Multiband (X, C, L) radar amplitude analysis for a mixed sand- and gravel-bed river in the eastern central Andes

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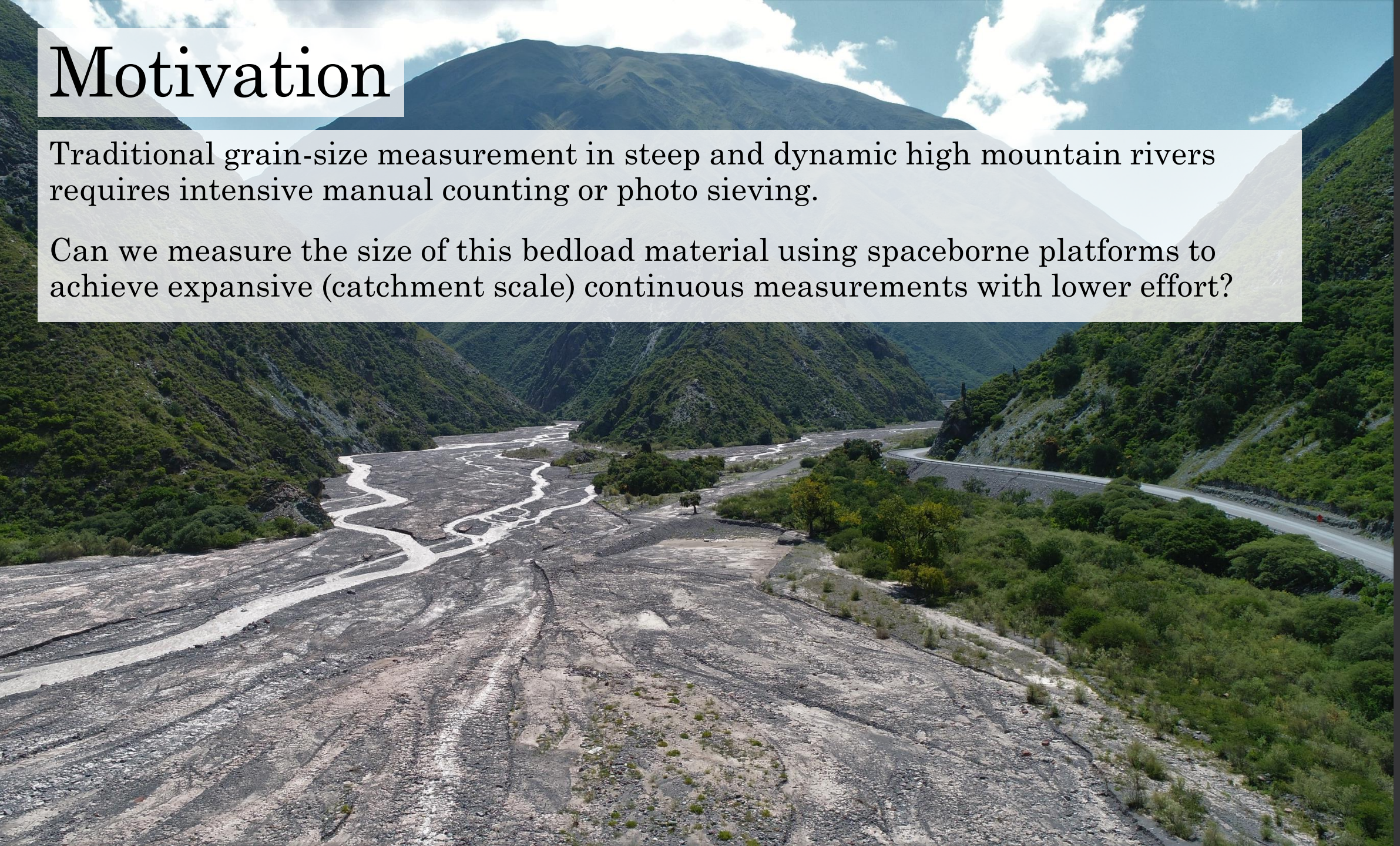
Motivation

Traditional grain-size measurement in steep and dynamic high mountain rivers requires intensive manual counting or photo sieving.

