The IGS Real-time Pilot Project

The Development of Real-time IGS Correction Products for Precise Point Positioning

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Background

- IGS RTWG Charter 2001
  - Design and implement real-time infrastructure and processes → network → data → products (iono, clock and orbits) → users
- IGS RTPP 2007 – 2010
  - 2009 extended until end of 2011
- 2010 RTWG and RTPP charter combined
  - 2011-2012 plan ➔ projects IGS rt-services starting 2013 → data, clocks and orbits → real-time PPP
- RT-Services are a part of the IGS strategic plan
  - IGS → IAG Service → GGOS Natural Hazards theme

Tracking Network 2011

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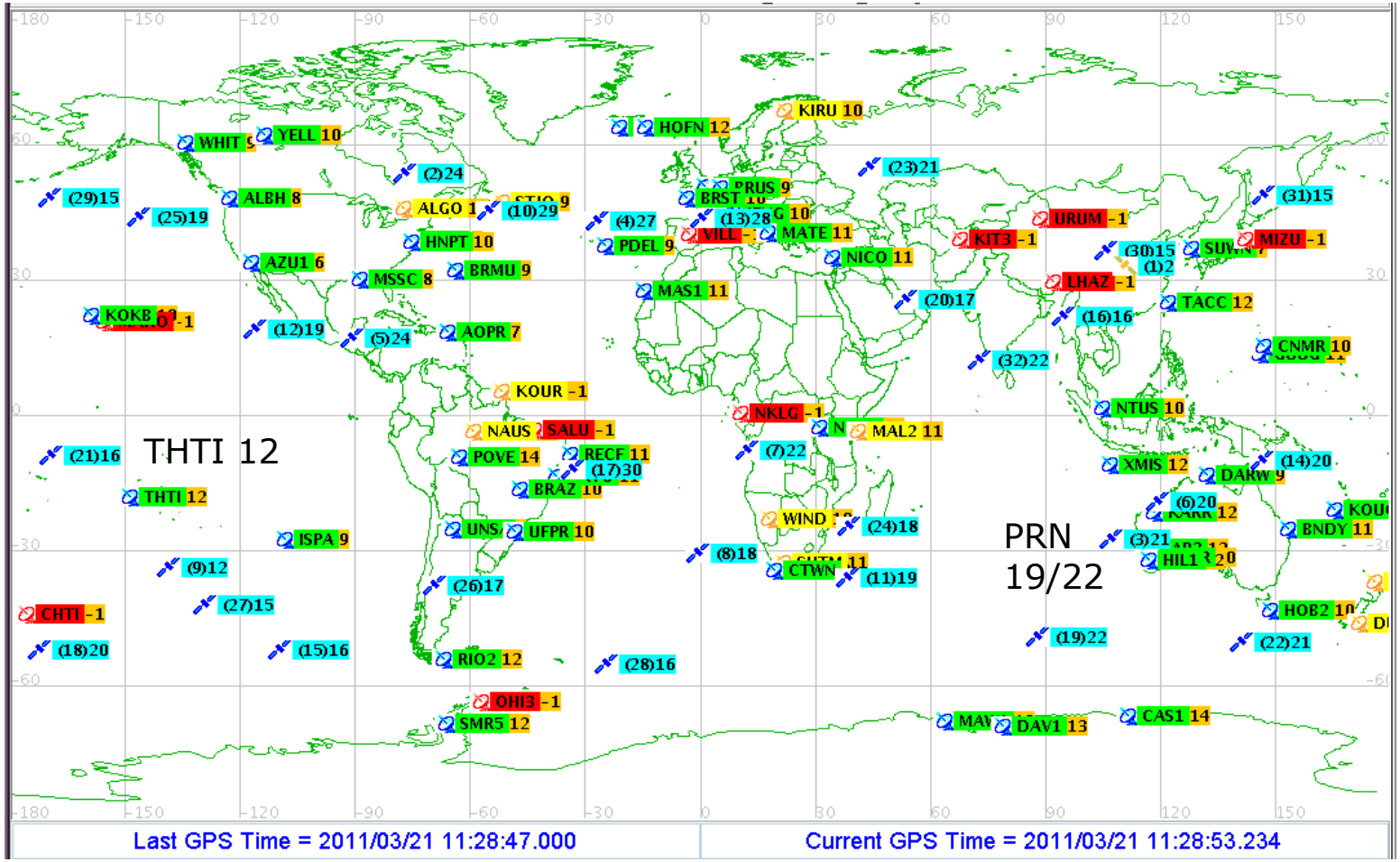

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RTCM Multiple Signal Messages (RTCM-MSM)

