

波線追跡計算ツールKARAT を用いた測位誤差評価

Position Error Simulation using KARAT
through the JMA Mesoscale Numerical Weather Data

市川隆一、Thomas Hobiger、
小山泰弘、近藤哲朗


情報通信研究機構 鹿島宇宙技術センター

contents

- **Introduction -KARAT-**
- **Position Error Simulation**
- **Result**
- **Mapping Function Error?**
- **Summary**

KARAT

(Kashima Ray-Tracing Tool)



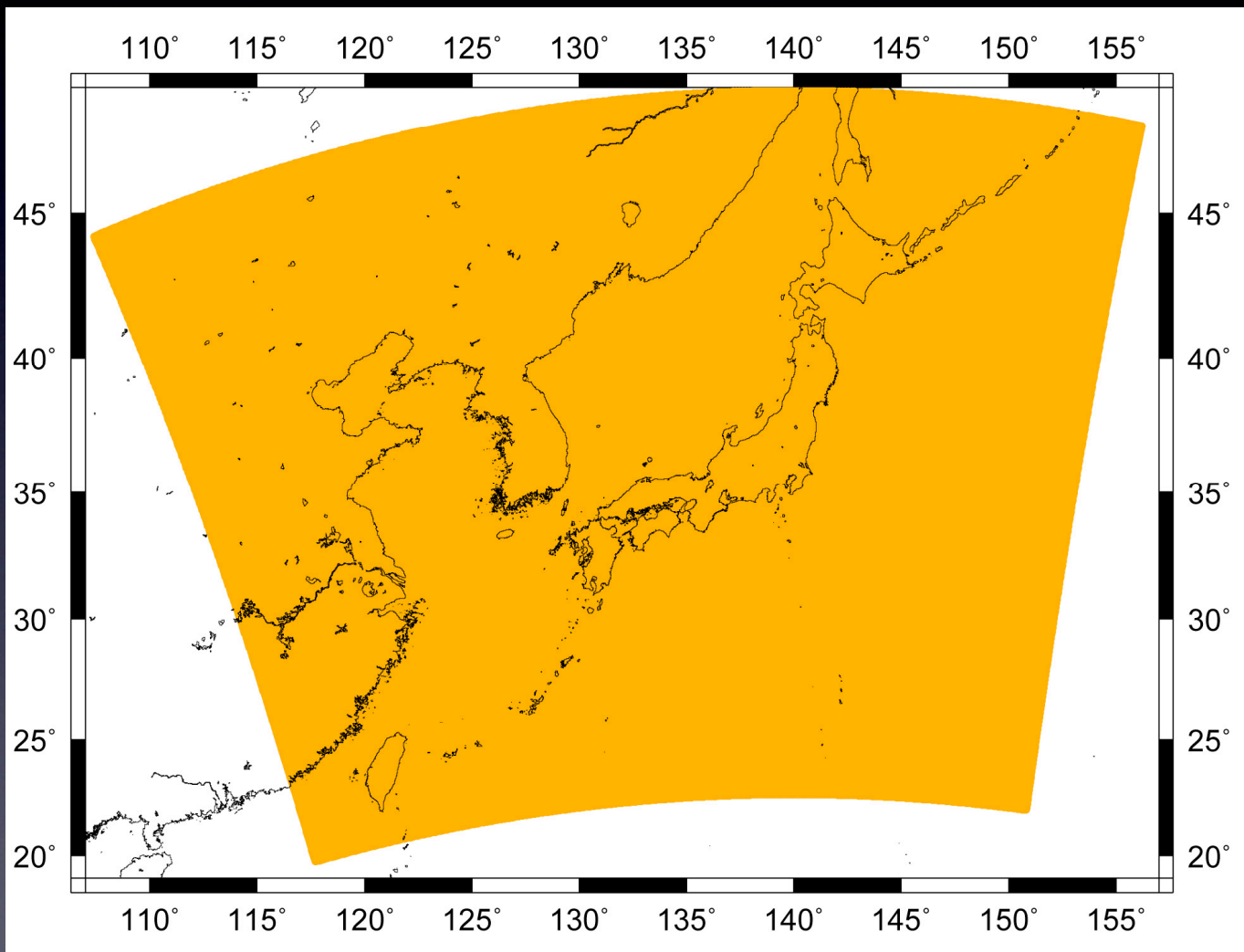
KASHIMA
RAY-
Tracing
Service
NiCT

Nu

other Model

covered area by JMA/MANAL

Mesoscale ANALysis Data by JMA



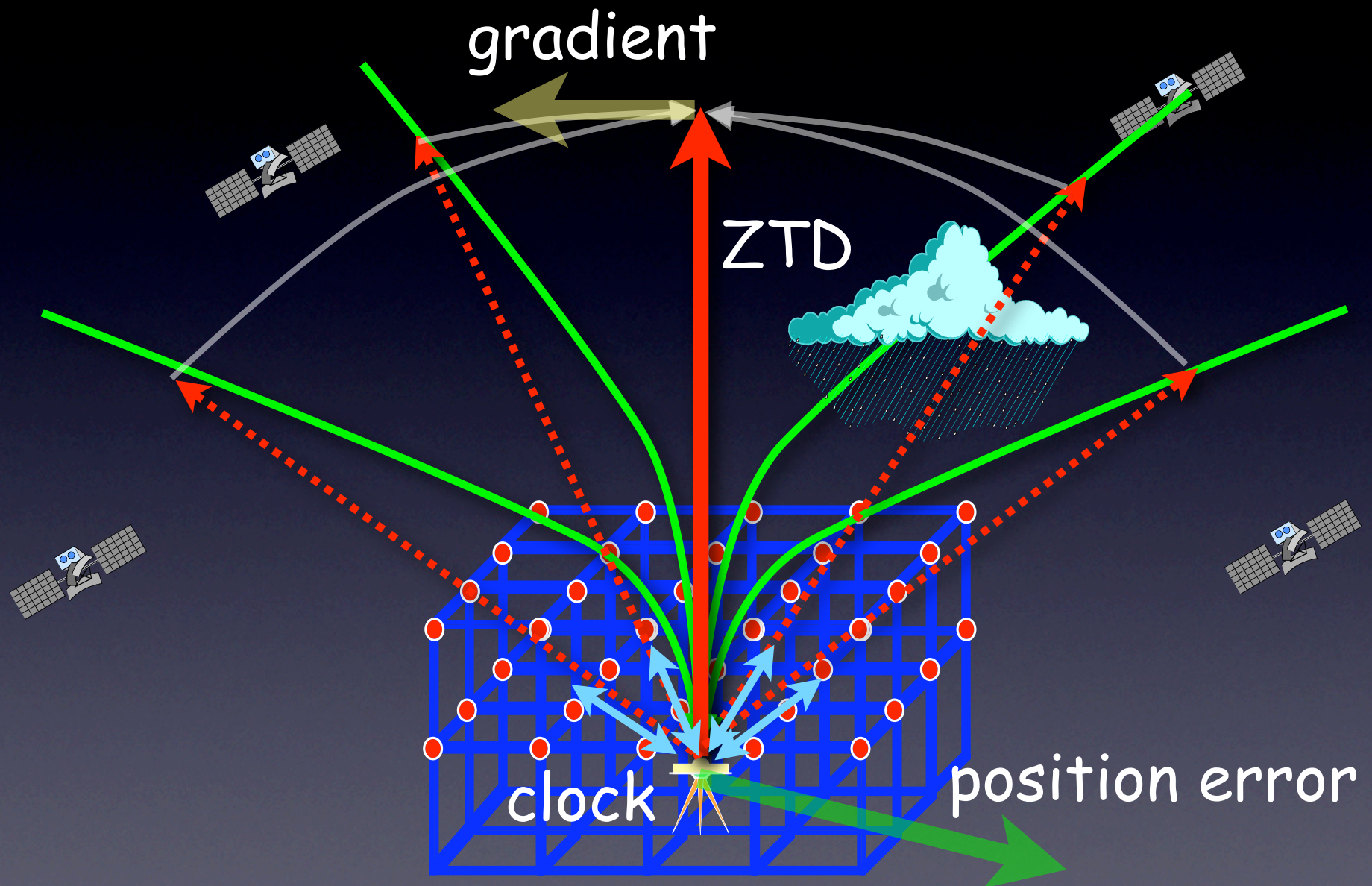
lon: 107°-157°E
lat: 19°-49°N

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

KARAT's capability

- Atmospheric Delay Correction for Space Geodetic Techniques
 - ex. VLBI, GNSS(GPS, Galileo, GLONAS, QZSS)
- Position Error Simulation
 - to evaluate analyzed results

