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Updating OPUS-S to Support Multi-GNSS

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Online
Positioning
User
Service
-Static

Overview

- Brief review of existing OPUS-S (4.0)
- Why update OPUS-S?
- New features in OPUS-S 5.0
- Alpha-Testing Plan
- Preliminary Results

Online
Positioning
User
Service
-Static

Brief review of existing OPUS-S v4.0

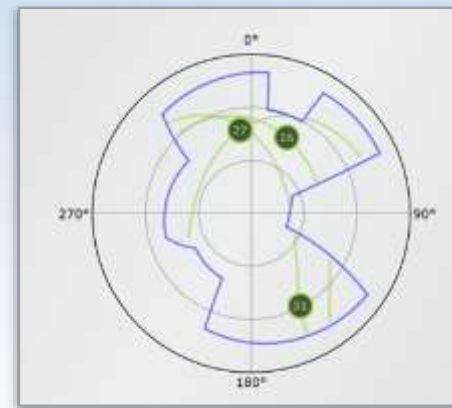
- <https://geodesy.noaa.gov/OPUS/>
- Uses PAGES* for sequential static baseline processing
- GPS L1/L2 only
- Averages best 3 of 5 baselines

*Program for the Addjustment
of GPS Ephemerides

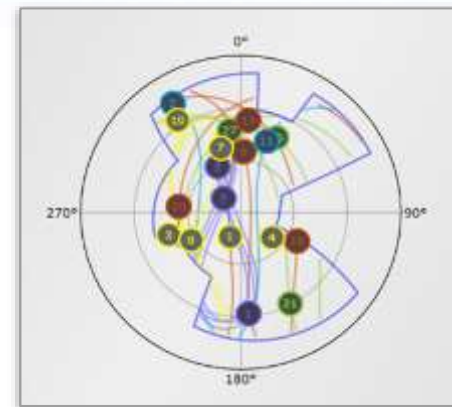
The screenshot shows the OPUS: Online Positioning User Service website. At the top, there is a navigation bar with links for NGS Home, About NGS, Data & Imagery, Tools, Surveys, Science & Education, and a search box. Below the navigation bar is a header with the NOAA logo and the text "OPUS: Online Positioning User Service" and "National Geodetic Survey". The main content area features a "NEW! Try Projects" section with links for "Upload Vectors" and "Export Adjustment" tools. A prominent "Upload your data file." section includes a "Choose File" button, a "NONE" dropdown menu, and a "sample" data file link. Below this, there are sections for "antenna" and "antenna height" with input fields and instructions. At the bottom, there are "Options" to customize the solution, "Upload to Rapid-Static" and "Upload to Static" buttons, and a footer with contact information and a copyright notice.

Why Update OPUS-S?

- More satellites = better positioning!
 - Improved geometry
 - Better coverage when signals are obstructed (bottom right)
- Various studies have already demonstrated the improvements in positioning with added systems (e.g., *Jamieson & Gillins 2018*)



versus



New features in OPUS-S 5.0

- Replaces PAGES with M-PAGES
 - Includes RINEX “sniffer” to scan available constellations
- Enhanced CORS-selection logic
- Slightly modified best 3-of-5 baselines selection
- Supports RINEX v3

**constellations
allowed**



GPS



GLONASS



GALILEO



BEIDOU



QZSS

DEV
Internal Development Area

OPUS: Online Positioning User Service
National Geodetic Survey

NGS Home | About NGS | Data & Imagery | Tools | Surveys | Science & Education | Search

Upload your data file.
Solve your GNSS position & tie it to the National Spatial Reference System.
What is OPUS? FAQs

Choose File | No file chosen
* data file of dual-frequency GNSS observations. **sample**

NONE

antenna - choosing wrong may degrade your accuracy.

0.000 meters above your mark.
antenna height of your antenna's reference point.

* email address - your solution will be sent here. **Privacy Act Statement**

Options to customize your solution

constellations allowed GPS GLONASS GALILEO BEIDOU QZSS

constellations explained:

formats standard

formats explained: Identify any CORS you wish to explicitly 'Use' or 'Exclude' from your solution by typing in 4-char site IDs separated with line break
- sample
- find site IDs

base stations Use: Exclude:

state plane Let OPUS choose your **SPCS zone**

project identifier enter the id provided by your project manager

sharing explained

required usage
We may use your data for internal evaluations of OPUS use, accuracy, or related research.

