Global Multi–GNSS Processing at CODE

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Outline

Global Multi–GNSS Processing at CODE:

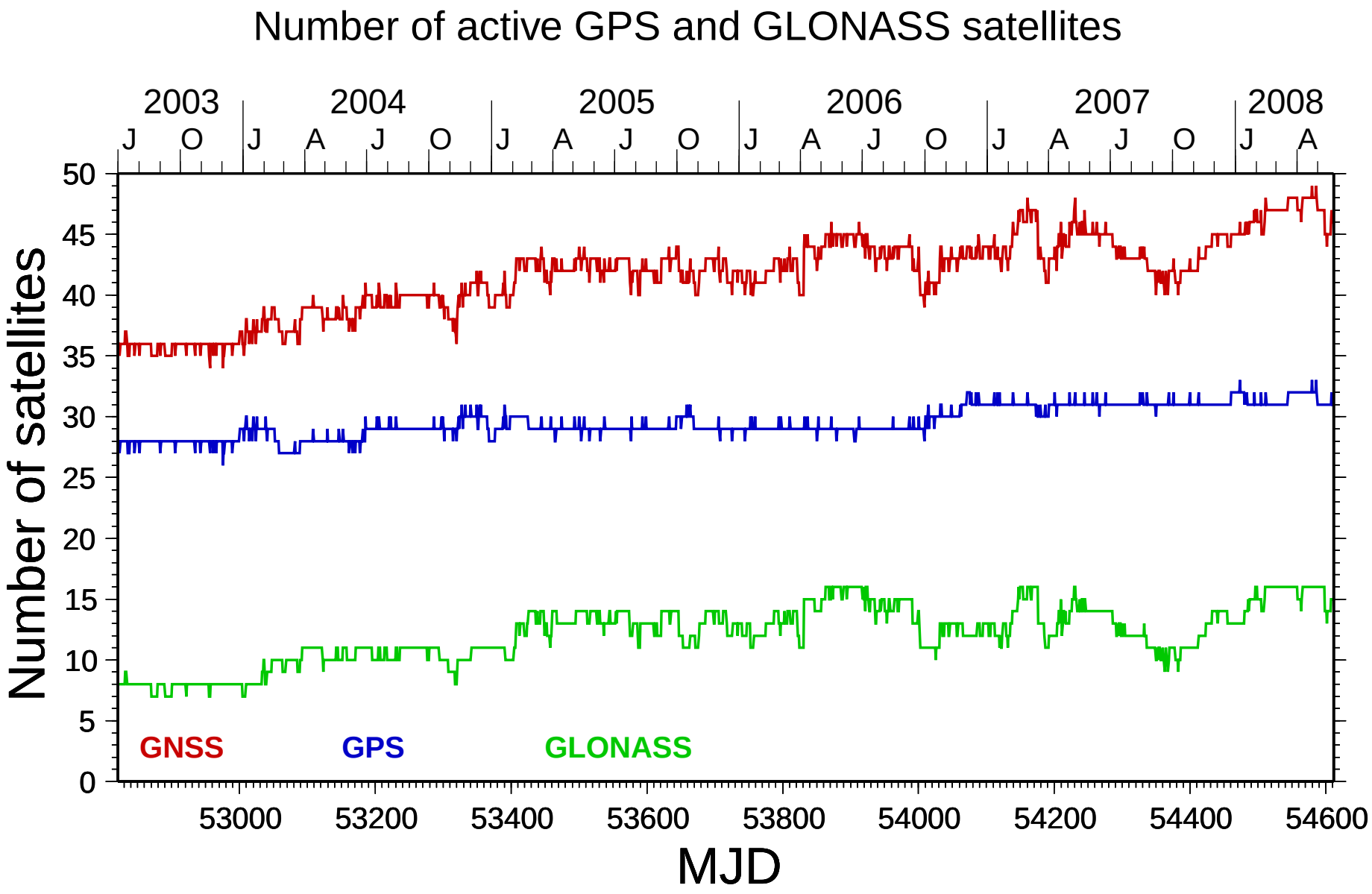
1. Development of GLONASS within the last five years

2. Orbit characteristics for the individual GNSS

3. Impact of adding GLONASS to GPS measurements
   - for navigation purposes
   - on global parameters

4. Summary and Outlook

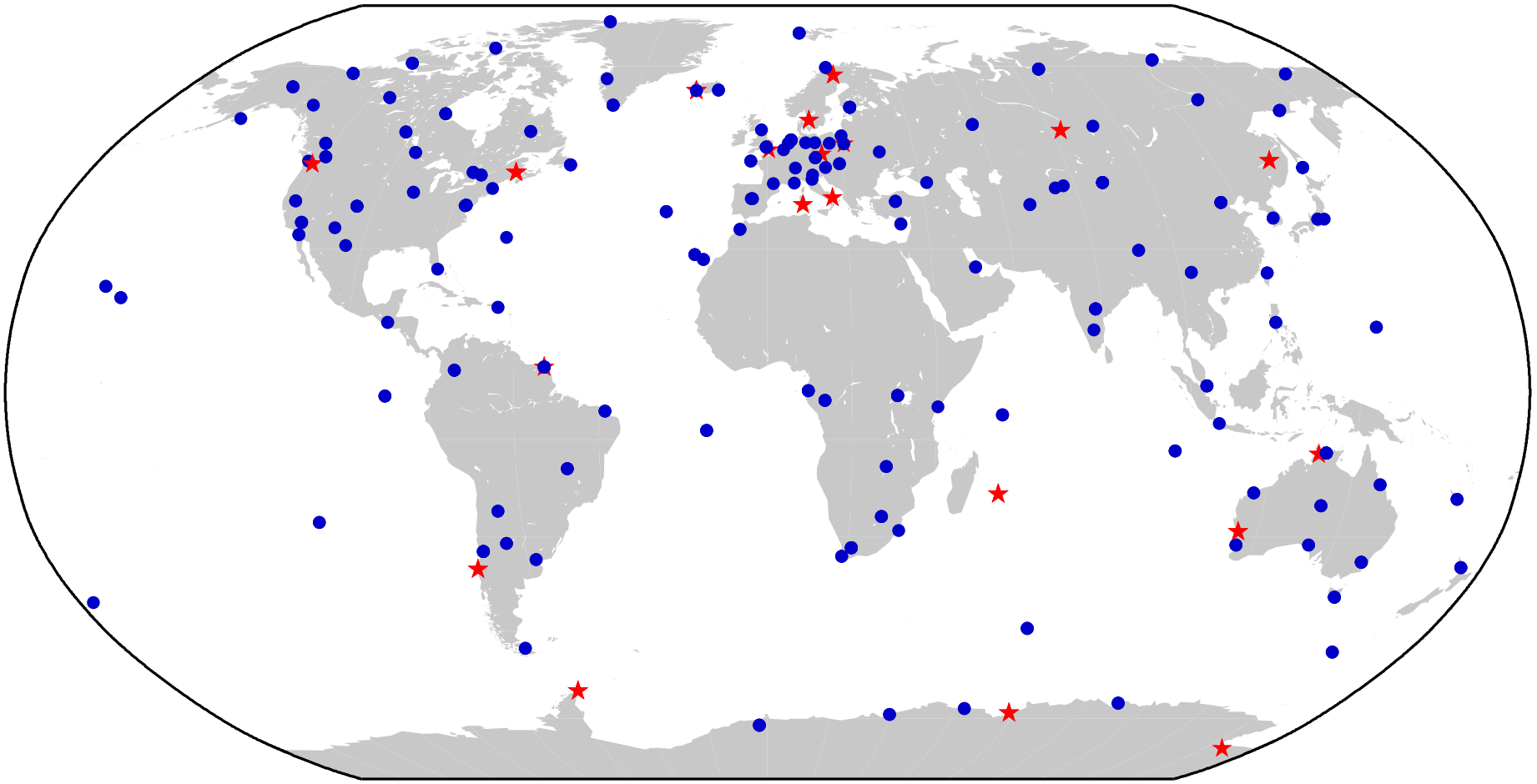
GPS/GLONASS Orbit Comparison



Development of the IGS multi–GNSS network

Distribution of the combined GPS/GLONASS receivers in the IGS–network

status: July 2003 (day of year 2003:182)

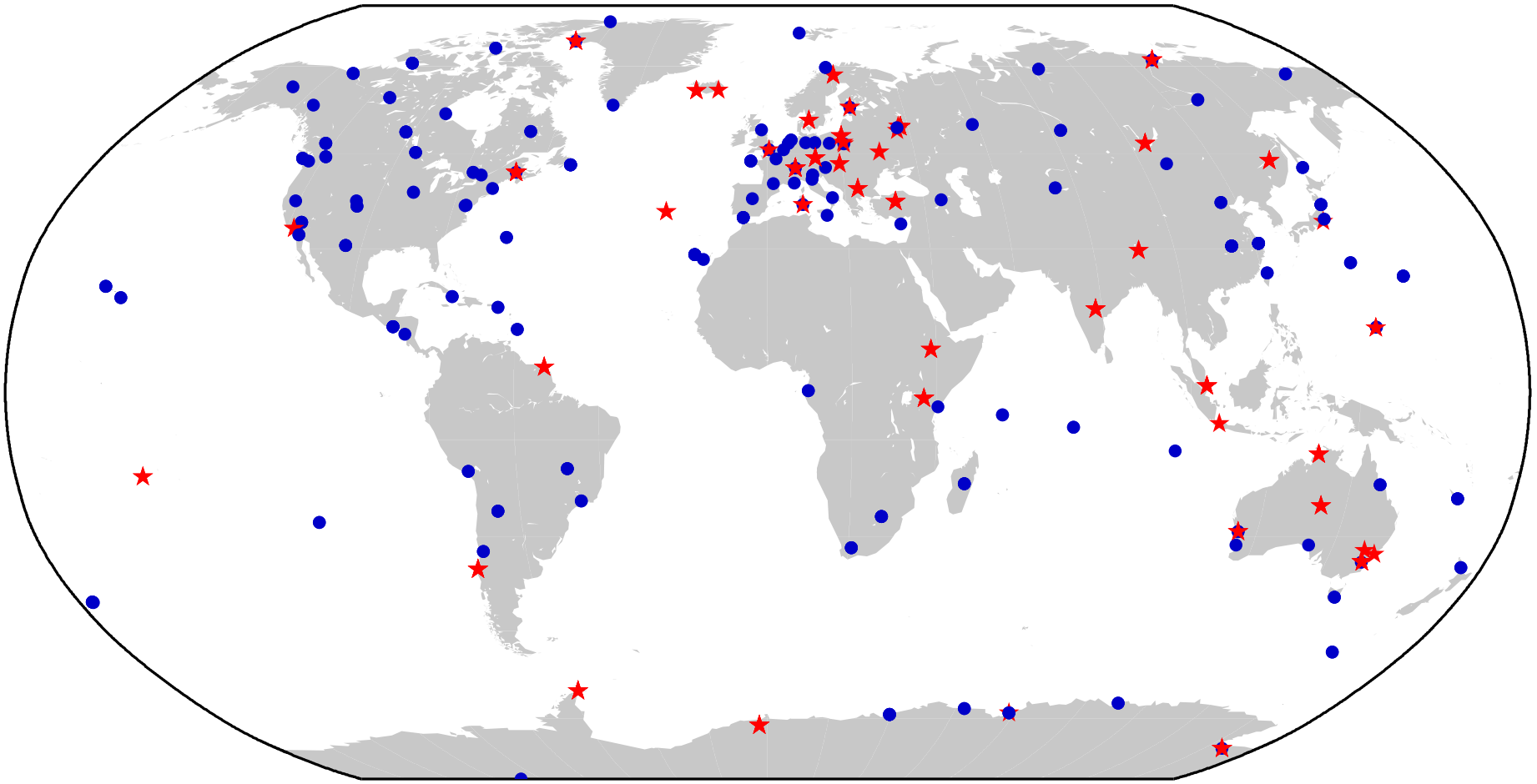


Receivers tracking: ★ GPS/GLONASS (21) ● only GPS (137)

Development of the IGS multi–GNSS network

Distribution of the combined GPS/GLONASS receivers in the IGS–network

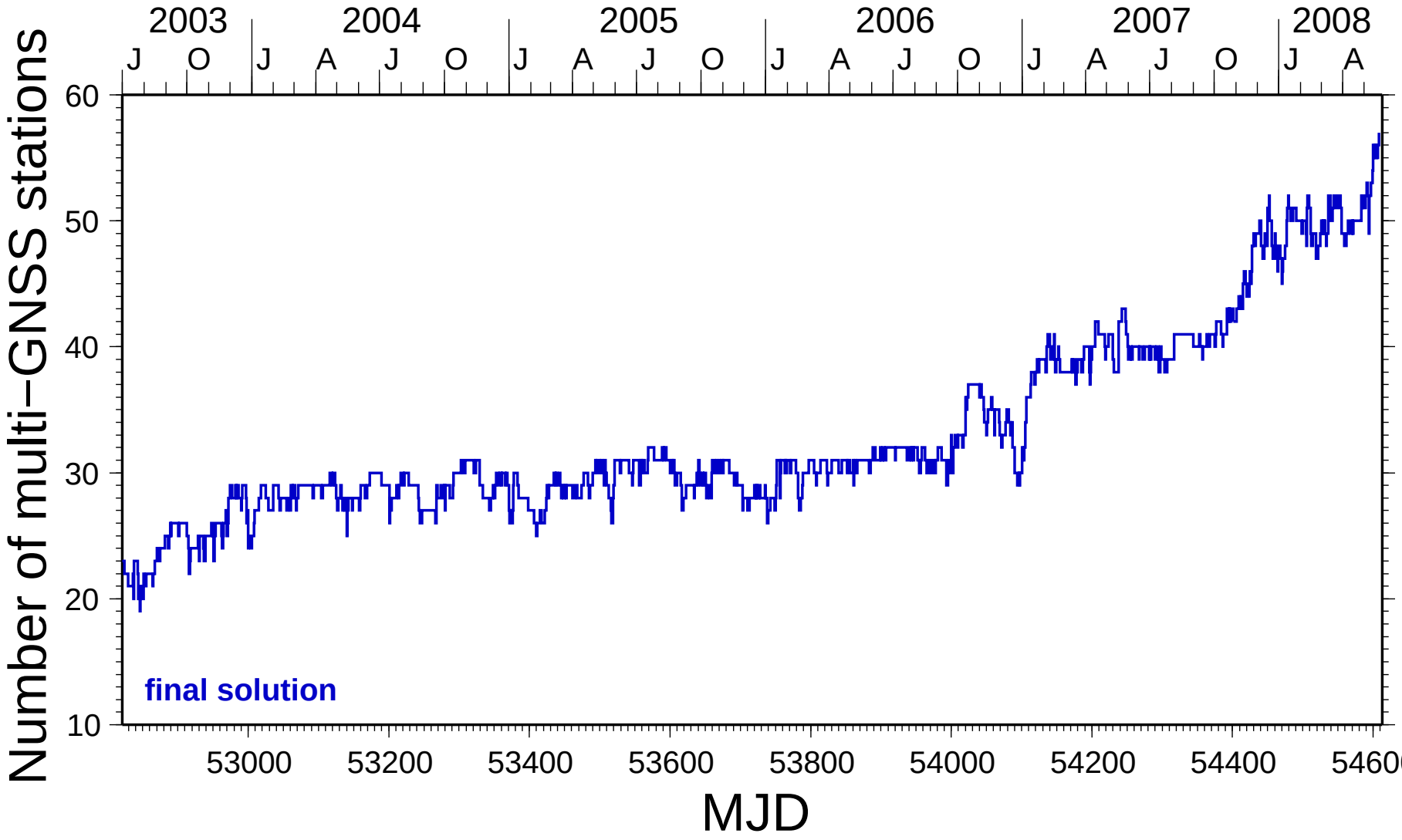
status: May 2008 (day of year 2008:140)



Receivers tracking: ★ GPS/GLONASS (53) ● only GPS (120)

