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

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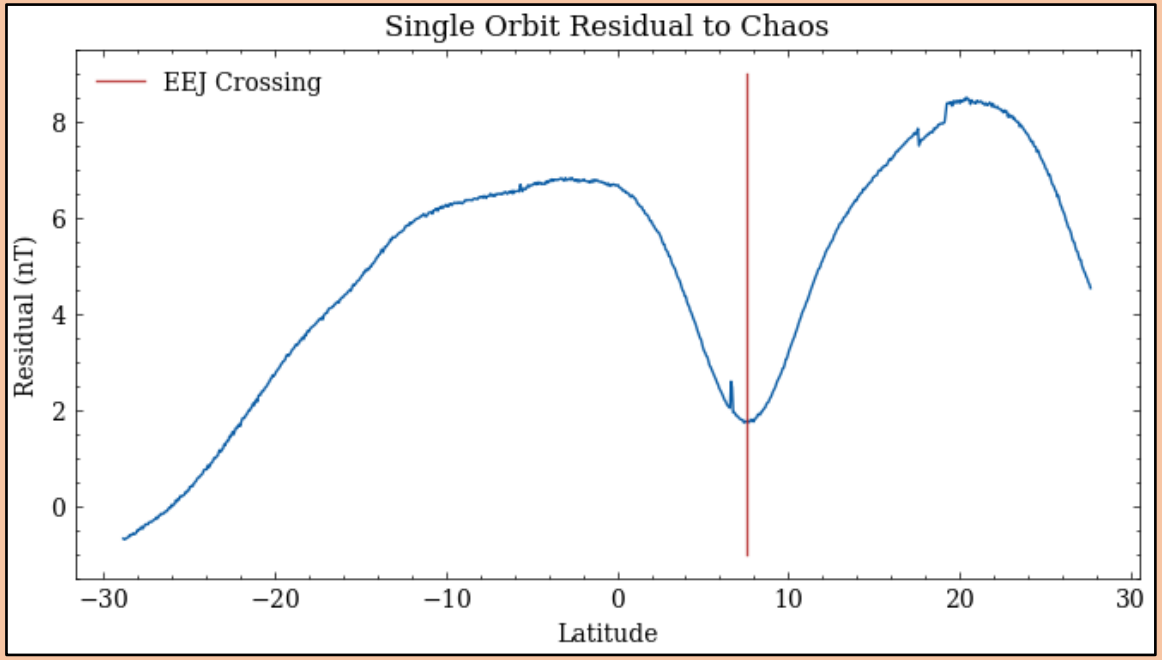
Introduction