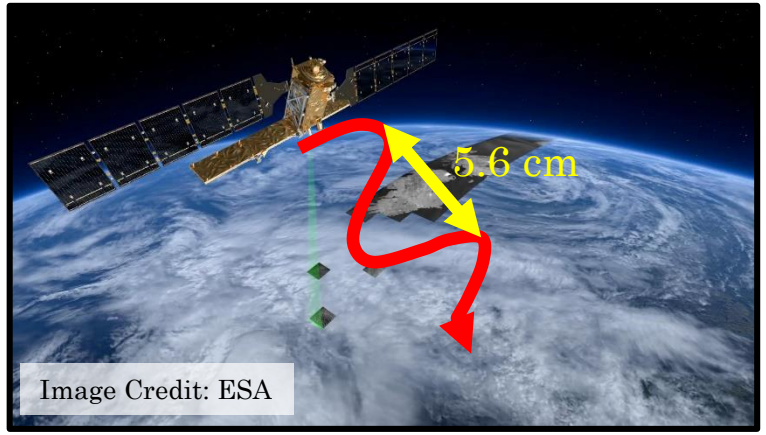
Can we measure the size of this bedload material using spaceborne platforms to achieve expansive (catchment scale) continuous measurements with lower effort?



Data: Synthetic Aperture Radar (SAR)

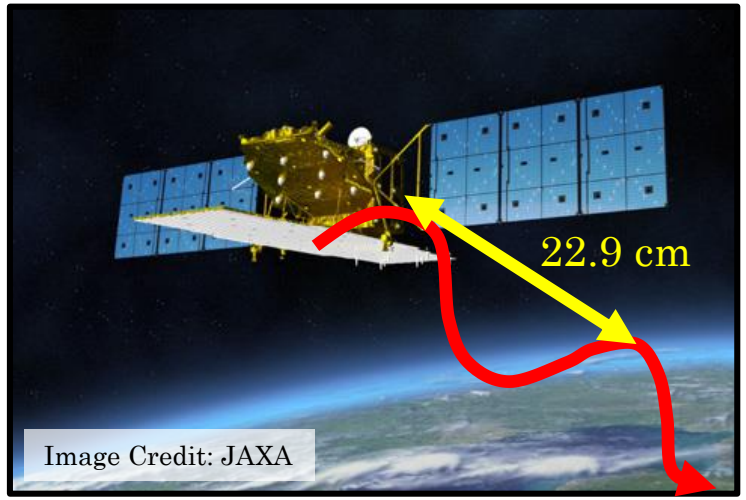
Sentinel-1 (S1):

- C-band radar (λ = 5.6 cm)
- 15 scenes (June 2017 – Mar 2019)
- 15 m gridded resolution



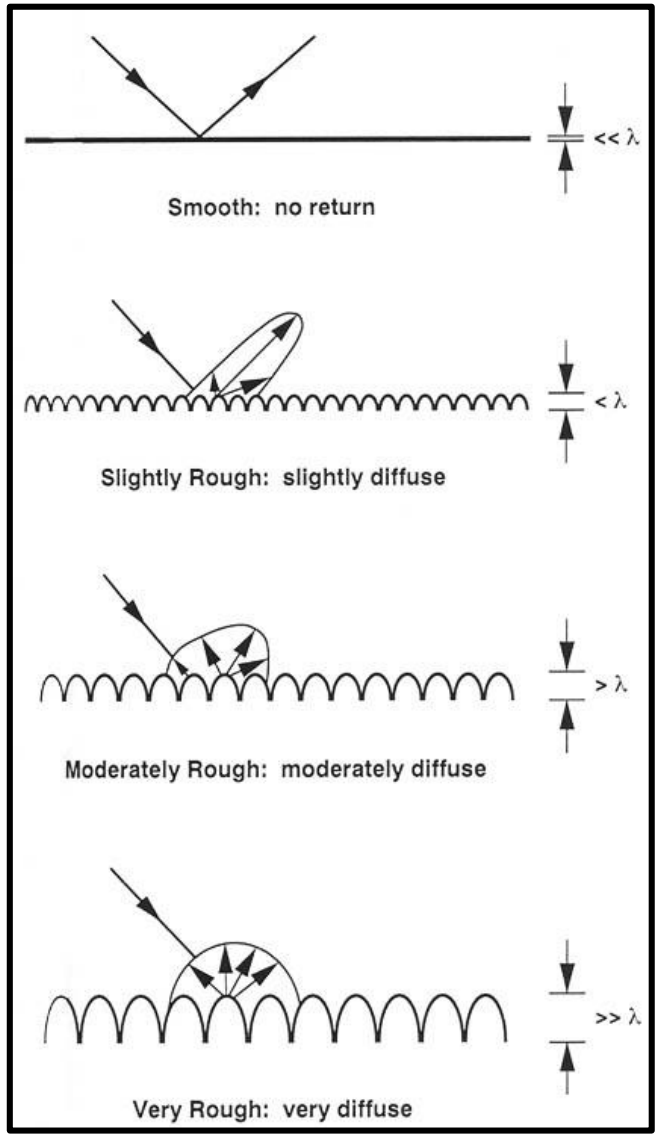
ALOS-2 PALSAR-2 (ALOS2):

