IERS Rigorous Inter-Technique Combination

Implications to IGS

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- IERS Combination Pilot Project (CPP) and IERS2005
- Reduction of Systematic Effects
- Reprocessing Capabilities
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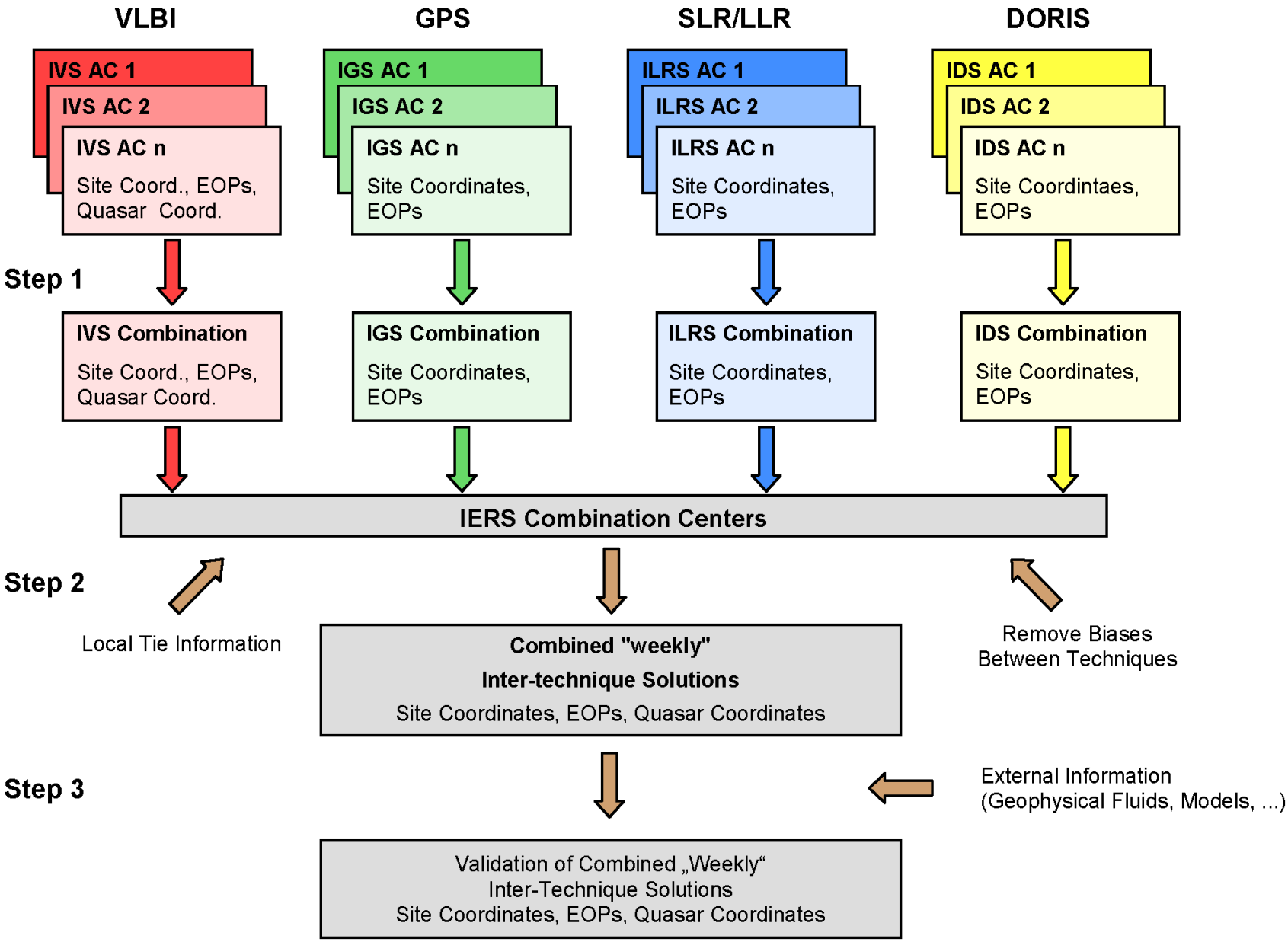
IERS Combination Pilot Project

Parameter space for a rigorous combination:

Parameter Type	VLBI	GPS/ GLON.	DORIS/ PRARE	SLR	LLR	Alti- metry
Quasar Coord. (ICRF)	X					
Nutation	X	(X)		(X)	X	
Polar Motion	X	X	X	X	X	
UT1	X					
Length of Day (LOD)		X	X	X	X	
Coord.+Veloc.(ITRF)	X	X	X	X	X	(X)
Geocenter		X	X	X		X
Gravity Field		X	X	X	(X)	X
Orbits		X	X	X	X	X
LEO Orbits		X	X	X		X
Ionosphere	X	X	X			X
Troposphere	X	X	X			X
Time/Freq.; Clocks	(X)	X		(X)		

