Event prediction at the outer planets

B. Grison and IAP team
Institute of Atmospheric Physics, Prague Czech Rep.

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Outline

1) Propagation to Saturn:
One-dimensional MHD propagation tool Tao et al (2005)

- propagation of one component of the IMF
- Propagation of solar wind parameters (velocity, density, dynamic pressure, temperature).

2) Prediction at Jupiter? Proptool prediction + Hubble + Nançay observations

1D-MHD propagation tool (Tao et al., 2005)

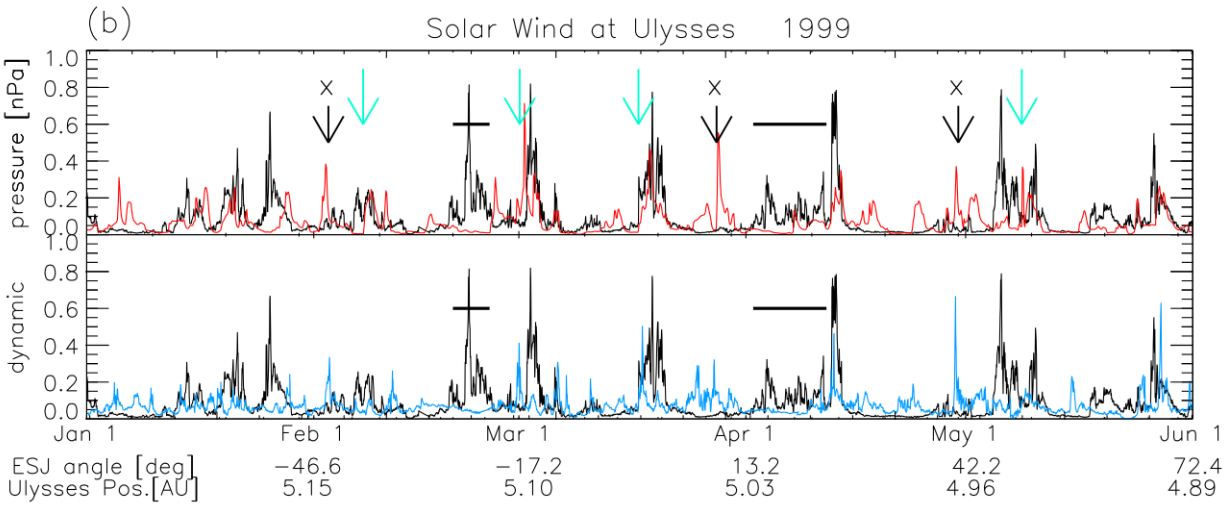
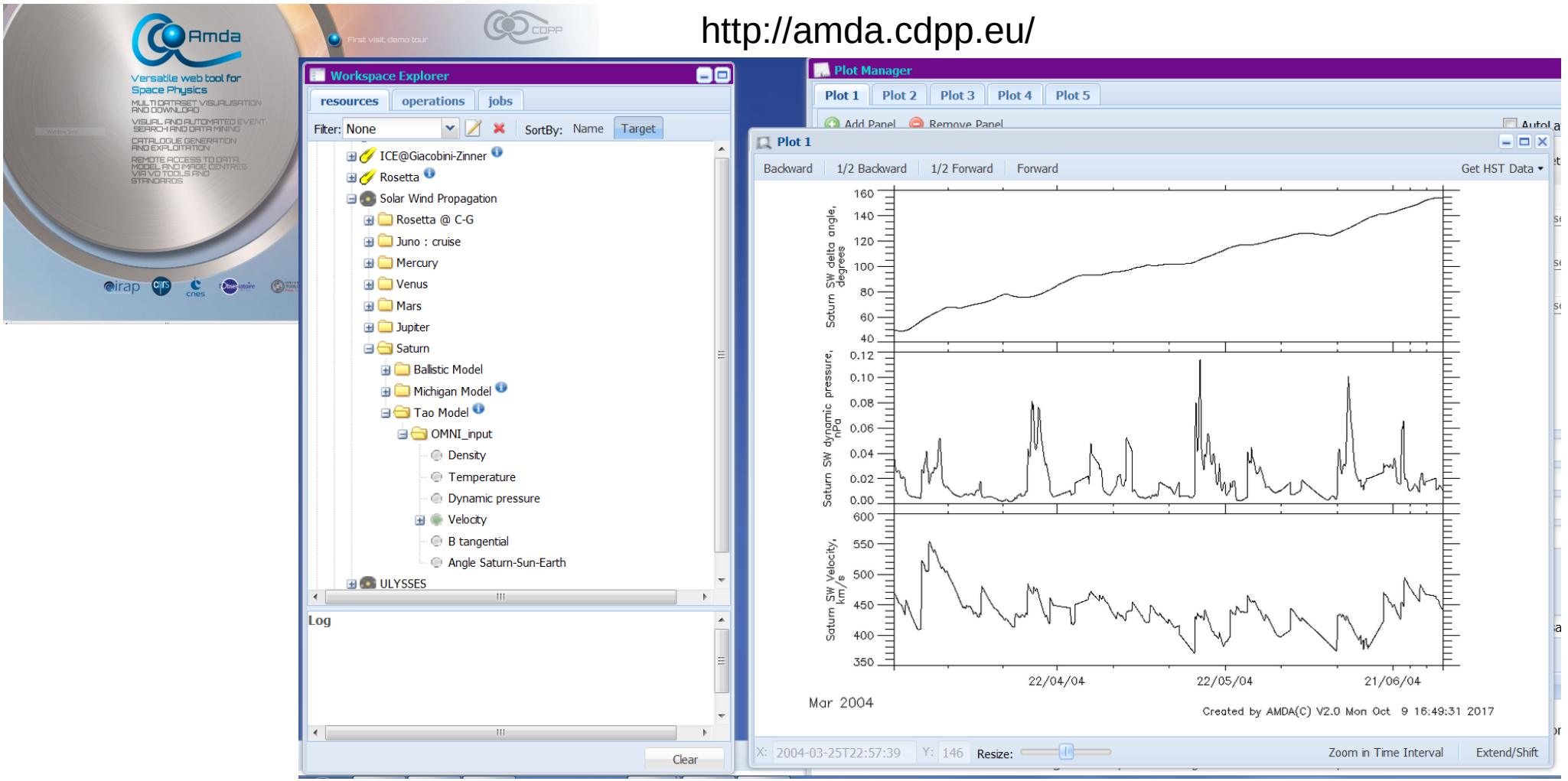


Figure 2. Solar wind dynamic pressure variations for the time intervals (a) 1 January 1998 to 1 June 1998 and (b) 1 January 1999 to 1 June 1999. Data from Ulysses observation, solar wind MHD simulation, and advection shift method are shown by black, red, and blue lines, respectively. Vertical green arrows indicate the arrival time of large-amplitude pressure pulses >0.25 nPa as predicted by MHD simulation. Pulses indicated by black arrows with crosses show the events without correspondence between observation and simulation. Black bars show the intervals affected by gaps of input data at 1 AU.

