Intraction between Sub-daily ERP and GNSS Orbit Modeling

R. Dach, D. Thaller, G. Beutler

rolf.dach@aiub.unibe.ch

Astronomical Institute, University of Bern, Sidlerstrasse 5, CH-3012 Bern

S. Schaer

Federal Office of Topography (swisstopo), Seftigenstrasse 264, CH-3084 Wabern

U. Hugentobler

TU Munich, Research Group Satellite Geodesy, Arcisstrasse 21, D-80333 München, Germany

European Geosciences Union; General Assembly 2008

Vienna, Austria; 13–18 April 2008

Outline

Interactions between Sub-daily ERP and GNSS Orbit Modeling:

1. Motivation: Why is this topic important
2. GNSS orbit parametrization and Earth rotation parameters
3. Solving the problem with the retrograde terms
4. Impact of orbit parameters on sub–daily Earth rotation parameters
5. Summary and Outlook

Why we want to study this?

The data from the IGS network are predestinated to estimate sub-daily ERPs because of:

- the dense tracking network
- the continuous observation with a high sampling(30 s)
- the large number of simultaneously observed satellites (32 GPS and 16 GLONASS)

Why we want to study this?

The data from the IGS network are predestinated to estimate sub-daily ERPs because of:

- the dense tracking network
- the continuous observation with a high sampling(30 s)
- the large number of simultaneously observed satellites (32 GPS and 16 GLONASS)

Due to the shift of the daily sessions between GNSS and VLBI the combination of the ERPs from both techniques is impracticable.

See e.g., Thaller et al, poster XY0285, tomorrow.

Why we want to study this?

The data from the IGS network are predestinated to estimate sub-daily ERPs because of:

- the dense tracking network
- the continuous observation with a high sampling(30 s)
- the large number of simultaneously observed satellites (32 GPS and 16 GLONASS)

Due to the shift of the daily sessions between GNSS and VLBI the combination of the ERPs from both techniques is impracticable.
See e.g., Thaller et al, poster XY0285, tomorrow.

If the discontinuities at the day boundaries for an offset and drift modeling per day for the ERPs show a clear systematic effect (see J. Rays presentation in Session G4) an increasing in the temporial resolution needs to be considered.

Where is the problem?

Parametrization of the orbit for the GNSS satellites:

- one set of inital conditions
- constant and periodic parameters to absorb the solar radiation pressure
  (in a sun–oriented coordinate system at the satellite)
- empirical velocity changes of the satellites (e.g., every 12 hours)
  (according to the orientation of the satellite: radial, along track, out-of-plane)

Where is the problem?

Parametrization of the orbit for the GNSS satellites:

- one set of inital conditions
- constant and periodic parameters to absorb the solar radiation pressure
  (in a sun–oriented coordinate system at the satellite)
- empirical velocity changes of the satellites (e.g., every 12 hours)
  (according to the orientation of the satellite: radial, along track, out-of-plane)

Solving for all these parameters the estimation of sub–daily ERPs becomes impossible. $\Rightarrow$ Empirically constrain some of these parameters

Where is the problem?

Parametrization of the orbit for the GNSS satellites:

- one set of inital conditions
- constant and periodic parameters to absorb the solar radiation pressure
  (in a sun–oriented coordinate system at the satellite)
- empirical velocity changes of the satellites (e.g., every 12 hours)
  (according to the orientation of the satellite: radial, along track, out-of-plane)

Solving for all these parameters the estimation of sub–daily ERPs becomes impossible. $\Rightarrow$ Empirically constrain some of these parameters

Sub–daily ERPs are highly correlated with some of these parameters.
$\Rightarrow$ Decorrelate by additional conditions

Where is the problem?

Parametrization of the orbit for the GNSS satellites:

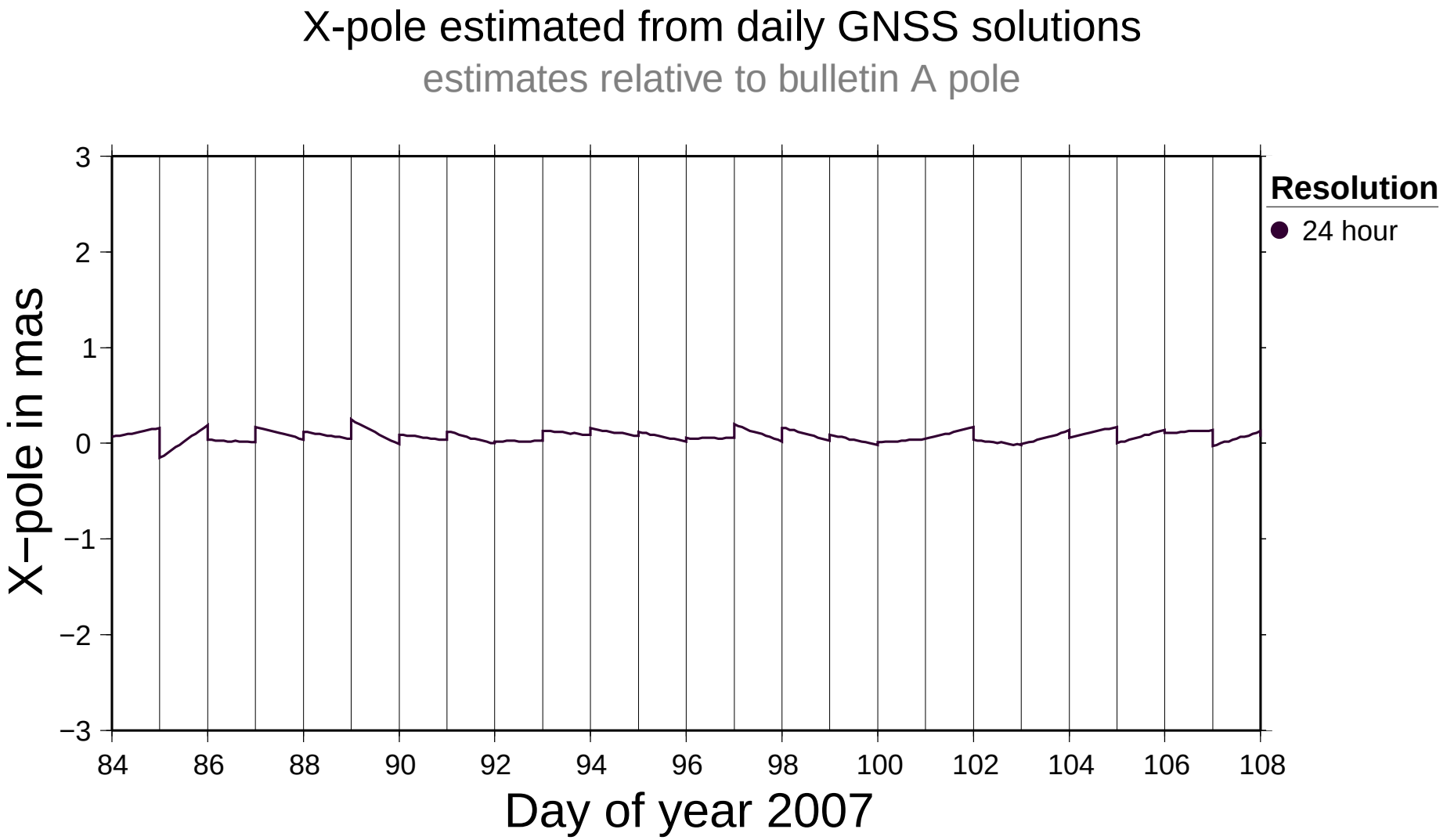
- one set of inital conditions
- constant and periodic parameters to absorb the solar radiation pressure
  (in a sun–oriented coordinate system at the satellite)
- empirical velocity changes of the satellites (e.g., every 12 hours)
  (according to the orientation of the satellite: radial, along track, out-of-plane)

Solving for all these parameters the estimation of sub–daily ERPs becomes impossible. $\Rightarrow$ Empirically constrain some of these parameters

Sub–daily ERPs are highly correlated with some of these parameters.
$\Rightarrow$ Decorrelate by additional conditions

Is the GNSS technique really capable to provide sub–daily ERPs?

