Demonstration of Decimeter-level Real-time Positioning of an Airborne Platform

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ION NTM 2003

22 - 24 Jan 2003

Outline

- Benefits of Internet-Based Global Differential GPS (IGDG)
- System Overview
- System Enhancements
- Data Campaigns
- Truth Data
- Results
- Conclusions
- Acknowledgements
- For more information. . .

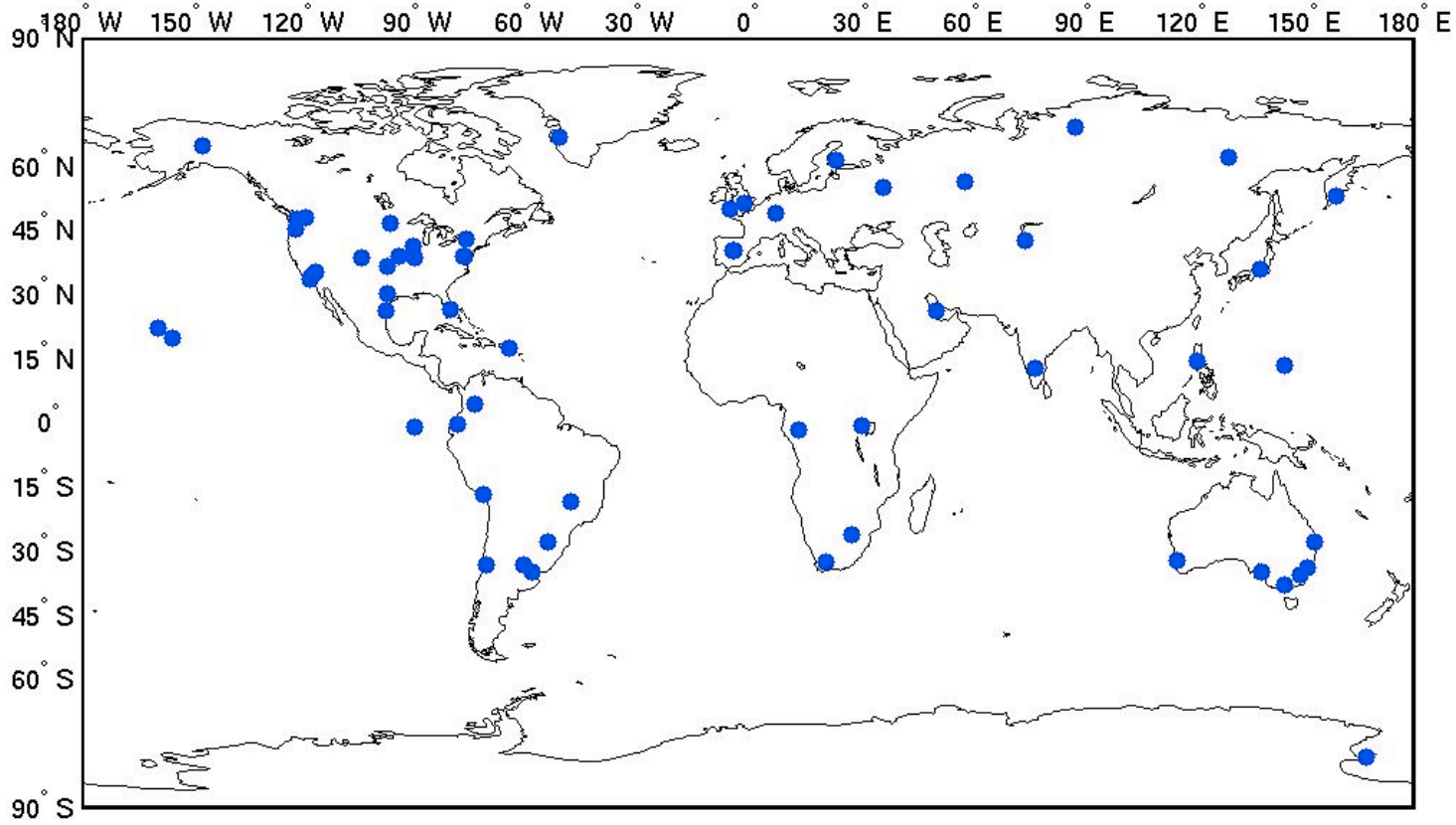
Benefits

- **Continuous global coverage**
  - 24/7 dual string paths and processing
  - No need for local DGPS equipment
- **Portable**
  - Standard rackmount chassis with twice redundant receivers
  - Linux laptop
  - GPS antennas
  - Pressure transducer for dry tropo measurements
  - Iridium and Inmarsat correction channels.
- **Flexible**
  - Can be used with multiple dual-frequency receivers

