VLBI-SLR Combination Solution Using GEODYN

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Overview

- Background and Motivation
- Geodyn Solution Procedure
- Comparison of GEODYN and CALC/SOLVE Solutions
- VLBI + SLR Combination Solution
- Conclusions

Background and Motivation

- IERS currently makes an ITRF from technique solutions from each technique analysis center (VLBI, SLR, GPS, DORIS)

- Problems with this method of combination:
  - Inconsistent a priori models
  - Different analysis software used by technique analysis centers
  - Different solution parametrizations used in technique analysis center solutions

Background and Motivation

- Working Group on Combination at the Observation Level was started by IERS

- To improve precision, resolution, and consistency of EOP, TRF, and CRF products

- Questions to be resolved:
  - weighting of different techniques
  - accuracy of colocation site ties
  - effect of common technique parameters like troposphere and clocks

Background and Motivation

- We want to generate a multi-technique solution using
  1) same analysis software
  2) same a priori models

- Our goal is to combine all the geodetic techniques at the observation level

- We use GEODYN to initially make a VLBI + SLR combination solution

GEODYN Solution Procedure

VLBI Input

- Observed Delays
- Calibrations
- Solution parametrization
- A priori model specifications

GEODYN

- Compute a priori model delays
- Run independent VLBI session solutions
- Generate session normal equations

GEODYN SOLVE

- Combine VLBI and SLR normal equations
- Estimate common parameters: Station positions, EOP (future: include any common atmosphere or clock parameters)

Input from the other geodetic techniques similarly passes through GEODYN

CALC/SOLVE Solutions

- Compared solutions for single 24-hour VLBI solutions using CALC/SOLVE and GEODYN.

- *A priori* position coordinates are in ITRF2005. *A priori* EOP series was IERS C04.

- Standard VLBI solution parametrization:
  - 20 minute troposphere parameters
  - 60 minute clocks
  - daily EOP estimated at session midpoint
  - station coordinates

- Each day was processed <u>independently.</u>

- We ran two types of solutions for sessions observed from 2007-2008

  1) estimate EOP and fix site positions to ITRF2005.
  2) estimate both EOP and site positions

CALC/SOLVE vs. GEODYN

Solution 1. Estimate EOP and fix site positions (2007-2008)

Difference Statistics

Parameter	Bias	WRMS	Chi2
X-Pole (uas)	9.6	46	1.31
Y-Pole (uas)	-1.2	37	0.97
UT1 (us)	-0.47	1.9	1.09

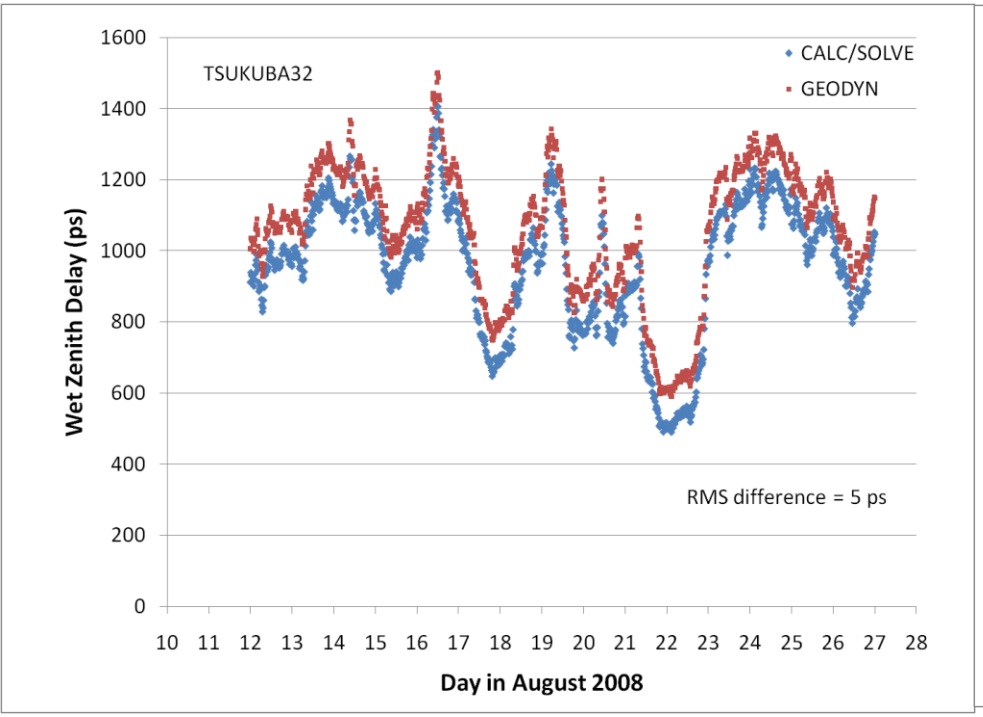
Solution 2. Estimate both EOP and site positions (2007-2008)