- Tao et al. (2005) tested this tool with Ulysses and Galileo data
- Successful propagation of density pulses from 1au to Ulysses.
- We test this tool to Saturn (Cassini data). Another target could be Jupiter (Cassini or Juno data)

1D-MHD propagation tool (Tao et al., 2005)

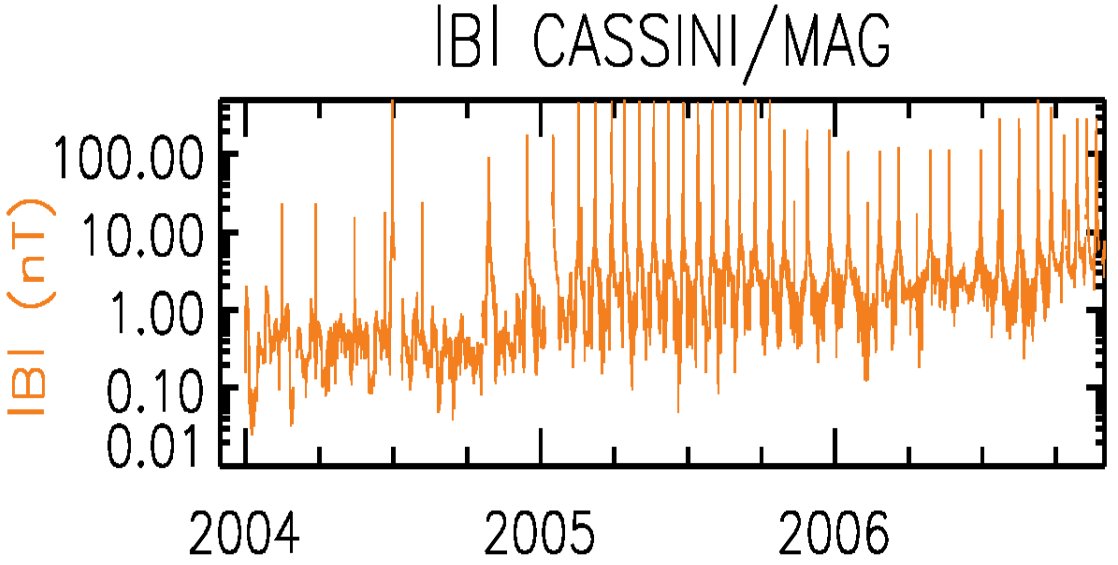
http://amda.cdpp.eu/

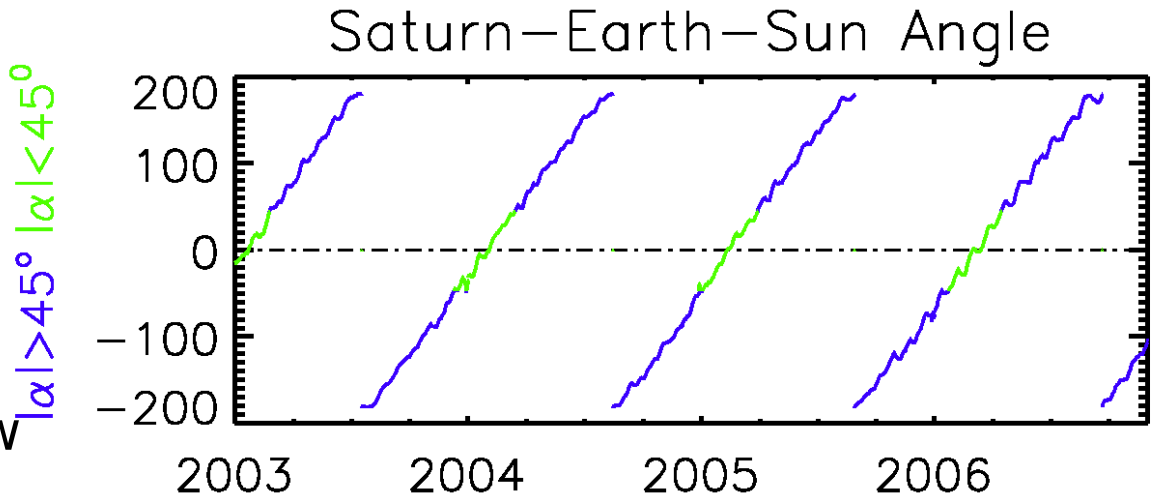


- Input: This model has been implemented in AMDA with OMNI data as input and various solar system bodies as output.
- We test it with Saturn as target. 1H time resolution

Can we test propagating to Saturn ?

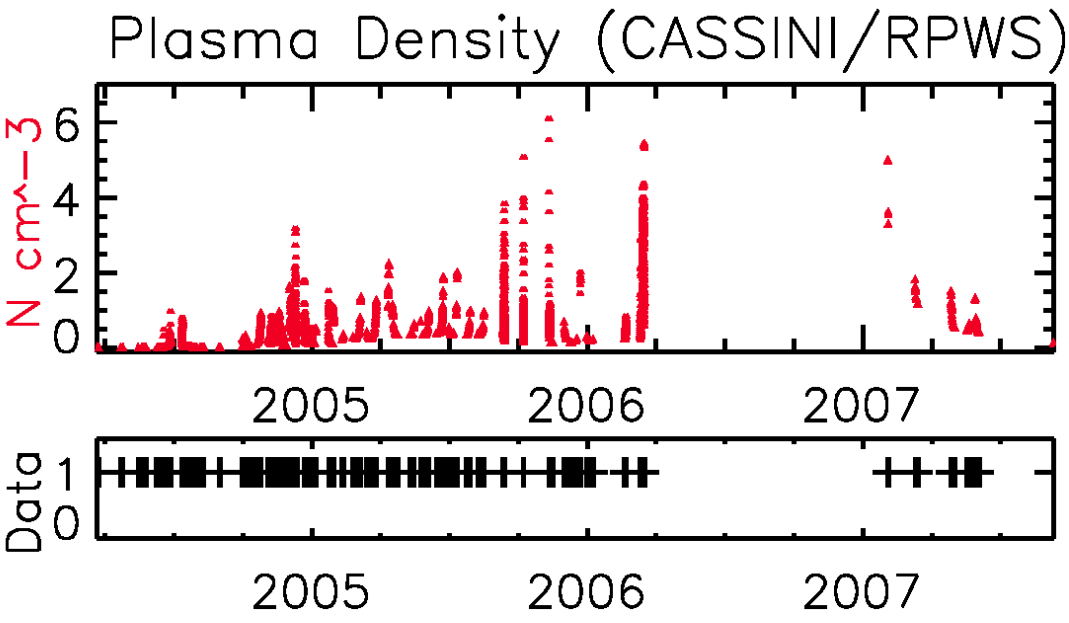
- When? Before year 2005
  - The mean propagation time is about 30 days. To compare propagated and observed data long <u>continuous</u> periods (>5 days) of observations in the SW in the vicinity of Saturn are requested: We consider CASSINI data before and after orbit insertion at Saturn.
  - The **Saturn-Sun-Earth angle** (**α**) should be as low as possible (close to 0°)

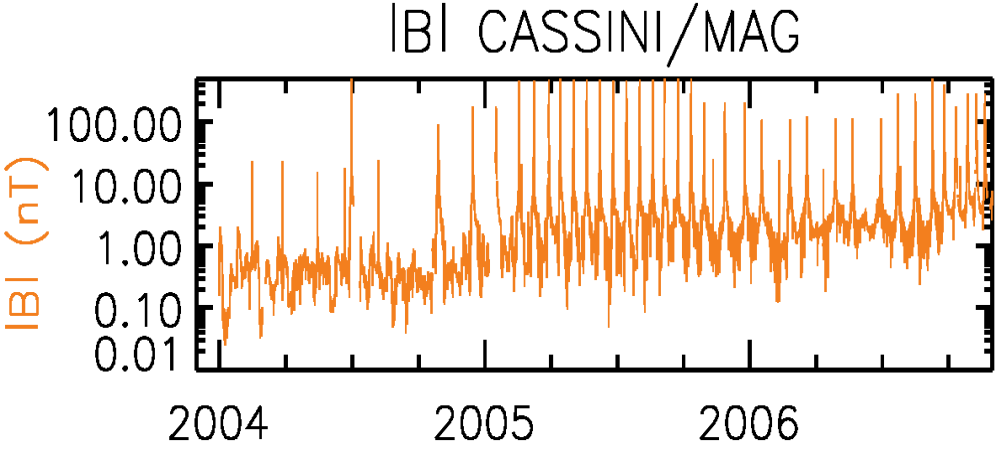




Cassini density measurements
(thanks to G. B. Hospodarsky, Univ. of Iowa)

