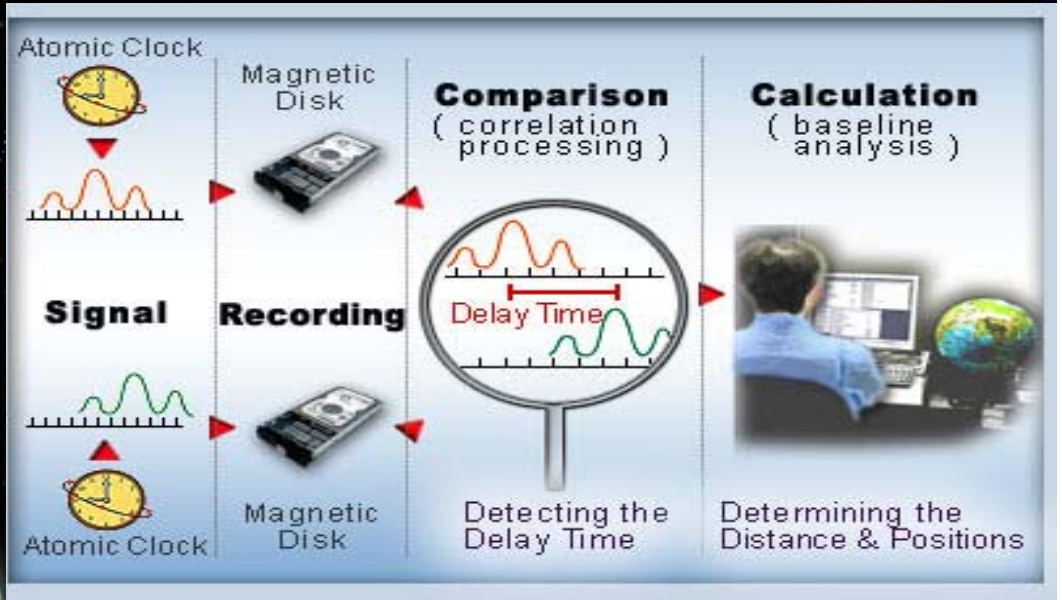
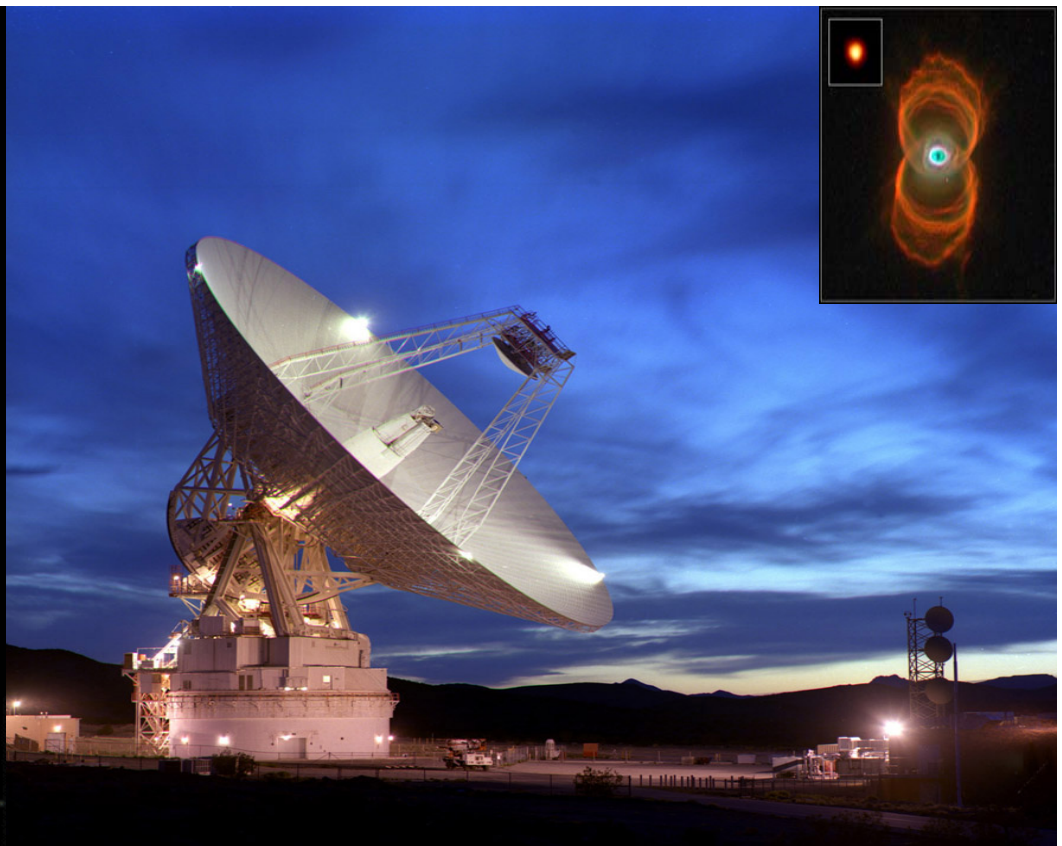
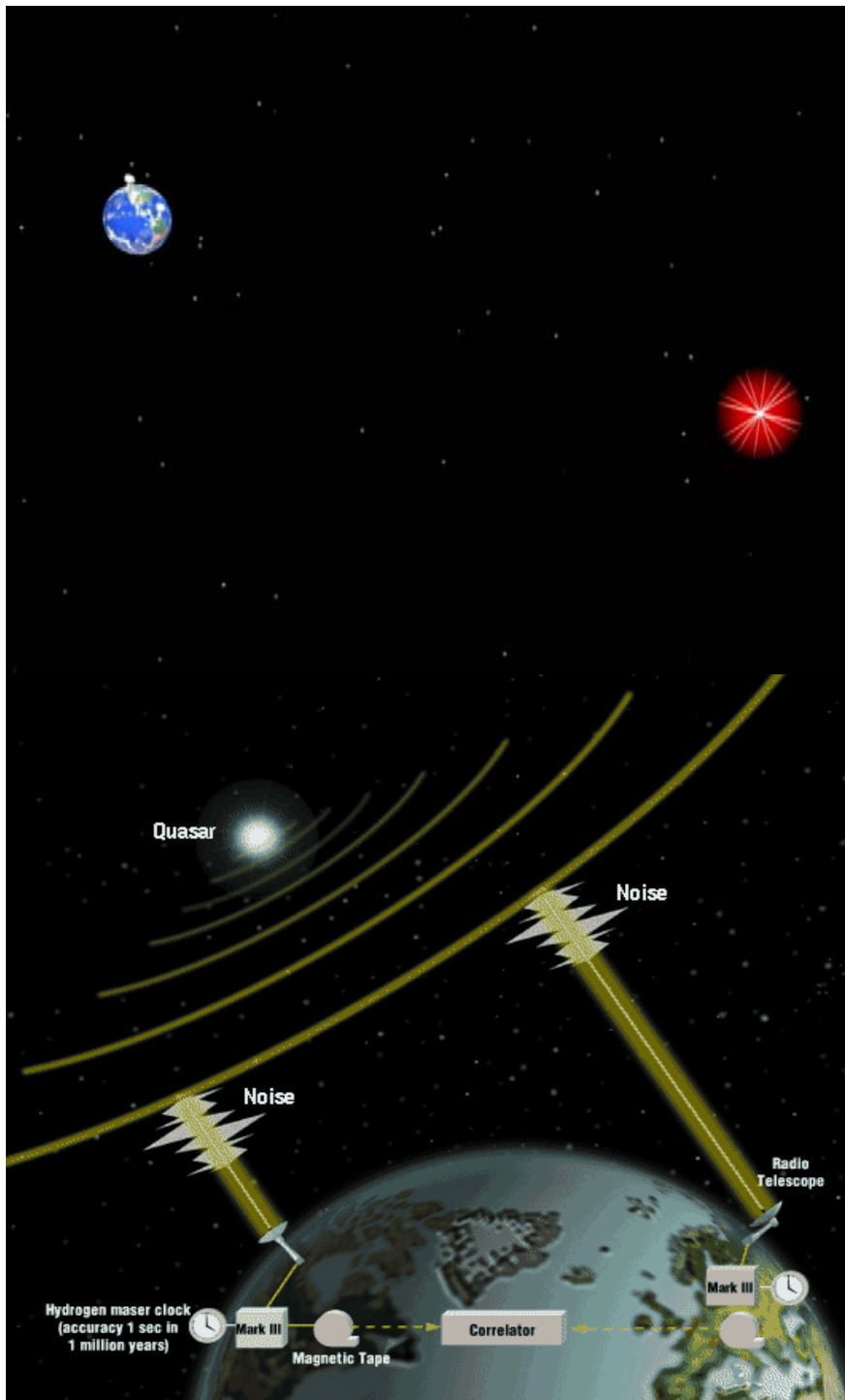


4. Mühendislik Ölçmeleri Sempozyumu

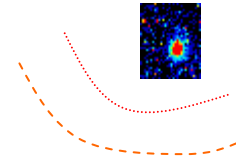
JEODEZİK VLBI ÇALIŞMALARININ IERS ÜRÜNLERİNE KATKISI
ve
KTÜ GEOD IVS ANALİZ MERKEZİNİN ÖNGÖRÜLEN FAALİYETLERİ

Emine Tanir
Kamil Teke
Johannes Boehm
Harald Schuh





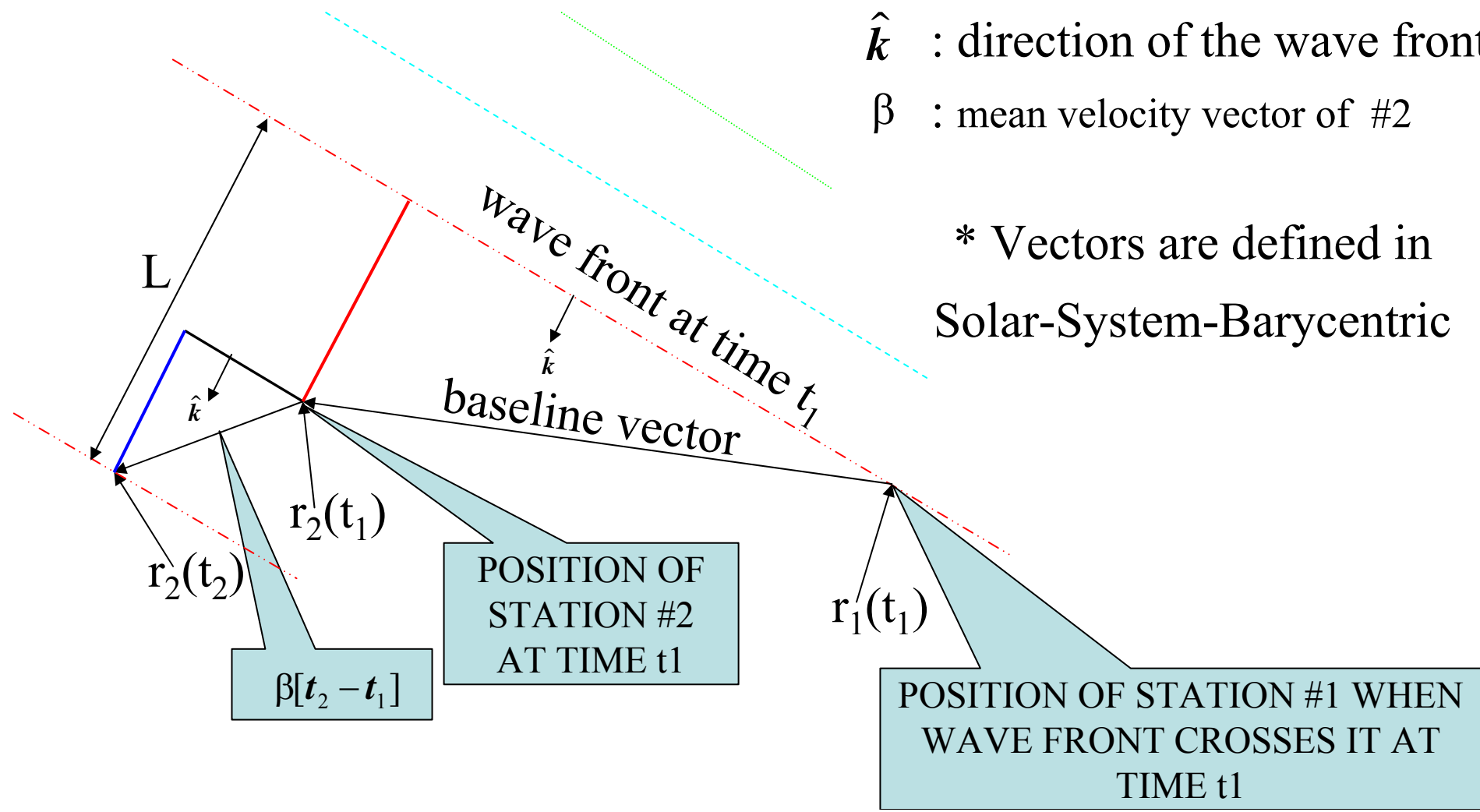
VLBI GEOMETRIK MODELI



$$c(\tau_{\text{obs}} - (\tau_{\text{clock}} + \tau_{\text{trop}} + \tau_{\text{ionos}} + \tau_{\text{rel}})) = c \cdot (t_2 - t_1) = \hat{k} [r_2(t_1) - r_1(t_1)] + \hat{k} \beta [t_2 - t_1]$$

\hat{k} : direction of the wave front
 β : mean velocity vector of #2

* Vectors are defined in
 Solar-System-Barycentric



VLBI TEMEL ESITLIGI

$$\tau_{obs} = -\frac{1}{c} \cdot k_{CRF} \cdot \Phi \cdot R \cdot W \cdot b_{TRF} + \tau_{corrections}$$

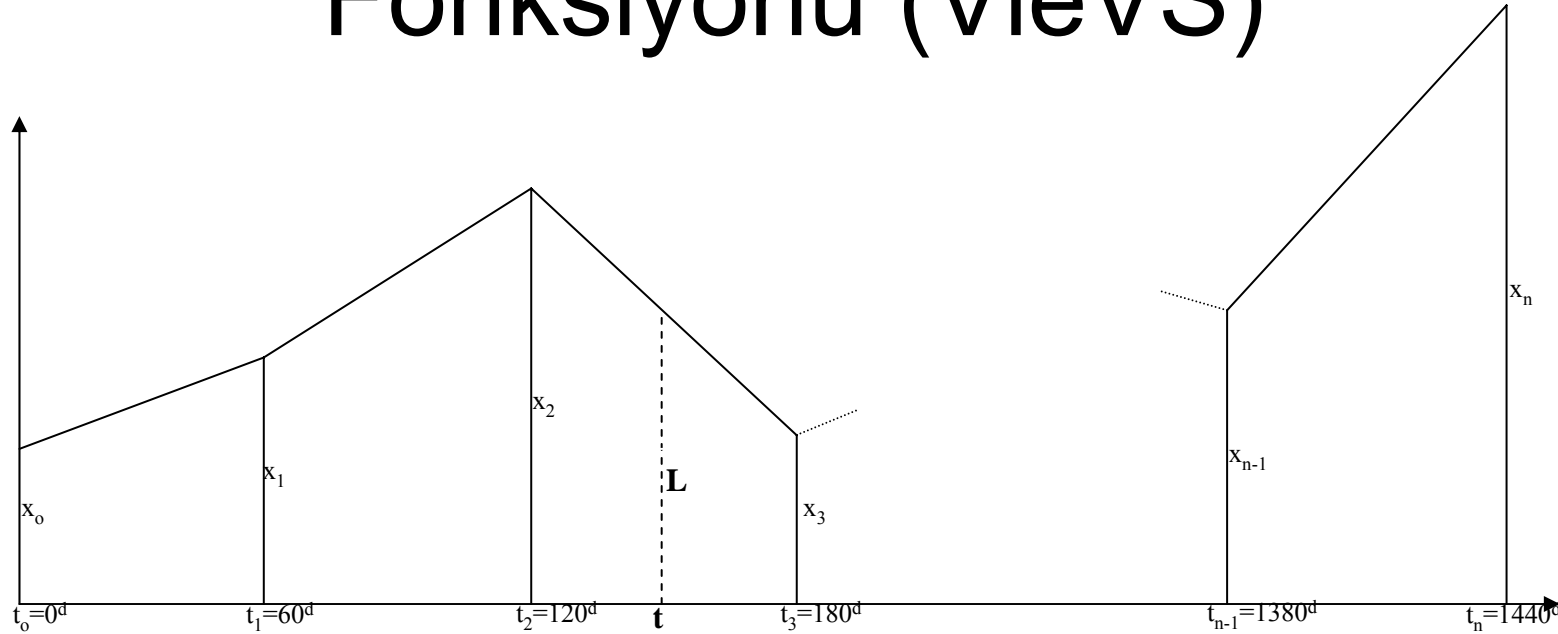
$$\tau_{obs} = -\frac{1}{c} \cdot \begin{pmatrix} \cos \delta \cdot \cos \alpha \\ \cos \delta \cdot \sin \alpha \\ \sin \delta \end{pmatrix}_{CRF} \Phi R W \begin{pmatrix} X_2(t_2) - X_1(t_1) \\ Y_2(t_2) - Y_1(t_1) \\ Z_2(t_2) - Z_1(t_1) \end{pmatrix}_{TRF}$$

$$+ \tau_{j-abb.} + \tau_{t-abb.} + \tau_{Rel.} + \tau_{Tid.} + \tau_{Load.}$$

$$+ \tau_{Instr.} + \tau_{Clock} + \tau_{Ion.} + \tau_{Atm_h} + \tau_{Atm_w}$$

Sovers, vd., 1998

Sürekli Parçalı Lineer (SPL) Ofset Fonksiyonu (VieVS)



$$L(t) = x_{i,j} + \frac{t - t_j}{t_{j+1} - t_j} (x_{i,j+1} - x_{i,j})$$

SPL offset fonksiyonu

$$\frac{dL^k}{dx_{i,j}} = \left(1 - \frac{t - t_j}{t_{j+1} - t_j}\right) dy(k)_{\text{model}(s)}$$

$s = 1, 2, \dots, 15$ Birinci ofsete göre kısmi türev

$$\frac{dL^k}{dx_{i,j+1}} = \left(\frac{t - t_j}{t_{j+1} - t_j}\right) dy(k)_{\text{model}(s)}$$

$s = 1, 2, \dots, 15$ İkinci ofsete göre kısmi türev

Teke, vd., 2009

Sürekli Parçalı Lineer (SPL) Ofset Fonksiyonu ve Dizayn matrisi (VieVS)

$$\begin{bmatrix} \frac{dL^1}{dx_{1,1}} & \frac{dL^1}{dx_{1,2}} & \frac{-dL^1}{dx_{2,1}} & \frac{-dL^1}{dx_{2,2}} & 0 & 0 \\ 0 & 0 & \frac{dL^2}{dx_{2,1}} & \frac{dL^2}{dx_{2,2}} & \frac{-dL^2}{dx_{3,1}} & \frac{-dL^2}{dx_{3,2}} \\ \frac{dL^3}{dx_{1,1}} & \frac{dL^3}{dx_{1,2}} & 0 & 0 & \frac{-dL^3}{dx_{3,1}} & \frac{-dL^3}{dx_{3,2}} \end{bmatrix}$$

Üç radyo teleskobunun, bir kuasara yaptığı taramadan elde edilen üç ölçüyü içeren, tek kestirim aralıklı dizayn matrisi

$$x_{i,j+1} - x_{i,j} = 0 \pm m_{\Delta x}$$

Ofsetler arasındaki relatif kısıtlayıcılar

(dizayn matrisine eklenen sahte-ölçü denklemleri)

A(1).sm (Clock error model, piecewise linear offsets)	A(2).sm (Clock error model, rates & quadratic terms)	A(3).sm (Tropospheric zenith wet delay (zwd) model, pwl offsets)	A(4).sm (Tropospheric north gradients, pwl offsets)	A(5).sm (Tropospheric east gradients, pwl offsets)	A(6).sm (Earth Orientation Parameters (EOP), Xpol, pwl offsets)	A(7).sm (EOP, Ypol, pwl offsets)	A(8).sm (EOP, dUT1, pwl offsets)	
H(1).sm (Relative constraints between clock pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	
<u>0</u>	<u>0</u>	H(3).sm (Relative constraints between zwd, pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	
<u>0</u>	<u>0</u>	<u>0</u>	H(4).sm (Relative constraints between north gradients, pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	H(5).sm (Relative constraints between east gradients, pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>	
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	H(6).sm (Relative constraints between Xpol, pwl offsets)	<u>0</u>	<u>0</u>	
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	H(7).sm (Relative constraints between Ypol, pwl offsets)	<u>0</u>	
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	H(8).sm (Relative constraints between dUT1, pwl offsets)	
. . . .								

