Analysis of seasonal position variation for selected GNSS sites in Poland — Validation of results using loading modelling and GRACE data

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GNSS

GRACE

GNSS

IGS reprocessing campaign

- weekly

WUT LAC reprocessing

- weekly
- daily

WUT PPP

GRACE

GNSS

IGS reprocessing campaign	WUT LAC reprocessing	WUT PPP
■ weekly	■ weekly ■ daily	

↓

$$\Delta X,\ \Delta Y,\ \Delta Z \longrightarrow \Delta n,\ \Delta e,\ \Delta u$$
$$-\text{trend, outliers} \longrightarrow \Delta n,\ \Delta e,\ \Delta u$$

GRACE

GNSS

IGS reprocessing campaign	WUT LAC reprocessing	WUT PPP
▪ weekly	▪ weekly ▪ daily	

$$\Delta X,\ \Delta Y,\ \Delta Z \longrightarrow \Delta n,\ \Delta e,\ \Delta u$$
$$-\text{trend, outliers} \longrightarrow \Delta n,\ \Delta e,\ \Delta u$$

$$\Delta n,\ \Delta e,\ \Delta u \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$$
$$(\Delta n,\ \Delta e,\ \Delta u) - \text{ATML} \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$$

GRACE

GNSS

IGS reprocessing campaign	WUT LAC reprocessing	WUT PPP
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$\Delta n,\ \Delta e,\ \Delta u,\ \Delta n,\ \Delta e,\ \Delta u$

GRACE

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↓

$\Delta n,\ \Delta e,\ \Delta u,\ \Delta n,\ \Delta e,\ \Delta u$

GRACE

↓

$\Delta g \longrightarrow TWE$

GNSS

IGS reprocessing campaign	WUT LAC reprocessing	WUT PPP
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↓

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↓

$\Delta n,\ \Delta e,\ \Delta u,\ \Delta n,\ \Delta e,\ \Delta u$

GRACE

↓

$\Delta g \longrightarrow TWE$

↓

GRACE TWE

- Groupe de Recherche en Géodésie Spatiale (GRGS) TWE
- spatial resolution: $1^\circ \times 1^\circ$
- temporal resolution: 10 days

GNSS

IGS reprocessing campaign	WUT LAC reprocessing	WUT PPP
▪ weekly	▪ weekly ▪ daily	

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$\Delta X,\ \Delta Y,\ \Delta Z \longrightarrow \Delta n,\ \Delta e,\ \Delta u$

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↓

$\Delta n,\ \Delta e,\ \Delta u \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$

$(\Delta n,\ \Delta e,\ \Delta u) - \text{ATML} \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$

↓

$\Delta n,\ \Delta e,\ \Delta u,\ \Delta n,\ \Delta e,\ \Delta u$

GRACE

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↓

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- temporal resolution: 10 days

↓

$$\mathbf{L}(\mathbf{r}) = \rho \cdot \iint G(|\mathbf{r} - \mathbf{r}'|) \cdot \mathbf{H}(\mathbf{r}')\,\mathrm{d}A$$

GNSS

IGS reprocessing campaign
- weekly

WUT LAC reprocessing
- weekly
- daily

WUT PPP

↓

$\Delta X,\ \Delta Y,\ \Delta Z \longrightarrow \Delta n,\ \Delta e,\ \Delta u$

$-\text{trend, outliers} \longrightarrow \Delta n,\ \Delta e,\ \Delta u$

↓

$\Delta n,\ \Delta e,\ \Delta u \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$

$(\Delta n,\ \Delta e,\ \Delta u) - \text{ATML} \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$

↓

$\Delta n,\ \Delta e,\ \Delta u,\ \Delta n,\ \Delta e,\ \Delta u$

GRACE

↓

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↓

GRACE TWE

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- spatial resolution: $1^\circ \times 1^\circ$
- temporal resolution: 10 days

↓

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↓

$\Delta n,\ \Delta e,\ \Delta u$

GNSS

IGS reprocessing campaign	WUT LAC reprocessing	WUT PPP
■ weekly	■ weekly ■ daily	

↓

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$-\text{trend, outliers} \longrightarrow \Delta n,\ \Delta e,\ \Delta u$

↓

$\Delta n,\ \Delta e,\ \Delta u \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$

$(\Delta n,\ \Delta e,\ \Delta u) - \text{ATML} \xrightarrow{\text{MA}} \Delta n,\ \Delta e,\ \Delta u$

↓

$\Delta n,\ \Delta e,\ \Delta u,\ \Delta n,\ \Delta e,\ \Delta u$

GRACE

↓

$\Delta g \longrightarrow TWE$

↓

GRACE TWE	HYDRO TWE
■ Groupe de Recherche en Géodésie Spatiale (GRGS) TWE ■ spatial resolution: $1^\circ \times 1^\circ$ ■ temporal resolution: 10 days	■ WaterGAP Hydrology Model ■ spatial resolution: $0.5^\circ \times 0.5^\circ$ ■ temporal resolution: month

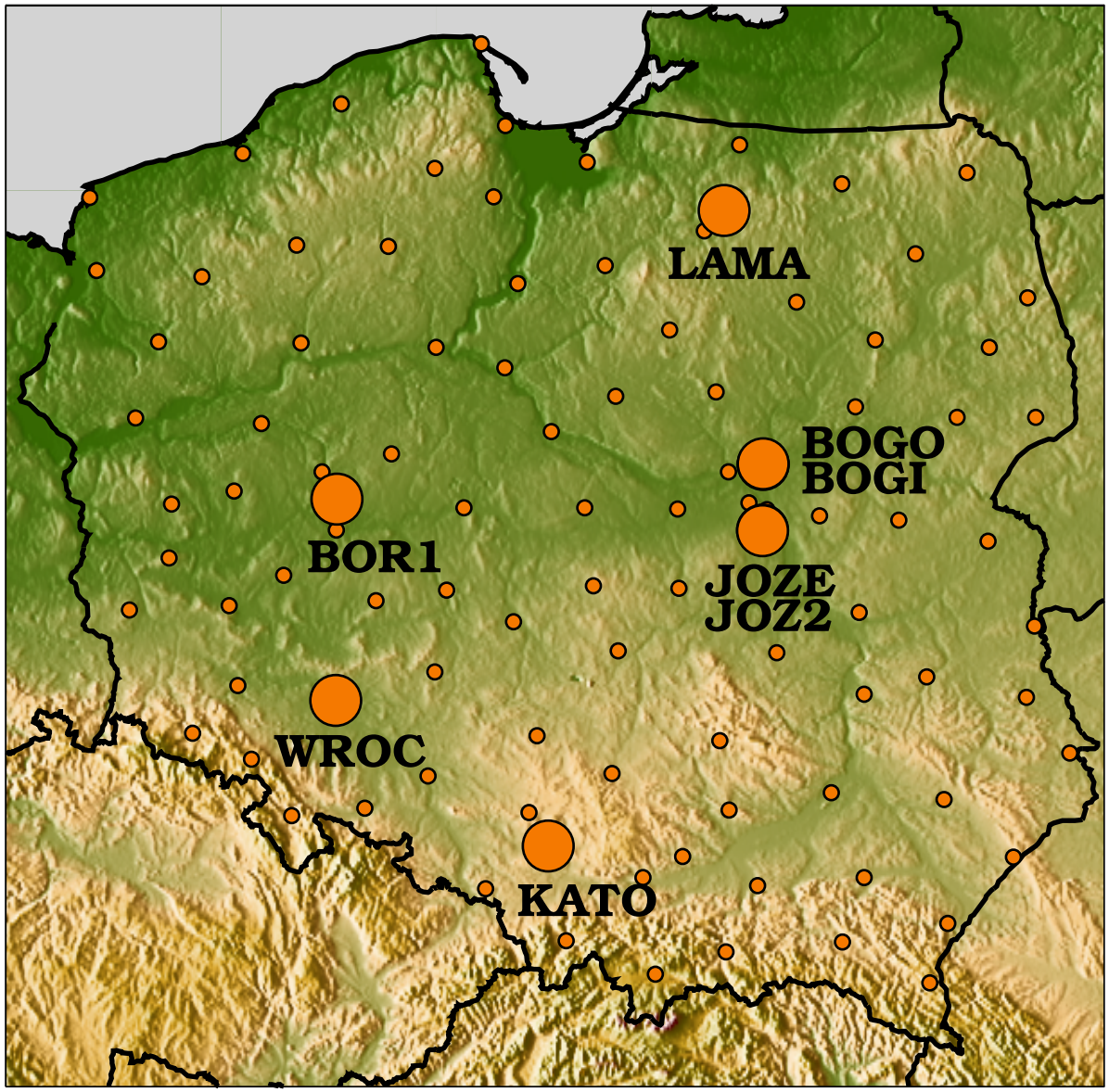
↓

$$\mathbf{L}(\mathbf{r}) = \rho \cdot \sum\sum G(|\mathbf{r} - \mathbf{r}'|) \cdot \mathbf{H}(\mathbf{r}')\,\mathrm{d}A$$

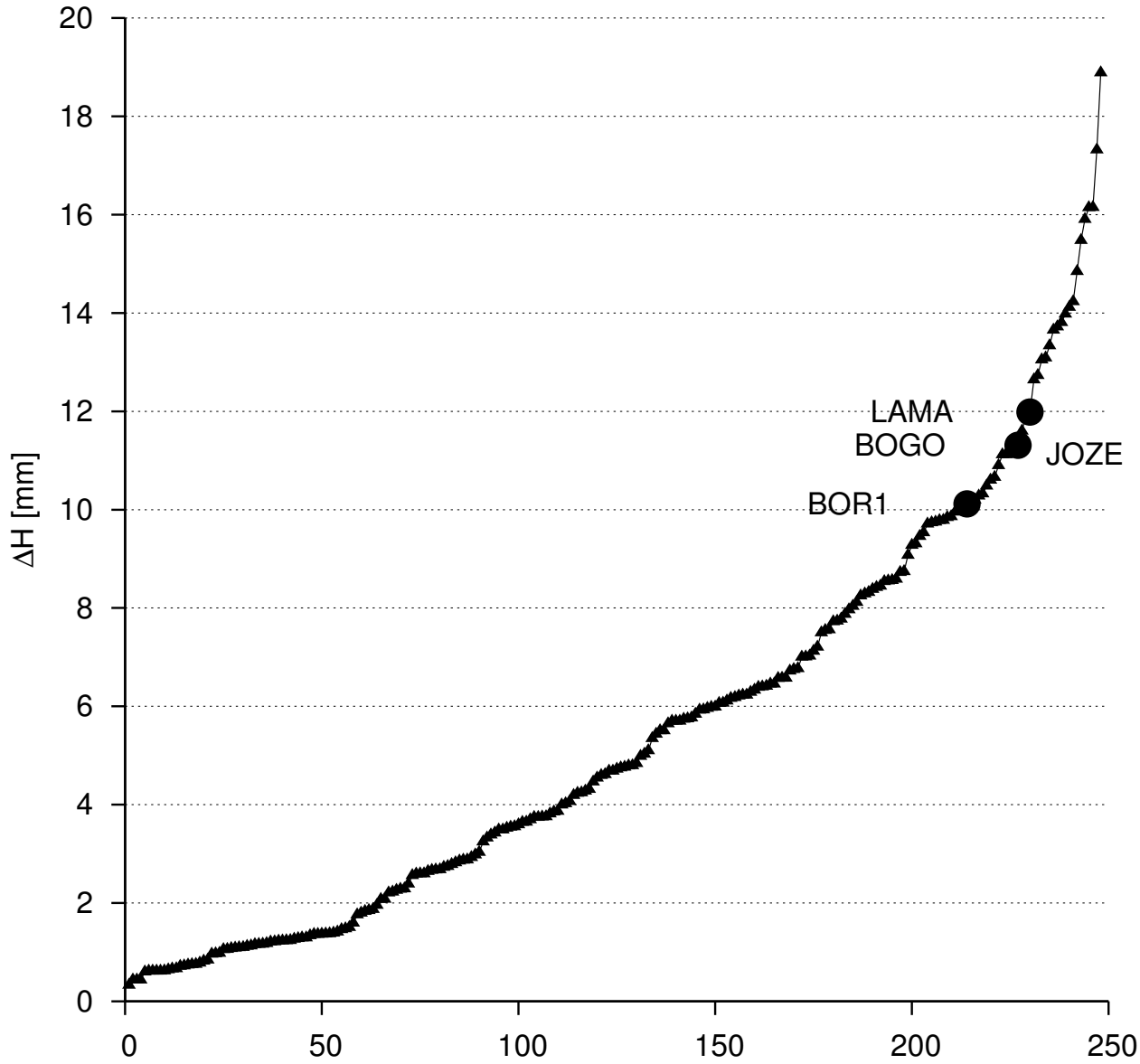
↓ ↓

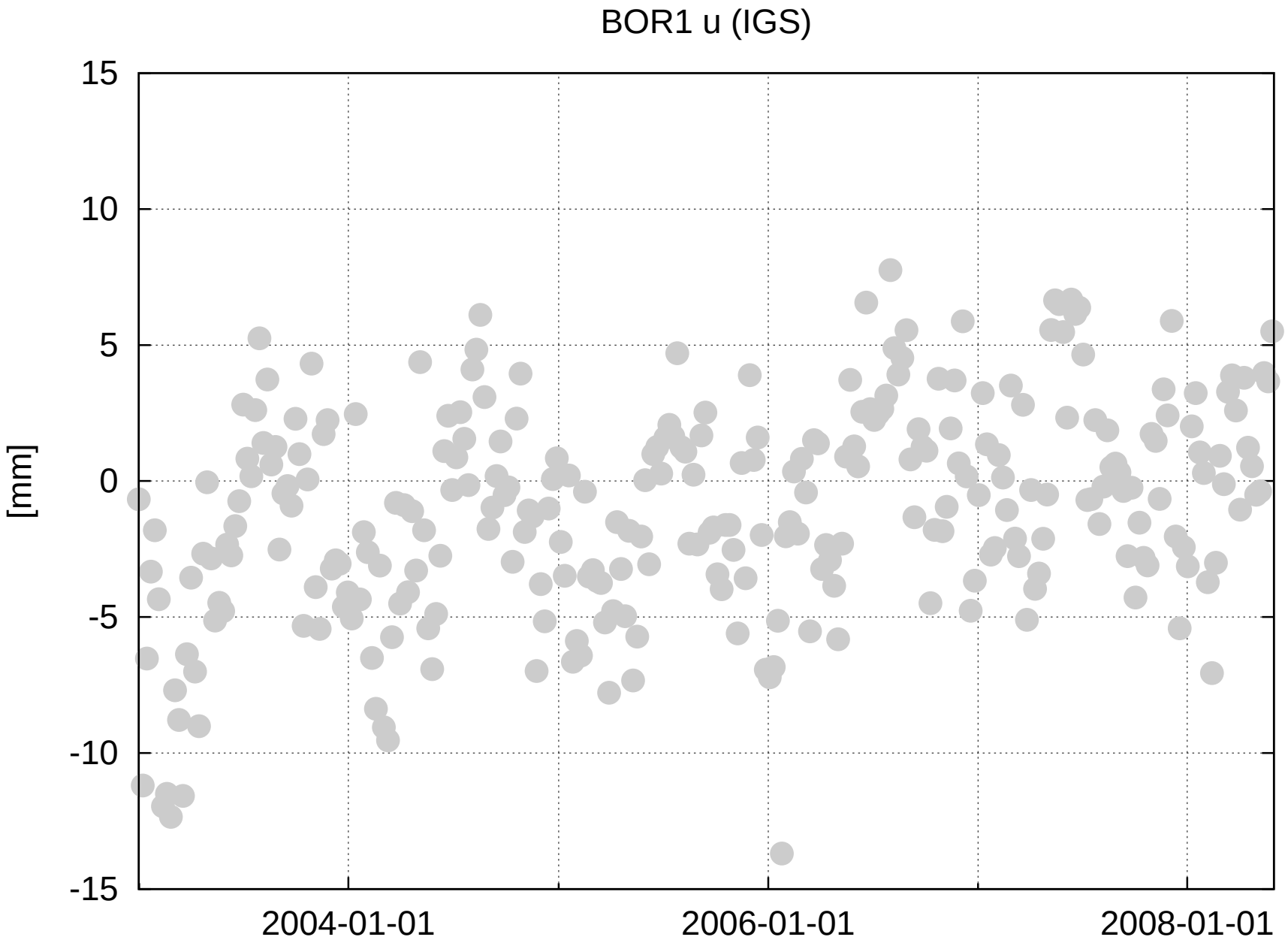
$\Delta n,\ \Delta e,\ \Delta u\ \ \Delta n,\ \Delta e,\ \Delta u$