- 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

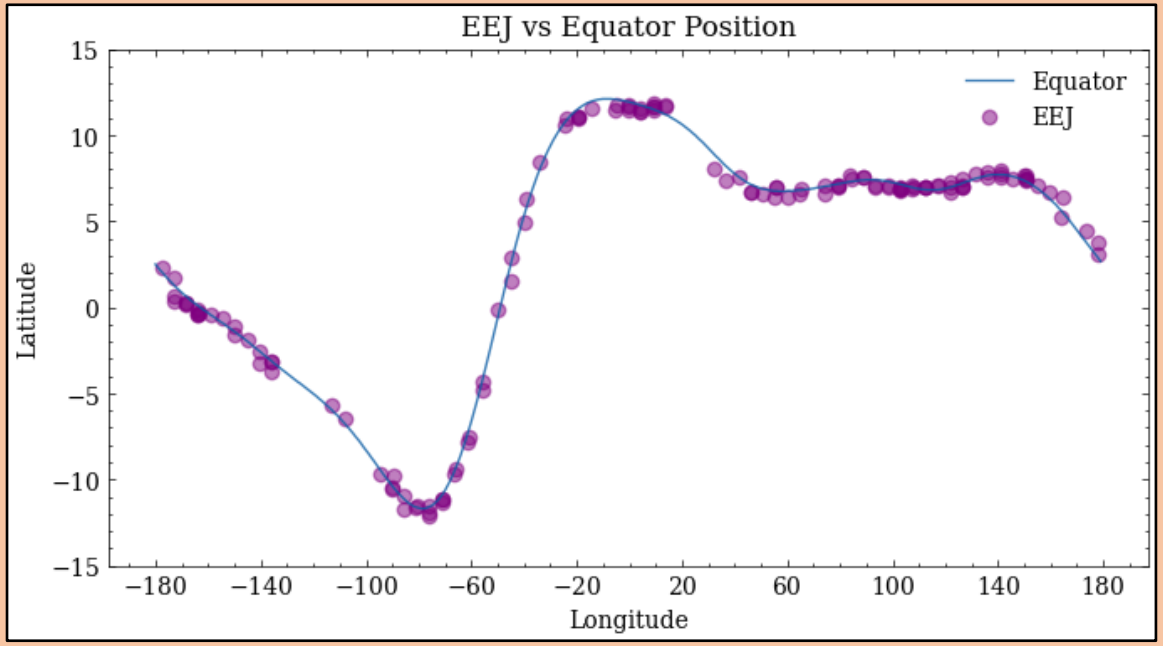
Finding the EEJ

- 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



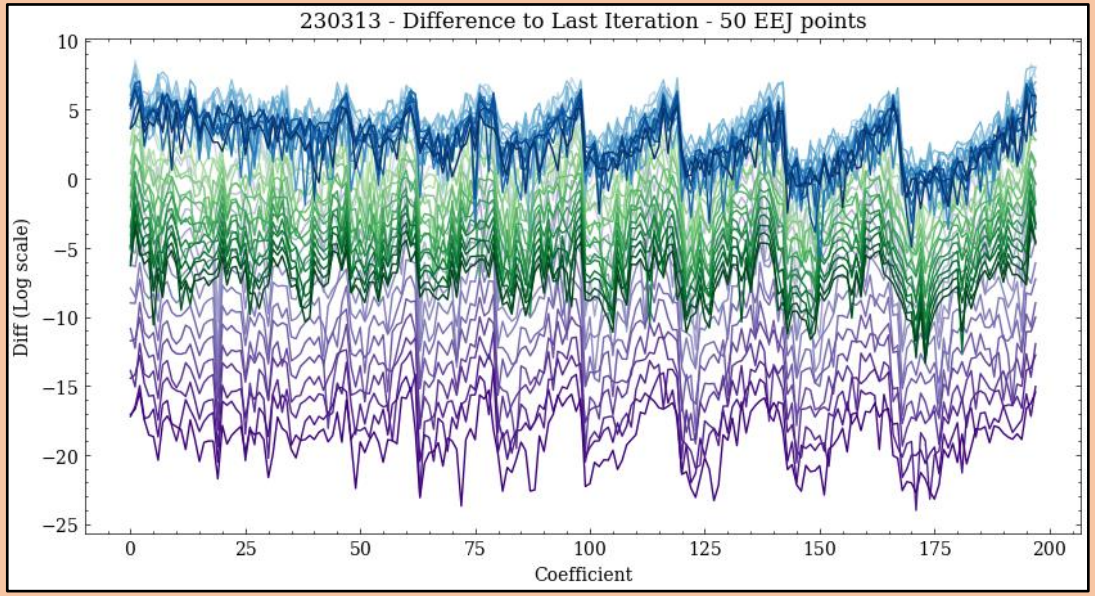
Comparison to Magnetic Equator

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

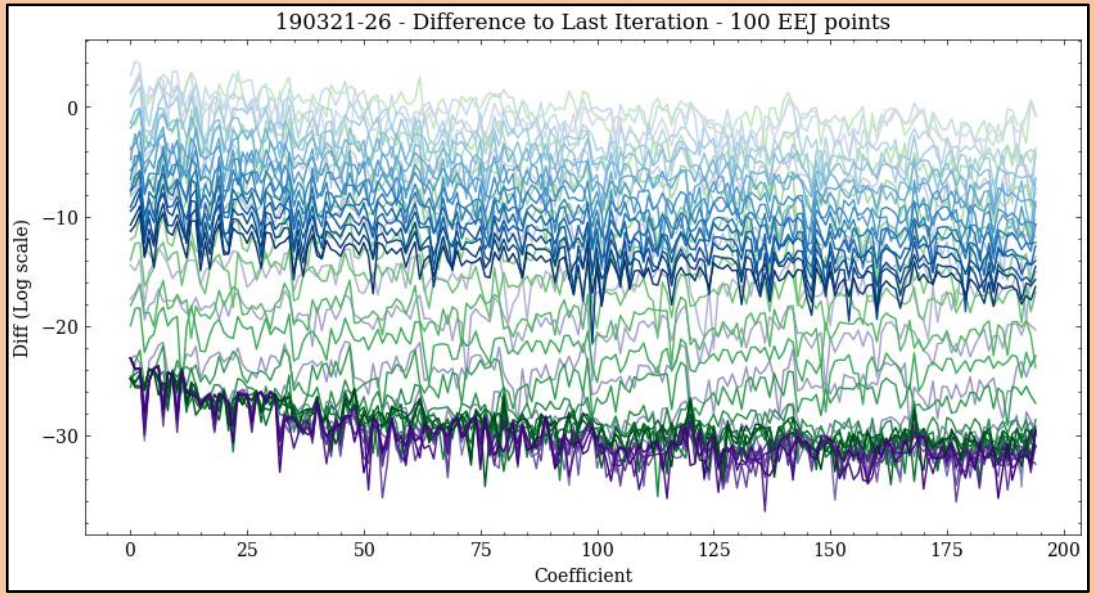


Convergence

