Hybrid plasma modeling of the Reiner Gamma magnetic anomaly: *Implications for surface weathering and source magnetization*

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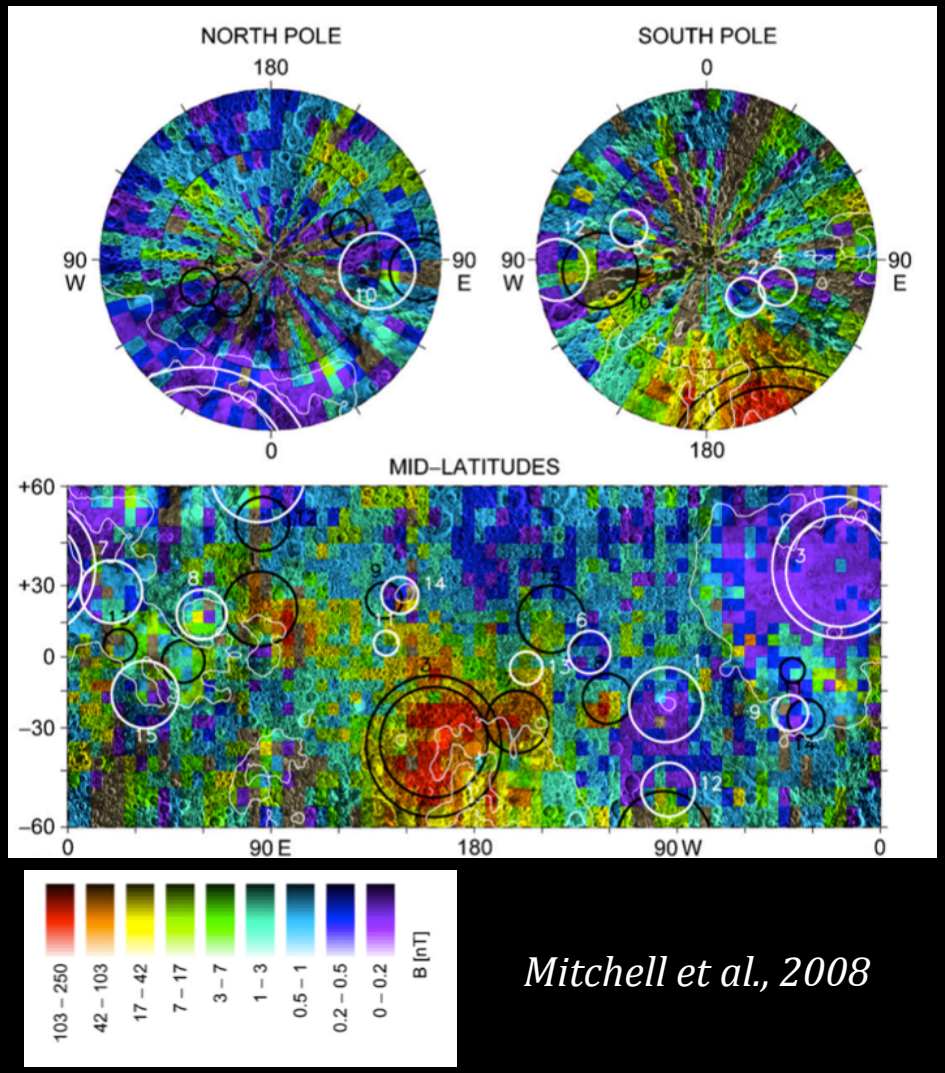
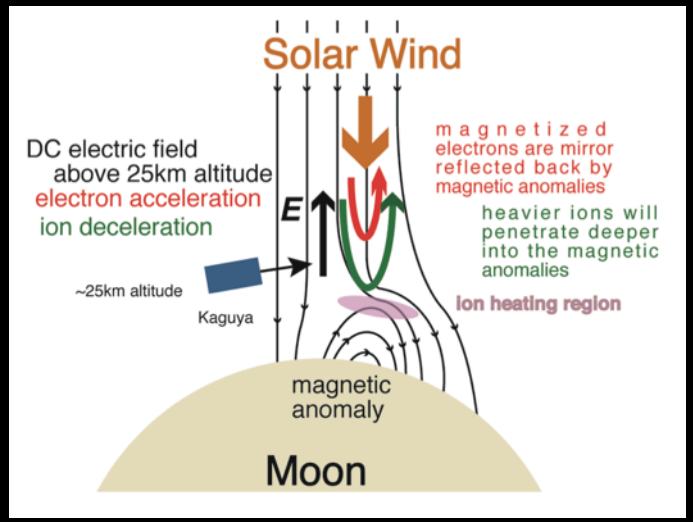
Crustal Magnetic Anomalies & Lunar Swirls

