Tutorial for Lecture 2: The Sun and the Solar Wind

1. The mean distance from the sun to Jupiter is 5.2 AU. Calculate magnetic field strength and the spiral angle at the planet for the intermediate (400 km/s) and fast (800 km/s) solar winds.
2. The solar wind
   at the NASA space weather website for solar predictions
   (http://iswa.ccmc.gsfc.nasa.gov/IswaSystemWebApp/):
   a) Find the Parker spiral angle near the Earth (arctan(By/Bx) or angle phi, in GSM coordinate system, use, e.g., Heliosphere/ACE Magnetic field) for 11th of November 2025 during quiet time before the geomagnetic storm on 12th of November.
   b) To which solar wind speed would this correspond?
   c) Compare the speed with the solar wind speed observed by the "Solar Wind Electron Proton Alpha Monitor (SWEPAM)" on ACE (Heliosphere/ACE Solar Wind time line)
   d) Calculate the time of travel of the CME to the Earth and from the Sun.
   e) Did the ACE spacecraft cross the heliospheric current sheet (Bx component)?

3. The Sun
   (the same website as above but for Solar observations)
   a) How many sun spots were visible on the solar disk (use, e.g., the SDO HMI Magnetogram (color)) at time of probable CME release?
   b) Are the sunspots observed together with prominences/filaments (use, e.g., the 171 A Upper transition region/Quiet corona)?
   c) Are they related to solar flares (use, e.g., the SDO AIA 131 A Flaring regions)?
   d) Are there CMEs (use, e.g., SOHO LASCO C2)?
   e) Where are coronal holes (use, e.g., SDO AIA 193 A Corona/Flare plasma)?
   f) At which phase is the solar cycle now?
4. Is the Sun's magnetic field now southward or northward (use, e.g., simulations of the current magnetic field configuration http://hmi.stanford.edu/MHD/daily_mhd.html, blue/red color means that the magnetic field is pointed towards/outwards the sun)?
5. At the NASA space weather website (above) for heliospheric predictions:
   a) At Magnetosphere/GOES Primary X-Ray Flux timeline, check to which class the X-Ray emission belongs.
   b) At Heliosphere/ENLIL CME and Ambient Gallery (Velocity), check if the predicted solar wind velocity is comparable with observed one.
   c) Which region of the Sun is connected with the Earth by the solar wind (closed magnetic field lines (coronal helmet streamers) or open magnetic field lines (coronal hole))?

d) Which density does the solar wind have? Where are regions with high solar dynamic pressure observed and why? (Heliosphere/ENLIL CME and Ambient Gallery (Density, pressure))
e) Did Earth encounter CIR or HSS?

6. Do the same analysis for the strong disturbance event from Lecture 1. For example, consider the solar storm event on November 4, 2015.
7. Find two errors in the following text taken from Swedish news:

'Solar storm' grounds Swedish air traffic

Published: 04 Nov 2015 17:01 GMT+01:00

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Planes were grounded at some of Sweden's busiest airports on Wednesday afternoon because of a "solar storm" interfering with air traffic control radar systems, authorities said.

No aircraft were allowed to take off from airports in southern and central Sweden due to a massive geomagnetic solar flare storm causing problems for radar systems.

Ulf Wallin, press spokesperson at Swedavia, the organization managing Sweden's airports, told TT that airports at Landvetter in Gothenburg and Arlanda and Bromma in Stockholm were affected.

"Those airplanes that are in the air are allowed to land at the airports they're going to, but no planes are taking off," he said.

The problems began at around 3.30pm on Wednesday. An hour later, traffic had begun to return to normal, but it was not known when airports would be operating at full capacity again, said Per Fröberg, press spokesperson for Luftfartsverket, responsible for air traffic control in Sweden.

"[The solar storm] has meant that we haven't been able to see the airplanes on our radar screens. We are starting to get the systems up and running again but it's unclear when everything will be back to normal," he told the Aftonbladet tabloid.

Solar flares are bursts of radiation emitted from the sun during a geomagnetic storm. If powerful enough, it can disrupt satellite-based communications, including radar and GPS systems. In 2003 a similar storm caused power blackouts for thousands of homes in southern Sweden.

The Swedish Armed Forces said its own systems had not been affected.

"We have been given the information for our reference, but we have separate systems and have not been affected at all," spokesman Johannes Hellqvist told Aftonbladet.

Heavy delays were expected for air travellers for the rest of Wednesday afternoon and evening.

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