Hyperspectral Remote Sensing

Lecture 9

September 26, 2005

Basics

- Many remote sensing systems record energy over several separate wavelength ranges at various spectral resolutions. These are referred to as **multi-spectral sensors.** Advanced multi-spectral sensors called **hyperspectral** sensors, detect hundreds of very narrow spectral bands throughout the visible, near-infrared, and mid-infrared portions of the electromagnetic spectrum.
- Hyper-: Narrow bands ($\leq$ 20 nm in resolution or FWHM) and continuous measurements.
- **Imaging spectrometry**: the simultaneous acquisition of images in many relatively narrow, contiguous and/or non-contiguous spectral bands throughout the ultraviolet, visible, and infrared portions of the spectrum.
- The very high spectral resolution facilitates fine discrimination between different targets based on their spectral response in each of the narrow bands

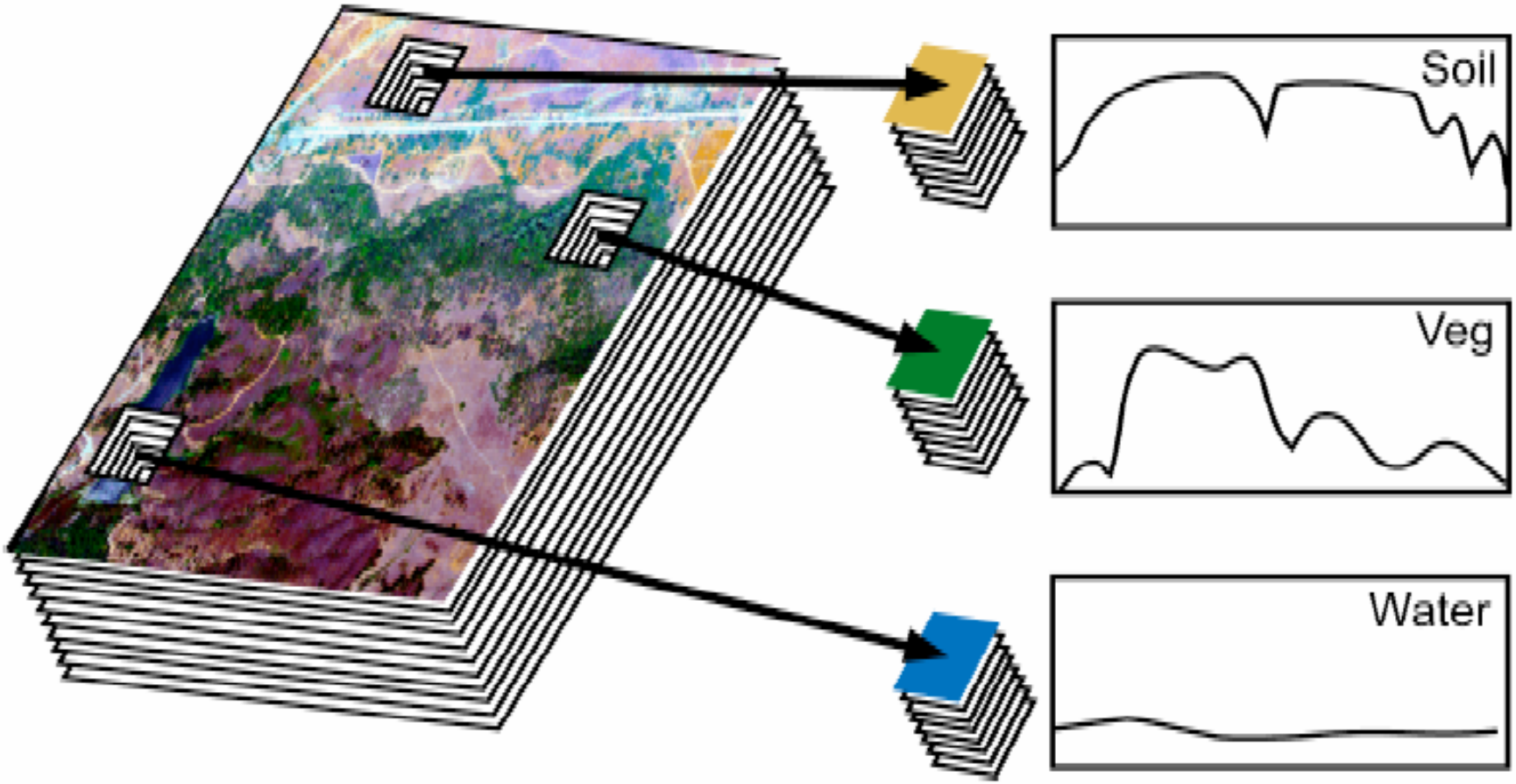
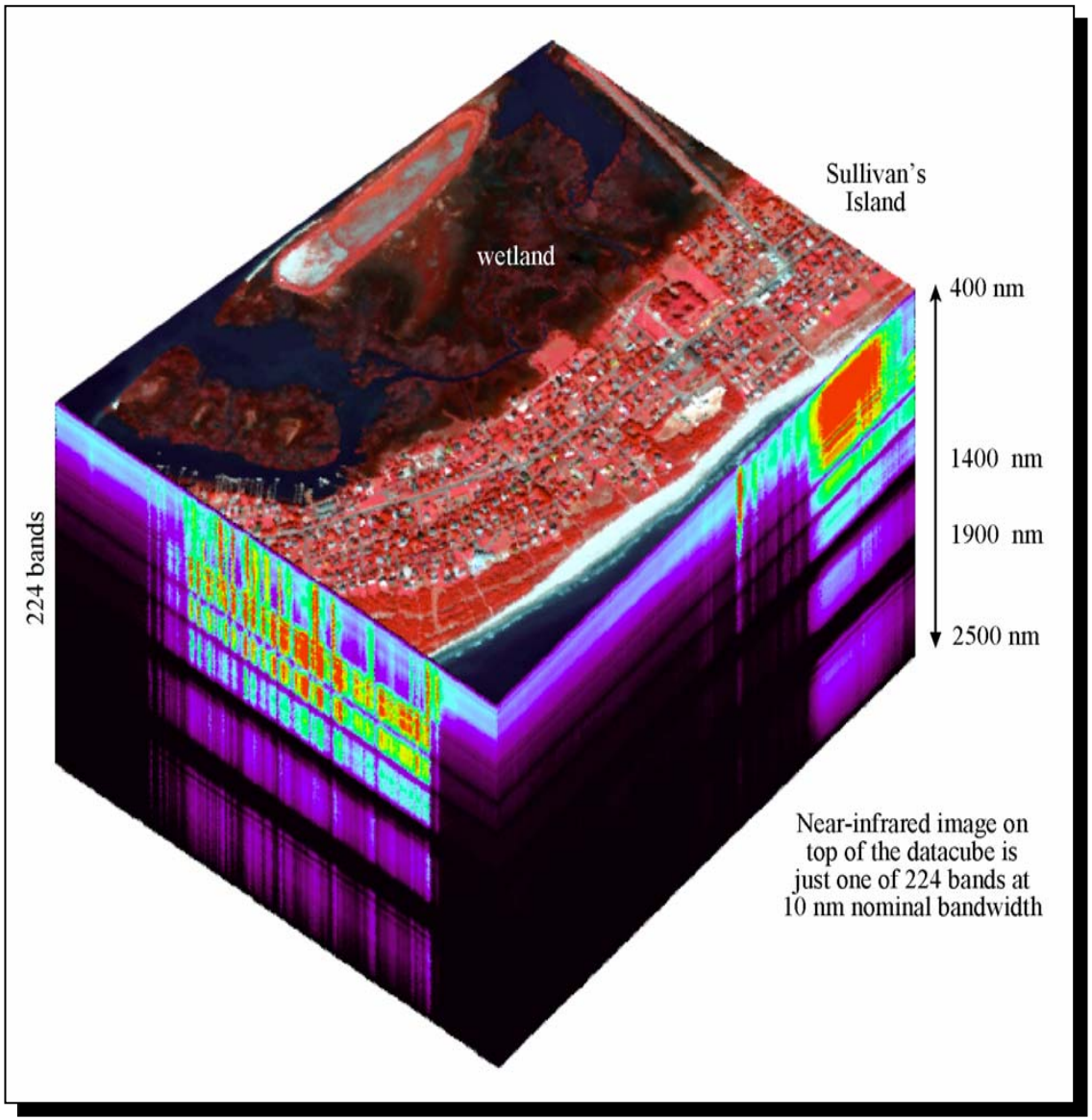


