Ionosphere Workshop Warsaw
2/3 June 2016
Summary

Agenda

GENERAL SESSION TO SET THE SCENE

9.00-9.20 Introduction: Setting the scene - Maaijke Mevius

9.20-9.40 Interferometric calibration - Emanuela Orru'

9.40-10.00 GPS/TEC Ionosphere diagnostics and IGS services - Andrzej Krankowski

10.00-10.20 Observing Ionospheric Scintillation with LOFAR - Richard Fallows

10.20-10.40 Muti-instrument radio diagnostics Hanna Rothkaehl

IONOSPHERIC CALIBRATION

11.10-11.40 Ionospheric calibration / SPAM - Huib Intema:

11.40-12.00: Deriving ionospheric information from LOFAR - Maaijke Mevius

12.00-12.20: Interferometric observations at 60MHz: the effect of the ionosphere - Francesco de Gasperin

12.20-12.40 LOFAR/GNSS project - Maaijke Mevius, Hein Zelle

GPS/TEC and RO techniques

15.00–15.20 Mapping of the ionosphere parameters - Adam Fron, Kacper Kotulak, Andrzej Krankowski , German Olivares and Manuel Hernandez-Pajares.

15.20–15 40 Radio occultation diagnostics and ionosphere behaviour - Barbara Matyjasiak

15.40-16 00 Studies of interstellar scintillation and scattering of pulsars using polish LOFAR stations

SCINTILLATION

9.00-9.20 Radio wave scintillation: aspects of interest for ionospheric physics and radio astronomy - Biagio Forte, Richard Fallows, and Mario Bisi.

9.20-9.40 TEC and scintillation modelling - Marcin Grzesiak

9.40-10.00 Ionospheric scintillation diagnostics - Mariusz Pozoga

10.00-10.20 Space Weather Service in CBK - Beata Dziak-Jankowska

+ a lot of time allocated for discussion

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Goals of this meeting

- Define common factors between methods/goals of the different communities
- What can we learn from each other
- Where can we contribute to each others data/goals
- Define working groups to further expand on the ideas of this meeting

Diagnostics

- Can we define a method to characterize the ionospheric quality, before, during or after an observation?

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- Can we define a method to simplify the calibration?

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Calibration

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- Can LOFAR data be used to improve ionospheric monitoring?

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GPS/TEC Ionosphere diagnostics and IGS services

Andrzej Krankowski

University of Warmia and Mazury in Olsztyn,
Space Radio Diagnostics Research Centre (SRRC/UWM)

UNIWERSYTET WARMIŃSKO-MAZURSKI W OLSZTYNIE

Manuel Hernández-Pajares
UPC-IonSAT res. group

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

IGS IONO WG activities

Recommendations of IGS 2016 Workshop

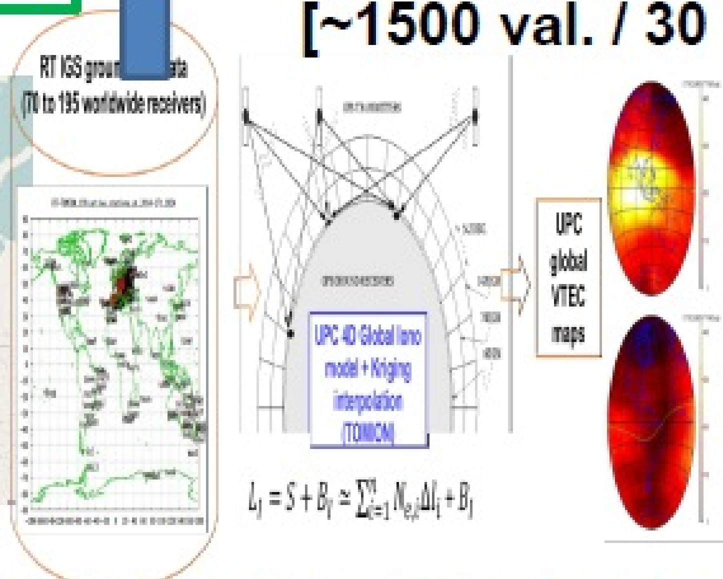
- **To accept CAS-IGG, NRCan and WHU as new Ionospheric Analysis Centers, contributing to the IGS combined VTEC GIMs.**
- **The IONEX format shall be updated in order to accommodate contributions using multiple constellations and adequately describe the associated resulting differential code biases.**
- **Cooperation with IRI COSPAR group for potential improvement of both IRI and IGS TEC.**
- **Cooperation with International LOFAR Telescope (ILT) for potential synergies.**

