# New Developments in GNSS Support at SWPC

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# Outline

ICAO
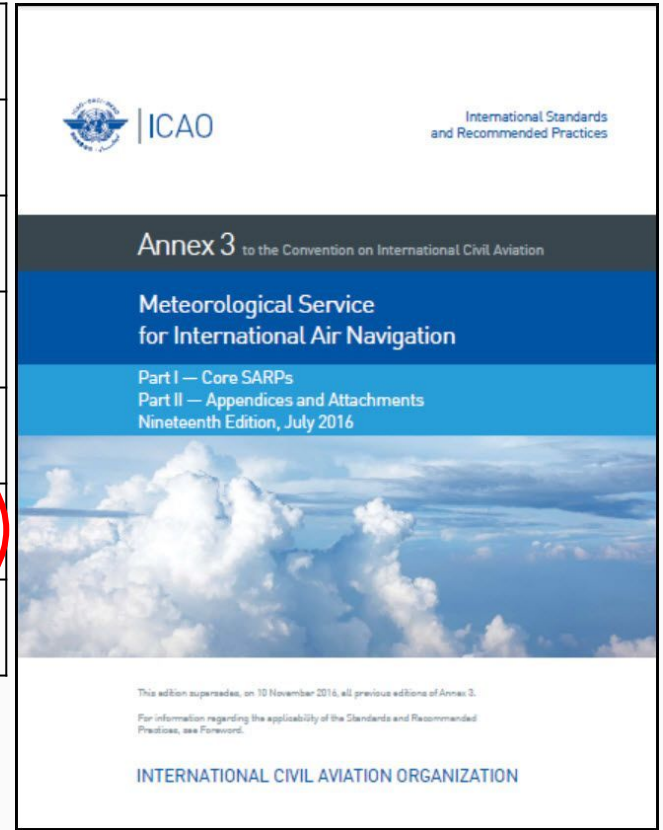
CWDP

CTIPe

WAM-IPE

# ICAO Products

| | | |
|---|---|---|
| **HF/Ionosphere** | Kp-index<br>- Mod: 8<br>- Sev: 9 | |
| | dB from 30 MHz riometer data<br>- Mod: 1.5 dayside<br>- Sev: 2.0 dayside | |
| | X-ray flux (0.1-0.8 nm)<br>- Mod: 1x10^-4 W/m2<br>- Sev: 1x10^-3 W/m2 | |
| | MUF depression<br>- Mod: 20%<br>- Sev: 30% | |
| **GNSS** | Amplitude Scintillation (S4) (dimensionless)<br>- Mod: 0.5<br>- Sev: 0.8 | |
| | Phase Scintillation (Sigma-Phi) (radians)<br>- Mod: 0.4<br>- Sev: 0.7 | |
| | Total Electron Content (TEC)<br>- Mod: 125 TEC units<br>- Sev: 175 TEC units | |

ICAO
International Standards
and Recommended Practices

Annex 3 to the Convention on International Civil Aviation

Meteorological Service
for International Air Navigation

Part I — Core SARPs
Part II — Appendices and Attachments
Nineteenth Edition, July 2016

This edition supersedes, on 10 November 2016, all previous editions of Annex 3.

For information regarding the applicability of the Standards and Recommended Practices, see Foreword.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

## ATTACHMENT E.   SPATIAL RANGES AND RESOLUTIONS FOR SPACE WEATHER ADVISORY INFORMATION

*Note.— The guidance contained in this table relates to Appendix 2, 6.1 Space weather advisory information.*

| Element | | Range | Resolution |
|---|---|---|---|
| Flight Level affected by radiation: | | 250-600 | 30 |
| Longitudes for advisories:          (degrees) | | 000 – 180 | 15 |
| Latitudes for advisories:          (degrees) | | 00-90 | 10 |
| Latitude bands for advisories: | High latitudes northern hemisphere (HNH) | N9000 - N6000 | 30 |
| | Middle latitudes northern hemisphere (MNH) | N6000 - N3000 | |
| | Equatorial latitudes northern hemisphere (EQN) | N3000 - N0000 | |
| | Equatorial latitudes southern hemisphere (EQS) | S0000 - S3000 | |
| | Middle latitudes southern hemisphere (MSH) | S3000 - S6000 | |
| | High latitudes southern hemisphere (HSH) | S6000 - S9000 | |

End of new Attachment E.

