

Geodetic Monumentation

USGS Meeting Geodesy Workshop

March 12, 2010

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Monumentation

❖ Planning

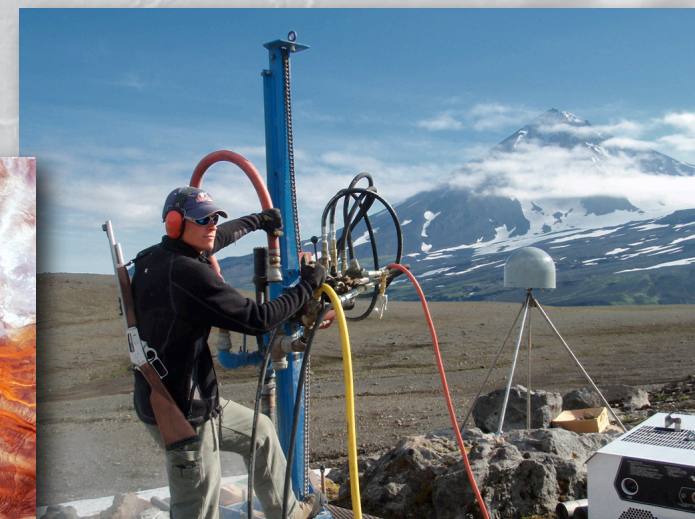
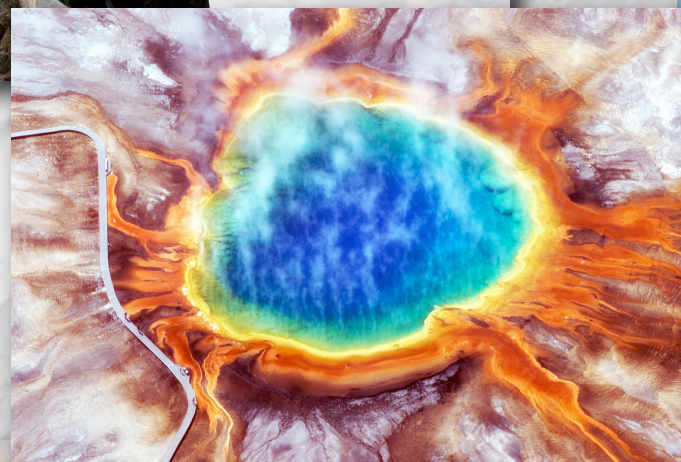
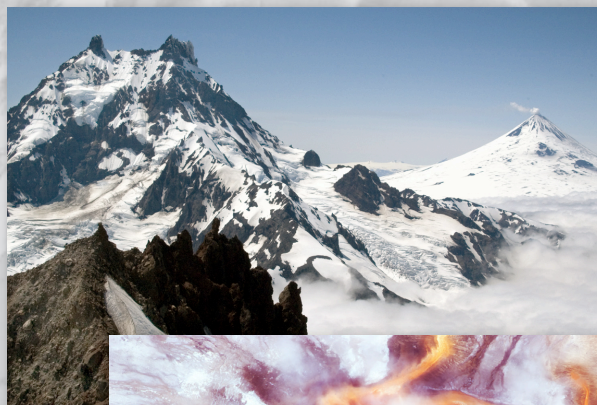
- ❖ Application drives the type
- ❖ If in doubt over engineer

❖ Monument types

- ❖ Deep
- ❖ Short
- ❖ Pillar
- ❖ Center Mast
- ❖ Short Non-drilled
- ❖ Thermopile


❖ Location, location, location

- ❖ Poor Geology Example
- ❖ Poor Location Example



- <http://facility.unavco.org/kb/questions/104/UNAVCO+Resources:+GNSS+Station+Monumentation>

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Supporting high-precision techniques
for the measurement of crustal deformation

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UNAVCO Resources: GNSS Station Monumentation

UNAVCO Resources: GNSS Station Monumentation

[Current as of December 2008.]


UNAVCO can provide assistance with design, purchasing, and construction of geodetic monumentation to NSF- and NASA-funded science groups. We currently support and recommend the following monument types for permanent, long-term, and campaign GNSS site installations. Click on the links below for more information on each.


Things to consider in choosing a monument type include stability (precision) needed, funds available, time available, site accessibility, site security, substrate, and materials available. For details on site selection and additional information on monumentation in general consider reading: [Physical Site Specifications: Geodetic Site Monumentation](#).


Article Details


Last Updated
24th of February, 2010


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

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Permanent and Long-term Monument Comparison Table

	Type	Stability*	Cost**	Install Time	Labor	Substrate	Site Impact
	Deep drilled braced (permanent)	 high	 \$7,500-15,000	 2-4 d	 3-4	BR, U	 high
	Shallow drilled braced (permanent)	 high	 \$800+	 1-3 d	 2-3	BR	 med

P515 Deep Monument

Back to comparison table	Mount Commonly Used	Stability	Cost	Install Time	Labor	Substrate	Site Impact
	 SCIGN mount	 high	 \$7,500-15,000	 2-4 d	 3-4	BR, U	 high

Pros

- high stability
- longevity
- can be installed in either bedrock or unconsolidated materials

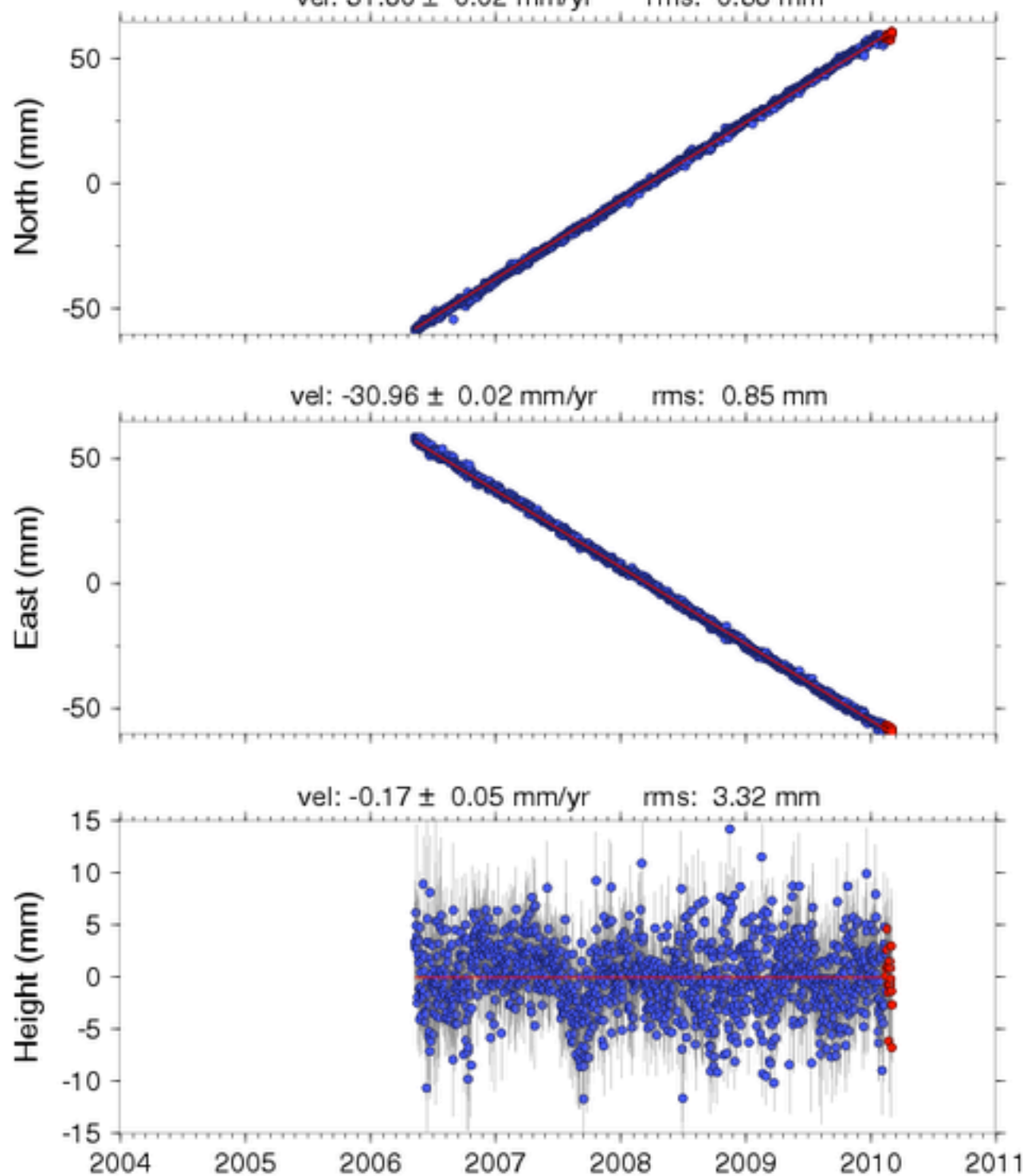
Cons

- labor and tool intensive (requires a drilling rig and crew)
- expensive (can be \$7,500 to \$15,000, depending on drilling)
- time intensive (requires 2-4 days)
- may not be able to install in some remote locations... depends upon ease of site access
- large construction disturbance footprint



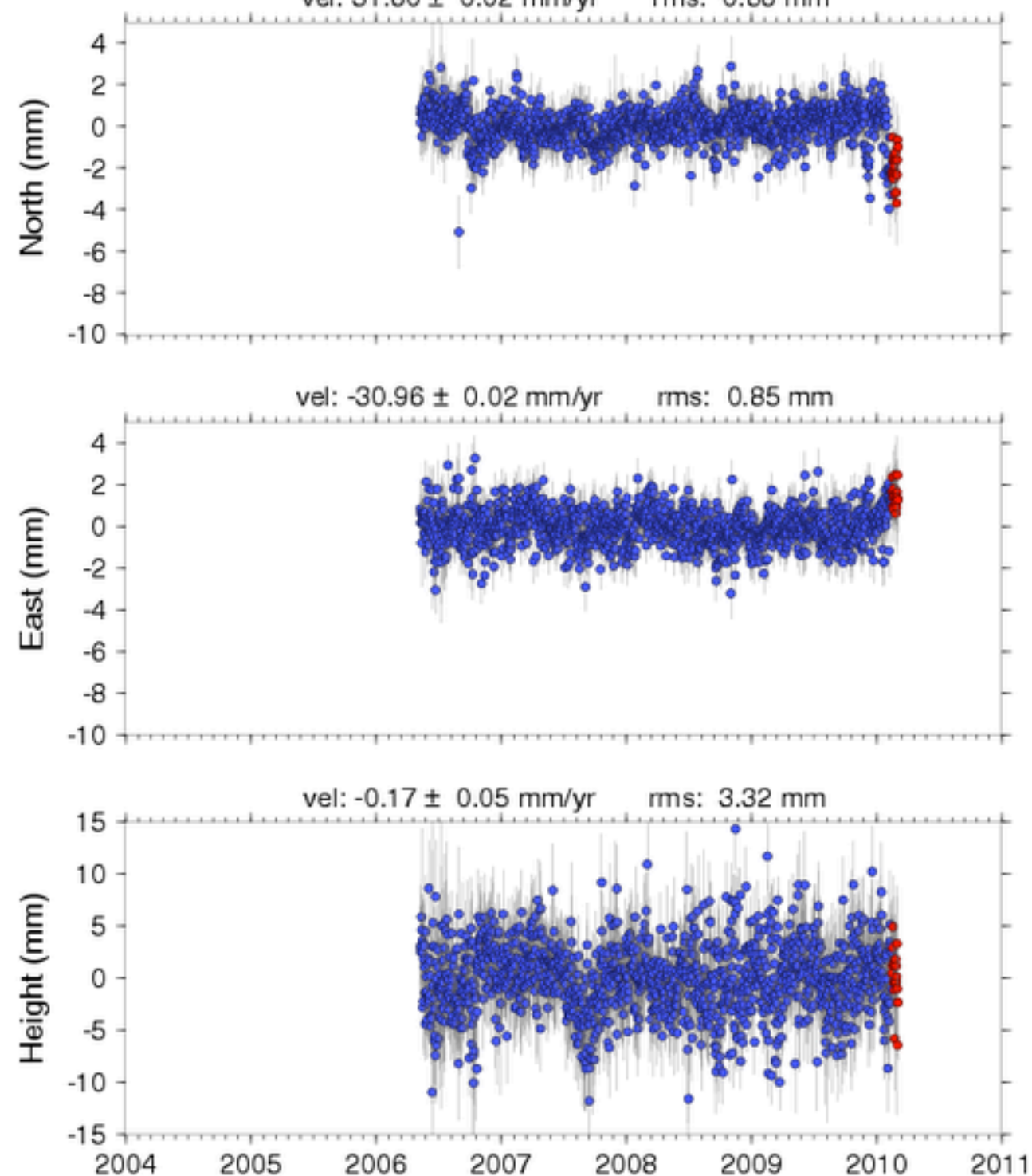
Unfiltered Plot








P515 (Tepusquet_CS2006)

vel: 31.60 ± 0.02 mm/yr rms: 0.86 mm

Detrended Plot

P515 (Tepusquet_CS2006) - Detrended

vel: 31.60 ± 0.02 mm/yr rms: 0.86 mm

Back to comparison table	Mount Commonly Used	Stability	Cost	Install Time	Labor	Substrate	Site Impact
	 SCIGN mount	 high	 \$800+	 1-3 d	 2-3	BR	 med

