

NGS Updates

MSPS Surveyors' Conference

Dave Zenk

NGS Advisor

February 21, 2014

NGS Activities

- OPUS
- GRAV-D
- Geoid Slope Validation Survey in Iowa
- MN Level Network Remediation

OPUS SUITE

- OPUS Suite has several services
 - OPUS STATIC (OPUS-S)
 - OPUS RAPID STATIC (OPUS-RS)
 - OPUS DATABASE (OPUS-DB)
 - OPUS PROJECTS (OPUS-P)

OPUS STATIC

- 2 hours to 48 hours occupation time, dual frequency receiver.
- Choose OPTIONS to control some aspects of how OPUS will compute your solution

OPUS STATIC

- OPUS Submission Page

OPUS: Online Positioning User Service
National Geodetic Survey

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

Tuesday* maintenance planned
OPUS will be unavailable Tuesday 07 January for server reconfiguration. Downtime *may* extend for multiple days.

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

Step 1 ← No file selected.
* **data file** of dual-frequency GPS observations. [sample](#)

Step 2 ← no antenna selected
antenna type - choosing wrong may degrade your accuracy.

Step 3 ← meters above your mark.
antenna height of your antenna's reference point.

Step 4 ←
* **email address** - your solution will be sent here.

Step 5 ← to **customize** your solution.

for data > 15 min. < 2 hrs. for data > 2 hrs. < 48 hrs.

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


OPUS Menu
Upload
about OPUS
Projects
Published Solutions
Contact OPUS

sample solutions

OPUS STATIC

- Click OPTIONS (Step 5) to expand choices

Options to customize your solution.

| | | | |
|----------------------------|--|--|--|
| formats | <input type="text" value="standard"/> | | format details |
| base stations | Use: <input type="text"/> | Exclude: <input type="text"/> | type in 4-char site IDs, or select from map, any CORS you wish to explicitly include or exclude from your solution sample |
| | | Look up site IDs  | <i>NOTE: the automated selection of base stations has recently improved; this option should now be used only sparingly</i> |
| state plane | <input type="text" value="let OPUS choose"/> | | override your native SPCS zone |
| project identifier | <input type="text"/> | | |
| my profile | <input type="text"/> | | |
| publish my solution | <input type="text" value="No, don't publish"/> | | |

Upload to Rapid-Static for data > 15 min. < 2 hrs. **Upload to Static** for data > 2 hrs. < 48 hrs

OPUS STATIC

- Click **UPLOAD** to **STATIC**
- You will receive your solution by email in about 5 minutes.
- Solution is the average of 3 baselines to nearby CORS stations.
- Single Occupation – no check.
- Multiple Occupations - each computed as standalone – you must compare them.

OPUS RAPID STATIC

- 15 minutes to 2 hours of dual frequency data
- Like OPUS STATIC, you submit the file via the OPUS Submission Page.
- Click OPTIONS to expand choices
- Click UPLOAD to RAPID STATIC
- You will receive your solution by email in about 10 minutes.
- Solution is the least squares adjustment (not simple average) of baselines to up to 9 nearby CORS stations
- Single and/or Multiple Occupations – you compare.

OPUS DATABASE

- OPUS-DB is a service that allows users to voluntarily “*share*” their OPUS solution with the public.
- Service is open to all – no special training.
- Requires a single 4 hour occupation, a mark description, and 2 photographs.
- Gateway is via OPUS Submission page
 - <http://www.ngs.noaa.gov/OPUS/>

OPUS DATABASE

The screenshot shows the OPUS: Online Positioning User Service interface. At the top, there is a navigation bar with links for NGS Home, About NGS, Data & Imagery, Tools, Surveys, and Science & Education. A yellow banner at the top left contains a warning: "Tuesday* maintenance planned. OPUS will be unavailable Tuesday 07 January for server reconfiguration. Downtime may extend for multiple days." Below this, the "Upload your data file." section includes a "Browse..." button, a "data file" field, and a dropdown menu for "antenna type" set to "NCRZ". There is also a "meters above your mark" field and an "email address" field. A red circle highlights the "Options" button. Below the "Options" button, there are sections for "formats" (with a dropdown set to "standard"), "base stations" (with "Use:" and "Exclude:" columns), "state plane" (with a dropdown set to "let OPUS choose"), "project identifier", "my profile", and "publish my solution" (with a dropdown menu). At the bottom, there are two buttons: "Upload to Rapid-Static" and "Upload to Static".

Under OPTIONS
just say: "YES, publish"

This close-up shows the "publish my solution" dropdown menu with three options: "No, don't publish", "No, don't publish", and "Yes, publish". The "Yes, publish" option is highlighted in blue. Below the dropdown are two buttons: "Upload to Rapid-Static" and "Upload to Static".

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

OPUS DATABASE

- Once you say YES and submit, you will receive an email that asks you whether you want to share and, if so, to approve the solution shown.
- After you agree to share and you approve the solution – NGS personnel will review the solution for any obvious problems and allow it for inclusion in OPUS-DB.
- Note that your name and organization will be shared for others to contact you for more information

OPUS DATABASE

- Reasons to *SHARE* your solution:
 - Some agencies require you to do so (by contract)
 - Encourages use of shared control marks by fellow surveyors
 - NGS will use the ellipsoid height to improve future geoid models (GPS on BM)

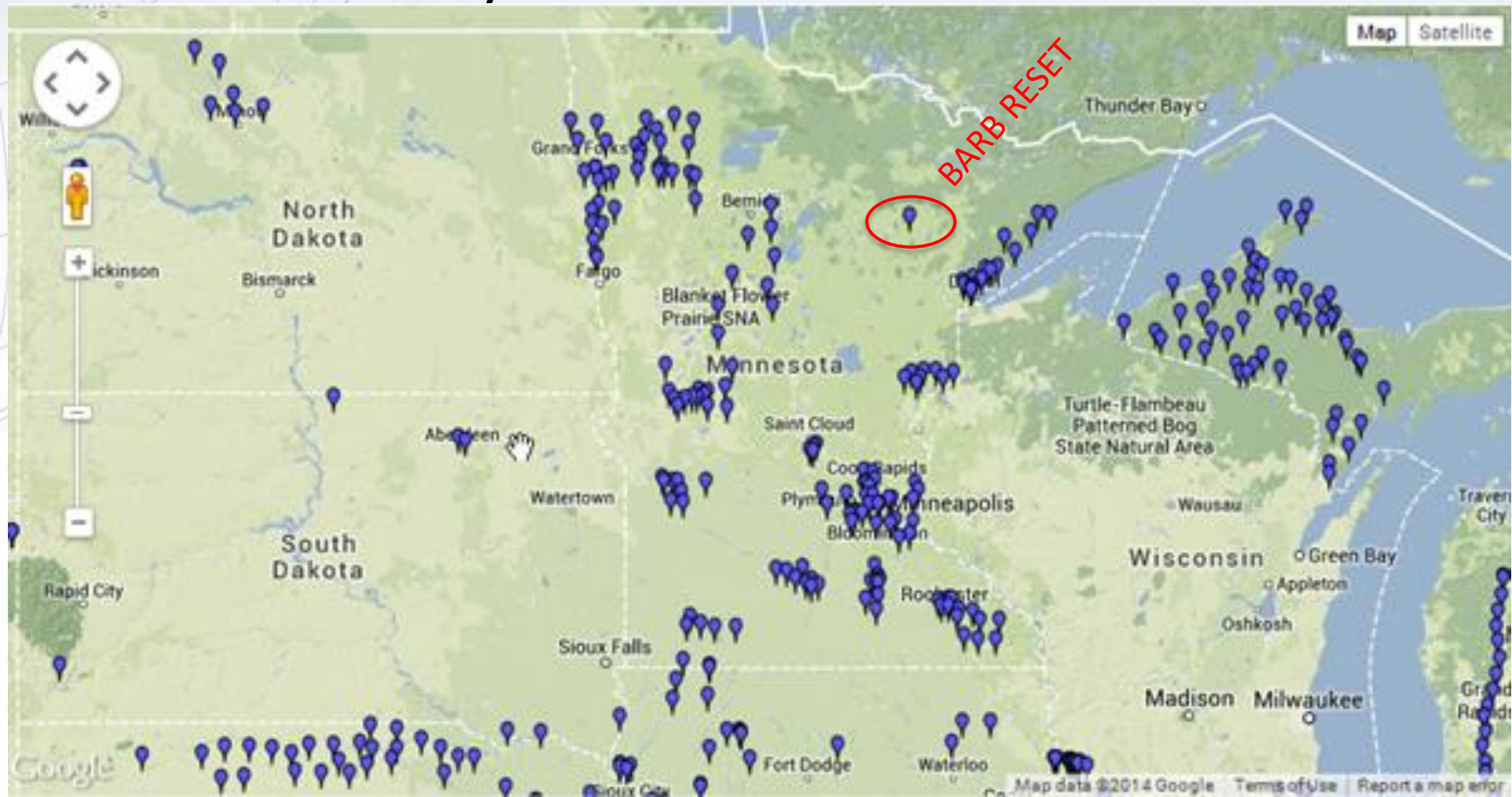
OPUS DATABASE

- Regional Activity



OPUS DATABASE

- Local Activity



OPUS DATABASE

- Sample **shared mark solution** for BARB RESET

SURVEY DATASHEET (Version 1.0)

