Simultaneous estimation of a TRF, a CRF and the EOP using VLBI

Volker Tesmer, Deutsches Geodätisches Forschungsinstitut

- solution setup

- comparison of DGFI05R02 TRF, CRF, EOP w.r.t. “IERS et al.”

- consistency analysis of “IERS et al.”

Solution description of DGFI05R02 (I)

- VLBI software OCCAM 6.1e

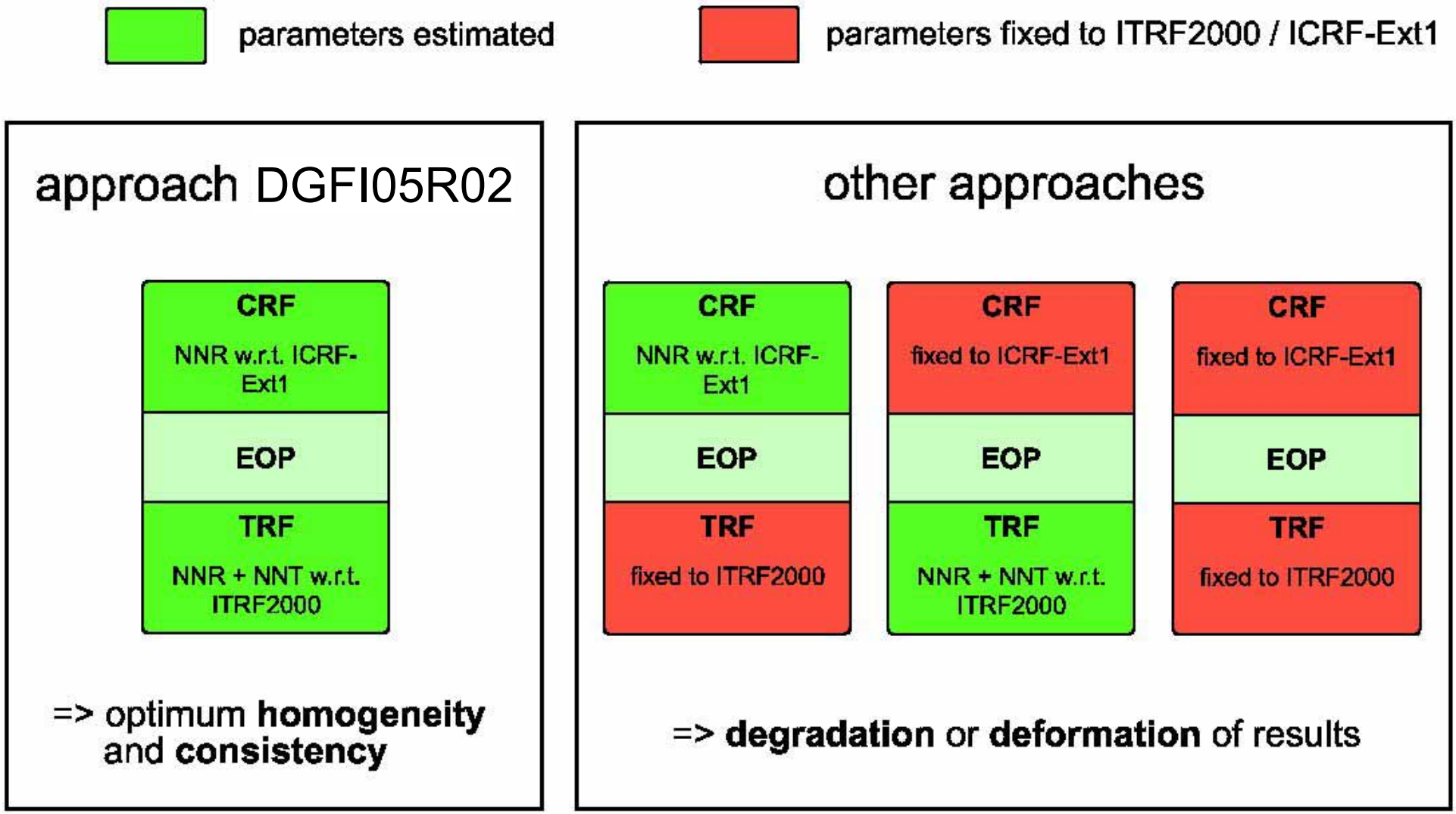
- 2699 daily sessions between 1984 and 2005

- 49 telescopes (45 in ITRF2000)
  1954 sources (561 in ICRF-Ext1 which includes 667)

- normal equations set up session-wise, accumulated to one large equation system with DOGS-CS

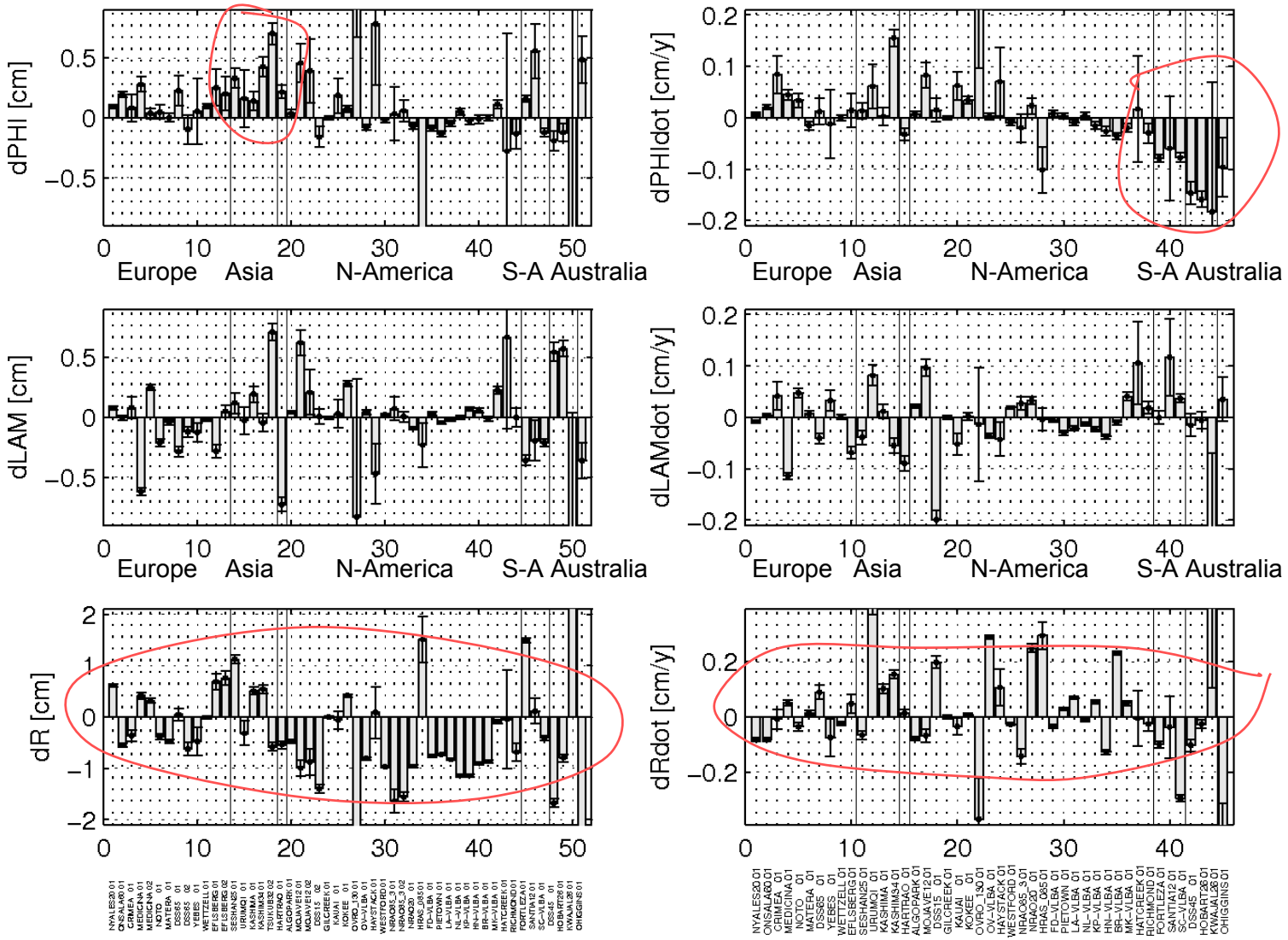
- NNT and NNR of 25 telescopes w.r.t. ITRF2000
  NNR of 199 stable *(Feissel, A&A, 2003)* sources w.r.t. ICRF-Ext1