European TEC maps based on SRRC\UWM and UPC-IonSAT

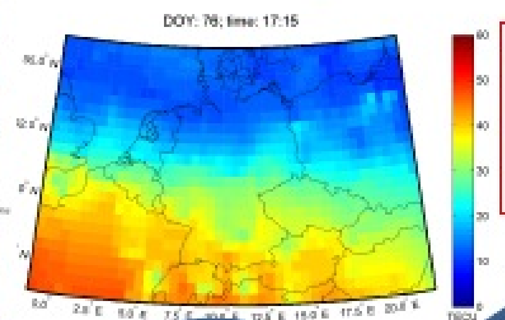
Providing RIMs for ILT in real time (15min–time resolution) to this study

126 EPN Stations

From each obs. we get one STEC value:
V=S/M=(Li-Bi)/M.
[~1500 val. / 30 s]



Interpolation by Splines



Natural neighbour Interpolation

New European VTEC maps

Layout summarizing the global VTEC computation from ground G data by means of the UPC TOMION software, including the mai tomographic model equation[*]

[*](data: ionospheric combination of carrier phases LI, and length intersection within each voxel, Δli; unknowns: its ambiguity BI, the STEC, S, which includes the mean electron density within each given voxel, Ne,i).

(see for instance Hernandez-Pajares, M., Juan, M. and Sanz, J., 1999. *New approaches in global ionospheric determination using ground GPS data*. Journal of Atmospheric and Solar-Terrestrial Physics 61, pp. 1237–1247.).

European TEC maps based on SRRC\UWM and UPC-IonSAT

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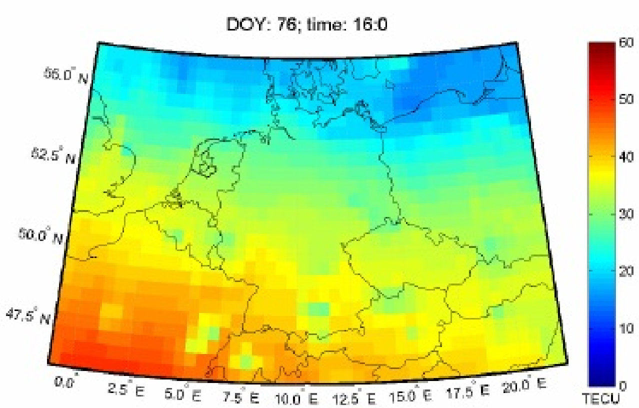
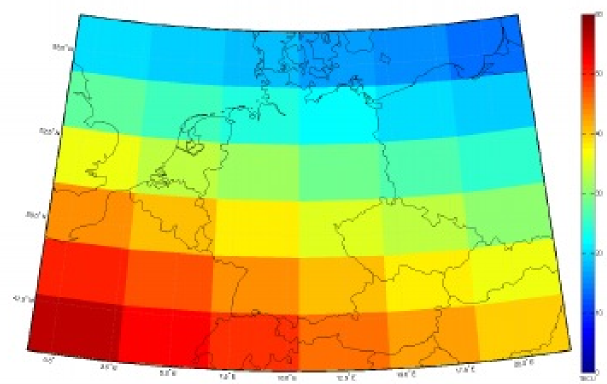
Interpolation by Splines

Maps comparision

126 EPN Stations





Layout summarizing th
data by means of the U
tomographic model equ
[*](data: ionospheric combina
each voxel. Δli: unknowns: it

ILT IONEX regional TEC map
0.5 ° lat/lon spatial resolution
15 minutes temporal resolution

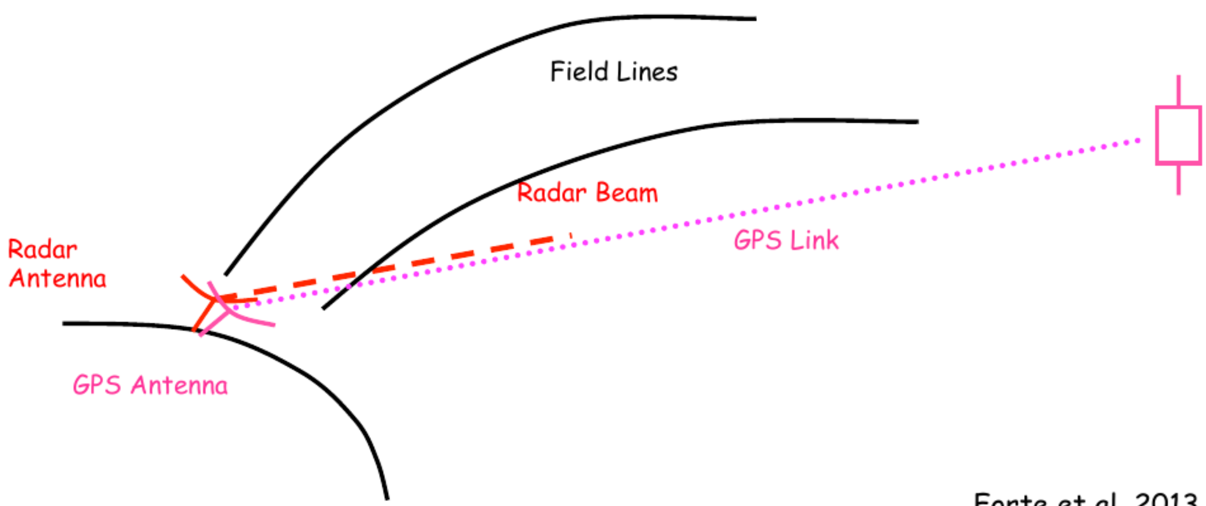
IGS IONEX regional TEC map
2.5 ° lat and 5 ° lon spatial resolution
2 hours temporal resolution

