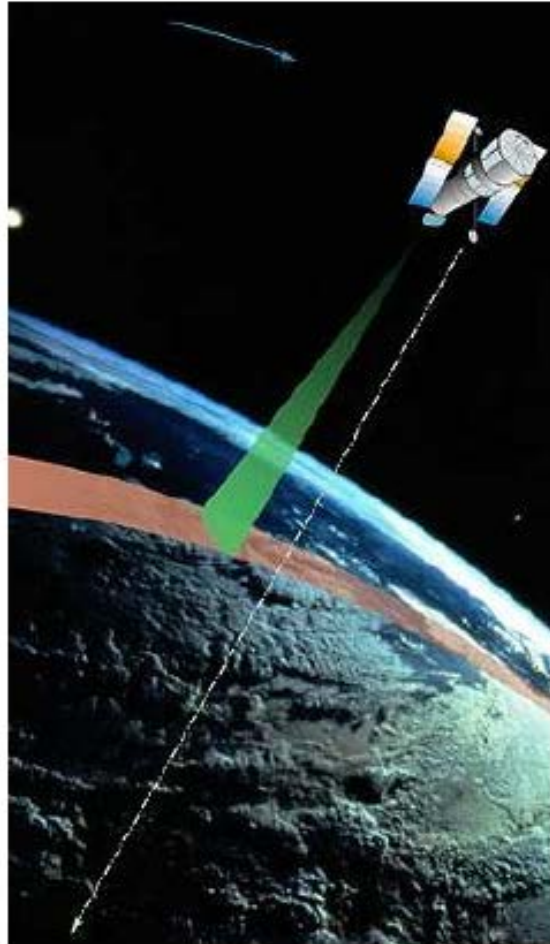


Remote Sensing



- **Remote sensing**: *def.* the acquisition of information about a target without direct physical contact
- Accomplished via
 - acoustic waves
 - gravity measurements,
 - electromagnetic radiation (transmitted through, reflected from, or emitted by a target)
- **Total area encompassed in our vistas is considerably enlarged if we peer downward from a tall building or a mountain top. This increases even more - to hundreds of square miles - as we gaze outwards from an airliner cruising above 30000 feet or from space. This is why remote sensing is most often practiced from platforms such as airplanes and spacecraft with onboard sensors that survey and analyze these features over extended areas from above, unencumbered by the immediate proximity of the neighborhood.**

Alternative Perspectives...

The art of dividing up the world into little multi-coloured squares and then playing computer games with them to release unbelievable potential that's always just out of reach.

- Jon Huntington, Geoscience, Australia

Remote Sensing is the most expensive way to make a picture.

- Andrew Bashfield, Intergraph Corporation

Staying as far away from the problem as possible.

- G. Archer, World Bank

Seeing what can't be seen, then convincing someone that you're right.

- David Pairman, Landcare Research, New Zealand

Legitimised voyeurism.

- John Creasey, Australian Geological Survey Organisation

Being as far away from your object of study as possible and getting the computer to handle the numbers.

- Clare Power, National Remote Sensing Centre, England

Astronomy in the wrong direction.

- Tom Alföldi, Canada Centre for Remote Sensing

...Are these fair? (you decide at the end of the term)

Advantages of Remote Sensing (for land evaluation)

- May be the **only way of obtaining data** (planetary)
- It is the only practical way to **obtain data from relatively inaccessible regions**, e.g. Antarctica, Amazonia.
- Relatively **cheap** and **rapid** method of acquiring **up-to-date** information over a large geographical area.
- At small scales, **regional phenomena** which are invisible from the ground are clearly visible (ex. faults and other geological structures, the forest instead of the trees)
- Cheap and rapid method of constructing **base maps** in the absence of detailed land surveys.
- **Easy to manipulate** with the computer, and **combine** with other geographic coverages in the GIS.

Disadvantages of Remote Sensing (for land evaluation)

- Images are ***not direct samples*** of the phenomenon, so ***must be calibrated*** against reality. This calibration is never exact.
- They must be ***corrected geometrically*** and ***georeferenced*** in order to be useful as maps, not only as pictures. This can be easy or complicated.
- Distinct phenomena ***can be confused*** if they look the same to the sensor, leading to classification error. Example: clouds and white sand in visible (but infrared light can distinguish them).
- Phenomena which were not meant to be measured (for the application at hand) can ***interfere*** with the image. Examples for land cover classification: clouds, variable lighting (sun & shadow)
- ***Resolution*** of satellite imagery is ***too coarse for detailed mapping*** and for distinguishing small contrasting areas.
 - Rule of thumb: a land use must occupy at least 16 pixels (picture elements, cells) to be reliably identified by automatic methods.

However, new satellites are being proposed with 1m resolution, these will have high data volume but will be suitable for land cover mapping at a detailed scale.

Mapping acid hydrothermal alteration zones

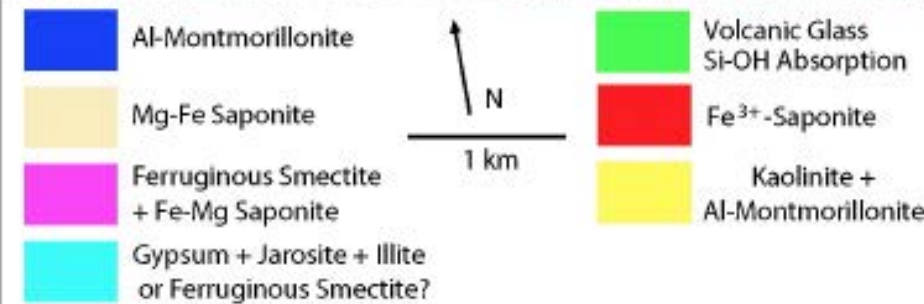
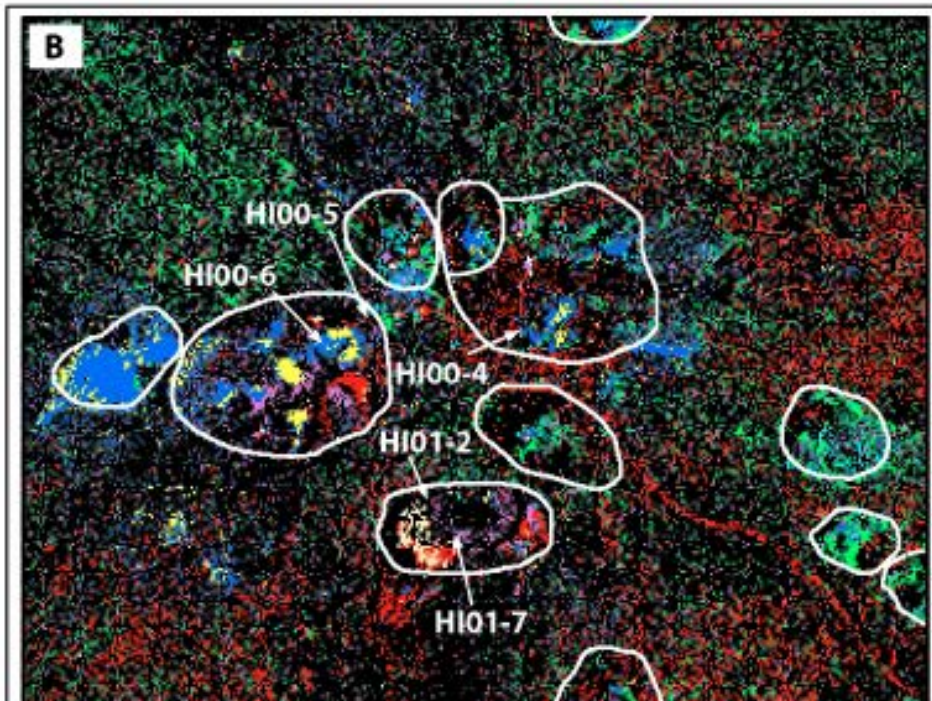
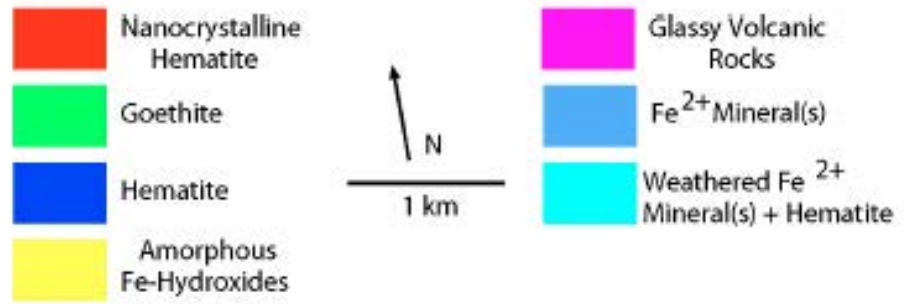
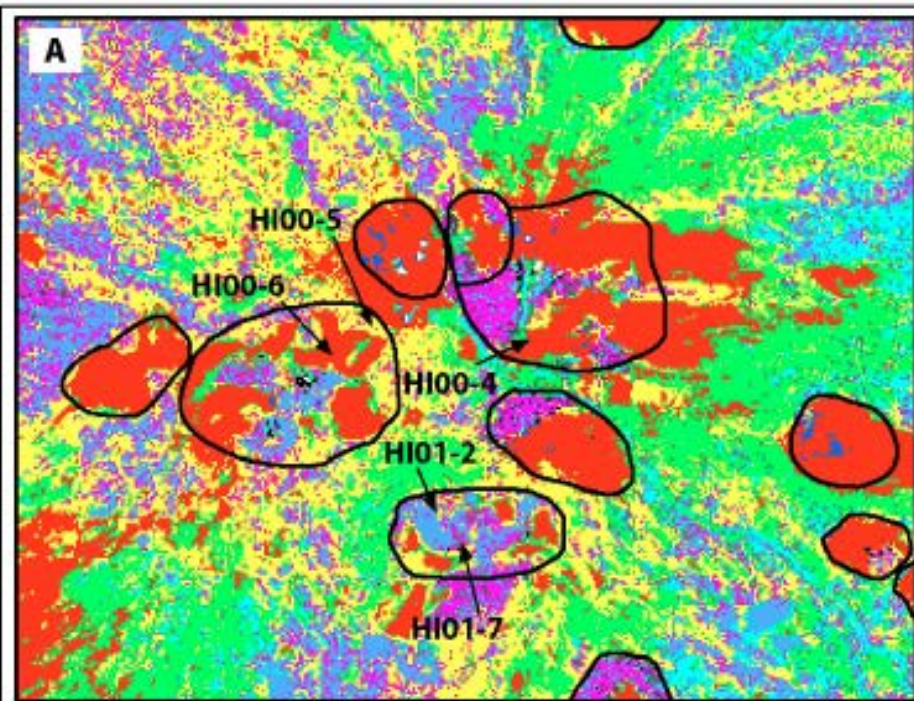
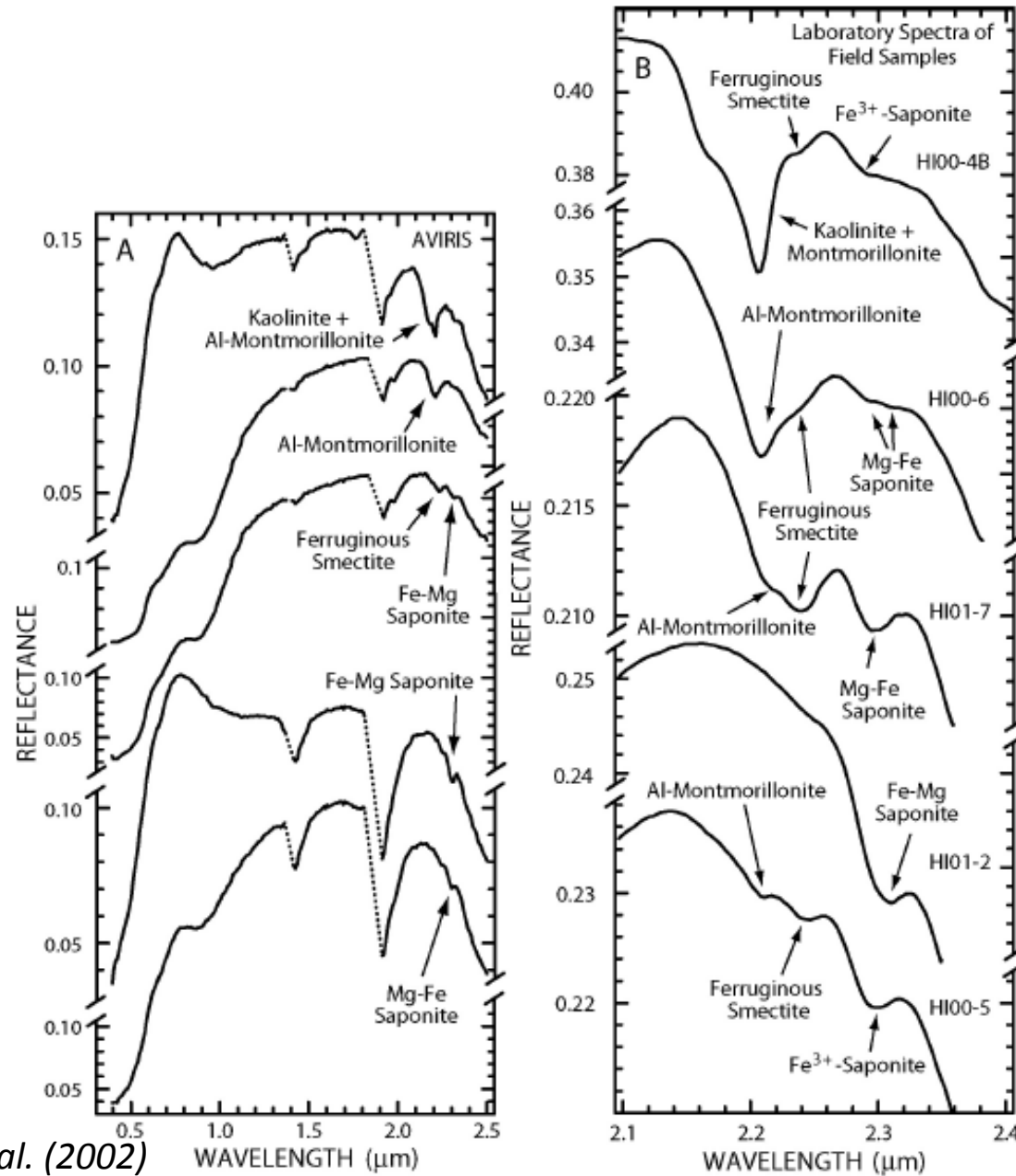


