BIRKELAND CENTRE FOR SPACE SCIENCE

Hands-on activities: Experiences from collaboration with a local Norwegian high school and suggestions for exploratory student exercises

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Introduction to hands-on activities

Motivation behind outreach activities:

- **Benefit is mutual!**

- Introduce physics to high school students (16-18 years, pre uni)
    - What is the job of a physicist like?
    - Why is the study of natural sciences important?
    - Job security

- We need good and motivated students!
    - Some of our master and PhD candidates are recruited from targeted outreach activities
    - Make your institution visible to the young generation!
    - Outreach activities is a long-term recruitment investment in your field!

Introduction to hands-on activities

Specific experiences learned

- Involved in outreach activities since starting graduate school (2010)
    - Side commitment, in parallel to research (2-5% of my time)

- Being rooted in a research environment makes a difference
    - In Norway, 1% is working with research. Students look up to you.

- *Teachers: Get in touch with local research institutions.*
    - Outreach is one of the 3 main tasks for universities
    - Students typically appreciate doing something different, and broaden their perspectives
    - **The long term benefit is mutual**

Introduction to hands-on activities

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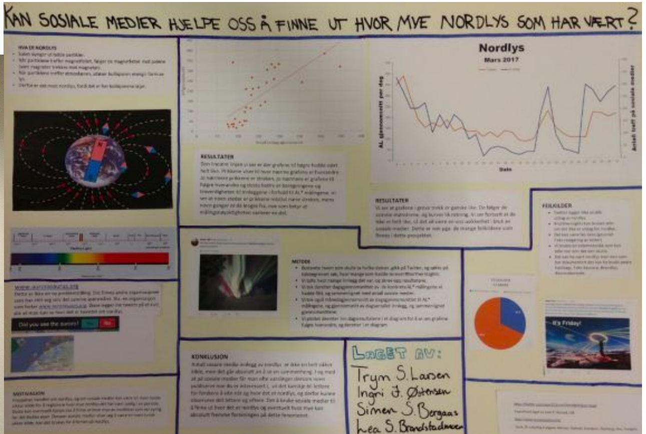
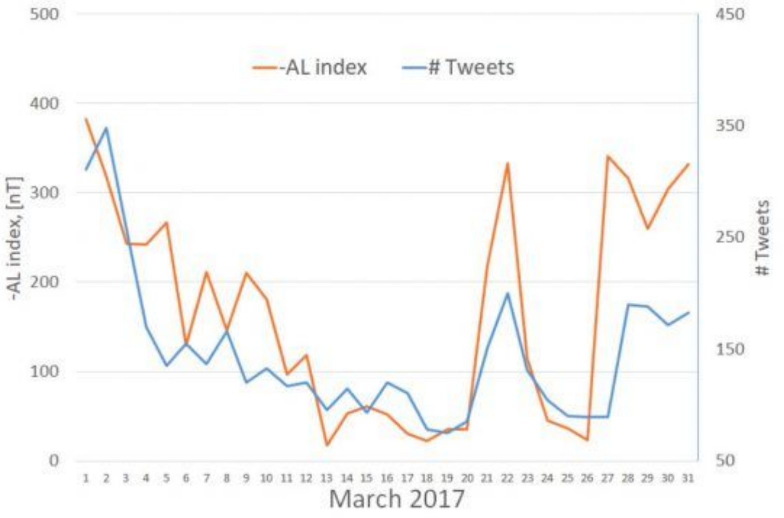
Exploratory projects related to space science

"Twitter project":

- **Explore to what extent social media posts can be used to quantify the degree of high latitude geomagnetic activity**
- **Details can be found on the EGU ST blog**





Todays hands-on activities

A geomagnetic storm: Learning from hands-on experience with scientific data

Here is an example exercise given to high school students, typically at age 16-17 years. The exercises are designed to make the students reflect and explore concepts that are new to them, by using their existing theoretical knowledge.

