DIGITAL MAPPING TECHNIQUES 2021

The following was presented at DMT'21
(June 7 - 10, 2021 - A Virtual Event)

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2021)

http://ngmdb.usgs.gov/info/dmt/

Using old and new topographic information to improve the fidelity and value of legacy geologic maps

A progress report

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USGS Cooperative Agreement G20AC00416

Kentucky Geological Survey

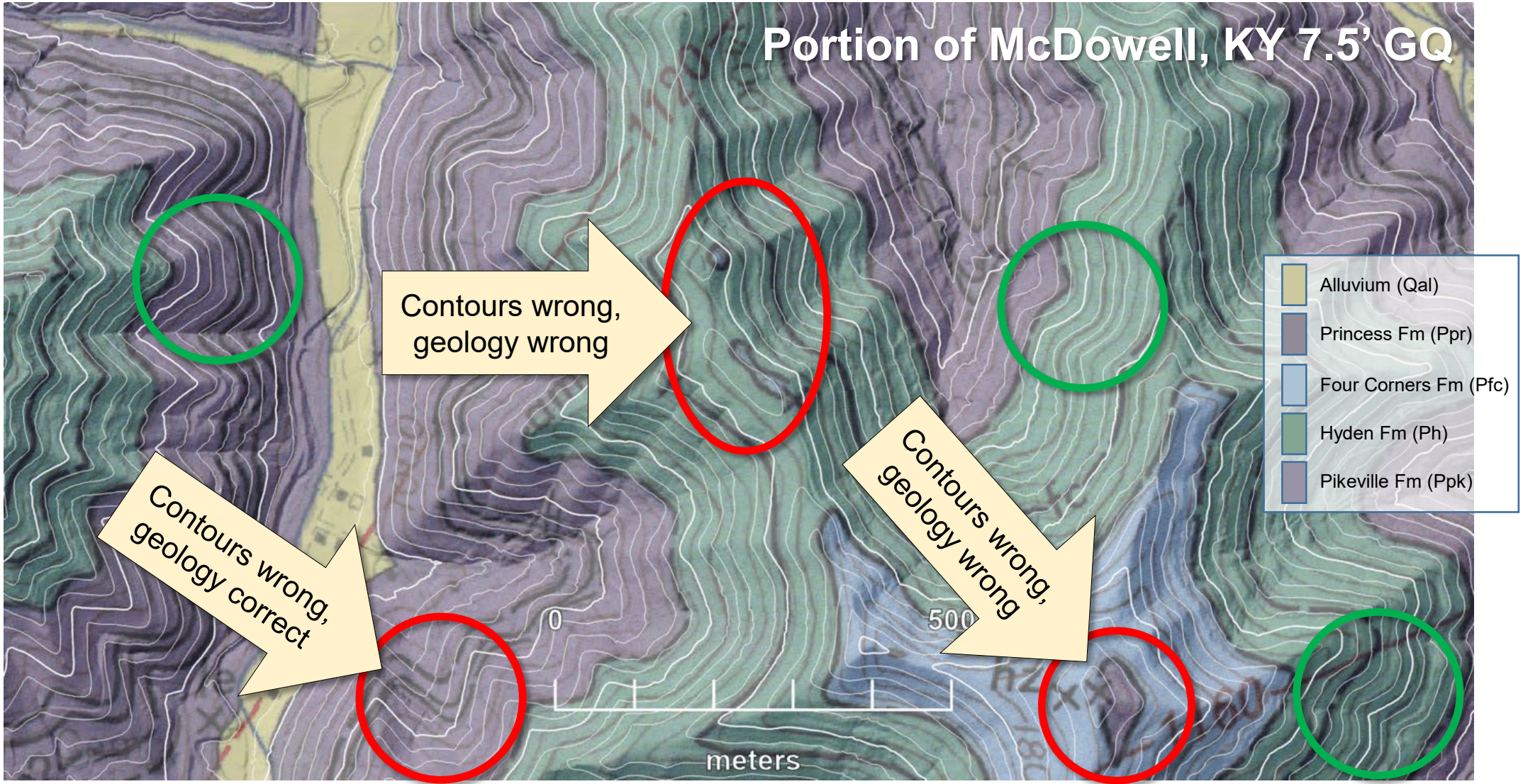
A postulate, some facts, and two questions

DEAL
Digital Earth Analysis Lab
Kentucky Geological Survey

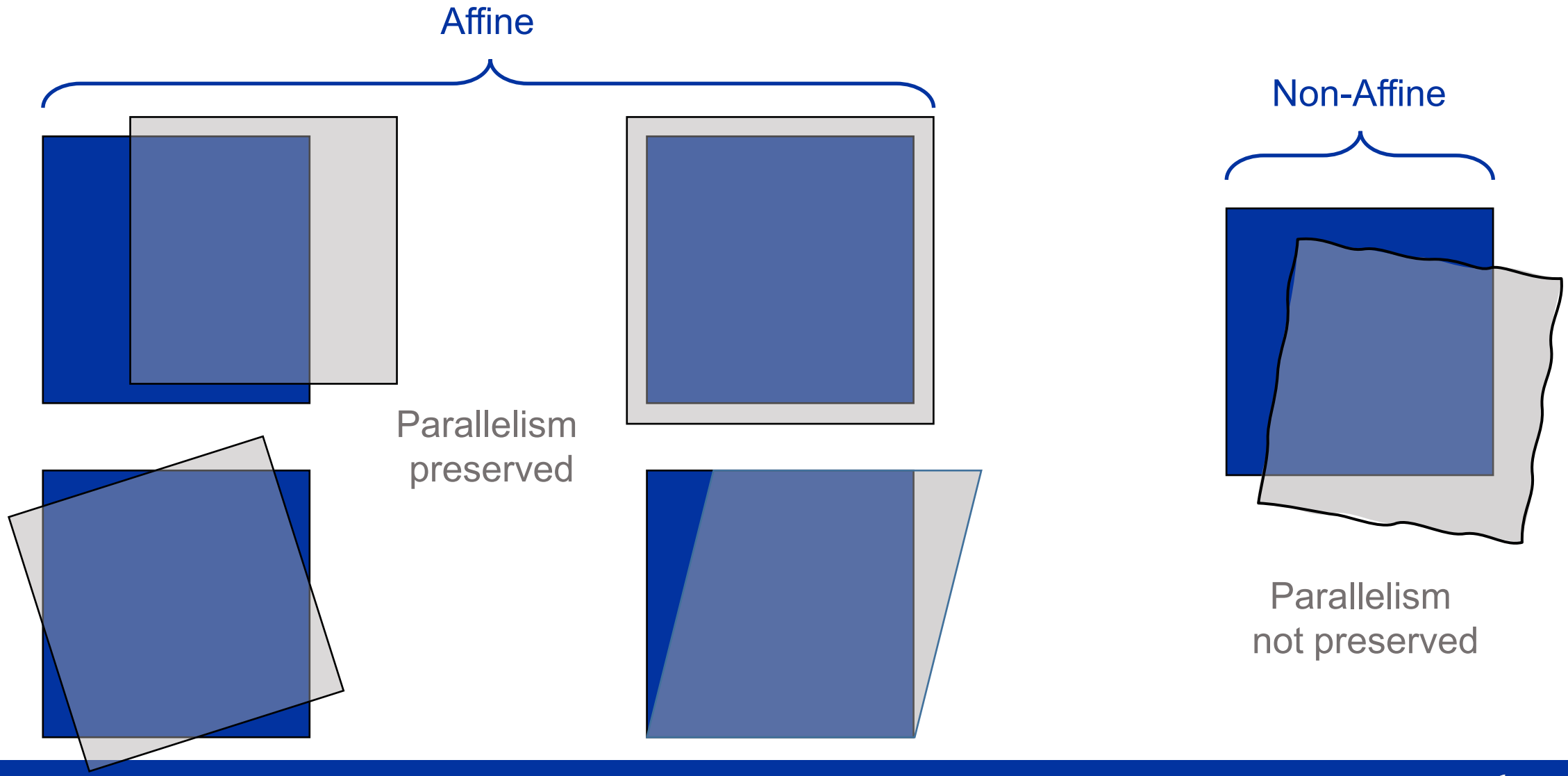
- **A geologic map can only be as good as its geospatial framework—its base map—and base map quality can affect geologic map utility and value**
- Many legacy geologic maps are excellent products faithful to the topographic base maps available when the maps were made
- But…the topos might have been made decades ago
- **What if the topo maps turn out to be wrong?**
- And, **if they are wrong enough to care about**, can we fix the problem with every geologist's favorite tool: math!?

