

気象庁メソスケール客観解析データ による大気遅延除去のための 高速計算ツールの開発

A Development of Fast Ray-Tracing Tool
through the JMA Mesoscale Analysis Data
for High Precision Positioning using Space
Geodetic Techniques

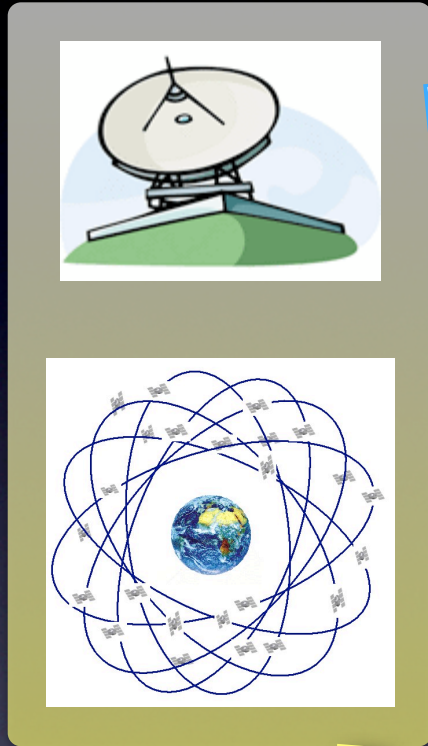
Ichikawa, R., Hobiger T., Koyama, Y., and Kondo, T.
National Institute of Information and Communications Technology

Overview

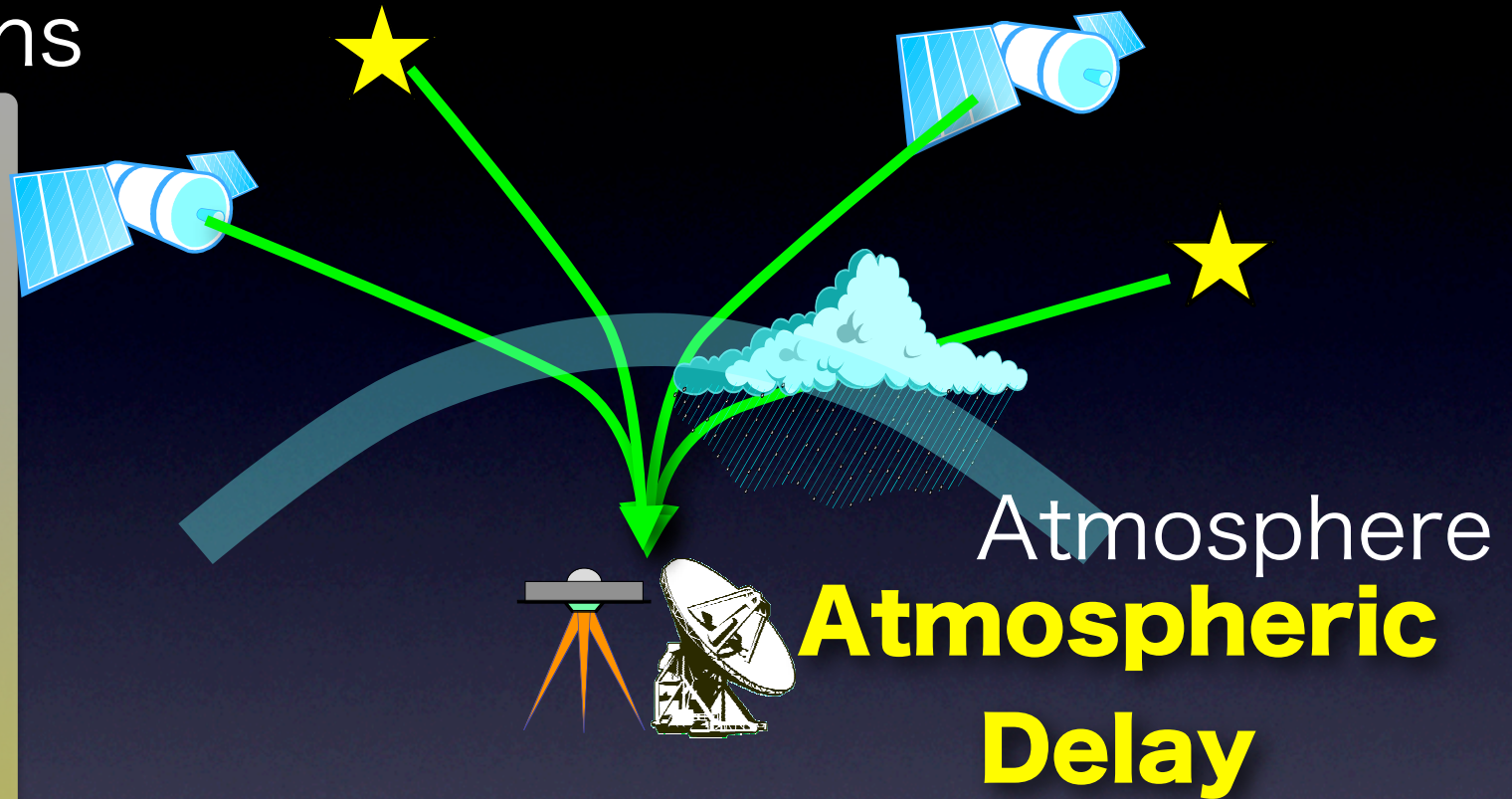
- **Motivation**
- **Mapping Function**
- **Fast Ray-tracing through NWM**
- **Atmospheric delay correction of GNSS Processing**
- **Summary**

