Aircraft Ocean Altimetry: Recent Results (Part II, C/A code)

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OUTLINE

- Justification
- Experimental Campaign
- Inversion approach: roughness and altimetry
- Altimetric products: precision
- Altimetric products: accuracy
- Discussion

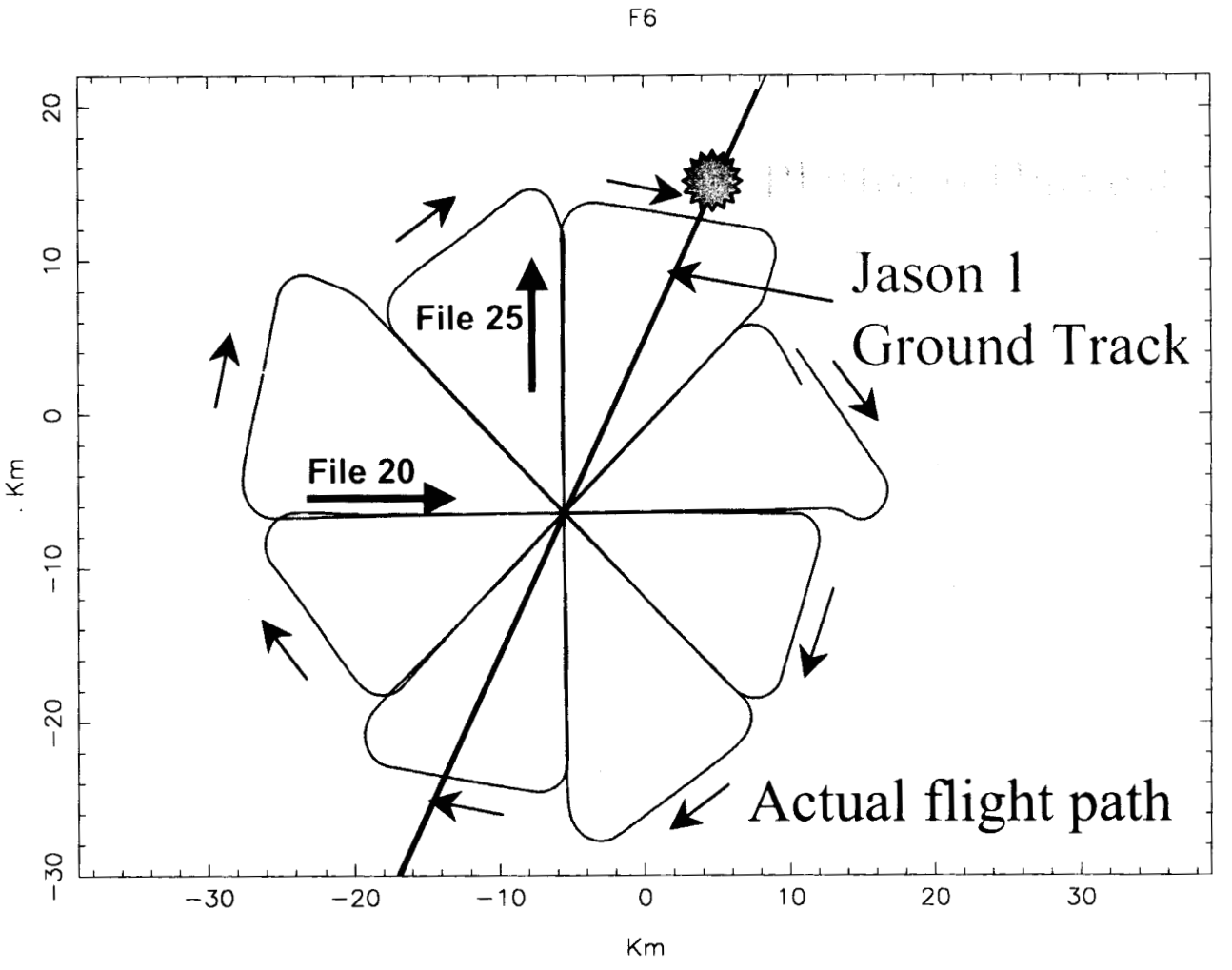
Justification

The use of coarse code observations from aircraft has interest because:

- The precise code is generally not available.
- The coarse code (C/A) measurements are useful for roughness determination, complementing the altimetric products.

