SHARAD Processing

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SHARAD User Workshop
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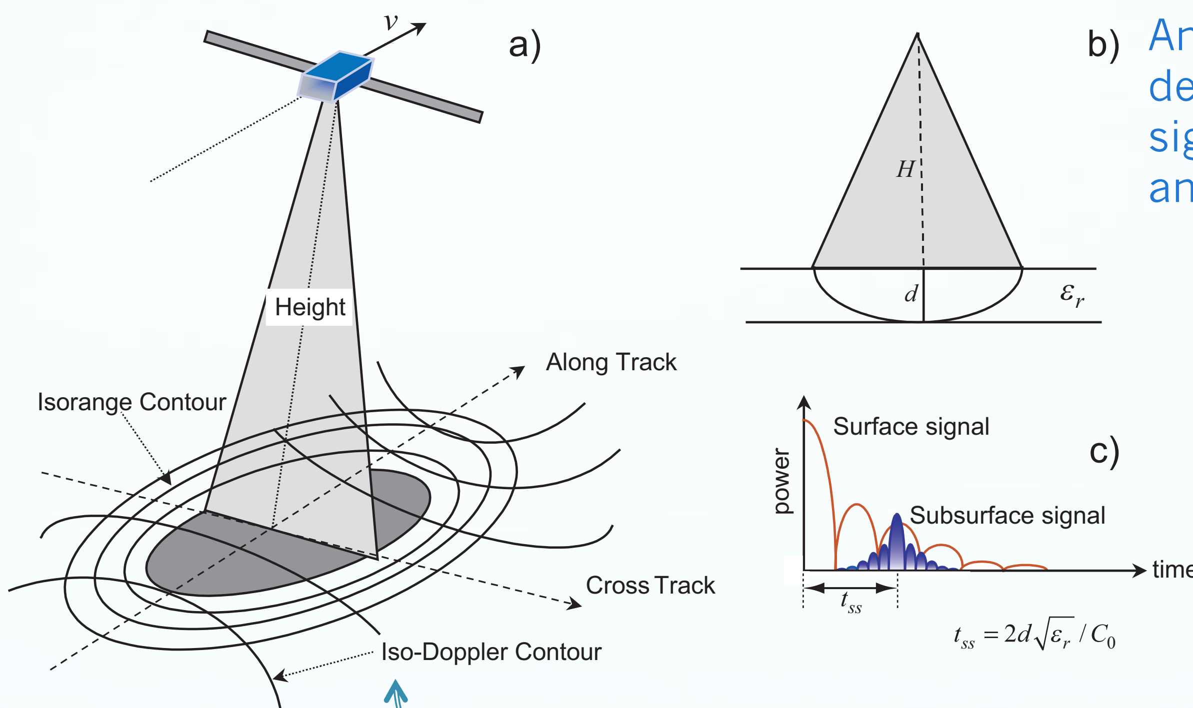
Synthetic Aperture Radar

