SATELLITES

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Weather Satellites and Sensors

- Examples:
- (1) GOES (Geostationary Operational Environmental Satellite)
- (2) NOAA AVHRR (Advanced Very High Resolution Radiometer)
- (3) DMSP (Defense Meteorological Satellite Program)
- (4) Meteosat

GOES Bands

	Wavelength	Spatial Resolution	Application
1	0.52 - 0.72 (visible)	1 km	cloud, pollution, and haze detection; severe storm identification
2	3.78 - 4.03 (IR)	4 km	identification of fog at night; discriminating water clouds and snow or ice clouds during daytime; detecting fires and volcanoes; night time determination of sea surface temperatures
3	6.47 - 7.02 (IR)	4 km	estimating regions of mid-level moisture content and advection; tracking mid-level atmospheric motion
4	10.2 - 11.2 (tIR)	4 km	identifying cloud-drift winds, severe storms, and heavy rainfall
5	11.5 - 12.5 (tIR)	4 km	identification of low-level moisture; determination of sea surface temperature; detection of airborne dust and volcanic ash

# NOAA Advanced Very High Resolution Radiometer (AVHRR)

- Stands for **National Oceanic and Atmospheric Administration**, which is US-government body.
- Onboard **NOAA's** Polar Orbiting Environmental Satellite (POES) platform
- Visible, NIR, Thermal
- 1.1 km Resolution - **local area coverage (LAC)**
- 4 km Resolution - **global area coverage (GAC)**
- Used for meteorological studies
- Vegetation pattern analysis
- Gaining popularity for global modeling
- Broad spectral bands
- Not ideally suited for vegetation but used to determine general patterns.

NOAA AVHRR Bands

	Wavelength	Spatial Resolution	Application
1	0.58 - 0.68 (red)	1.1 km	cloud, snow, and ice monitoring
2	0.725 - 1.1 (near IR)	1.1 km	water, vegetation, and agriculture surveys
3	3.55 -3.93 (mid IR)	1.1 km	sea surface temperature, volcanoes, and forest fire activity
4	10.3 - 11.3 (tIR)	1.1 km	sea surface temperature, soil moisture
5	11.5 - 12.5 (tIR)	1.1 km	sea surface temperature, soil moisture

