Temporal and spatial ionospheric disturbances and their effects on Satellite Navigation Services

Jens Berdermann, Mainul Hoque, Norbert Jakowski, Martin Kriegel and Volker Wilken

German Aerospace Center, Institut of Communication and Navigation

The ionosphere with all its temporal and spatial variations is a significant threat to the precision of GNSS-based navigation services. Strong ionospheric perturbations, usually characterized by severe gradients and/or rapid changes of the electron density integrated along the used satellite-receiver links, can seriously degrade the performance of GNSS. Strong ionospheric gradients have effects on GNSS positioning services used by aviation, maritime and land users and are either caused by space weather events (e.g. Solar Flares, Solar Radio Bursts or Solar Storms) or due to special regional ionospheric conditions (e.g. at Polar or Equatorial latitudes). A solar flares can trigger an temporal ionospheric gradients on the dayside, wich can cause critical situations for navigation applications and services used in aviation and maritime navigation [1]. An ionospheric storm as result of an Earth directed Coronal Mass Ejection (CME) can cause strong spatial gradients propagating from polar to equatorial latitudes lasting for hours with significant impact on accuracy and integrity of the navigation performance. Small scale ionospheric irregularities in the equatorial ionosphere can cause amplitude and phase scintillation of GNSS signals at receivers [2,3].

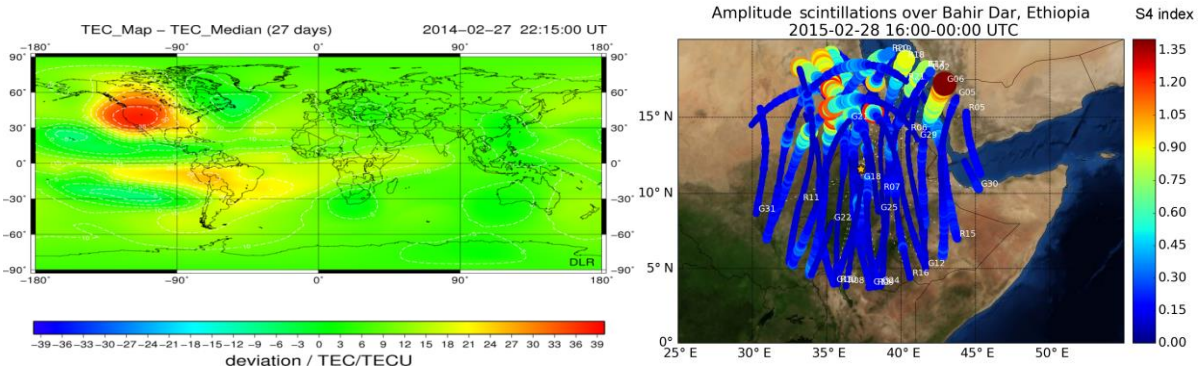

Figure 1: The Left panel shows a disturbed region over North America caused by an ionospheric storm impacting satellite based navigation systems [4]. The right panel shows strong amplitude scintillations at Bahir Dar/Ethiopia in the equatorial crest region [2].

Analyzing real data sets ee will demonstrate the crucial impact of spatial and temporal ionospheric gradients on GNSS navigation services and applications used in the aviation, maritime and land transportation domain.

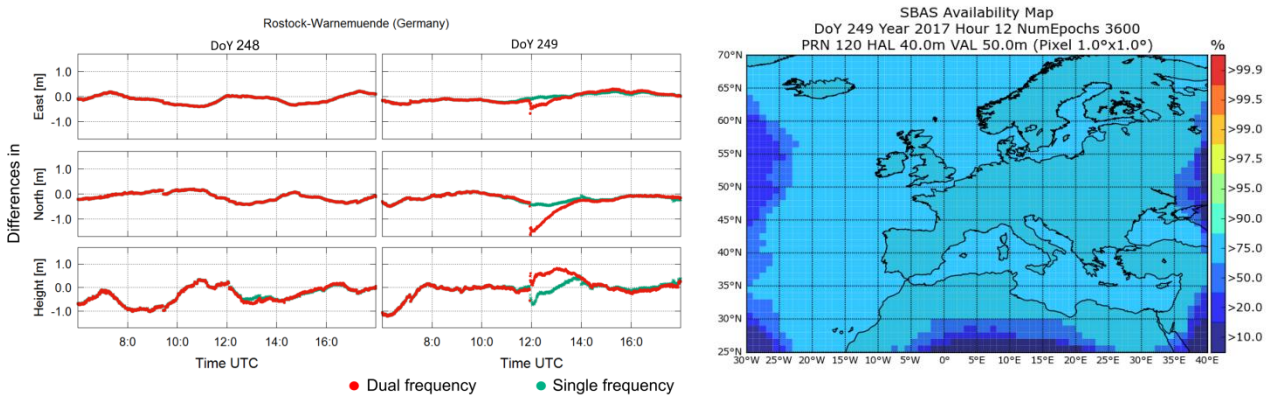

Figure 2: Left Panel shows the direct impact of a X9.3 Flare on the precise point poositioning (PPP) performance compared to the previous undisturbed day [1]. The Right Panel shows the impact oft he same flare on the Space Based Augmentation System EGNOS reducing its availability to about 75% [1].

We will categorize the different ionospheric disturbances with its specific features for navigation applications on the user side. Finally we will provide information on suitable indices, which allow to rate the current ionospheric conditions on a regional level [5, 6]. We will discuss how such real time indices can help to limit service outages of essential navigation services to the minimum time required.

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