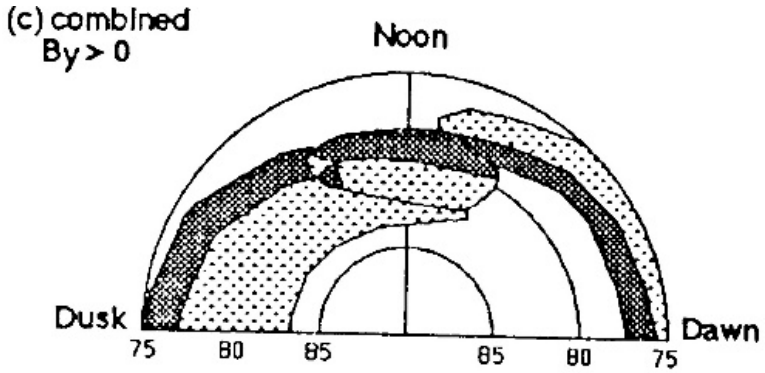
Dayside field-aligned current systems revisited

Masakazu Watanabe[1,2], Takashi Tanaka[1], Shigeru Fujita[3,4]

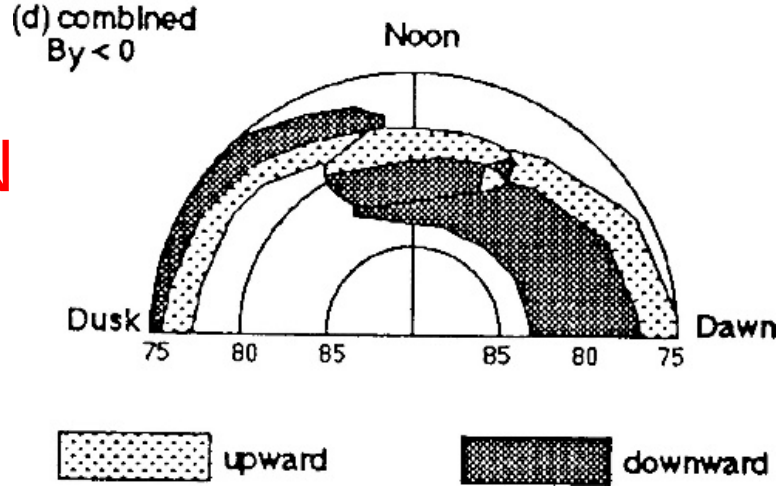
1. **International Center for Space Weather Science and Education, Kyushu University, Japan.**
2. **Graduate School of Science, Kyushu University, Japan.**
3. **Meteorological College, Japan.**
4. **National Institute of polar research, Research Organization of Information and Systems, Japan.**

The FACs in the dayside cusp/mantle region are controlled by IMF B_y. They are believed to be distinct from the region 1 and 2 systems on the flanksides.

B_y+, N



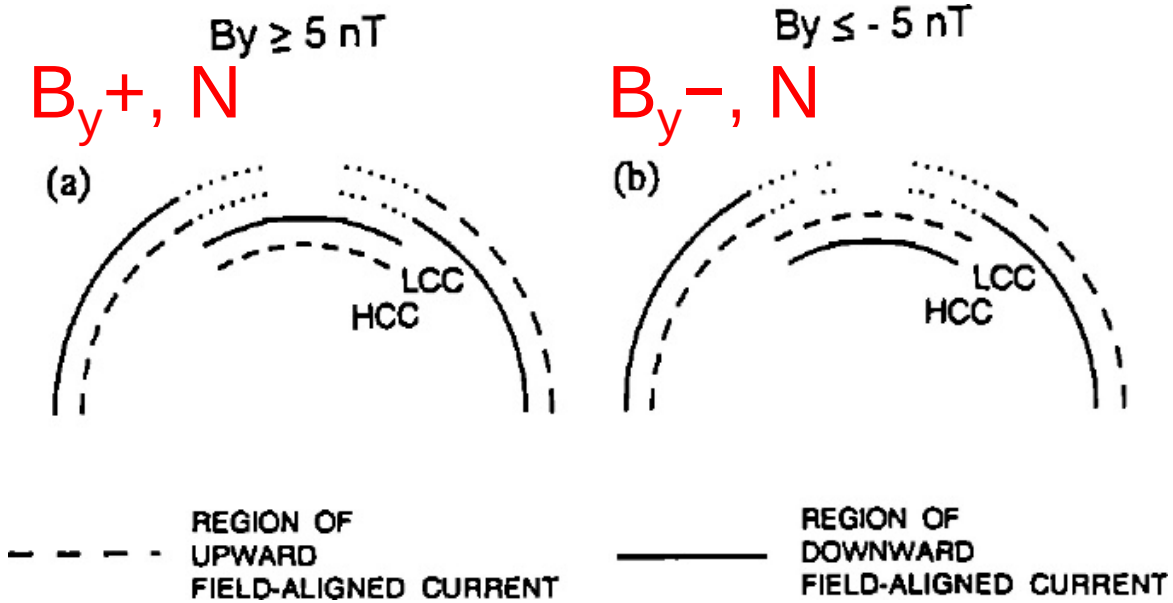
B_y−, N



Yamauchi et al., 1993

B_y+, N

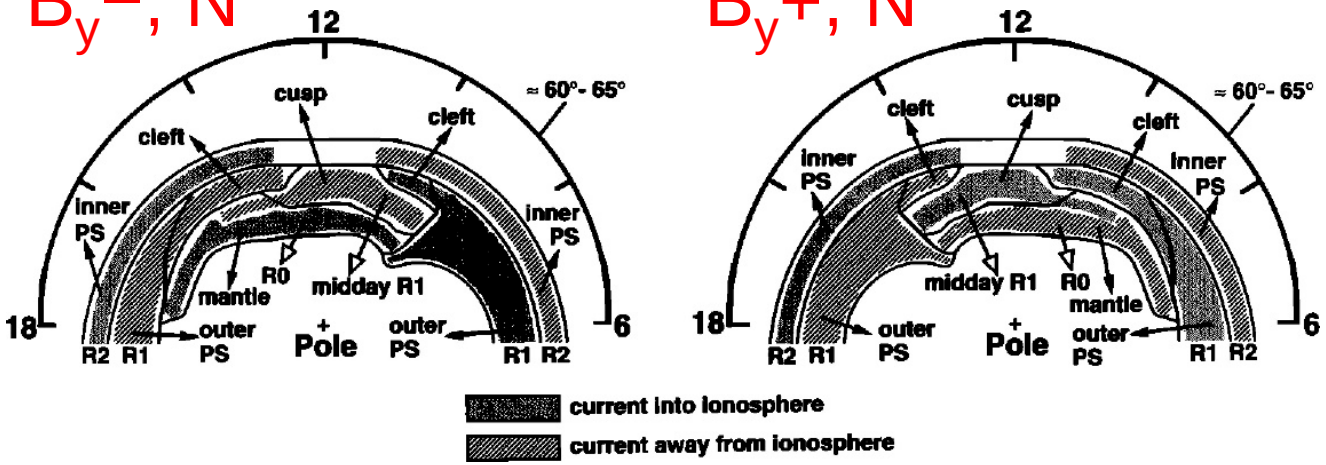
B_y−, N



Taguchi et al., 1993

B_y−, N

B_y+, N



Watanabe et al., 1996

In order to investigate the source mechanisms of the dayside FAC systems, we performed MHD simulation.

