

DANISH ILWS ACTIVITIES

ILWS Tenth Anniversary Symposium and
Working Group meeting

Eigil Friis-Christensen, DTU Space



- ESA Swarm Constellation Mission.
Launch 2013



- ASIM: The Atmosphere-Space Interactions Monitor
on the International Space Station.
Launch 2015



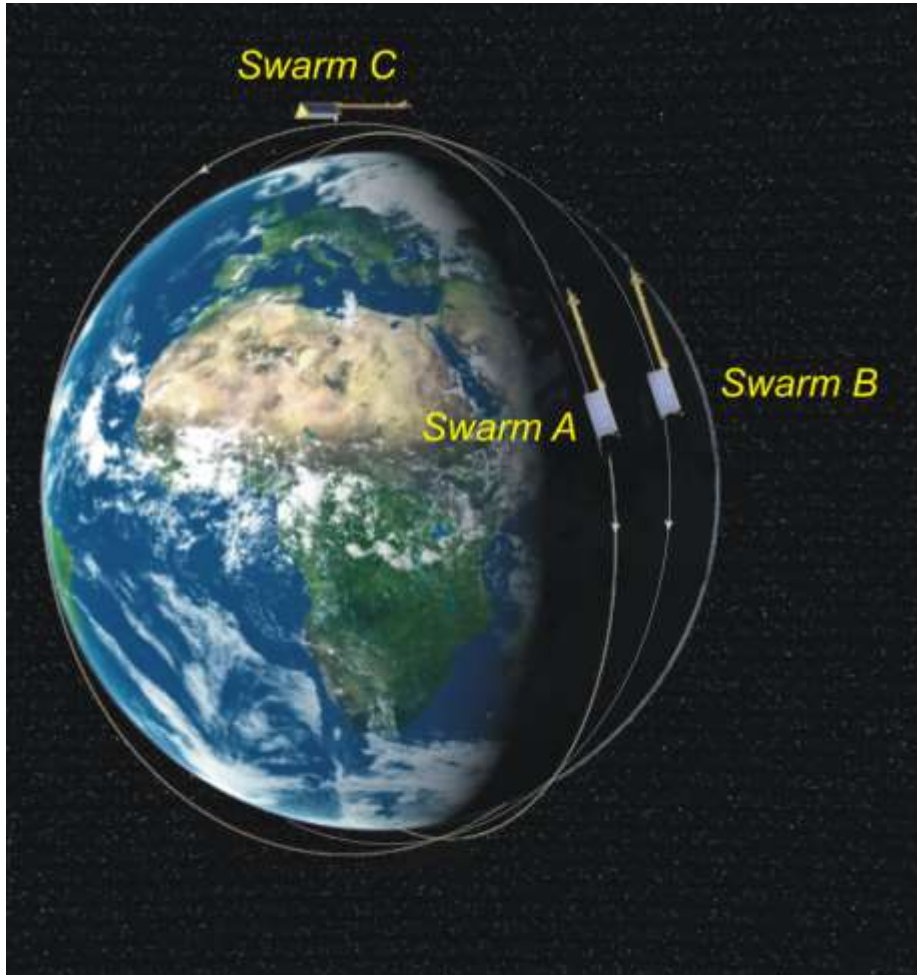
- Denmark joins the Space Weather Part of ESA's SSA
Program 2013. Continued efforts understanding
Sun's effect on Climate.



- Ground based complement to spaced based
observations. Danish space and ground
observations in the same institute, DTU Space.

13 February 2013, Vienna, Austria

The *Swarm* constellation mission



Mission and Constellation

- Fifth Earth Explorer Mission of the European Space Agency (ESA)
- Three low orbiting satellites
- Launch scheduled spring 2013
- Operation 5+ years
- DTU is lead proposer and main contractor regarding major product development projects (L2 products)

Satellite A + B:

- Initial altitude 460km (~350km after 4 years)
- Side-by-side flying (Δlon : 1.4° , ΔLT : 6 min, 160km distance (at equator))
- Inclination 87.4°

Satellite C:

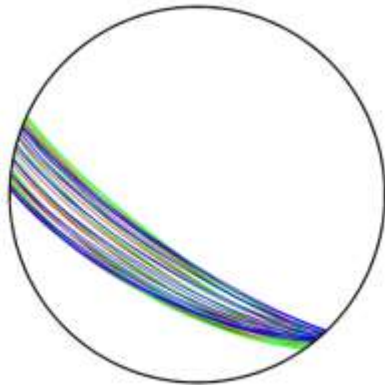
- Initial altitude 530km
- Inclination 86.8°