Figure 3. The concept of hyperspectral imagery. Image measurements are made at many narrow contiguous wavelength bands, resulting in a complete spectrum for each pixel.

Source: http://satjournal.tcom.ohiou.edu/pdf/shippert.pdf



Airborne Visible Infrared Imaging Spectrometer (AVIRIS) Datacube of Sullivan's Island Obtained on October 26, 1998

Jensen, 2000

Linear and Area Arrays

- Airborne Visible Infrared Imaging Spectrometer (AVIRIS,NASA JPL)
  - 224 12-bit bands: 400-2500 nm, band width 10 nm
  - IFOV 1.0 mrad (pixel width depends on airplane altitude); AFOV 30°
- Compact Airborne Spectrographic Imager (CASI-2, ITRES Research, Ltd.)
  - 2 modes:
    - Spatial: 19 bands (400 – 1000 nm), band width 1.9 nm
    - Spectral: 48 to 288 bands (400 – 1000 nm), band width 1.9 nm
  - IFOV 1.0 mrad, 512 pixels (spatial mode) or 39 to 511 pixels (spectral mode)

Linear and Area Arrays

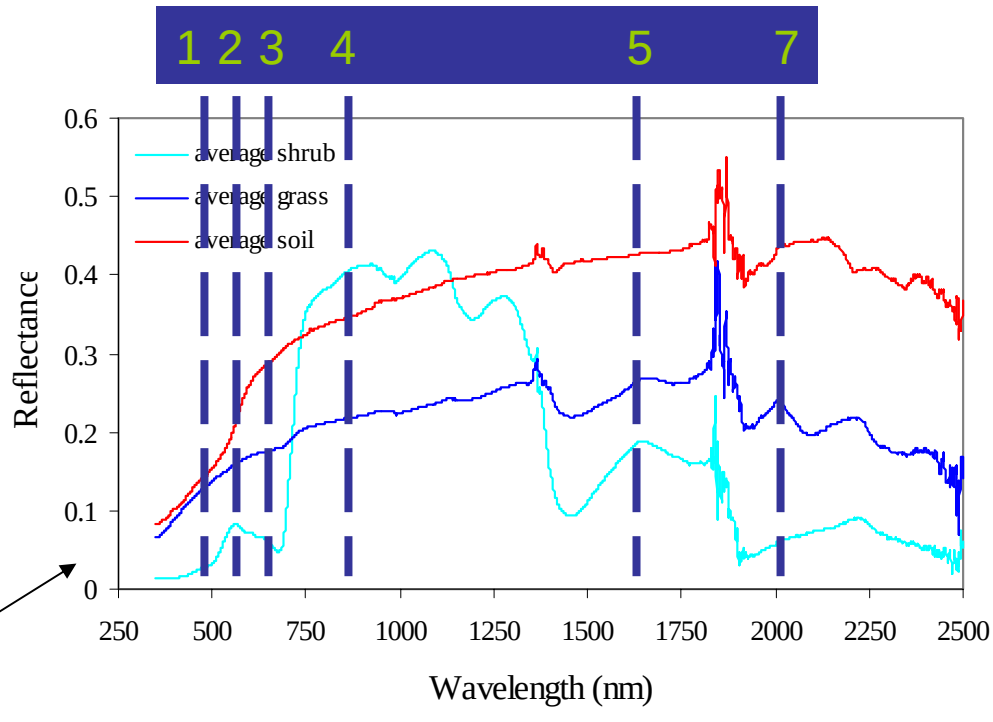
- Hyperion (EO-1, NASA)
  - 220 bands: 400-2500 nm, band width 10 nm
  - Pixel size 30 x 30 m, swath width 7.5 km
  - 11/21/2000 to present, it is the first satellite-based hyperspectral remote sensor.

