

Current Status and the Future of the CORS Network



59th Meeting of the Civil GPS
Service Interface Committee



Francine Coloma

Continuously Operating Reference Stations Branch

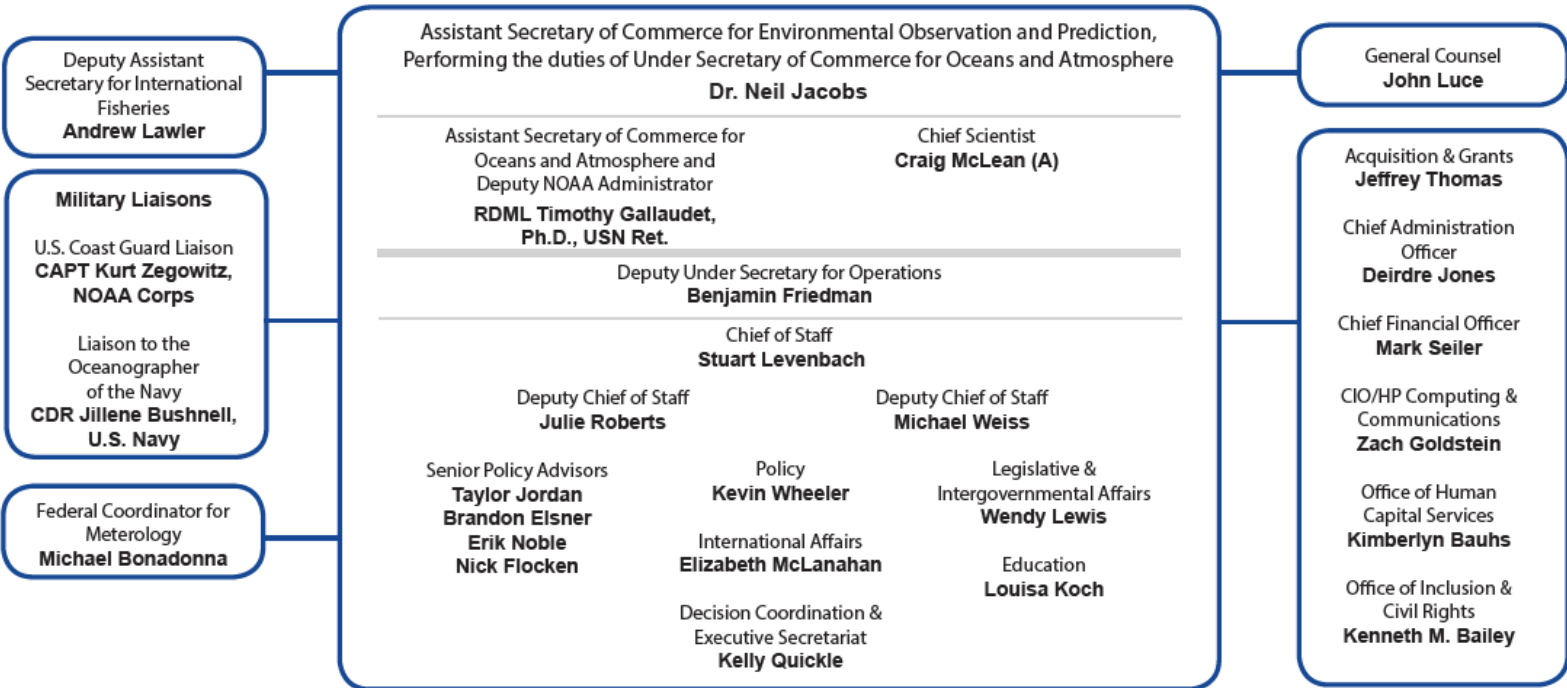
NOAA National Geodetic Survey

NOAA HEADQUARTERS ORGANIZATION

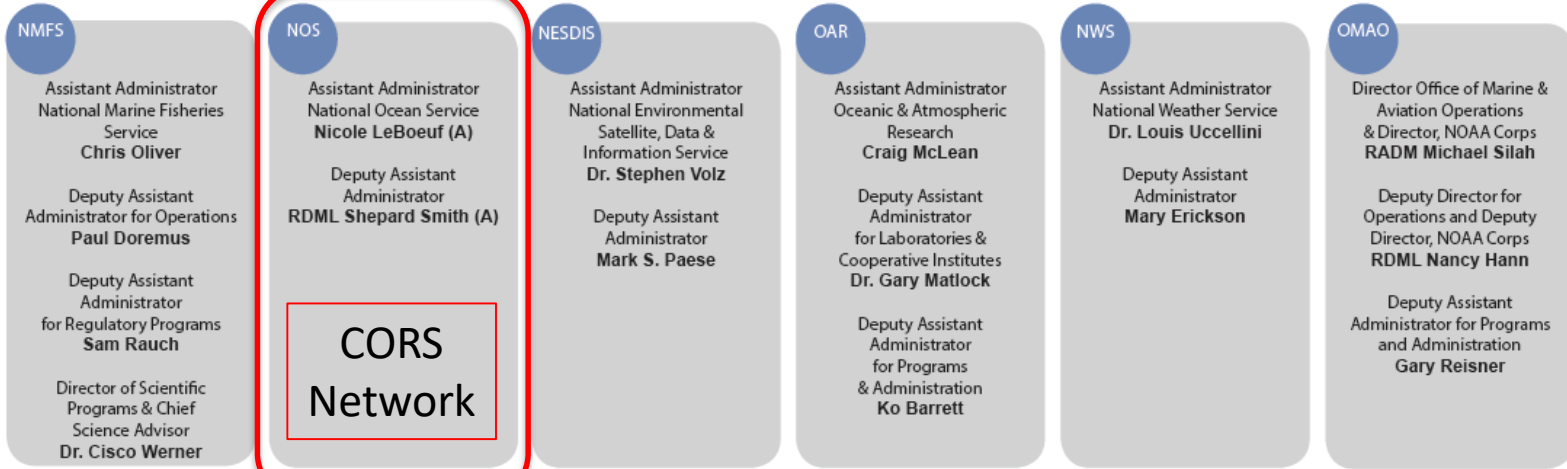


geodesy.noaa.gov

CORPORATE FUNCTIONS



LINE OFFICES



NOAA's Mission

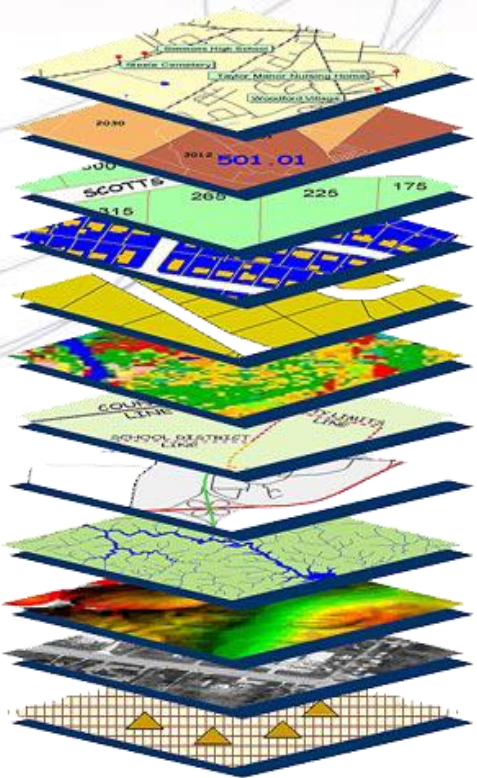
To **understand** and **predict changes** in climate, weather, oceans, and coasts, to **share that knowledge** and **information** with others, and to **conserve** and **manage** coastal and marine ecosystems and resources.