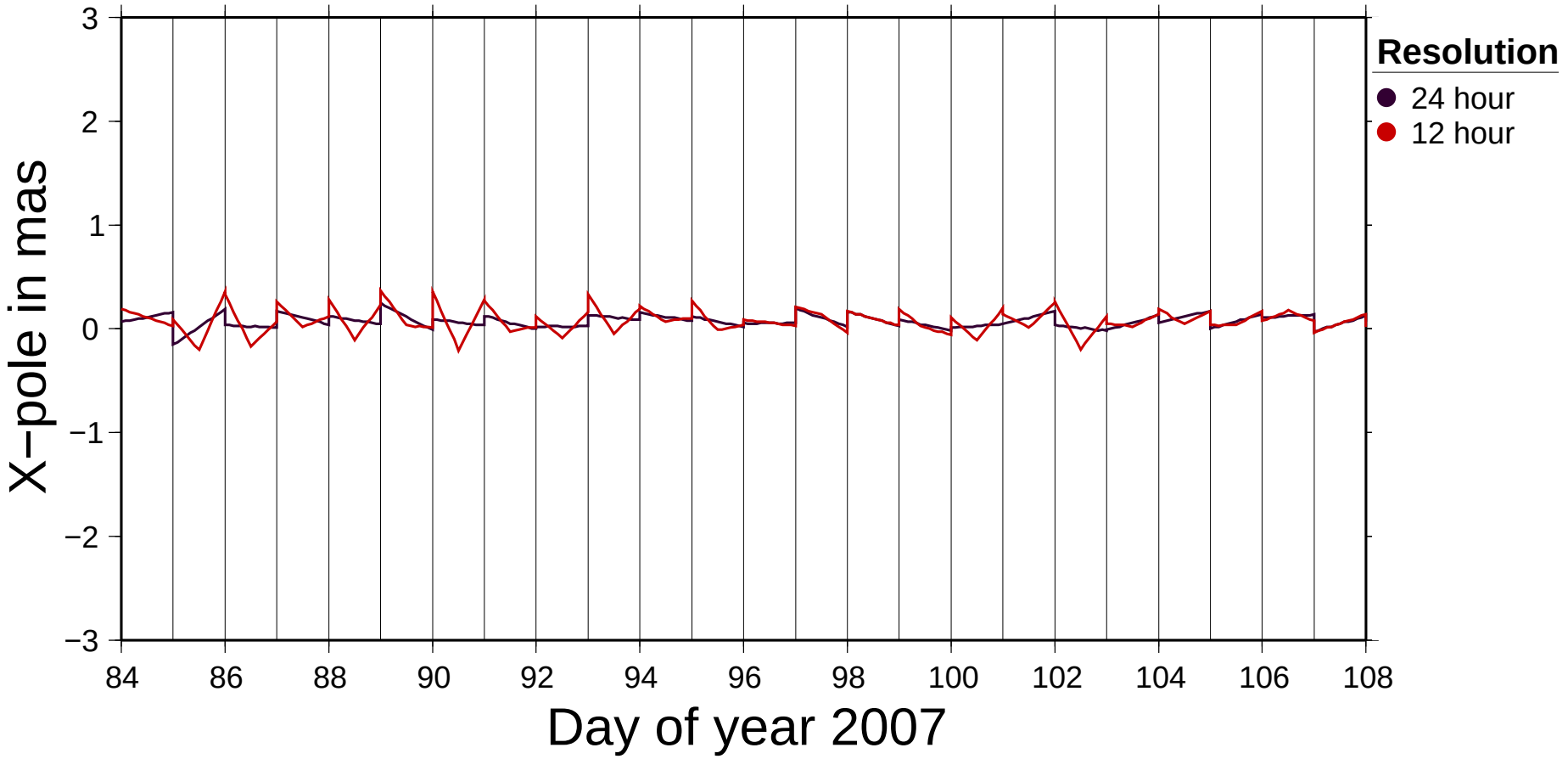
ERP Resolution



ERP Resolution

X-pole estimated from daily GNSS solutions

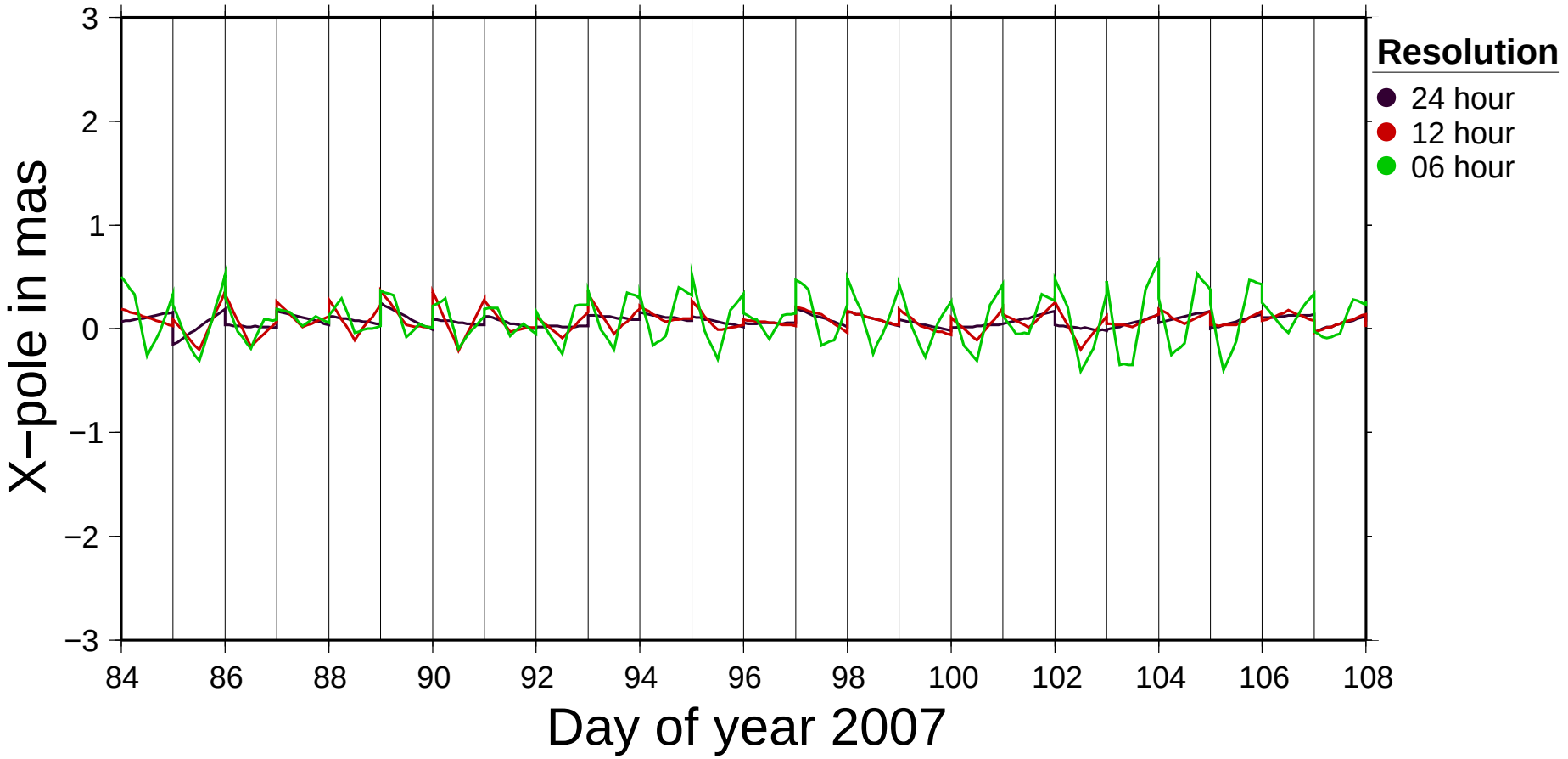
estimates relative to bulletin A pole



ERP Resolution

X-pole estimated from daily GNSS solutions

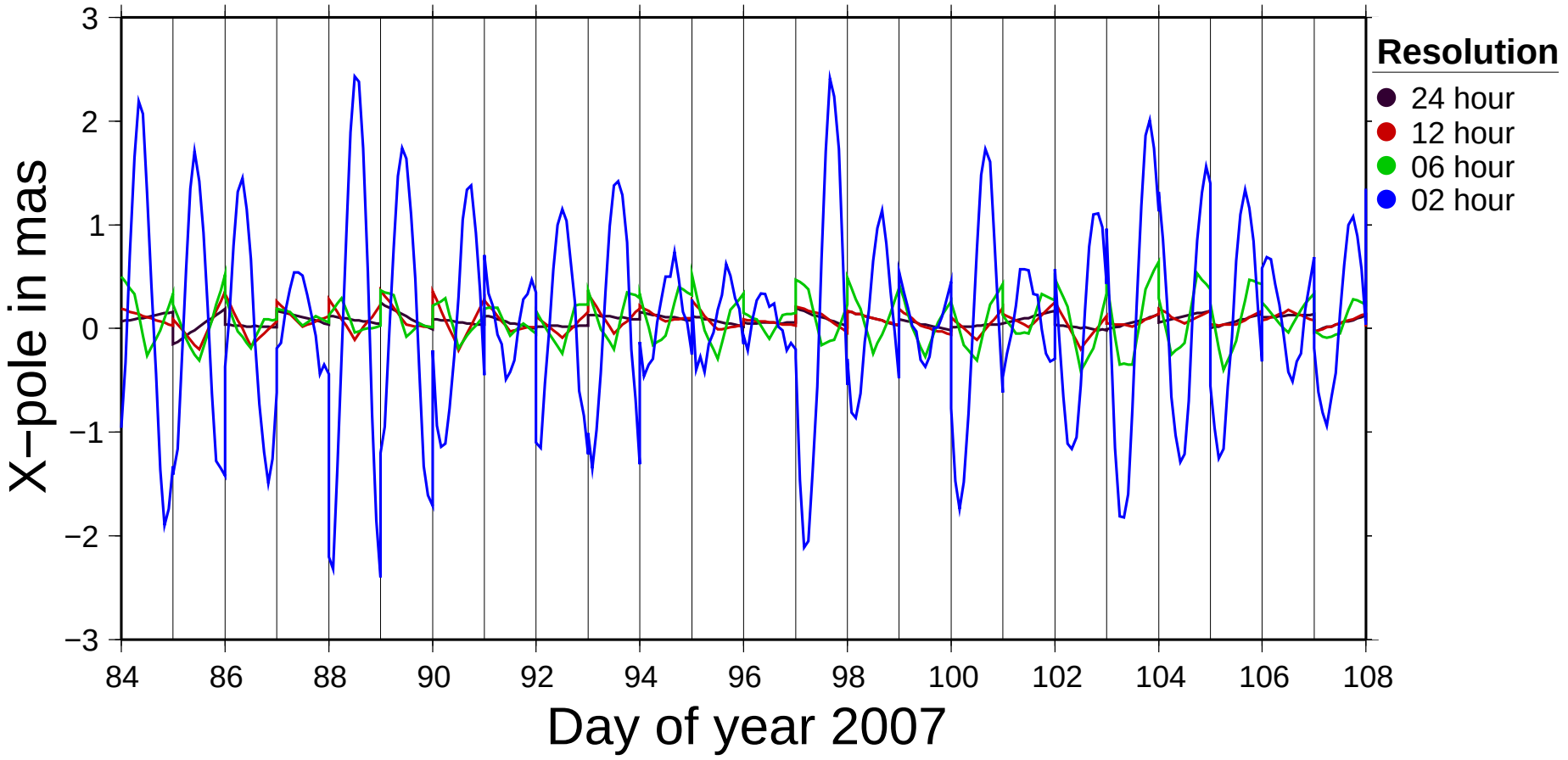
estimates relative to bulletin A pole



ERP Resolution

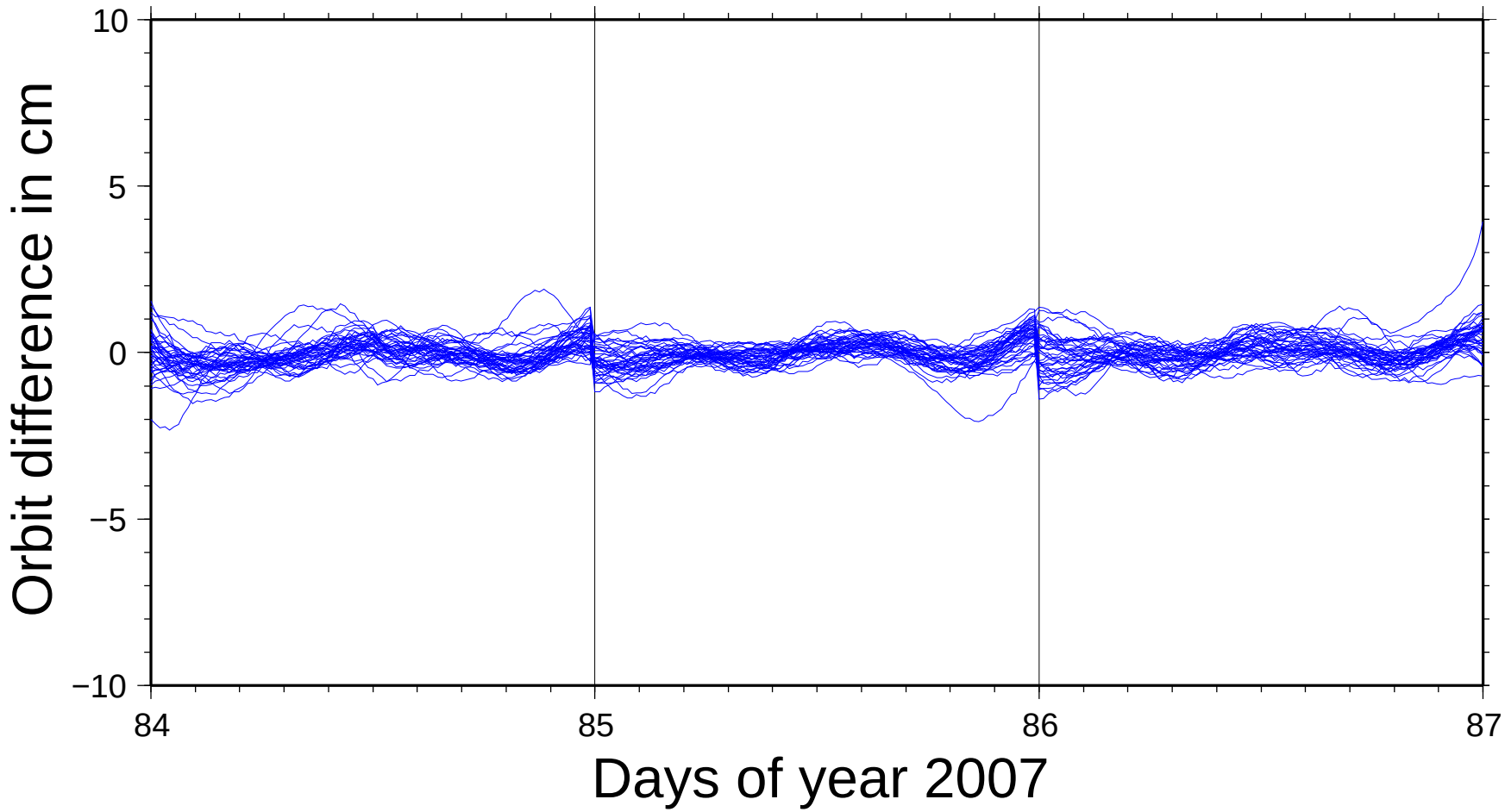
X-pole estimated from daily GNSS solutions

estimates relative to bulletin A pole



Orbit Comparison, Earth fixed system

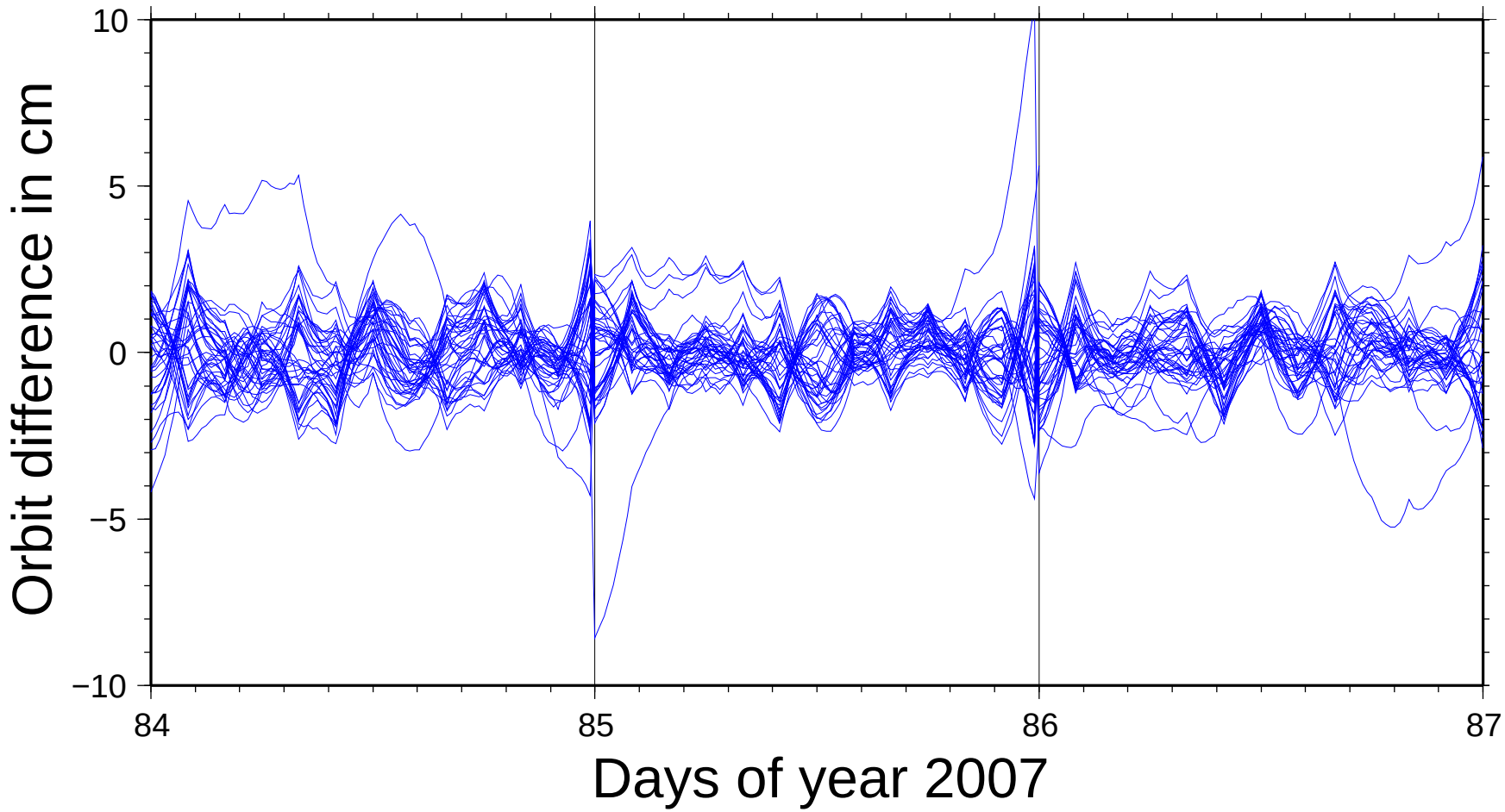
Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the Earth fixed system