PID: DL3192
Designation: BARB RESET
Stamping: BARB 1990 RESET 2007
Stability: Monument will probably hold position well
Setting: Aluminum alloy rod without sleeve (10FT+ or 3.048M+)
Mark Condition: G
Description: 5 MILES EAST OF HIBBING, AT TRUNK HIGHWAY 37 MILEPOINT 4.7, 3.85 MILES EAST ALONG TRUNK HIGHWAY 37 FROM JUNCTION OF TRUNK HIGHWAY 37 AND TRUNK HIGHWAY 169, 135.4 FEET SOUTH OF TRUNK HIGHWAY 37, 25.0 FEET WEST OF AIRFIELD ENTRANCE, 28.2 FEET EAST NORTHEAST OF FENCE CORNER, 46.8 FEET SOUTH OF FIRE HYDRANT
Observed: 2007-07-19T10:58:00Z [See Also 2009-06-30](#) [See Also Original](#)
Source: OPUS - page 1209.04



Close-up View

| REF_FRAME | EPOCH | SOURCE | UNITS | SET PROFILE | DETAILS |
|---|-----------|---|-------|-------------|---------|
| NAD_83(2011) | 2010.0000 | NAVD88 (Computed using GEOID12A) | m | | |
| LAT: 47° 23' 38.16889" ± 0.008 m ELL HT: 382.398 ± 0.019 m X: -214809.798 ± 0.001 m Y: -4320477.240 ± 0.019 m Z: 4671804.483 ± 0.008 m ORTHO HT: 412.450 ± 0.033 m | | UTM 15 SPC 2201(MN N) NORTHING: 5248953.723m 199413.261m EASTING: 511595.578m 819148.406m CONVERGENCE: 0.11309418° 0.18801414° POINT SCALE: 0.99960165 0.99993233 COMBINED FACTOR: 0.99954174 0.99987240 | | | |

CONTRIBUTED BY

[dave.zenk](#)
 Minnesota Department of Transportation



Horizon View



The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.

OPUS DATABASE

- Note that sharing a solution via OPUS-DB is **not** a datasheet but a **shared mark solution**. As such, NGS will adopt the use of the following definitions:
 - **Share**: The act of a user releasing to NGS the observations (via OPUS or OPUS Projects), metadata and results of geodetic surveys tied to the NSRS for public dissemination.
 - **Publish**: The action of NGS providing to the public, the official, National Spatial Reference System (NSRS) time-dependent geodetic coordinates set on a mark.
 - **Submit**: The act of a user releasing to NGS the observations, metadata and results of geodetic surveys tied to the NSRS for the express purpose of the NGS evaluating the survey and publishing if appropriate.
 - **Datasheet**: A report containing the published NSRS time dependent coordinates on a mark, as well as subsidiary information and metadata such as superseded coordinates, descriptions and recovery history of the mark.

OPUS PROJECTS

- OPUS PROJECTS is a newly operational service that extends the OPUS suite in a powerful new way.
- OPUS-P allows trained users to submit multiple data files on multiple marks in a project.
- OPUS-P assigns each file to a session based on logical methods.
- User makes decisions on how to process each session, how to adjust the project, and whether to Bluebook the results.
- All web-based, nothing to install.



OPUS Projects - Manage "New Ulm Airport PACS and SACS"

National Geodetic Survey

- NGS Home
- About NGS
- Data & Imagery
- Tools
- Surveys
- Science & Education

 Search

OPUS Projects was made operational on Wednesday, January 8.
 On Wednesday afternoon, January 8, OPUS Projects was made operational. Although it should appear virtually unchanged, several significant changes occurred internally. Please notify us of any issues. Thank you for your patience. **OPUS-Projects Team**, (2014-01-09)

Results From **network-PACS**

Controls

Preferences

Project List

Design

Serfil

Solutions

Show File

Send Email

Get up Adjustment

Review and Publish

Delete Project

LEGEND

MARKS: ● meet preferences ● do not meet preferences ● are not included ● have error

CORS: ● meet preferences ● do not meet preferences ● are not included

Baselines: —

MARKS

- bm02
- cbn1
- e115
- ulma
- ulmb
- ulmc

Add MARKS

CORS

- mnbe
- mnhw
- mnjf
- mnlc
- mnik
- mnls

Add CORS

| MARKS | Sessions & Solutions | | | | | | | MARKS |
|-------|----------------------|----------|----------|----------|---------|---------|---------|-------|
| | 2013-121 | 2013-122 | 2013-122 | 2013-122 | network | network | network | |
| | A | A | B | C | PACS | SACS | final | |
| bm02 | ⊗ | ⊗ | | | ● | | ⊗ | bm02 |
| cbn1 | ⊗ | ⊗ | | | ● | | ⊗ | cbn1 |
| e115 | ⊗ | ⊗ | | | ● | | ⊗ | e115 |
| ulma | ⊗ | ⊗ | ⊗ | ⊗ | ● | ⊗ | ⊗ | ulma |
| ulmb | | | ⊗ | ⊗ | | ⊗ | ⊗ | ulmb |
| ulmc | | | ⊗ | ⊗ | | ⊗ | ⊗ | ulmc |

6 marks, 4 sessions
 2 occupations per mark

OPUS PROJECTS

- OPUS-P advantages:
 - Field crew can submit RINEX data at end of day via OPUS interface.
 - Project Manager can see data and watch progress via web login.
 - Party Chief can process daily sessions to determine if re-observations are needed.
 - OPUS-P produces Bluebook (B and G) files for optional Bluebook submissions.

OPUS PROJECTS

- OPUS-P advantages:
 - Provides independent solution to compare to your existing software.
 - Solutions and adjustments are true least squares analysis.
 - Highly automated handling of CORS data.

OPUS PROJECTS

- OPUS-P requires training to become authorized user.
 - Local Advisor can deliver training.
 - Check NGS Corbin Training Center for schedule or call Advisor.
 - In-person, 2 days, includes time to practice.
- I will offer OPUS-P training several times this year.

GRAV-D

- NGS has embarked on a long-term project to measure the Earth's gravity field over all 50 states, the Great Lakes, and nearby oceans to produce a GEOID that is accurate to 2 cm.
- This GEOID will allow NGS to define an orthometric height system based on gravity and fully compatible with GPS.



