Aalto University
School of Electrical
Engineering

ELEC-E42200 – Space instrumentation

Final assignment introduction - The Halloween Storm of 2003

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Halloween Storm of 2003 October 19 – November 7

-The largest solar storm of the modern era

-Several records broken with regards to size of several solar phenomena

-Occurred during the declining phase of the solar cycle 23

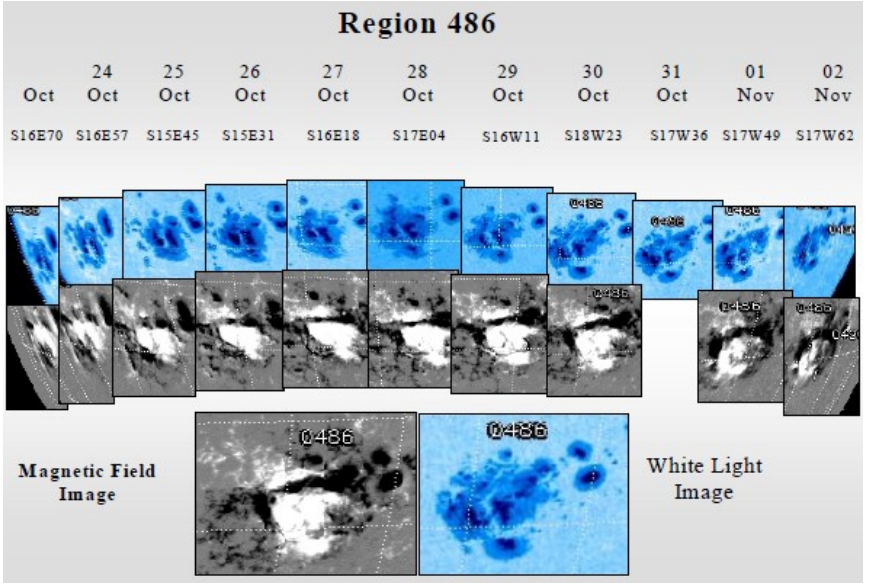
-”Once in a 100 years event”, large societal impact

Course of events – sunspot region emerges

-Began with the emergence of a large sunspot group, Region 486

-Several major flares, especially on October 28th (X17), October 29th (X10), and November 4th (X28e)

