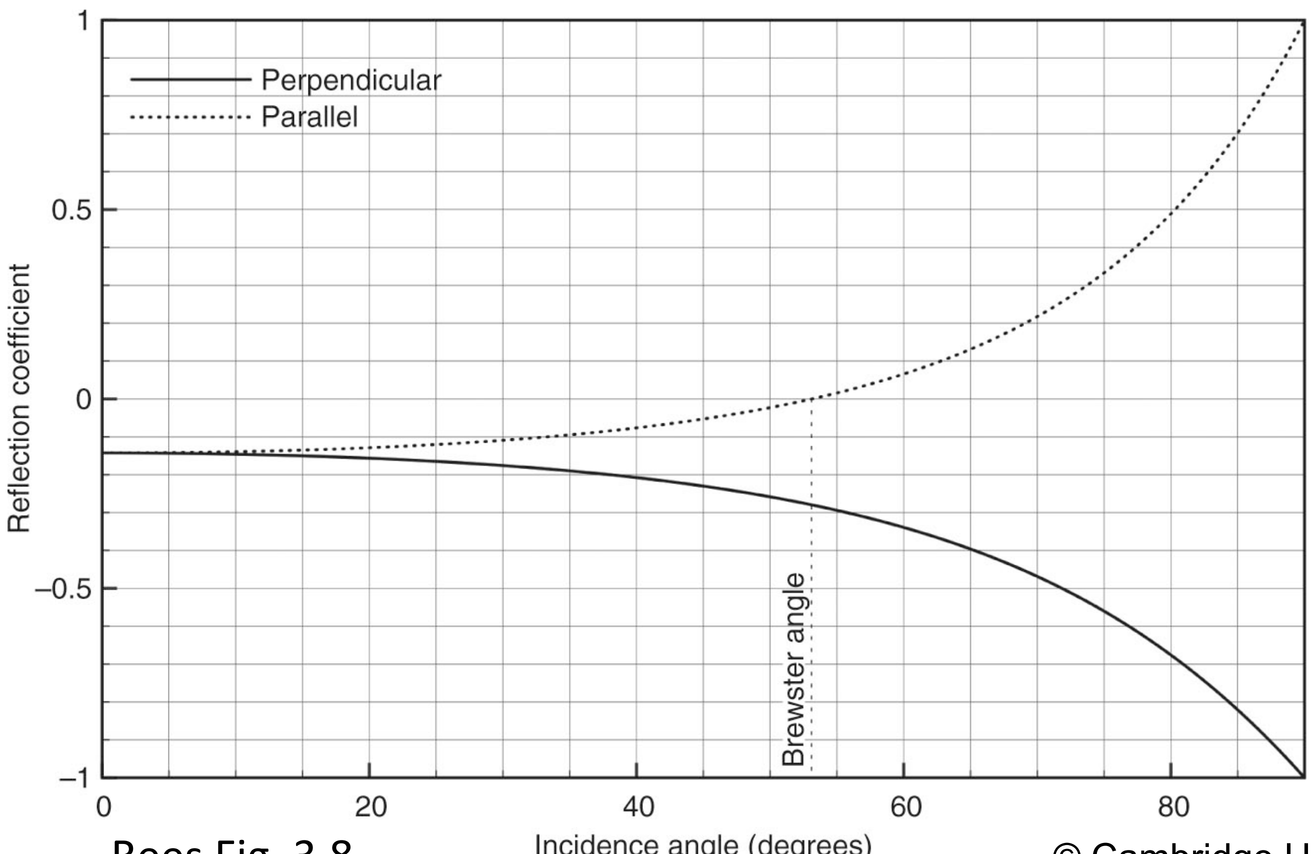
Recall: Fresnel's equations…

give the reflection, transmission coefficients as functions of θ_1, θ_2, polarization

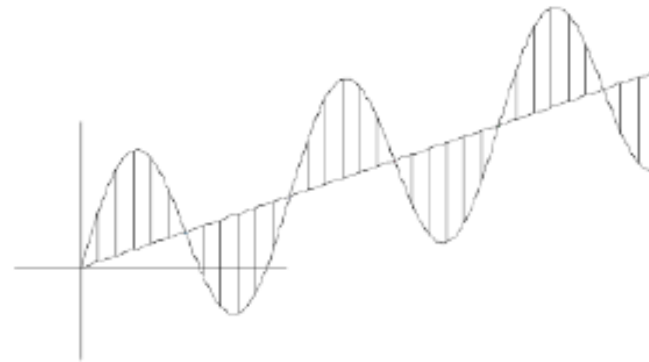


Rees Fig. 3.8

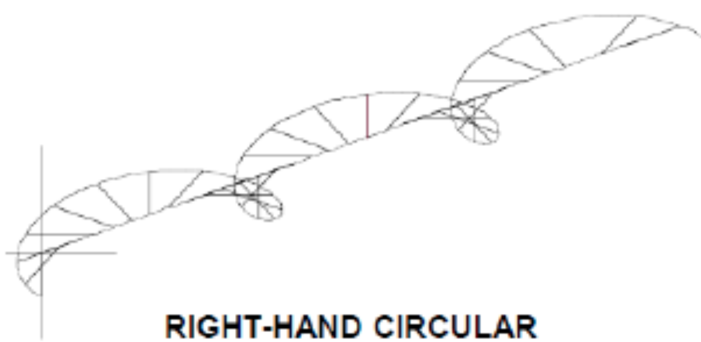
POLARIMETRIC SYNTHETIC APERTURE RADAR

WAVE POLARIZATIONS: EXAMPLES

HORIZONTAL (LINEAR)



VERTICAL (LINEAR)



RIGHT-HAND CIRCULAR

LEFT-HAND CIRCULAR

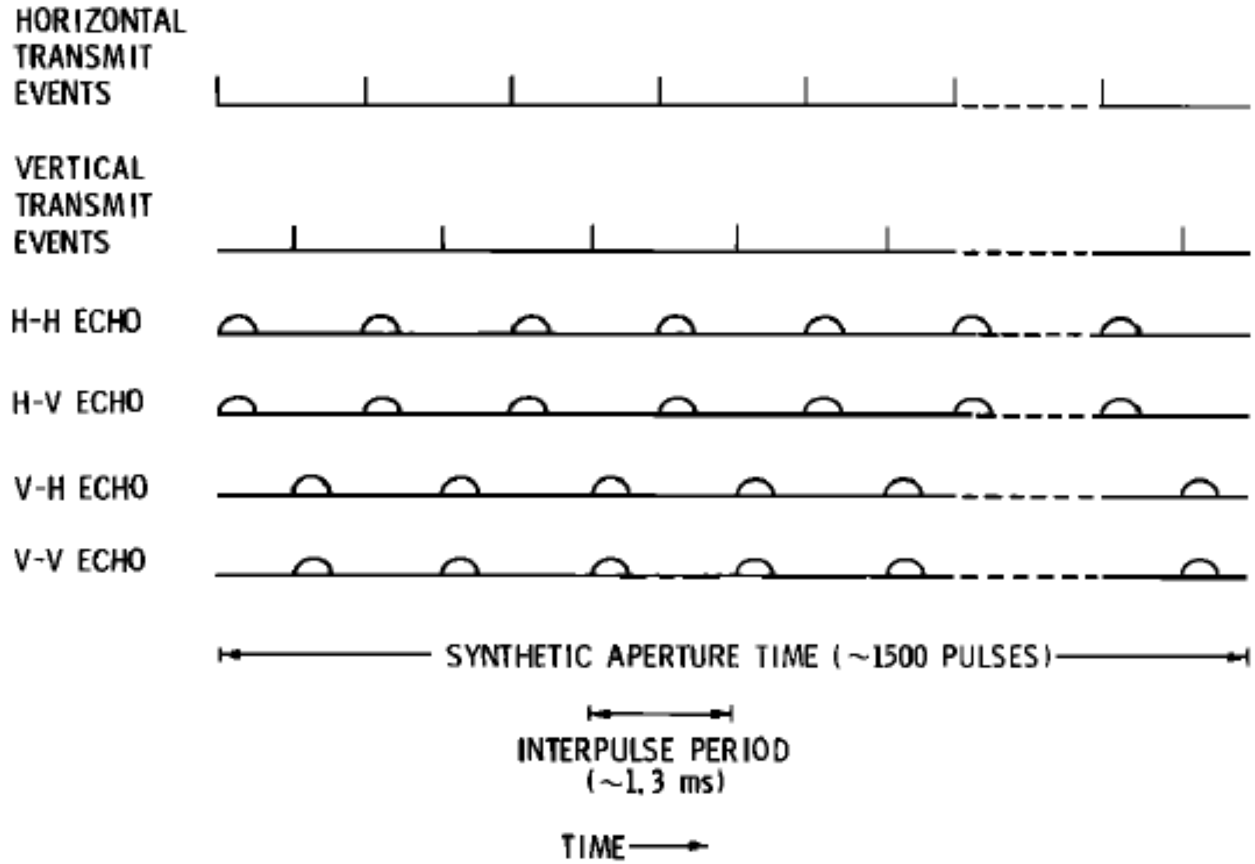


Fig. 4. Near simultaneity is achieved from overlapping sets of pulses. Each horizontally polarized transmit pulse and vertically polarized transmit pulse is offset in time from the other by one half the interpulse period, typically 0.5–1.0 ms. In the data processor we form a synthetic aperture by coherent integration of many pulses; however, pulses corresponding to each different polarization combination are isolated and integrated independently of the other pulses. The total coherent integration required to achieve 3-m single-look resolution consists of approximately 1500 pulses over a 2-s period; therefore the interspersed sets of pulses correspond to very nearly the same synthesized spatial array.

