Interpretations of Complete Bouguer Gravity Anomalies from the GRAV-D Project in Alaska
(Gravity for the Redefinition of the American Vertical Datum)

G21B-0802

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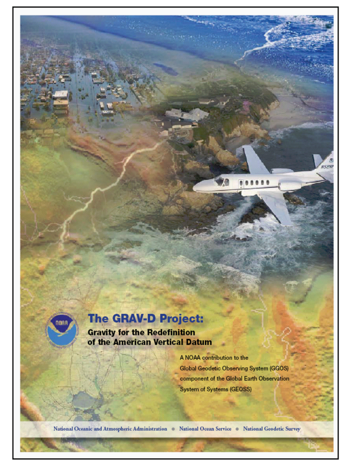
1. What is GRAV-D?

The GRAV-D (Gravity for the Redefinition of the American Vertical Datum) Project of the U.S. National Geodetic Survey plans to collect airborne gravity data across the entire U.S. and its holdings over the next decade. The goal of the project is to create a gravimetric geoid model to use as the national vertical datum by 2021.



It is NGS' mission to define and maintain a spatial reference system for the U.S. Part of this mission is to provide access to heights useful for measuring water flow (particularly for flood hazard estimation) and for construction/transportation projects. Based on current errors and requirements in the era of GPS, a new datum with 1-2 cm accuracy is needed.

The project plan and more details are available: http://www.ngs.noaa.gov/GRAV-D

2. Data Collection in Alaska

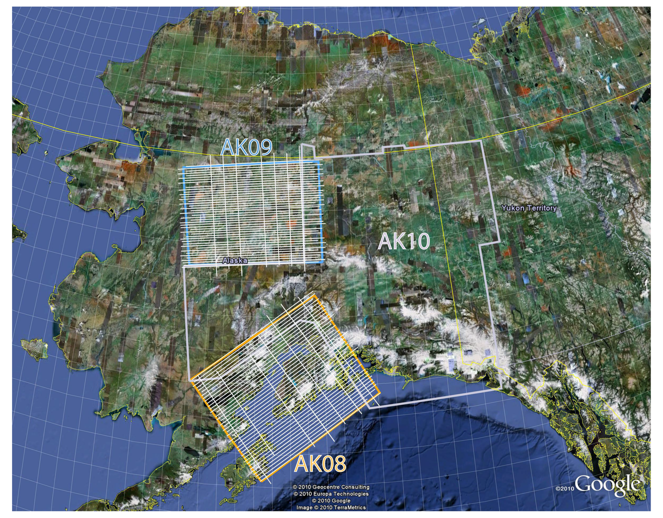
Airborne gravity survey work in Alaska began more than two years ago and will be ongoing for several more years. Several surveys have been completed (see table and figure below):

2008: AK08, centered over Cook Inlet near Anchorage (orange box below)
- a 400 km stretch of the active plate boundary
- gravity effects of all the near-trench features, from accretionary prism to the volcanic arc

2009: AK09, over the Interior, to the north of the Alaska Range, and west of Fairbanks (blue box below)
- gravity effect of distal metamorphic deformation in the Interior of Alaska

2010: AK10, the remainder south-central/south-eastern Alaska. Data not shown on this poster (gray box below).

Survey Name	AK08	AK09
Date Completed	July 2008	July-August 2009
Location	Anchorage/Cook Inlet	Fairbanks/N of AK Range
Gravimeter	Micro-g LaCoste TAGS	Micro-g LaCoste TAGS
Aircraft	NOAA Cessna Citation	Naval Research Lab RC-12
Altitude Flown	35,000 ft/10 km	12,500 ft/3.8 km
Data Line Spacing	10 km	7.5 km
Tie Line Spacing	60 km	37.5 km
Size	~ 400 km x 500 km	~ 300 km x 400 km
Nominal Resolution	> 20 km	> 15 km
Datums	WGS84 and ITRF00	WGS84 and ITRF00
Color box at Right	Blue	Orange