Science information: http://eo1.gsfc.nasa.gov/overview/eo1Overview.html

Data order from: http://edc.usgs.gov/products/satellite/eo1.html

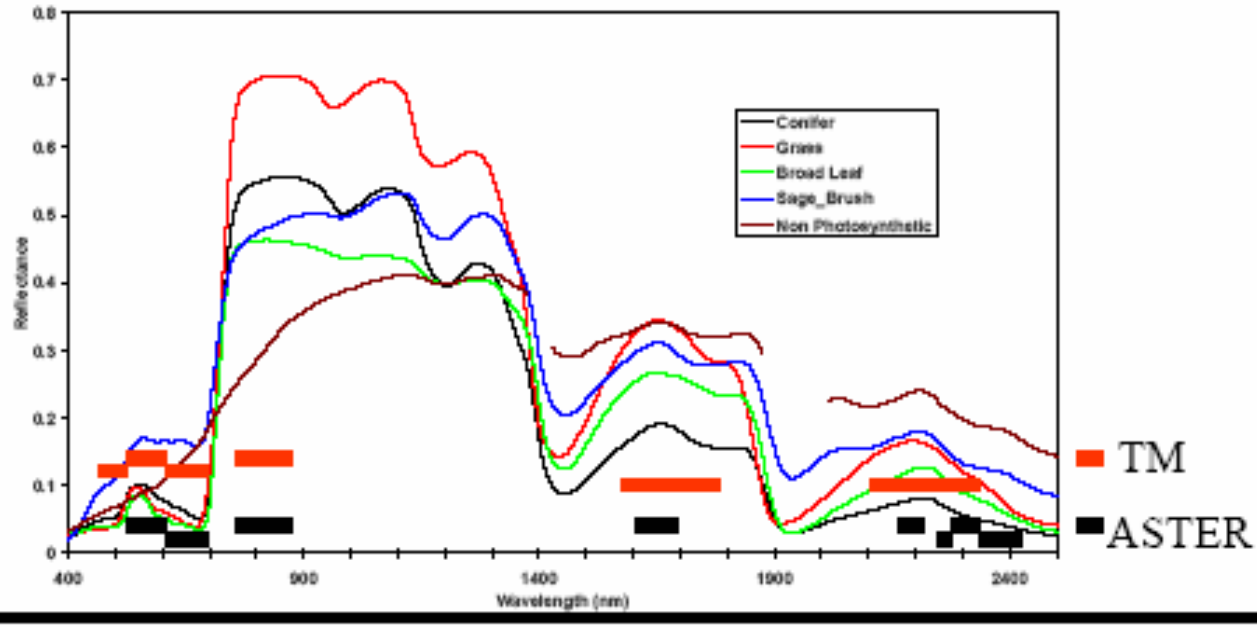
Hyper- and Multi- spectrum

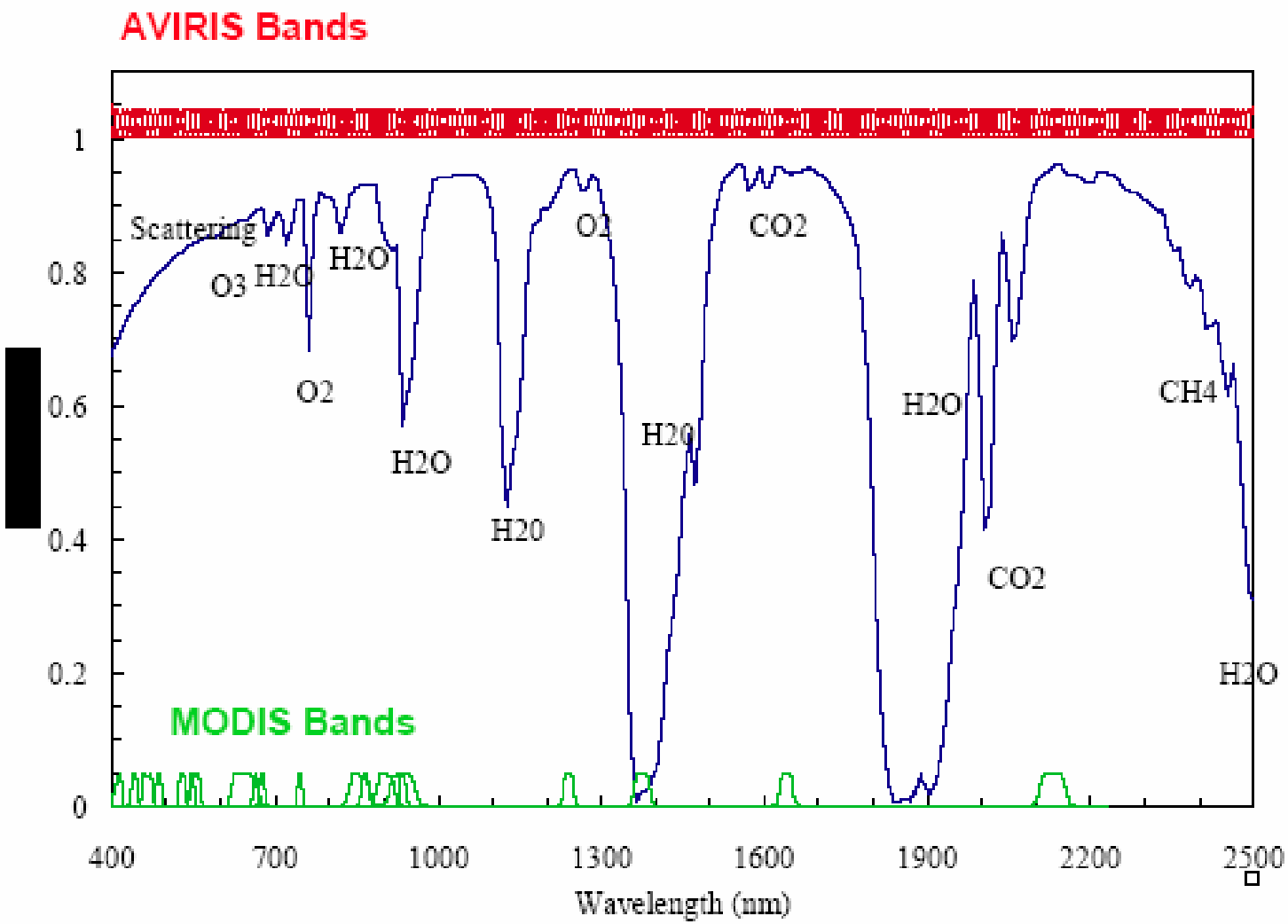
TM image Band 1 to Band 7



Continuous hyperspectral curve for any one pixel in an image

	ASTER	TM
Repeat Orbit:	16 d	16 d
Scene	60km	185km
Bands:		
Pan	0	1 15m
VIS	2 15m	3 30m
NIR	1 30m	1 30m
*SWIR	6 30m	2 30m
*TIR	5 90m	1 90m