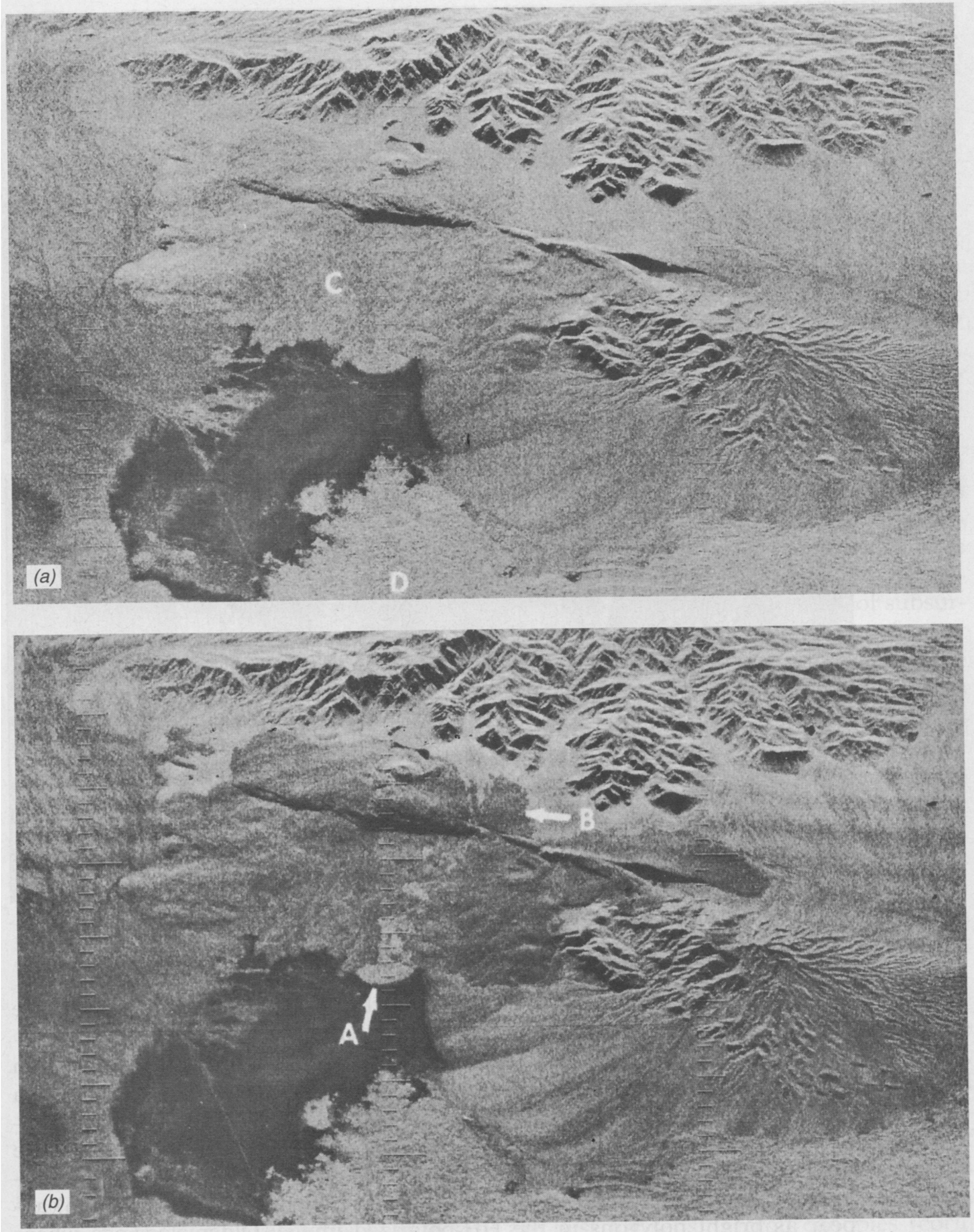


Figure 8.27 SLR images, Sunshine Crater Area, CA, K band, real aperture (scale 1:75,000): (*a*) HH polarization; (*b*) HV polarization. (Courtesy Westinghouse Electric Corp.)

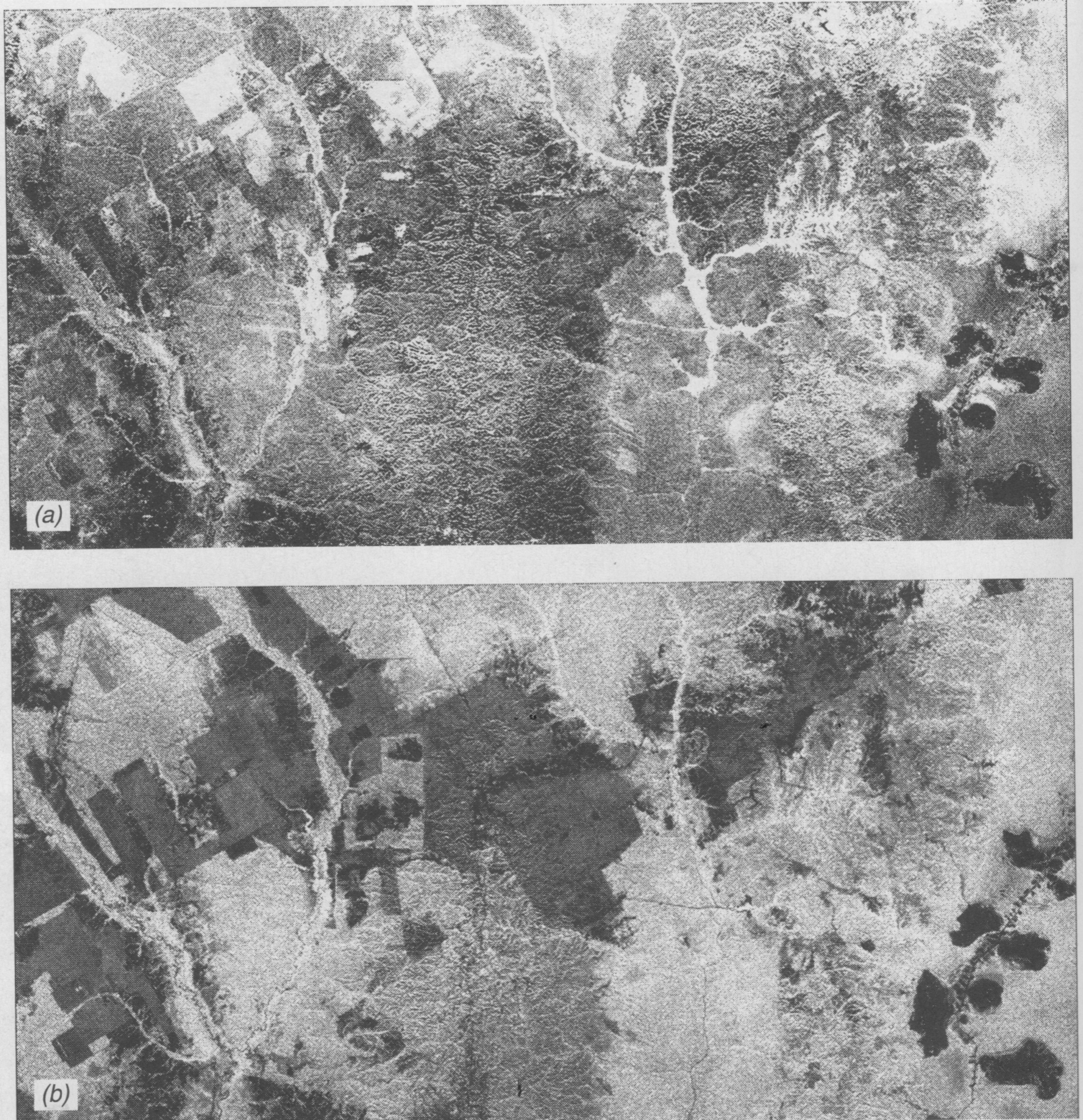
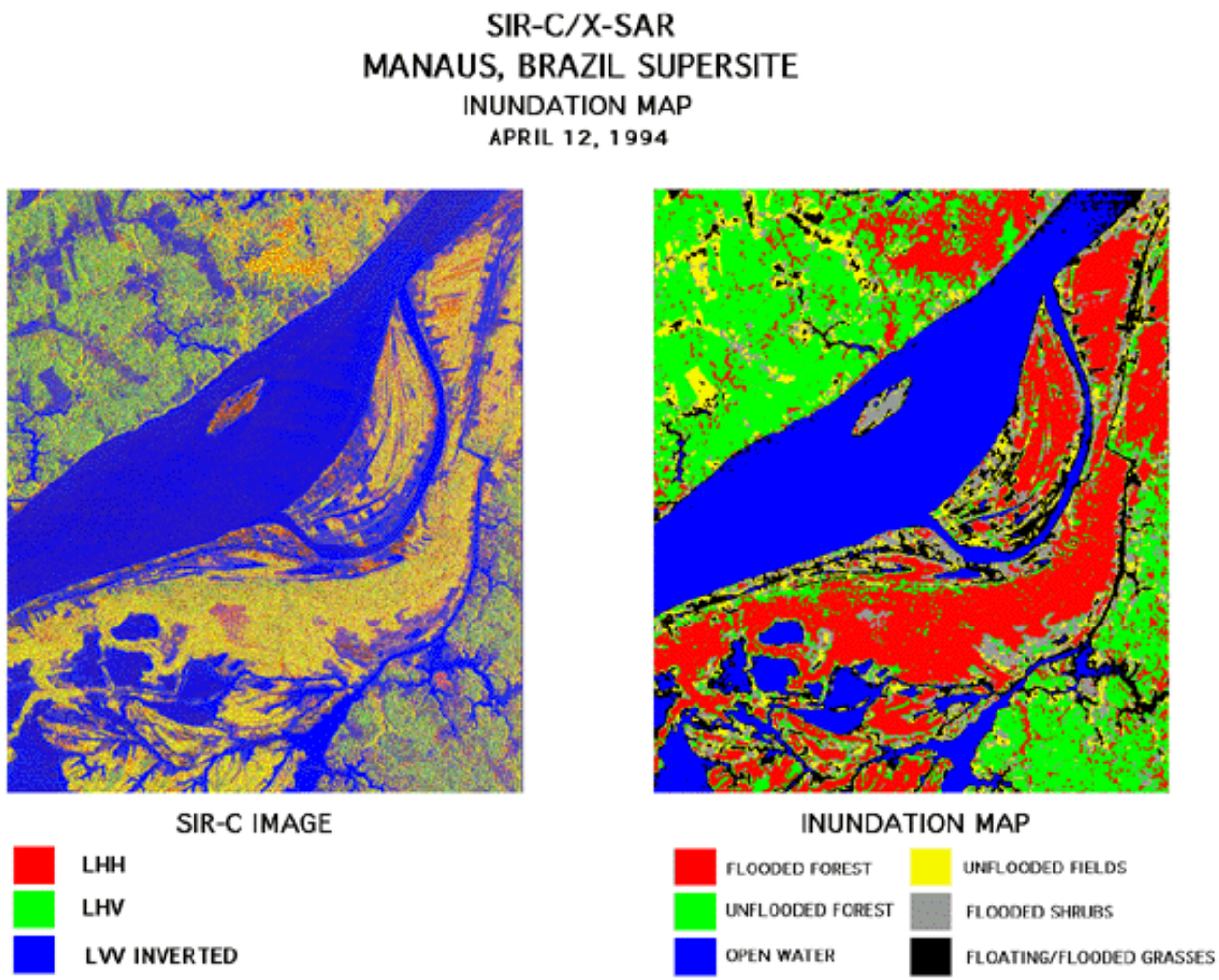


