ACCURACY EVALUATION OF THE NEXT-GENERATION VLBI SYSTEMS FROM FIRST OBSERVATIONS

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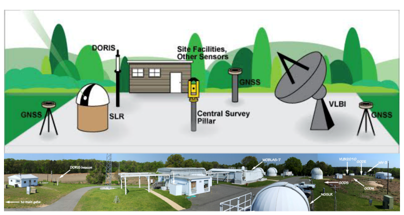
CONTEXT The rollout of the next-generation VLBI network has begun with the deployment in February 2016 of a new VLBI antenna at the Kokee Park Geophysical Observatory (KPGO), Hawaii, a joint effort of the NASA Goddard Space Flight Center, the United States Naval Observatory, and MIT Haystack Observatory. The new VLBI systems (a.k.a. the VLBI Global Observing System, or VGOS) are a key component for achieving the accuracy goals of the Global Geodetic Observing System (GGOS). Some salient observational features of VGOS, such as broadband (2-14 GHz) feeds, dual-polarization receivers, wideband digital backends, and fast-slewing small (12-13 m) antennas, address the need for improved geodetic accuracy by decreasing the observable noise while increasing sampling of the atmosphere. The VGOS system at KPGO joins the successful VGOS prototype systems at the Goddard Geophysical and Astronomical Observatory (GGAO), Maryland, and at Westford, Massachusetts, which have been making VGOS geodetic observations since December 2014. Preliminary geodetic analysis from these early VGOS observations suggests mm-level positioning precision.

1- NEXT-GENERATION VLBI SYSTEMS

- VGOS is the next-generation VLBI system being developed to meet the 1-mm position accuracy needed for stringent geophysical applications such as global sea level rise.
- VGOS redefines the "legacy S/X-bands" VLBI in terms of novel technology (e.g., agile antennas, broadband feeds, high-rate data sampling) and with continuous, automated operations and data processing.
- Co-location of VGOS with other space geodetic techniques (i.e., GPS, Satellite Laser Ranging, DORIS) is essential for synergistic, robust global reference frame realization.

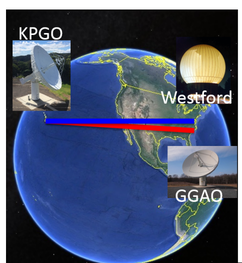


(Top) Multi-technique co-location concept and (bottom) particular realization at GGAO, Maryland.

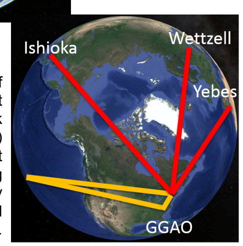
(Left) New 12-m VGOS antenna and (right) old 20-m VLBI antenna at KPGO, Hawaii, a 31-m baseline.

2- VGOS NETWORK OBSERVATIONS

- We built a VGOS baseline prototype by 2014, one site at Westford, Massachusetts, the second at GGAO, Maryland;, and the first VGOS site at KPGO, Hawaii, in early 2016.
- Regular observations between Westford and GGAO, and KPGO since 2016, are being used for VGOS verification and validation.
- Test observations are also sporadically run with international collaborators for technology compatibility



Geographical locations of Westford, GGAO, and KPGO, the current VGOS network, forming baselines lengths of approximately 600 and 7500 km.

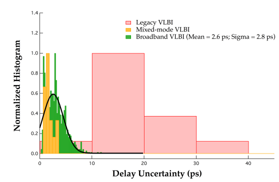


Locations of (yellow) the current VGOS network and (red) baselines to test systems by bing developed by international collaborators.

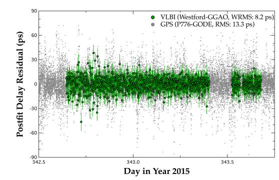
3- GEODETIC ANALYSIS, PRECISION, AND ACCURACY EVALUATION

(DISTANCE-TIME EQUIVALENCE NOTE: 1 mm = 3 ps)

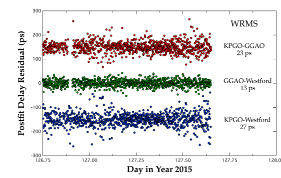
- Estimated VLBI delay precision has improved from 10-30 ps level in "legacy S/X" VLBI to about 3 ps in the VGOS broadband, largely accomplished by the over 10-fold increase in effective bandwidth (Figure top-left).
- Weighted root-mean-square (WRMS) scatter of the postfit broadband delay residuals from geodetic solutions is about 10 ps for the 600-km-long baseline between Westford and GGAO, and about 30 ps for the 7500-km-long trans-Pacific baselines to KPGO (Figures top-middle and top-right).
- WRMS scatter of baseline length residuals between Westford and GGAO during the period from 19 December 2014 to 30 August 2016 are 1.5 mm (Figure bottom).



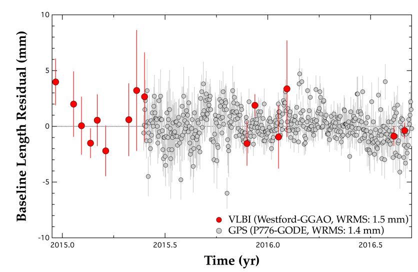
Legacy vs VGOS delay precision, as well as a "mixed-mode" observable.



Postfit residuals from VGOS delays, and (equivalent) GPS phases.



Postfit delay residual scatter from the trans-Pacific, 3-site VGOS network.



Residuals of the average length of (red) the 601-km-long VGOS baseline between sites Westford and GGAO, and (gray) the 678-km-long GPS baseline between sites GODE at GGAO and P776 of the Plate Boundary Observatory (PBO) network north of Westford, during the 1.5 year period of VGOS demonstration sessions.

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