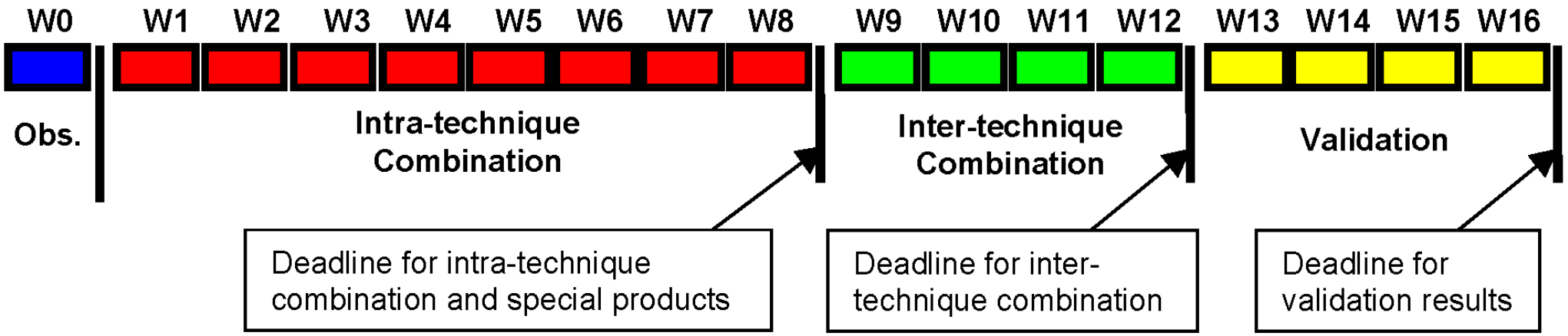
IERS Combination Pilot Project: sub-space (red rectangle)

IERS Combination Pilot Project



IERS CPP: Submission Schedule

- **Intra-technique combinations** (weekly SINEX files) due 8 weeks after the observations → no problem for the IGS
- **Inter-technique combinations** (weekly SINEX files) due 12 weeks after the observations
- **Validation of inter-technique combinations** (report) due 16 weeks after the observations
- **Special combined products** due 8 weeks after the observations



IERS CPP: Proposals

Institution	Intra-Techn. (Step 1)	Inter-Techn. Comb. (Step 2)	Validation (Step 3)	Misc. Comb.
ILRS	SLR	—	—	—
IDS	DORIS	—	—	—
IVS	VLBI	—	—	—
IGS	GPS	—	—	—
IGN/OP/BIPM	—	GPS,SLR,VLBI,DORIS	S,E,R	—
JPL	—	—	E	—
DGFI	SLR	GPS,SLR,VLBI,DORIS	—	—
FESG	—	(07/04)	—	E
USNO	—	—	E	E
JCET/GSFC	SLR	SLR, LEO GPS (07/04)	S,E (07/04)	S,E,O (12/04)
NCL	GPS,SLR	GPS,SLR	S,E	—
GRGS/CNES.	—	GPS,SLR/LLR,VLBI, DORIS: Obs.Level	—	—
CAS	—	GPS,SLR,VLBI,DORIS	—	—

S: Site Coordinates; **E**: EOP; **R**: Radio sources; **O**: Orbits

IERS CPP: Timetable

January 26, 2004:	Dissemination of the Call for Participation
February 22, 2004:	Due date for proposals
February 27, 2004:	Information of participants about proposal acceptance
February 29, 2004:	Start of IERS Combination Pilot Project with GPS Week 1260 (first intra-technique combinations due 8 weeks later, i.e. end of April 2004; first inter-technique solutions due 12 weeks later, i.e., end of May).
April 25, 2004:	Meeting of IERS WG on Combination (before the EGU Meeting in Nice)
October 2004:	Progress Meeting of the IERS CPP at the IERS Workshop 2004
October 2005:	Evaluation of the CPP and discussions concerning the transitions to new IERS products

IERS2005: Plan

- "**I**ntegrated **E**arth orientation parameters, **R**adio sources, and **S**ite coordinates **2005**"
- **IERS2005 = ITRF2005 + EOP2005 + ICRF2005 = first rigorously combined solution**
- IERS2005 will be based on **"weekly" SINEX files** from all techniques (site coordinates, EOP, and quasar coordinates) over the **entire history** of their data acquisition
- This step will **complement the IERS CPP** for years already past
- The Technique Services (TS) should deliver time series as **homogeneous** as possible over a time span as long as possible (following IERS conventions)
- **Individual AC solutions** might be accepted if the corresponding TS agrees

IERS2005: Timetable

Draft Schedule:

