
Measurement Bias Estimation and Modeling - Data QC



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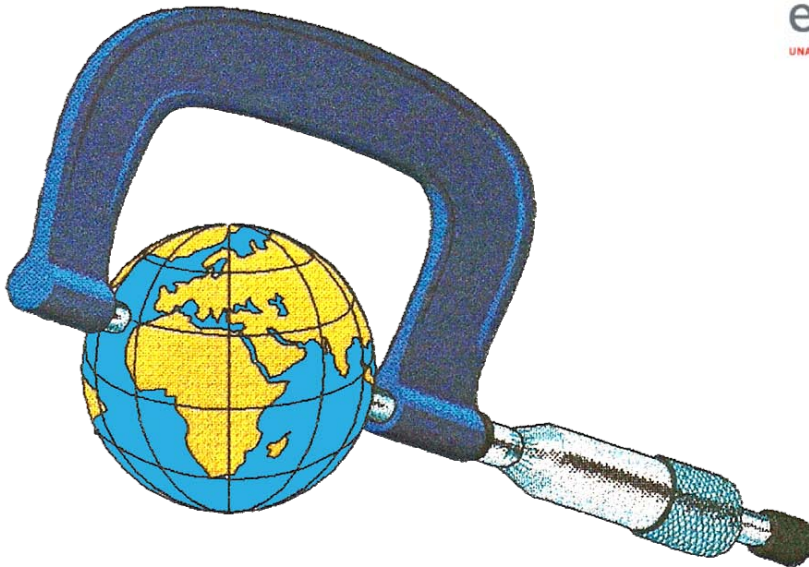
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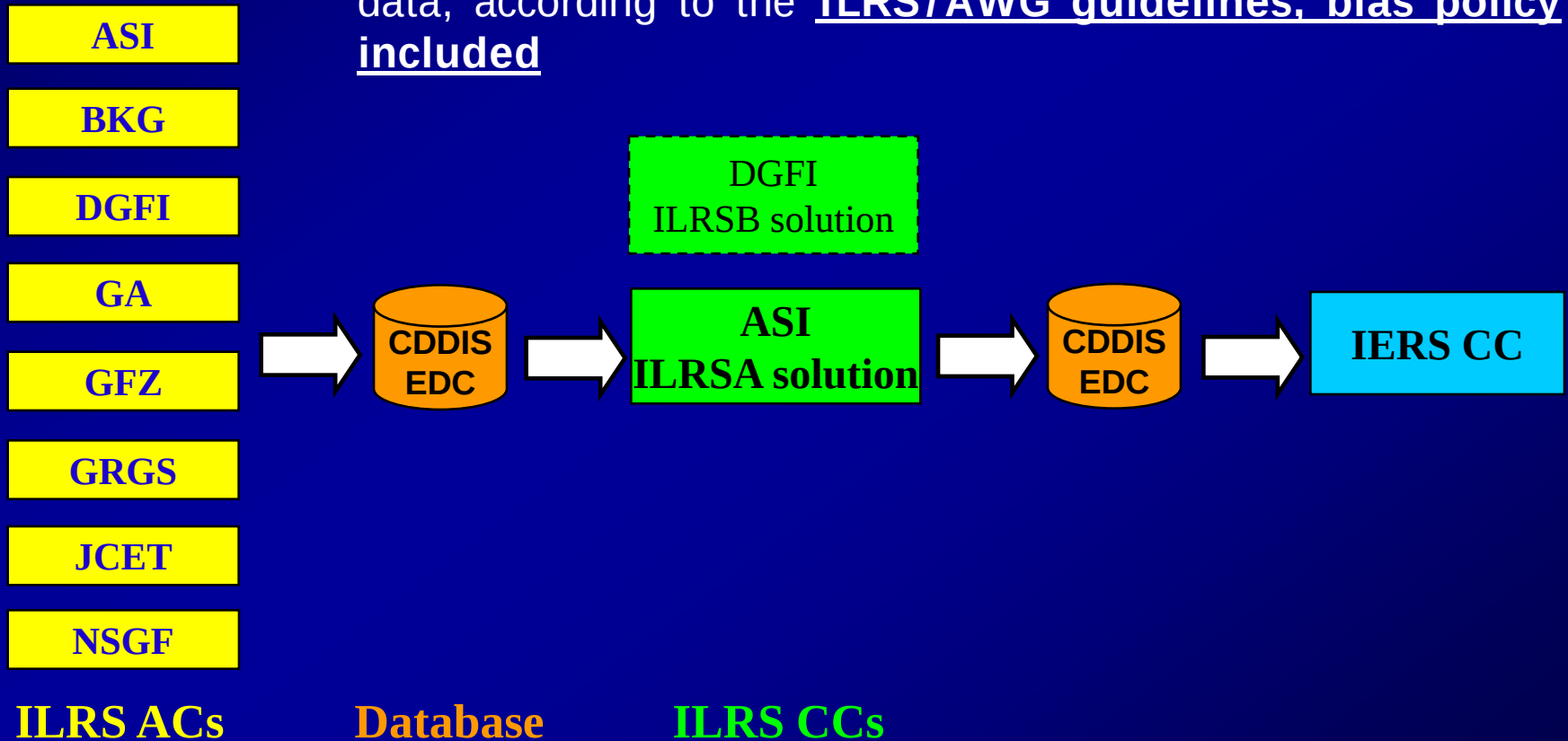
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The ILRS contribution to ITRF

- The official ILRS analysis centers (ACs) weekly solutions are combined by the two combination centers (CCs)
- Solutions contain SSC and daily EOP, using Lageos and Etalon data, according to the ILRS/AWG guidelines, bias policy included



SLR biases

- ❑ SLR is a clean, absolute ranging technique with the potential of *two types of bias* due to errors at the stations e.g. calibration and/or synchronization issues, hardware malfunctioning:
 - time biases
 - range biases
- ❑ The range bias is the most critical, being highly correlated with height over short periods
- ❑ The presence of intermittent biases can introduce jumps in the coordinate time series
- ❑ A non homogeneous treatment of biases among the Analysis Centers affects the combined product, i.e. the ILRS contribution to ITRF