A(9).sm (EOP, nutation in obliquity (nutdx ~ deps) pwl offsets)	A(10).sm (EOP, nutation in celestial longitude (nutdy ~ dpsl) pwl offsets)	A(11).sm (Source coordinates (Greenwich hour angle, right ascension) pwl offsets)	A(12).sm (Source coordinates (CRF) (declination) pwl offsets)	A(13).sm (Antenna coordinates (TRF) (dX) one offset or pwl offsets)	A(14).sm (Antenna coordinates (TRF) (dY) one offset or pwl offsets)	A(15).sm (Antenna coordinates (TRF) (dZ) one offset or pwl offsets)
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
H(9).sm (Relative constraints between nutdx, pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	H(10).sm (Relative constraints between nutdy, pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	H(11).sm (Relative constraints between right ascension, pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	H(12).sm (Relative constraints between declination, pwl offsets)	<u>0</u>	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	H(13).sm (Relative constraints between antenna dX, pwl coordinate offsets)	<u>0</u>	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	H(14).sm (Relative constraints between antenna dY, pwl coordinate offsets)	<u>0</u>
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	H(15).sm (Relative constraints between antenna dZ, pwl coordinate offsets)

Kisitleyici ve Kosul Denklemleri (VieVS)

- Dizayn matrisine eklenen pseudo-gözlem denklemleri (ofsetler arasindaki kisitleyicilar – relative constrain equations)

$$x_{i,j+1} - x_{i,j} = 0 \pm m_{\Delta x}$$

$$H_i = \begin{bmatrix} 1 & -1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & -1 & \cdots & 0 & 0 \\ 0 & 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 1 & -1 \end{bmatrix} \quad H = \begin{bmatrix} H_1 & 0 & \cdots & 0 \\ 0 & H_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & H_{15} \end{bmatrix}$$

- Normal denklemlerin katsayilari matrisine eklenen kosul denklemleri (Condition equations) (TRF koordinat sistemine Helmert dönüsümü için NNT/NNR kosullari)

$$C = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -z_i'' & -y_i'' \\ z_i'' & 0 & -x_i'' \\ -y_i'' & x_i'' & 0 \\ x_i'' & y_i'' & z_i'' \end{bmatrix} \begin{array}{l} \left. \vphantom{\begin{matrix} 1 \\ 0 \\ 0 \end{matrix}} \right\} \text{NNT} \\ \left. \vphantom{\begin{matrix} 0 \\ z_i'' \\ -y_i'' \end{matrix}} \right\} \text{NNR} \\ \rightarrow \text{NNS} \end{array}$$

Saat hata modeli pwl ofsetleri					B^T	C^T	Saat hata modeli NNT kosul denklemleri
	Saat hata modeli rate ve kuadratik terimleri						
		.					
			Source koordinatlari pwl ofsetleri $[N_{ra} \& N_{de}]$		Source koordinatlari NNR kosul denklemleri		
				Istasyon koordinatlari pwl ofsetleri $[N_x, N_y, N_z]$	Istasyon koordinatlari NNT/NNR kosul denklemleri		
B				Istasyon koordinatlari NNT/NNR kosul denklemleri	$\underline{0}_{6 \times 6}$		
C			Source koordinatlari NNR kosul denklemleri			$\underline{0}_{2 \times 2}$	
Saat hata modeli NNT kosul denklemleri	D						$\underline{0}_{1 \times 1}$

EKK Dengeleme Modeli (VieVS)

$$\begin{bmatrix} v \\ v_c \end{bmatrix} = \begin{bmatrix} A \\ H \end{bmatrix} dx - \begin{bmatrix} l \\ h \end{bmatrix} \quad \begin{bmatrix} P & 0 \\ 0 & P_c \end{bmatrix} \quad A = [A_1 \quad A_1 \quad \dots \quad A_{15}]$$

$$N_{toplam} = \begin{bmatrix} A^T P A + H^T P_c H & C^T \\ C & 0 \end{bmatrix} \quad b_{total} = \begin{bmatrix} A^T P l + H^T P_c h \\ b_c \end{bmatrix}$$

$$dx_{toplam} = \begin{bmatrix} dx \\ x_c \end{bmatrix} = N_{toplam}^{-1} b_{toplam}$$

$$m_o = (v^T P v + v_c^T P_c v_c) / dof$$

$$dof = n_{ölçü} + n_{kosul} - n_{bilinmeyenler}$$

Atomik saatler ve Hidrojen Maserlar

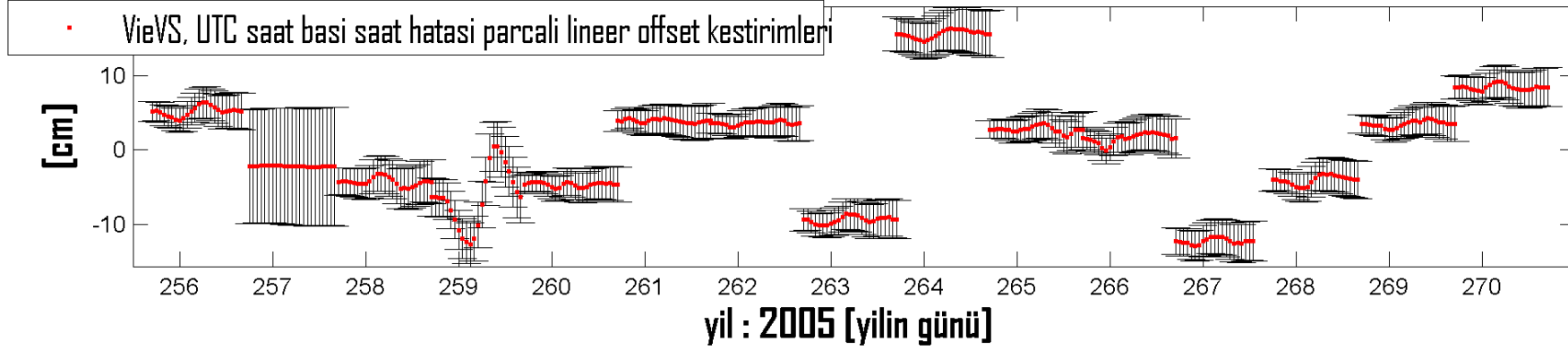
- Sezyum atomik saatlerin yerine VLBI istasyonlarında hidrojen maserlar kullanilmaya baslanmistir. Hidrojen maserlar 63 milyon yilda 1 saniye hata yaparlar. Diger bir ifade ile zamani belirleme duyarliklari $\sim 3 \times 10^{-12}$ saniyedir (~ 3 pikosaniye), bu zaman icerisinde isik ~ 1 mm yol alabilir. Tüm frekans ve ofset tutarsizliklarindan arindirilmis bu saatler ile atmosfersiz, gravite potansiyeli sabit, jeofizik ve relativistik etkenlerin olmadigi inersiyal bir sistemde sadece gecikme (delay) modeli ile hesaplanan VLBI konum duyarligi 1 mm'nin altinda olacaktir. Günümüz VLBI konum duyarligi, mm'ler düzeyindedir. Jeofizik ve stokastik hata modellerinin duyarligi arttirildikca da VLBI parametrelerinin kestirim duyarligi artacaktır.
- Her VLBI istasyonundaki atomik saatin frekans tutarsizliklarindan ve offsetlerindeki farklılıklardan kaynaklanan hatalar, ve eger sicrama (break, jump) olusmus ise bunlar modellenerek giderilir.
- Saat hatasi modeli:

$$\tau_{saat(s)} = \beta_0^{saat(s)} + \beta_1^{saat(s)} (t_i^{saat(s)} - t_0) + \beta_2^{saat(s)} (t_i^{saat(s)} - t_0)^2 \longrightarrow \text{Kvadratik polinom}$$

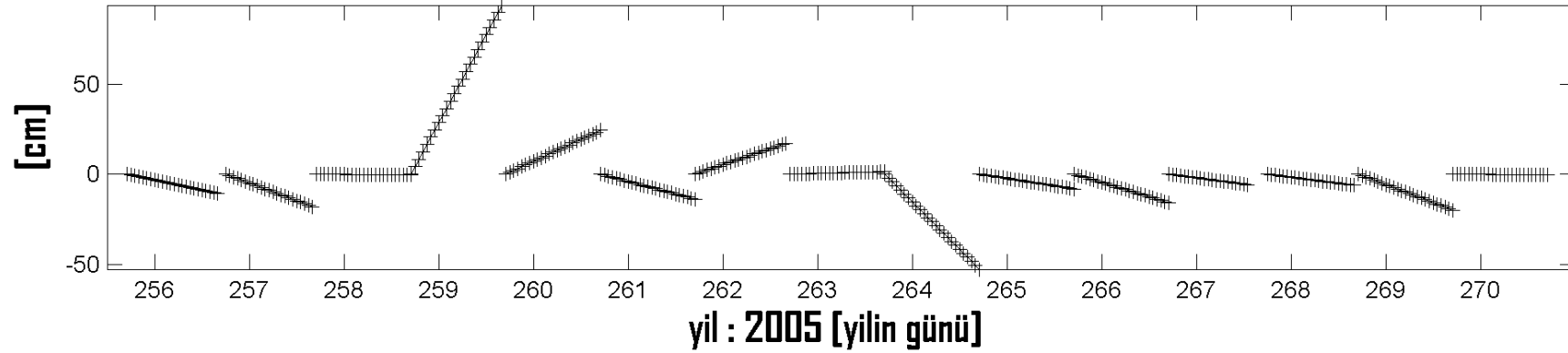
$$L(t) = x_{i,j} + \frac{t - t_{n-1}}{t_n - t_{n-1}} (x_{i,j+1} - x_{i,j}) \quad \text{Parcali lineer ofsetler fonksiyonu}$$

$$\Delta \tau_{saat(s-1,s)} = \tau_{saat_{s-1}} - \tau_{saat_s} \quad \text{Saatler icin ölçü denklemi iki saat toplam hatalari farki}$$

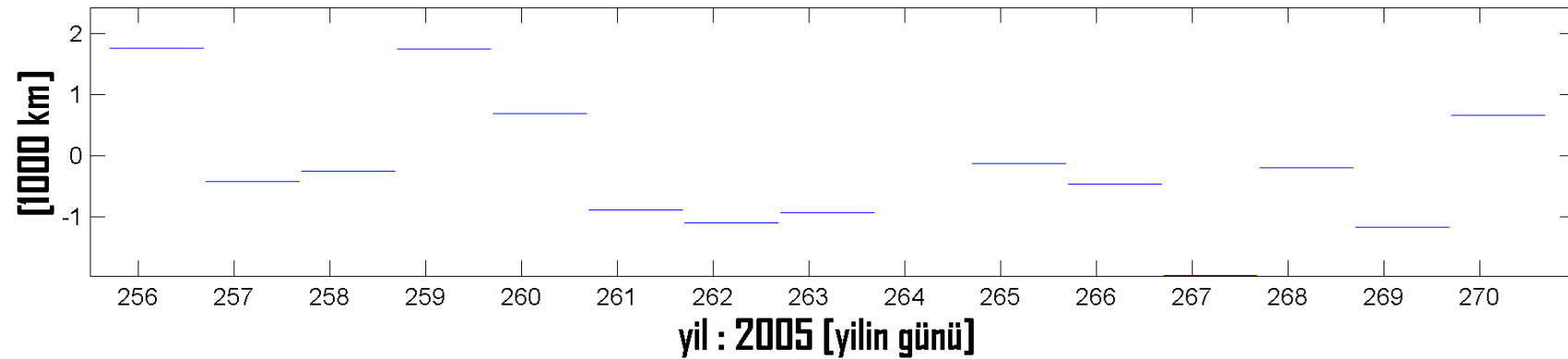
VLBI istasyonu: TIGOCONC [saat fonksiyonu [parcali linear offset] - üçüncü iyilestirme (frekans tutarsizliklari)]



VLBI istasyonu: TIGOCONC [saat fonksiyonu [rate ve quadratic terim] - ikinci iyilestirme (frekans tutarsizliklari)]

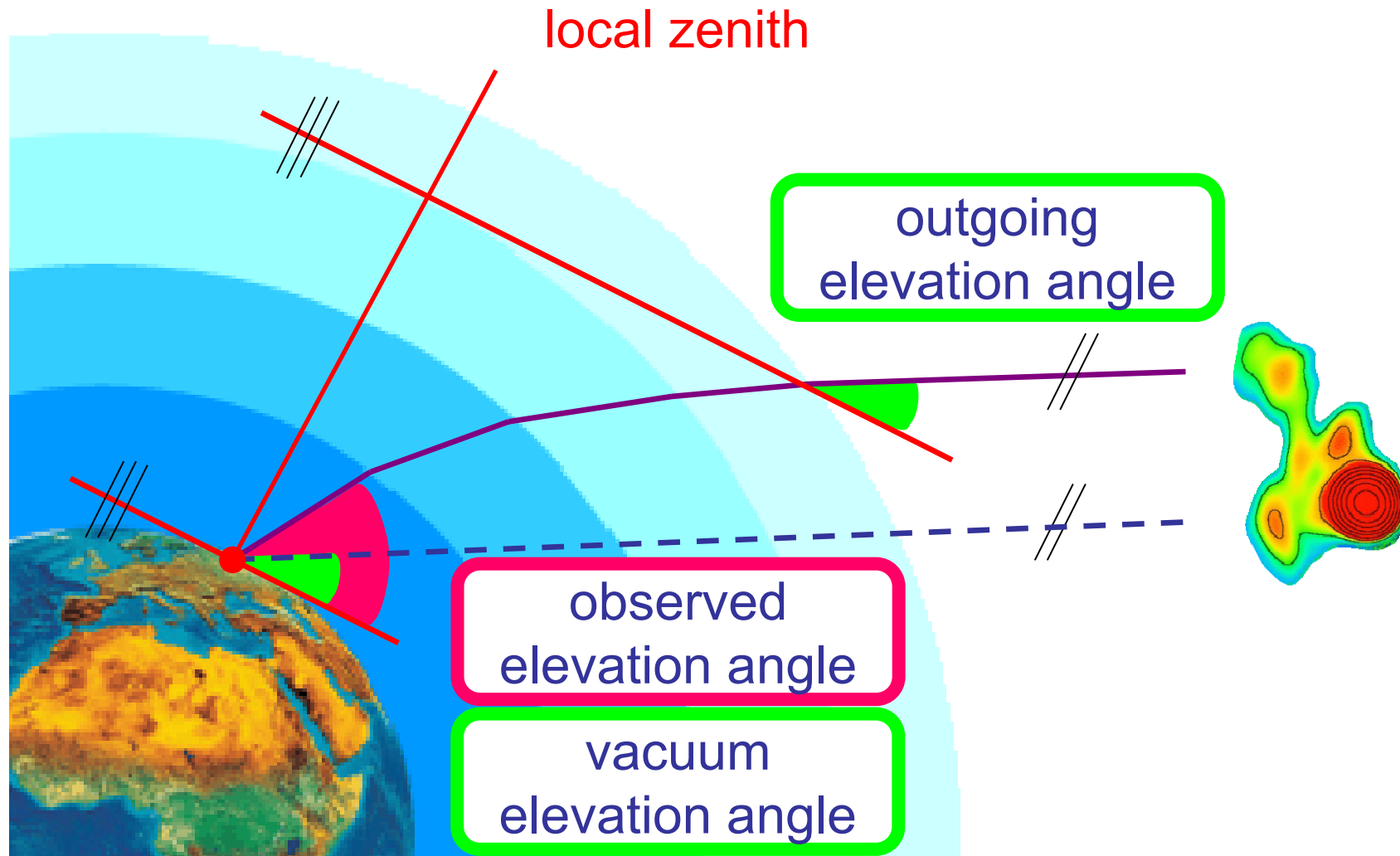


VLBI istasyonu: TIGOCONC [saat fonksiyonu (offset + rate + quadratic term) - ilk iyilestirme (senkronizasyon tutarsizliklari)]



Troposferin modellenmesi

Principle of ray-tracing



by courtesy of Andrea Pany

Troposphere Delay

- state-of-the-art modeling of troposphere delay:

$$\Delta L = \Delta L_h^z \cdot mf_h(e) + \Delta L_w^z \cdot mf_w(e) + mf_g(e) \cdot [G_N \cdot \cos(\alpha) + G_E \cdot \sin(\alpha)]$$

ΔL troposphere total delay

$\Delta L_h^z / \Delta L_h^w$ zenith hydrostatic/wet delay
 mf_h / mf_w mapping function hydrostatic/wet
 e elevation angle

mf_g $mf_h \cdot \cot(e)$ or $mf_w \cdot \cot(e)$
 G_N / G_E north/east gradient
 α azimuth

