The temporary ILRS reference frame: SLRF2005

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ILRS Fall Meeting, 24-28 September 2007, Grasse
Benefits from:

- ITRF2000
  - Pre-1993 sites
- ITRF2005 rescaled
  - New models, better estimates
    - New sites up to 2005
- Updated solution
  - New sites since 2006

Existing Reference Frame
SLRF2005 generation flowchart

ITRF2000_SLR

ITRF2005_ILRS_rescaled

ASI.93-07 loose

Propagation & Roto-translation to ITRF2005

Combination

SLRF2005.snx

Note:
ASI.93-07 was downweighted and a subnetwork "core sites"+"new sites" was extracted from the solution to be combined with the other 2 TRF with the aim to minimize its influence over the network.
### Bad stations in ITRF2005 — edited before combination

<table>
<thead>
<tr>
<th>Code</th>
<th>PT</th>
<th>SOLN</th>
<th>T</th>
<th>Data_start__</th>
<th>Data_end___</th>
<th>Mean_epoch__</th>
<th>Status</th>
</tr>
</thead>
</table>
Coordinate sigma comparison

Sites with 3D sigma difference greater than 0.002 m

Coordinate sigmas (XYZ)
Velocity sigma comparison

Sites with 3D sigma difference greater than 0.001 m/yr
Higher residuals for those sites with short history in one of the two frames.
SLR2005 coordinate comparison: selected sites

Edited sites: all SOLN > 1 for 7210, 7839, 7840, 7403, 1953, 1868, 1873, 7884, 7236, 7530, 1831, 7589, 7294, 7824A, 7502, 7505, 7543, 7850, 7097, 7831, 1893, 7604, 7839, 8833, 7548, 7356

Most of this sites have a longer history in ITRF2000
Stations with jumps: Haleakala (7210)

ITRF2005 SOLN 1 combined with ITRF2000 to get a better estimate (above all for velocities)
Stations with jumps: Graz (7839)

ITRF2005 SOLN 1 combined with ITRF2000 to get a better estimate
Velocities: North America
Velocities: North America
Velocities: South America

Note: 7403 ITRF2005 SOLN 1
velocity in SLRF2005
Velocities: Europe

BarGiyyora - Helwan

simeiz

ankara

riyad
Velocities: Western Pacific
Conclusions

- SLRF2005 is temporary until a new ILRS reference frame will be set
- It takes the best from ITRF2000 and ITRF2005
- All SLR sites are represented in one reference frame
ILRS/AWG  Core sites

V. Luceri – e-GEOS S.p.A.

G. Bianco – ASI
MacDonald: range residuals from solution CGS2006_new

Station: 7080; Satellite: 7603901;

wmean = 0.0193

wmean = -0.0403
range residuals from solution CGS2006_new

Station: 7090; Satellite: 7603901;

Yarragadee

Station: 7105; Satellite: 7603901;

Greenbelt
range residuals from solution CGS2006_new

Quincy

Monument

Station: 7109; Satellite: 7603901;

Station: 7110; Satellite: 7603901;
Haleakala: range residuals from solution CGS2006_new

**Lageos-1**

- Station: 7210; Satellite: 7603901;
- HP5370A FREQUENCY INPUT SWITCHED TO EXTERNAL
- True Time GPS steered rubidium
- wmean = 0.0245
- wmean = -0.0116
- wmean = -0.0003
- ???

**Lageos-2**

- Station: 7210; Satellite: 9207002;
- wmean = 0.0017
- wmean = -0.0105

- 25 mm -37 mm -11 mm

Proposal for both satellites
Beijing: range biases from solution CGS2006_new

Data before 1999 deleted

Non core

Core
range residuals from solution CGS2006_new

Arequipa

Hartebeestock
Zimmerwald: blue range bias from solution CGS2006_new

Lageos-1
Bias start
Bias stop
CSPAD
Swapped counters
Riga event timer

Lageos-2

Proposal for both satellites
range residuals from solution CGS2006_new

Riyadh

Potsdam
Grasse: range biases from solution CGS2006_new

**Lageos-1**
- Station: 7835; Satellite: 7603901;
- Detection change:
- Oct 1998
- Sep 1991: ??
- \( w_{mean} = 0.0402 \)
- \( w_{mean} = 0.0141 \)
- \( w_{mean} = -0.0130 \)

**Lageos-2**
- Station: 7835; Satellite: 9207002;
- \( w_{mean} = 0.0313 \)
- \( w_{mean} = 0.0114 \)

**Proposal for both satellites**
- Non core
- Core
- 25 mm
Shanghai: range biases from solution CGS2006_new

Data before 1990 to be deleted

new counter HP5370B

Core Non core
Graz: range biases from solution CGS2006_new

Lageos-1

New calibration

$w_{\text{mean}} = -0.0115$

$w_{\text{mean}} = 0.0090$

Lageos-2

$w_{\text{mean}} = 0.0071$

$w_{\text{mean}} = -0.0170$

Proposal for both satellites

-22 mm
Herstmonceux: range biases from solution CGS2006_new

Station: 7840, Satellite: 7603901;

Lageos-1

Sept 15 1988

Stanford removal

wmean = 0.0211

wmean = -0.0123
wmean = -0.0089

Station: 7840; Satellite: 9207002;

Lageos-2
Stromlo: range biases from solution CGS2006_new
Matera (7939) : range biases from solution CGS2006_new

Station: 7939, Satellite: 7603901;

Station: 7939, Satellite: 9207002;
Matera (7941) : range biases from solution CGS2006_new
Wettzell: range biases from solution CGS2006_new

- Dual-color
- Electronic update
- New control system

Proposal for both satellites

Core Non core

- Lageos-1
  - $w_{mean} = 0.0350$
- Lageos-2
  - $w_{mean} = 0.0353$

Proposal for both satellites

- 5 mm
- 40 mm
- -30 mm

Station: 8834, Satellite: 7603901
Station: 8834, Satellite: 9207092
Range residuals from solution CGS2006_new

Arequipa (7907)

Wettzell (7834)

Zimmerwald old

Wmean = 0.0518
50 mm Proposal

Matera (7939)

Wmean = -0.0440
-30 mm Proposal
ILRS core sites for EOP referencing

- 7080
- 7090
- 7105
- 7109
- 7110
- 7210
- 7249
- 7403
- 7501
- 7810
- 7825
- 7832
- 7834
- 7835
- 7836
- 7837
- 7839
- 7840
- 7849
- 7907
- 7939
- 7941
- 8834

- actual core sites for ILRS AWG
### ILRS core sites for EOP referencing

<table>
<thead>
<tr>
<th>Site No.</th>
<th>dome</th>
<th>Wav</th>
<th>from</th>
<th>to</th>
<th>Notes</th>
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<td>40442M006</td>
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<td>1981</td>
<td>1997</td>
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<td>7110</td>
<td>40433M002</td>
<td>G</td>
<td>1981</td>
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<tr>
<td>7210</td>
<td>40497M001</td>
<td>G</td>
<td>1976</td>
<td>2004</td>
<td>only from 1994 on??</td>
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<tr>
<td>7249</td>
<td>21601S004</td>
<td>G</td>
<td>2002</td>
<td>--</td>
<td>subset</td>
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<td>7403</td>
<td>42202M003</td>
<td>G</td>
<td>1990</td>
<td>dec 2000</td>
<td>subset</td>
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<td>7501</td>
<td>30302M003</td>
<td>G</td>
<td>2000.5</td>
<td>--</td>
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<td>14001S007</td>
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<td>1998</td>
<td>--</td>
<td></td>
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<td>50119S003</td>
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<td>2004</td>
<td>--</td>
<td>Stromlo</td>
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<td>7832</td>
<td>20101S001</td>
<td>G</td>
<td>2001</td>
<td>--</td>
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<td>7834</td>
<td>14201S002</td>
<td>G</td>
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<td>1991</td>
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<td>10002S001</td>
<td>G</td>
<td>oct 1988</td>
<td>2005</td>
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<td>G</td>
<td>1993</td>
<td>2004</td>
<td></td>
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<td>G</td>
<td>1997</td>
<td>2005</td>
<td>subset</td>
</tr>
<tr>
<td>7839</td>
<td>11001S002</td>
<td>G</td>
<td>1983</td>
<td>--</td>
<td></td>
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<td>13212S001</td>
<td>G</td>
<td>1983</td>
<td>--</td>
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<td>7849</td>
<td>50119S001</td>
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<td>1998</td>
<td>2003</td>
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<td>1992</td>
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<td>12734S001</td>
<td>G</td>
<td>1983</td>
<td>2000</td>
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<td>7941</td>
<td>12734S008</td>
<td>G</td>
<td>2001</td>
<td>--</td>
<td></td>
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<tr>
<td>8834</td>
<td>14201S018</td>
<td>G</td>
<td>may 1996</td>
<td>--</td>
<td>subset</td>
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</table>
REMARK

