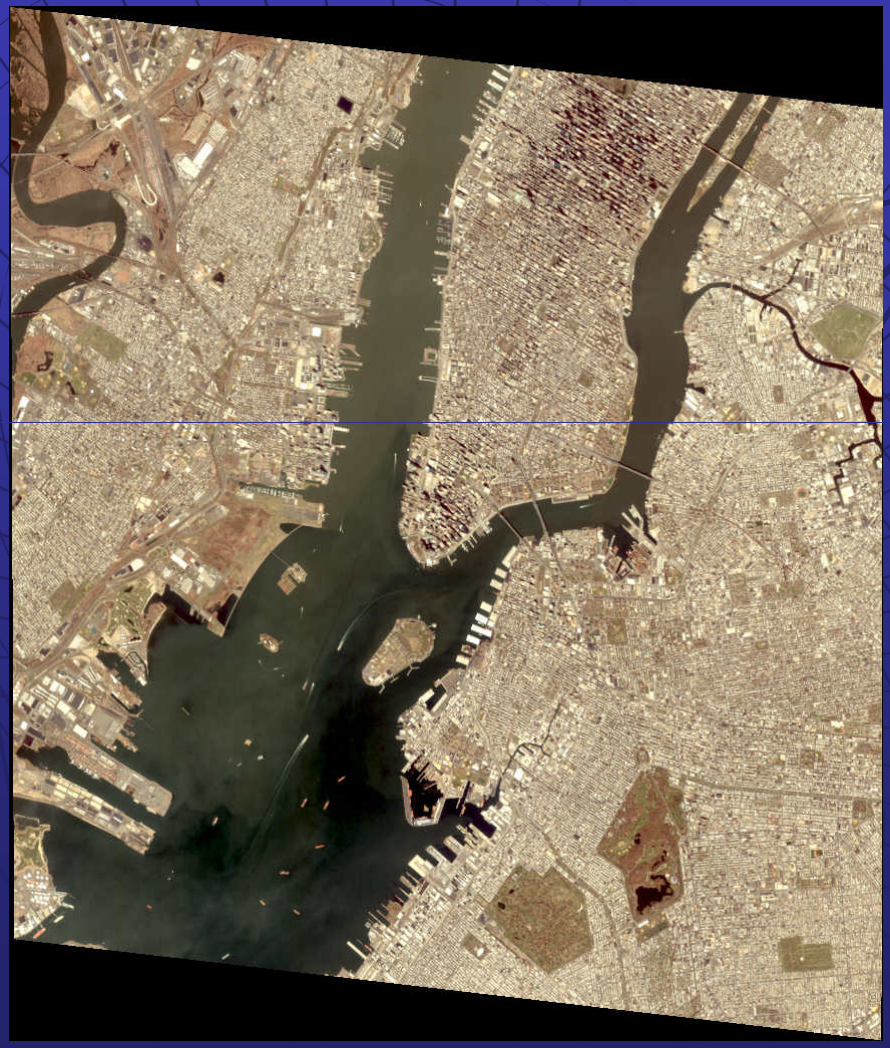
Landslides, Volcanoes and Wildfires: Views from Above

Kristina R. Czuchlewski, Ph.D.

Research supported by
Columbia University and NASA

Views from Above



Google Earth

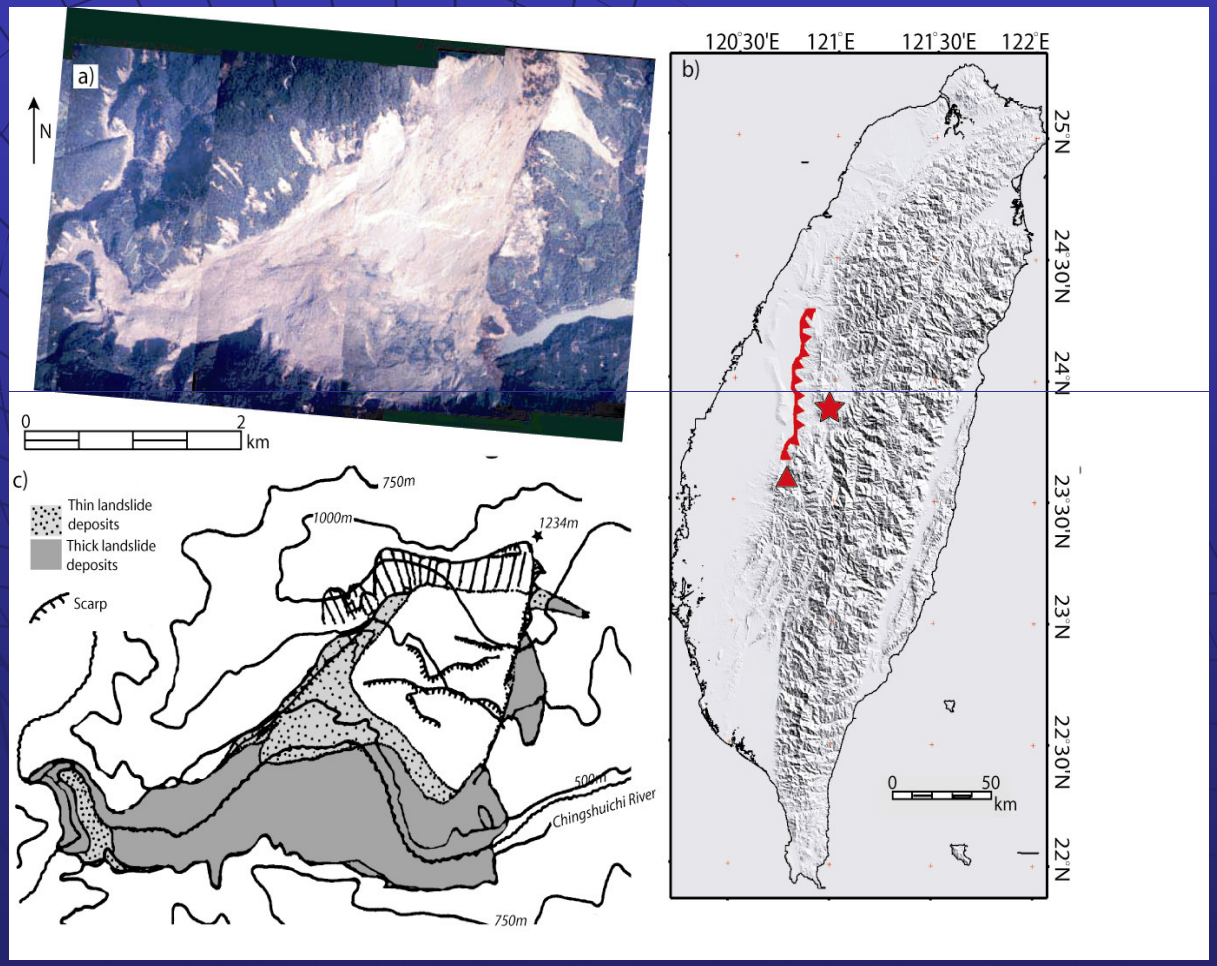
http://maps.google.com/maps?f=q&hl=en&q=25+W+43rd+Street,+NY,+NY&sll=37.0625,-95.677068&sspn=50.51141,82.265625&layer=&ie=UTF8&z=16&ll=40.753564,-73.978972&spn=0.011898,0.020084&t=k&om=1

At Night (no lights)

Dense Clouds

Landslides, Volcanoes and Wildfires

Taiwan Earthquake



Ch-Chi Earthquake
9/20/1999
Mw 7.6
1:47 am, local time

- severe aftershocks
- 10,000 landslides
- 2,400 people killed
- isolated communities
- Monsoon season

Czuchlewski et al., 2003

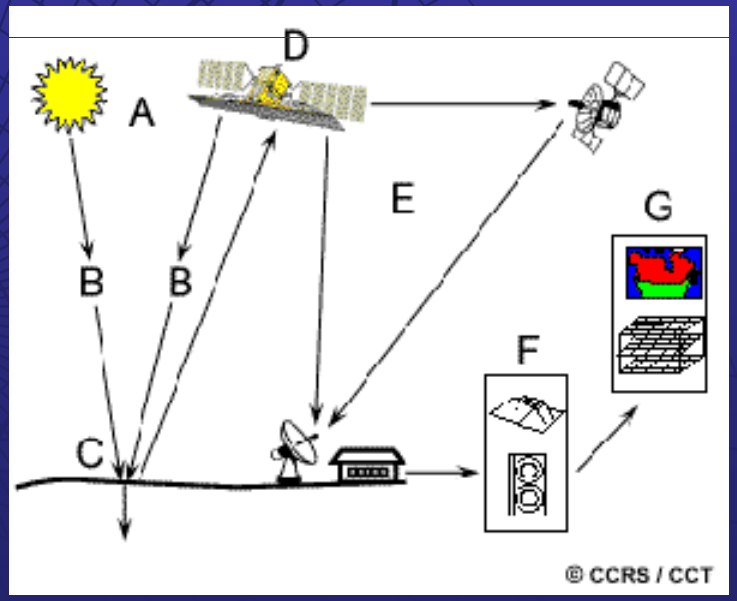
Dealing with Disasters

- Preparedness
- Mitigation
- Relief
- Recovery

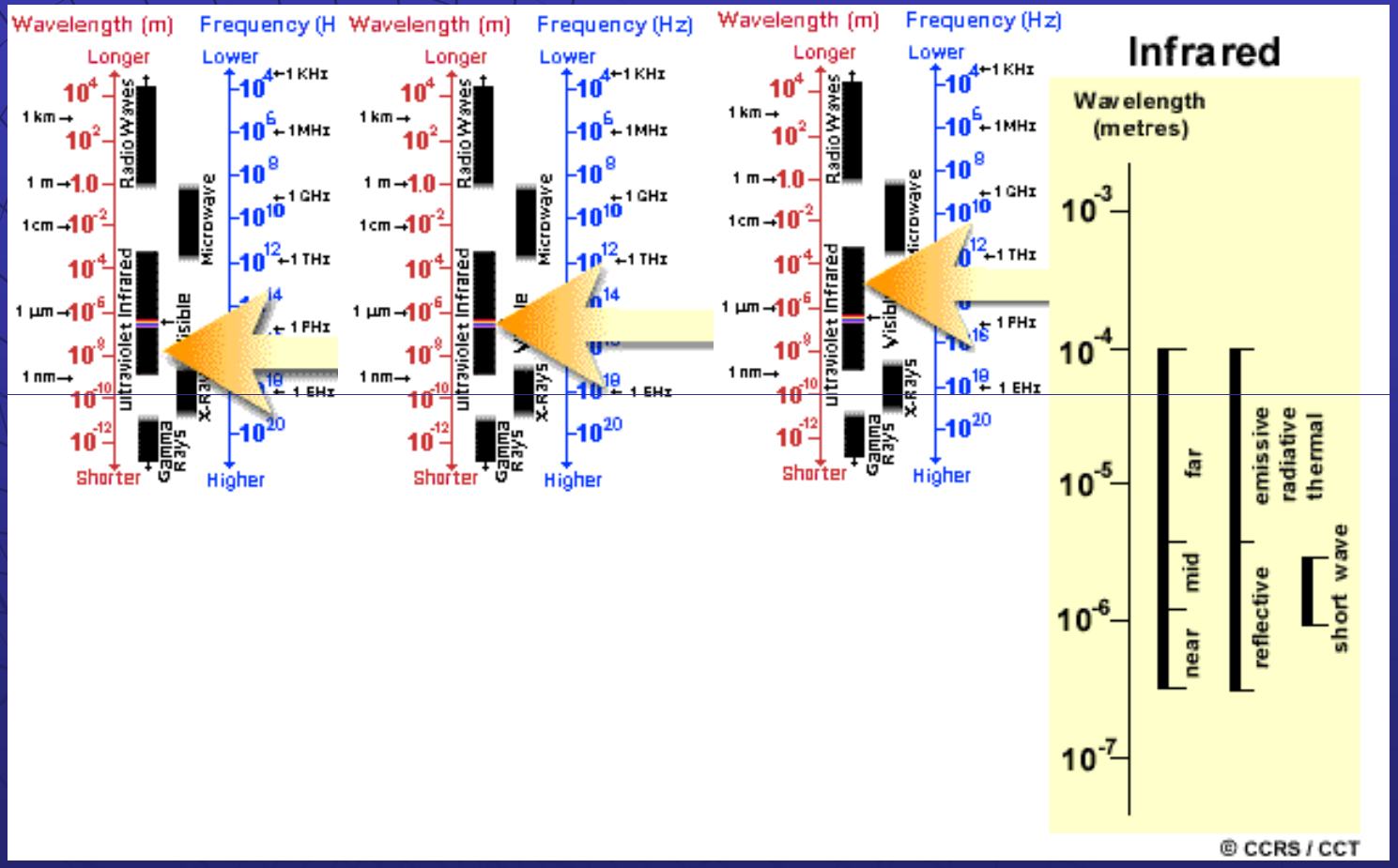
How can we harness remote sensing technology to deal with disasters?