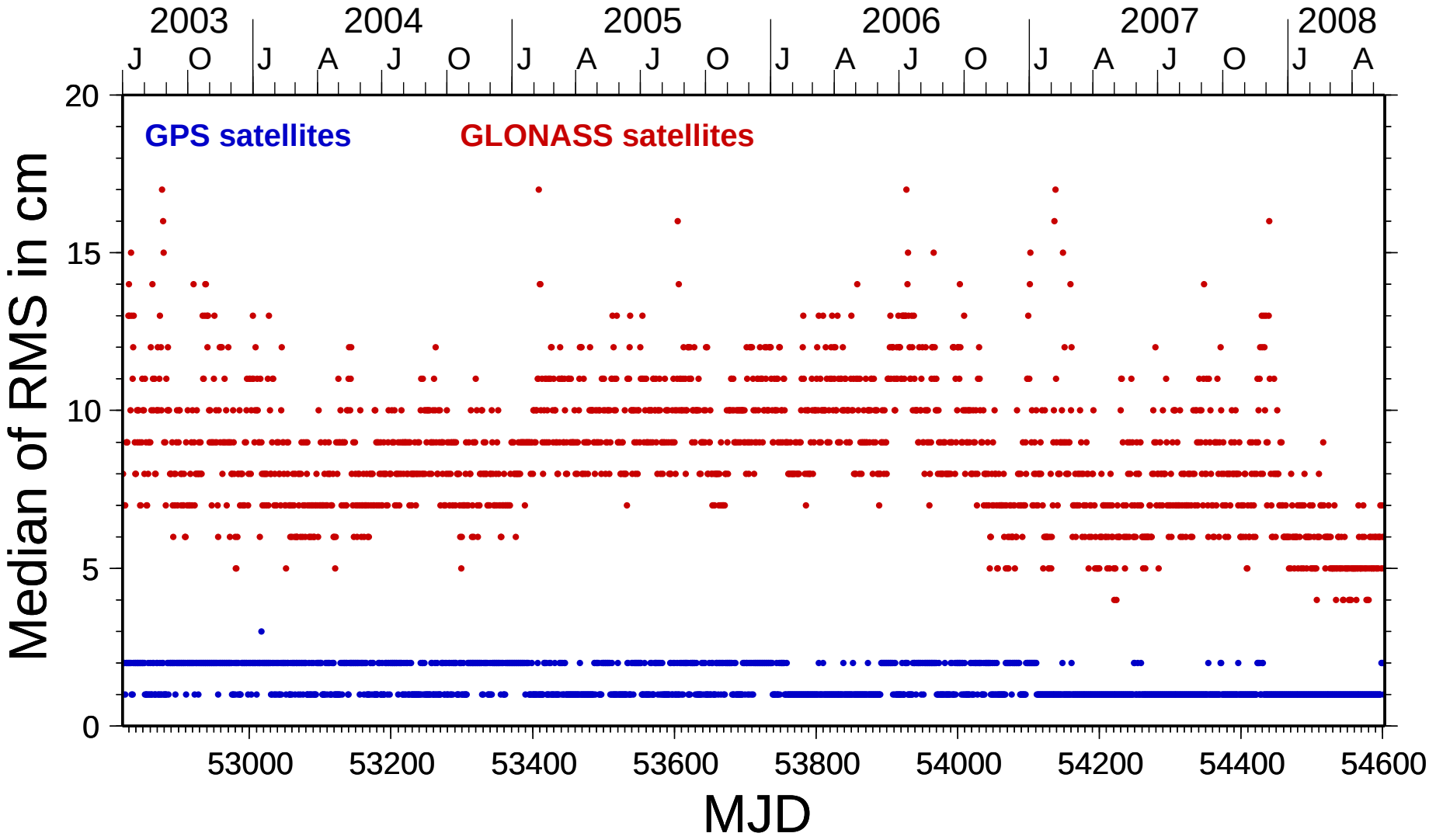
Development of the IGS multi–GNSS network

Number of the combined GPS/GLONASS receivers in the IGS–network



GPS/GLONASS Orbit Comparison

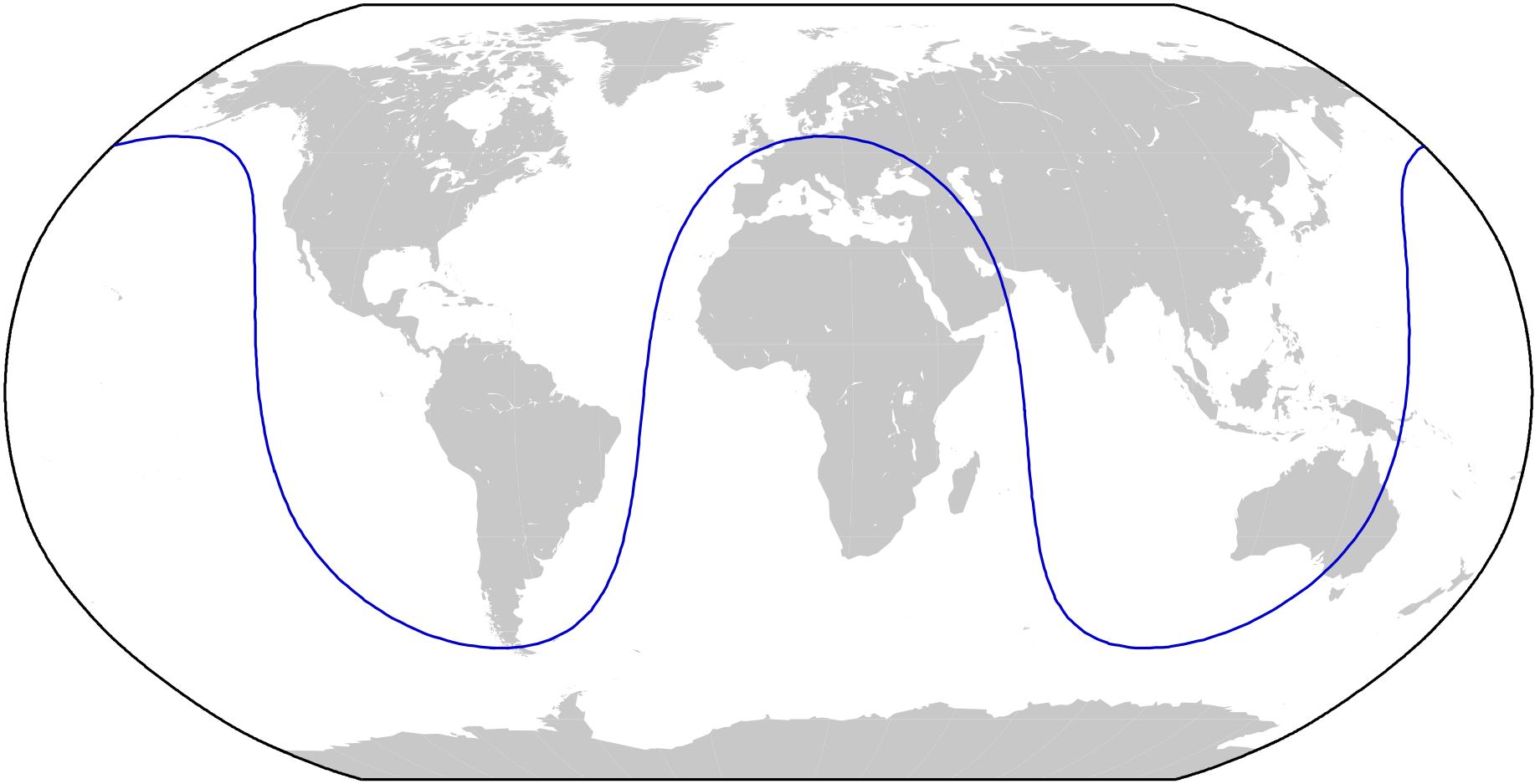
Development of GLONASS satellite orbit accuracy provided by CODE



