EURASIAN-PACIFIC-N.AMERICAN PLATE MOTIONS FROM VERY LONG BASELINE INTERFEROMETRY

AILIN MAO AND ZHIHAN QIAN
Shanghai Observatory
Chinese Academy of Sciences
80 Nandan Road
Shanghai 200030
P. R. of China

ABSTRACT. We use the baseline variation rates, which are obtained by the VLBI measuring in the past years (1979.7-1991.1), to estimate the relative motions among Eurasian, Pacific and North American plates. A comparion with the geological-based models has been made. In order to strengthen the VLBI constraints on the Euler vectors, we estimate the velocities of unstable stations in addition to the Euler vectors.

1. Introduction

The recent VLBI(Very Long Baseline Interferometry) global solution,the GLB754 obtained by NASA GSFC VLBI Data Analysis Team, includes the variation rates of 174 vector baselines connecting 50 stations which were surveyed during the period of 1979.7-1991.1. Most of the stations are on Eurasian, Pacific and North American Plates. Instantaneous relative motions among these three plates can be extracted from the VLBI data, and a comparion with the geological-based models, such as NUVEL and RM2 can be made. Furthermore, the characteristics of the motions of stations in deformation areas can also be elucidated.

2. Method

The Euler vecters(Ω) of plate motions can be estimated from the length and transverse rates of Baselines($\dot{B}_{ij},\dot{T}_{ij}$) determined by the VLBI. The observation equations for each baseline are

$$\begin{bmatrix} \dot{B}_{ij} \\ \dot{T}_{ij} \end{bmatrix} = \begin{bmatrix} -P_i^p \times b_{ij} & P_j^q \times b_{ij} \\ -P_i^p \times t_{ij} & P_j^q \times t_{ij} \end{bmatrix} \begin{bmatrix} \Omega_p \\ \Omega_q \end{bmatrix} \tag{1}$$

Where,suppose station P_i locates on plate p, station P_j locates on plate q. P_i,P_j--geocentric vectors of stations. b_{ij},t_{ij}--the direction vectors of the Baseline and its transverse.

I.I. Mueller and B. Kołaczek (eds.),
Developments in Astrometry and Their Impact on Astrophysics and Geodynamics, 179–184.

The topocentric velocities of stations (V_n,V_e) can also be estimated. The equations for each baseline are follows

$$\begin{bmatrix}\dot{B}_{ij}\\ \dot{T}_{ij}\end{bmatrix} = \begin{bmatrix} -b_{ij}\cdot n_i & -b_{ij}\cdot e_i & b_{ij}\cdot n_j & b_{ij}\cdot e_j \\ -t_{ij}\cdot n_i & -t_{ij}\cdot e_i & t_{ij}\cdot n_j & b_{ij}\cdot e_j \end{bmatrix} \begin{bmatrix} V^i_n \\ V^i_e \\ V^j_n \\ V^j_e \end{bmatrix} \qquad (2)$$

Where,n_i,e_i--the direction vectors of the local north and east of the i station.

The crucial step in an estimation is to find subsets of VLBI stations which ride on the same plates. Since some stations, which locate in the deformation areas should not be included in estimating plate motions, we estimate the velocities of these unstable stations while estimating the Euler vector in order to include all change rates of 174 baselines. Thus, we can strengthen the constructions of the network and improve the accuracy of Euler vector estimations significantly.