The *Swarm* constellation mission

Magnetic Local Time frame

After 15 days
in orbit

12 LT

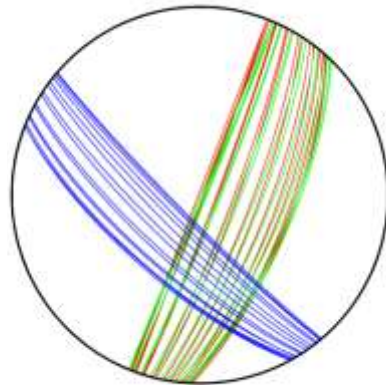


00 LT

SwarmA SwarmB SwarmC

After 2yrs + 15
days
in orbit

12 LT



00 LT

Mission and Constellation

Satellites A + B + C:

- Good global geographic coverage
- Longitudinal aligned at low latitudes
- Frequent passes at polar regions

Satellites A + B:

- Local time precession 12h/**133** days

Satellite C:

- Local time precession 12h/**144** days

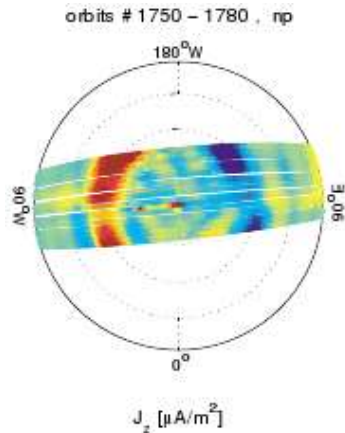
- ⇒ Local time separation from 0 to 10 hours between **A+B** and **C**
- ⇒ Excellent opportunity to monitor ionospheric and magnetospheric **gradients**

Simulated Swarm orbits:

ftp://ftp.space.dtu.dk/data/magnetic-satellites/Swarm/E2Eplus/constellation_4/orbits

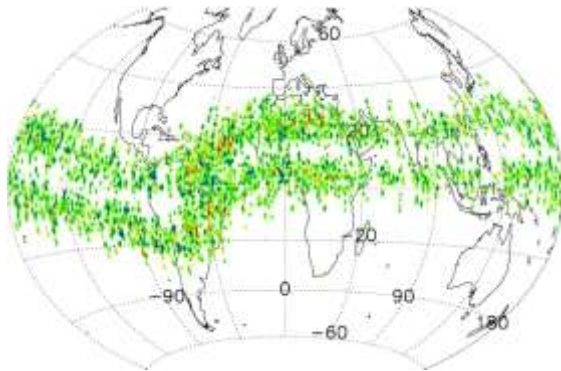
Swarm Level 2 Products (Realtime versions could be developed)