Motivation

Observations



- GNSS(ex. GPS)
- VLBI
- In-SAR
- Spacecraft Tracking

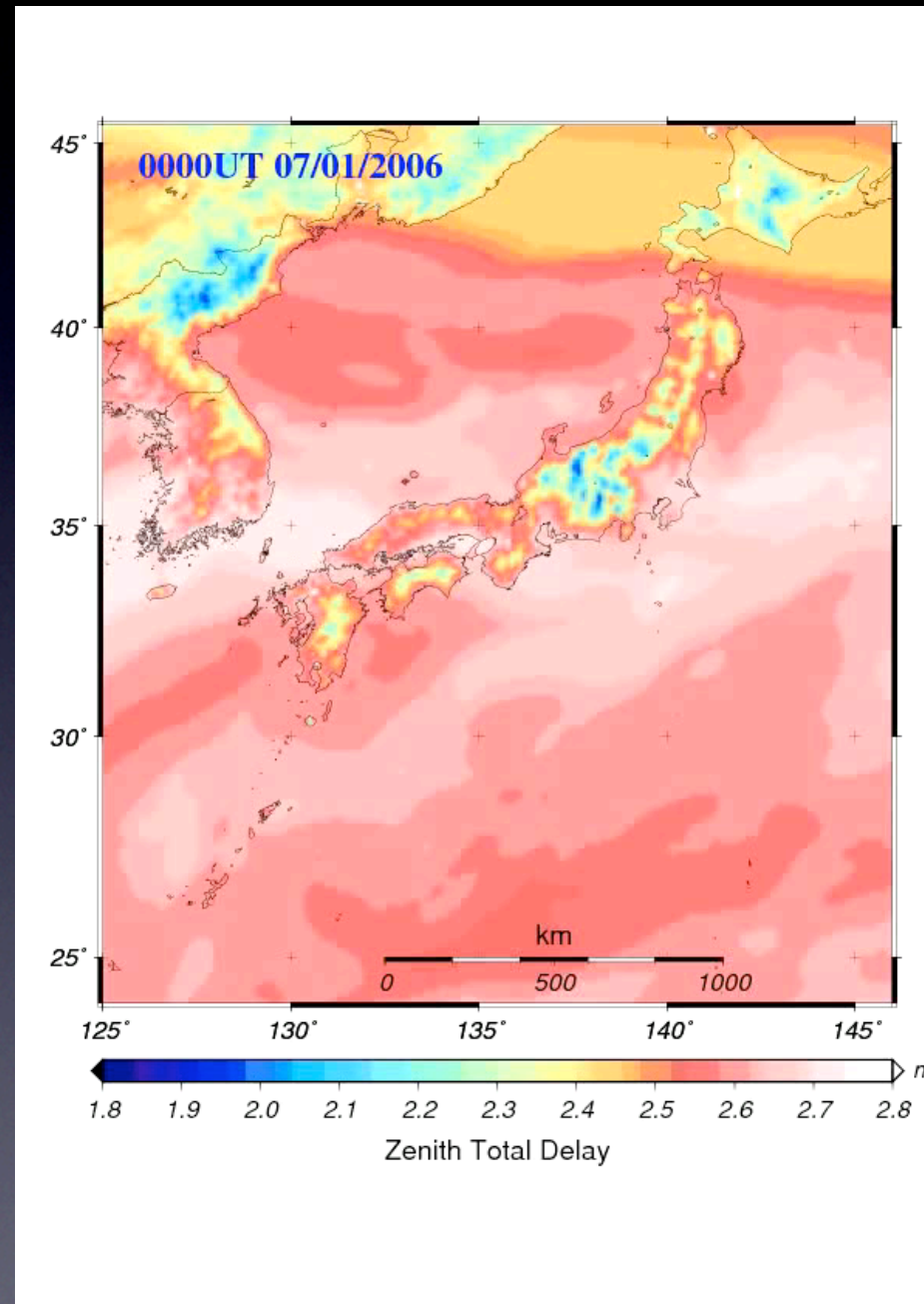


Analysis

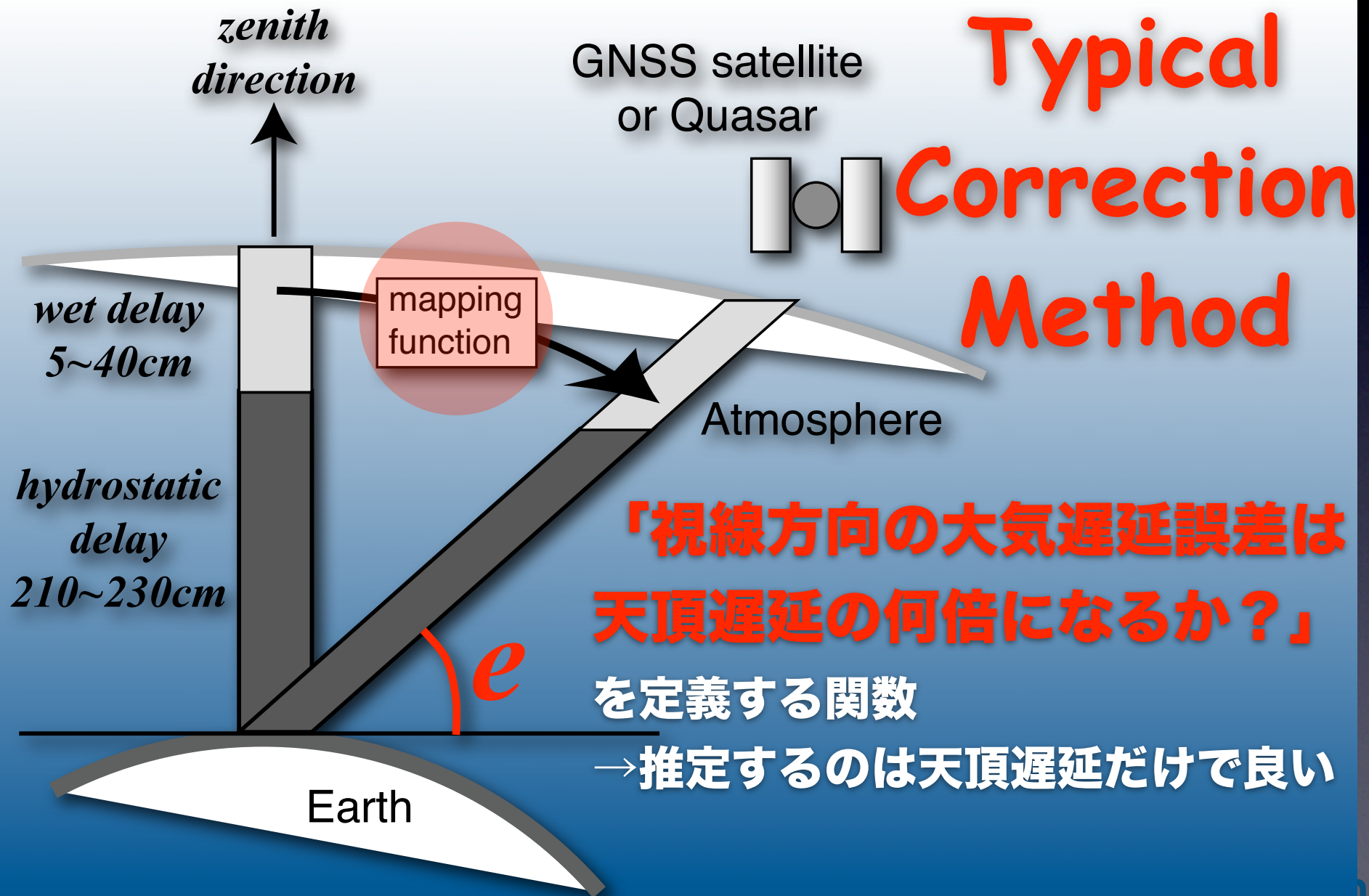
Results



Water Vapor



mapping function



Example of MF

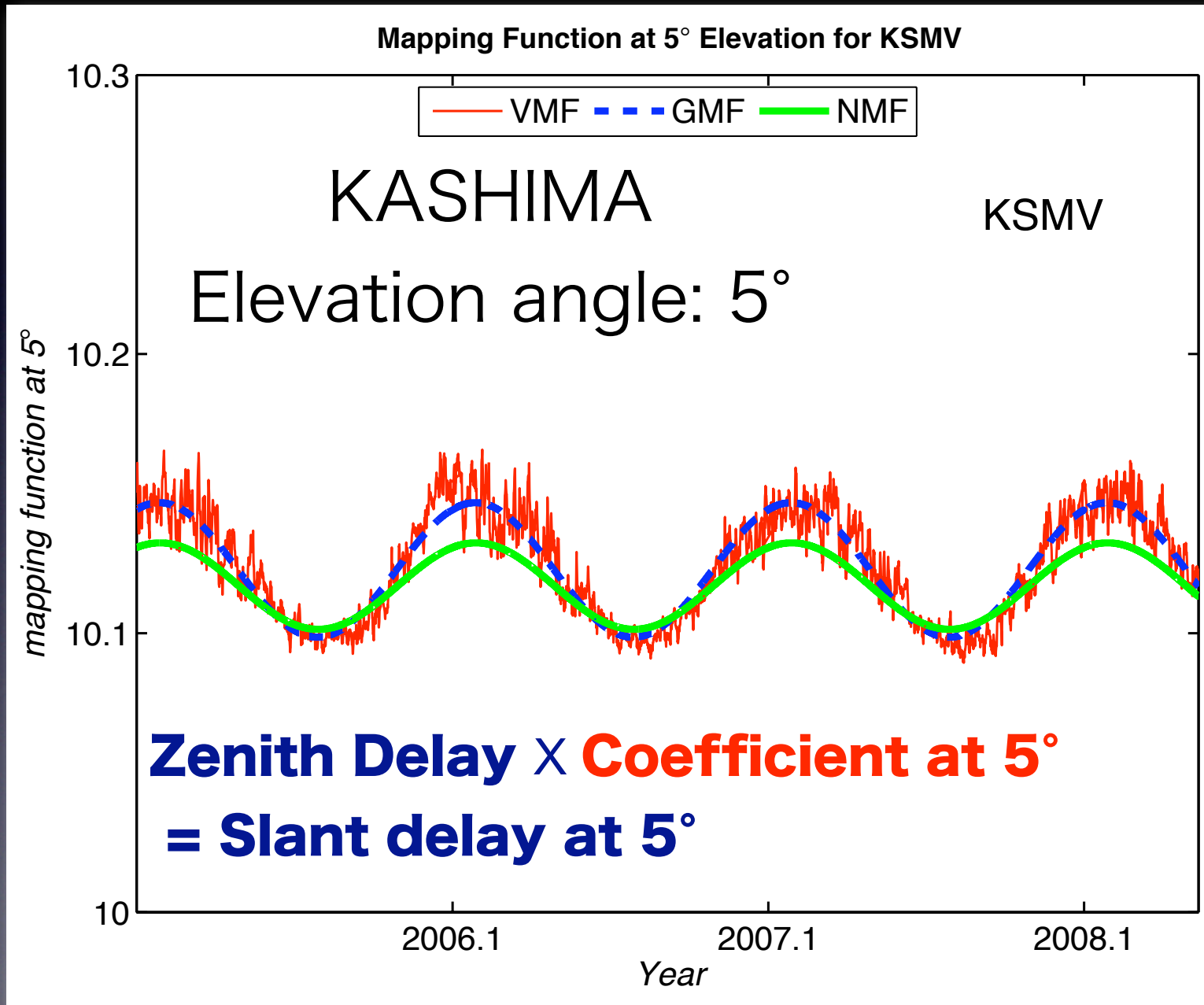
$$mf(e) = \frac{1 + \frac{a}{1 + \frac{b}{1 + c}}}{\sin(e) + \frac{a}{\sin(e) + \frac{b}{\sin(e) + c}}}$$

