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VLBI scheduling using a source-based strategy

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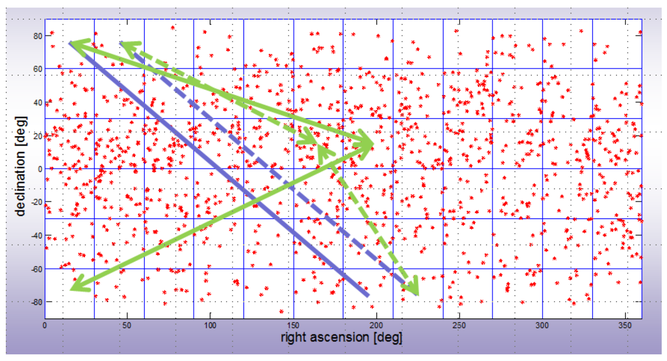
Introduction

Within the International VLBI Service for Geodesy and Astrometry (IVS) the next generation VLBI system, called VLBI2010, is under development. This system has completely new features in terms of VLBI hardware (radio telescopes, receiver technology, …) and software (software correlation, data analysis, …). This requires also to reconsider the scheduling of the observing sessions, thus a new VLBI scheduling package (VIE_SCHED) is being developed at the Institute of Geodesy and Geophysics (IGG) of the Vienna University of Technology. It takes into consideration all present and future VLBI2010 requirements as for instance very fast slewing radio telescopes and short observing times of a few seconds only. VIE_SCHED is one part of VieVS, the Vienna VLBI software, which has been developed at IGG in the last three years.

Considering a more uniform network than the current one of fast slewing antennas, one possible scheduling strategy is source-based scheduling. This means that the schedule program selects radio sources from the catalogue for the best coverage of the celestial sphere, without regard for their direct impact on individual stations. This simplification can easily be applied for globally distributed networks and greatly increases the efficiency of the scheduling software. Optimization is performed in order to have a good geometry and a high number of observations, using all possible baselines of the network for the observations.

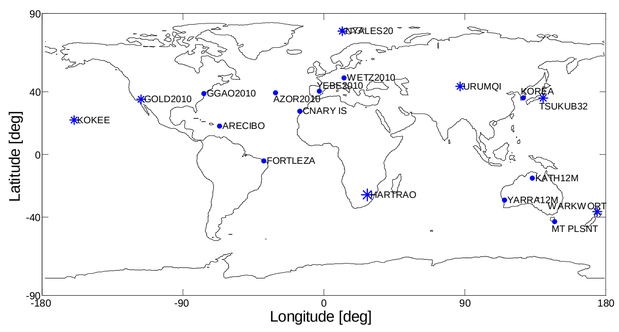
Two schedules were generated considering two or three sources for a subnet of VLBI observing stations, respectively. And they were compared with another schedule using the conventional station-based strategy.



Schedule parameters

➢The network is an interim network containing 18 stations, including both VLBI2010 and legacy antennas. The table summarizes the slew rate parameters of the antennas. The distribution of 18 stations is shown in the figure below.

Sta Index	Sta Name	Slew Rate AZ (deg/min)	Slew Rate EL (deg/min)
1	*HARTRAO	120	60
2	*KOKEE	120	120
3	*NYALES20	120	120
4	*GOLD2010	180	60
5	*URUMQI	180	60
6	*WARKWORT	180	60
7	*TSUKUB32	180	180
8	°ARECIBO	300	75
9	°FORTLEZA	300	75
10	°GGAO2010	300	75
11	°KATH12M	300	75
12	°MT_PLSNT	300	75
13	°YARRA12M	300	75
14	°KOREA	300	300
15	°AZOR2010	720	360
16	°CNARY_IS	720	360
17	°WETZ2010	720	360
18	°YEBE2010	720	360



➢Source structure models (elliptical Gaussian models) are used in VIE_SCHED to calculate the predicted observed flux on each baseline of a scan. The minimum observed flux is 0.3 Jy.

➢Considering two bands (X and S), the recording rate is 8 Gbps (the number of channels 14, bw 128 MHz, sample rate 256 MHz and 2 bits quantification). The minimum SNR is 20 (X band) and 15 (S band), respectively. The cutoff elevation angle is 5 degrees.

