Replacing NAD 83

What Does That Mean for the Geospatial Professional?

WVAGP Conference
May 2022

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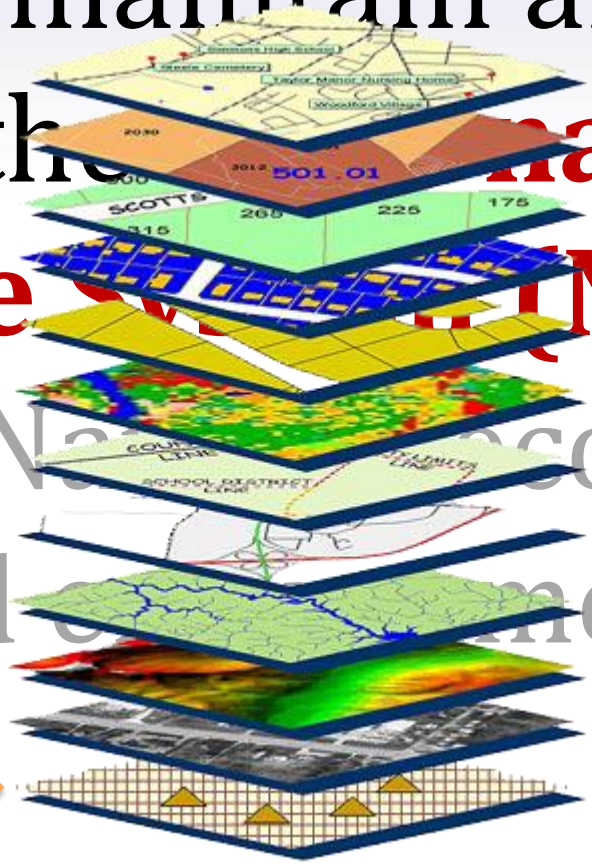
NGS Mission

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



NSRS

NSRS Modernization

What's going to stay the same?

What's going to be different?

National Spatial Reference System

A **common** and **consistent** geospatial framework to meet the economic, social, and environmental positioning needs of our Nation.

Foundational elements include:

Horizontal Datums	**Vertical Datums**

Great Lakes Datums	Geoid Models

- Latitude
- Longitude
- Height → Elevation
- Gravity
- Shoreline Position

...how these change over time

Positional Components of the NSRS

Geometric → NAD83

aka "Horizontal"

Latitude, Longitude, *Ellipsoid Height*

Geopotential → NAVD88

aka Orthometric Height

aka "Elevation"

North American Datum of 1983

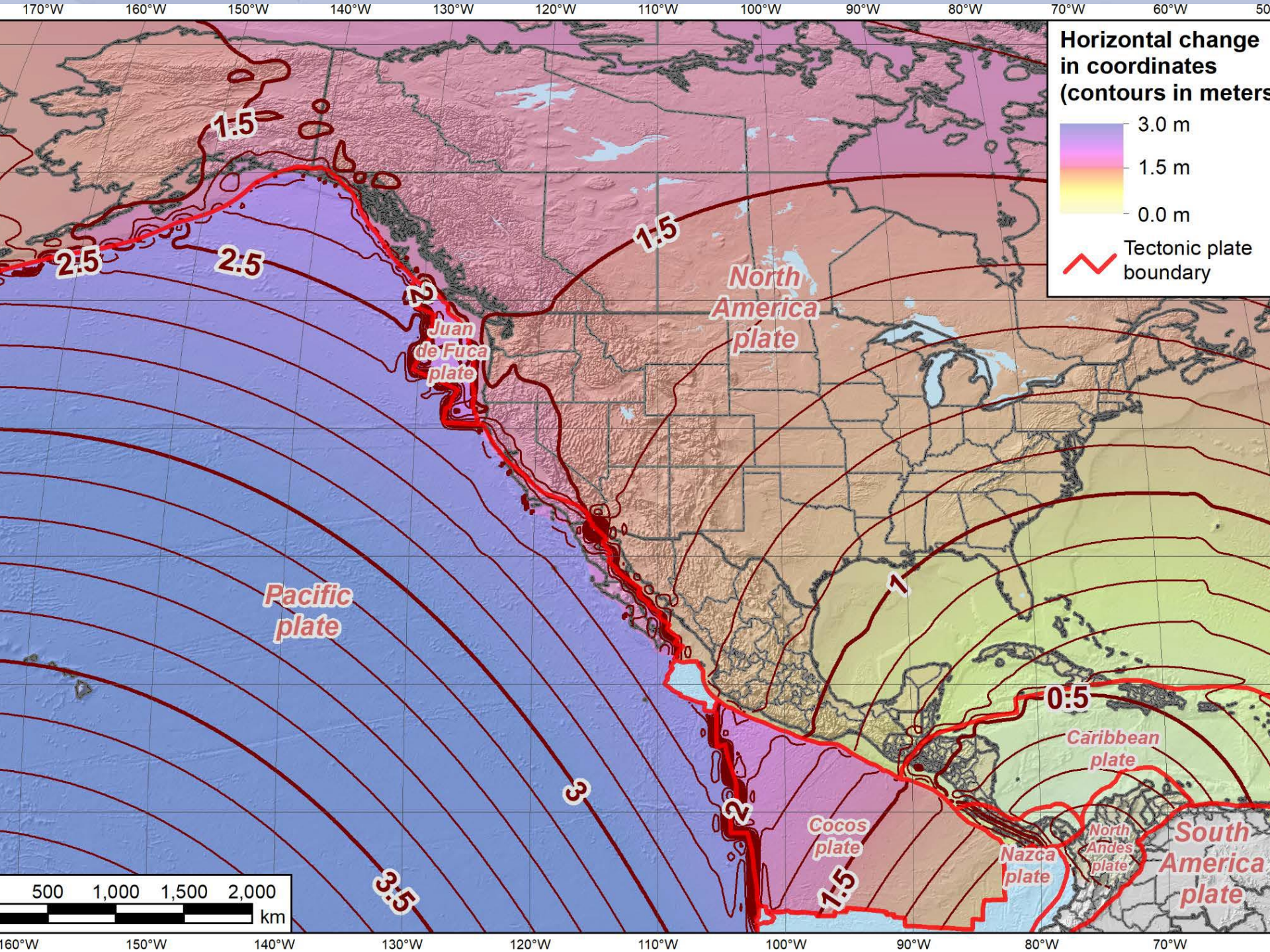
NAD83

will be replaced by

North American Terrestrial Reference Frame of 2022

NATRF2022

(pronounced: nat-ref)


Horizontal change in coordinates (contours in meters)
3.0 m
1.5 m
0.0 m
Tectonic plate boundary
North America plate
Juan de Fuca plate
Pacific plate
Cocos plate
Nazca plate
Caribbean plate
North Andes plate
South America plate
1.5
2.5
2
3
3.5
1
0.5
500 1,000 1,500 2,000 km
170°W 160°W 150°W 140°W 130°W 120°W 110°W 100°W 90°W 80°W 70°W 60°W


GLS
ockey?
SHIFT HAPPENS
NATRF2022

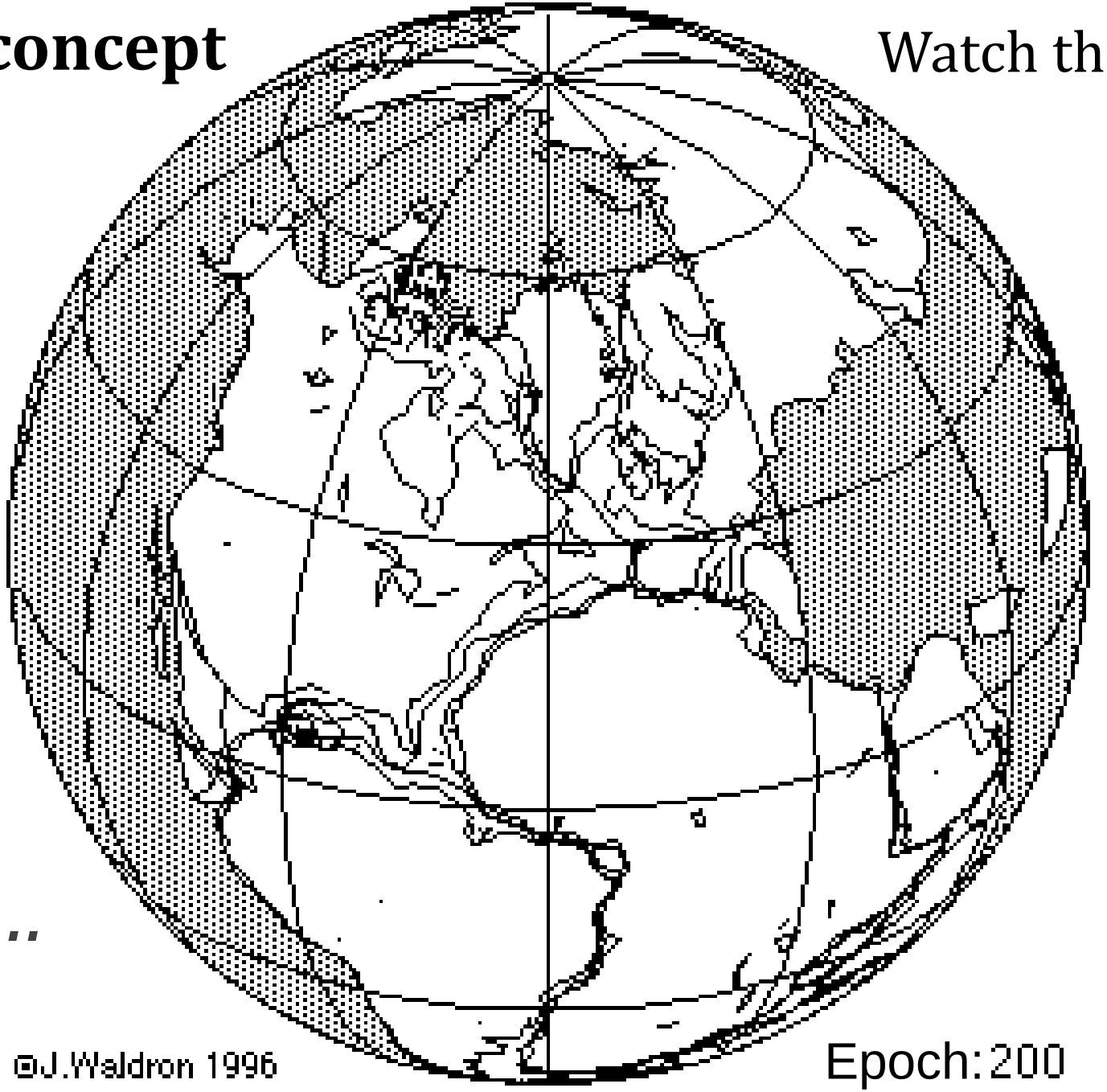
Terrestrial Reference Frame?