The **National Spatial Reference System (NSRS)**

constitutes the official system of the civilian government for enabling a user to determine geodetic latitude, longitude, and height, plus orthometric height, geopotential, acceleration of gravity, and deflection of the vertical at any point within the United States and its territories.

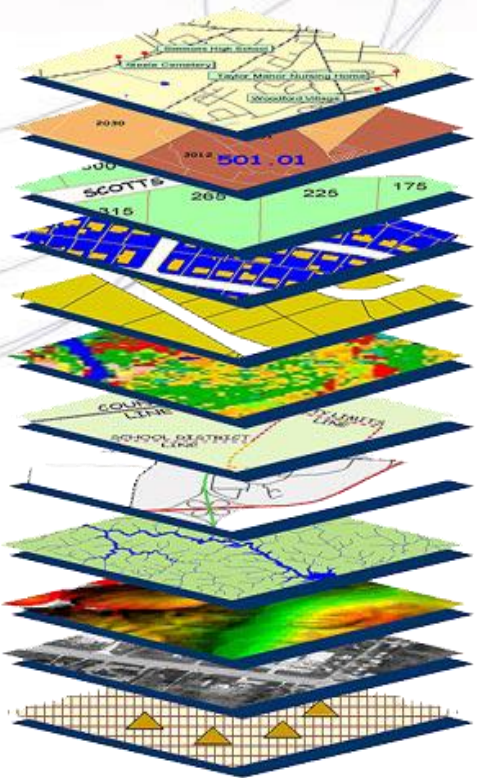
Contains information about its orientation and scale relative to international reference frames, as well as the precise orbits of all satellites used in defining or accessing the NSRS.

The NSRS is crucial for meeting our nation's economic, social and environmental needs.



NSRS = Geodetic control

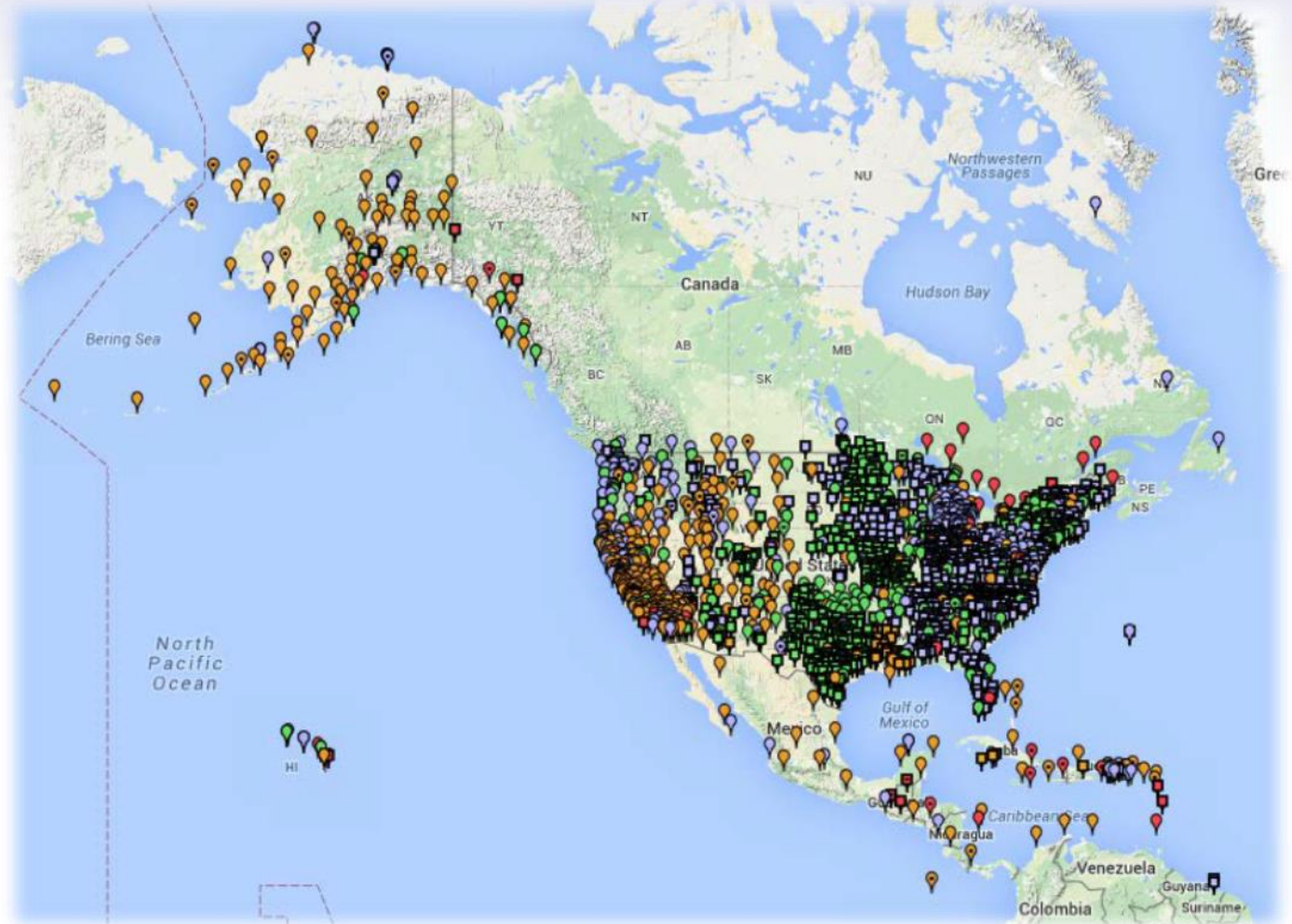
Without a geodetic control “base map” layer,
GIS applications will not work properly!



Unattributed photo from internet

Continuously Operating Reference Stations (CORS)

- NGS operates a network of **~1900** stations that provide GPS or GNSS data consisting of carrier phase and code range measurements in support of three dimensional positioning
- **Contributions by more than 200 organizations** (various government, academic, and private organizations)





NGS' Mission

To define, maintain and provide access to the **National Spatial Reference System (NSRS)** to meet our Nation's economic, social, and environmental needs.

OPUS: Online Positioning User Service
National Geodetic Survey

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

OPUS now using ITRF2014 and GEOID18
The new ITRF2014 reference frame provides updated CORS positions and velocities. The new GEOID18 model provides improved orthometric heights.
Prefer the older? A legacy version of OPUS is available for a limited time.

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

Choose File: No file chosen
* data file of dual-frequency GPS observations. [sample](#)

Antenna: NONE
antenna - choosing wrong may degrade your accuracy.

Antenna Height: 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.

Upload to Rapid-Static for data 15 min. - 2 hrs. | Upload to Static for data 2 hrs. - 48 hrs.