Figure 5. A) Electronic region (0.4 - 1.35 μm) minerals on the summit of Mauna Kea. Cinder cones are outlined in black. Arrows show collection locations of samples. B) Vibrational region (1.35 - 2.5 μm) minerals on the summit of Mauna Kea. Cinder cones are outlined in white.

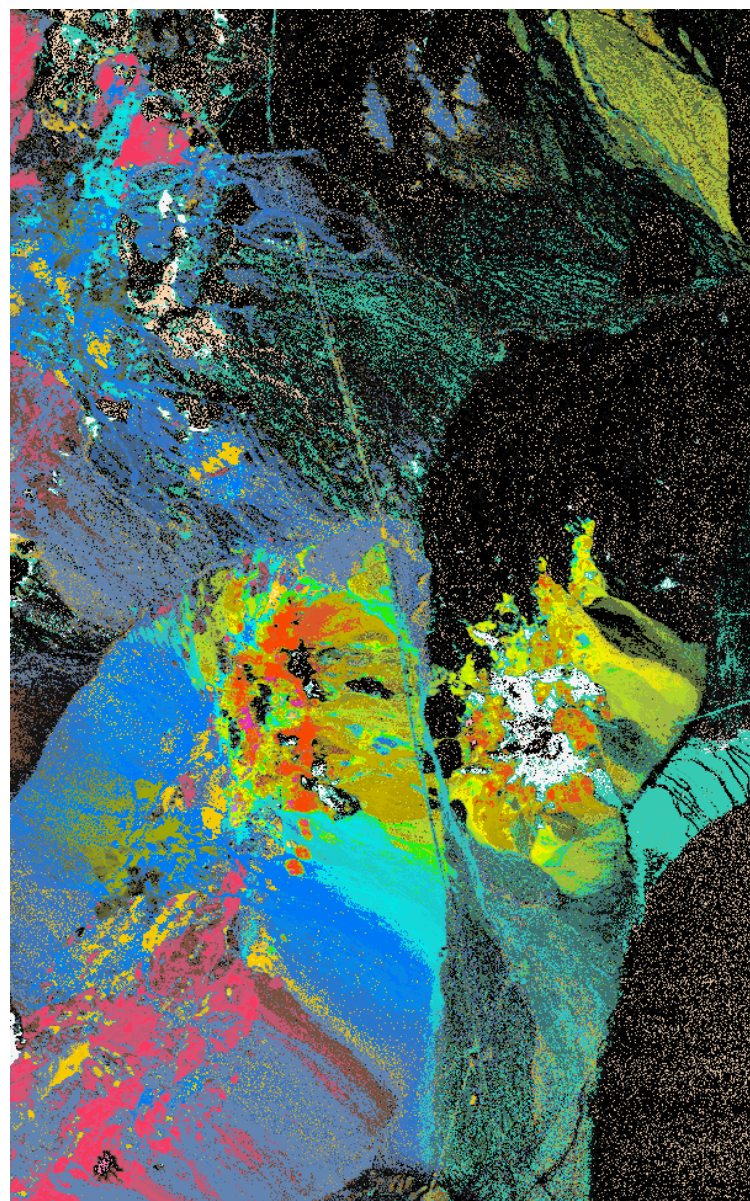
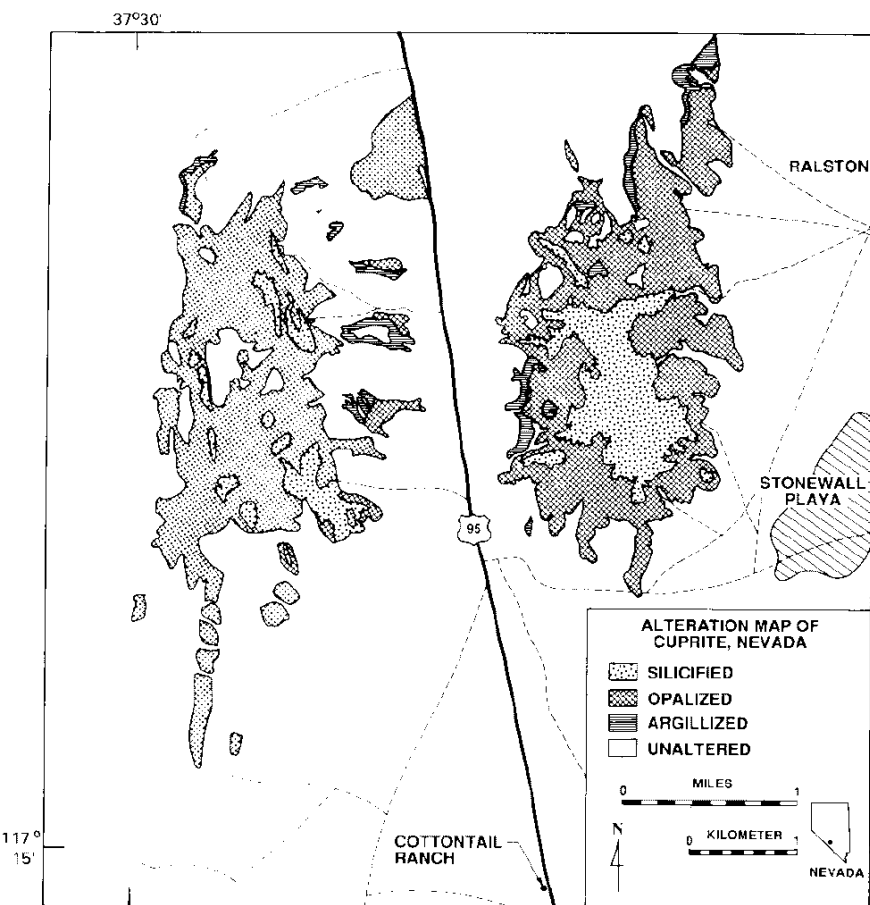
Mapping acid hydrothermal alteration zones