The definition of core sites for the ILRS should be unique.
No difference anymore between “core sites” and “sites for EOP referencing”
ILRS/AWG  Data corrections

V. Luceri – e-GEOS S.p.A.
G.. Bianco – ASI

ILRS/AWG Meeting September 24, 2007 ,
Grasse
## LIST OF DATA TO BE DELETED

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

<table>
<thead>
<tr>
<th>Site No.</th>
<th><strong>Wav</strong></th>
<th>Core</th>
<th>NonCore</th>
<th>Solve ?</th>
<th>Model ?</th>
<th>bias in sol V50</th>
<th>SOLUTION PROPOSAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1864</td>
<td><strong>G</strong></td>
<td>NC</td>
<td>YES</td>
<td>NO</td>
<td>1993.0 -&gt;</td>
<td>bias to be estimated over all the period</td>
<td></td>
</tr>
<tr>
<td>1868</td>
<td><strong>G</strong></td>
<td>NC</td>
<td>YES</td>
<td>NO</td>
<td>1993.0 -&gt;</td>
<td>bias to be estimated over all the period</td>
<td></td>
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<tr>
<td>1953</td>
<td><strong>G</strong></td>
<td>NC</td>
<td>YES</td>
<td>NO</td>
<td>--</td>
<td>bias to be estimated over all the period</td>
<td></td>
</tr>
<tr>
<td>7237</td>
<td><strong>G</strong></td>
<td>NC</td>
<td>YES</td>
<td>NO</td>
<td>1993.0 -&gt;</td>
<td>bias to be estimated over all the period</td>
<td></td>
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<tr>
<td>7530</td>
<td><strong>G</strong></td>
<td>NC</td>
<td>YES</td>
<td>NO</td>
<td>--</td>
<td>bias to be estimated over all the period</td>
<td></td>
</tr>
<tr>
<td>7548</td>
<td><strong>G</strong></td>
<td>NC</td>
<td>YES</td>
<td>NO</td>
<td>--</td>
<td>bias to be estimated over all the period</td>
<td></td>
</tr>
<tr>
<td>7810</td>
<td><strong>I</strong></td>
<td>C</td>
<td>YES</td>
<td>NO</td>
<td>--</td>
<td>bias to be estimated over all the period</td>
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<tr>
<td>7845</td>
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<td>YES</td>
<td>NO</td>
<td>--</td>
<td>bias to be estimated over all the period (bad for EOP referencing)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- **Wav:** G for GPS, I for INS
- **Core** and **NonCore** columns indicate whether the site is considered as core or non-core in V50.
- **Solve ?** and **Model ?** columns indicate whether the site solves the model and the model is used, respectively.
- **bias in sol V50** column indicates the bias in the solution for V50.
- **SOLUTION PROPOSAL** column provides the proposed solution for each site.
LIST OF SITES WITH RANGE BIAS APPLICATION
The range correction should be subtracted from the data and is one-way

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Wav</th>
<th>Core</th>
<th>NonCore in V50</th>
<th>Solve?</th>
<th>Model?</th>
<th>bias in sol V50</th>
<th>SOLUTION PROPOSAL</th>
<th>Bias Source</th>
</tr>
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<tbody>
<tr>
<td>7080</td>
<td>G</td>
<td>C</td>
<td>NO</td>
<td>YES</td>
<td>__</td>
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<td>Start Date</td>
<td>End Date</td>
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<td>Jan 31, 1993</td>
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<td>April 25, 1996</td>
<td>May 8, 1996</td>
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<td>G</td>
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<td>NO</td>
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<td>Jan 9, 1997</td>
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<td>NO</td>
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<td>Jan 25, 1988</td>
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<td>May 1984</td>
<td>Mar 15, 1987</td>
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<td>7123</td>
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<td>July 14, 1987</td>
<td>Oct 8, 1987</td>
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<tr>
<td>7210</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>1993 -2005</td>
<td></td>
<td>1983.0</td>
<td>Sep 15, 1987</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Sep 16, 1987</td>
<td>Jan 21, 1994</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Jan 22, 1994</td>
<td>2000</td>
</tr>
<tr>
<td>7308</td>
<td>G</td>
<td>NC</td>
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<td>YES</td>
<td>__</td>
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<td>Mar 7, 1995</td>
<td>May 19, 1995</td>
</tr>
<tr>
<td>7512</td>
<td>G</td>
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<td>NO</td>
<td>YES</td>
<td>__</td>
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<td>Mar 1992</td>
<td>May 1992</td>
</tr>
<tr>
<td>7517</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>__</td>
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<td>June 1992</td>
<td>August 1992</td>
</tr>
<tr>
<td>ID</td>
<td>State</td>
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<td>Dates</td>
<td>Magnitude</td>
<td>CDDIS/Analysis</td>
<td></td>
<td></td>
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<td>------</td>
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<tr>
<td>7525</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>March 1992 June 1992 11 mm</td>
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<tr>
<td>7544</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>Sept 1992 Dec 1992 -85 mm</td>
<td>Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7545</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>Oct 1993 Mar 1994 15 mm</td>
<td>Analysis</td>
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<tr>
<td>7580</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>Nov 1992 Jan 1993 68 mm</td>
<td>Analysis</td>
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<tr>
<td>7587</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>Aug 1992 Oct 1992 30 mm</td>
<td>Analysis</td>
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<td></td>
</tr>
<tr>
<td>7810</td>
<td>G</td>
<td>C</td>
<td>NO</td>
<td>YES</td>
<td>May 24, 1988 Sept 30 1989 50 mm</td>
<td>Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7811</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>May 20, 1993 May 19, 1998 -50 mm</td>
<td>Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7831</td>
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<td>NC</td>
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<td>YES</td>
<td>1987 June 1990 +85 microsec</td>
<td>CDDIS</td>
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<tr>
<td>7834</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>Mar 11, 1985 Jul 18, 1986 -30 mm</td>
<td>Analysis</td>
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<td></td>
</tr>
<tr>
<td>7835</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>Sep, 1991 Sept 9, 1997 25 mm</td>
<td>Analysis</td>
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<td></td>
</tr>
<tr>
<td>7836</td>
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<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>Jan 1, 1994 Oct 12, 1994 18.45 mm</td>
<td>CDDIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7839</td>
<td>G</td>
<td>C</td>
<td>NO</td>
<td>YES</td>
<td>1983 April 17, 1996 -22 mm</td>
<td>Analysis</td>
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<td></td>
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<tr>
<td>7840</td>
<td>G</td>
<td>C</td>
<td>NO</td>
<td>YES</td>
<td>Jan 1984 Dec 1984 30 mm</td>
<td>Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7843</td>
<td>G</td>
<td>NC</td>
<td>NO</td>
<td>YES</td>
<td>May 29, 1992 Feb 28, 1993 492.9 mm</td>
<td>CDDIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8834</td>
<td>G</td>
<td>C</td>
<td>NO</td>
<td>YES</td>
<td>1993 - 1997 1990 Sept 9, 1992 -35 mm</td>
<td>CDDIS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Site range biases

V. Luceri – e-GEOS S.p.A.

G. Bianco – ASI

ILRS/AWG Meeting September 24, 2007, Grasse
Bias estimation

- The biases are estimated with a long arc solution from Jan 1983 to Jul 2007 (CGS2006_new).
- The solution is loose and SSC/SSV are estimated over the entire time span.
- The biases before 1992, distributed by Erricos, have been applied.
- One bias estimate every 15 days after the SSC/SSV/EOP adjustment.
- The biases are one-way and should be subtracted by the observations.
- The pressure values from McDonald in 1995 and 1996 are corrected.
- Monument Peak bias of 16.36 cm from Aug 27, 1996 to Oct 2 is corrected.
CDDIS bulletin 7080 MLRS data was biased long by 2.5 cm between April 4, 1990 and January 31, 1993.

<table>
<thead>
<tr>
<th>Start Date</th>
<th>End Date</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>jan 1, 1988</td>
<td>dec 15, 1989</td>
<td>-40 mm</td>
</tr>
<tr>
<td>mar 30, 1990</td>
<td>jan 28, 1993</td>
<td>20 mm</td>
</tr>
</tbody>
</table>
Platteville: range biases from solution CGS2006_new

Data before 1985 to be deleted?
Mazatlan: range biases from solution CGS2006_new

<table>
<thead>
<tr>
<th>Start Date</th>
<th>End Date</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 1984</td>
<td>Mar 15, 1987</td>
<td>30 mm</td>
</tr>
</tbody>
</table>
From CDDIS Bulletin vol. 8, num 6
ATSC reports that TLRS-2 data from the 1987 occupation of Huahine, French Polynesia (July 14 to October 08) was biased short by 3 cm.