OPUS menu
home / upload
about OPUS
projects
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OPUS Today
as of 2019-09-13T10:20 EDT

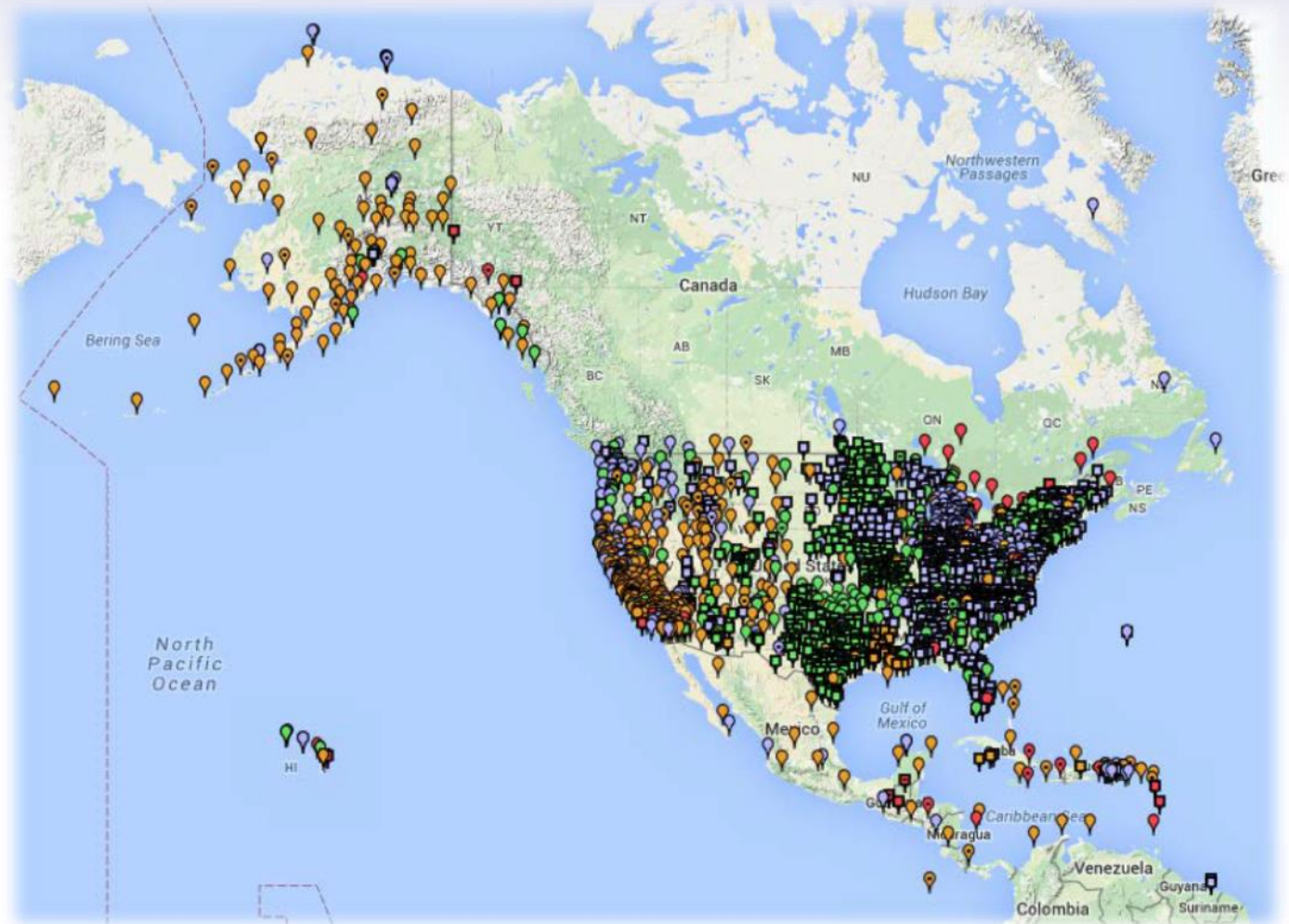
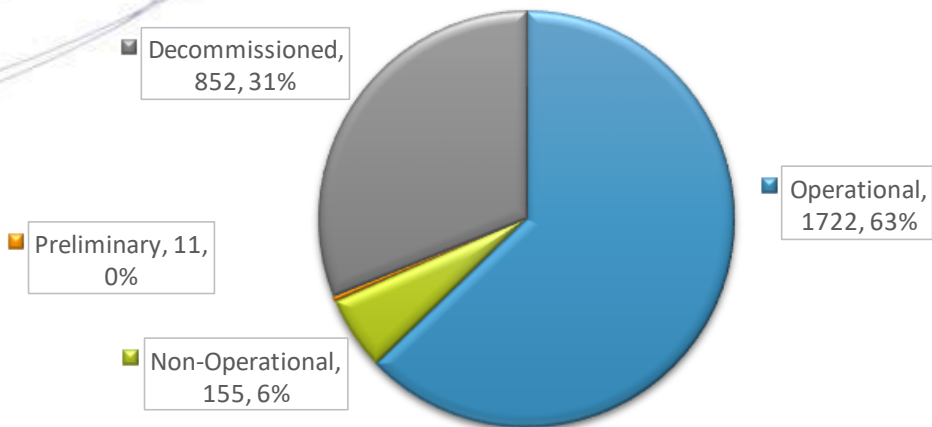
Category	Count
Rapid-Static	150
Static	225