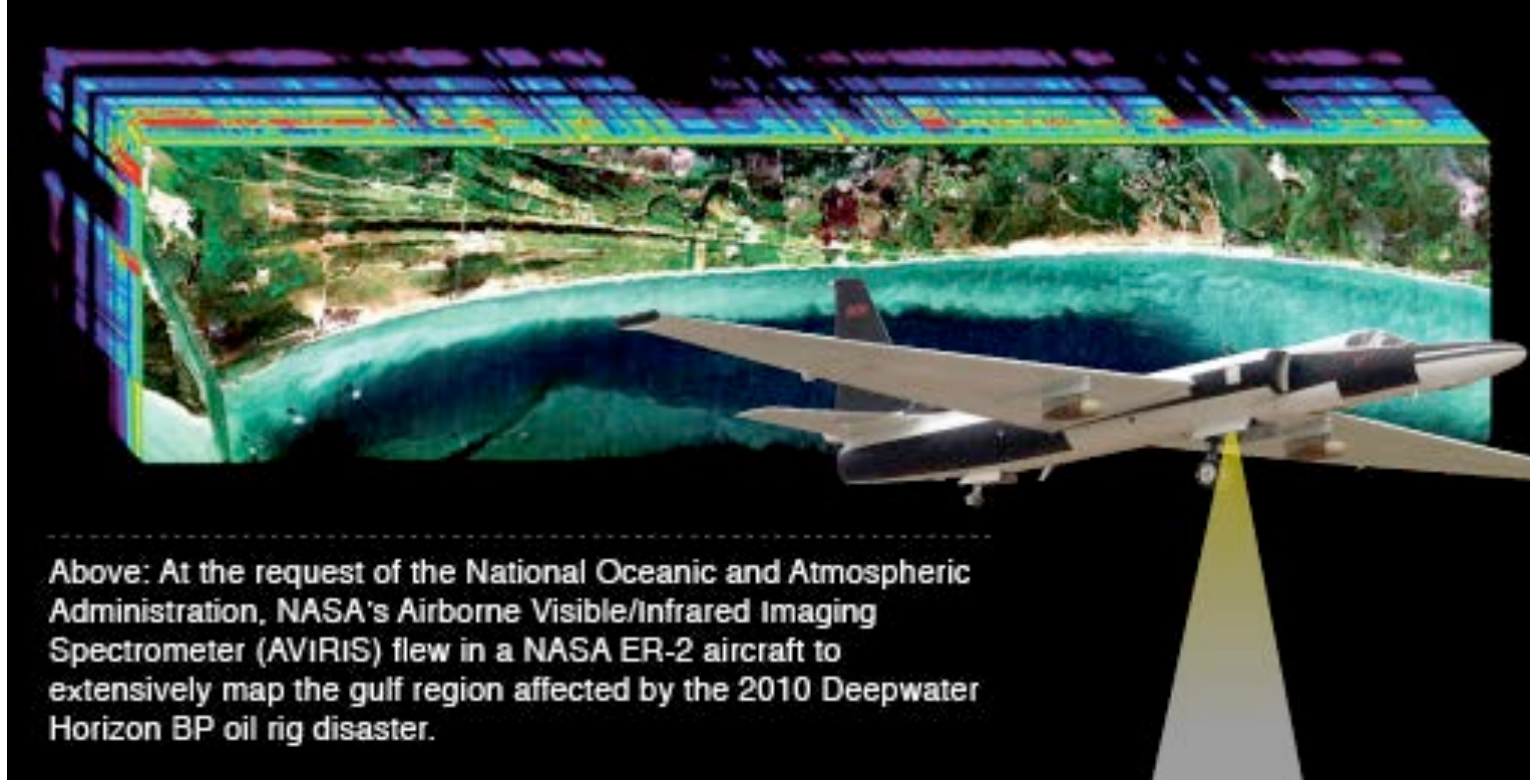


Resource exploration in Cuprite mining district

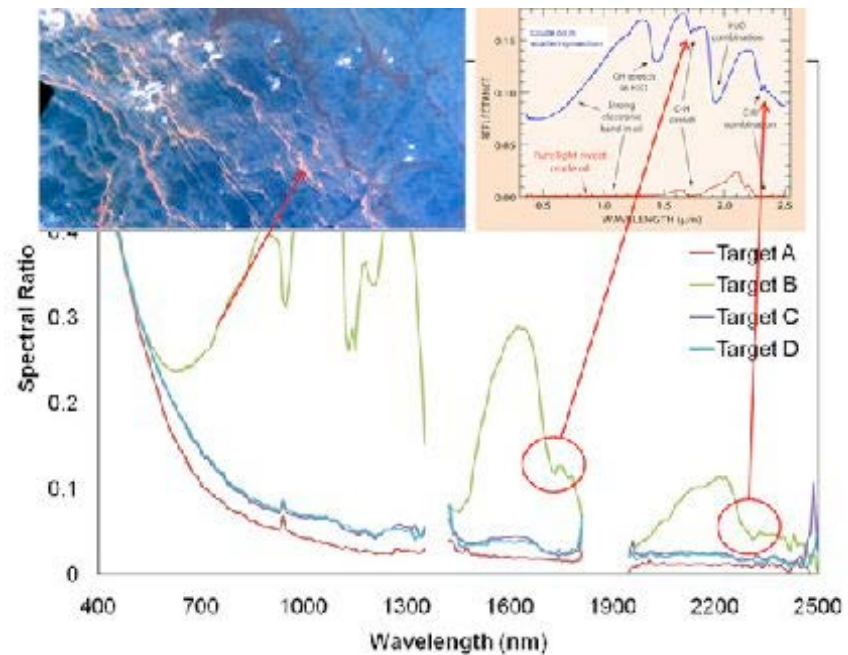
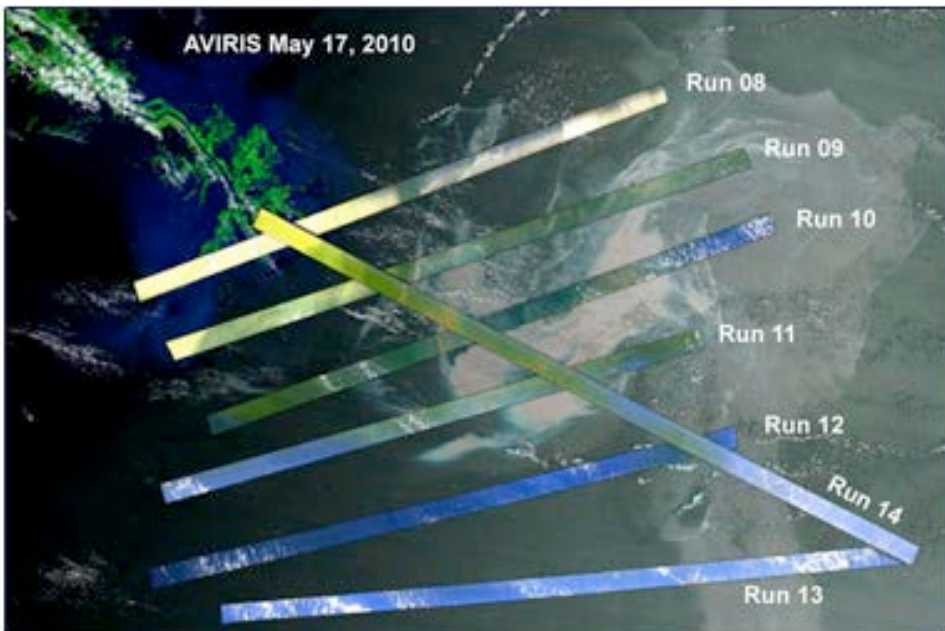
AVIRIS mineral map