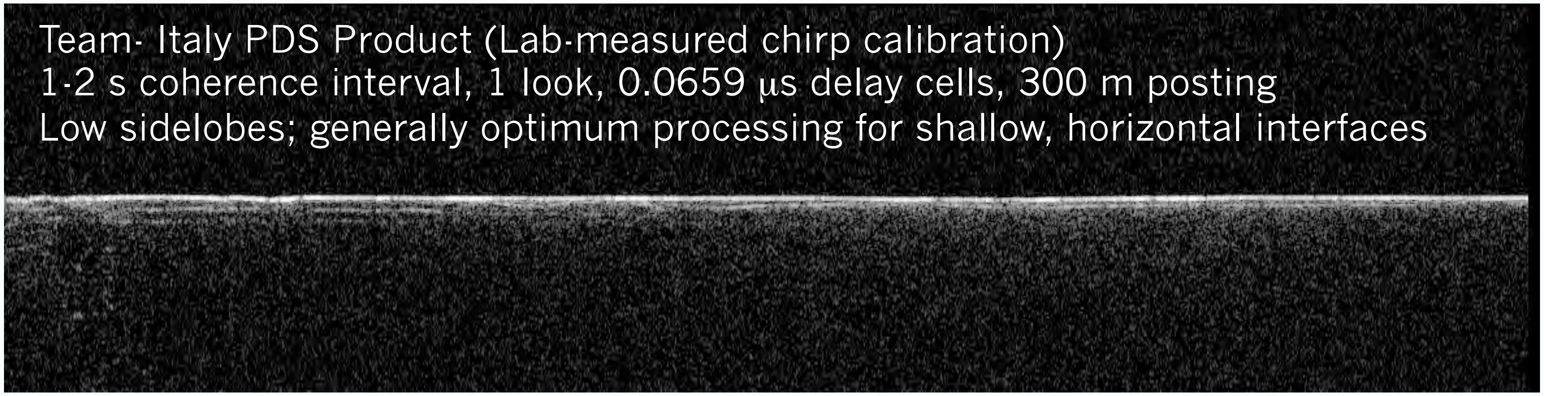


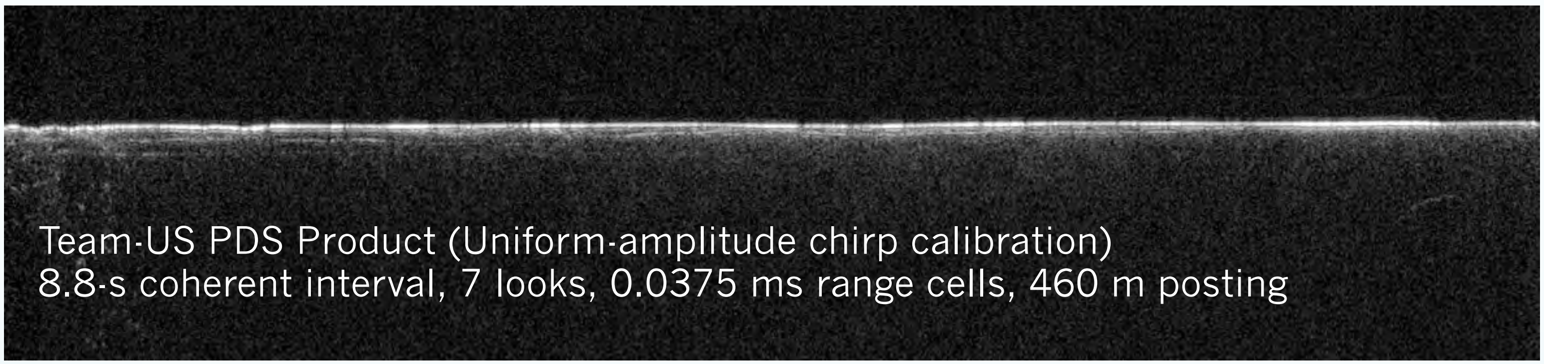
Any chosen time delay includes signals from surface and subsurface

All echoes have sidelobes due to range compression

- Synthetic aperture processing uses the varying position of the sensor platform to substitute for a long physical antenna.
- Different parts of the surface and subsurface return echoes from each pulse along the aperture with different Doppler shifts.
- By compensating for the changes in distance and velocity, we can "focus" energy from a target footprint, improving both resolution and SNR.