USGS Topographic Division, photo by E.F. Patterson, USGS, August 1952

GQ and LiDAR contours differ…implications for geology?

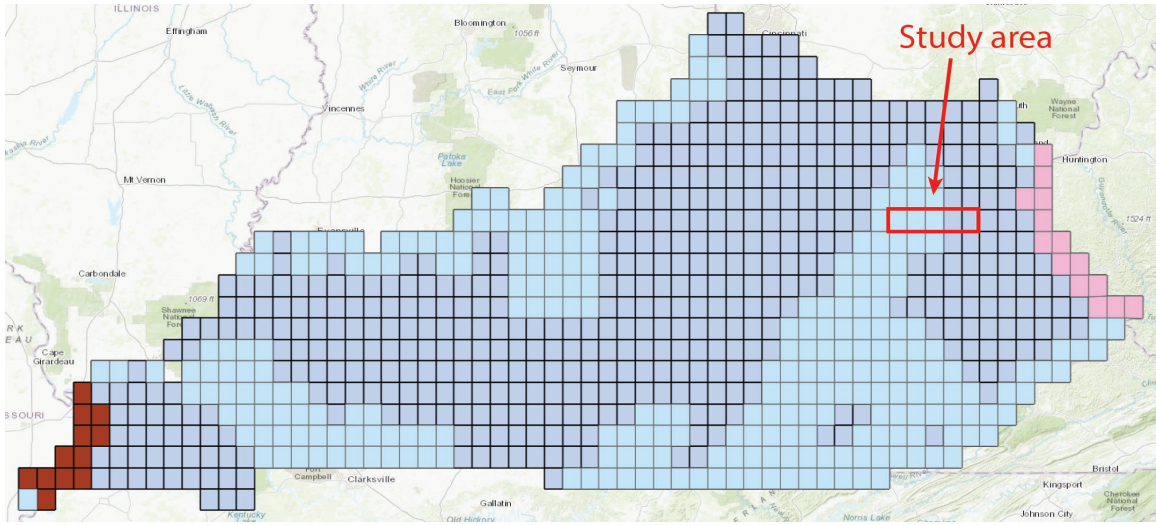


Our strategy: transform the topography then the geology



The epic quest for old DEMs

- Finding suitable legacy DEMs could save a LOT of work!
- Full coverage of our 5-quad study area is only available from L1 30 m DEM and the L2 30 ft DEM series.
- Don’t forget datum and projection! Our digital GQs are NAD 83 Kentucky State Plane and US survey feet
- Your mileage may vary



J49 Salt Lick	J50 Bangor	J51 Wrigley	J52 Sandy Hook	J53 Isonville
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salt_lick_ky_482255_7pt5_30x30m_L2_1975				
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salt_lick_ky_565971_7pt5_10x10m_L2_1950	bangor_ky_565897_7pt5_10x10m_L2_1950	wrigley_ky_565984_7pt5_10x10m_L2_1950		
salt_lick_ky_1964399_7pt5_30x30ft_L2_1950	bangor_ky_1972761_7pt5_30x30ft_L2_1952	wrigley_ky_1964401_7pt5_30x30ft_L2_1975	sandy_hook_ky_1964459_30x30ft_L2_1947	Isonville_ky_1964460_30x30ft_L2_1947

Legacy DEM vs GQ contour comparison

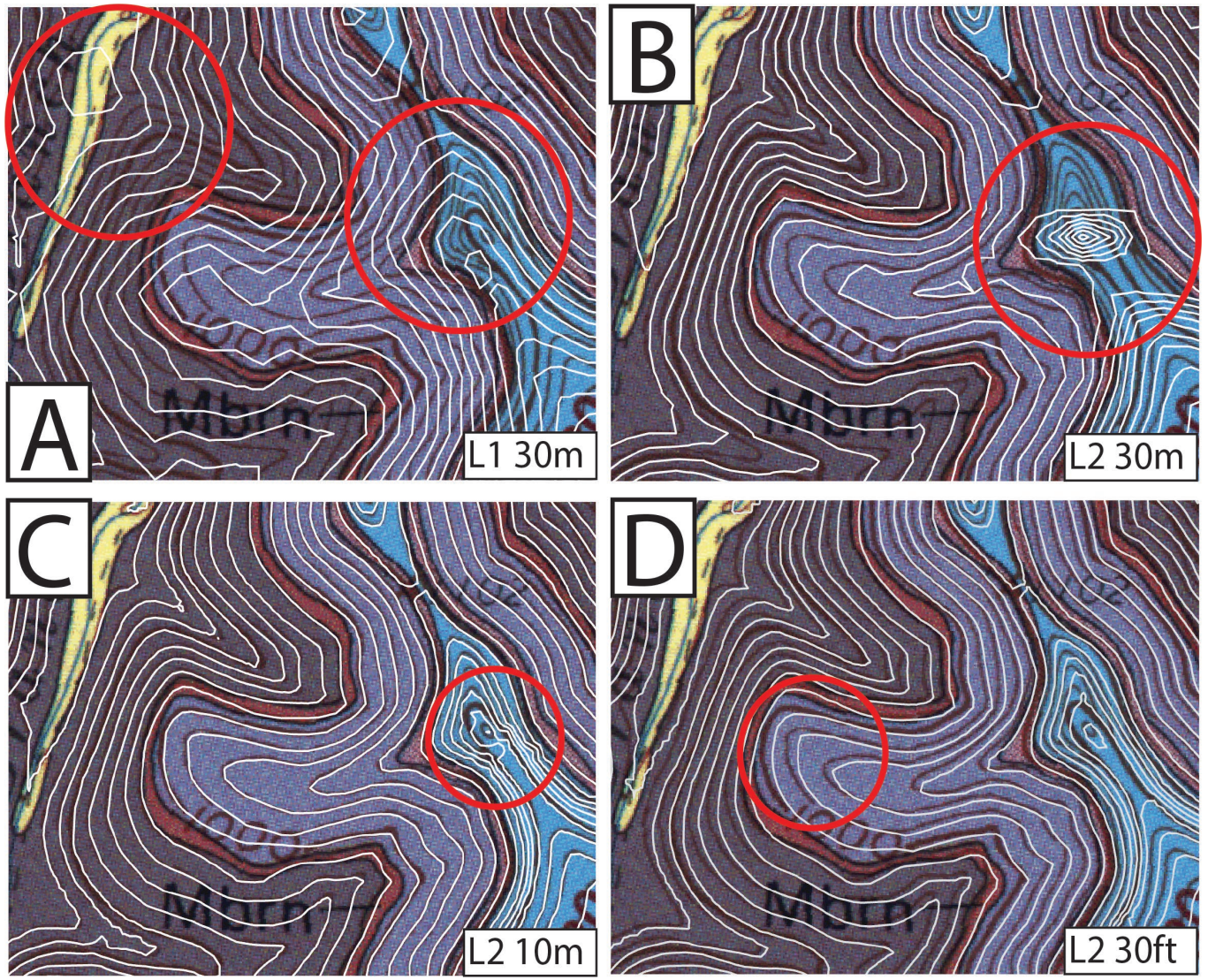
20-foot legacy DEM derived contours (white) draped over part of the Salt Lick GQ

