GPS ionospheric mapping at Natural Resources Canada

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Natural Resources Canada | Ressources naturelles Canada

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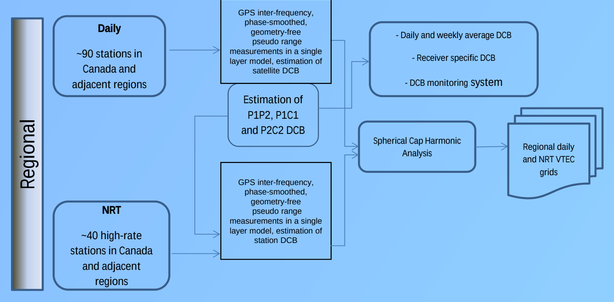
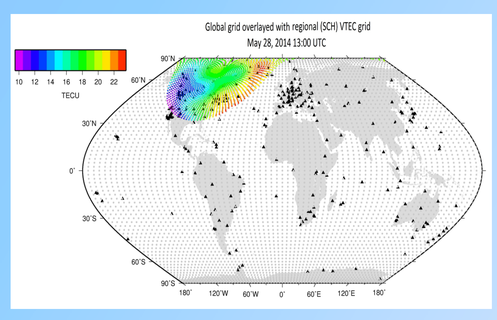
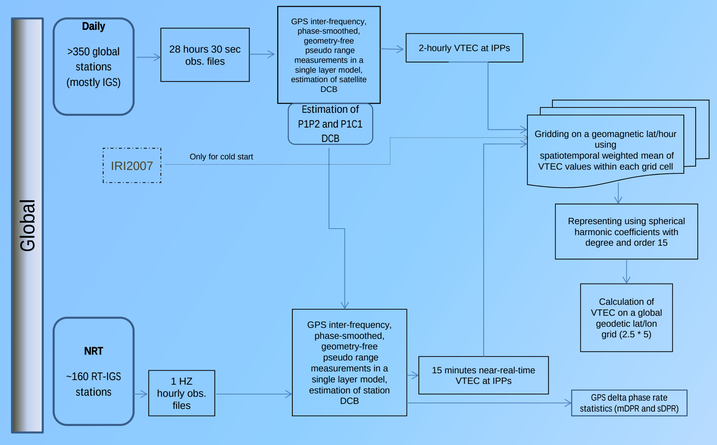
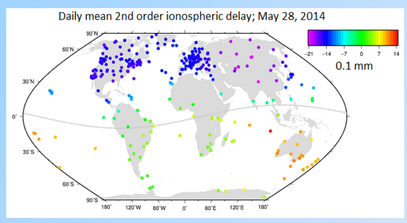
Canadian Geodetic Survey of Natural Resources Canada (NRCan) has developed a number of products from GPS sensing of the ionosphere. These include: 1) regional near-real-time and daily vertical Total Electron Content (TEC) maps represented using Spherical Cap Harmonic Analysis that covers Canada and adjacent regions, 2) near-real-time global TEC maps from GPS Real Time (RT) IGS stations represented using Spherical Harmonic (SH) coefficients of degree and order 15 which are also available in 96 daily IONosphere map EXchange (IONEX) format, and 3) daily global TEC maps from around 350 GPS stations which are represented using SH coefficients of degree and order 15 and are also available in IONEX format. In addition, as a by-product of regional and global TEC mapping processes, GPS satellites and receiver differential code biases (DCB) are estimated daily and in the form of weekly moving averages. These include P1P2, P1C1 and P2C2 DCBs from all processed receiver types as well as receiver-model specific estimates. As a by-product of near-real-time global TEC mapping from high rate RT-IGS GPS stations, dual-frequency phase rate measurements are used to derive proxy indices for monitoring the ionospheric irregularities. Schematic regional and global maps of such indices are updated in near-real-time and are being studied to correlate with independent space weather indices. Higher order ionospheric delays are also being estimated in near-real-time and are stored for studies on their amount and spatial variations.

