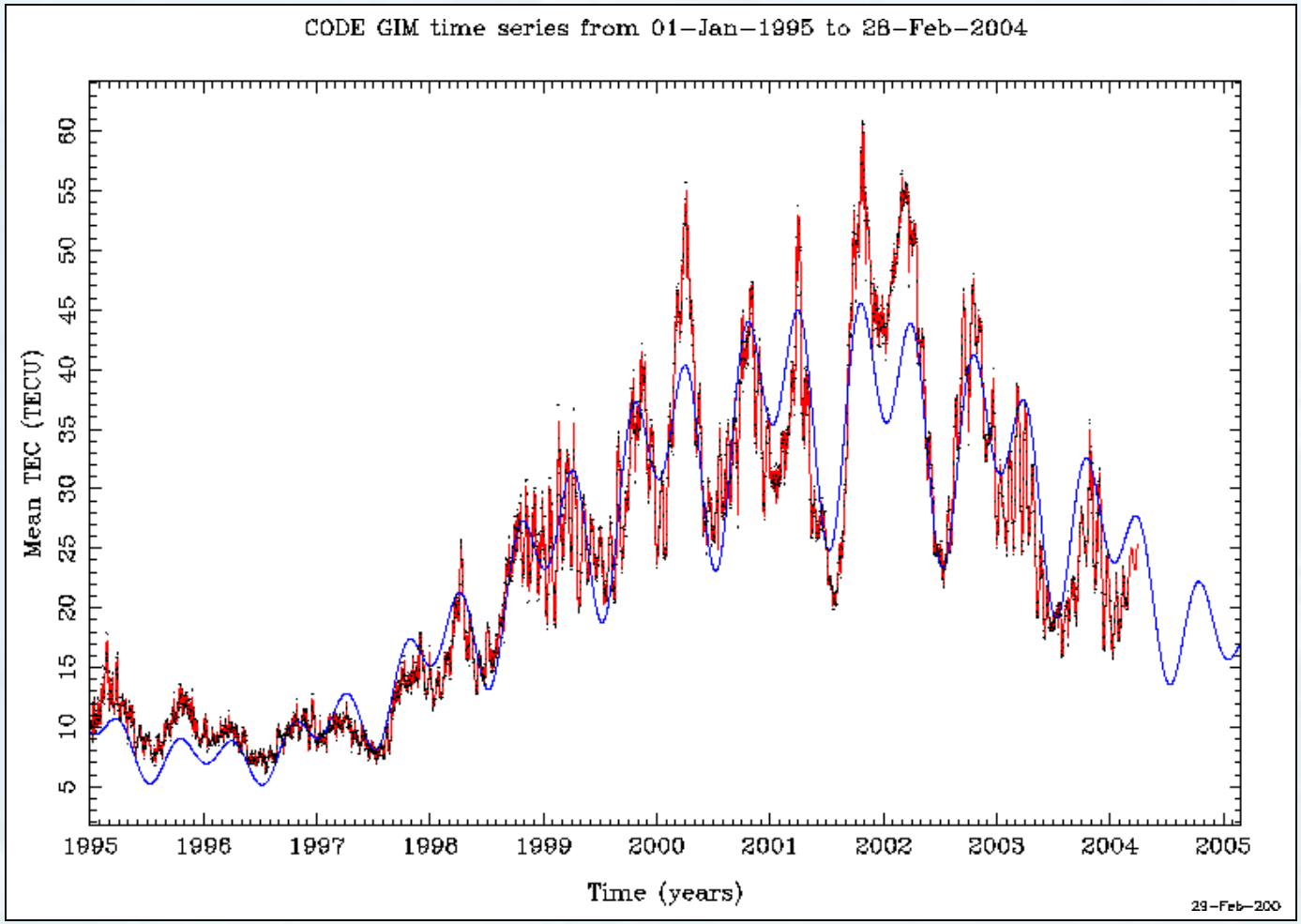
GNSS Ionosphere Analysis at CODE

Stefan Schaer

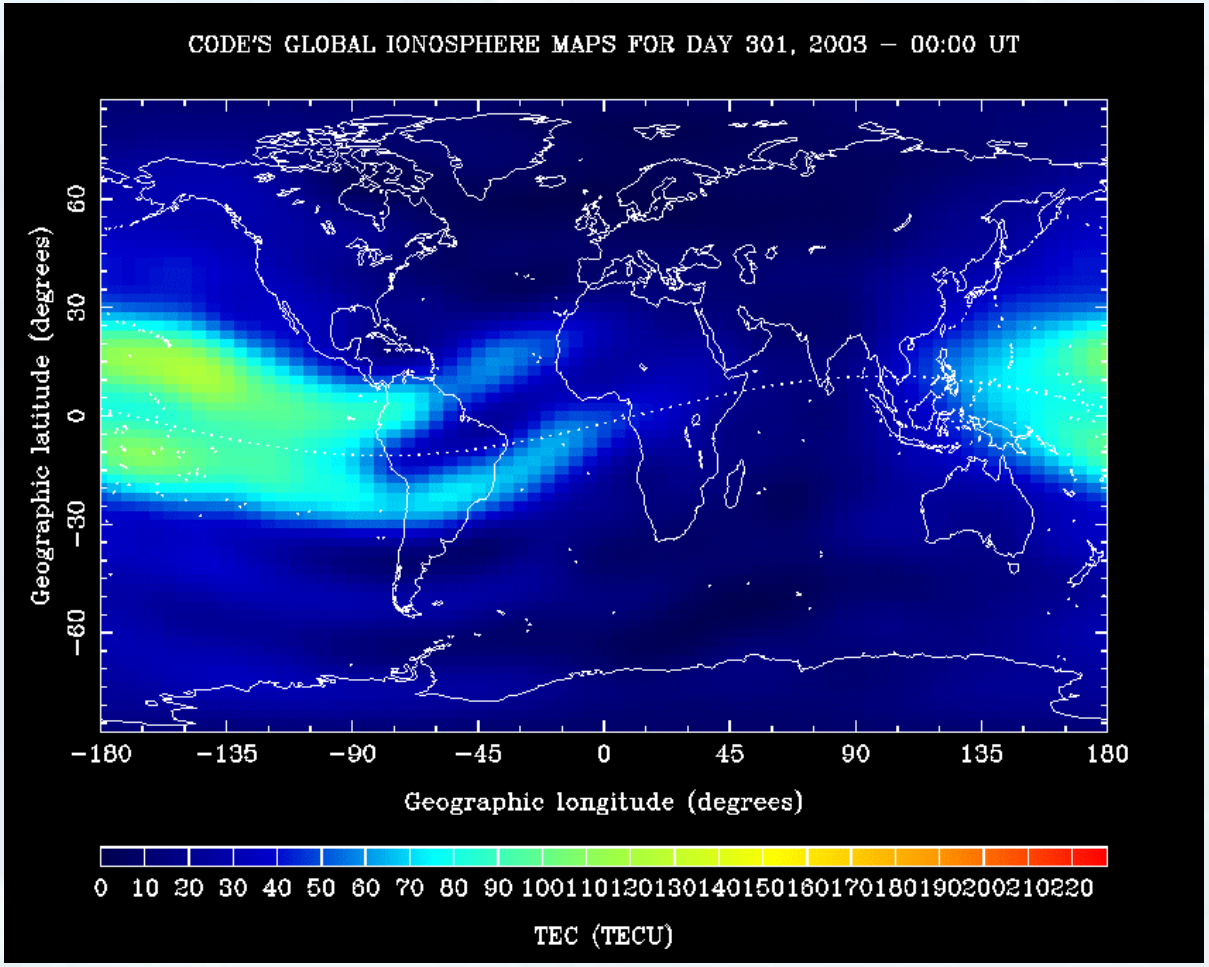
2004 IGS Workshop
Berne, Switzerland
March 1-5

Astronomical Institute, University of Berne

Time Series of Global Mean TEC Covering Nearly One Solar Cycle as Generated at CODE