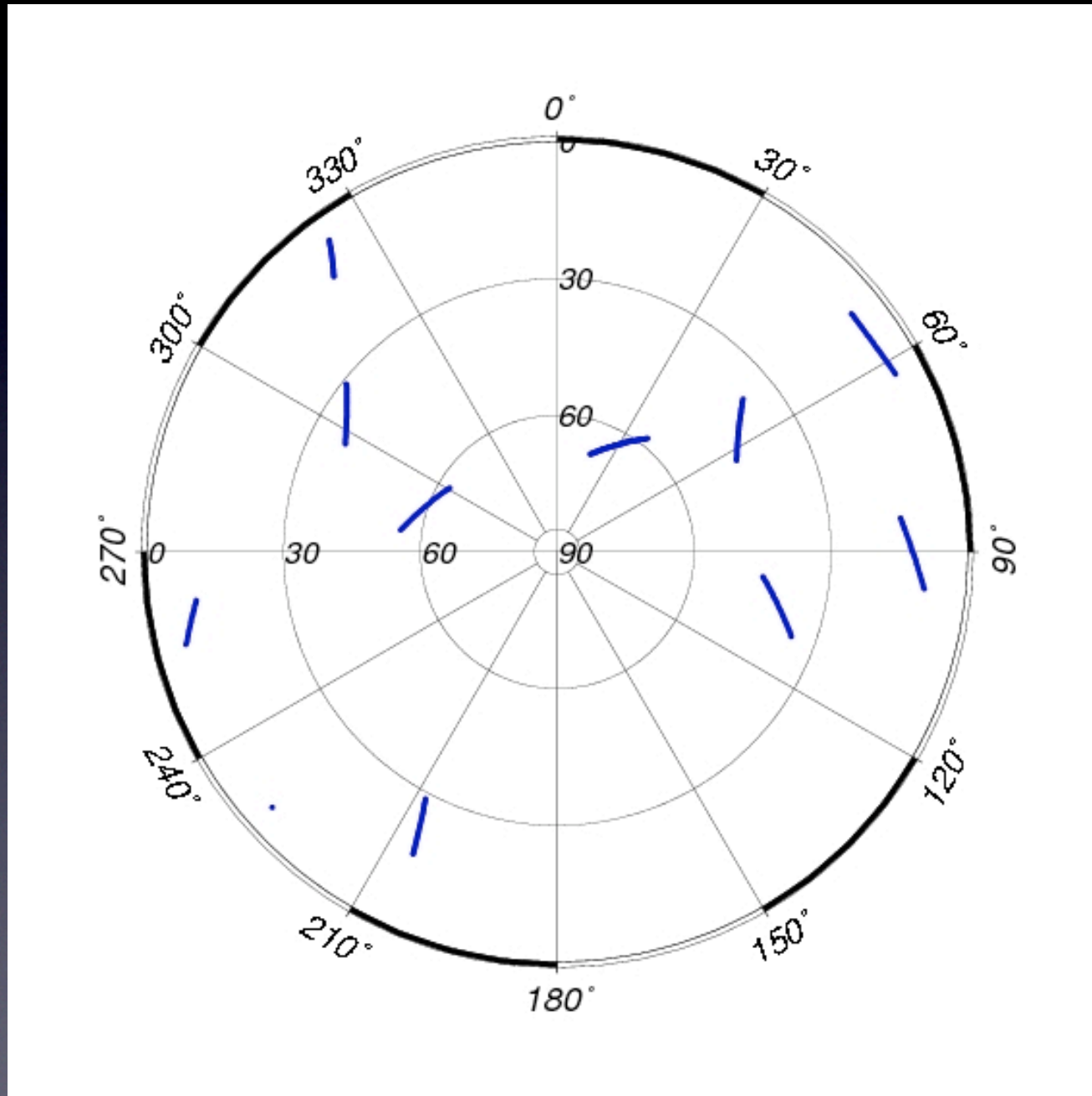
position error simulation

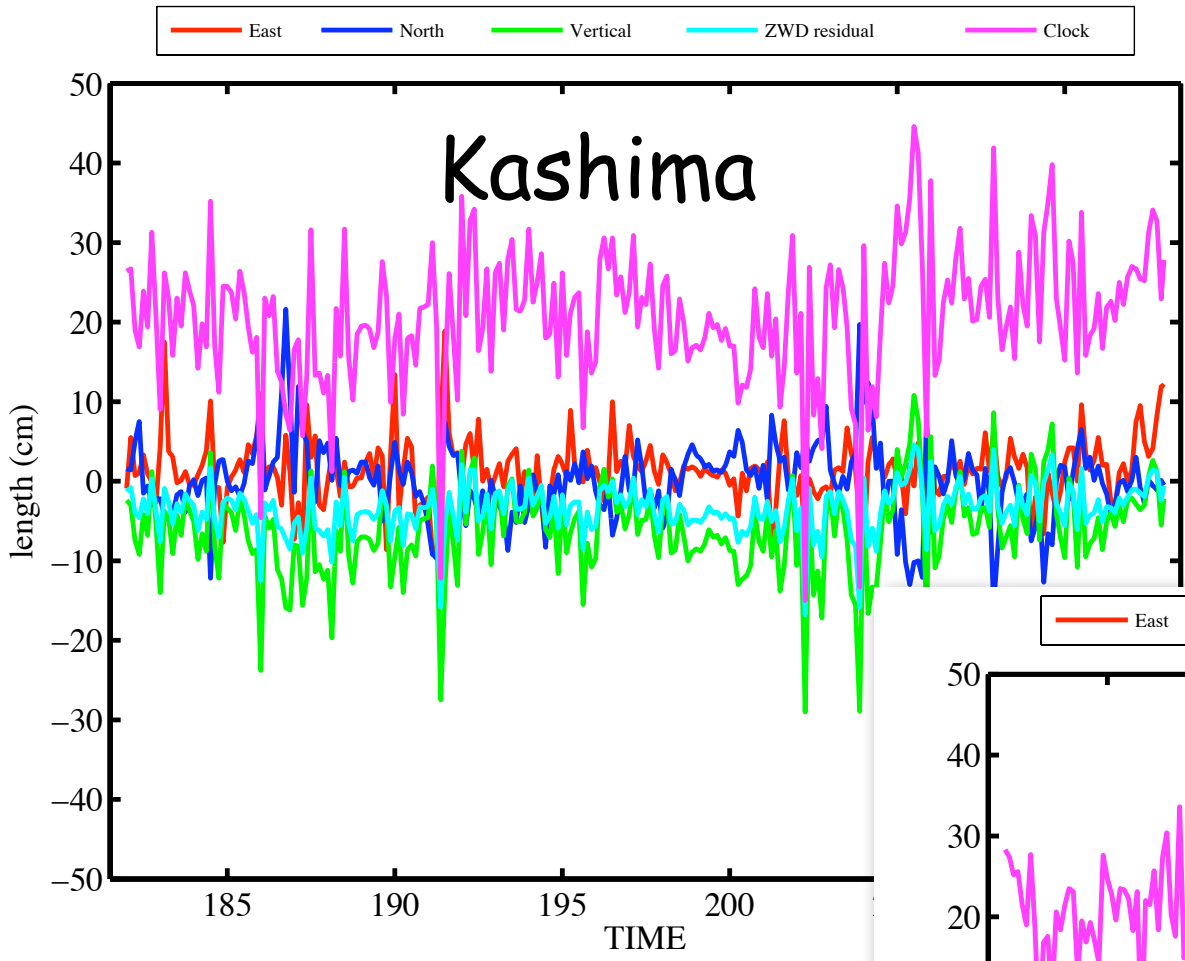


GPS/PPP simulation

- DATA: KARAT slant delay
- ZTD: GMF[Boehm et al., 2006]
- gradient: Chen & Herring[1997]
- clock: 100ps(~30mm)
- position error estimation
- period: 2006.7.1-31
- Tsukuba, Kashima, Aira, Uchinoura