ILRS range bias information sources

Engineering bias report from CDDIS database and from the stations through SLRMail

Rapid, daily bias analysis report from the ILRS ACs

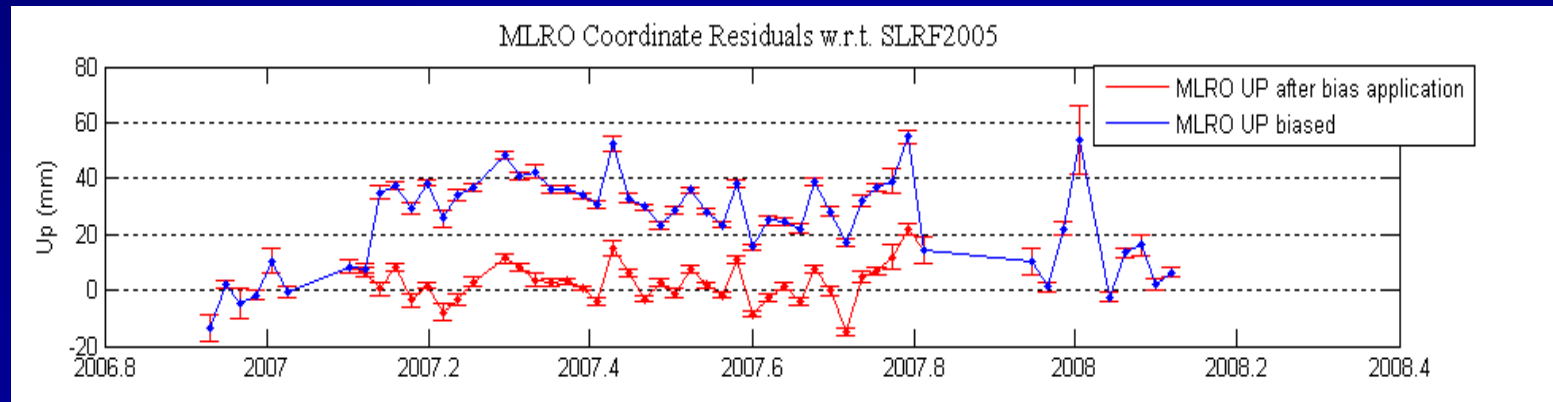
Bias time series estimated from a multi-year solution

Using these sources of information, the AWG has defined:

- **biases to be applied**
- **biases to be estimated**
(to be kept at minimum)
- **unrecoverable data to be edited**

Engineering bias report

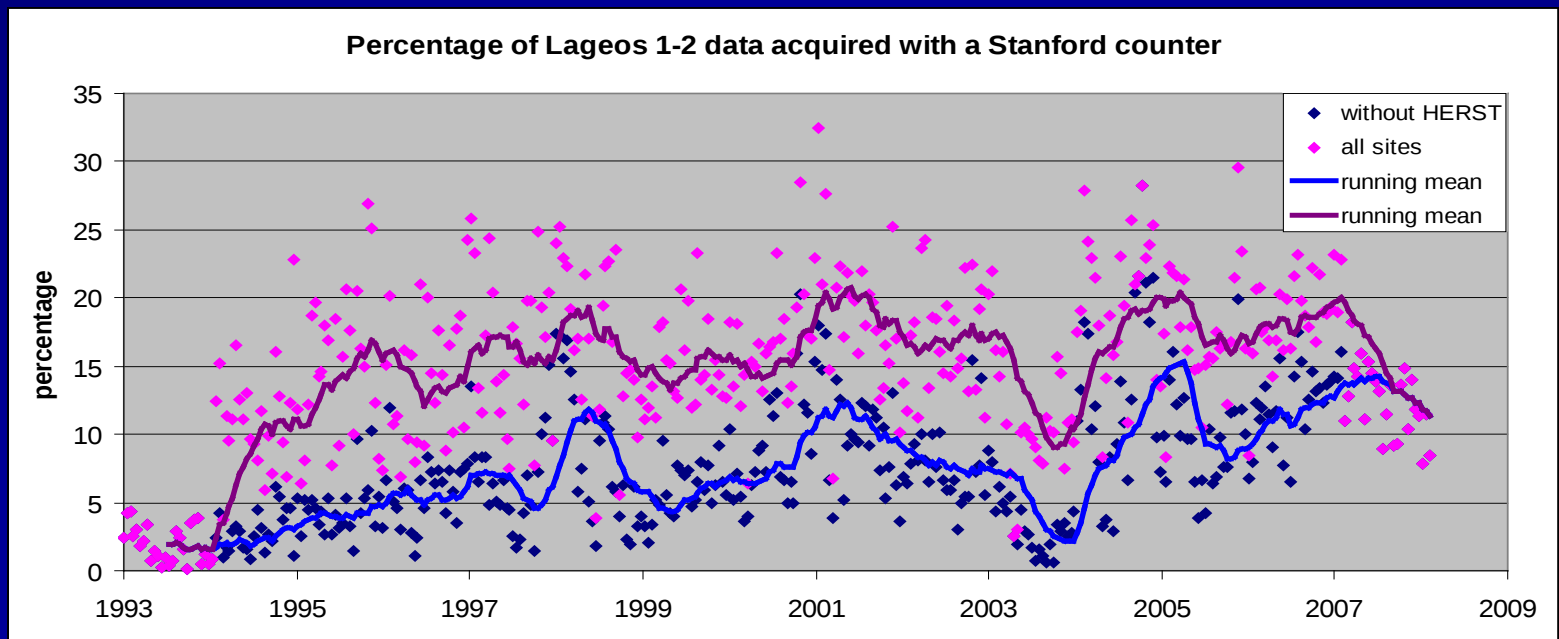
- ❑ System calibration is fundamental
- ❑ Finding the cause is often non-trivial
- ❑ The analysis support is necessary
- ❑ An example: MLRO



