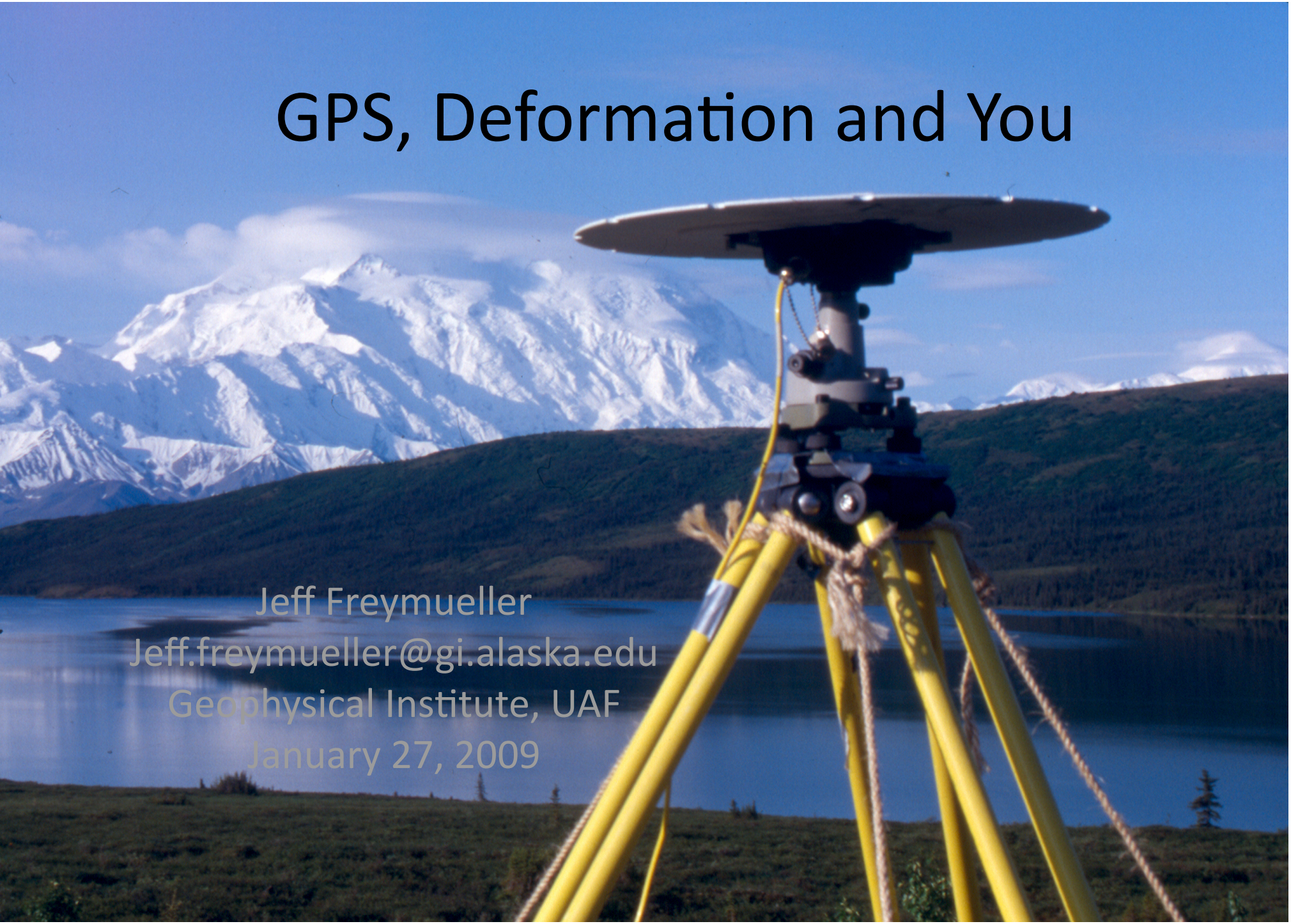
GPS, Deformation and You



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Geophysical Institute, UAF
January 27, 2009

Topics

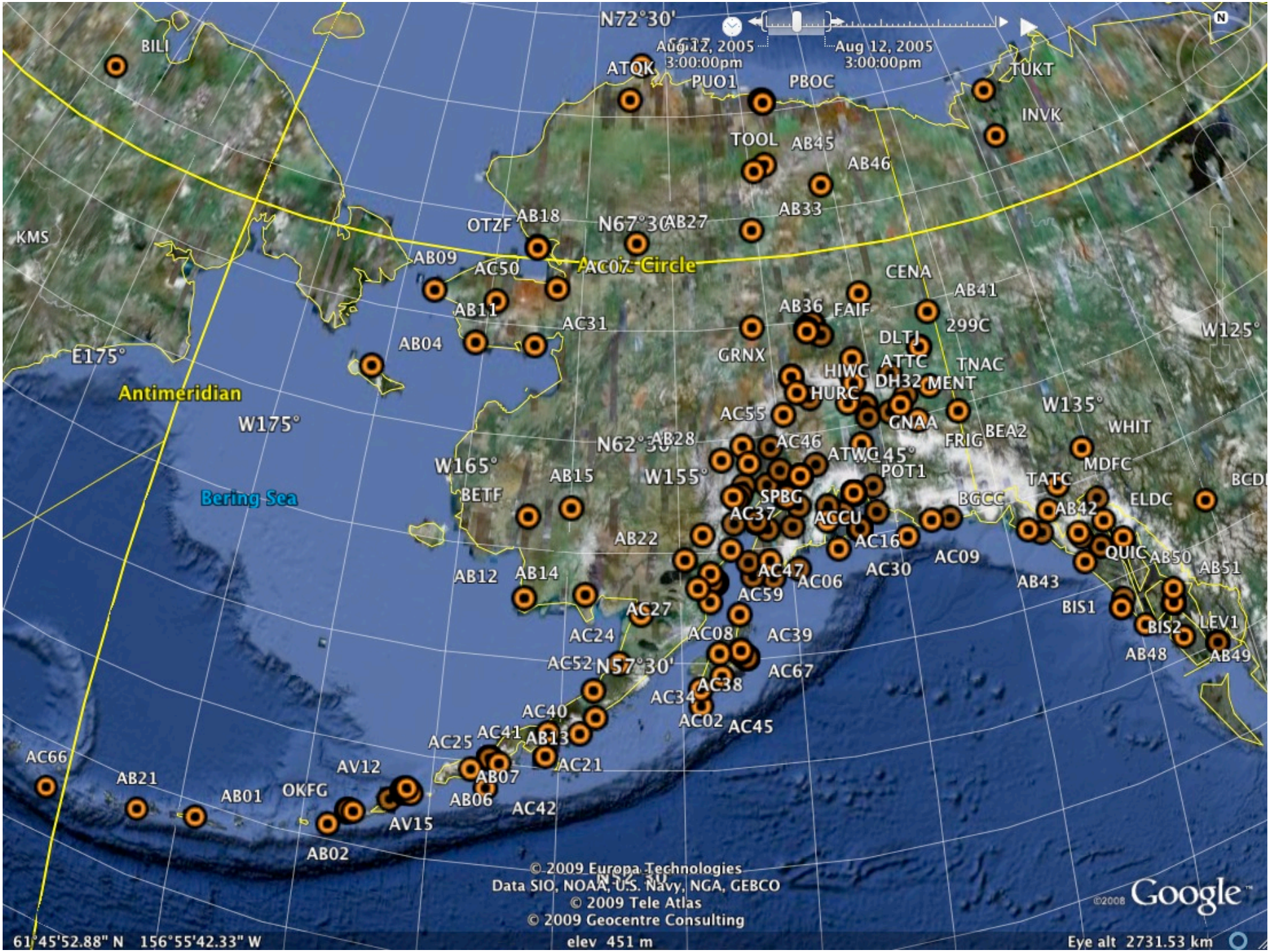
- Continuous GPS and CORS
  - Some definitions
  - Update on sites, data availability
  - Where to get data, who to call
- Motion and Deformation in Alaska
  - HTDP
  - Some recent results

Continuous GPS and CORS

- There are many continuous GPS sites, and some of them are branded “CORS” by NGS. Why?
  - Site operators register with NGS and provide documentation; NGS accepts all sites that meet basic quality standards. Commits to providing:
    - Data in CORS archive
    - Positions and velocities
  - Process is not onerous but does require non-trivial effort.
- Result: Data are available from many sites that are not in NGS CORS archive

Data Sources in Alaska

- CORS
- Plate Boundary Observatory (UNAVCO)
  - Funded by National Science Foundation
  - Goal is to measure crustal deformation
  - Most former UAF sites have been taken over (based on NSF's preferences for funding).
- UAF
- Several sites in Anchorage