GPS satellite constellation

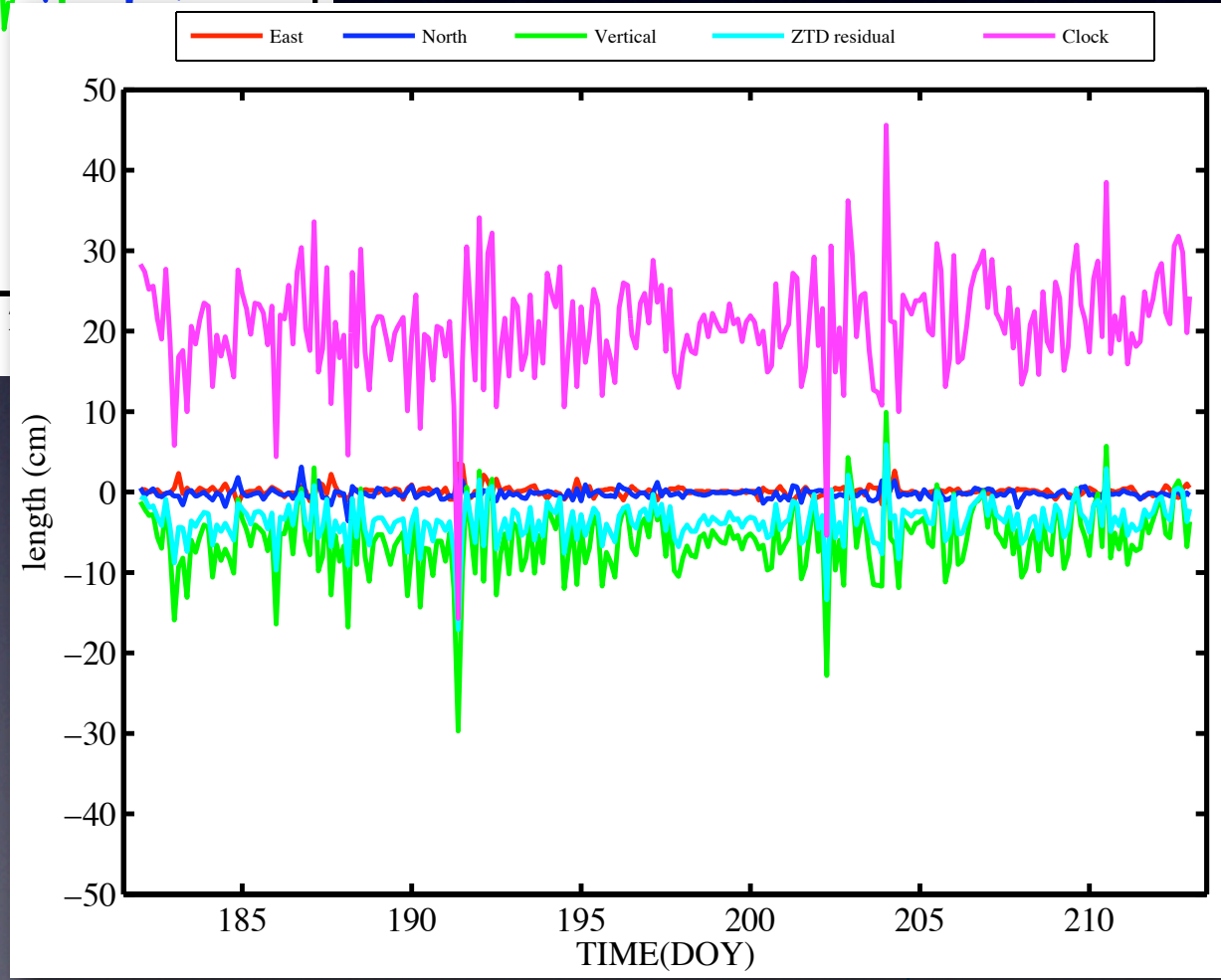
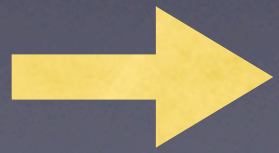


