GNSS Analysis at CODE

Stefan Schaer, Urs Hugentobler, Rolf Dach,
Michael Meindl, Heike Bock, Claudia Urschl,
Gerhard Beutler

2004 IGS Workshop
Berne, Switzerland
March 1-5

Astronomical Institute, University of Berne

CODE Rapid GNSS Orbit Product

- Since the beginning of May 2003, the CODE AC has been computing a rapid orbit product for both the GPS and the GLONASS satellite constellation.
- GPS and GLONASS orbits are generated at the same time in a rigorous GNSS analysis, ensuring best possible consistency between GPS and GLONASS orbits.
- This may be considered as an essential step towards routine analysis of multi satellite navigation systems, specifically in view of the upcoming *European GALILEO system*.
- The CODE rapid orbit product is usually available between 9 and 12 UT of the following day.

Motivation for Inclusion of GLONASS Tracking Data

1. First step for routine analysis of tracking data originating from two or more navigation satellite systems.
2. Regular testing of our development version of the Bernese Software in terms of the GLONASS capability.
3. Possible improvement of specific global parameters was definitively *not* a reason for this effort.

Important remark:

In our final analysis we benefit from products coming from our rapid analysis. It was therefore an absolute requirement for us to include GLONASS data already at the stage of the rapid analysis (to prevent dublicate analysis!). Data availability problems could be anticipated.

Detailed GNSS Data Monitoring

- Detailed monitoring concerning completeness and availability of IGS/IGLOS tracking data initiated at CODE.
- Corresponding charts are regularly posted to http://www.aiub.unibe.ch/download/igsdata/.
- Numerous e-mails sent to achieve improvement in terms of both completeness and availability of GNSS data.

Monitoring of Completeness of IGS/IGLOS GNSS Data (1)

```
bogi0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS EUROCARD
conz0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
crar0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  TPS LEGACY
darr0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
dlft0310.04o: G01 G02 G03             G07 G08         G11     G14 G15 G16     G18 G20         G23 G24 G25     G27 G28         G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
drej0310.04o: G01 G02 G03 G04         G07 G08 G09 G10     G13     G15 G16 G17 G18     G21         G24     G26 G27 G28 G29     G31 R03 R04 R05             R21 R22 R23 R24  JPS LEGACY
dwh10310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
ffmj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
godz0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
gope0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17     R21 R22 R23 R24  ASHTECH Z18
helj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
hert0310.04o: G01         G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
hueg0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
irkj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
joz20310.04o: G01 G02     G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17     R21 R22 R23 R24  ASHTECH Z18
khaj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22         G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
kir00310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS E_GGD
kou10310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
leij0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
lhaz0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
mar60310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
mat10310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
mdvj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
metz0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS EUROCARD
mtbg0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
mtka0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
novj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22         G25 G26 G27 G28 G29 G30     R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
ohi30310.04o: G01 G02     G04 G05 G06 G07     G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
onsa0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
reun0310.04o: G01 G02 G03 G04     G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
reyz0310.04o: G01         G04 G05 G06 G07     G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17     R21 R22 R23 R24  ASHTECH Z18
spt00310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
str20310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  TPS LEGACY
thu20310.04o: G01         G04 G05 G06 G07     G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
titz0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
unb10310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  TPS LEGACY
vis00310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS E_GGD
wroc0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
wtzj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
wtzz0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS E_GGD
yarr0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
zimj0310.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
```

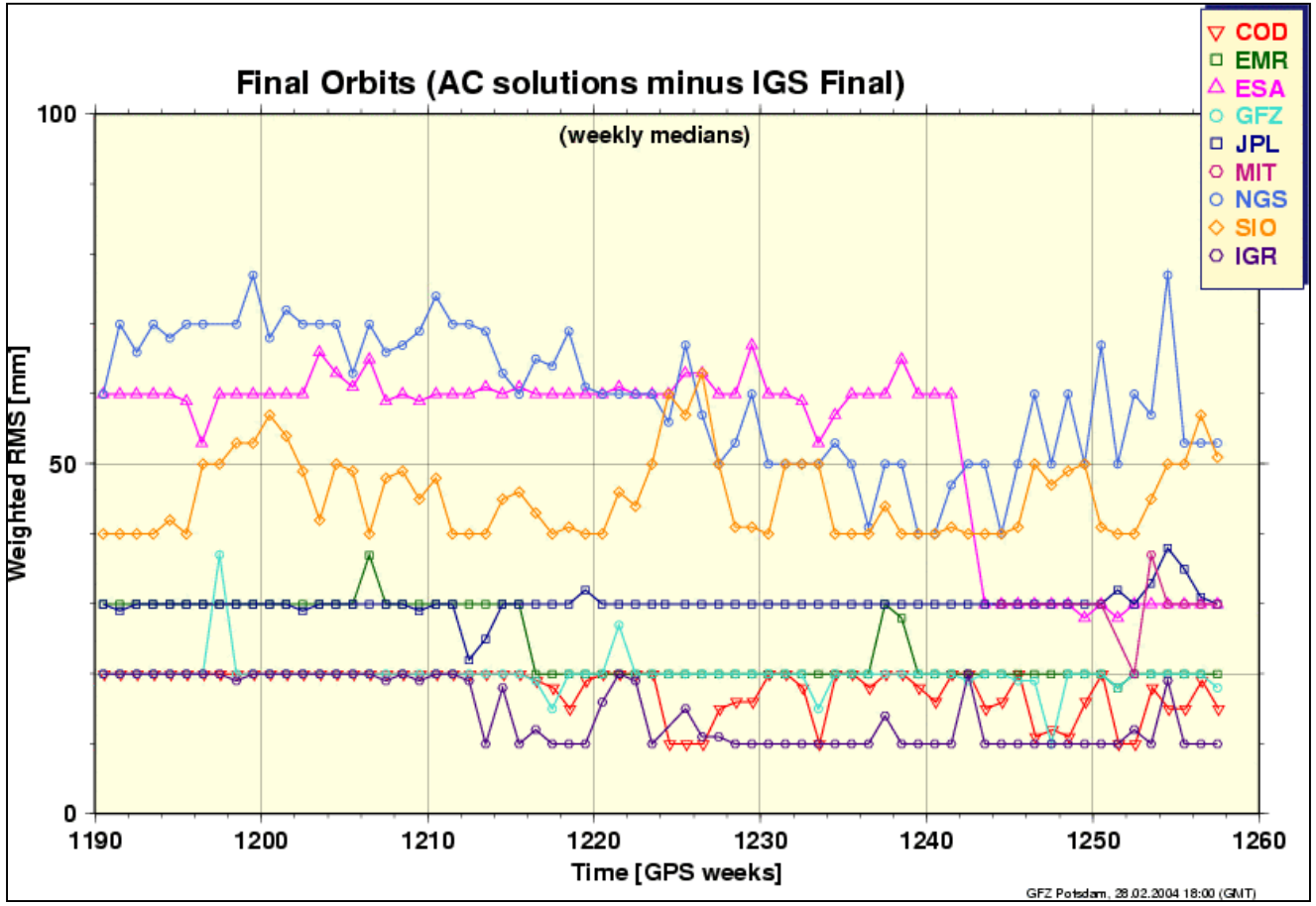
Monitoring of Completeness of IGS/IGLOS GNSS Data (2)

```
bogi0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS EUROCARD
conz0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
crar0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  TPS LEGACY
darr0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
dlft0300.04o: G01 G02 G03             G07 G08         G11     G14 G15 G16     G18 G20         G23 G24 G25     G27 G28         G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
drej0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
dwh10300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
ffmj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
godz0300.04o: G01         G04 G05     G07         G10     G13             G17     G20             G24     G26 G27 G28 G29 G30     R03 R04         R17 R18         R23 R24  ASHTECH Z18
gope0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17     R21 R22 R23 R24  ASHTECH Z18
helj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
hert0300.04o: G01 G02     G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
hueg0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
irkj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
joz20300.04o: G01 G02     G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17     R21 R22 R23 R24  ASHTECH Z18
khaj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22     G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
kir00300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS E_GGD
kou10300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
leij0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
lhaz0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
mar60300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
mat10300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
mdvj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
metz0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS EUROCARD
mtbg0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
novj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22         G25 G26 G27 G28 G29 G30     R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
ohi30300.04o: G01 G02     G04 G05 G06 G07     G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
onsa0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
reun0300.04o: G01 G02 G03 G04     G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
reyz0300.04o: G01         G04 G05 G06 G07     G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17     R21 R22 R23 R24  ASHTECH Z18
spt00300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
str20300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  TPS LEGACY
thu20300.04o: G01         G04 G05 G06 G07     G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
titz0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
unb10300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  TPS LEGACY
vis00300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS E_GGD
wroc0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
wtzj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05     R17 R18 R21 R22 R23 R24  JPS LEGACY
wtzz0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS E_GGD
yarr0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03     R05     R17 R18 R21 R22 R23 R24  ASHTECH Z18
zimj0300.04o: G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G13 G14 G15 G16 G17 G18 G20 G21 G22 G23 G24 G25 G26 G27 G28 G29 G30 G31 R03 R04 R05 R06 R17 R18 R21 R22 R23 R24  JPS LEGACY
```

CODE Final GNSS Products

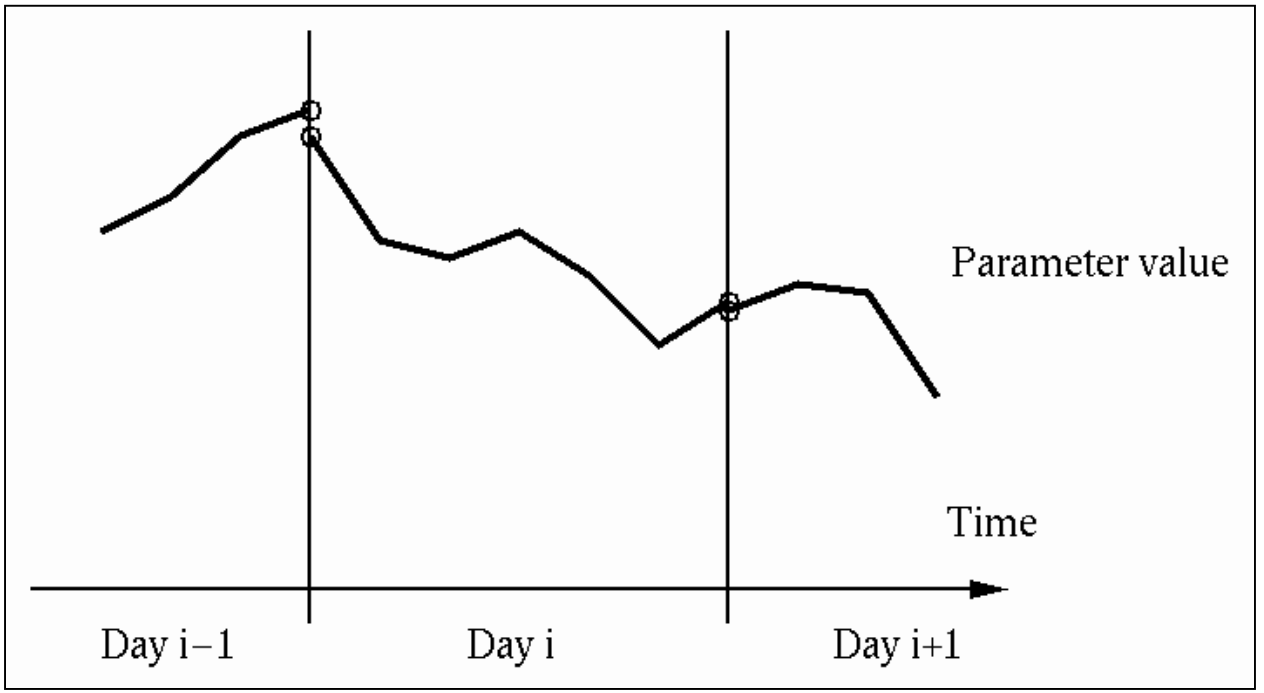
- CODE final analysis extended to GNSS on June 8, 2003 (GPS week 1222) for all products, apart from the clock product.
- Orbits: SP3 orbital positions are consistently referred to IGS00 (and the GPS time frame).
- SINEX: Weekly SINEX contributions now include station coordinates for a significant number of GPS/GLONASS tracking stations. GNSS-based ERP parameters (and geocenter coordinates) are the consequence of the common GNSS analysis.
- Tropospheric SINEX: Troposphere zenith path delay estimates are in addition available for a significant number of GPS/ GLONASS tracking stations.
- Clock RINEX: Not affected. Clock RINEX results are still a GPS-only product. Precise GLONASS satellite clock offset values are not yet computed.

