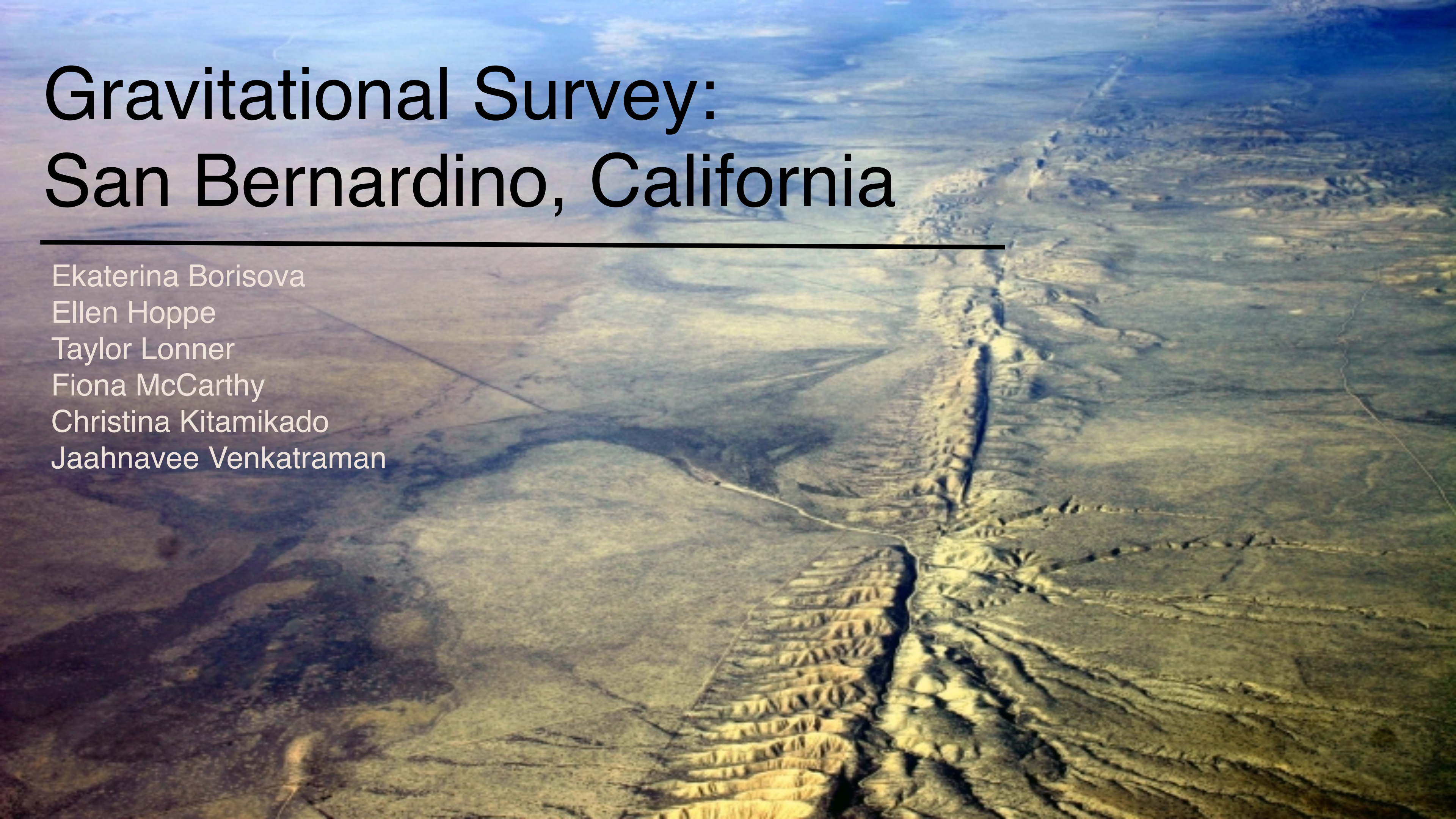
Gravitational Survey: San Bernardino, California

