# Forecasting the arrival of Coronal Mass Ejections: The Drag-Based Model

B. Vršnak, T. Žic, J. Čalogović, M. Dumbović
Hvar Observatory, Faculty of Geodesy, Zagreb, Croatia

## THE MODEL

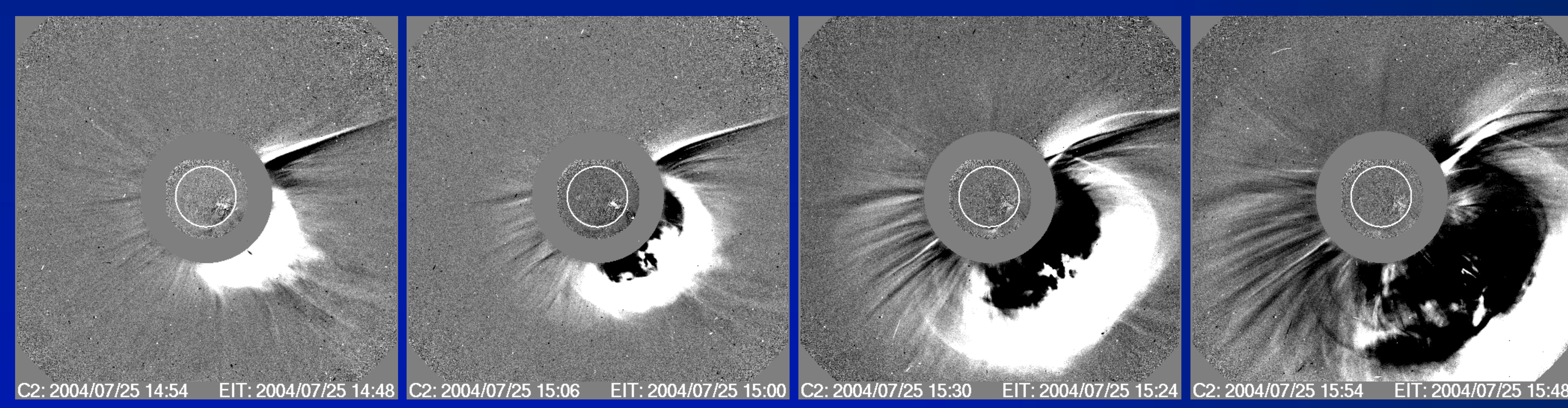
**AIM:** Prediction of ICME arrival

**BASIC ASSUMPTION:** Beyond ~20 solar radii the MHD "aerodynamic" drag caused by the interaction of ICME with solar wind, becomes the dominant force, so the equation of motion becomes:

$$\ddot{r} = -\gamma\,(\dot{r} - w)\,|\dot{r} - w|\;.$$

**CONSEQUENCE:** fast ICMEs are decelerated, slow are accelerated ( $\dot{r} \longrightarrow w$ ).

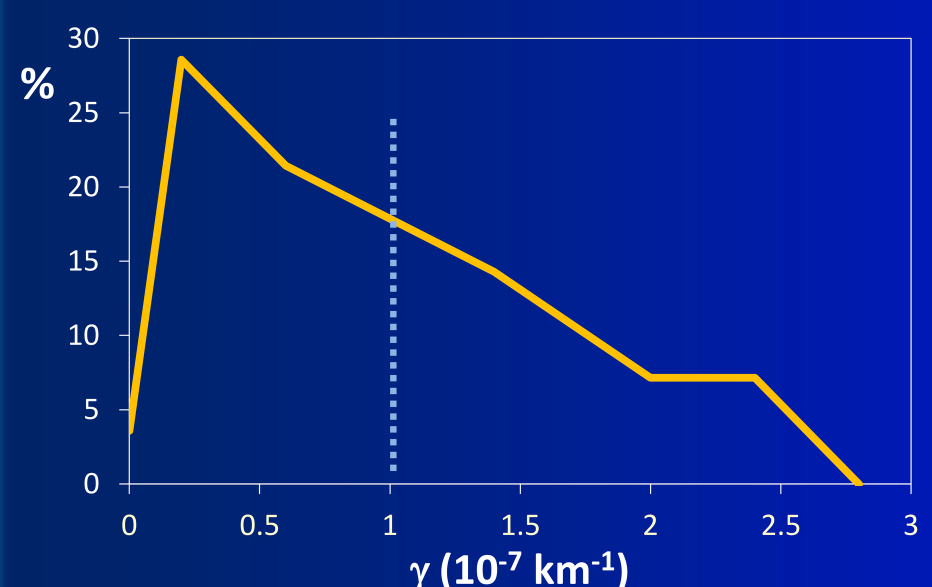
**PARAMETERS:** In the simplest form, we assume **$\gamma, w$ = const**. The drag parameter $\gamma$ depends on characteristics of both ICME and solar wind – the drag is stronger for broader, low-mass ICMEs in a high-density (slow) solar wind.

