Analysis of ionospheric errors and correction techniques in high-rate GPS glaciology

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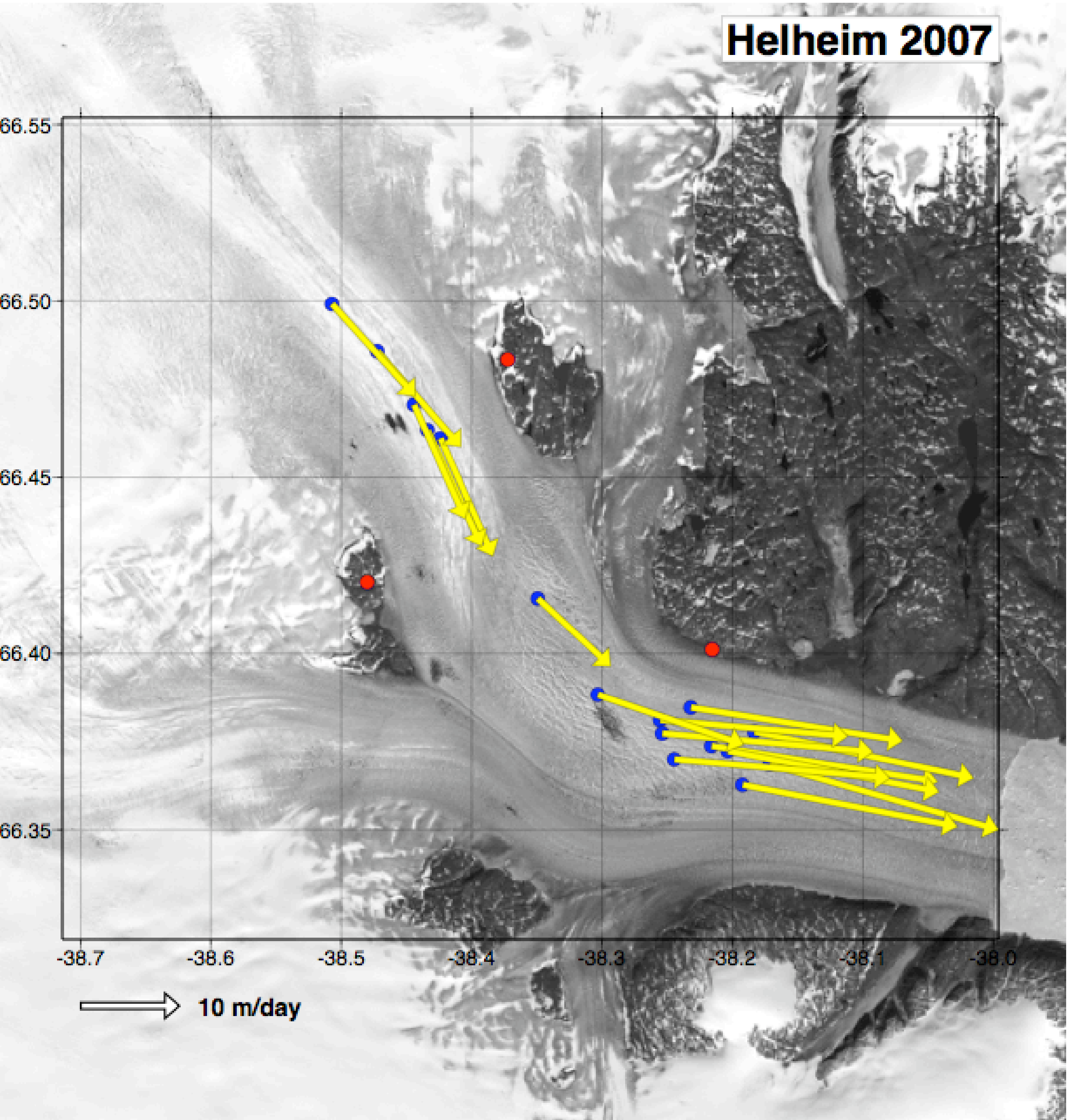
Scientific Motivation

GPS-derived average glacier flow



- GPS is starting to be used on fast-flowing glaciers to investigate detailed kinematics & dynamics
- Requires small station spacing (~km) over small network size (~20 km)
- High position accuracy is required at wide range of time scales, from sec (speed-ups associated with glacial EQs) to months (seasonal)
- GPS receivers are at high risk for loss
- Can we use L1-only systems to reduce cost without sacrificing accuracy?