Ekaterina Borisova
Ellen Hoppe
Taylor Lonner
Fiona McCarthy
Christina Kitamikado
Jaahnavee Venkatraman



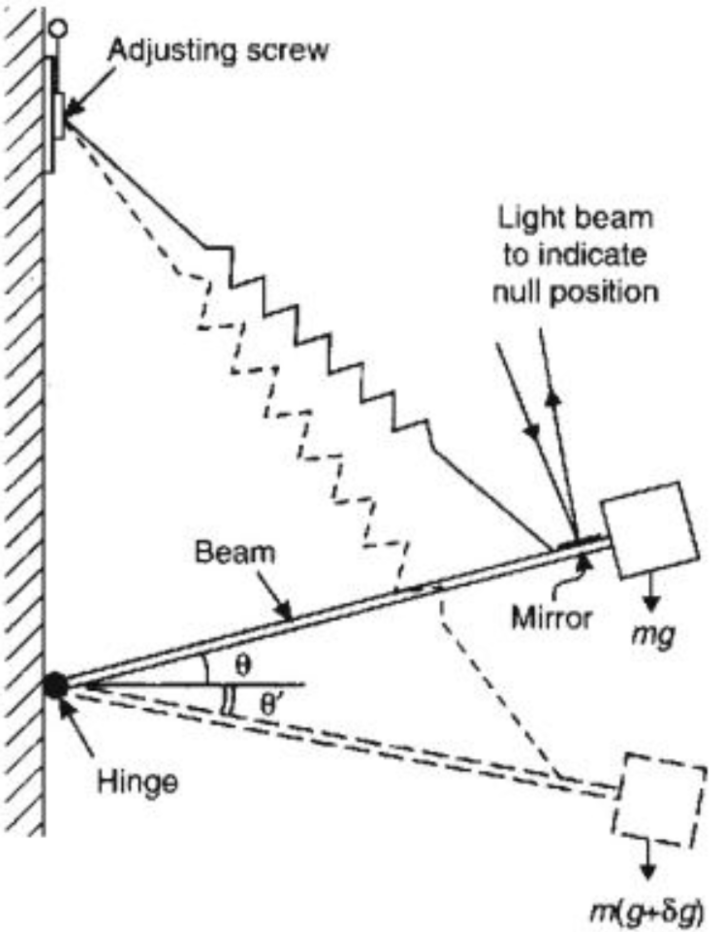
Background

$$F_g = \frac{-GMm}{r^2}$$

- What is gravity?
- Why do we use gravity?
  - Density gradients
  - What's going on underground?
- How do we measure it?
  - Lacoste-Romberg Gravimeter
- Where was our survey?
  - San Bernardino, CA

Inside the Gravimeter

- Gravity displaces the mass
- The spring supporting the mass is attached to an adjusting screw, which is adjusted until theta is zero
- When theta is equal to zero, there is no displacement in the beam, and the mirror reflects light