(same date, hour and color/TEC scale)

Adam Froń, Kacper Kotulak, German Olivares Pulido, Andrzej Krankowski, Manuel Hernandez Pajares

999. *New approaches in global ionospheric* ... Solar-Terrestrial Physics 61, pp. 1237–1247.).

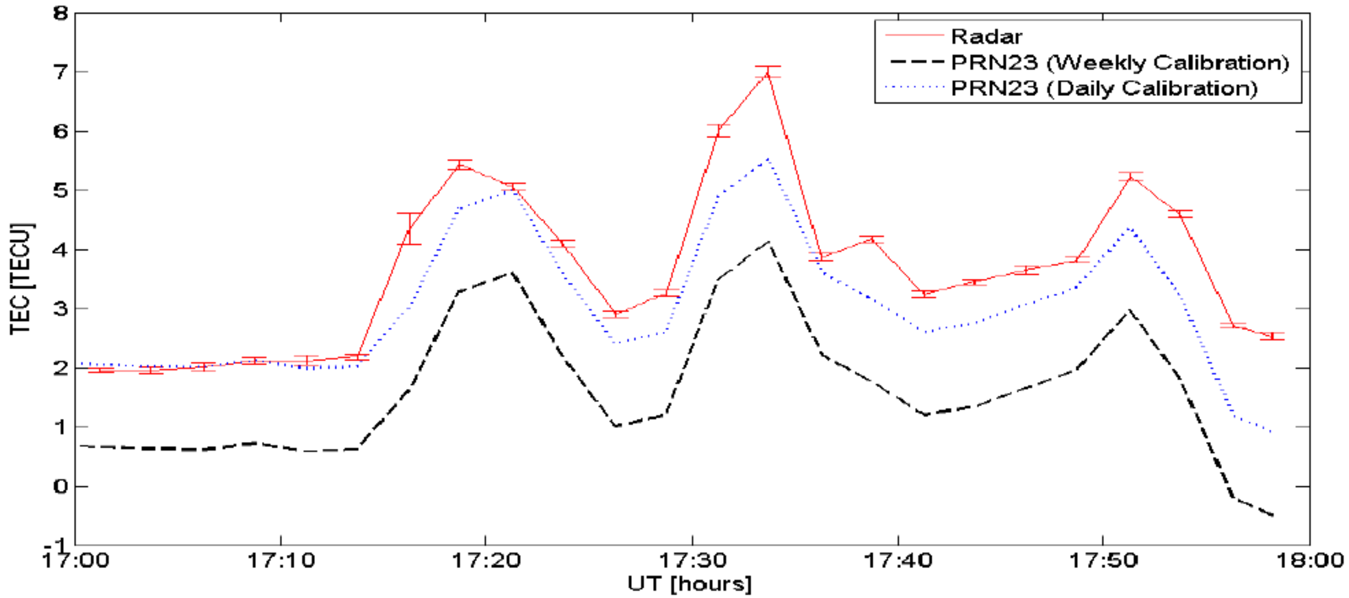
EISCAT measurement geometry – new experiment



Forte et al, 2013

TEC: EISCAT vs GPS

GPS data follows time variation, but there often is an offset



Tromso, 12 December 2011

Forte et al, 2013

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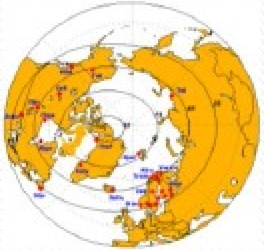
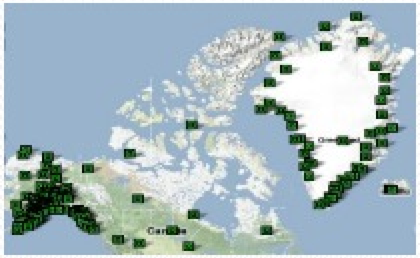
Multi instruments diagnostic

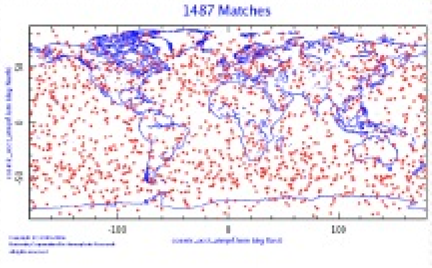
- In situ diagnostics LO satellite; waves and plasma diagnostic
  DEMETER RELEC

