NADCON 5.0: your tool for easy, consistent coordinate transformations

A Bilich, DA Smith (dru.smith@noaa.gov)
NOAA / National Geodetic Survey

G21B-0999
2016 AGU Fall Meeting

What is NADCON 5.0?

This tool is used to shift coordinates for map-grade transformations, allowing users to move between different datums.

NADCON (for North American Datum CONversion program) is a grid-based tool that transforms latitude, longitude and ellipsoid heights between datums in the United States and its territories.

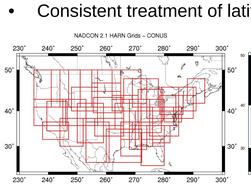
NADCON 5.0 is a brand-new addition to the National Geodetic Survey's Geodetic Toolkit. It replaces all previous versions of GEOCON and NADCON as the official transformation tool for NGS.

Motivation

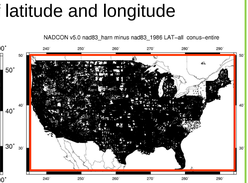
Create a fresh approach, learning from legacy tools and products, while preparing for 2022 datum update.

Consistent approach

- Do not jump over transformations
- Use regional approach (no state-by-state grids)
- Apply a uniform approach to data selection and transformation generation
- Correct naming errors
- Consistent treatment of latitude and longitude



NADCON 2.1 used multiple independent, overlapping state-by-state grids for the HARNs



NADCON 5.0 uses one grid, combining all HARNs

Better documentation

- Extensive master report: history, motivation, approach, how to generate transformation grids, data analysis, comparison to previous transformations
- All decision points are made transparent
- All products (files, plots, software) available in digital archive

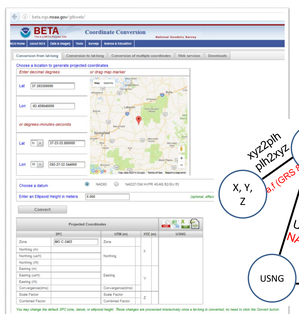
Improved accessibility = web service

Approach for NADCON 5.0

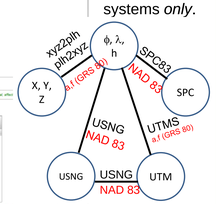
- Fresh pull of data from NGS Integrated Database (IDB)
- Define "supported realizations" of various datums
- Skip no realizations
- Build a completely new suite of analysis tools
- Rigorous outlier removal
- Generate new grids from scratch
- Provide local error estimates

NADCON 5.0 in the Geodetic Toolkit

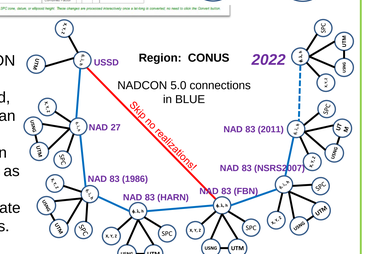
NADCON 5.0 will be available for community testing and use in Feburary 2017:
http://beta.ngs.noaa.gov/gtkweb/



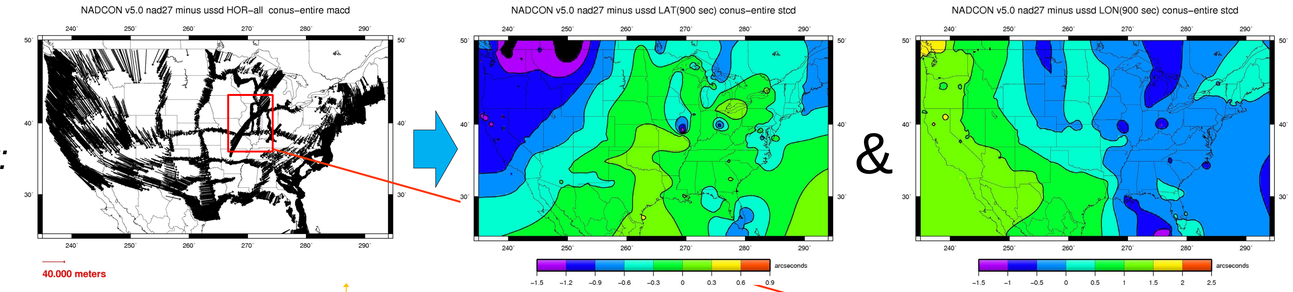
Currently the Toolkit helps users move between coordinate systems *only*.



With NADCON 5.0 included, users can move between datums as well as coordinate systems.



Case Study:



USSD to NAD27

The transformation from the US Standard Datum (USSD) to the North American Datum of 1927 (NAD 27) is a horizontal-only transformation centered around Meades Ranch, Kansas. There are 24,000 possible points available for the transformation, with a tri-modal distribution of magnitudes (11, 18, and 43 meters).

(1) Pull data from IDB

NADCON 5.0 uses only data contained in IDB. Coordinate latitude, longitude, and ellipsoidal height (if available) are the fundamental data going into the process.