Software Components

- **Remote ground station software (RTNT)**
  - Data transfer
- **Operations center software (RTG)**
  - Compute corrections
- **End-user software (RTG)**
  - Combine GPS data with corrections

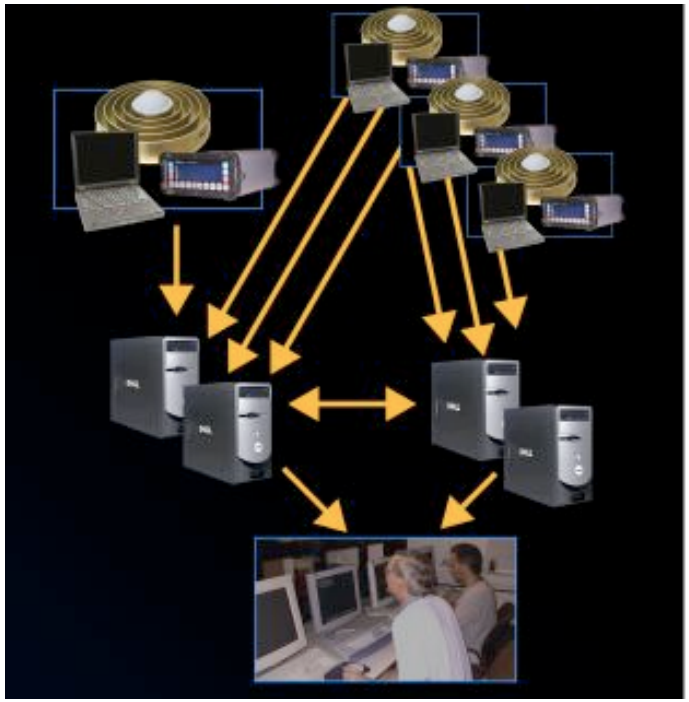
Global Real-Time GPS Network



62-station combined JPL and Navcom real-time network

Global Real-Time GPS Network

Multiply redundant network and data paths



JPL sites use

Real-Time Network Transfer