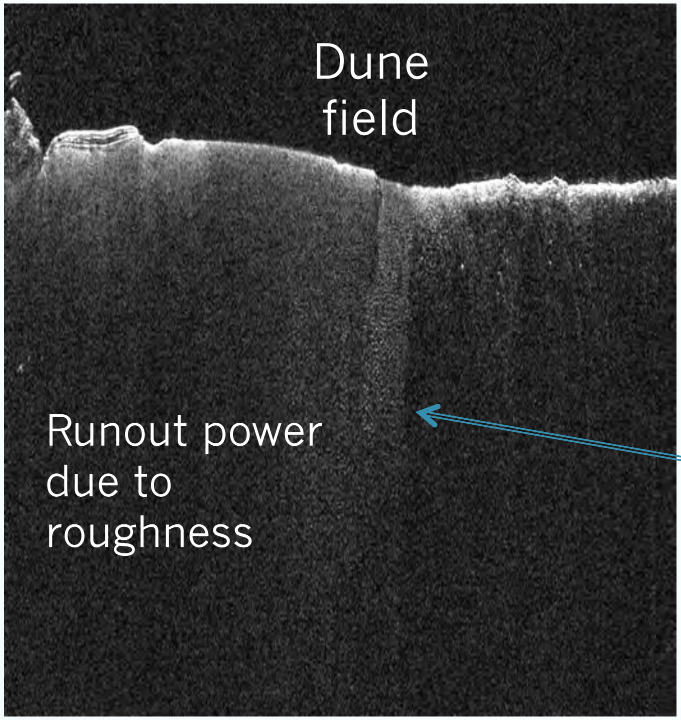
Range Compression

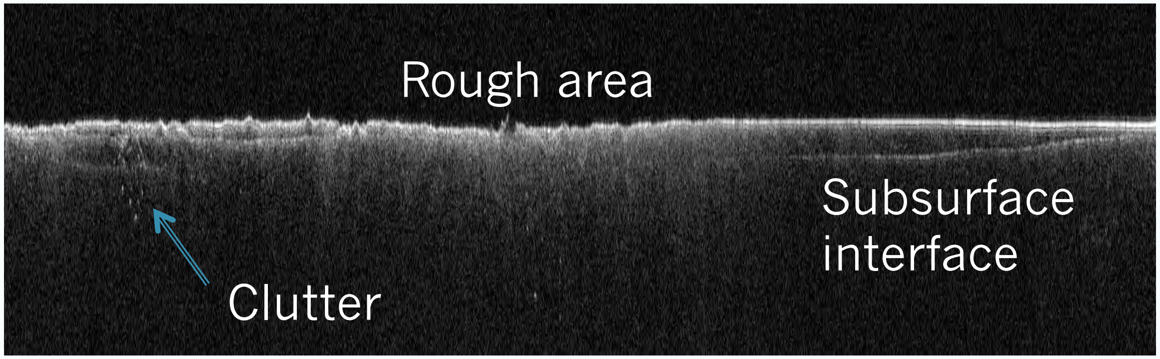




- The SHARAD transmitted signal is a linear "chirp" from 25 MHz down to 15 MHz.
- To obtain fine time resolution, "compress" by convolving received signals with model for amplitude at each frequency in chirp.
- This amplitude varies due to the antenna matching network.
- Compression yields sidelobes around an echo, evident if greater than the noise background.
- US and Italian PDS products use different approaches to compress the signal.

Roughness and Clutter

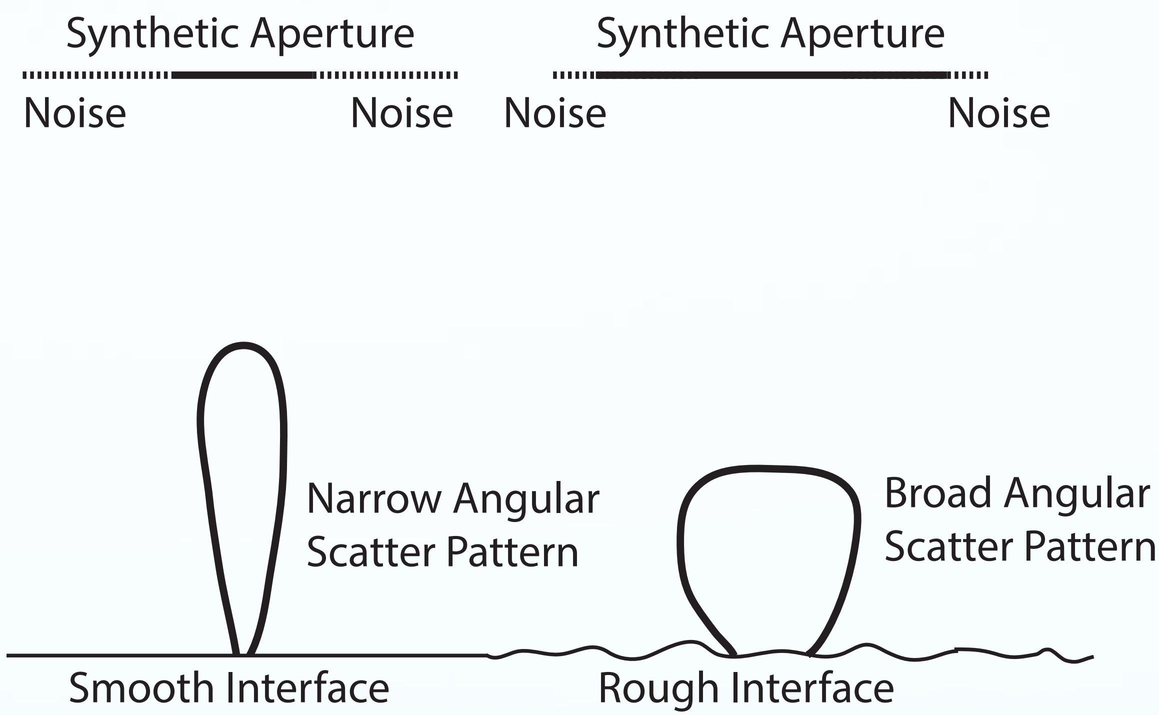




While sounder data primarily show echoes from a 2-d slice directly below the spacecraft, there can be a component very similar to a side-looking radar image.

