International Committee on
Global Navigation Satellite Systems

New Transformation Parameters at Epoch 2010.0 from PZ-90.11 to ITRF2014

THIRTEENTH MEETING OF THE INTERNATIONAL COMMITTEE ON
GLOBAL NAVIGATION SATELLITE SYSTEMS
ICG-13
Xi'an, China, 4 – 9 November 2018

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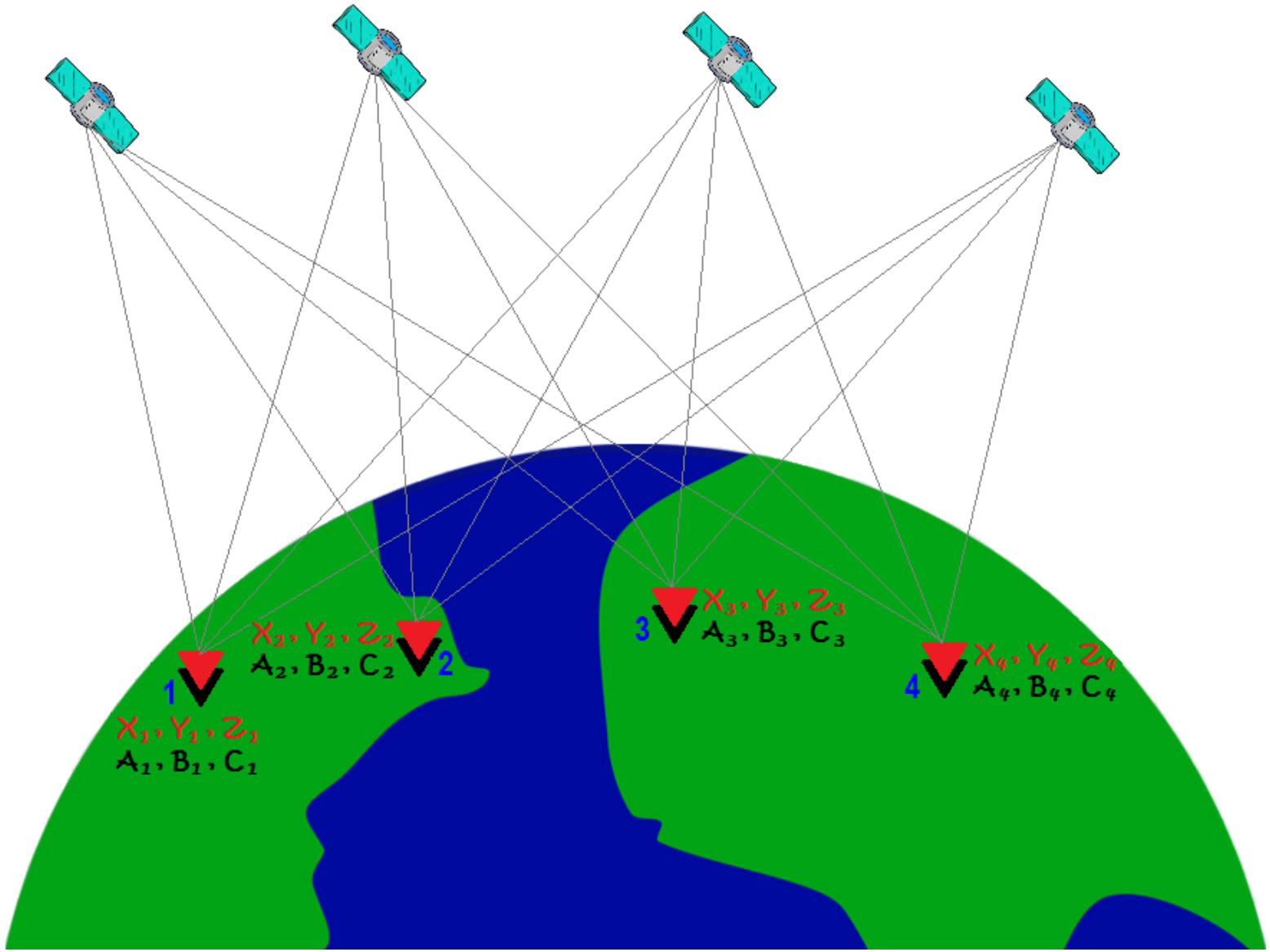
Agenda

- New Transformation Parameters at Epoch 2010.0 from PZ-90.11 to ITRF2014;
- Monitoring Results of PZ-90 Reference Stations.

Two ways to define Transformation Parameters

1) direct use the same station coordinates in both reference frames;
2) use of GNSS orbits that were determined from ground stations specified in two reference frames.



