The CONT Campaigns as a Precursor to VGOS Observing

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NVI, Inc. at NASA/GSFC

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Overview

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- CONT Campaign Results
  - EOP and Scale

- Future Networks
  - Continuous broadband observing
  - NASA Space Geodesy Project:
    VLBI+SLR+GPS TRF combination simulation

- Simulations of current and future performance

CONT Campaigns

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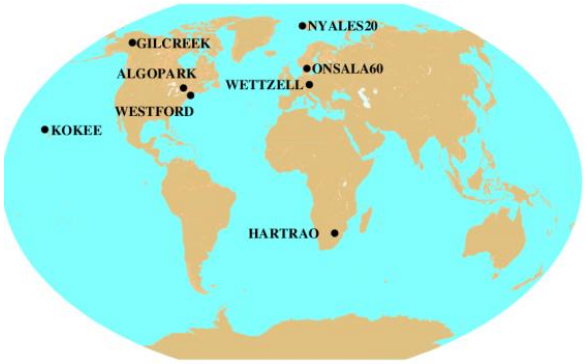
CONT02, 8 sites



CONT05, 11 sites

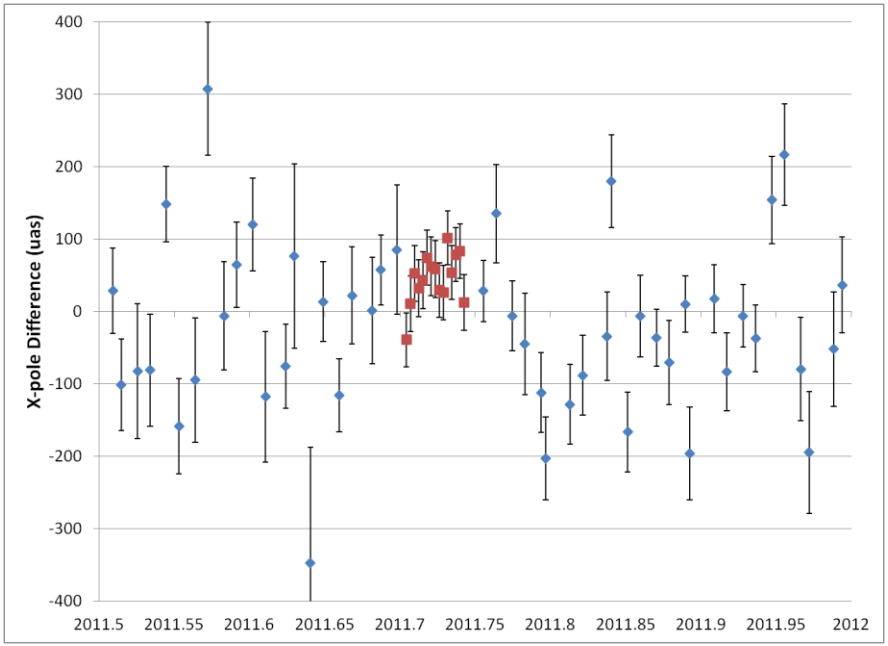
CONT08, 11 sites

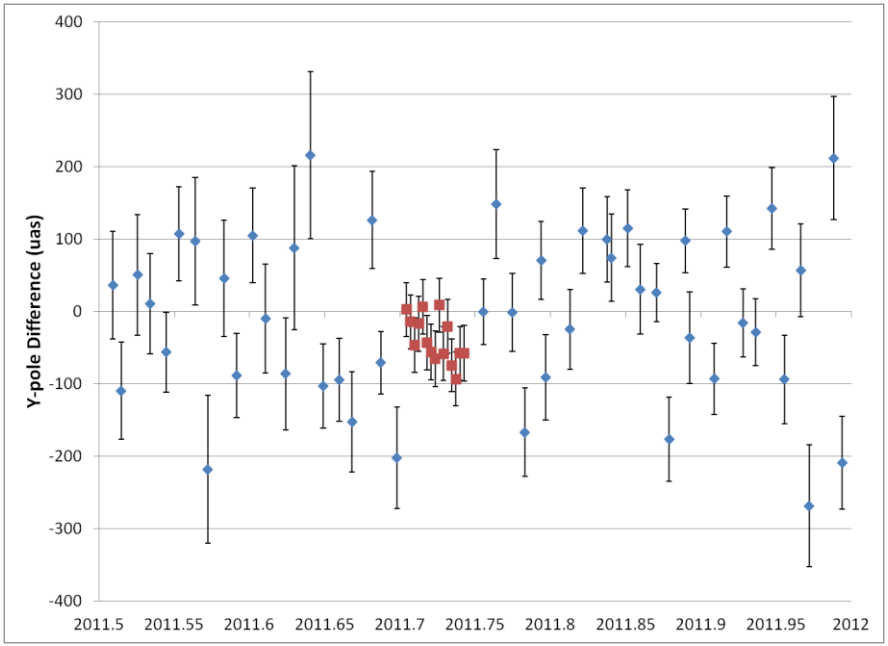
CONT11, 14 sites

CONT14, 16 sites

VLBI – GPS Comparisons

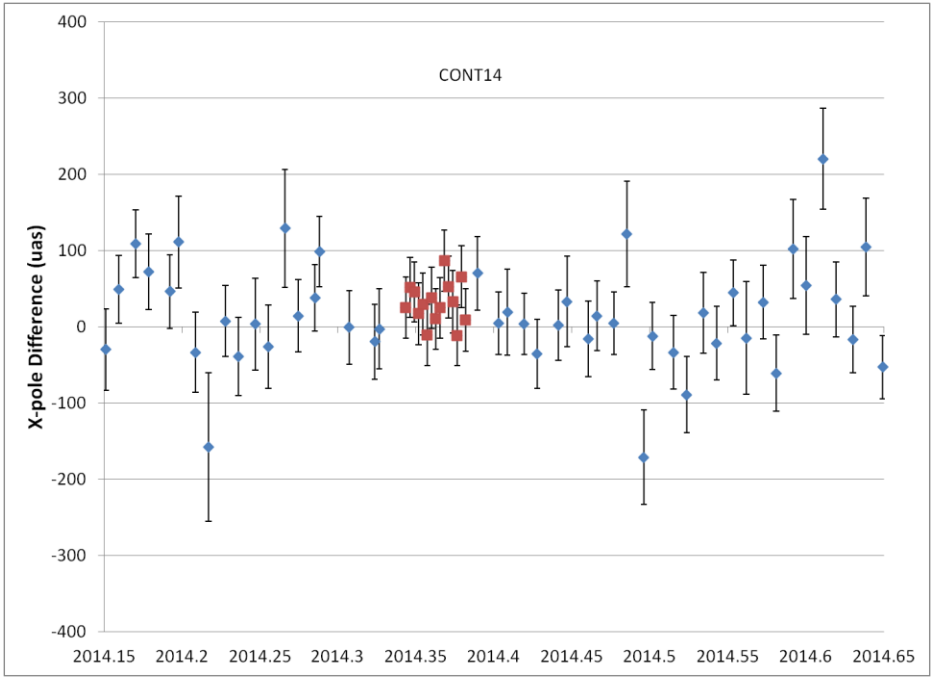
CONT11 Polar Motion

