

Atmospheric Delay Reduction Using KARAT for GPS Analysis and Implications for VLBI

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Content

- KARAT
- PPP processing results
- KARAT^S
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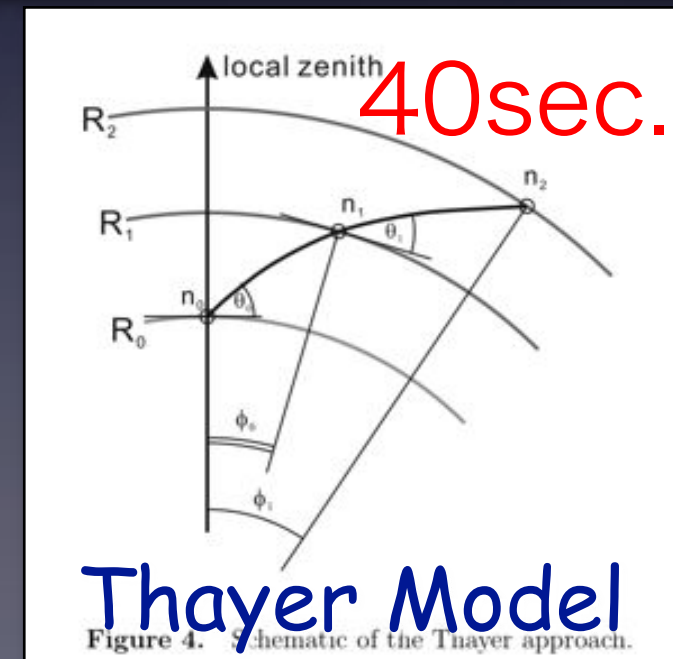
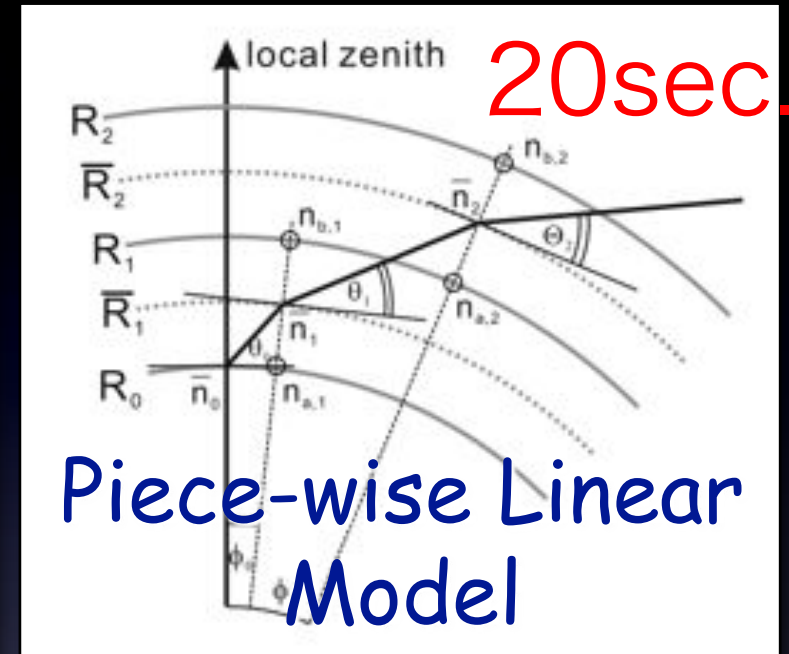
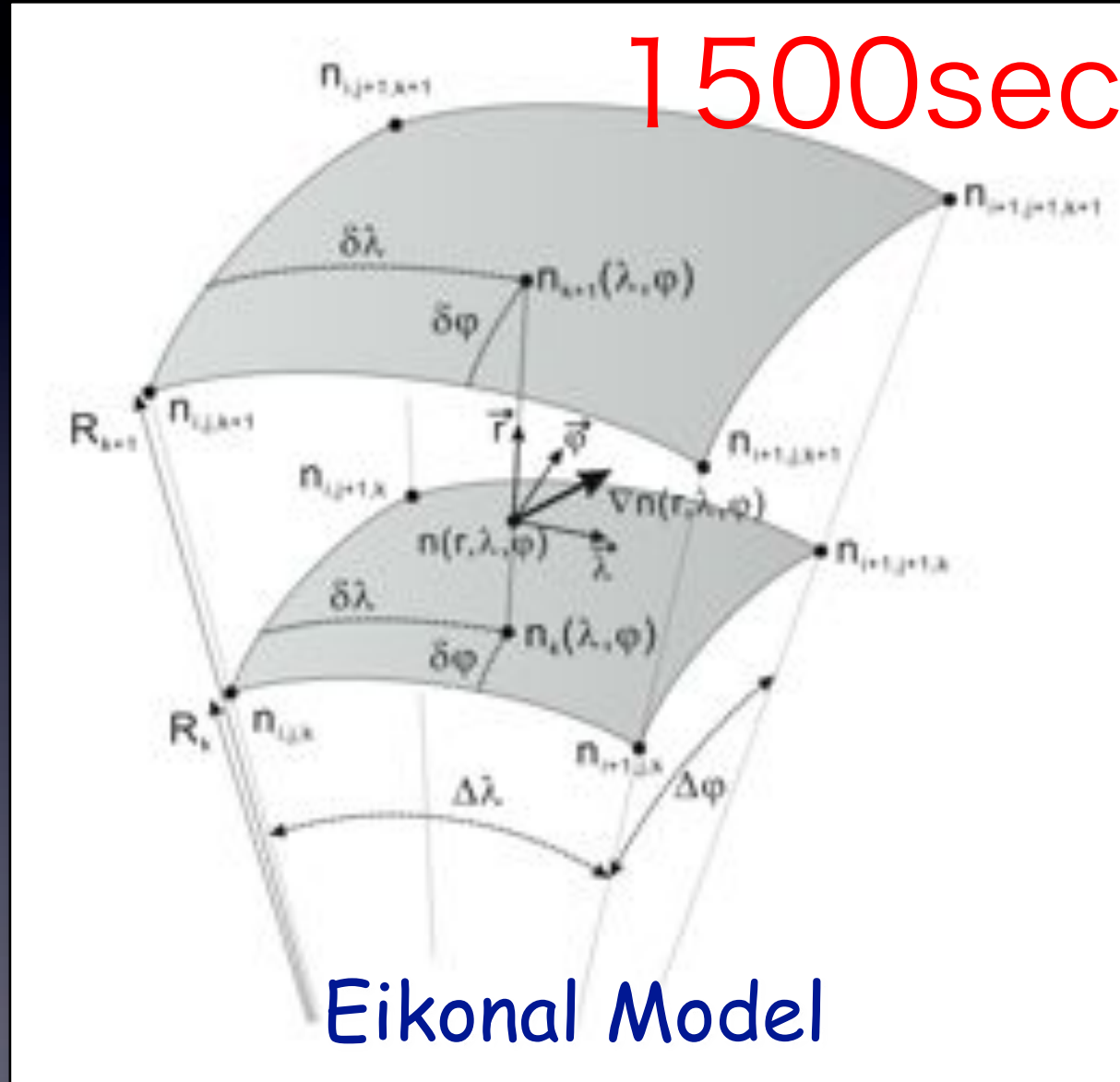
KARAT

- **Kashima RAY Tracing Tools**
 - slant delay calculated using ray tracing
- **JMA Meso-scale Analysis Data**
 - 10km grid interval (until Apr. 6th, 2009)
 - 5km grid interval (after Apr. 7th, 2009)



