STEREO Inverse Reconstruction

3D Reconstruction of STEREO-observed CME Events

Antunes, Cook, Newmark & Yahil

- **Morphology:** What is the intrinsic 3D shape of a CME, and why?

- **Kinematics:** How fast do they move, accelerate, decelerate, what are the effects of the IPM and solar wind?

- **Origins:** CMEs are magnetic structures, so understanding them gives us insight into the solar magnetic field and how CMEs are created.

- **Predictability:** Can we predict the creation, arrival time, point of arrival, mass, magnetic energy, and estimated damage potential of a given CME?
Our Approach

Inverse Reconstruction

Front

Side

Front + Side
Our Approach

PIXON (Puetter & Yahil)

- Alternative to maximum entropy methods
- Elements are spatially extended, overlapping 'Pixons'
- Uses kernel-based smoothing across Pixons
- Map key is minimum complexity: a solution using fewer underlying Pixon map elements is presumed to be superior
- Produces minimum number of elements required to fit the solution as allowed by the noise. e.g. Pixon would consider the bottom pair to be roughly as good a final goal as the top pair.
**STEREO Inverse Reconstruction**

Sim Satellites: X-Y-Z & Ecliptic

Data In == Recon Out

'best case' 3-axis input data

Data at 0°, 90°, and from top

Recon at 0°, 90°, and from top

Two at 44° (B: 76°, A: 120°)

View at 0°, 44°

Recon at 0°, 44°

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Sim Satellites: 3-axis vs Ecliptic 90° & 44°

Flyby

3-axis 'best' case  Ecliptic 2-view case  Only 44° separation

3-axis and ecliptic flybys comparing XYZ result (left) with 'just 2 satellites' ecliptic result (middle) and 'just 2 at narrow separation' (right)
Dec 31\textsuperscript{st}, 2007 CME

Reality is Messy and Evolving

*Running Difference*

- View at 0°
- View at 44°
- Data A
- Data B
- Recon A
- Recon B

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CME over time
(unconstrained, uncorrelated solutions)
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Constraining the Solution Space
STEREO Inverse Reconstruction

Dec 31st, 2007, 2:22

Running Difference
Unconstrained CME solution
using Cone
using FM (large)
using FM (small)
Fluxrope reconstruction as comparison

Prior Frame Subtracted
Conclusions

- Inverse methods can help distinguish between current theoretical models, at different solar distances.

- Inverse methods can model asymmetrical features (which pure forward models cannot).

- Inverse reconstruction can separate components. e.g. for Dec 31, separate the streamer from the above and lower CME portions

- Solution is probability space map for CM

- Computational issues: fast, but resolution-limited and require high S/N
Conclusions

Collaboration is Key

1) Study Kinematics-- CM vs time, expansion/compression, trace back/fwd
2) Apply model-based masks
3) Separate components
4) Overlay Forward Models (Thernisien et al)
5) Compare with other geometric methods (de Koning)
6) Compare with centroid location (Vourlidas et al)
7) Add the '3rd Eye' of LASCO (Cook)
8) Let others use our tools
9) Wait for a >90° CME
10) Don't like it? Use our framework and tools to try your own!