ETRF2020: a realization of the ETRS89

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Outline

- Recall ITRS and ETRS89 relationship
- ITRFyy origin stability
- ITRF2020 Plate Motion Model
  - Inversion model: with and without a translation rate
  - Site selection
  - Preliminary results, but close to final
- Evaluation of the EURA rotation Pole
- Proposal for ETRF2020

ETRS89 Realization

ETRS89 adoption: Firenze (Florence), 1992

Fundamentally based on transformation from ITRS to ETRS89

Transformation formula ITRFyy ==> ETRFyy

Positions

$$X^E(t_c) = X^I_{YY}(t_c) + T_{YY} + \begin{pmatrix} 0 & -\dot{R}3_{YY} & \dot{R}2_{YY} \\ \dot{R}3_{YY} & 0 & -\dot{R}1_{YY} \\ -\dot{R}2_{YY} & \dot{R}1_{YY} & 0 \end{pmatrix} \times X^I_{YY}(t_c).(t_c - 1989.0)$$

Velocities

$$\begin{pmatrix} \dot{X}^E_{YY} \\ \dot{Y}^E_{YY} \\ \dot{Z}^E_{YY} \end{pmatrix} = \begin{pmatrix} \dot{X}^I_{YY} \\ \dot{Y}^I_{YY} \\ \dot{Z}^I_{YY} \end{pmatrix} + \begin{pmatrix} 0 & -\dot{R}3_{YY} & \dot{R}2_{YY} \\ \dot{R}3_{YY} & 0 & -\dot{R}1_{YY} \\ -\dot{R}2_{YY} & \dot{R}1_{YY} & 0 \end{pmatrix} \times \begin{pmatrix} X^I_{YY} \\ Y^I_{YY} \\ Z^I_{YY} \end{pmatrix}$$

Main focus next : Frame origin and EURA rotation pole

Transformation Parameters: From ITRF2020 to past ITRFs

Transformation parameters from ITRF2020 to past ITRFs at Epoch 2015.0

SOLUTION	Tx	Ty	Tz	D	Rx	Ry	Rz
UNITS---------->	mm	mm	mm	ppb	.001"	.001"	.001"
	.	.	.	.	.	.	.
RATES	Tx	Ty	Tz	D	Rx	Ry	Rz
UNITS---------->	mm/y	mm/y	mm/y	ppb/y	.001"/y	.001"/y	.001"/y
ITRF2014	-1.4	-0.9	1.4	-0.42	0.00	0.00	0.00
rates	0.0	-0.1	0.2	0.00	0.00	0.00	0.00
ITRF2008	0.2	1.0	3.3	-0.29	0.00	0.00	0.00
rates	0.0	-0.1	0.1	0.03	0.00	0.00	0.00
ITRF2005	2.7	0.1	-1.4	0.65	0.00	0.00	0.00
rates	0.3	-0.1	0.1	0.03	0.00	0.00	0.00
ITRF2000	-0.2	0.8	-34.2	2.25	0.00	0.00	0.00
rates	0.1	0.0	-1.7	0.11	0.00	0.00	0.00

Inversion models

$$\dot{X}_i = \omega_p \times X_i \quad \textbf{(1)}$$

$$\dot{X}_i = \omega_p \times X_i + \dot{T} \quad \textbf{(2)}$$

Translation Rate: $\dot{T}$ **: Origin Rate Bias (ORB)**

- **In principle** $\dot{T}$ **= CM/CL translation rate**
- **CL: residual center of surface lateral figure, or "geometric center of tectonic plate motion" (Blewitt 2003)**
- **But in practice it is strongly dependent on site selection (network effect)**
- **==> Hazardous to attribute any geophysical meaning to the estimated ORB**
- **T_z-rate varies between zero and 1 mm/yr**

ITRF2020-PMM: Site Selection

1. Sites with time span > 3 years
2. Exclude PSD sites, with few exceptions where the linear velocity fits the adjusted model
3. At least 100 km away from plate boundaries
4. Outside regions impacted by Glacial Isostatic Adjustment (GIA) with vertical velocities > 0.80 mm/yr, except Antarctica
5. Outside of regions with significant deformation (Kreemer et al. 2014),
6. Outside regions impacted by present-day ice melting and trends in continental hydrology (GRACE-based horizontal velocities > 0.3 mm/yr)