3. Results and analysis

3.1 Finding subsets of stations which ride on the same plate

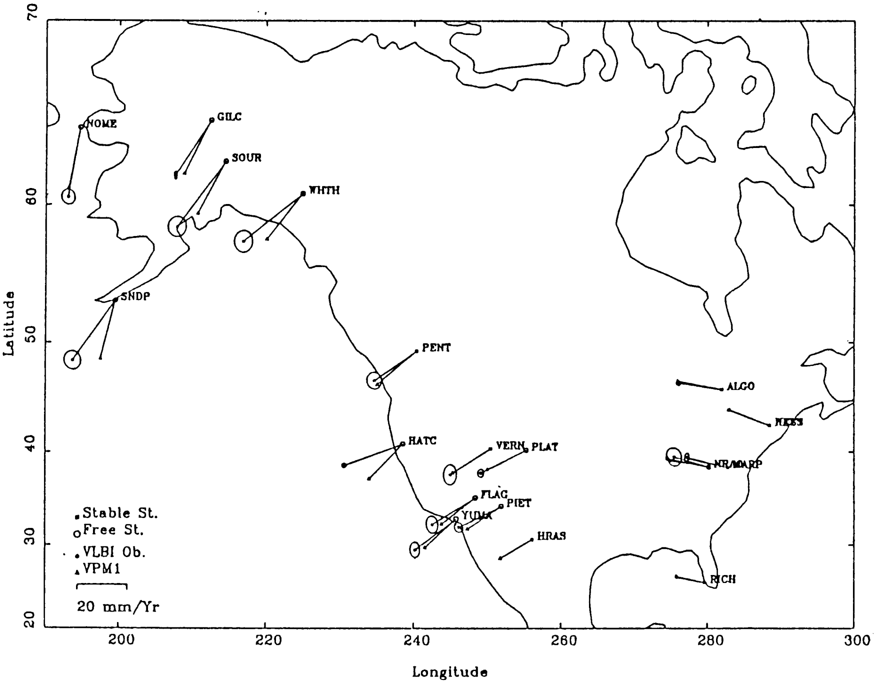

Fig.1 VLBI velocity field on North America
in North American fixed frame

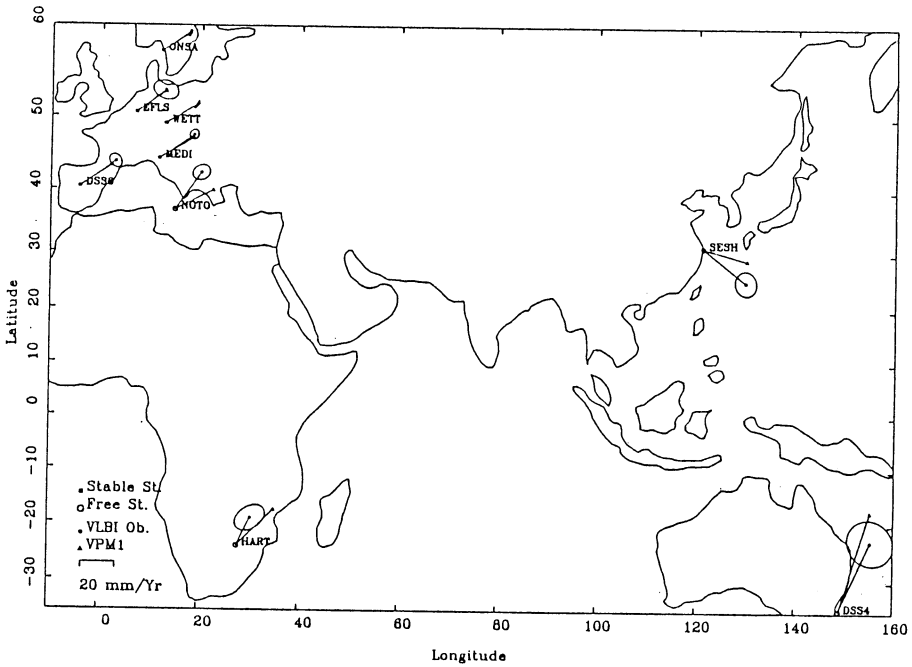

Fig.2 VLBI velocity field on Eurasia
in North American fixed frame

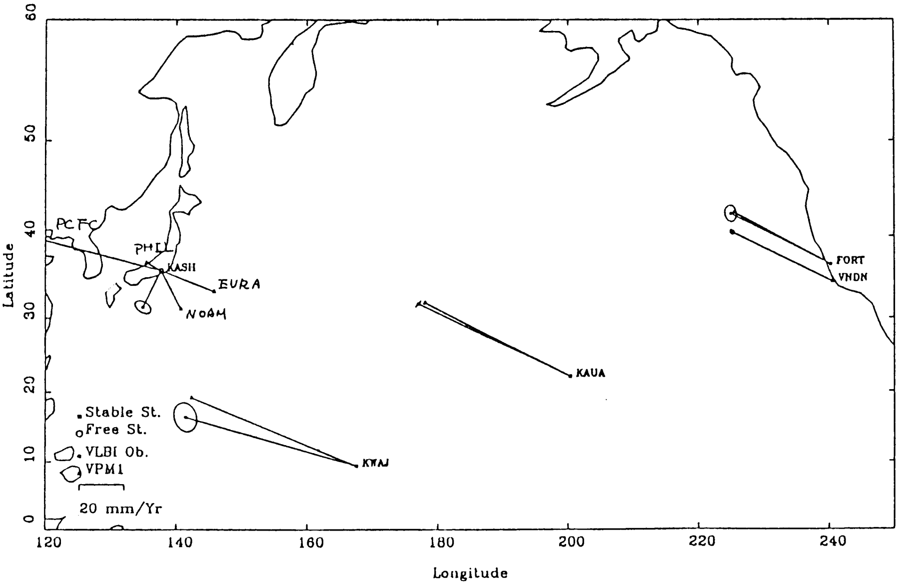

Fig.3 VLBI velocity field on Pacific
in North American fixed frame

North America (NOAM) Velocity residuals of the stations in Alaska and in California, such as Gilcreek and Yuma are beyond the 3σ error ellipses (Figure 1). These stations have resolvable local motions with respect to North America and cannot be considered to be stable on the North American plate. We select 9 stations as the menbers of stable subset for it.

Eurasia (EURA) Noto has a 12.2±1.6 mm/yr(N23W) velocity and Shanghai has a 11.0±2.0 mm/yr(N175E±11) velocity with respect to Europe. Thus, Noto and Shanghai cannot be considered as riding on the Eurasian plate. The other five stations are considered riding on the same plate because of the small residuals of their velocities. (Figure 2).

Pacific (PCFC) The velocity residuals of Kauai and Kwajal26 are a little out of the 3σ Error ellipse because of the high quality of VLBI observations. But there are only 4 VLBI stations on the Pacific plate, so we consider all the 4 stations as stable ones on it (Figure 3).