- What is Remote Sensing?
- Radar's unique capabilities
- Radar disaster mapping
  - Chi-Chi Earthquake, Taiwan
  - Manan Volcano Eruption, PNG
  - Rodeo-Chediski Wildfire, AZ, USA

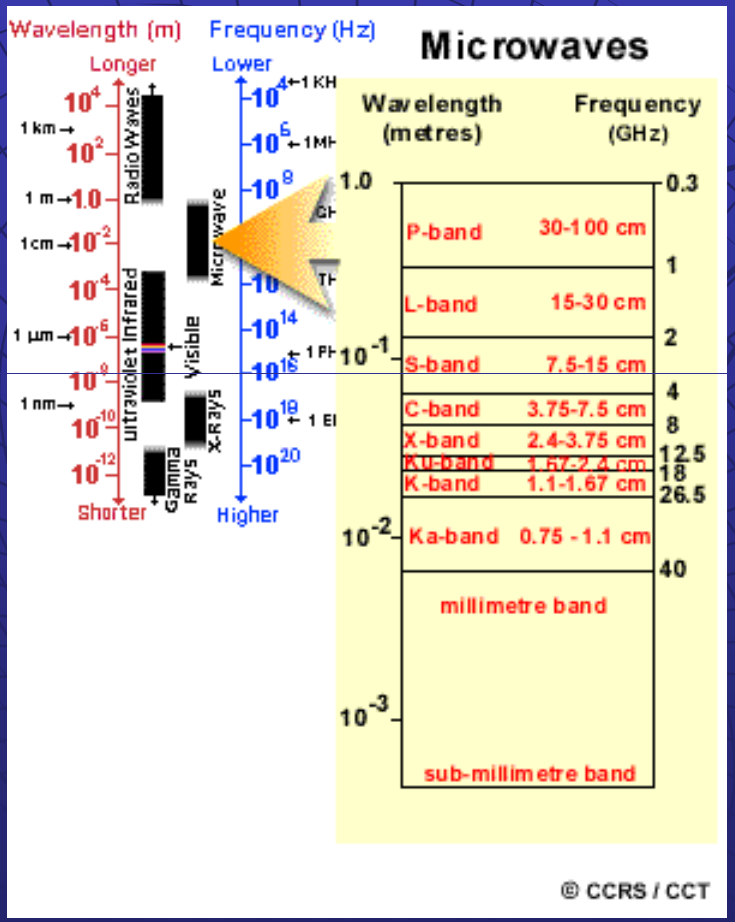
Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.



Electromagnetic Spectrum



RAdio Detection And Ranging



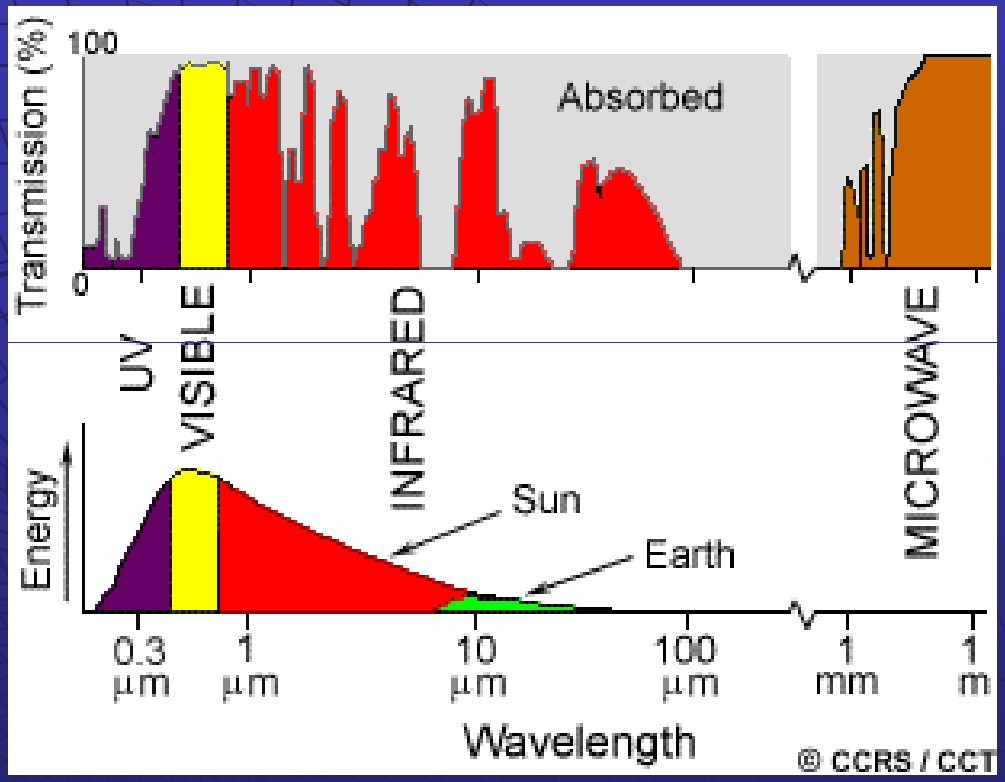
P-Band: 68 cm (~ 2 ft)

L-Band: 24 cm (~ 10 in)

C-Band: 5.6 cm (~ 2 in)

X-Band: 3.1 cm (~ 1 in)

Atmospheric Windows

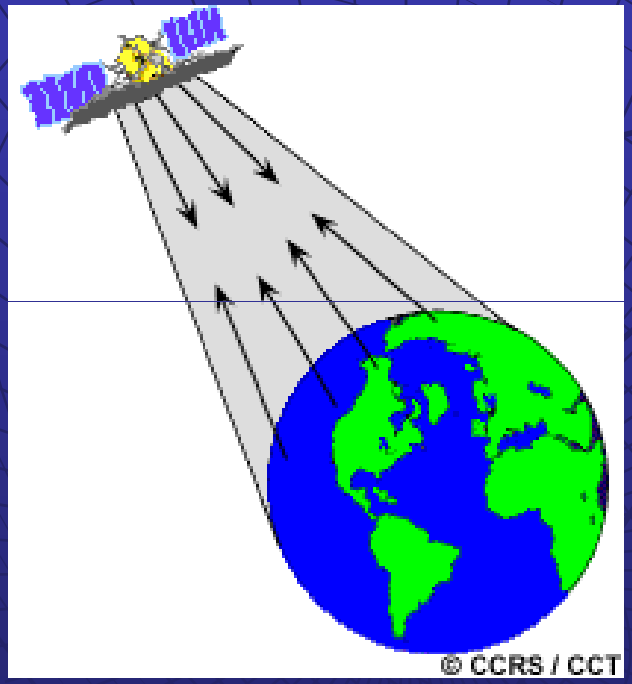


Colors represent what "shines through"

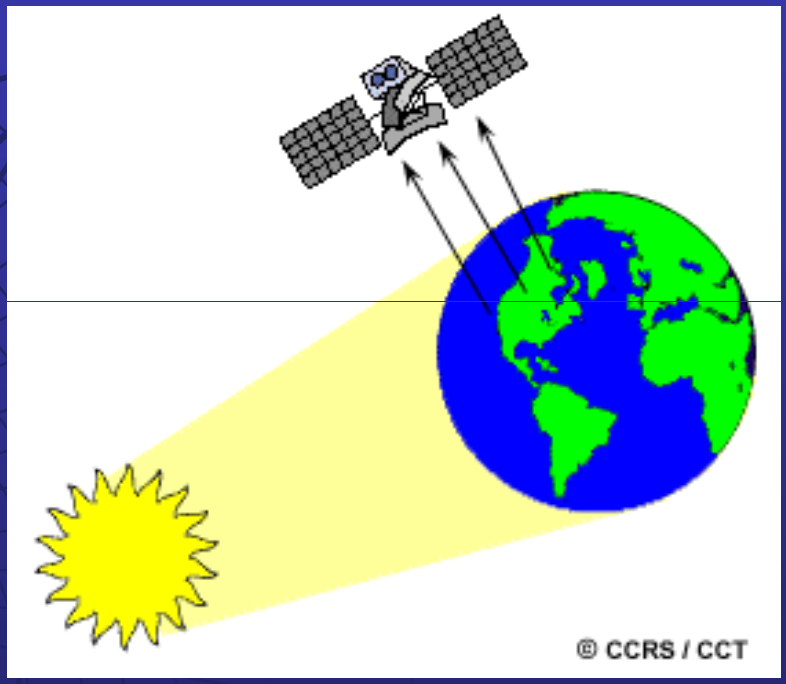
Colors represent what's emitted

Active vs. Passive

Energy from batteries



Energy from the sun



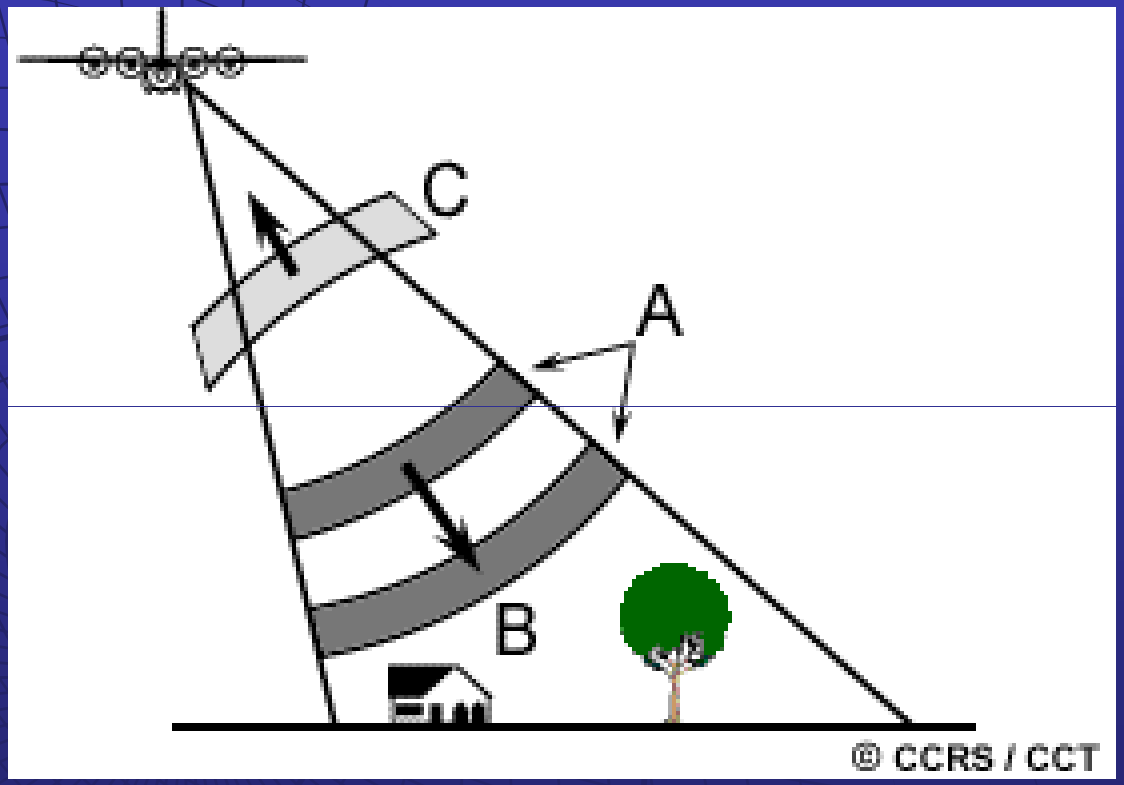
WHY USE EXPENSIVE BATTERIES?

- What is Remote Sensing?
- Radar's unique capabilities
- Radar disaster mapping
  - Chi-Chi Earthquake, Taiwan
  - Manan Volcano Eruption, PNG
  - Rodeo-Chediski Wildfire, AZ, USA

Radar & Disasters

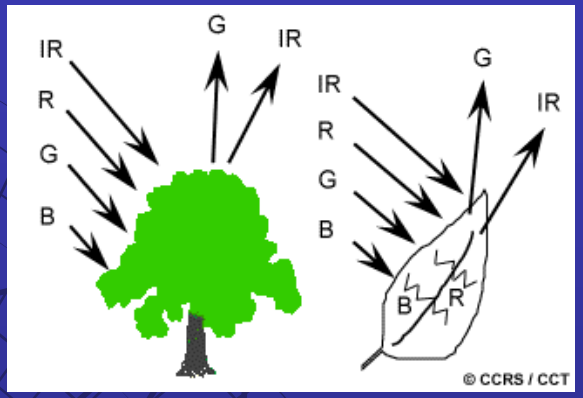
- Darkness, clouds or smoke can delay relief efforts.
- Detailed characterizations of radar returns provide information about surface cover changes.