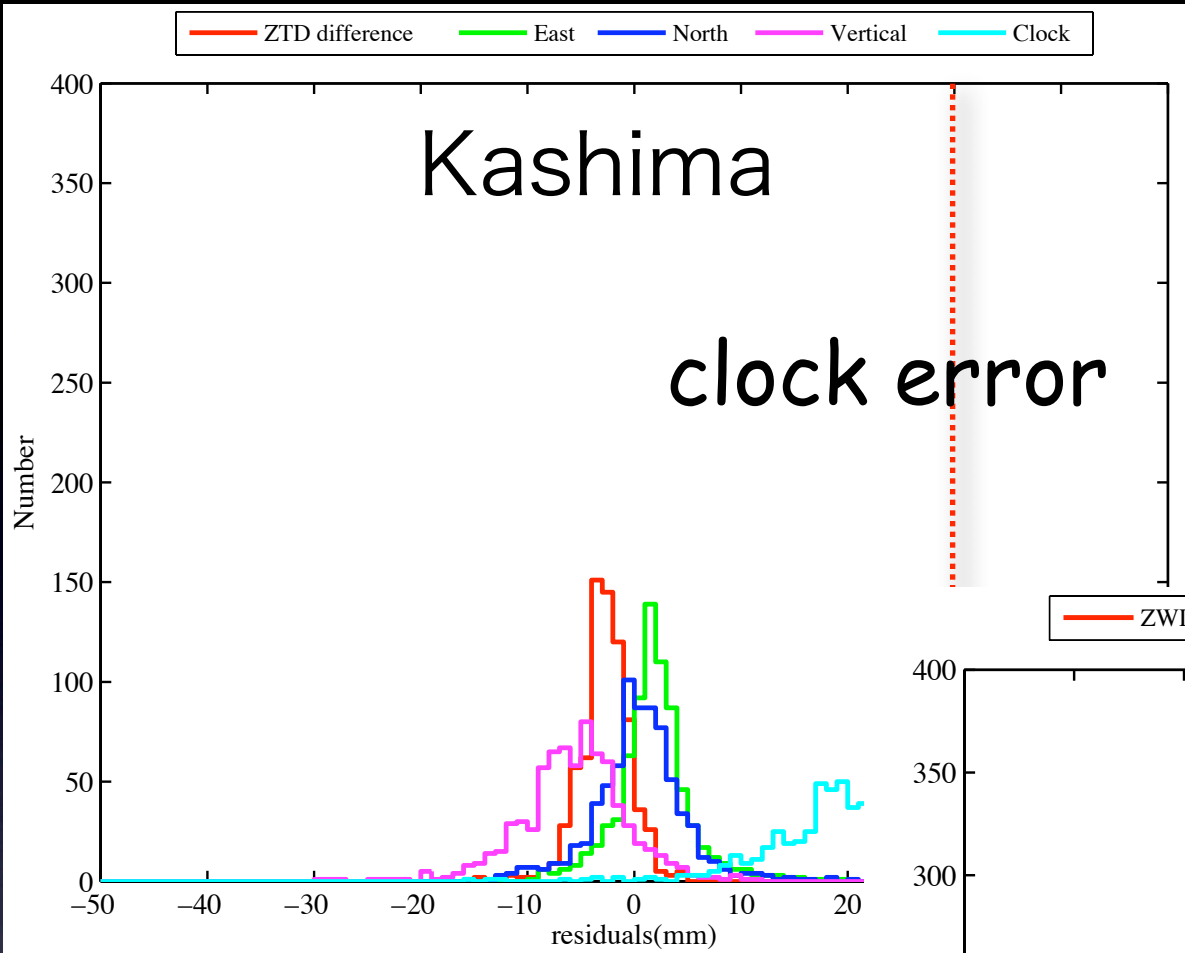


Elevation Cut Off: 10°
no atmospheric
gradient

