Modeling azimuthal asymmetries of the troposphere delay during a 14-days typhoon period in Tsukuba

A. Pany, J. Boehm, T. Hobiger, R. Ichikawa, H. Schuh

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March 24-25, 2009

Motivation

- state-of-the-art modeling of troposphere delay:

$$\Delta L = \Delta L_h^z \cdot mf_h(e) + \Delta L_w^z \cdot mf_w(e) +$$

$$mf_g(e) \cdot [G_N \cdot \cos(\alpha) + G_E \cdot \sin(\alpha)]$$

ΔL troposphere total delay

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symmetric part

asymmetric part

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ΔL	troposphere total delay
ΔL_h^z / ΔL_h^w	zenith hydrostatic/wet delay
mf_h / mf_w	mapping function hydrostatic/wet
e	elevation angle
mf_g	$mf_h \cdot \cot(e)$ or $mf_w \cdot \cot(e)$
G_N / G_E	north/east gradient
α	azimuth

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- high resolution numerical weather models (NWM) allow ray-tracing through atmosphere
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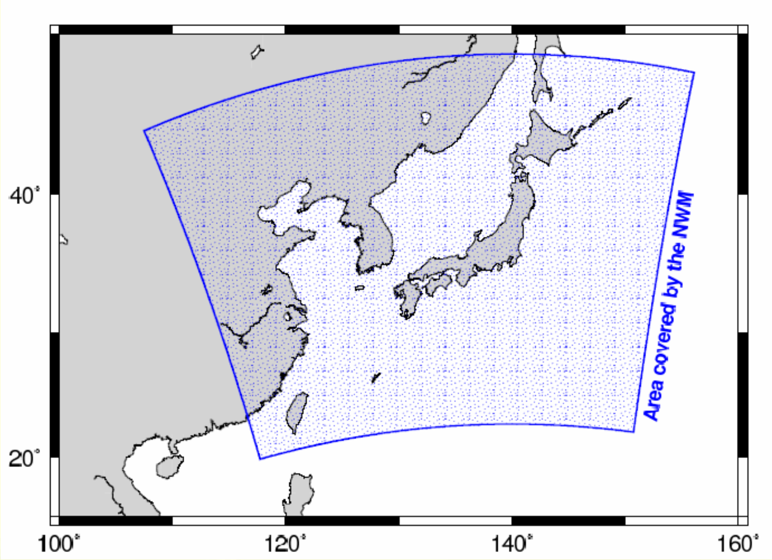

Real-time ray-tracing through numerical weather models for space geodesy, T. Hobiger, R. Ichikawa, Y. Koyama, T. Kondo, NICT IVS Technical Development Center News, 2008

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→ use ray-traced delays to improve mapping functions and explore possibilities for improving the modeling of azimuthal asymmetries

Data

- ray-traced delays were computed with the **KA**shima **RA**y-tracing **T**ools (KARAT) (Hobiger et al., 2008)
- from meteorological fields of the **J**apan **M**eteorological **A**gency (JMA)