# ICAO GNSS Products

| | | | |
|---|---|---|---|
| **GNSS** | Amplitude Scintillation (S4) (dimensionless)<br>- Mod: 0.5<br>- Sev: 0.8 | COSMIC 2, NOAA Buoys, Future scintillation product (ROTI?) | **Climatology**/WAM-IPE?/Propagation of observations |
| | Phase Scintillation (Sigma-Phi) (radians)<br>- Mod: 0.4<br>- Sev: 0.7 | COSMIC-2, CEDP, GOLD, Future scintillation product (ROTI?) | Climatology/WAM-IPE?/Propagation of observations |
| | Total Electron Content (TEC) [departure from average]<br>- Mod: 125 TEC units<br>- Sev: 175 TEC units | GloTEC (DIX) | ??? |

Sources of S4 and Sigma-Phi: COSMIC 2, CWDP?, NOAA Buoys, ASTRA GNSS data, Future scintillation product based on numerical models

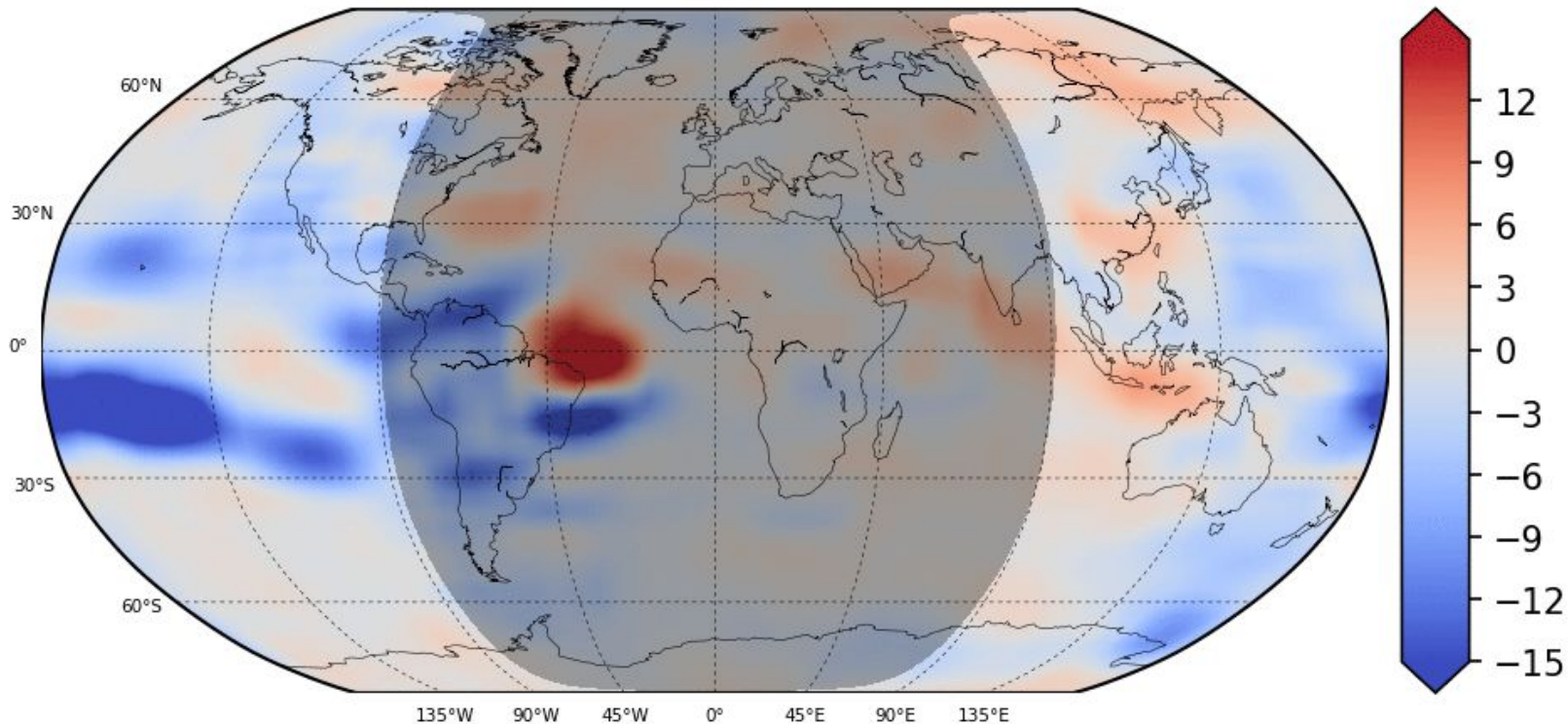Ground based ROTI
17-Mar-2015 from 00:00 to 00:10 UT