- TEC measurements IGS , **Antarctic and Arctic**

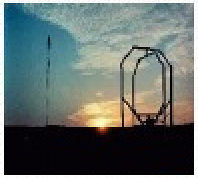




- RO satellite diagnostics
  FORMOSAT-3/COSMIC



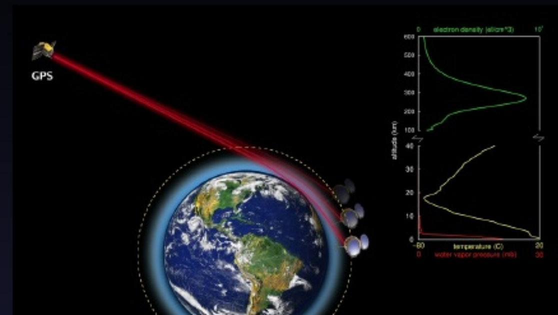
- grand based Ionosondes, radars, LOFAR(radio telescope interferometer)



High temporal and spatial resolution: topside in situ waves and plasma diagnostics, and remote diagnostics (limited area)

Radio occultation method

- remote sensing technique measuring signal form the transmitter to the receiver
- the signal pass through the atmosphere and gets refracted or bent along the way
- magnitude of the refraction depends on the gradient of refractivity, which depends on the vertical density gradient
- GNSS-RO technique makes use of radio signals transmitted by the global positioning system (GPS) satellites
- vertical scanning of successive layers of the atmosphere (the GPS and LEO satellite satellite position changes)
- spherical symetry, Abel transform -> refraction index



Barbara Matyjasiak

Analysis of Main Ionospheric Trough with COSMIC data

- depleted region of ionospheric plasma typical for the topside ionosphere
- its variability strongly affects the propagation of different natural and artificial signals
- strongly dependent on sesonal and geomagnetic conditions
- mostly night-time phenomenon
- characteristic shape, extended in longitudes but narrow in latitudes
- storm-phase dependent structure, very sensitive for geomagnetic conditions
- its location is condsidered to coincide with the plasmapause position [E. Yizengaw et al.(2005)].

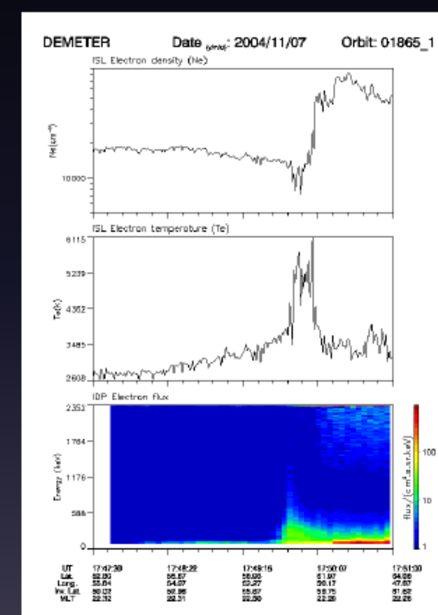
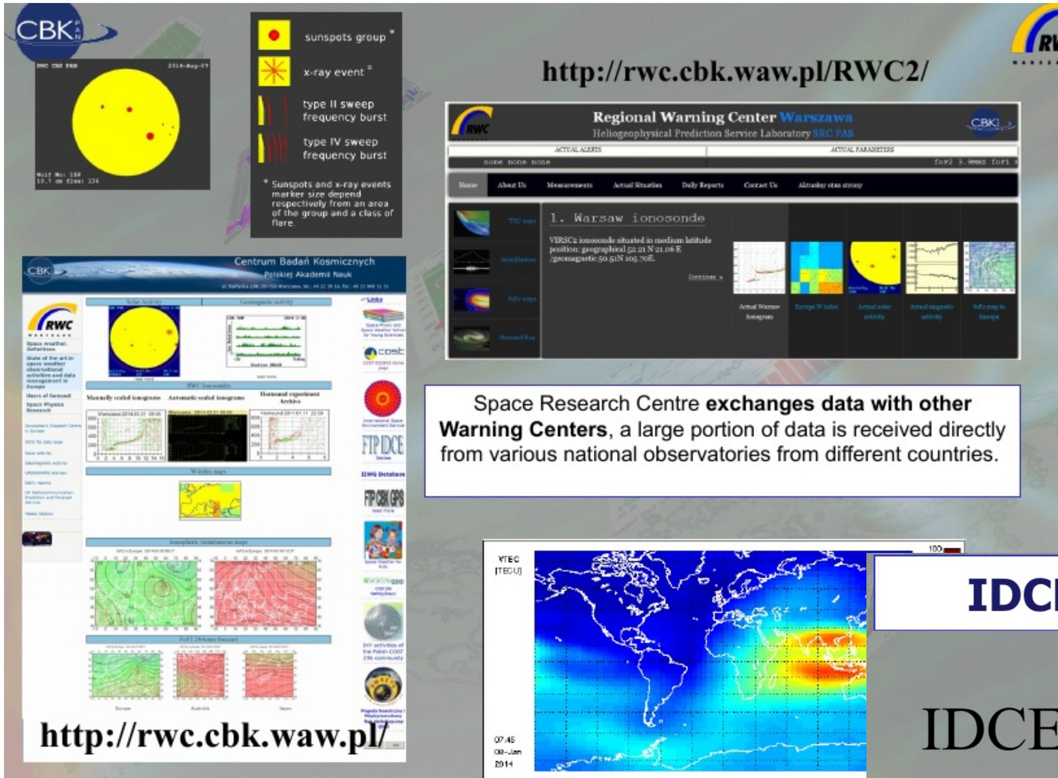


