



Myndigheten för
samhällsskydd
och beredskap

**-Consequences of GNSS failure
within vital societal functions**

**-Space weather and its impact
on GNSS**

2017-10-18

Kristoffer Hultgren

**Executive Officer, Space Issues
CIP and CIIP section**



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Why we are needed





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MSB:s mission

MSB contributes to society's ability to ...

... prevent incidents

Such that actors can increase their abilities to:

- conduct fire and accident prevention
- have continuity in essential services
- manage hazardous substances
- manage information securely

... manage incidents

Such that actors can increase their abilities to:

- carry out rescue efforts
- coordinate activities during incidents
- support the Armed Forces

Scenario

**The following scenario was used in the
2013 National Risk and Capability
Assessment**



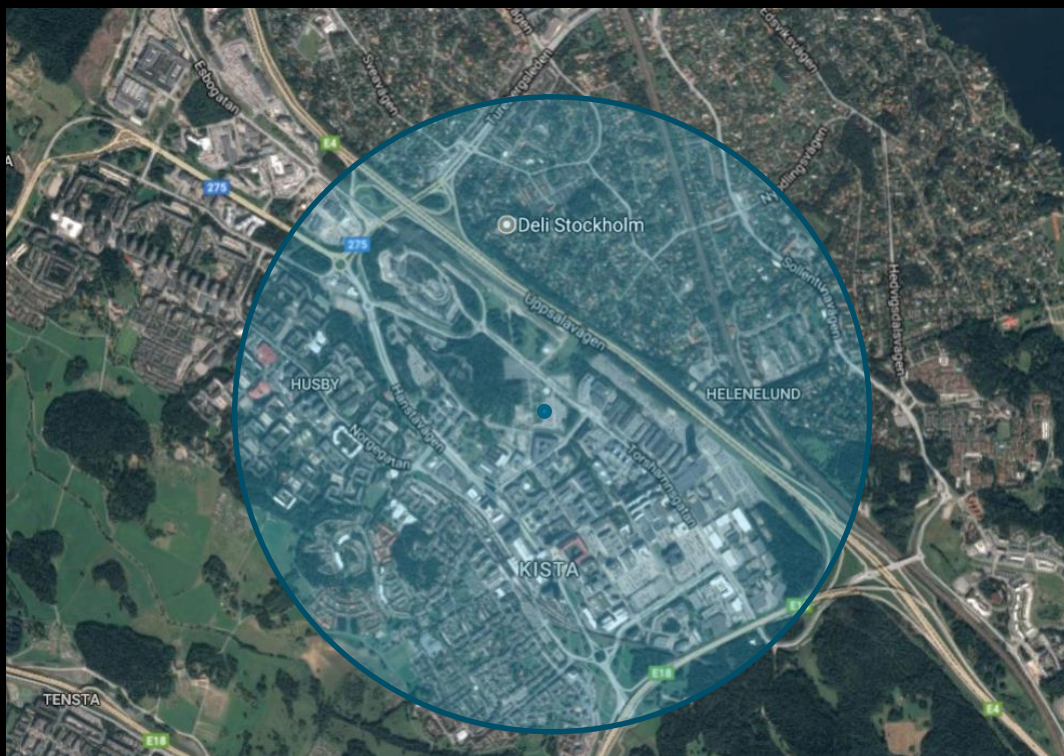
Scenario

**Its an ordinary work day at
16:30 the 18th of October.
People are on their way
home from work and
schools.**



Scenario

Suddenly, without warning, Sweden no longer has access to GNSS enabled services.



Scenario analysis

Transport	Energy	Finance	Trade/industry
Healthcare	Communication	Security	Food



Scenario analysis

Transport	Energy	Finance	Trade/industry
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Transports

- **Air traffic uses conventional navigation techniques**
 - Will not be affected
 - Possible to direct by radar
- **Road and rail maintenance and construction work will suffer**
- **Commercial sea traffic will suffer**
- **Deliveries will be delayed**

Scenario analysis

Transport	Energy	Finance	Trade/industry
Healthcare	Communication	Security	Food

Energy

- **Power grid**
 - **Alternative solutions available**
 - **Atomic/internal clocks**
 - **Fuel supply (deliveries)**
 - **District heating ("fjärrvärme")**
- **GNSS loss leads to increased administrative work, but no power outages are expected**

Scenario analysis

Transport	Energy	Finance	Trade/industry
Healthcare	Communication	Security	Food

Financial services

- **Agencies within the financial sector will have no major problems**
- **Ticketing systems for municipal transportation might experience problems**