A. L1-30m

B. L2-30m

C. L2-10m

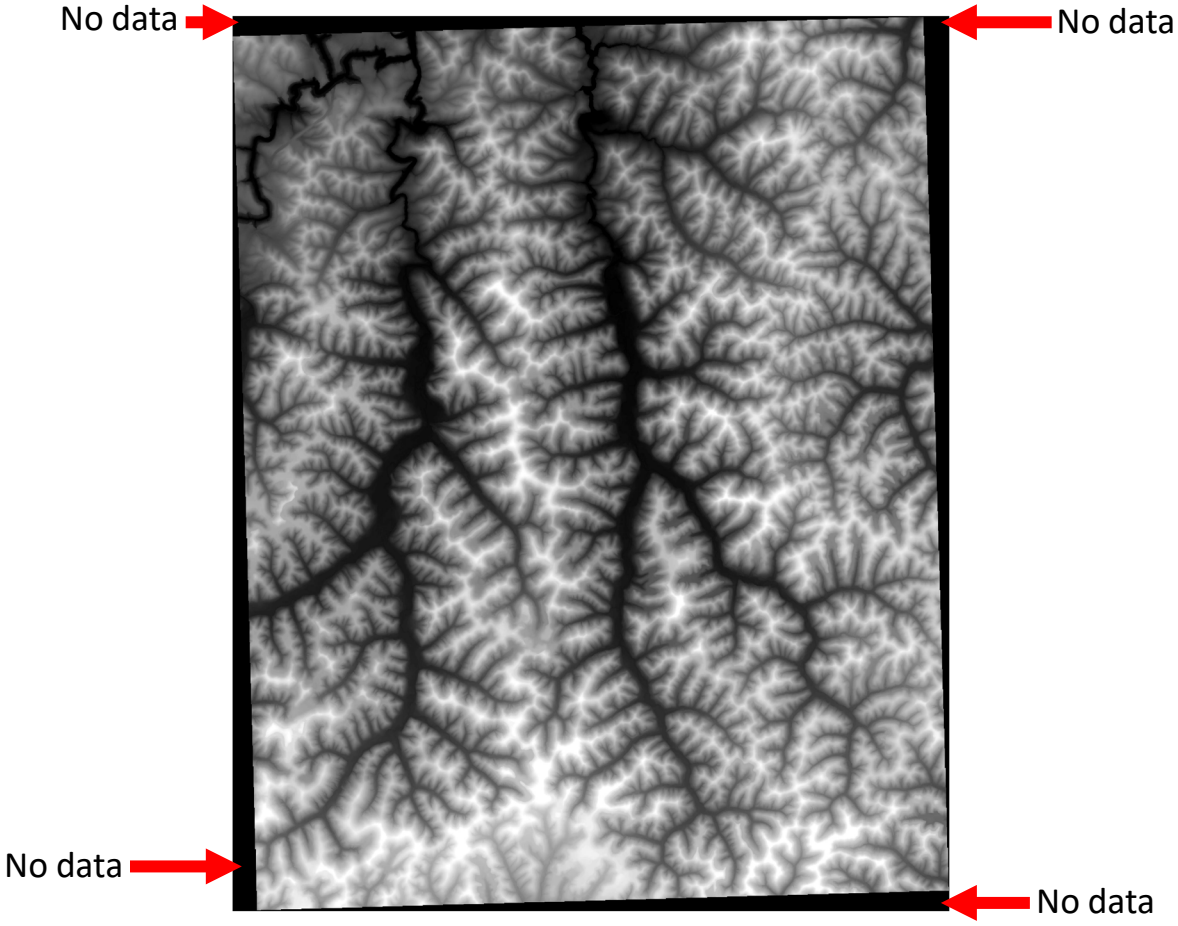
D. L2-30ft



Masked phase registration

$$NCC(u,v) = \frac{\sum[(f_1(x,y) - \overline{f_{1,u,v}})(f_2(x-u,y-v) - \overline{f_{2,u,v}})]}{\sqrt{\sum(f_1(x,y) - \overline{f_{1,u,v}})^2}\sqrt{\sum(f_1(x-u,y-v) - \overline{f_{2,u,v}})^2}}$$

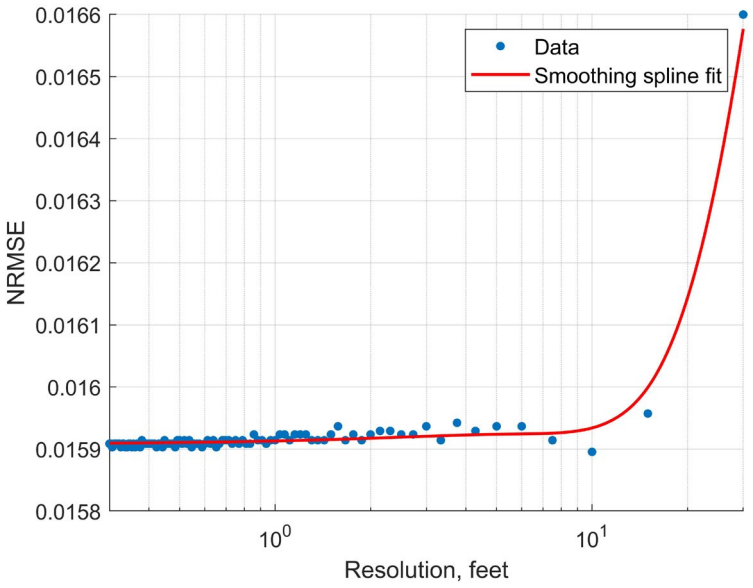
Evaluation of the registration by locating **the peak of the cross-correlation** $NCC(u,v)$**.**