- At a first glance, no change in the calibration procedure
- High correlation with system delay variations
- Problem finally traced in the new PMT configuration and bias computed

The effect of the Stanford counters

- ❑ Systematic Effects in Stanford counters used for SLR (~ 1 cm with a few exceptions)
- ❑ ~15 sites using Stanford counters; Herstmonceux is among them



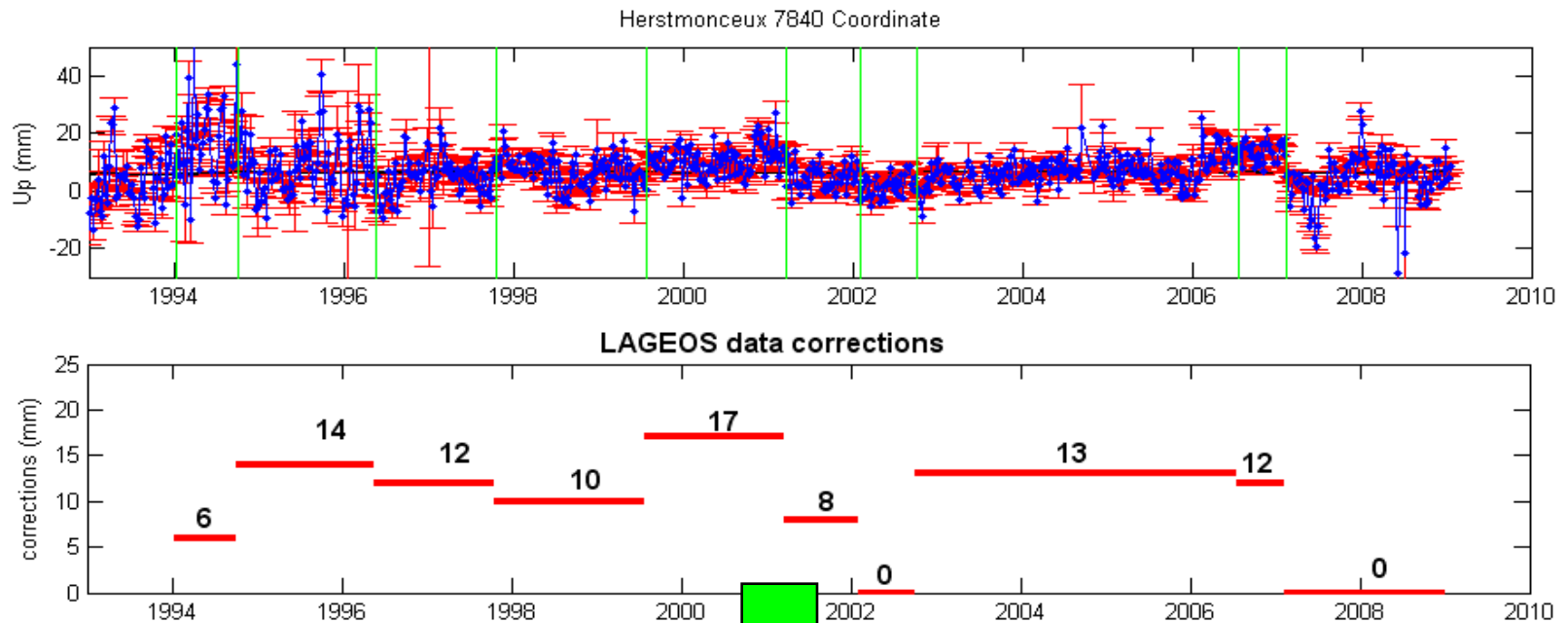
Multi-year solutions

- ❑ Most biases are not known and reported by the stations
- ❑ Discrepancies between daily AC bias reports are still present and ILRS is in the process of harmonization
- ❑ Daily AC bias reports are generally not homogeneous over years and have a partial temporal coverage, not useful for long term bias recovery
- ❑ A long term analysis overcomes the above mentioned problems and gives a complete, homogeneous detection of the biases decorrelating them from station heights

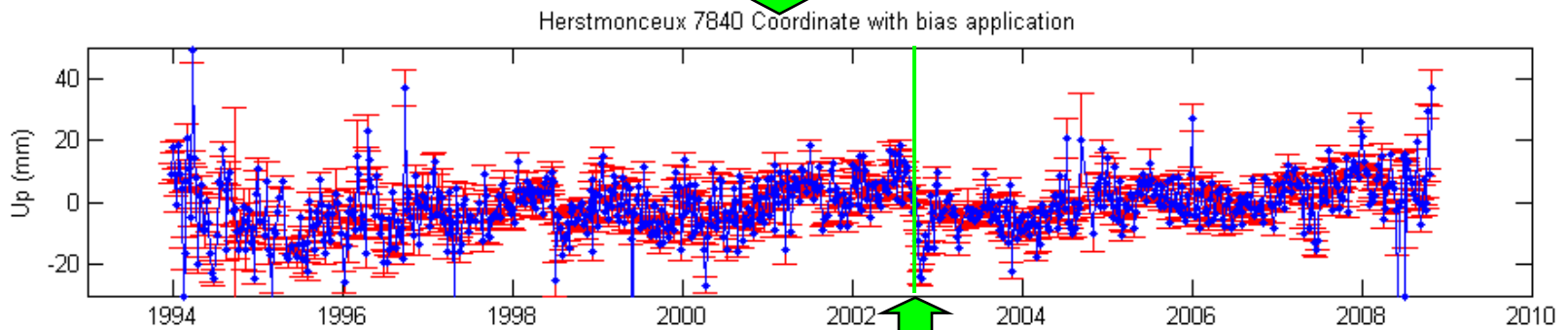
The ASI multi-year solution

- ❑ The biases are estimated with a multi-year solution from jan 1983 to dec 2008
- ❑ The solution is loose and SSC/SSV are estimated over the entire time span
- ❑ One bias estimate every 15 days after the SSC/SSV/EOP adjustment
- ❑ Biases estimated in the multi-year solution are used whenever a field measured correction doesn't exist and in close contact with the site engineers