REPPU code [Tanaka, 2016]
level 6 (medium spatial resolution)
Inner boundary at 2.6 R_E

- Solar wind parameters

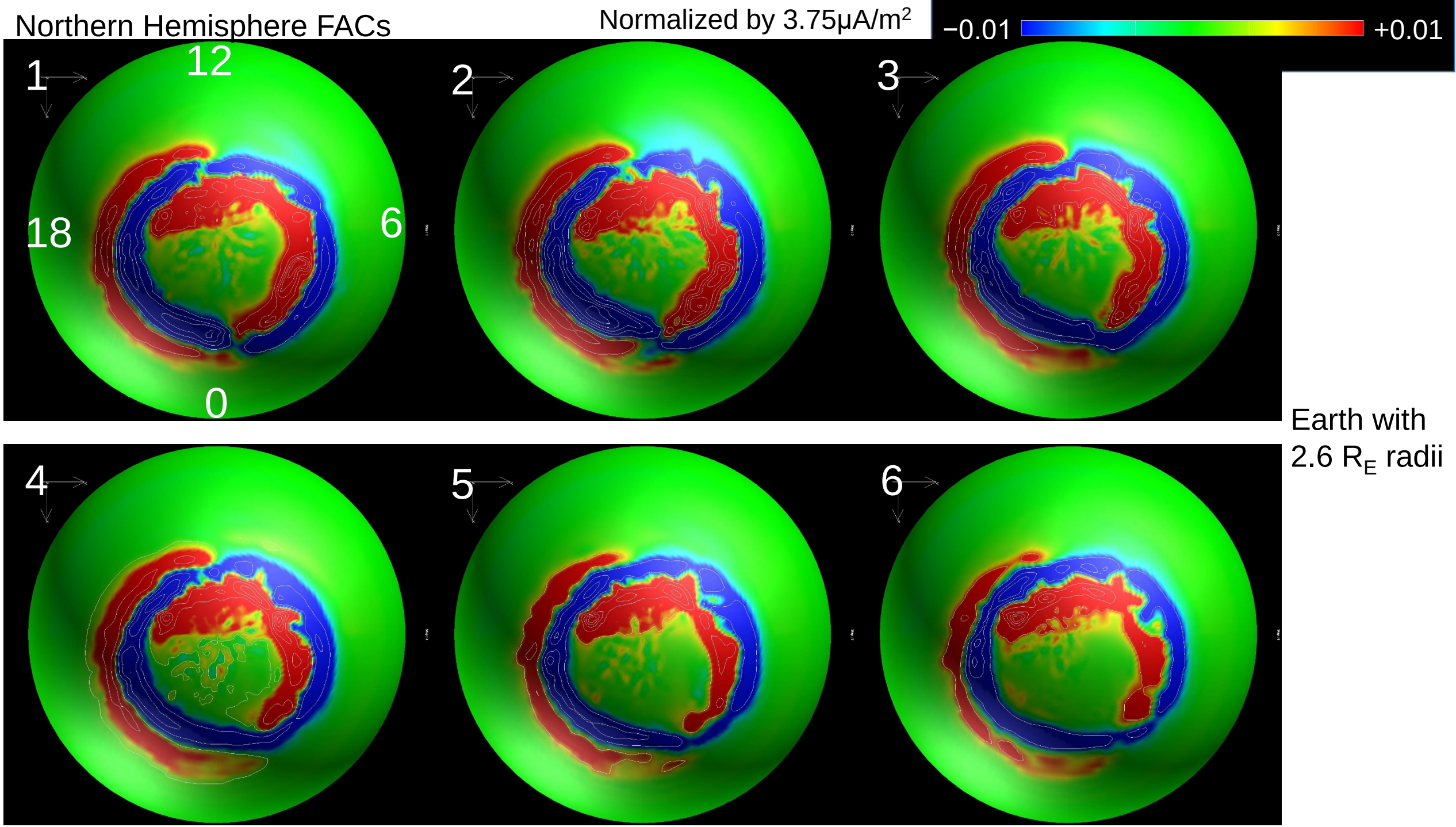
N = 5#/cc
V = 372 km/s
T = 200,000 K

- IMF parameters

B_x = 0 nT,
B_y = −5.2 nT,
B_z = −3.0 nT
(B_t = 6 nT, $\theta = 60^\circ$)