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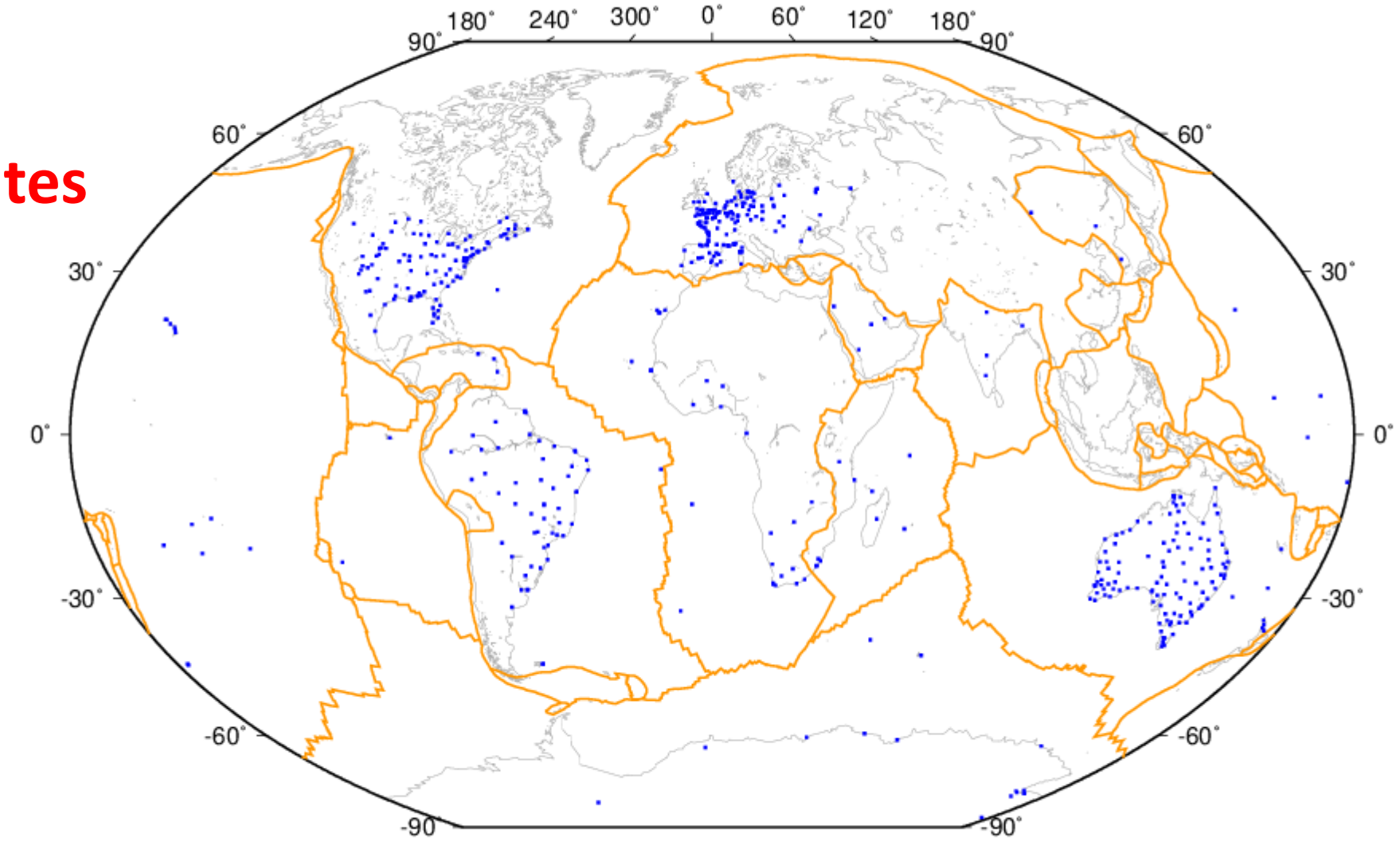
7. Iterative adjustment till raw residuals < 1 mm/yr and normalized residuals < 3-sigma (1-mm/yr-3-sigma condition)