Pros

- very stable
- materials relatively inexpensive (~\$800)
- longevity
- materials and equipment can be flown to remote locations by helicopter
- can be installed in environmentally sensitive sites (small construction footprint)
- relatively quick deployment
- site permitting potentially easier than for the deep drilled braced monument

Cons

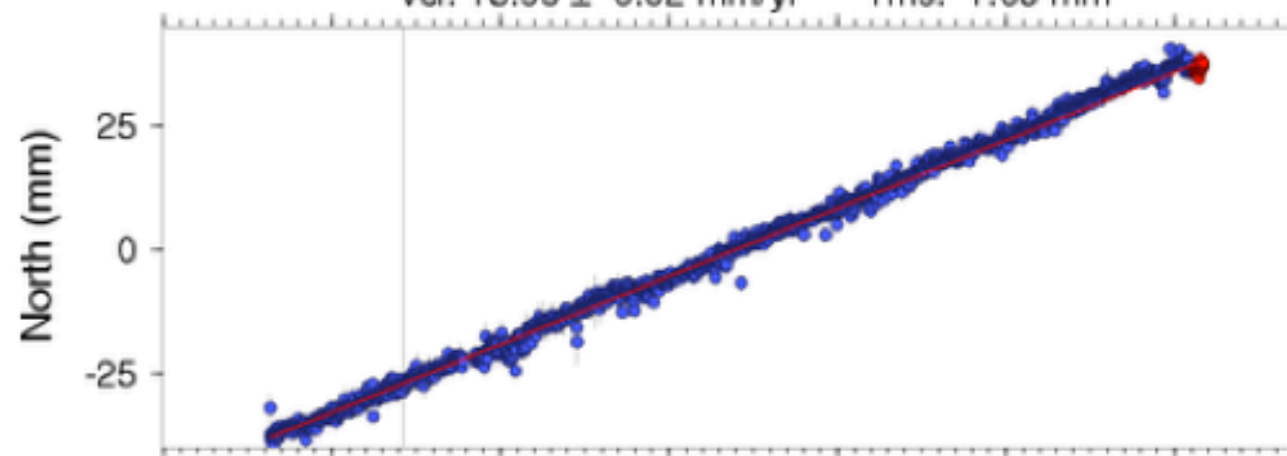
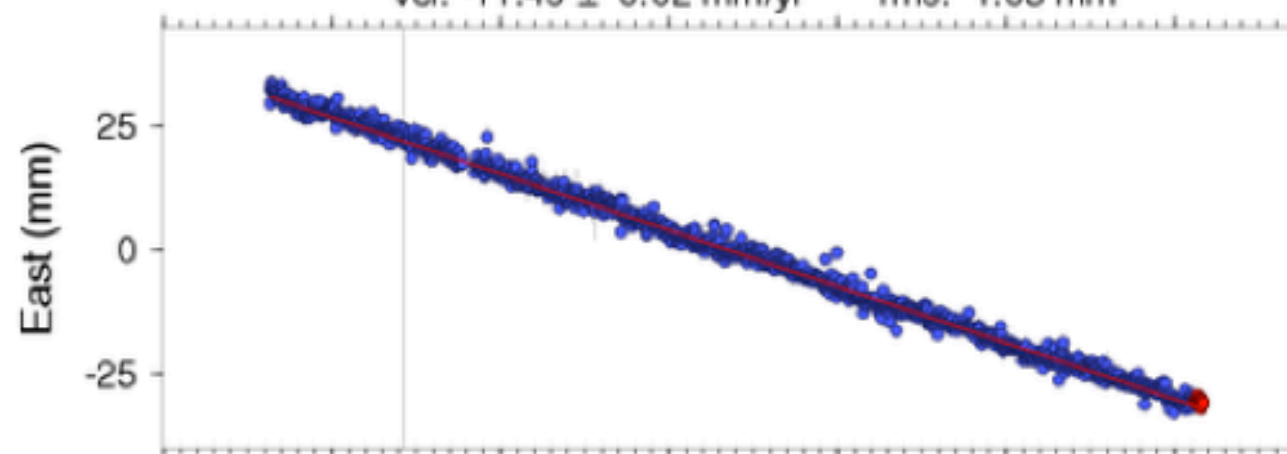
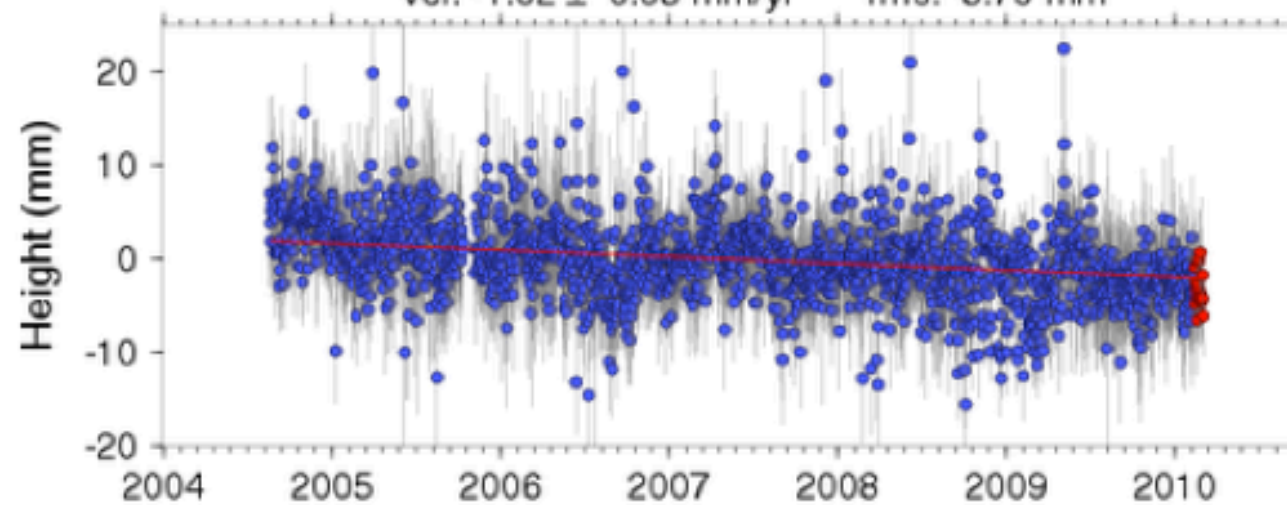
- labor and tool intensive
- requires competent bedrock at or within 0.5m of the surface
- is possibly less stable than the deeply anchored monument
- initial cost to purchase required tools potentially expensive



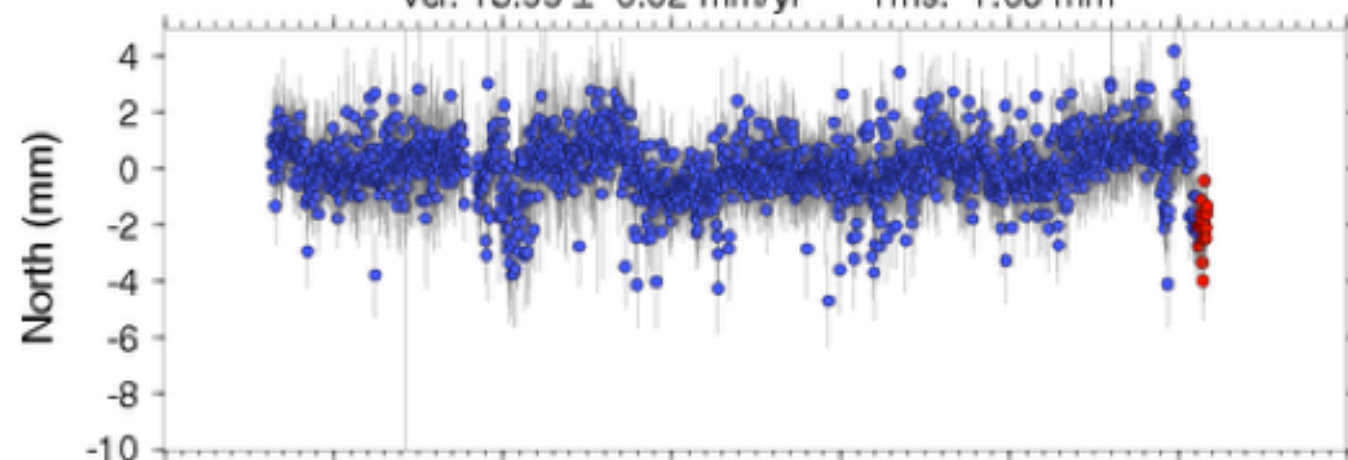
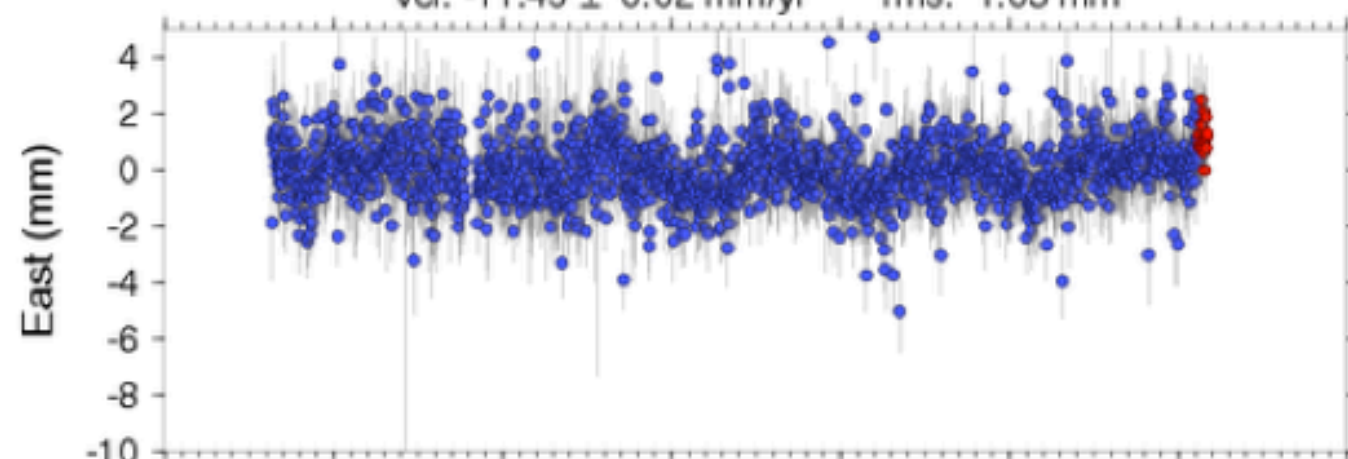
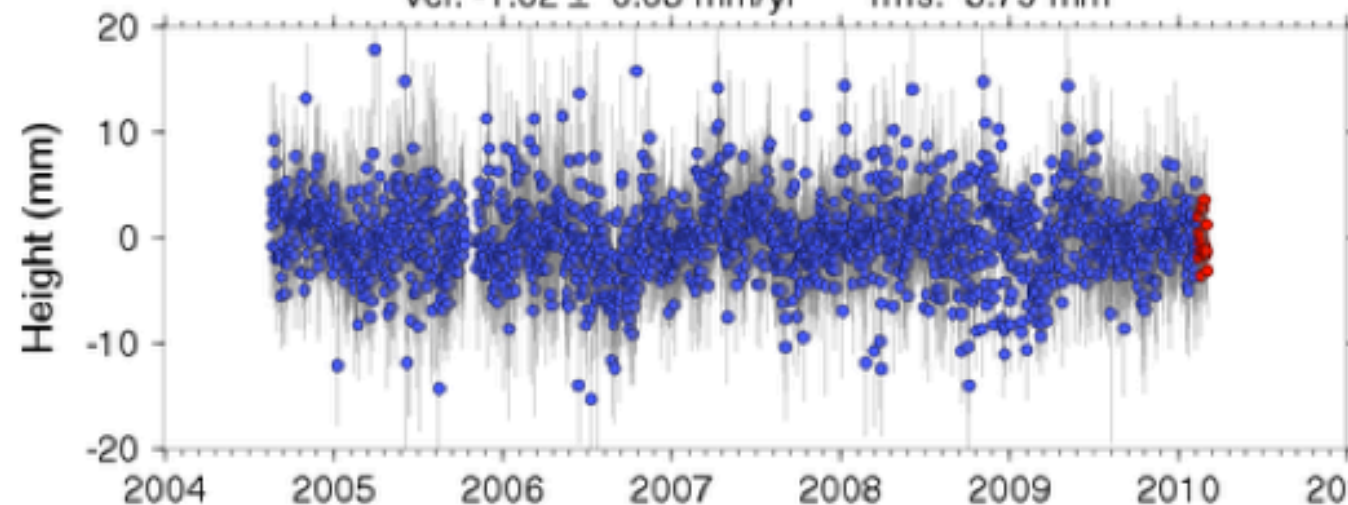
Unfiltered Plot