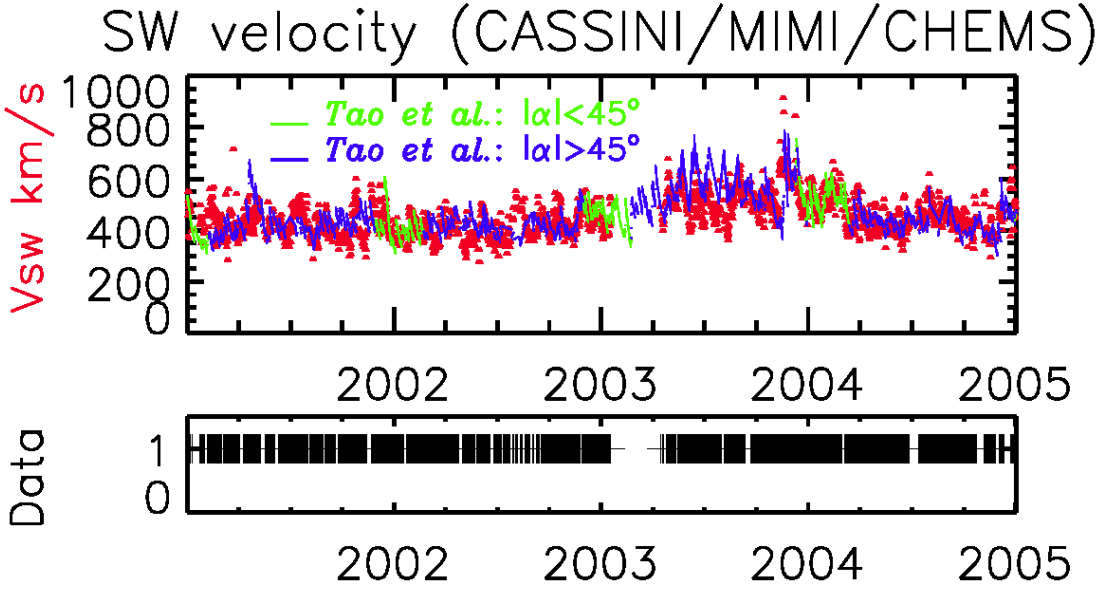
- RPWS measurements are available during short period of times
- Observations are made close to the magnetopause.
- Comparison with the model are thus not possible (magnetosphere compression events?)

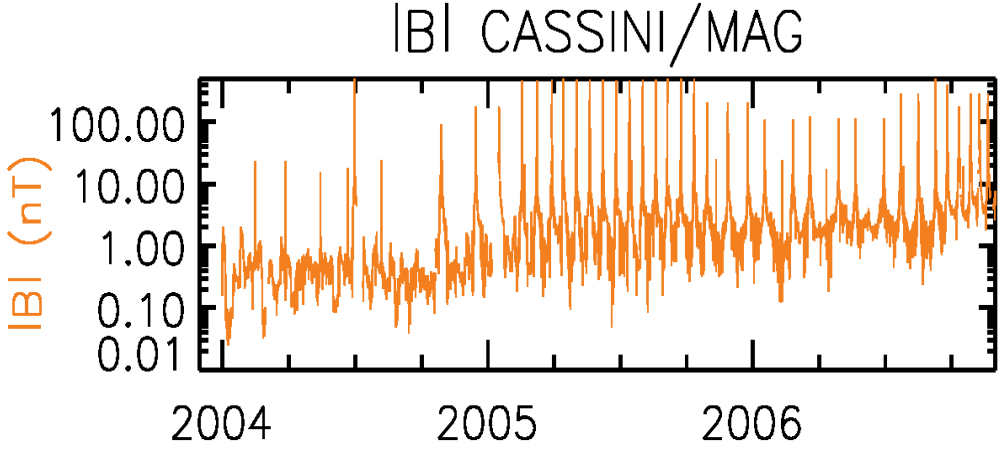




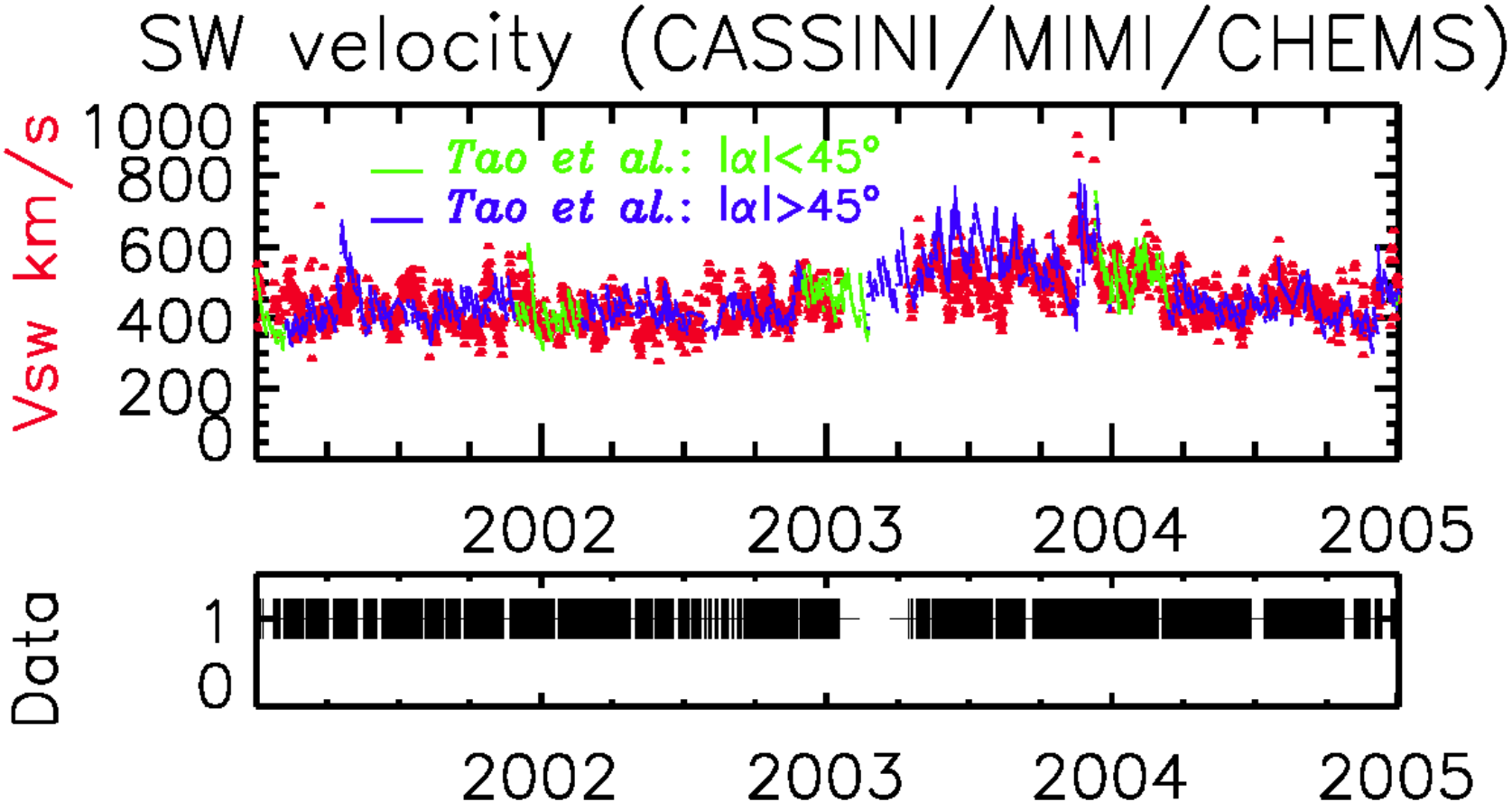
Cassini velocity measurements
(thanks to the team of M. E. Hill (JHU/APL))

- MIMI measurements are available (1/day) during the cruise phase
- Propagated and observed values are in the same range for low **α** periods **(in green)**. During high **α** periods **(in blue)**, the evolution of observed and numerical data can also be remarkably similar (see year 2002 and 2004).





