THE IGLOS PILOT PROJECT - TRANSITIONING AN EXPERIMENT INTO AN OPERATIONAL SERVICE

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OUTLINE OF PRESENTATION

- Motivation for Initial Experiment
- International GLONASS Experiment (IGEX-98)
  - Objectives
  - Accomplishments
- Key Elements for Integrating GLONASS into IGS
- International GLONASS Service Pilot Project (IGLOS)
  - Goals and Objectives
  - GLONASS Constellation
  - Station Network
  - Data Products
  - Product Usage
- Summary and Conclusions

MOTIVATION FOR IGEX-98

- GLONASS already existed
- GLONASS comparable to GPS so relatively “easy” to assimilate into existing processing
- Significant augmentation to GPS alone
- Dual-frequency P-code
- Added geometric strength
- Receiver technology available
- Scientific and navigation communities interested in exploiting system
- Uncertain future (now or never)

IGEX-98 OBJECTIVES

- Collect globally-distributed GLONASS data set over long time period, using dual-frequency receivers collocated with GPS receivers at known ITRF locations.
- Compute precise orbits (1 m or better)
- Evaluate receivers
- Develop data processing software
- Compare PZ-90, WGS-84 and ITRF reference frames
- Facilitate timing and time transfer
- Stimulate other scientific applications.

IGEX-98 CAMPAIGN STATISTICS

- 19 October 1998 – 19 April 1999
- 13-14 GLONASS satellites
- 61 GLONASS receiver tracking sites
- 68 receivers deployed
- 26 countries
- 30 SLR stations in 15 countries
- 6 regional data centers
- 2 global data centers

IGEX-98 ACCOMPLISHMENTS

- First global tracking network for GLONASS
- First extensive use of geodetic-quality, dual-GNSS receivers capable of tracking all satellites in view
- First precise GLONASS orbits
  - 11 Analysis Centers generated orbits
  - Orbit solutions consistent at 20-30 cm level
- Development of prototype data processing software and procedures for processing GPS and GLONASS data
- 5 independent determinations of PZ-90 to WGS-84/ITRF transformation

KEY ELEMENTS REQUIRED FOR INTEGRATING GLONASS INTO IGS OPERATIONS

- GPS knowledge base
- Receiver hardware and software
- Common geodetic reference frame
- Common time standard
- Standardized data formats
- Data communications and data distribution infrastructure
- Global tracking network
- Data processing software
- Analysis Centers

THE IGS GLONASS PILOT PROJECT

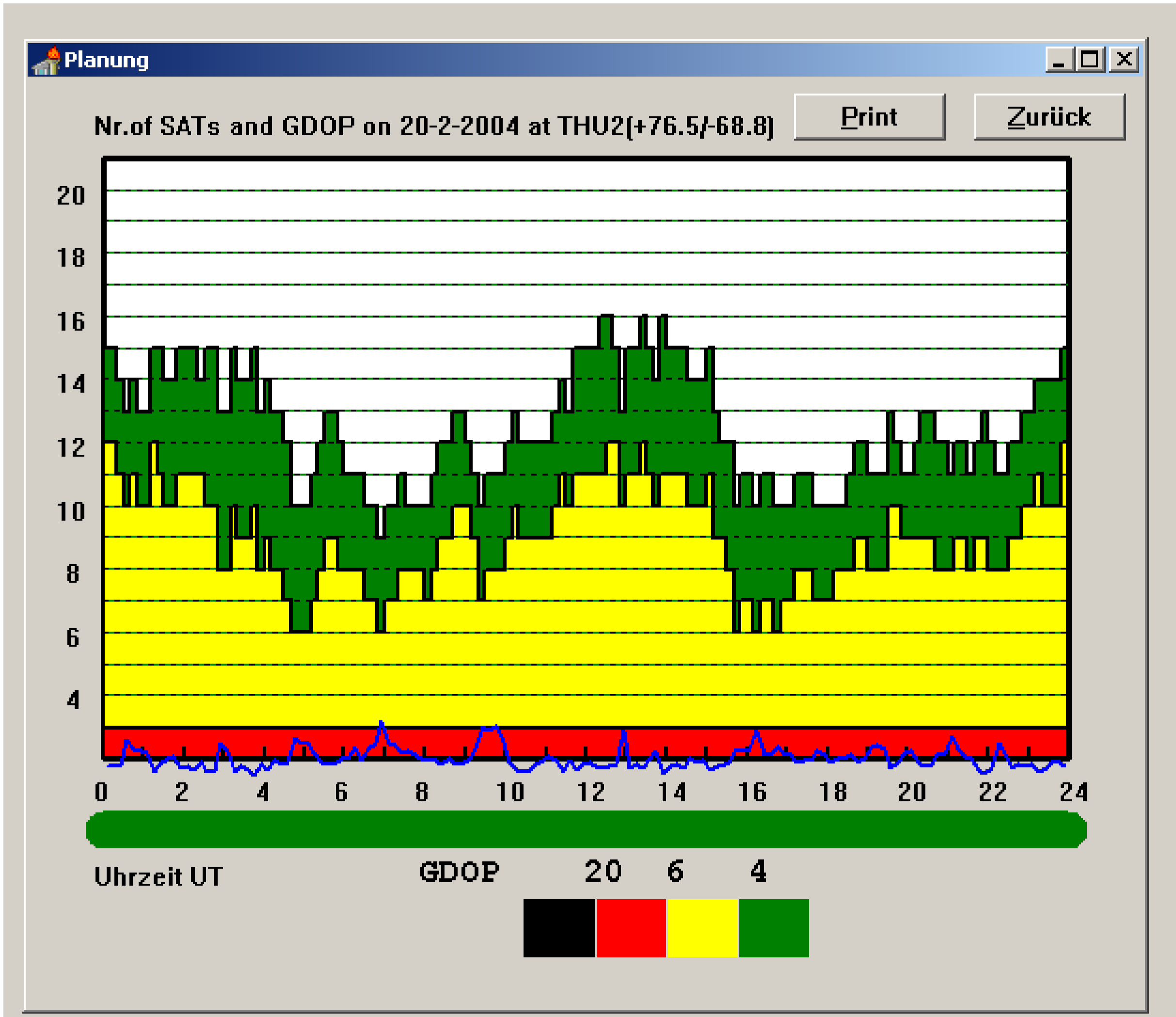
- Officially started February 2000
- Goals and Objectives:
  - Establish and maintain global GLONASS tracking network
  - Produce precise (10-cm level) orbits, satellite clock estimates and station coordinates
  - Monitor and assess GLONASS system performance
  - Investigate use of GLONASS to improve Earth orientation parameters
  - Improve IGS atmospheric products
  - Fully integrate GLONASS into IGS products, operations and programs.
- Requirements:
  - Use only dual-frequency GLONASS receivers
  - Apply IGS network operations standards
  - Include SLR orbits in combination orbit product
  - Obtain independent orbit, clock and station solutions from Analysis Centers within 3 weeks of observations
  - Calibrate GPS/GLONASS receivers and antennas.