April, 2004:	**Call** for submission of homogeneous **weekly SINEX files**
July, 2004:	Due date for **submissions** of weekly SINEX files
March 2005:	Submission of **IERS2005 solutions** by the Combination Centers (e.g, the ITRF CCs)
August, 2005:	IERS2005 solutions **evaluated** and **compared;** Presentation at the **IAG Scientific Assembly 2005** (Cairns, Australia)
Ocotber 2005:	After final refinements and documentation, official IERS2005 ready for **IERS DB decision** at IERS Workshop 2005 (Evaluation of IERS CPP)

Systematic Effects

General Modeling Consistency (IERS Conventions 2003):

- Solid Earth and pole tides
- Subdaily ERP ocean tide model; IAU2000 precession/nutation
- Ocean loading, atmospheric loading
- Subdaily geocenter variations
- Troposphere mapping functions

Antennas and Environment (easily reaching 1cm or more):

- Antenna phase center variations (PCV) of receiver antennas
- Antenna phase center variations of satellite antennas
- Multipath effects, environment (e.g. snow), equipment changes

Orbit modeling and parameterization:

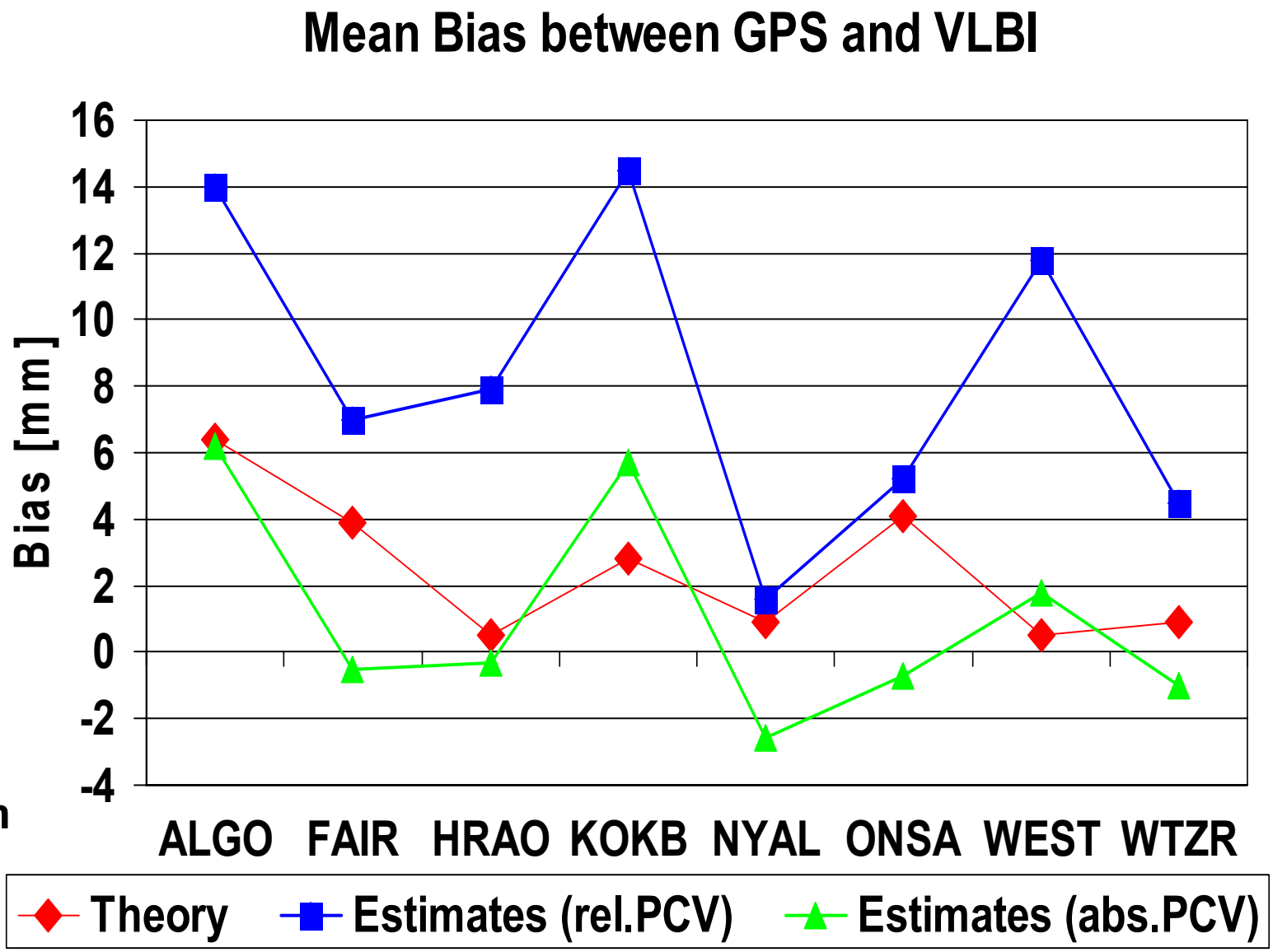
- Systematic effects in geocenter variations; SLR-GPS orbit bias of 5cm
- Systematic effects in LOD and nutation rates