Reference frame OXYZ

Reference frame OABC

IGS Sites used to determine Transformation Parameters

Three main criteria to determine Transformation Parameters are

1) number of reference stations;
2) the best possible site distribution;
3) accuracy of the relative position of the reference stations.

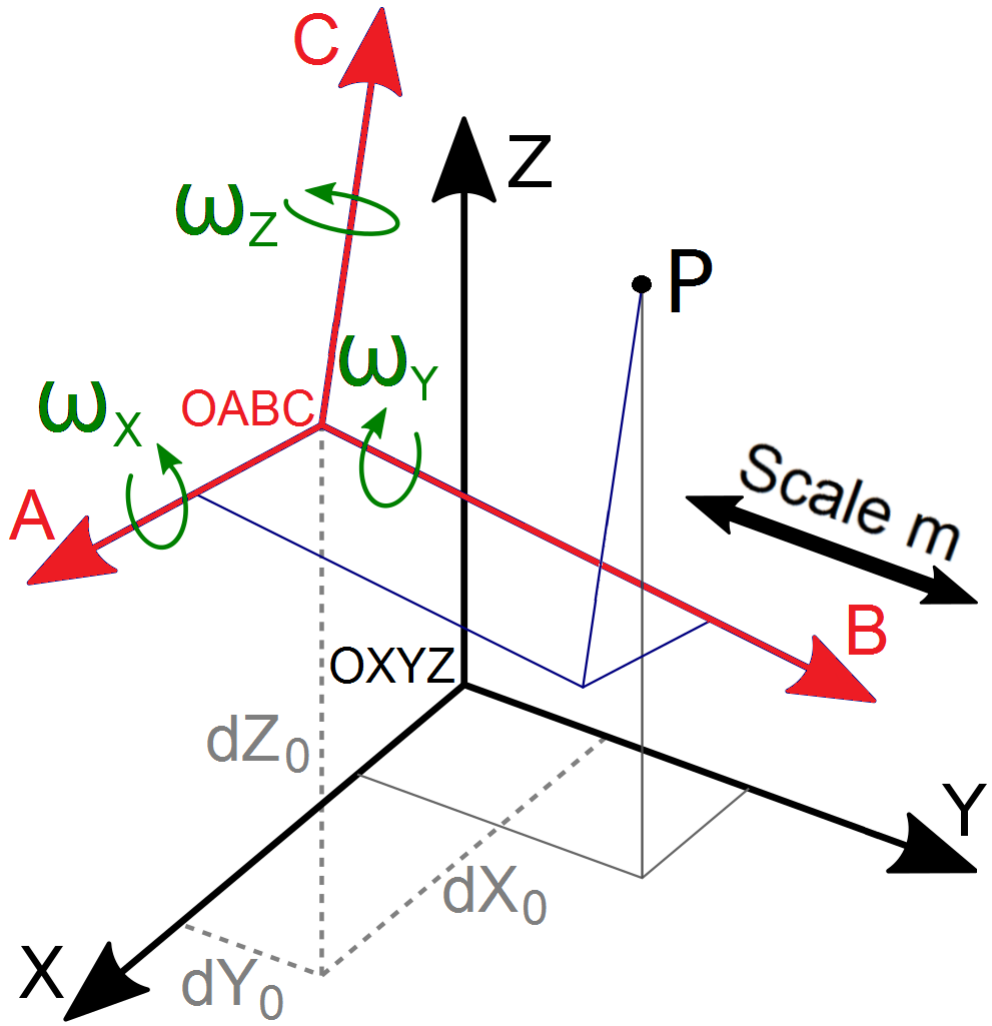
IGS Sites

1) ALRT	13) JPLM	25) PDEL
2) ARTU	14) KELY	26) PETS
3) BRAZ	15) KERG	27) RAMO
4) CHAT	16) KOKB	28) SOFI
5) DAV1	17) LHAZ	29) SUTH
6) DGAR	18) MAC1	30) TIXI
7) GUAM	19) MCM4	31) VESL
8) GUAT	20) NKLG	32) WHIT
9) HOFN	21) NYA1	33) XMIS
10) IISC	22) NRIL	34) YAKT
11) IRKJ	23) OHI2	35) YELL
12) ISPA	24) ONSA	36) ZECK

Helmert Transformation

<u>Three-step procedure</u> was done to determine new transformation parameters

1) IGS Station Positions were determined in PZ-90.11.
2) Least mean square procedure was apply.
3) Accuracy assessment was perform.