Cassini velocity measurements



Difference between mid-2001, mid 2002 and mid-2004 (good correlation) vs mid 2003 (poor correlation) comparisons

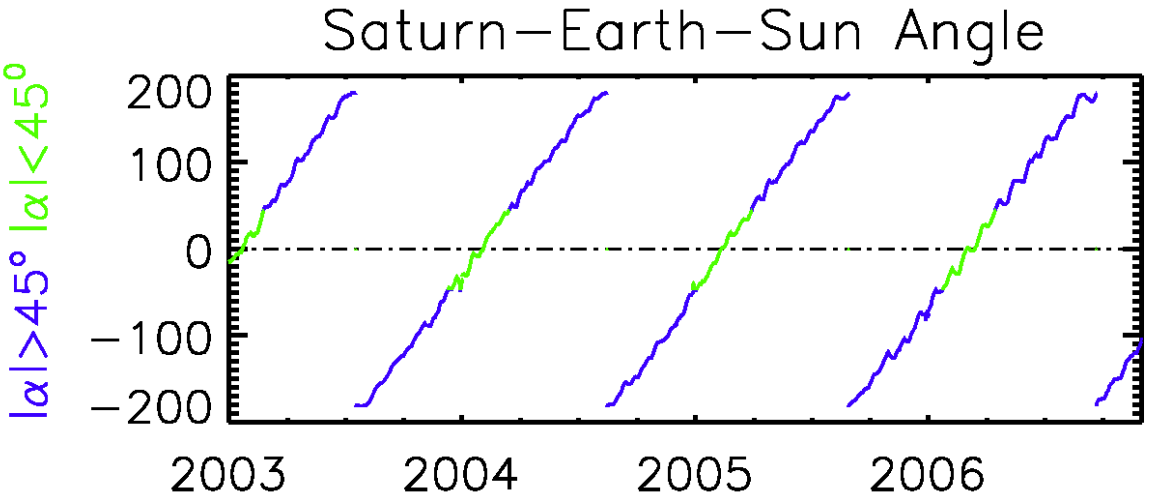
- Recurrence ratio?
- Influence of solar activity?

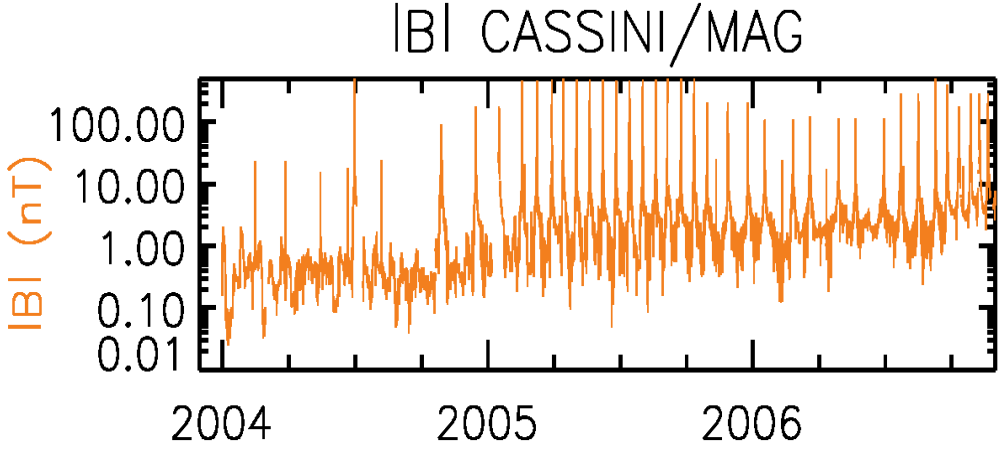
Cassini Bt measurements

Bt: Year 2004 seems to be the best period to perform comparisons.

Afterwards, CASSINI might not stay long enough in the SW.

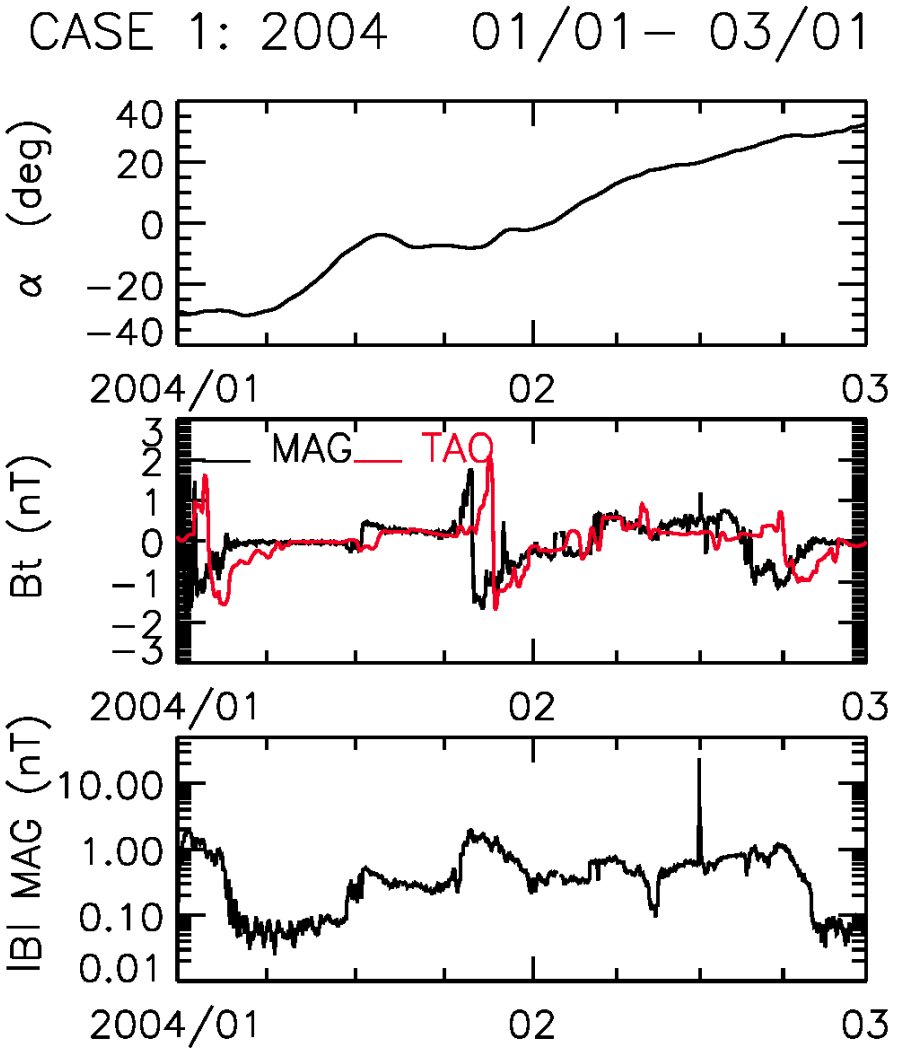
And no data before 2004/01/01.