transformed to radial component

Orbit Comparison, Earth fixed system

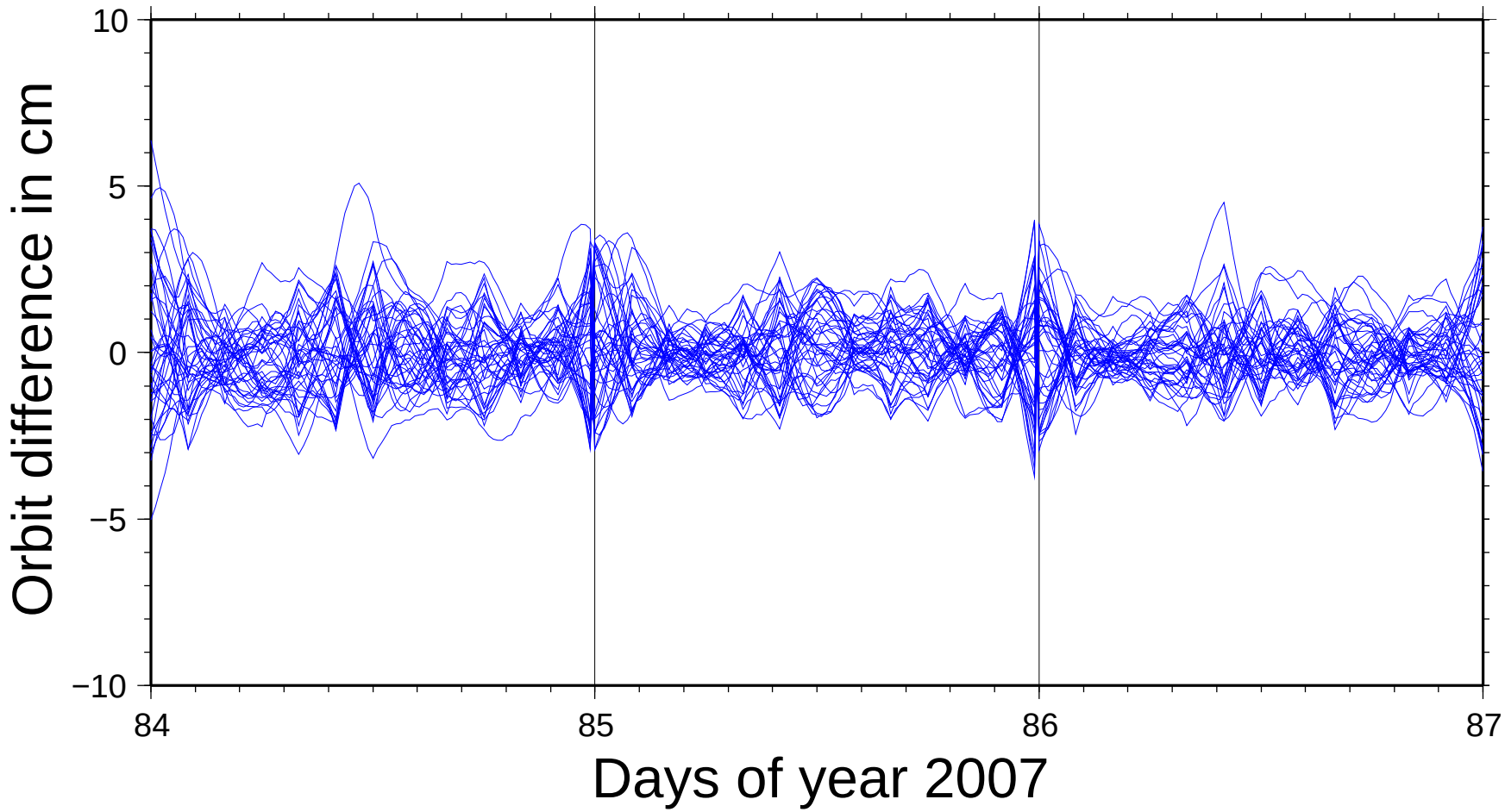
Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the Earth fixed system



transformed to along track component

Orbit Comparison, Earth fixed system

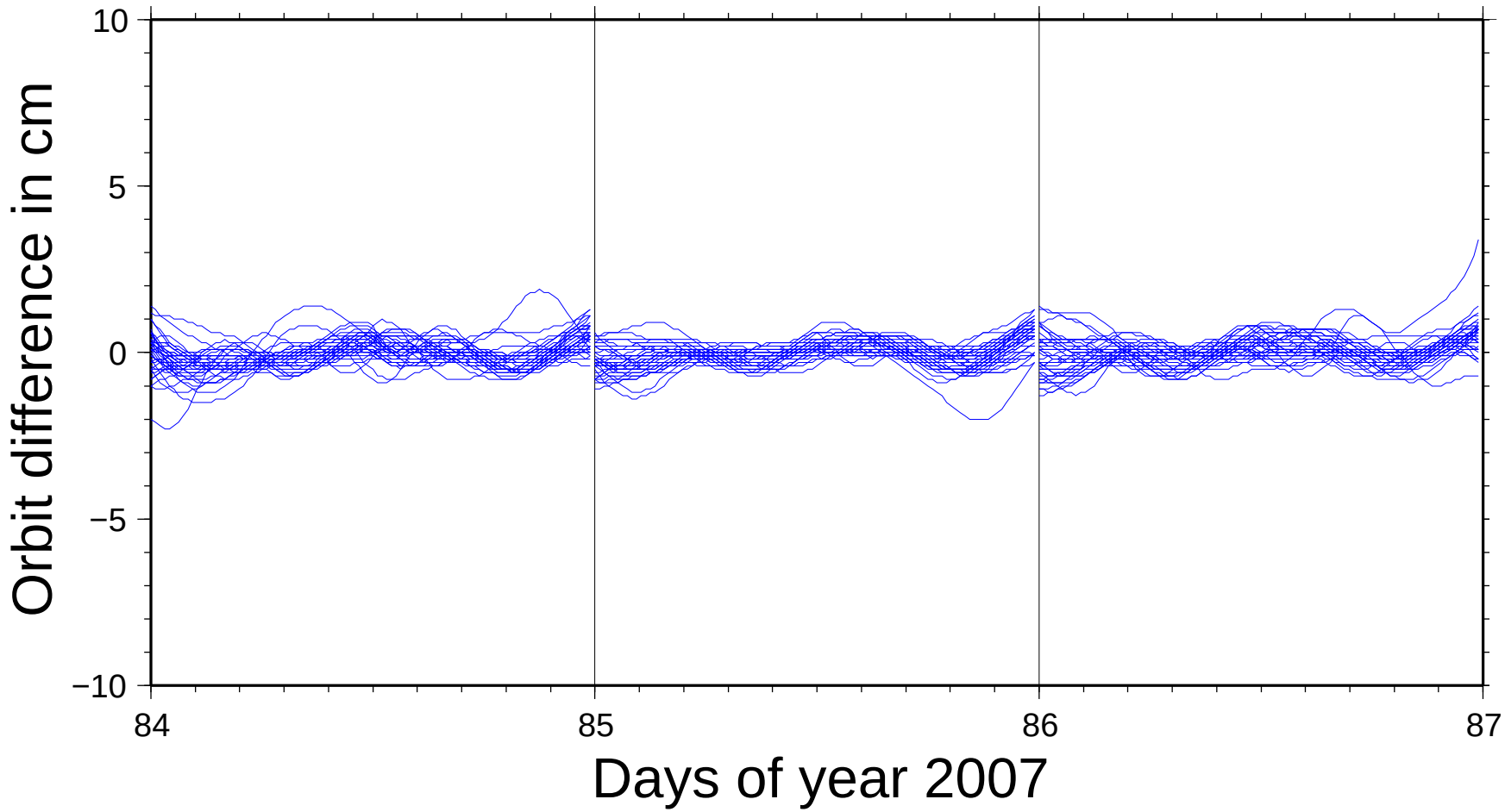
Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the Earth fixed system



transformed to out of plane component

Orbit Comparison, Celestial system

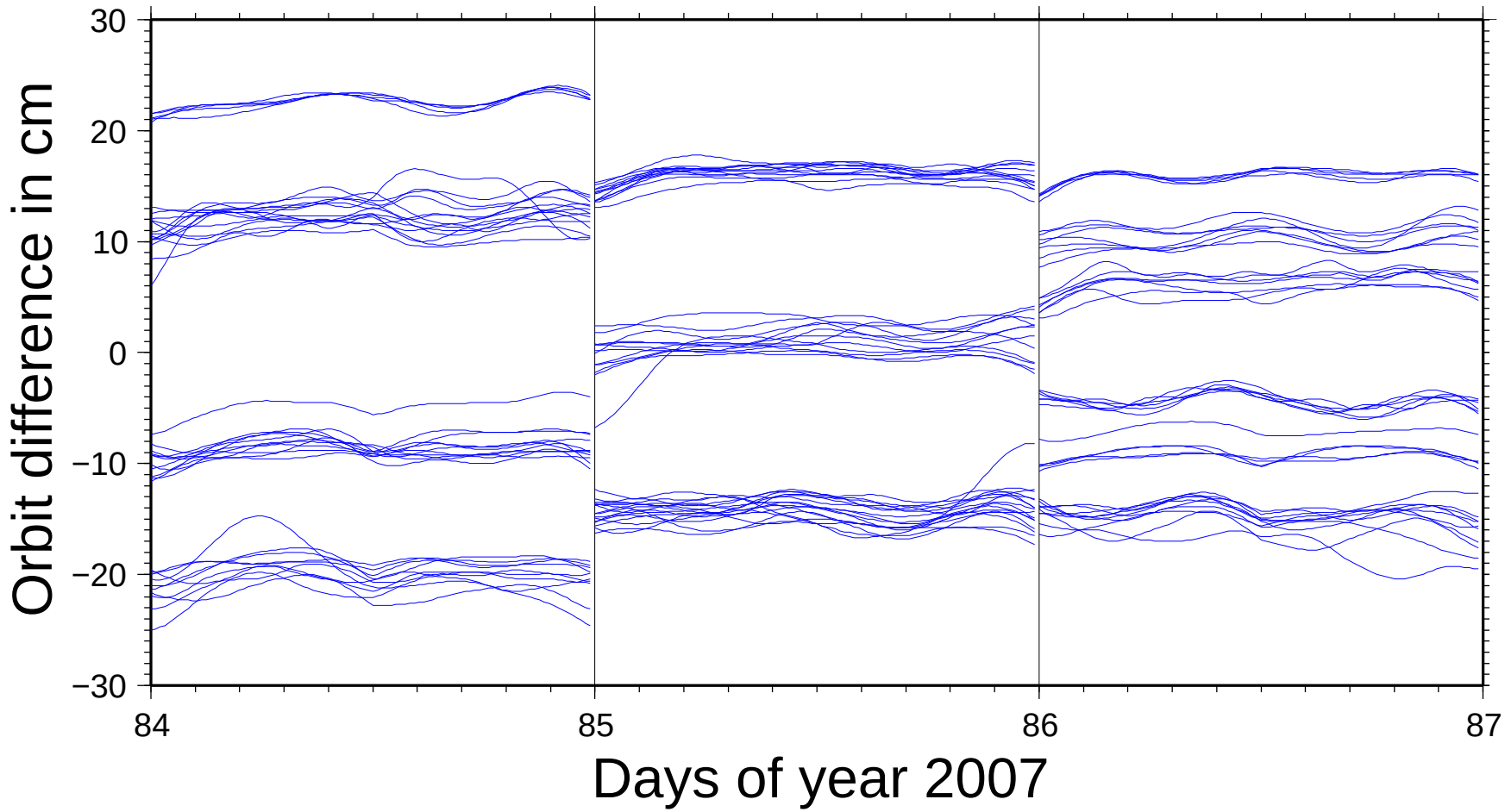
Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the celestial system