TROPOSPHERIC MAPPING FUNCTIONS

$$m_{h,w}(e) = \frac{1 + \frac{a_i}{1 + \frac{b_i}{1 + \frac{c_i}{1 + \dots}}}}{\sin(e) + \frac{a_i}{\sin(e) + \frac{b_i}{\sin(e) + \frac{c_i}{\sin(e) + \dots}}}}$$

e : Elevation cut off angle

$a_i, b_i, c_i, \dots = f(\varphi, H, \text{doy}, t, \alpha, \dots)$

φ : station latitude

H : station orthometric height

doy : day of year

P : surface total pressure

t : surface temperature

α : temperature lapse rate

Niell Mapping Function

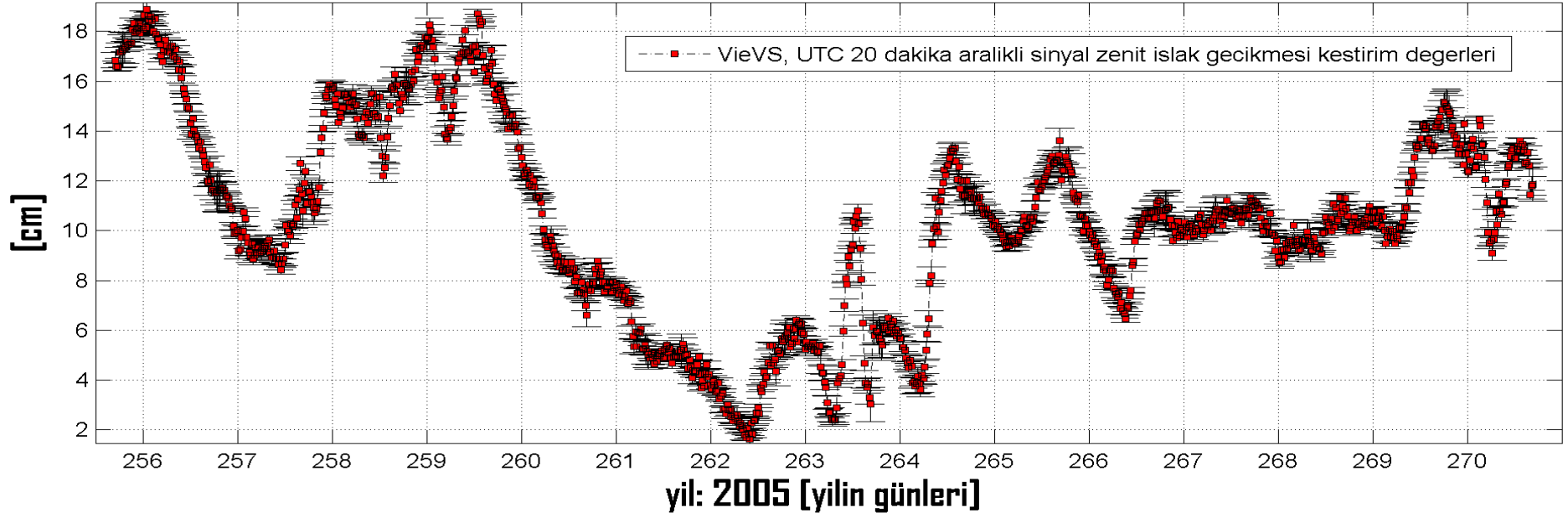
Isobaric Mapping Function

Vienna Mapping Function

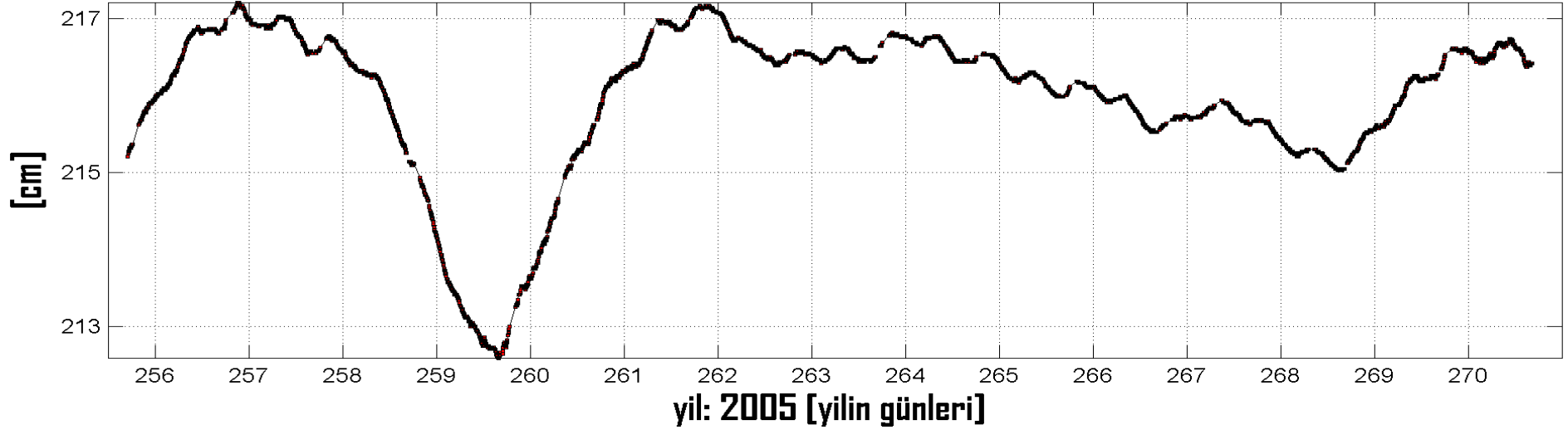
Some other mapping functions:

Chao, Lanyi, CfA, Ifadis, Davis, MTT, B&E, F&K, UNBabc, UNBab

VLBI istasyonu : WETTZELL - Almanya [sinyal zenit ıslak gecikmeleri]



WETTZELL [sinyal zenit kuru gecikmeleri]

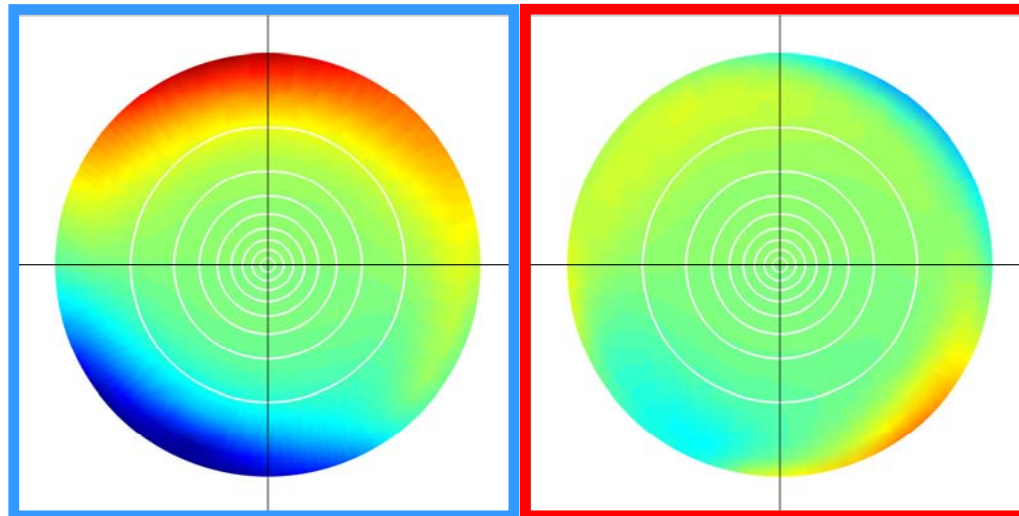


Boehm, vd., 2009

Modeling azimuthal asymmetries

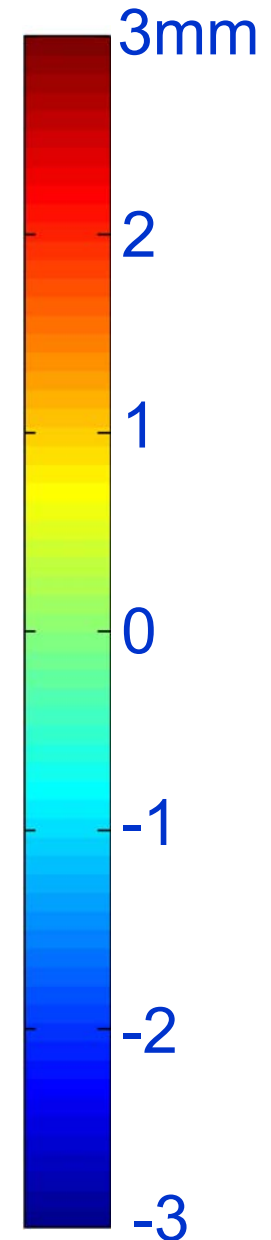
„classical“ gradients (IERS Conventions 2003)

$$\Delta L_{\text{asymm}} = mf_g(e) \cdot [G_N \cdot \cos(\alpha) + G_E \cdot \sin(\alpha)]$$



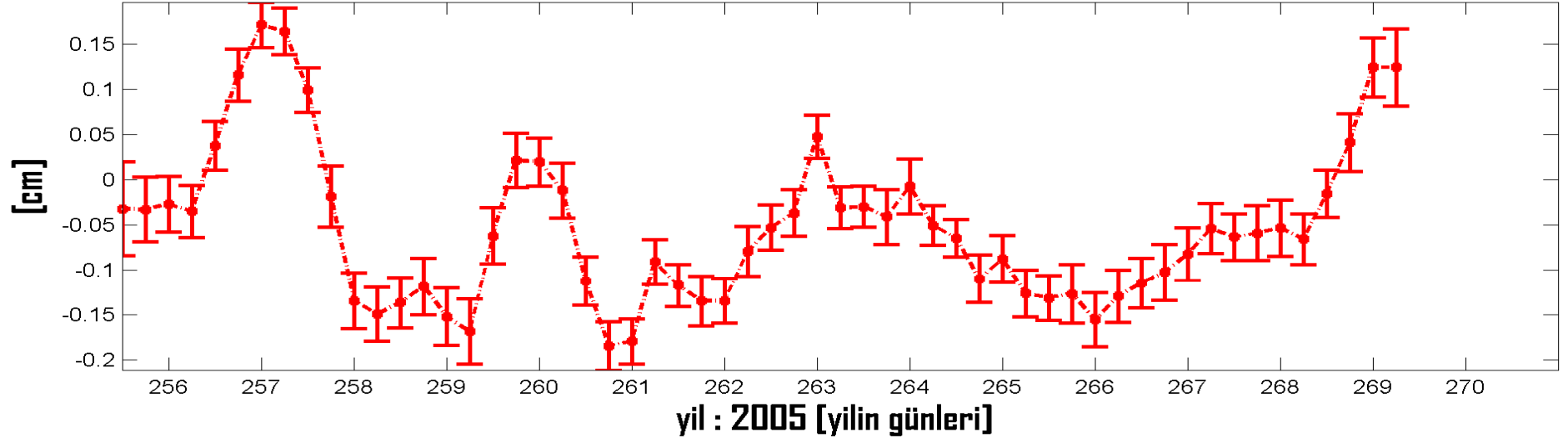
without modeling
asymmetries

classical gradients
applied

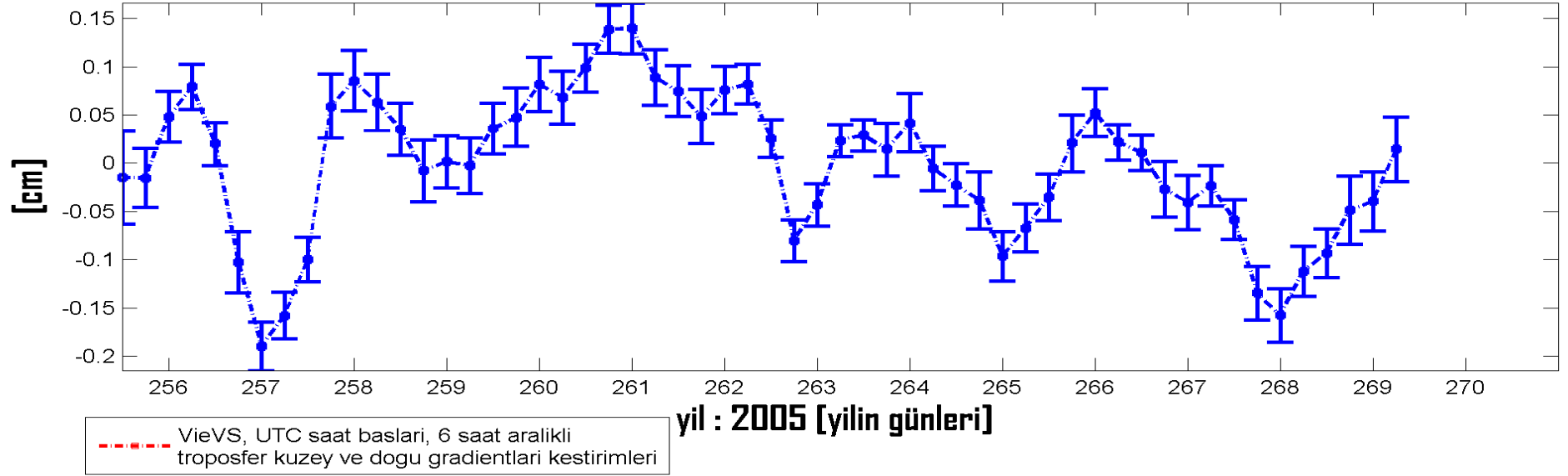


by courtesy of Andrea Pany

VLBI istasyonu: ALGOPARK - USA [Troposfer kuzey gradientlari]



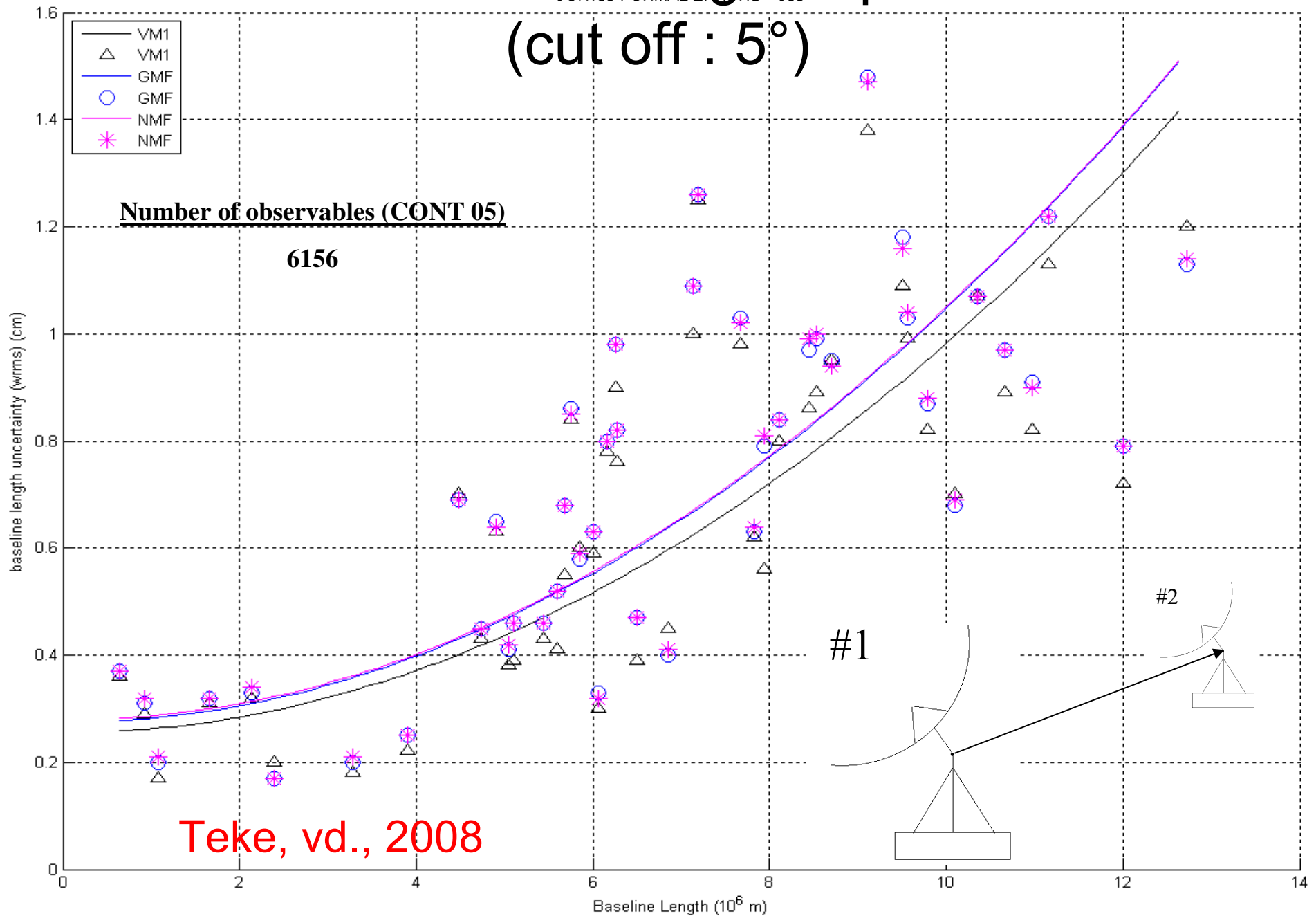
VLBI istasyonu: ALGOPARK - USA [Troposfer dogu gradientlari]



