Preliminary Study of Uncertainty Analysis of Ionosphere-Thermosphere Predictions

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Motivation

How does uncertainty within global models of ionosphere and thermosphere affect the results?

- External Forcing
  - solar flux F10.7
  - solar wind parameters: IMF clock angle

- Internal Parameter
  - O^+-O momentum transfer collision frequency: Burnside Factor (a ratio of the empirical to the theoretical frequencies).

Method

- Focus on the effects of the uncertainties on
  TEC (Total Electron Content) over North American Sector

CTIPE_0001 TEC 2013/03/17 19:30:00 UT

GPS TEC 2013/03/17 20:00:00 UT
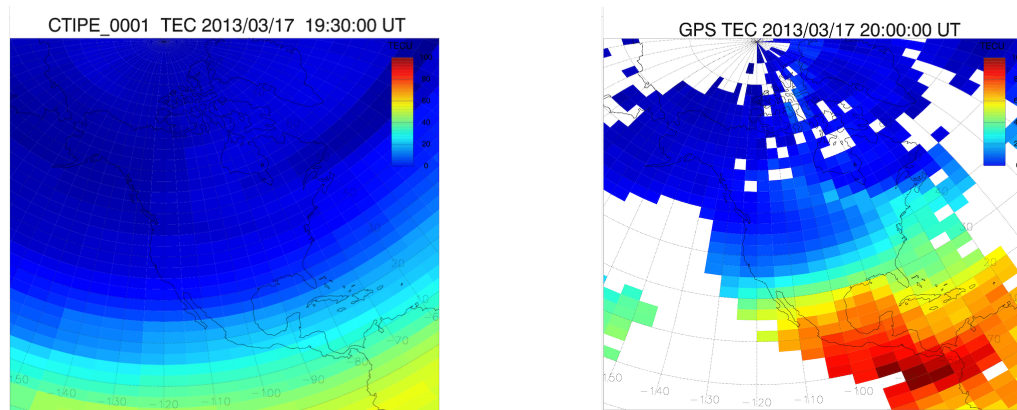
- Time interval:
  - 2013/03/16 00:00 UT - 03/18 23:55 UT (Dst_min = -132 nT)

- We used CTIPe (Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics Model) hosted at the CCMC.

Two Sets of Ensemble of CTIPe runs

- **Internal parameter**
    - o Burnside Factor (BF):

        12 runs (0.7 ≤ BF ≤ 1.8, with an increment of 0.1)

- **External drivers**
    - o F10.7:
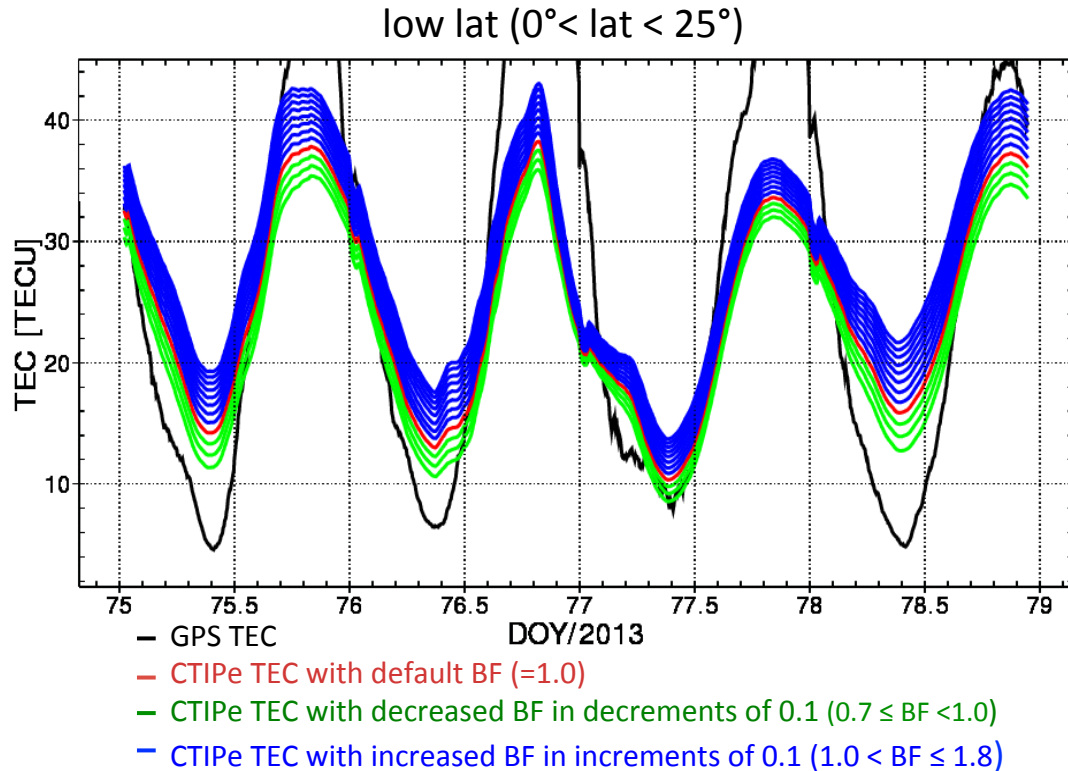
        15 runs (~80 < F10.7 < ~240, with an increment of 10)