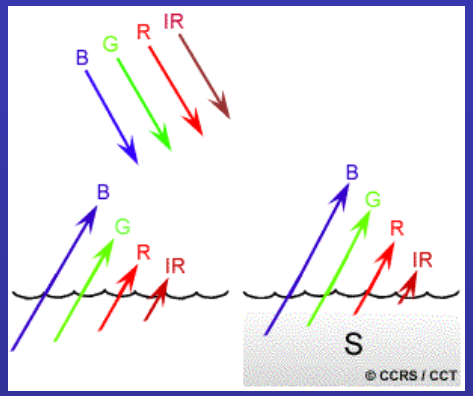
Actively Sending Signals

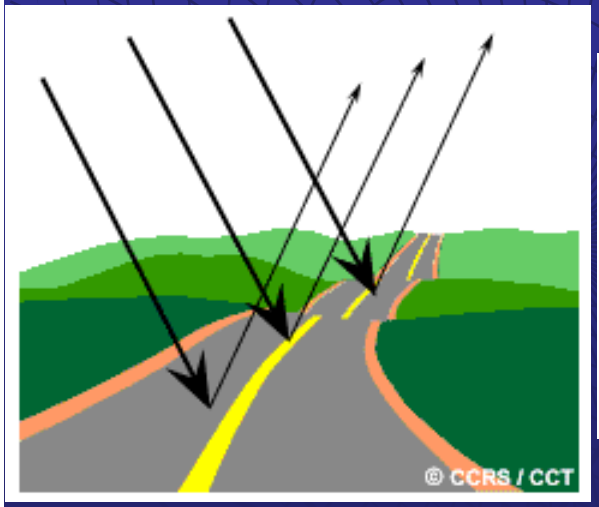


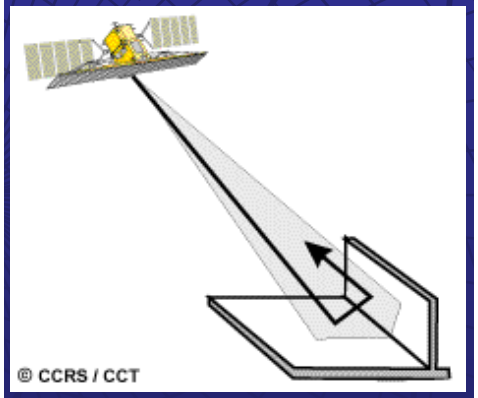
Surface Interactions

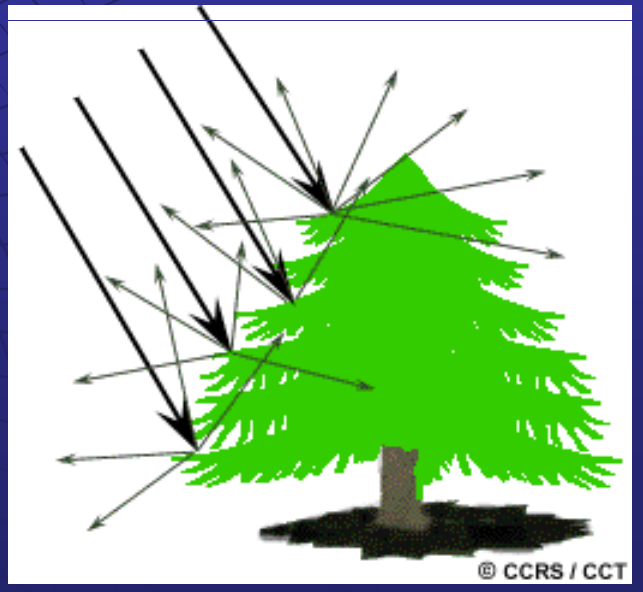
SHORT





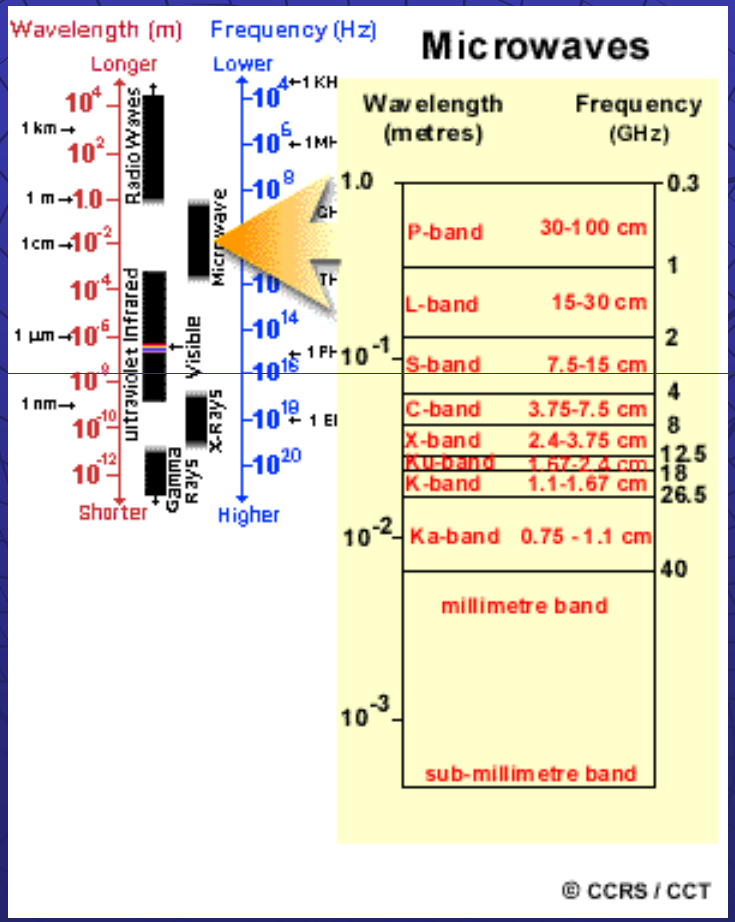


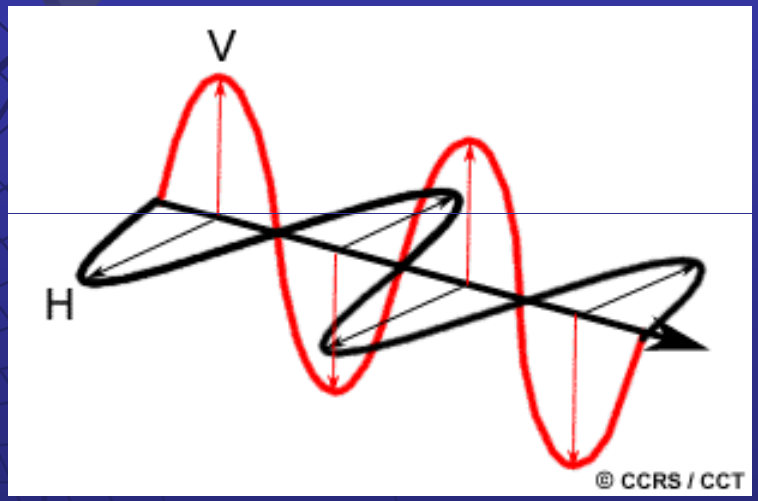




LONG

Exploiting Polarimetry

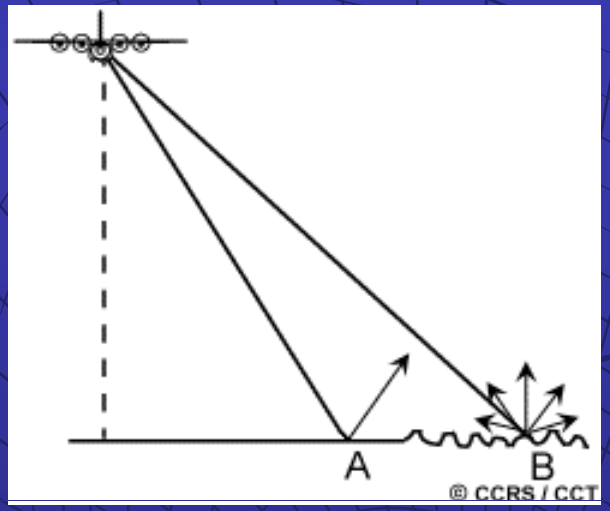


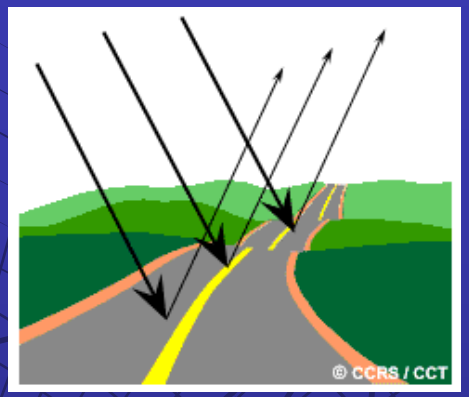


Transmit & Receive

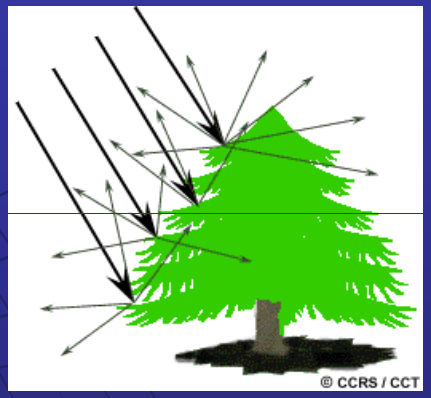
HH, HV, VH, VV

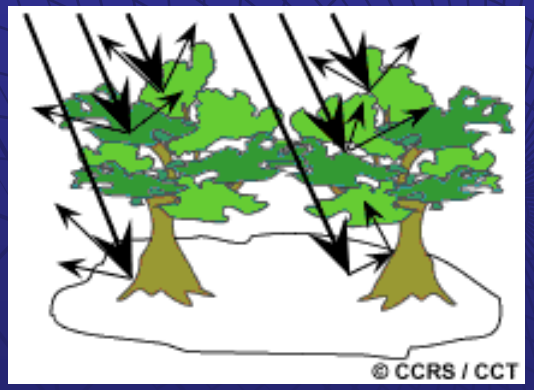
Radar-Surface Interaction





Bare surface:
Specular reflection,
"Bragg" scattering



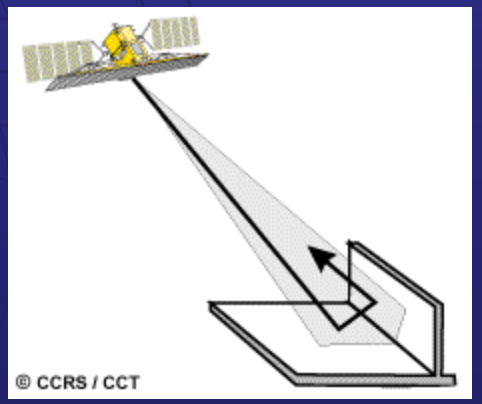


Single & double bounces

Dipole scattering

Volume scattering

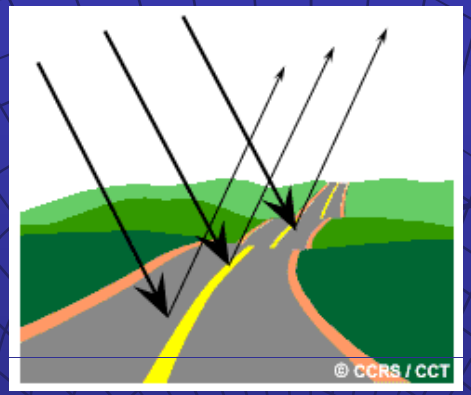
Corner reflection



The key parameters

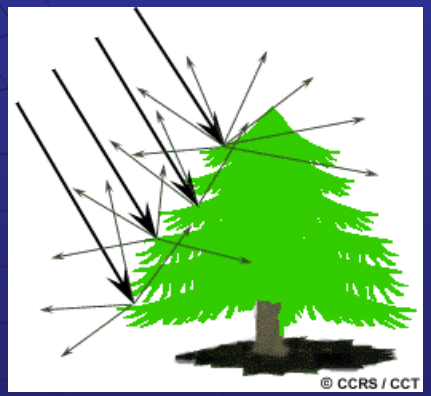
Parameter	Function	Source
Scattering Vectors	Microwave energy back scattered from a pixel.	Raw data
Average Alpha Angle	This is a measure of the type of scattering within a pixel or *scattering mechanism.*	Derived from eigenvectors
Entropy	This is a measure of disorder or the relative contribution of each scattering mechanism.	Derived from eigenvalues

abstract -> plain English

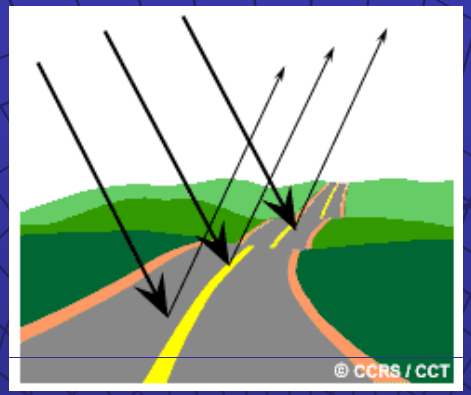


road

tree

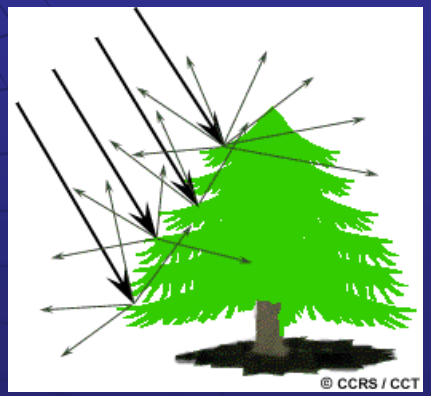


plain English -> abstract



Road: single bounce

- one scattering mechanism (alpha)
- low entropy (H)
- low disorder



Tree: diffuse bouncing

- lots of scattering mechanisms (alpha)
- high entropy (H)
- high disorder

An analysis that takes the simple transmission and reception of microwaves, and turns it into a sensitive and specific tool for examining the landscape.