Cleaned Plot

P562 (SoledadMtnCS2004)

vel: 13.99 ± 0.02 mm/yr rms: 1.06 mmvel: -11.49 ± 0.02 mm/yr rms: 1.05 mmvel: -1.02 ± 0.03 mm/yr rms: 3.79 mm

P562 (SoledadMtnCS2004) - Cleaned

vel: 13.99 ± 0.02 mm/yr rms: 1.06 mmvel: -11.49 ± 0.02 mm/yr rms: 1.05 mmvel: -1.02 ± 0.03 mm/yr rms: 3.79 mm

Back to comparison table	Mount Commonly Used	Stability	Cost	Install Time	Labor	Substrate	Site Impact
	 e.g. SECO 2072-series	 med	 \$500-2,000	 1-3 d	 2-3	BR, U	 med

Pros

- Can be very inexpensive
- Materials and tools required are widely available
- Easy to construct (varies with design)
- Can be installed upon bedrock or in unconsolidated material

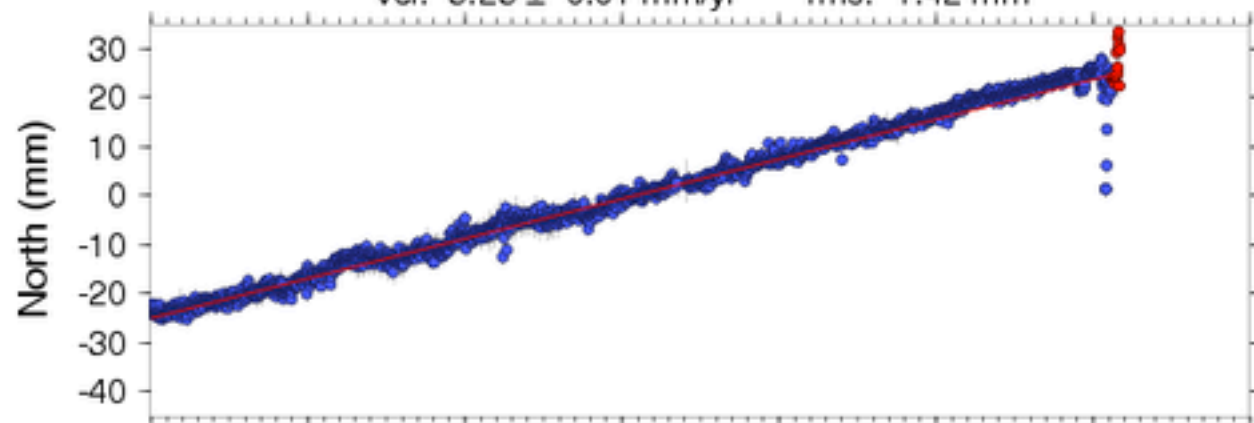
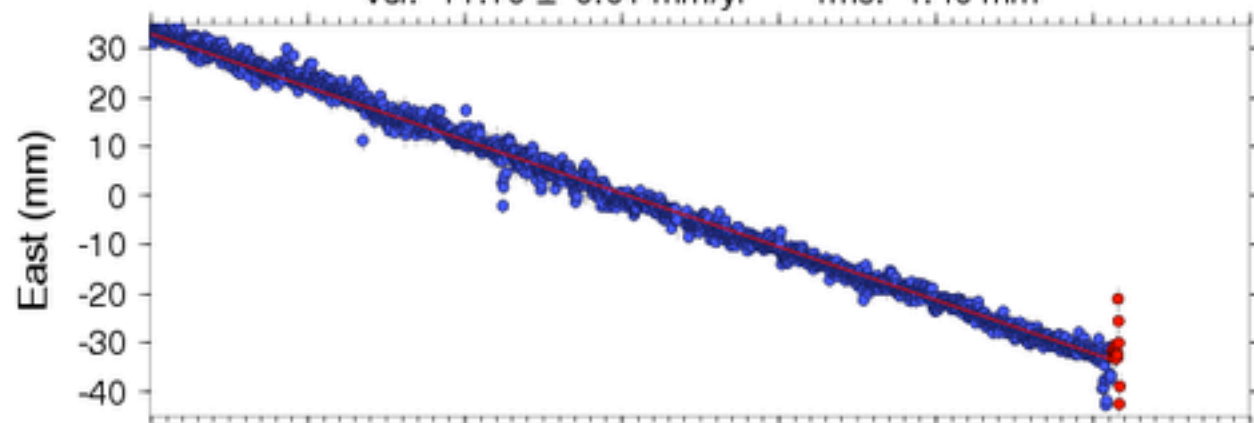
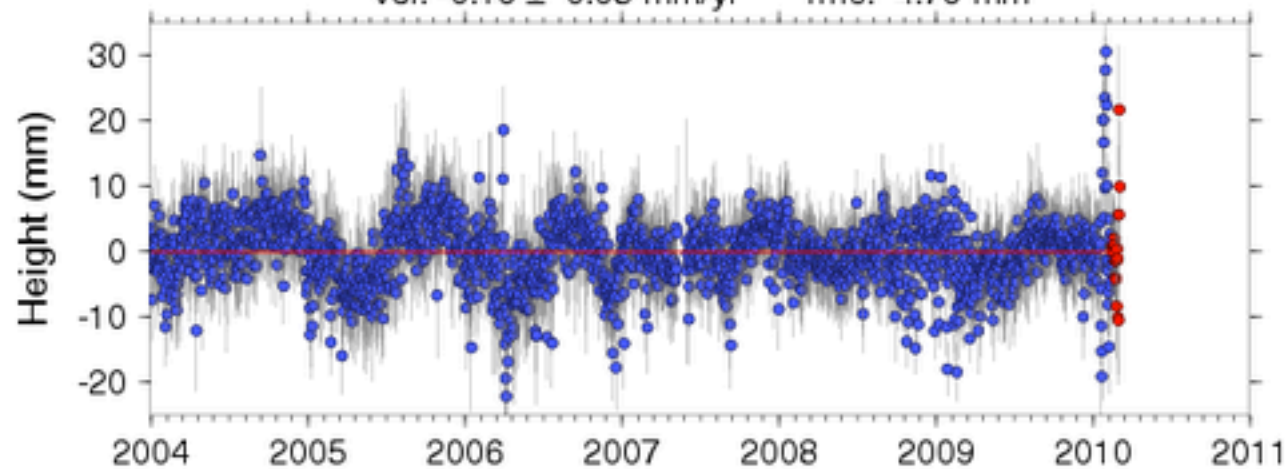
Cons

- Concrete can degrade over time through freeze-thaw action
- Weight of concrete mass can settle in certain unconsolidated materials over time
- Probably does not provide the long-term stability of a drilled-braced type monument