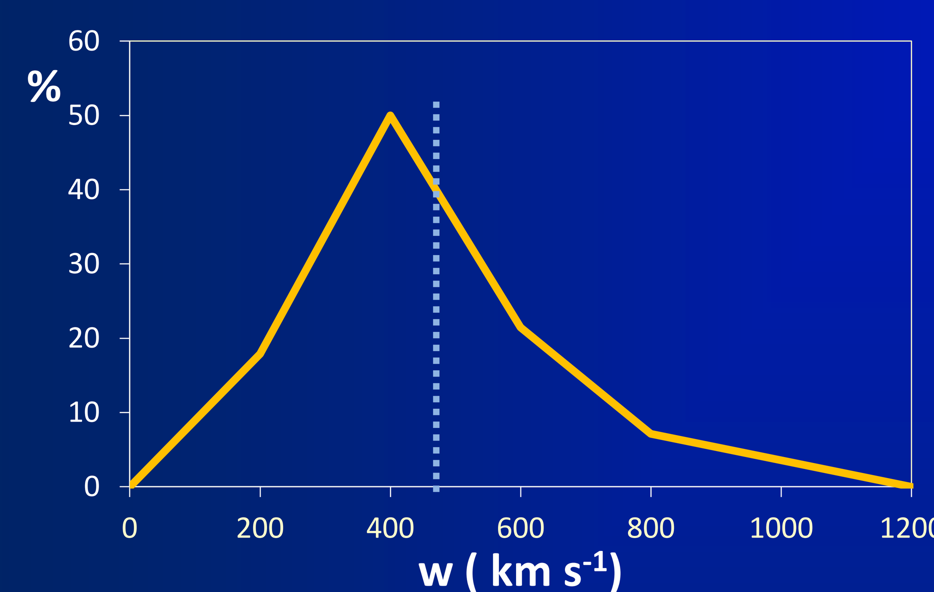



Running-difference images of the ICME take-off (LASCO/SoHO), providing the model input values $v_0(R_0,t_0)$.

## STATISTICAL STUDY (I)

Comparing calculated and observed transit times and speeds at 1 AU we estimated range of values for $\gamma$ and *w*.