    - o Solar wind parameters from
        - ENLIL prediction 40-hr in advance
        - adjusted ENLIL to ACE data after the event occurred
   - the parameters are obtained by SWRC/CCMC

        3 IMF clock angle simulations (90°, 135°, 180°)

Burnside Factor (BF) Ensemble

low lat (0°< lat < 25°)

- GPS TEC
- CTIPe TEC with default BF (=1.0)
- CTIPe TEC with decreased BF in decrements of 0.1 (0.7 ≤ BF <1.0)
- CTIPe TEC with increased BF in increments of 0.1 (1.0 < BF ≤ 1.8)

- BF ensemble has Standard Deviation (STD) of about 1.3 TECU, which is about 6% of the mean values.

Latitudinal Dependence of BF Ensemble
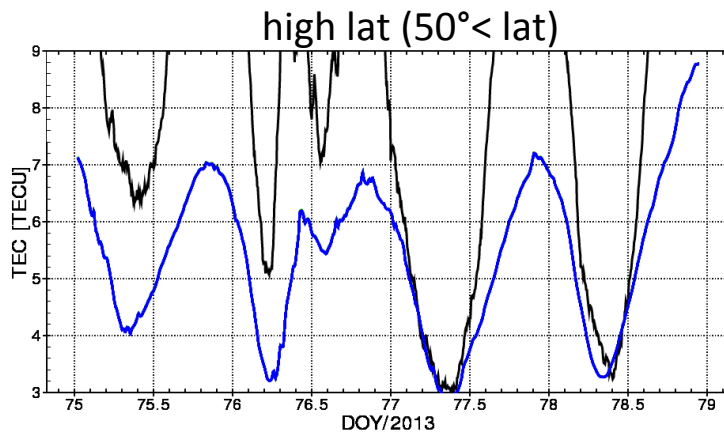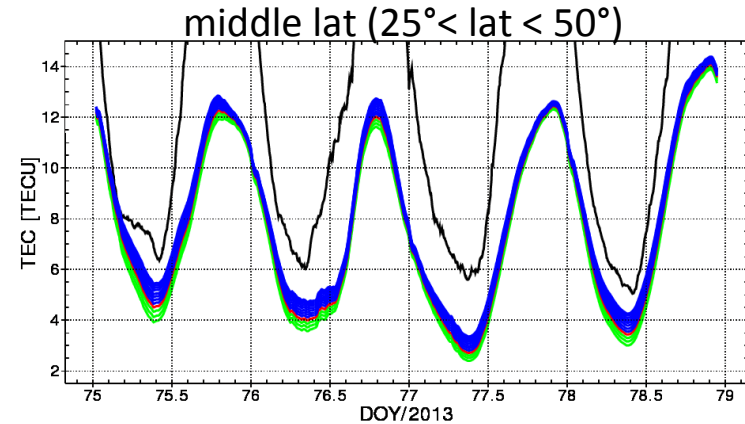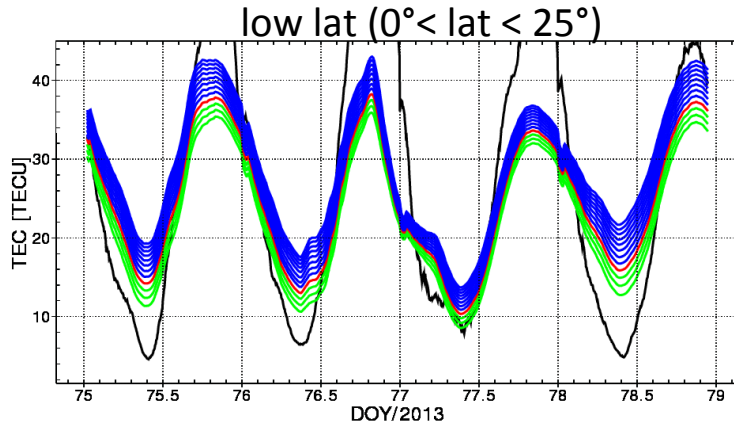
low lat (0° < lat < 25°)