GRAV-D

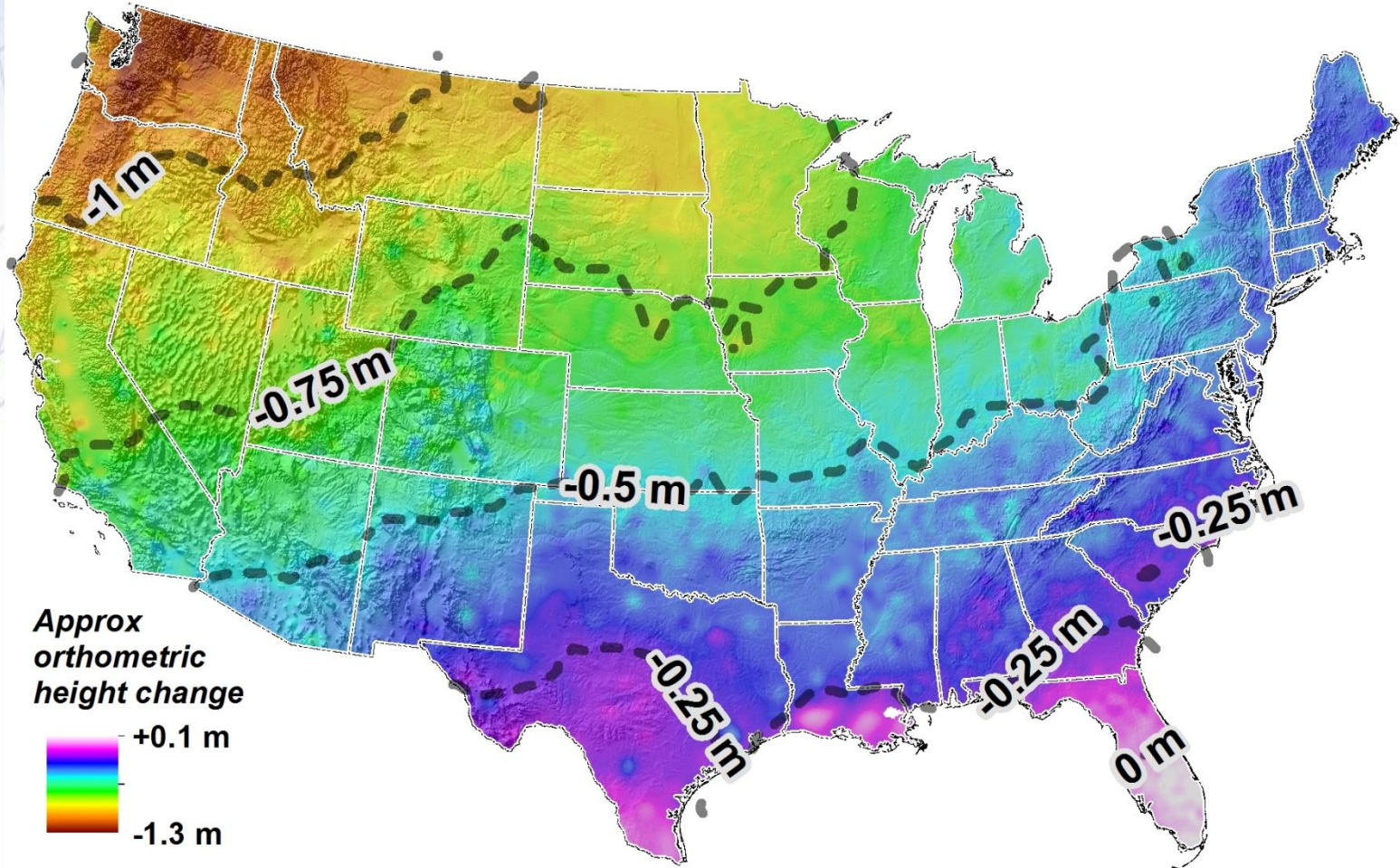
- Current GEOID models are hybrid models and depend on leveling results as well as gravity.
- Errors in leveling and assumptions made in NAVD88 have been proven to yield an orthometric height system that does not agree with known gravity field of the Earth.
- Water still runs downhill of course, but there are at least 2 problems from a national perspective.

GRAV-D

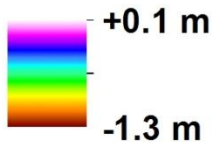
- 1) Heights in the CONUS cannot be compared to heights on islands (Hawaii, Puerto Rico, etc)
 - Islands all have their own datums!
- 2) There is about 1 meter of height discrepancy when comparing NAVD88 heights to what the gravity field alone would indicate.

GRAV-D

Approximate predicted change from NAVD 88 to new vertical datum



Approx
orthometric
height change



Predicted change estimated as NAVD 88 "zero" (datum) surface
minus most recent NGS gravimetric geoid (USGG2009)

GRAV-D

- NGS has flown data gathering missions over the Gulf Coast, Alaska, Great Lakes (includes MN and WI).
- Operations will continue over coastal zones, then over the interior of the USA.
- Expect to take several more years.
 - Only 1 airborne gravity meter available.
- New GEOID model will coincide with new 3D North American Datum in (fill-in date here).

GRAV-D

- Complete information about GRAV-D can be found at:
 - <http://www.ngs.noaa.gov/GRAV-D/index.shtml>
 - http://www.ngs.noaa.gov/GRAV-D/pubs/GRAV-D_v2007_12_19.pdf



GRAV-D

- Basically GRAV-D measures gravity all over the USA (and globally) in order to solve the following equation which will yield the GEOID separations:

$$N(\phi_0, \lambda_0) = \int_{\phi=-90}^{+90} \int_{\lambda=0}^{360} \Delta g(\phi, \lambda) S(\phi, \lambda, \phi_0, \lambda_0) \cos \phi d\phi d\lambda$$

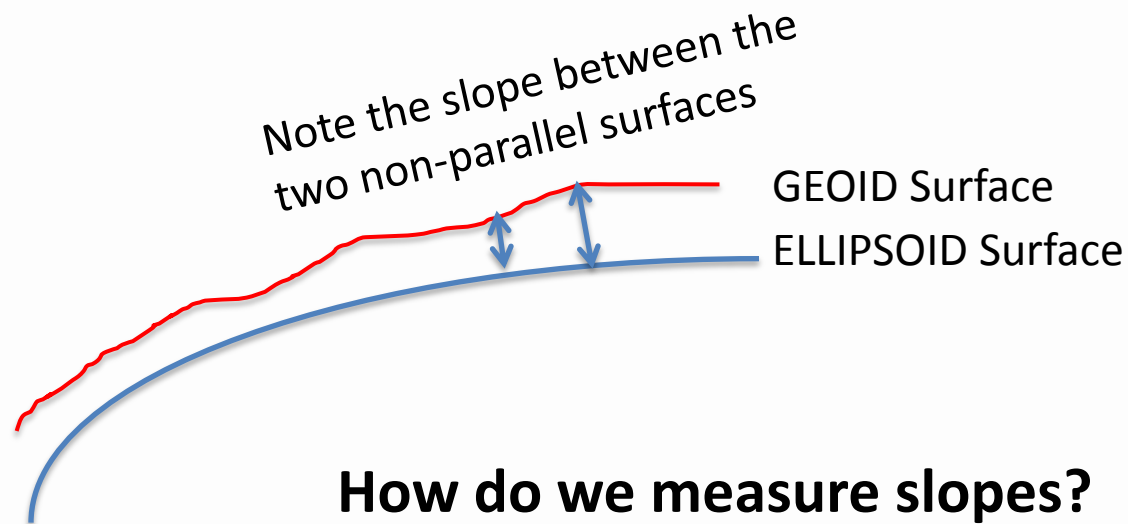
- Needless to say, one must **validate** the correctness of the GEOID separations.
- But how?

GRAV-D

- In order to validate the results of the project, NGS is embarked on a series of Geoid Slope Validation Surveys (GSVS)
 - 1 in Texas (GSVS11)
 - 1 in Iowa (GSVS14)
 - 1 in a mountainous region to be named later.

GSVS14

- Geoid Slope Validation Survey
- Iowa along US 30 from Sioux City to Cedar Falls
- What does it validate?

