

Rigid Plate Transformations to Support PPP and Absolute Positioning in Africa

Richard Stanaway & Craig Roberts

School of Surveying and Spatial Information Systems

University of New South Wales, Australia



FIG Working Week, Marrakech, Morocco, 18-22 May 2011



CORS Distribution in Africa

Sparse GNSS CORS infrastructure overcome by use of PPP and Global Differential Services

image: Centro GNSS de Canarias
www.canarygnsscenter.org



Natural Resources Canada
www.nrcan.gc.ca

Francais Home Contact us Help Search

Natural Resources Canada > Earth Sciences Sector > Priorities > Canadian Spatial Reference System

Canadian Spatial Reference System

CSRS Home
Online Database
Data Request
CACS Data
Software
ACP
CBN
CGSN
Northern 2D
PVC
LOGOUT
CSRS-PPP
Users' Guide
Latest News
(last updated Nov. 25, 2009)

CSRS-PPP

CSRS-PPP is an on-line application for GPS data post-processing that a submit observation data over the Internet and recover, using precise G information, enhanced positioning precisions in the Canadian Spatial Ref (CSRS) and the international Terrestrial Reference Frame (ITRF).

Select RINEX Observation File
Browse...

(Name: use only Western Roman alphanumerics, including hyphen and underscore (Compression: none or zip (.zip), gzip (.gz) or UNIX Compress (.Z)) (Format: RINEX or Compact RINEX (Hatanaka))

Select Mode of Processing
Static
Kinematic

Select Reference System
NAD83(CSRS)
ITRF (Epoch of GPS data)

Enter/Change E-Mail to which results will be sent
richard.stanaway@quickclose.com.au

START File Upload/Processing

Date Modified: 2009-02-25

NRCan
(PPP)

Canada

rabt0010

The estimated coordinates / standard deviations for the rabt0010 RINEX file are as follow:

Latitude (ITRF05): 33 59 53.1751 (dms) / 0.003 (m)
Longitude (ITRF05): -6 51 15.4384 (dms) / 0.009 (m)
Ellipsoidal Height (ITRF05): 90.110 (m) / 0.019 (m)

UTM (North) Northing: 3764021.294m Easting: 698173.709m Zone: 29 Scale Factor: 1.00008

Australian Government
Geoscience Australia

AUSPOS Version 2.00

Home > Earth Monitoring and Reference Systems > Geodesy and Global Navigation Systems >

Geodesy and Global Navigation Systems

Basics
Geodetic Techniques
Global Navigation Satellite System Networks
Geodetic Datums
Astronomical Information

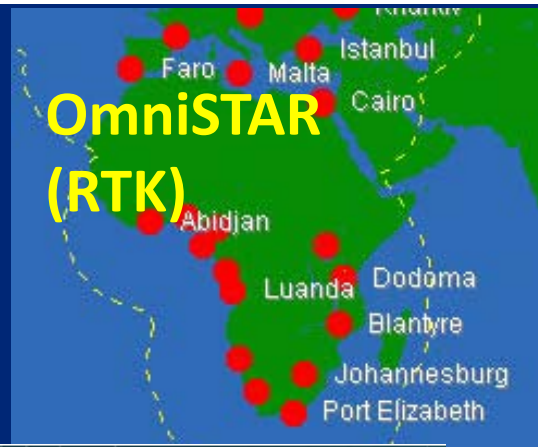
Number of RINEX files: 1
Submit RINEX using: upload ftp

File Name	Height (m)	Antenna Type
	0.0000	DEFAULT(NONE)

Your Email Address:

submit start over

AUSPOS
(double-differenced
static processing)



3.2 Geodetic, GRS80 Ellipsoid, ITRF2005

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at <http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/>

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height (m)	Derived Above Geoid Height (m)
RABT	33 59 53.17590	-6 51 15.43821	90.153	44.805