Huahine: range biases from solution CGS2006_new

From CDDIS Bulletin vol. 8, num 6
ATSC reports that TLRS-2 data from the 1987 occupation of Huahine, French Polynesia (July 14 to October 08) was biased short by 3 cm.
Tokyo: range biases from solution CGS2006_new

From 950307 to 950519 the bias is -300 mm
Kattavia: range biases from solution CGS2006_new

In the 1992 occupation the bias is -30 mm
In the 1992 occupation the bias is -94 mm
Melengiclik: range biases from solution CGS2006_new

In the 1992 occupation the bias is 68 mm
Yigilca: range biases from solution CGS2006_new

In the 1992 occupation the bias is 30 mm
Lampedusa: range biases from solution CGS2006_new

In the 1992 occupation the bias is -85 mm
Cagliari: range biases from solution CGS2006_new

In the 1993 occupation the bias is 15 mm

Bias to be estimated
Zimmerwald coordinate time series from ITRF web page

Events reported from Zimmerwald web pages

Start identified bias

Bias correction

Identified bias

CSPAD introduction

Reference Position of the plot:

X = 4331283.615 m  Y = 567549.835 m  Z = 4633140.324 m
Zimmerwald: ILRSA UEN residuals w.r.t. ITRF2000

- 1997 biases not explicitly reported but evident in the time series
- 2007 ILRSA solutions to be neglected due to wrong Stanford corrections applied
Zimmerwald Range Biases from Zimmerwald web page (http://aiuli3.unibe.ch:8000/slr/zm_calibration.html)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Jan 1997</td>
<td>ZIMLAT: Start of Operation</td>
</tr>
<tr>
<td>09 Jul 1997</td>
<td>Begin identified range bias</td>
</tr>
<tr>
<td>17 Jul 1997</td>
<td>End range bias</td>
</tr>
<tr>
<td>30 Jul 1997</td>
<td>Begin identified range bias</td>
</tr>
<tr>
<td>03 Sep 1997</td>
<td>End range bias</td>
</tr>
<tr>
<td>01 Jan 1998</td>
<td>Begin identified range bias</td>
</tr>
<tr>
<td>29 May 2002</td>
<td>End range bias</td>
</tr>
<tr>
<td>29 May 2002</td>
<td>Start applying Stanford counter corrections</td>
</tr>
<tr>
<td>11 Mar 2003</td>
<td>Blue: Start using CSPAD</td>
</tr>
<tr>
<td>28 Dec 2004</td>
<td>Blue: Swapped counters: 0236--&gt;3113</td>
</tr>
<tr>
<td>28 Dec 2004</td>
<td>Infrared: Swapped counters: 3113--&gt;0236</td>
</tr>
<tr>
<td>03 Feb 2006</td>
<td>Blue: Riga Event timer replaces Stanford</td>
</tr>
<tr>
<td>03 Feb 2006</td>
<td>Infrared: Applying new Stanford counter corrections</td>
</tr>
<tr>
<td>22 Mar 2006</td>
<td>Infrared: Riga Event timer replaces Stanford</td>
</tr>
<tr>
<td>21 Jun 2006</td>
<td>Blue and IR: Switched to external calibration</td>
</tr>
<tr>
<td>06 Mar 2007</td>
<td>Blue: Temporarily using PM again</td>
</tr>
</tbody>
</table>

Observations between **09 July 1997 and 17 July 1997**: All ranges are too long by 0.45 ns = 68 mm

Observations between **30 July 1997 and 03 Sept 1997**: All ranges are too short by 0.43 ns = 64 mm

Observations between **January 1998 and 29 May 2002, 00:00 UT**: All ranges are too short by 0.12 ns = 18 mm.

After February 6, 2006 **423 nm**: Lageos 1/2 flight times will become shorter by about 50 ps (i.e. -> from 1/1/97 to 6/2/06 range too long by 50 ps)

**846 nm**: Lageos 1/2 flight times will become longer by about 100 ps (i.e. -> from 1/1/97 to 6/2/06 range too short by 100 ps)
Zimmerwald: Lageos-1 range bias (blue) from solution CGS2006_new
Bias with ITRF2000 coordinates

<table>
<thead>
<tr>
<th>Start Date</th>
<th>End Date</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 9, 1997</td>
<td>July 17, 1997</td>
<td>All ranges are too long by 0.45 ns (68 mm 1-way)</td>
</tr>
<tr>
<td>July 30, 1997</td>
<td>Sept 30, 1997</td>
<td>All ranges are too short by 0.43 ns (64 mm 1-way)</td>
</tr>
<tr>
<td>January 1998</td>
<td>May 29, 2002</td>
<td>All ranges are too short by 0.12 ns (18 mm 1-way)</td>
</tr>
<tr>
<td>January 1997</td>
<td>Feb 6, 2006</td>
<td>50 ps too long for 423 (blue)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 ps too short for 846 (infrared)</td>
</tr>
</tbody>
</table>

The biases have been estimated without applying any correction to the data, the table on the right side reports the corrections reported by the stations, as a reference.
Zimmerwald: blue range bias from solution CGS2006_new

- Lageos-1
  - Bias start
  - Bias stop
  - CSPAD
  - Swapped counters
  - Riga event timer
  - Proposal for both satellites

- Lageos-2
  - Proposal for both satellites
Zimmerwald: infrared range bias from solution CGS2006_new

Proposal: bias estimation for both satellites
SLRMail 0013: new calibration from April 17, 1996 and no bias to be applied.

Jump probably due to the estimation of the bias until the end of 1996.
Graz: ILRSA UEN residuals w.r.t. ITRF2000

- New calibration
- HP5370+3Stanford substituted by Graz event timer
- kHz ranging

7839 Coordinate Residuals w.r.t. auxiliary\ITRF2000\JCETSLR.SNX

Up (mm)

- ilrsa: WMEAN: -2.932 WRMS: 7.393

East (mm)

- ilrsa: WMEAN: 0.676 WRMS: 3.559

North (mm)

- ilrsa: WMEAN: -0.747 WRMS: 5.988
Graz: information from configuration file

78393402 5 1995289 HP5370A: Trigger Thresholds from 0.25/0.21 to 0.25/0.17 V

78393402 6 1996025 HP5370A+2xSR620 now measure parallel; not yet in results
78393402 7 1996030 All 3 Counter Results now fully used

78393402 1 1996254 Counter #4 (SR620) added for parallel measurements
78393402 5 1996271 Time Walk Compensation: New Adjustment
78393402 6 1996296 3 Counters only; last SR620 removed
78393402 8 1996351 4 Counters again: HP5370A + 3 x SR620

78393402 1 1997030 UTC(TUG) supplies 1 pps, 10 MHz again
78393402 2 1997034 SR620/#1 now as reference counter (instead of HP5370A)

78393402 8 1997114 SR620#3 removed; HP5370A+2xSR620 remain
78393402 9 1997126 SR620#3 added again; Now: HP5370A+3xSR620

78393402 0 2000213 HP5370A + all 3 SR620's replaced by Graz Event Timer

October 9, 2003 kHz ranging
Graz: range biases from solution CGS2006_new

Lageos-1

New calibration
wmean = -0.0115

Graz event timer
wmean = 0.0090

kHz ranging

wmean = -0.0170

-22 mm

Proposal for both satellites

Lageos-2

Station: 7839; Satellite: 7603901;

Station: 7839; Satellite: 9207002;
Herstmonceux coordinate time series from ITRF web page

13212S001 7840

Reference Position of the plot:

X = 4033463.690 m   Y = 23662.520 m   Z = 4924305.198 m
Herstmonceux: ILRSA UEN residuals w.r.t. ITRF2000

<table>
<thead>
<tr>
<th>Start Date</th>
<th>End Date</th>
<th>Correction to be subtracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1, 1994</td>
<td>February 1, 2002</td>
<td>-2.5 mm</td>
</tr>
<tr>
<td>February 1, 2002</td>
<td>February 10, 2007</td>
<td>5.5 mm</td>
</tr>
</tbody>
</table>
Herstmonceux: range biases from solution CGS2006_new

Station: 7840, Satellite: 760390!