# NOAA AVHRR
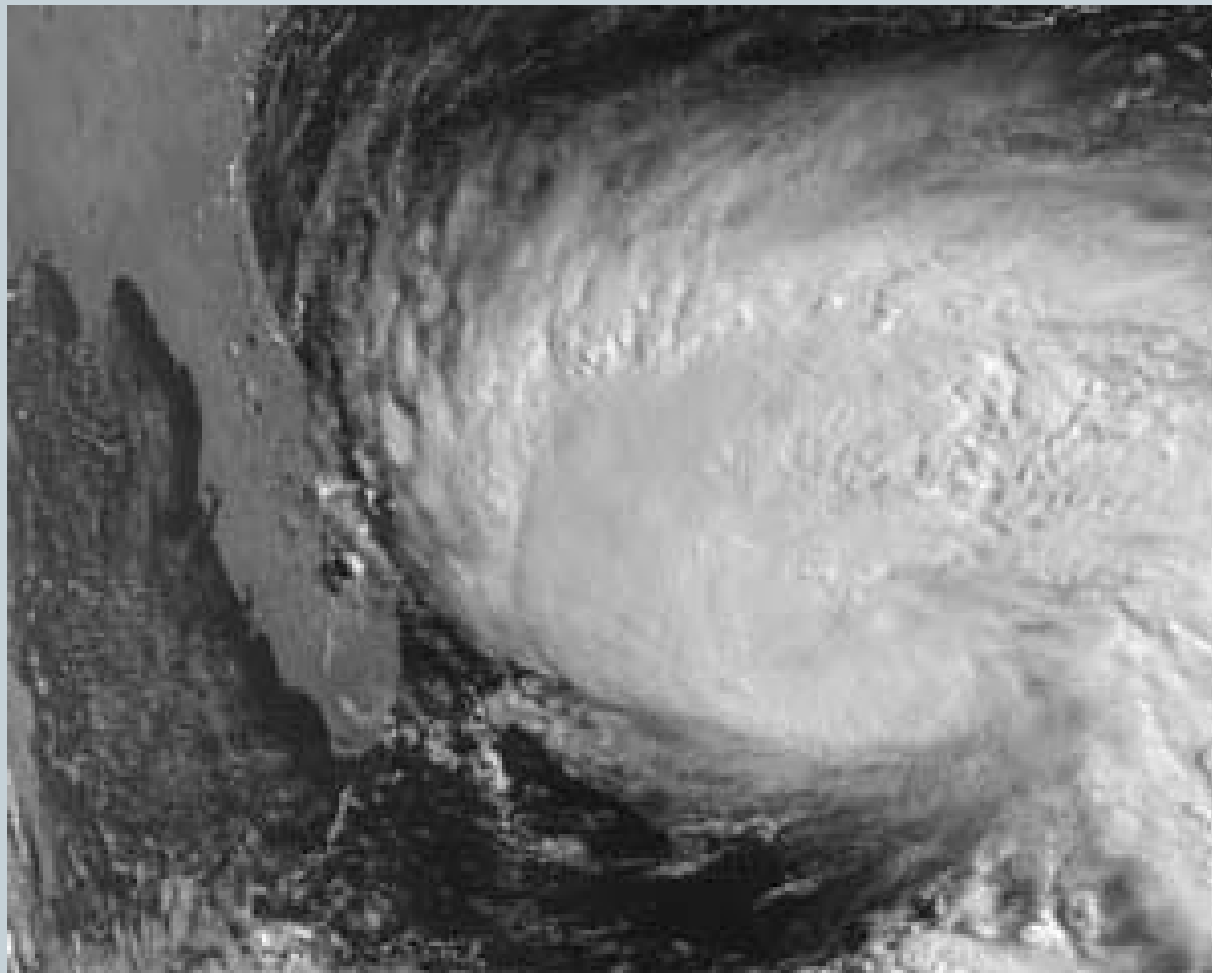