Figure 8.28 SIR-C radar images of Sumatra, Indonesia. (*a*) L-HH. (*b*) L-HV. (Courtesy NASA/JPL/Caltech.)

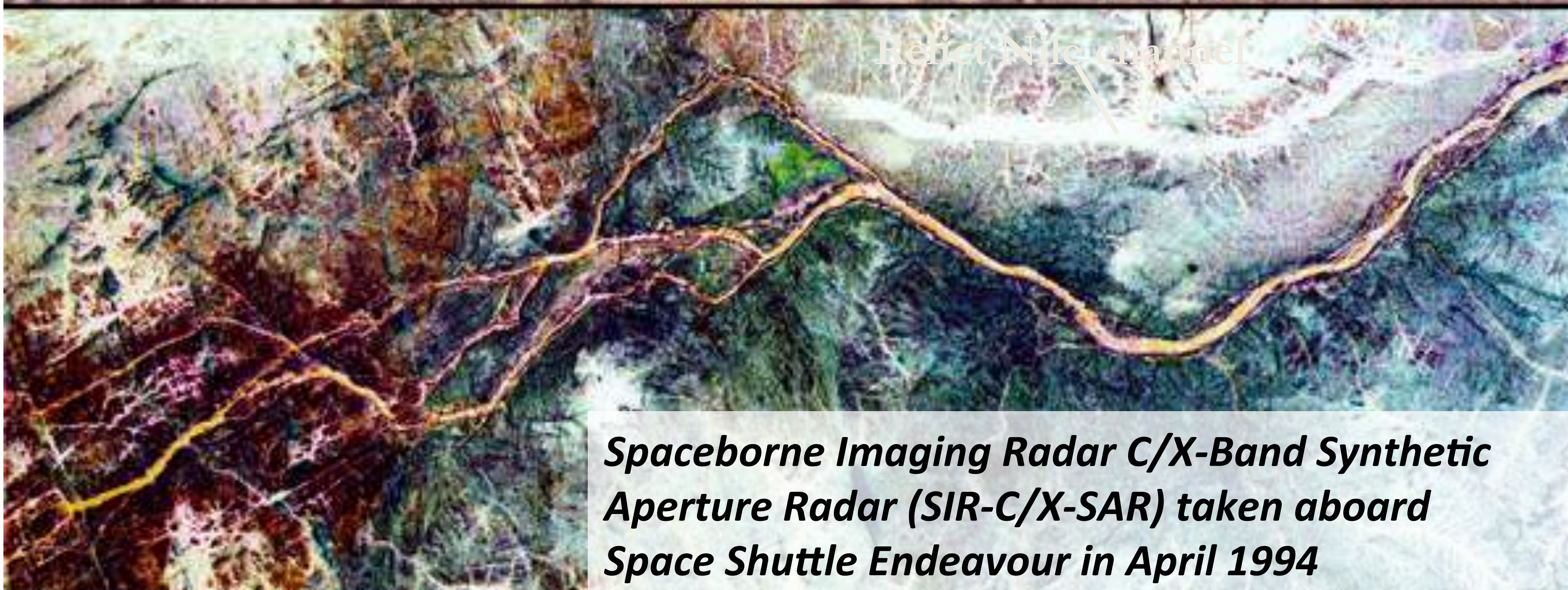
Brazil - Forest Inundation



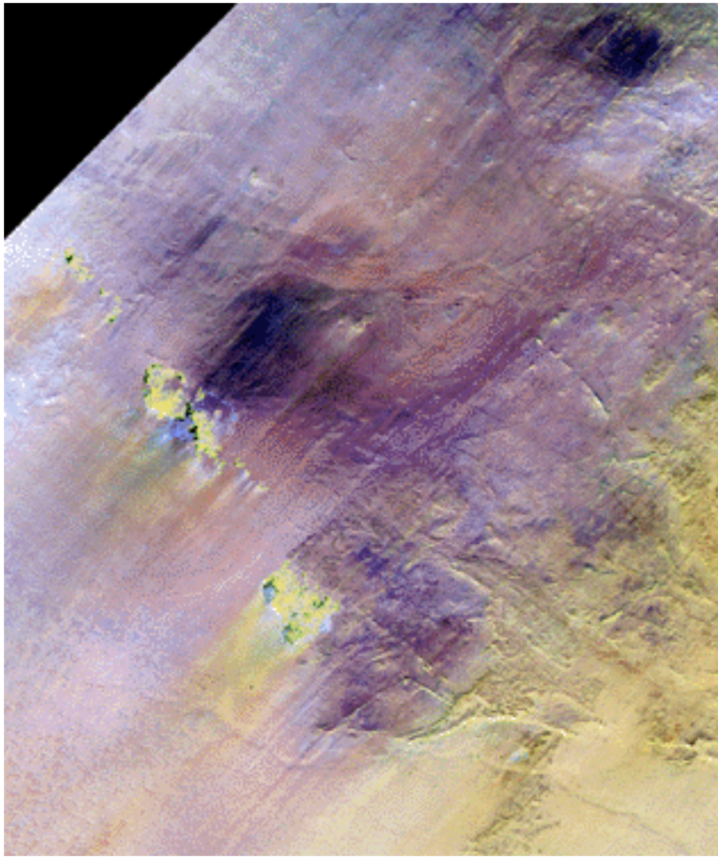
Mt. Rainier

R - Lhh, G - Lhv, B - Chv

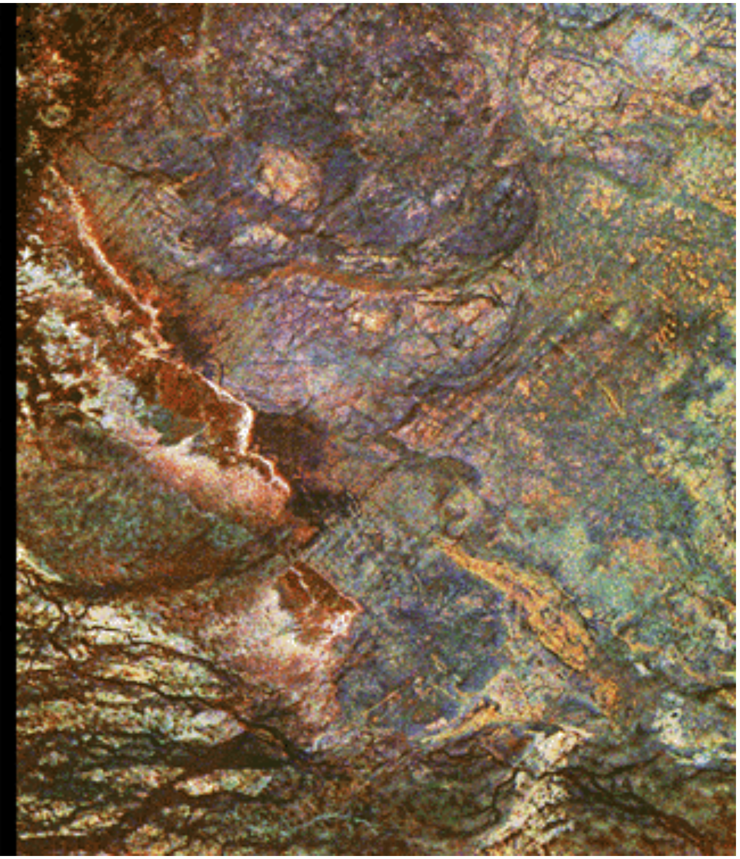

Sand sea
(very dry and well sorted)
Color infrared photo taken from Shuttle Columbia, November 1995


Relict Nile channel
Spaceborne Imaging Radar C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR) taken aboard Space Shuttle Endeavour in April 1994

Example of Radar Penetration from the Sahara



TM image



R-Lhh
G-Chh
B-Chv

Radar image

Example of Radar Bathymetry

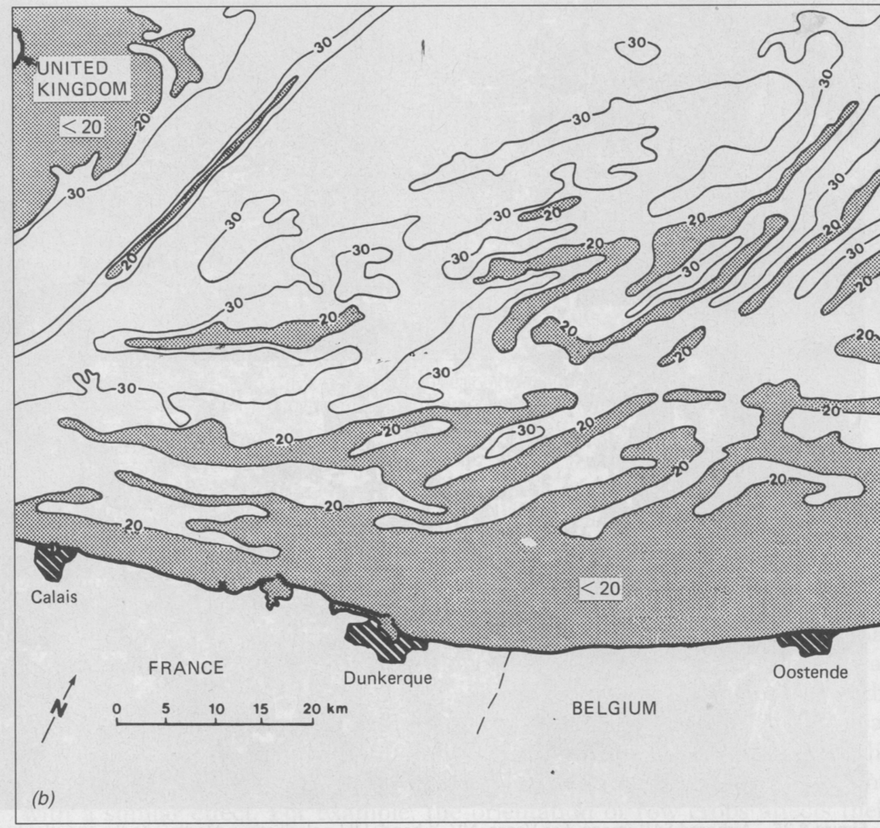


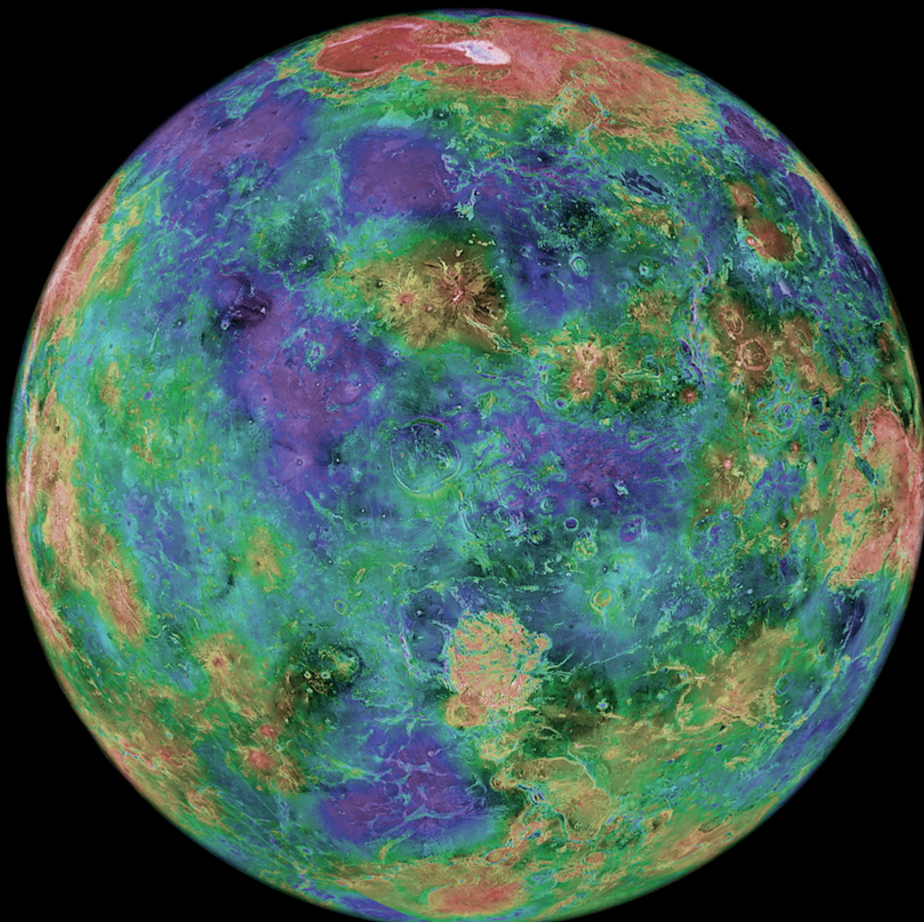
Figure 8.34 English Channel near the Strait of Dover: (*a*) Seasat SAR image, L band, midsummer; (*b*) map showing ocean bottom contours in meters. (Courtesy NASA/JPL/Caltech.)

