Climatological behaviour of the Ionospheric-Plasmaspheric Total Electron Content over Antarctica

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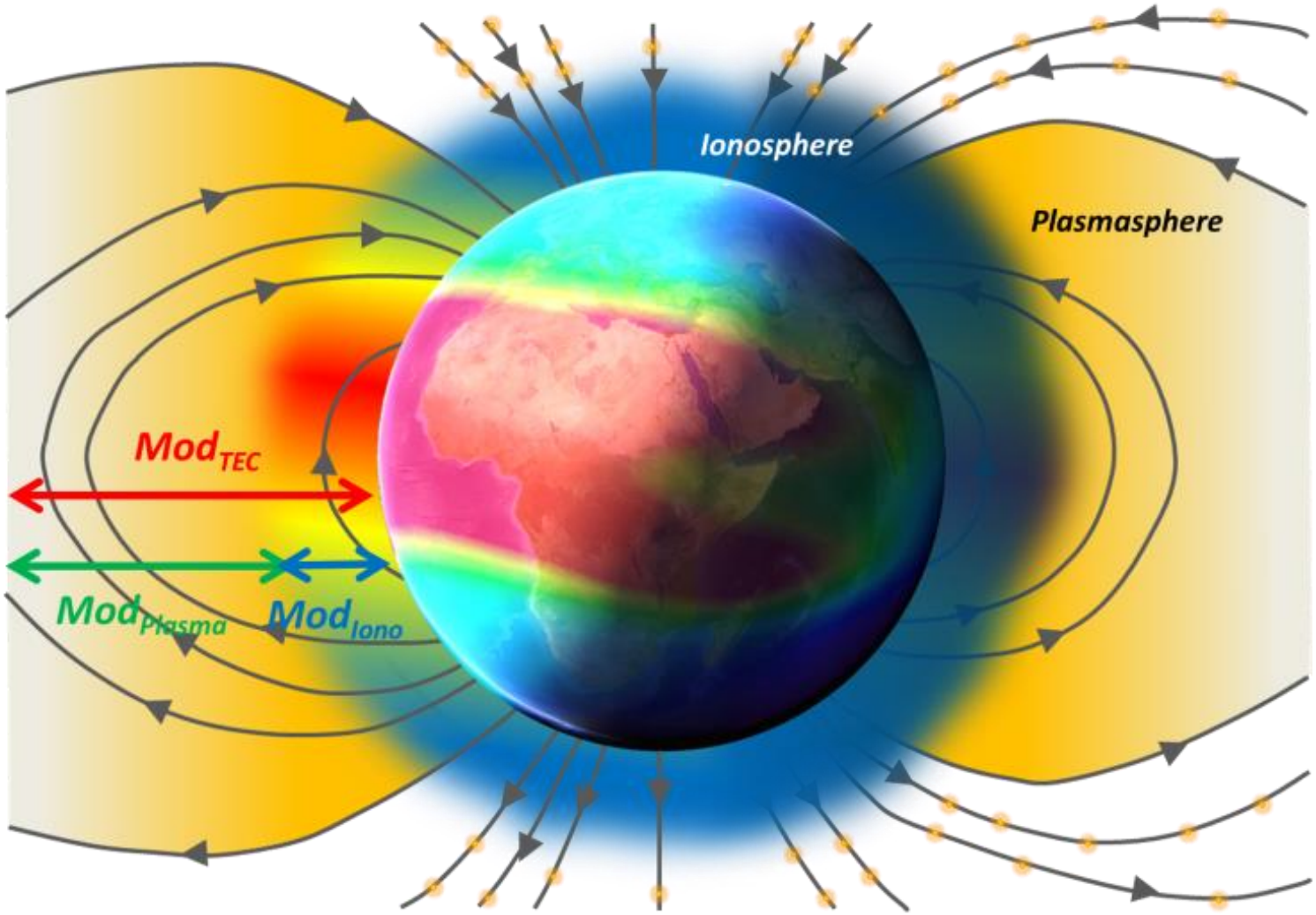
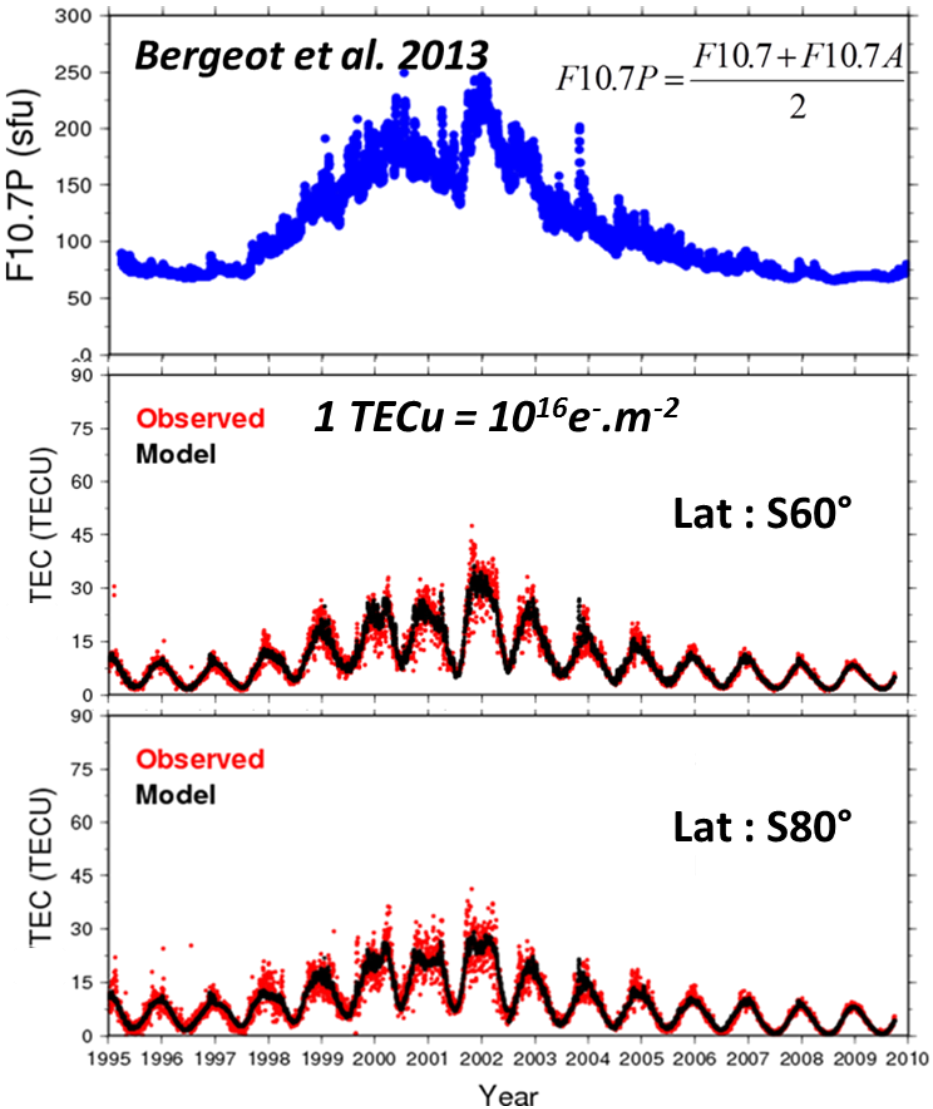


