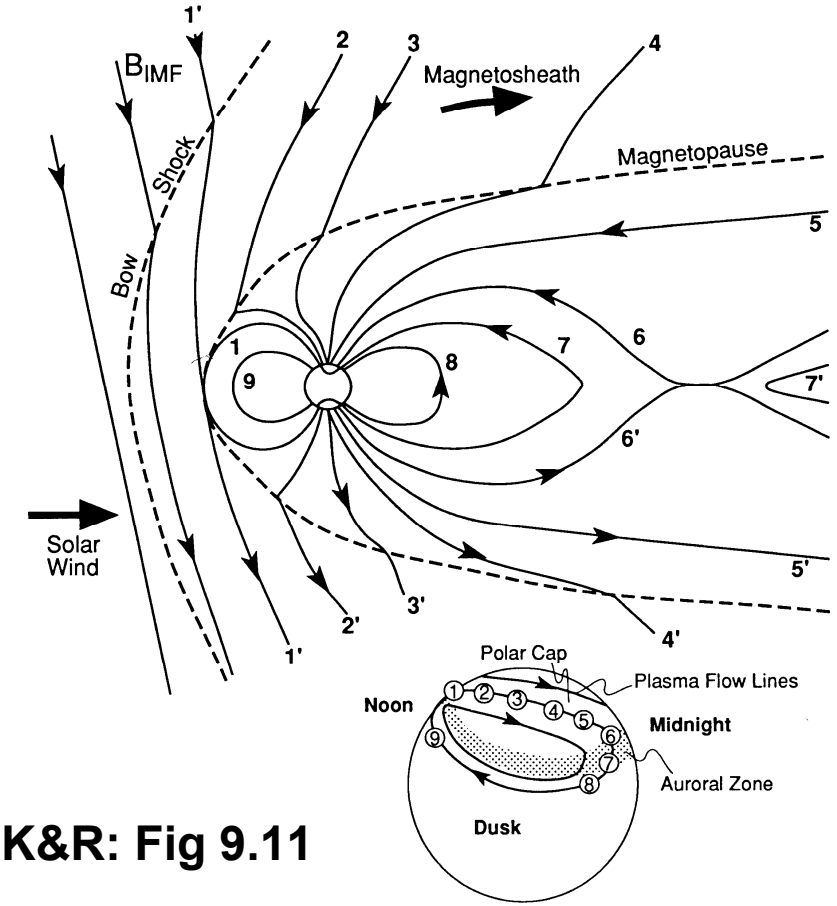
Solar wind driven ionospheric convection





K&R: Fig 9.11

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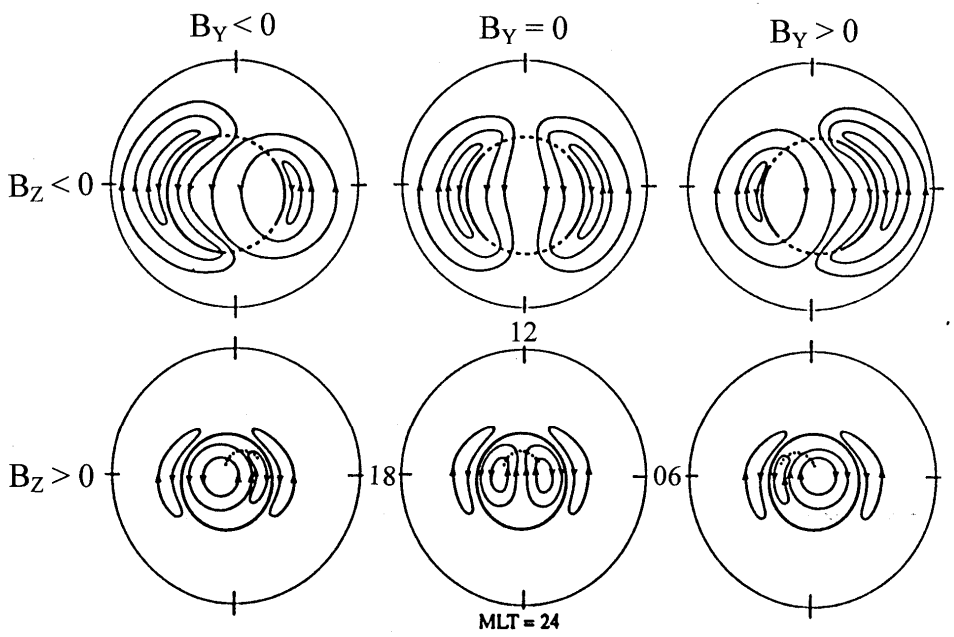
IMF controlled convection patterns