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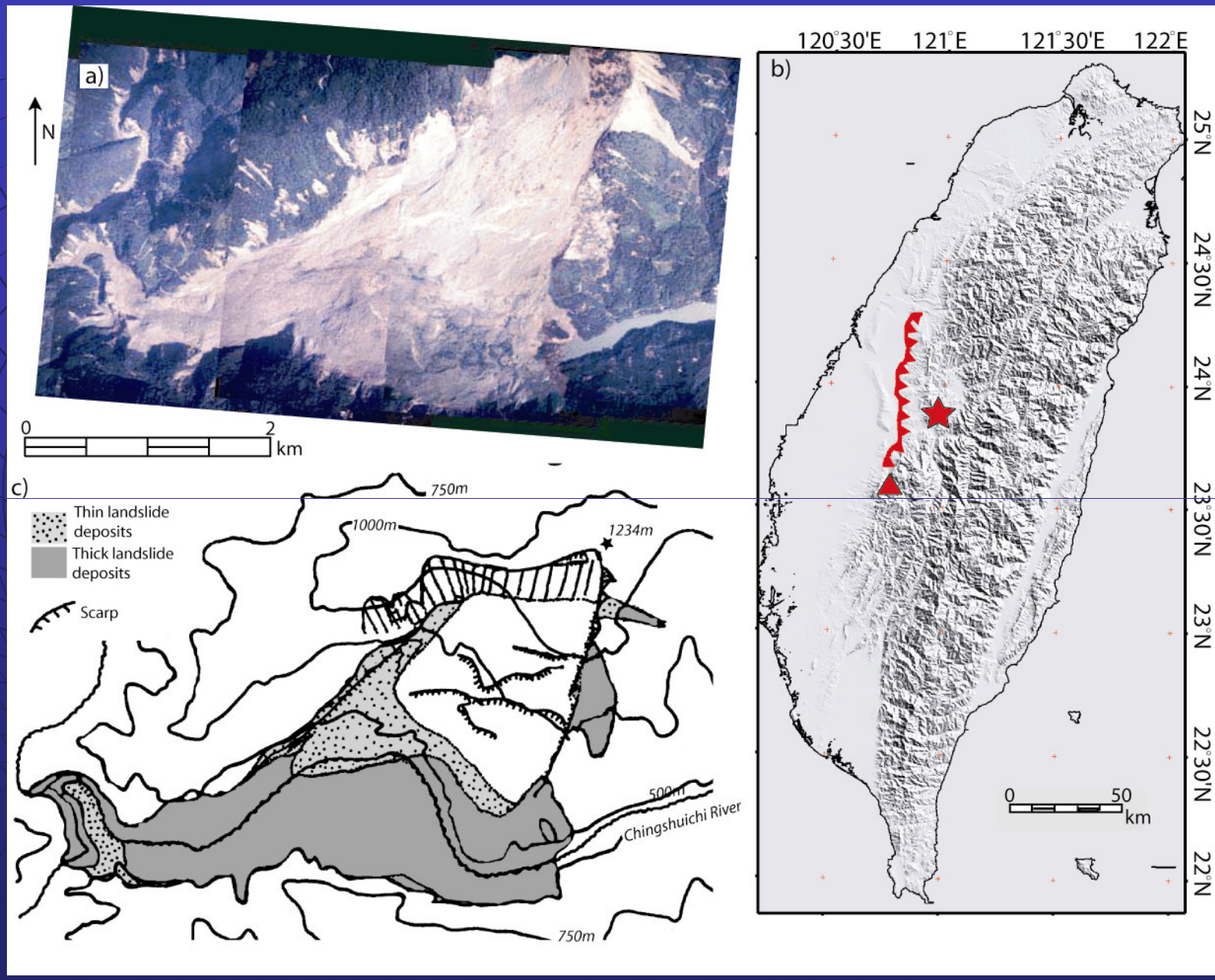
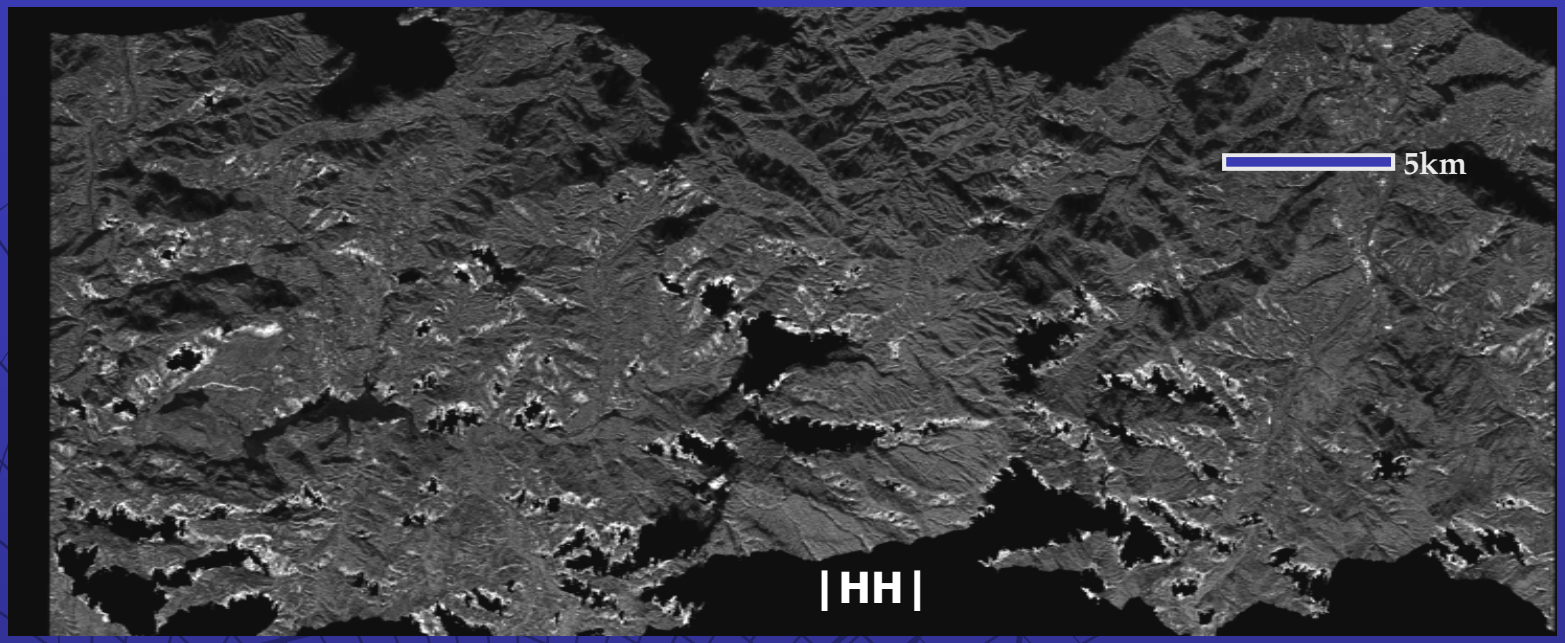
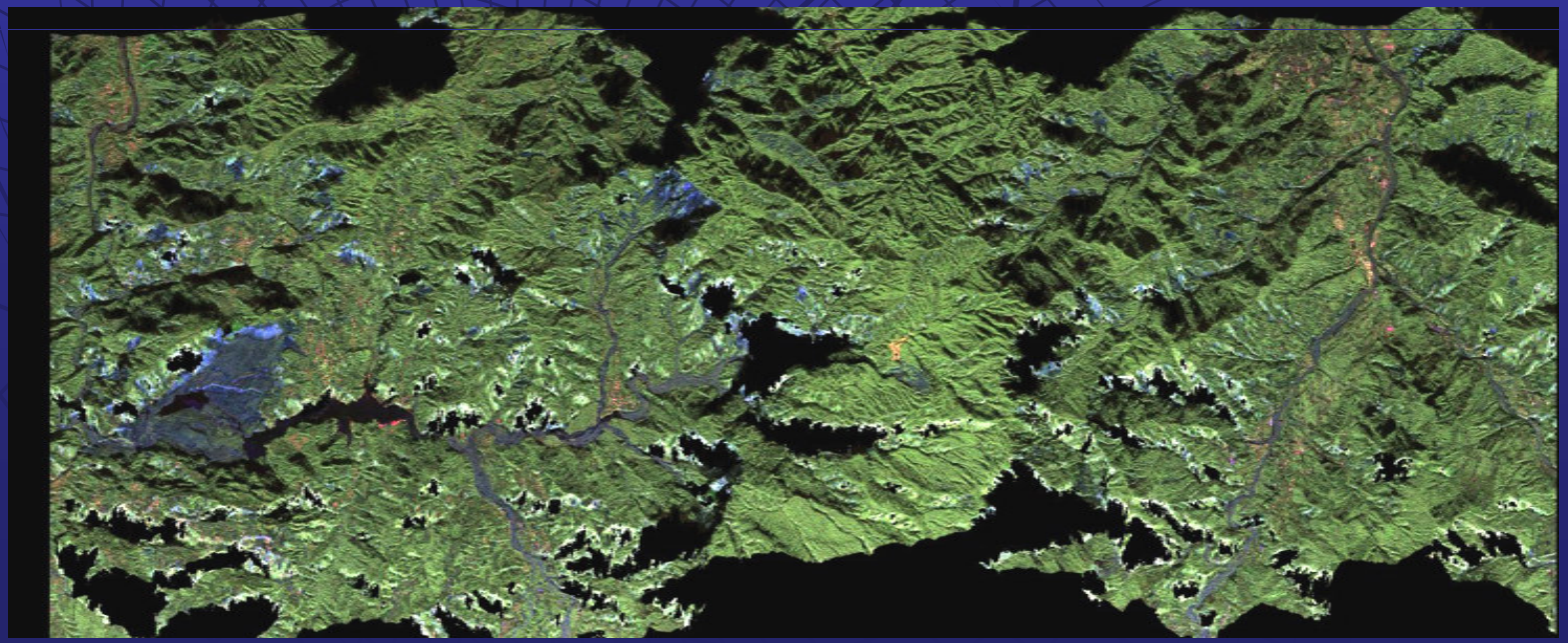