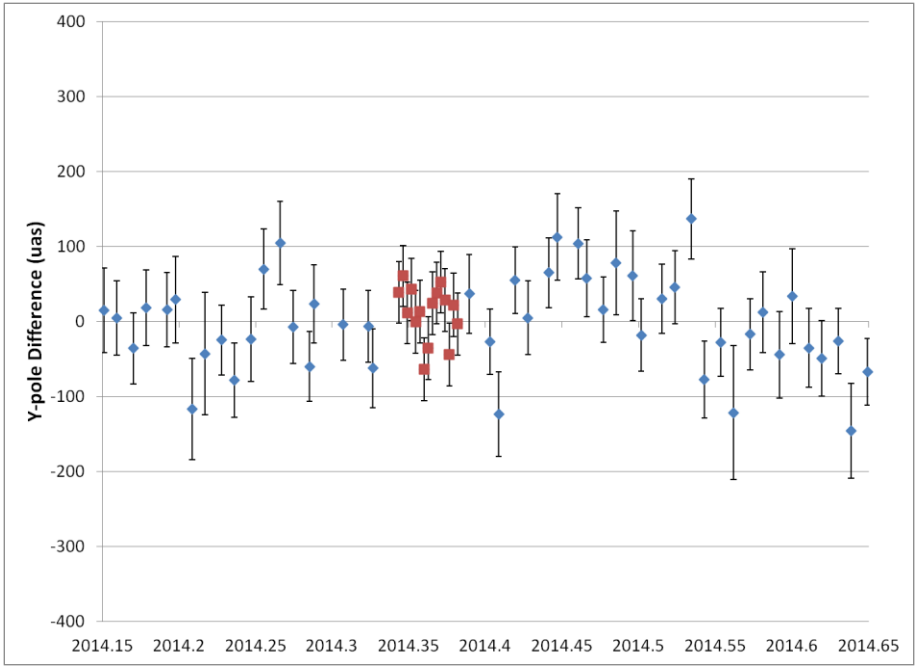




VLBI – GPS Comparisons

CONT14 Polar Motion





VLBI – GPS Comparisons

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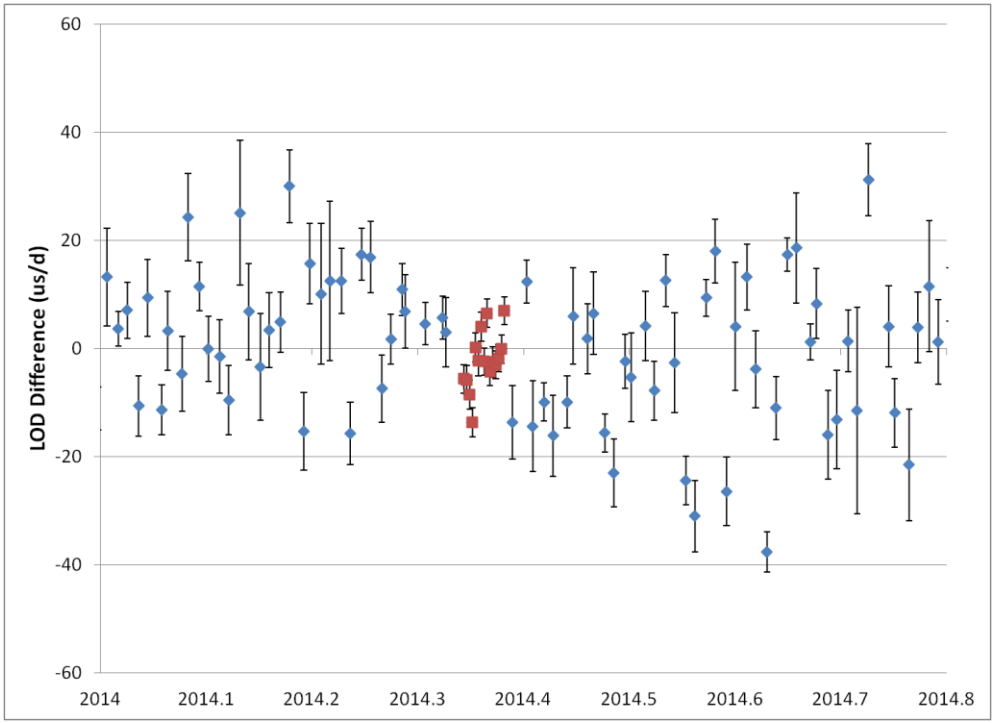
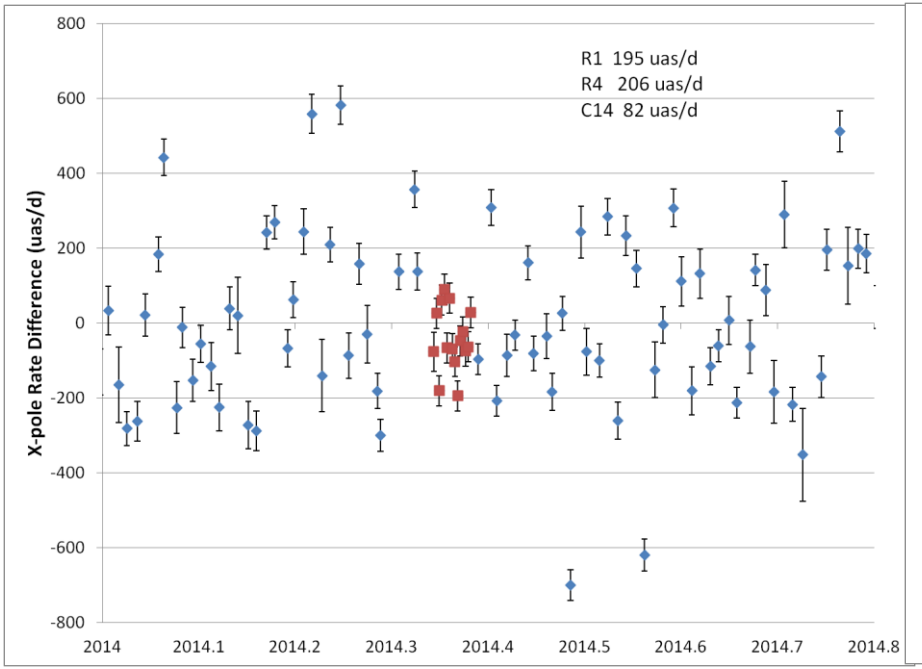
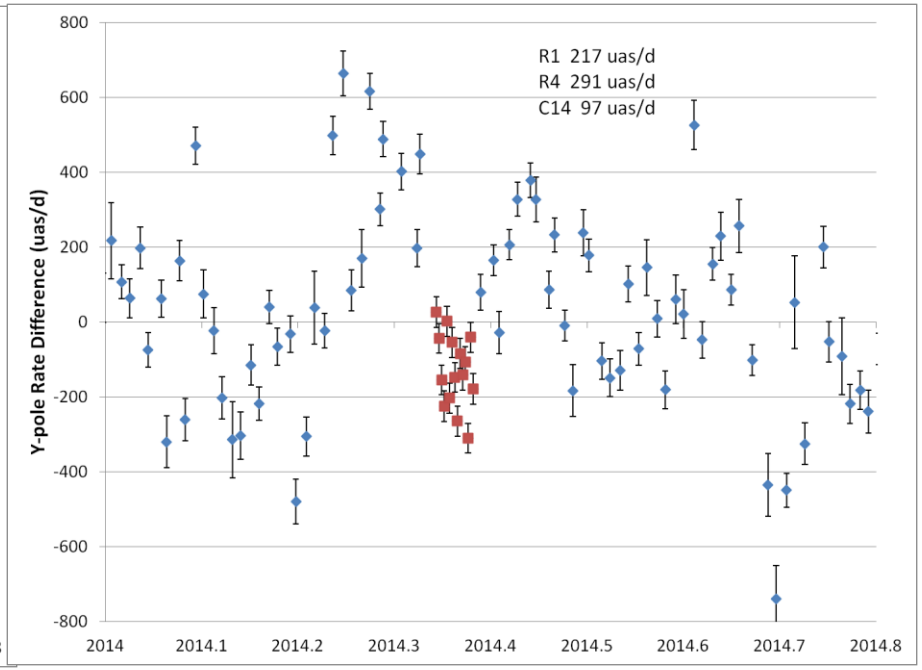
CONT14 LOD