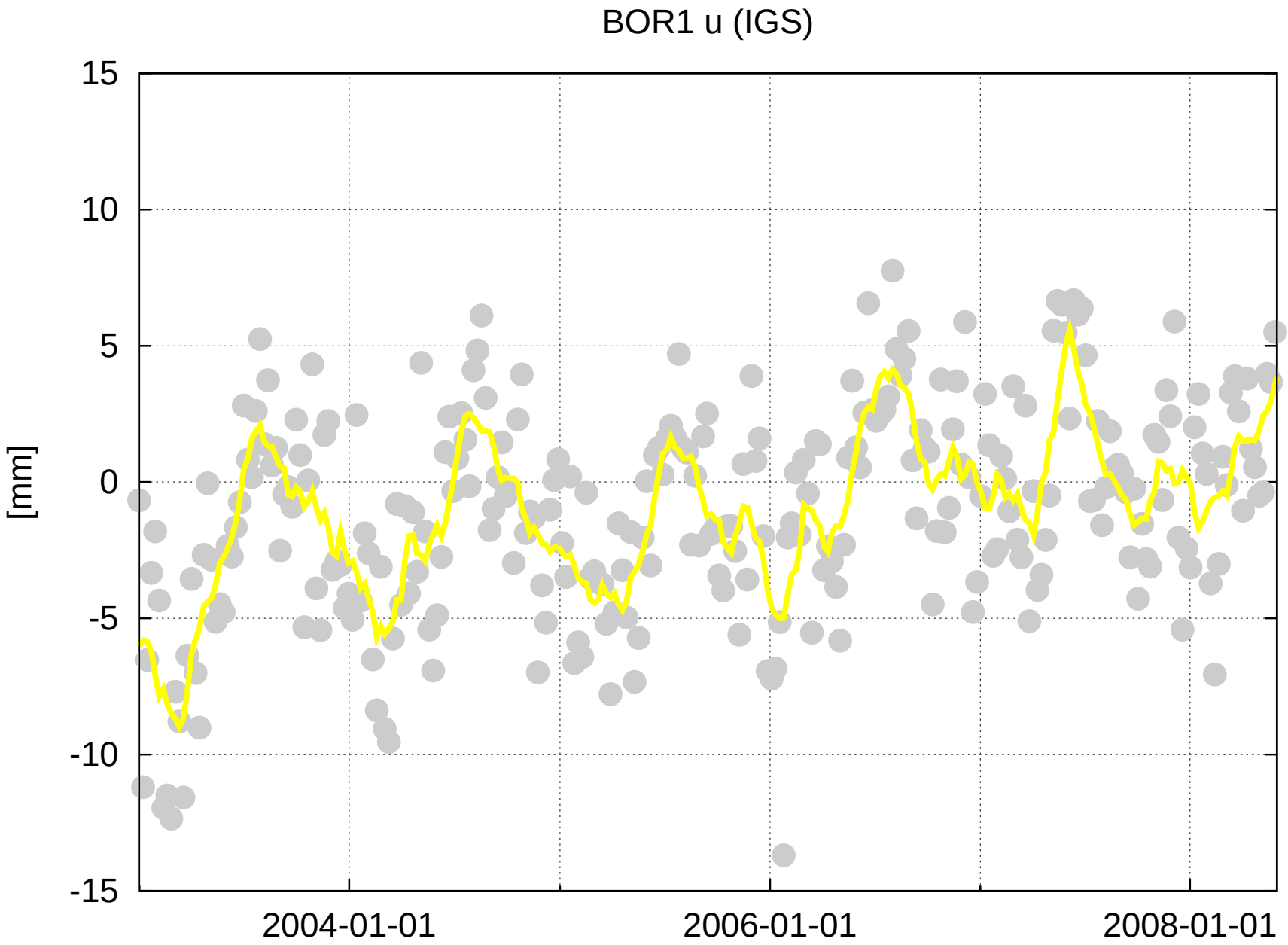
Selected sites

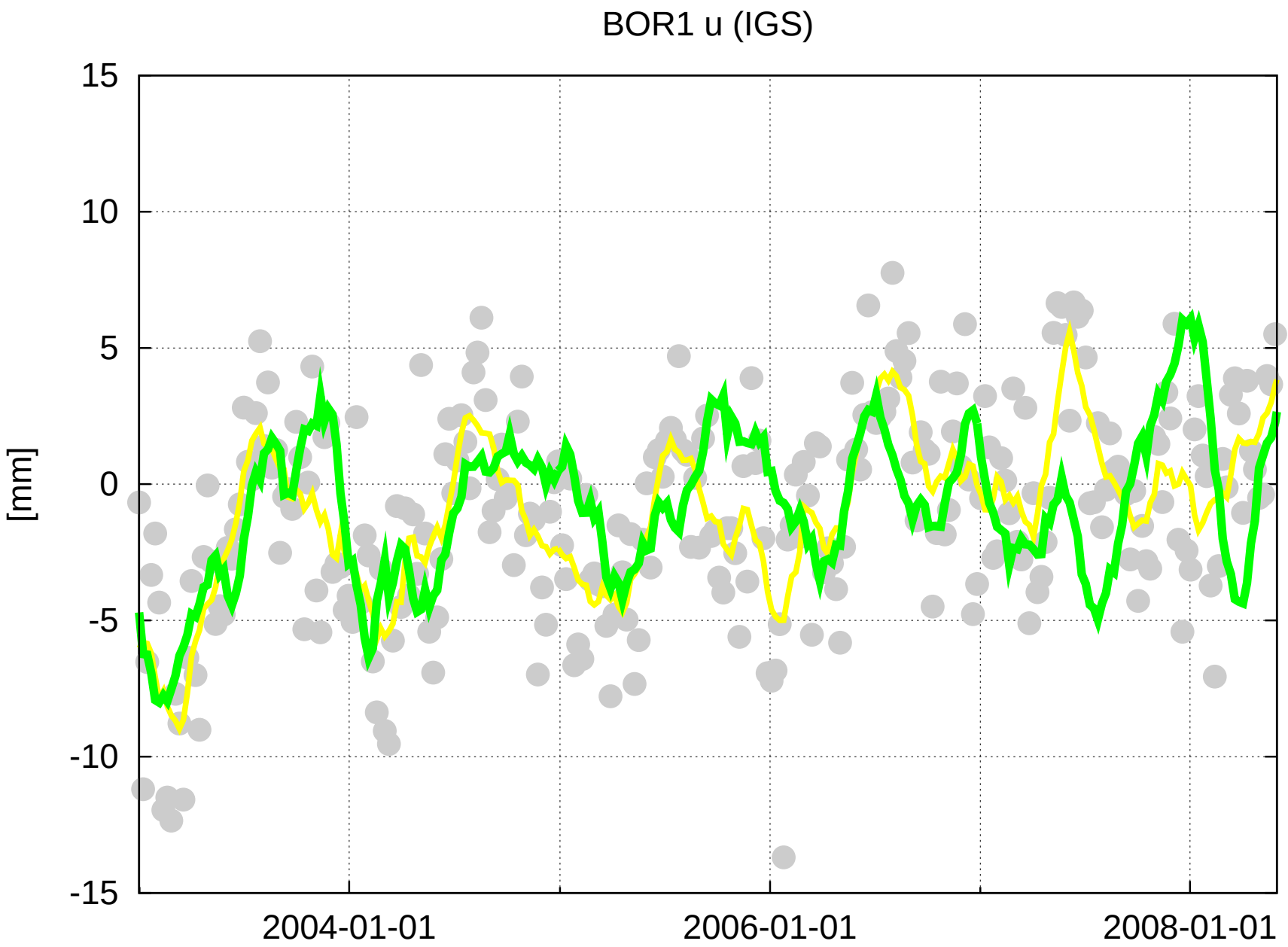


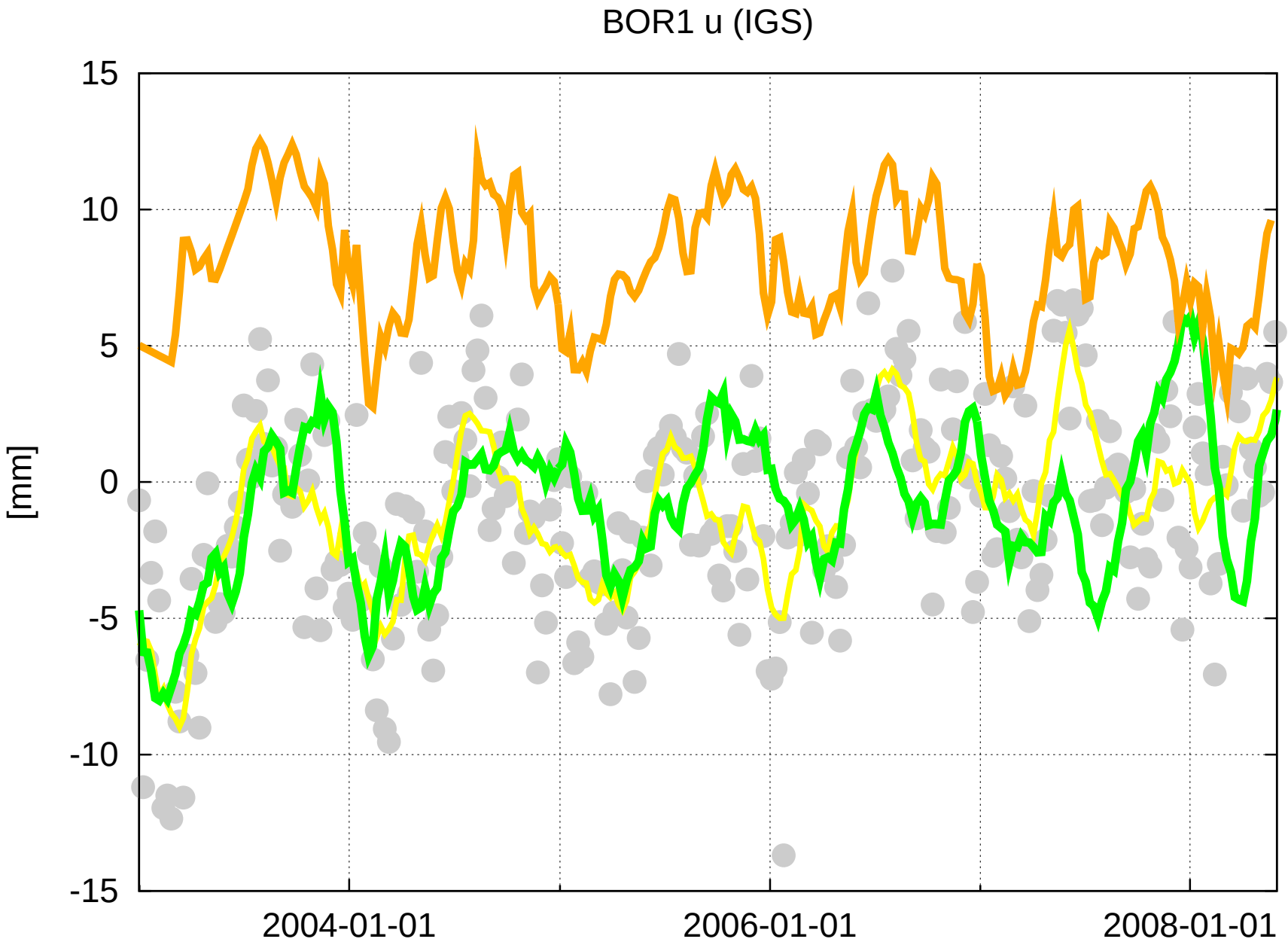
Selected sites vs EPN sites (seasonal loading)