Scenario analysis

Transport	Energy	Finance	Trade/industry
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Trade and industry

- **SWEPOS is based on GNSS**
- **Transport delays implies severe consequences**
- **The forestry will have no major problems**

Scenario analysis

Transport	Energy	Finance	Trade/industry
Healthcare	Communication	Security	Food

Healthcare

- Ambulance services will suffer from initial problems, but stabilise with backup systems
- Uncertain effect on hospital IT and communication systems
- Sea transports will suffer from navigational difficulties

Scenario analysis

Transport	Energy	Finance	Trade/industry
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Information and communications

- **Synchronization is essential for communications**
 - Important actors have access to alternative methods
- **RAKEL:**
 - Positioning will fail
 - Timing unaffected due to internal clocks

Scenario analysis

Transport	Energy	Finance	Trade/industry
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Protection and security

- **Police and rescue services use GNSS two-fold**
 - For command to locate vehicles
 - For units to navigate
- **Personal safety alarms will fail**
- **Position tagging of criminals will suffer**
- **Rescue services at sea will suffer from loss of positioning**

Scenario analysis

Transport	Energy	Finance	Trade/industry
Healthcare	Communication	Security	Food



Food

- Suffers mainly from delays in deliveries

Scenario analysis

Transport	Energy	Finance	Trade/industry
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Crisis management

- **Situational awareness will suffer**
- **IT systems not affected**

Scenario analysis

Summary

- **Dependence of GNSS positioning is widely spread**
 - Functions will be able to continue, although with decreased efficiency
- **Timing is more critical**
 - Redundant systems most often available
 - Will however drift with time

The scenario will likely lead to:

- **Limited consequences for human life and health**
- **Severe consequences for the economy and the environment**

Mitigation

- **Need for proper knowledge of redundant systems**
- **Continuity planning**

MSB

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Vikten av var och när

**Samhällets beroende av korrekt tids- och
positionsangivelse**



Google "Vikten av var och när" to find the report



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**-Consequences of GNSS failure
within vital societal functions**

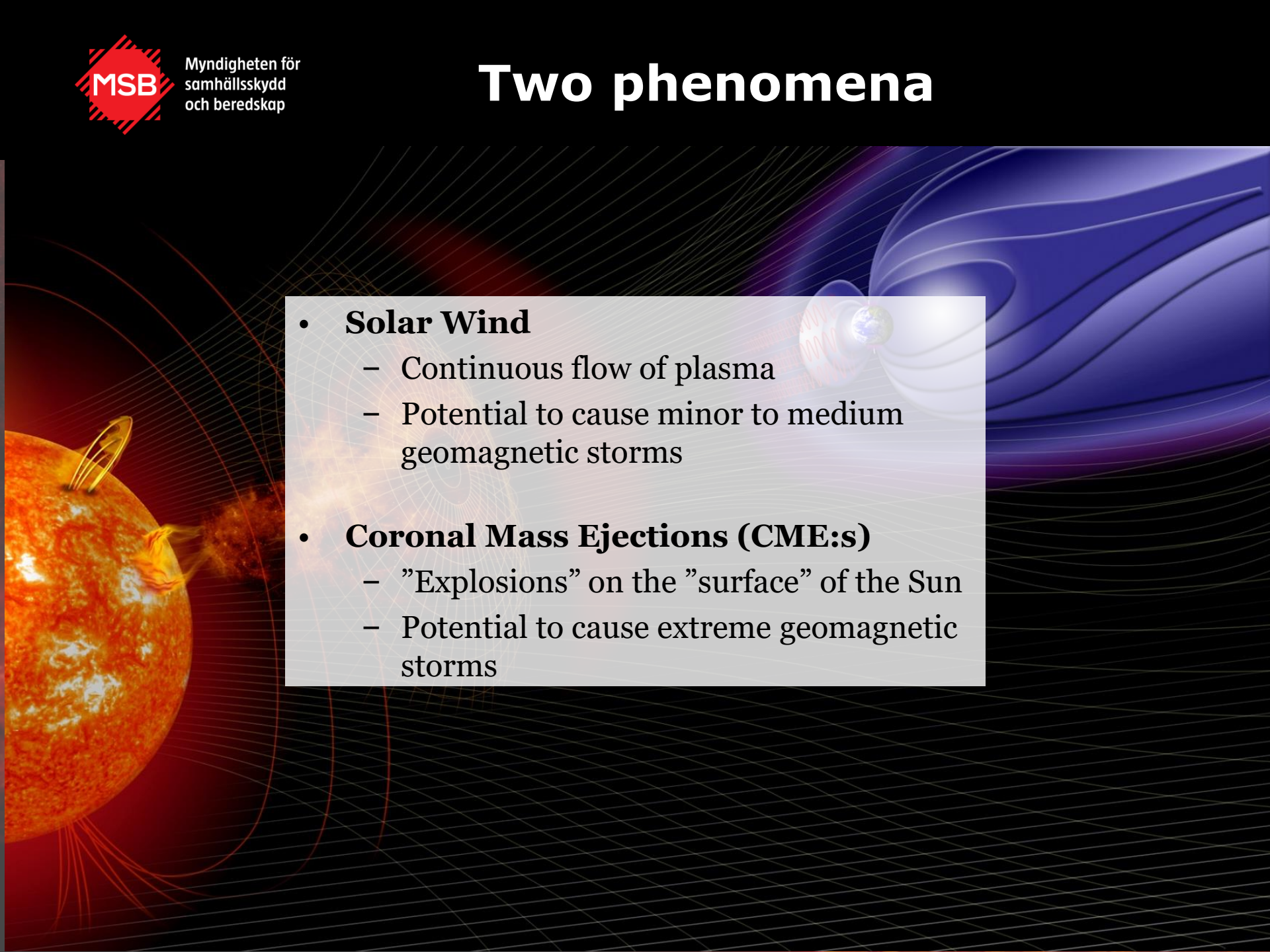
**-Space weather and its impact
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Two phenomena