The Moon possesses diverse and scattered crustal magnetism

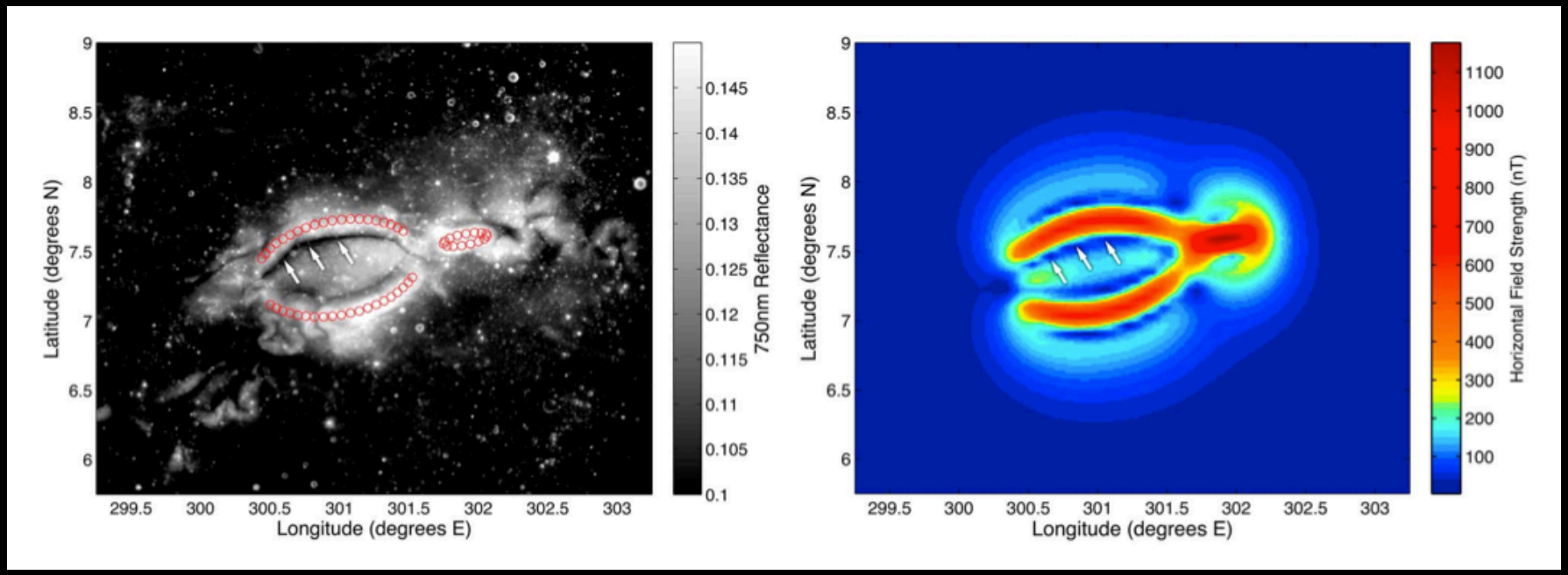


Mitchell et al., 2008



Saito et al., 2010

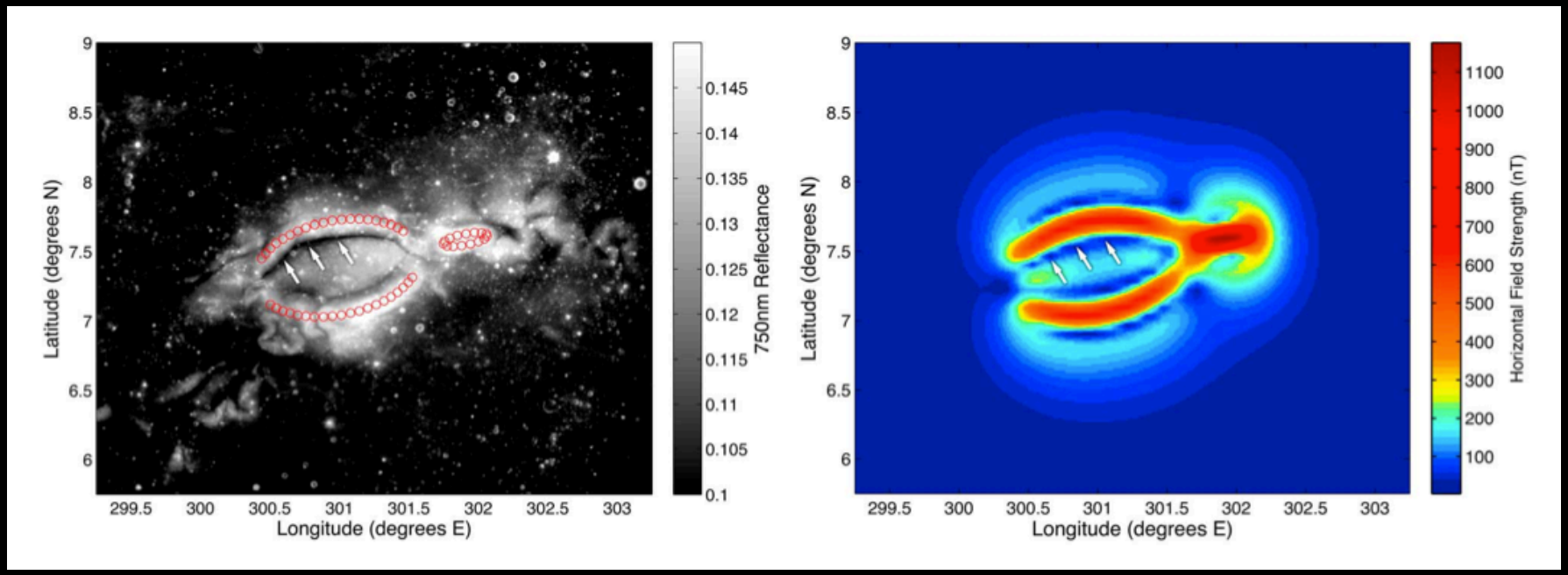
Magnetic source modeling of Reiner Gamma



Hemingway and Garrick-Bethell, 2012

Guided by Clementine albedo observations (along with the solar wind shielding hypothesis), and constrained by Lunar Prospector magnetometer data, Hemingway and Garrick-Bethell [2012] have proposed a possible source magnetization for Reiner Gamma