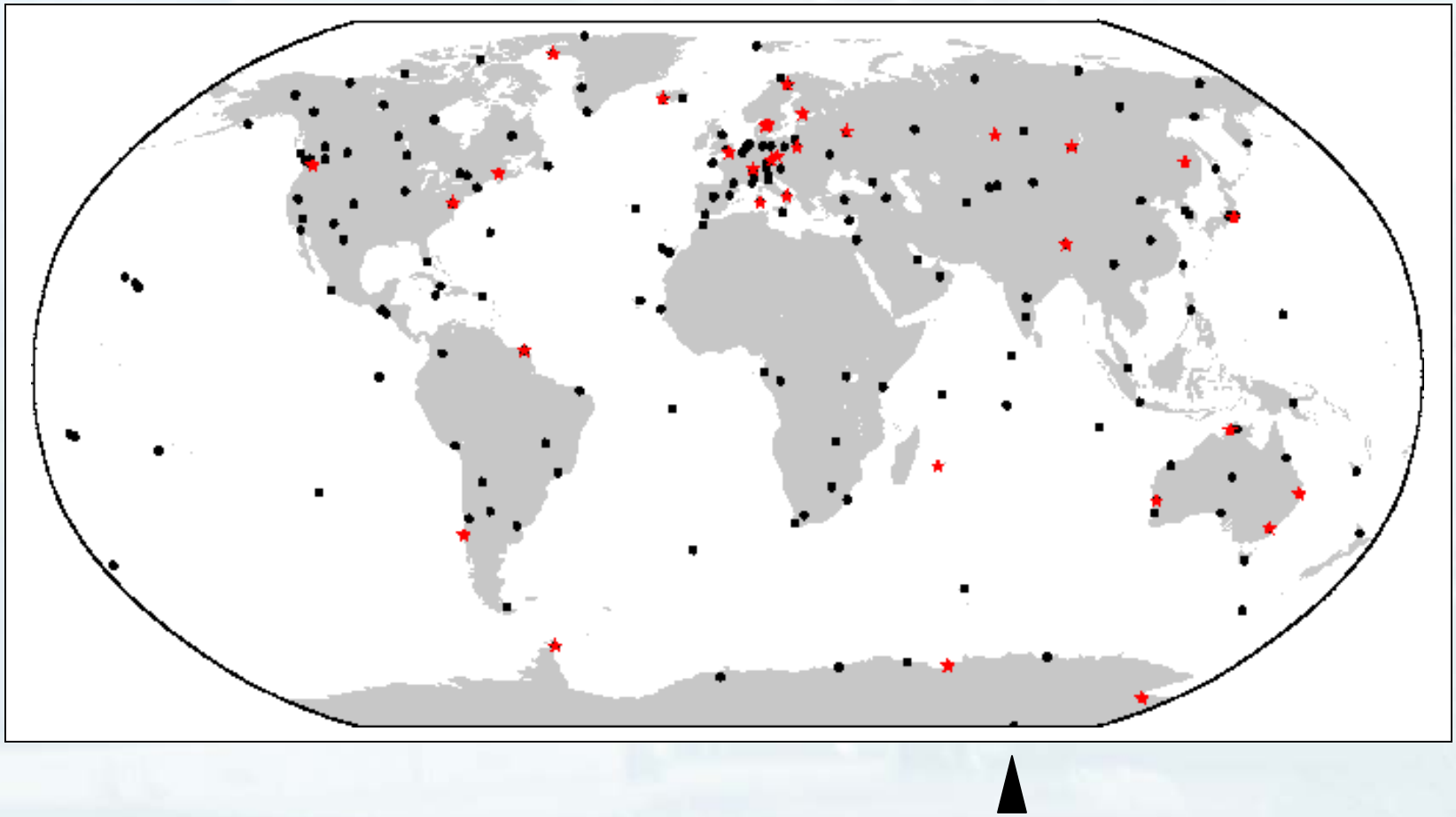
Exceptionally High TEC Levels due to X17.2 Solar Flare (CME)



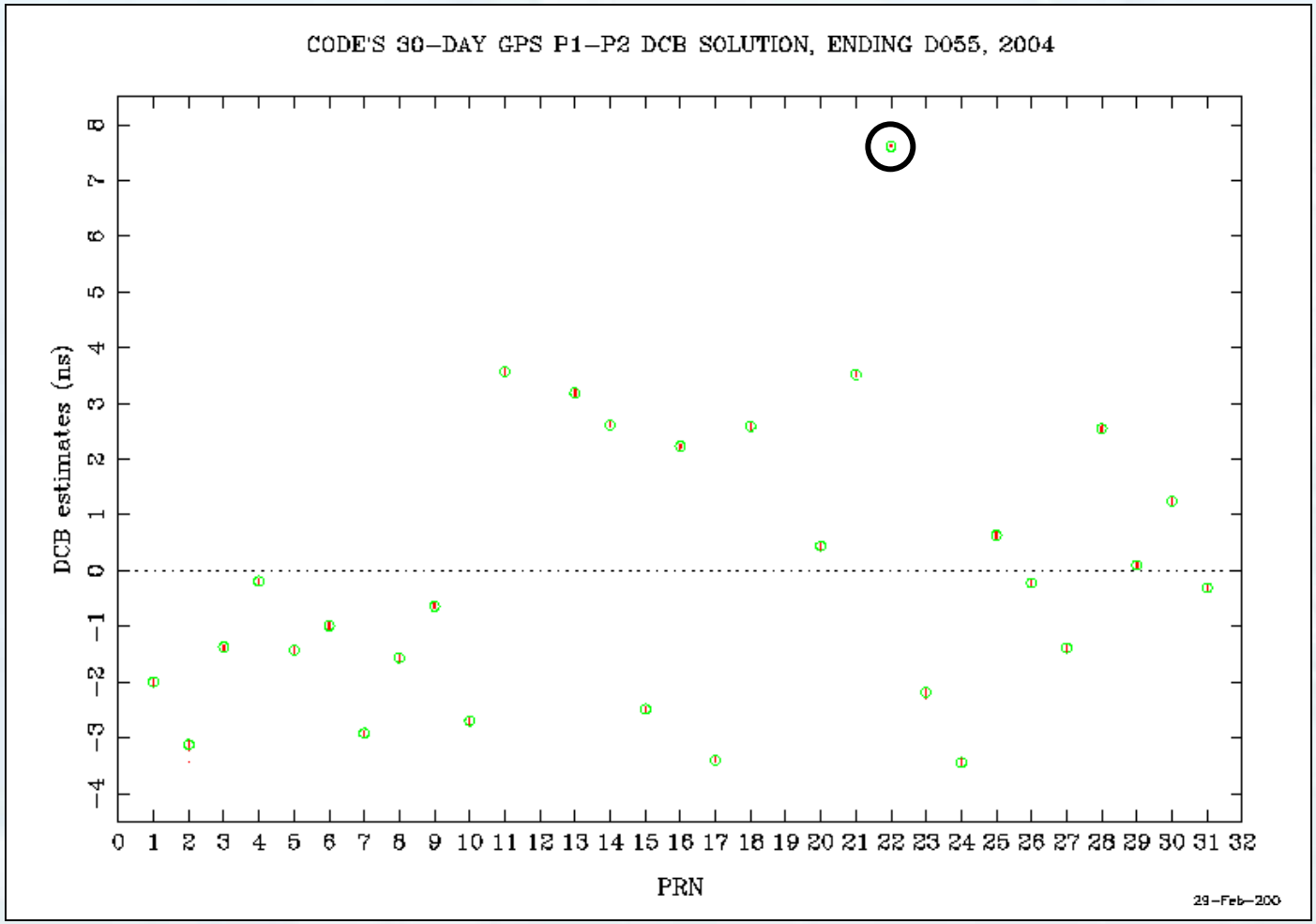
Combined GPS/GLONASS Ionosphere Analysis at CODE