$$NCC(u,v) = \frac{\mathrm{F}^{-1}(F_1 \cdot F^*_2) - \frac{\mathrm{F}^{-1}(F_1 \cdot M^*_2)\cdot \mathrm{F}^{-1}(M_1 \cdot F^*_2)}{\mathrm{F}^{-1}(M_1 \cdot M^*_2)}}{\sqrt{\mathrm{F}^{-1}(\mathrm{F}(f_1 \cdot f_1)\cdot M^*_2) - \frac{(\mathrm{F}^{-1}(F_1 \cdot M^*_2))^2}{\mathrm{F}^{-1}(M_1 \cdot M^*_2)}}\sqrt{\mathrm{F}^{-1}(M_1 \cdot \mathrm{F}(f'_2 \cdot f'_2)) - \frac{(\mathrm{F}^{-1}(M_1 \cdot F^*_2))^2}{\mathrm{F}^{-1}(M_1 \cdot M^*_2)}}}$$

Optimization of cell size

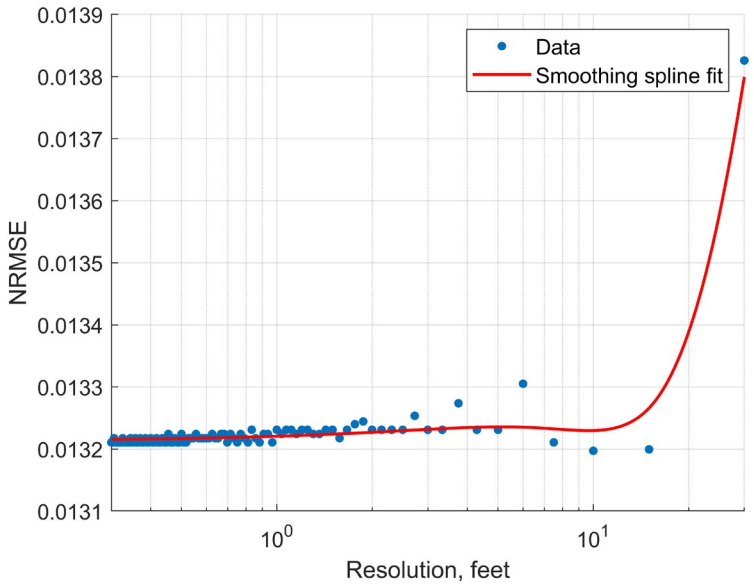
Isonville quadrangle



East: 12.9 ft

South: 19.5ft

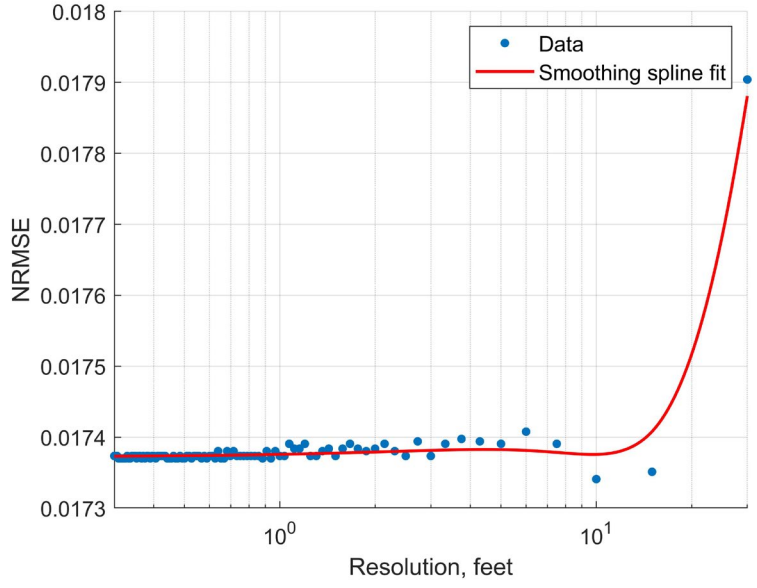
Sandy Hook quadrangle



East: 20.0 ft

South: 0.0 ft

Wrigley quadrangle