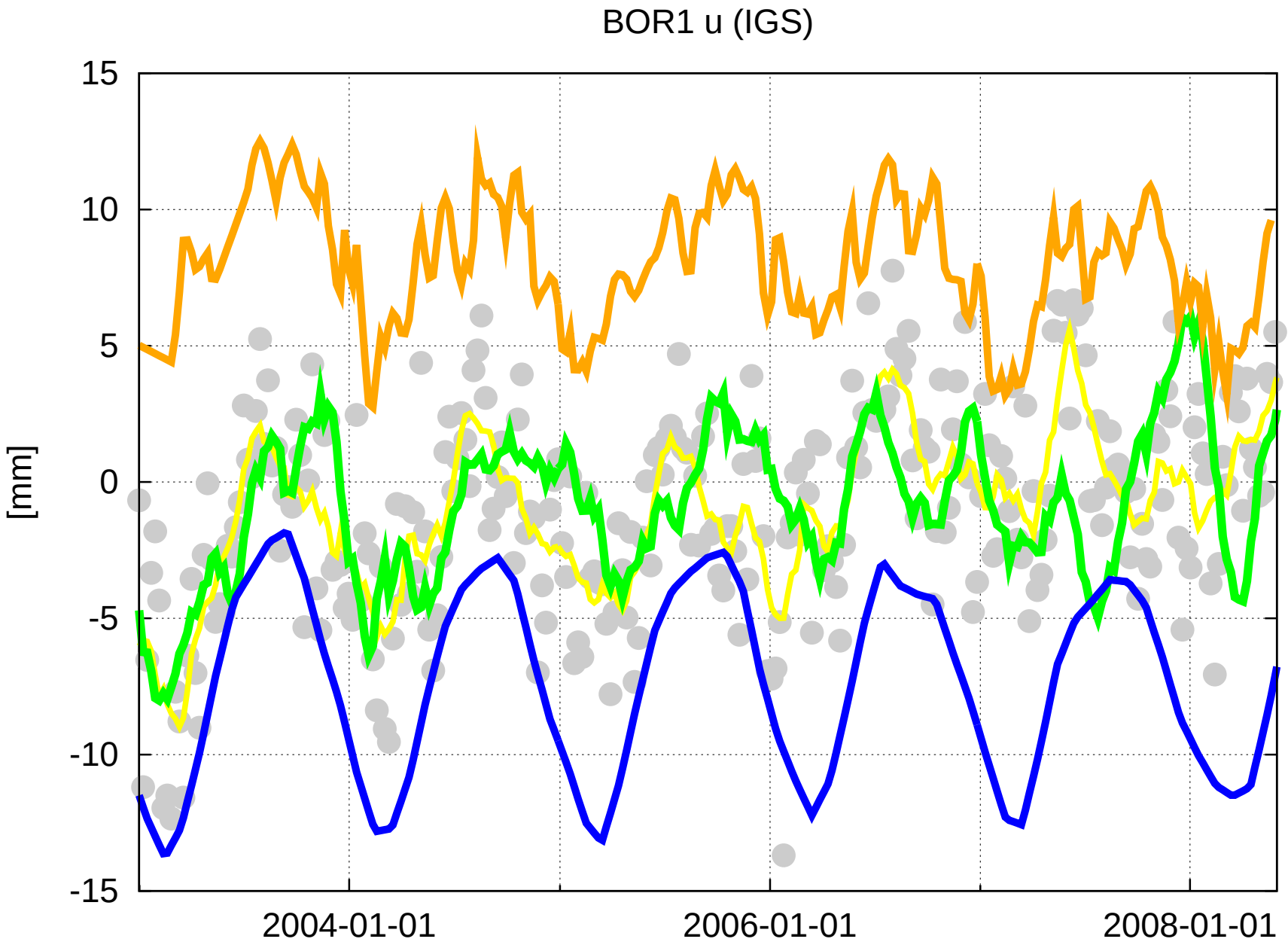


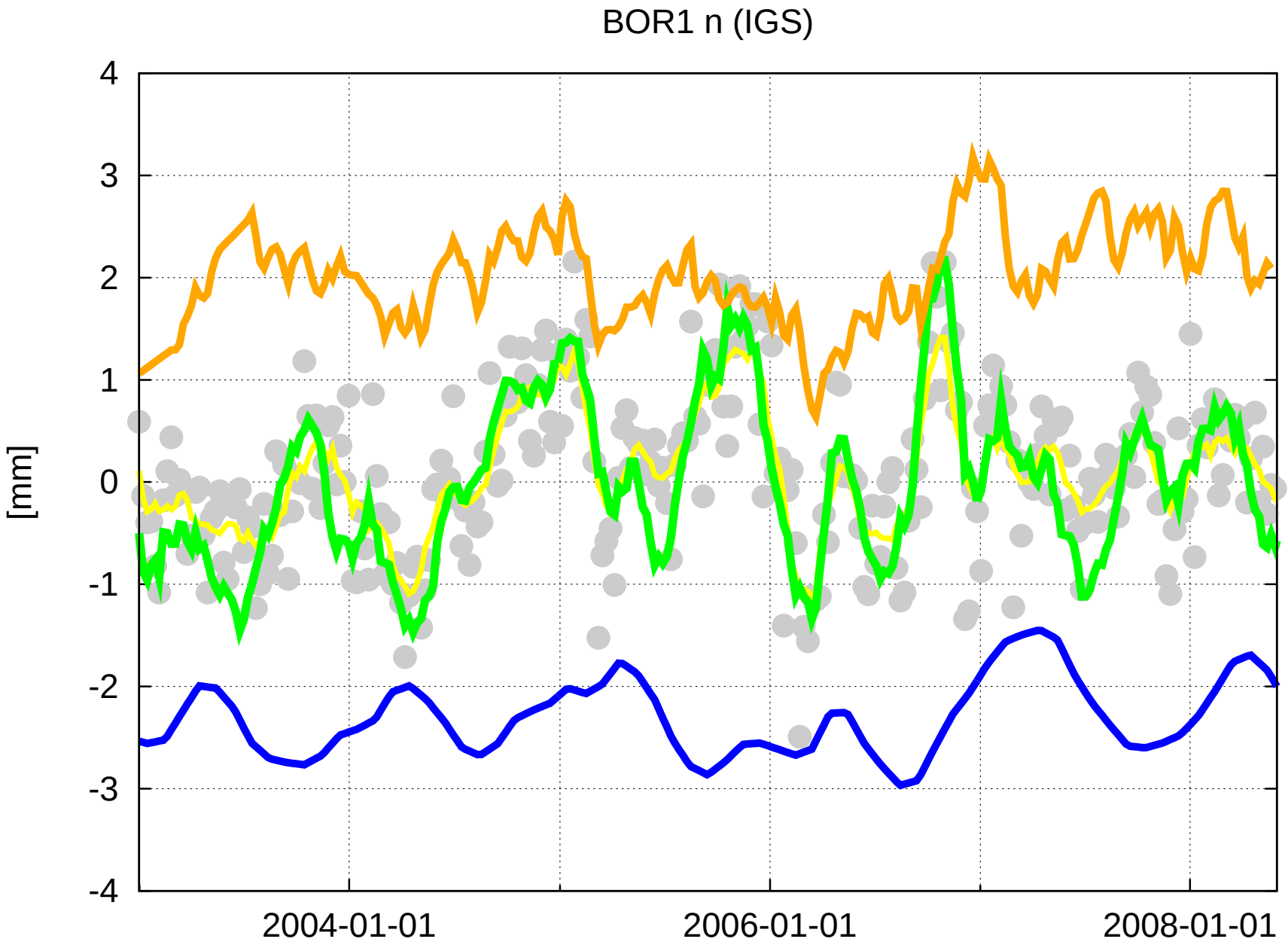

BOR1 u (IGS)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01
2008-01-01

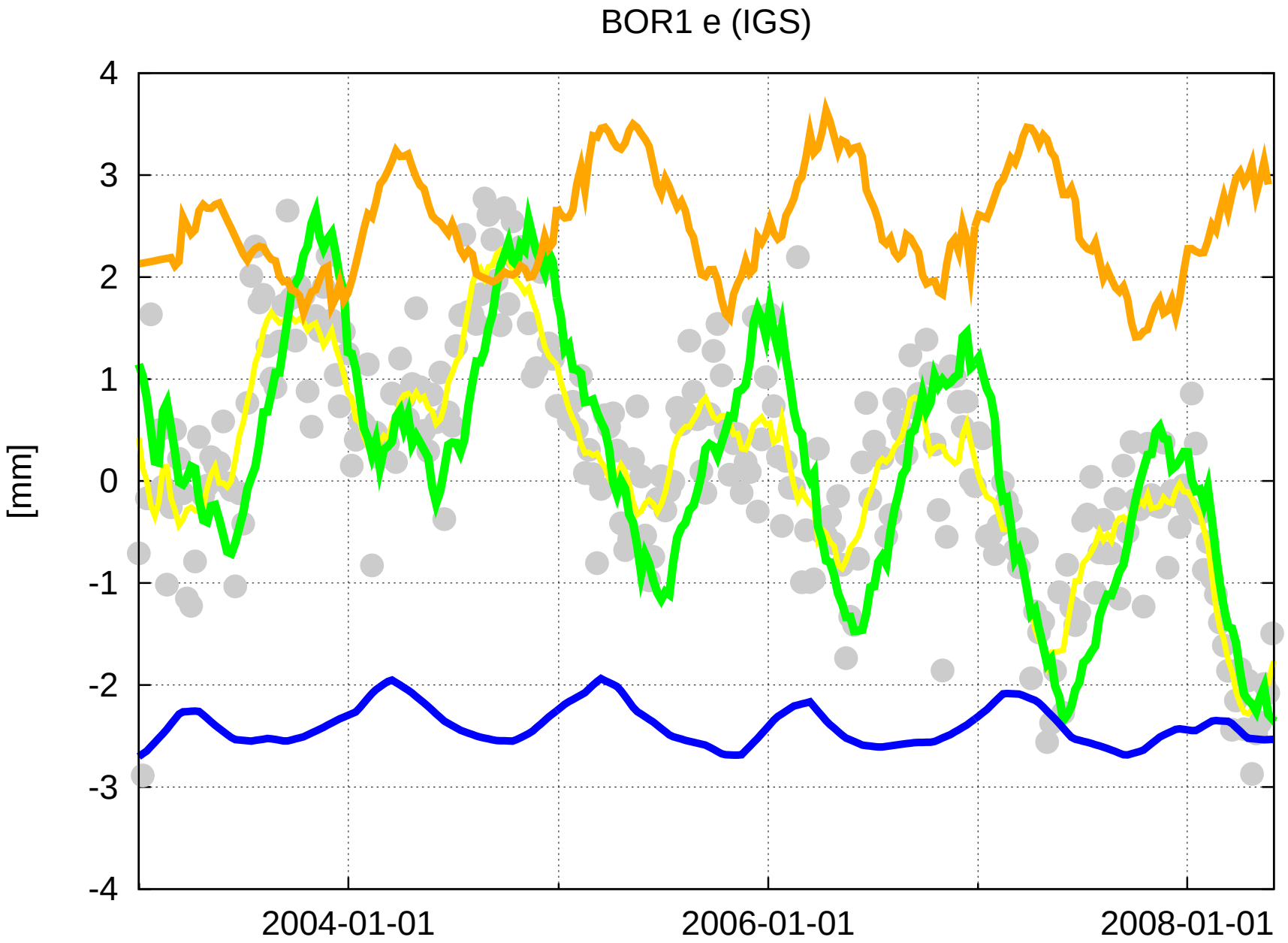

BOR1 u (IGS)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01
2008-01-01

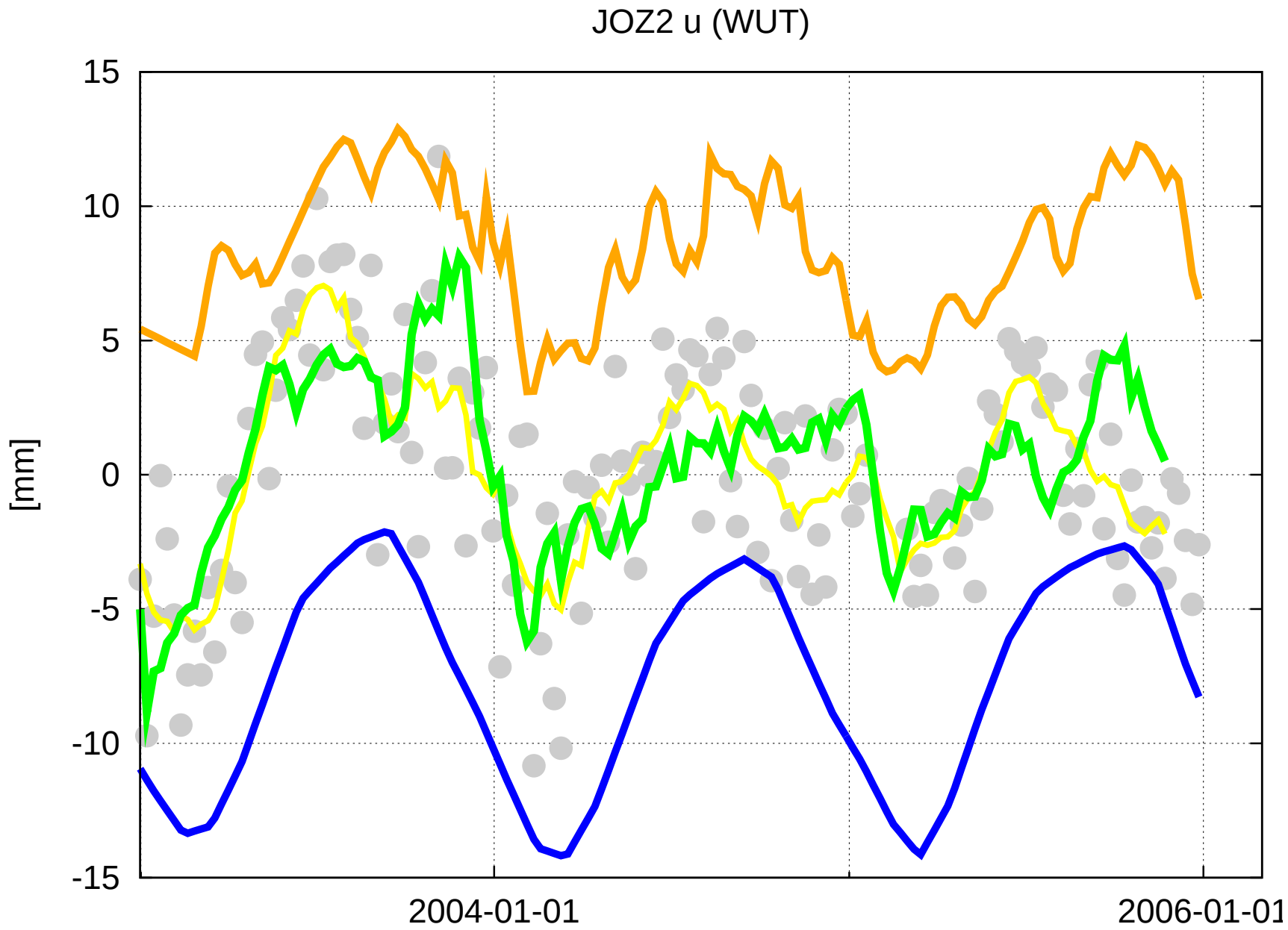

BOR1 u (IGS)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01
2008-01-01

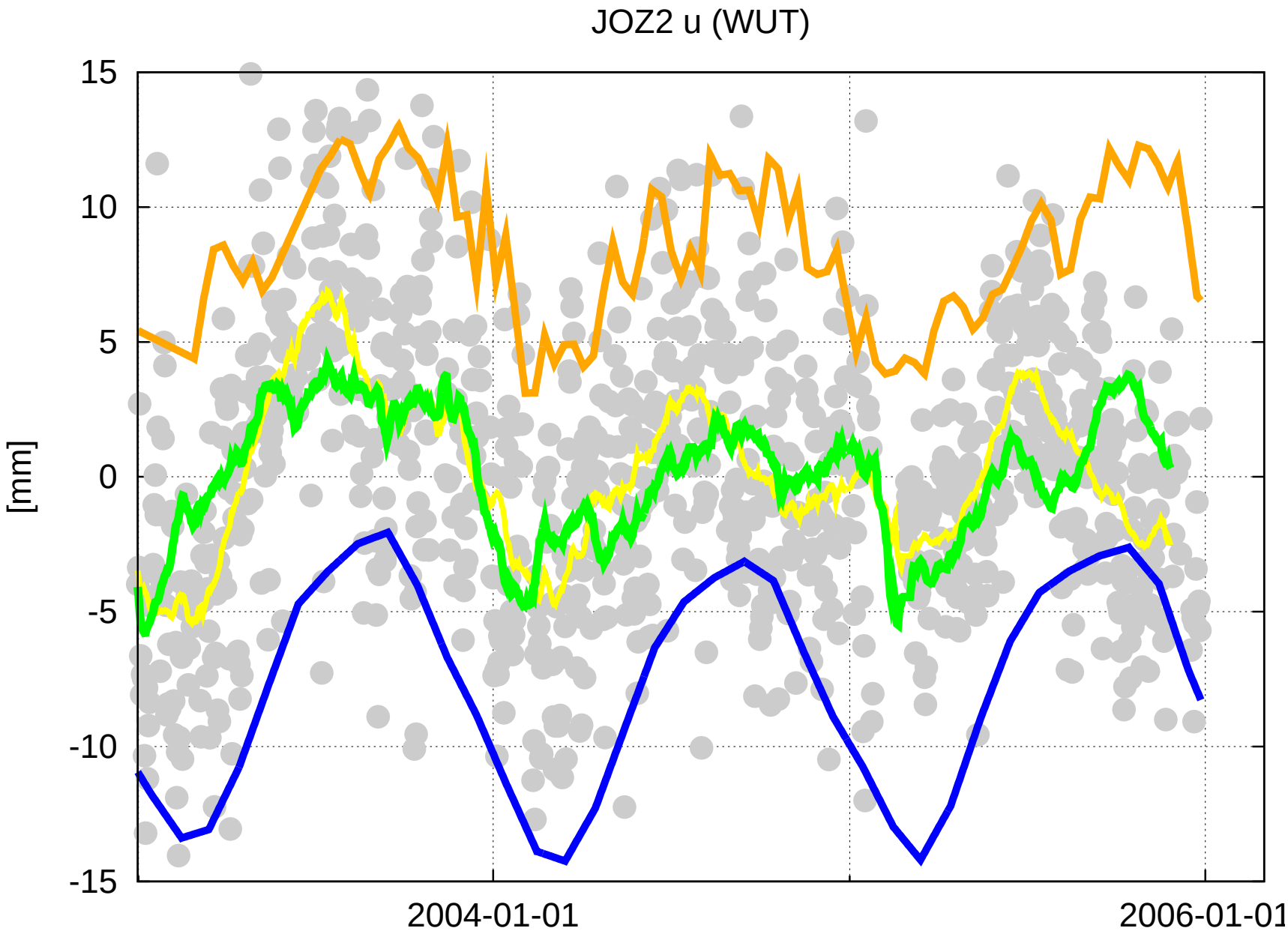

BOR1 u (IGS)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01
2008-01-01

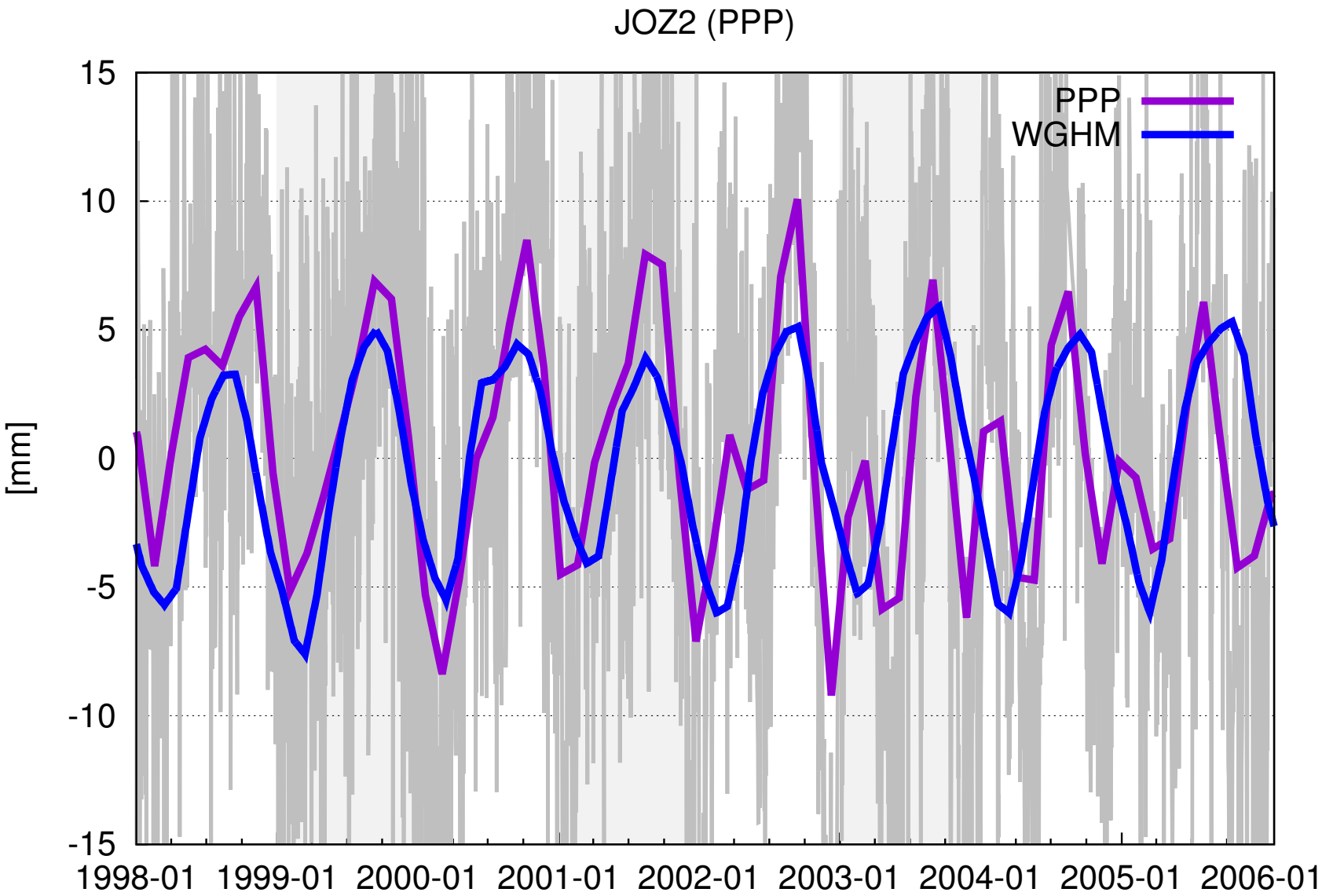

BOR1 u (IGS)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01
2008-01-01

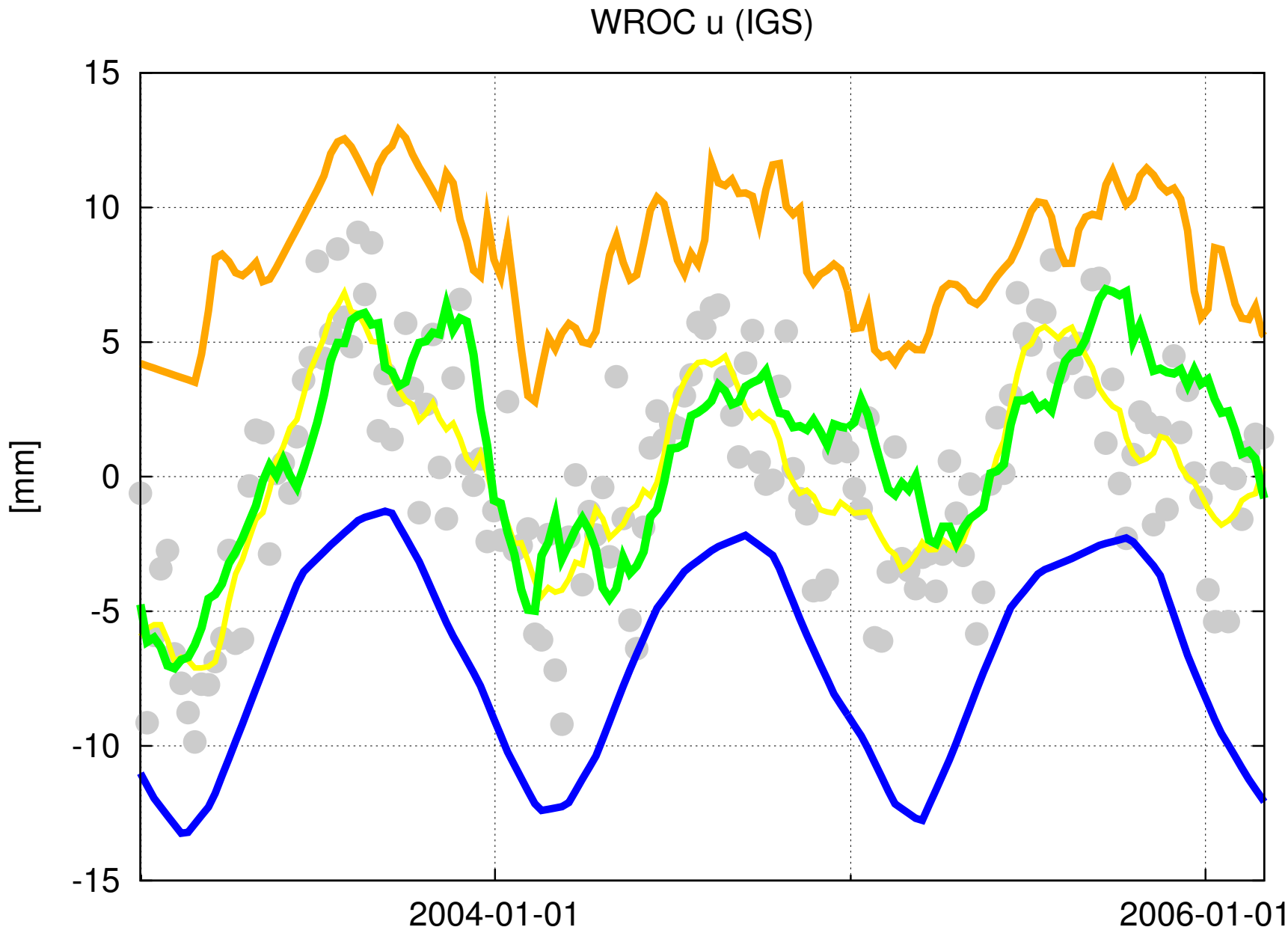