Reiff and Burch, JGR, 1985

Up to the 1980s the main information about flow patterns was from low-altitude polar orbiting satellites –

Resulted in 10-15 min averages of the polar cap flow potential.

Based on high time resolution radar data we know that large scale convection can be pulsed

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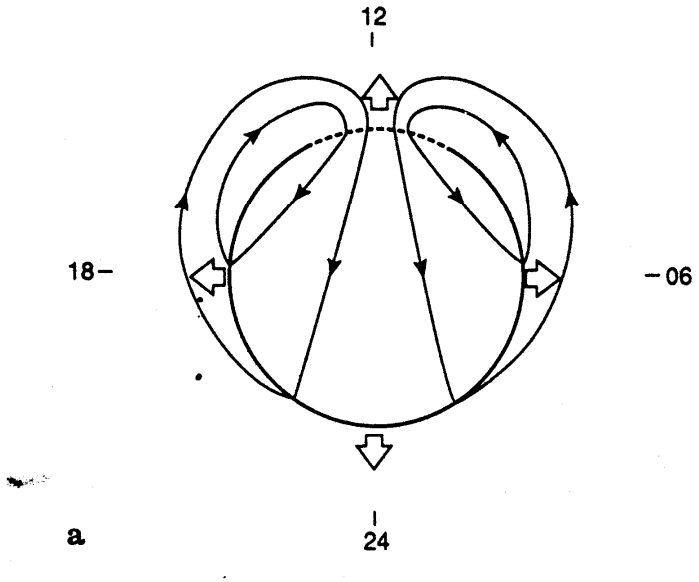
Cowley-Lockwood time dependent model of excitation of large scale flows

The two component flow model:

- The flow is driven by dayside reconnection and by nightside reconnection
- Unbalanced dayside reconnection expands the polar cap.
- Unbalanced nightside reconnection contracts the polar cap.

Ann. Geophys.,pp103-115,1992.

Magnetopause reconnection –> add open flux into the polar cap –> polar cap expands



Polar Cap Boundary or (PCB)

Open-Closed-Boundary (OCB):

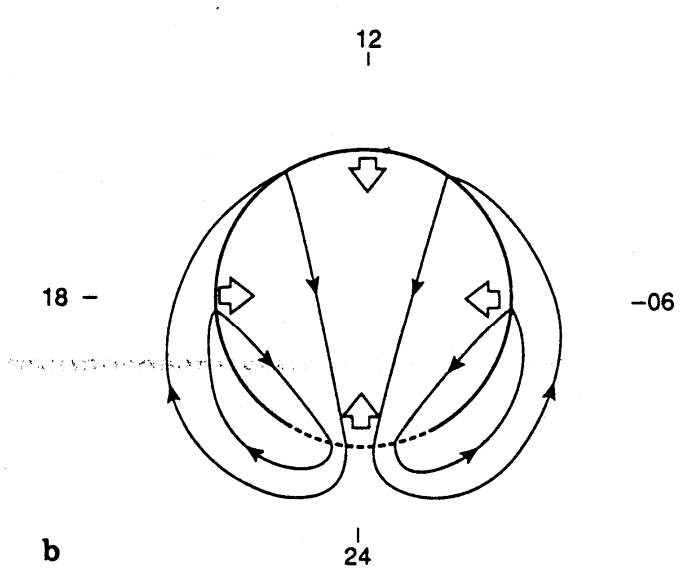
Dashed line = reconnection boundary – plasma flow across this boundary during episodes of reconnection

Full line = adiaroic boundary – this boundary is frozen into the plasma movement. I.e. there is no plasma transport across the full line OCB.