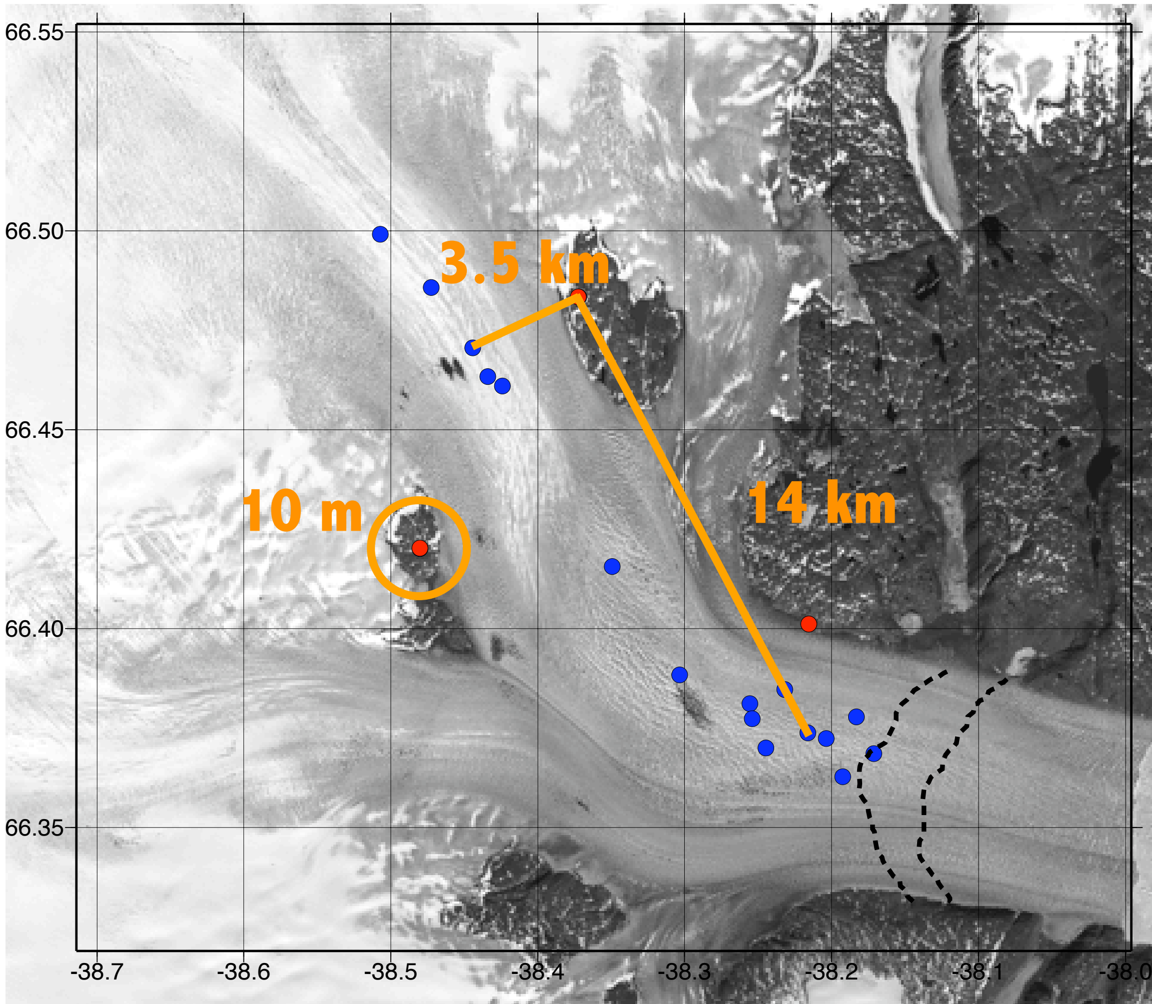
Experimental approach

Problem: Assess accuracy of high-rate L1-only solutions in a fast-flowing glacier environment.