BOR1 n (IGS)
[mm]
4
3
2
1
0
-1
-2
-3
-4
2004-01-01
2006-01-01
2008-01-01


BOR1 e (IGS)
[mm]
4
3
2
1
0
-1
-2
-3
-4
2004-01-01
2006-01-01
2008-01-01

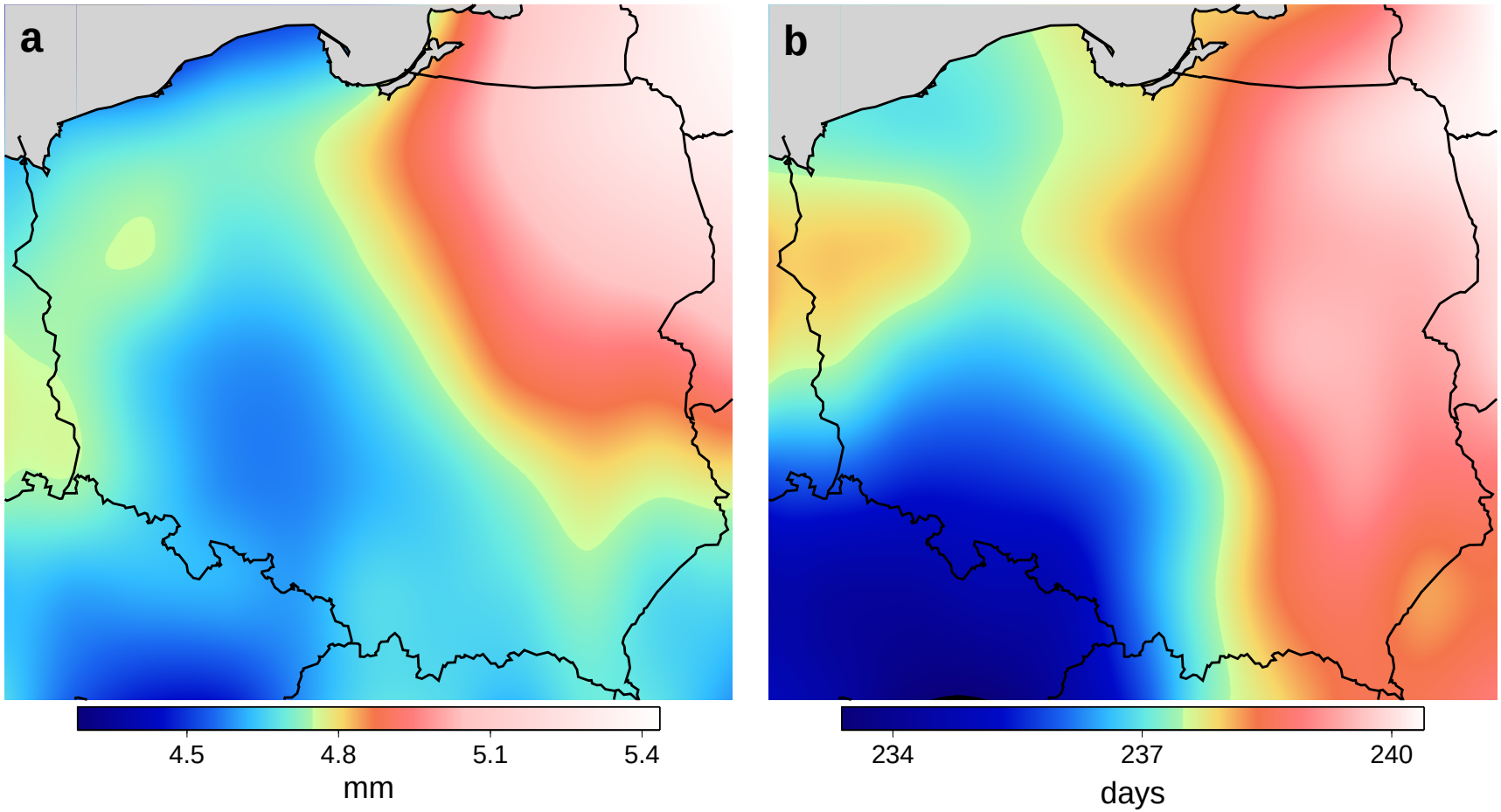

JOZ2 u (WUT)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01

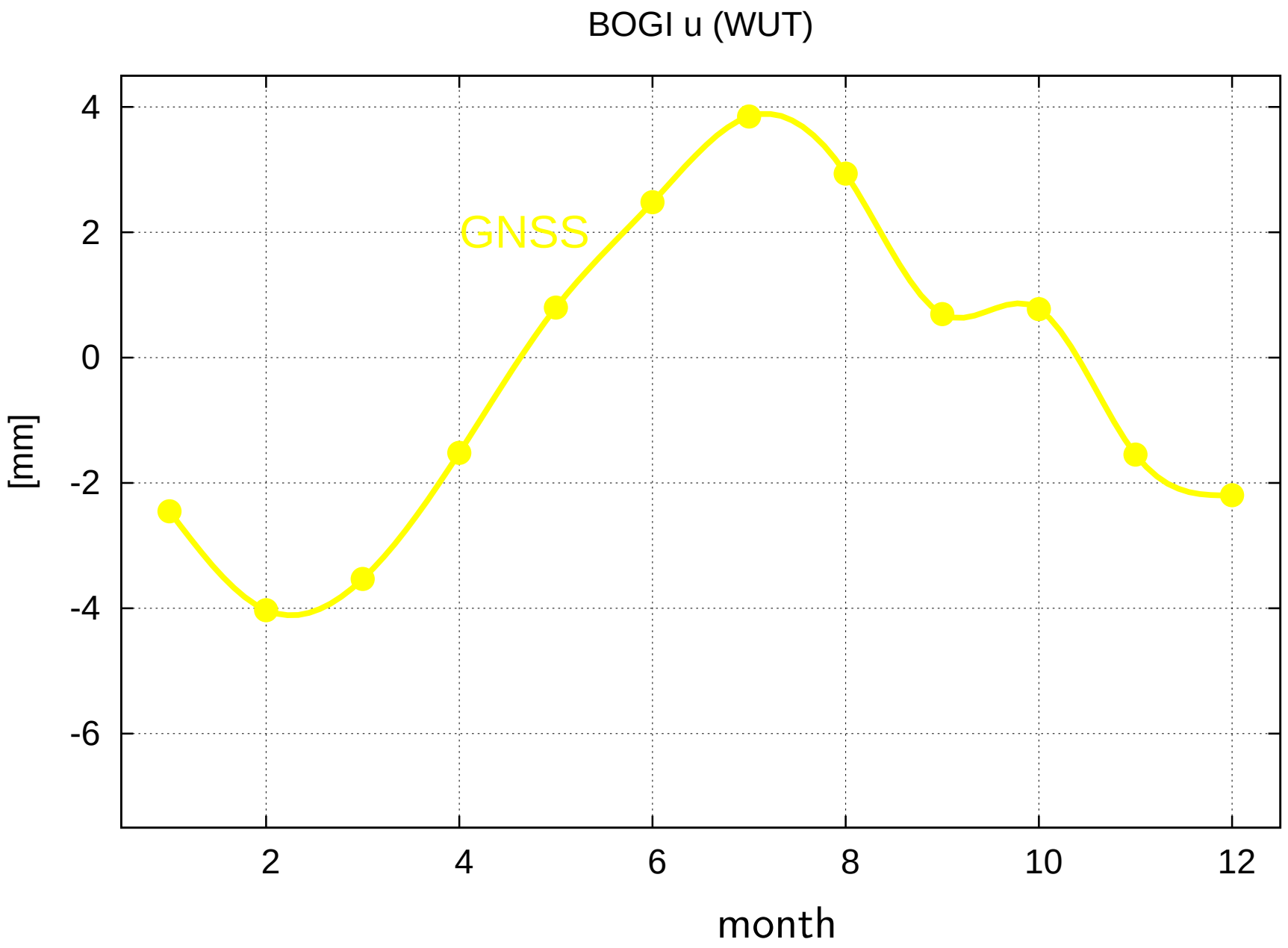

JOZ2 u (WUT)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01

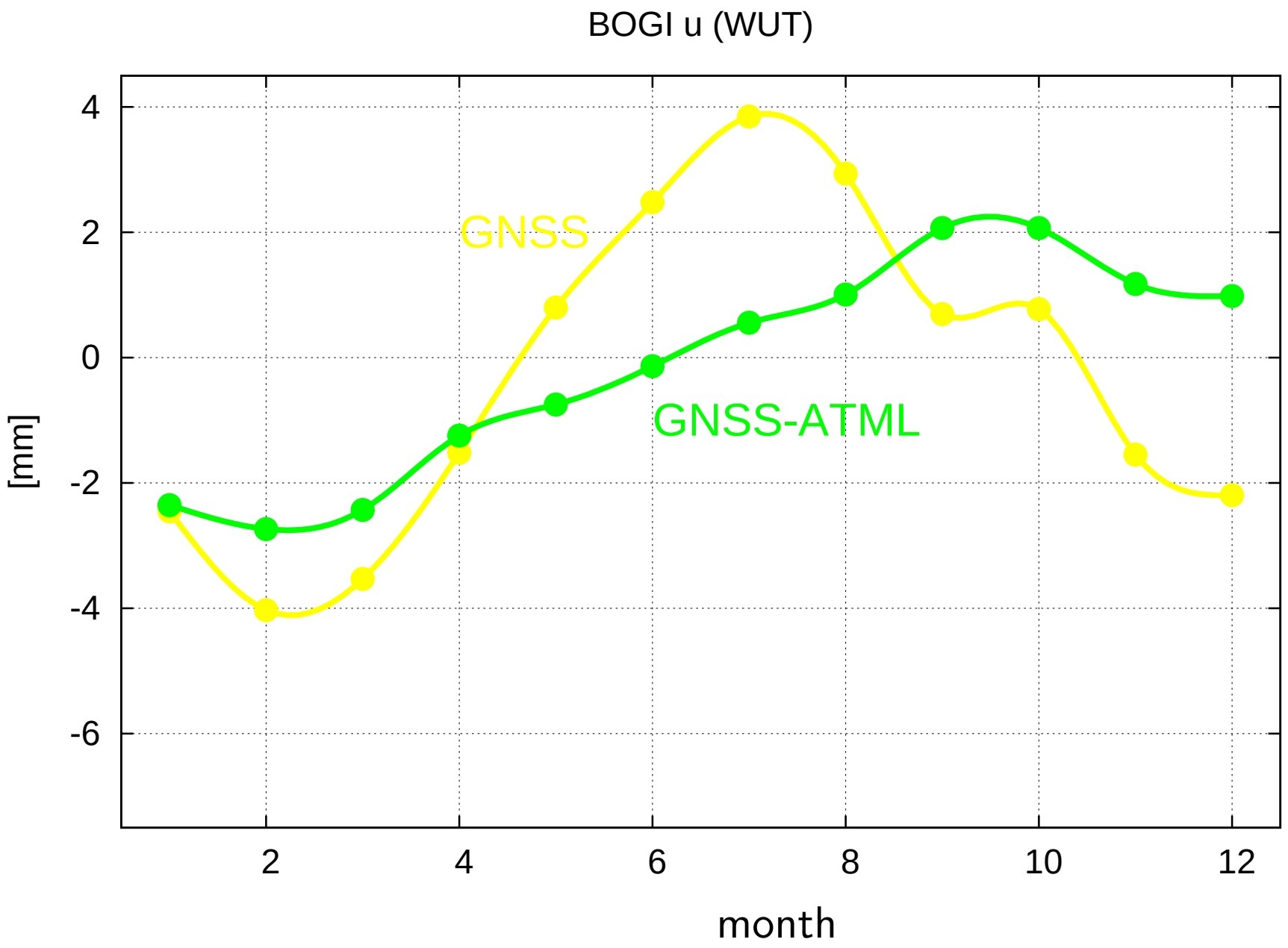

JOZ2 (PPP)
PPP
WGHM
[mm]
15
10
5
0
-5
-10
-15
1998-01
1999-01
2000-01
2001-01
2002-01
2003-01
2004-01
2005-01
2006-01

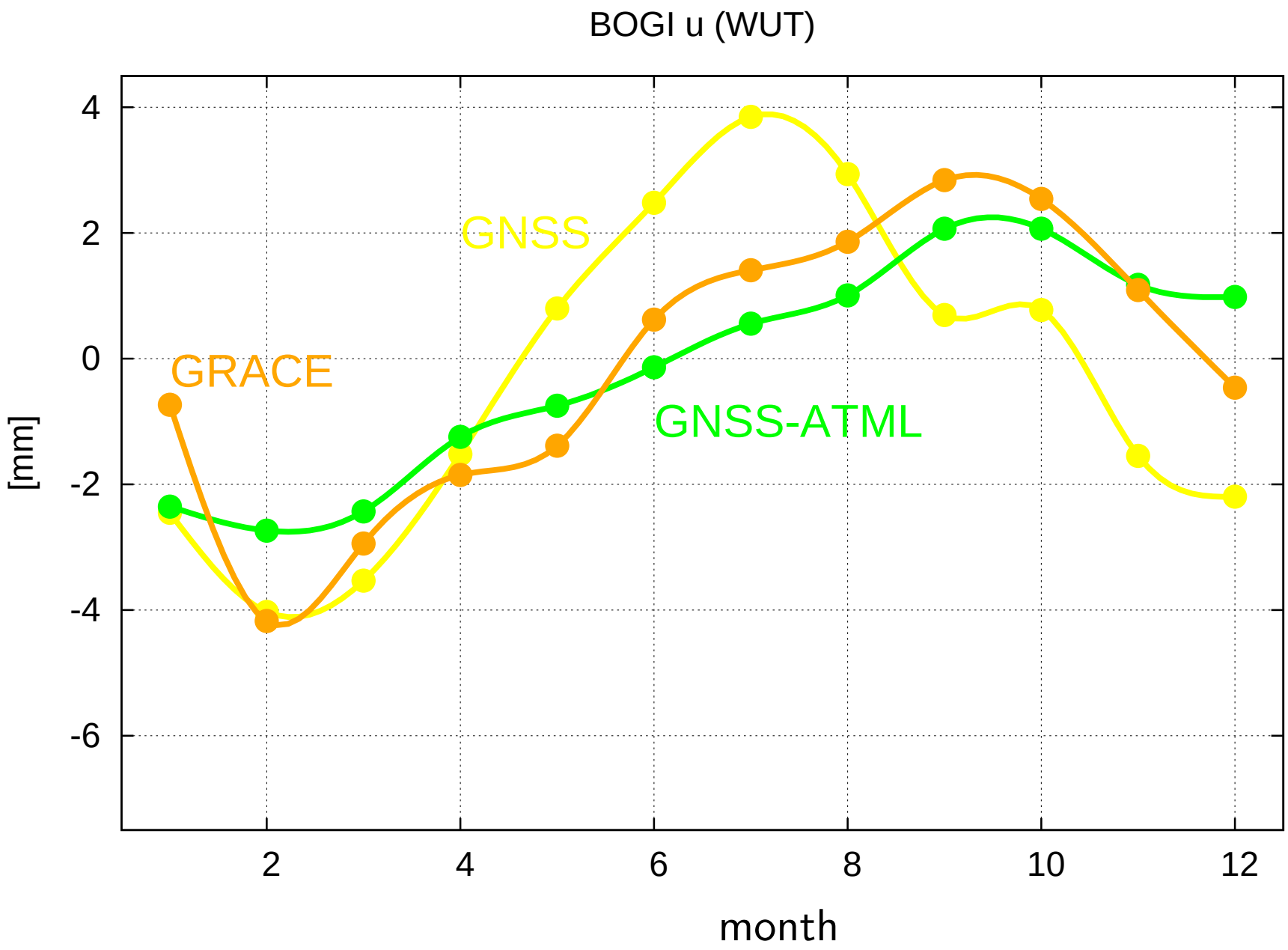

WROC u (IGS)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01

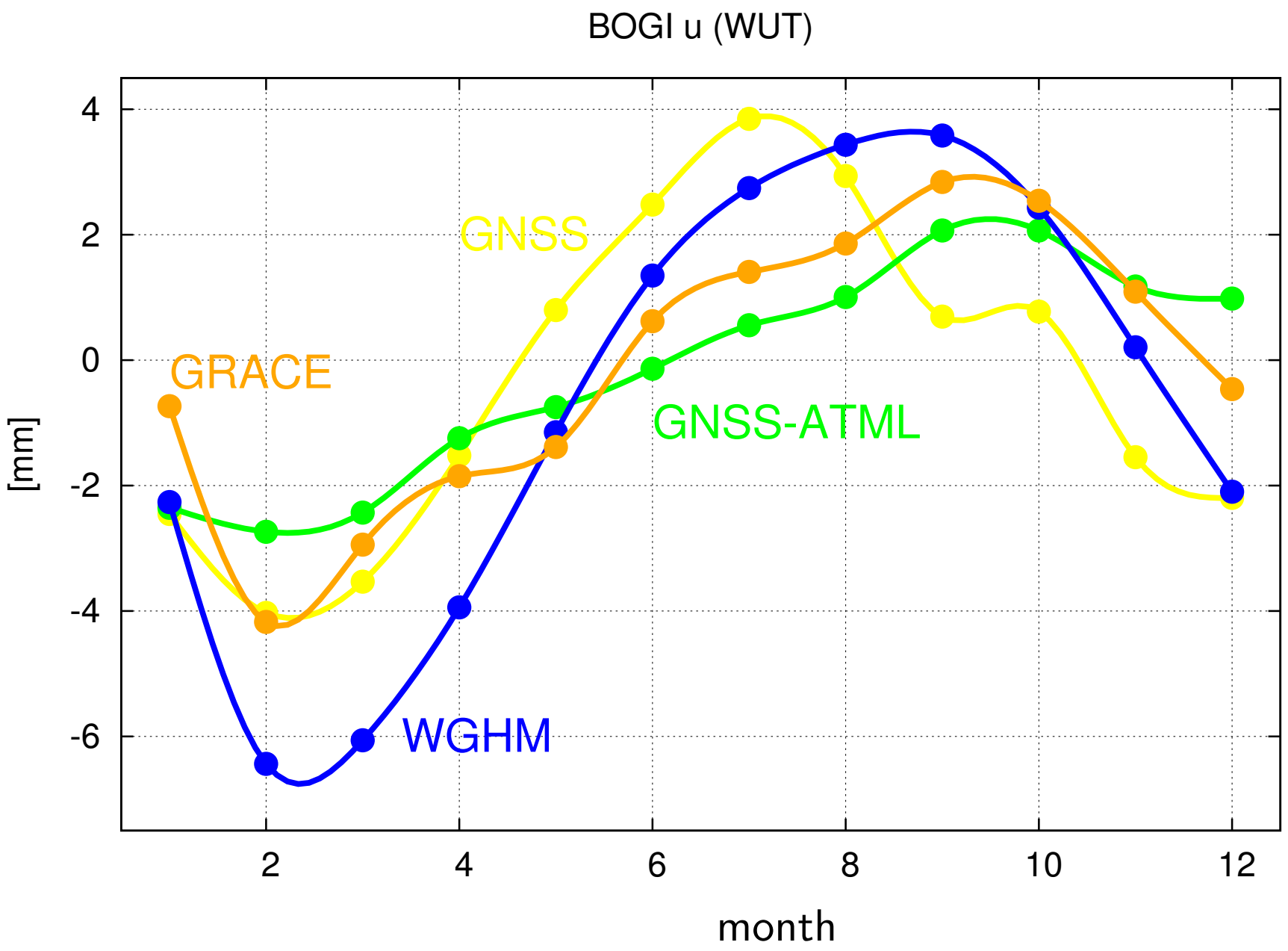