F6: Flower Pattern Fligth

- Flight at H~3000 m altitude
- Flower-like pattern in the trajectory to find out about <u>geometrical effects</u> onto the <u>altimetric</u> products and roughness estimates.
- Schedule with high elevation GPS satellite
- Schedule with Jason 1 overpass, flower centered on path



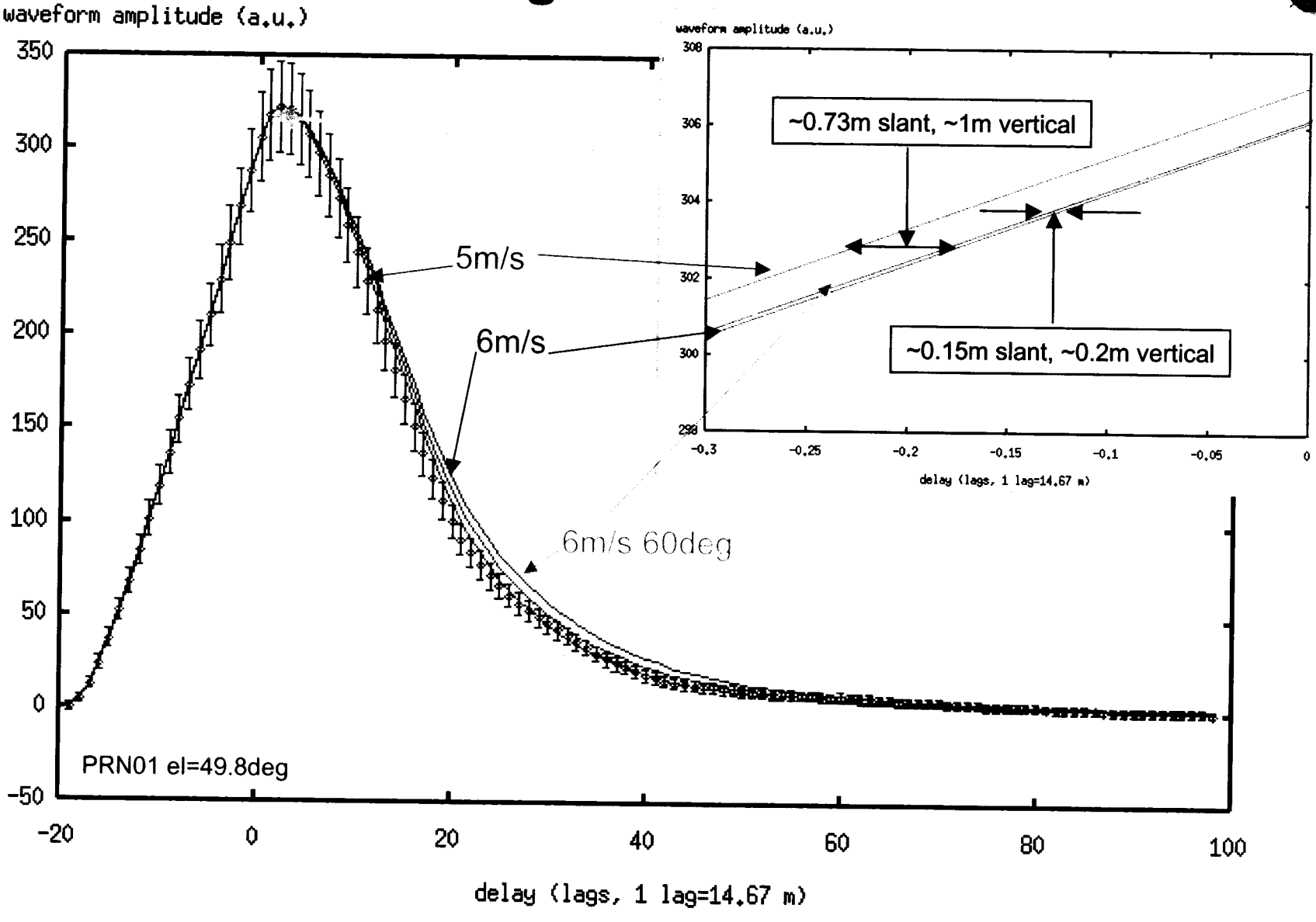
Inversion Approach

- Pre-processing: the bit stream data collected at 20.456 Mbps are pre-processed with a JPL's software receiver, using C/A code replicas, with the following features:
  - C/A group delay loop in the direct and reflected link
  - phase lock loop in the direct signal
  - open loop for reflected signal processing
  - OUTPUT: delay waveforms, used at Ti=10ms
- Geophysical Inversion: The leading edge depends on the surface's roughness, so it does the location of the tracking point within the edge (specular reflection delay). Need of solving for roughness as intermediate product:
  - 1st step: fit of the delay waveform against a roughness parameterized model to infer roughness state (non-coherent averaging of 2 seconds).
  - 2nd step: the best fit solution waveform is used to locate the specular point. Together with the precise trajectory we can then infer altimetric products.