- On April 27, 2003 (GPS week 1216), more or less at the same time when GNSS rapid orbit production commenced at CODE, we started to consider GLONASS tracking data collected by GPS/GLONASS receivers of the IGLOS network also in our ionosphere analysis.
- *Rapid* as well as *final* ionosphere analysis is done in GNSS mode from that date.
- Retrieval of GLONASS group delay (GD), or P1-P2 code bias values established.
- CODE is at present the only ionosphere AC producing global TEC map information on the basis of both GPS and GLONASS data.
- Data with respect to GPS satellites being repositioned is no longer disregarded.

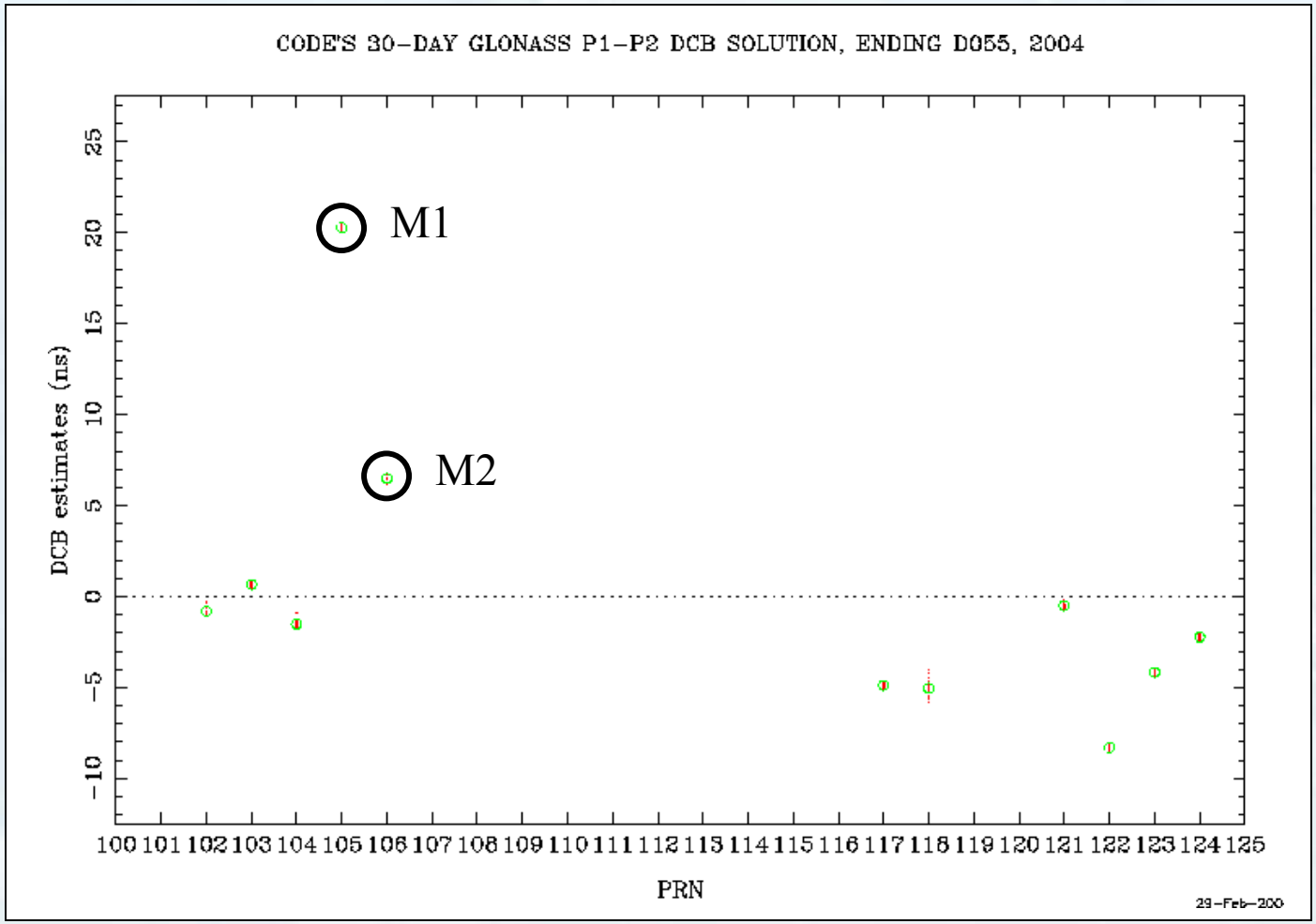
IGS/IGLOS Tracking Network as Considered in CODE´s Ionosphere Analysis