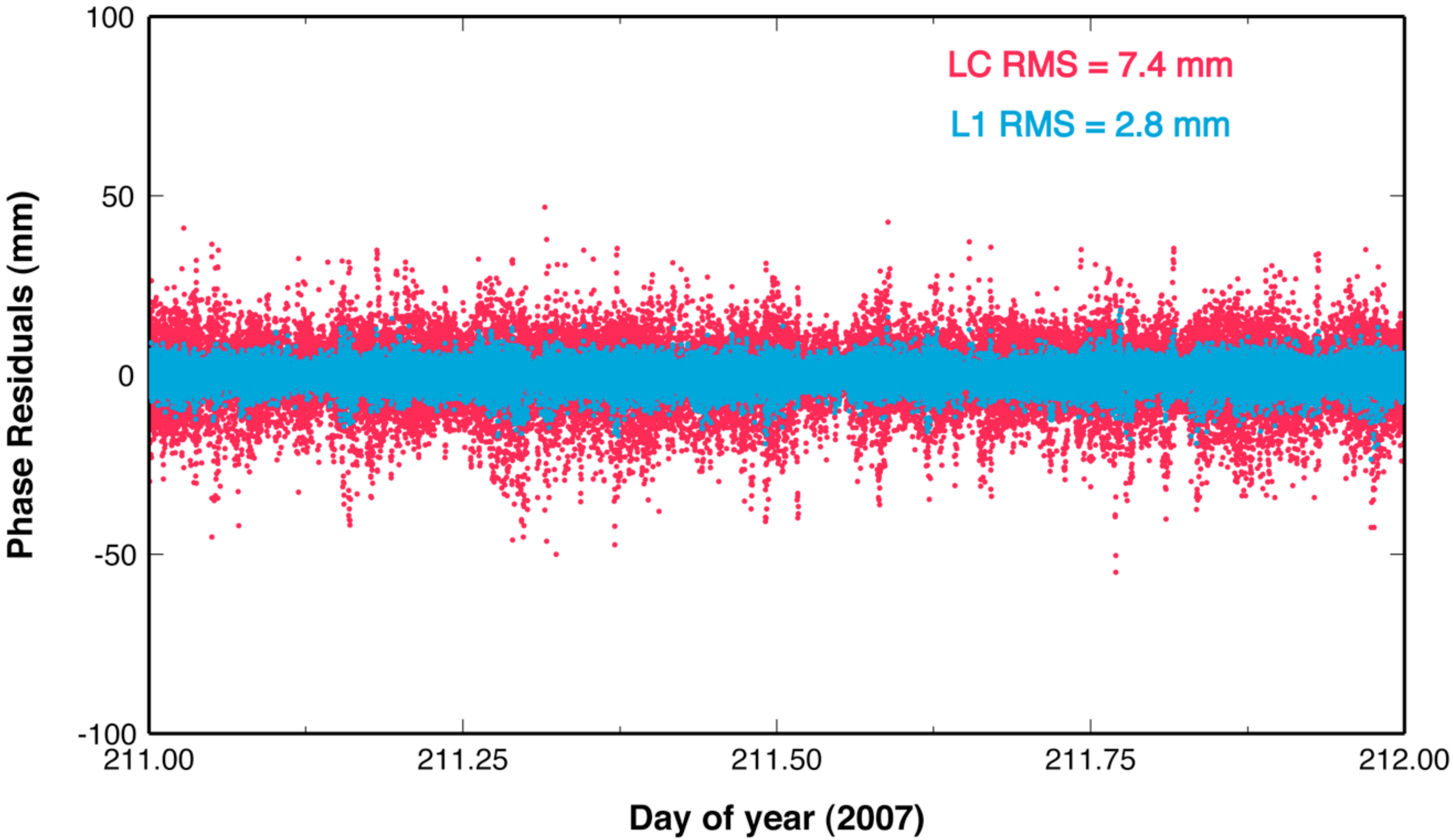
Method: Compare LC and L1 high-rate GPS solutions processed using TRACK (GAMIT/GLOBK) for different baselines and configurations:

- ✦ 10-m, rock sites (static)
- ✦ 3.5-km, glacier sites (flow~12 m/d)
- ✦ 14-km, glacier sites (flow~22 m/d)

