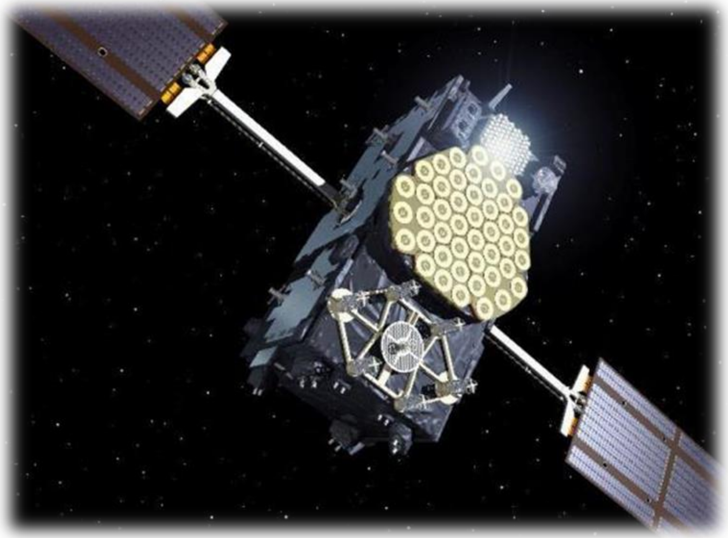
GNSS SEMINÁŘ 2017
BRNO UNIVERSITY OF TECHNOLOGY, 02.02.2017

WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES



GNSS data analysis
for Geodesy and Atmospheric Research
at the Institute of Geodesy and Geoinformatics

Krzysztof Sośnica, Witold Rohm, Jan Kapłon, Jarosław Bosy, Tomasz Hadaś, Karina Wilgan, Paweł Hordyniec, Kamil Kaźmierski, Grzegorz Bury, Mateusz Drożdżewski, Elżbieta Lasota, Estera Trzcina, Iwona Kudłacik, Jan Sierny, Andrzej Borkowski

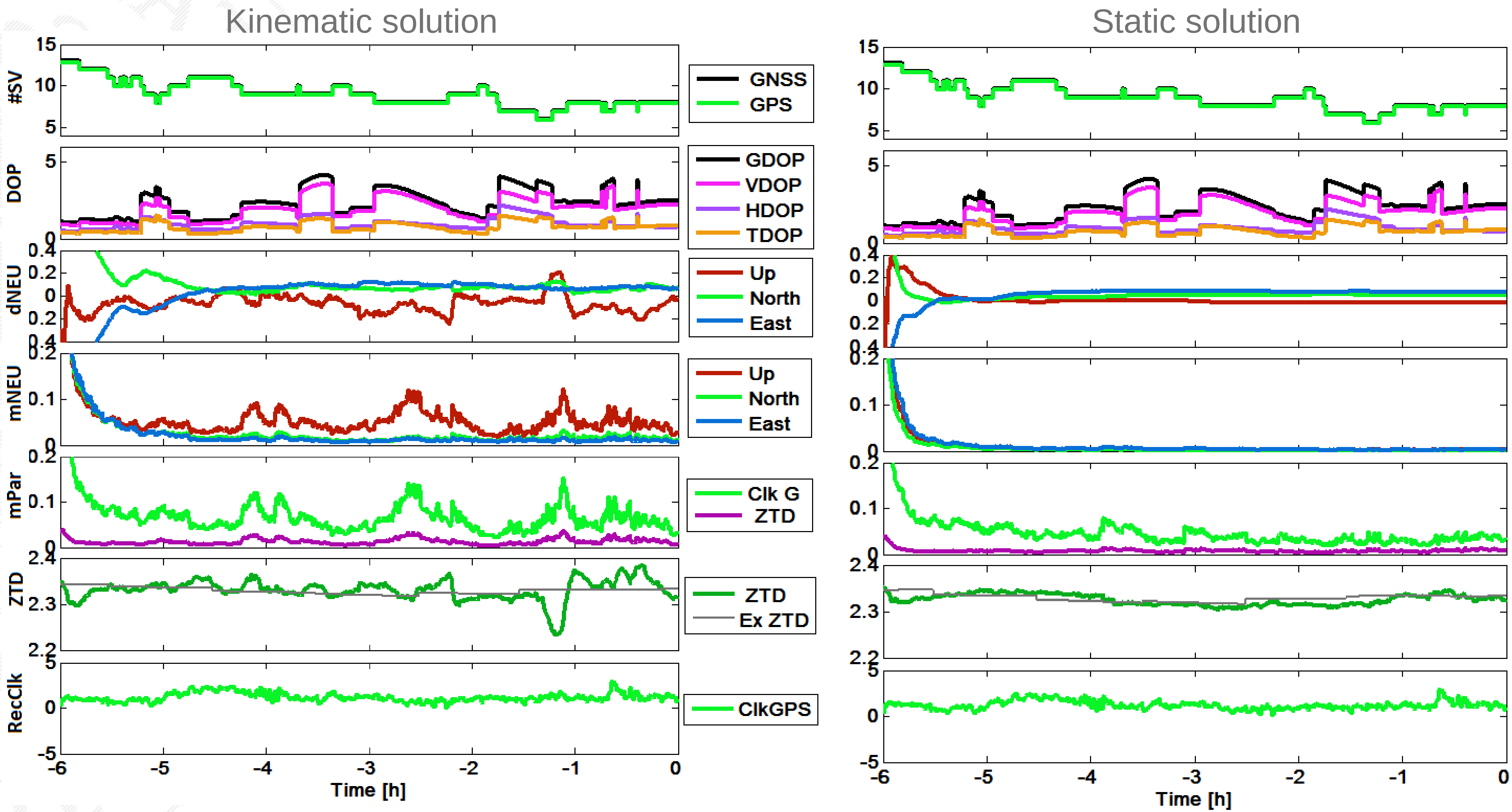
http://www.igig.up.wroc.pl/igg/

GNSS-WARP

Wroclaw **A**lgorithms for **R**eal-time **P**ositioning

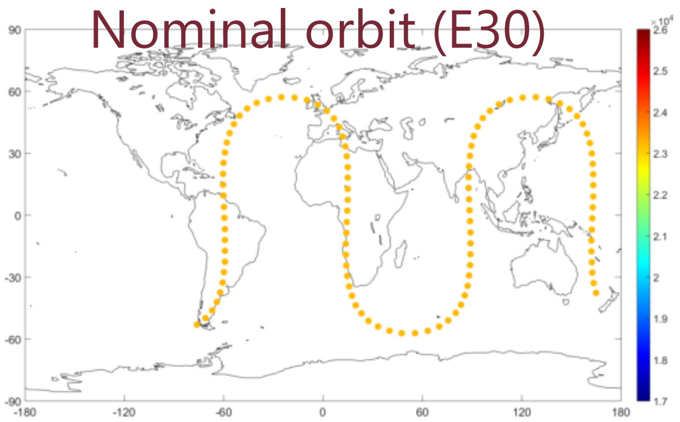
- original, self-developed, state-of-the-art PPP software
- purpose: multi-GNSS RT-PPP & PPP-RTK algorithms development
- GNSS: GPS+GLO, GAL & BDS only with MGEX products, RT
- implemented in Matlab (2015a) + Instrument Control Toolbox
- BNC used as RTCM decoder of IGS RTS streams