Czuchlewski et al., 2003





L-Band

Range

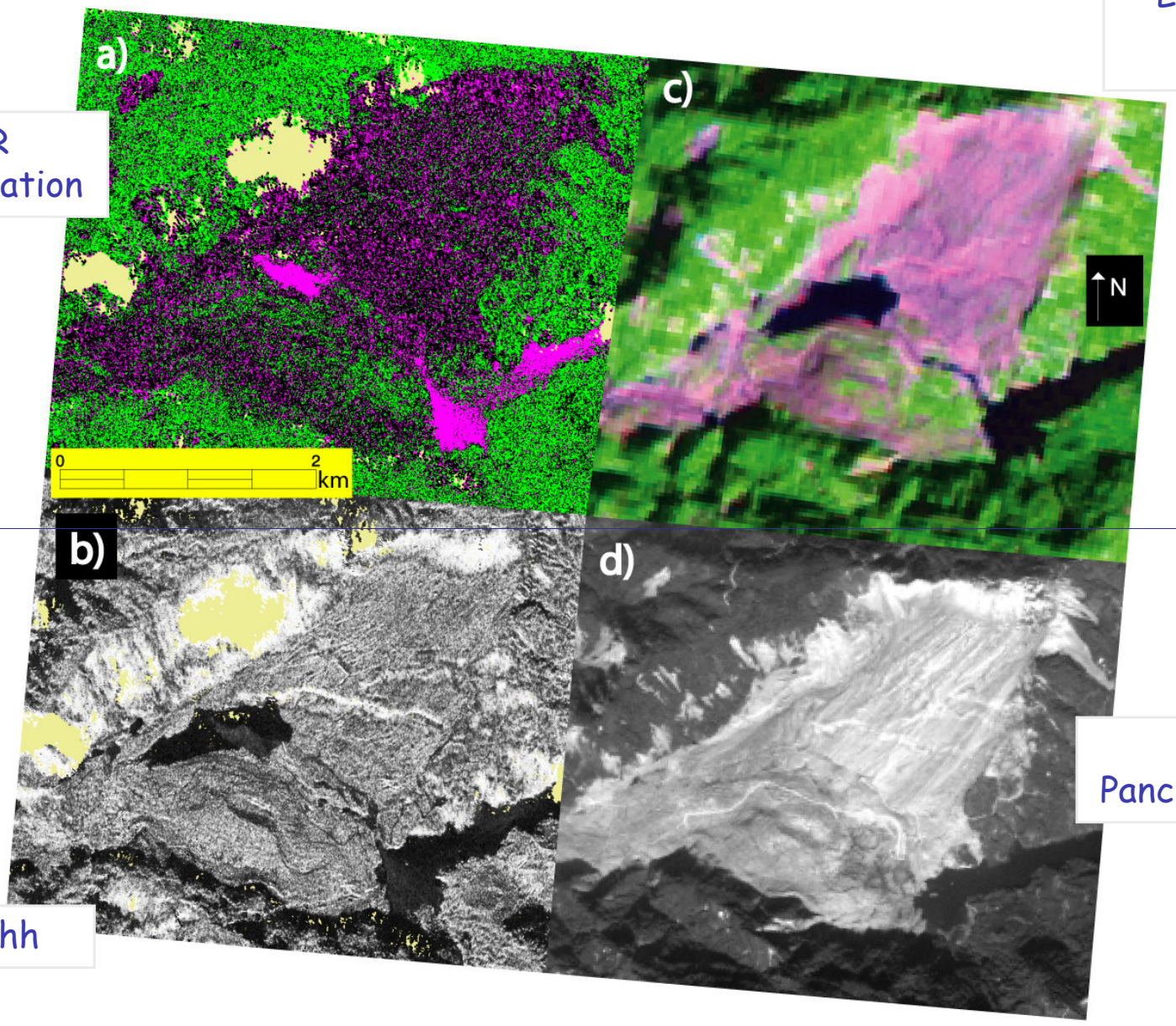
Azimuth

|HH-VV|, |HV|, |HH+VV|

SAR classification

Landsat 7

7,4,3

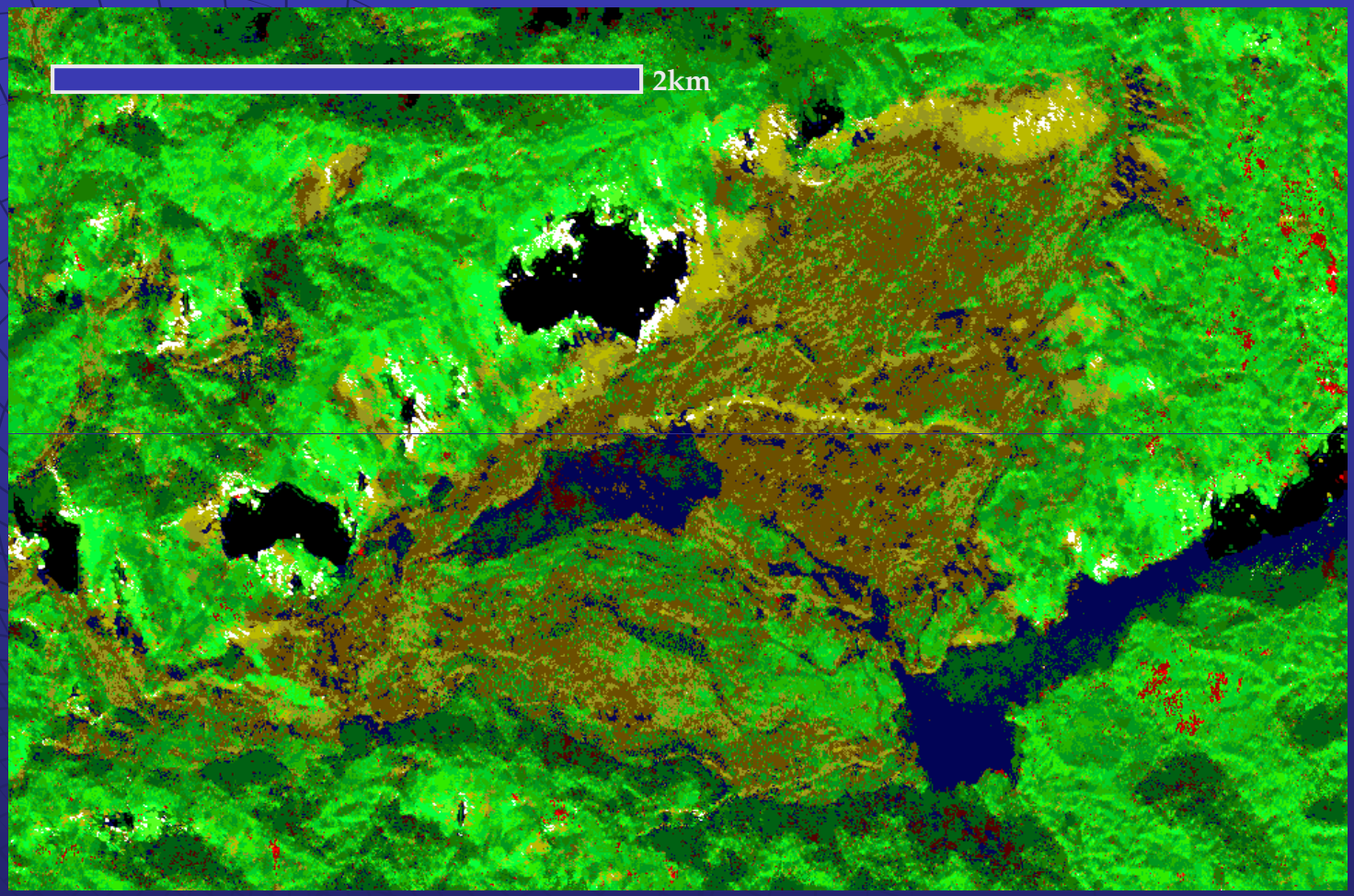


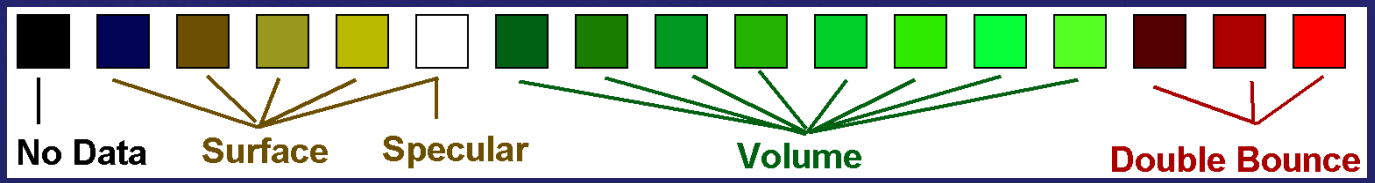
SAR L-hh

IRS Panchromatic

Czuchlewski et al., 2003

Even Better: Unsupervised Terrain Classification (Filtered)





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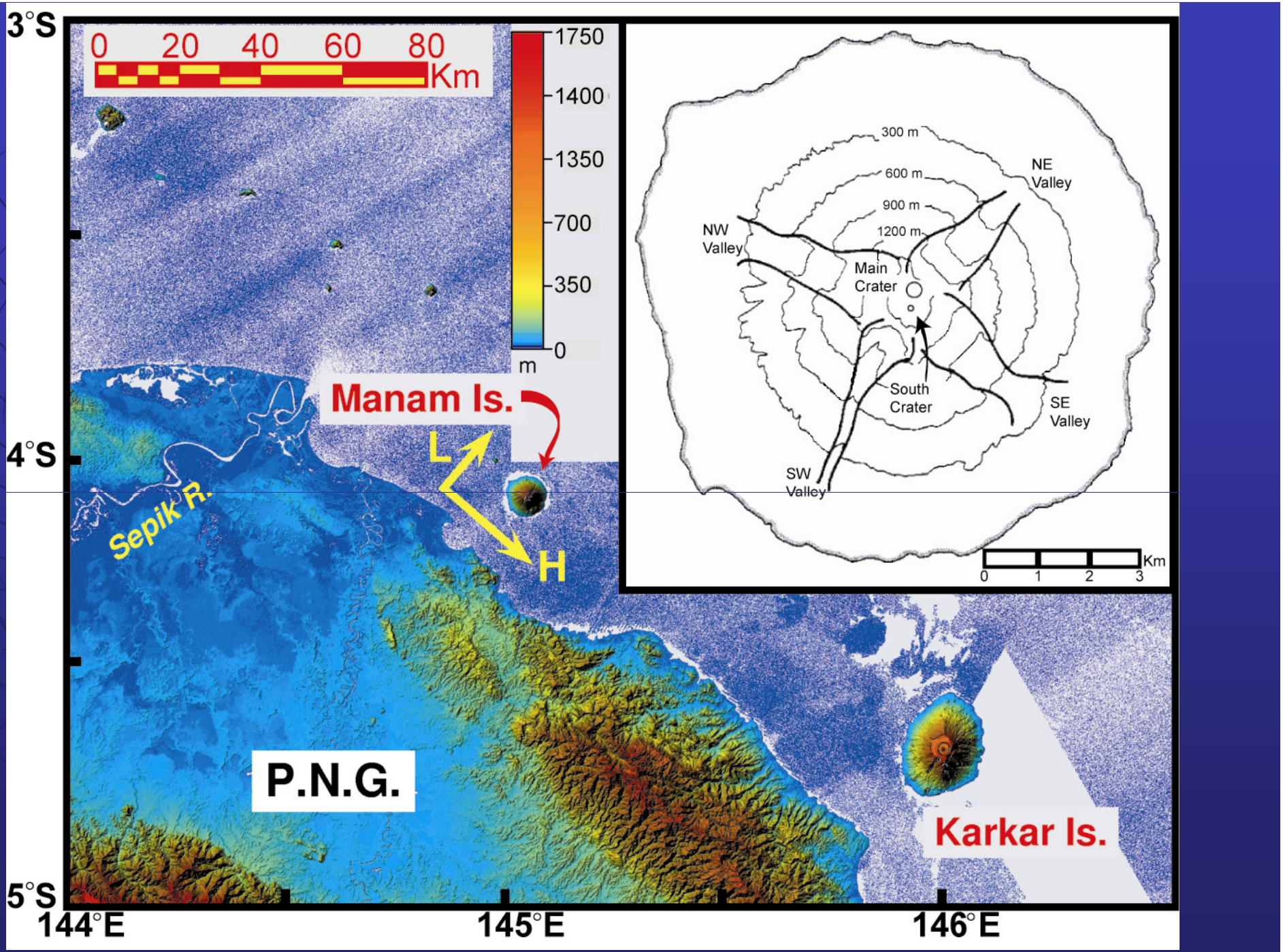
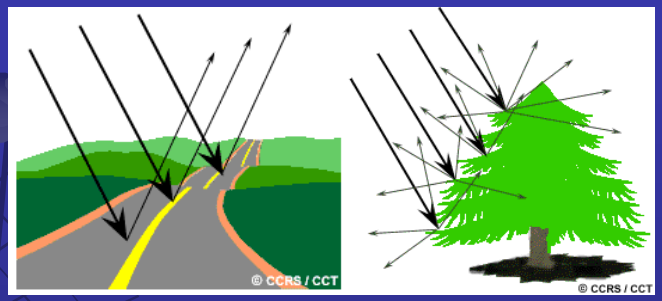


Weissel et al., 2004

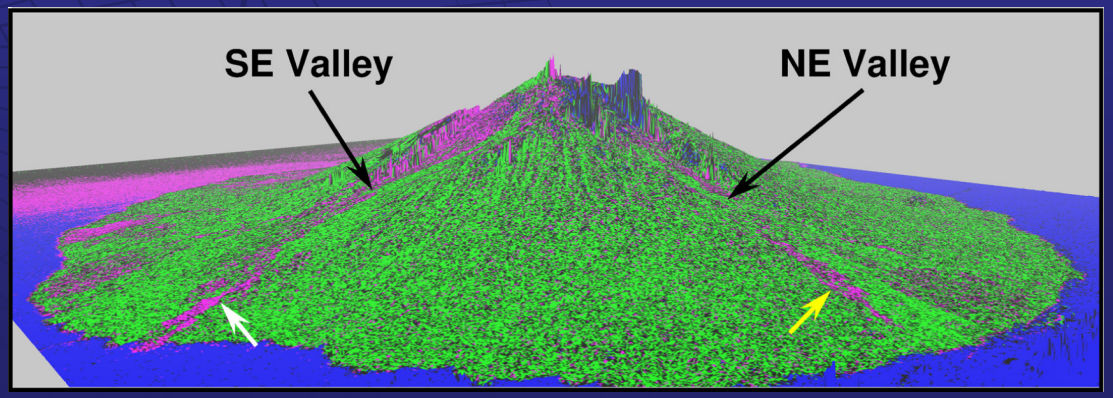
Manam Volcano Lava Identification

Nir Halman (November, 1995)