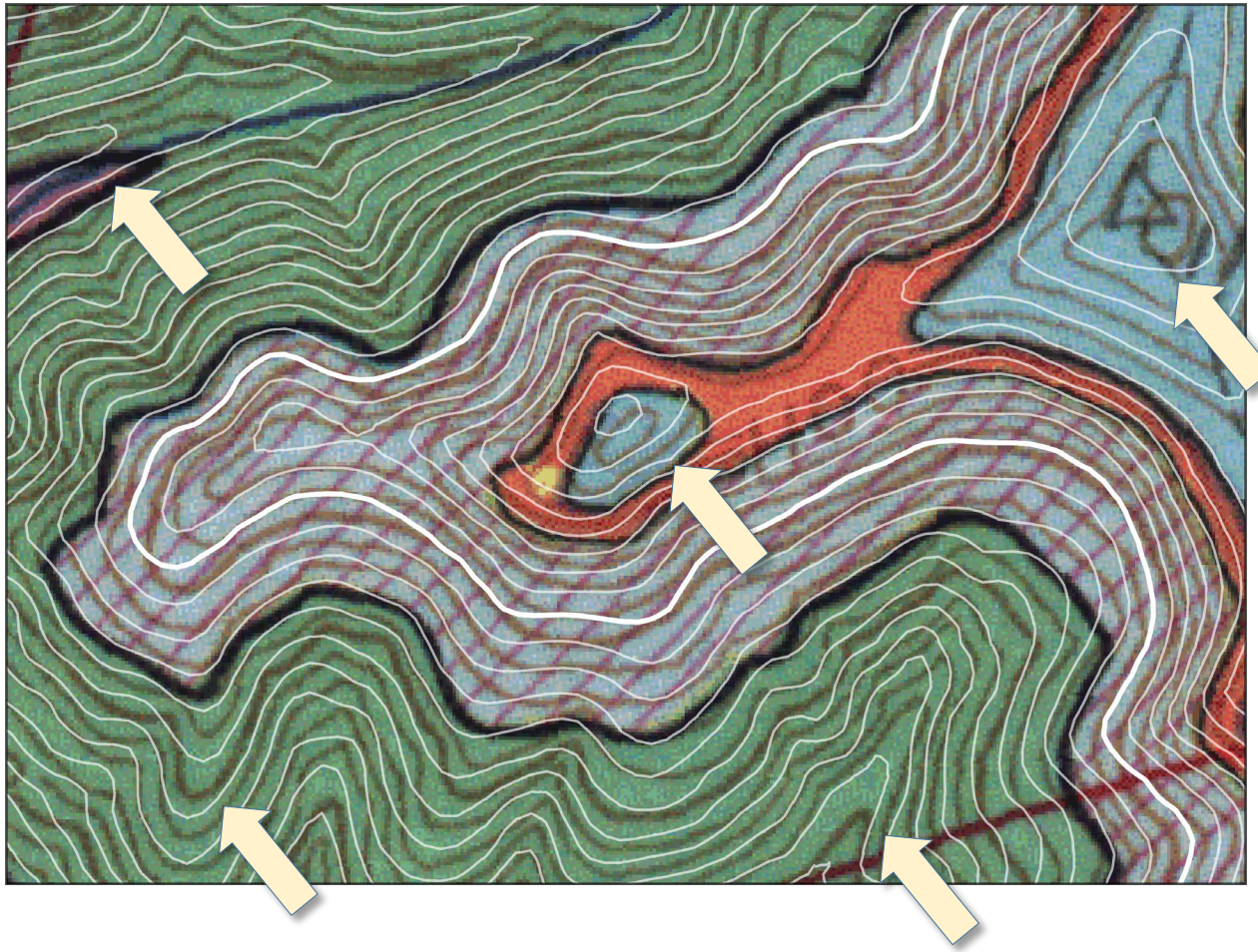


East: -10.5 ft

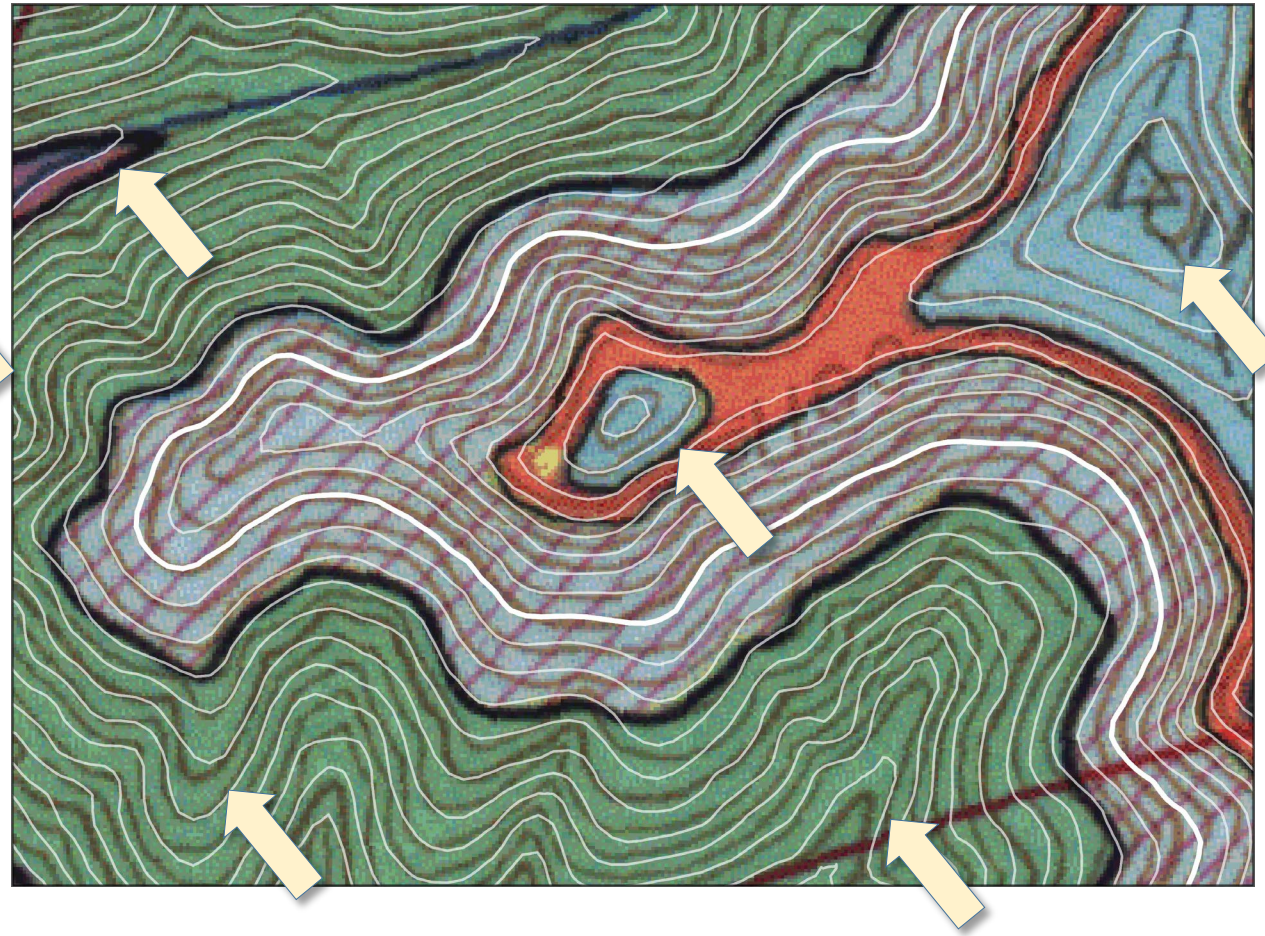
South: -12.3 ft

Preliminary rectification results: Isonville quadrangle

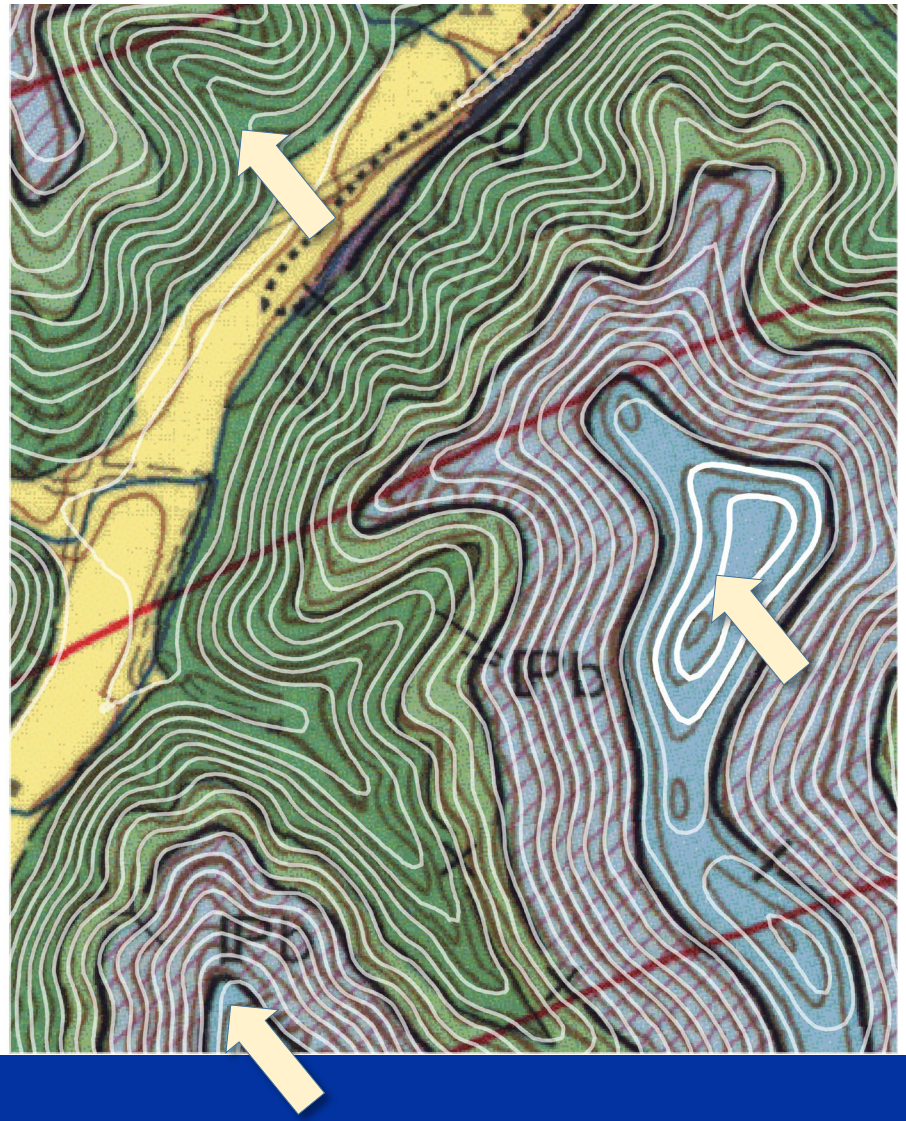
Before

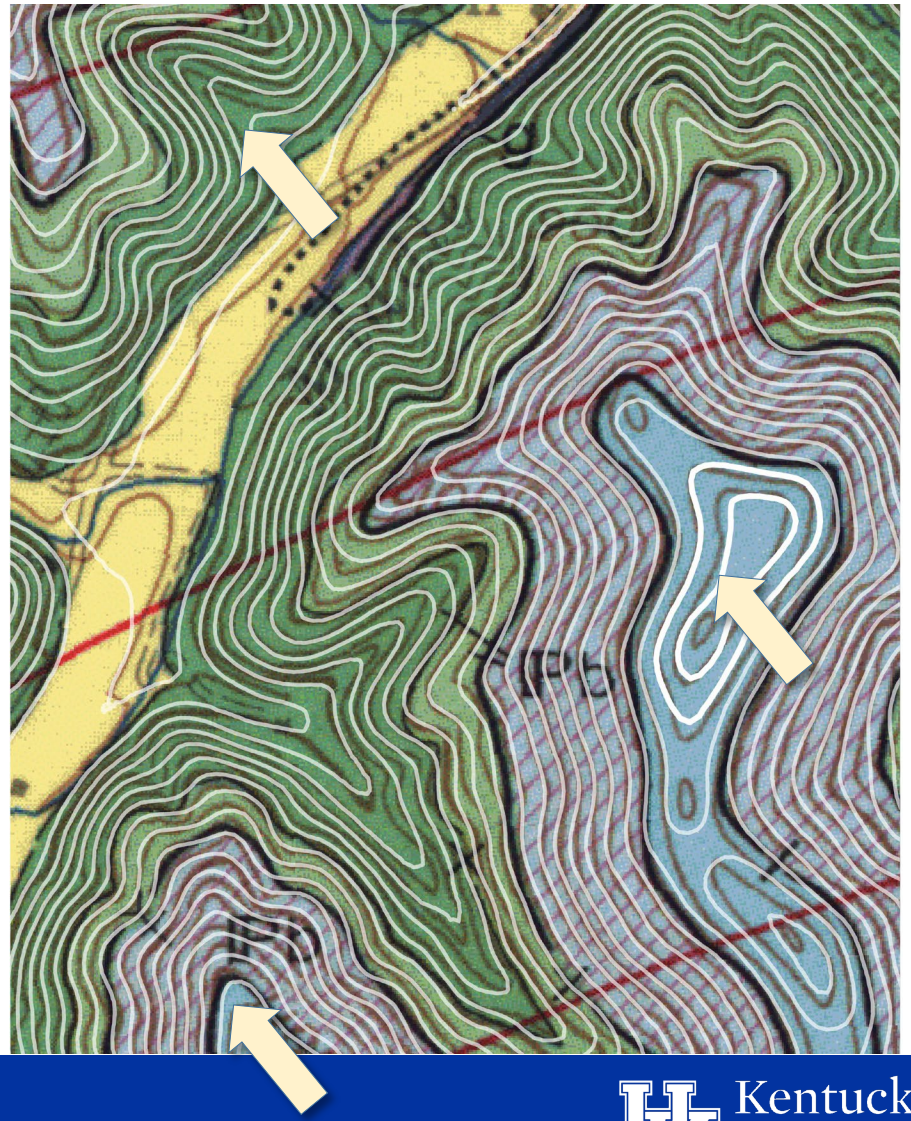


After

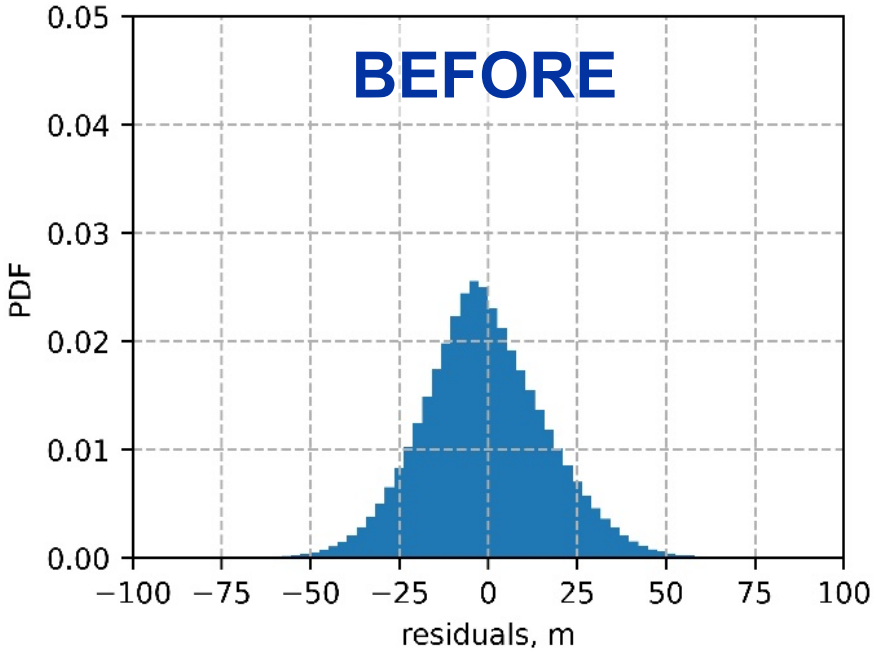


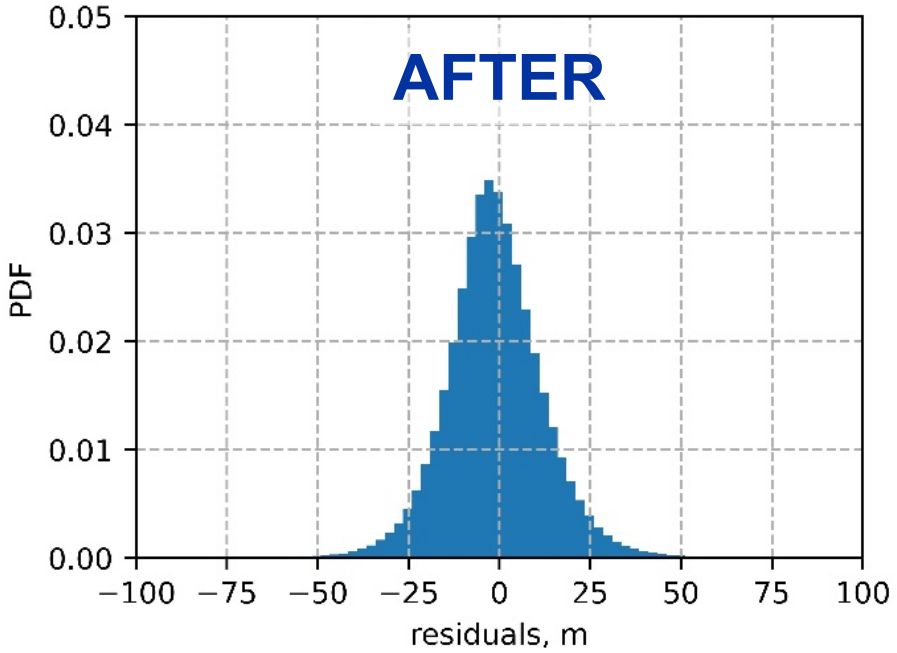