N72°30'
Aug 12, 2005
3:00:00pm
Aug 12, 2005
3:00:00pm
BILI
ATQK
PUO1
PBOC
TUKT
INVK
TOOL
AB45
AB46
AB33
AB27
N67°30'
OTZF
AB18
KMS
AB09
AC50
AC07
Arctic Circle
CENA
AB41
AB36
FAIF
299C
AB11
AC31
DLTJ
W125°
AB04
GRNX
ATTC
TNAC
HIWC
DH32
MENT
E175°
HURC
Antimeridian
W135°
AC55
GNAA
FRIG
BEA2
WHIT
W175°
N62°30'
AB28
AC46
ATWC
45°
MDFC
W165°
AB15
W155°
POT1
TATC
BCD
Bering Sea
BETF
SPBC
BGCC
ELDC
AB42
AC37
ACCU
AB22
AC16
QUIC
AB50
AB51
AC09
AB12
AB14
AC47
AC06
AC30
AB43
AC59
BIS1
AC27
BIS2
LEV1
AC24
AC08
AC39
AB48
AB49
AC52
N57°30'
AC67
AC38
AC34
AC40
AC02
AC45
AC41
AB13
AC25
AC21
AC66
AV12
AB07
AB21
AB01
OKFG
AB06
AC42
AV15
AB02
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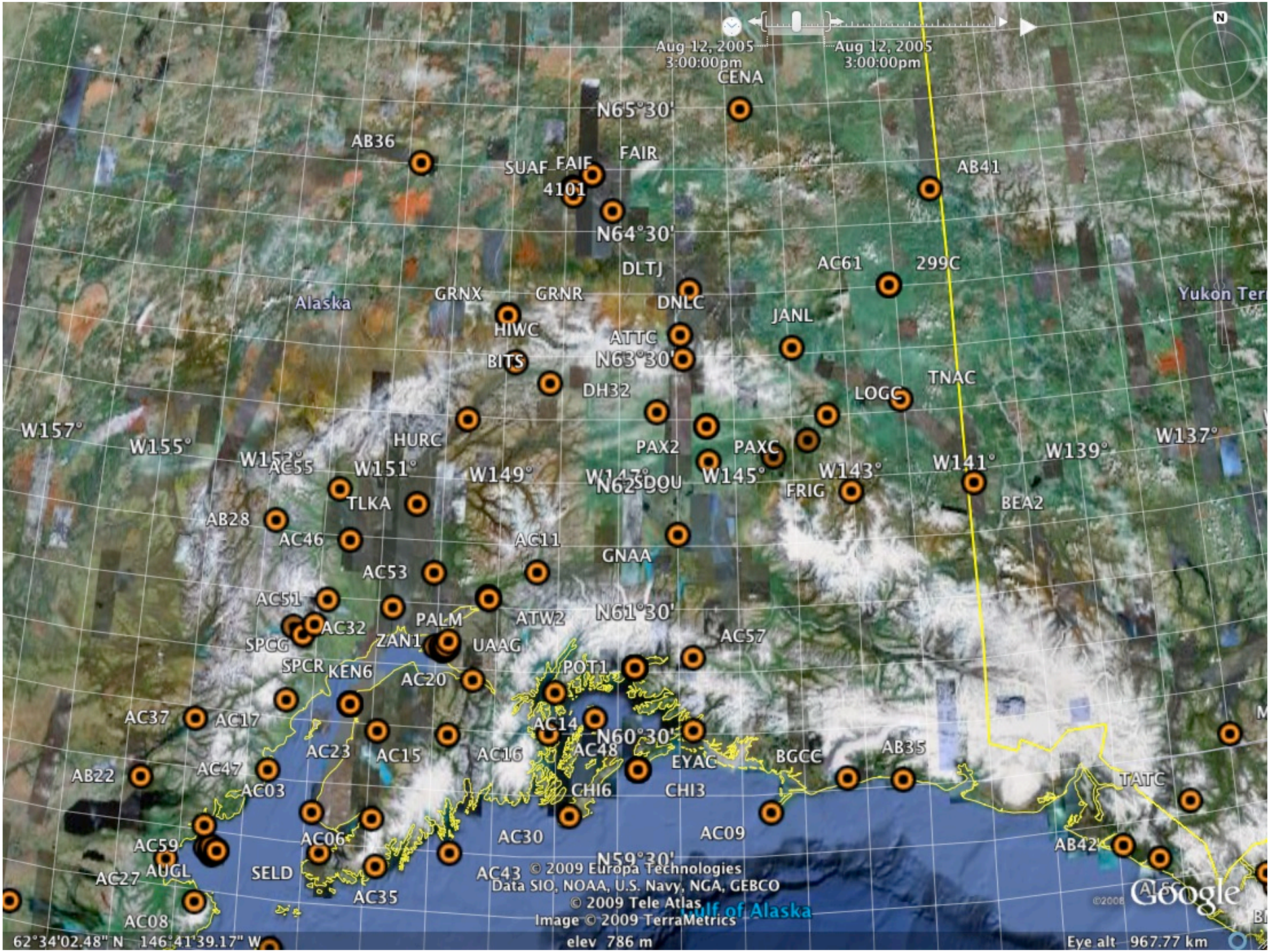
©2008 Google
61°45'52.88" N 156°55'42.33" W
elev 451 m
Eye alt 2731.53 km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AB41
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299C
Alaska
GRNX
GRNR
DNLC
Yukon Ter
HIWC
JANL
ATTC
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N63°30'
TNAC
DH32
LOGG
W157°
W155°
HURC
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AC55
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PAX2
PAXC
W145°
W143°
W141°
W139°
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N62°30'
SDQU
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BEA2
AB28
AC46
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GNAA
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PALM
ATW2
N61°30'
SPCG
ZAN1
UAAG
AC57
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AC14
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AC23
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EYAC
BGCC
AB35
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AC06
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AB42
AC27
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SELD
AC43
N59°30'
AC35
AC08
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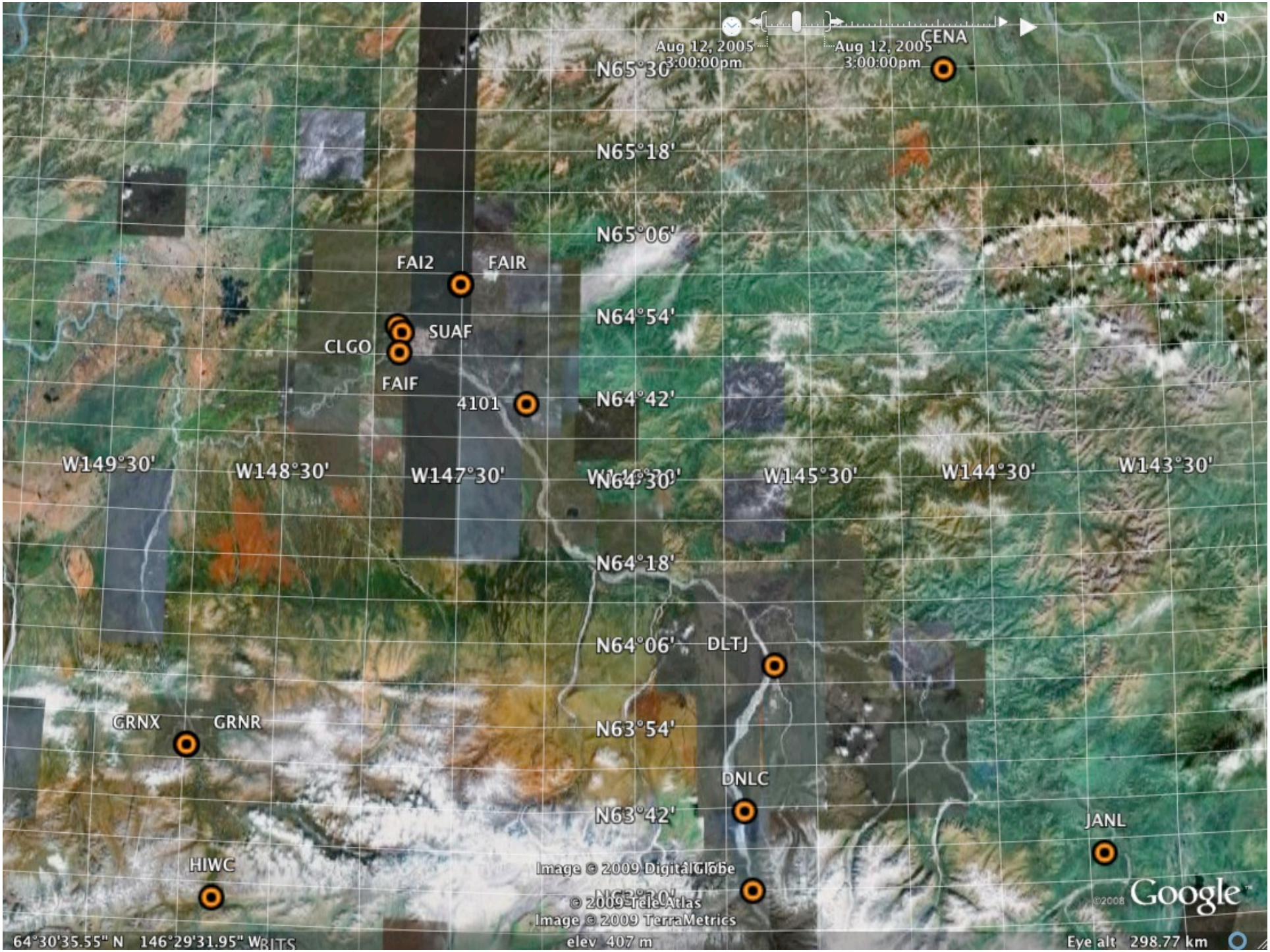
© 2009 Tele Atlas
Image © 2009 TerraMetrics
Gulf of Alaska
Google
62°34'02.48" N 146°41'39.17" W
elev 786 m
Eye alt 967.77 km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CENA
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N64°54'
N64°42'
N64°30'
N64°18'
N64°06'
N63°54'
N63°42'
FAI2
FAIR
SUAF
CLGO
FAIF
4101
DLTJ
GRNX
GRNR
DNLC
JANL
HIWC
W149°30'
W148°30'
W147°30'
W145°30'
W144°30'
W143°30'
Image © 2009 DigitalGlobe
© 2009 Tele Atlas
Image © 2009 TerraMetrics
elev 407 m
Google
Eye alt 298.77 km
64°30'35.55" N 146°29'31.95" W