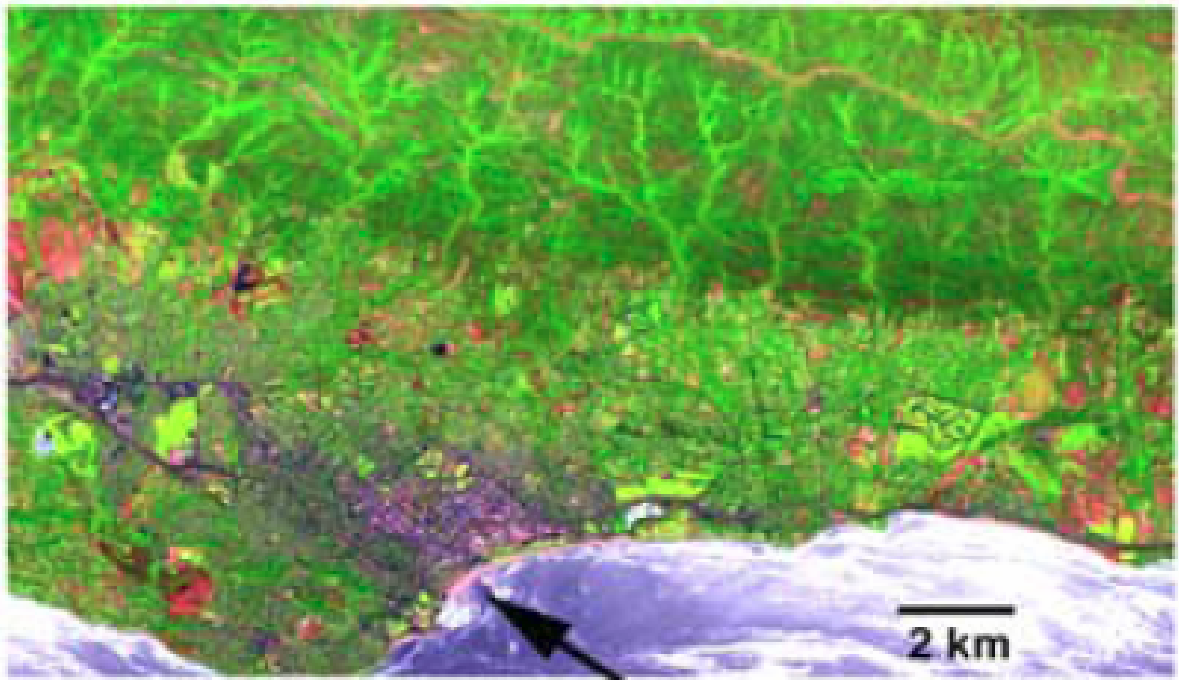



AVIRIS Bands
MODIS Bands
Scattering
O3
H2O
H2O
O2
H2O
H2O
O2
H20
CO2
H2O
CO2
CH4
H2O
1
0.8
0.6
0.4
0.2
0
400
700
1000
1300
1600
1900
2200
2500
Wavelength (nm)

Ustin, 2003

Santa Ynez Mountains
Study Site

AVIRIS: June 14, 2001



HYPERION: June 12, 2001

1650, 830, 670 nm: RGB

Summary table: current and recent hyderspectral sensors

Table 1. Current and Recent Hyperspectral Sensors and Data Providers

Satellite Sensors	Manufacturer	Number of Bands	Spectral Range
FTHSI on MightySat II	Air Force Research Lab www.vs.afrl.af.mil /TechProgs/MightySatII	256	0.35 to 1.05 µm
Hyperion on EO-1	NASA Goddard Space Flight Center eo1.gsfc.nasa.gov	220	0.4 to 2.5 µm
OMEGA	ESA Mars Express	351	0.35 to 5.12 µm

Spectral resolution:

7 or 4 nm in 0.5-1.1 microns
13 nm in 1.0-2.7 microns
20 nm in 2.6-5.2 microns

Spatial resolution: 300 m – 5 km

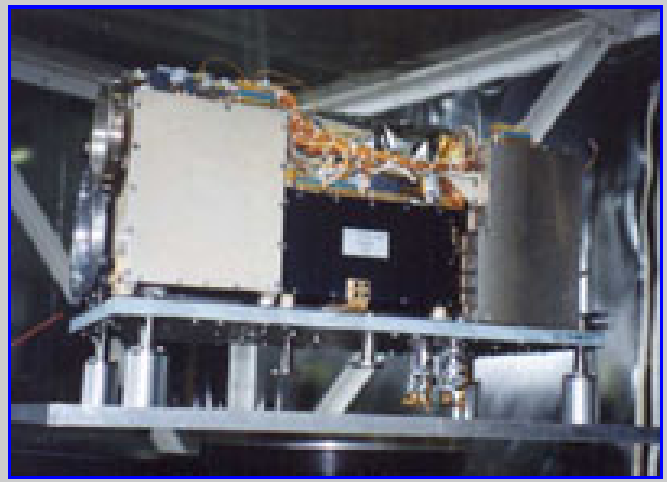
Airborne Sensors	Manufacturer	Number of Bands	Spectral Range
AVIRIS (Airborne Visible Infrared Imaging Spectrometer)	NASA Jet Propulsion Lab makalu.jpl.nasa.gov/	224	0.4 to 2.5 µm
HYDICE (Hyperspectral Digital Imagery Collection Experiment)	Naval Research Lab	210	0.4 to 2.5 µm
PROBE-1	Earth Search Sciences Inc. www.earthsearch.com	128	0.4 to 2.5 µm
casi (Compact Airborne Spectrographic Imager)	ITRES Research Limited www.itres.com	up to 228	0.4 to 1.0 µm
HyMap	Integrated Spectronics www.intspec.com	100 to 200	Visible to thermal infrared
EPS-H (Environmental Protection System)	GER Corporation www.ger.com	VIS/NIR (76), SWIR1 (32), SWIR2 (32), TIR (12)	VIS/NIR (.43 to 1.05 µm), SWIR1 (1.5 to 1.8 µm), SWIR2 (2.0 to 2.5 µm), and TIR (8 to 12.5 µm)

Cont'

			(8 to 12.5 μm)
DAIS 7915 (Digital Airborne Imaging Spectrometer)	GER Corporation	VIS/NIR (32), SWIR1 (8), SWIR2 (32), MIR (1), TIR (6)	VIS/NIR (0.43 to 1.05 μm), SWIR1 (1.5 to 1.8 μm), SWIR2 (2.0 to 2.5 μm), MIR (3.0 to 5.0 μm), and TIR (8.7 to 12.3 μm)
DAIS 21115 (Digital Airborne Imaging Spectrometer)	GER Corporation	VIS/NIR (76), SWIR1 (64), SWIR2 (64), MIR (1), TIR (6)	VIS/NIR (0.40 to 1.0 μm), SWIR1 (1.0 to 1.8 μm), SWIR2 (2.0 to 2.5 μm), MIR (3.0 to 5.0 μm), and TIR (8.0 to 12.0 μm)
AISA (Airborne Imaging Spectrometer)	Spectral Imaging www.specim.fi	up to 288	0.43 to 1.0 μm

Scientific Objectives

OMEGA (which stands for Observatoire pour la Mineralogie, l'Eau, les Glaces et l'Activit) is an infrared mapping spectrometer, designed to examine the global distribution of minerals and chemicals on the surface of Mars. Its goals are to:



The optics and electronics of the OMEGA instrument
Image: Institut d'Astrophysique Spatiale.

Click here for more images from *Mars Express*

- Map surface materials, including silicate minerals, hydrated minerals, oxides and carbonates, organic frosts, and ices
- Map the concentrations of carbon dioxide, carbn monoxide, and water in the atmosphere and how they change over time
- Identify the aerosols and dust particles in the atmosphere and observe their time and space distributions
- Monitor the transportation of dust across the surface

http://www.esa.int/SPECIALS/Mars_Express/SEMUC75V9ED_0.html

Field based measurements for calibration, validation, and other purposes

- http://www.utsa.edu/LRSG/Fieldwork/spec_measu.htm
- A demo and some results prepared by PhD student: Blake Weissling