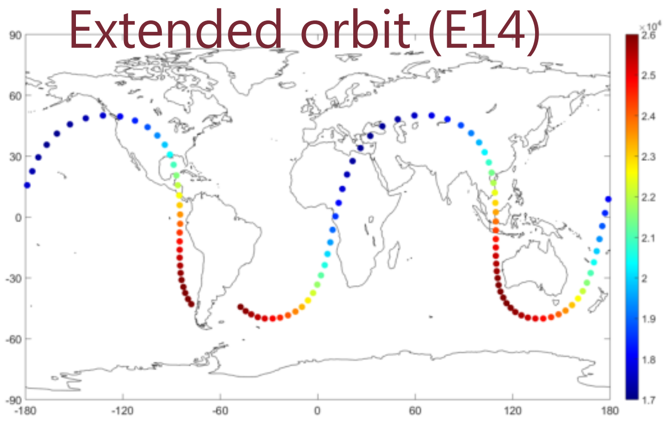
Real-time PPP – GPS solution



Station WROC, 6h of data, 30 sec. interval, 5º elevation cut-off angle, VMF

New GNSS systems



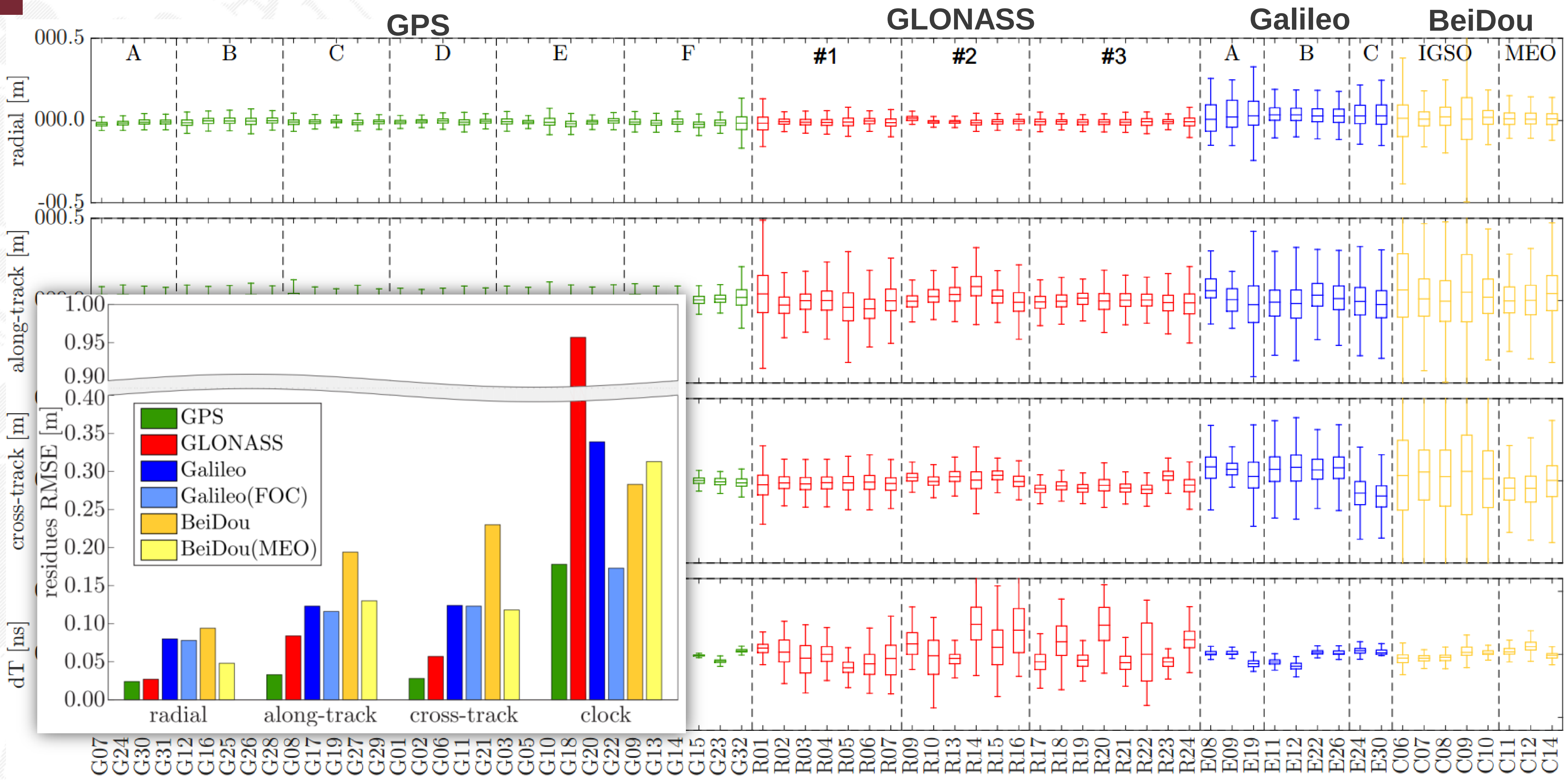


Variable velocities:
from 1.9 km/s in the apogee
up to 3.4 km/s in the perigee

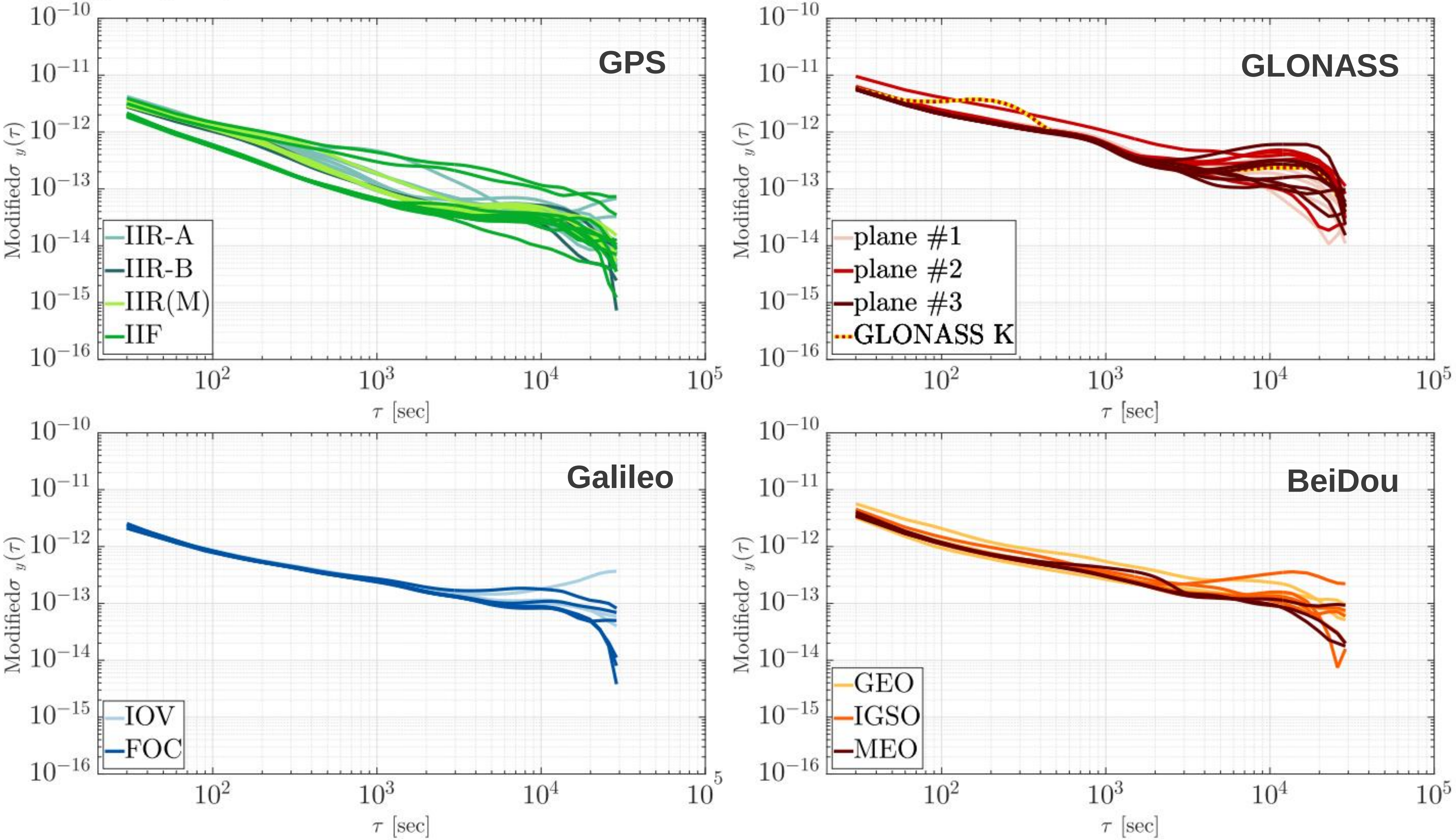
(in the Earth-fixed frame, w.r.t. the observer)

System	GLONASS		Galileo			BeiDou			QZSS
Type	GLONASS-M	GLONASS-K	IOV	FOC (extended orbit)	FOC	MEO	IGSO	GEO	QZS-1
PRN Number	R01-R08 R10-R19 R21-R25	R09, R20	E11, E12, E19, E20	E18, E14	E26, E22, E24, E30, E08, E09, E01, E02, E07, E03, E04, E05	C11, C12, C13 (retired), C14, C33, C34 , C35	C06, C07, C08, C09, C10, C31, C32, C13	C01, C03, C04, C05, C02, C17	J01
Retroreflectors	115	132	84	60	60	42	42	90	42
Mass [kg]	1450	750	695-697	661/662	706-709	1 900	1 900	1 550	1 800
Semi-major axis [km]	25 500	25 520	29 600	27 978	29 600	27 878	42 164	42 164	42 164
Altitude [km]	19 130	19 130	23 225	17 178-26 019	23 226	21 507	35 793	35 793	32 000 - 40 000
Orbit	MEO	MEO	MEO	MEO	MEO	MEO	Geosynchronous	Geostationary	Geosynchronous
Eccentricity	0.0001	0.0001	0.0001-0.0002	0.1585/0.1584	0.0001-0.0004	< 0.003	0.0023	0.0002	0.099
Inclination [deg]	64.8	68.8	54.93-55.57	50.10/50.16	54.94-57.25	55.00	55.60	~0.0-1.8	43.0