Northern Hemisphere FACs

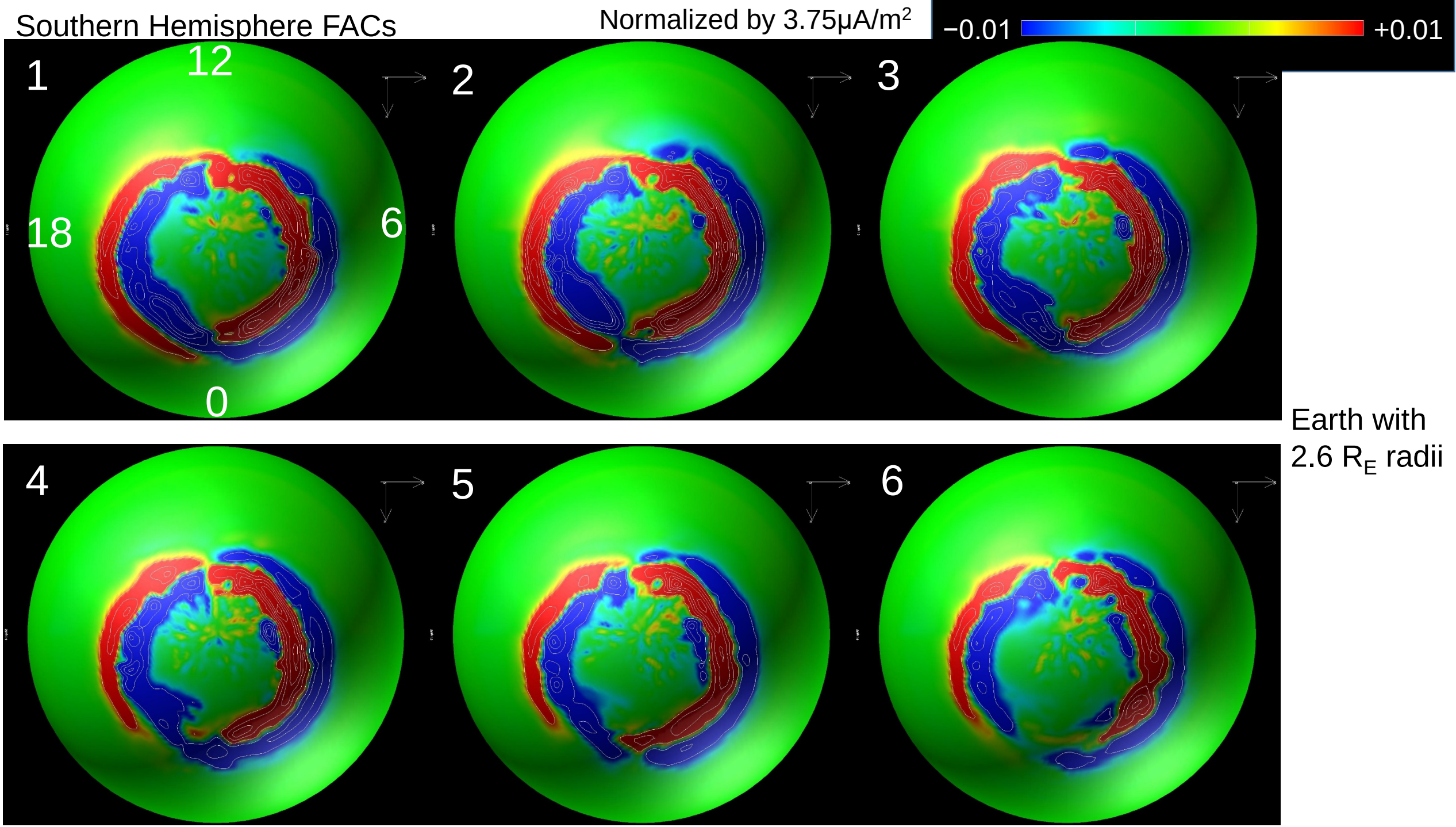
Normalized by 3.75μA/m^2



Earth with 2.6 R_E radii

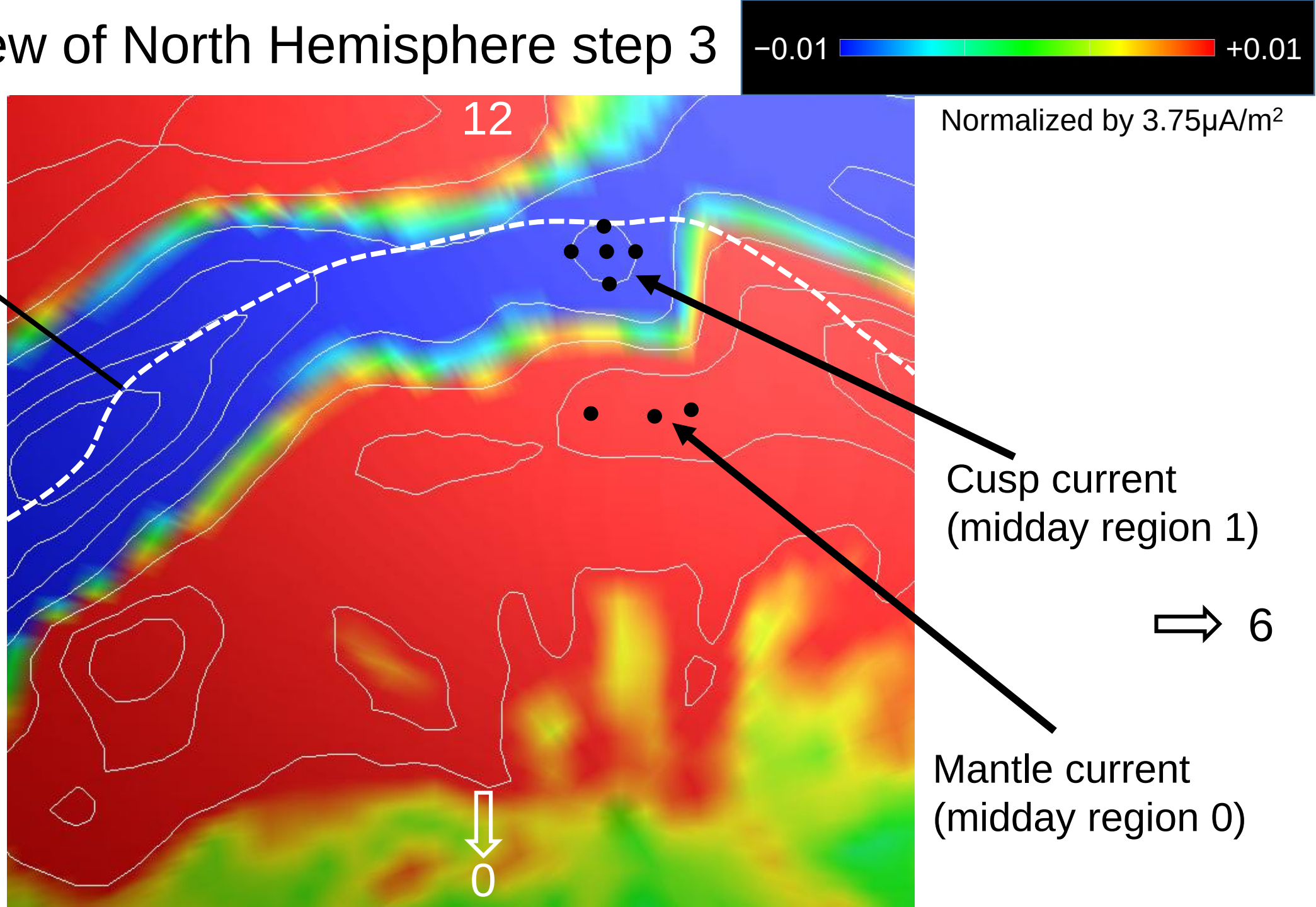
Southern Hemisphere FACs

Normalized by 3.75μA/m^2

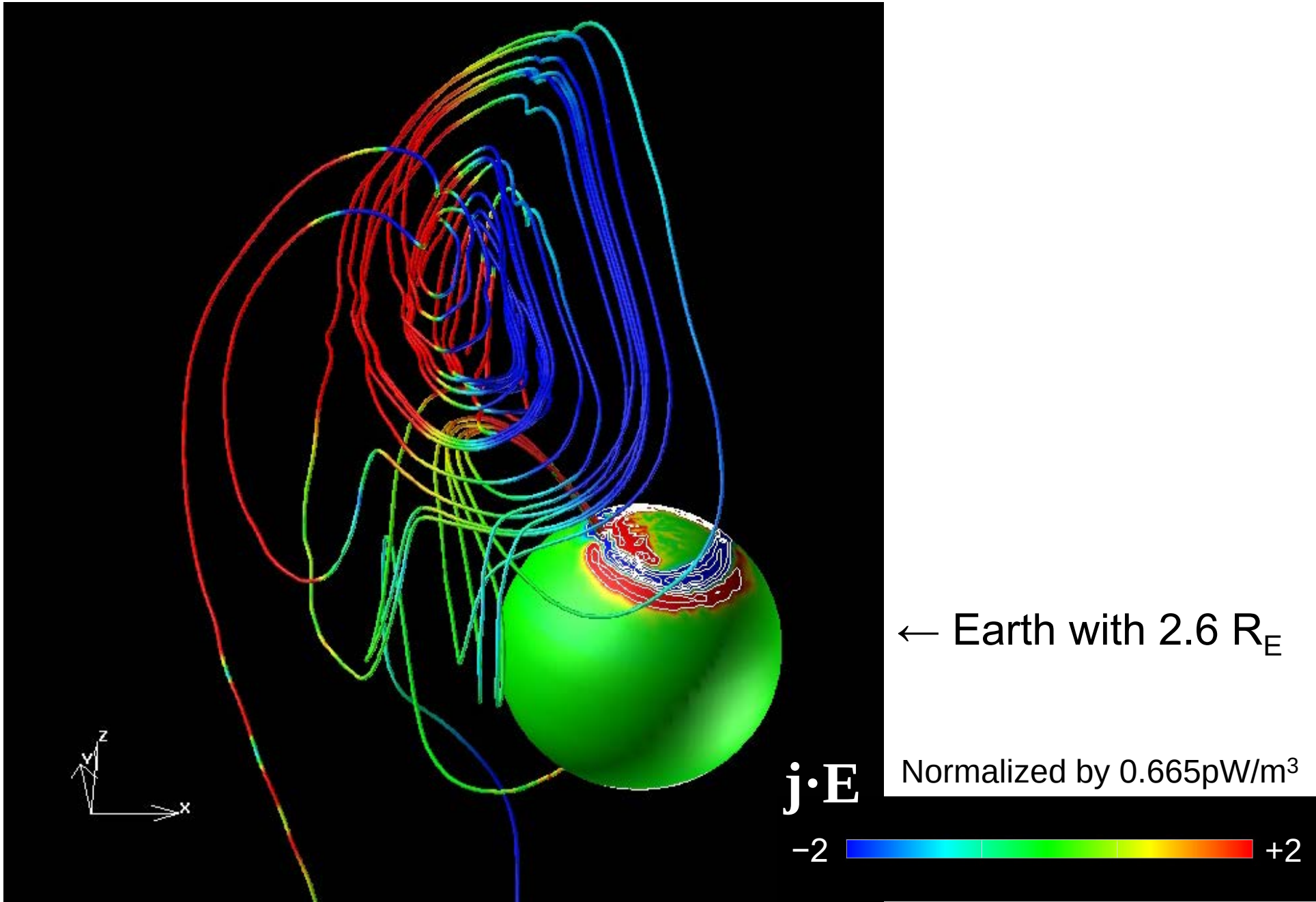


Earth with 2.6 R_E radii

Close-up view of North Hemisphere step 3

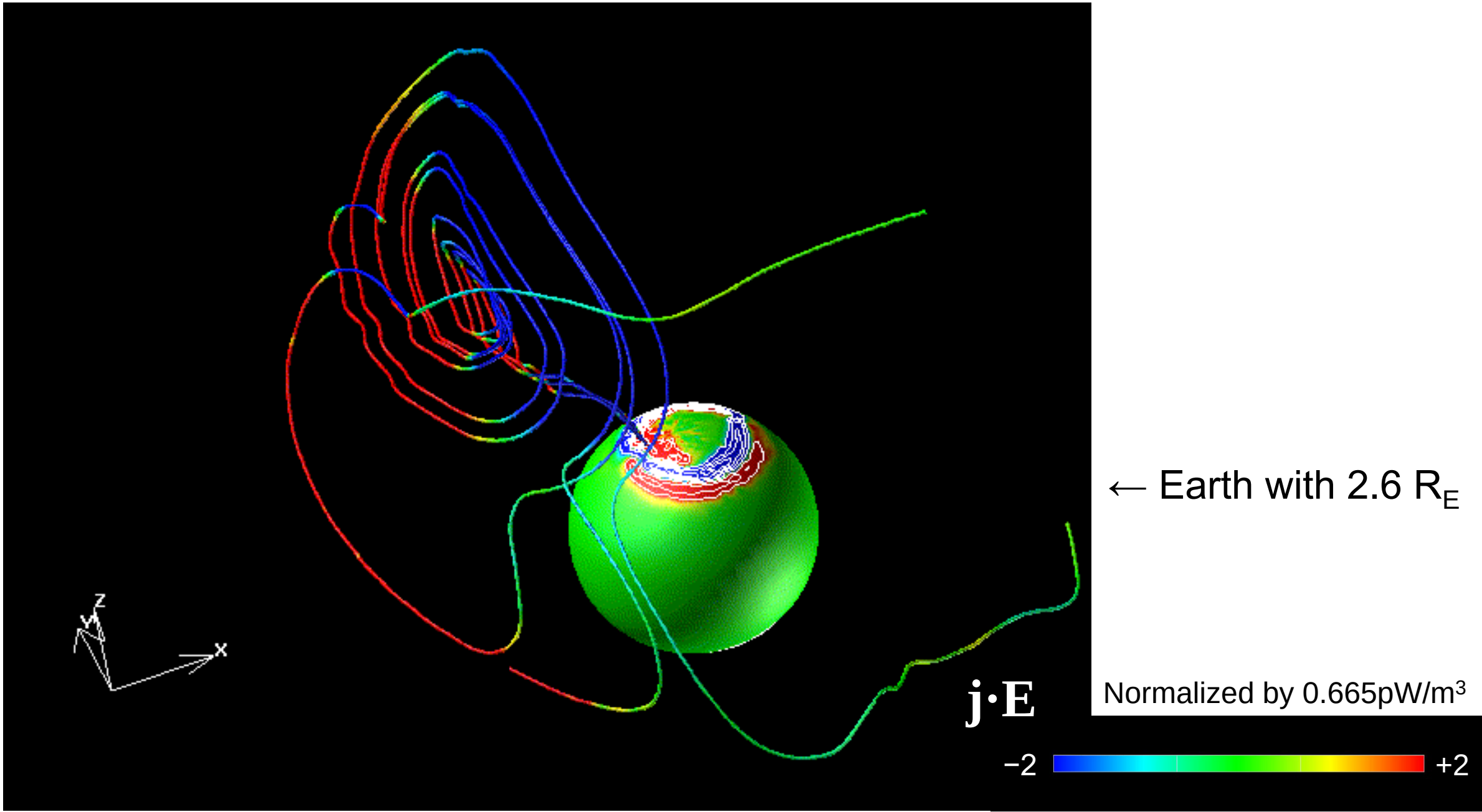


Tracing of cusp current lines