-All of the following are in the R4-R5 alert range

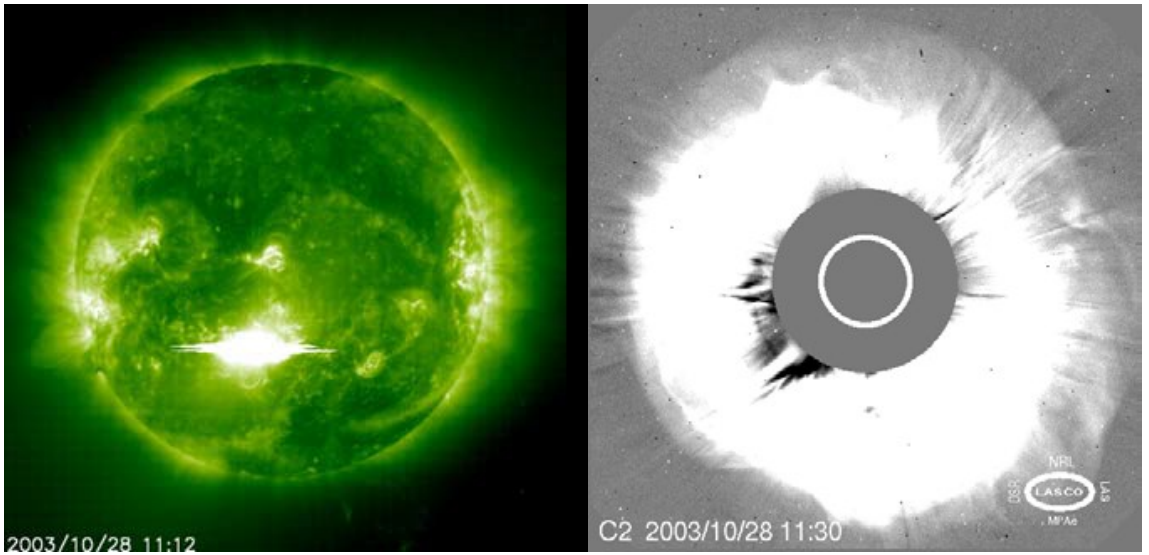


Course of events – CME impact

-Large flares followed by coronal mass ejection (CME) and a solar radiation storm (S3 and S4 levels)

-CME very fast, 2125 km/s, arrival to the Earth at 19 hours (fastest transit time on record at 14.6 hours)

-G5 geomagnetic storm when the CME hit the Earth

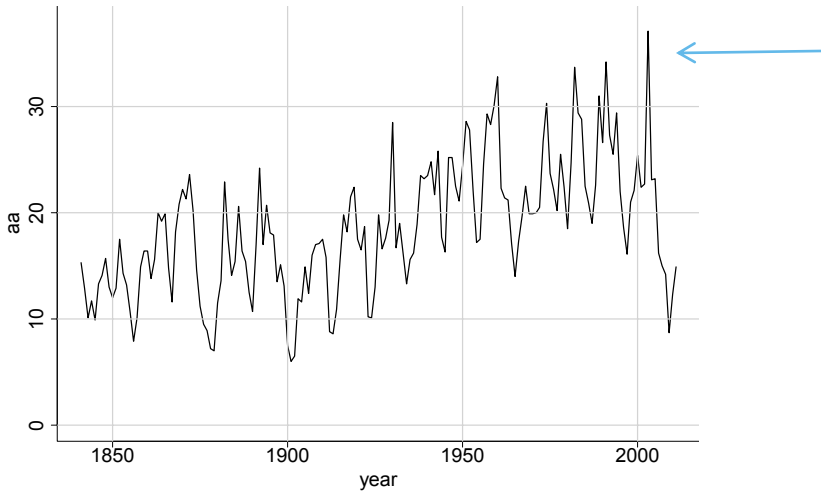


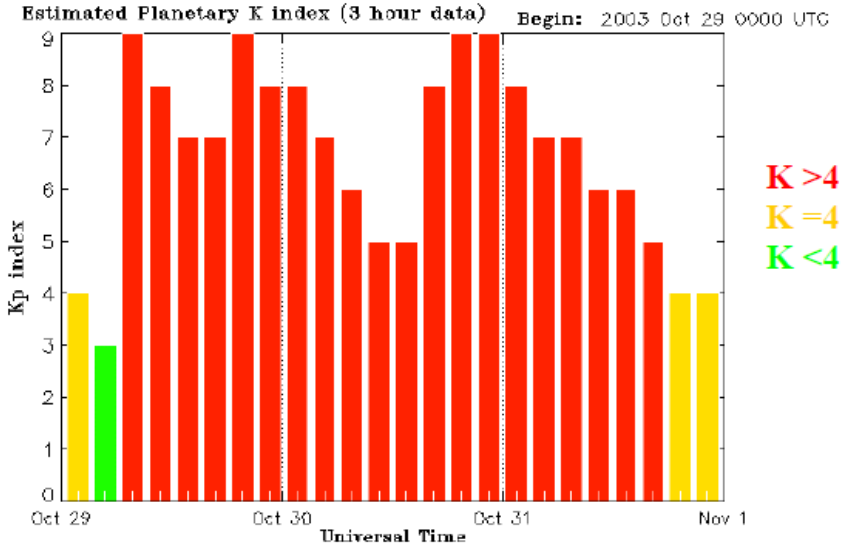
Course of events – flare into flare

-More large flares, another fast CME

-Similar effects on the Earth with another G5 geomagnetic storm

-Third major flare CME directed somewhat away from the Earth, producing only S2 and G1 alerts