(RTNT) software

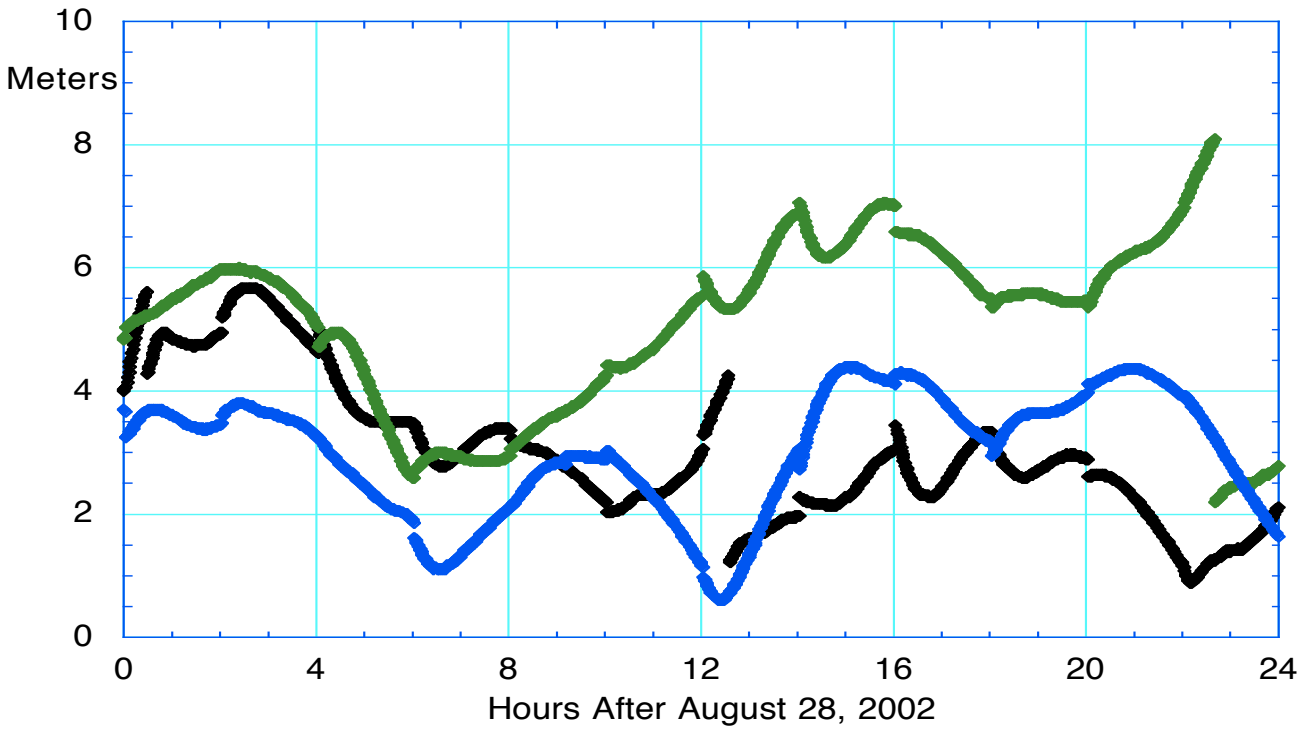
IGDG Software at Operations Center

- **Computes**
  - GPS satellite orbits
  - 1-Hz GPS clocks
  - Tropo estimates
- **Differences**
  - Real-Time orbits and clocks with Broadcast orbits and clocks

→ **GDGPS Corrections**

Correction Magnitude

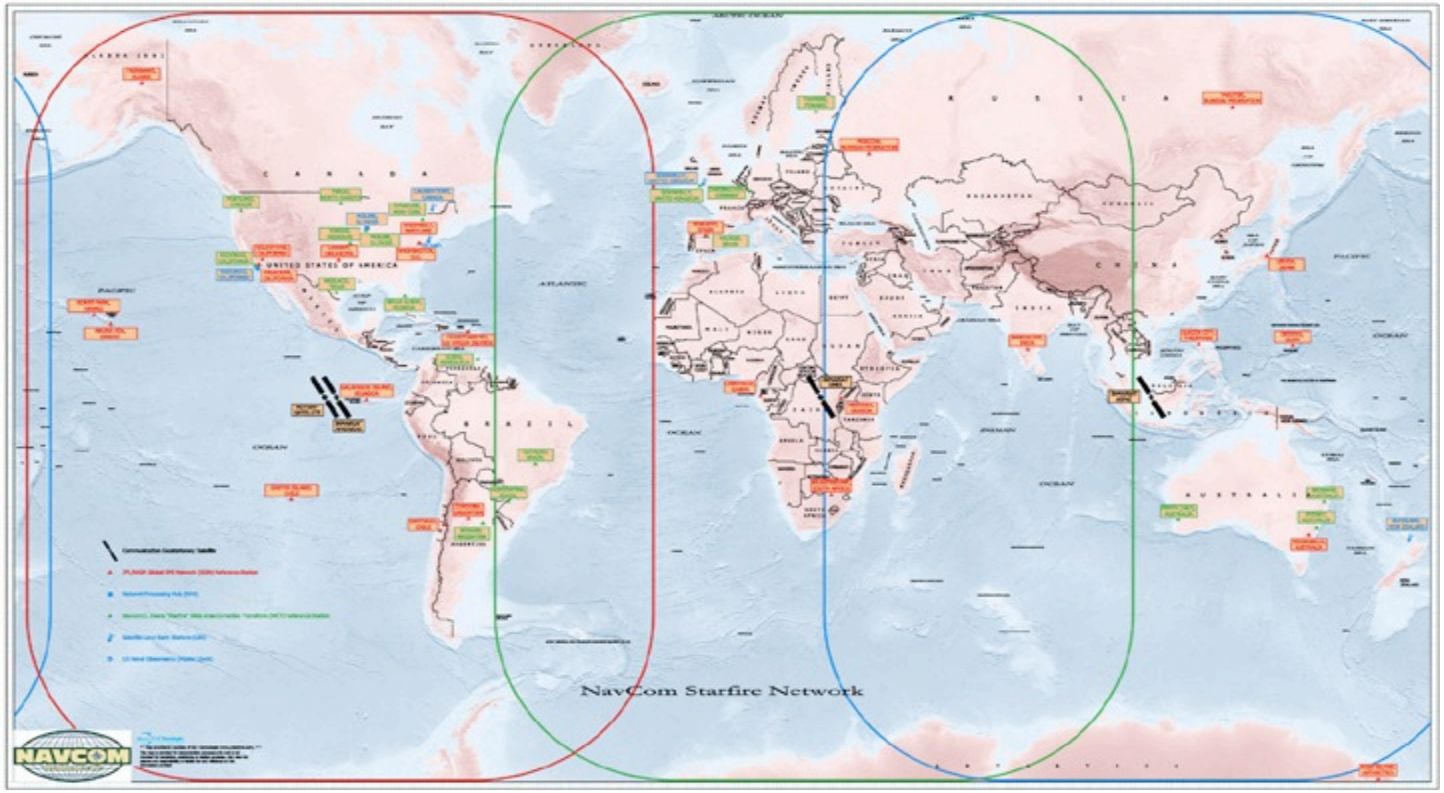
Magnitude of GDGPS Orbit Differential Corrections for SVNs 25 (black), 34 (green), and 35 (blue) on August 28 2002