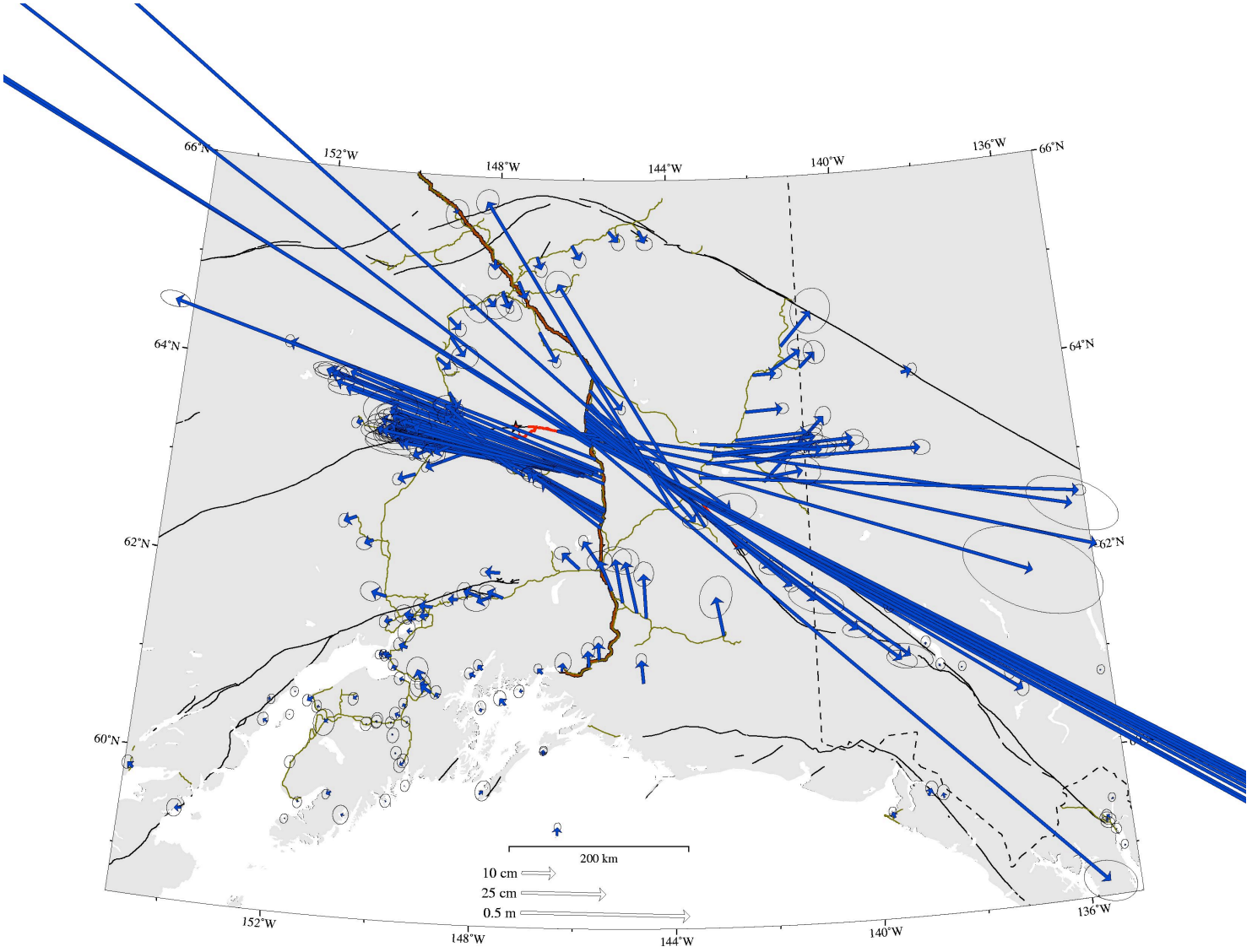

Aug 12, 2005
3:00:00pm
Aug 12, 2005
3:00:00pm
N65°02'
N65°01'
N64°59'
N64°57'
N64°55'
N64°53'
N64°51'
N64°49'
N64°47'
N64°45'
N64°43'
N64°41'
N64°39'
FAI2
FAIR
CLGO
SUAF
FAIF
4101
W148°06'
W147°54'
W147°42'
W147°30'
W147°18'
W147°06'
Image © 2009 DigitalGlobe
© 2009 Tele Atlas
Image © 2009 TerraMetrics
Google
64°51'24.62" N 147°35'15.54" W
elev 177 m
Eye alt 55.18 km

Data Sources for Interior

Site Name	Data Center
FAIR, FAI2	IGS Data Centers
CLGO, GRNX (Healy), DLTJ (Delta Junction)	UNAVCO
SUAF	UAF, The Surveyor's Exchange
4101/EIL1, EIL2 (Eielson, NGA site)	IGS Data Centers
CENA	NGS CORS

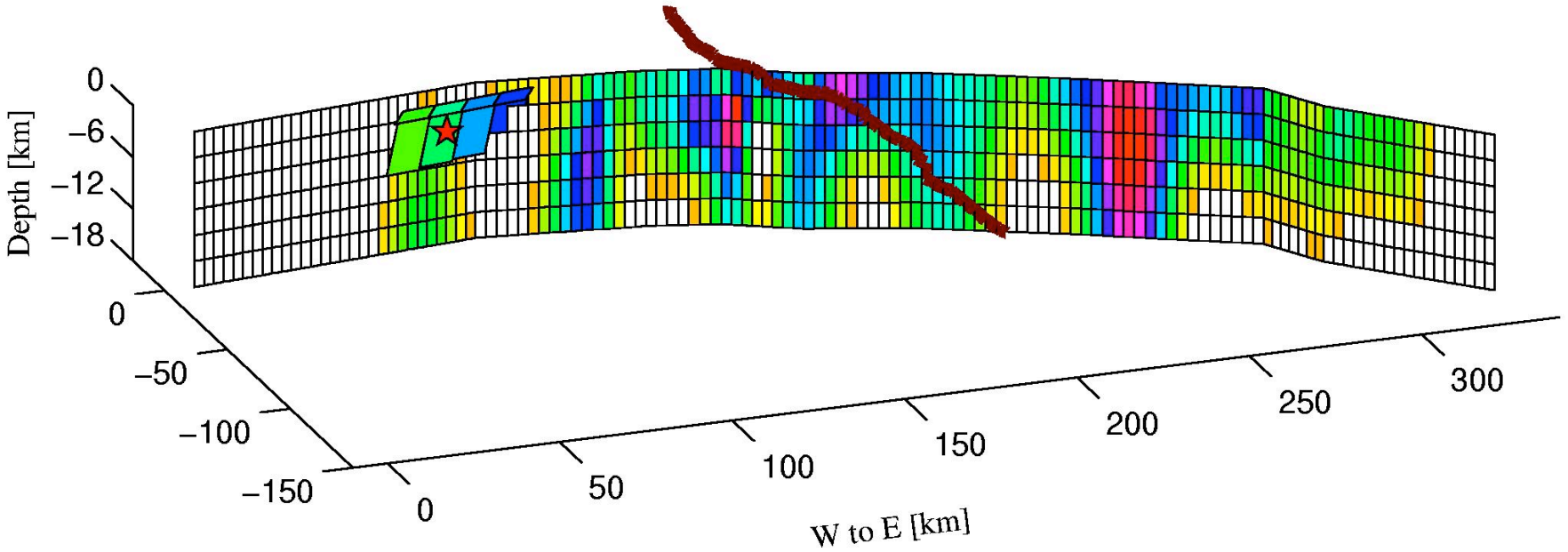
Data Center	Address(es)
IGS Data Centers	sopac.ucsd.edu, cddis.gsfc.nasa.gov
UNAVCO	pbo.unavco.org, (ftp) data-out.unavco.org
NGS CORS	cors.ngs.noaa.gov
The Surveyor's Exchange	ftp://ftp.tse-ak.com/SUAF/
UAF	ftp://gps.alaska.edu/pub/gpsdata/