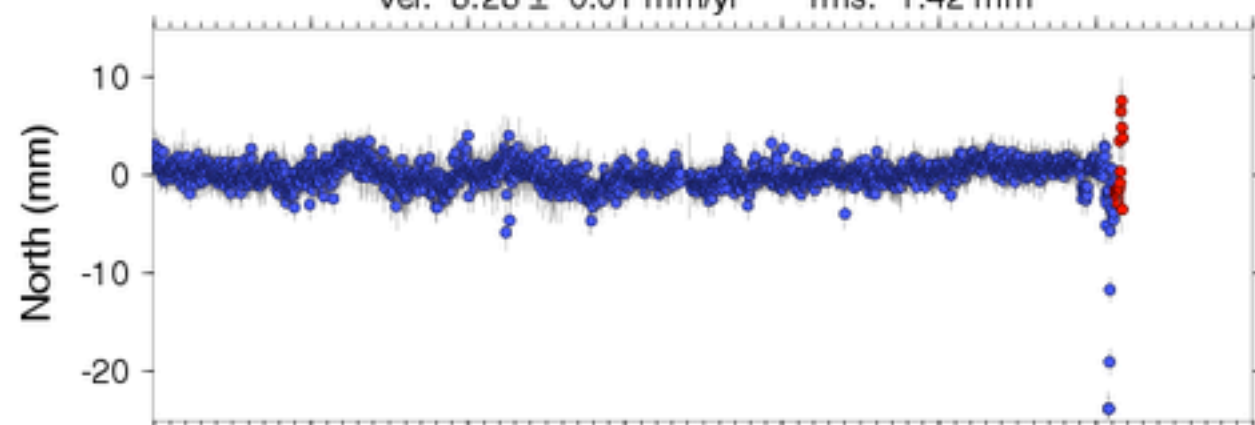
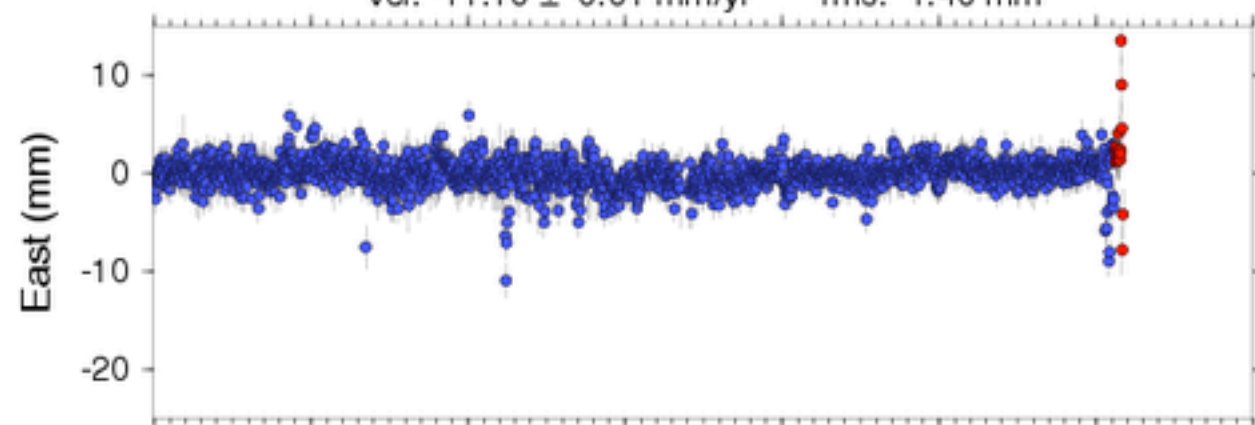
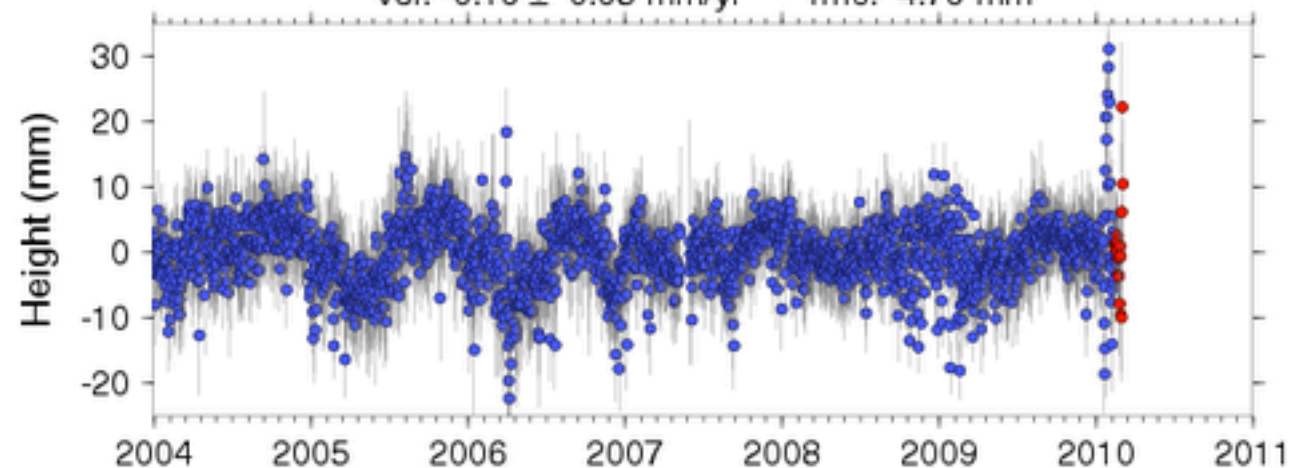
Unfiltered Plot

MUSB (MUSB_BARD_CN1997)








vel: 8.28 ± 0.01 mm/yr rms: 1.42 mmvel: -11.10 ± 0.01 mm/yr rms: 1.40 mmvel: -0.19 ± 0.03 mm/yr rms: 4.79 mm

Detrended Plot

MUSB (MUSB_BARD_CN1997) - Detrended

vel: 8.28 ± 0.01 mm/yr rms: 1.42 mmvel: -11.10 ± 0.01 mm/yr rms: 1.40 mmvel: -0.19 ± 0.03 mm/yr rms: 4.79 mm

Center Mast - TSWY

Back to comparison table	Mount Commonly Used	Stability	Cost	Install Time	Labor	Substrate	Site Impact
	 SCIGN mount	 med-high	 \$150	 1-2 d	 1	BR	 low

Pros

- Inexpensive (approximately \$150 for basic materials)
- Materials are readily available
- Small footprint, low-profile

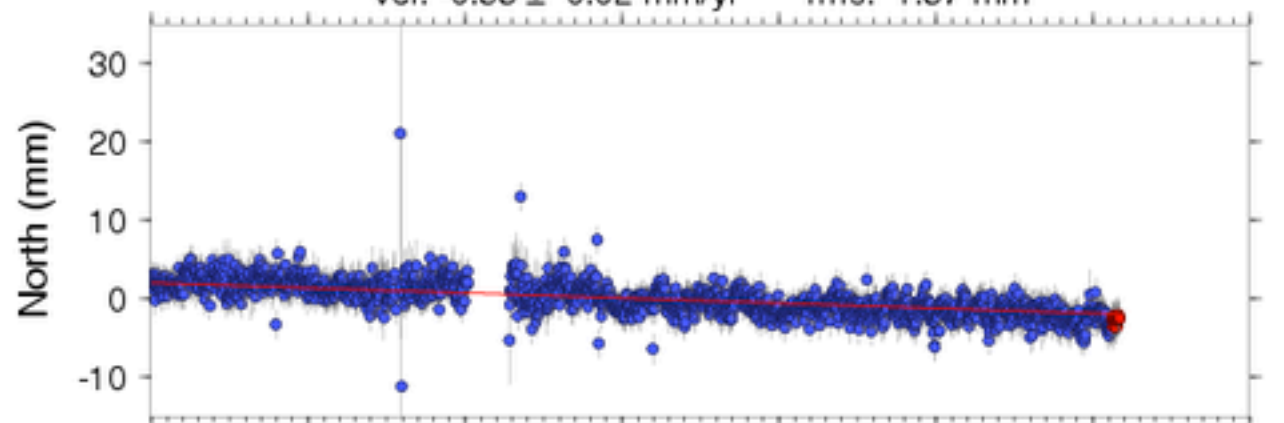
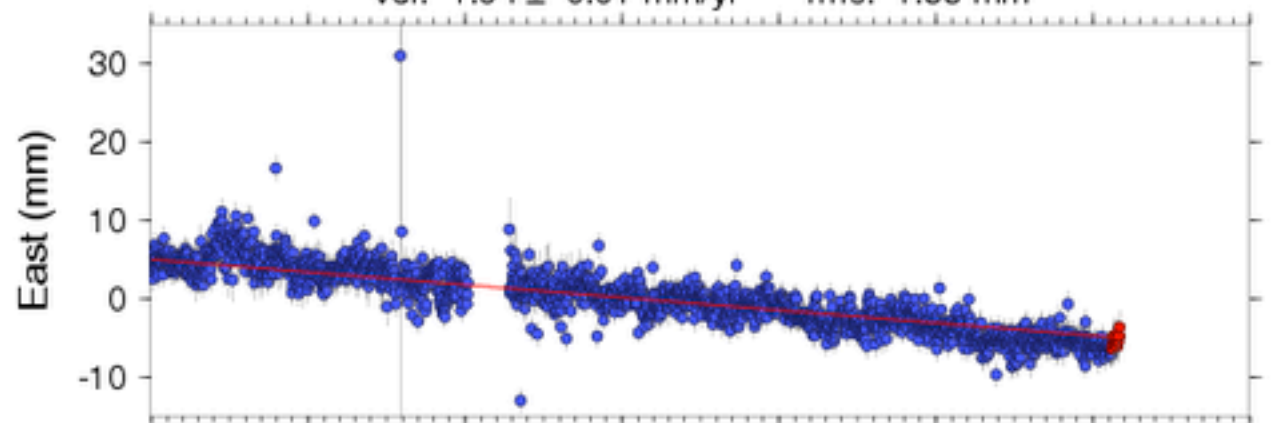
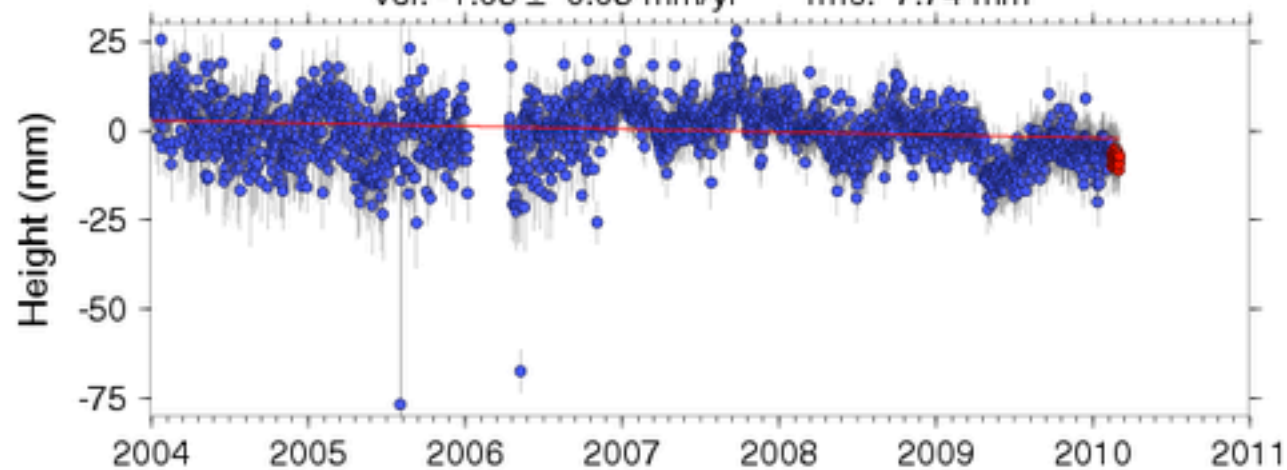
Cons