Inversion Approach: The models

- The waveform model includes:
  - Kirchhoff at G.O. limit, anisotropic.
  - Instrumental and processing filters accounted.
  - Round Earth effects.
  - Roughness spectrum based on [Elfouhaily et al., 1997]
- Altimetric model:
  - H= (reflected- direct delay) /(2 sin(el))
  - Where the reflected-to-direct delay is computed using the estimated location of the specular point through step-1.
  - Clock errors assumed cancelled.
  - Nor troposphere neither ionosphere included yet.

Roughness effect:

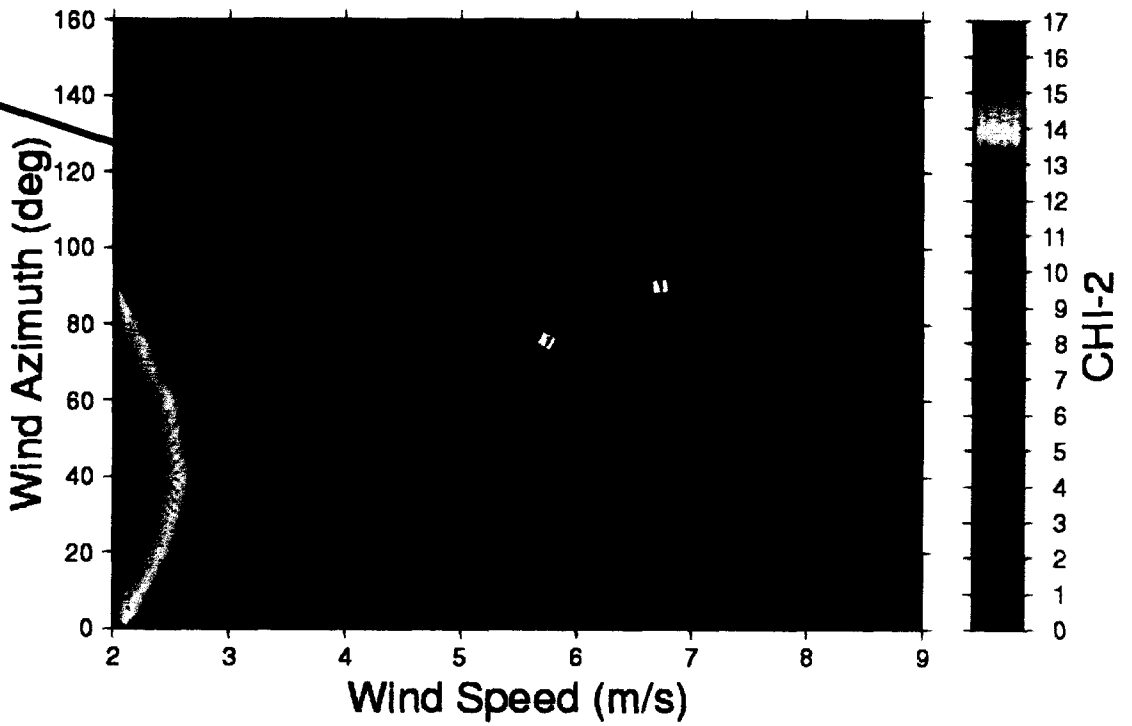


Sensitivity to roughness

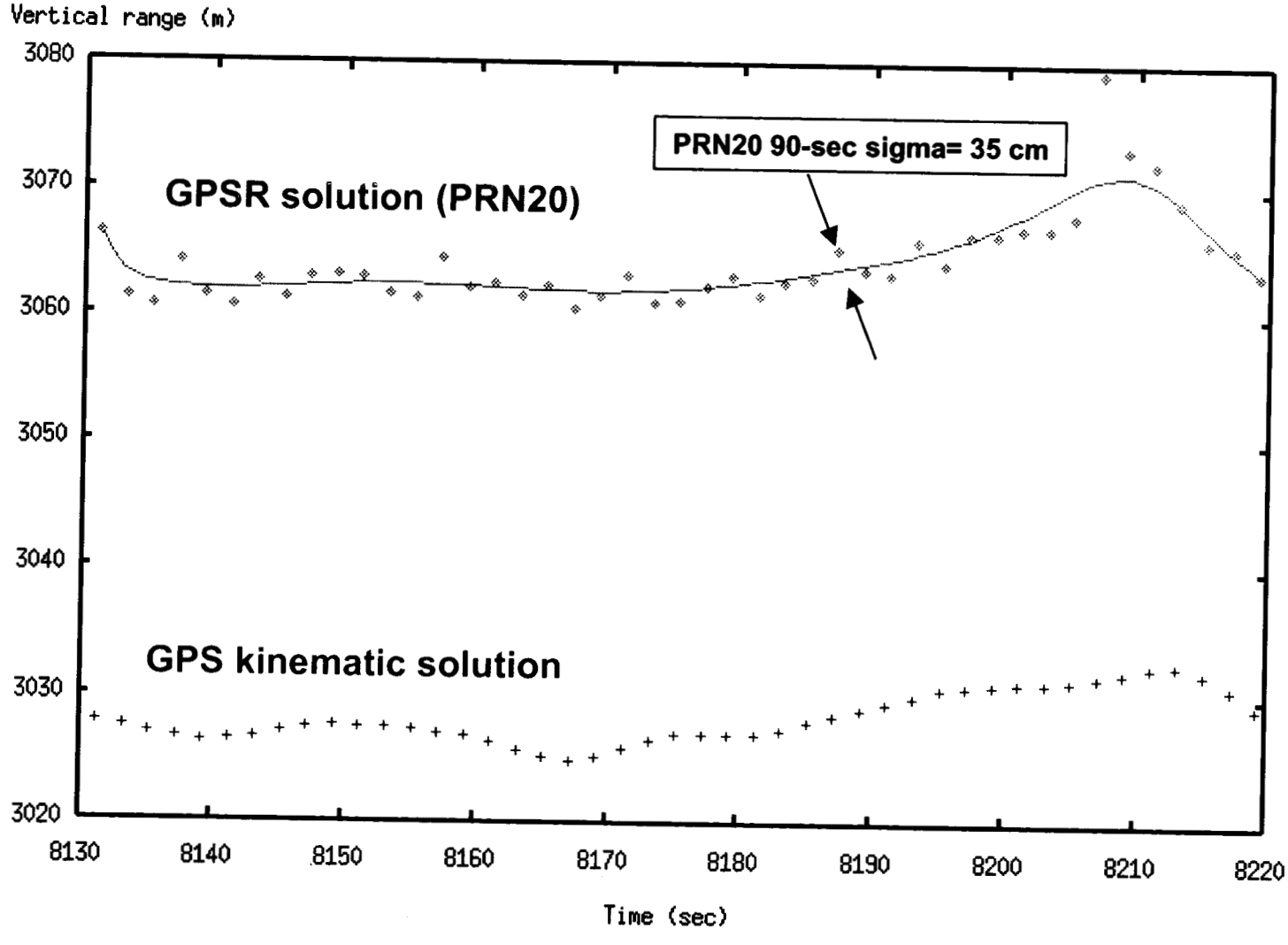
- **Delay-waveform ambiguous in roughness direction. Meaning that different surface roughness states yields similar waveform shapes: USELESS FOR ROUGHNESS RETRIEVAL BUT <u>USEFULL FOR ALTIMETRIC CORRECTION</u>.**

Model parameters with similar waveform shape and similar <u>roughness correction</u>