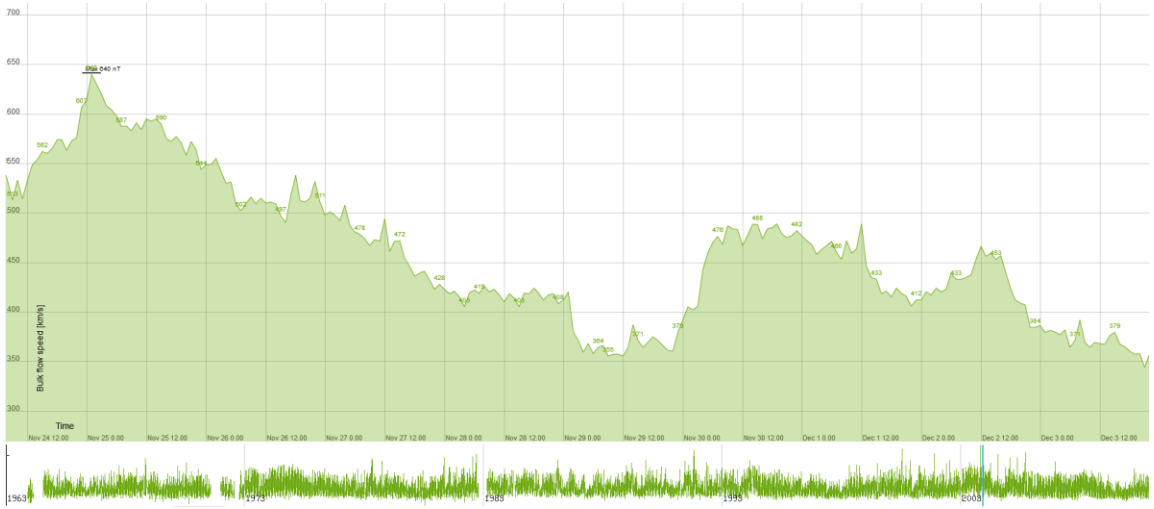


Forecasting of the event

-Solar activity expected beforehand by NOAA

-Scale of events unexpected

-Several instruments of the ACE satellite were rendered useless due to the severe radiation storm, (usefull info for the final assignment!), but the rapid approach of the coming CME was detected



Halloween storm effects – Space borne systems

-Economic and infrastructural effects

-Numerous societal impacts on communication, navigation and energy supply

-ISS crew ordered to shelter on two occasions

-Loss of the Martian Radiation Environment Experiment (MARIE) on the NASA Mars Odyssey mission

-numerous lesser effects, 30 large satellite anomalies and total loss of ADEOS-2 satellite

-Advanced Composition Explorer EPAM instrument lost (don't use that for the assignment!)

Power and electric utilities

-When a CME impacts the Earth's magnetic field, the fluctuations generate electric fields on the Earth, which can cause potentially damaging Geomagnetically Induced Currents (GICs) in power grids, pipelines and other "long" infrastructures

-Unwanted currents degrage surfaces and in the worst case can damage power infrastructure

-Power blackout in Malmö, Sweden due to the Halloween storm

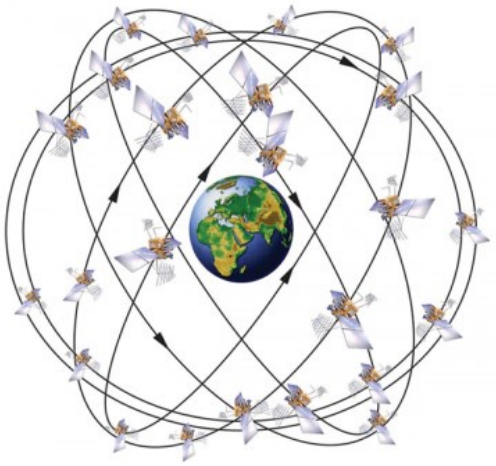
-Several precautionary actions taken around the globe