- Existing, accepted terminology
  - **I**nternational **TRF**
  - first realization of the ITRF was 1992
  - NATRF2022 will be based on ITRF2020

- "Horizontal Datum" - misnomer for NAD83

ITRF concept

Watch the grid!



Drift…

ITRF	NATRF
Frame = constant	Frame = rotating
NA Plate = rotating	NA Plate = constant

ITRF

Frame = constant

NA Plate = rotating

NATRF

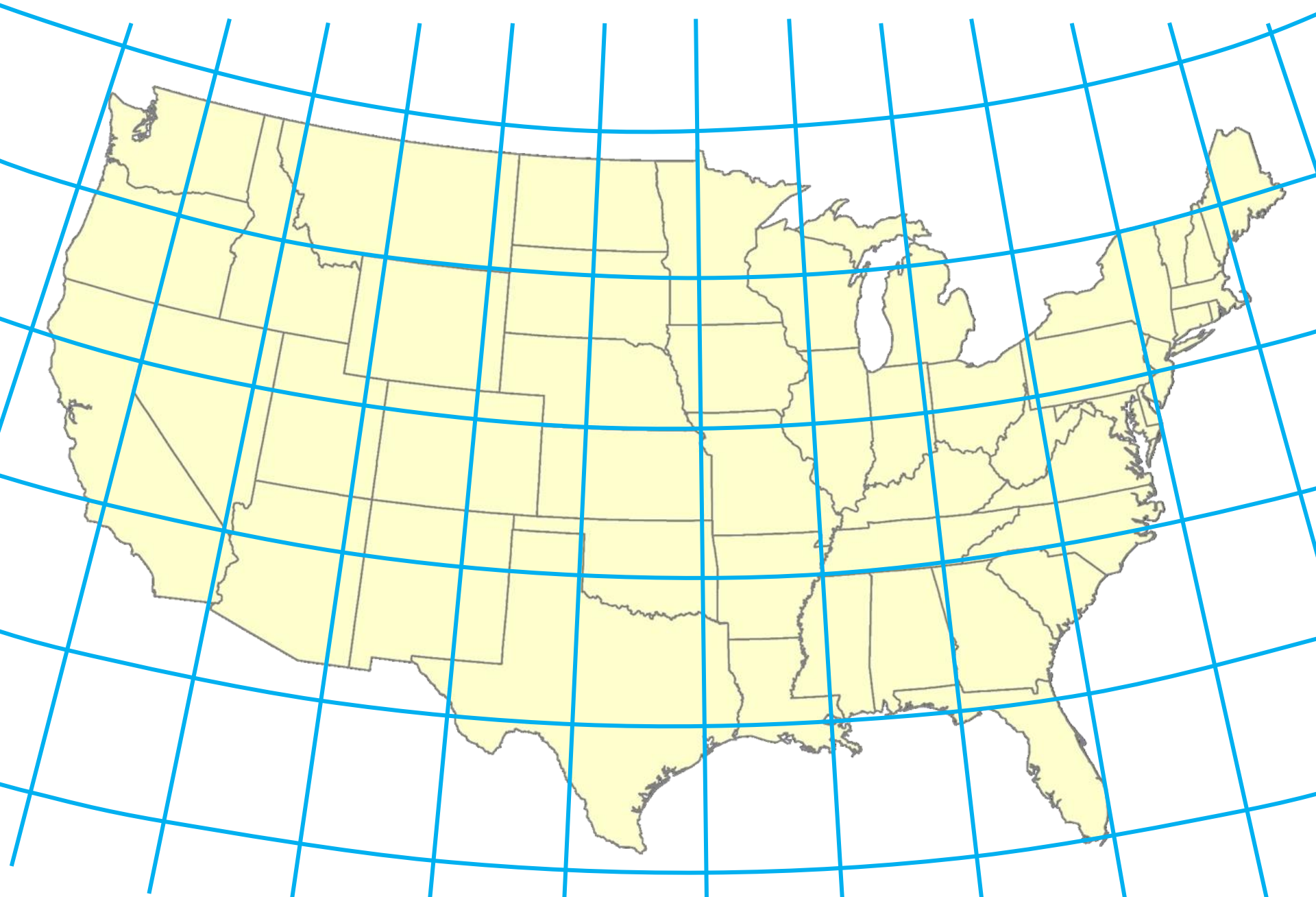
Frame = rotating

(*relative to ITRF*)

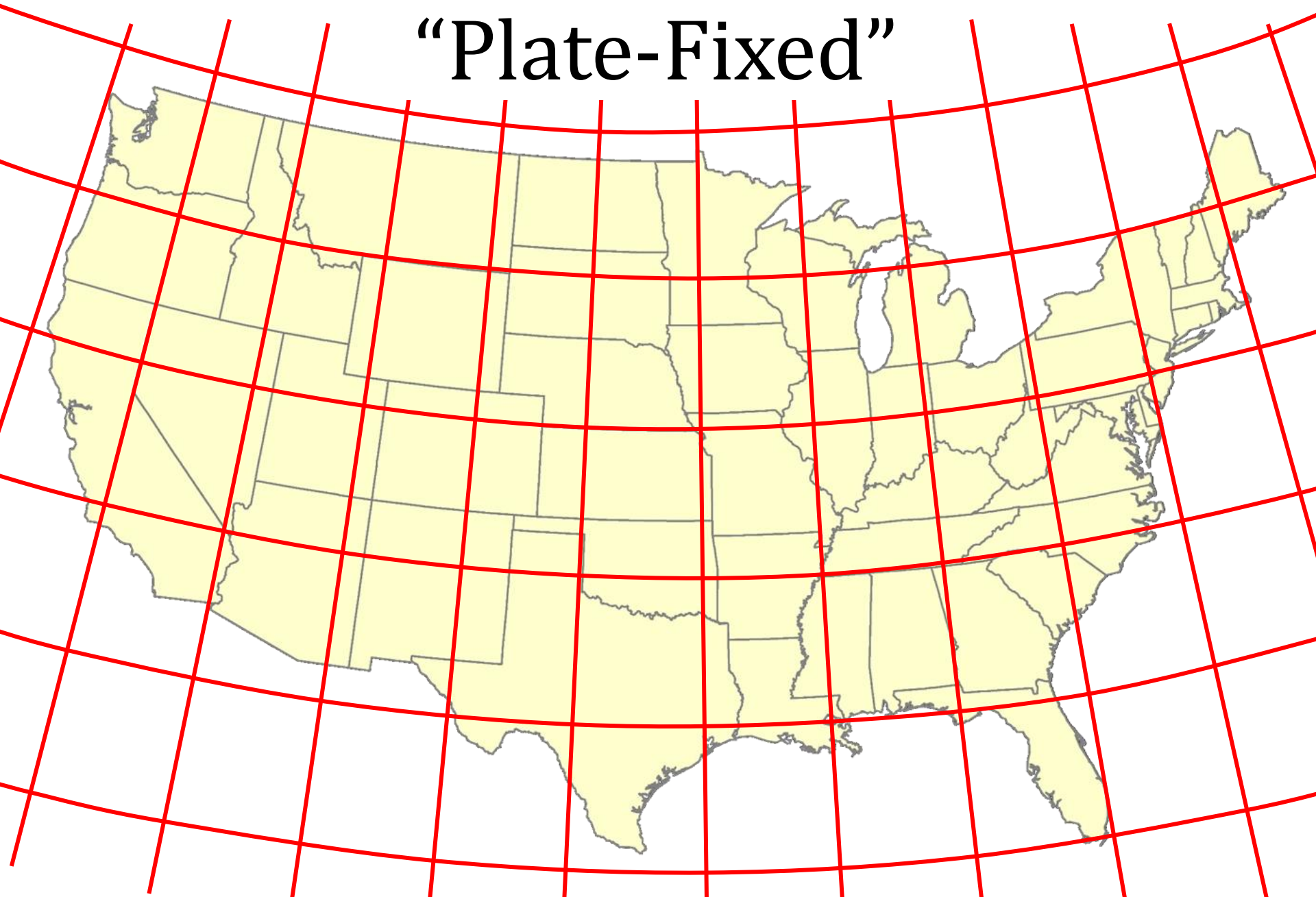
NA Plate = constant

(*relative to NATRF*)