IGS AC Final (GPS) Orbit Consistency



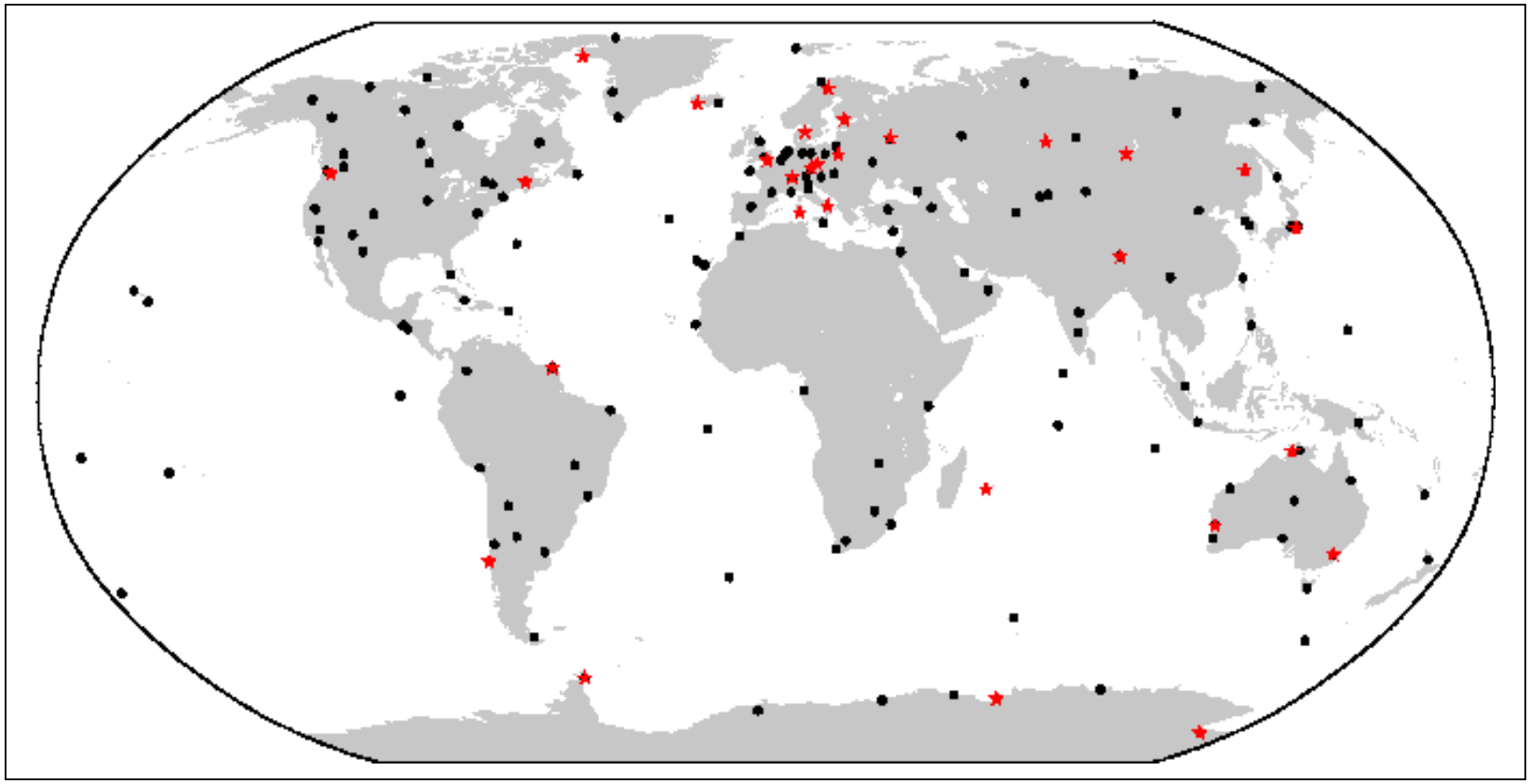
Courtesy: G. Gendt, GFZ, Potsdam, Germany

EOP and Troposphere Parameterization Continuous in Time



- 3-day solutions traditionally generated on the NEQ level.
- 1-day NEQ files include on average (explicitly) 4000 unknown parameters each ($8 \times 4000^2 = 128$ Mbytes/file).

IGS/IGLOS Tracking Network as Considered in CODE´s Final GNSS Analysis



Current GPS/GLONASS Satellite Constellation

List of GNSS satellites active within the last 30 days:

- 29 GPS satellites: G01, G02[1], G03, G04, G05, G06, G07, G08, G09, G10, G11, G13, G14, G15, G16, G17, G18, G20, G21, G22, G23[2], G24, G25, G26, G27, G28, G29, G30, G31
- 11 GLONASS satellites: R02, R03, R04, R05[3], R06[1,3], R17, R18, R21, R22, R23[1], R24

[1]Satellite currently inactive, or marked unhealthy

[2]Satellite decommissioned from service (16-Feb-2003)

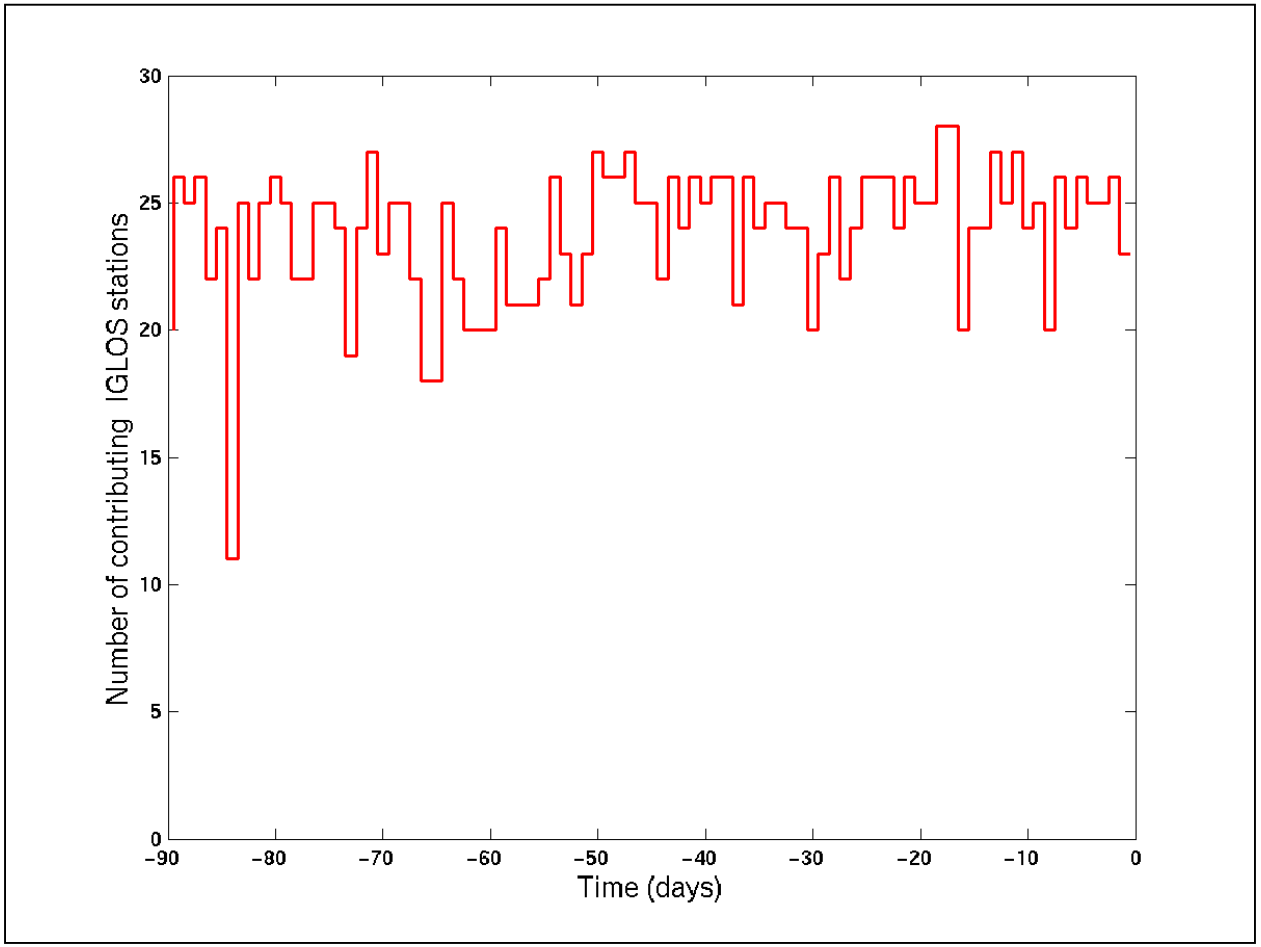
[3]Satellite of GLONASS-M modernization program

IGLOS Daily Data Availability for Rapid and Final Analysis

```
DoY       032     039     046     053
Week      1256    1257    1258    1259
DoW   56 0123456 0123456 0123456 0123456
-----------------------------------------------
crar: ** ******* ******* ******* ******* 100.0%
dwh1: ** ******* ******* ******* ******* 100.0%
hert: ** ******* ******* ******* ******* 100.0%
joz2: ** ******* ******* ******* ******* 100.0%
mat1: ** ******* ******* ******* ******* 100.0%
onsa: ** ******* ******* ******* ******* 100.0%
zimj: ** ******* ******* ******* ******* 100.0%
darr: ** ******* ******* ****L** *******  96.7%
gope: ** ******* ******* ******* *L*****  96.7%
ohi3: ** ******* ******* L****** *******  96.7%
reyz: ** ******* ******* L****** *******  96.7%
unb1: ** L****** ******* ******* *******  96.7%
cagz: -- -****** ****L** ******* *******  96.3%
irkj: ** ***L*** ******* ******* *L*****  93.3%
conz: ** ******* ******* L*****L L******  90.0%
kou1: ** L*L**** ******* -****** *******  90.0%
mdvj: ** ***LL** ******* ******* *L*****  90.0%
wtzz: ** ***LL** ******* L****** *******  90.0%
str2: LL L*-**** ****L** L****** *******  88.9%
kir0: ** *L**L** ***L*** ******* *L*****  86.7%
metz: ** *L*L*** LL***** *L***** *******  83.3%
reun: ** ****L** ******* ******- **-**--  83.3%
thu2: ** LL***** ******* ***LL** ****L**  83.3%
yarr: ** ******* *L***** *L-**** ***--**  83.3%
novj: ** LL*L*** ******* LLL**** *L*****  76.7%
mtka: -* L*L**LL *---L** ****-** *-*L***  62.1%
khaj: *L ***L*LL L**L*** **L**LL LL*L*L-  53.3%
davr: -L -L*L*L* *LL**** LLL***L LLLL*--  46.2%
lhaz: LL LL**L*- ------- ------- -------  11.5%
-----------------------------------------------
```

```
DoY         032     039     046     053
Week        1256    1257    1258    1259
DoW   23456 0123456 0123456 0123456 0123
-----------------------------------------------
conz: ***** ******* ******* ******* **** 100.0%
crar: ***** ******* ******* ******* **** 100.0%
darr: ***** ******* ******* ******* **** 100.0%
dwh1: ***** ******* ******* ******* **** 100.0%
gope: ***** ******* ******* ******* **** 100.0%
hert: ***** ******* ******* ******* **** 100.0%
irkj: ***** ******* ******* ******* **** 100.0%
joz2: ***** ******* ******* ******* **** 100.0%
khaj: ***** ******* ******* ******* **** 100.0%
kir0: ***** ******* ******* ******* **** 100.0%
mat1: ***** ******* ******* ******* **** 100.0%
mdvj: ***** ******* ******* ******* **** 100.0%
novj: ***** ******* ******* ******* **** 100.0%
ohi3: ***** ******* ******* ******* **** 100.0%
onsa: ***** ******* ******* ******* **** 100.0%
reyz: ***** ******* ******* ******* **** 100.0%
thu2: ***** ******* ******* ******* **** 100.0%
unb1: ***** ******* ******* ******* **** 100.0%
wtzz: ***** ******* ******* ******* **** 100.0%
zimj: ***** ******* ******* ******* **** 100.0%
kou1: ***** ******* ******* -****** ****  96.7%
metz: ***** ******* ******* *L***** ****  96.7%
str2: ***L* **-**** ******* ******* ****  93.3%
yarr: ***** ******* ******* **-**** ***-  93.3%
cagz: ***-- -****** ******* ******* ****  90.0%
reun: **-** ******* ******* ******- **-*  90.0%
mtka: ***-* ******* *---*** ****-** *-**  80.0%
davr: ----L -****** **LL*** LL**LLL L***  66.7%
lhaz: LLLLL ******- ------- ------- ----  24.0%
-----------------------------------------------
```