- L-band radar (λ = 22.9 cm)
- 5 scenes (Sep 2015 – May 2018)
- 15 m gridded resolution



***Note**: See full study (linked on last slide) for our application of X-band (TerraSAR) data as well*

SAR Amplitude Response: Theory



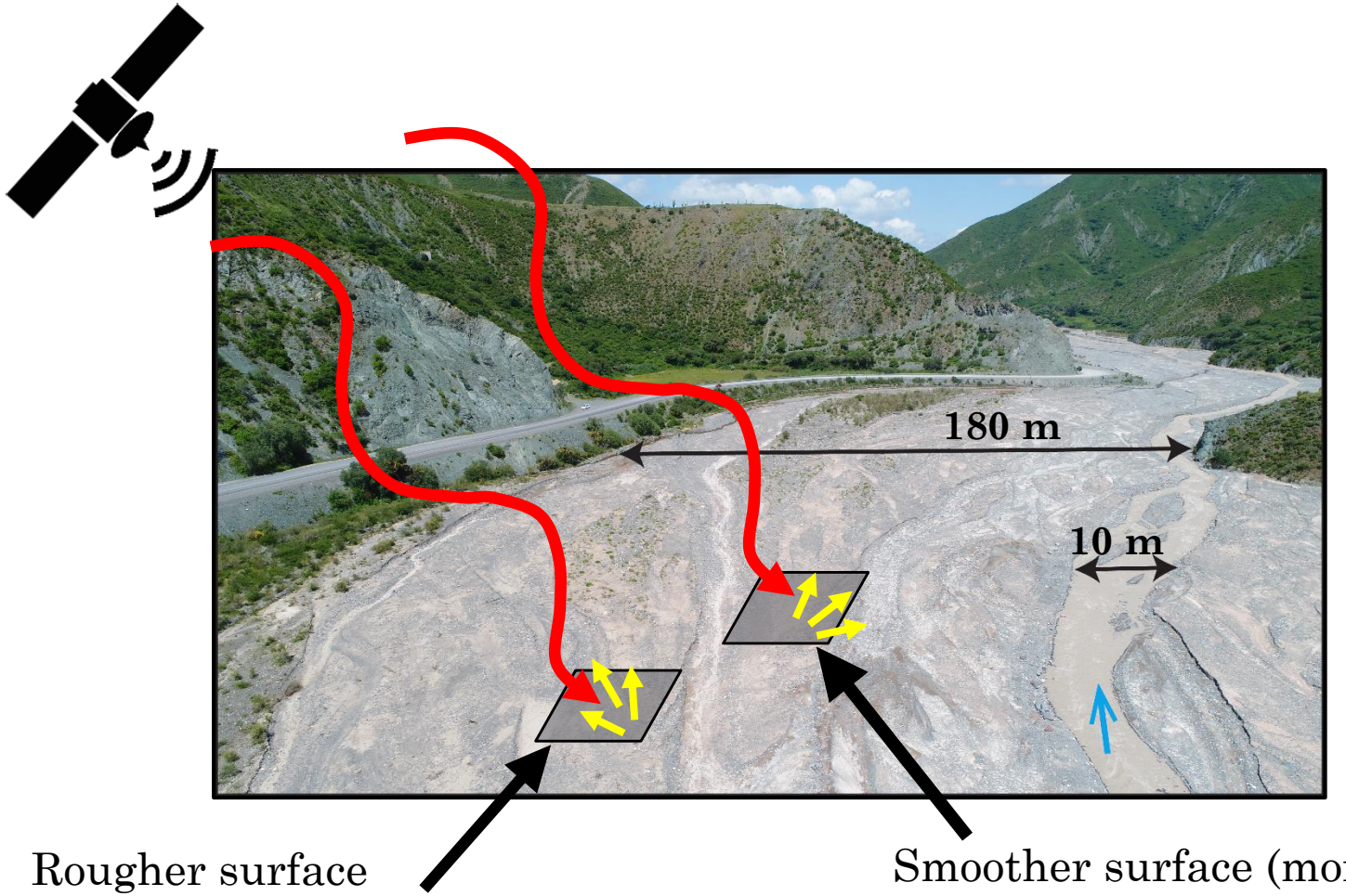
Peak and Oliver (1971); Farr (1993)

Increasing Surface Roughness (Grain Size) & Increasing Amplitude Measured

Depending on the radar wavelength and the roughness of the surface, the signal will reflect smoothly off of the surface leading to a low amplitude at the pixel.