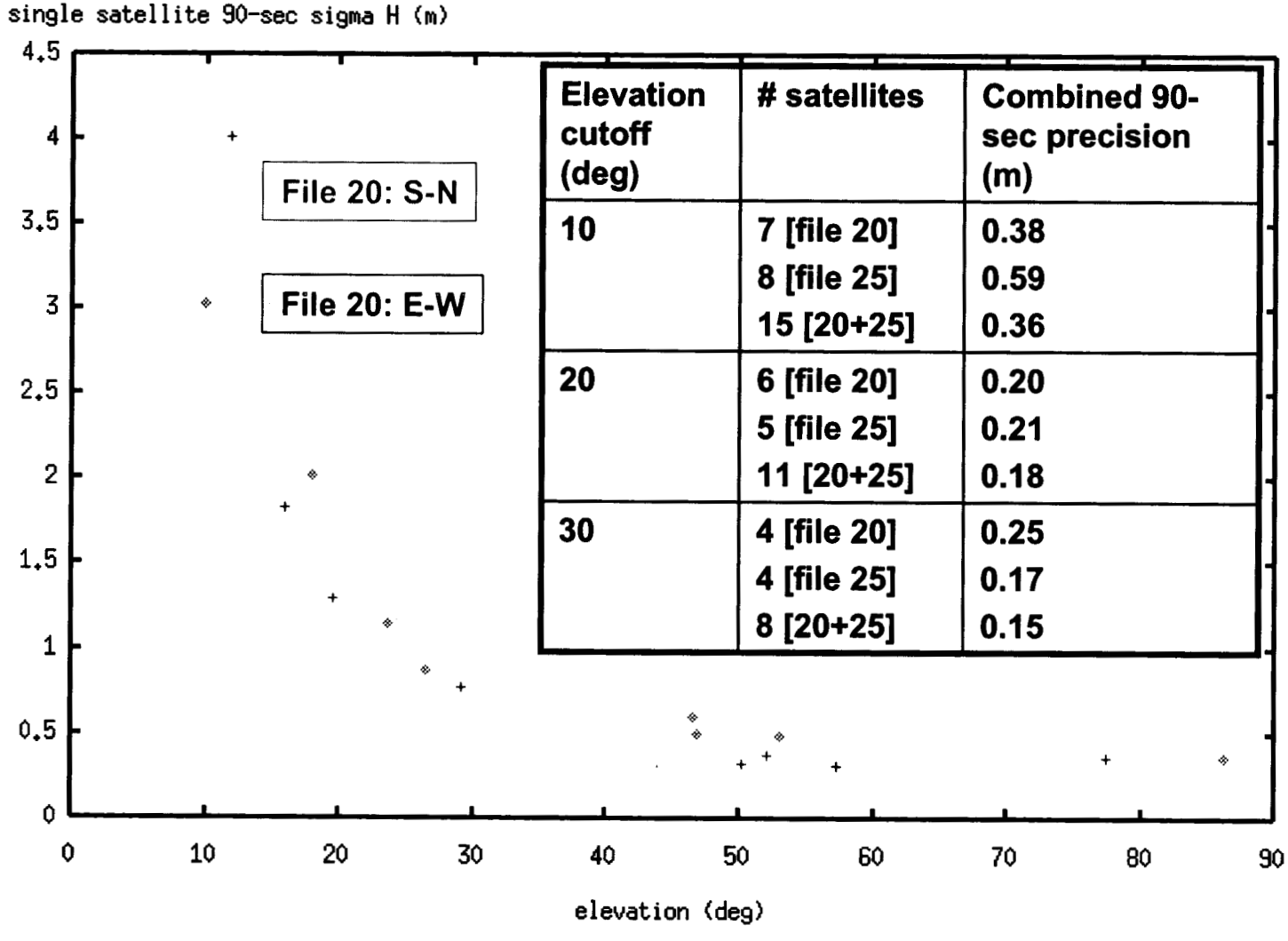
Other techniques required to unambiguously infer roughness parameters: frequency domain, satellite combination... Out of the scope of this study.