3. Project Data Collection Priorities and Progress

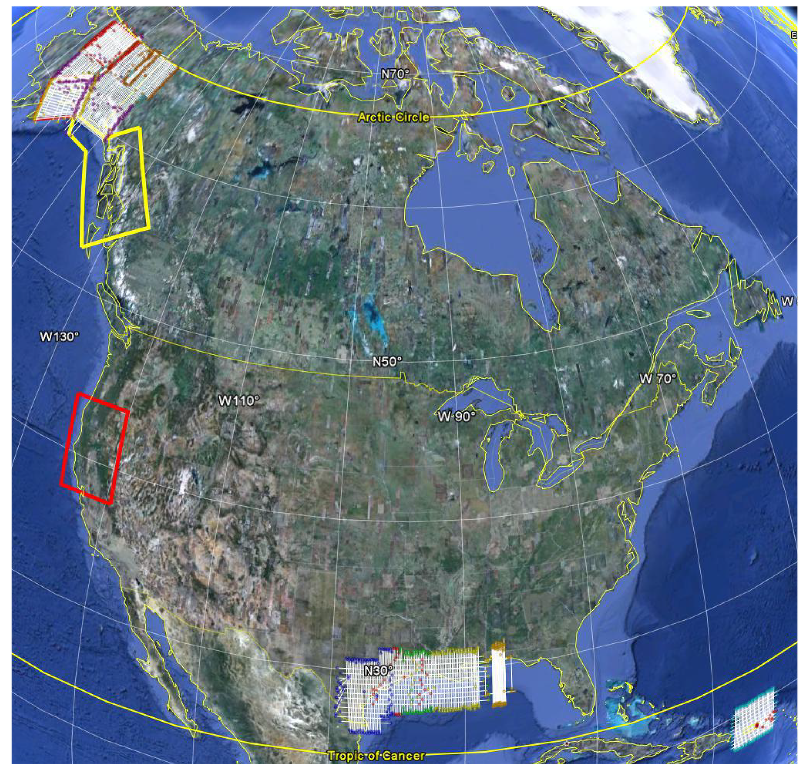
Airborne surveys are planned to collect high-altitude gravity data in all states and the U.S. holdings by 2021.

Priorities: 1. Puerto Rico & Virgin Islands, 2. Alaska, 3. Gulf Coast, 4. Great Lakes, 5. East and West Coasts, 6. Hawaii, 7. Island Holdings & Interior Continental U.S.

Data Collection Finished (see right): Western & Central Gulf of Mexico (2008-2009), Puerto Rico and the Virgin Islands (2009), Alaska (2008, 2009, 2010).

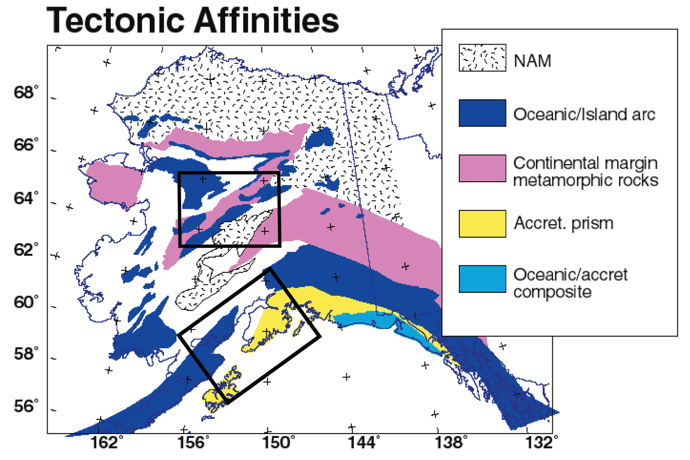
Planned for 2011: Northern and Central California (red box at right), SE Alaska (yellow box, Juneau and Ketchikan), and continued work in northern and/or western Alaska.

Data processing for precise GPS and gravity is an on-going area of development. Version 1 data products will start to be available for download in early 2011.



