Nevada Young Surveyors Network

March 2020 Meeting

Presentation on the new NGS Datum of 2022!

WHO is the NGS? What is a Datum?

Geodetic coordinate systems have been around for over the past 2 centuries and are defined by the **National Geodetic Survey (NGS)**. There have been many different realizations that have been released since the first realization in 1900 and more will continue to be released in the future.

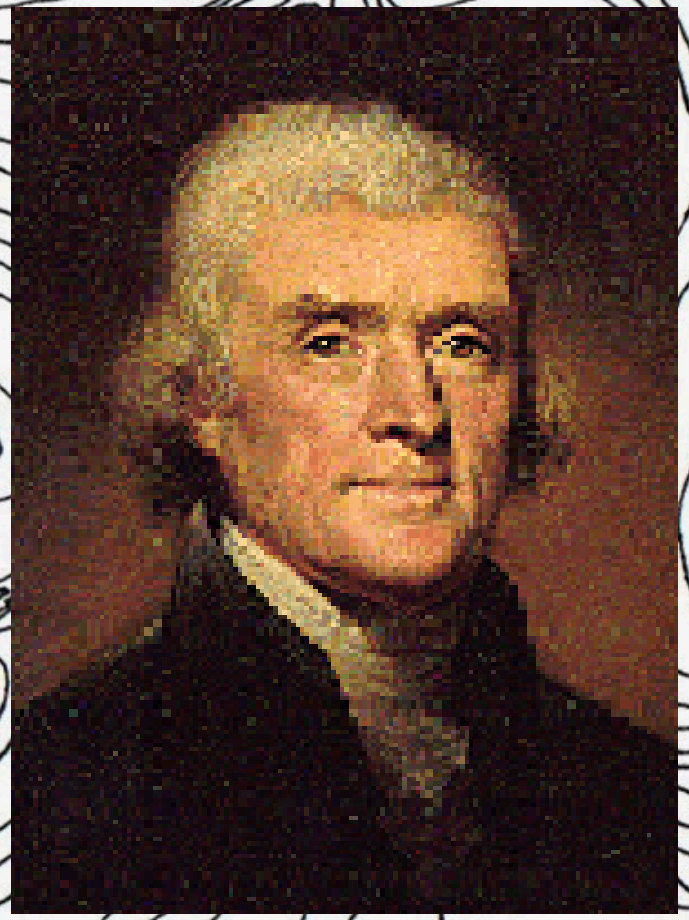
Each new realization of how to define the system is also known as a ***Datum or Reference Frame***. Our current reference system utilizes the *horizontal datum* of NAD 83 (2011) and the *vertical Datum* of NGVD 88.

NGS is currently working on a new realization that is expected to be released the year of 2022 and thus has been named
North American Geopotential Datum of 2022 (NAGPD 2022).

BUT WAIT!

First you get some fun facts…

Thomas Jefferson – President/Land Surveyor



- Thomas Jefferson's father, Peter Jefferson, worked as a surveyor and cartographer for most of his adult life.

- Thomas Jefferson was appointed to work as the Albermarle County surveyor in Virginia in 1773.

- He promoted surveying by sending Lewis & Clark on their expedition to explore the land gained through the Louisiana Purchase

-**Thomas Jefferson established the Survey of the Coast in 1807 (today knows as NOAA)**

NEVADA YSN

History of Vertical Datums

Mean Sea Level Datum 1900

United States Lake Survey 1903

*Mean Sea Level Datum 1929

United States Lake Survey 1935

International Great Lakes Datum 1955

*National Geodetic Vertical Datum 1929

**International Great Lakes Datum 1985

**North American Vertical Datum 1988

History of Vertical Datums

Early vertical datums were established for charting and hydrographic surveys of harbors

1856-1857 - The first leveling survey of Geodetic Quality in the U.S. was done by the U.S. Coast Survey. The leveling survey was required to support *river current and tide studies* in the Hudson River and New York harbor area, to assist maritime commerce.

1900 - the network of vertical control had over **21,000 km** of geodetic leveling. That year a reference surface was determined by holding elevations referenced to local mean sea level fixed at ***5 tide stations***.