$$\begin{bmatrix} X_P \\ Y_P \\ Z_P \end{bmatrix} = (1+m) \cdot \begin{bmatrix} 1 & \omega_Z & -\omega_Y \\ -\omega_Z & 1 & \omega_X \\ \omega_Y & -\omega_X & 1 \end{bmatrix} \cdot \begin{bmatrix} A_P \\ B_P \\ C_P \end{bmatrix} + \begin{bmatrix} dX_0 \\ dY_0 \\ dZ_0 \end{bmatrix}$$

$$\begin{bmatrix} X-A \\ Y-B \\ Z-C \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & X & 0 & -Z & Y \\ 0 & 1 & 0 & Y & Z & 0 & -X \\ 0 & 0 & 1 & Z & -Y & X & 0 \end{bmatrix} \cdot \begin{bmatrix} dX_0 & dY_0 & dZ_0 & m & \omega_X & \omega_Y & \omega_Z \end{bmatrix}^T$$

A method for determining transformation parameters (1)

Step 1. Positions of selected IGS stations were determined in PZ-90.11 reference frame using GNSS observations.

$$\vec{X}_{\text{IGS}}^{\text{ITRF}} \Rightarrow \vec{X}_{\text{IGS}}^{\text{PZ-90}}$$

Step 2. Least Mean Square Procedure was apply.

$$\mathbf{L} = \mathbf{D}\,\mathbf{x}$$
$$\mathbf{V}^{\mathrm{T}}\,\mathbf{P}\,\mathbf{V} = \min$$
$$\mathbf{x} = (\mathbf{D}^{\mathrm{T}}\,\mathbf{P}\,\mathbf{D})^{-1}\,\mathbf{D}^{\mathrm{T}}\,\mathbf{P}\,\mathbf{L}$$
$$\mathbf{V} = (V_{\mathrm{x}}, V_{\mathrm{y}}, V_{\mathrm{z}})$$
$$\mathbf{Q} = (\mathbf{D}^{\mathrm{T}}\,\mathbf{P}\,\mathbf{D})^{-1}$$

A method for determining transformation parameters (2)

Step 3. Accuracy assessment was performed.

Normalized Correlation Matrix

	dX	dY	dZ	m	wX	wY	wZ
dX	1,000	-0,006	-0,005	-0,071	0,009	0,262	-0,072
dY		1,000	-0,003	-0,052	-0,263	-0,009	0,097
dZ			1,000	-0,231	0,057	-0,079	0,000
m				1,000	0,000	0,000	0,000
wX					1,000	0,039	0,015
wY						1,000	0,010
wZ							1,000