AVHRR Global Composite
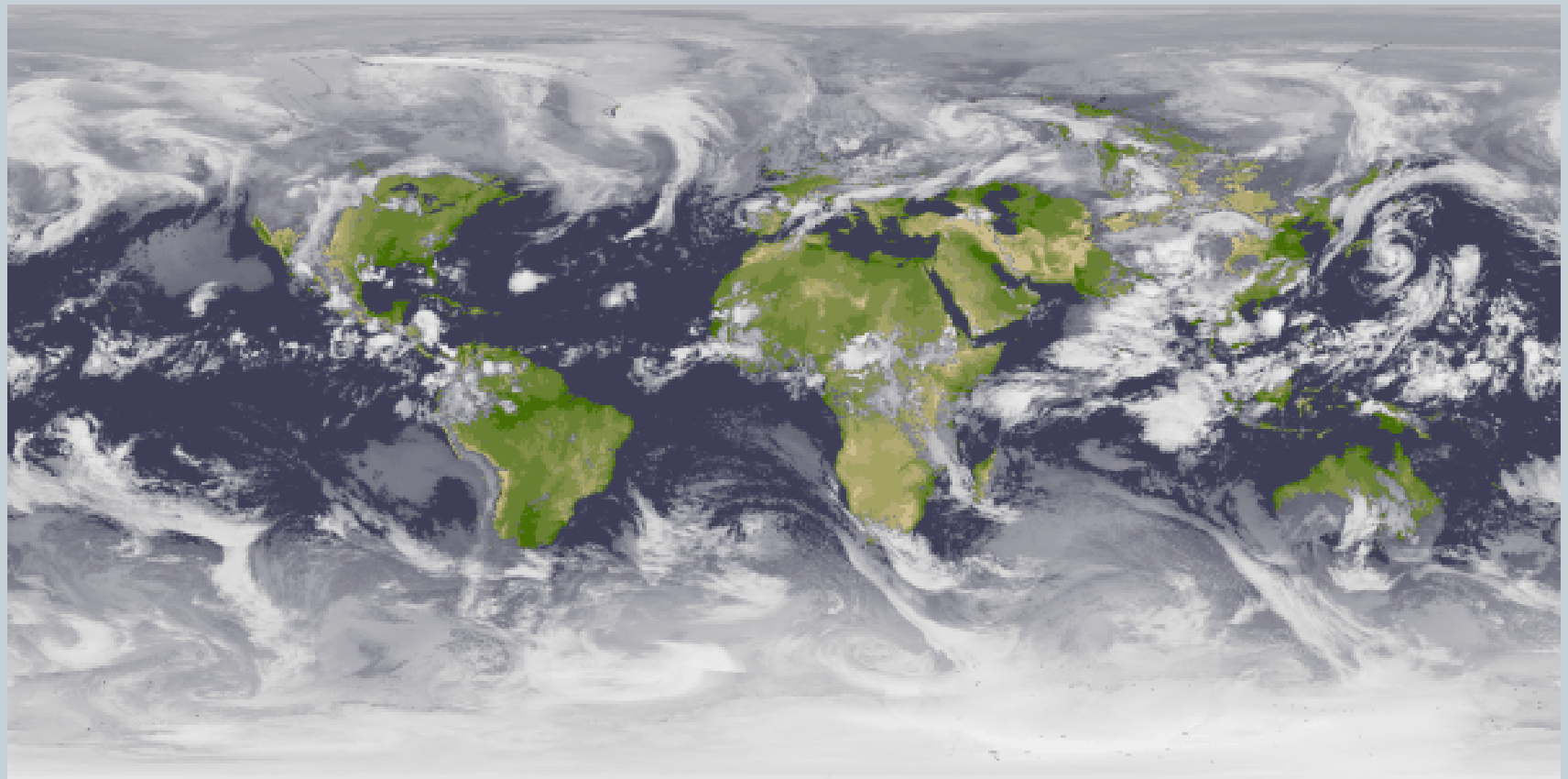
AVHRR