- 
- The background features a large, glowing orange Sun on the left with visible solar flares and coronal loops. On the right, a smaller Earth is shown with its blue and white atmosphere, surrounded by magnetic field lines. The background is a dark space with a grid of thin, light-colored lines.
- **Solar Wind**
 - Continuous flow of plasma
 - Potential to cause minor to medium geomagnetic storms
 - **Coronal Mass Ejections (CME:s)**
 - "Explosions" on the "surface" of the Sun
 - Potential to cause extreme geomagnetic storms

CME = solar storm

The background of the slide features a composite image. On the left, a large, bright orange sun is shown with a solar flare erupting from its surface. A grid of magnetic field lines is depicted around the sun. On the right, a blue, elongated, and wavy structure representing a Coronal Mass Ejection (CME) is shown moving towards the Earth. The Earth is depicted as a small globe with a red and white striped ring around it, representing the ionosphere. The background is a dark, textured space with a grid of lines.

1. Flare

Flare

- Emits radiation that enhances the ionosphere
- Reaches the Earth in ~8 min
- Affects communication/GNSS

CME = solar storm

A diagram showing a solar flare on the left, with a bright orange sun and a large, glowing orange and red cloud of plasma being ejected. Magnetic field lines are shown as a grid of lines around the sun. A label '1. Flare' is in a white box. On the right, a diagram shows a CME (Coronal Mass Ejection) as a large, blue, wavy cloud of plasma moving towards Earth. The Earth is shown as a small globe with a red and white striped magnetic field. A label '2. Proton shower' is in a white box. A text box on the right lists the effects of proton showers.

1. Flare

2. Proton shower

Proton showers

- Reaches the Earth in ~15-60 min
- Affect Earth and Space bound electronics
- Affect biologic DNA (astronauts, air traffic crew)
- Enhances the lower ionosphere (electron currents)

CME = solar storm

The background of the slide is a detailed illustration of a solar storm. On the left, the sun is shown as a large, orange, textured sphere with a grid of magnetic field lines around it. A bright orange and red plasma cloud is being ejected from the sun's surface. In the center, a large, billowing cloud of orange and red plasma is shown moving towards the right. On the right, the Earth is depicted as a small blue and white sphere with a large, blue, wavy magnetic field around it. A red, wavy line representing a proton shower is shown hitting the Earth's magnetic field.

