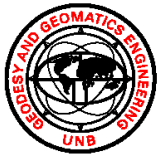

UNB

The Canada-wide Differential GPS Service: Initial Test Results

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Introduction

- Purpose:
  - ***Evaluation of the CDGPS Performance in Canada***
- Data:
  - 2003 June 7- June 21.
  - 24 hours RINEX data used from six IGS stations - To see the overall accuracy.
  - CDGPS NMEA output data and UNB1 Javad RINEX data - To evaluate the CDGPS receiver performance.
  - CDGPS and WAAS Correction Messages - To analyze the errors by UNB RTCA/MRTCA Correction Software.
  - CHUR RINEX Data – To compare WAAS and CDGPS positioning results
- Analysis for ionospheric correction:
  - *2003 June 9 and 2003 June 18.*

What is CDGPS?

A Canadian Federal/Provincial/Territorial collaborative program to provide:

- Public infrastructure of real-time GPS Corrections ("GPS.C") via L-band geostationary communications satellite (initially).

- Develop an initial user radio/receiver.

- Create enabling environment for private sector adoption of the infrastructure

CDGPS Key Team Members

- *Amin Kassam (Project Manager), Brad Hlasny, & Vern Vogt* (British Columbia government)
- *Kim Lochhead* (Canadian government)
- *Gyles Panther* (WiSys, Inc.;Mobile Knowledge Inc.)
- *Michael Carter* (M.A. Carter & Associates)

CDGPS Background

- National proposal at CCOG (Sept '99) by British Columbia and Ontario.

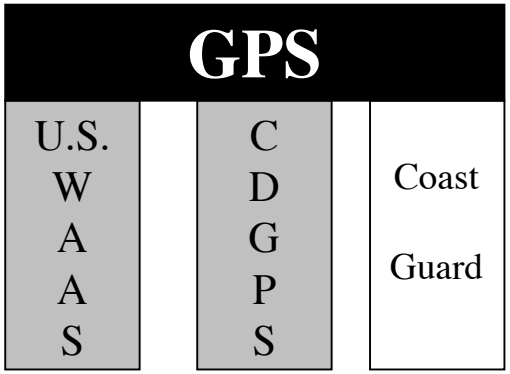
- Program sponsors: Federal, Provincial, Territorial Governments ($3.6 million over 5 years)

CDGPS Context

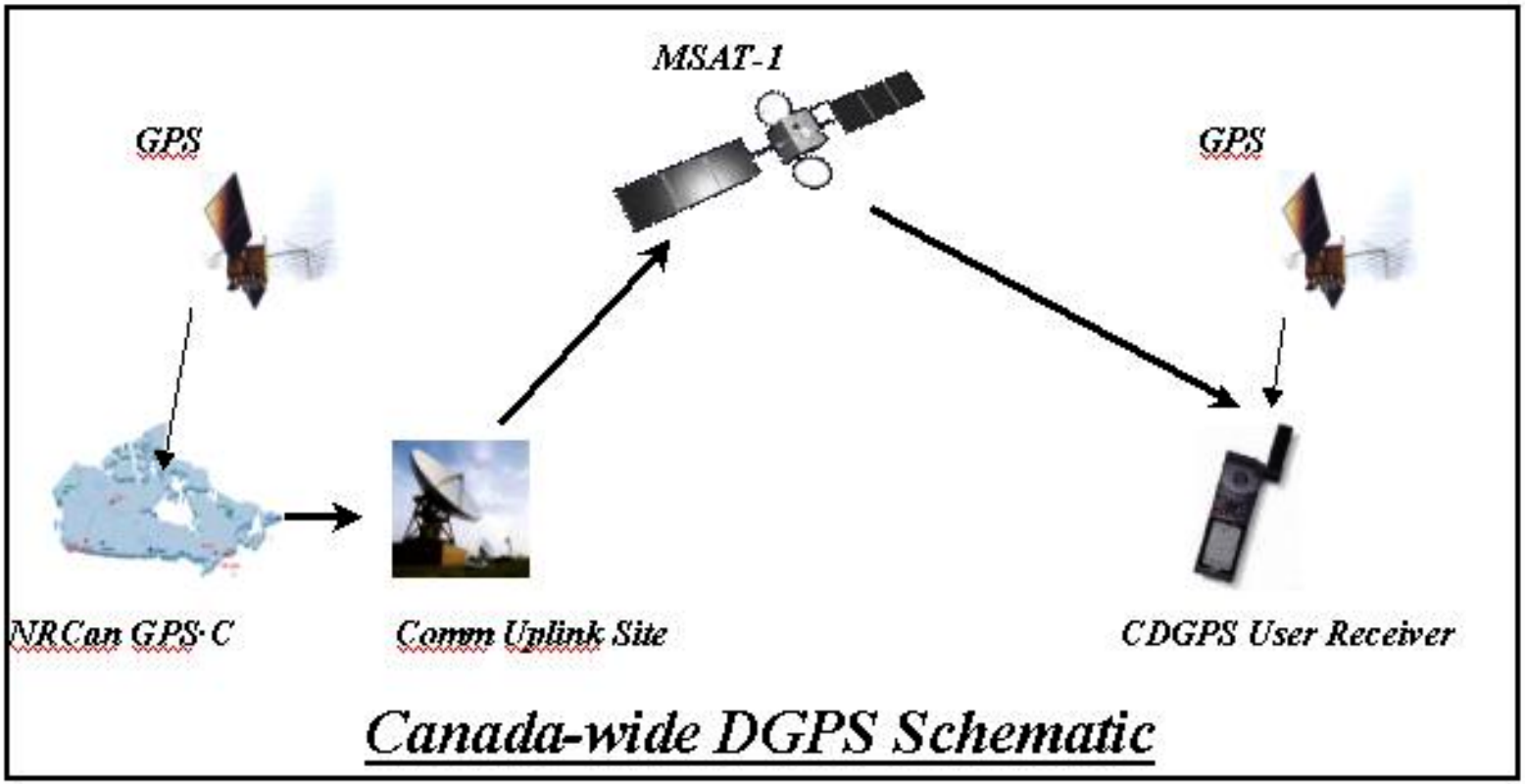
- Provides an infrastructure to enhance delivery of the Canadian Spatial Reference System (CSRS) to all Canadians