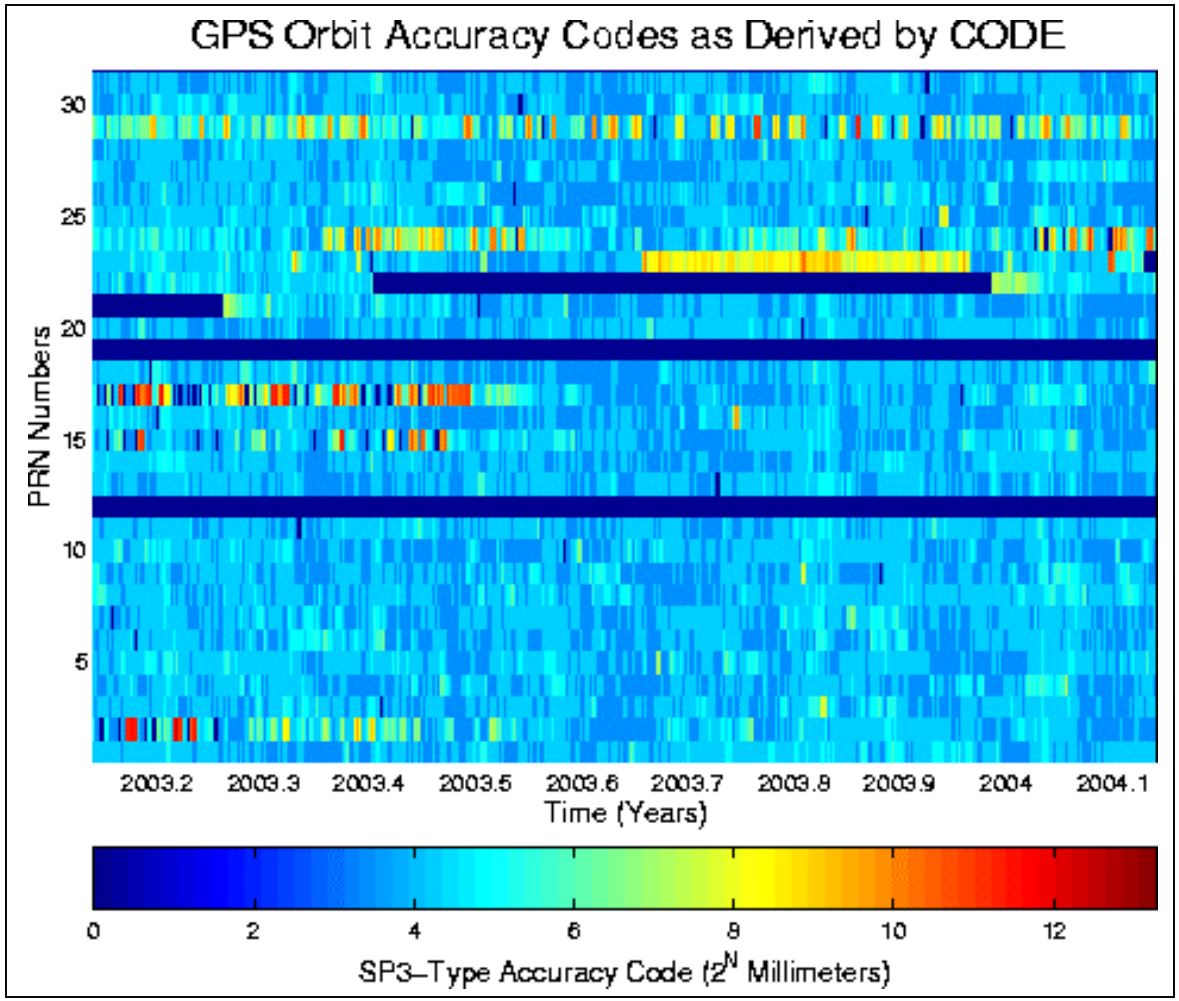
Number of IGLOS Stations Contributing to the CODE Rapid Orbit Product



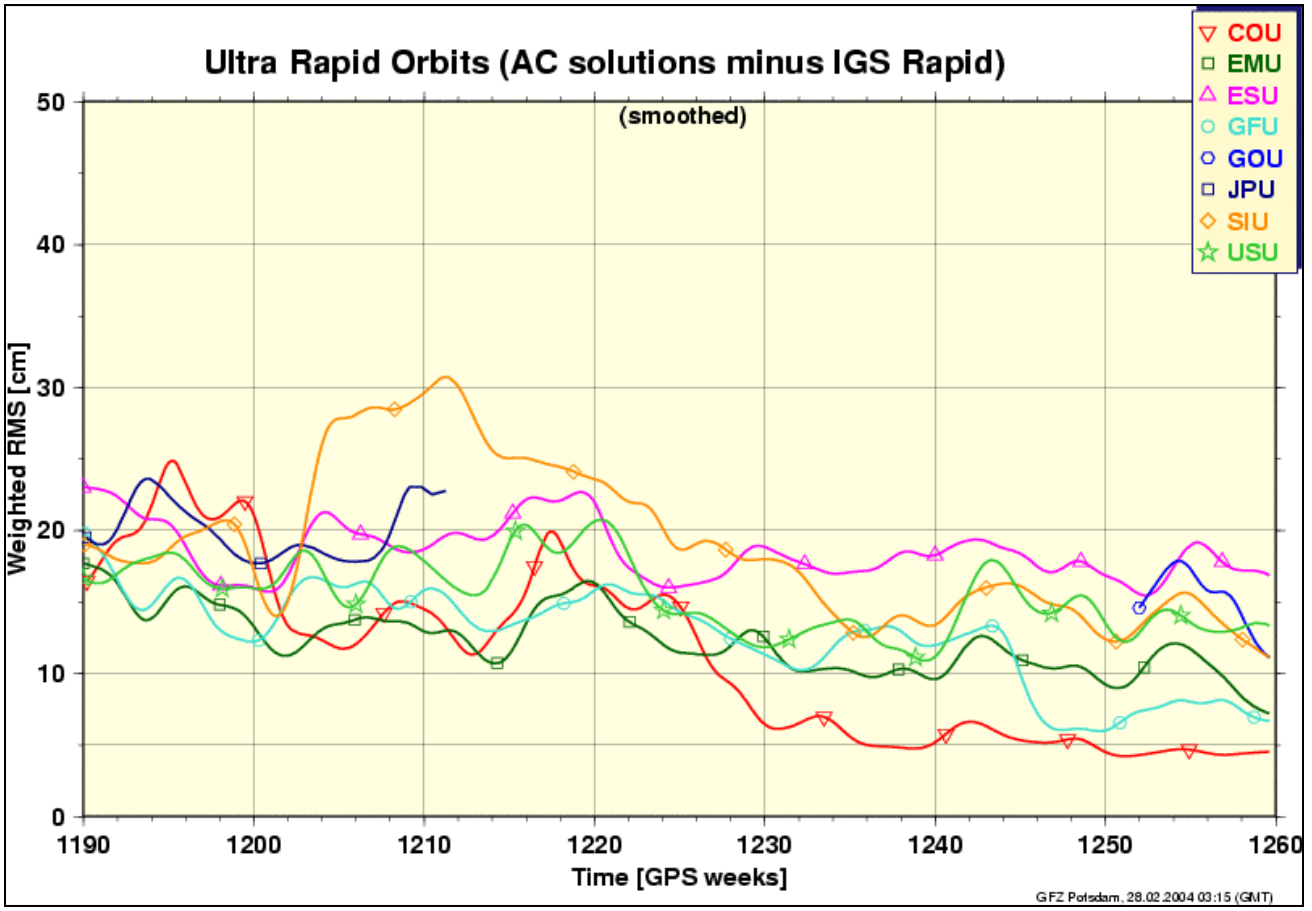
CODE Ultra-Rapid Orbit Product

- Production of CODE ultra-rapid orbits commenced officially on July 30, 2003, now considering NRT tracking data.
- From the beginning, this product did cover orbits for the GLONASS satellite constellation.
- Ultra-rapid orbit updates include ambiguity resolution for baselines up to 6000 km length. Historical rapid orbit information is used for long-arc combination on the NEQ level.
- It is complete with respect to all transmitting satellites and has been available *without exception* since the start.
- Reliable SP3-type accuracy codes are provided.