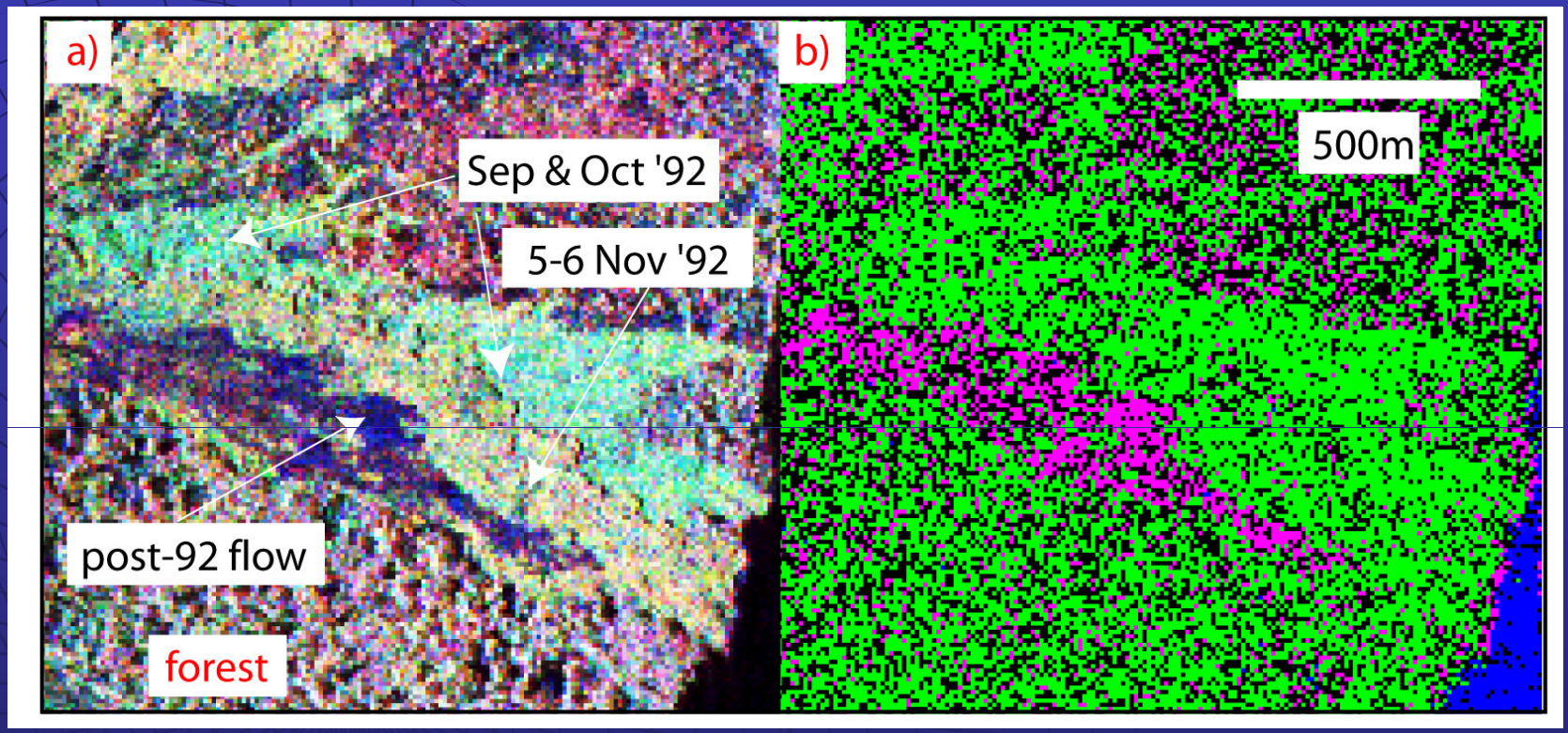


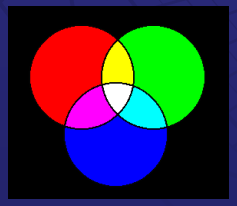
SE Valley Lava flow erupted in 1994

PACRIM 1996



Weissel et al., 2004





resurfacing & revegetation

Weissel et al., 2004

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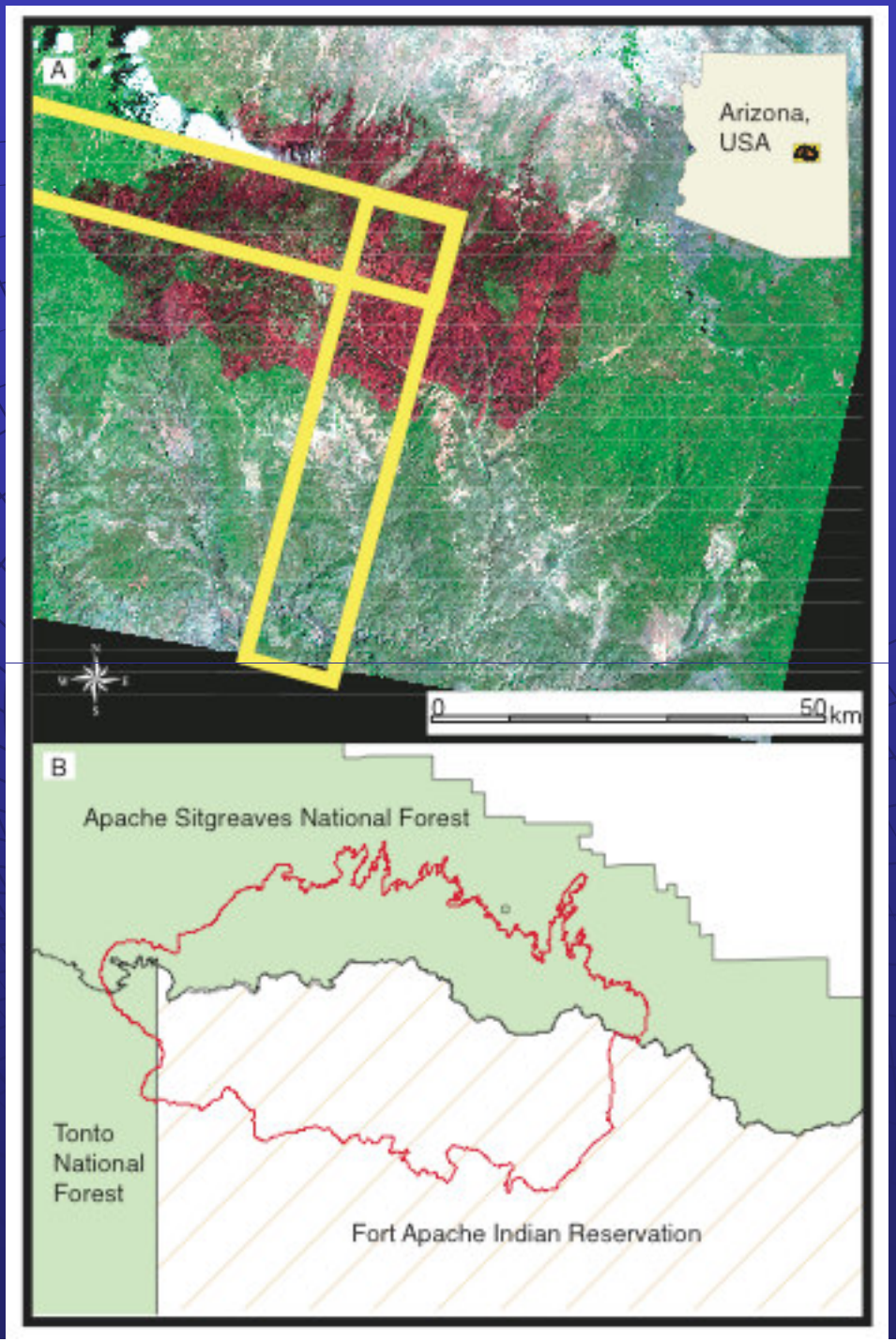
Understand and rehabilitate the altered landscape

- Rodeo-Chediski burn severity
  - Summer of 2002
  - Apache-Sitgreaves Forest, East Central Arizona
  - ~500,000 acres burned