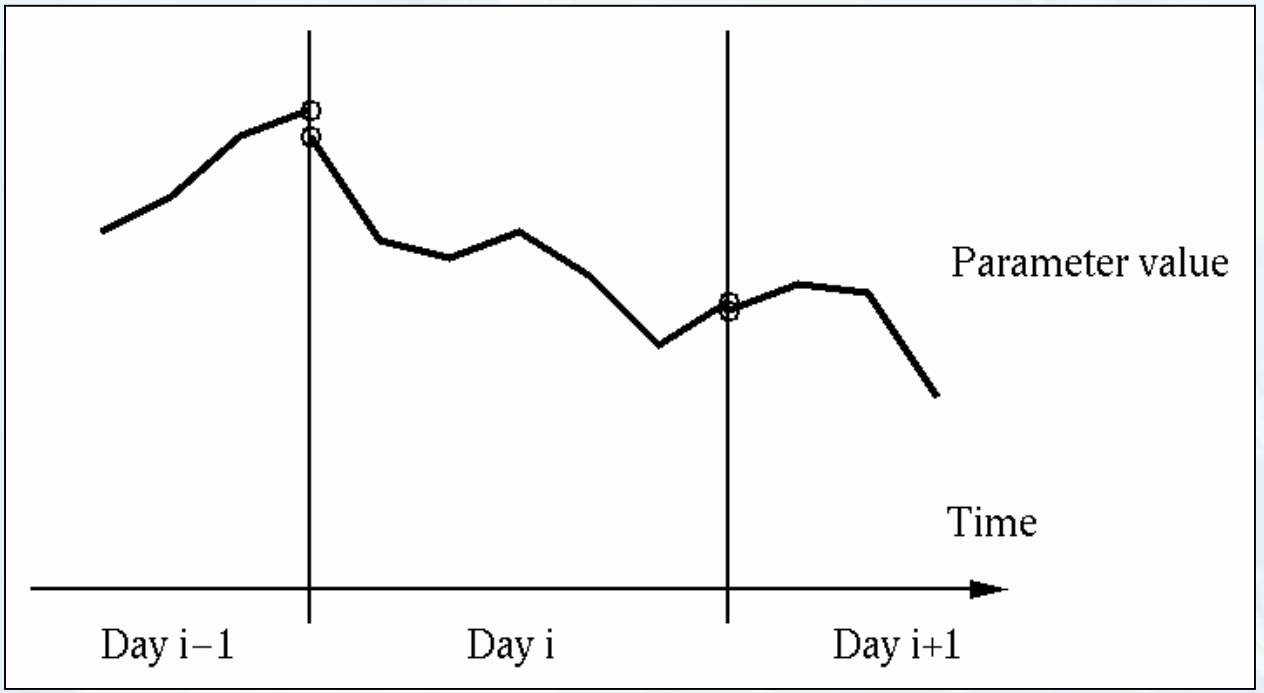
Group Delay (GD), or P1-P2 DCB Values for GPS



Group Delay (GD), or P1-P2 DCB Values for GLONASS



SH TEC Parameterization Continuous in Time



- 3-day ionosphere solutions computed on the NEQ level.
- 1-day ionosphere NEQ files include approximately 3700 unknown parameters each ($8 \times 3700^2 = 110$ Mbytes/file).