Comparison of GPS & VLBI Troposphere

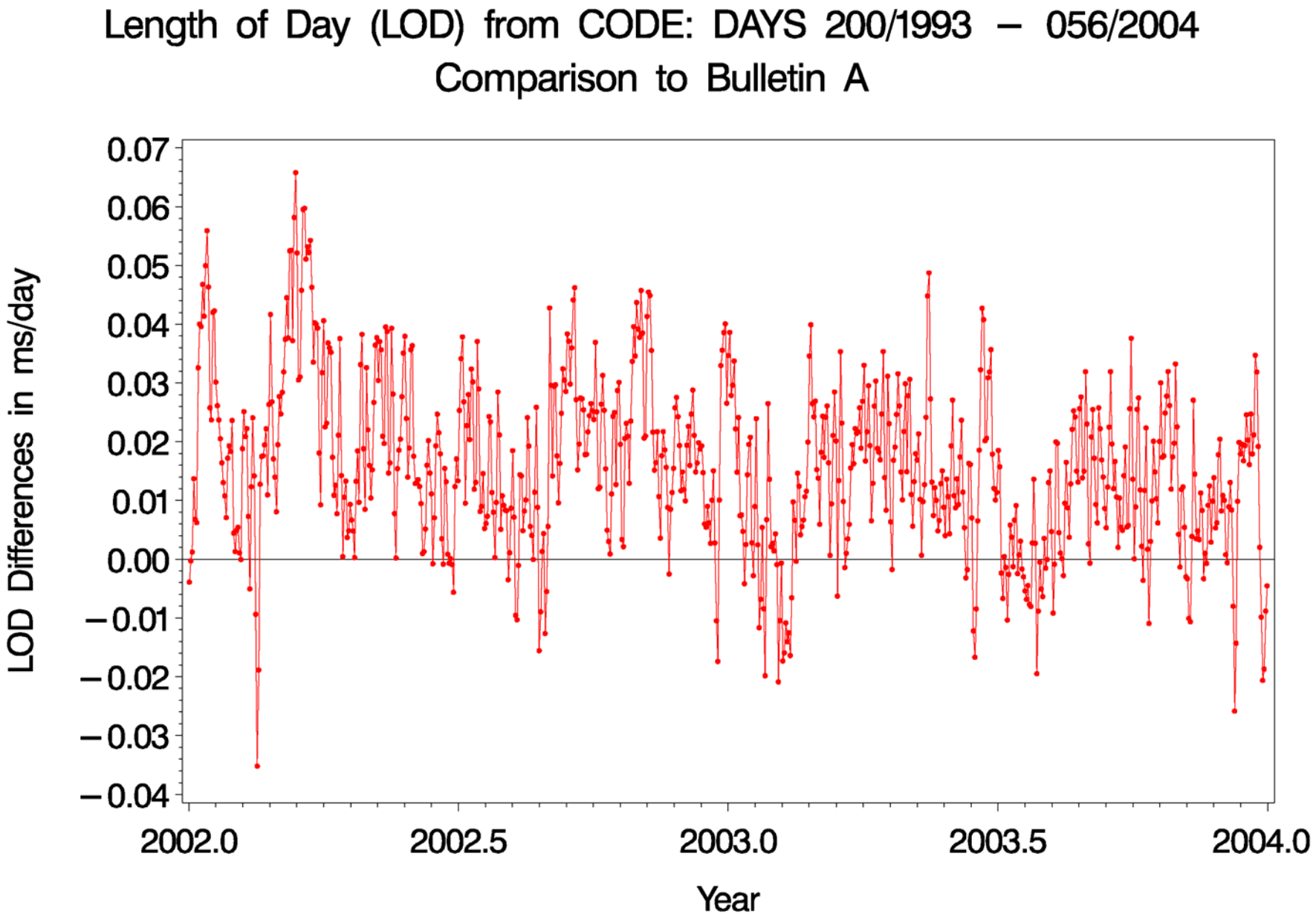
Station	ΔHeight (local tie) [m]
ALGO	23.11
FAIR	13.08
HRAO	1.54
KOKB	9.24
NYAL	3.07
ONSA	13.71
WEST	1.75
WTZR	3.10