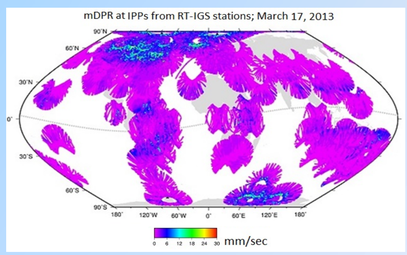
Regional and global TEC mapping processes and their by-products

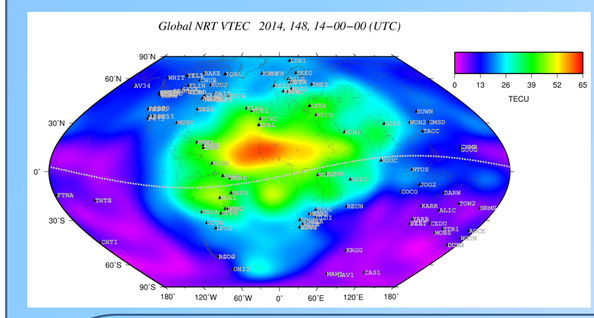


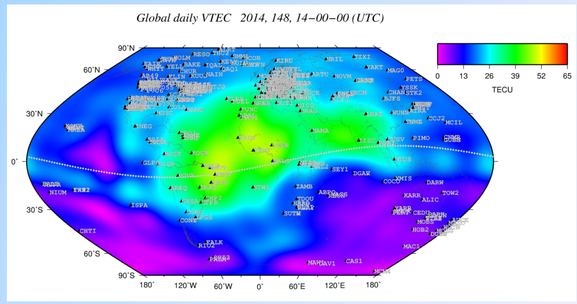




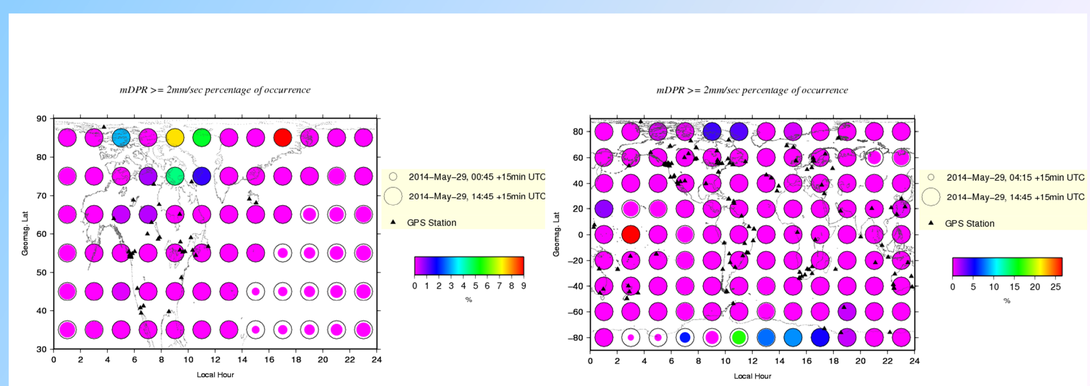




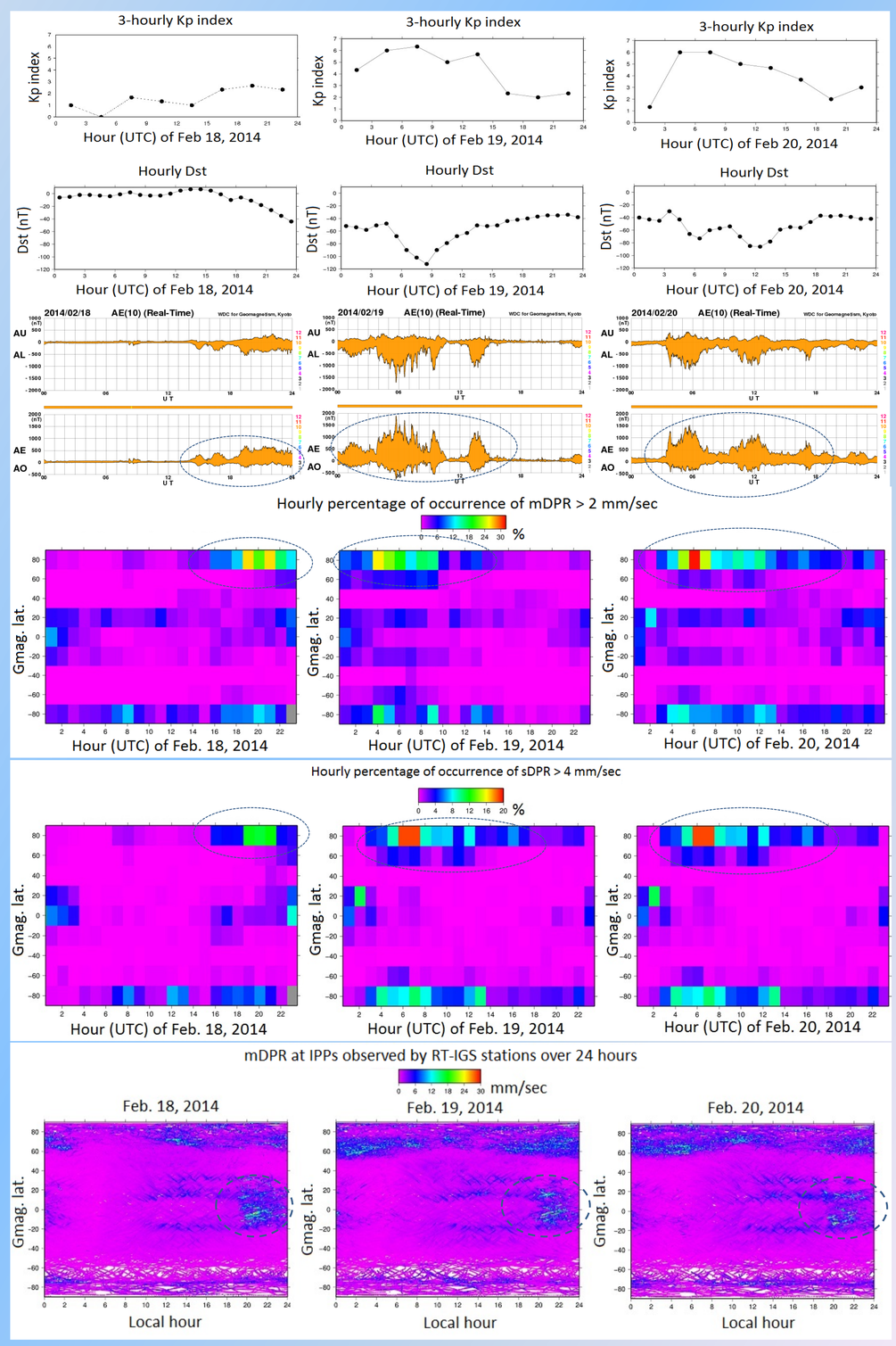




A schematic near-real-time ionospheric irregularity and data coverage representation system: regional (left), global (right).



Monitoring GPS phase rate variation statistics vs. geomagnetic indices (Kp, Dst, AE)



- Statistics of GPS phase disturbances over auroral region best correlated with events detected by AE index over the period shown here.
- Post sunset ionospheric irregularities in equatorial region is detected in GPS phase rate indices.

