Recent Modeling Improvements in SOLVE Analysis

Dan MacMillan

John Gipson

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Overview

- Antenna Thermal Expansion

- Troposphere Modeling Improvement
  - Improved Mapping Functions
  - Correlated Noise

Antenna Thermal Expansion

- Model includes delay contributions arising from deformation of the antenna pillar and foundation, axis offset, vertex and subreflector heights.

- Nothnagel [2008] provides description of the model

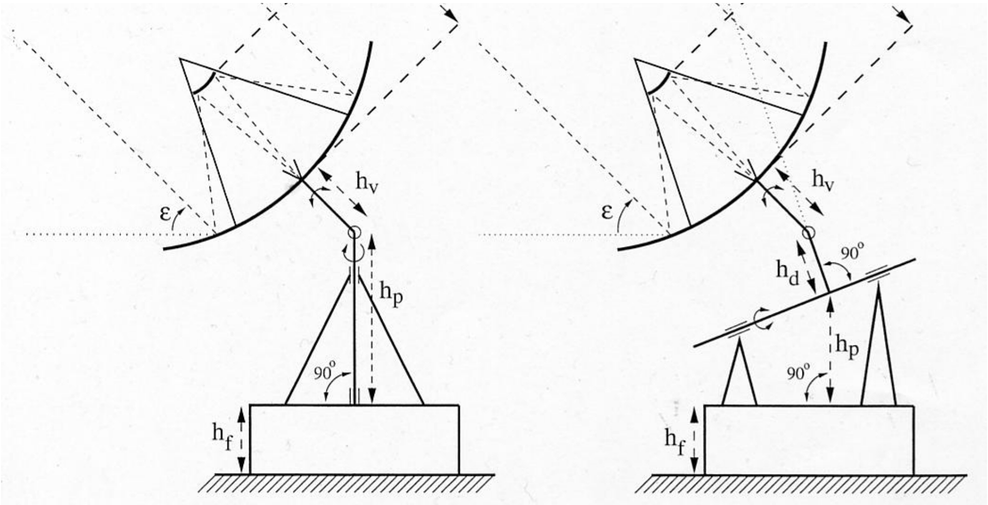


Figure 12: Left: Alt-azimuthal telescope mount. Right: Polar telescope mount.