middle lat (25° < lat < 50°)

high lat (50° < lat)

- GPS TEC
- CTIPe TEC with default BF (=1.0)
- CTIPe TEC with decreased BF in decrements of 0.1 (0.7 ≤ BF <1.0)
- CTIPe TEC with increased BF in increments of 0.1 (1.0 < BF ≤ 1.8)

- Uncertainty in Burnside Factor has larger impact on TEC in low latitude region than on TEC in higher latitude region.

F10.7 Ensemble

low lat (0°< lat < 25°)

- GPS TEC
- CTIPe TEC with measured F10.7
- CTIPe TEC with increased F10.7 in increments of 10
- CTIPe TEC with decreased F10.7 in increments of 10
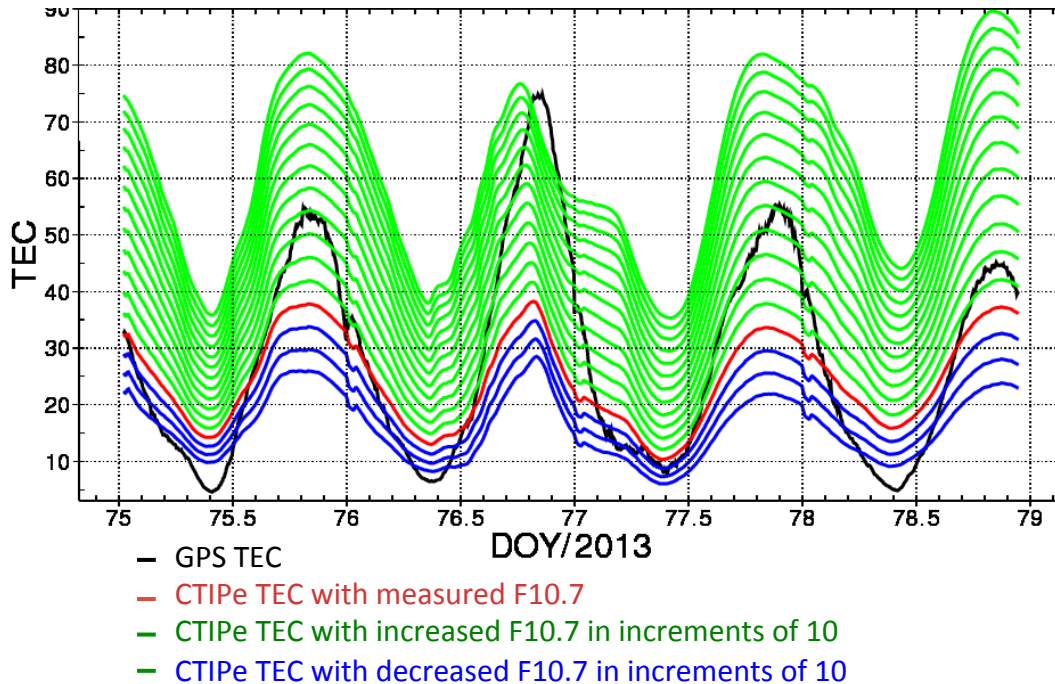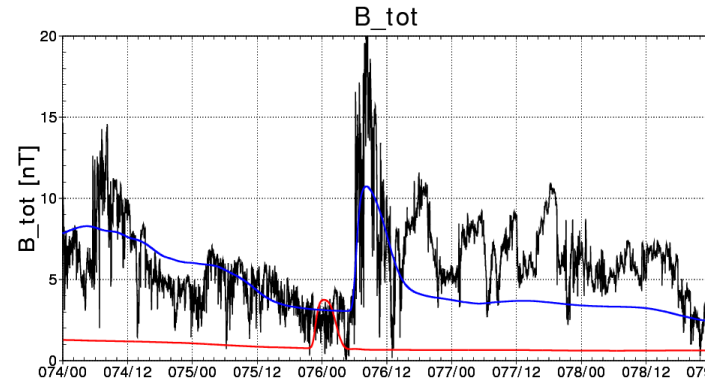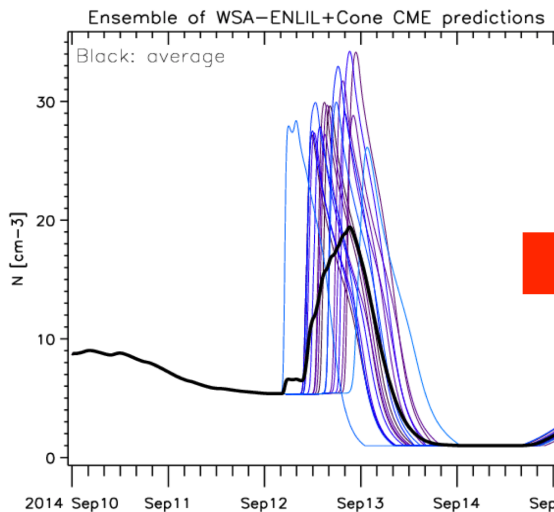
- Uncertainty in F10.7 has larger impact on TEC than uncertainty in BF.
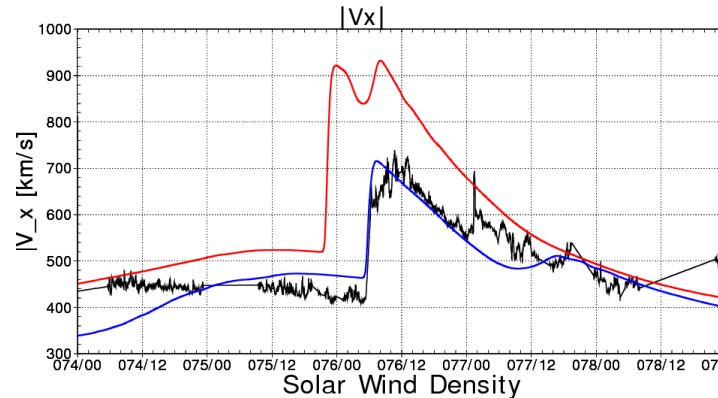
F10.7	Average of STD/MEAN		
	Low lat.	Middle lat.	High lat.
80 < F10.7 <120	21.4%	17.5%	15.3%
120 < F10.7 <180	19.2%	18%	14.6%
160 < F10.7 < 240	14.3%	15.6%	11.4%