  ⇒ Complements Coast Guard and WAAS infrastructures

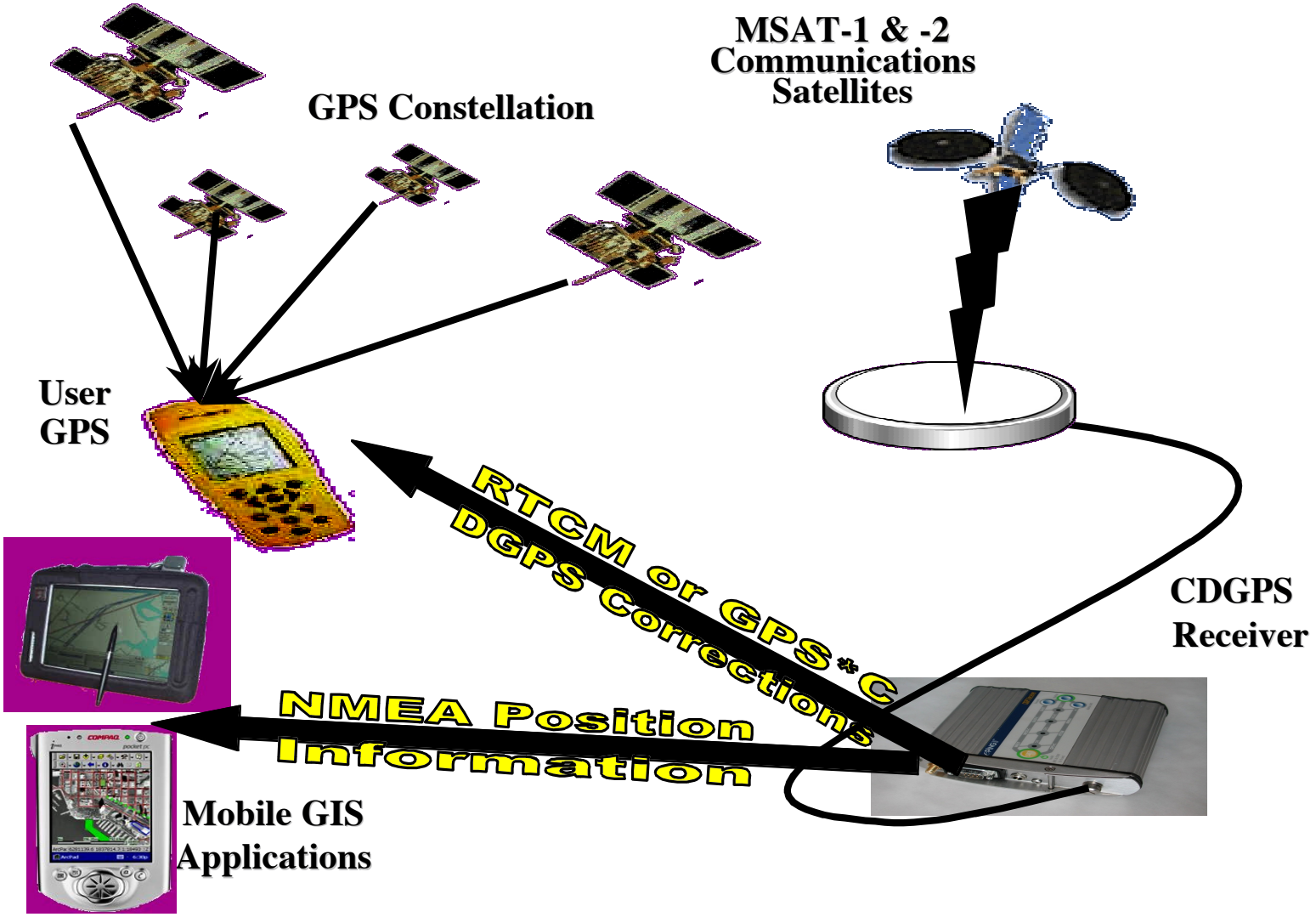
  ⇒ Dual frequency benefits



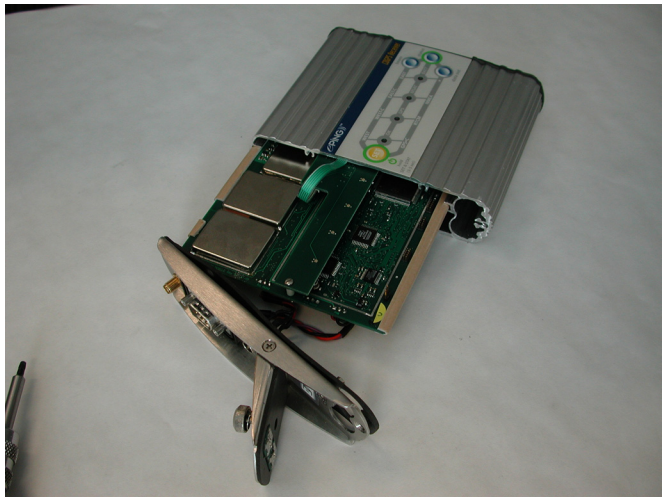
CDGPS System Architecture



End User *Open* Interface



CDGPS Receiver (antenna not shown)



Size and Mass

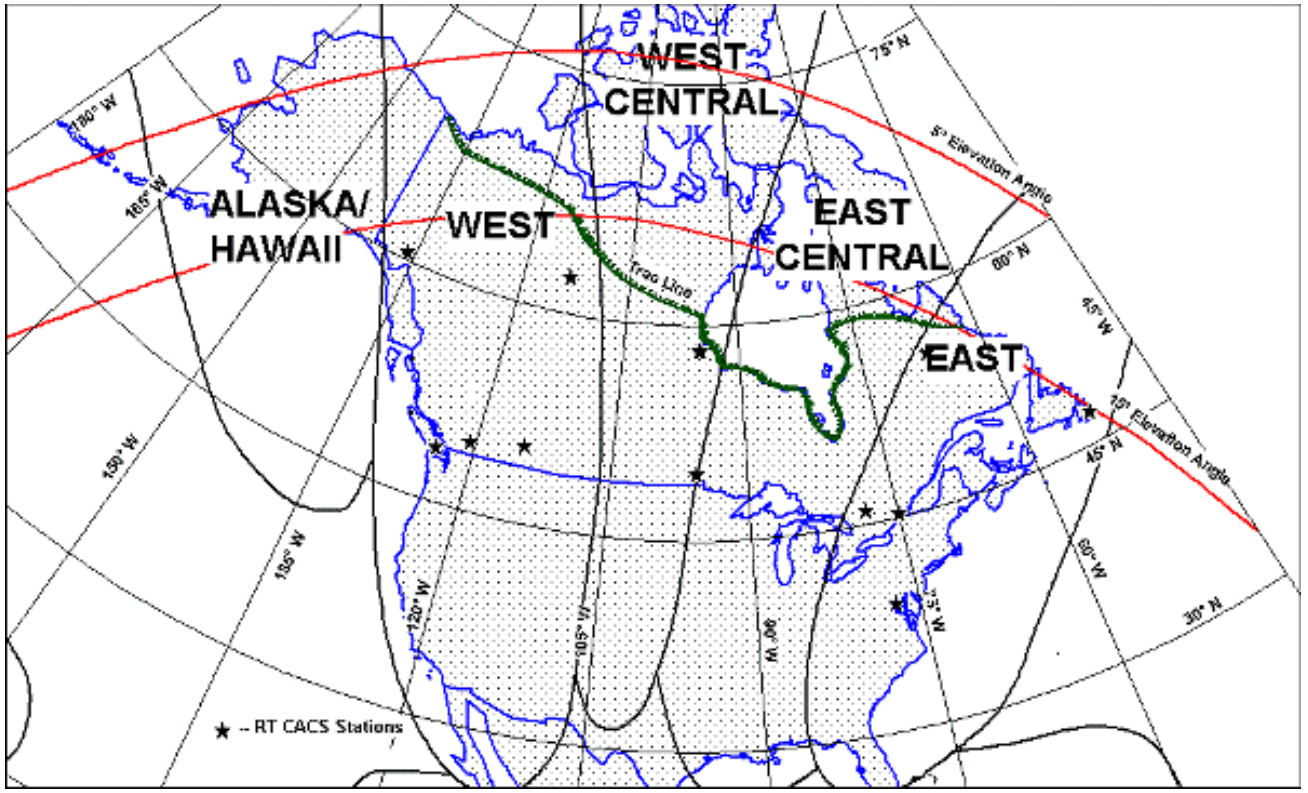
14 x 11 x
3.5 cm. (500 g)
(5.5” x 4.5” x
1.5” 1 lb)

Output

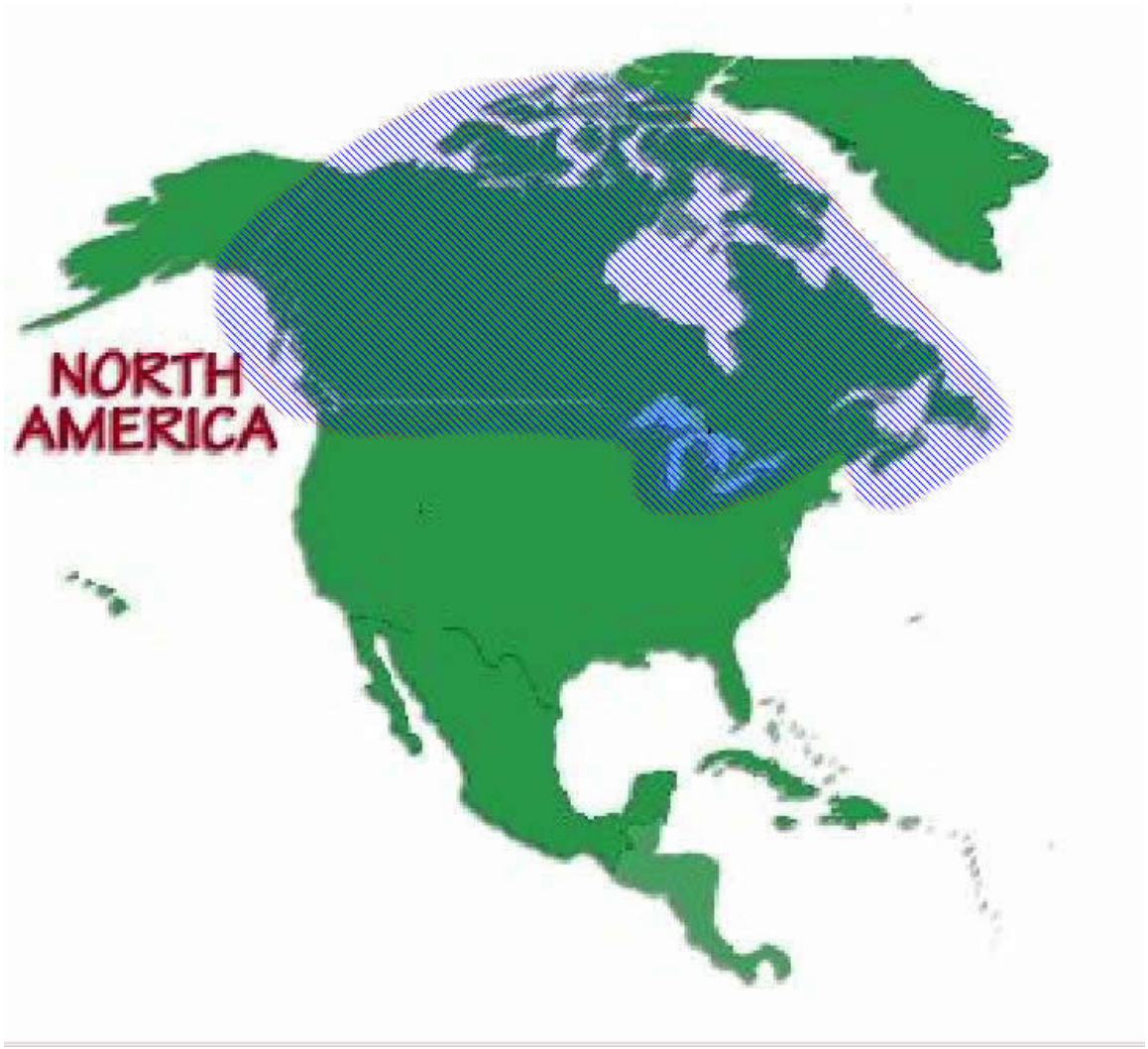
3 options:

- NMEA
- RTCM
- MRTCA(GPS•C)

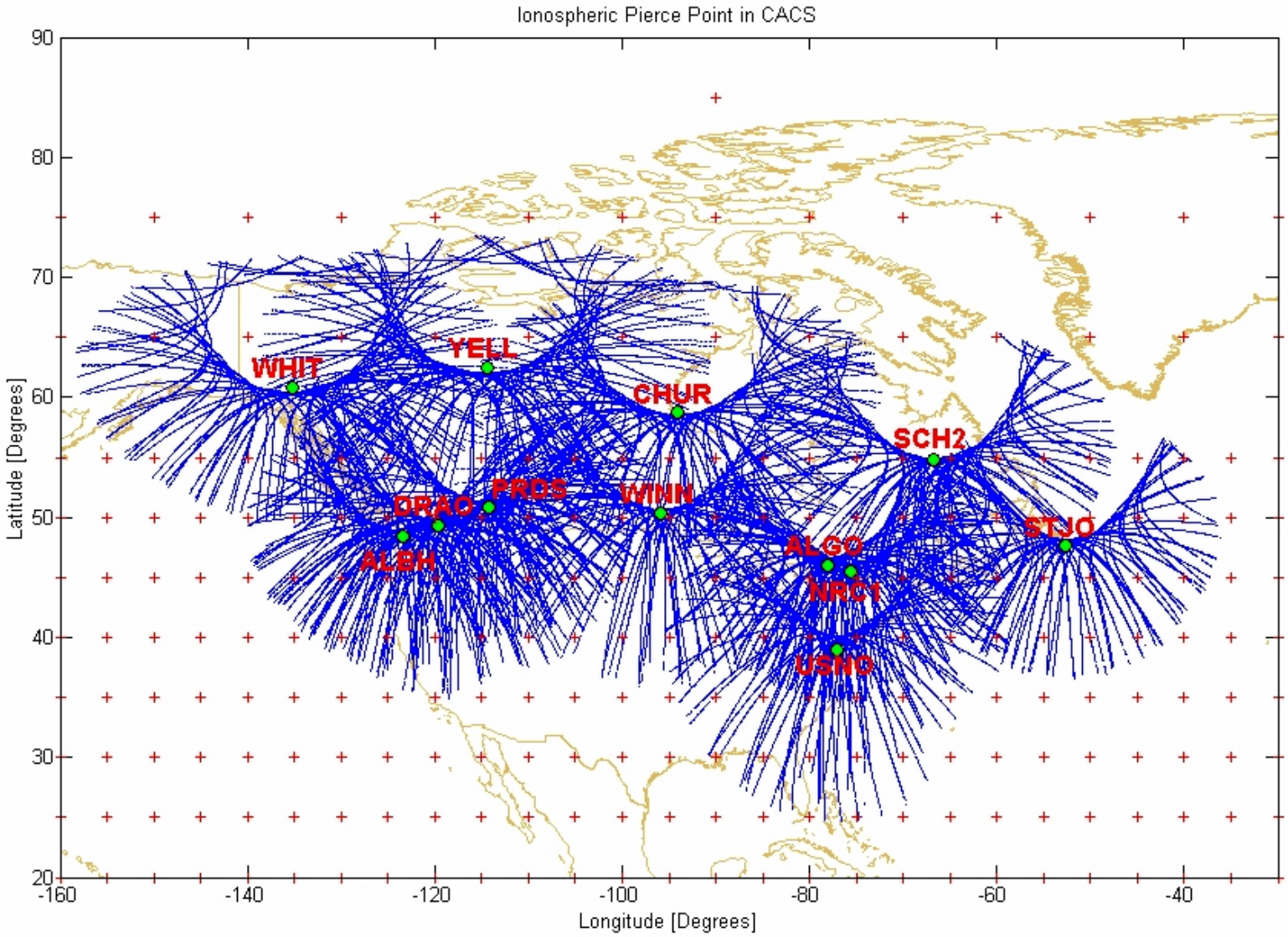
MSAT-1 and -2 Coverage



CDGPS Effective Coverage



CDGPS Ionospheric Modeling Availability



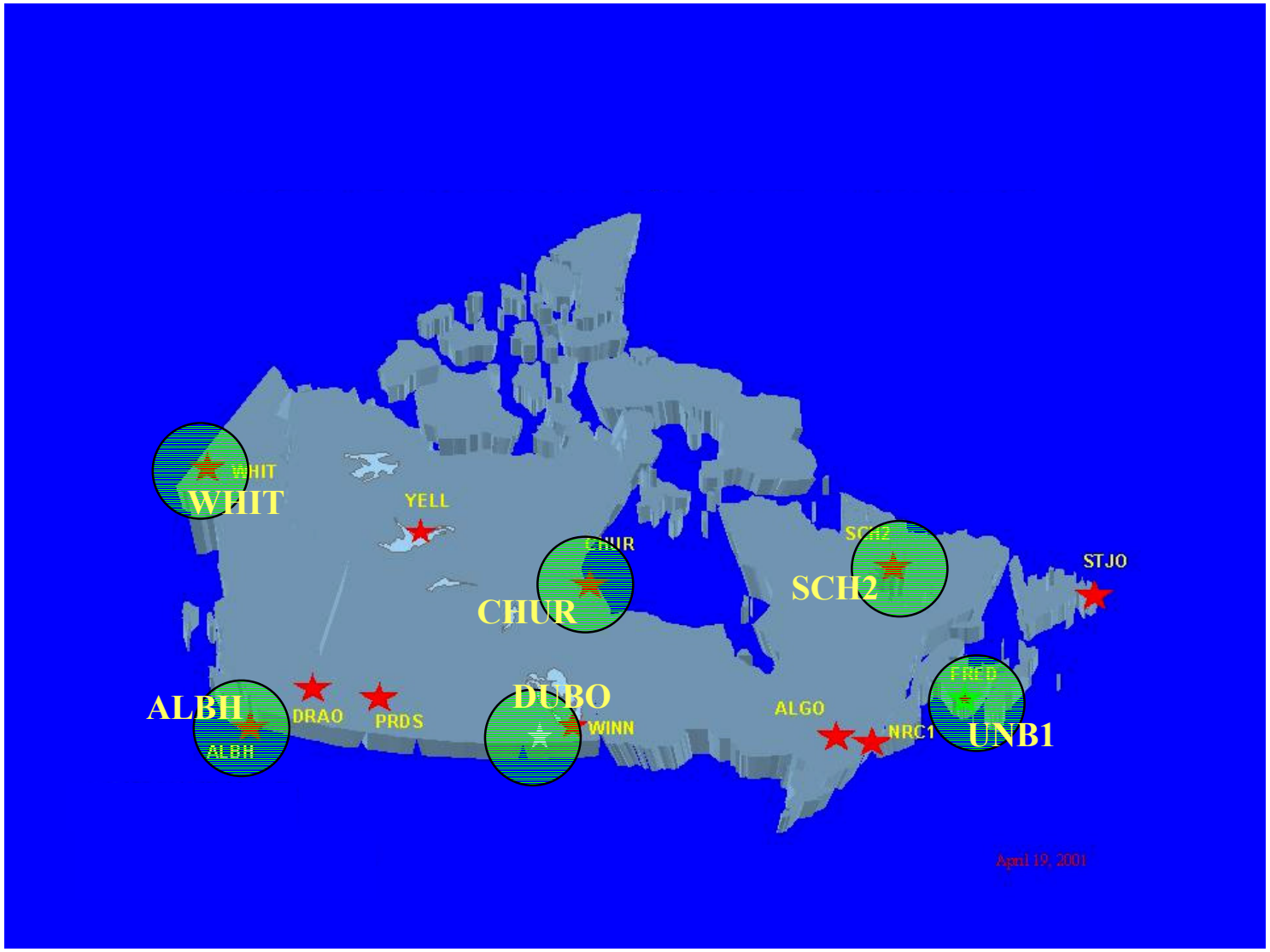
CDGPS Launch Status

- Alpha trials October 2002
- Beta trials June 2003
- Service launch July 2003
- 1000 radios to be manufactured in 2002/03.