Solution description of DGFI05R02 (II)



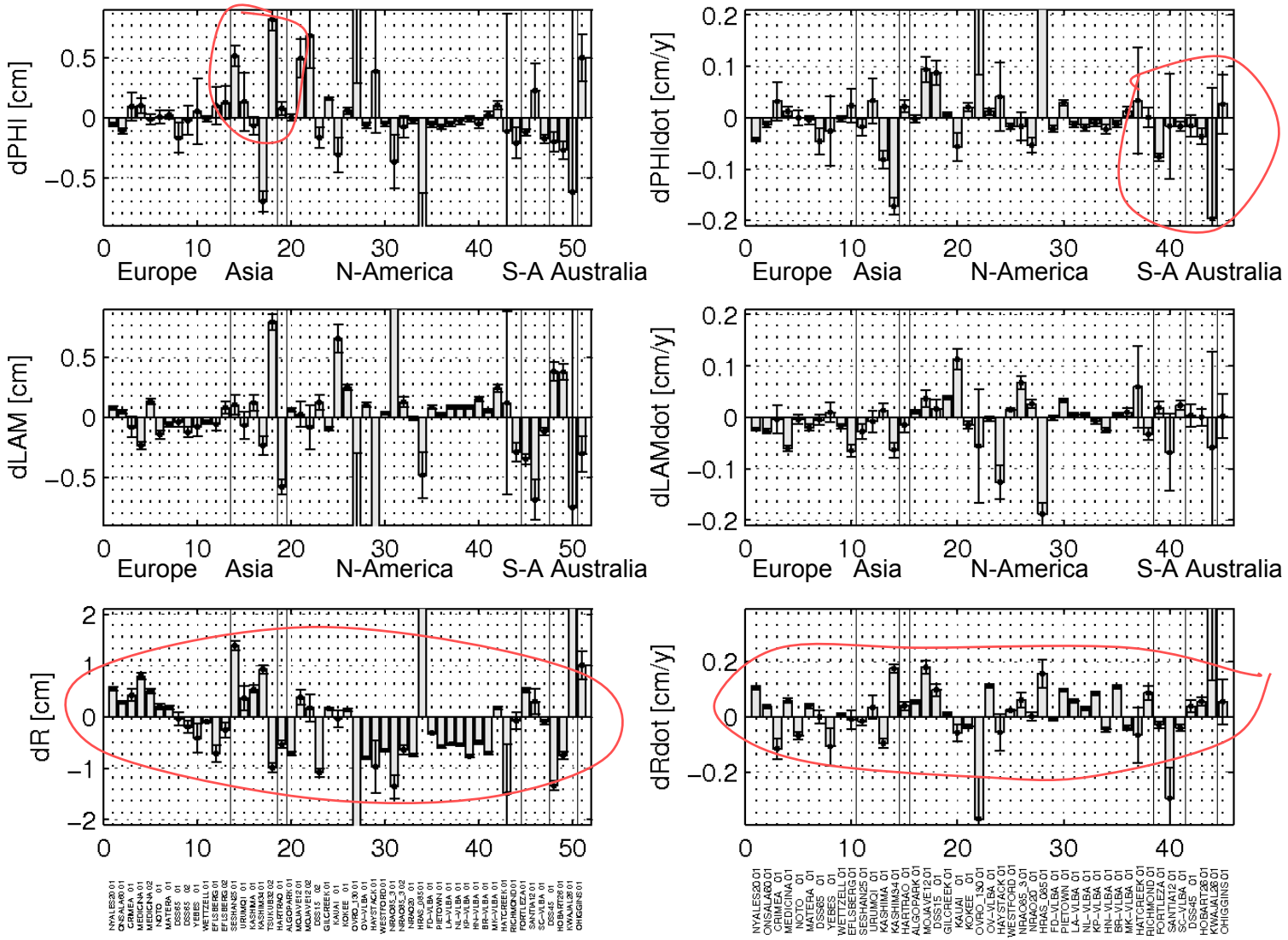
Comparison of DGFI05R02 TRF, CRF, EOP w.r.t. “IERS et al.”