Todays hands-on activities

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A geomagnetic storm on October 2-3, 2013: Aurora was visible in Bergen, Norway (57° MLAT)

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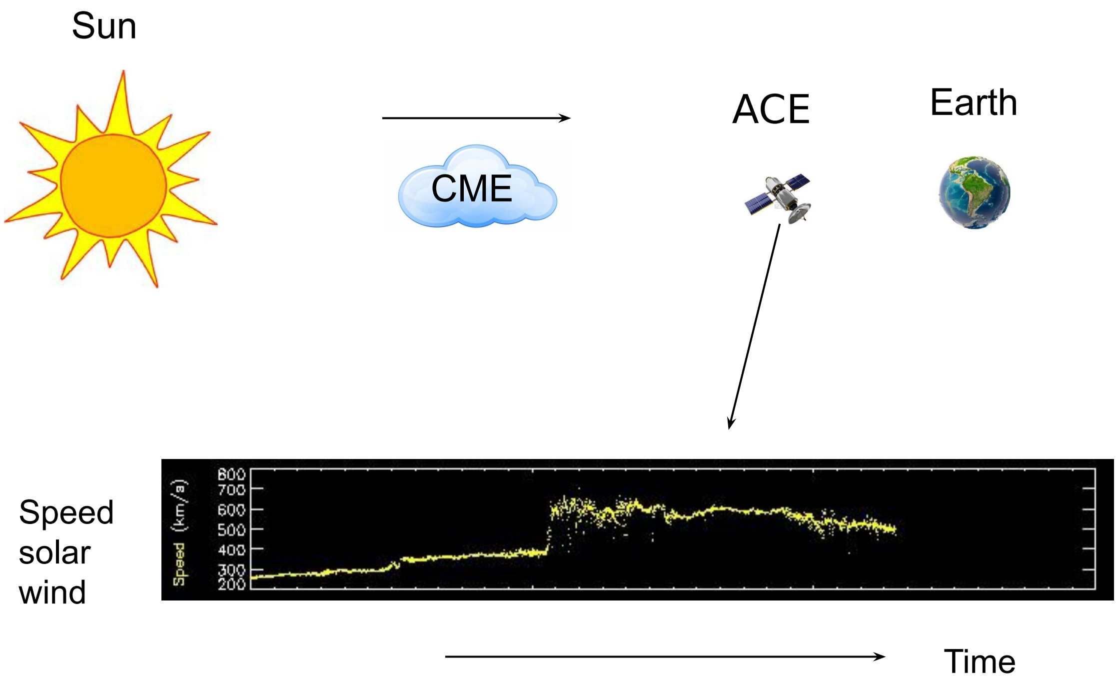

Todays hands-on activities

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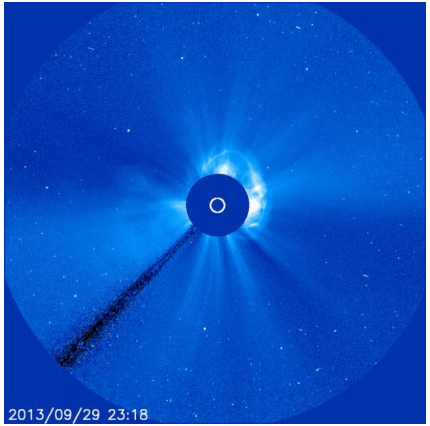
A small geomagnetic storm on October 2-3, 2013: Aurora was visible in Bergen, Norway (57° MLAT)

1. Use data from figures to the right to estimate the time of travel for the CME to reach the ACE satellite (the abrupt speed increase)