Figure: The main ionospheric trough seen from DEMETER data. Electron density: top, electron temperature-middle. Bottom figure: energy flux.

Space Weather Service in CBK PAN

Beata Dziak-Jankowska



IDCE - Ionospheric Dispatch Centre in Europe

IDCE allows to have convenient access to some recent ionospheric data from vertical sounders located mainly within European area as well as to data available in ISES network.

IDCE offers also the catalogues of disturbed and quiet days, as well as the list of disturbed periods of few hours duration. The catalogues contain data since January 1997.

Can we find parameters that classify the ionospheric quality of LOFAR observations
Test on existing data

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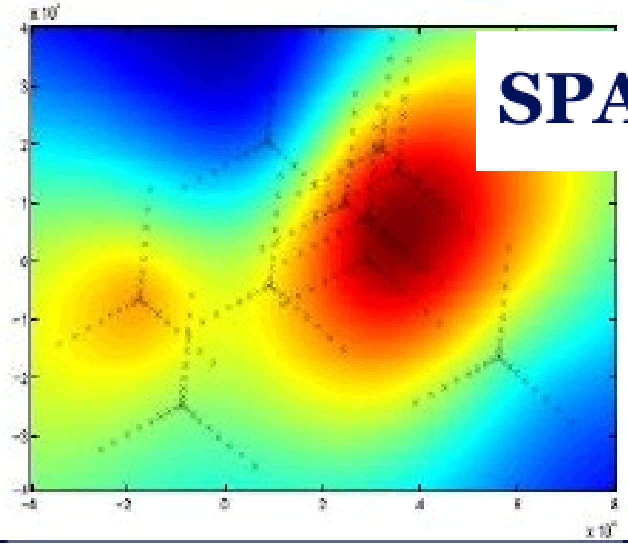
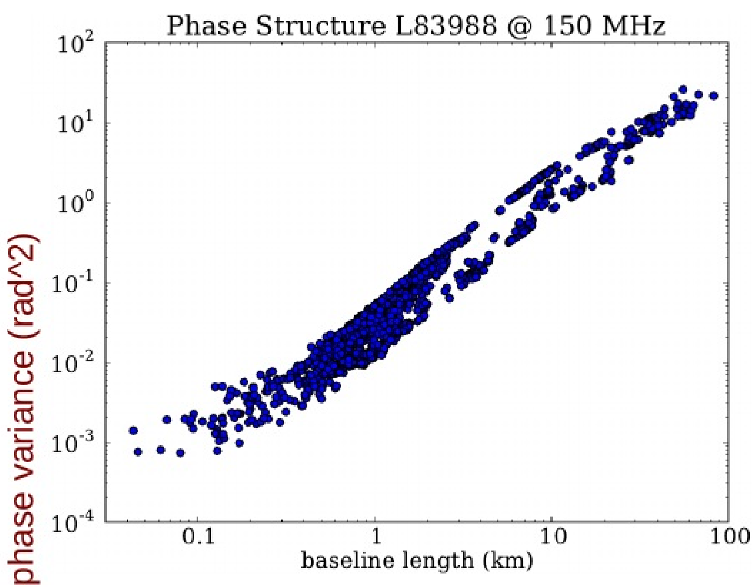
SPAM ionosphere model