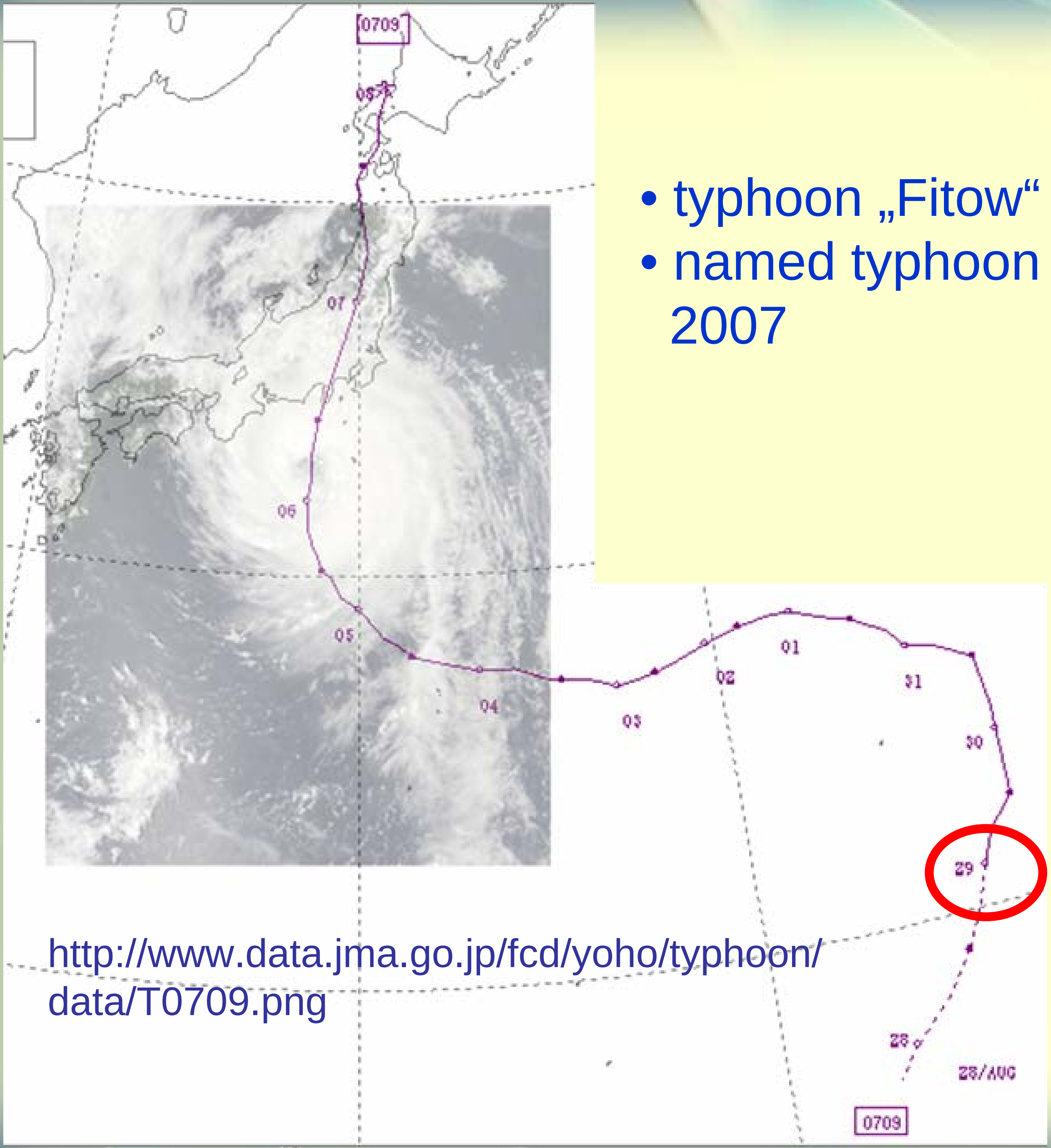
Data

- typhoon „Fitow“

photo taken on 06/09/2007,
1:15 pm local time

http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=18973

- typhoon „Fitow“
- named typhoon on August 29, 2007



http://www.data.jma.go.jp/fcd/yoho/typhoon/data/T0709.png

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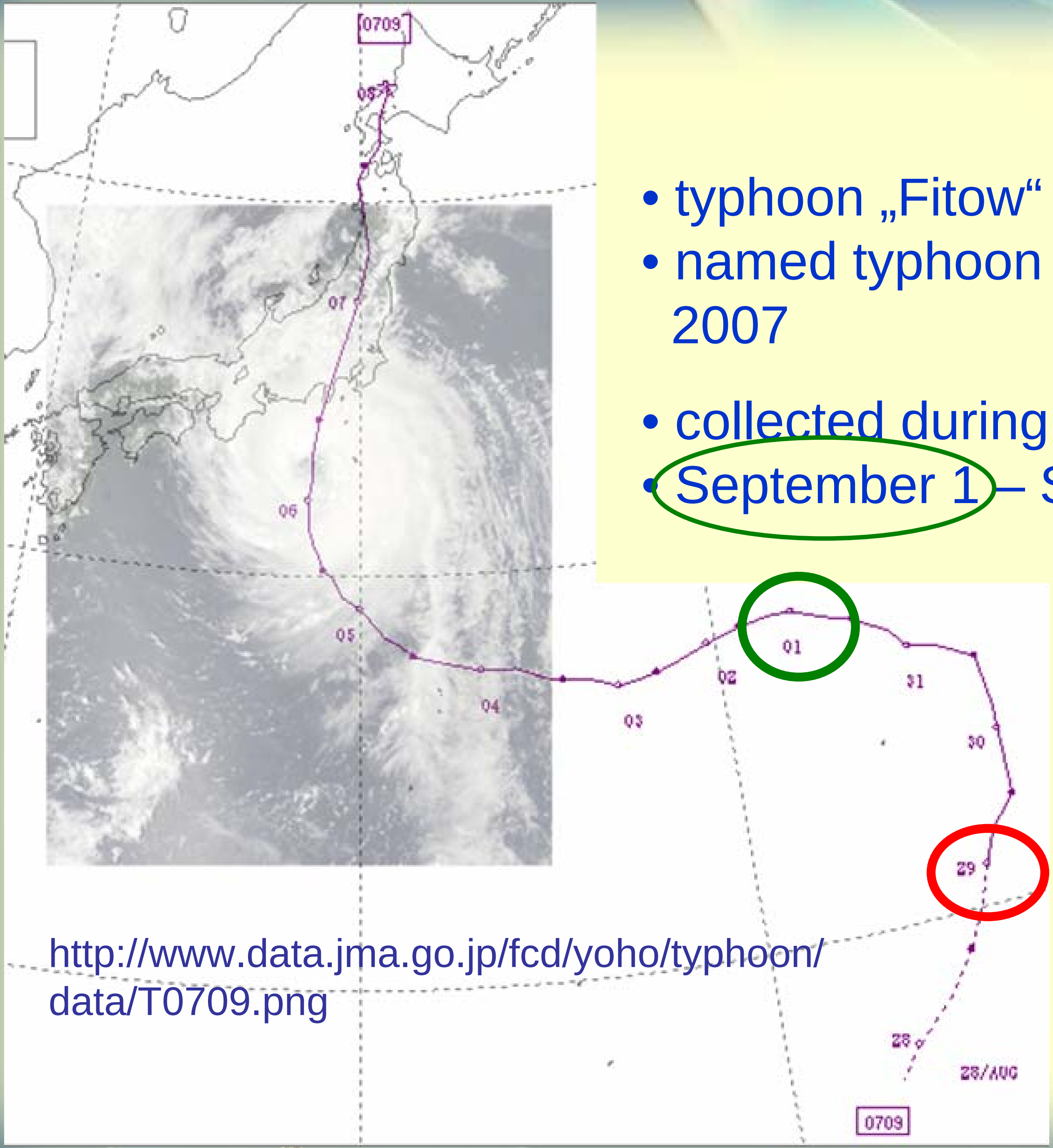