- ✓ RMS statistics
- ✓ Position estimates



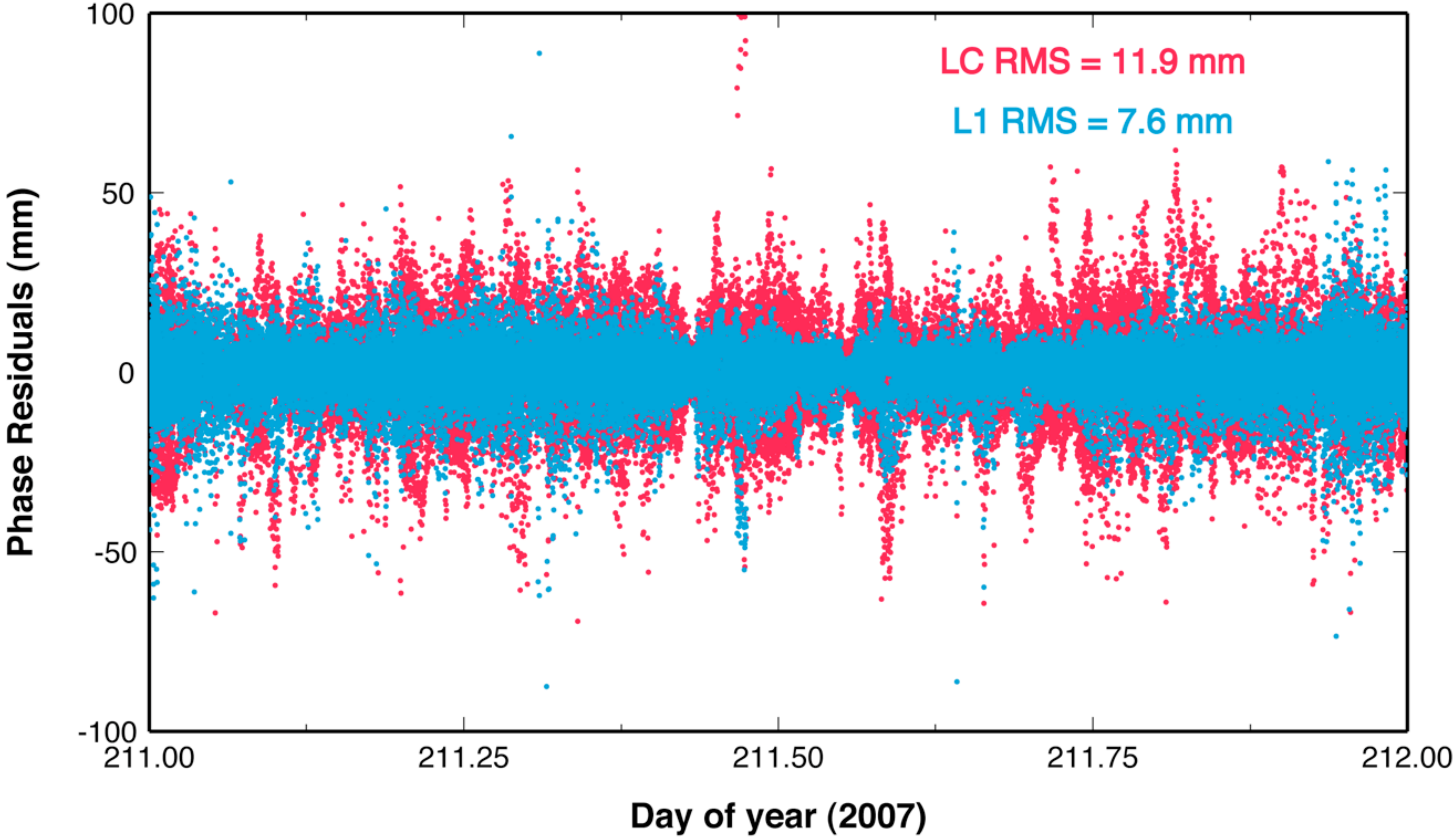
Statistics for rock site: 10-m baseline



1 day

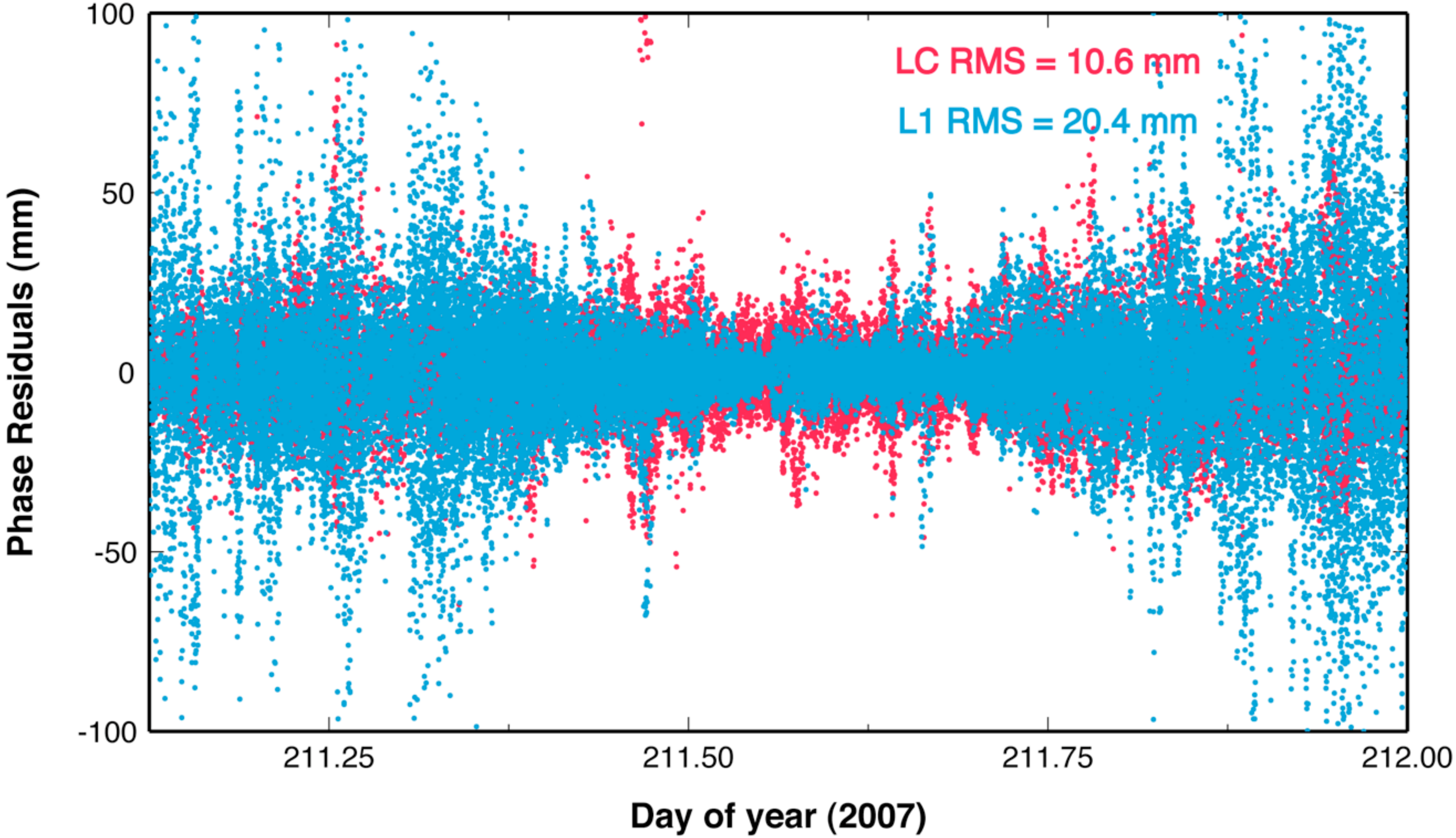
Statistics for glacier site: short baseline