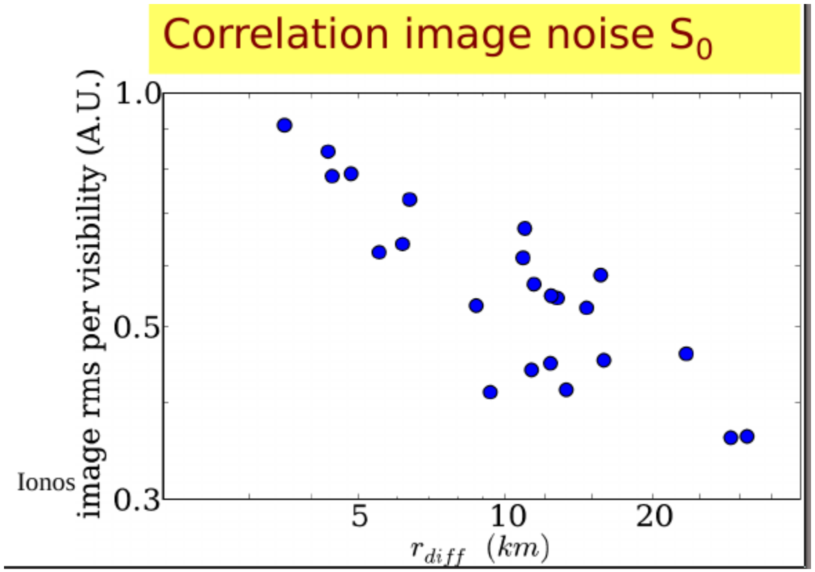


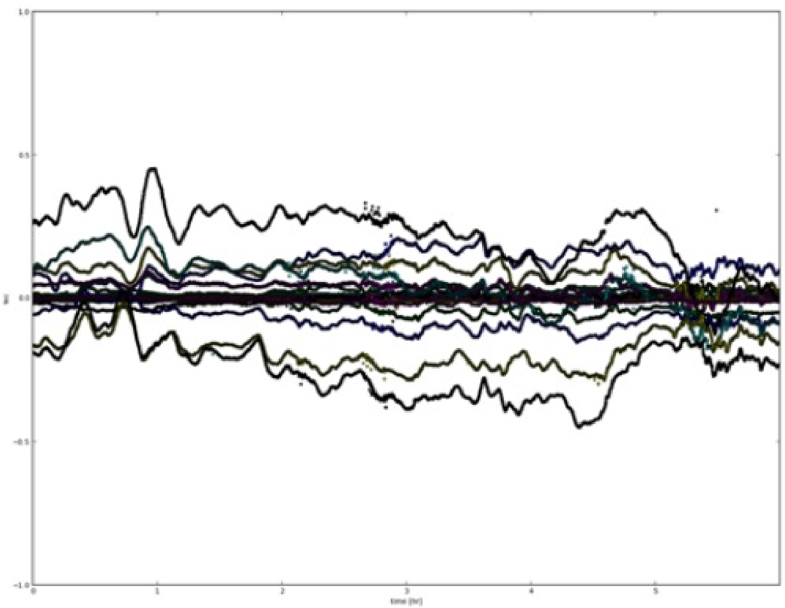
Can GPS data be used to
improve the phasescreen
Knowledge about TEC-screen modeling

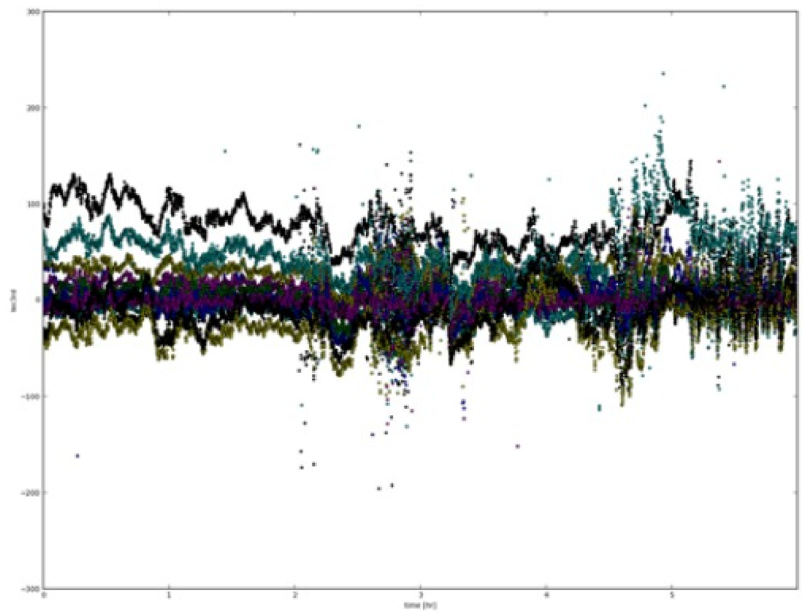


baseline length (km)

Can we use high resolution raw GPS data to
measure the ionospheric phase structure.
Diagnostics