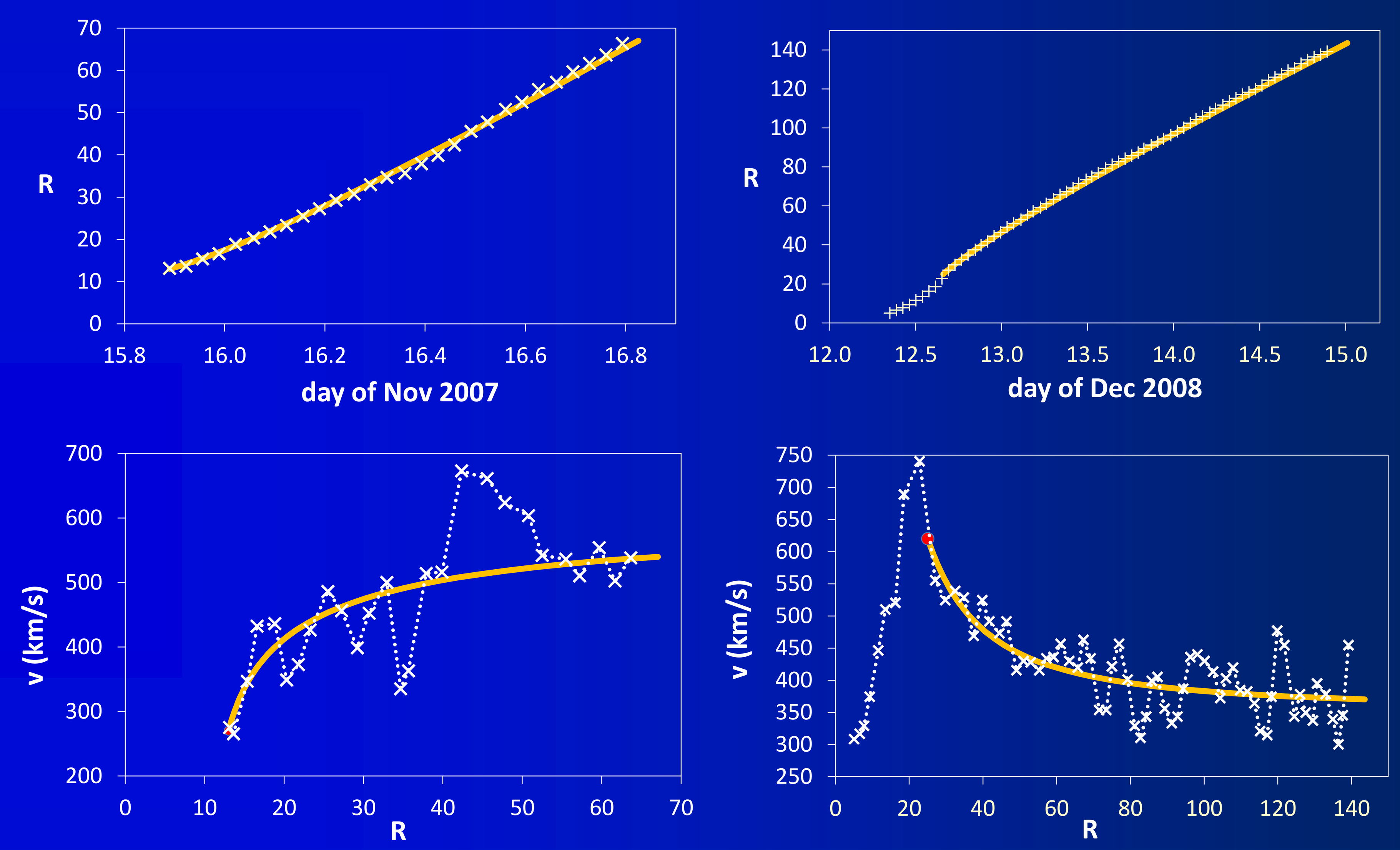



Samples used:
Schwenn et al., 2005, AnnGeo. 26, 1033
Manoharan, 2006, SPh 235, 345

## CASE STUDIES

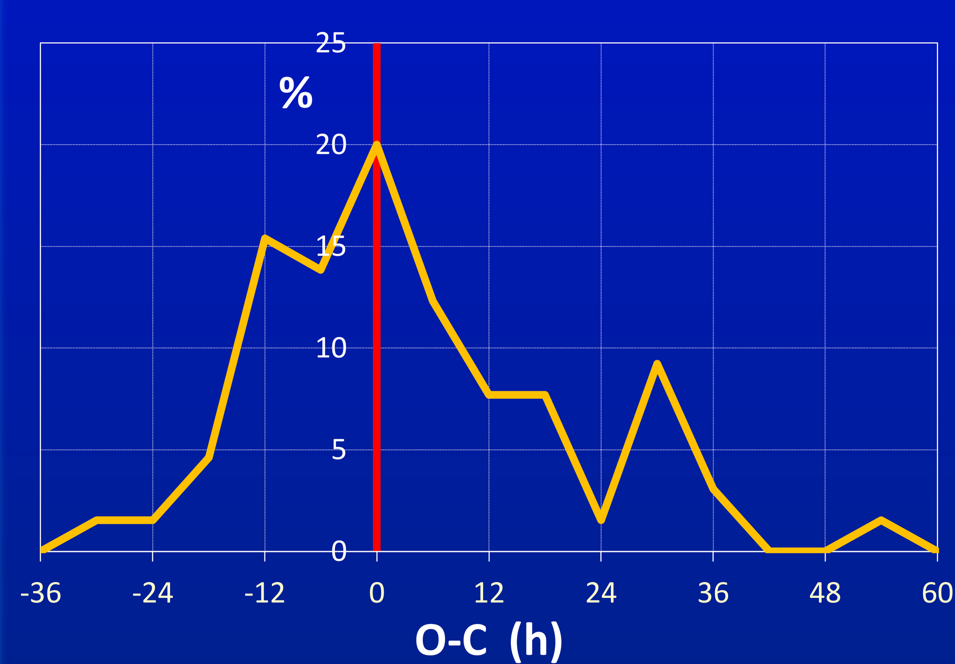
Comparison of the modeled and observed ICME kinematics (based on STEREO A&B data)