3.2 Estimating the relative motions of the 3 plates

With three subsets of stable stations mentioned above, the model of relative motions of Eurasian, Pacific and North American Plates VPM1 are evaluated, and the velocity of unstable stations are estimated simultaneously (Figure 4, Figure 5, Table 1). The reduced χ^2_R is 1.835.

TABLE 1

plate pair	model	φ	λ	ω	σ_{max}	σ_{min}	ξ_{max}	$\sigma\omega$
EURA-PCFC	VPM1	62.9	-82.8	0.877	2.4	0.4	12.9	0.025
	NUVEL	61.1	-85.8	0.900	1.3	1.1	90.9	0.020
	RM2	60.6	-78.9	0.980	1.5	1.0	78.0	0.030
NOAM-PCFC	VPM1	50.0	-79.8	0.749	1.0	0.2	5.6	0.013
	NUVEL	48.7	-78.2	0.780	1.3	1.2	-61.0	0.010
	RM2	48.8	-73.9	0.850	1.3	1.1	-71.0	0.020
NOAM-EURA	VPM1	-67.5	-65.7	0.223	9.5	3.1	20.2	0.017
	NUVEL	-62.4	-44.8	0.220	4.1	1.3	-11.0	0.010
	RM2	-65.8	-47.6	0.230	6.4	1.4	-14.0	0.020

Relative motion between the Pacific and North American Plates is in a good agreement with the NUVEL's, but its difference with RM2's is significant (Figure 4). The Euler pole of North American-Eurasian shows difference with that of the geological-based models (Figure 5), but its uncertainty is large because of the poor spatial distributions of the VLBI stations on Eurasian plate. When the Urumqi and Kunming stations of China can participate into the global VLBI network in the future, the constraint of Eurasian plate motions will be improved obviously (Table 2).