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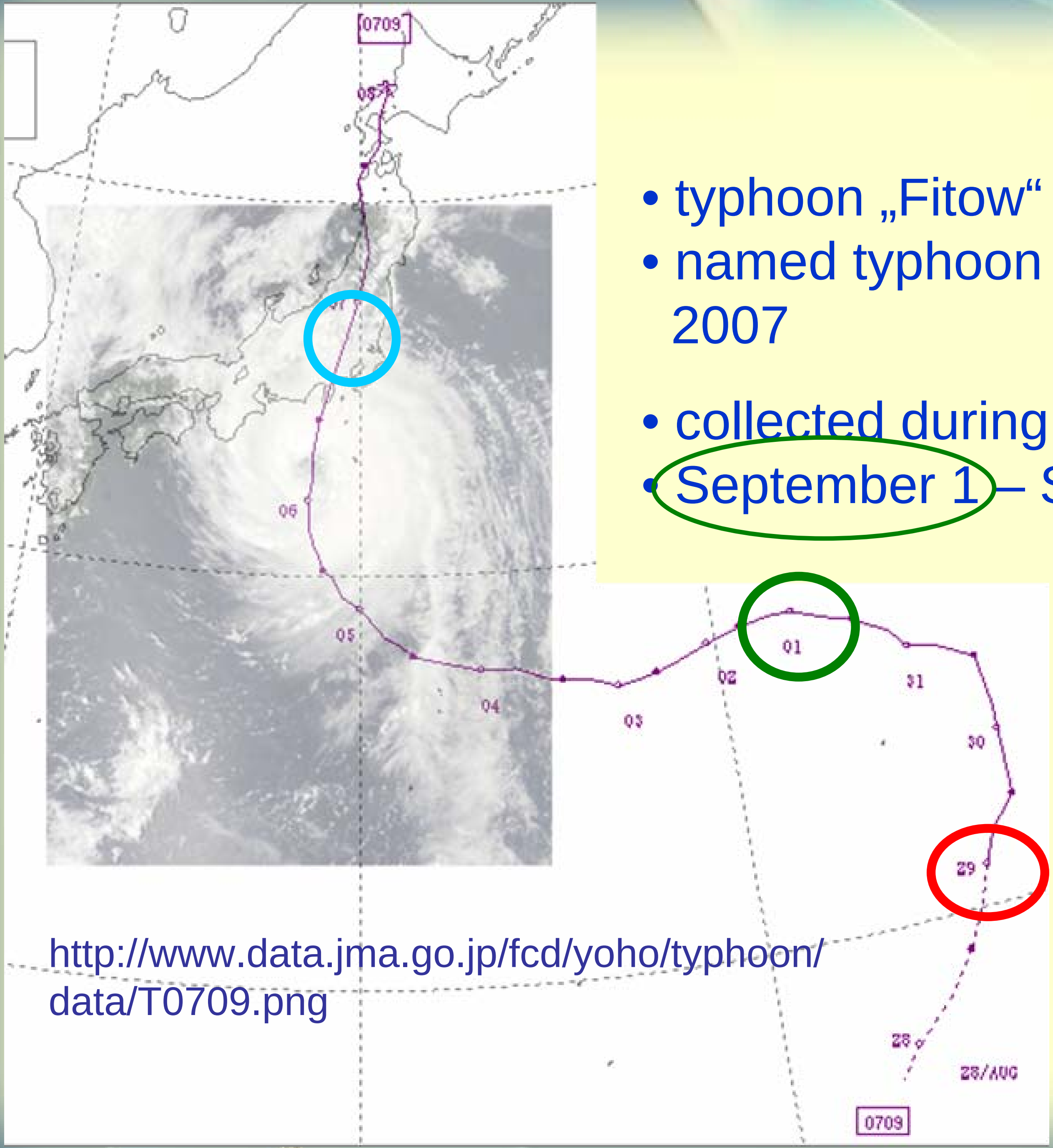
passed near Tsukuba on September 7



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- delays exhibit significant azimuthally asymmetric characteristics

Mapping Function

continued fraction form

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

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how coefficients are determined depends on the mapping function that is used

- e.g. from ray-traced delays

Vienna Mapping Function 1 (VMF1)

remove hydrostatic delay and estimate
wet mapping function

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mean ***a*** (over all α)

