Quantifying Ionospheric TEC Forecasts for High-Speed-Stream Events

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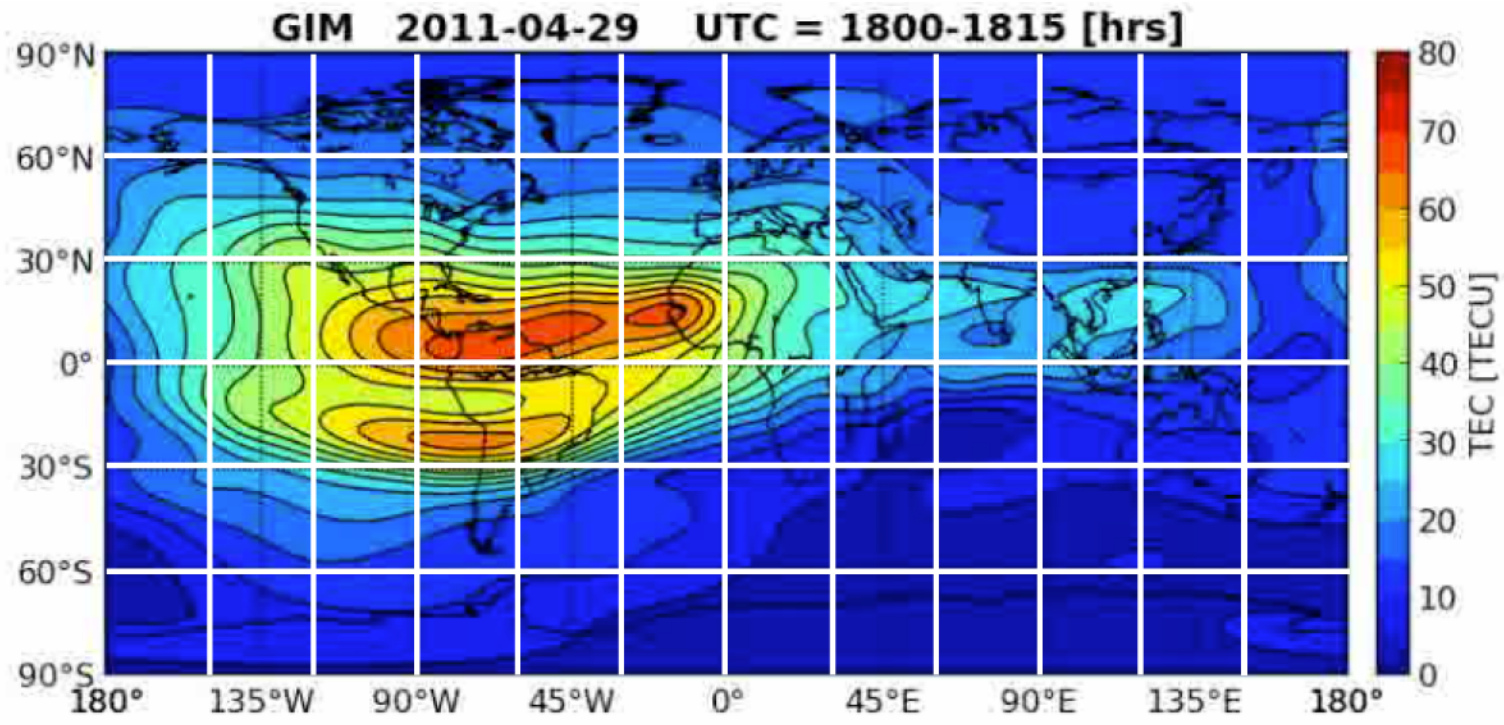
Motivation

- Quantitatively identify TEC changes during HSS events
- Characterize HSS storm effects in different local regions and during different times
- Preliminary experiments towards ionospheric space weather forecasting products

Method

A typical TEC map from Global Ionospheric Maps (GIM)



- **Step 1**: Divide the globe into longitude-latitude grids of size 30° x 30°

Method

- **Step 2**: Find several quiet days just before the HSS storm of interest. Criterion of a quiet day: daily Ap < 6

- **Step 3**: Compute the mean TEC within each grid for all universal times on both quiet and storm days.