Final selection of sites

509 sites



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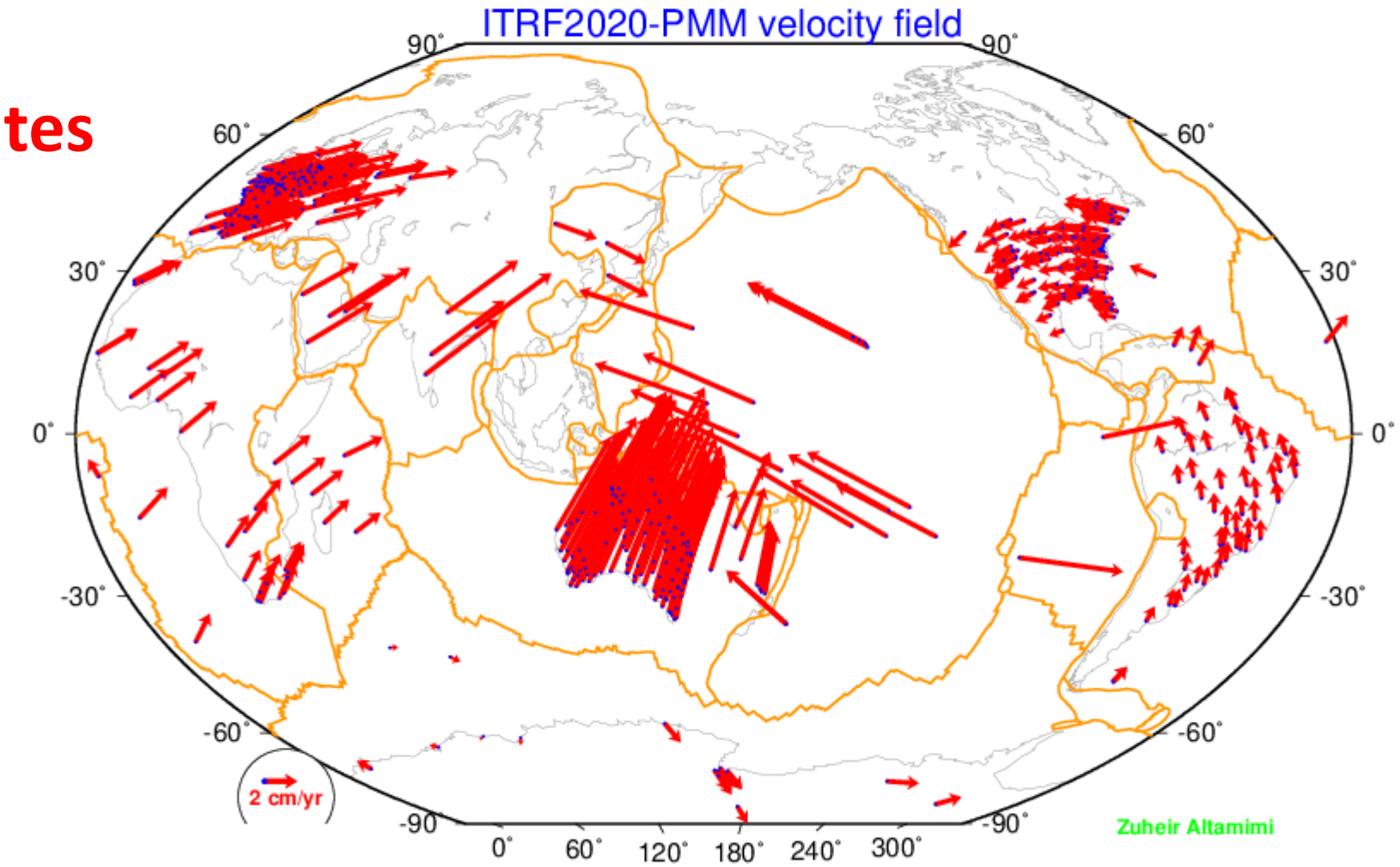
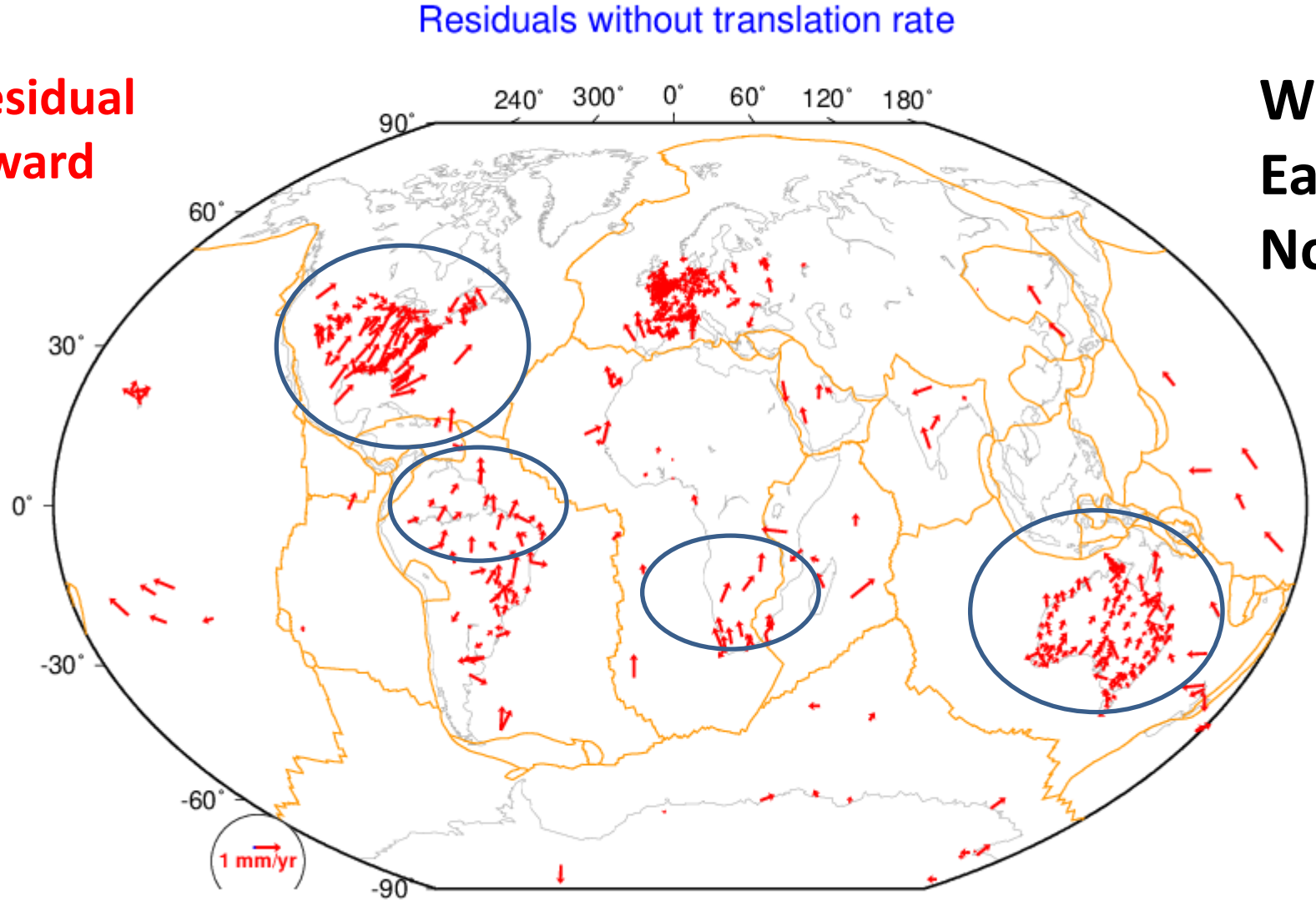