radial component

Orbit Comparison, Celestial system

Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the celestial system

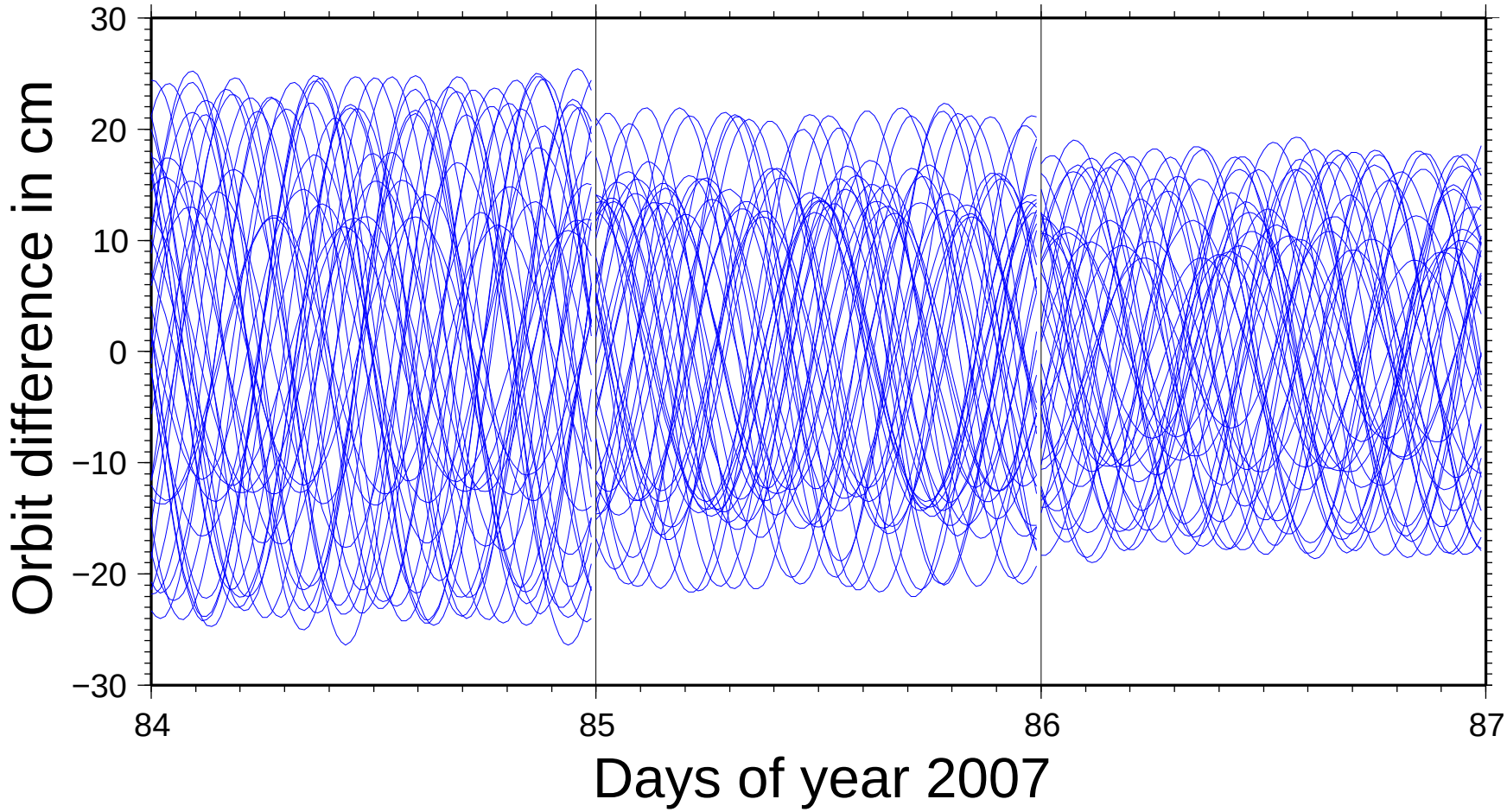


along track component

Please note, different scale!

Orbit Comparison, Celestial system

Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the celestial system

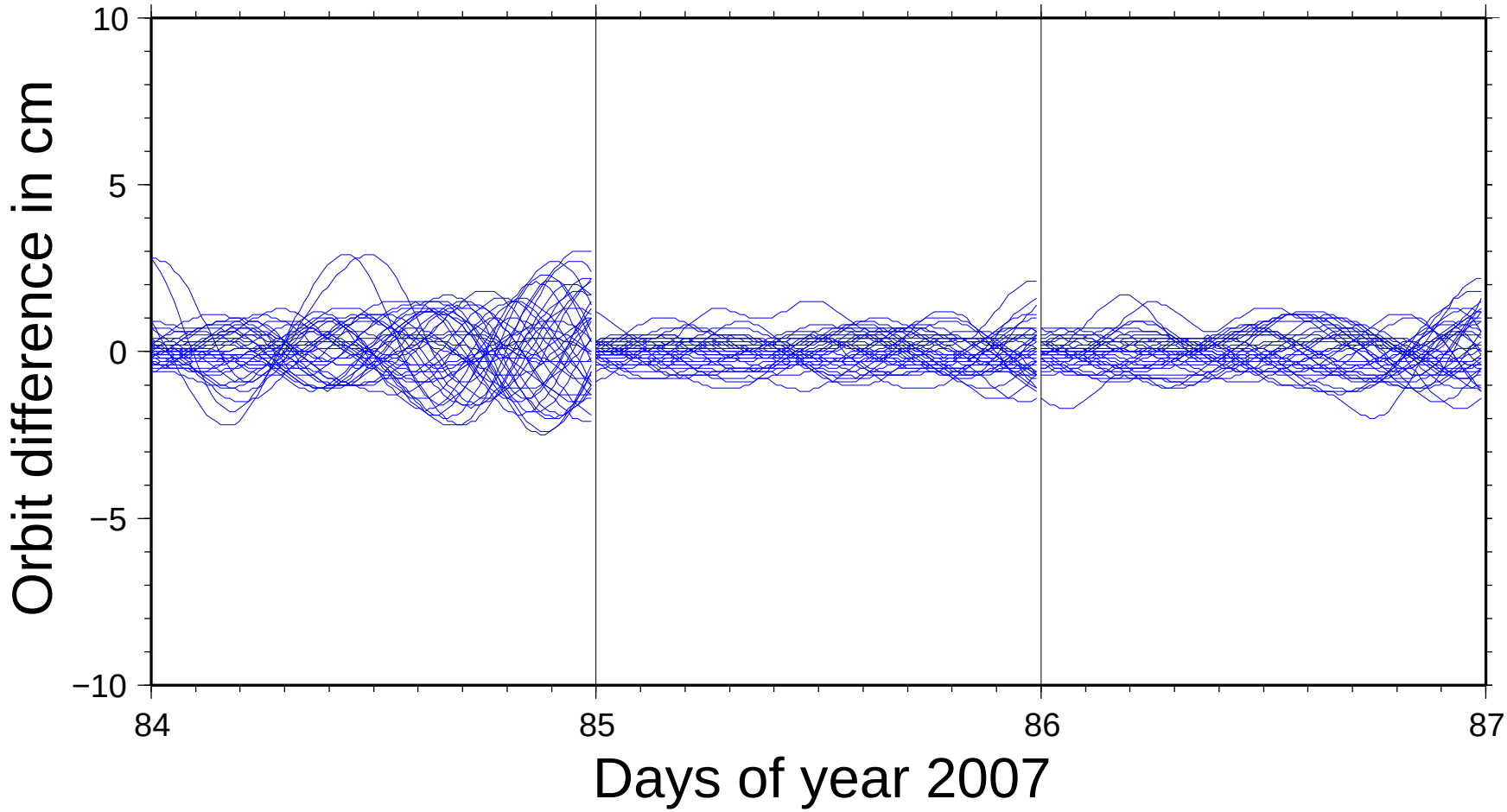


out of plane component

Please note, different scale!

