

# WP 3230

# PROTOTYPING Activity : MHD-Based

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# Prototyping Activities

## Objective

- To develop a prototype forecasting scheme that predicts conditions at 1 AU based on solar input of coronal mass ejections (CMEs)

## Methodology

- To make use of current physical understanding of CMEs based on analysis of solar and interplanetary data.

## Validation

- Comparison of predictions with five selected events from 1997 – 2000 interval.

## Methodology

- Relation between CME onset speed and CME speed (and arrival time) at 1 AU (Gopalswamy et al., 2000).

- Relation between CME speed at 1 AU and magnetic field strength there (Owens and Cargill, 2001).

- Relation between hemisphere of origin, “handedness” of CME, and solar cycle number (Bothmer and Rust, 1997))

- Relation between CME speed and 2 – 6 MeV particles at 1 AU (Reames, 1997)

- Relation between Dst index and solar wind speed and magnetic field (Burton et al., 1975; O'Brien and McPherron, 2000)

## Events Selected

- January 6 – 11, 1997. Slow magnetic cloud (Telstar-401 event)
- November 3 – 6 , 1997: Fast magnetic cloud.
- April 20 – 24, 1998. Confused event, perhaps high speed at Sun. Expected to be a tricky one.
- May 2 – 5, 1998: Major CME, magnetic cloud.
- April 2 – 6, 2000: Major CME, magnetic cloud.

# Results: Observed Quantities

| Date | V(Sun) | V(1AU) | T(1AU) | B(1AU) | Dst (min) | Duration |
|---|---|---|---|---|---|---|
| 6/1/97 | 200 km/s | 550 km/s | 3d,12h | 16 | -80 nT | 4h |
| 4/11/97 | 830 | 450 | 2d,16h | 19 | -80 | 6h |
| 20/4/98 | 1640 | 500 | 3d,10h | 17 | -80 | 0h |
| 2/5/98 | 1040 | 850 | 1d,12h | 38 | -220 | 40h |
| 4/4/00 | 1000 | 600 | 2d,0h | 30 | -70 | 0h |

# Results: Predicted Quantities

| Date | Storm onset | V(1AU) | T(1AU) | B(1AU) | Dst (min) | duration |
|---|---|---|---|---|---|---|
| 6/1/97 | 4d,18h | 482 km/s | 4d,14h | 22 nT | -126 nT | 12h |
| 4/11/97 | 2d,10h | 532 | 2d,7h | 24 | -145 | 14h |
| 20/4/98 | 1d,4h | 1231 | 1d,2h | 57 | -623 | 38h |
| 2/5/98 | 1d,22h | 691 | 1d,19h | 31 | -221 | 22h |
| 4/4/00 | 2d,0h | 658 | 1d,21h | 30 | -207 | 20h |

# Comments

- Four events are not too bad. One event fails badly. Believed to be erroneous velocity at Sun.
- Method compromised to a degree by not being able to predict the duration of Southward IMF at 1 AU.
- This affects Dst prediction. Dst values will be increased by shorter events.
- Magnetic field predictions at 1 AU do surprisingly well.
- Arrival times assume simple model. Recent work (Gopalswamy) suggests can do better.

# The Future

**Major failings are seen to be**:

- Velocity at Sun is projection on sky. Need line-of-sight velocity for accurate forecasting.
- At present, no prediction of duration of Southward IMF at 1 AU. Present observations cannot give this.
- Direction of CME not known on the basis of single spacecraft observations.

**Major successes are**:

- Magnetic field prediction at 1 AU based on correlations seems to work better than expected.
- Empirical models of arrival times worth pursuing.

# Conclusions

- Magnetic storm prediction based on solar observations works for some aspects, not for others.
- Additional observations (especially from Stereo spacecraft) are likely to be invaluable.
- Never make a definite storm prediction based on solar-only data (too many uncertainties).
- Underpinning science must be understood in parallel.
- Web-based implementation is available.