Website Owner: National Geodetic Survey / Last modified by NGS.OPUS v/2.0 Sep 01 2022

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Overview of PAGES v. M-PAGES

PAGES

- GPS L1/L2 only
- Double differencing
- Outputs custom-format file
- FORTRAN
- Used in OPUS, OPUS-Projects, and Orbit Production

M-PAGES*

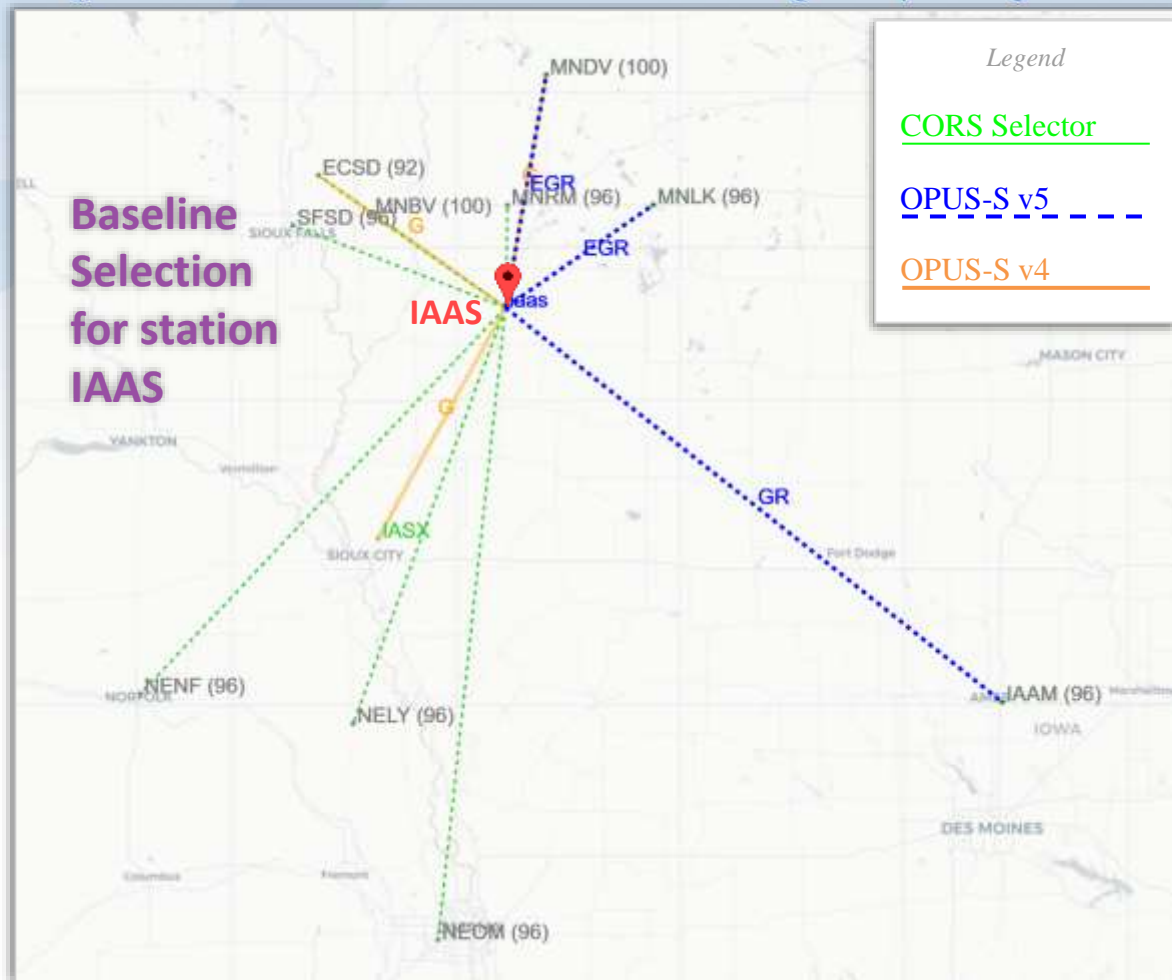
- All dual-frequency systems
- Single differencing
- Outputs JSON file
- C++ (with Python utilities)
- Currently only used in OPUS-S v5-alpha