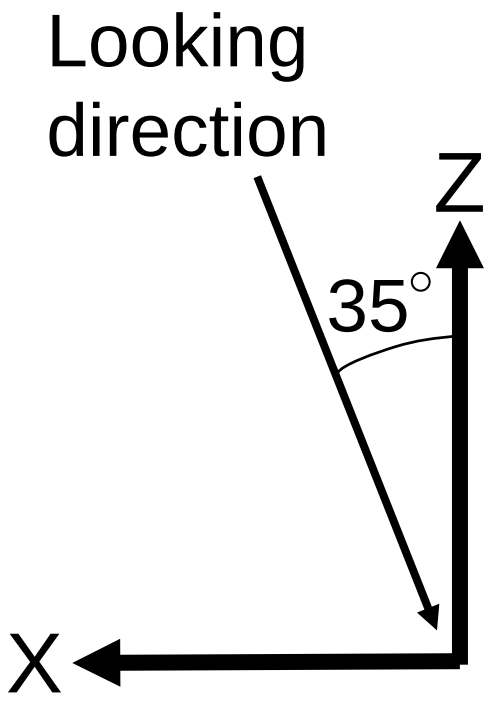
← Earth with 2.6 R_E

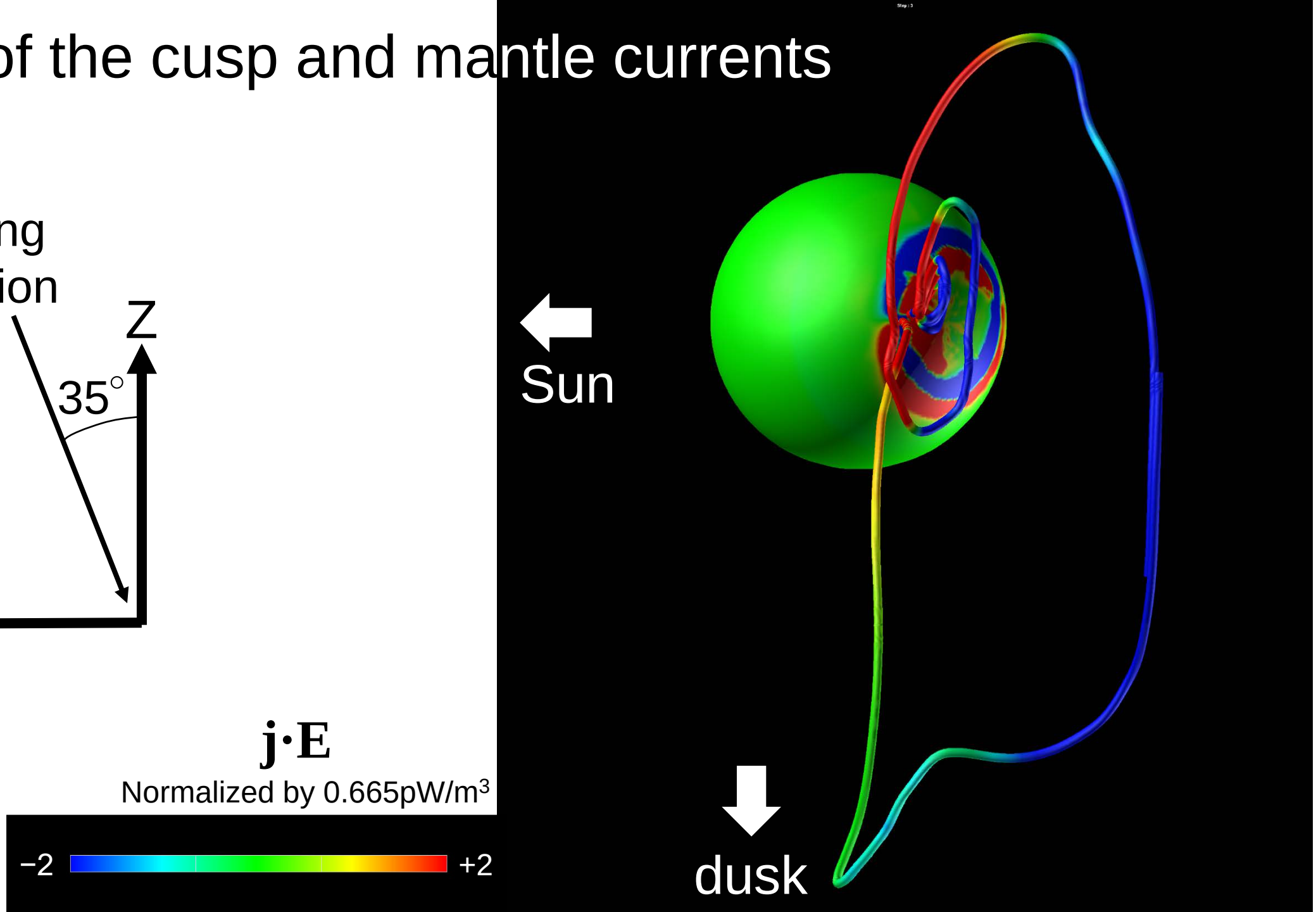
Tracing of mantle current lines

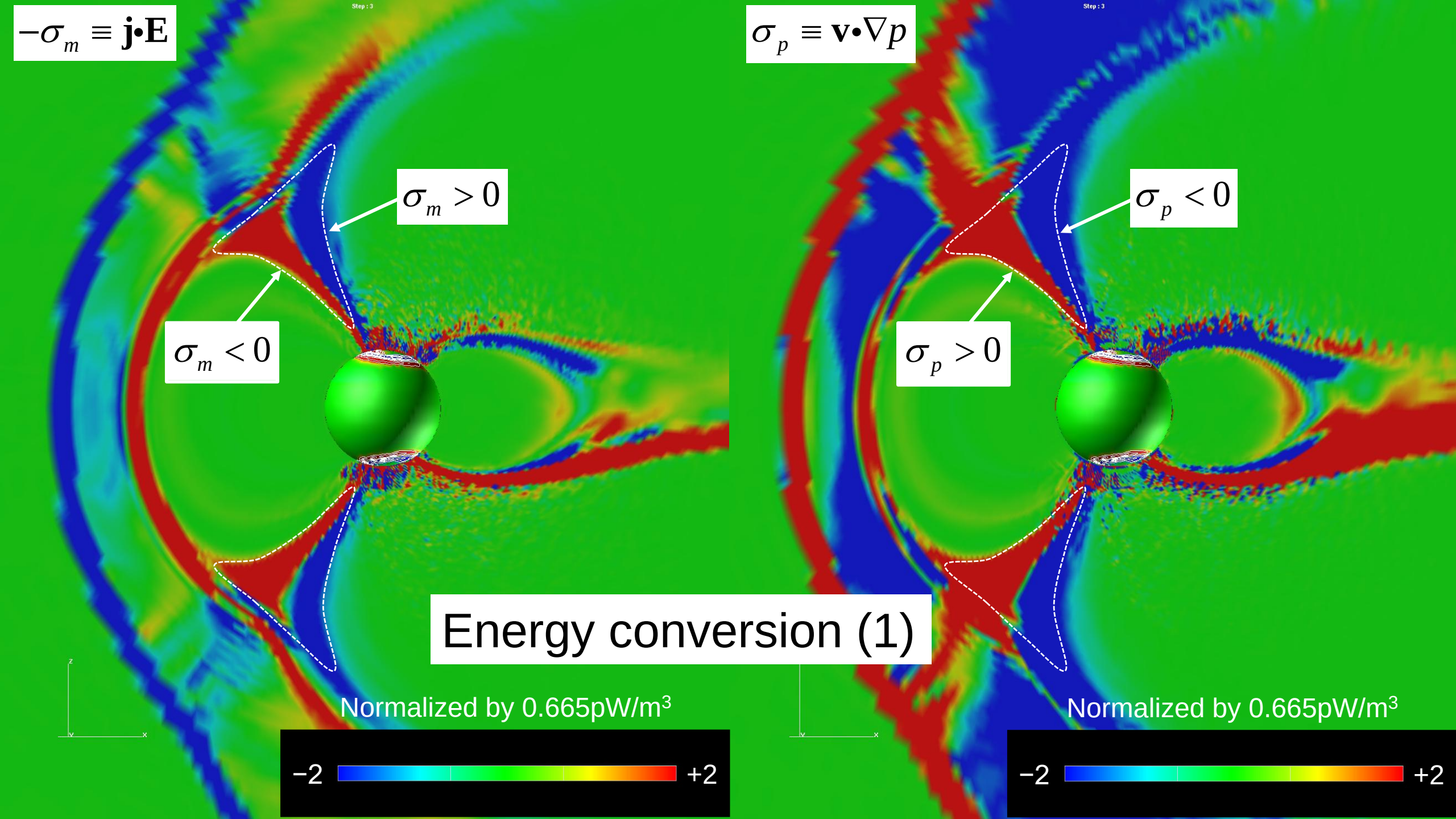


← Earth with 2.6 R_E

Closure of the cusp and mantle currents





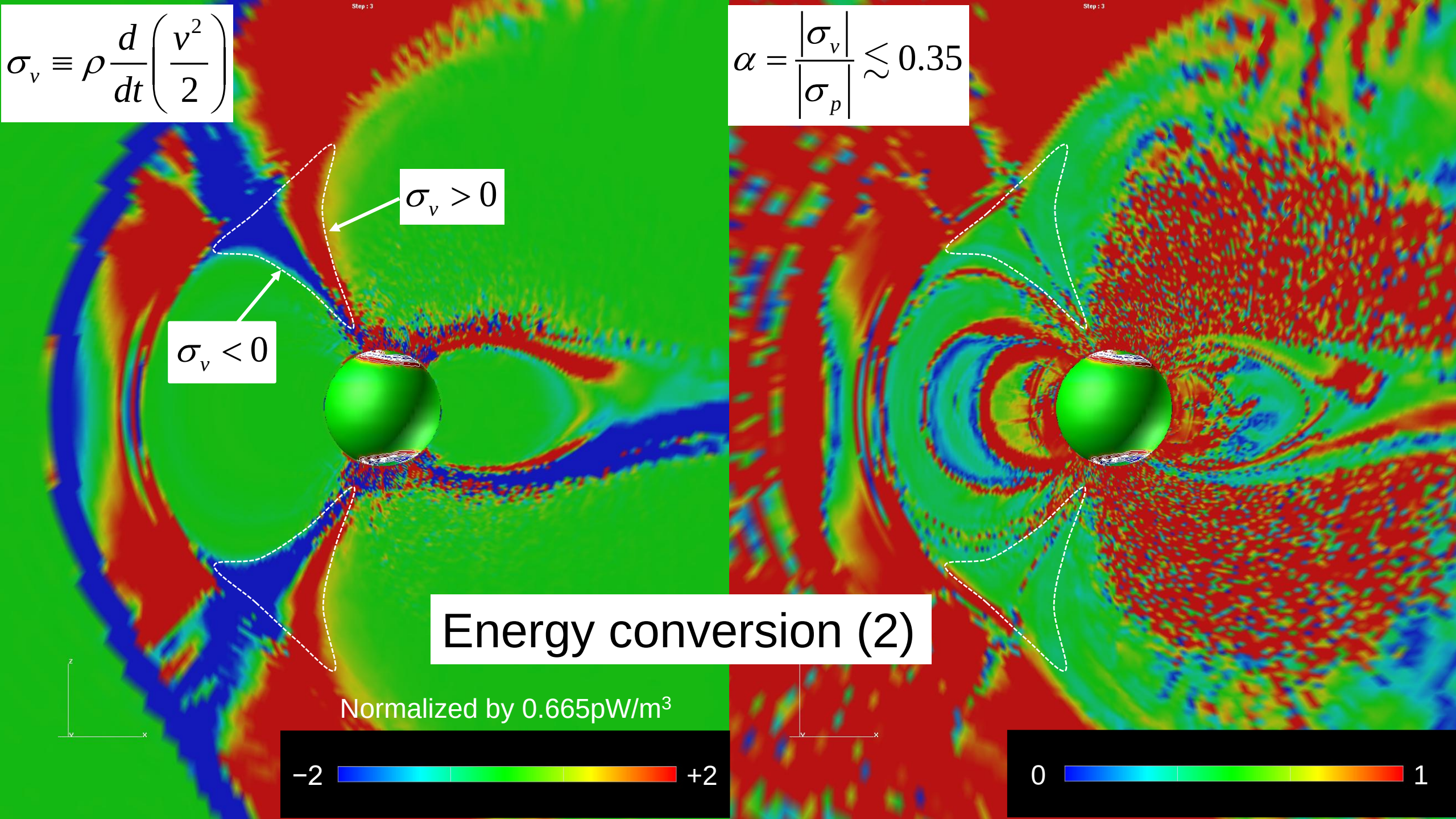


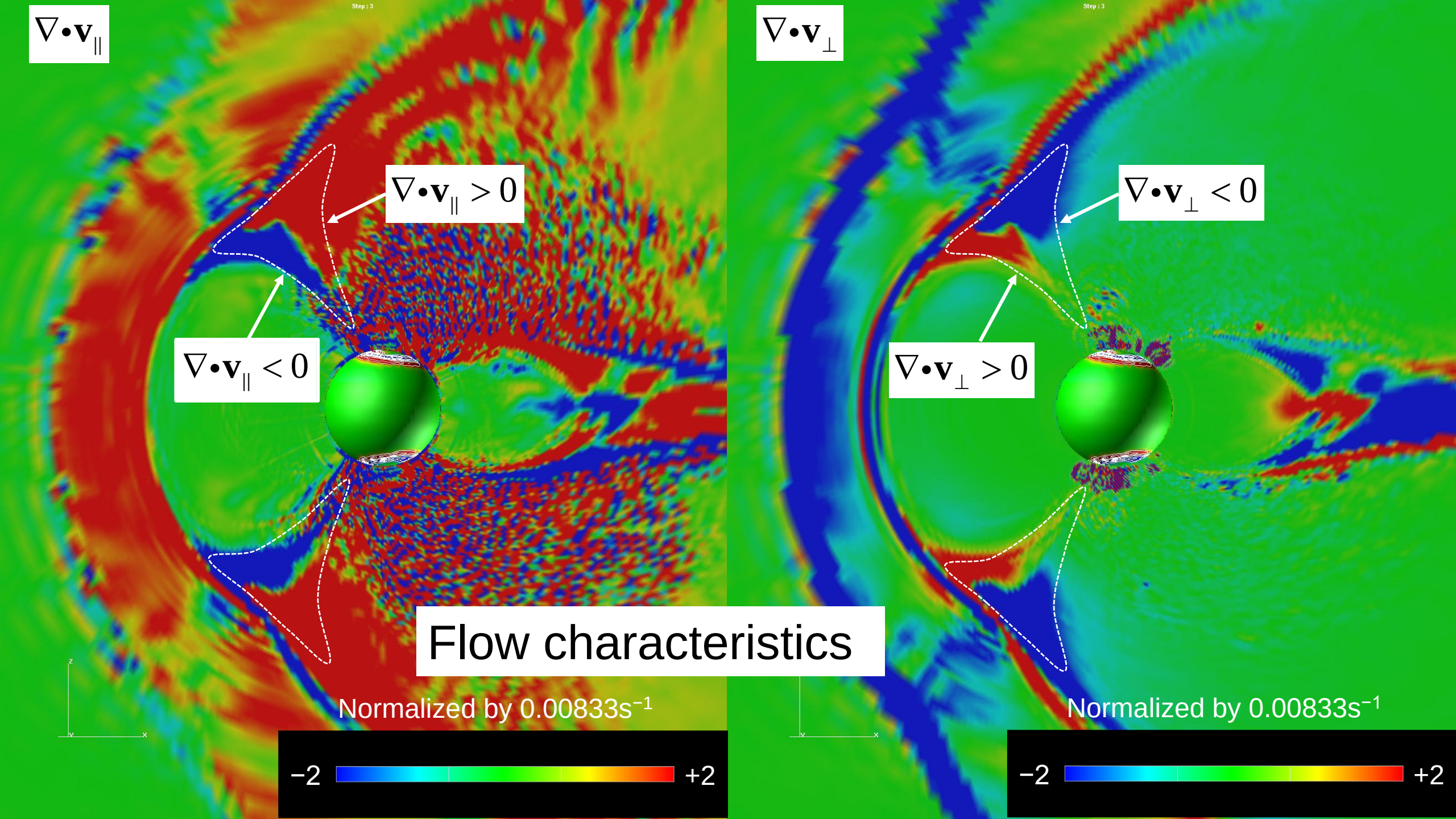
Energy conversion (1)

Energy conversion (2)