Comparison of real-time orbit and clocks w.r.t. MGEX final IGS solutions

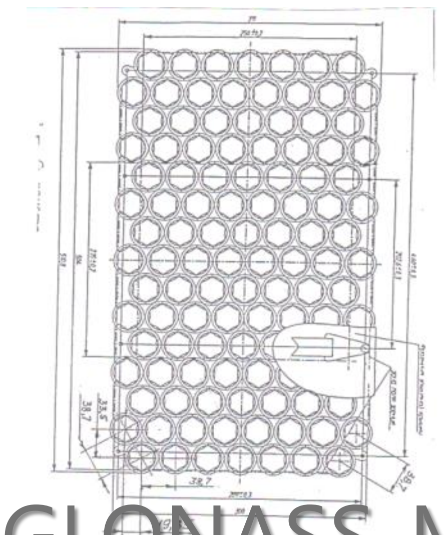


Validation of GNSS clocks

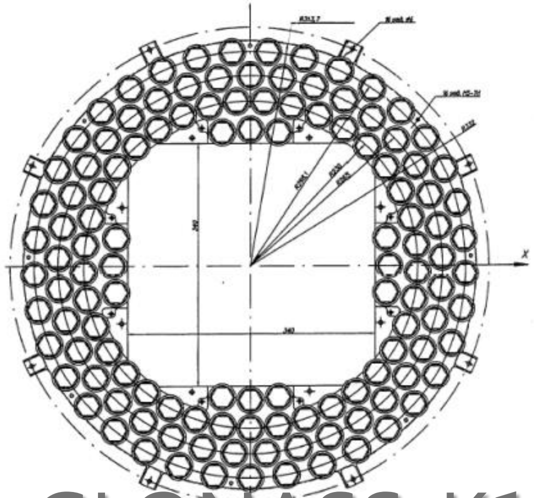


Laser retroreflectors installed on GNSS satellites

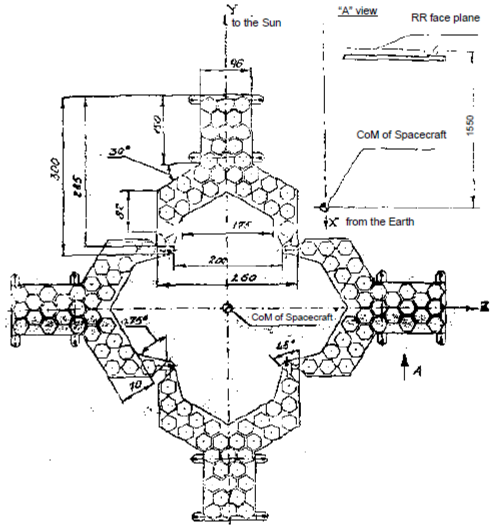
GPS-35/36



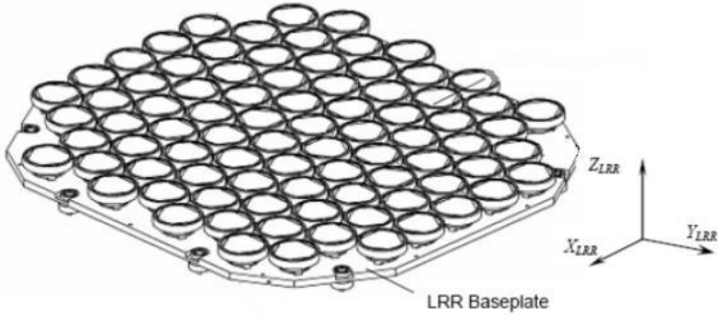
GLONASS-M



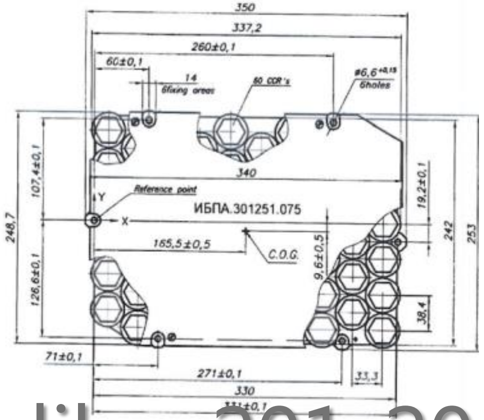
GLONASS-K1



GLONASS

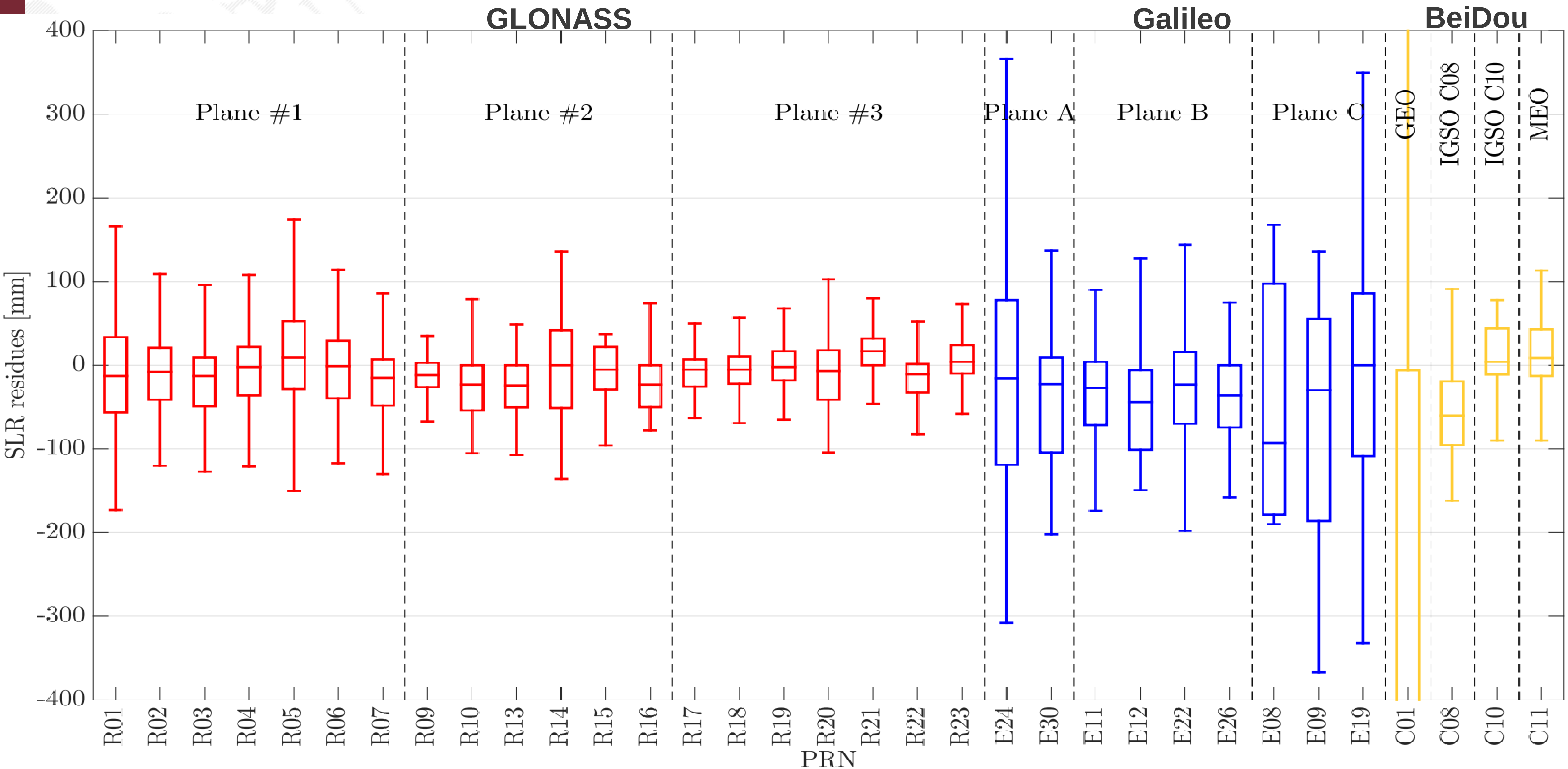


Galileo 101-104
(84 CCRs)

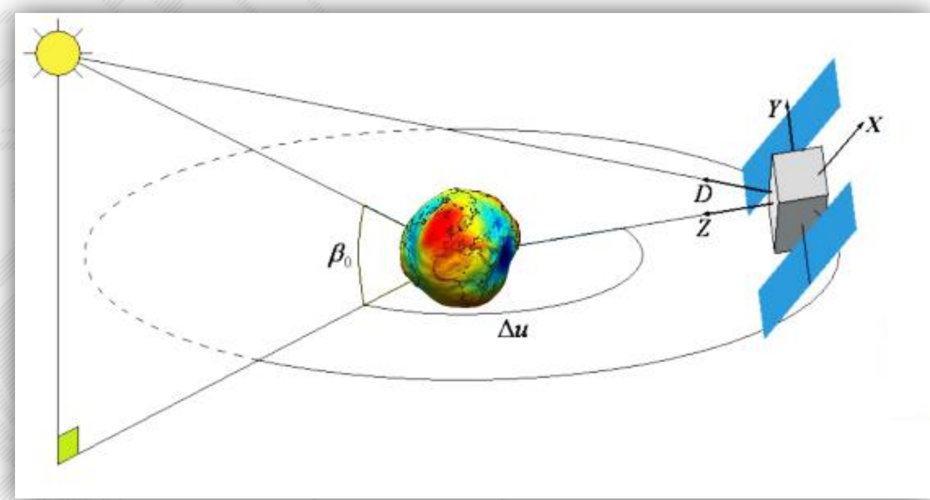


Galileo 201-204
(60 CCRs)

Validation of real-time orbits using Satellite Laser Ranging (SLR)



Validation of GNSS orbit models using SLR



The classical Empirical CODE Orbit Model (ECOM1) includes the following parameters:

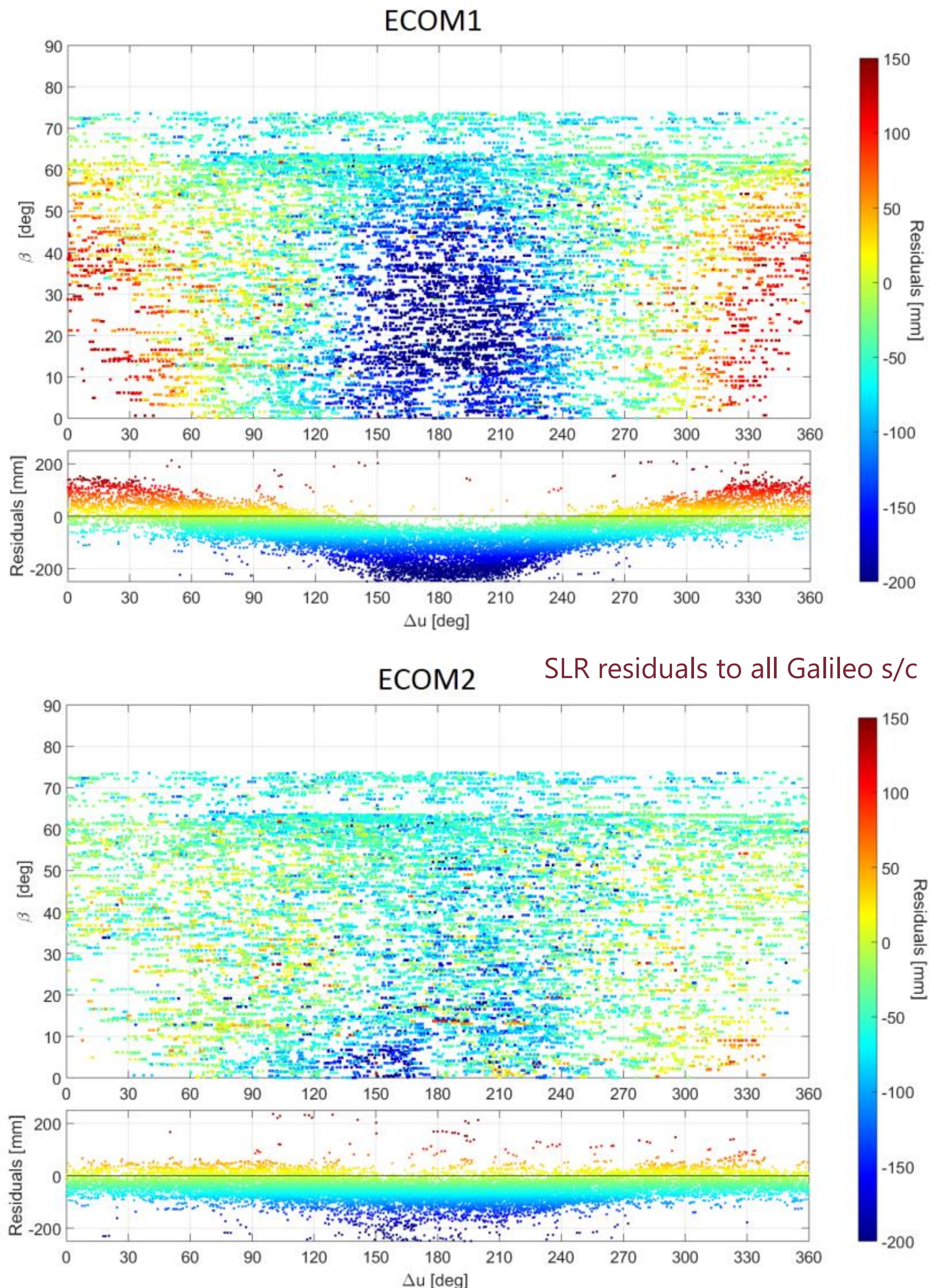
$$\begin{cases} D = D_0 \\ Y = Y_0 \\ X = X_0 + X_C \cos u + X_S \sin u \end{cases}$$

where u is the satellite argument of latitude.

ECOM2 includes following parameters:

$$\begin{cases} D = D_0 + D_{C2} \cos 2\Delta u + D_{S2} \sin 2\Delta u \\ \quad + D_{C4} \cos 4\Delta u + D_{S4} \sin 4\Delta u \\ Y = Y_0 \\ X = X_0 + X_C \cos \Delta u + X_S \sin \Delta u \end{cases}$$

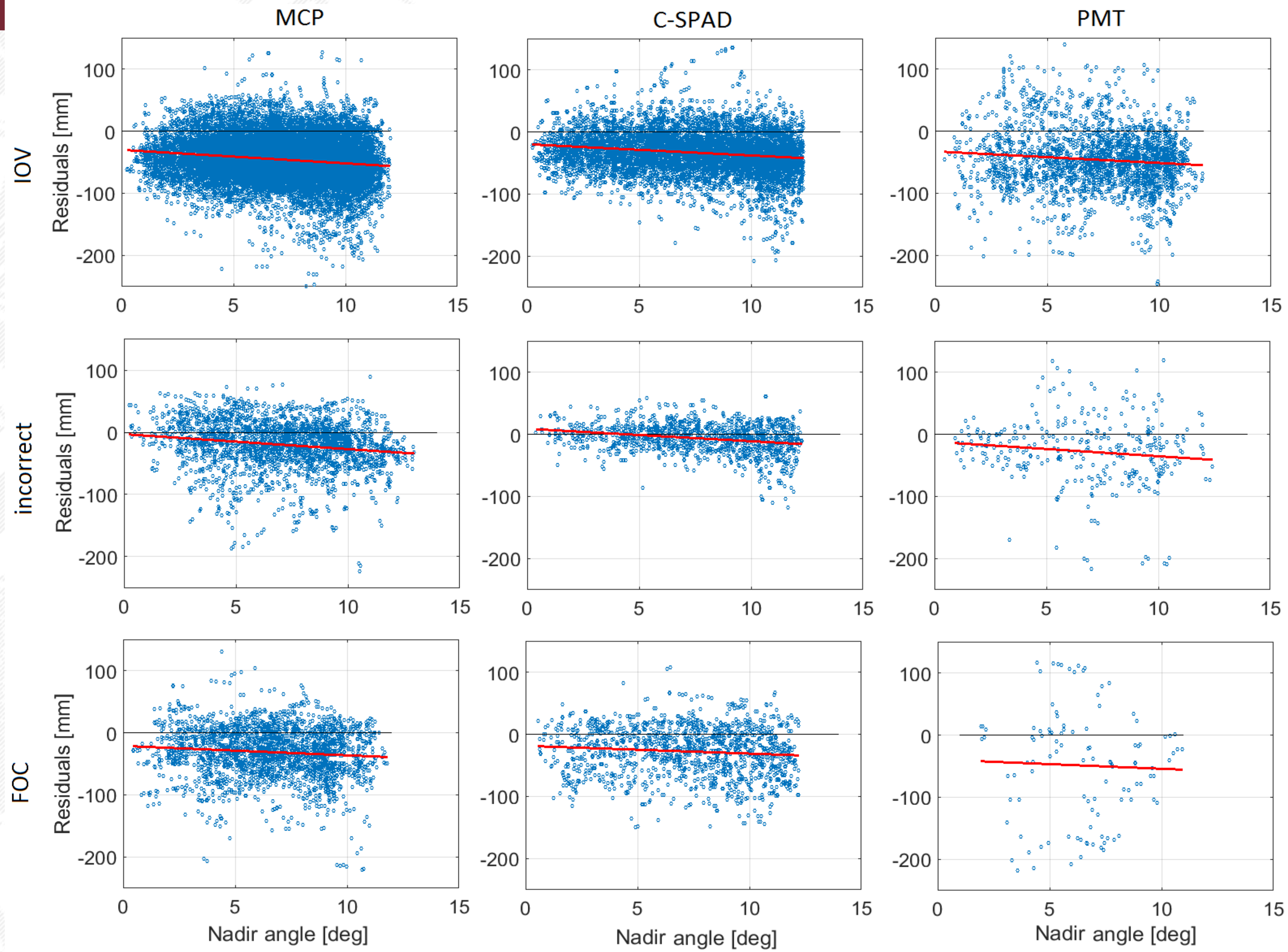
where Δu is the satellite argument of latitude with respect to the argument of latitude of the Sun.



SLR residuals to all Galileo s/c

Arnold, D., Meindl, M., Beutler, G. et al. J Geod (2015) 89: 775. doi:10.1007/s00190-015-0814-4

SLR signature effect for different satellites and detector types



The smallest offset and RMS of SLR residuals is obtained for C-SPAD stations tracking Galileo in incorrect orbital planes.