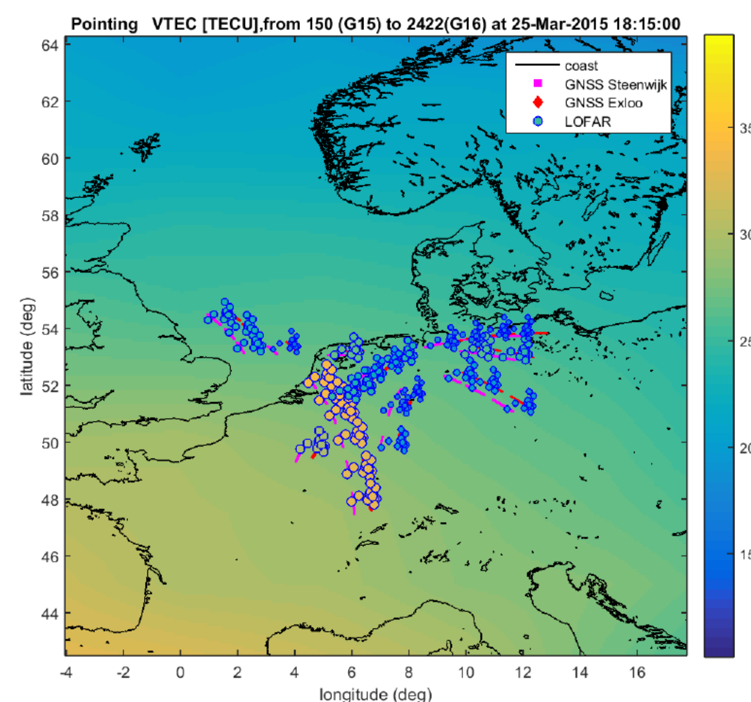




TEC (1/f)

EC2 (1/f^3)

LOFAR can provide high accuracy differential TEC +2nd (Faraday rotation)
and 3rd (LBA) order effects.
Investigate possible use for high accuracy GPS measurements



Repeat” the LOFAR/GNSS project with Polish stations

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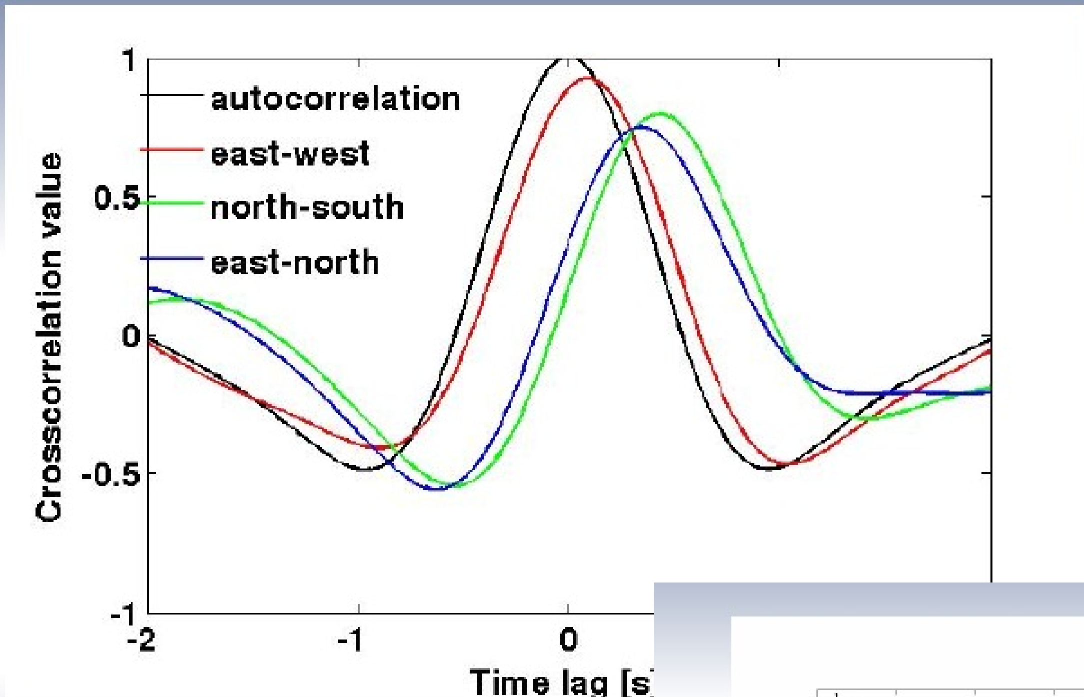
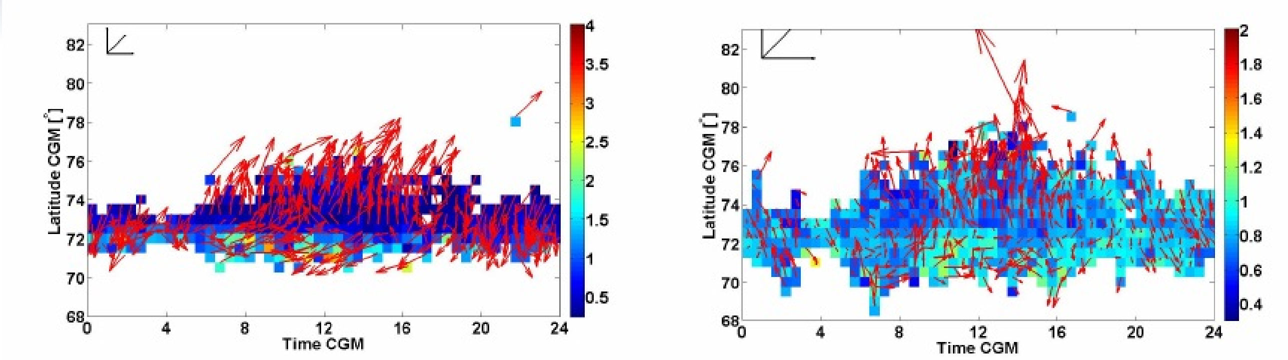
Example of crosscorrelation function



Ionospheric scintillation diagnostics

Mariusz Pożoga



Amplitude and phase drift pattern during high activity.