Performance Evaluation

- Used Software:
  - UNB RTCA/MRTCA Correction Software
- Used IGS Stations
  - ALBH- South West Side of CDGPS Coverage.
  - WHIT- North West Side of CDGPS Coverage.
  - CHUR –Northern Middle Side of CDGPS Coverage.
  - DUBO –Southern Middle Side of CDGPS Coverage.
  - SCH2 – North East Side of CDGPS Coverage.
  - UNB1 – South East Side of CDGPS Coverage.

The Six IGS Stations
(Overall accuracy for CDGPS)



UNB RTCA/MRTCA Correction Software

RINEX DATA (Nav, Obs)

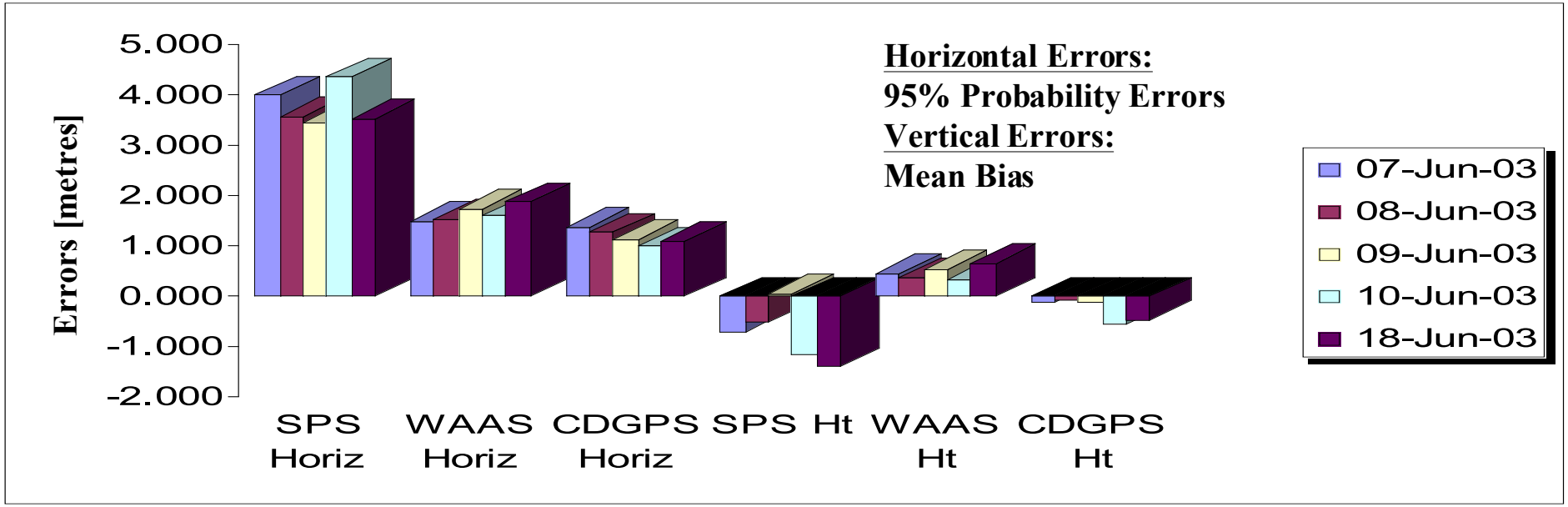
↓

	SPP Program	WAAS Program	CDGPS Program
Corrections:			
Satellite Ephemeris/Clock:	**No**	**WAAS**	**CDGPS(NAD83(CSRS))**
Ionospheric Correction:	**Klobuchar**	**WAAS/Klobuchar**	**CDGPS/Klobuchar**
Tropospheric Correction:	**UNB3/Niell**	**UNB3/Niell**	**UNB3/Neill**
Weighting Scheme: (Reduce Noise)	**Elevation angles**	**WAAS Eph. Sigma+ WAAS Iono. UIVEs+ Elevation angles**	**CDGPS Eph. Sigma+ CDGPS Iono. UIVEs+ Elevation angles**
Carrier Phase Smoothing:	**Yes (Optional)**	**Yes (Optional)**	**Yes (Optional)**

↓

Point Positioning Results (N, E, H)

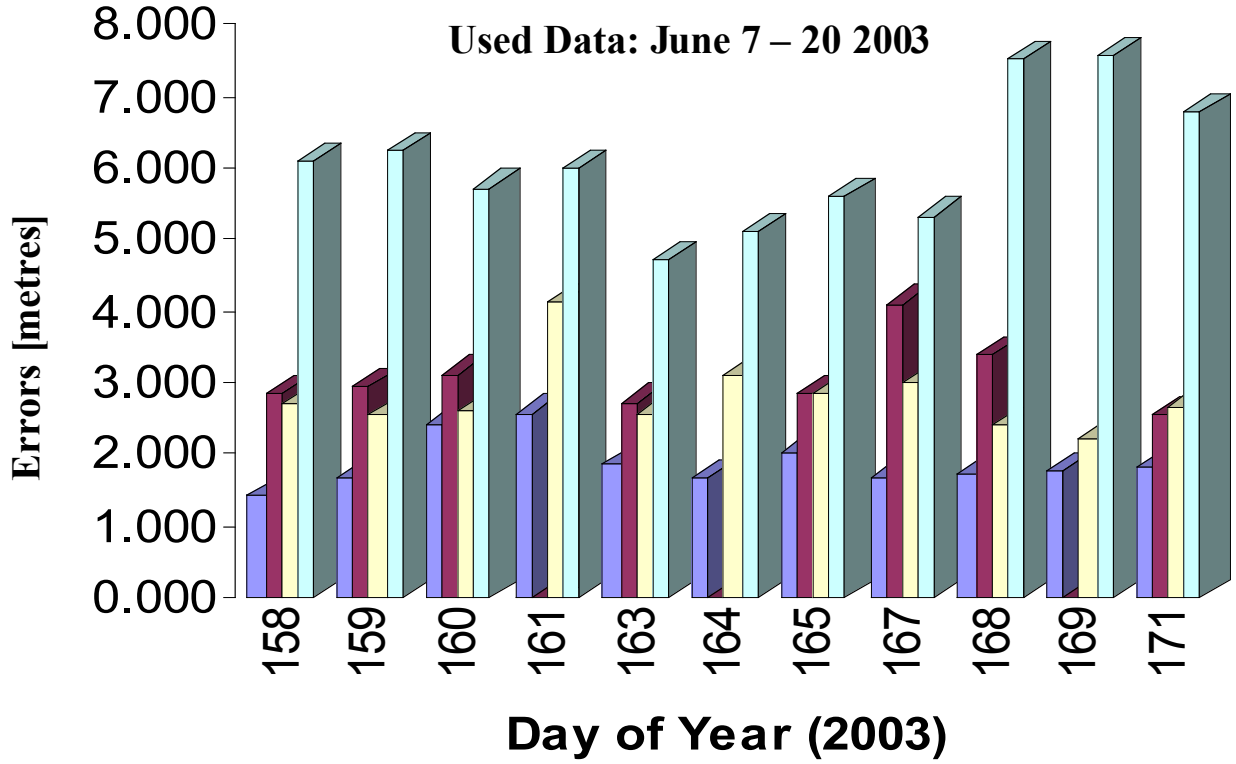
Comparison SPS, CDGPS and WAAS Positioning Results at CHUR