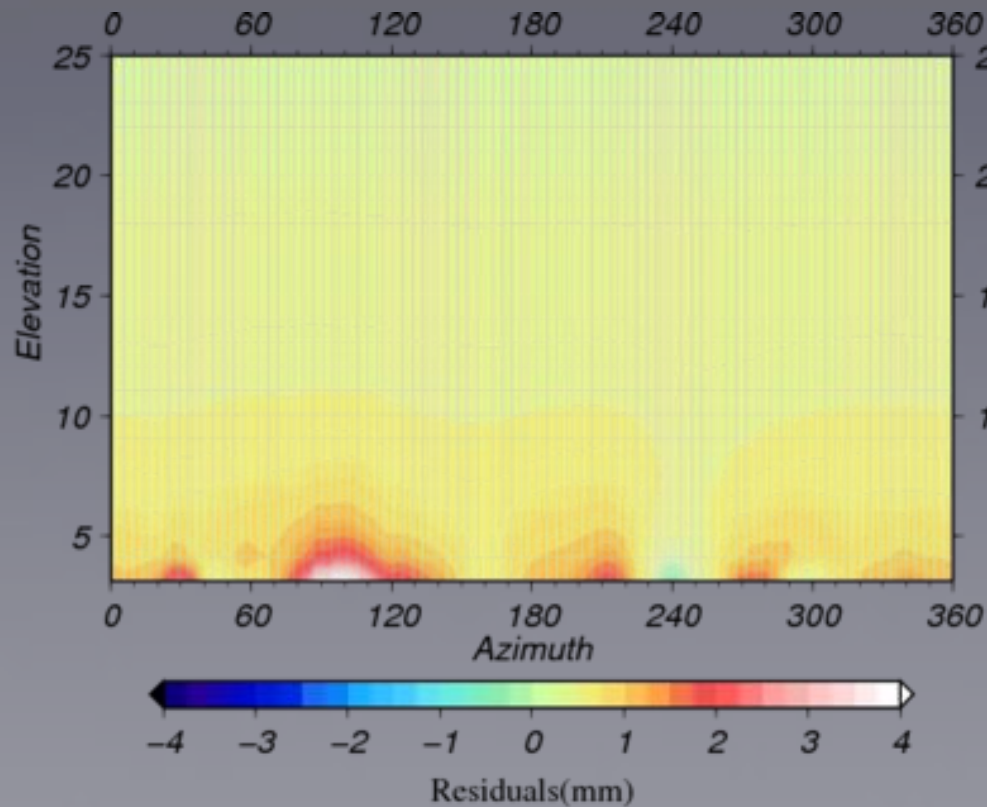
- Hobiger et al., Ray-traced troposphere slant delays for precise point positioning, *Earth Planets Space*, 60, e1-e4, 2008a.
- Hobiger et al., Fast and accurate ray-tracing algorithms for real-time space geodetic applications using numerical weather models, *J. Geophys. Res.*, doi: 10.1029/2008JD010503, 2008b.
- Hobiger et al., Computation of Troposphere Slant Delays on a GPU, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 47(10), pp. 3313-3318, 2009.
- Hobiger et al., Improving GPS positioning estimates during extreme weather situations by the help of fine-mesh numerical weather models, *Journal of Atmospheric and Solar-Terrestrial Physics*, vol. 72, no. 2-3, pp. 262-270, 2010.