$$\sigma_v \equiv \rho \frac{d}{dt}\left(\frac{v^2}{2}\right)$$

$$\alpha = \frac{|\sigma_v|}{|\sigma_p|} \lesssim 0.35$$




$\nabla \bullet \mathbf{v}_{\parallel}$
$\nabla \bullet \mathbf{v}_{\parallel} > 0$
$\nabla \bullet \mathbf{v}_{\parallel} < 0$
$\nabla \bullet \mathbf{v}_{\perp}$
$\nabla \bullet \mathbf{v}_{\perp} < 0$
$\nabla \bullet \mathbf{v}_{\perp} > 0$
Flow characteristics
Normalized by 0.00833s^{-1}
−2
+2
Normalized by 0.00833s^{-1}
−2
+2

Energy conversion summary

	σ_m	σ_p	σ_v (small)	div($V_{\|\|}$)	div($V_\perp$)	
High latitude side	+	−	(+)	+	−	**Expanding-slow dynamo (phase 1)**
Low latitude side	−	+	(−)	−	+	**Contracting-slow load (phase 2)**

$$\sigma_m \equiv -\mathbf{j}\bullet\mathbf{E}$$

Electromagnetic energy

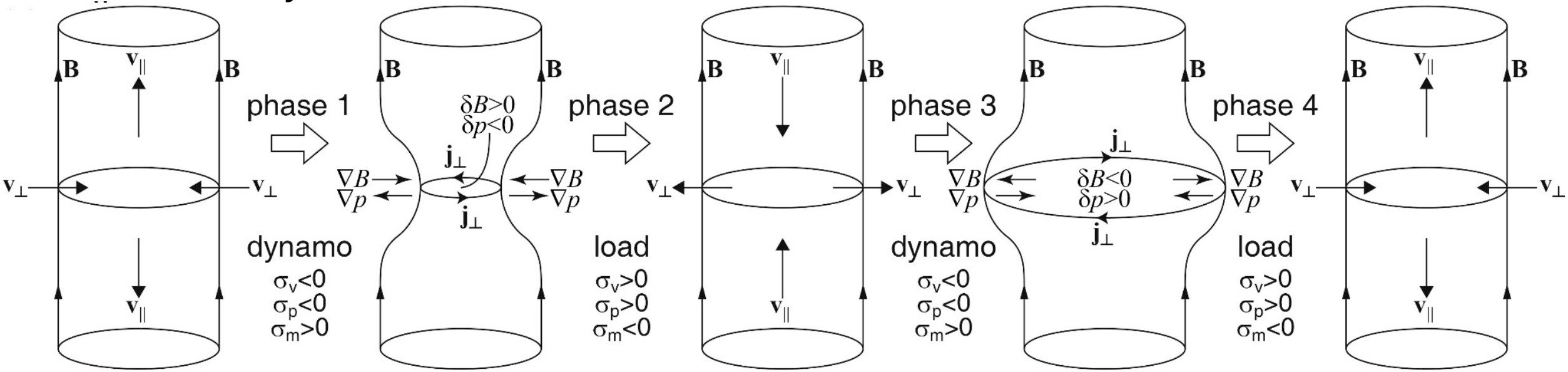
$$\sigma_p \equiv \mathbf{v}\bullet\nabla p$$