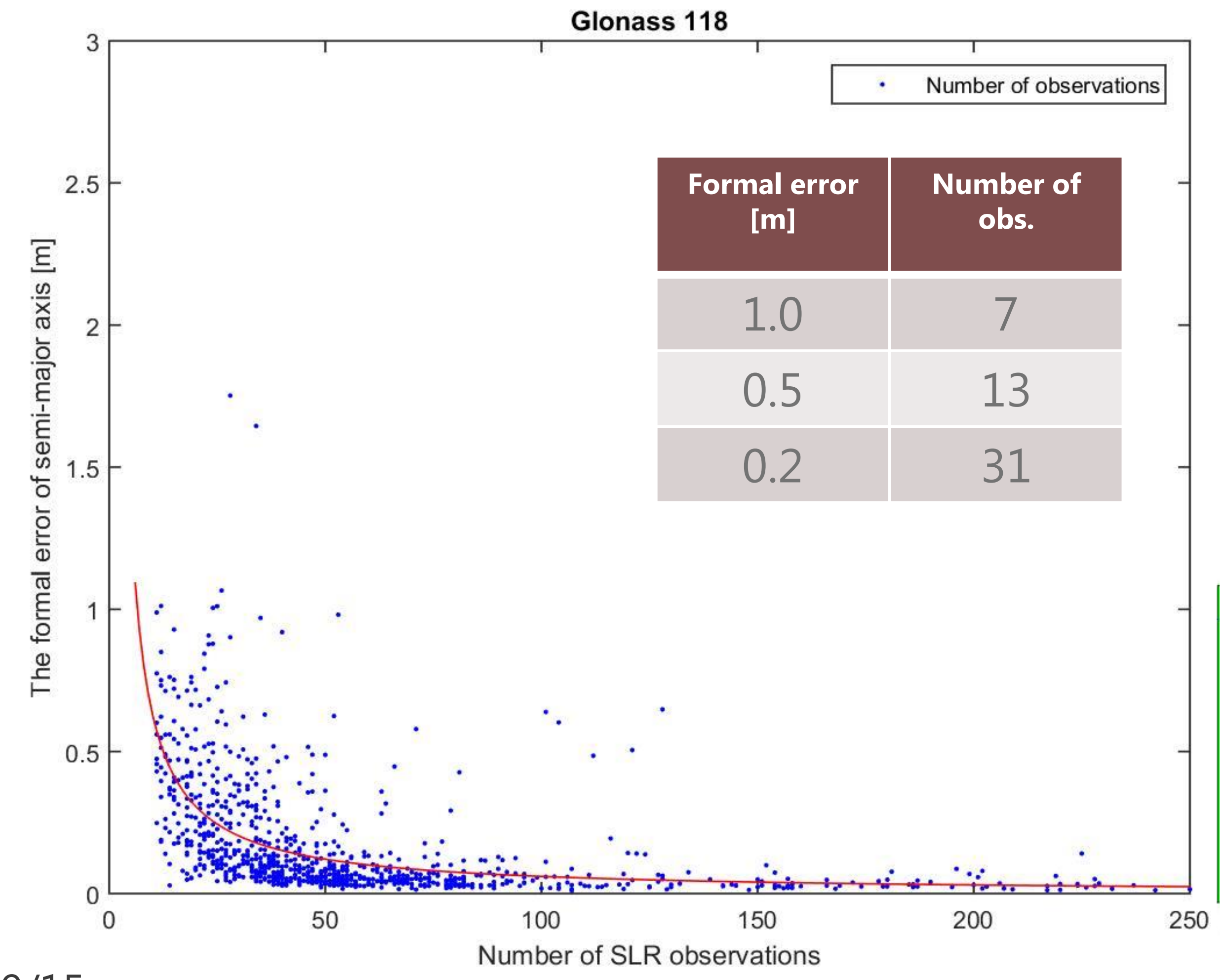
The smallest offset cannot be explained by the change of satellite center-of-mass due to the fuel consuption during the manouvers when correcting the orbit eccentricity.

The difference of the mean offsets between C-SPAD and MCP is about. 12 mm for IOV and incorrect.

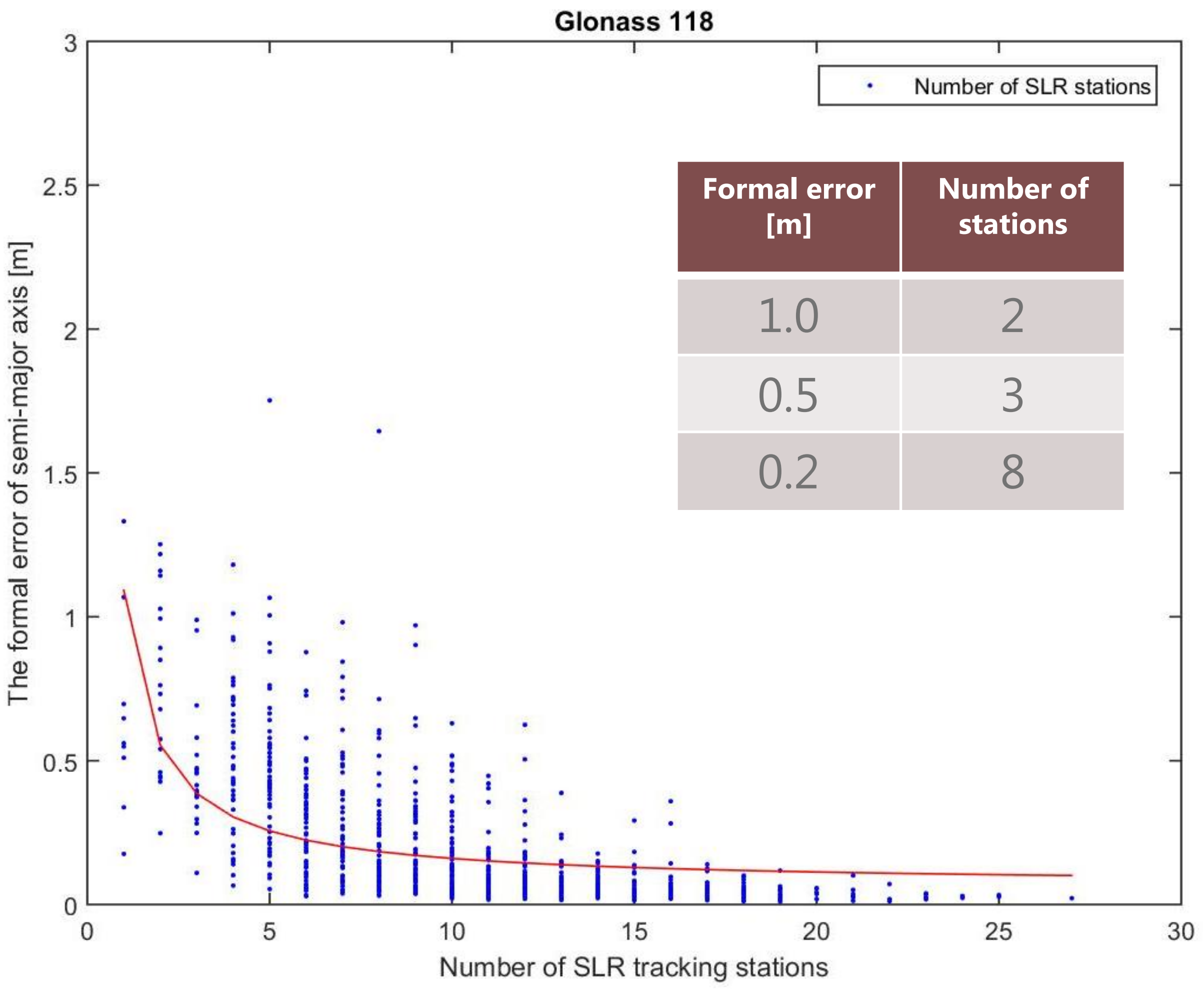
	MCP	C-SPAD	PMT
	Mean offset [mm]		
IOV	-45.8	-33.5	-46.1
incorrect	-18.6	**-6.7**	-27.0
FOC	-30.0	-27.7	-48.8
	RMS [mm]		
IOV	36.3	33.3	47.8
incorrect	35.7	**23.0**	54.3
FOC	37.3	37.2	89.1
	No. obs.		
IOV	15625	7059	2314
incorrect	2383	1238	314
FOC	2329	1361	110

GNSS orbit determination using SLR - GLONASS

The dependency of the determination accuracy of GLONASS semi-major axis on the numer of SLR observations and tracking stations