If the surface becomes more rough (e.g., there are more large gravels and boulders), then the signal will reflect more energy back towards the satellite sensor leading to a higher amplitude at the pixel.

SAR Amplitude Response: Riverbed

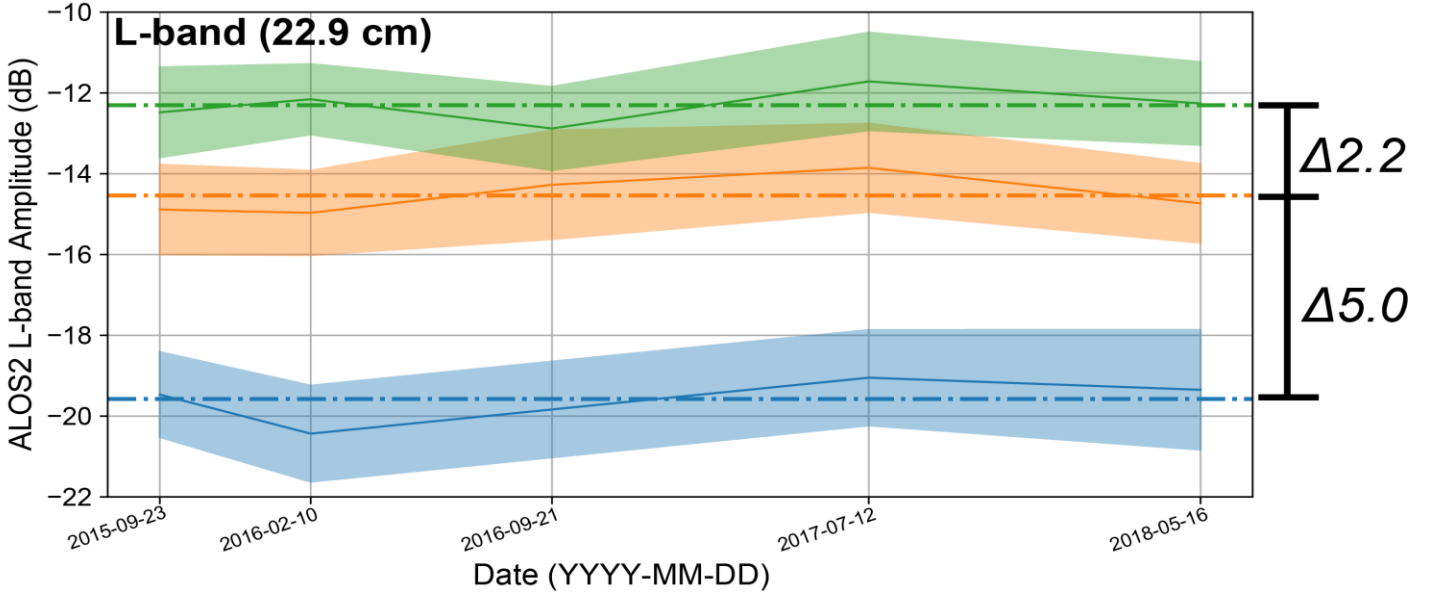


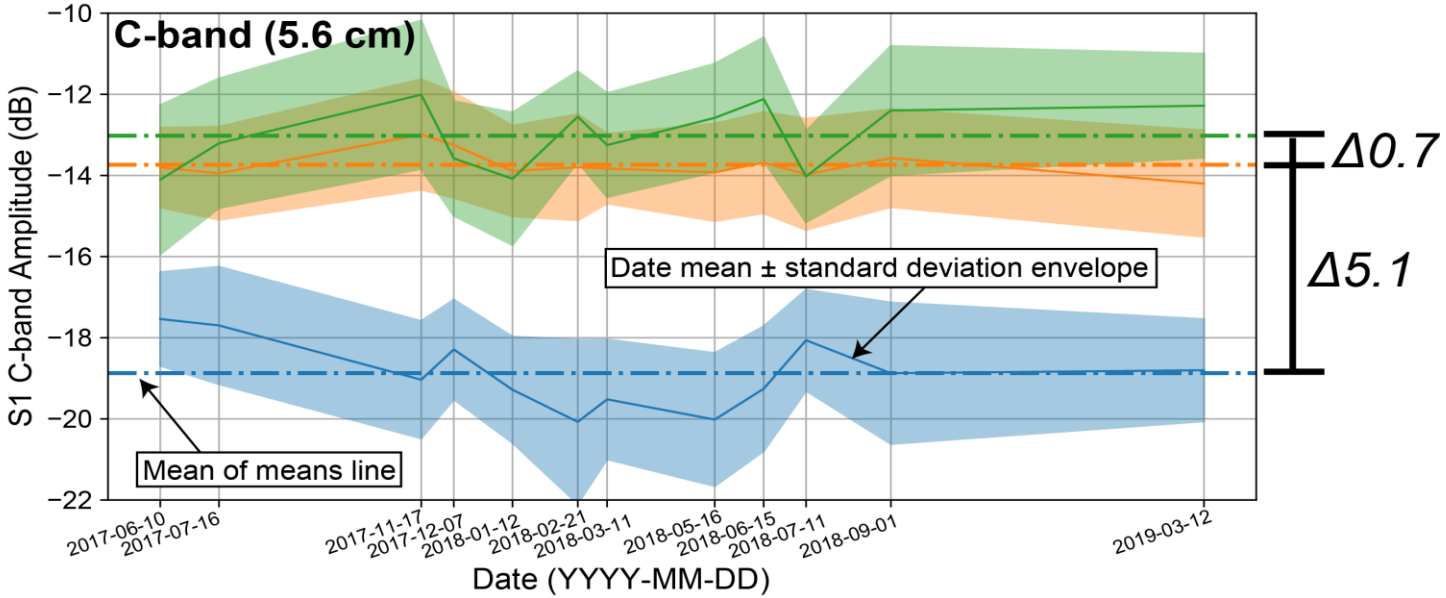
Rougher surface (more and/or larger gravels) = Higher amplitude return to sensor at this pixel

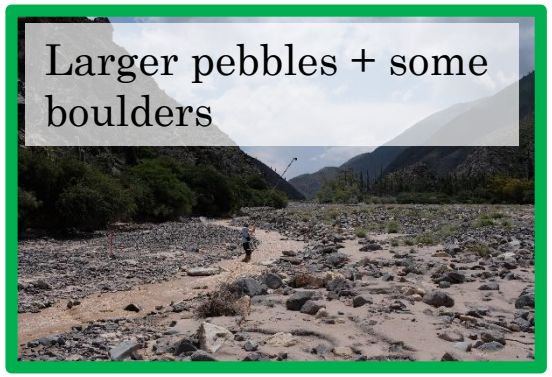
Smoother surface (more smooth sand surfaces and/or smaller gravels) = Lower amplitude return to sensor at this pixel

Relative Calibration

Using three endmember sites within the channel bed check the average amplitude response.