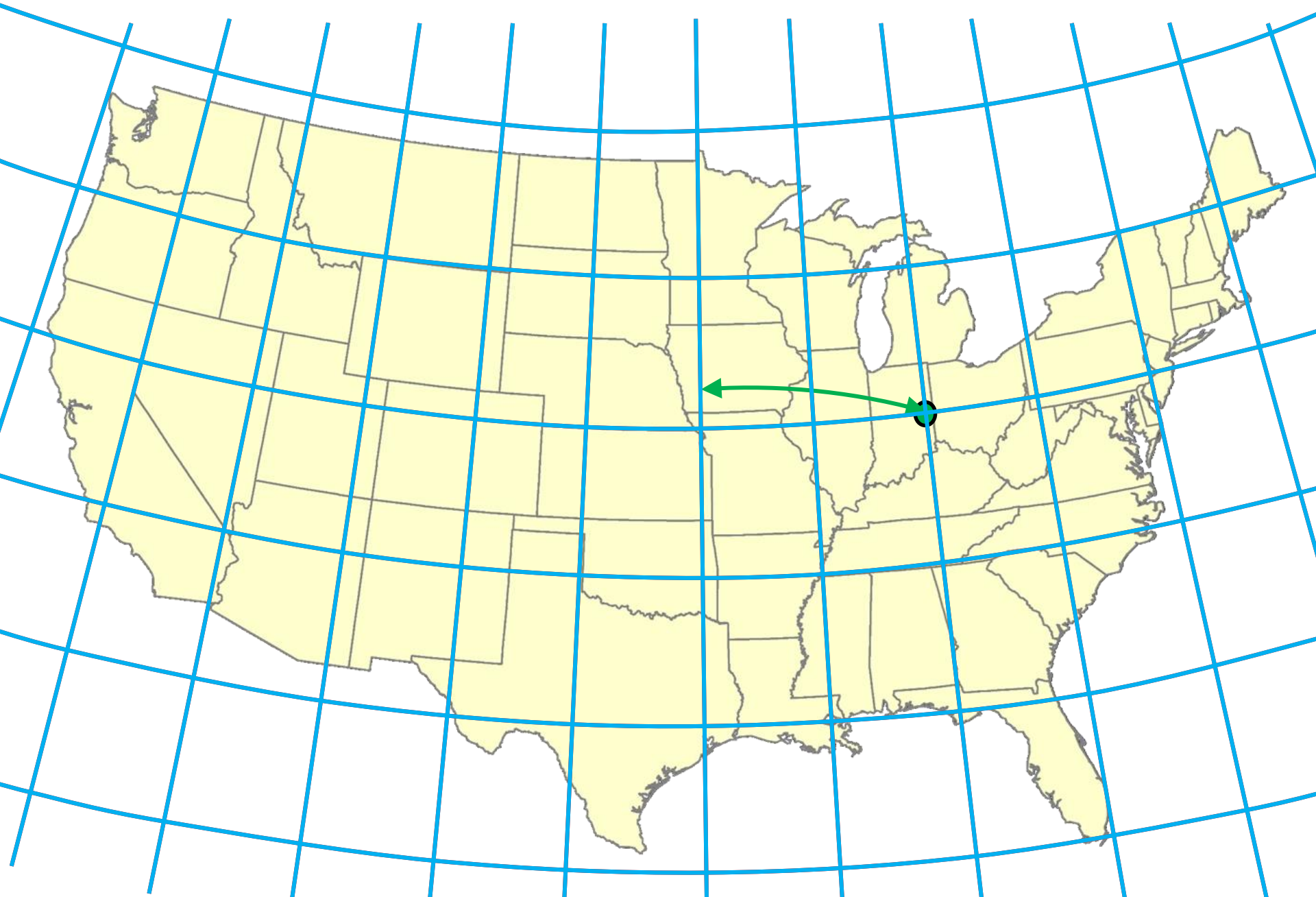
ITRF – constant frame, rotating plate



NATRF – rotating frame, constant with plate



ITRF or NATRF – your choice, we'll provide both



How?

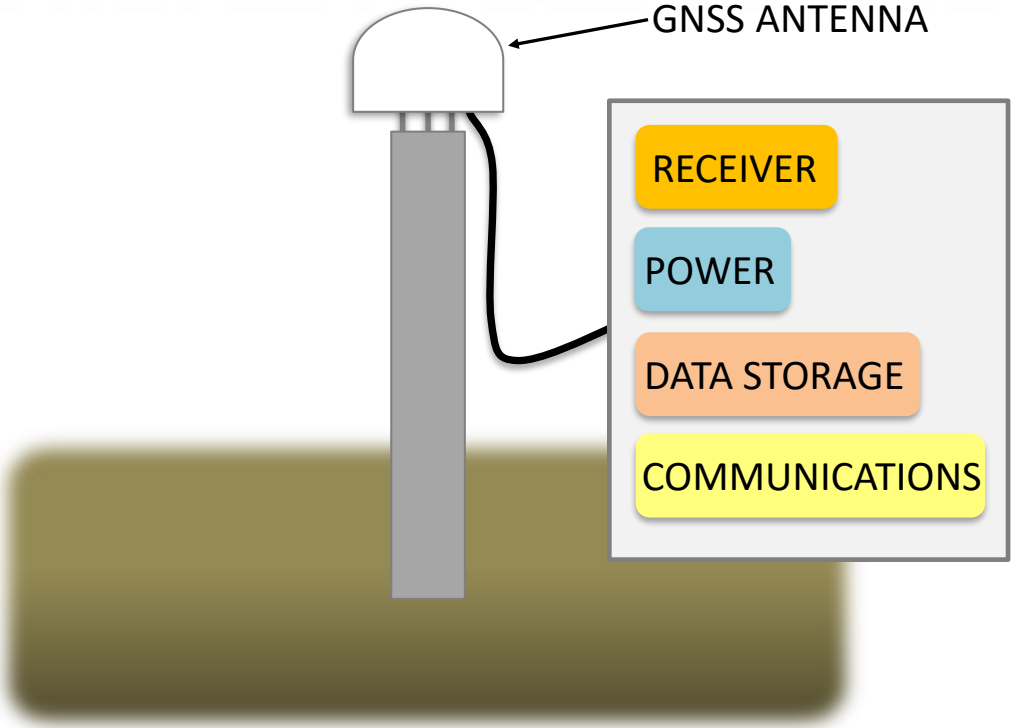
CORS

Epochs/Time/4D

Terminology – Geodetic Control

CORS

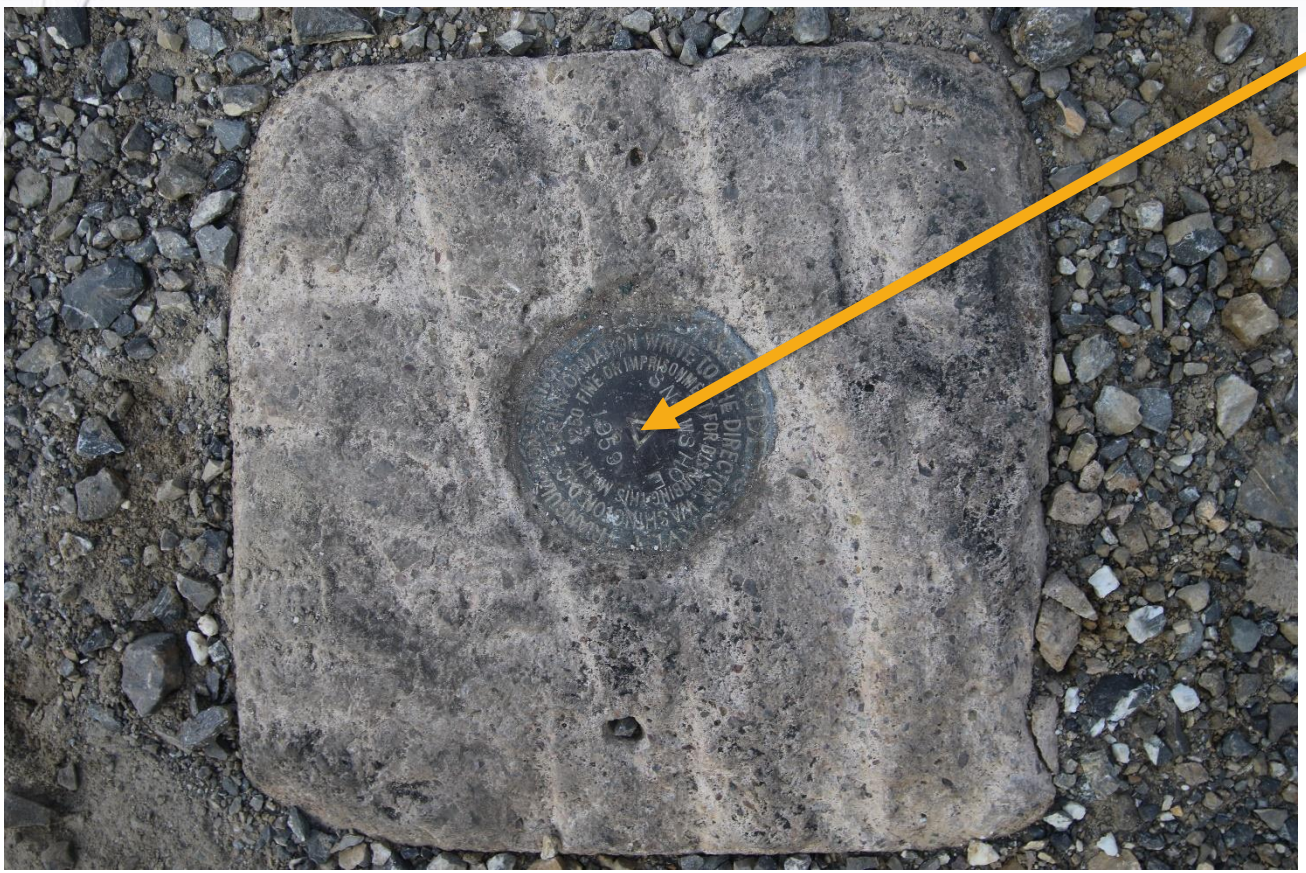
Continuously Operating Reference Station