Web site: <https://www.ngs.noaa.gov/CORS/>

Email: ngs.cors@noaa.gov

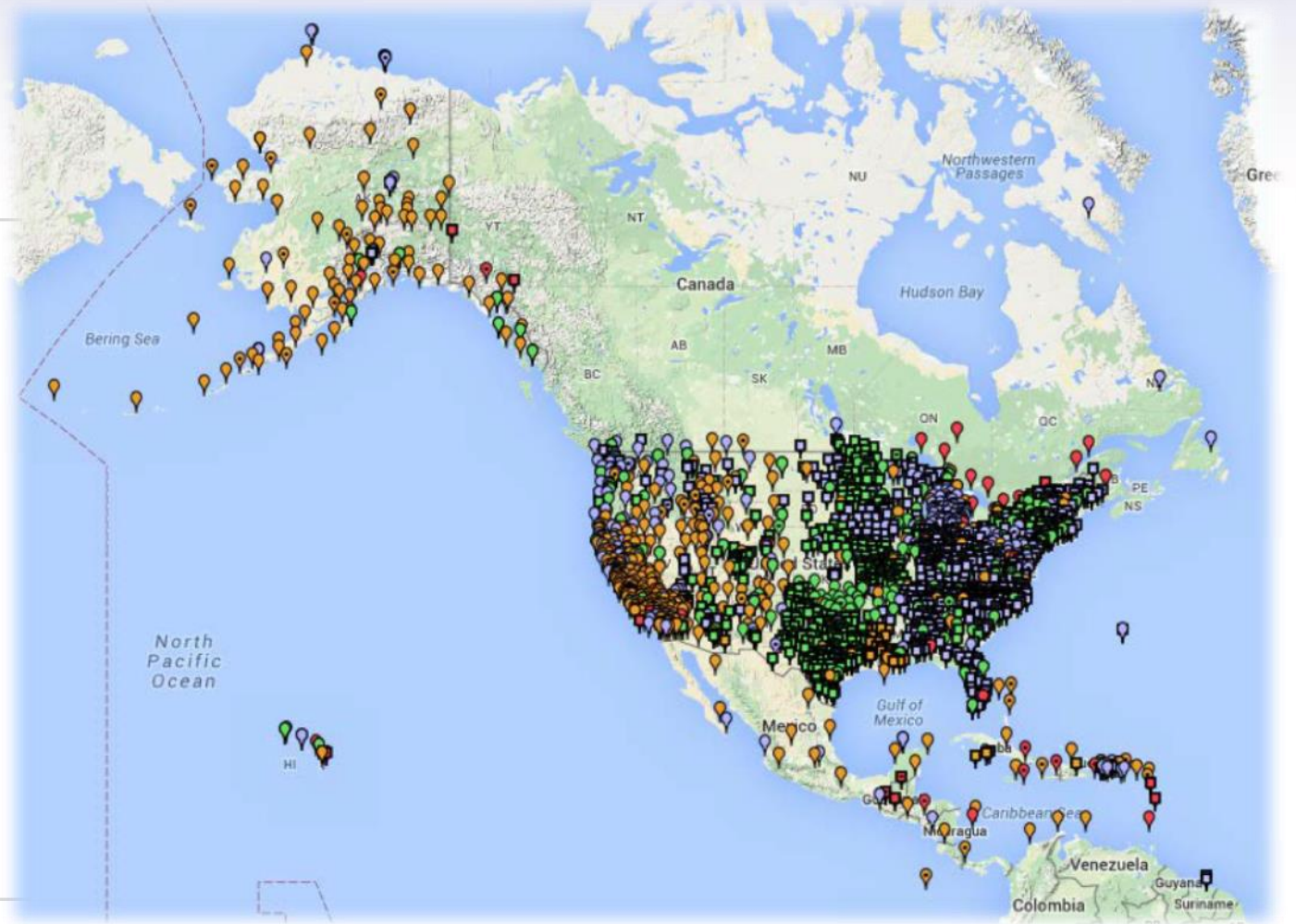
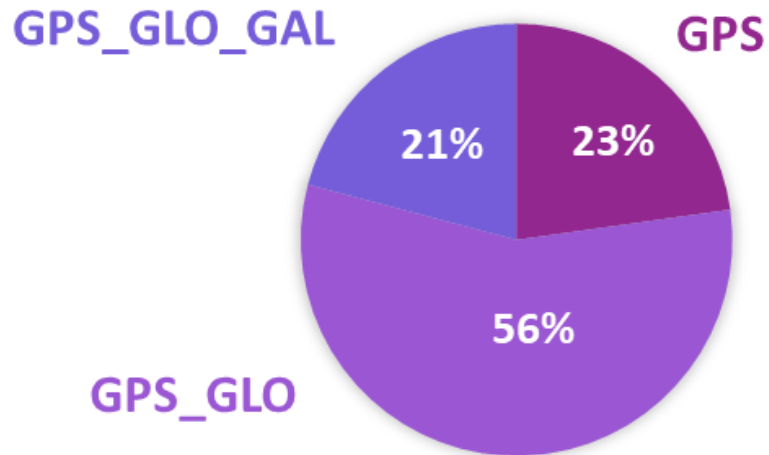
Continuously Operating Reference Stations (CORS)

CORS Cumulative Network Status
1888 active
(852 decommissioned)



Continuously Operating Reference Stations (CORS)

CORS by Signal Type
(snapshot of 2019-239)



- Around CLASS
- » Home
- » Search for Data
- » Upload Search
- » Search Results
- » Shopping Cart
- » Order Status
- » Help
- User Account
- » User Profile
- » User Preferences
- Advanced Options
- » Download Keys
- Release Info
- » Version 6.2.3.1
July 23, 2013
- Other Links
- » CLASS Home
- » NODC
- » NCDC
- » NGDC
- » NESDIS
- » NOAA
- » DOC

Please select a product to search >>GO



NEWS

Attention CORS users (07/2013):
The National Geodetic Survey's CORS data archived at the National Geophysical Data Center has been transitioned into CLASS. The data collections include RINEX since 1994 and raw GPS from selected CORS sites since 2004. The original at-sampling rate was retained except where there was only the 30-second decimated rate data. For more info see the CORS CLASS search page.

Attention Metop users (03/26/13):
With the exception of IASI and GOME Level 2 data, all Metop-B level 1b satellite data is now publicly available beginning January 15, 2013 to present. Pre-operational data collected prior to that date remains restricted. Please contact the CLASS Help Desk if assistance is needed.

Suomi NPP data access status (03/28/13):
Below is a list of S-NPP products released to the public and now available through CLASS. The complete list of products along with the begin dates of product availability are located on the Suomi NPP FAQ page. The remaining NPP products will be released to the user community over a time frame of several months. Please note that all newly released products are at 'Beta' maturity level as defined in the Product Maturity Level page. Details of high priority issues related to the data quality are contained in the Readme files provided by the NPP Project Scientist. Please read these before ordering and using the data!

ATMS:

Readme for released S-NPP ATMS SDR data

SEARCH FOR DATA

- Environmental Data from Polar-orbiting Satellites
- Environmental Data from Geostationary Satellites
- Defense Meteorological Satellite Program (DMSP)
- Suomi National Polar-orbiting Partnership (NPP)
- Sea Surface Temperature data (SST)
- RADARSAT
- Altimetry / Sea Surface Height Data (JASON-2)
- Global Navigation Satellite Systems (GNSS)
 - Continuously Operating Reference Stations (CORS)
 - Global Navigation Satellite System Receiver for Atmospheric Sounding Level 1B (GRAS)
- Other - Miscellaneous products in CLASS

SEARCH COLLECTION METADATA >>GO

CORS Archive

Since 2004, at-sampling CORS RINEX data (where available) is directly available online.

NGS only keeps 30 days of at-sampling data, then decimates to 30-second sampling rate online.

Data is free, but you must register



CORS online **archive** repository at NOAA's CLASS

Guiding Principles for Continuously Operating Reference Stations (CORS)

- By 2022, the National Spatial Reference System (**NSRS**) will be modernized, with **CORS** becoming a more foundational component.
- The International Earth Rotation and Reference Systems Service (**IERS**) International Terrestrial Reference System (**ITRF**) will continue to be the worldwide standard reference system.
- NGS will continue to support the **ITRF** through International GNSS Service (**IGS**) reference sites with the “**Foundation CORS**” network
- The NSRS will continue to be defined in relation to the **ITRF**.

Notable Events

- Ongoing [discontinuance of the USCG DGPS Service](#) to culminate in year 2020
- [GPS Rollover](#), second epoch ended on 2019 April 06
 - GPS Time was defined in the legacy GPS navigation message (ICD-200), and used 10-bit to count GPS Week Numbers: a finite period of 1024 weeks (19.7 year epoch)
 - Modernized GPS Navigation has 13-bit week number, and mitigates the former ambiguity
- Ridgecrest Earthquake Sequence in 2019 July 4 – 6
 - Mw 7.1 (2019 July 16 03:19 UTC)
- Completion of Multi-Year CORS Solution 2 (MYCS2)
 - An undertaking of several years' work
 - New CORS coordinates and velocities available in NAD83 and ITRF
- Foundation CORS process underway

Multi-Year CORS Solution 2 (MYCS2) Released

As of Last Week (Sept 13th): You now have access to more accurate NOAA CORS Network station coordinates and velocities in both the national (NAD83) and international (ITRF) reference frames

What:

New robust coordinates and velocities in ITRF2014 and NAD83(2011) epoch 2010.00 (a within-realization update) for all NCN stations installed before 2014.

Modeled coordinates and velocities available for stations installed between 2014 and present.

New GPS orbits to match with ITRF2014.

Updated OPUS online positioning software uses the new coordinates and velocities, and new GEOID18.

How:

Two years of detailed quality control on all data collected by the NCN over 22 years (1995-2017).

A full network adjustment of 3050 stations, 1100 weeks of data for all NCN stations installed before 2014 (active and decomm.), IGS, and NGA stations.