- 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



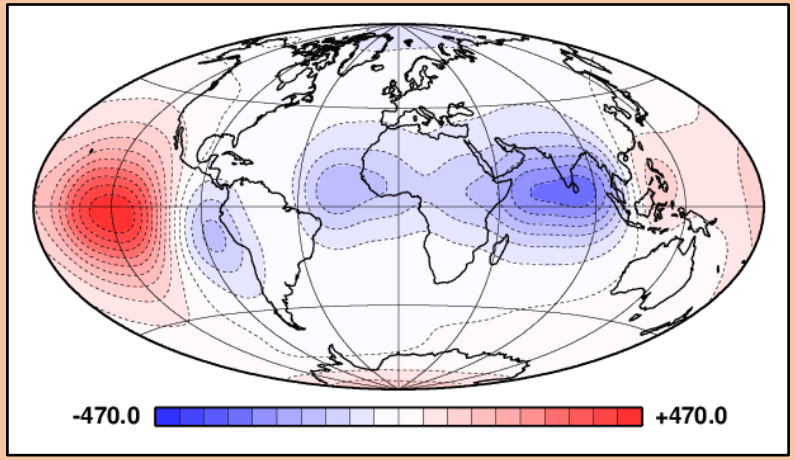
Single day (2023/03/13)



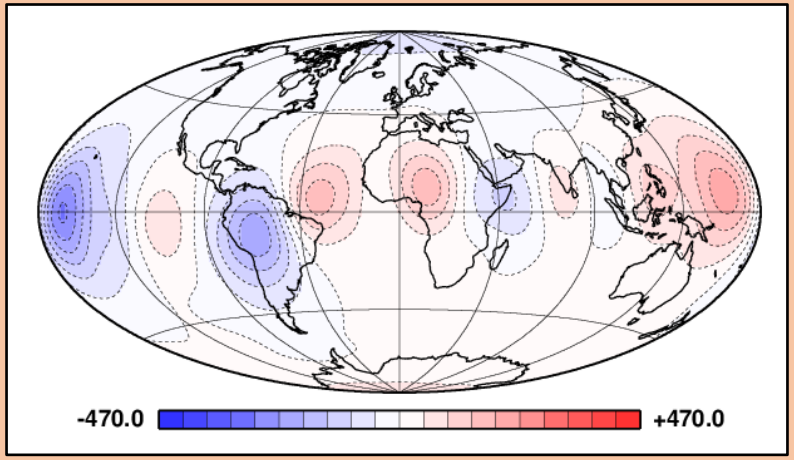
String of 6 days (2019/03/21-26)

Field Residual Maps

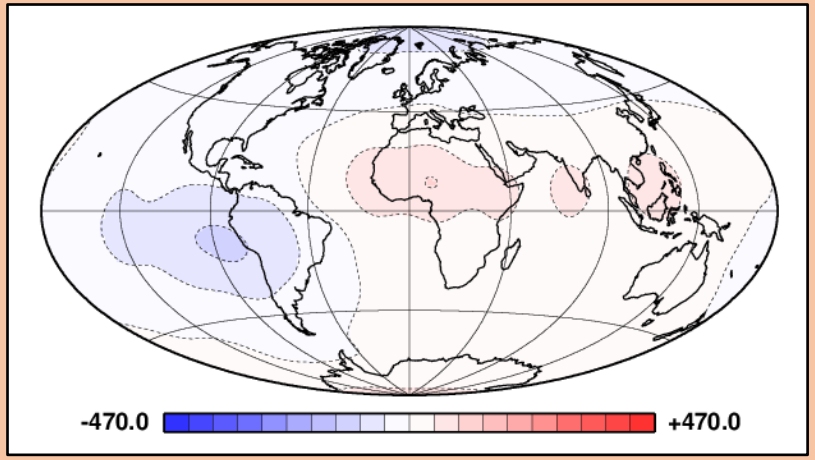
- Mapping the residual of our models to Chaos
- Compare EEJ to perfect equator – Calculated from Chaos for -180 -> 180 in 1-degree steps (360 points)