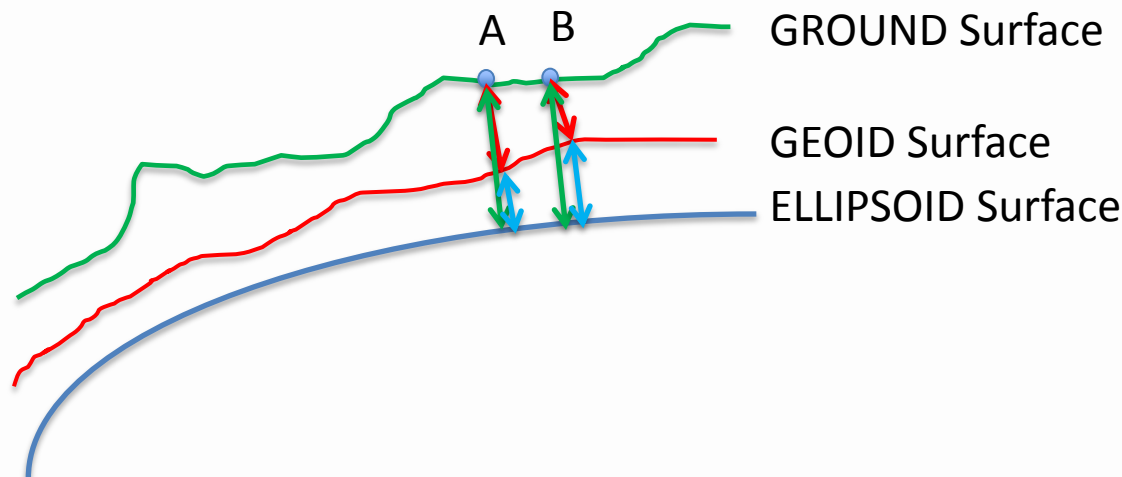


GSVS14

- The comparison will use independently computed geoid slopes from two methods:
- 1) Differential orthometric heights and differential ellipsoid heights from leveling and GPS campaigns, respectively (both minimally constrained)
- 2) Astro-Geodetic deflections of the vertical from observations with the Swiss DIADEM camera

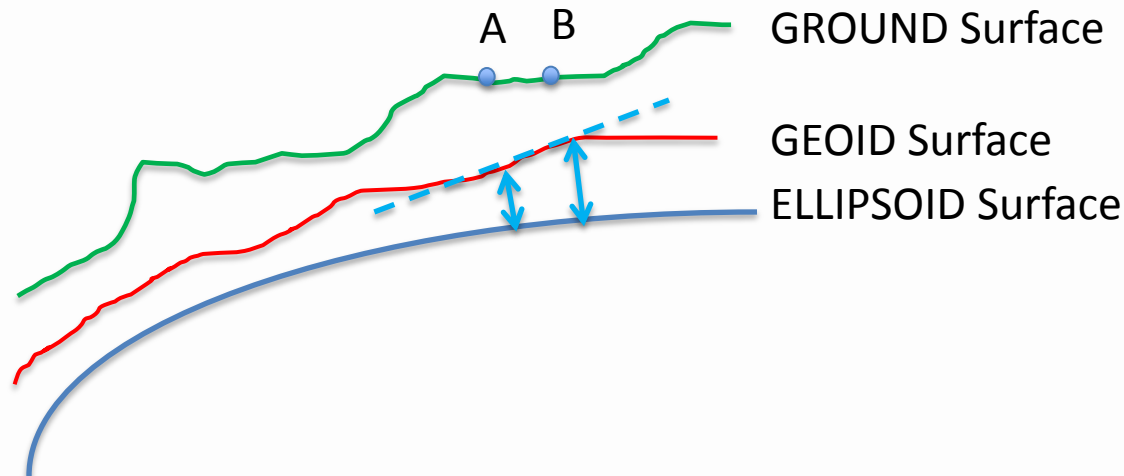
GSVS14

- Observe GPS positions at A and B to obtain
 - Ellipsoid distance between A and B
 - Ellipsoid heights at A and B (**green**)
- Also observe, by leveling, the Orthometric heights
 - Subtract to get orthometric heights (**red**)
- Difference = GEOID separations at A and B (**blue**)



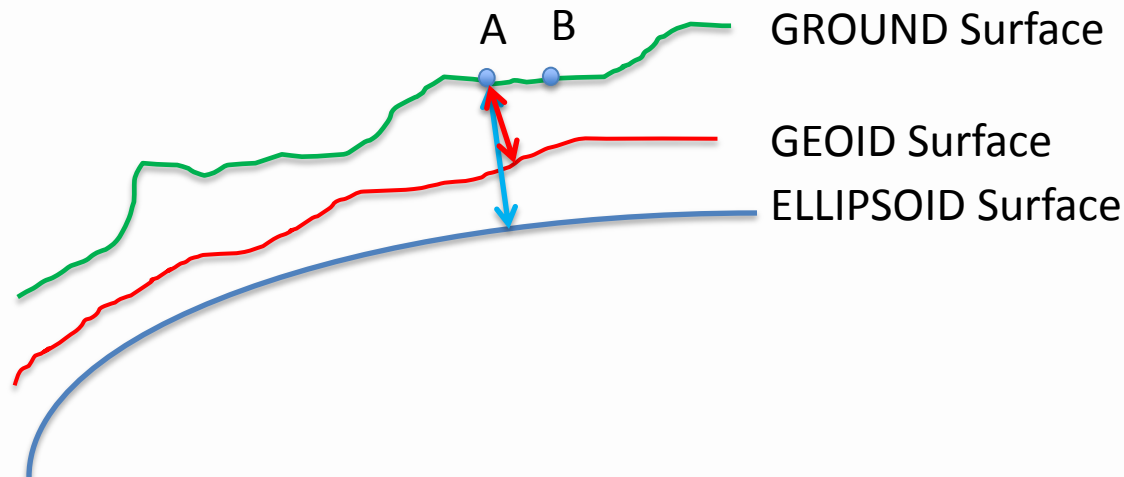
GSVS14

- Then compute the geoid slope (**blue dash**)
 - subtract the geoid separations at A and B,
 - then divide by the distance from A to B.



GSVS14

- Deflection of the Vertical
 - Angular difference in arcseconds between
 - Line perpendicular to the ellipsoid and
 - Line perpendicular to the geoid

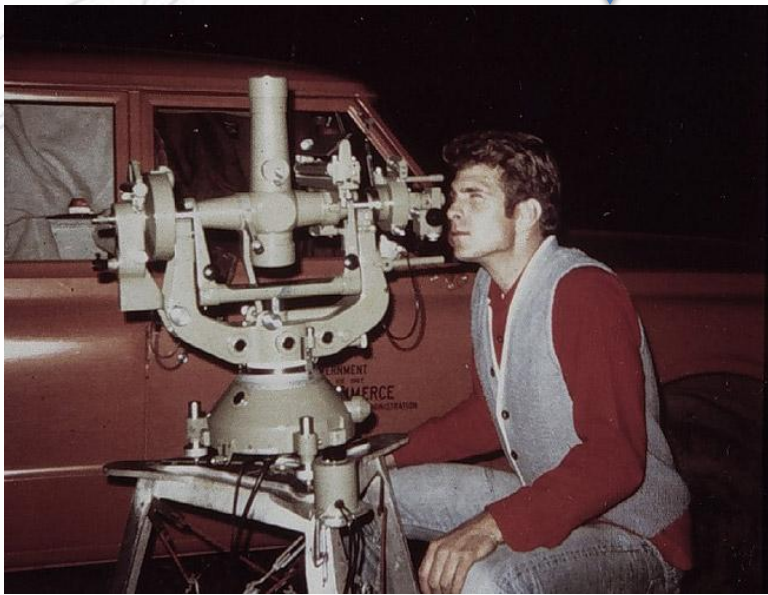
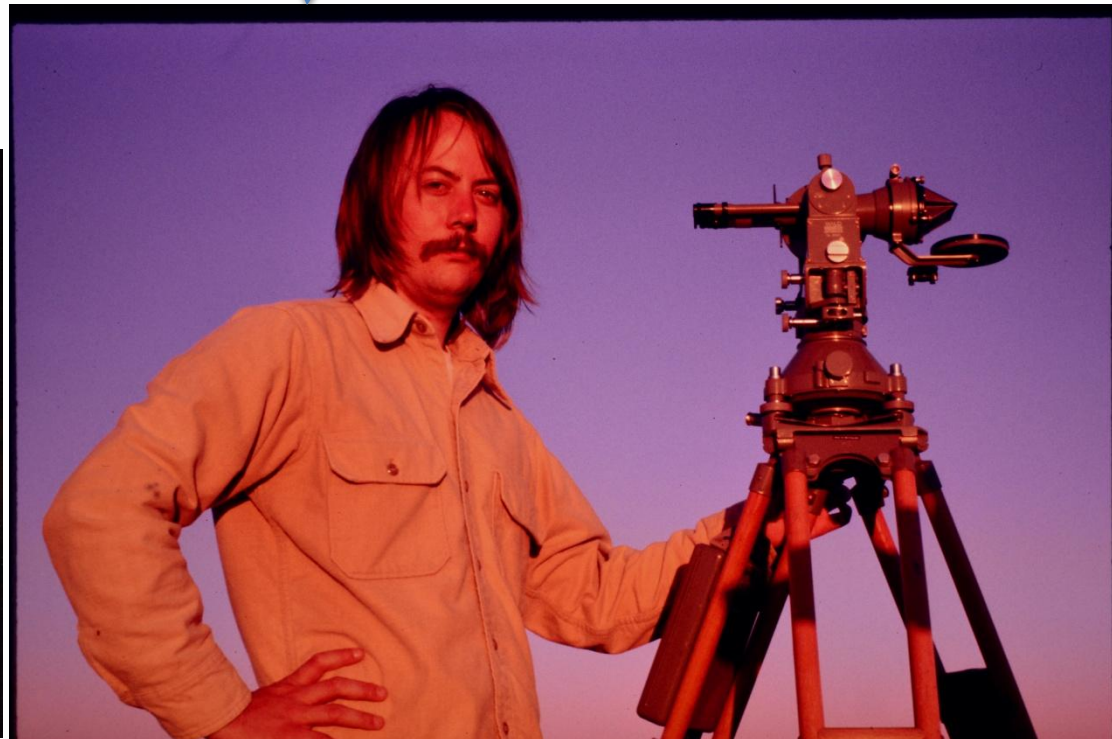