IGLOS OPERATIONS – GLONASS CONSTELLATION

- Annual launches of new satellites in 2000-2003
- 10 operational satellites as of 25 February 2004
- Only 2 of 3 orbit planes populated
- Provide significant contribution to satellite visibility as addition to GPS constellation
- Examples:
  - Thule, Greenland (76ºN)
  - Capoterra, Italy (39ºN)
  - Kourou, French Guyana (5ºN)
  - Mattersburg, Austria (47ºN)

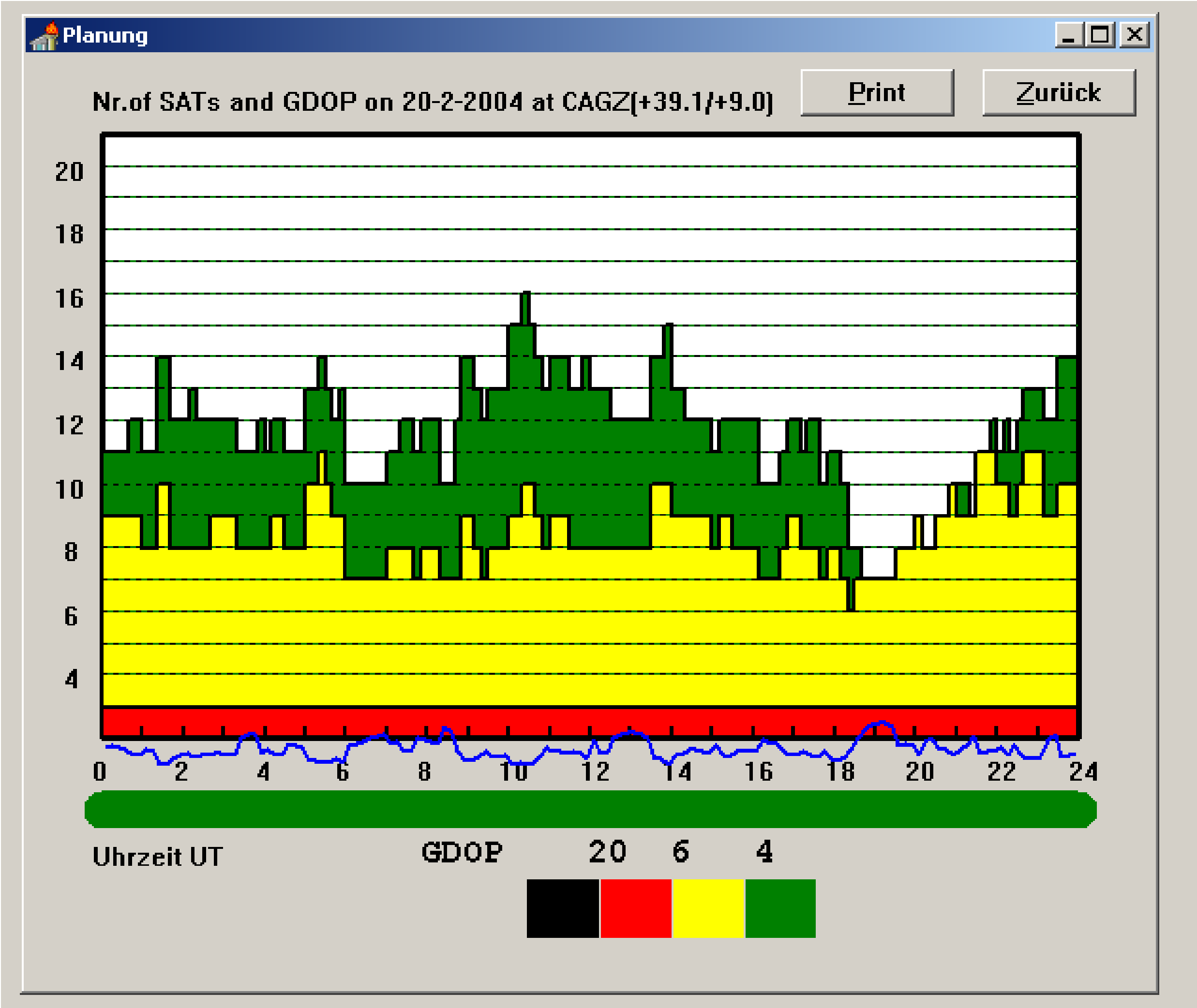
GLONASS AND GPS SATELLITE VISIBILITY AND GDOP THULE, GREENLAND (76ºN)