THUS came about our first vertical datum: Mean Sea Level Datum of 1900

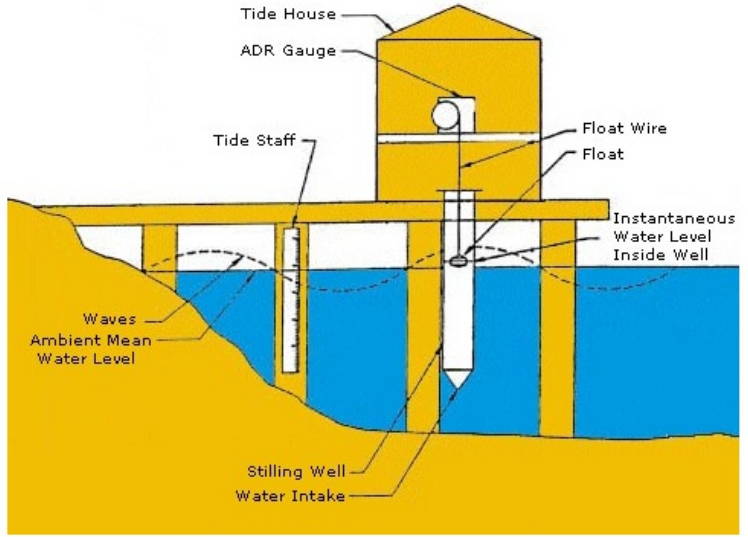
There were MULTIPLE adjustments to this network due to increased tidal observations

History of Vertical Datums
Mean Sea Level Datum of 1900

Adjustments to North American vertical datum based on increased tidal observations

Year of Adjustment	Kilometers of Leveling	Number of Tide Stations
1900	21,095	5
1903	31,789	8
1907	38,359	8
1912	46,468	9
1929	75,159 (U.S.)	21 (U.S.)
	31,565 (Canada)	5 (Canada)

Typical Tide Gauge Diagram



National Geodetic Vertical Datum of 1929 (NGVD 29)

Initially, it was the **Mean Sea Level Datum of 1929** following as the 5th adjustment released in that datum, however it was later renamed in 1973

It was renamed because it was **not** sea level or any other equipotential surface due to variations of *ocean currents, winds, barometric pressures and other physical causes.*

26 Tidal Stations were observed. 21 in the U.S. and 5 in Canada

HOWEVER, the need for a new datum was recognized. A datum based on tidal station observations was not sufficient.

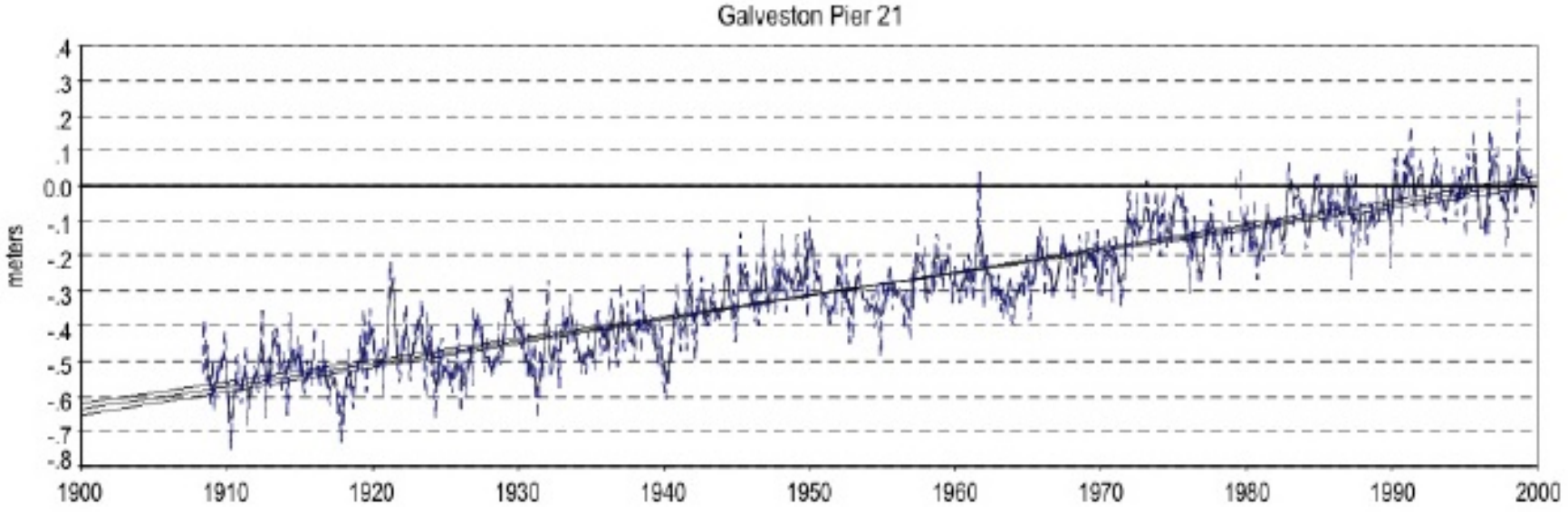
The Mean Sea Level is Changing! (increasing)

Gauge 8771450 - Galveston Pier 21

mean sea level trend is ~ + 6.5 mm – per year

(2.13 feet per century)

Mean Sea Level Data from 1908 to 1999



Mean Sea Level Trend – Galveston

Since the mean sea level is increasing every year, the shape of the geoid would continue to change with each new set of tidal observations.