GPS/GLONASS Orbit Characteristics

Ground track for the GPS constellation

Ground track for G06 for one day

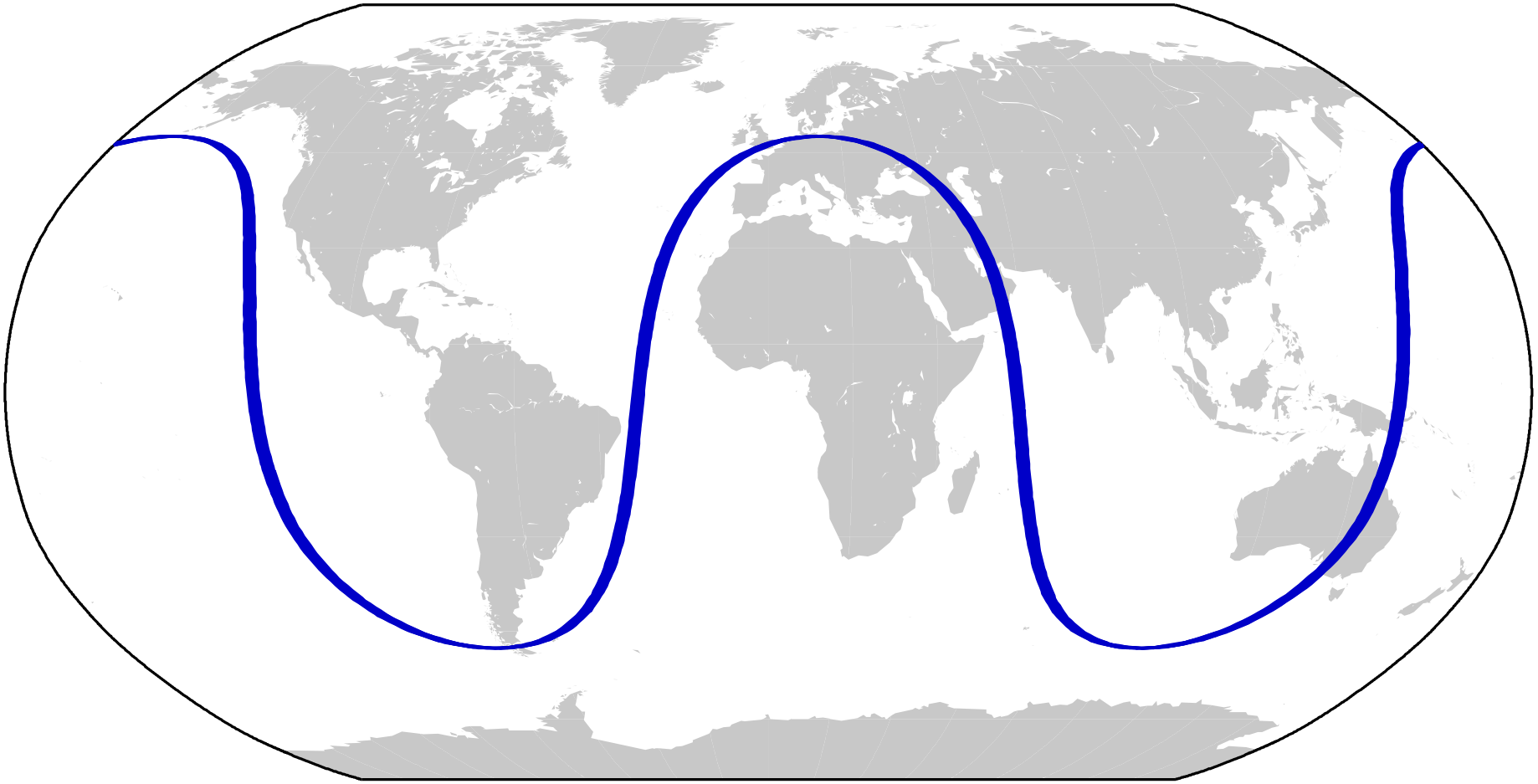


day of year 2008:060

GPS/GLONASS Orbit Characteristics

Ground track for the GPS constellation

Ground track for G06 for ten days

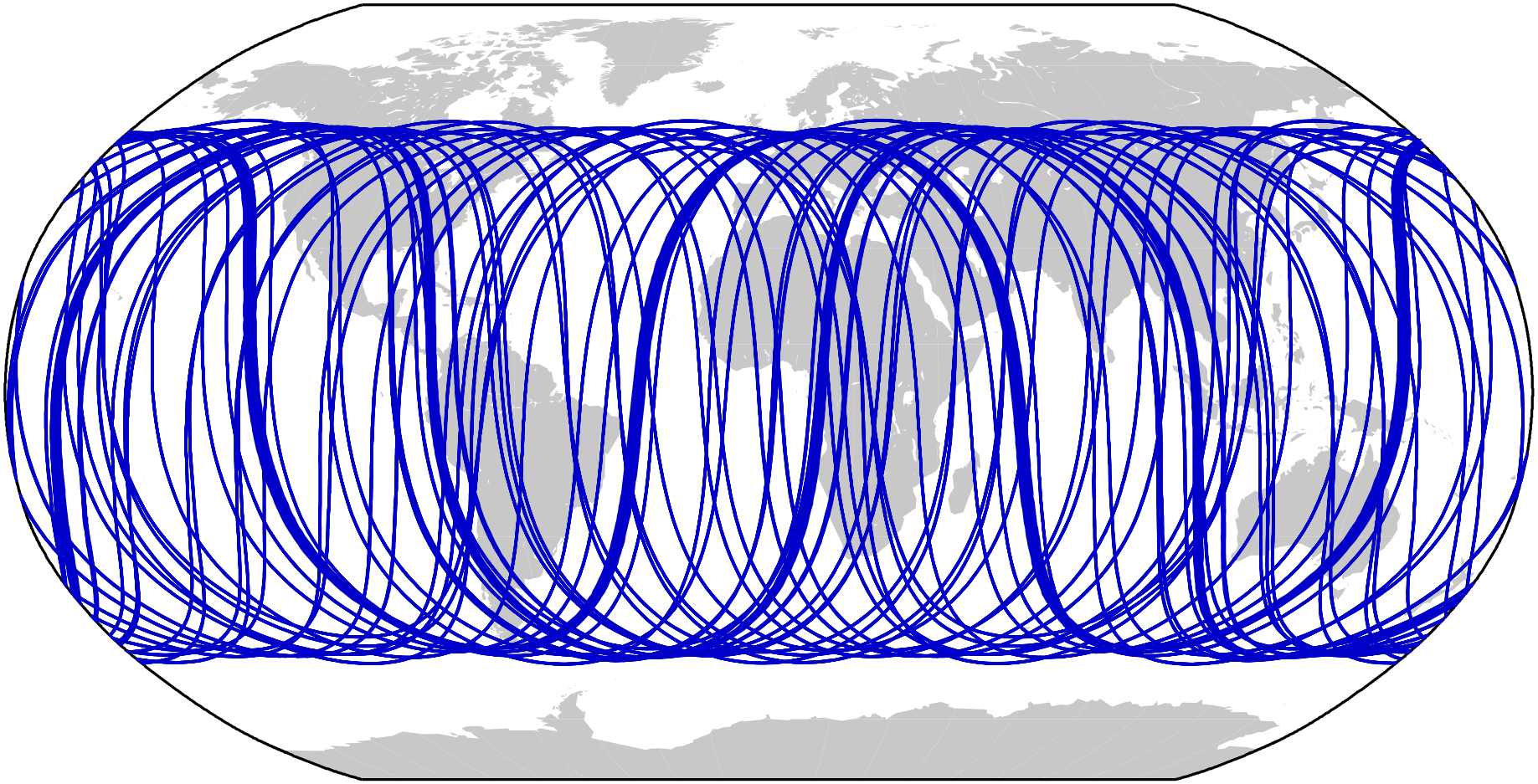


day of year 2008:060 to 069

GPS/GLONASS Orbit Characteristics

Ground track for the GPS constellation

Ground track for all satellites for ten days

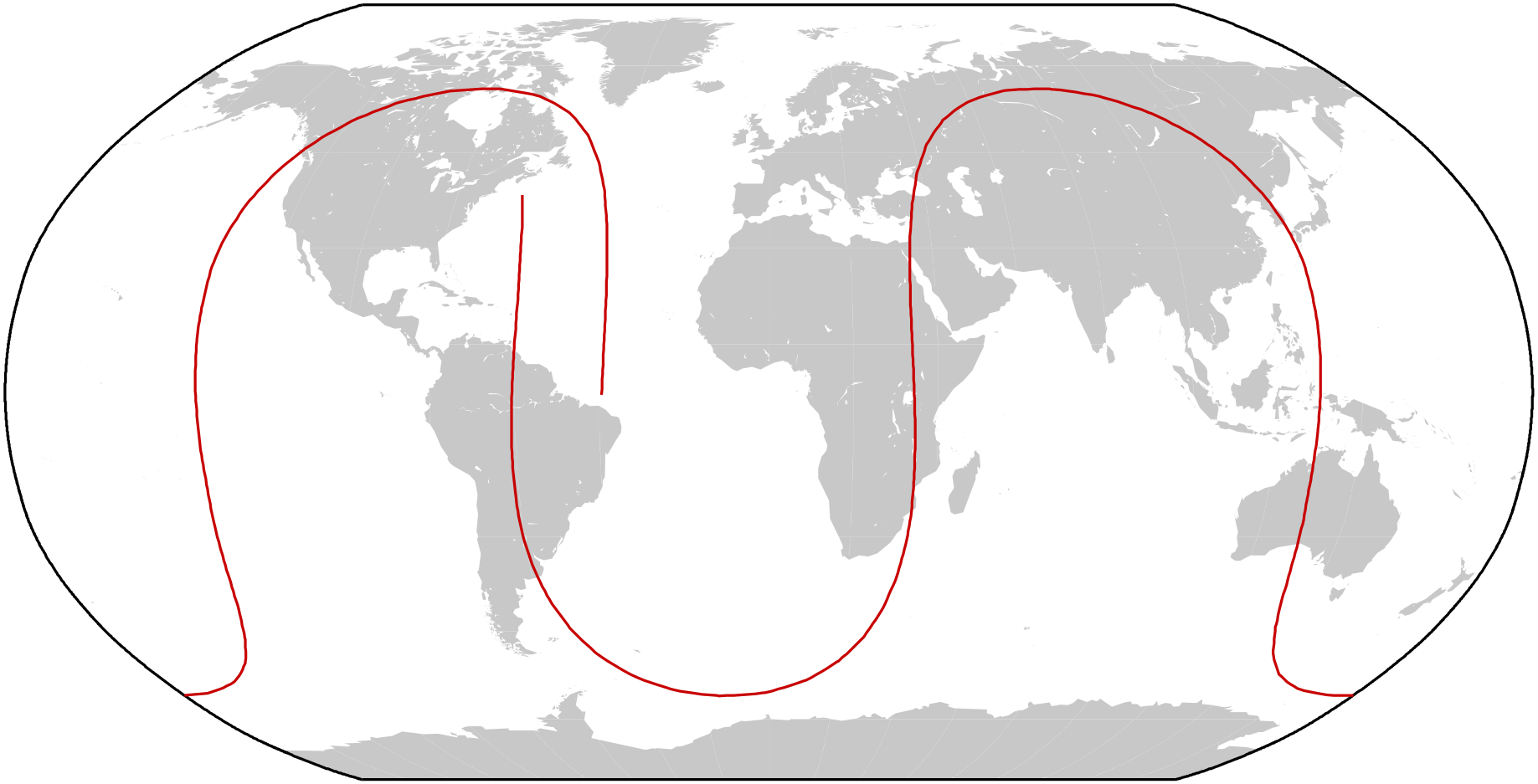


day of year 2008:060 to 069

GPS/GLONASS Orbit Characteristics

Ground track for the GLONASS constellation

Ground track for R04 for one day

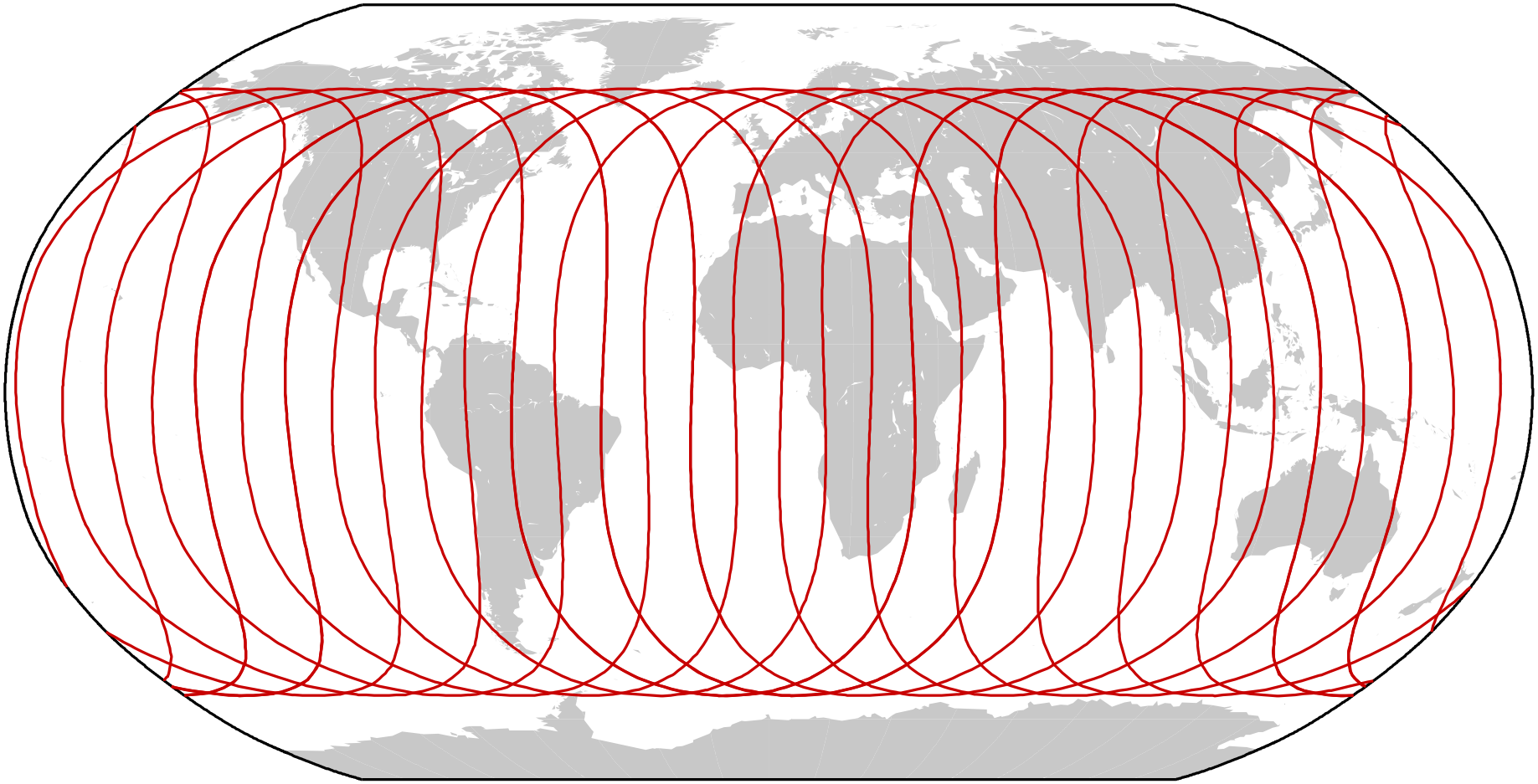


day of year 2008:060

GPS/GLONASS Orbit Characteristics

Ground track for the GLONASS constellation

Ground track for R04 for ten days

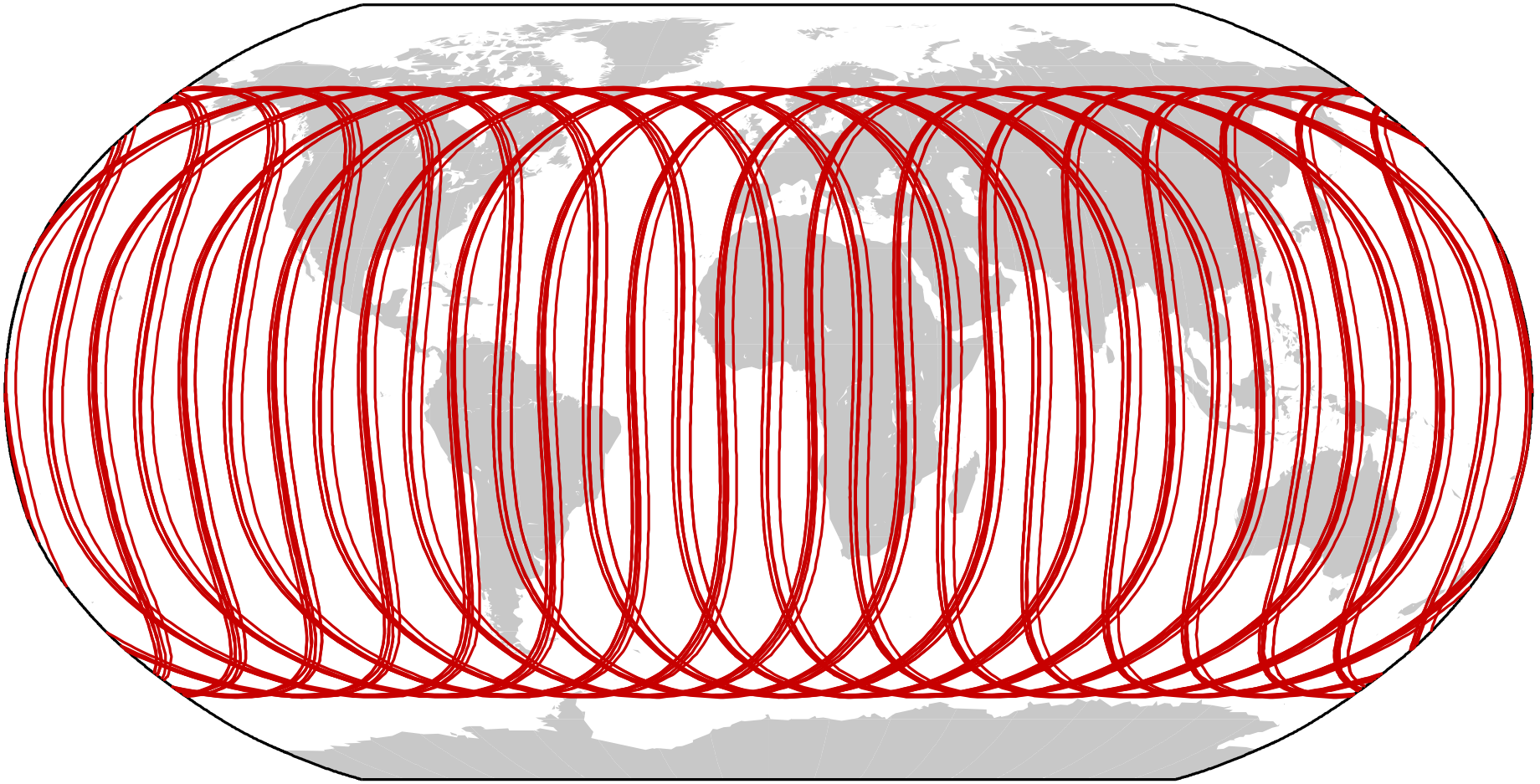


day of year 2008:060 to 069

GPS/GLONASS Orbit Characteristics

Ground track for the GLONASS constellation