4. Alaska Setting for 2008/2009 Airborne Gravity Surveys

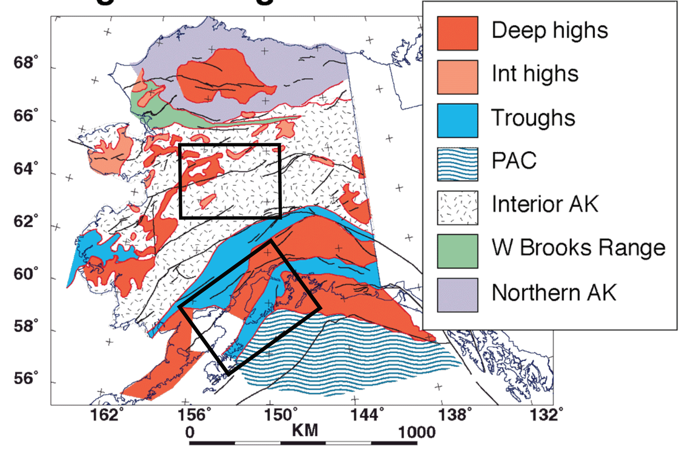
Tectonic Affinities



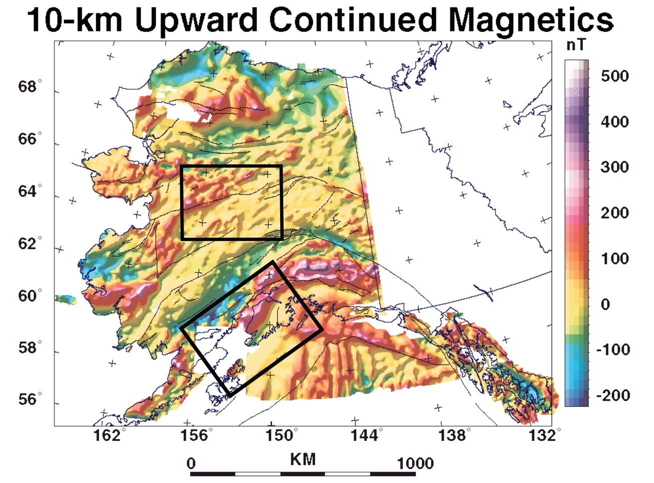
Tectonic (left) and Magnetic (lower left) Domains of Alaska, and Magnetic Data (lower right) from Saltus, et al. (1999).

Modified: Black boxes are the approximate locations of GRAV-D airborne gravity surveys (shown on other figures, to the right). The northerly survey (AK09) was done in July-August 2009 and the southerly survey (AK08) in July 2008.

Regional Magnetic Domains

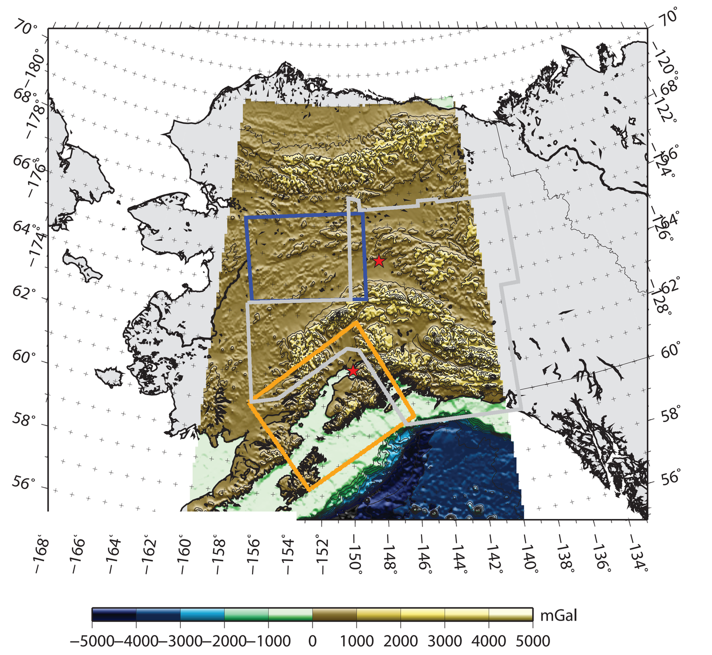


10-km Upward Continued Magnetics



Bathymetry derived from ship depth measurements and ERS-1/Geosat satellite marine gravity (Smith and Sandwell, 1997) and topography from GTOPO30 (see References for download locations of these data sets). Data exists at 2" resolution over all of AK, but only a subset is shown here. The blue box is the 2009 survey, orange box is the 2008 survey, and gray box is 2010 (the 2010 gravity is not presented here). Red stars are the cities of Anchorage and Fairbanks.