Plasma thermal energy

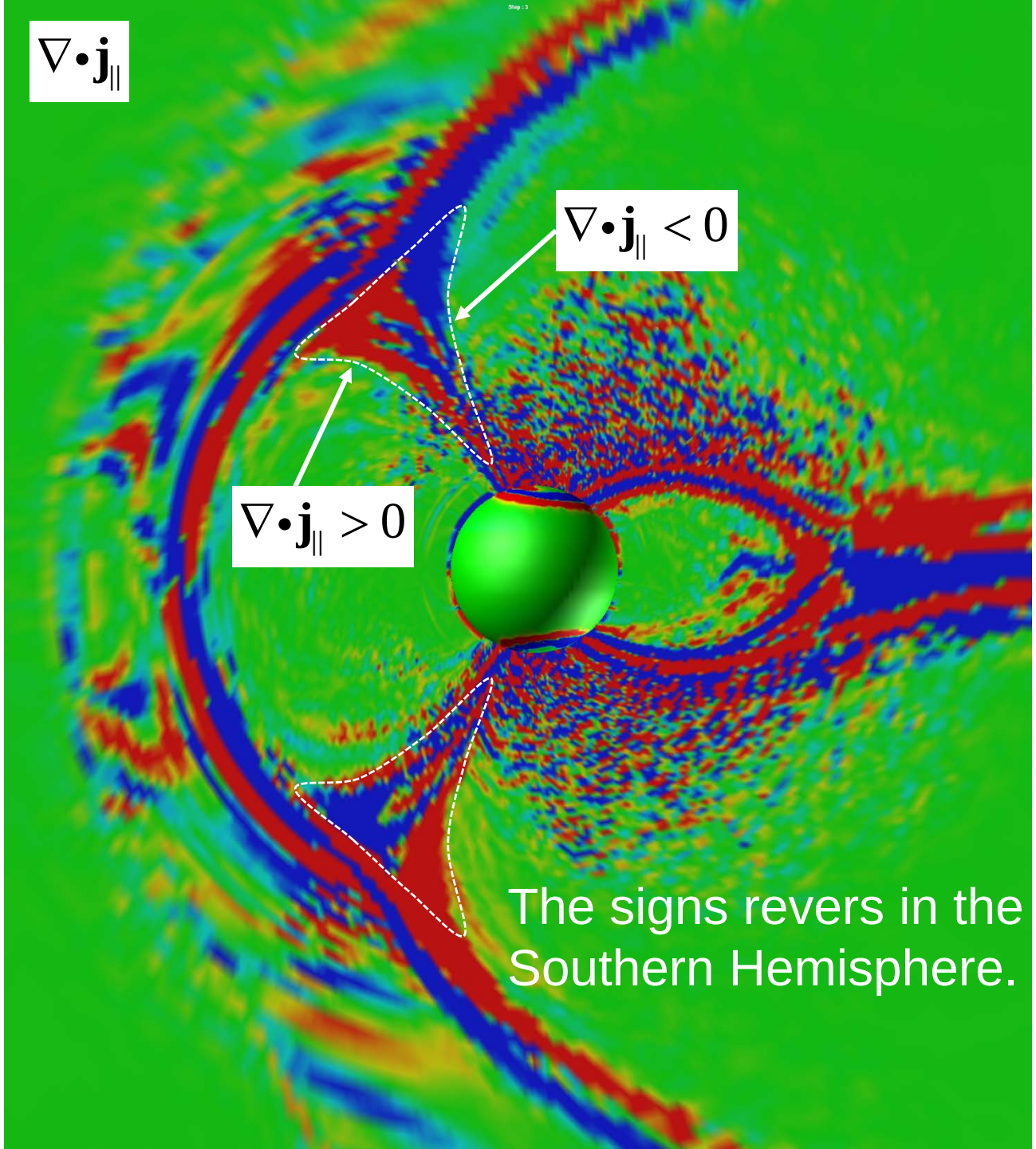
$$\sigma_v \equiv \rho\frac{d}{dt}\left(\frac{v^2}{2}\right) \quad \left(=-\sigma_m-\sigma_p\right)$$

Flow kinetic energy

Slow mode cycle



FAC generation



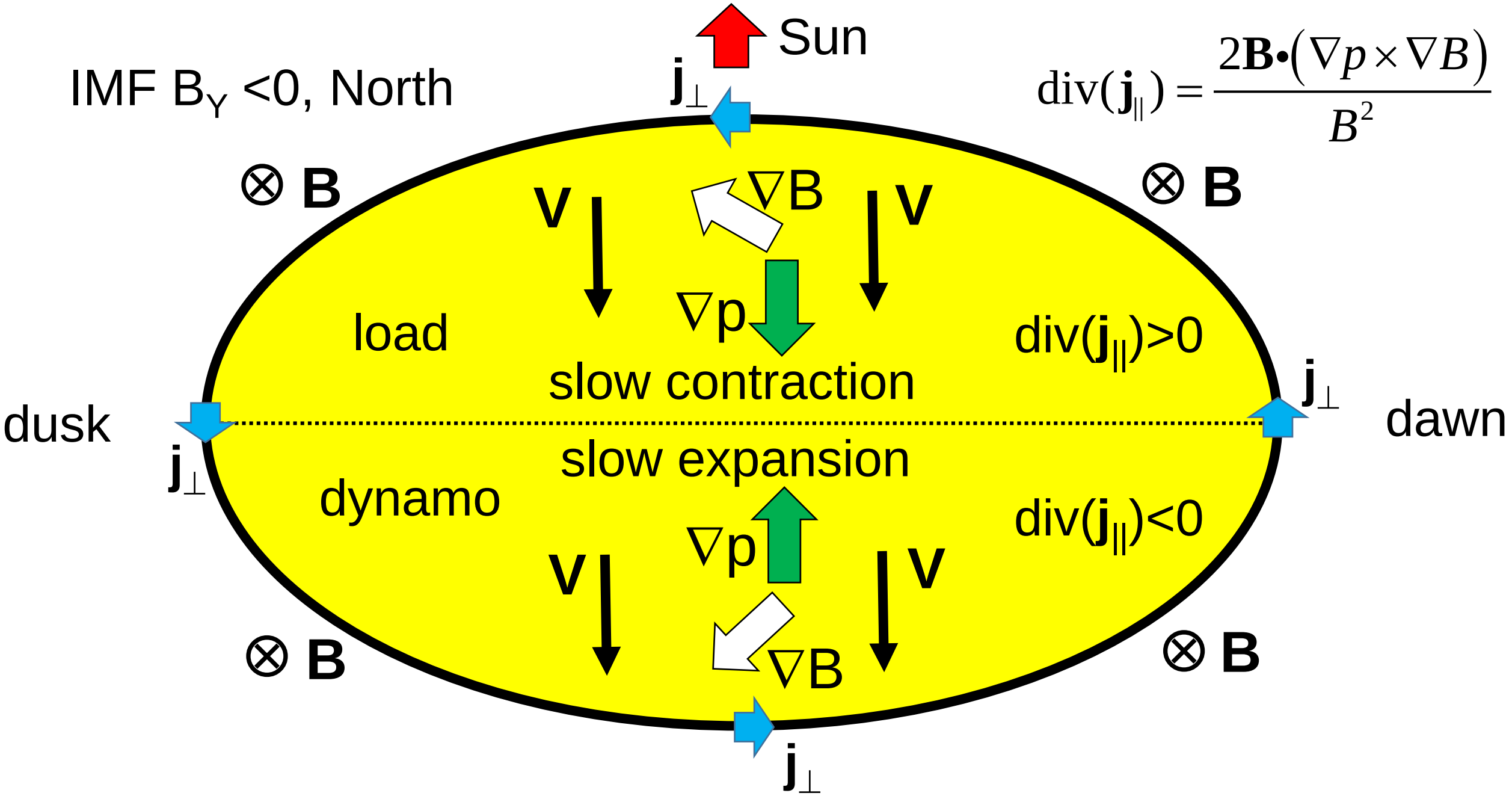
$\nabla \bullet \mathbf{j}_{||}$

Normalized by 0.196fA/m^3

Energy conversion + FAC generation summary

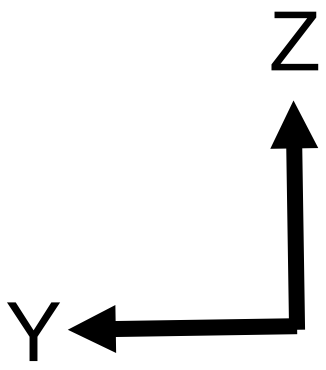
IMF B_Y <0, North

$$\mathrm{div}(\mathbf{j}_{\parallel}) = \frac{2\mathbf{B}\bullet\left(\nabla p \times \nabla B\right)}{B^2}$$

