Ionospheric Monitoring and Prediction Center (IMPC)

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- DLR is Germany's national research center for aeronautics and space. Research and development work in aeronautics, space, transportation, energy

- DLR is also the national space agency

- The Institute of Communications and Navigation, located at Oberpfaffenhofen and Neustrelitz, develops and investigates new systems and methods for radio transmission and positioning.

- The Ionosphere Group in Neustrelitz is investigating transionospheric radio wave propagation, is active in monitoring and modelling the ionosphere and studying ionospheric impact on radio signals.
Ionospheric Monitoring and Prediction Center (IMPC) established at DLR (formerly SWACI)

http://impc.dlr.de
Regional and global TEC monitoring/mapping

Assimilation of calibrated TEC data into a background model of TEC (NTCM) to generate TEC maps.

Procedure allows extrapolating TEC into areas without measurements. Accuracy increases with number of used stations.

Global TEC map routinely provided via IMPC, data base primarily IGS

Space Based Sounding of the Ionosphere

- Occultation (1 Hz)
- Navigation (0.1 Hz)
- LEO Orbit

- CHAMP
- GRACE
- TerraSAR-X
- TanDEM-X
TEC Model for range error correction and forecast

Data base for ionospheric modelling

**NTCM-GL**
(Neustrelitz TEC Model - global)

- Uses only 12 coefficients +
- solar 10.7 cm radio flux

Klobuchar: current correction model for GPS
NeQuick: foreseen correction model for Galileo
Disturbance Ionosphere Index

The index is designed to be reliable and robust and allows an easy and objective interpretation of the complex variations of the electron density.
Rate Of TEC Index (ROTI)

- ROTI is defined as the normalized standard deviation of ROT along satellite links in a similar way as the sintillation index $S_4$.
- It can be considered as a dynamic measure of ionospheric activity.
- DLR provides global NRT maps of ROTI (2min average) based on more than 160 GNSS ground stations of IGS, EUREF and NMA. (pixel size: 2 deg x 2 deg).

$$ROT I = \left( \frac{\langle \Delta TEC^2 \rangle - \langle \Delta TEC \rangle^2}{\langle \Delta TEC \rangle^2} \right)^{1/2}$$

Global ROTI map that are provided in near real time via the Ionosphere Monitoring and Prediction Center (IMPC) of DLR. [http://impc.dlr.de](http://impc.dlr.de)
Scintillation Monitoring Network of DLR

- Network of high rate receivers
- Network provides scintillation data, distributed via SWACI

http://swaciweb.dlr.de

DLR operational
JAXA
Data exchange planned
Scintillation monitoring in Africa

$S_4$ Scintillation activity enhances regularly in Bahir Dar / Ethiopia at evening hours around 18:00 LT probably due to the Rayleigh-Taylor instability (RTI).

Scintillations occur primarily in North-South direction (crest).
Scintillation occurrence Bahir Dar 2013

Number of satellites received
- GPS: 32
- GLONASS: 23
- Galileo: 4

Impact
- Effect on L5 larger than on L1
- GLONASS L2 strongly affected

Frequency dependence
- Ogawa, 1980: $S_4 \sim f^{-0.5}$
Ionosphere weather service: Forecast

- Forecast derived from actual state and average behaviour
- Immediate control of forecast quality by comparing forecasted with measured values

One hour global TEC forecast and subsequent control check one hour later
Accuracy of global TEC forecasts provided by DLR

- Accuracy depends on geographic/geomagnetic location

- Absolute range errors < 0.5 m peak near crest

- Relative errors up to 20% peak at high latitudes
European TEC forecast model using ACE data

Perturbation model uses solar wind data from ACE satellite (DLR Neustrelitz belongs to the Real Time Solar Wind Network of NOAA)

Correlation of TEC with solar wind parameters is the basis of the TEC perturbation forecast model.
Ionospheric warning and prediction system for European customers developed within AFFECTS

AFFECTS - Project
coordinated by the University of Göttingen (Volker Bothmer)
supported by the European Commission (FP7 programme)
Forecasting the ionosphere requires international cooperation

Early warning from Solar observations provided by the Royal Observatory Belgium (ROB)

TEC forecast via SWACI / DLR using ACE data

[http://www.affects-fp7.eu/]
Use of the Coupled Thermosphere-Ionosphere-Plasmasphere Electrodynamics Model (CTIPe)

State of the art research tool used at the Space Weather Prediction Center to study thermosphere-ionosphere phenomena in order to develop new monitoring and predicting techniques.

Model requires input data from all geo-spheres used in the model

Comparison with GNSS observation based TEC maps

Long-term goal:
Development of a data driven physics based model
International collaboration

The ionosphere group is involved in several projects and proposals supported e.g. by ESA, EC, DFG

Bilateral agreements with NOAA, NMA, SANSA, Jaxa, Bahir Dar University

Main goal is the establishment of an Ionospheric Monitoring and Prediction Center (IMPC) to provide near real time ionospheric information and data service

Proposal for defining and developing Space Weather ESCs in Europe under leadership of Astrium / Germany submitted to ESA.
IMPC – Data Processing System

- IMPC is networked at international level
- Provides data and information for various projects of ESA and EC
- ESC in SSA program of ESA
- Provides operational data base for ionospheric research and GNSS impact studies in DLR

IMPC is operated by DFD and IKN in DLR Neustrelitz

http://impc.dlr.de
IMPC – Broad user community

Registered Users – Type of Organization

Registered Users – Country

Number of Annual Visits

Last update: October 2013
Thank you for your attention!

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