North American Vertical Datum of 1988 (NAVD 88)

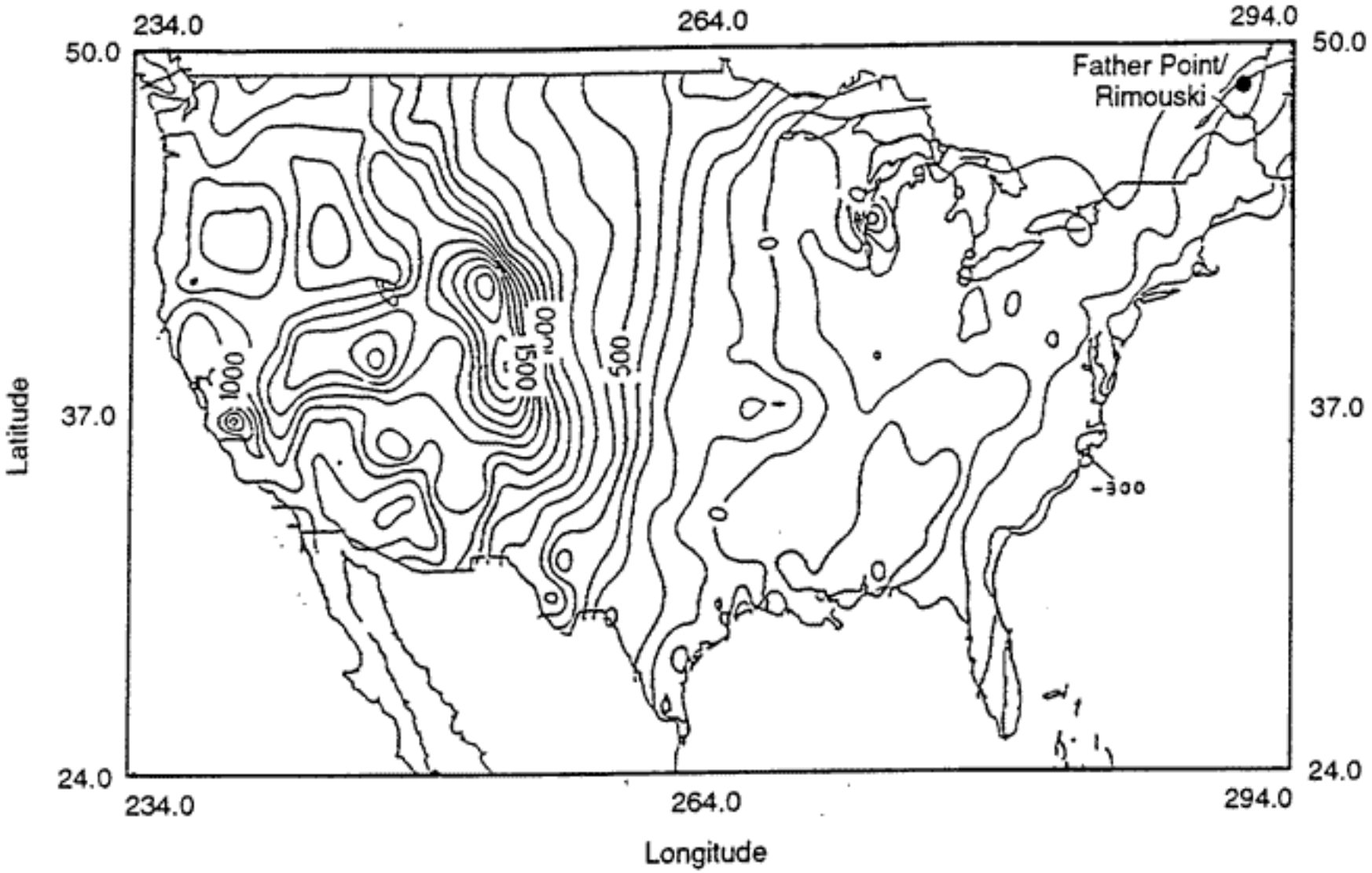
- NAVD 88 is based on ***mass*** or ***density*** of the Earth, instead of the varying values of mean sea level.

