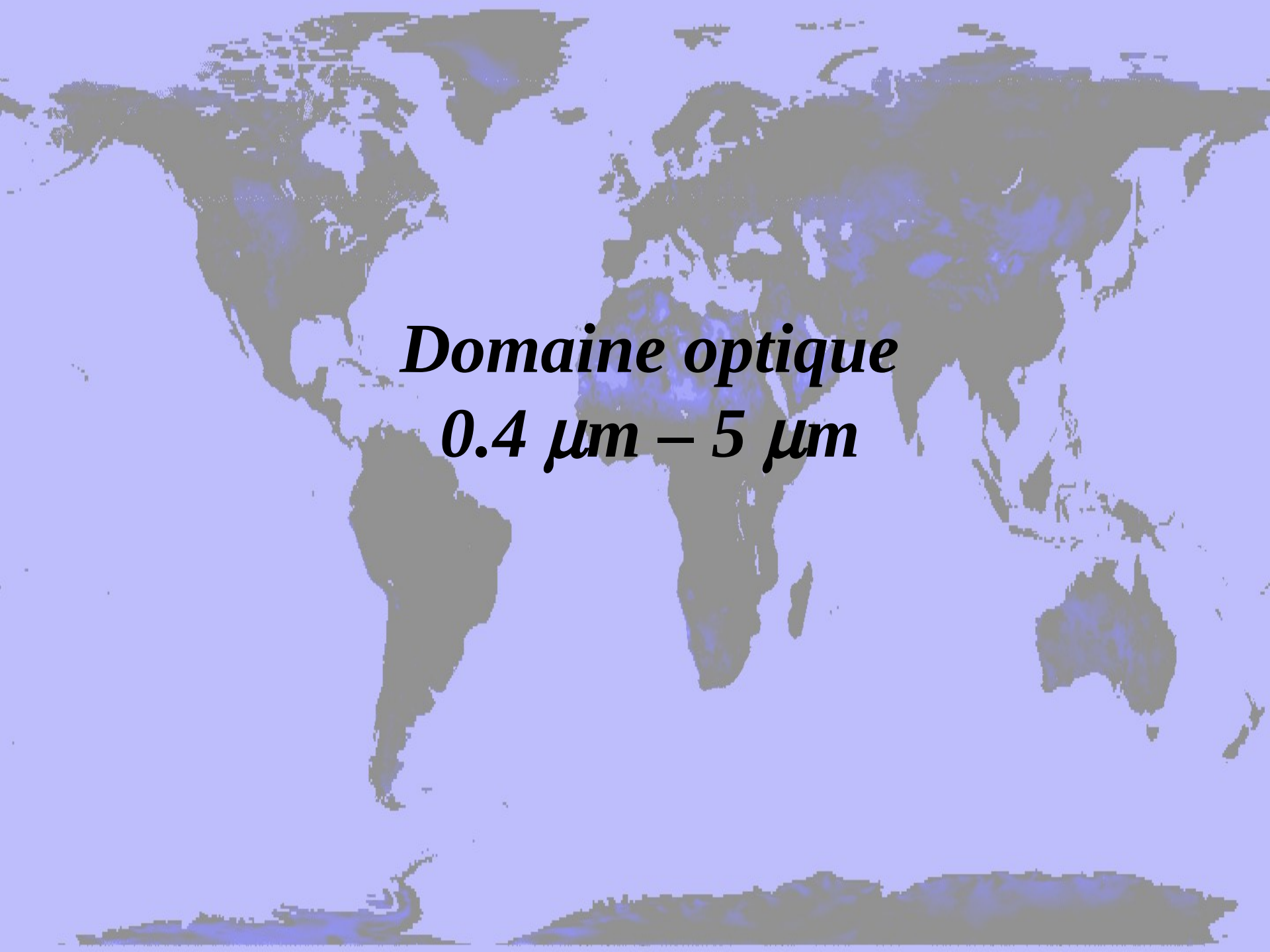
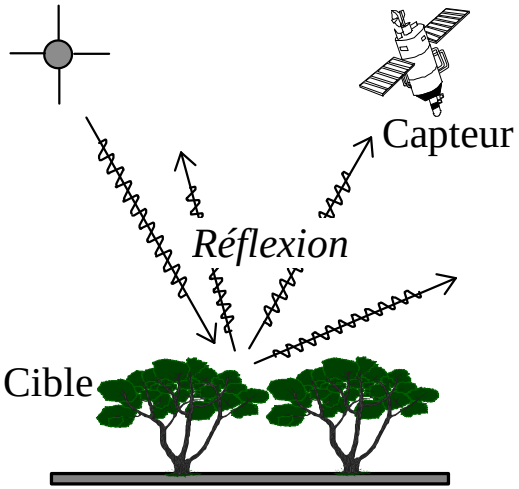
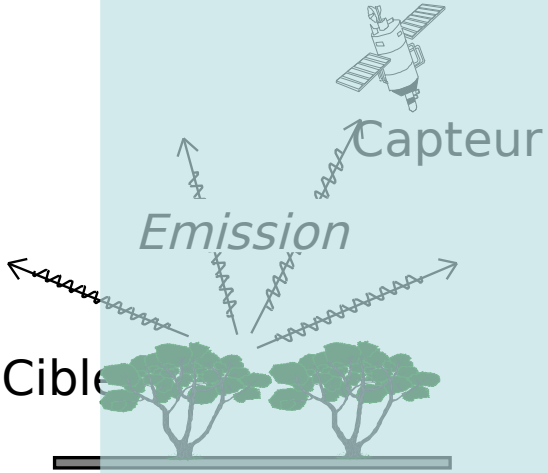