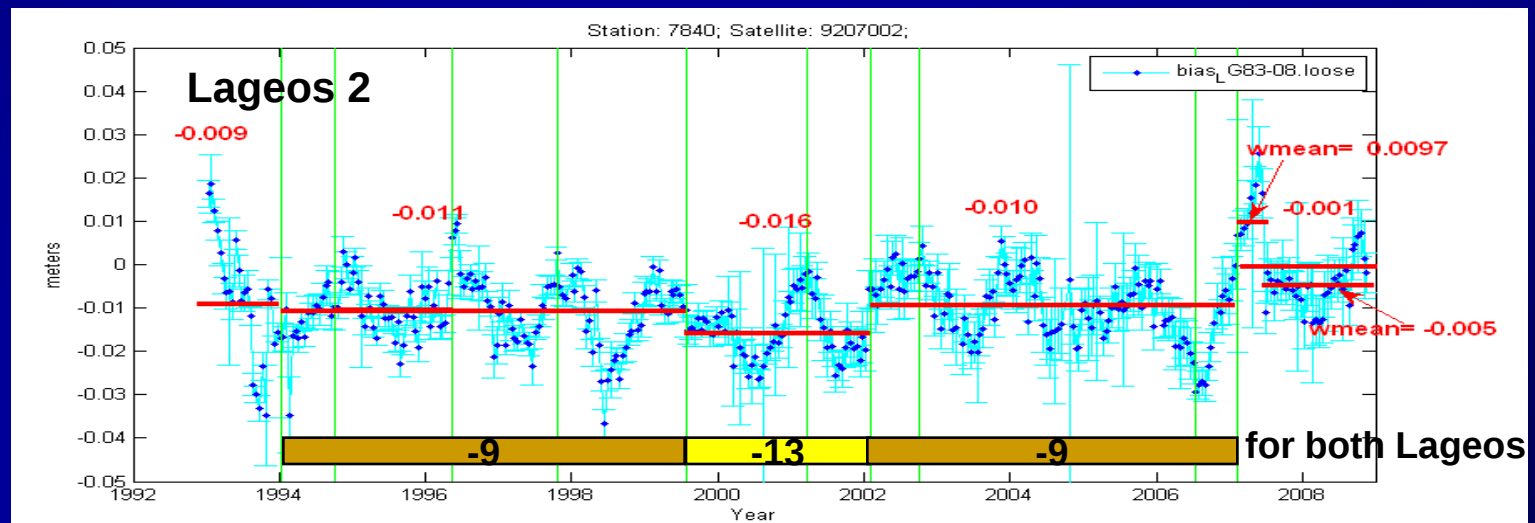
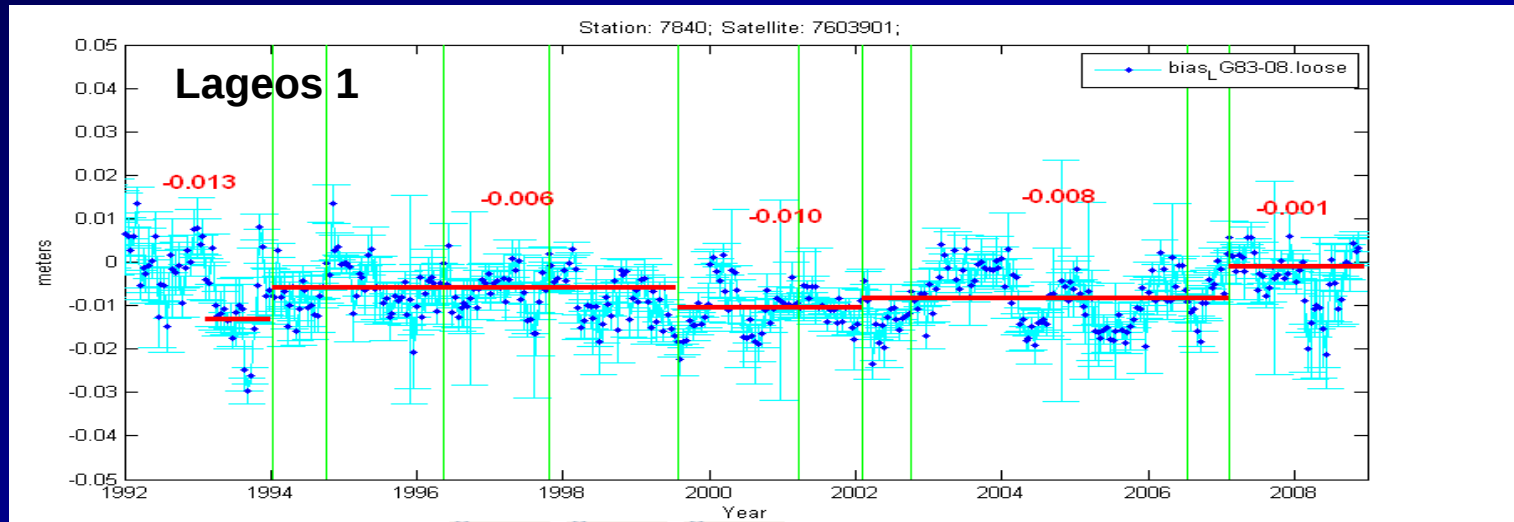
The Herstmonceux case



