FIG WORKING WEEK 2017
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Inclusion of Leveling with GNSS Observations in a Single, 3-D Geodetic Survey Network Adjustment

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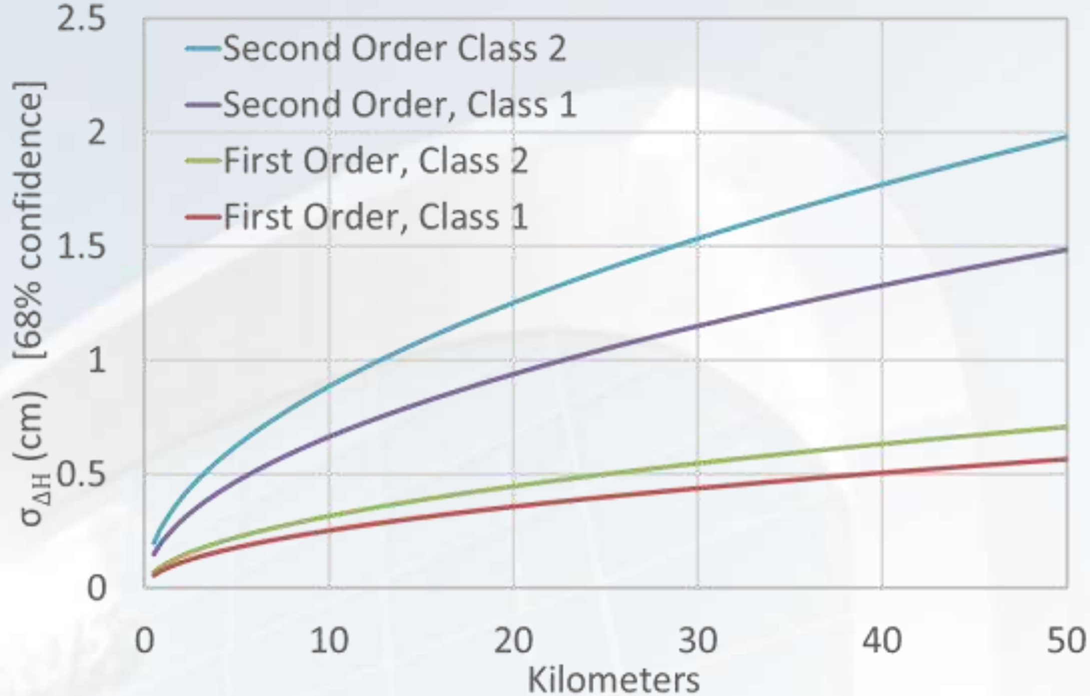
Background

- Currently, the United States has two official datums:
  - ”Horizontal” or ”Geometric” = NAD 83→ realized with GPS/GNSS
  - ”Vertical” = NAVD 88 →realized with differential leveling
- Replace datums in 2022
  - “Geometric” control will be derived with GNSS
  - Vertical control will be derived with GNSS and a high-accuracy gravimetric geoid model (H = h – N)

Problem & Objectives

- Differential leveling is more precise than GNSS for finding *ΔH* for a short distance (i.e., < 50 km)