- **Step 4**: Compute quiet time mean-TEC averages and standard deviations. For example, with 7 quiet days:

$$\overline{TEC}_{quiet}(UT, lon, lat) = \left(\sum_{iday=1}^{7} TEC_{quiet,iday}(UT, lon, lat) \right) /7$$

$$\sigma_{TEC,quiet}(UT, lon, lat) = \sqrt{\left[\sum_{iday=1}^{7} \left(TEC_{quiet,iday}(UT, lon, lat) - \overline{TEC}_{quiet}(UT, lon, lat) \right)^2 \right] /7}$$

- **Step 5**: For each day, define and calculate TEC perturbations as

$$dTEC(UT, lon, lat) = \frac{TEC(UT, lon, lat) - \overline{TEC}_{quiet}(UT, lon, lat)}{\sigma_{TEC,quiet}(UT, lon, lat)}$$

Method

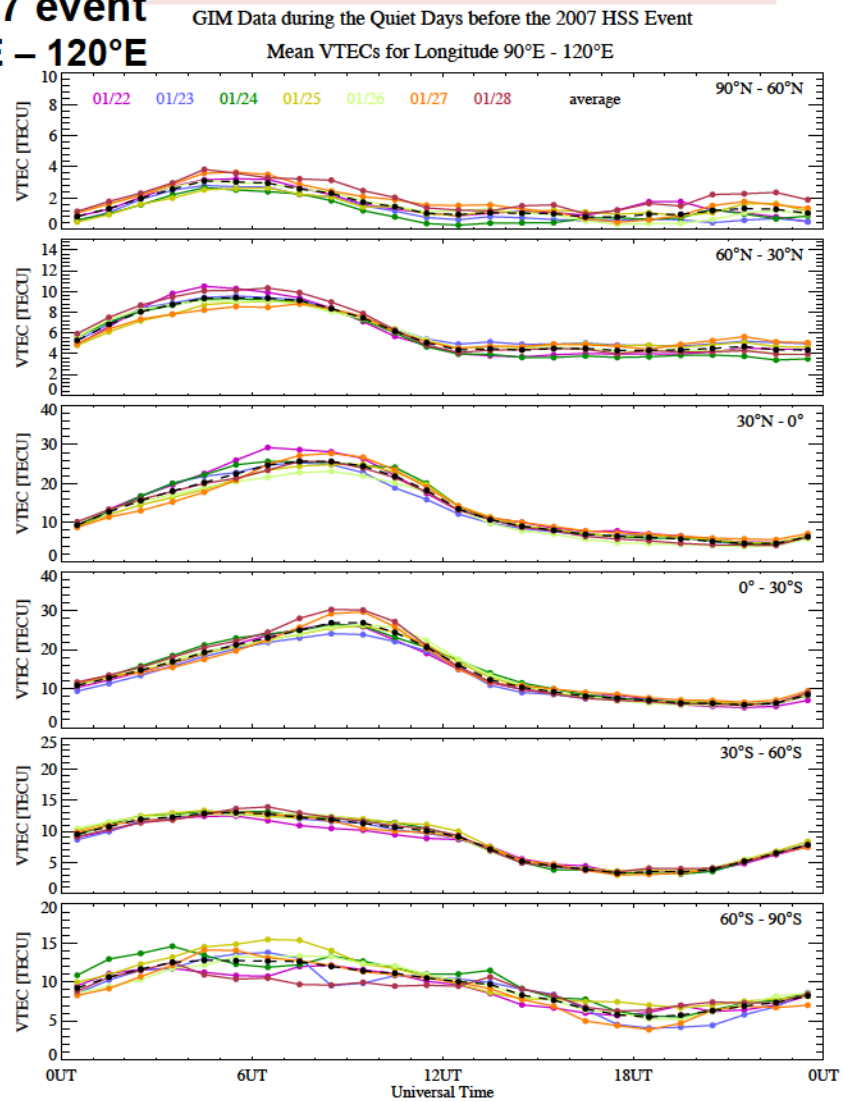
- **4 HSS events studied**
  1. January 2007
  2. April – May 2011
  3. May 2012
  4. June 2012

- **TEC maps from**
  - GIM data: hourly-averaged, 24 maps per day
  - Weimer-driven Global Ionosphere-Thermosphere Model (GITM) simulations: one map every hour, from 0UT to 23UT, 24 maps per day