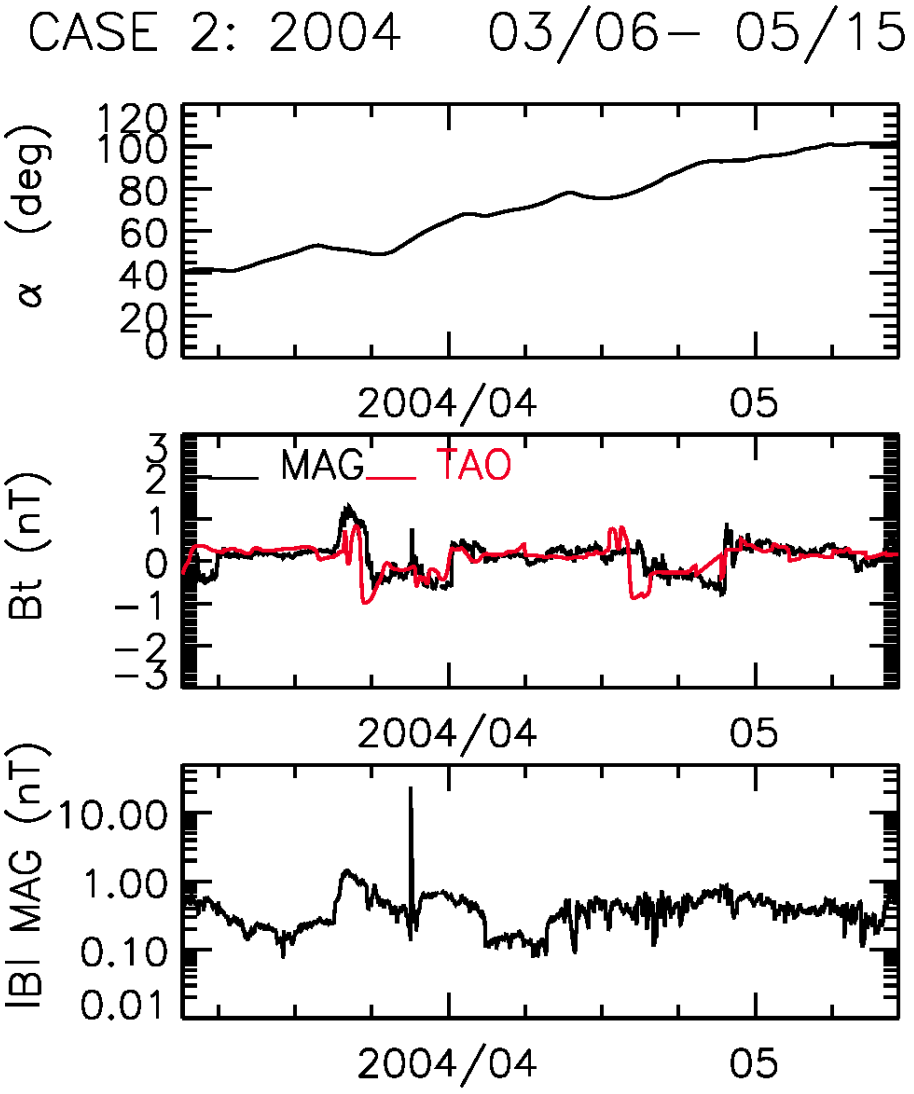
Cassini Bt measurements case 1 Comparisons with Tao et al. model

	Lag (h)	Correlation
Case 1	0	0.12
	-45	**0.68**
Case 2	0	0.40
	21	0.52
Cas 3	0	0.42
	31	0.50



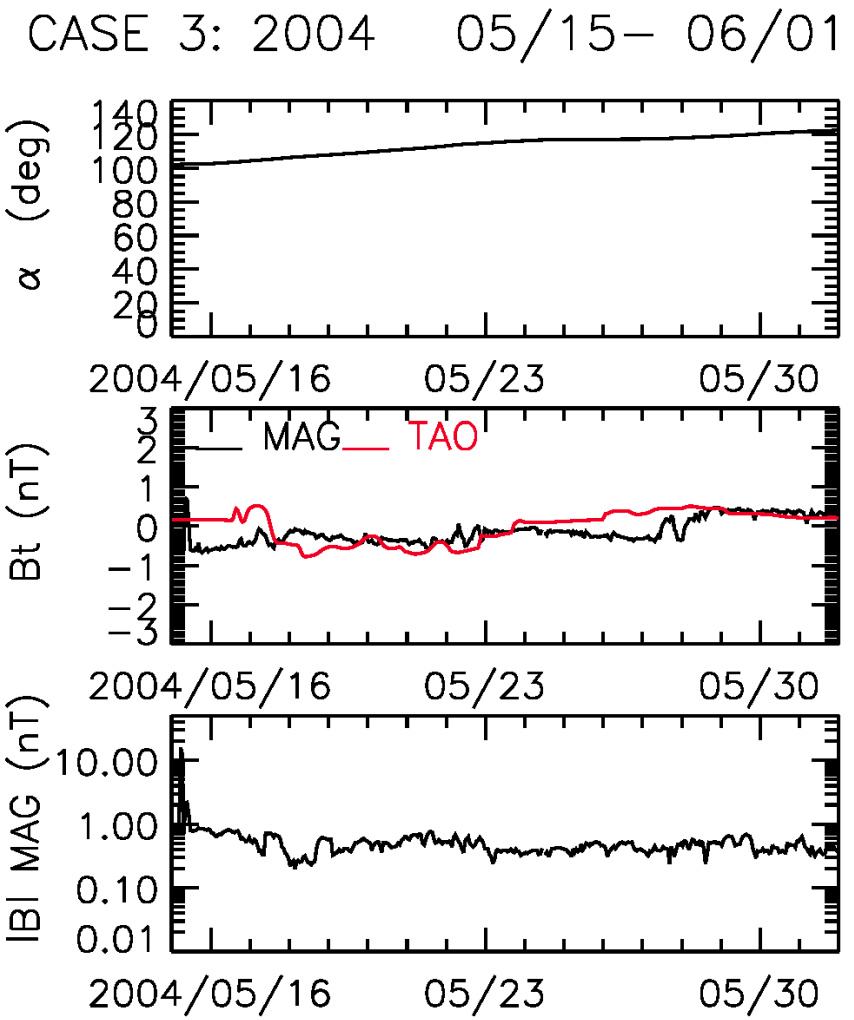
Cassini Bt measurements case 2

	Lag (h)	Correlation
Case 1	0	0.12
	-45	0.68
Case 2	0	0.40
	21	**0.52**
Cas 3	0	0.42
	31	0.50

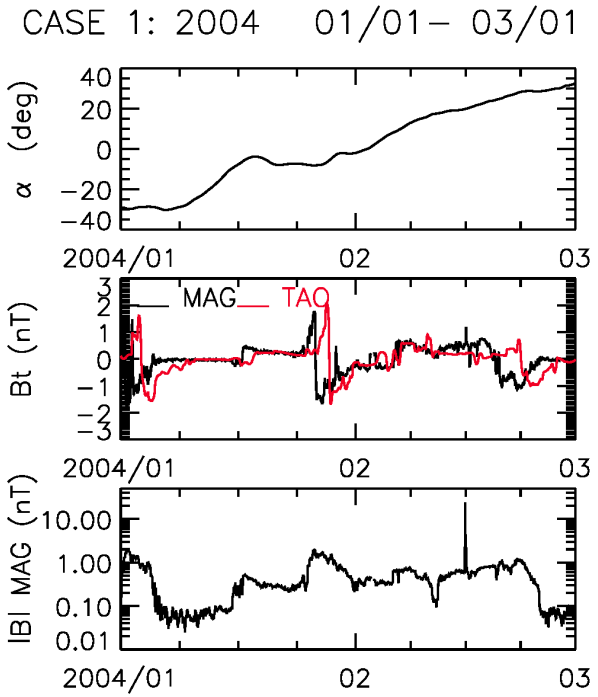


Cassini Bt measurements case 3

	Lag (h)	Correlation
Case 1	0	0.12
	-45	0.68
Case 2	0	0.40
	21	0.52
Cas 3	0	0.42
	31	**0.50**



