VLBI Scale Effects

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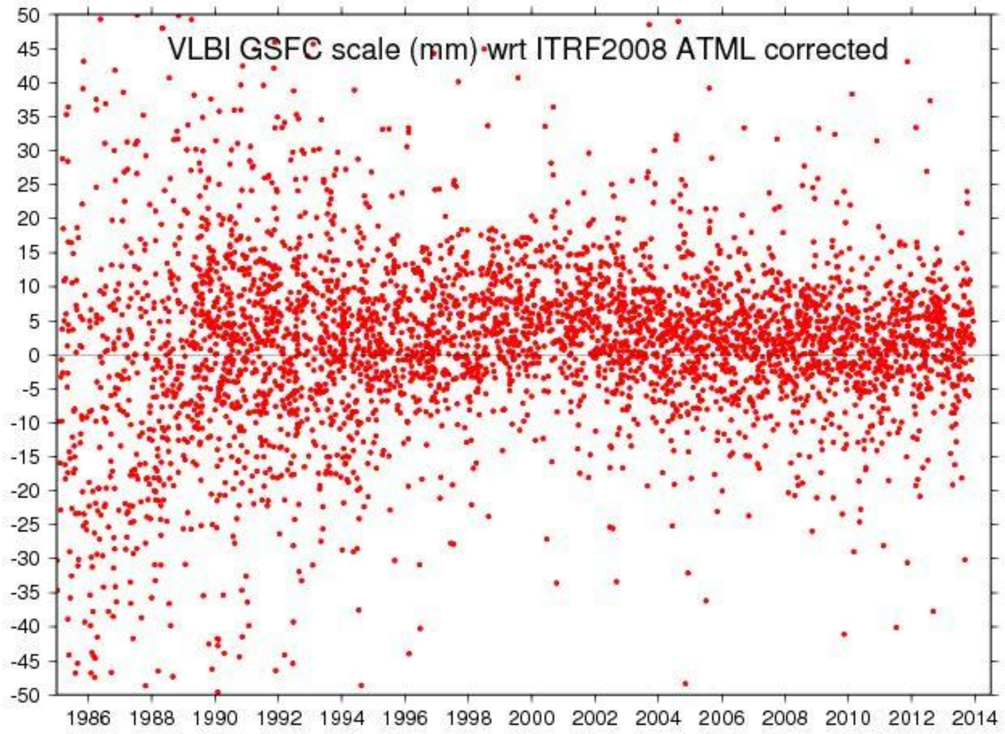
Overview

Systematic Errors Contributing to VLBI Scale

- Pressure loading and hydrology loading
- Antenna gravitational deformation
- Atmospheric delay modeling
- Radio source structure

VLBI Scale Series



VLBI daily series relative to ITRF2008

GSFC2011b sinex

weighted mean difference =1.98 mm (0.33 ppb)

(from Z. Altamimi)