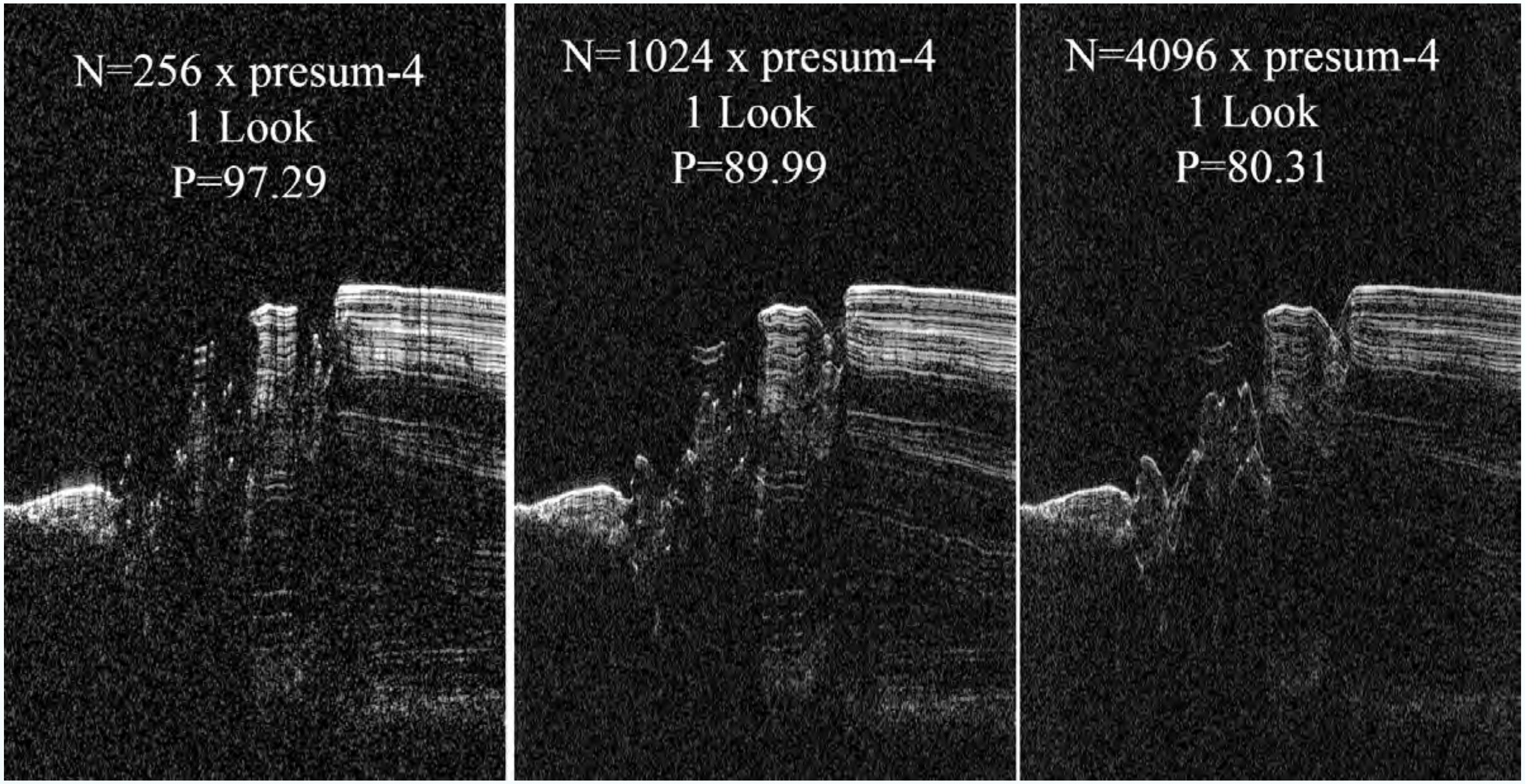
- Doppler processing narrows the along-track resolution by filtering out signals that return to the sensor with more than a specified Doppler shift.
- Echoes from areas perpendicular to the flight path at this band of Doppler components are characterized only by round-trip delay, so reflections from features far from the ground track can appear as apparent subsurface returns.
- There is also a component of the radar echo from random roughness, which creates a "waterfall" effect after the strong surface echo peak.

Processing Parameters - I



- Smoother interfaces direct most of the scattered energy into a narrow lobe along the specular direction. Rough surfaces have broader lobes.
- Longer apertures capture more of the rough or tilted-surface echoes, but at the cost of added noise-dominated "empty space" when interfaces are planar and horizontal.
- Choosing the aperture length is a tradeoff between SNR for the horizontal layers and sensitivity to sloping or rough terrain.