Identification of Misbehaving, or Badly Predictable GPS Satellites

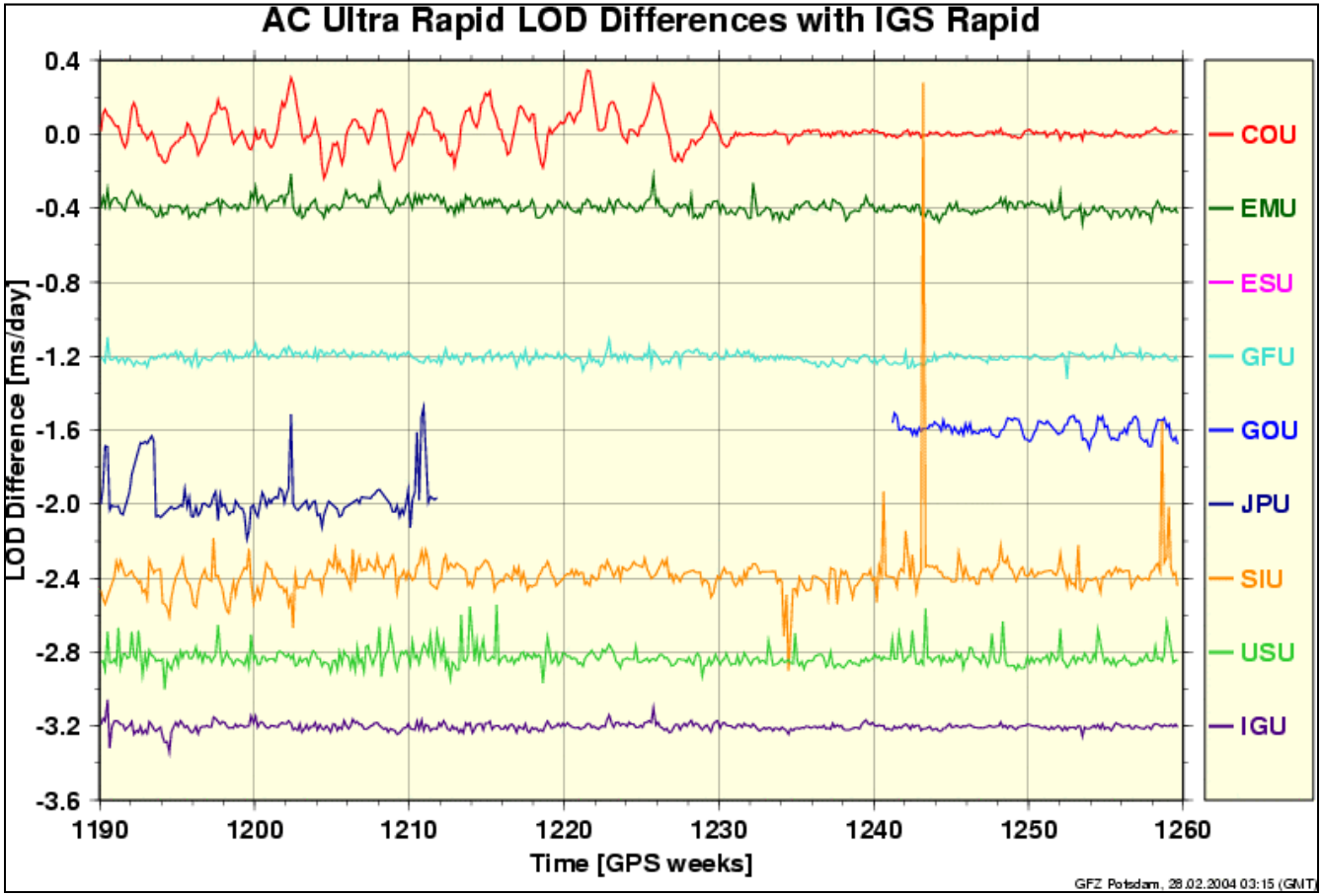


IGS AC Ultra-Rapid (GPS) Orbit Consistency



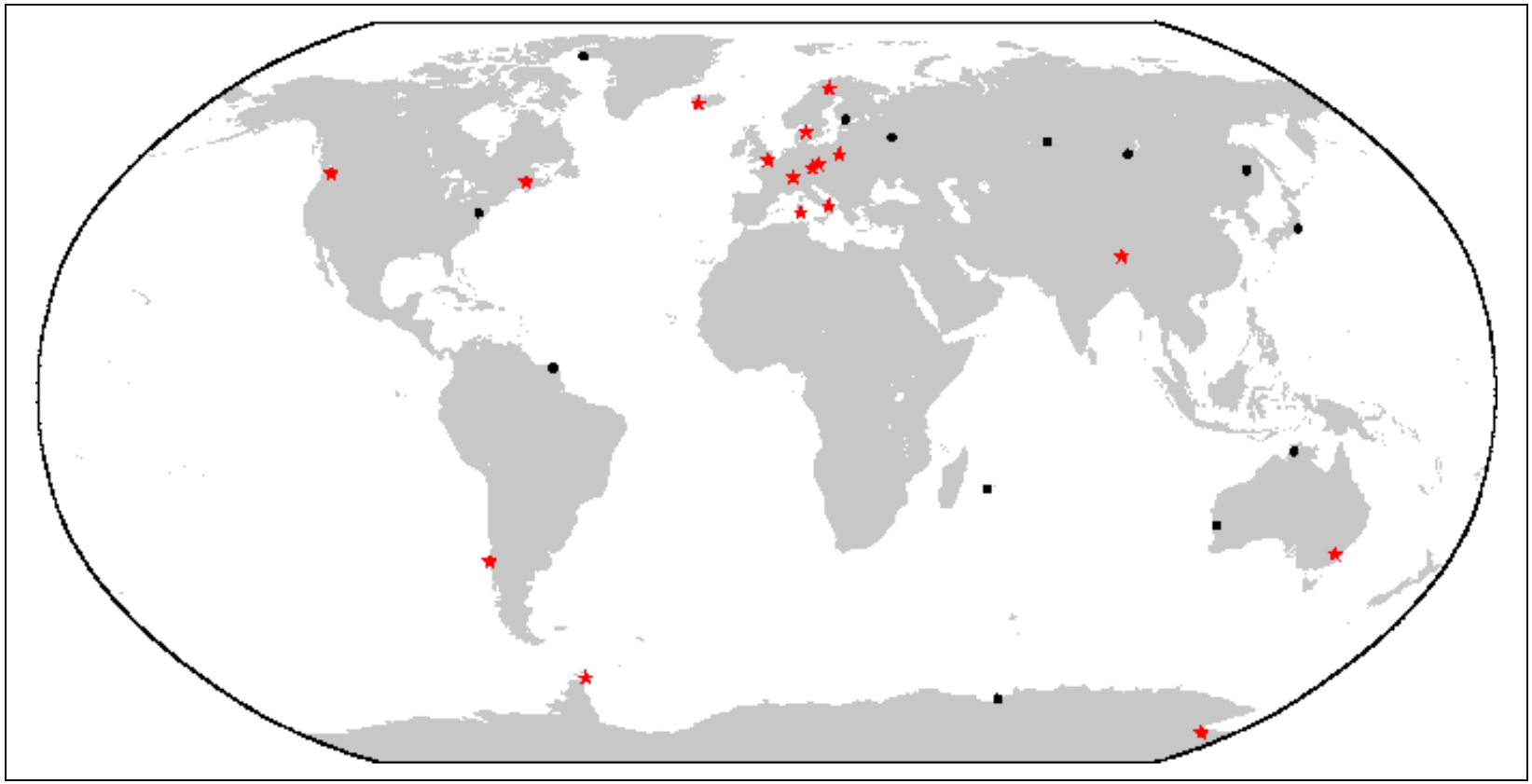
Courtesy: G. Gendt, GFZ, Potsdam, Germany

