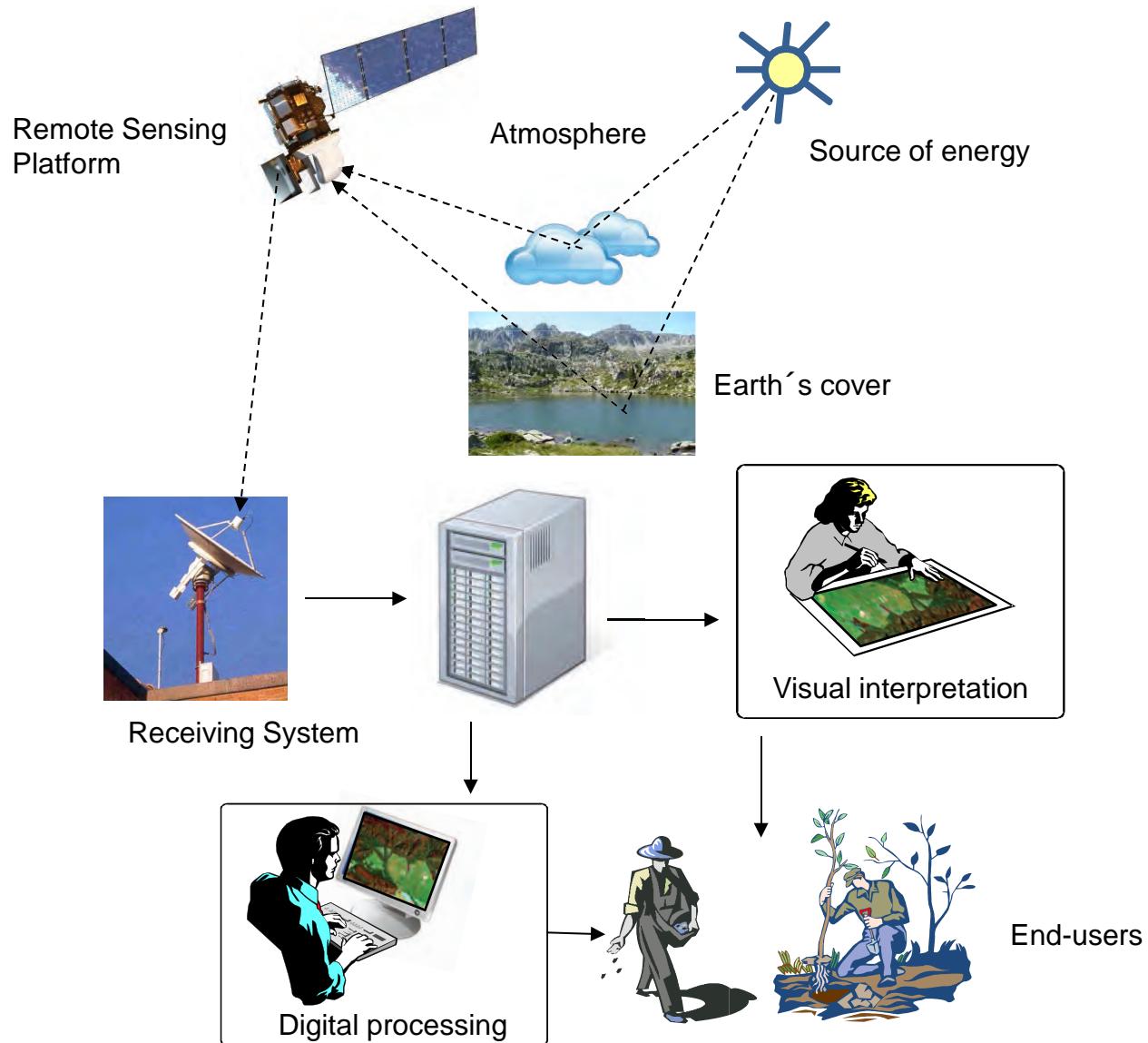
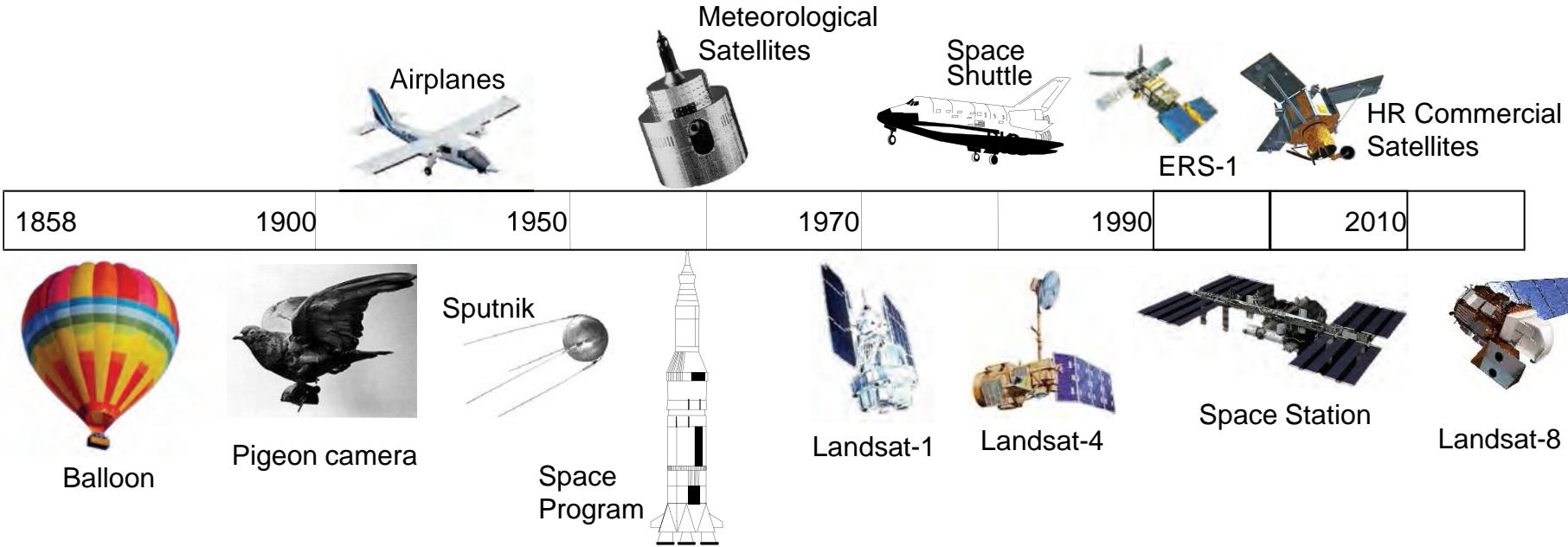


## → 6th ESA ADVANCED TRAINING COURSE ON LAND REMOTE SENSING

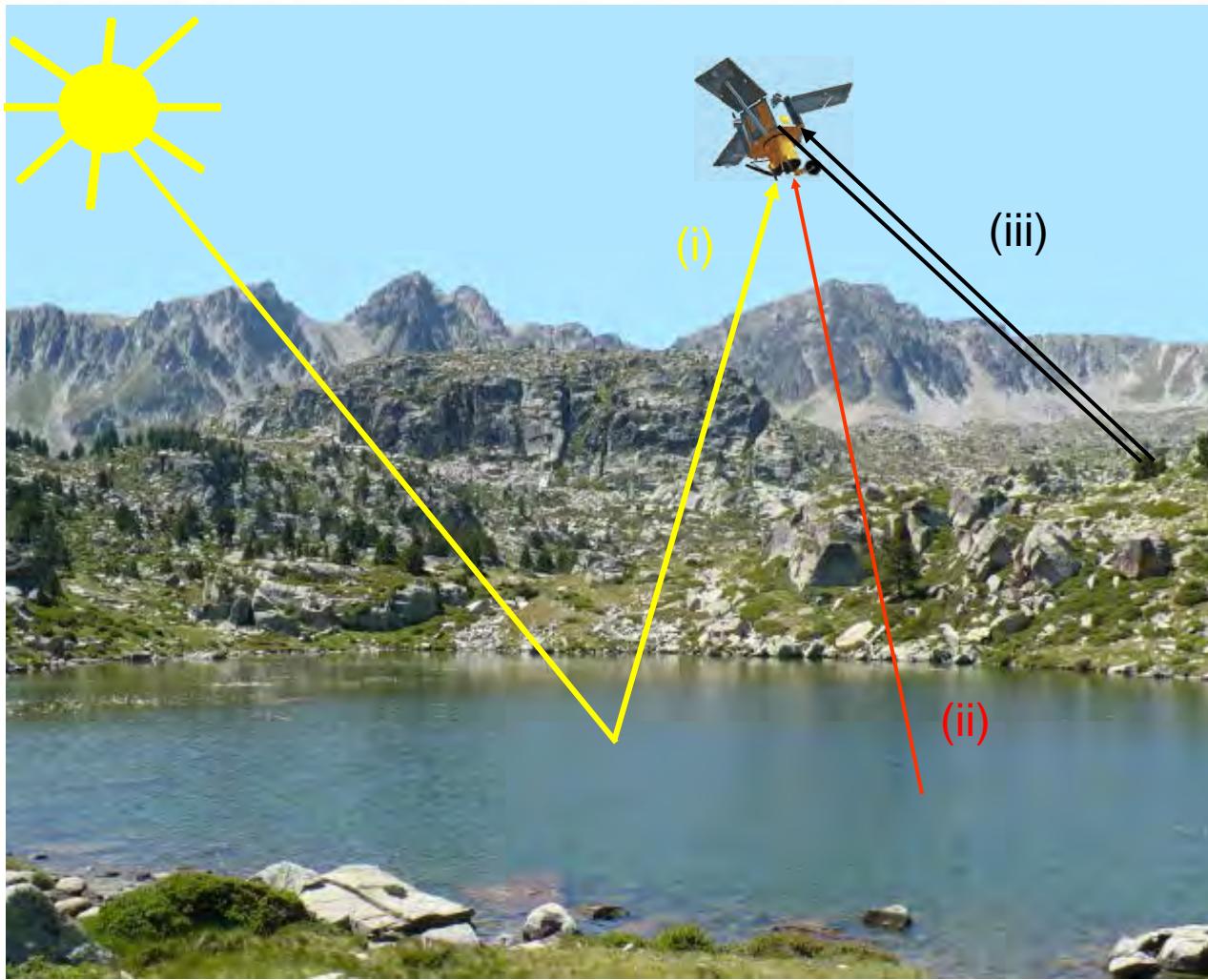
### Introduction to Optical/Thermal Remote Sensing