- Measurements were made at vertical control points to measure acceleration of gravity at each point.

- One tidal gauge, in Quebec Canada, which was named Father Point was held as a fixed point.

NGVD-29 to NAVD-88 Differences

- In the United States – differences in elevation range from – 0.40 m to + 1.50 m.
- In Alaska – differences in elevation range from + 0.94 m to + 2.40 m.
- In more stable areas of the United States – differences in elevation are less than 0.1 m.



Contour map depicts height differences between NGVD 88 and NAVD 88

THE NEW VERTICAL DATUM of 2022

North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

NAVD 88 is both biased (by about one-half meter) and tilted (about 1 meter coast to coast) relative to the best global geoid models available today

The Geoid is going to change due to a better way of modeling gravity!

North American-Pacific Geopotential Datum of 2022 (NAPGD2022)

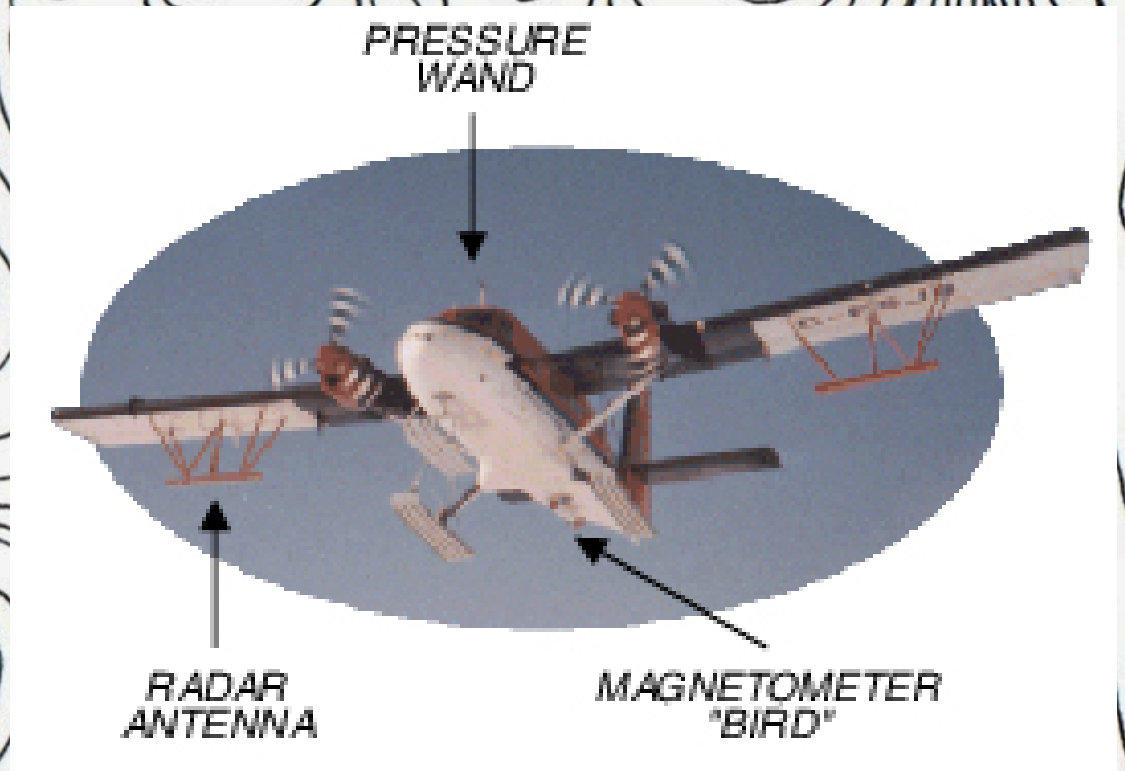
What GRAV-D means is creating a GNSS geoid utilizing a gravity-based model of the United States of America and our territories.

The areas being covered by GRAV-D include Puerto Rico, Hawaii, Guam, American Samoa, Alaska, and the continuous United States.

A gravity-based vertical datum with desired results to be accurate at the 2 cm level where possible for much of the country.

