¿Do We Really Understand Solar-Wind/Magnetosphere Coupling?

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- **We have major unsolved issues about**
  - **A. what controls dayside reconnection**
  - **B. the magnitude of and physics of the viscous interaction.**
- **We have lack of understanding of post-reconnection coupling physics.**
- **We have a problem using data correlations to confirm physical principles.**

Discuss 7 deficiencies/impediments in our understanding.

1 What Controls the Dayside Reconnection Rate: E_{sw} or $0.1v_AB$?

(1) Since the reconnection rate $v_{in}B$ has the dimension of an electric field, it has been argued that $E_{recon} = E_{sw} = v_{sw}B_z$.

The solar-wind "electric field" evolved to $v_{sw}{}^{x}B^{y}\sin^{z}(\theta_{clock}/2)$.

(2) The Petschek $0.1v_AB$ yields derivations $R(n_{sw},v_{sw},M_A,\theta_{clock})$

$$R_{quick} = n_{sw}{}^{1/2}\, v_{sw}{}^{2}\, M_A{}^{-1.35}/[1 + 680M_A{}^{-3.30}]^{1/4}\, \sin^2(\theta/2)$$

Both (1) and (2) do well in correlations with geomagnetic activity.

Is one correct? Is one wrong?

2a Correlations: Physics Versus Math

Correlation Game:

How well can solar-wind variables describe the variance of geomagnetic indices?

Physics improvement of correlation coefficient:

Choose solar-wind variables that more accurately describe the coupling mechanism of the solar wind to the magnetosphere.

Mathematical improvement of correlation coefficient:

Choose solar-wind variables that better describe the variance of the solar wind, with a better chance of describing magnetospheric variance.

When the variables are noisy, how can you tell better physics from better math?

Solar-Wind Function	*Correlation (7-index average)*
Newell (v_{sw},B_{perp},θ_{clock})	+0.700
R_{quick} (n_{sw},v_{sw},M_A,θ_{clock})	+0.702
v_{sw} + 75 B $\sin^2(\theta_{clock}/2)$	+0.737

2b Correlations: Cause and Effect

In the solar wind, all variables are correlated or anti-correlated.

And all variables are noisy (imperfect).

(1) A solar-wind variable can be acting as a proxy for another solar-wind variable.

(2) A solar-wind variable may be acting to suppress the noise on another solar-wind variable.

(3) A solar-wind variable may be acting to supply information about the type of solar-wind plasma.

Sorting out cause and effect in correlations is ... difficult.

3 ¿What Is the Nature of the Viscous Interaction?

(1) What is the magnitude of the viscous interaction?

(viscous interaction versus reconnection behind the cusps)