Preliminary rectification results: Sandy Hook quadrangle





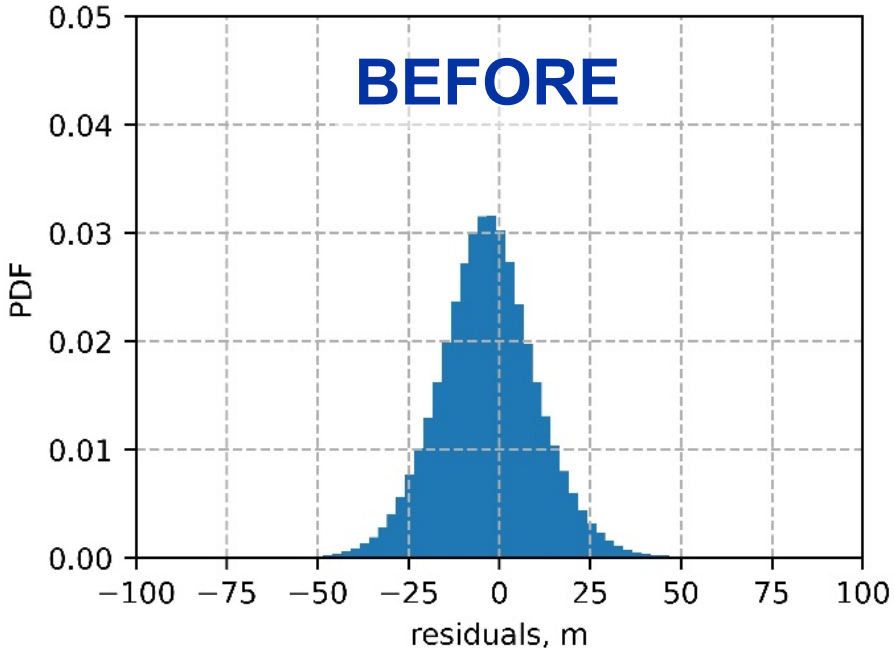
Residuals: Isonville quadrangle (22% reduction)

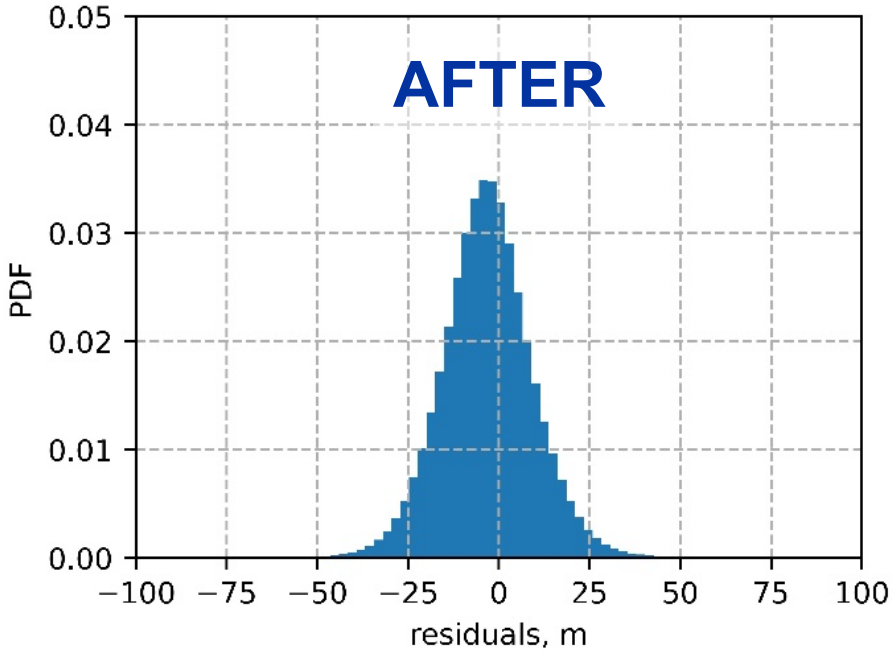




Metric	Before	After
Mean of residuals (m)	-1.18	-1.04
Standard deviation of residuals (±m)	17.8	13.8
Sum of absolute residuals (m)	227,839,488	170,336,080