Deformation in Alaska



Hreinsdóttir et al., 2006

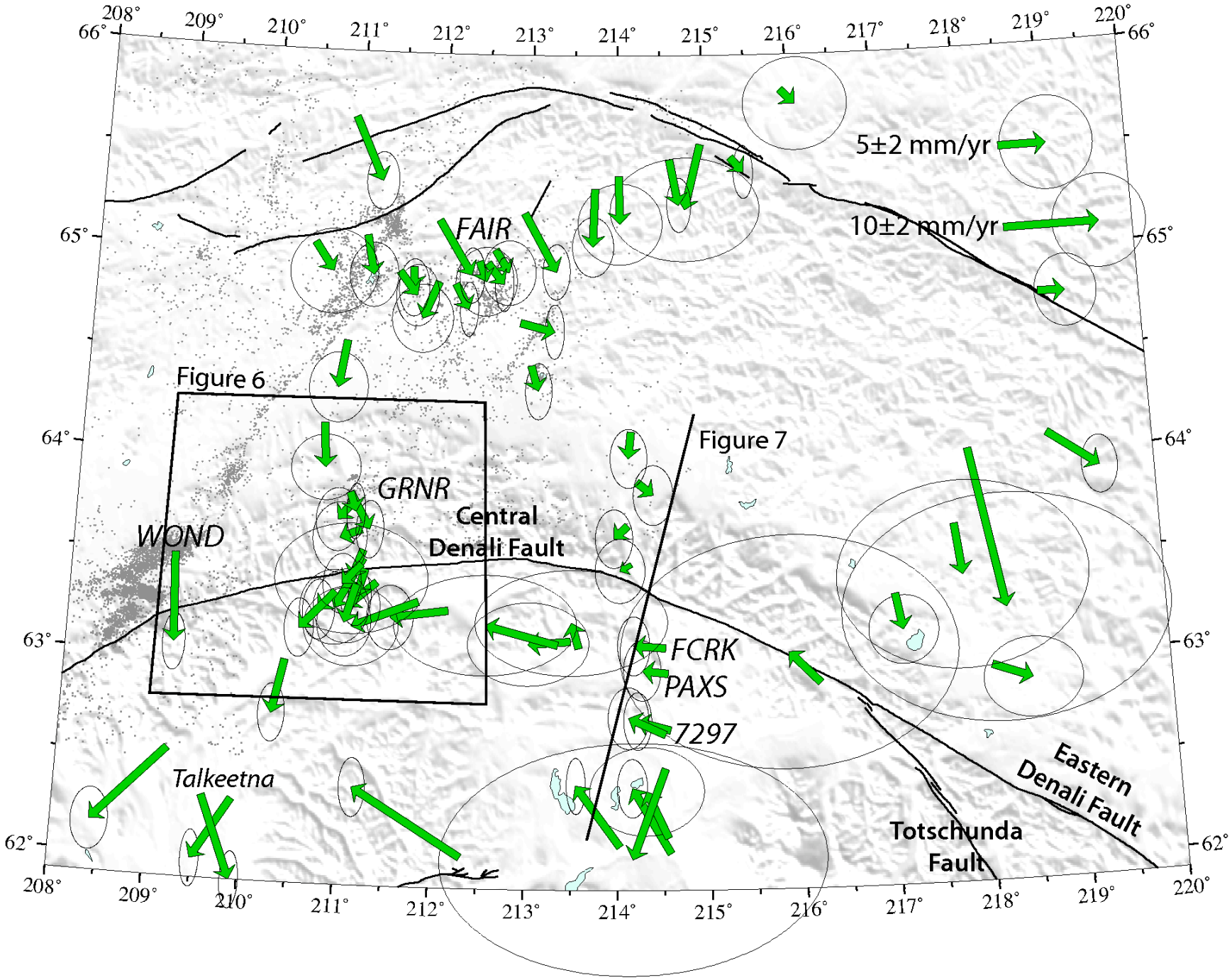
Coseismic Slip Model



- Can use elastic dislocation model to calculate surface displacements from a model of slip on a fault (e.g., Okada [1985]).
- Or can use displacement to estimate slip model

HTDP (Horizontal Time-Dependent Positioning) Model

- Model of crustal deformation, including steady motion and earthquakes, to allow you to correct positions from one time to another.
- Model for Alaska has been ZERO motion = TOTALLY WRONG!
- NGS is preparing a functional HTDP model for Alaska
  - Step 1 (done): Correction for 2002 Denali earthquake
  - Step 2: (next ~2 years): Velocity model and other events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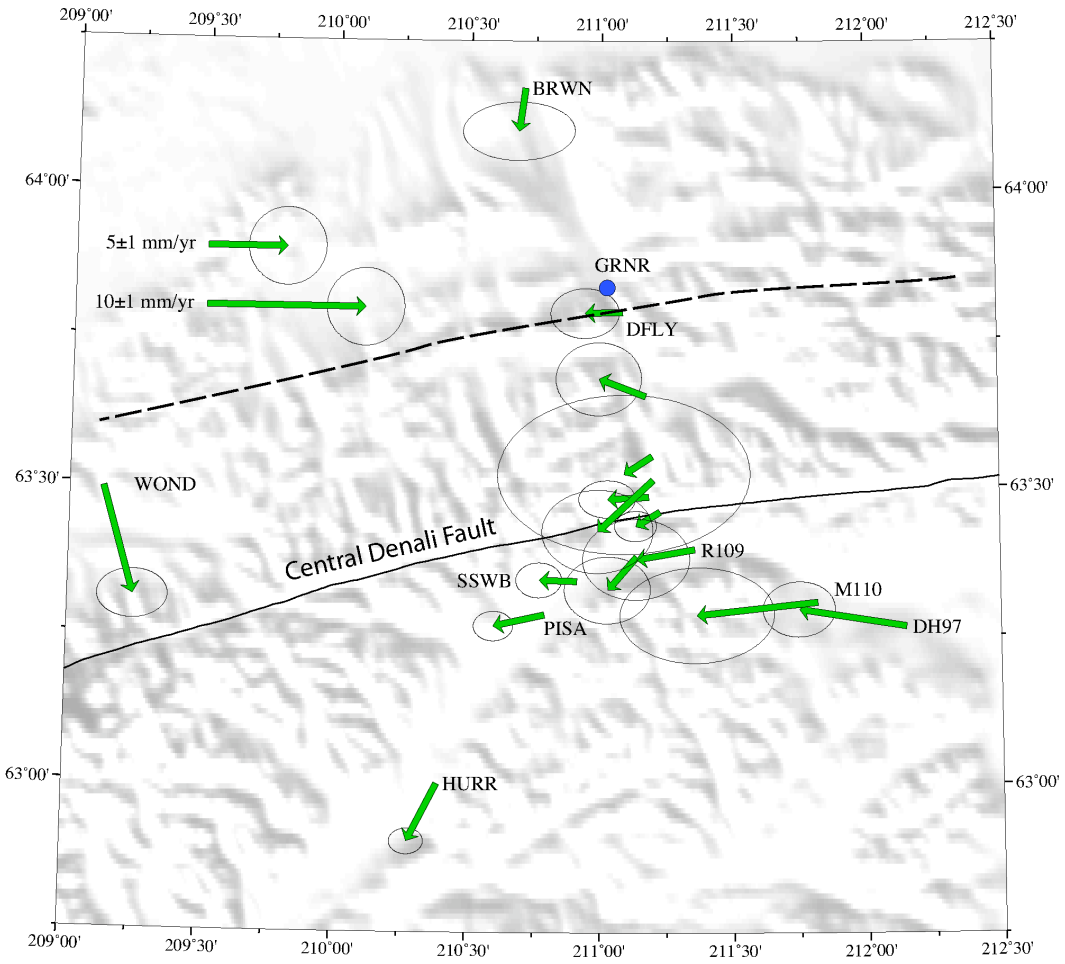
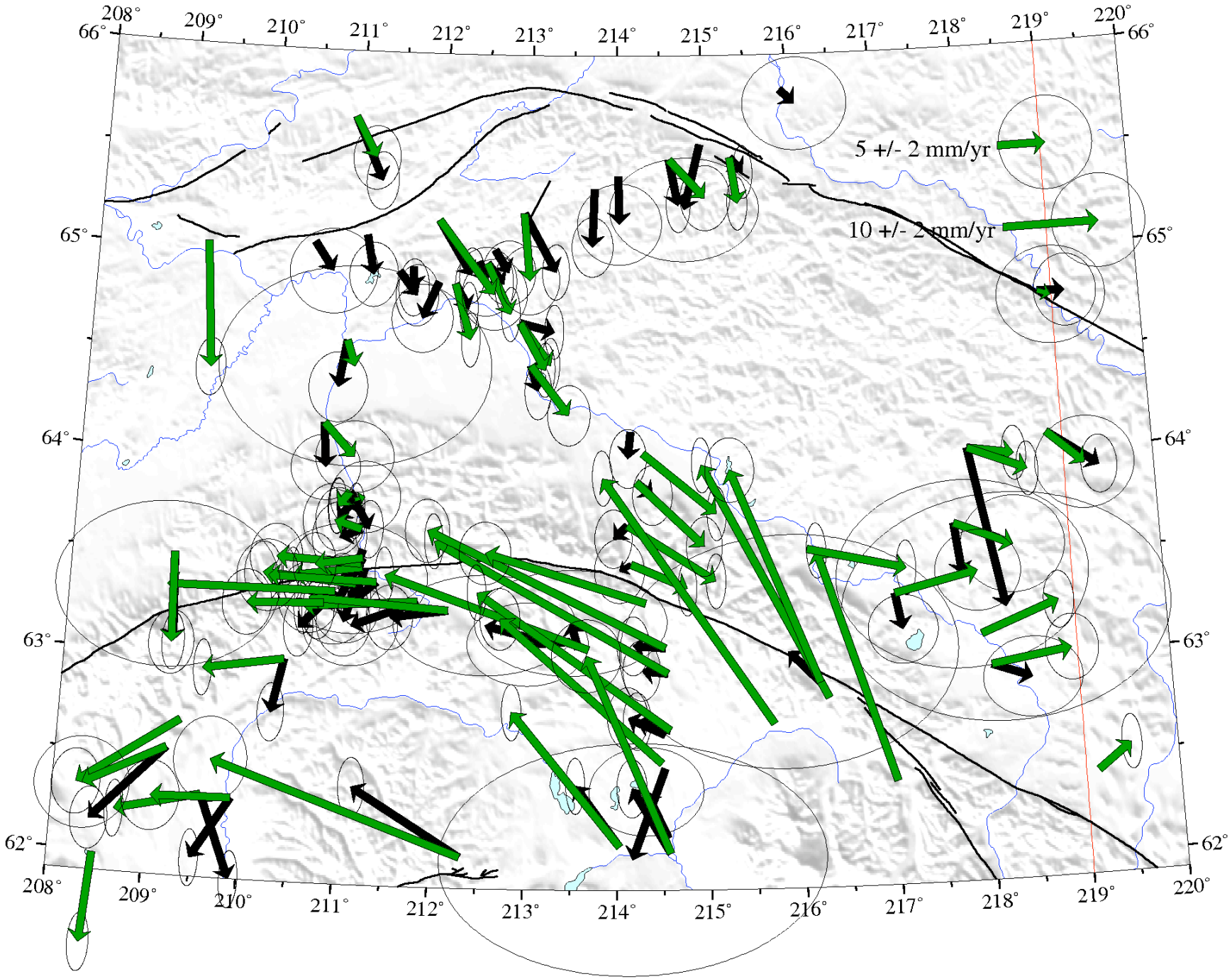
65°
64°
63°
62°
5±2 mm/yr
10±2 mm/yr
FAIR
Figure 6
Figure 7
GRNR
WOND
Central
Denali Fault
FCRK
PAXS
7297
Talkeetna
Eastern
Denali Fault
Totschunda
Fault