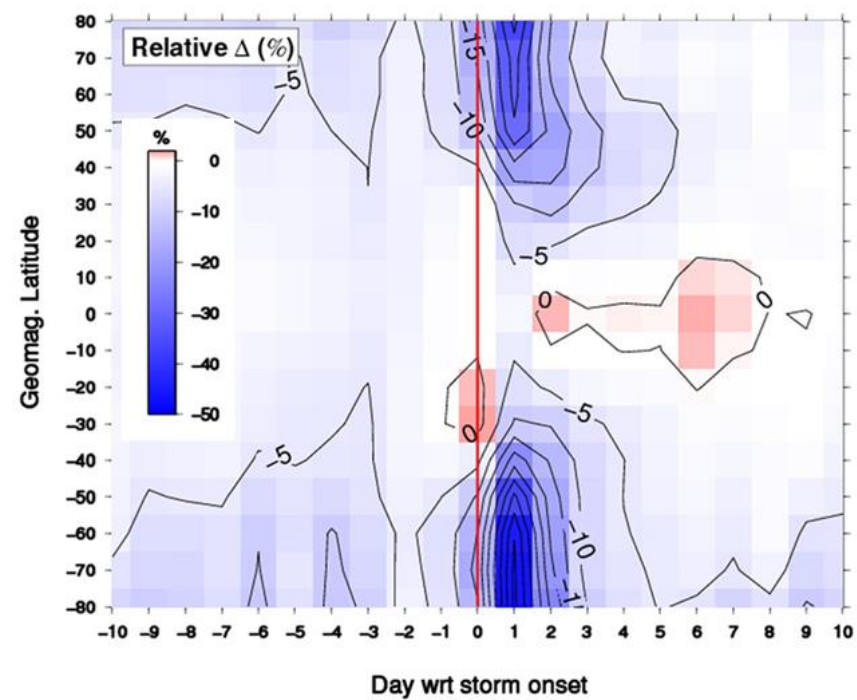
Climatological behaviour of the Antarctica ionosphere and plasmasphere in response to variations in the solar activity.

Climatological behavior of the daily mean TEC (DMTEC) at high latitudes



Climatological behavior of the Daily mean Total Electron Content (DMTEC).

Impact of geomagnetic storms on the DMTEC (70 onsets detected from NASA ACE spacecraft for the period 1998 - 2005).

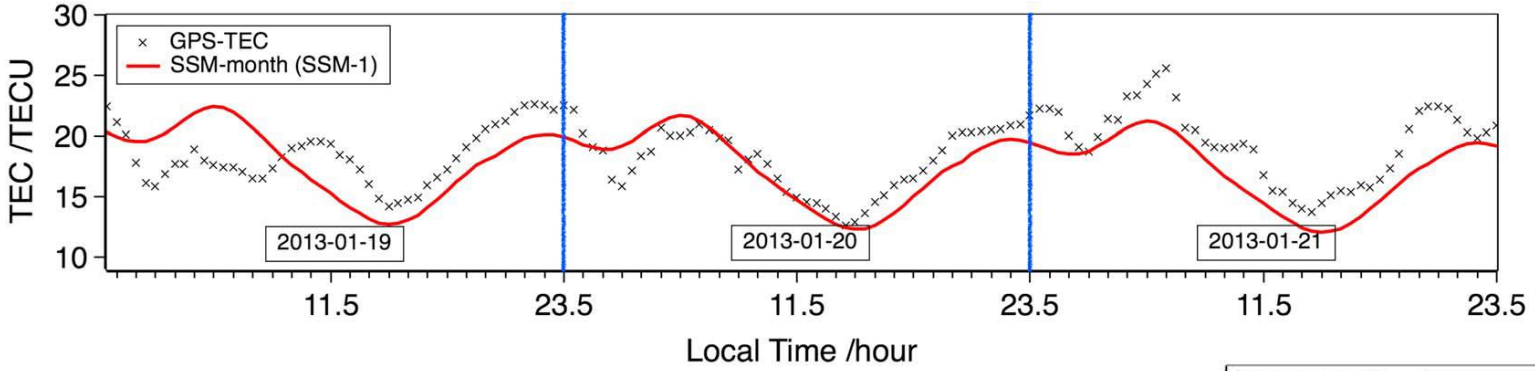


Climatological behavior of the TEC at high latitudes

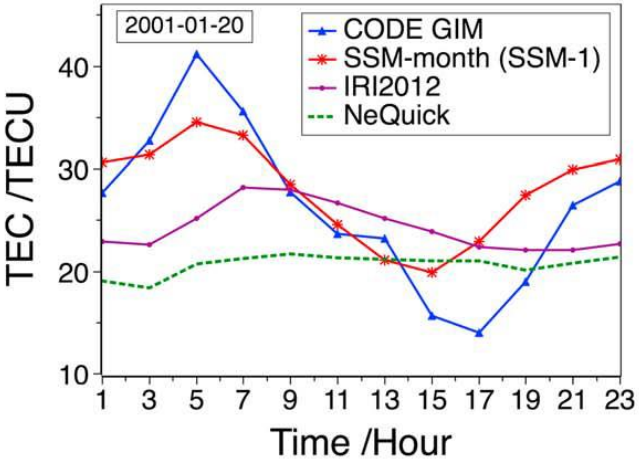
From Feng et al. 2017, Radio Science

A single-station empirical model for TEC over the Antarctic Peninsula (data from OHI3 station for period 2004-2015).