~240 new CORS (<3 yrs old) have approximate coordinates and velocities “modeled” with OPUS-Net and HTDP (lower accuracy than the network solution).

Multi-Year CORS Solution 2 (MYCS2) Released

New Coordinates (MYCS2): In ITRF2014 epoch 2010.00 and NAD 83(2011,MA11,PA11) epoch 2010.00

These coordinates were computed using absolute [antenna calibrations](#) and should only be used when processing data with absolute antenna calibrations.

[Position and Velocity](#)

[Data Sheet for Position at ARP](#)

[Data Sheet for Position at ARP and, if available, MON \(monument\)](#)

Old Coordinates (MYCS1): In IGS08 epoch 2010.00 and NAD 83(2011,MA11,PA11) epoch 2010.00

No longer supported as of September 1, 2019

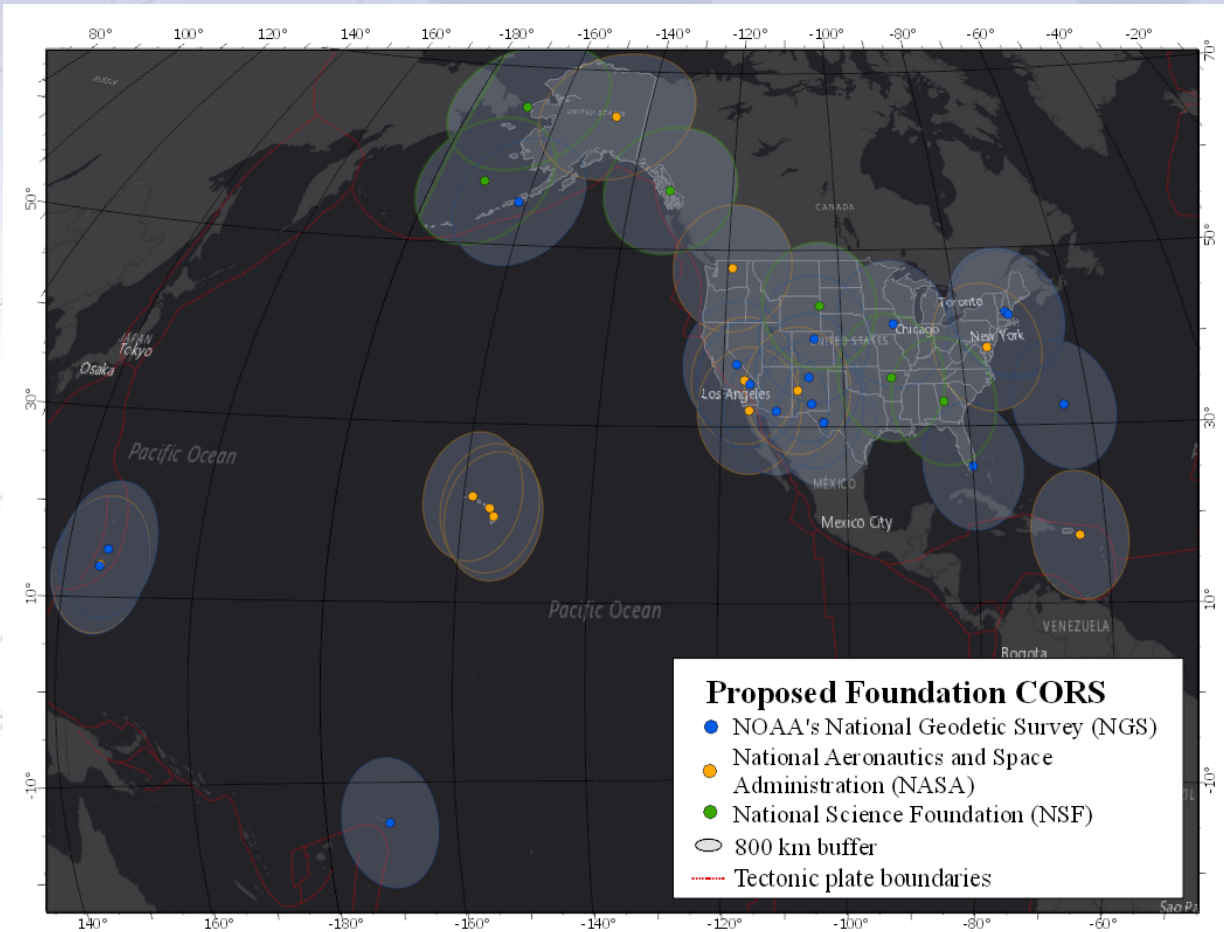
These coordinates were computed using absolute [antenna calibrations](#) and should only be used when processing data with absolute antenna calibrations.

[Position and Velocity](#)

For additional information on the differences between ITRF2014, NAD 83(2011,MA11,PA11) and IGS08, NAD 83(2011,MA11,PA11) consult:

geodesy.noaa.gov/CORS/coords.shtml

The NOAA Foundation CORS Network



26 in North America,
4 in the Pacific,
3 in the Caribbean, and
3 in the Marianas.

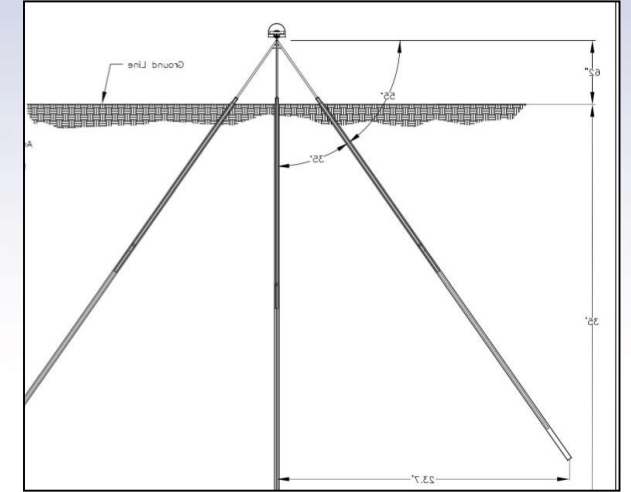
A set of federally-operated, high quality, highly reliable stations with the longevity to guarantee citizens' access to official NSRS positions and to support international positioning consistency efforts.

U.S. Federal Partners	GNSS Site ID	Location	Existing IGS or ITRF Site	
National Science Foundation (NSF)	AB09	Wales, AK		
	AB51	Petersburg, AK		
	ATQK	Atkasuk, AK		
	P043	New Castle, WY		
Existing Sites	P777	Dennard, AR		
	P804	The Rock, GA		
Program: Network of the Americas (NOTA)	CN11	Pedro Cay, Jamaica		
	SAN0	San Andres Island, Colombia		
NSF Existing Sites	BREW	Brewster, WA	ITRF	
	CRO1	St. Croix, VI	ITRF	
National Aeronautics and Space Administration (NASA)	FAIR	Fairbanks, AK	IGS	
	TBD	Greenbelt, MD	IGS/ITRF	
	GUAM	Dededo, Guam	IGS	
Existing Sites	HAL1	Haleakala, HI	IGS/ITRF	
	KOKB	Kauai, HI	IGS/ITRF	
Program: Global GNSS Network (GGN)	MDO1	McDonald Observatory, TX	ITRF	
	MKEA	Mauna Kea, HI	IGS/ITRF	
	MONP	Mount Laguna, CA	IGS/ITRF	
	PIE1	Pie Town, NM	IGS/ITRF	
	ASP	Pago Pago, American Samoa	IGS	
NOAA- National Geodetic Survey (NGS)	BRSG	St. George, Bermuda		
	CNMR	Saipan, Northern Mariana Islands	IGS	
	CORB	Woodford, VA		
	FLF1	Richmond, FL	Proposed IGS/ITRF	
	GUUG	Mangilao, Guam	IGS/ITRF	
	TMG2	Boulder, CO	Proposed IGS	
	Existing and New Sites	WES2	Westford, MA	IGS/ITRF
		NEW	Apache Point, NM	ITRF
	Program: NOAA CORS Network	NEW	Fort Davis, TX	ITRF
		NEW	Fort Irwin, CA	ITRF
NEW		Hancock, NH	ITRF	
NEW		Los Alamos, NM	ITRF	
NEW		Kitt Peak, AZ	ITRF	
NEW		Owens Valley, CA	ITRF	
NEW		Cold Bay, AK	ITRF	
NEW		North Liberty, IA	ITRF	

