G11A-0005

2006 AGU FALL MEETING

PHASE DELAY CONNECTION IN DIFFERENTIAL VLBI

Tetsuro Kondo*, Thomas Hobiger*&**, Mamoru Sekido*, Ryuichi Ichikawa*, Yasuhiro Koyama*, and Hiroshi Takaba***

* Kashima Space Research Center, National Institute of Information and Communications Technology, 893-1 Hirai, Kashima, Ibaraki 314-0012, Japan (e-mail: kondo@nict.go.jp)

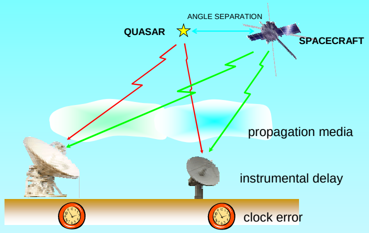
** Research Group Advanced Geodesy, Institute of Geodesy and Geophysics, Vienna University of Technology

*** Gifu University, Japan

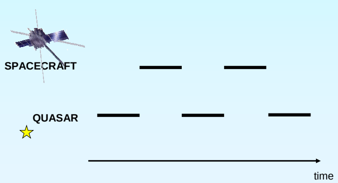
Abstract

Differential Very Long Baseline Interferometry (VLBI) is a technique to measure the angular separation between two nearby celestial-radio-sources accurately by observing each source alternately. The connection of fringe phases among consecutive scans is recognized as an important issue to improve the measurement accuracy in the differential VLBI. Fluctuations of fringe phase limit the gap length over which fringe phases can be connected. Thus an antenna-switching period should be less than this limit length. Therefore the maximum limit of gap length as well as source strength is a critical parameter for preparing an observation schedule. This parameter thought to be strongly related to weather condition and site location. A number of researchers investigated statistical characteristics of atmospheric phase fluctuations by using a radio interferometry including VLBI. Some hints regarding a gap limit may be obtained from their results of Allan variance and/or structure function, but it is not a straightforward one and the location of antenna is different from our concerned one. We have therefore carried out a series of VLBI sessions dedicated to investigation of fringe phase fluctuations in order to obtain a realistic scan gap limit. At first we developed a simple method to connect phase delays (fringe phases) between two consecutive scans. Then the relation between a scan length and a gap length was investigated statistically. Results will be reported for both the X and S bands.

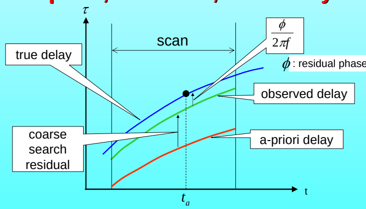
Delta (Differential) VLBI



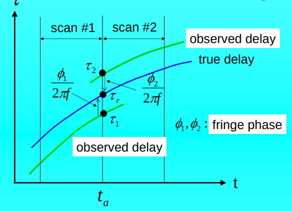
Observation Schedule



Relation Among A-priori, Observed, True Delays



Connection of Phase Delays



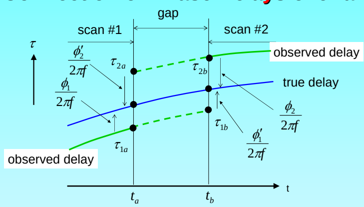
$$\tau_r = \tau_1 + \frac{\phi_1}{2\pi f} + \frac{l}{f} \quad \text{where } l = 0, \pm1, \pm2\cdots$$

$$\tau_r = \tau_2 + \frac{\phi_2}{2\pi f} + \frac{m}{f} \quad \text{where } m = 0, \pm1, \pm2\cdots$$

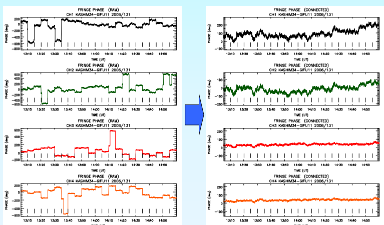
$$\tau_1 + \frac{\phi_1}{2\pi f} = \tau_2 + \frac{\phi_2}{2\pi f} + \frac{n}{f} \quad \text{where } n = 0, \pm1, \pm2\cdots$$

$$\therefore \frac{n}{f} = \tau_1 - \tau_2 + \frac{\phi_1 - \phi_2}{2\pi f}$$ add to scan #2