Courtesy Dominic Fuller-Rowell
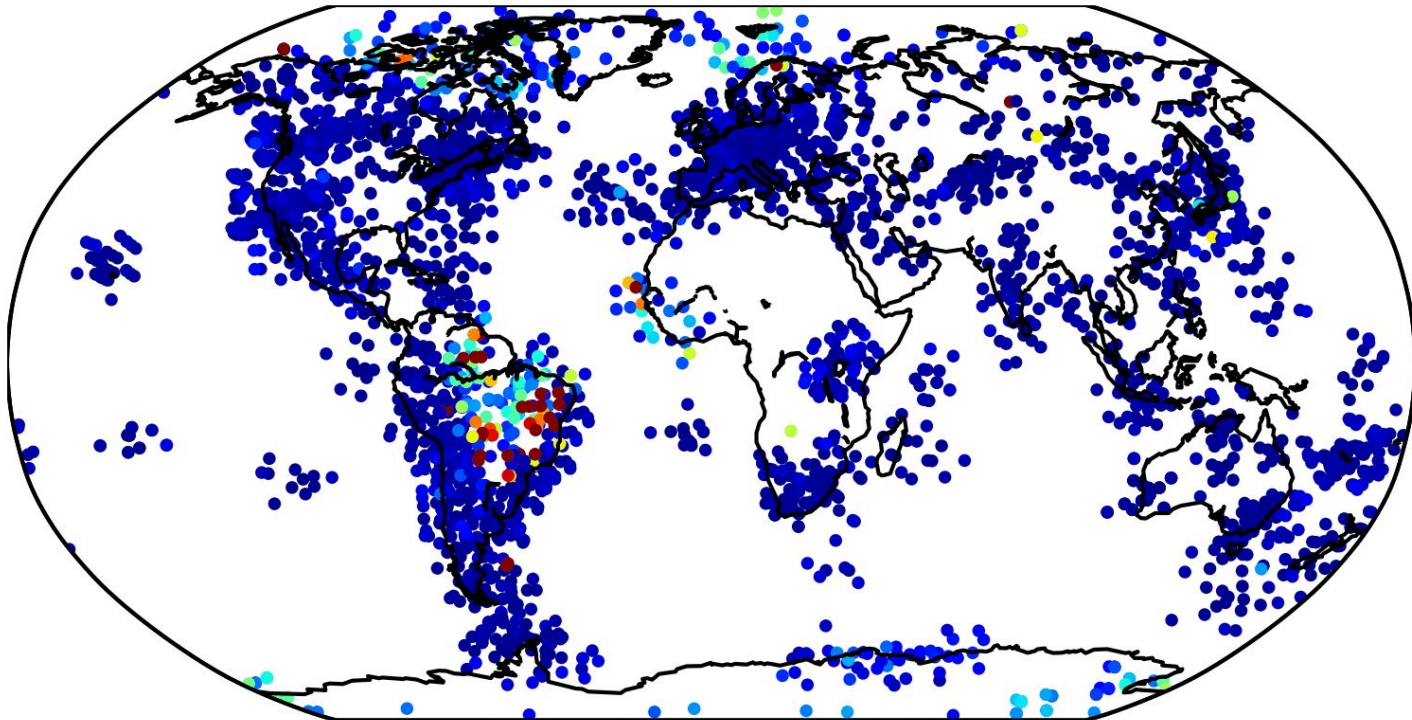
Ground based cROT
17-Mar-2015 from 16:31 to 16:32 UT