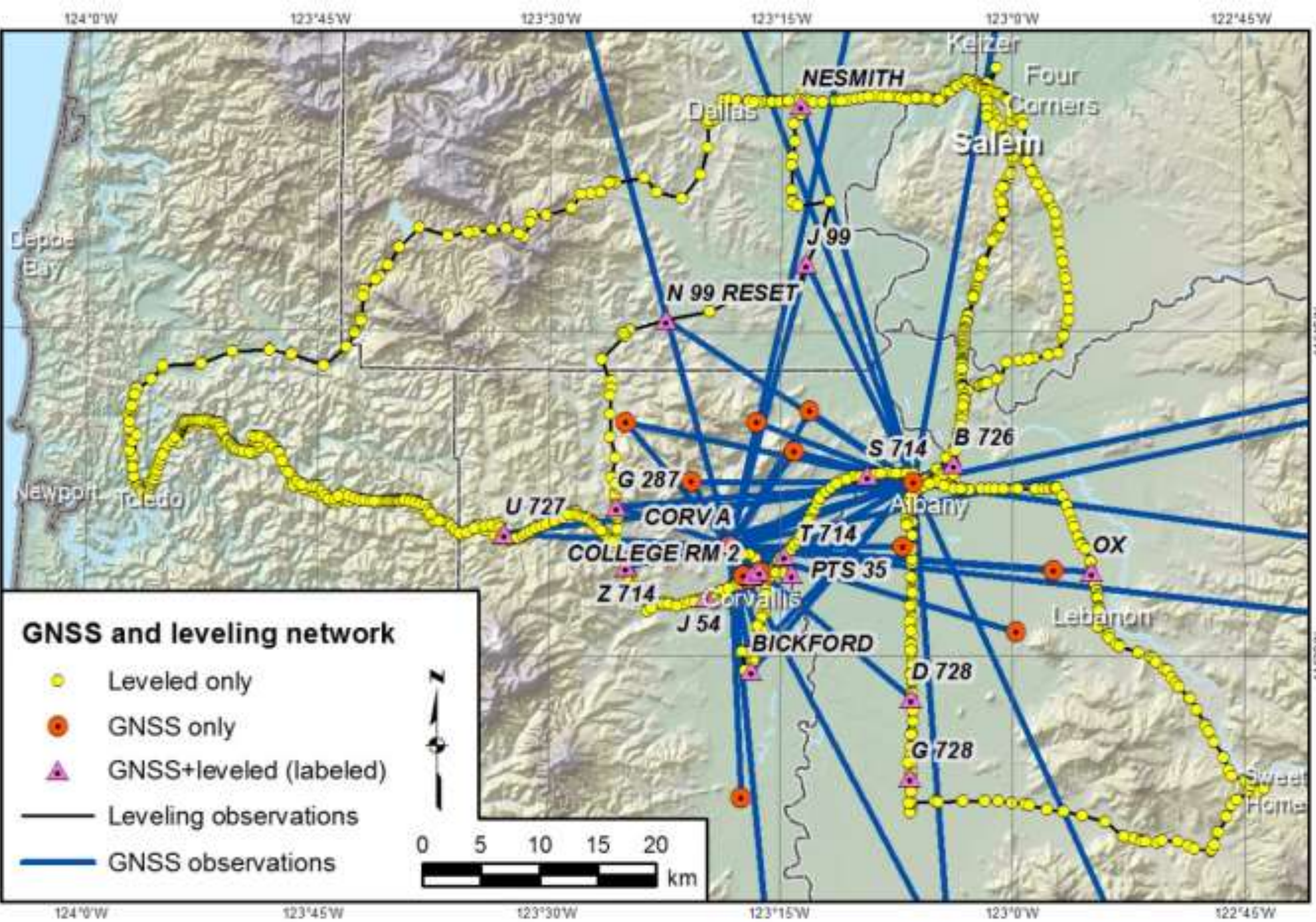


- Attempt to include differential leveling with GNSS vectors, and geoid heights in a 3-D geodetic survey network

