

Precise Point Positioning Developments at GSD: Products, Services

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GEOIDE - PPP Workshop

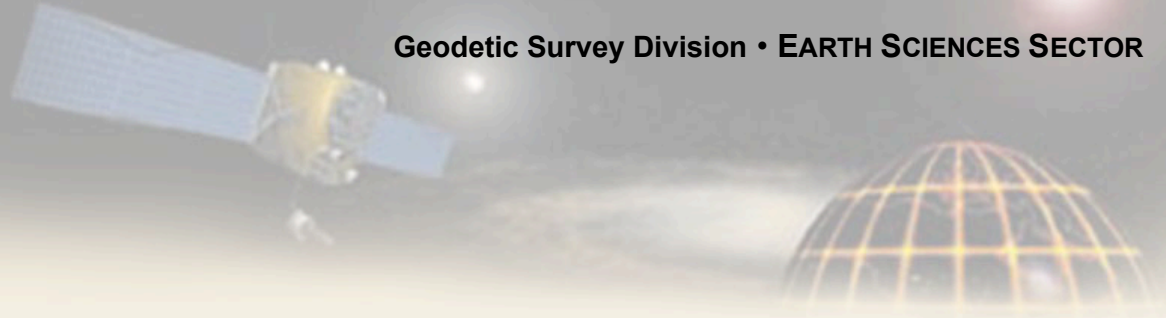
May 27, 2008

Niagara Falls, Ontario





Outline



- Introduction
- Canadian GPS Tracking Network
- NRCan Ultra Rapid Products (EMU)
- Online PPP Service (CSRS-PPP)
- Canadian High Precision RT GPS Wide-Area Correction Service (HP*GPS-C)
- Applications
- Summary





Introduction

- **Objective:**
stable, reliable, high accuracy positioning for ... for Canadians
- **New and innovative products developed throughout the years**
 - Network of high quality GPS tracking stations, Canadian Active Control System (**CACS**)
 - Timely **Ultra Rapid** satellite orbits and clocks
 - Precise Point Positioning (**CSRS-PPP**):
Post processed and near real-time
 - Real-time GPS correction information (**GPS-C**) to improve real-time user GPS positioning



Canadian GPS Tracking Network





NRCan Ultra Rapid Products (EMU)

Description

- Orbits and clocks for RT/NRT usage
- Covers 48h, i.e. 24h estimated and 24h predicted
- Produced **every hour** (since Jan2007)
- ~1h delay for orbits and ~1.5h delay for clocks
- Submission to IGS every 6h
- **Predicted orbits** used in **GPS-C**
- **Estimated orbits** and **30-sec** (Oct2007) satellite clocks used in **CSRS-PPP**





NRCan Ultra Rapid Products (EMU)

Precision*

NRCan Solutions (EMU)	Orbits* (cm)	Clocks* (ns)
Estimated portion (24h)	3–4 ^a	0.15 ^a
3h prediction	5 ^b	0.5
6h prediction	5	1
12h prediction	6	2
24h prediction	13	4

(*) Orbit and Clock Median RMS when compared to IGS Rapid (IGR)