*NGS M-PAGES Webinar:

https://geodesy.noaa.gov/web/science_edu/webinar_series/multi-ngss-world-at-ngs.shtml

Enhanced CORS-selection logic

- Each CORS within pool of candidates is graded, based on weighted components:
 - Data availability
 - Constellations availability
 - CORS quality metrics
- Spatial distribution over 4 quadrants is also considered

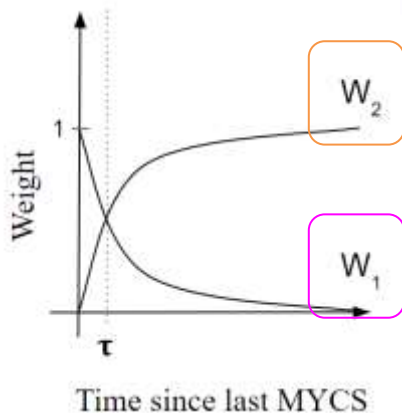


CORS Quality Metric

Helps choose better base stations

$$\text{DailyScore} = \alpha(W_1 * RMS_1 + W_2 * RMS_2) + \beta * RMS_3$$

Reference: AGU Fall Meeting Abstracts 2022, G25D-0249



RMS_1 : time period spanned by the most recent MYCS

RMS_2 : from the end of the most recent MYCS to present

RMS_3 : over the last 4 weeks from user date

Alpha-Testing Plan

- Upload numerous RINEX files
 - NCN, IGS, and user data
 - Spatiotemporally distributed
 - Represent good and bad data
- Assess results
 - Component testing
 - System (end-to-end) testing, including accuracy assessment



NCN Sites: 50 RINEX files

IGS Sites: 56 RINEX files

User Sites: 20 RINEX files

Accuracy Assessment

- Compare **ITRF** coordinates with...
 - IGS weekly solution
 - NRCAN PPP
 - OPUS-S v4 (PAGES)
 - Published coordinates
- Transform delta vector from XYZ to NEU
- Compare at survey epoch

NGS OPUS SOLUTION REPORT
=====

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: nick.forfinski-sarkozi@noaa.gov DATE: April 25, 2023
RINEX FILE: rm010190.20o TIME: 20:54:25 UTC

SOFTWARE: page5 2008.25 master273.pl 160321 START: 2020/01/19 00:00:00
EPOCH: igs20890.eph [precise] STOP: 2020/01/19 23:59:00
NAV FILE: brdc0190.20o OBS USED: 58319 / 63634 : 92%
ANT NAME: TRM115000.00 NONE # FIXED AMB: 204 / 227 : 90%
ARP HEIGHT: 1.1822 OVERALL RMS: 0.014 (m)