Antenna Thermal Expansion

- Each structural component expands according to the simple model

$$\Delta = \gamma_{\exp} L(T(t - \Delta t) - T_{ref})$$

L is the dimension of a component

γ_{exp} is the expansion coefficient

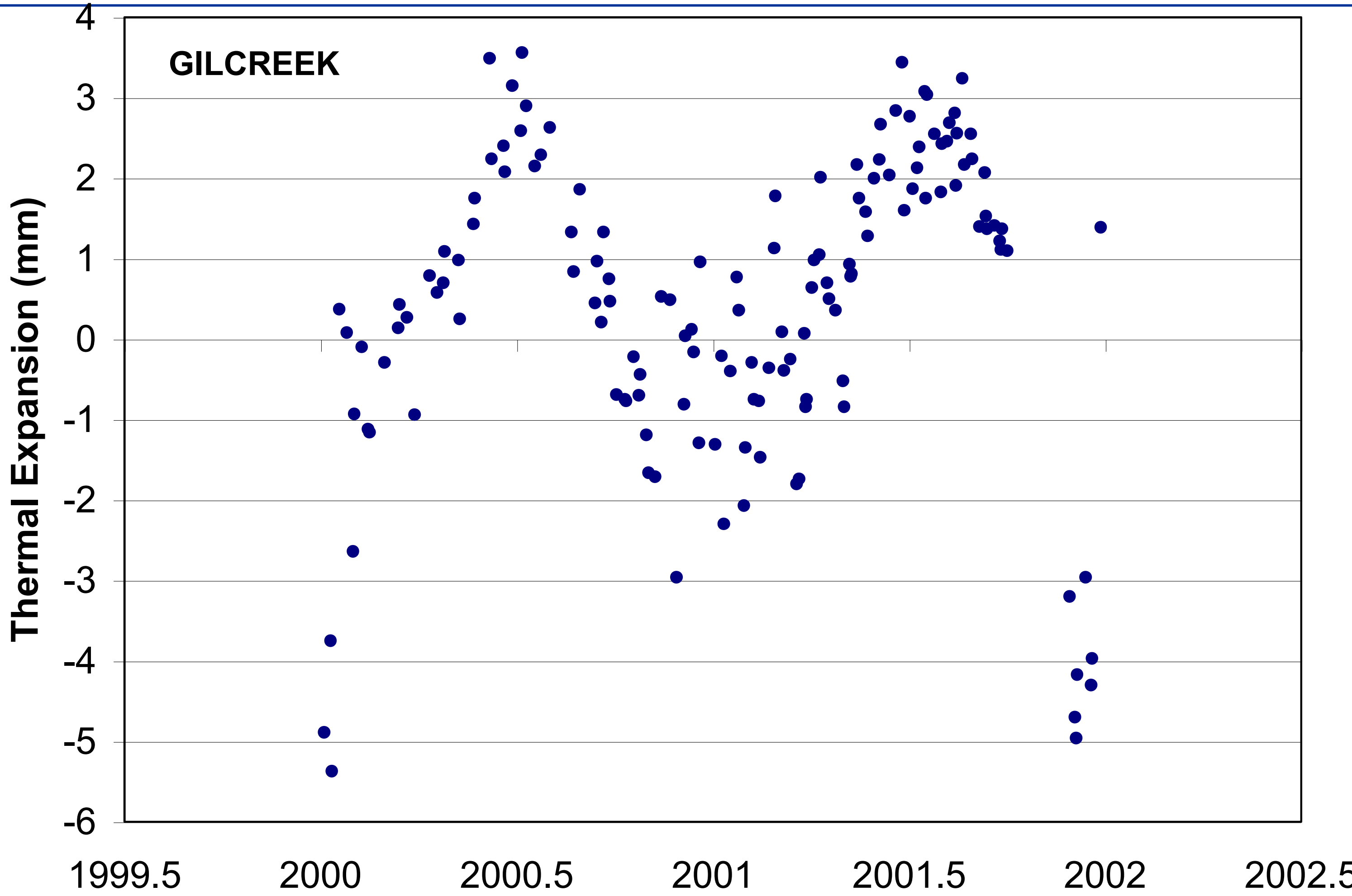
$T(t)$ is the component temperature

Δt is time lag

T_{ref} is the reference temperature

- The reference temperatures for each site are based on the global temperature and pressure model GPT [Boehm, 2007]

