Title : Sun Earth Connection

Team : International ISSI Team in Bern on the « Geoeffectivity of the CMEs (2010-2012)

Team PNST : managed in France with collaboration in Spain, UK, US and Argentine (2012-2013)
(Démoulin, Schmieder, Janvier: Observatoire de Paris, France; Dasso, Gulisano, Mandrini, Cremades: Argentina; Ruffenach , Lavraud et al : Toulouse, France, C.Cid etal : Spain; van Driel, Baker: MSSL ; Masson S.: George Mason Uni., US)

We have worked on different aspects on the Sun Earth connection after solar flares: the solar sources, the coronal mass ejections and finally the magnetic clouds. We have lead a series of workshop in Bern at the ISSI Institute from 2010 to 2012.

1. From CMEs to Magnetic Clouds

A coronal mass ejection (CME) starts typically in the low corona due to the destabilization of a sheared or twisted magnetic configuration (review of Schmieder et al 2013). We have tested for a CME observed on the 15 April 2001 that the white light observations was compatible with a model of twisted flux tube (Démoulin et al 2012). The precursors of CMEs are detected in the velocity field of the coronal plasma (Baker, et al. 2012). During intense events, the edge of the CME is detected in radio (i.e. Radio telescope of Nançay).

The flux tubes ejected during the CMEs are expanding in the interplanetary medium where they are observed with spacecraft. Sometimes we have data only in one leg of the tube leading to a difficult interpretation (Owens, et al. 2012). We have quantified the expansion of one cloud until the Jupiter orbit (Gulisano, et al. 2012). We have also shown that fast magnetic clouds reconnect in front with the surrounding magnetic field after a detailed study done with the data of STEREO and ACE of a magnetic cloud (Ruffenach, et al. 2012). We have as a project to compute the flux involved during such reconnection (Lavraud et al in preparation)

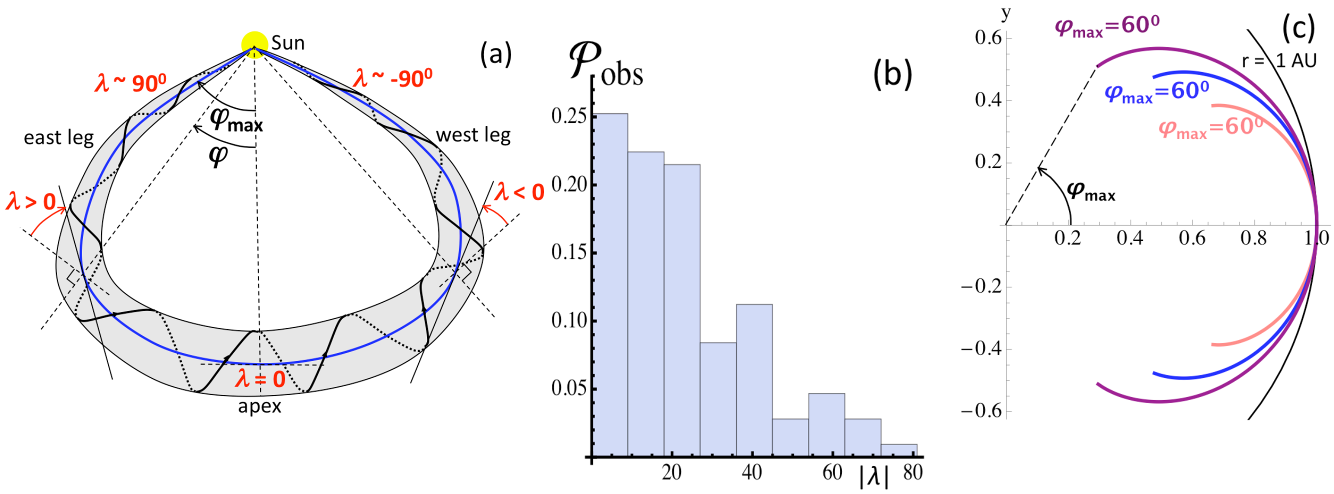

Figure 1 : Determination of the mean axis of a magnetic cloud.

(a) Definition of the angle λ (angle between the axis of the flux tube and the direction of the ortho-radial from the Sun).