Formal error [m]	Number of obs.
1.0	7
0.5	13
0.2	31



Formal error [m]	Number of stations
1.0	2
0.5	3
0.2	8

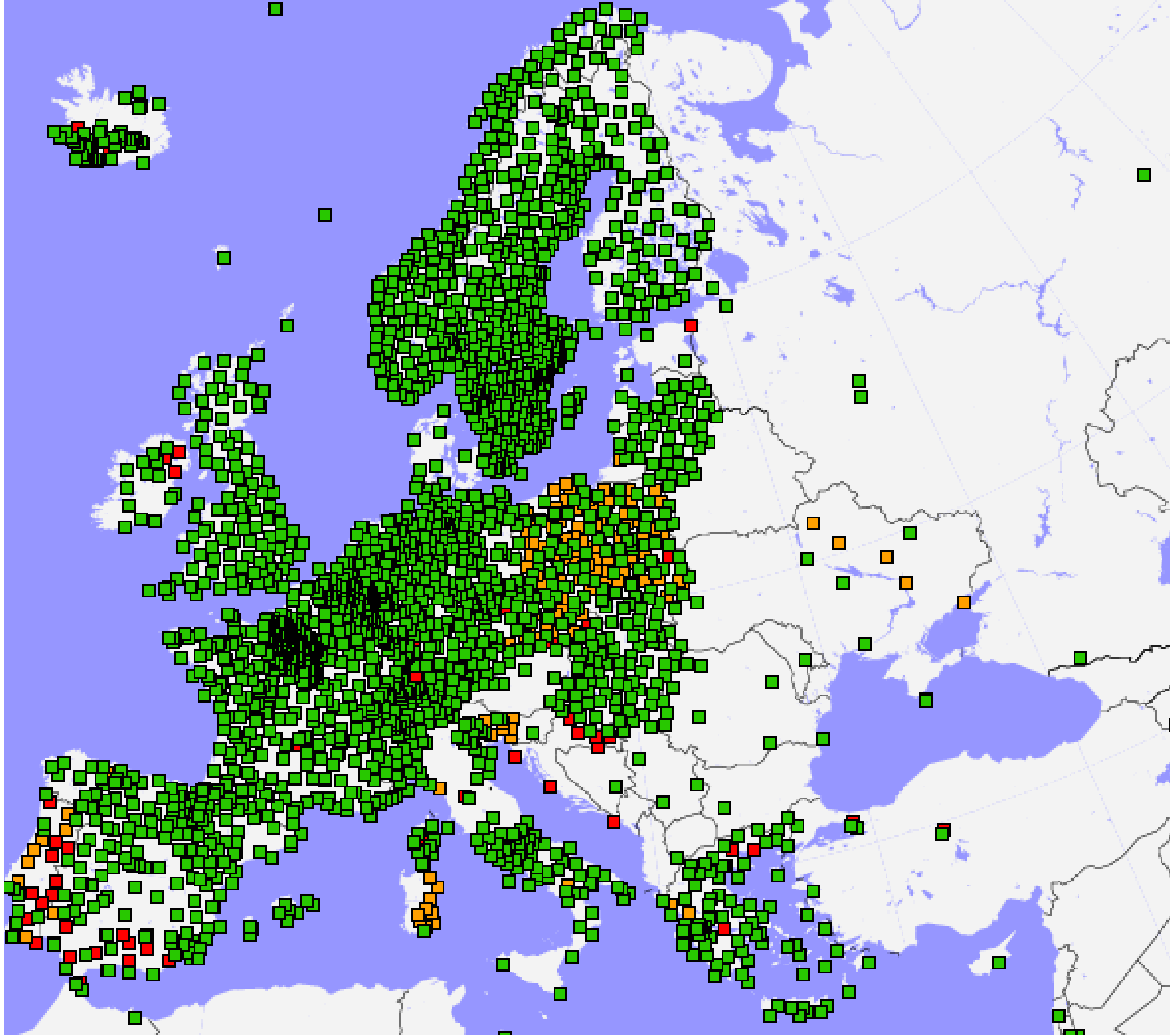
Near-Real Time troposphere recovery

E-GVAP

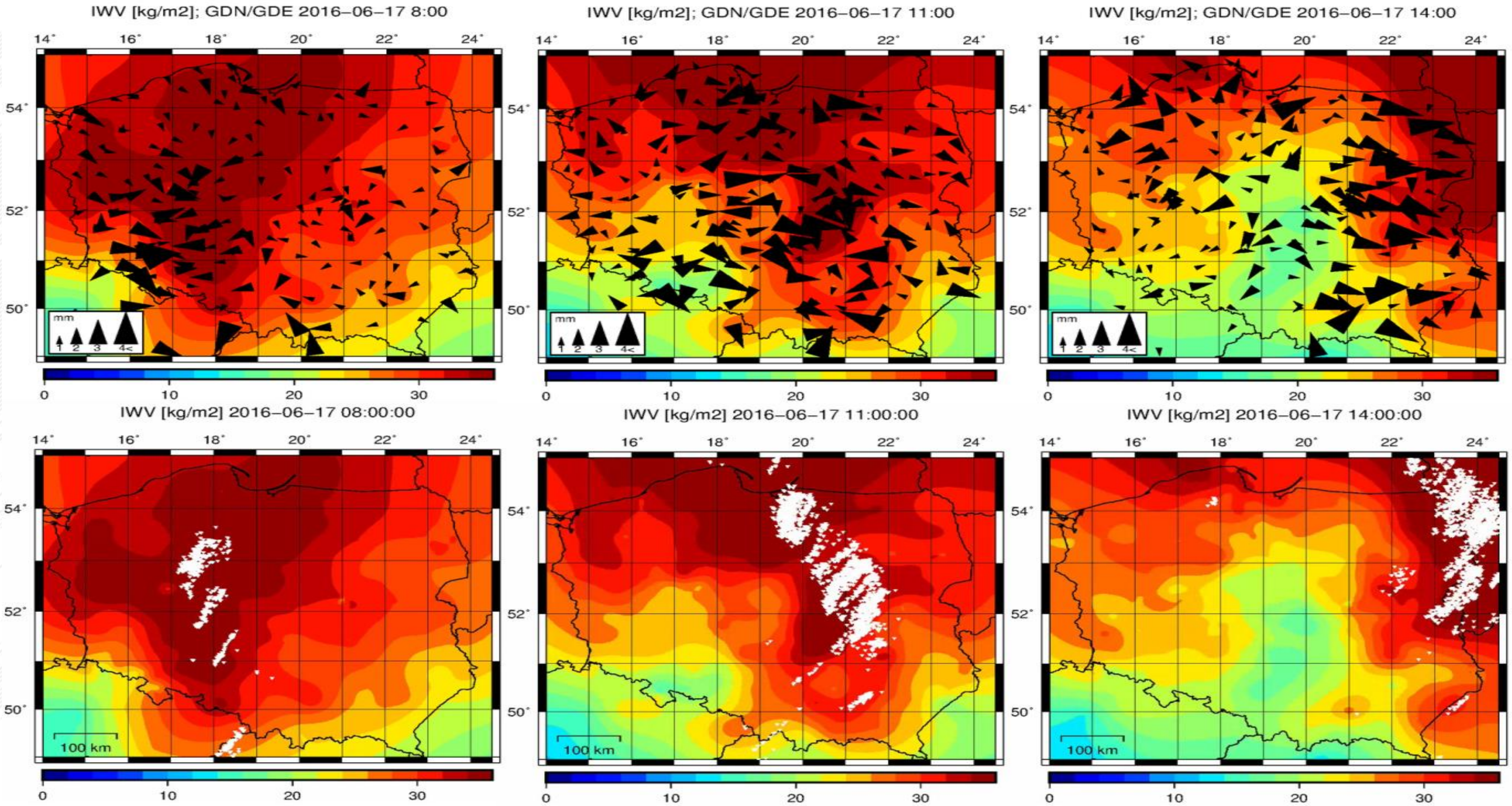
http://egvap.dmi.dk/

Arrival time window of Observations

- No Data or before **05/08 07h**
- between **05/10 04h** and **05/10 07h**
- between **05/10 01h** and **05/10 04h**
- between **05/10 01h** and **05/08 07h**

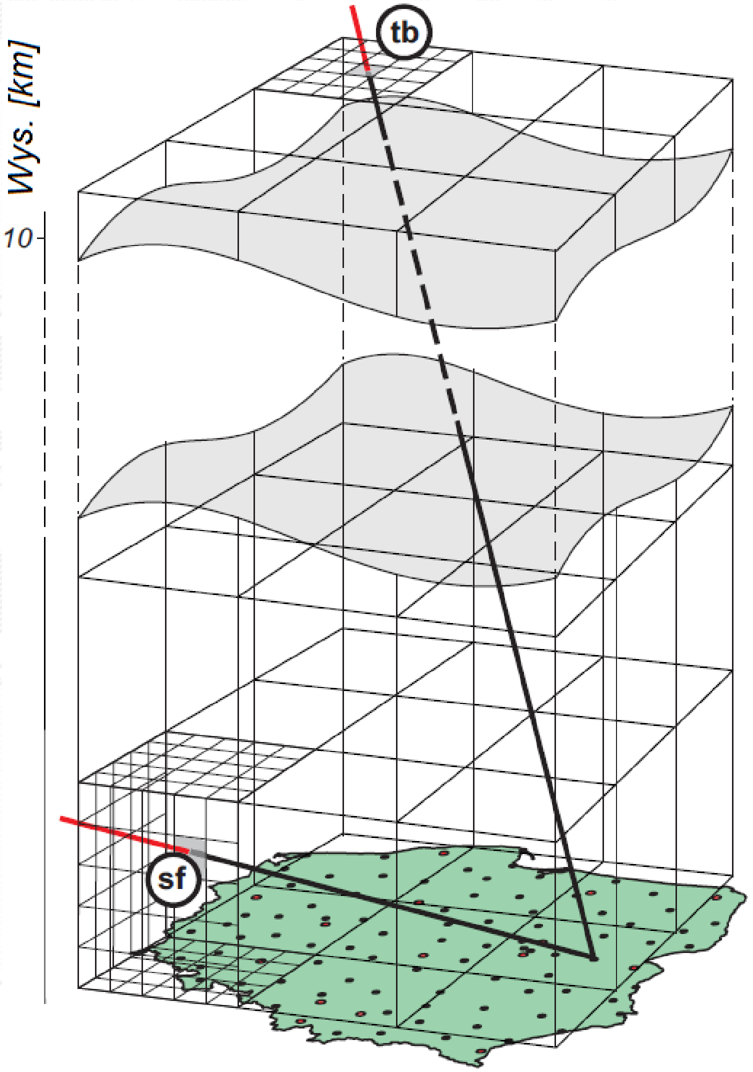


Near-Real Time troposphere recovery



Gradients and lighting strikes over distribution of 2D integrated water varpour (IWV) in tropopshere over Poland for June 2016 (selected)