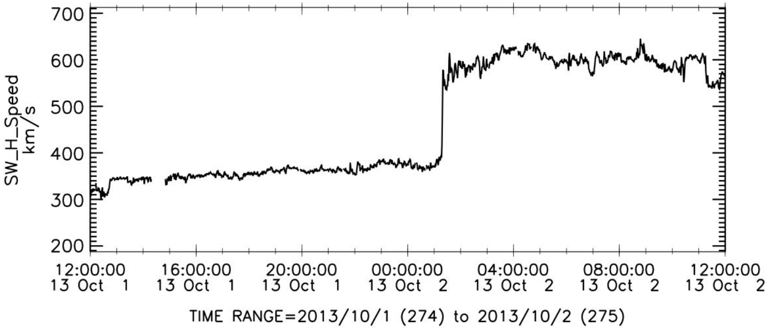
2. Use the time found above, together with the travel distance from the Sun to ACE, to estimate the average propagation speed of the CME through interplanetary space. (Hint: The Sun-Earth distance is a very good approximation.)

3. How does the average speed compare to the observed solar wind velocity at ACE? What may cause such a difference?

Launch of CME observed by SOHO satellite on September 30, 01:42 UT



Solar wind speed near Earth (ACE)



Todays hands-on activities

A small geomagnetic storm on October 2-3, 2013: Aurora was visible in Bergen, Norway (57° MLAT)

4. Look at the plot to the right. What was the time delay from the CME detection at ACE, and the onset of strong ground magnetic perturbations?

5. How does this actual response time compare to what may be predicted from the speed and location of the ACE satellite?

6. The best auroral photos from southern Norway was the night after the initial impact, showing weaker magnetic disturbances. What may be the reason for that? (Hint: UT vs local time in Norway)

Ground magnetic perturbations

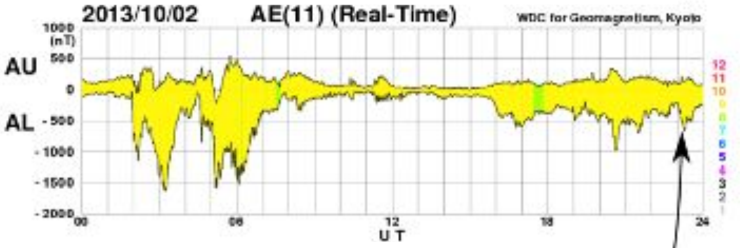


Image from Bergen, towards northwest, October 2, 2013, 23:07 UT

Another hands-on exercise (physics students)

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Ground induced currents:
Using the SuperMAG web portal to get access to ground magnetic perturbation data.

1) A hypothetical square power line structure with side legs of 300 km is located in the auroral zone.
   a) Which component of dB is responsible for increased/decreased flux through the square?
   b) What is a realistic value of the time rate of change of the magnetic field on the ground (dB/dt) during a geomagnetic storm/substorm? Go to supermag.jhuapl.edu and look at e.g. the storm during April 6, 2000, 16-17 UT.

2) Use Faradays law to calculate what the induced voltage on the powerline would be for the given dB/dt value found.

3) What may be the challenges related to the induced currents?

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

Another hands-on exercise (physics students)

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Ground induced currents:
Using the SuperMAG web portal to get access to ground magnetic perturbation data.

1) A hypothetical square power line structure with side legs of 300 km is located in the auroral zone.
   a) Which component of dB is responsible for increased/decreased flux through the square?
      i) Radial component
   b) What is a realistic value of the time rate of change of the magnetic field on the ground (dB/dt) during a geomagnetic storm/substorm? Go to supermag.jhuapl.edu and look at e.g. the storm during April 6, 2000, 16-17 UT.
      i) dBr/dT ~ 210 nT/3min ~ 1 nT/s (TIK station, Russia). This is a very strong event.
2) Use Faradays law to calculate what the induced voltage on the powerline would be for the given dB/dt value found.
   a) Change in flux per second: dBr*A/dt = 210 nT * (300 km)^2 / 180 s = 105 Volt

$$\mathcal{E} = -\frac{\mathrm{d}\Phi_B}{\mathrm{d}t}$$