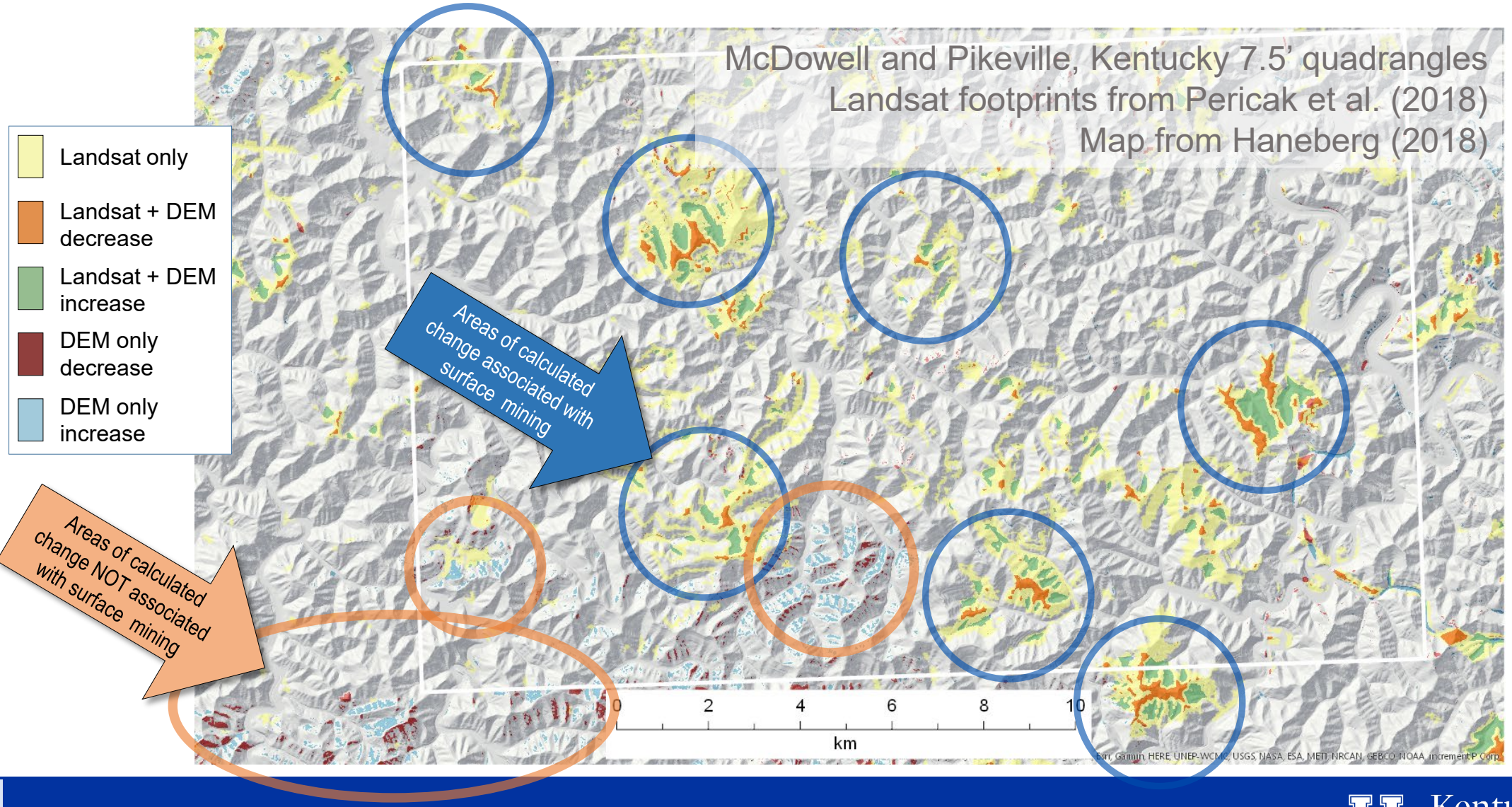
Residuals: Sandy Hook quadrange (8% reduction)



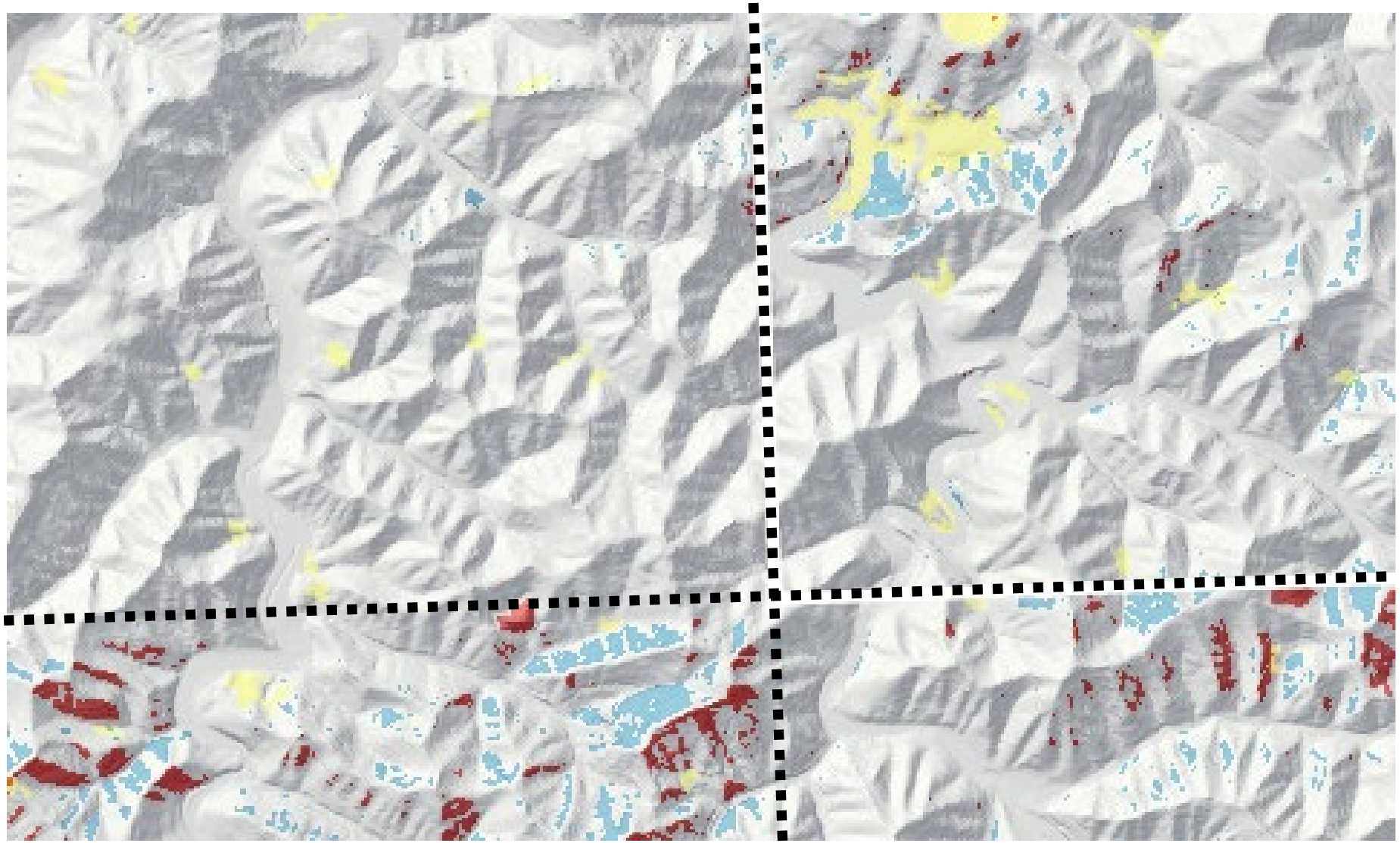


Metric	Before	After
Mean of residuals (m)	-3.1	-3.0
Standard deviation of residuals (±m)	13.8	12.7
Sum of absolute residuals (m)	180,611,120	165,402,832

But…we know that legacy DEM errors aren't homogeneous



Legacy DEM errors can end at quadrangle edges…hmmm



Next steps

- Develop a convolutional masked registration algorithm for moving window non-affine transformations
- Decide if non-affine transformations do a better job relative to increased computational complexity
- Figure out how to apply the transformations to typical digital GQ GIS elements (e.g., polylines or polygons)
- Write our report, submit a manuscript or two, and develop open-source software library documentation
- See you next year?
- Email: bill.haneberg@uky.edu