



(NCALM)





#### Challenges with Change Detection

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Differencing 3D point clouds assumes that they have been presented in the same coordinate frame.

However, this is very rarely the case.

Choice of reference frame for project is dependent upon data source (commercial vs. research) and time frame of collection and processing.

Can be very complicated if the project was collected internationally – for now lets focus on continental US.



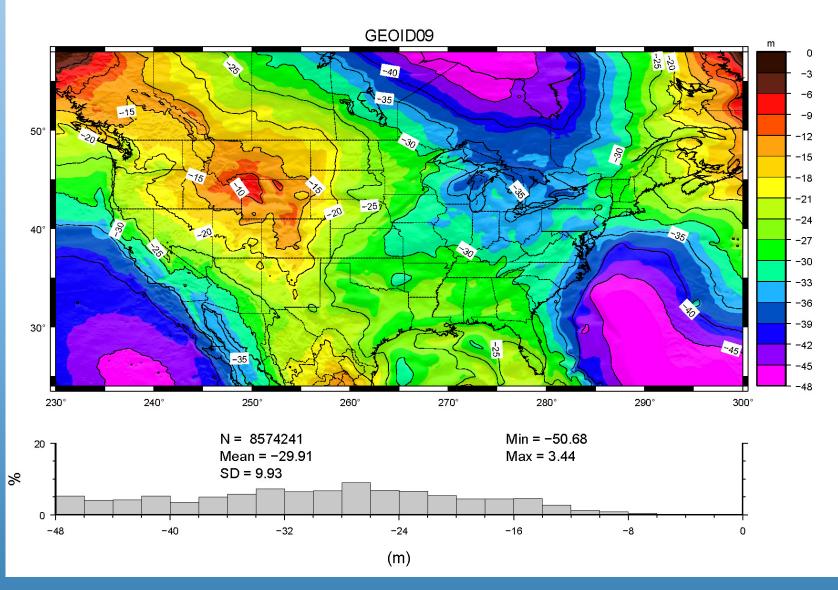
- Majority of commercial collections will be presented in orthometric height (NAVD88).
- Research collections tend to be delivered as ellipsoidal heights.
- Conversion between the two realized by NGS high resolution geoid models.
- The question is, which one? To date there are 5:
  - GEOID99
  - GEOID03
  - GEOID06 (Alaska Only)
  - GEOID09
  - GEOID12



### NCALM Magnitude of Geoid Model









#### VCALM Does The Geoid Model Version Matter? UNIVERSITY of Houston





Geoid Model	P041 (Marshell Field)	AC48 (Valdez, AK)
GEOID99	-16.178	-13.515
GEOID03	-16.205	-13.164
GEOID06	N/A	-11.443
GEOID09	-16.242	-11.567
GEOID12	-16.254 (0.041)	-11.523

- In most areas of the continental US, change from 99 to 12 is on the order of 20 cm max.
- Bigger in AK, HI, PR due to lack of gravity data
- Effect still significant for high accuracy differencing.