Data alone

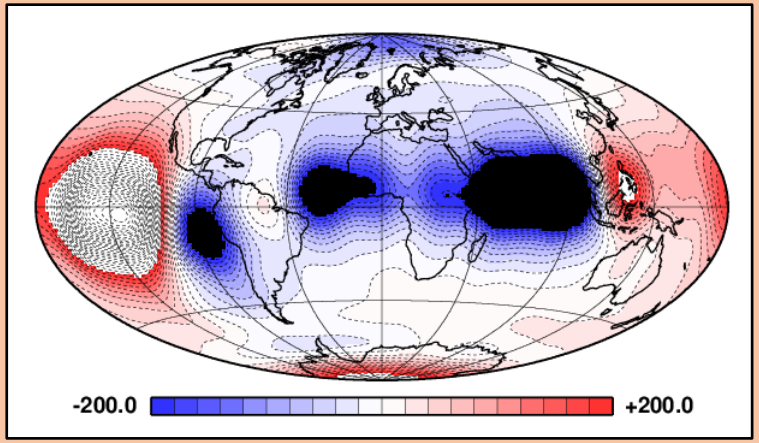


98 EEJ points

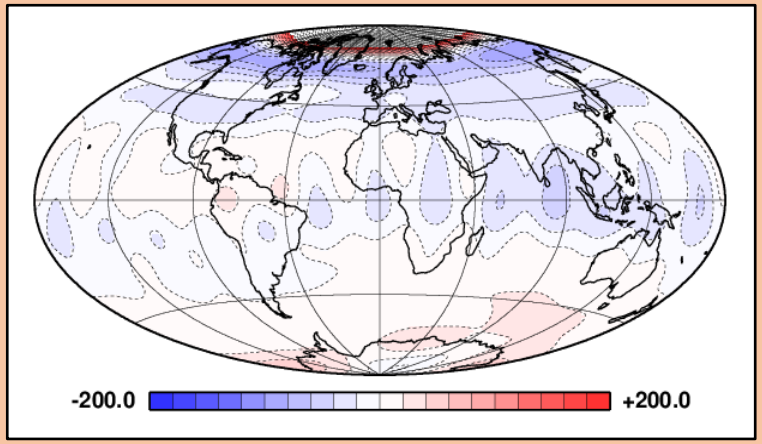


360 Equator points
(calculated from Chaos)

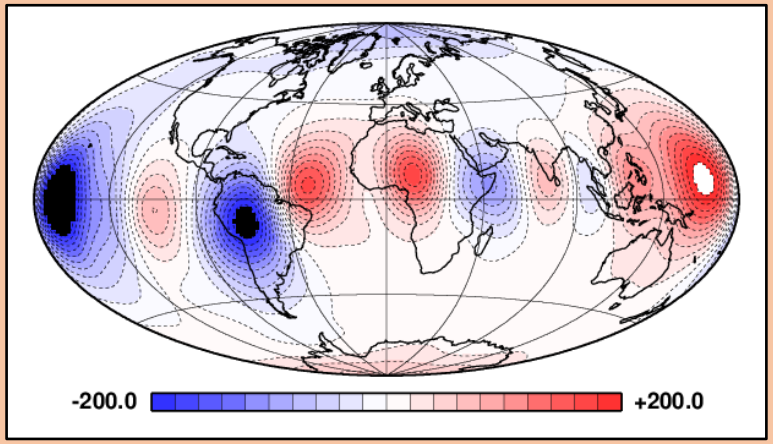
Comparison with Vector Data



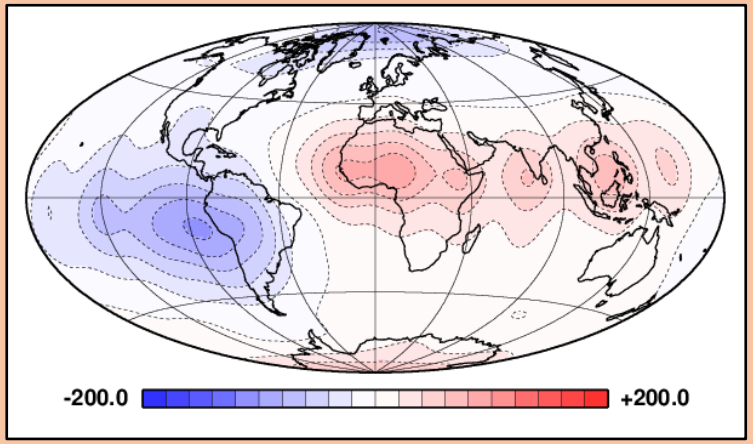
- We also have vector data for March 2019
- Limit to latitude range -50° -> +50°
- No Backus effect, but bigger problem of polar gap