Residuals without translation rate

Clear global residual motion northward



WRMS : (mm/yr)

East : 0.25

North : 0.40

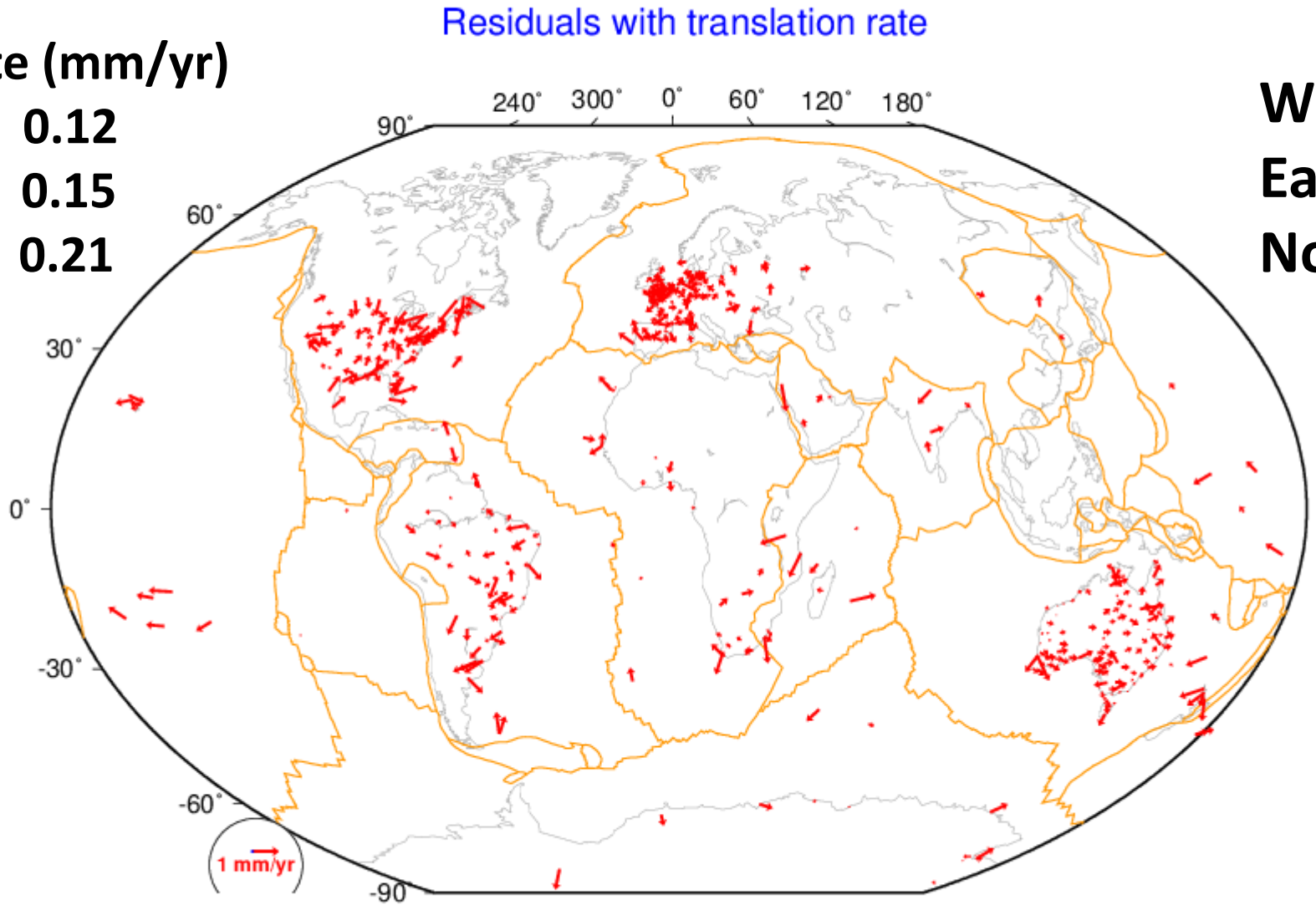
Residuals with translation rate $\dot{T}$

Translation rate (mm/yr)