4.1 Coordinate Precision - Geodetic, One Sigma

Station	σ East (m)	σ North (m)	σ Up (m)
RABT	0.001	0.002	0.003

ITRF positioning services (examples)

Kinematic coordinates illustrated



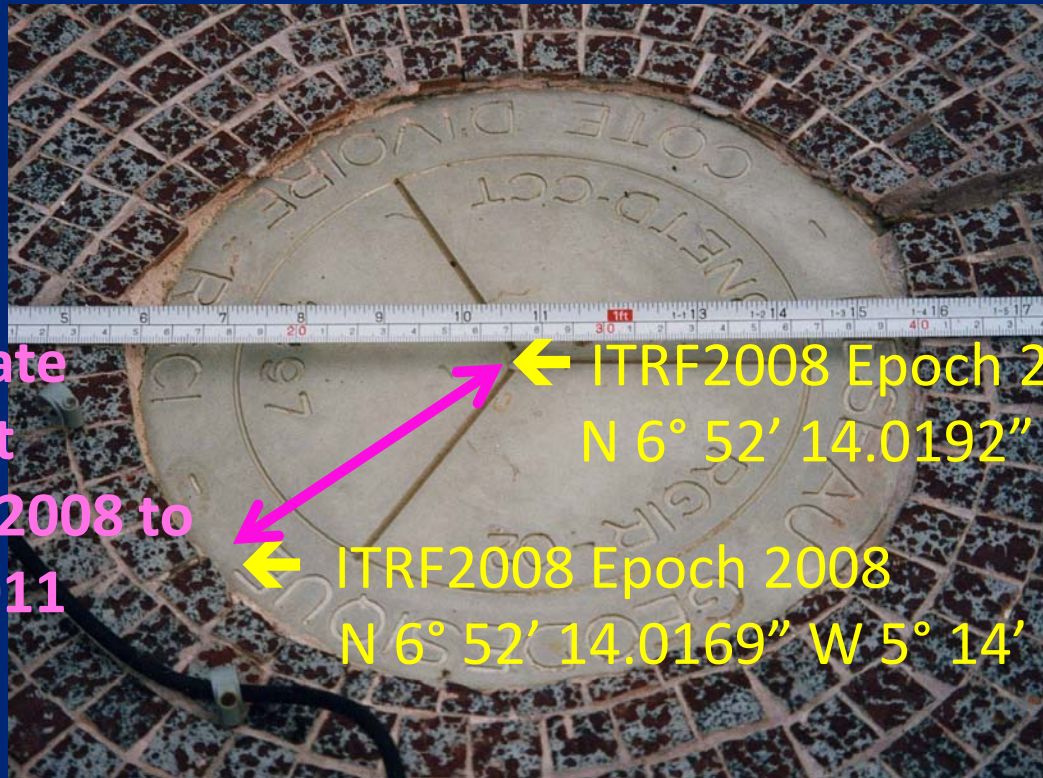
← ITRF2008 Epoch 2008

N 6° 52' 14.0169" W 5° 14' 24.3345"

YKRO – IGS Station
(Yamoussoukro, Cote d' Ivoire)
From IGS web-site

Kinematic coordinates illustrated

Nubian Plate
movement
1 January 2008 to
22 May 2011
109 mm!