Altimetric products: precision

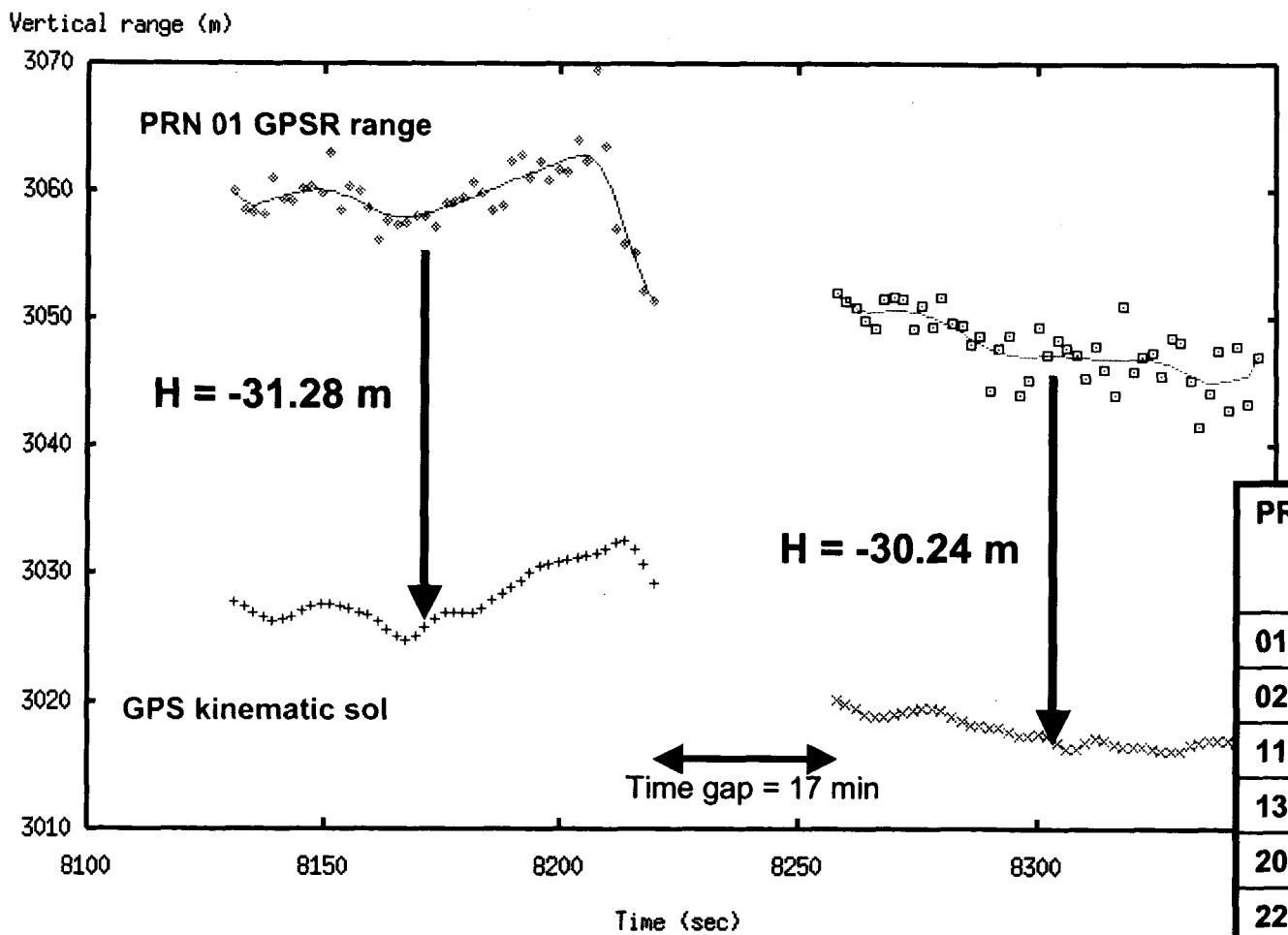


Altimetric Presicion



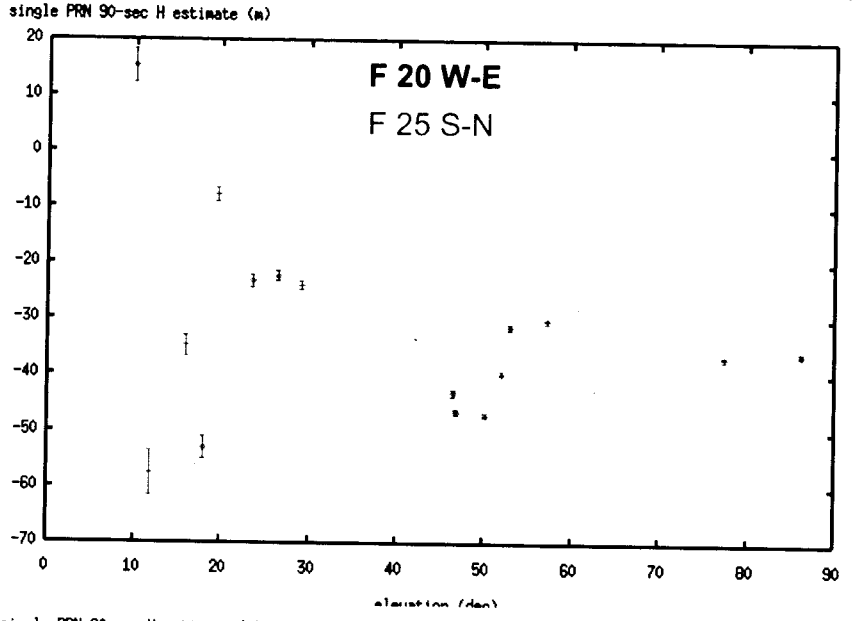
Elevation cutoff (deg)	# satellites	Combined 90-sec precision (m)
10	7 [file 20] 8 [file 25] 15 [20+25]	0.38 0.59 0.36
20	6 [file 20] 5 [file 25] 11 [20+25]	0.20 0.21 0.18
30	4 [file 20] 4 [file 25] 8 [20+25]	0.25 0.17 0.15