IGS AC Ultra-Rapid LOD Consistency

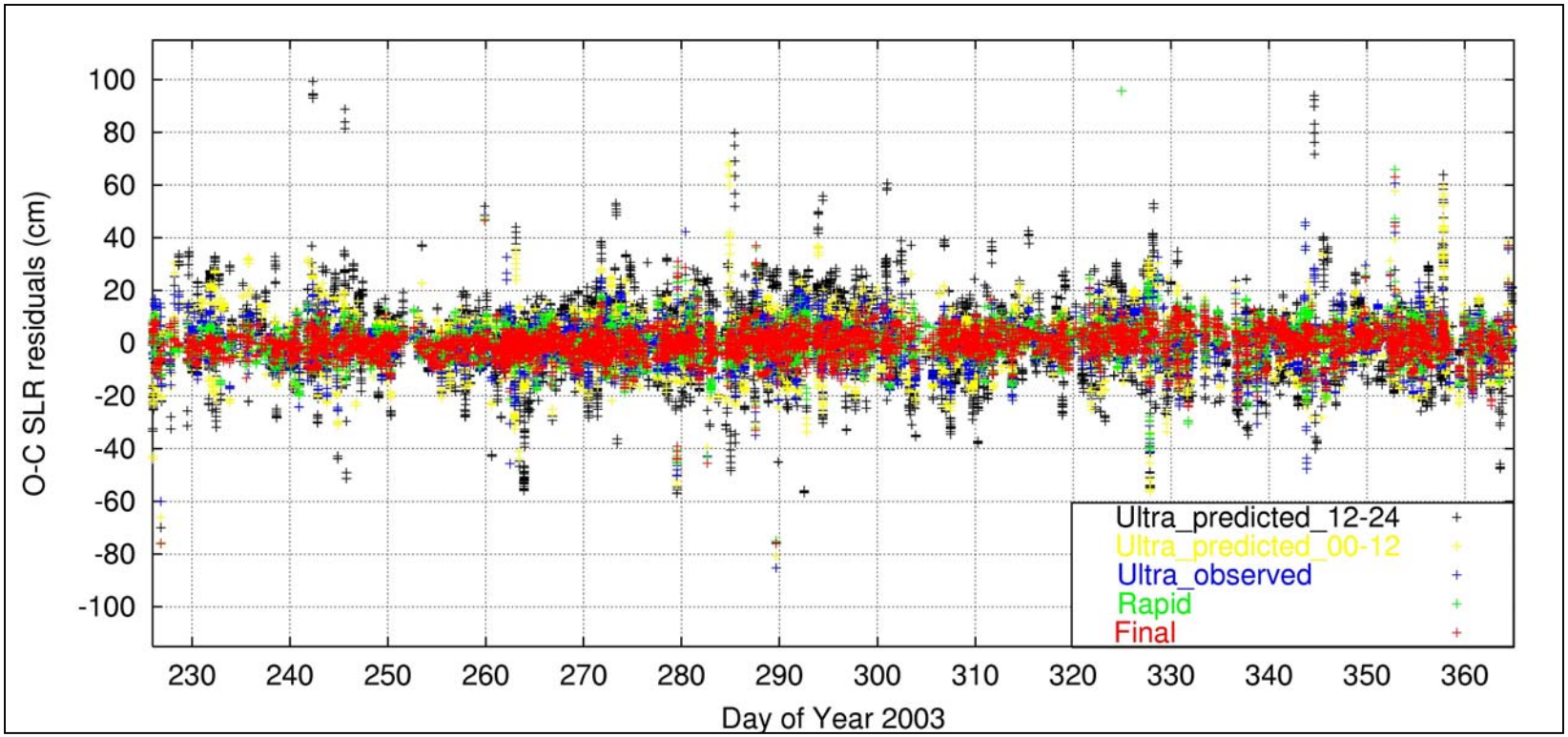


Courtesy: G. Gendt, GFZ, Potsdam, Germany

IGLOS Tracking Network as Considered in CODE´s Ultra-Rapid GNSS Analysis

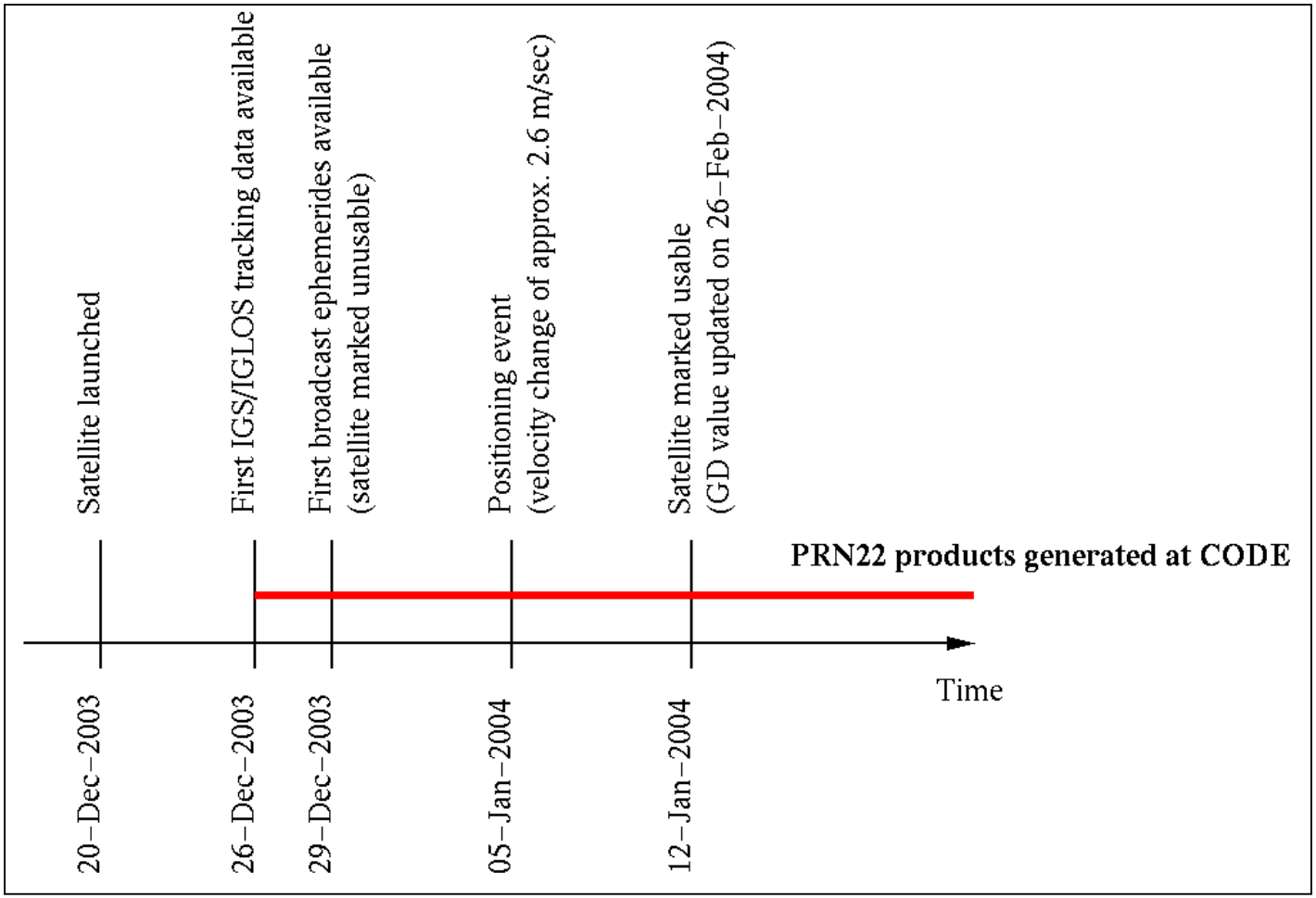


CODE GLONASS Orbit Validation Using SLR Data

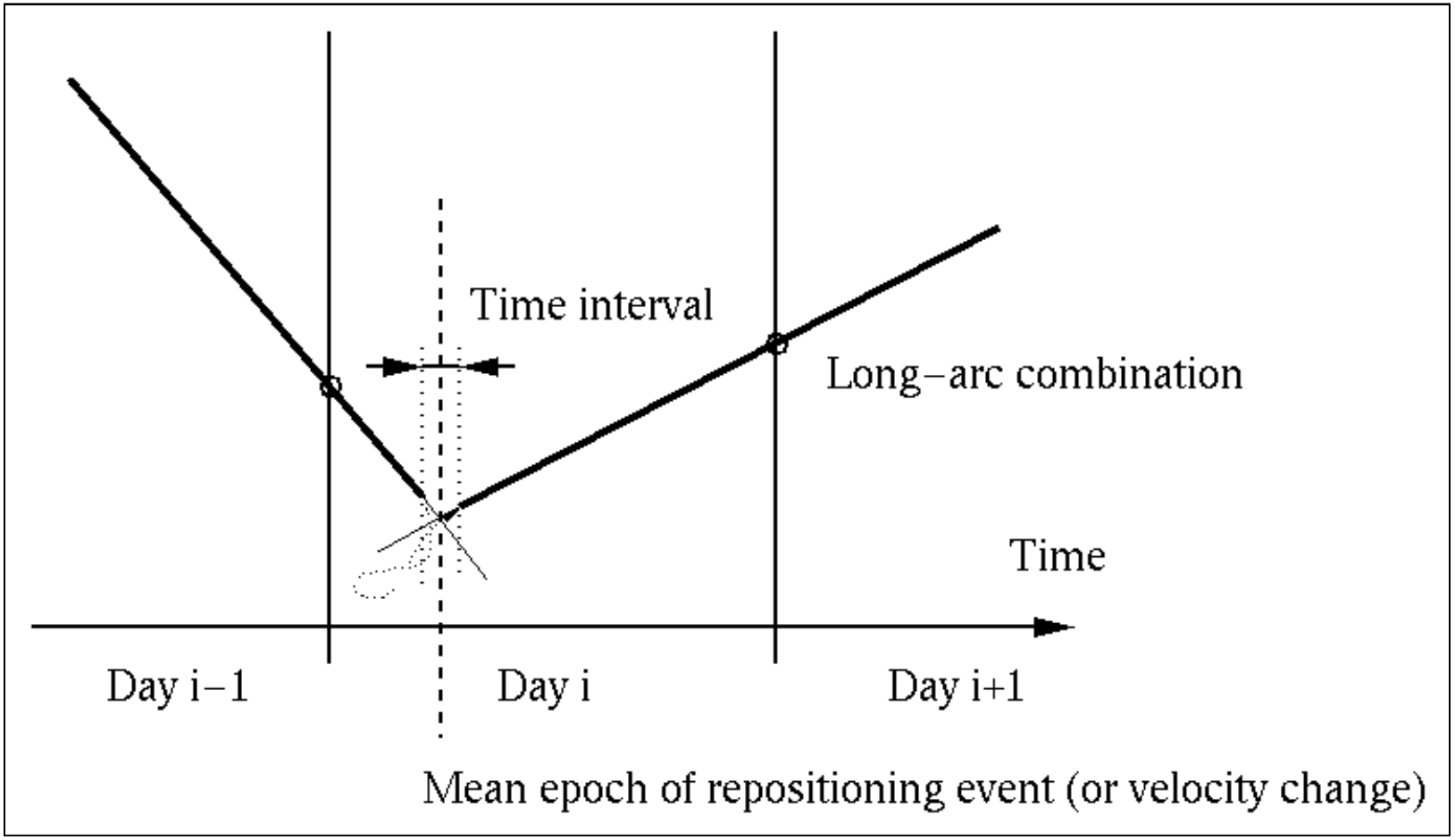


Standard deviation: 13 – 9 – 7 – 6 – 5 cm

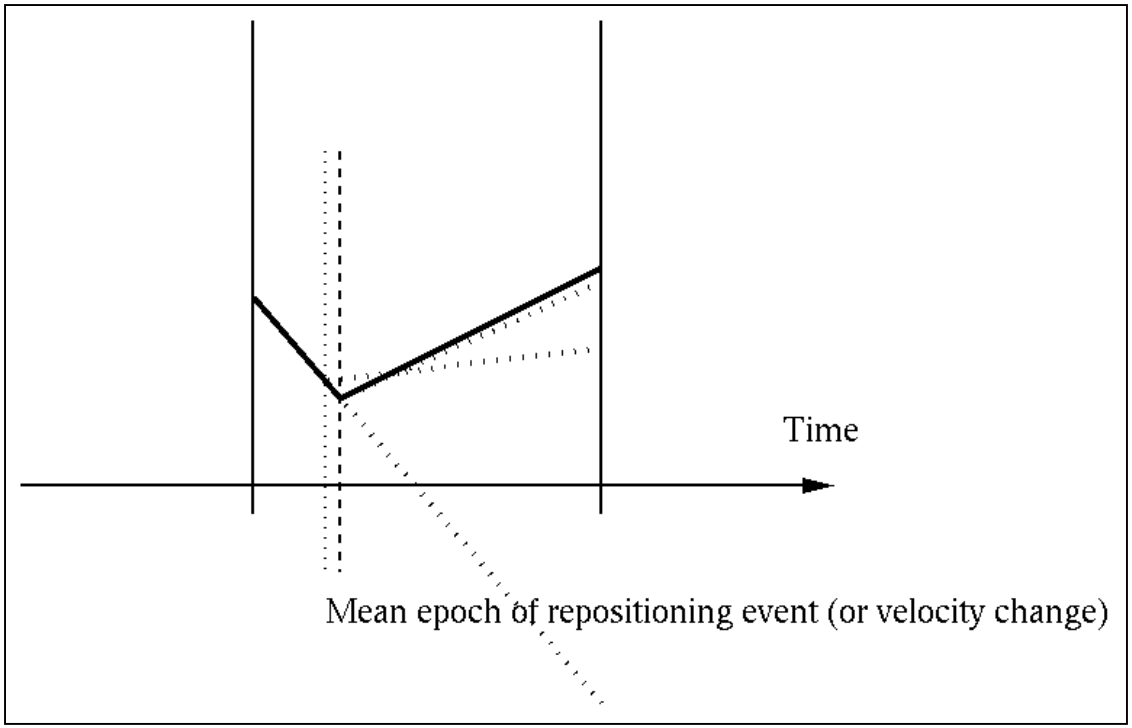
Chronology of the Most Recent GPS Block-IIR Satellite Launch (PRN22)