VIE_SCHED

VIE_INIT
VIE_MOD
VIE_SIM

VIE_INIT
VIE_MOD
VIE_LSM

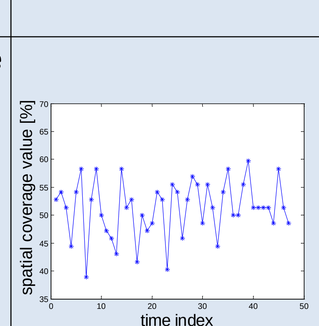
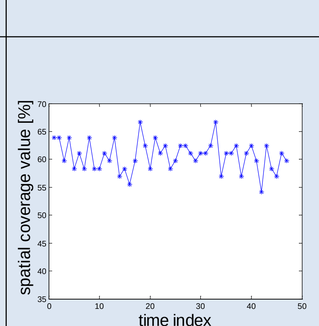
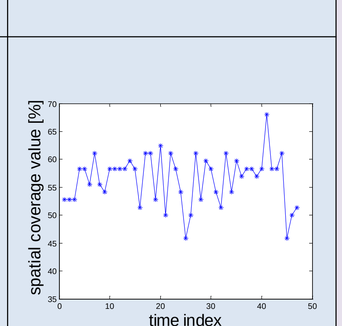
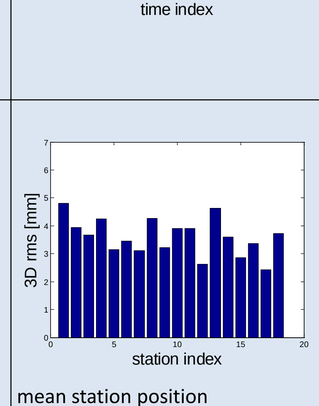
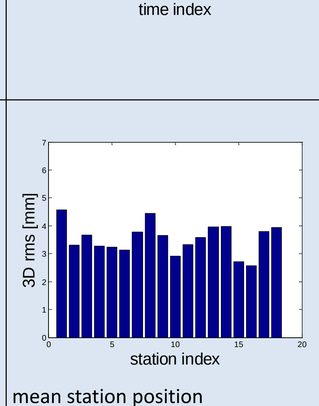
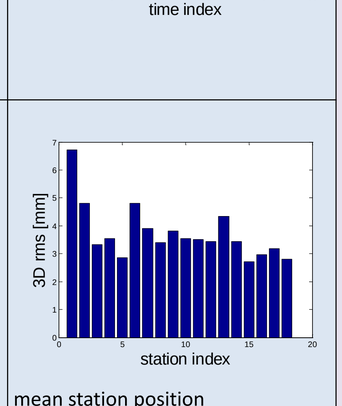
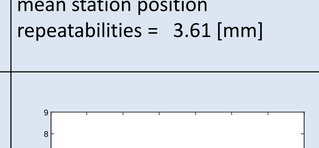
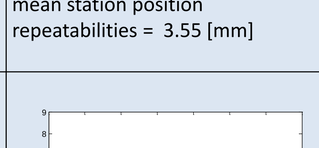
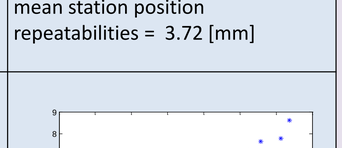
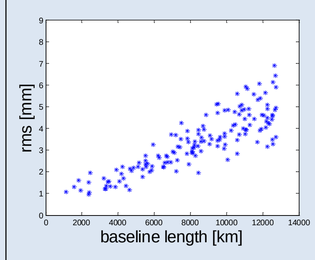
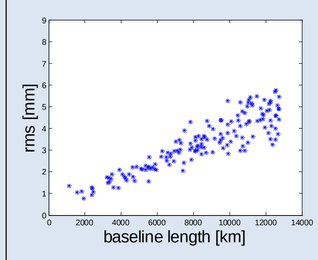
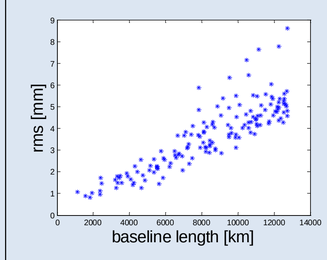
Simulation parameters

The schedules generated were tested through Monte Carlo simulations. The simulation values listed were chosen by the VLBI2010 Committee (V2C). The parameters include the refractive index structure constant Cn ($2.5*10^{-7}m^{-1/3}$), the effective height of the wet troposphere H (2000 m), and the wind velocity vector v (8.0 m/s) towards east. The stochastic variations of station clocks are computed as sum of a random walk and an integrated random walk, with a power spectral density corresponding to an Allan Standard Deviation (ASD) of 10^{-14} @ 50 min. A white noise of 16 ps per baseline observation is added.

Estimated parameters

- NNR/NNT for all a priori station coordinates; source coordinates fixed to ICRF2.
- EOP offsets for each 24-hour session.
- Quadratic function plus 60 min piecewise linear function for clocks with relative constraints of 42 ps.
- 6 min piecewise linear function for zenith wet delays with relative constraints of 19 ps.
- 10 min piecewise linear function for gradients with 1.4 mm relative constraints and 1 mm absolute constraints.

Results and comparisons

	From VIE_SCHED_1 (2 sources in a subnet)	From VIE_SCHED_2 (3 sources in a subnet)	From VIE_SCHED_3 (station-based strategy)
number of sources	197	190	225
number of scans	2102	3371	4138
number of observations	67633	53828	84398
distribution of observations			
spatial coverage of sources			
station position repeatabilities	 mean station position repeatabilities = 3.61 [mm]	 mean station position repeatabilities = 3.55 [mm]	 mean station position repeatabilities = 3.72 [mm]
baseline length repeatabilities			

Summary

Here we present preliminary results of the source-based scheduling strategy. Three different schedules have been generated and tested through simulations in order to evaluate what is the better observing strategy for the next generation VLBI network. These schedules differ in terms of the number of radio sources observed in one sub-configuration and the coverage of the celestial sphere with sources. The most accurate results are achieved with three sources observed simultaneously.

Future plans

The planned future developments of VIE_SCHED include an option to analyze the covariance information and allow to consider sites with multiple antennas like the fundamental station Wettzell which will have three operational VLBI radio telescopes in 2012. We also plan to develop a graphical interface.

References

- A. Niell, A. Whitney, B. Petrachenko, et al. VLBI2010: Current and Future Requirements for Geodetic VLBI Systems. IVS Memoranda 2006-008v01.
- T. Nilsson, J. Böhm, S. Böhm, et al. Status and future plans for the Vienna VLBI Software VieVS. Proceedings of the 20th Meeting of the European VLBI Group for Geodesy and Astrometry, 29-30 March 2011.
- A. Pany, J. Böhm, D. MacMillan, H. Schuh, T. Nilsson, J. Wresnik. Monte Carlo simulations of the impact of troposphere, clock and measurement errors on the repeatability of VLBI positions. J Geod (2011) 85:39-50, DOI 10.1007/s00190-010-0415-1.

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