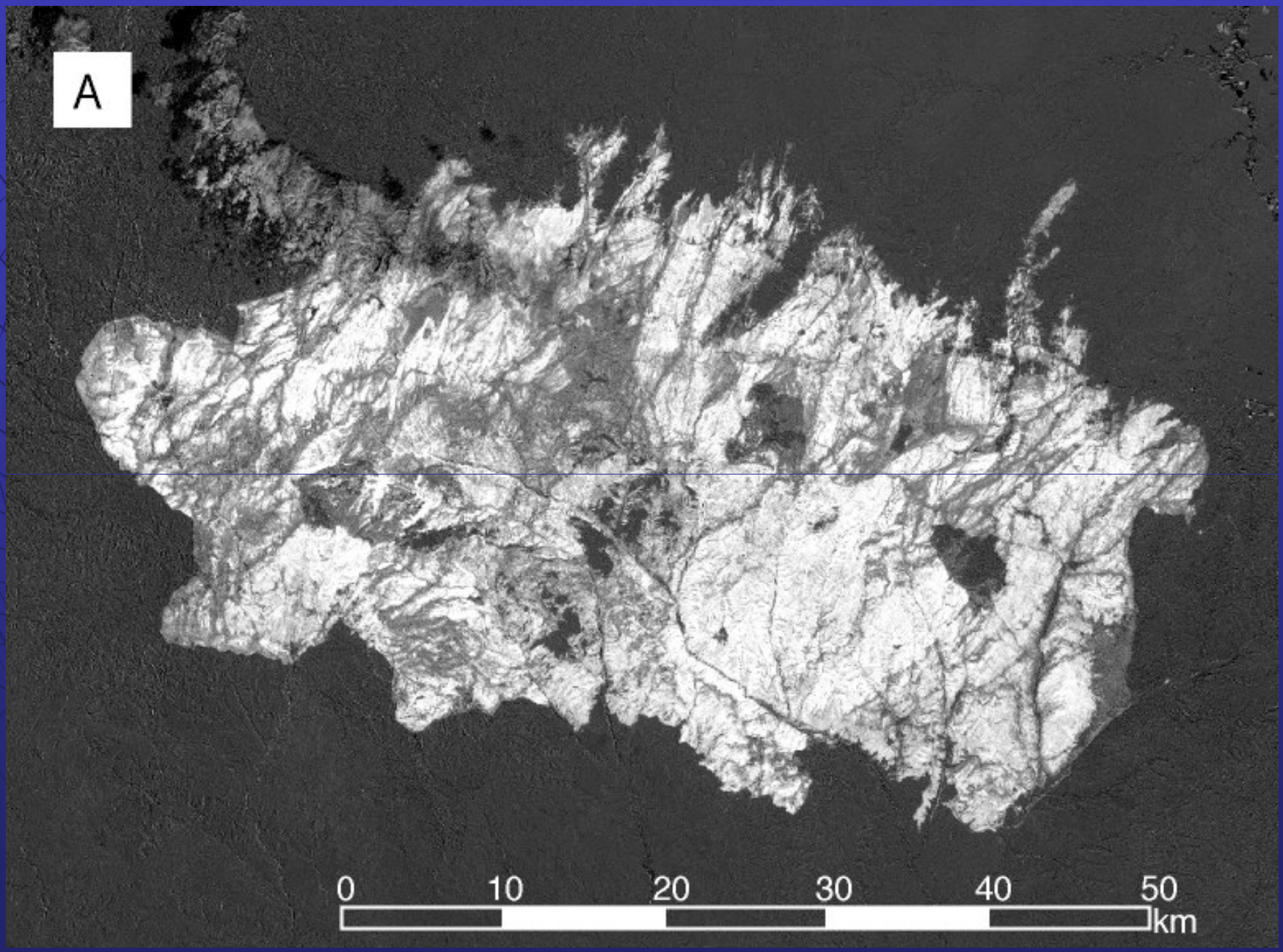
Rodeo-Chediski Photos

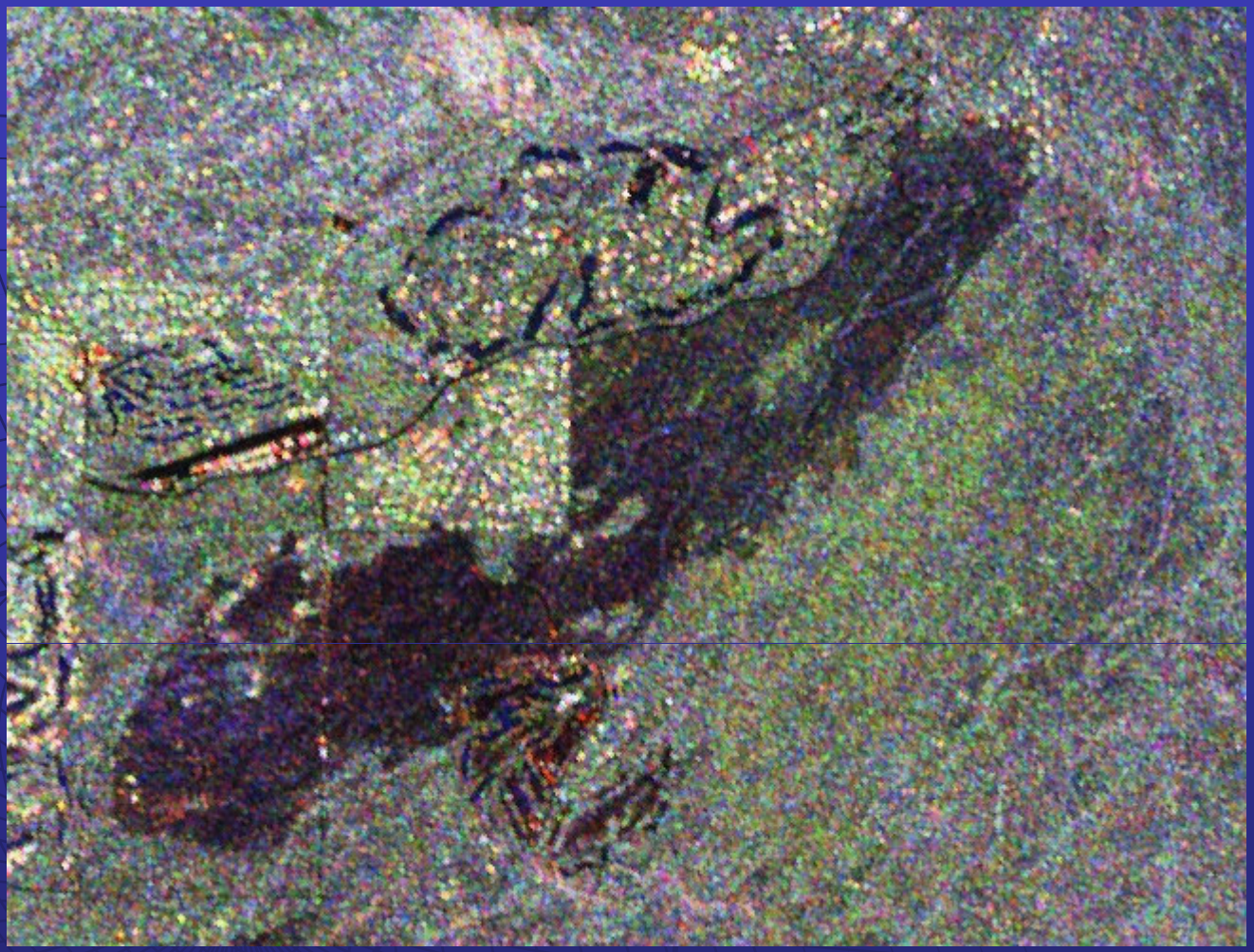
Wilmes et al., 2002



Rodeo-Chediski
Wildfire, Arizona, USA

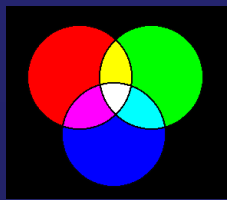
2002


A
0
10
20
30
40
50
km

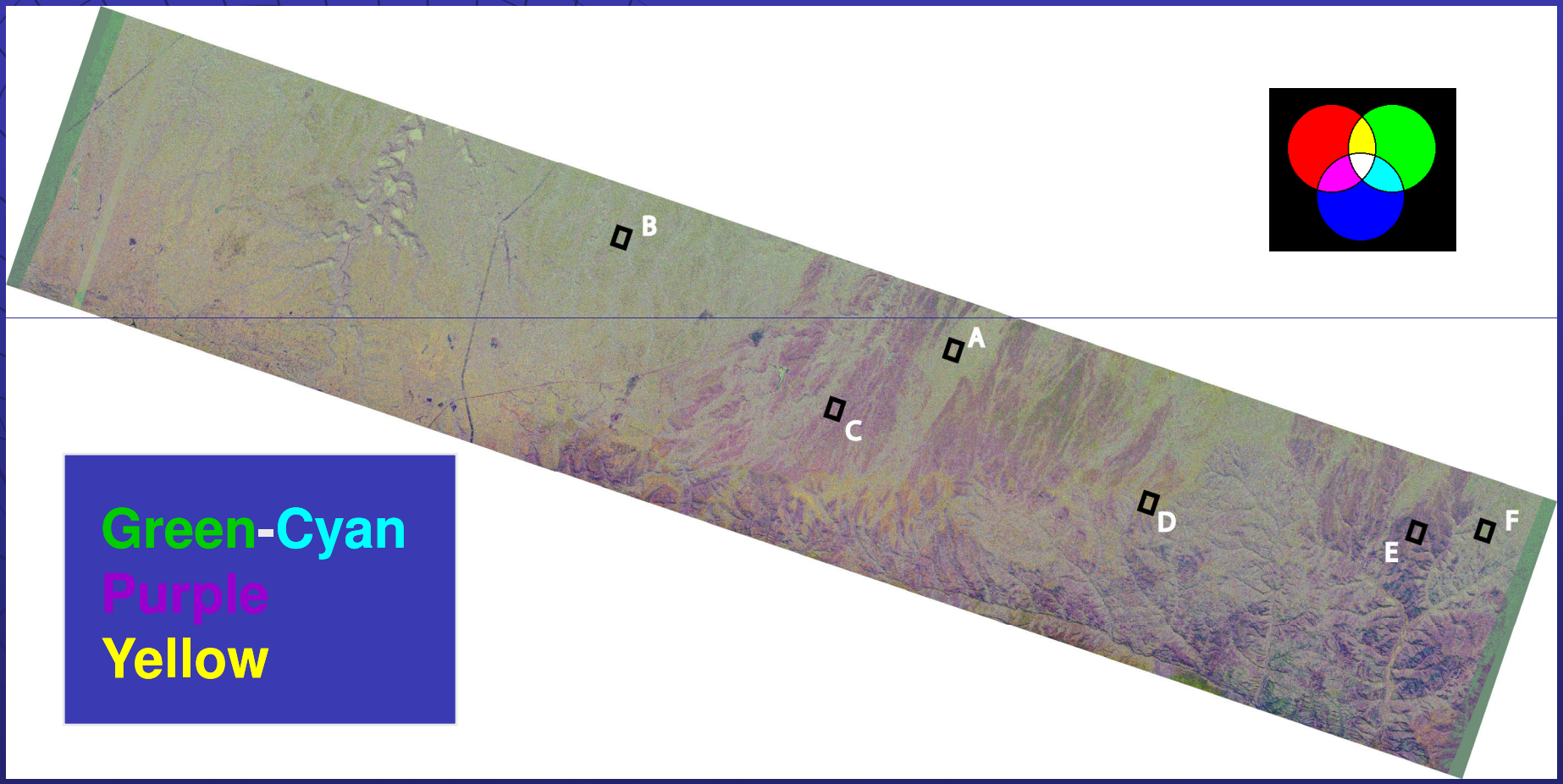


Cave Creek, AZ.
Image Visualization and Infrared Spectroscopy (IVIS) Laboratory,
University of Pittsburgh

http://ivis.eps.pitt.edu/projects/fire-flood/fig2.html

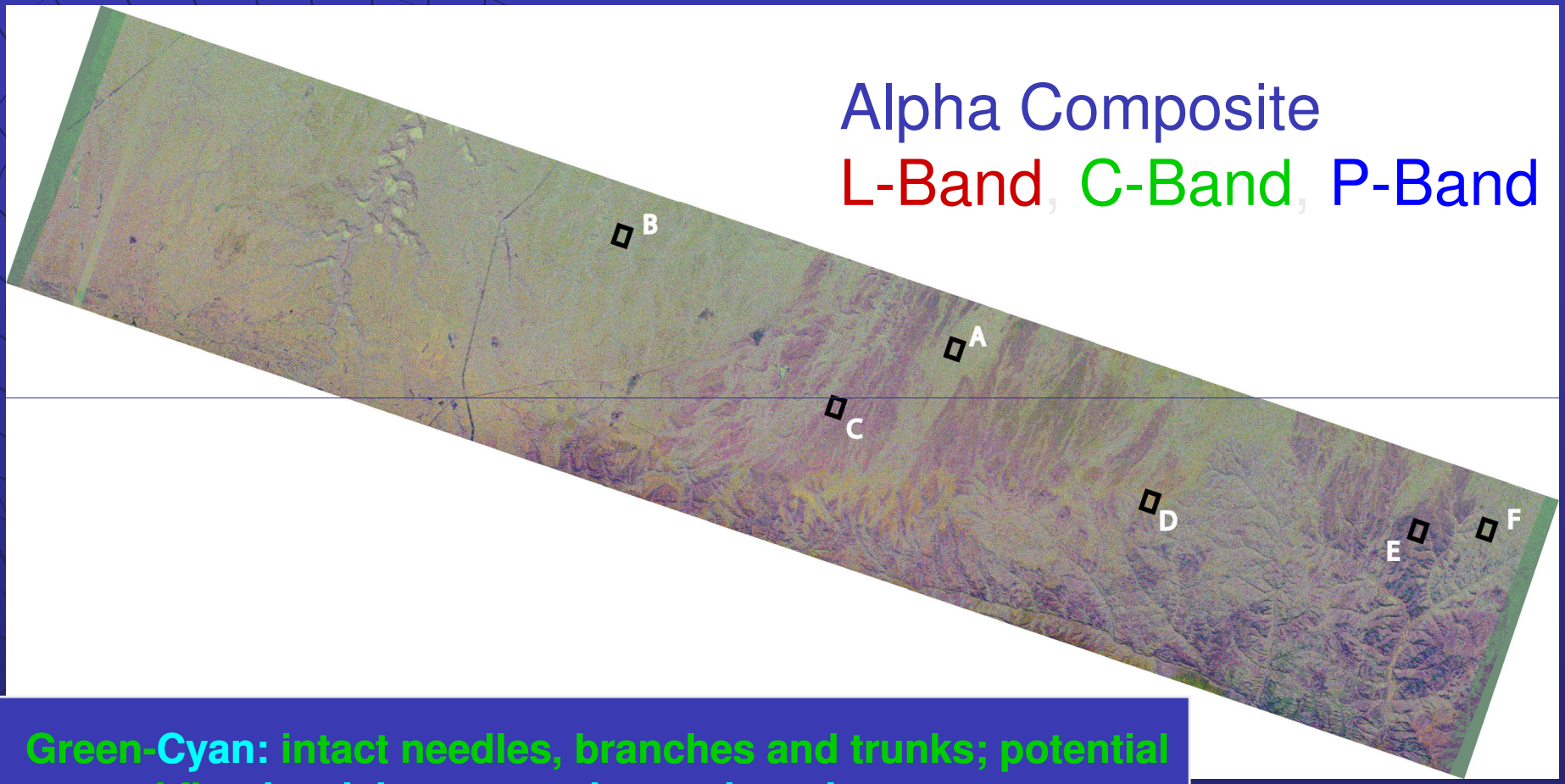


Scattering Mechanism Contribution
Alpha Composite
L-Band, C-Band, P-Band



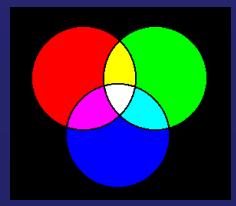
Green-Cyan
Purple
Yellow

SAR-Based Burn Severity



Alpha Composite
L-Band, C-Band, P-Band

Green-Cyan: intact needles, branches and trunks; potential ground fire, low lying vegetation and trunks
Purple: needles absent, trunks and branches present
Yellow: rough surface or low-lying vegetation, no trunks




Future Directions

Airplanes & UAVs

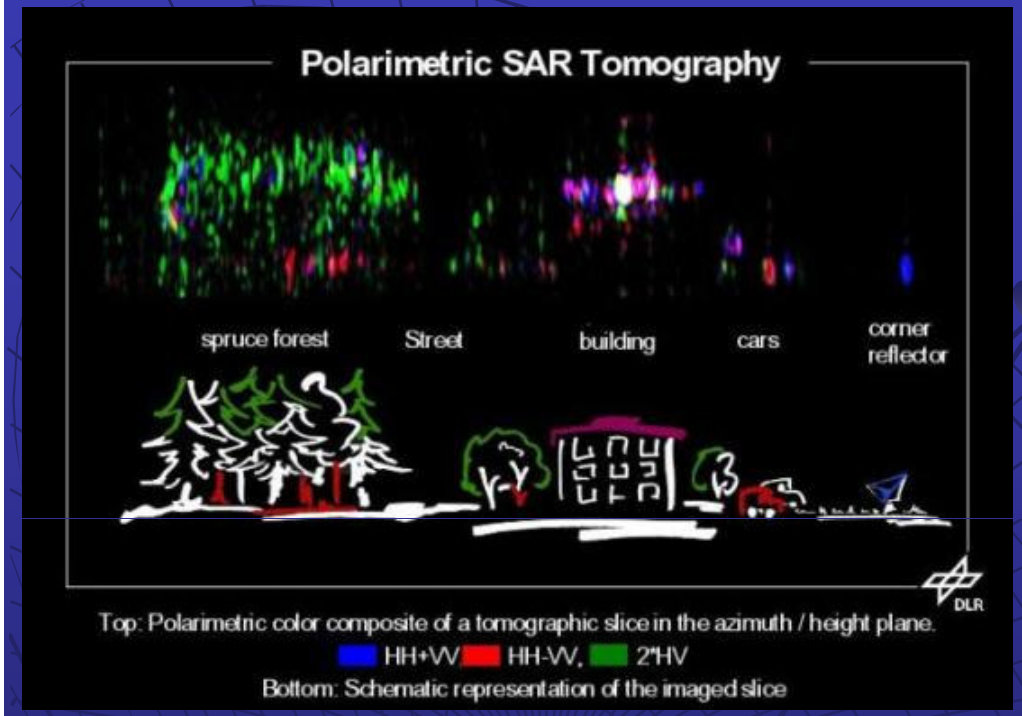
Flexible systems for rapid hazard mapping

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/Gallery/Photo/index.html
NASA Photo: EC04–0047–04 Date: February 24, 2004 Photo By: Jim Ross

NASA's Airborne Science DC–8, displaying new colors in a check flight Feb. 24, 2004, over the Dryden Flight Research Center.