VLBI – GPS Comparisons

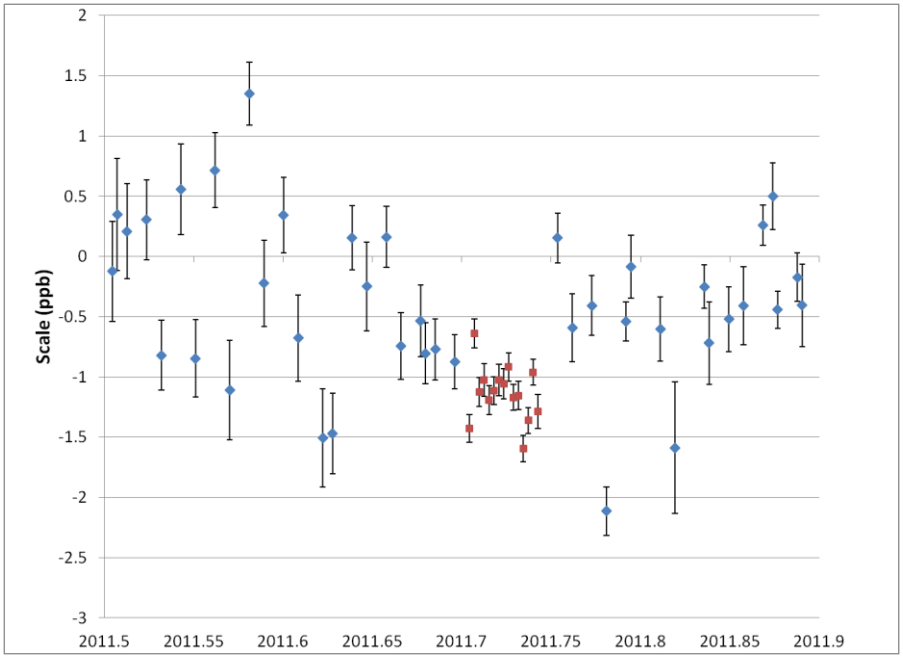
CONT14 Polar Motion Rates



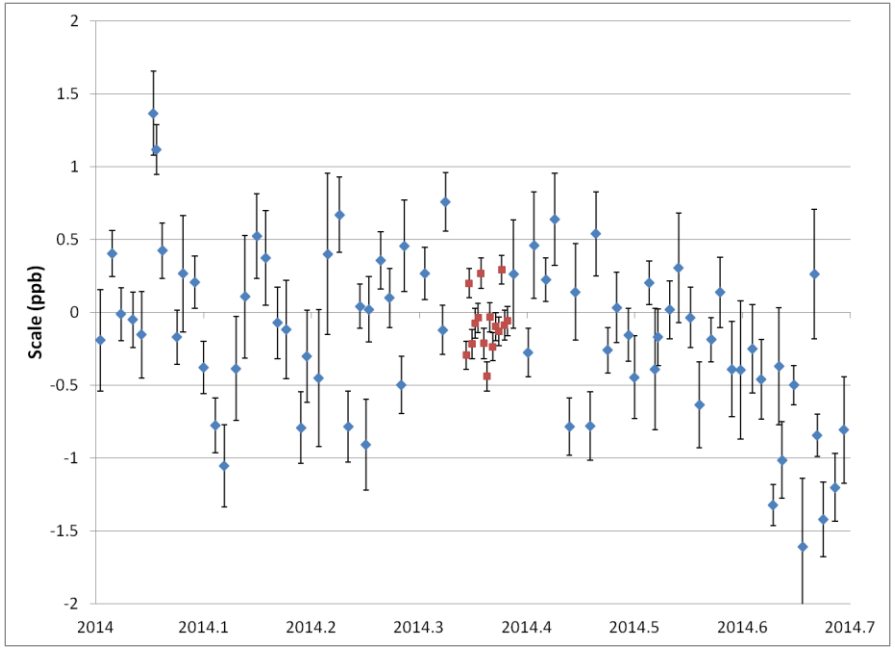


Scale Precision

CONT11 Scale



CONT14 Scale



Scale and EOP Precision

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	Scale		Xp	Yp	Xpr	Ypr	LOD
	ppb	mm	μas	μas	μas/d	μas/d	μs/d
CONT02	0.43	2.7	59	61	200	310	22
CONT05	0.31	2.0	64	40	240	150	18
CONT08	0.24	1.5	52	48	130	120	5.5
CONT11	0.23	1.5	37	31	120	120	5.7
CONT14	0.20	1.3	26	35	82	97	5.2
8-site subset			20	22	137	149	7.1
R1 2014	0.55	3.5	84	86	195	217	15
R4 2014	0.47	3.0	73	82	206	291	13

Scale precision = wrms (scale time series)

EOP precision = wrms (VLBI – IGS differences)

Scale and EOP Precision

VLBI – IGS EOP for the CONT14 period

Series	X	Y	Xr	Yr	LOD
	uas	uas	uas/d	uas/d	us/d
Ultra	25	28	110	110	5.1
Rapid	30	40	98	110	4.3
Finals	26	35	82	97	5.2

IGS Product Accuracies (IGS Website)

Series	X	Y	Xr	Yr	LOD
	uas	uas	uas/d	uas/d	us/d
Ultra	50	50	250	250	10