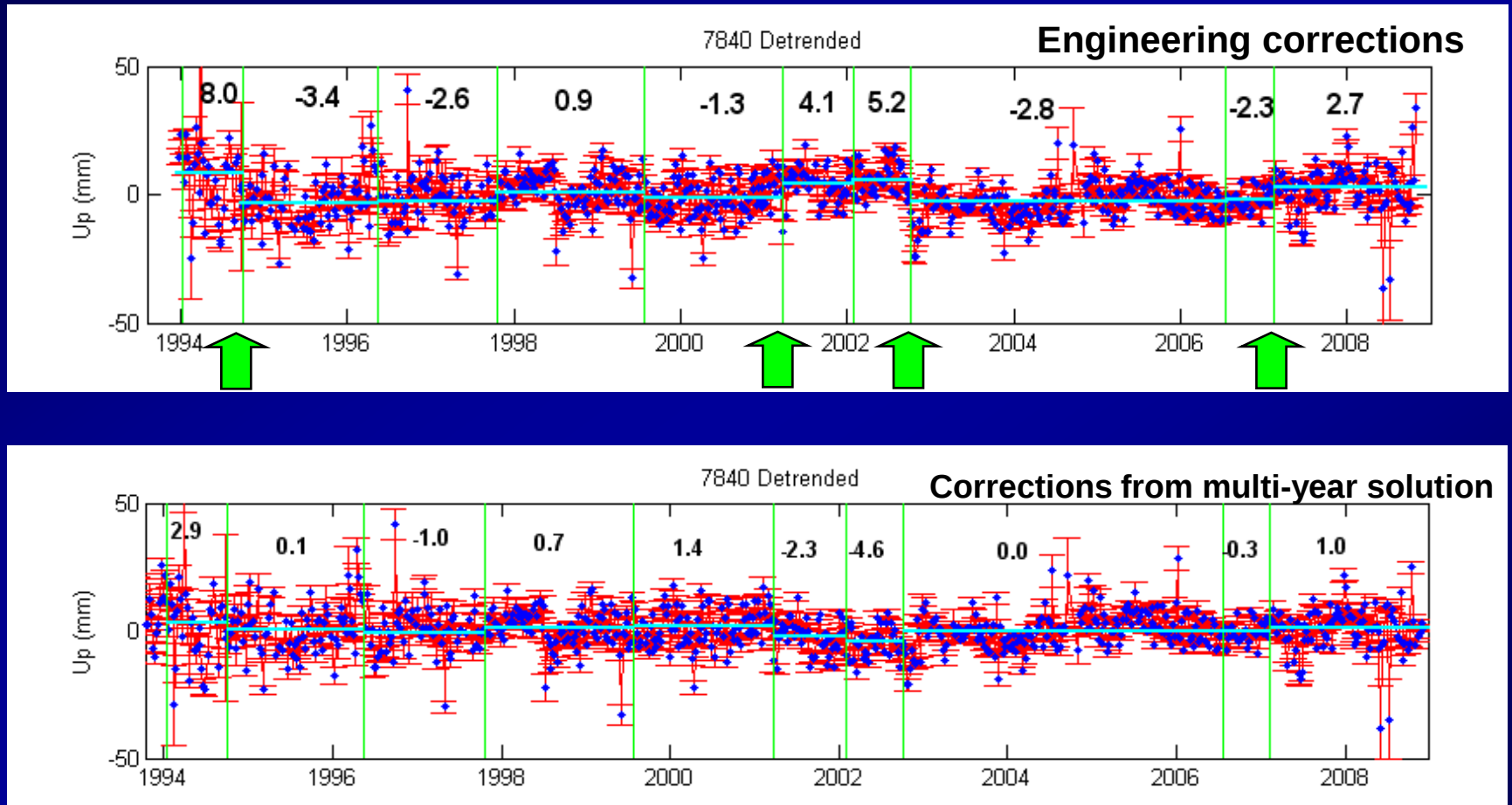
Range bias application



Herstmonceux bias from ASI multi-year solution 1983-2008



A test case: Herstmonceux



The difference between the two time series is, above all, in the jumps indicated by the green arrows: smaller with the corrections from the multi-year solution.

ILRS AWG recommendations

Lists of data editing and corrections (october 2007; REVISED 090118)

Those lists have been proposed by ASI at the AWG meeting in Grasse (september 2007) and accepted by the ILRS/AWG for the generation of the ILRS official products.

LIST OF DATA TO BE DELETED

Site No.	Wav	Core NonCore in V50	Solve ?	Model ?	bias in sol V50	SOLUTION PROPOSAL	Source
1863	G	NC	NO	NO	--	data before 1994.0	
1873	G	NC	NO	NO	--	data before 1995.0	
1884	G	NC	NO	NO	1993.0 ->	data before august 1994	
1893	G	NC	NO	NO	--	data before 1998.0	CDDIS
7112	G	NC	NO	NO	--	data before 1985.0	
7123	G	NC	NO	YES	--	data from 25 to 30 august, 1988 (3 m bias) data on may 12, 1993 (> 500 meter bias)	
7236	G	NC	NO	NO	--	data after 1998.0 (a few acquisitions)	
7237	G	NC	NO	NO	--	data before 1996.0	
7249	G	NC	NO	NO	--	data before 1999.0	
7355	G	NC	NO	NO	--	use only data in 2003	
7510	G	NC	NO	NO	--	data from 920623 to 920930 to be deleted	CDDIS
7585	G	NC	NO	NO	--	data from 920623 to 920930 to be deleted	CDDIS
7810	B	C	NO	YES	--	data from dec 18, 1996 to dec 29, 1997	
7811	G	NC	NO	YES	1993.0 -1994.0	data before 1993:202	CDDIS
7820	G	NC	NO	NO	--	data before 2000:291	CDDIS
7824	G	NC	NO	NO	--	data before 1996	
7831	G	NC	NO	YES	--	data before 1984	
7832	G	C	NO	NO	--	data before 1998	
7835	G	NC	NO	YES	--	data before oct 1988	
7837	G	C	NO	NO	--	data before 1990	
7841	G	NC	NO	NO	--	data before feb 19, 2004	

LIST OF SITES WITH BIAS ESTIMATION

Site No.	Wav	Core NonCore in V50	Solve ?	Model ?	bias in sol V50	SOLUTION PROPOSAL
1864	G	NC	YES	NO	1993.0 ->	bias to be estimated over all the period
1868	G	NC	YES	NO	1993.0 ->	bias to be estimated over all the period
1953	G	NC	YES	NO	--	bias to be estimated over all the period
7548	G	NC	YES	NO	--	bias to be estimated over all the period
7308	G	NC	YES	NO	--	bias to be estimated over all the period
7548	G	NC	YES	NO	--	bias to be estimated over all the period
7810	I	C	YES	NO	--	bias to be estimated over all the period
7845	G	NC	YES	NO	--	bias to be estimated over all the period (bad for EOP referencing)