New Transformation Parameters at Epoch 2010.0 from PZ-90.11 to ITRF2014

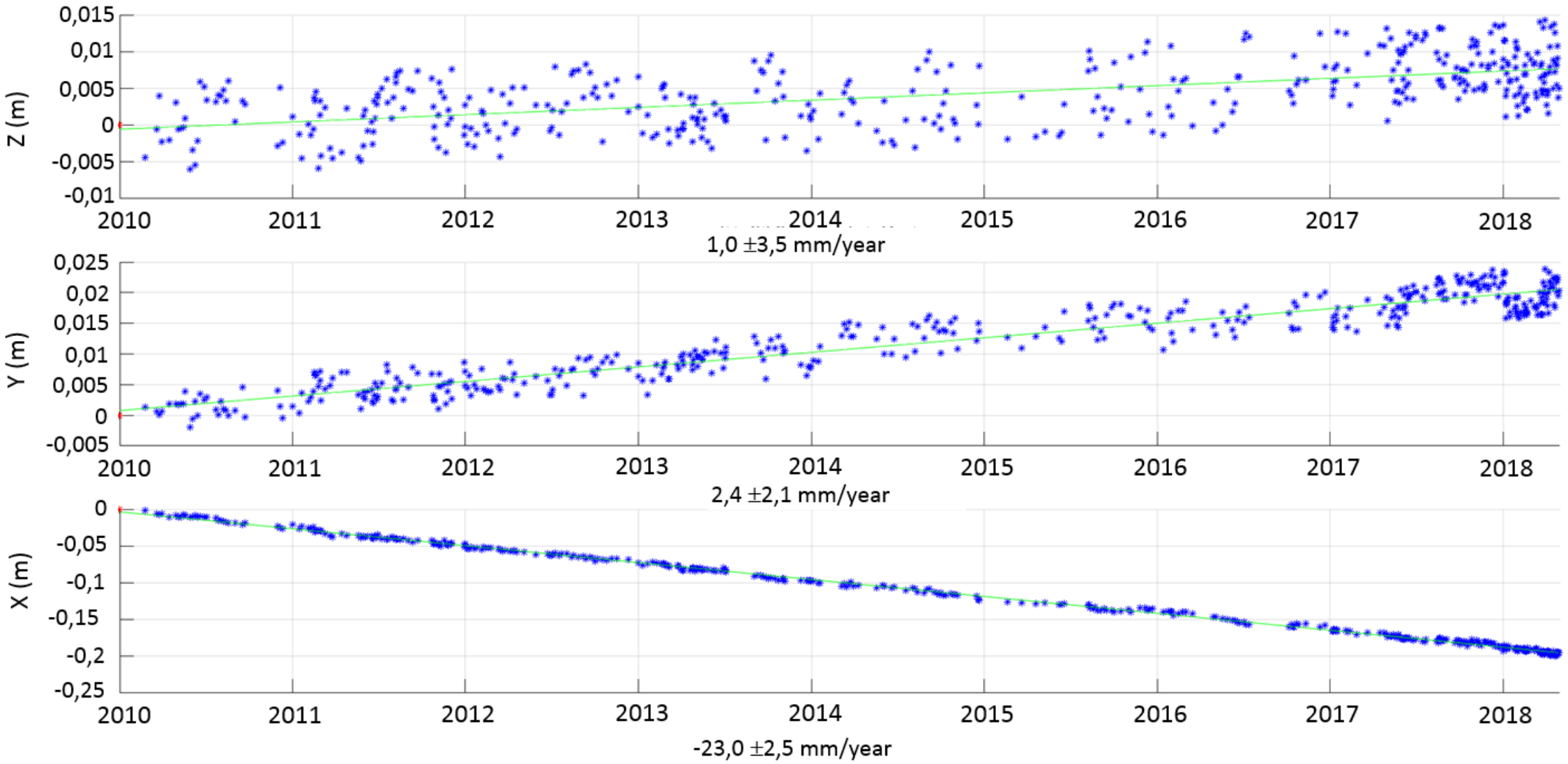
#	From	To	ΔX (m)	ΔY (m)	ΔZ (m)	ω_X (mas)	ω_Y (mas)	ω_Z (mas)	m (10^{-6})	Epoch
1	PZ-90	PZ-90.02	−1.07 ±0.10	−0.03 ±0.10	+0.02 ±0.10	0	0	−130 ±10	−0.220 ±0.020	2002.0
2	WGS 84 (G1150)	PZ-90.02	+0.36 ±0.10	−0.08 ±0.10	−0.18 ±0.10	0	0	0	0	2002.0
3	PZ-90.11	ITRF2008	−0.003 ±0.002	−0.001 ±0.002	+0.000 ±0.002	+0.019 ±0.072	−0.042 ±0.073	+0.002 ±0.090	−0.000 ±0.0003	2010.0
4	PZ-90.11	ITRF2014	−0.0053 ±0.0020	−0.0040 ±0.0020	−0.0032 ±0.0020	+0.035 ±0.073	−0.087 ±0.073	+0.036 ±0.090	−0.0000 ±0.0001	2010.0

$$\mathrm{RMS}_{\vec{X}^{\mathrm{PZ-90.11}}_{\mathrm{ITRF\,2014}}} = 1,2\ \mathrm{cm}$$