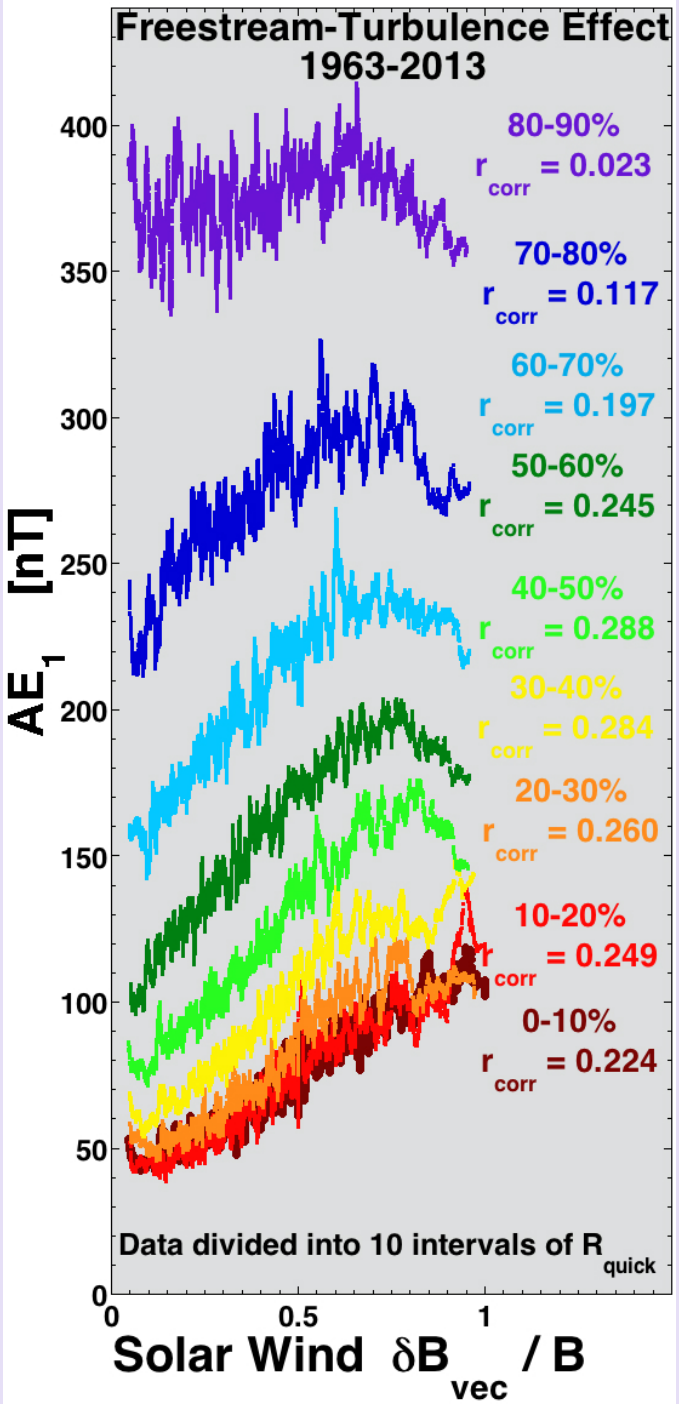
(2) What physical mechanisms are acting?

Kelvin-Helmholtz rollups?

Plasma-wave diffusion?

Other ?

(3) What variables in the solar-wind control the viscous interaction?



4 ¿What Is the Physics of the Turbulence Effect?

AE, AU, -AL, Kp, -Dst, and PCI are positively correlated with δB/B of the upstream solar wind.

These correlations hold when the reconnection driver functions are binned.

These correlations hold when the fluctuations are purely northward.

Is there a physical mechanism that couples solar-wind turbulence to the magnetosphere?

What type of solar-wind fluctuations are important?

5 The Feedback of Magnetospheric Mass Density on the Dayside Reconnection Rate

Magnetospheric plasma can mass-load dayside reconnection: predicted, simulated, and confirmed by spacecraft measurements.

Criterion from the Cassak-Shay equation: $\rho_{mag} \geq \rho_{sh} B_{mag}/B_s$.

Storm levels of driving bring a magnetospheric response via:

1 plasmaspheric drainage plume
2 oxygen-rich ion plasma sheet
3 warm plasma cloak.

1) We don't have surveys of the mass density ρ of the ion plasma sheet in the dayside magnetosphere.

2) We don't know the properties of the warm plasma cloak or its global evolution pattern.

⇒ We can't quantify the amount of mass loading of dayside reconnection by the magnetosphere.

6 ¿What is the Physics of Mass Coupling between the Solar Wind and the Magnetosphere?

1) We don't know the physical mechanisms that transport plasma from the magnetosheath into the magnetosphere.

2) We don't know how the plasma is processed upon entry.

3) Are there multiple pathways for plasma entry: LLBL versus mantle?

4) Can we quantitatively predict the mass transport.

7 The Physics of Post-Reconnection Coupling of the Solar Wind to the Magnetosphere-Ionosphere System

After dayside reconnection, magnetospheric magnetic field lines connect directly into the moving magnetosheath plasma.

1) How important is the solar-wind driving of antisunward convection in the polar-cap ionosphere?

2) When do Region-I type currents close in the magnetosheath and bow shock?

3) How does polar-cap-potential saturation work?

Several mechanisms, no consensus.

Summary

Our physics understanding of solar-wind/ magnetosphere coupling is in very poor shape.

(1) Control of dayside reconnection

(2) Interpretation of correlations

(3) The viscous interaction

(4) The turbulence effect

(5) Mass loading of dayside reconnection

(6) Plasma entry

(7) Post-reconnection coupling physics

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