DGFI05R02 TRF estimates w.r.t. ITRF2000



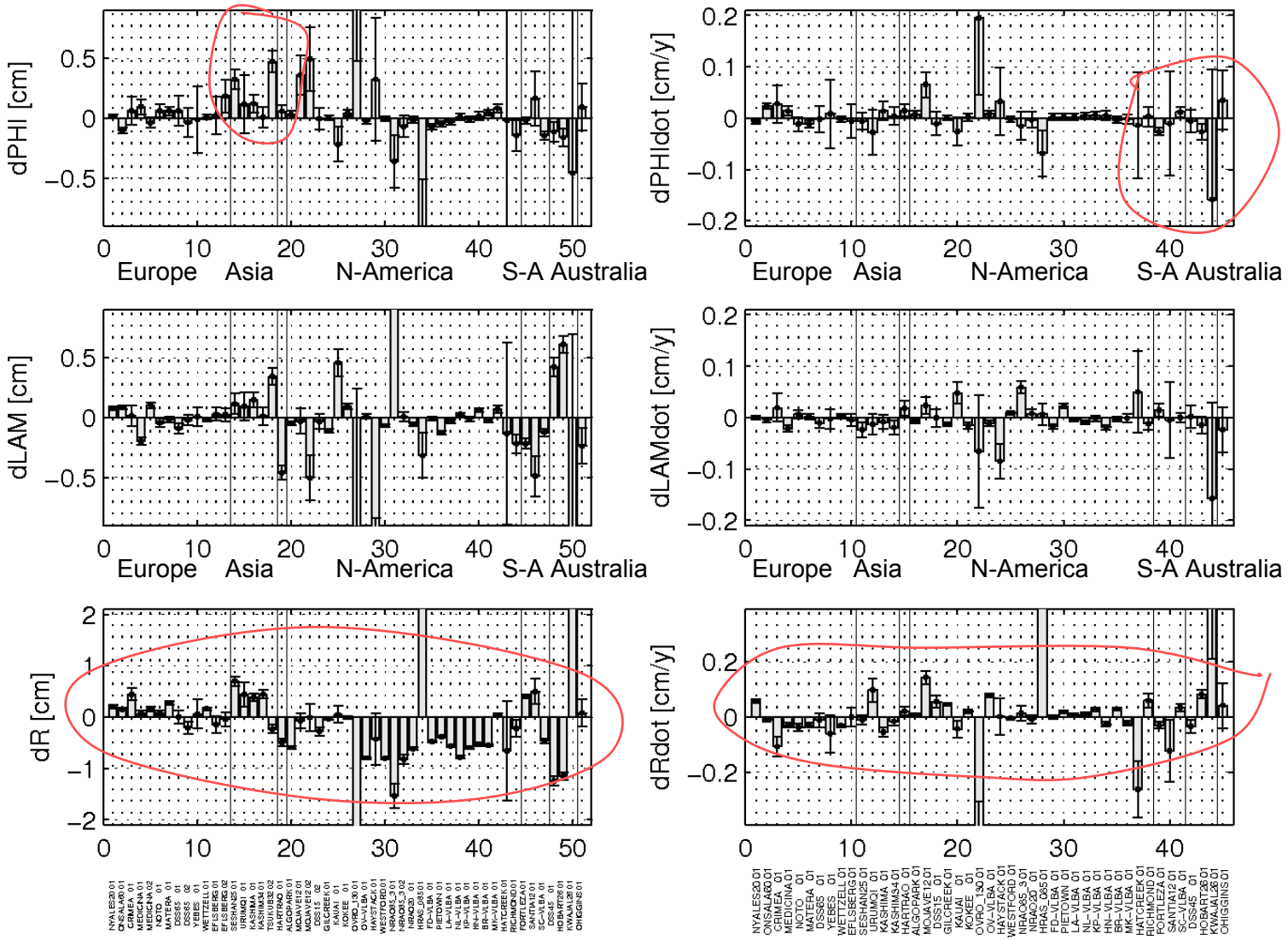
=> Some small systematics w.r.t. ITRF2000
(many solutions, GPS+SLR also, data until 00.0, OLD axis offets)

DGFI05R02 TRF estimates w.r.t. VTRF2003



=> Less systematics w.r.t. VTRF2003
(one solution only, VLBI only, data until 03.25, OLD axis offets)

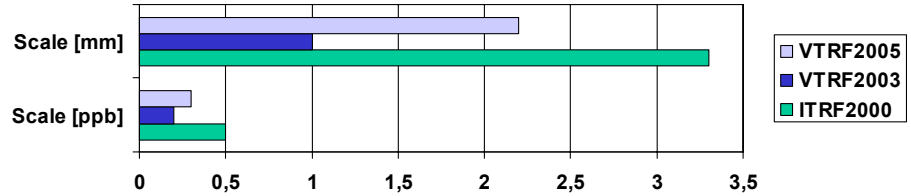
DGFI05R02 TRF estimates w.r.t. VTRF2005



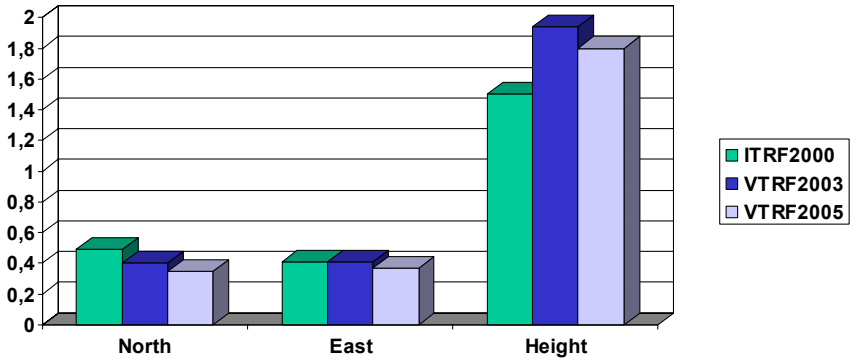
=> Even less systematics + scatter w.r.t. VTRF2005
(several solutions, VLBI only, data until 05.0, NEW axis offets)

DGFI05R02 TRF estimates summary

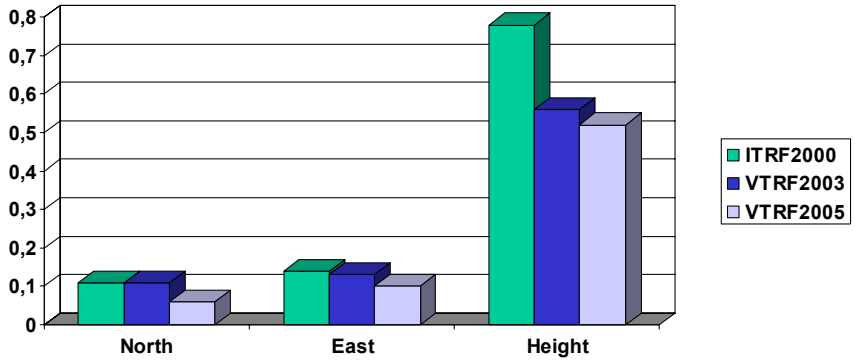
Scale differences w.r.t. DGFI05R02-TRF, 25 stations