Unit: Metres

	SPS Horiz	WAAS Horiz	CDGPS Horiz	SPS Ht	WAAS Ht	CDGPS Ht
07-Jun-03	4.006	1.502	1.389	-0.708	0.457	-0.095
08-Jun-03	3.578	1.535	1.283	-0.523	0.372	-0.085
09-Jun-03	3.463	1.750	1.132	0.051	0.543	-0.109
10-Jun-03	4.360	1.605	0.996	-1.140	0.336	-0.575
18-Jun-03	3.544	1.886	1.109	-1.402	0.662	-0.467
Mean	3.790	1.656	1.182	-0.744	0.474	-0.266

Comparison of CDGPS Receiver and UNB1 Javad Receiver Results at UNB



Horizontal Errors:
95% Probability Errors
Vertical Errors:
2 d. r.m.s

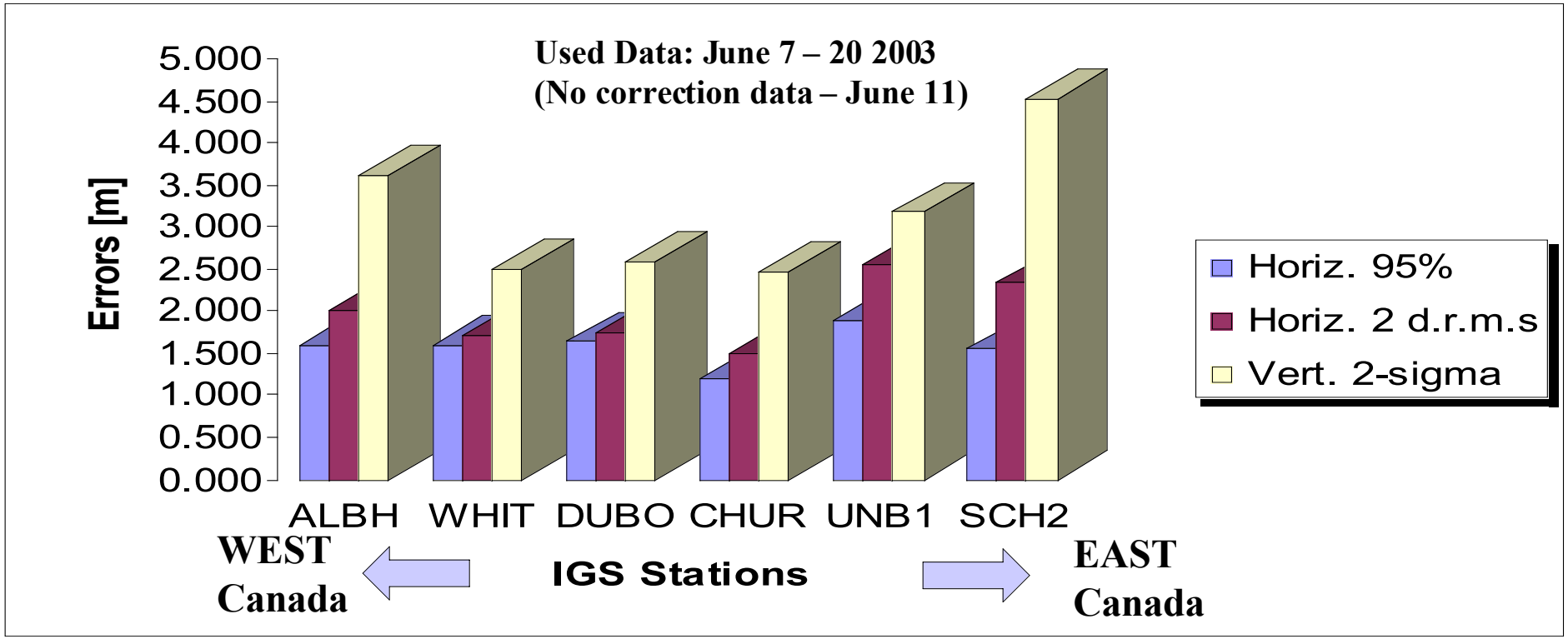
- Javad Horiz
- CDGPS Horiz
- Javad Ht
- CDGPS Ht

Unit: Metres

	Javad Horiz	CDGPS Horiz	Javd Ht	CDGPS Ht
MEAN	1.875	3.056	2.800	6.063

CDGPS Accuracy - Six IGS Stations

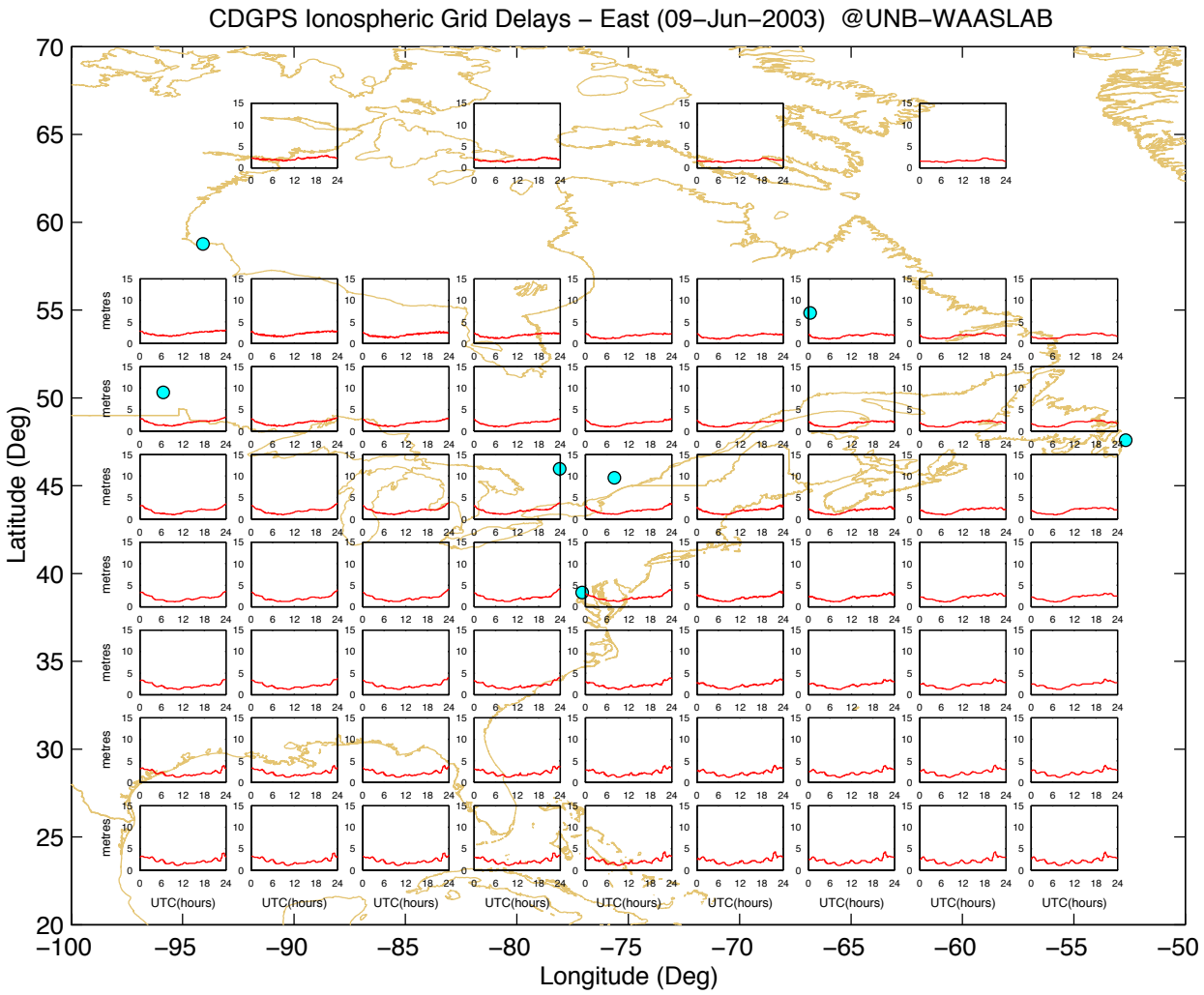
[High Quality Receiver – 13 day mean]