(b) Distribution of |λ| observed at 1 UA obtained with 107 magnetic clouds.

(c) Mean shape of the axis deduced from (b), with the maximum angular extension, φmax, the free parameter of this study (Janvier et al. 2013b).

2. Minimal distance between the spacecraft and the MC axis

(a) The distribution of the observed probability of the impact parameter (minimal distance spacecraft-axis) of the magnetic clouds is a uniform decreasing function and not a uniform distribution as it was expected. This is mainly due to the flateness of the section of the flux tube (Démoulin, et al. 2013). This has lead us to determine the shape of the magnetic cloud from the distribution of the angle λ between the axis of the flux tube and the direction of the ortho-radial from the Sun (Janvier, et al. 2013, Figure 4).

3. Geoeffectiveness of CMEs with a solar source at the limb.

The geoeffectiveness of halo CMES starting from a source at the limb cannot exceed a low level in normal conditions. If the limb halo CMEs follows a series of CMEs the geoeffectivenees can exceed -50nT (Cid et al. 2012). Around the active regions large plasma flows are detected and it appears it exists a relationship between these flows and the Solar Wind measured at 1AU (van Driel-Gesztelyi, et al. 2012).

The arrival of SEPs is also very important for the Solar Weather prediction. We proposed a new method to compute the delay between the arrival of the particles. It seems that the distances along the spiral of Parker depend on the energy of the particles (Masson, et al. 2012b).

Future Plans

*Development of new models of twisted flux tubes adapted to the observations
*Study of recurrent CMEs using three eyes (coronographs of SOHO et SDO/AIA)
*MHD data-driven simulation of the onset of CMES

Publications 2012-2013

1. Baker, D., van Driel-Gesztelyi, L., Green, L. M.
Forecasting a CME by Spectroscopic Precursor?
2012, Solar Physics, 276, 219

2. Cid C., Cremades H., Aran A., Mandrini C., Sanahuja B., Schmieder B. et al .
Can a halo CME from the limb be geoeffective ?
2012, Journal of Geophysical Research, 117, 11102

3. Démoulin, P., Vourlidas, A., Pick, M., Bouteille, A.
Initiation and Development of the White-light and Radio Coronal Mass Ejection on 2001 April 15
2012, The Astrophysical Journal, 750, 147

4. Janvier, M., Démoulin, P., Dasso, S.,
Global axis shape of magnetic clouds deduced from the distribution of their local axis orientation
2013b, Astronomy and Astrophysics, A50

5. Gulisano, A. M., Démoulin, P., Dasso, S., Rodriguez, L.
Expansion of magnetic clouds in the outer heliosphere
2012, Astronomy and Astrophysics, 543, A107

6. Masson, S., Aulanier, G., Pariat, E., Klein, K.-L.
Interchange Slip-Running Reconnection and Sweeping SEP Beams
2012a, Solar Physics, 276, 199

7. Masson, S., Démoulin, P., Dasso, S., Klein, K.-L.
The interplanetary magnetic structure that guides solar relativistic particles
2012b, Astronomy and Astrophysics, 538, A32

8. Owens, M. J., Démoulin, P., Savani, N. P., Lavraud, B., Ruffenach, A.
Implications of Non-cylindrical Flux Ropes for Magnetic Cloud Reconstruction Techniques and the Interpretation of Double Flux Rope Events
2012, Solar Physics, 278, 435

9. Ruffenach, A., Lavraud, B., Owens, M. J., Sauvaud, J.-A., Savani, N., Rouillard, A. P. Démoulin, P., Opitz, A., Fedorov, A., Jacquey, C. J., Génot, V., Luhmann, J. G., Russell, C. T., Farrugia, C. J., Galvin, A. B. and Angelopolous, V.
Multi-spacecraft observation of magnetic cloud erosion by magnetic reconnection during propagation
2012, Journal of Geophysical Research, 117, 9101

10. van Driel-Gesztelyi, Culhane J. L., Baker D., Démoulin P., Mandrini C.H., DeRosa M.L., Rouillard A. P., Opitz A., Stenborg G., Vourlidas A., Brooks D.
Magnetic topology of Active Regions and Coronal Holes: Implications for Coronal Outflows and the Solar Wind
2012, Solar Physics, 281, 237