Domaine optique
0.4 µm – 5 µm

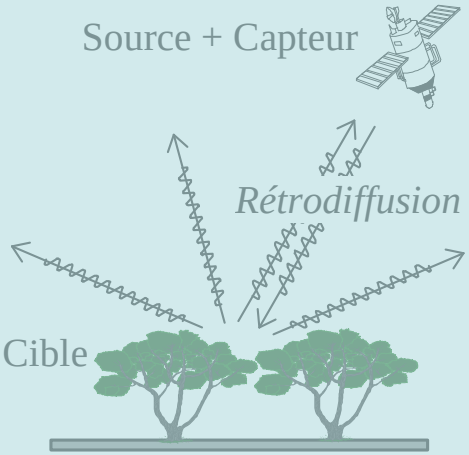
Modes d'observations



VIS
PIR, MIR



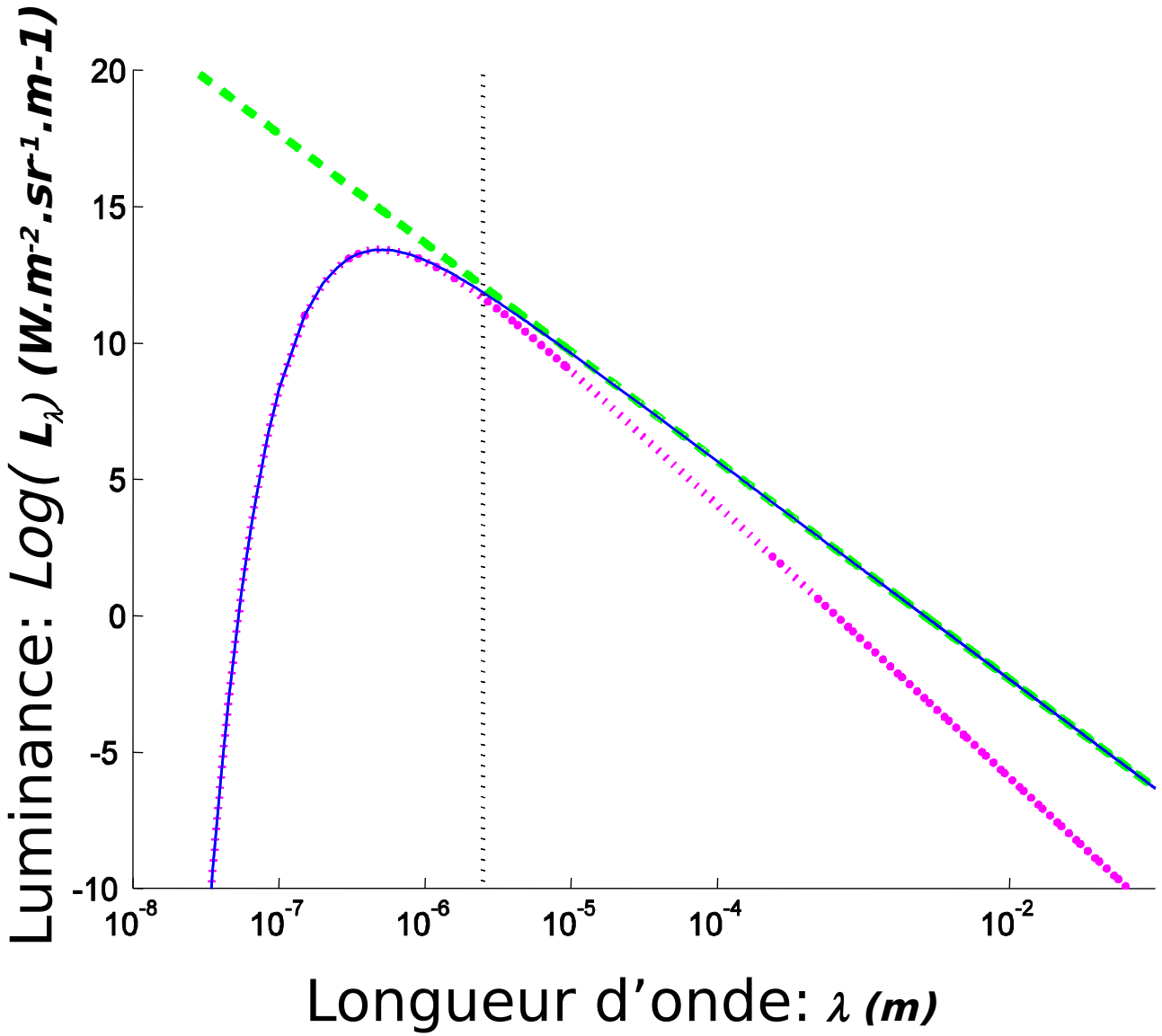
IRT
Micro-ondes passives



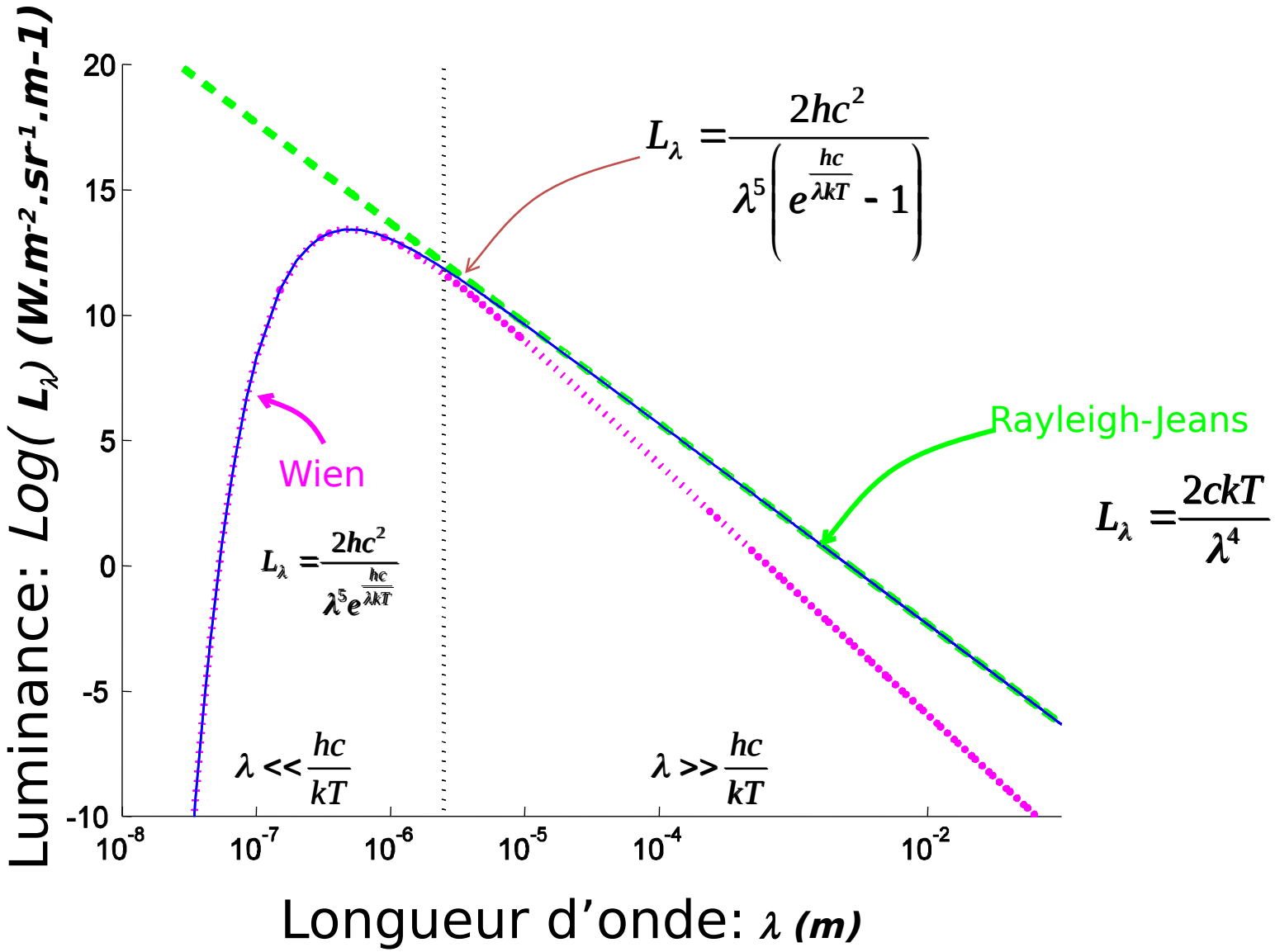
Micro-ondes 'actives'