Lageos-1

Bias removal
Stanford removal

wmean\(=\) 0.0211
Sept:15 1988
??
wmean\(=\) -0.0018
wmean\(=\) -0.0082
wmean\(=\) -0.0078

Lageos-2

Station: 7840; Satellite: 9207002;

wmean\(=\) -0.0123
wmean\(=\) -0.0089
Wettzell coordinate time series from ITRF web page

14201 S018 8834

Jump probably due to the estimation of the bias until the end of 1996 (AWG decision)

Reference Position of the plot:

\[ X = 4075576.816 \text{ m} \quad Y = 931785.497 \text{ m} \quad Z = 4801583.581 \text{ m} \]
Wettzell: ILRSA UEN residuals w.r.t. ITRF2000

Electronic update

New control system

8834 Coordinate Residuals w.r.t. auxiliary\TRF2000_JCETSLR.SNX


ilrsa: WMEAN: 1.491 WRMS: 5.872

ilrsa: WMEAN: -1.707 WRMS: 7.127
Baseline system configuration:
MCP, PMT constant fraction discriminator Tennelec TC454
200 ps (FWHM) ND: YAG laser 532nm/1064nm
timing system lecroy 2229 TDC
GPS time receiver TTR6 Allen Osborne and BVA-quarz
(oscilloquarz)
mercury barometer Lambrecht 809 Digiquarz

APD (SP114) for dual colour
PMT replaced by APD (SP114), 2 detektor setup
new T/R system installed
SP114 for start-diode installed
new APD (SP114) installed
new MCP installed
BVA-quarz replaced by h-maser
upgrade of the mcp-electronic, 2 detektor setup
new nd:YAG laser (diode pumped, 80 psec pulse length)
new control system
Wettzell: range biases from solution CGS2006_new

Proposal for both satellites

Lageos-1

Dual color
Electronic update
New control system

Station: 8834; Satellite: 7603901;

meters


Lageos-2

Station: 8834; Satellite: 9207002;

meters


CDDIS Bulletin
January 1991 through October 1992 too short by 3.5 cm
November through December 1992 too long by 4.15 cm

Proposal for both satellites

-30 mm  40 mm  5 mm

wmean = 0.0350  wmean = 0.0001  wmean = -0.0050
wmean = -0.0368
wmean = 0.0353  wmean = -0.0006  wmean = -0.0064
Monument Peak: range biases from solution CGS2006_new

Until April 30, 1984 -> 35 mm
Oct 20, 1987 to Jan 20, 1988 -> 35 mm
Rivedere le date
Haleakala coordinate time series from ITRF web page

1994:021 HP5370A FREQUENCY INPUT SWITCHED TO EXTERNAL
1999:233 True Time GPS steered rubidium

Reference Position of the plot:
\[ X = -5466006.635 \text{ m} \quad Y = -2404427.332 \text{ m} \quad Z = 2242187.803 \text{ m} \]
Haleakala: ILRSA UEN residuals w.r.t. ITRF2000

1994:021 HP5370A FREQUENCY INPUT SWITCHED TO EXTERNAL
1999:233 True Time GPS steered rubidium
Haleakala: range residuals from solution CGS2006_new

**Lageos-1**

Station: 7210; Satellite: 7603901;

- HP5370A
- Frequency input switched to external
- True Time GPS steered rubidium

- wmean = 0.0245
- wmean = -0.0116
- wmean = -0.0003

- 25 mm
- -37 mm
- -11 mm

Proposal for both satellites

**Lageos-2**

Station: 7210; Satellite: 9207002;

- wmean = 0.0017
- wmean = -0.0105

Proposal for both satellites
1993:202 Rb-frequency standard for PS-500 Timer (elimination of large range bias!)
1998:139 Time Interval Counter STANFORD SR620 replaced PS-500-2
2002:127 Time Interval Counter PS500-2 replaced by STANFORD SR620
2003:088 Discriminator B6 replaced by discriminator TENNELEC TC454 in stop channel

Reference Position of the plot:
X = 3738332.784 m  Y = 1148246.542 m  Z = 5021816.063 m
Borowiec: range biases from solution CGS2006_new

**Lageos-1**
- PS-500 timer
- Stanford counter
- Discriminator change
  - wmean = 0.0045
- wmean = -0.0423
- wmean = -0.0299

**Lageos-2**
- Proposal for both satellites??
  - wmean = 0.0038
  - wmean = -0.0545
  - wmean = -0.0364
- -50 mm
- -35 mm

Station: 7811; Satellite: 7603901/9207002.
Grasse (7835) coordinate time series from ITRF web page

September 8, 1997: new detection package

Reference Position of the plot :

\[
\begin{align*}
X &= 4581691.614 \text{ m} &
Y &= 556159.578 \text{ m} &
Z &= 4389359.508 \text{ m}
\end{align*}
\]
Grasse: ILRSA UEN residuals w.r.t. ITRF2000
Grasse: range biases from solution CGS2006_new

Detection change

Sep 1991: ??

Proposal for both satellites

Lageos-1

Station: 7835; Satellite: 7603901;

dele data?

Lageos-2

Station: 7835; Satellite: 9207002;

bias.solve.3.out

wmean = 0.0402

wmean = 0.0141

wmean = -0.0130

25 mm

Proposal for both satellites

wmean = 0.0313

wmean = 0.0114

Year
2004:050 A031 Event Timer replacing SR620 time interval counter

Potsdam coordinate time series from ITRF web page

Reference Position of the plot:

X = 3800432.185 m  Y = 881692.087 m  Z = 5029030.100 m
Potsdam (7841) : range biases from solution CGS2006_new

Proposal: delete data before feb 19, 2004 for both satellites
Potsdam (7836) : range biases from solution CGS2006_new

7836 Potsdam data must be corrected by subtracting this value (123 picoseconds) from the two-way laser range: period January 01, 1994 through October 12, 1994.

123 picosec two way = 0.01845 mm
Shanghai: range biases from solution CGS2006_new

Data before 1990 to be deleted

new counter HP5370B
Beijing: range biases from solution CGS2006_new

Data before 1999 deleted
Remarks

• Zimmerwald: The jumps in the Lageos-2 bias series are also visible in the coordinate time series: higher correlation with the heights? Biases are roughly aligned to latest estimates.
• Herstmonceux: 8 mm jump at feb 1, 2002 not visible. Jump at feb 2007 still not detectable. Biases from sep 15 1988 to 1993.0 have a drift.
• Wettzell: A bias change appears (~ 1 cm) before the new control system, from the beginning of 2000.0. Biases are aligned to latest estimates.
• Grasse: correction on the data before oct 1988? What happened on sept 1991?
• Potsdam (7841): remove data before feb 19, 2004?
• Platteville (7112): remove data before 1985?
ILRSA “backwards” Combined Solution
pre-1993

G. Bianco, C. Sciarretta, V. Luceri

ILRS AWG Meeting, September 24, 2007, Grasse, France
ILRSA “backwards” solution – 1983-92

Status

• ILRSA CCs have been requested to generate the “backwards” combined solution starting from 1983

• The contributing solutions have to be provided as SINEX files, ‘loose’, with 15-day SSC and 3-day EOP estimates.

• At present, a preliminary set of contributing solutions is available from:

  **ASI, JCET, NSGF, GA**

Even if the final solutions will be provided after the agreed ILRS AWG revision on the overall assumptions (e.g. bias), the preliminary solutions are useful to test the combination procedure under more difficult conditions: old solutions are expected to be less accurate and precise, due to the lower number of contributing SLR stations and lower overall data quality.
ILRSA “backwards” solution – 1983-92

Combination procedure test

• In order to give a feedback to the contributing ACs for the final solutions generation, a test combination has been performed on the 1985 SINEX files

• The test combination is necessary also to the CCs to verify if the combination strategy must be modified to take into account the worse quality of the old solutions

• In the test, the loose combination strategy has been relaxed: weak sites and EOP estimates are not pre-eliminated, to keep as much as possible the data information; instead, estimates other than SSC and EOP in the SINEX files are pre-eliminated
Combination procedure test

• The ASI CGS combination procedure performs a very rigorous check of the SINEX formalism for each contributing solution: misalignment in the SINEX blocks (e.g. SITE/ID vs SOLUTION/ESTIMATE, incoherent PT code, ...) causes the rejection of the input file

• Outlier rejection strategy in the combination procedure must be carefully revised and adapted to the case of the old solutions: in several cases the combination test failed due to excessive outlier rejection

Only 15 combined solutions out of the possible 24 have been successfully completed, partly due to input files inconsistency and partly to the severe outlier rejection.

The partial results however give several indications.
On average, 13 sites are included in each 15d combined solution.

The combined solution gives 15mm level 3d wrms for all sites and 10mm level for the core sites.

GA shows the best performances (12mm, 8mm)

NSGF seems to be less aligned with ITRF2000 (38mm, 22mm)
ILRSA “backwards” solution– EOP

Figure 1: X pole - 15d differences wrt USNO "finals.data" (mean)

Figure 2: X pole - 15d differences wrt USNO "finals.data" (std)
ILRSA “backwards” solution– EOP

**y pole - 15d differences wrt USNO "finals.data" (mean)**

**y pole - 15d differences wrt USNO "finals.data" (std)**
ILRSA “backwards” solution– EOP

lo d - 15d differences wrt USNO "finals.data" (mean)

lo d - 15d differences wrt USNO "finals.data" (std)
ILRSA “backwards” solution– EOP

• The table below summarizes the statistics on the EOP residuals w.r.t. USNO finals.data (1 value each 3d) for the 1985 combined solutions (15) and the relevant contributing ones.