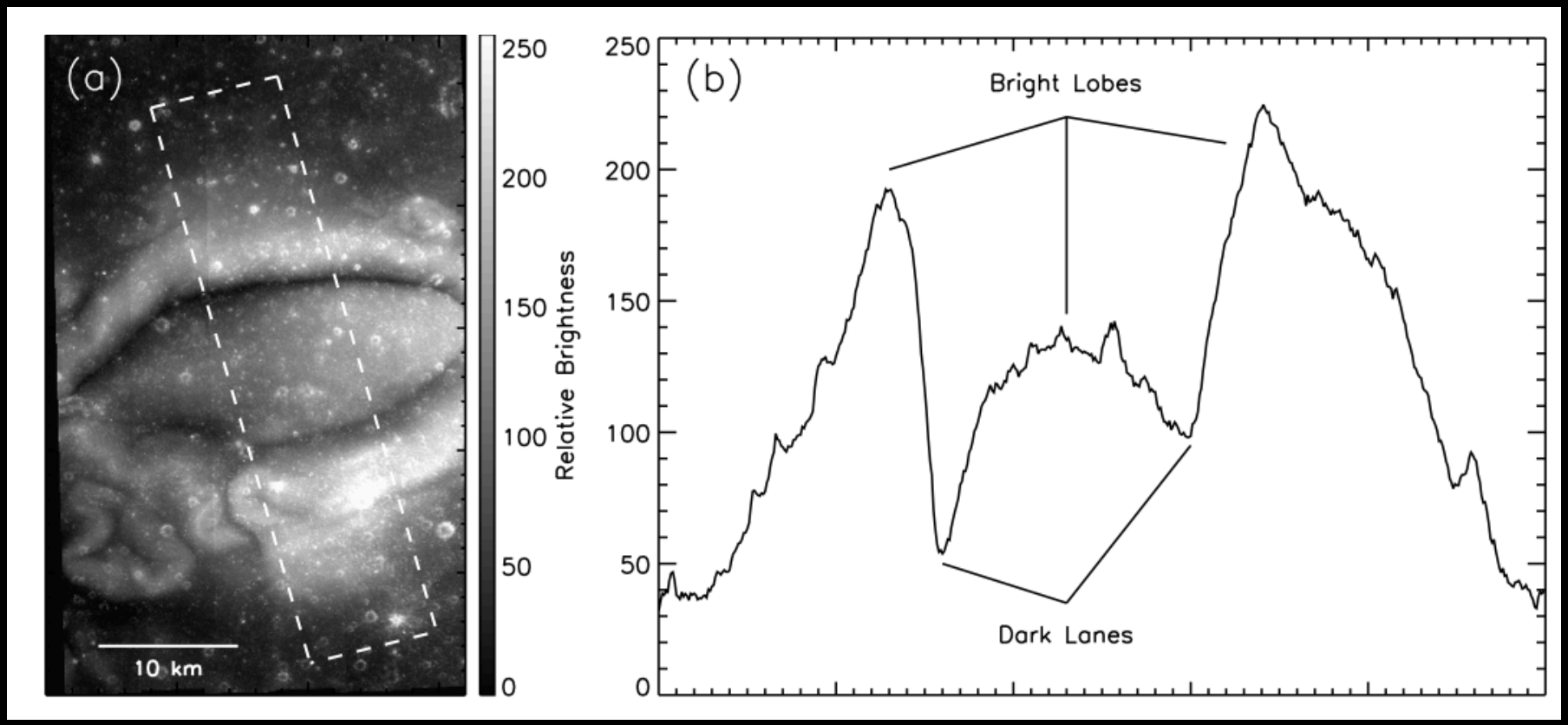
Magnetic source modeling of Reiner Gamma



Hemingway and Garrick-Bethell, 2012

Can we test whether specific magnetic source geometries produce surface weathering patterns similar to swirls, in order to further test the solar wind shielding hypothesis?