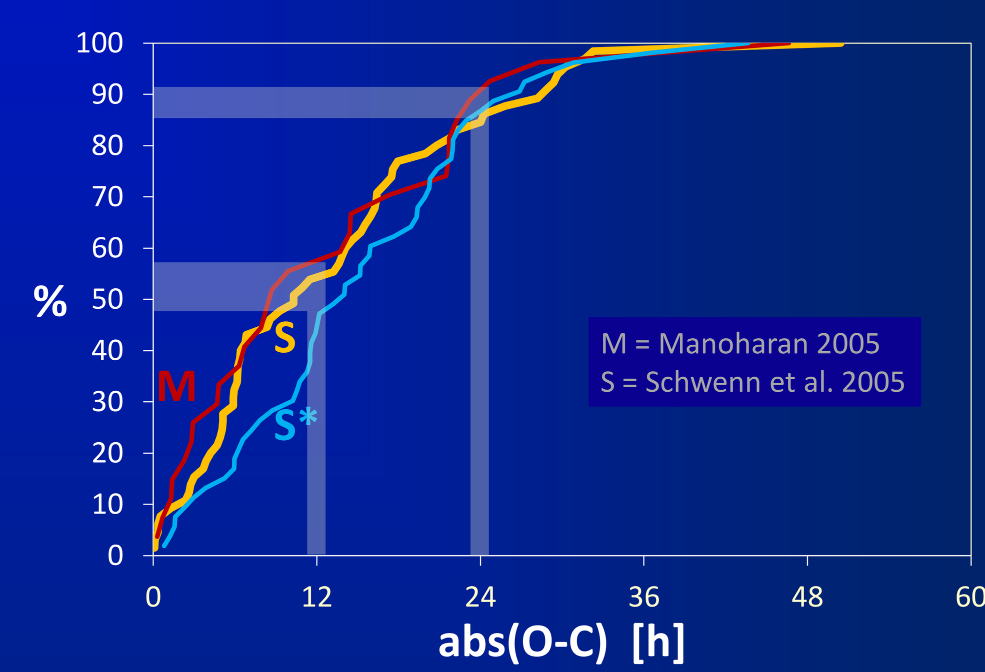



Measurements taken from:
Liu et al. 2010, ApJ 722, 1762

## STATISTICAL STUDY (II)

Optimal values, **$\gamma = 10^{-7}$ km$^{-1}$ and *w* = 500 km/s**, have been found also by minimizing the scatter of the difference between the observed and calculated transit times (O– C).




## ONLINE FORCAST TOOL

http://oh.geof.unizg.hr/CADBM/cadbm.php

Input page:

**Forecasting the Arrival of ICMEs at 1 AU: The Drag-Based Model**

Full description about the calculation method you can find **here**.

| | |
|---|---|
| CME take-off date: | Sep 21 2011 |
| CME take-off time: | 00 h 00 min |
| $R_0$ - starting radial distance of CME ($R_s$) | 20 |
| $v_0$ - speed of CME at $R_0$ (km/s) | 1000 |
| $\gamma$ - drag parameter ($10^{-7}$ km$^{-1}$) | 1 |
| **w** - asymptotic solar wind speed (km/s) | 500 |

Calculate | Reset!

**Output:**

CME arrival date & time : **2011-9-11 13h:5min**
Travel time: **61.08** h
Transit speed (at 214 $R_s$): **542** km/s

## CONCLUSION

DBM offers predictions of the ICME arrival for >90% of events with an accuracy better than 24 h, and for >50% of events better than 12h.

## ACKNOWLEDGMENT

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