Rapid	40	40	200	200	10
Finals	30	30	150	150	10

IGS Finals precision: X (25.3 uas), Y(31.3 uas)
J. Ray and J. Griffiths [2012] (3-corner hat P. Rebischung,IGN)

Space Geodesy Project Future Networks

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- Based on expected VLBI station availability in +5 years and +10 years
- Stations all have broadband (2-14 GHz) receivers
- Most antennas are "very-fast"
  => Slew at 12 deg/sec in azimuth and 6 deg/sec in elevation
- Several antennas are "fast"
  => Slew at 5-6 deg/sec in azimuth and 1-2 deg/sec in elevation
  (GGAO12M, 3 Australian + 1 New Zealand antennas)
- The legacy antenna at Westford slews at 3 deg/sec in azimuth
- Average azimuth slew rate of current (legacy) antennas~1.3 deg/sec

Space Geodesy Project Future Network

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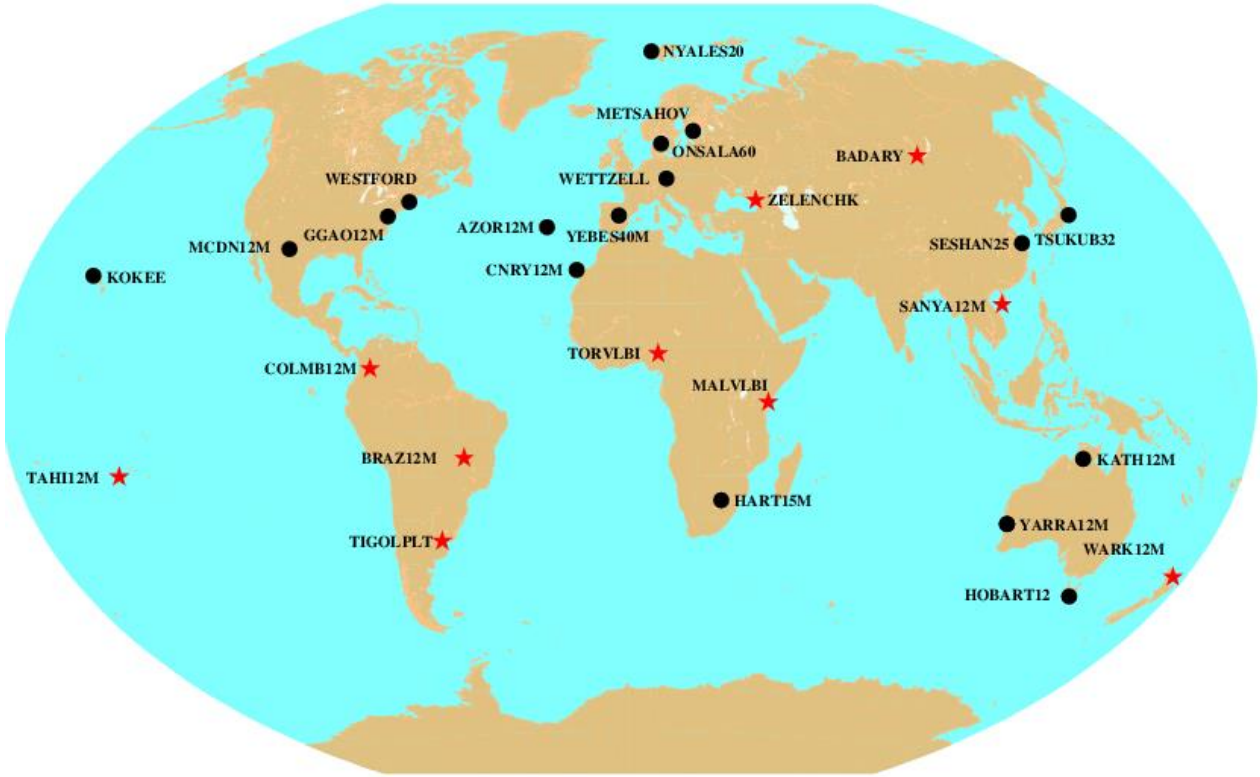
Projected Broad Band Networks:
+5 years (17 sites)
+10 years (27 sites)