KARAT calculation schemes



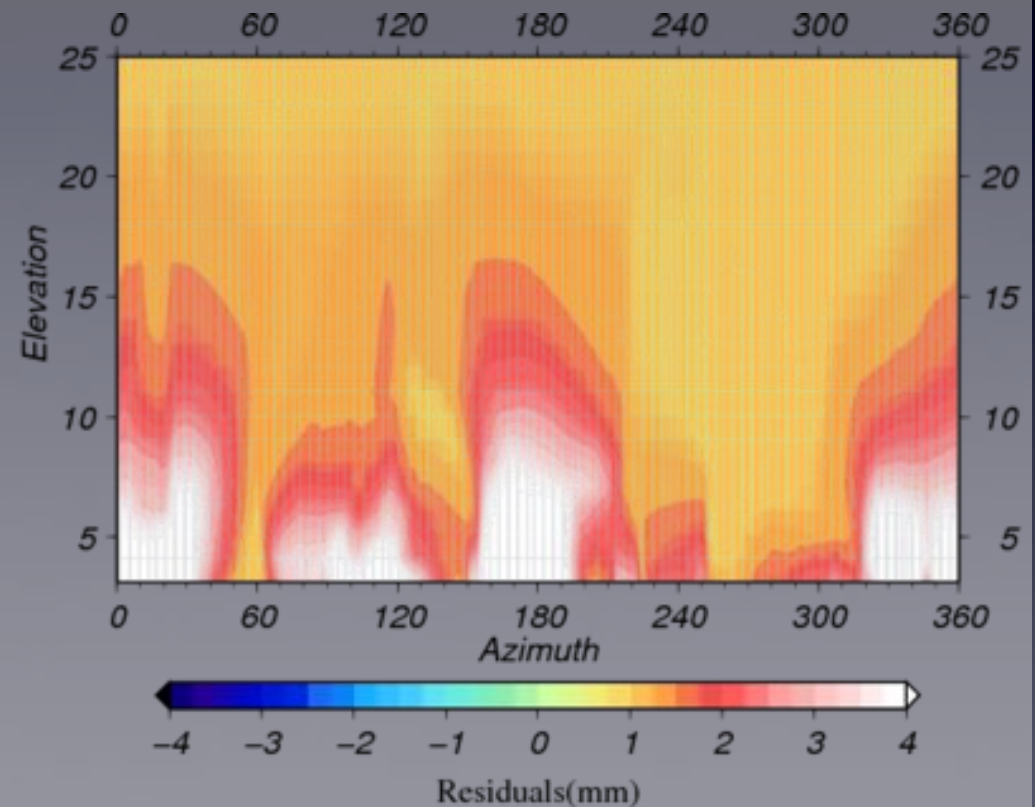
Azimuthal Residuals

Thayer - Symmetry



GM 2009 May 21 00:52:44 Thayer - Symmetry

Eikonal - Symmetry



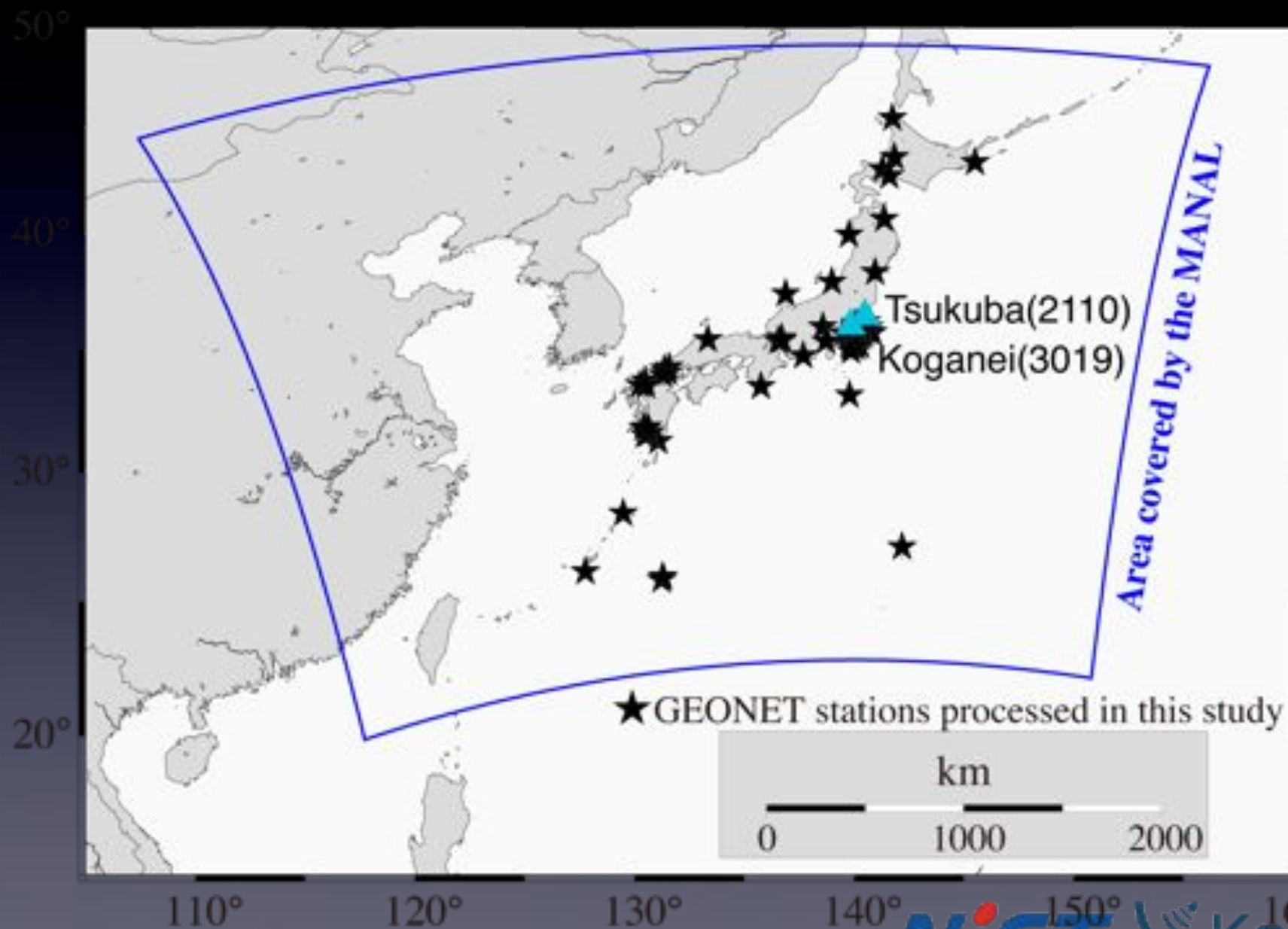
GM 2009 May 21 00:52:47 Eikonal - Symmetry

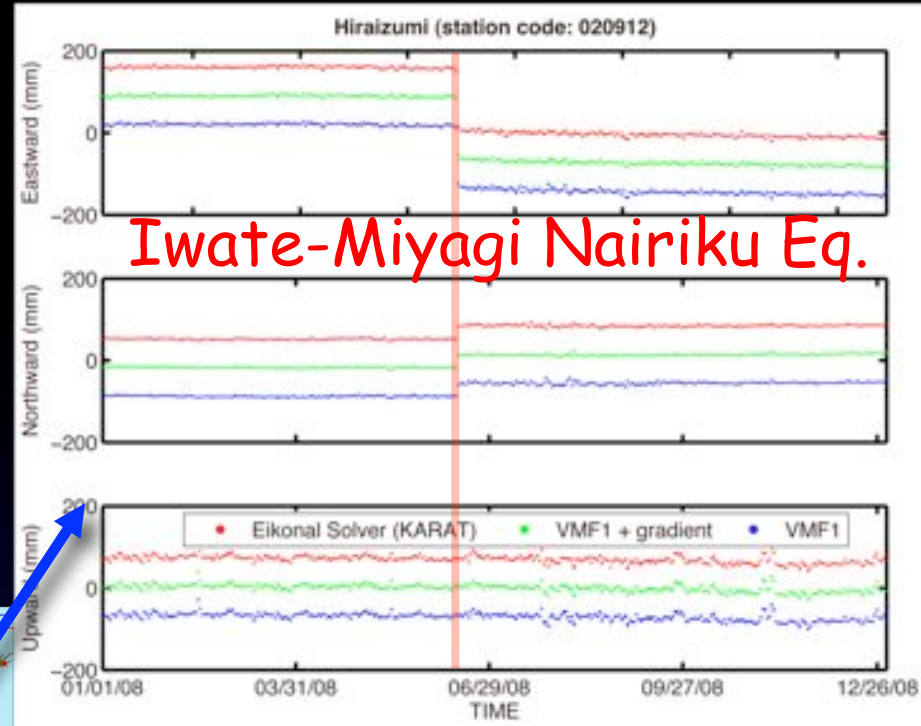
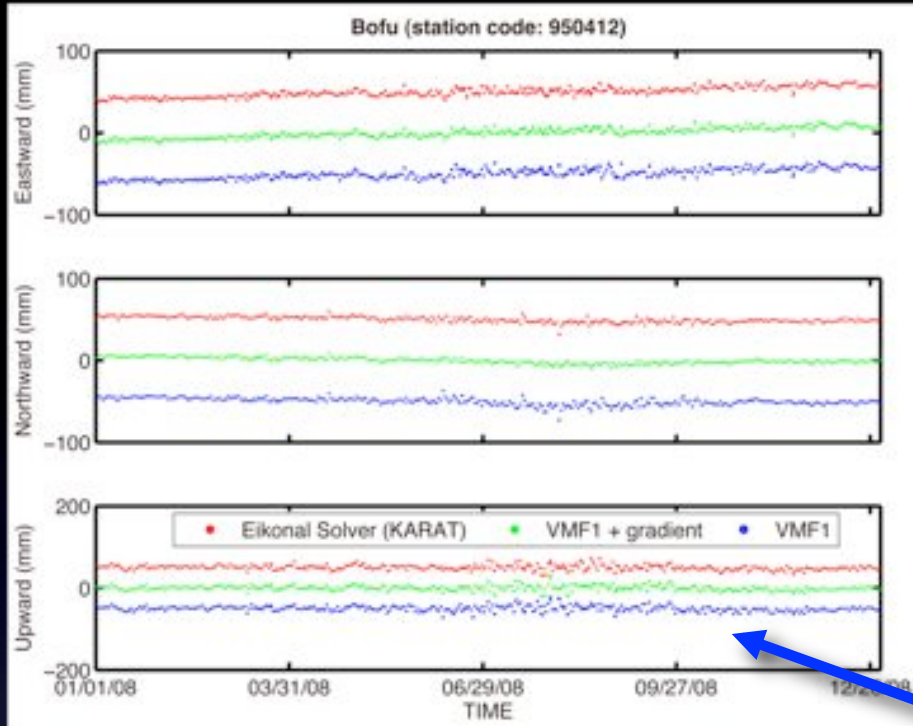
Hobiger et al. [2009]