E. Chuvieco  
(Univ. of Alcala, Spain)



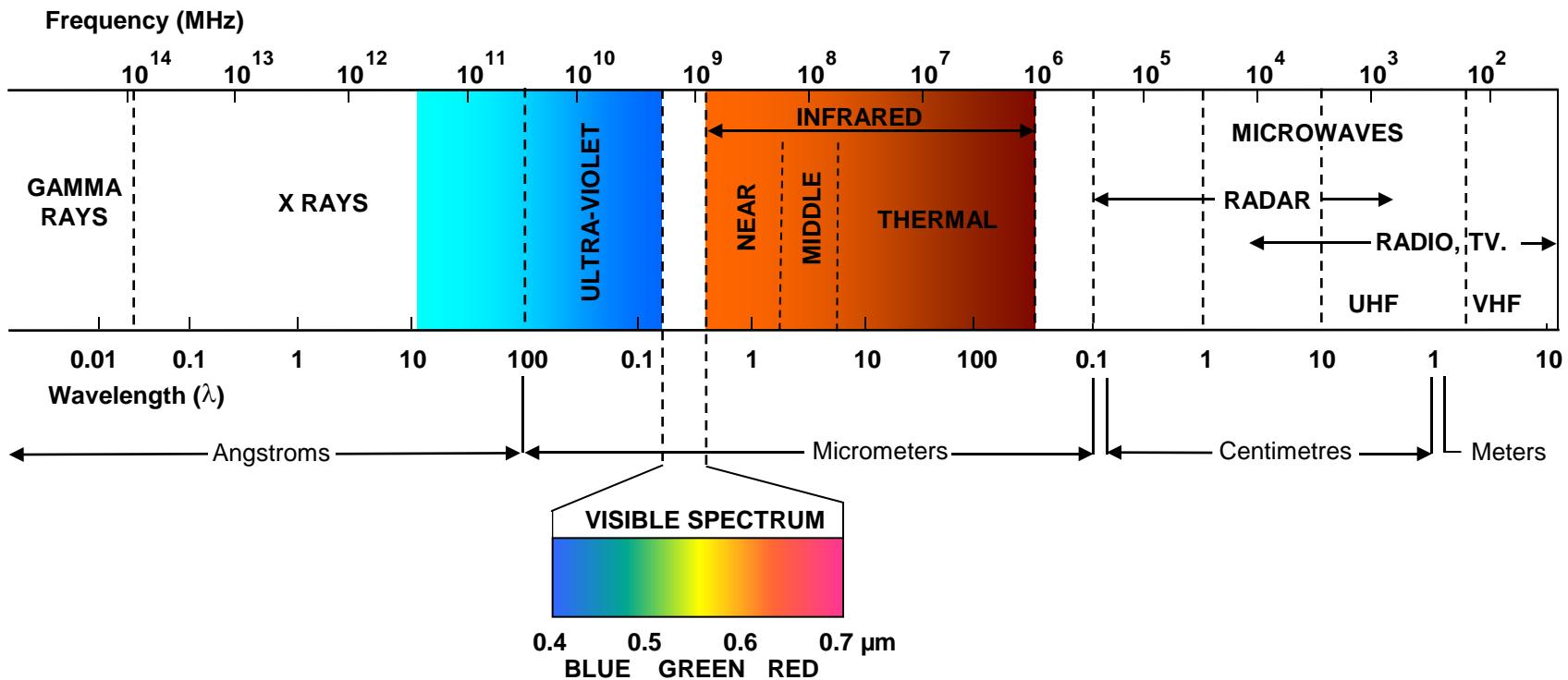


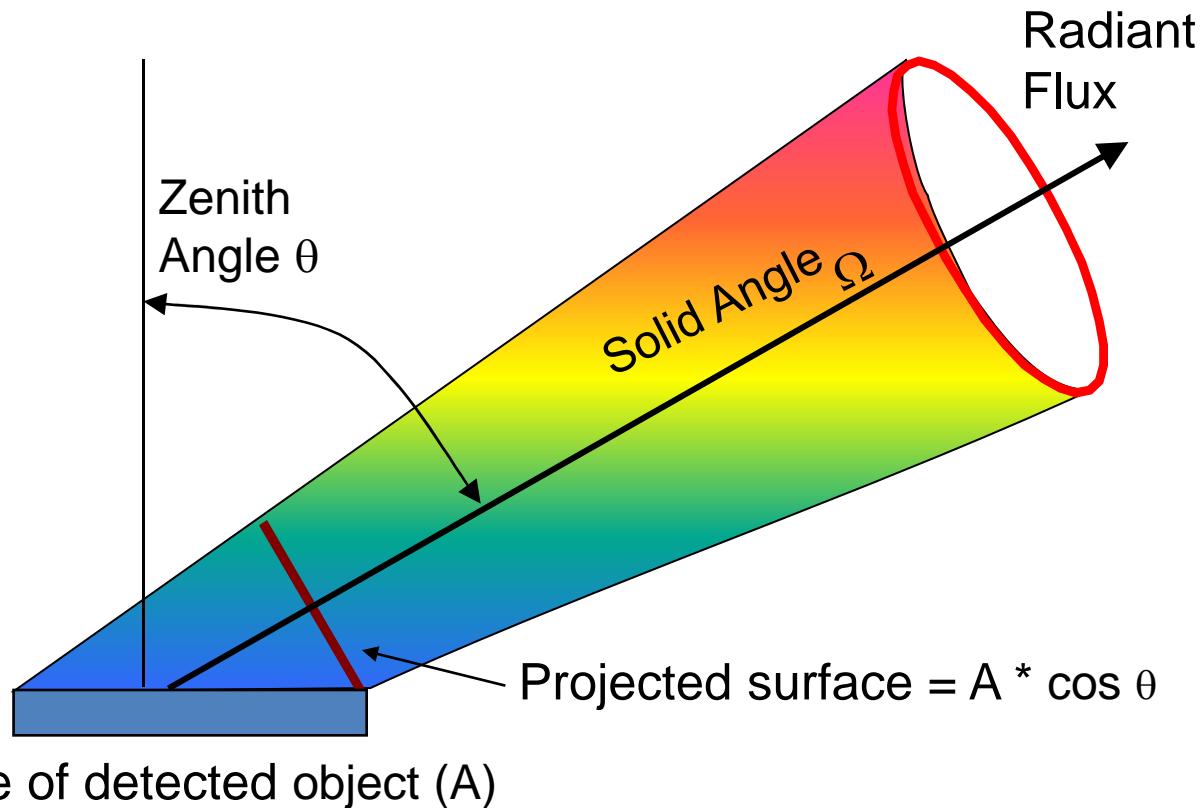
# Physical basis



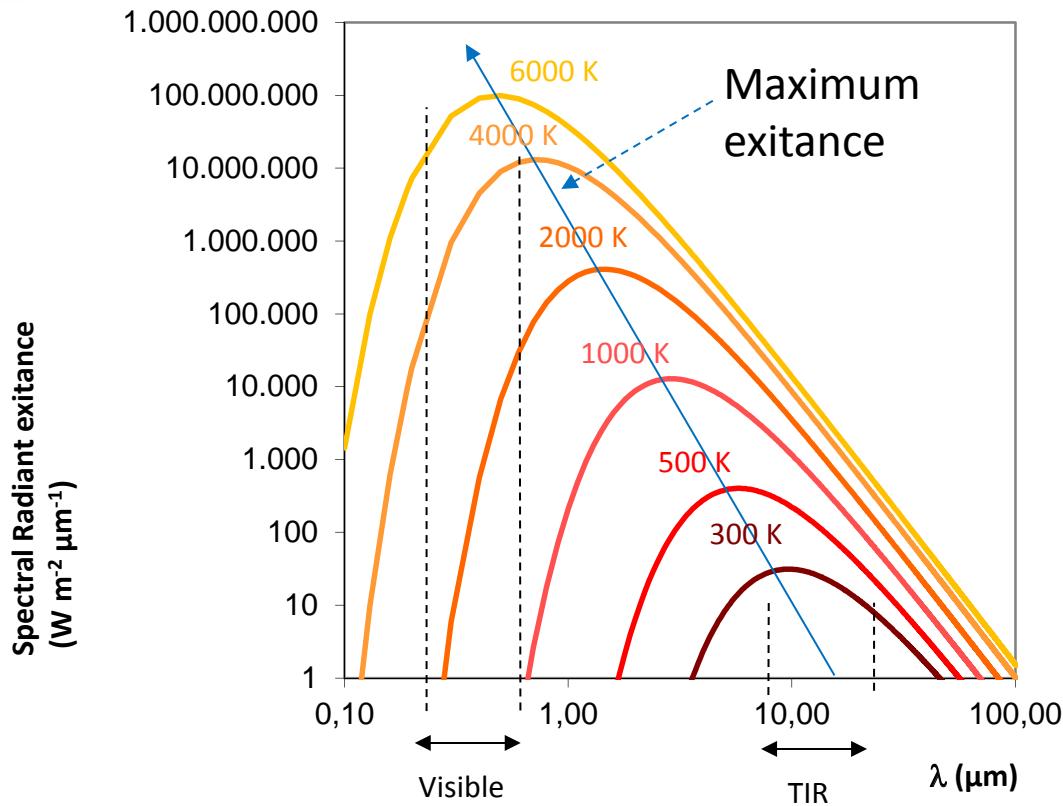


# Electromagnetic spectrum

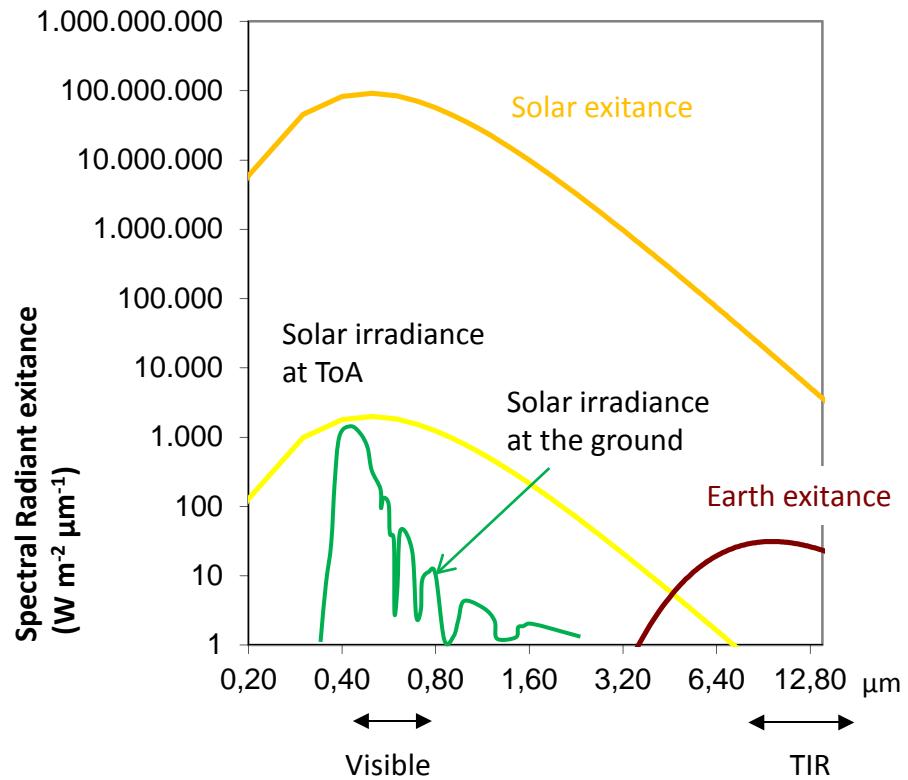


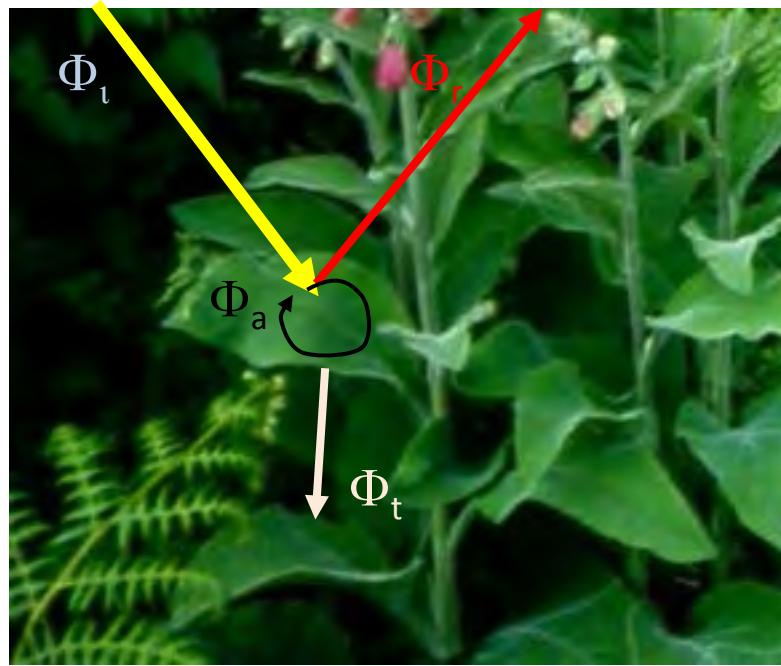


# Radiant emittance



# Solar-Earth emittance





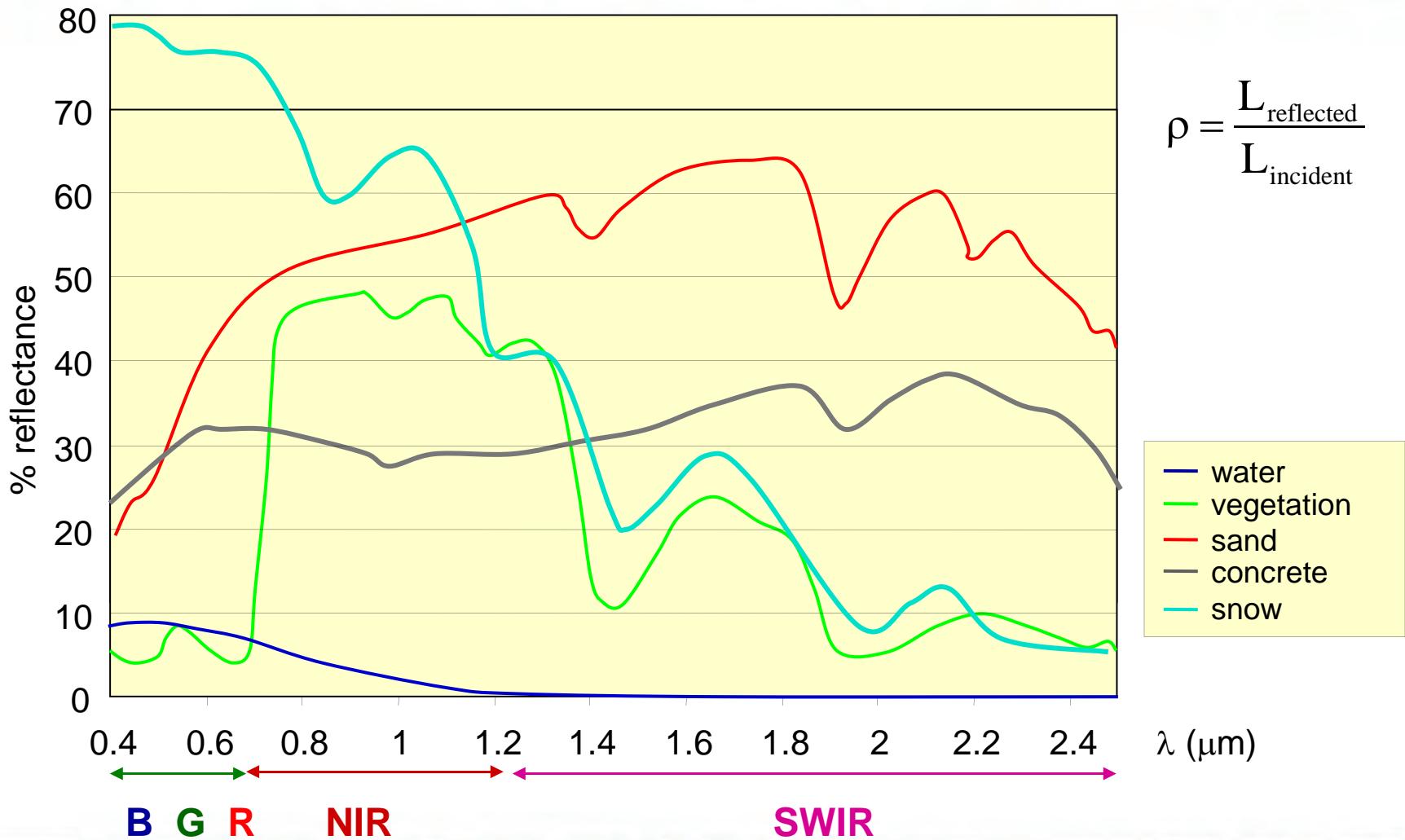
$\Phi_i$  Incident energy

$\Phi_r$  Reflected energy

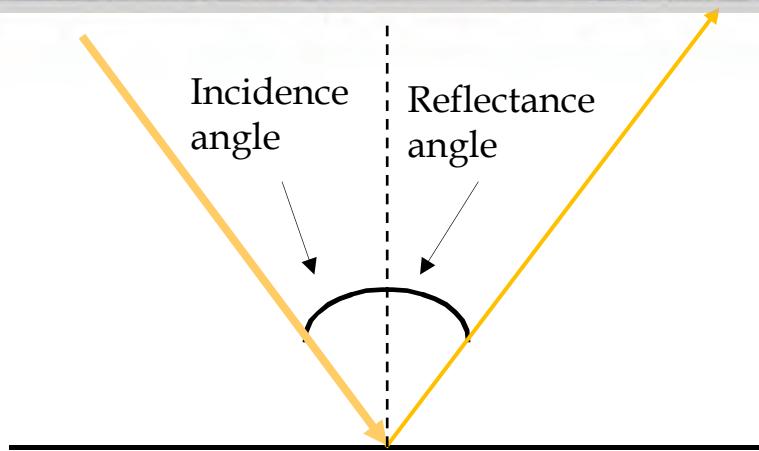
$\Phi_a$  Absorbed energy

$\Phi_t$  Transmitted energy

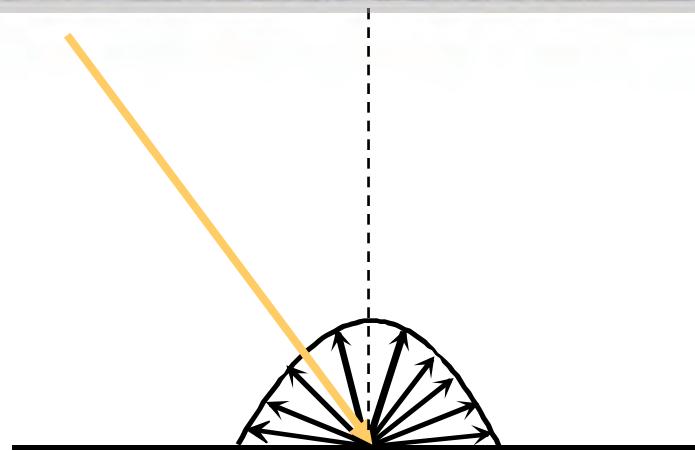
# Spectral signatures



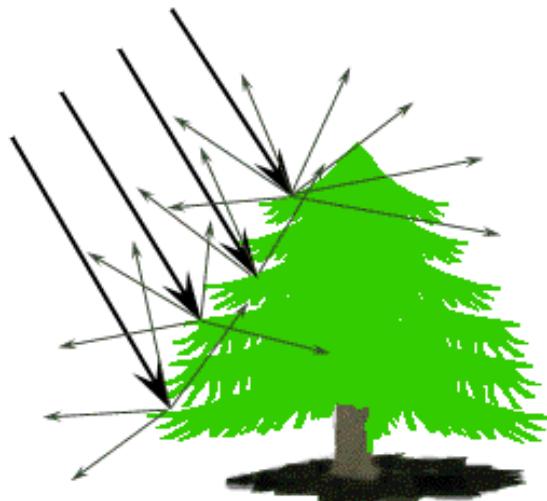
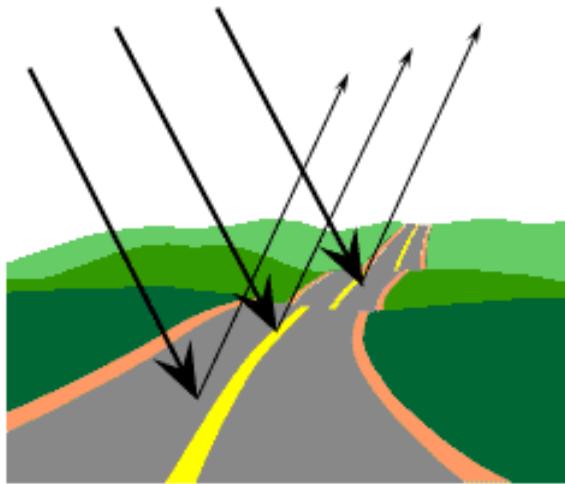
# Type of reflectors



Specular reflector

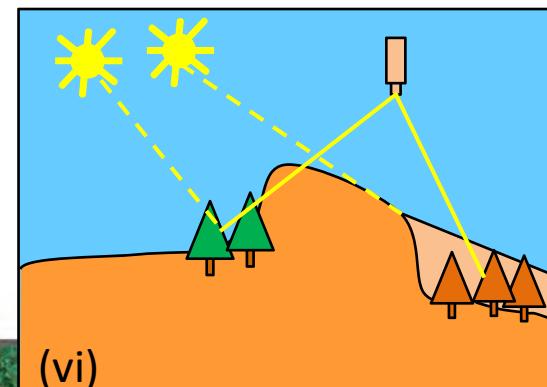
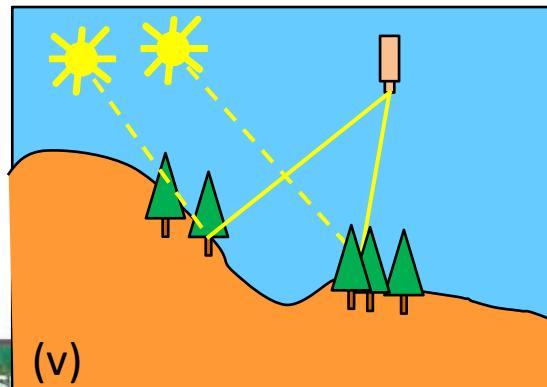
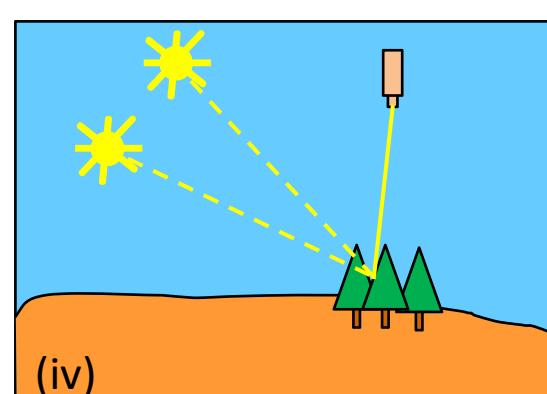
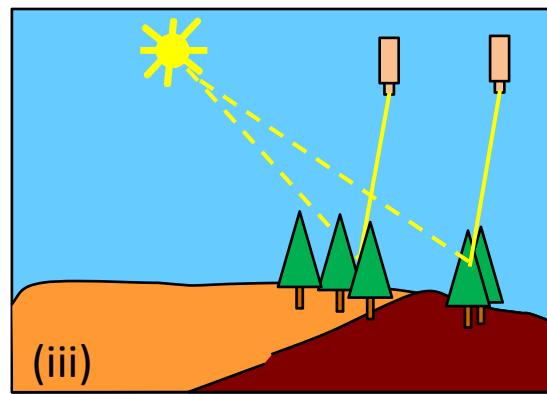
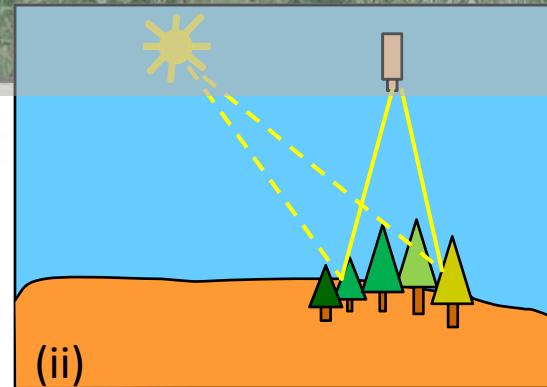
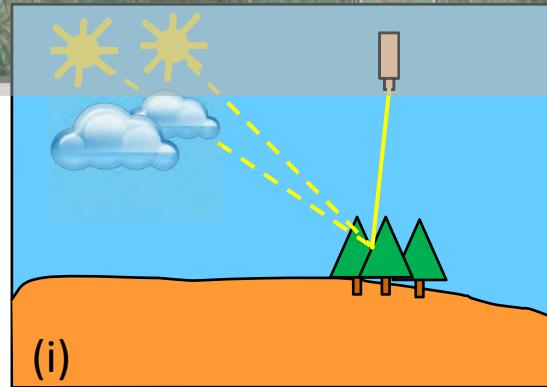


Lambertian reflector

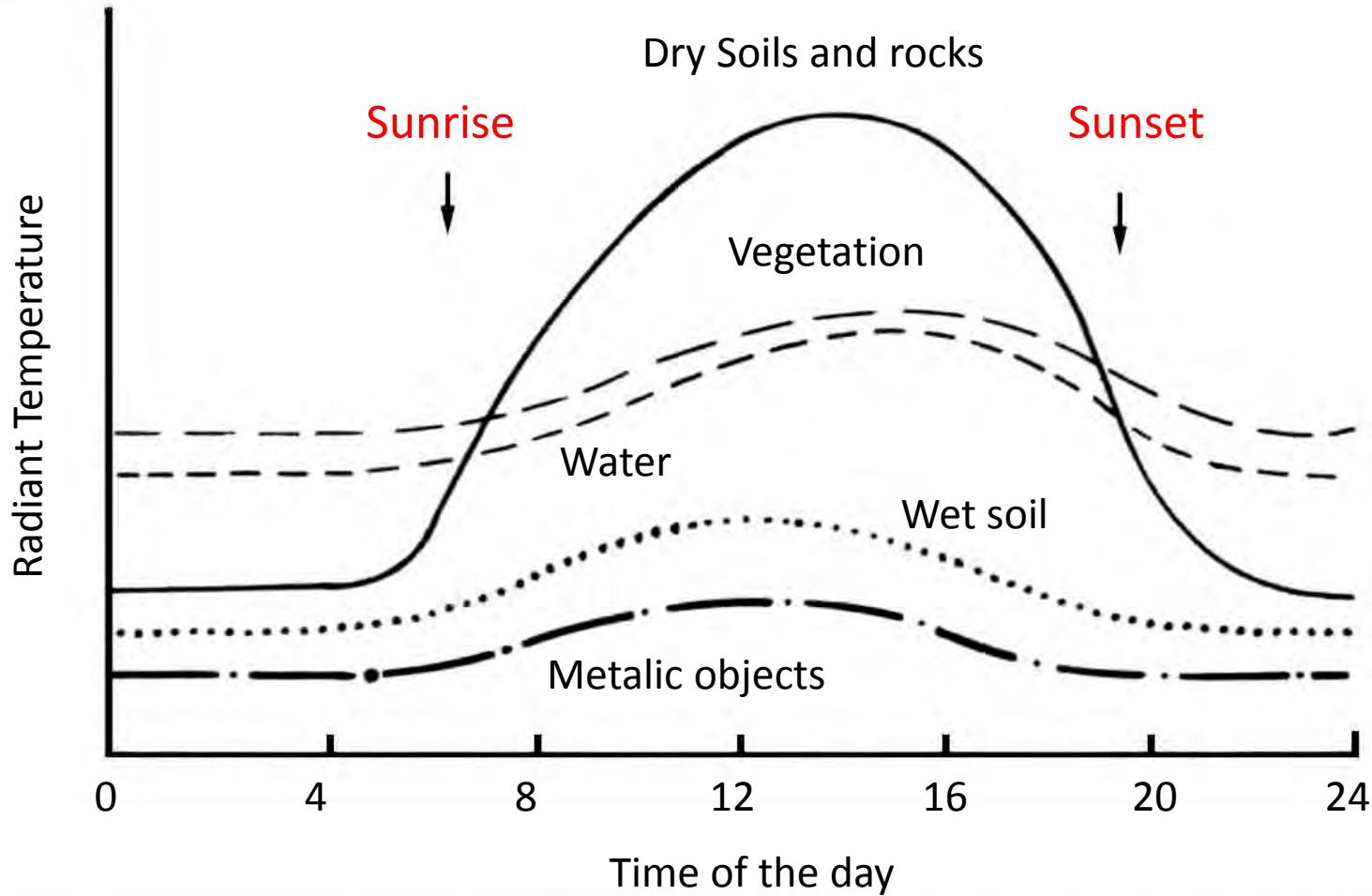


# Sun glint





# Thermal inertia





# Sea surface temperature

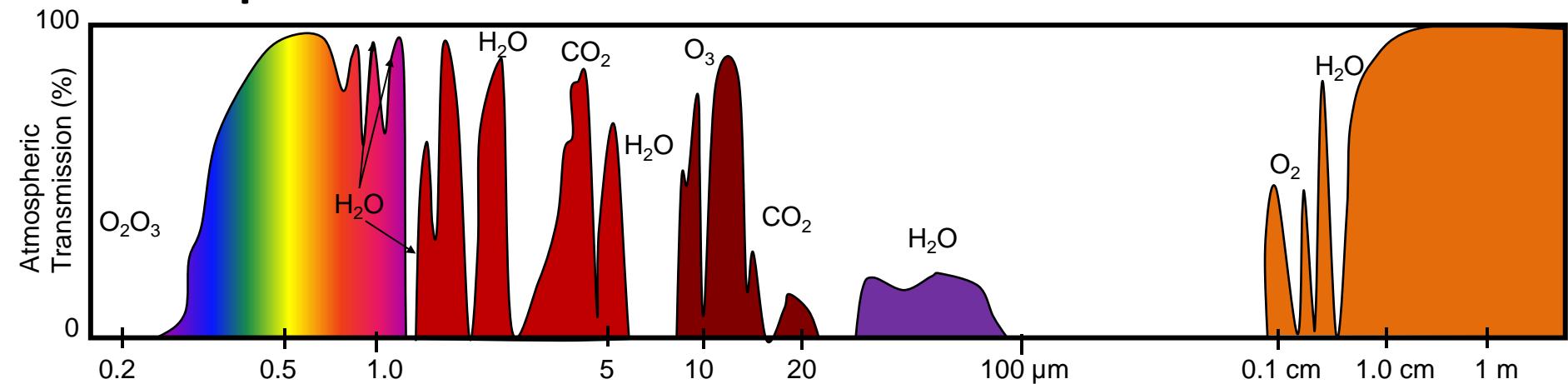


July

→ 6th ESA ADVANCED TRAINING COURSE ON LAND REMOTE SENSING

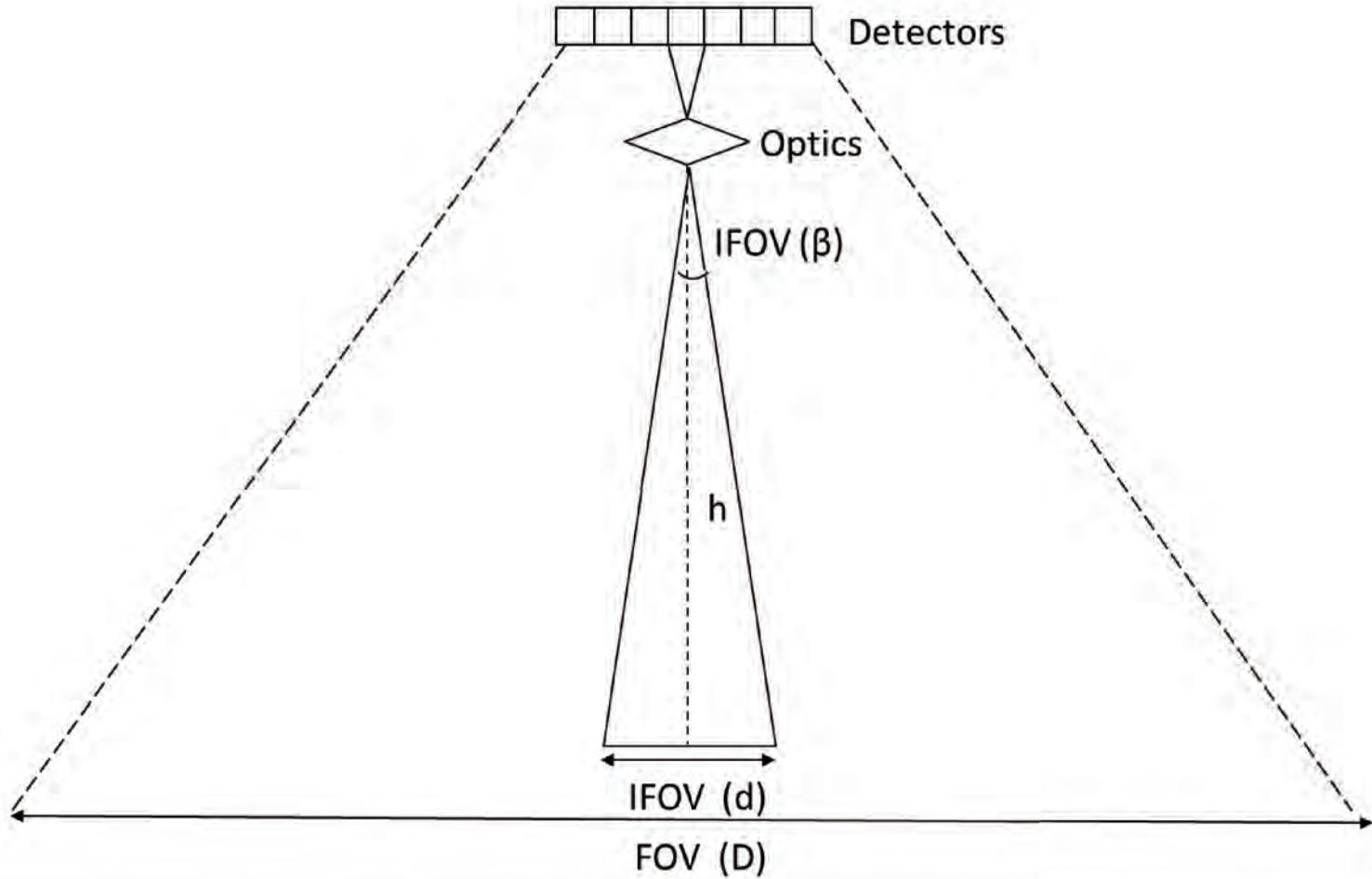
14–18 September 2015 | University of Agronomic Science and Veterinary Medicine Bucharest | Bucharest, Romania