Goals of Foundation CORS Project

Federally-owned and operated “backbone”

- Chosen for location, longevity, and high quality
- Operational Goals:
 - Non-operational time minimized for each station
 - 90% of NOAA Foundation CORS Network available at any time (no more than 4 stations non-operational)



Deep-drilled, braced monument design for some new installations

All stations are critical to some function of the new NSRS, including:

- A geographic distribution no greater than 800 km to provide minimum 1.5 cm accuracy ellipsoidal height results through NGS' OPUS tools anywhere in the U.S.
- 22 out of 36 stations are (currently or will be) co-located with other space geodetic stations supporting the IGS/ITRF, which the NSRS depends on

Three Ongoing Phases of Foundation CORS

Phase 1: Incorporate partner stations

Existing NASA, NSF, and Caribbean partner stations brought into the Foundation CORS network.

[NASA MOU expected approval by November 2019. Started discussions with NSF.]

Phase 2: Upgrade existing NGS CORS

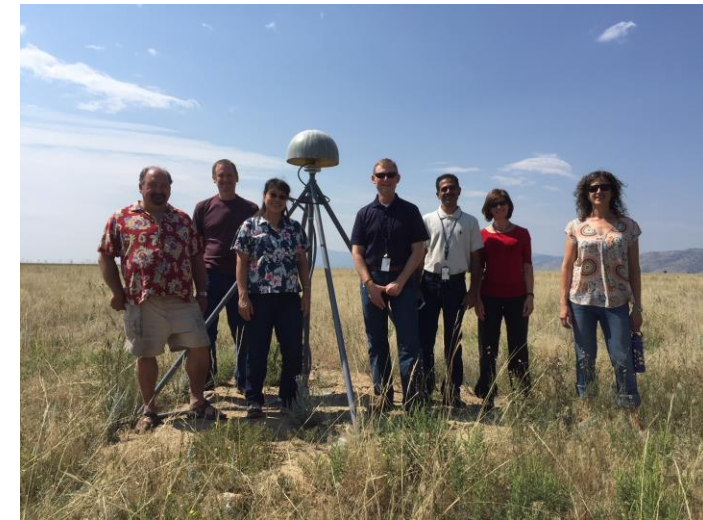
Upgrades include fully-GNSS equipment and submission to IGS to meet Foundation CORS requirements

[RINEX3 development underway. 5 of 7 existing NGS Foundation CORS are fully-GNSS enabled]

Phase 3: Construct ~8 new stations

These NGS-owned stations will be co-located at sites with existing space geodetic techniques

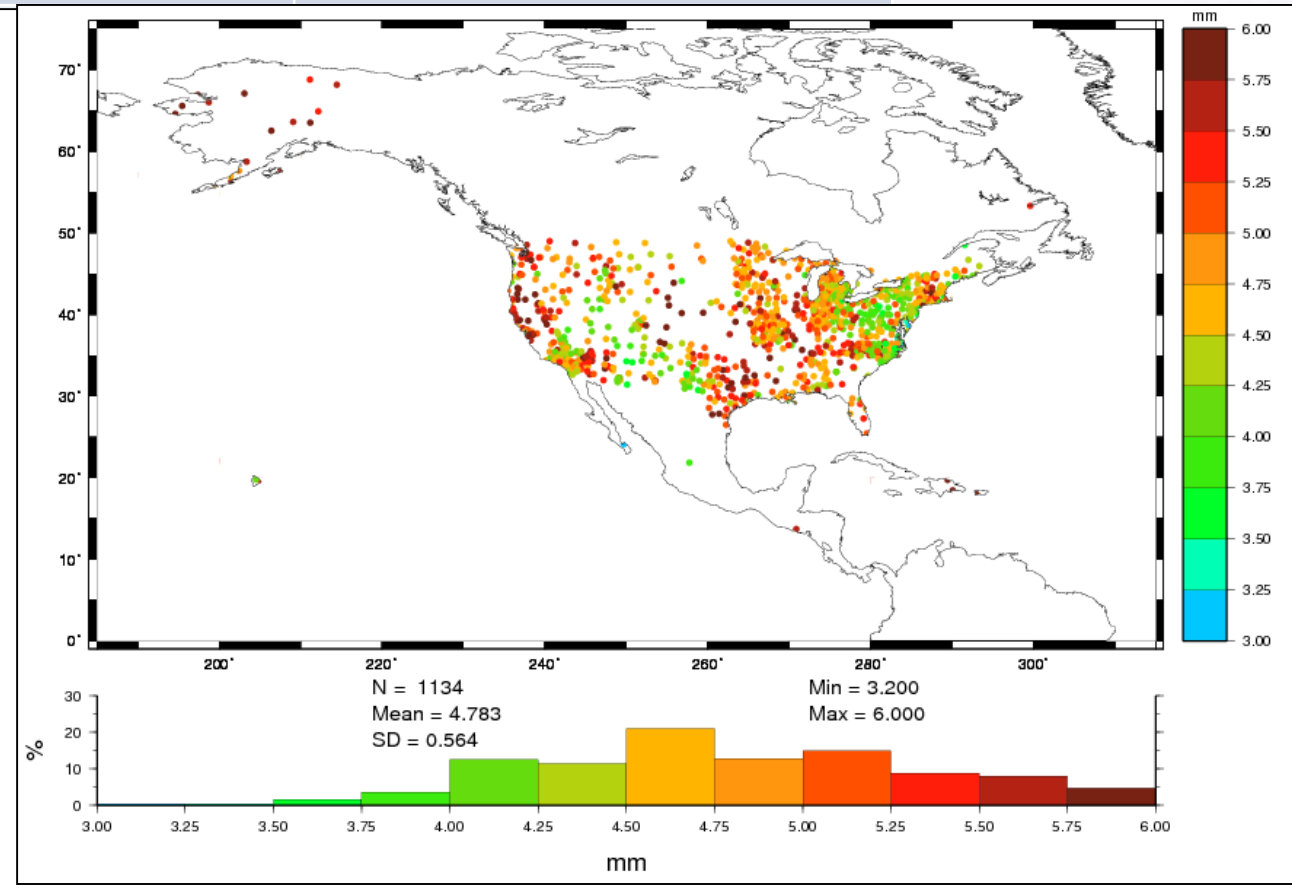
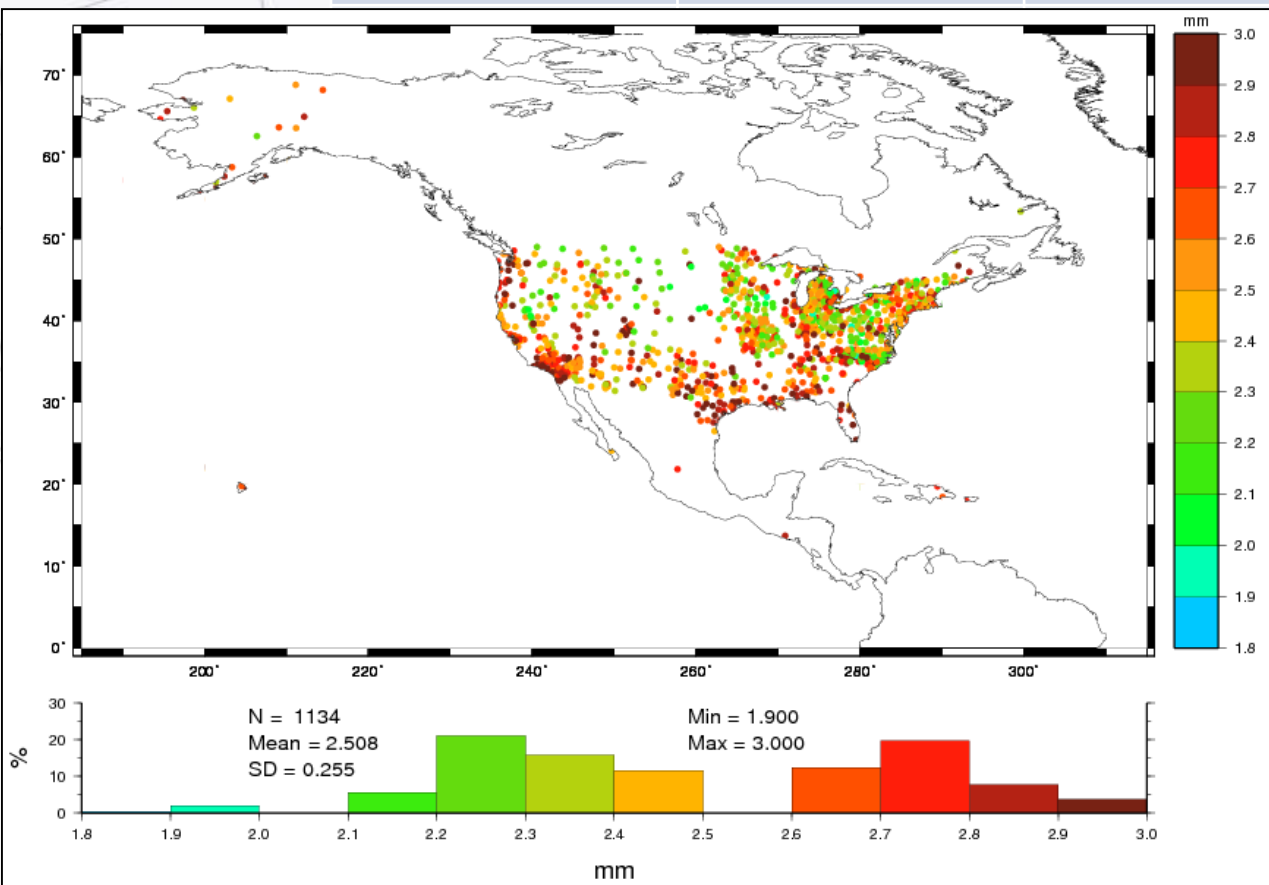
[Planning for Fort Davis, TX and Apache Point, NM station installations in 2020]