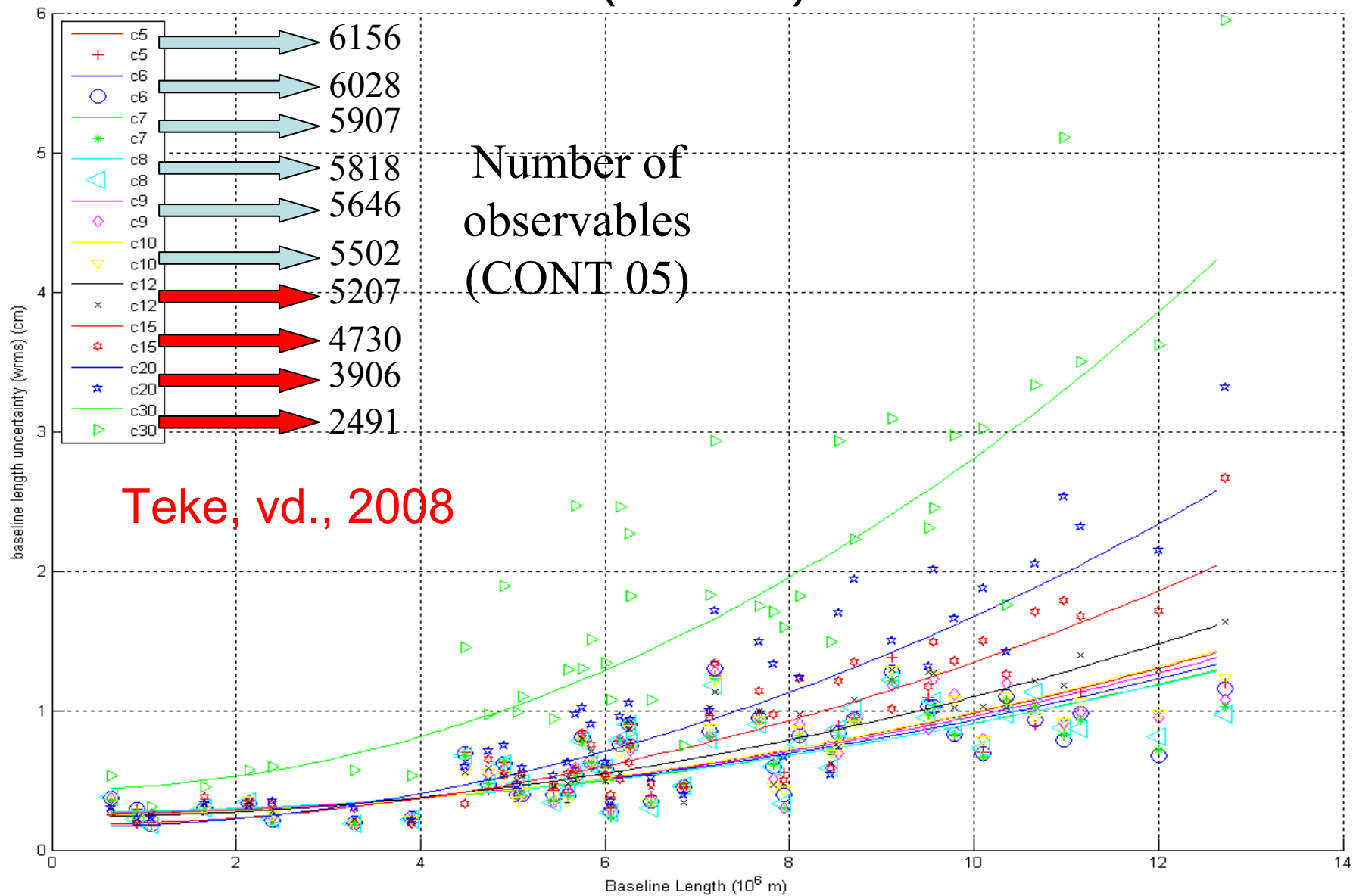
Boehm, vd., 2009

CONT05 baseline length repeatabilities

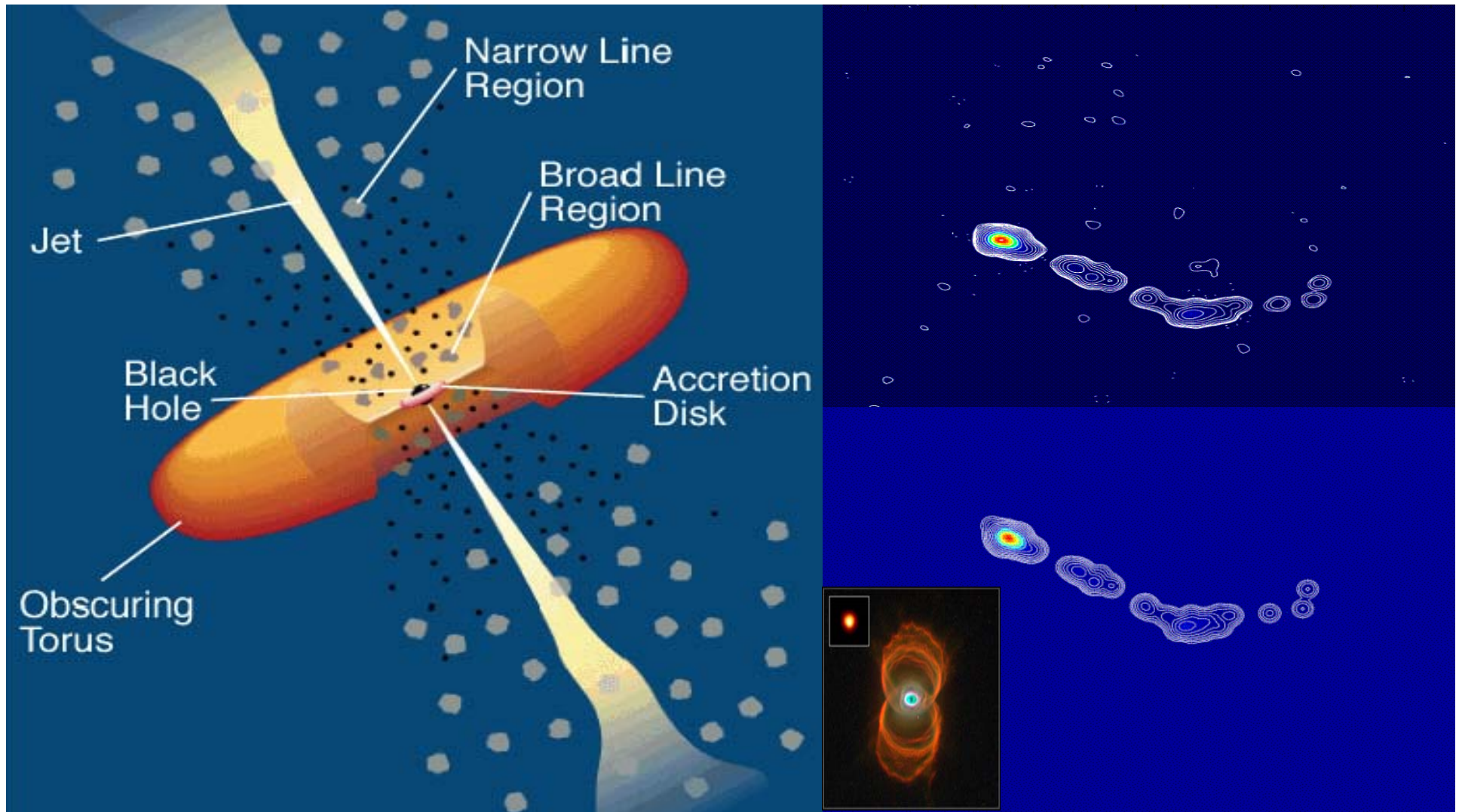
(cut off : 5°)



CONT05 baseline length repeatabilities (VMF1)

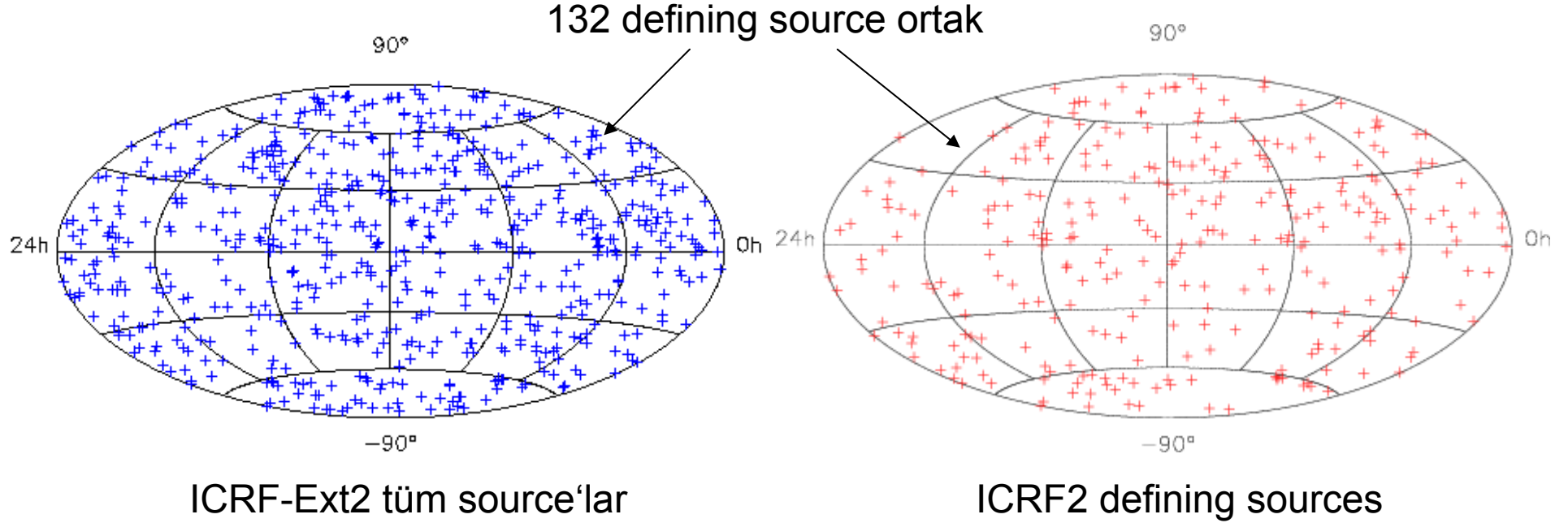


Source (kuazar) yapisi



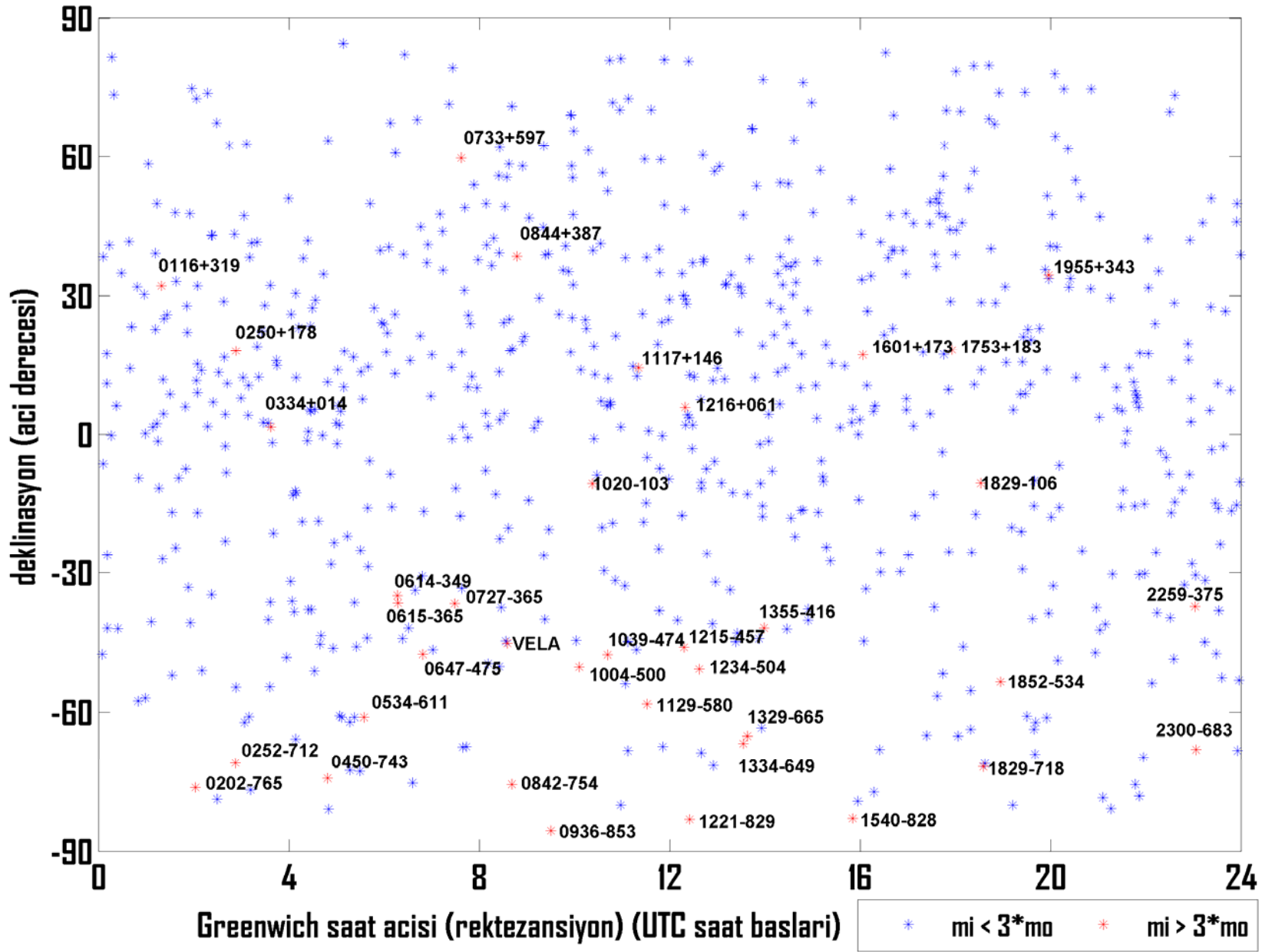
by courtesy of Bill Petrachenko

Uluslararası Göksel Referans Catisi (ICRF)



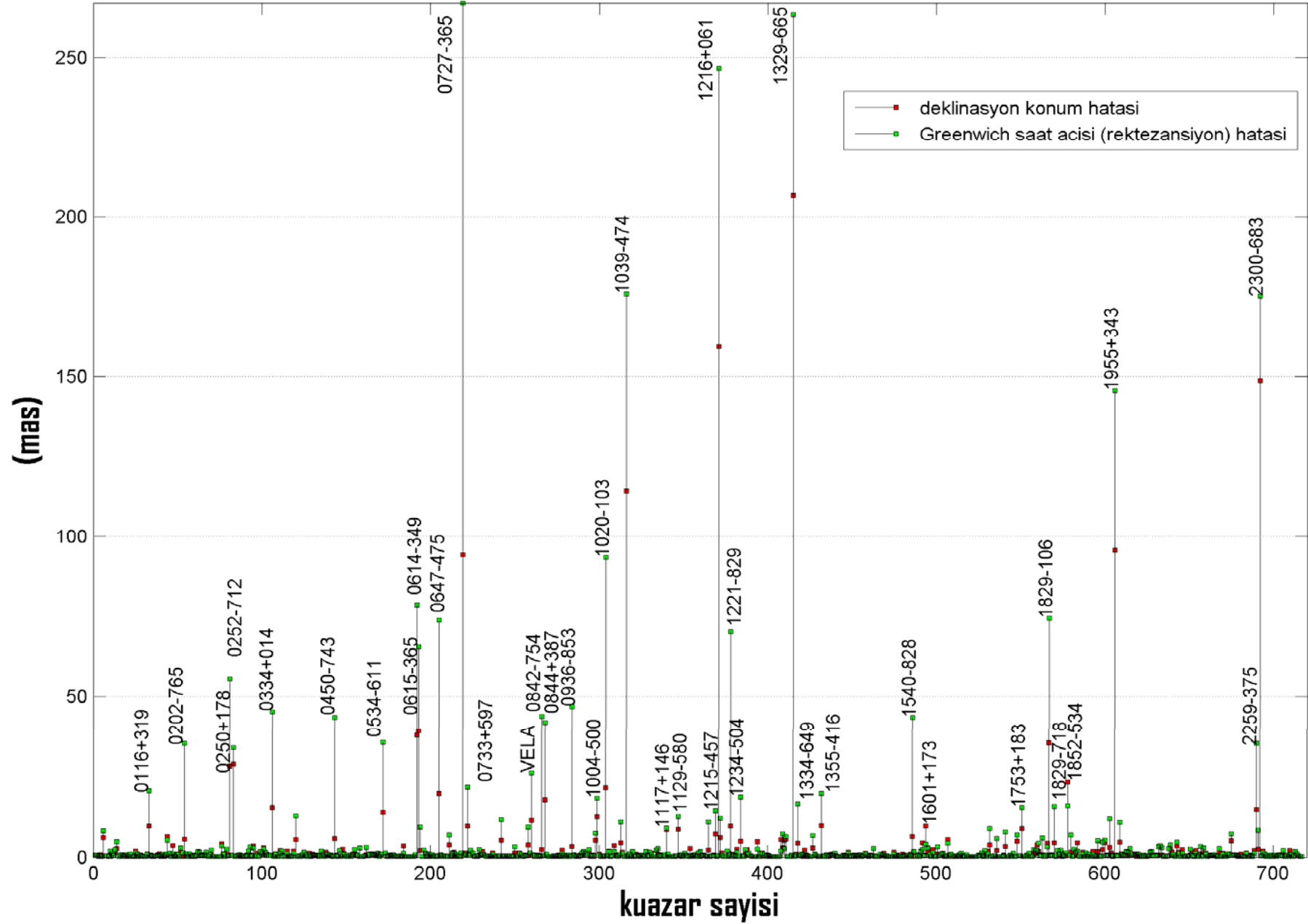
- 717 source, 212 si tanımlayıcı (NNR kosul denklemleri uygulananlar) (ICRF-Ext2)
- ICRF2 bu bildirinin hazırlanması esnasında resmi olarak oluşturulmuştur. 295'i tanımlayıcı olmak üzere 40 micro-as noise flooru aşmayan 3414 adet stable ve kompakt source'dan (kuazardan) oluşmaktadır
<http://hpiers.obspm.fr/icrs-pc/>.

ICRF-EXT.2 [717 kuazar]



Ma, vd., 1998; Fey, vd., 2004

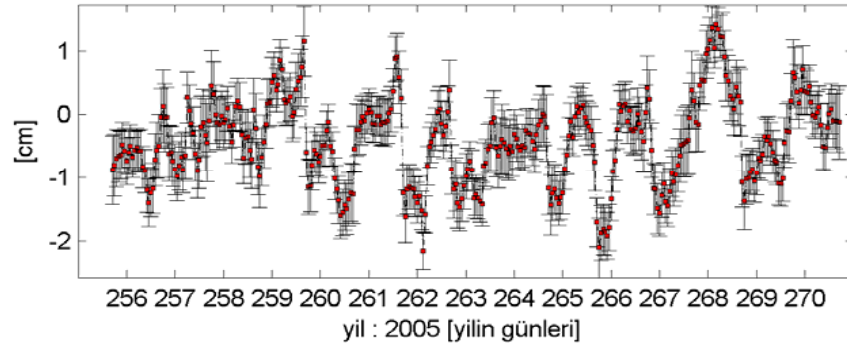
ICRF-EXT.2 [kuasar koordinatlari konum hatalari (chi-squared)]



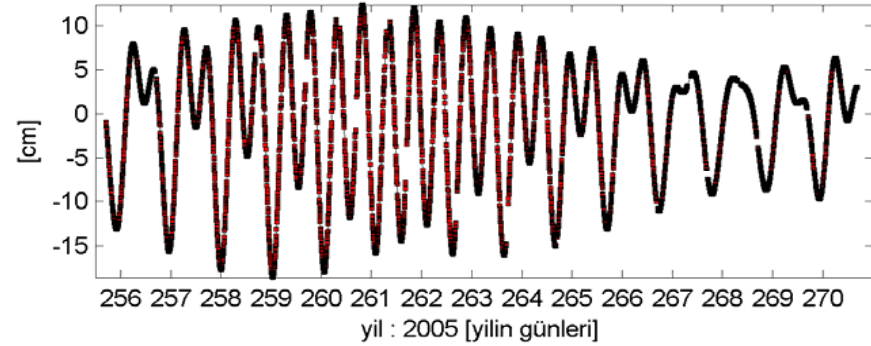
IERS Conventions 2003

$$X(t) = X(t_{2000.0})^{ITRF2005} + v_{\Delta X}^{ITRF2005} \cdot (t - t_{2000.0}) + \Delta X_{jeofizik_model(i)}(t) + \Delta X_{kestirim}$$

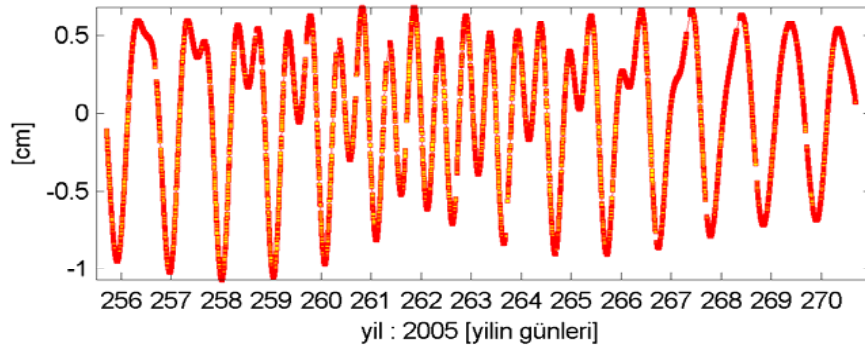
VLBI istasyonu: TSUKUB32 - JAPONYA [TRF koordinatları - VieVS kestirim degerleri - DX]



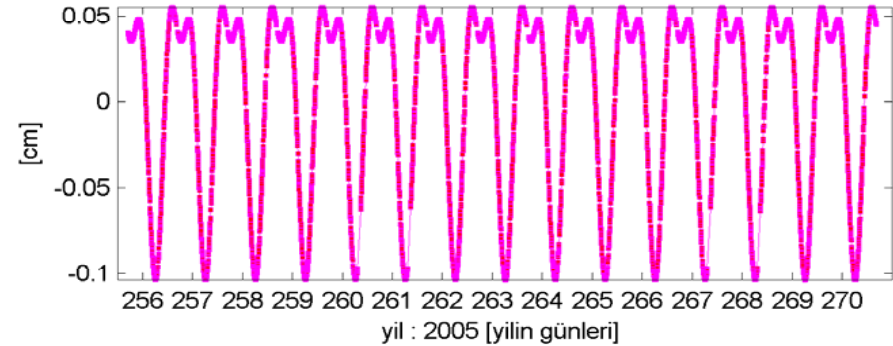
TSUKUB32 [solid Earth tides - kati Yer gel-gitleri - DX]



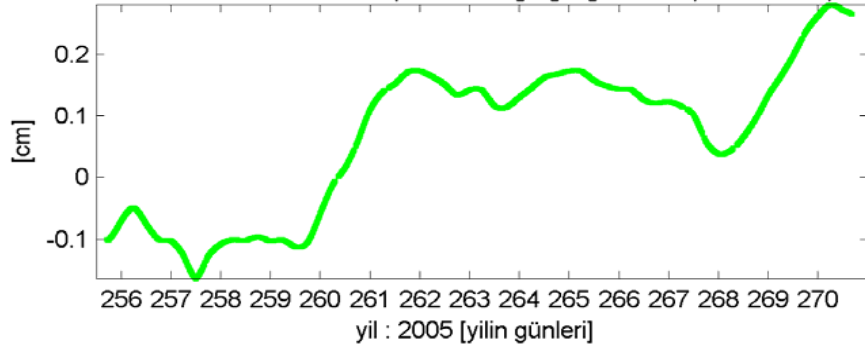
TSUKUB32 [tidal ocean loading - okyanus gel-git yüklemeleri - DX]