Pumping plasma accross the OCB, into the polar cap, the polar cap expands. The intake near noon, and the push away elsewhere, set up a twin cell convection pattern.

From Cowley and Lockwood, 1992

Tail reconnection –> close open flux in the polar cap –> shrinks the cap



Polar Cap Boundary or (PCB)

Open-Closed-Boundary (OCB):

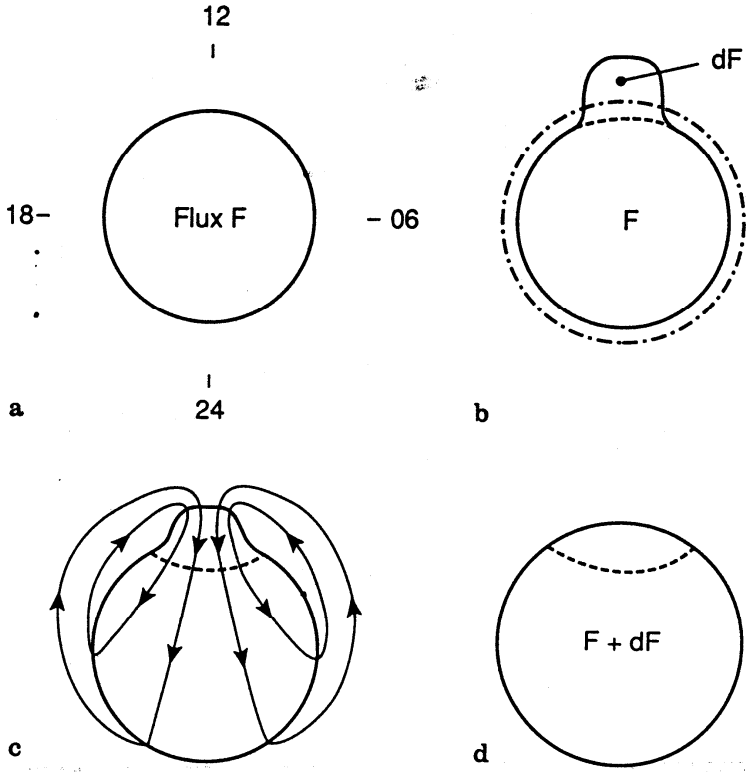
Dashed line = reconnection boundary – plasma flow across this boundary during episodes of reconnection

Full line = adiaroic boundary – this boundary is frozen into the plasma movement

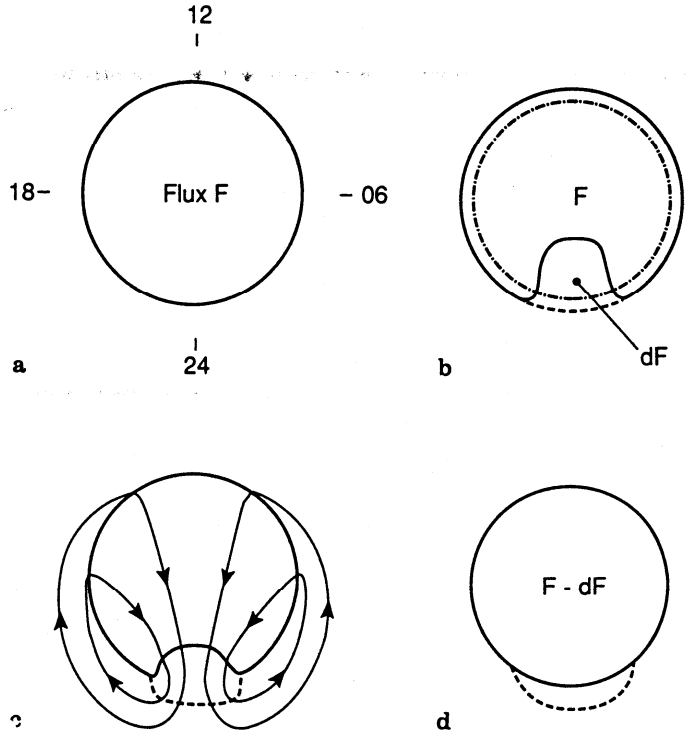
Whem plasma exit the polar cap near midnight, the polar cap shrinks, i.e. the OCB pushes inward, and a twin cell flow pattern is set up.