Field Aligned Currents



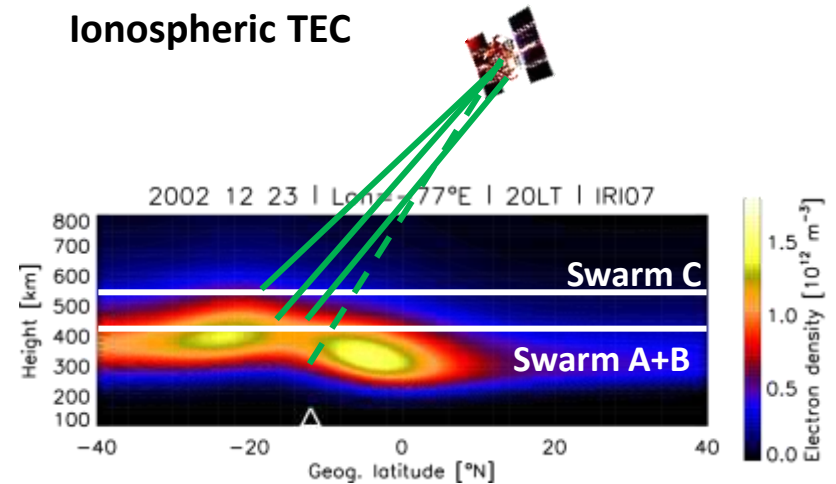
Ritter and Lühr, EPS 2006

Equatorial bubble index

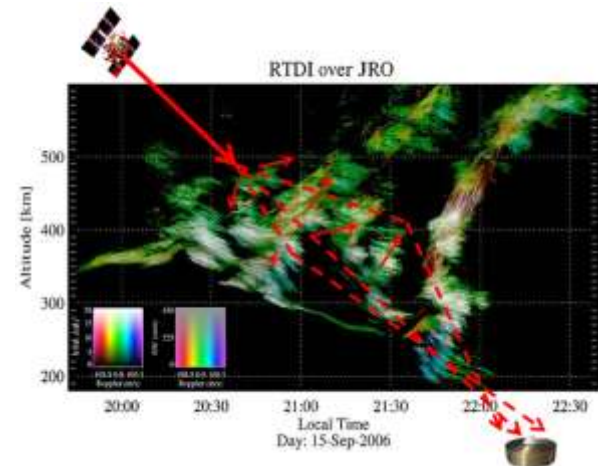


Stolle et al., JGR 2006

Ionospheric TEC



Monitoring Ionospheric irregularities



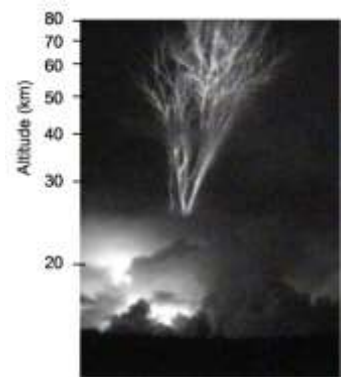
Unique opportunity to develop and derive new satellite based products for Space Weather monitoring and prediction!



ASIM Scientific Objectives

High-energy thunderstorm processes

- What is the physics that create photons with energies up to 100 MeV?
- What is the proficiency of thunderstorm discharges in creating antimatter?
- What makes thunderstorms discharge in giant lightning flashes reaching the ionosphere?



Atmospheric science

- How do thunderstorms affect the stratosphere and thereby the climate?
- Can we predict severe storm intensification from electrical activity?
- To what extent is thunderstorm electrical activity affected by dust particles?



Atmosphere-space interactions

- Quantify energetic particle precipitation and its relation to aurora and to solar conditions
- Measure meteors to determine their origin
- How large is the atmospheric source of high-energy electrons in the magnetosphere?



ASIM Payload

MMIA

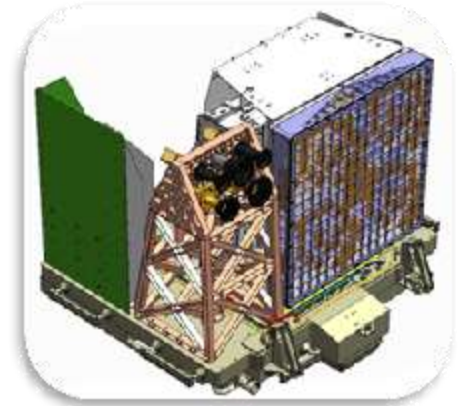
- Three photometers (100 kHz sampling)
 - Bands: 180-250 nm; 337.0 nm; 777.4 nm
- Two light-sensitive cameras (400 m resolution)
 - Bands: 337.0 nm; 777.4 nm

MXGS

- 1000 cm² area
- Low-energy detector, CZT with coded mask:
 - 15-300 keV; source direction with $\sim 1\sigma$ accuracy
- High-energy detector BGO crystal:
 - 0.2 – 20 MeV

Mission Status

- ASIM is in phase C with CDR completed during the spring 2013
- Launch on SpaceX Dragon to the ISS end 2015
- The mission will last for a minimum of 2 years
- The International Science Team includes more than 80 groups from 30 countries. New members are welcome



Denmark joined ESA's SSA program

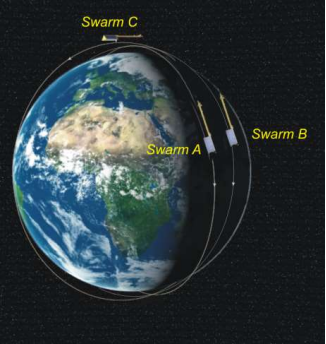
DTU is linking expertise in 3 important space weather areas:

1. The polar ionosphere - communication and navigation
2. High latitude geomagnetic activity - geomagnetic storms
3. Interplanetary disturbances - space weather coupling and forecast