Ground track for R01 to R08 for ten days

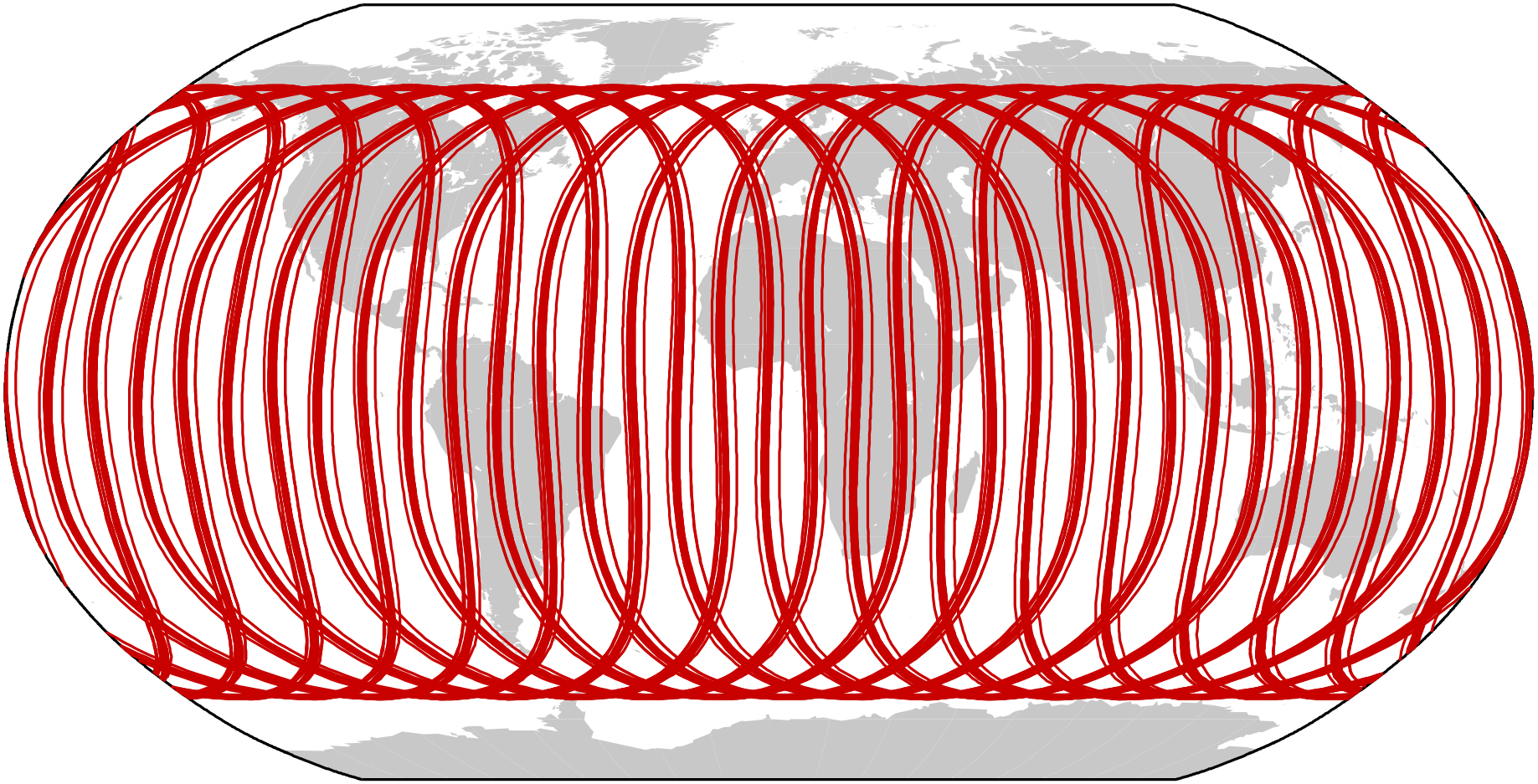


day of year 2008:060 to 069

GPS/GLONASS Orbit Characteristics

Ground track for the GLONASS constellation

Ground track for all satellites for ten days

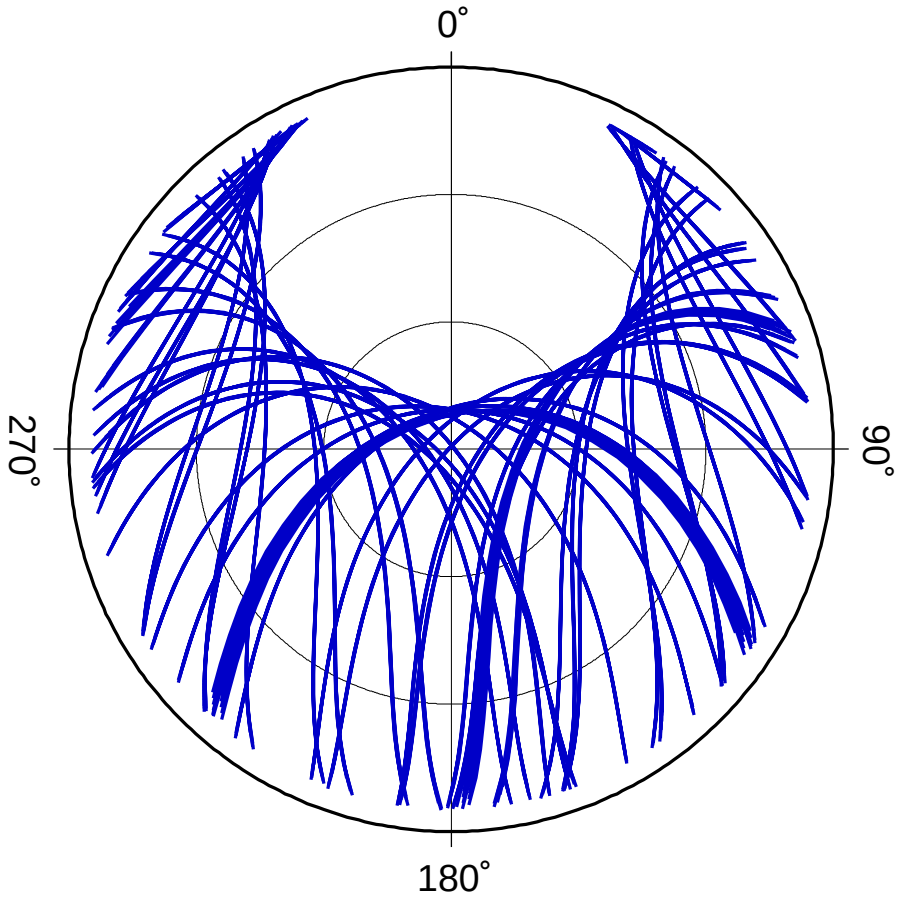


day of year 2008:060 to 069

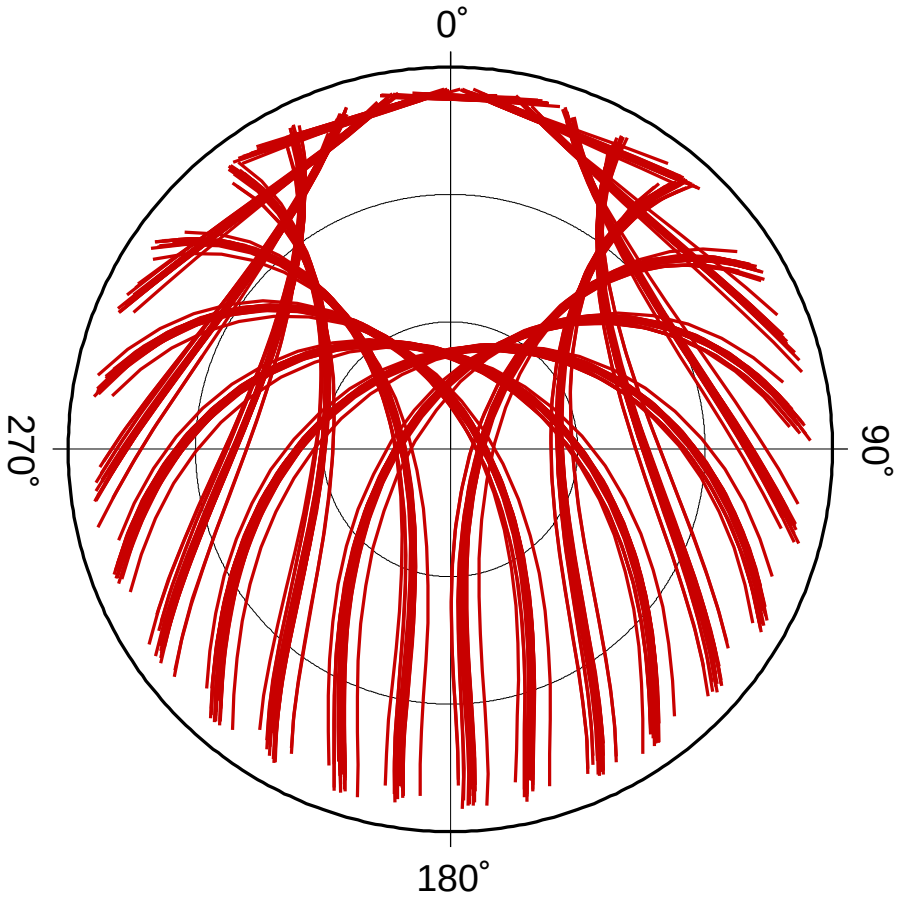
GPS/GLONASS Orbit Characteristics

Elevation–Azimuth–Diagram

Zimmerwald (Lat: 46° 52'; Lon: 7° 28')



all GPS satellites



all GLONASS satellites

day of year 2008:060 to 069

GPS/GLONASS Orbit Characteristics

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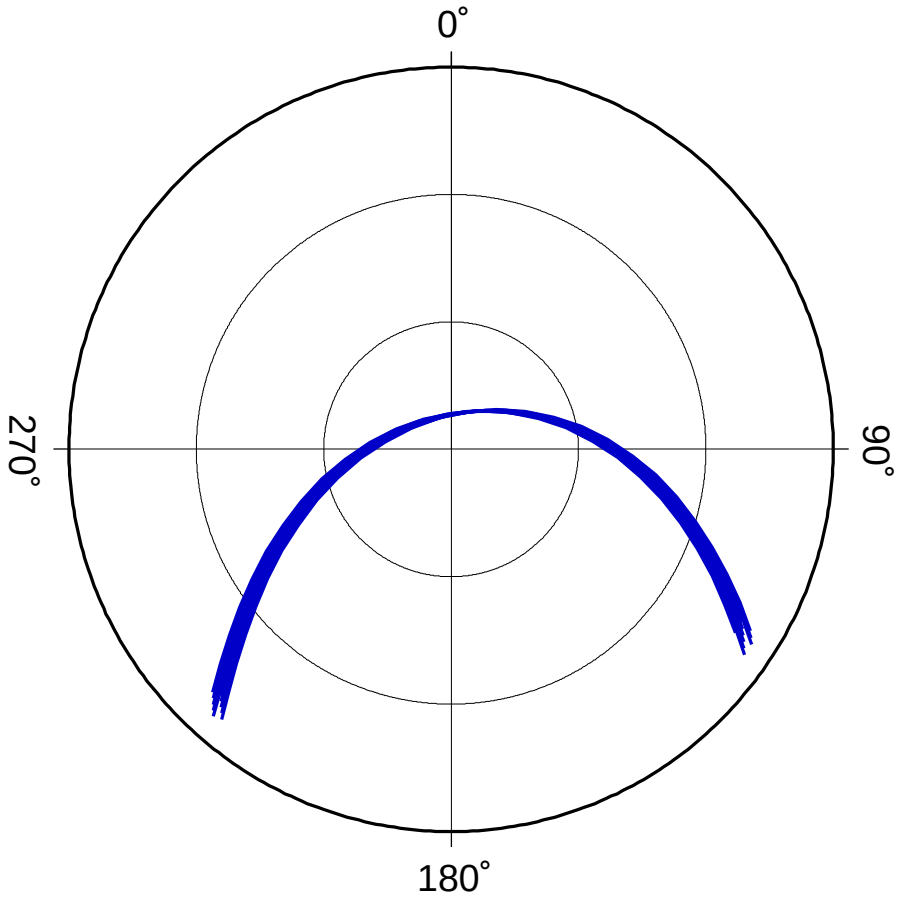
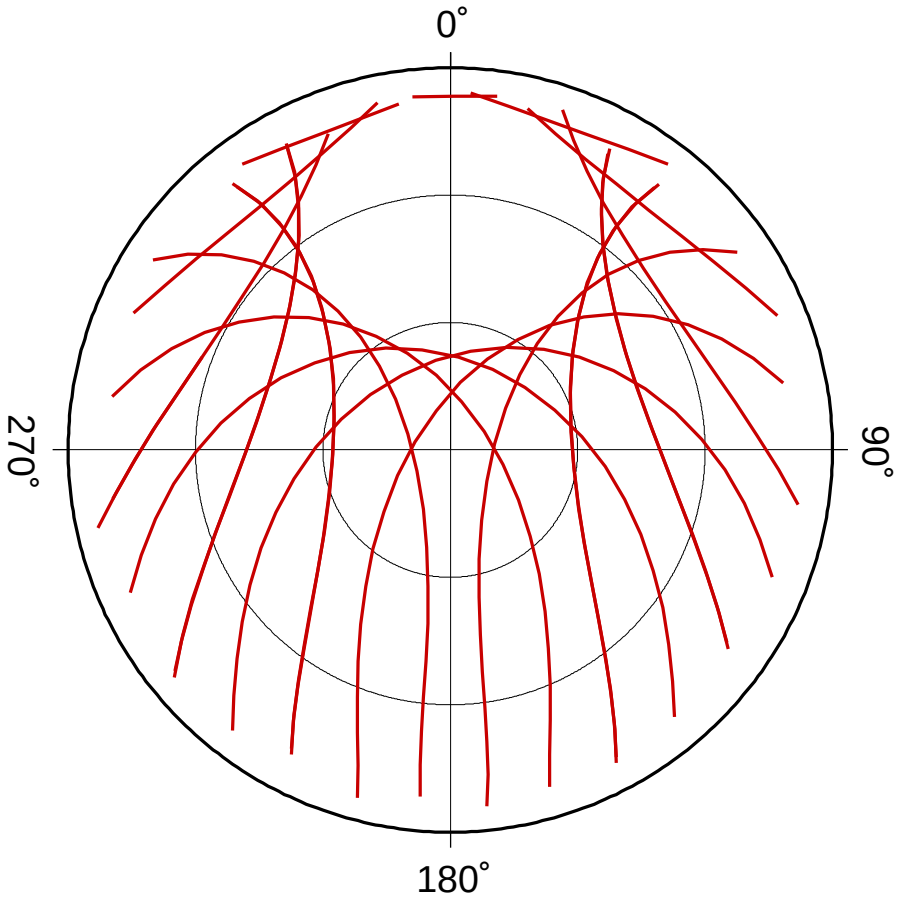


satellite G06



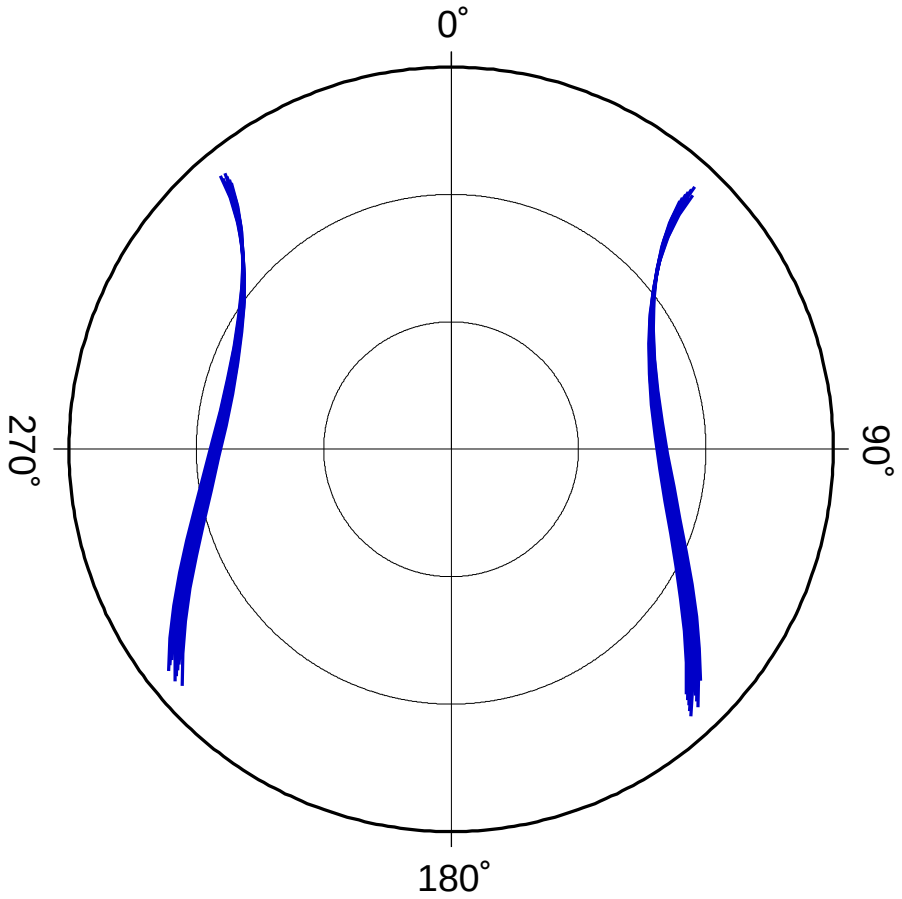
satellite R04

day of year 2008:060 to 069

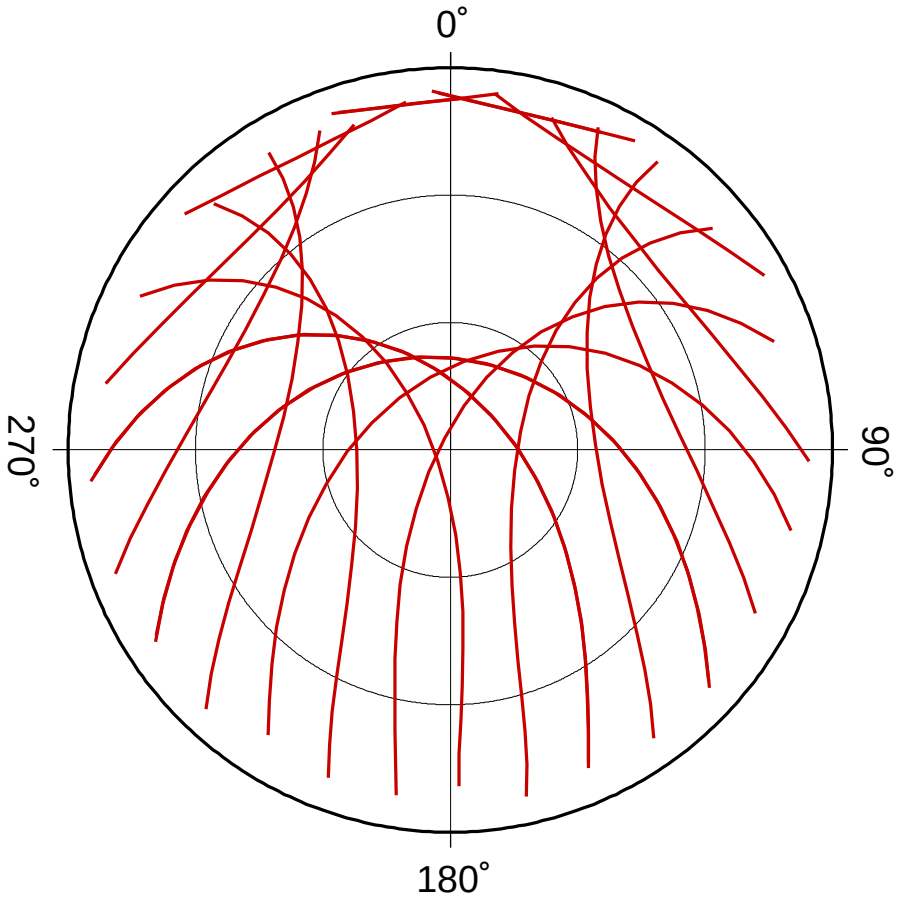
GPS/GLONASS Orbit Characteristics

Elevation–Azimuth–Diagram

Ulaanbataar (Lat: 47° 40'; Lon: 107° 3')