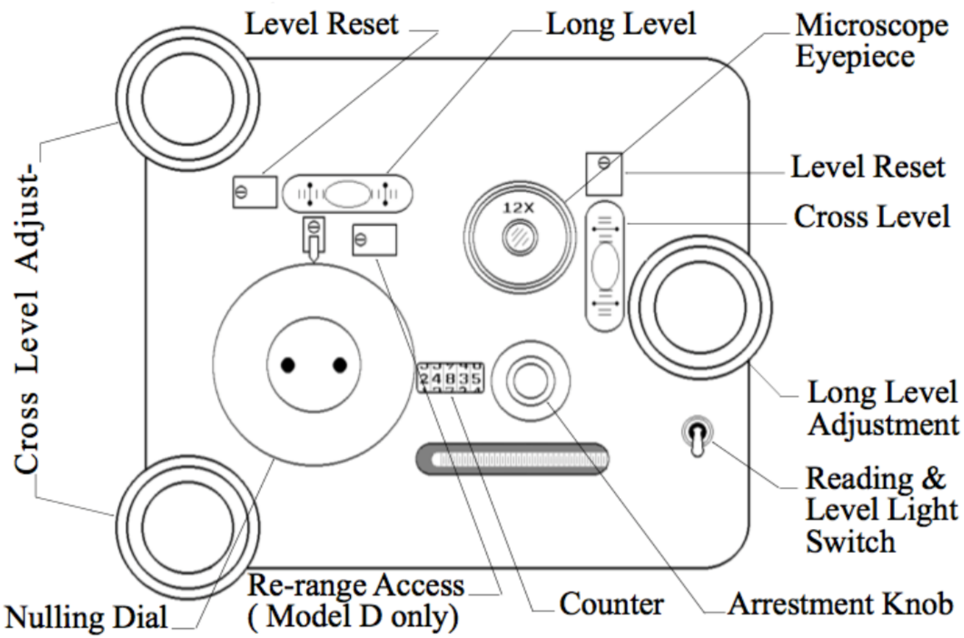


Before Taking Gravity Measurements

- The Gravimeter must be level
- The Gravimeter must be kept at 52 degrees C

Reading Gravity Measurements

- First, unlock the gravimeter
- The gravity reading is taken from left to right
- The crosshair should be just touching the 2.5 mark when a measurement is recorded
- The measurements are read off the counter and nulling dial



Converting Gravity reading to mGals

1. Round counter reading down to nearest hundreds place and find corresponding mGal value
2. Subtract the rounded value from the counter value and multiply by the given interval factor
3. Add the values obtained in steps 1 and 2 for the gravity reading in mGals

TABLE 1

MILLIGAL VALUES FOR LACOSTE & ROMBERG, INC. MODEL G GRAVITY METER #G- 530

COUNTER READING*	VALUE IN MILLIGALS	FACTOR FOR INTERVAL	COUNTER READING*	VALUE IN MILLIGALS	FACTOR FOR INTERVAL
000	000.00	1.02702			
100	102.70	1.02693	3600	3698.52	1.02785
200	205.40	1.02689	3700	3801.30	1.02783
300	308.08	1.02689	3800	3904.09	1.02780
400	410.77	1.02691	3900	4006.87	1.02776
500	513.46	1.02695	4000	4109.64	1.02772
600	616.16	1.02702	4100	4212.41	1.02767
700	718.86	1.02707	4200	4315.18	1.02760
800	821.57	1.02708	4300	4417.94	1.02754
900	924.28	1.02706	4400	4520.69	1.02747
1000	1026.98	1.02704	4500	4623.44	1.02740
1100	1129.69	1.02703	4600	4726.18	1.02733
1200	1232.39	1.02706	4700	4828.91	1.02722
1300	1335.10	1.02708	4800	4931.64	1.02702
1400	1437.80	1.02715	4900	5034.34	1.02694
1500	1540.52	1.02721	5000	5137.03	1.02678
1600	1643.24	1.02727	5100	5239.71	1.02661
1700	1745.97	1.02733	5200	5342.37	1.02642
1800	1848.70	1.02738	5300	5445.01	1.02623
1900	1951.44	1.02743	5400	5547.64	1.02603
2000	2054.18	1.02747	5500	5650.24	1.02582
2100	2156.93	1.02751	5600	5752.82	1.02560
2200	2259.68	1.02755	5700	5855.38	1.02537
2300	2362.43	1.02759	5800	5957.92	1.02510
2400	2465.19	1.02763	5900	6060.43	1.02482
2500	2567.96	1.02767	6000	6162.91	1.02452
2600	2670.72	1.02770	6100	6265.36	1.02420
2700	2773.49	1.02774	6200	6367.78	1.02387
2800	2876.27	1.02776	6300	6470.17	1.02349
2900	2979.04	1.02778	6400	6572.52	1.02312
3000	3081.82	1.02780	6500	6674.83	1.02270
3100	3184.60	1.02782	6600	6777.10	1.02229
3200	3287.38	1.02783	6700	6879.33	1.02183
3300	3390.17	1.02783	6800	6981.51	1.02140
3400	3492.95	1.02784	6900	7083.65	1.02093
3500	3595.73	1.02785	7000	7185.75	