Bt comparisons case 1

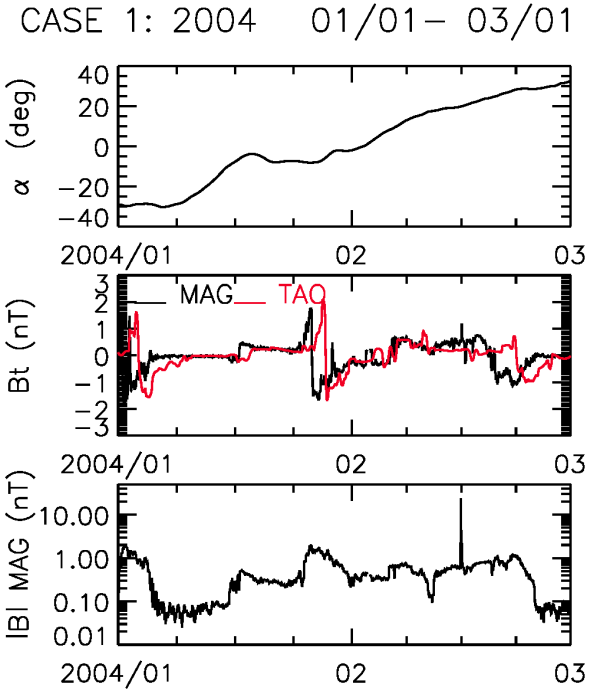


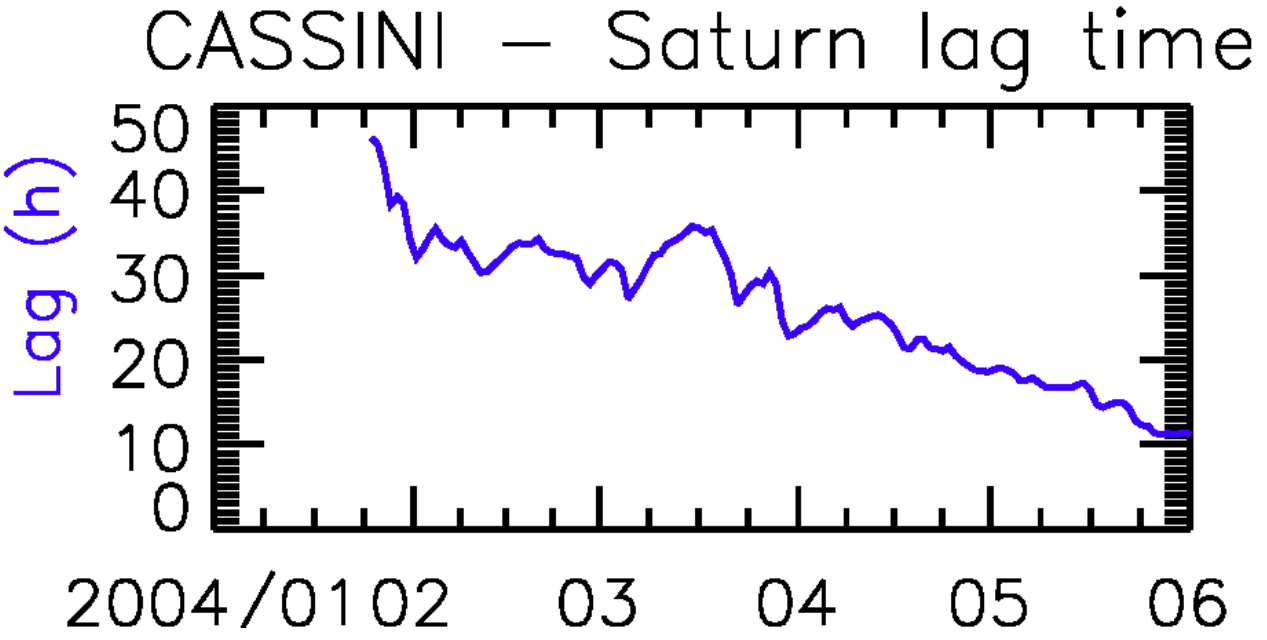
	Lag (h)	Correlation
Case 1	0	0.12
	-45	**0.68**

The propagated Bt values are remarkably similar to the observed ones for case 1 and case 2. The cross-correlation between the two signals is the highest (0.68) for a small α angle (case 1):

- The corresponding lag time is about -2days.
- Note that the period duration is 2 months.
- Tested lag time: from -3 days to +3 days

Cassini Bt comparisons

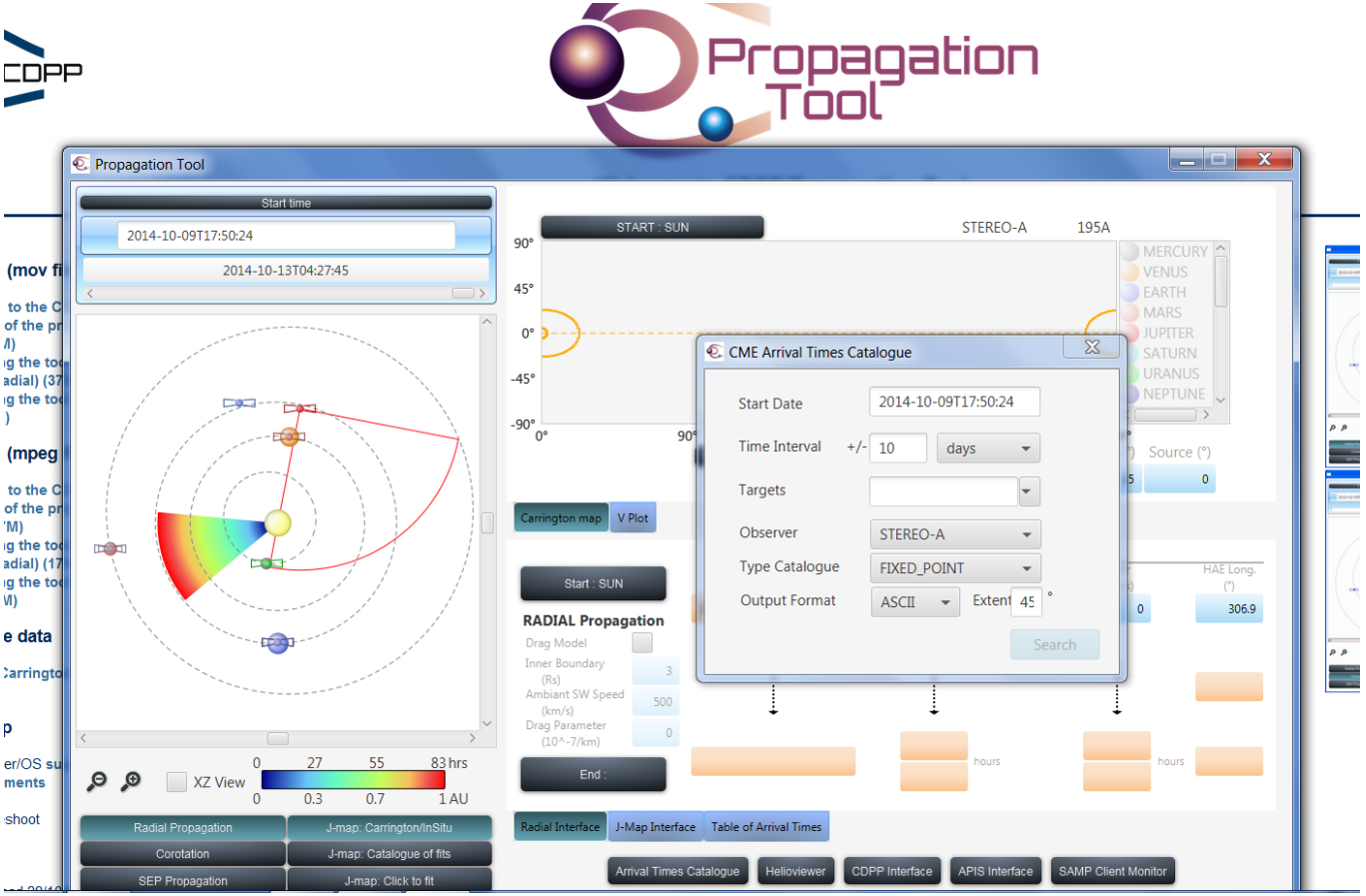




	Lag (h)	Correlation
Case 1	0	0.12
	-45	**0.68**

We explain the 2 days lag time between propagated and observed values by the SW radial propagation time between CASSINI and Saturn.