satellite G06

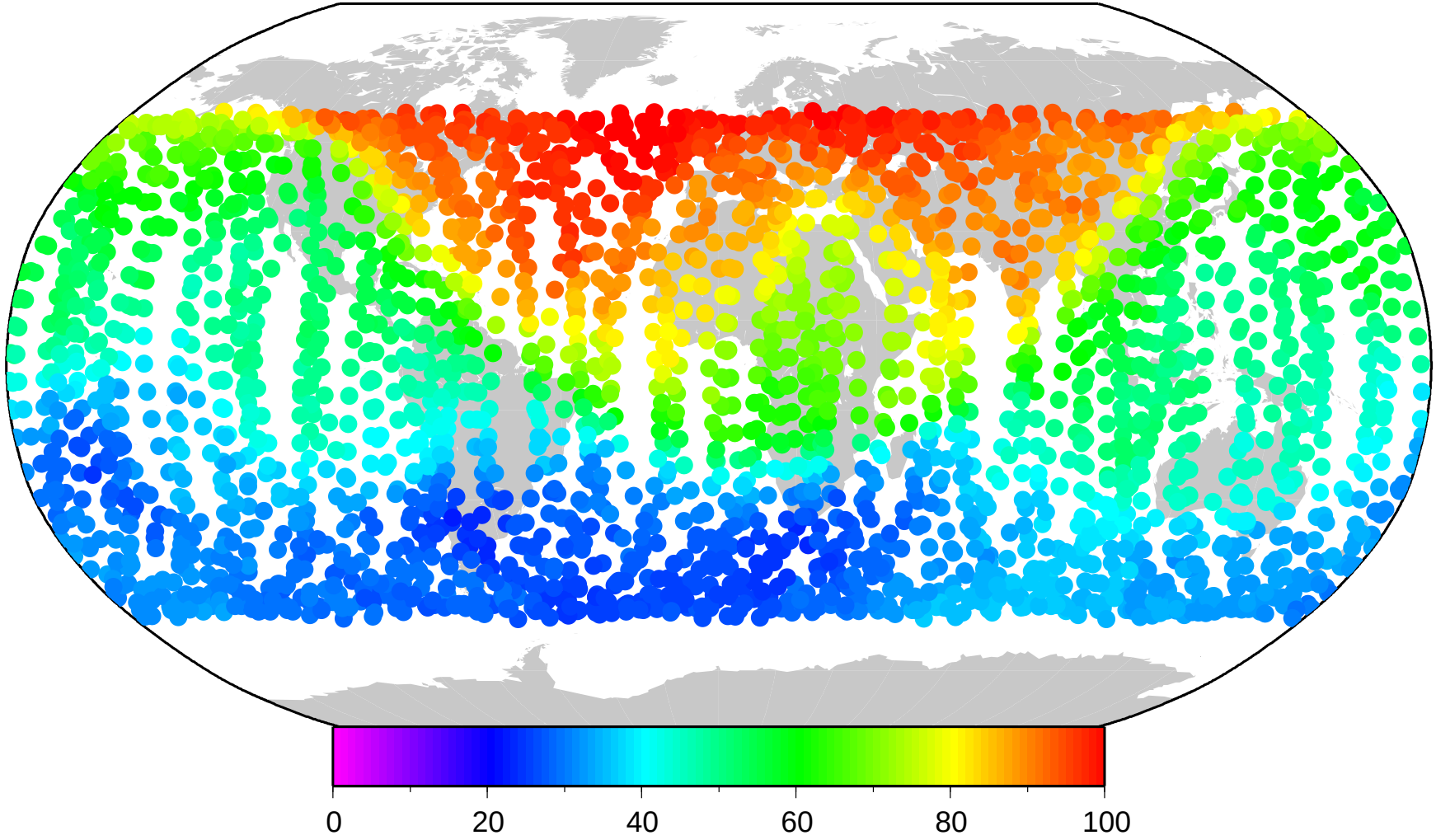


satellite R04

day of year 2008:060 to 069

GPS/GLONASS Orbit Characteristics

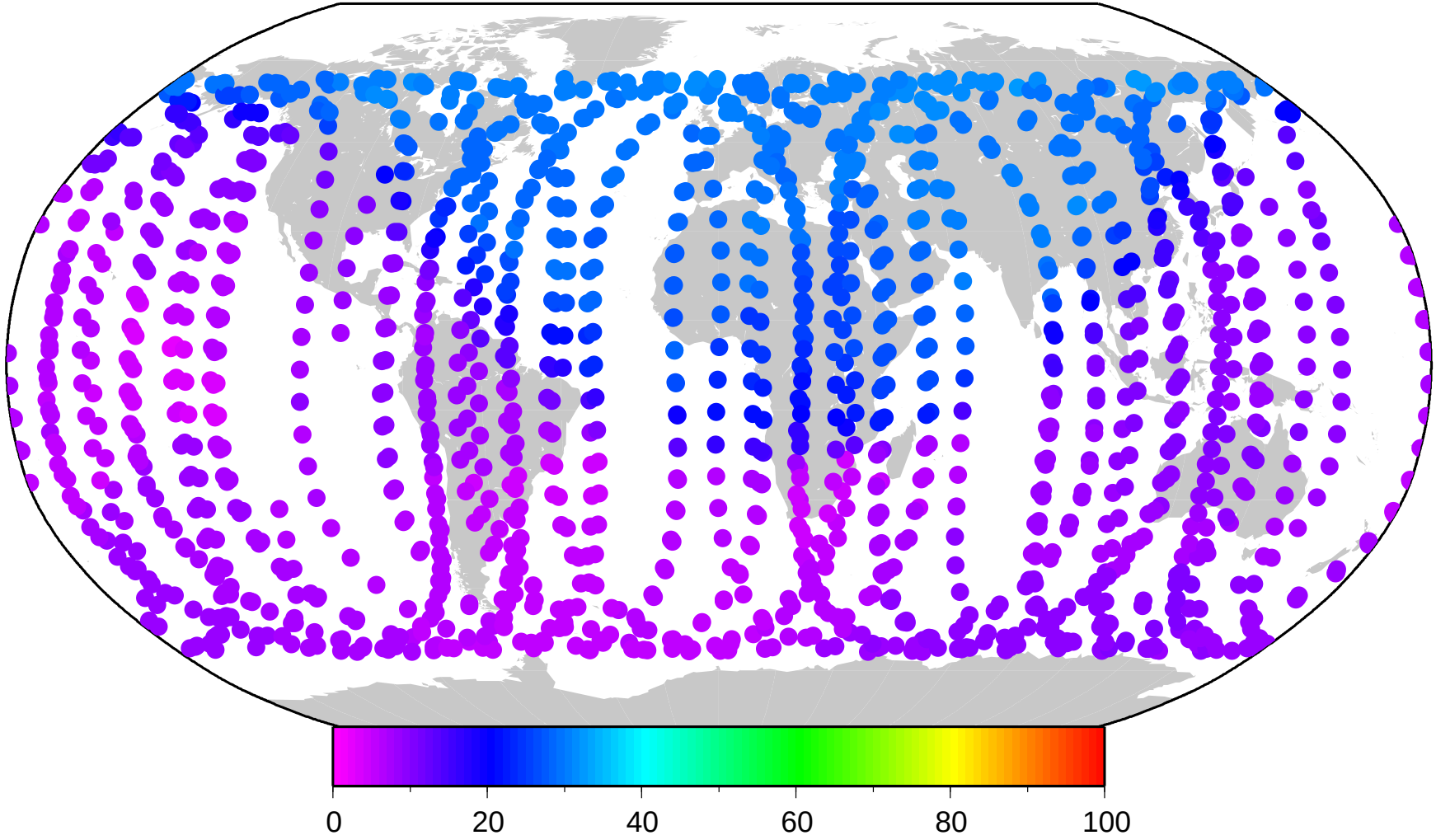
Number of stations tracking a GPS satellite



Assuming the CODE final network with 5° cut–off and 15 minutes sampling, day of year 2008:060

GPS/GLONASS Orbit Characteristics

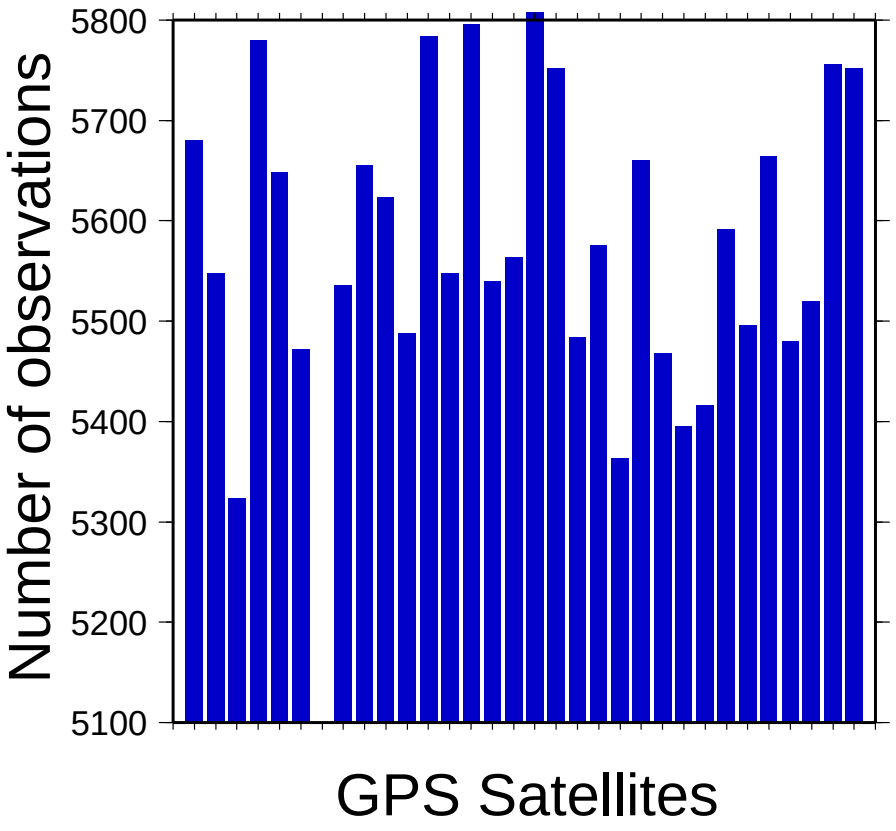
Number of stations tracking a GLONASS satellite

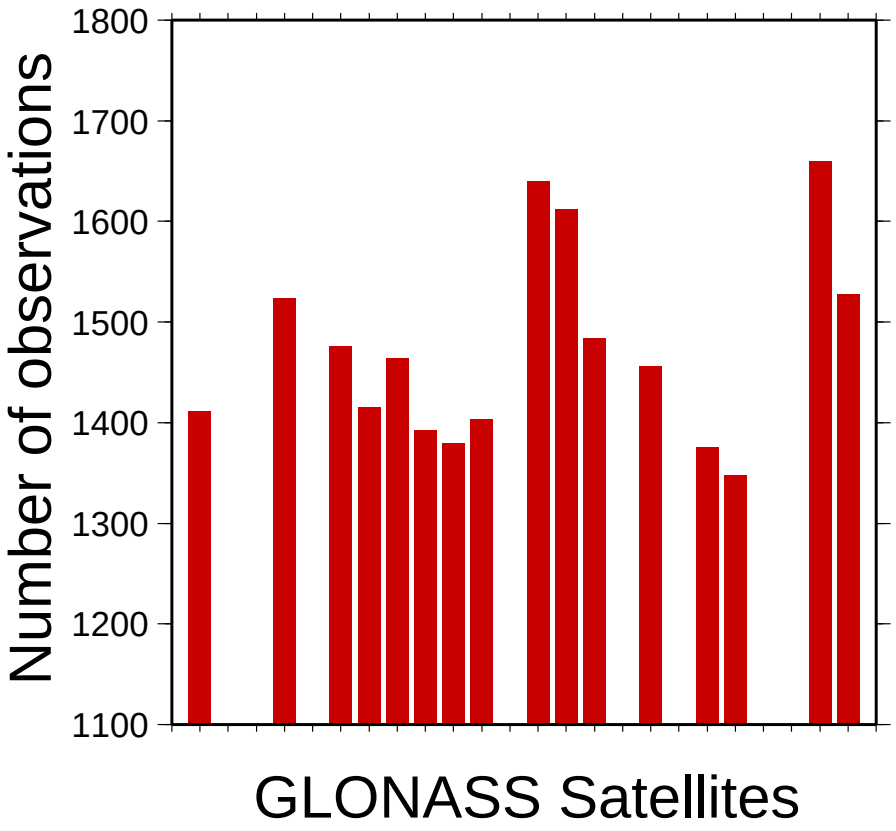


Assuming the CODE final network with 5° cut–off and 15 minutes sampling, day of year 2008:060

GPS/GLONASS Orbit Characteristics

Total number of observations per day and satellite



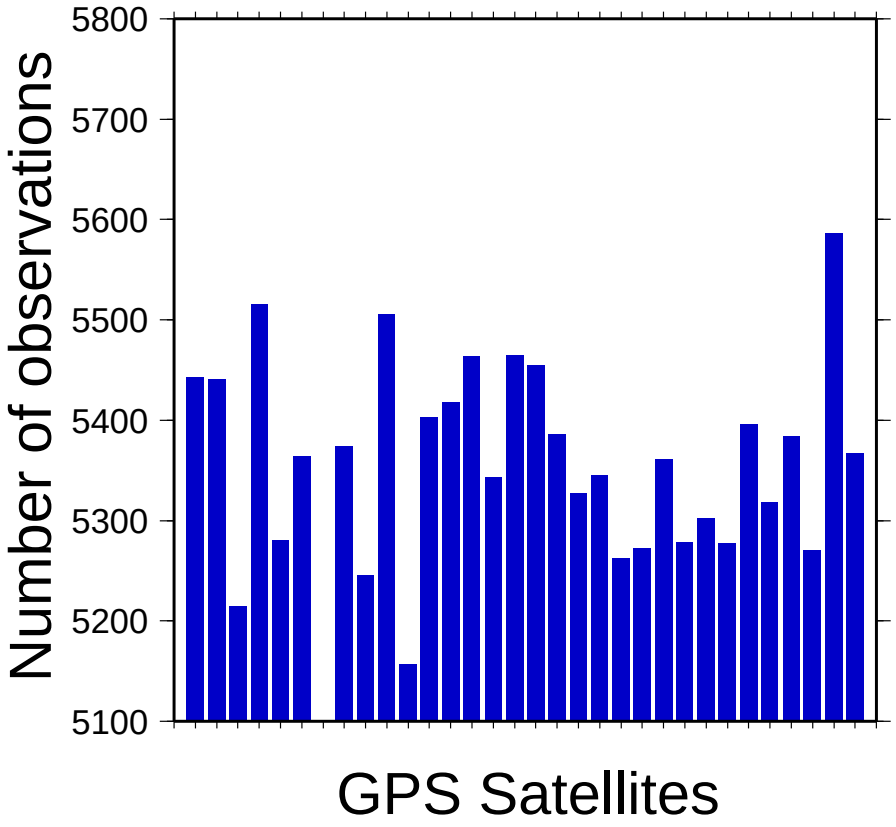


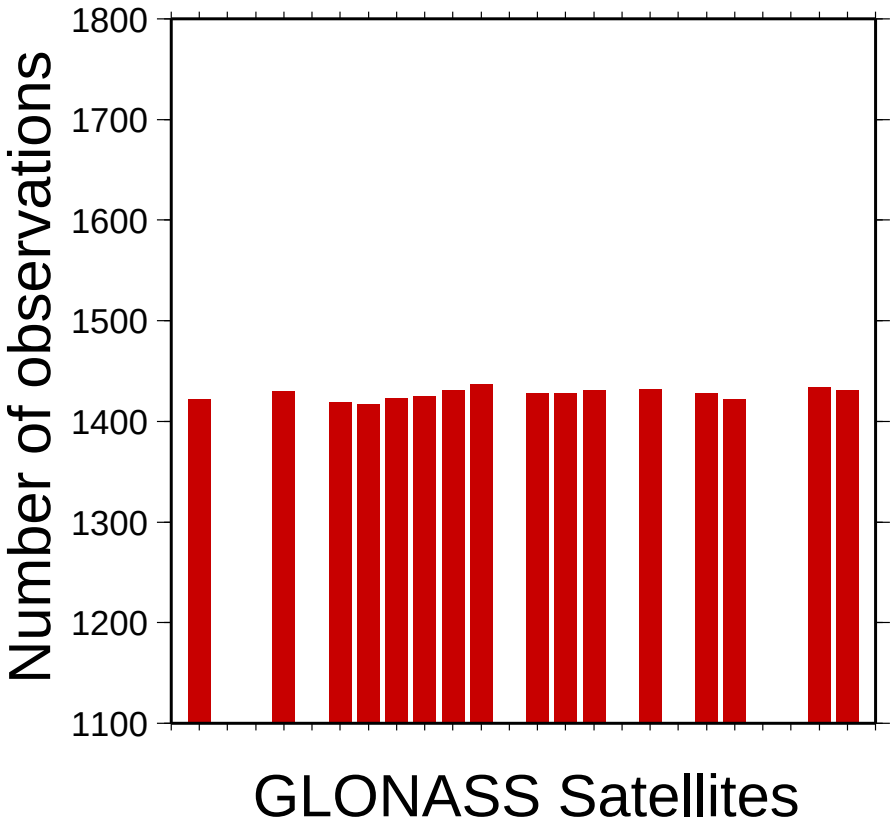
Assuming the CODE final network with 5° cut–off and 15 minutes sampling, day of year 2008:060