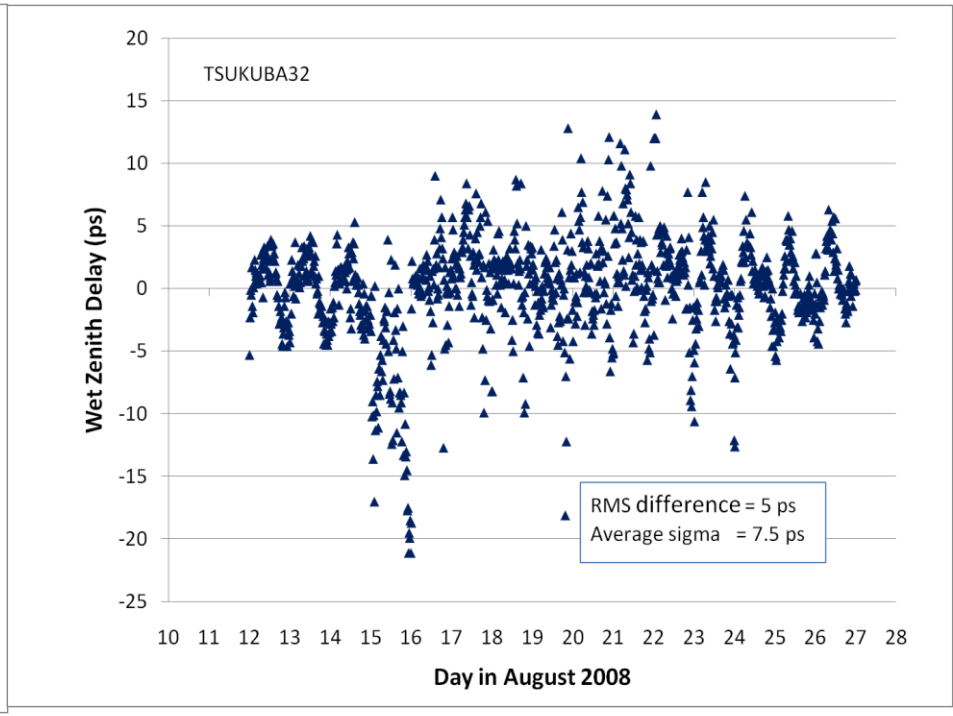
Difference Statistics

Parameter	Bias	WRMS	Chi2
X-Pole (uas)	16.5	64	1.09
Y-Pole (uas)	-14.2	71	1.29
UT1 (us)	-0.41	3.4	1.57