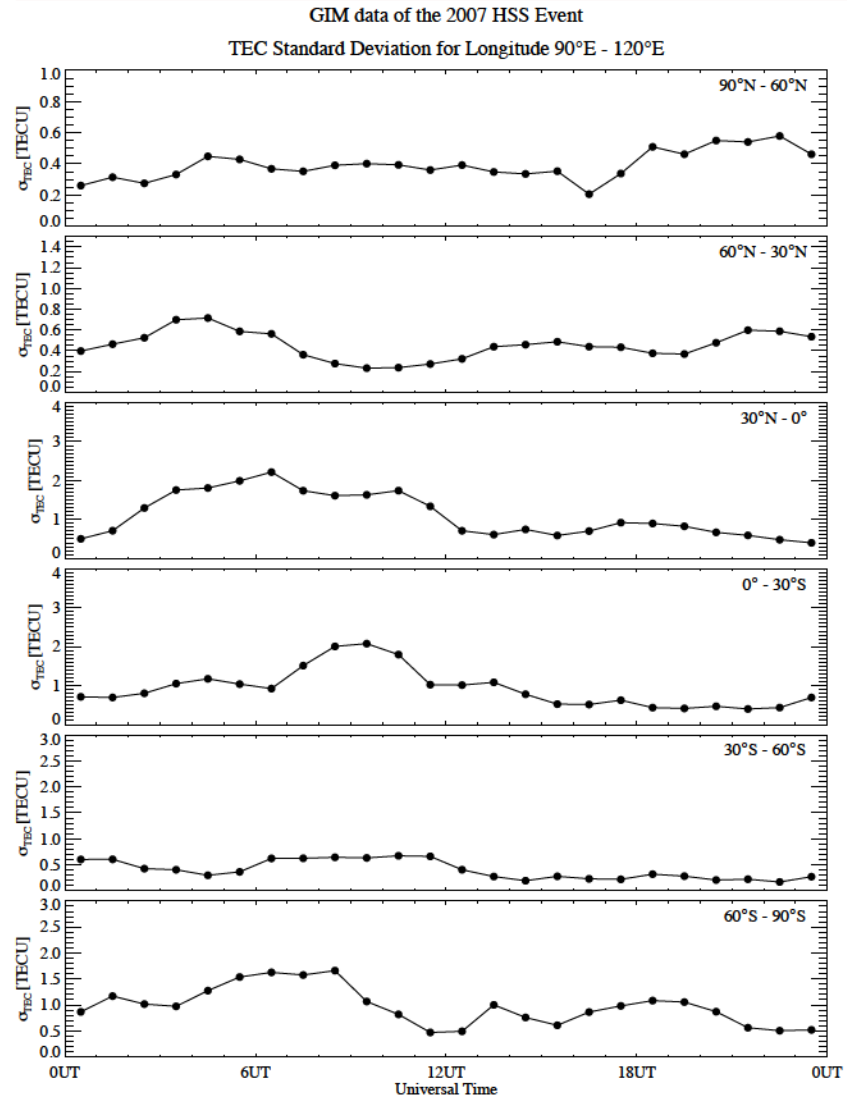
Results -- GIM

2007 event
90°E – 120°E

Quiet time mean-TEC averages



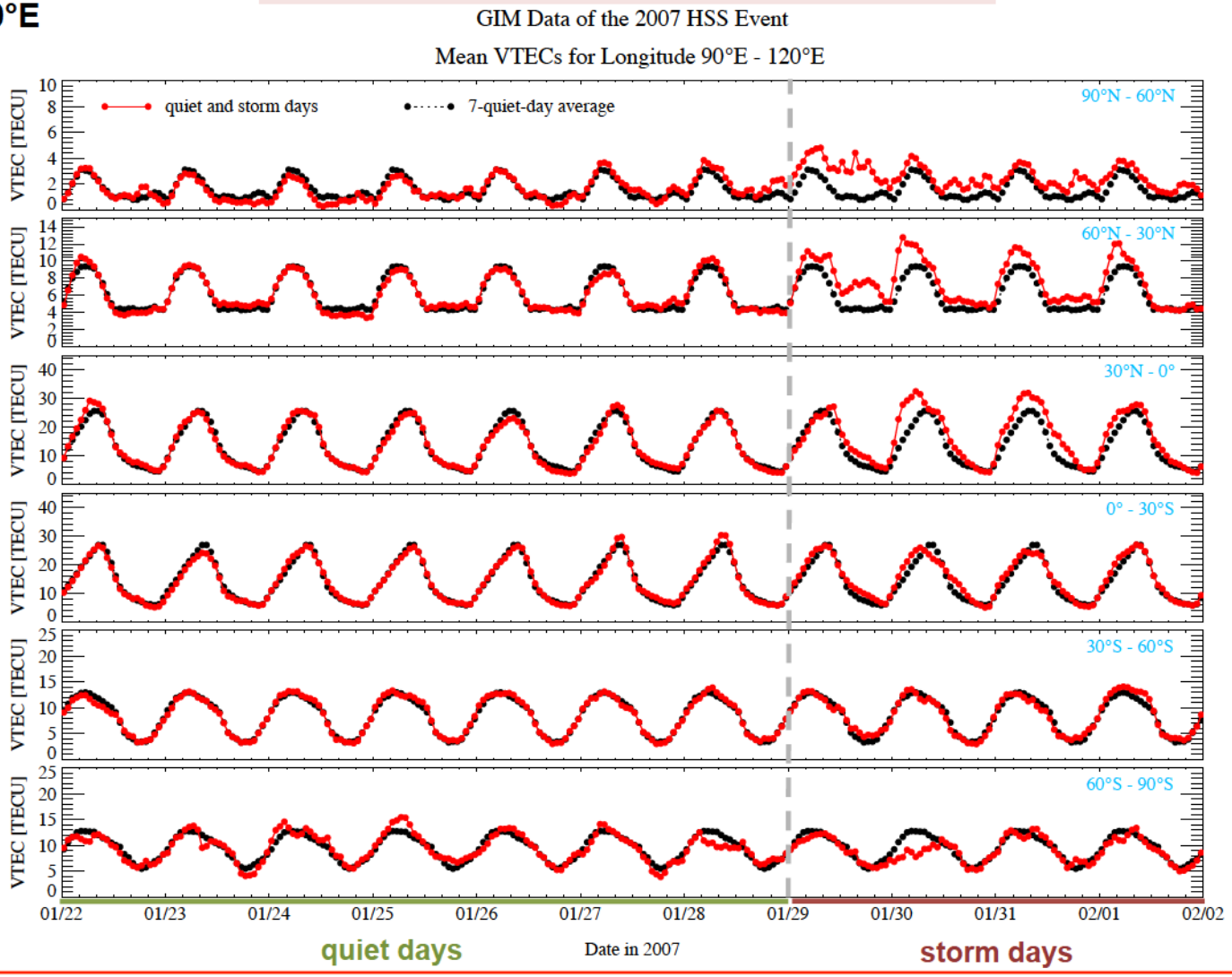
Quiet time mean-TEC standard deviations



Results -- GIM

2007 event
90°E – 120°E

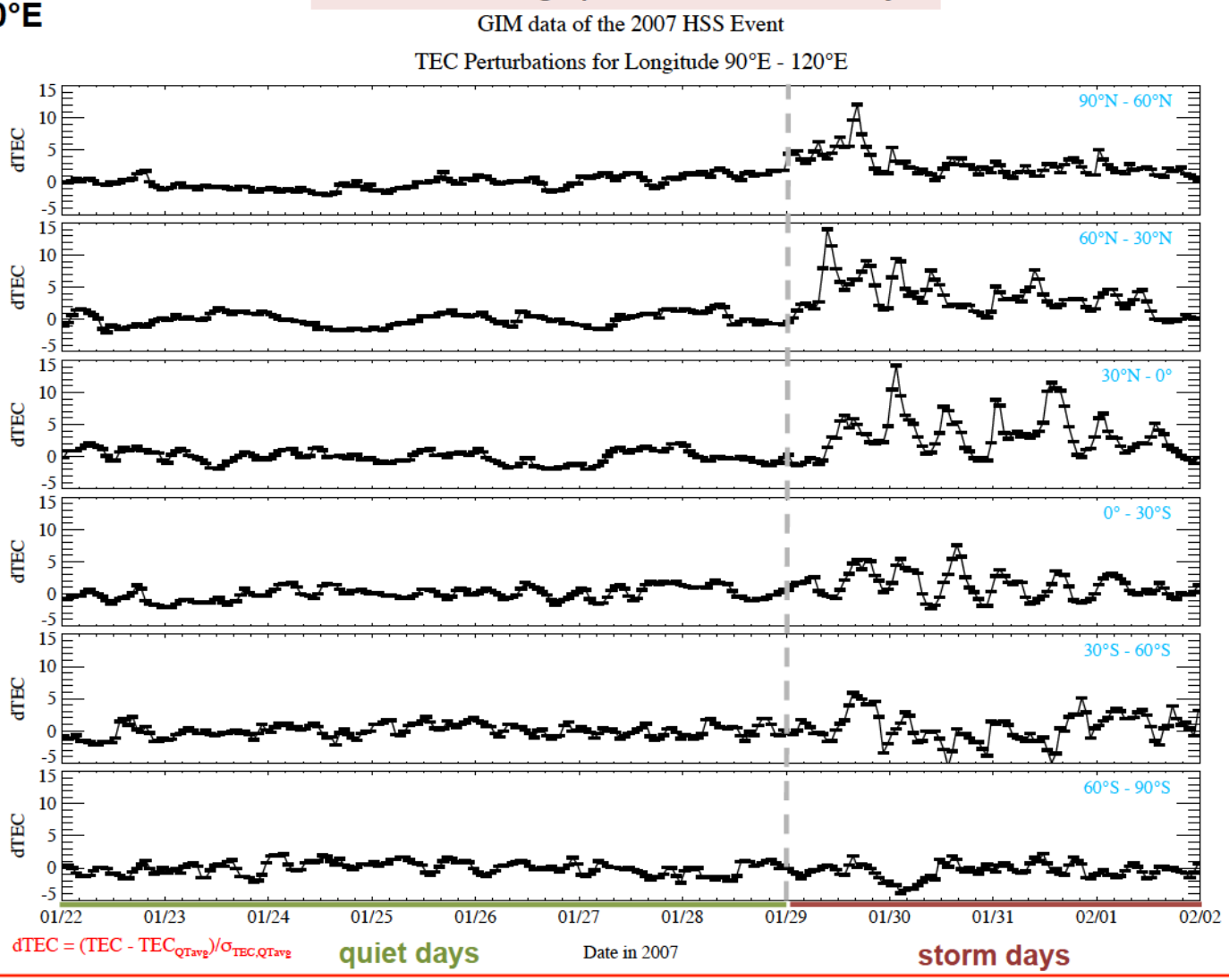