GPS/GLONASS Orbit Characteristics

Total number of observations per day and satellite

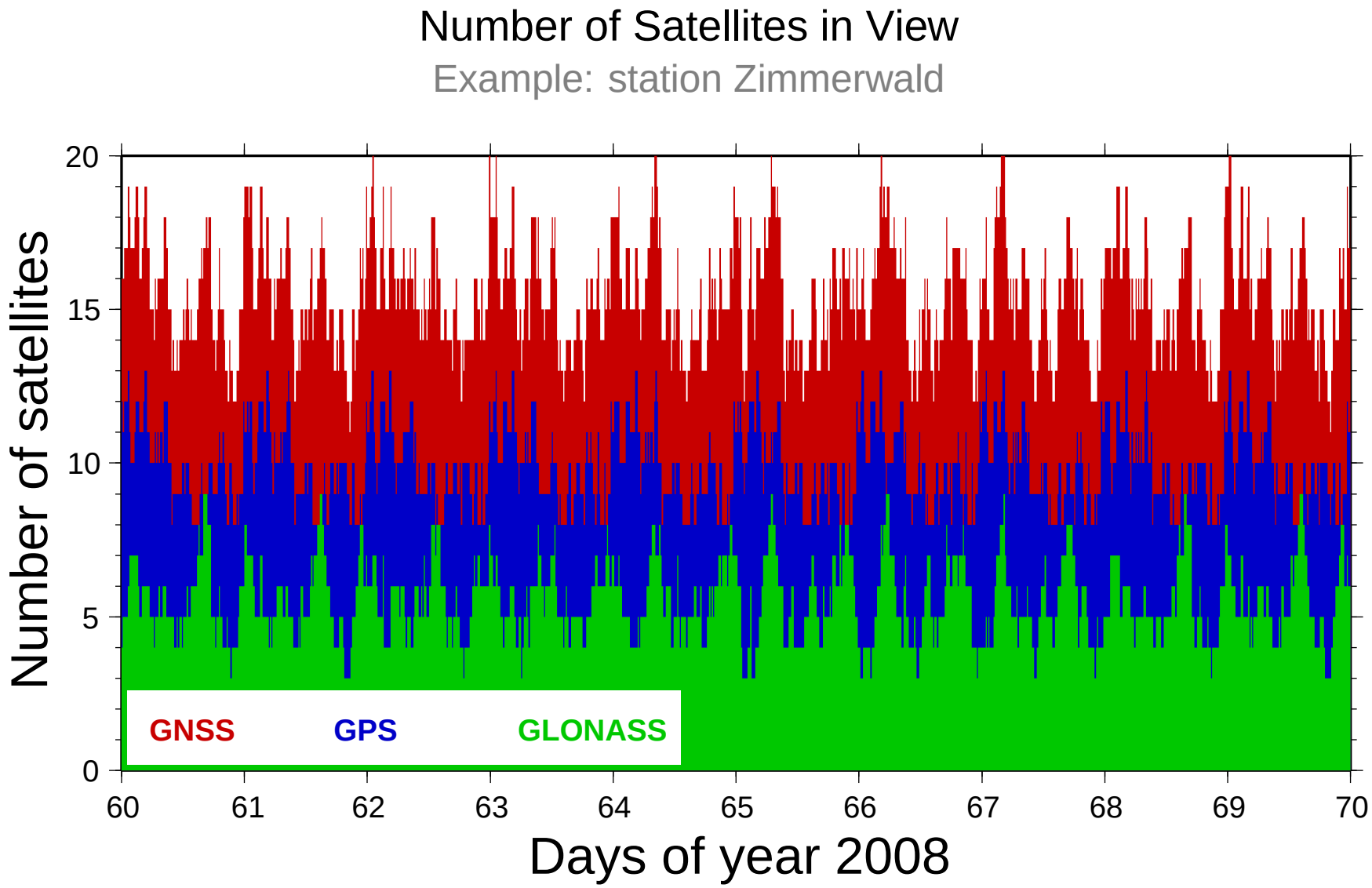
Mean value after eight days





Assuming the CODE final network with 5° cut–off and 15 minutes sampling, day of year 2008:060 to 067

PDOP: Constellation Effects

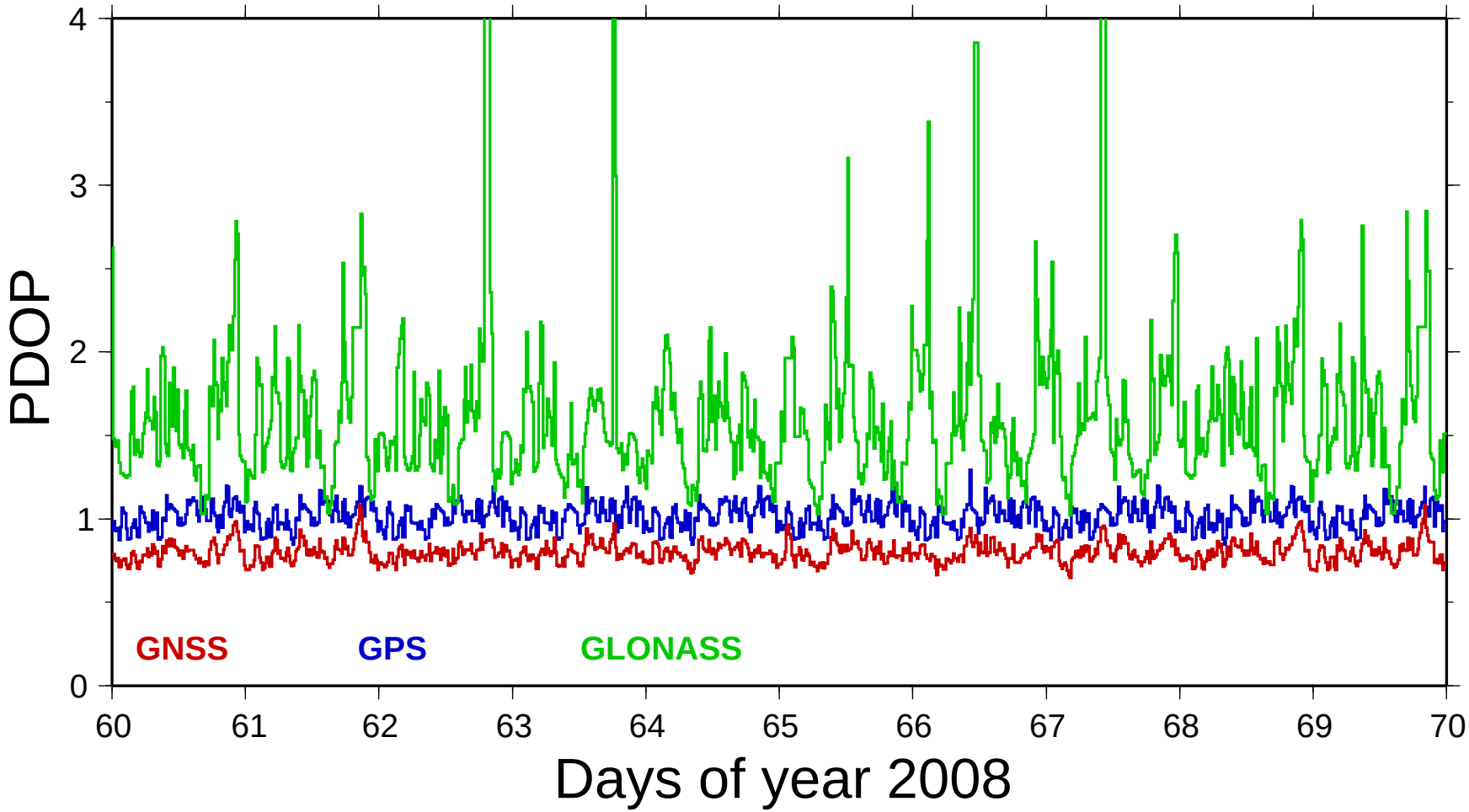


elevation cut–off 5°, day of year 2008:060 to 069

PDOP: Constellation Effects

PDOP values for satellite constellation in view

Example: station Zimmerwald

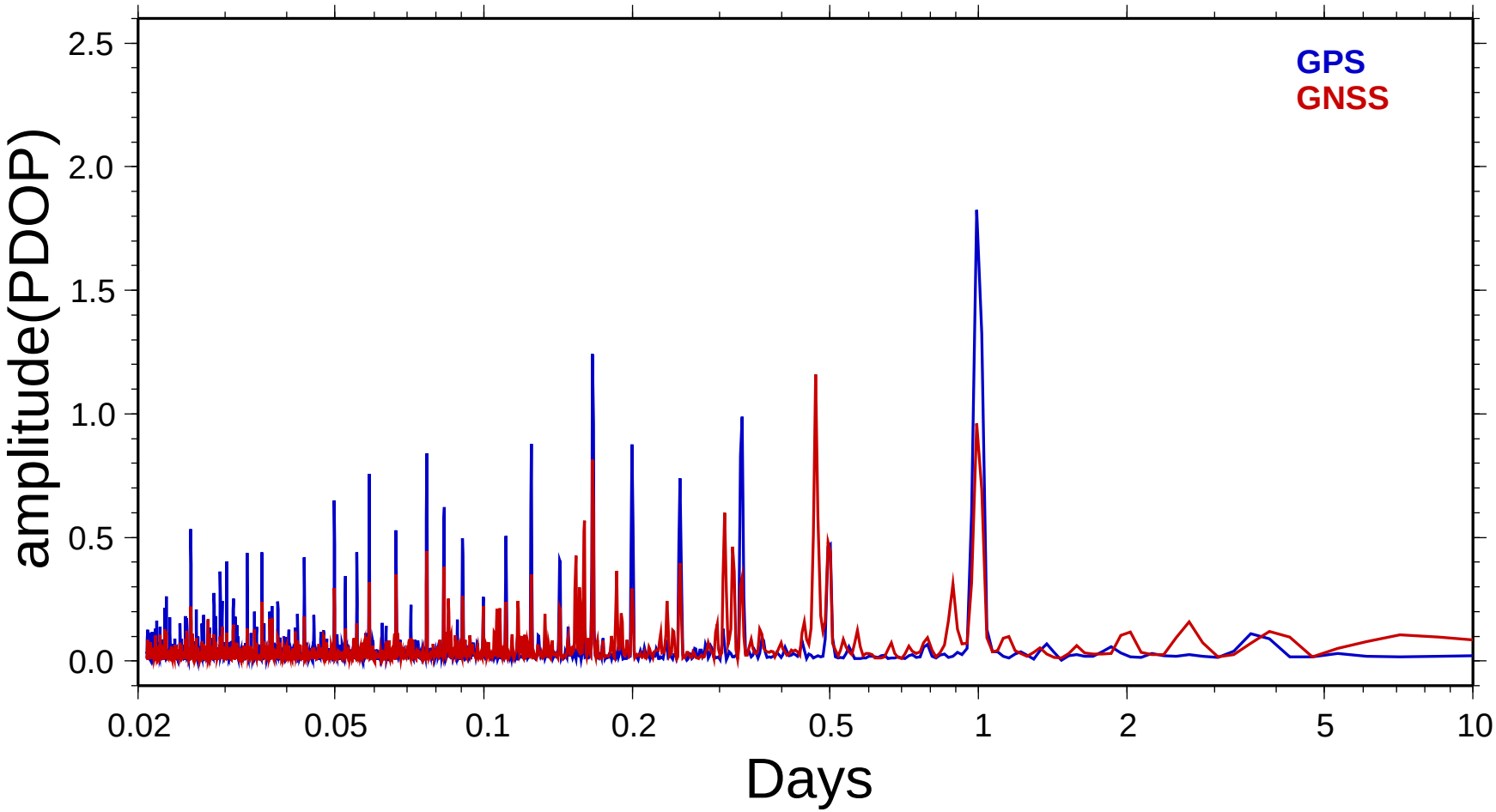


elevation cut–off 5°, day of year 2008:060 to 069

PDOP: Constellation Effects

Spectra of PDOP values for satellite constellations

Example: station Zimmerwald



elevation cut–off 5°, day of year 2008:020 to 069

PDOP: Constellation Effects

Spectra of PDOP values for satellite constellations

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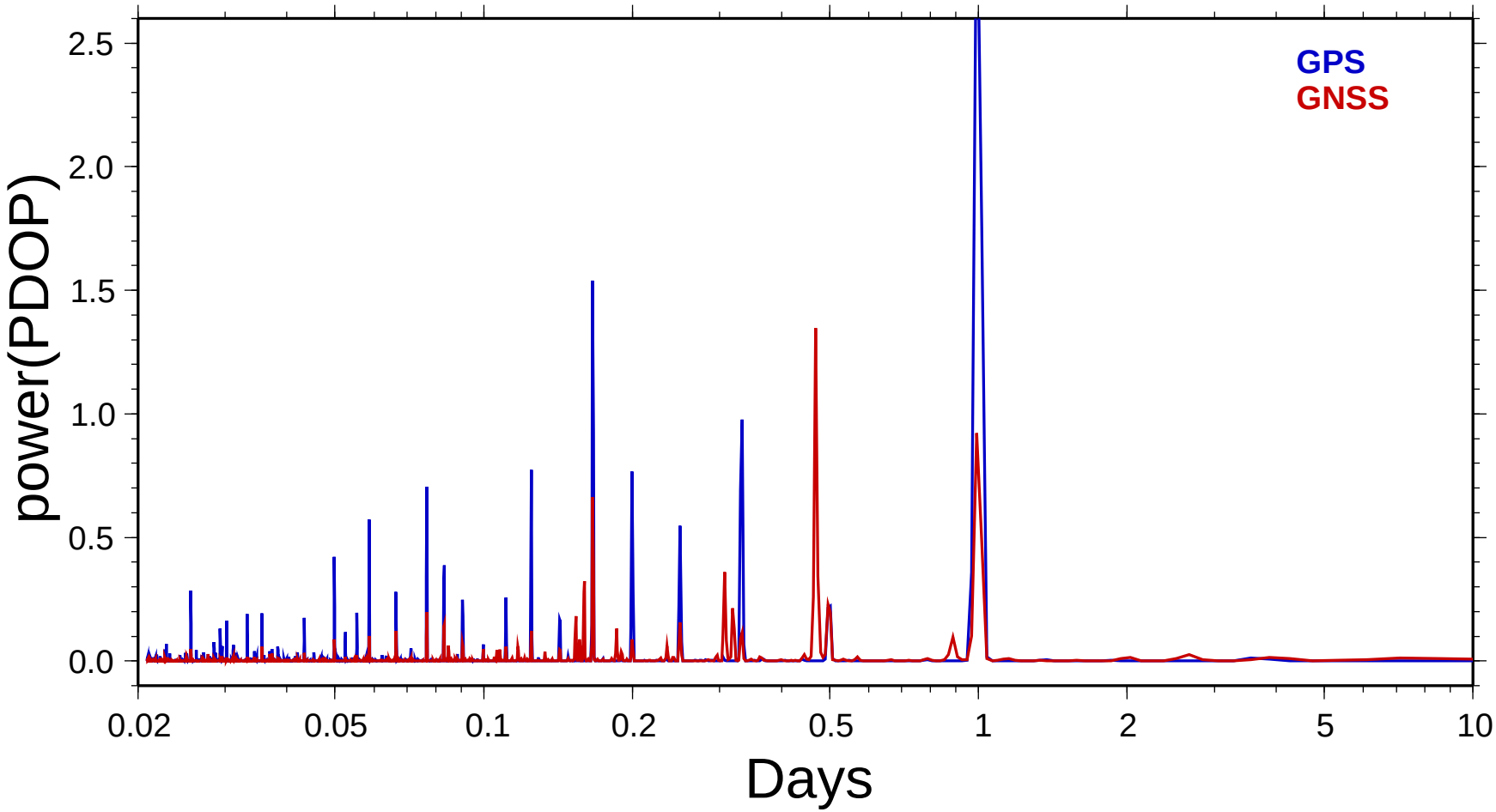

elevation cut–off 5°, day of year 2008:020 to 069

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Spectra of PDOP values for satellite constellations