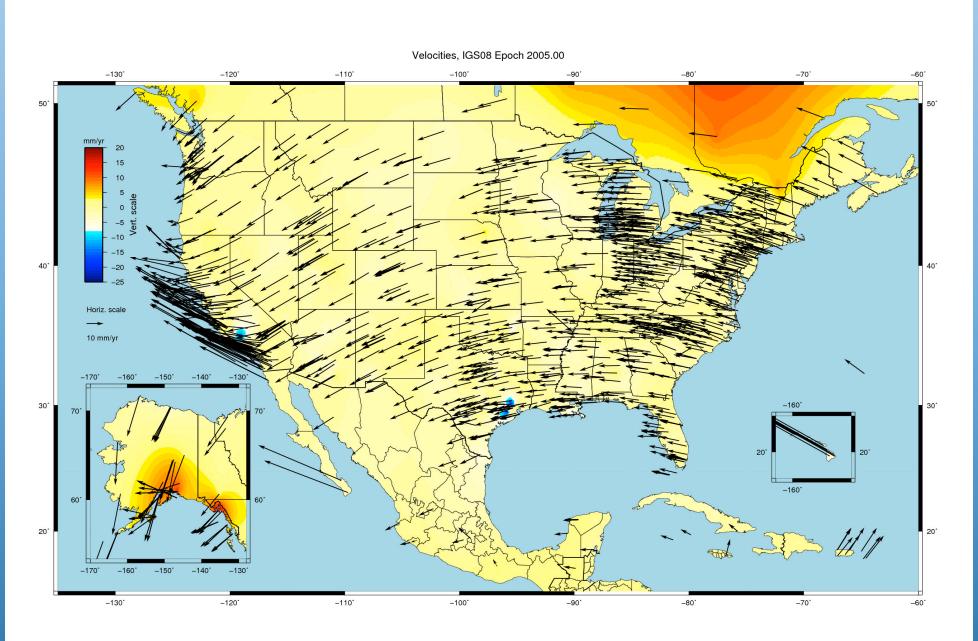
#### VCALM Reference Frame Differences



- Typically commercial work is tied to NGS reference frames the current realization of the North American Datum. For LiDAR, primary ones of interest are NAD83(CORS 96) and NAD83(2011)
- Scientific work tends to be tied to the current realization of the International Terrestrial Reference Frame. There are several of these: ITRF94, ITRF96, ITRF97, ITRF2000, ITRF2005, ITRF2008 and ITRF2014. Last four are of interest for legacy lidar.
- Main difference is that NAD83 is fixed to the North America plate, whereas ITRF considers plate tectonics and publishes station velocities.
- Thus for ITRF, the epoch of reference is also of significant importance.

# NCALM ITRF08 Station Velocities







## NCALM Size of Datum Differences Houston Berkeley



 Table below gives UTM coordinate differences for P041 (Marshall Field) in 4 different reference frames. ITRF00 is reference for differences.

DELTA FROM ITRF00 (meters)	NAD83 (CORS96)	ITRF08 (2005.0)	NAD83(2011)
North	0.72	0.05	0.71
East	-0.87	0.13	-0.87
Up	-0.88	-0.024	-0.883





### Computing Geoid/Datum Corrections

- For vertical differences, National Geodetic Survey (NGS) provides software tools for converting elevations to various Geoid models (www.ngs.noaa.gov).
  - These conversions don't work on point clouds directly.
- For Datum differences, NGS also provides the tool HTDP (Horizontal Time Dependent Positioning) to compute correction vectors between datums and epochs.
- Crux is actually determining the datum and geoid used for legacy datasets...

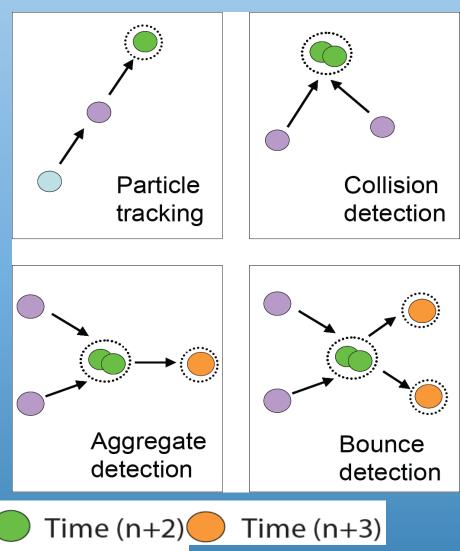


## ENCALM Particle Image Velocimetry (PIV) I UNIVERSITY of Houston Berkeley





Developed in the fluid dynamics community to track particles seeded into a fluid





Time (n)



Time (n+1)



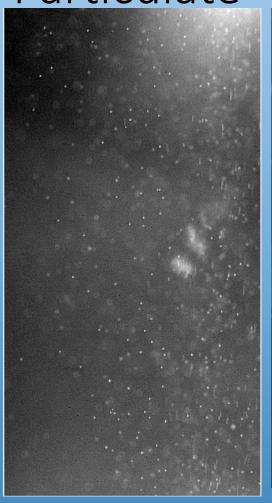


## PIV Example – 125 to 250 μm





Particulate





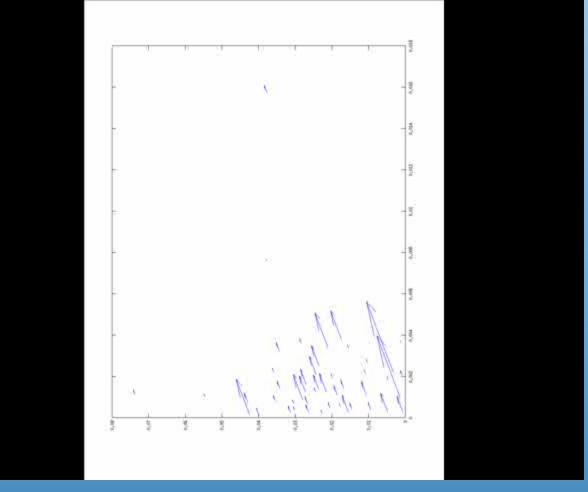


## PIV Example – 125 to 250 μm

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Partic<u>ulate</u>





#### C A L VI Applying PIV to LiDAR data



- PIV is inherently image based but point clouds are not images
- Point clouds need to be rasterized prior to running PIV
  - Ex. Matlab, MicroStation
  - Raster resolution is key
    - Raster grid too large features are obscured or lost
    - Raster grid too small data too noisy
    - For instance, if detectable motion is on the scale of 10 m, a 20 m raster would not show real motion

#### Algorithms

- PIVLab uses a combination of pixel mapping and larger feature tracking to reduce scatter
- Home built algorithms
- Commercial software