- Can only be installed in solid material
- Requires heavy-duty hammer drill



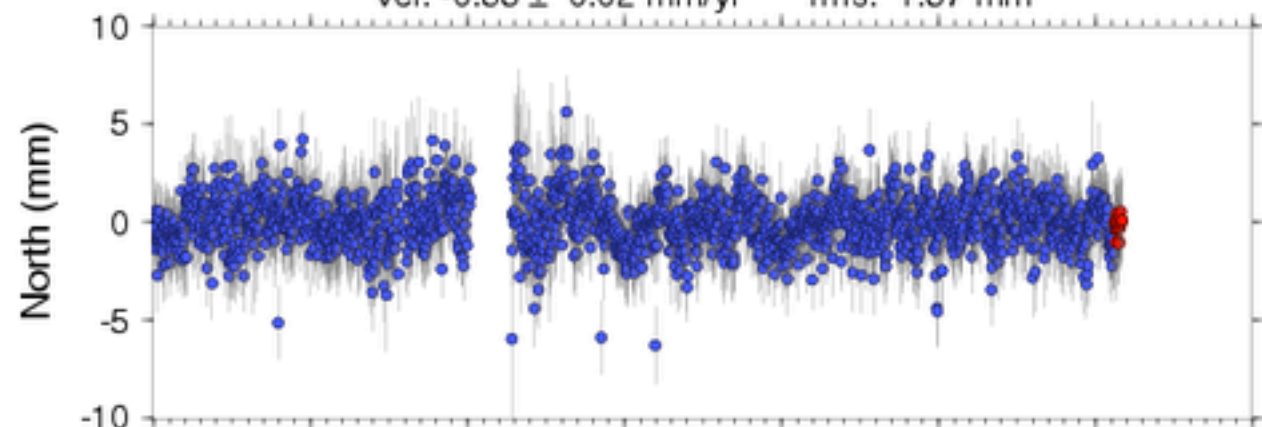
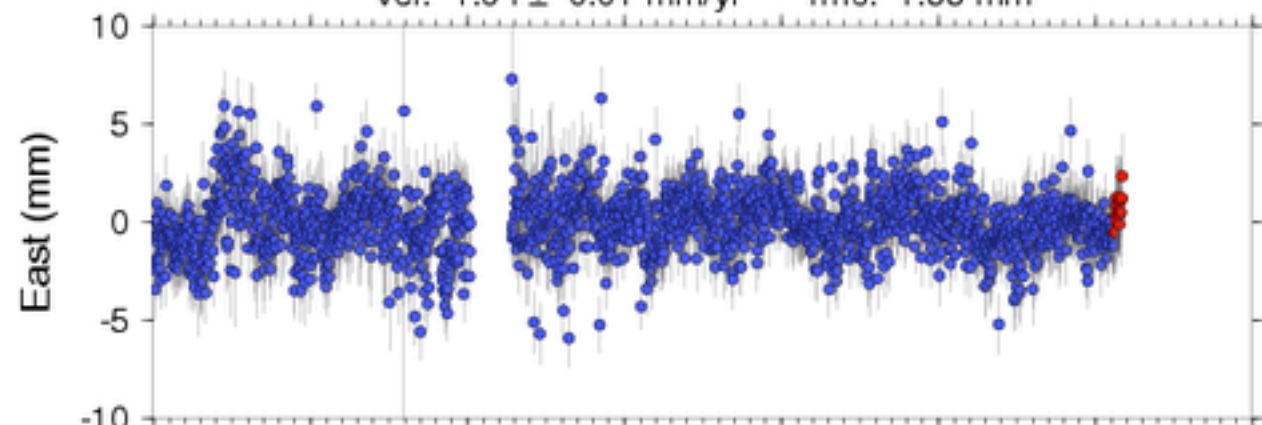
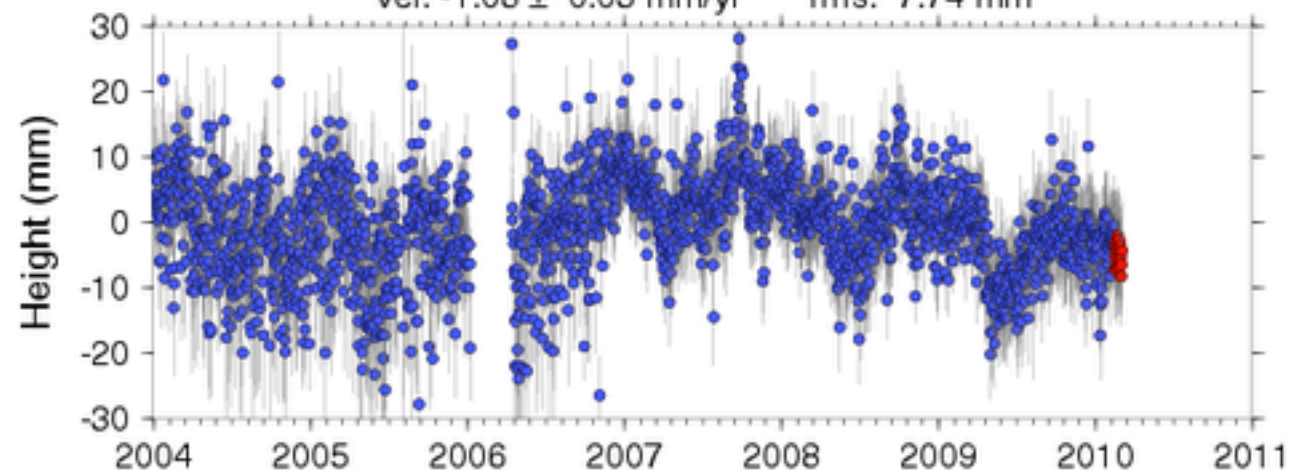
Unfiltered Plot

TSWY (TSWY_EBRY_WY2001)








vel: -0.83 ± 0.02 mm/yr rms: 1.37 mmvel: -1.94 ± 0.01 mm/yr rms: 1.66 mmvel: -1.08 ± 0.03 mm/yr rms: 7.74 mm

Cleaned Plot

TSWY (TSWY_EBRY_WY2001) - Cleaned

vel: -0.83 ± 0.02 mm/yr rms: 1.37 mmvel: -1.94 ± 0.01 mm/yr rms: 1.66 mmvel: -1.08 ± 0.03 mm/yr rms: 7.74 mm

Shallow Braced (non-drilled) Monument

Back to comparison table	Mount Commonly Used	Stability	Cost	Install Time	Labor	Substrate	Site Impact
	 SCIGN mount	 med	 \$800	 1 d	 2-3	U	 med

Pros

- installable in unconsolidated substrate
- materials relatively inexpensive
- drill bits will not get stuck (as in short drilled braced monument)
- materials and equipment can be flown to remote locations by helicopter
- can be installed in environmentally sensitive sites
- relatively quick deployment
- site permitting potentially easier than for the deep drilled braced monument

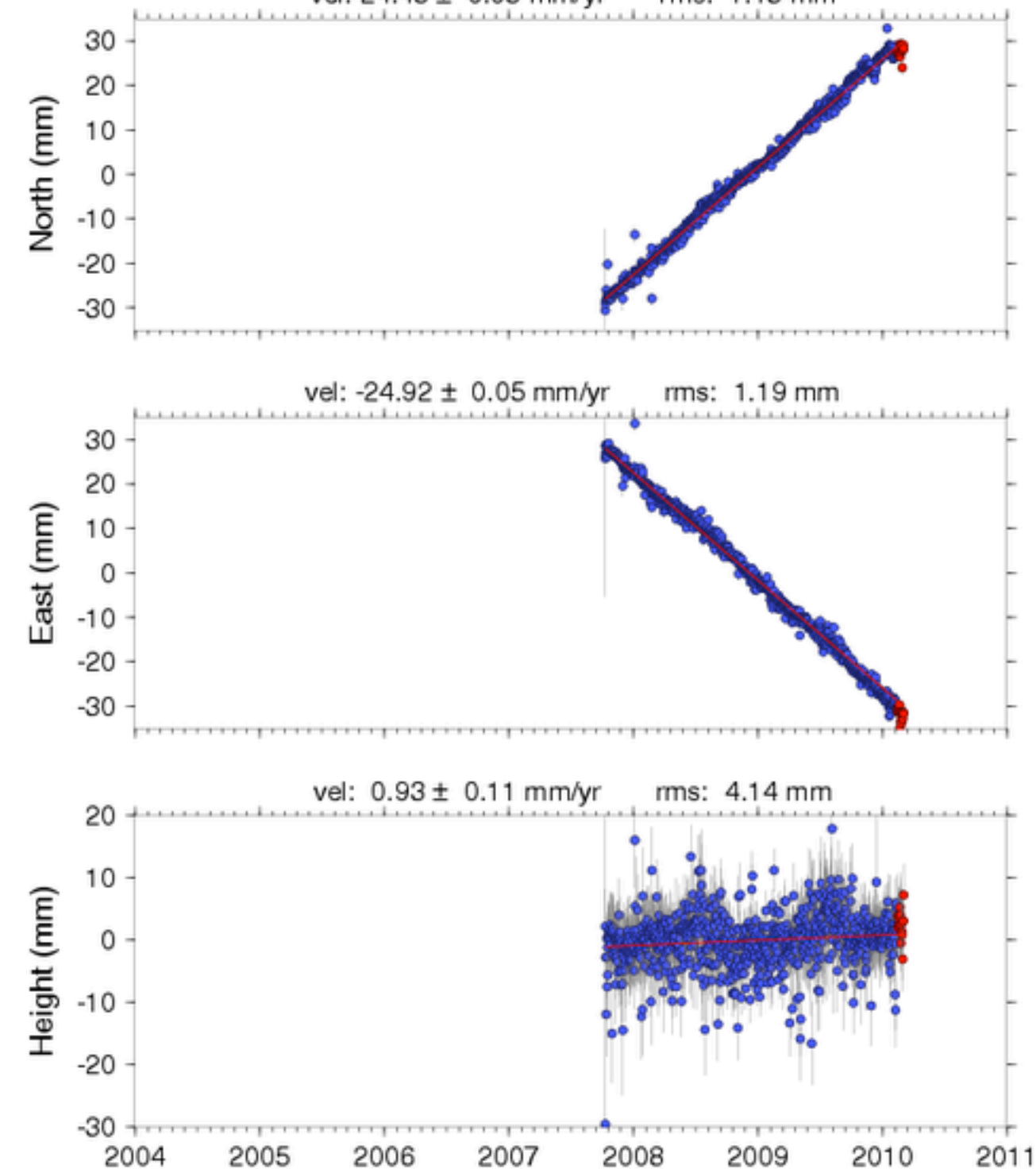
Cons

- labor and tool intensive
- is probably less stable than the deep drilled braced monument
- initial cost to purchase required tools potentially expensive



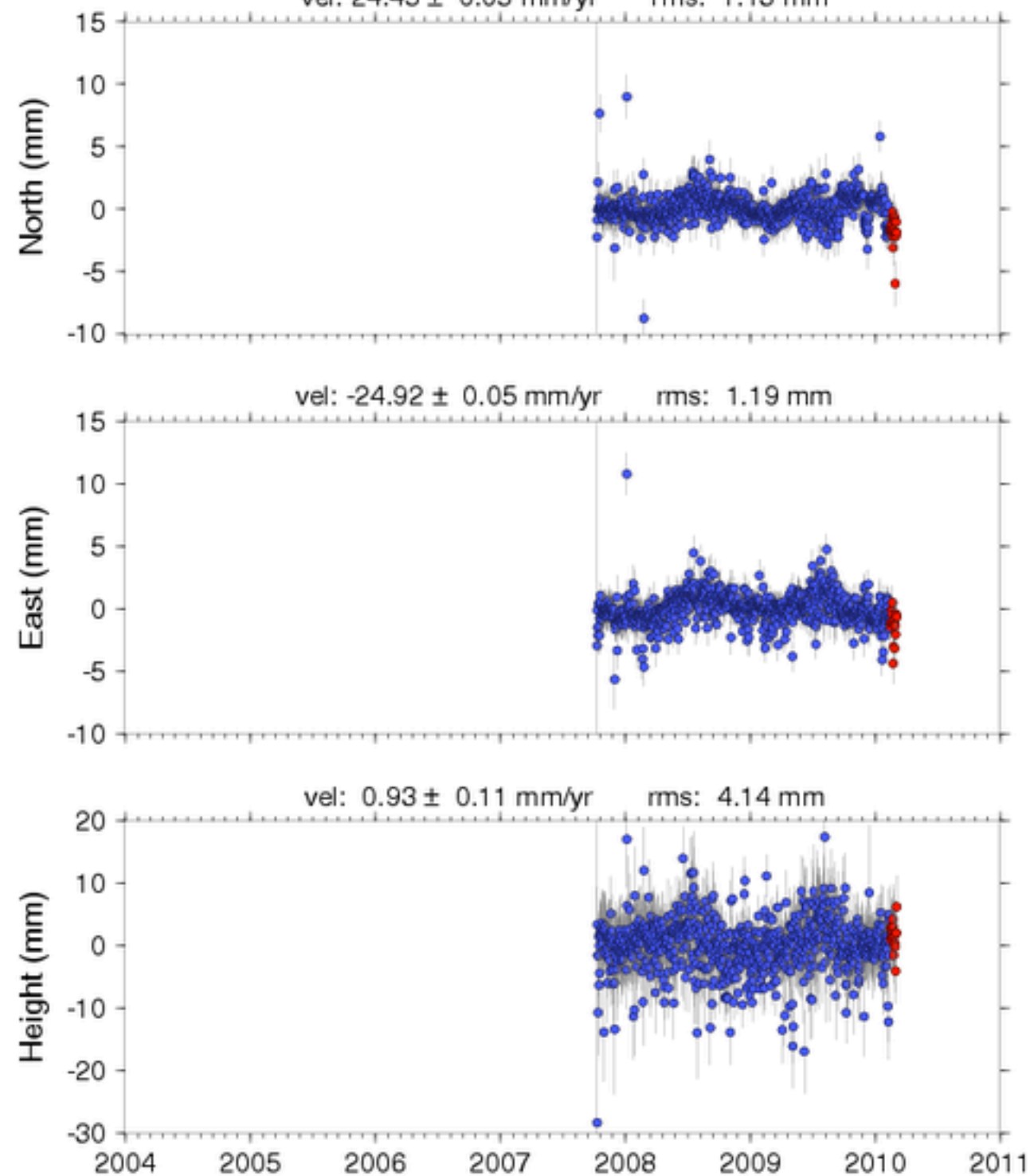
Unfiltered Plot

P492 (CrzoBadIndCS2007)








vel: 24.45 ± 0.05 mm/yr rms: 1.13 mm

Detrended Plot

P492 (CrzoBadIndCS2007) - Detrended

vel: 24.45 ± 0.05 mm/yr rms: 1.13 mm

Thermopile AB18

Back to comparison table	Mount Commonly Used	Stability	Cost	Install Time	Labor	Substrate	Site Impact
	 SCIGN mount	 med-high	 \$6,700-16,000	 1-4 d	 1	U	 high