CALC/SOLVE GEODYN Comparison

CONT08 Wet Zenith Delays



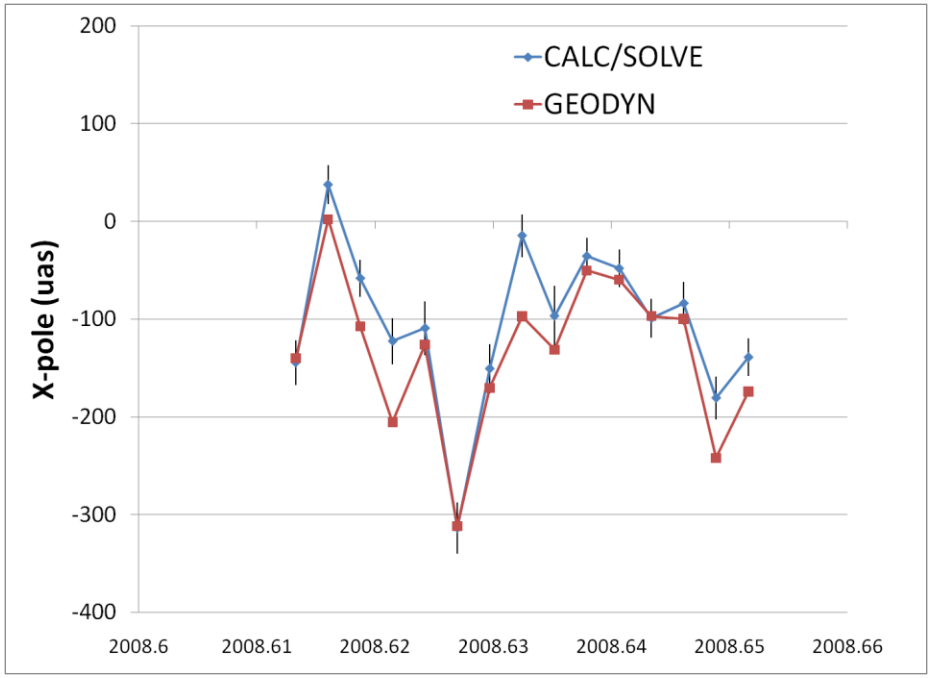


Comparison of the wet zenith delays estimated every 20 minutes at TSUKUB32 using CALC/SOLVE and GEODYN. The series were offset by 100 ps for clarity.

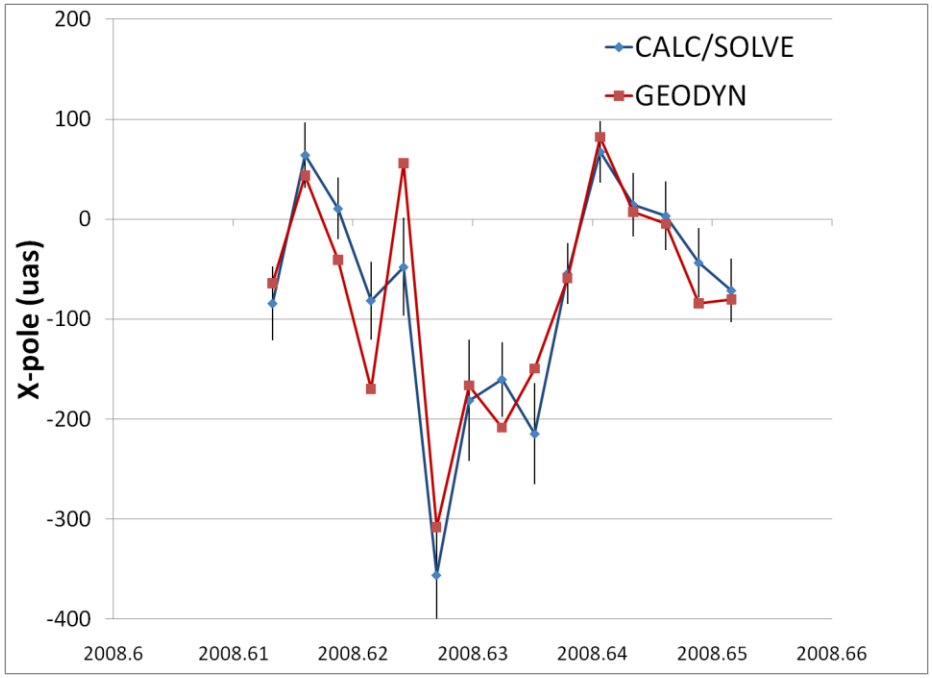
Daily signal in difference => Modeling difference