There new model is able highlight the Weddell Sea Anomaly (WSA).

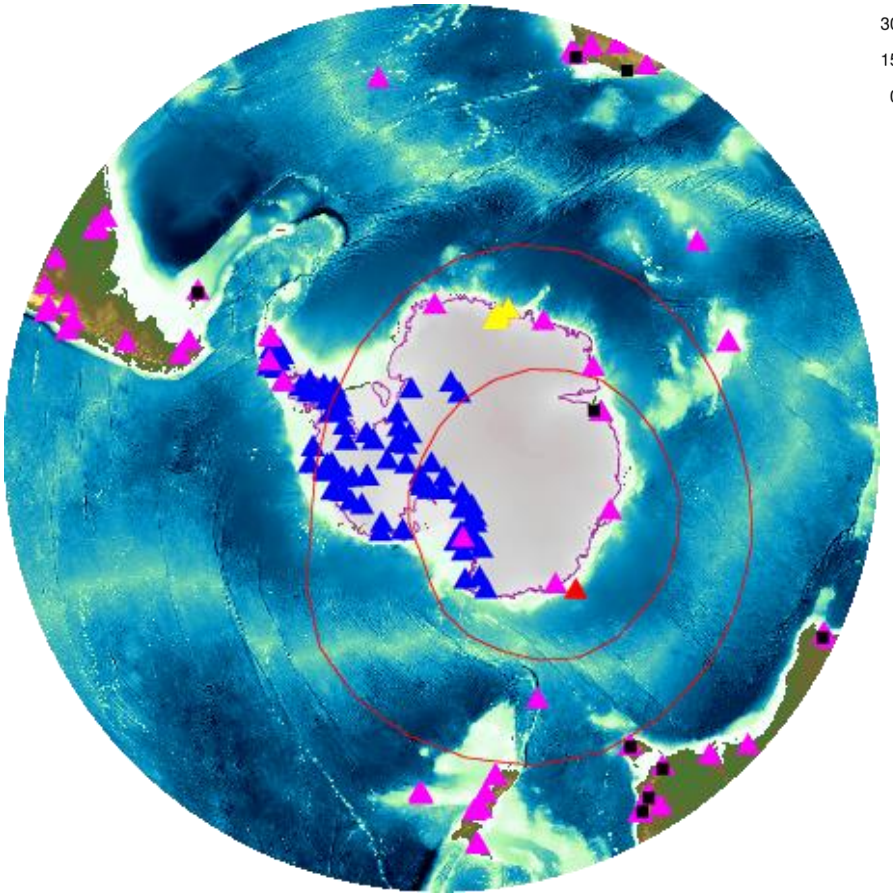


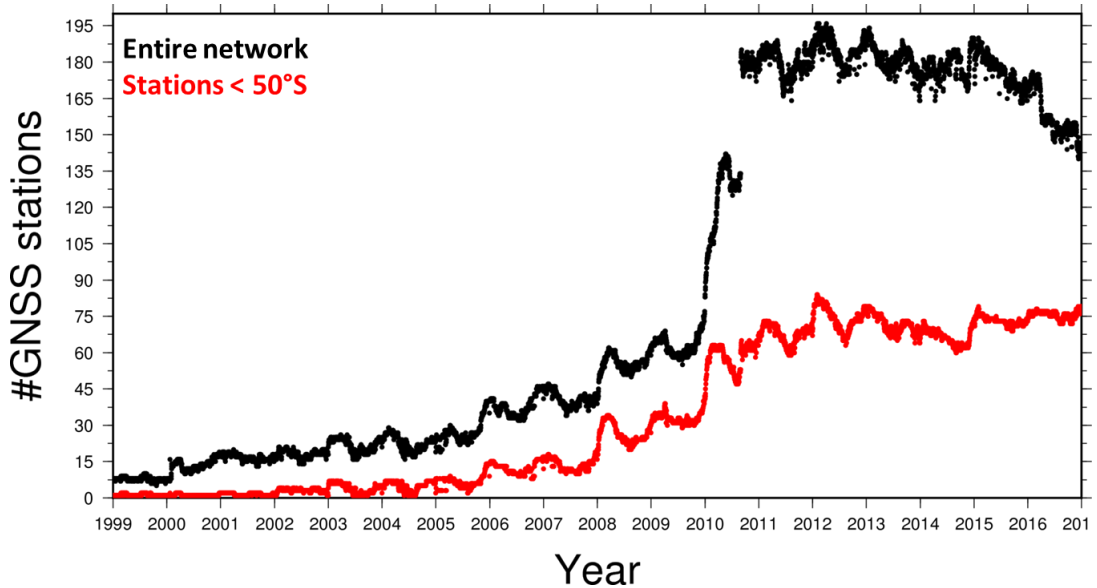
Their model is more concordant with CODE GIM's compare IRI2012 and NeQuick models.



IGS + POLENET + BE/LUX (PEA) GNSS stations

- IGS GNSS stations
- Polenet GNSS stations
- Be/Lu GNSS stations
- Ionosondes
- Geomagnetic pole
- Aurora oval





IGS (Dow et al. 2009) http://www.igs.org/

POLENET http://polenet.org/

http://www.unavco.org/

BE-LUX Stations

Important for the densification in North-East Antarctica region.