Map produced by field work

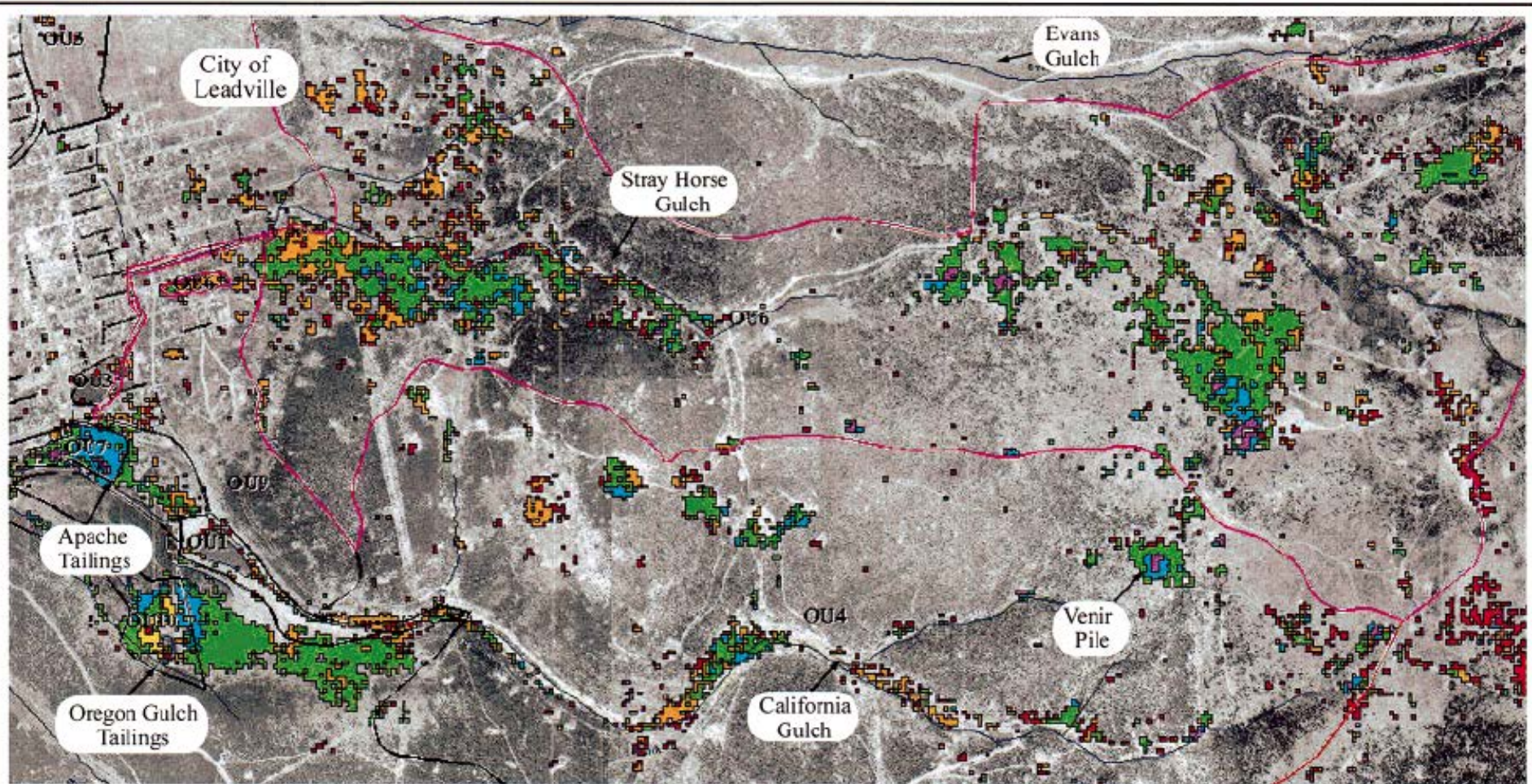




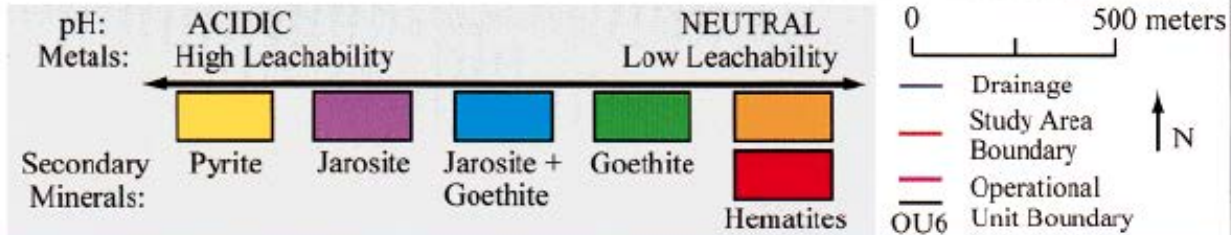
Above: At the request of the National Oceanic and Atmospheric Administration, NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) flew in a NASA ER-2 aircraft to extensively map the gulf region affected by the 2010 Deepwater Horizon BP oil rig disaster.



Localizing Acidic Mine Waste



AVIRIS Mineral Map
California Gulch Superfund Site
Leadville, Colorado
U.S. Geological Survey



Vegetation Maps: Bridger-Teton National Forest

Pre Fire: 2007 Forest Vegetation



Post Fire: 2009 Forest Vegetation



- Legend**
- Fire Perimeters
 - Urban/Developed
 - Water
 - Snow/Ice
 - Barren/Rock
 - Sparse Vegetation
 - Alpine Vegetation
 - Tall Forbland
 - Riparian Herbland
 - Agriculture
 - Grassland/Forbland
 - Low/Alkali Sagebrush
 - Sagebrush/Bitterbrush Mix
 - Mountain Big Sagebrush
 - Spiked Big Sagebrush
 - Mountain Mahogany
 - Mountain Shrubland
 - Silver Sagebrush/Shrubby Cinquef
 - Willow
 - Cottonwood
 - Aspen
 - Aspen/Conifer Mix
 - Rocky Mountain Juniper
 - Lumber Pine
 - Douglas Fir Mix
 - Lodgepole Pine Mix
 - Spruce/Subalpine Fir Mix
 - White Bark Pine
 - White Bark Pine Mix



0 0.5 1 2 Miles

Case Study 1: Uses of Remote Sensing *Disaster Relief following the 2004 Indian Ocean tsunami*



Question:

You are chairperson of the Indonesian Red Cross/Red Crescent Society. Three days after the disastrous tsunami, IKONOS announces that it will make satellite images of the area available for free to facilitate relief operations (visible wavelengths, meter-scale resolution). Describe how you will employ these images in organizing and implementing your efforts. What may be some disadvantages of using satellite data?

Northern Aceh Province,
Sumatra -- BEFORE



BEFORE: This detailed view of the northern tip of the island was taken on Jan. 10, 2003.

Northern Aceh Province,
Sumatra -- AFTER



taken of the same area on Dec. 29, 2004, shows the extreme destruction caused by the earthquake and tsunami. On Thursday, Indonesian officials issued a new death toll of nearly 80,000 for that country alone.

Banda Aceh, Sumatra -- BEFORE



BEFORE: This detailed view of northern Banda Aceh was taken on Jan. 10, 2003.

Banda Aceh, Sumatra -- AFTER



AFTER. News services on Thursday reported that pilots in Sumatra had discovered about 28,000 more dead in Banda Aceh while dropping food to remote villages still unreachable by rescue workers.

Potential Uses of IKNOS Data for Relief

- Determining **status of roads** for supply trucks, safe passages in waterways
- **Mapping of damage severity** to target aid (e.g. tent shelters) to most needed areas
- Assessing damage to agricultural lands and making **predictions** for the quantity and duration of food aid
- Determining the **disease potential** (e.g. from standing water)
- Using as **base map** to plot and keep track of relief center locations, hospitals, command centers
- Longer Term: **Assessing recovery** 1 month, 6 months, 1 year after the disaster

Potential Drawbacks to Using IKONOS

- **Equipment available?** -requires computers/software to access and high quality printers to distribute to relief workers
- **Too large scale**, doesn't depict human element
- **Training?** Are relief workers equipped in techniques for interpreting remotely sensed images?
- **Accurate interpretation/prediction is time consuming** Is it better to spend efforts on direct ground muscle power?



Hurricane Sandy, October 2012

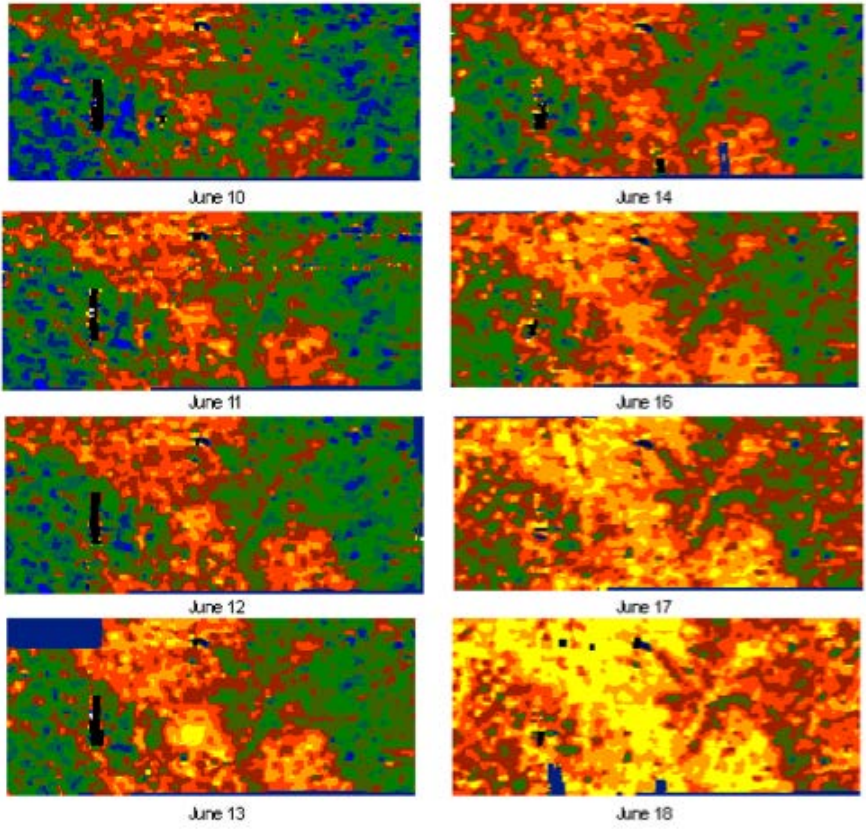
- 233 casualties
- ~\$70 billion damage



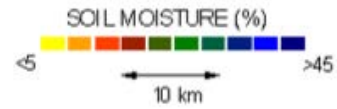
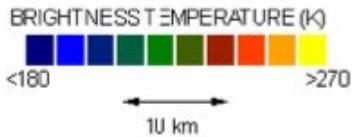
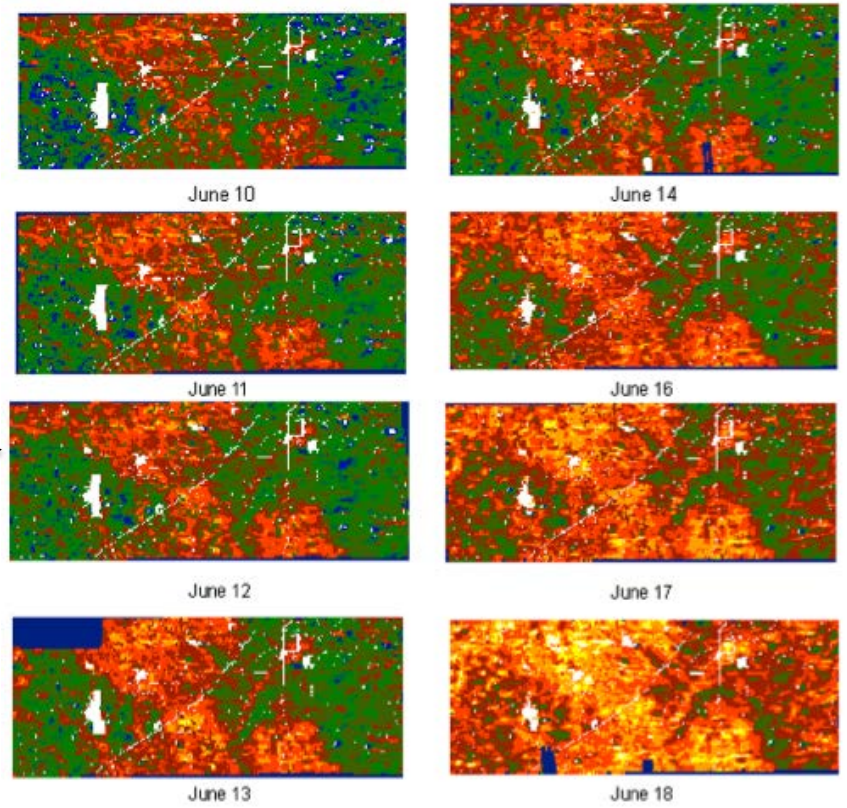
A swan swims near the flooded home of the Maziekien family on November 21, 2012 in Mantoloking, New Jersey. Mantoloking was one of the hardest hit areas by Superstorm Sandy. Picture: Mario Tama/Getty Images/AFP.