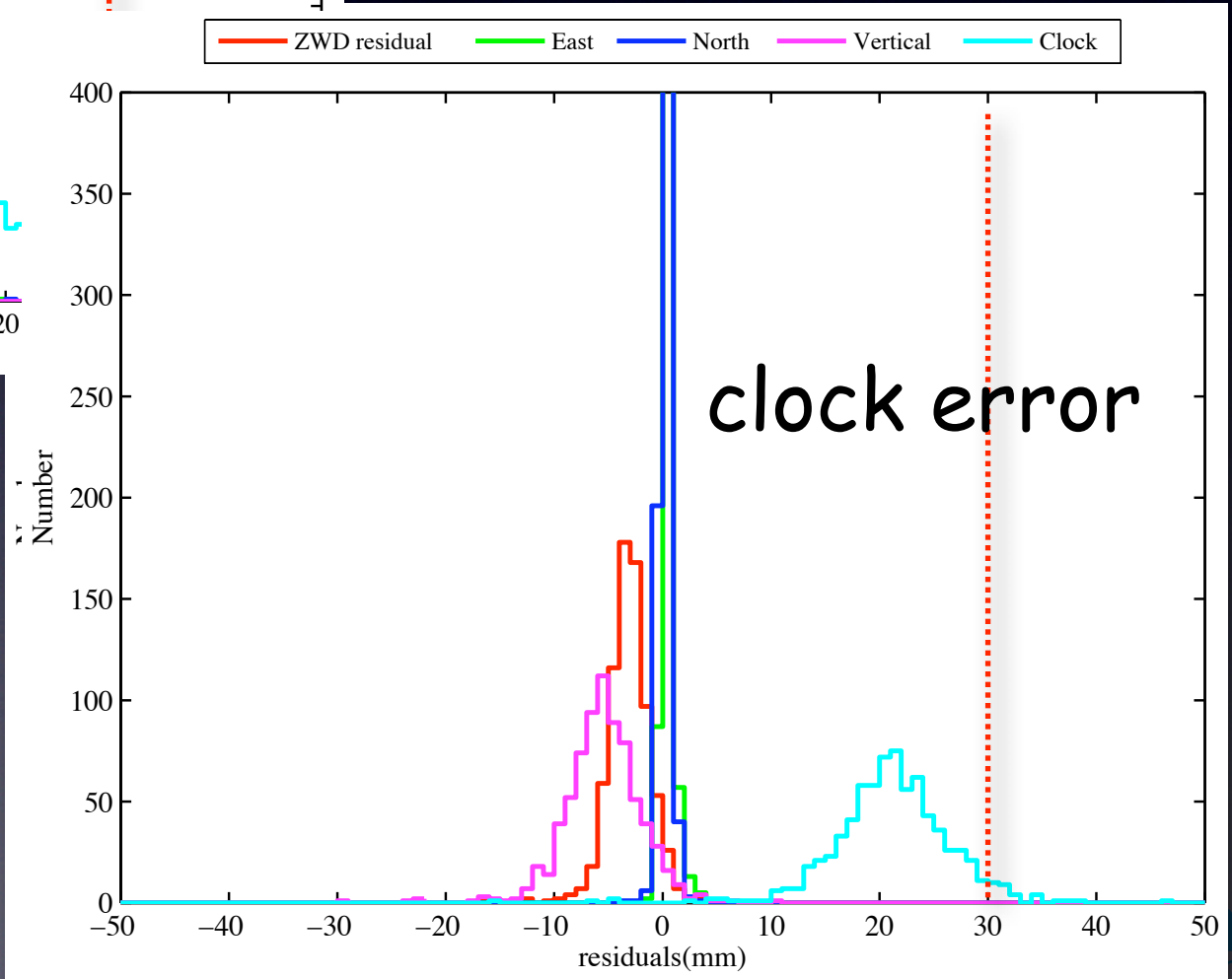


with atmospheric
gradient





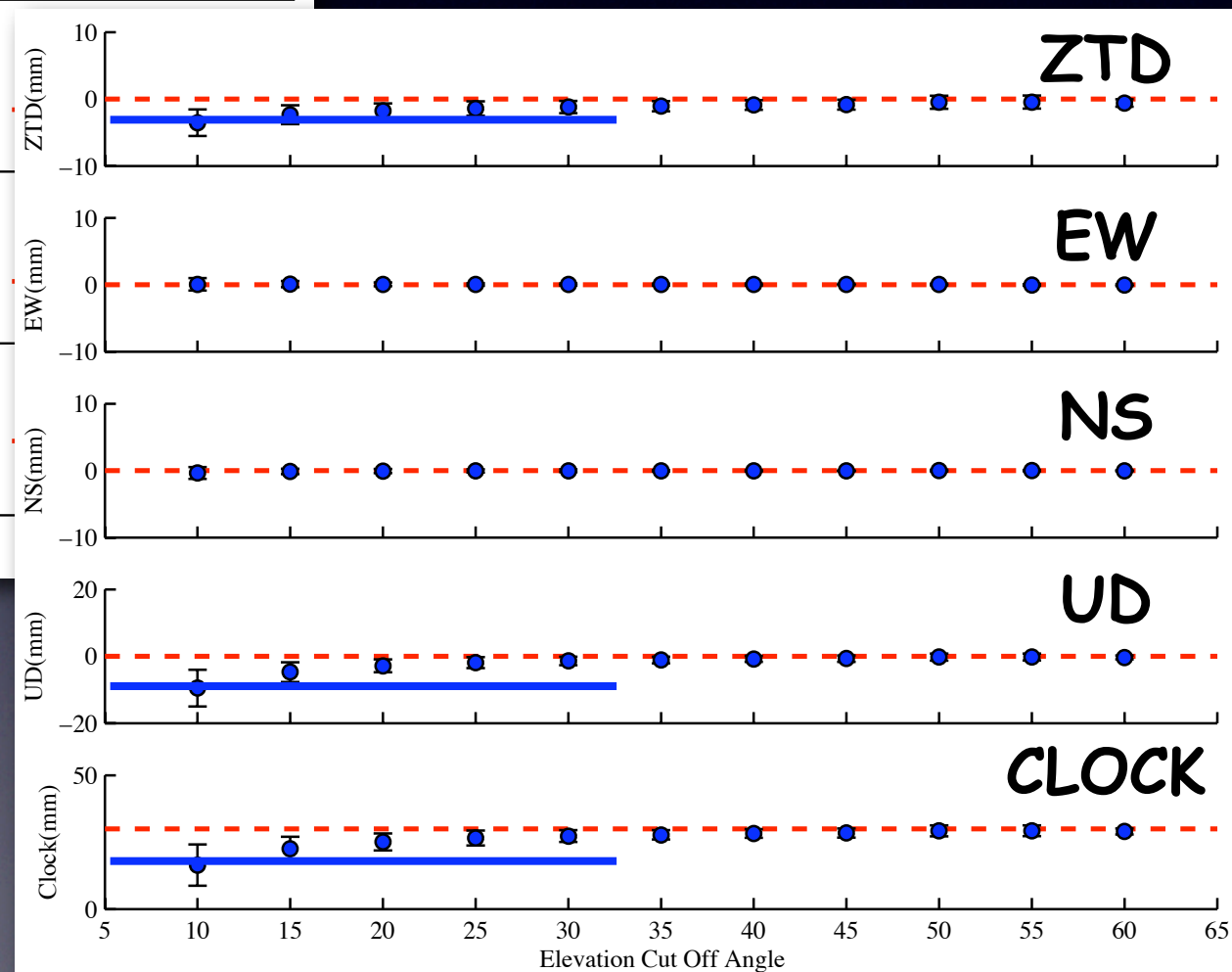