$$\Delta h = \Delta H + \Delta N$$

$$\sigma_{\Delta h} = \sqrt{\sigma_{\Delta H}^2 + \sigma_{\Delta N}^2}$$

Study Area

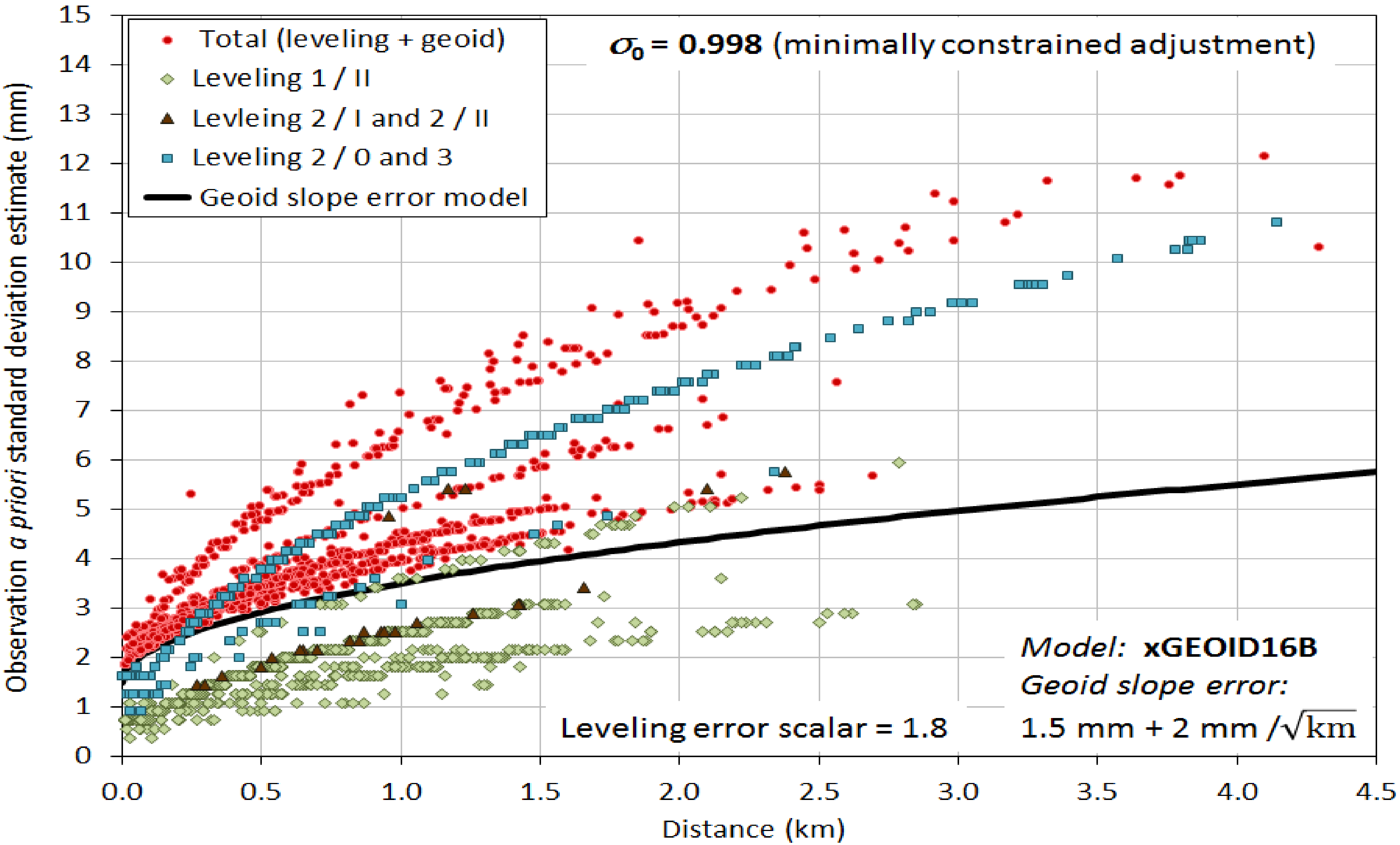


<u>1062 Stations</u>

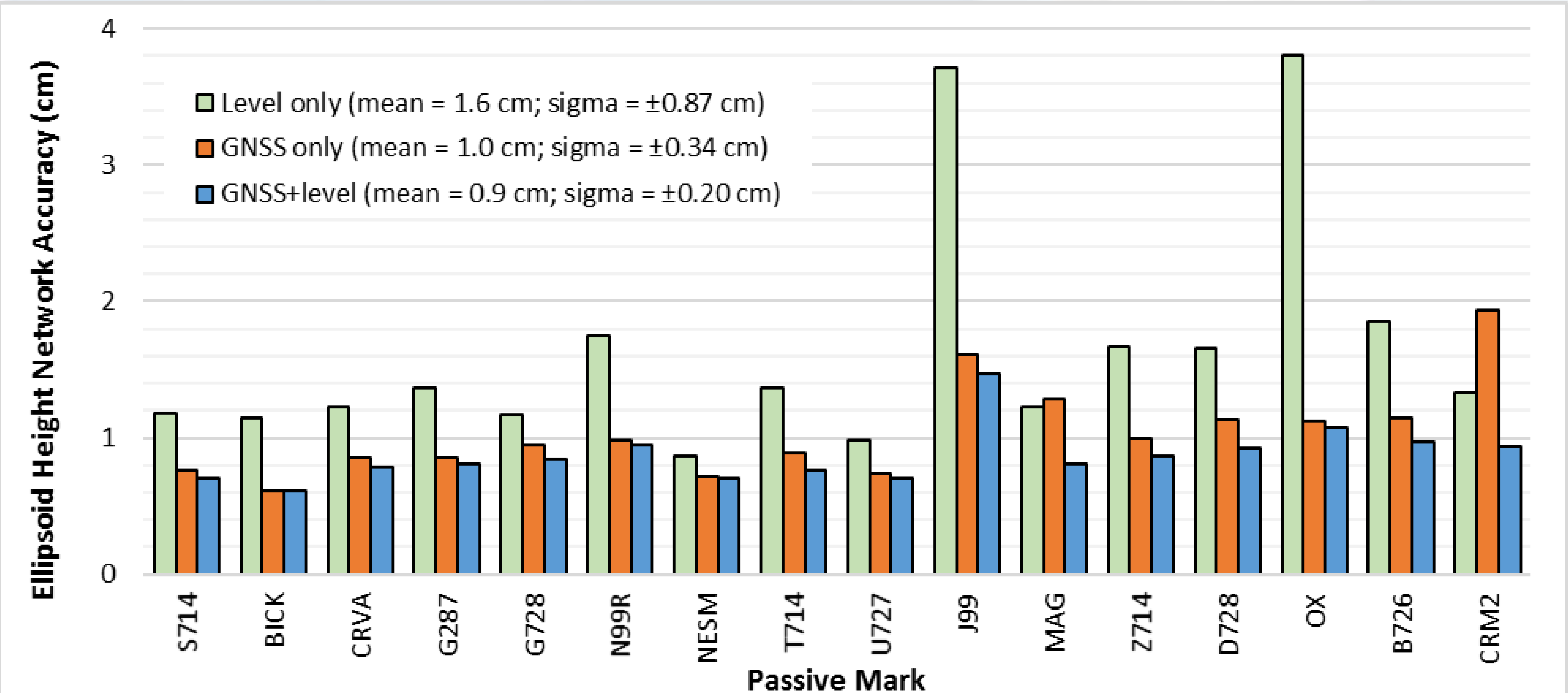
- 18 GNSS+Leveling
- 22 GNSS-only
- 1022 Leveling-only

<u>1615 Observations</u>

- 1256 Leveling Observations
- 359 GNSS vectors


Total (leveling + geoid)
Leveling 1 / II
Levleing 2 / I and 2 / II
Leveling 2 / 0 and 3
Geoid slope error model
σ_0 = 0.998 (minimally constrained adjustment)
Model: xGEOID16B
Geoid slope error:
1.5 mm + 2 mm /$\sqrt{\text{km}}$
Leveling error scalar = 1.8
Observation a priori standard deviation estimate (mm)
Distance (km)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

Adjustment Results (95% confidence)



Conclusions

GNSS+Leveling Networks:

- Useful for identifying bench marks with poor leveled heights
- Roughly doubled the precision of the adjusted observation residuals (in up)
- GNSS added redundancy to the leveling, and helps control the increase in error when leveling over long distances.
- Adding leveling provided greater vertical precision over short distances than can be achieved with GNSS alone
- GNSS+Leveling network accuracies (in up) were consistently smaller and more precise than the leveling-only network