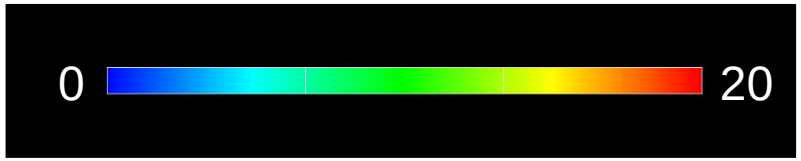


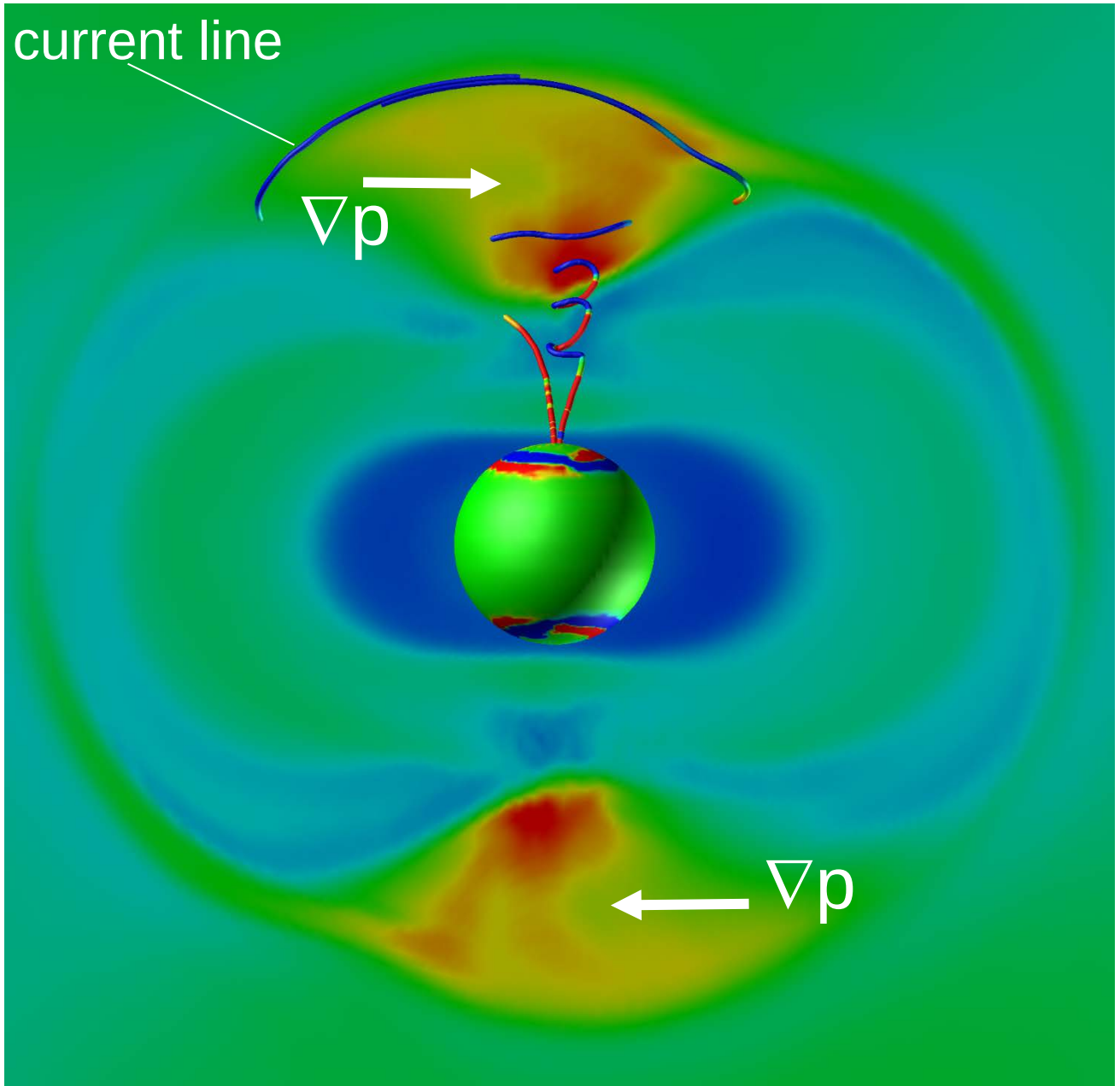
Duskward and dawnward pressure gradient?

Plasma pressure in the X=3.5 R_E plane

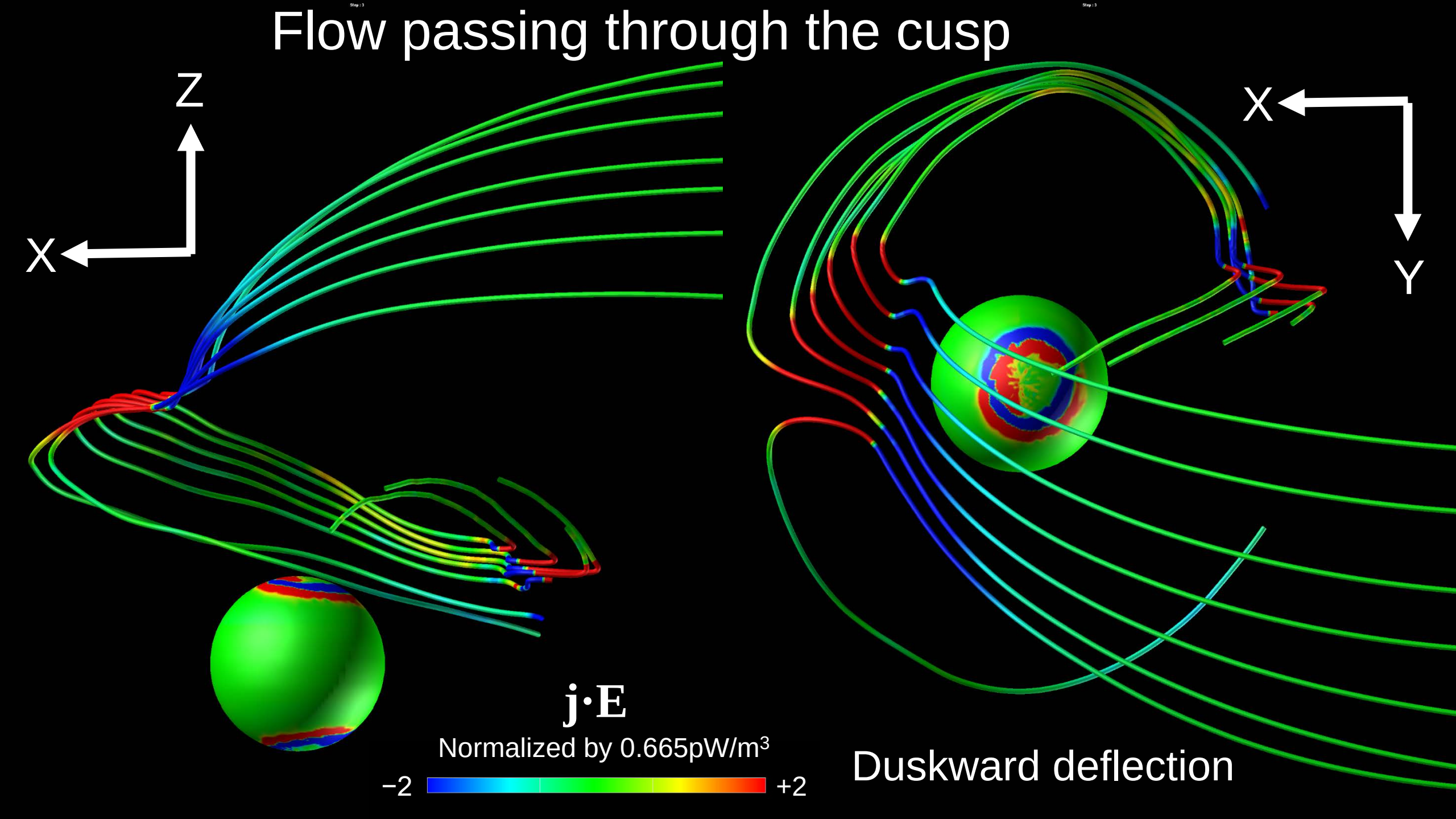


Normalized by 46.9pPa





Flow passing through the cusp



Conclusion

With numerical modeling, we examined the dayside current systems for $B_y<0$ in the Northern Hemisphere. We conclude that midday region 1 (“cusp” current) and midday region 0 (“mantle” current) are closed in the magnetospheric cusp, spiraling around the high-pressure region. The dynamo is located in the poleward of side of the cusp, where the plasma process is interpreted in terms of expanding slow mode disturbances. Other characteristics are summarized as follows.

	B_Y and hemisphere independent			B_Y and hemisphere dependent	Dominant plasma process
High latitude side	dynamo	$div(V_{\|\|})>0$	$div(V_{\perp})<0$	$div(j_{\|\|})<0$	**Expanding slow**
Low latitude side	load	$div(V_{\|\|})<0$	$div(V_{\perp})>0$	$div(j_{\|\|})>0$	**Contracting slow**