Almanac Date: 17 Feb 04 Observation Date: 20 Feb 04 Elevation Cutoff: 5º



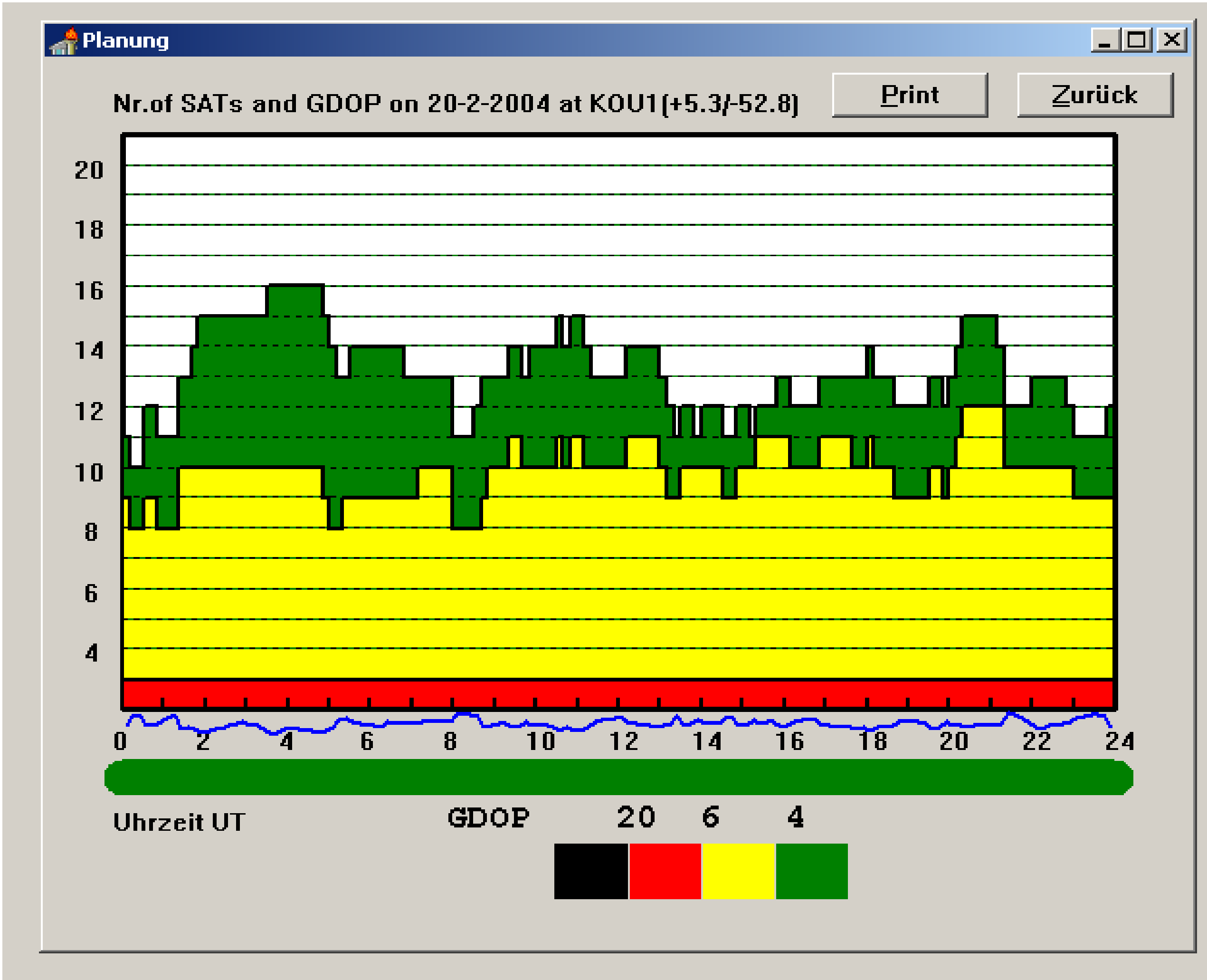
GLONASS AND GPS SATELLITE VISIBILITY AND GDOP CAPOTERRA, ITALY (39ºN)

Almanac Date: 17 Feb 04 Observation Date: 20 Feb 04 Elevation Cutoff: 5º



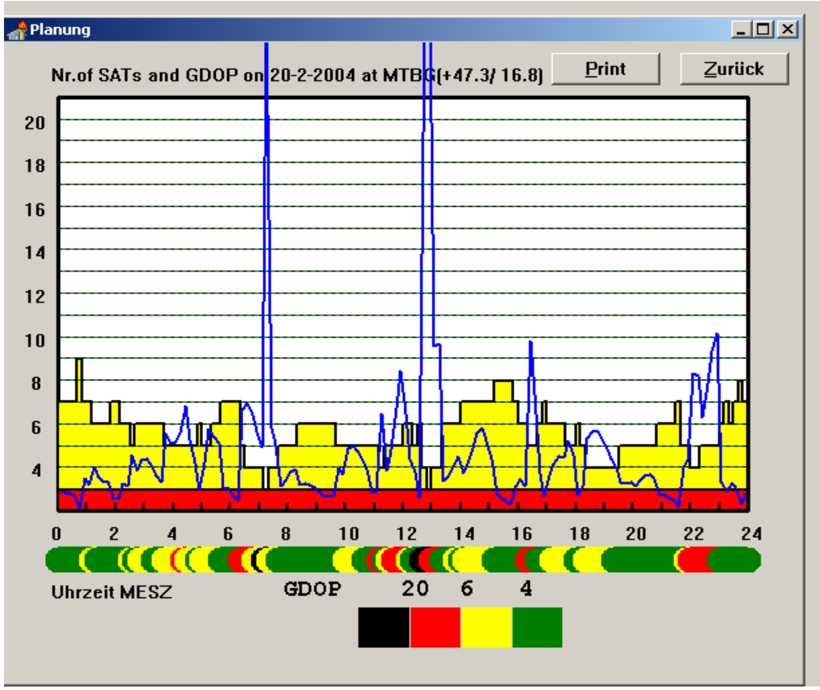
GLONASS AND GPS SATELLITE VISIBILITY AND GDOP KOUROU, FRENCH GUYANA (5ºN)