GSVS14

- The angular difference can be measured by
 - Performing a series of astronomic (star) observations which yield the astronomic latitude and longitude (which are influenced by local gravity)
 - Comparing to the geodetic latitude and longitude which are based on ellipsoidal computations.
- Use a telescope, or better yet, a digital camera

GSVS14

- DIADEM Camera →
- Dave with Wild T-3 →
- Wild T-4 →

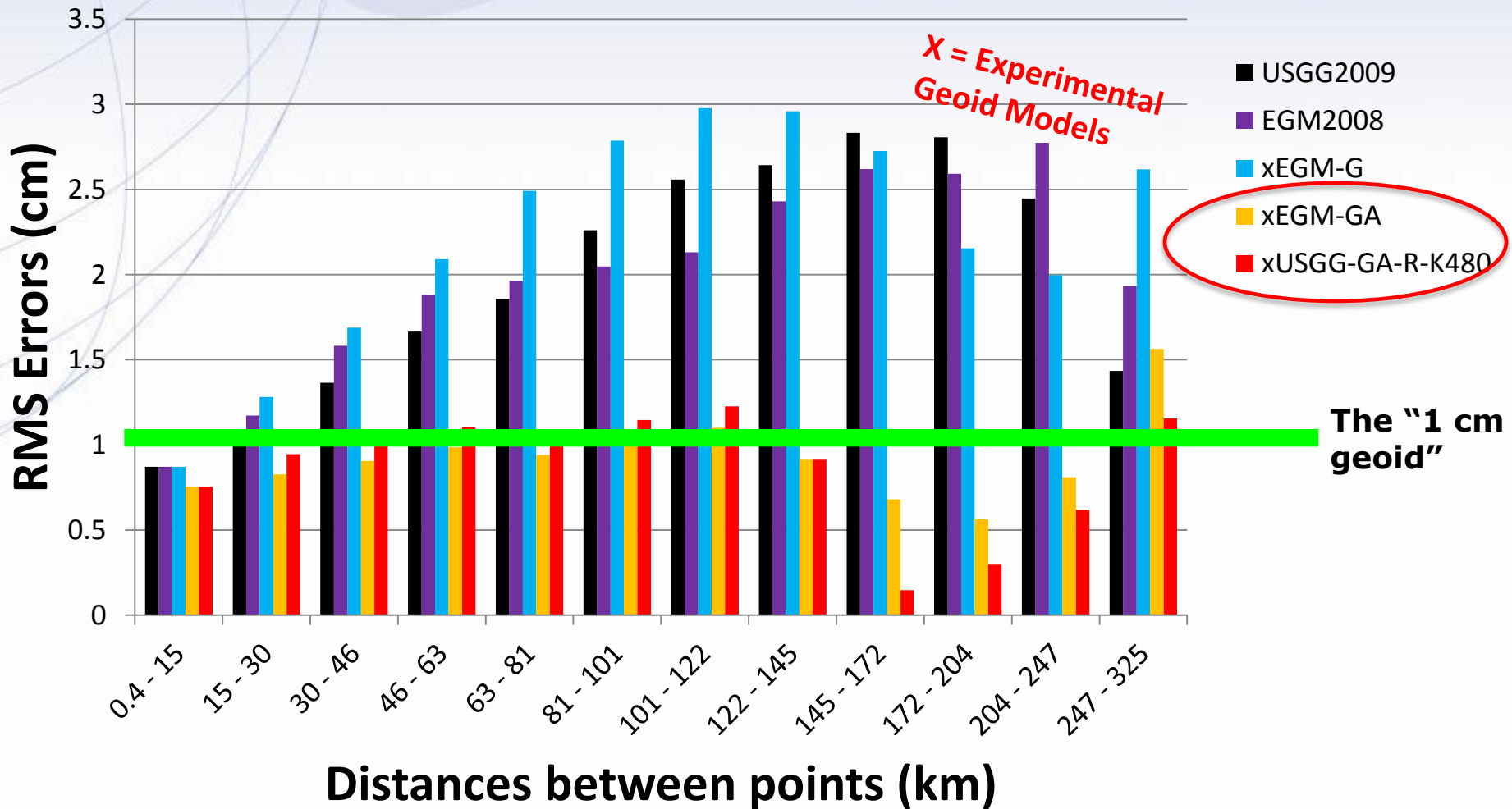


GSVS14

- By performing a GPS survey, a leveling survey, a camera survey, AND gravity measurements:
- You get 3 independent measurements of the GEOID SLOPE.
- If all 3 agree – good – if not, do 2 agree?
- Start problem solving.
- See Results from GSVS11 – next slide!

Results of GSVS11

Predicted Errors of various geoid models over GSVS11
after removal of GPS/Leveling error budget



MN Level Network Remediation

- The MN Level Network is statewide, densely spaced, and is known to have some problems.
- Known problems include:
 - Aging infrastructure (over 30 years)
 - Disconnected networks (orphans)
 - Leveling lines that failed to connect at crossings
 - Leveling lines that are spurs that could be extended to close nearby loops
 - Areas of large residuals
 - Areas of large elevation discrepancies

MN Level Network Remediation

- In order to efficiently locate and correct areas that need remedial attention, MNDOT hired a student worker for Summer 2013.
- She created multi-county networks that could be adjusted and analyzed.
- She located many orphans, spurs, and crossovers – all of which are being remediated.

MN Level Network Remediation

- Her adjustment showed where the published elevation did not match the adjusted elevation.
- She created a series of impressive maps which show areas of these large elevation changes in color.

RED ≥ 0.06

ORANGE ≥ 0.03

YELLOW > 0

WHITE = 0 (Fixed Points)

PURPLE ≥ -0.03

BLUE ≥ -0.06

GREEN < -0.06

MN Level Network Remediation

- In a perfect adjustment, the colors would be expected to shade smoothly from one to the next.
 - Like a rainbow-type pattern.
 - No color sequence jumps.