GPS disruptions

-Ionosphere total electron content affects GPS operations

-Day-to-day usage rather small, but precision GPS measurements severely affected

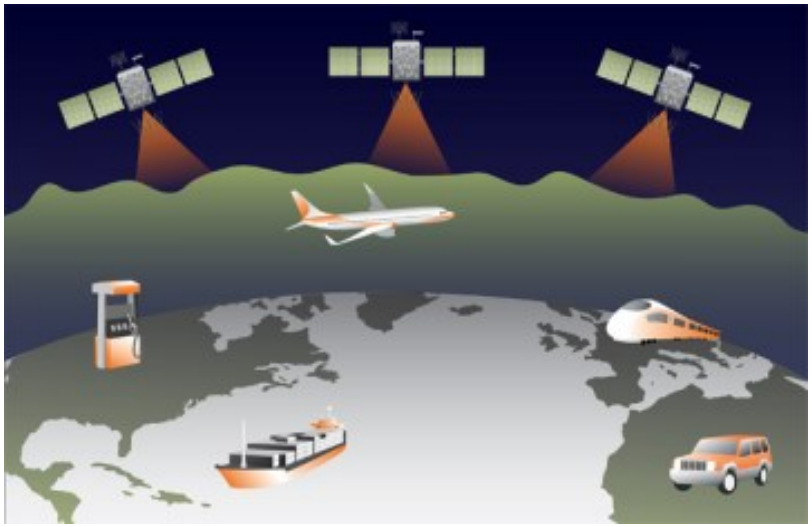
-Users include land surveying, topographic work, deep-sea drilling and Department of Defence usage

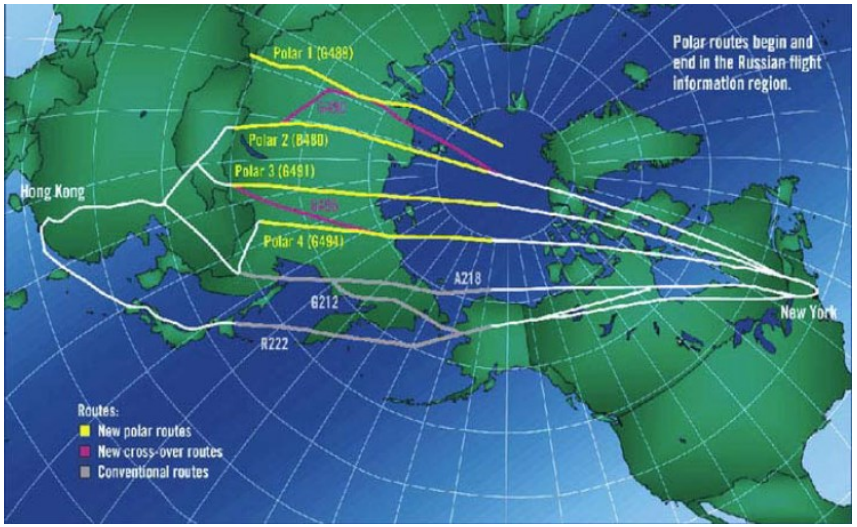


Air traffic effects

-Rerouting of flights due to issues with degraded communications, navigation and increased radiation dosage

-Quite significant economic impact due to less economic routes and cancelled flights





Auroras and media coverage

-Quite spectacular auroras, also in very southern latitudes such as Colorado

-Significant media coverage, the word “space weather” enters popular usage

-Economic impact significant, lost satellites, instruments, power, navigation and tertiary effects