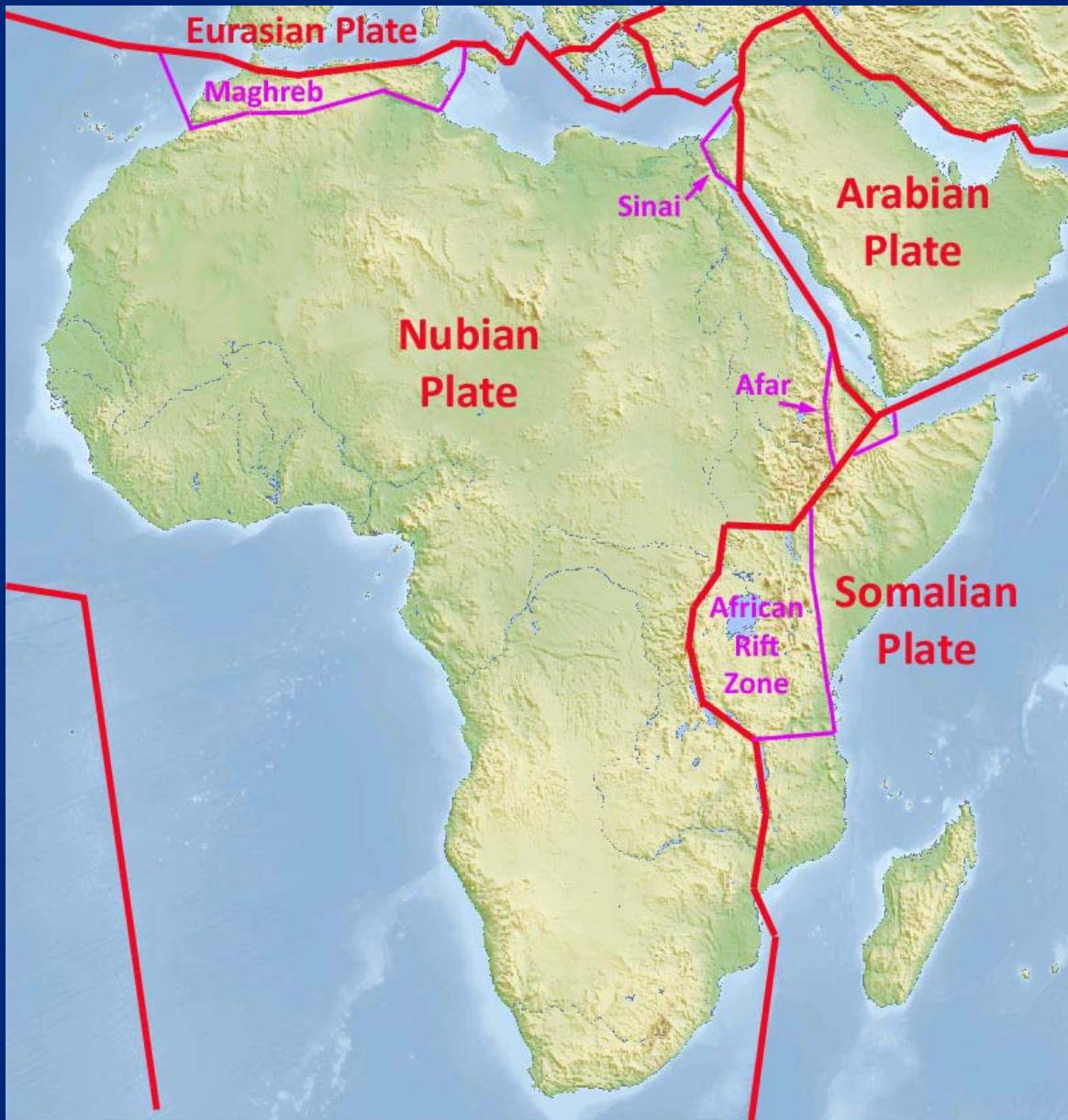
← ITRF2008 Epoch 2011.4

N 6° 52' 14.0192" W 5° 14' 24.3317"