RED ≥ 0.06

ORANGE ≥ 0.03

YELLOW > 0

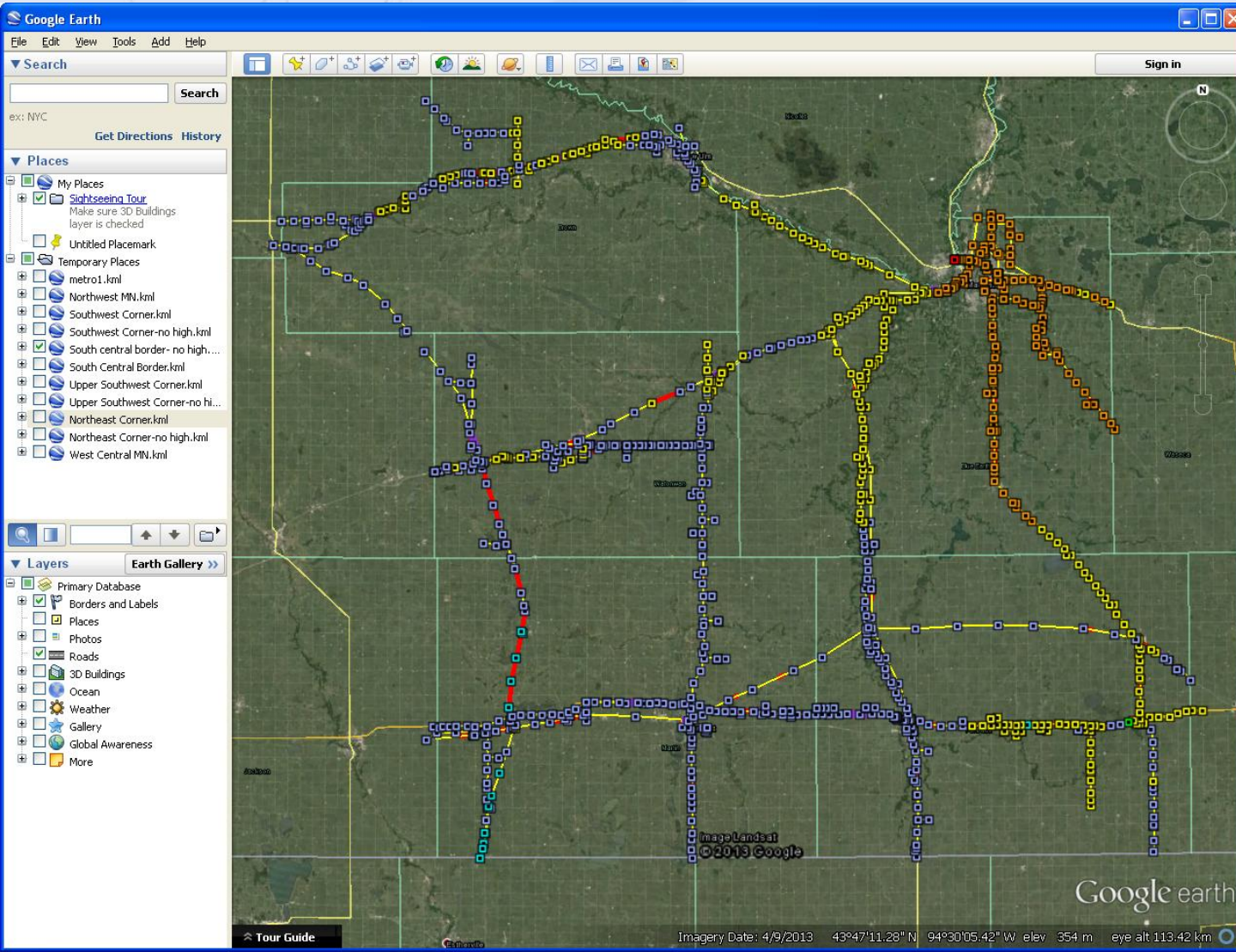
WHITE = 0

PURPLE ≥ -0.03

BLUE ≥ -0.06

GREEN < -0.06

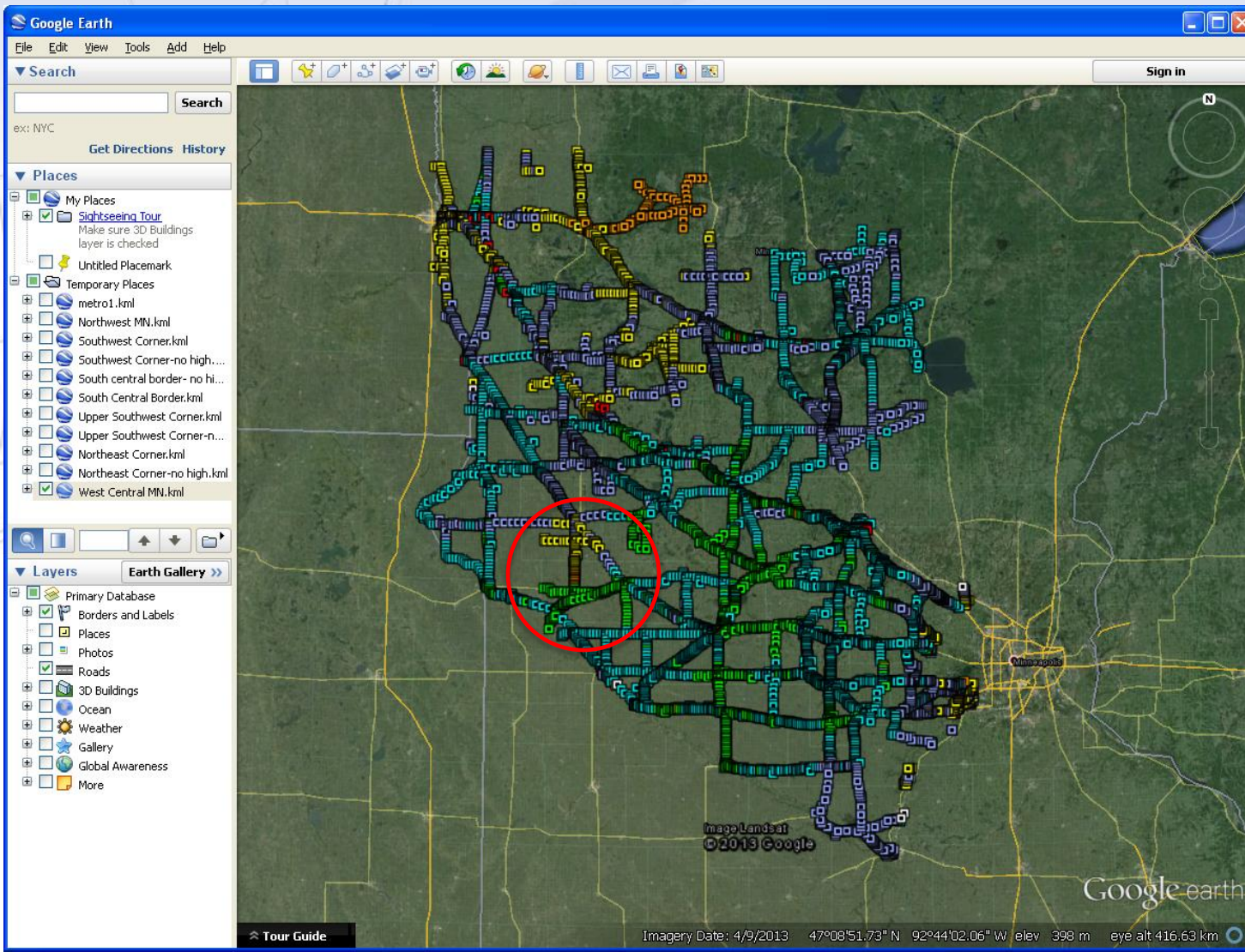
MN Level Network Remediation



South Central
Minnesota

- RED ≥ 0.06
- ORANGE ≥ 0.03
- YELLOW > 0
- WHITE = 0
- PURPLE ≥ -0.03
- BLUE ≥ -0.06
- GREEN < -0.06

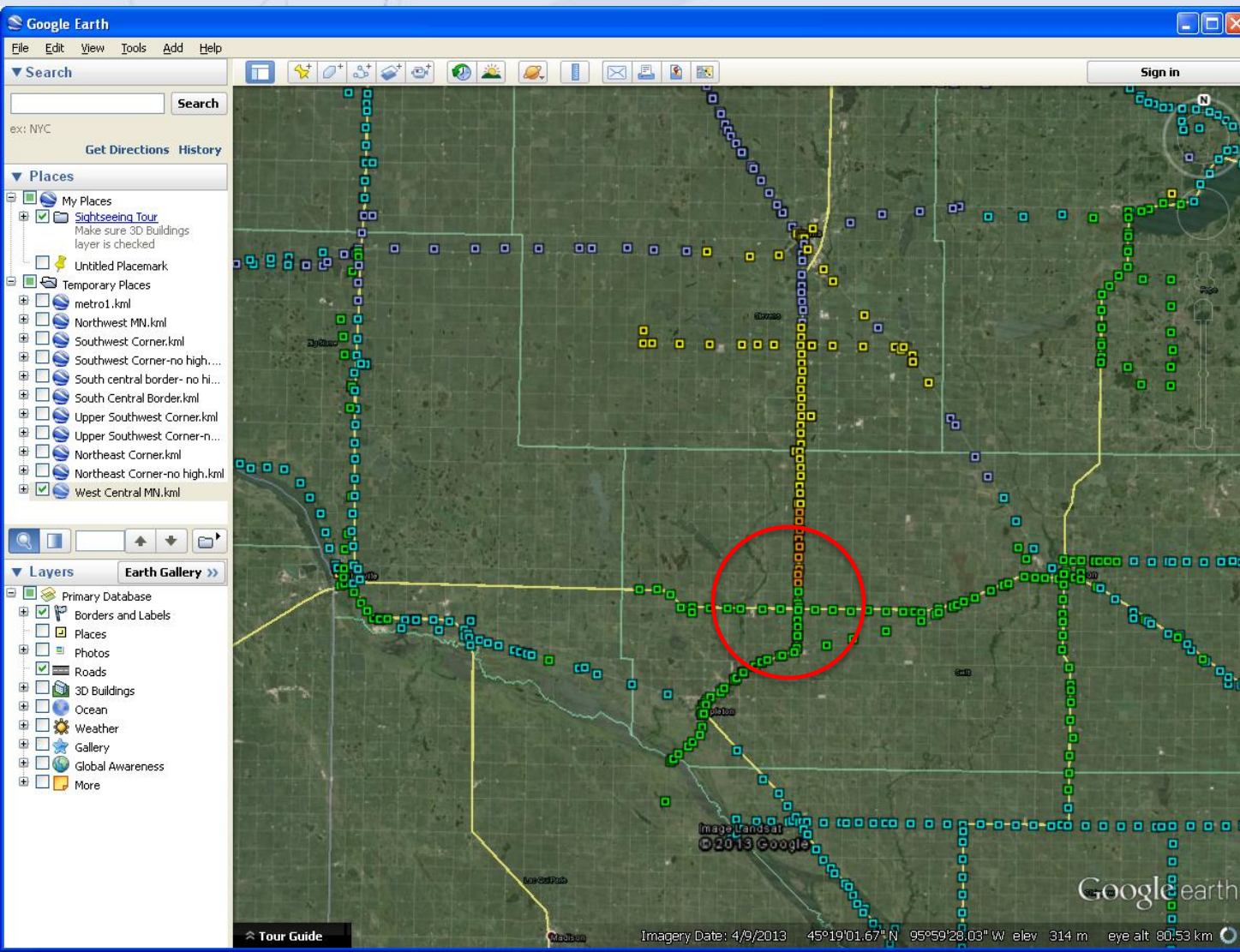
MN Level Network Remediation



West Central
Minnesota