AVHRR data are used primarily in day-to-day meteorological forecasting where it gives more detailed information than Meteosat. In addition, there are many land and water applications.

AVHRR data are used to generate *Sea Surface Temperature maps* (SST maps), which can be used in climate monitoring, the study of El Niño, the detection of eddies to guide vessels to rich fishing grounds, *et cetera*. *Cloud cover maps* based on AVHRR data, are used for rainfall estimates, which can be input into crop growing models. Another derived product of AVHRR data are the *Normalized Difference Vegetation Index maps* (NDVI). These 'maps' give an indication about the quantity of biomass (tons/ha). NDVI data are used as input into crop growth models and also for climate change models. The NDVI data are, for instance, used by FAO in their food security early warning system (FEWS). AVHRR data are appropriate to map and monitor regional land cover and to assess the energy balance of agricultural areas.
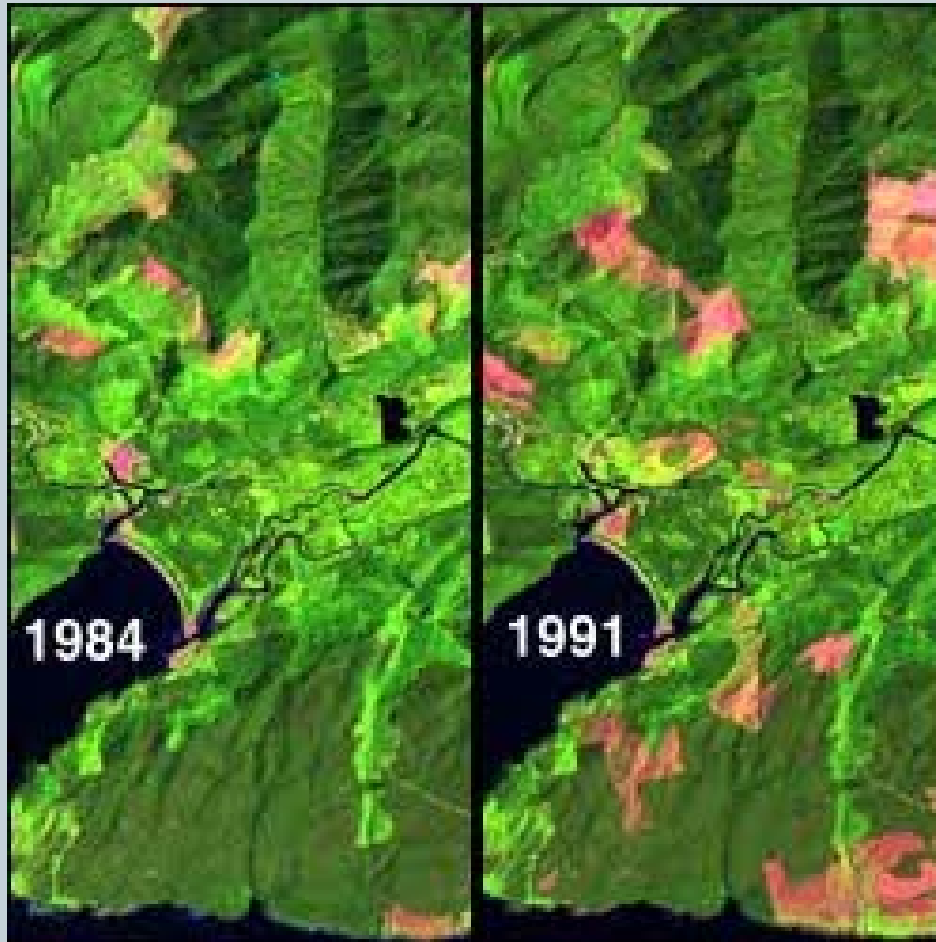
AVHRR Sea Surface Temperature
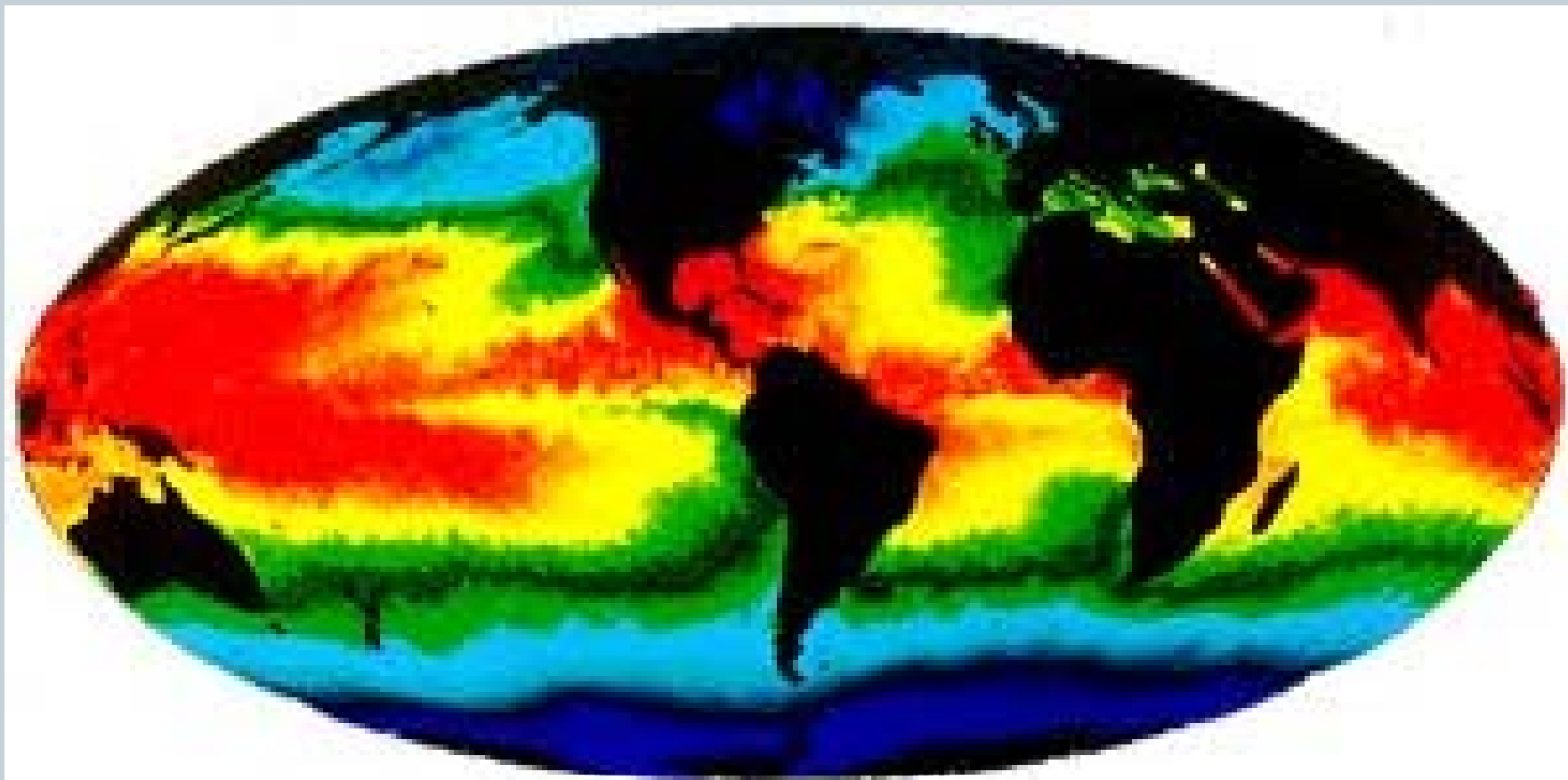
Landsat Program