Solar Wind Parameters
from Ensemble of WSA+ENLIL+Cone Model runs
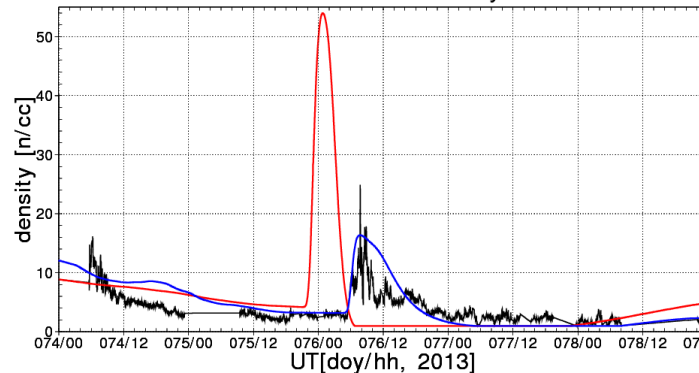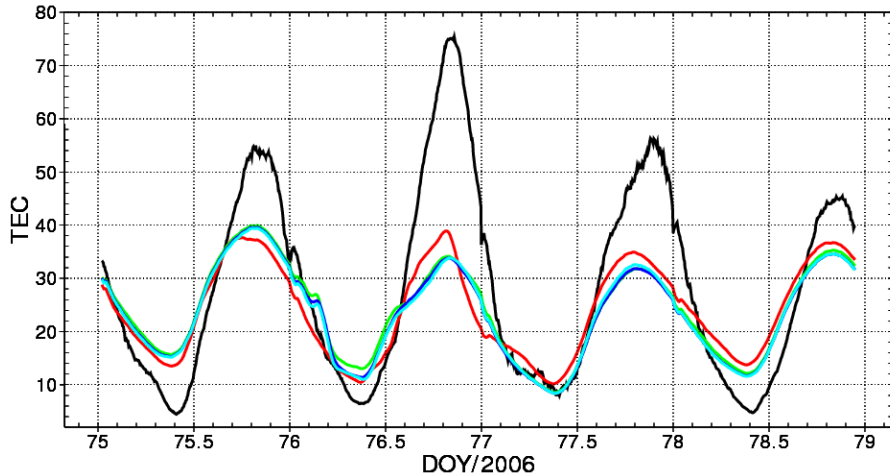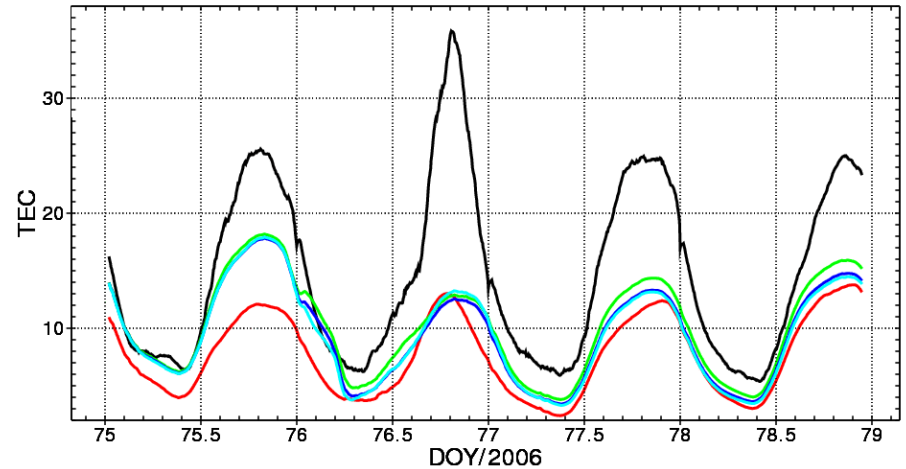