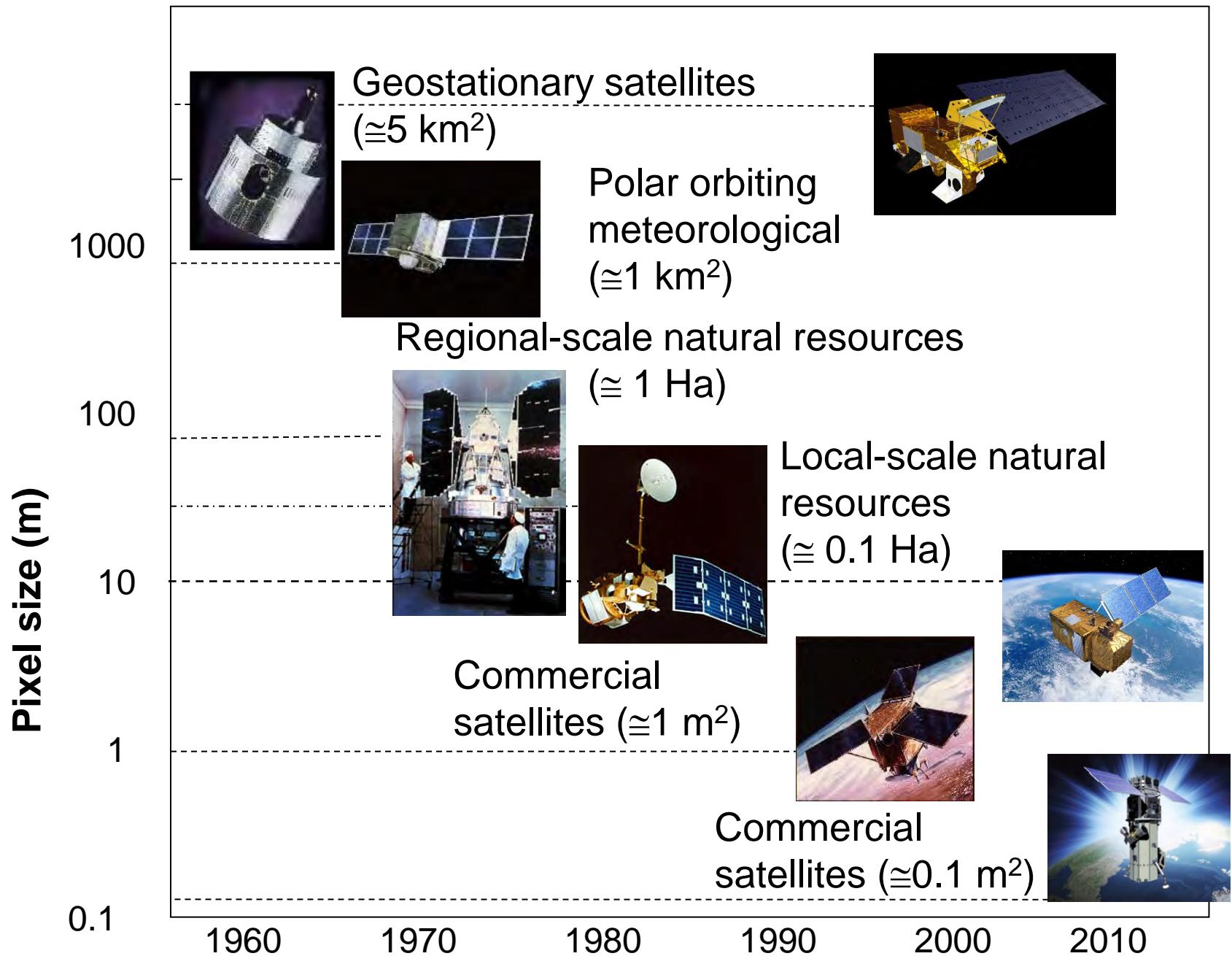
## Atmospheric windows



- Atmospheric transmissivity.
- Atmospheric dispersion.
- Atmospheric emissivity.

# Spatial resolution



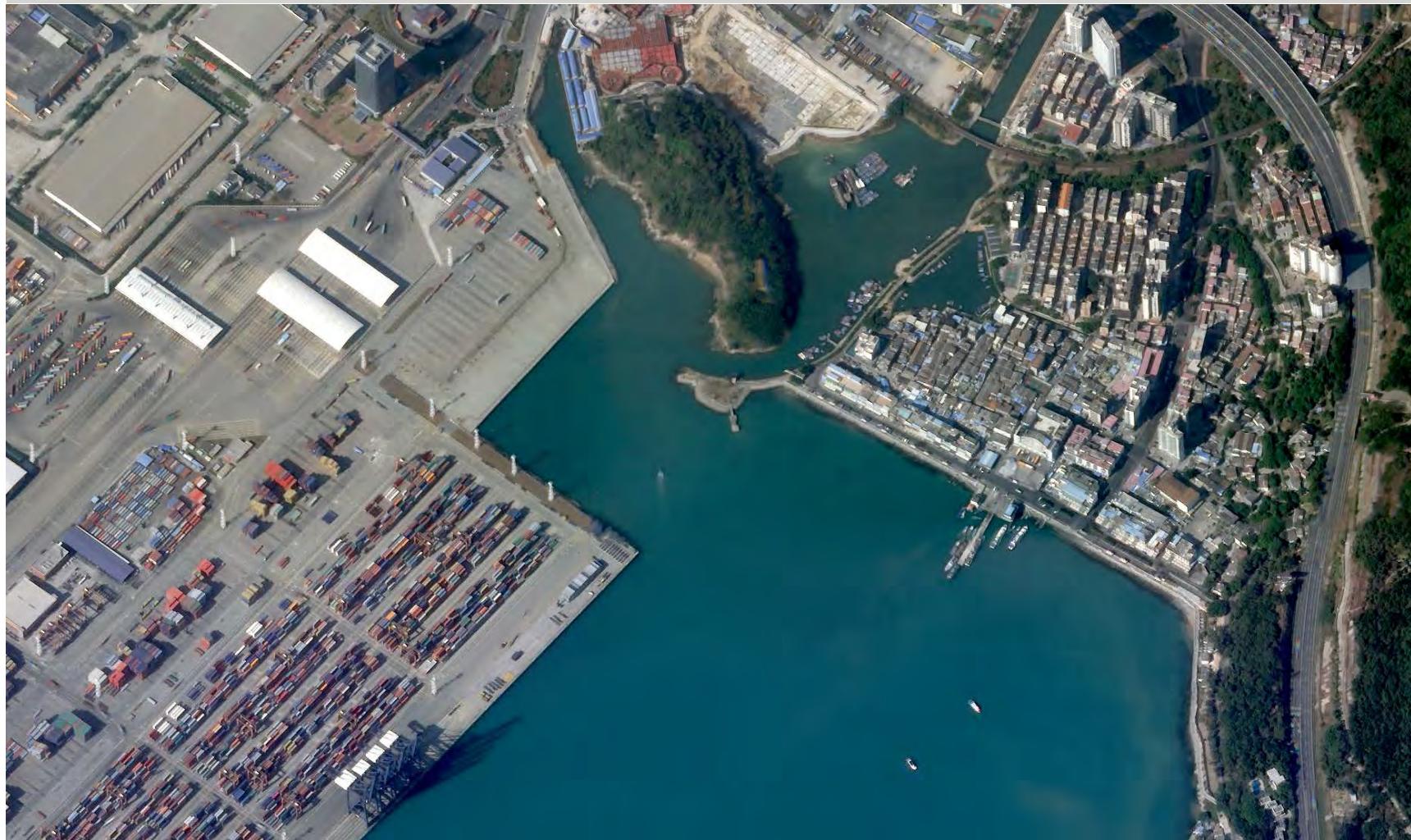


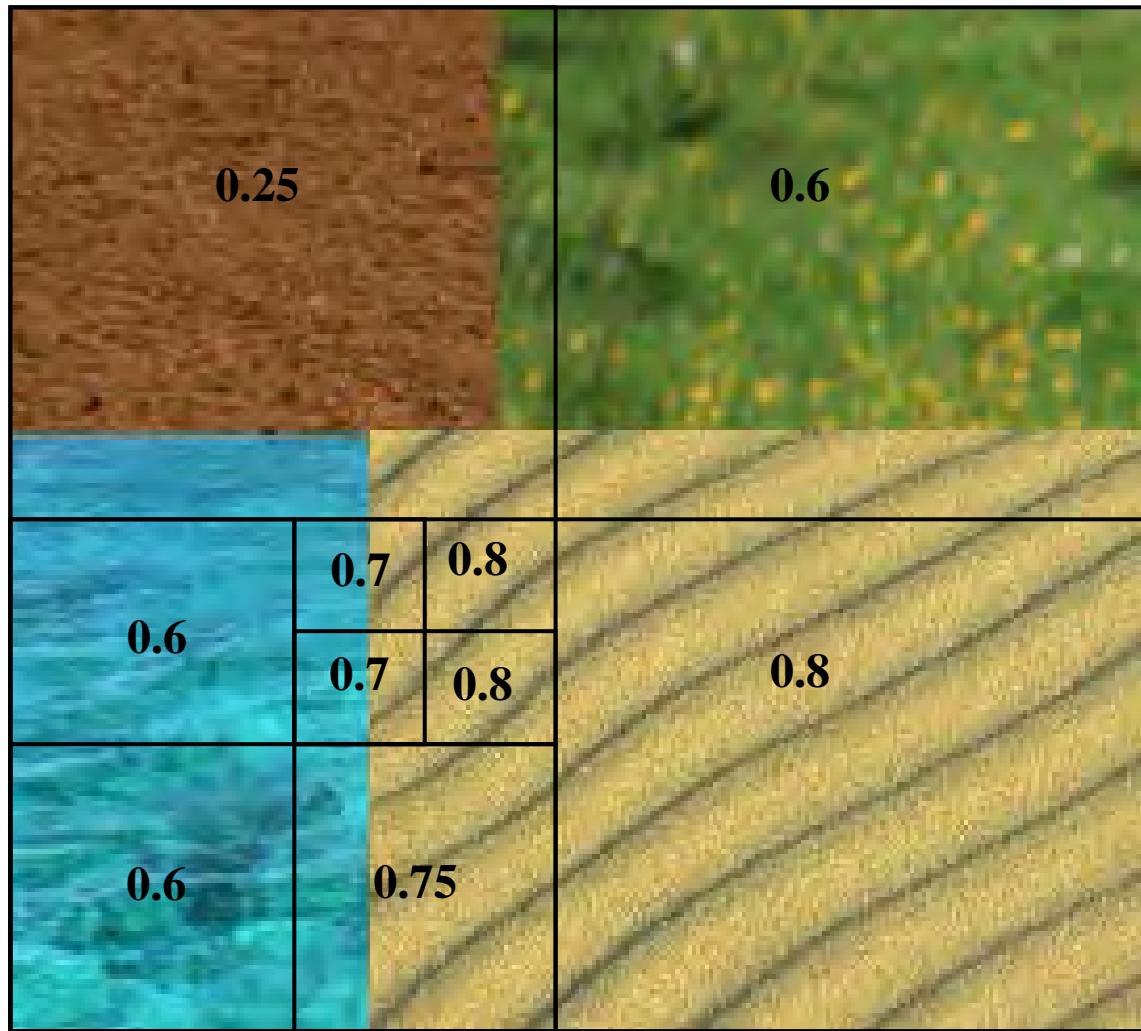
# High-resolution satellites: Geoeye esa



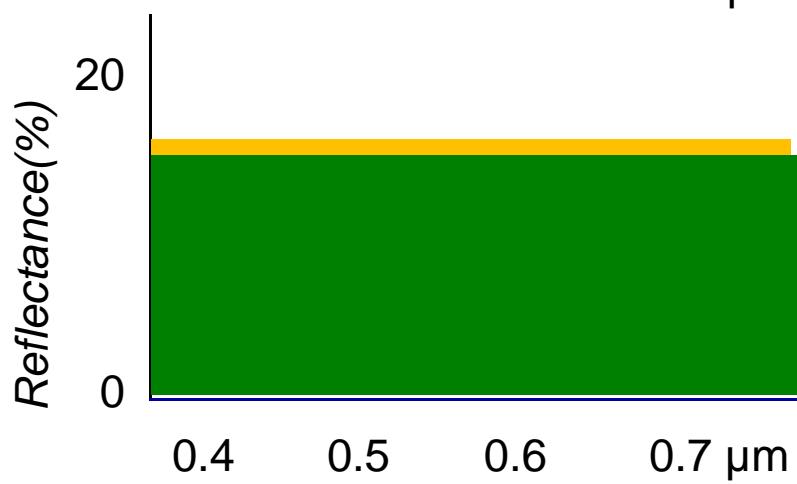
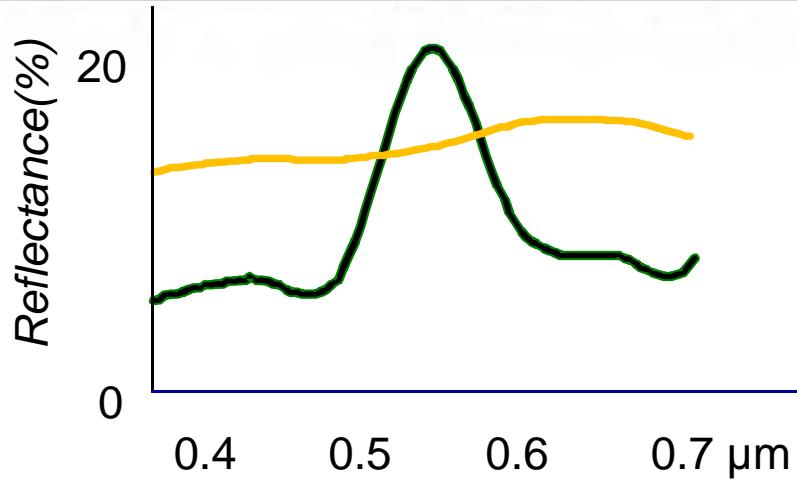