Figure 8.34 *(Continued)*

SAR Imaging Radar Experiments

	Seasat	*SIR-A*	*SIR-B*	*SIR-C*	*ERS-1*	*JERS-1*	*Almaz*	*Magellan*	*Radarsat*
Launch date	1978	1981	1984	1994	1991	1992	1991	1989	1995
Wavelength, cm	23.5 (L)	23.5 (L)	23.5 (L)	3.0 (X) 6.0 (C) 24.0 (L)	5.7 (C)	23.5 (L)	9.6 (S)	12.6 (S)	5.7 (C)
Depression angle	70°	40°	30 to 75°	Variable	67°	55°	40 to 58°	65°	40 to 70°
Spatial resolution, m	25	38	25	Variable	218	18	15	100	Variable
Polarization	HH	HH	HH	Multiple	VV	HH	HH	HH	HH
Swath width	100	50	40	30 to 60	100	75	50 to 100	20	50 to 100
Altitude, km	790	250	225	225	785	568	350	290 to 2000	800
Latitude covered	72°N to 72°S	50°N to 50°S	58°N to 58°S	57°N to 57°S	Polar	Polar	Polar	Polar	Polar
Nationality	USA	USA	USA	USA	Europe	Japan	Russia	USA	Canada

Venus topography and radar brightness (Magellan)



Key Spacecraft Characteristics

- Single radar instrument operates simultaneously (by interleaving) in Synthetic Aperture Radar (SAR), altimeter, and radiometer modes.
- High Gain Antenna (3.7m diameter) is used as both the radar and telecommunications antenna.
- X-band downlink data rate of 268.8 or 115 kbps.
- Coherent X- and S-band radio subsystem used for gravity field measurement by precision tracking of the spacecraft's orbit.
- Spacecraft on-orbit dry mass of 1035 kg.
- Monopropellant hydrazine thruster system (0.9 to 445N thrust).
- Powered by solar panels with rechargeable batteries.
- Three orthogonal electrically powered reaction wheels used for spacecraft pointing control.

Key Radar Characteristics

- Synthetic Aperture Radar (SAR)
    - Frequency: 2.385 GHz
    - Peak Power: 325 W
    - Pulse Length: 26.5 microsec
    - PRF: 4400-5800 Hz
    - Swath Width: 25 km (variable)
    - Data Acquisition Rate: 806 kbps
    - Downlink Quantization: 2 bits
- Operates in SAR, altimeter, and radiometer modes
    - SAR Resolution: 150m range/150m azimuth
    - Altimeter Resolution: 30m
    - Radiometer Accuracy: 2 degree C

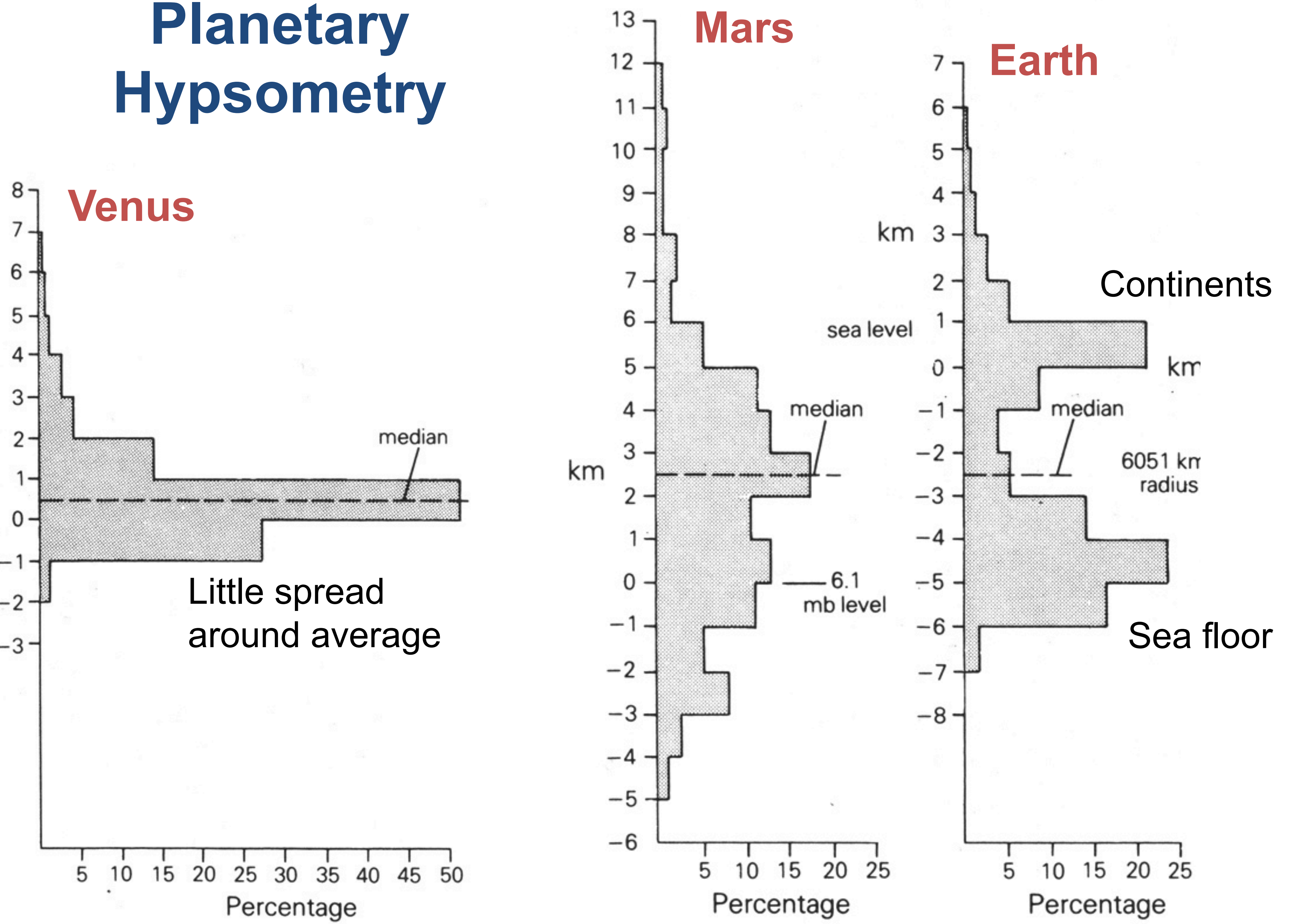
Kallistos Vallis, Venus (Magellan SAR)

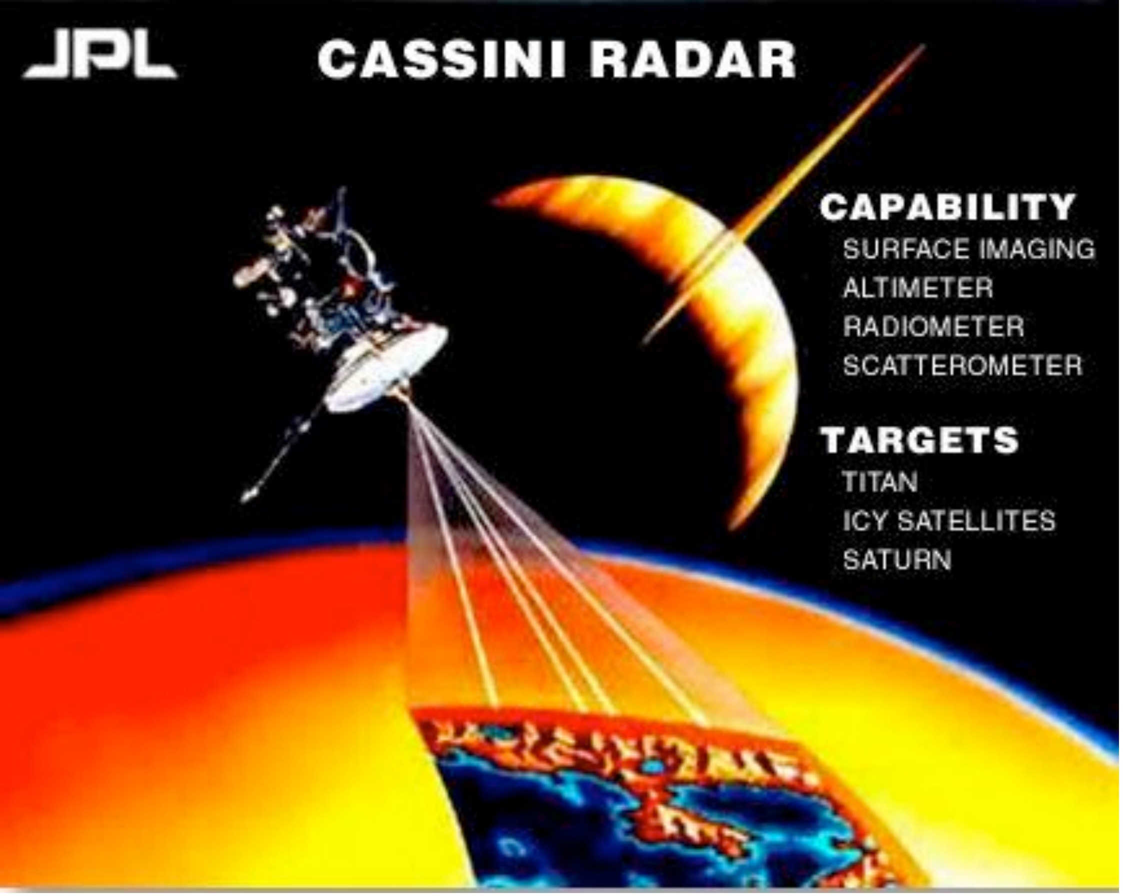
Anastomosing channels on Venus (SAR)