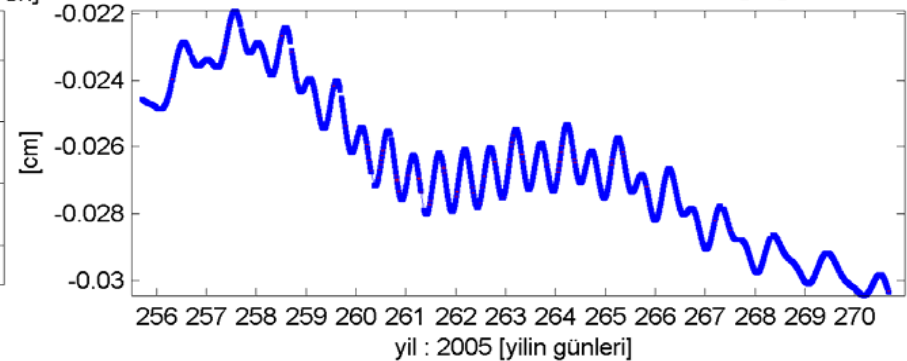
TSUKUB32 [tidal atmosphere loading - atmosfer gel-git yüklemeleri - DX]



Station: TSUKUB32 [Non-tidal atmosphere loading - gel-gitsel olmayan atmosfer yük. DX]



Station: TSUKUB32 [Pole tide -Yer dönme eksenine kutbu gel-git etkisi - DX]

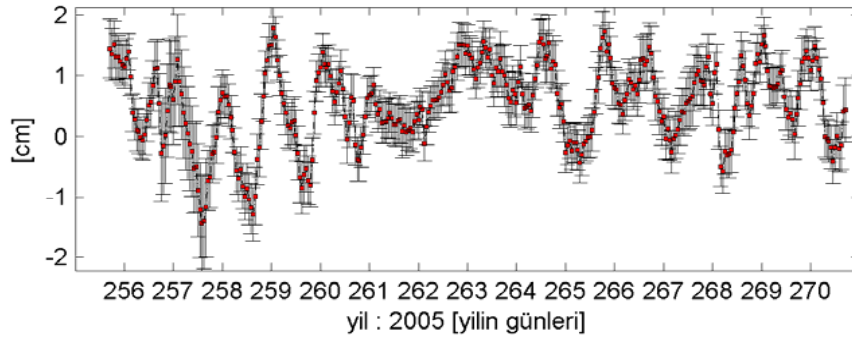


Boehm, vd., 2009; by courtesy of Hana Spicakova

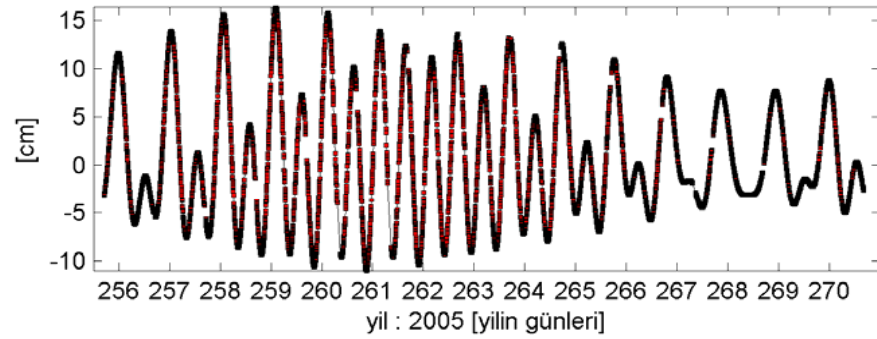
IERS Conventions 2003

$$X(t) = X(t_{2000.0})^{ITRF\ 2005} + v_{\Delta X}^{ITRF\ 2005} \cdot (t - t_{2000.0}) + \Delta X_{jeofizik_model(i)}(t) + \Delta X_{kestirim}$$

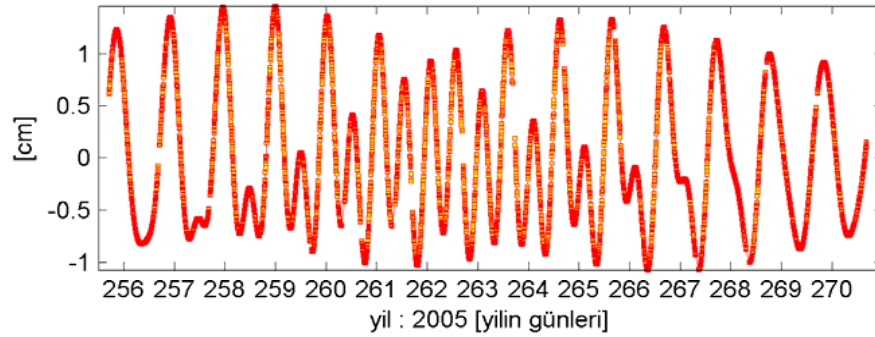
VLBI istasyonu: TSUKUB32 - JAPONYA [TRF koordinatlari - VieVS kestirim degerleri - DY]



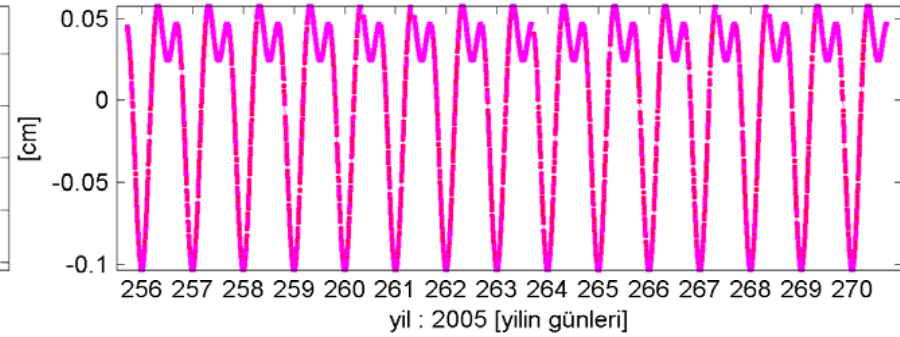
TSUKUB32 [solid Earth tides - kati Yer gel-gitleri - DY]



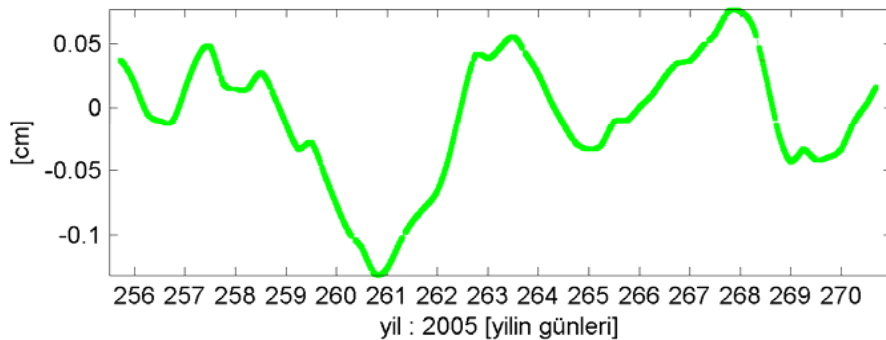
TSUKUB32 [tidal ocean loading - okyanus gel-git yüklemeleri - DY]



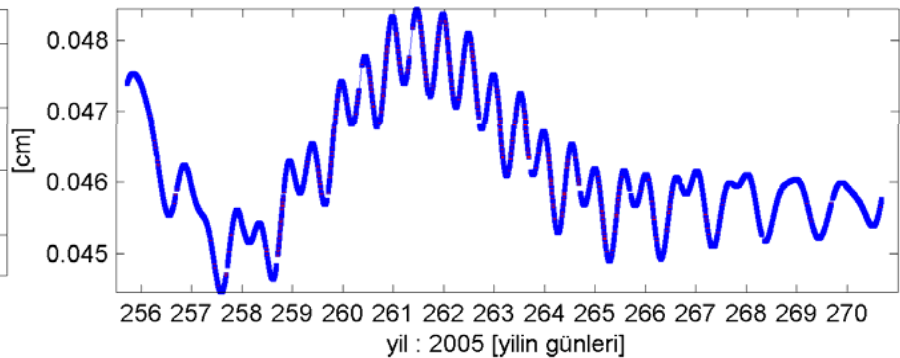
TSUKUB32 [tidal atmosphere loading - atmosfer gel-git yüklemeleri - DY]



TSUKUB32 [Non-tidal atmosphere loading - gel-gitsel olmayan atmosfer yük. DY]



TSUKUB32 [Pole tide -Yer dönme eksenini kutbu gel-git etkisi - DY]

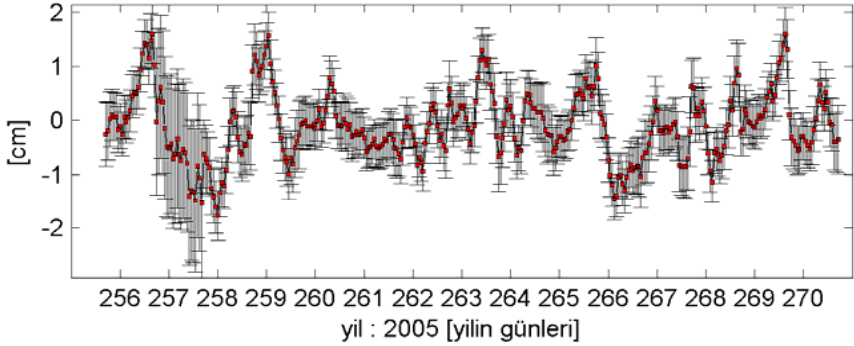


Boehm, vd., 2009; by courtesy of Hana Spicakova

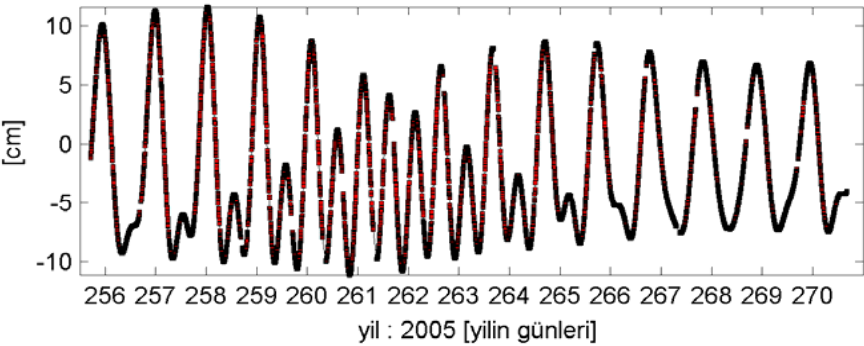
IERS Conventions 2003

$$X(t) = X(t_{2000.0})^{ITRF\ 2005} + v_{\Delta X}^{ITRF\ 2005} \cdot (t - t_{2000.0}) + \Delta X_{jeofizik_model(i)}(t) + \Delta X_{kestirim}$$

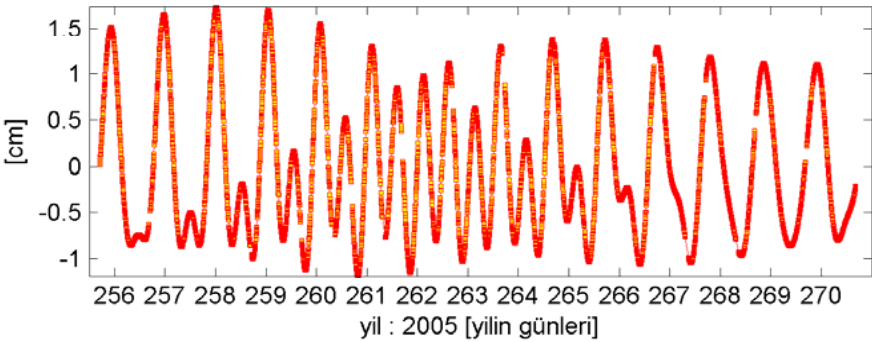
VLBI istasyonu: TSUKUB32 - JAPONYA [TRF koordinatları - VieVS kestirim degerleri - DZ]



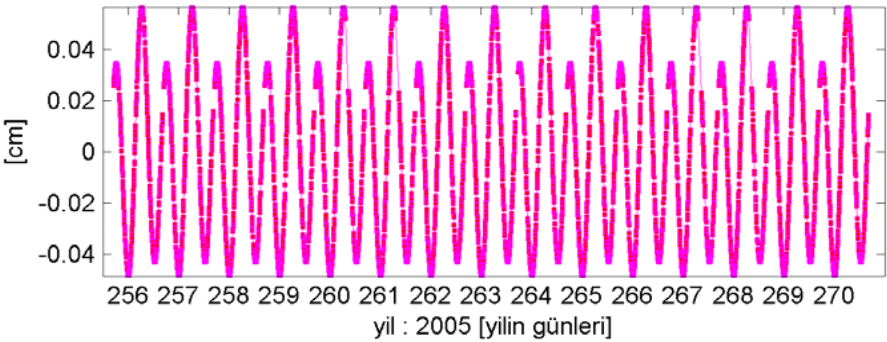
TSUKUB32 [solid Earth tides - kati Yer gel-gitleri - DZ]



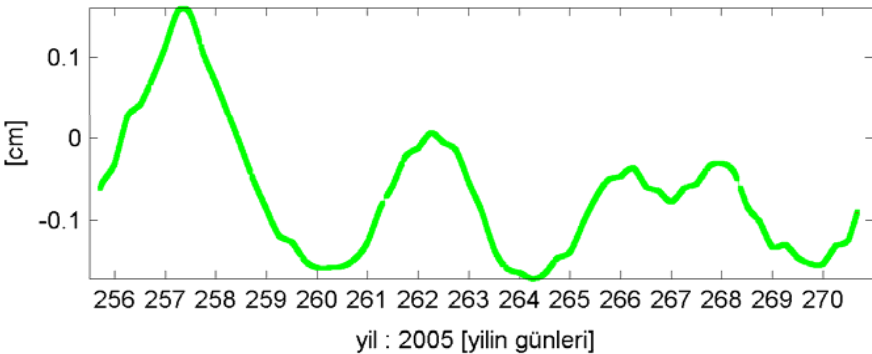
TSUKUB32 [tidal ocean loading - okyanus gel-git yüklemeleri - DZ]



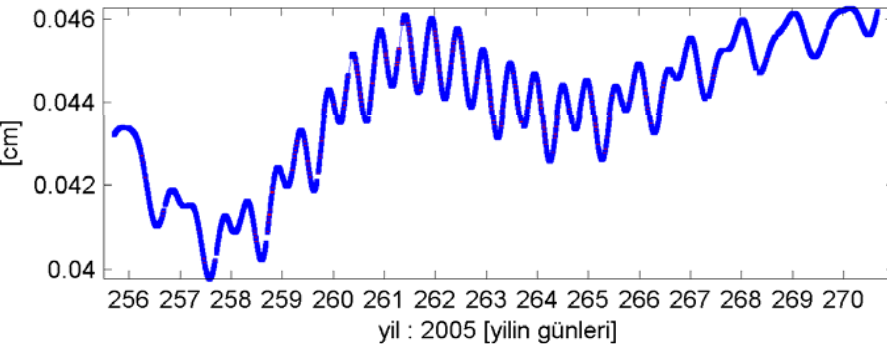
TSUKUB32 [tidal atmosphere loading - atmosfer gel-git yüklemeleri - DZ]



TSUKUB32 [Non-tidal atmosphere loading - gel-gitsel olmayan atmosfer yük. DZ]

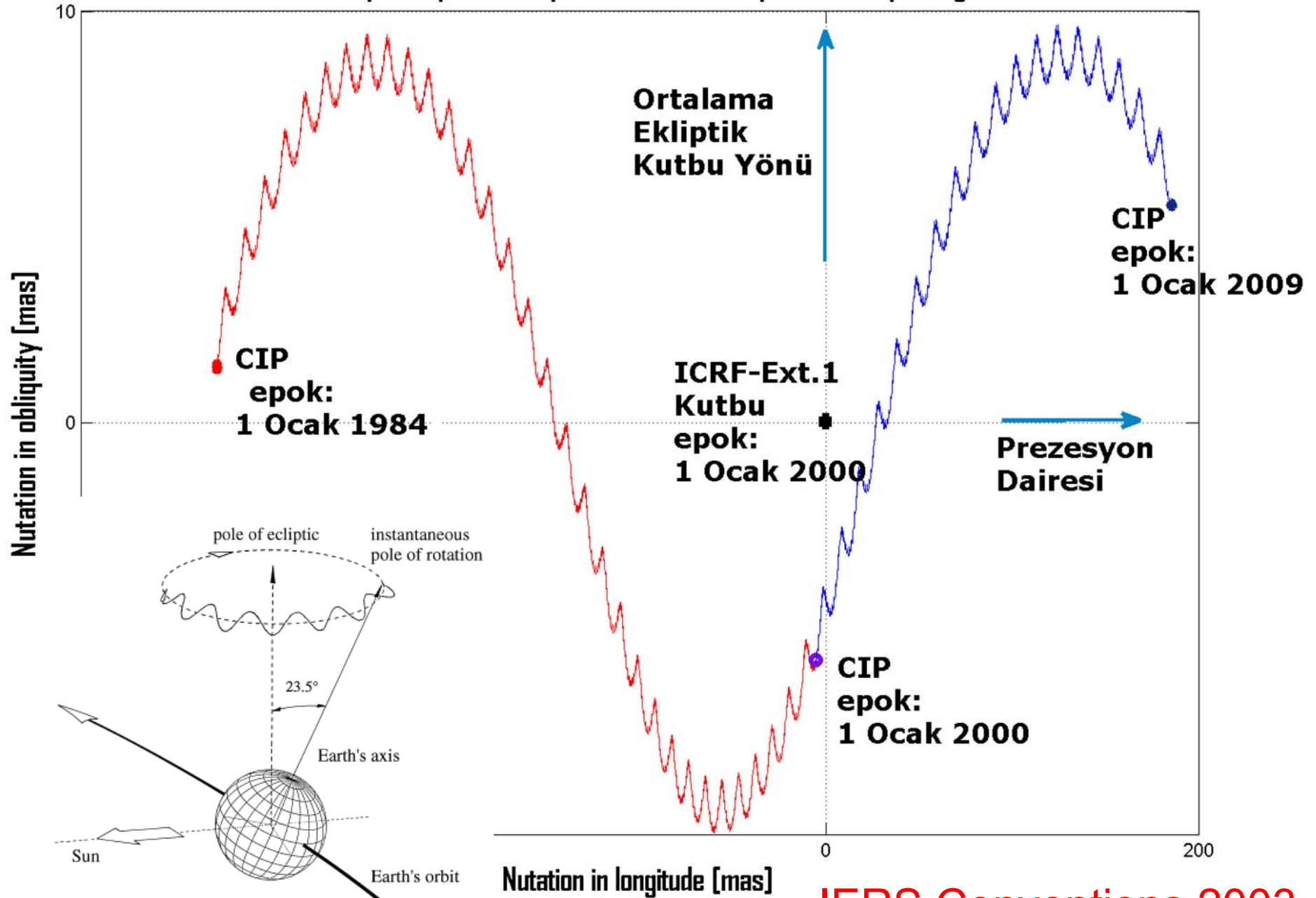


TSUKUB32 [Pole tide -Yer dönme eksenini kutbu gel-git etkisi - DZ]