VIS | PIR-MIR | IRT | Micro-ondes

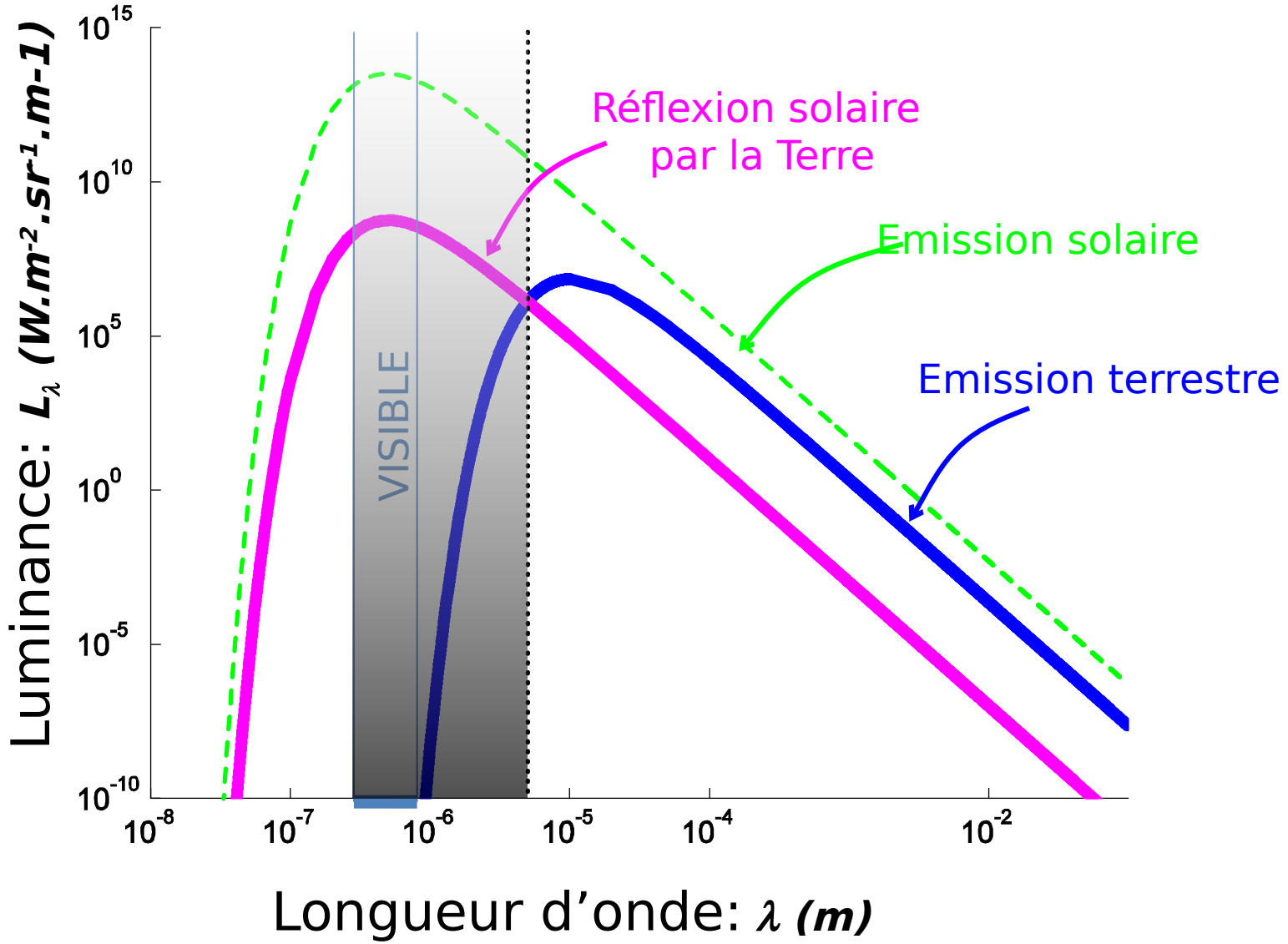
0.4-0.7 µm | 5 µm | 0.75-150 cm


Luminance: Log(L_λ) (W.m-2.sr-1.m-1)
20
15
10
5
0
-5
-10
10^{-8}
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-2}
Longueur d'onde: λ (m)

Rayonnement du corps noir: Approximations de Wien et de Rayleigh-Jeans



DOMAINE OPTIQUE



Eclairement solaire reçu par la Terre

Luminance totale émise par un corps noir : $L = \int_0^{\infty} L_\lambda \, d\lambda$ *(W.m^{-2}.sr^{-1})*

Emitance totale émise par un corps noir : $M = \pi L = \sigma T^4$ *(W.m^{-2})*

Cste de Stefan-Boltzmann: $\sigma = 5.67\ 10^{-8}$ SI

Flux total émis par le soleil : $\Phi = \sigma T_{sol}^4 \, 4\pi R_{sol}^2$

Eclairement reçu par la Terre : $E = \dfrac{\sigma T_{sol}^4 \, 4\pi R_{sol}^2}{4\pi D_{ST}^2} = \dfrac{\sigma T_{sol}^4 R_{sol}^2}{D_{ST}^2}$

A.N.: $R_{sol} = 696\ 10^6$ m
$D_{ST} = 150\ 10^9$ m
$T_{sol} = 5800$ K

$\Rightarrow$ $E = 1380$ W.m^{-2}

Quelques ordres de grandeur

Rayonnement émis par Soleil (par Unité de Surface): $M = \sigma T^4$ *64 MW.m^{-2}*

(σ = 5.67 10^{-8} SI, T_{sol} = 5800 K)

Longueur d'onde d'émission max.: $\lambda_{max} = \frac{2.898.10^{-3}}{T}$ ***500 nm*** (□ *dans le visible*)