Observations from ground and satellites

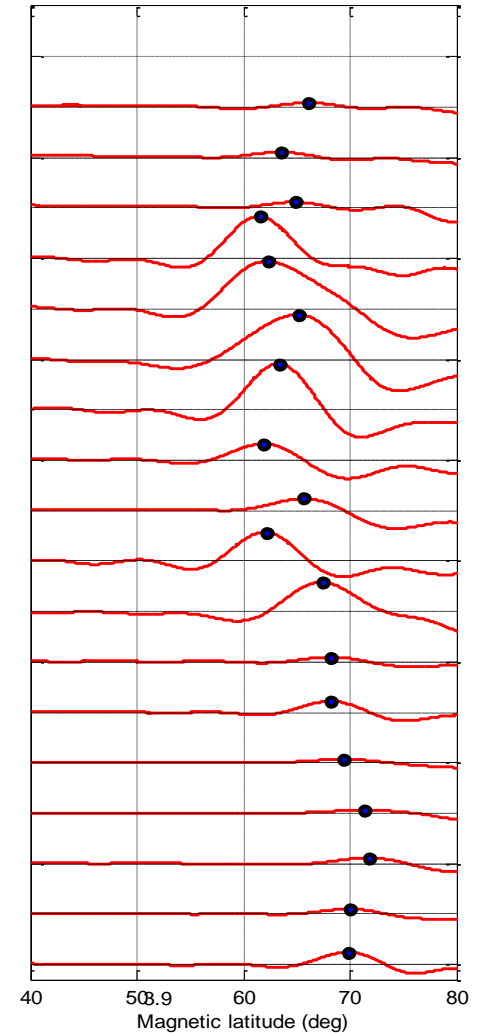
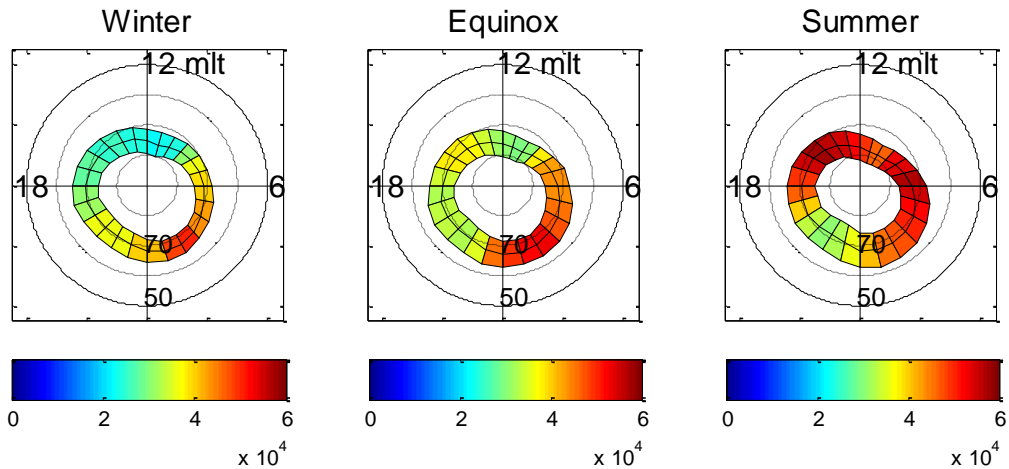
Development and implementation of models for use in forecast and trends schemes

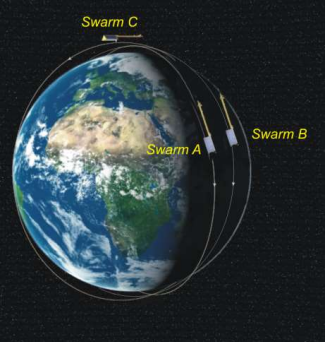
Derivation of space weather relevant parameters



Global monitoring of the auroral electrojets - *Swarm*

- Based on *Swarm* passes in real-time combined with a statistical electrojet-oval, we will provide monitoring of the electrojets in both hemispheres.





Possibility for additional Swarm Products

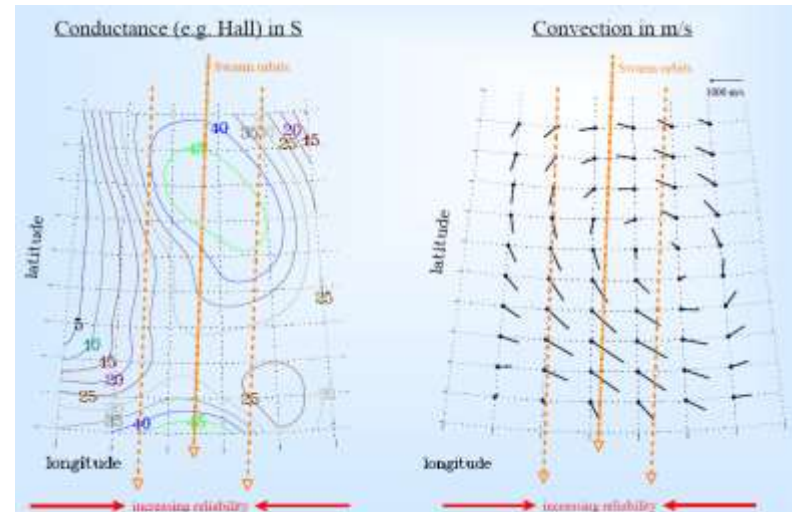
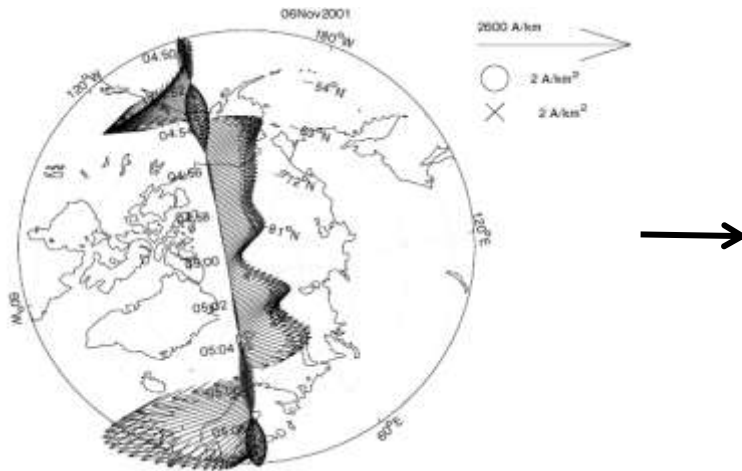
for space weather application