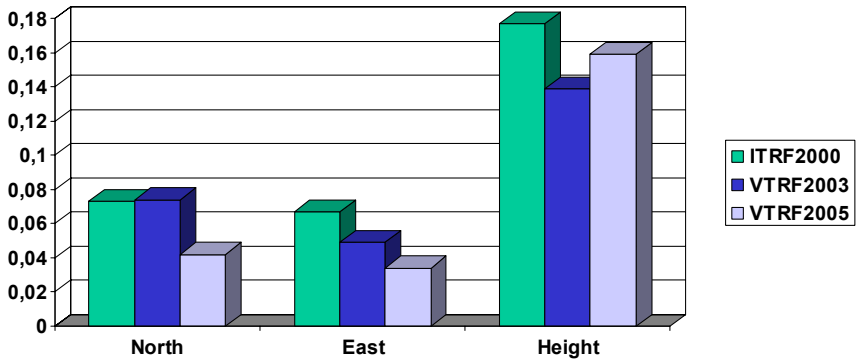
RMS [cm], 51 positions



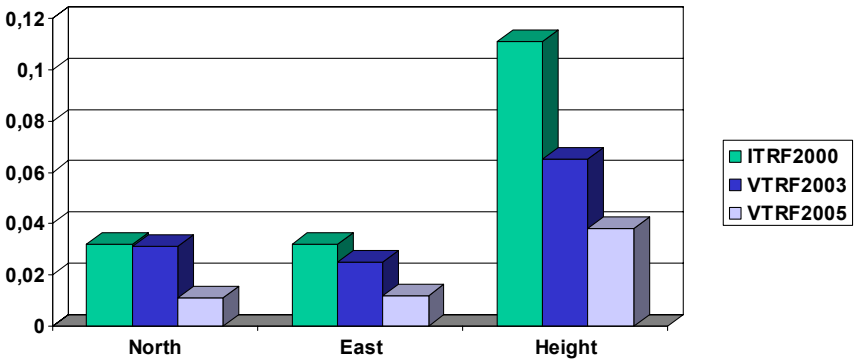
WRMS [cm], 51 positions



RMS [cm/y], 45 velocities



WRMS [cm/y], 45 velocities



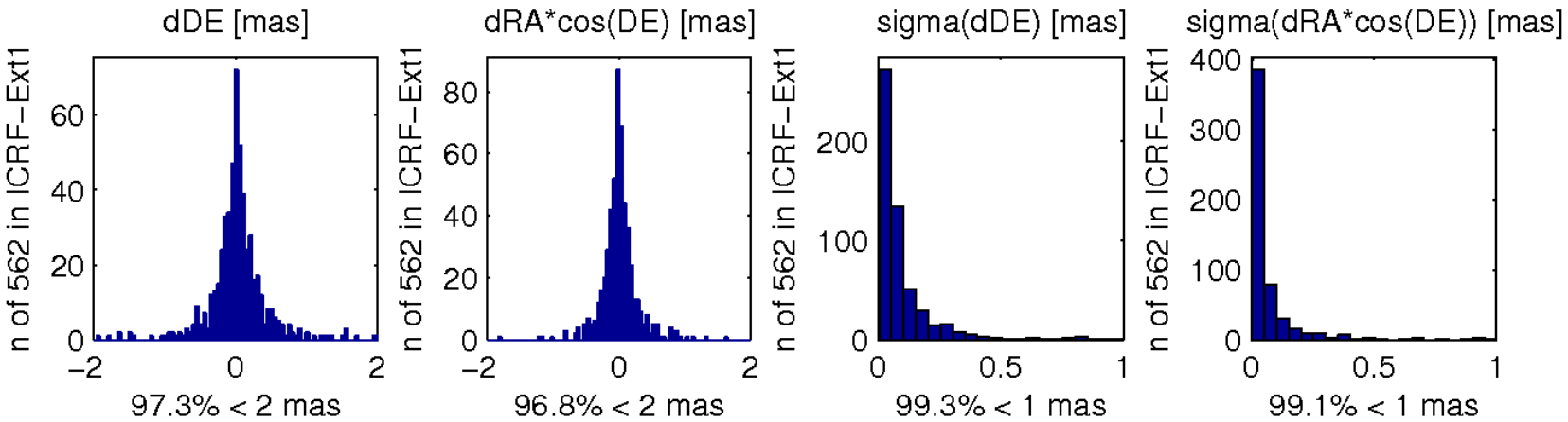
Reasons for differences:

- # contributing solutions (“averaging”)
- different techniques (pos+vel ties)
- amount / length of data
- systematic differences (axis offsets, troposphere…)

DGFI05R02 CRF estimates w.r.t. ICRF-Ext1

very inhomogeneously observed (1-2600 sessions with 4-233 avg obs)

