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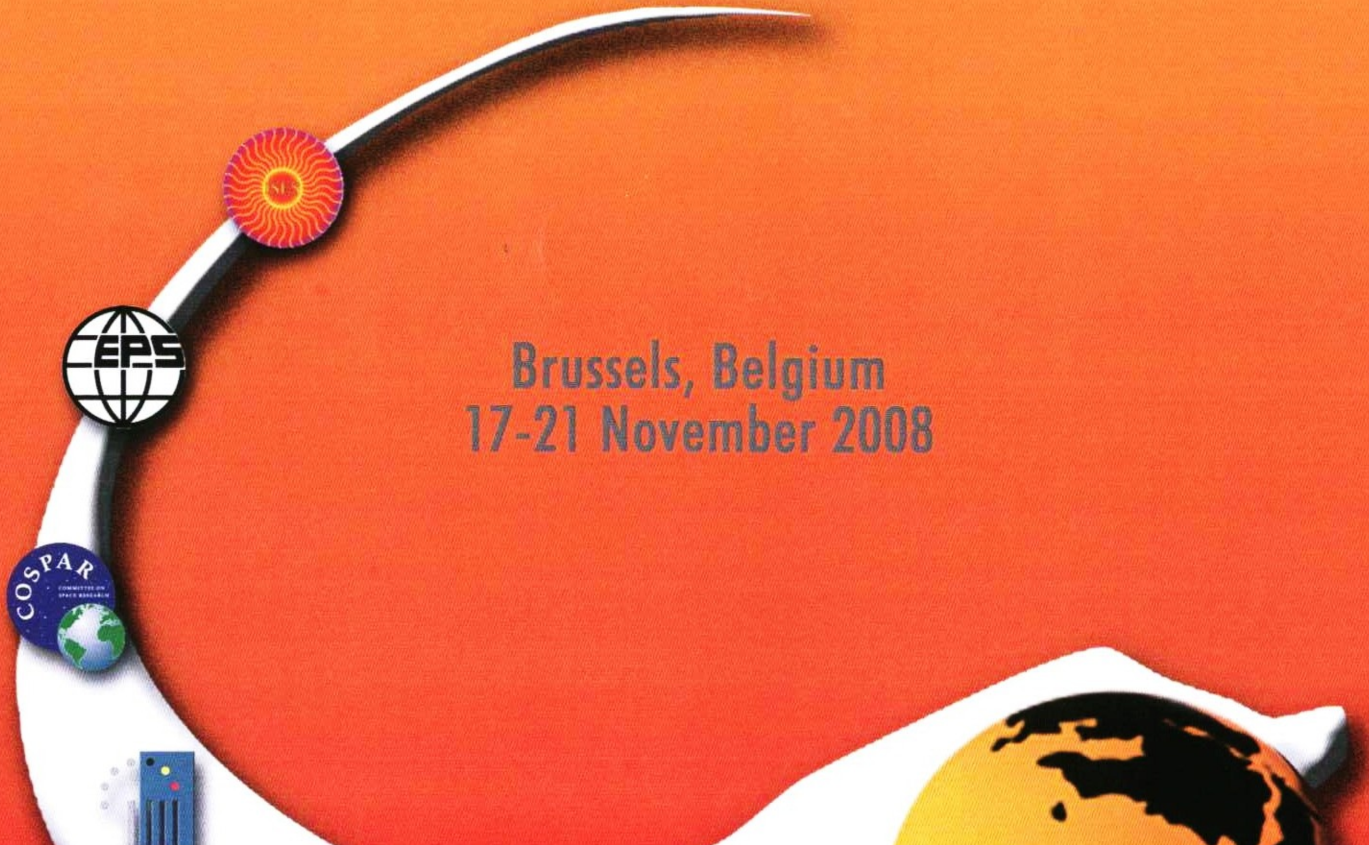
Fifth European Space Weather Week



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systems. When using redundant satellite information (RAIM), correlated propagation effects, such as ionospheric effects may reduce the effectiveness of the algorithms used.

