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Geodetic Space Weather Monitoring by means of Ionosphere Modelling

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The term space weather indicates physical processes and phenomena in space caused by radiation of energy mainly from the Sun. Manifestations of space weather are (1) variations of the Earth's magnetic field, (2) the polar lights in the northern and southern hemisphere, (3) variations within the ionosphere as part of the upper atmosphere characterized by the existence of free electrons and ions, (4) the solar wind, i.e. the permanent emission of electrons and photons, (5) the interplanetary magnetic field, and (6) electric currents, e.g. the van Allen radiation belt. It can be stated that ionosphere disturbances are often caused by so-called solar storms. A solar storm comprises solar events such as solar flares and coronal mass ejections (CMEs) which have different effects on the Earth. Solar flares may cause disturbances in positioning, navigation and communication. CMEs can effect severe disturbances and in extreme cases damages or even destructions of modern infrastructure. Examples are interruptions to satellite services including the global navigation satellite systems (GNSS), communication systems, Earth observation and imaging systems or a potential failure of power networks.

Currently the measurements of solar satellite missions such as STEREO and SOHO are used to forecast solar events. Besides these measurements the Earth's ionosphere plays another key role in monitoring the space weather, because it responses to solar storms with an increase of the electron density. Space-geodetic observation techniques, such as terrestrial GNSS, satellite altimetry, space-borne GPS (radio occultation), DORIS and VLBI provide valuable global information about the state of the ionosphere. Additionally geodesy has a long history and large experience in developing and using sophisticated analysis and combination techniques as well as empirical and physical modelling approaches. Consequently, geodesy is predestinated for strongly supporting space weather monitoring via modelling the ionosphere and detecting and forecasting its disturbances.

At present a couple of nations, such as the US, UK, Japan, Canada and China, are taken the threats from extreme space weather events seriously and support the development of observing strategies and fundamental research. However, (extreme) space weather events are in all their consequences on the modern highly technologized society, causative global problems which have to be treated globally and not regionally or even nationally. Consequently, space weather monitoring must include (1) all space-geodetic observation techniques and (2) geodetic evaluation methods such as data combination, real-time modelling and forecast. In other words, geodetic space weather monitoring comprises the basic ideas of GGOS and will provide products such as forecasts of severe solar events in order to initiate necessary activities to protect the infrastructure of modern society.