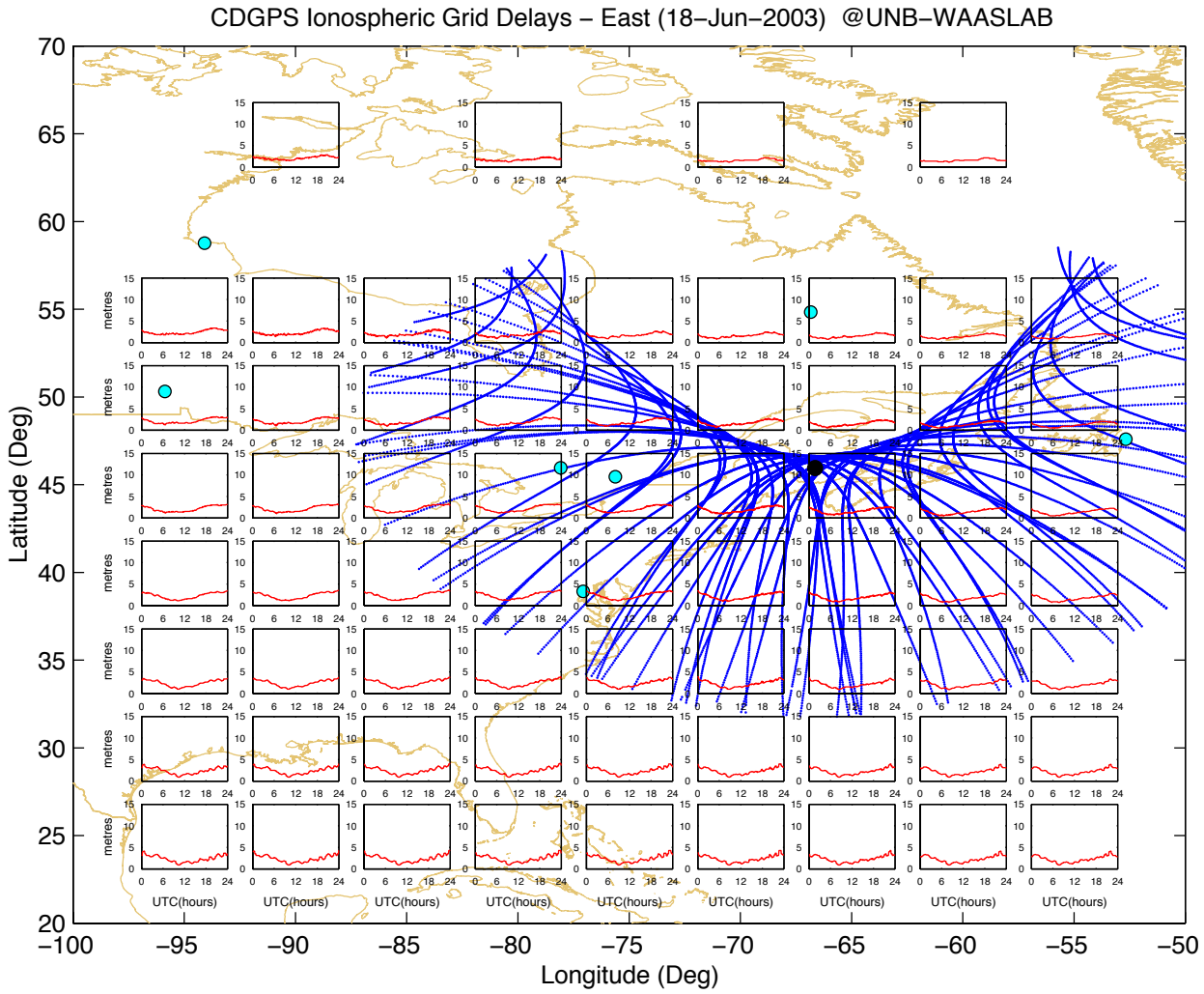
Unit: Metres

	ALBH	WHIT	DUBO	CHUR	UNB1	SCH2
Horiz. 95%	1.595	1.599	1.635	1.210	1.886	1.547
Horiz. 2 d.r.m.s	2.021	1.720	1.738	1.499	2.550	2.335
Vert. 2-sigma	3.629	2.489	2.590	2.457	3.180	4.530

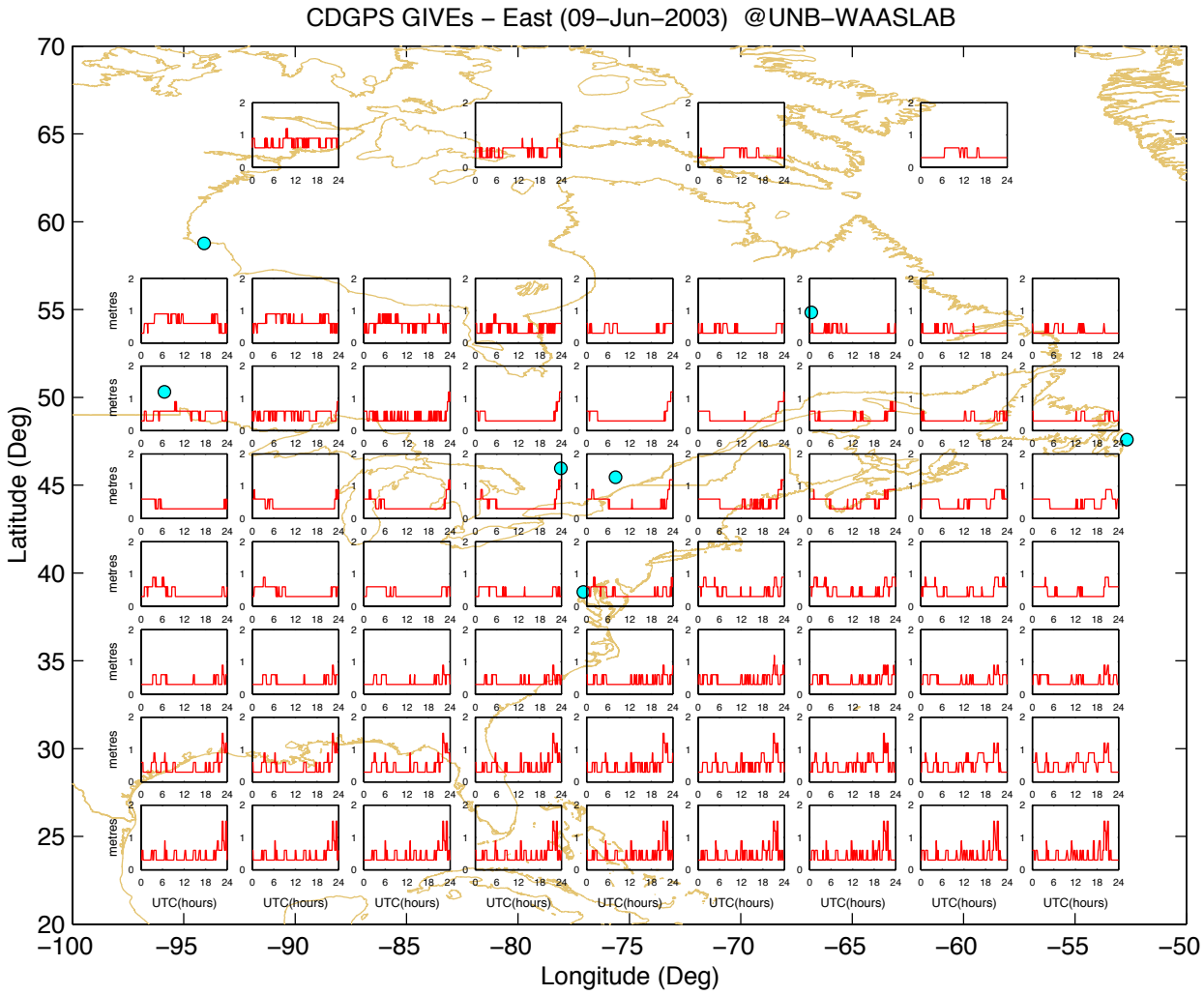
CDGPS Ionospheric Grid Delays (2003 June 9)