This is all thanks to:

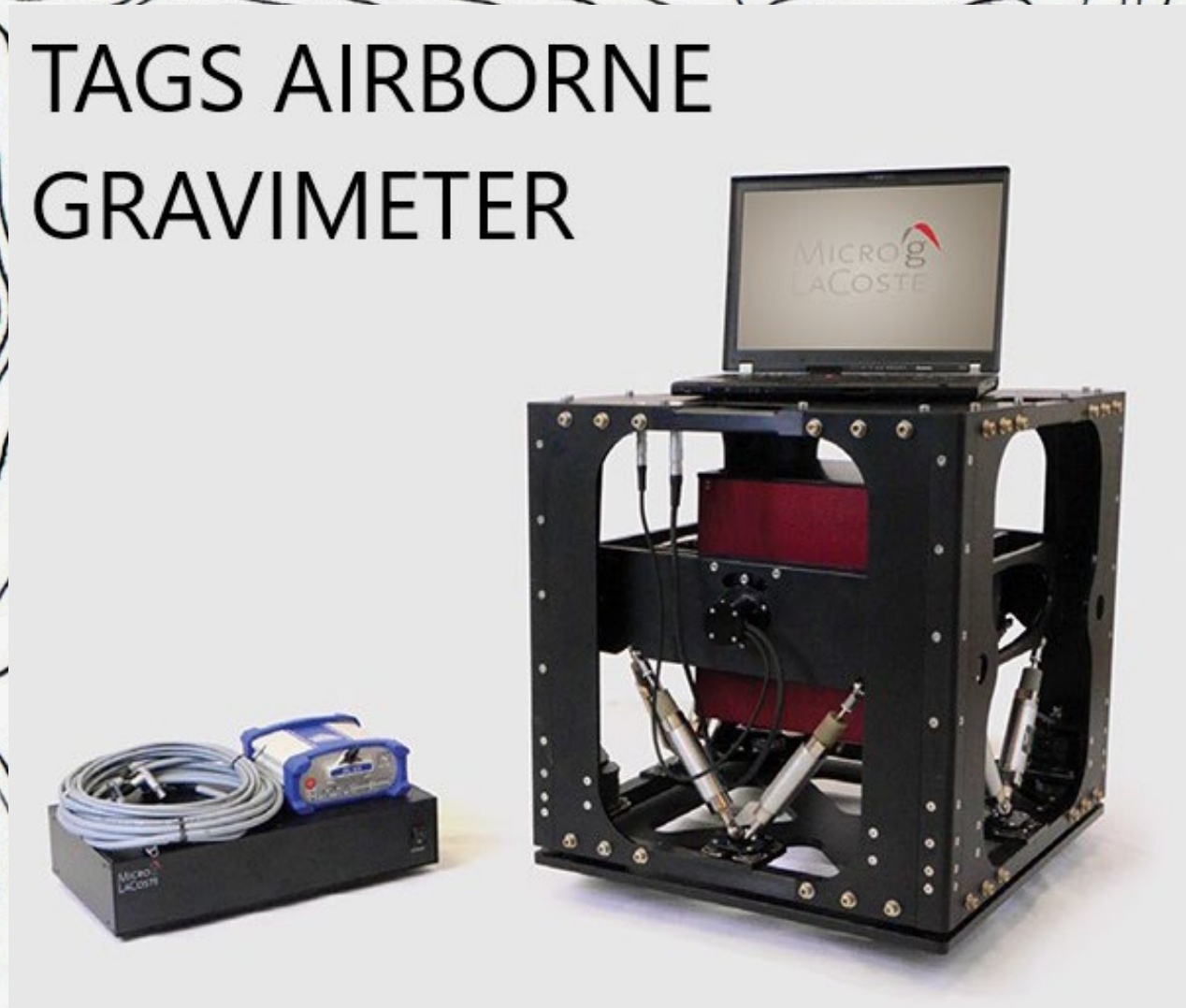
AIRBORNE GRAVIMETERS



This technology is used to define GRAV-D

The MGL TAGS-7 airborne gravity system is the instrument that will be utilized for parts of the aerial leg of the GRAV-D project.

TAGS stands for turnkey airborne gravity system



The History of the Horizontal Datum

- The first nationally adopted datum was the United States Standard Datum (USSD) and it was adopted in 1901 by the United States Coast and Geodetic Survey that would later become the National Geodetic Survey or NGS.

- This new datum was based on the Clarke Ellipsoid of 1866 and centered on the triangulation station called Meades Ranch (1891), which is in Kansas.

- USSD was a datum that was created using other regional datums that had started overlapping and the transcontinental arc that ran across the country along the 39th parallel.