Distribution

- **How do we distribute corrections?**
  1. Internet
     - Dedicated Frame Relay Lines
  2. Satellite
  3. Dial-up connection

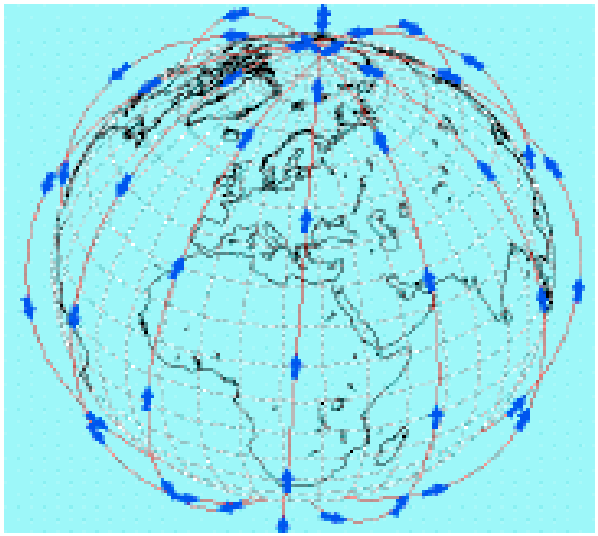
Inmarsat link



Global coverage to +/- 75 deg latitudes

Dial-up connection

Iridium satellite phones - complete global coverage



Recent Enhancements

- **The following enhancements have improved the accuracy of our airborne system over previously published data:**
  - Additional ground stations
  - New tropospheric estimation technique
    - Estimate height-dependent scale factor
  - Improved convergence
    - Estimate phase biases while holding position fixed taking measurements for 15 minutes while plane is on the tarmac
    - When the aircraft is ready to move, send signal to software to begin kinematic positioning.
  - Robust system selects optimal solution from a multiple receiver architecture.
  - Real-time latency of solution is less than 1/10th second.

Flight Campaigns

- **NASA P3 ice-mapping flights over Greenland**
  - May and June 2002
  - Used Iridium modem connection
  - Over 17 hours of data