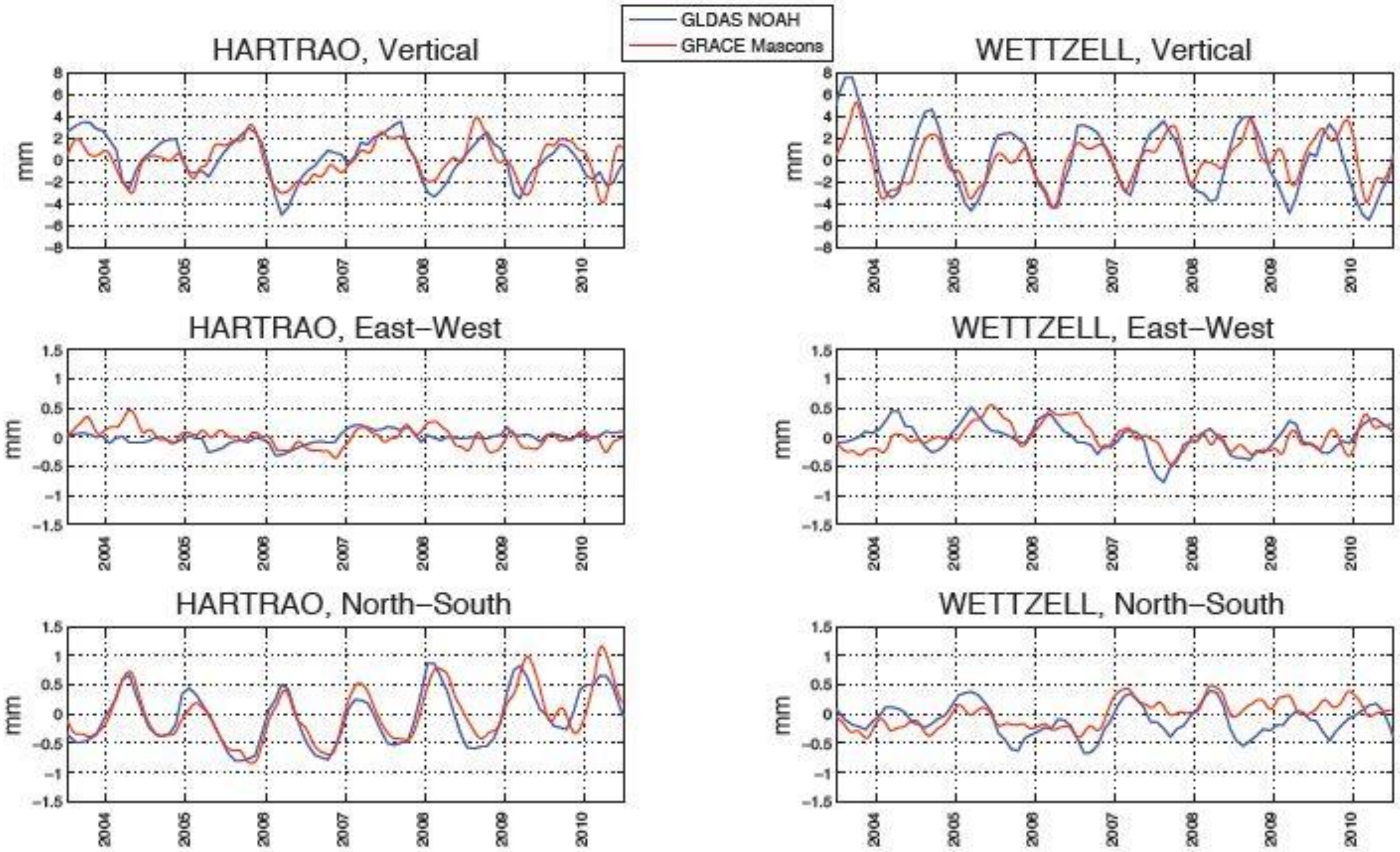
ITRF2008 paper:

(1980-2008 data)