Baseline ~3.5 km   Velocity ~12 m/d

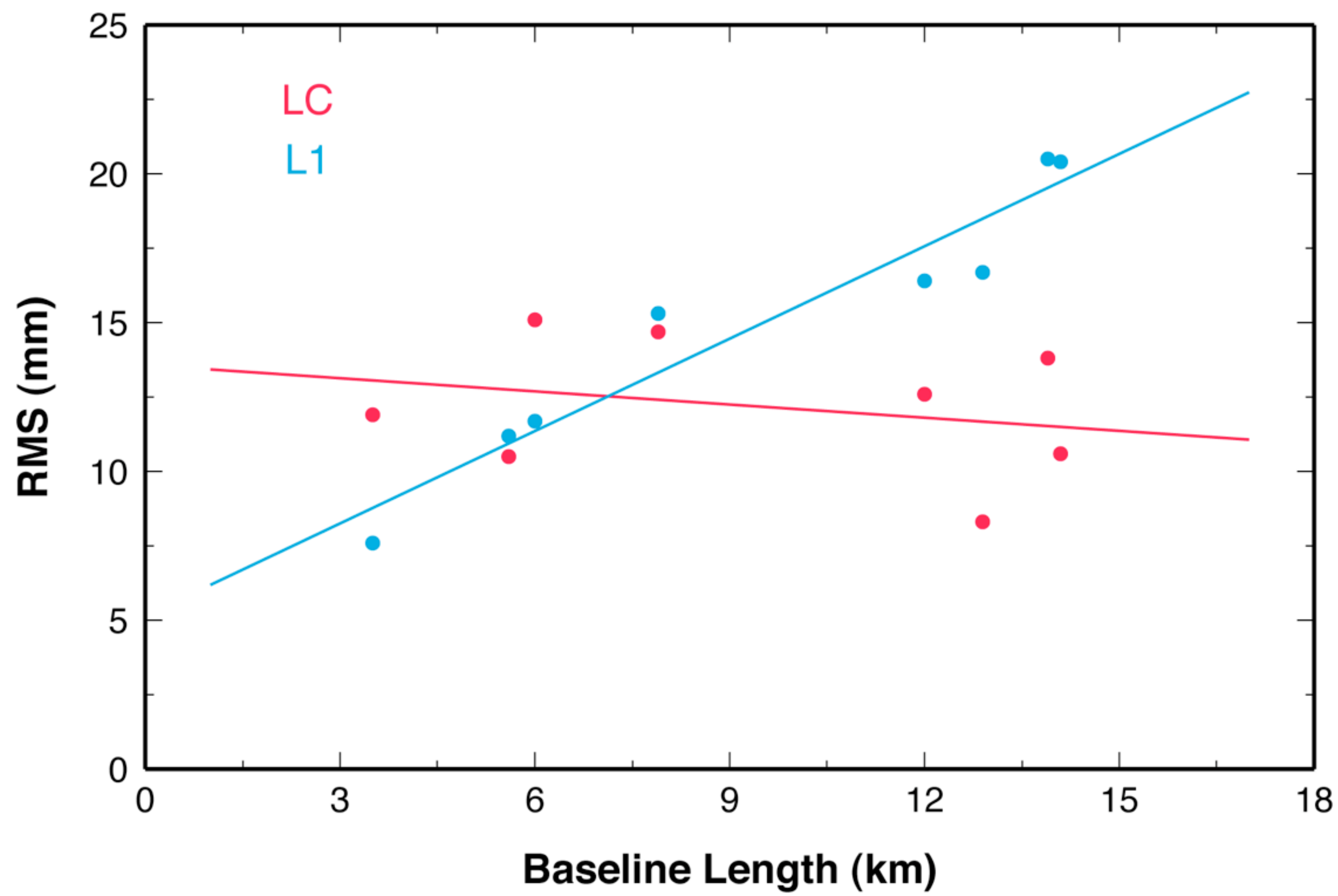


Statistics for glacier site: long baseline

Baseline ~14 km   Velocity ~22 m/d



Statistics for all glacier sites

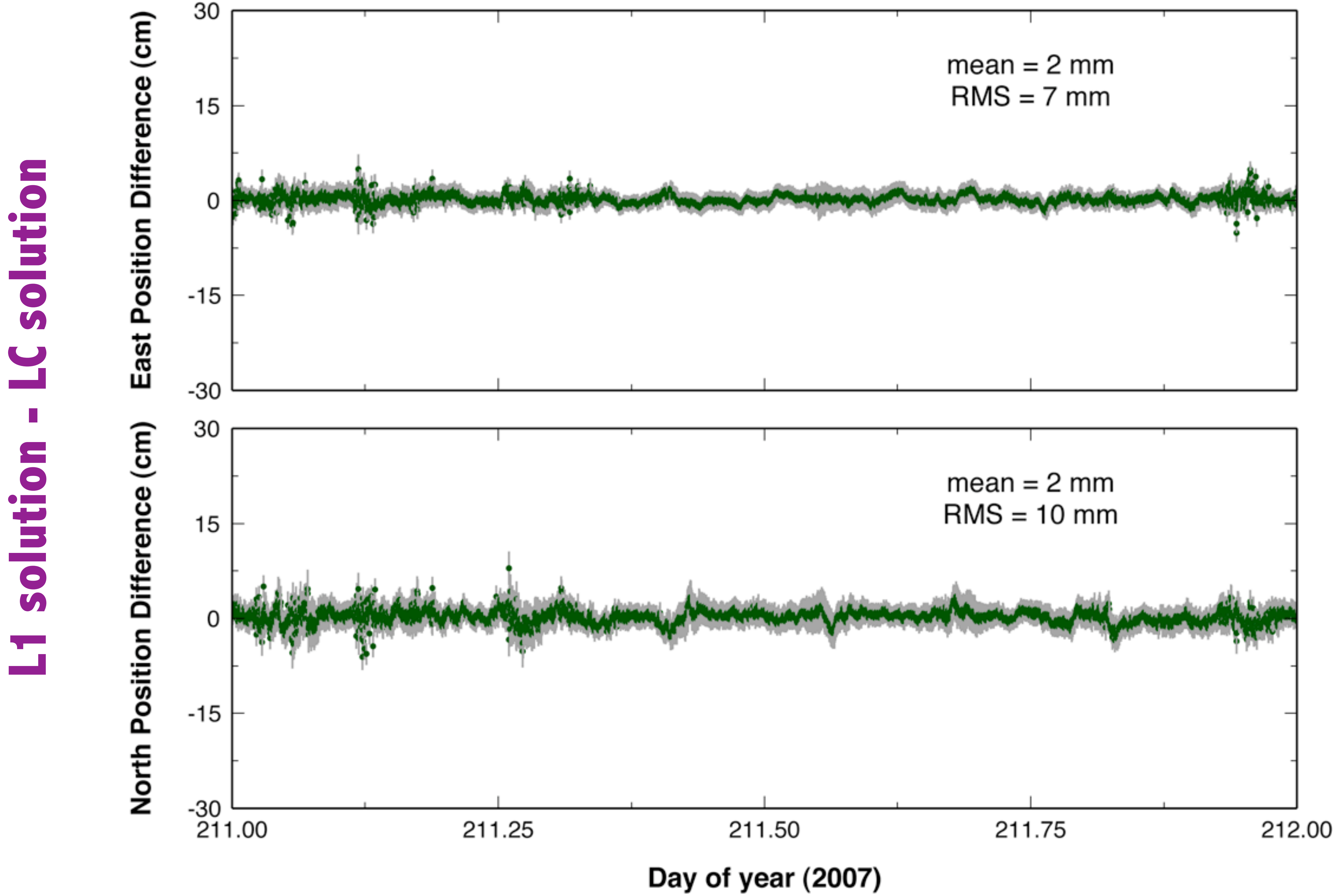