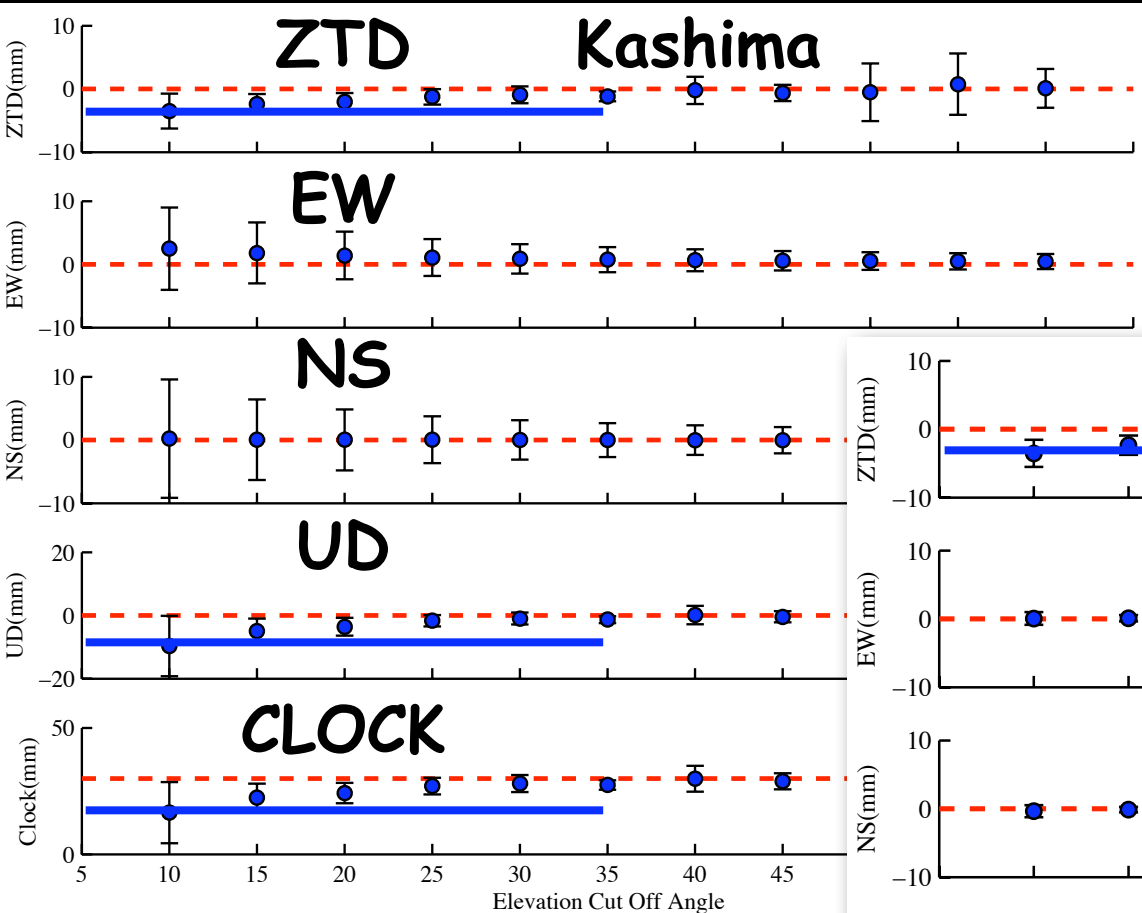
Elevation Cut Off: 10°
 no atmospheric gradient



