Recent Improvements of the WSA-ENLIL-Cone Modeling System and Using IPS Data for Operational Predictions

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- Observationally driven, near-real time, “hybrid” modeling system
- Routine simulation of co-rotating streams & CMEs, event-by-event, much faster than real-time
- Used at NASA/CCMC & NOAA/SWPC; further development supported mainly by NASA & AFOSR
- CME axis close to the Sun-Earth direction — no Bz by shock compression and/or IMF draping
- Model can predict arrival of shock and/or ejecta, and IMF topology
- Simulation is very fast — operational predictions, parametric studies, ensemble modeling
All CMEs (>500 km/s) fitted by CCMC in past 8 months are used for 4-months prediction at NH

History (light-grey background) and prediction (white background) for heliospheric missions

Can be used for mission planning and operational support at NASA/CCMC
- All ("classical-propulsion") missions to Mars follow the Hohmann trajectory
- Spacecraft close to IMF line passing through Earth with SEP measurements for alerts
- Simulations confirm the Posner’s idea except periods when IMF is disturbed by CMEs
Driving Heliospheric Computations — 4 Cases

(1) STELab-UCSD → ipsbd2bc → bnd.nc

(2) STELab-UCSD → wsadu2bc → bnd.nc

COR-SWRC → cone2bc → bnd.nc

(3) GONG-WSAdu → wsadu2bc → bnd.nc

COR-SWRC → cone2bc → bnd.nc

(4) GONG-WSAAdt → wsadt2bc → bnd.nc

COR-SWRC → cone2bc → bnd.nc
No ICME on 2011-09-27 in Richardson & Cane caused by poor ACE data
The 2011-09-24 CME arrives at Earth similarly on 09-27 for all cases
Overall solution looks fine; global solar wind structure is predicted in the inner heliosphere.
- Velocity is nicely reproduced.
Overall solution looks fine; global solar wind structure is predicted in the inner heliosphere.

Density has too large peak around 2011-10-26.
Reference temperate at the inner boundary increased from 1 MK to 3 MK
- Density peak is reduced due to large characteristic speed that broadens structures
Total energy equation solves compression waves and shocks more accurately.

Large differences between dynamic and thermal energy => temperature (and thermal pressure) can have large numerical noise.
- Total energy where compression, thermal energy where rarefaction
- Results very close to total energy results but without numerical noise
Hydrodynamic ejecta is launched with density 4x the reference stream value to simulate initial CME over-pressure.

Ejecta is compressed during interaction with background and its temporal profile at Earth has shorter duration and high density.
Magnetic field of a spheromak and background solar wind (for this event) has the same (opposite) orientations; magnetic reconnection is the southern part of the spheromak.

As a result, magnetic structure seems to have its center deflected northward.
IPS-ENLIL Predictions at KSWC

- IPS observations from STELab + UCSD tomographic reconstruction — values at 0.1 AU
- Time-dependent boundary values drive ENLIL heliospheric computations
- Fully automatized alternative (backup) to coronagraph fitting — will improve with more radio arrays
Summary

- Using STELab/UCSD solar wind data at 0.1 AU (IPSBD) provides an additional possibility for heliospheric space weather research and forecasting.
- This prediction system can be fully automatized (no need for human intervention like with WSA-ENLIL-Cone system).
- Limited observations result in lower resolution of solar wind structures and in impossibility to predict fast transients.
- Calibration/validation studies are ongoing for finding suitable model-free parameters and for reducing eventual bias.

Future Work

- Incorporate data from the World IPS Stations (WIPSS) Network.
- Incorporate ENLIL into UCSD-IPS tomographic reconstruction.
- Develop procedures for ensemble modeling / parametric runs.
- Develop procedures for “mid-course correction” (white-light, g-levels).
- Provide modeling support to upcoming heliospheric missions.