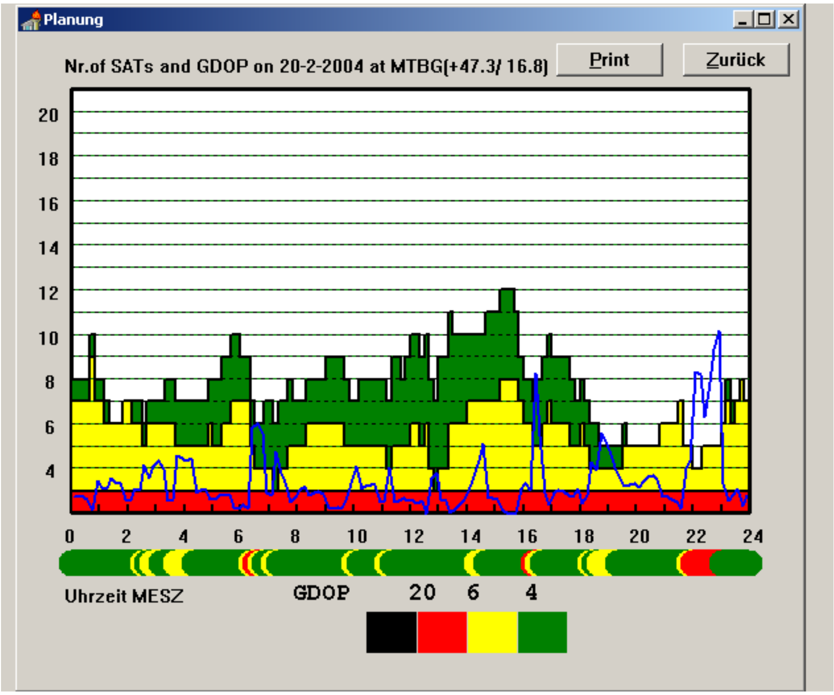
Almanac Date: 17 Feb 04 Observation Date: 20 Feb 04 Elevation Cutoff: 5º



GLONASS AND GPS SATELLITE VISIBILITY AND GDOP MATTERSBURG, AUSTRIA (47ºN)

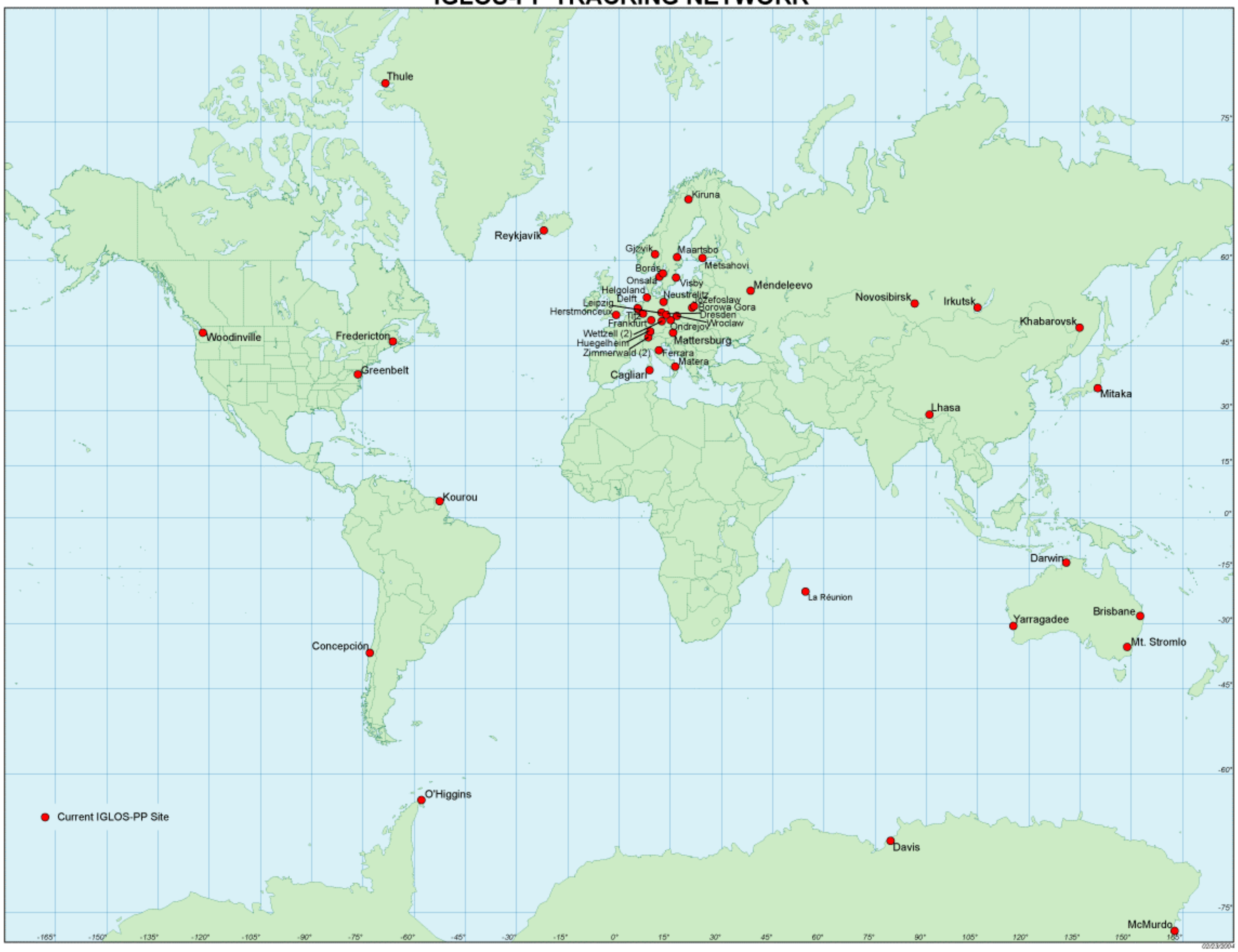
Almanac Date: 17 Feb 04   Observation Date: 20 Feb 04