Amplitude and phase of HYDL



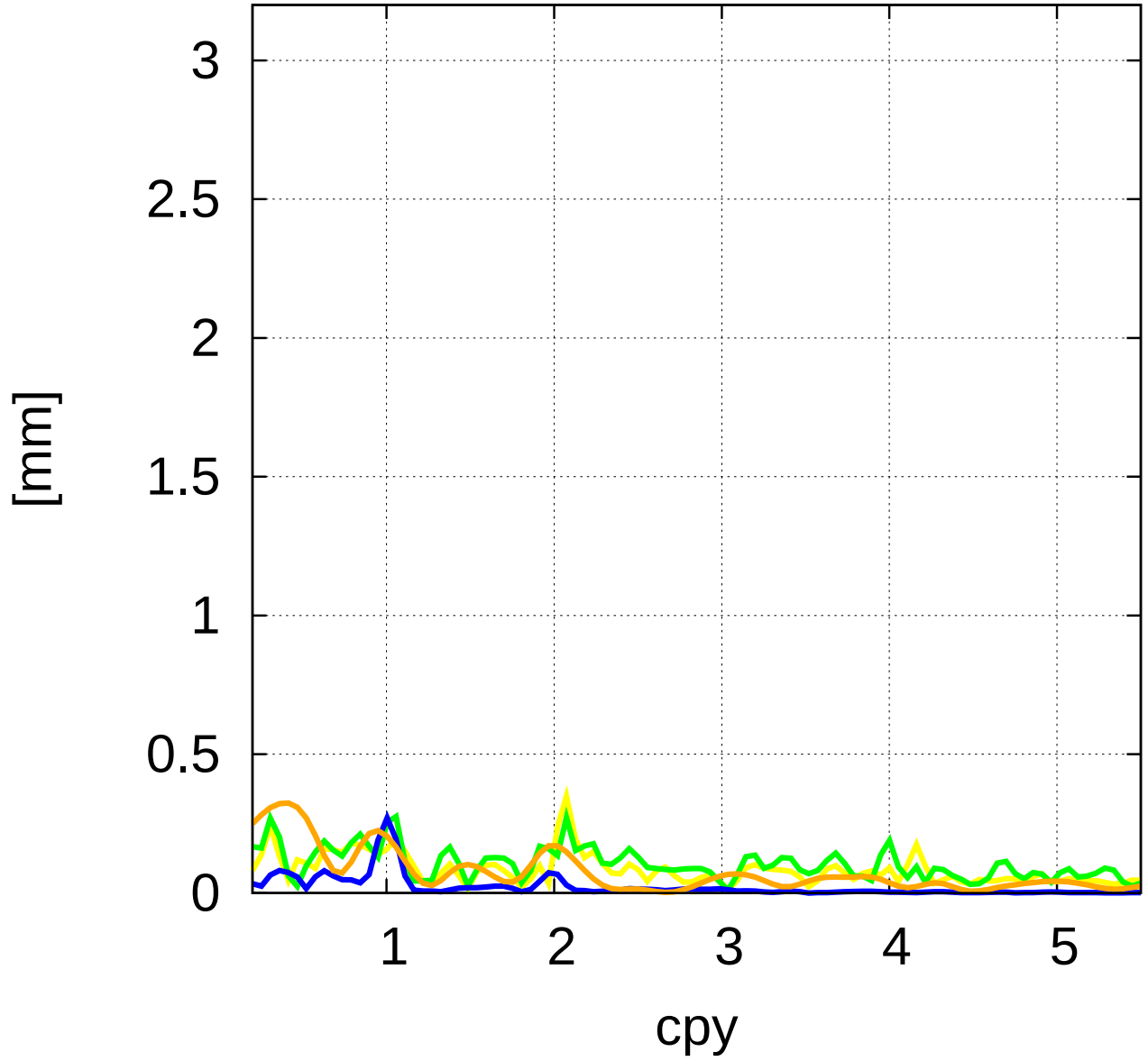

BOGI u (WUT)
GNSS
[mm]
4
2
0
-2
-4
-6
2
4
6
8
10
12
month


BOGI u (WUT)
GNSS
GNSS-ATML
[mm]
4
2
0
-2
-4
-6
2
4
6
8
10
12
month

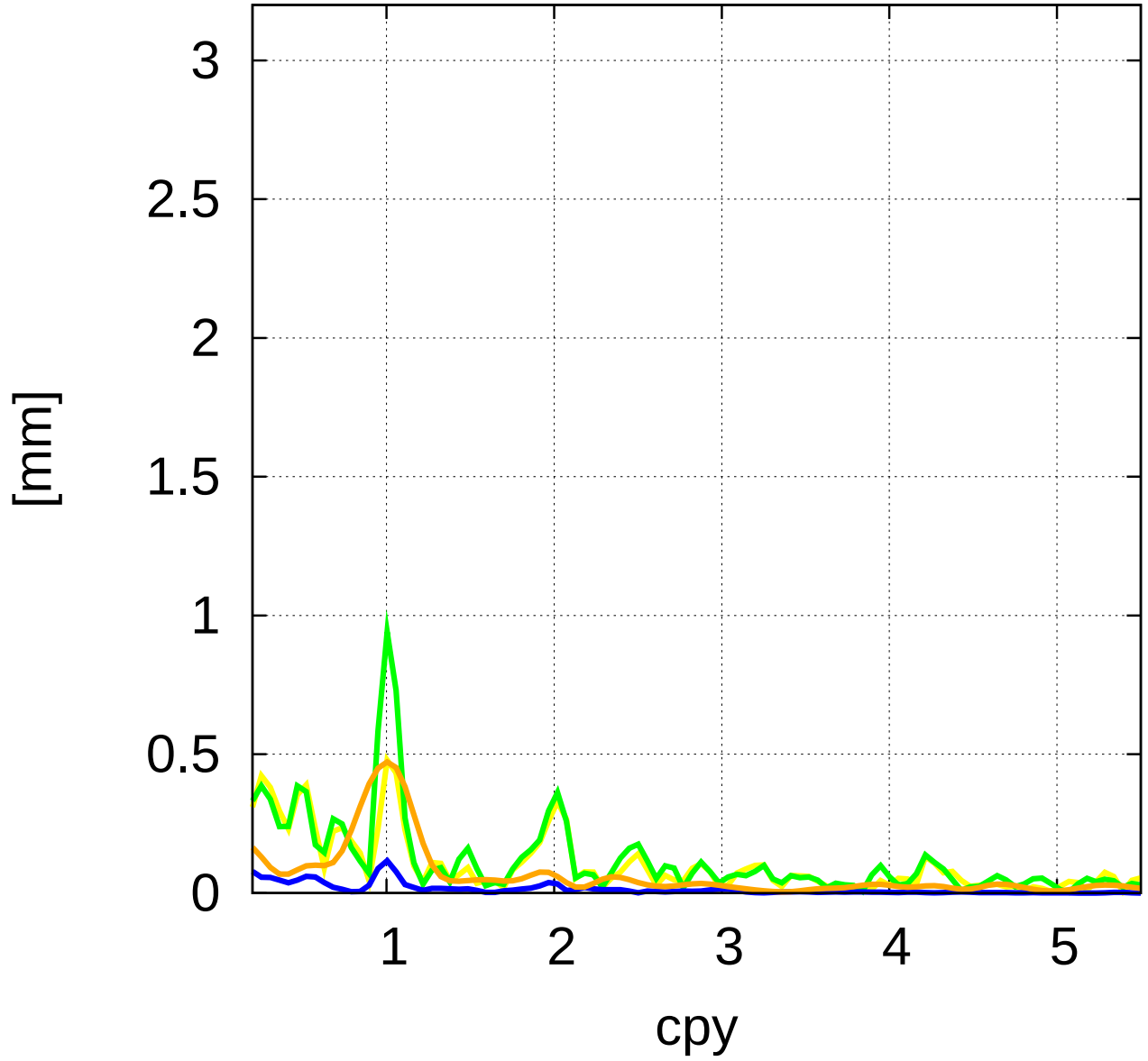

BOGI u (WUT)
GNSS
GRACE
GNSS-ATML
[mm]
4
2
0
-2
-4
-6
2
4
6
8
10
12
month


BOGI u (WUT)
GNSS
GRACE
GNSS-ATML
WGHM
[mm]
month
4
2
0
-2
-4
-6
2
4
6
8
10
12

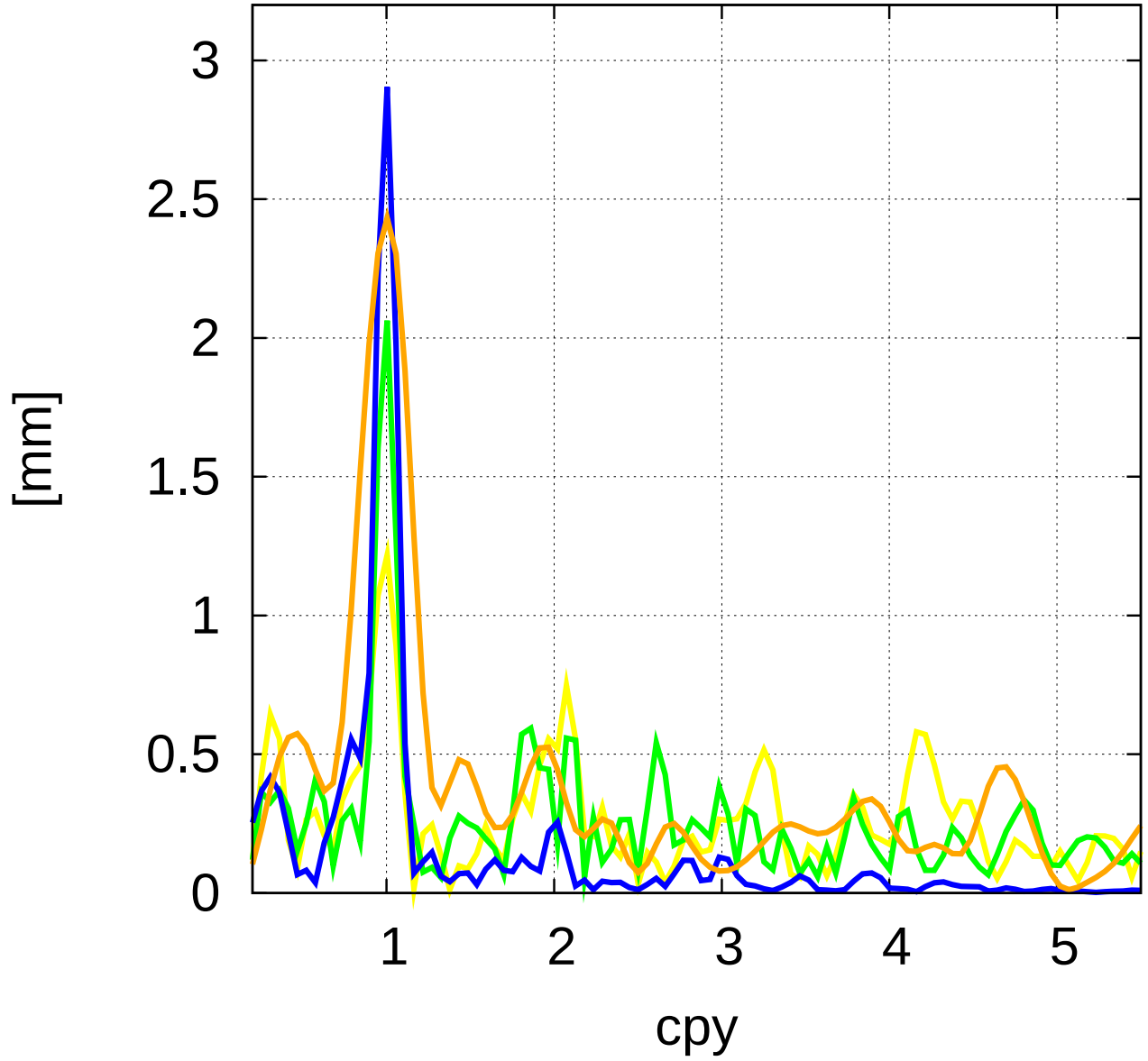
Józefosław n



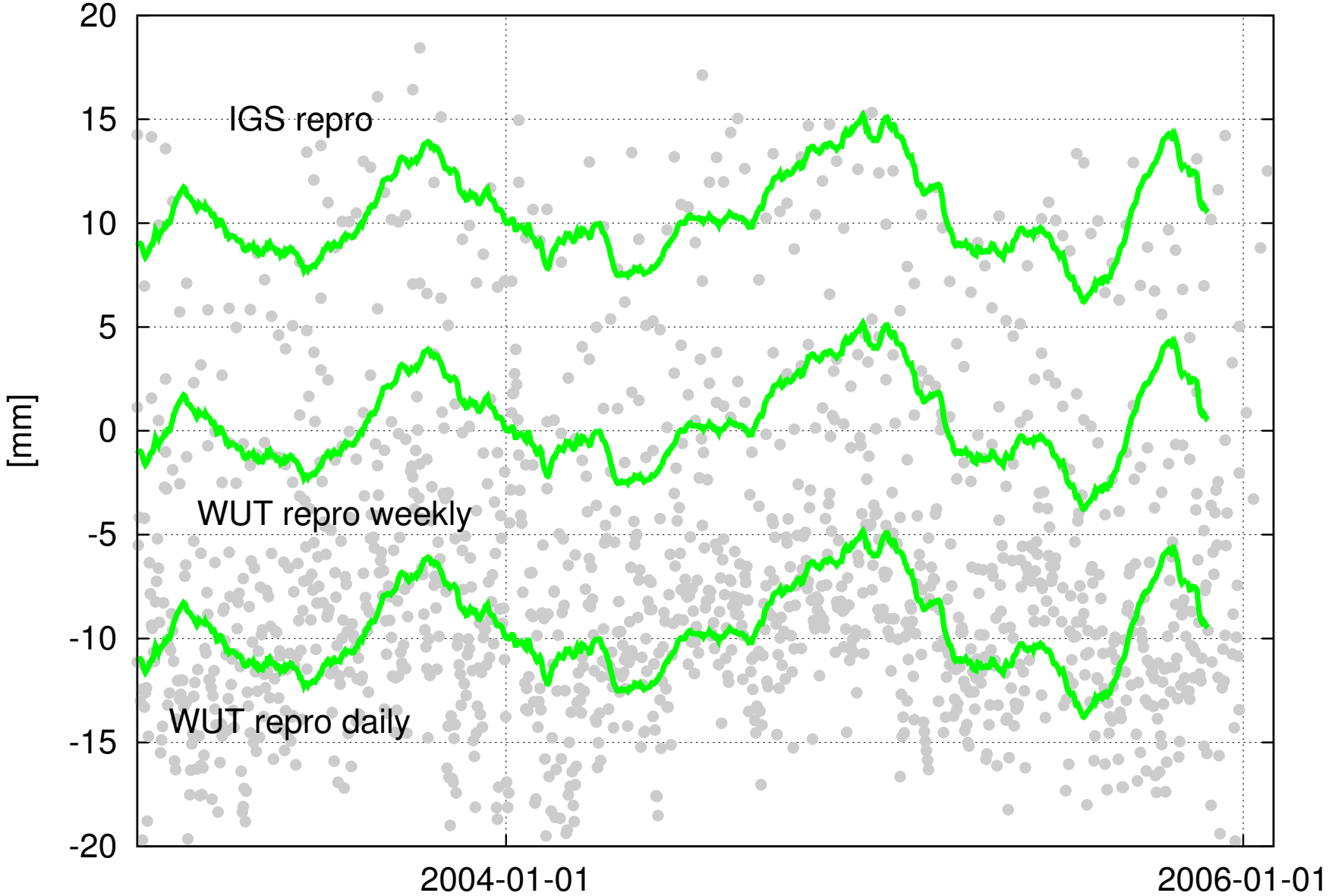
Józefosław e



Józefosław u



JOZE u


20
15
10
5
0
-5
-10
-15
-20
[mm]
IGS repro
WUT repro weekly
WUT repro daily
2004-01-01
2006-01-01

Conclusion

- large number of GNSS sites in Poland with long measurement history allow to study temporal and spatial variation of loading phenomena
- good agreement in amplitude and phase between modelled seasonal deformations and positioning measurements for height component
- still interpretation on horizontal component is ambiguous
- WGHM model gives slightly overestimated amplitudes (we found similar results using GLDAS – not shown here)
- while the most power of ATML is in weekly periods this correction is crucial in GNSS seasonal variation
- good agreement of regional and global GNSS results (the statistic not shown in presentation favor global solutions for loading phenomena studies)