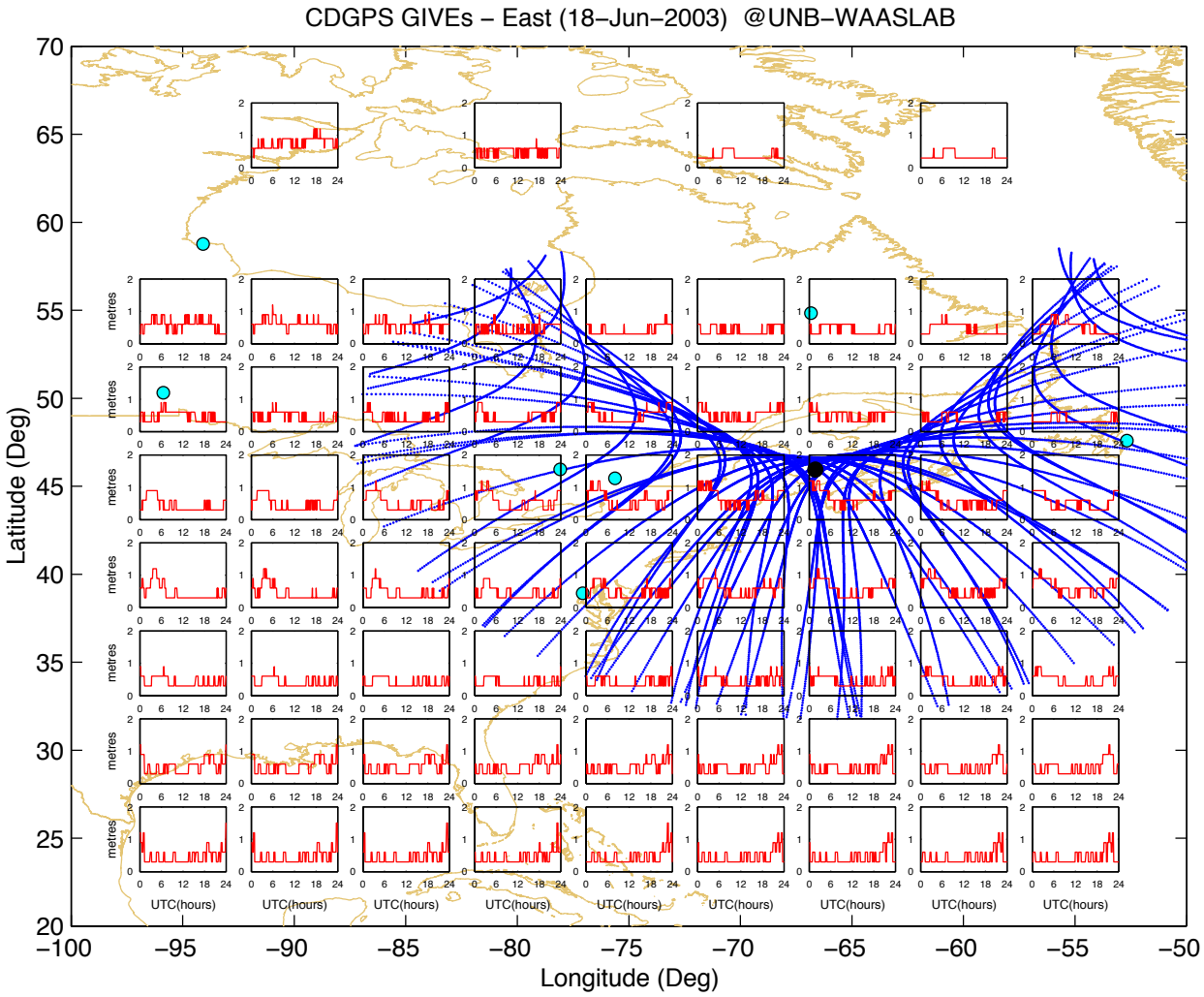
CDGPS Ionospheric Grid Delays (2003 June 18)



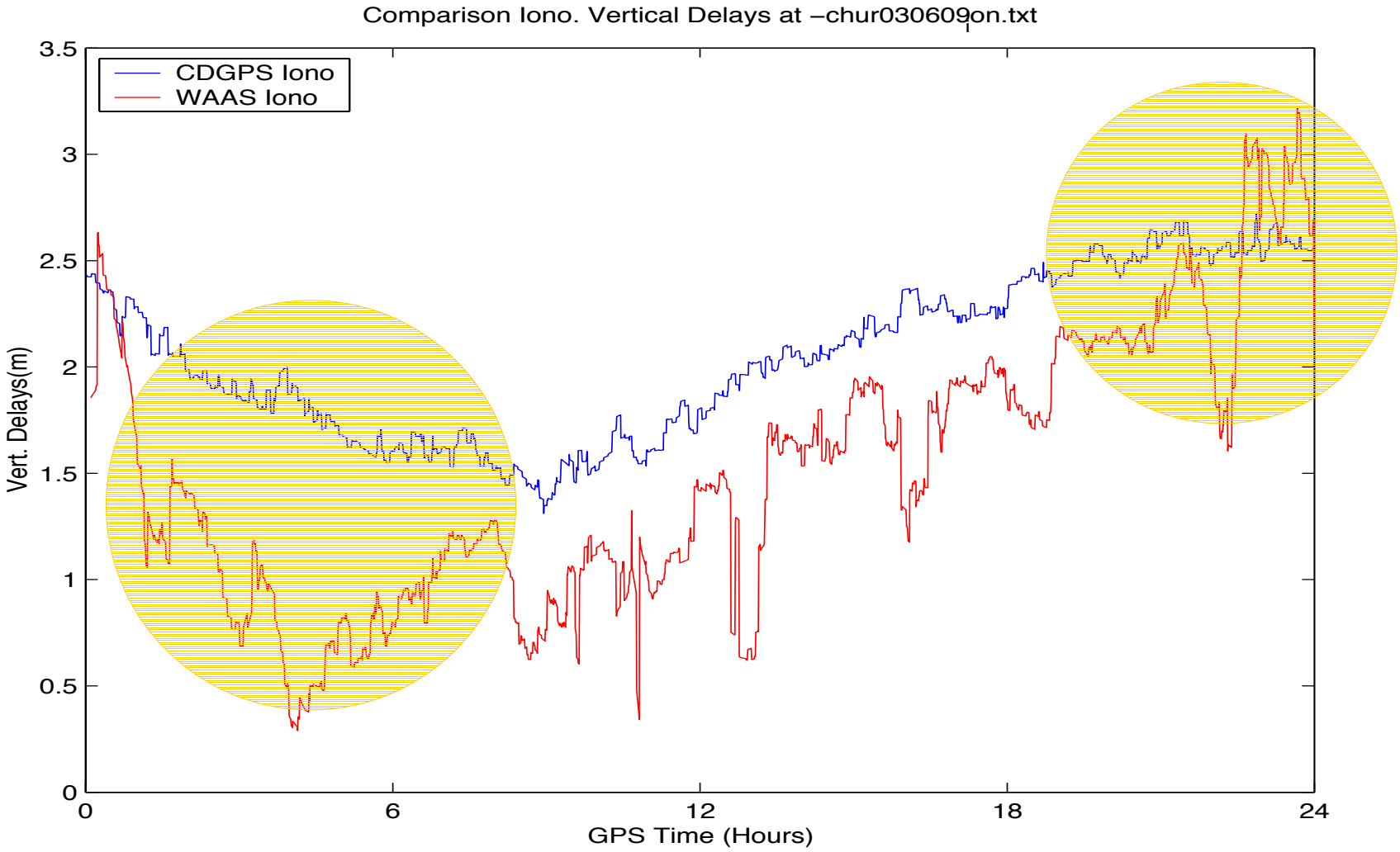
CDGPS Grid Ionospehric Vertical Errors (2003 June 9)