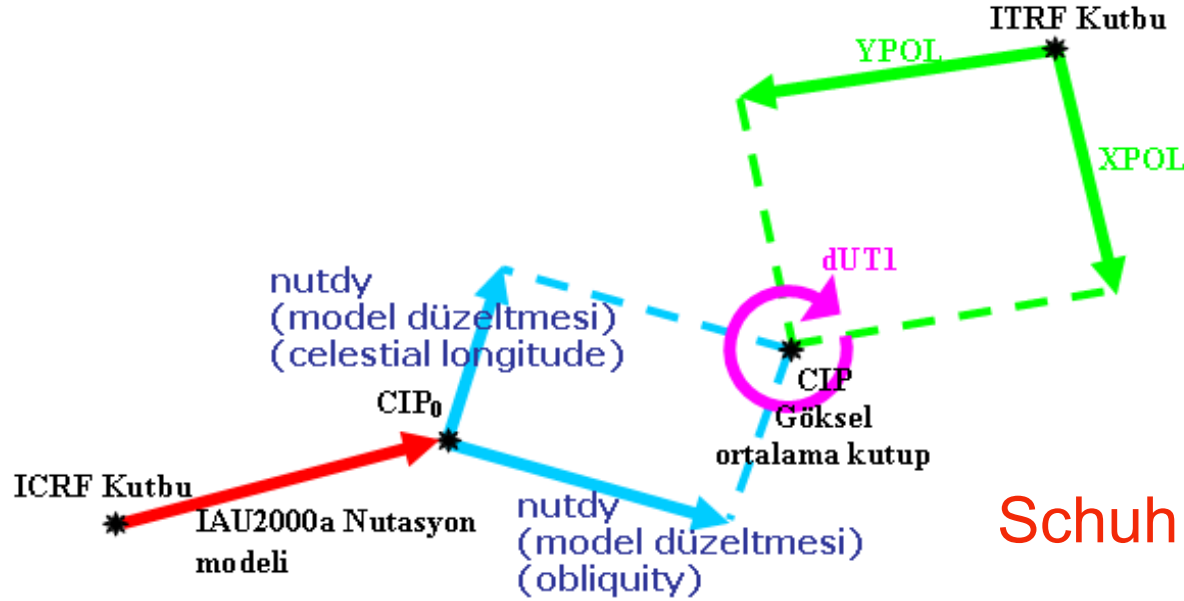
Boehm, vd., 2009; by courtesy of Hana Spicakova

IAU2000A prezesyon-nuatasyon modelinden hesaplanan nutasyon degerleri



IERS Conventions 2003

Yer dönme parametreleri (EOP), ICRF ve ITRF arasındaki ilişki



Schuh, vd., 2008

$$Y = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(y_p) & \sin(y_p) \\ 0 & -\sin(y_p) & \cos(y_p) \end{bmatrix}$$

$$X = \begin{bmatrix} \cos(x_p) & 0 & -\sin(x_p) \\ 0 & 1 & 0 \\ \sin(x_p) & 0 & \cos(x_p) \end{bmatrix}$$

$$R = \begin{bmatrix} \cos(H) & -\sin(H) & 0 \\ \sin(H) & \cos(H) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$X(t)_{CIP} = X(t)_{CIP_{IAU2000A}} + nutdx_{IERS C04}$$

$$Y(t)_{CIP} = Y(t)_{CIP_{IAU2000A}} + nutdy_{IERS C04}$$

Nutasyon (CIP koordinatları)

$$RXY = \begin{bmatrix} \cos(H) & -\sin(H) & -\sin(x_p)\cos(H) - \sin(y_p)\sin(H) \\ \sin(H) & \cos(H) & -\sin(x_p)\sin(H) + \sin(y_p)\cos(H) \\ \sin(x_p) & -\sin(y_p) & 1 \end{bmatrix}$$

H : gercek ekinoks saat acisi

x_p, y_p : Yer ortalama dönme eksenini kutbu koordinatları

IERS Conventions 2003

Kutup gezinmesi ve gün uzunluğu (Yerin dönme hızı)

Figure axis



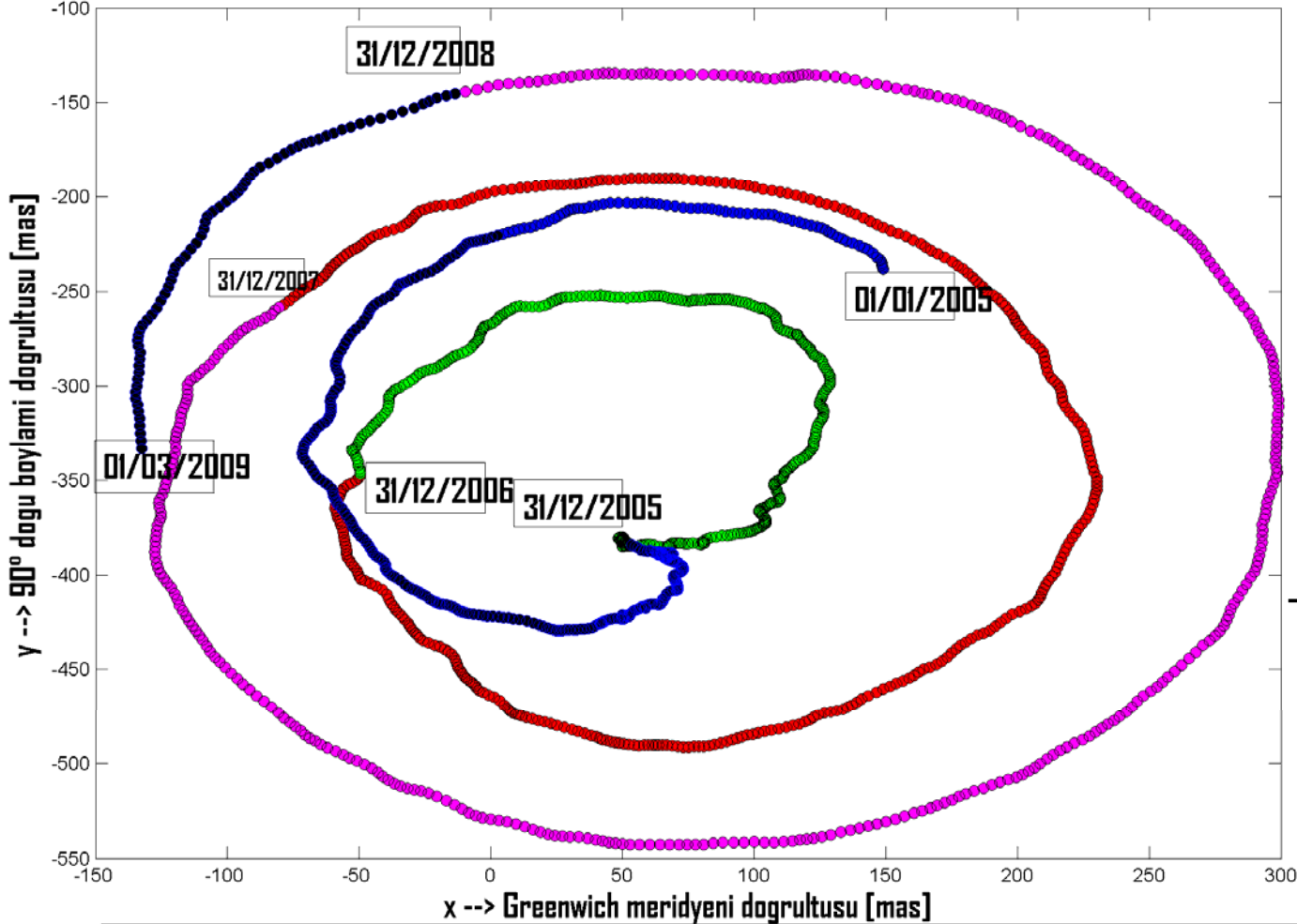
Atalet (Eylemsizlik momenti)

$$\sum_i L_i = r_i m_i v_i \sin(\theta_i)$$

Tork (Kuvvet momenti)

$$\sum_i \tau_i = \sum_i r_i F_i \sin(\theta_i)$$

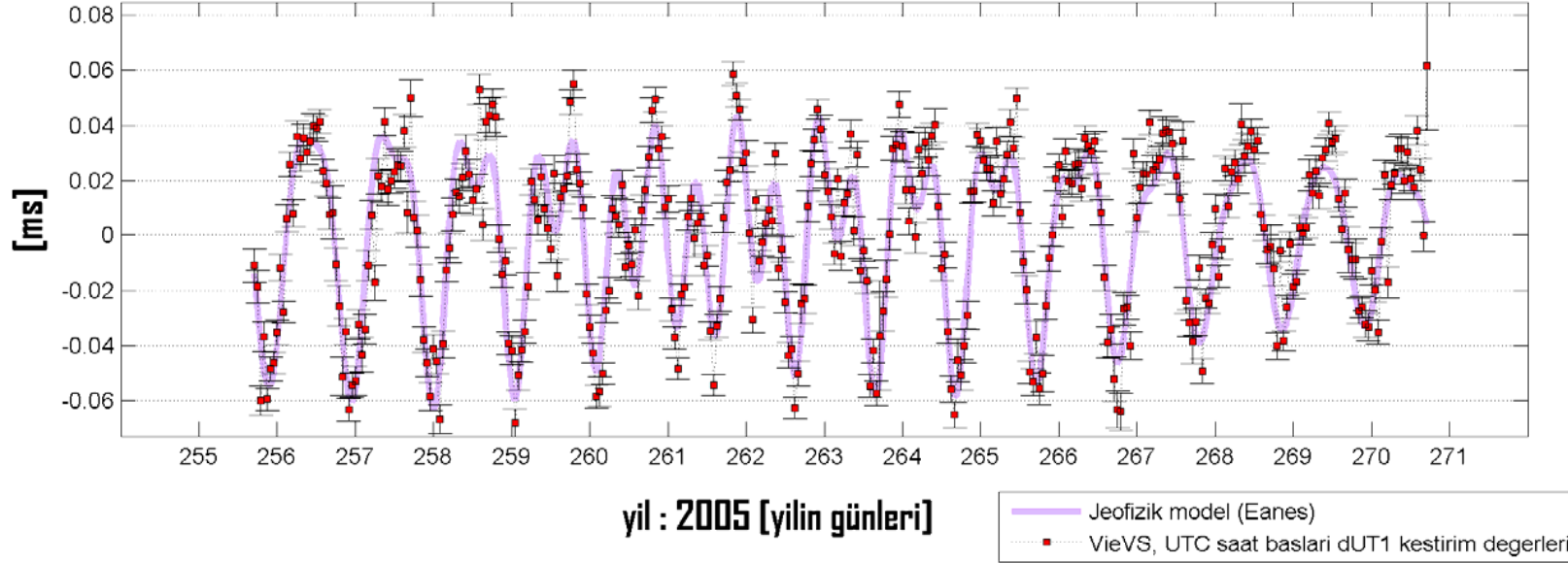
Yer dönme eksenini kutbu TRF koordinatları (kutup gezinmesi)
[IERS-CD4 günlük inter-teknik (VLBI+GPS+DORIS+SLR/LLR) kombinasyon değerleri]



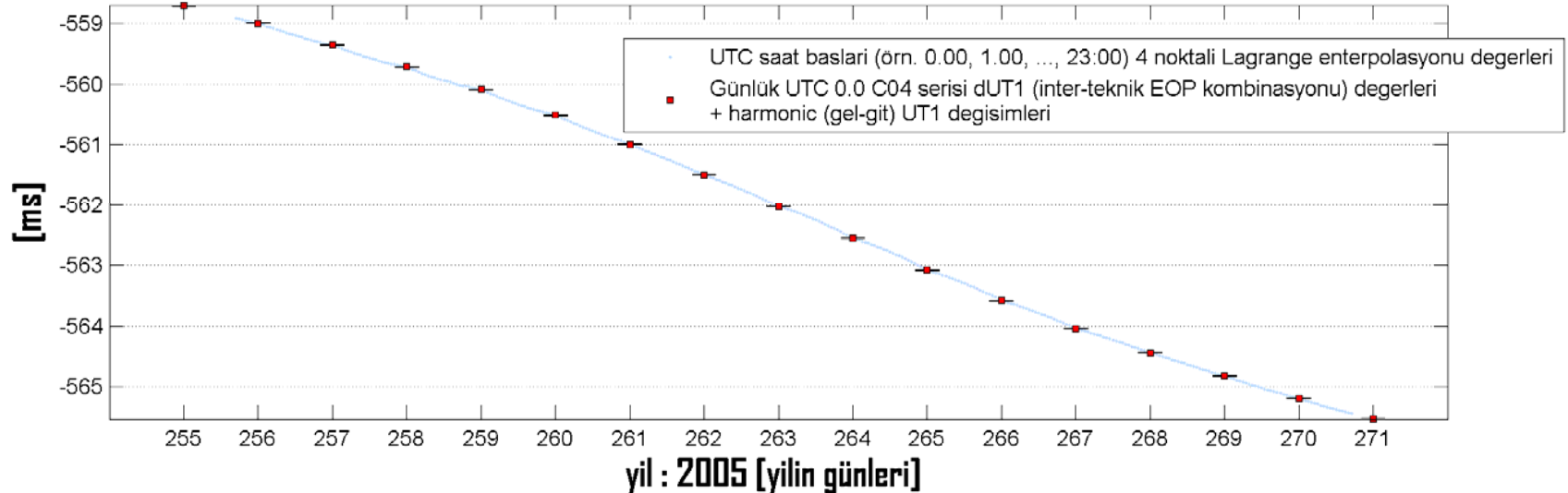
Chandler wobble (serbest nutasyon) Periyot : ~433 gün Çap ~ = 0.6~0.7 aci sanyiesi = 15-20 metre

Yüksek frekanslı (saatlik) Yer dönme eksenini açısı (hızı) Eanes modeli ile hesaplanan degerleri ve VieVS kestirim deęerleri

Yer dönme eksenini dönüklüğü (dUT1) [mjd ilk: 53625 - mjd son: 53641]

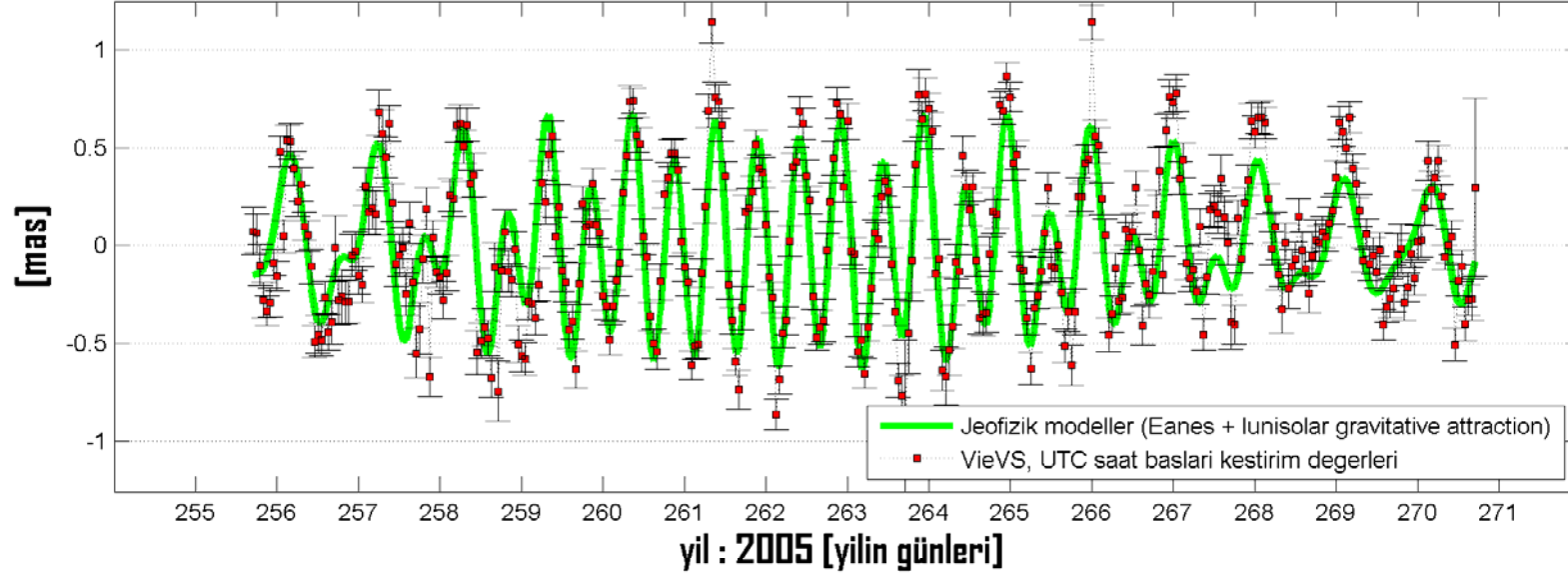


Yer dönme eksenini apriori deęerleri (dUT1) IERS C04 Serisi + tidal UT1 variations [mjd ilk: 53625 - mjd son: 53641]

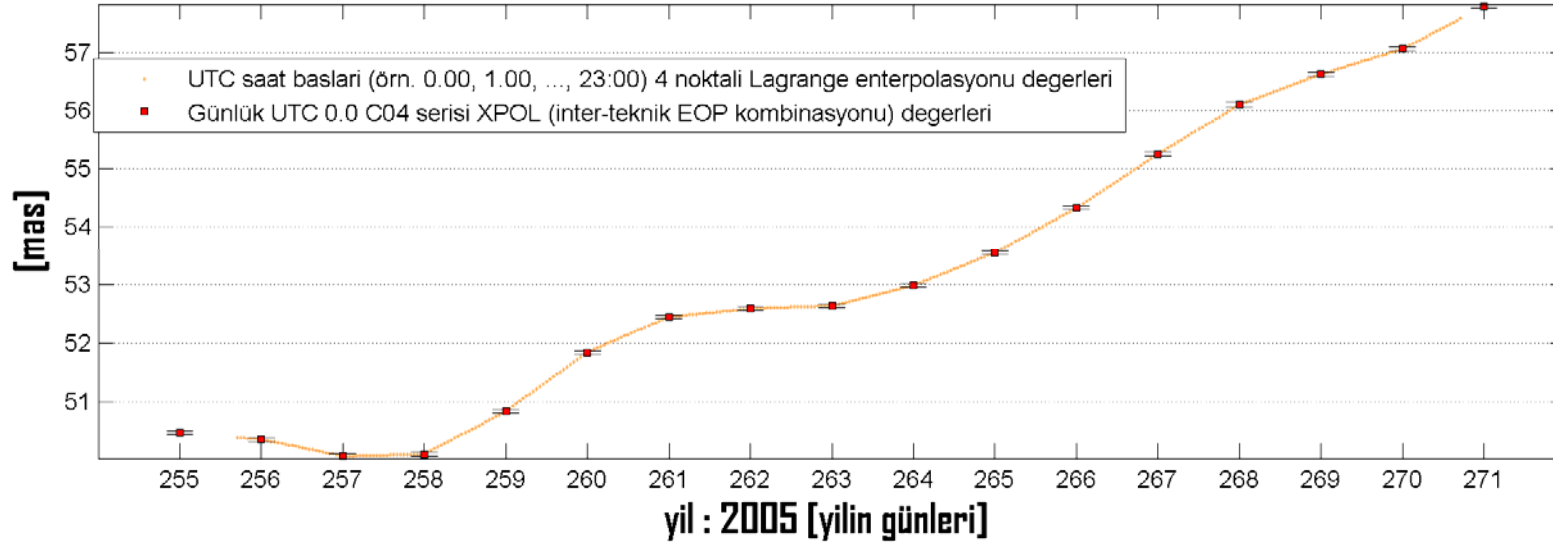


Yüksek frekanslı (saatlik) Yer dönme eksen kutbu referans meridyeni doğrultusu koordinatları ve jeofizik modeller ile VieVS kestirim değerleri