- RED ≥ 0.06
- ORANGE ≥ 0.03
- YELLOW > 0
- WHITE = 0
- PURPLE ≥ -0.03
- BLUE ≥ -0.06
- GREEN < -0.06

MN Level Network Remediation



West Central
Minnesota near
Swift County

- RED ≥ 0.06
- ORANGE ≥ 0.03
- YELLOW > 0
- WHITE = 0
- PURPLE ≥ -0.03
- BLUE ≥ -0.06
- GREEN < -0.06

MN Level Network Remediation

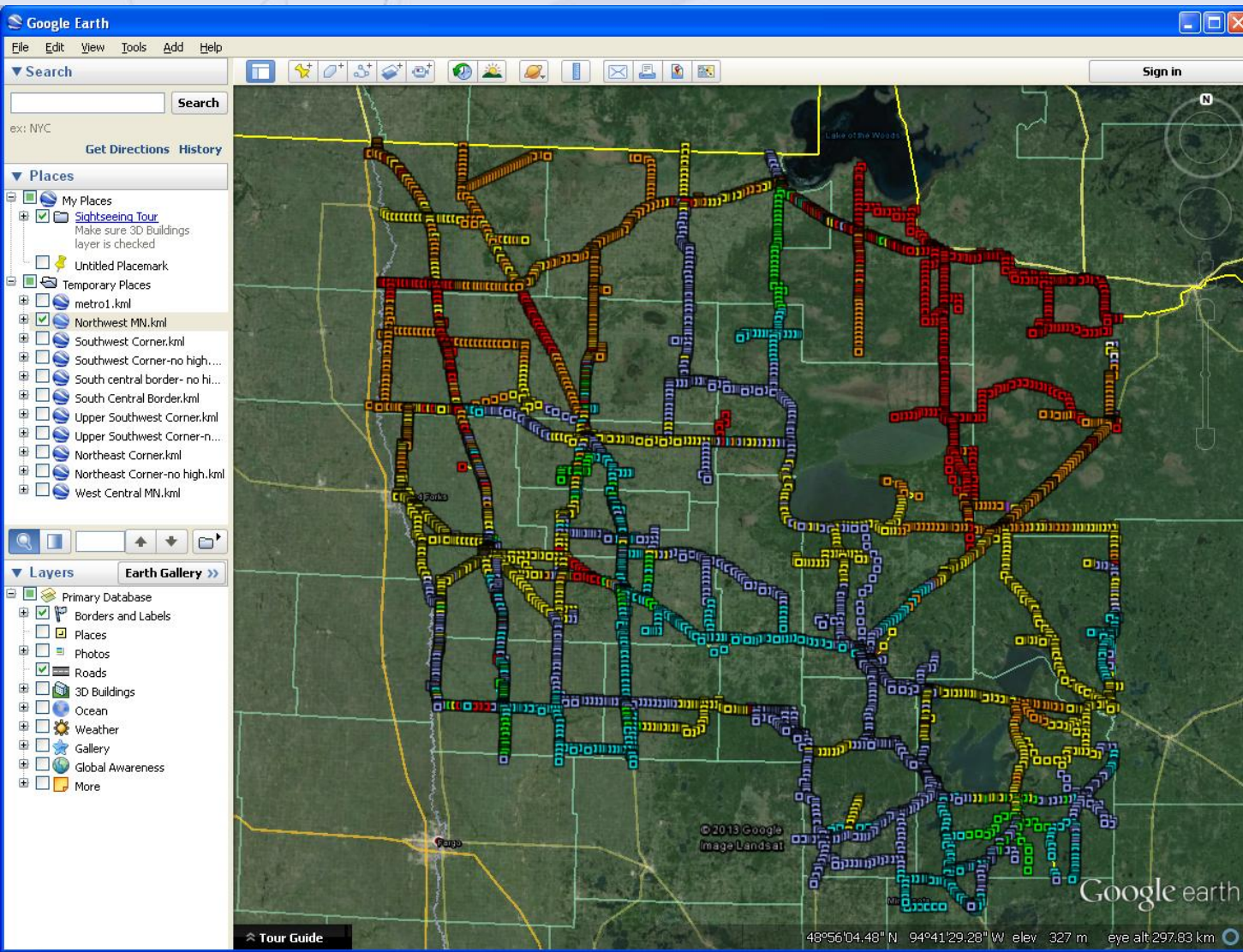


West Central
Minnesota in
Swift County

Can we jump
from Green to
Orange ?