Overview of Ionosphere Products Generated at CODE

- Final, rapid, and predicted GPS/GLONASS-based global ionosphere map (GIM) products in IONEX as well as Bernese ION format
- P1-P2 differential code bias (DCB) values for both satellite constellations and a considerable number (>200) of IGS/IGLOS tracking stations (system-specific values for GPS/GLONASS-combined receiver models)
- Monthly averages of daily DCB retrievals, including P1-C1 values (ambiguity-fixed P1-C1 results internally available)
- Improved Klobuchar-style ionospheric (alpha and beta) coefficicents in RINEX format, specifically for the entire GIM product line
- Daily updated plots and animated gif files posted to http://www.aiub.unibe.ch/ionosphere/
- GIM/DCB data archive accessible at http://www.aiub.unibe.ch/download/CODE/

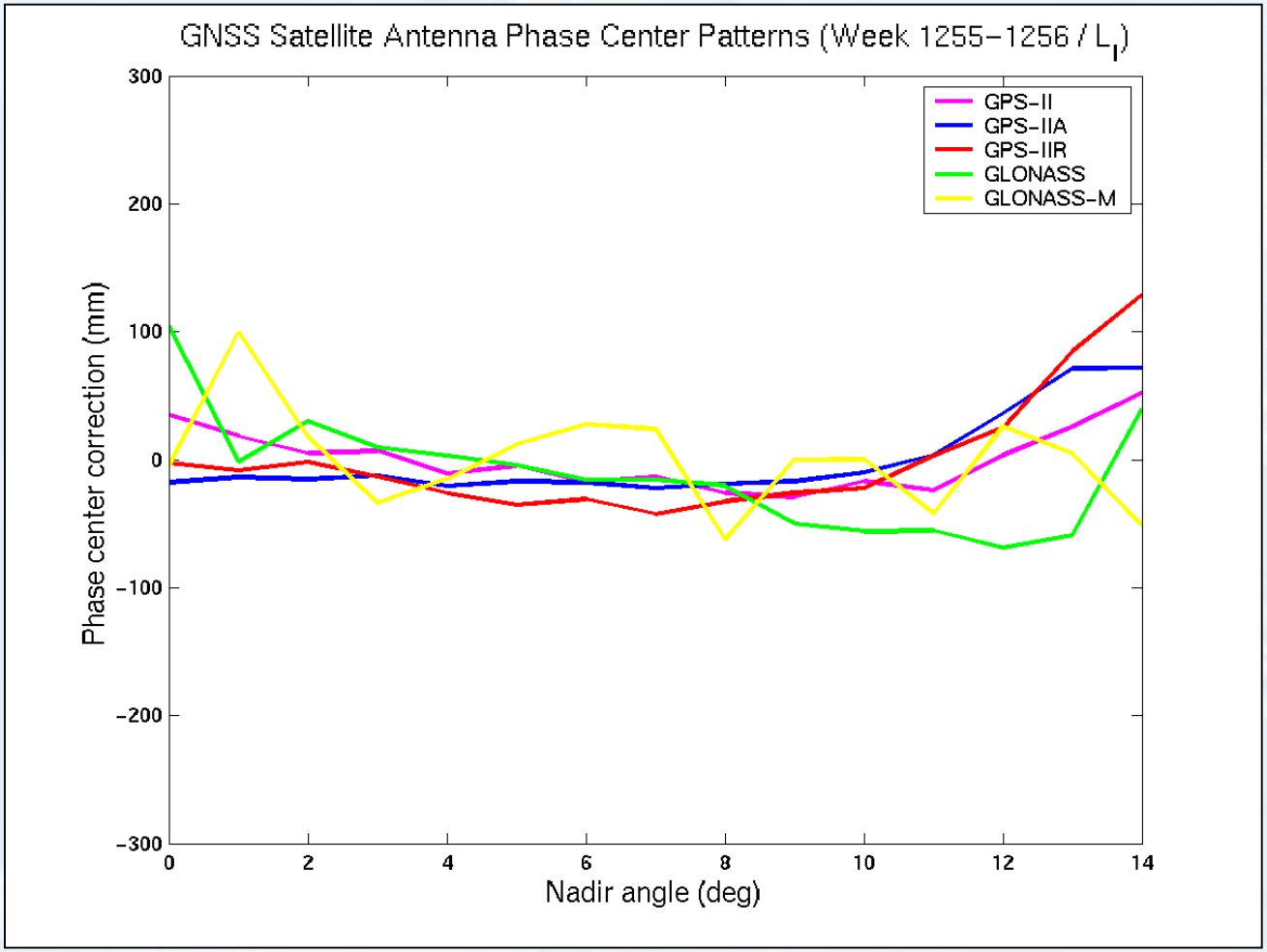
Estimation of GNSS Satellite Antenna Phase Center Offsets and Patterns Responding to the Geometry-Free (L1-L2) LC (1)

- Estimation of satellite antenna phase center offsets and patterns responding to the ionosphere-free linear combination is well-established.
- In principle, the rules valid for ionosphere-free PCV retrieval are applicable to retrieval of PCV signal responding to the geometry-free (L1-L2) linear combination. The two essential differences concern
  - the measurement noise, which may be, dominated by unpredictable short-term TEC fluctuations, higher by orders of magnitudes, and
  - ionospheric mapping functions, which are not as precisely known as tropospheric mapping functions.
- Short-term TEC fluctuations may be expected to average out over longer time scales.