e: elevation angle

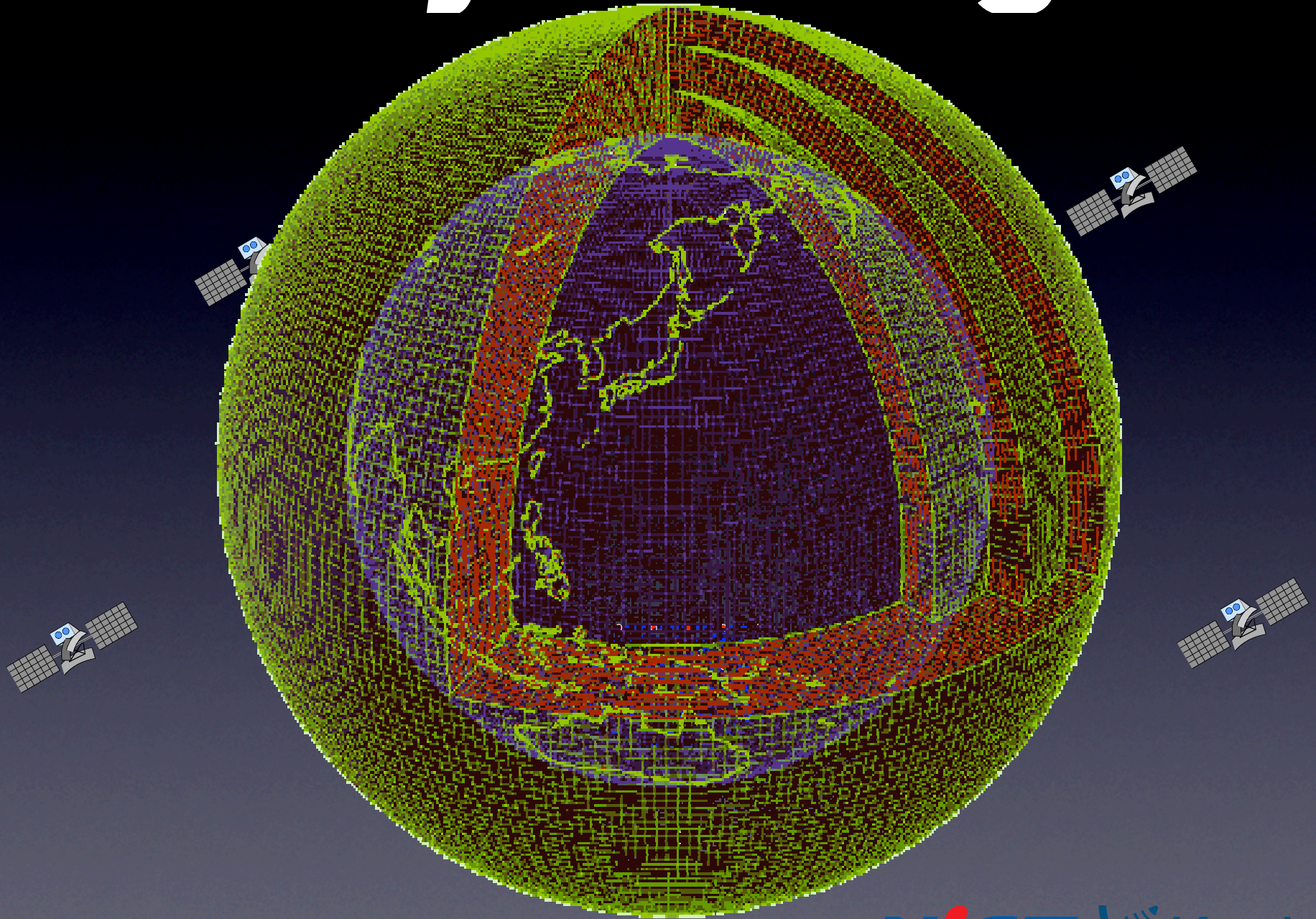
Typical Mapping Functions

		a , b , and c are determined by	NWM
NMF	Niell[1996]	lat, doy, hgt	[none]
IMF	Niell et al.[2001]	NWM	NCEP
GMF	Boehm et al.[2006]	lat, lon, doy, hgt (indirect use of NWM)	ECMWF
VMF	Boehm and Schuh[2004]	NWM	ECMWF