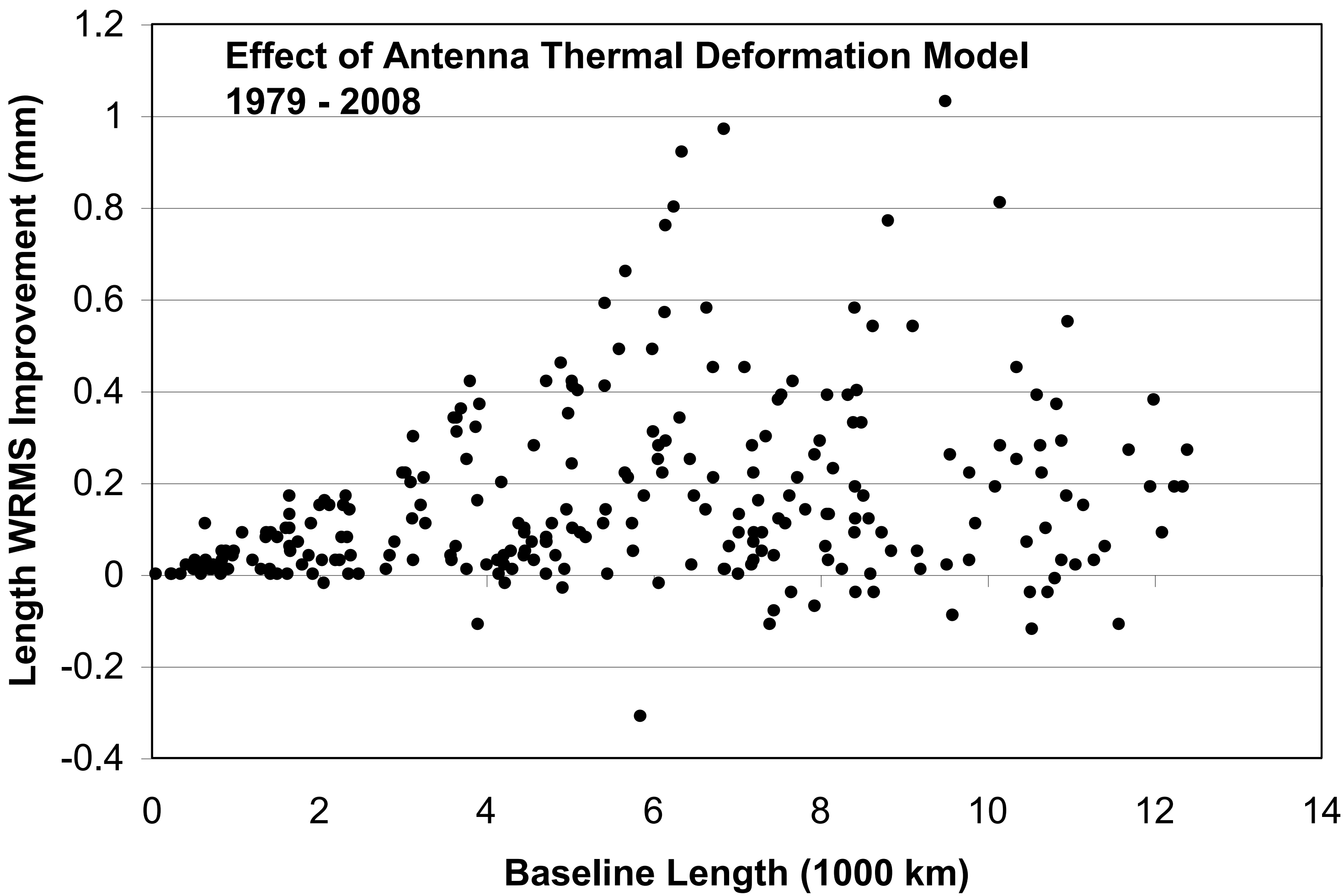
Thermal Expansion



antenna height ~ 15 m, annual temperature swing ~ 40 K,

expansion coefficient ~ 1.2x10-5   =>   peak-to-peak variation ~ 7 mm

Thermal Expansion



Antenna Thermal Expansion

Effect on TRF

	X	Y	Z
Translation mm mm/y	 0.22±0.05 0.018±0.003	 0.16±0.06 0.020±0.003	 -0.07±0.05 -0.017±0.003
Rotation mm mm/y	 0.06±0.07 0.007±0.004	 -0.15±0.06 -0.015±0.004	 -0.07±0.04 -0.005±0.003
Scale ppb ppb /y	 -0.013±0.007 -0.0001±0.0004		