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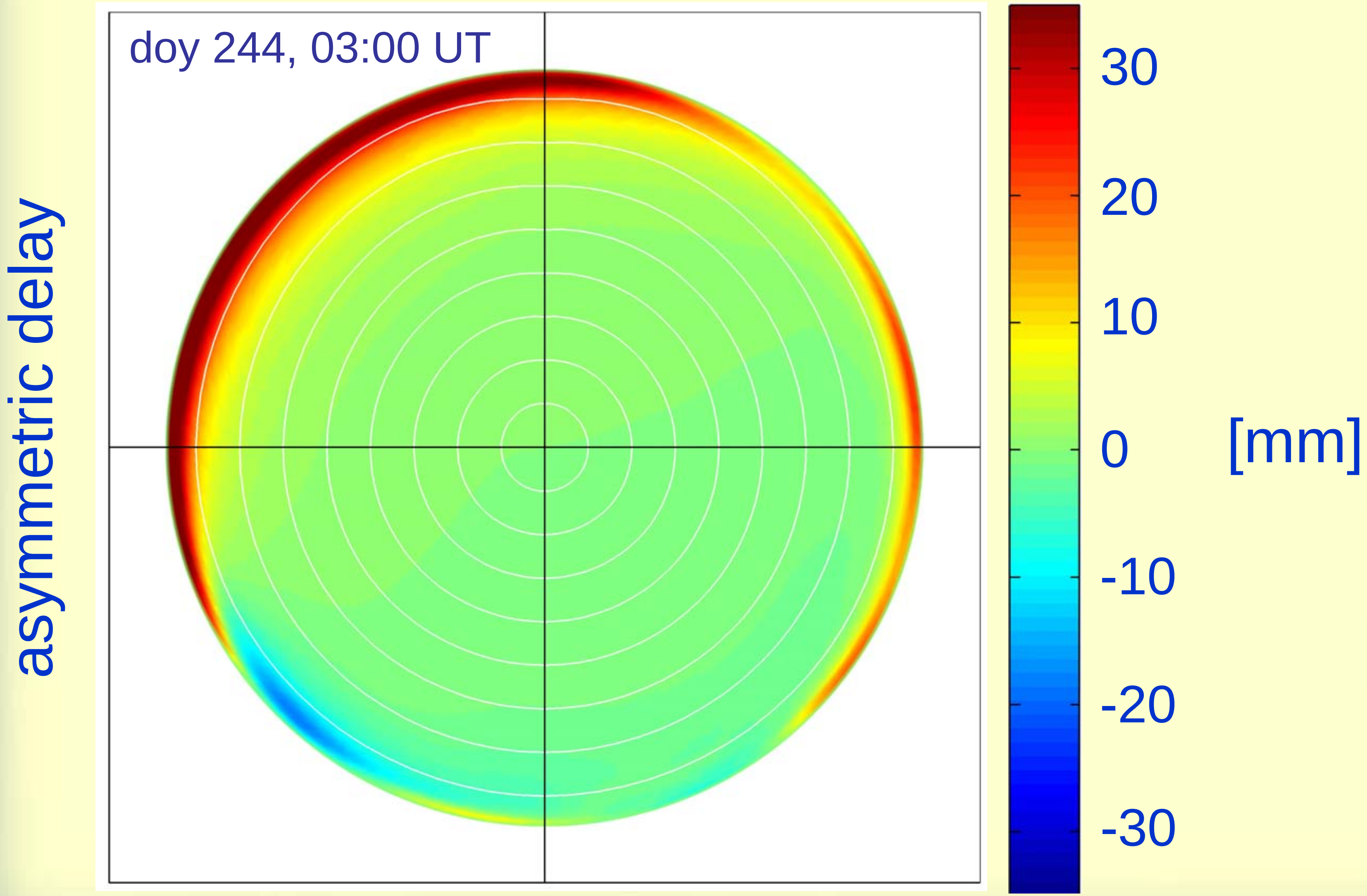