# Low-cost high-resolution satellites

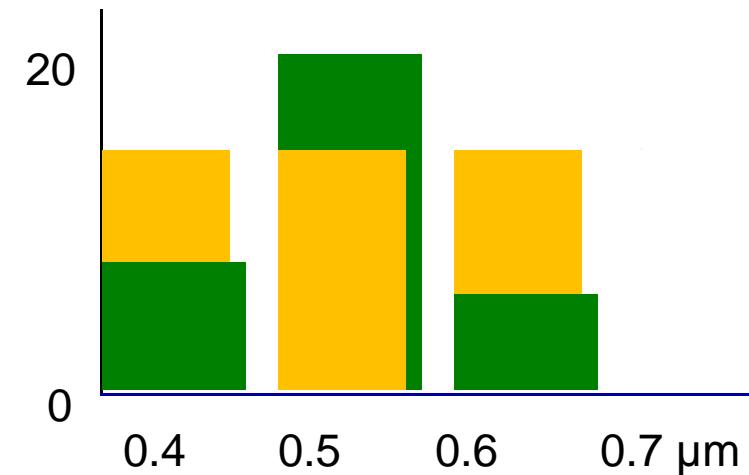




# Spectral resolution



One band



Three bands

# Radiometric resolution

11 bits: 2048



8 bits: 256



AREA 1: Bright areas



AREA 2: Dark areas

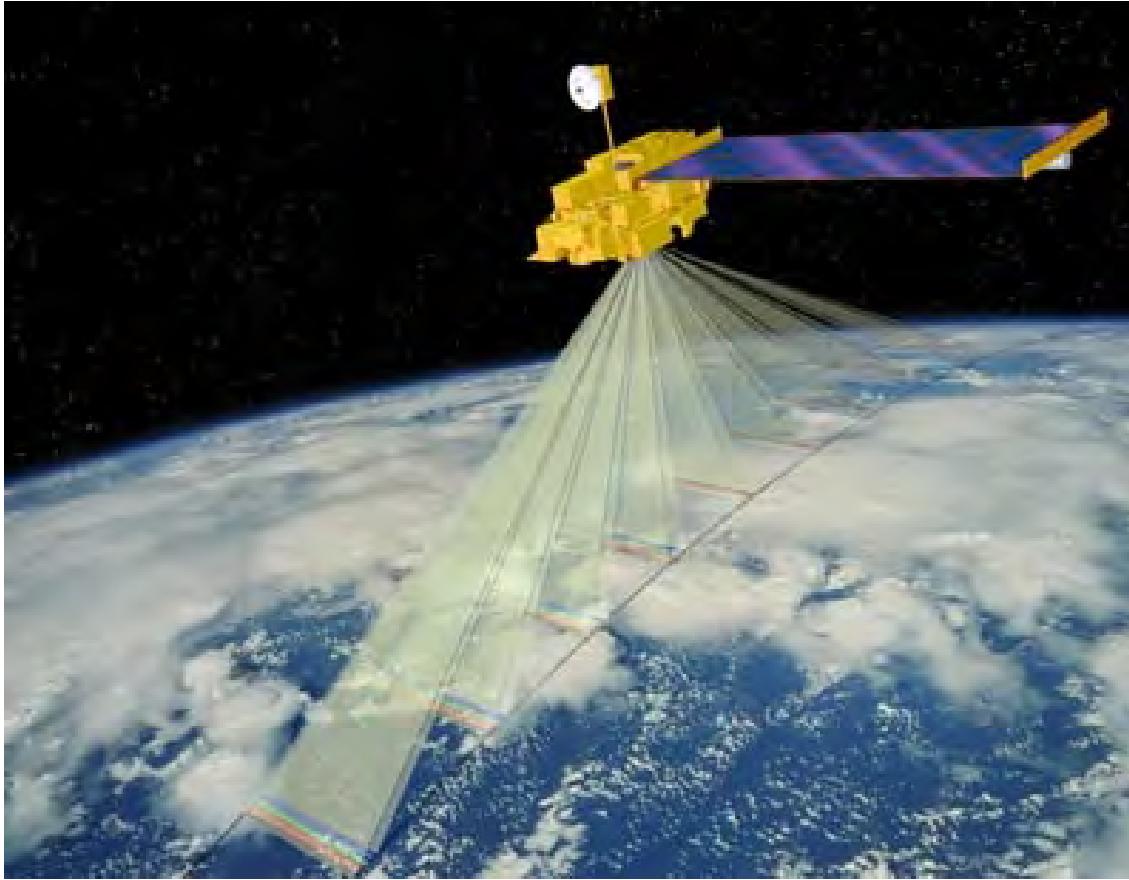


# Temporal resolution

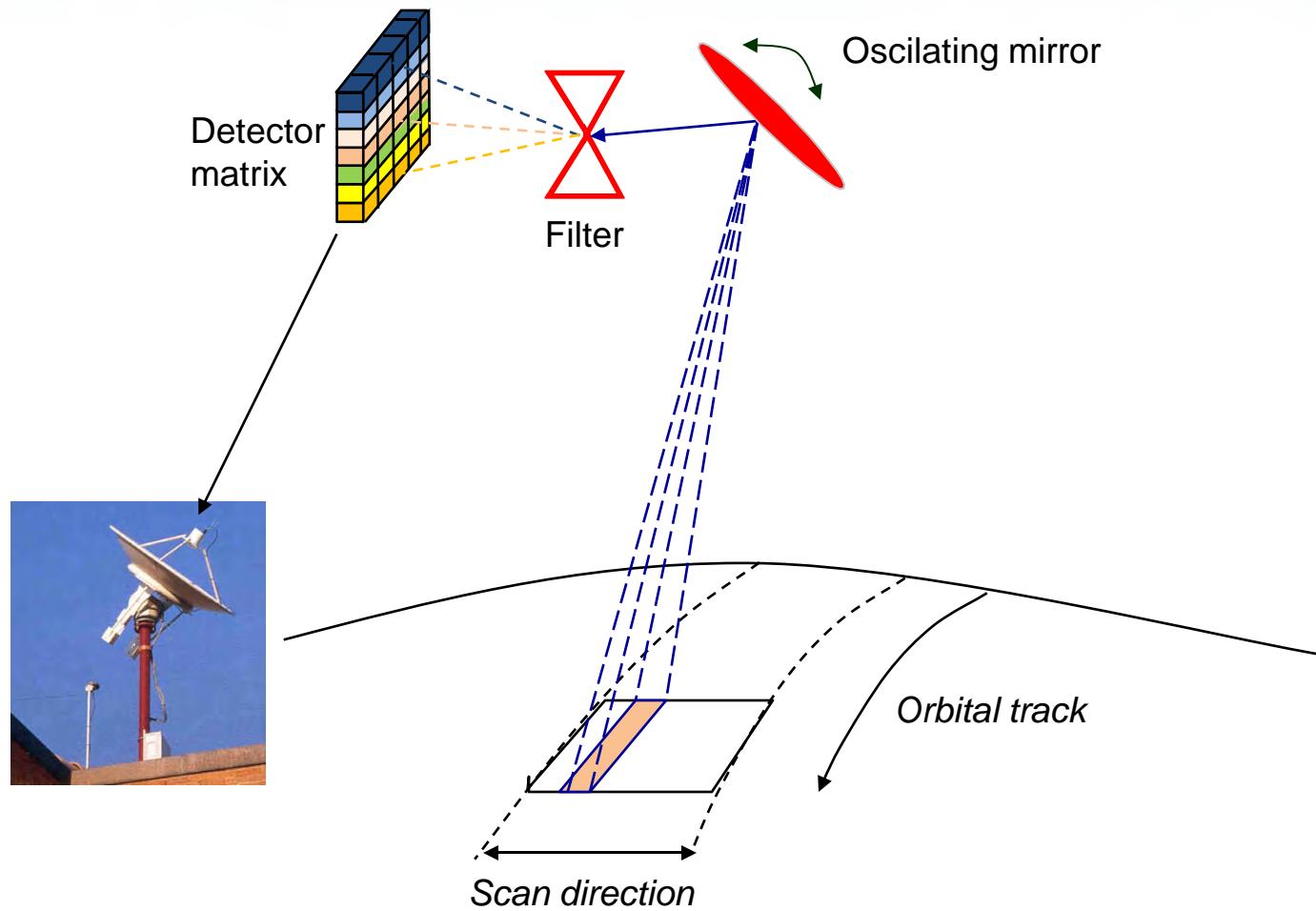




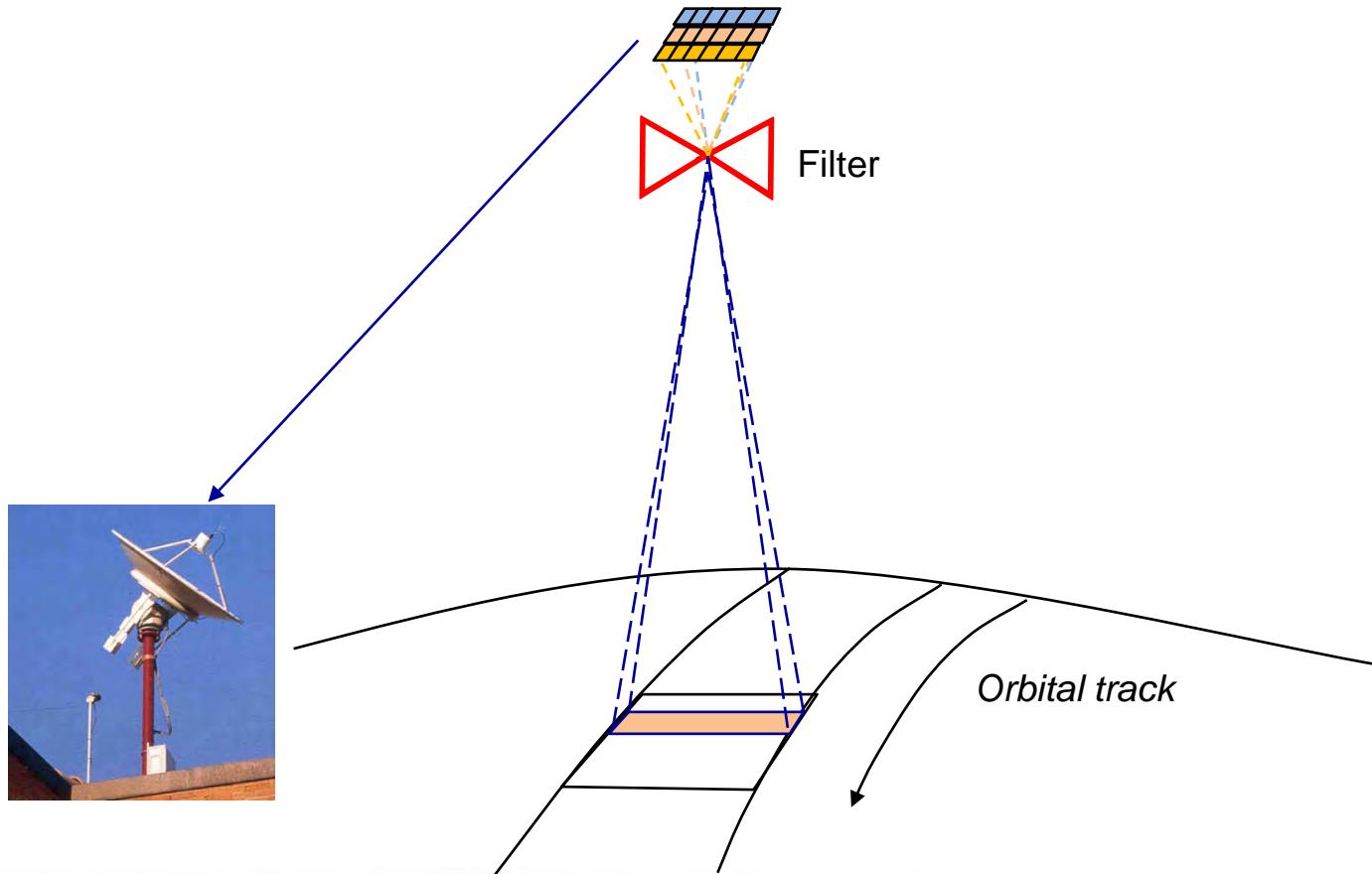
# Angular resolution



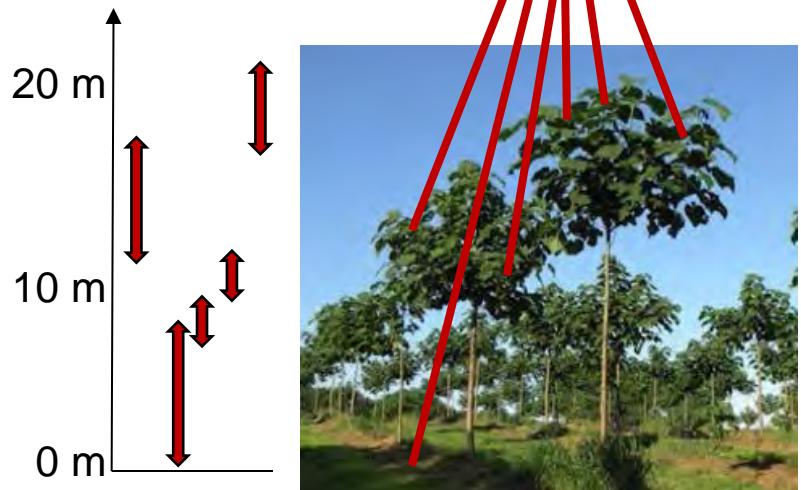
# Multispectral Scanners



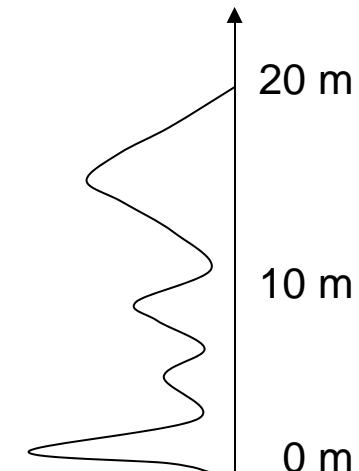
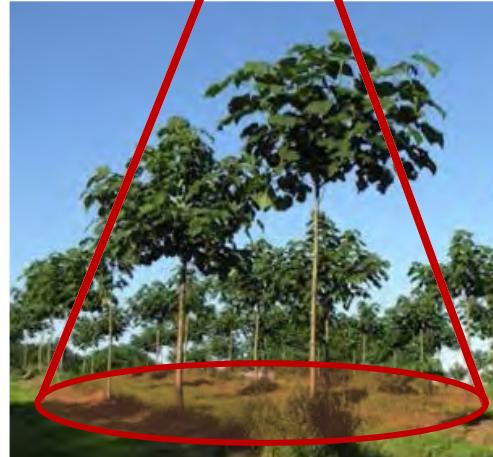
# Pushbroom scanners