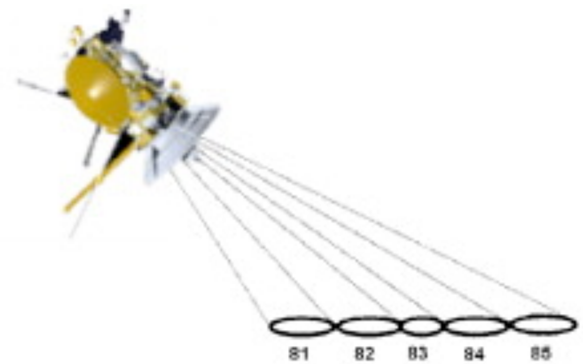
Meandering channels (rilles) on Venus

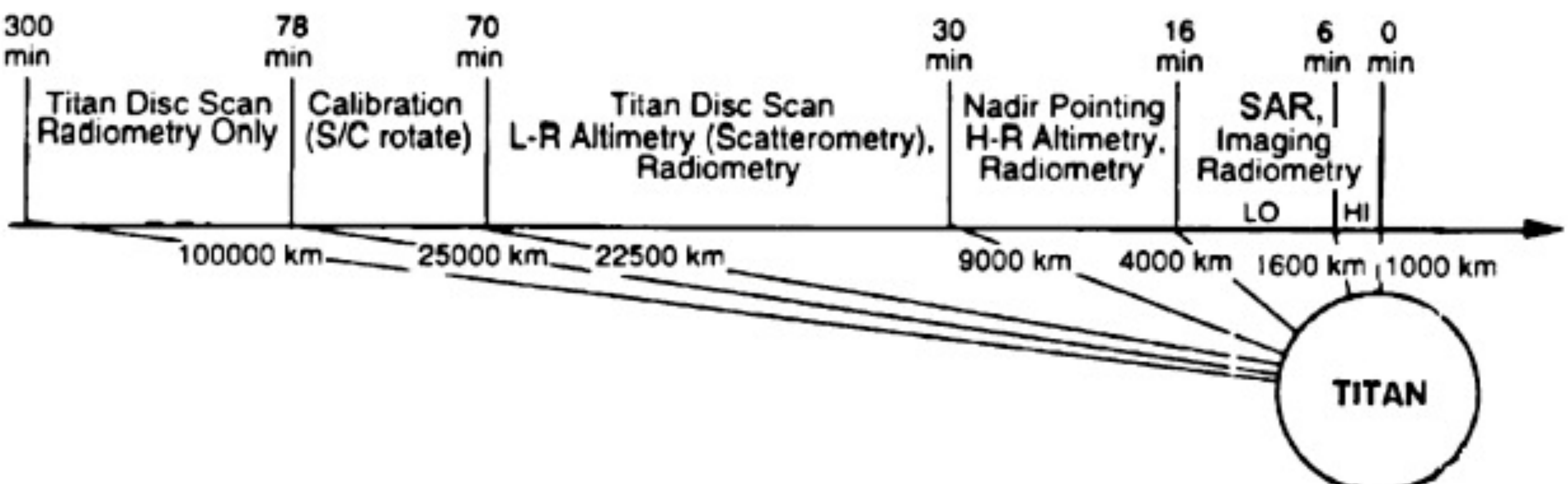
Figure 12. Simple Venusian rille located at ~2°S, 273°18′E, in Phoebe Regio (Magellan Full Resolution synthetic aperture radar (SAR) Map of Venus (FMAP) left-look mosaic). Lava flows that formed this channel emerged from topographic depressions at d, flooding small basins

Planetary Hypsometry




JPL
CASSINI RADAR
CAPABILITY
SURFACE IMAGING
ALTIMETER
RADIOMETER
SCATTEROMETER
TARGETS
TITAN
ICY SATELLITES
SATURN



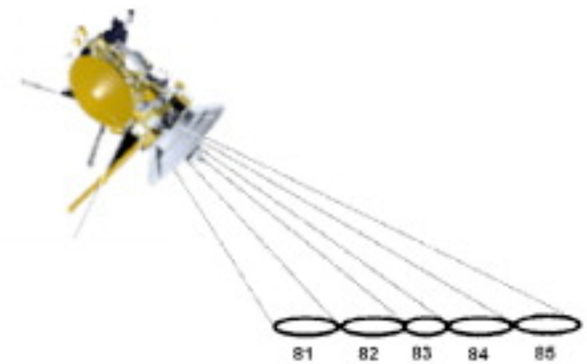

300 min
78 min
70 min
30 min
16 min
6 min
0 min
Titan Disc Scan Radiometry Only
Calibration (S/C rotate)
Titan Disc Scan L-R Altimetry (Scatterometry), Radiometry
Nadir Pointing H-R Altimetry, Radiometry
SAR, Imaging Radiometry
LO
HI
100000 km
25000 km
22500 km
9000 km
4000 km
1600 km
1000 km
TITAN

