Topical Discussion Meeting report

A Topical Discussion Meeting aims at active participation or interaction between the participants. The participants work and discuss on a predefined theme or problem heading towards an outcome or target. A working meeting is a 1h 15min informal afternoon meeting with NO abstract submission form and therefore NO poster contributions.

Name of the meeting: What does Space Weather need from Space Science?

Conveners: J. De Keyser and I. Dandouras

Data – Time – Room: Friday 9 November 2018 – 14:00-15:15 – MTC 00.10 Aula Major

Nr of participants: ~70

Objective of the TDM

The scientific community working in the field of Space Plasma Physics has taken an initiative to try to develop a roadmap for Space Physics research in Europe through a broad consultation of all interested parties (in analogy to what the Space Weather community has done). This roadmap should set the scientific goals for the field on a 5-10 year horizon and should sketch a path to achieve these goals. As part of this exercise we organized this Topical Discussion Meeting "What does Space Weather need from Space Science?" during ESWW15 with the aim of gathering inputs. In particular, we wanted to identify key areas where Space Weather activities would benefit from advances in Space Physics. Conversely, we also wanted to assess where data acquired in the Space Weather domain can push Space Physics forward.

Some discussion highlights

The meeting started with a very short introductory presentation by J. De Keyser clarifying the objectives. Based on an initial listing of the major domains, an interactive discussion took place with the public regarding various aspects of space physics, interesting science questions, and space weather data that could be exploited. Topics that were being addressed include

- Solar wind dynamics
    - There was a consensus that Solar Orbiter and Parker Solar Probe would bring substantial new scientific input to this field.
    - Having operational solar wind monitors at a variety of positions (L1, L2, L5, Stereo-like orbits) is seen as providing also substantial data to further research on CIR development, CME propagation and interaction with the ambient solar wind, etc.
- Solar wind – magnetosphere interaction
    - In spite of missions such as Cluster and MMS, there remain still a lot of unknowns regarding basic plasma physics at shocks. Also, structures as HFA and SLAMS are ill

understood. It is not immediately obvious how these phenomena affect space weather, although HFA and SLAMS certainly affect the magnetopause position.
    - In general, the topic of solar wind entry and plasma mixing deserves more attention, but it is not clear how to set up a mission to do provide closure regarding this matter.
- Solar energetic particles (SEP)
    - While people voiced concerns regarding the ability of Solar Orbiter and Parker Solar Probe to elucidate SEP acceleration processes, there was agreement that these will help to clarify SEP propagation, which is of primordial importance for space weather.
    - The role of turbulence in the propagation of SEP and of galactic cosmic rays is not well documented and remains of interest.
- Magnetospheric dynamics & convection
    - The issue of the composition of the magnetospheric plasma was highlighted. Not too much is known about composition and about its time variability. Nevertheless, composition affects the dynamics. Participants stressed the possible role of composition on both nightside and dayside reconnection and on the overall substorm cycle.
    - The role of composition is linked to the question of ionospheric upflow and magnetospheric outflow, atmospheric escape, the ability of a planetary magnetic field to protect a planet from escape or not, etc. Several recent mission proposals have been focusing on this (NITRO, ESCAPE, FATE).
- Inner magnetosphere and radiation belts
    - The magnetospheric electric field is not well understood. In particular the role of induced electric fields is not clear. Understanding the dynamical changes in the electric field and the accompanying magnetospheric convection would imply a significant advance for space weather.
    - With the Van Allen Radiation Belt Probes, as well as other space-borne instruments that measured the radiation belts (e.g. CSSWE/ REPTile, Proba-V/EPT), scientists now have a lot to work on. The perception is that we understand particle sources better than we do particle loss processes. It was noted that radiation belt models are empirical. The so-called physics-based models rely on semi-empirical diffusion coefficients that represent wave-particle interactions, while we do not know the space and time occurrence of the different types of waves involved. There seemed to be an agreement that scientists first have to digest the flurry of recent data, and then will come up with more specific science questions that could be addressed by future missions.
- Mesosphere and thermosphere
    - This is widely considered to be an important link in the chain for space weather. Very little is known about the thermosphere, its 3D distribution and its time variability. There is a clear need to provide altitude density profiles and composition for both ions and neutrals.
    - Nevertheless this is crucial for a number of space weather applications, e.g. spacecraft orbit and reentry predictions. An opportunity lies in cheaper access to low Earth orbit, which could somehow make up for the rapid decay of spacecraft from such low altitude

orbits. In this context, the Daedalus mission proposal in the context of ESA's Earth Observation Program was highlighted.