← ITRF2008 Epoch 2008

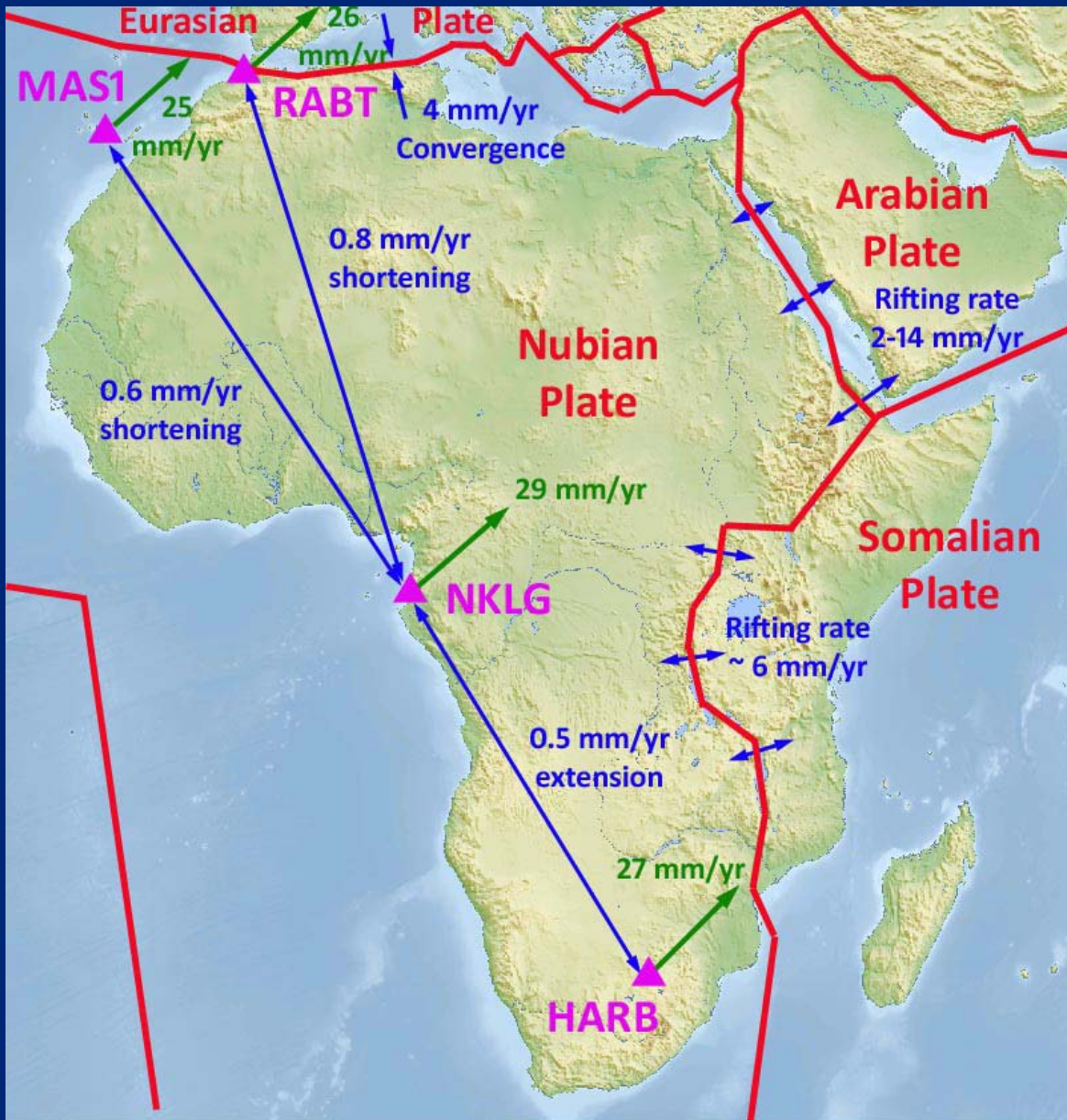
N 6° 52' 14.0169" W 5° 14' 24.3345"