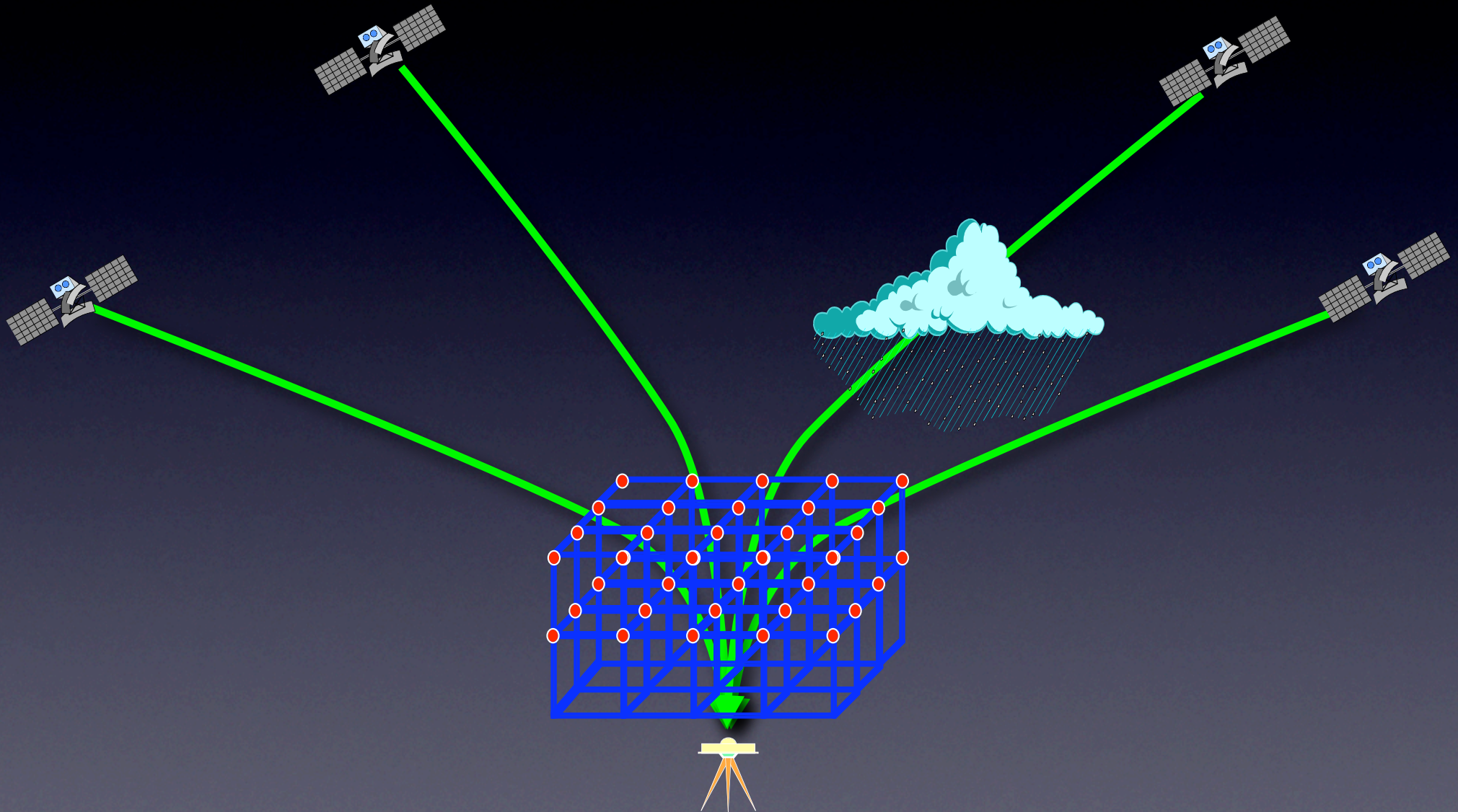
Mapping Functions -cont'd-



ray tracing

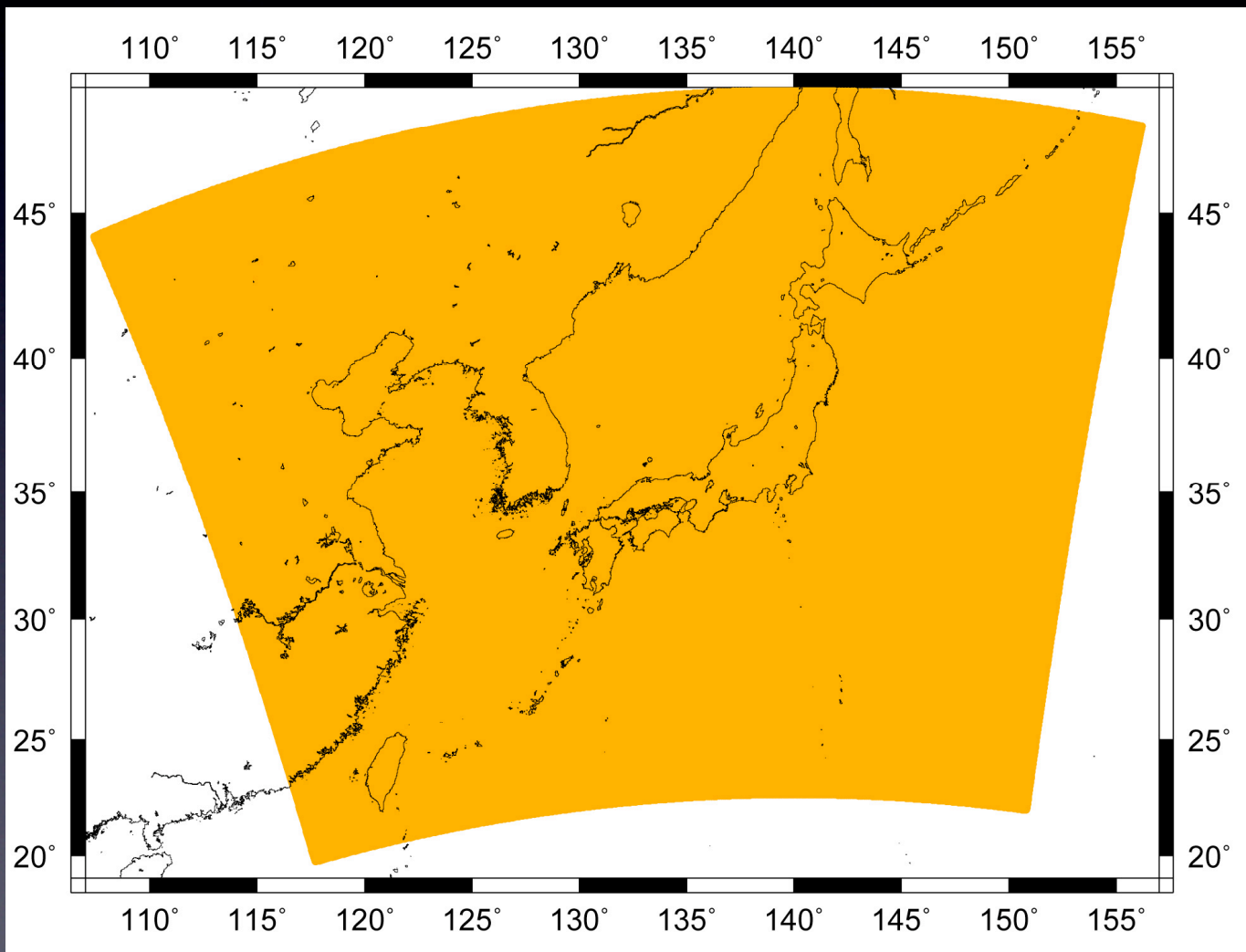


ray tracing



covered area by JMA/MANAL

*Mesoscale **ANAL**ysis Data by JMA*

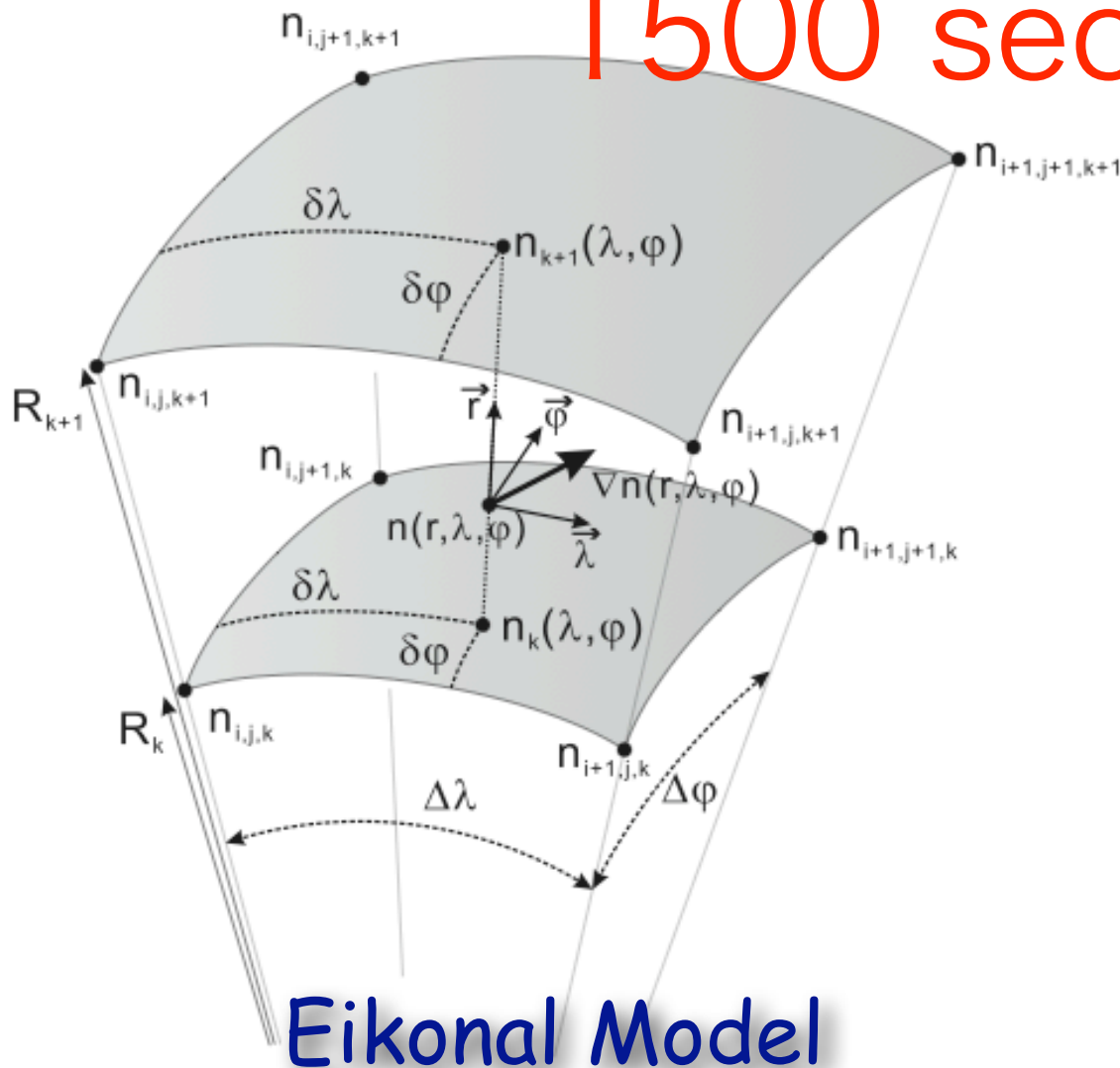


lon: 107°-157°E
lat: 19°-49°N

Countries covered:
Japan (100%)
Korea (100%)
Taiwan (100%)
China (partly)