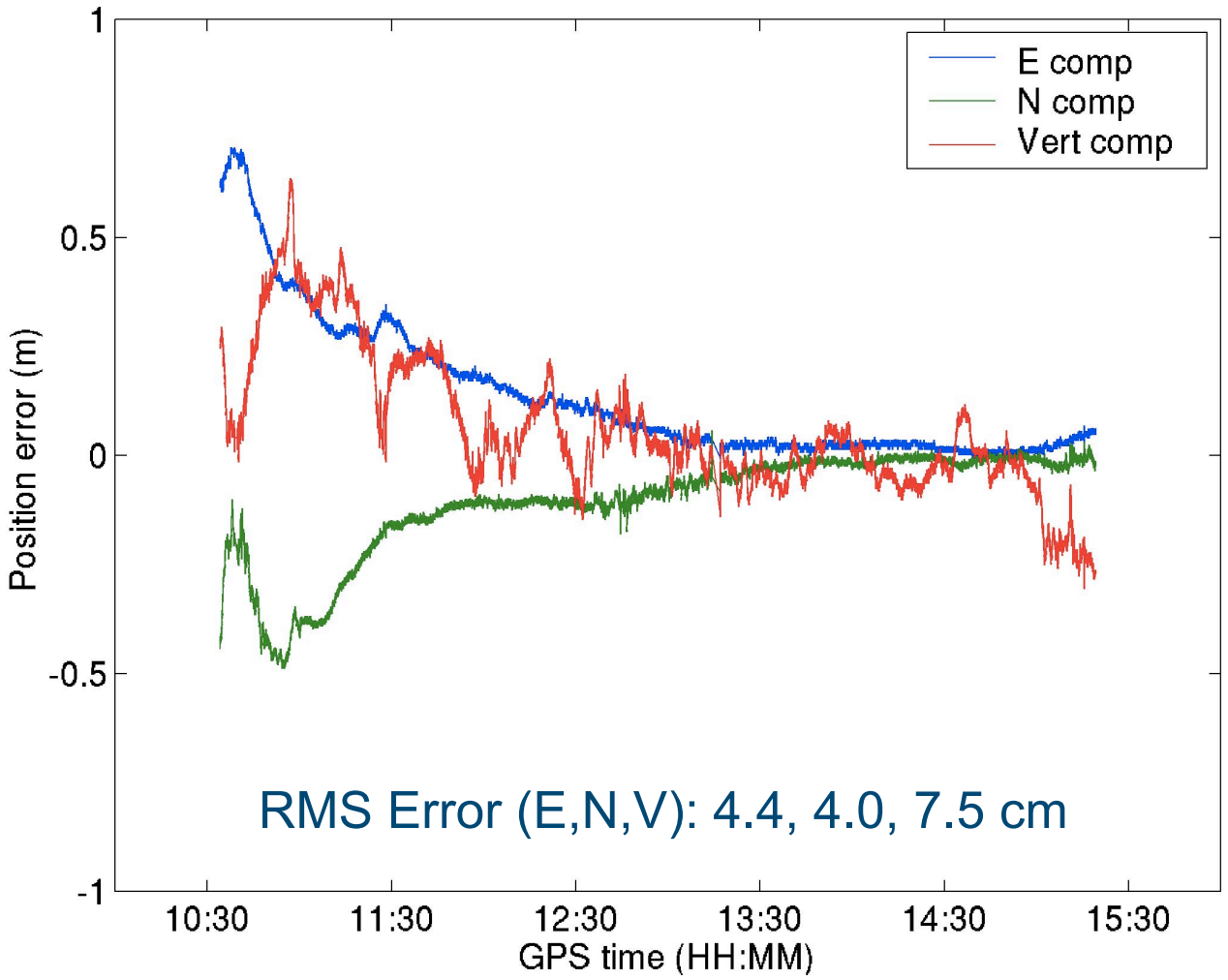
Flight Campaigns

- **NASA DC-8 AirSAR flights over continental U.S.**
  - February - September 2002
  - Used Inmarsat satellite link
  - Over 9 hours of data
- **NASA DC-8 SOLVE III deployment over polar region**
  - January - February 2003
  - Support AROTAL LIDAR ozone profile measurements
  - Routine and automated operations up to 81 deg latitude