Field aligned and horizontal ionospheric currents along satellite orbit

Spherical Elementary Current Systems
(Juusola et al., EPS 2006)

Conductance and convection maps along stripe of lower satellite pair

Spherical Elementary Current Systems
(running ESA science study)

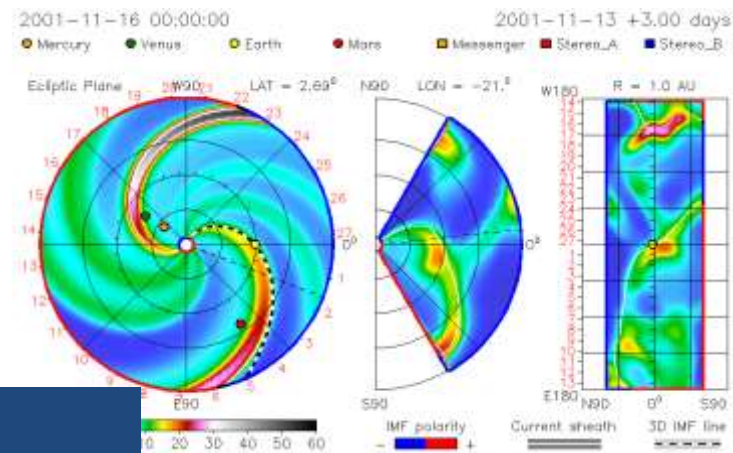




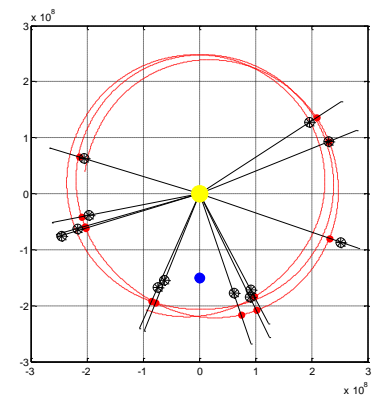
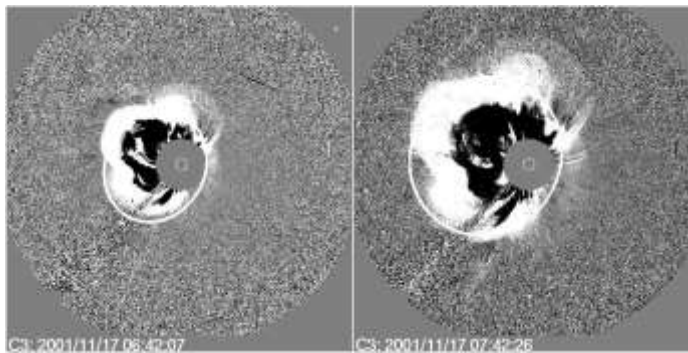
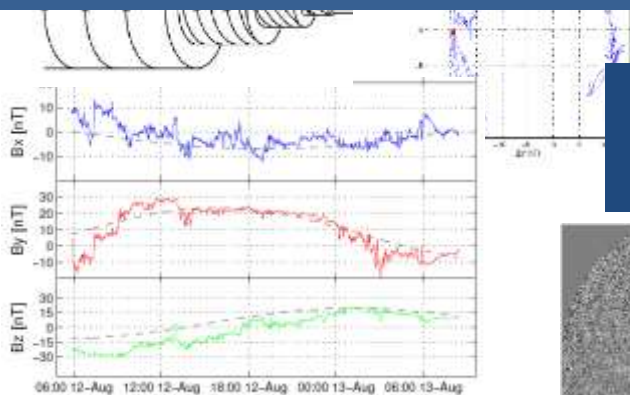
COMESSEP (EU FP7) + GSFC collaboration heliospheric propagation of solar eruptions

Applying propagation models

Analysing multi-spacecraft in situ observations of the solar wind:
ACE, Messenger, VEX, MGS
Soon also Juno, MEX