GNSS data reprocessing

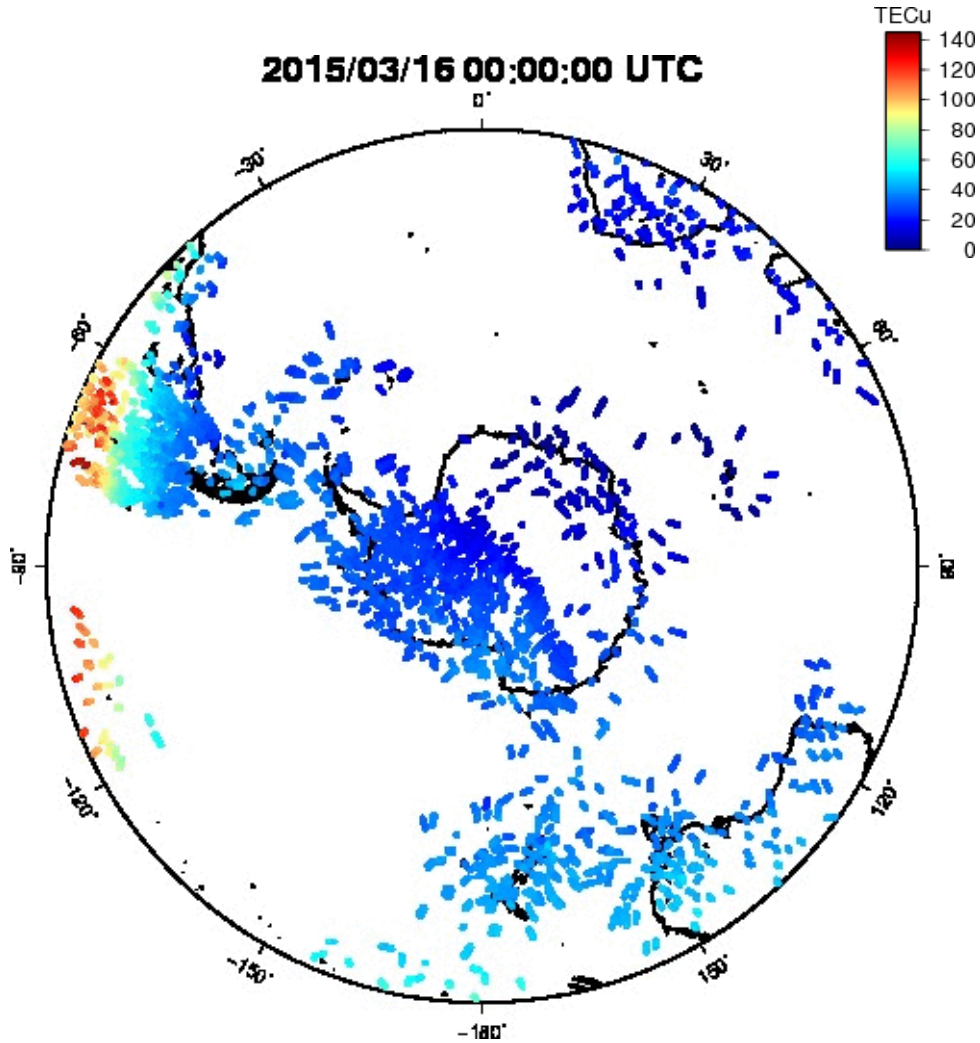
Reprocessing of the entire network using GPS + GLONASS data for the period 1999-2017

ROB-IONO software (Bergeot et al 2014):

- Phase-smoothed code observables
- A two phases processing approach (DCB then sTEC_2_vTEC)

Output : vTEC at IPPs for every 30s

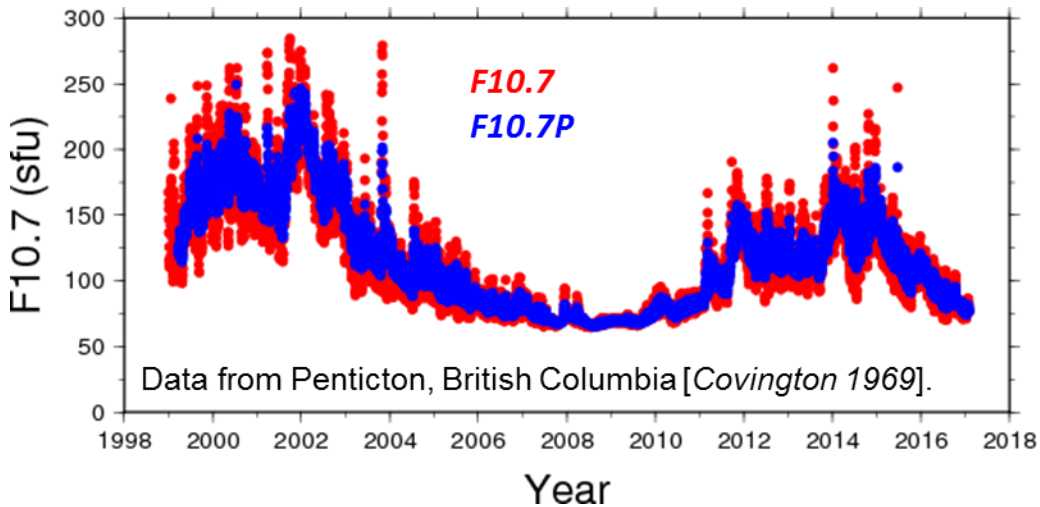
Cut –off angle : 40°



Multi-Stations empirical TEC-model

Empirical model based on F10.7P index (~ EUV emission from the Sun)

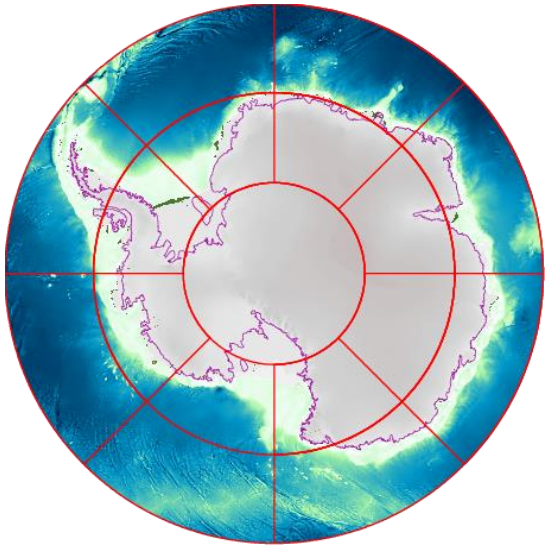
The data set is then employed to constrain an empirical model to predict the vTEC at a given time and location from F10.7P solar index in entrance using a least-square adjustment.



To minimize the differences between the modelled and observed vTEC we considered:

- An eight-order polynomial function with monthly coefficients between the vTEC and F10.7P
- A discretization with respect to different zones over Antarctica region to highlight different climatological patterns.