with atmospheric gradient

Elevation Cut Off Test

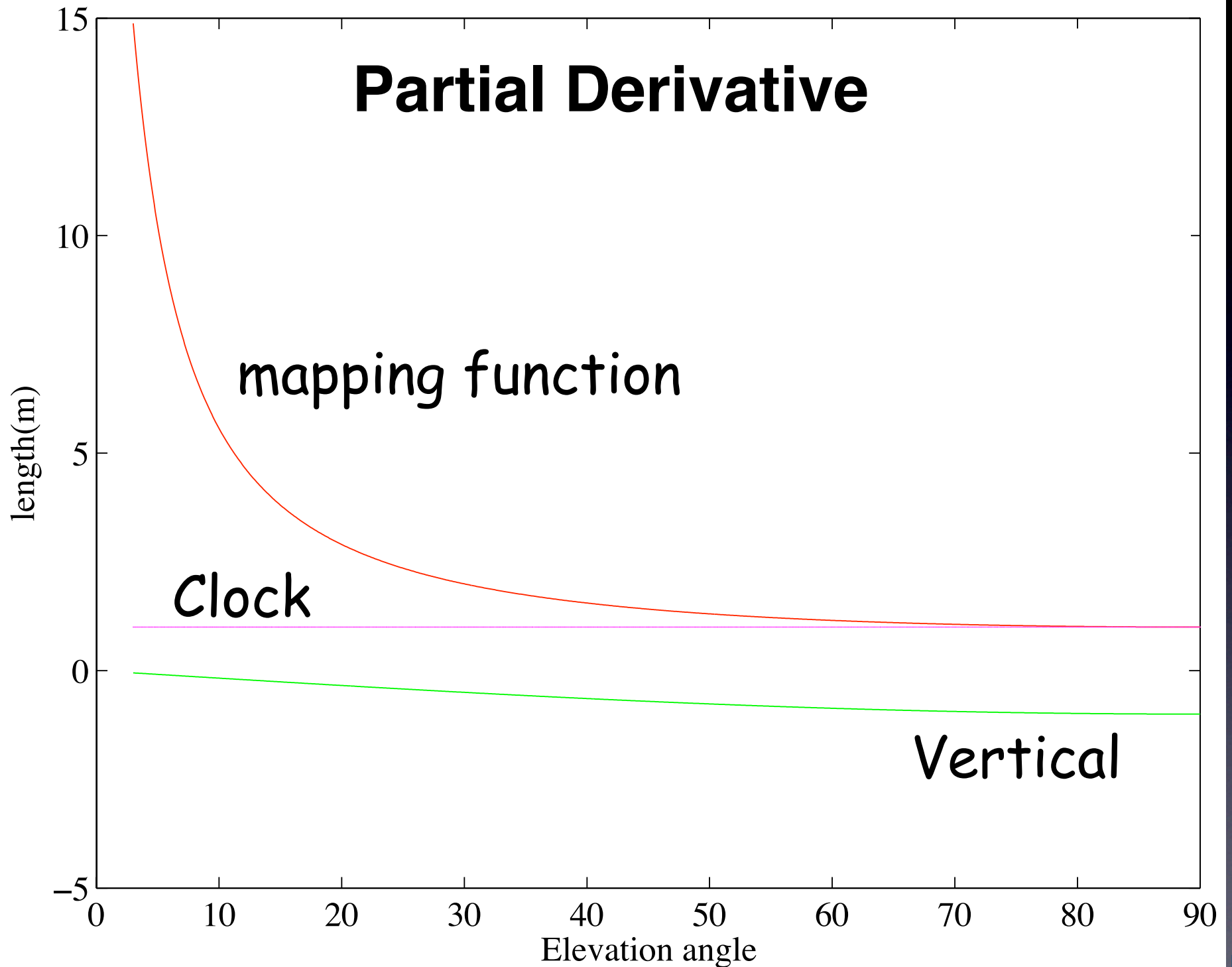
no atmospheric gradient



with atmospheric gradient



Partial Derivative



mapping function

Clock

Vertical

従来の議論と逆？

- 低仰角ほどクロック、ZTD、位置の各推定値の分離が良くなるはず？ -> **逆の結果**

bendingの効果？

- 一つの可能性
 - 多くの推定：wetとhydrostaticの2つの項に分けてマッピング関数を適用
 - KARAF: total slant delayを計算する。bendingもtotal refractive indexで計算

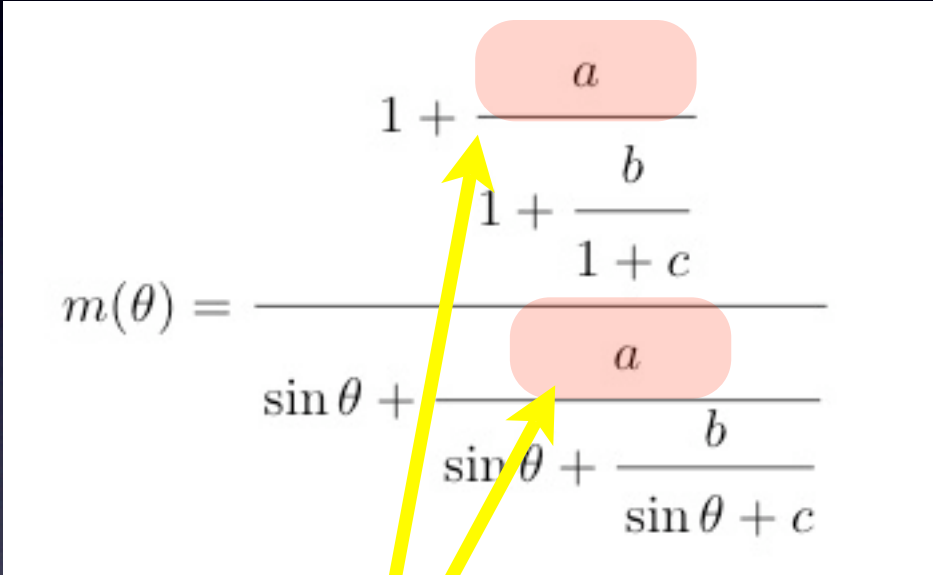
bending angle

total delay > wet + hydrostatic

そもそもそのマッピング関数の 作り方に問題ある？

● 最近のmapping function

- *ex.*
 - IMF[Niell, 2001]
 - VMF[Boehm et al., 2004]
 - GMF[Boehm et al., 2006]