IGS GLONASS TRACKING NETWORK (Feb 04)

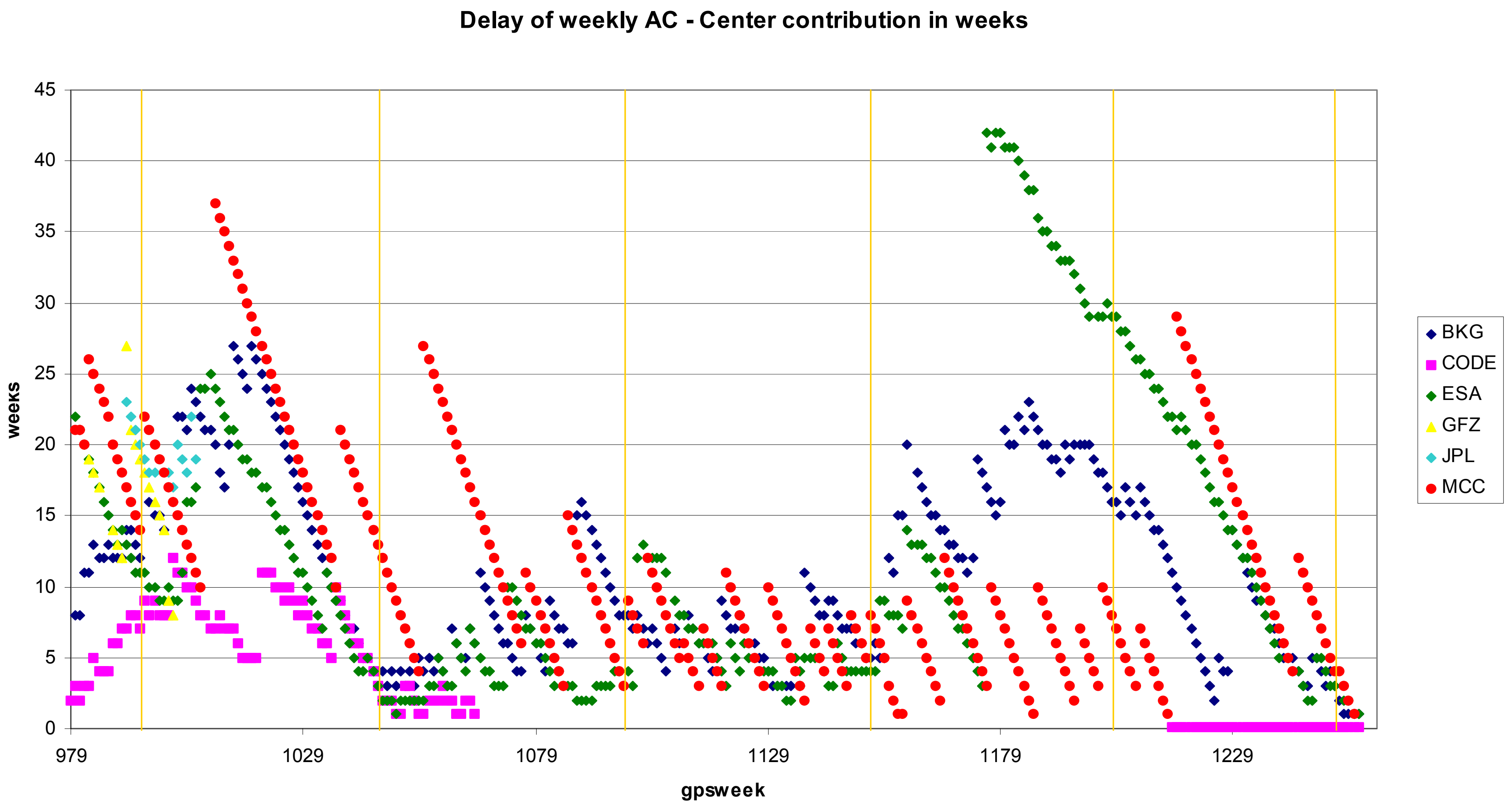
IGLOS-PP TRACKING NETWORK



IGLOS DATA PRODUCTS

Analysis Center	Products
BKG	Daily orbits
CODE	Daily orbits, Rapid orbits
	Ionosphere, Troposphere
	Earth orientation parameters, Station coords.
ESA	Daily orbits, Satellite clock estimates
	Station coords.
MCC	Weekly orbits

IGLOS ANALYSIS CENTER ORBITS
DELAY IN SUBMISSION (OCT 98 – Feb 04)