Soil moisture from microwave/radar radiometry

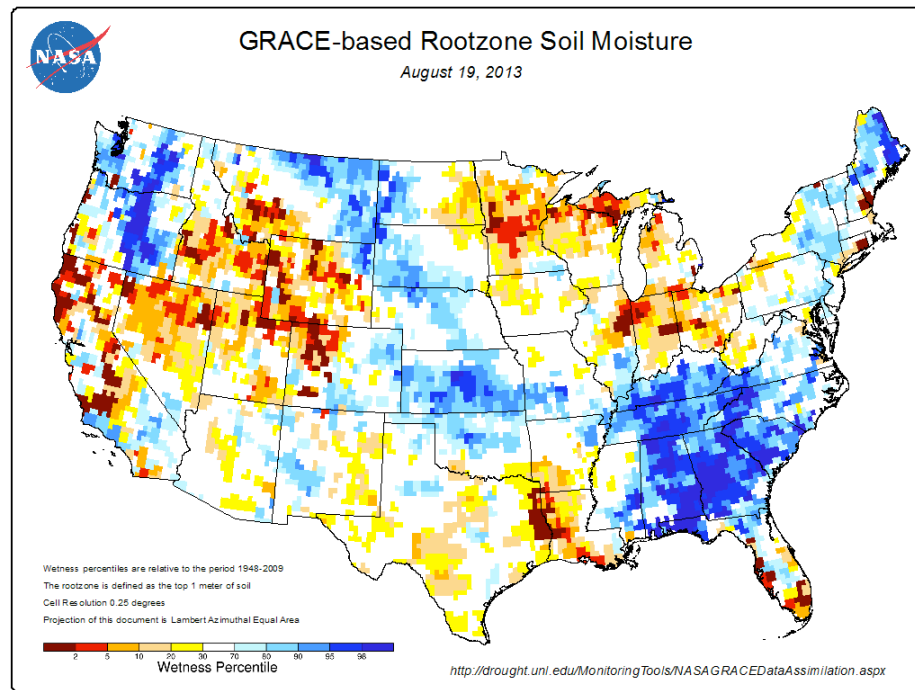
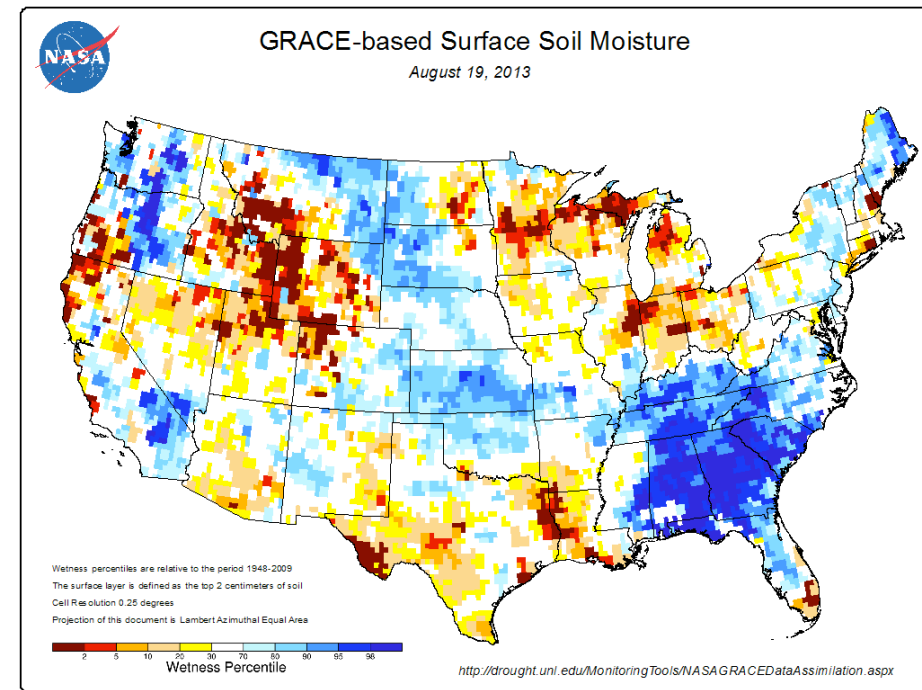
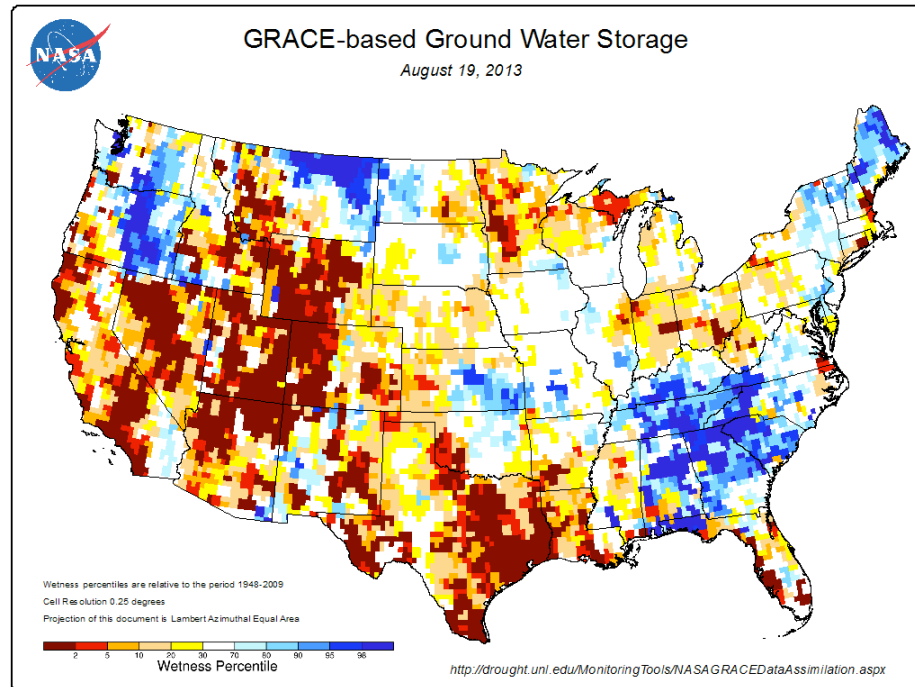
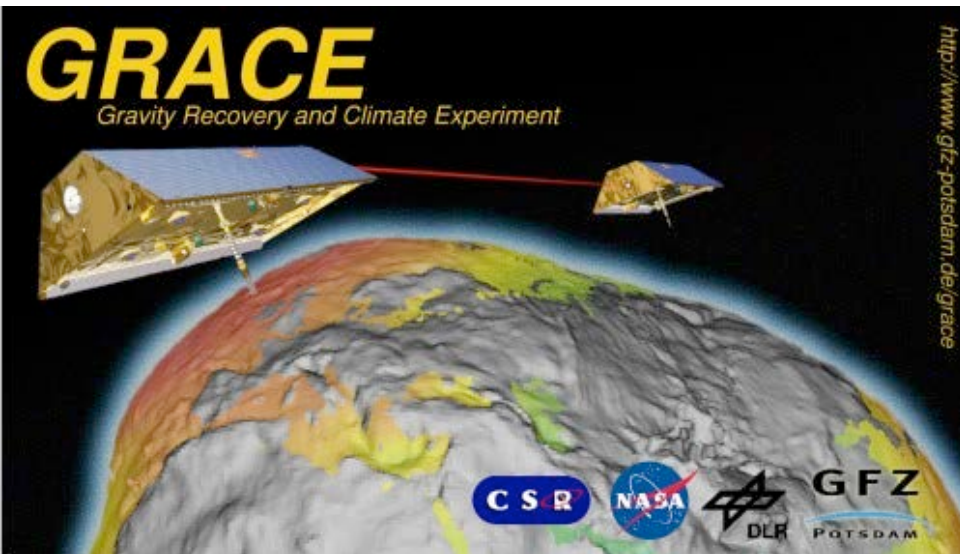
USDA ESTAR microwave radiometer data
June 1994