(a) Orbits and clocks are used in NRT PPP

(b) Orbits are used in GPS-C





CSRS-PPP Service

Description

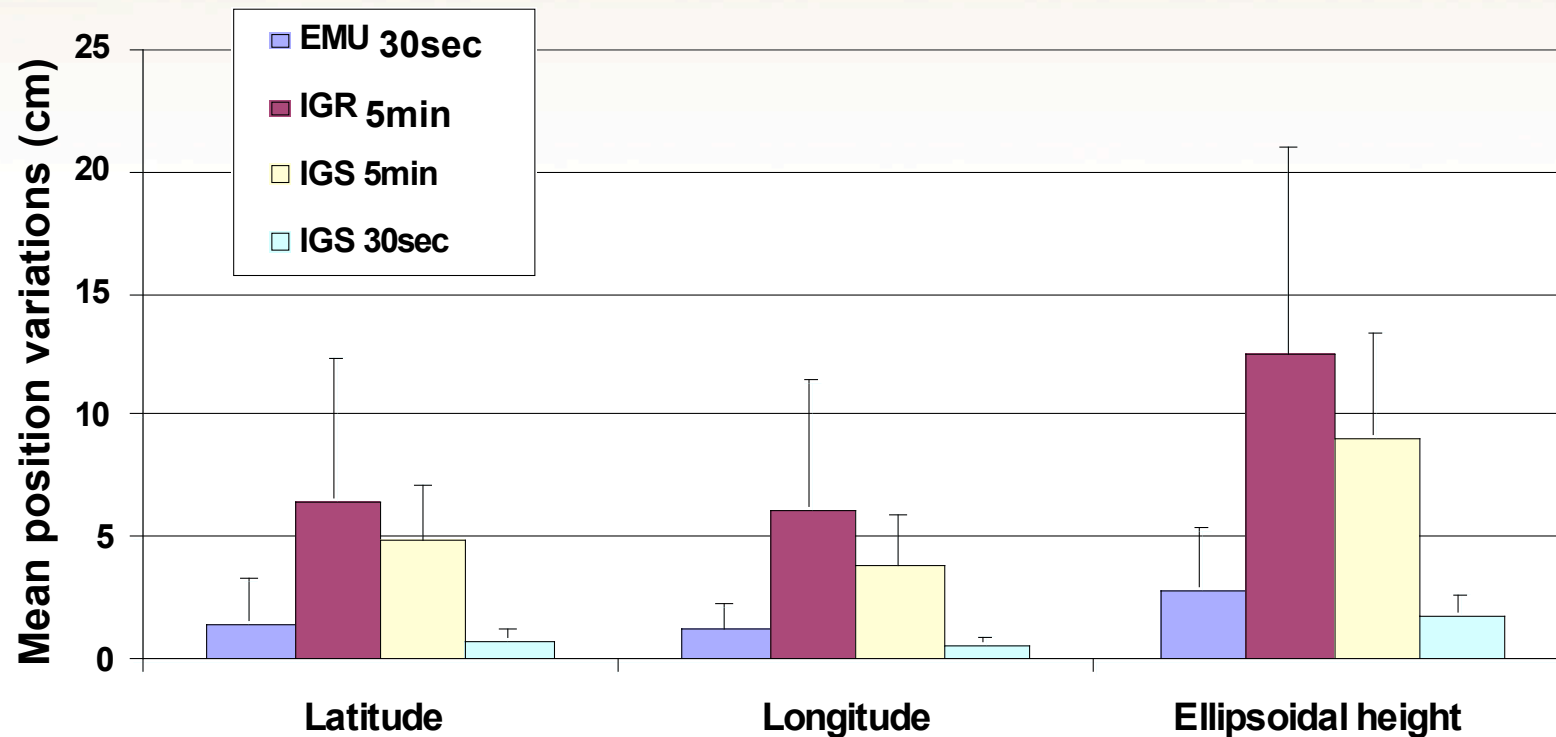
- A Web based global positioning service for single GNSS datasets (currently GPS only)
- Process static or kinematic with single or dual frequency data
- Delay reduced from 17hr to **90min** (May 2008) using NRCan Ultra Rapid orbits and 30sec clocks
- 2008 Usage
 - 85% static dual-frequency - 24hr sessions
 - 10% static single-frequency - ~1hr sessions
 - 5% kinematic – 2-3hr sessions