Effect of Aperture Length

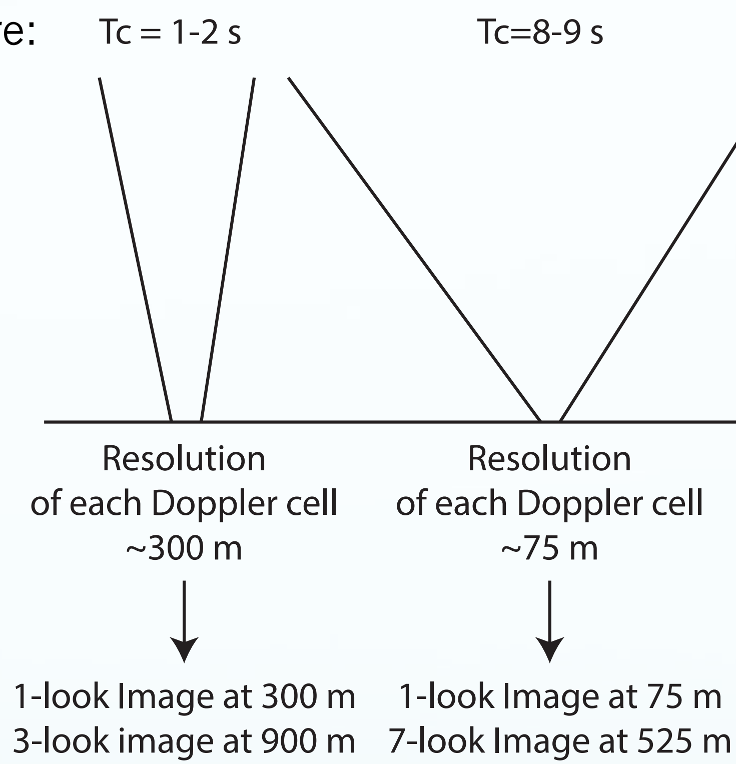


- Long apertures integrate signals where the echo is spread over a large angular range (rough or sloping terrain), but for smooth targets simply add noise beyond the specular return.

- Radargram for track 10589-01, using coherence intervals 1.46 s, 5.85 s, 23.4 s. Note the increase in sensitivity to sloping surface and subsurface features, but significant SNR loss, with longer aperture. *P* metric is total of all squared SNR values in scene.

Processing Parameters - II

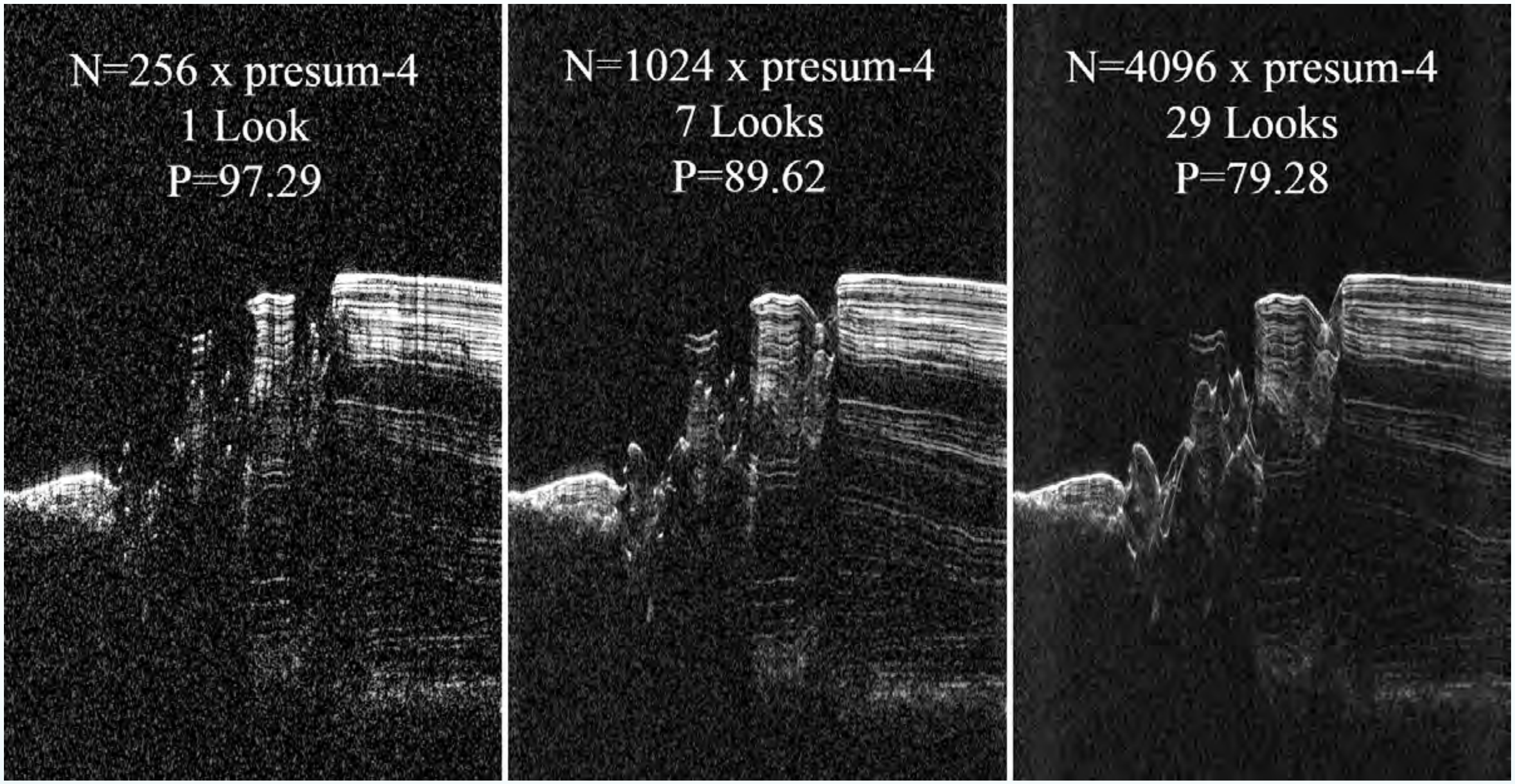
Synthetic Aperture:



Longer apertures yield finer resolution in Doppler shift, and thus along-track spacing of echo samples.

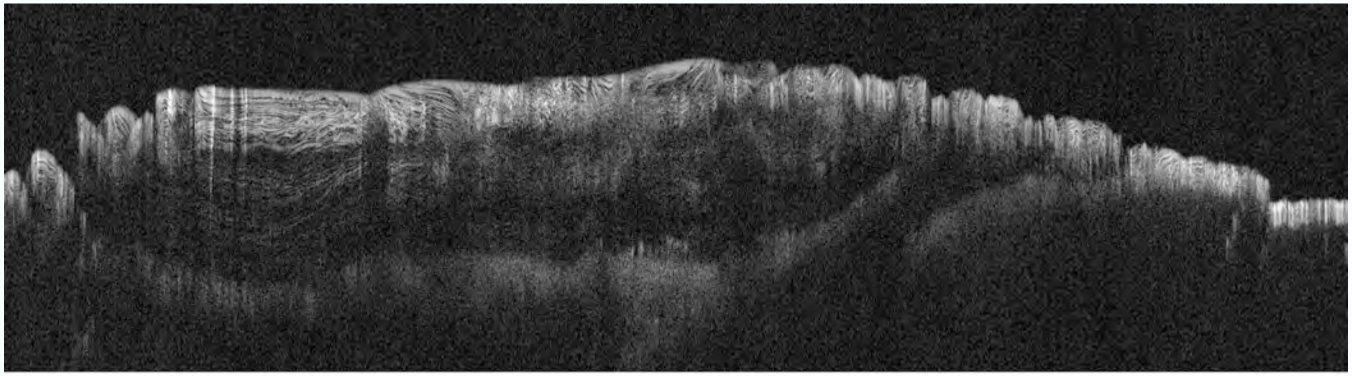
- The Doppler bandwidth term describes the degree of summing that occurs around the zero-Doppler center of the spectrum after focused radar processing.
- Choice of Doppler bandwidth is a trade between the along-track spatial resolution of the radargram, sensitivity to sloping or rugged terrain, and the amount of speckle.

Effect of Doppler Bandwidth



- Doppler bandwidth affects the number of looks that are summed to make the final radargram backscatter values. More looks smooth speckle-driven "noise" in the image, at the expense of coarser along-track resolution.
- Radargram processed using coherence intervals 1.46 s, 5.85 s, 23.4 s, and allowing multi-look averaging to about 800-m along-track spatial resolution.

Ionospheric Effects



Blurring due to phase distortion.