Calc/Solve GEODYN Comparison

CONT08



Station positions were fixed



Station positions were also estimated

Calc/Solve GEODYN Comparison

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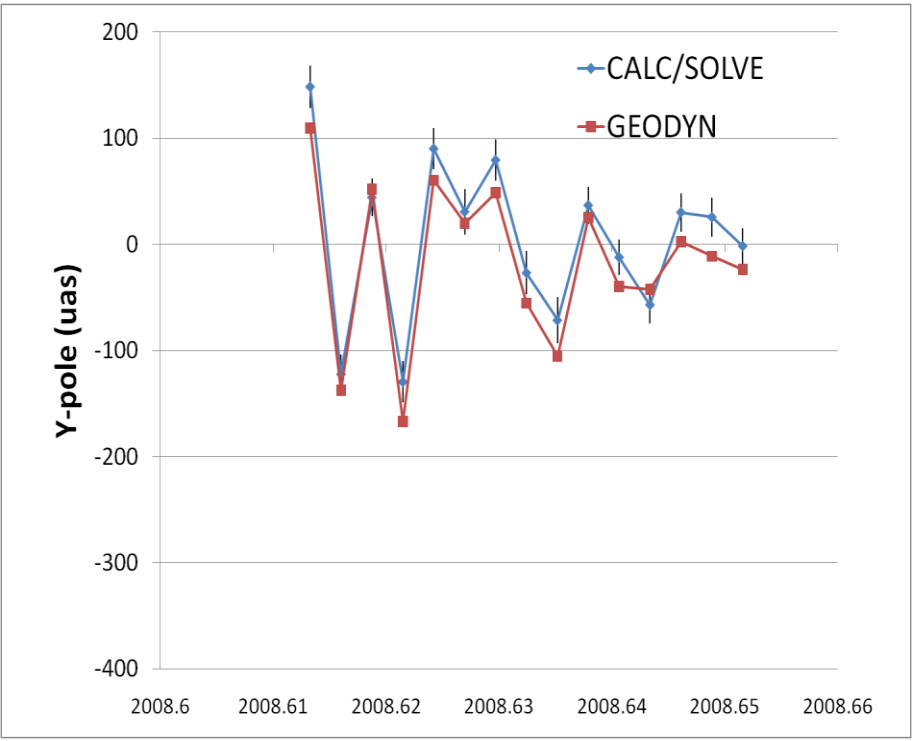
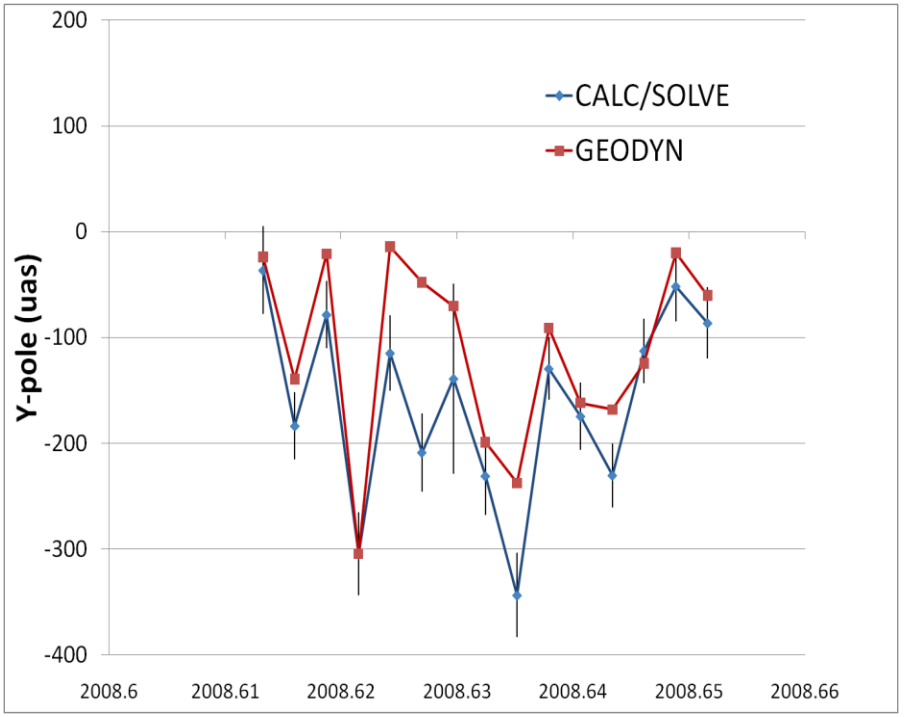