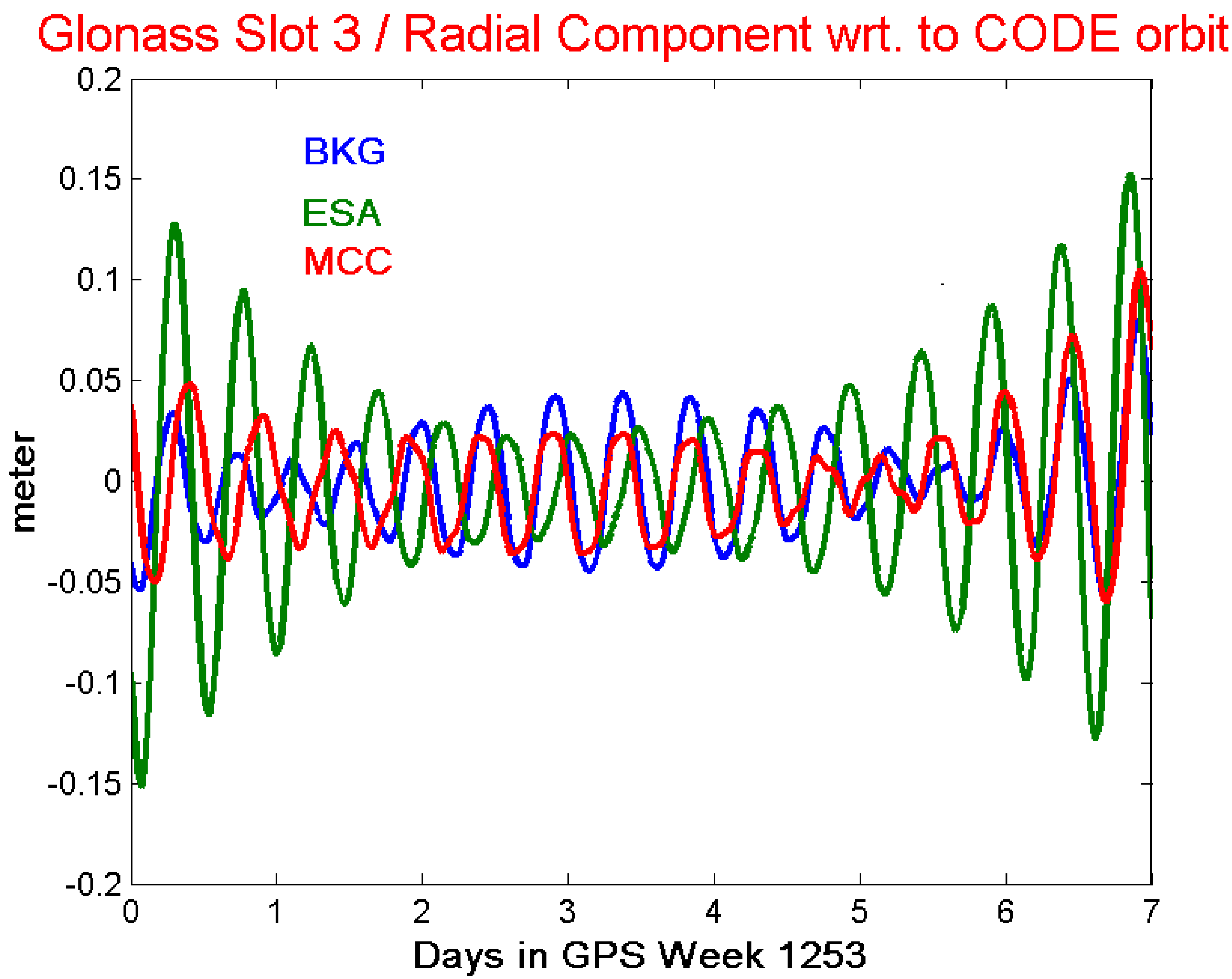


GLONASS LONG ARC (7 DAYS) SOLUTION RMS
GPS Week 1253

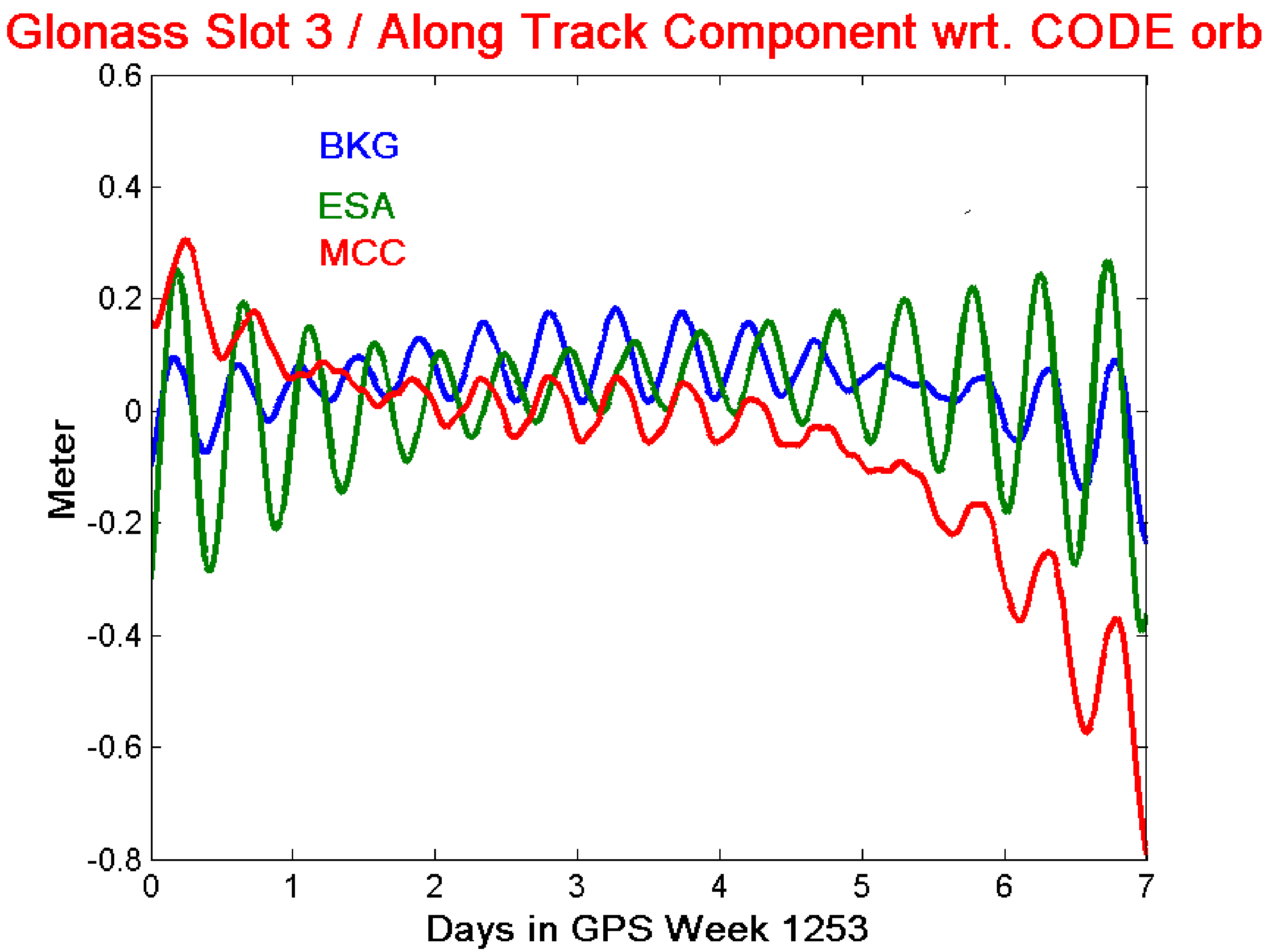
(RMS values in cm)