TX = 0.24 +/- 0.12

TY = 0.37 +/- 0.15

TZ = 0.58 +/- 0.21



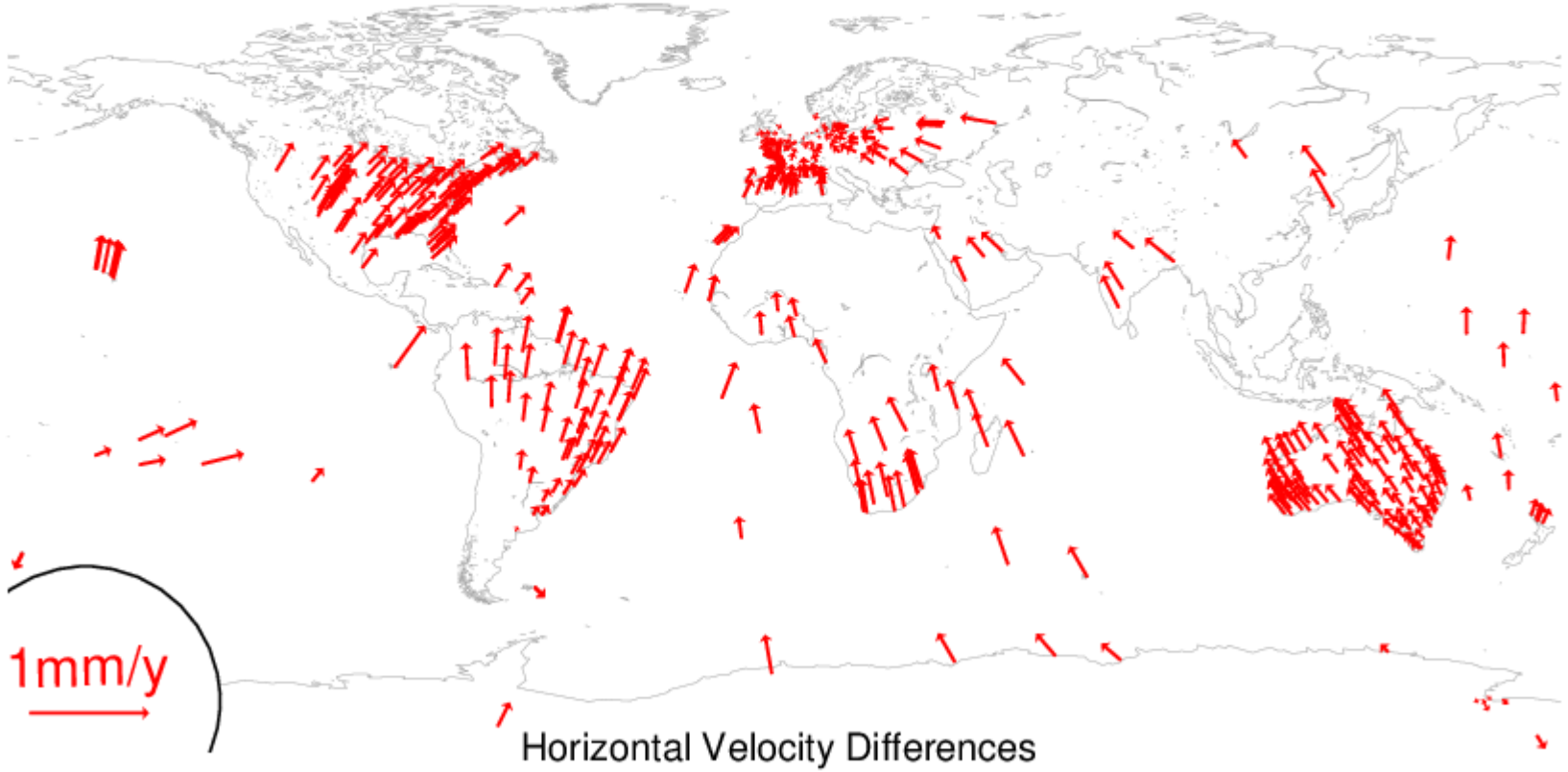
WRMS : (mm/yr)