$$cROT_i^k = \left| \frac{\Delta STEC_i^k}{\Delta t \cdot \Delta s_i} \right|.$$
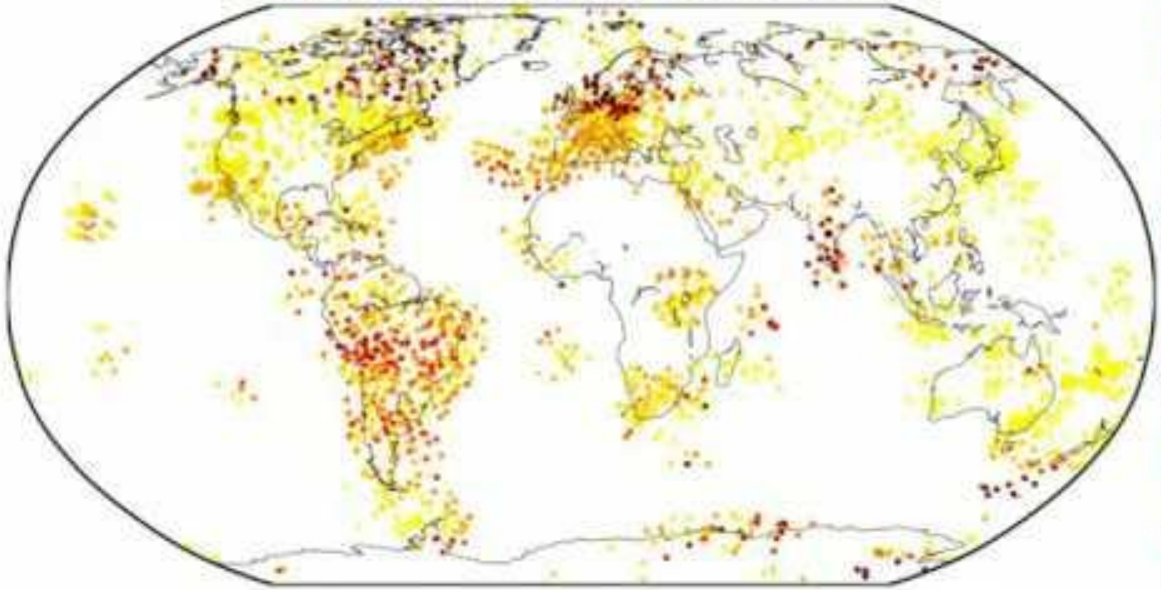
Courtesy Dominic Fuller-Rowell

Global 100ANOM
17-Mar-2015 00:05 UT  Max: 19.8 Min: -27.7

Courtesy Dominic Fuller-Rowell

# Commercial Weather Data Pilot

# NOAA Awards Commercial Weather Data Pilot Round 2 Contracts

Posted on **September 17, 2018**

On September 17, 2018, NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) awarded contracts to GeoOptics, Inc., Spire Global, Inc., and Space Sciences and Engineering LLC as part of the Commercial Weather Data Pilot Round 2.

Building on the CWDP Round 1 purchase and evaluation of radio occultation data, Round 2 incorporates additional operational considerations for a second radio occultation data purchase and evaluation period. NOAA will use CWDP Round 2 to (1) evaluate the data's impact on NOAA's numerical weather prediction models to further support the demonstration of radio occultation data, and (2) develop internal infrastructure needed to pursue procurement of commercial radio occultation data for operational use.