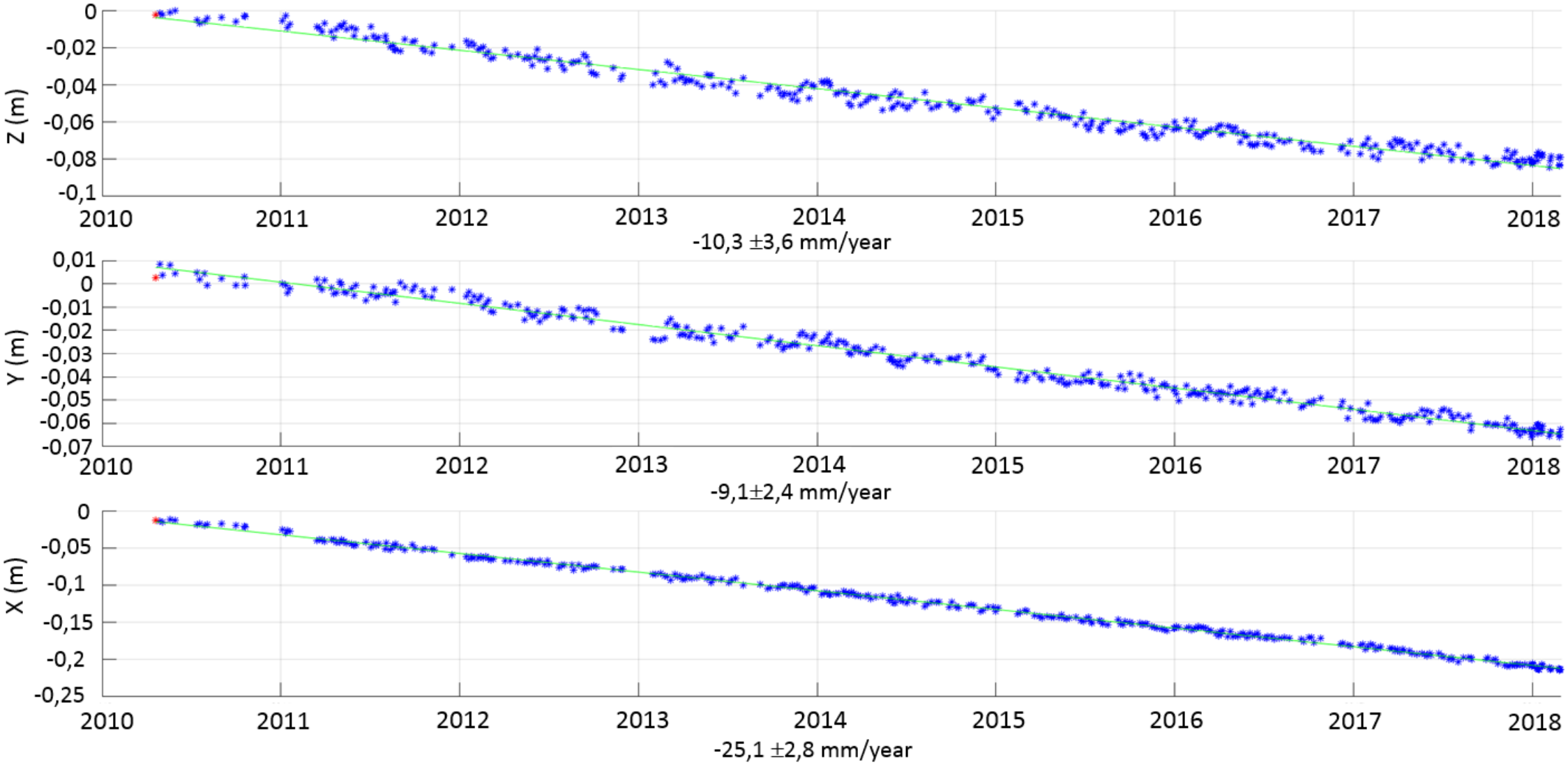
Monitoring Results of PZ-90 Reference Stations

Velocities of Norilsk and Blagoveshchensk Reference Stations were observed during a period 2010.0-2018.33

Norilsk Station Position. Data span: 2010.0-2018.33



Blagoveshchensk Station Position. Data span: 2010.0-2018.33



Monitoring Results

To reduce the residuals between observed and computed station position **three different methods** are investigated.

Observed and computed station motions for Norilsk and Blagoveshchensk sites in a period 2010.0-2018.33

	Observed station motion Δ_O and their RMS in cm	Site velocities at epoch 2010.0 in mm/year	Computed station motion Δ_C in cm	Residuals $\Delta_O - \Delta_C$ in cm
		Norilsk		
X	–20.18 ±0.25	−2.21	−18.66	−1.52
Y	+2.00 ±0.21	+0.24	+2.00	+0.00
Z	+0.83 ±0.35	−0.05	−0.42	+0.88
		Blagoveshchensk		
X	–20.91 ±0.36	−2.25	−18.74	−2.17
Y	–7.50 ±0.24	−0.54	−4.50	−3.00
Z	–8.58 ±0.28	−0.64	−5.33	−3.25

These are:

1) extended parametrization based on the estimation of the periodic signals embedded in the time series of the station positions;
2) improved geophysical modeling like postseismic deformation model;
3) frequent estimation of station positions as a result of station positions monitoring.

Conclusion & Future Plans

- New transformation parameters at epoch 2010.0 from PZ-90.11 to ITRF2014 were defined.
  - ✓ PZ-90 Template (description) was already updated and may be published on the ICG Web-site.
- The work on organization of PZ-90 reference stations monitoring continues.
  - ✓ GNSS observing data from several PZ-90 reference stations are put on the Web in test mode.
  - ✓ New approaches to improve the reference frame stability are investigated.
- PZ-90 reference stations located in Russian Federation are planed to be included in IGS network.
  - ✓ IGS requirements to new IGS site were investigated.
  - ✓ PZ-90 reference stations were upgraded.
- New version of PZ-90 reference frame will be designed by 2022 year.