* Note: Right-hand wheel on counter indicates approximately 0.1 milligal.

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- Base station, took measurements every 200 meters for 10 measurements
    - 3 measurements, take median
    - Ending elevation ~871m
    - Returned to base station to check for drift

Corrections

$$\Delta g_L = 0.000811 \sin(2\phi) \times \Delta s$$

$$\Delta g_D = m_{drift} \Delta t$$

- Latitude corrections
  - Geo-Spheroid
  - Radial Effects of Position
  - Correction: Subtract when moving North in the Northern Hemisphere

- Drift Correction
  - Imperfect instrumentation
  - Time-dependent
  - Retaking base station data
  - Correction: Calculate and subtract from each reading

Corrections

$$\Delta g_{FA} = 0.3086 \times h$$

$$\Delta g_{B} = 0.04192\rho \times h$$

$$\Delta g_{topography} = (0.3086 - 0.04192\rho) \times h$$

- Free Air
  - Radial Effects of Elevation
  - Derived from the gravitational acceleration at the surface
  - Correction: If above sea level, this correction should be added

- Bougeur
  - Mass from topography
  - Derived from Gauss' Infinite Slab (small scale correction)
  - Correction: If you are above sea level due to mass (ie: on a mountain), it should be subtracted

Since these equations use the same measurement for elevation, they can be combined:

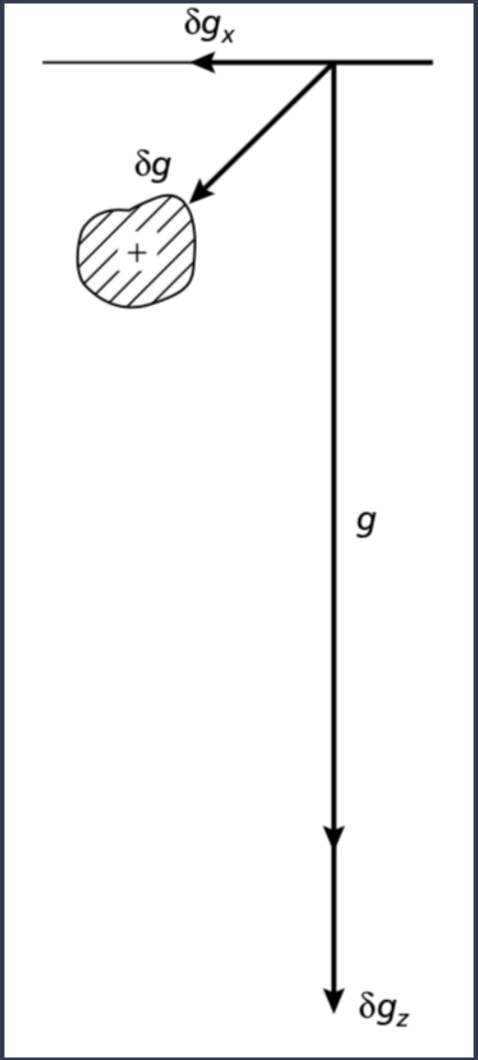
Gravity Anomalies

The other kinds of anomalies that you could model:

1. most general - some kind of excess mass, with no defined shape/irregular cross section

2. sphere
3. cylinder
4. thin dipping sheet
5. horizontal sheets
6. thick two dimensional dike

We chose to use semi-infinite sheet because we are looking assuming that a fault is an semi infinite sheet