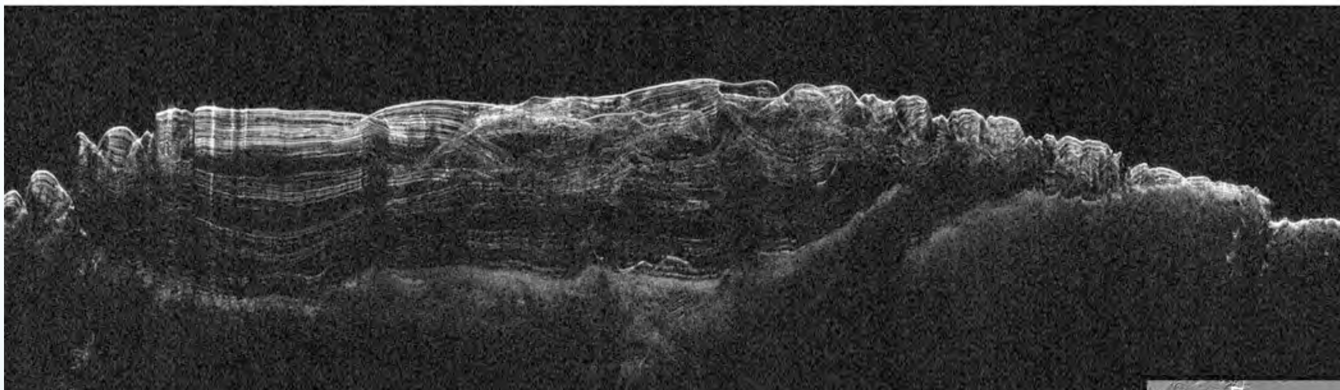
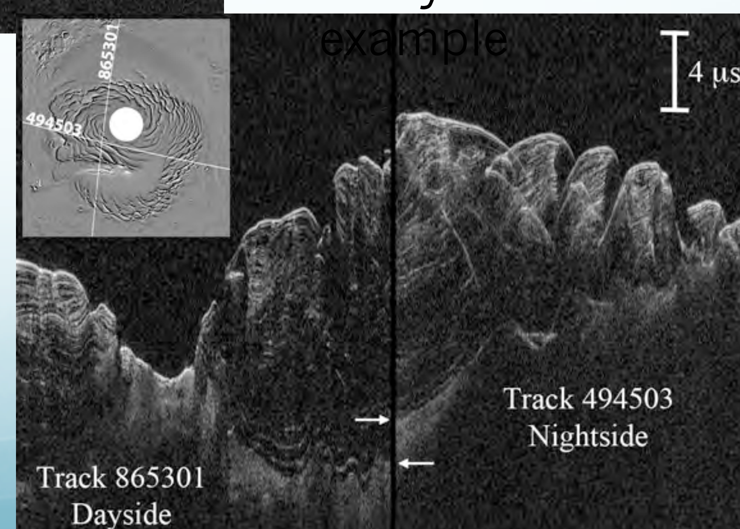


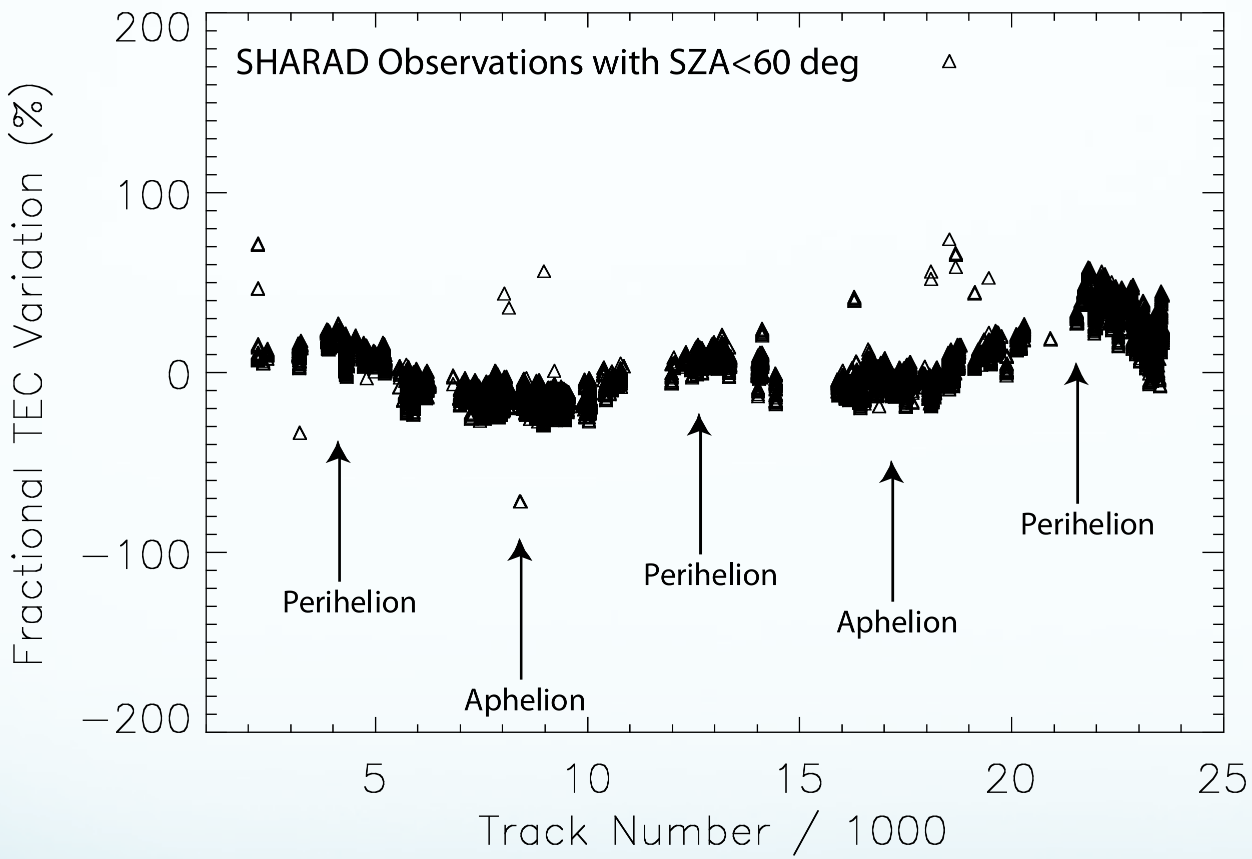
Image corrected for phase distortion.

