Summary for Ionospheric Group

Four Working Teams:

- **Ionosphere Plasma Density**
- **Global & Regional TEC**
- **Scintillation**
- **Neutral Density and Orbit Determination at LEO**

Overview of the progress

- **Need of different metrics for science and applications**

- Impact of the selection of the **background conditions** on storm time metrics

- Aware of impact of **uncertainties** in ionospheric/thermospheric observations on metrics (e.g, biases in the data, plasmaspheric contribution)

Selection of Time Intervals

Time Intervals: Selection was mainly based on data availability

→ Proposed to study entire year 2012

→ Understand quiet times

→ Understand importance of background conditions

→ Proposed Storm Events

Date	Min Dst (nT)
29 March – 3 April 2001	-387
18 - 31 July 2004	-99 -126 -170
14 - 16 May 2005	-247
8 - 11 March2012	-74 -131
16 - 20 March 2013	-132
31 May – 4 June 2013	-119
21 - 24 June 2015	-204

Proposed metrics for Ionosphere Plasma Density

Physical quantities: foF2/NmF2, hmF2, vTEC, MUF

Location: High, Middle and Low latitudes (Northern and Southern Hemisphere)

Time: Different Local Time sectors (e.g., 03-09 LT; 09-15 LT; 15-21 LT; 21-03 LT)

Data: Ionosondes, Incoherent Scatter Radars (ISRs), GNSS receivers, Radio occultation data

Time resolution: 15 min

Proposed metrics for Ionosphere Plasma Density

Metrics:

Complementary analysis of a set of metrics [e.g., RMSE, ME, MAE, Correlation Coefficient]

For each physical quantity, the metrics will be calculated to **measure ability to model**:

- Climatological variations
- Day-to-day variability
- Storm impact (deviation from climatological estimates over storm events)

Metrics for Global and Regional TEC

Physical quantities:

Scientific Metrics: vertical TEC, slant TEC

We will follow past measures for metrics (etc., RMSE, NRMSE, Ratio of the modeled to observed maximum increase (Yield))

Operational Metrics: Position Error for GNSS Users

-> Errors in TEC affect single frequency GNSS positioning

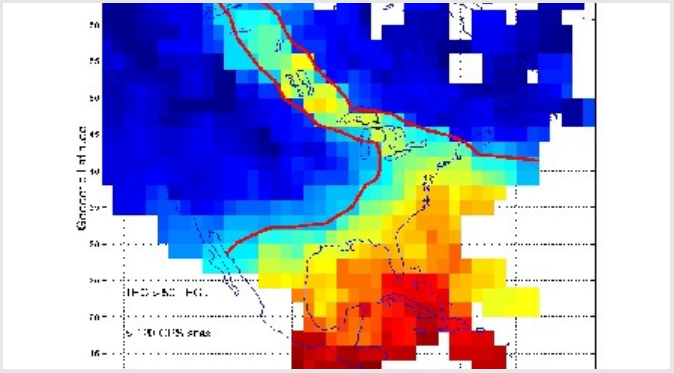
Data: TEC measurements from the global network of GNSS ground receivers

Time resolution: 15 min

Metrics for TEC Gradients

We propose to included TEC gradients in out metric study

Initial focus on mid-latitude



We will use cross correlation measures

We propose to explore the use of new index G55:

G55 will be calculated as the maximum absolute zonal TEC gradient at 55° magnetic latitude.

G55 Index will be calculated every 15 minutes on a 1° grid

Advantage of this index is that it is largely ignorant of biases but captures dynamical response due to storms!

Metrics for Scintillation Model Validation

- Discussion about **user needs**
  - The end users would like to know where and when their signals will be safe
- Discussion about the **weakness and strength** of the current model performances
  - Reproduce the climatology scintillation distributions fairly well
  - Have problem in reproducing the day-to-day variability
- Way forward to **improve** the current model prediction capability
  - Fair **estimation of the drivers** is essential
  - More **ground-based observations** are required

Metrics for Scintillation Model Validation

- What is the onset time of scintillation activity?
- What is the maximum/peak value of the scintillation index?
- What is the duration of scintillation activity (above a certain S4-index level?
- What is the spatial (latitudinally and longitudinally) variability of scintillation activity?

Data Sources

- GNSS receivers / S4 index and ROTI
- UHF/VHF receivers
- LEO satellite in-situ density

Proposed Neutral Density Metrics

Physical Quantities:

- Neutral density in the altitude range 200 – 800 km

Data Sources:

- Accelerometer/GPS measurements by CHAMP/GRACE/GOCE/SWARM
- Global mean neutral density survey by John Emmert
- Daily mean density @800km from Starlette and Stella
  - Standard versions to be provided by Doornbos, Bruinsma, & Emmert

Study intervals:

- Proposed Years:
  - 2002, 2007, 2012
- Storms from list adopted by ionosphere group
- USAF "problem storms" from 2005

Spatial / Temporal resolution:

- Comparisons at a *range of scales*:
  - Daily mean
  - Orbit averaged
  - Model sampled at satellite locations, binned 5° along track

Proposed Neutral Density Metrics

Bias Adjustments:

- Baseline metrics performed on data and model output without normalization
- For storm response studies, additional metrics with pre-storm bias normalized

For comparison with accelerometer data:

- Compute Observed/Modeled at full measured resolution
- Calculate mean, standard deviation, and correlation coefficient for:
  - Model sampled at satellite locations, binned 5° along track
  - Orbit averaged for satellite orbits
  - Daily mean

For comparison with Emmert global mean daily data and Starlette/Stella data:

- Compute model global mean daily mean
- Calculate mean, standard deviation, and correlation coefficient of time series

For storm studies:

- Perform statistics without and with pre-storm bias normalization

Future Plans

- Presentation of the results in conferences and workshops (EGU, IES2017, CEDAR, IAUS, ESWW14)