Connection of Phase Delays over a Gap



Fringe Phase Connection

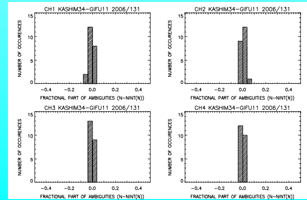


Validation of Phase Delay Connection

$$\frac{n}{f} = \tau_1 - \tau_2 + \frac{\phi_1 - \phi_2}{2\pi f}$$

$$n = f \cdot (\tau_1 - \tau_2) + \frac{\phi_1 - \phi_2}{2\pi}$$

must be an integer

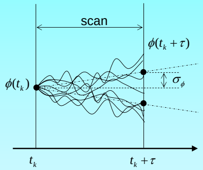


Gap Limit Estimation

Method A: using the true variance of fringe phase fluctuations

Method B: using the linear fitting of fringe phases

Gap Limit Estimation (Method A)



$$\bar{y}_k = \frac{\phi(t_k+\tau) - \phi(t_k)}{2\pi f_0 \tau}$$

true variance $I^2(\tau) = \langle \bar{y}_k^2 \rangle$

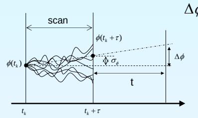
structure function $\sigma_\phi^2(\tau) = \langle [\phi(t+\tau) - \phi(t)]^2 \rangle$

$$\sigma_\phi^2(\tau) = 4\pi^2 \tau^2 f_0^2 I^2(\tau)$$ structure function

$\dot{\phi} = \frac{d\phi}{dt}$: fringe phase changing rate

$\sigma_{\dot{\phi}} = \sigma\left(\frac{d\phi}{dt}\right) = \frac{\sigma_\phi(\tau)}{\tau} = 2\pi f_0 I(\tau)$ ⇦ 1sigma error of fringe rate

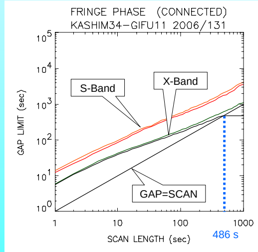
$\Delta\phi$: phase error over gap t



$$\Delta\phi = 2\pi f_0 I(\tau) \cdot t$$

$$\Delta\phi < 1$$

$$t < \frac{1}{2\pi f_0 I(\tau)}$$



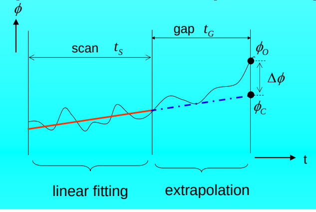
conditions

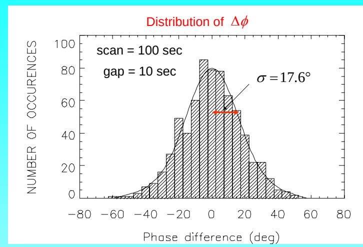
$$t < \frac{1}{2\pi f_0 I(\tau)}$$

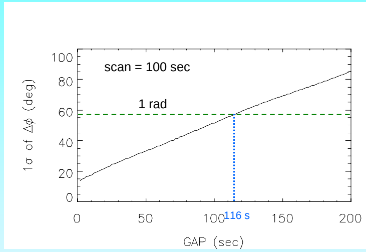
+

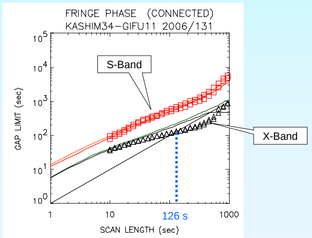
$$\sigma_\phi(\tau) < 1$$

Gap Limit Estimation (Method B)

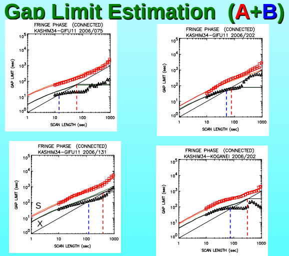




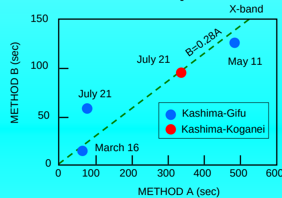




Gap Limit Estimation (A+B)



Maximum Gap Limits



Conclusion

- We have developed a scheme to connect phase delays over a gap.
- Maximum gap limits were studied by using the linear fitting of fringe phases (Method B) as well as the true variance of fringe phase fluctuations (Method A)
- Maximum gap limits for X band varies depending on weather condition from 60 – 486 s for "A" and 16 – 126 s for "B" (B=0.28A).
- As for S band, maximum gap limits are > 1000 s.

Future Perspectives

- to investigate a cause of the difference between "Method A" and "Method B"
- to accumulate the number of sessions for investigating the relation with weather condition
- to apply a scheme developed by this study to actual differential VLBI

Acknowledgements

T.K. is deeply grateful to Prof. Harald Schuh for providing him a nice and fruitful opportunity to stay in Vienna for 6 months. He thanks all staff members of the HG for all they have done to make his stays memorable.

T.K.'s stay was supported by the research project P16136-N06 "Investigation of the ionosphere by geodetic VLBI" founded by the Austrian Science Fund (FWF).