Pros

- can be installed in permafrost

Cons

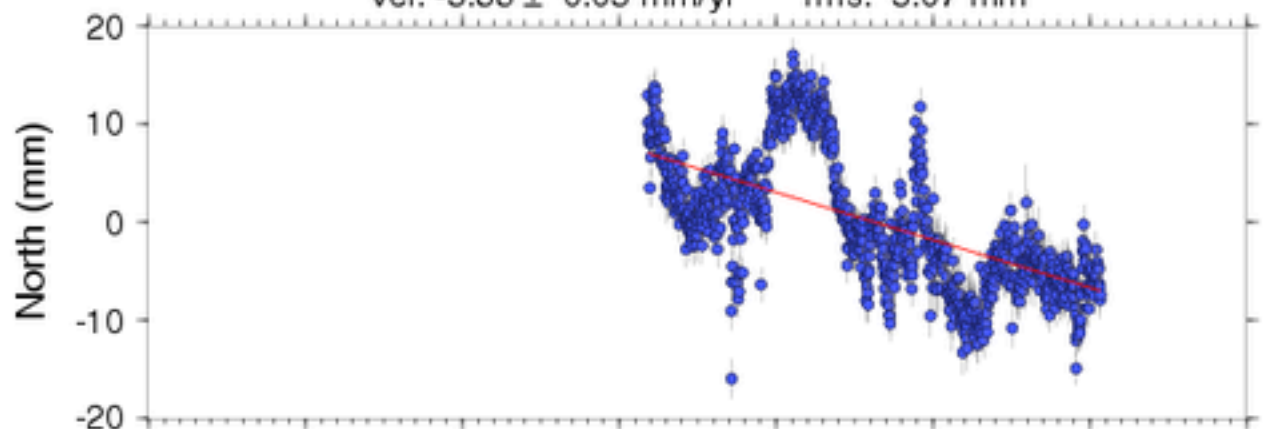
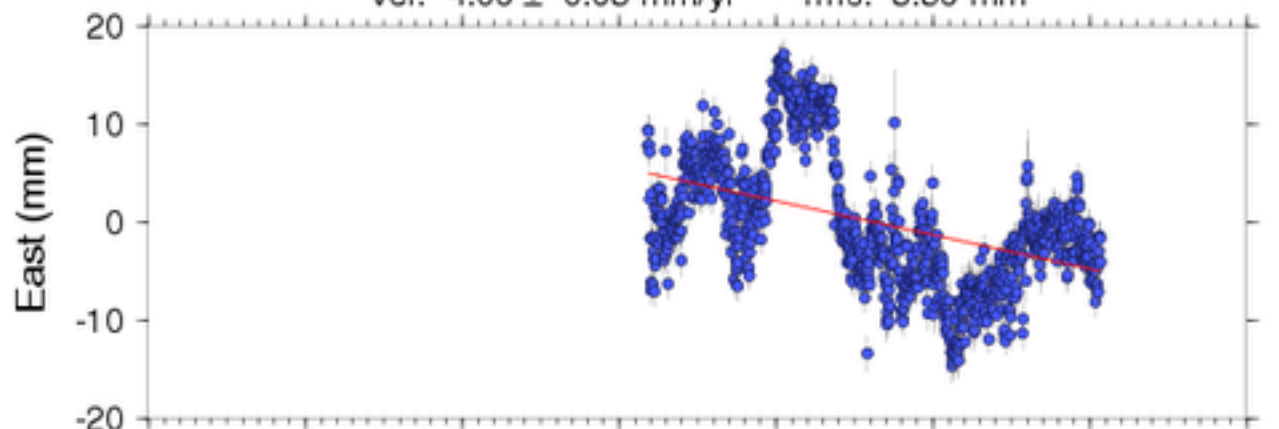
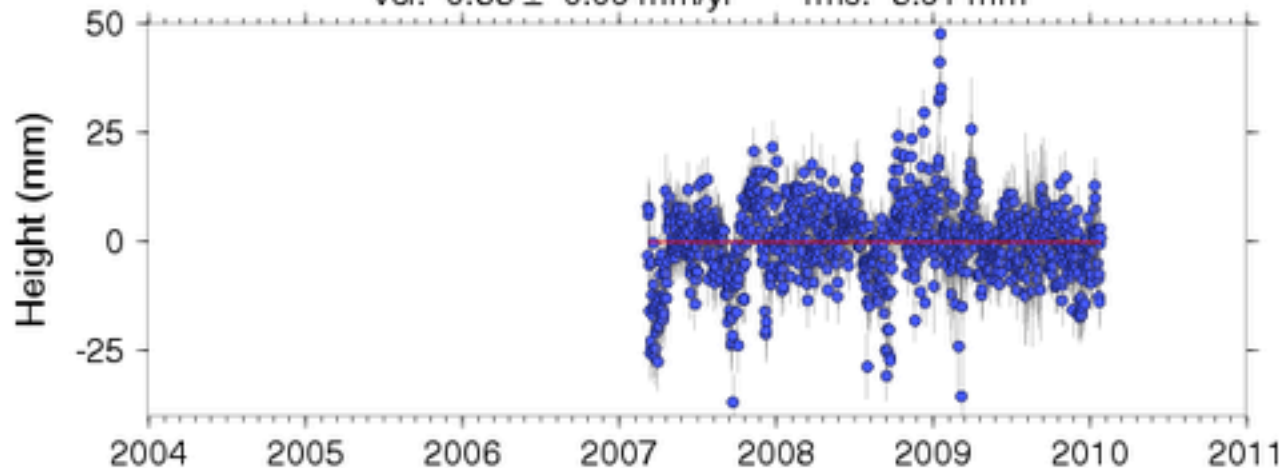
- labor and tool intensive (requires a drilling rig and crew)
- expensive (can be \$6,700 to \$16,000, depending on drilling)
- can be time intensive (requires 1-4 days)
- may not be able to install in some remote locations... depends upon ease of site access
- large construction disturbance footprint



Thermopile AB18

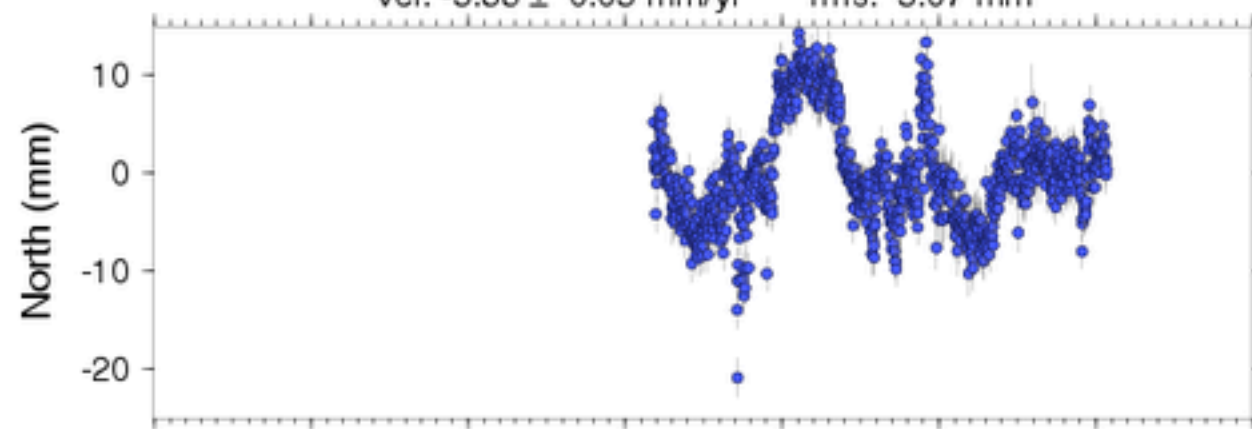
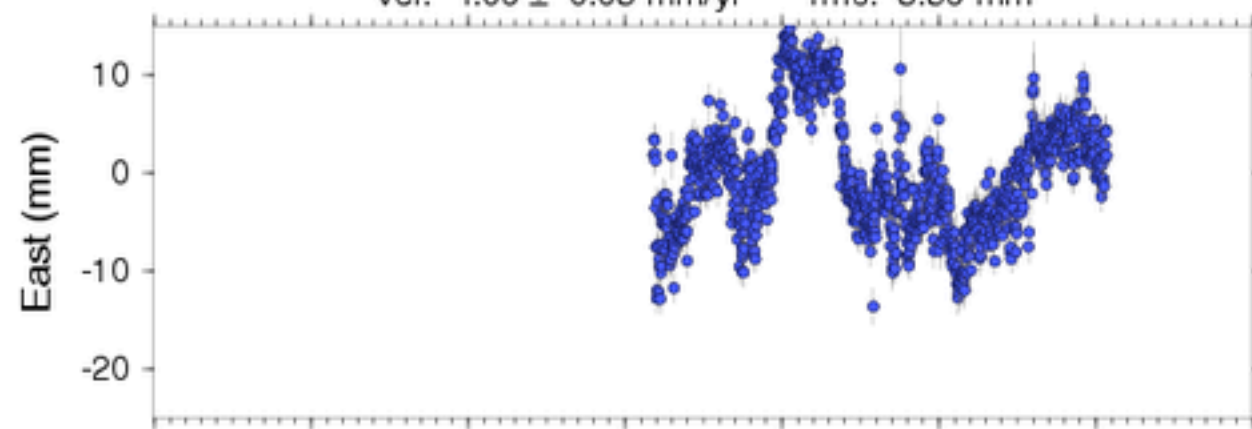
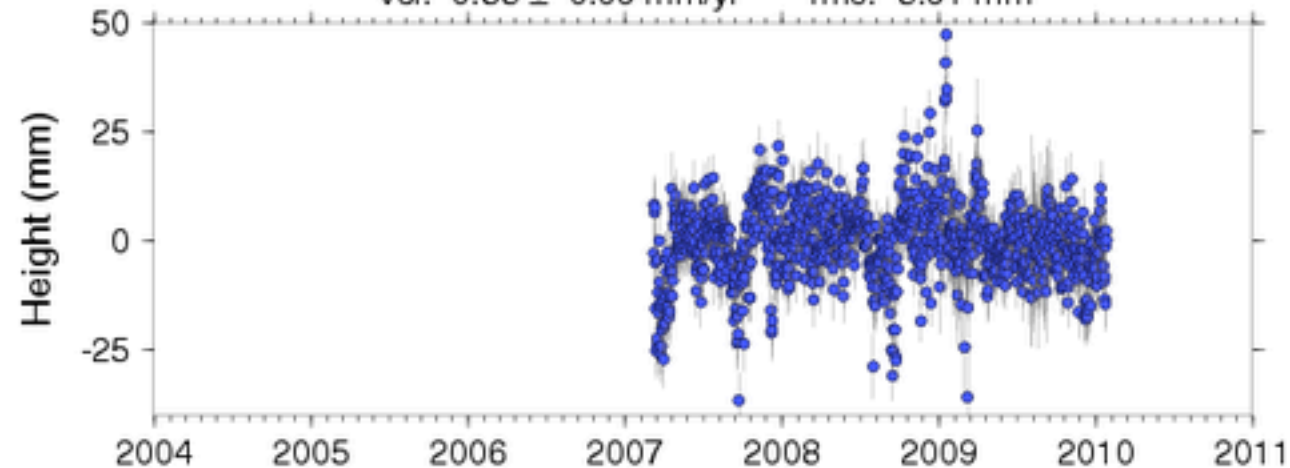
Unfiltered Plot