Fitting of the Model

The python code that we used was used to do three things:

1. Convert the counter reading from the gravimeter into relative mGals

2. Make latitude, free air, bouguer corrections

3. Using curvet to solve for the parameters that were just “guesses” before

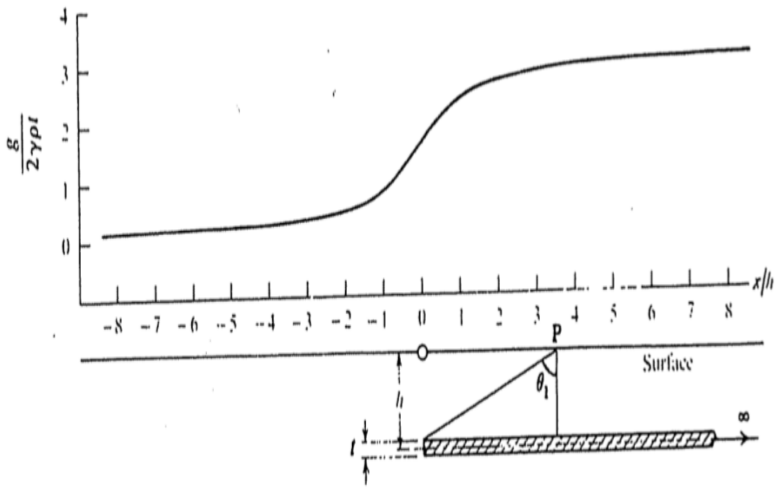
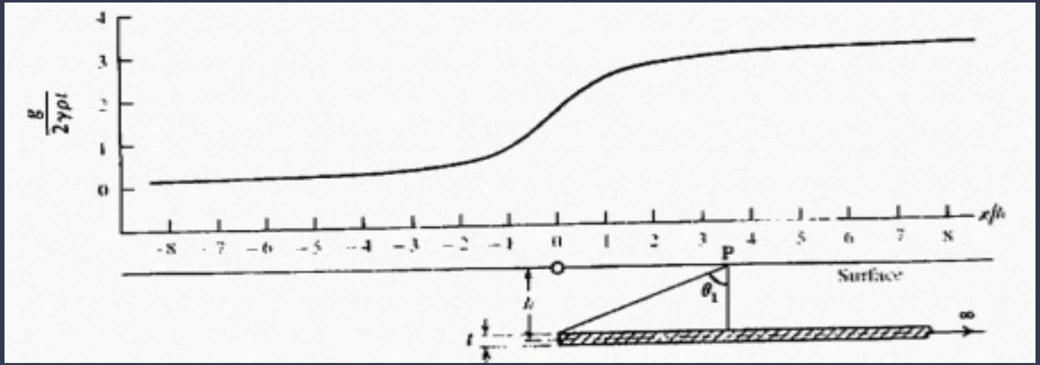


Figure 2.28. Gravity effect of a semiinfinite horizontal sheet.

$$g = 2\gamma\rho t\left\{\pi/2 + \tan^{-1}(x/h)\right\} \qquad (2.67)$$

Data —— our final model



- A gravity anomaly from the San Andreas Fault can be modeled as a horizontal sheet, whose length extends to infinity on one side:

$$\boxed{g = 2\gamma\rho t\left(\frac{\pi}{2} + \arctan\left(\frac{x - x_{offset}}{h}\right)\right) + y_{shift}}$$

where, g = acceleration due to gravity (m/s^2)
gamma = universal gravitational constant (kgm/s^2)
rho = density contrast b/w the sheet and surrounding area (kg/m^3)
t = thickness of the sheet (m)
x = horizontal distance from reference (m)
x_{offset} = distance offset of sheet edge or fault edge from x = 0 (m)
h = depth of the sheet or fault (m)
y_{shift} = gravity shift along the y-axis (mGals)