209°00'
209°30'
210°00'
210°30'
211°00'
211°30'
212°00'
212°30'
64°00'
63°30'
63°00'
BRWN
5±1 mm/yr
10±1 mm/yr
GRNR
DFLY
WOND
Central Denali Fault
R109
SSWB
M110
PISA
DH97
HURR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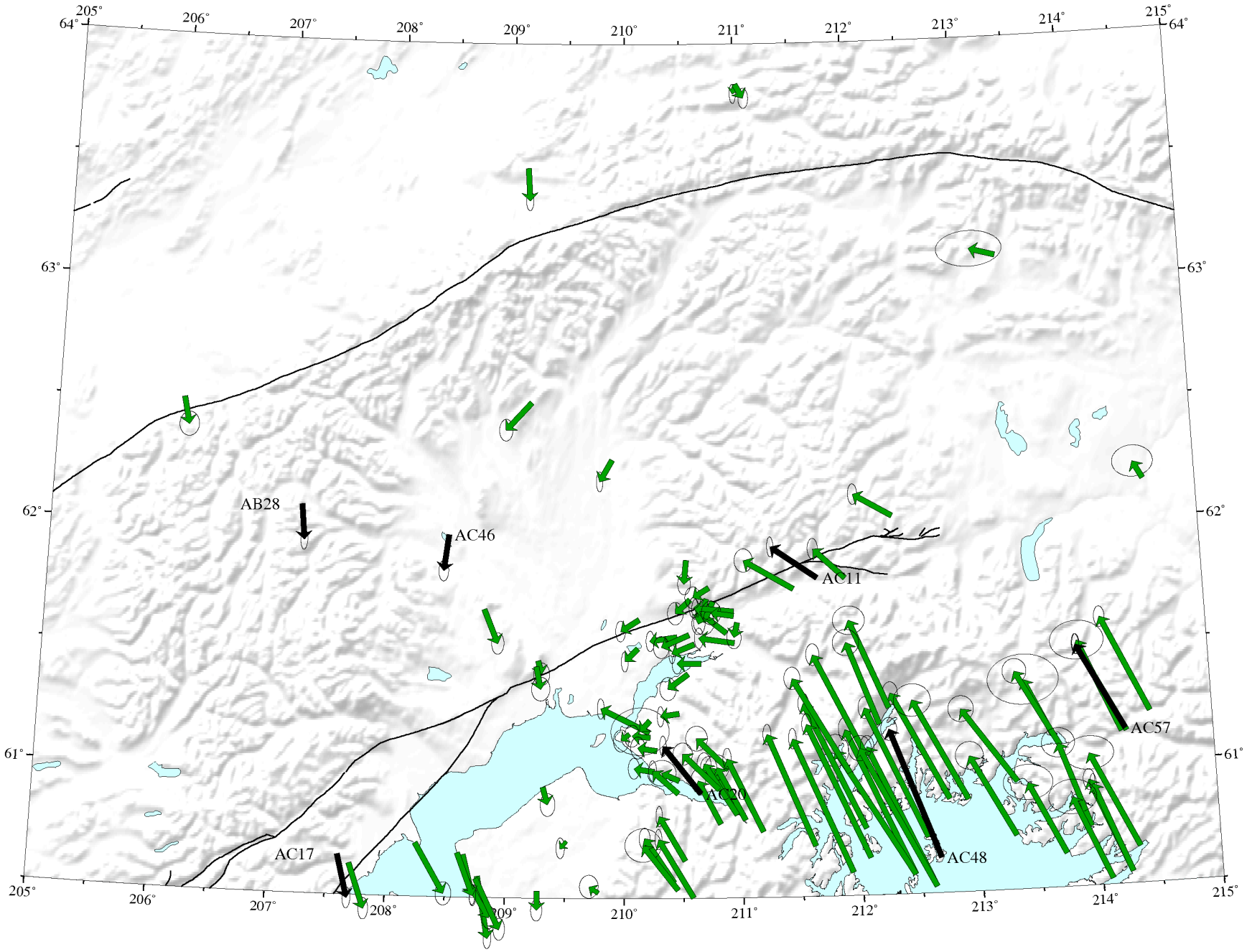
5 +/- 2 mm/yr
10 +/- 2 mm/yr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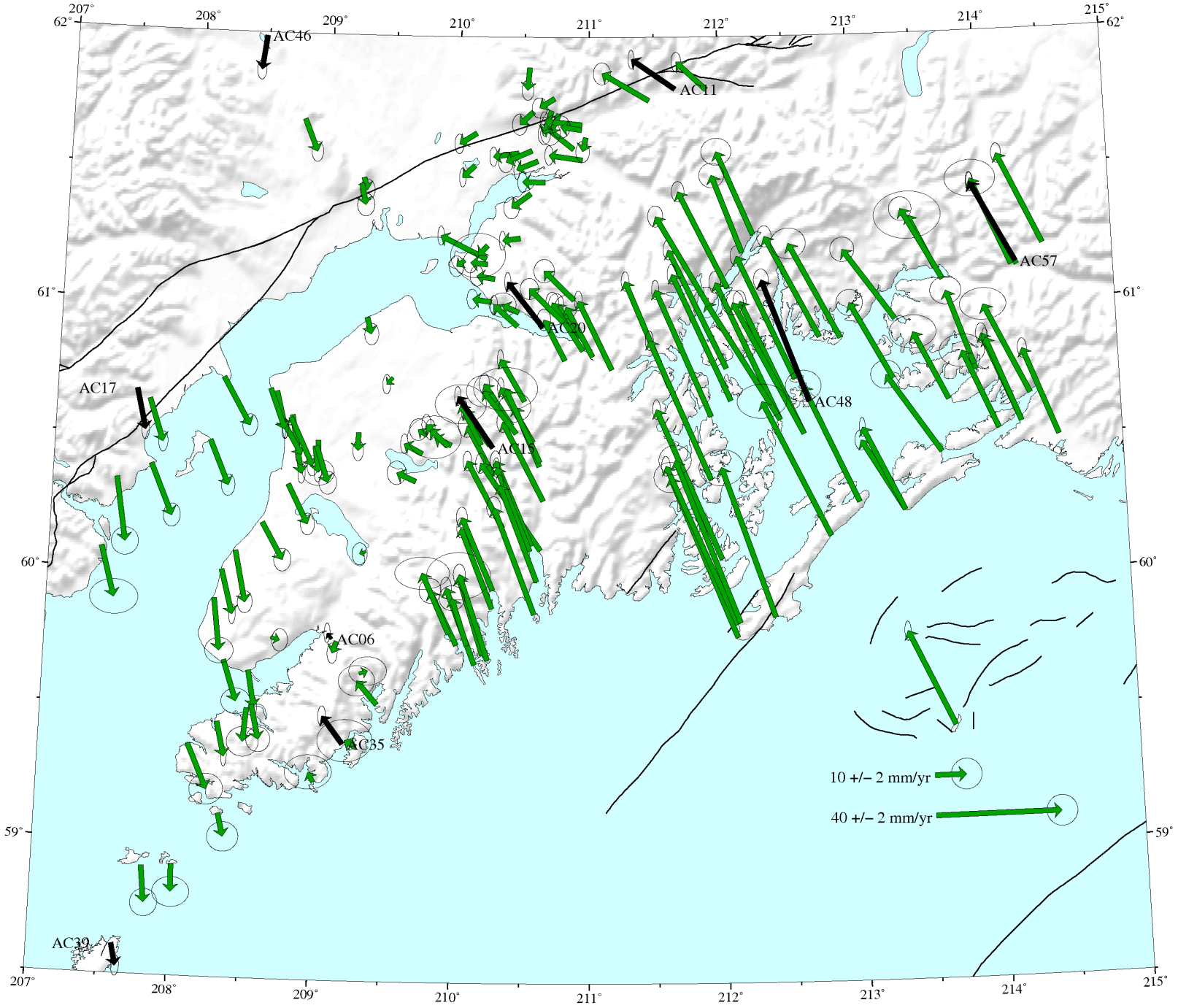
AC48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62°
61°
60°
59°
AC46
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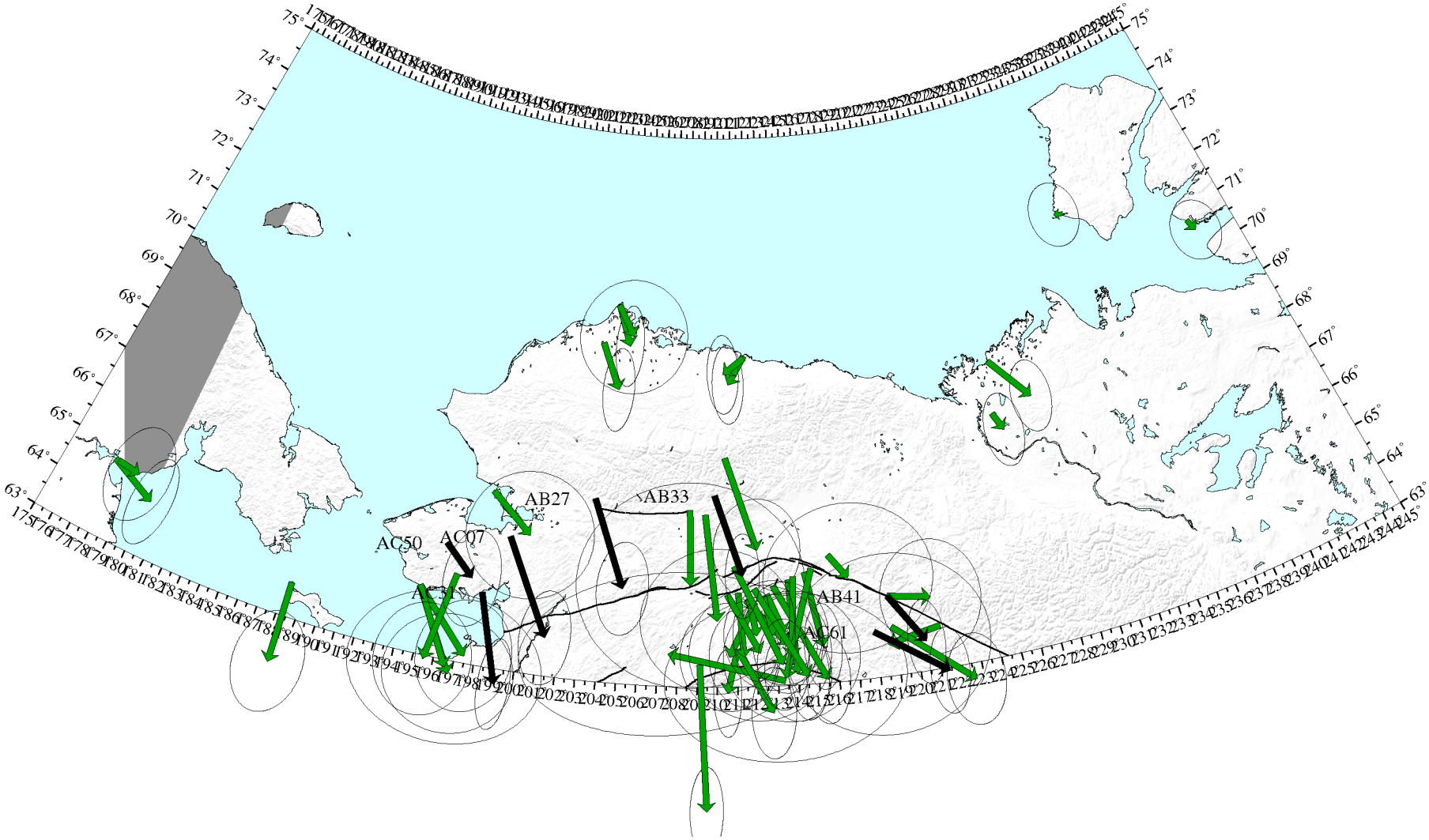