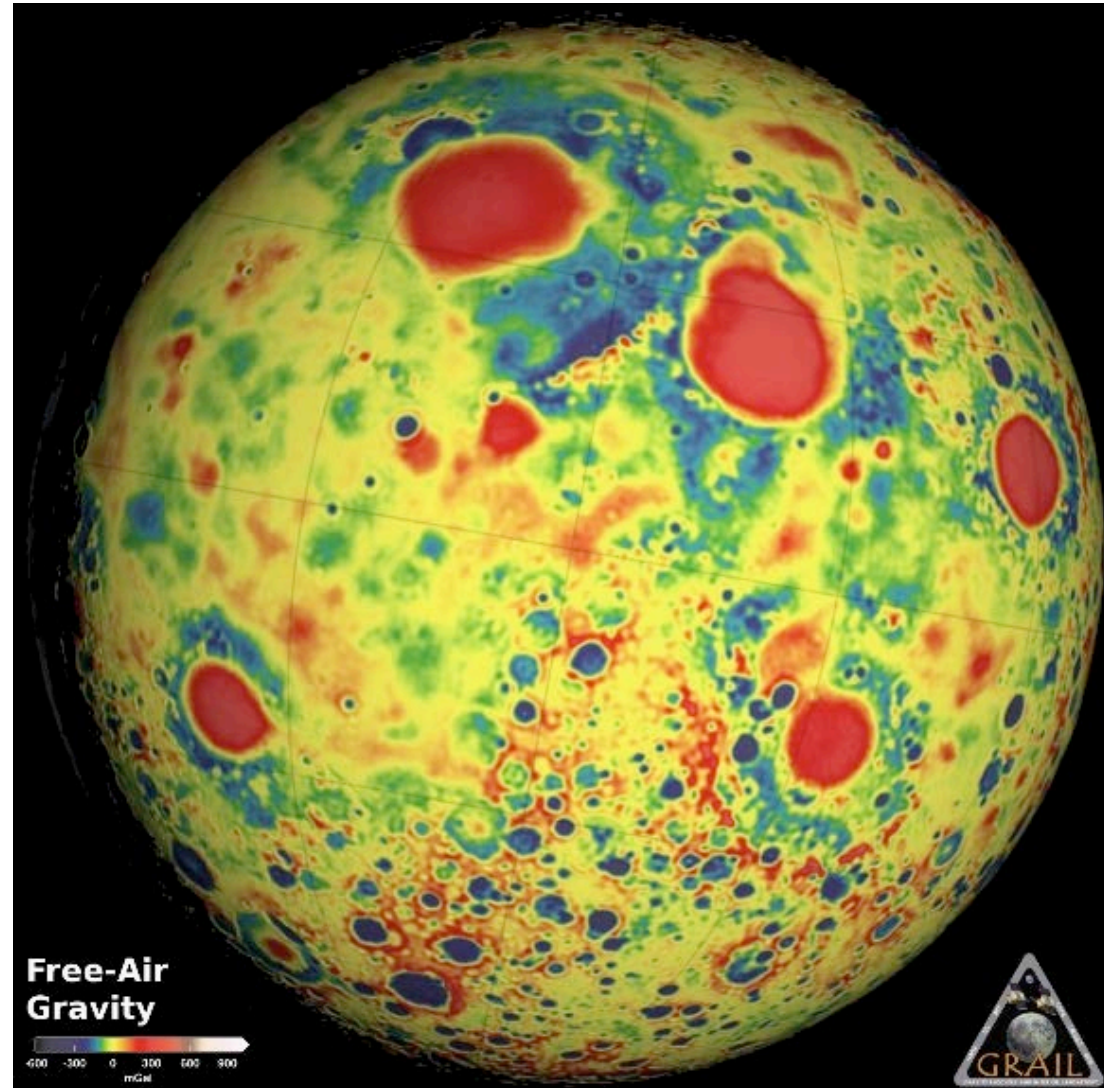
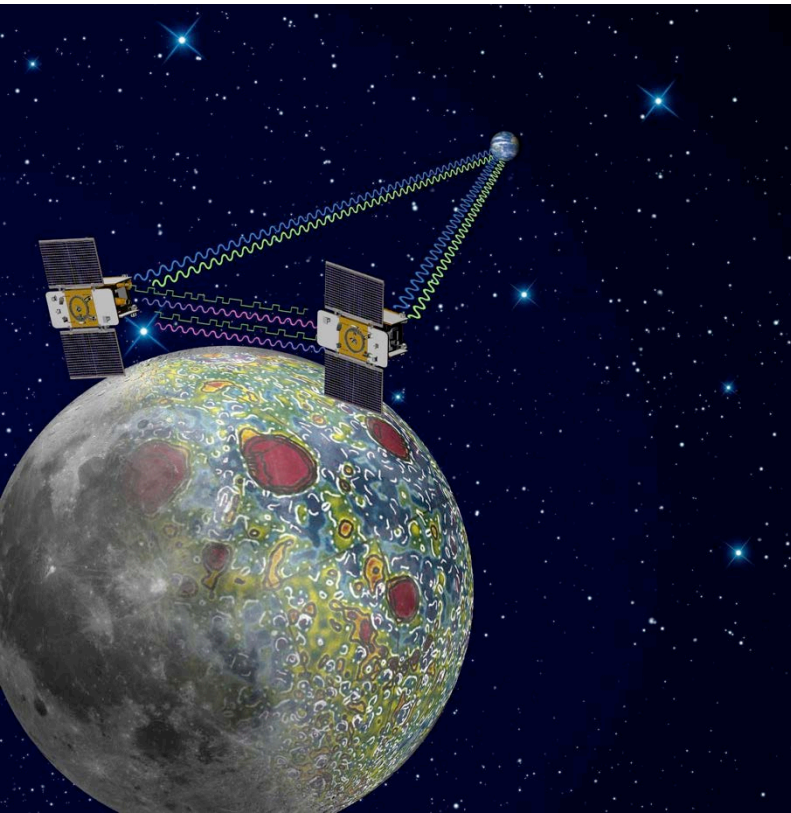
After modeling effects of vegetation,
topography, surface roughness