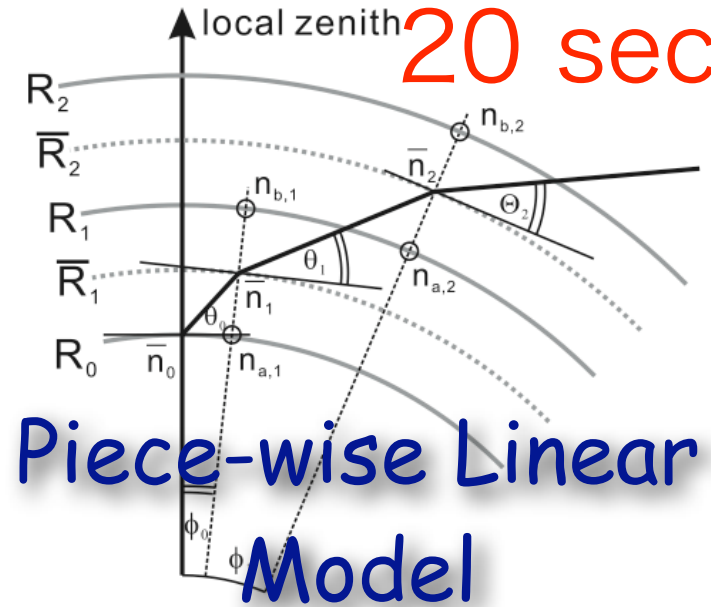
Ray-tracing calculation schemes

1500 sec



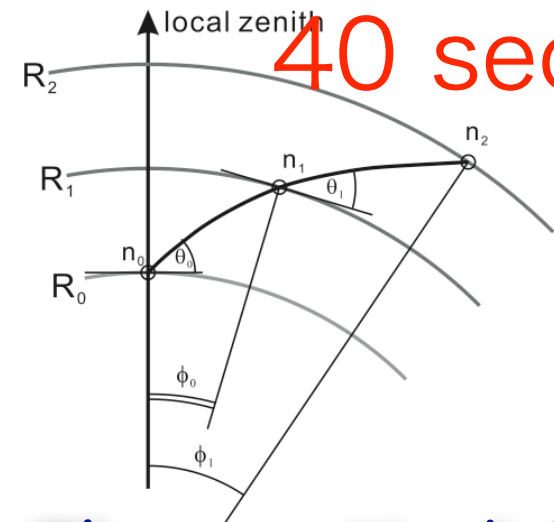
Eikonal Model

20 sec



Piece-wise Linear Model

40 sec



Thayer Model

Figure 4. Schematic of the Thayer approach.

Ray-tracing calculation schemes

1500 sec

20 sec

- 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.

Eikonal Model

Thayer Model

Figure 4. Schematic of the Thayer approach.

原理はカーナビ
測位と同じ

PPP

(Precise Point
Positioning
/高精度単独測位)