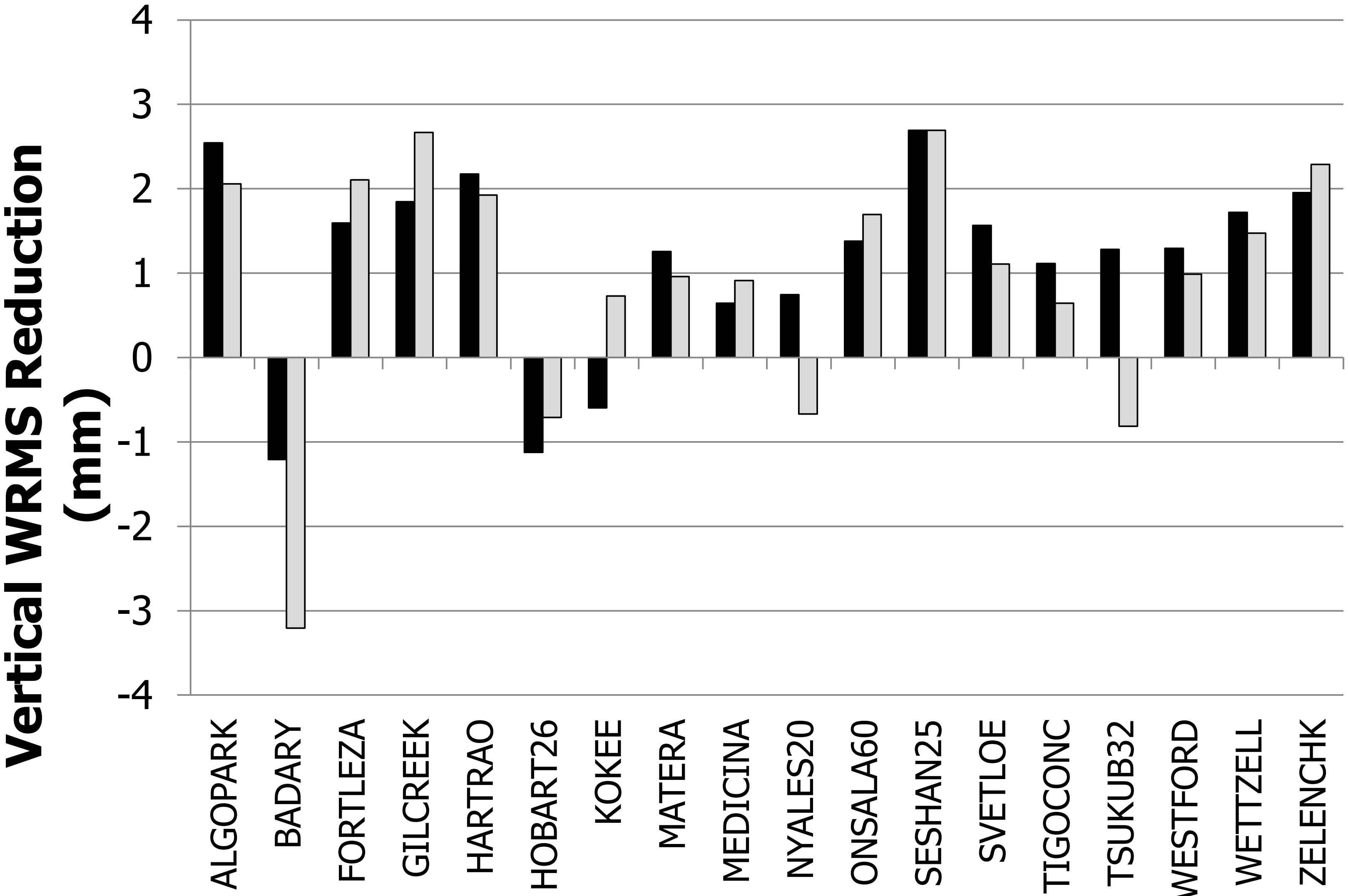
(Altamimi et al.)