Moisture from Gravity



GRAIL: GRACE for the Moon

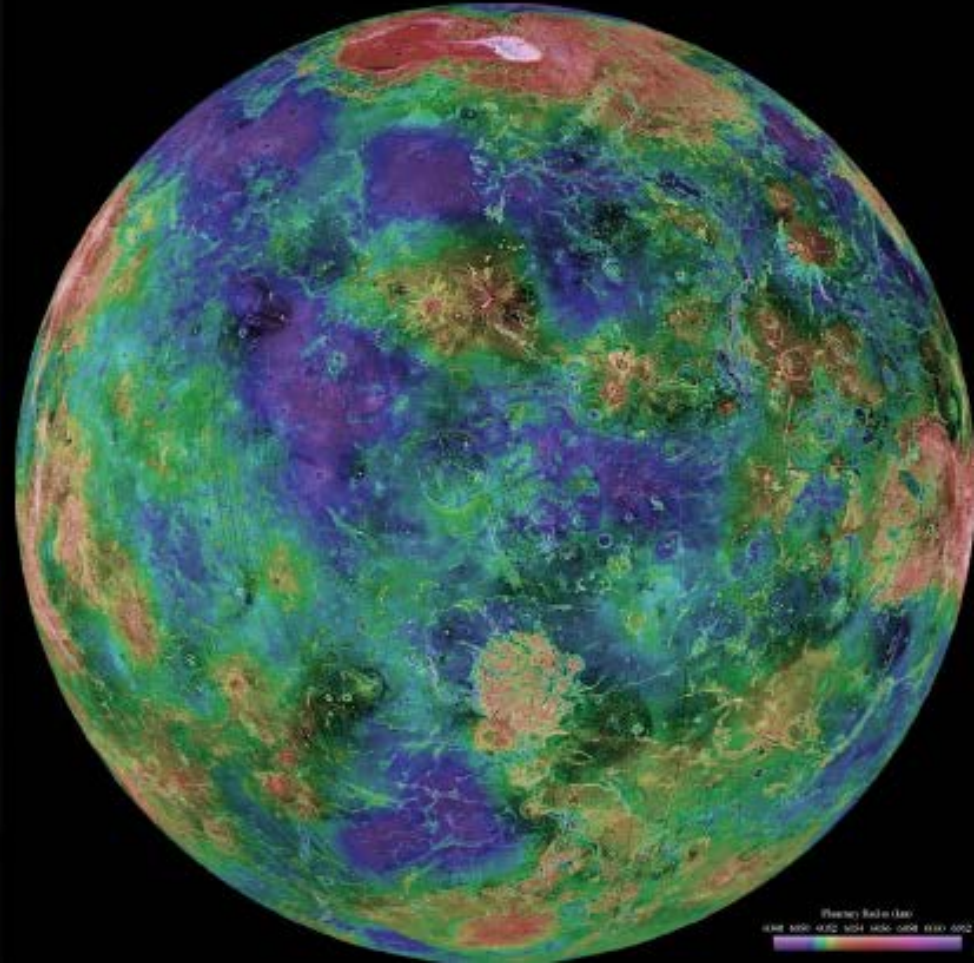


Atm windows are not the same for all planets

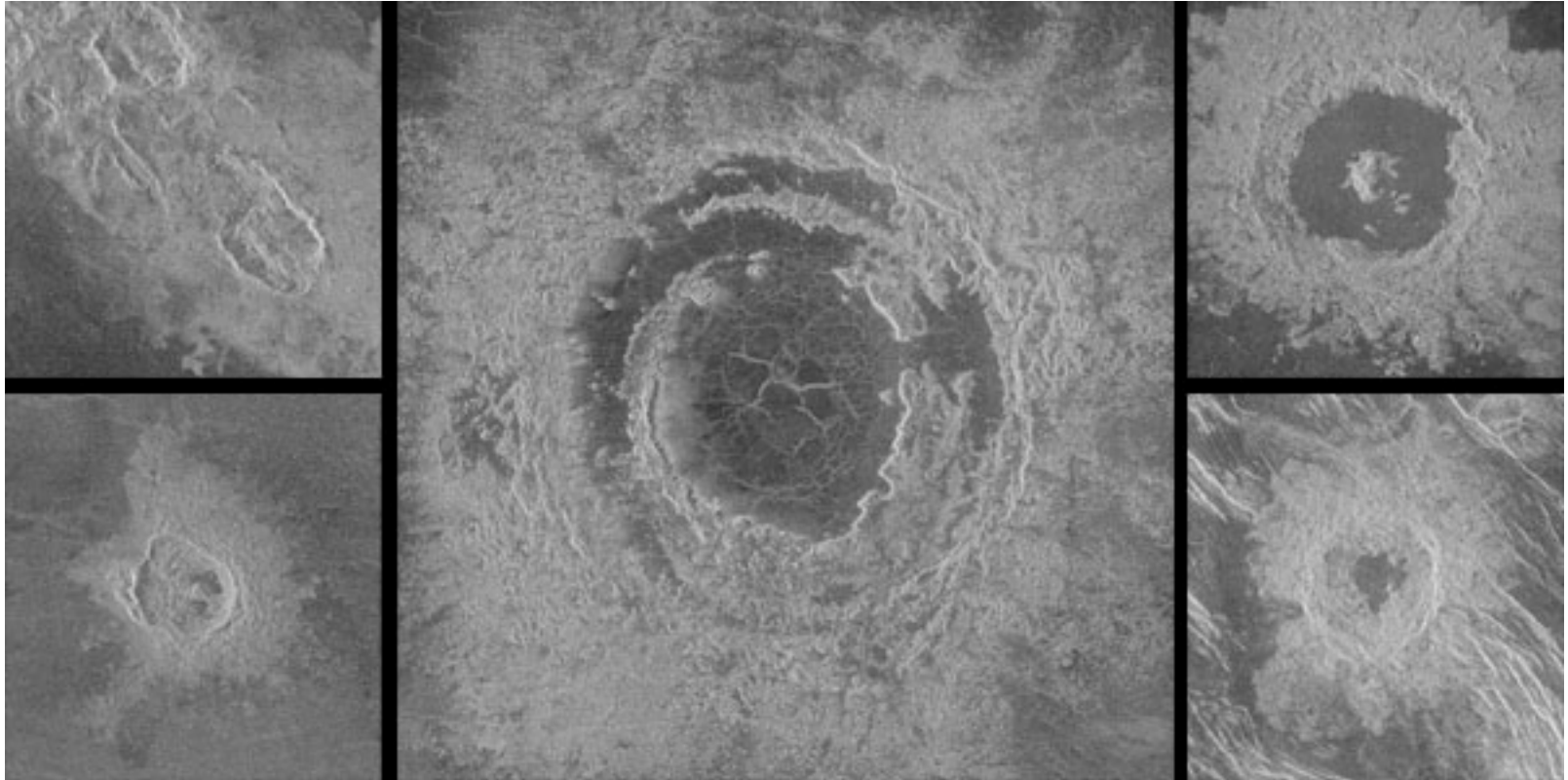
Venus

Mariner 10: Visible Near IR cannot penetrate cloud cover

Magellan: Radar allows surface features to be seen



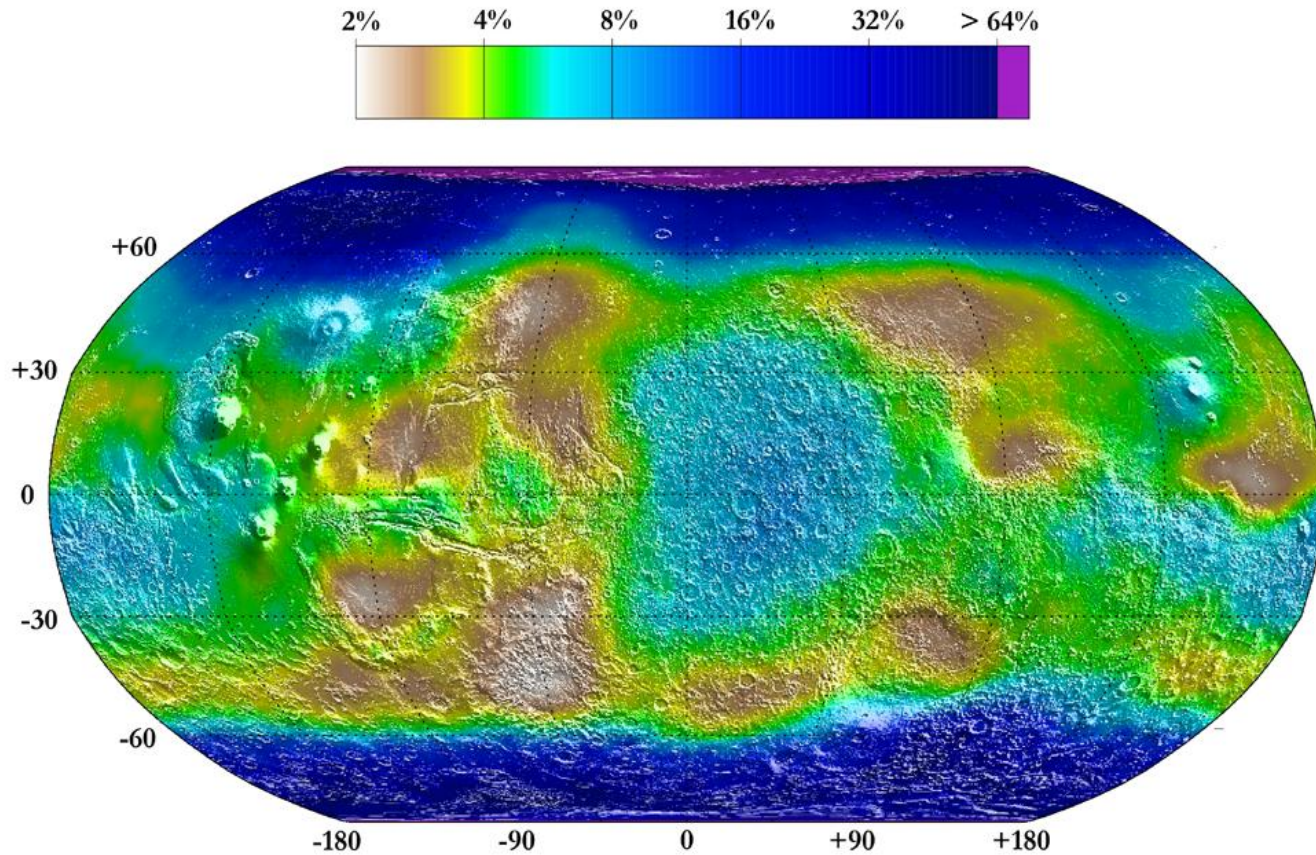
Radar Brightness = Surface Roughness



Magellan data

Ground Ice (and hydrated minerals): Evidence from Neutron Spectroscopy

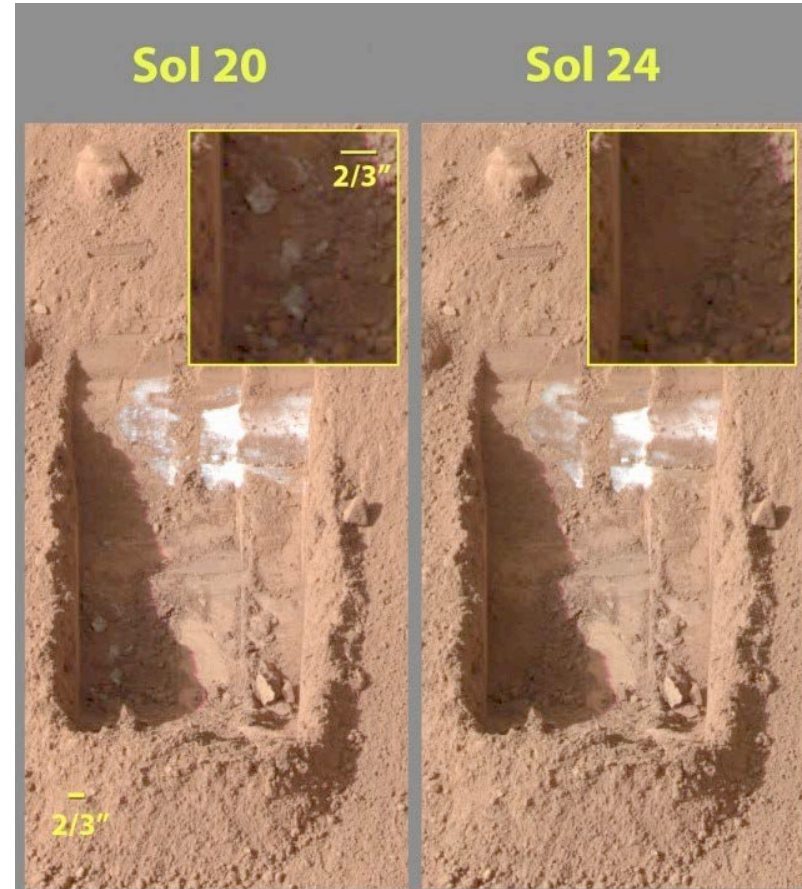
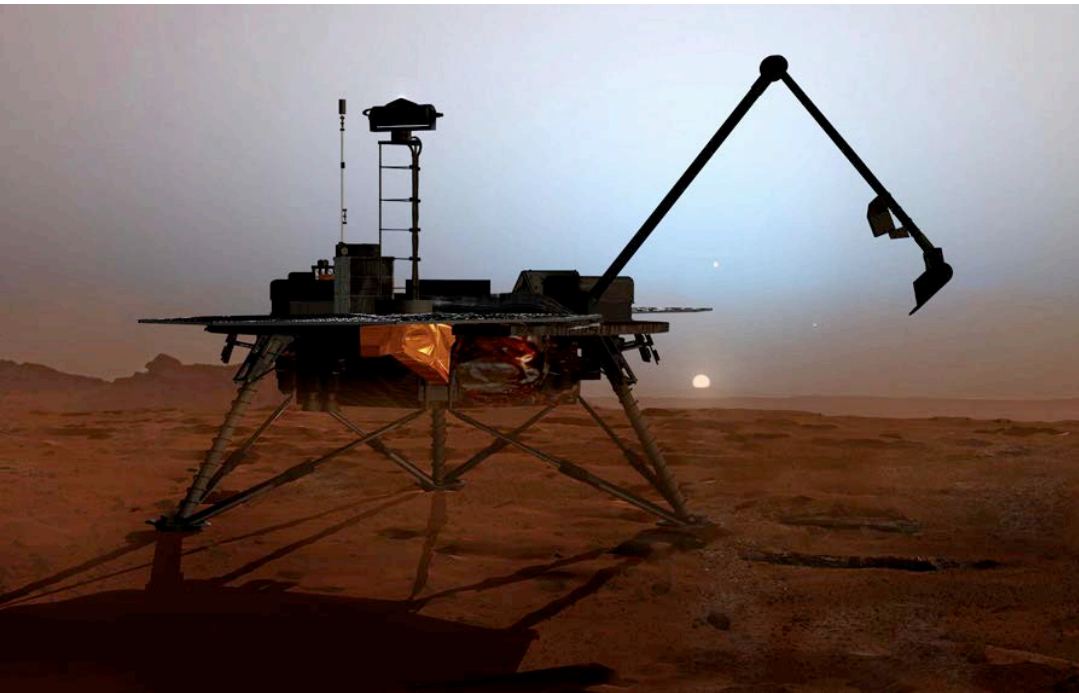
Lower-Limit of Water Mass Fraction on Mars