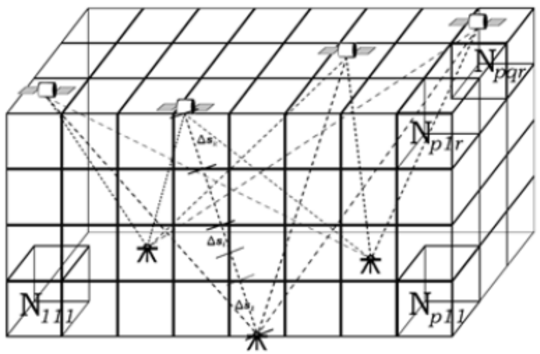
GNSS Tomography



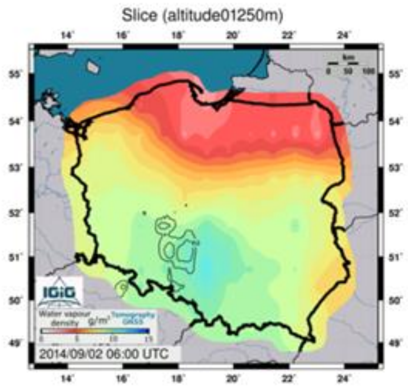
TOMO2

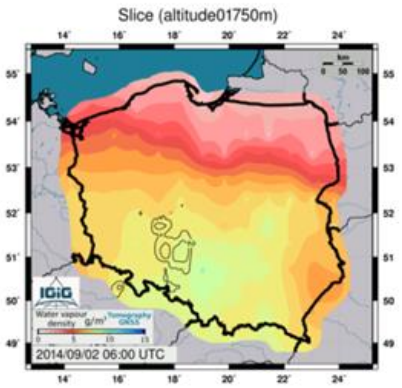
$$L_{atm}(\epsilon, \alpha) = STD = 10^{-6} \int N ds$$

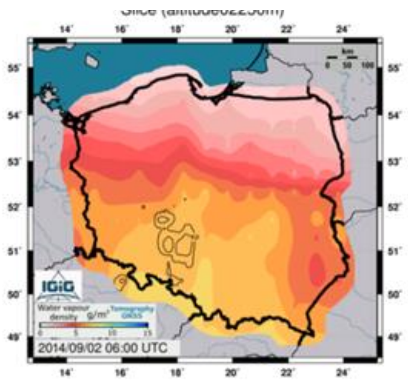
- resolving vertical structure of severe weather
- 3D NRT model for area of Poland
- a way to derive wet refractivity
- Kalman filter for forward processing



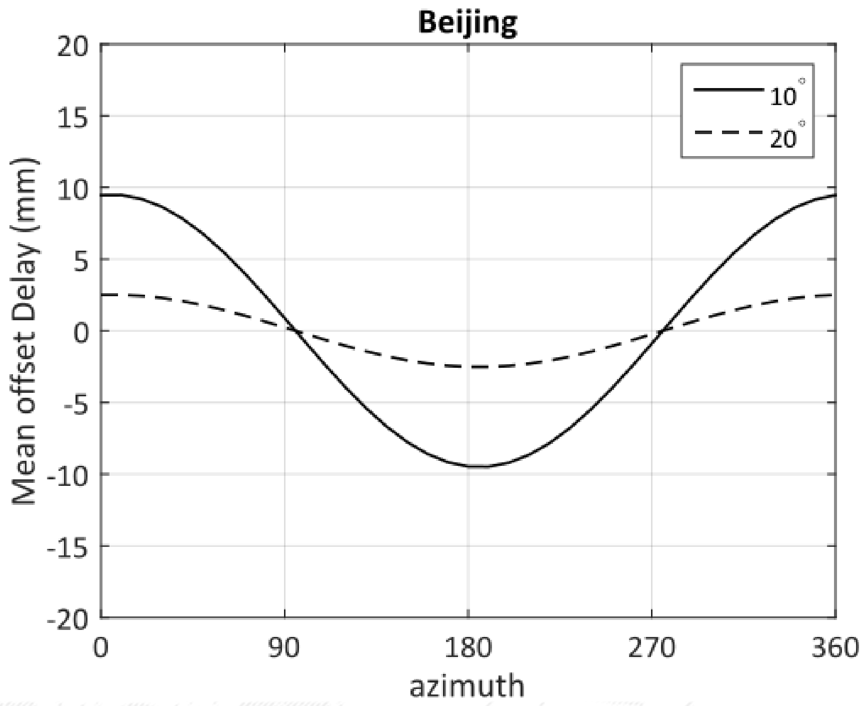
Reference: Rohm, W., and Bosy, J. (2011). The verification of GNSS tropc
area. Advances in Space Research, 47(10), 1721-1730, DOI:

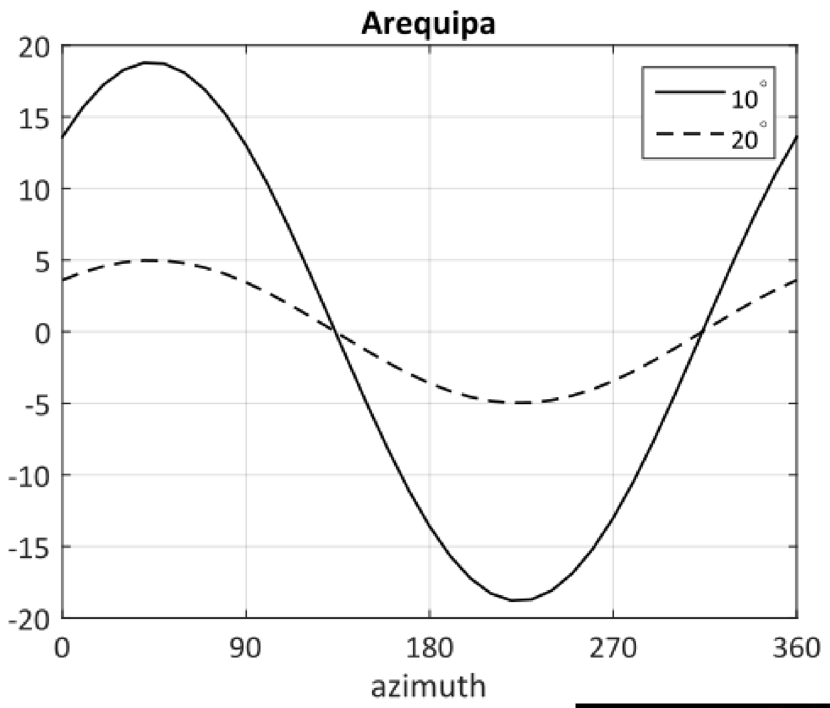


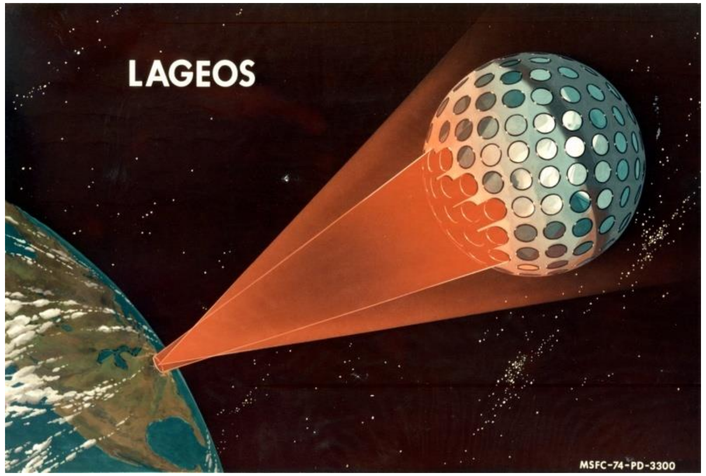




Troposphere delay modeling for SLR (horizontal gradients)

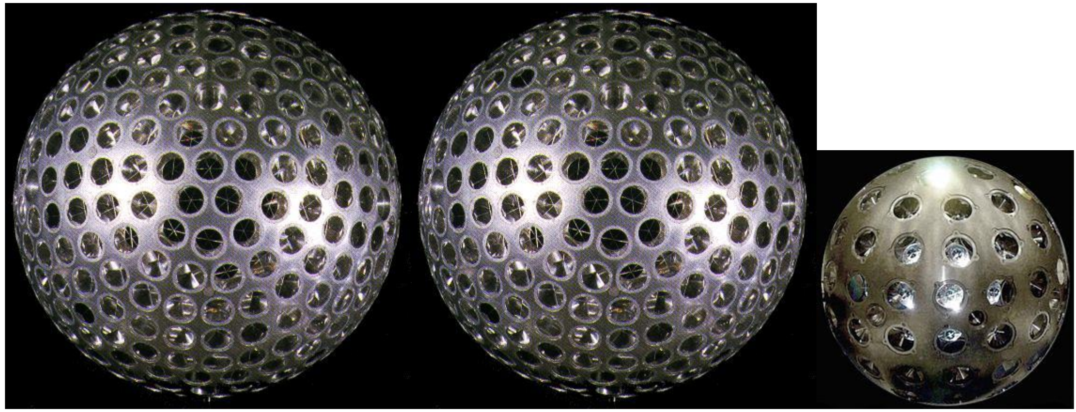






$$d_{atm} = m_{fs} * \left(d_h^2 + d_w^2\right) + \tau(\epsilon) * [G_N\, cos\alpha + \; G_E sin\alpha]$$

$$\tau(\varepsilon) = \frac{1}{\sin(\varepsilon)\tan(\varepsilon) + c} \cdot [G_N \cos(\alpha) + G_E \sin(\alpha)]$$



From left : LAGEOS, LAGEOS -2, LARES

EUREF 2017 Symposium

WROCŁAW   May 17-19, 2017

» GENERAL INFORMATION

The Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences would like to cordially invite you to the EUREF 2017 Symposium, that will be held in Wroclaw, Poland, on May 17-19, 2016 (Wednesday to Friday).