Reiner Gamma: Region of modeling interest



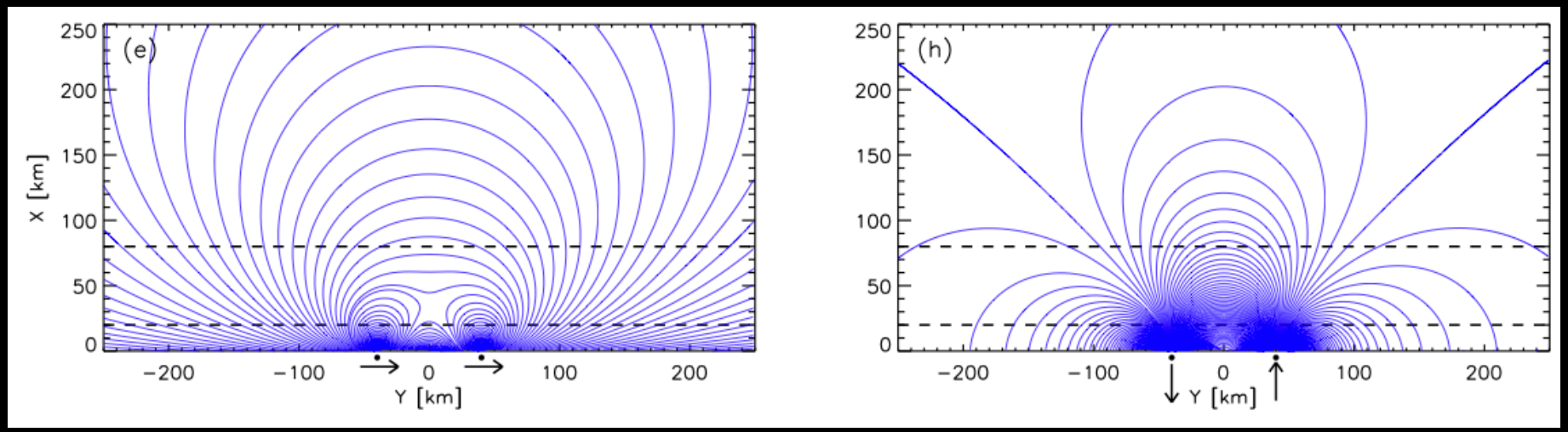
LRO/LROC image

Hybrid plasma model is three-dimensional, particle ions/fluid electrons

Focus on a cross section of the Reiner Gamma albedo/magnetic feature for a simplified geometry: Alternating bright lobes and dark lanes

Hybrid plasma modeling of Reiner Gamma

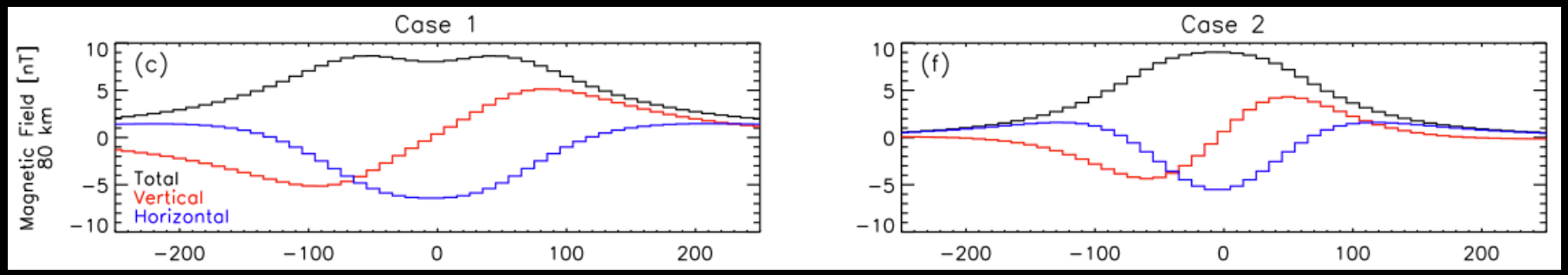
Case 1 *Case 2*



Compare two simple arrangements of underlying source magnetization

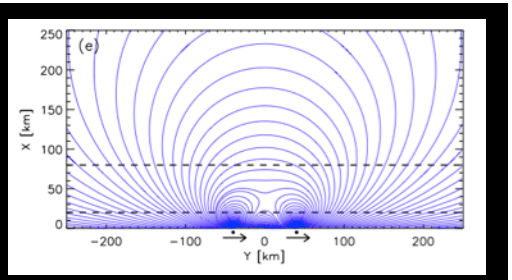
Case 1: Dipoles parallel to the surface (Hemingway & Garrick-Bethell, 2012)