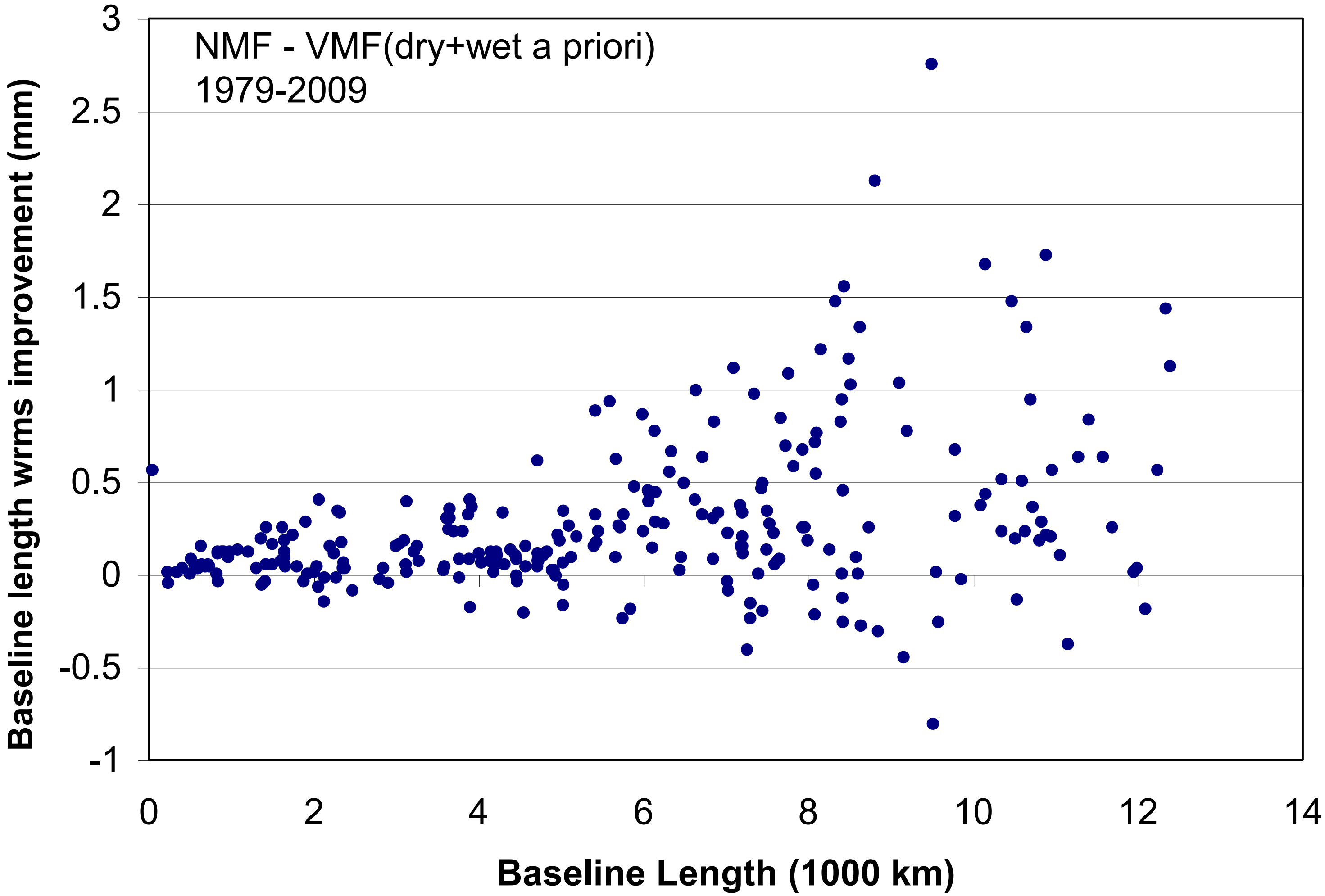
- Site positions and velocities change by less than 1-sigma
- The choice of reference temperature could bias position estimates

Troposphere Modeling

- NMF -> VMF
- Elevation-dependent weighting
- Correlated noise
- Slant-path delays

Troposphere Modeling

VMF vs. NMF



Troposphere Modeling

WRMS Differences between VLBI and IGS EOP

2000.0 - 2008.5

Parameter	WRMS NMF	WRMS VMF
X-pole (uas)	113.7	112.8
Y-Pole (uas)	110.5	108.9
X-pole rate (uas/d)	308.5	306.4
Y-pole rate (uas/d)	301.5	298.9
LOD (us/d)	19.5	19.4

TRF Differences between VMF and NMF

	X	Y	Z
Translation			
mm	0.71±0.35	0.21±0.36	-0.20±0.33
mm/y	0.01±0.01	-0.02±0.01	0.00±0.01
Rotation			
mm	0.06±0.44	-0.20±0.42	-0.00±0.31
mm/y	-0.02±0.02	-0.01±0.02	-0.00±0.01
Scale			
ppb	0.073±0.04		
ppb/y	-0.001±0.002		

Elevation Dependent Weighting

$$\sigma_{2}(el) = \sigma_{2} + \varepsilon^{2}_{2} + \varepsilon\, m(el_1)]^2 + \varepsilon\, m(el_2)]^2$$