LC ➡ RMS baseline independent: RMS ~ 8-15 mm

L1 ➡ RMS baseline dependent: RMS = 5 mm + 1 mm/km * Baseline Length

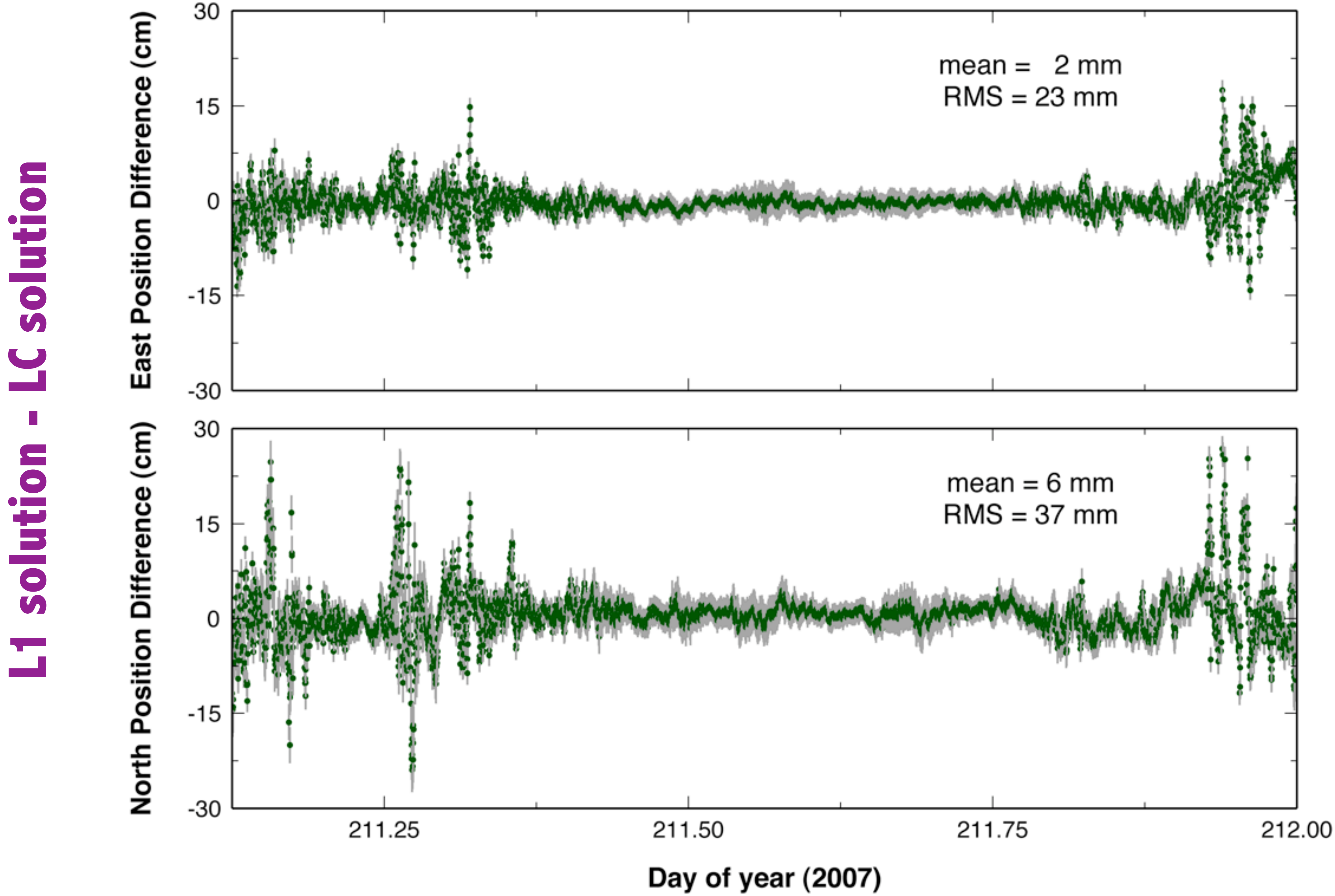
Estimates for glacier site: short baseline