Orbit Comparison, Celestial system

Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the celestial system

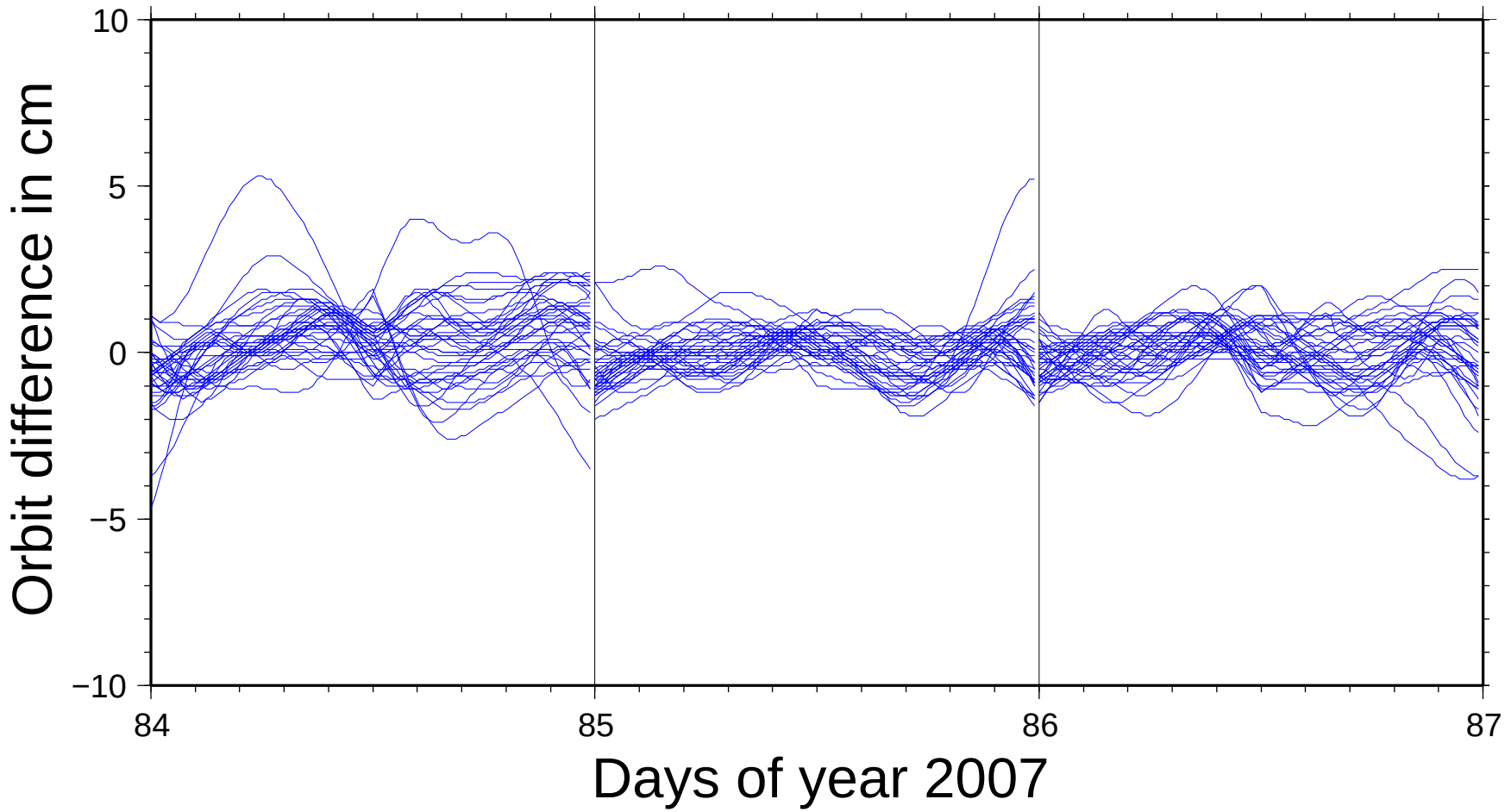


out of plane component

node fixed to solution with 24–hour ERPs

Orbit Comparison, Celestial system

Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the celestial system

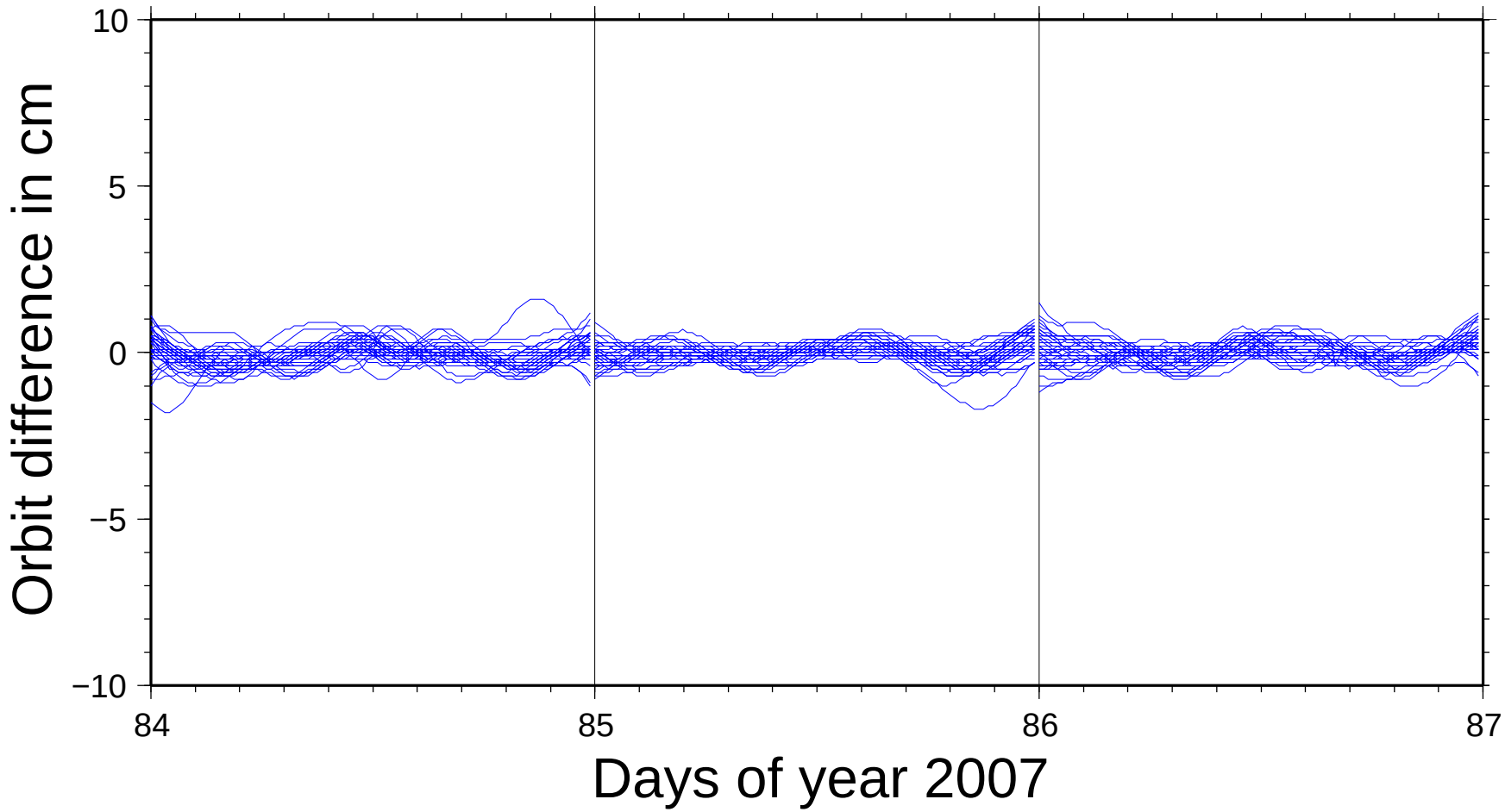


along track component

node fixed to solution with 24–hour ERPs

Orbit Comparison, Celestial system

Comparison between the orbits obtained with
24 resp. 2 hourly resolution for ERPs in the celestial system