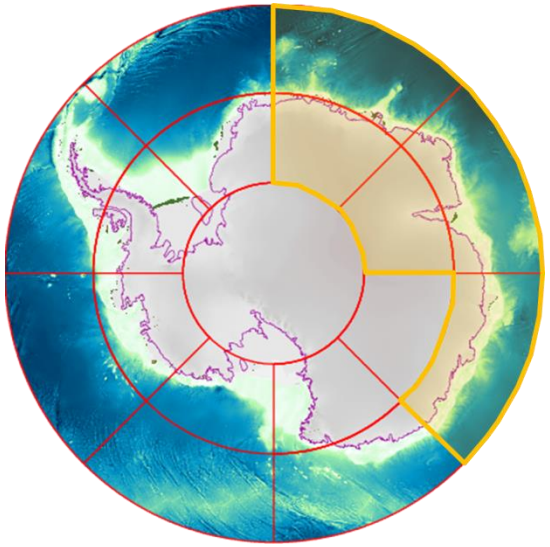
Multi-Stations empirical TEC-model

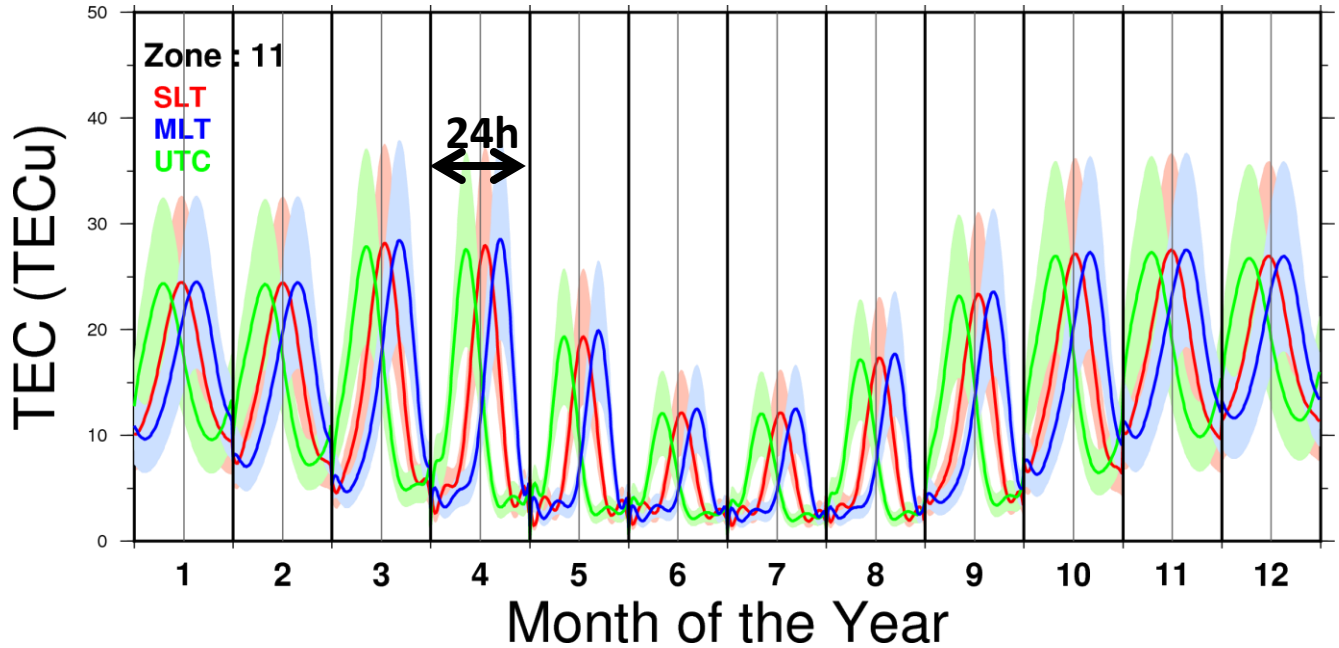


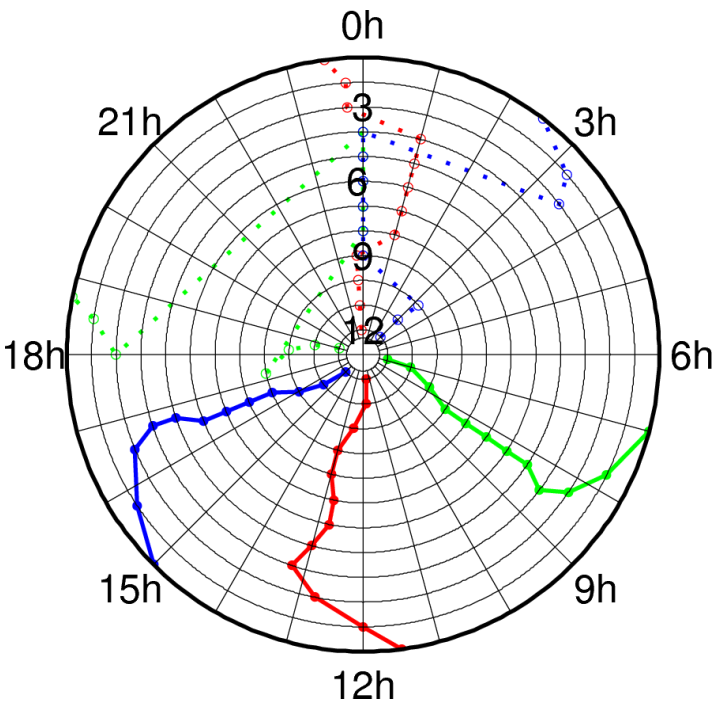
Antarctica divided in 17 zones.