LIST OF SITES WITH RANGE BIAS APPLICATION

The range correction should be subtracted from the data and is one-way

Site No.	Wav	Core NonCore in V50	Solve?	Model?	bias in sol V50	SOLUTION PROPOSAL			Bias Source
						Start Date	End Date	Correction	
1873	G	C	NO	YES	--	1995	2000	-270 mm	Analysis
7080	G	C	NO	YES	--	Jan 1, 1988	Dec 15, 1989	-40 mm	Analysis
						April 4, 1990	Jan 31, 1993	25 mm	CDDIS
						March 6, 1995	Jan 26, 1996	2.1 mB	CDDIS
						Jan 26, 1996	April 25, 1996	10.3 mB	CDDIS
						April 25, 1996	May 8, 1996	9.7 mB	CDDIS
7109	G	NC	NO	YES	--	Jan 9, 1997	Jan 18, 1997	164.9 mm	CDDIS
7110	G	C	NO	YES	--	Jan 01, 1984	May 15, 1984	30 mm	Analysis
						Oct 27, 1987	Jan 25, 1988	30 mm	Analysis
						Aug 27, 1996	Oct 3, 1996	163.6 mm	CDDIS
7122	G	NC	NO	YES	--	May 1984	Mar 15, 1987	30 mm	Analysis
7123	G	NC	NO	YES	--	July 14, 1987	Oct 9, 1987	-30 mm	CDDIS
7210	G	NC	NO	YES	1993 -2005	1983.0	sep 12, 1987	25 mm	Analysis
						sep 12, 1987	Jan 21, 1994	-37 mm	Analysis
						Jan 21, 1994	2000	-11 mm	Analysis
7237	G	NC	NO	YES	--	1996.0	1998.0	20 mm	Analysis
						1998.0	June 24, 2002	-20 mm	Analysis
7512	G	NC	NO	YES	--	Mar 1992	May 1992	-30 mm	Analysis
7517	G	NC	NO	YES	--	June 1992	August 1992	-94 mm	Analysis
7525	G	NC	NO	YES	--	March 1992	June 1992	11 mm	CDDIS
7544	G	NC	NO	YES	--	Sept 1992	Dec 1992	-85 mm	Analysis
7545	G	NC	NO	YES	--	Oct 1993	Mar 1994	15 mm	Analysis
7580	G	NC	NO	YES	--	Nov 1992	Jan 1993	68 mm	Analysis
7587	G	NC	NO	YES	--	Aug 1992	Oct 1992	30 mm	Analysis
7810	B	C	NO	YES	--	May 24, 1988	Sept 30 1989	50 mm	Analysis
						Jan 1998	May 29, 2002	-26 mm	Analysis
						May 29, 2002	Dec 28, 2004	-20 mm	Analysis
						Dec 28, 2004	Feb 6, 2006	-26 mm	Analysis
7811	G	NC	NO	YES	1993 -1994	Jul 20, 1993	May 19, 1998	-50 mm	Analysis
						May 19, 1998	Mar 28, 2003	-35 mm	Analysis
7831	G	NC	NO	YES	--	1987	June 1990	+85 microsec	CDDIS
7834	G	NC	NO	YES	--	Mar 11, 1985	Jul 18, 1986	-30 mm	Analysis
7835	G	NC	NO	YES	1993 - 1998	sep, 1991	Sept 9, 1997	25 mm	Analysis
7836	G	NC	NO	YES	--	Jan 1, 1994	Oct 12, 1994	18.45 mm	CDDIS
7839	G	C	NO	YES	93.0 to 09/96	1983	Sept 28, 1996	-22 mm	Analysis
7840	G	C	NO	YES	--	Jan-1984	Dec-1984	30-mm	Analysis
						Sep-15-1988	Dec-1992	Bias-drift	Analysis
						Oct-1-1994	Feb-1-2002	-2.5 mm	Appleby
						Feb-1-2002	Feb-10-2007	5.5 mm	Appleby
8834	G	C	NO	YES	1993 - 1997	Nov 1, 1990	Nov 1, 1992	-35 mm	CDDIS
						Nov 1, 1992	April 15, 1996	40 mm	Analysis
						April 15, 1996	Oct 13, 2000	5 mm	Analysis

* Consult new (separate) table of corrections for 7840

Data & Bias in the ILRSA combination

ASI CC deeply investigated the application of the AWG guidelines for data and biases.