IMF Clock angle
ensemble of
CTIPe runs:
90°, 135°, and 180°

IMF Clock Angle Ensemble
w/ Predicted Solar Wind Parameters

low lat (0°< lat < 25°)

middle lat (25°< lat < 50°)
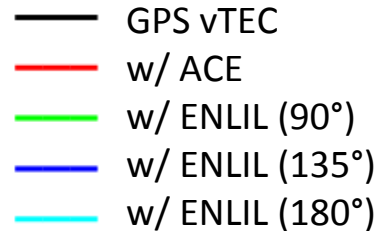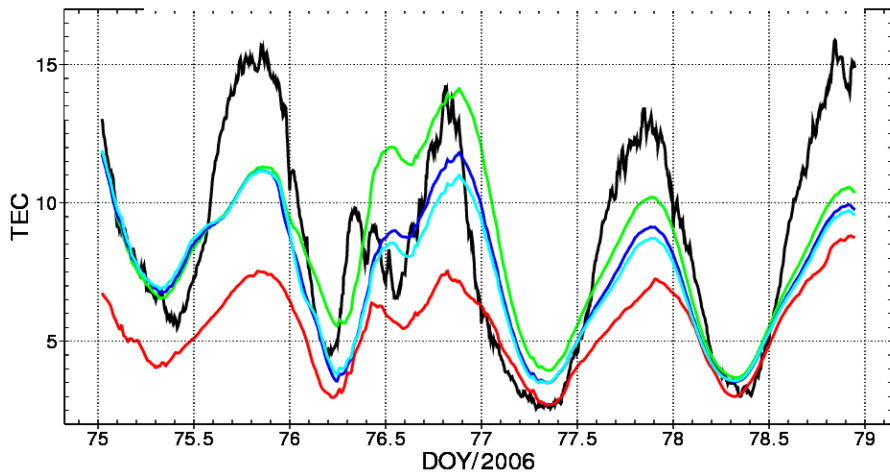
high lat (50°< lat)

- GPS vTEC
- w/ ACE
- w/ ENLIL (90°)
- w/ ENLIL (135°)
- w/ ENLIL (180°)

- Uncertainty in TEC due to IMF clock angle uncertainty is larger in high latitudes during the main phase.

IMF Clock Angle Ensemble
w/ Adjusted Solar Wind Parameters

low lat (0°< lat < 25°)

middle lat (25°< lat < 50°)

high lat (50°< lat)