=> 0.53±0.10 ppb

Hydrology Loading



Hydrology Loading



Loading

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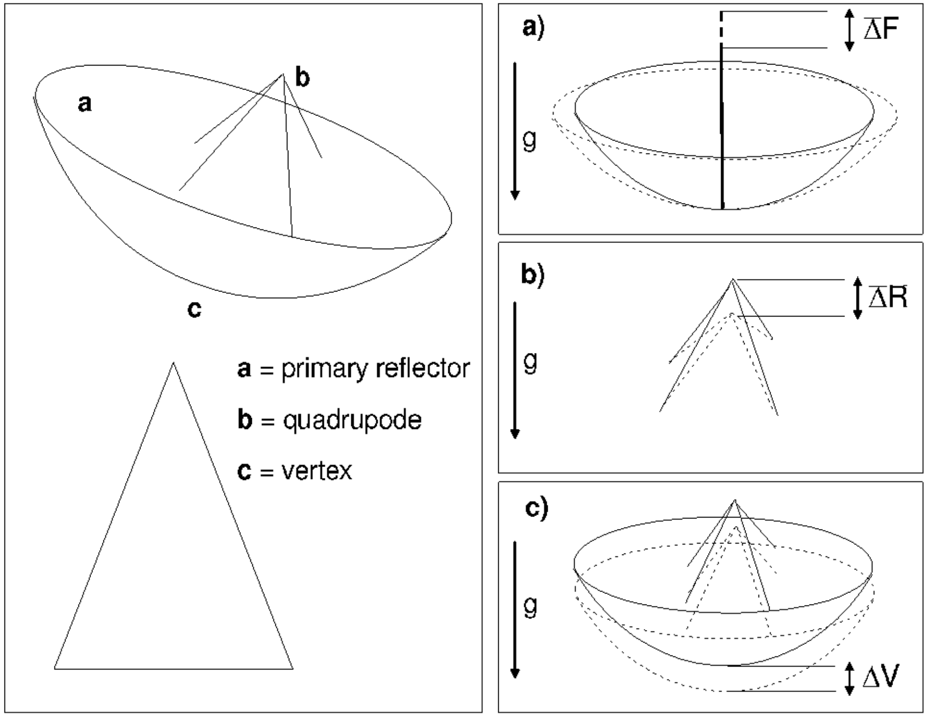
			Annual	
	Offset ppb	Rate ppb/yr	Cosine ppb	Sine ppb
No Loading	0.44 ±0.03	0.005 ±0.003	-0.15 ±0.02	-0.29 ±0.02
Atmos Loading	0.44	0.001	-0.19	-0.32
Atmos+Hydro Loading	0.30	-0.007	-0.03	-0.01

Estimates are relative to ITRF2008. Data period 1980-2008.

Gravitational Deformation



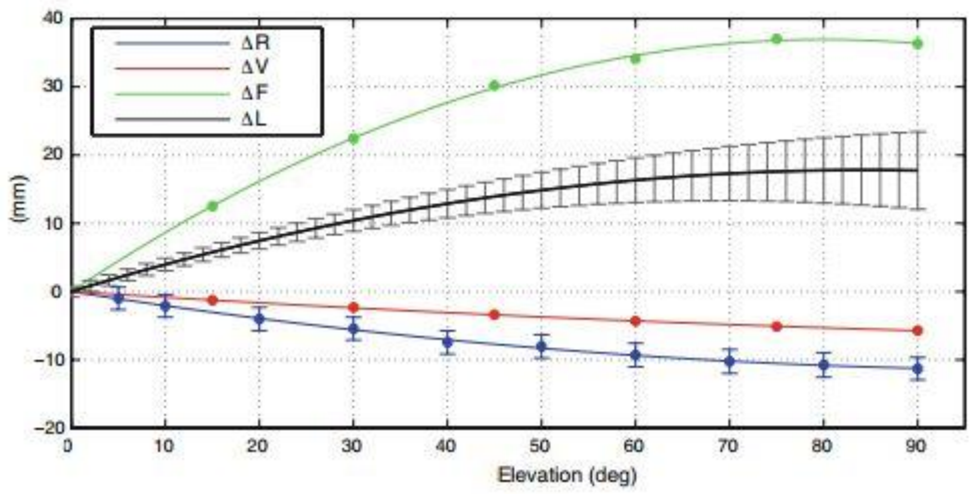
Clark and Thomsen (1988) model for signal path delay depends on variations of

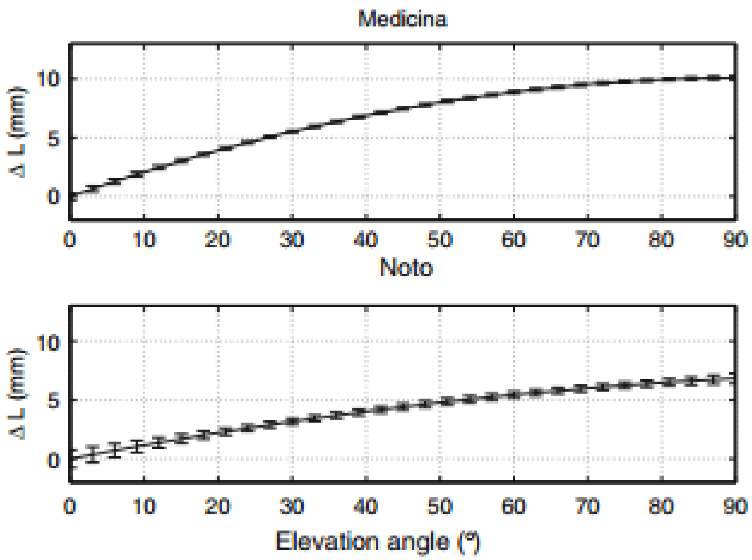
1) focal length
2) vertex position
3) receiver position