# Lidar systems



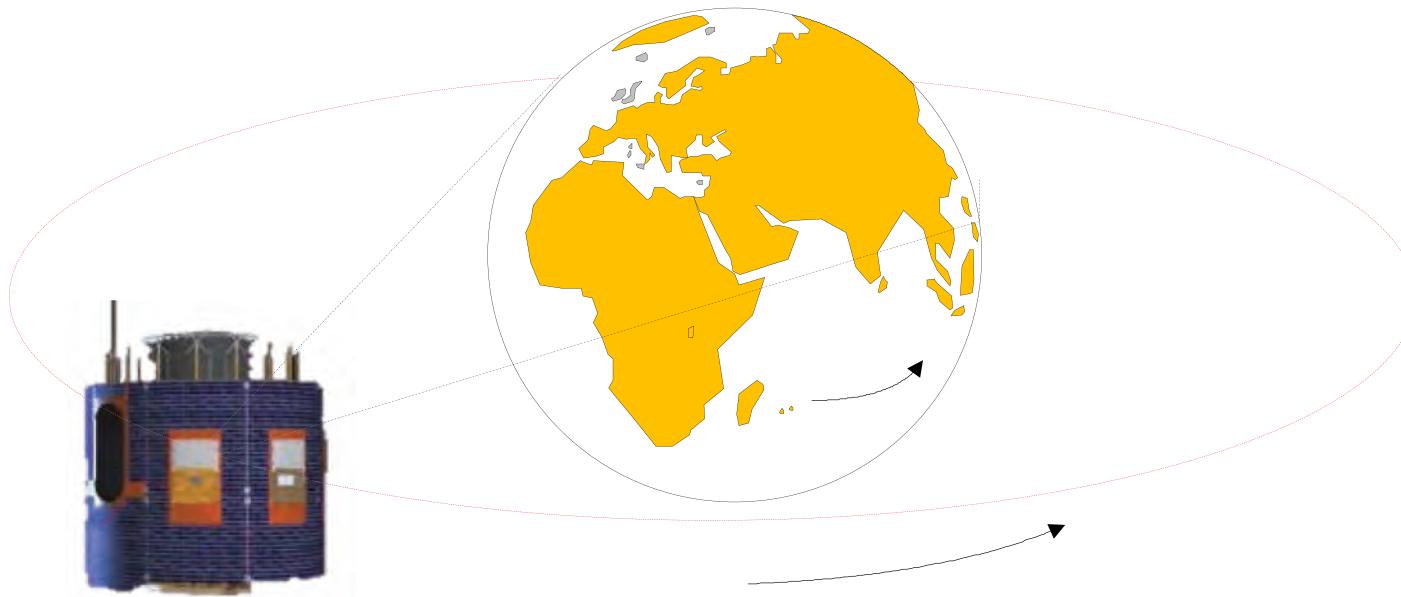
Discrete pulses



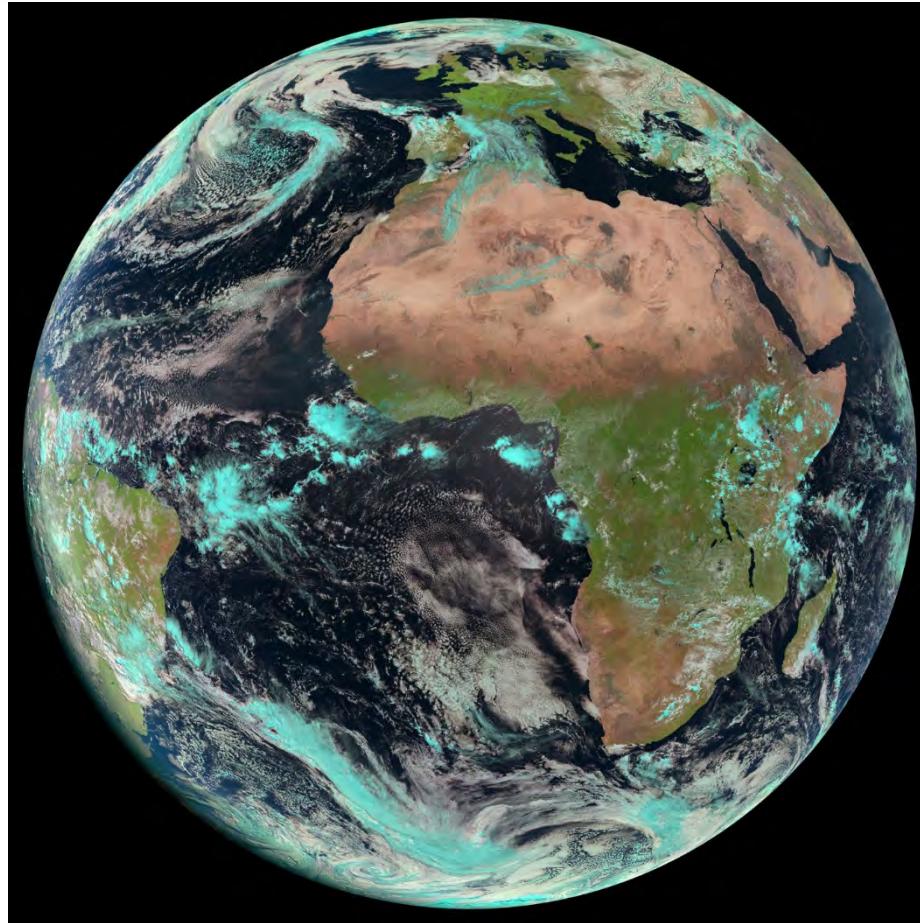
Full waveform



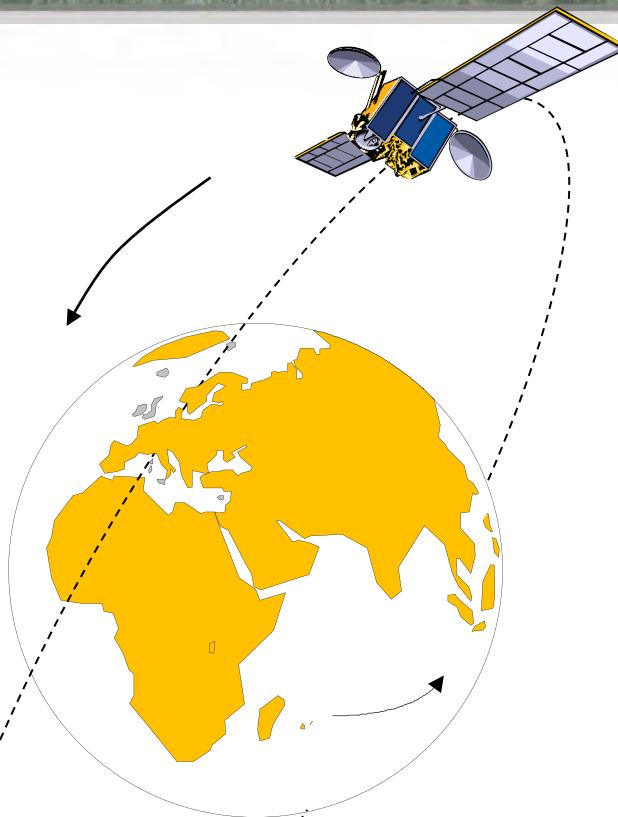
# Geosynchronous satellites

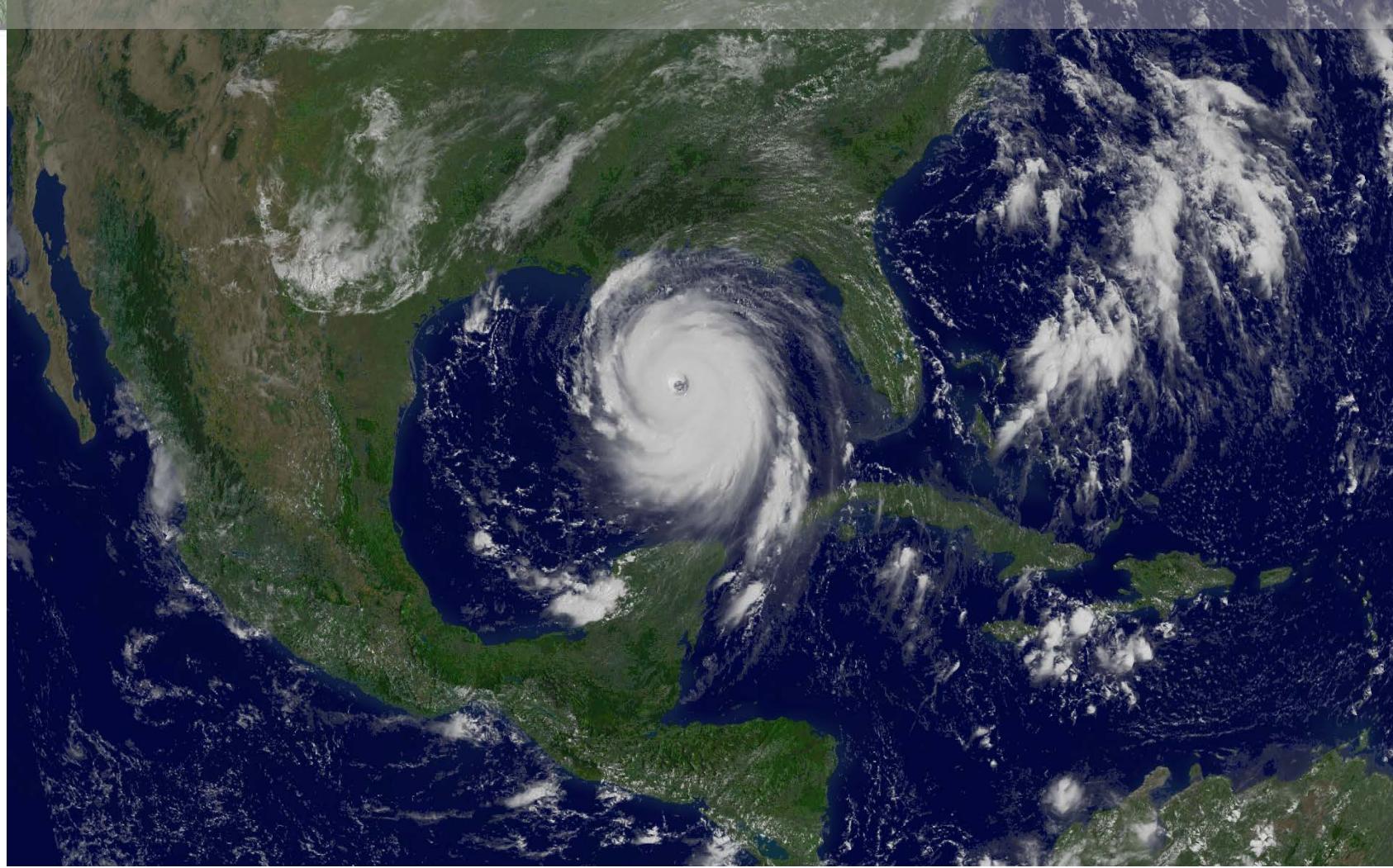


# Meteosat image

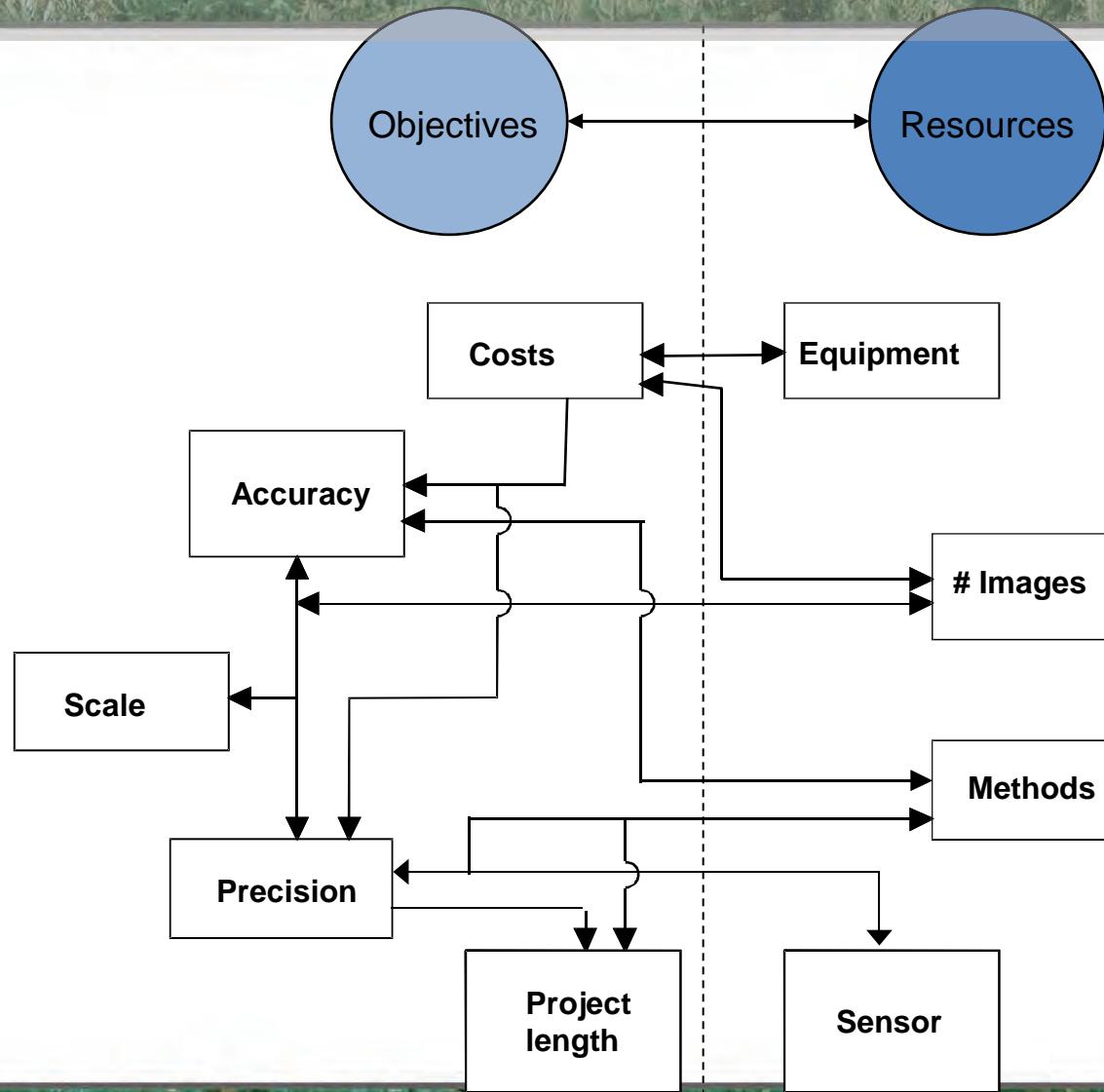


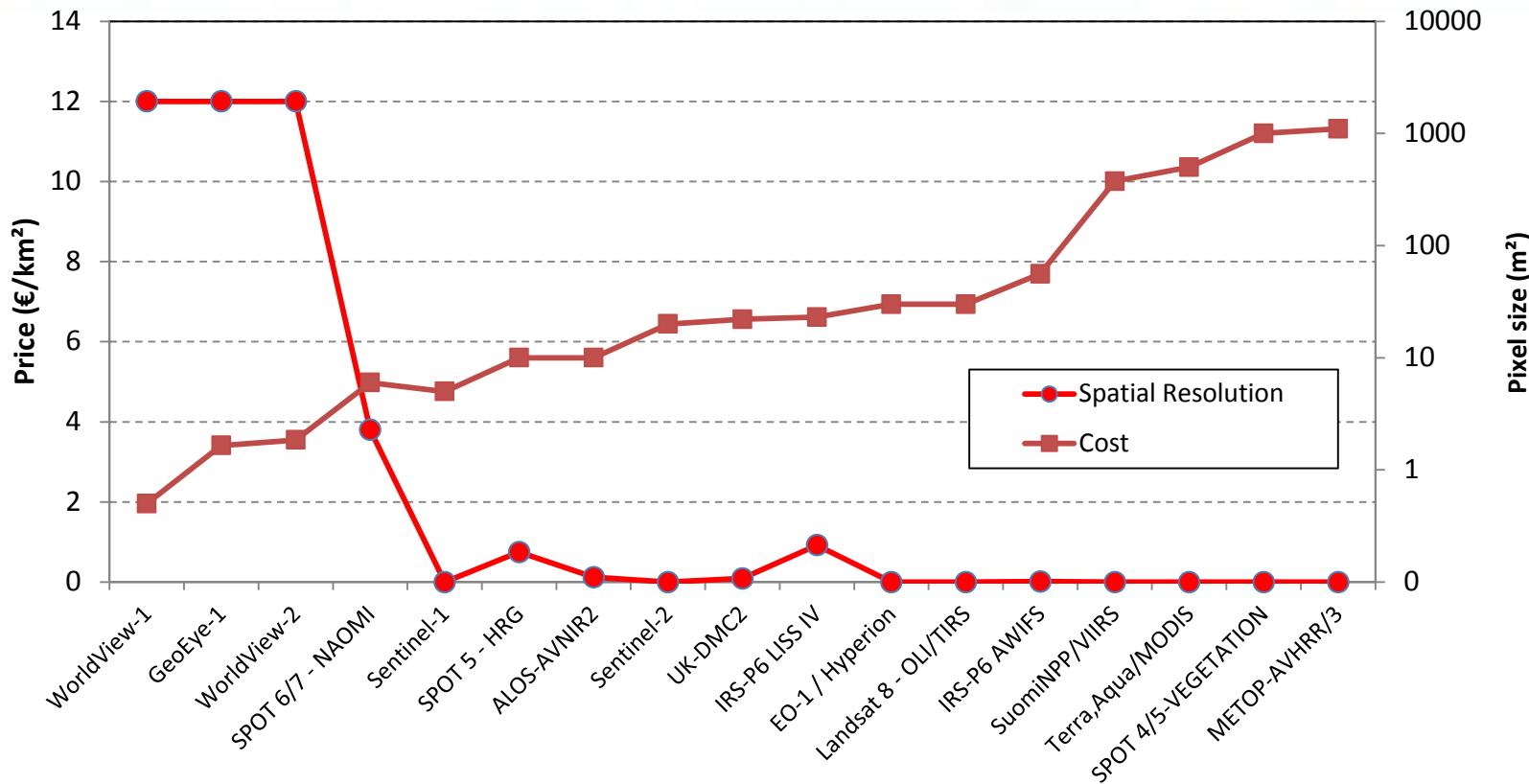
# Polar-orbital satellites

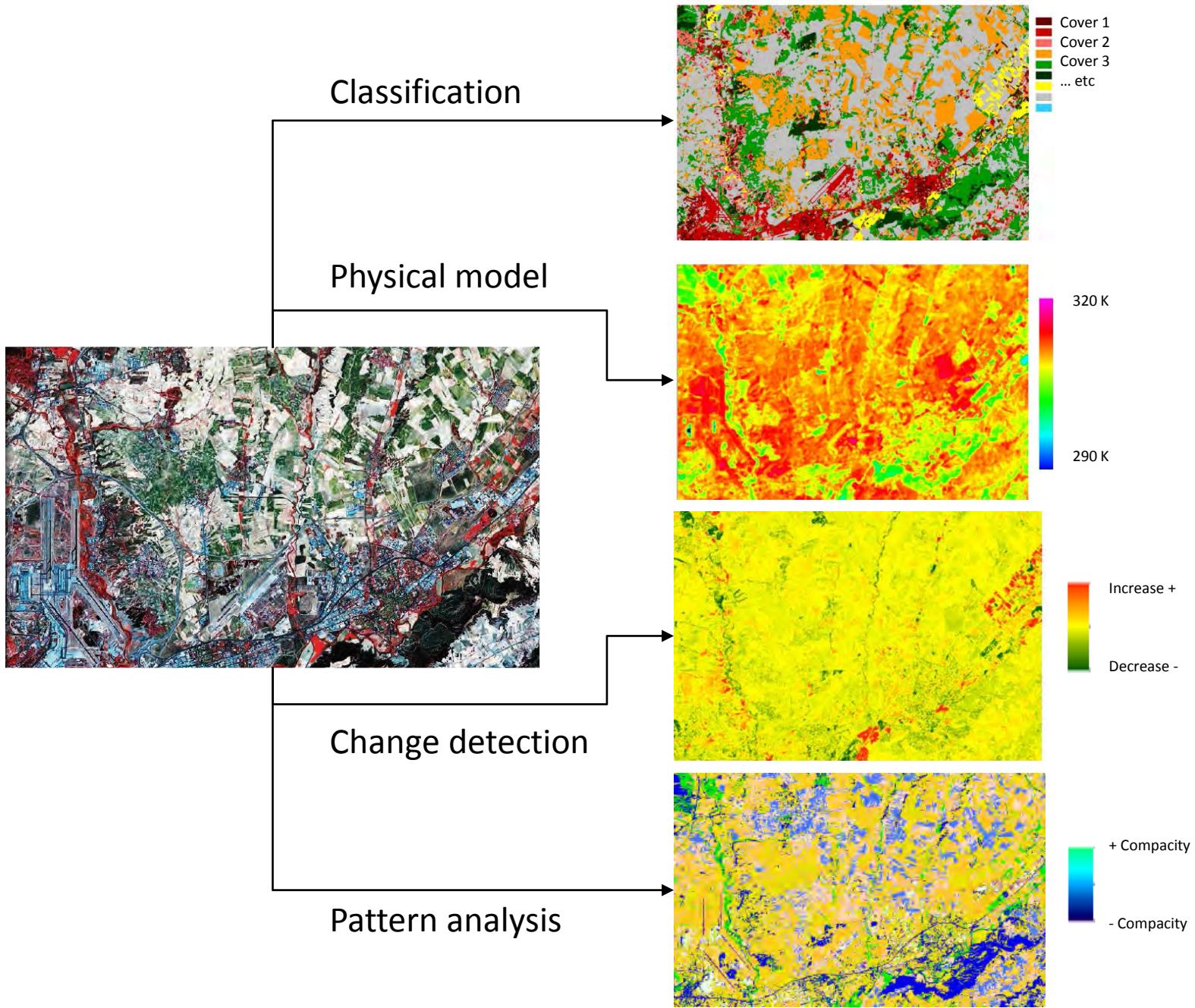




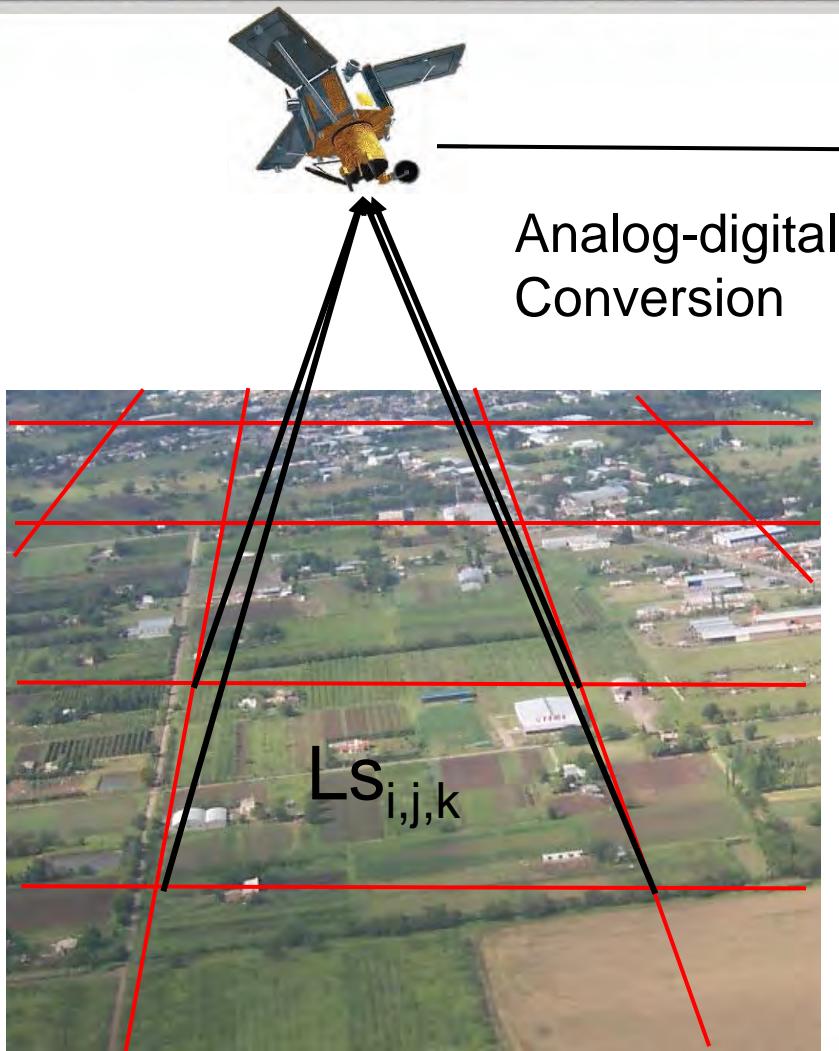
# Taken interpretation decisions



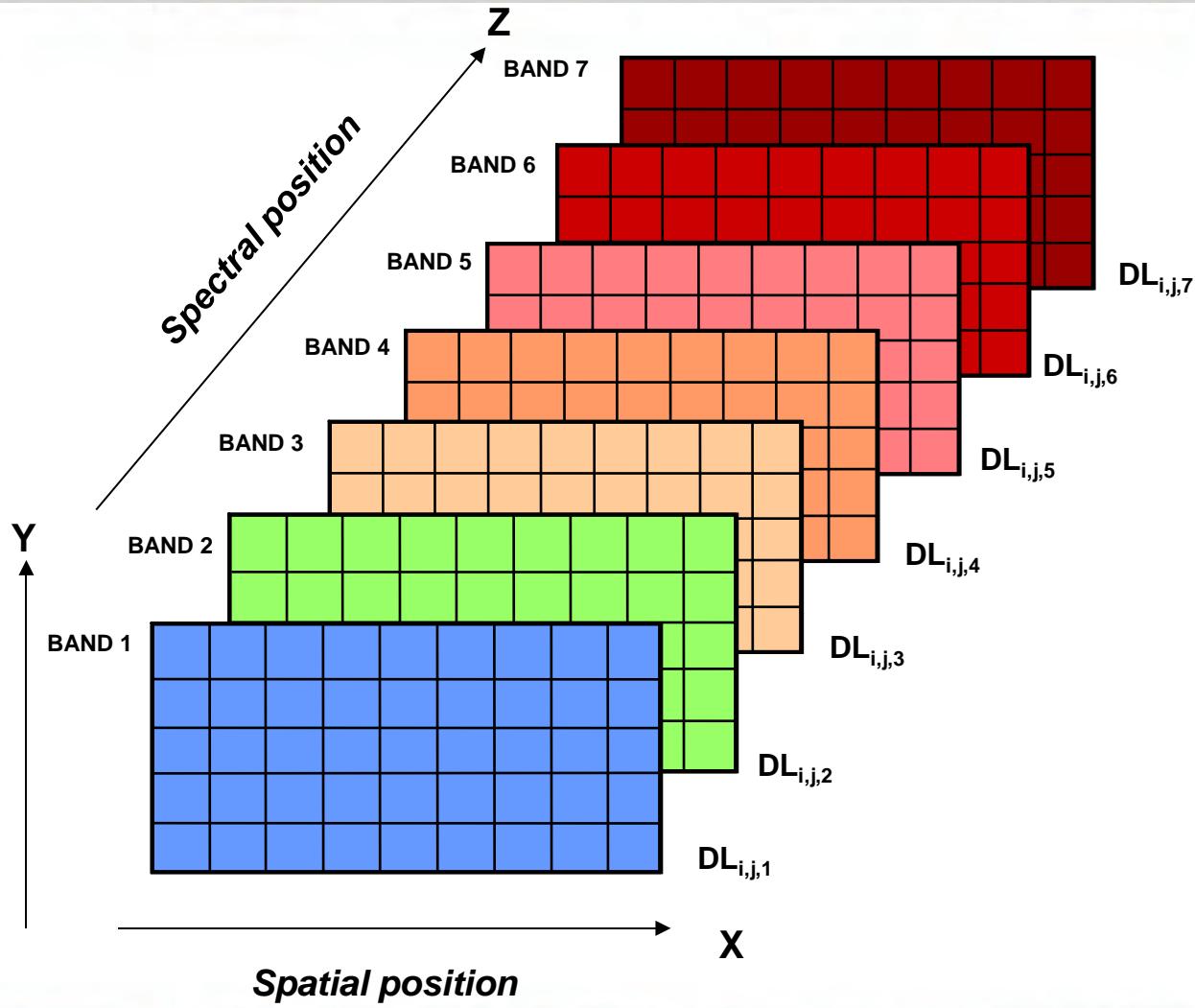




# Radiance to DL conversion



# Raster image structure



## Image processing potentials

- File operations.
- Image display.
- Image enhancement.
- Georectification.
- Generation of biophysical variables.
- Classification.
- Multitemporal change detection.
- Spatial analysis

Fig 5.6

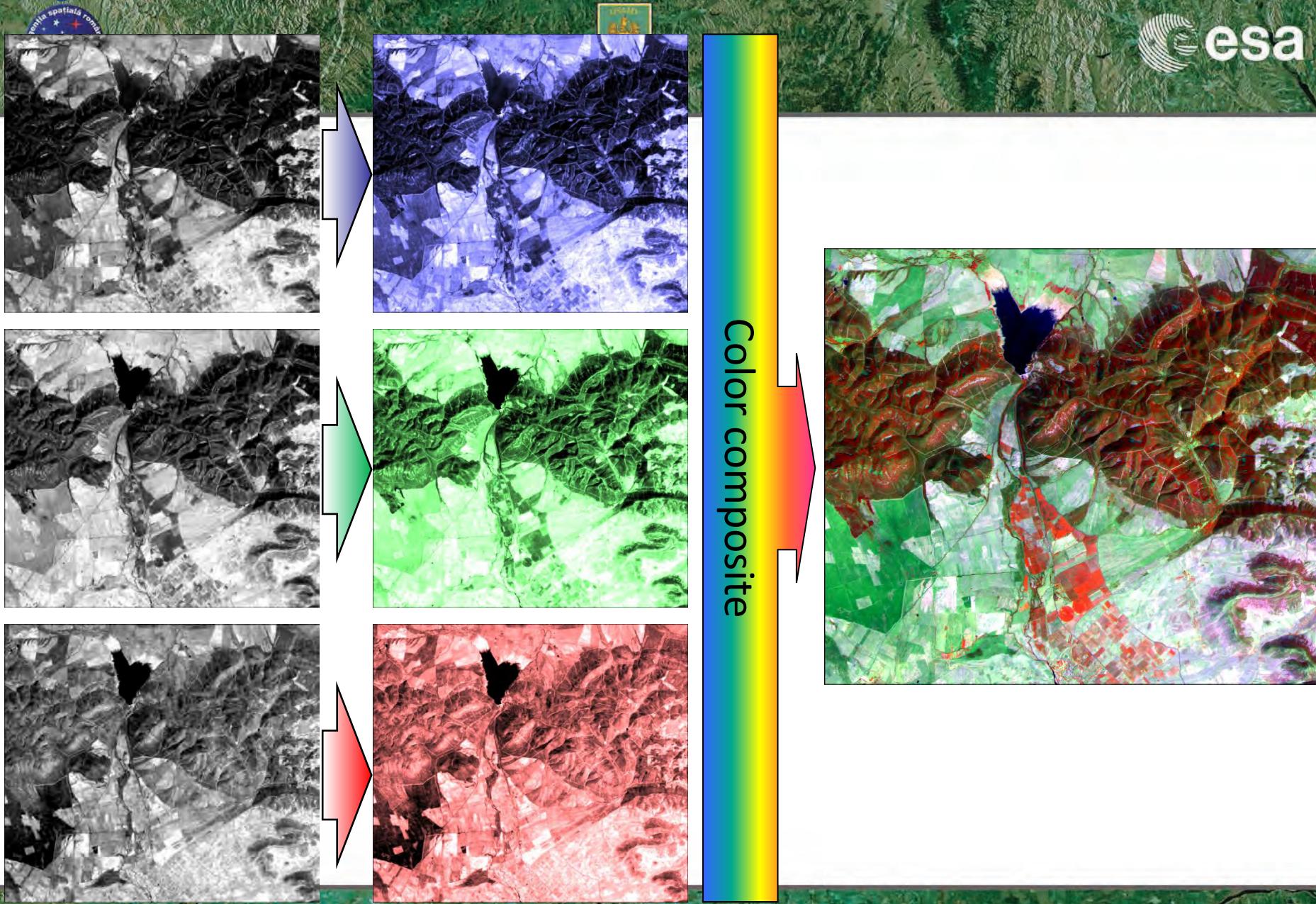
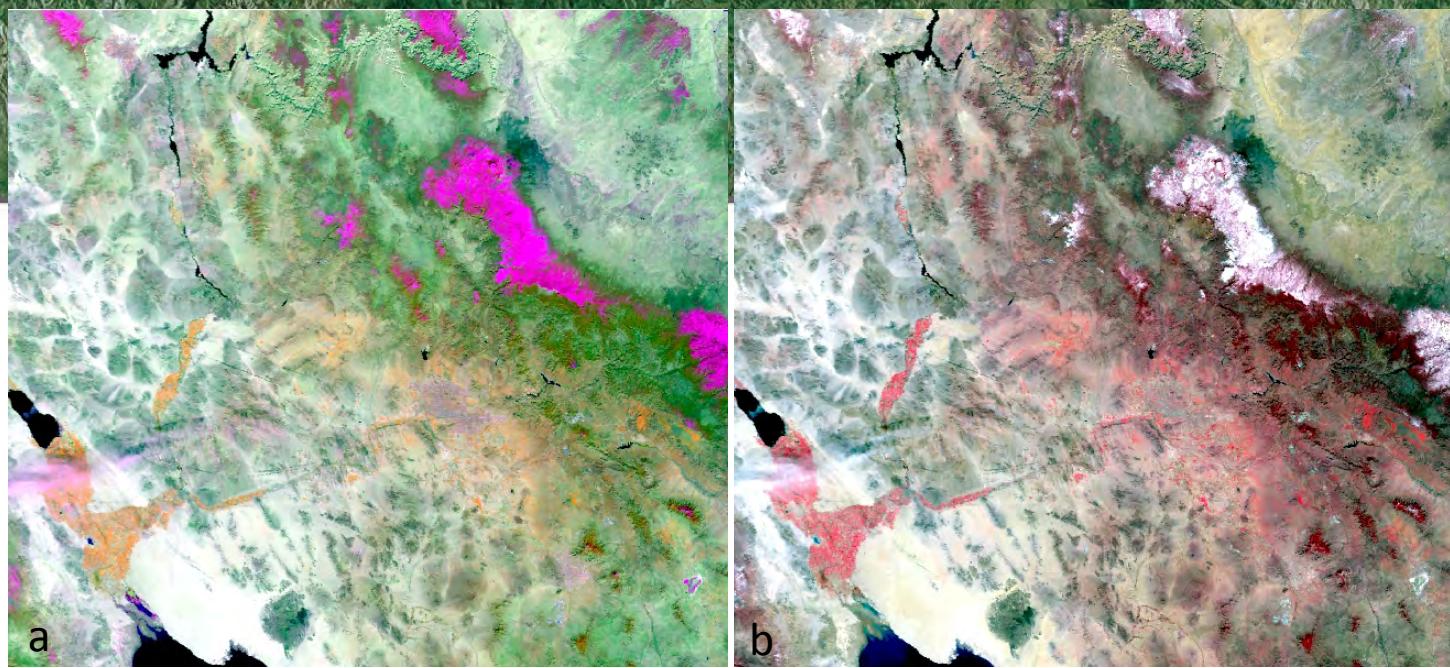
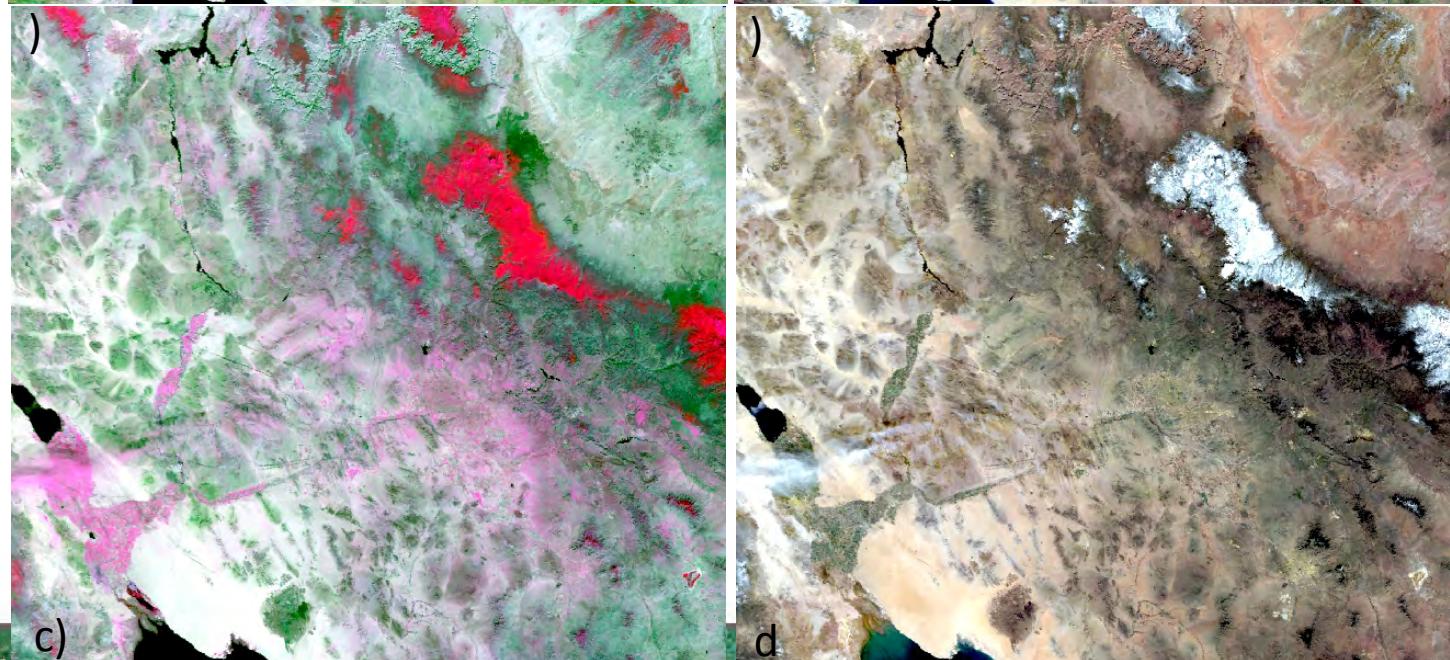


