GNSS processing techniques : Review of some topics over recent years

Gérard Petit
Bureau International des Poids et Mesures
92312 Sèvres Cedex, France
gpetit@bipm.org

- Goal: push down the present performance of GPS (GNSS) T/F transfer
  - ~ < $1x10^{-15}$ @ 1 day in frequency
  - ~ several hundred ps in time??

- At the CCTF'2012, I presented some ideas in this direction and would like to update the issues:
  - GPS Precise Point Positioning
  - The problem of code (and phase) biases
  - New codes and new combinations (e.g. Galileo)

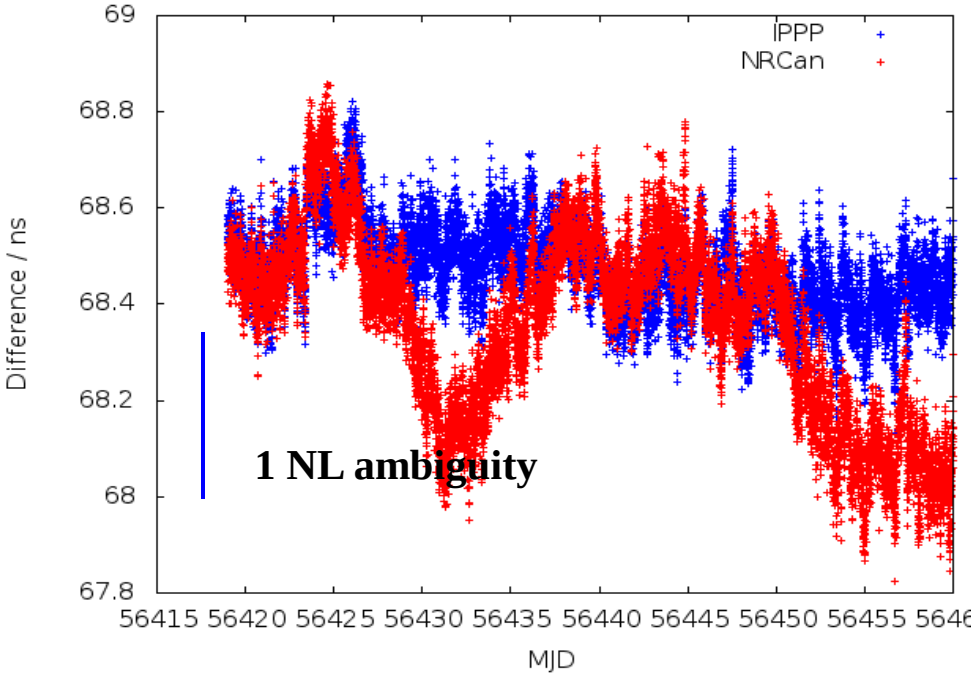
GPS PPP

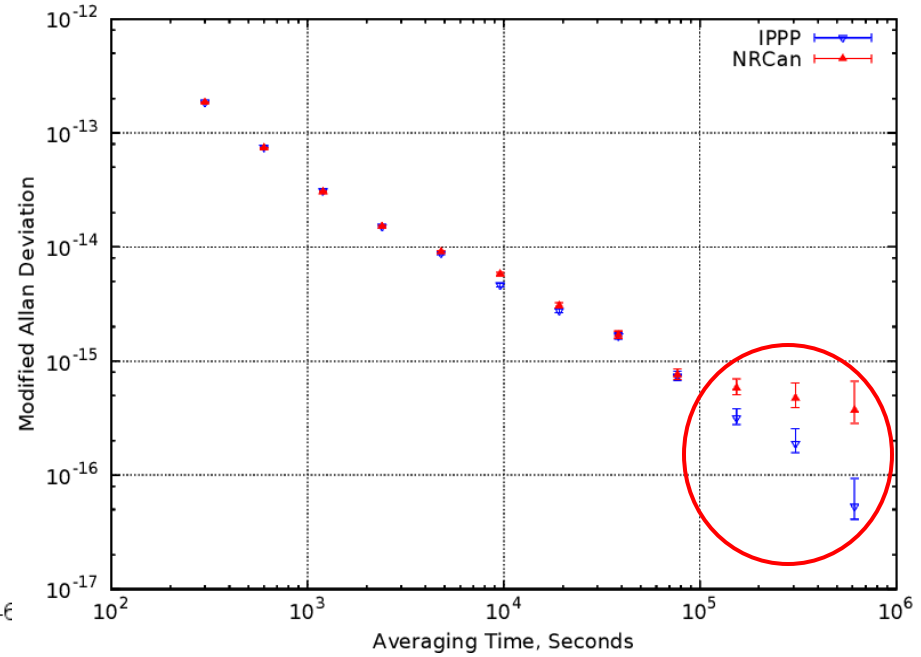
- Recent work all go in the 10^{-16} region
- Petit et al. "1×10^{-16} frequency transfer by GPS PPP with integer ambiguity resolution"
- Droste et al. "Characterization of a 450-km Baseline GPS Carrier-Phase Link using an Optical Fiber Link"
- Yiao et al "Comparison of Two Continuous GPS Carrier-Phase Time Transfer Techniques" (RRS technique) at IFCS/EFTF 2015

IPPP and PPP vs. 420-km fiber link

- IPPP technique: 100% success at solving integer λ_c boundaries over ~6 months
- A 41-day period (longest continuous operation for all systems):
  - Stability of IPPP better at few hours and at long term : 5.3×10^{-17} @ 7.1 days
  - PPP apparent slope of order 1×10^{-16} , IPPP has no significant slope

Blue = IPPP – Fiber link
Red = NRCan – Fiber link





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The problem of code (and phase) biases

- IGS has a Bias and Calibration Working Group (BCWG)
  - Maintains operational determination of GPS biases (P1C1, P2C2, P1P2, quarter-cycle biases)
  - Starts developing homogeneous treatment for GLONASS interfrequency biases
  - Galileo biases expected to be smaller but more numerous
  - Workshops on GNSS biases in Bern
    - January 2012
    - November 2015

- Code-phase biases: observed limitation from the hardware, may be at the 10^{-15} level
  - Defraigne & Sleewagen "Correction for Code-Phase Clock Bias in PPP"
  - Matsakis et al. "Carrier Phase and Pseudorange Disagreement as Revealed by Precise Point Positioning Solutions"
  - Recommendation to be passed

Other GNSS and multi-GNSS

- IFCS-EFTF'2015
  - Yi et al. "Research on Time and Frequency Transfer based on BeiDou Common View "
  - Wei & Defraigne "CGGTTS results with BeiDou using the R2CGGTTS"
  - Junqueira et al "RIOS: First iGMAS tracking station in Brazil"

- Example of Galileo AltBOC on the L5 frequency (material from Mari Carmen Martinez Belda's PhD thesis, 2012)