- **Originally called (ERTS)** - Earth Resources Technology Satellite.

  – Launched in 1972

  – Broad scale repetitive surveys of the landscape

  – Visible, NIR spectral bands (Landsats 1,2,3), and MIR and Thermal (Landsats 4 and 5)

  – Multispectral scanner (**MSS**)

  – Return beam vidicon (**RBV**)

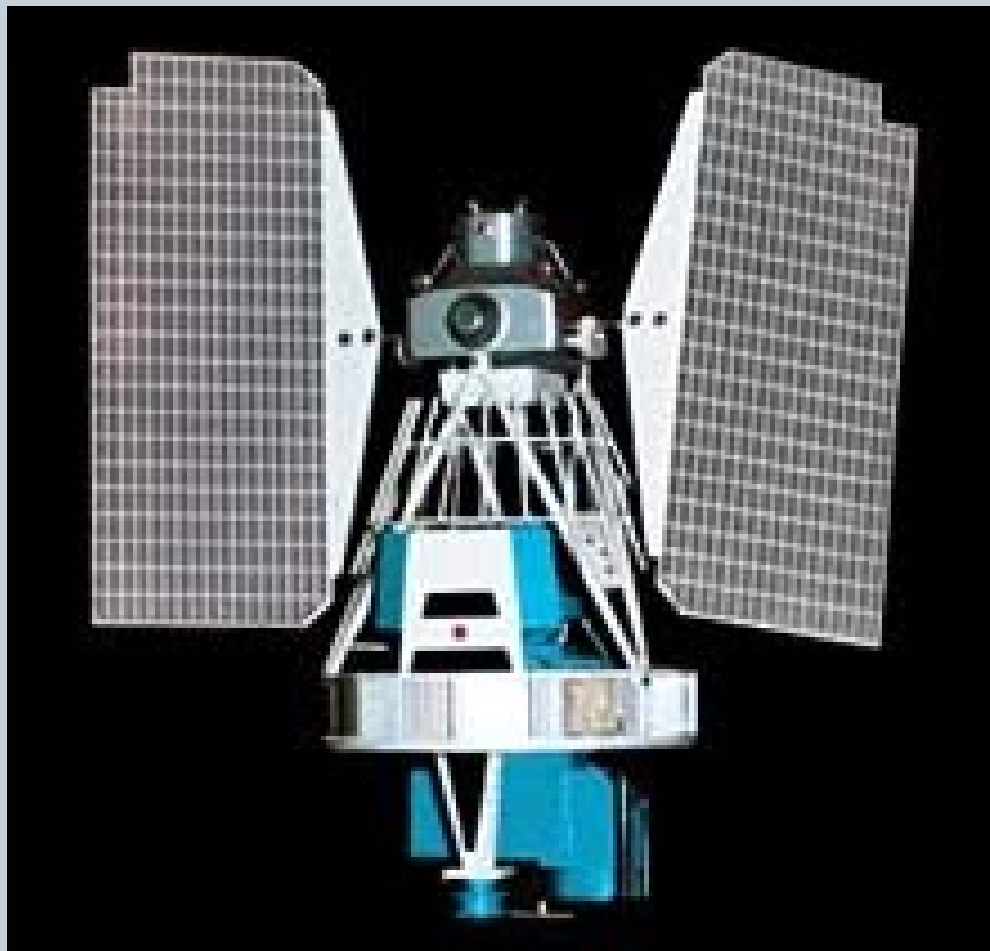 – Thematic mapper (**TM**)