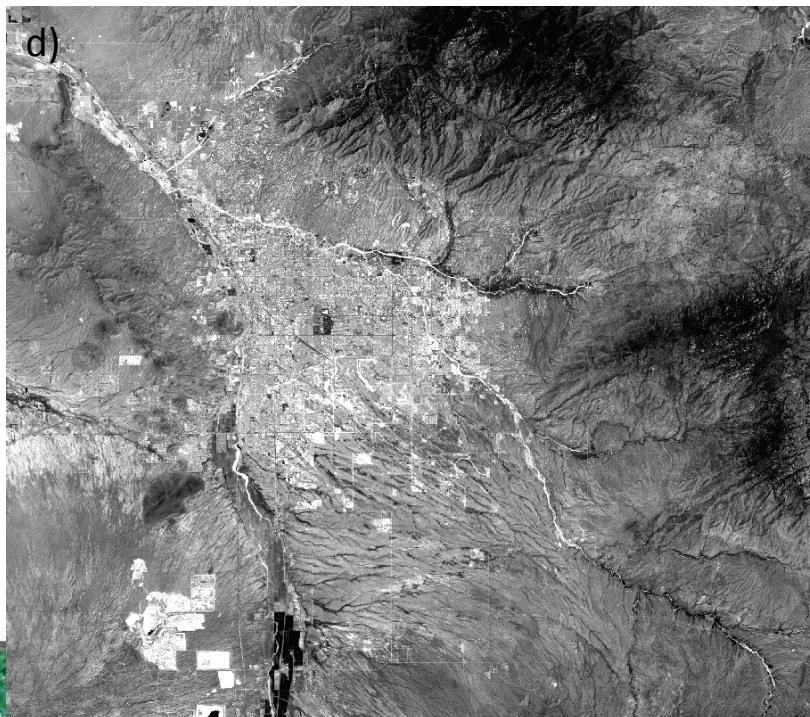
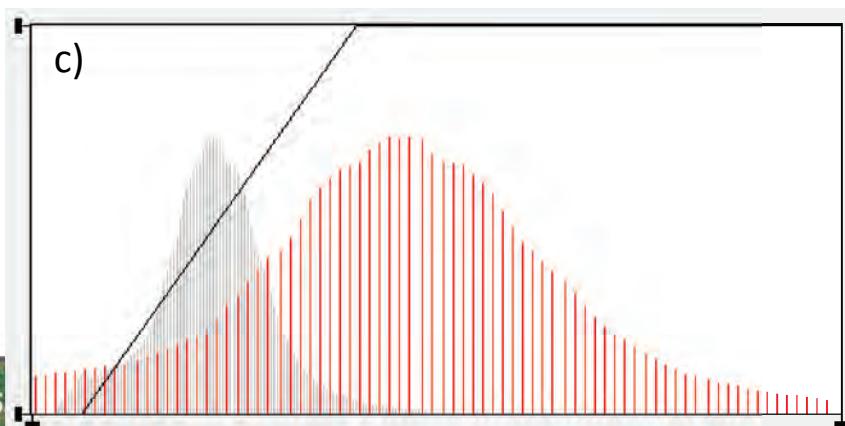
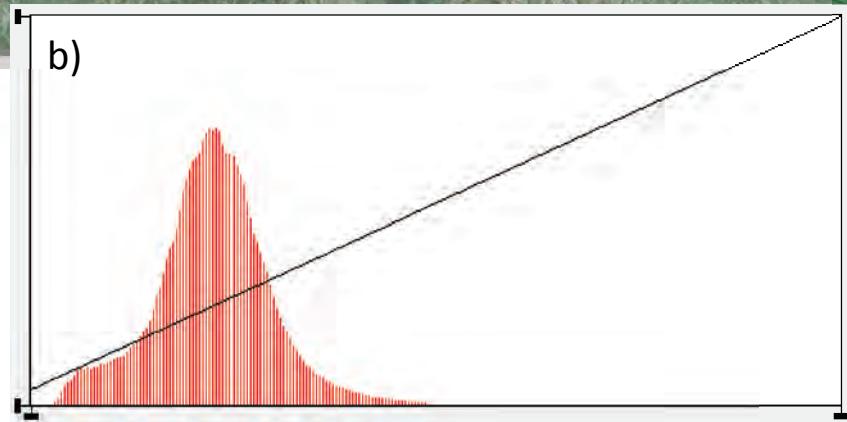
Fig. 5.7



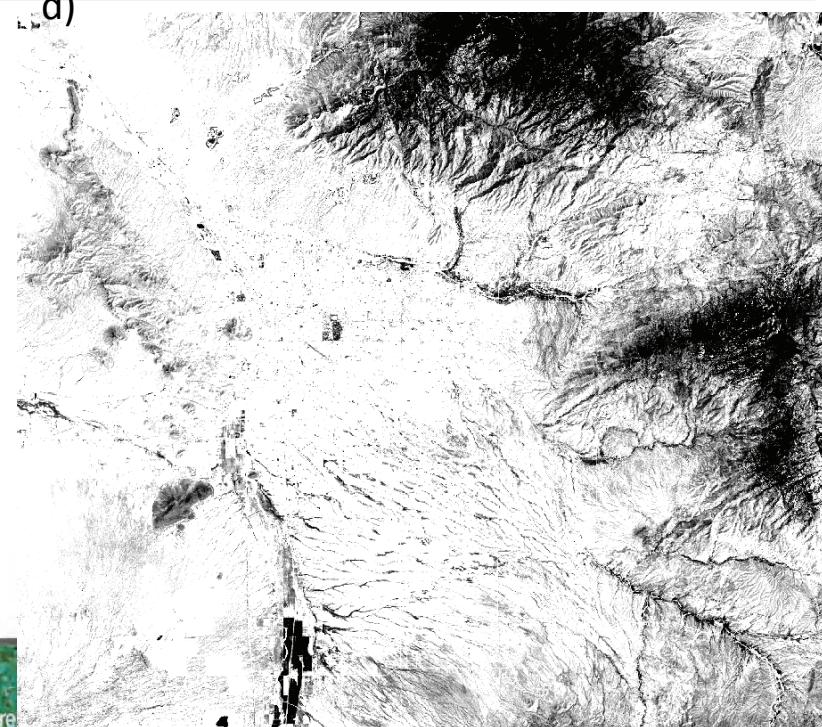
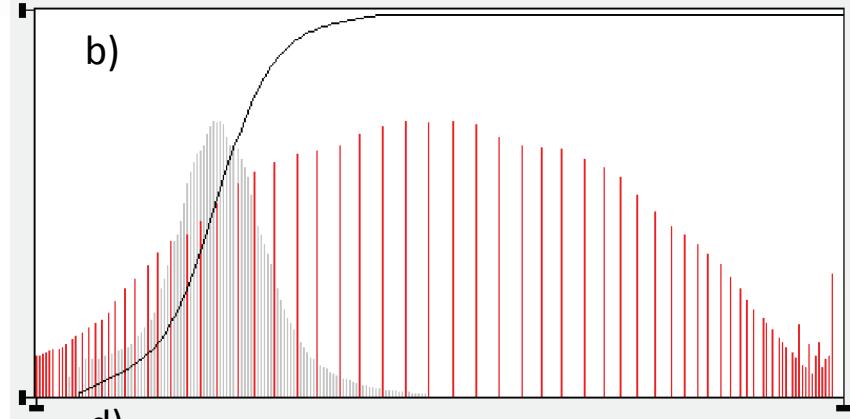
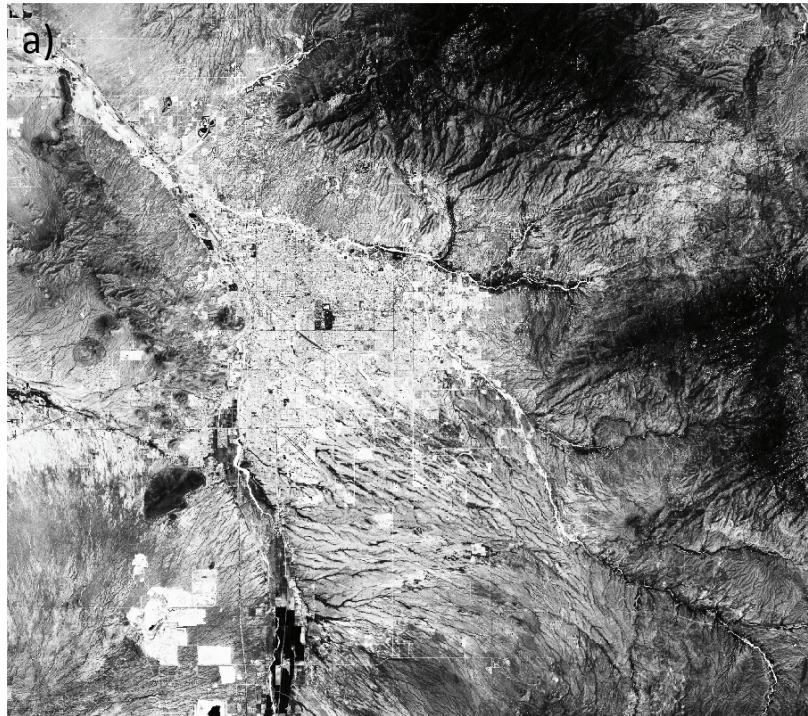
esa

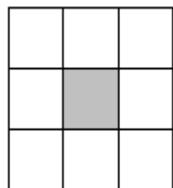


# Image enhancement



# Image enhancement

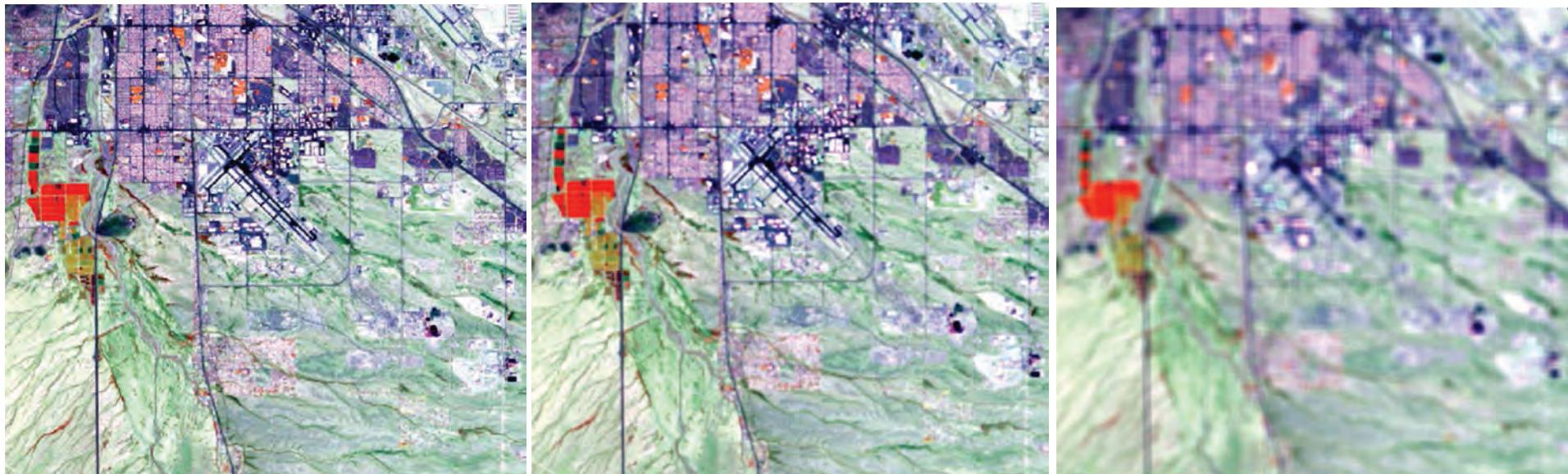




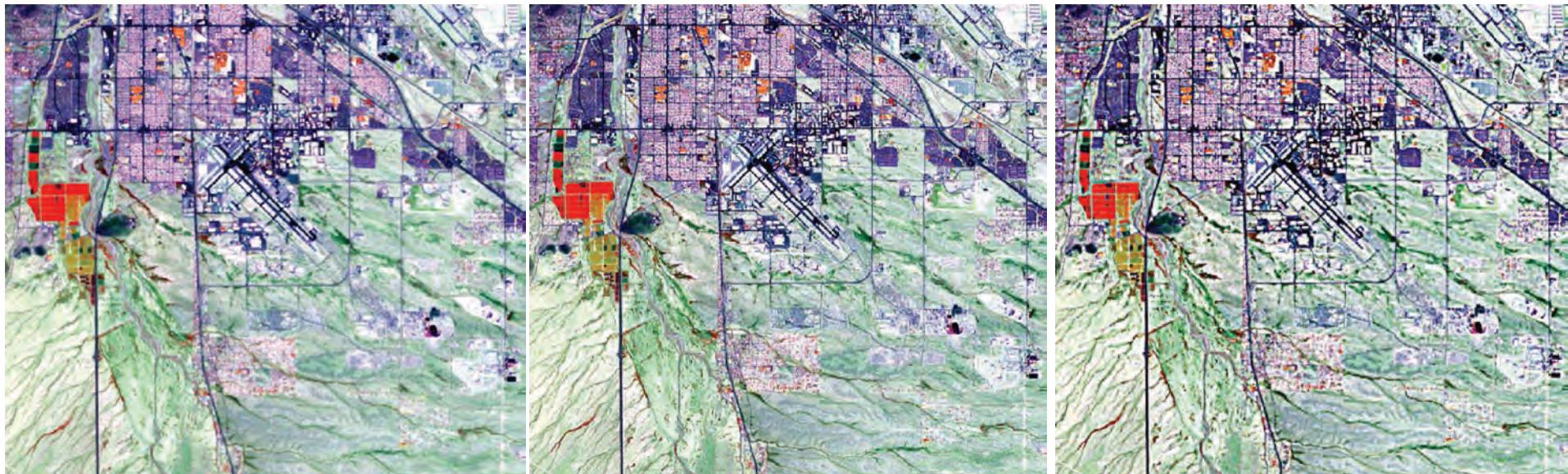
Kernel



# Filtering



# Filtering

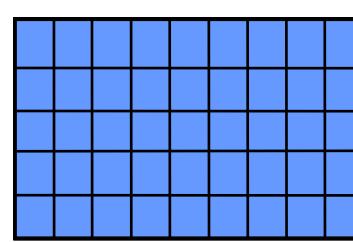




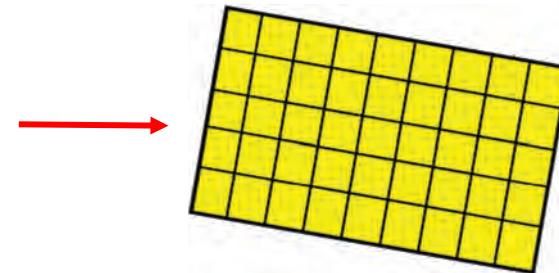
# Image geo-rectification



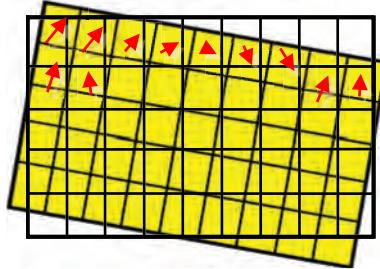
# Image geo-rectification



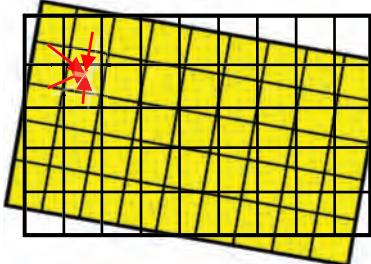
Original image



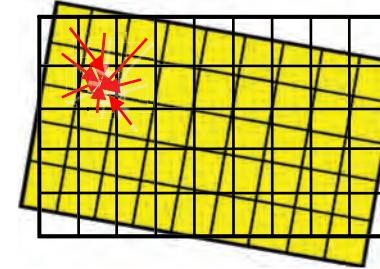
Corrected Image



Nearest neighbour



Bilineal interpolation

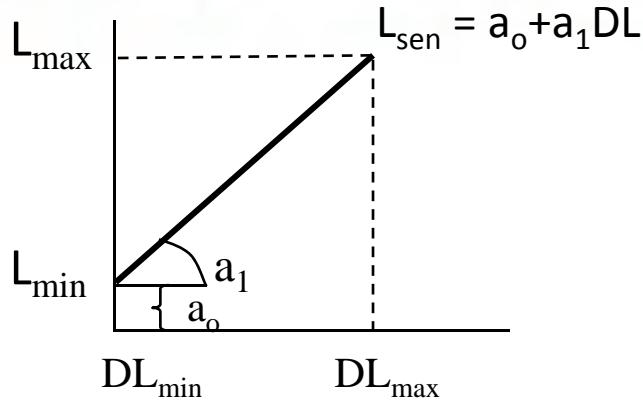


Cubic convolution

## DL to reflectance conversion

- DL to Radiance (calibration).
- Radiance to ToA reflectance.
- Atmospheric correction.
- Topographic shade removal.
- BRDF effects.