Yer Dönme Eksen kutup koordinatları - Greenwich referans meridyeni doğrultusu (XPOL) [mjd ilk: 53625 - mjd son: 53641]

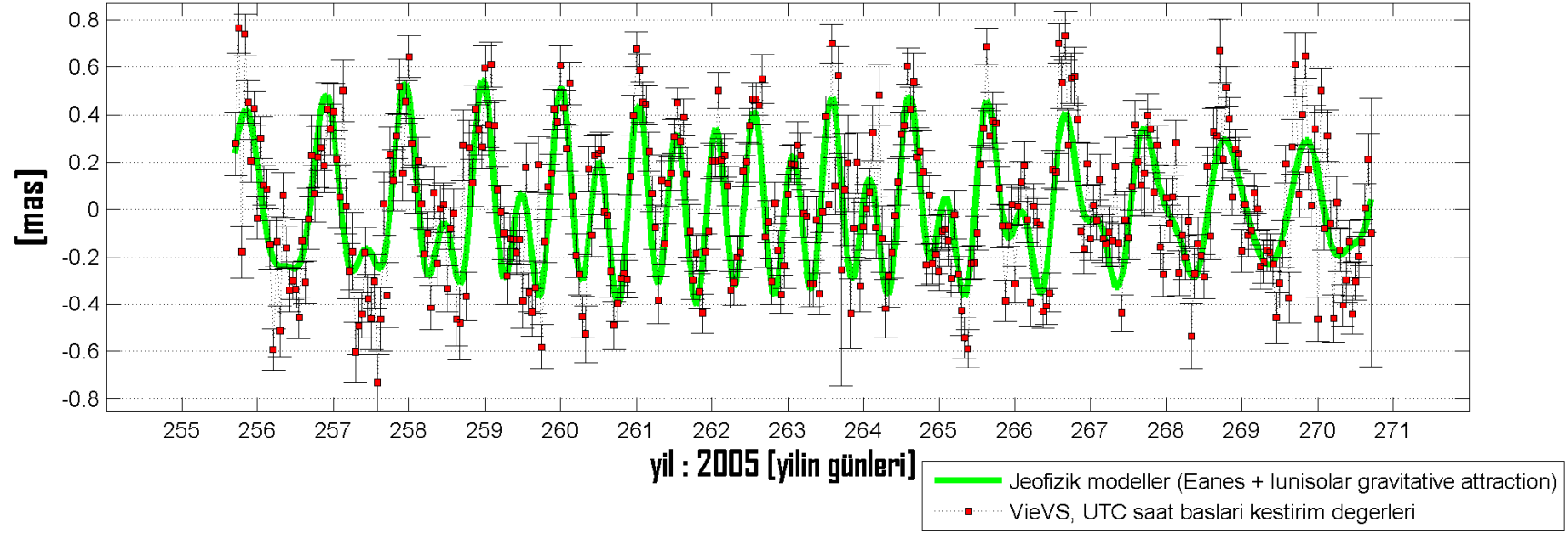


IERS C04 EOP Serisi XPOL apriori koordinatları [mjd ilk: 53625 - mjd son: 53641]

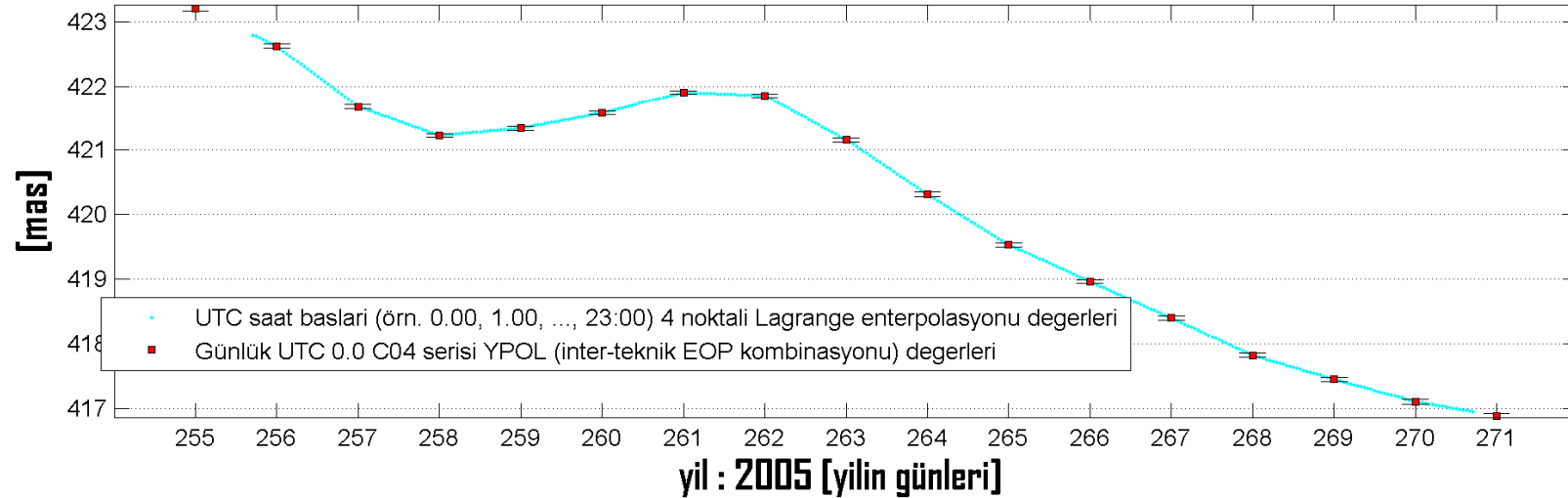


Yüksek frekanslı (saatlik) Yer dönme eksen kutbu 90° batı boylamı doğrultusu koordinatları ve jeofizik modeller ile VieVS kestirim değerleri

Yer Dönme Eksen kutup koordinatları - 90° batı boylamı doğrultusu (YPOL) [mjd ilk: 53625 - mjd son: 53641]

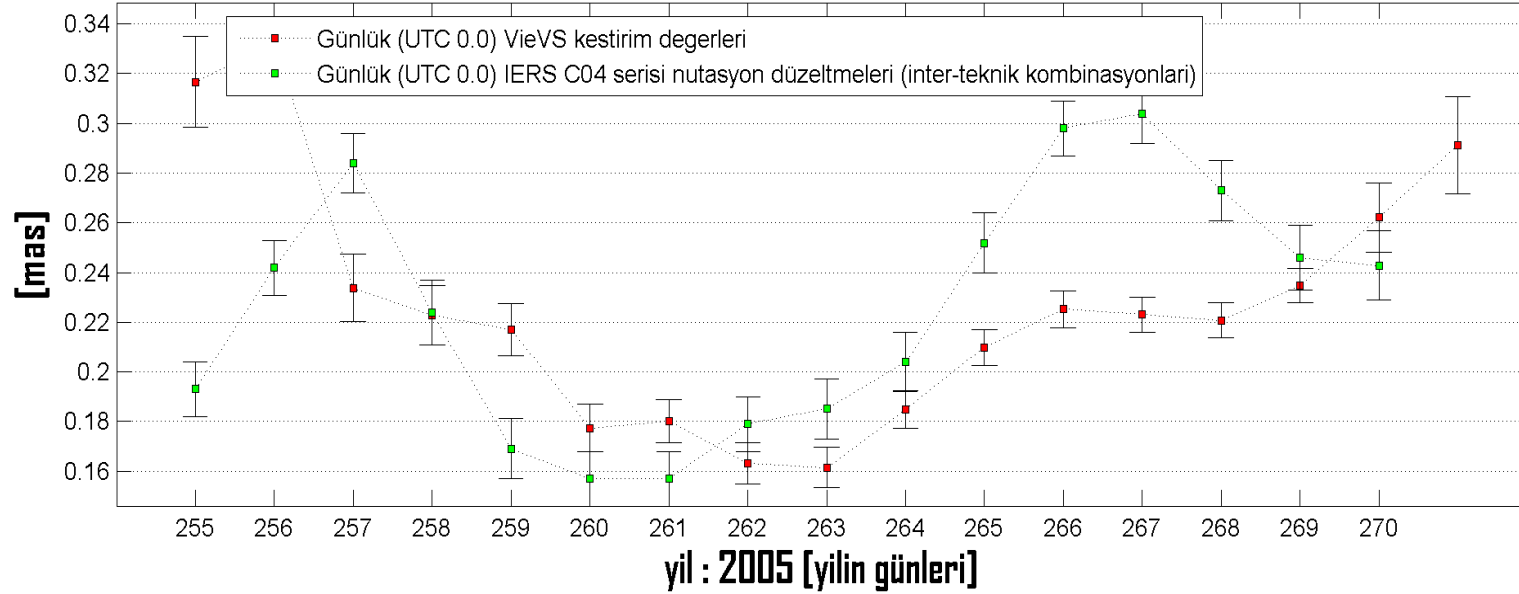


IERS C04 EOP Serisi YPOL apriori koordinatları [mjd ilk: 53625 - mjd son: 53641]

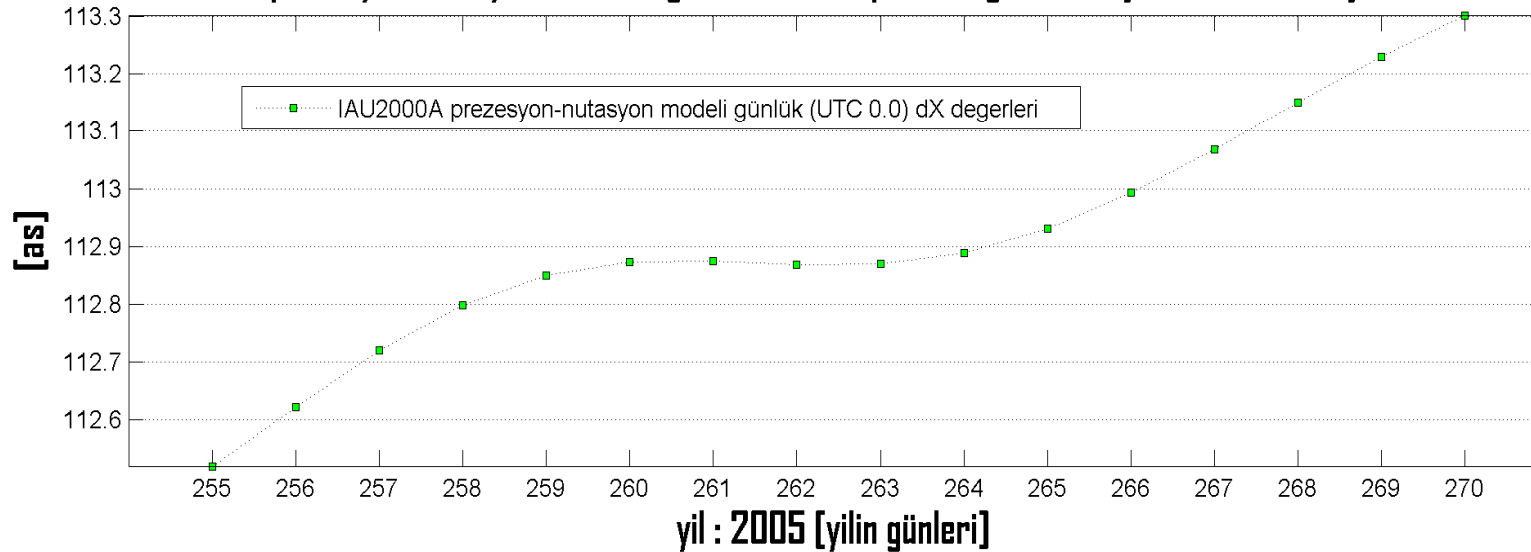


IAU 2000A prezasyon-nutasyon modelinden hesaplanan nutasyon açılıarı, IERS C04 serisi düzeltmeleri, ve VieVS kestirim deęerleri

Göksel ortalama kutup (CIP) dX (nutasyon in obliquity ~ dEPS) koordinatları (GCRS'de tanımlı) [mjd ilk: 53625 - mjd son: 53640]

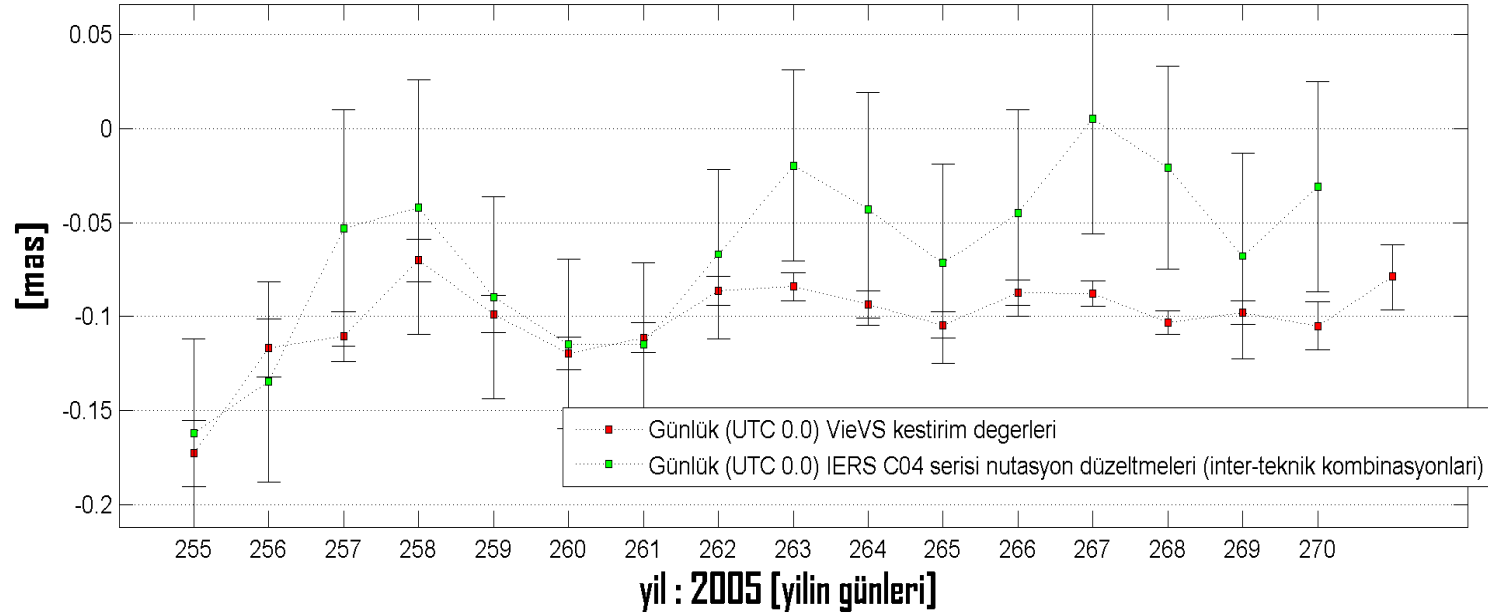


IAU2000A prezasyon-nutasyon modeli deęerleri - dX (apriori deęerler) [mjd ilk: 53625 - mjd son: 53640]

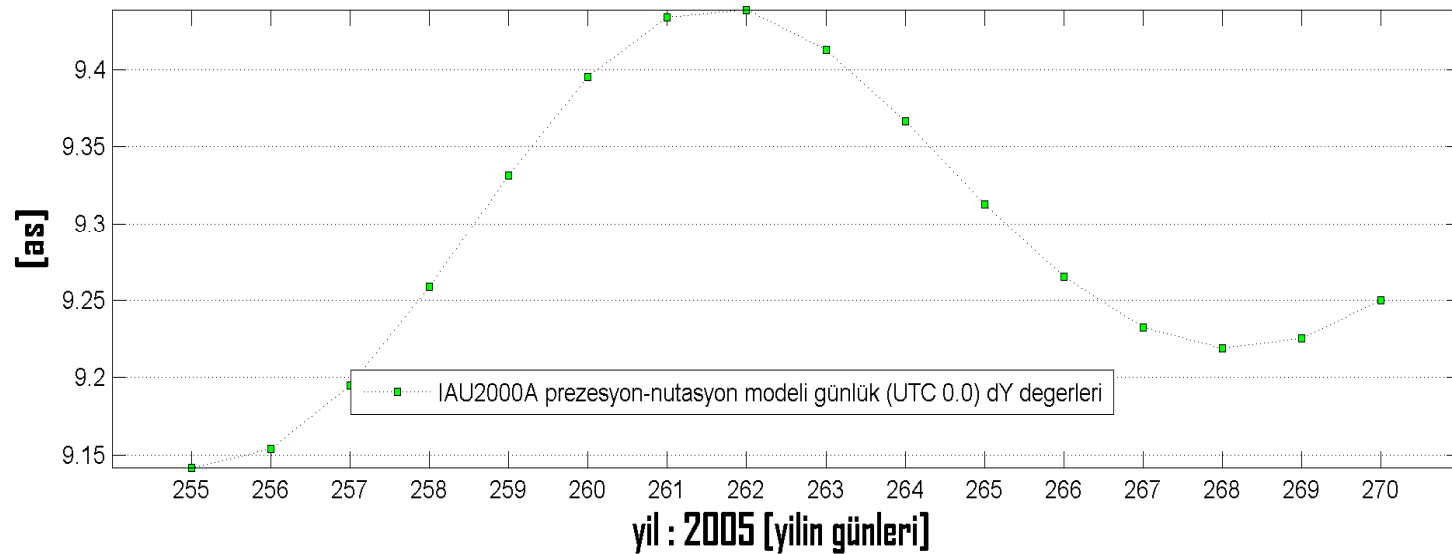


IAU 2000A prezasyon-nutasyon modelinden hesaplanan nutasyon açılıarı, IERS C04 serisi düzeltmeleri, ve VieVS kestirim deęerleri

Göksel ortalama kutup (CIP) dY (nutation in longitude ~ dPSI) koordinatları (GCRS'de tanımlı) [mjd ilk: 53625 - mjd son: 53640]



IAU2000A prezasyon-nutasyon modeli deęerleri - dY (apriori deęerler) [mjd ilk: 53625 - mjd son: 53640]



Koordinat zaman serisi analizi

$$r_k(t) = r_k(t_0) + \dot{r}_k(t - t_0) + \sum_{p=1}^n A_{kp} \cos(2\pi f_{kp}t + \phi_{kp}) + \frac{t - t_i}{t_{i+1} - t_i} (\Delta r_{k,i+1} - \Delta r_{k,i}) + \varepsilon_{kt} \quad (t_i < t < t_{i+1})$$