Linking to solar observations



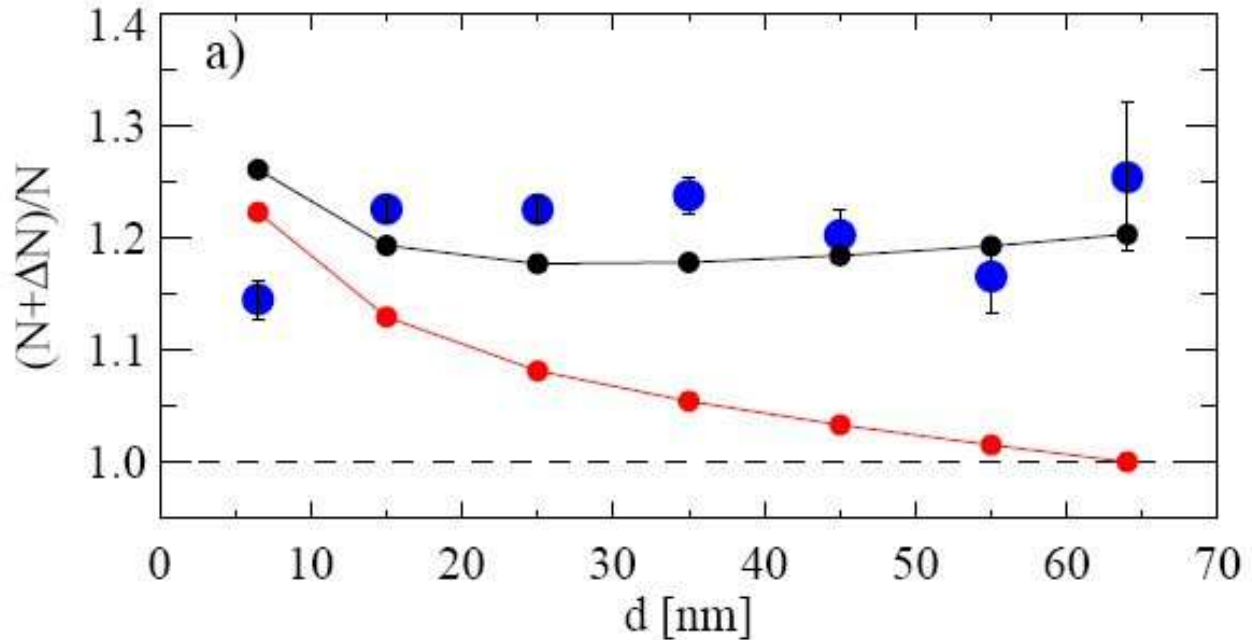
Sun-Climate Research: Theory, observations, experiments

GCR effect on formation of aerosols

Growth of clusters

Blue points: relative number of clusters of that size before and after experimental runs.

Red points: prediction of previous theories, that growth should cease when the size passes 50 nanometres.



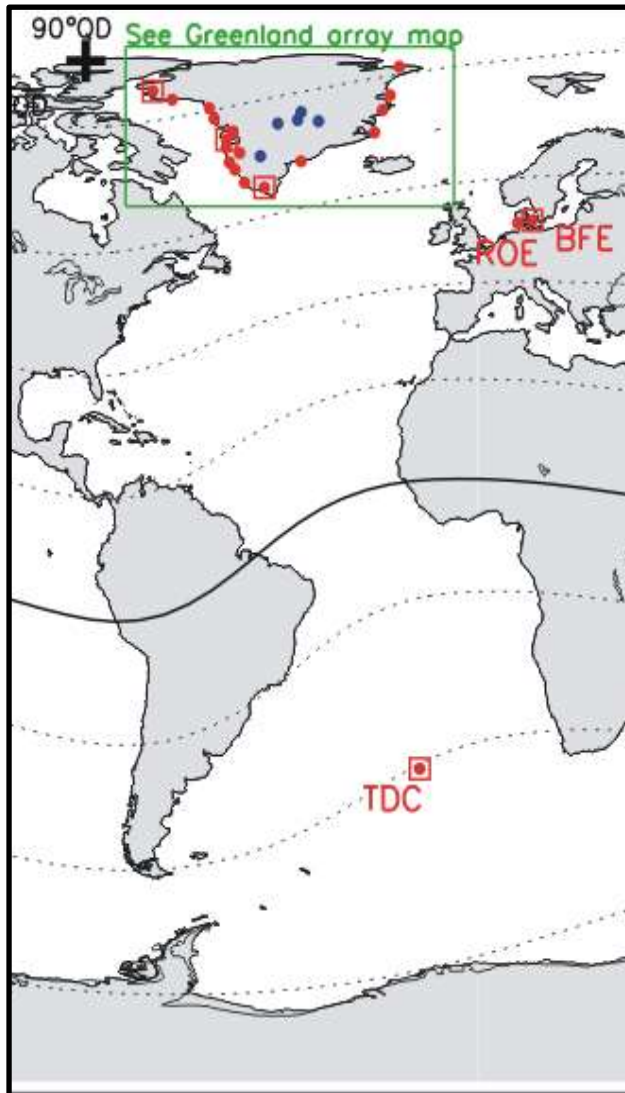
Svensmark et al. (2012) submitted

Black curve: expected for continual supply of sulphuric acid.