Landsat

Landsat

- Originally managed by NASA, transferred to NOAA in 1983. In 1985, the program became commercialized

- Landsat's success is due to several factors, including: a combination of sensors with spectral bands tailored to Earth observation; functional spatial resolution; and good areal coverage

- The long life span of the program has provided a voluminous archive of Earth resource data facilitating long term monitoring.

Landsat-1

Landsat Sensors

- Return Beam Vidicon (RBV)
- Multispectral Scanner (MSS)
- Thematic Mapper (TM)
- Enhanced Thematic Mapper Plus (ETM+)

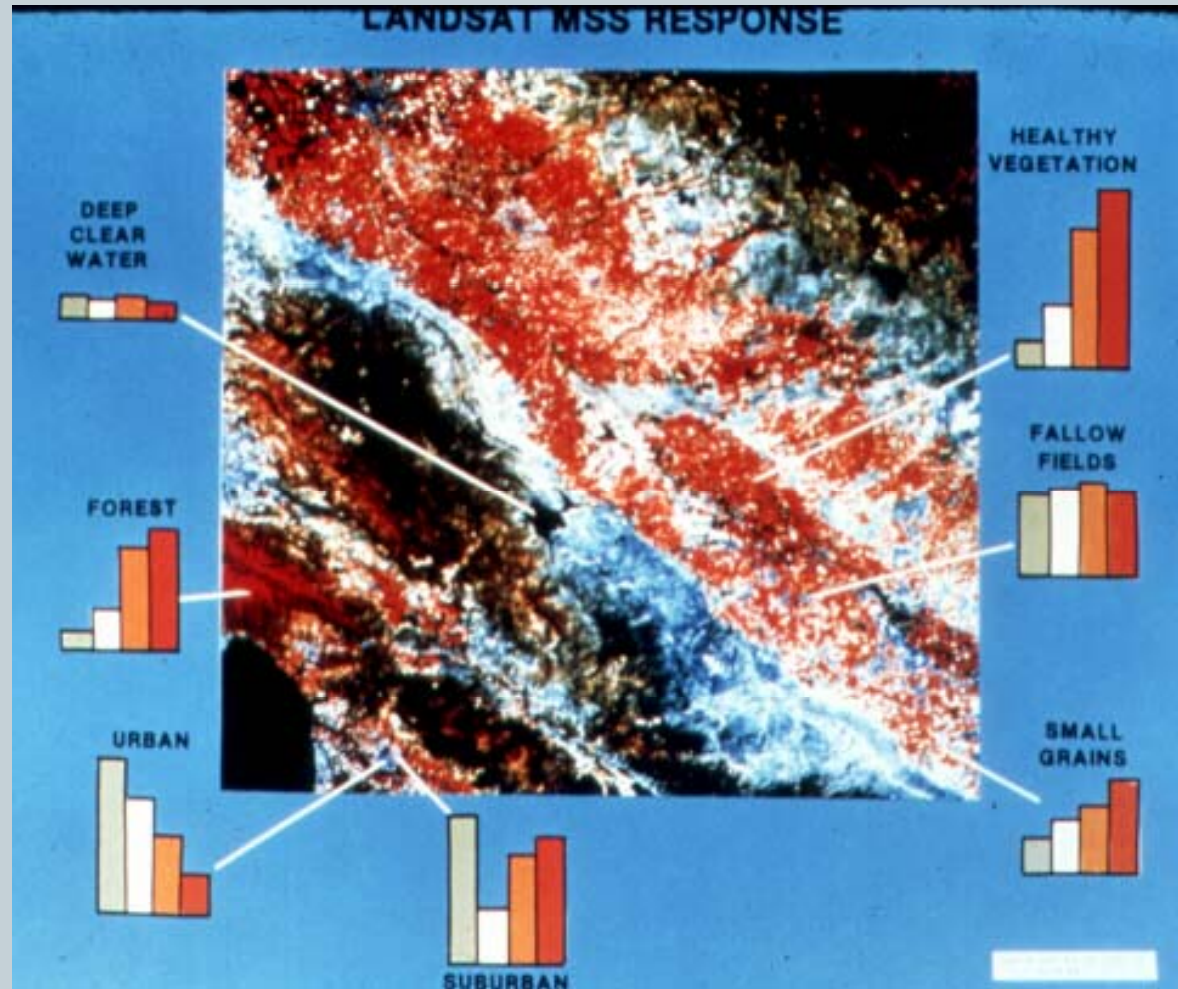# Landsat RBV Image Cape Canaveral

Landsat MSS (Multispectral Scanner)

- On Landsats 1,2,3,4,5
- 79 meter spatial resolution
- 4 spectral bands
    Green, Red, and 2 NIR
- 570 mile orbit (for Landsat 1,2,3)
- Swath Width = 185 km
- Each spectral band has 6 detectors

Landsat MSS

Landsat Thematic Mapper (TM)

– On Landsat 4,5

– 30 meter resolution reflected / 120 meter emitted.

– 7 spectral bands
  Blue/Green, Green, Red, NIR, MIR, MIR, Thermal

– 423 mile orbit

– Swath Width = 185 km

– 16 day repeat cycle

TM Bands

Spatial Resolution: 30 meters (120 meters for band 6)

	Wavelength Range ($\mu\mu$)	Application
TM 1	0.45 - 0.52 (blue)	soil/vegetation discrimination; bathymetry/coastal mapping; cultural/urban feature identification
TM 2	0.52 - 0.60 (green)	green vegetation mapping (measures reflectance peak); cultural/urban feature identification
TM 3	0.63 - 0.69 (red)	vegetated vs. non-vegetated and plant species discrimination (plant chlorophyll absorption); cultural/urban feature identification
TM 4	0.76 - 0.90 (near IR)	identification of plant/vegetation types, health, and biomass content; water body delineation; soil moisture
TM 5	1.55 - 1.75 (short IR)	sensitive to moisture in soil and vegetation; discriminating snow and cloud-covered areas
TM 6	10.4 - 12.5 (thermal IR)	vegetation stress and soil moisture discrimination related to thermal radiation; thermal mapping (urban, water)
TM 7	2.08 - 2.35 (short IR)	discrimination of mineral and rock types; sensitive to vegetation moisture content

Landsat TM Death Valley

Landsat-7

- ETM+
- Landsat TM bands + 15 meter panchromatic channel
- 60 meter thermal channel

Landsat-7 Satellite

SPOT

- **HRV** -High resolution visible
- February 21 1986 launch date
- Multispectral and panchromatic
- 20 meter multispectral resolution
- 10 meter panchromatic resolution
- 3 spectral bands
     green, red, nir
- Swath Width = 60 km

SPOT

- SPOT-1 was launched in 1986, with successors every 3-4 years.

- All satellites are sun-synchronous with orbit repetition every 26 days.

- Each HRV is capable of sensing either in

  - a high spatial resolution (10 meter) single-channel **panchromatic (PLA)** mode, or

  - a coarser spatial resolution (20 meter) three-channel **multispectral (MLA)** mode.

SPOT **HRV Mode Spectral Ranges**

- **Mode/Band**   **Wavelength Range (μμ)**
- Panchromatic (PLA)   0.51 - 0.73
- Multispectral (MLA)
- Band 1   0.50 - 0.59 (green)
- Band 2   0.61 - 0.68 (red)
- Band 3   0.79 - 0.89 (near infrared)

IRS

- The Indian Remote Sensing (IRS) satellite series, combines features from both the Landsat MSS/TM sensors and the SPOT HRV sensor.