CSRS-PPP Service

Kinematic Positioning Variation wrt ITRF05



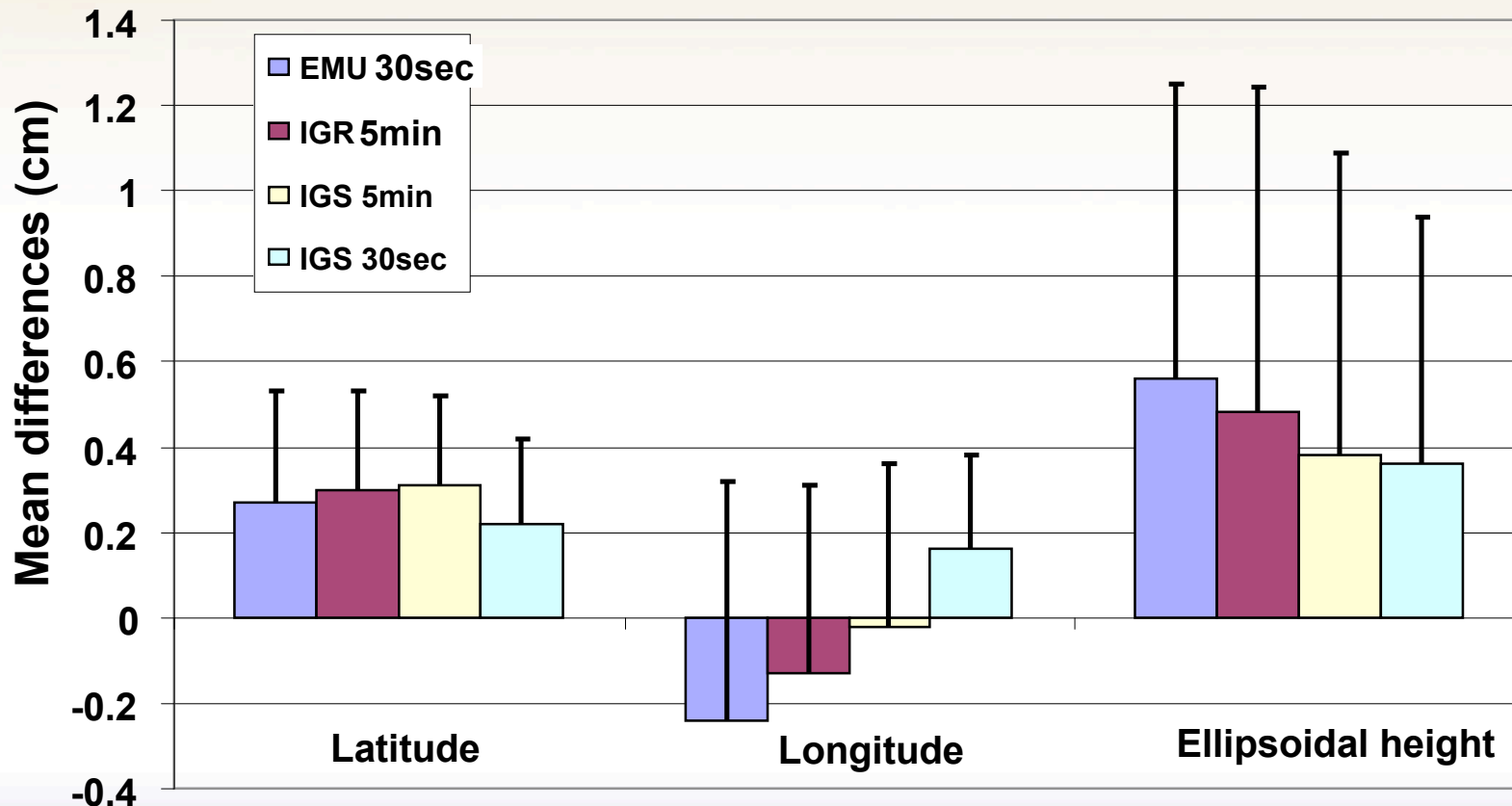
**Statistics based on 24 hour 30sec files for ALGO
DRAO RESO SASK STJO for GPS Week 1470**