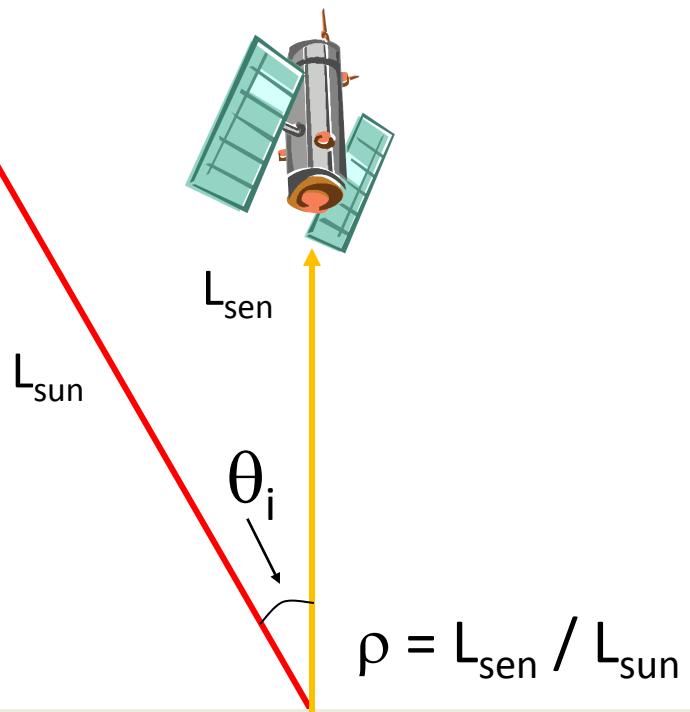
# DL to reflectance conversion



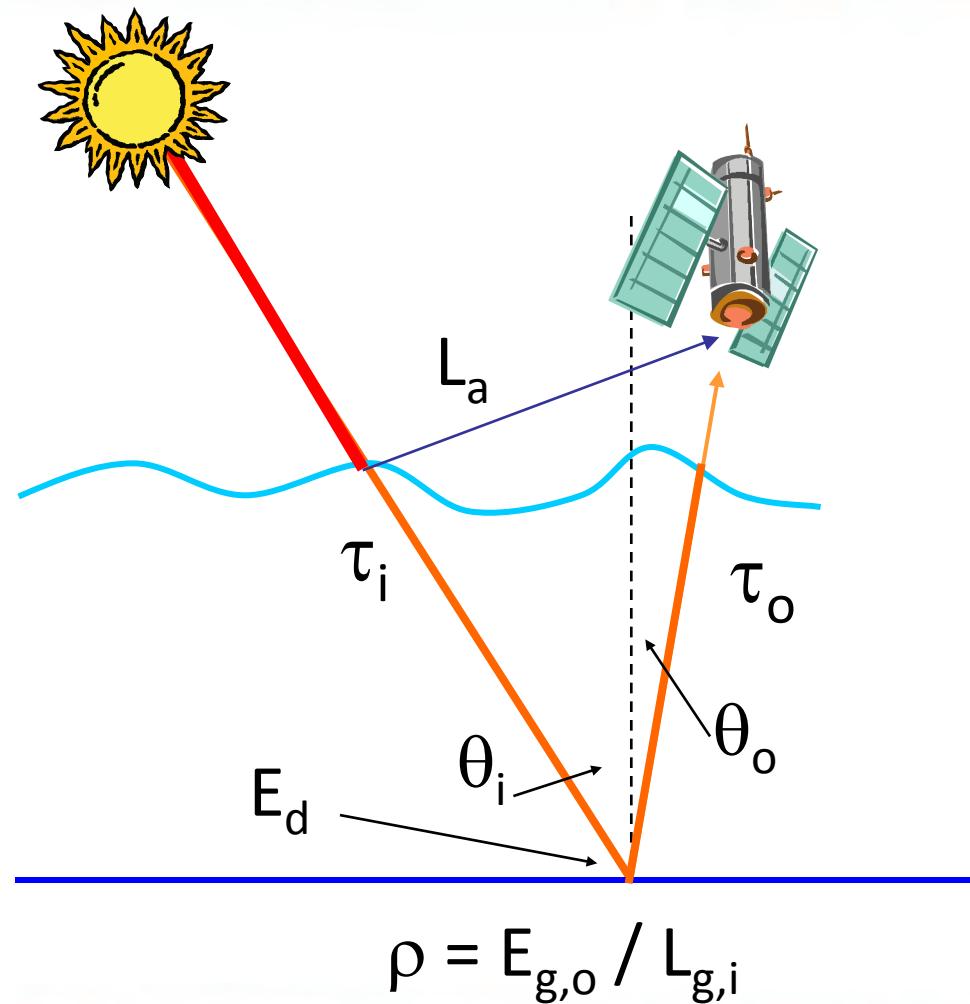
$\theta_i$

$$L_{\text{sun}} = L_o * \cos \theta_i$$

$$L_o = E_o * \pi$$



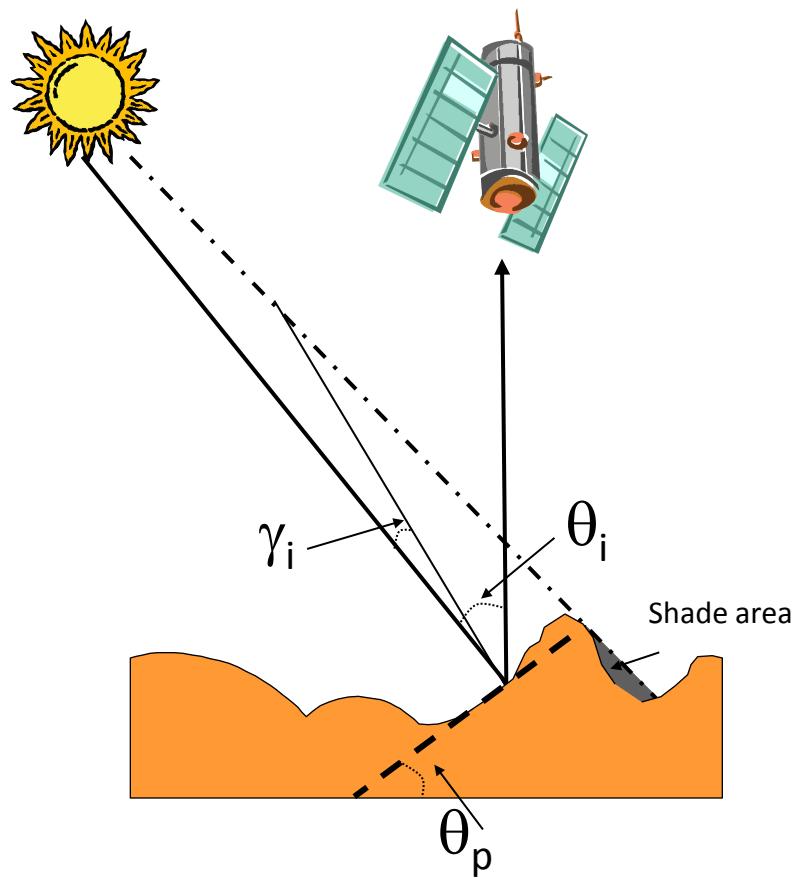
# Atmospheric impacts

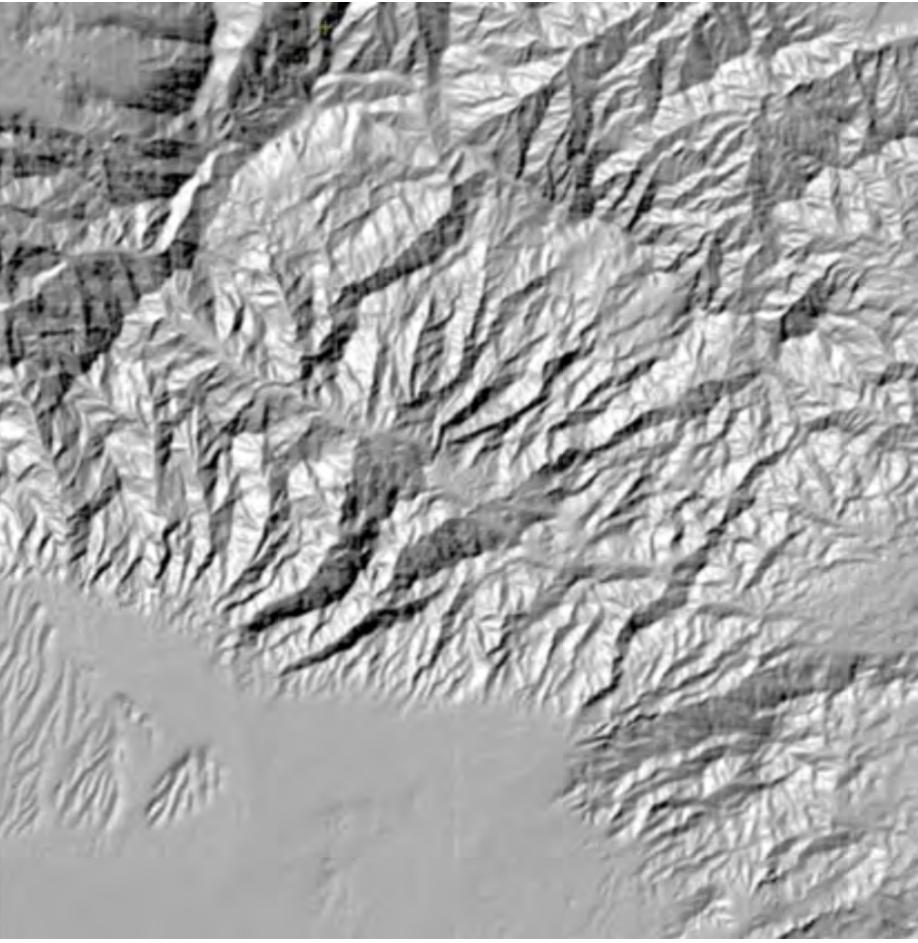


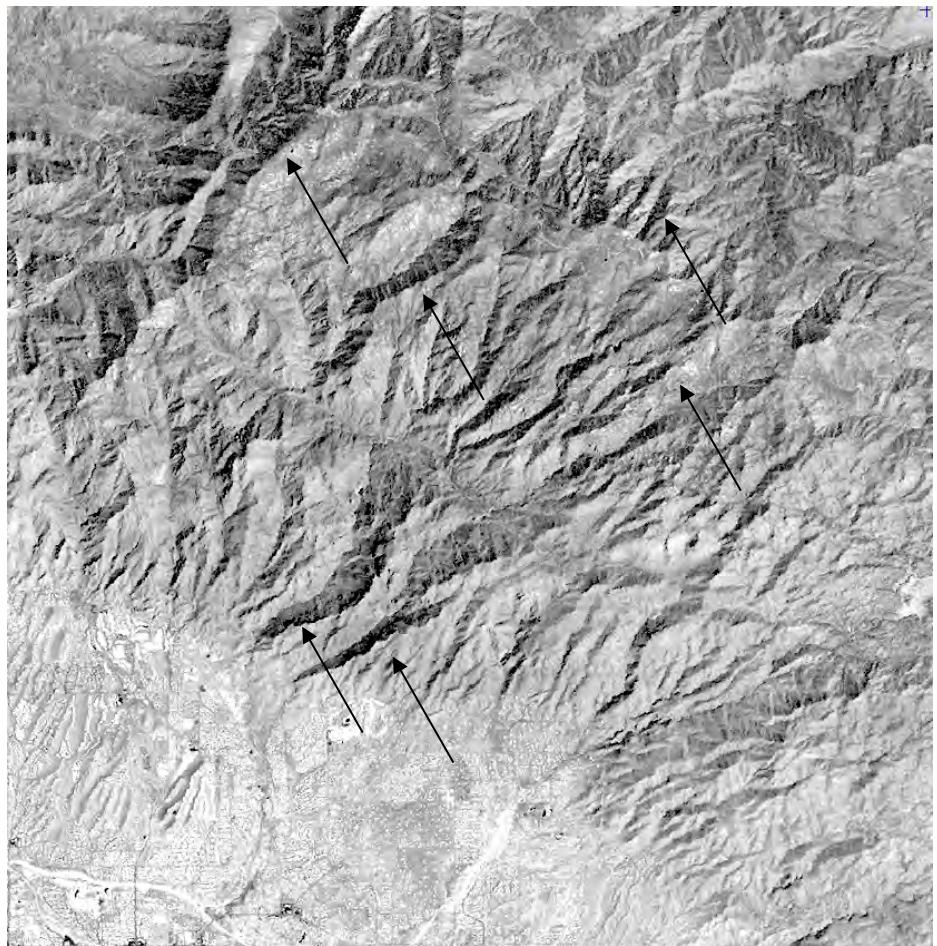
# Empirical correction



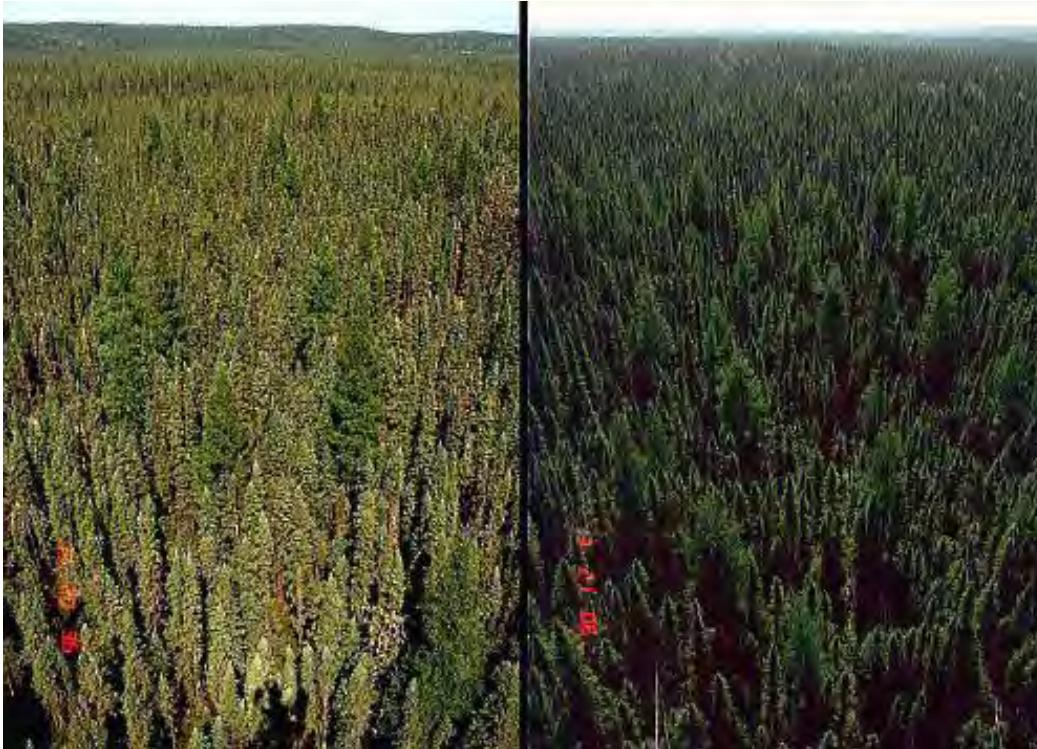
# Topographic shade correction

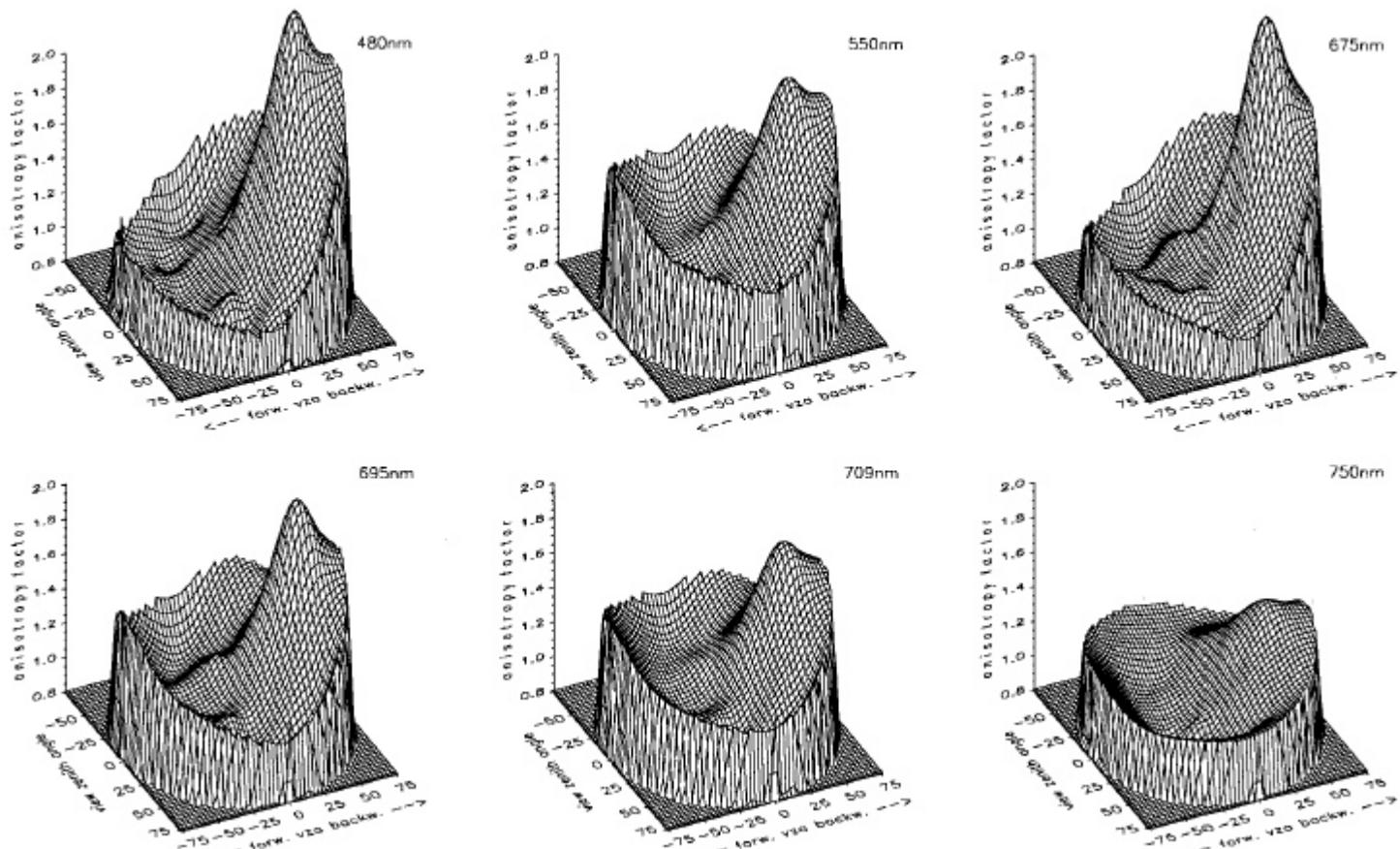




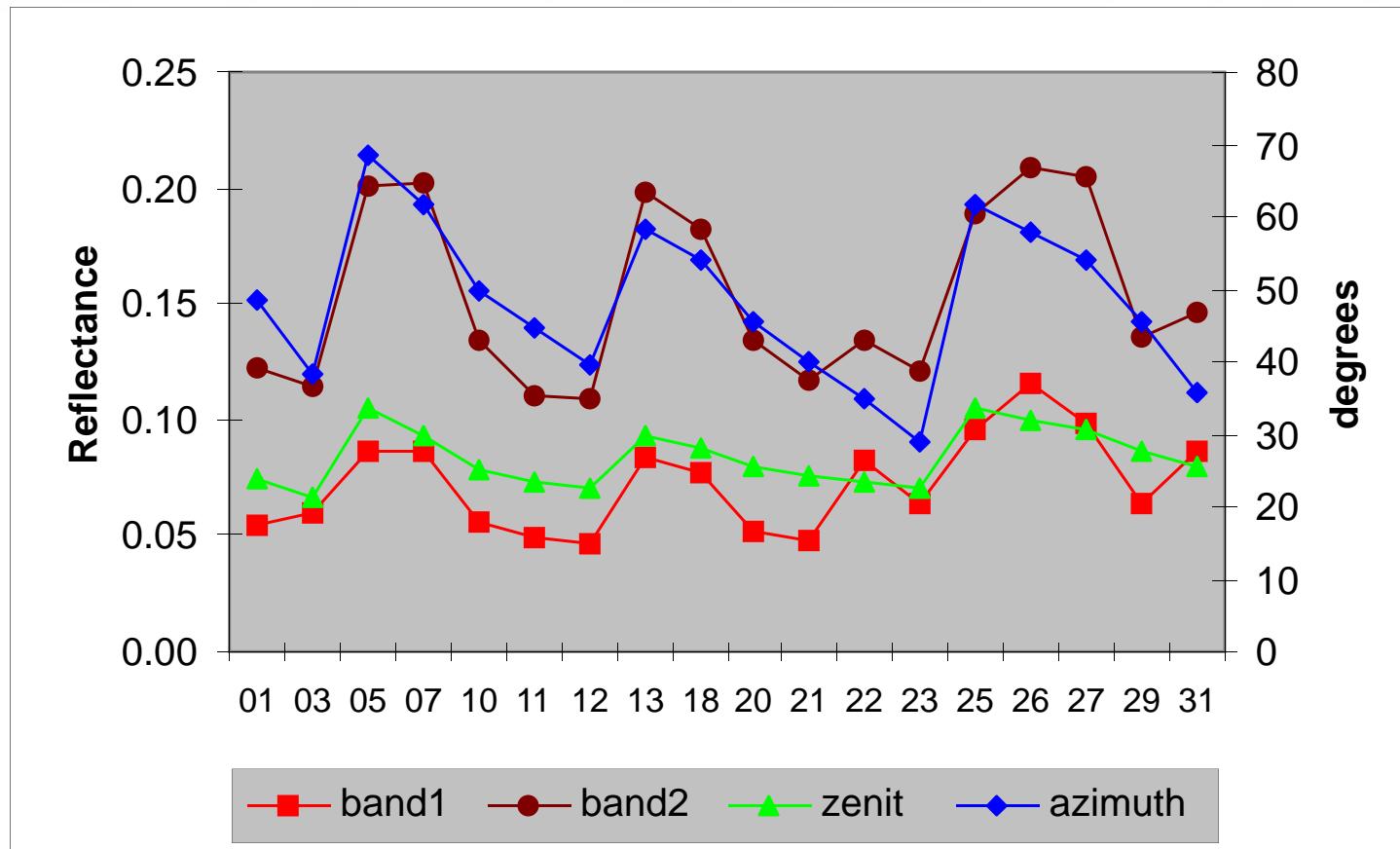


# BRDF effects

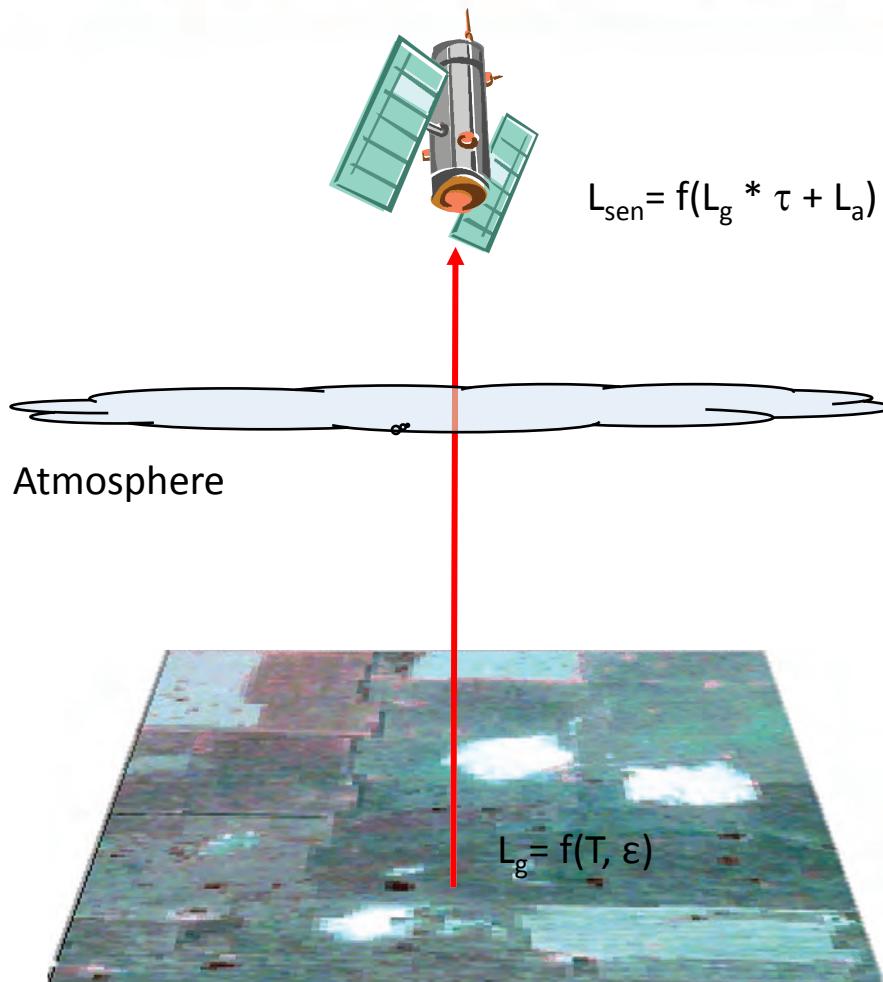




# AVHRR angular effects



# Temperature calculation



## DL to temperature conversion

- DL to Radiance (calibration).
- Radiance to ToA temperature.
- Atmospheric correction.
- Emissivity correction.