> 9 000 000 of vTEC at IPPs per zone/per month

Daily-TEC climatological patterns

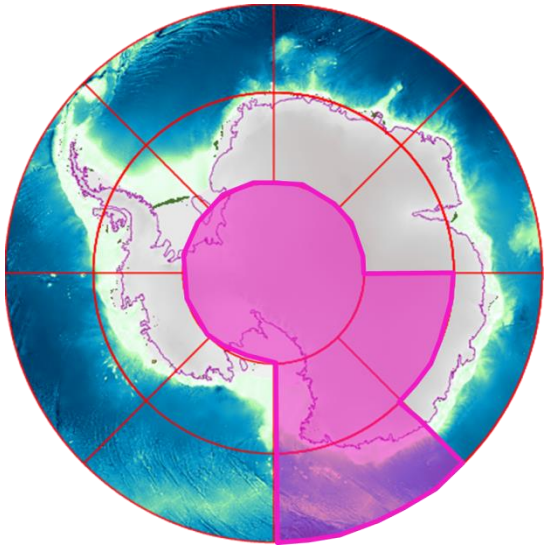


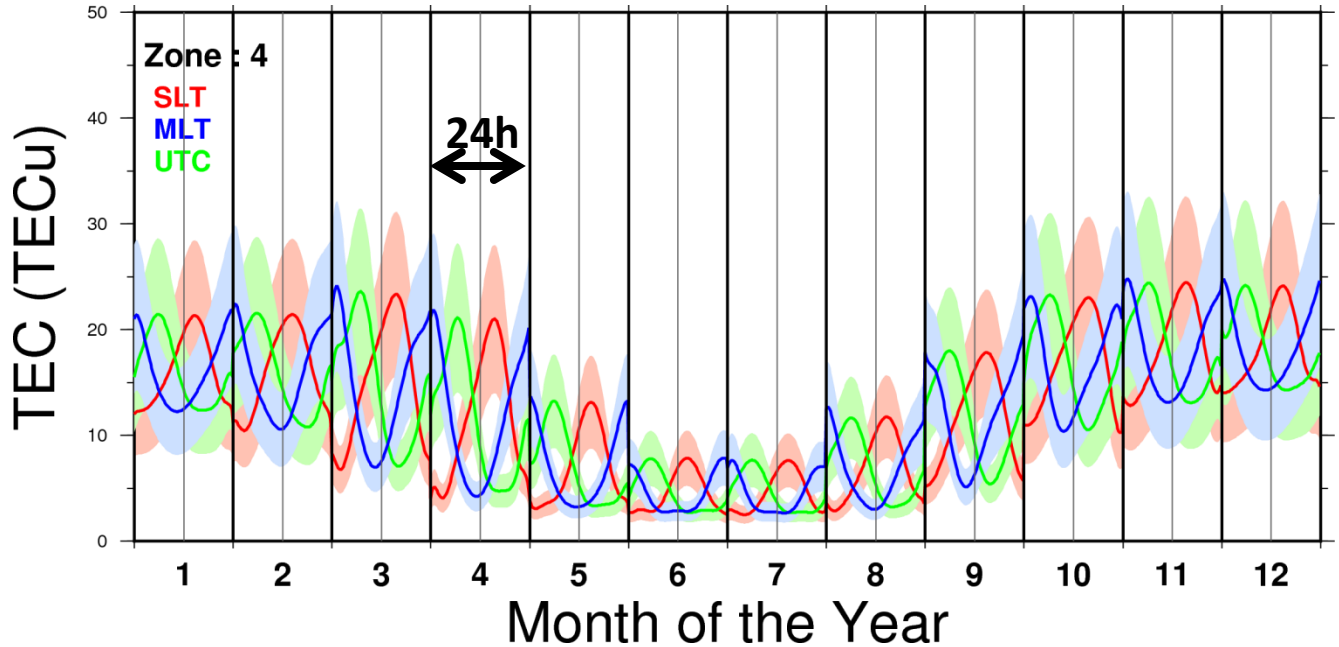


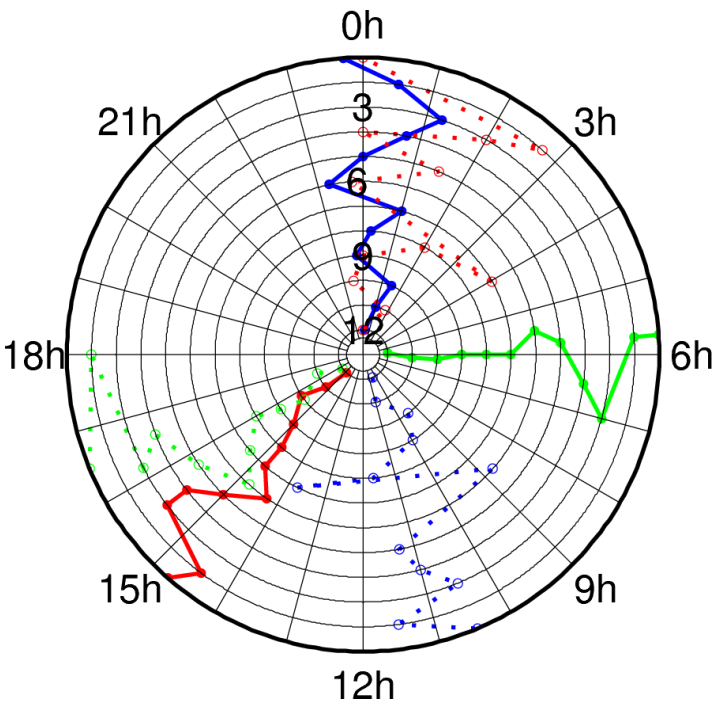


The maximum TEC occurs around 12:00 SLT, 16:00 MLT and 08:00 UTC with no significant variation w.r.t the month of the year.