GPS/PPP Analysis

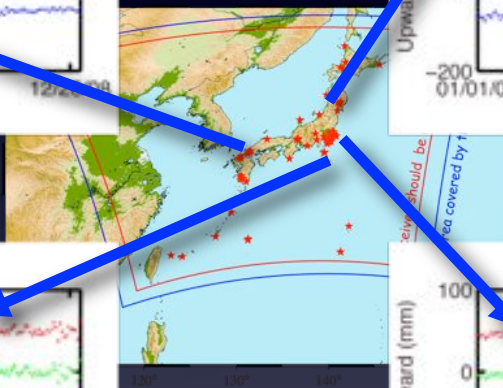
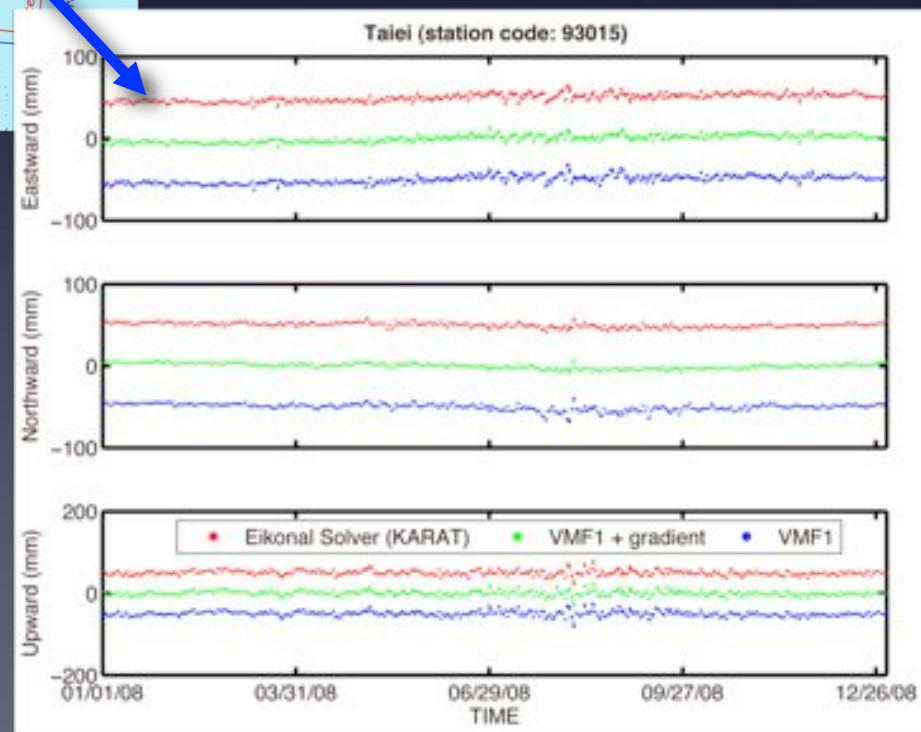
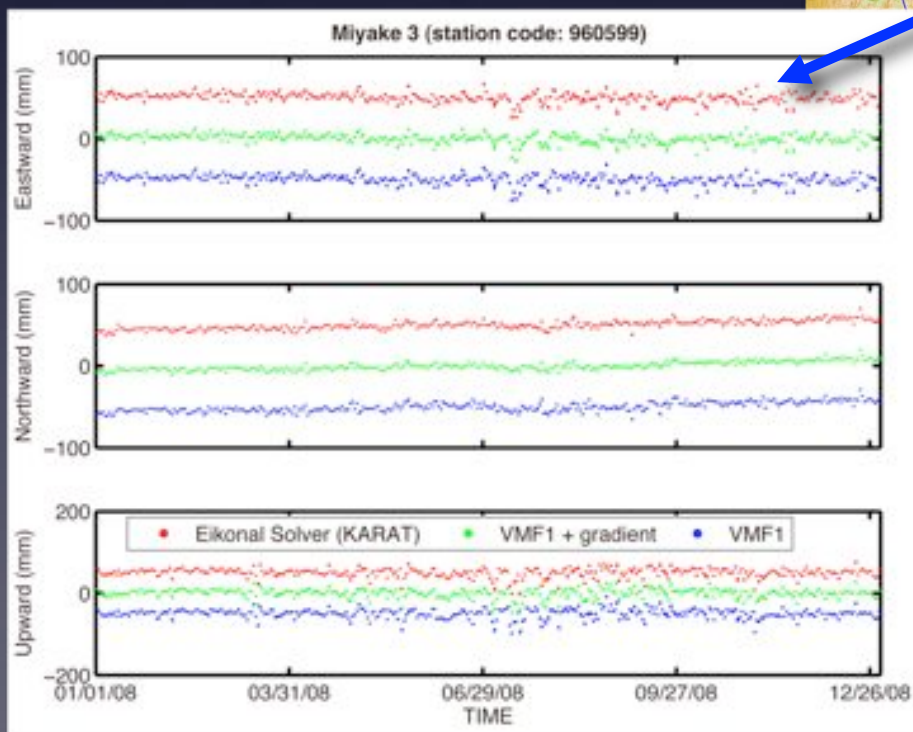
- **DATA: GEONET/RINEX**
 - KARAT reduced and Original
- **period: 2008.1.1-12.31** (interval: 300sec.)
- **Stations: 58 GEONET Stations**
- **mapping functions: VMF1, GMF**
 - with gradient & w/o gradient
- **Elevation cut off: 10°**
- **processing: GPStools Ver. 0.64**(Takasu and Kasai [2003])

Study Field



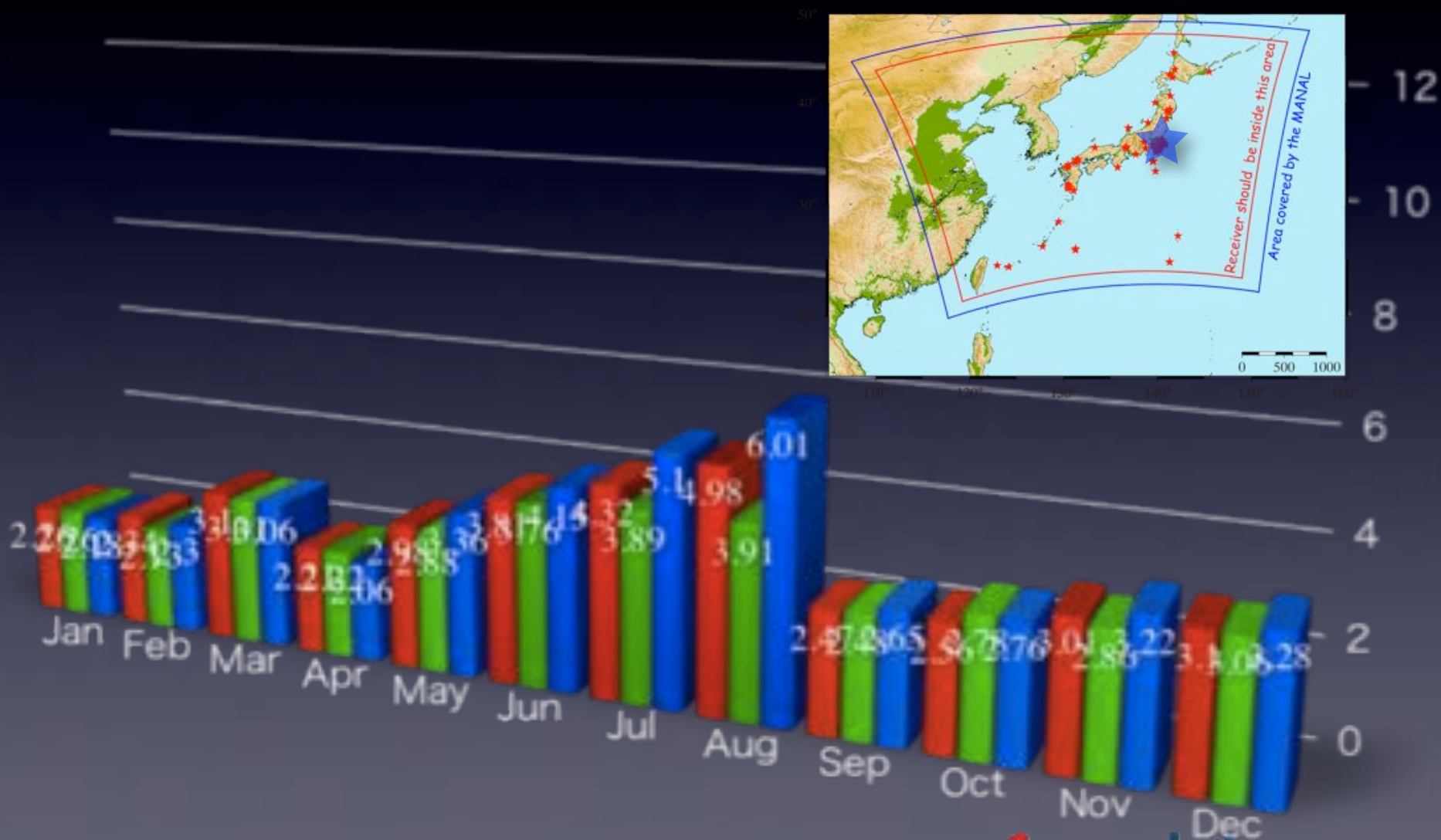


Iwate-Miyagi Nairiku Eq.