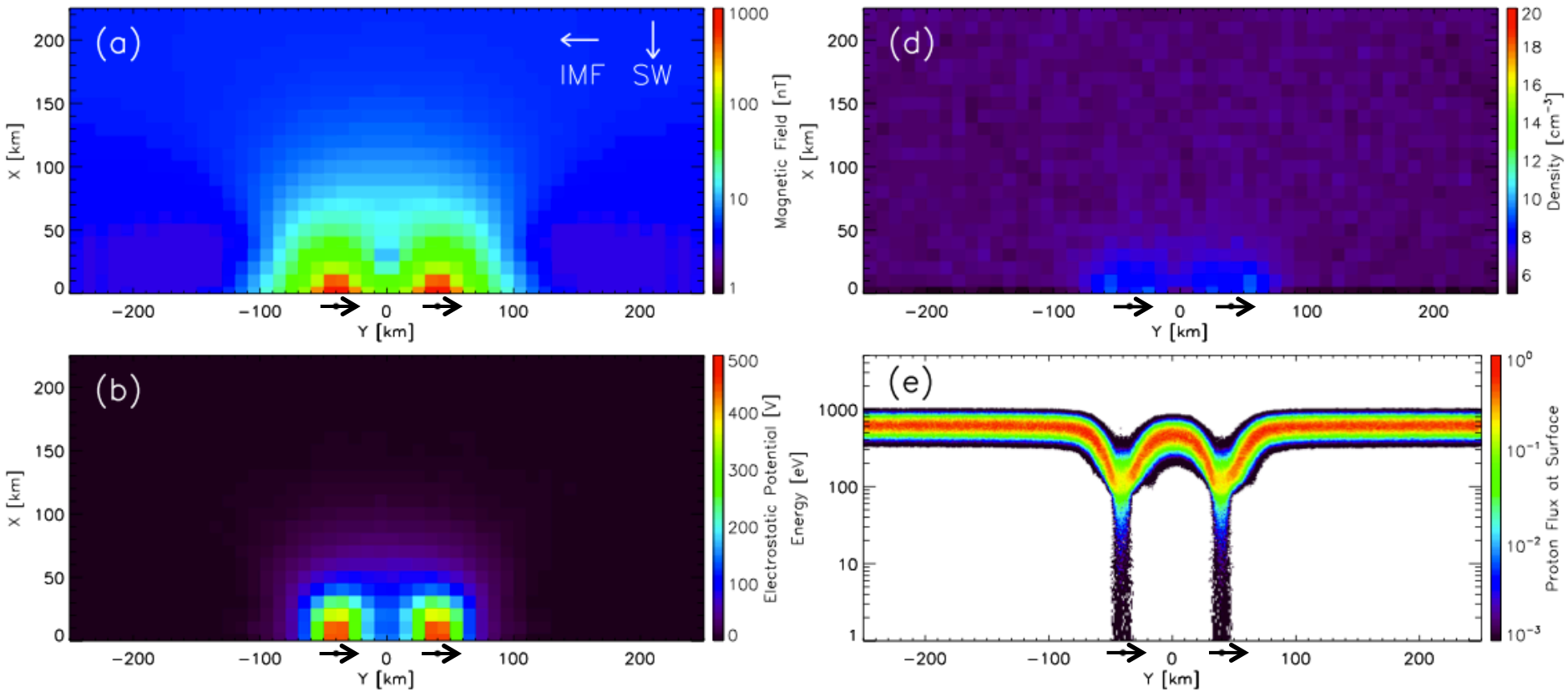
Case 2: Same spatial arrangement, with dipoles vertically anti-aligned