# A plot of Total Ionosphere Delay from the Real Time Run of CTIPe
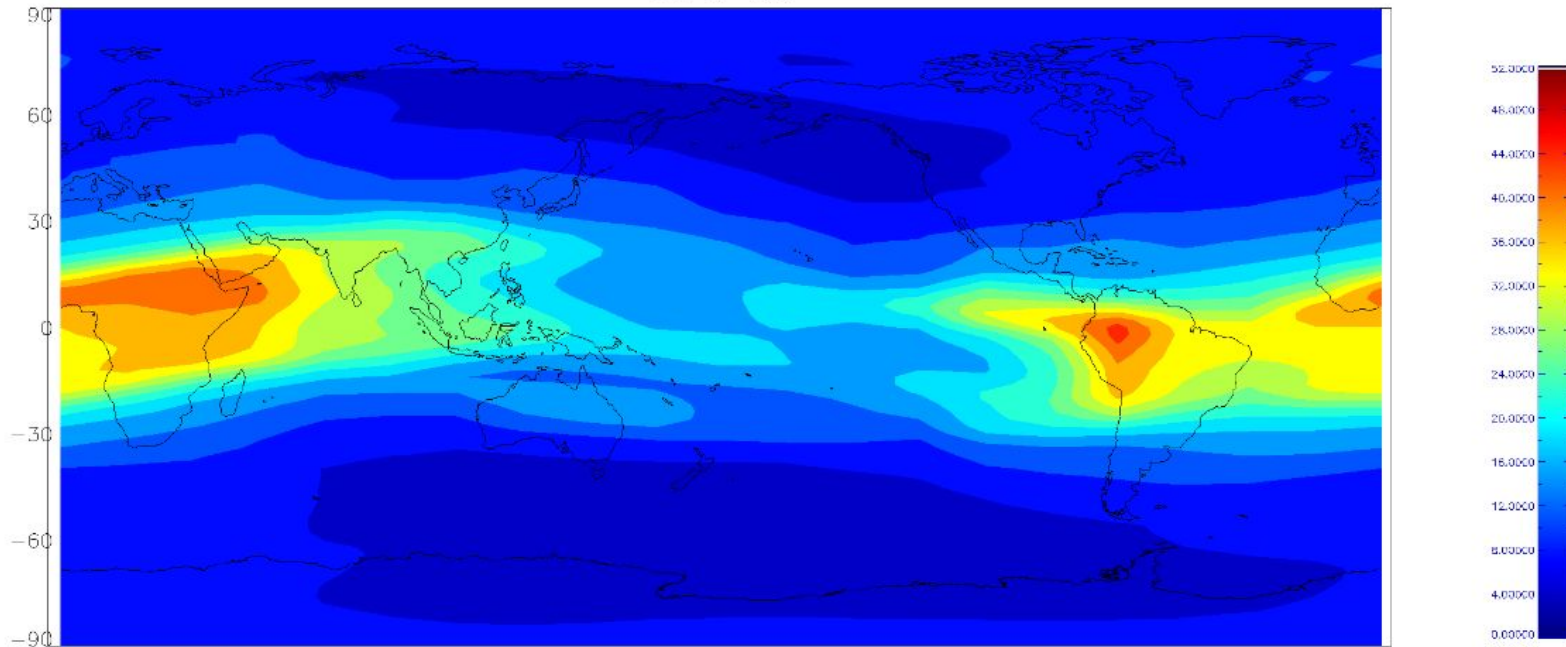


CTIPe Iono Total Error at L1
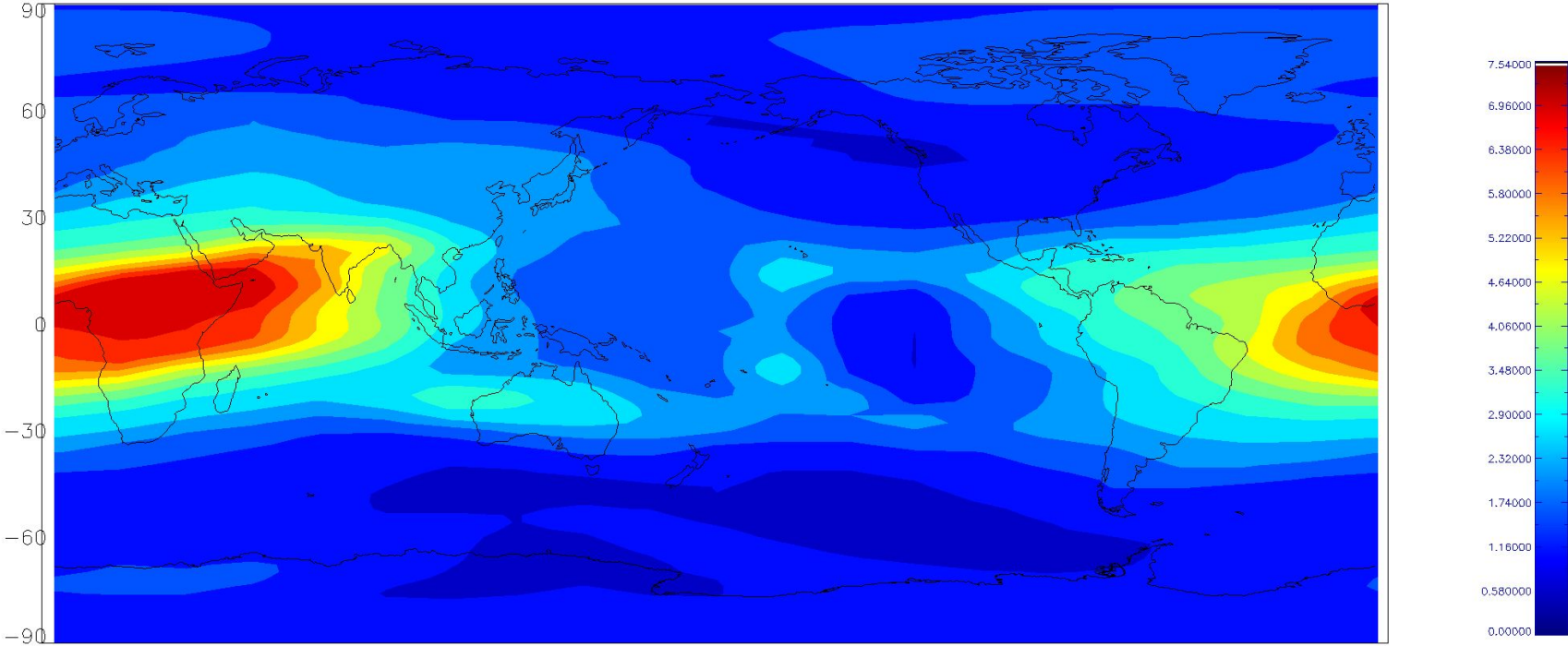
09-22-2018T14:00:00