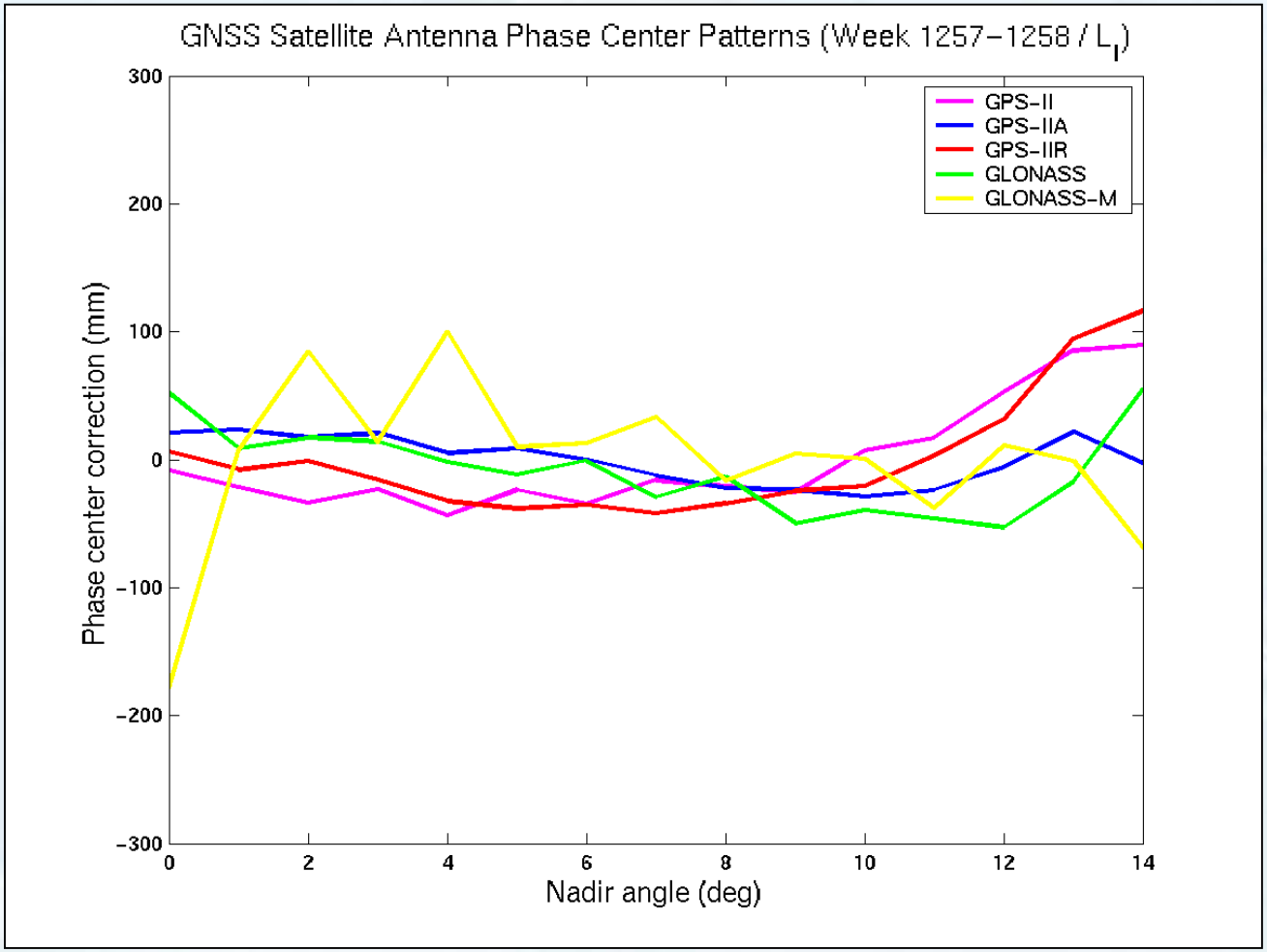
Estimation of GNSS Satellite Antenna Phase Center Offsets and Patterns Responding to the Geometry-Free (L1-L2) LC (2)