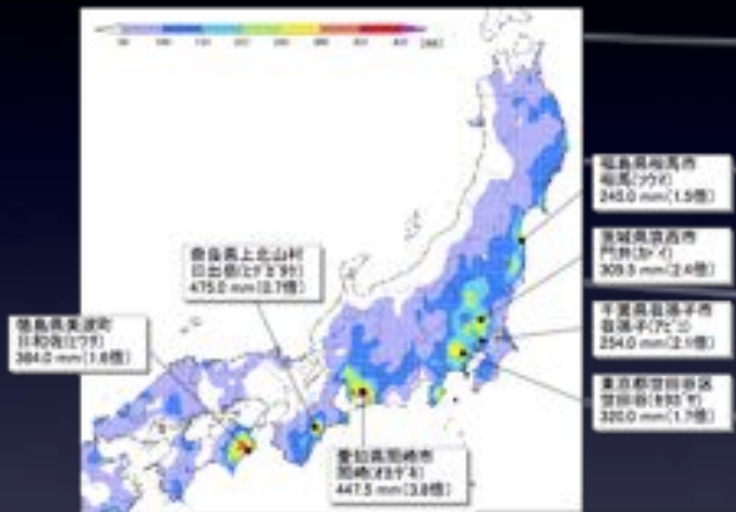
93015 -EW-

■ Eikonal EQ.
 ■ VMF1+grad
 ■ VMF1



93015 -NS-

■ Eikonal EQ. ■ VMF1+grad ■ VMF1

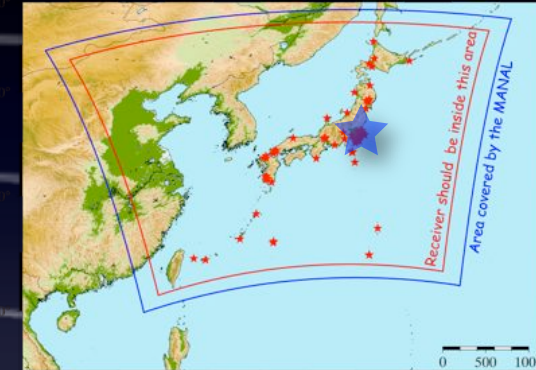
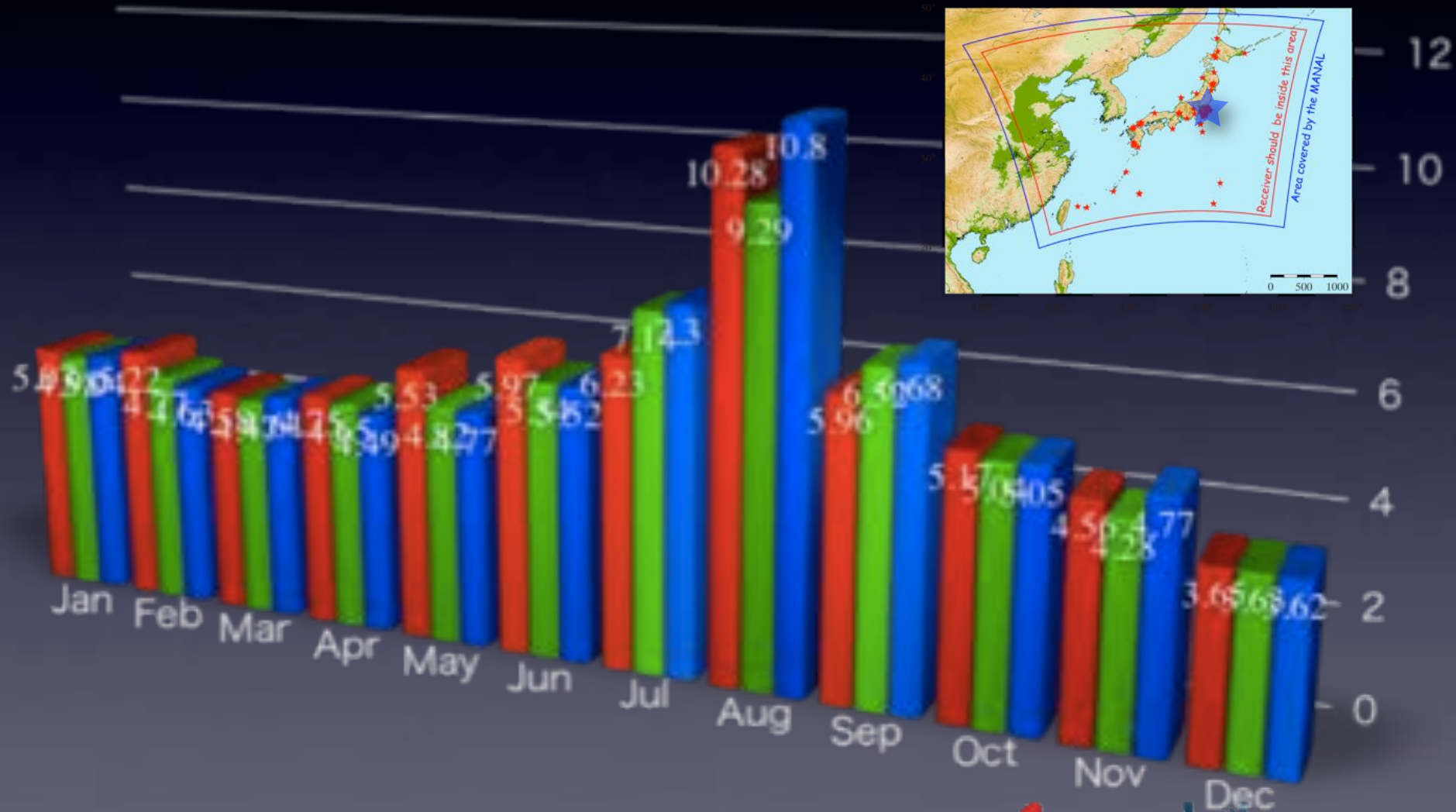