Theory: ΔHeight = 10m

→ ΔZD ≈ 3mm



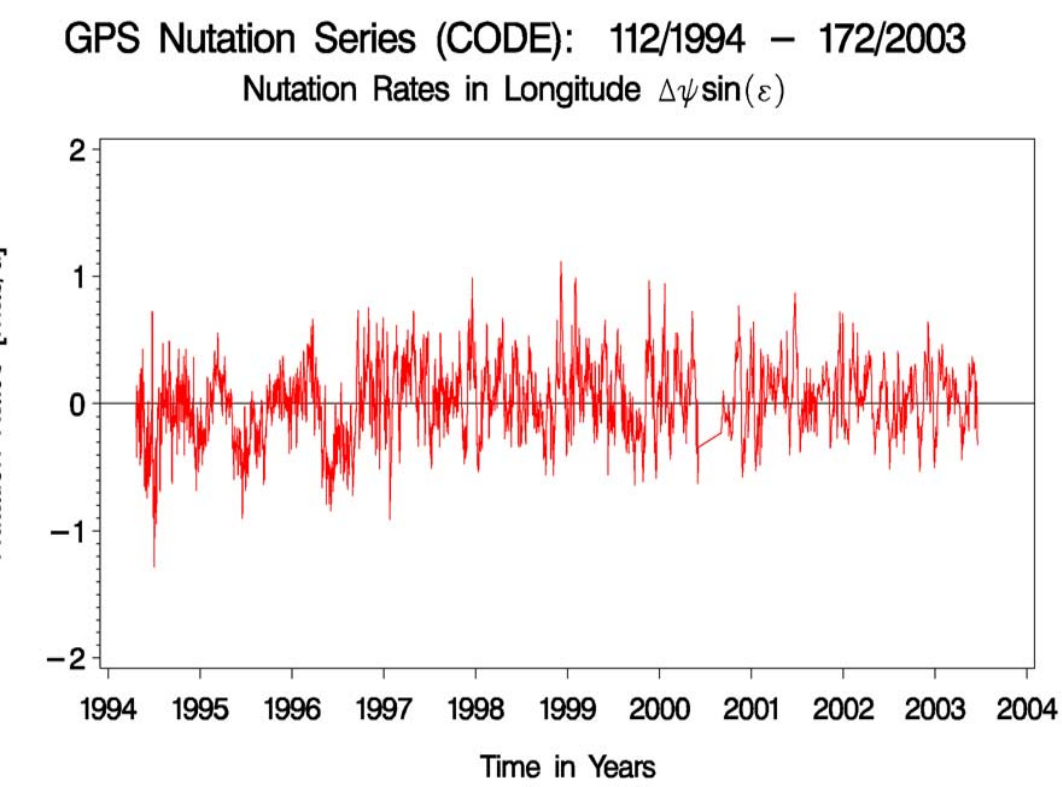
Systematic Effects: LOD

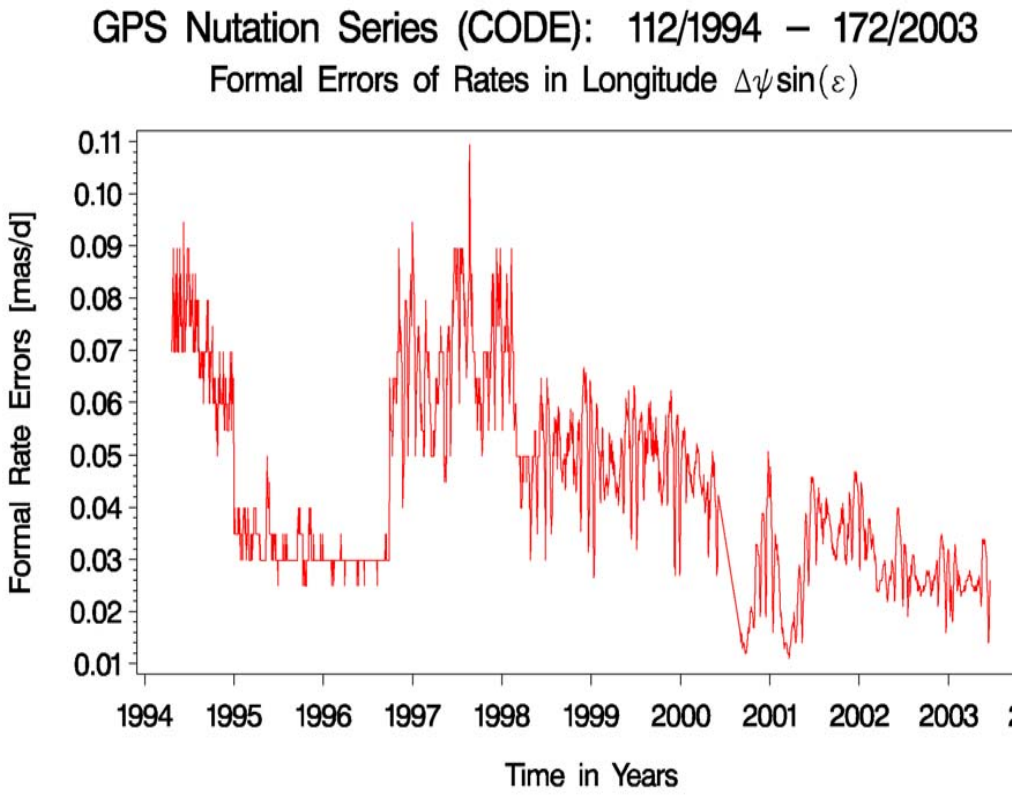


Systematic Effects: Nutation

GPS nutation rates in longitude:

- systematic effects due to orbit modeling and parameterization
- visible in the values and the formal errors





Reduction of Systematic Effects

Statement 1: All systematic effects in the IGS results have to be eliminated or reduced to the extent possible for an IERS inter-technique combination to be successful.