AC20
AC17
AC48
AC13
AC06
AC35
AC39
10 +/– 2 mm/yr
40 +/– 2 mm/yr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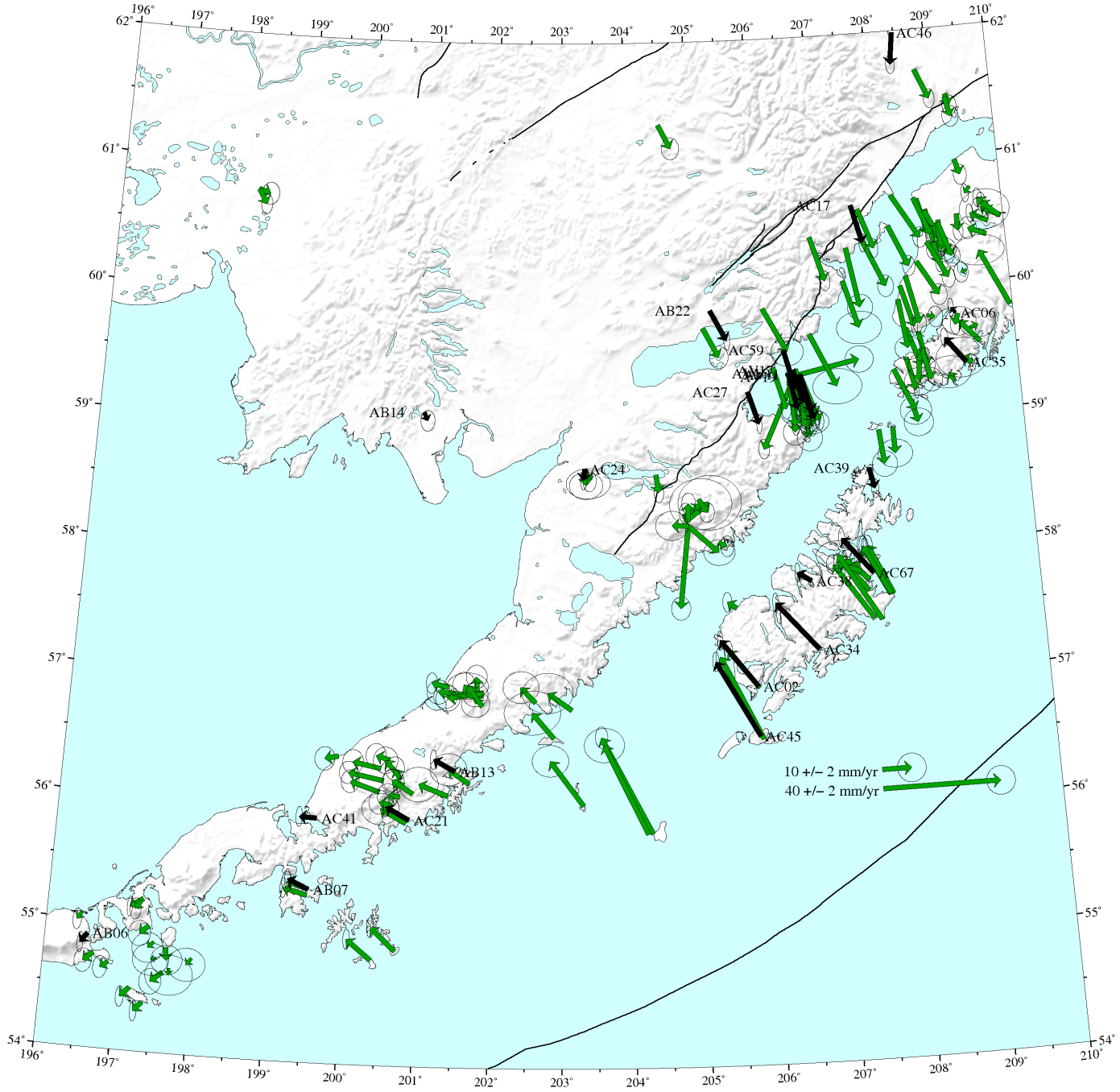
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AC17
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AC06
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AC35
AC27
AB14
AC24
AC39
AC67
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AC02
AC45
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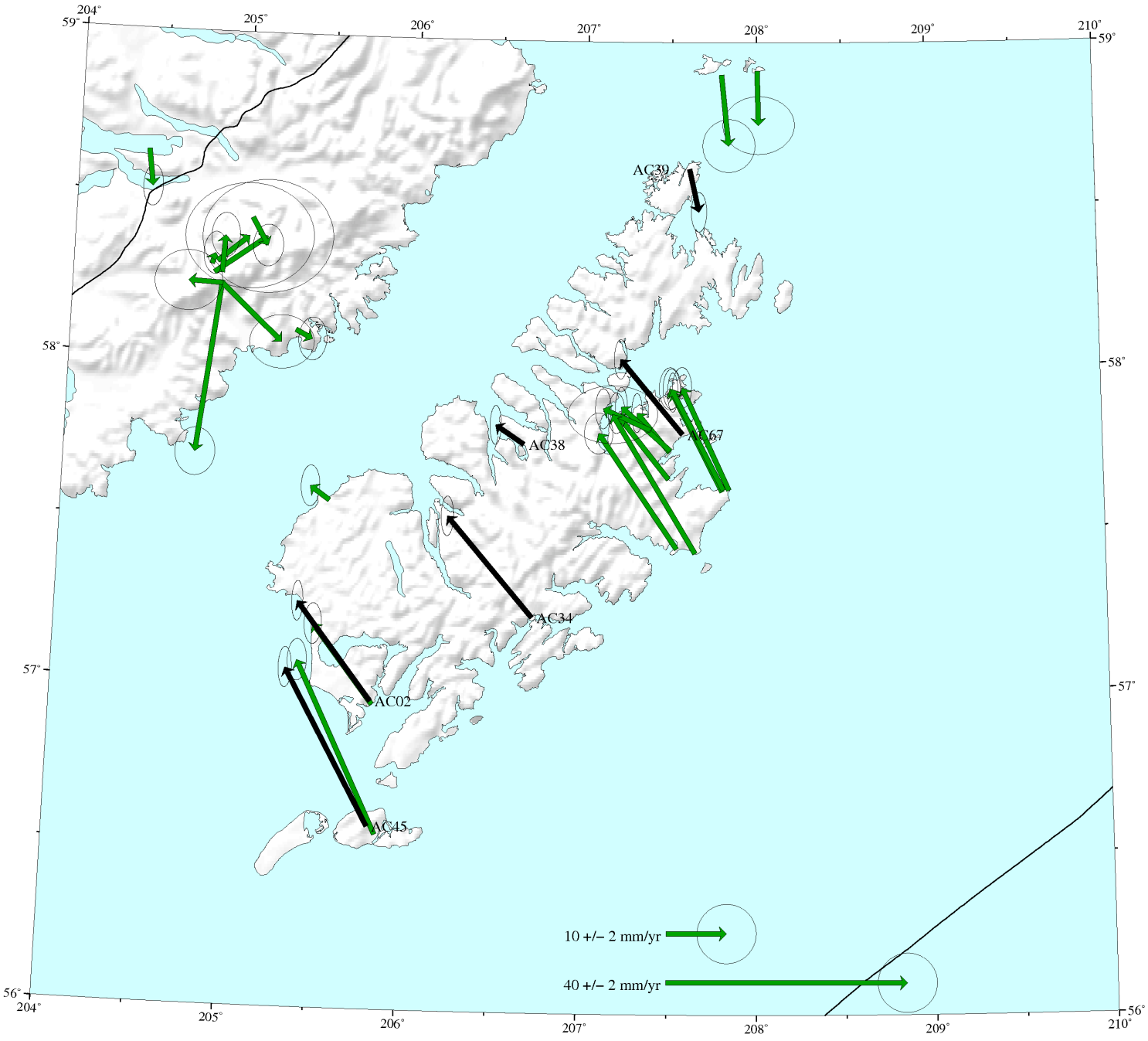
AB07
AB06
10 +/– 2 mm/yr
40 +/– 2 mm/yr