Topography/Bathymetry for Central and Western Alaska



5. Methods: GPS, Free-Air Gravity, Bouguer Gravity

1. Kinematic GPS: Solutions for each flight were obtained using the commercial packages of GrafNav and POSPac.

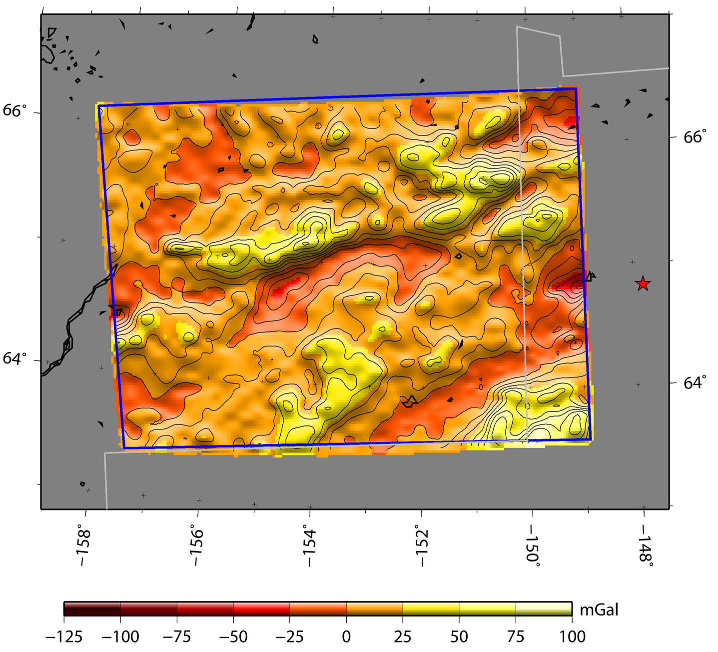
2. Free-Air Gravity Disturbances (FAD): The FAD for each survey were computed with an in-house NGS airborne gravity software package called Newton v.1.1. This software package (programmed in Matlab) applies standard techniques, with a few changes to account for the high-altitude data collected and the geodetic accuracy needed for GRAV-D.

3. Complete Bouguer Gravity Disturbance: The complete (terrain-corrected) Bouguer gravity disturbances were calculated with Gauss-Legendre quadrature integration (von Frese, et al., 1999) using standard density assumptions: 2.67 g/cm^3 for rock and 1.025 g/cm^3 for seawater. Topography used to calculate the corrections came from the freely-available GTOPO30 (USGS, online) and bathymetry from the Smith and Sandwell (1997) altimetry-derived data (see map above).

6. Gravity Products and Initial Tectonic Interpretations

Free-Air Gravity Disturbance - Complete Bouguer Correction (includes terrain) = Bouguer Gravity Disturbance

Free–Air Disturbance for West of Fairbanks



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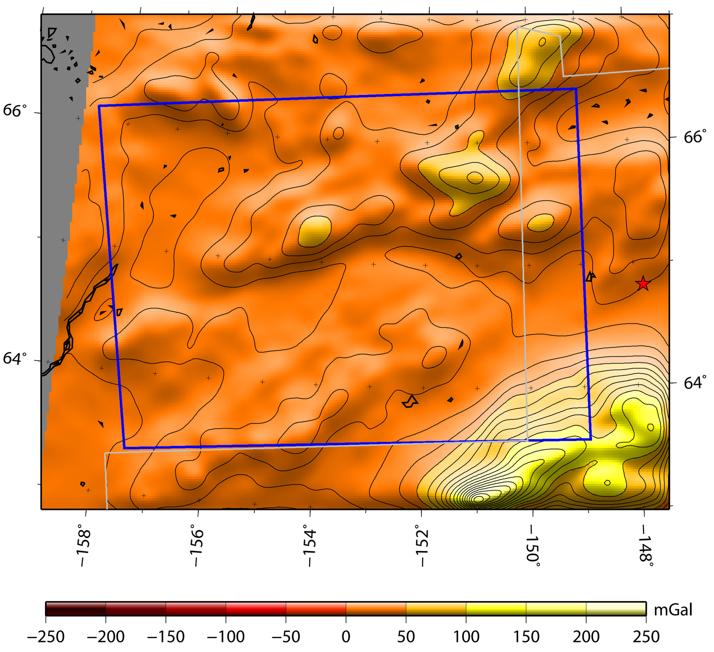
Complete Bouguer Correction, Area West of Fairbanks