- Multi-constellation observation data messages defined for GPS, Glonass and Galileo and others
  - Internet distribution via NTRIP Protocol
  - Messages capable of encoding 64 SV's and 32 signals for each constellation
  - Generic GNSS observations supported (Code, Phase, Doppler, SNR and Loss of Lock Indicator)
  - Able to develop Rinex 2 and 3 compatible files
  - RTCM-MSM format and protocol nearing adoption by RTCM-SC104 members

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RTCM State Space Representation (RTCM-SSR)

- Development of RTCM State Space Representation messages in 3 stages:
  - 1) GPS and GLONASS: Satellite orbit corrections, satellite clock corrections, code biases and URA messages to allow dual frequency code based RT-PPP
  - 2) Galileo support, ionosphere (VTEC) corrections and phase biases messages to allow single frequency RT-PPP and support of ambiguity resolution
  - 3) Ionosphere (STEC) and troposphere corrections to allow RTK applications, i.e. cm accuracy in seconds.

RTCM State Space Representation (Stage 1)

- Multi-constellation correction data messages defined to support GPS and Glonass.
  - Internet distribution via NTRIP Protocol
  - SV Clock correction message supports 1mm resolution
  - SV Orbit correction message supports 1mm resolution
  - GNSS Code Bias correction message supports 0.01m resolution
  - RTCM-SSR format and protocol currently being voted on by RTCM-SC104

RT-IGS Global Ionospheric VTEC maps

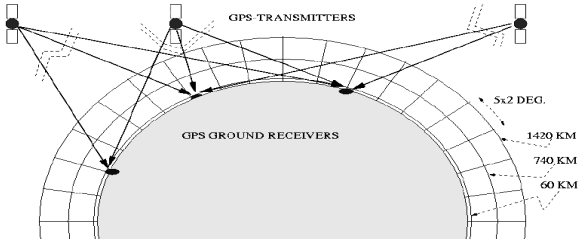
- IGS ionospheric group has provided global VTEC maps since 1998 (12 day) and 2003 (2 day)
  - optimal combination of 4 analysis centers
- Availability of precise real-time ionospheric delay model
  - Sub-meter single frequency navigation
  - Space Weather effects monitoring.
- RT global VTEC maps are being developed by UPC and DLR
  - Target is a combined RT IGS ionospheric product

RT-IGS global VTEC: First results

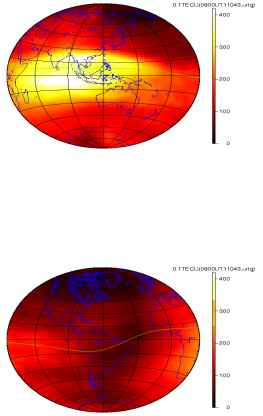
UPC 4D Iono model + Kriging interpolation (RT-TOMION)

RT-IGS GNSS data-streams

First UPC predicted global VTEC maps



First real-time global VTEC maps



- RT-VTEC map (2D) in IONEX format, 15 minutes rate and latency (in future it could be provided as 3D grid and data stream).
- Main problem found so far: lack of worldwide distributed receivers
- In the meantime the availability of a good background model and the use of an efficient interpolation strategy are very important.

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ACC Developments

- Assisted ACs to develop and improve their products:
  - 8 ACs in daily batch submissions for comparison and batch combination (see http://www.rtigs.net/pilot/products.php)
  - 6 AC RT streams used for RT combination and daily clock and orbit comparisons (RT comparisons used to isolate encoding and availability issues)
  - Emphasis on experimentation towards improved PPP solutions (see http://igs.bkg.bund.de/ntrip/ppp)
- Initiated WG on Ambiguity Fixing in PPP (led by M.Ge)
  - Performed a review of current techniques
  - Working on defining product set for potential IGS service