Heavy rain fall event



93015 -UD-

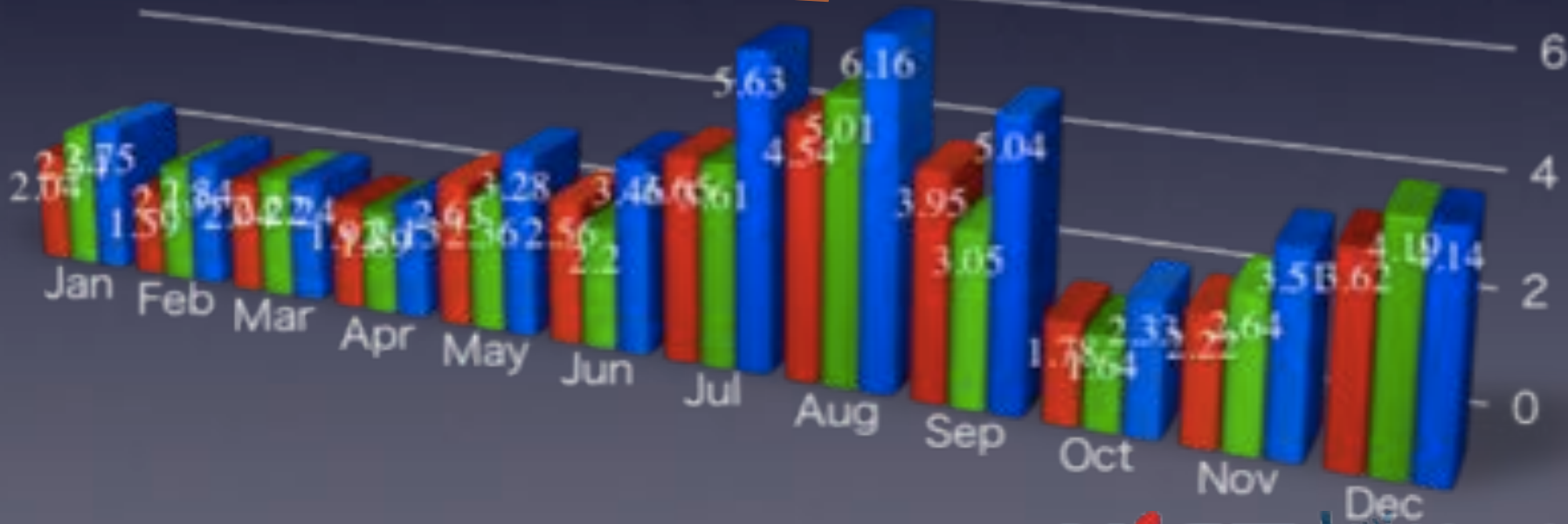
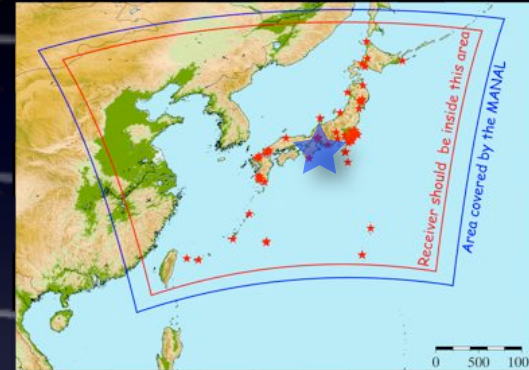
■ Eikonal EQ.
 ■ VMF1+grad
 ■ VMF1