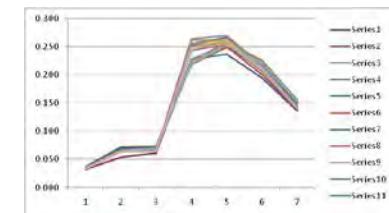
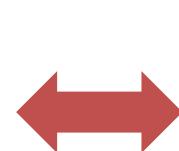
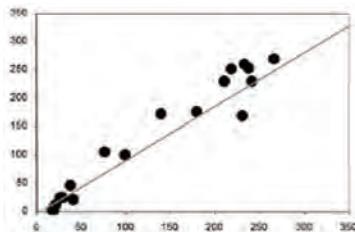
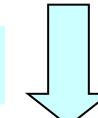
# Empirical and RTM retrieval



N  
C<sub>ab</sub>  
C<sub>w</sub>  
C<sub>m</sub>



Forward modeling

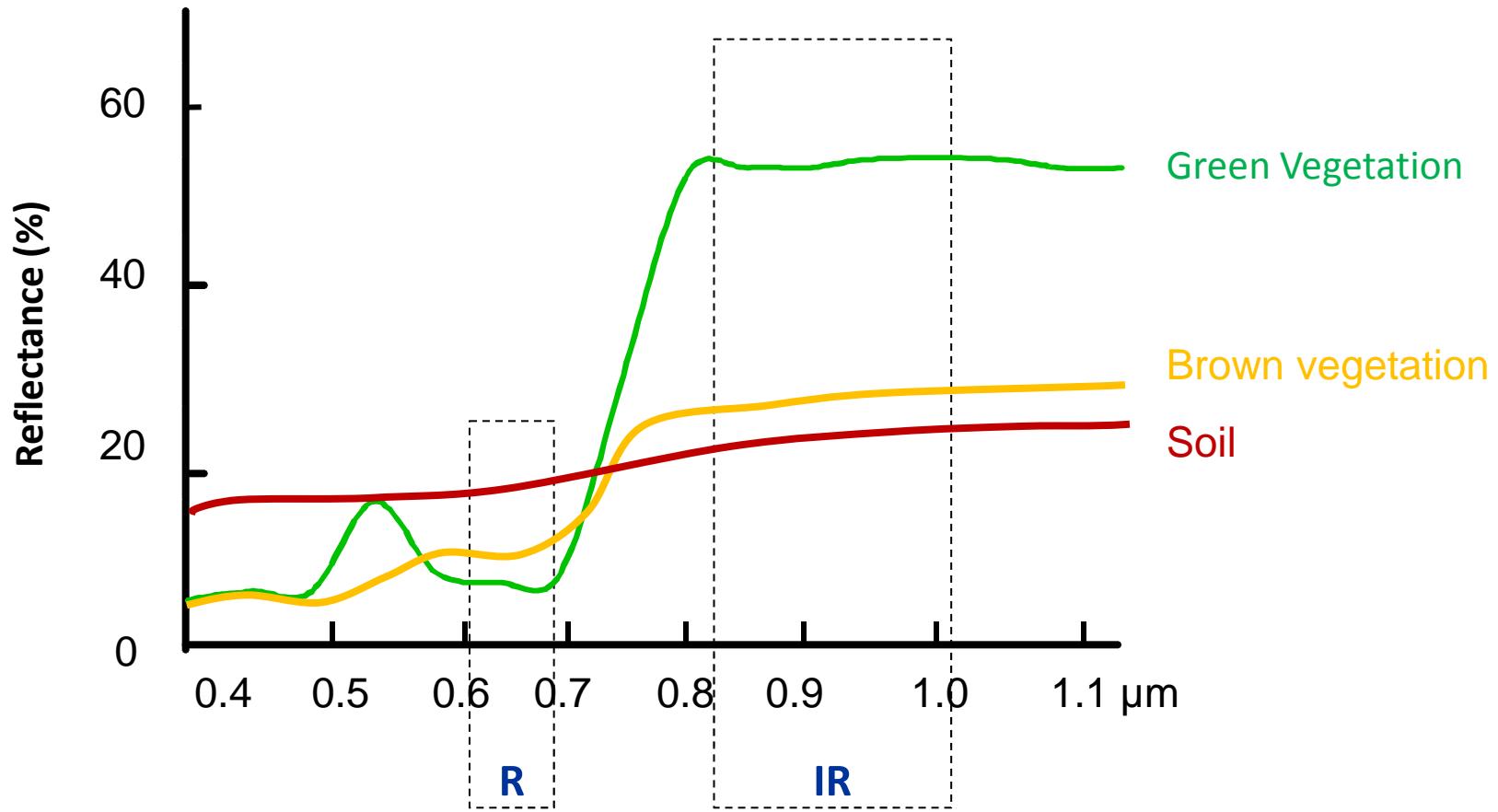


Empirical fitting

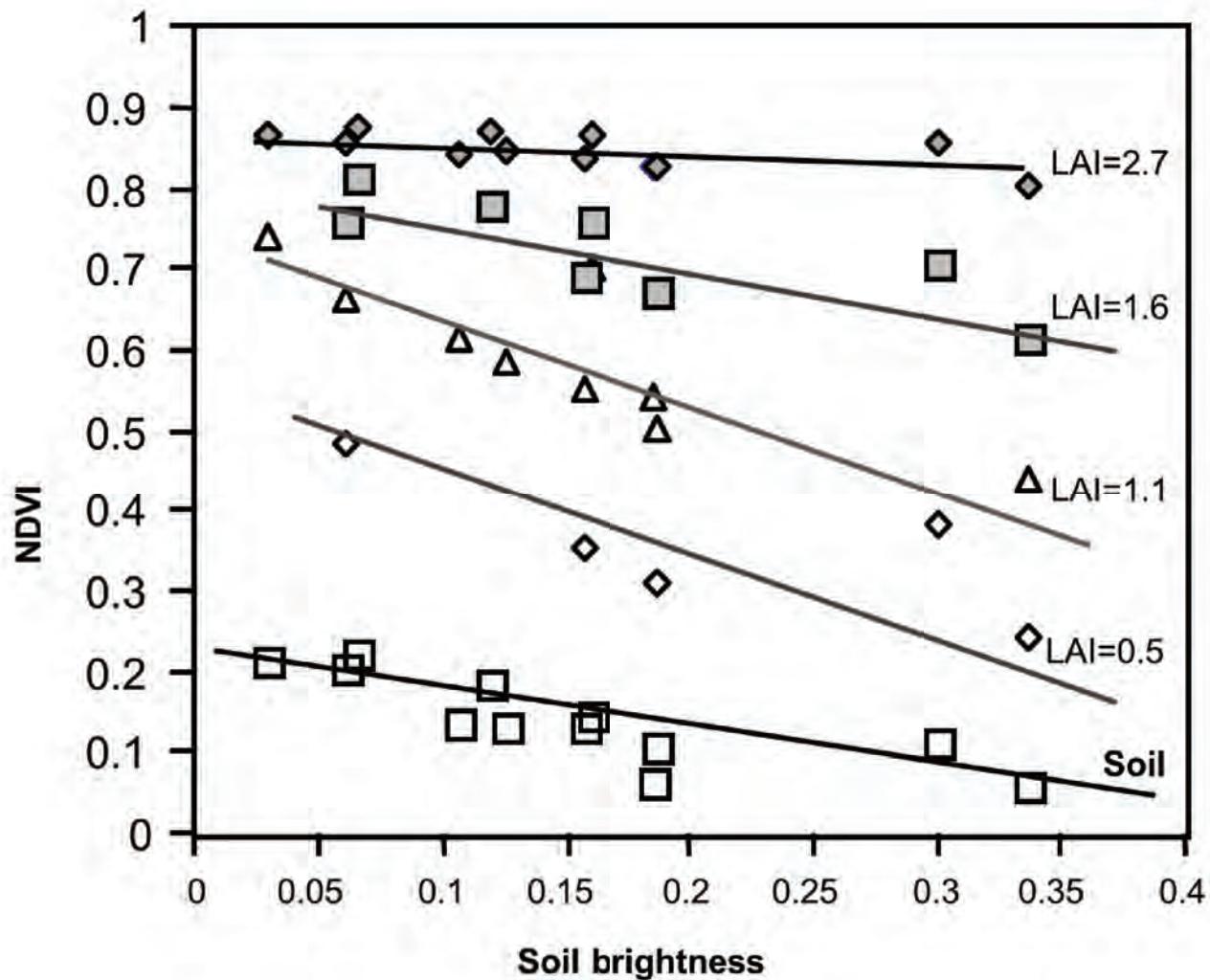


Model Inversion

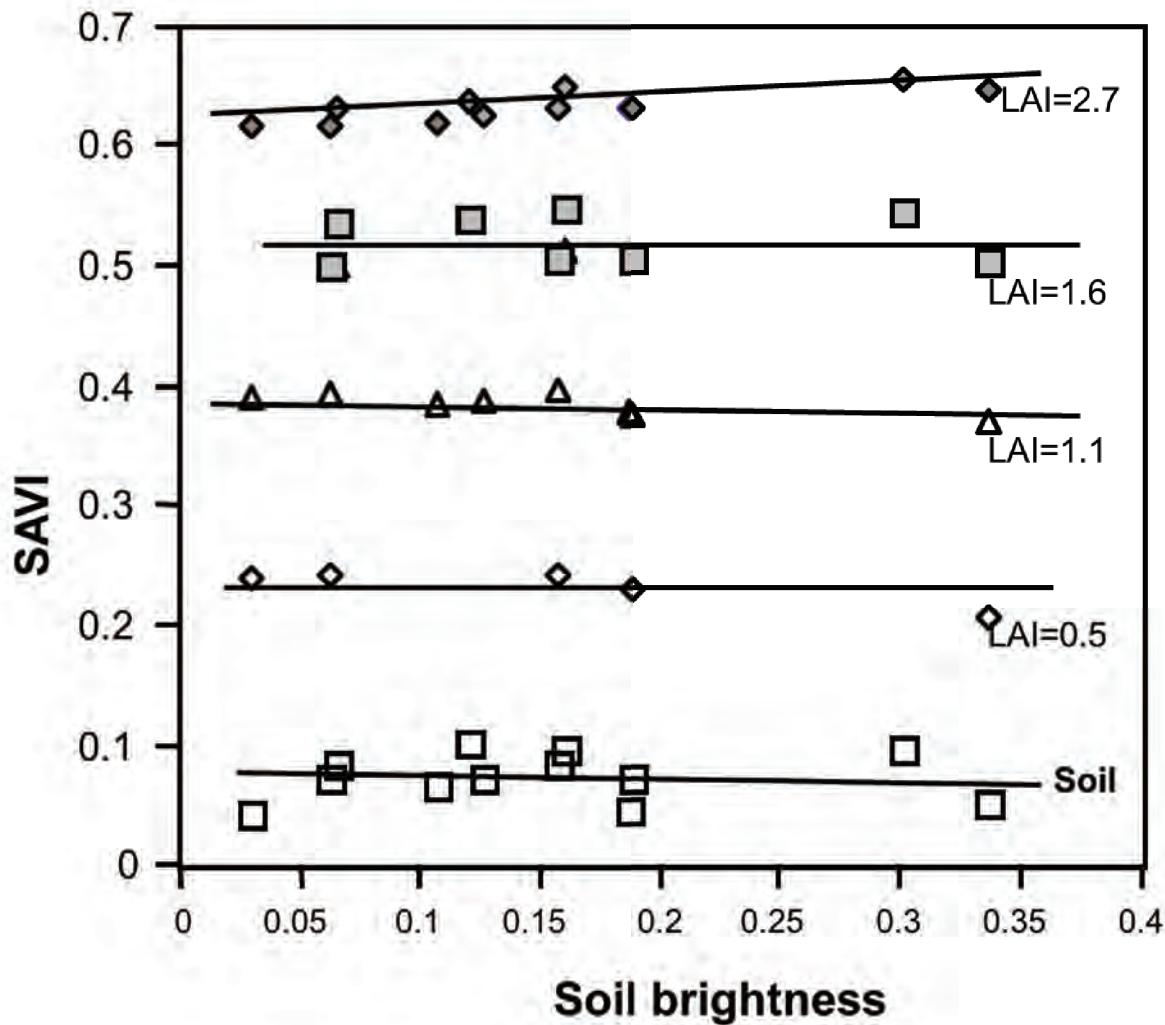
# Spectral vegetation indices



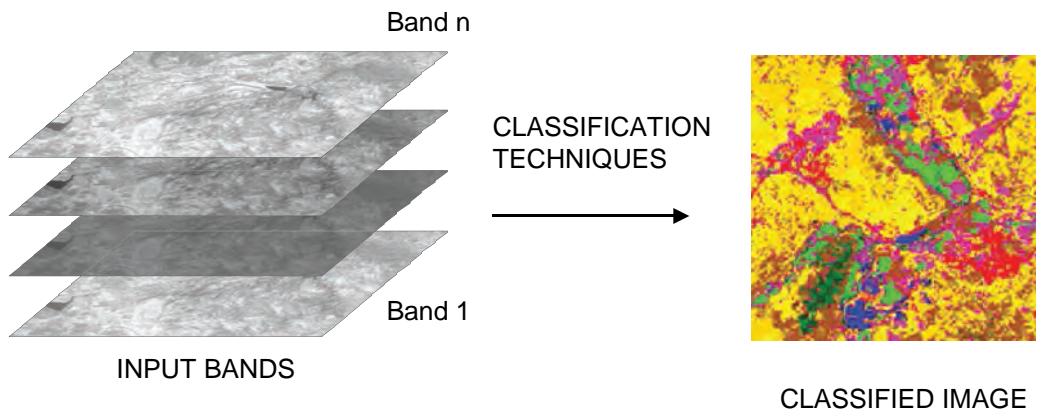
# External factors



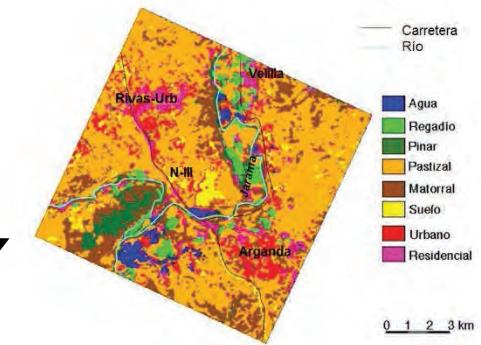
# External factors



# Classification



THEMATIC  
MAP

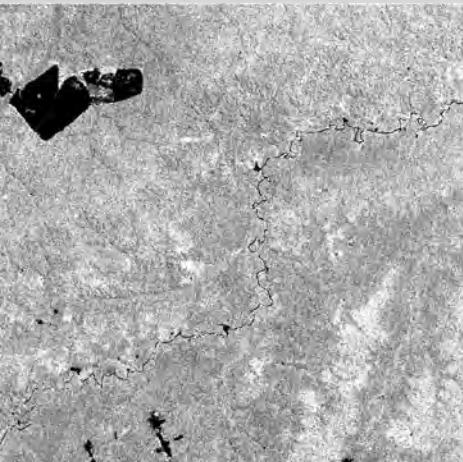


AREA  
INVENTORY

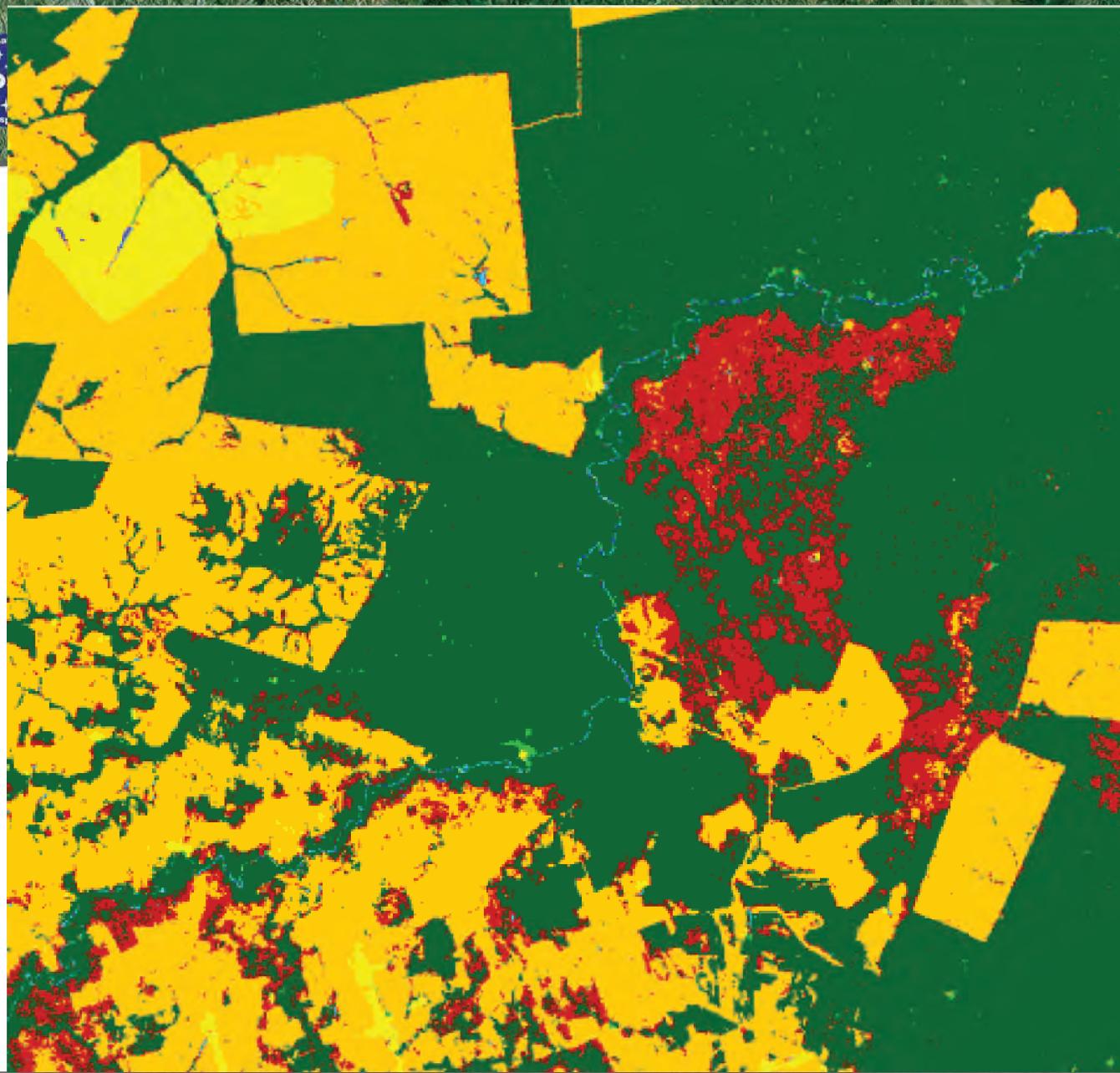
	Clasificación de máxima probabilidad			Clasificación por RNA		
	Píxeles	Hectáreas	%	Píxeles	Hectáreas	%
Urbano	110553	6909	13,27	67365	4210	8,08
Pastizal	178735	11170	21,45	226811	14175	27,22
Matorral	275265	17204	33,03	380854	23803	45,71
Pinar-encinar	9839	614	1,18	16766	1048	2,01
Suelo	9133	570	1,10	12150	759	1,46
Cultivo	236848	14803	28,42	97519	6095	11,70
Aqua	12907	806	1,55	31815	1988	3,82
Total	833280	52080	100	833280	52080	100

# Change detection analysis

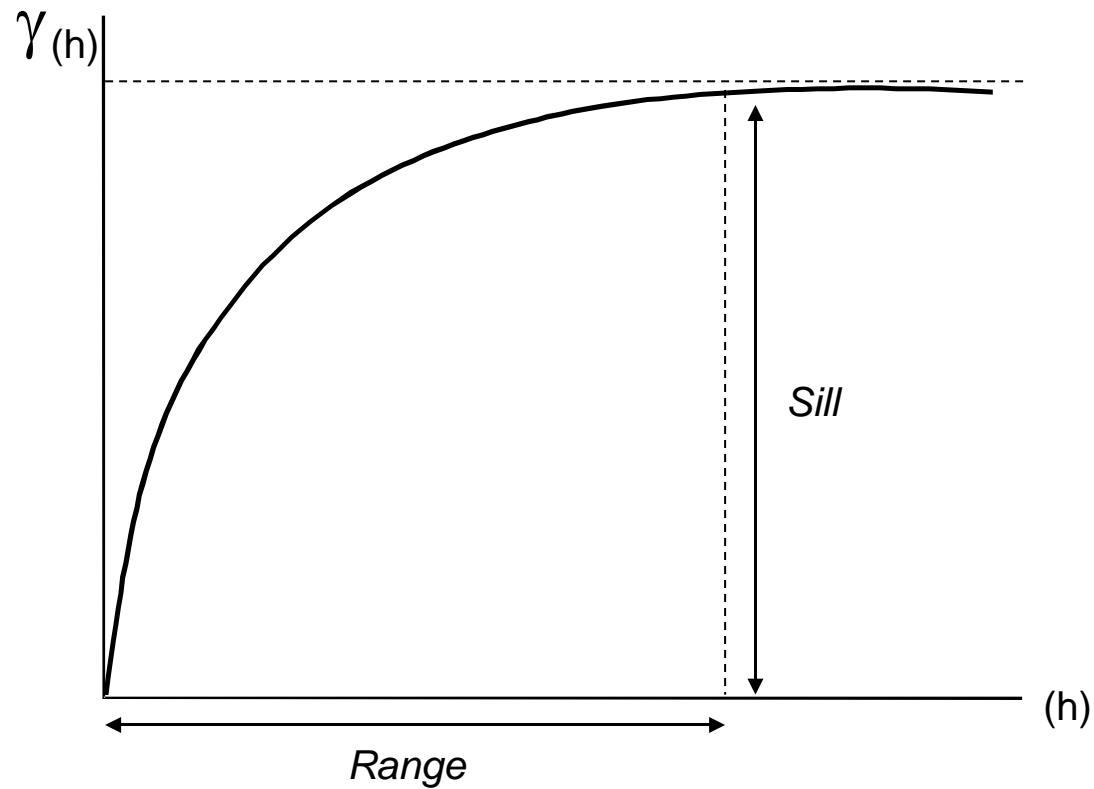
1990



2010



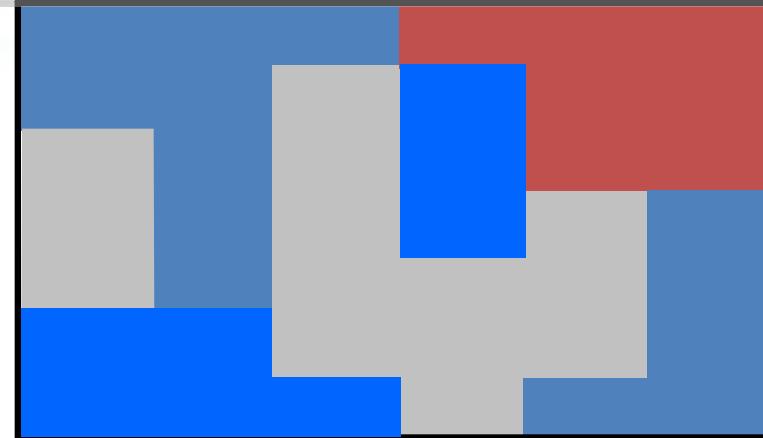
- Forest-Forest
- Forest-Crops
- Forest-Water
- Forest-Burned
- Crop-Forest
- Crops-Crops
- Crops-Water
- Crops-Burned
- Water-Forest
- Water-Crop
- Water-Water
- Water-Burned



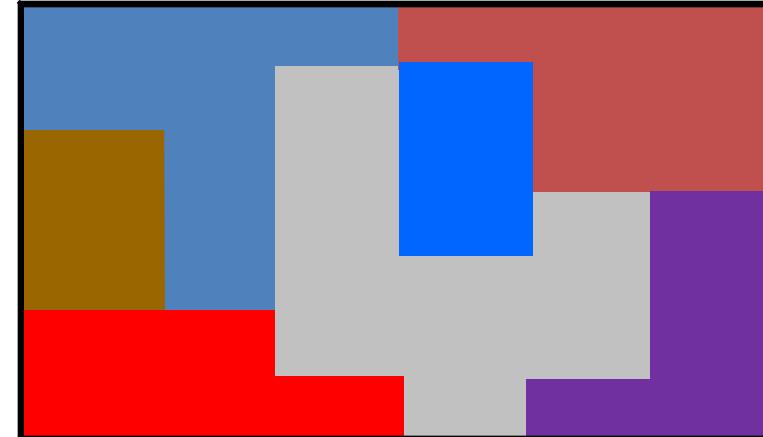
# Generation of patches



1	1	1	3	3	3
1	1	2	4	3	3
2	1	2	4	3	3
2	1	2	4	2	1
2	1	2	2	2	1
4	4	2	2	2	1
4	4	4	2	1	1



1	1	1	2	2	2
1	1	3	4	2	2
5	1	3	4	2	2
5	1	3	4	3	7
5	1	3	3	3	7
6	6	3	3	3	7
6	6	6	3	7	7



# Patch analysis