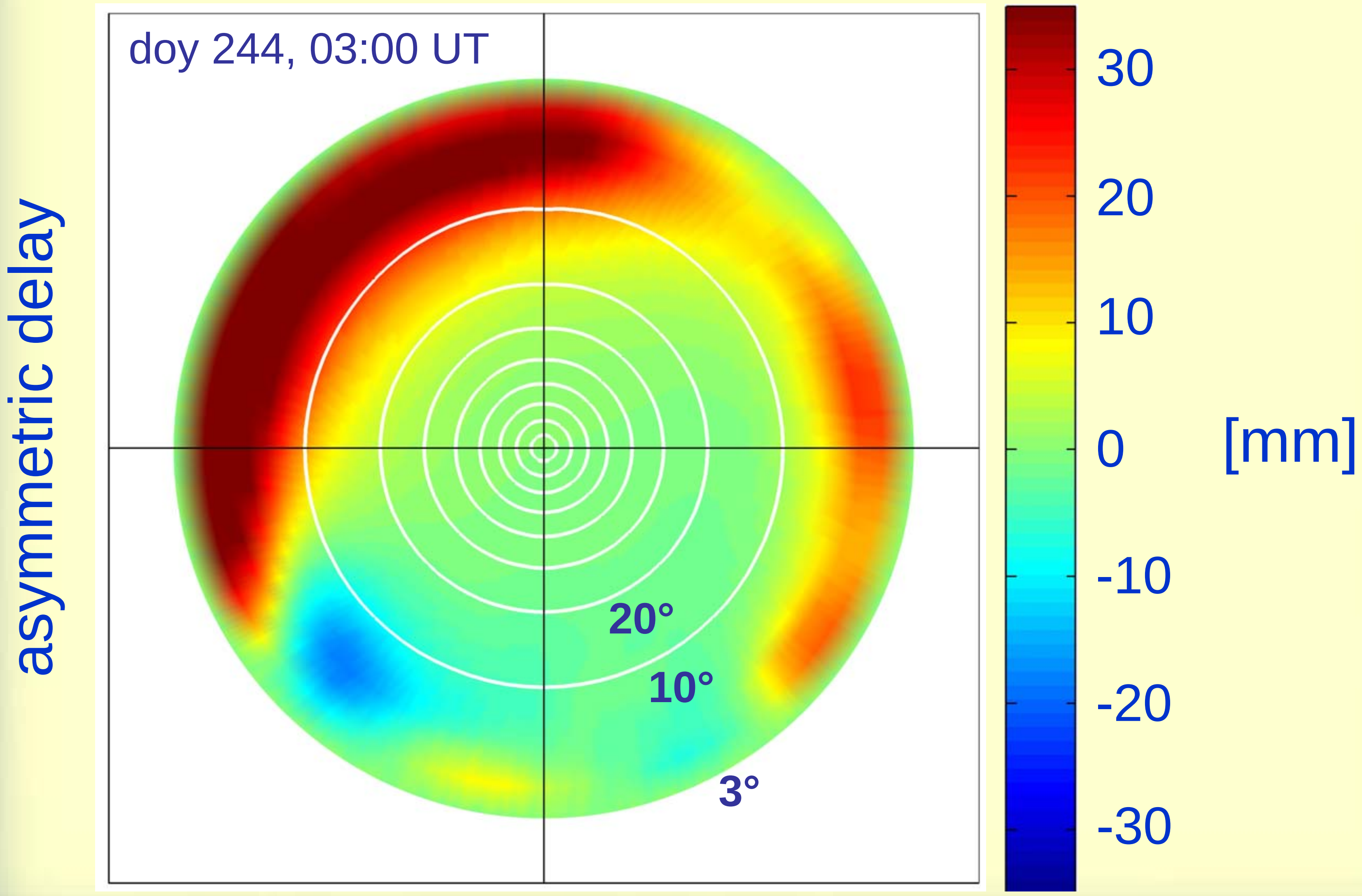
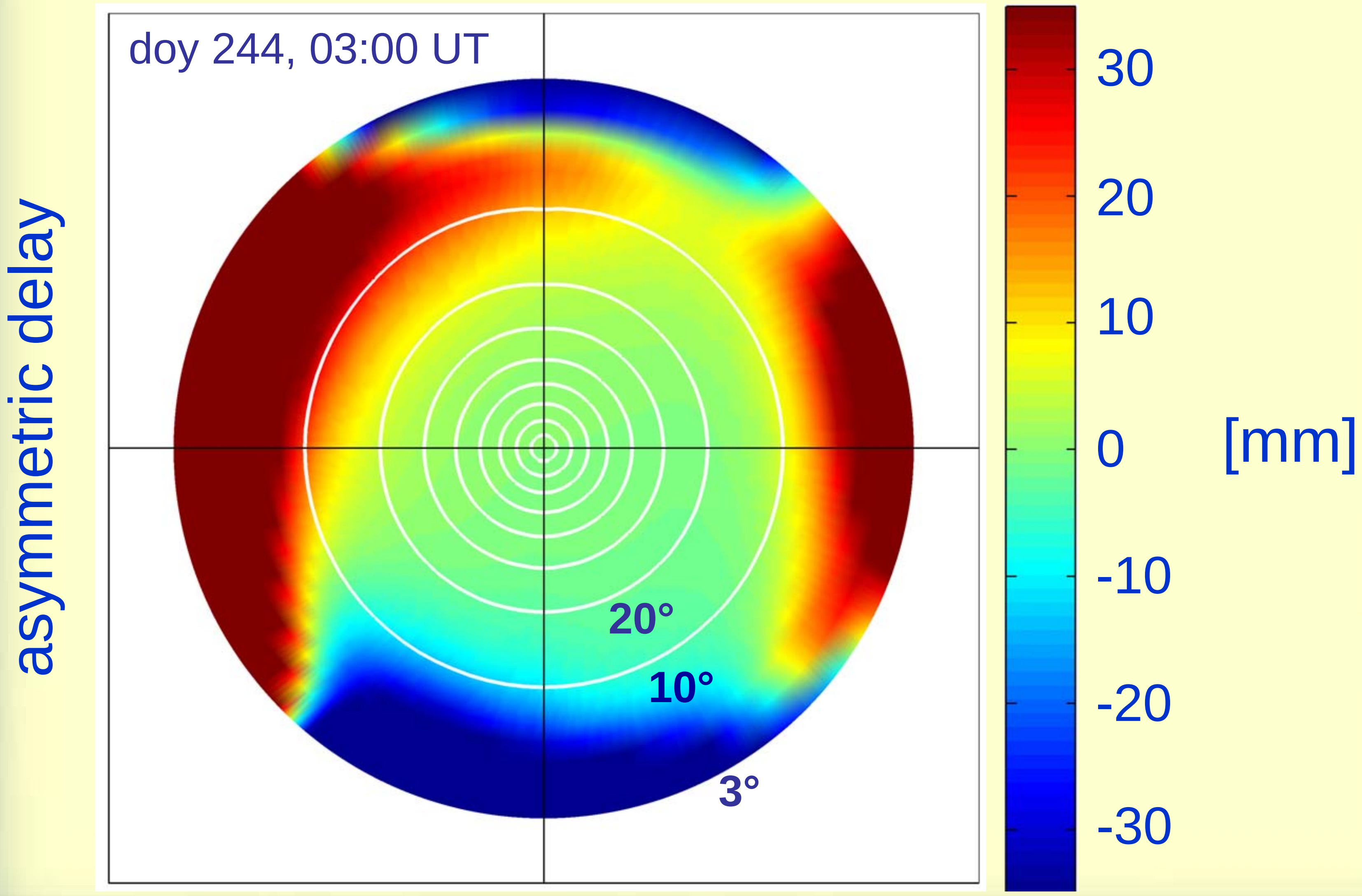