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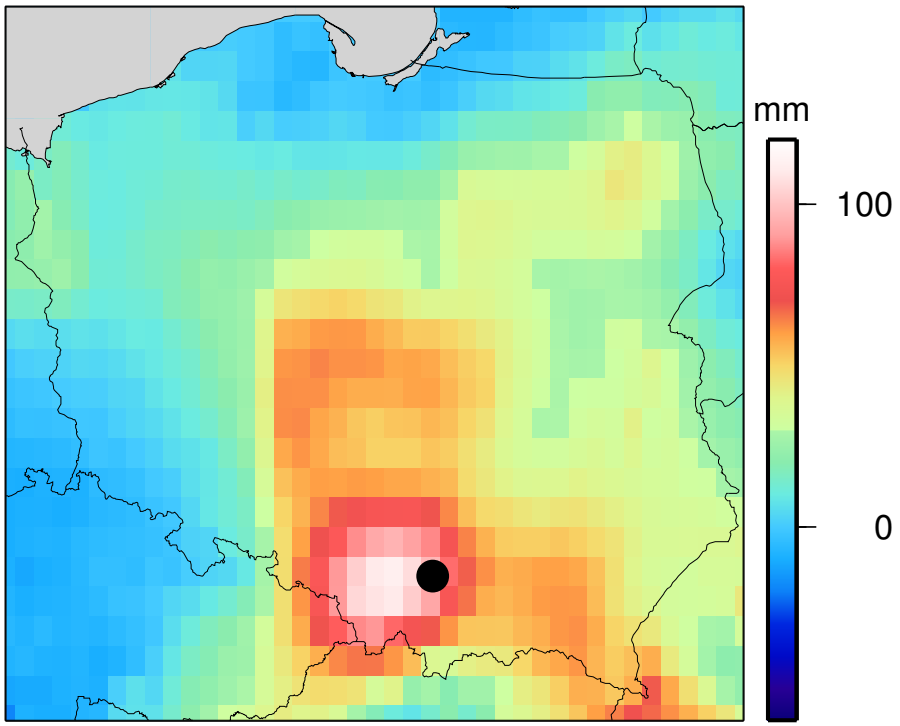
Analysis of seasonal position variation for selected GNSS sites in Poland — Validation of results using loading modelling and GRACE data

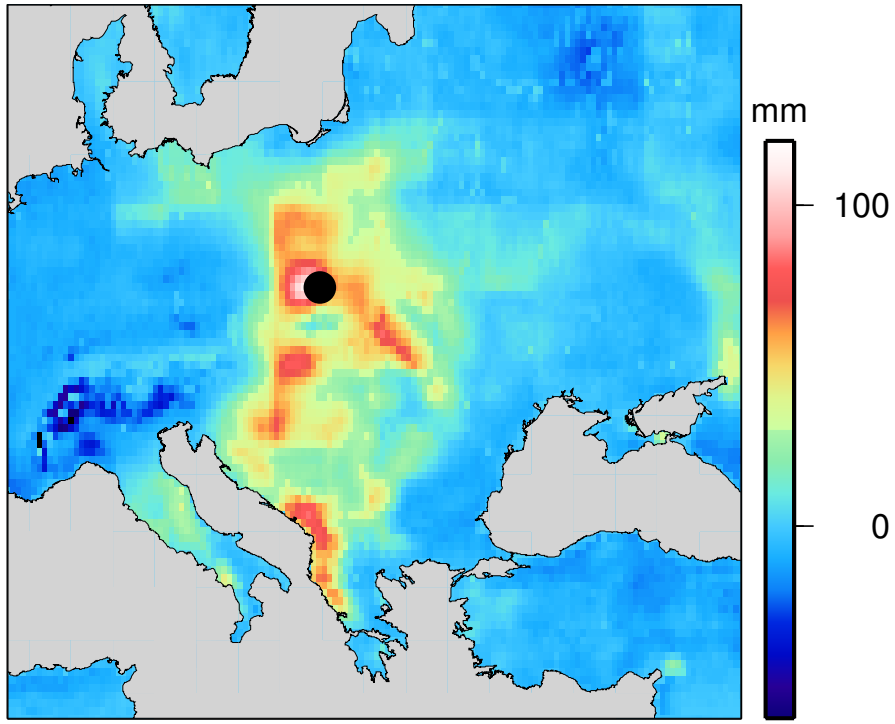
A. Güntner (GFZ Potsdam) generously provided WGHM data