• The statistics on EOP residuals from the ILRSA combined solution for the jan-jun 2007 period are also reported as reference.

<table>
<thead>
<tr>
<th>Solution</th>
<th>X mean μas</th>
<th>X std μas</th>
<th>Y mean μas</th>
<th>Y std μas</th>
<th>LOD mean μs</th>
<th>LOD std μs</th>
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<td>jan-jun 07</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
ILRSA “backwards” solution
Next Future work

- 1983-1992 contributing solutions should be re-issued after conclusive ILRS AWG discussion on assumptions (e.g. bias)
- Contributing solutions are expected in the dedicated, agreed archive folder and with the agreed naming convention (at present, GA is different)
- Careful revision to be performed by ACs on the SINFEX formalism, in particular block alignment and coherence and on the analysis strategy if discrepant evidences result from the combination test (1985)
- Individual feedback on specific solution problems given (e.g. JCET)
- Careful analysis of the outliers rejection criteria by ILRSA CC; in particular, specific issues related to the loose combination strategy will be checked
ILRSA Weekly Combined Solution Status Report

G. Bianco, C. Sciarretta

ILRS AWG Meeting, September 24, 2007, Grasse, France
ILRSA solution – Jan/Sep 2007

Status

• ILRSA CC performed the combination activities in a nominal way

• The contributing solutions and the derived combination are still compared to ITRF2000 for SSC

• The contributing solutions and the derived combination are compared to “finals.daily” USNO values; they have been aligned to ITRF2005 since 14 June 2007: it causes visible bias in the residual series, as described by the USNO note n.24

• GA solution routinely ‘in’ since 070404

• 7941 excluded from core sites (to frame in ITRF2000) since 070411: 
  
  *apriori SSC/SSV to be updated*

• No major criticality has been found in the 2007 solutions
ILRSA solution – 3d WRMS

3d wrms wrt ITRF2000 - 2007 - all sites

3d wrms wrt ITRF2000 - 2007 - core sites
ILRSA solution – EOPs

![Graph of x pole - weekly differences wrt USNO "finals.daily" (mean)](image)

![Graph of x pole - weekly differences wrt USNO "finals.daily" (std)](image)
ILRSA solution – EOPs

**y pole - weekly differences wrt USNO "finals.daily" (mean)**

**y pole - weekly differences wrt USNO "finals.daily" (std)**
ILRSA solution – EOPs

**lod - weekly differences wrt USNO "finals.daily" (mean)**

**lod - weekly differences wrt USNO "finals.daily" (std)**
ILRSA solution – Helmert Parameters

Helmert Translation Parameters wrt ITRF2000

Scale wrt ITRF2000
Remarks

• The performance indicators show the expected good agreement of the combined solution w.r.t. the references (e.g. 1cm level 3d wrms for ITRF2000 residuals, core sites)

• The contributing solutions show an overall high-level behavior; ACs may check their individual performance from the weekly reports.

Future activities

• Inclusion of new AC contributions (e.g. OCA-GRGS)

• Alignment to ITRF2005
Status of ILRSB

Rainer Kelm
Deutsches Geodätisches Forschungsinstitut

Actual combination
Analysis 1983 -1992
Reanalysis 1993 -2007
Daily Combination
SP3C
Actual combination (1)

variance factors vf: 060107 - 070915

Weeks

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (3)

variance factors sig: 060107 - 070915

Weeks

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (4)

variance factors sig: 070106 - 070915

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (5)

Helmert parameter $t_\alpha$: 060107 - 070915

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (6)

Helmert parameter tx: 070106 - 070915

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (7)

Helmert parameter ty: 060107 - 070915

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (8)

Helmert parameter ty: 070106 - 070915

Weeks

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (9)

Helmert parameter tz: 060107 - 070915

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (9)

Helmert parameter tz: 070106 - 070915

ILRS AWG Meeting Grasse, September 24, 2007
Actual combination (10)

Helmert parameter sc: 070106 - 070915

ILRS AWG Meeting Grasse, September 24, 2007
Analysis 1983 - 1992

* Software is updated

* Remarks to test week 890607:
  - only GA solution available

Variance factors and their variances (VCE)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
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<td>0.70269</td>
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</table>
Renalysis 1993 - 2007

* waiting for new input solutions

Daily Combination

* waiting for input solutions
Test files of DGFI and JCET for Lageos 1, 2 and Etalon 1, 2 received on 2007-09-18

After a first look: no precision information (in contrast to GPS)
large discrepancies between the two orbits (about 10 km)

Combination strategy: Helmert transformation, then computation of mean?

Software updating in preparation
Activity Report to ILRS AWG

Ramesh GOVIND

ILRS AWG Meeting
24th September 2007
Grasse
Current Status and Activities

- Upgraded from Geodyn0401 to Geodyn0511
- Lageos-1 & Lageos-2 recomputed with new version for the period beginning 2002 to mid-2007 – testing new features (ATGRAV, annual variable gravity) + GGM02C
- Continue to submit the weekly SINEX product using Geodyn0401 – change from October 2007 submissions
# Status of Reprocessing –

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stella and Starlette (Progressing)</td>
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<td>Etalon-1</td>
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</tr>
<tr>
<td>Glonass-99</td>
<td>070121</td>
<td>070520</td>
</tr>
</tbody>
</table>
Re-processing

• Stella/Starlette experiments for appropriate parametisation
• Combinations for Glonass/Etalon/Giove to be re-done for the Geodyn0511 processing
JCET AC Activities Report

Erricos C. Pavlis
ILRS Analysis Coordinator
JCET/UMBC & NASA Goddard
• JCET Activities since last AWG:
  - Tested new SLRF2005 (*not implemented in routine ops yet*)
  - Running 1\textsuperscript{st} EOP DAILY with L 1 & 2 and E 1 & 2 since June
  - Added Starlette & Ajisai in test mode (*in ops by November?*)
  - Implemented a bias report for all sites (*L1/2, E1/2, ST & AJ*)
  - Updated eccentricities file, ready for release (*Haleakala???)
  - Addressed most action items from Vienna/Perugia (*SP3,...*)
  - ...

"Challenges for laser ranging in the 21st century"
ILRS Fall 2007 AWG Meeting, Grasse, France, 25–28 Sept., 2007
Comments

- SLRF2005 performs equally well and at times a lot better for tested sample arcs from various periods of the 1976 - present period

- Separate report on the 1d EOP from DAILY solutions (7-day arcs)

- Starlette & Ajisai analysis is limited to EOP results at present (more...)

- Developed a station bias report, format is a mix of CSR & Hit-U Rpts.

- An updated SINEX of eccentricities was developed (CDDIS 070625), release is pending imminent release of new Haleakala survey (when ???)

- Working on atmospheric correction files from ECMWF (soon :-)

- Testing the proposed CRD format that will replace the FR(QL/NP format...)

“Challenges for laser ranging in the 21st century”
ILRS Fall 2007 AWG Meeting, Grasse, France, 25-28 Sept., 2007
LEO s/c in weekly ops

- Starlette & Ajisai data were used for one year (2006) to test the improvement in 1\textsuperscript{st} EOP estimates due to the improved tracking geometry (more longitude coverage compared to just L1/2 & E1/2)

- Proper analysis of these data in TRF products will require the inclusion of atmospheric circulation modeling, on the ground and in orbit

- This makes the inclusion of these targets dependent on the regular availability of atmospheric field products from ECMWF

- We are currently obtaining such fields on a monthly basis from J.P. Boy

- We need a quicker turn-around and we need to work with the IERS Geophysical Fluids Center for such a service, using possibly the forecasts too, if we want these included for the DAILY EOP product (makes a big difference)
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<td>#</td>
<td>[mm]</td>
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</tr>
<tr>
<td>18645401</td>
<td>7/07/24 17:11 L1</td>
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DAILY Delivery Schedule

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- With this schedule the weekly product covering Sunday-Saturday of the week, could be delivered as early as the following Monday at 12:00 UTC (07:00 EST) instead of the current delivery on Wednesday

- **Do the ACs and CCs in particular, see this as a feasible schedule?**
Atmospheric de-aliasing fields

- The topic has the attention of many groups as IERS is looking into adopting a consistent treatment across techniques.

- If we use a purely mean gravitational field, we then need to account for the atmospheric signals (beyond those at TIDAL frequencies!!!) on the orbit and their loading part on the sites’ positions.