Richard Fallows doing similar things with LOFAR auto-correlation data
Francesco with LBA -amplitude scintillation

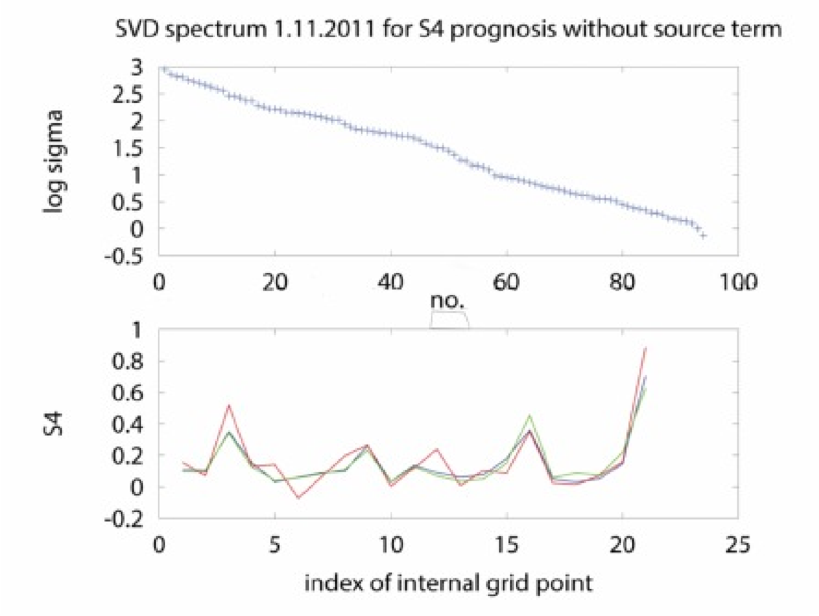
TEC and scintillation modeling

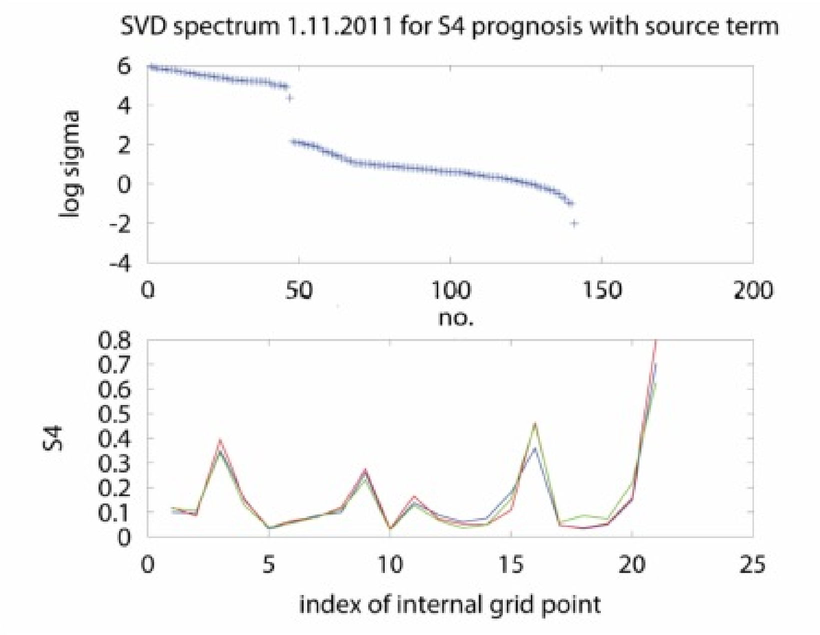
Marcin Grzesiak

Scintillation parameters prediction

$$\frac{\partial}{\partial t}\int_{\Delta_k} dVf = -\int_{\partial\Delta_k} d\mathbf{s}\cdot(f\mathbf{v}_k)$$

$$\frac{\partial}{\partial t}\int_{\Delta_k} dVf = -\int_{\partial\Delta_k} d\mathbf{s}\cdot(f\mathbf{v}_k) + \int_{\Delta_k} dV\pi_k,$$





NEXT

- WGs defined
- Follow up meeting high resolution GPS:
  - Fall 2016 , Astron
  -
- Next ionosphere meeting:
  - Spring 2017, Leiden