Financial support from Organizers is greatly appreciated

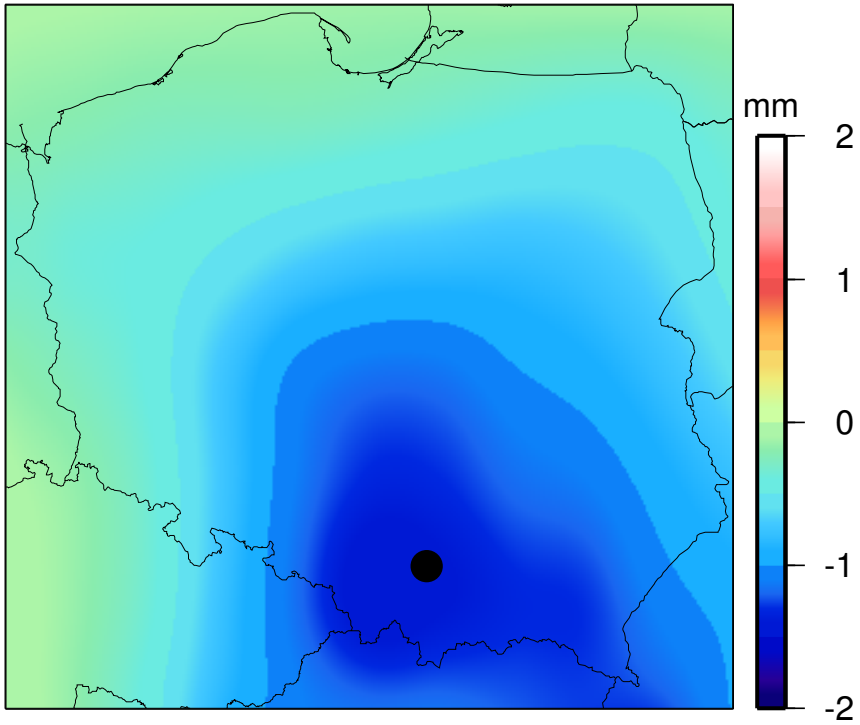
Backup Slides

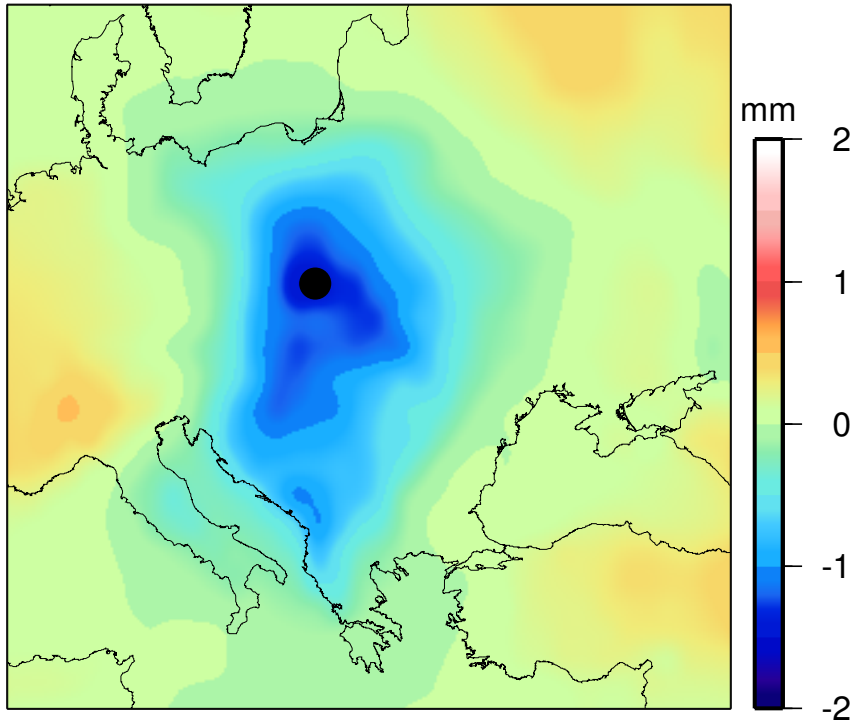
flood — 2010



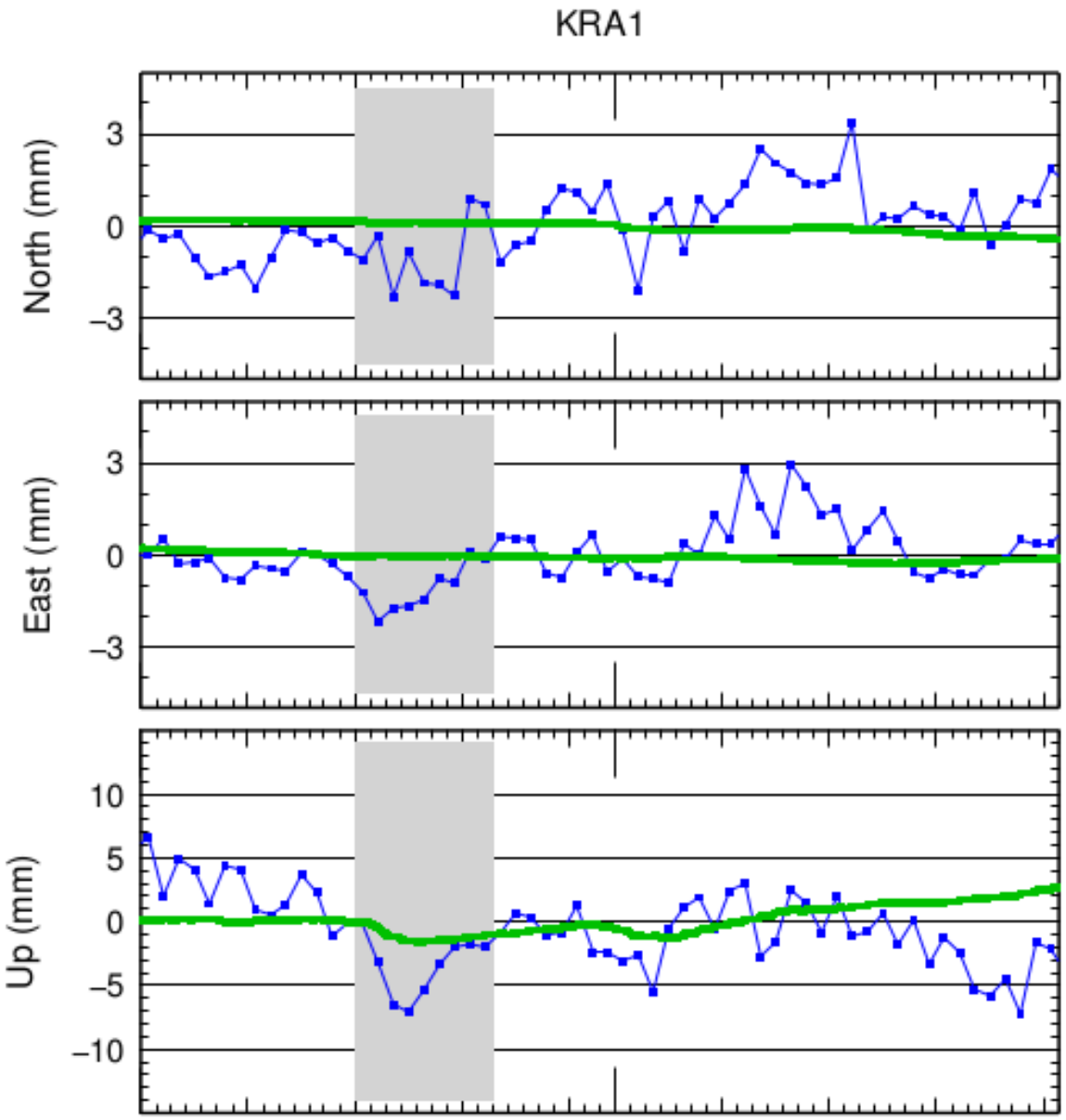


flood — 2010

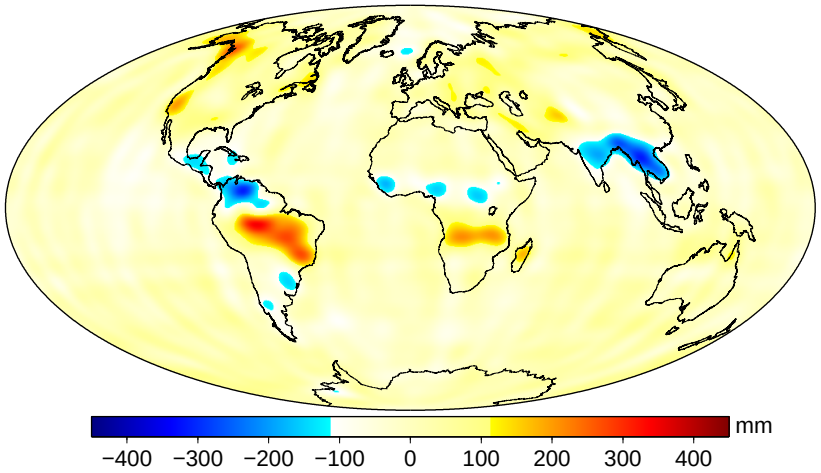




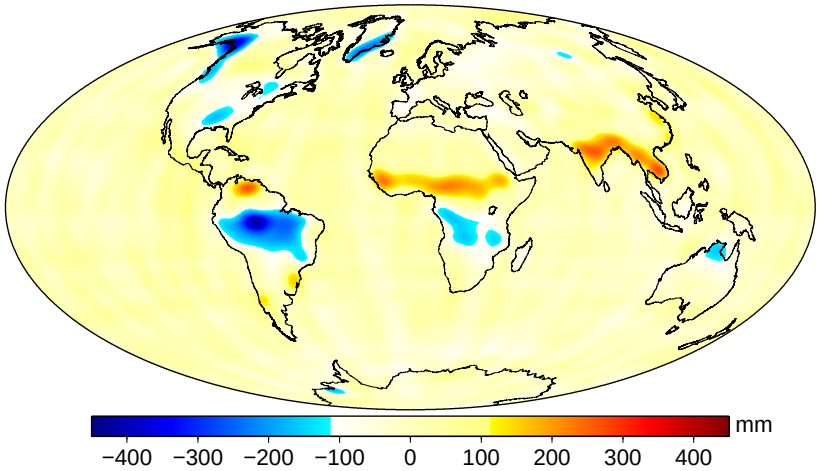
flood — 2010



GRACE

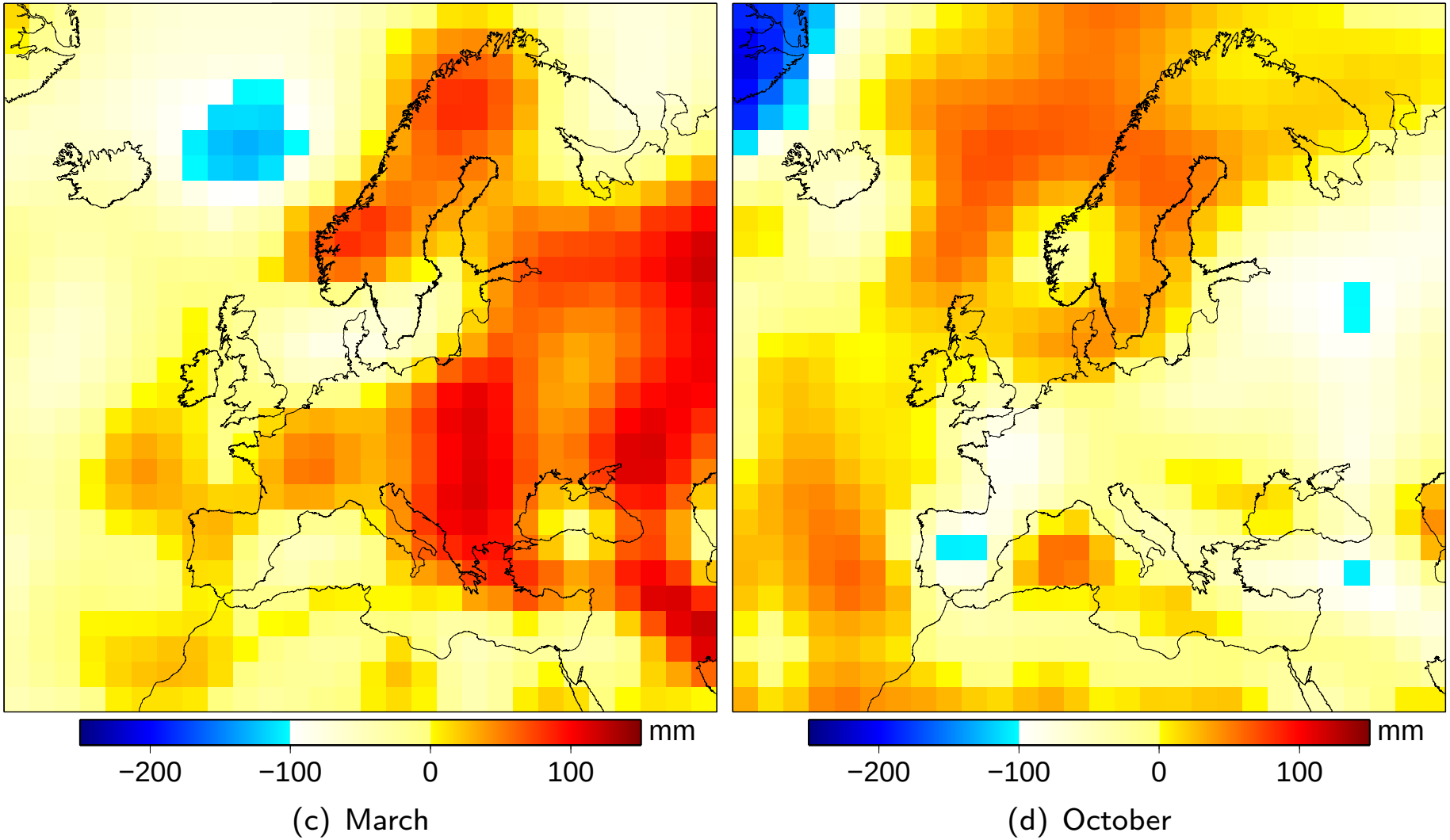


(a) March



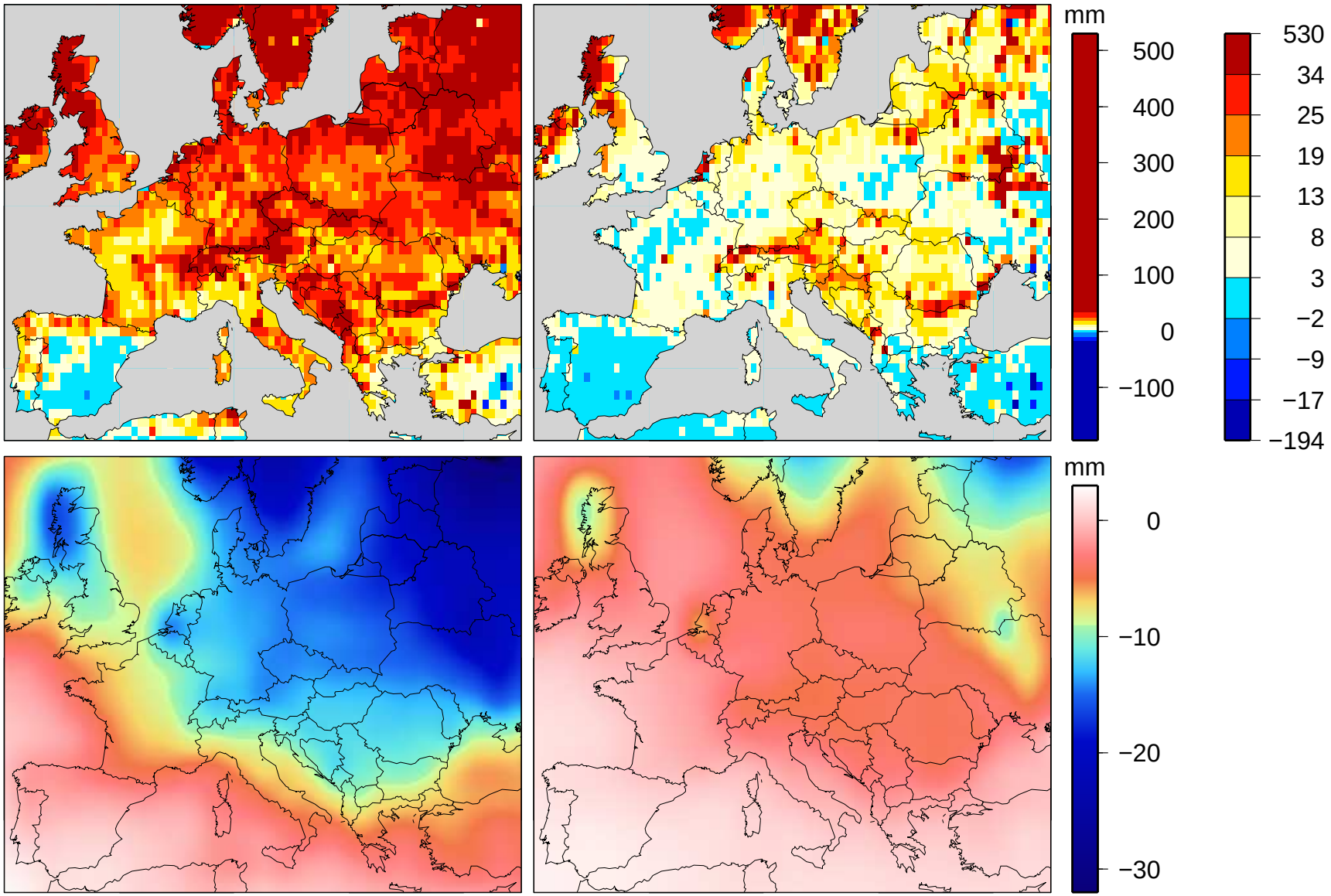
(b) October

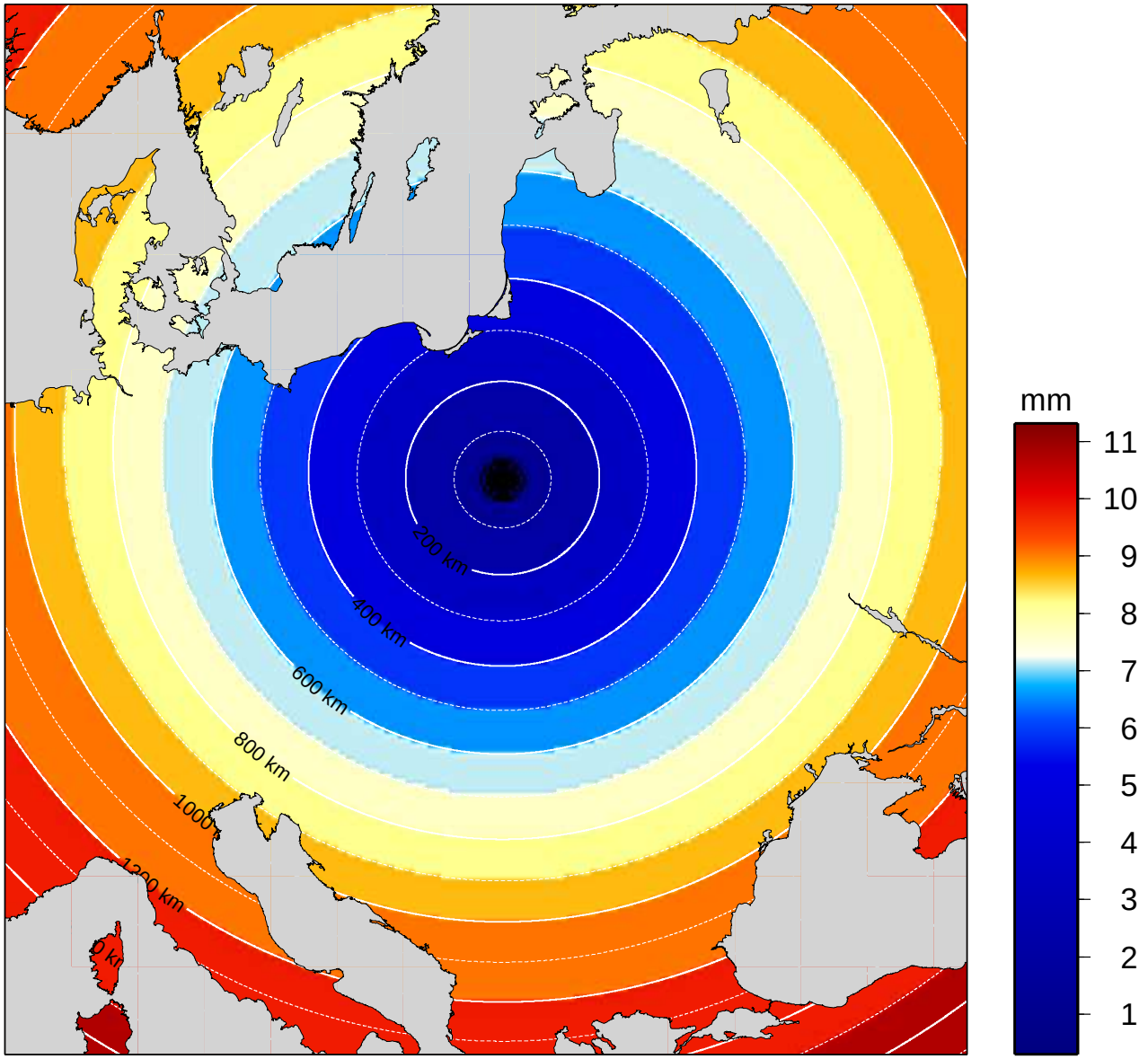
GRACE

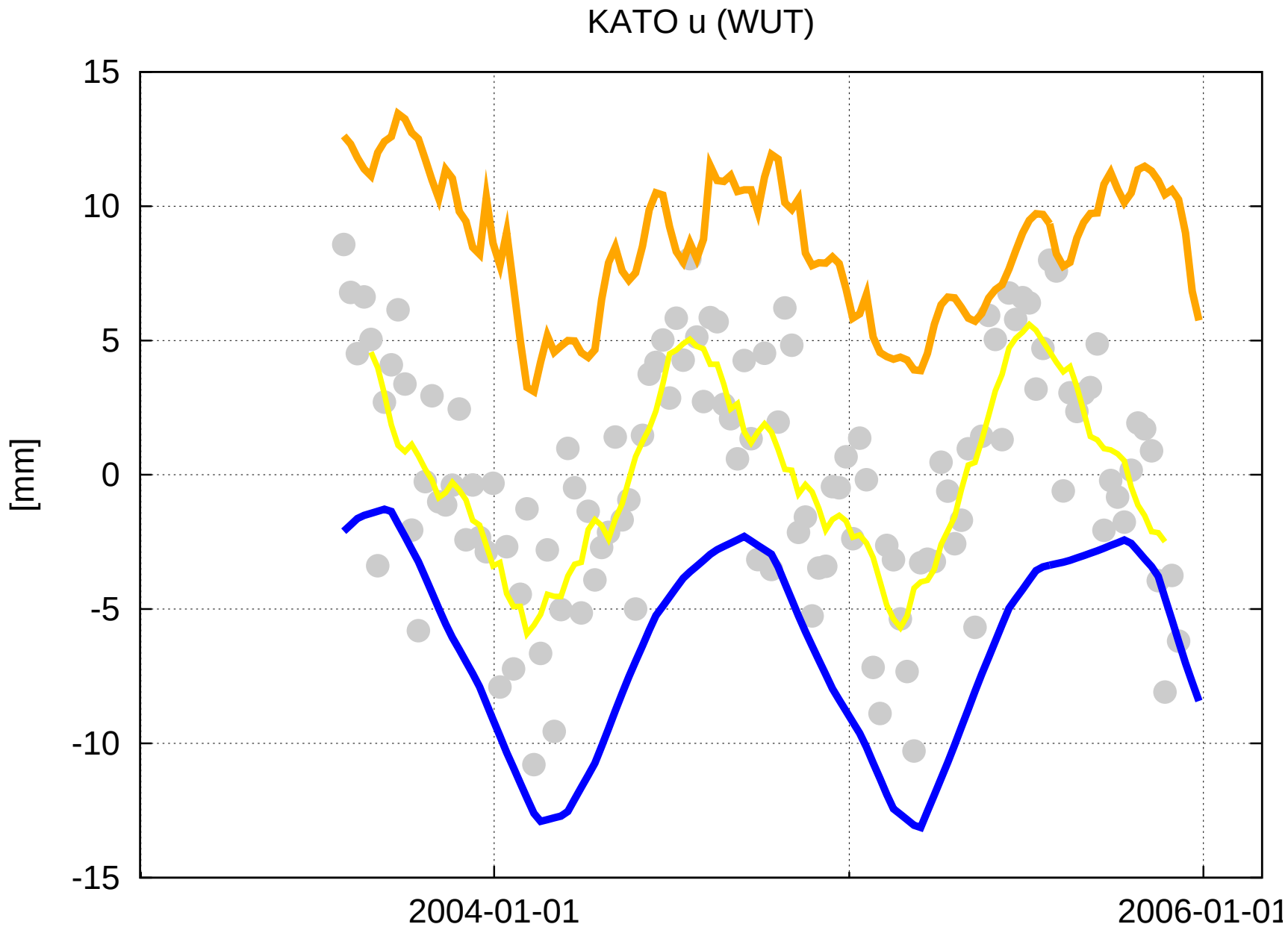


(c) March (d) October

WGHM


mm
500
400
300
200
100
0
−100
530
34
25
19
13
8
3
−2
−9
−17
−194
mm
0
−10
−20
−30


200 km
400 km
600 km
800 km
1000
mm
11
10
9
8
7
6
5
4
3
2
1


KATO u (WUT)
15
10
5
0
-5
-10
-15
[mm]
2004-01-01
2006-01-01