East : 0.24

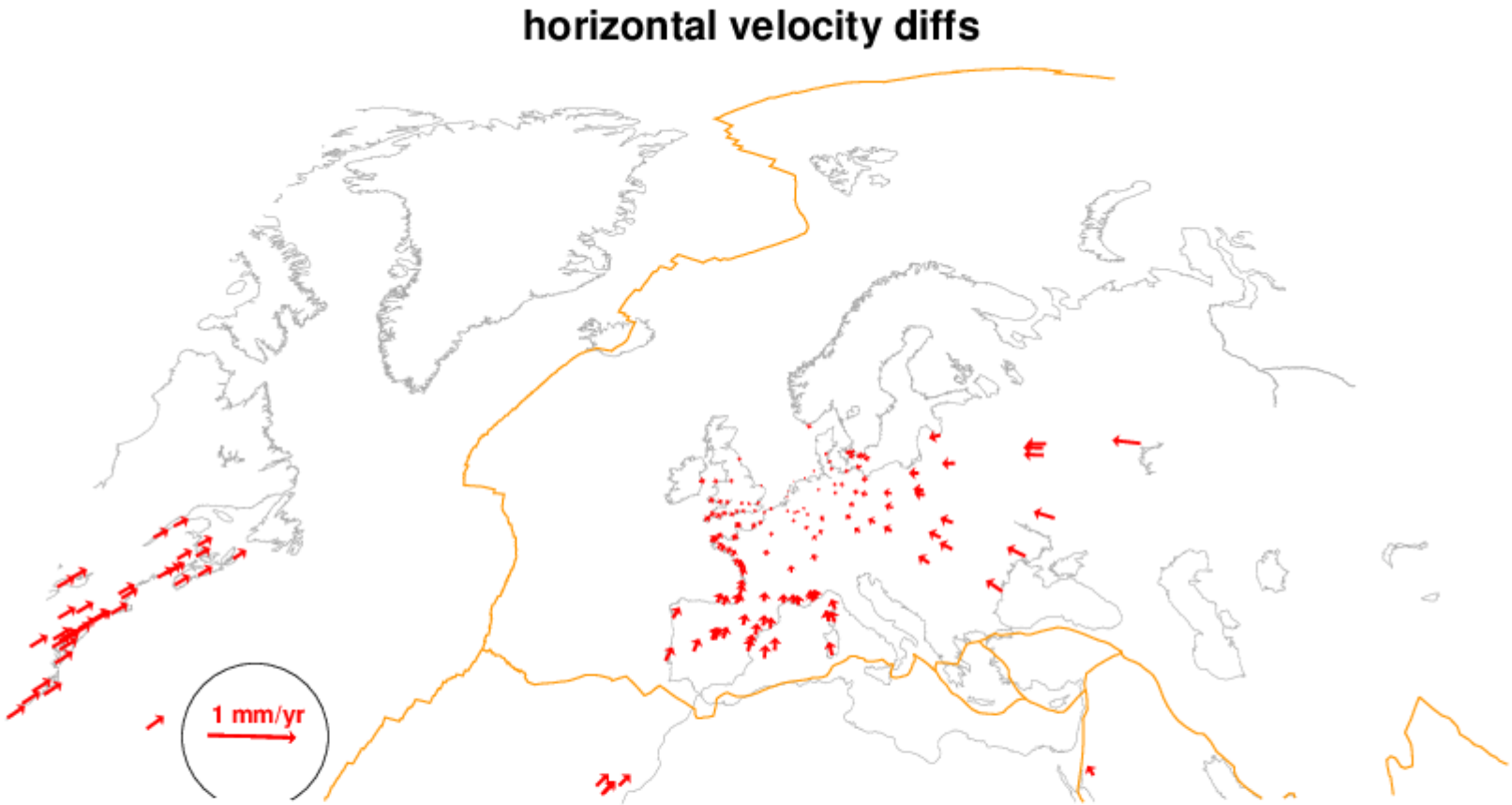
North : 0.26

ITRF2020 PMM will include a translation rate

Velocity differences between the two models



Velocity differences between the two models in Europe

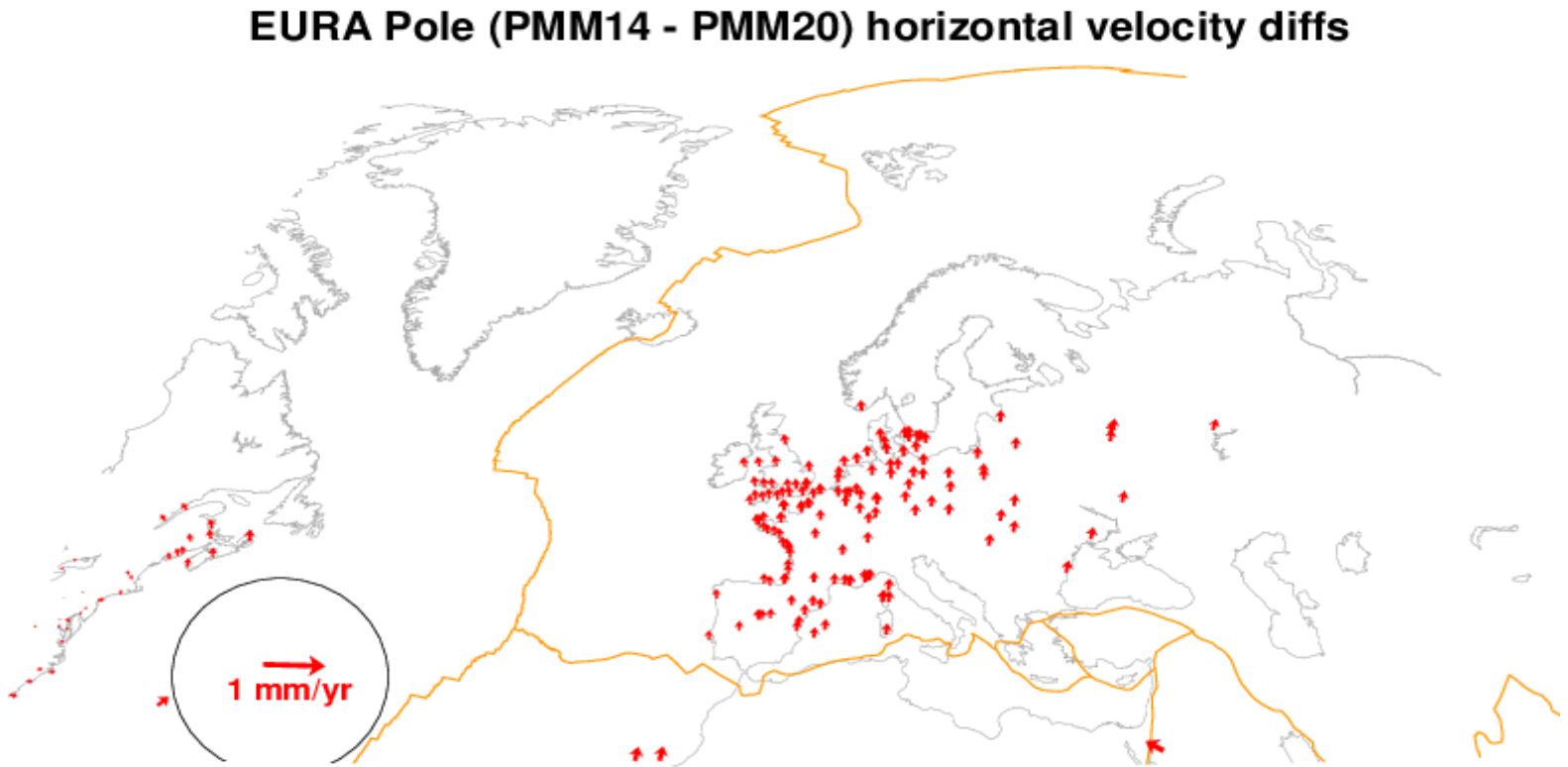


==> Ignore the translation rate in the ETRF2020 definition

ETRF2020

- Geocentric: no translations or translation rates with respect to ITRF2020
- EURA rotation pole = EURA rotation pole derived from ITRF2020-PMM
- Ignore the translation rate of ITRF2020-PMM

EURA rotation pole predicted Velocity differences between PMM2014 & PMM2020



Next steps

- **Finalize ITRF2020 PMM ==> publication**
- **Derive ETRF2020 with zero transformation parameters wrt ITRF2020, except the three rotation rates**

  ==> ETRF2020 is coherent with ETRF2014 at a few mm and fractions of mm/yr level thanks to the ITRF origin stability and the tiny EURA rotation pole difference between the two frames
- **Update EUREF-TN-1**

Table 1: Transformation parameters from ITRF$_{yy}$ to ETRFyy **at epoch 1989.0** and their rates/year

ETRF$_{yy}$	T1 mm	T2 mm	T3 mm	D 10^{-9}	R1 mas	R2 mas	R3 mas
ETRF2020	0.0	0.0	0.0	0.00	0.000	0.000	0.000
rates	0.0	0.0	0.0	0.00	0.079	0.518	-0.757
ETRF2014	0.0	0.0	0.0	0.00	0.000	0.000	0.000
rates	0.0	0.0	0.0	0.00	0.085	0.531	-0.770