CSRS-PPP Service

Static Positioning wrt ITRF05



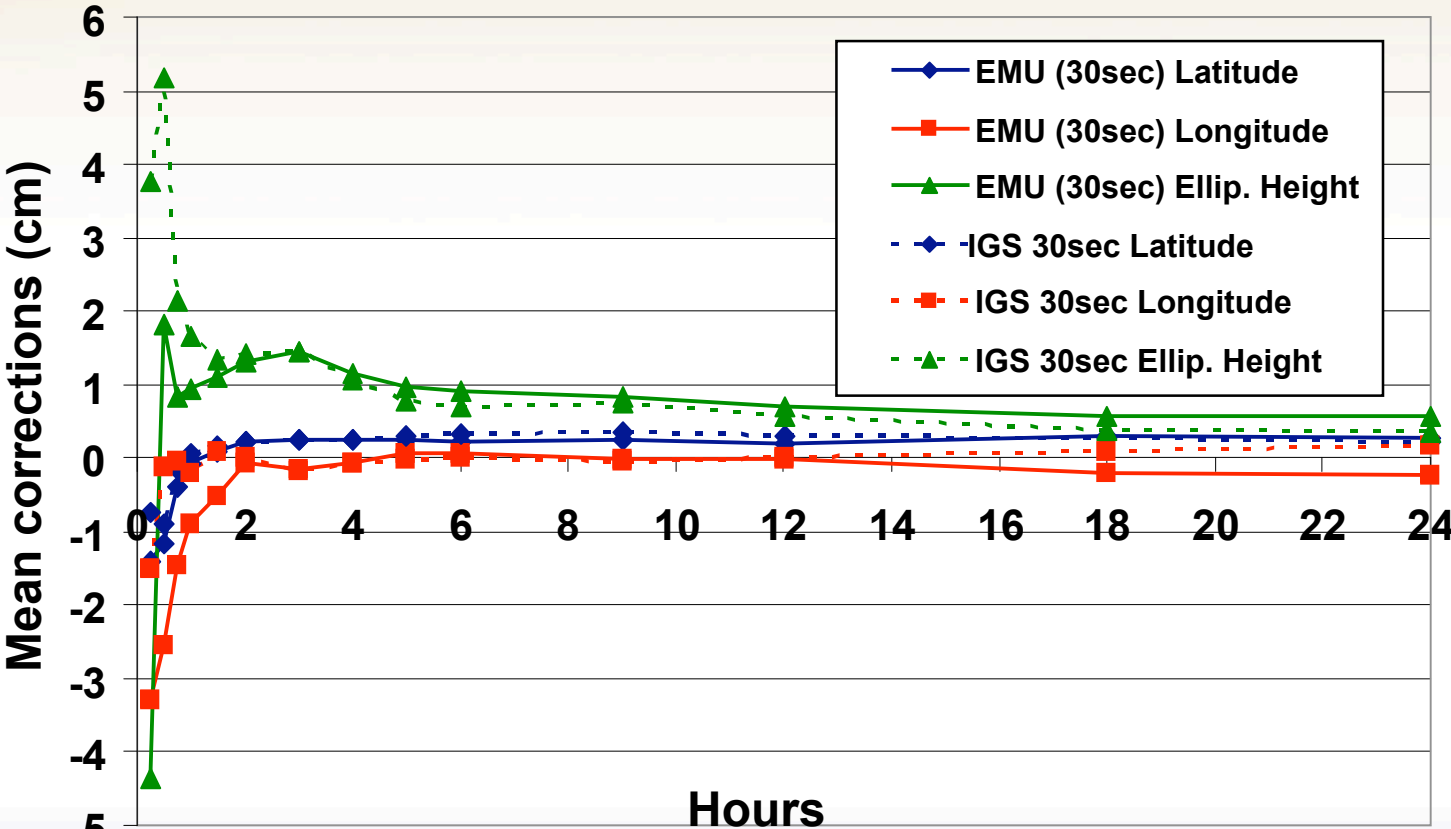
Statistics based on 24 hour 30sec files for ALGO
DRAO RESO SASK STJO for GPS Week 1470