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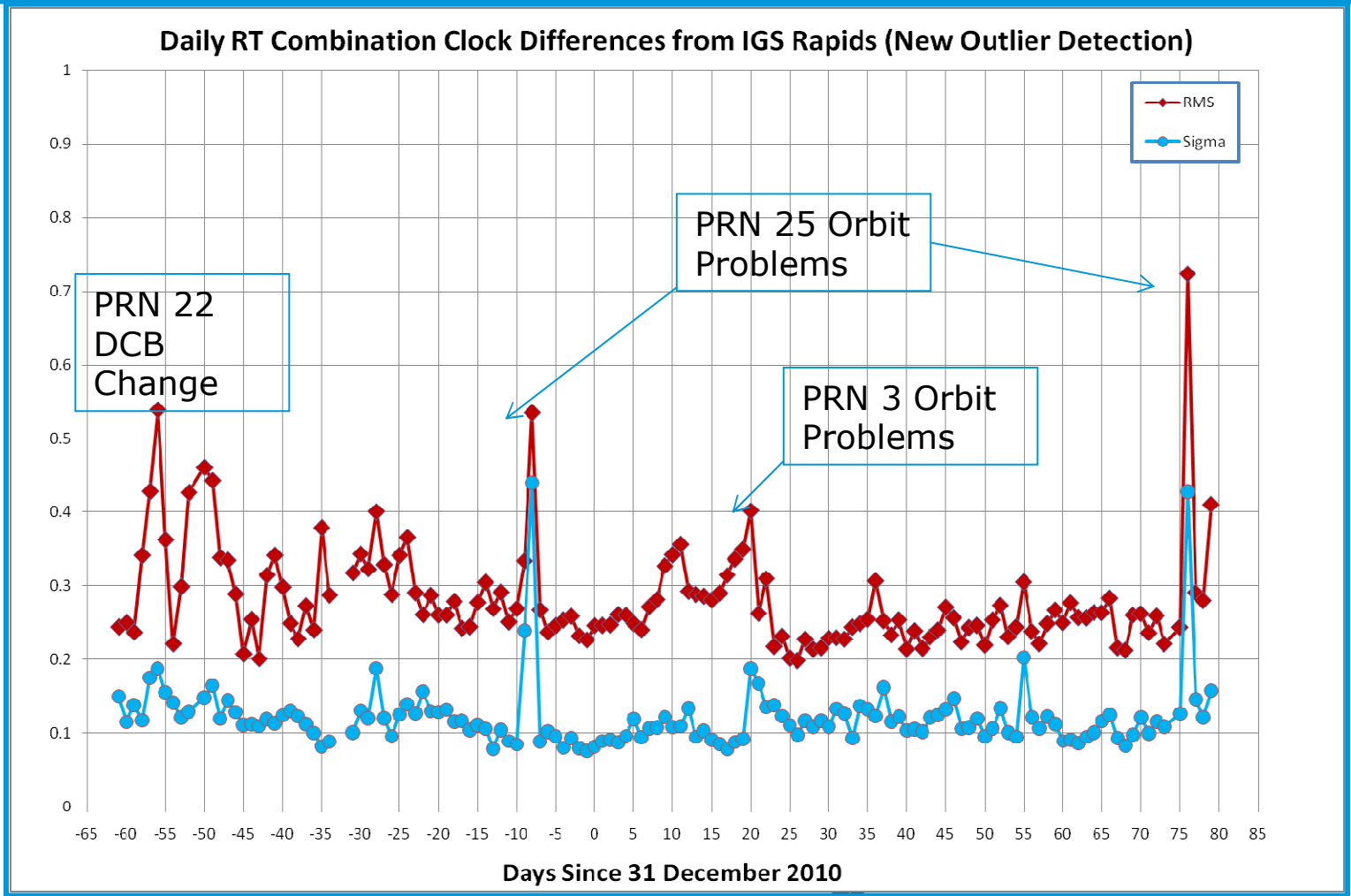
ACC Developments (2)

- Generation/Evaluation of RT Combination Streams
  - Improvements in clock outlier detection of IGS stream (disseminated as CLK30 in CoM and CLK31 in APC coordinates)
    - New scheme catches clock outliers but orbit problems (especially in the Ultras) are difficult to detect
  - Reduction in the latency (thanks to BKG/TUP changes to BNC) from approx 25 sec to around 15 sec, which can now be easily reduced further if contributing ACs reduce their latency
  - Evaluation of alternative combination technique developed by BKG

RT Combination Performance



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AC Performance

AC	Feb 6 2009		June 8 2010		March 9 2011	
	Clock RMS (ns)	Clock Sigma (ns)	Clock RMS (ns)	Clock Sigma (ns)	Clock RMS (ns)	Clock Sigma (ns)
Comb	0.29	0.22	0.16	0.10	0.18	0.08
RTComb	-	-	0.15	0.11	0.21	0.08
BKG	6.72	2.97	0.20	0.12	1.20	0.08
CNES	-	-	-	-	0.24	0.10
DLR	0.38	0.10	0.20	0.12	0.38	0.26
ESOC	0.42	0.38	0.21	0.12	0.20	0.16
ESOC2	0.36	0.30	0.19	0.11	0.30	0.09
GFZ	-	-	-	-	0.31	0.07
NRC	0.67	0.62	0.24	0.10	0.23	0.08
GMV	1.67	1.66	0.28	0.14	0.34	0.17
TUW			0.70	0.53	0.71	0.55