- Standard processing adds only the baseline reweighting term

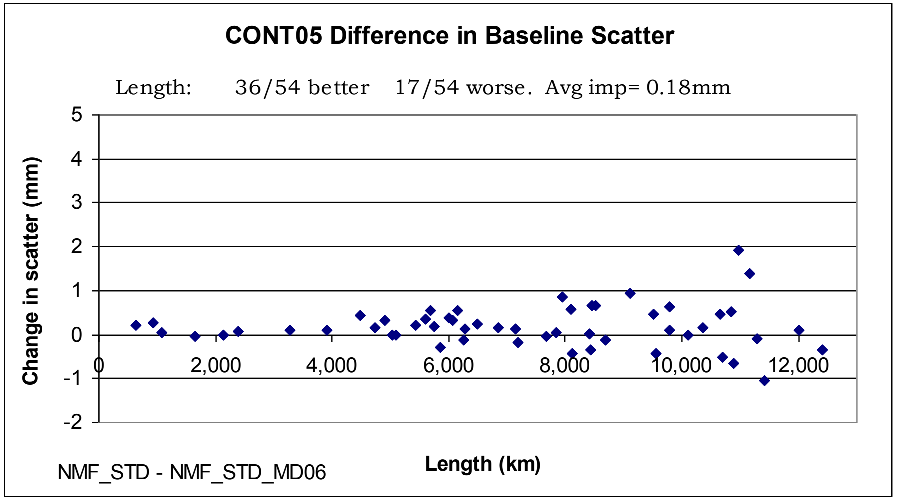
=> experiment session chi2 ~ 1

=> chi2 of estimated baseline length or position time series

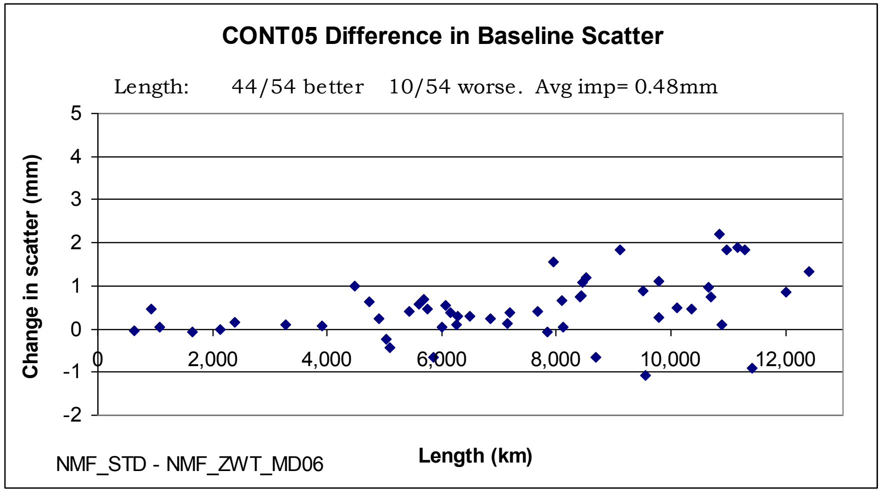
~ 2-6 for 7-8 site R1/R4s and ~ 4-20 for 18-20 site RDVs

- Introducing elevation-dependent noise accounts for troposphere mismodeling at low elevations

Troposphere Modeling NMF



=> Adding elevation-dependent weighting (6 ps) to standard reweighting reduces length scatter



=> Keeping only the elevation-dependent weighting yields more improvement

Correlated Noise

Site-dependent troposphere modeling error produces correlation between observations involving the same site

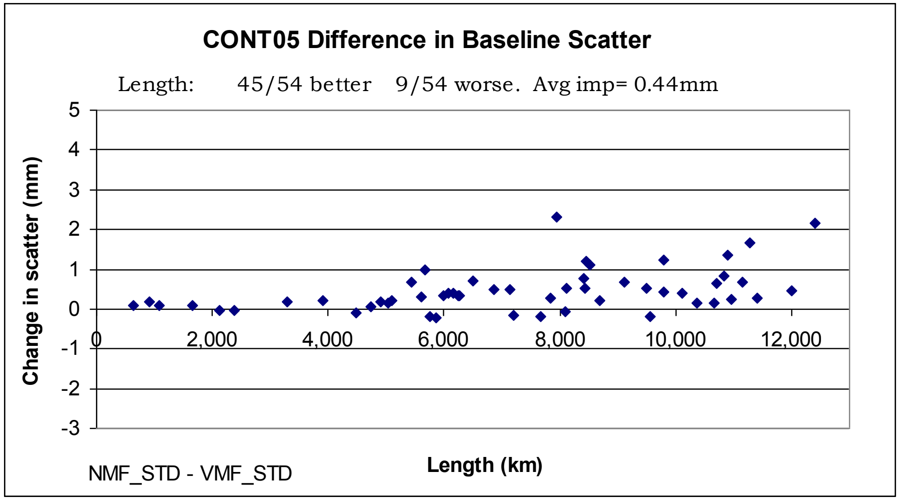
For example, 2 observations at the same epoch that are common to site 1

$$\sigma_{12}^2(el) = \sigma_{12}^2 + \varepsilon_{12}^2 + [\varepsilon_1 m(el_1)]^2 + [\varepsilon_2 m(el_2)]^2$$

