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Ionospheric effects over Europe during the solar eclipse on 20 March 2015

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A total solar eclipse occurred on March 20, 2015 moving from the North-West Europe towards the North-East. Due to strong solar radiation changes dynamic processes were initiated in the atmosphere and ionosphere causing a measurable impact e.g. on the temperature and ionization during the eclipse. We analyzed the 20 March 2015 solar eclipse effects on the ionospheric structure over Europe using multi-sensor observations such as vertical sounding (VS) and Global Positioning System (GPS) measurements. Whereas the VS measurements are used to provide peak electron density information at the ionospheric F2, F1 and E layers over selected ionosonde stations, a dense network of GPS stations is used to provide high spatial resolution of the total electron content (TEC) estimates over Europe. We reconstructed the TEC maps with 5 minutes time resolution and thus investigated the original TEC maps and differential TEC maps obtained by subtracting 27 days medians from the actual TEC map values on 20 March 2015. By combining VS and GPS measurements the equivalent slab thickness has been estimated over several ionosonde stations to get information how the shape of the vertical electron density profile changes during the eclipse. The analysis of the solar eclipse on 20 March 2015 presented here will contribute to understand the ionospheric response on solar eclipses occurring at different latitudes. The observations indicate that a number of competitive processes initiated by an eclipse are often enhanced by dynamic forces associated with large scale geophysical conditions not directly impacted by the solar eclipse.
Our TEC estimation shows that the total ionization reduces up to 60% (after bias correction 40%) as a function of obscuration. Since the 20 March 2015 eclipse occurred during the negative phase of a severe geomagnetic storm on 17 March 2015, the observed TEC depletion is higher than those reported earlier for 1999 and 2005 eclipses. Thus, a negative bias of up to 20% was observed over Northern Europe already before the eclipse occurred. Moreover, the eclipse path of the solar eclipse in 2015 is traced at higher latitudes compared with eclipses observed in the years 1999 and 2005.
The ionospheric response to the obscuration function is delayed up to 40 minutes decreasing with growing distance from the totality zone and increasing with altitude. The increasing delay with altitude is in agreement with earlier findings for other eclipses. The equivalent slab thickness was found to increase by approximately 80 -100 km during the solar eclipse on 20 March 2015 showing evidence for a pronounced loss in the bottomside ionosphere causing a delayed depletion of the topside ionosphere.