$$m(\theta) = \frac{1 + \frac{a}{1 + \frac{b}{1 + c}}}{\sin \theta + \frac{a}{\sin \theta + \frac{b}{\sin \theta + c}}}$$

(slant delay at 3.3°)/(zenith delay)

Simulation

$$\Delta d_{h+w}(\varepsilon) = \hat{d}_{h,z} + \hat{d}_{w,z} - \left(\frac{\hat{d}_h(\varepsilon)}{m f_h(\varepsilon)} + \frac{\hat{d}_w(\varepsilon)}{m f_w(\varepsilon)} \right)$$

ray traced delayからmapping

function推定値を減じる

$$\Delta d_t(\varepsilon) = \hat{d}_{t,y} - \frac{\hat{d}_t(\varepsilon)}{m f_t(\varepsilon)}$$

h: hydrostatic delay

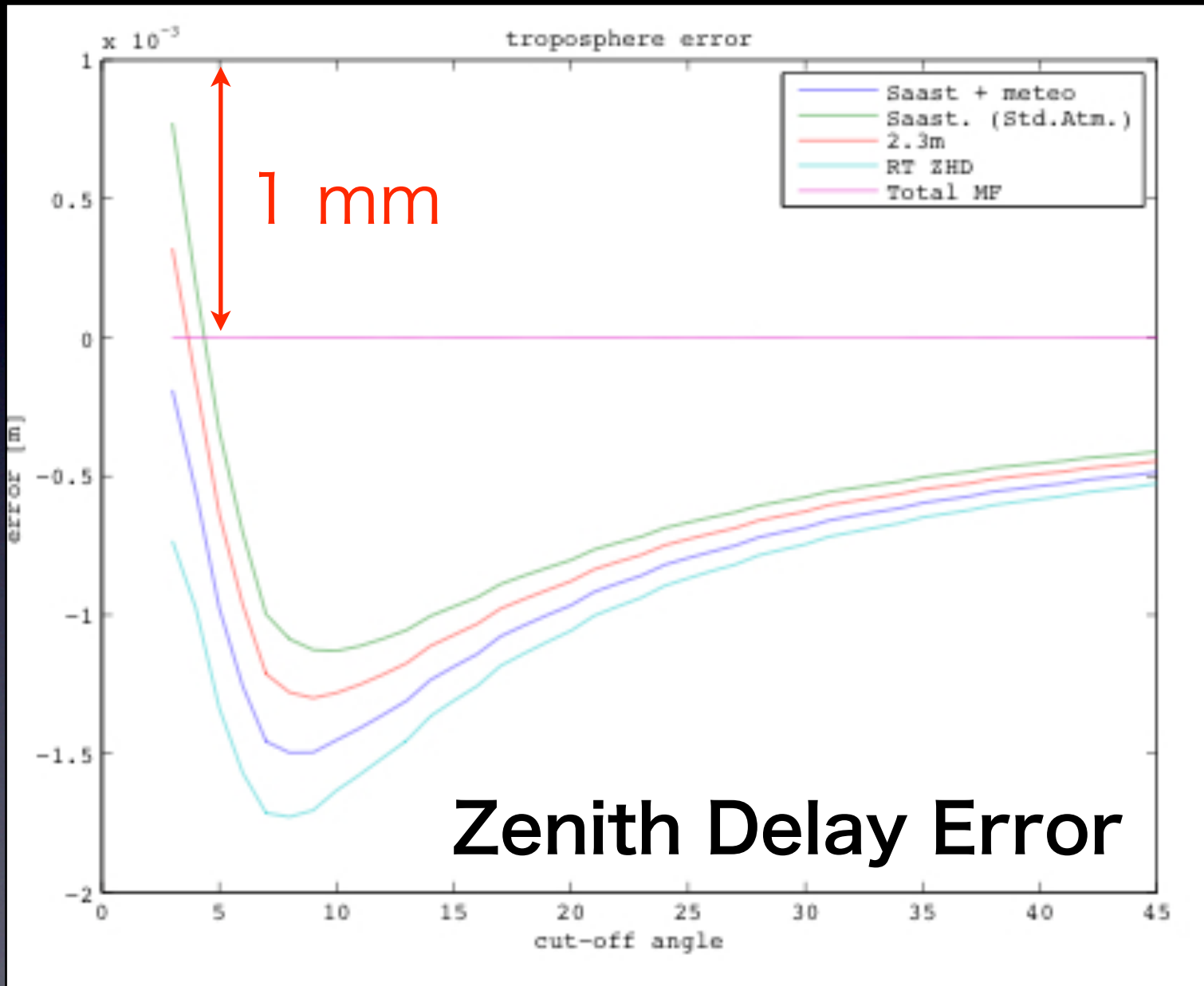
w: wet delay

t: total delay

z: zenith delay

[^]付きは"ray traced delay"

Simulation(cont'd)



Zenith Delay Error

まとめ

- KARAT slant delayをデータとして、クロック、位置、測位誤差をシミュレーション
- 低仰角ほど分離悪い -> mfに起因する系統誤差？
 - bending delayの影響か？ -> X
 - mapping functionそのものに問題あるらしい -> 調査中