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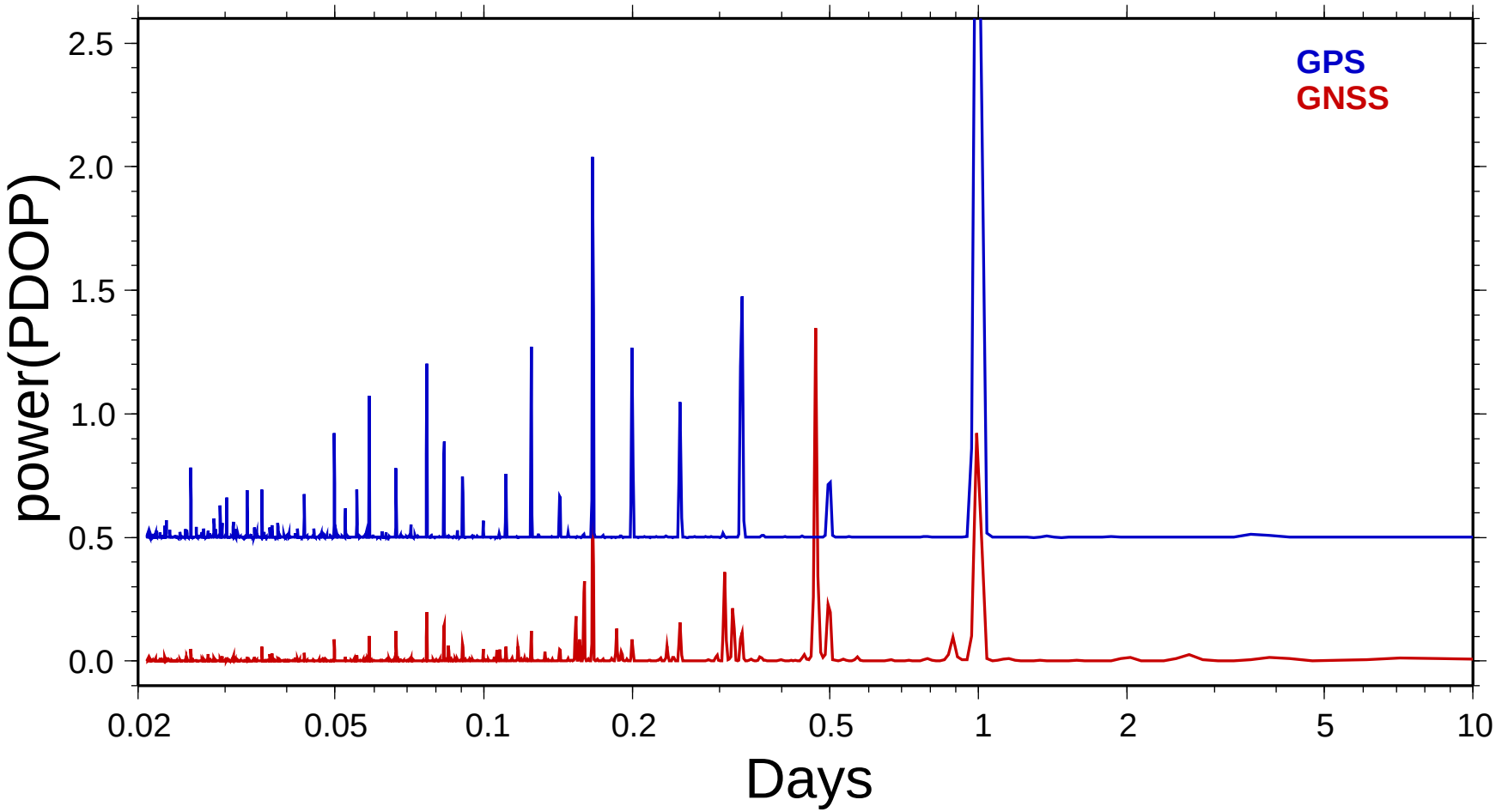
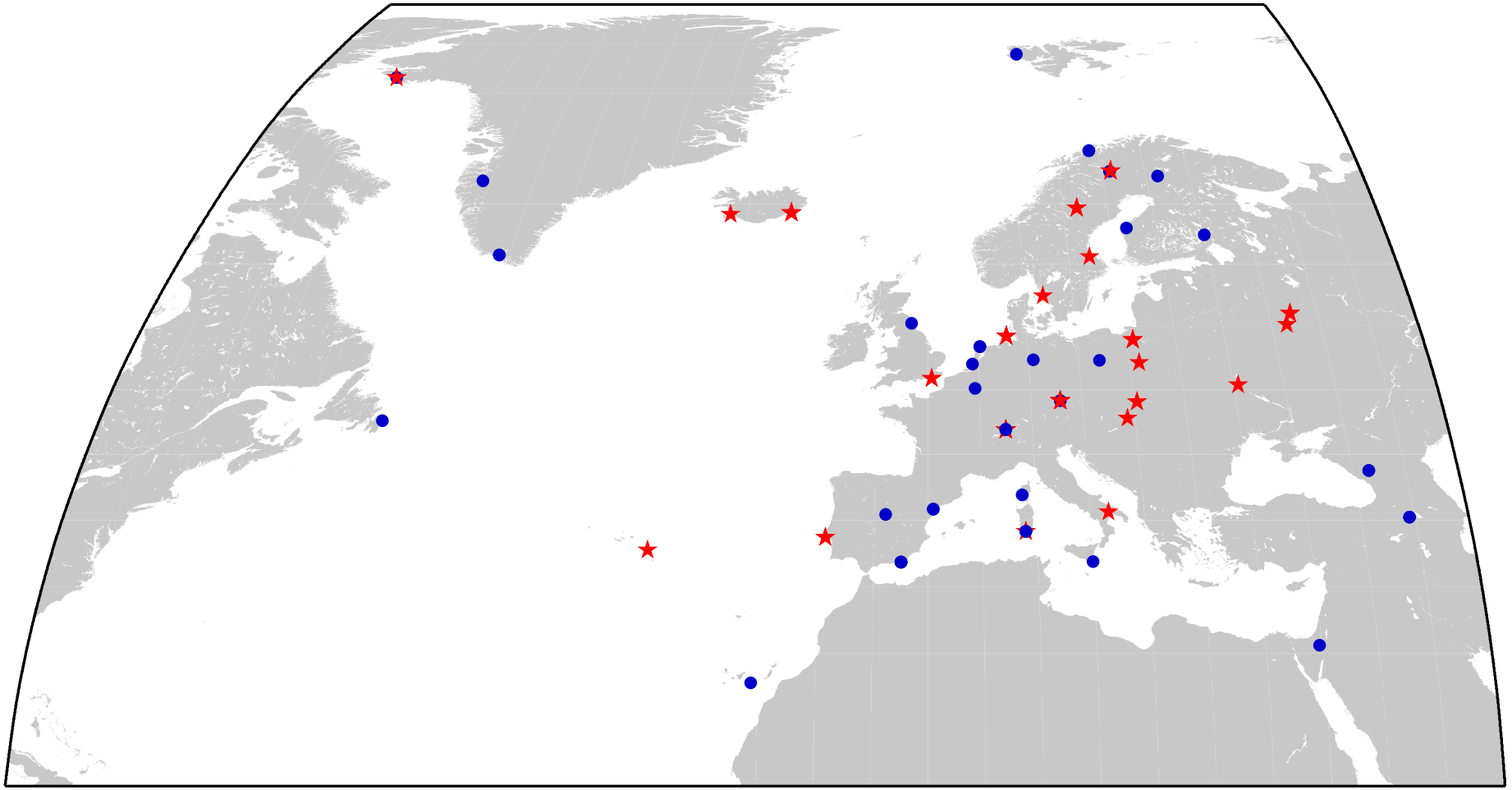


elevation cut–off 5°, day of year 2008:020 to 069

Performance of a Kinematic Positioning

CODE EPN network



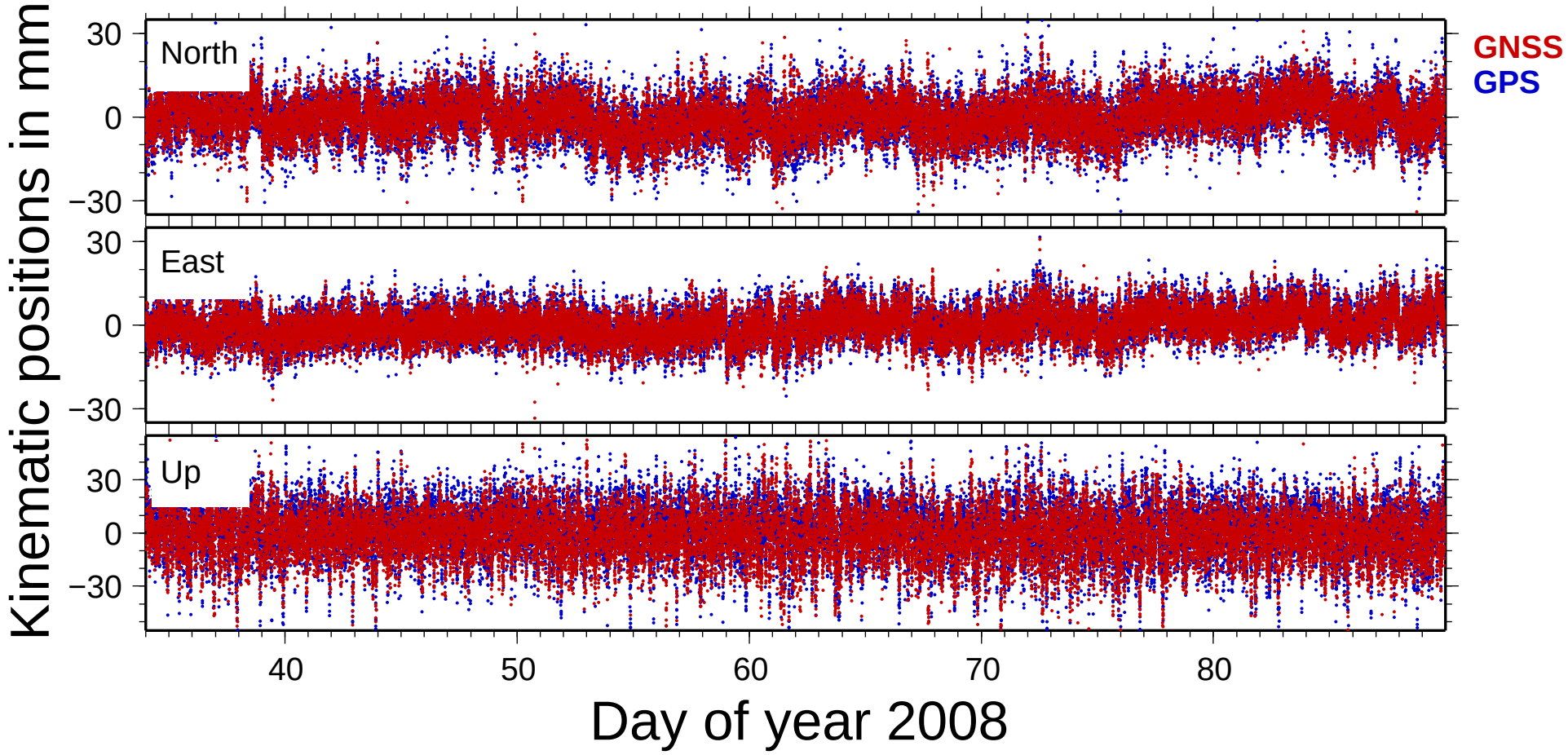
Receivers tracking: ★ GPS/GLONASS (24) ● only GPS (29)

CODE EPN solution for day of year 2007:034 to 089

Performance of a Kinematic Positioning

Results from a kinematic positioning

Example: station Zimmerwald (ZIM2)



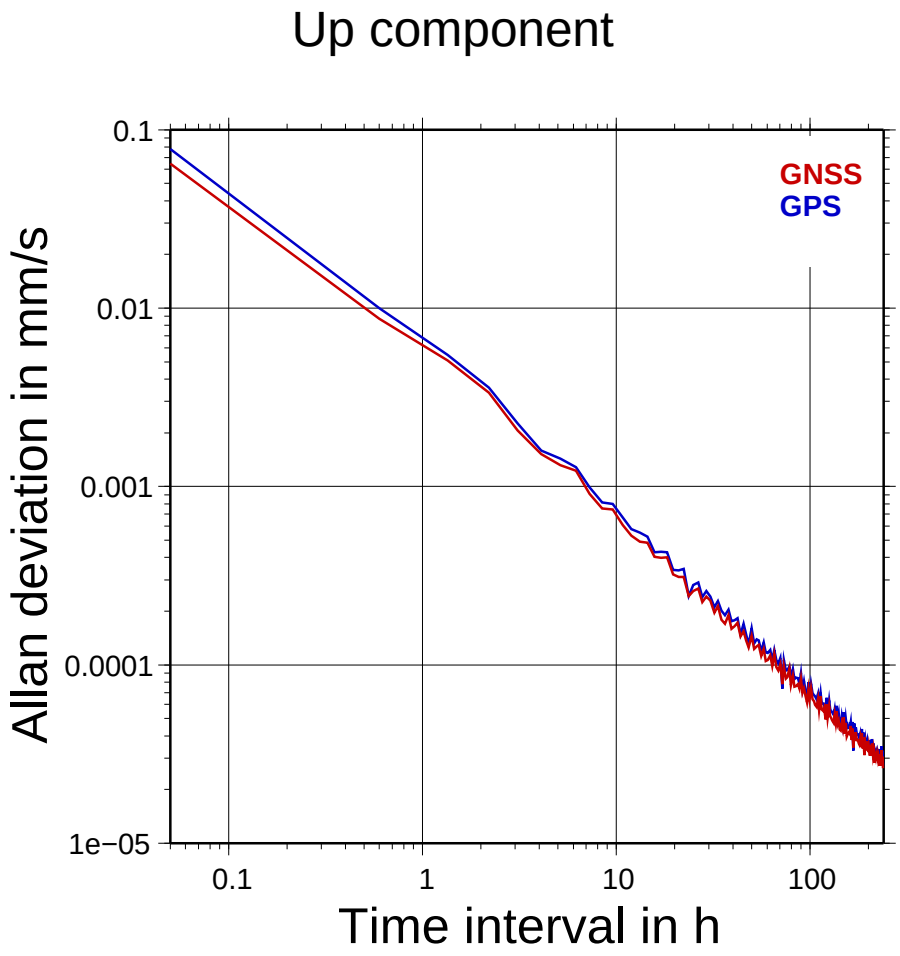
CODE EPN solution for day of year 2007:034 to 089

Performance of a Kinematic Positioning

Allan deviation from a kinematic positioning

Example: station Zimmerwald (ZIM2)

- The Allan deviation reflects the noise behavior of a time series.
- It is comparable with the RMS of epoch differences.
- The time interval gives the length between these epochs.