Terminology – Geodetic Control

Passive Control

- *All marks* are **passive**—they sit there and hold a **point**

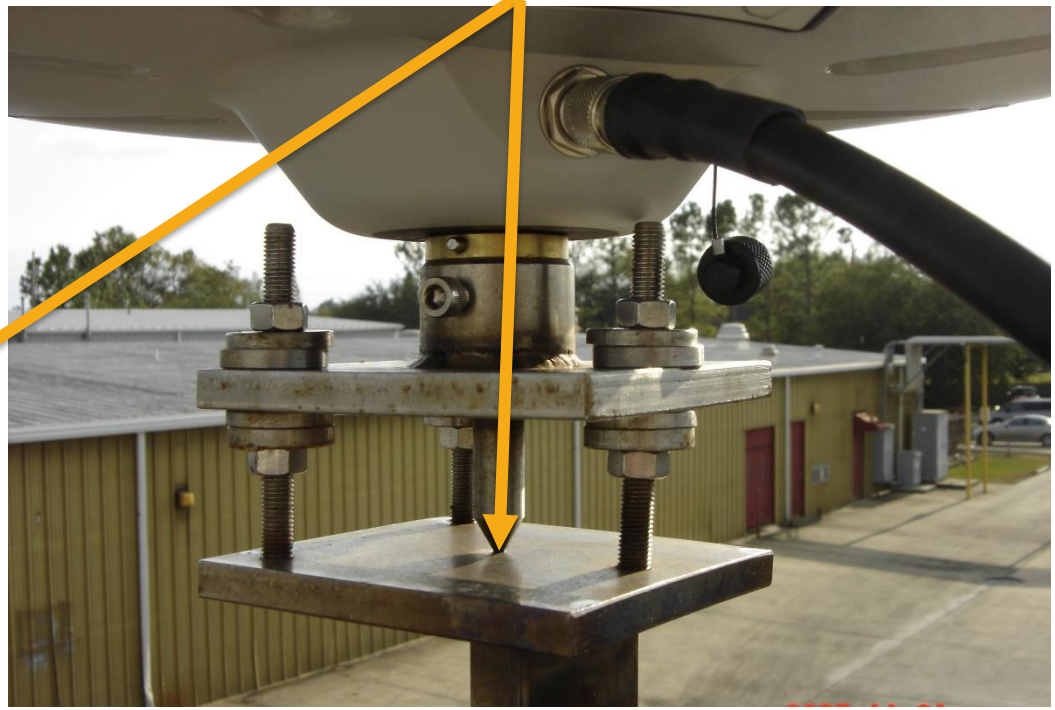


Terminology – Geodetic Control

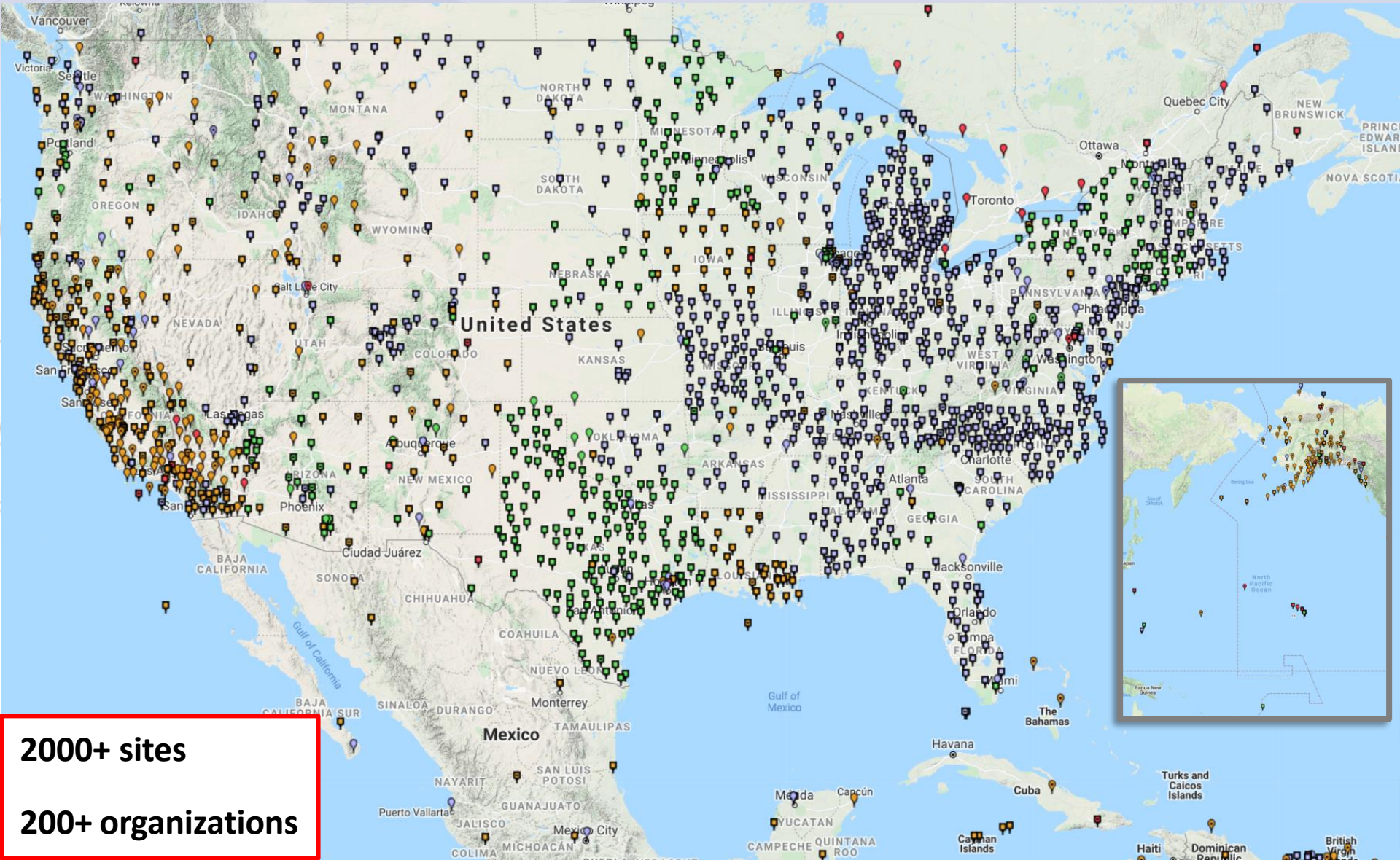
Active Control

- *Some marks* have permanently installed antennas that enable *continuously logged observations*

(they still sit there and hold a **point**)



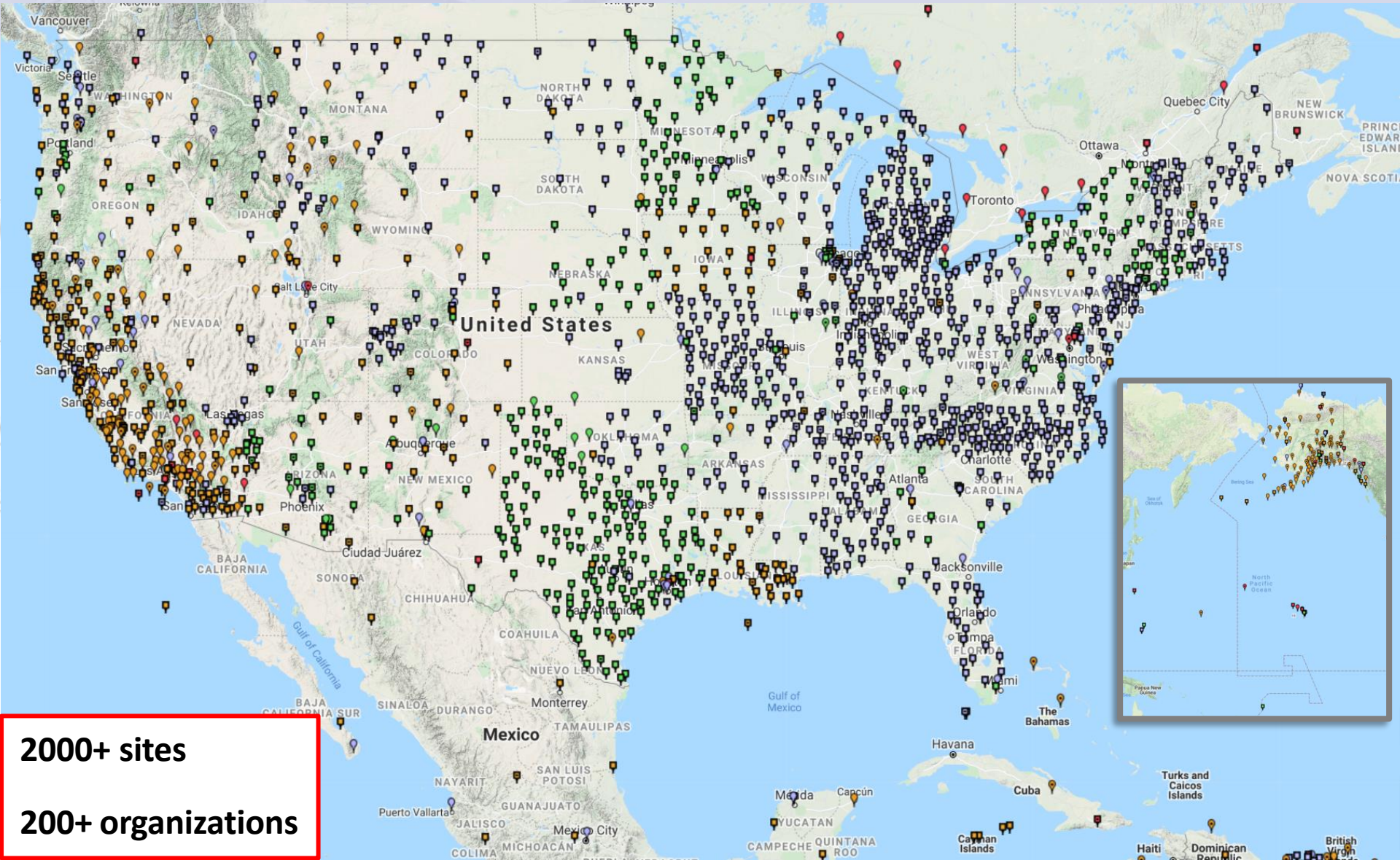
Continuously Operating Reference Stations (CORS)



2000+ sites

200+ organizations

NOAA CORS Network (NCN)



