GGOS

GLOBAL GEODETIC OBSERVING SYSTEM

GGOS Focus Area 4: Geodetic Space Weather Research

Chair: Michael Schmidt[1] , **Vice-Chair**: Klaus Börger[2]

[1] Deutsches Geodätisches Forschungsinstitut der Technischen Universität München (DGFI-TUM), Munich, Germany, Contact: mg.schmidt@tum.de

[2] German Space Situational Awareness Centre (GSSAC), Uedem, Germany

Introduction

- **Space weather** is a very **up-to-date** and **interdisciplinary field of research**.
- It describes **physical processes** in space mainly caused by the Sun's **radiation** of energy.
- The are multiple **manifestations** of **space weather**, e.g. (1) the variations of the Earth magnetic field, (2) the polar lights in the northern and southern hemisphere, (3) the variations of the **ionosphere** and **thermosphere** (due to coupled processes), (4) the solar wind, (5) the interplanetary magnetic field, and (6) the electric currents.
- The most extreme known space weather event happened at September 1, 1859 – the **Carrington storm**.
- Prominent recent events are the **Halloween storm** at October 28 – 30, 2003, the **Bastille Day Event** at July 14, 2000 or the **St. Patrick's storm** at March 17, 2015.
- The **strength** of these events, their **impacts** on modern society and the possibility of much stronger **future events** have brought several countries such as US, UK, Japan, Canada and China to recognize the necessity
  - of studying these **impacts scientifically**,
  - of developing protection strategies and procedures and
  - to establish space weather data centers and **space weather services.**

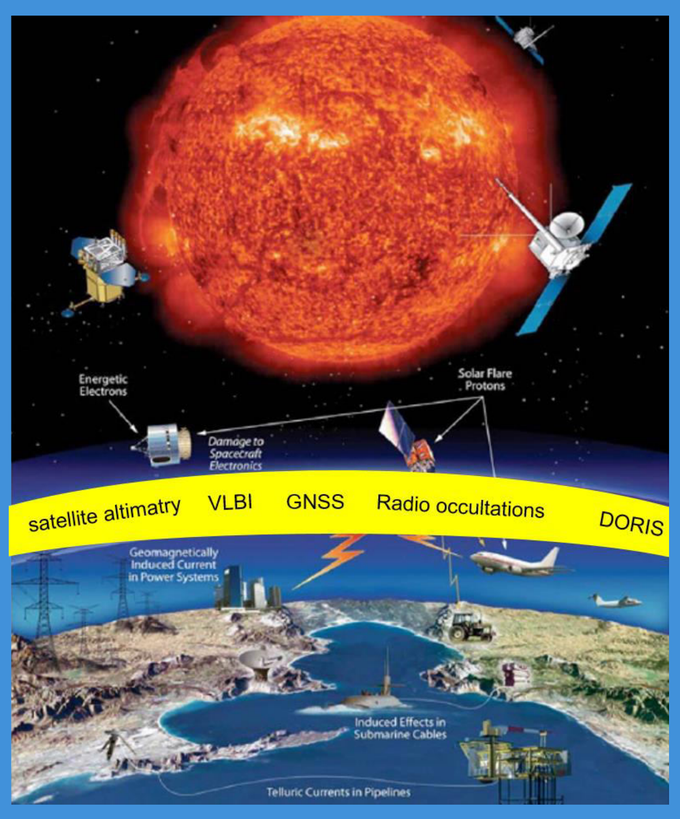

Figure 1: Space-geodetic observation techniques in the context of satellite missions monitoring solar events.

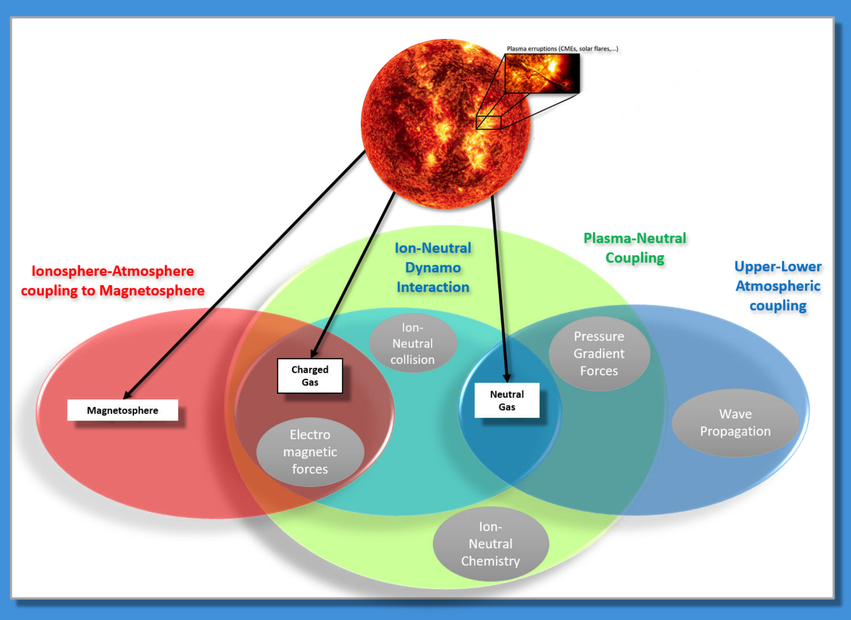

Figure 2: Events effecting different parts of the atmosphere including the coupling processes from the lower to the upper atmosphere.

Geodetic Monitoring of the Ionosphere and the Thermosphere

- Figure 1 gives an overview about the space-geodetic observation techniques which provide valuable information about the state of the **ionosphere**.
- Satellite Geodesy has to deal with the thermosphere, since **thermospheric drag** is the most important force acting on Low-Earth Orbiting (LEO) satellites and objects in the re-entry stage.
- Figure 2 illustrates symbolically the **coupled processes** between magnetosphere, ionosphere and thermosphere.
- Geodesy has a long history and large experience in developing and using sophisticated **analysis techniques** and **modelling approaches**.

Conclusion: **Space Weather is a geodetic topic as well**!

Consequences

Geodetic space weather research must be based on

- the use and combination of all space-geodetic observation techniques,
- geodetic methods for real-time modelling and
- forecast approaches.

Assimilation strategies must be developed to consider additional information such as Sun observations.

Consequently, geodetic space weather research comprises the **basic ideas of GGOS.**

Objectives of Focus Area 4

The **main objectives** are:

- improvement of **positioning** and **navigation** by developing high-precision and high-resolution models of the electron density,
- improvement of **precise orbit determination** (satellites and space debris) by developing high-precision and high-resolution **thermospheric drag models.**

Joint Study Groups (JSG) related to the Focus Area 4

For the **realization** of the objectives at least **2 new GGOS JSGs** have to be installed:

- JSG 1: **Electron density modelling** of the ionosphere including **space weather** effects from the combination of space-geodetic measurement techniques.
- JSG 2: Improvement of **thermosphere models** including physics-based realisations of coupled thermosphere-ionosphere processes, in particular for applications to LEO precise orbit determination (POD).