CODE EPN solution for day of year 2007:034 to 089

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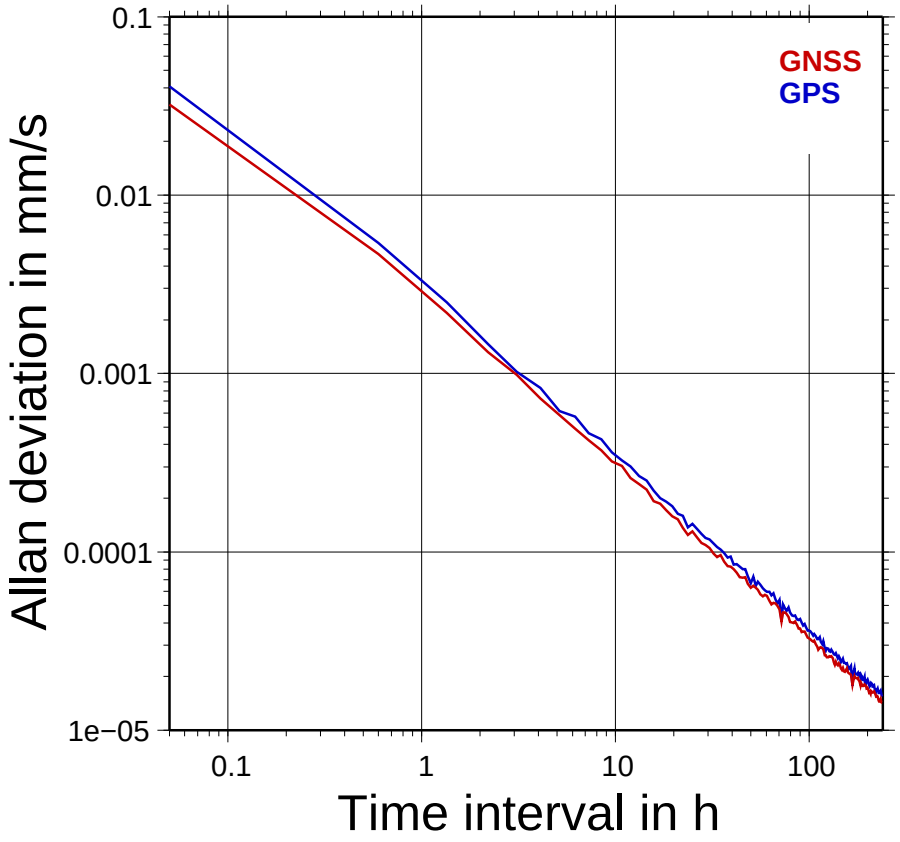
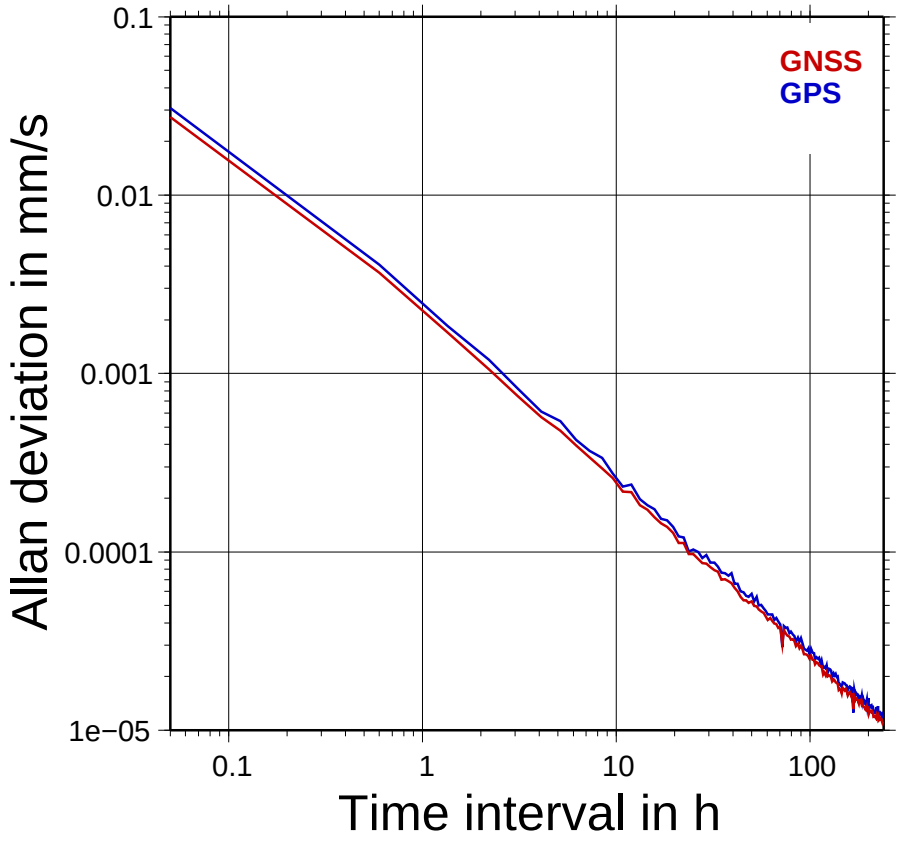
North component



East component

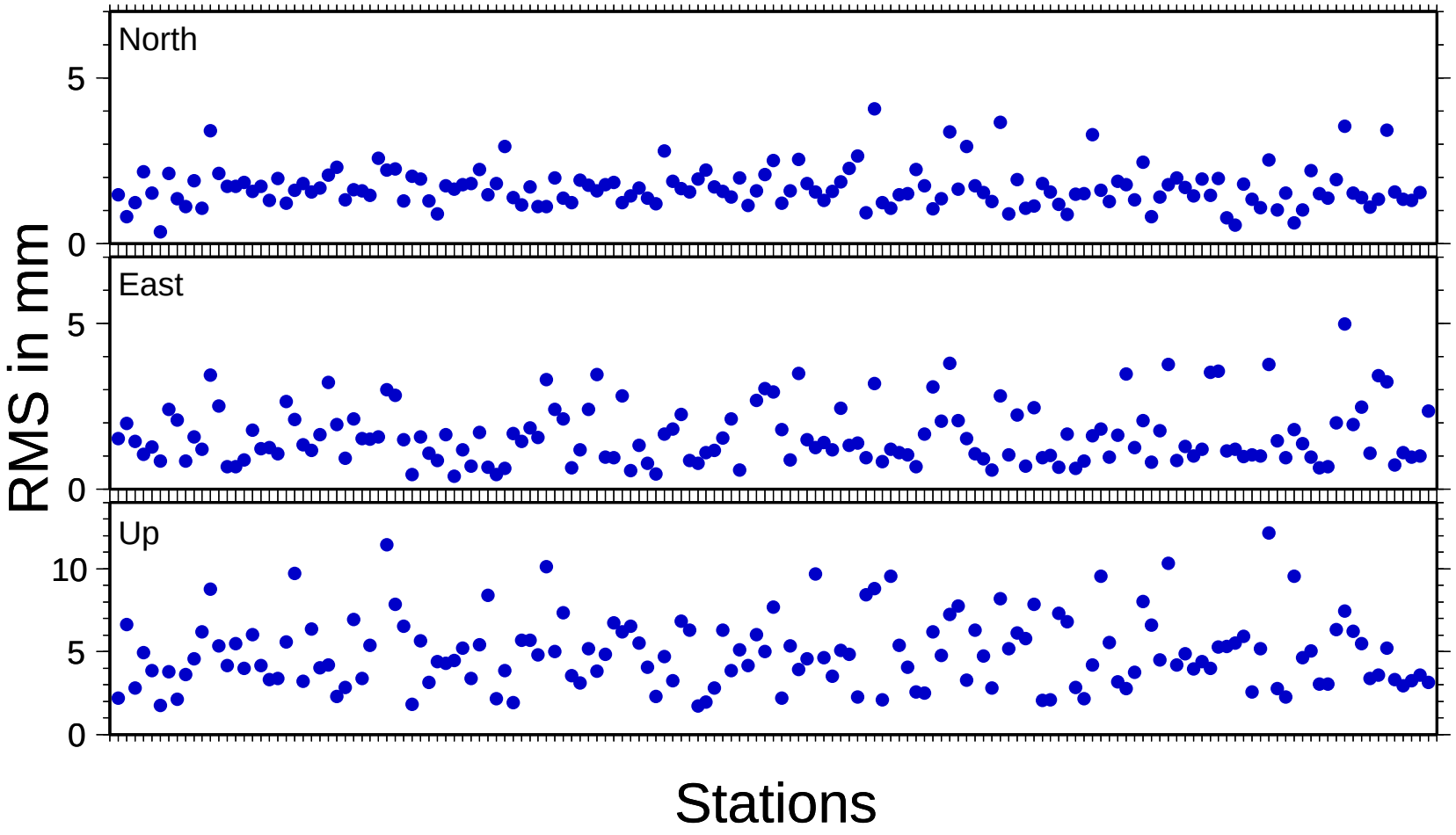


CODE EPN solution for day of year 2007:034 to 089

Comparisons of Global Solutions

Repeatability of daily station coordinate solutions

RMS of 8 daily coordinate solutions



Solution includes

- only GPS measurements

CODE final solution for day of year 2007:060 to 067

Comparisons of Global Solutions

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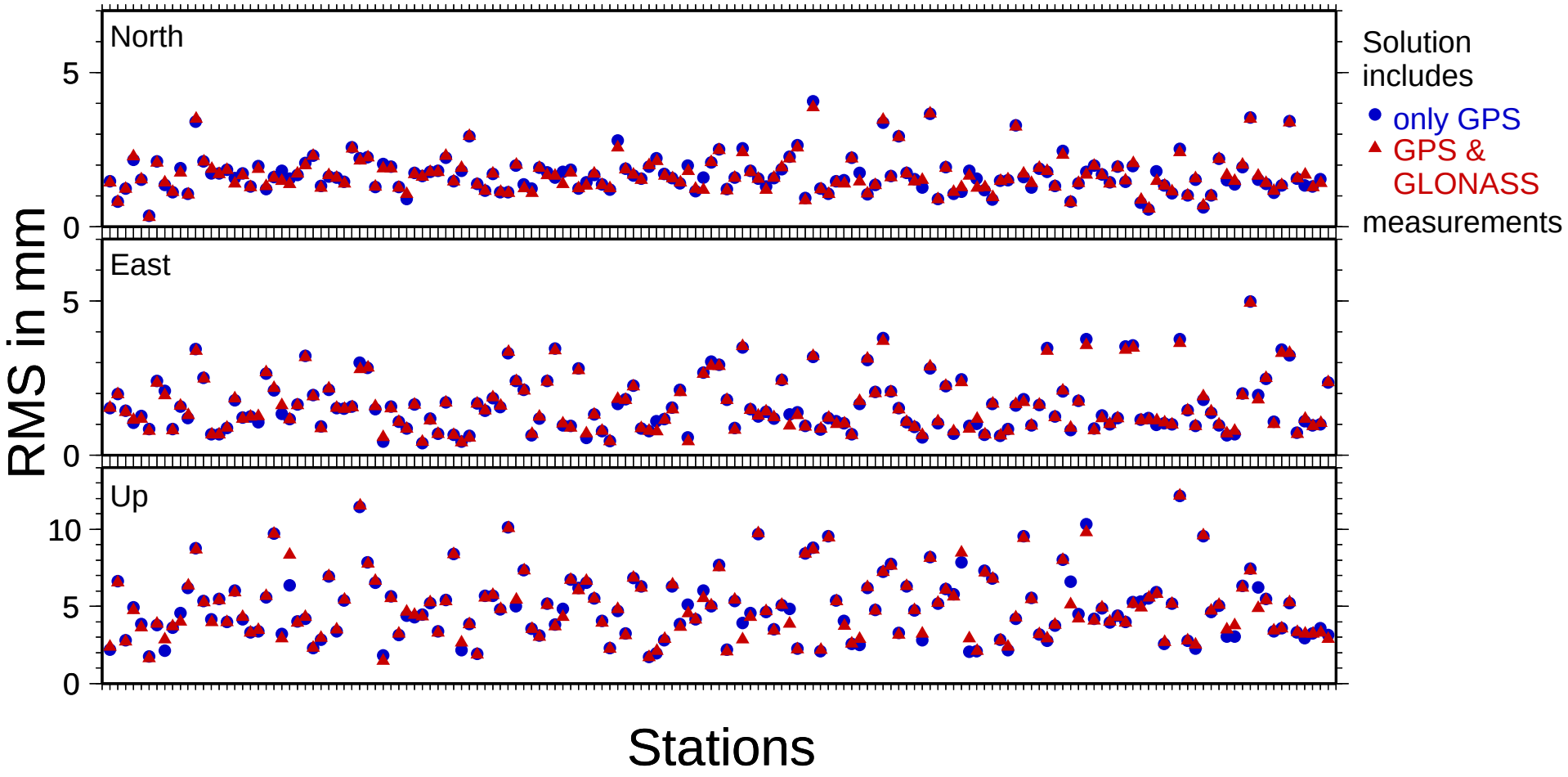
RMS of 8 daily coordinate solutions



CODE final solution for day of year 2007:060 to 067

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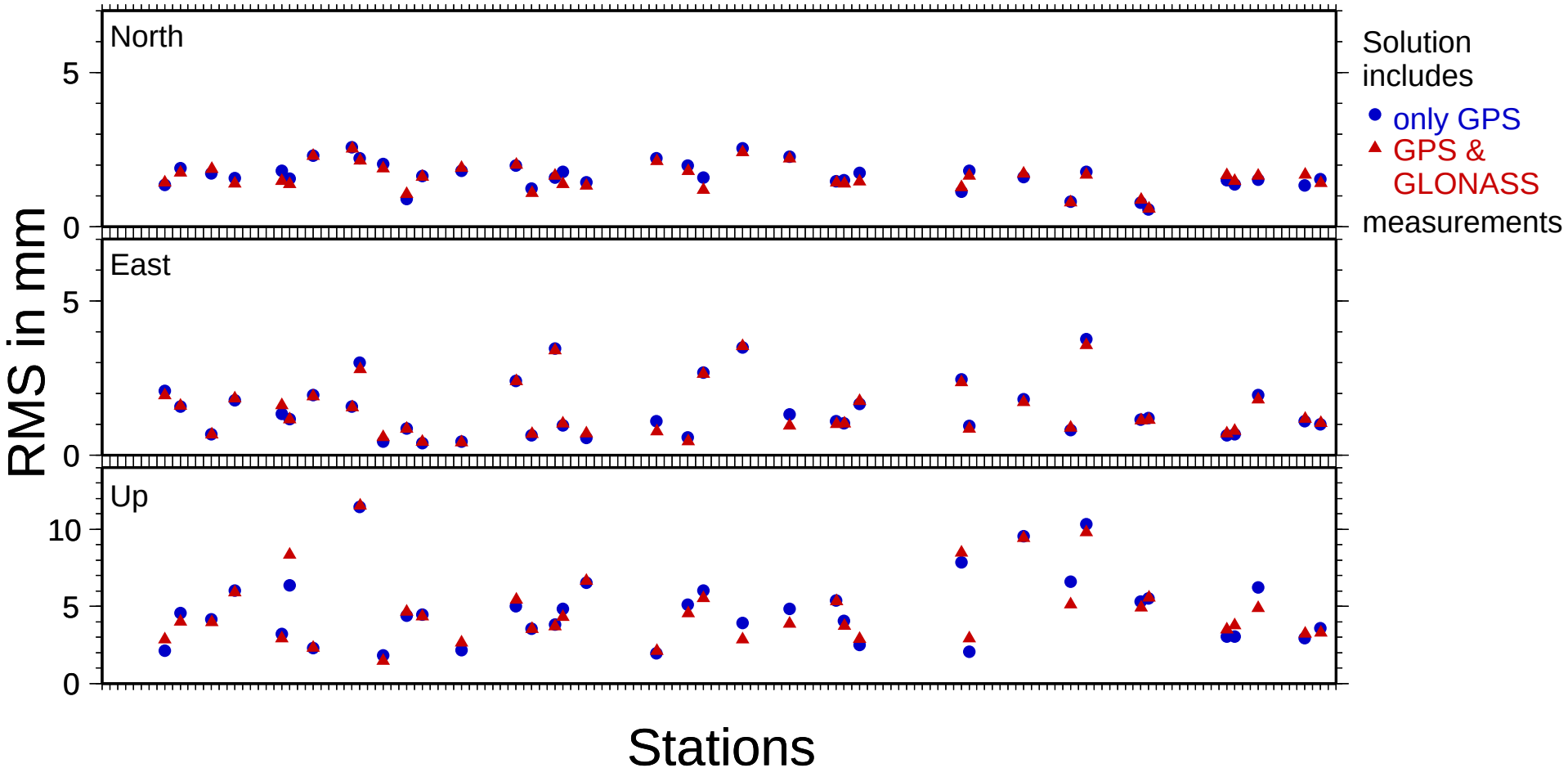

CODE final solution for day of year 2007:060 to 067

Summary and Conclusions

What did we learn from studying the orbit geometry?

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The GPS constellation

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The GLONASS constellation

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Summary and Conclusions

What did we learn from studying the orbit geometry?

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The GPS constellation

- has a strong repetition rate of a sideral day.
- is longitude dependent because each satellite follows its own ground track.
- has the dominant frequency at a sideral day in the spectrum of the variation of the satellite geometry.

The GLONASS constellation

- has a higher variability (repetition rate of 8 sideral days after 17 revolutions).
- is independent from the longitude because of the shift in the ground track for each day.
- has the dominant frequency at once per revolution in the spectrum of the variation of the satellite geometry (uncertainty of the orbits?).

Summary and Conclusions

Why to generate a multi–GNSS solution?

- to reduce the impact of the strong GPS constellation frequency of one sideral day to the obtained products.
- to improve products with a high resolution in time ($\sqrt{n}$–law, robustness).
- to reduce the impact of multipath to the solution.
- to be in place for including the new GNSS (Galileo, Compass?) as soon as data are available.

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What can a multi–GNSS solution never procide?

- to replace general improvements of the GNSS modelling (e.g., troposphere modelling).

IGS and multi–GNSS

IGS: from GPS to GNSS service

- since January 2008: two AC provide full multi–GNSS solutions
- merged GPS/GLONASS orbit file from the two final combinations
- development of a full multi–GNSS (orbit) combination procedure
- densification of the GLONASS tracking network in North America