YKRO – IGS Station
(Yamoussoukro, Cote d' Ivoire)
From IGS web-site

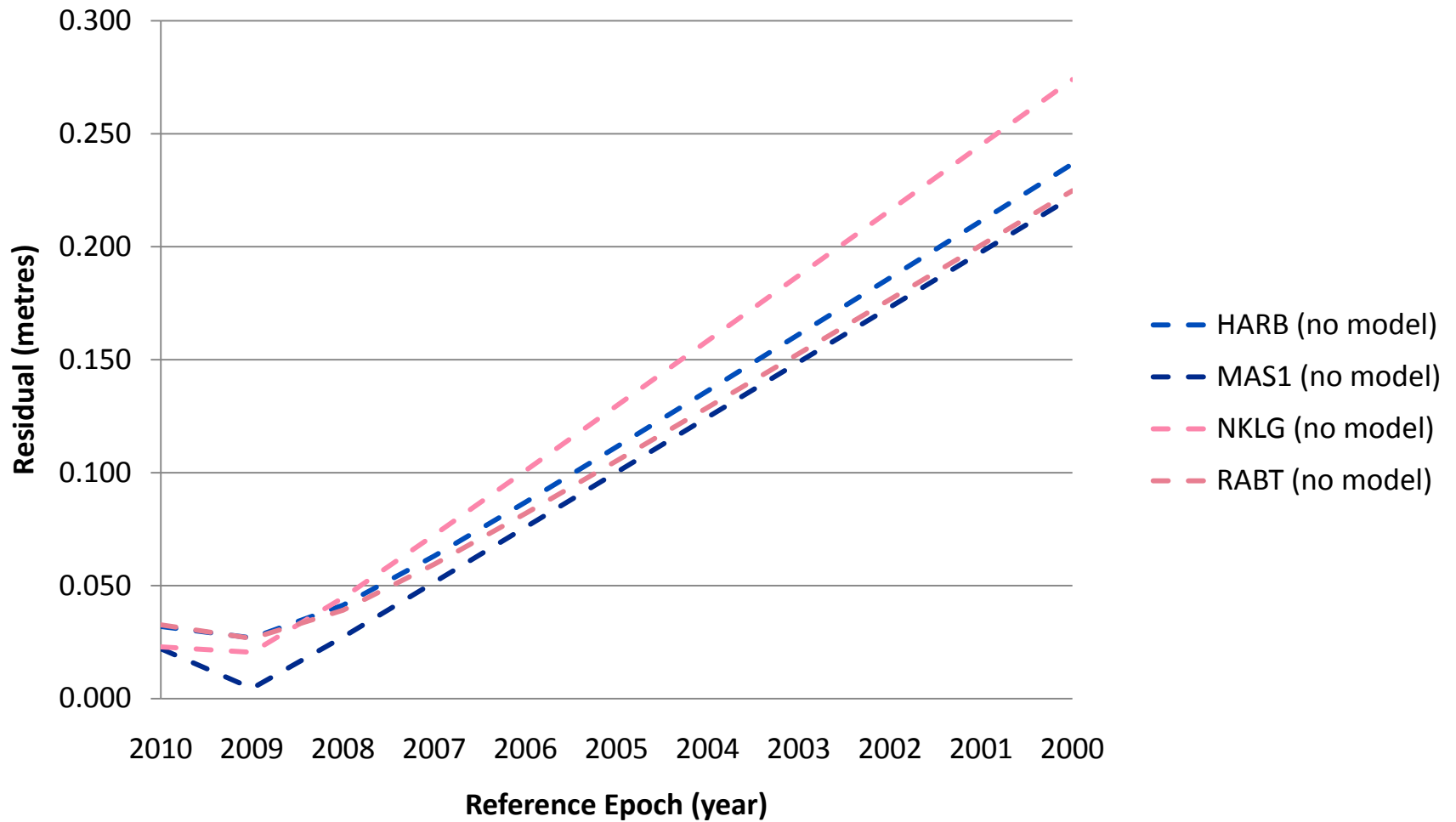


Principal Plates and Plate Boundaries in Africa

Stability of the Nubian Plate



Deformation rates computed from ITRF2008 GPS SSC Solution <http://itrf.ensg.ign.fr>