Satellite	BKG	CODE	ESA	MCC
Slot 3/Plane 1	4	10	5	8
Slot 5/Plane 1	8	10	9	---
Slot 17/Plane 3	4	6	6	---
Slot 18/Plane 3	24	19	19	---
Slot 21/Plane 3	6	9	5	---
Slot 22/Plane 3	6	6	4	25
Slot 23/Plane 3	6	6	6	---
Slot 24/Plane 3	6	6	6	36

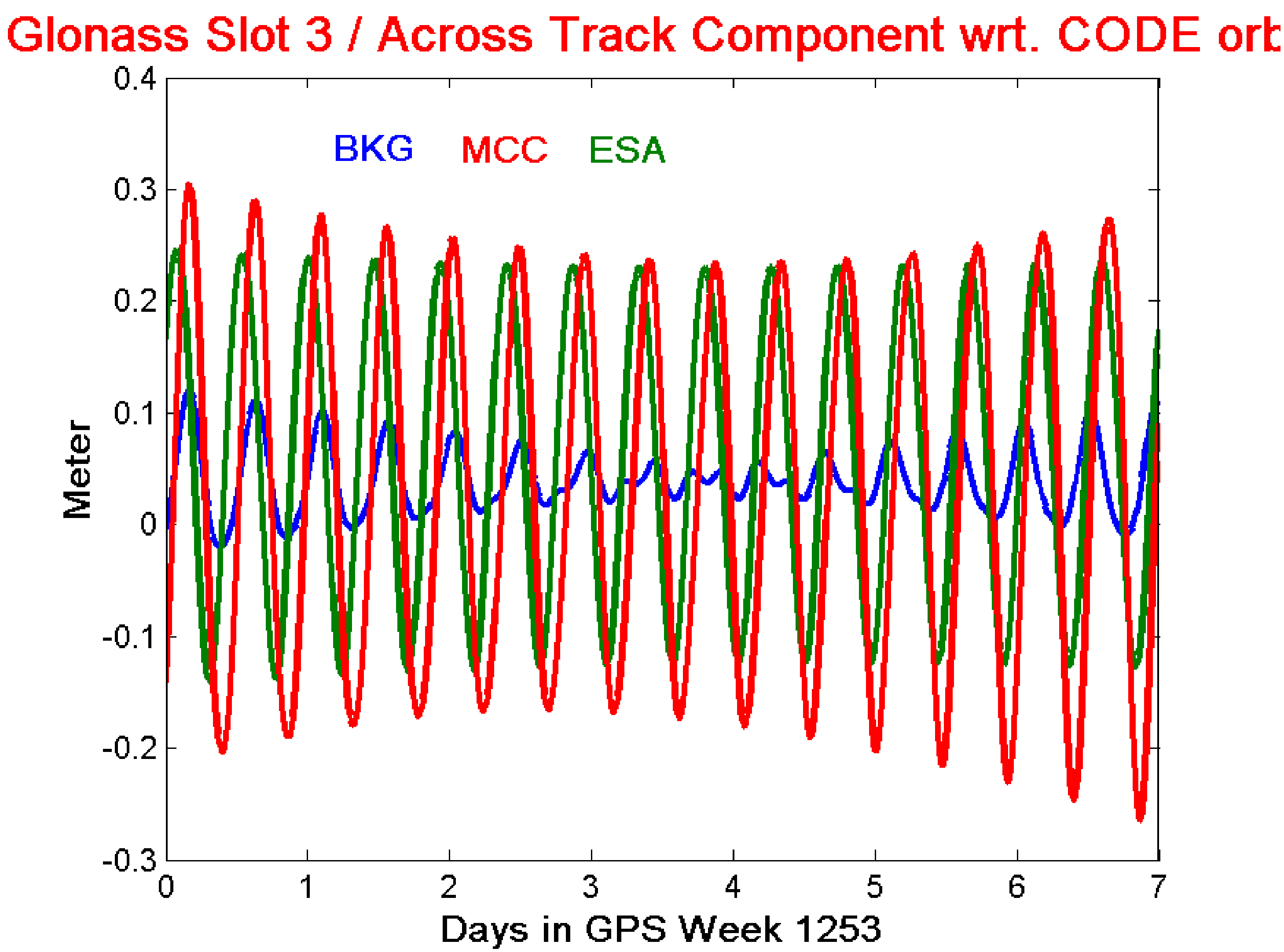
GLONASS SLOT 3 LONG ARC (7 DAYS) SOLUTION
GPS Week 1253 – RADIAL COMPONENT