North American Datum (NAD)

In 1913, Canada and Mexico agreed to base their triangulation networks on the U.S. Standard Datum. To reflect this broader coverage, the U.S. Standard Datum was re-named North American Datum.

North American Datum of 1927 (NAD 27)

Origin: (KG0640) MEADES RANCH **Ellipsoid:** Clarke 1866

The large triangulation arcs for the framework in the western part of the United States were completed in 1926. As the skeleton of the triangulation network was filled in, adjustments were disproportionally forcing large misclosures on shorter and shorter arcs. There was a need for a complete readjustment and it was an opportune time to do so.

North American Datum of 1983 (NAD 83)

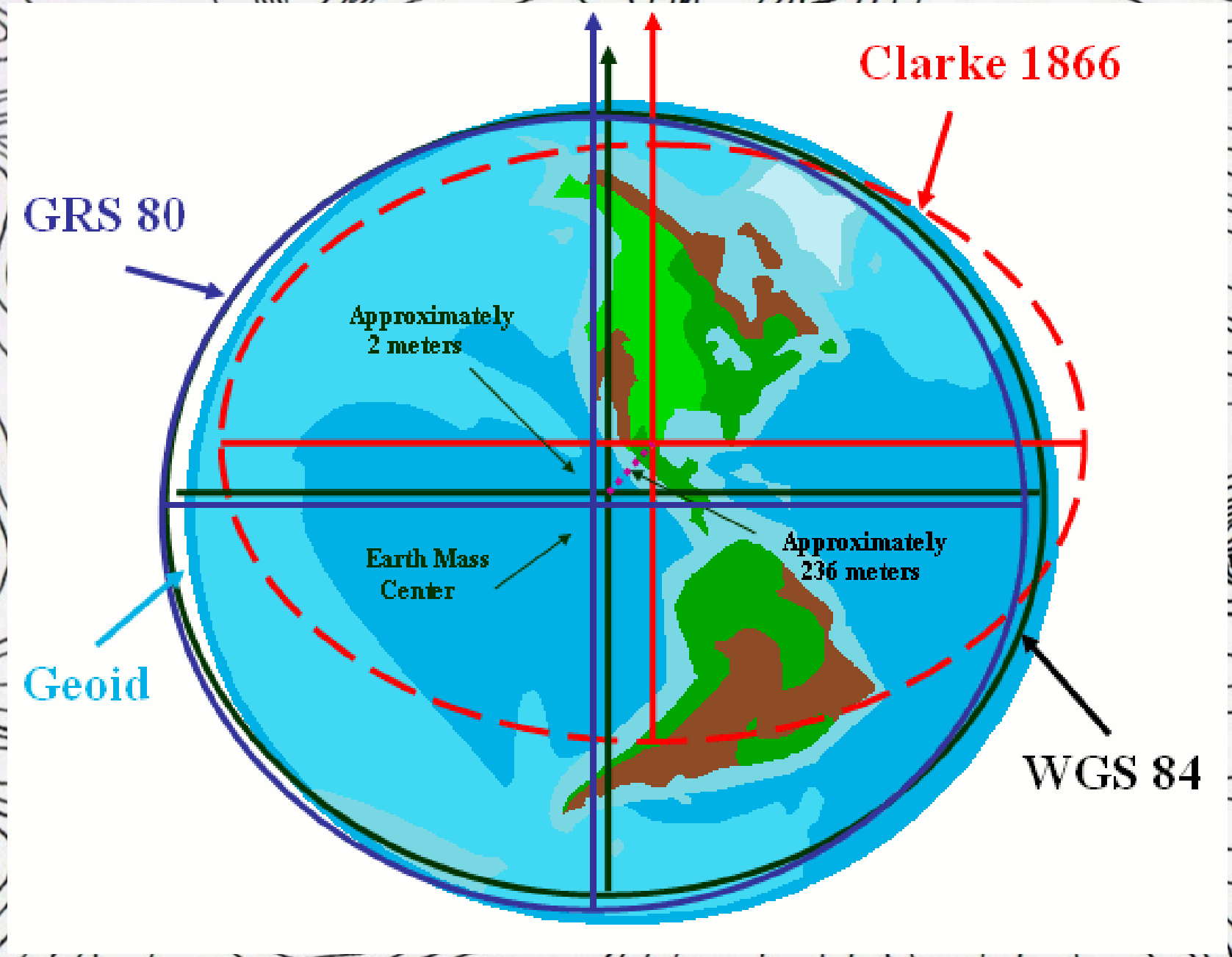
Origin: Earth centered (various) **Ellipsoid:** GRS80

NAD 83 is a Geocentric datum, which means that it is earth centered rather than centered on a monument, like Meades Ranch.