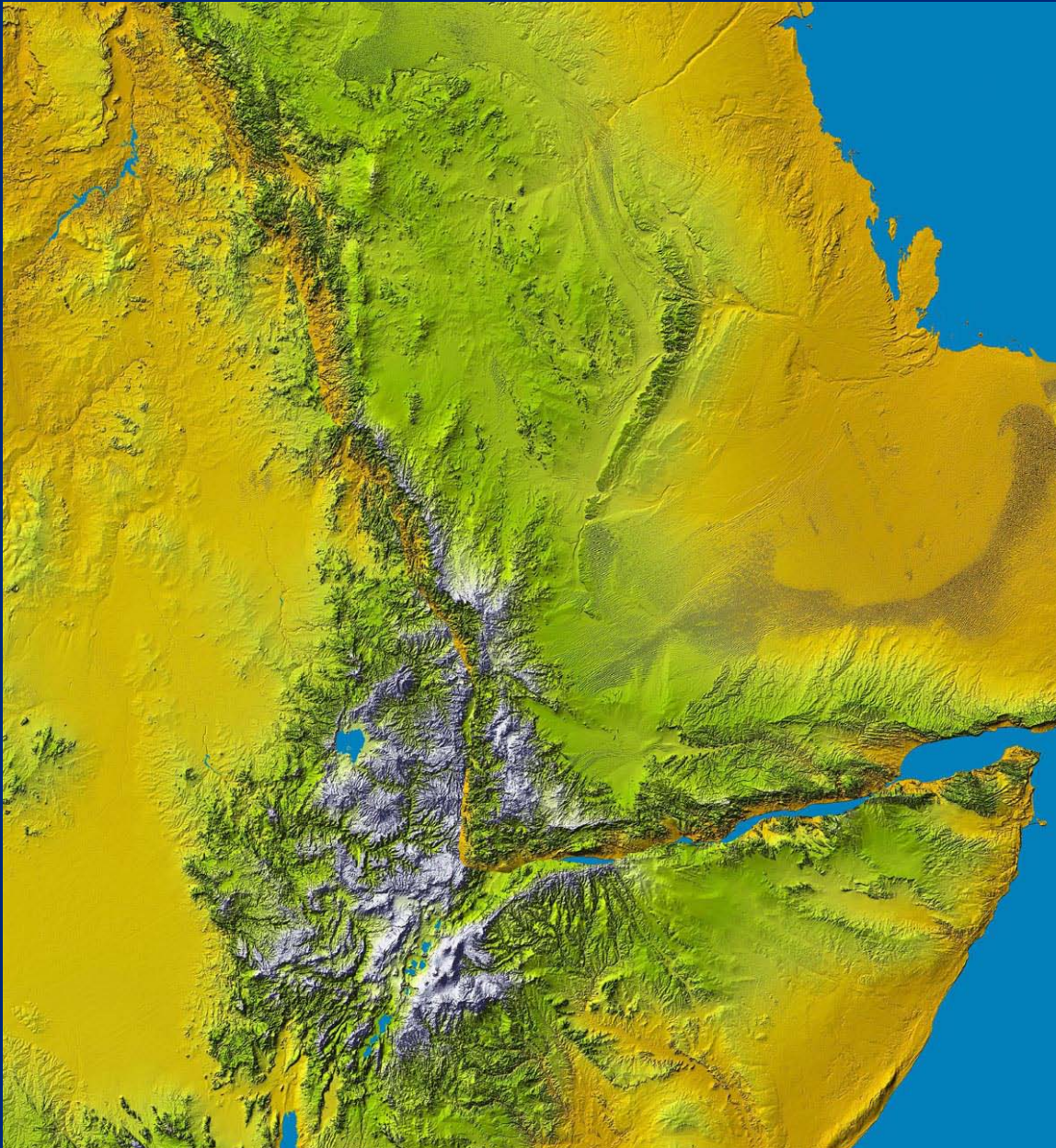
Divergence between ITRF (Epoch 2009) and ITRF (epoch of measurement)