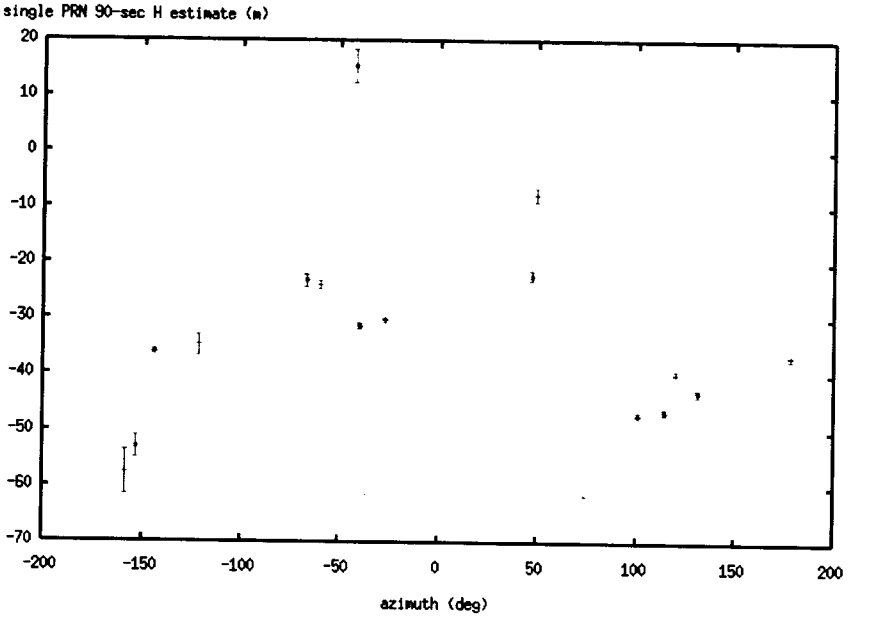
Satellite repeatability

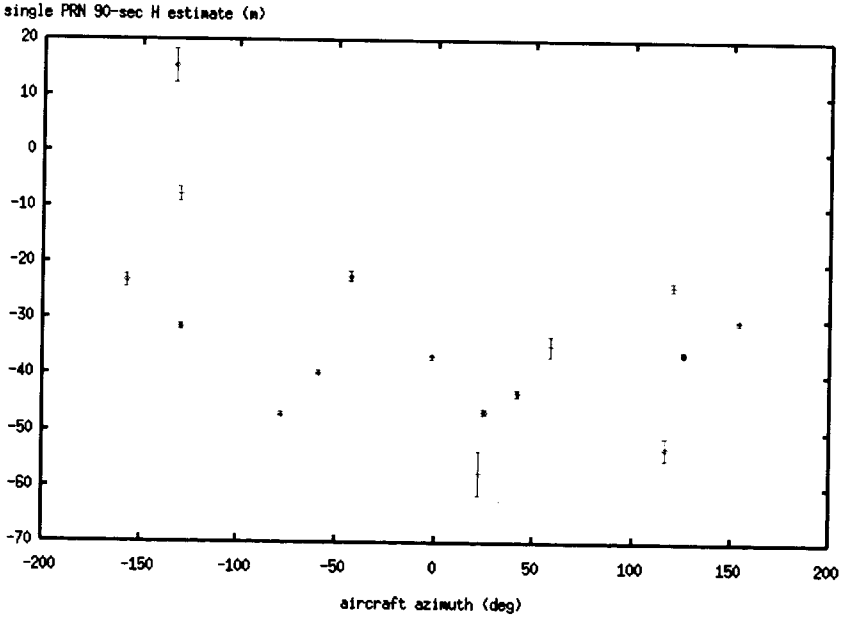


PRN	F20 elev (deg)	F25 elev (deg)	H difference (m)
01	52.9	57.2	-1.03
02	46.4	52.0	-3.64
11	17.9	11.7	4.50
13	23.5	29.0	0.61
20	86.2	77.3	0.59
22	46.8	50.0	0.34
25	26.5	19.5	-14.77