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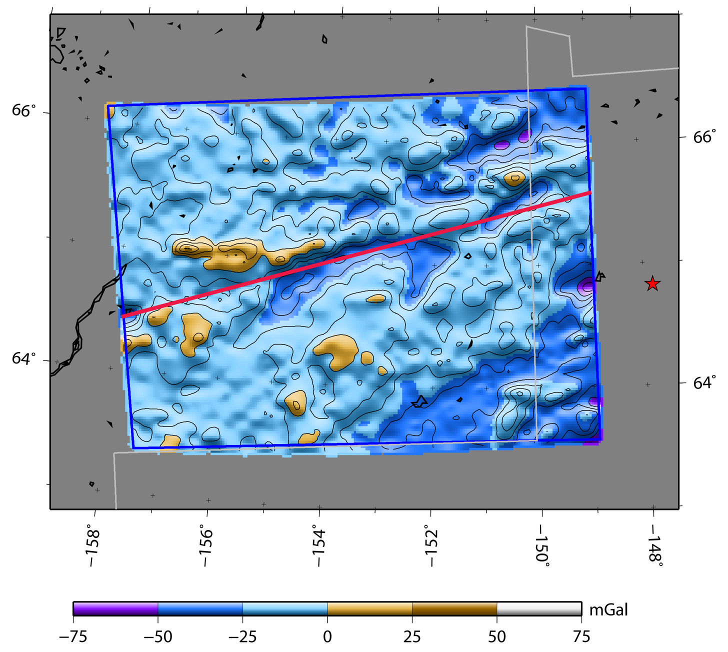
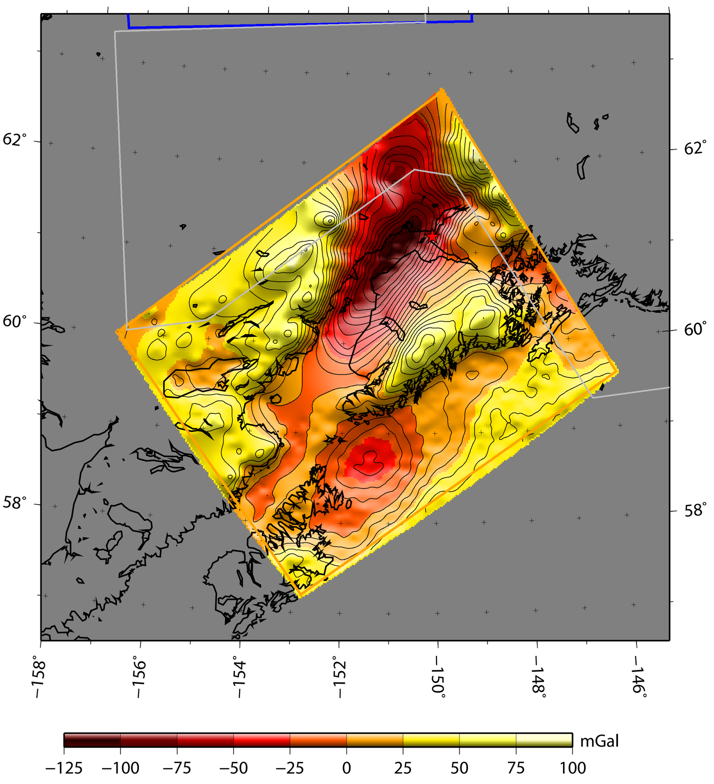
Bouguer Disturbance for West of Fairbanks



Key for all gravity plots: Red stars mark the cities of Anchorage and Fairbanks, blue box is the AK09 survey area, orange box is the AK08 survey area, and gray box is the AK10 survey area (no data shown here).

Red line marks the approximate location of a major fault (see maps in center of poster)

Free–Air Disturbance for the Anchorage Area



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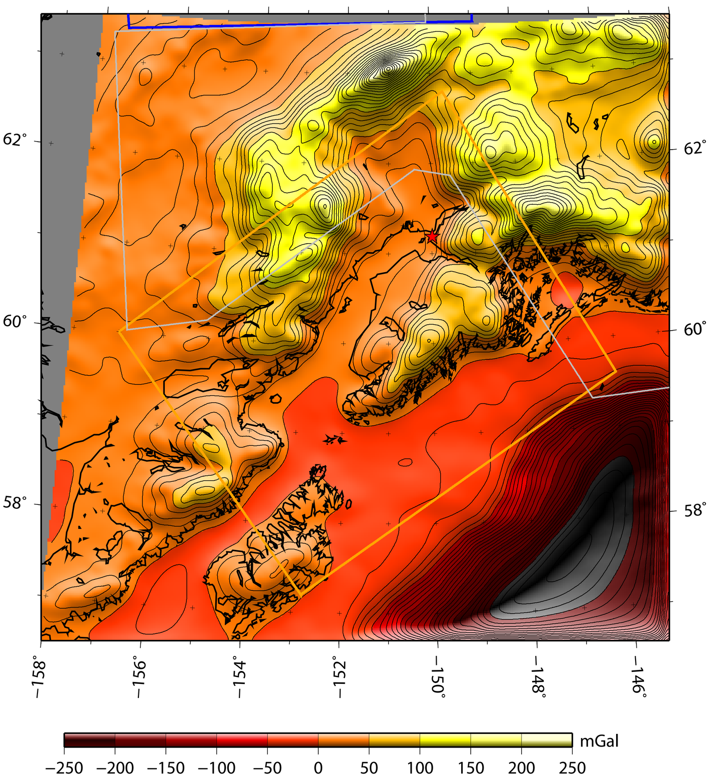
Complete Bouguer Correction for the Anchorage Area