Orbit Determination for GPS Satellites Being Repositioned

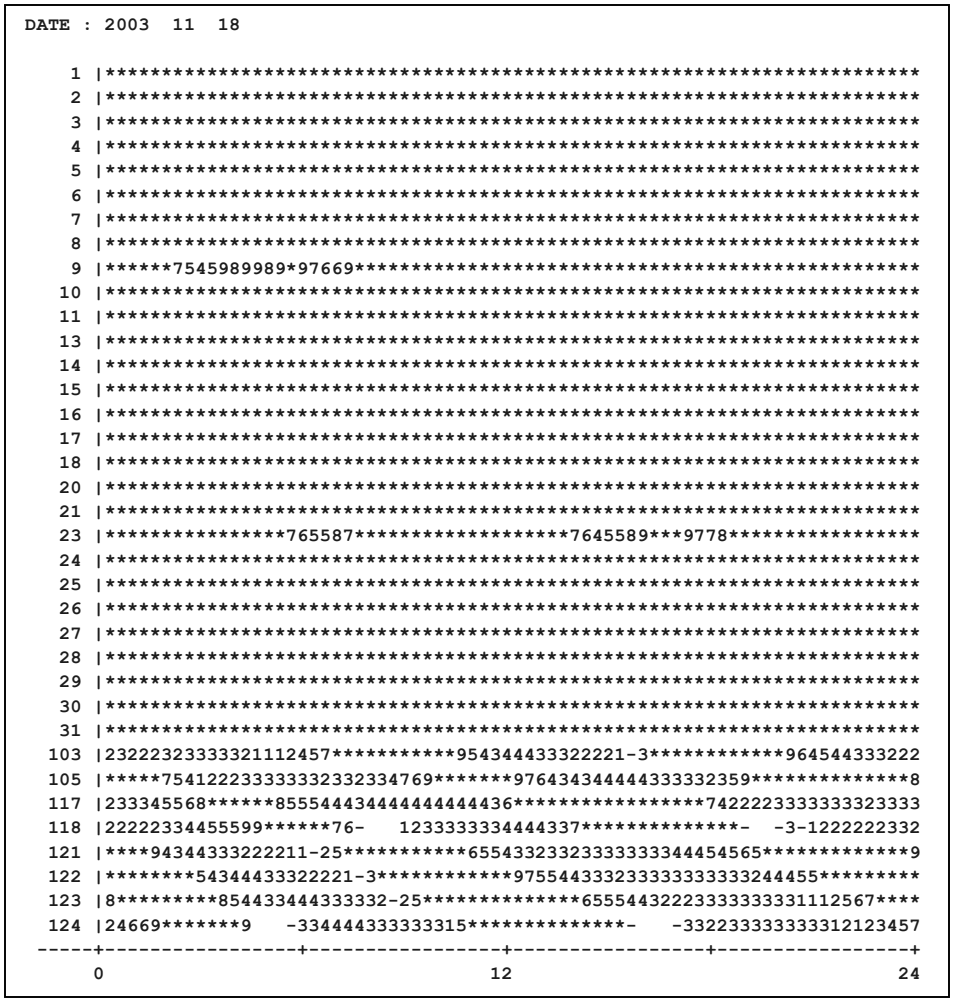


Orbit Initialization for GPS Satellites Being Repositioned

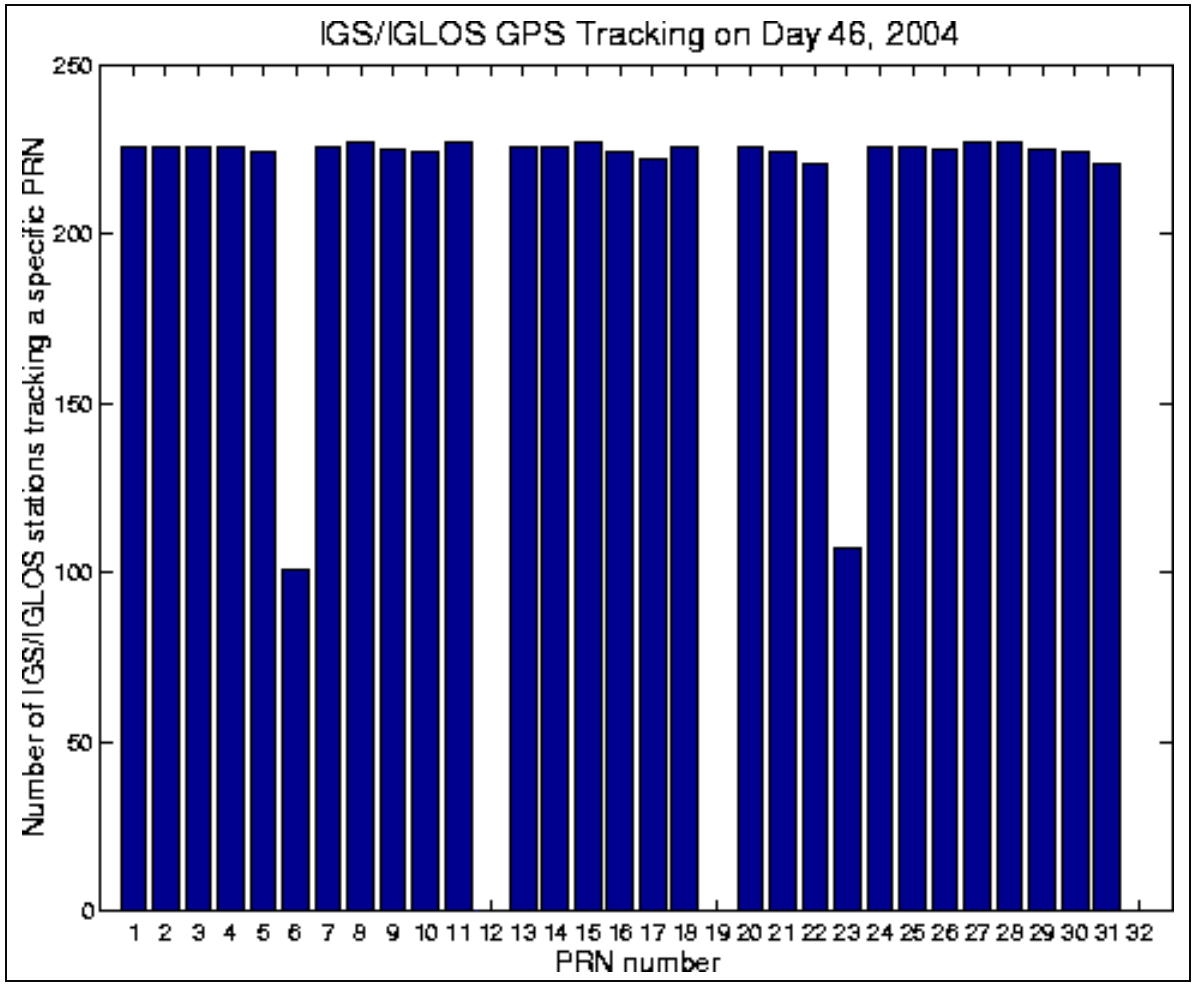


- Data used: double-difference pseudorange measurements
- Parameters solved for: Keplerian orbit elements and inter-system (GPS-GLONASS) receiver DCB parameters

Tracking Situation Concerning G09 Being Repositioned, G23 Marked Unusable, and Eclipsing R18 and R24



IGS/IGLOS Tracking of GPS Satellites Marked Unhealthy



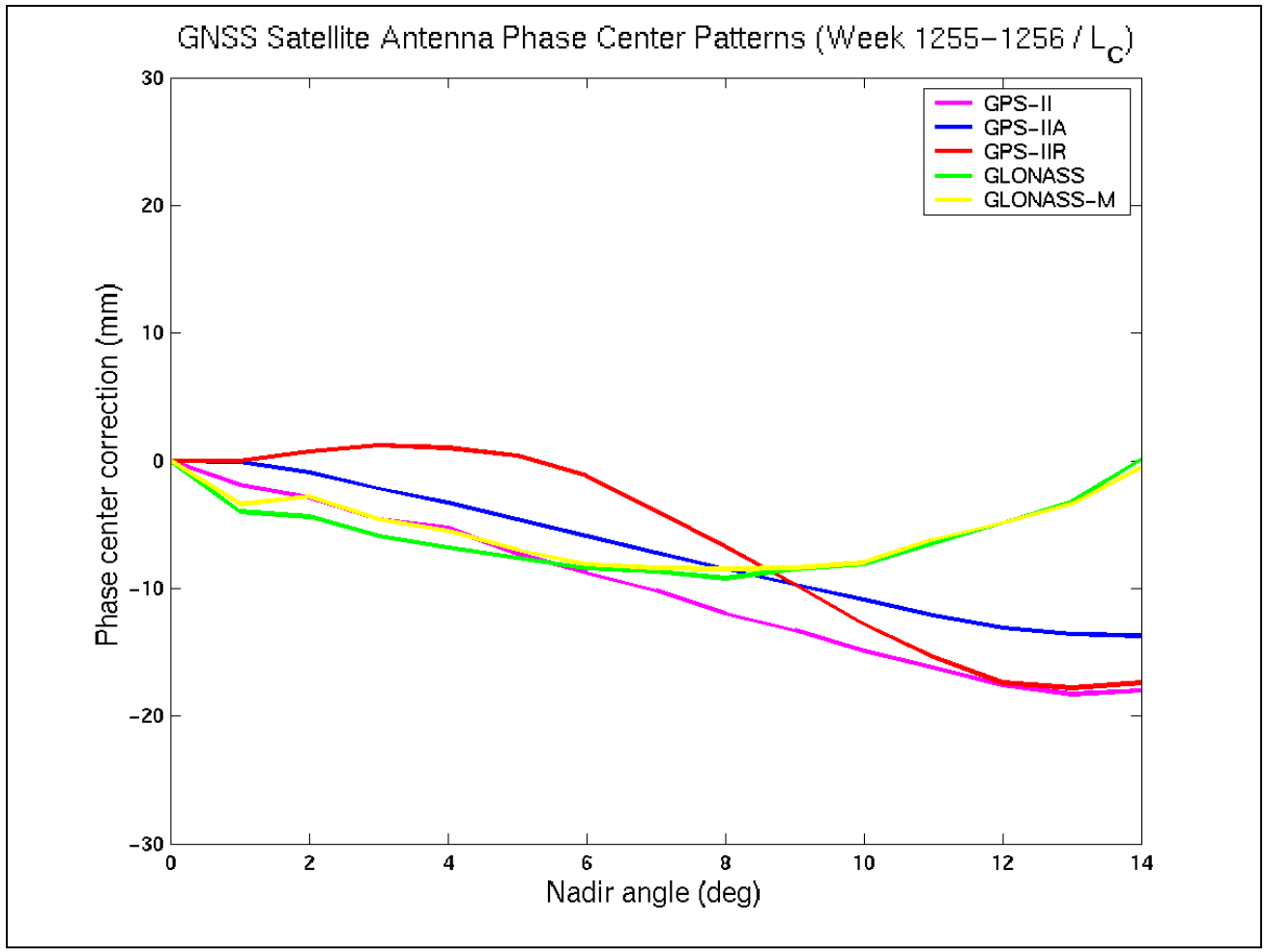
IGLOS Hourly Data Latency at the BKG Data Center

	Delay in minutes				
Site	Min	Mean	SDev	Availability	Data center
BOGI	3	3.2	1.0	86.7%	BKG_IGEX
CAGZ	36	36.0	0.5	85.4%	BKG_IGEX
CONZ	3	4.7	4.2	88.8%	BKG_IGEX
DREJ	3	3.2	1.0	96.4%	BKG_IGEX
FFMJ	3	3.2	1.0	96.1%	BKG_IGEX
GOPE	3	4.2	0.9	91.4%	BKG_IGEX
HELJ	3	3.2	1.0	82.9%	BKG_IGEX
HERT	3	4.2	0.9	99.2%	BKG_IGEX
HUEG	3	3.2	1.0	91.4%	BKG_IGEX
JOZ2	4	4.4	1.0	97.6%	BKG_IGEX
LEIJ	3	3.2	1.0	95.0%	BKG_IGEX
MAT1	4	4.8	3.1	89.9%	BKG_IGEX
OHI3	3	5.2	4.0	74.6%	BKG_IGEX
REYZ	3	5.3	4.3	91.1%	BKG_IGEX
SPT0	3	4.1	3.3	93.5%	BKG_IGEX
TITZ	3	3.2	1.0	92.4%	BKG_IGEX
WROC	3	4.2	1.5	92.2%	BKG_IGEX
WTZJ	3	3.2	1.0	95.8%	BKG_IGEX
WTZZ	3	5.4	4.1	96.4%	BKG_IGEX
ZIMJ	3	3.3	1.3	99.3%	BKG_IGEX
ZIMJ	24	25.8	5.8	82.5%	CDDIS
ZIMJ	35	35.2	0.8	79.0%	JPL
ZIMJ	31	33.2	3.3	71.9%	SOPAC
DWH1	3	3.1	1.1	95.4%	CDDIS
DWH1	0	1.0	4.9	95.4%	SOPAC

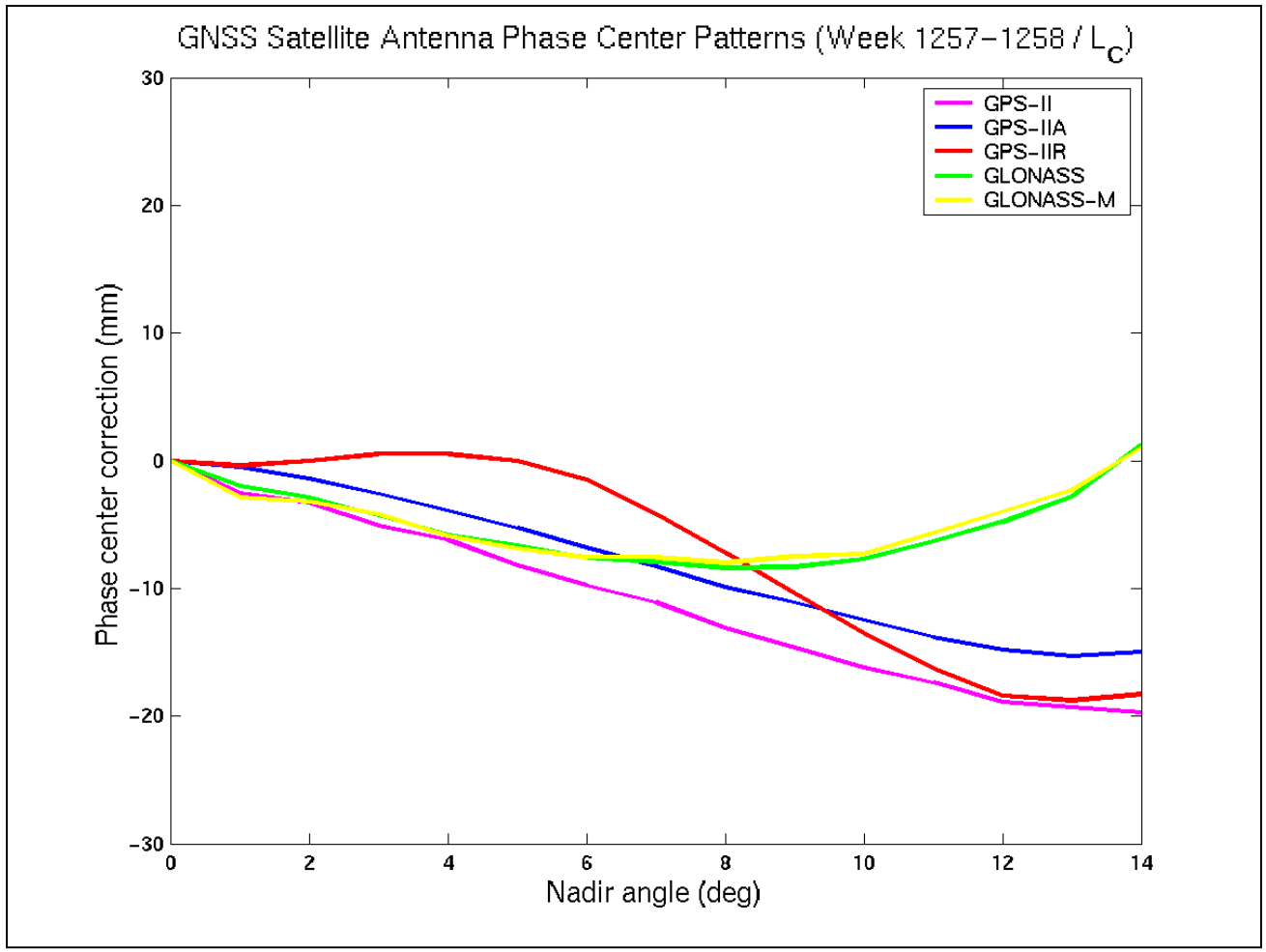
Estimation of GNSS Satellite Antenna Phase Center Patterns and Offsets Responding to the Ionospere-Free LC