水平精度: 2-3mm
鉛直精度: $\leq 10\text{mm}$

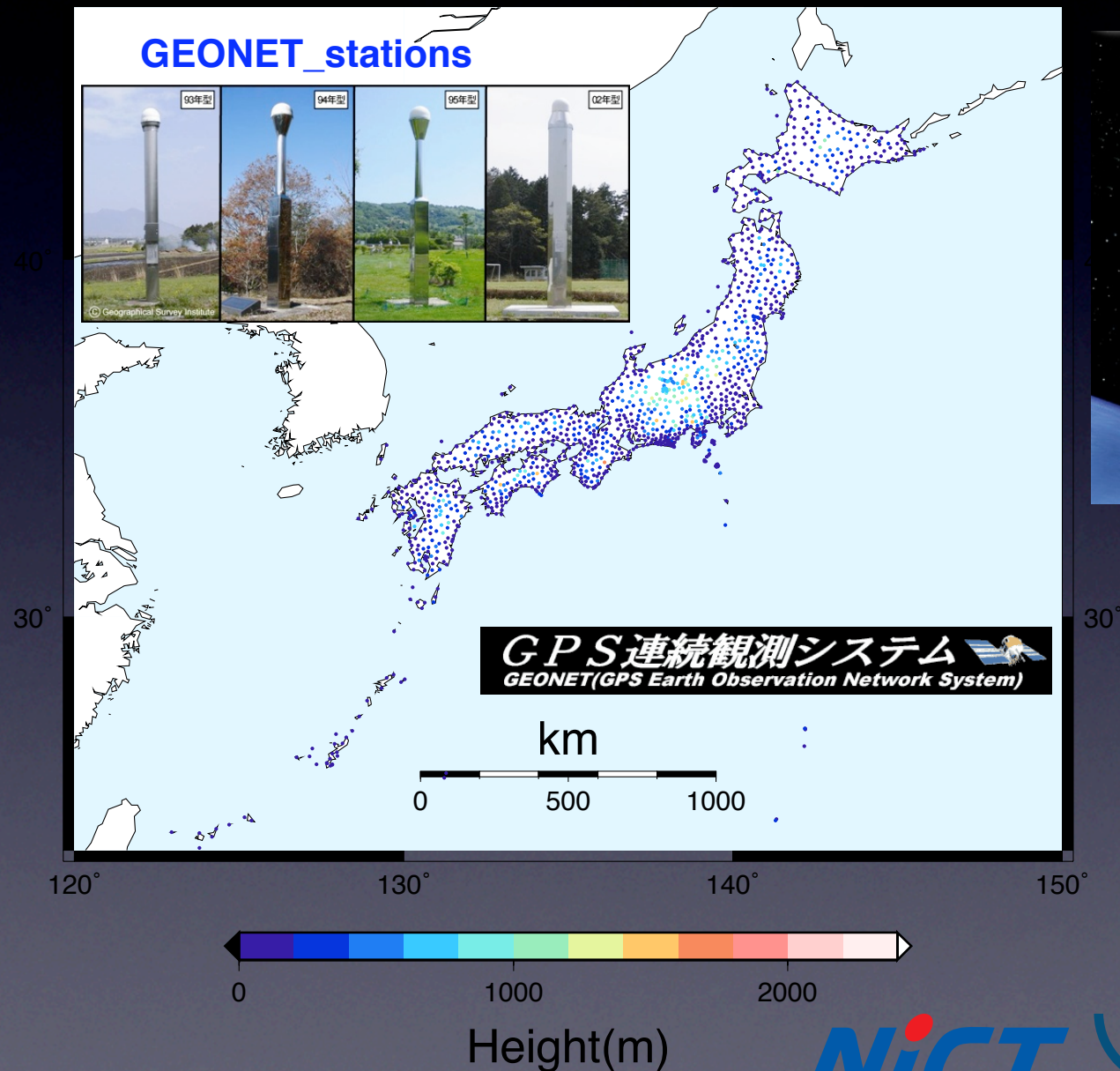
Processing

GPS/PPP Analysis

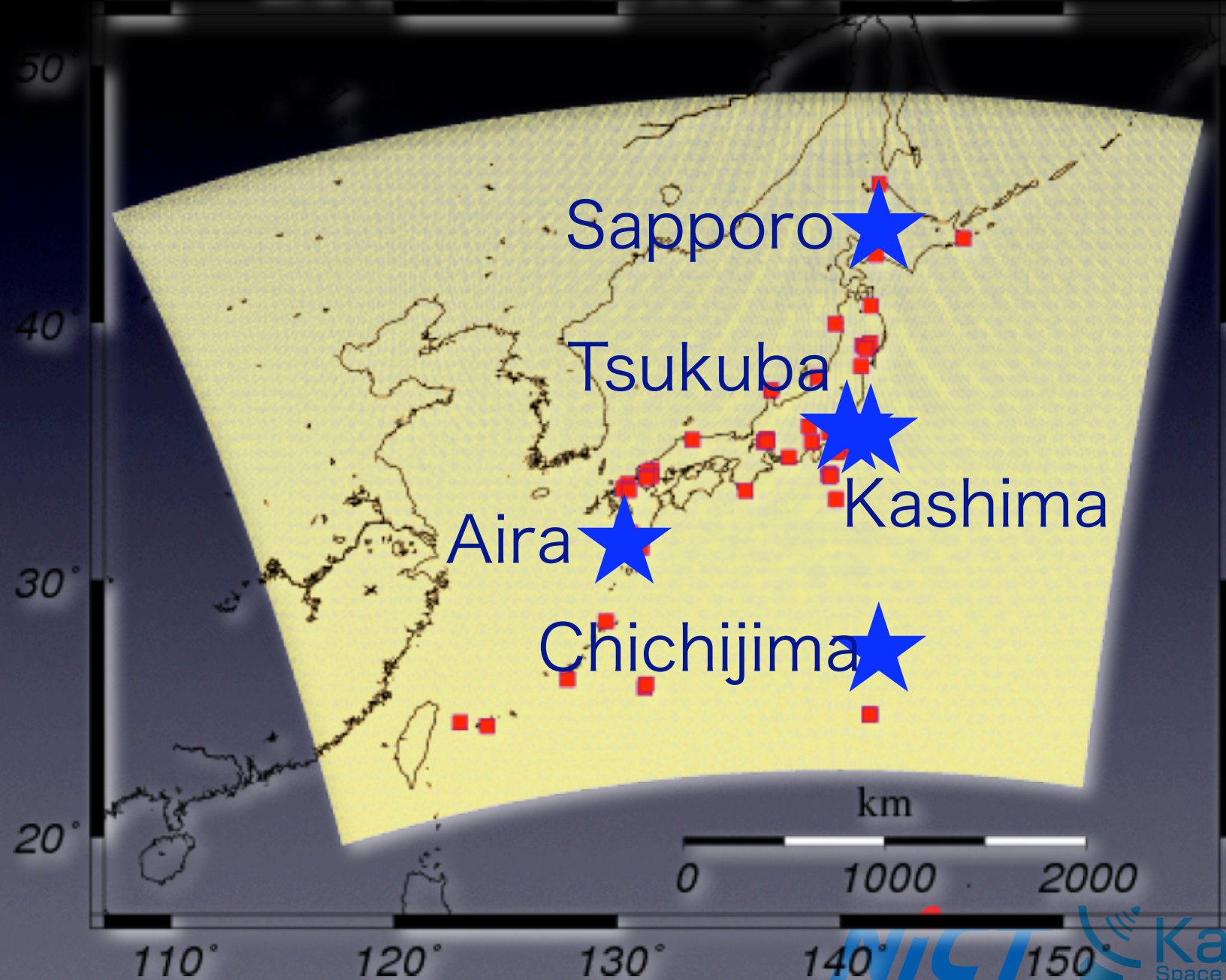
- DATA: GEONET/RINEX
 - KARAT reduced and Original
- period: 2008.1.1-12.31 (interval: 300sec.)
- Stations: 68 GEONET Stations