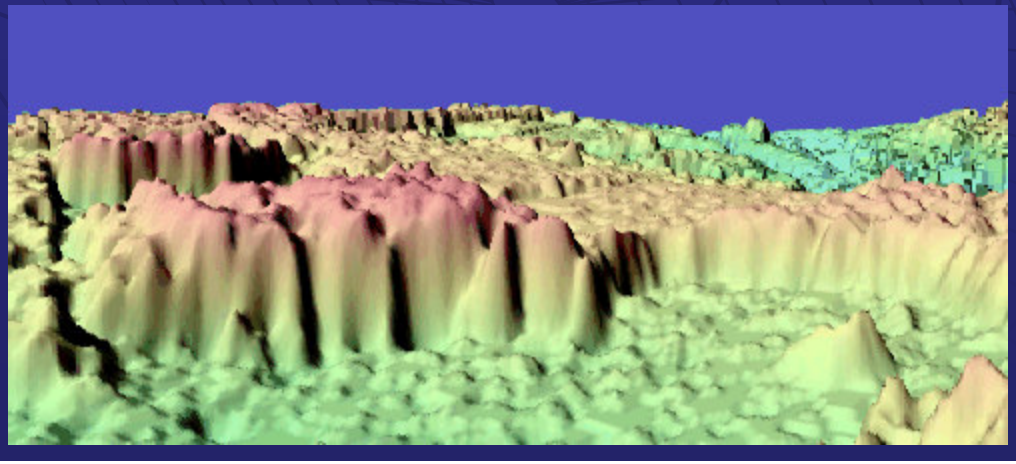
NOAA

What is the 3-D spatial extent of surface cover?



Tomographic slice generated from 13 parallel flight tracks with a mutual distance of 20m.
Sensor: Experimental SAR (E-SAR) in L-band, operated on a Do228 aircraft.

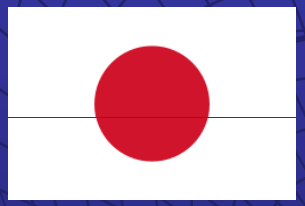
http://www.cv.tu-berlin.de/forschung/sar/tomo.phtml



Animated flight over Thetford forest. Elevation model generated from X-band VV polarised interferometric DEM. Data (C) DLR

Current & Nearly Launched Satellites

Envisat (at right)



ALOS PALSAR

Terra SAR-X

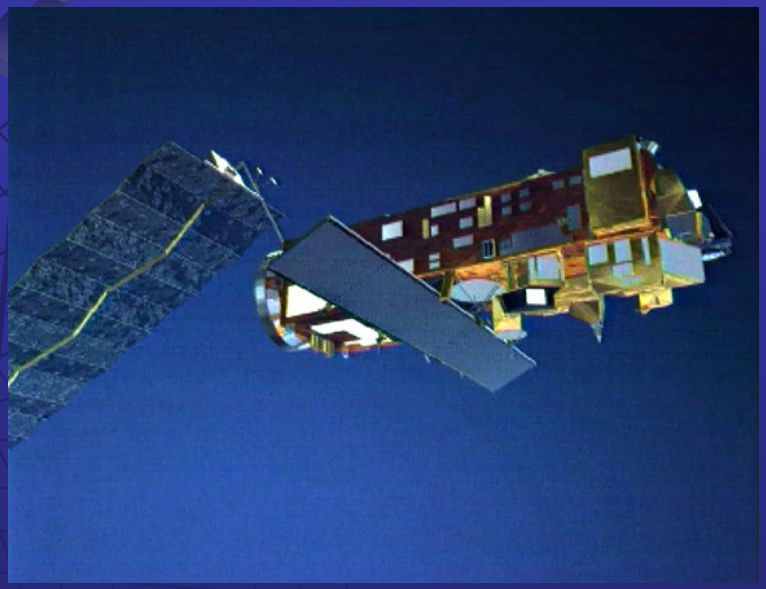
RADARSAT 2

Envisat ASAR: 3/2002

C-Band, Advanced SAR

Alternating Polarization (AP)

Interferometry in a different mode



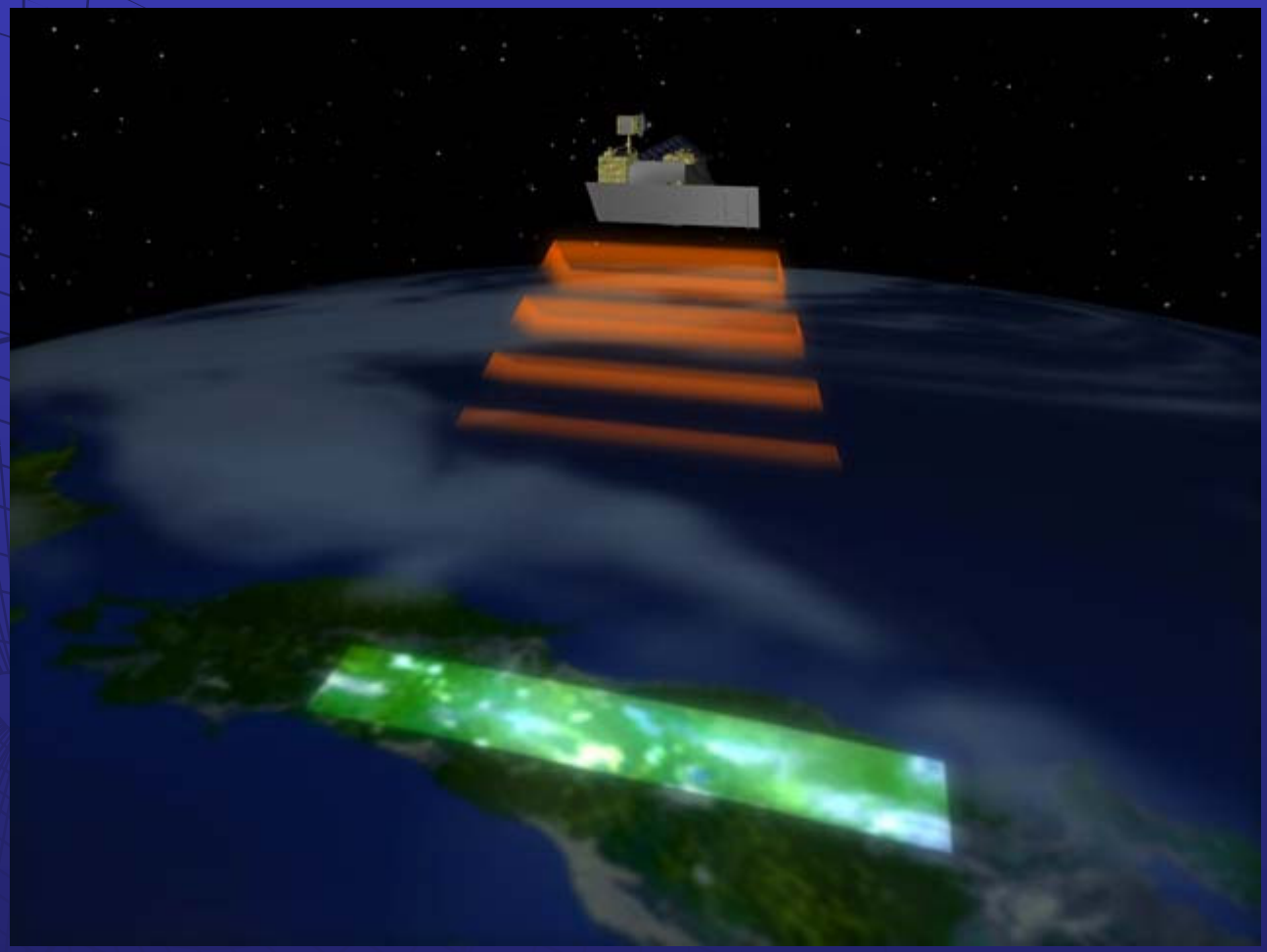
http://envisat.esa.int/instruments/asar/

ALOS-PALSAR: 11/2006

Advanced Land Observing Satellite

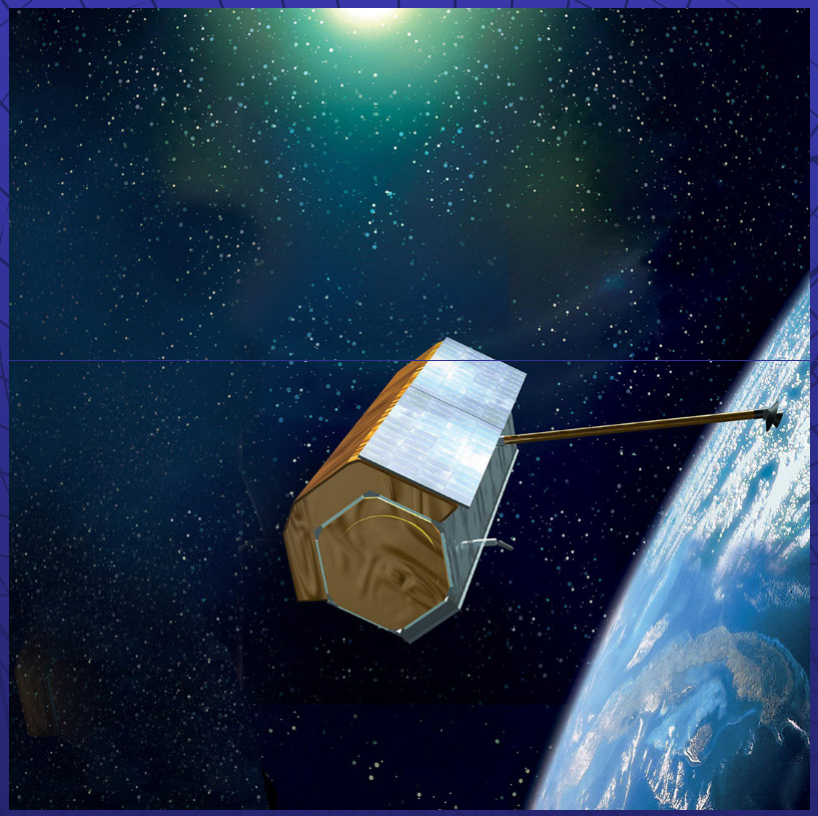
L-Band, full polarimetry

Interferometry



http://earth.esa.int/object/index.cfm?fobjectid=1657

TerraSAR X : 5/2007



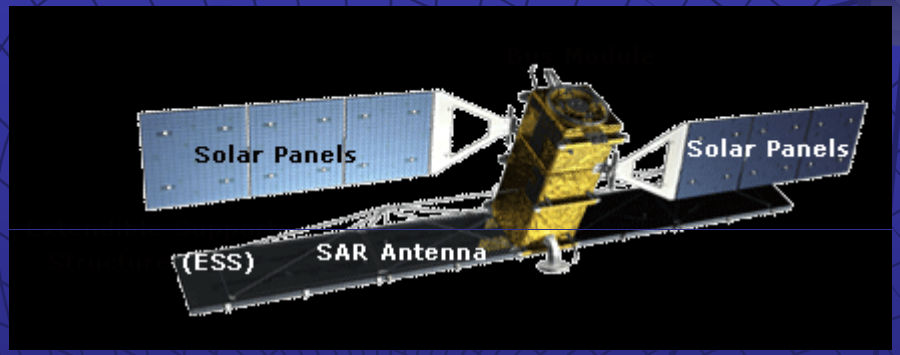
X-Band

Full polarimetry,

Experimental polarimetric interferometry

http://www.terrasar.de/

Radarsat-2: Summer 2007



C-Band, Full polarimetry

Interferometry

http://www.radarsat2.info/

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