And Jupiter

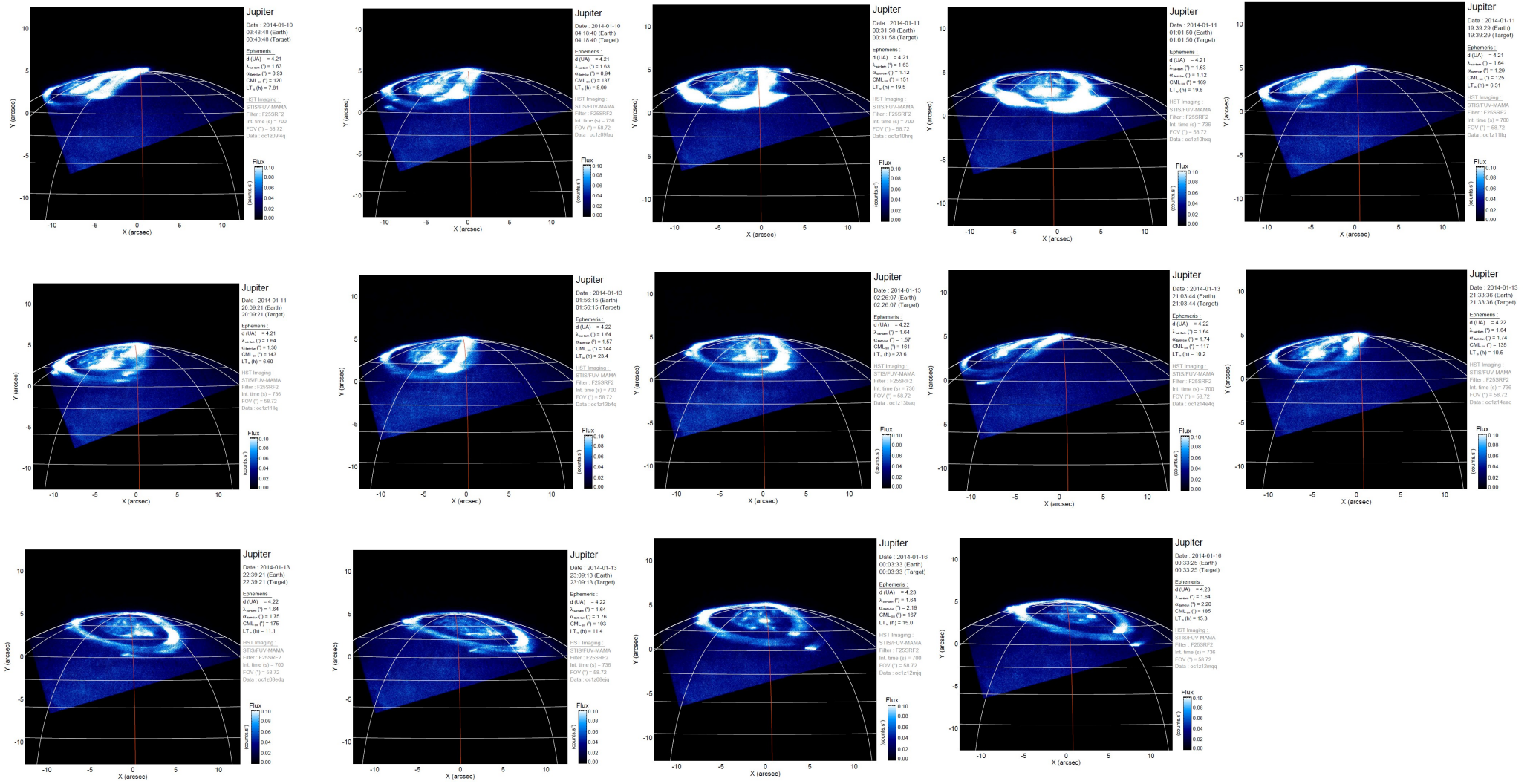


Applying the propagation tool to all ICME events observed by Stereo A and B in the HELCATS catalog, 149 ICMEs potentially impacted the Jovian magnetosphere in the 2007-2014 period.

The HST images of Jovian aurorae (APIS database) and the Nançay decameter array spectra are available through the Europlanet/VESPA web service.