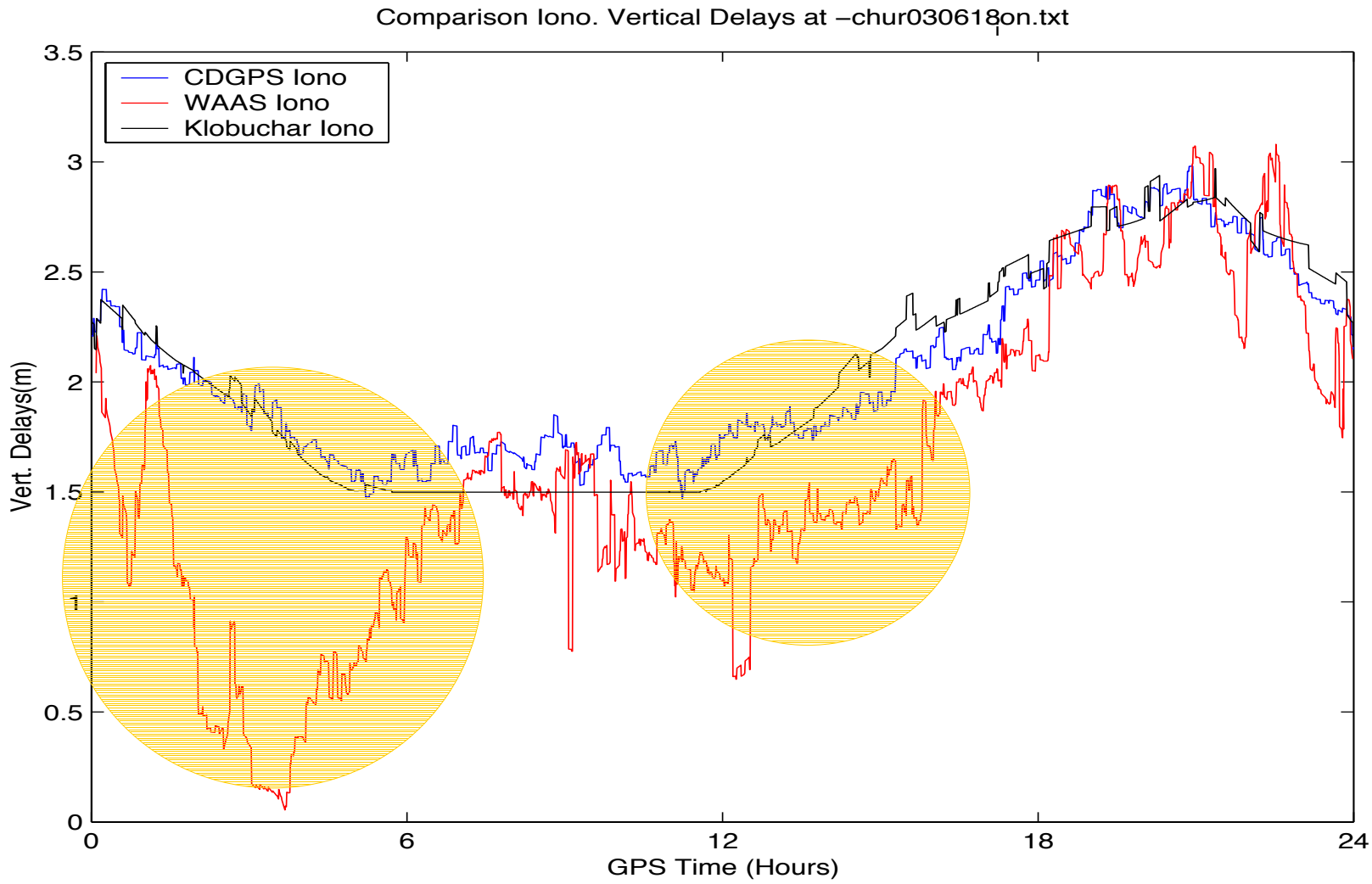
CDGPS Grid Ionospehric Vertical Errors (2003 June 18)



Comparison Ionospheric Vertical Delays at CHUR [Absolute Mean – 20030609]



Comparison Ionospheric Vertical Delays at CHUR [Absolute Mean – 20030618]



Summary

- ✓ Overall positioning accuracy for CDGPS is around 1.5 metres in horizontal and 3 metres in vertical component.
- ✓ The accuracy depend on quality of receiver.
- ✓ In the case of CDGPS receiver, the accuracy is almost two times worse than high quality receiver in horizontal and vertical components
- ✓ The accuracy of the ionospheric delays depend on the numbers and locations of reference stations.
- ✓ There are small differences (around 1.6m in early morning) of ionospheric vertical delays between CDGPS and WAAS.

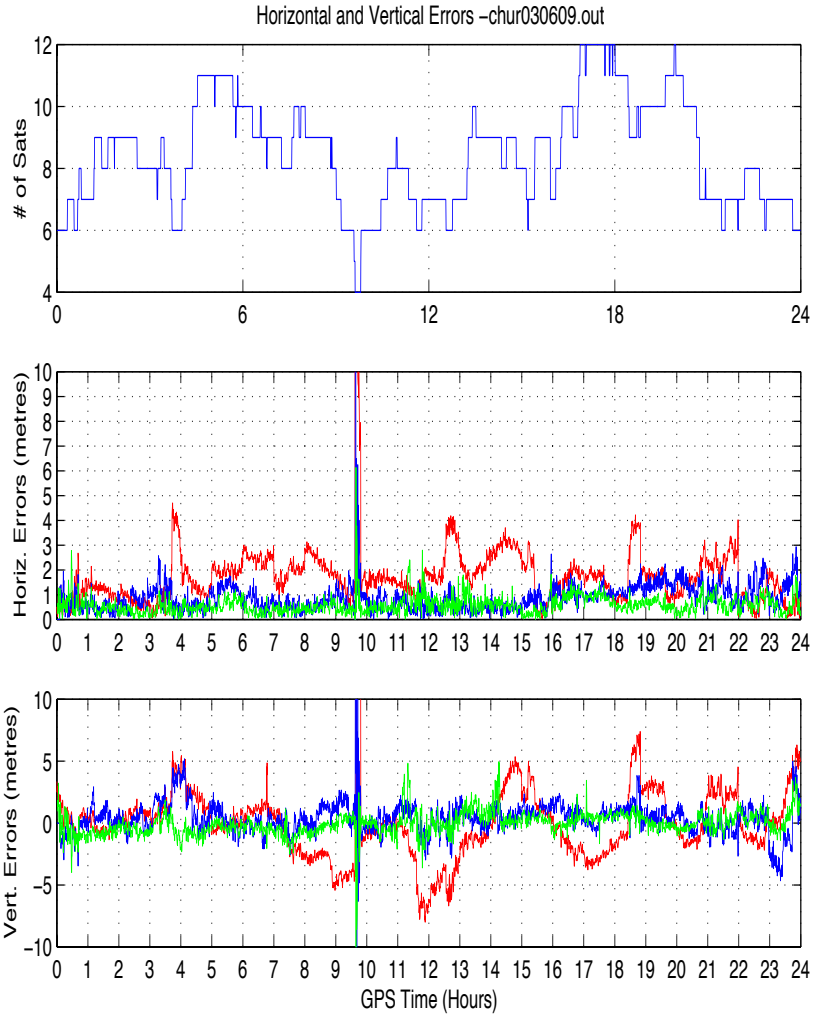
Conclusions and Future Developments

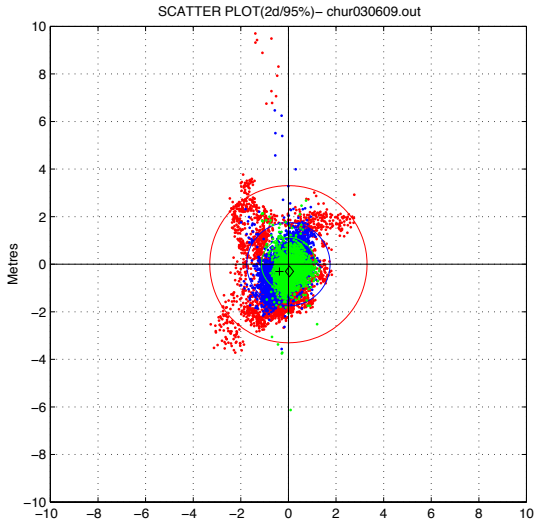
- During the time periods of analysis, there was no strong ionospheric disturbances.
- It is better to further analyze the CDGPS ionospheric model in ionospheric storm conditions.
- We might get better accuracy by improving ionospheric grid model in CDGPS.
- To improve the CDGPS corrections and positioning overall accuracy, it might be good to consider to adding a few more reference stations.

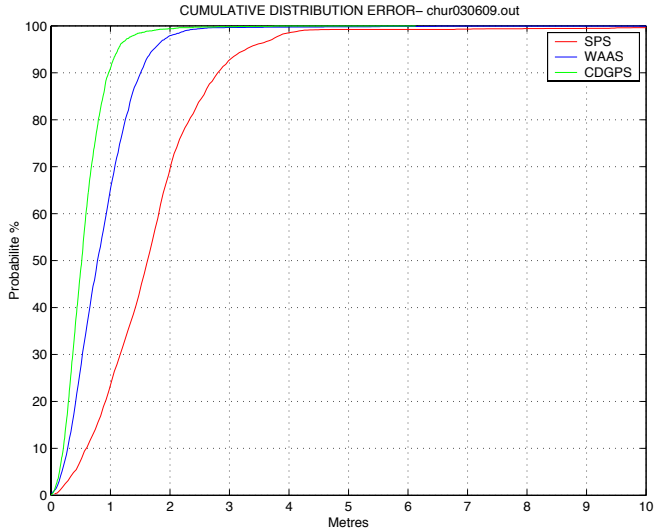
CDGPS Future Plans

- Improve ionospheric grid modelling
- Add additional reference stations
- Encourage receiver manufacturers to
  - Utilize MRTCA output from CDGPS Rx
  - Directly demodulate MSAT signal
- Dual-frequency capability possible
  - Expect 20-30 cm (95 %) positioning

Comparison Positioning Results at CHUR 20030609







Comparison Positioning Results at CHUR 20030618