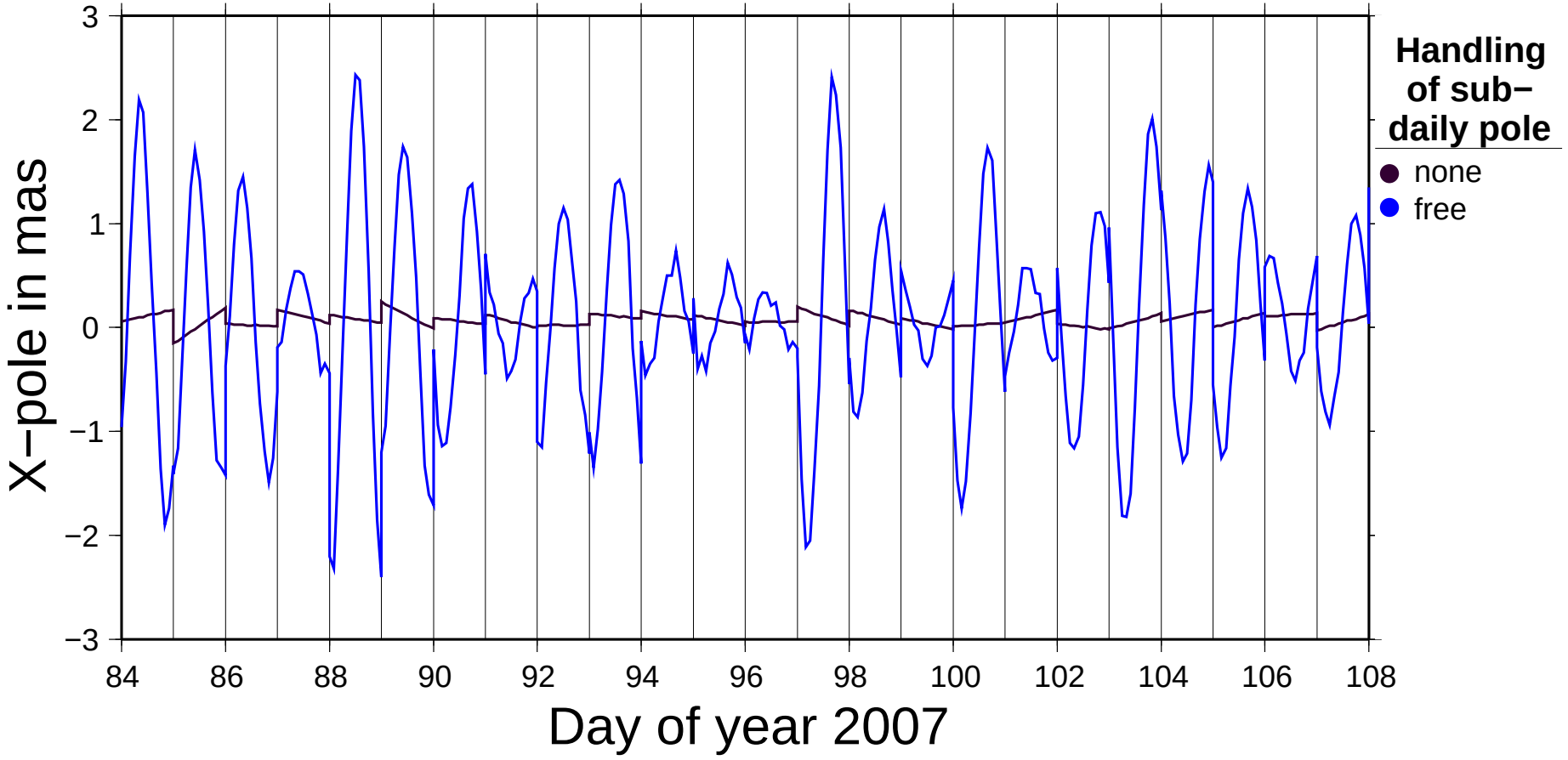
radial component

node fixed to solution with 24–hour ERPs

Sub–daily ERP Estimation

X-pole estimated from daily GNSS solutions

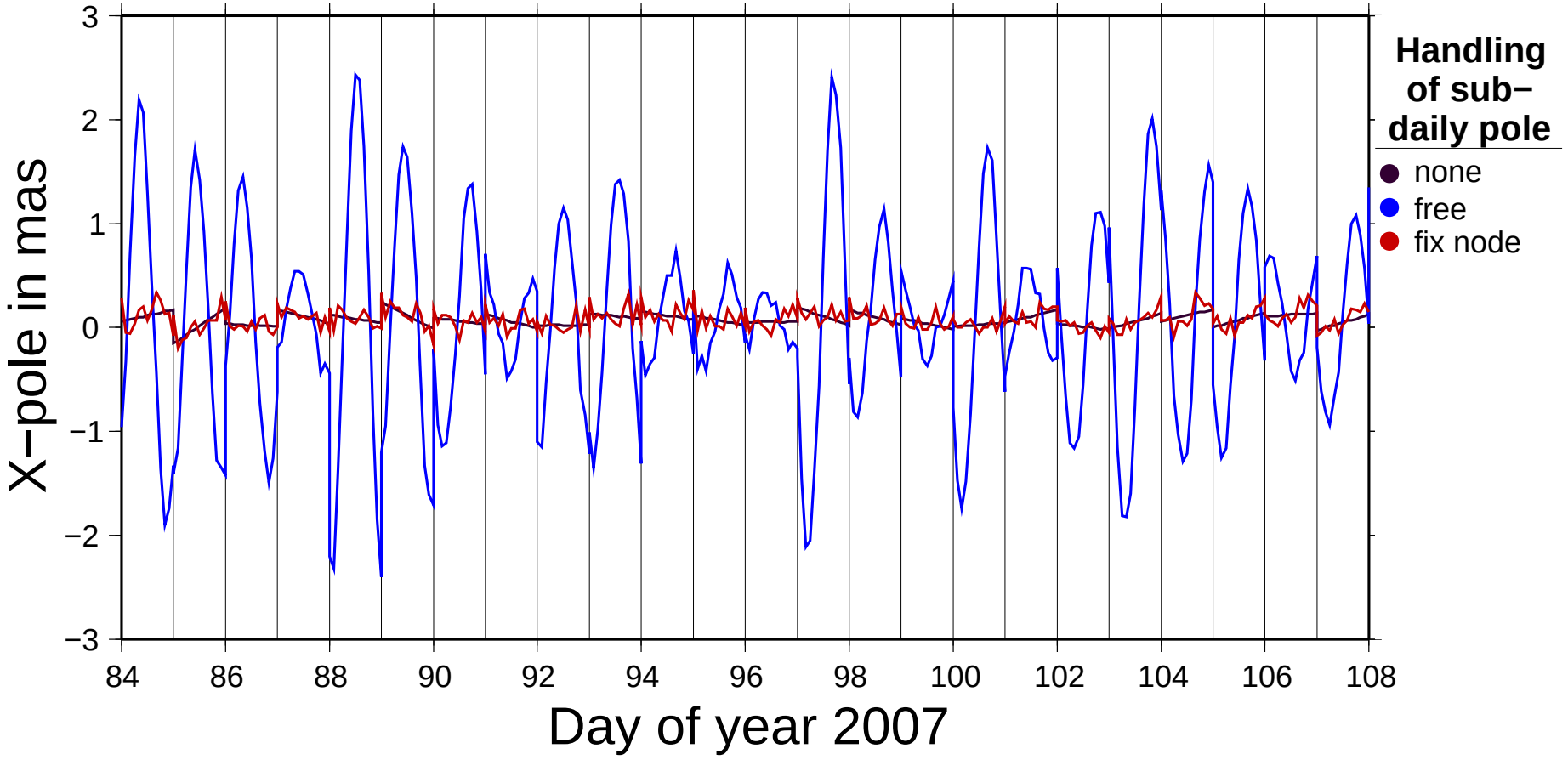
estimates relative to bulletin A pole



Sub–daily ERP Estimation

X-pole estimated from daily GNSS solutions

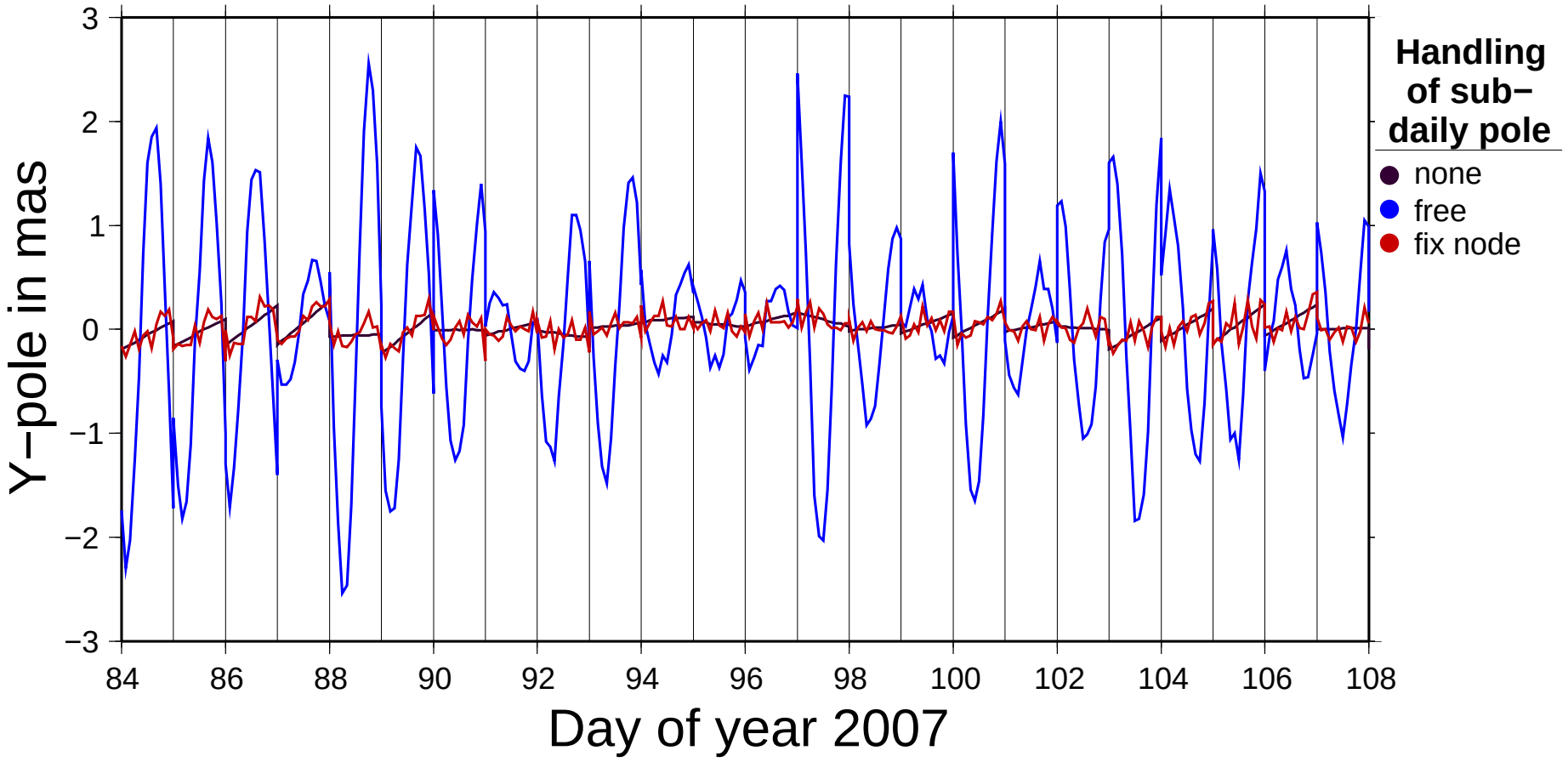
estimates relative to bulletin A pole



Sub–daily ERP Estimation

Y-pole estimated from daily GNSS solutions

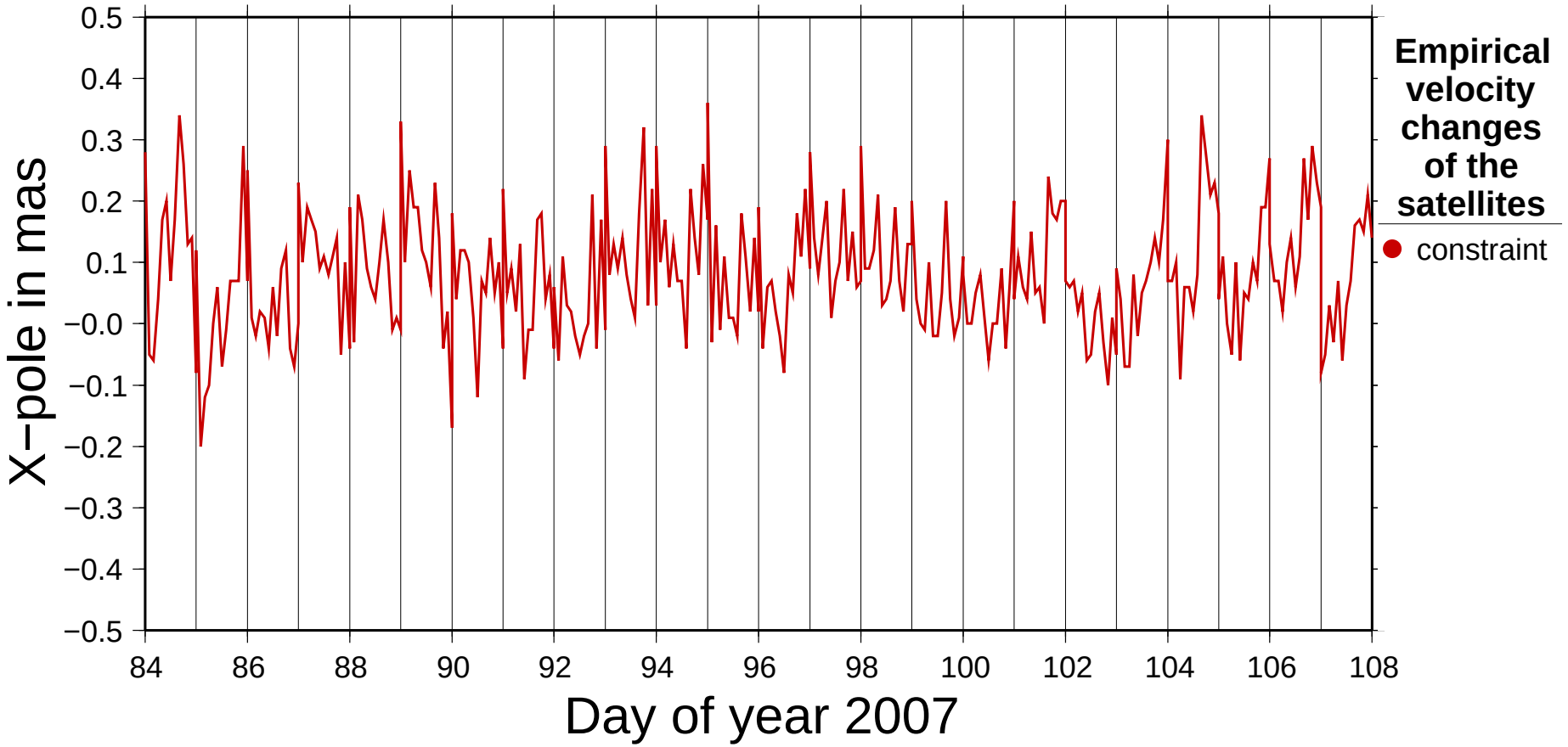
estimates relative to bulletin A pole



Sub–daily ERP Estimation

X-pole estimated from daily GNSS solutions

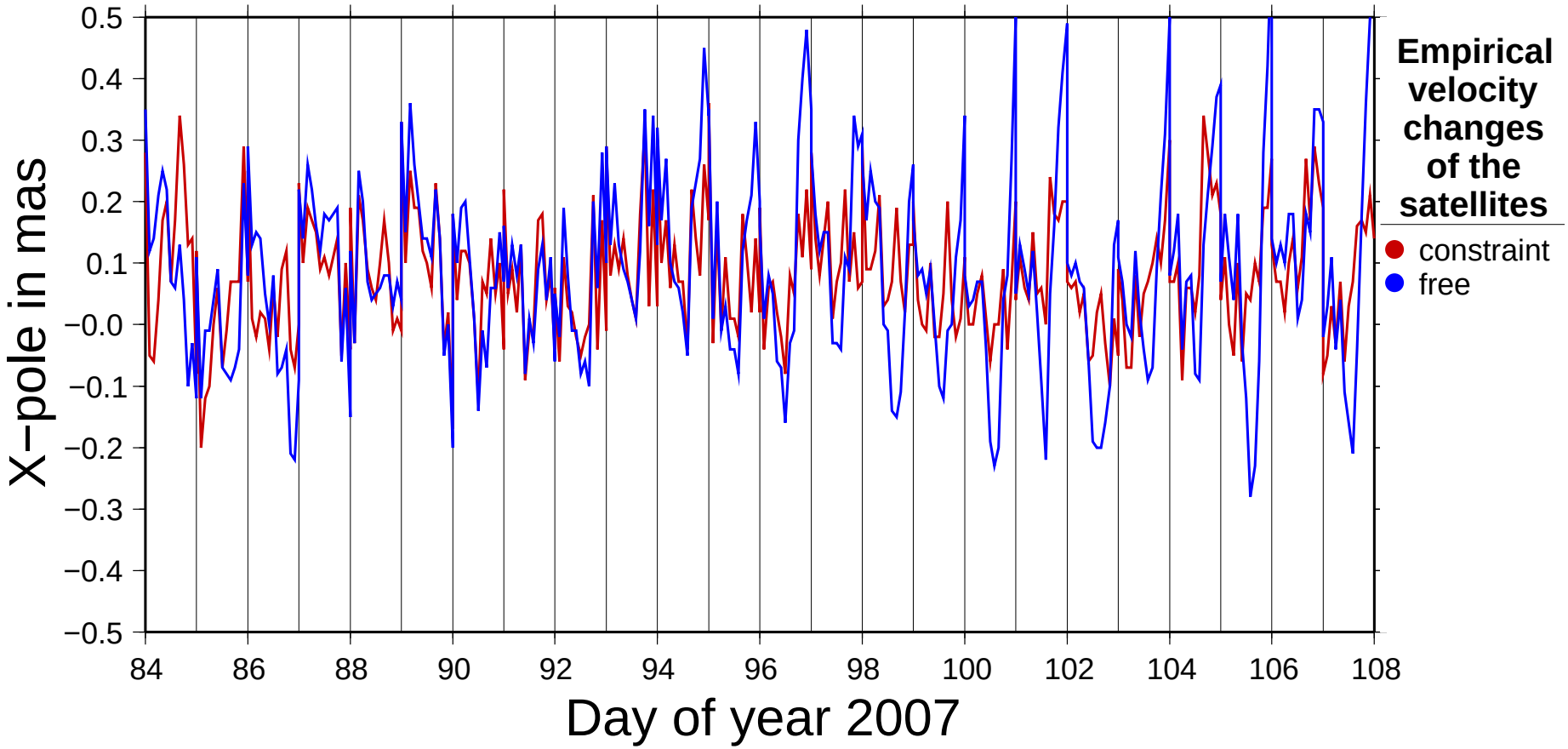
estimates relative to bulletin A pole



Sub–daily ERP Estimation

X-pole estimated from daily GNSS solutions

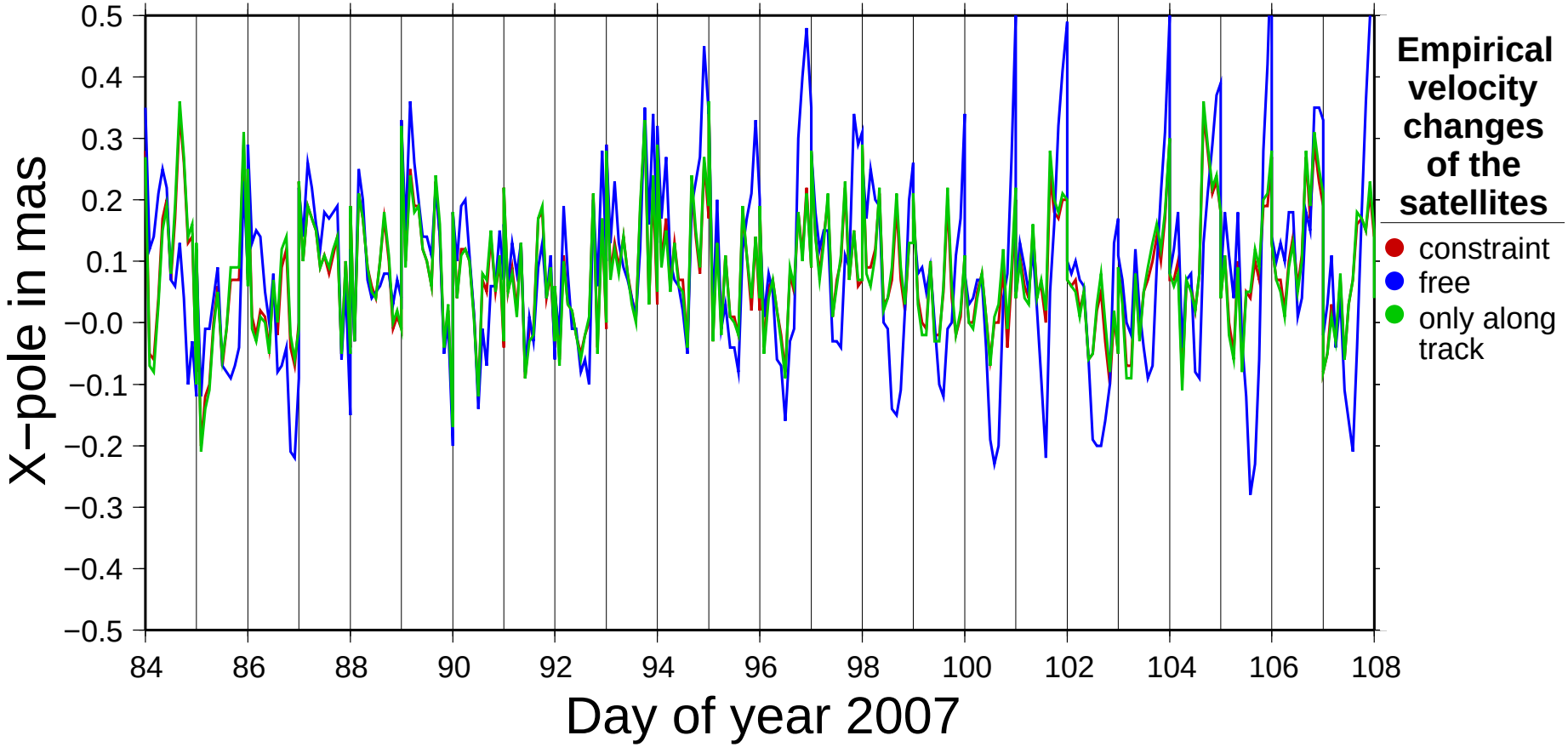
estimates relative to bulletin A pole