US Standard Datum			NAD 27	
AA9371 TX 453 N301622.34000 W0974420.01000	N/A	N301622.45000 W0974419.16000	N/A
AA9372 TX 453 N301626.15000 W0974420.01000	N/A	N301626.24000 W0974419.16000	N/A
AB0076 TX 061 N255754.23000 W0971201.91000	N/A	N255754.37580 W0971200.95657	N/A
AB0225 TX 061 N260619.42900 W0971915.79500	N/A	N260619.57300 W0971914.85300	N/A
AB0289 TX 061 N260845.57000 W0972809.47200	N/A	N260845.77867 W0972808.60964	N/A
AB0338 TX 061 N260341.34400 W0971609.71700	N/A	N260341.48900 W0971608.77400	N/A
AB0917 TX 215 N260507.70300 W0975157.70400	N/A	N260507.83900 W0975156.76000	N/A
AB0992 TX 261 N263645.56300 W0974517.08600	N/A	N263645.69300 W0974516.14900	N/A
AB1366 TX 061 N255728.87000 W0971516.23000	N/A	N255729.02000 W0971515.29000	N/A

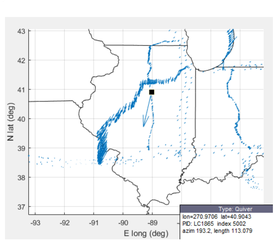
(2) Form coordinate differences

Forming the coordinate difference (new datum minus old datum) creates a vector which can be plotted on maps for analysis.

(3) Outlier removal

Omit points which are so far outside the norm that any good surveyor would have rejected these points.

Outliers are rare: for the horizontal transformations in NADCON 5.0, only 5751 out of 693,582 total points (< 1%) were identified as outliers.



(4) Thin the data

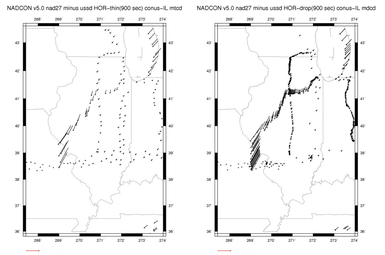
The transformation is most robust if a representative sub-set of data is used to build it.

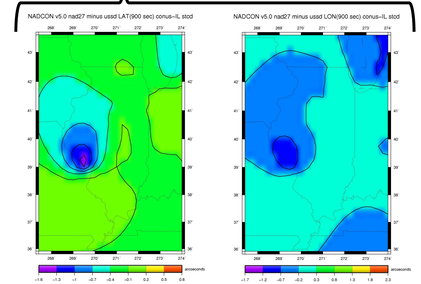
We use a median filter to separate data into thinned and dropped datasets. The thinned data are the representative median out of a group of vectors, and are used to form the transformation; the dropped data are retained for forming error estimates.

Implicit to thinning is that points must be grouped together, so that only one point can be "thinned" from the group. To do this, we must overlay a uniform grid of a certain size for each transformation vector field.

The selection of grid size involved heavy analysis. On the whole, we selected the coarsest grid which explained the data while also creating small residuals, without oversampling or undersampling any local details. Each transformation in NADCON 5.0 has a unique grid size between 1 and 30 arcminutes.

Thinned data | Dropped data





(5) Grid the data

The **transformation** is created by fitting a surface under tension to the thinned data. Separate surfaces are applied to latitude, longitude, and ellipsoidal height data.

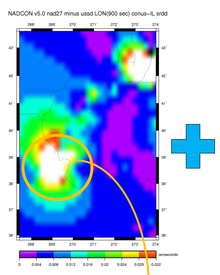
NADCON 5.0 uses the Generic Mapping Tools *surface* routine to generate the transformation. Experience shows that tension = 0.4 is a good value for coordinate differences; this value was used in GEOCON, and is used in NACON 5.0 as well.

(6) Error estimates

Local **error estimates** are available for any point in the region. Error estimates are the RMS sum of two grids: data noise and method noise.

Data noise: how messy are the vectors?

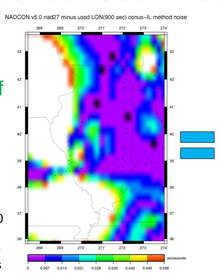
1) Residuals of all data (transformation with tension=0.4, minus original coordinate differences)
2) In each cell, take RMS of residuals
3) Pull *surface* with tension=0.9 to the RMS values.



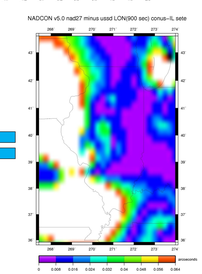
Data noise is large where two conflicting vector sets come together (large RMS).

Method noise: what is the effect of GMT *surface*?

1. Fit thinned data with two surface tensions: 0.0 (minimum curvature) and 1.0 (harmonic).
2. Summarize range of possible values as 0.6*(surface$_{0.0}$ – surface$_{1.0}$)
3. Expresses the error from data gaps



Method noise is small in areas with data, and large where there are no data.



Error:

$$\sqrt{\text{dataNoise}^2 + \text{methodNoise}^2}$$