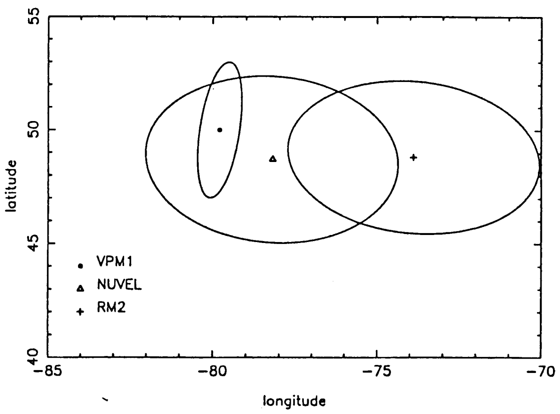

Fig.4 Euler pole position of NOAM-FCPC

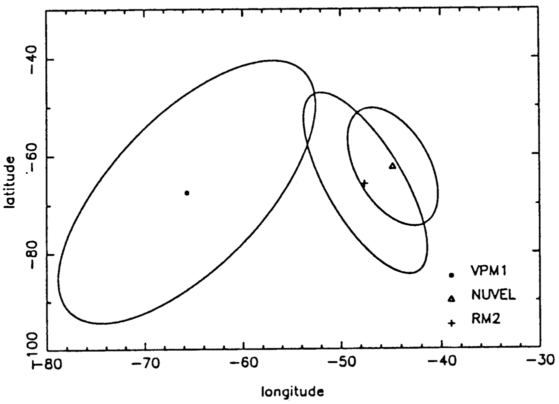

Fig.5 Euler pole position of NOAM-EURA

TABLE 2

	Ω of NOAM-EURA			
	σ_{max}	σ_{min}	ξ_{max}	σ_{min}
at present	9.5	3.1	20.2	0.02
including 2 chinese new st.	6.0	1.5	6.7	0.01

Table 3 shows the efficacy of including the velocities of stations which do not attach to any plates in estimating.

TABLE 3

paramaters	total number of rates used	number of paramaters	χ^2_R	Ω of NOAM-PCFC		
				σ_{max}	σ_{min}	σ_ω
Ω	44	6	2.07	4.0	1.3	0.05
Ω, V_n, V_e	326	73	1.84	1.0	0.2	0.01

4. Conclusions

- Estimating the velocities of stations attached to no plates while extracting the Euler vectors will improve the acurracy of Euler vector estimations signigicantly.

- Relative motion between Pacific and North American Plates agrees with NUVEL but disagrees with the RM2's. Euler pole position of North America-Eurasian is not identical with geological-based models. Shanghai is not stable with respect to Europe plate.

- The pole position of Eurasia is not well constrained by VLBI. Participations of two Chinese new VLBI stations will improve the present condition.The global space geodetic network should be expanded and densificated with SLR and GPS in future.

Acknowledgement. We thank professor Wenyao Zhu for his helpful suggestions. Thanks are also given to Mr. Yuyang Chen for his helping us drawing the figures.

References

Demets,C., R.G.Gordon, D.F.Augus and S.Stein, (1990) Current Plate Motions, Geophys.J.,101,425-478

Minster,J.B., T.H.Jordan, (1978) Present-day Plate Motions, JGR, vol.83, No.B11,5331-5354

Ward,S.N., (1990) Pacific-North America Plate Motions: New Results from Very Long Baseline Interferometry,JGR,vol.95,No.B13, 21,965- 21,981

Ward,S.N., (1992).Eurasian Plate Motions from Very Long Baseline Interferometry,JGR, in printing