- SBAS systems provide an estimation of ionospheric effects through a network of ground-based reference stations. Central algorithms try to either detect or compensate for ionospheric disturbances, but may not be able to correct for all types of disturbances, affecting system availability.
- GBAS systems are based on a single ground system and, although designed to bound any potential error sources with sufficient integrity, may not be able to detect all relevant disturbances. The resulting conservative assumptions in the error estimations may affect system availability, notably at large distances from the ground system.

In general terms, the adequate monitoring and prediction of the space weather and the availability of technologically advanced receivers are the main mitigations against the effects of the solar activity on the GNSS signals. Significant measures are being taken by service providers, certification authorities and user representatives to limit the impact of space weather effects. These include detailed reviews of data collected in the past. However, reuse of data collected for other purposes may miss specificities of the aviation threat model, so further work is necessary and measurement campaigns for the next solar maximum are currently being planned.

Galileo Local Component for the Detection of Atmospheric Threats

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The presence of small-scale structures in the atmosphere (ionosphere and troposphere) can strongly affect the reliability of GNSS high precision real time applications. The concepts of reliability and integrity play a crucial role in the development of Galileo. In particular, small-scale structures in the ionosphere TEC due to Travelling Ionospheric Disturbances or to geomagnetic storms can be the origin of strong disturbances in high precision positioning. The GALOCAD project has been submitted in response to Galileo Joint Undertaking call for proposals 2423. GALOCAD stands for "GALileo LOCal Component for the Detection of Atmospheric Disturbances which affect high accuracy Galileo applications". The objective of GALOCAD was to develop a methodology for the implementation of a Galileo Local Component for the nowcasting and the forecasting of atmospheric threats (ionosphere and troposphere) which can degrade the "integrity" of high precision Galileo applications. The paper presents the tools developed in the frame of the project in order to monitor the integrity of GNSS precise real time applications with respect to ionospheric threats and shows in how far these tools could be used to implement real time services for GNSS users.

Total Electron Content Monitoring using Triple Frequency GNSS Data: A Three-Step Approach

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The objective of our work is to develop an improved real time Total Electron Content (TEC) monitoring technique, which is based on triple frequency Global Navigation Satellite Systems (GNSS) data and whose accuracy will not be affected by code delays (hardware and multipath) anymore. This will allow to improve ionospheric corrections and therefore to increase the precision and reliability of several GNSS navigation and positioning techniques. This paper describes the three steps of the technique which has been fully validated on simulated data and partially on real Giove-A data.

As the third frequency was not yet available at the beginning of our work, we have developed a software allowing to simulate realistic GNSS (GPS and Galileo) measurements on L1,L2 and L5 frequencies. Thanks to this triple frequency simulation software, we are able to test our triple frequency TEC monitoring technique which is divided in three steps. The objective of the first step is to resolve the extra-widelane (EWL) ambiguities. These ambiguities are integer numbers and can be estimated by computing the extra-widelane-narrowlane (EWLNL) combination. The wavelength of the EWLNL combination equals 5.861m for GPS and 9.768m (almost double) for Galileo. The results show that, despite the existence of a residual term, the use of the EWLNL combination allows to resolve the EWL ambiguities, i.e. to fix them at their correct integer values. The objective of the second step is to resolve the widelane (WL) ambiguities. These ambiguities are also integer numbers and are estimated by computing the differenced widelane (DWL) combination. This combination includes the so-called WL and EWL phase combinations and is based on the EWL ambiguities which are considered as resolved from the first step. The wavelength of the DWL combination equals 0.862m for GPS and 0.814m for Galileo. Unfortunately, as the DWL combination also contains a residual term, it is impossible to fix the WL ambiguities at their correct integer values. Nevertheless, the DWL combination gives approximated integer values of WL ambiguities, which are used in the next step. The objective of the third step is to use the results of the first two steps in order to achieve the monitoring of the TEC. Thanks to the availability of triple frequency data we form two independent dual frequency Geometric Free phase combinations. By introducing the values of the EWL ambiguities – resolved in the first step – and the values of the WL ambiguities – approximated in the second step – in those combinations, we only find approximated values of the two remaining unknowns which are TEC values and ambiguities on L2. Nevertheless, using two specific properties concurrently with an estimation of TEC values obtained by the usual dual frequency method, we are able to fix the WL ambiguities at their correct integer values. As a consequence, we obtain the correct integer values of the WL ambiguities and we are