$$\Delta L(e) = \alpha_F \Delta F(e) + \alpha_V \Delta V(e) + 2\alpha_R \Delta R(e)$$

- Coefficients depend on dimensions and structure of antenna
- The functions F, V and R have to be measured for each antenna

Gravitational Deformation





- Measurements of Noto and Medicina (Sarti and Abondanza, 2009,2010) laser scanner (F)+ terrestrial survey (R)+ finite element model (V)

- Model of deformation from Clark and Thomsen (1988) XY mount antenna at Fairbanks (26 meter diameter)

$$\Delta L(e) = -\,2.4\,(1 - \sin(e)\,)\ \text{mm}$$

Gravitational Deformation

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	Offset ppb	Rate ppb/yr
No Model	0.44 ± 0.03	0.005 ± 0.003
Medicina Model	1.24	0.014
Noto Model	0.89	0.011
Fairbanks Model	0.75	0.01

- Scaled each model delay (~ $Diam^2$) to the antenna diameter of each antenna in the solution.

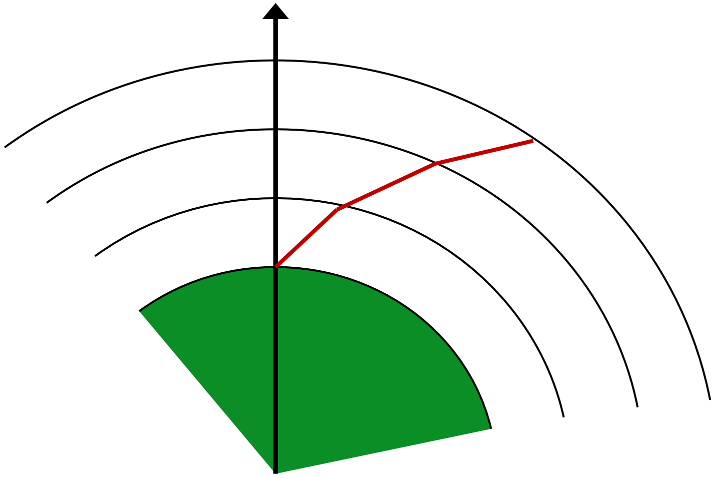
- Estimates are relative to ITRF2008. Data period 1980-2008.

Troposphere Raytracing

- Compute total (dry+wet) delays and wet mapping function from numerical weather model for each VLBI observation

- Weather model is the NASA/GSFC GEOS 5.9.1
  - parameters: pressure, temperature, specific humidity, geopotential height
  - time resolution: 3 hours
  - horizontal resolution: 0.5º x 0.625º (~ 50 km)
  - vertical resolution: 72 levels