differences of DGFI05R02-TRF w.r.t. ICRF-Ext1

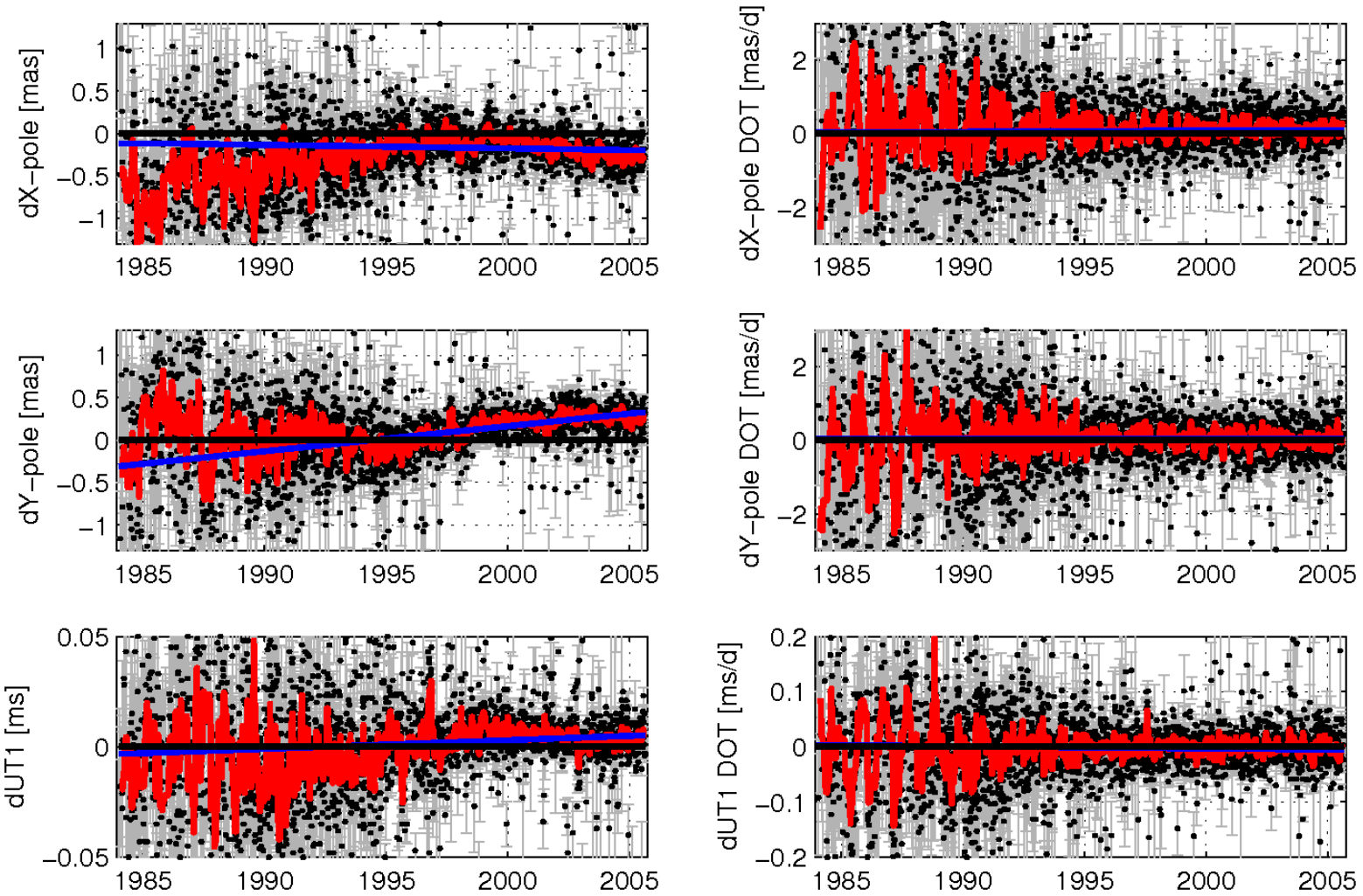


differences of DGFI05R02-TRF w.r.t. ICRF-Ext1

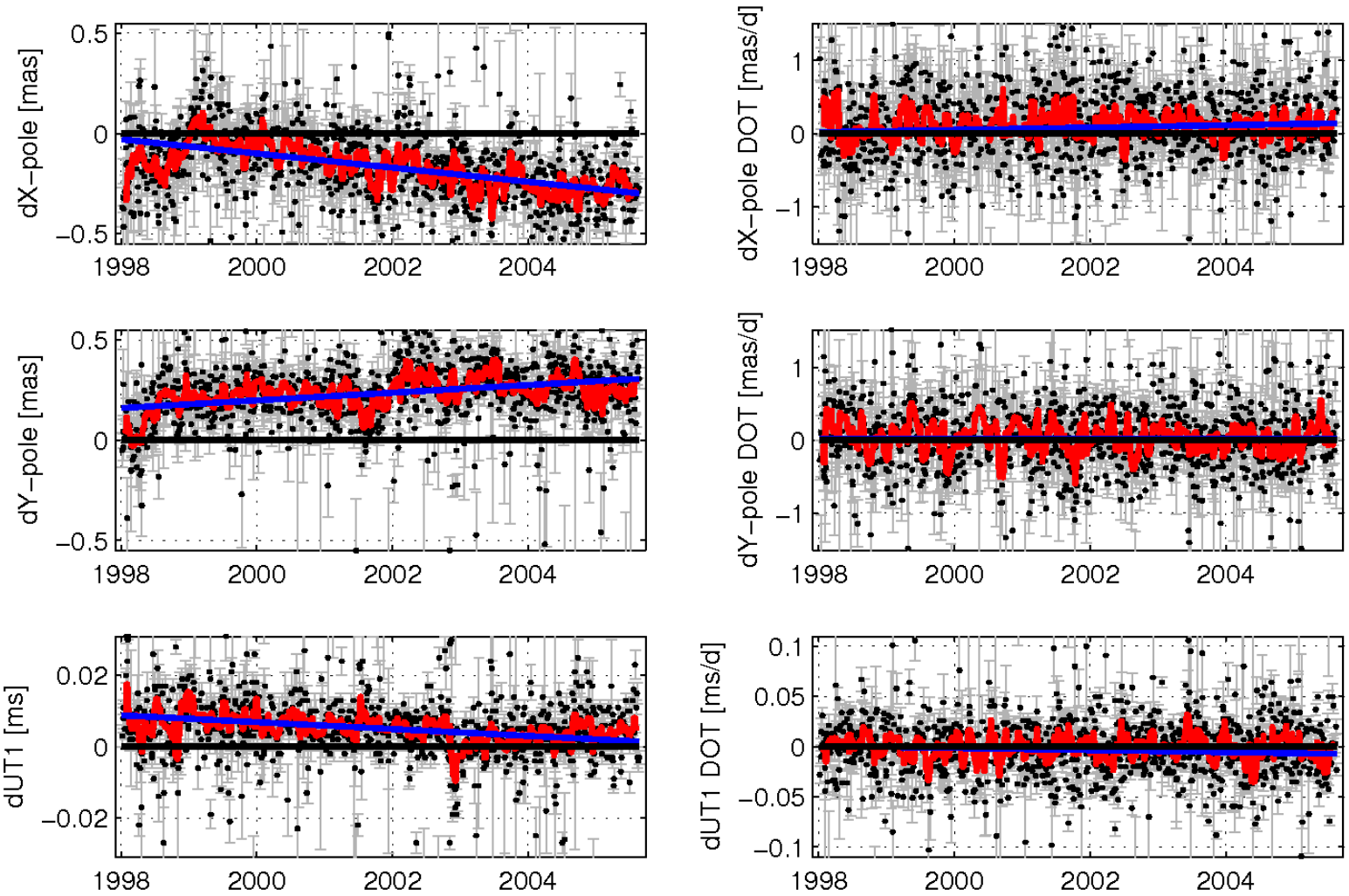
	dDE **199** stable	**dRA***cos(DE) **199** stable	**dDE** **562** sources	**dRA***cos(DE) **562** sources
RMS [mas]	0.237	0.143	1.178	1.377
WRMS [mas]	0.094	0.082	0.136	0.131

=> RMS/WRMS: formal errors reflect precision well

DGFI05R02 EOP estimates 84-05 w.r.t. IERS-C04 (I)



DGFI05R02 EOP estimates 98-05 w.r.t. IERS-C04 (II)



=> **Three problems become clear:**

- difficult to process series like C04 **homogeneously** (see e.g. IGS series)
- difficult to **reference** series like C04 to ITRF and ICRF
- **tilts** of techniques in ITRF2000? (ties: offsets / eq. vel.: rates)

Consistency analysis of “IERS et al.”

Consistency: solution approaches

parameters estimated

parameters fixed to ITRF2000 / ICRF-Ext1

approach DGFI05R02

CRF	EOP	TRF
NNR w.r.t. ICRF-Ext1		NNR + NNT w.r.t. ITRF2000

=> optimum **homogeneity** and **consistency**

other approaches

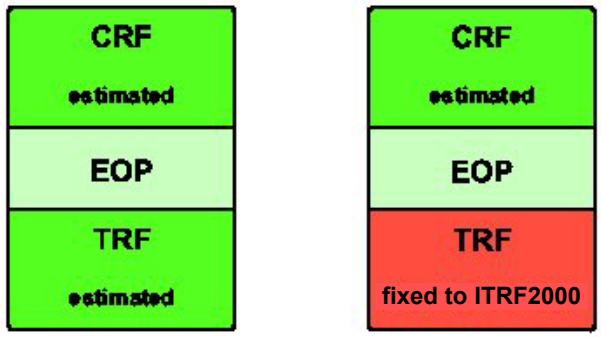
CRF	CRF	CRF
NNR w.r.t. ICRF-Ext1	fixed to ICRF-Ext1	fixed to ICRF-Ext1
EOP	EOP	EOP
TRF	TRF	TRF
fixed to ITRF2000	NNR + NNT w.r.t. ITRF2000	fixed to ITRF2000