Altimetric accuracy

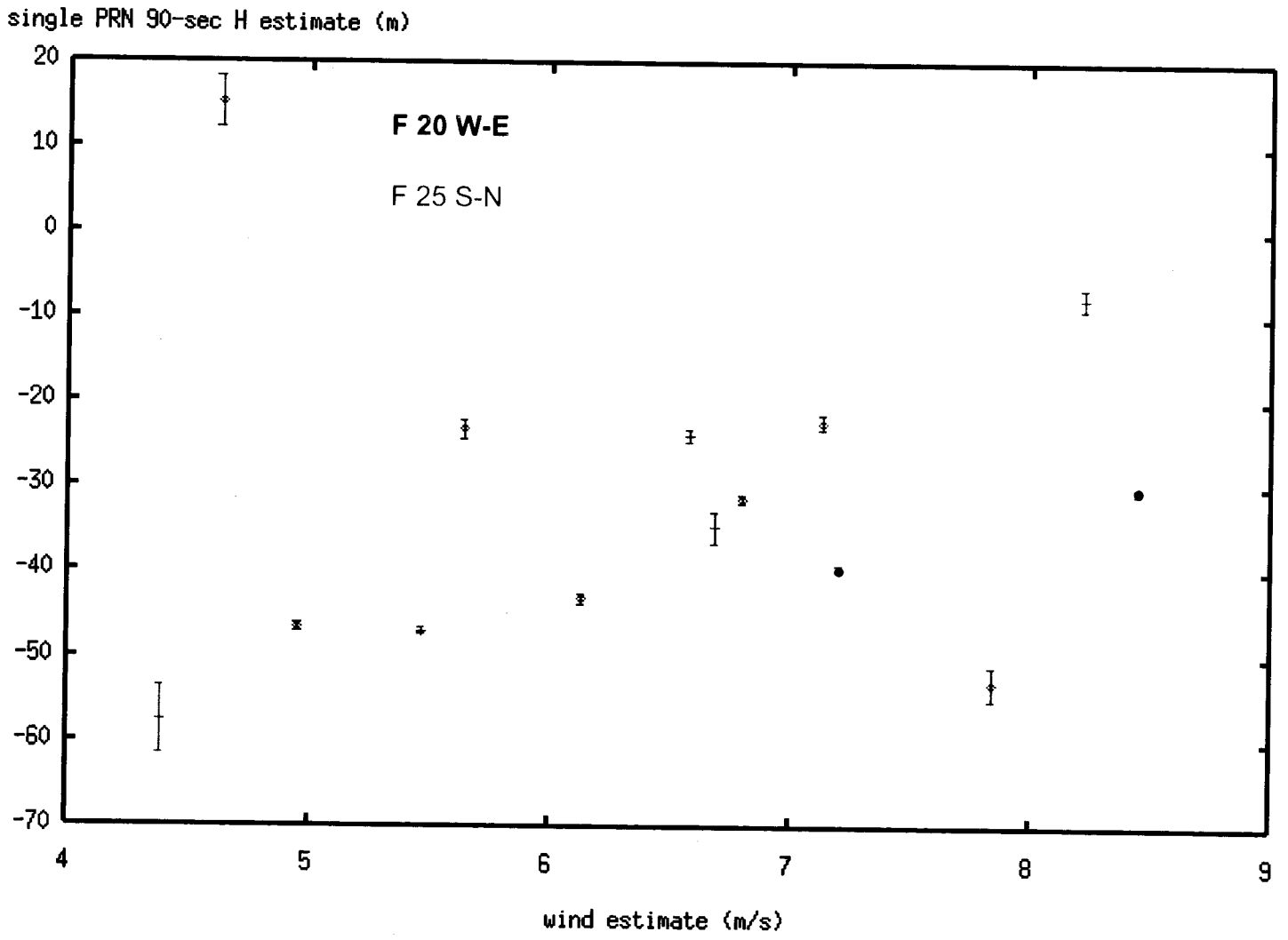






- **PROBLEM! Poorly related to geometry (except severe failure at low elevation)**

Altimetric accuracy



Altimetric accuracy

- ACCURACY: PROBLEM!!
- Differences up to 40 m between PRNs' independent solutions.
- Single satellite self-consistency, for different tracks: 2.3 m [1.0 m if outlier PRN 25 removed]
- Except for low elevations failure, NOT CORRELATED WITH ANY GEOMETRICAL PARAMETER, NEITHER ROUGHNESS ESTIMATES.

→ It does not look like mismodeling errors. Then? Need to investigate other possible reasons (clock error residuals? Troubles in lag labeling?).

Conclusions

- Single satellite 90-sec precision at 35 cm level,
- Multi-satellite 90-sec precision better than 20 cm,
- Multi-satellite 2-track precision at 15 cm,
- Accuracy: FAILURE
  - PRN self-consistency at 1 m level,
  - Huge differences between different satellites

- Mismodeling?
  - No correlation with any parameter... It doesn't seem mismodeling.
- Then?
  - Watch carefully at pre-processing features (clocks? Lag labeling...)