Foundation CORS at NGS' Table Mountain Geophysical Observatory in Boulder, CO, installed 2018 (ID: TMG2)

NOAA CORS Network Quality

% of Stations	# of Stations	Horizontal Motion	Vertical Motion
64%	1139	≤ 3 mm	AND ≤ 6 mm



Continued Modernization Efforts

Better access to the National Spatial Reference System (NSRS)

- Goal: achieve sustained quality of 5 mm horizontal, 10 mm vertical
(See Blueprint Part 3)
- That's nearly **75% BETTER** than before
- All but 16 CORS met the standard as of MYCS2 end date in 2017
- Today (2.5 yrs later), motion (e.g. Ridgecrest Earthquake, July 2019) means more stations are out of spec and need to have coords/velocities repaired.

Continued Modernization Efforts

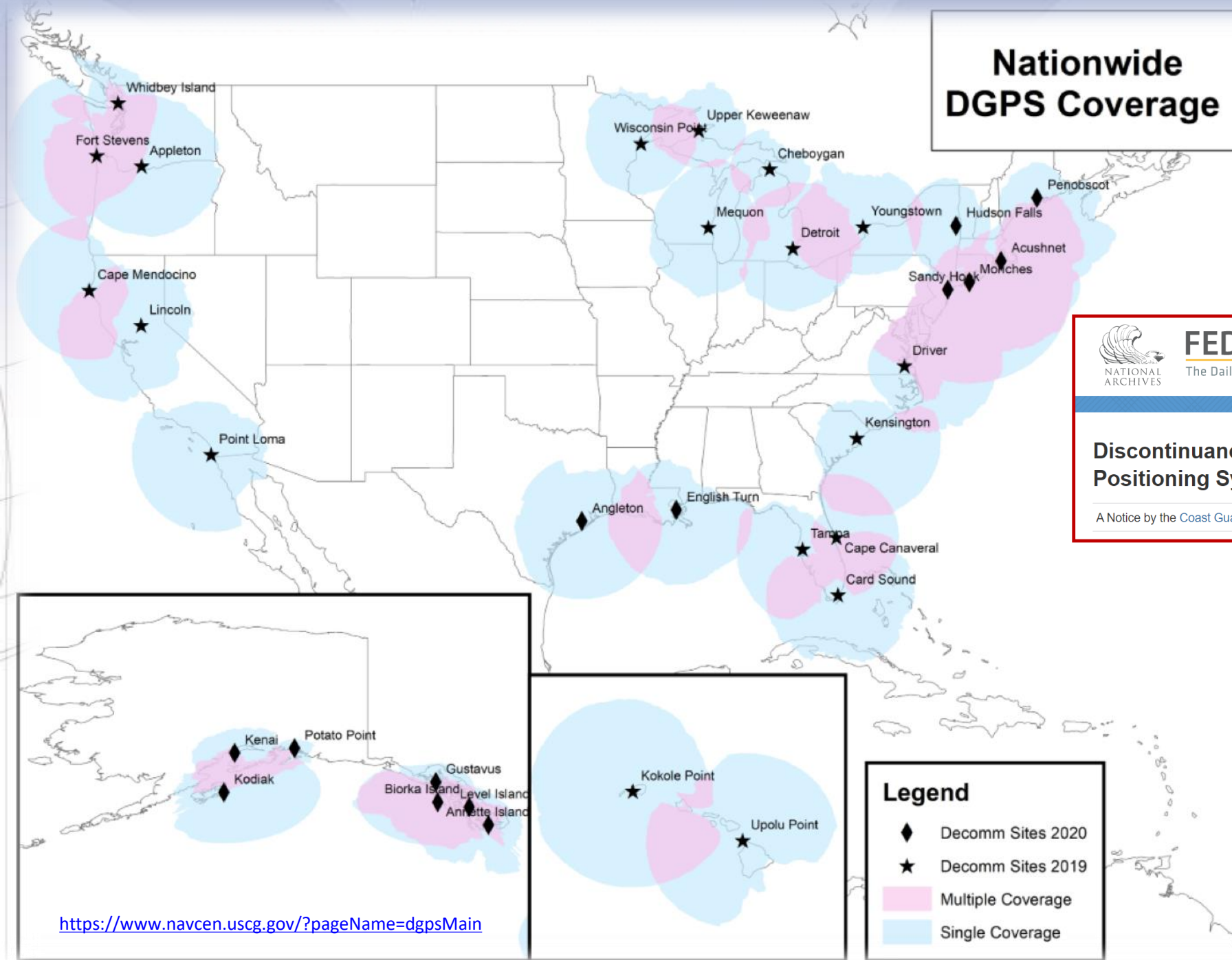
NOAA CORS Network Comprehensive Plan (Expected Fall 2020)