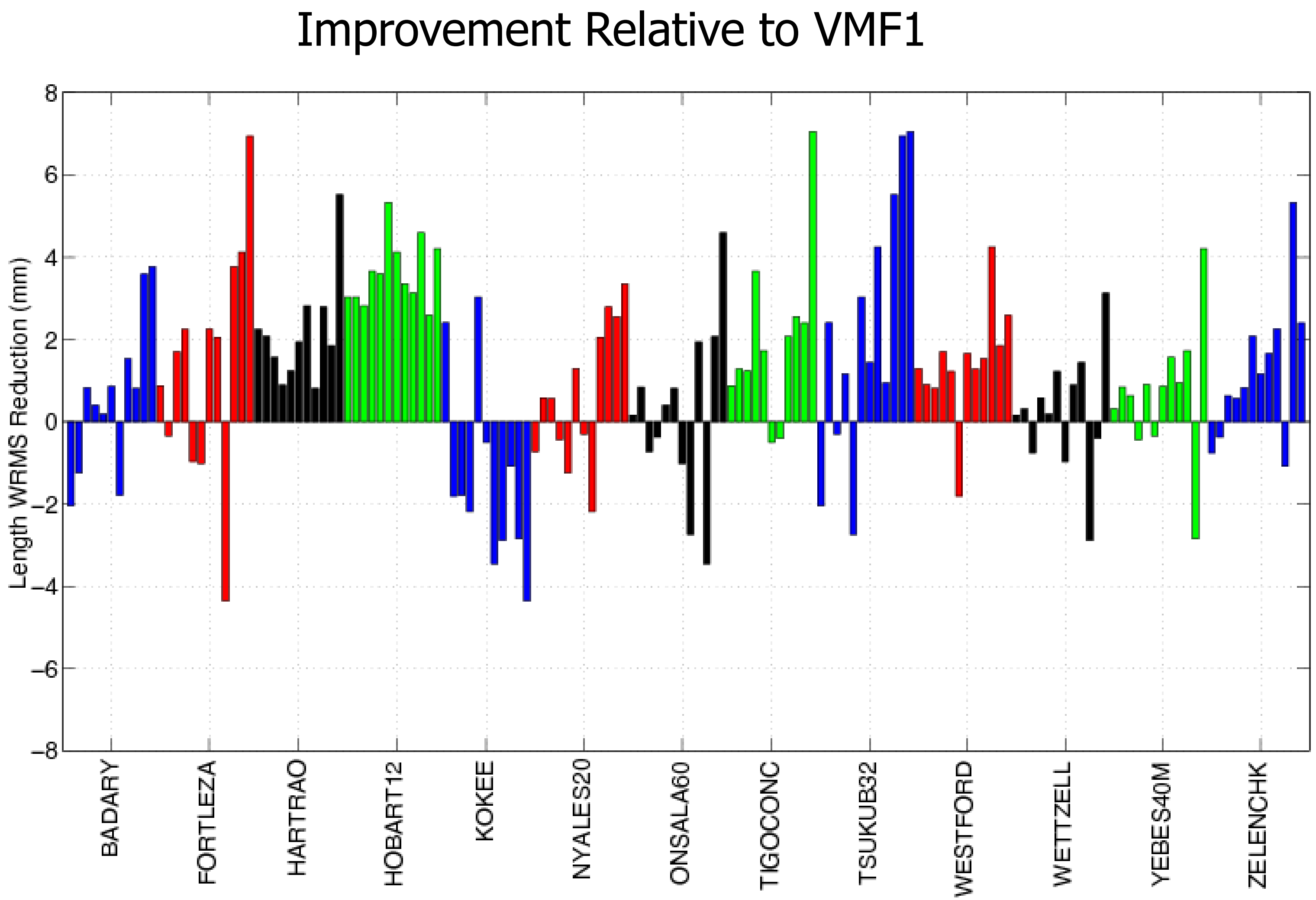
- Refractivity along raypath is determined by interpolation of the 4D refractivity field



- Use piecewise linear approach to compute raytraced delays

- Constrain propagation of the ray to a plane of constant azimuth (to minimize computation time)