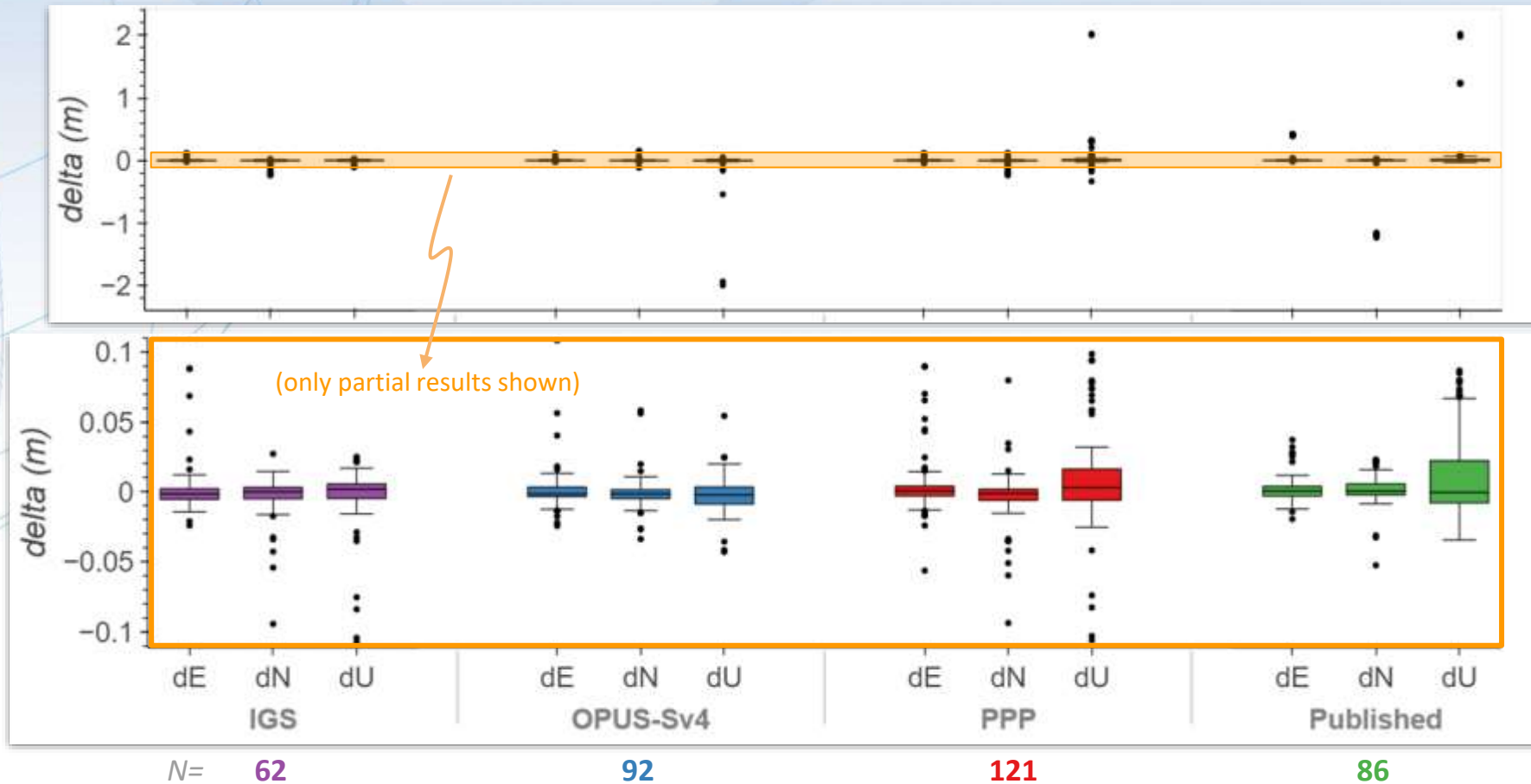
REF FRAME: NAD_83 (PA11) (EPOCH:2010.0000)

	XYZ	ITRF2014 (EPOCH:2020.0506)
X:	-5464049.608 (m) 0.007 (m)	-5464050.691 (m) 0.007 (m)
Y:	-2495220.635 (m) 0.003 (m)	-2495217.551 (m) 0.003 (m)
Z:	2148357.621 (m) 0.005 (m)	2148358.961 (m) 0.005 (m)