=> **degradation** or **deformation** of results

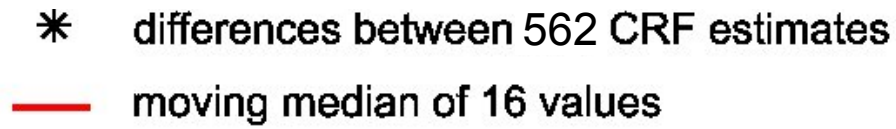
DGFI

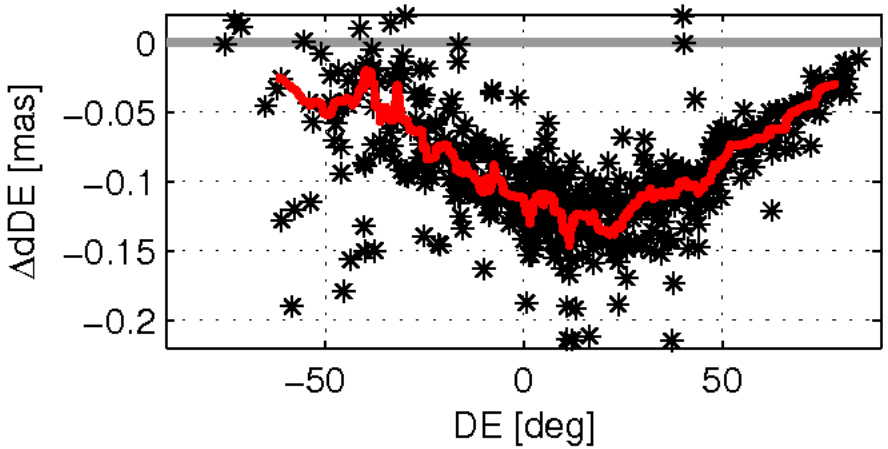
Consistency: CRF estimates & ITRF2000

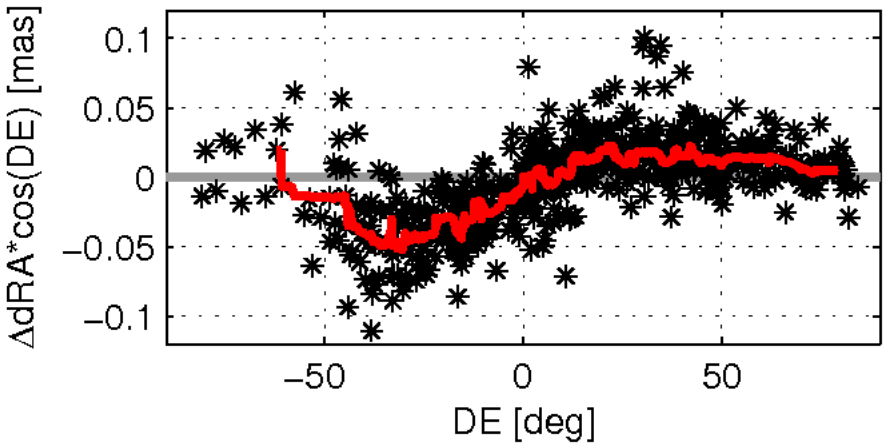
Differences between two solution setups:



=> **ITRF2000** fixed !!!





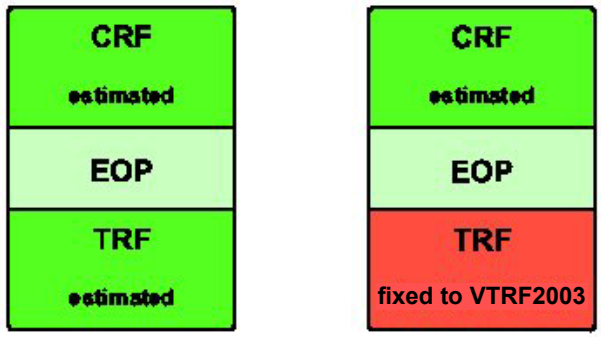


=> **Systematics in dDE** like not estimating gradients, but smaller (*here:* up to -0.15 mas vs. *MacMillan and Ma,1997*: up to -0.5 mas)

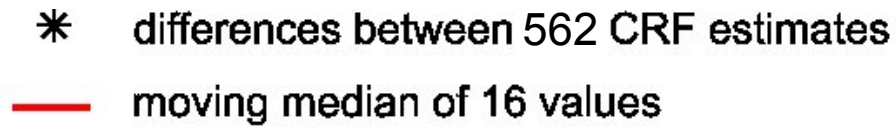
DGFI

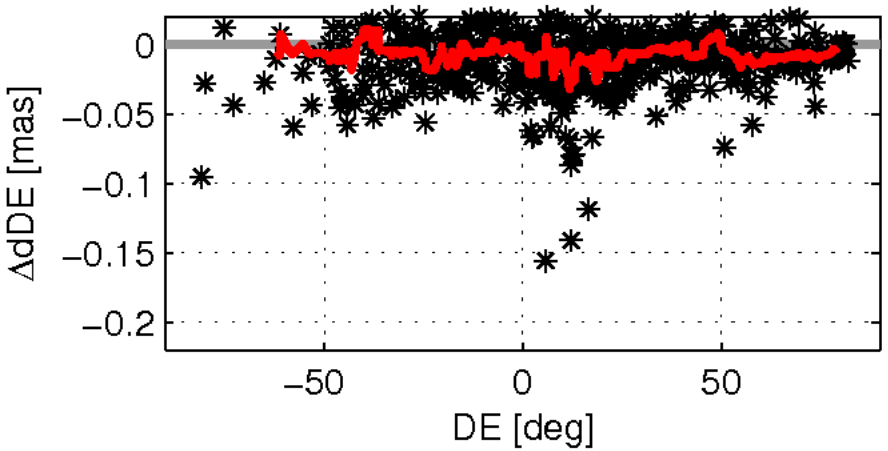
Consistency: CRF estimates & VTRF2003

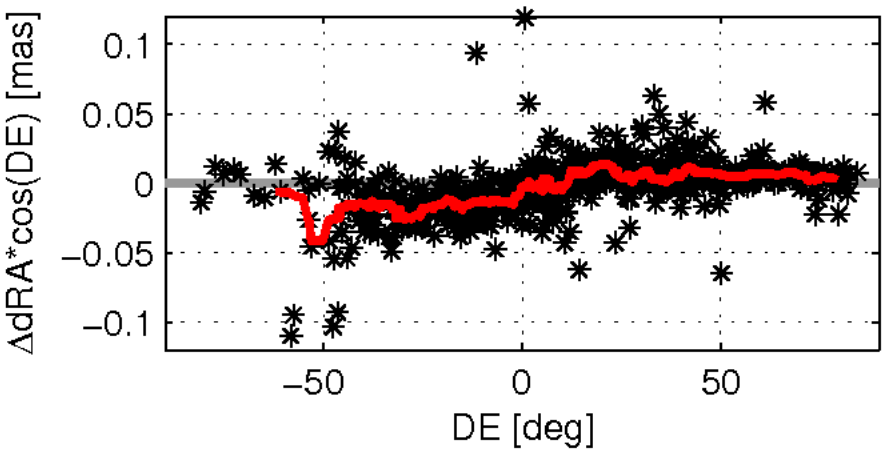
Differences between two solution setups:



=> **VTRF2003** fixed !!!