- Magnetosphere-ionosphere electric current circuit
    - The auroral current circuit is understood in its overall aspects and configuration. Participants indicated that there are still a number of fundamental aspects missing, regarding the currents and the particles that carry those currents (e.g. auroral acceleration mechanisms). The Alfven and Alfven+ proposals have not been successful.
    - An interesting approach is the following question : to which degree are the auroras in both hemispheres conjugate? This would allow to combine a space weather approach (monitoring the auroras in both hemispheres) with an attempt to answer more fundamental science questions (cf. Ravens mission proposal).
- Ionospheric dynamics
    - People appreciate that missions such as SWARM allow to achieve interesting objectives that are at the same time relevant for a variety of users and for space weather physicists, and this within the frame of ESA Earth Observation.
    - Such missions help to bridge the gap between what happens in space and the neutral atmosphere lower down. Ionospheric physics has to be studied concurrently with the mesosphere/thermosphere if one ever wants to understand the dynamics of both, since they are coupled.

The participants then had the opportunity to formulate an idea for a space physics mission in support of space weather during a 10' discussion round in smaller subgroups. The ideas were then brought forward. Noteworthy suggestions were

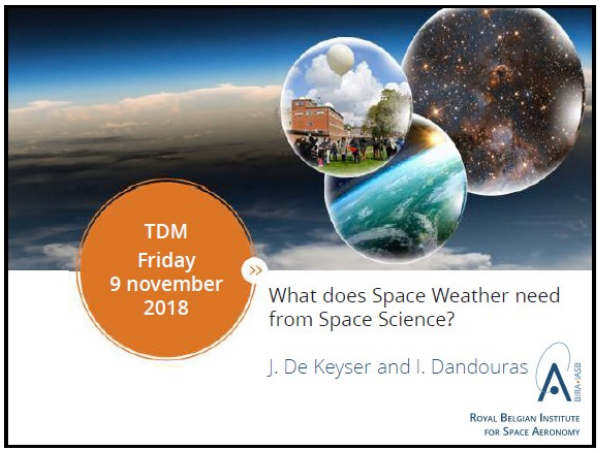
- Set up a constellation of ~20 cubesats to collect global data regarding the physical properties of the thermosphere (density, temperature, composition, convection) in order to be able to build a dynamical 3D description of the thermosphere and its response to solar and geomagnetic activity.
- Conduct a multi-spacecraft mission to study what happens between 8 and 10 RE in the nightside magnetosphere, so as to fill in the gap in our knowledge regarding the behavior of the inner edge of the plasma sheet, injection of particles, creation of the ring current, etc. After all the work that has been done regarding substorms (e.g. with THEMIS and Cluster), this still is largely uncharted territory.
- Launch every two years a STEREO-type spacecraft on a STEREO-type orbit, and let it drift relative to Earth. In this way, after some years, one will have a constellation of interplanetary solar and solar wind monitors providing a good coverage in terms of different heliospheric longitudes.
- There was a more general discussion regarding the pros and cons of monitoring missions versus missions that are tailored to answer a specific science question.