950291 -NS-

■ Eikonal EQ. ■ VMF1+grad ■ VMF1

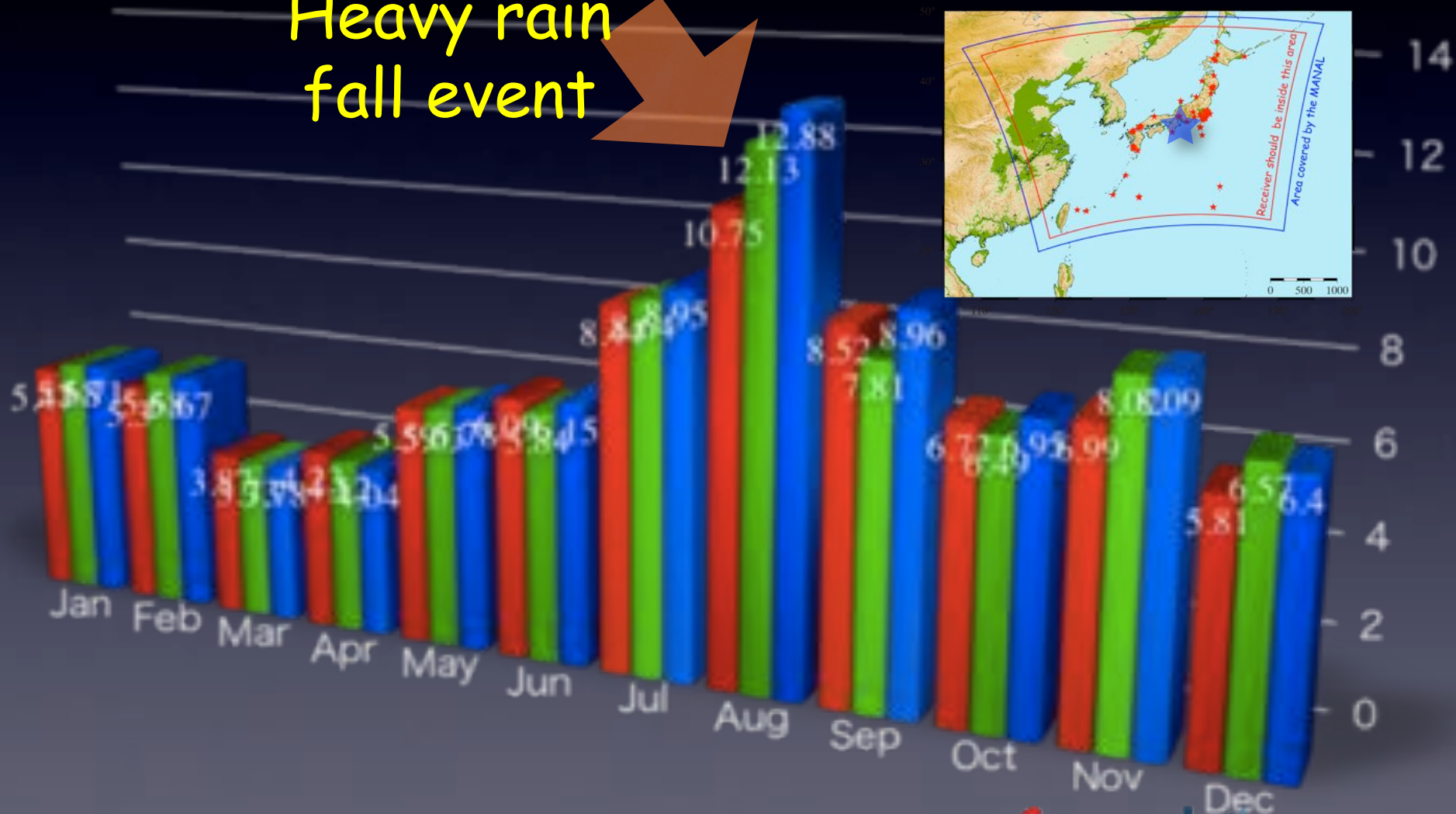
Heavy rain fall event



950291 -UD-

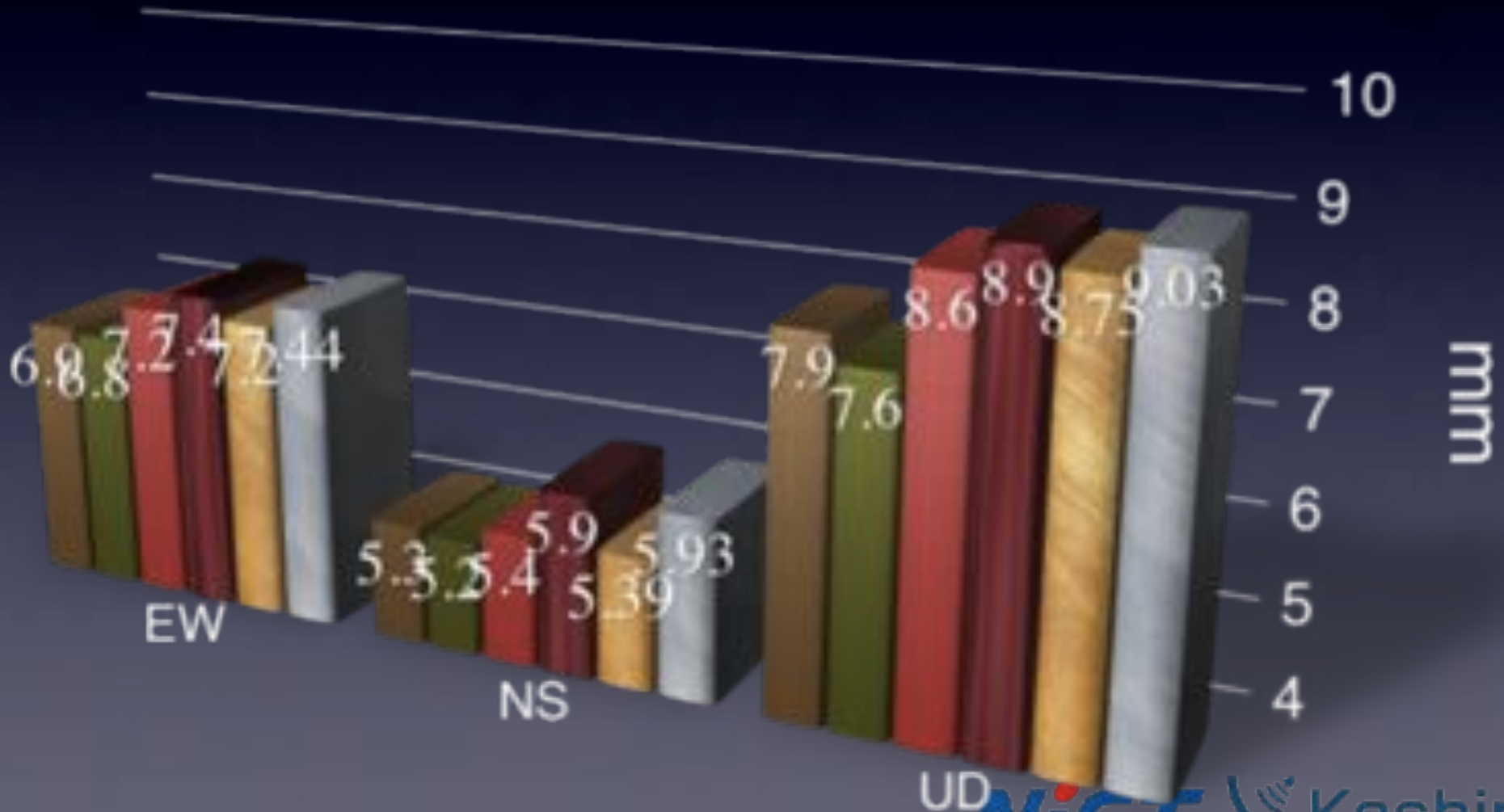
■ Eikonal EQ. ■ VMF1+grad ■ VMF1

Heavy rain
fall event



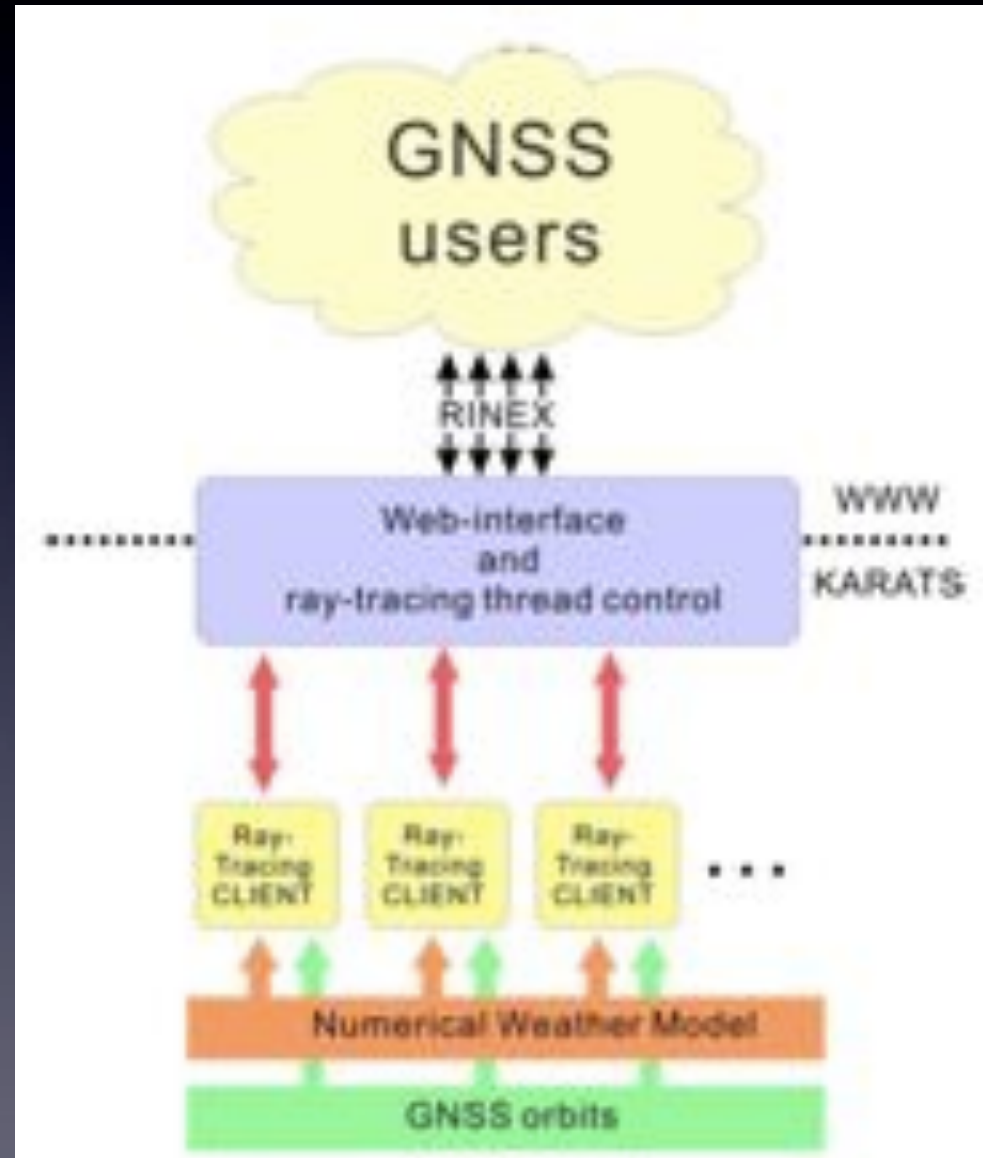
repeatability

- Eikonal EQ (KARAT)
- Thayer Model (KARAT)
- VMF1 + grad
- VMF1
- GMF + grad
- GMF