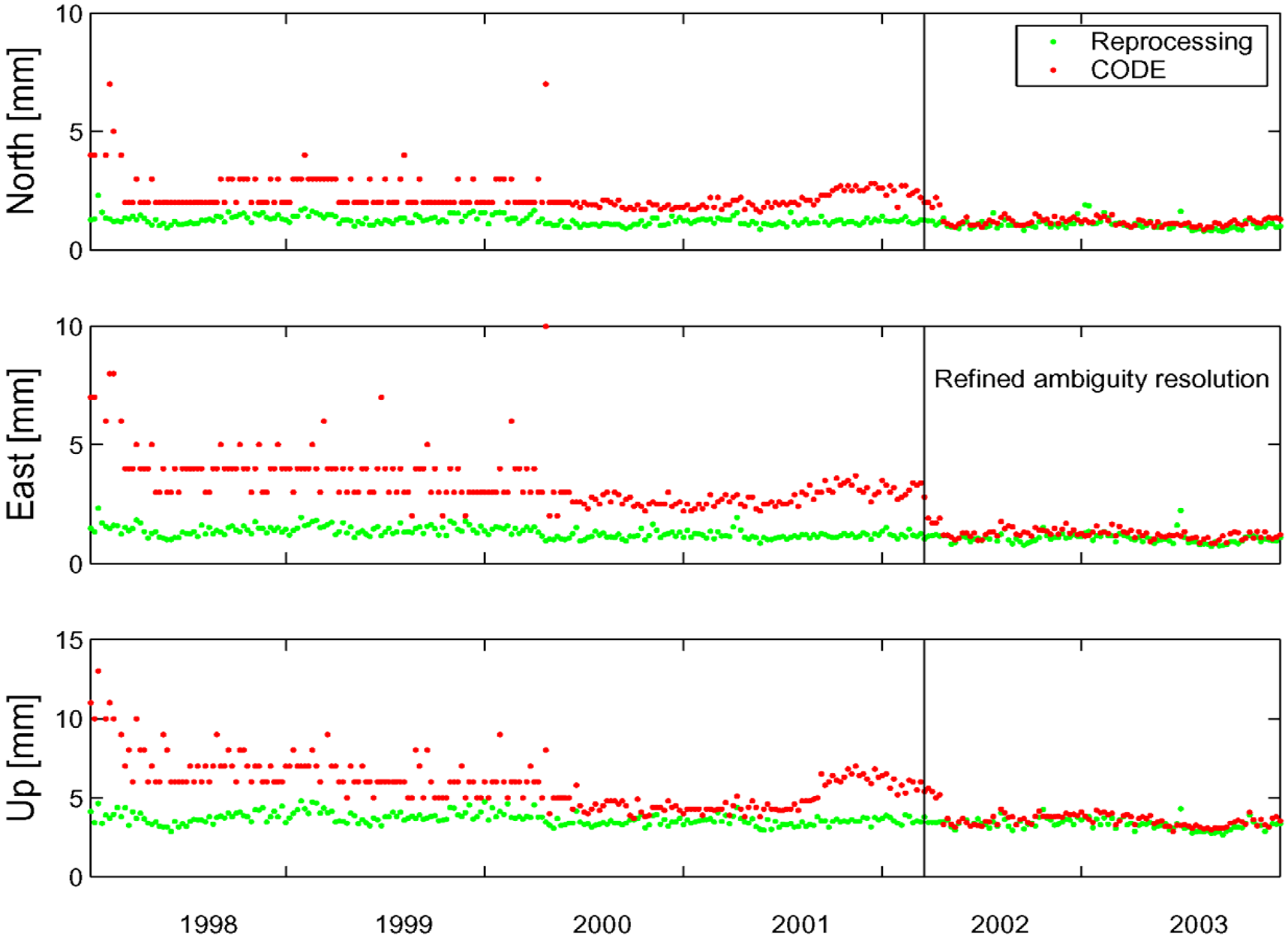
- **Not only internal consistency is important, but also absolute accuracy**
- **We should try to come as close as possible to the point, where ITRF coordinates are as consistent as the IGS GPS-only realization of the ITRF**
- **Each technique has its own systematic biases to care about**