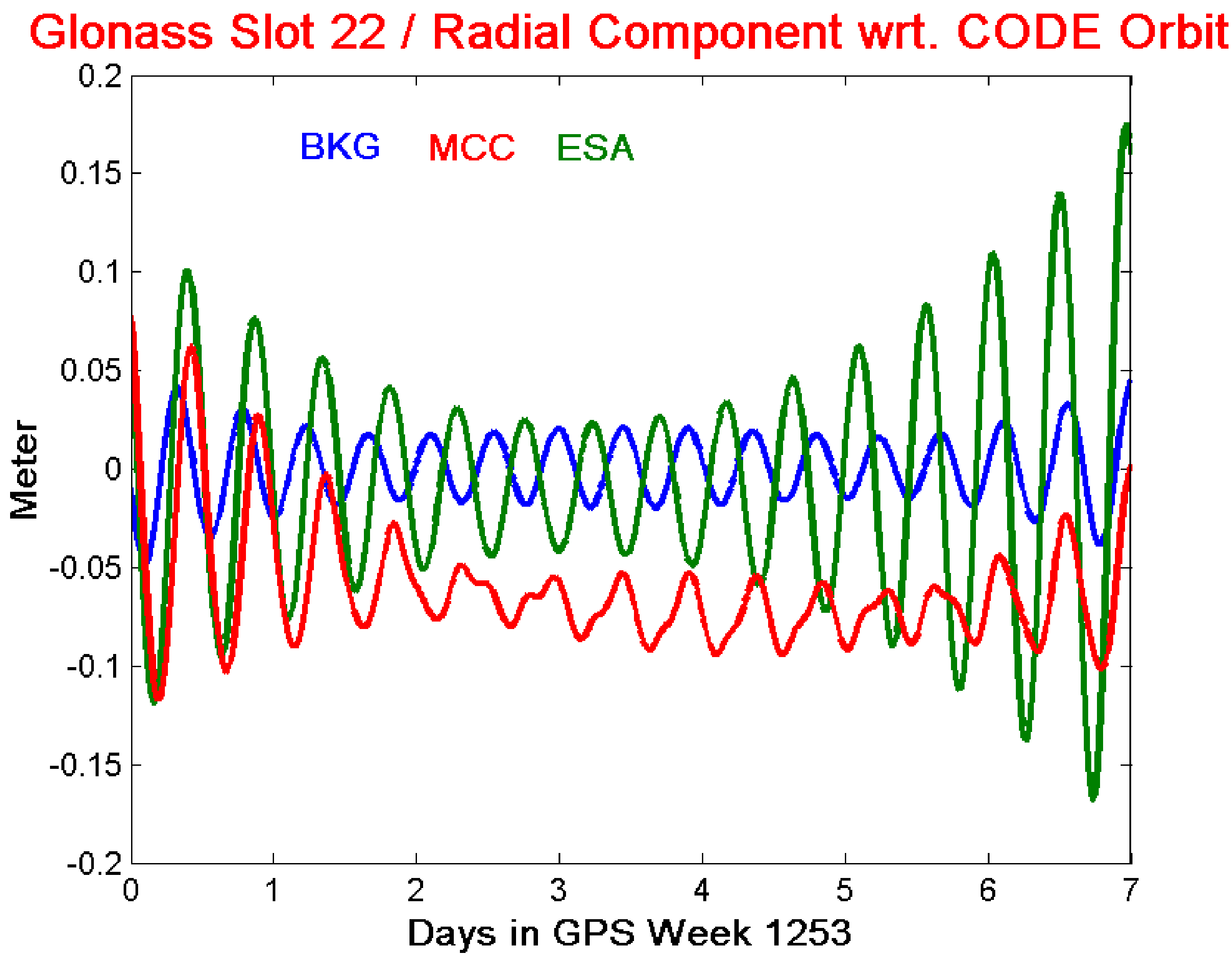
GLONASS SLOT 3 LONG ARC (7 DAYS) SOLUTION
GPS Week 1253 – ALONG-TRACK COMPONENT



GLONASS SLOT 3 LONG ARC (7 DAYS) SOLUTION
GPS Week 1253 – CROSS-TRACK COMPONENT



GLONASS SLOT 22 LONG ARC (7 DAYS) SOLUTION
GPS Week 1253 – RADIAL COMPONENT



IGLOS PRODUCT USAGE

- GLONASS observations imbedded with GPS in RINEX files – impossible to tell how many "GLONASS" users
- Products available at NASA CDDIS Global Data Center
  - Users from 21 countries in 2003
  - Russia – biggest user (no. of downloaded files)
  - British government – 2nd biggest user

SUMMARY AND CONCLUSIONS

- IGEX-98 was proof-of-concept
- IGLOS Pilot Project – operational implementation of concept
- Demonstrated integrated operation of 2 GNSS's in single operational framework
- Process was aided by similarity of the two systems
- Required –
  - Retooling GPS data processing software at IGS Analysis Centers
  - Minor modifications to GPS data formats
  - Application of IGS standards to incorporation of GLONASS receivers and data in tracking network and at Data Centers
- Standardization of data formats, tracking stations, communications protocols and data management critical to success of project

SUMMARY AND CONCLUSIONS (Cont'd)

- Receiver manufacturers produced geodetic-quality equipment and firmware that tracked 2 constellations simultaneously, output data relative to a single time reference and in a standard format
- IGLOS tracking network has been very stable
  - Now consists exclusively of Ashtech and Javad receivers
- Reference frame compatibility issue solved by tying stations to ITRF (thru GPS)
- Undifferenced observables rather than double-differences may be preferable for cases where satellites are sparse due to constellation build-up or depletion

SOME REMAINING ISSUES

- Global network is uneven – overconcentration in Europe, no stations in Africa, few stations in N. and S. America and Asia
- Broadcast orbits still in PZ-90 - would be more useful if based on global realization of ITRF
- Receiver antenna calibrations needed for GLONASS frequencies
- Impact of additional satellites –
  - 10 GLONASS satellites measurably improve satellite visibility in combination with GPS
  - Benefit to IGS products, but extra burden for network operations, Analysis Centers and Data Centers
  - Data management problem to ensure throughput, archiving and retrieval capabilities keep up with data volume

THE NET RESULT….

- Key objectives of IGLOS have been met
- Uncertainty still exists about long-term viability of GLONASS
- Lessons learned from IGLOS will make road to Galileo a little smoother.