CSRS-PPP Service

Static Positioning differences wrt ITRF05

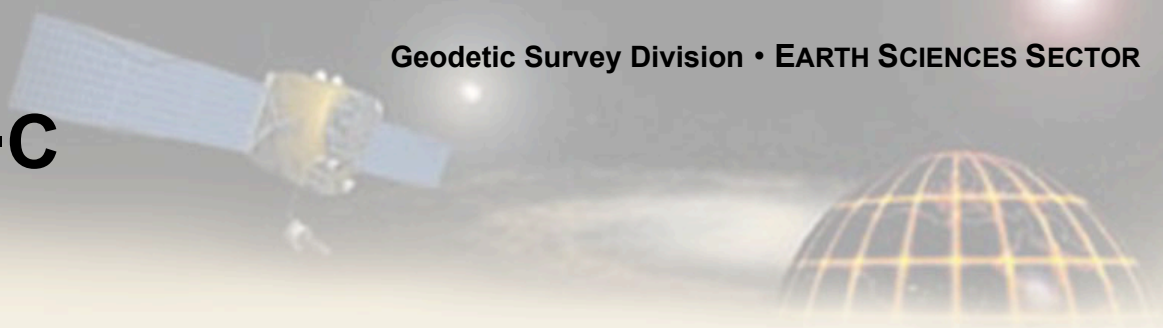


Statistics based on 24 hour files for ALGO DRAO
RESO SASK STJO for GPS Week 1470





HP-GPS-C



Description (1/2)

- Enhancement of the current code-based service
- Pseudorange & Phase Processing from IGS-RT + RT-CACS Stations

$$P3 = \rho(X_{\text{sta}}, X_{\text{sat}}) + c \cdot (dt_{\text{sta}} - dt_{\text{sat}}) + dt_{\text{trop}} + \varepsilon$$

$$L3 = \rho(X_{\text{sta}}, X_{\text{sat}}) + c \cdot (dt_{\text{sta}} - dt_{\text{sat}}) + dt_{\text{trop}} + \lambda N + \varepsilon$$

→ X_{sat} predicted by EMU (1h cycle) || IGU (6hr cycle)

→ $dt_{\text{sta}}, dt_{\text{sat}}, dt_{\text{trop}}, N$ estimated in real-time

→ X_{sta} fixed to ITRF (IGS05)





HP-GPS-C

Description (2/2)

- **Modeled Effects**

- Earth & ocean tides
- Sta & sat absolute PCV
- Relativity
- Phase wind-up
- ITRF station velocity

- **Parameters Estimated**

- Station and satellite clocks (white noise parameters wrt VRC)
- Station troposphere ZPD (random-walk)
- Constant (float) ambiguities

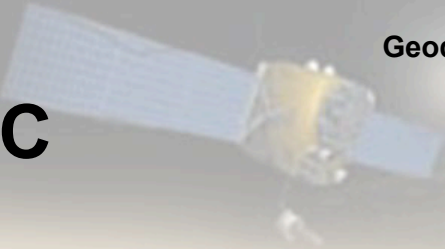
- **RT High Precision Correction Stream**