To completely avoid the risk of uncorrect application of the ILRS AWG

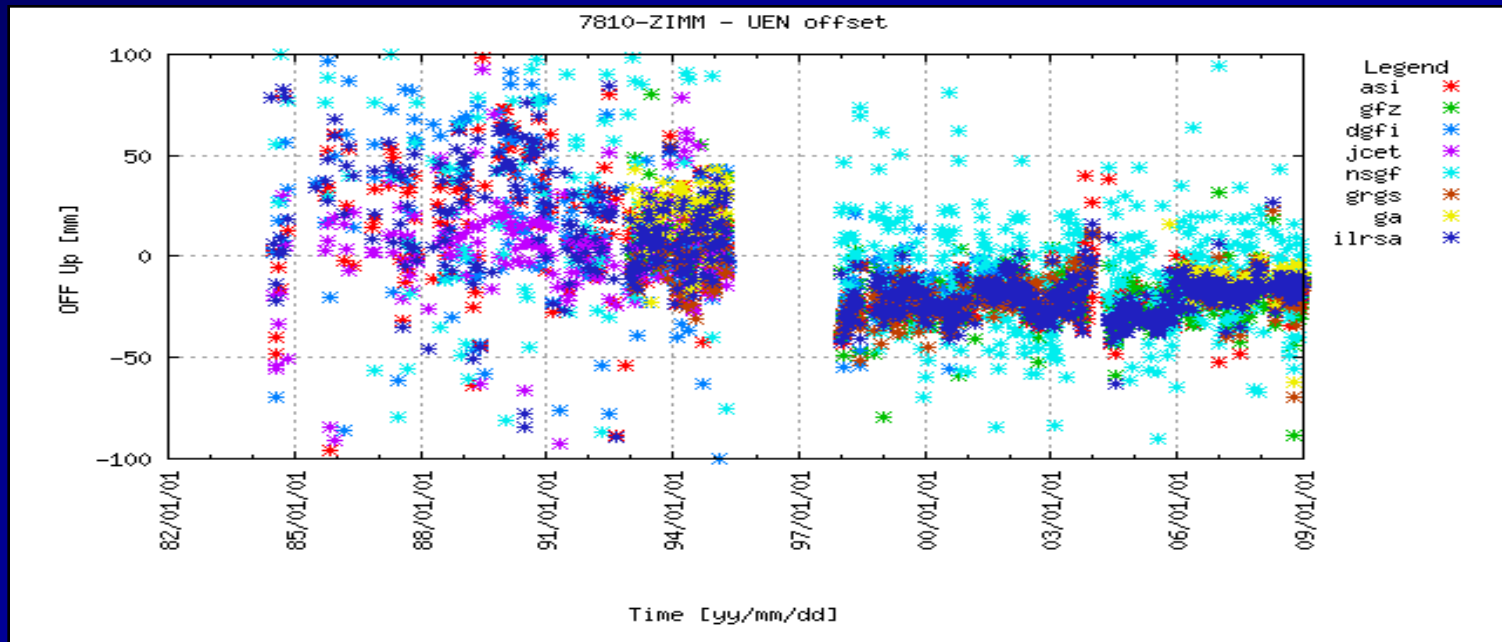
recommendations in terms of data to be deleted, all the incoming SNX files at ILRSA CC have been purified, by an automatic procedure, of the SSC estimates relevant to those forbidden periods, if present.

ACs have been provided of:

- ❑ a detailed feedback about the correct implementation of ILRS AWG in terms of data to be deleted by ILRSA CC
- ❑ final decision in terms of bias application for critical sites (e.g. Herstmonceux) by ILRS Analysis Coordinators

Data & Bias in the ILRSA combination

After a preliminary combination phase, a specific problem is detected for **7810**, causing a reworking for the combination from the year 1998 onwards.



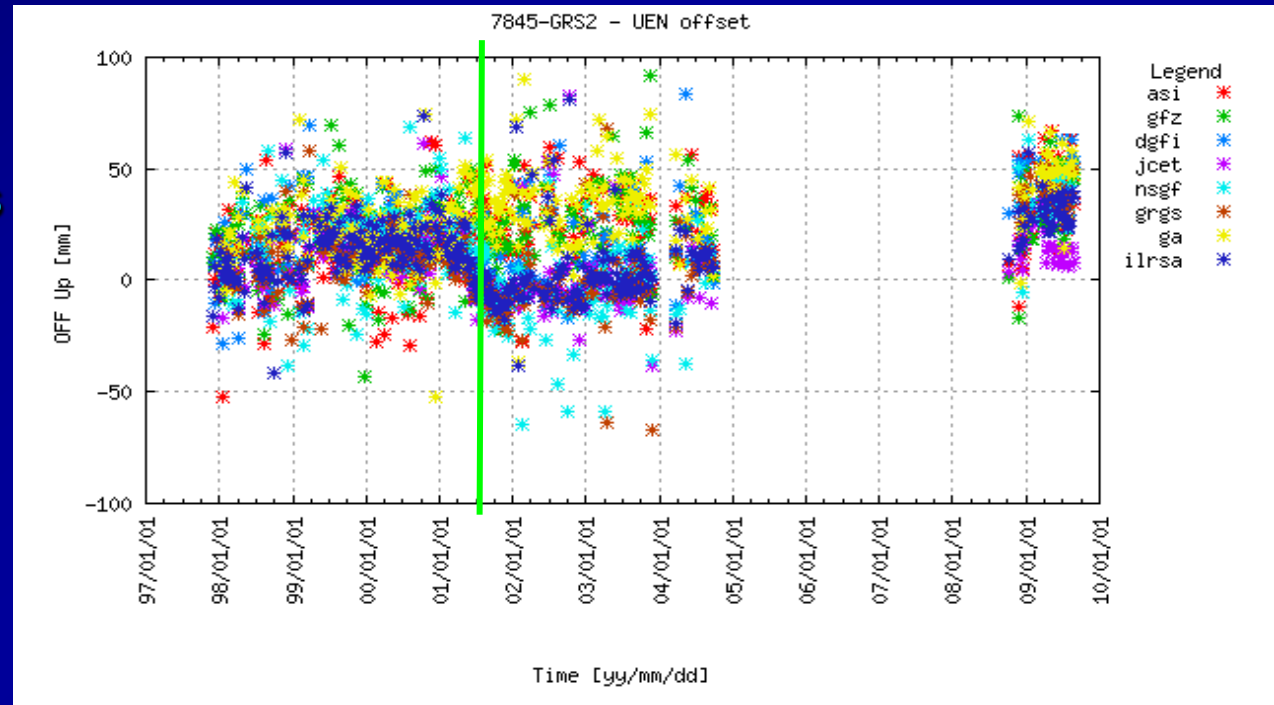
GA, GRGS, **JCET** excluded

AWG guideline:	7810	880524	890930	50
	7810	980101	020529	-26
	7810	020529	030311	-15
	7810	030311	041228	-22
	7810	041228	060206	-26

Data & Bias in the ILRSA combination

Two ACs groups:

- asi, gfz, ga
- dgfi, jcet, nsgf, grgs



AWG guideline: bias to be estimated over all the period

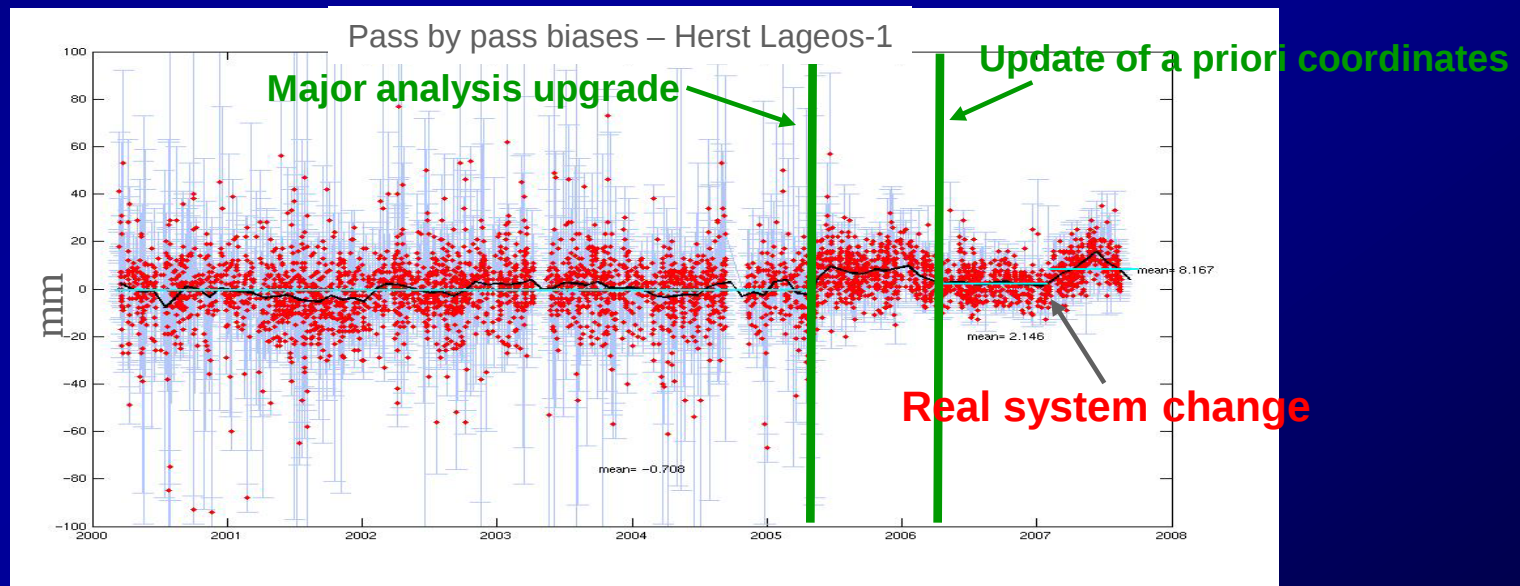
Data & Bias: status

- ❑ Major issues solved
- ❑ Some refinement needed :
 - Grasse (7845),
 - Orroral (7843 – biases not modeled from 1988 to 1994),
 - Quincy (7109, 1 cm bias after 1995),
 - Herstmonceux (7840 - bias not modeled from 1985 to 1988)
- ❑ A SINEX data handling file has been prepared and a discontinuity file is under preparation to be commonly used in the SLR data analysis.
- ❑ Daily and weekly QC is a common practice;

Daily QC

Daily biases from:

- HIT-U: Lageos, Etalon, Ajisai, Starlette, Stella, GPS, GIOVE, Jason. Hitotsubashi University in close contact with the stations
- JCET : Lageos, Etalon, Ajisai, Starlette



ILRS combined range bias Report – Lageos

weekly

ILRS Combined Range Bias Report 1

2009-11-22 00:00 UT - 2009-12-02 00:00 UT

Compiled by: SLR Observatory Zimmerwald
Date : 2009-12-02 12:30 UT
E-Mail : Werner.Gurtner@aiub.unibe.ch

7090 YARL Yarragadee		sat		wl		DGFI		MCC		HIT-U		SAO		JCET	
						rb	pr	rb	pr	rb	pr	rb	pr	rb	pr
7090	Average	532		4		3	5	2	2	2	0	2	1	6	
7237	Average	532		-16		2	-12	2	-19	1	39	3	-14	4	
7405	Average	847		-3		4	21	3	-3	2	14	1	5	6	
7406	Average	532		-7		5	-3	4	-6	2	-9	3	-10	9	
7501	Average	532					8	2	2	1			2	5	
7810	Average	532		16		2	-4	2	12	1	11	1	17	3	
7821	Average	532		34		6	150	5	36	5	219	8	29	7	
7825	Average	532		-7		4	-7	3	-4	4			-14	6	
7839	Average	532		-1		2	-9	1	-9	0	0	0	-10	3	
7841	Average	532		5		4	0	2	-6	3			-14	4	
7845	Average	532		-16		4	-6	3	-25	3	23	2	-24	5	
7941	Average	532		1		3	9	2	-8	2	21	3	-3	3	
8834	Average	532		33		3	18	2	23	1	22	0	22	4	

sc : Satellite
wl : Wavelength (nm)
rb : Range bias (mm)
pr : Precision estimate (mm)

DGFI : Deutsches Geodaetisches Forschungsinstitut (Munich)
MCC : Mission Control Center (Moscow)
HIT-U : Hitotsubashi University (Kunitachi, Tokyo)
SAO : Shanghai Astronomical Observatory
JCET : Joint Center for Earth System Technology, UMBC/GSFC

Remarks

- ❑ The latest ILRS official product has adopted a common bias strategy for the single AC solutions to avoid artificial jumps in the coordinate time series
- ❑ The bias estimation has been kept at minimum to avoid weakening the weekly solution and corrupting the coordinate (mostly the UP)
- ❑ The latest ILRS contribution to the next ITRF clearly shows the benefit of the work done on the biases: small refinement needed
- ❑ A data handling SINEX file contains the recommendations to be adopted by all ILRS ACs. A “discontinuity file” is under preparation.
- ❑ Engineering reports, daily QC are routinely used