The persistent growth of clusters occurs only in the presence of gamma rays that set electrons free to influence the chemistry.

Supporting Ground Stations

Magnetometers operated by DTU Space

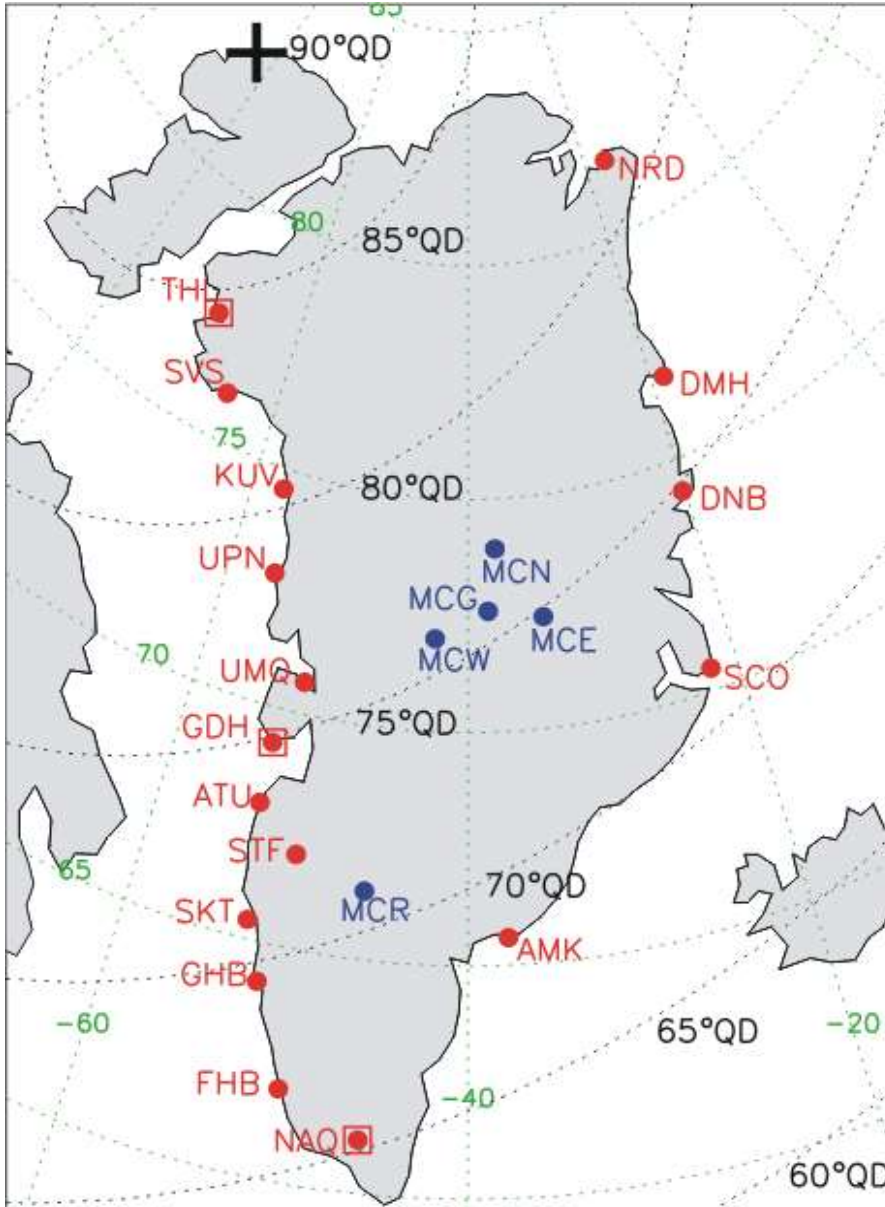


19 magnetometer stations in the Atlantic Sector:
Polar Cap & Cusp region
Auroral & subauroral latitudes
mid/low latitude & South Atlantic Anomaly
including observatories
Vector magnetic field measurements
1 Hz data stream
Calibrated data in near real-time

5 geomagnetic observatories:
long-term stability, calibrated to measure SV
Intermagnet stations
3 in Greenland (THL, GDH, NAQ)
1 in Denmark DK (BFE)
1 in the South Atlantic Anomaly (TDC)