Delay offset example



- SHARAD daytime observations are affected by the ionosphere: blurring, delay offset, and attenuation.
- PDS-delivered products are corrected "locally" along track for the blurring and delay offset, using a simplified model of the phase errors.
- Attenuation is small for most observations, but must be considered in seasonal change studies.

Ionosphere Tracking

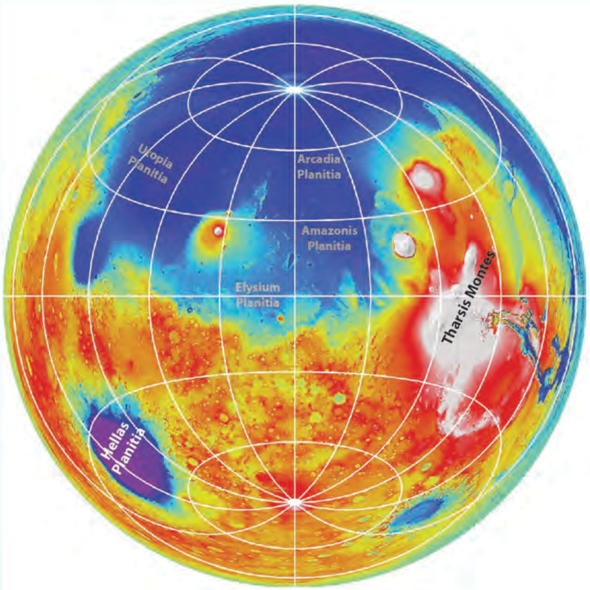


Plot of variation in Total Electron Content over time from SHARAD autofocusing.

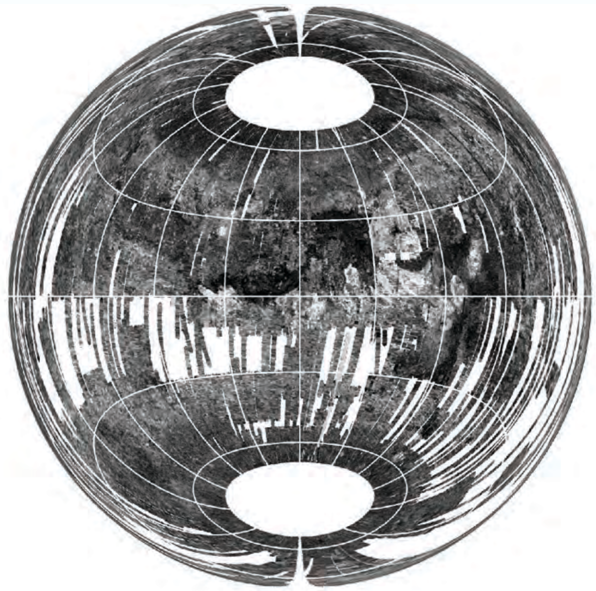
SHARAD provides independent measure of the TEC for any dayside track.

Fine detail in ionospheric variations (non-Chapman) evident in some tracks.

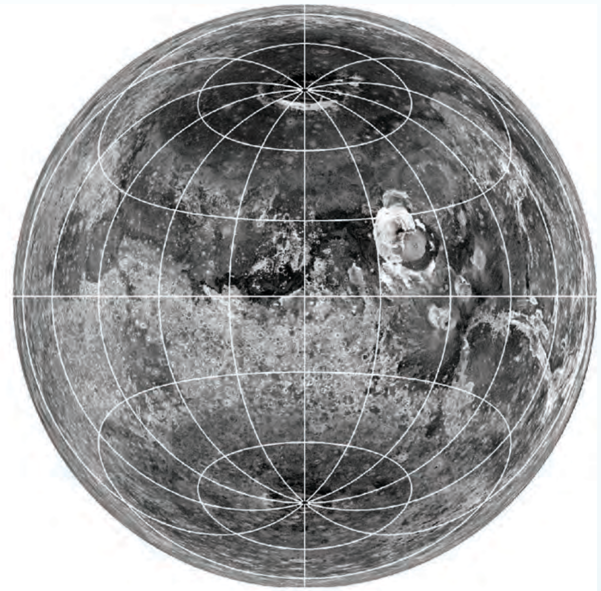
Roughness Mapping



MOLA



SHARAD Roughness



MOLA 0.6 km Baseline Roughness

SHARAD echoes from the surface contain information on meter to 10-m scale roughness

Comparison of derived roughness and peak echo strength indicates variations in near-surface density