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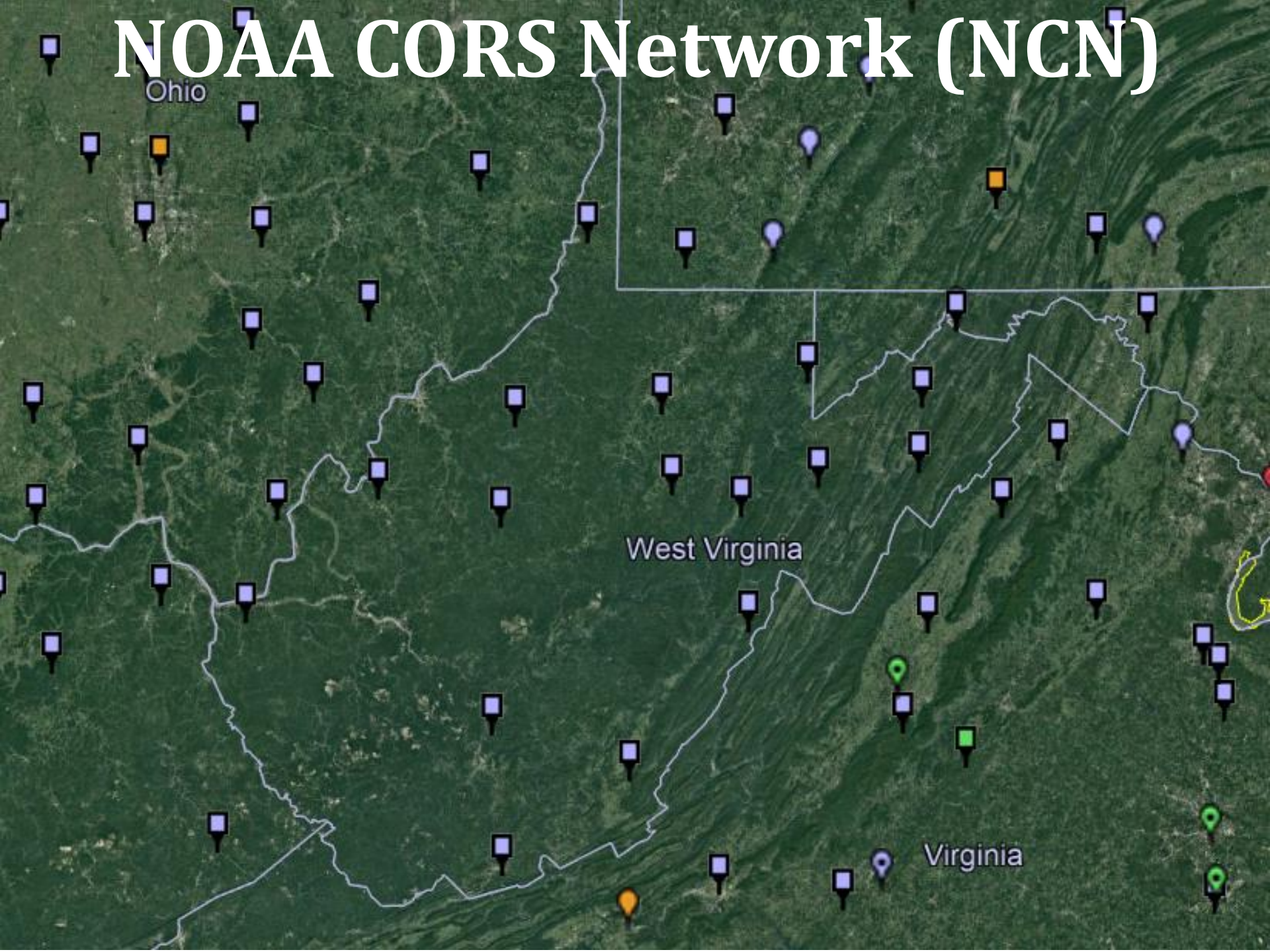
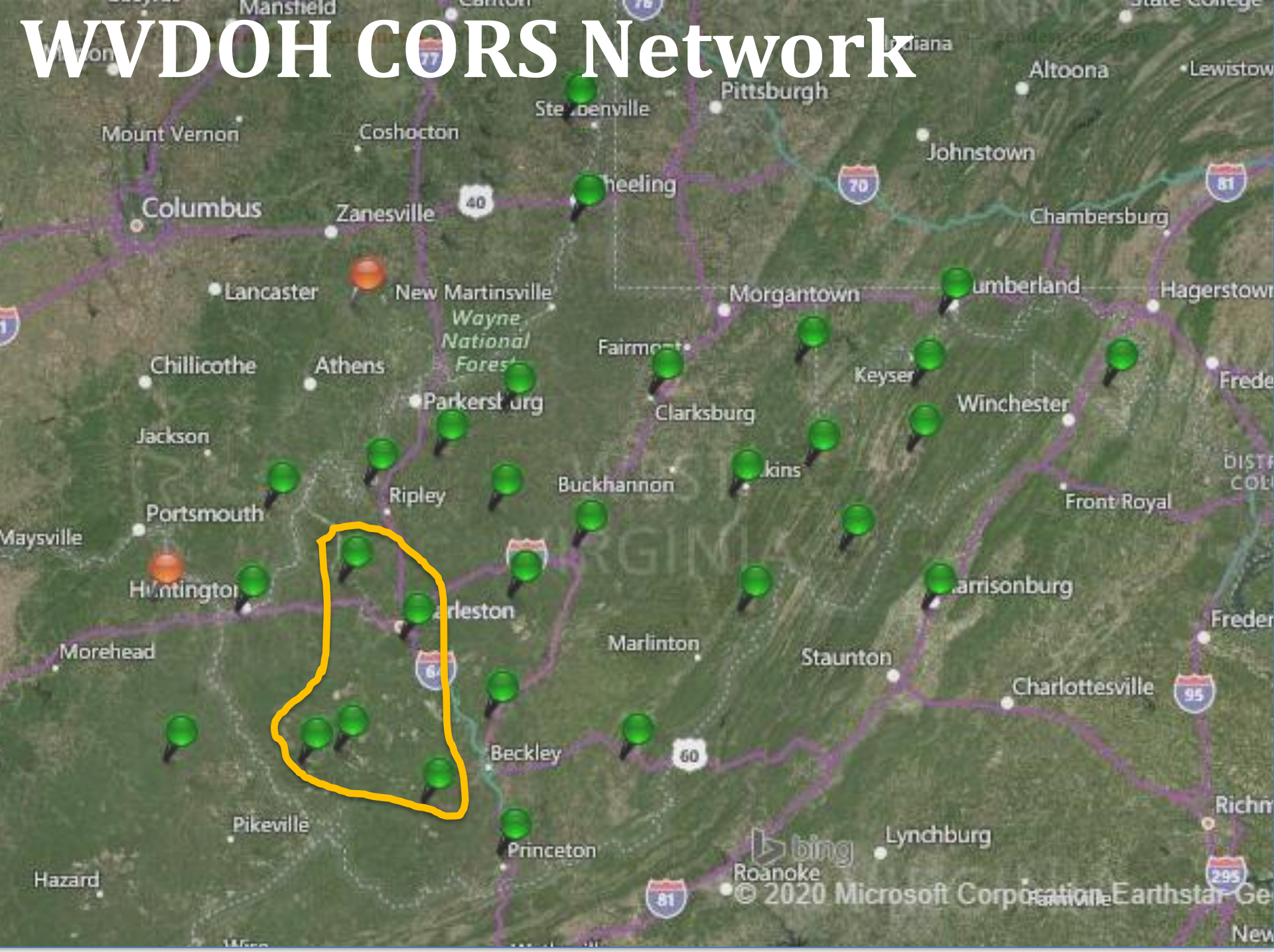


WVDOH CORS Network



Terminology – Time/4D

Epoch

- eh-puck? ee-pock? … *to-may-to, to-mah-to*
- **an instant of time**
- astronomy & geodesy use a decimal date
  - 2021.4762 = 23 June 2021 (@ ~7:15pm)
  - doesn't have to be!
  - using epochs is important, not format
    - It doesn't have to be in decimal years… just start assigning dates to your data

Terminology - Changing Coordinates

Conversion

- change the ***type*** of coordinate
- e.g. NAD83(2011) *latitude & longitude* → NAD83(2011) *SPCS*

Transformation

- change the ***datum*** of coordinate
- e.g. *NGVD29* height in feet → *NAVD88* height in feet
- e.g. *NAD 27* latitude & longitude → *NAD 83(2011)* latitude & longitude

Propagation

- change the ***epoch*** of coordinate
- e.g. NAPGD2022 *epoch 2020.00* to NAPGD2022 *epoch 2087.2570*
- e.g. NATRF2022 *epoch 2020.00* to NATRF2022 *epoch 2023.243*

NGS OPUS SOLUTION REPORT

==========

All s are lister

For //www.ngs. y

aa.gov

RIN

Reference Epoch

Survey Epoch

```
  SOFTWARE: page5  1801.18 master93.pl 160321      START: 2019/12/02  05:00:00
 EPHEMERIS: igu20821.eph [ultra-rapid]              STOP: 2019/12/02  08:00:00
  NAV FILE: brdc3360.19n                        OBS USED:  2267 /  2437   :  93%
  ANT NAME: NONE            NONE              # FIXED AMB:    13 /    17   :  76%
ARP HEIGHT: 0.000                             OVERALL RMS: 0.010(m)

 REF FRAME: NAD_83(2011)(EPOCH:2010.0000)        ITRF2014 (EPOCH:2019.9185)
```

```
DG4400  DESIGNATION -  WBW C                                  2.178(m)   0.057(m)
DG4400  PID         -  DG4400                                 8.806(m)   0.050(m)
DG4400  STATE/COUNTY-  PA/LUZERNE                             6.666(m)   0.044(m)
DG4400  COUNTY      -  US
DG4400  USGS QUAD   -  PITTSTON (2019)
DG4400                                                        97951      0.036(m)
DG4400                     *CURRENT SURVEY CONTROL            24576      0.073(m)
DG4400  ___________________________________________________    75424      0.073(m)
DG4400* NAD 83(2011) POSITION- 41 17 59.62508(N) 075 50 45.11678(W)   ADJUSTED
DG4400* NAD 83(2011) ELLIP HT -   133.105 (meters)      (06/27/12)   ADJUSTED   6.321(m)   0.028(m)
DG4400* NAD 83(2011) EPOCH    -  2010.00                            d using GEOID18)]
DG4400* NAVD 88 ORTHO HEIGHT -   164.99  (meters)      541.3   (feet) GPS OBS
```