Sub–daily ERP Estimation

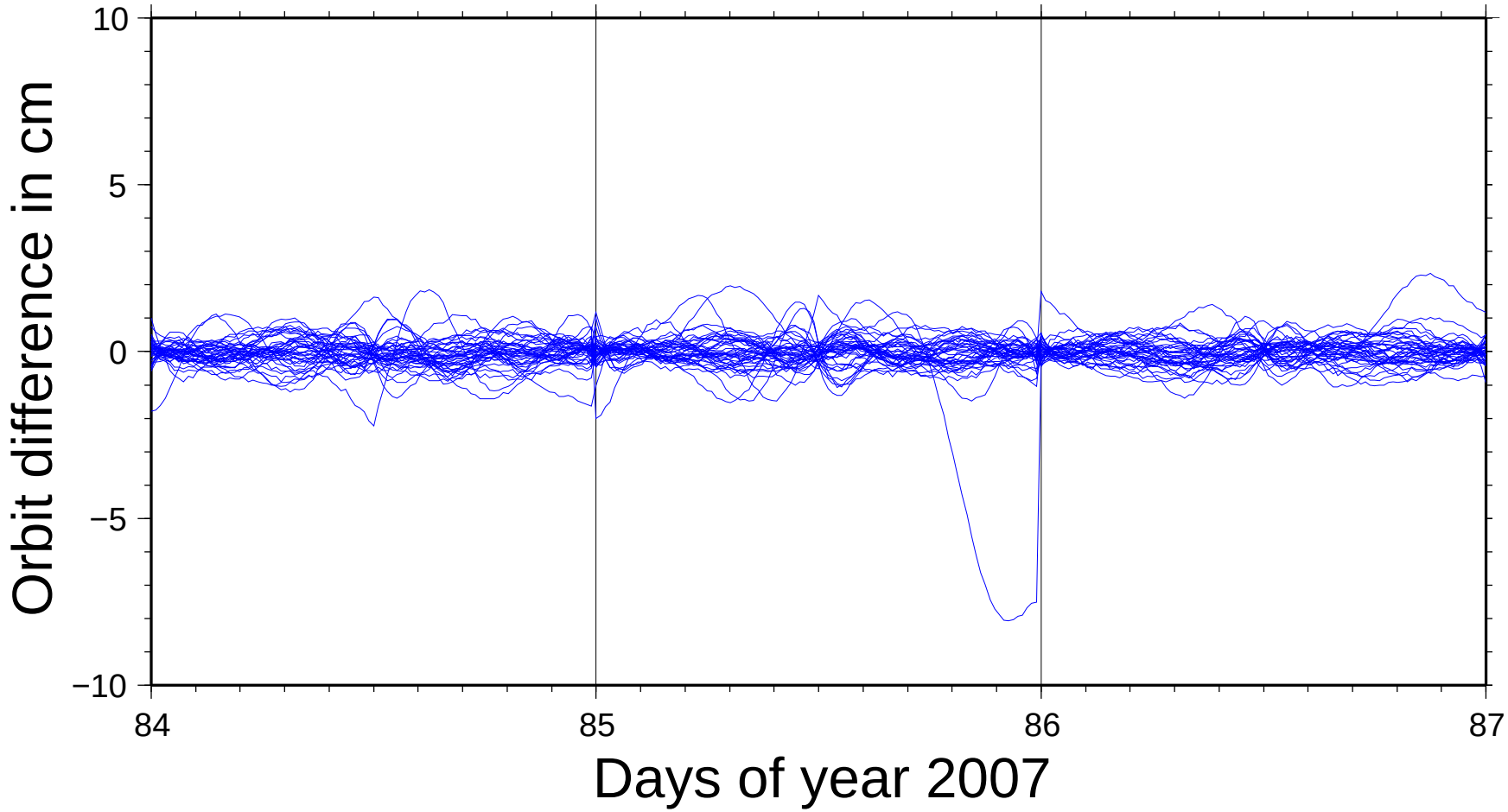
X-pole estimated from daily GNSS solutions

estimates relative to bulletin A pole



Orbit Comparison, Earth fixed system

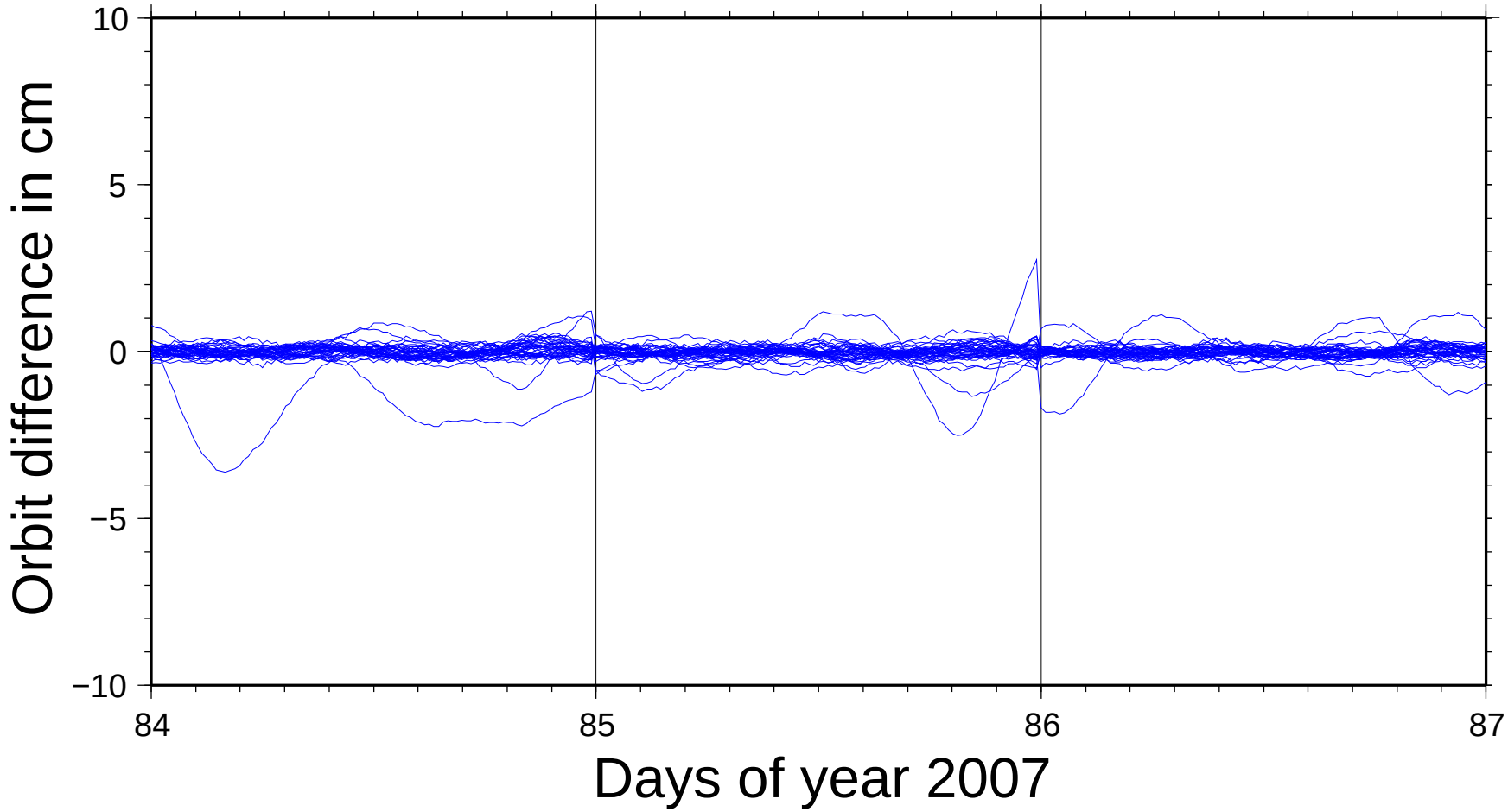
Comparison between the orbits obtained with empirical vel. changes constrained for all components resp. for only along track component, but free



transformed to along track component

Orbit Comparison, Earth fixed system

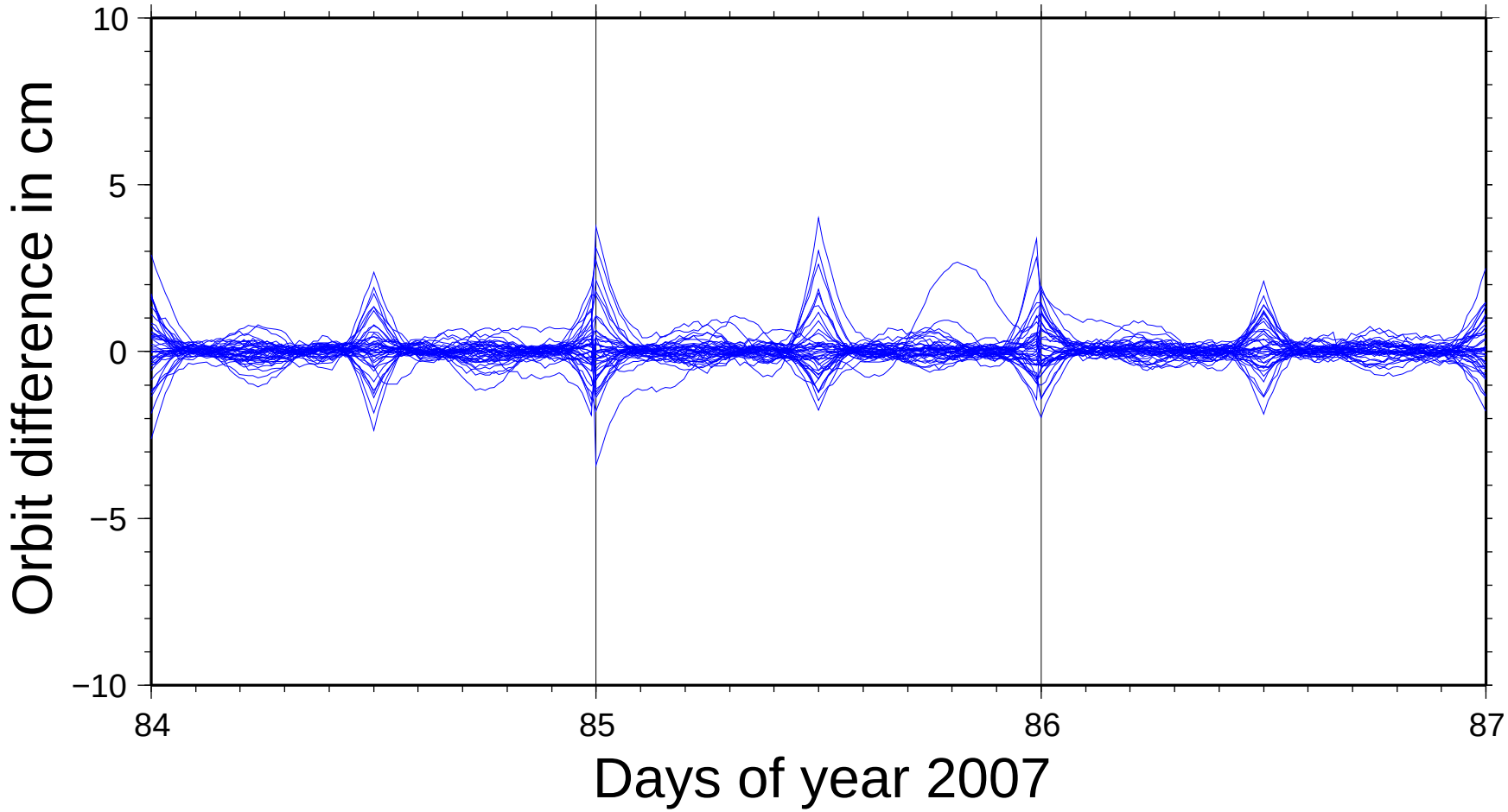
Comparison between the orbits obtained with empirical vel. changes constrained for all components resp. for only along track component, but free



transformed to out of plane component

Orbit Comparison, Earth fixed system

Comparison between the orbits obtained with empirical vel. changes constrained for all components resp. for only along track component, but free