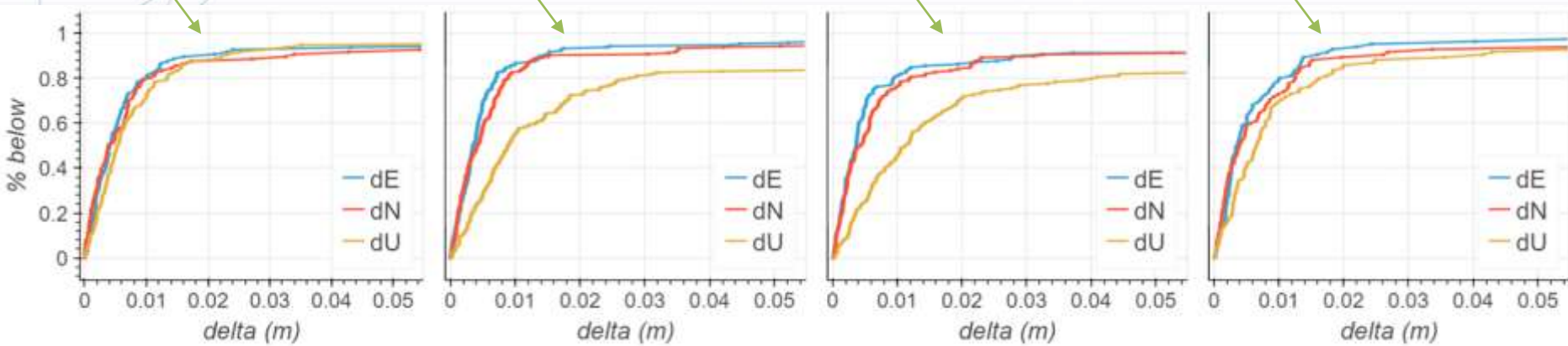
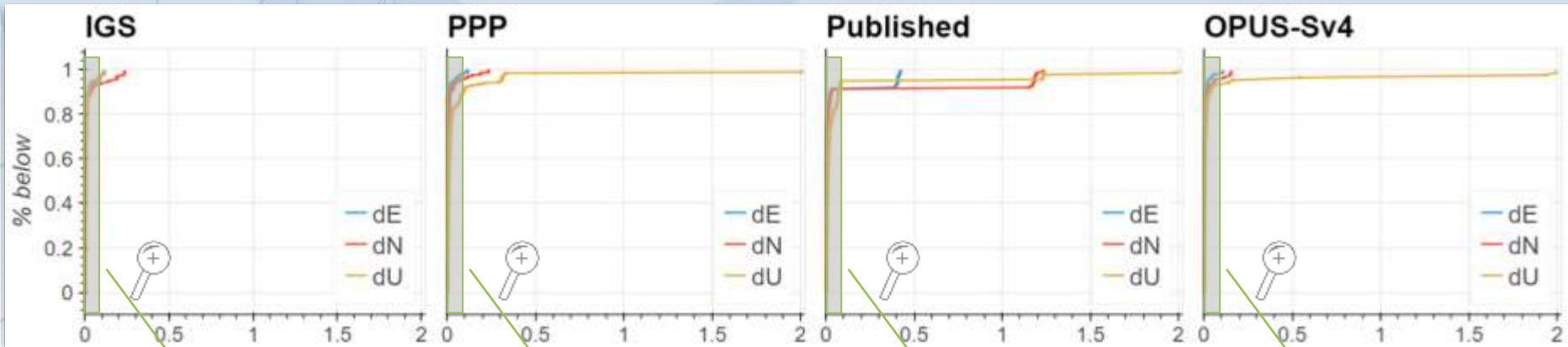
	LAT	LONG	HGT	ORTH
LAT:	19 48 7.21375 0.005 (m)	19 48 7.25800 0.005 (m)		
E LON:	204 32 39.66295 0.002 (m)	204 32 39.55117 0.002 (m)		
W LON:	155 27 20.33705 0.002 (m)	155 27 20.44883 0.002 (m)		
EL HGT:	3750.804 (m) 0.008 (m)	3750.980 (m) 0.008 (m)		
ORTHO HGT:	3724.366 (m) 0.056 (m)			[H = h-N (N = GEOID12B HGT)]

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 05)	SPC (5101 HI 1)
Northing (Y) [meters]	2191439.691	107224.901
Easting (X) [meters]	242745.514	504646.805
Convergence [degrees]	-0.83236111	0.01502500
Point Scale	1.00041807	0.99996693
Combined Factor	0.99982857	0.99937770

Preliminary Accuracy Results: residual NEU components



Empirical Cumulative Distribution Functions of Residuals



Summary

- OPUS-S v5.0-alpha supports Multi-GNSS
 - M-PAGES replaces PAGES
 - Enhanced logic when selecting CORS
- Preliminary results show good agreement with comparison solutions
- Alpha-testing results will feed further M-PAGES development



Future BETA Testers:
anticipate OPUS-S v5.0-beta
release around August 2023



**BETA
VERSION
COMING
SOON!**

BETA OPUS-S URL

<https://beta.ngs.noaa.gov/OPUS/>

Please feel free to contact me with any questions.

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