AB18 (Kotzebue__AK2007)

vel: -5.38 ± 0.05 mm/yr rms: 5.07 mmvel: -4.09 ± 0.05 mm/yr rms: 5.89 mmvel: 0.38 ± 0.09 mm/yr rms: 8.91 mm

Detrended Plot

AB18 (Kotzebue__AK2007) - Detrended

vel: -5.38 ± 0.05 mm/yr rms: 5.07 mmvel: -4.09 ± 0.05 mm/yr rms: 5.89 mmvel: 0.38 ± 0.09 mm/yr rms: 8.91 mm

West

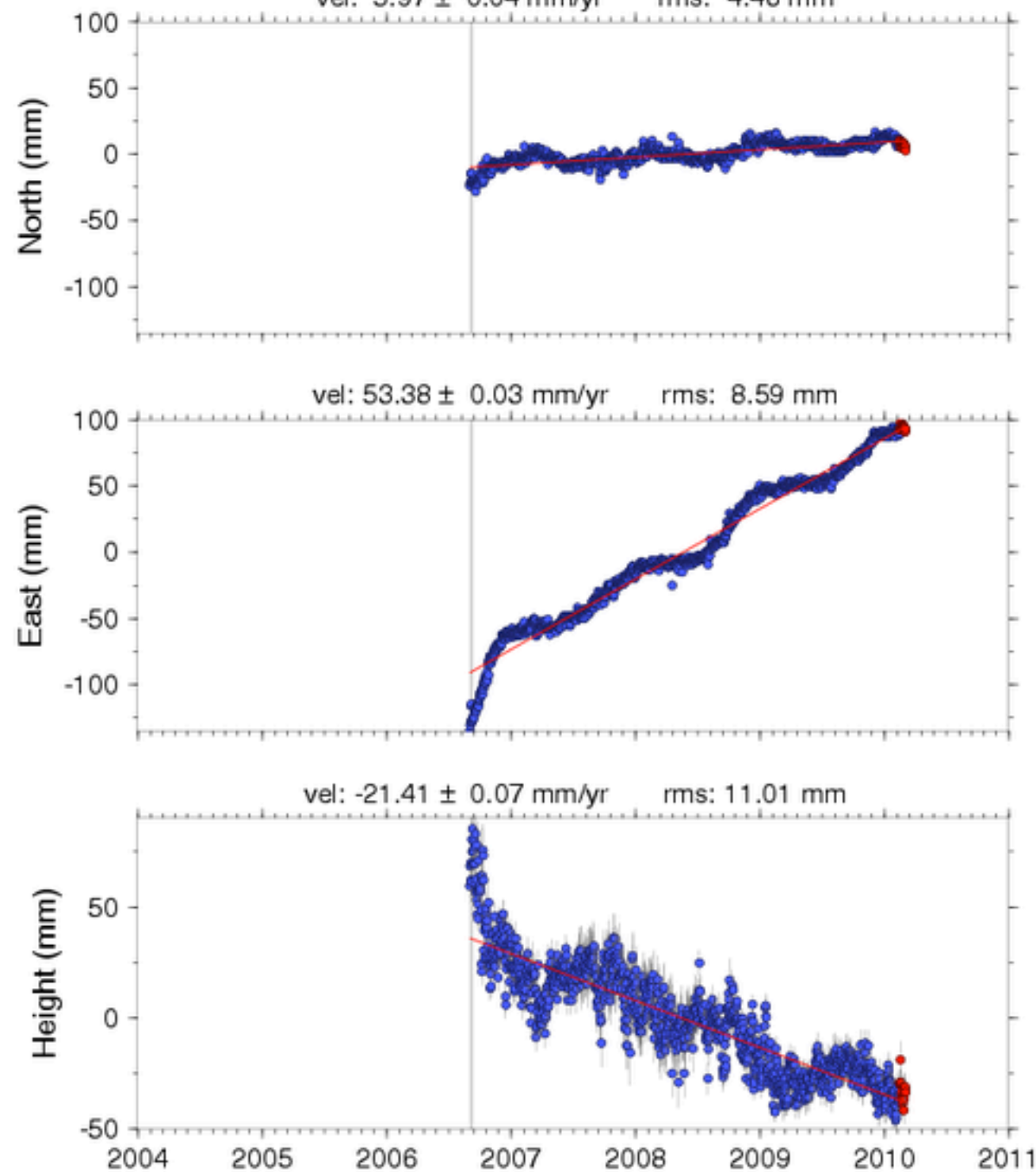
Vegetation lineament may be fissure



Poor location - AC55

Unfiltered Plot

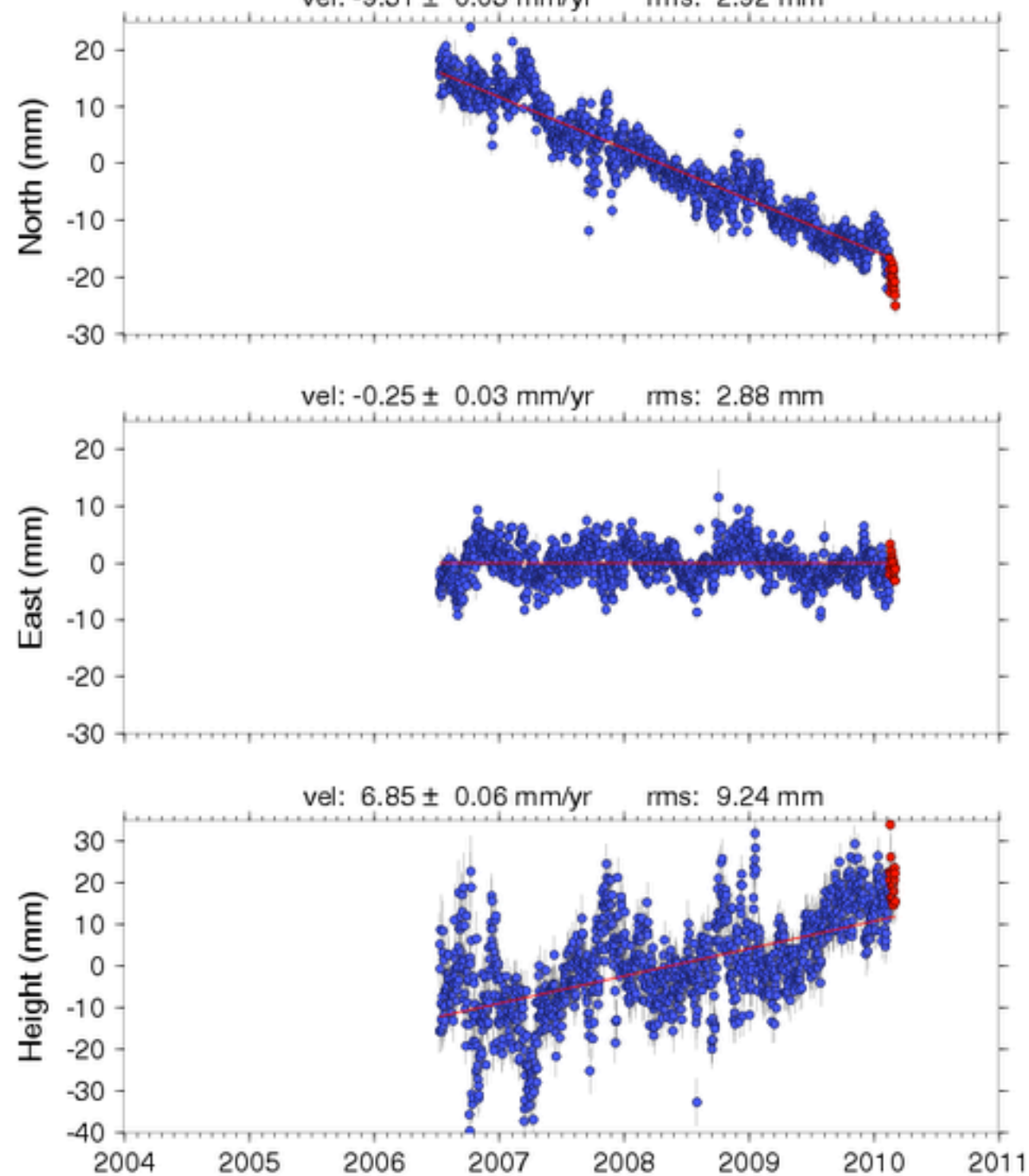
AC55 (Yentna_RvrAK2006)

vel: 5.97 ± 0.04 mm/yr rms: 4.46 mm

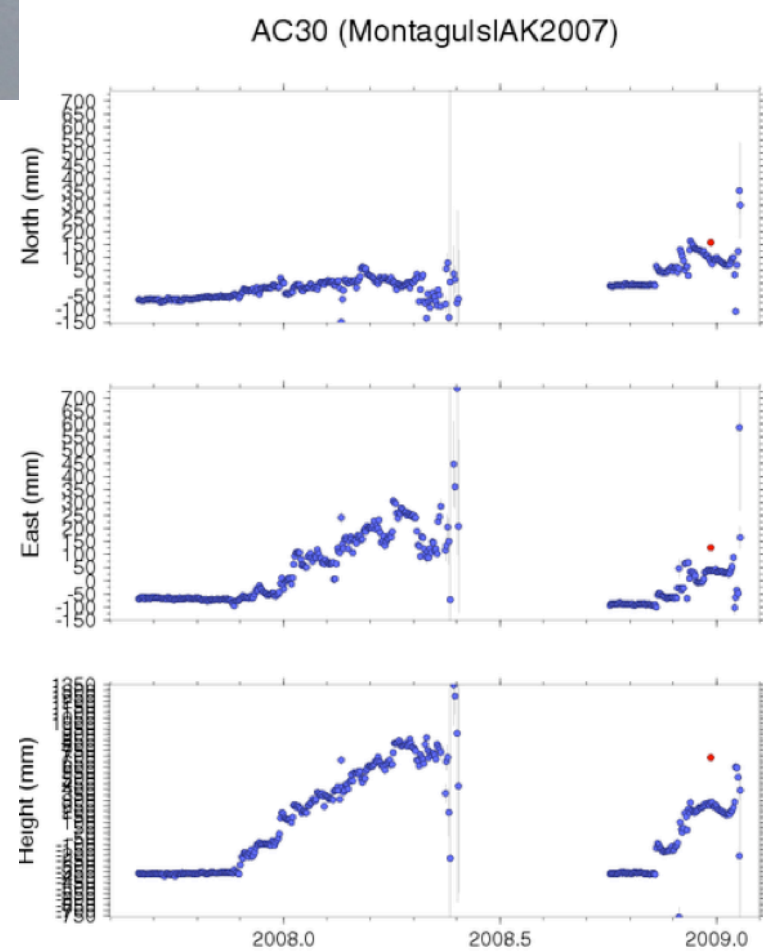
Unfiltered Plot

~50 km from AC55

AB28 (Rainy_PassAK2006)