- **Xsat**-BRD @ 120sec (linear over 240sec)
- **dtsat**-BRD @ 2sec

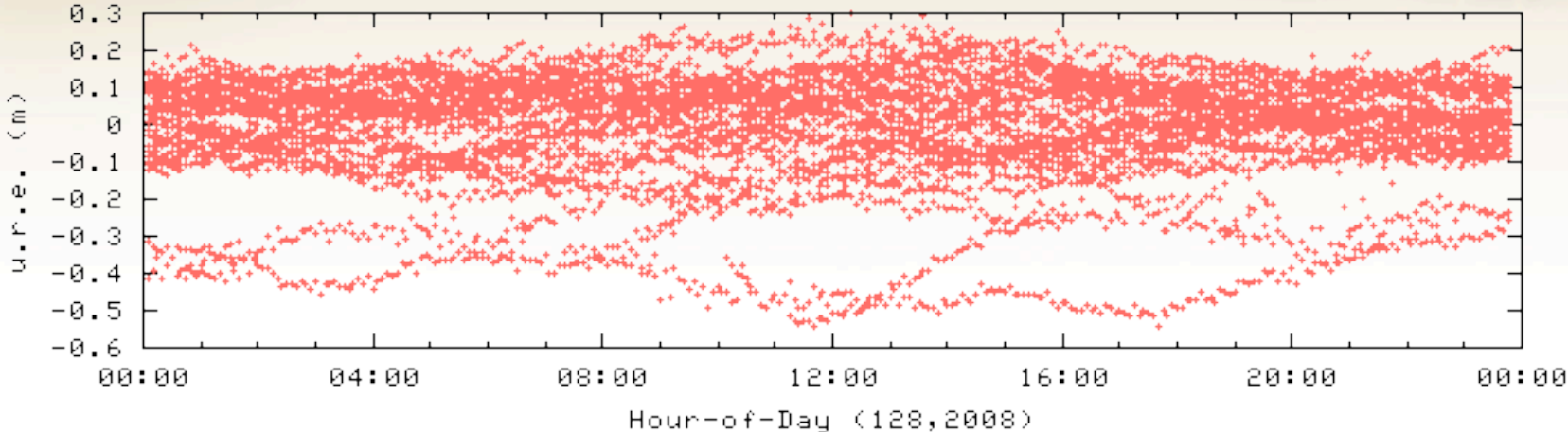




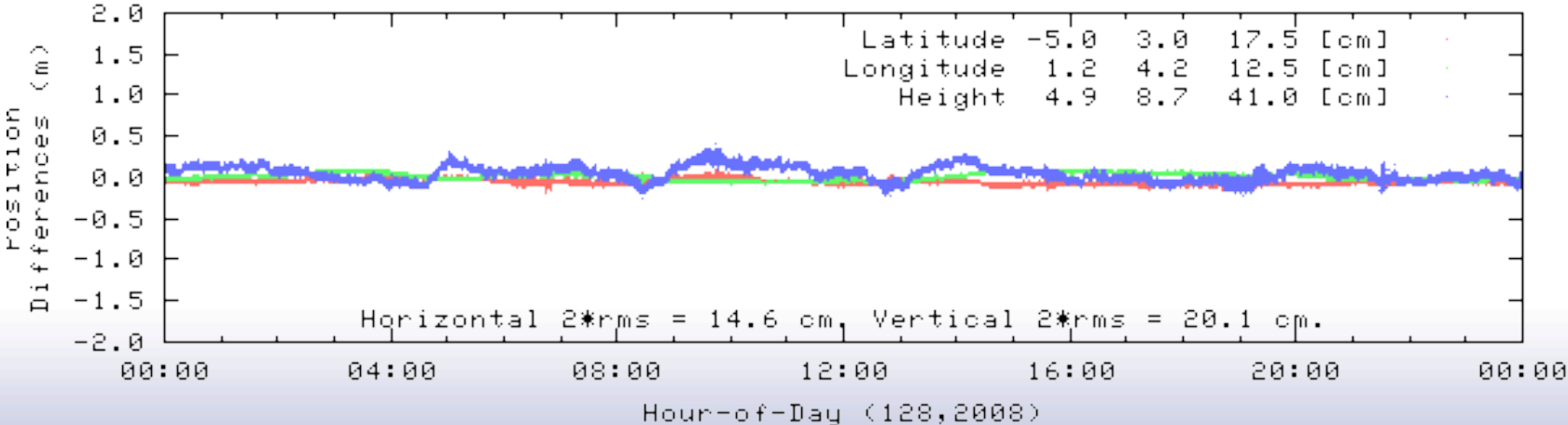
HP-GPS-C



User Range Errors for RTMACSD (RMS 13.8cm)



Position Differences for SCH2





HP-GPS-C

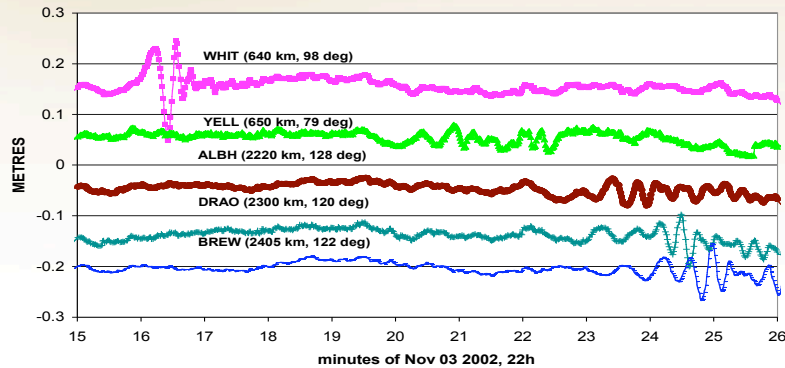
- **Status**
 - Access to potential 50+ real-time stations globally
 - Finalizing stress-tests & application robustness improvements
 - IOC targeted for Fall 2008
 - FOC targeted for early 2009
- **Further Refinements to the Phase-based Algorithm & Models**
 - Kouba's YAW model (GPS Solutions (online))
 - Integer ambiguity resolution with decoupled clocks
 - Define BRD-independent orbit messages
 - Define messages for tropo-mapping grid, satellite DCB's
 - Define messages required for PPP ambiguity resolution