Daily-TEC climatological patterns

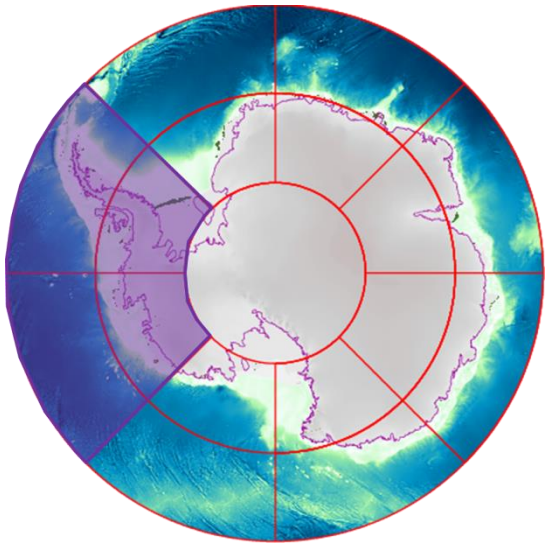


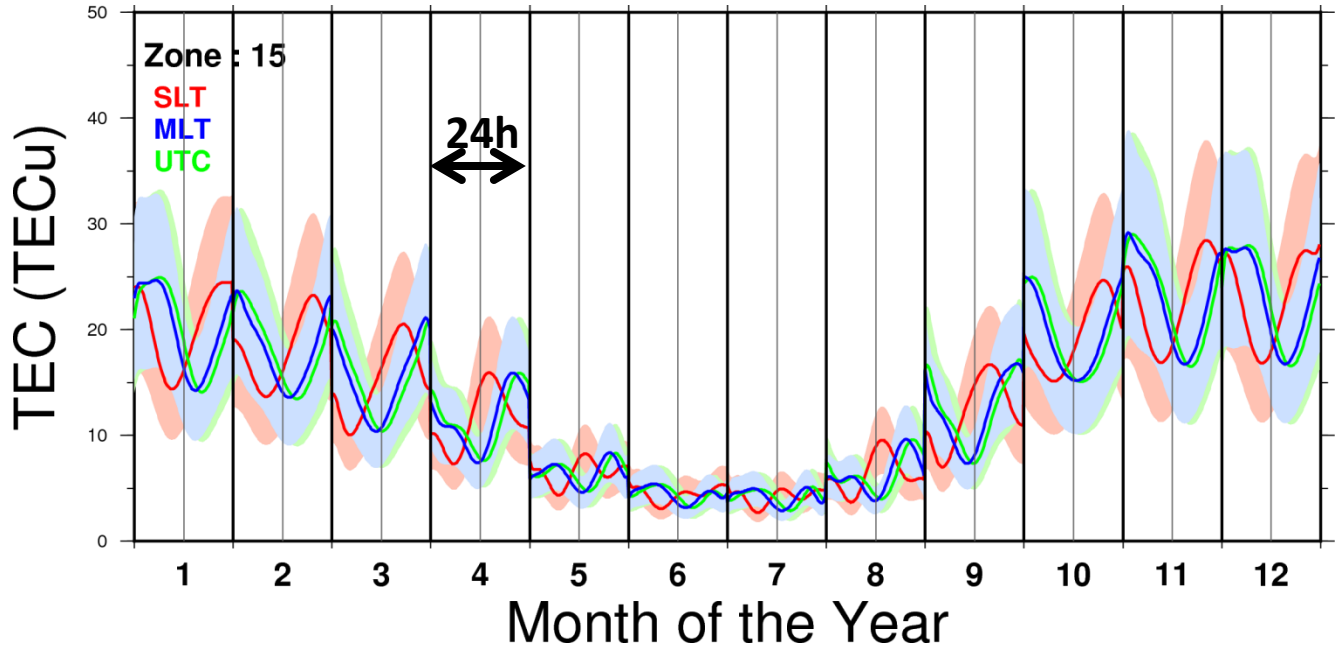


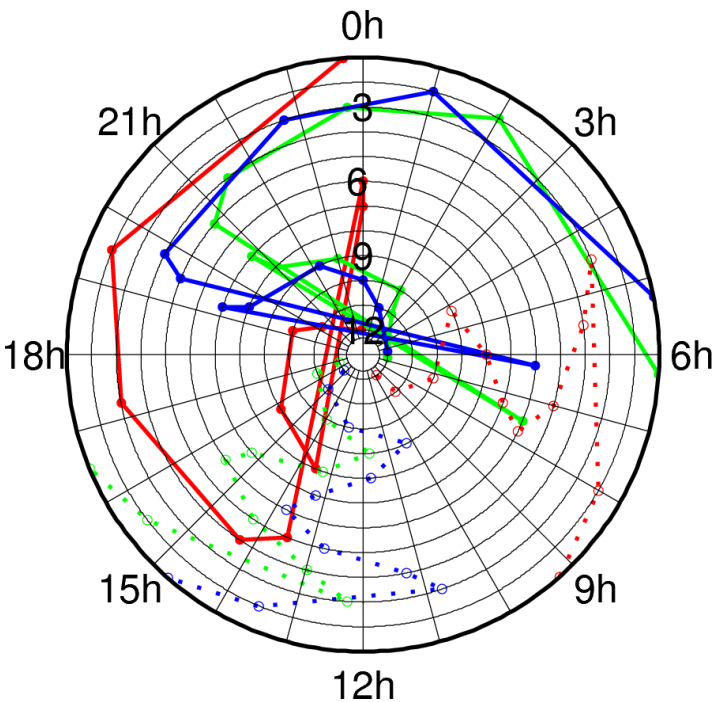


The maximum TEC is constant over the year and at 00:00 MLT showing a clear dependence w.r.t to the geomagnetic pole location. Maximum TEC is around 06:00 UTC and 15:00 SLT with no significant change the entire year. The minimum TEC hours are well separated from the maximum.

Daily-TEC climatological patterns







The maximum TEC is observed during the afternoon and evening for the three time definitions. This is due to the Weddell Sea Anomaly.

During the winter season SLT noon TEC maximum is present.