- Regular estimation of GNSS satellite antenna phase center patterns for GPS-II, GPS-IIA, GPS-IIR, GLONASS and GLONASS-M satellite types started with GPS week 1254.
- Corresponding patterns are not only available for the ionosphere-free linear combination but also for the geometry-free (L1-L2) linear combination.

GNSS PCV Patterns – First Results (1)



GNSS PCV Patterns – First Results (2)



Summary (1)

- Final (>150), rapid (100), as well as ultra-rapid (65) orbit products computed at CODE do *generally* include both GPS and GLONASS. GLONASS results get automatically filtered out in all IGS combination processes.
- CODE GNSS orbit information is provided in SP3**c**.
- By submitting additional backup ultra-rapid orbit solutions, a 100% reliability could be reached until now.
- We demontrate that operational GNSS POD is possible, even for satellites being repositioned.
- Generation of final as well as rapid (phase-consistent) high-rate (30-sec) GPS clock products.
- Use of new, powerful BPE (Bernese Processing Engine) V5.0 for automated and efficient GNSS data processing.

Summary (2)

- Implementation of alerting via e-mail, computer terminal, and SMS messages in case of BPE processing failures, computer, or disk problems, ftp connection problems, general IGS/IGLOS data flow problems, GNSS satellite constellation changes, IGS/IGLOS tracking stations becoming active or inactive (concerning both hourly and daily data flow).

Concluding Remarks on IGS/IGLOS Tracking

Let us remind once more that GNSS tracking data, the primary product line of the IGS, is the basis for all IGS analysis products and consequently a crucial factor for their quality!

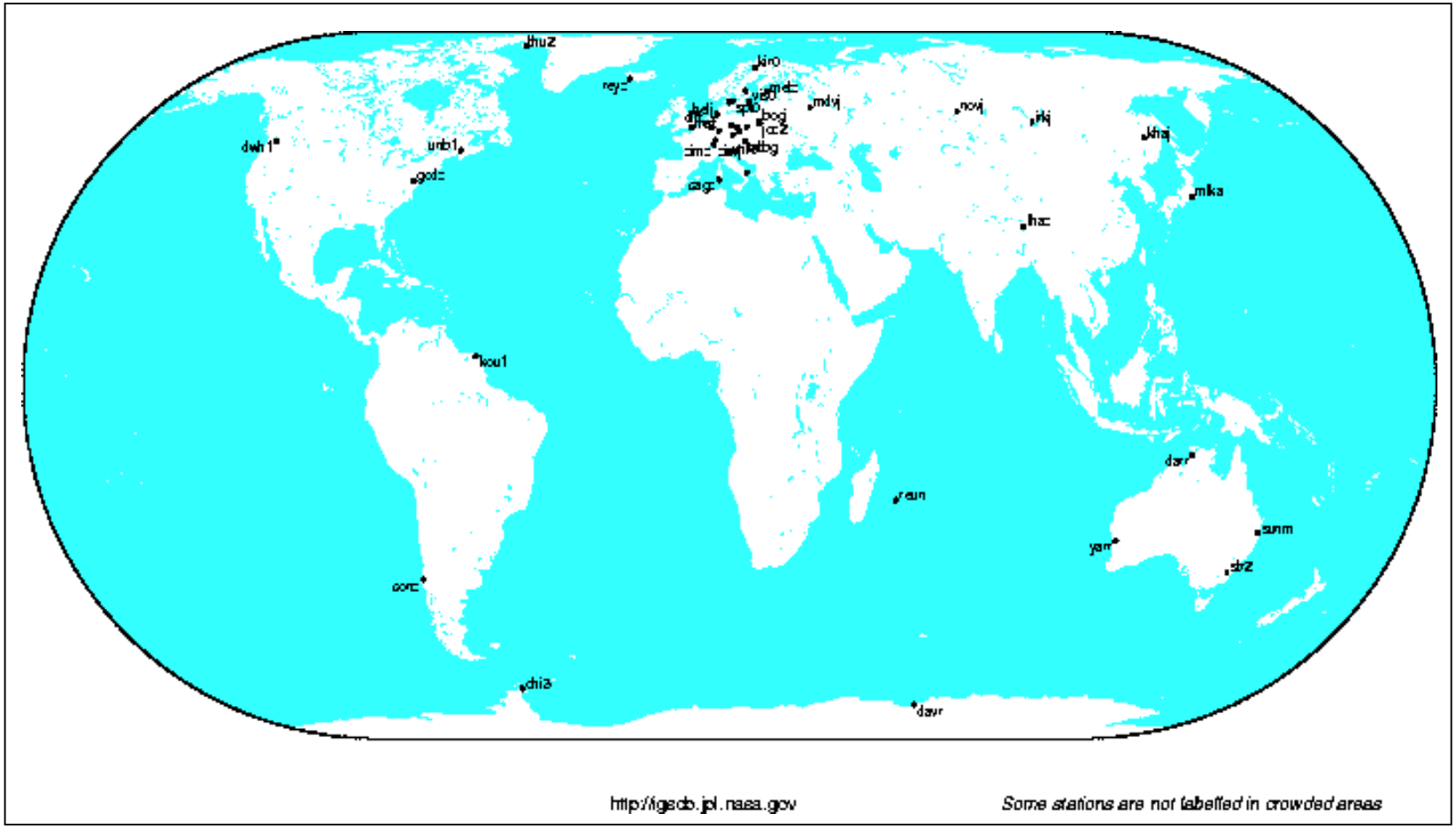
From our point of view, each GNSS station of the IGS/IGLOS ground network should, as far as possible, *sample all transmitting satellites from horizon to horizon* (barring obstructions).

This implies that a GPS/GNSS receiver being operated as continous station should allow for an *all-in-view* tracking mode (at the station operator´s specific request).

IGS-Combined Final GNSS Orbit Product?

- In addition to CODE´s final GNSS orbit product, GLONASS-only products computed at BKG and at ESA/ESOC are meanwhile regularly available with nominal delay as applied to the final GPS orbit product, in principle enabling synchronous GPS and GLONASS orbit combination.
- In this context, it is worth mentioning that there is a serious interest from the EUREF/EPN analysis community in estabishment of an IGS-combined final GPS/GLONASS orbit product.