Mean TECs during quiet and storm days



Results -- GIM

2007 event
90°E – 120°E

dTEC during quiet and storm days



Results -- GIM

2007 event

dTEC maps

dTEC > 8

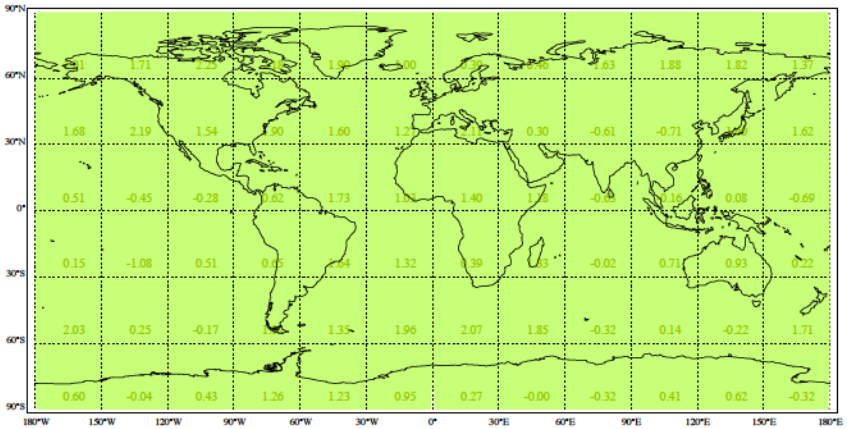
dTEC < -8

4 < dTEC < 8