2. Proton shower

3. Plasma cloud

Plasma cloud

- Includes magnetic fields
- Reaches the Earth in ~1-3 days
- Potential to cause major geomagnetic storms

Impacts of space weather



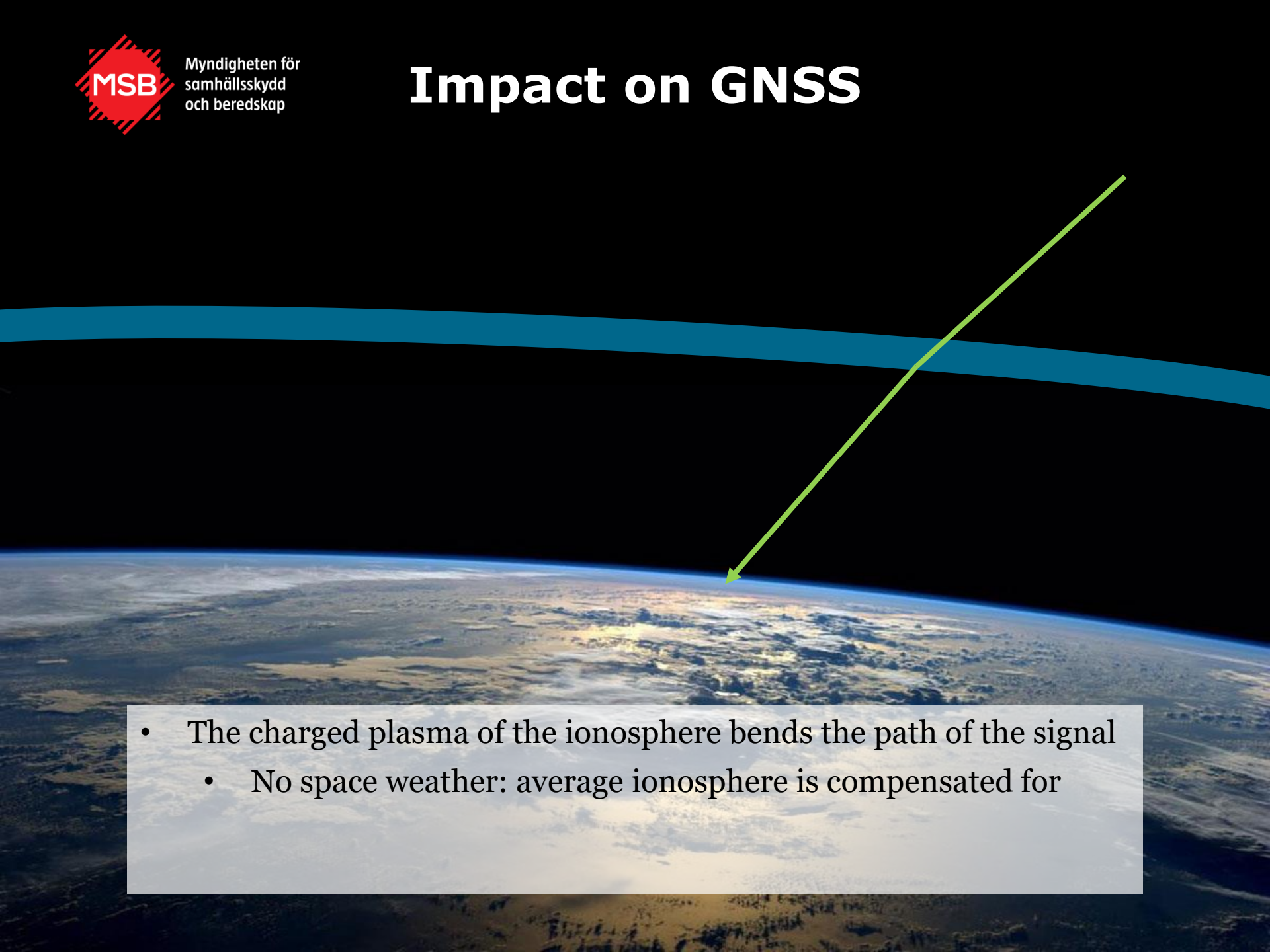
Solar storms – powerful ejections of plasma and electromagnetic radiation

- **Affects**
 - high frequency radio communication
 - GNSS
 - satellite communication
 - air transportation
- **Induces currents into**
 - the power grid
 - pipelines
 - railways
- **Damages** satellite electronics