Vector data



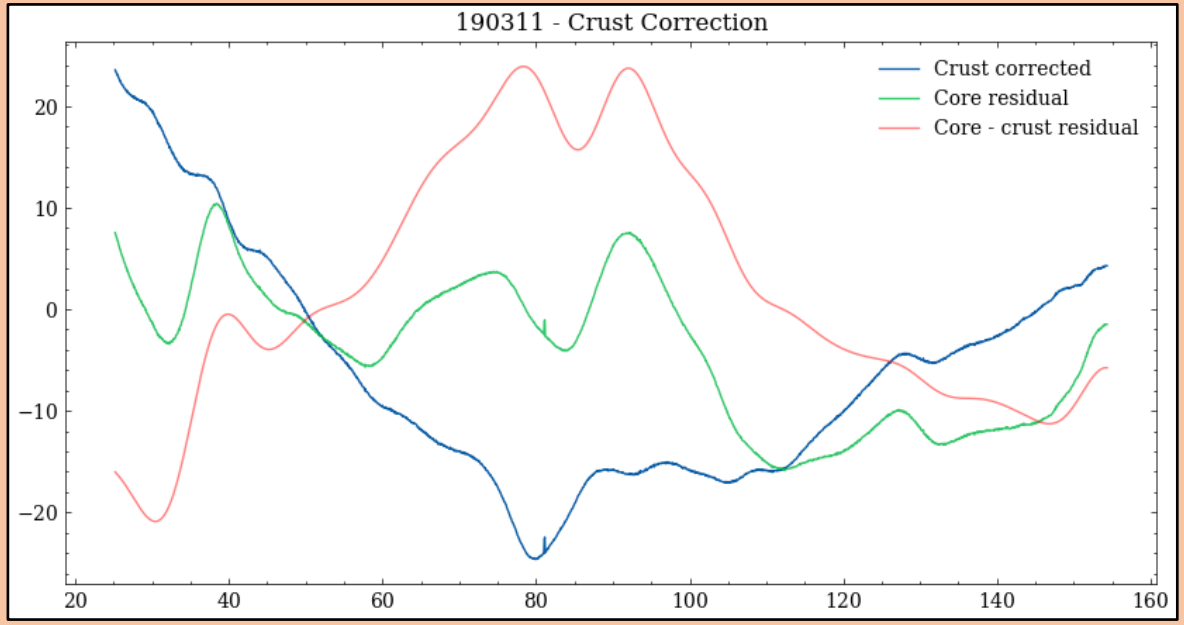
98 EEJ points



360 Perfect Equator points

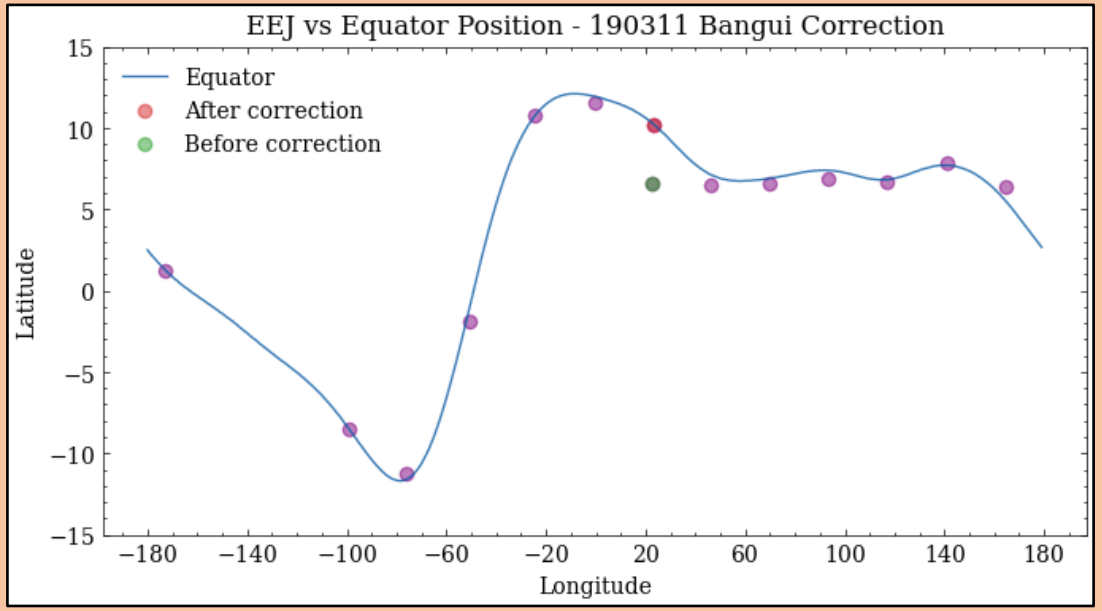
Correcting for the Crustal Field

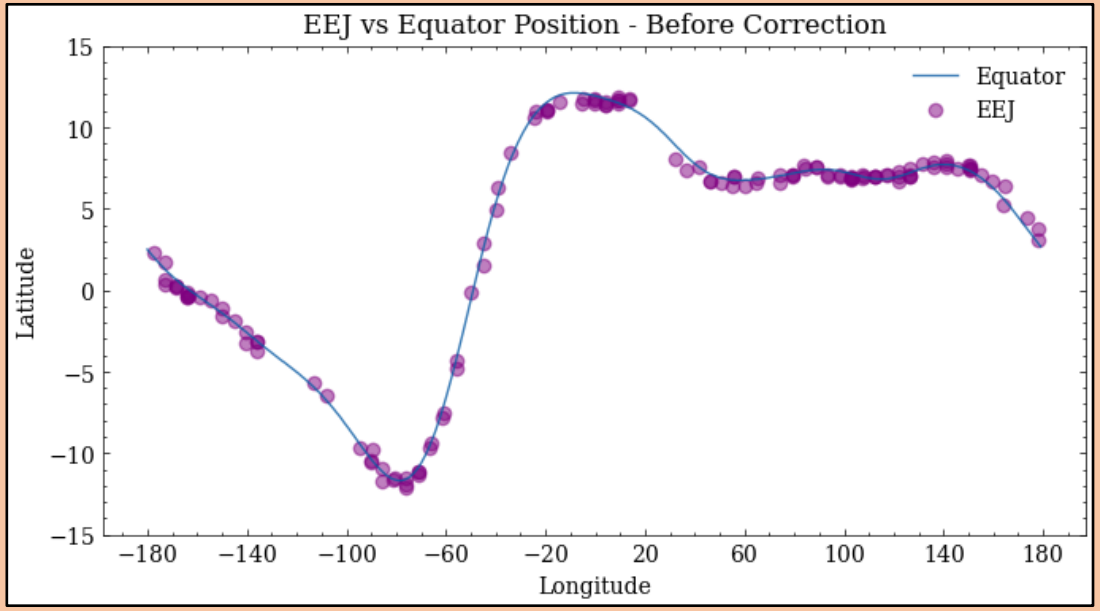
- Static part of field – degree 20-40
- Take residual of data to degree 20 and 40 field
- Look at difference between the two residuals for signals that could influence the minimum of EEJ signal
- Clear signal around 4 degrees latitude, 22 longitude (Bangui)