Reprocessing Capability

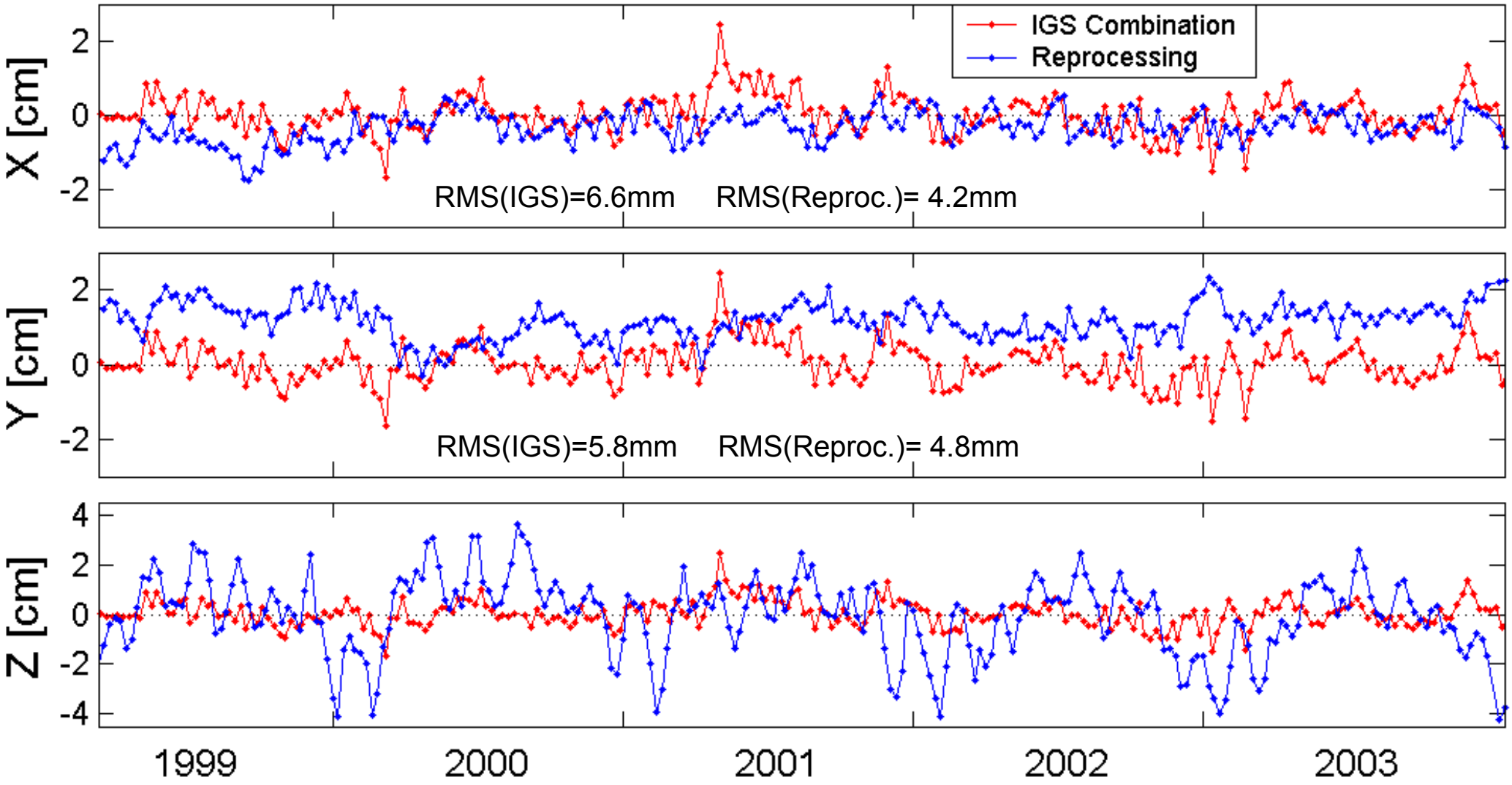
Importance of reprocessing:

- **Inhomogeneous** old time series with inconsistent modeling → quality, consistency and long-term stability cannot be guaranteed
- Upgrades of solution series to **new standards** in modeling and parameterization are necessary (e.g. orbit parameterization)
- Improvements in **processing strategies** (e.g. ambiguity resolution) should be exploited for the entire GPS series
- Effects of **reference frame changes** cannot be fully removed (GPS week 1143: ITRF97 → ITRF2000)
- Examples: introduction of **absolute antenna PCV** or switch to **IERS Conventions 2003** → reprocessing necessary
- IERS requires most up-to-date and consistent time series of products from all techniques (e.g., for IERS2005 products)