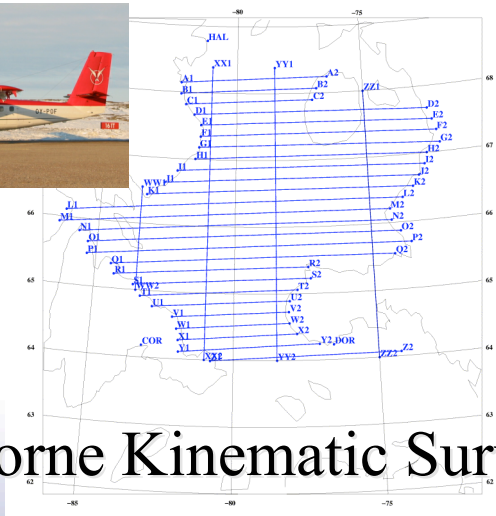
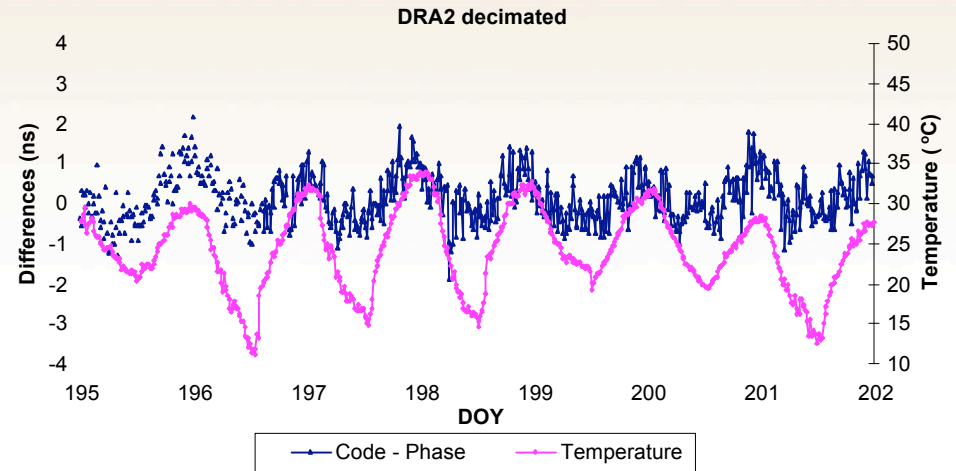


PPP Applications

Seismic Wave Monitoring



Monitoring Reference Station Biases



Airborne Kinematic Survey

- Atmosphere
- Space weather
- Engineering
- ...





Summary

- **NRCan Ultra Rapid Products**
 - Hourly cycle
 - Delay of 1h for orbits and 1.5h for clocks
 - Precision of ~5cm for a 3h orbit prediction
 - Precision of ~0.15ns for estimated clocks
 - **30sec clocks** also available!
- **NRCan Precise Point Positioning (PPP)**
 - Post processed and NRT using our Ultra Rapid Products
 - Static or kinematic solutions with single or dual frequency data
 - Delay of **90min** (May 2008) using NRCan Ultra Rapid orbits and 30sec clocks





Summary

- **Canadian High Precision RT GPS Wide-Area Correction Service (GPS-C)**
 - Soon available for Canadian users (Fall 2008)
 - 30+ active global stations used (7-8 Canadians, 15 for iono)
 - Real-time decimetre accuracy ($\leq 10\text{cm}$ CEP, $\leq 20\text{cm}$ SEP)
 - Parameters estimated: station and satellite clocks, ZPD
- **All products/services targeted towards relevant and identified applications (...)**