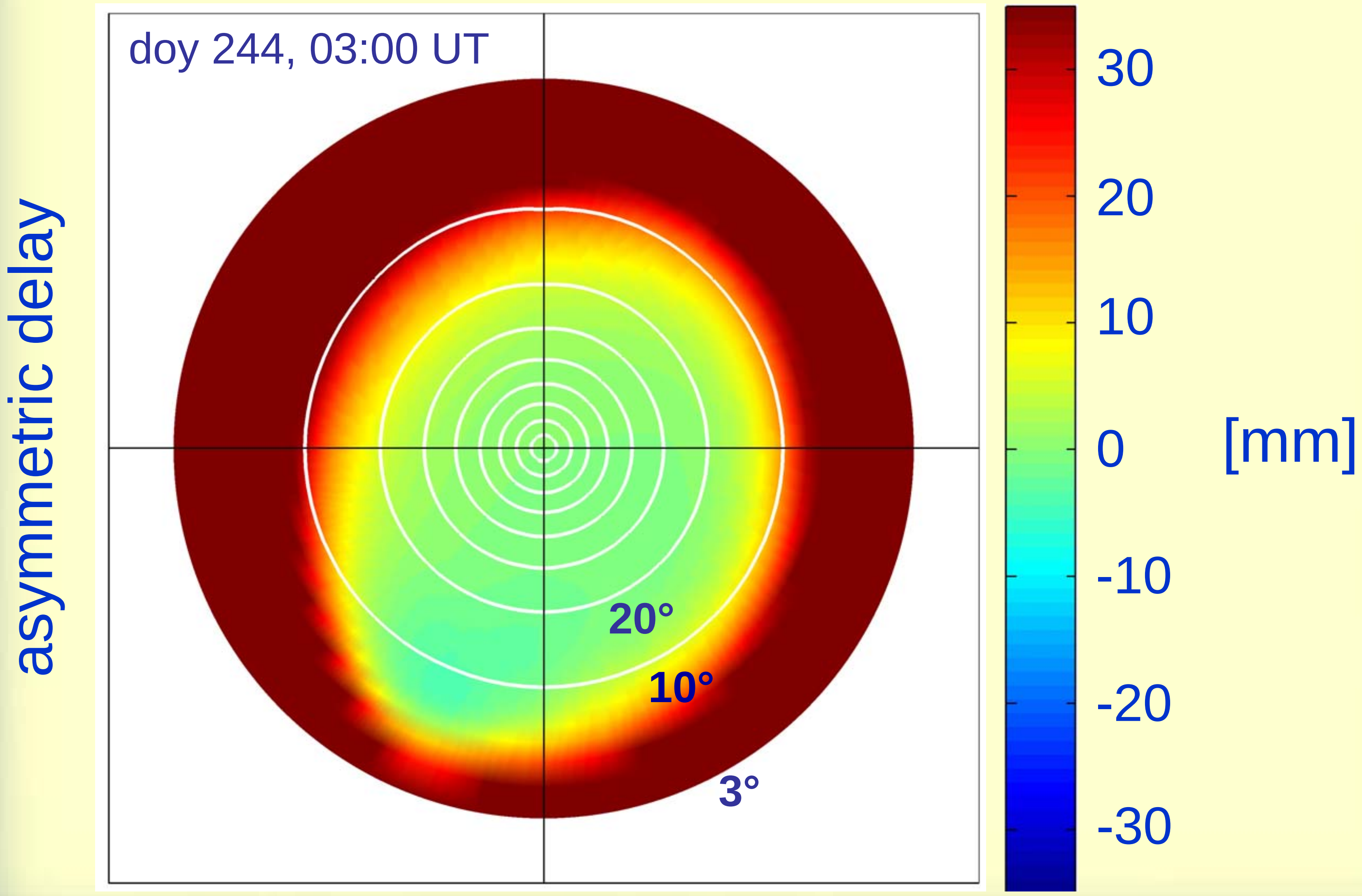
a at 3° for each azimuth



mean of ***a*** at 3°

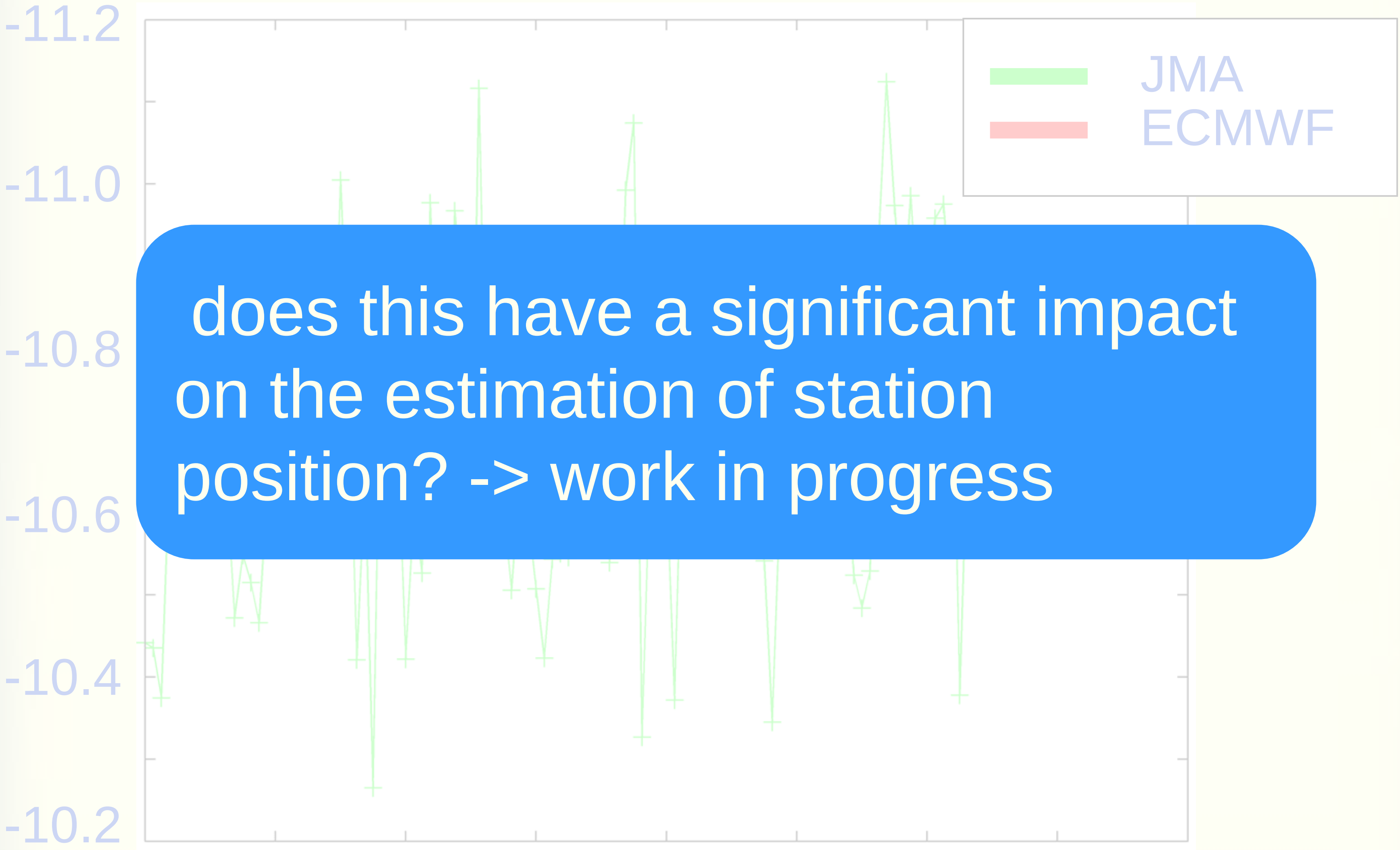


a from ECMWF (mean)



mapping function @ 5 degree elevation

wet delay @ 5 degree elevation



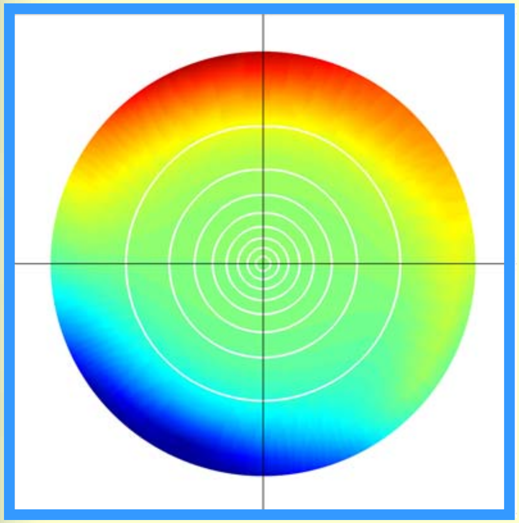
does this have a significant impact on the estimation of station position? -> work in progress

Modeling azimuthal asymmetries

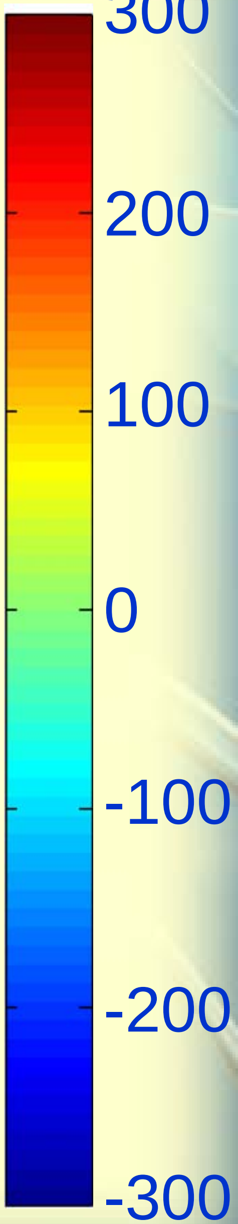
„classical“ gradients (IERS Conventions 2003)

$$\Delta L_{asymm} = mf_g(e)\cdot[G_N \cdot\cos(\alpha) + G_E \cdot\sin(\alpha)]$$

day 245, 06:00 UT [mm]