Nubian and Arabian Plate Boundary today



image:
JPL NASA SRTM

**Nubian and
Arabian Plate
Boundary
30 Ma**



$$\Omega_x = \text{COS}(\Phi)\text{COS}(\Lambda)\omega$$

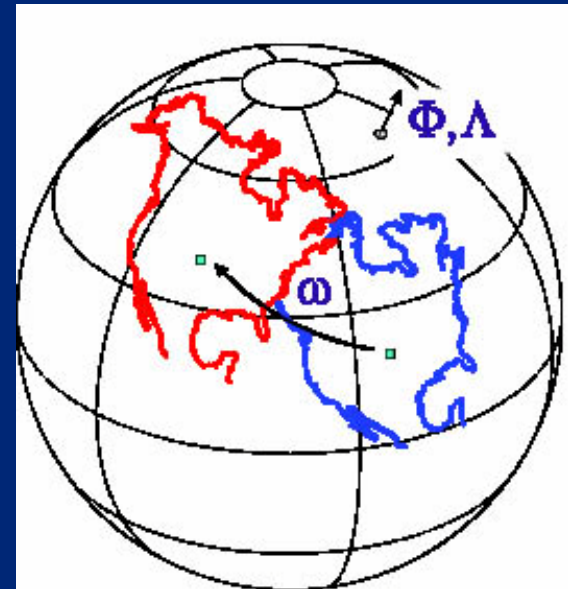
Rigid Plate Model

Euler Poles to Cartesian rotation rates

$$\Omega_x = \text{COS}(\Phi)\text{COS}(\Lambda)\omega$$

$$\Omega_y = \text{COS}(\Phi)\text{SIN}(\Lambda)\omega$$

$$\Omega_z = \text{SIN}(\Phi)\omega$$



ITRF2005 African
plate parameters
(Altamimi *et al.* 2007)

Plate	Euler pole of rotation			Equivalent Cartesian angular velocity		
	Φ (°)	Λ (°)	ω (°/Ma)	Ω_x (Rad/Ma)	Ω_y (Rad/Ma)	Ω_z (Rad/Ma)
Arabia	49.6	5.1	0.579	0.006518	0.000577	0.007700
Eurasia	56.3	-96.0	0.261	-0.000263	-0.002512	0.003791
Nubia	50.0	-82.5	0.269	0.000394	-0.002995	0.003594
Somalia	53.7	-89.5	0.309	0.000026	-0.003196	0.004344

Kinematic to Static transformation

$$\begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} = \begin{bmatrix} T_X \\ T_Y \\ T_Z \end{bmatrix} + S \cdot \begin{bmatrix} X_t \\ Y_t \\ Z_t \end{bmatrix} + \begin{bmatrix} \Omega_Y Z_t - \Omega_Z Y_t \\ \Omega_Z X_t - \Omega_X Z_t \\ \Omega_X Y_t - \Omega_Y X_t \end{bmatrix} \cdot (t_0 - t) \cdot 1E-6$$

