Ensemble CME Forecasting

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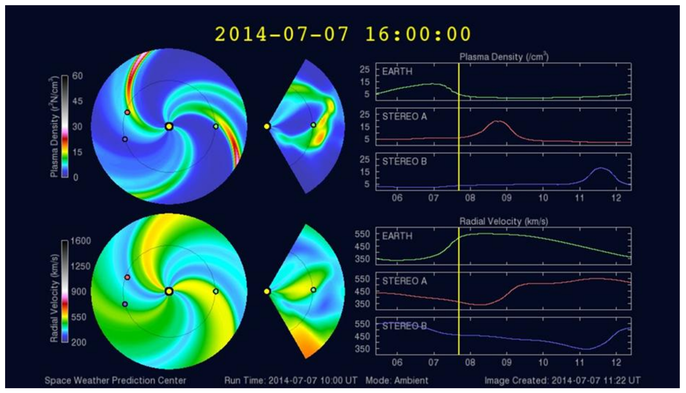
Introduction

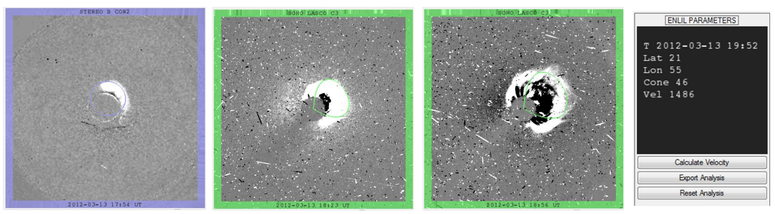
Since Oct 2011, the Space Weather Prediction Center (SWPC) has used Enlil, a well-documented magnetohydrodynamic model of the heliosphere, to make numerical space weather forecasts of the arrival of coronal mass ejections (CMEs) at Earth. Earth-directed CMEs are characterized using the SWPC CME Analysis Tool, which uses three views of a CME provided by SOHO and the two STEREO spacecraft to parameterize the CME speed, width, and direction of propagation. Because of the nature of the observations, all CME and solar wind inputs used at the inner boundary of Enlil have inherent uncertainty. We have conducted a retrospective ensemble study of six events from 2012 and early 2013. We compare ensemble output against in-situ WIND data to ascertain which model inputs most strongly affect the error in the CME arrival time. As part of the outcome of this study, we suggest a simple ambient flow correction that can be used in near-real-time to improve CME forecasts.

Forecast Tools

WSA – Enlil Model



CME Analysis Tool



Methods

6 Near-Real-Time CME Events

Date	Speed (km/s)	Half-Width	Latitude	Longitude
1-23-2012	1796	52	29	17
3-13-2012	1512	51	18	55
7-12-2012	1453	55	-14	-1
7-29-2012	382	43	-21	-37
8-31-2012	1010	33	6	-30
1-13-2013	463	36	1	-3

