Not Swarm - a reassessment of possibilities with a lower quality mission

Richard Holme and Isaac Salt
University of Liverpool

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Introduction

• What if we only had intensity data – no directions
• Non-uniqueness (Backus effect)
• Feature of dayside data - EEJ (Equatorial Electrojet)
• Intensity data are provided by the Chinese CSES satellite
• Focus on March 2019 – a string of solar quiet days 21-26
  - Vector data also available to compare
• Can we use the position of the EEJ as a sufficient constraint as to alleviate the Backus effect?
• Spoiler – not well enough, but useful if only have intensity data
Finding the EEJ

• Dayside reduction in total field intensity along the EEJ
• Residual of the dayside data to Chaos model – Polynomial shape as spacecraft crosses over the EEJ
• Take position of crossing at the minimum
Comparison to Magnetic Equator

• The EEJ follows the magnetic equator
• Compare our measured points against equator
• Assume zero radial component at these points
• Additional constraint – Resolves non-uniqueness
Convergence

- Plot difference in each coefficient to last iteration
- Measure of convergence
- Iteration number increasing from light to dark color (15 total)
- Data alone (Blue), EEJ (Green), Perfect Eq (Purple)
- Benefit to convergence is clear
Field Residual Maps

- Mapping the residual of our models to Chaos
- Compare EEJ to perfect equator – Calculated from Chaos for -180 -> 180 in 1-degree steps (360 points)

![Data alone](image1)
![98 EEJ points](image2)
![360 Equator points (calculated from Chaos)](image3)
Comparison with Vector Data

- We also have vector data for March 2019
- Limit to latitude range $-50^\circ \rightarrow +50^\circ$
- No Backus effect, but bigger problem of polar gap

Vector data

98 EEJ points

360 Perfect Equator points
Correcting for the Crustal Field

- Static part of field – degree 20-40
- Take residual of data to degree 20 and 40 field
- Look at difference between the two residuals for signals that could influence the minimum of EEJ signal
- Clear signal around 4 degrees latitude, 22 longitude (Bangui)
Correcting for the Crustal Field

• Correction helps fill in gaps in EEJ position along the equator
Maps after Correction

230 EEJ points

Changed scale

Vector data
Observatory means

• Add in available monthly means
• Correct for observatory bias
• Vector data – observatory only – independent starting model
• Much better convergence with electrojet data
• However, closer to Chaos model with these data removed
• Suggests electrojet data very useful but must be correct!
Reflections

• Magnetic equator information from dayside data picking electrojet
• Highly sensitive to small picking errors
• Convergence issues – small changes to misfit bring closer to expected model
• Corrected for crustal field – external field as well?
• Provide a stable model, but position errors bias model
• Vector data clearly more reliable for equatorial field
• However, if only scalar data available, careful work will produce a quality model, although vector data are better
• Hopefully, future satellites will be equipped that this method is not necessary!