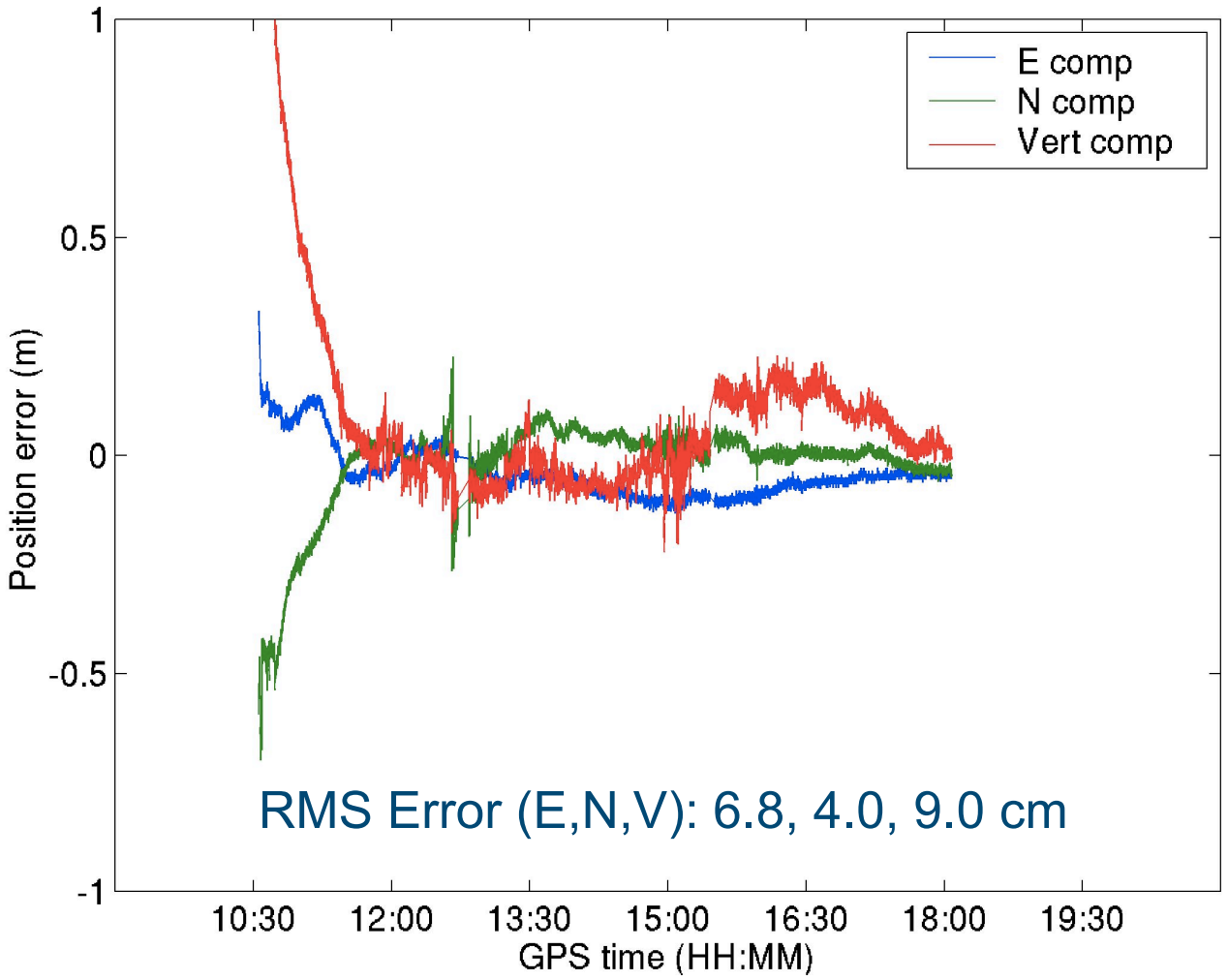
Truth data

- **GIPSY-OASIS II**
  - JPL's orbit determination, point positioning and ambiguity resolution software
  - Combine GPS observables saved during flight with JPL's precise GPS orbits and clocks
- **Wallop's post-processed solution**
  - Post-processed, short-baseline differential solution
  - Completely independent solution
  - Available only during Greenland experiments