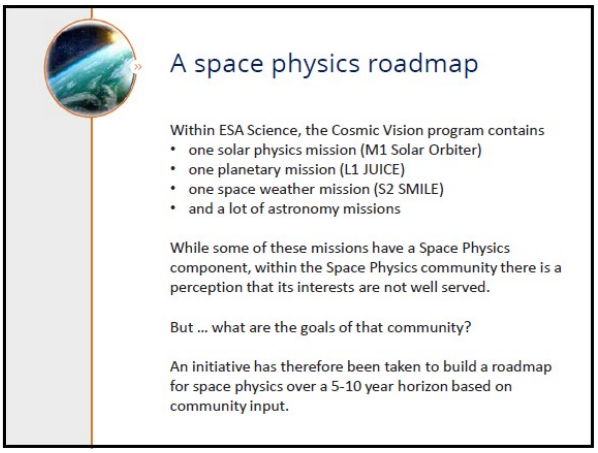
Main conclusion of the meeting

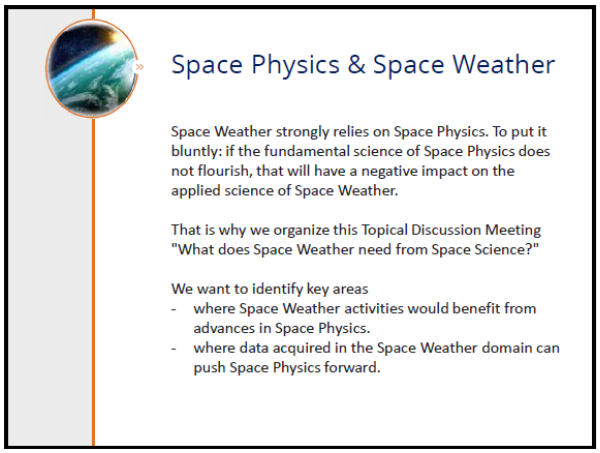
The meeting was productive in providing input on open space physics questions relevant for space weather, and in suggesting even a few missions that could help to respond to such questions. The goal is now to transmit those inputs to a still-to-be-formed working group that will coordinate the construction of a Space Physics roadmap. The best platform to do so is still being examined, with as most concrete proposal the creation of an ISSI working group.

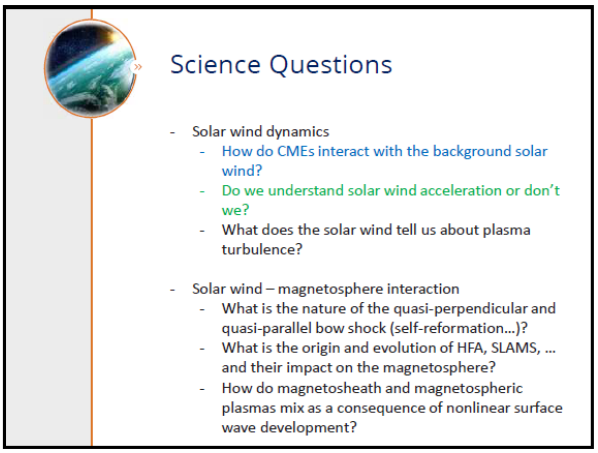
Annexes

Slides of the meeting with introduction and topics to be addressed:









- Solar energetic particles
  - Is shock acceleration sufficient to produce the spectra that are observed? What is the seed population?
  - How do energetic particles propagate? How is this affected by solar wind structures and by turbulence?
- GCR
  - How do GCRs enter the heliosphere and propagate into the inner solar system?
  - What is the shape and structure of the heliospheric boundary?

- Magnetospheric dynamics & convection
  - What is the role of high latitude reconnection?
  - Which fraction of ionospheric upflow returns?
  - What is the composition inside the magnetosphere?
  - Do we understand the substorm process?
  - Do we understand the origin of the magnetospheric electric field? What is the role of induced electric fields? Polarization electric fields?

- Radiation belts
  - Do we have a full understanding of all loss mechanisms (mostly wave-particle interaction)? Under what circumstances are the different types of waves excited?
  - How are the radiation belts exactly fed during storms?
  - Do we understand the ring current, the origin of its asymmetry?

- Mesosphere and thermosphere and coupling to the ionosphere
  - What controls the height of the thermosphere?
  - How does the ionosphere affect the dynamics in the mesosphere and thermosphere?
  - What chemistry arises as a consequence of electromagnetic radiation and particle precipitation?

- Magnetosphere-ionosphere electric current circuit
  - What is the precise relation between quasi-static and Alfvénic auroral acceleration ?
  - What is the physics in the return current region?
  - Do we understand the (limited) conjugate nature of the aurora in both hemispheres?
- Ionospheric dynamics
  - What is the coupling to the neutral atmosphere?
  - Can we identify the altitude, composition, and flux of ionospheric upflow?

- Interaction of solar wind with magnetized / unmagnetized bodies with an atmosphere
  - What is the net outflow? Composition?
  - What are the mechanisms?
  - Does a magnetic field really protect a planet's atmosphere?
- Interaction of solar wind with airless bodies
  - What is the energetic particle and cosmic ray-induced chemistry in ices at the surfaces of comets, asteroids, icy moons, ...?
  - How does solar wind cause weathering of the lunar surface? How does it alter and charge the regolith?

- What is the secular variation of the geomagnetic field? This may affect empirical space weather models (eg RB models).
- ...

THANK YOU!
MORE INFO?

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