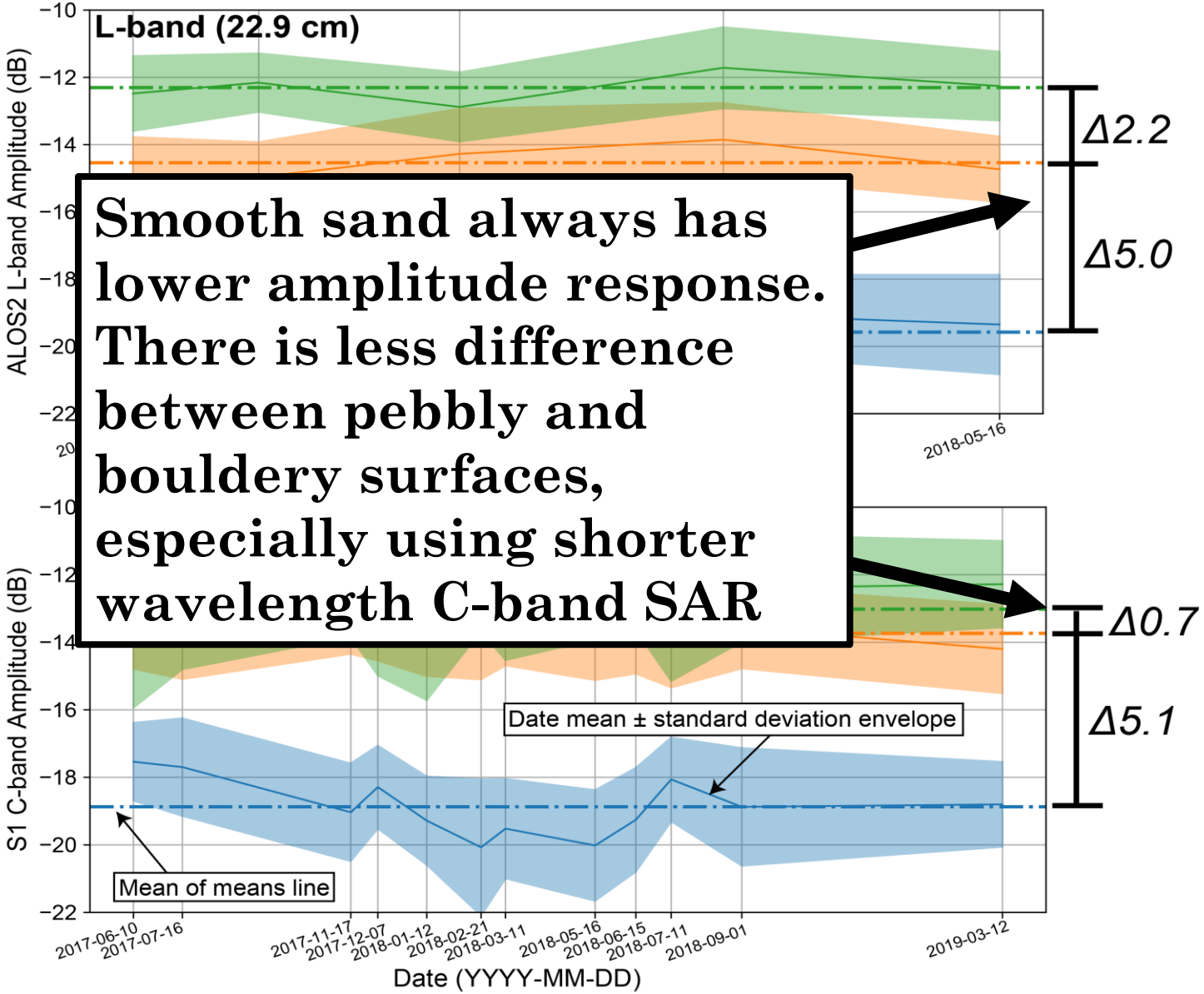




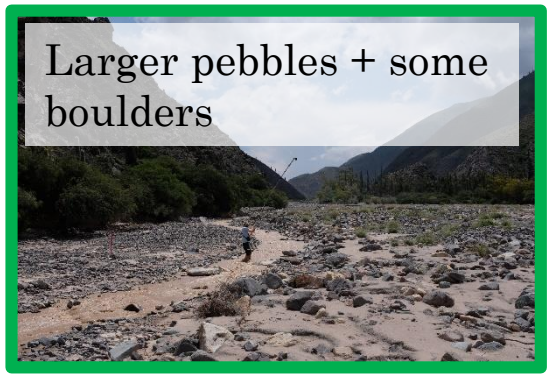


Relative Calibration

Using three endmember sites within the channel bed check the average amplitude response.



Smooth sand always has lower amplitude response. There is less difference between pebbly and bouldery surfaces, especially using shorter wavelength C-band SAR



Conclusions

- SAR amplitude is a weather-independent tool to measure surface roughness from space
- L-band is more sensitive to grain size, whereas C-band has a lower saturation and is mostly sensitive to the sand fraction
- There is the potential to map and monitor gravel-sand transitions at the scale of large mountain catchments using Sentinel-1 C-band SAR

Purinton, B., & Bookhagen, B. (2020). Multiband (X, C, L) radar amplitude analysis for a mixed sand- and gravel-bed river in the eastern Central Andes. *Remote Sensing of Environment*, 246C, https://doi.org/10.1016/j.rse.2020.111799
https://authors.elsevier.com/a/1b1EE7qzSr6Xz (50 day share link valid until 26 June 2020)

Additional bibliography:

Farr, T. (1993). Guide to magellan image interpretation. https://history.nasa.gov/JPL-93-24/ch5.htm.
Peake, W., & Oliver, T. (1971). The response of terrestrial surfaces at microwave frequencies. Technical Report AFAL-TR-70-301 U.S. Air Force Avionics Lab.