NGS OPUS SOLUTION REPORT

==========

All s are lister

For //www.ngs. y

aa.gov

RIN

Reference Epoch

Survey Epoch

```
  SOFTWARE: page5  1801.18 master93.pl 160321      START: 2019/12/02  05:00:00
 EPHEMERIS: igu20821.eph [ultra-rapid]              STOP: 2019/12/02  08:00:00
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  ANT NAME: NONE            NONE              # FIXED AMB:    13 /    17   :  76%
ARP HEIGHT: 0.000                             OVERALL RMS: 0.010(m)

 REF FRAME: NAD_83(2011)(EPOCH:2010.0000)        ITRF2014 (EPOCH:2019.9185)

        X:     -2577621.302(m)   0.057(m)      -2577622.178(m)   0.057(m)
        Y:     -3806030.040(m)   0.050(m)      -3806028.806(m)   0.050(m)
        Z:      4406776.637(m)   0.044(m)       4406776.666(m)   0.044(m)
```
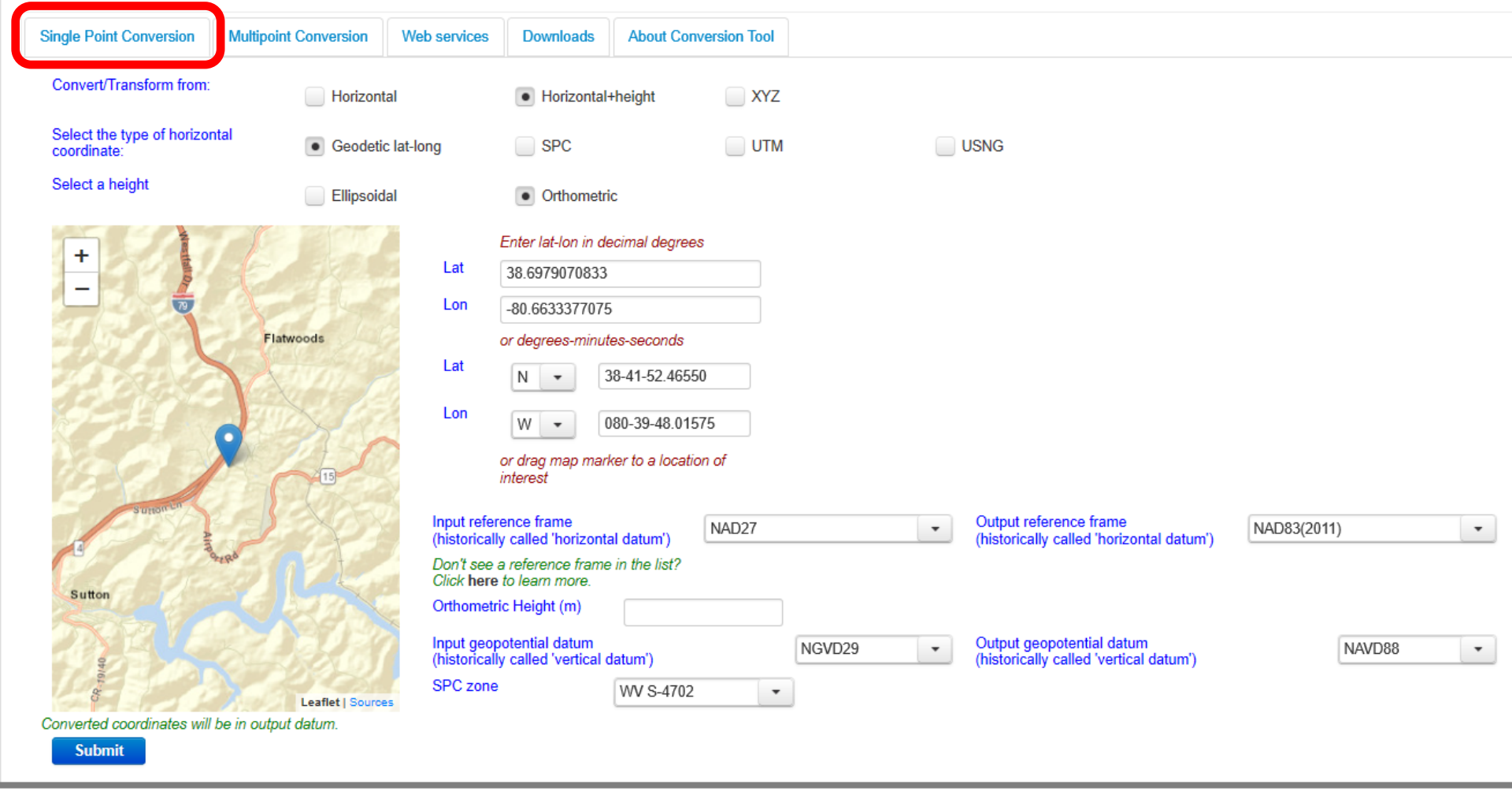
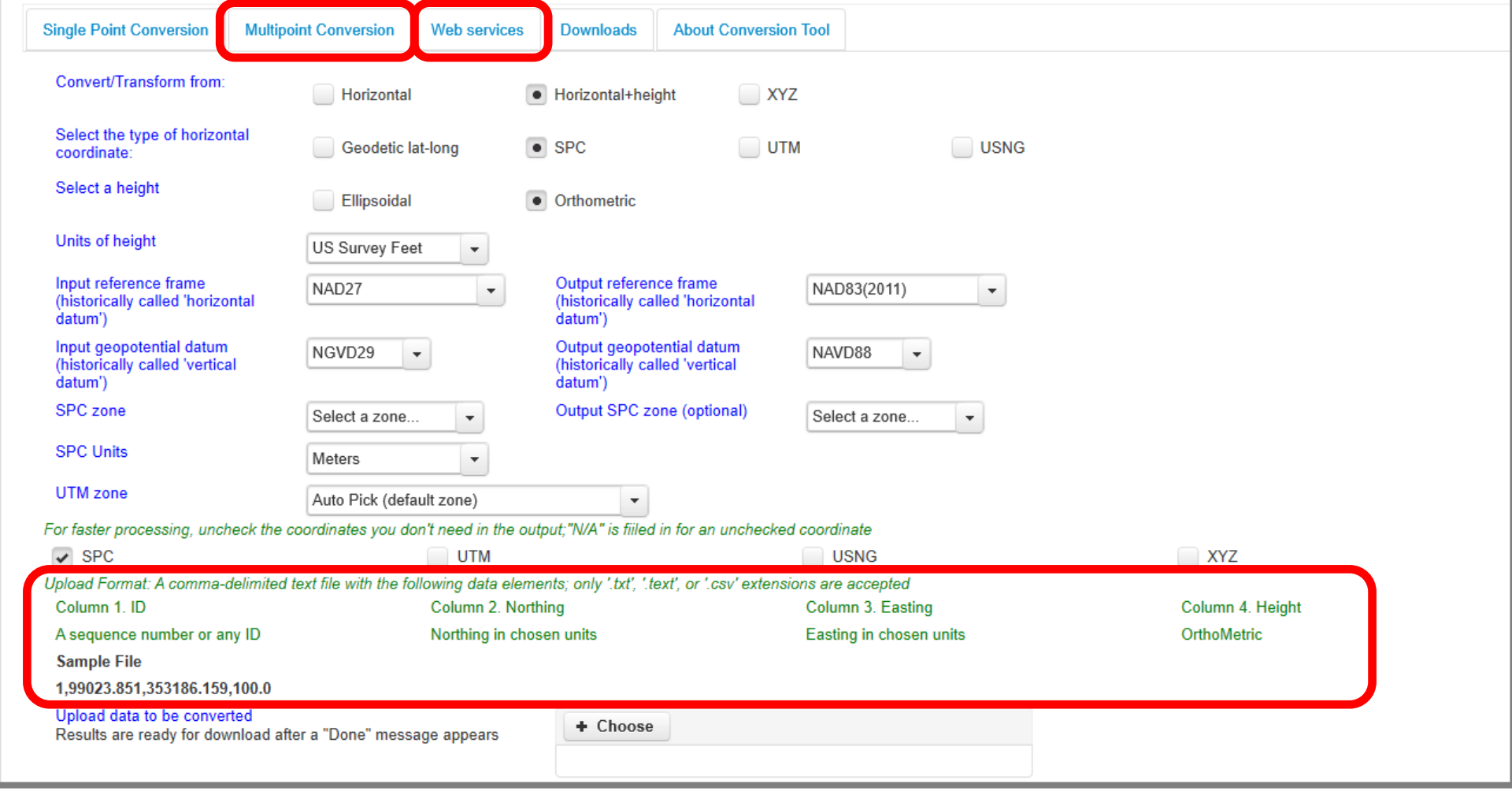

Here above we're looking at a

Transformation and Propagation



NGS Coordinate Conversion And Transformation Tool (NCAT)



NGS Coordinate Conversion And Transformation Tool (NCAT)

NCAT is available via web services

Web Services
Home
Geoid Height Service API
Gravity Predictor using GRAV-D API
NGS Data Explorer API
NGS Coordinate Conversion and Transformation Tool (NCAT) API
VDatum Tidal API
OPUS API

Tools & Software
PC Products
Geodetic Tool Kit
Web Services
User-Contributed Software
Other Products & Programs

Subscribe for email notifications

API for NGS's Coordinate Conversion and Transformation Tool (NCAT)

NGS Coordinate Conversion and Transformation Tool (NCAT) allows users to easily convert between different coordinate systems and/or transform between different reference frames and/or datums, in a single step. For coordinate conversion, NCAT allows conversion between lat/long/height, SPC, UTM, XYZ, and USNG systems. NCAT currently uses NADCON 5.0 to perform three-dimensional (latitude, longitude, ellipsoid height) coordinate transformations and VERTCON 3.0 to perform orthometric height transformations. Transformations are provided for a wide range of frames/datums and regions in the National Spatial Reference System. NADCON and VERTCON provide local error estimates for each transformation, and do not support transformations which are outside the boundaries of the supported areas (generally, CONUS, Alaska, Hawaii, Puerto Rico and the US Virgin Islands, American Samoa, and Guam and Northern Mariana Islands).

Please note that, although either orthometric or ellipsoidal heights can be used as inputs to NCAT, at this time NCAT does not convert between orthometric and ellipsoidal heights. Only orthometric-to-orthometric and ellipsoidal-to-ellipsoidal height transformations are currently possible in NCAT.

Metadata

The following URL provides metadata for various parameters used in the JSON response: **https://geodesy.noaa.gov/api/ncat/meta**

NCAT Web Services
Latitude-longitude-height Service
SPC Service
UTM Service
XYZ Service
USNG Service

NCAT is available via web services


```
{
  "ID": "1601382115072",
  "nadconVersion": "5.0",
  "vertconVersion": "3.0",
  "srcDatum": "NAD83(1986)",
  "destDatum": "NAD83(2011)",
  "srcVertDatum": "N/A",
  "destVertDatum": "N/A",
  "srcLat": "40.0000000000",
  "srcLatDms": "N400000.00000",
  "destLat": "39.9999983008",
  "destLatDms": "N395959.99388",
  "deltaLat": "-0.189",
  "sigLat": "0.000263",
  "sigLat_m": "0.0081",
  "srcLon": "-80.0000000000",
  "srcLonDms": "W0800000.00000",
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  "destLonDms": "W0795959.99141",
  "deltaLon": "0.204",
  "sigLon": "0.000221",
  "sigLon_m": "0.0052",
  "srcEht": "100.000",
  "destEht": "N/A",
  "sigEht": "N/A",
  "srcOrthoht": "N/A",
  "destOrthoht": "N/A",
  "sigOrthoht": "N/A",
  "spcZone": "PA S-3702",
  "spcNorthing_m": "76,470.391",
  "spcEasting_m": "407,886.681",
  "spcNorthing_usft": "250,886.607",
  "spcEasting_usft": "1,338,208.220",
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  "spcEasting_ift": "1,338,210.896",
  "spcConvergence": "-01 27 35.22",
  "spcScaleFactor": "0.99999024",
  "spcCombinedFactor": "N/A",
  "utmZone": "UTM Zone 17",
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  "utmScaleFactor": "0.99968970",
  "utmCombinedFactor": "N/A",
  "x": "N/A",
  "y": "N/A",
  "z": "N/A",
  "usng": "17SNE8536028235"
}
```


API for NGS's Coordinate Conversion and Transformation Tool (NCAT)

- Note that each operation is a separate service

Struggling?
Contact us.
We can help!

NCAT Web Services

- Latitude-longitude-height Service
- SPC Service
- UTM Service
- XYZ Service
- USNG Service

NCAT source code is on GitHub

Product Team Enterprise Explore Marketplace Pricing Search / Sign in Sign up

noaa-ngs / ncat-lib Public

Notifications Fork 2 Star 1

Code Issues Pull requests Actions Projects Wiki Security Insights

main 1 branch 1 tag Go to file Code

SriReddy-NOAA Added docs folder 77bcff1 on May 6, 2021 15 commits

docs	Added docs folder	13 months ago
lib	Delete lib/.svn directory	13 months ago
src	Purged unneeded data	13 months ago
test	Delete test/.svn directory	13 months ago
NCAT_lib_user_guide.pdf	Added User guide	13 months ago
README.md	Update README.md	13 months ago
build.xml	Adding version 2.4.4	13 months ago
buildjar.xml	Adding version 2.4.4	13 months ago
license.txt	Create license.txt	14 months ago
manifest.mf	Adding version 2.4.4	13 months ago

README.md

About

Library of transformation modules used by the NCAT web based tool.