vel: -9.31 ± 0.03 mm/yr rms: 2.92 mm

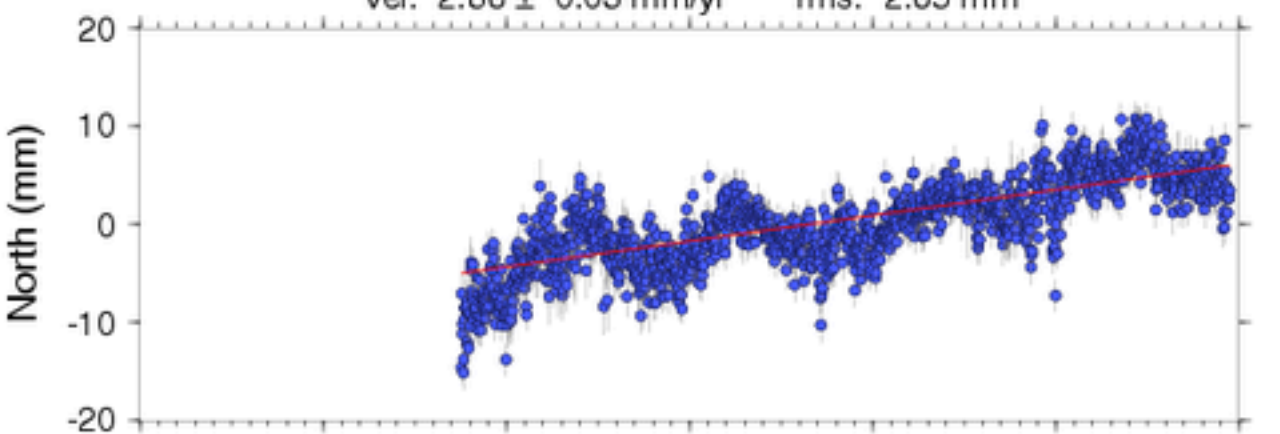
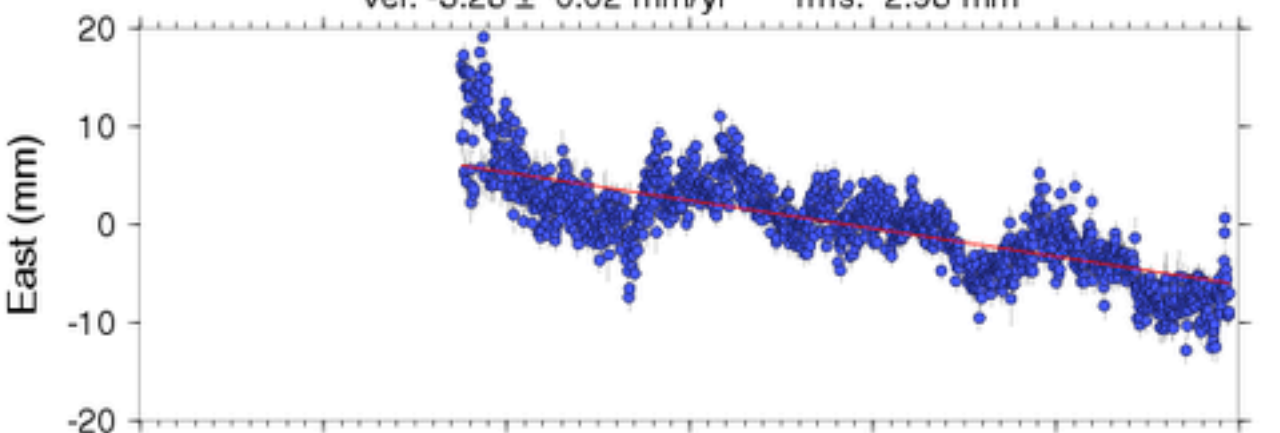
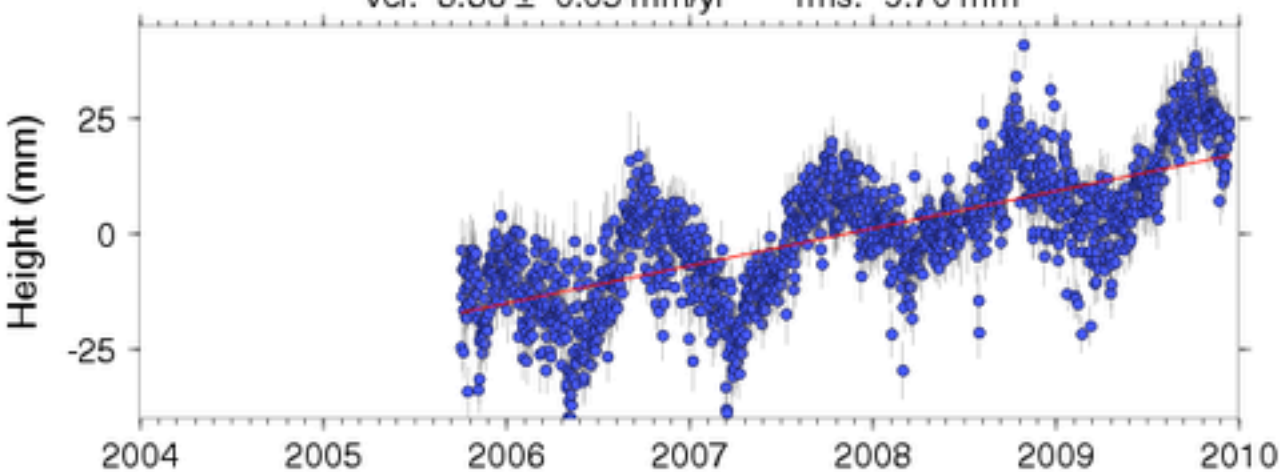
AC30 Poor Location





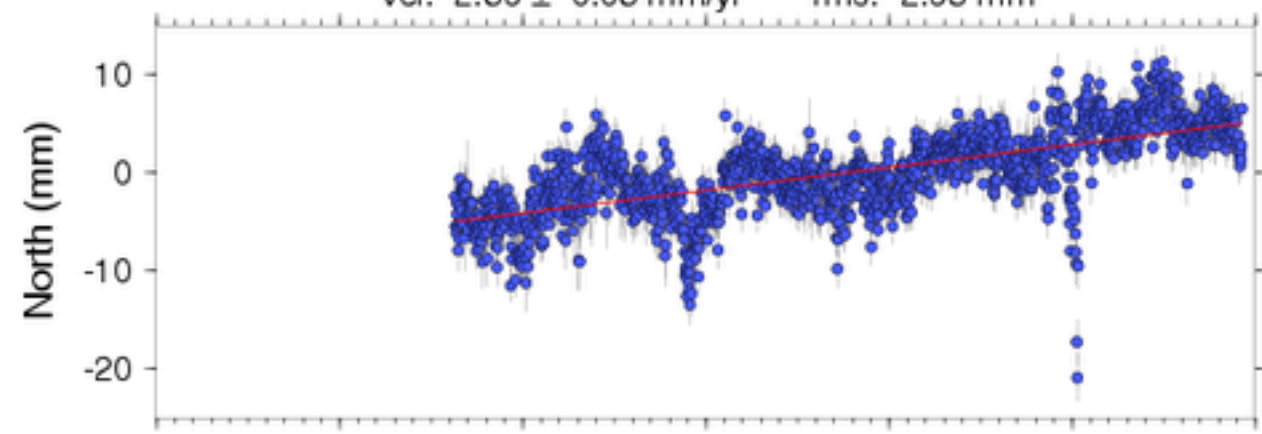
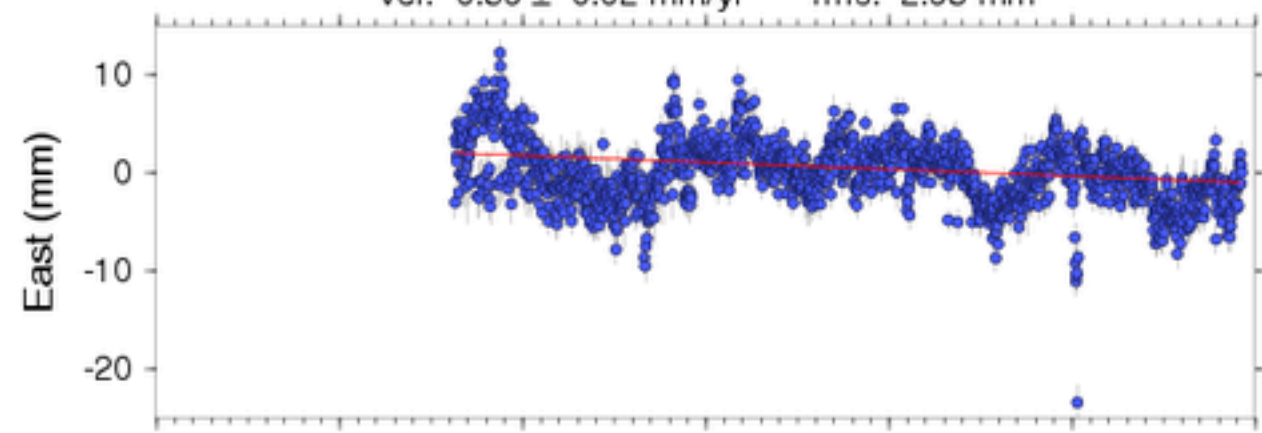
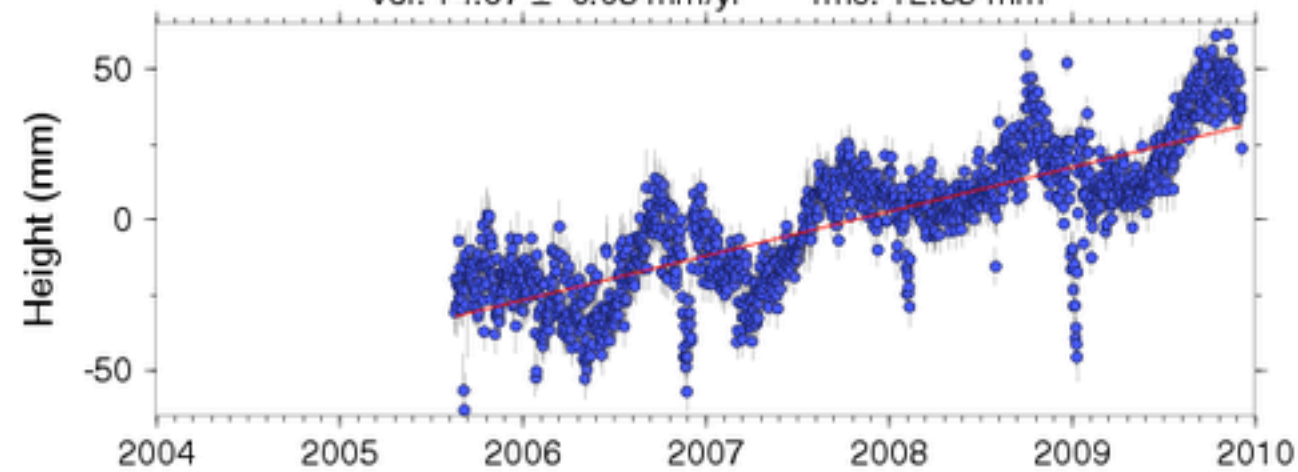
Unfiltered Plot

AB51 (PetersburgAK2005)

vel: 2.86 ± 0.03 mm/yr rms: 2.65 mmvel: -3.28 ± 0.02 mm/yr rms: 2.98 mmvel: 8.36 ± 0.05 mm/yr rms: 9.70 mm

Unfiltered Plot

AB50 (MendenhallAK2005)

vel: 2.39 ± 0.03 mm/yr rms: 2.95 mmvel: -0.89 ± 0.02 mm/yr rms: 2.95 mmvel: 14.97 ± 0.05 mm/yr rms: 12.88 mm

Good Monuments Gone Bad



Truck intentionally ran into monument



Augustine Volcanic Eruption



Landowner removes station