Web: www.space.dtu.dk/MagneticGroundStations

DTU magnetometer array in Greenland



- Magnetic observatory
- Variometer station
- Variometer station (MAGIC)

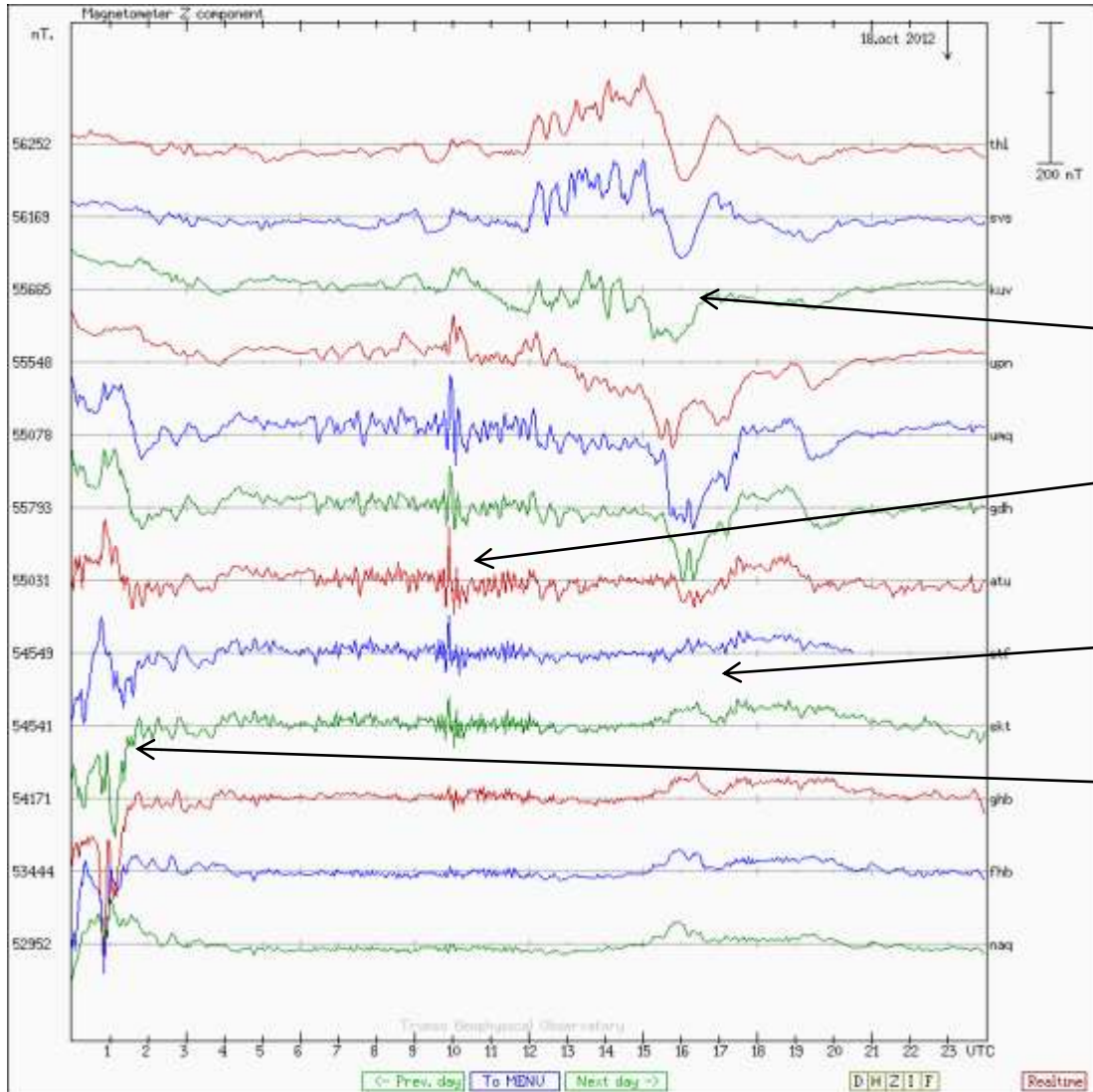
West coast stations along a geomagnetic longitude (approx 35° E)

Closing a gap in scientific space weather infrastructure between North America and Europe

Data availability:

Observatories: Intermagnet and WDC
Magnetometer stations: for Archive and real-time data access contact DTU Space.
Regarding MAGIC: Virginia Tech.

Magnetometer array in Greenland: Observations



Z-component
of the geomagnetic field
variations
(18. Oct 2012)

Polar cap

Cusp

Eastward electrojet

Westward electrojet

Website:
<http://www.space.dtu.dk/MagneticGroundStations>



Thanks for your attention