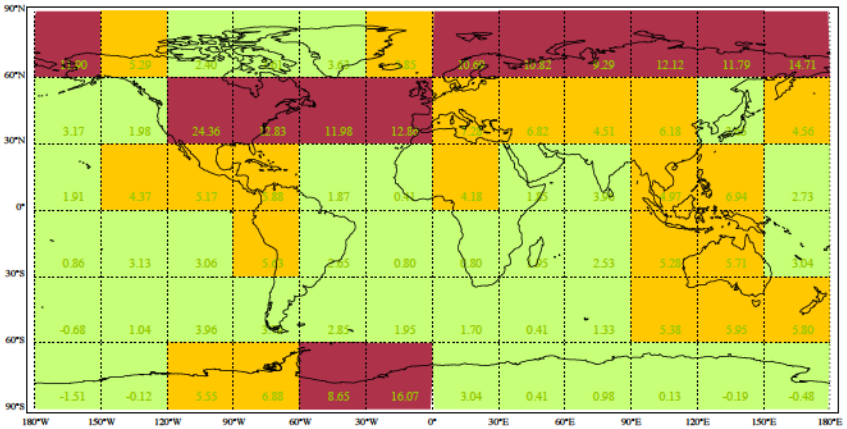
-8 < dTEC < -4

before the storm

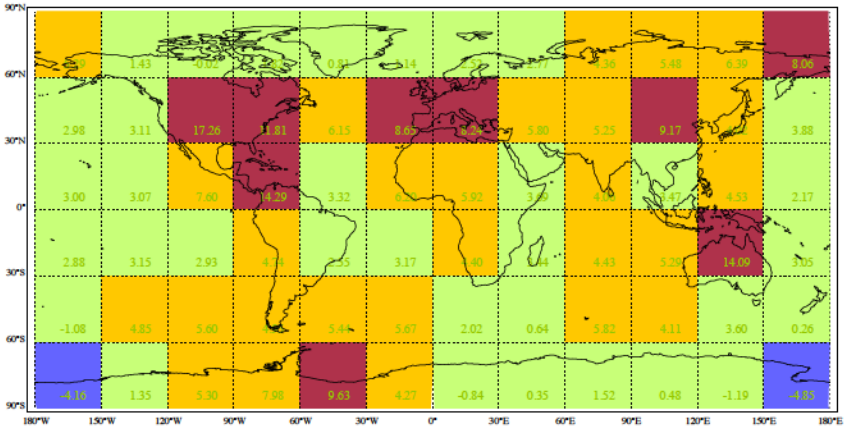
20070128 23UT – 20070129 00UT



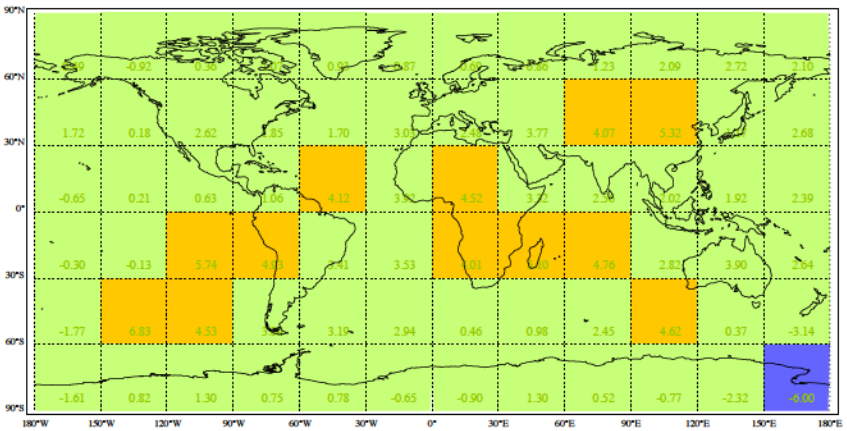
20070129 16UT – 17UT



20070129 18UT – 19UT



20070129 20UT – 21UT