The EUREF Symposium is the forum where the EUREF activities are discussed and the resolutions are taken. It has been organized every year since 1990.

EUREF is the IAG Reference Frame Sub-Commission for Europe, integrated in the Sub-Commission 1.3, Regional Reference Frames, under Commission 1 - Reference Frames, following the implementation of the new IAG structure at the IUGG (International Union of Geodesy and Geophysics) General Assembly held in Sapporo, 2003. The Sub-Commission EUREF was founded in 1987 at the IUGG General Assembly held in Vancouver.

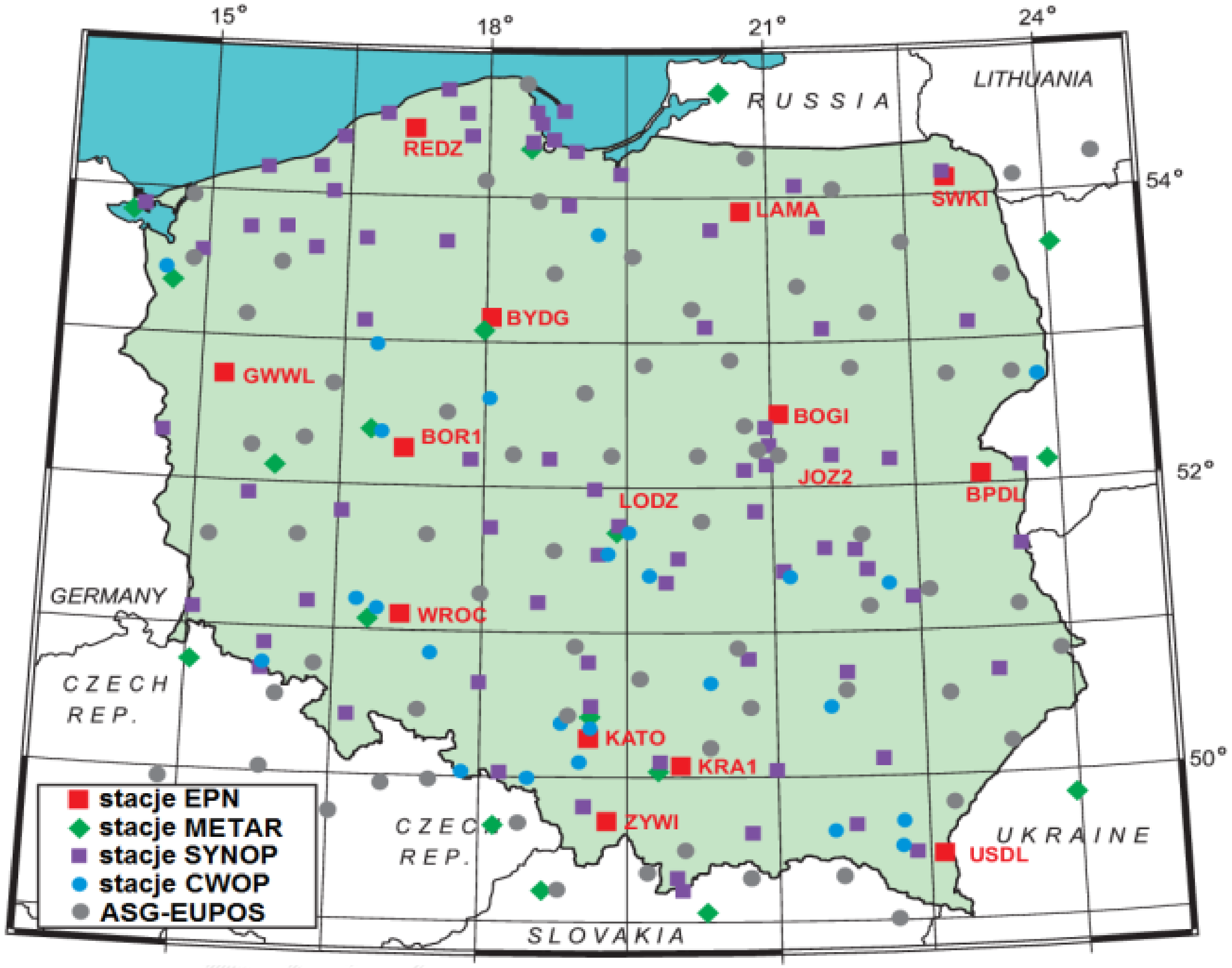
The scope of the symposium covers the definition, realization and maintenance of the European Reference Frame - the geodetic infrastructure for multinational projects requiring precise geo-referencing (e.g. three-dimensional and time dependent positioning, geodynamics, precise navigation, geo-information) - in close cooperation with the IAG components (Services, Commissions, and Inter-commision projects) and EuroGeographics, the consortium of the National Mapping Agencies (NMA) in Europe.

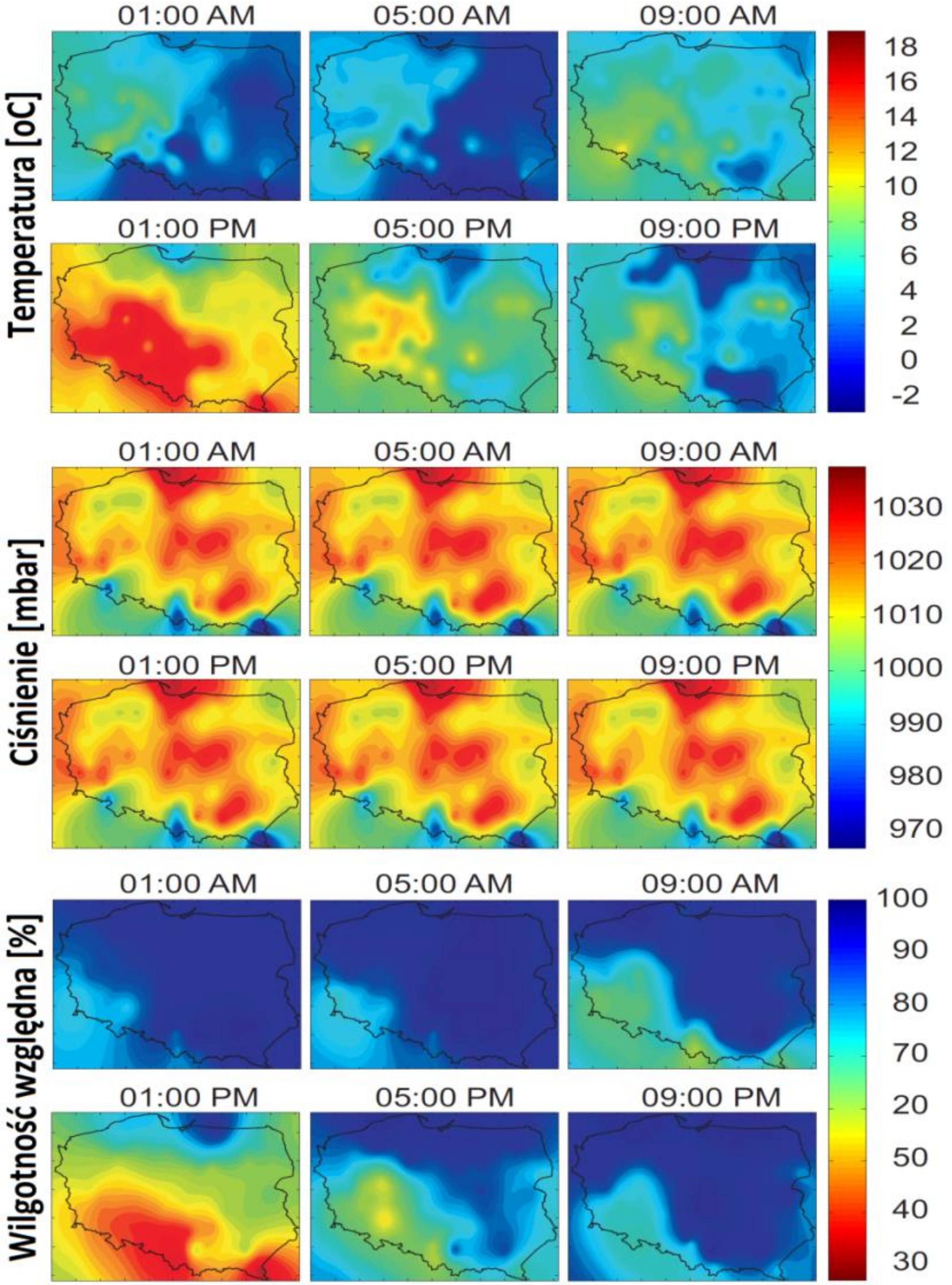
Thank you for your Attention

WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES

Krzysztof Sośnica
krzysztof.sosnica@igig.up.wroc.pl
Institute of Geodesy and Geoinformatics

Near-Real Time troposphere - METEO





Ground meteo networks: EPN, METAR, SYNOP i CWOP