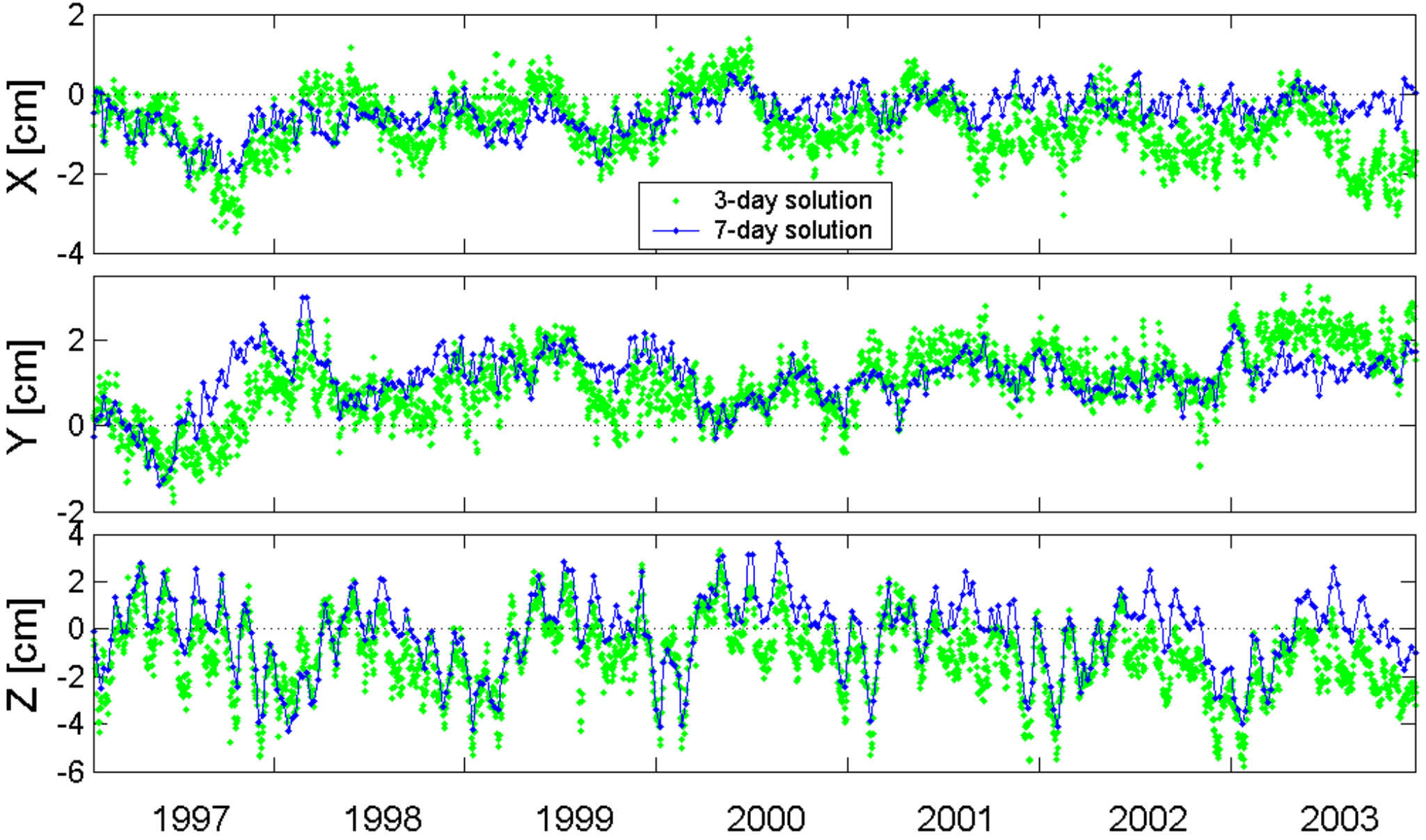
Reprocessing: Coordinate Repeatability



Reprocessing: Geocenter



Reprocessing: Geocenter 3- and 7-Day Solutions



Reprocessing Capability

Statement 2: Development of reprocessing capabilities must be an important goal for the IGS in the near future

- Most other techniques already have such capabilities (VLBI, SLR,DORIS, LLR)
- Some or most of the IGS Analysis Centers should reach a status, where they can periodically (e.g., once a year) reprocess the entire global IGS dataset
- Associate Analysis Centers might join the effort (?)
- IGS strategy required on how to improve products of the past (new submissions, new combinations, …)

Consistency of AC and IGS Products

Troposphere Zenith Delays:

- Systematic and quite large differences between individual ACs
- Indicates inconsistencies in modeling
- Effects heavily correlated with the station height and the global scale
- Try to understand these effects, not just remove them
- Troposphere zenith delay product not consistent with core products

Geocenter, Scale and LOD:

- Quite large systematic offsets and variations exist in these quantities
- They make a rigorous combination difficult

Statement 3: Despite the consistency already reached, the IGS should to strive for further consistency between AC solutions and between IGS products

Conclusions

- IERS is on the way to a **rigorous combination** of its products (IERS CPP, IERS2005).
- **Systematic effects** have to be understood and removed to the extent possible before a successful combination can be done.
- **Reprocessing capabilities** are important for the IGS to contribute official consistent long-term series to the IERS.
- The **consistency between ACs** as well as the **consistency between IGS products** should further be improved.
- **Work together with the IERS** to obtain a set of rigorously combined IERS products, which will be beneficial to the IGS and all other space geodetic techniques.