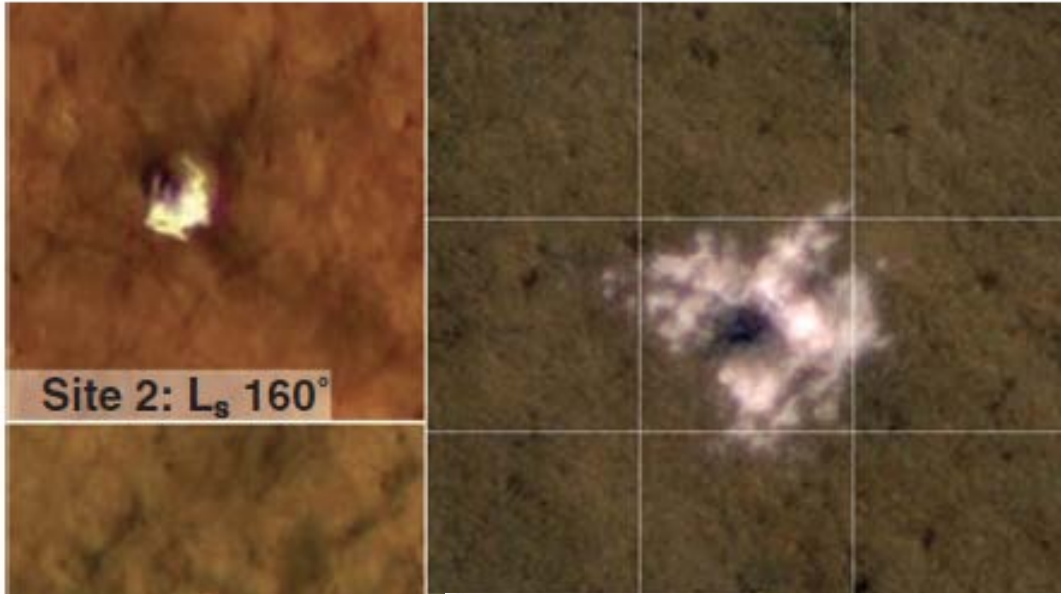
Data from Mars Odyssey Neutron Spectrometer [Feldman et al. 2004]

Curiosity now mapping the water content of ground beneath it as it drives with DAN

Phoenix observed Martian ground ice directly



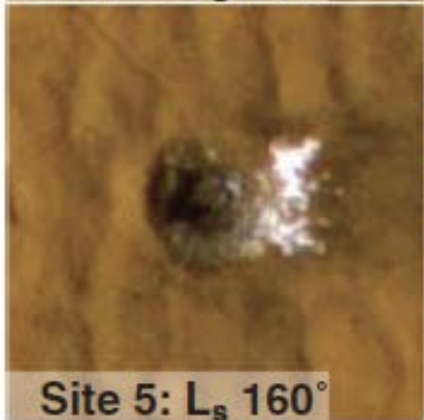
Ice revealed by impacts



Site 2: L_s 160°



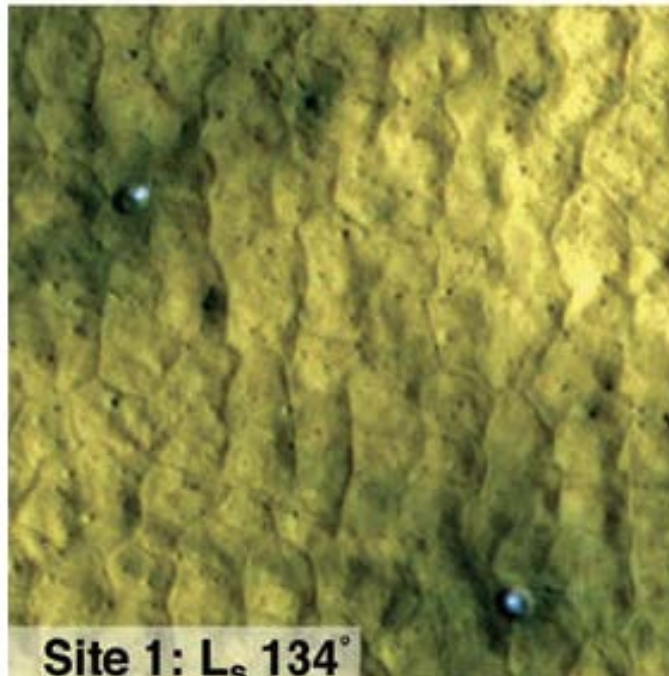
Site 4: L_s 149°



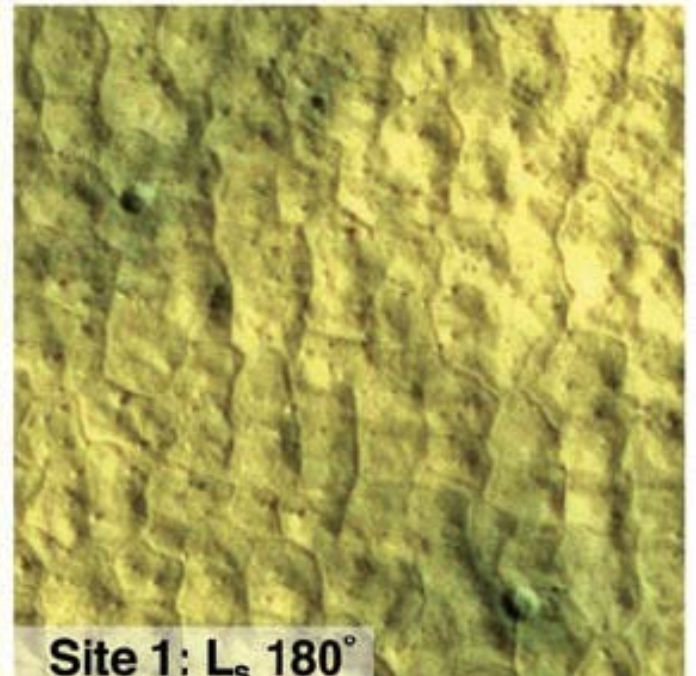
Site 5: L_s 160°

Faded over time:

Sinnlaenattarinn Alheds



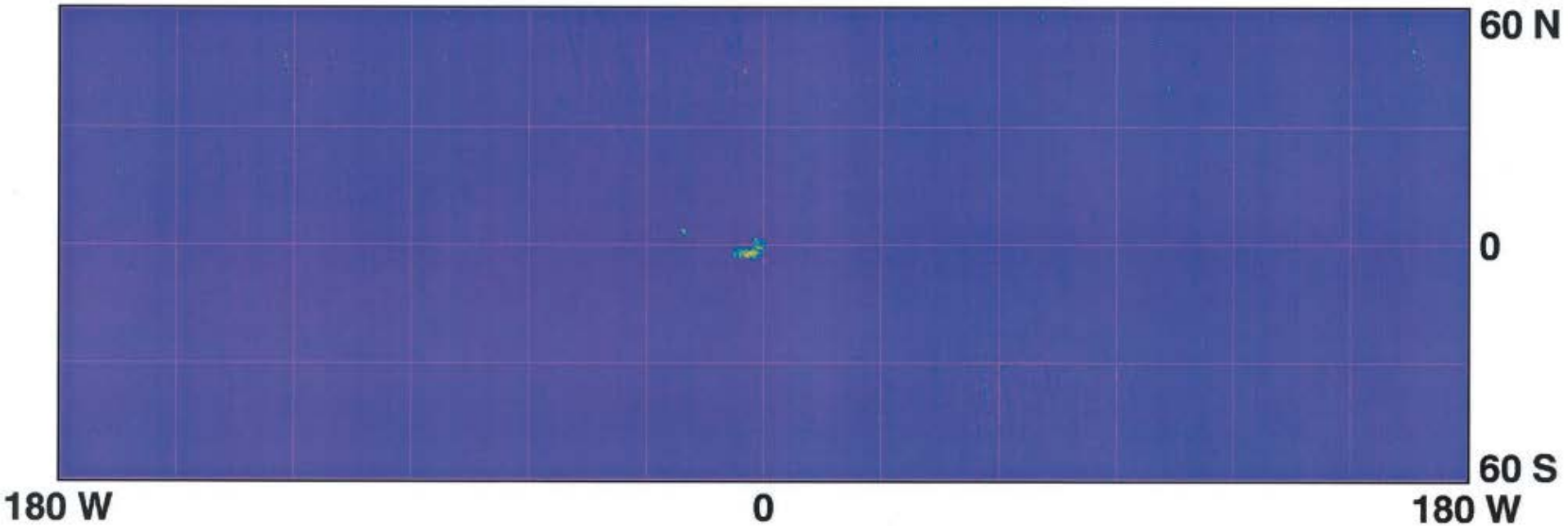
Site 1: L_s 134°



Site 1: L_s 180°

E

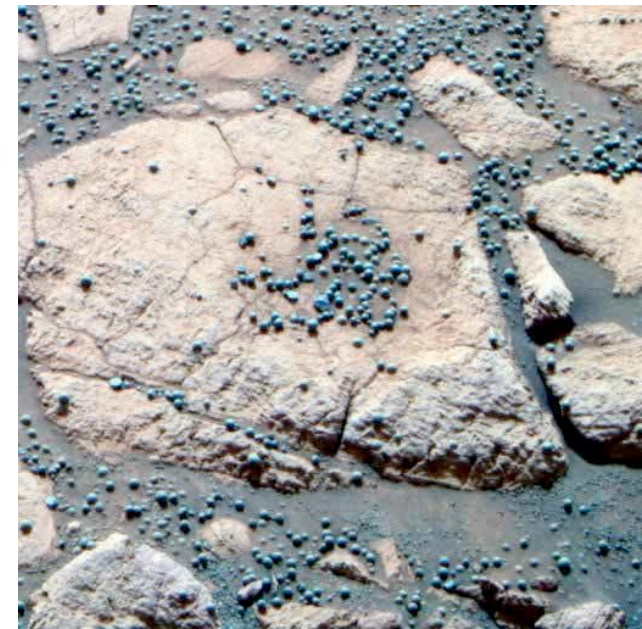
Landing site selection



Christensen et al. (2001)



~15 remote sensing datasets
used for Curiosity site selection



Columbus crater, Mars: IR spectroscopy + topography → bathtub ring of salts!