- The third satellite in the series, IRS-1C, launched in December, 1995 has three sensors:

  - a single-channel panchromatic (PAN) high resolution camera,

  - a medium resolution four-channel Linear Imaging Self scanning Sensor (LISS-III),

  - and a coarse resolution two-channel Wide Field Sensor (WiFS).

IRS Image Southern Iran
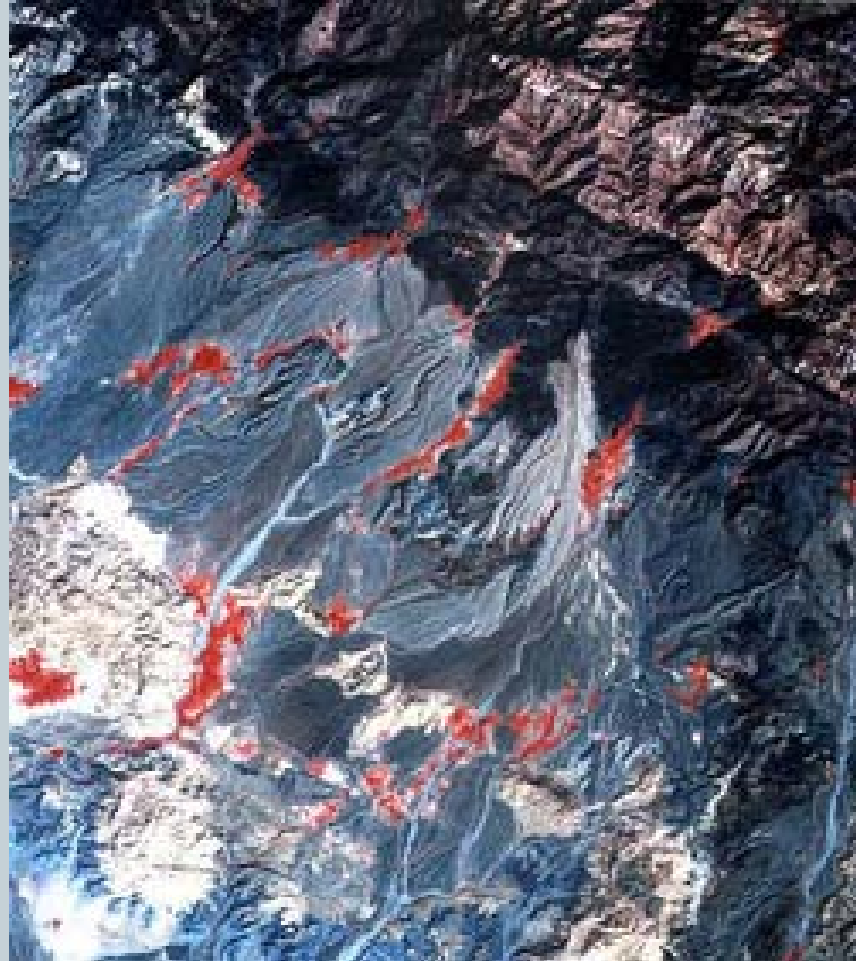
IRS Sensors

Sensor		Wavelength	Spatial Resolution	Swath Width
PAN		0.5 - 0.75	5.8 m	70 km
LISS-II				
	Green	0.52 - 0.59	23 m	142 km
	Red	0.62 - 0.68	23 m	142 km
	Near IR	0.77 - 0.86	23 m	142 km
	Shortwave IR	1.55 - 1.70	70 m	148 km
WiFS				
	Red	0.62 - 0.68	188 m	774 km
	Near IR	0.77 - 0.86	188 m	774 km

Marine Satellites and Sensors

- Coastal Zone Color Scanner (CZCS)
- Marine Observation Satellite (MOS)
- SeaWifs

Commercial Satellites

- *Space Imaging* IKONOS
- *Orbimage* OrbView 3, 4
- *Earthwatch* Quickbird
- Resource-21
- SPIN