The North American Datum of 1983 (NAD 83) is the horizontal and geometric control datum for the United States, Canada, Mexico, and Central America. NAD 83 was released in 1986.

State-by-state adjustments were completed in the 1990s, an effort referred to as the High Accuracy Reference Network (HARN).

PROBLEM: The North American Plate is held Fixed



The ellipsoid needed adjusting. Just as it does now.

Current Vs. New Horizontal Reference Frames

The driving force to update the horizontal locations is because NAD 83 is non-geocentric by about 2.2 meters. There are expected shifts up to **3 meters** depending on the location.

Current reference frames NAD 83:

North American Datum of 1983 (2011)	North American Plate
North American Datum of 1983 (PA11)	Pacific Plate
North American Datum of 1983 (MA11)	Mariana Plate

New reference frames in 2022:

North American Terrestrial Reference Frame of 2022 (NATRF2022)	North American Plate
Pacific Terrestrial Reference Frame of 2022 (PATRF2022)	Pacific Plate
Caribbean Terrestrial Reference Frame of 2022 (CATRF2022)	Caribbean Plate
Mariana Terrestrial Reference Frame of 2022 (MATRF2022)	Mariana Plate

Current Vs. New Horizontal Reference Frames

- These new reference frames will be plate-independent and time-dependent.
- They will model the rotations that are occurring on each plate by applying three-parameter model around the specific plates' Euler pole.
- The Euler pole is specific to each plate and is really just a fancy term for the unique rotation axis that is defined in each plate rotation model.
- These 4 new reference frames are not restricted to the plate they are named after, but are global models. For any given location, one will now receive 4 different coordinates, each pertaining to their reference frame.

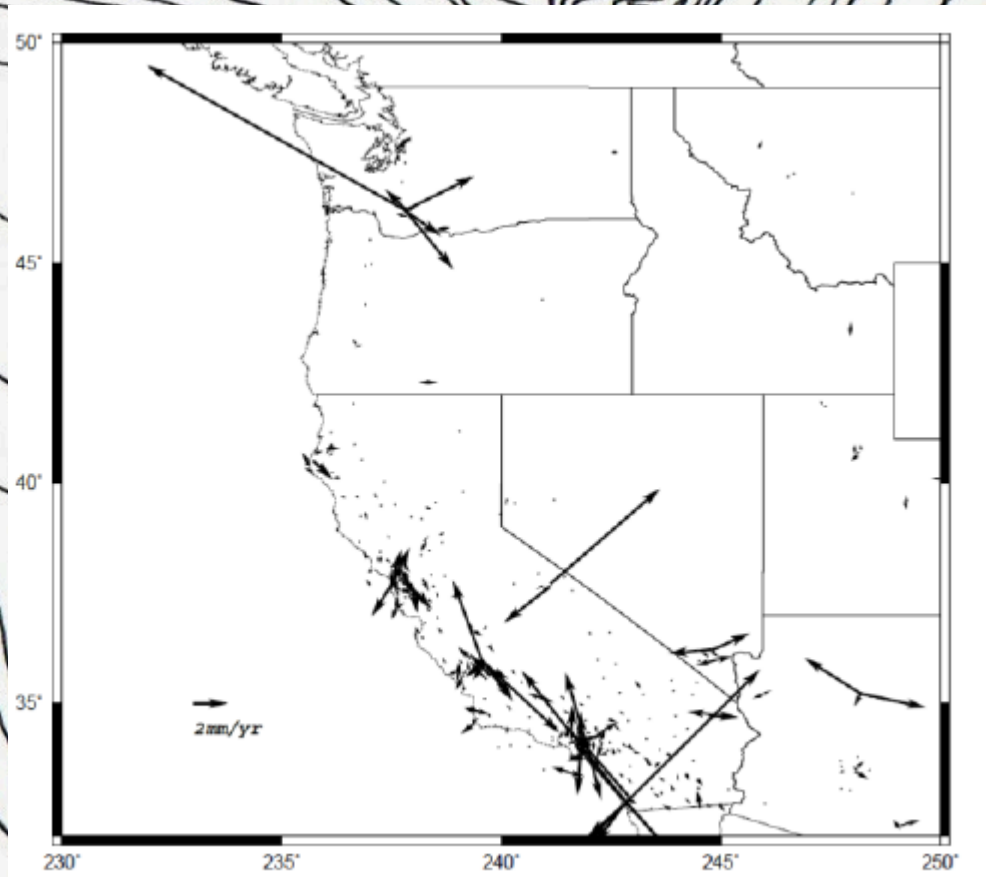
Intra-Frame Velocity Model (IFVM)

The intra-frame velocities will not be removed when NGS provides coordinates in the new reference frames. Instead, they will be provided as a separate service.