Observing Session Comparison

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Session Type	Number of Stations	Site average scans/hr	Range of scans/hr	Number of Observations
Weekly R1 (operational)	8-10	15	12-21	5100
CONT11	14	16	12-20	10900
CONT14	17	19	14-24	20300
+5yr	17	79	58-97	141800
+10yr	27	76	61-86	274200

Simulation Modeling

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EOP and Scale Precision From Simulation

	X	Y	UT1	LOD	Scale
	(μas)	(μas)	(μs)	(μs/d)	ppb
CONT11	33.4	31.2	2.35	4.61	0.43
CONT14	26.7	28.5	1.86	5.16	0.30
+5 yr	16.3	19.2	0.79	2.6	0.16
+10yr	12.8	11.5	0.74	2.1	0.11

Simulated CONT14 X, Y and scale overestimated compared with observed precision by about factor of 1.4 =>
9 uas PM, 0.5 us UT1, 0.08 ppb scale for +10 yr

Space Geodesy Project Future Networks

NVI, INC.

- Simulation of network performance 5 and 10 years in the future

  - network designs based on the "Network Model" based on GGOS proposals for next generation SLR and VLBI sites

  - 15 collocated sites for +5yr simulation

  - VLBI+SLR TRF Simulation using the +5 year network=> 1 mm geocenter and 0.1 ppb with one year of observing (~0.3 mm and 0.03 ppb after 10 years of observing)

  - Next to be done: Combined +5yr and +10yr => TRF stability

Conclusions

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- CONT11 and CONT14 EOP and scale precision
  more than twice as good as operational R1 and R4 sessions

- CONT11 and CONT14 PM precision
  ~ same as GPS (IGS finals)

- Simulations of future broadband network (+10yr) =>
  Precisions of 9 uas PM, 0.5 us UT1, 0.08 ppb scale

- VLBI+SLR reference frame accuracy based on +5yr SLR and
  VLBI network simulation of 1 year of observing
  => 1 mm geocenter, 0.1 ppb scale

Simulation Modeling

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Simulation Procedure

- Run Monte Carlo simulation using observing schedule for a given network with the VLBI SOLVE analysis program

- Clock delays for each station modeled as random walk +integrated random walk processes corresponding to clock Allan standard deviation

- Wet delay contribution based on Kolmogorov turbulence delay model

  - Model parameters are effective troposphere height, wind velocity, and refractive index structure constant C_n
  - C_n are site-dependent (based on either GPS wet zenith delay or high resolution radiosonde profiles) [Tobias Nilsson]

- Add a white noise contribution corresponding to the observation uncertainty