- Corresponding GNSS PCV parameters are regularly set up in our final ionosphere analysis for test purposes (patterns starting with GPS week 1254).
- Successful L1-L2 satellite PCV retrieval would actually allow for separate reconstruction of L1 and L2 satellite PCV corrections:
  - $L1 = L_C - 1.55 \times L_I$
  - $L2 = L_C - 2.55 \times L_I$

GNSS L1-L2 PCV Patterns - First Results (1)



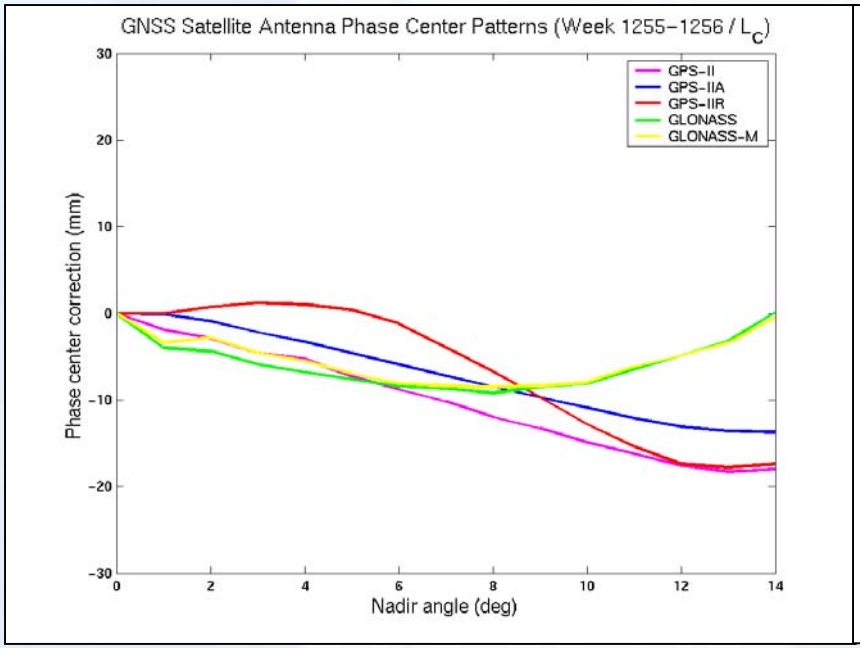
GNSS L1-L2 PCV Patterns - First Results (2)

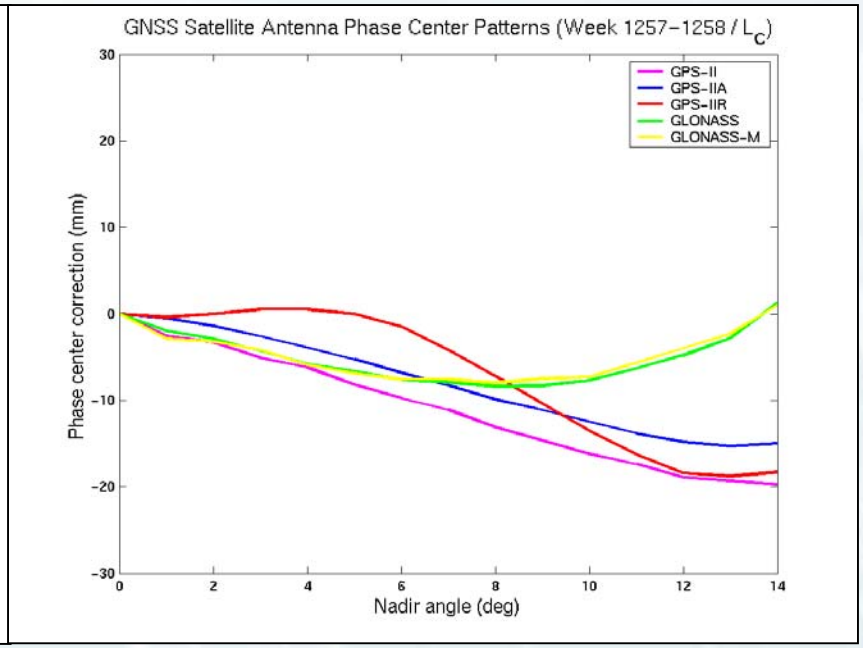


Possible Future Developments

- Provision of absolutely calibrated P1-P2 GPS DCB values based on absolute receiver calibrations (all known time service stations are considered in CODE´s ionosphere analysis)
- ... to establish interaction between GPS timing and ionosphere community
- Inclusion of LEO-originated GPS tracking data for GIM generation (CHAMP, SAC-C, etc.)

GNSS Satellite Antenna Phase Center Patterns Responding to the Ionosphere-Free LC - First Results





GNSS Satellite Antenna Phase Center Patterns Responding to the Geometry-Free (L1-L2) LC - First Results