Station positions were fixed



Station positions were also estimated

Calc/Solve GEODYN Comparison

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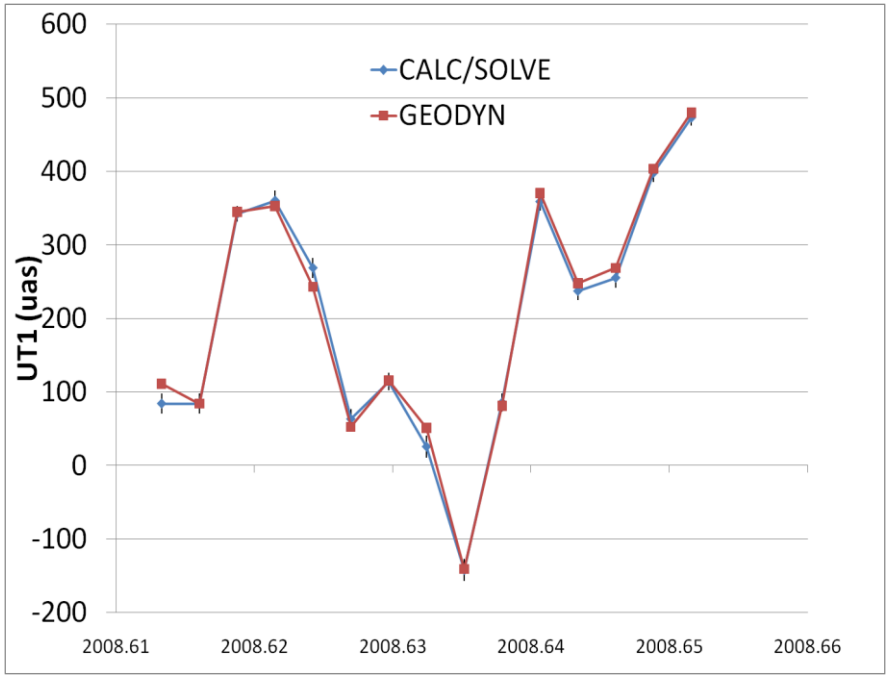
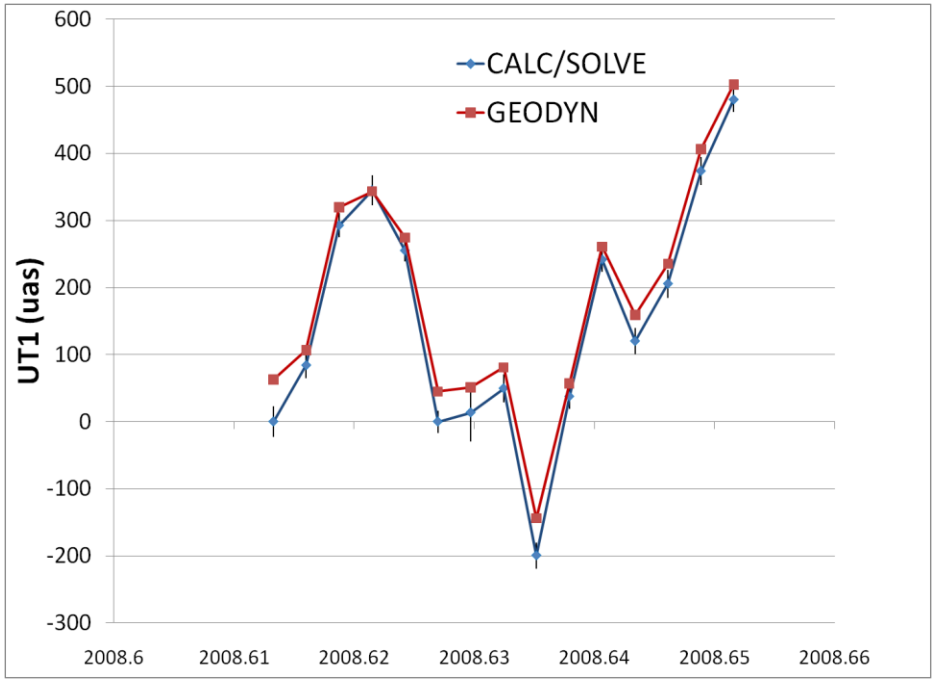


Station positions were fixed



Station positions were also estimated

SLR and VLBI GEODYN Solutions

1. Develop Normal equations for SLR data & VLBI data Using GEODYN for 2007-2008.

2. SLR processing uses Lageos1, Lageos2, Starlette, Stella, processed in 7-day arcs.

3. A single combined technique-specific normal equation is created to solve for EOP's from 2007-2008.

4. We have taken care to apply the same models to process both sets of data (e.g. pole tide, ocean loading with GOT4.7, Tidal EOP & COM). VLBI-session-specific parameters (troposphere and clocks) are adjusted separately and backsubstituted