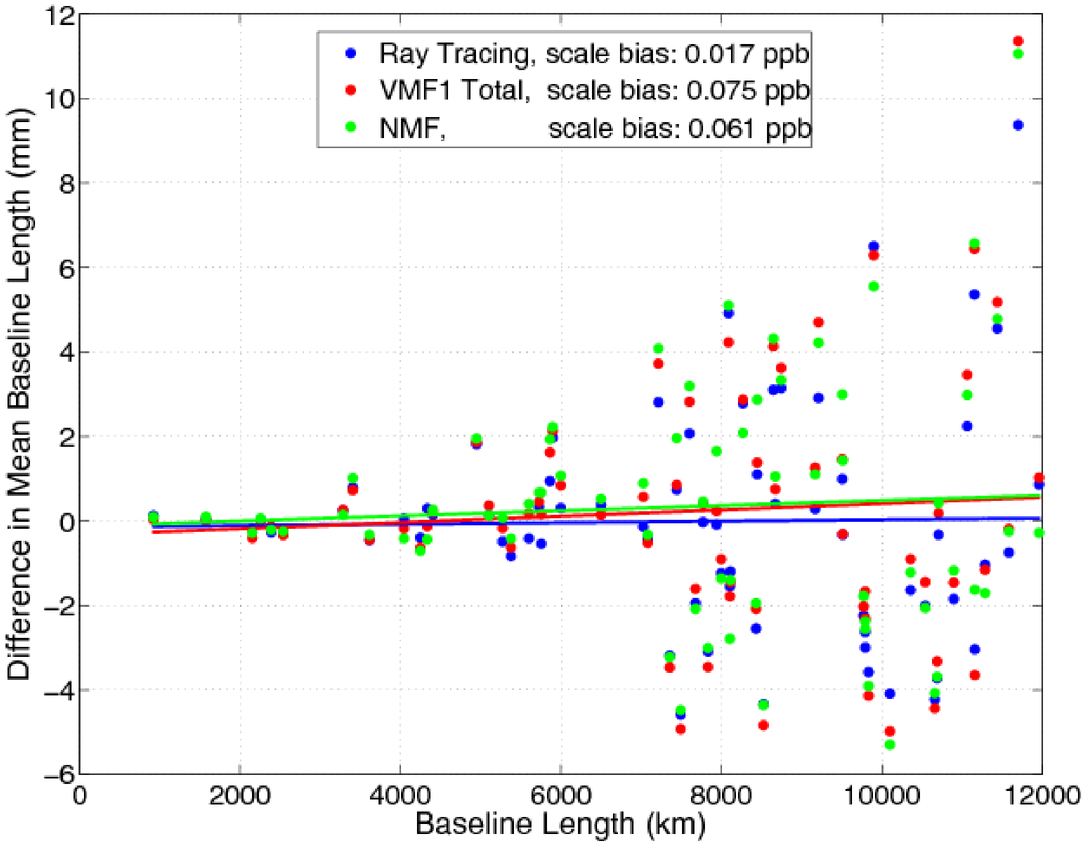
CONT11 Baseline Lengths



- Ordered by baseline length for each site

Troposphere Scale Bias Error

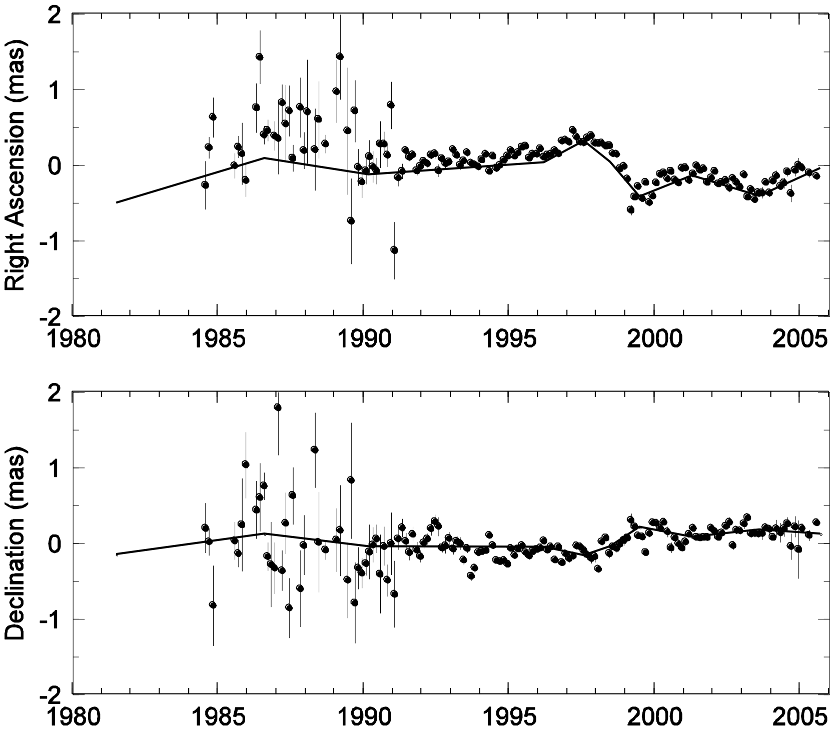
Elevation cutoff test: Difference 5º and 12º solutions CONT11 (2011)
=> measure of atmosphere model error