Legend:
- GPS vTEC (black)
- w/ ACE (red)
- w/ ENLIL (90°) (green)
- w/ ENLIL (135°) (blue)
- w/ ENLIL (180°) (cyan)
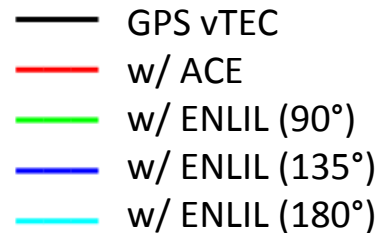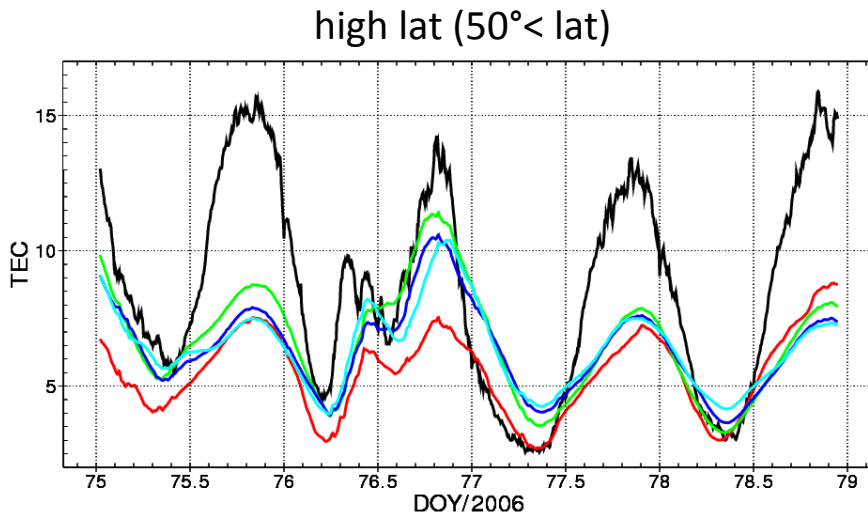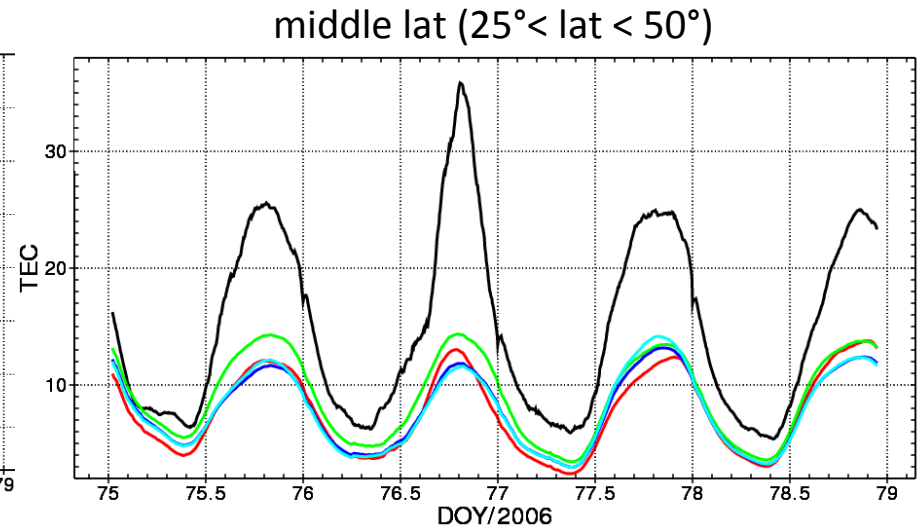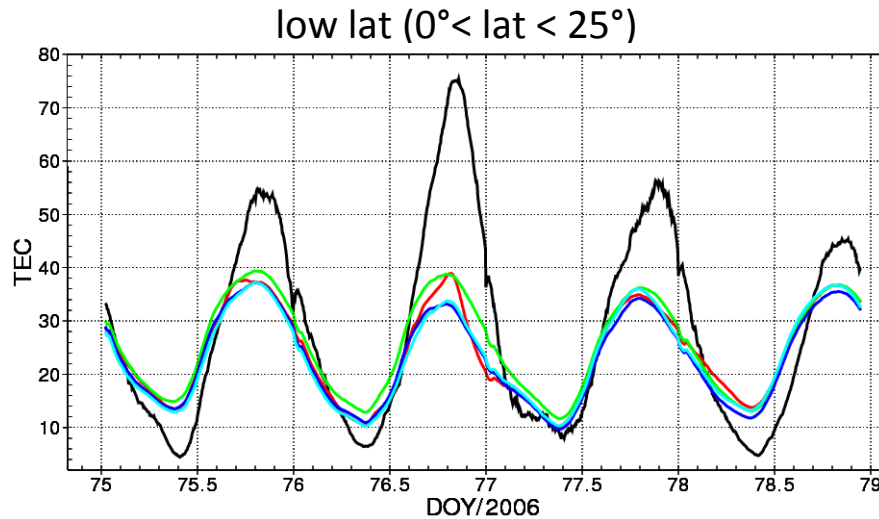
- Uncertainty in TEC due to IMF clock angle uncertainty is larger in low and middle latitudes during the main phase.

Summary

- Uncertainty in O^+ - O collision frequency (0.7 < Burnside Factor < 1.8)
  - has larger impact on TEC in low latitude region than on TEC in higher latitude region.

- Uncertainty in F10.7 (about 80 < F10.7 < 230)
  - has also larger impact on TEC in low latitude region than on TEC in higher latitude region.
  - has larger impact than uncertainty in BF.

- Uncertainty in IMF clock angle (w/ predicted solar wind parameters) has larger impact on TEC in high latitude region during the main phase, while opposite holds true for IMF clock angle ensemble (w/ adjusted solar wind parameters).

- TEC simulations with adjusted solar winds are more close to the results obtained with ACE level 2 data than those of the TEC simulations with predicted solar winds.