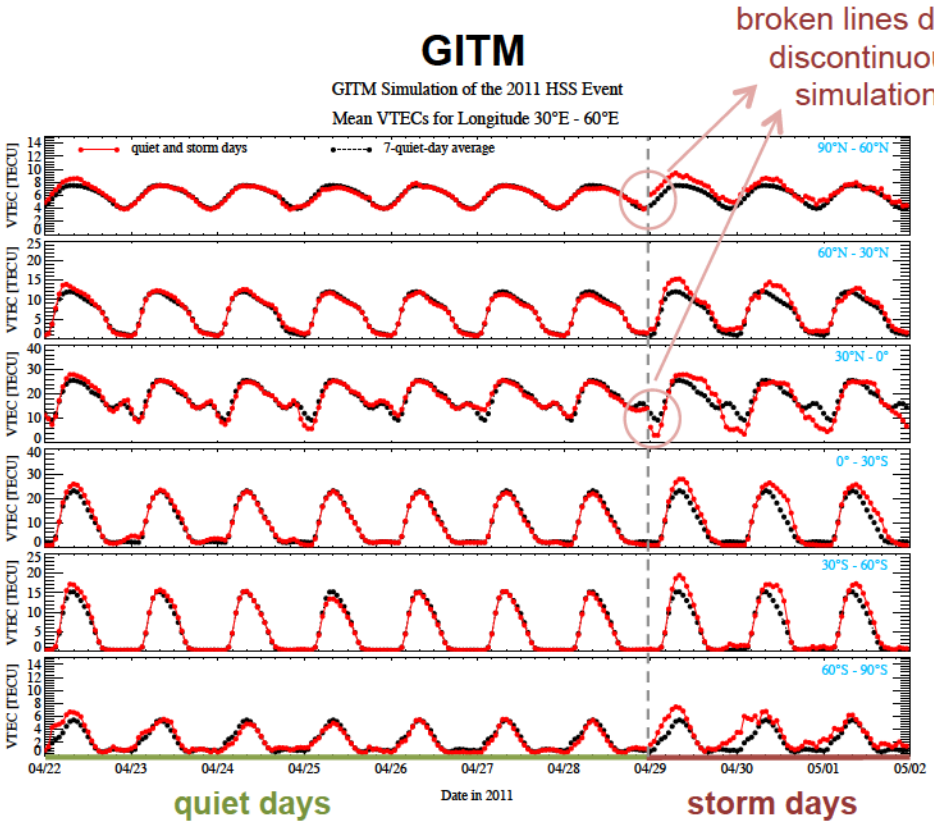


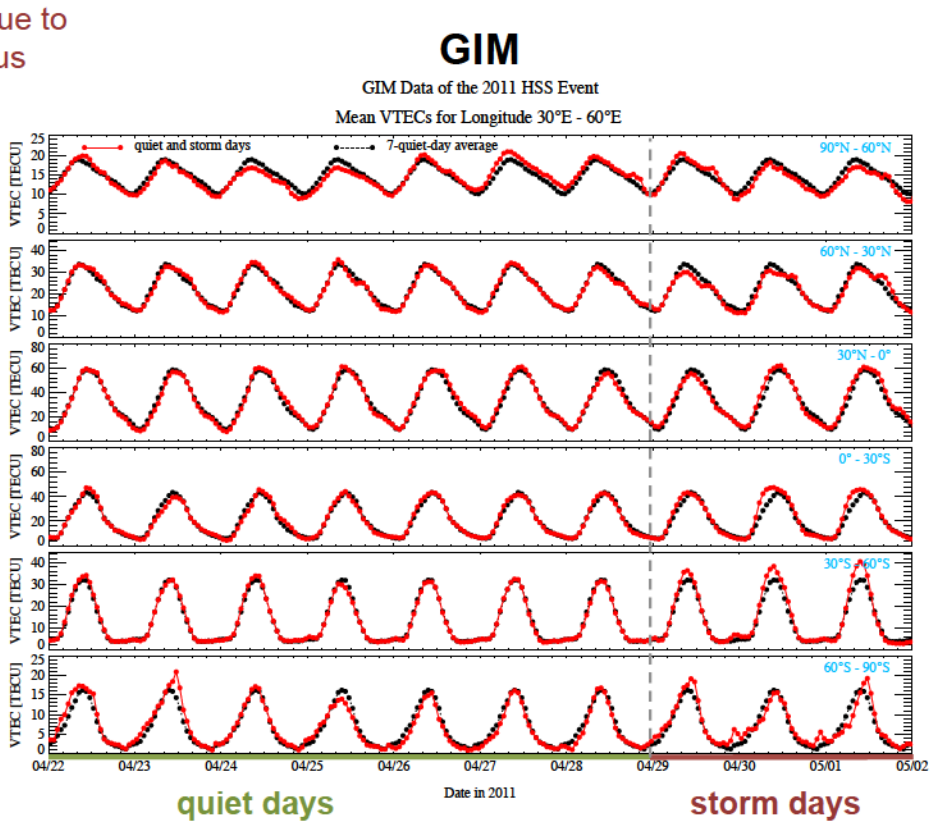
Results – GITM vs GIM

2011 event
30°E – 60°E

Mean TECs during quiet and storm days

broken lines due to discontinuous simulation



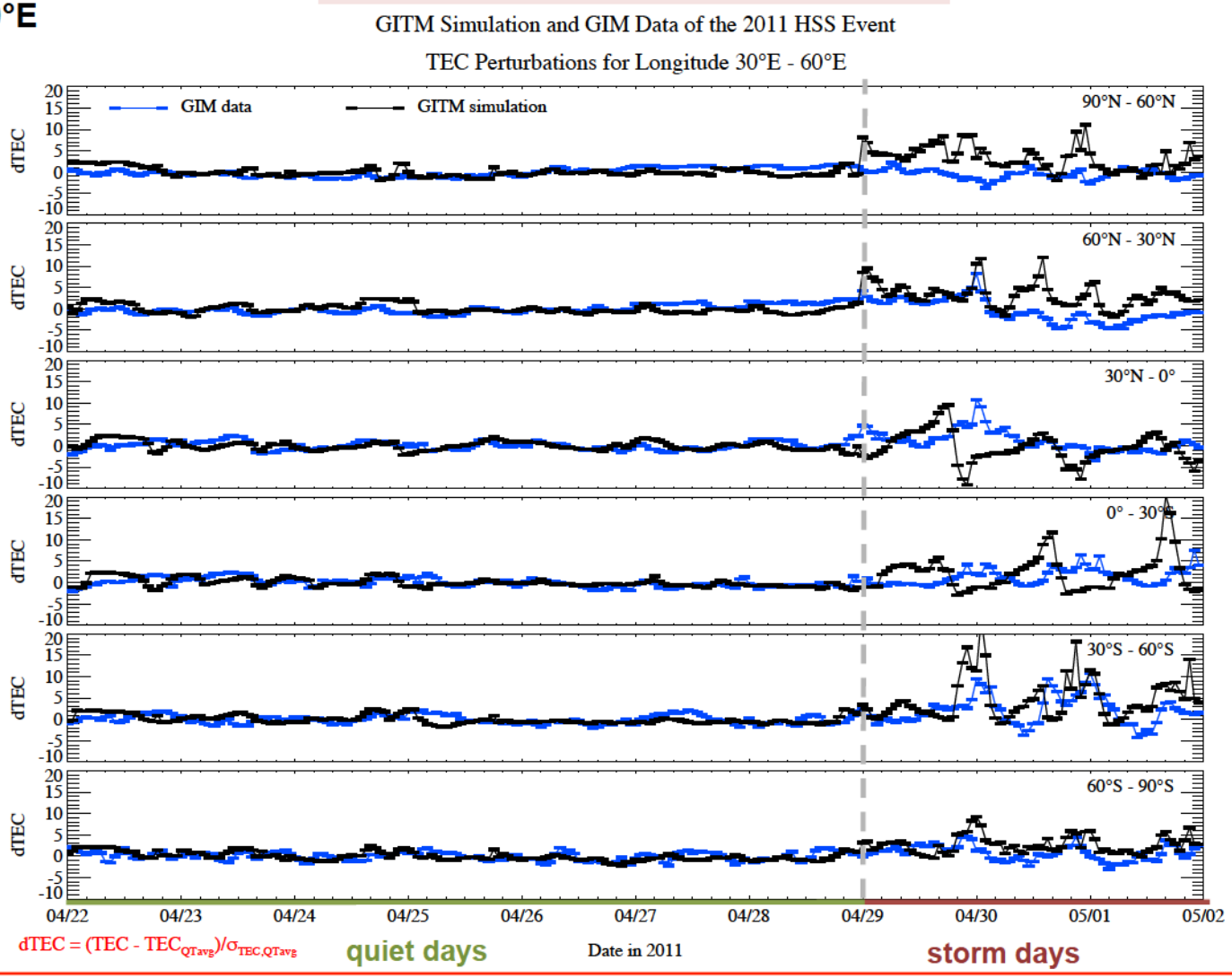


Note: GITM has an altitude limit, therefore the simulated TECs are smaller than the GIM data.

Results – GITM vs GIM

2011 event
30°E – 60°E

dTEC during quiet and storm days



$dTEC = (TEC - TEC_{QTavg})/\sigma_{TEC,QTavg}$

Summary

- Our methodology, including the $dTEC$ we defined, seems capable of quantifying ionospheric TEC changes due to HSS events.
- The GITM results are very different from the GIM results.
- GITM is sensitive to pre-history conditions. It would be better to run continuously from quiet days into storm days.