Results: Case 1

Dipoles oriented parallel to the surface

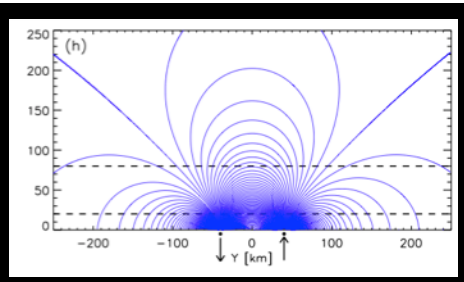


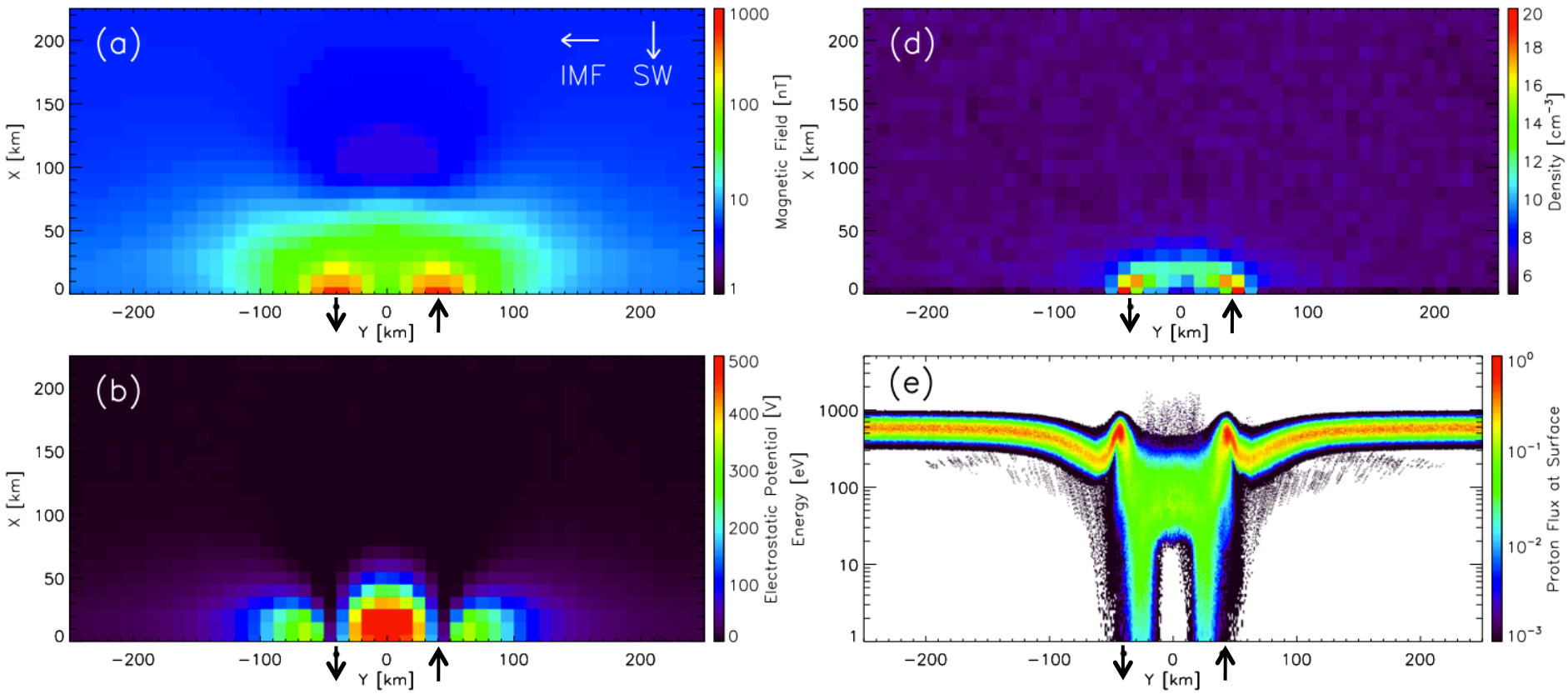


Horizontal dipole effective at shielding solar wind plasma from the surface through the generation of electrostatic fields (similar to that seen in Jarvinen et al., 2014)