=> **Systematics almost disappeared** ! But…

Consistency: CRF estimates & VTRF2005

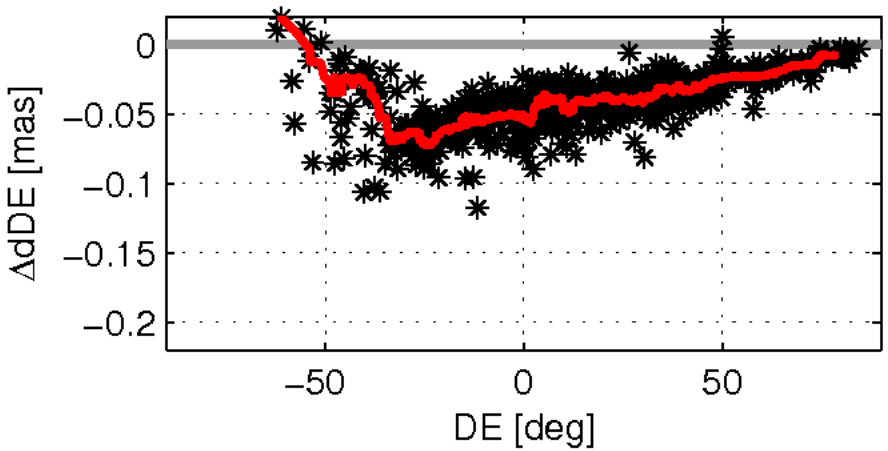
Differences between two solution setups:

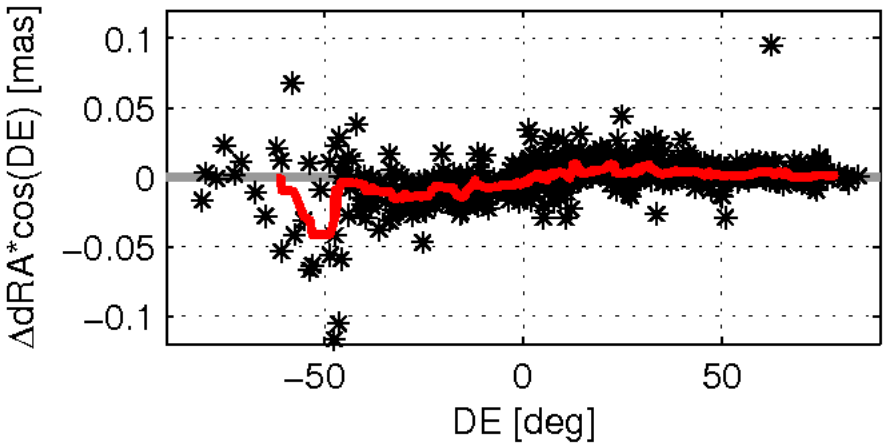
CRF estimated	CRF estimated
EOP	EOP
TRF estimated	TRF fixed to VTRF2005

=> **VTRF2005** fixed !!!

* differences between 562 CRF estimates

— moving median of 16 values

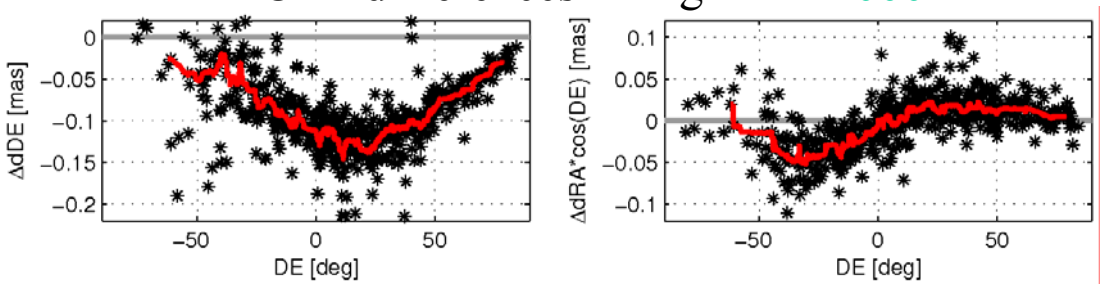




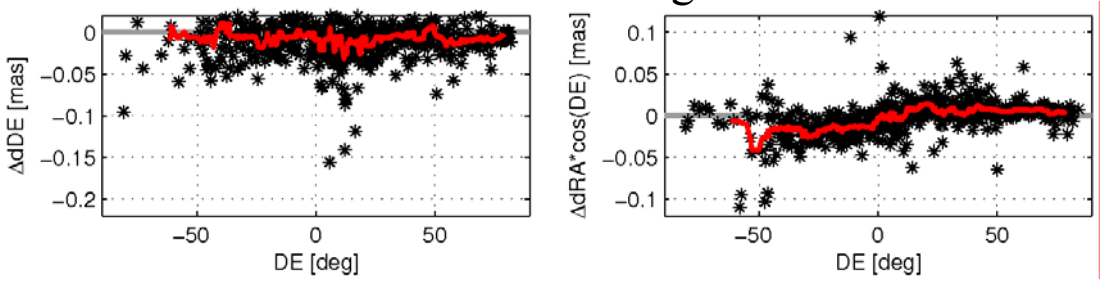
=> Grmph! **Even more systematics…**

Consistency: CRF estimates summary

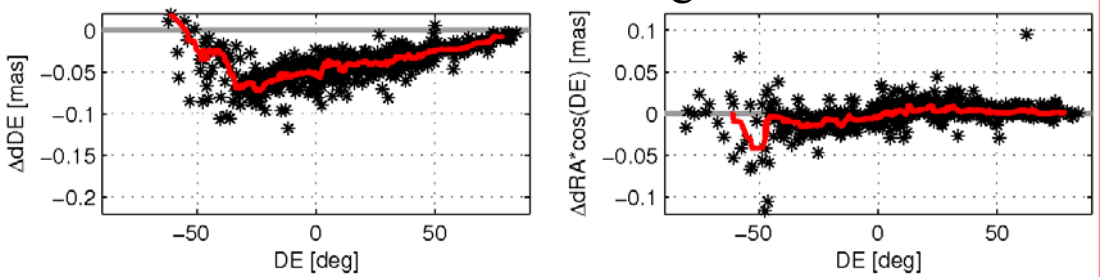
CRF differences fixing **ITRF2000**



CRF differences fixing **VTRF2003**



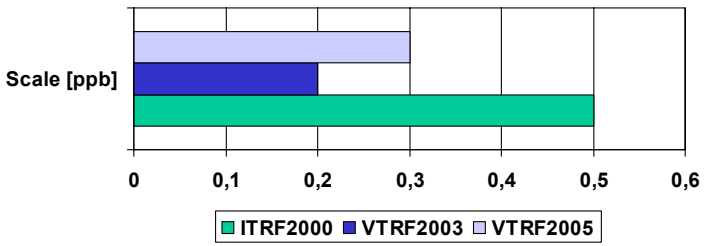
CRF differences fixing **VTRF2005**



Possible reasons for systematics:

- handling of **tropospheric gradients** (ITRF2000 GPS-solutions, some VTRF2005-solutions)

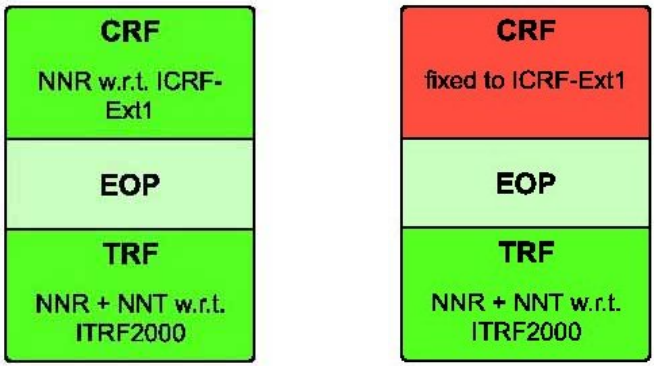
- **scales** of fixed TRF (*MacMillan and Ma, 1997*: not estimating gradients leads to ~ 0.7 ppb scale)



- **???**

Consistency: TRF estimates & ICRF-Ext1 (I)

Differences between two solution setups



TRF differences fixing ICRF-Ext1

	NORTH [mm]	EAST [mm]	HEIGHT [mm]	NORTH dot [mm/y]	EAST dot [mm/y]	HEIGHT dot [mm/y]
RMS	0.6	0.5	1.3	0.14	0.07	0.15

=> Differences are very small

=> Any systematics ? …

Consistency: TRF estimates & ICRF-Ext1 (II)

TRF differences fixing ICRF-Ext1:

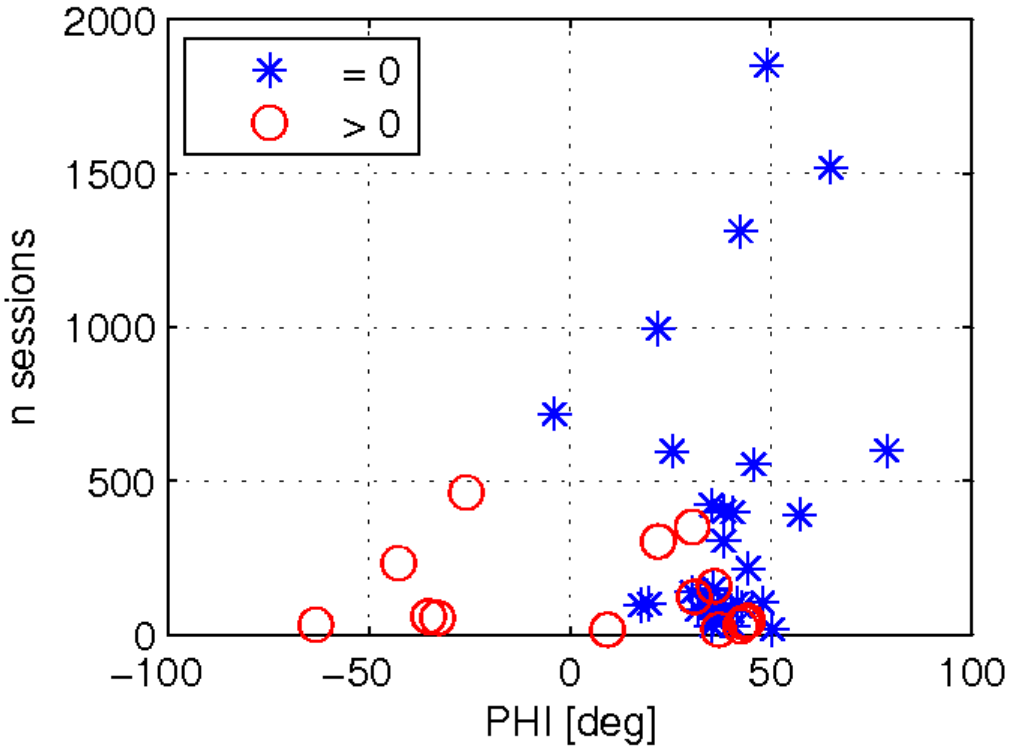
(14 stations with the 5 biggest values for each component)

	PHI [deg]	**n sessions**	**NORTH** [mm]	**EAST** [mm]	**HEIGHT** [mm]	**NORTH dot** [mm/y]	**EAST dot** [mm/y]	**HEIGHT dot** [mm/y]
OHIGGINS	-63	33		1.3		-0.22	-0.19	
HOBART26	-43	234	-0.9	-0.9			0.17	
DSS45	-35	61		-1.0				
SANTIA12	-33	56	-2.7		1.7	-0.82		
HARTRAO	-26	463	-1.5				0.11	-0.32
KWAJAL26	9	17	1.0	2.0	6.5		0.19	0.61
KAUAI	22	303	0.9			0.14		
HRAS 085	30	351				0.15		
SESHAN25	31	124				-0.14		
TSUKUB32	36	159			3.1			
OVRO_130	37	17		1.1			0.15	0.21
HAYSTACK	42	29			-2.9			-0.35
URUMQI	43	40						0.23
CRIMEA	44	46			-1.7			

Consistency: TRF estimates & ICRF-Ext1 (III)

TRF differences fixing ICRF-Ext1:

(dependence on latitude and number of sessions)



o 14 stations from table

* 35 other stations

Biggest differences due to:

- sparse south network
- stations with few sessions (also: mostly observed in small networks)

=> **poorly redundant observing geometry (correlated CRF, TRF)**

Summary and conclusions

DGFI05R02 provides 100% **consistent TRF, CRF and EOP**, which essentially **confirm "IERS"**, but also:

- stresses the benefits to have TRF, CRF and EOP in a common solution:
  - to **consider all dependencies** between parameters (not always obvious!)
- points out the necessity to combine such **solutions with other techniques**:
  - to make sure the techniques are not tilted (**EOP ⇔ pos+vel ties**)
  - to benefit from **redundant and complementary information**
- emphasizes that such efforts need **carefully adapted models and parameterizations**