Readme
View license
1 star
2 watching
2 forks

Releases 1

Release 2.4.4 Latest
on May 6, 2021

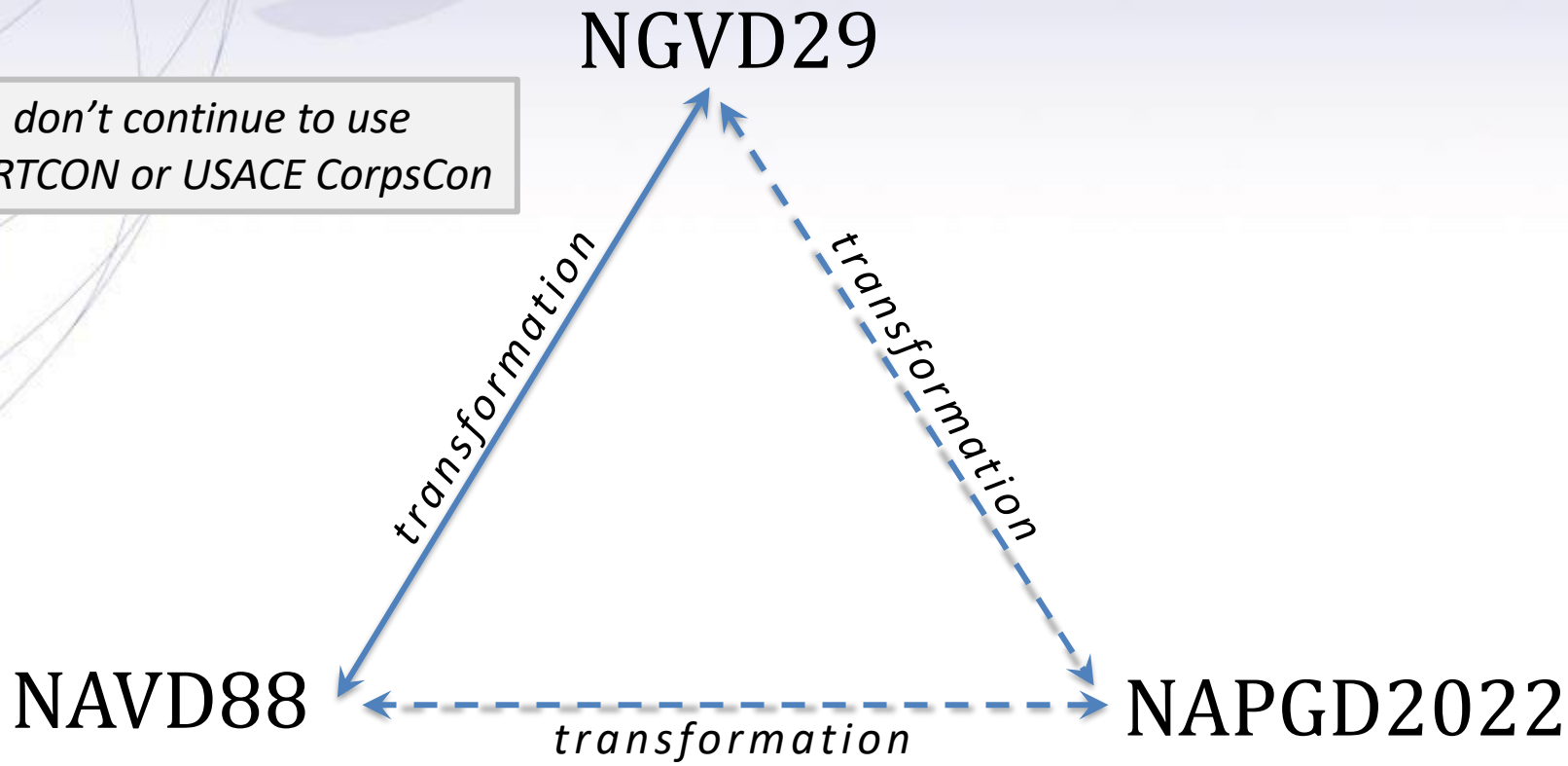
Packages

No packages published

Languages

NGS Coordinate Conversion and Transformation Tool (NCAT)

Please… don't continue to use NGS VERTCON or USACE CorpsCon



- NCAT is a container for newest version of VERTCON
- It will be upgraded to include NAPGD2022

I'll be selling these bumper stickers
at the next WVAGP conference ☺

SPCS2022

MAKING EARTH FLAT AGAIN

...ONE ZONE AT A TIME

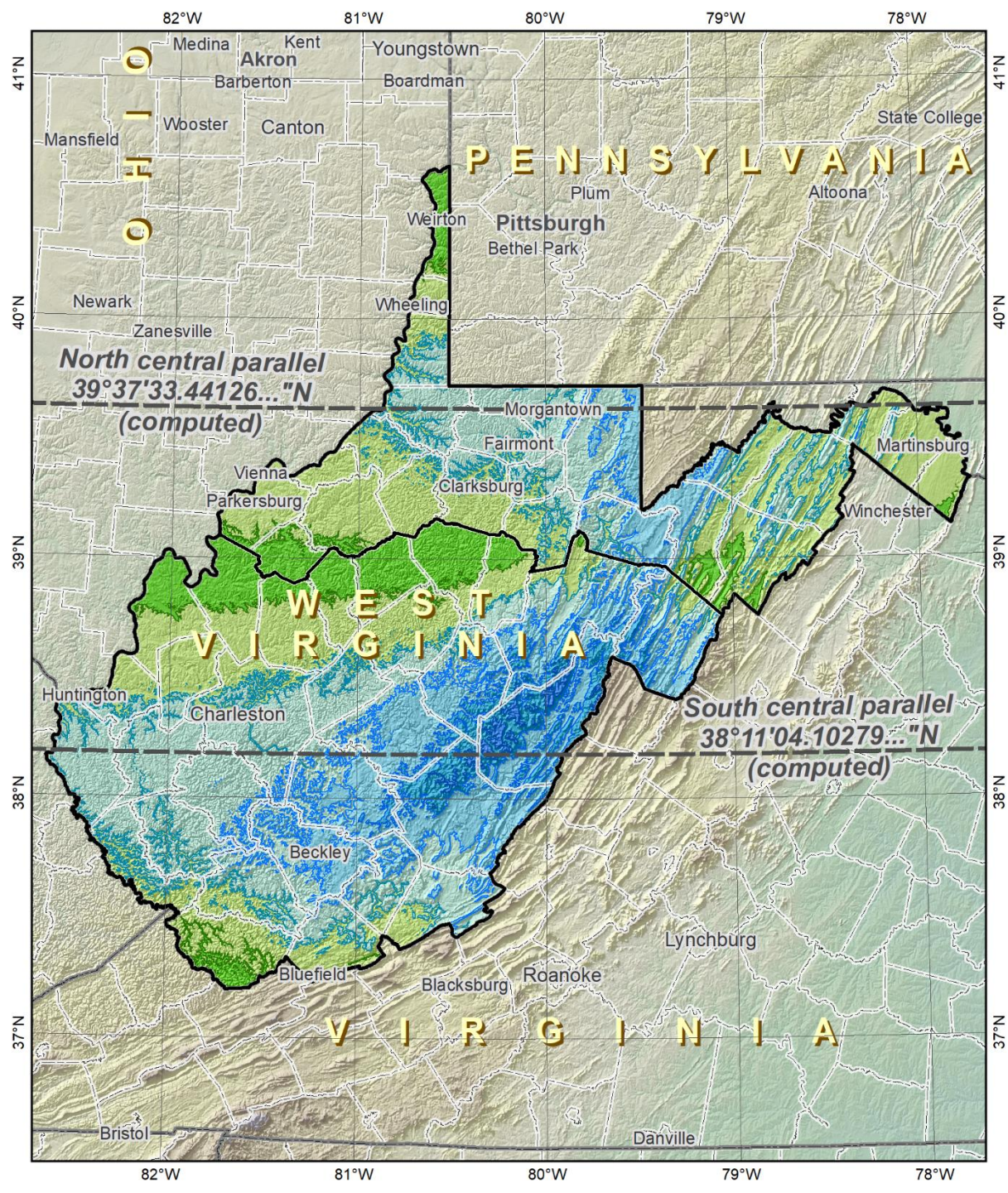
Existing SPCS 83: West Virginia North and South zones

NOAA's National Geodetic Survey

Lambert Conformal Conic projections (North American Datum of 1983)

North central parallel: 39°37'33.4..."N
Cen parallel scale: 0.999 940 741...

South central parallel: 38°11'04.1..."N
Cen parallel scale: 0.999 925 678...



Areas within ±100 ppm distortion (1:10,000 = ±0.53 ft per mile):
64% of population
67% of all cities and towns
44% of entire zone area

Distortion values (ppm)

Combined zone:	***All cities and towns:***
Min, Max = -291, +69	Min = -231
Range = 360	Max = +61
Mean = -112	Range = 292
Weighted mean = -93	Mean = -93
(weighted by population)	

Linear distortion at topographic surface (parts per million)