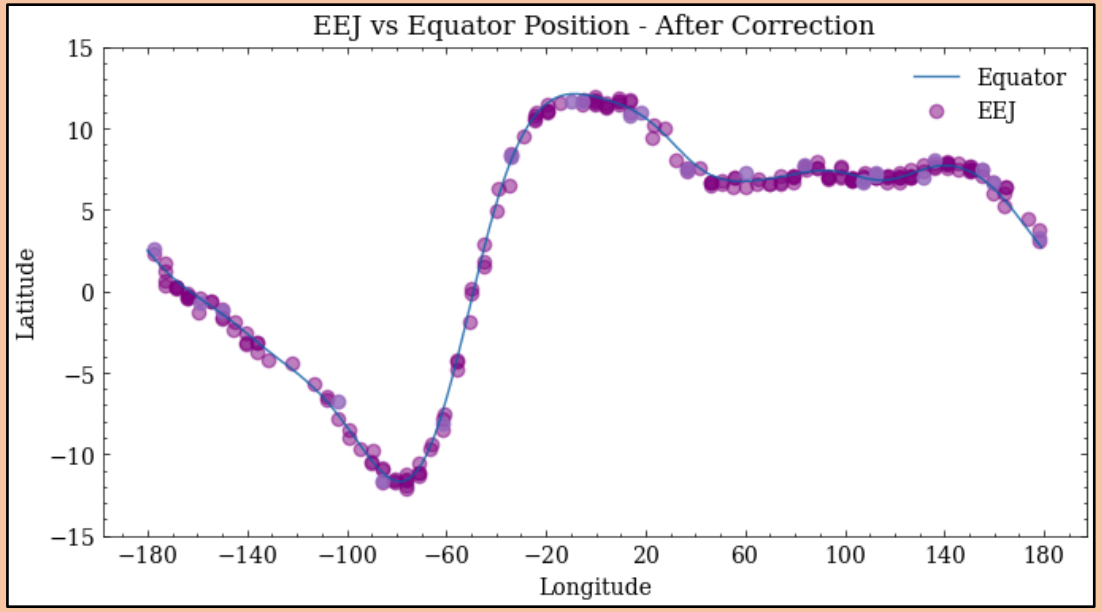


Correcting for the Crustal Field

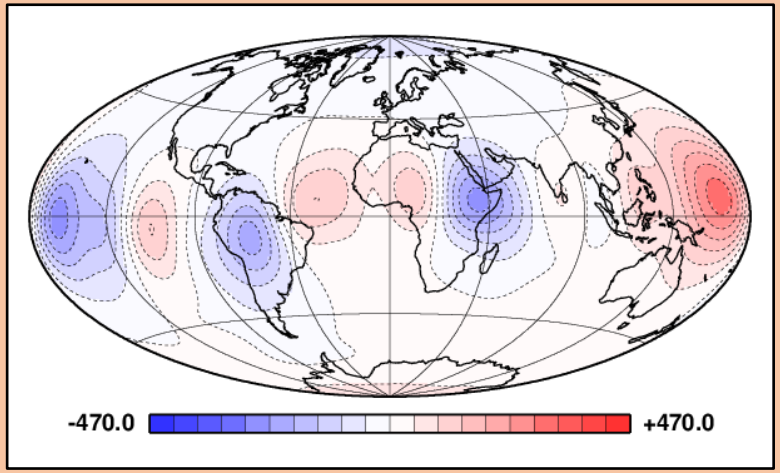
- Correction helps fill in gaps in EEJ position along the equator