Products in Real Time

Centre	Description	NTRIP Mountpoint
RTACC ESOC	RT combination from BKG, CNES, DLR, ESOC, ESOC2 and GFZ streams (CoM /APC)	CLK30/31
CNES	RT clocks based on IGU orbits (CoM/APC)	CLK90/91
BKG with TU Prague	GPS and GPS + GLONASS RT clocks using IGS ultra-rapid orbits (CoM/APC).	CLK00/10 CLK01/11
DLR	RT clocks using IGS ultra-rapid orbits.	CLKC1/A1
ESOC	RT clocks and TZD NRT batch orbits every 2 hours (ESOC) and using IGS ultras (ESOC2) (CoM /APC)	CLK50/51 CLK52/53
GFZ	RT clocks (CoM/APC)	CLK70/71
GMV	RT clocks based on GMV orbit solution (CoM/APC).	CLKC1/A1
TUW	RT clocks based on IGU orbits (CoM/APC)	CLK80/81

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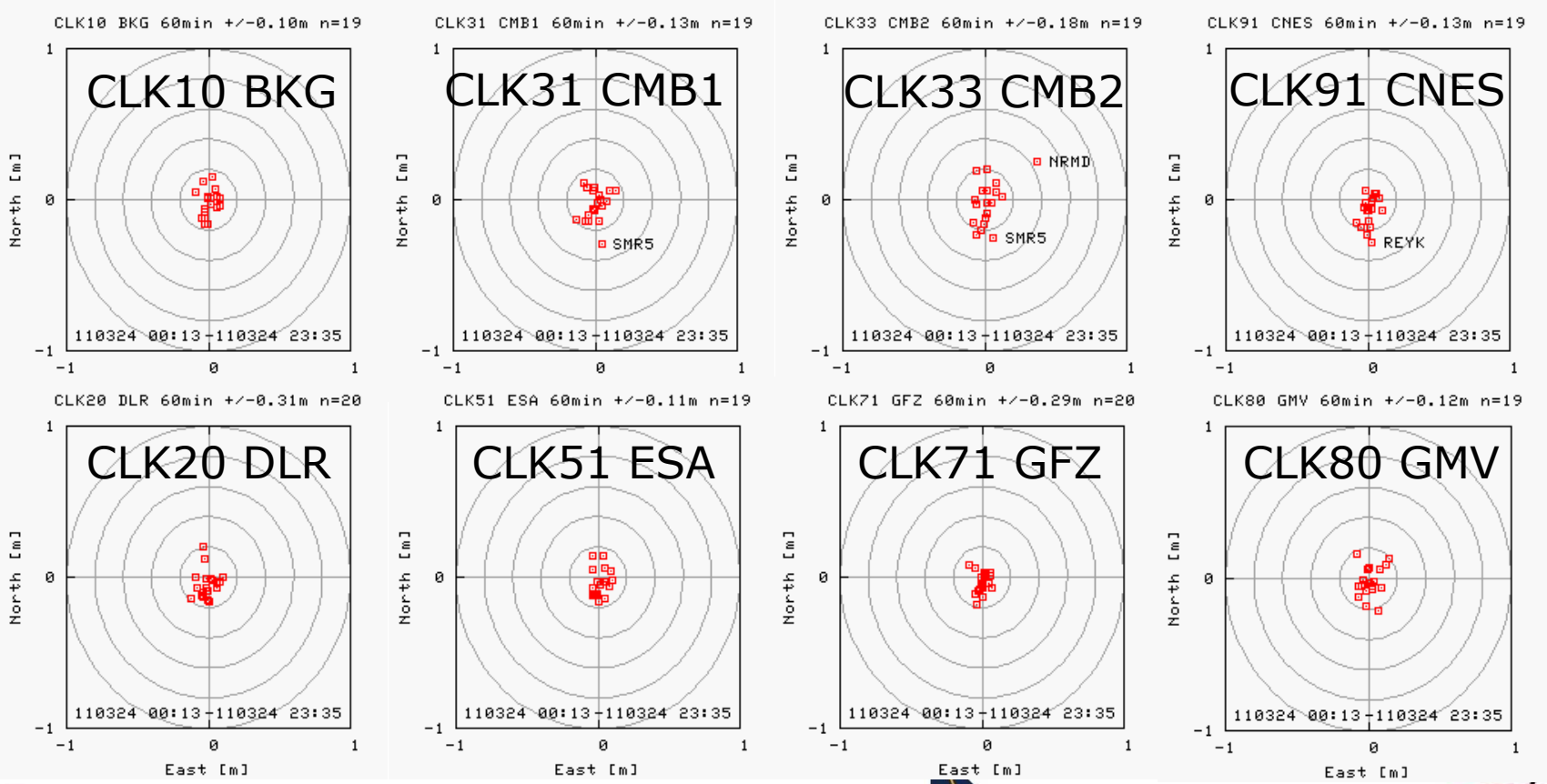
BNC rtppp results

-- kinematic solutions using globally distributed IGS sites.