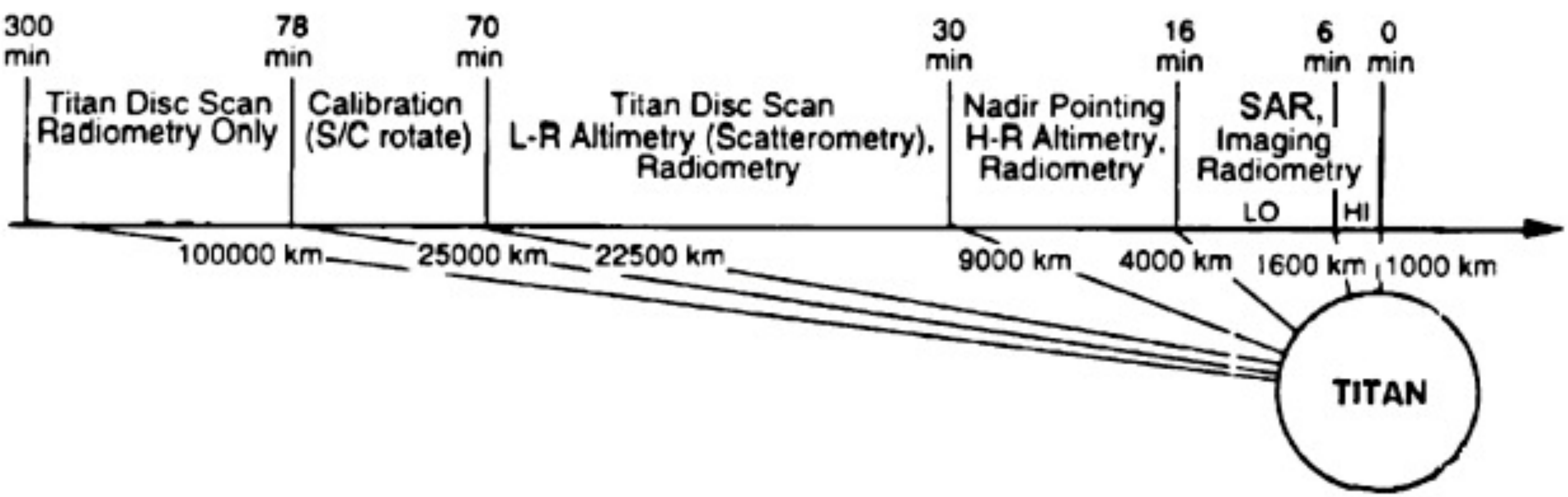
Cassini’s 3-meter antenna

Table 1
Nominal radiometer characteristics

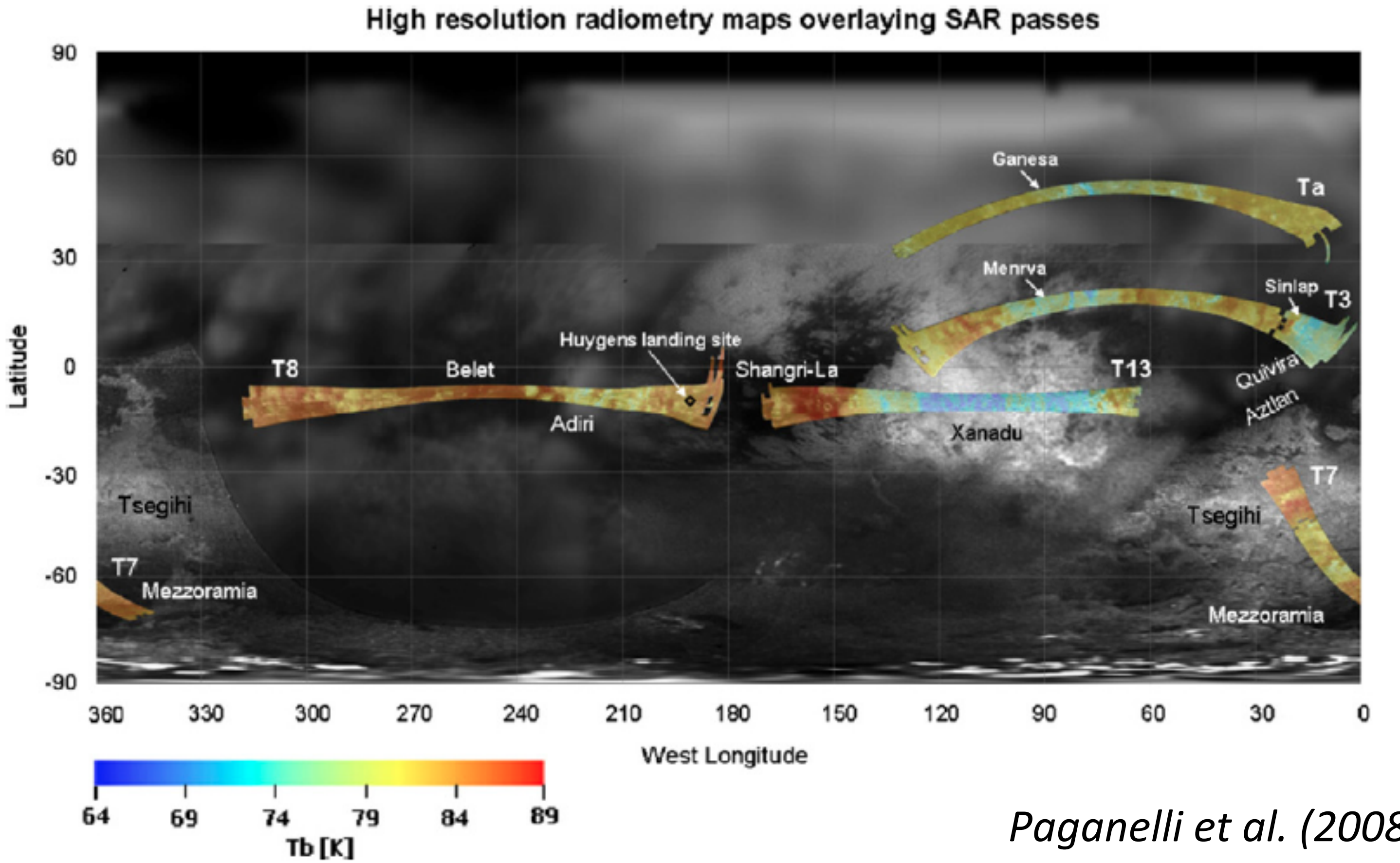
Frequency	13.78 GHz
Wavelength	2.18 cm
Bandwidth	135 MHz
Measurement noise	$0.025\,\mathrm{K}/\sqrt{\mathrm{Hz}}$
Beamwidth (beam 3)	$0.35^\circ \times 0.35^\circ$
Beamwidths (beam 1, 2, 4, 5)	0.35° (along track) $\times$ 1.35° (across track)
Footprint width, beam 3	6 km periapsis, 20 km start/end of SAR
Footprint diameter, beam 1, 2, 4, 5, cross-track	23 km periapsis, 75 km start/end of SAR

Paganelli et al. (2008)