- mapping functions: VMF1, GMF
 - with gradient & w/o gradient
- processing: GPStools Ver. 0.64 (Takasu and Kasai [2003])

GEONET operated by GSI

(GPS Earth Observation Network)



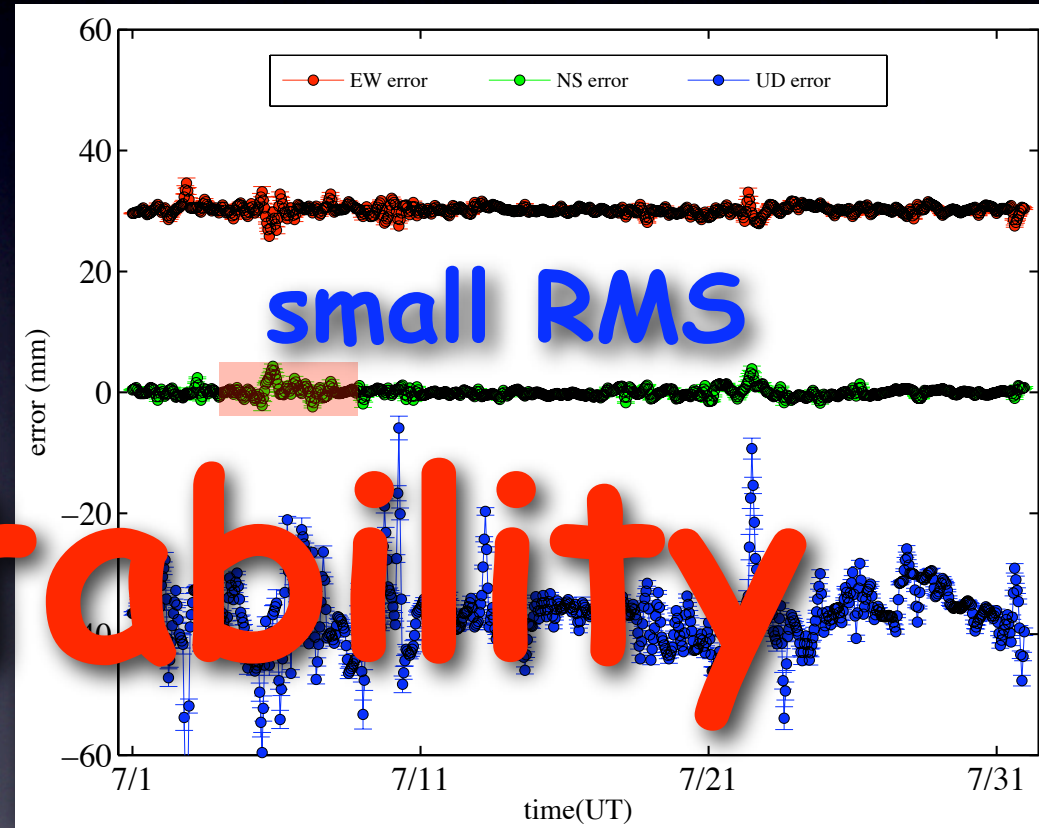
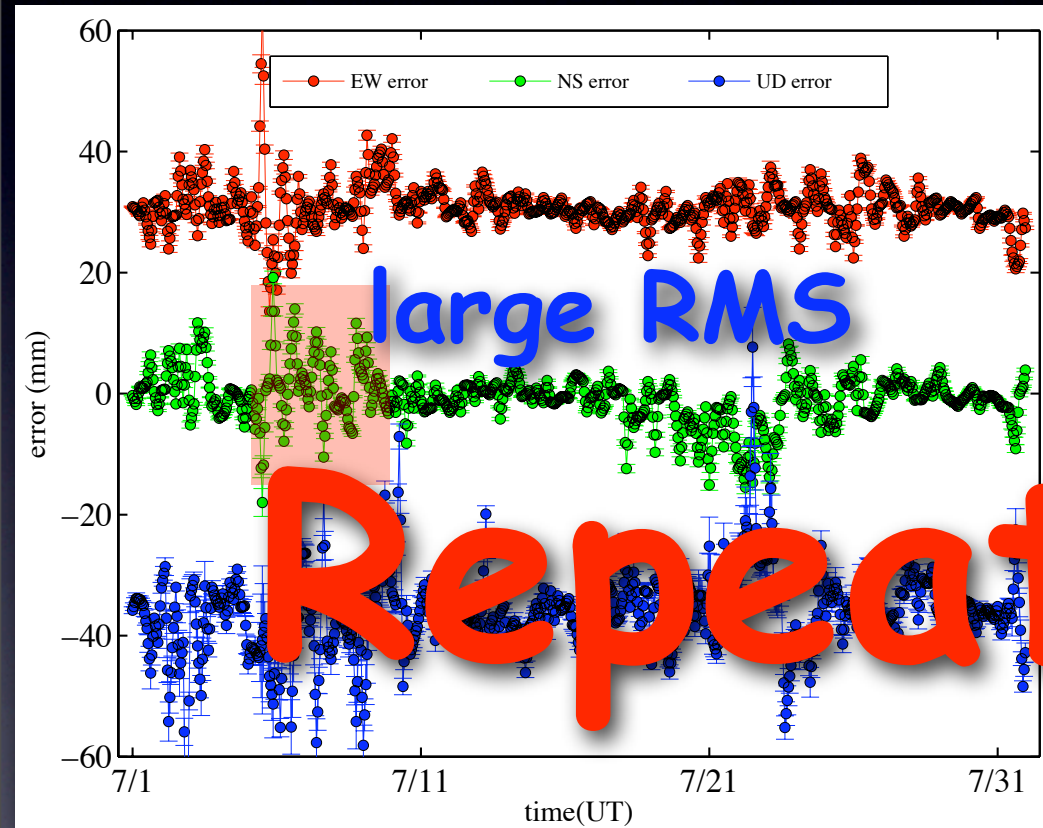
GEONET stations used in this study