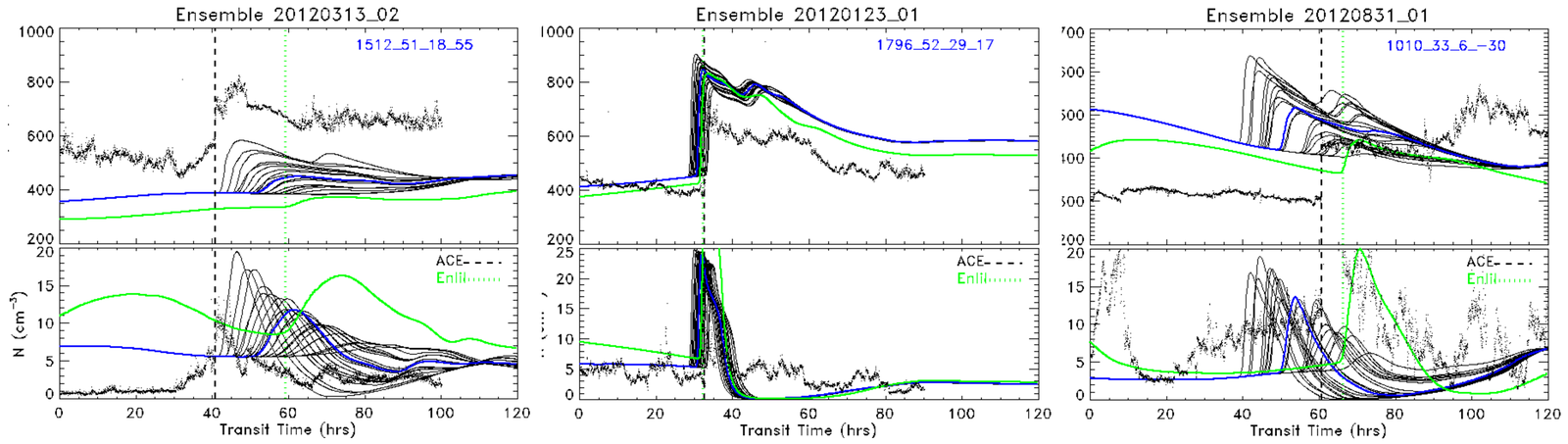
- 21-member ensemble run for each event using A5B1
- 'Official CME Parameters' run for each event using A3B2
- 'Official CME Parameters' run for each event with improved background speeds using A5B1

A5B1 and A3B2 refer to different versions of the Enlil program used for the ambient background in research and operations respectively.

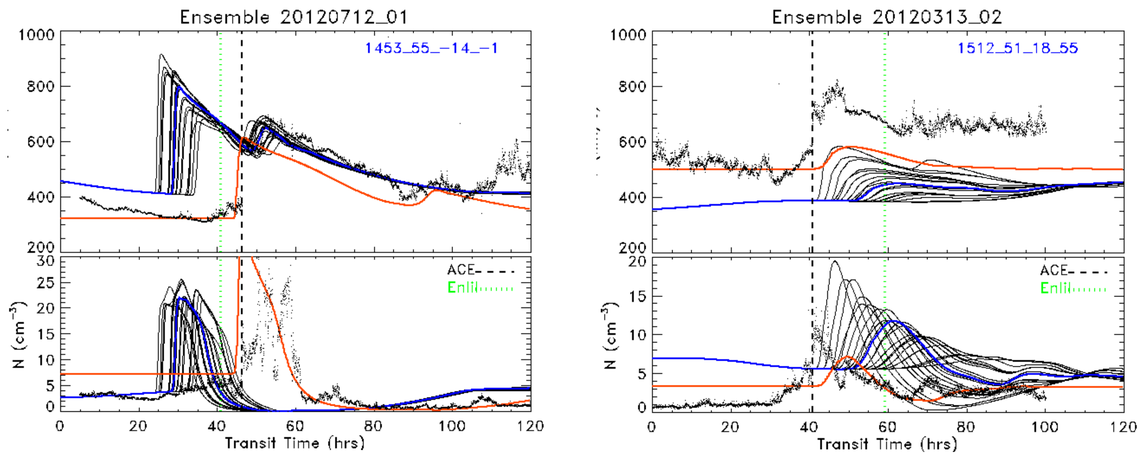
Results

Blue: Official CME Parameters with A5B1 background
Green: Official CME Parameters with A3B2 background
Orange: Official CME Parameters with improved ambient background
Black - Solid: Ensemble members
Black – Dotted: in-situ WIND data
Top Plot: Velocity (km/s) v. Transit Time Bottom Plot: Density (cm^{-3}) v. Transit Time

Standard Model Runs



Runs with Improved Ambient Backgrounds



Conclusion

- Accurate ambient background is important for arrival time prediction
- Average error decreases from 10.8 hours to 5.8 hours with improved ambient background (A5B1)
- Further improvement in predictions may result from better CME characterization

Future Work

- More than 50 events will be analyzed in the same manner
- Verify ambient background results
- Implement tools to update forecast using improved ambient background
- Investigate ways to reduce error in cone parameters

Acknowledgements

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