For a single event (over the 149) there is a match with more than one HST image

And Jupiter

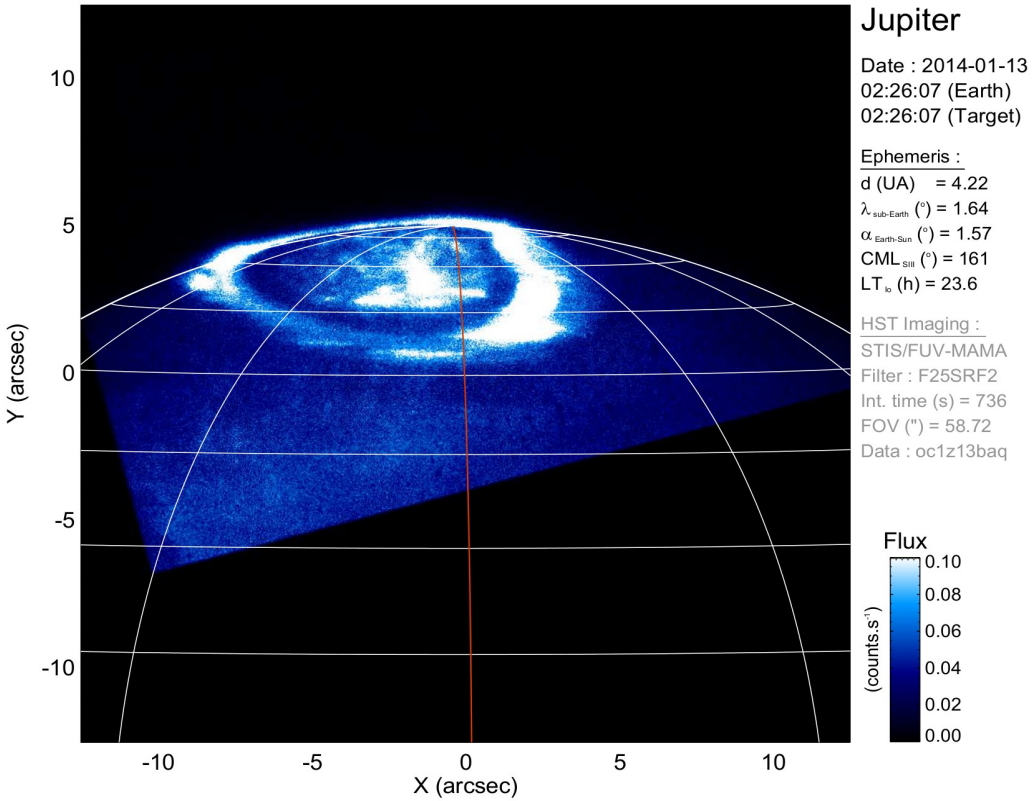


Predicted arrival date : 2014-01-13T17:31:00

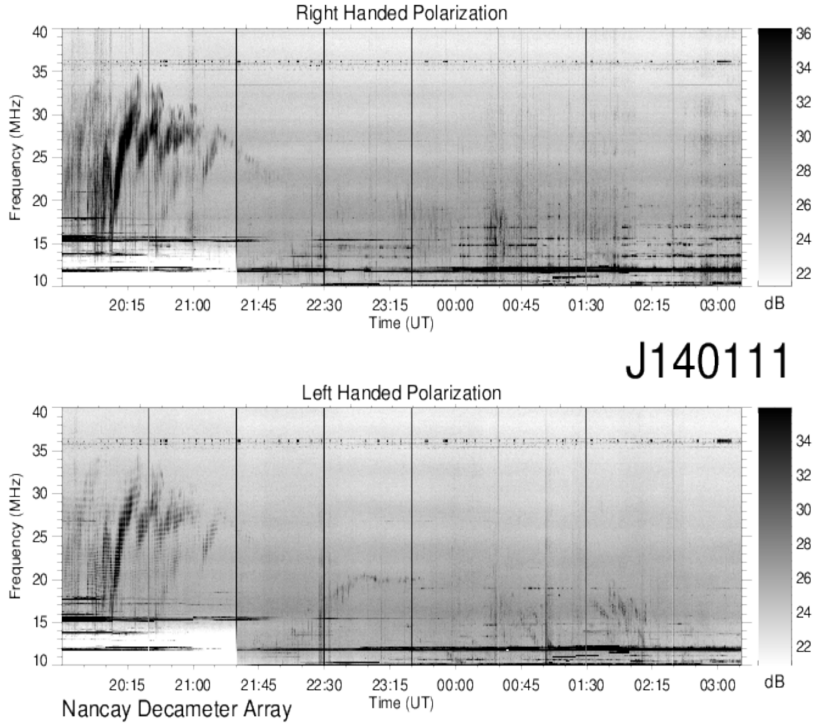
Date of HST images 01/10 (2), 01/11 (4), 01/13 (6) and 01/16 (2)

And Jupiter

Before ICME predicted arrival



HST (via APIS) 2014/01/13 02:26



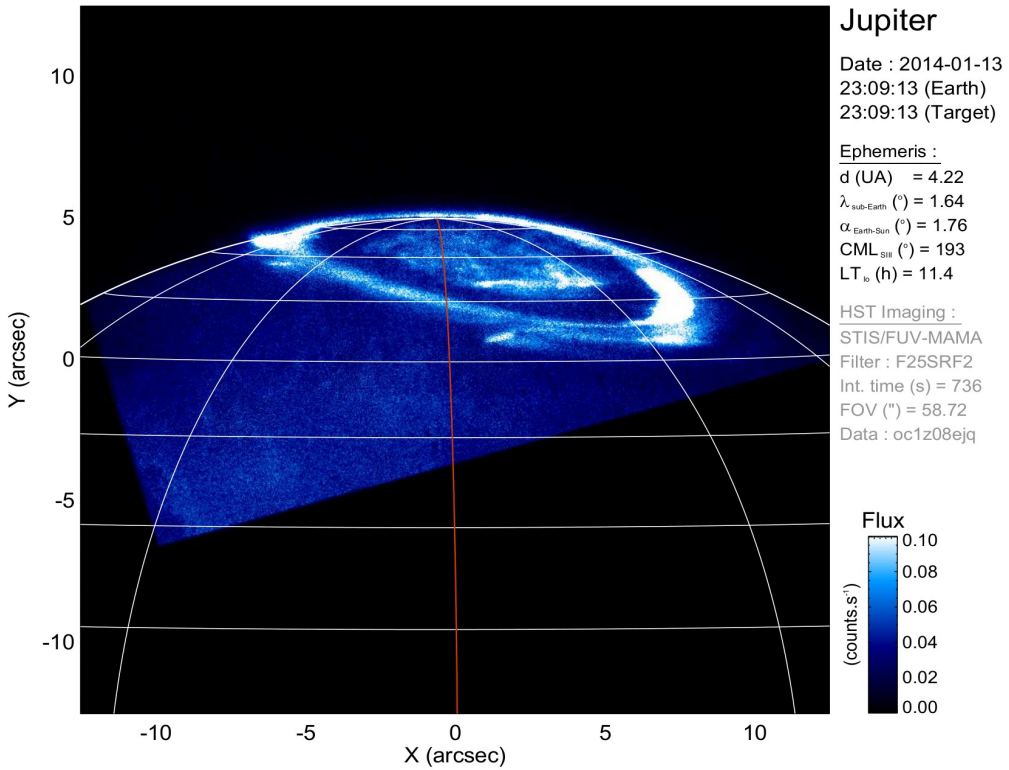
Nançay DA 2014/01/12

Predicted arrival date : 2014-01-13T17:31:00

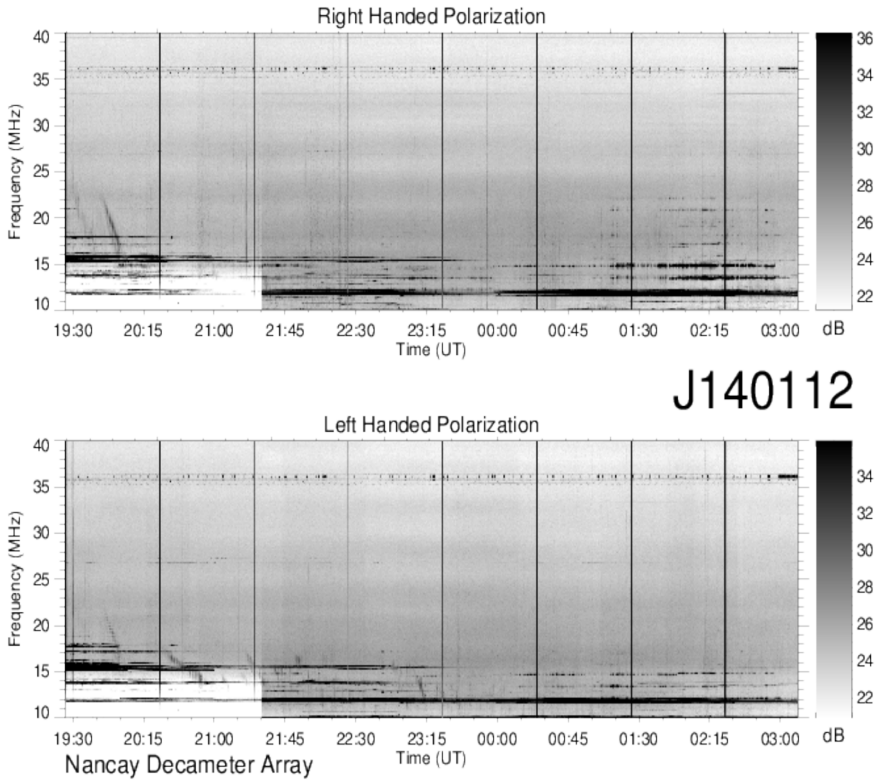
Date of HST images 01/10 (2), 01/11 (4), 01/13 (6) and 01/16 (2)

Nançay observations

And Jupiter
After ICME predicted arrival



HST (via APIS) 2014/01/13 23:09



Nançay DA 2014/01/13

Predicted arrival date : 2014-01-13T17:31:00

Date of HST images 01/10 (2), 01/11 (4), 01/13 (6) and 01/16 (2)

Nançay observations

Summary

- 1D-MHD model accurately propagates SW velocity and Bt IMF component from Earth to Saturn
- Density propagation could not be tested
- Difficult to observe ICME effect on HST images