# CTIPe TEC on Experimental Page

# WAM-IPE Progress

| Milestone | Date | Status |
|---|---|---|
| Updated WAM | 12/31/2017 | completed |
| IPE high-latitude transport upgrade | 06/30/2018 | completed |
| Low-latitude electrodynamics | 07/31/2018 | in progress |
| WAM-IPE 2-way coupling | 08/30/2018 | In progress |
| Code cleanup/refactoring, documentation for code/build/run | 10/12/2018 | in progress |

**FY19 Q4 Milestone:  Develop 2-way coupled WAM-IPE**

*Milestone Outcome* The Whole Atmosphere Model (WAM) coupled with the Ionosphere Plasmasphere Electrodynamics (IPE) model ready for transition to operations (running on WCOSS_Dev) and submitted to NCO for transition. The WAM-IPE model will provide products and services with multi day forecasts for critical customers and technologies including satellite navigation (GPS/GNSS), radio communication, satellite communication, and, in the future, satellite orbit prediction/ collision avoidance.

# WAM-IPE Forecast Validation

- Example of animation of global IPE TEC for November 21 2017

- WAM-IPE forecasts will validated against TEC maps from GloTEC, a data assimilation scheme combining ground (GNSS) and space-based (COSMIC RO) data (Courtesy Dominic Fuller-Rowell)

## WAM-IPE Forecast of TEC



WAM-IPE, Ionospheric TEC : 2017-11-21  00:15 UTC

Space Weather Prediction Center
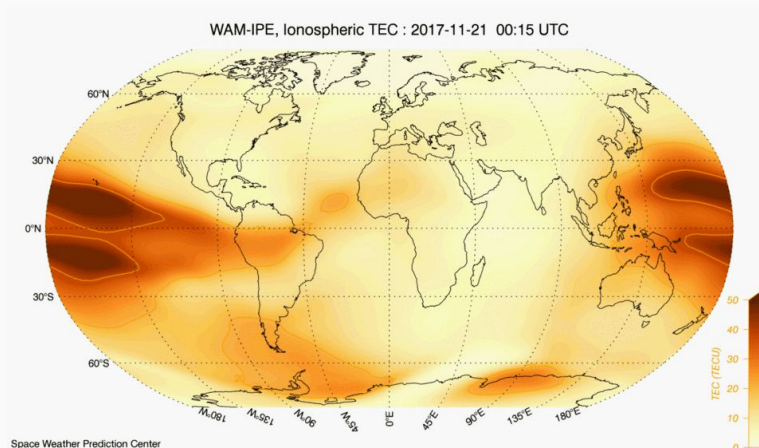
## GloTEC Ionospheric Data Assimilation



2017.11.021 00:05UT Max: 51.4 Min: 0.6