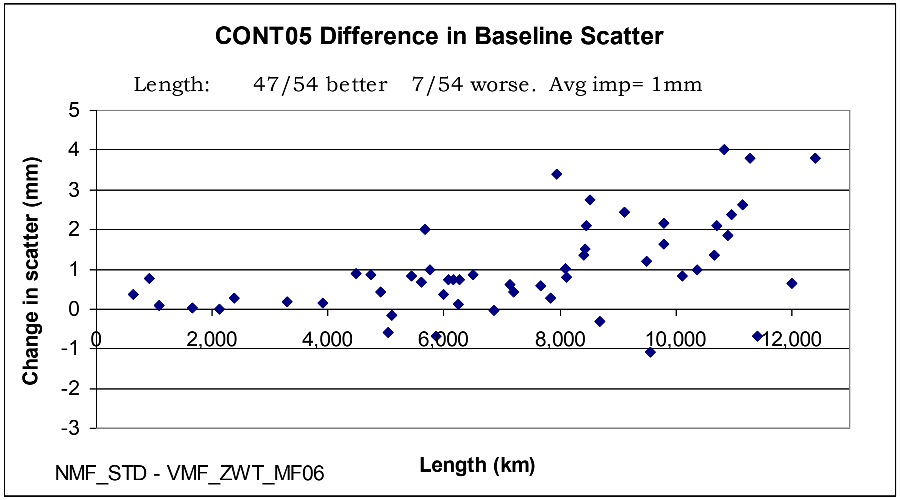
$$\sigma_{13}^2(el) = \sigma_{13}^2 + \varepsilon_{13}^2 + [\varepsilon_1 m(el_1)]^2 + [\varepsilon_3 m(el_3)]^2$$

=> Based on CONT05 repeatability tests, the optimal average choice for the ε_i = 6 ps