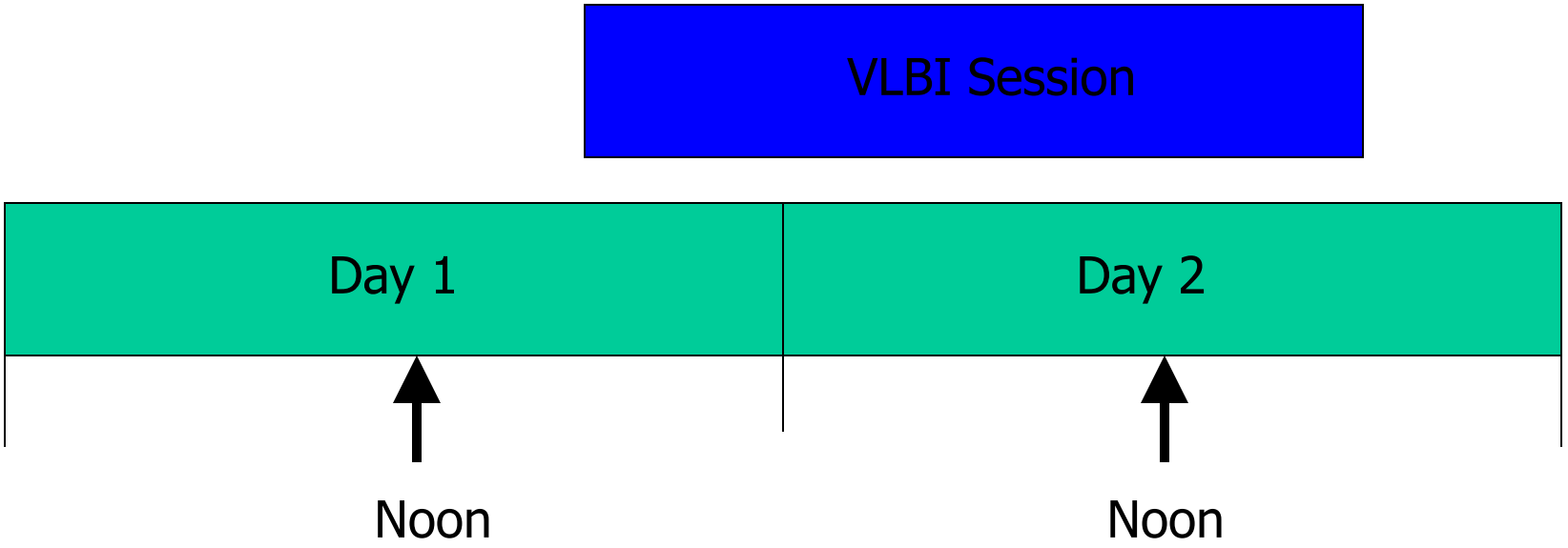
SLR and VLBI GEODYN Solutions

1. At first, only EOP adjusted so as to compare results and intercompare the GEODYN processing of the two space geodetic techniques. *A priori* coordinates are in ITRF2005 (VLBI) & LPOD2005 (derived from ITRF2005 for SLR sites: adjusted scale, add missing sites, add data from 1983-1992)

2. The results are compared with IERSC04; All GEODYN solutions are daily values at 12:00 UT.

3. Daily EOP epochs at 12:00 UT are not necessarily optimum for VLBI, as sessions have different time boundaries.
   - EOP is estimated for 2 noon epochs for each VLBI session

SLR and VLBI GEODYN Solutions



Each 24-hour VLBI session contributes to two Noon epochs of EOP estimation

SLR and VLBI GEODYN Solutions

Series	npts	Edit (mas)	RMS EOPx (mas)	Avg EOPx (mas)	RMS EOPy (mas)	Avg EOPy (mas)
VLBI Geodyn Noon	422	1	0.217	-0.033	0.251	-0.024
VLBI Geodyn Midpoint	272	1	0.203	0.044	0.203	-0.039
VLBI Calc/Solve Midpoint	278	2	0.132	-0.049	0.131	0.022

DIFFERENCES RELATIVE TO IERS C04

SLR and VLBI GEODYN Solutions

Series	npts	Edit (mas)	RMS EOPx (mas)	Avg EOPx (mas)	RMS EOPy (mas)	Avg EOPy (mas)
B. 4SLR (L1,L2+ Starlette+ Stella)	714	1	0.245	----	0.236	----
D. VLBI	433	1	0.212	----	0.247	----
E. VLBI+SLR	678	1	0.215	----	0.237	----

DIFFERENCES RELATIVE TO IERS C04

Conclusions

1. GEODYN and CALC/SOLVE parameter estimates for 24-hour VLBI sessions mostly agree at about the 1-formal sigma level : ~50 μas wrms for EOP.
2. More investigation is required to understand discrepancies between CALC/SOLVE and GEODYN when site positions are estimated along with EOP in independent 24-hour session solutions
3. RMS EOP differences between C04 and GEODYN SOLVE VLBI solutions are 1.5 times greater than for standard VLBI solutions --- Need to resolve this.
4. We need to investigate the optimal strategy for combining VLBI and SLR normal equations – considering e.g. ground ties and solution weighting
5. Add GPS and DORIS in the combination