- RED ≥ 0.06
- ORANGE ≥ 0.03
- YELLOW > 0
- WHITE = 0
- PURPLE ≥ -0.03
- BLUE ≥ -0.06
- GREEN < -0.06

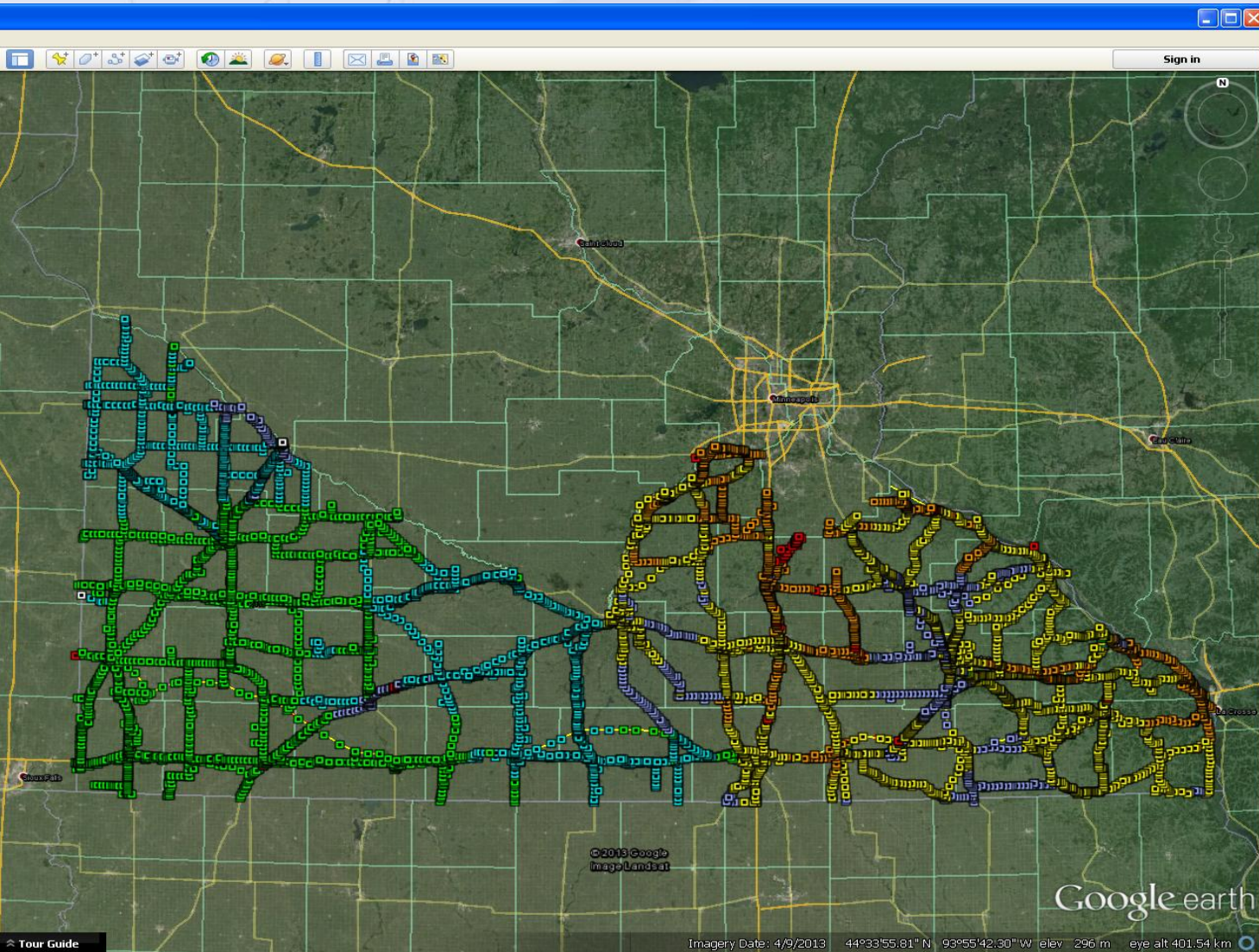
MN Level Network Remediation



Northwest
Minnesota

- RED ≥ 0.06
- ORANGE ≥ 0.03
- YELLOW > 0
- WHITE = 0
- PURPLE ≥ -0.03
- BLUE ≥ -0.06
- GREEN < -0.06

MN Level Network Remediation



Southern
Minnesota

- RED ≥ 0.06
- ORANGE ≥ 0.03
- YELLOW > 0
- WHITE = 0
- PURPLE ≥ -0.03
- BLUE ≥ -0.06
- GREEN < -0.06

MN Level Network Remediation

- NGS will not readjust the MN Level Net until the new 3D Datum is released in (pick a year).
- Until then MNDOT will continue to address known areas of concern by
 - performing new leveling,
 - adjusting multi-county areas,
 - submitting the work to NGS,
 - and monitoring for improvement.

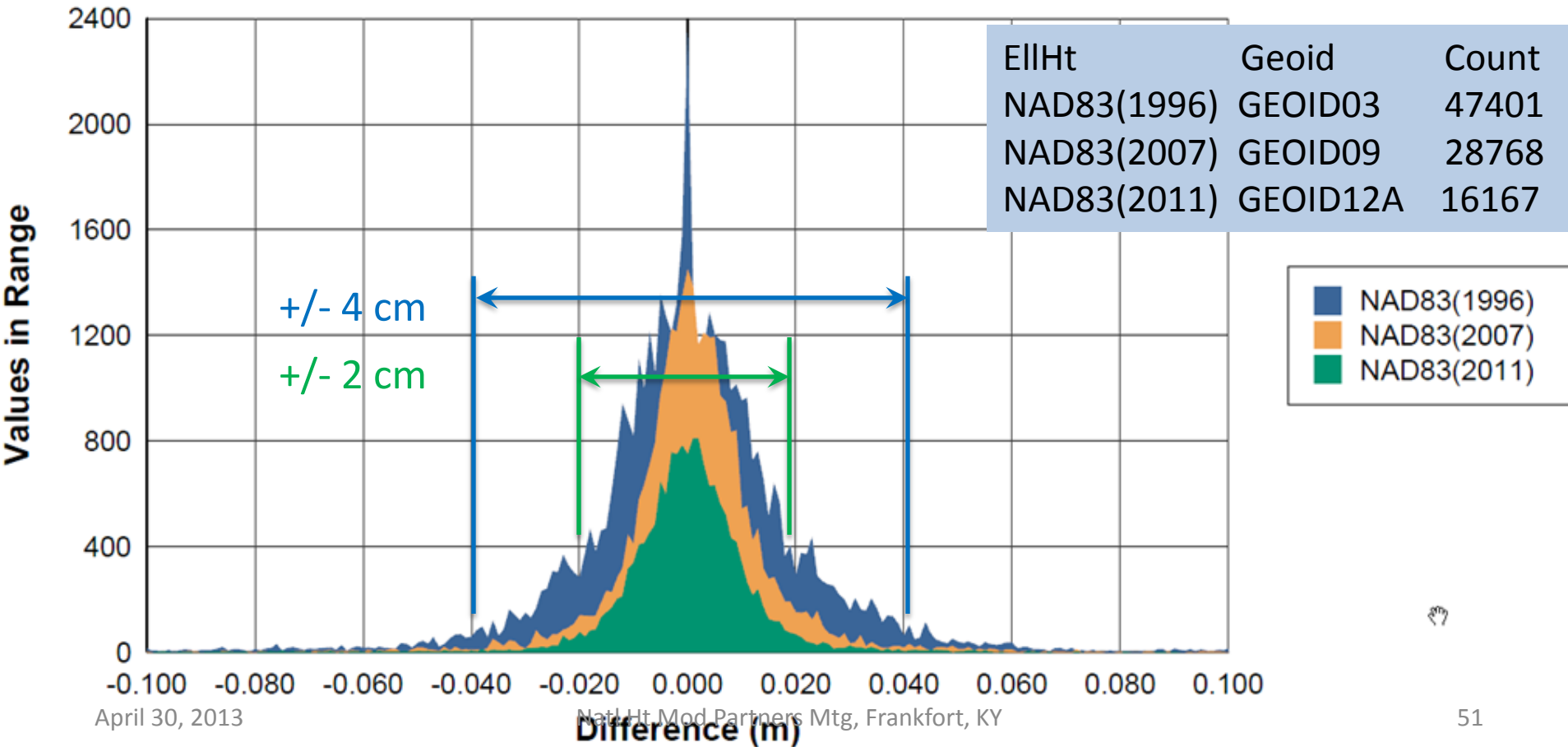
Cumulative Impact of Activities

- All of the activities in this presentation have a single goal:
 - *To provide products that the public can use to efficiently and accurately obtain horizontal and vertical positions.*
- The next slide shows the fruitful impact of these activities.
- GPS-derived orthometric heights at 95% is:
+/- 2 cm, (not +/- 4 cm)

Benefit of Height Modernization

Leveled NAVD88 - GPS Derived

Outliers (>.1m different) disregarded



The End

- Questions