There is one IFVM for each reference frame that captures the motion at any location.

It is a global frame but should only be used in North America. It includes vertical motions that are occurring anywhere (GRAV-D data).

It also includes horizontal motions from residual motion (it does not encompass the 3-parameter Euler pole plate rotation; the reference frames cover that)



Residual intra-frame horizontal velocities (tectonic plate rotation removed, followed by a removal of gridded intra-frame CORS-based horizontal velocities)

Intra-Frame Velocity Model (IFVM)

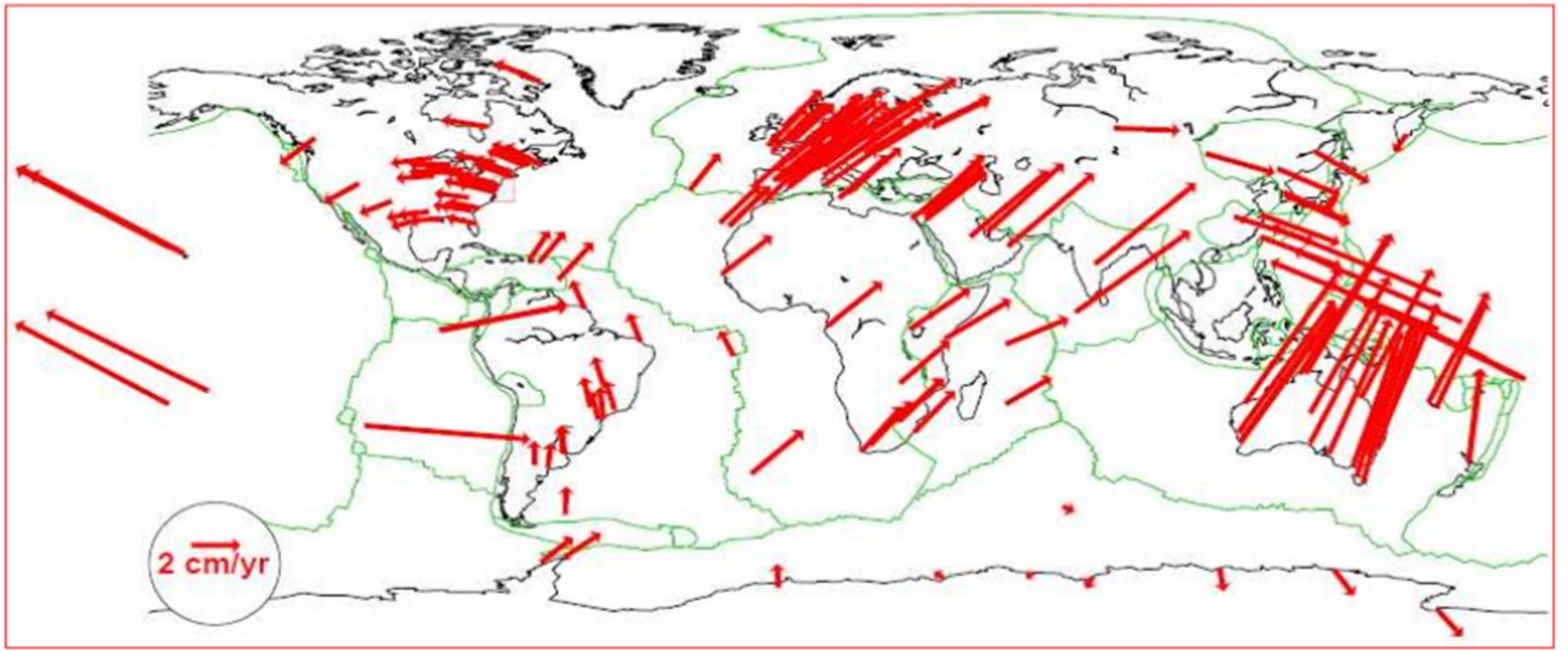


Figure 1. Horizontal velocities of the 203 selected sites for the ITRF2008 PMM estimation

Thank you

Great Basin College will be competing at the NSPS Student Competition at the end of this month. **Wish them luck!**

Nick Montoya

Sarah Walker

Brett Clarke

Cole Hamlin