From Cowley and Lockwood, 1992

The principle of flow-free equilibrium



The ionospheric response to an impulse of magnetopause reconnection



The ionospheric response to an impulse of tail reconnection

From Cowley and Lockwood, 1992

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The relationship between time rate of change in open flux and flow voltage

$$\frac{\Delta \mathrm{F}}{\Delta \mathrm{t}} = \mathrm{Voltage}$$

$$[\mathrm{F}] = [\mathrm{AB}] = \mathrm{Tm}^2 = \mathrm{kgs}^{-1}\mathrm{C}^{-1}\mathrm{m}^2$$

$$\left[\frac{\Delta F}{\Delta t}\right] = \frac{\mathrm{kgm}^2}{\mathrm{s}^2\mathrm{C}} = \frac{\mathrm{J}}{\mathrm{C}} = \mathrm{V}$$

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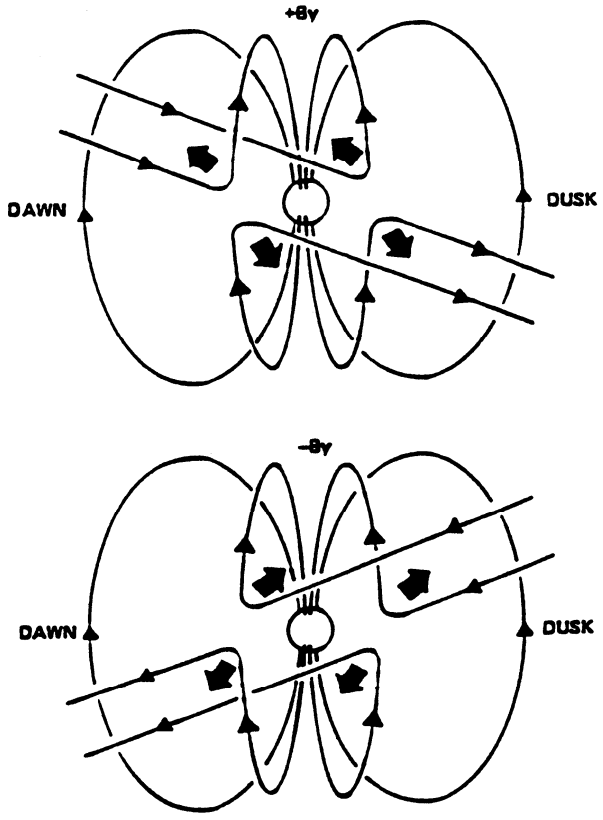
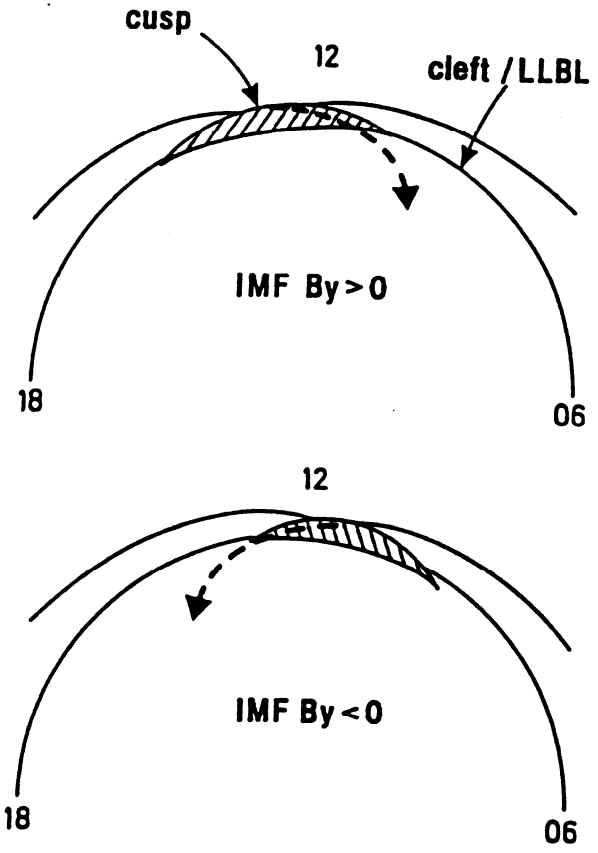
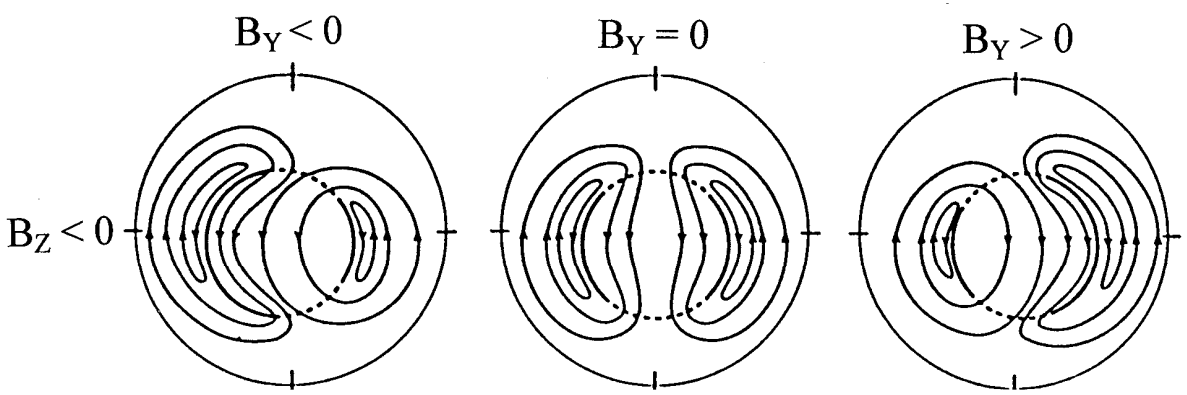
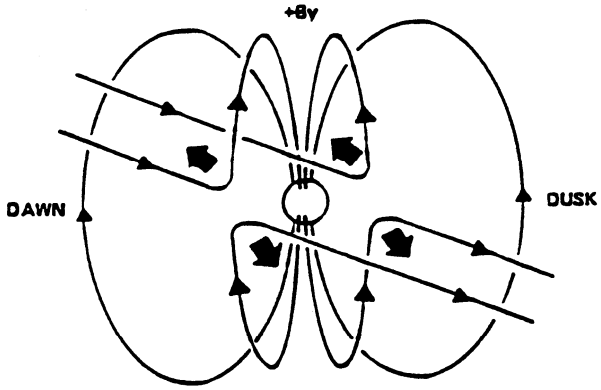
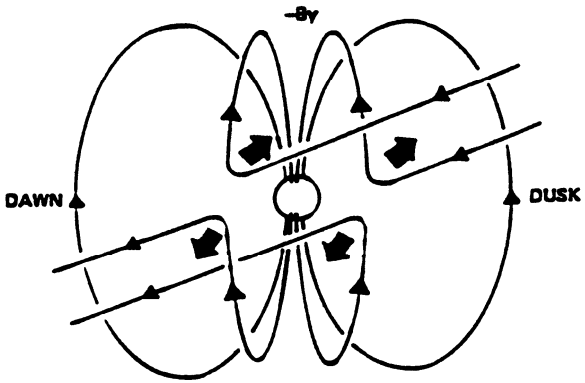
IMF By asymmetry on movement











The asymmetric flow around magnetic noon is a characteristic feature of magnetic reconnection (K&R page 268)