Results: Case 2

Dipoles oriented perpendicular to the surface

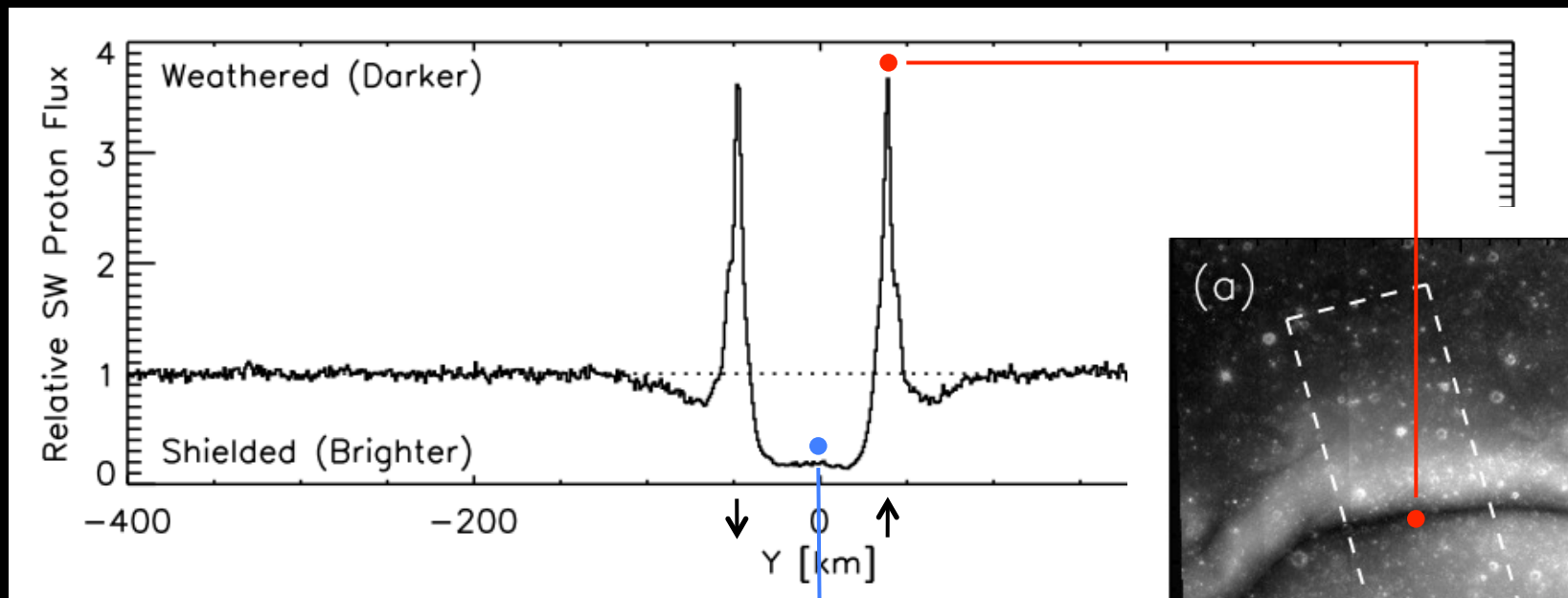


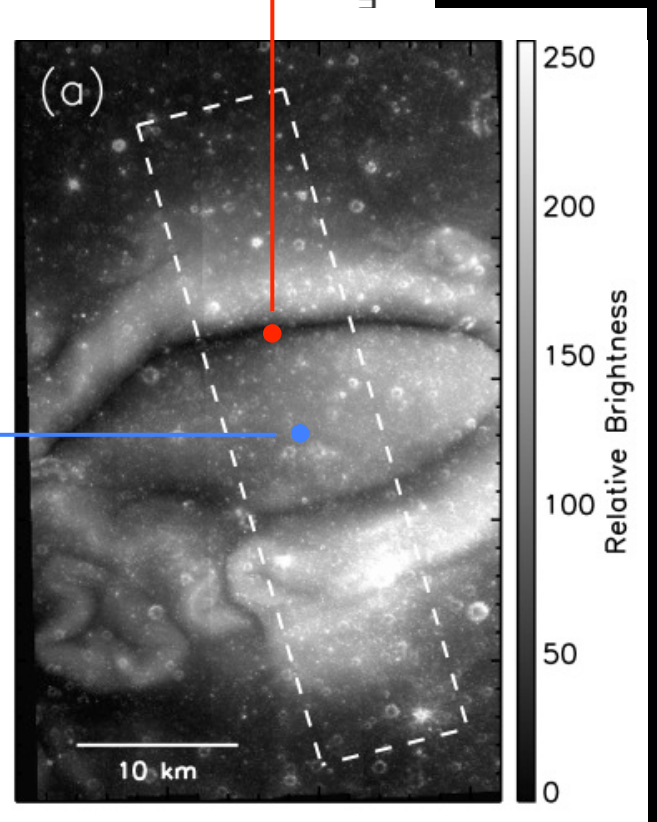


Vertical dipoles allow <u>very narrow</u> access of solar wind to the surface – a la "dark lanes" – neighboring regions are shielded with horizontal fields

Comparison of albedo to simulated weathering

Case 2





Case 2 yields relatively high, very narrow regions of solar wind weathering of the surface surrounded by three regions of varying shielding

<u>Qualitative</u> agreement with observed Reiner Gamma albedo features

Summary and Future Work

- Plasma simulations can relate proposed magnetic anomaly source distributions to surface plasma flux and weathering patterns
  - *Still need to understand the quantitative relation between solar wind fluences and regolith albedo*

- For Reiner Gamma, simulations suggest that some amount of highly-vertical magnetization is required to produce the “dark lanes”

- Future work: How do these result vary with:
  - Solar zenith angle?
  - Ambient IMF / solar wind plasma parameters
  - Different source magnetizations (*that are still consistent with LP magnetometer data*)
  - *If solar wind shielding hypothesis is true, then shielding pattern should hold over the ranges of above parameters*

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