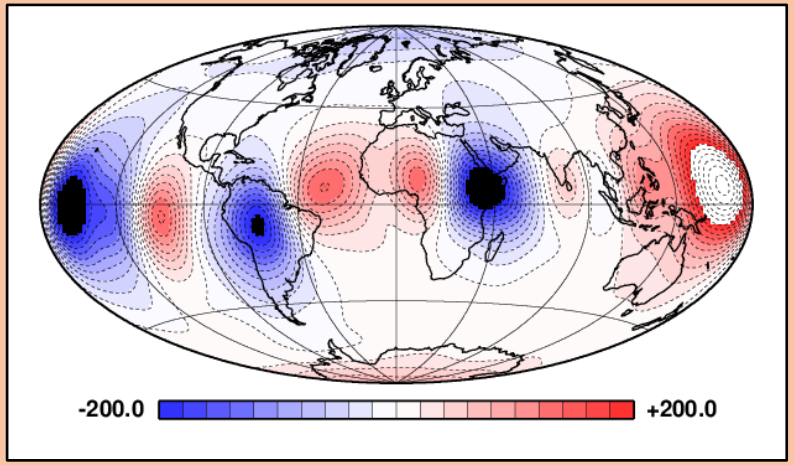




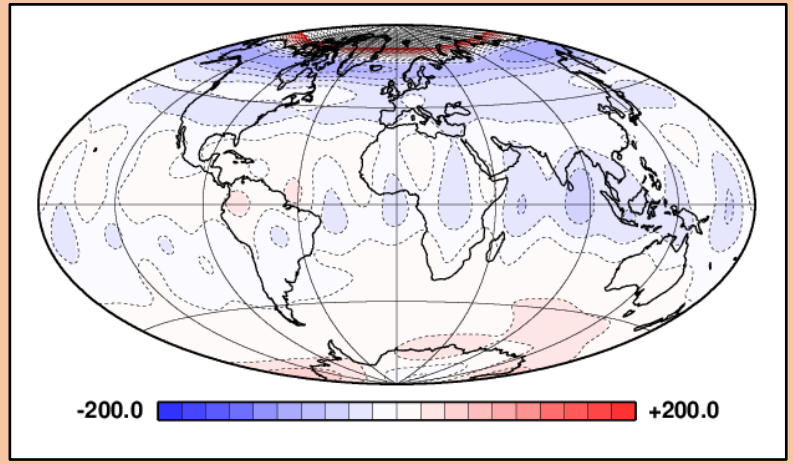
Maps after Correction



230 EEJ points



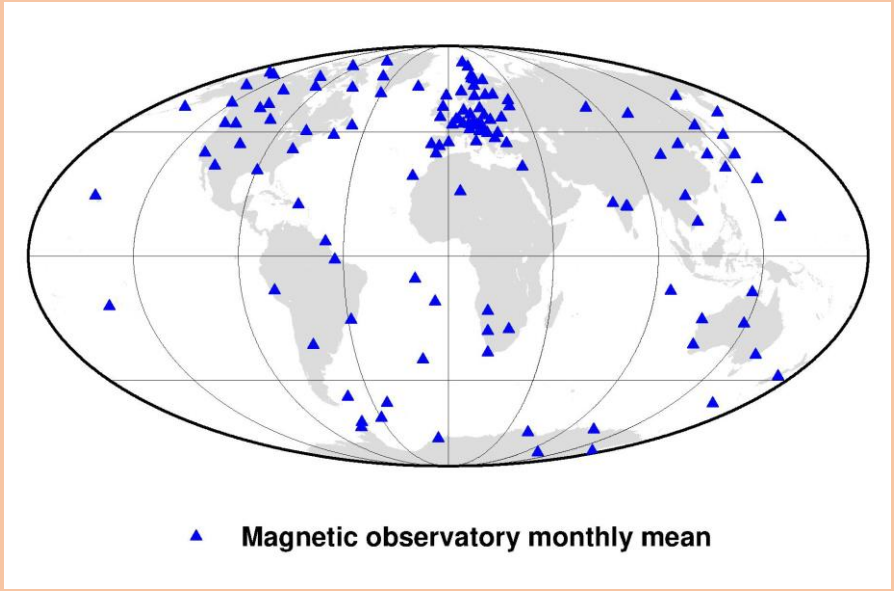
Changed scale

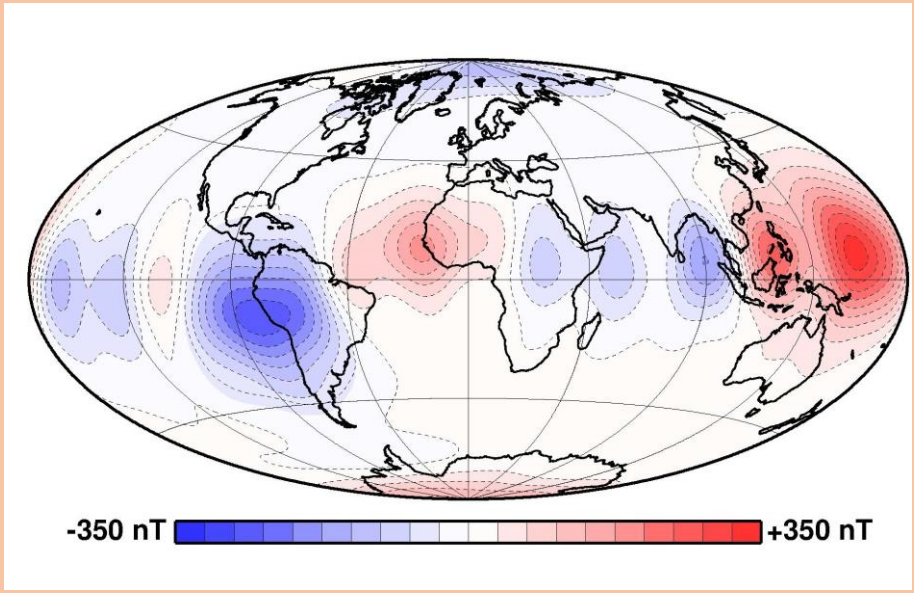


Vector data

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 modl
- 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!