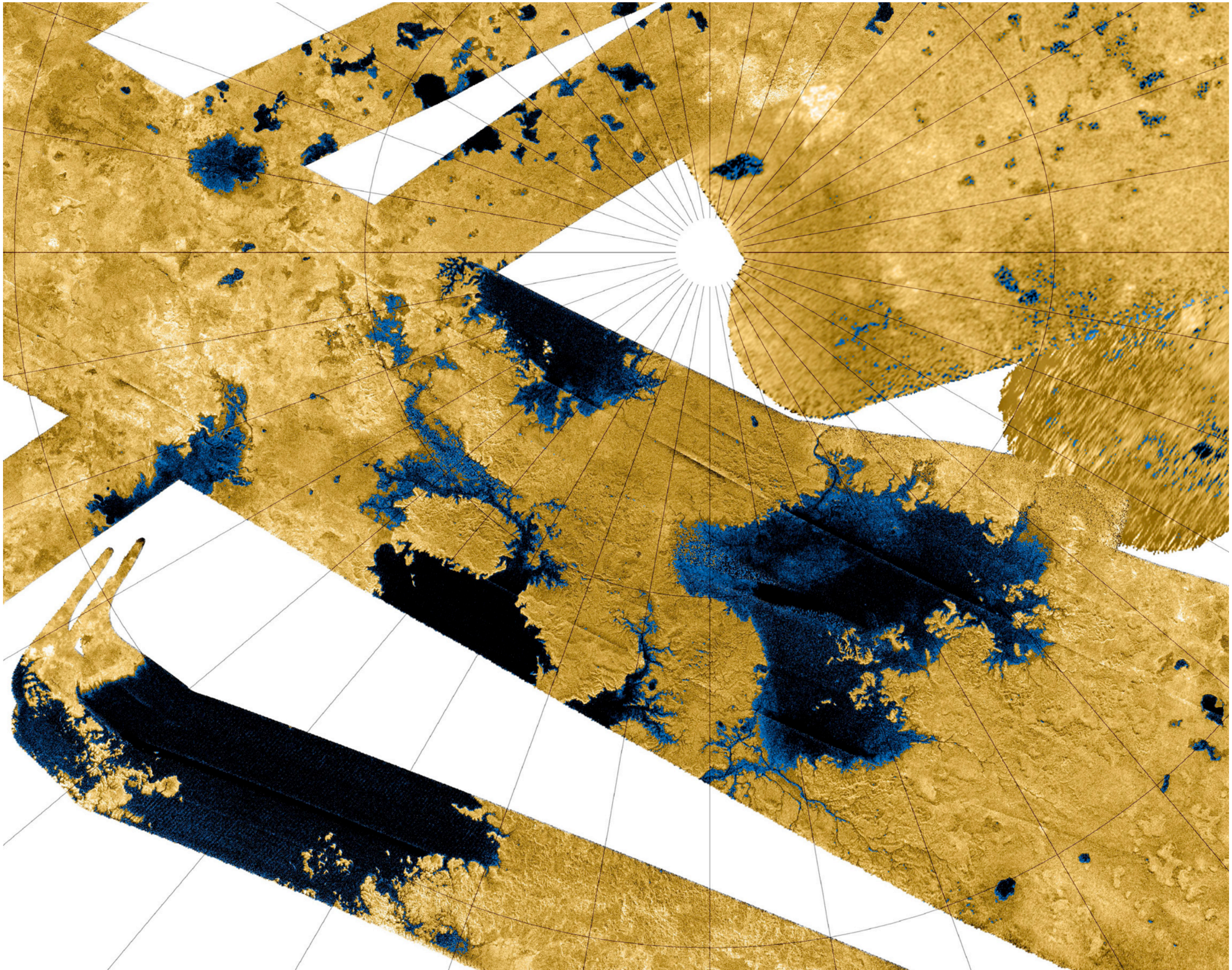
Cassini radar data from Titan



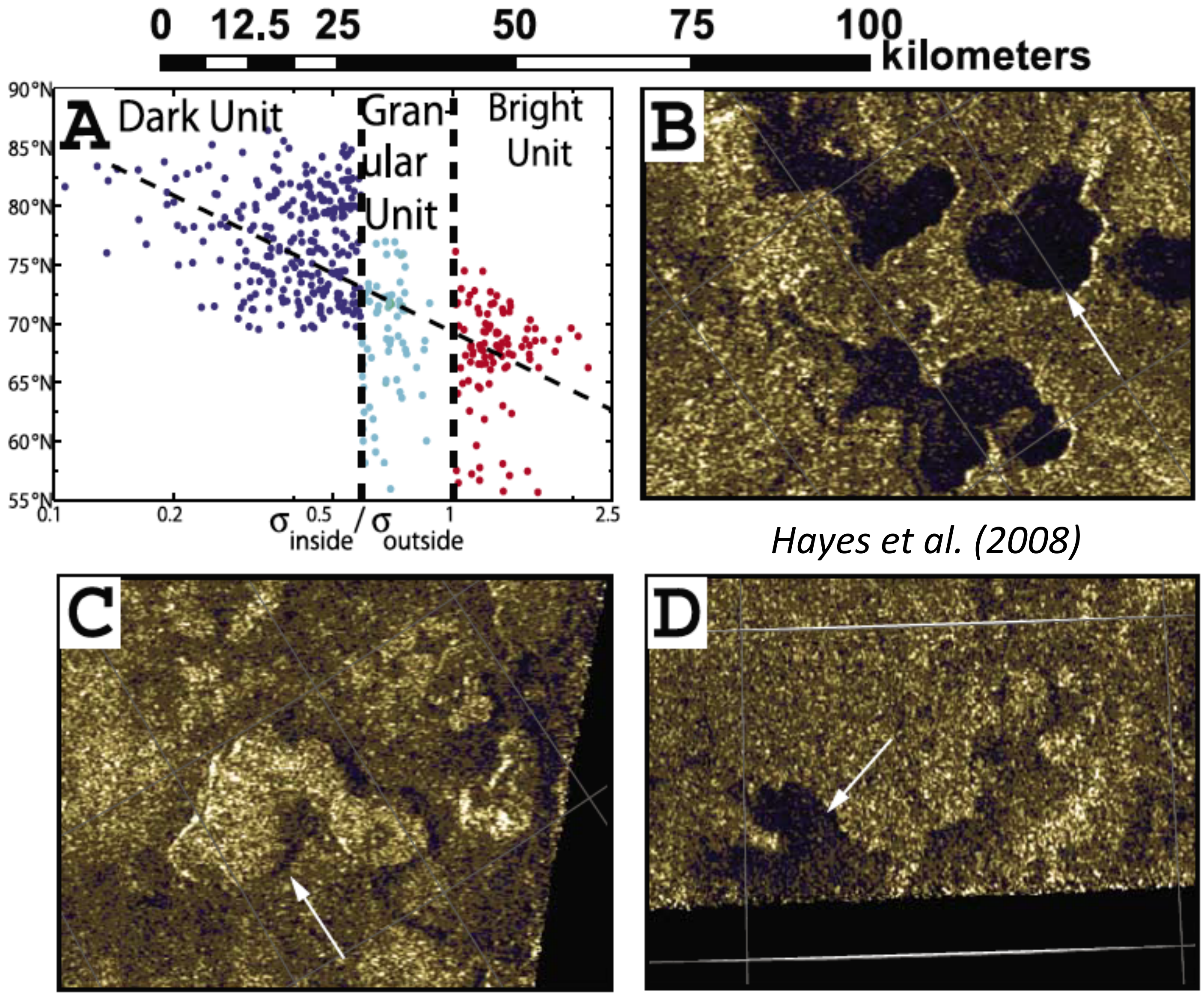
Paganelli et al. (2008)

Fig. 3. Integrated SAR and SAR-radiometry swaths for for Ta, T3, T7, T8, and T13. High-resolution radiometry with transparency level of 60% is overlaid on SAR swaths rendering the anti-correlation between SAR swath and high-resolution radiometry readily apparent while enhancing the characteristics of geological features and associated SAR and radiometry properties. Scale bar for overlaying high-resolution radiometry as in Fig. 2b.

