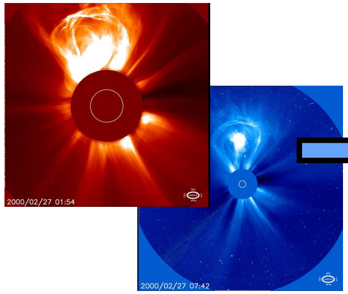
On the Drag Parameter Probability Distribution Function for Coronal Mass Ejection propagation models

Gianluca Napoletano[1], Raffaello Foldes[2], Francesco Berrilli[1], Daniele Calchetti[5], Giancarlo De Gasperis[1], Dario Del Moro[1], Ajay Tiwari[3], Jannis Teunissen[3], Enrico Camporeale[4]

[1]Dipartimento di Fisica, Università degli studi di Roma "Tor Vergata"
[2]Dipartimento di Scienze Fisiche e Chimiche, Università degli studi dell'Aquila
[3]Centrum Wiskunde & Informatica (CWI), Amsterdam, The Nederlands
[4]CIRES, University of Colorado, Boulder, CO, USA
[5]Max Plank Institute

Coronal mass ejections

Remote observations of CME initiation and launch



Goals of a forecasting service:
- Probability of Earth impact
- Travel time
- Impact speed
- Geomagnetic effects

The Drag-Based Model

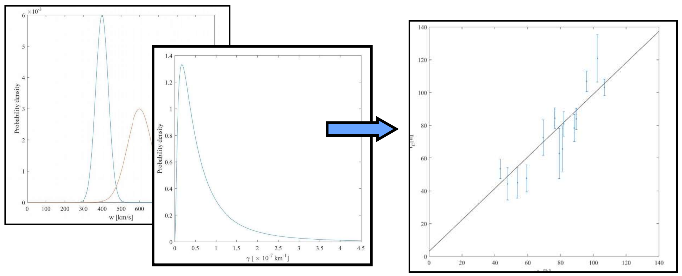
$$\frac{d^2r}{dt^2} = -\gamma\left(\frac{dr}{dt} - w\right)\left|\frac{dr}{dt} - w\right|$$

r_0 initial distance
v_0 initial speed
d target distance
w solar wind speed
γ drag parameter

→ ICME transit time T
Impact speed at target distance v_d

Ensemble approaches

Introducing parameter distributions to evaluate uncertainty on forecast.

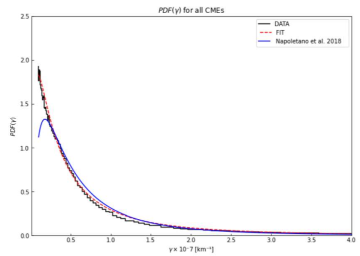


Parameters distributions from observational data

We invert of the DBM equations leaving the model parameters as unknown values

$$(r_0, v_0, t_{1AU}, v_{1AU}) \xrightarrow{\text{Inverse-DBM}} (w, \gamma)$$

To do this, we employ a list of events obtained by joining LASCO and Richardson & Cane database. This procedure allows us to obtain statistical distributions for the model parameters



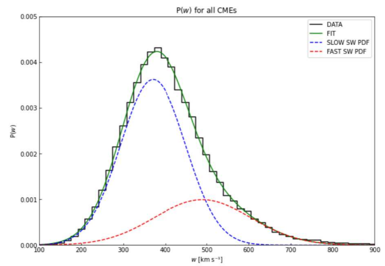
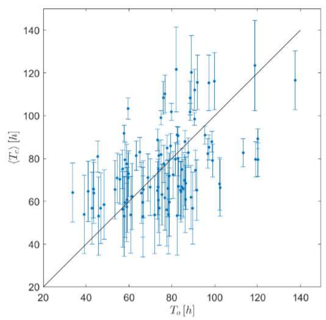
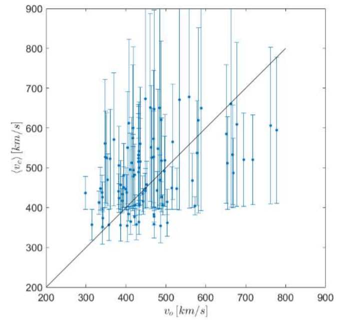


Figure 1. Histograms for the empirical values of the DBM parameters obtained after the inversion procedure of the DBM equations .

Test of the new distributions

New distributions are used to compare the model results with observational data on the database compiled by Paouris & Mavromichalaki, 2017. This list of event is independent from the one employed in the parameter inversion procedure.





$\langle \Delta T \rangle$ [h]	-0.2 ± 19.5
$\langle \lvert\Delta T\rvert \rangle$ [h]	16.3
$\langle \Delta v_1 \rangle$ [km/s]	30.0 ± 102.4
$\langle \lvert\Delta v_1\rvert \rangle$ [km/s]	88.8
RMSE(T)[h]	15.5
RMSE(v_1)[km/s]	80.4

Figure 2. Plot of the observed vs computed arrival times (left), and of the observed vs computed speed (right).

Conclusions

Choice of parameters in semi empirical models is of critical importance for forecasting accuracy, and a better knowledge of the parameter distributions may improve forecast accuracy through ensemble models. The poor or missing knowledge of model parameters is faced by introducing the related PDFs, which allow, in addition, to evaluate the forecast uncertainty. There is no prior knowledge about these distributions, which must be evaluated on empirical basis.

References

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