- Currently GEODYN handles both, however:
  - For our operations we need a prompt service.
  - JPB provides monthly fields only, 5-10 days post-fact.
  - DAILY 1\textsuperscript{d} EOP with LEOs would require these within 1 day.
Consolidated Laser Ranging Data Format (CRD)

Version 0.26

R. L. Ricklefs  
The University of Texas at Austin / Center for Space Research  
C. J. Moore  
EOS Space Systems Pty. Ltd.  
For the ILRS Data Formats and Procedures Working Group  

28 March 2007

Abstract

Due to recent technology changes, the existing International Laser Ranging Service (ILRS) formats for exchange of laser fullrate, sampled engineering and normal point data are in need of revision. The main technology drivers are the increased use of kilohertz firing-rate lasers which make the fullrate data format cumbersome, and anticipated transponder missions, especially the Lunar Reconnaissance Orbiter (LRO), for which various field sizes are either too small or non-existent. Rather than patching the existing format, a new flexible format encompassing the 3 data types and anticipated target types has been created.
Sample of new format data

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<tr>
<td>H9</td>
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</tbody>
</table>

“Challenges for laser ranging in the 21st century”
ILRS Fall 2007 AWG Meeting, Grasse, France, 25–28 Sept., 2007
Future Work

- SLRF2005: Reanalysis of 1976 to present (new IERS C04 \textit{a priori} series)
- 1d EOP DAILY: submit to NEOS for comments
- Starlette & Ajisai: more tests with improved modeling
- Station bias report: release on a weekly basis (more often?)
- Updated SINEX of eccentricities: release without Haleakala now?
- Atmospheric correction files from ECMWF: format conversion soon
- Testing CRD format: Test files from CSR on CDDIS
DAILY 1\textsuperscript{d} EOP ILRS products

Erricos C. Pavlis
ILRS Analysis Coordinator
JCET/UMBC & NASA Goddard

"Challenges for laser ranging in the 21st century"
ILRS Fall 2007 Workshop
25-28 September 2007 Grasse, France
Introduction

- 1st EOP PP for Daily delivery at JCET
- Status:
  - EOP ($x_p$, $y_p$, and LOD)
  - Running with L1 & 2 and E1 & 2 since June
  - Comparison with NEOS “finals”
  - Add Starlette & Ajisai (October)
  - Other items to be delivered if desirable (SINEX)…
Potential users

- For the EOP: primarily the **IERS Rapid Service (NEOS)**

- ITRF-origin-to-geocenter vector: **IERS/ITRS, IAU, geophysicists**

- Station health reports: of interest to **station managers**

- Orbit files: may be of interest to **other techniques** that use SLR to calibrate their systems (GNSS, RADAR, etc.)

- Daily SINEX files: may be of interest to **ITRS**
The operational scheme for the daily products is:

- **WEEKLY ARC (Sunday - Saturday)**
- **WEEKLY ARC -1st day + 1 new day**
- **WEEKLY ARC -1st&2nd day + 1 new day**
- **DELIVERED WEEKLY ARC**
- **SATURDAY EOP**
- **SUNDAY EOP**
- **MONDAY EOP**
- **TUESDAY EOP**
- **WEDNESDAY EOP**
- **THURSDAY EOP**
- **WEEKLY PRODUCT**

The PP is running at JCET since June 2007.
JCET Analysis Process

CDDIS/EDC

LAGEOS 1

LAGEOS 2

ETALON 1

ETALON 2

LAGEOS NEQs

ETALON NEQs

LAGEOS + NEQs ETALON

Relative weighting

ACCUMULATED NEQs OF LAGEOS AND ETALON FROM PREVIOUS WEEKLY REDuctions

~ 2 hours

• STATION COORDINATES
• STATION VELOCITIES
• EOP SERIES (1st EOP SINCE 1993)
• WEEKLY "geocenter-ITRF" offset
• WEEKLY 2nd deg. HARMONICS
• Higher HARMONICS
• ORBITAL PARAMETERS, …

"Challenges for laser ranging in the 21st century"
ILRS Fall 2007 AWG Meeting, Grasse, France, 25–28 Sept., 2007
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- With this schedule the weekly product covering Sunday-Saturday of the week, could be delivered as early as the following Monday at 12:00 UTC (07:00 EST) instead of the current delivery on Wednesday

- **Do the ACs and CCs in particular, see this as a feasible schedule?**
Daily EOP Test Statistics

• DAILY production test running at JCET since June

• Characterize the quality and stability of the product and its dependence on the available data by examination of the multiple estimates for each day (7) during each cycle of the process

• We have computed statistics for:
  – Orbital fits for different “7-day” arcs
  – The mean of the seven estimates and its std. deviation
  – The day being reported (last day of the arc, next to last, etc.)
SLR Daily $x_p$ vs. NEOS Finals

Date


x-pole (JCET 7-day mean & NEOS) [mas]
SLR Daily $y_p$ vs. NEOS Finals

$y$-pole (JCET 7-day mean & NEOS) [mas]


Date

Challenges for laser ranging in the 21st century
ILRS Fall 2007 AWG Meeting, Grasse, France, 25–28 Sept., 2007
SLR Daily $\text{UT1-UTC} \ vs. \ \text{NEOS Finals}$

Date

$\text{UT1-UTC (7-day mean)}$

$\text{UT1-UTC NEOS}$
SLR Daily EOP Statistics

Weighted mean std. dev. of $x$-pole [$\mu$as] | $92 \pm 11$

Weighted mean std. dev. of $y$-pole [$\mu$as] | $91 \pm 9$

Weighted mean std. dev. of $UT1-UTC$ [$\mu$s] | $157 \pm 14$

Daily 1st EOP Statistics vs. NEOS Finals

“Challenges for laser ranging in the 21st century”
ILRS Fall 2007 AWG Meeting, Grasse, France, 25–28 Sept., 2007
Summary

- New ILRS product: DAILY EOP SINEX (with respect to adopted ITRF)
- Initially only EOP to be reported
  - We can extend this to full SINEX
- A 3-month test at JCET shows consistency with WEEKLY products
  - Estimated Std. Dev. of EOP at ~ 90 μas (PM) and ~160 μs (UT1)
  - Combined product of more ACs, will likely improve by a factor of 2
- We expect that all ACs and CCs will participate by the end of 2007
- Currently investigating the addition of Starlette & Ajisai in our analysis to improve the geometry in longitude coverage for even more robust EOP estimates

“Challenges for laser ranging in the 21st century”
ILRS Fall 2007 AWG Meeting, Grasse, France, 25–28 Sept., 2007
Orbital Arc Fit vs. DOW
Orbital Arc Fit vs. DOW

Challenges for laser ranging in the 21st century
ILRS Fall 2007 AWG Meeting, Grasse, France, 25–28 Sept., 2007
Daily Products’ Issues

• The routine delivery of ILRS products daily raises some issues:
  – Network non-uniformity (short- and long-term issues)
  – Data delivery latency
  – Quality AC products to facilitate CC’s work in tight schedule
    • *Daily delivery means that CCs will operate in an automated fashion, so no more “fixing” of e.g. SINEX format problems!*
  – DCs need to be aware of increased traffic and ensure 24/7 availability of their servers, minimizing down-times and ftp outages
The ILRS Network

NORTH SITES: 16

SOUTH SITES: 6

~ 135° gap in longitude!

"Challenges for laser ranging in the 21st century"
Network Delivery Record

Normal Point Data Latency
April - May 2007

Within 12 hours

Within 4 hours

DAYS

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Simosato  San Fernando  Matera  Borowiec  Wettzell  Yarragadee  Zimmerwald  San Juan  Potsdam  McDonald  Arequipa  Beijing  Greenbelt  Changchun  Haleakala  Hartbeeshoek  Monument Peak  Liv  Riyadh  Herstmonceux  Shanghai  Koganei  Concepcion  Tanegashima  Riga  Simeiz  Graz  Maidanak 1  Katziely  Mt Stromlo
Data Center availability

• Over the past couple of years we have encountered cases where unavailability of a DC delayed deliveries from one day to weeks

• ACs would like to see DC operate in a “mirror” mode, with identical data, organization and access privileges

• With the price reduction of GBs/$ it should be possible for each DC to run a second disk on a separate server (much smaller than the primary one), with ONLY the data of the last 12 months

• If something happens to the main server, switching to the secondary one should minimize ftp disruptions for AC access
Daily Product(s)

- Due to the peculiarities of the SLR data delivery schedule and the sparseness of the network, there are also questions about what to deliver as the “daily product”

- Some of the issues are being checked now and will be decided with input from the user community (and primarily NEOS):
  - The day to be reported (last day of the arc, next to last, etc.)
  - Weigh trade-off between having a “fresher” set of EOP vs. a more accurate one, etc.
Daily Product(s)

• Currently working on a DAILY IERS product, initially for EOP only
  – Pilot project (PP) in progress
  – Evaluating the quality and reliability of this product
  – Exploring interest for additional products (full SINEX?)