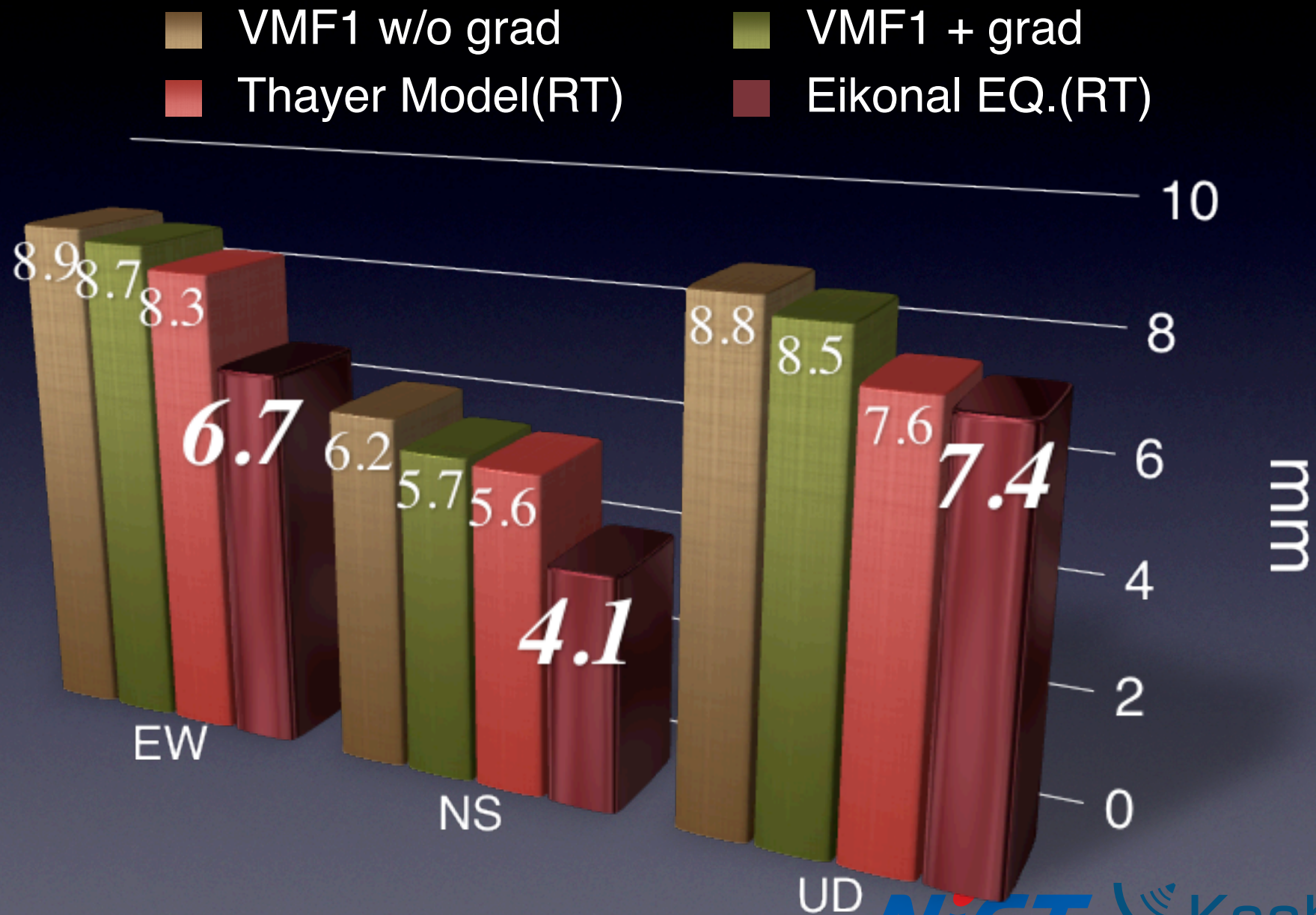
Site coordinate change at Kashima

w/o gradient

with gradient



repeatability (5 sites)



Summary

- **Fast ray-tracing tool for reducing position error due to atmosphere is available.**
- **Asymmetric contributions are completely removed using our tool.**

Thank you for your attention