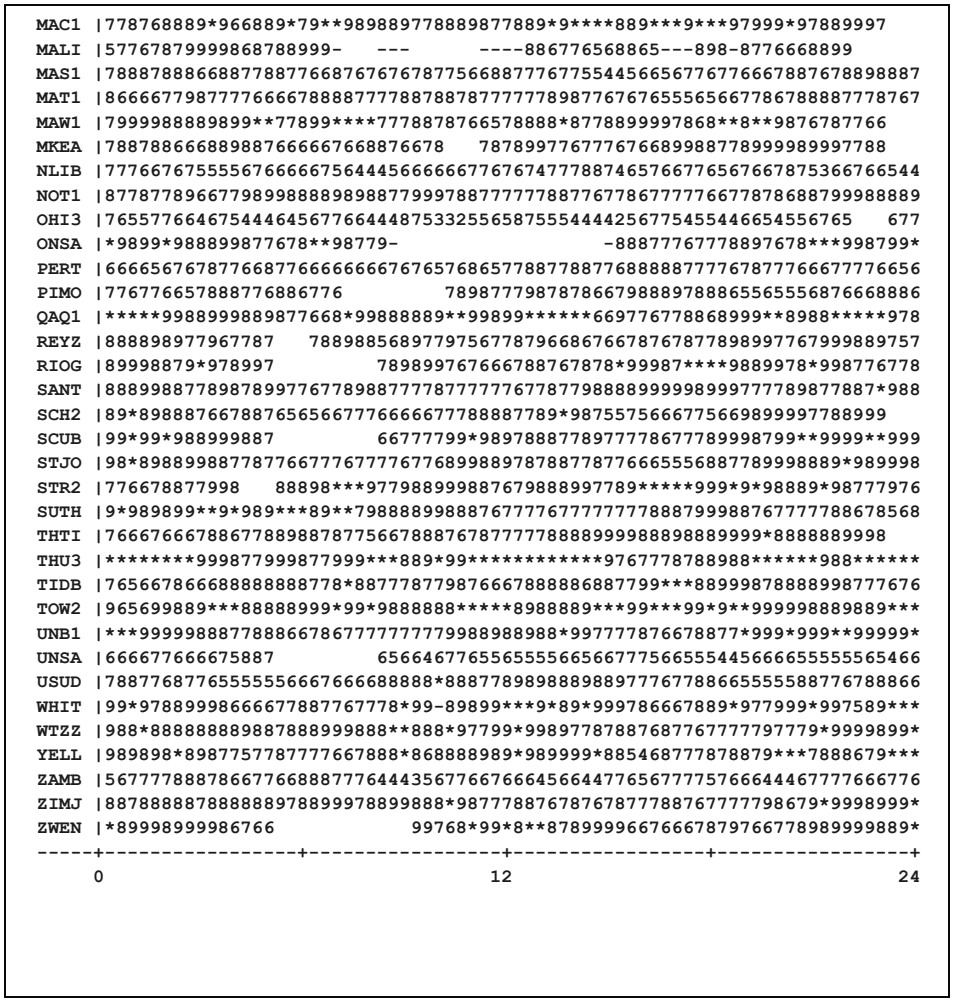
GPS/GLONASS Tracking Network of the IGS



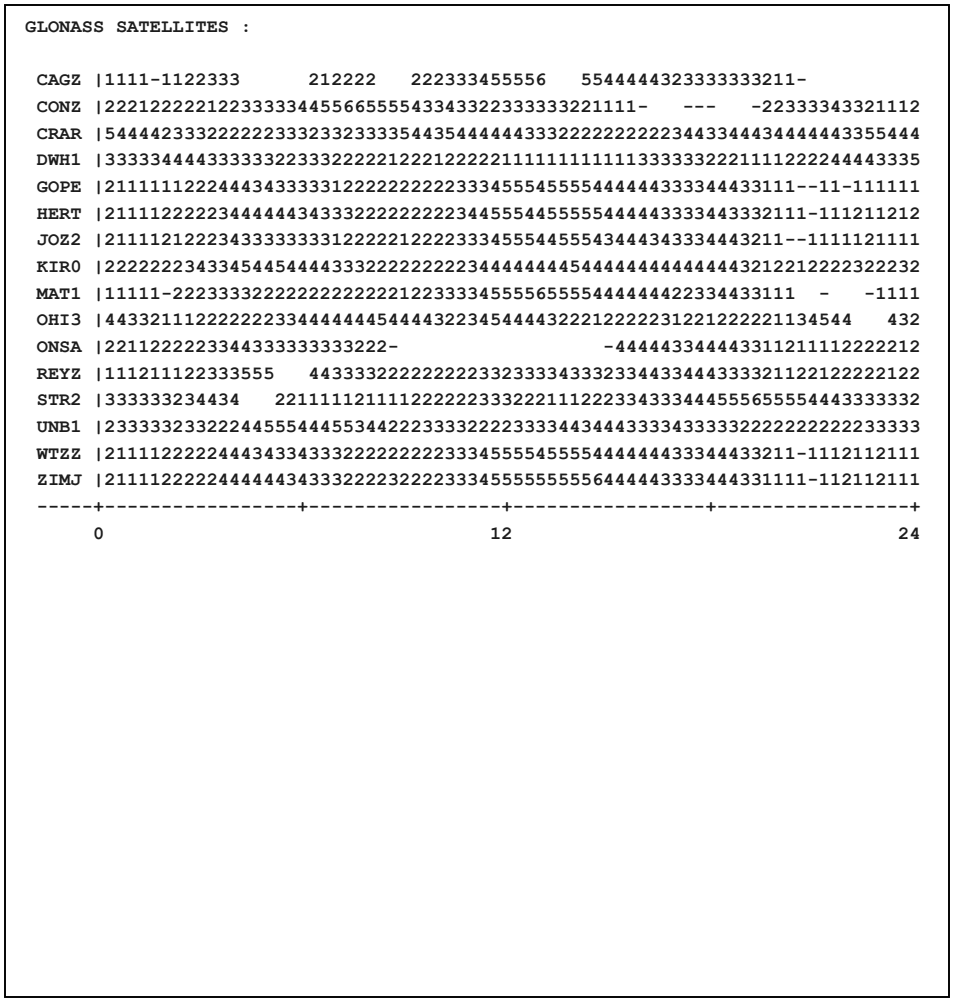
Example of Hourly Data Availability for Recent 24UT Ultra-Rapid Update (1)

```
DATE : 2004   2  28

GPS SATELLITES :

ALBH |9887888878866455666656667767666878888877887677766565577777878778767899899
ALGO |9*888867776799766755677656765766778878878777655766667756899988877678888
ALIC |666777788788***77788888877879998988788878899789**89999988888897
AMC2 |****898889**98786787766568777787788899998887798897788878899777789*99*9
AREQ |666755776766677655576656776555766656554677787776656788666
ARTU |*988*99*9876777778887779**9897779**999*89988998666788887777899968989
AUCK |787765666787777768987998887899867788788889889899*9999***99888889*9988766
BOR1 |77767777888767777678888678877686677888878678788777766777776777787875778
BRST |88989*9888789876678998778779*96678788899677777767766777787789898
BRUS |8877878888878866668998777777998786678888*886767766676567777776678998888897
CAGZ |776778897887      899888   889898876777   867877777766777877677998889
CAS1 |989878***9**99*9**********9999777788**9*88*****9899********9*99888866
CHAT |776776677688666788989898888777767777878899888**8898889**9
CHPI |98898899*99***889899889899987899998877677778899*****889888888897999*9
COCO |876788898889**99*89999988778879*****887249*989**99988878878888997788888888
CONZ |888888766887789776677878866776666766667776667888778888866677887776767878
CORD |88767877655657676765776656678767666666556756777668666668766677656566567
CRAR |97889***9*88**8********9***9777787799999*****99798******9***9*9988679888
CRO1 |8878766677889777656666545556655677777654444455555444-444555556566766677
DAKA |8899*9***9*9888          9998*9*9989888788877877677877898999**99*99*88999
DAV1 |9*99989*99******9***********9*87988999****8**98**8*****9***9*9988867
DWH1 |87777888777554446556445655555567667775788766663444665676577666676988889
FAIR |***976889877856678866667789989889 7**9*9987988887756778778877897**97578*99
GLPS |**99*****9**76798988899888888777988888999999889999*9*9****999999***99****
GOPE |766655577788755676899977798778855567775565787776666656777776779878886788
GUAM |87786677777789**98788788889999887899899978988**999*76777789976678777788
HERT |79867886788887645688877787779985667787777678887867876777787767888878897
HOB2 |677777787787988888899*98767888787667788898988887*****9999*998888899777766
HOFN |******9899*98866879779**78**99*88989*****98988887658887*99888999***99789
IISC |888868898888899888888799899*******99**888898988979987678878867888788998
JOZ2 |766665567777545777788876789778965577787656787776667666777767778987876677
KERG |6766668778799*878878788889977787656566567676778776467887998876675565 5
KIR0 |****99**8999777789**9*88*****979*******9*99999888766899998789**9**9**9**
KOKB |676776787756665456775578777778778988*--667   8--6----7778888876768889
KOUR |77788789678887777788866776556666677775677677677899977866676667778887766776
```

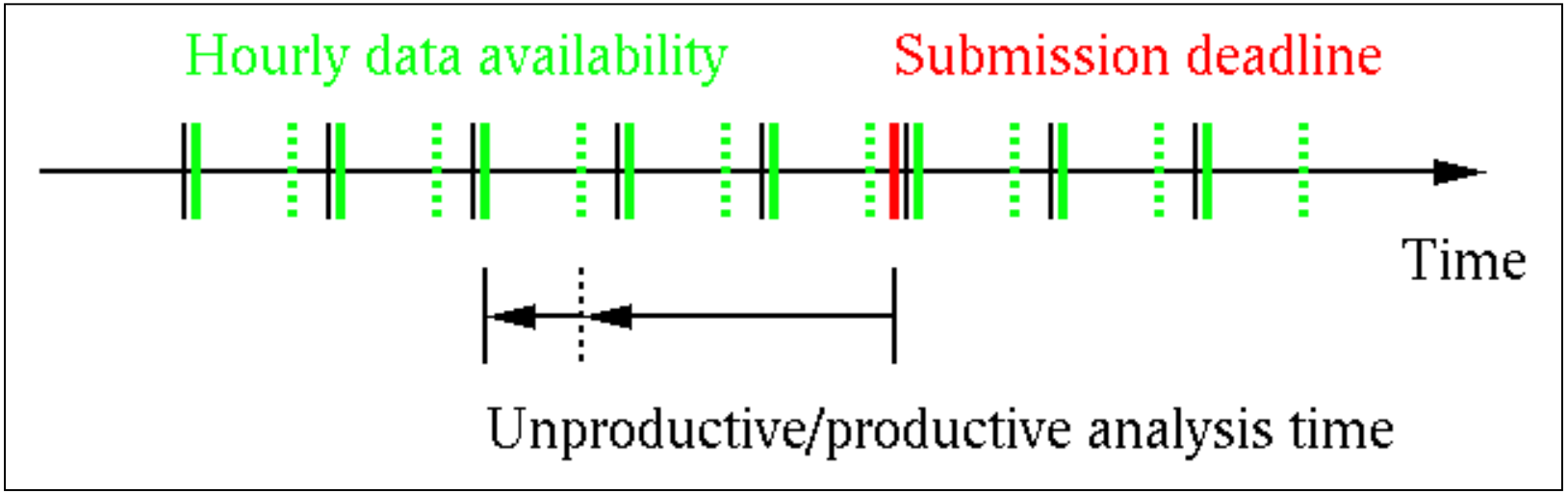
Example of Hourly Data Availability for Recent 24UT Ultra-Rapid Update (2)



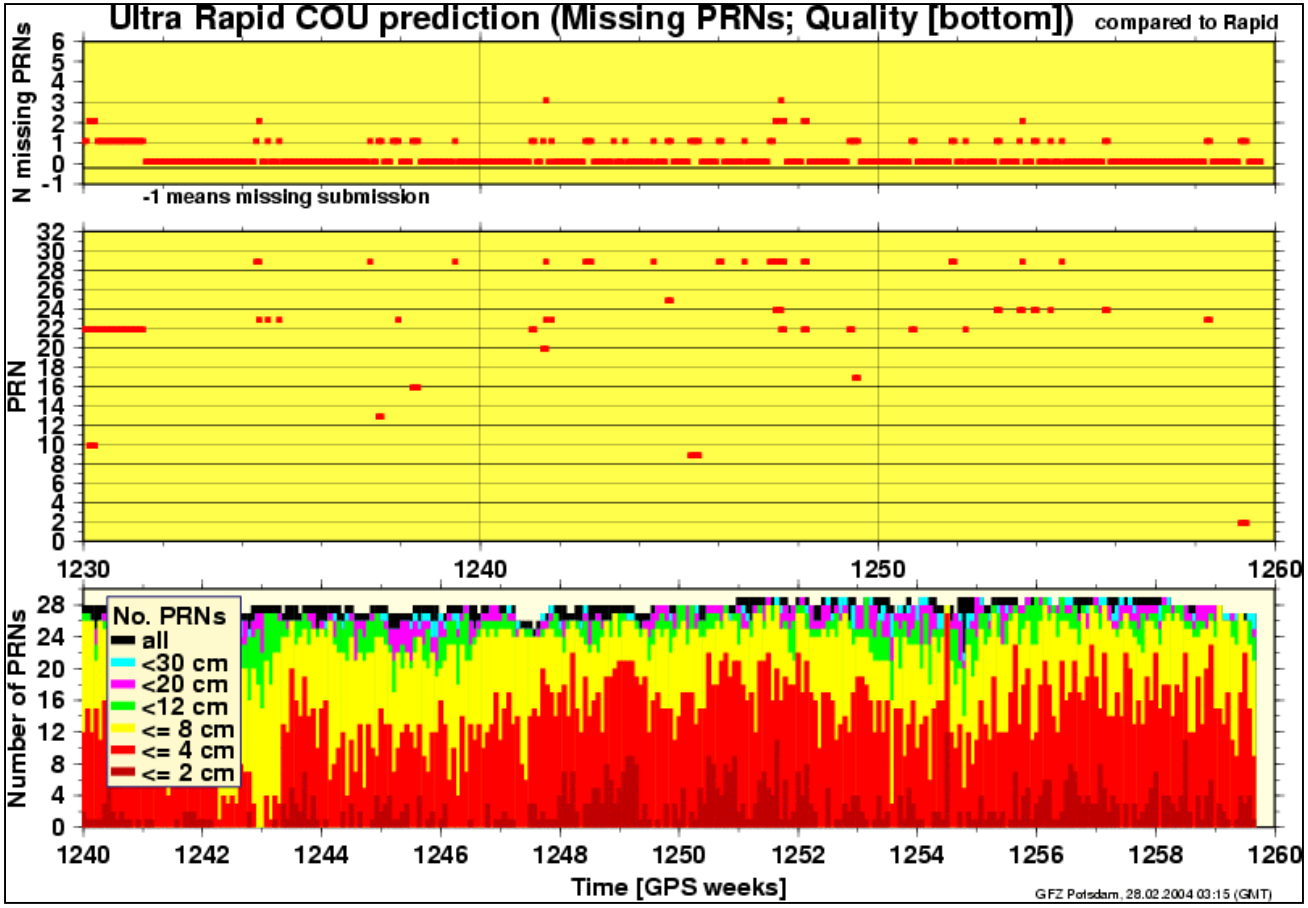
Example of Hourly Data Availability for Recent 24UT Ultra-Rapid Update (3)



Hourly Data Availability



Missing Satellites and Submissions Concerning CODE Ultra-Rapid Product



Courtesy: G. Gendt, GFZ, Potsdam, Germany