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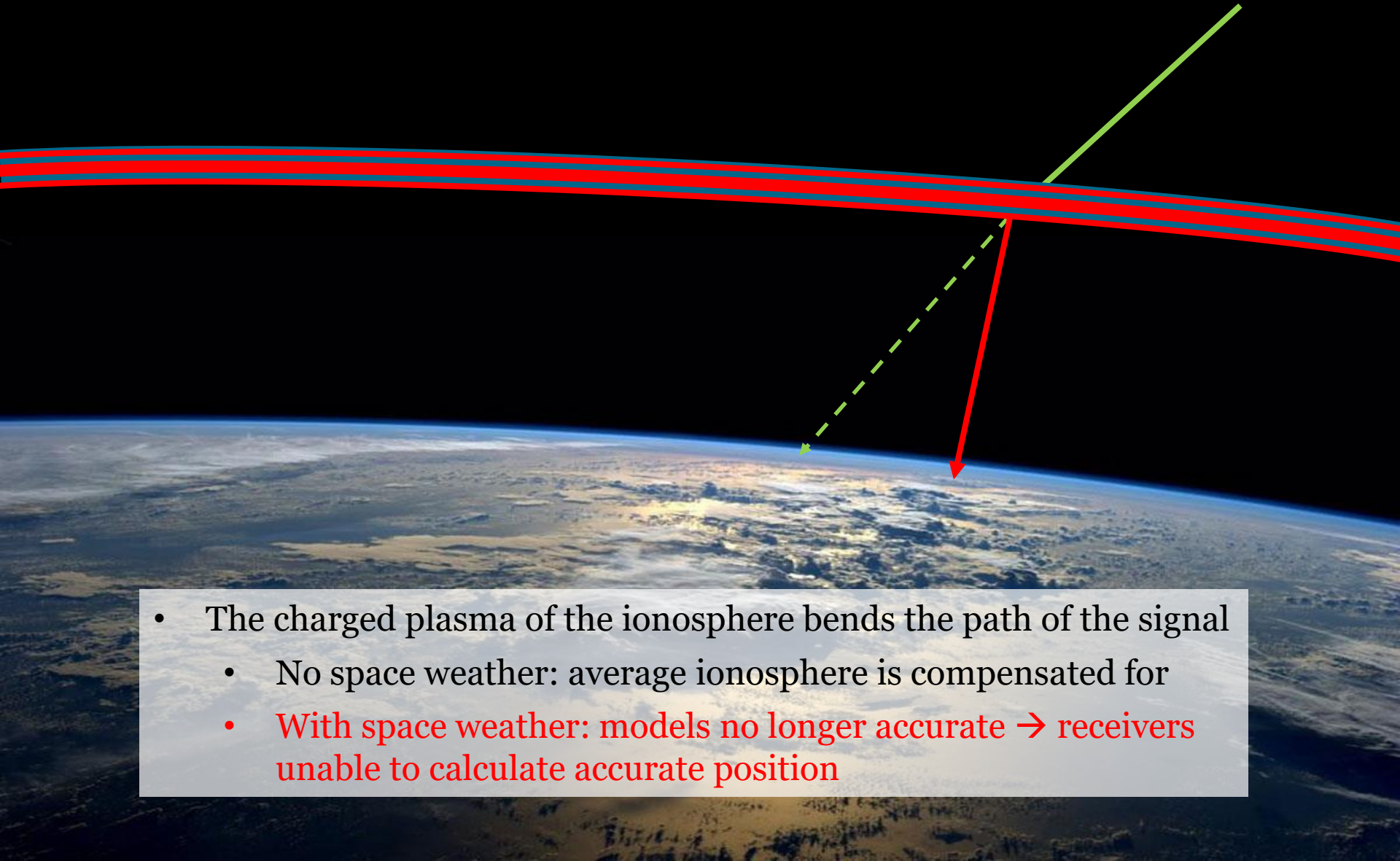
Impact on GNSS

- 
- The background of the slide is a photograph of the Earth from space, showing the horizon and the atmosphere. A thick blue curved line represents the Earth's surface. A green arrow originates from the top right, passes through the blue line, and points towards the Earth's surface, illustrating the bending of a signal path by the ionosphere.
- The charged plasma of the ionosphere bends the path of the signal
 - No space weather: average ionosphere is compensated for



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Impact on GNSS



- The charged plasma of the ionosphere bends the path of the signal
 - No space weather: average ionosphere is compensated for
 - **With space weather: models no longer accurate → receivers unable to calculate accurate position**