Troposphere Modeling



=>VMF with standard weighting yields better repeatabilities than NMF

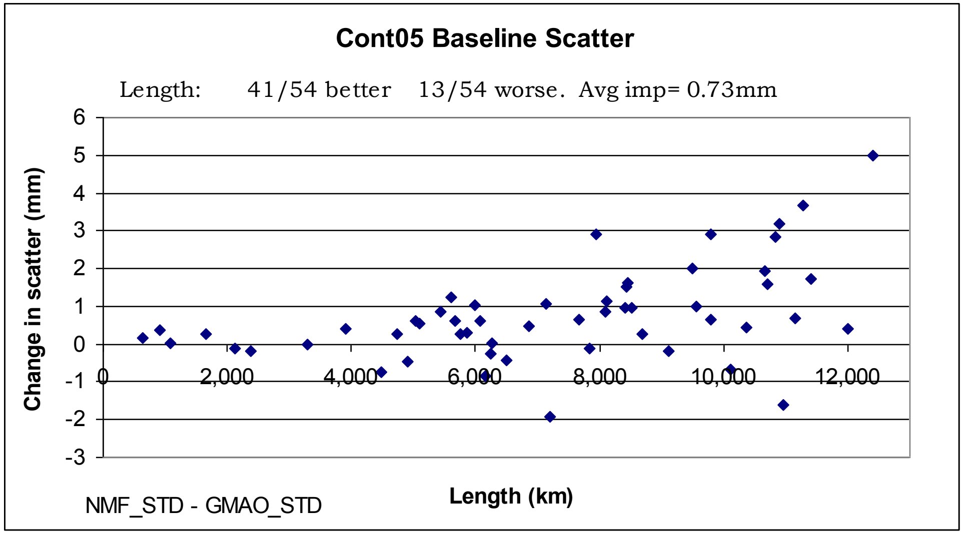


=>VMF with correlated noise and no standard reweights gives the best improvement

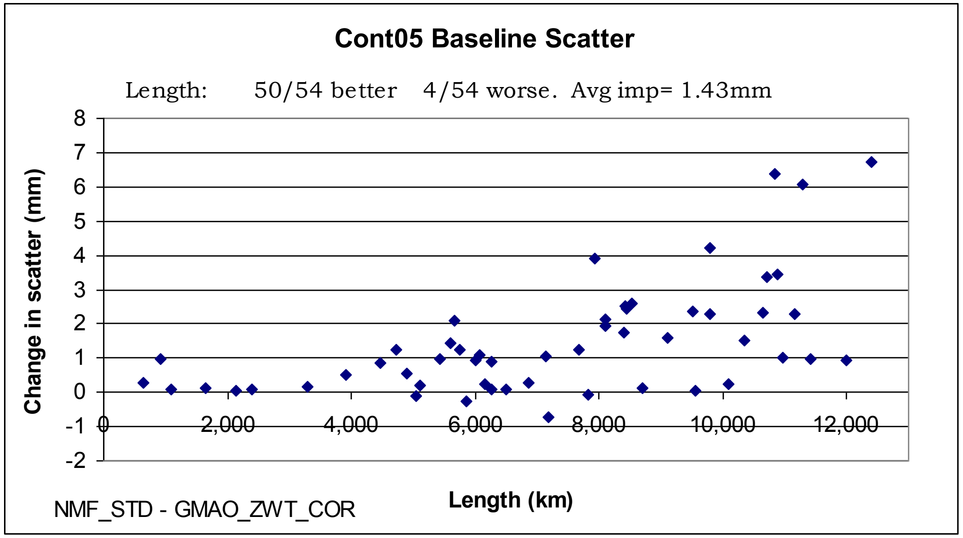
Slant Path Delay

- Previous approaches assume azimuthal independence of the refractivity field
- New approach [L. Petrov] computed the slant-path delay from 3D numerical weather models
- Results here used the GEOS-5 model from the NASA Goddard Modeling and Assimilation Office (GMAO)

Troposphere Modeling



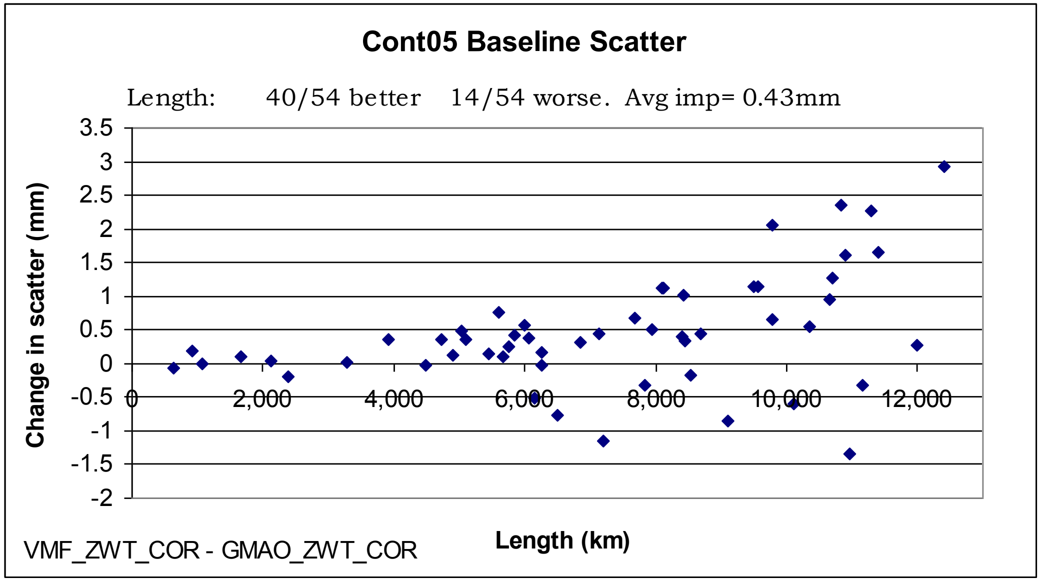
=>GMAO with standard weighting yields better repeatabilities than NMF



=>GMAO with correlated noise and no standard reweights gives the best improvement

Troposphere Modeling

VMF - GMAO



=> GMAO produces the best length repeatabilities

Conclusions

- Thermal deformation modeling accounts for seasonal temperature swings and removes up to 1 mm of baseline length scatter
- Thermal deformation does not significantly effect the TRF
- VMF reduces length scatter by up to 2 mm and produces a TRF scale difference of 0.07 ppb.
- Correlated noise + slant path delays each remove an additional scatter of ~ 2mm on the longest baselines