without modeling asymmetries



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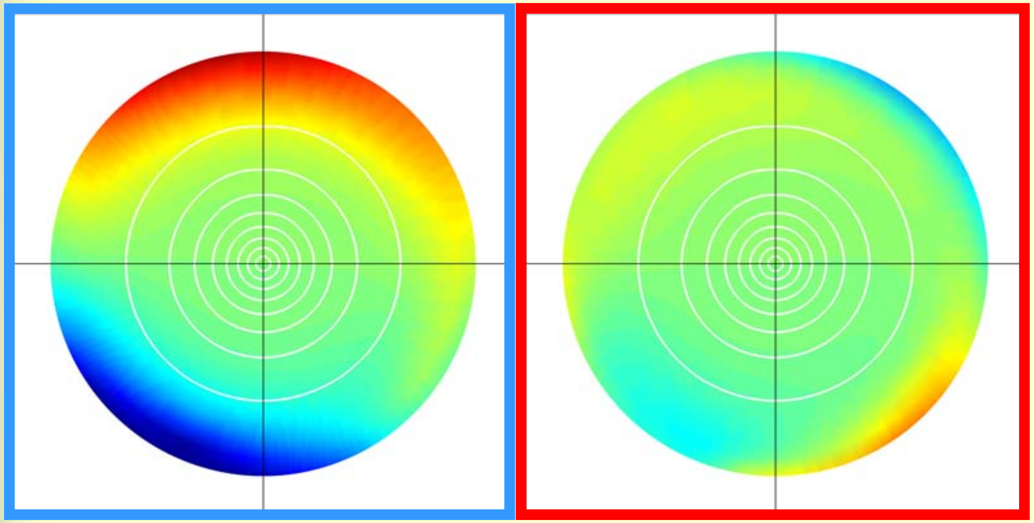

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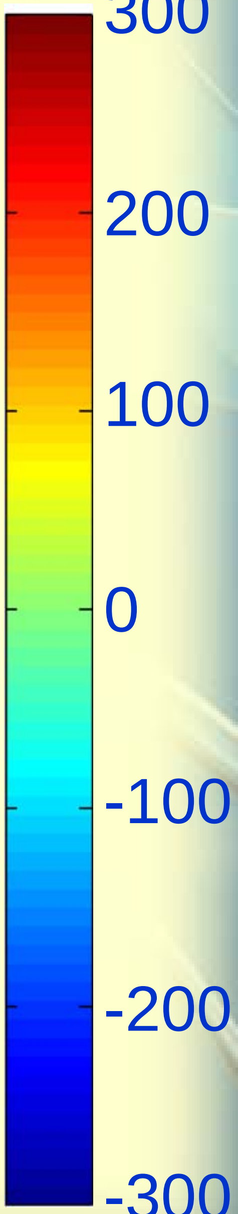

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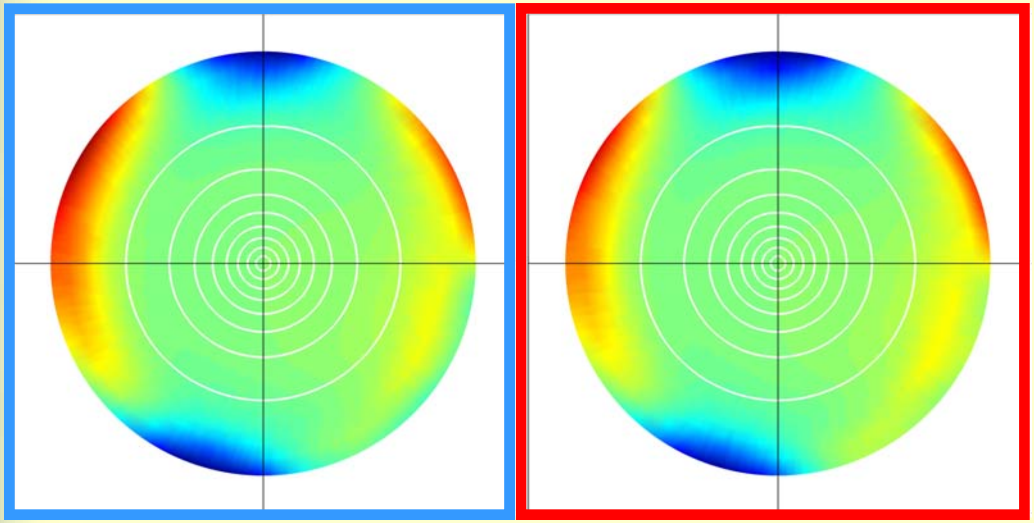

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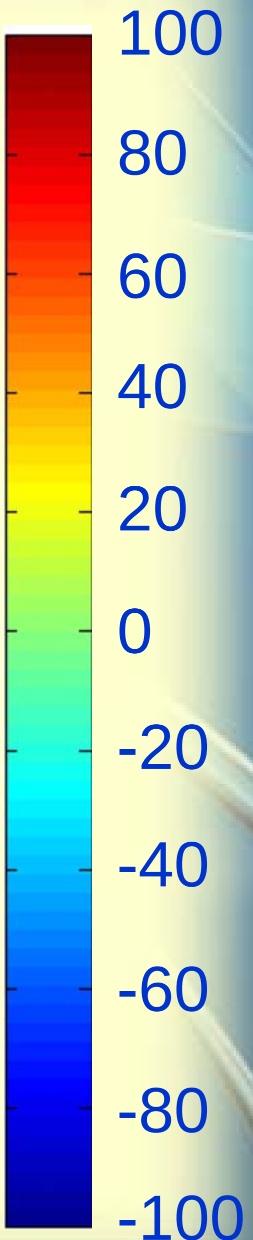

Modeling azimuthal asymmetries

„double“ gradients

$$\Delta L_{asymm} = mf_g(e)\cdot[G_N \cdot\cos(2\alpha) + G_E \cdot\sin(2\alpha)]$$

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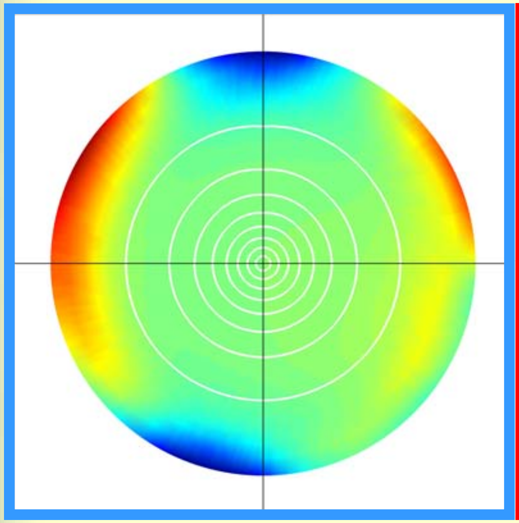