204°
205°
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208°
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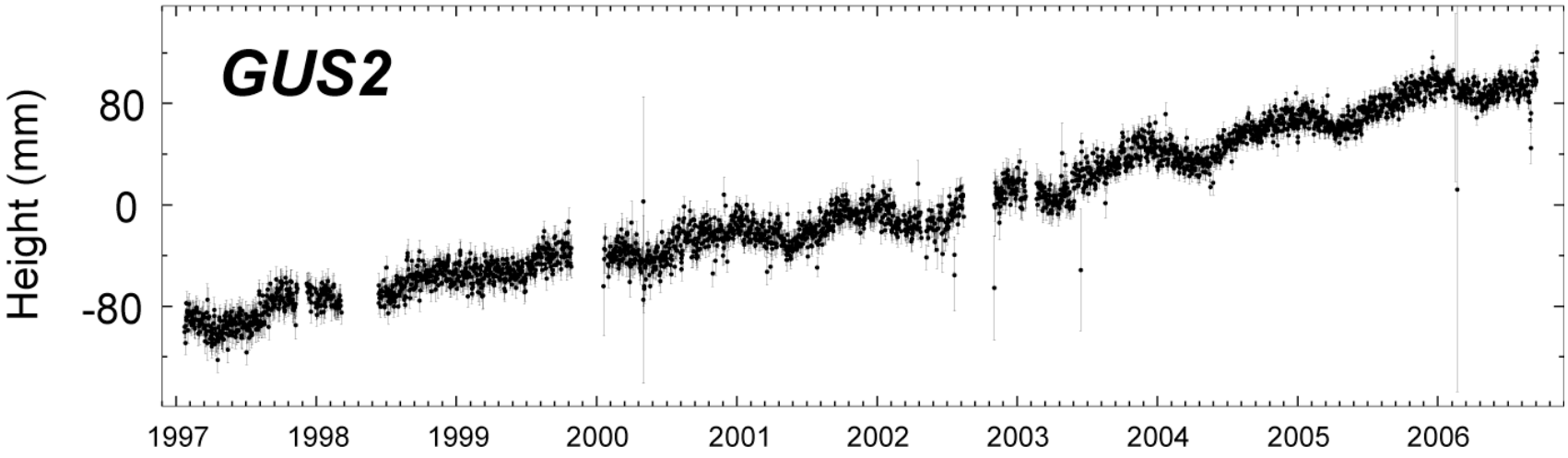
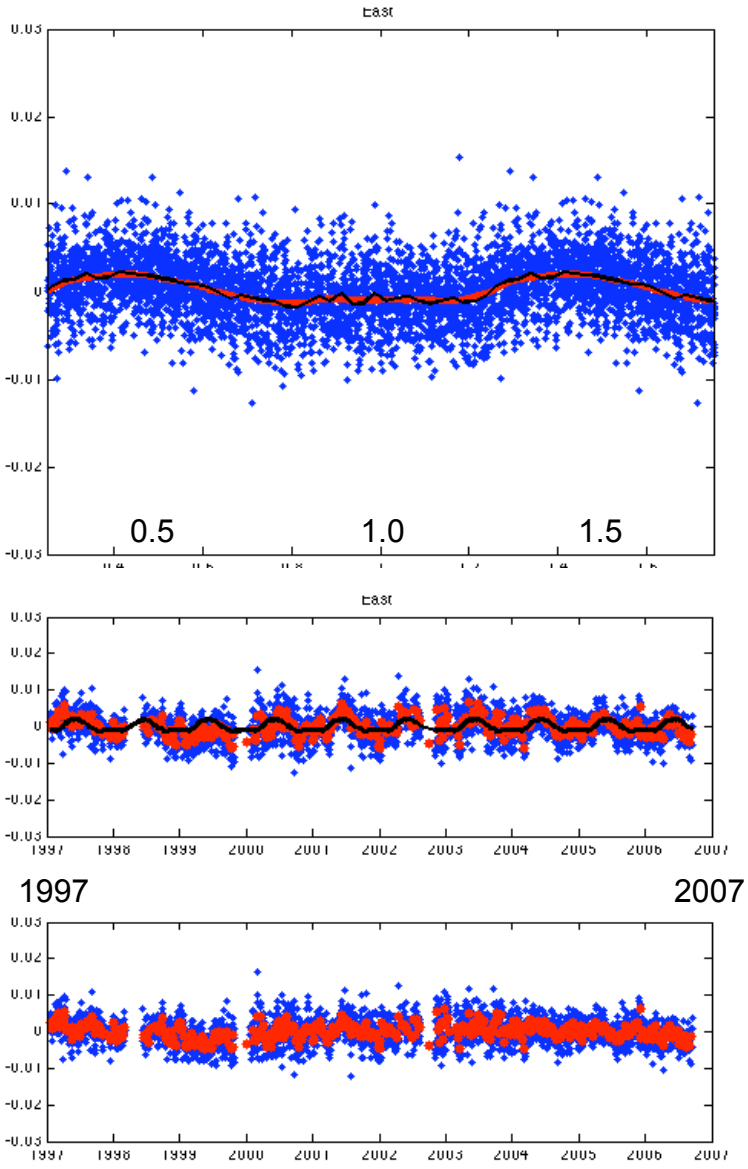
210°
59°
58°
57°
56°
AC39
AC38
AC67
AC34
AC02
AC45
10 +/– 2 mm/yr
40 +/– 2 mm/yr