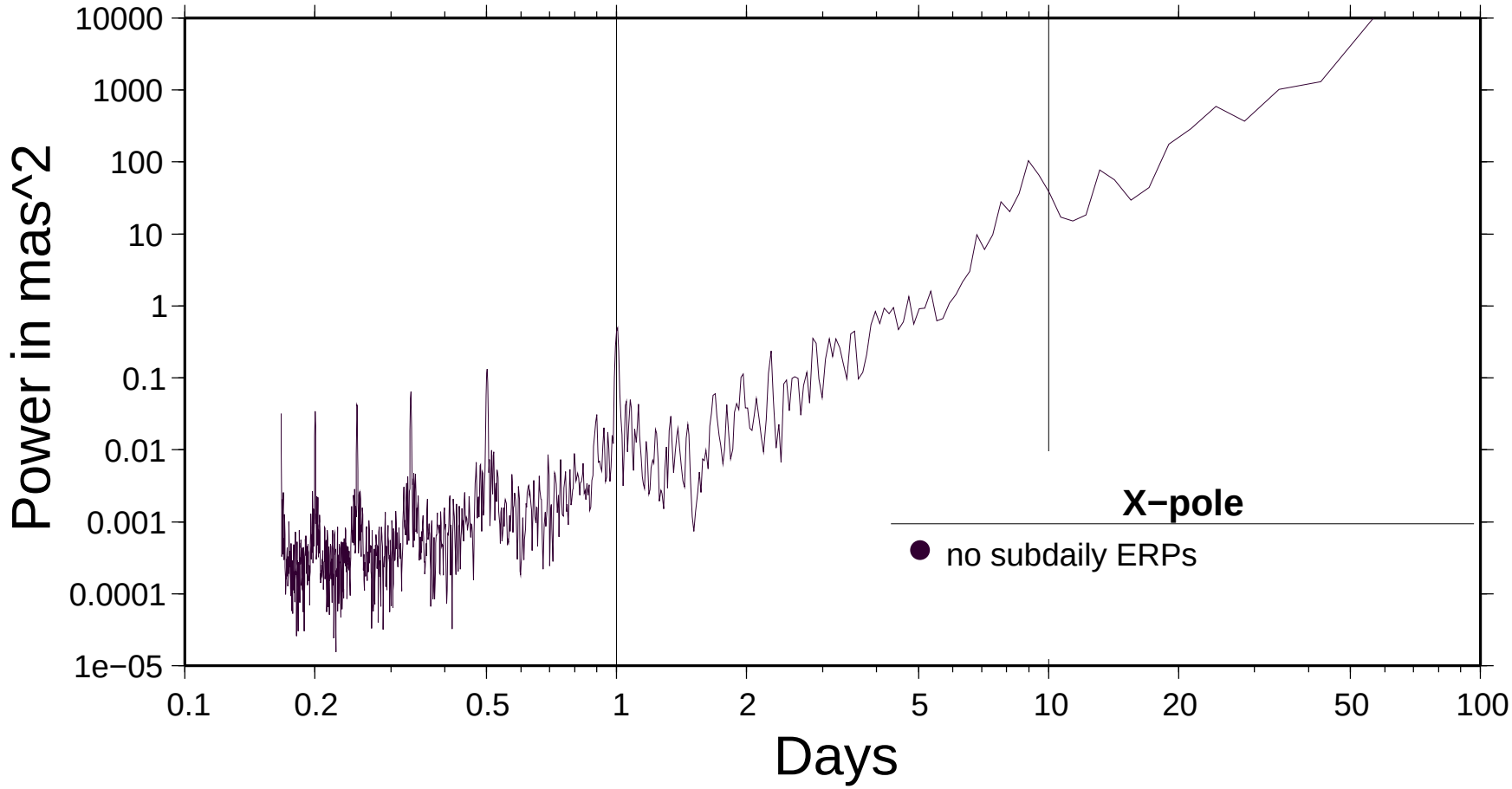


transformed to radial component

Comparison of ERP Time Series

Comparison between the power spectra from different sub–daily ERP series

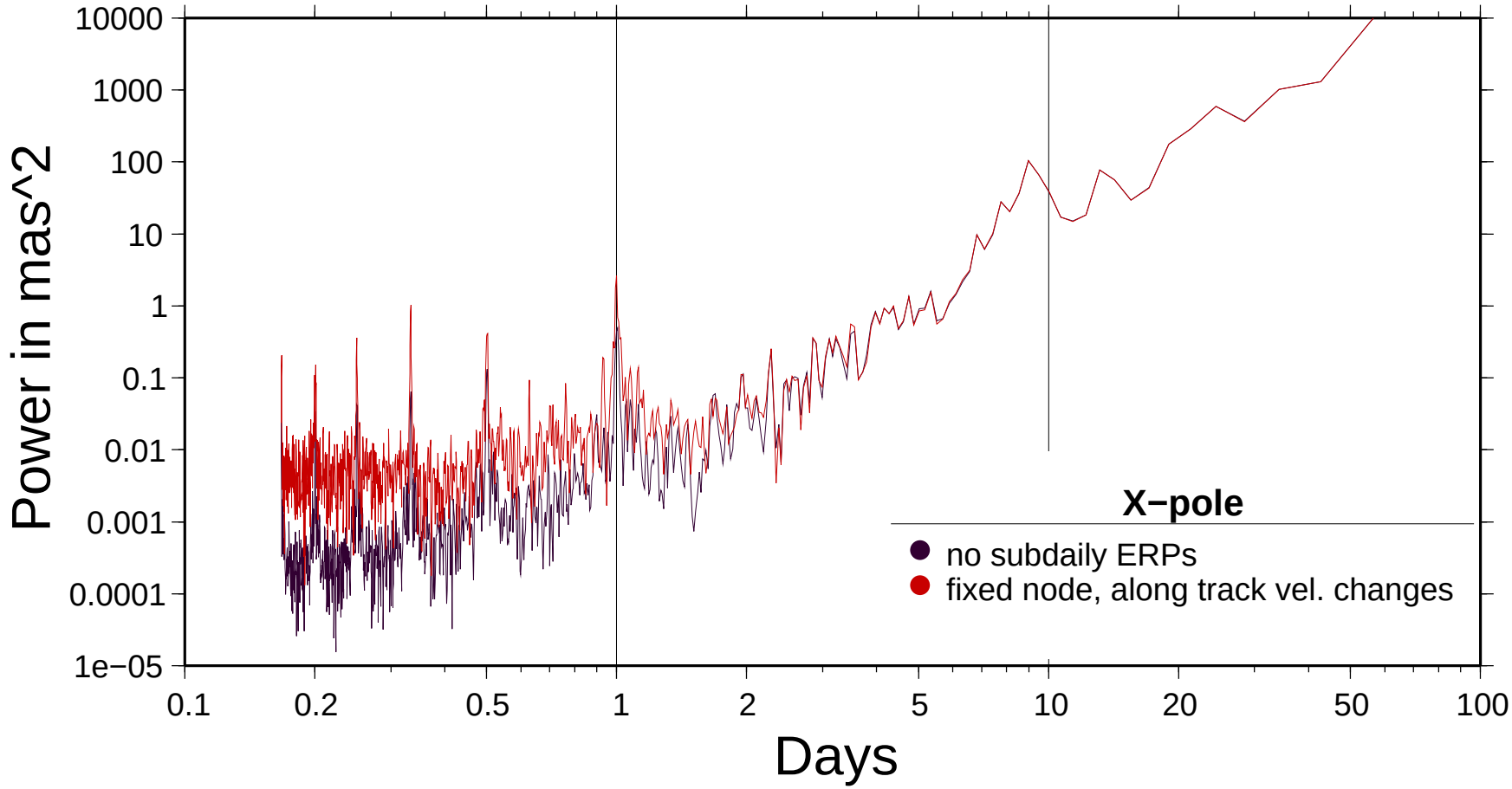
(200 days in 2007)



Comparison of ERP Time Series

Comparison between the power spectra from different sub–daily ERP series

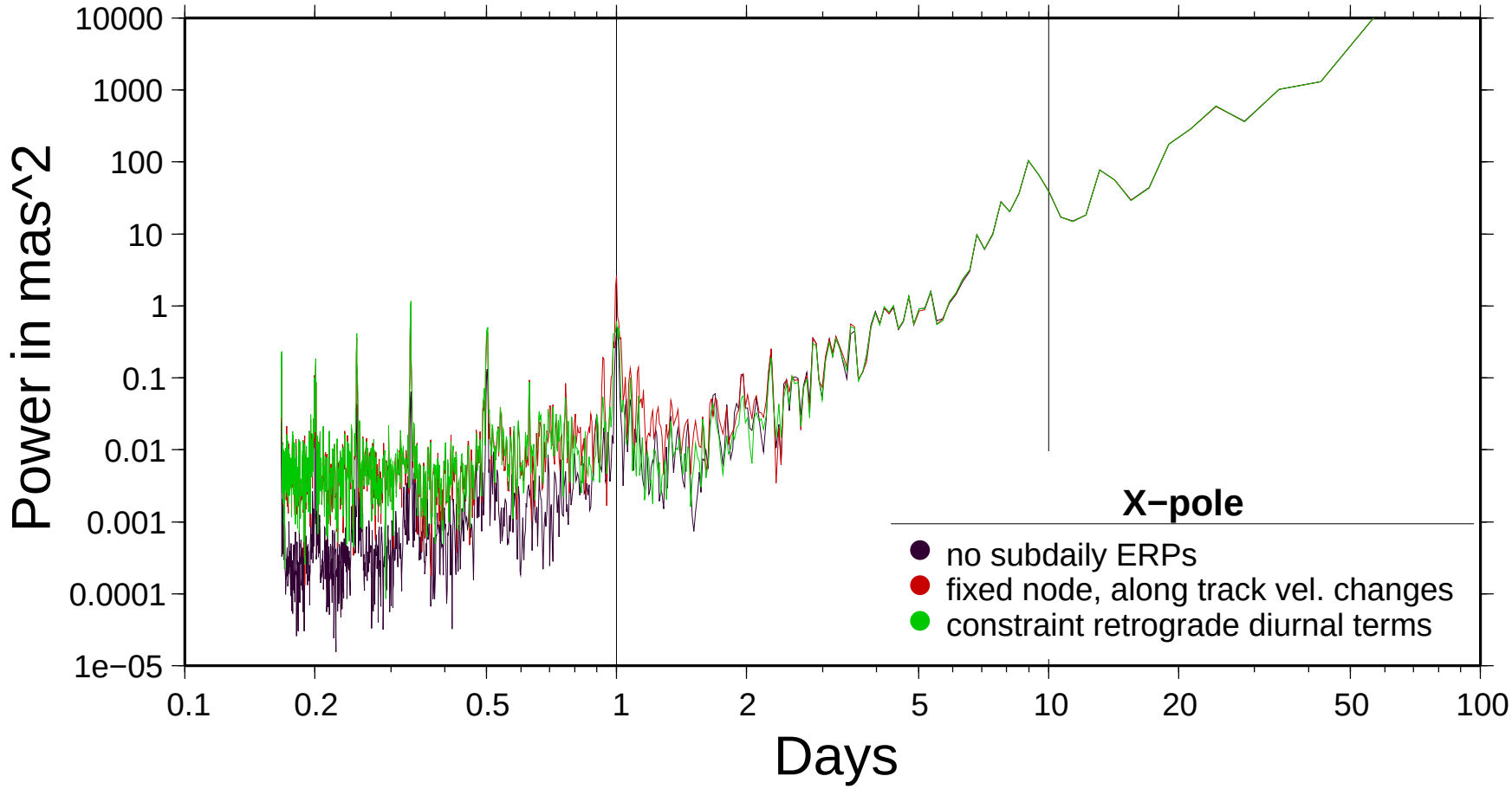
(200 days in 2007)



Comparison of ERP Time Series

Comparison between the power spectra from different sub–daily ERP series

(200 days in 2007)



Summary and Outlook

Estimating sub–daily Earth rotation parameters from GNSS data:

- Alternatively to constraining the retrograde terms the solution for the ascending node orbit parameter can be introduced from a solution with daily resolution for the ERPs.
- The selection and constraining of the GNSS orbit parameters is relevant to the obtained sub–daily ERP time series.

Summary and Outlook

Estimating sub–daily Earth rotation parameters from GNSS data:

- Alternatively to constraining the retrograde terms the solution for the ascending node orbit parameter can be introduced from a solution with daily resolution for the ERPs.
- The selection and constraining of the GNSS orbit parameters is relevant to the obtained sub–daily ERP time series.

It would be desirable that the IGS AC start to consider sub–daily resolution for ERPs.