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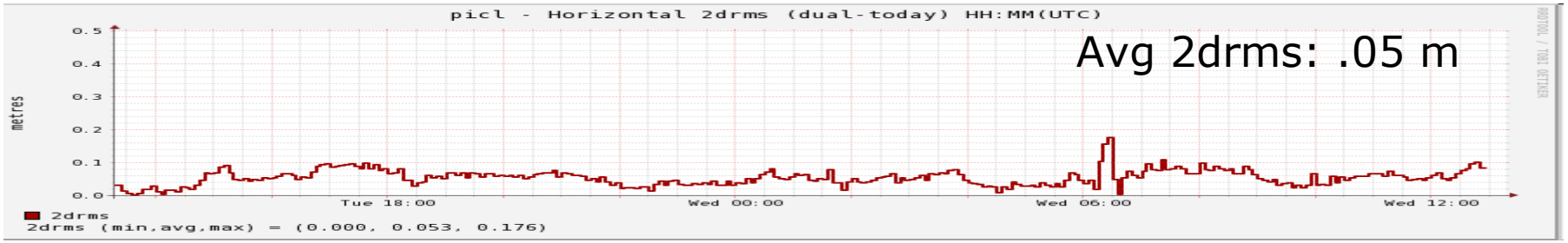
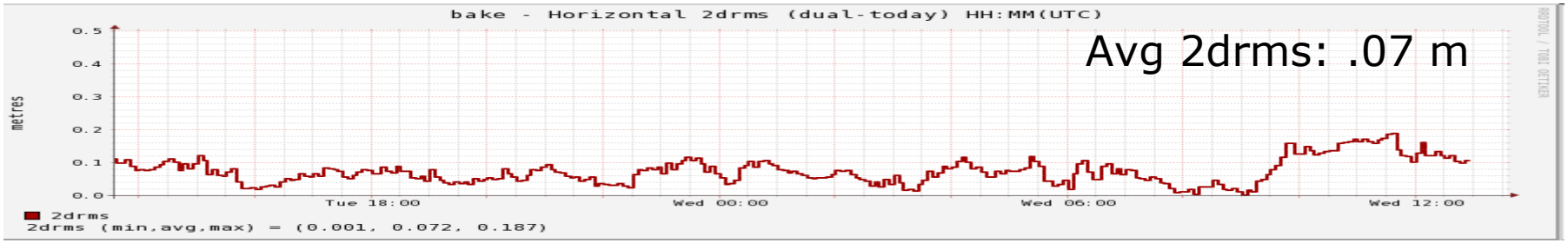
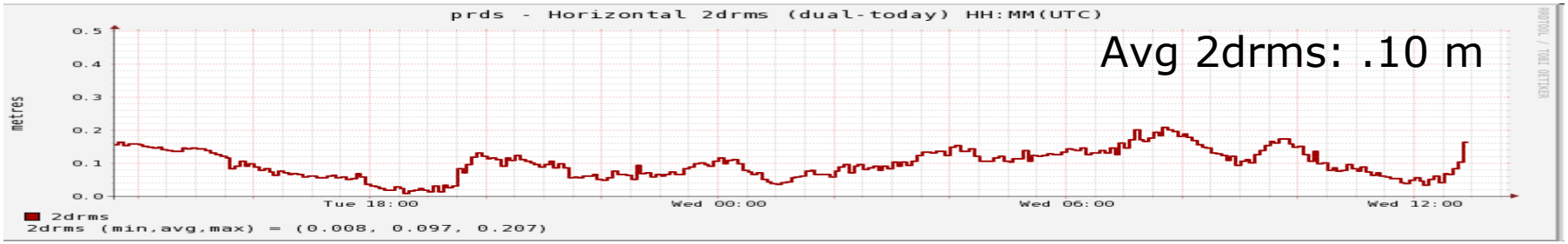
NRCan – rtppp results

-- kinematic solutions using Canadian sites







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Summary

- RTIGS is working within RTCM to further develop international standards for rt-data and rt-product formats – RTCM expected to adopt both in 2011
- Traditional IGS products are transitioning to real-time (data, iono, orbits, clocks)
- The IGS will offer real-time clocks and orbits to serve rtppp users (decimetre level)
  - Current target is 2011 IOC (within RTpilot) : 2013 FOC
  - http://www.rtigs.net

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