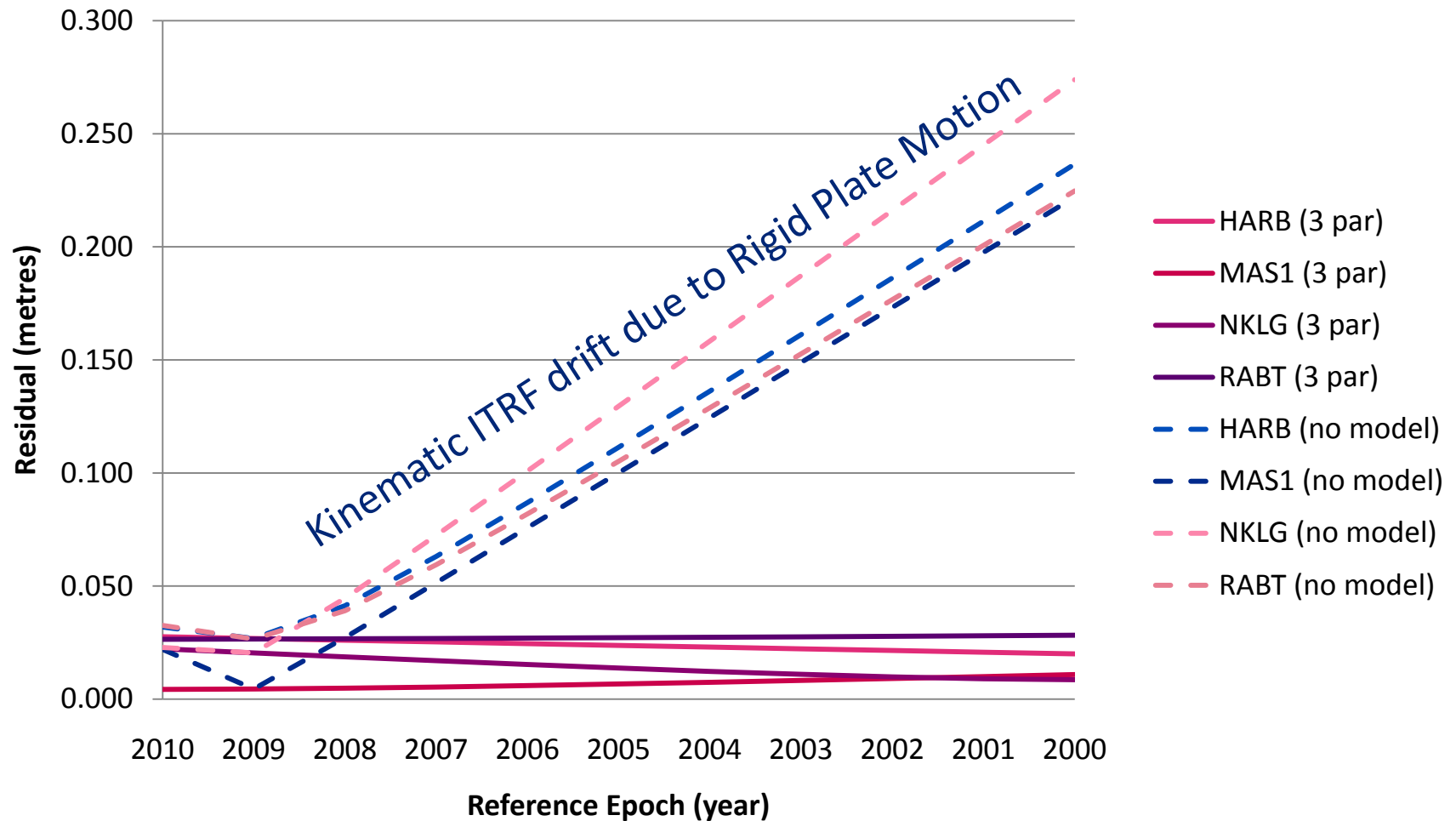
↑ Local frame translation & scale (only if required)
↑ Plate rotation parameters
↑ reference epoch
↑ measurement epoch

“Static” coordinates at reference epoch

“Measured” ITRF coordinates

$$\begin{aligned} X_0 &= X_t + (\Omega_Y Z_t - \Omega_Z Y_t) \cdot (t_0 - t) \cdot 1E-6 \\ Y_0 &= Y_t + (\Omega_Z X_t - \Omega_X Z_t) \cdot (t_0 - t) \cdot 1E-6 \\ Z_0 &= Z_t + (\Omega_X Y_t - \Omega_Y X_t) \cdot (t_0 - t) \cdot 1E-6 \end{aligned}$$

Simplified
3-parameter equations
Kinematic ITRF to
Static ITRF
 (no scale or translation parameters)



Improved coordinate consistency using a 3 parameter rigid plate transformation

Limitations of a Rigid Plate Model

Intraplate deformation not accounted for
(usually small magnitude < 1 mm/yr anyway)

Fails near plate boundaries
(requires additional modelling of locked faults)

Coseismic and Postseismic deformation not
modelled

Thank you

Merci