• The PP will likely run until the product is accepted, at which time it will become part of the operational routine of the ACs & CCs
The IERS Conventions Workshop and Journées on Spatio-Temporal Reference Systems

IERS Workshop on Conventions 2007
20-21 Sept. 2007, Sèvres, France

Journées "Systèmes de référence spatio-temporels"
17, 18, 19 September 2007 - France

JSR2007
17-19 Sept. 2007, Meudon, France
ILRS Presentation at Jounées

- See the 1st EOP DAILY product presentation
IERS Workshop on Conventions: 20-21 September 2007

Summary

Over the last three years the IERS Conventions Center has worked on updating the IERS Conventions (2003), since 2005 with the help of an Advisory Board on IERS Conventions Update. This work is reflected in the website http://bai.bipm.org/iers/convupd/convupd.htm, which keeps track of all updates since the 2003 version.

Nevertheless much remains to be done in order to present a consistent set, in agreement with the current state of knowledge, and to have it actually put into practice by analysis centres. To this end a workshop on the IERS Conventions will be organized at the BIPM on 20-21 September 2007, with the following goals:

- to discuss models recently introduced or considered for introduction in the Conventions, and to present results of tests for these models;
- to define the directions towards a next edition of the IERS in the not-too-distant future;
- to discuss possible longer term issues, either institutional (e.g. scope of the Conventions, links to GGOS Working Group on Conventions, Analysis and Modelling), or technical, such as the definition of the regularized positions of stations (which displacement effects should be modelled and removed in the analysis, and which should not).

Scientific Organizing Committee:


The workshop is organized in conjunction with the Journées 2007 “Systèmes de référence spatio-temporels”, to be held from 17-19 September 2007 in Meudon.
Preliminary scientific programme

The scientific programme will cover five themes, as indicated below. Contributed papers are welcome for all five themes. In addition, some of the themes will include position papers, invited talks, and discussions.

Theme 1. Recent advances and validations of the IERS Conventions models
- Ocean pole tide
- Atmospheric S1/S2
- Models of tropospheric propagation
- ITRF2005
- ...

Theme 2. Conventional contributions to local station displacements: what to include?
- Should non-tidal loading effects be considered as conventional?
- How should loading effects be handled?
- How should conventional models (for loading) be distributed?
- Accounting for geocenter motion
- ...

Theme 3. Evolution of the realization of reference systems
- ITRF: possible new approaches / new datum specifications
- ICRF
- Transformation Celestial-Terrestrial e.g.:
  - specification for translational (geocenter) motion
  - new theories
- ...

Theme 4. Technique-dependent conventions
- Presentations for each IERS technique
- Definition of a reference temperature
- Impact of technique-dependent effects on local ties
- ...

Theme 5. Evolution of the Conventions
- Scope of the IERS Conventions
- Guiding principles for IERS Conventions models
- The Conventions as an electronic document
- Conventional software
- SINEX documentation of models
- ...
Workshop Links

• Journées on Spatio-Temporal Reference Systems 2007:
  http://syrte.obspm.fr/journees2007/

• IERS Conventions Workshop 2007:
  http://www.bipm.org/en/events/iers/
Overview of SLR topics

- The ILRS Network
  - Geometry and (in)homogeneity
- A look at the LR measurement chain
  - Level of uncertainty in the various components
  - Deficiencies in LR modeling (by choice or real)
- ILRS plans to address deficiencies
  - Areas where IERS can coordinate the consistent adoption of models for all space geodetic techniques
The ILRS Network

NORTH SITES: 16

SOUTH SITES: 6

~ 135° gap in longitude!
SLR Error Budget

Uncertainties due to Limited Knowledge or Modeling *NOW*

Improvements:
- Improved s/c CoM offsets
- New refraction modeling with gradients
- Atmospheric Loading & Gravitational Potential
- Better ground survey and eccentricity monitoring

Copyright 2006 © Teddy Pavlis
The SLR scale “non-problem*”

*AKA the VLBI Pole Tide Problem
Force Models

• **Satellite orbit (force) modeling:**
  - gravity (temporal signal primarily) from Earth fluid envelope, secular and seasonal signals (GRACE)
  - empirical accelerations, (catch-all “sponges”)
  - Earth albedo (setup a service?),
  - Solar Flux at 1 AU (adopt a new constant? - 1367.2035 W/m²),
  - thermal force modeling (L1/L2 ~OK, other s/c?),
  - solar/lunar eclipsing, etc.

• **Conventions:** should conventional model and parameterization strategies be documented (some effects apply to other techniques too)?

• **Relation to other techniques:** similar situation for GNSS, DORIS, and other satellite systems

• **Impact:** uniform treatment of similar phenomena, consistent products
Attitude Models

• **Satellite attitude modeling:**
  - Limited mostly to non-TRF contributing s/c, e.g. altimeter satellites (JASON, ENVISAT, etc.) and to GNSS s/c that in the future will contribute to TRF products with SLR observations
  - For cannonball s/c it amounts to a time series of the spin-axis direction and spin rate (adequate models only for L1/2).

• **Current treatment:** documentation in progress for remote sensing s/c, improved models for LAGEOS s/c, difficult to maintain without observations from the ground

• **Relation to other techniques:** similar situation for GNSS, DORIS, and other satellite systems

• **Impact:** it can strongly influence estimated orbital parameters, especially in describing the thermal response of the s/c in orbit
• **Satellite Center-of-Mass offset:**
  - Once a fixed correction determined from pre-launch measurements
  - For GGOS/ITRF this correction is not only S/C dependent (obvious), but also "tracking-station-ops-regime dependent"

• **Current practice:** ILRS descriptions for all LR-tracked s/c: [http://ilrs.gsfc.nasa.gov/satellite_missions/center_of_mass](http://ilrs.gsfc.nasa.gov/satellite_missions/center_of_mass)

• **Relation to other techniques:** issue exists for all s/c whose position is determined with SLR technique

• **Impact:** strongly affects network scale, scale-rate, and deformation, as well as cm-level position of tracking sites, current knowledge indicates that this is an error source that limits the quality of SLR orbital products
Spacecraft Targets

- **At present:**
  - LAGEOS 1 & 2
    - 1993 - present
  - ETALON 1 & 2
    - April 2001 - present

- **Considering to add:**
  - Starlette
  - Ajisai
  - ???

International Laser Ranging Service

NASA GODDARD SPACE FLIGHT CENTER

UMBC
Atmospheric delay modeling

• **Atmospheric delay models:**
  - LR is insensitive to water in the atmosphere, the delay being mainly that due to the hydrostatic effects. For high accuracy applications though, both effects need to be corrected for.
  - Few stations (2-3) range in two different wavelengths in hopes of using the different delay paths for the two wavelengths to correct for the atmosphere. Unfortunately, we are far from able to make use of this technique due to extremely stringent timing requirements in measuring the differential delay.

• **Current practice:** precise modeling has been used for many decades, using environmental observations at the site, during the observing session.
  - Until recently, ILRS used a model developed in 1973 (Marini-Murray).
  - Since January 2006, a new model (Mendes-Pavlis) that incorporates a new zenith delay model and new mapping functions, is used (already in the new IERS Conventions).
  - It is now evident that for even higher accuracy at low elevation tracking, we will need to introduce the modeling of horizontal gradients. There are plans to do so in the near future, but success depends largely on the availability of global synoptic satellite measurements from space (e.g. AIRS, COSMIC, etc.).

• **Relation to other techniques:** VLBI & GPS affected even more, but able to self-estimate the signal due to strong geometry of data.