CH_4 Lakes on Titan



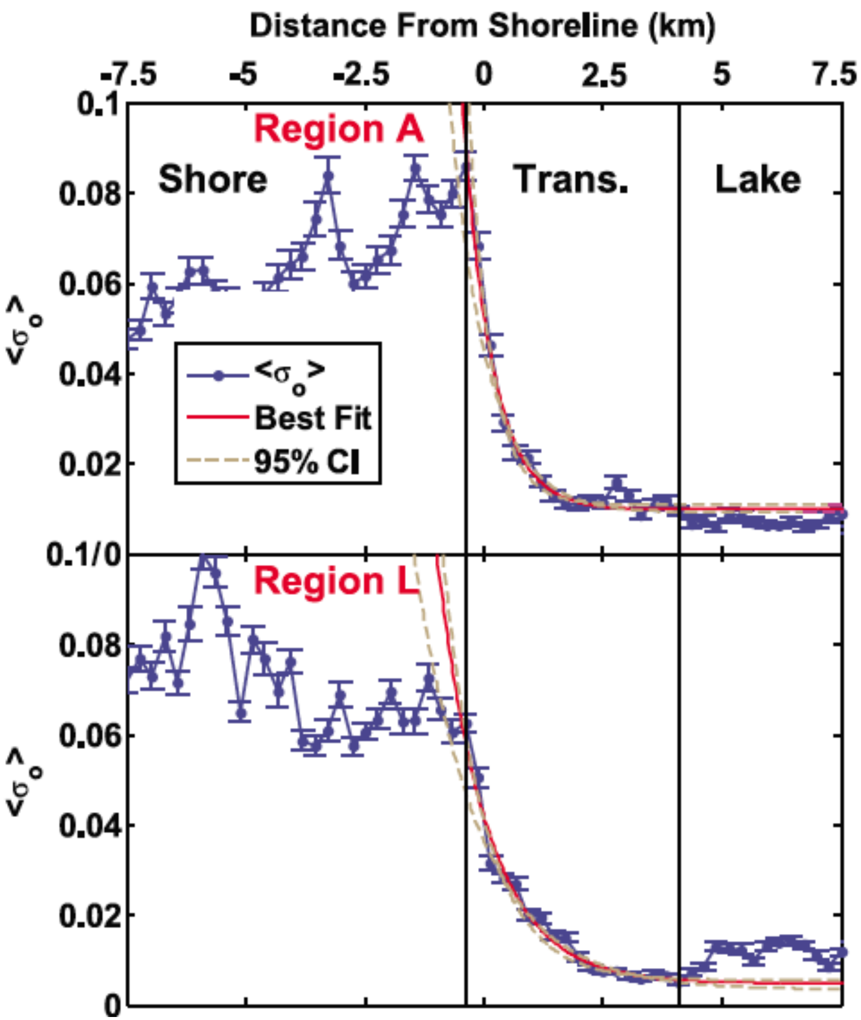
Titan: deep vs. shallow vs. dry lakes



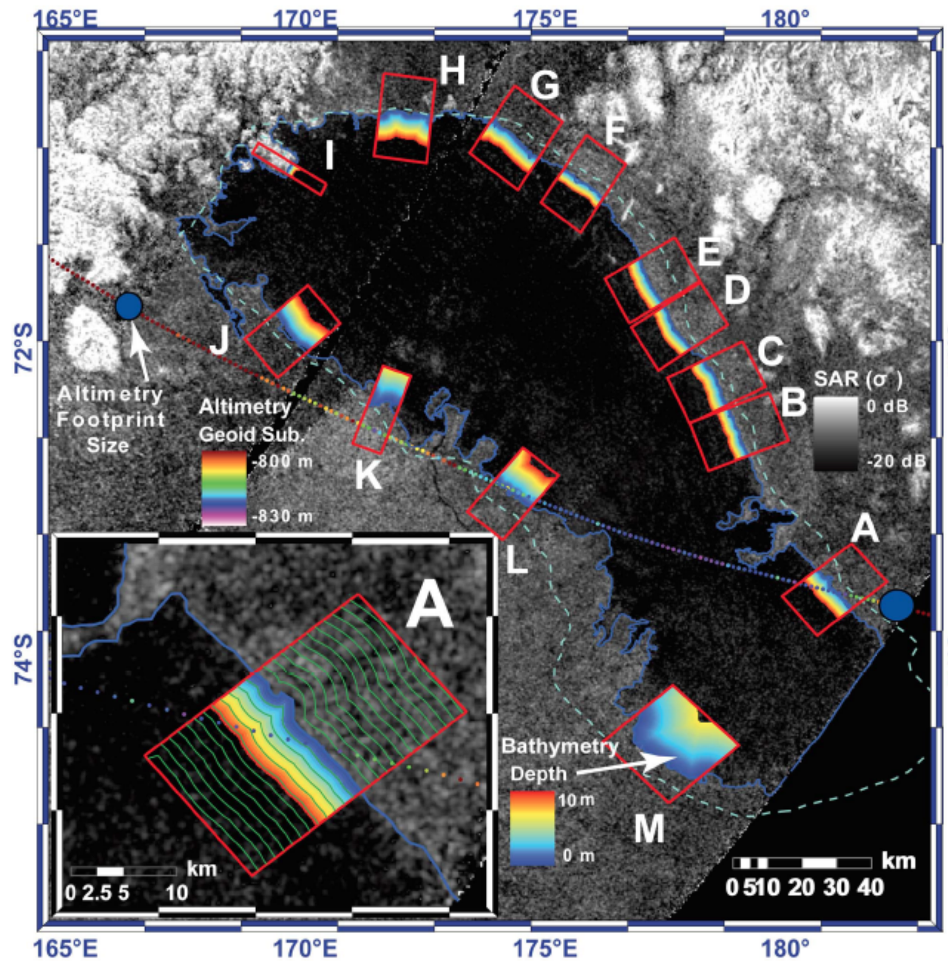
Hayes et al. (2008)

Figure 1. Mapping Units: (a) Ratio between median incidence-angle-corrected off-axis backscatter within and immediately surrounding feature, (b) Dark Unit, (c) Bright Unit, and (d) Granular Unit.

Titan: shoreline bathymetry from backscatter



Hayes et al. (2010)



Titan: Cassini radar vs. IR spectral windows

Dunes!