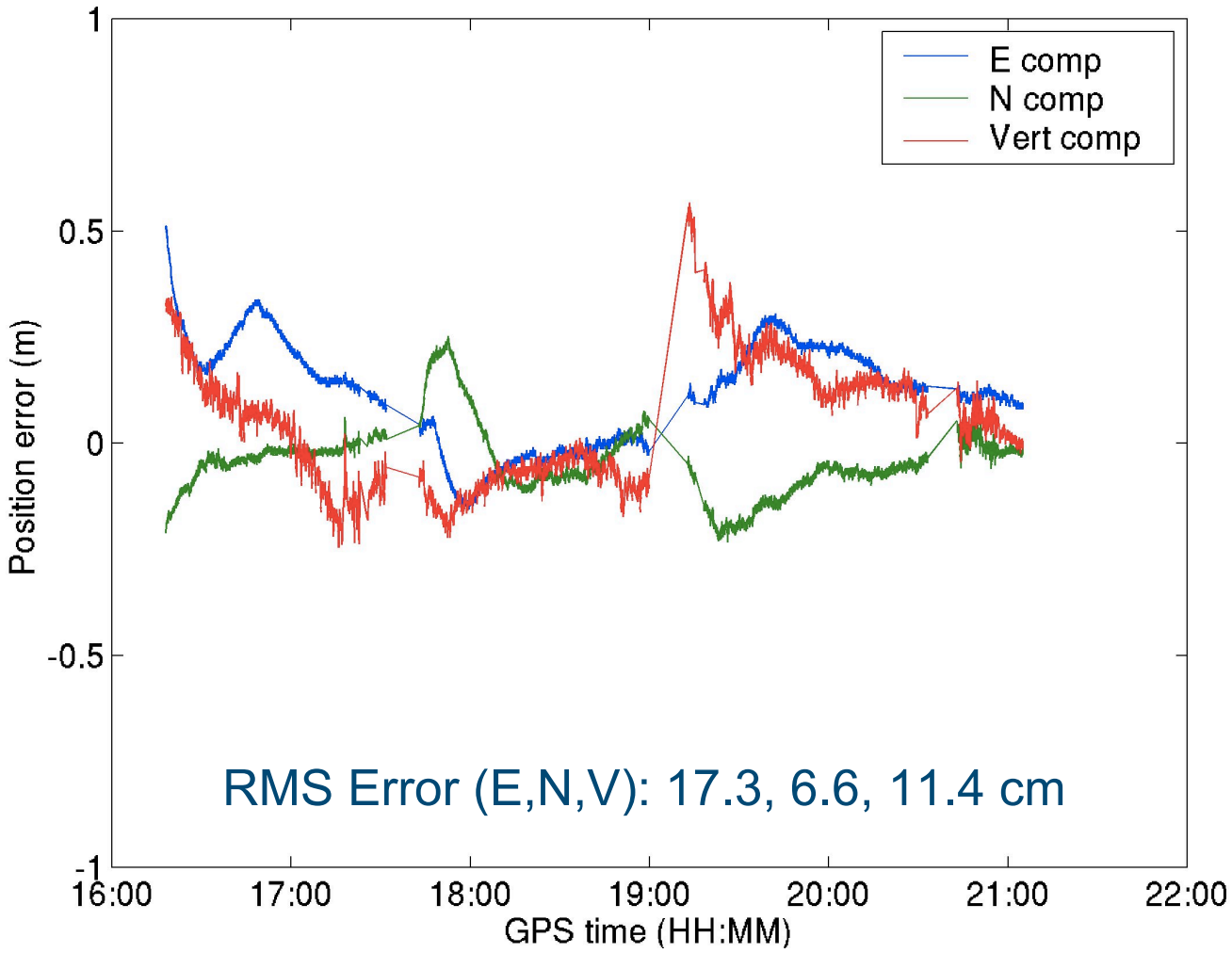
02Jun01 Data



02Jun04 Data



02May31 Data



Real-time vs. Wallops Comparisons (cm RMS)

Greenland Arctic Ice-Mapping campaign

Date	# 1-Hz Pts	East Comp Error	North Comp Error	Vert Comp Error
31May02	9790	17.2	10.1	13.0
02Jun01	10463	4.5	4.6	5.9
02Jun04	21645	8.0	6.1	12.6

Conclusions

- **We have shown consistent decimeter-level positioning capability with results often sub-decimeter.**
- **We have demonstrated seamless global performance over vast distances.**
  - Iridium satellite phones are a viable source of corrections.

Acknowledgements

- Thanks to my co-authors.
- Thanks to Ice-mapping, AirSAR, and SOLVE III projects for test opportunities.
- Thanks to the Wallops team for sharing their post-processed solutions.

For more information:

- **See our website**
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