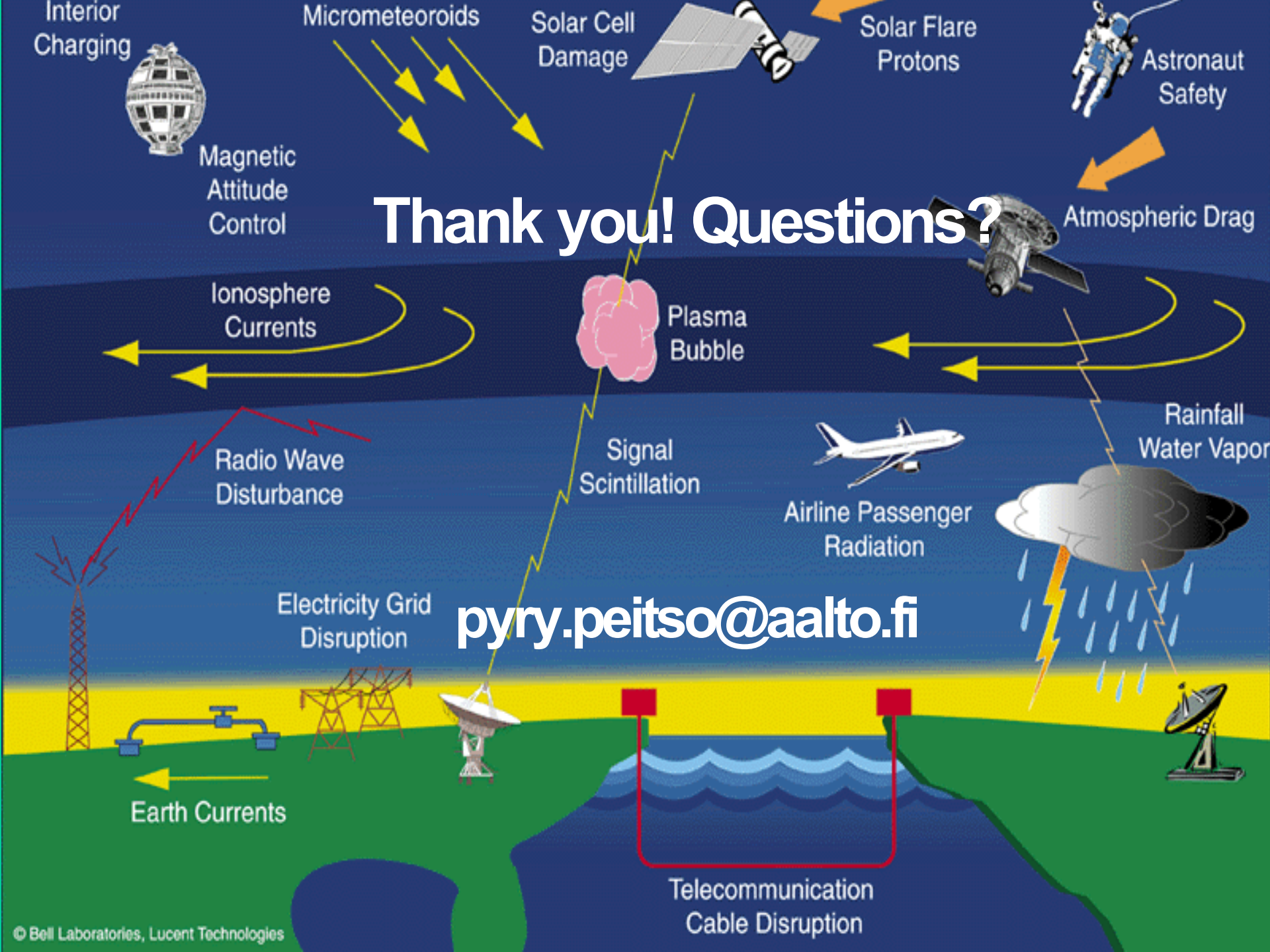
Final mission:

A geospace CubeSat during the Halloween solar storm like event

-The final assignment will be a case study of the Halloween storm event using real data

-Instruments chosen based upon lectures and previous assignments

-Could be plausibly mounted on a CubeSat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Solar Cell Damage
Solar Flare Protons
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