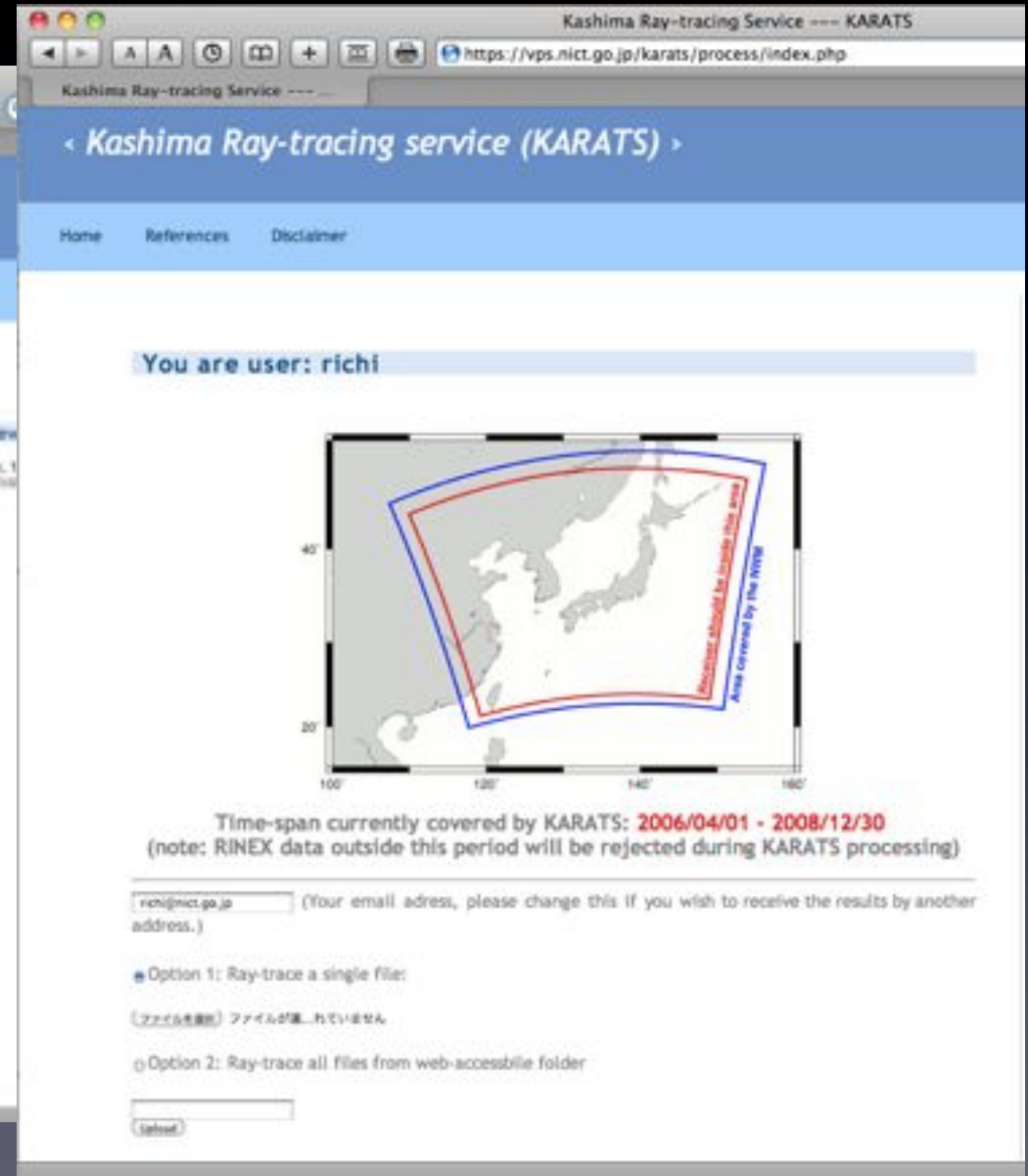
KARATS

Atmospheric delay correction for users



after Hobiger et al.
[2009]

KARATS_S(cont'd)



for VLBI

The direct ray-tracing has the potential to improve UT₁ estimates. [Boehm et al., JoG, in submitting]

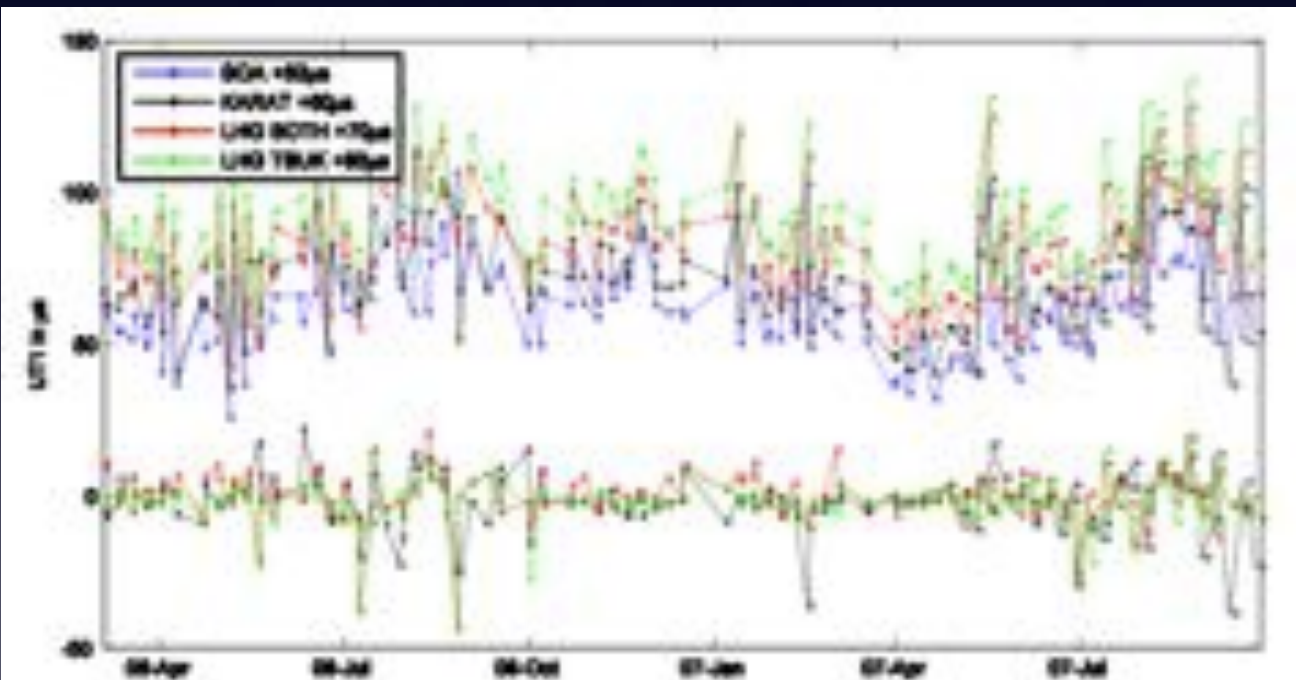


Figure 4 Hourly offsets of UT₁ values for the INT2 sessions w.r.t. IERS 05 C04 (shifted by 30, 60, 70, and 80 μ s for clarity). The differences are shown in the three lower lines (around zero) and they are in the sense KARAT/LHO minus SOA. The standard deviation of the differences is about 10 μ s.

after Boehm
et al.[2010]

Concluding Remarks

- The KARAT solution is almost identical to the solution using VMF₁ with linear gradient model
- The advantage of KARAT is an efficient reduction of atmospheric path delay with the numerical weather model improvement
- No big difference between Thayer Model and Eikonal Solver

Outlook

- We need more high speed for Eikonal solver processing!!
 - **GPGPU technique**
- MANAL improvements
 - 5 km grid (after Apr. 7th, 2009)
 - Data assimilation of GPS PWV (after Oct. 28, 2009)

Thank you for your attention