Baseline ~3.5 km   Velocity ~12 m/d

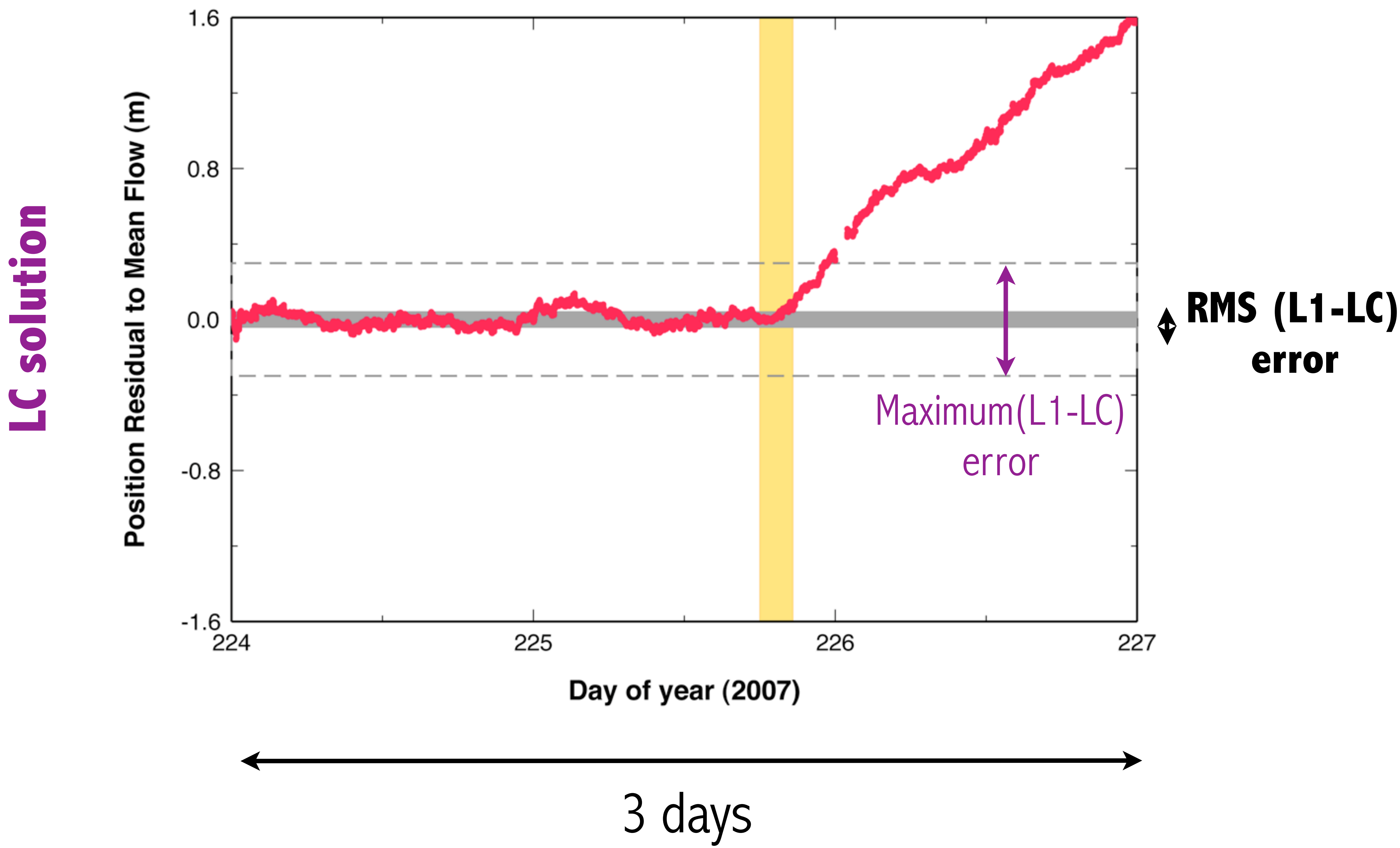


Estimates for glacier site: long baseline

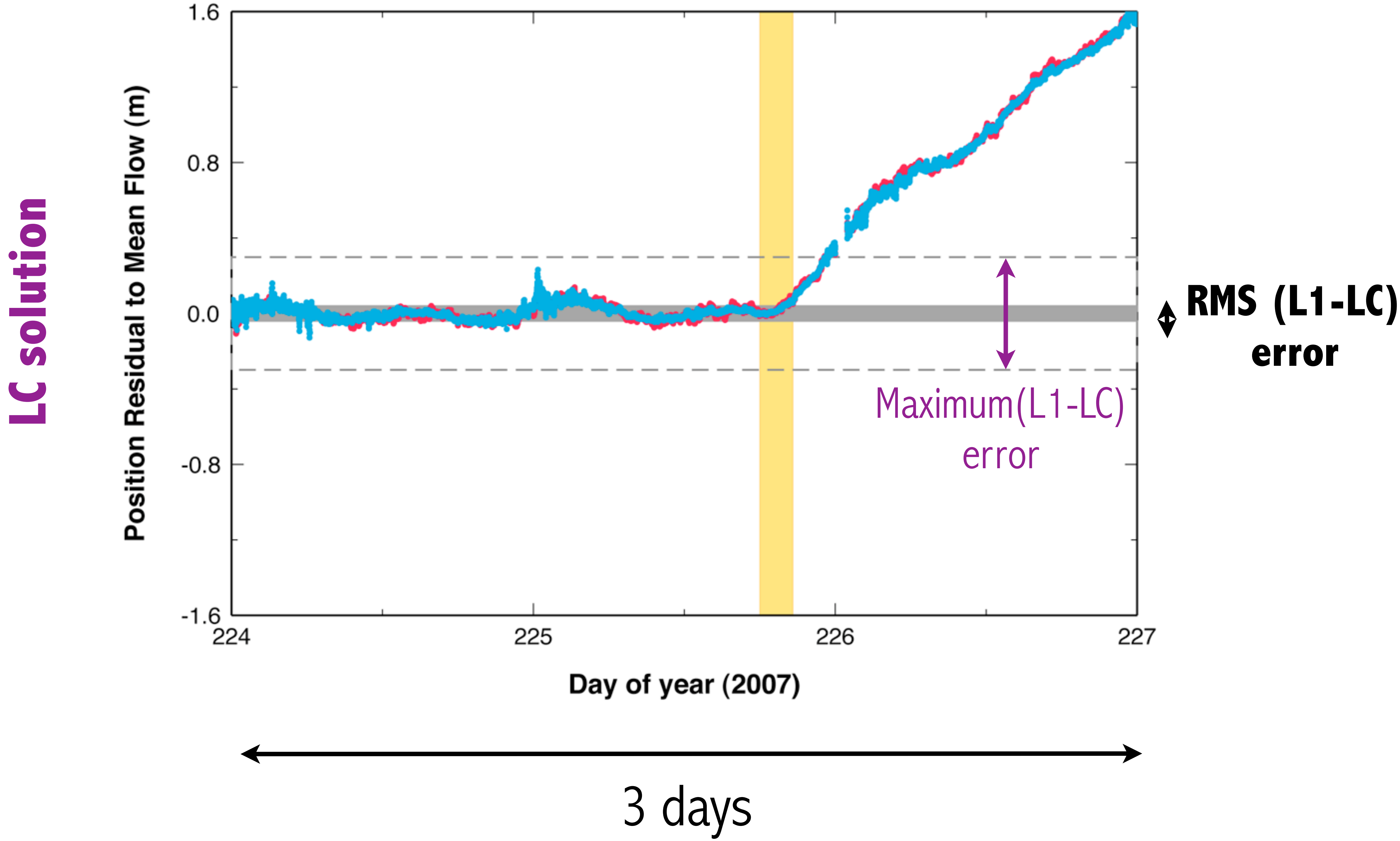
Baseline ~14 km   Velocity ~22 m/d



Ability to resolve glacier speed-ups



Ability to resolve glacier speed-ups



Conclusions

- RMS baseline-length dependence, L1 vs LC:
  - Short baseline (<6 km): L1 more precise than LC.
  - Long baseline (>6 km): L1 precision is time dependent, LC is better overall.
- The RMS is a combination of errors associated with multipath, fast flow, and others.
- Increasing L1 RMS with increasing baseline length suggests a significant ionospheric contribution to the L1 error, though its temporal variation remains to be explained.
- Mean position differences between L1 and LC are less than 6 mm over 24h.
- Maximum L1 - LC instantaneous position difference is less than 30 cm.
- L1 suitable for detection of glacier speed-ups associated with glacial earthquakes.
- But remember we are at the minimum of an 11-year ionospheric cycle and at high latitudes, so evaluation will continue into the future.