Present new ways to:

- Redesign the CORS website with dynamic plots, new metrics, faster refresh
- Improve OPUS' selection of CORS by providing it with better CORS data quality statistics
- Repair out-of-spec stations and provide new station coordinates more quickly
- Provide an OPUS tool to track NSRS coords/velocities for any continuous GNSS station
- Increase CORS data provider and data user communications
- Better models of motion, for both plate rotation and regional motion (IFVM)
- Automate more of the network management at NGS

Nationwide DGPS Coverage

Planned NDGPS discontinuance by 2020



FEDERAL REGISTER
The Daily Journal of the United States Government

Notice

Discontinuance of the Nationwide Differential Global Positioning System (NDGPS)

A Notice by the Coast Guard on 03/21/2018

Legend

- ◆ Decomm Sites 2020
- ★ Decomm Sites 2019
- Multiple Coverage
- Single Coverage



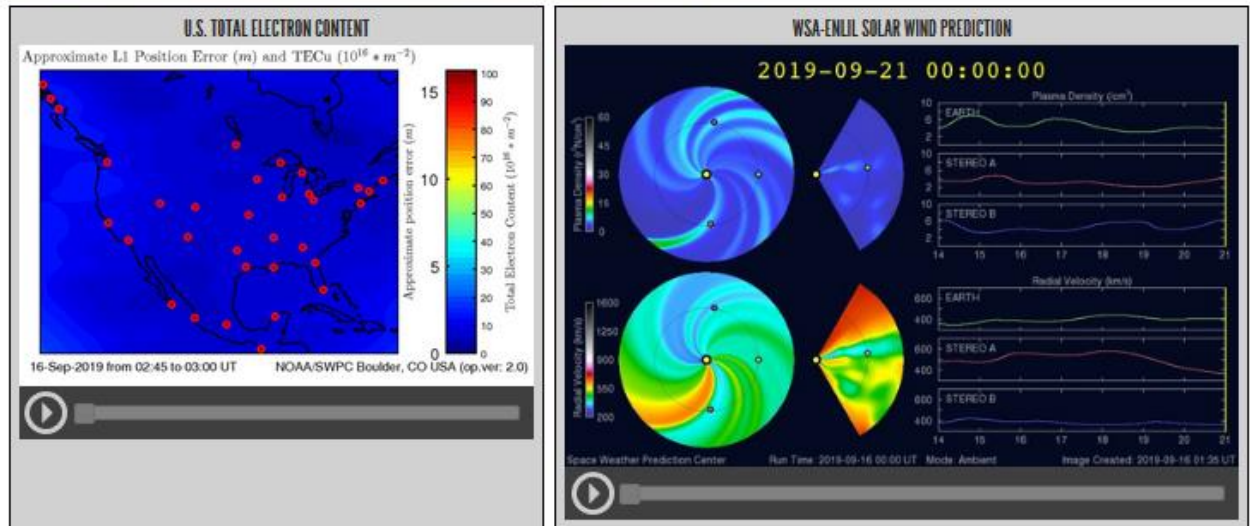
<https://www.navcen.uscg.gov/?pageName=dgpsMain>

SPACE WEATHER CONDITIONS on NOAA Scales



Solar Wind Speed: 453 km/sec Solar Wind Magnetic Fields: Bt 5 nT, Bz -3 nT Noon 10.7cm Radio Flux: 68 sfu

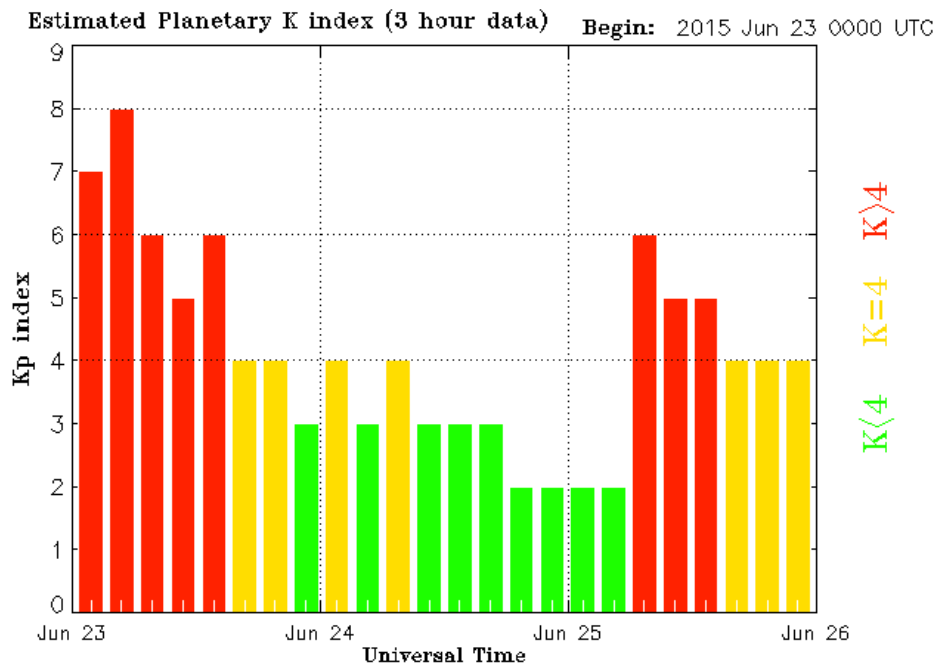
GLOBAL POSITIONING SYSTEM (GPS) COMMUNITY DASHBOARD



SWPC's GPS Dashboard

<https://www.swpc.noaa.gov/communities/global-positioning-system-gps-community-dashboard>

Learn more about space weather and GPS/GNSS later this session.



Updated 2015 Jun 26 00:30:21 UTC

NOAA/SWPC Boulder, CO USA

Hurricane DORIAN (2019 Aug-Sep)

Station **NCBX** at Cape
Hatteras Secondary
School in Buxton, NC

Hurricane DORIAN Imagery About Download Contact

National Weather Service - National Hurricane Center
Tropical Storm and Hurricane Force Wind Swaths of Dorian
From Advisories 1 Through 64

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Acknowledgements to the following:

CORS Division Chief Theresa Damiani, for her contribution of the Foundation CORS and Multiyear CORS Solution 2 (MYCS2) powerpoint slides

To Kevin Choi, Giovanni Sella, and Richard Snay, the previous Chairs of the CGSIC User Forum (now the Survey, Mapping and Geosciences) subcommittee, for their guidance and support

To the CORS team: Steve Briedenbach, Will Freeman, Don Haw, Phillip McFarland, Jarir Saleh, Ira Sellars, Lijuan Sun, Sungpil Yoon, for their expertise, endurance, and support

Our Partners and Data Contributors for volunteering their geodetic stations, networks, time and efforts in coordination with NGS to make a robust contribution towards the NSRS. You are all deeply appreciated