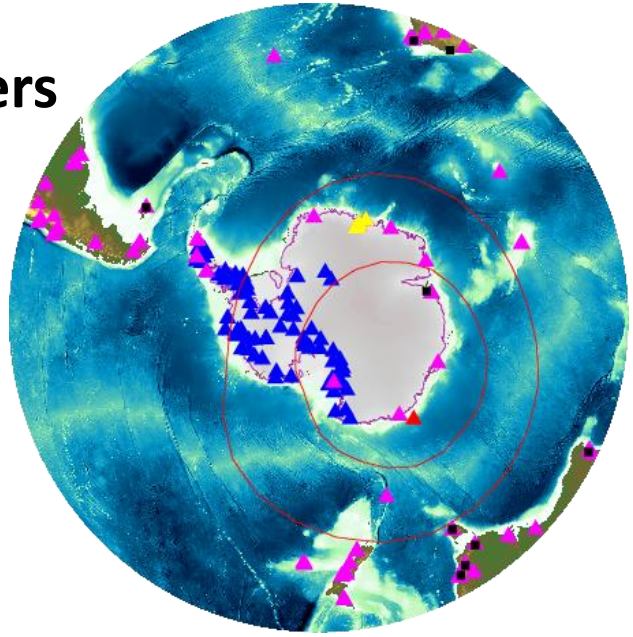
Conclusion and perspectives

From ionospheric-plasmaspheric TEC point of view

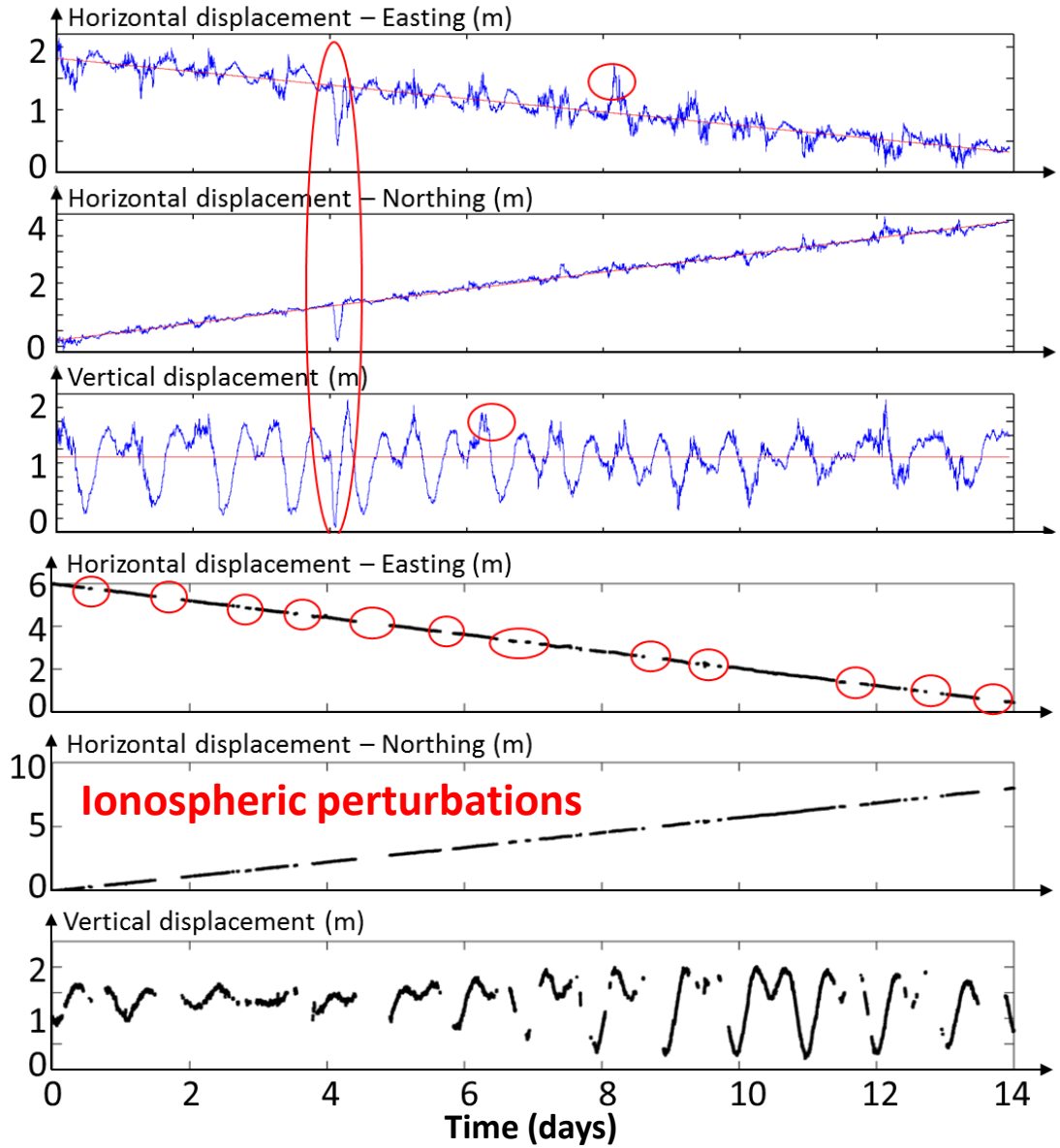
- **Important to maintain few high precision GNSS in North-East**
- **Complex and different behaviors of the TEC over the Antarctica**
  - **Separate ionospheric from plasmaspheric contribution**

From long-term perspective

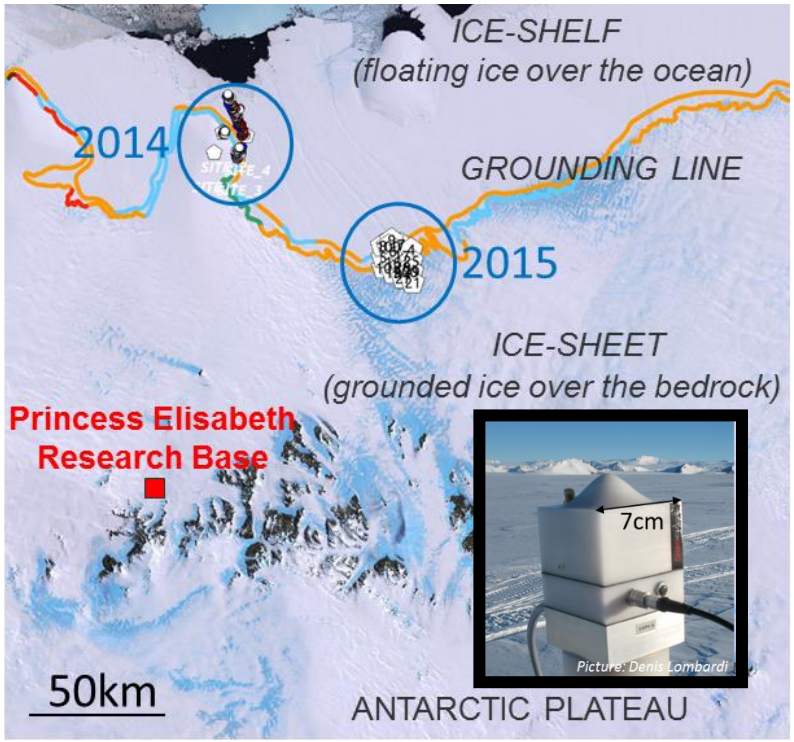
  - **Test such models on single frequency users**



Dense networks of single-frequency GPS receivers in North-East Antarctica ?



Courtesy: L. Benoit, D. Lombardi, C. Thom (IGN-ROB) – Lombardi et al. 2016



Ionospheric un-modelled electron content is the main obstacle to extend single-frequency GPS positioning from <1km to 1-10km baselines.

Conclusion and perspectives

From ionospheric-plasmaspheric TEC point of view

- **Important to maintain few high precision GNSS in North-East**
- **Complex and different behaviors of the TEC over the Antarctica**
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From long-term perspective

- **Test such models on single frequency users**
- **Single-frequency receivers need for more accurate TEC models !!**