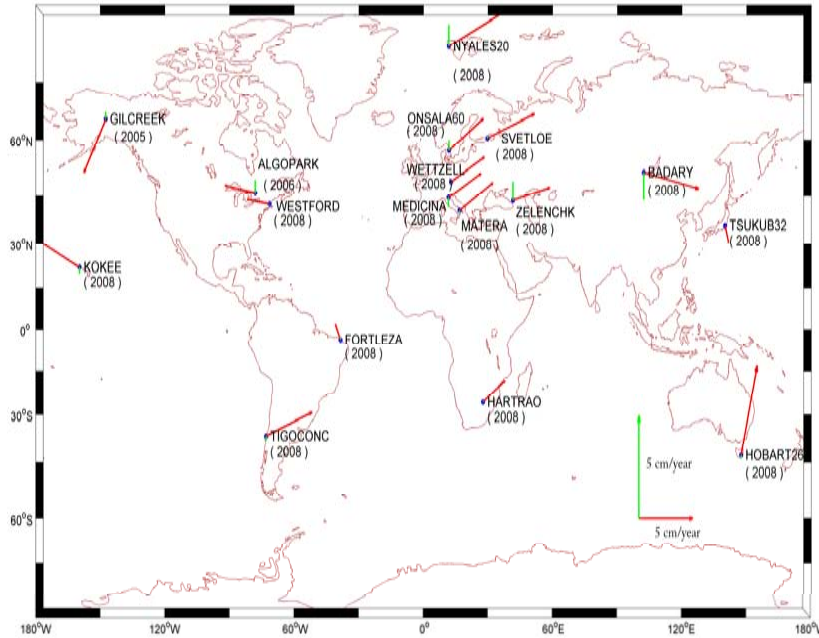
T_0 epogu koordinatlari

Lineer trend (hiz) bilezeni

Harmonik (periodik örn. tidal yüklemeler) bilezen

Lineer ve harmonik olmayan (episodik, örn. deprem vs.) bilezen

random noise



A_{kp} : k . istasyon, ve p . harmonige ait amplitude (genlik)

f_{kp} : k . istasyon, ve p . harmonige ait frekans

ϕ_{kp} : k . istasyon, ve p . harmonige ait faz

$\Delta r_{k,i}$: k istasyonunun, i . ofset kestirimi

t_i : i . kestirimin epogu

Site name	ITRF 2000 at epoch 1997.0			from IVS-R1 and -R4 sessions		
	v_{north} [cm]	v_{east} [cm]	v_{up} [cm]	v_{north} [cm] (year)	v_{east} [cm] (year)	v_{up} [cm] (year)
Algopark	0.13	-1.66	0.23	0.17 (2005)	-1.61 (2005)	0.23 (2002)
Fortaleza	1.21	-0.43	0.09	1.16 (2008)	-0.48 (2008)	0.11 (2006)
Kokee	3.24	-6.24	-0.08	3.29 (2008)	-6.46 (1995)	-0.09 (2007)
Matera	1.81	2.37	-0.10	1.81 (2003)	2.36 (2003)	-0.11 (2003)
Wettzell	1.44	2.03	-0.09	1.37 (2008)	2.02 (2008)	-0.07 (2008)

Tanir, vd., 2009

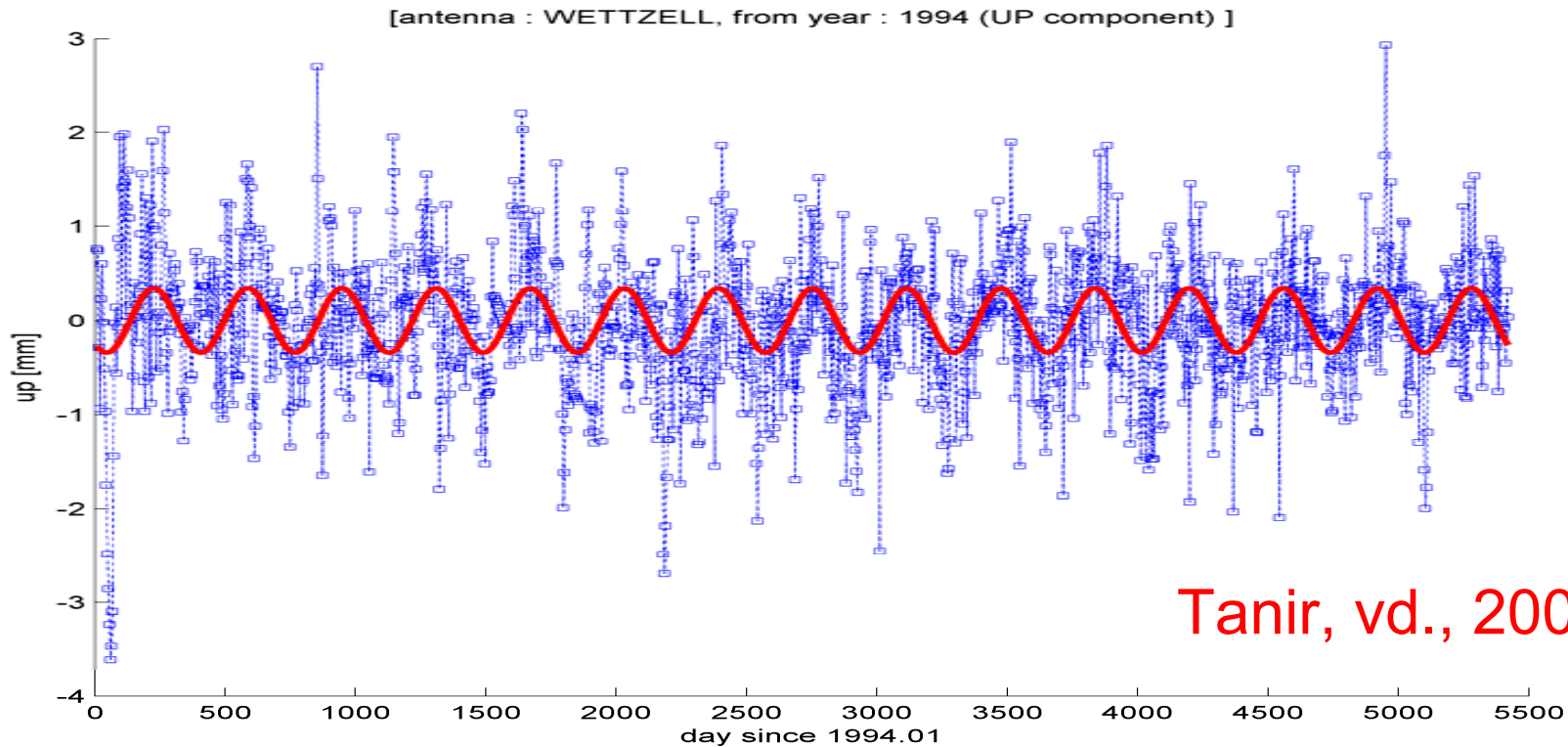
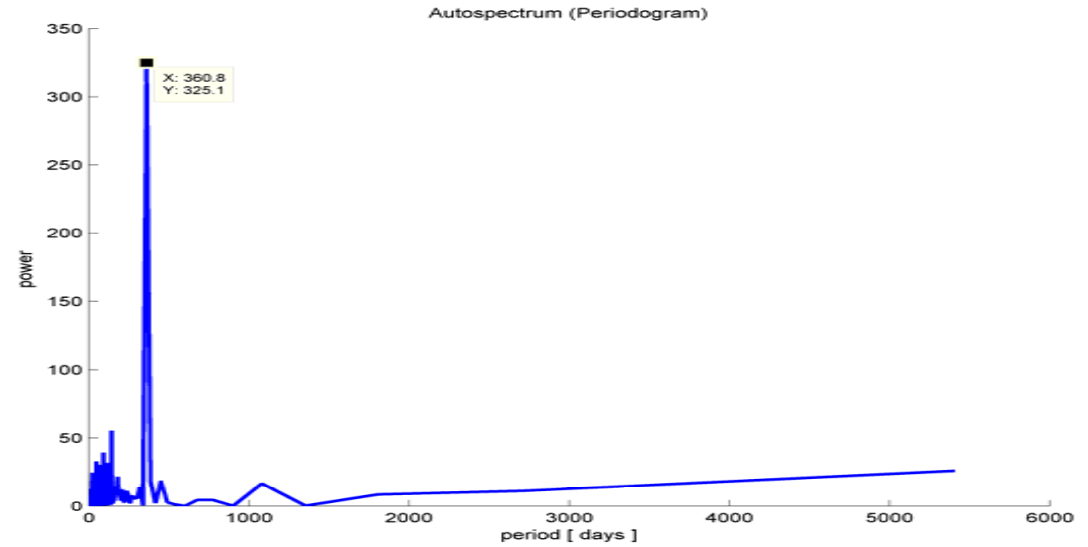
$$X_t = \sum_{p=1}^k R_p \cos(\omega_p t + \Phi_p) + Z_t \quad (\omega_p = 2\pi f_p)$$

$$\cos(\omega t + \Phi) = \cos \omega t \cos \Phi - \sin \omega t \sin \Phi$$

$$(a_p = R_p \cos \Phi_p, \quad b_p = R_p \sin \Phi_p)$$

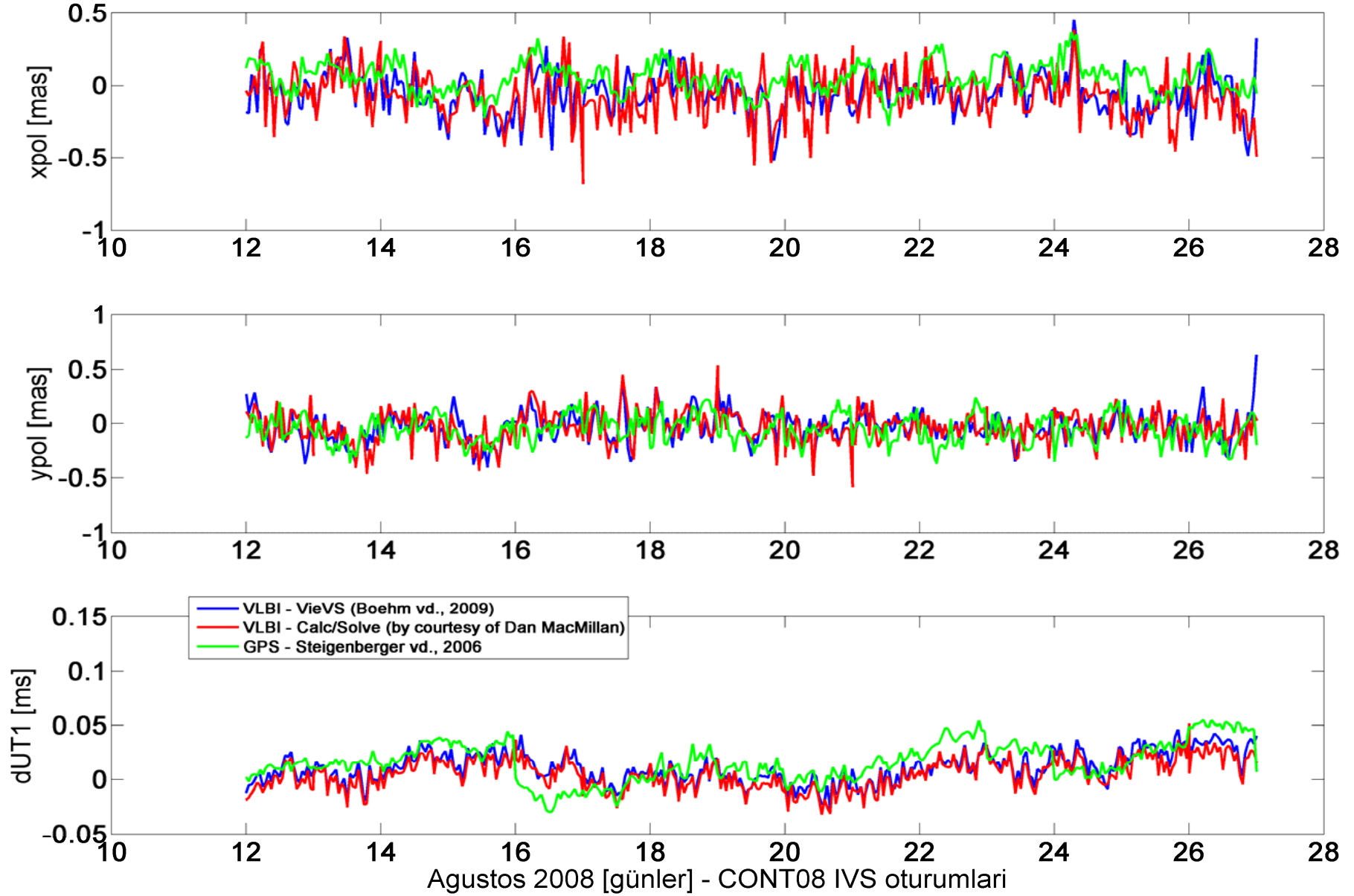
$$X_t = \sum_{p=1}^k (a_p \cos \omega_p t - b_p \sin \omega_p t) + Z_t$$

$$R_p = \sqrt{a_p^2 + b_p^2} \quad \Phi_p = \tan^{-1}(-b_p / a_p)$$



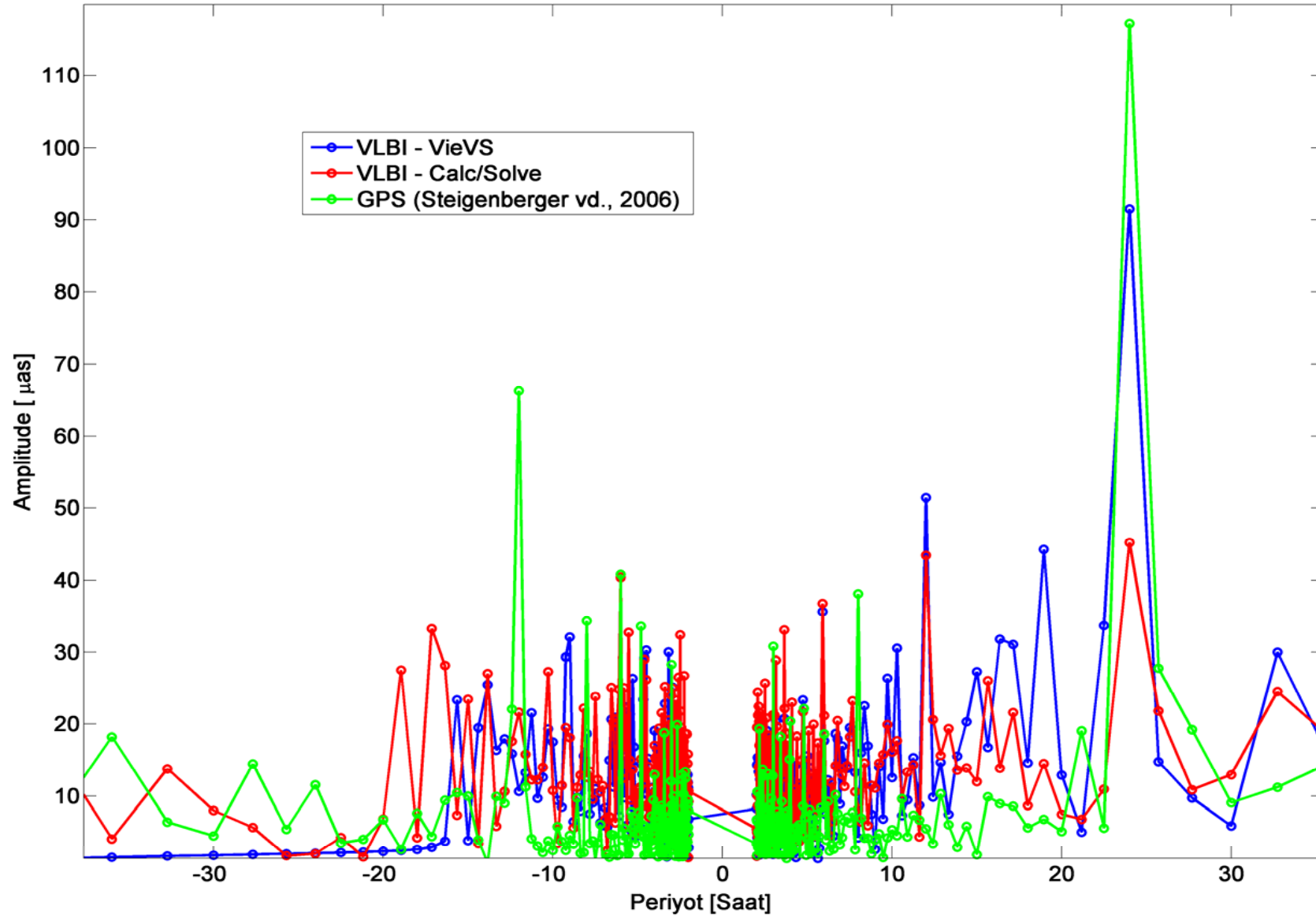
Tanir, vd., 2009

Yer dönme eksenini yüksek frekansli (60 dakika) kutup koordinatları zaman serisi



by courtesy of Tobias Nilsson and Lucia Plank

Yer dönme eksenini yüksek frekanslı (60 dakika) kutup koordinatları (X_{pol}, Y_{pol})
zaman serisi spektrasi



by courtesy of Tobias Nilsson and Lucia Plank

„KTU GEOD“ IVS ANALİZ MERKEZİ ÖNGÖRÜLEN FAALİYETLERİ

- 23 Mart 2009, Fransa'nın Bordo sehrinde alınan IVS yönetim kurulu kararı ile kuruldu.
- Öngörülen katkıları:
 - EVN ağı oturumlarının analizi, IVS-R1 ve -R4 oturumlarının analizi, CONT oturumlarının analizi, INT oturumlarının analizi.
 - Yazılım geliştirme çalışmalarları.
 - VLBI ve diğer uzay ve uydu jeodezik tekniklerden elde edilen parametrelerinin kestiriminde **stokastik modellerin kullanımı**.
 - Uydu ve uzay jeodezik tekniklerin **intra- ve inter-teknik kombinasyonu** ile ilgili algoritmaların geliştirilmesi.
 - Farklı VLBI Analiz Merkezleri tarafından elde edilen ürünlerin (istasyon koordinatları başta olmak üzere) üretilmesinde kullanılan **parametre kestirim yöntemlerinin kıyaslanması**,
 - IERS'in belirlediği **konvansiyonlara uyumun sağlanması**.

Sonucular

- IVS, başta IERS, ve IAU olmak üzere bir çok kurumsal yapıya, Yer ve uzay arařtırmalarına iliřkin bilim dallarına veri saęlar.
- Nutasyonu ve Yer ortalama dönme ekseninin inersiyal tabanlı bir referans sistemine (quasi-inersiyal: ICRF) baęlı mutlak dönüklüğünü (dUT1) doğrudan varsayimsız ölçebilen, CIP'nin ICRF'deki konumunu en duyarlı belirleyen ve ICRF'in oluşturulmasında ölçüleri (oturumları) analiz edilen tek uzay tabanlı konum belirleme sistemidir.
- IVS, VLBI2010 projesi kapsamında IAG'in Küresel Jeodezik Gözlem Sistemi (Global Geodetic Observing System, GGOS) gerçekleştirme projesinin öngördüğü hedeflere ulaşmak amacı ile radyo teleskoplarından, analiz yazılımlarına kadar tüm alt yapısını güncellemektedir.
- Viyana Teknik Üniversitesi, Jeodezi ve Jeofizik Enstitüsü, IVS analiz merkezi bu bağlamda simülasyon ve yazılım geliştirme çalışmalarını başarı ile yürütmektedir.
- EVN ölçülerinin analizleri, intra- ve inter-teknik kombinasyonlar ve yazılım geliştirme çalışmalarına hizmet etmek üzere, KTU, Harita Mühendisliği Bölümü bünyesinde yeni bir analiz merkezi kurulması önerisi, IVS Yönetim Kurulunun 23 Mart 2009 tarihinde Fransa'nın Bordo şehrindeki toplantısında oy birliği ile kabul edilmiştir.
- Bu bağlamda yapılacak olan çalışmalar yeni oluşturulacak IERS ürünlerine (ICRF, ITRF, EOP vd.) doğrudan katkı sağlayacaktır.

Dinlediginiz icin tesekkür ederiz.

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Bu calismada kullanilan ham verileri saglayan IVS'e tesekkür ederiz.