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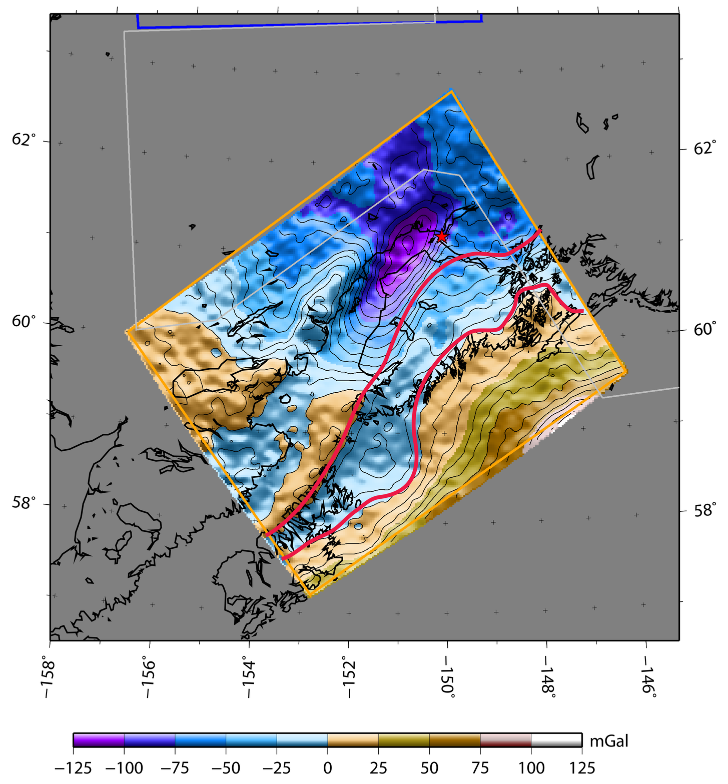
Bouguer Disturbance for the Anchorage Area



Key for all gravity plots: Red stars mark the cities of Anchorage and Fairbanks, blue box is the AK09 survey area, orange box is the AK08 survey area, and gray box is the AK10 survey area (no data shown here).

Red lines enclose the gravity trend correlated to the magnetic low of the accretionary prism (see magnetic map in center of poster)

7. Initial Interpretations and Further Work

1. Fairbanks Area, Interior of Alaska (AK09): The Bouguer gravity distrubance for the Fairbanks area is fairly simple and lacks large gradients that would indicate sharp edges between the tectonic domains of the area. This is similar to the magnetics of the area, which also does not show the tectonic domains. However, the Bouguer gravity trends do run SW-NE, as do the tectonic domains there.

2. Anchorage area, Cook Inlet (AK08): The Bouguer gravity disturbance is complex and of both large positive and negative magnitudes. A major feature is the negative gravity disturbance at the northern side of Cook inlet, which splays in three directions (roughly N, NW, and NE). The red lines on the Bouguer gravity plot enclose the area where the gravity corresponds to the accretionary prism's magnetic and tectonic domain extents.

3. Further Work: Isostatic gravity anomalies, gradient calculations, and spectral analyses.

8. References

Saltus, R.W., P.L. Hill, G.G. Connard, T.L Hudson, and A. Barnett. (1999) "Building a Magnetic View of Alaska." U.S. Geological Survey Open-File Report 99-0418. Available: http://pubs.usgs.gov/of/1999/ofr-99-0418/

Smith, W.F. and D.T. Sandwell. (1997) "Global Sea Floor Topography from Satellite Altimetry and Ship Depth Soundings." *Science* **277**, 1956-1962. Data available: http://www.mathworks.com/support/tech-notes/2100/2101.html; ftp://topex.ucsd.edu/pub/global_topo_2min/; http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html

von Frese, R.R.B., W.J. Hinze, L.W. Braile, and A.J. Luca. (1981) "Spherical earth gravity and magnetic modeling by Gauss-Legendre quadrature integration." *J. Geophys*, **49**, 234-242.