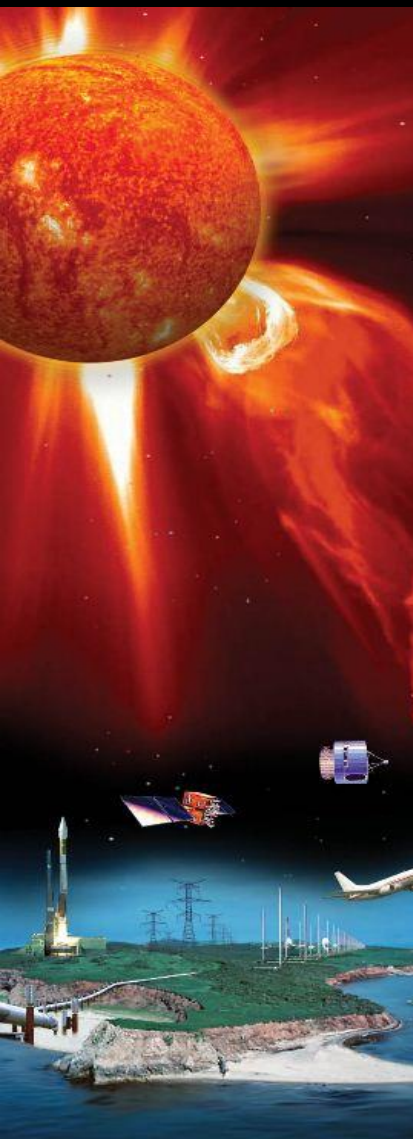


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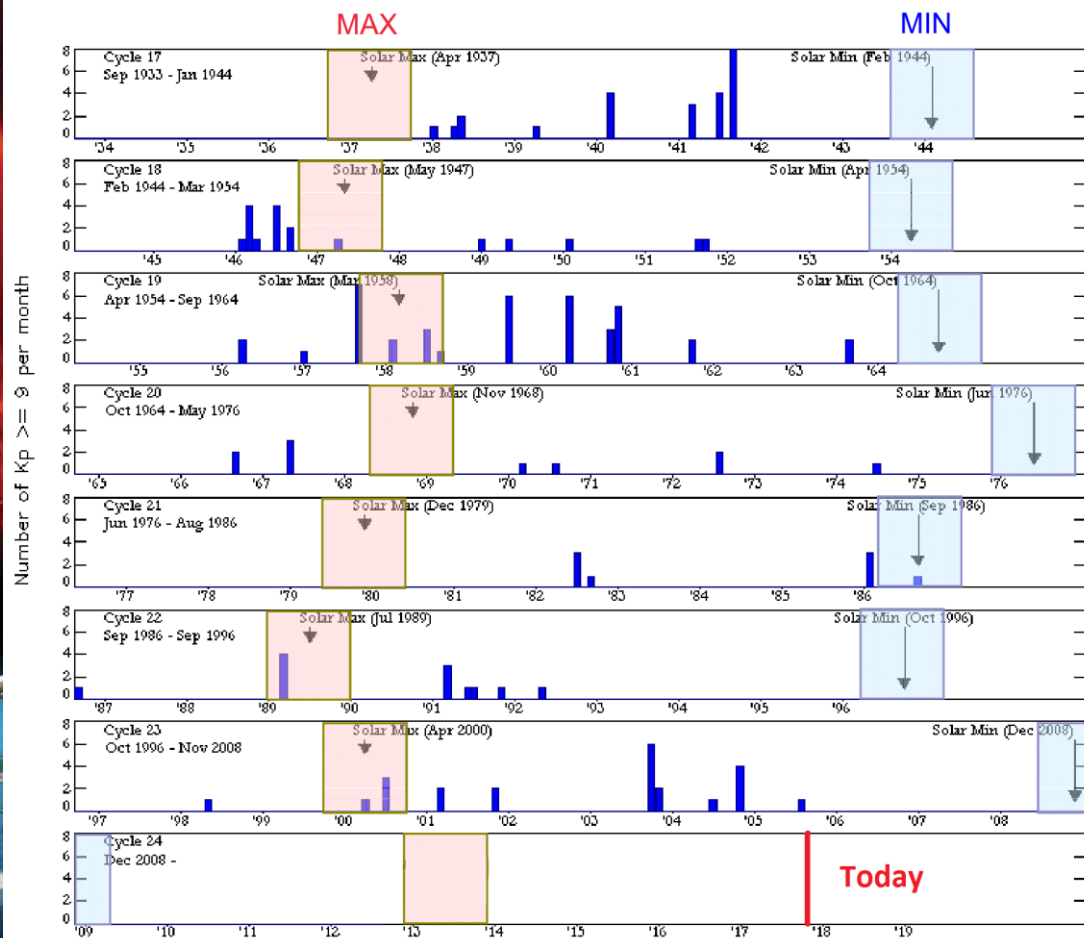
Why MSB?

- **The space threat** is unknown and the risks are relatively new
- We increasingly trust the technology, nonetheless within **vital societal functions**
- **Increased awareness and knowledge** is needed
- Need to integrate space weather with the work of **risk- and capability assessments** and **continuity methods**





Periods with $K_p \geq 9$





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