• **Impact:** neglected effects cause small internal deformations in frame.
Atmospheric Gradients

LAGEOS 1

ΔBiasE (mm)

Station

HX  GZ  ZM  MA  GR  MP  MD  HH  YA  MS

AIRS 3d
AIRS 2d+grad

LAGEOS 1

Δc_0^2 (%)

Station

HX  GZ  ZM  MA  GR  MP  MD  HH  YA  MS

AIRS 3d
AIRS 2d+grad
Measurement Biases

• **Types of biases encountered:**
  - LR is in general a bias-free, absolute ranging technique. However, stations can develop biases due to errors in calibration, hardware malfunctioning, incorrect application of sub-system corrections, etc.
  - Simple measurement biases, timing biases or scale biases (very rare) can occur at times

• **Current practice:** Biases need to be monitored for all sites and for a number of sites (very few, poor data-yield sites) ILRS requires that biases be determined at all times
  - Pilot project is in progress, to monitor the biases and report back to the stations in near-realtime to minimize their impact on solutions and avoid the persistence of faulty operations for extended periods of time

• **Relation to other techniques:** VLBI & GPS probably face similar problems, but the relative nature of the measurements requires estimation of bias-type parameters anyway and this alleviates the problem for the most part

• **Impact:** if neglected, they will cause disastrous internal frame deformations
# Event Timer Biases

**Worse-case error estimates (mm)**

<table>
<thead>
<tr>
<th>Station</th>
<th>ID</th>
<th>Calibration error</th>
<th>LAGEOS error</th>
<th>Total error</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEIL</td>
<td>7249</td>
<td>-12</td>
<td>+10</td>
<td>-2</td>
</tr>
<tr>
<td>BORL</td>
<td>7811</td>
<td>-9</td>
<td>+0 meas</td>
<td>-9</td>
</tr>
<tr>
<td>BREF</td>
<td>7604</td>
<td>-10</td>
<td>+10</td>
<td>0</td>
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<tr>
<td>GLSV</td>
<td>1824</td>
<td>-6</td>
<td>+10</td>
<td>+4</td>
</tr>
<tr>
<td>HELW</td>
<td>7831</td>
<td>0</td>
<td>+10</td>
<td>+10</td>
</tr>
<tr>
<td>KTZL</td>
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</tr>
<tr>
<td>POT3</td>
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<td>+10</td>
<td>+10</td>
</tr>
<tr>
<td>POTL</td>
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<td>0</td>
<td>+5 meas</td>
<td>+5</td>
</tr>
<tr>
<td>SFEL</td>
<td>7824</td>
<td>0</td>
<td>+8 meas</td>
<td>+8</td>
</tr>
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<td>-3</td>
<td>+8 appl</td>
<td>-3</td>
</tr>
</tbody>
</table>

Closed sites:
- GRSL Grasse 7835 -1 10 11

meas = measured on particular Stanford counters; appl = applied at station
Site motion models

• **Types of models:**
  - Local deformation, tidal, loading, transient

• **Current practice:** LR at present follows the IERS Conventions 2003 in applying tidal motions at sites, including ocean loading effects and allows for local deformation (beyond linear tectonic motions) with ad hoc resets of the reference epoch of the position
  - At present there are no other loading signals considered (e.g. atmospheric)
  - Pilot project is in progress, to quantify the effect of atmospheric loading in the SLR products delivered to IERS.

• **Relation to other techniques:** The implementation of loading (and other similar signals) should be coordinated across all techniques and implemented simultaneously to avoid skewing the IERS/ITRF products

• **Impact:** if neglected, causes severe systematic signals in heights of sites and a component maps on the TRF scale due to the network shape and distribution
Summary

- LR analysis is in general well-supported by the current standards and conventions
  - Recent revisions of atmospheric delay models included already

- Analysis now suffers more from the non-implementation of known geophysical models (e.g. atmospheric loading, atmospheric gravity variations on orbits, etc.) and some coordination here is needed
  - A clear definition of cross-technique “tools” (e.g. SINEX for estimated parameters, SP3 format for orbits, etc.) is also required to ensure that all techniques’ needs and peculiarities are accommodated in any changes/extensions

- All of the (known at present) deficiencies in the LR processing and modeling chain are being addressed

- In the future, it will be desirable to cross-examine the compatibility of certain models across techniques, e.g. GR implementation
NSGF AC

- Regular weekly solutions automatic;
- Using new IERS C04_05 for a-priori
- Using LAGEOS and ETALON
- Re-processed 2000-2007 using Stanford corrections:
Herstmonceux 7840 SGF solution reprocessed with Stanford corrections included
Herstmonceux 7840 SGF solution

SGF 7-day L1+L2 coord series v10

NORTH (mm)

EAST (mm)

UP (mm)

Date
Herstmonceux 7840 SGF solution

SGF 7-day L1+L2 coord series v10

NORTH (mm)

EAST (mm)

UP (mm)

Date
Herstmonceux 7840 SGF solution

SGF 7-day L1+L2 coord series v10

NORTH (mm)

EAST (mm)

UP (mm)
Progress on Systematic Effects in Stanford counters used for Laser Ranging Observations

Graham Appleby, and Philip Gibbs

Space Geodesy Facility, Herstmonceux, UK

ILRS AWG, Grasse, 24th Sept 2007
Tests on counter linearity

- Relative to a ‘perfect’ time-of-flight counter, what are the characteristics of the counters in common use over the last 15+ years?
- Work was started by a careful examination of Stanford counters in use at Herstmonceux, relative to a high-spec, ps-level event timer.
- Counters from Potsdam and Boroweic also tested at Herstmonceux.
- Studied effects at LAGEOS and at local calibration target distances.
Herstmonceux counters

- A ps-level event timer (HET) has been built in-house from *Thales* clock units;
- A prerequisite for the upcoming kHz operations.

- Extensive use of HET to calibrate existing cluster of *Stanford* counters prior to routine use of HET;
- In particular we wish to back-calibrate Hx data 1994–present.
Comparisons between HxET and the Stanford counters for calibration boards’ distances;
Behaviour very similar to spec;
Errors up to 100ps (15mm), with some systematic detailed structure
Comparison between Hx ET and SRa, SRb & SRd

SRa - HxET
SRb - HxET
SRd - HxET

Range Difference (ps)

Range (milliseconds)

LAGEOS
Summary of effect on range measurements at Herstmonceux (1994–2007)

· The non-linearity of the Stanfords:
  · imparts an average of $\sim -5.5 \pm 2\text{mm}$ error onto the observed \textit{calibration} range;
    - The calibrations are too short;
    - Hence calibrated satellite ranges are \textit{too long by} 5.5\text{mm}.

· Value is dependent on the target range, electronic delays and on the particular Stanford;
  - Hence the inherent 2\text{mm} uncertainty in this correction
Summary of effect on range measurements at Herstmonceux (1994–2002)

- At distance of **LAGEOS**, range error is $\sim -8 \pm 2\text{mm}$;
  - observed raw LAGEOS ranges are too short
- **So total range error is:**
  - $+5.5 - 8.0 = -2.5 \pm 3\text{mm}$
  - i.e. need to add 2.5mm to LAGEOS ranges
- This correction applies to the period 1994 October 1 to 2002 January 31
Summary of effect on range measurements at Herstmonceux (2002–2007)

- From 2002 February 1 the satellite-range-dependent correction has been applied on-site
- The calibration error has **not been applied**
- So for the period 2002 February 1–2007 February 10:
  - Subtract 5.5mm from **all satellite ranges** from Herstmonceux

- From 2007 February 11, range error for all satellites is ~ zero, using new event timer
Effect present in other ILRS stations?
Tests at Hx with Potsdam (7836) and Borowiec counters - at calibration ranges

Comparisons for Potsdam (black), Borowiec (red), SRd (green) vs ET. Data is collected at 22ns interval.

Data has been aligned to the first data set at ~70ns.
Data is collected at 22ns intervals so that all data is on the same point of the 22ns error curve.
Tests at Hx with Potsdam (7836) and Borowiec counters - at calibration and LAGEOS ranges

- We find similar behaviour at ‘calibration’ ranges between the two counters and when compared with Stanford manual and with Hx counters;
- For Potsdam 7836 for 1992 May onwards, add 3 mm to LAGEOS ranges;
- For Potsdam 7841, estimate that between 2001 July and 2004 February add 5 mm to LAGEOS ranges (counter no longer available to test);
- For Borowiec for 2002 May onwards subtract 9 mm from LAGEOS ranges.
Effect present in other ILRS stations?

- At this stage, we confine our investigation to Stanford counters;
  - Our limited experience with e.g. HP timers suggests they do not have problem - used by NASA network
- We have made ‘worst case’ estimates of calibration error and total range error at LAGEOS for all ‘Stanford stations’:
- We take target range from Log files and calibration values from ILRS NP headers;
- Thus estimate $t_{of}$ for calibration ranging, hence Stanford error.
- Use worst-case estimate at LAGEOS range.

- Error span is $-9$ to $+11$mm, frequent error $+10$mm
- Uncertainty in these estimates could be up to $\sim 5$mm
## Worse-case error estimates (mm)

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<td>11</td>
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</table>

**meas** = measured on particular Stanford counters; **appl** = applied at station
Comments

• We emphasise the preliminary nature of this table;
  – The plots of the 3 Herstmonceux Stanford counters show large inter-counter differences;

• Calibration of each stations’ counter(s) is valuable but not absolute – still uncertainty in ‘zero point’.

• Interested to get other examples;

• Particularly important to look at San Juan, San Fernando
Summary/outlook

- We also note that:
- The stations are a subset of the full ILRS network, but do contain some core sites;
- The counters’ errors can be estimated (ongoing) and data reprocessed;
  - Counter characteristics remain static over time;
- Several of the stations have already upgraded to higher-quality counters.