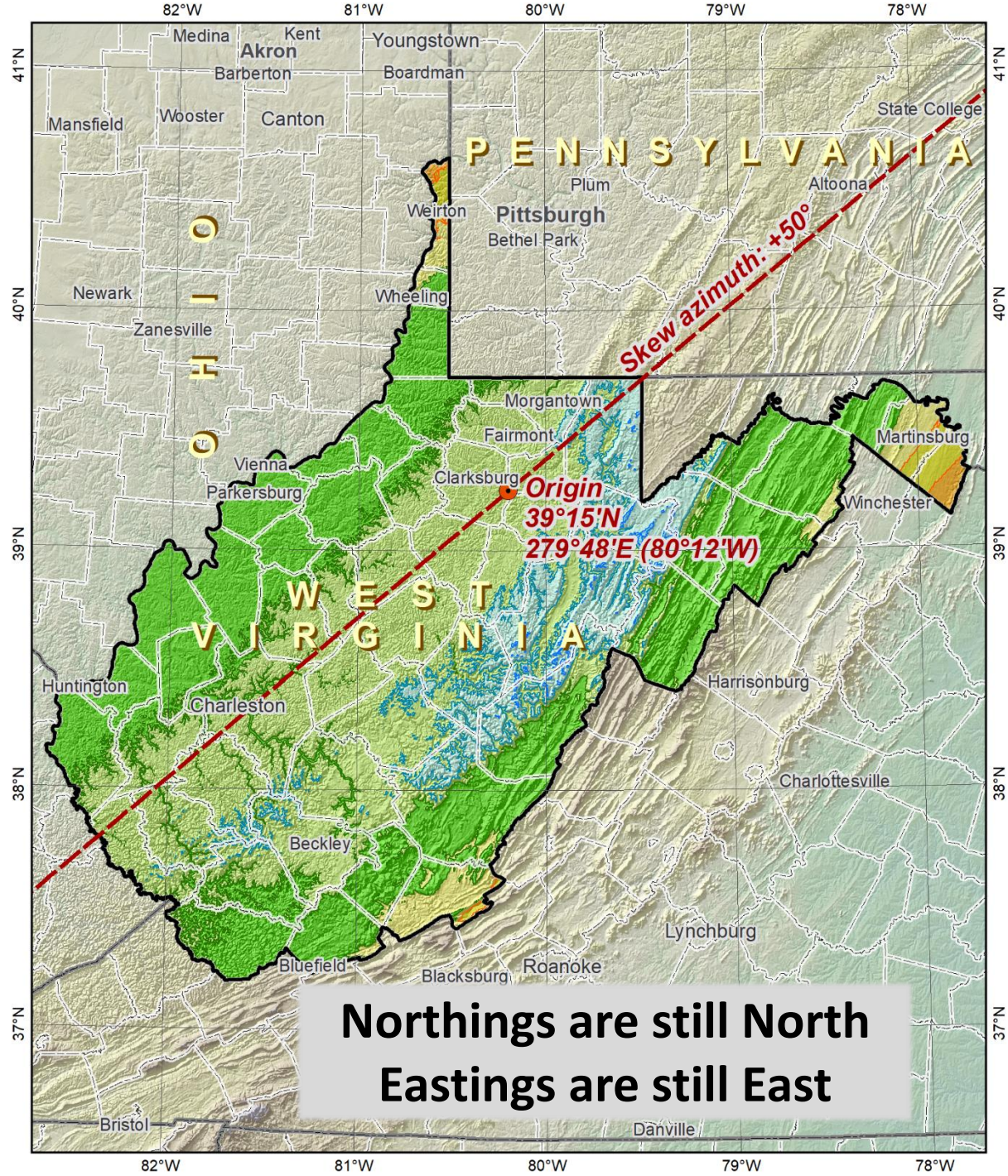
< -400	to -200	to +150
to -400	to -150	to +200
to -350	to -100	to +250
to -300	±50	to +300
to -250	to +100	> +300

0 50 100 150 200 km

Created 7/1/2020 (Michael Dennis)

Preliminary SPCS2022 statewide zone design: West Virginia

NOAA's National Geodetic Survey



Northings are still North
Eastings are still East

Oblique Mercator projection

North American Terrestrial Reference Frame of 2022

Origin latitude: 39° 15' N
Origin longitude: 279° 48' E
Skew axis azimuth: +50°
Skew axis scale: 0.999 98 (exact)

Areas within ±100 ppm distortion (1:10,000 = ±0.53 ft per mile):

91% of population
93% of all cities and towns
87% of entire zone area

Distortion values (ppm)

Entire zone:	***Cities and towns:***
Min, Max = -182, +196	Min = -134
Range = 377	Max = +185
Mean = -44	Range = 319
Weighted mean = -19	Mean = -27
(weighted by population)	

Linear distortion at topographic surface (parts per million)

< -400	to -200	to +150
to -400	to -150	to +200
to -350	to -100	to +250
to -300	±50	to +300
to -250	to +100	> +300

0 50 100 150 200 km

Created 7/1/2020 (Michael Dennis)

...or Feets Don't Fail Me Now

RIP
Paul
Barrere

The Issue at Hand…

- **Two versions of same unit in current use**
  - "New" international foot and "old" U.S. survey foot
  - Intl. shorter than US by 2 ppm (**0.01 ft per mile**)
- **What's in a name?**
  - "U.S. survey" versus "international"
- **Who is using U.S. survey feet?**
  - Surveyors exclusively
    - Derivative products are then

But this impacts everyone here.

What's impacted?

- **When does this matter?**
  - ***Not*** typically in lengths/distances
  - Published planar coordinate systems
    - Why? → large false eastings and northings
- **Like what?**
  - SPCS and UTM are very popular and ***both*** fall victim to mix-ups
    - due to… the large false E/N in their zones

2 parts per million (ppm)?

- 1,000,000.00 sft = 999,99**8**.00 ift
- 10,000,000.00 sft = 9,999,9**80**.00 ift
- 1,000.00 sft = 999.99**8** ift (can you measure that?)

- International → 1 ft = .3048 m
- US → 1 ft = .30480061 m (approx.)

Remember…

- What's the goal of NATRF2022?
  - Give you the **stability** in positions that you expect
- That's the point of Reference Epochs (REs)
  - Like the different realizations/versions of NAD83
  - REs will be published every 5 or 10 years
    - you choose when you update
    - in a perfect world, everyone would stay current

Preparing for NATRF2022

- Two factors will dictate your frequency of coordinate updates
  1) Your accuracy needs
  2) The region you work in → tectonic motion
     - Do manholes need cm-level updates annually?
     - We accommodate that… you choose
     - Just because we're chasing the millimeter… it doesn't mean you need to.

Preparing

- Know the epoch of your data/datasets
  - consider how you will track this
    - full to-the-second timestamp on every feature?
    - labeling a year for each dataset?
    - something in-between that works for your needs?

Preparing

- Reprocessing your data
  - in a perfect world, everyone would reprocess
    - what does this mean?
      - » consider a hydro-enforced DEM
        - start over with the raw flight data (GNSS/IMU)
        - generate new point clouds
        - recreate all the drainage features in new datum
    - ***unrealistic!*** … and unnecessary for majority users

Preparing

- Transforming your data
  - NCAT - NGS Coordinate Conversion and Transformation Tool
    - available now: ASCII upload, Web Services, GitHub
    - ask your software provider(s) about integration
      - » we envision this as most popular method of access
      - » Industry Workshop held May 2021
        - Esri, Trimble, Blue Marble, etc… all the well known names attended

National Geodetic Survey

Positioning America for the Future

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

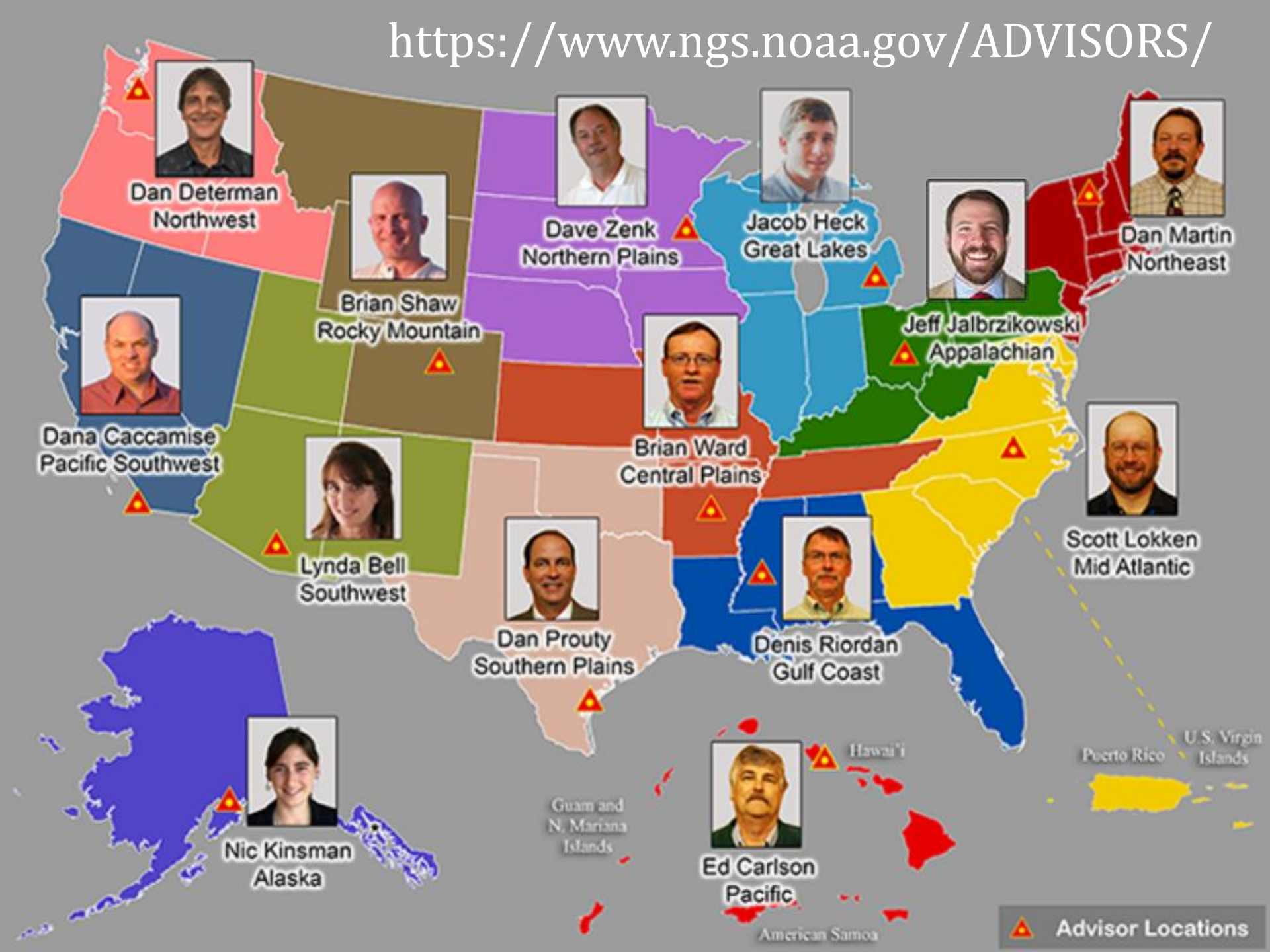
Learn more about GPS on Bench Marks

NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, and shoreline information impact a wide range of important activities.

- Process GPS Data (OPUS)
- NGS Data Explorer
- Looking for Bench Marks
- Conversion & Transformation (NCAT)
- NOAA CORS Network
- New Datums

NGS homepage: **geodesy.noaa.gov**

https://www.ngs.noaa.gov/ADVISORS/



https://www.ngs.noaa.gov/ADVISORS/

-use any major search engine: "NGS advisors"

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