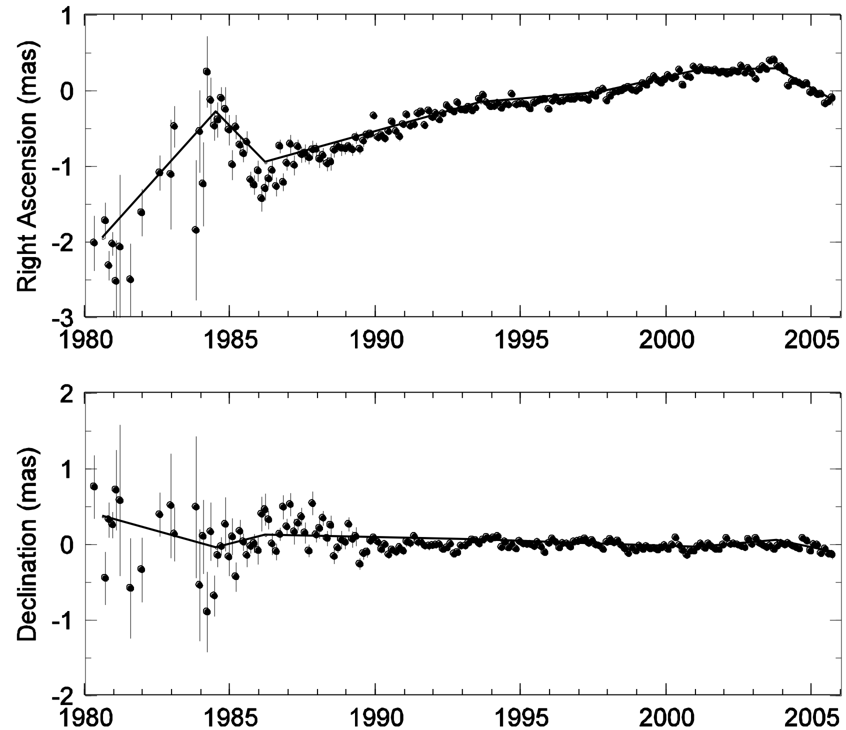
Raytrace: 0.017 ppb VMF1: 0.075 ppb NMF: 0.061 ppb

Radio Source Instability

- Radio source position estimates can have large rates or even nonlinear variation
  - Identified sources with unstable position time series from among the most frequently observed (geodetic) sources



Radio source 2145+067



Radio source 4C39.25

Radio Source Instability

- Modeled the position variation of unstable sources either by

(1) estimating global spline parameters to fit the variation

or (2) estimating positions for each 24-hour observing session

Effect of radio source instability =>

1) Spline	-0.02 ± 0.01 ppb	0.004 ± 0.002 ppb/yr
2) Local	-0.02 ± 0.02 ppb	0.008 ± 0.002 ppb/yr

Scale Error Budget

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Error Source	Annual Cos	Annual Sin	Rate ppb/yr	Bias ppb
Gravitational Deformation	--	--	−0.005 to −0.009	−0.78 to −0.31
Hyd Load	−0.16	−0.31	0.008	0.14
Atm Load	0.04	0.03	0.004	0
Atmosphere	--	--	0.010	0.08
Radio source	---	--	−0.006	0.02
ITRF2008	−0.16 ± 0.02	−0.30 ± 0.02	0.025 ± 0.010	0.53 ± 0.10