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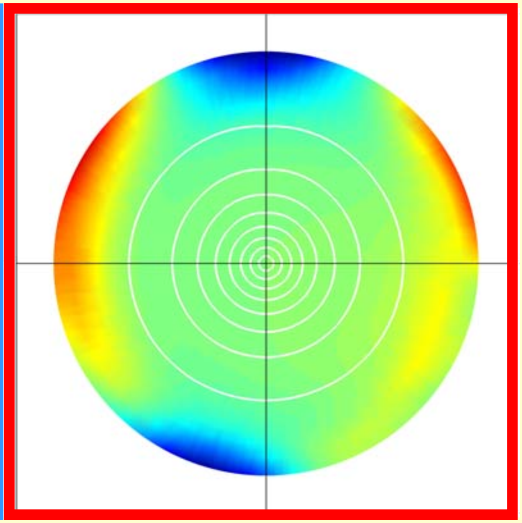

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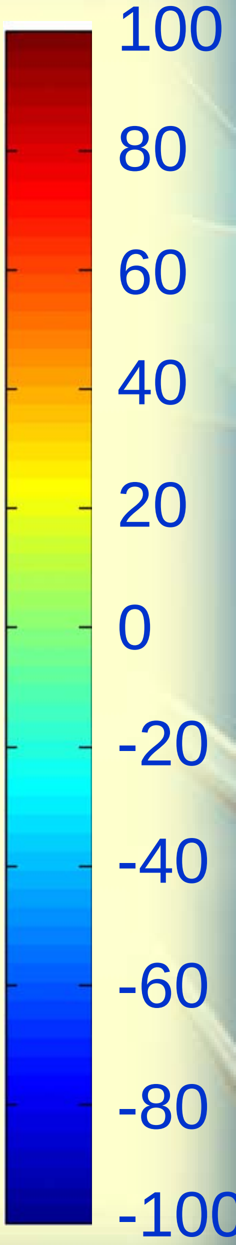

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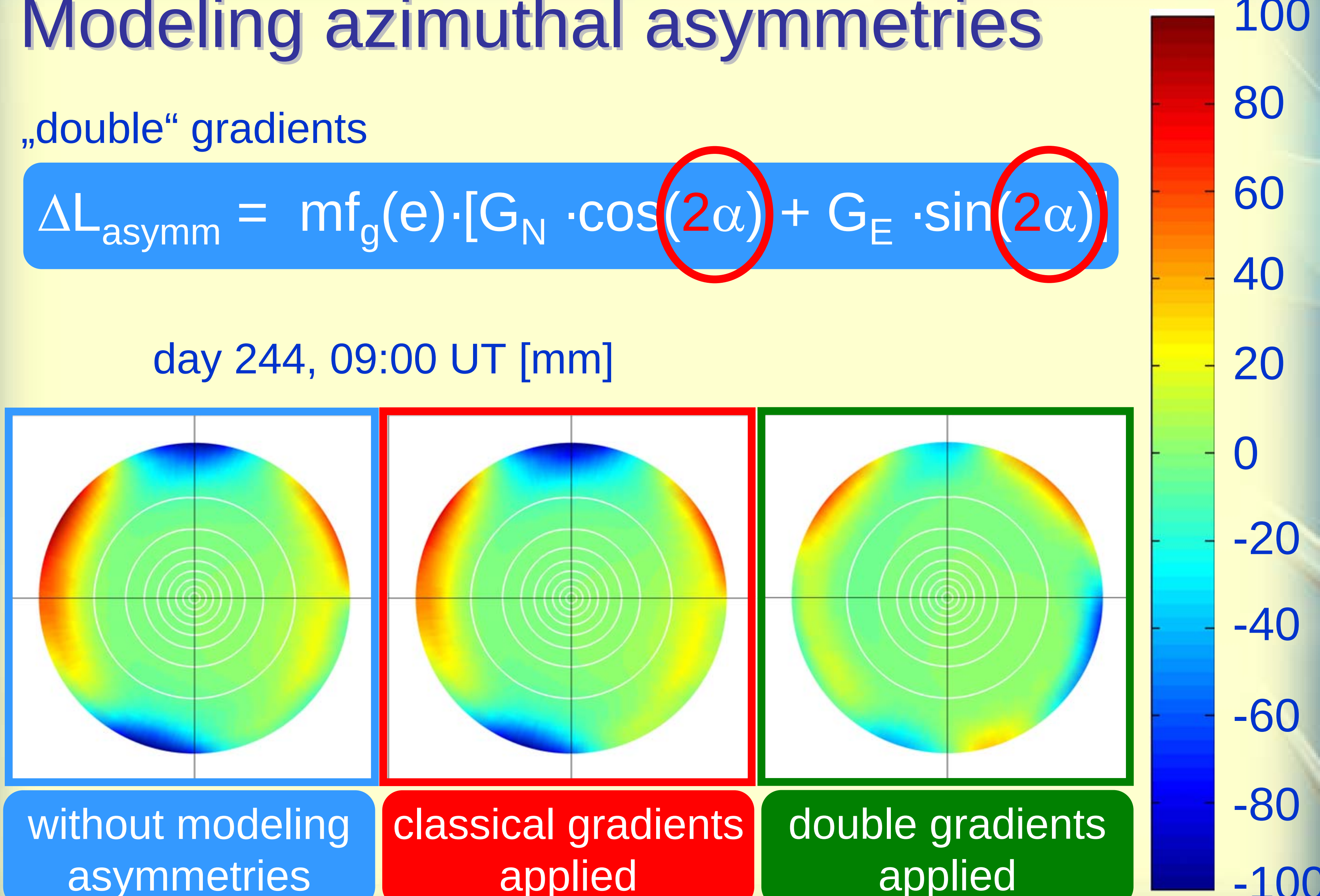

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- the asymmetric delay is dependent on the method of determining the mapping function coefficients
- asymmetric delays exhibit not only gradient like behaviour -> possibilities of a better modeling have to be explored in more detail

Thanks for your attention!

The author is recipient of a DOC-fFORTE fellowship of the Austrian Academy of Sciences at the Institute of Geodesy and Geophysics, Vienna University of Technology.