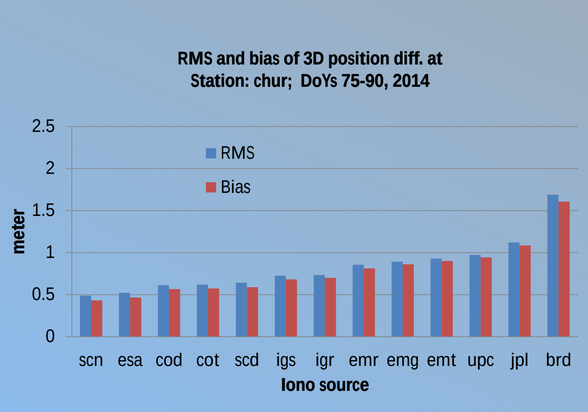
TEC maps validation in position domain

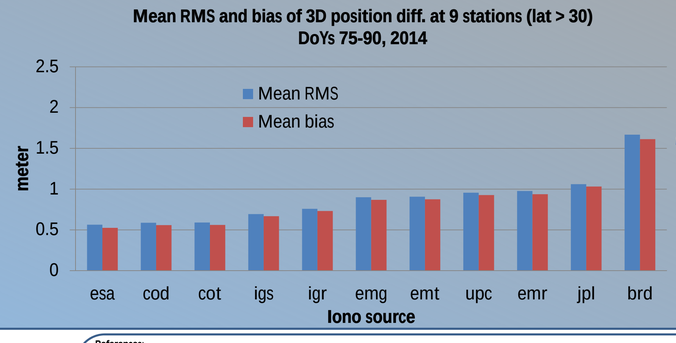
PPP validation campaigns:

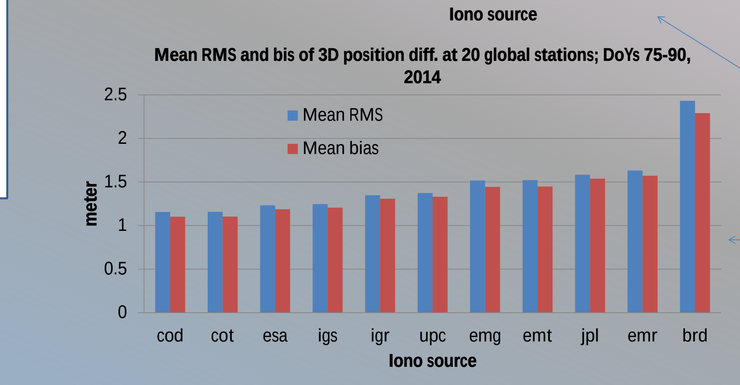
NRCan's in-house PPP 24 hours static GPS position difference between dual-frequency iono-free and P1 code only solutions.

Processing parameters:

- NRCan's emr rapid orbits and clocks.
- Estimation of tropospheric zenith delays for dual frequency and modeled for P1 code only solution.
- Applying P1P2 DCB from IONEX header unless otherwise noted.

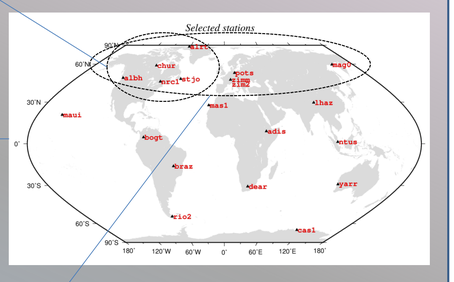






scn: NRT reg NRCan*
scd: Daily reg NRCan*
cot: Final CODE*
cod: Final CODE
emg: Final NRCan
emt: Final NRCan*
emr: NRT NRCan
brd: Broadcast
igs: Final IGS
igr: Rapid IGS
upc: Final UPC
jpl: Final JPL
esa: Final ESA

* Used with yearly averages of CODE DCBs



NRCan's regional NRT together with final ESA and CODE preformed closest to iono-free solution during the studied period over Canadian stations. Over selected global stations CODE and ESA performed closest to iono-free solution.

References:

- Ghoddousi-Fard R., P. Héroux, D. Danskin, and D. Boteler (2011). Developing a GPS TEC Mapping Service over Canada. Space Weather, Vol. 9, S06D11, DOI: 10.1029/2010SW000621.
- Ghoddousi-Fard R., P. Prikryl, and F. Lahaye (2013). GPS phase difference variation statistics: A comparison between phase scintillation index and proxy indices. Advances in Space Research, 52, 1397-1405, DOI: 10.1016/j.asr.2013.06.035.

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