Isolating Seasonal Height Variation



1. Remove linear or long-term trend
2. Stack residuals by fractional year (e.g. Jan 1-10), to get mean residual for that time period
    1. 40 seasonal bins (9.125 days each)
    2. 5 point smoothing applied to bin averages
    3. Daily seasonal variation derived by linear interpolation

East

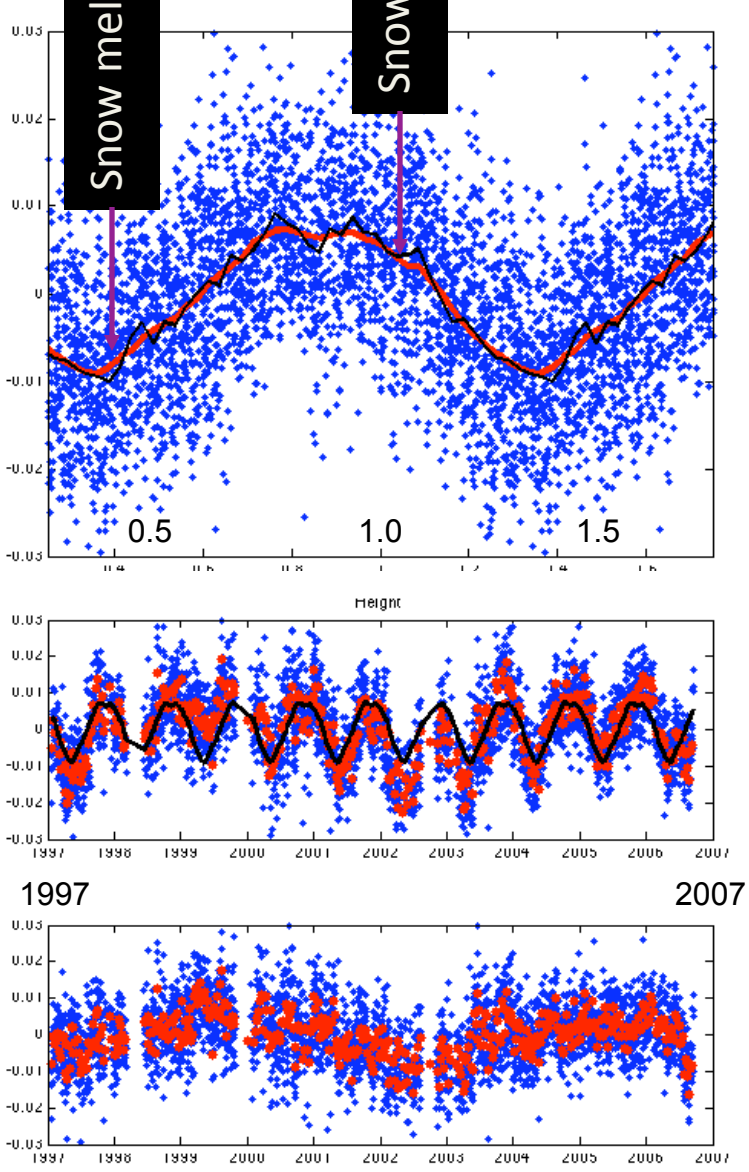


1997 2007

Hei

Snow melts

Snow falls



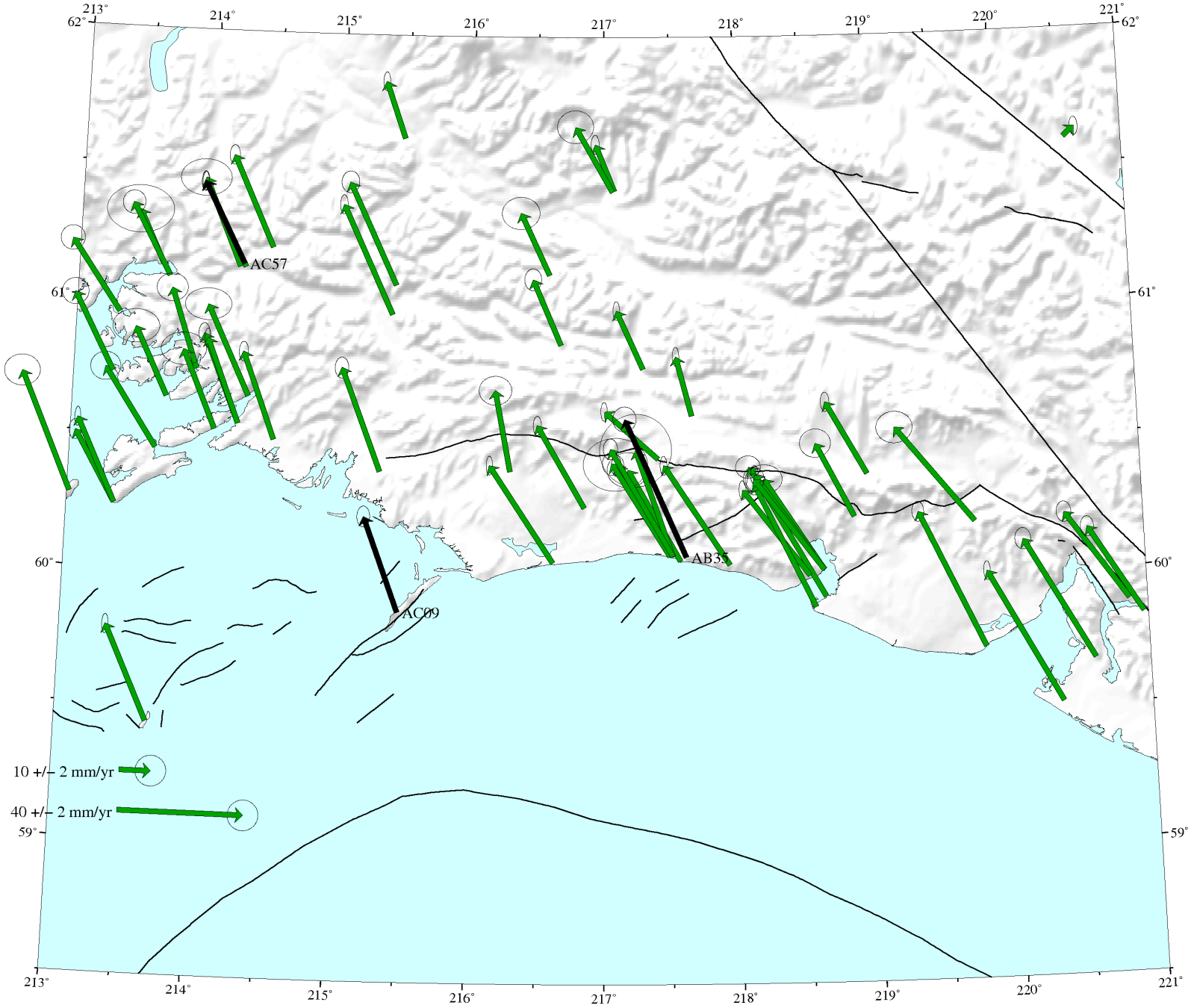
1997 2007

ITRF2000

- Geocenter defined by SLR (Satellite Laser Ranging) data
  - SLR satellites are simple spheres and orbits can be modeled over a several year period
  - GPS satellites are complex and orbits can be modeled over a few days to a week.
- Scale defined through speed of light (in practice, through VLBI (Very Long Baseline Interferometry)
- GPS densifies frame

Velocity Reference

- To know what is moving, you must know what is fixed (zero motion)
- But all plates are moving
- Solution is to define plates within ITRF and choose a global rotation rate that makes plate rotations consistent with the NUVEL1A-NNR plate model
- Result is set of positions and velocities


213°
214°
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221°
62°
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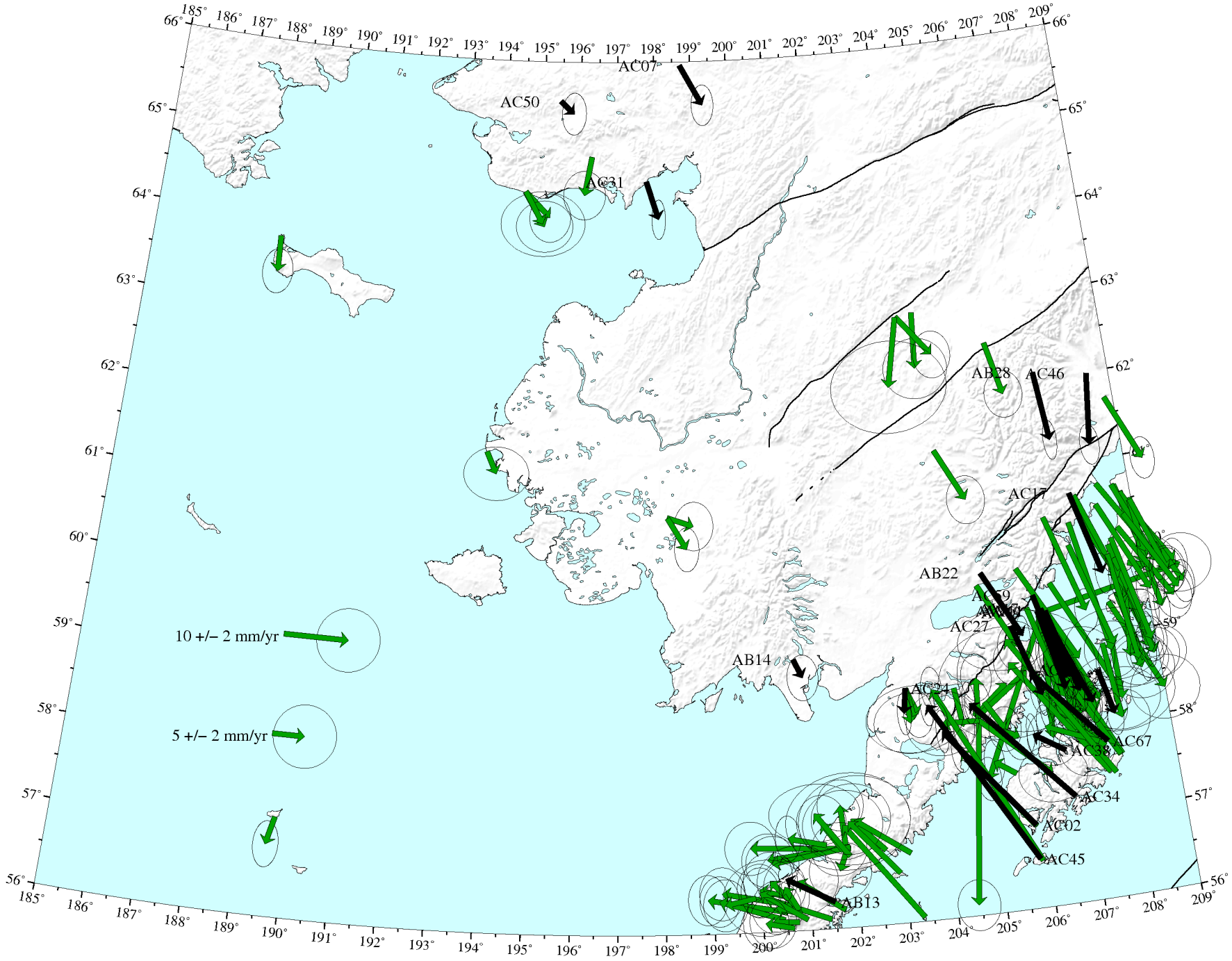
60°
59°
AC57
AB35
AC09
10 +/– 2 mm/yr
40 +/– 2 mm/yr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AC24
AC67
AC38
AC34
AC02
AC45
AB13
10 +/– 2 mm/yr
5 +/– 2 mm/yr