Eclairement reçu par la Terre: $E = \frac{\sigma T_{sol}^4 \, 4\pi R_{sol}^2}{4\pi D_{ST}^2} = \frac{\sigma T_{sol}^4 R_{sol}^2}{D_{ST}^2}$ 1380 W.m^{-2}

(R_{sol} = 696 10^6 m, D_{ST} = 150 10^9 m)

TERRE: ~~Disque ($S=\pi R^2$)~~ mais **Sphère** ($S=4\pi R^2$) ⇒ ***E 345 W.m^{-2}***

Absorbe / Emet: 240 W.m^{-2} ⇒ $T = \sqrt[4]{\frac{240}{\sigma}}$ ***-18°C***

Longueur d'onde d'émission max.: $\lambda_{max} = \frac{2.898.10^{-3}}{T}$ ***10 μm*** (□ *dans l'infrarouge*)

Le Rayonnement électromagnétique à la surface de la Terre

LA SURFACE TERRESTRE:

- ***Reçoit*** rayonnement dans le ***visible***
- ***Emet*** rayonnement dans l'***Infrarouge***

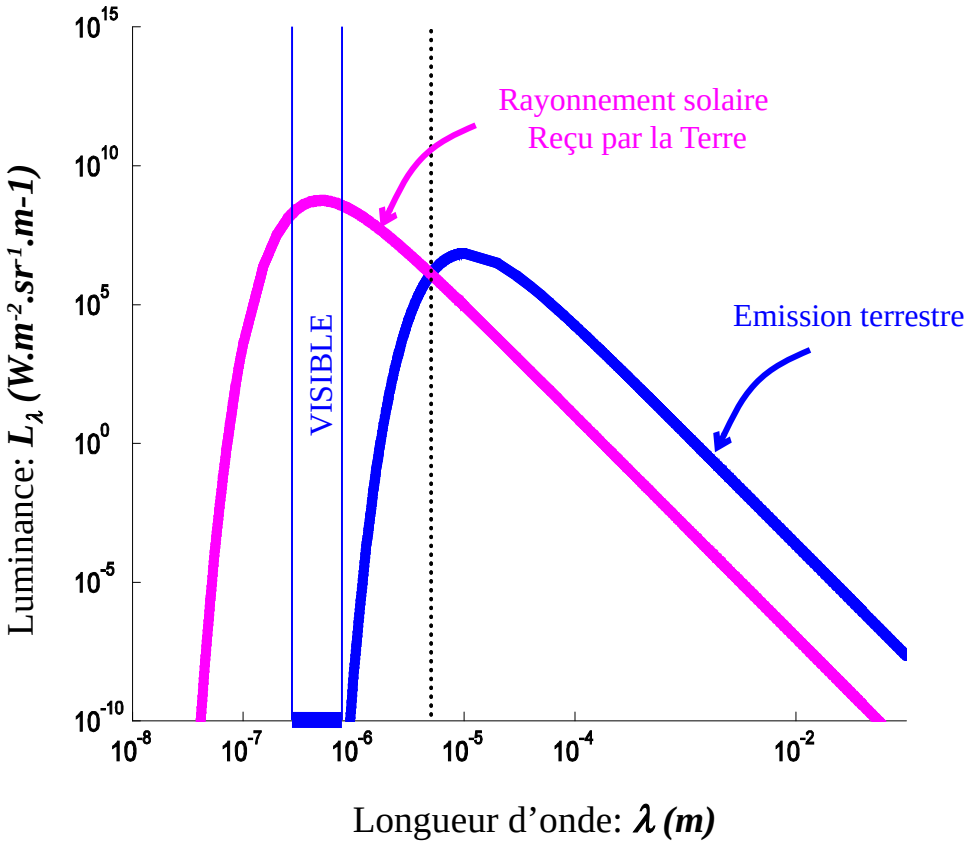
L'ATMOSPHERE:

- ***Transparente*** dans le ***visible***
- ***Absorbe*** le rayonnement ***Infrarouge***

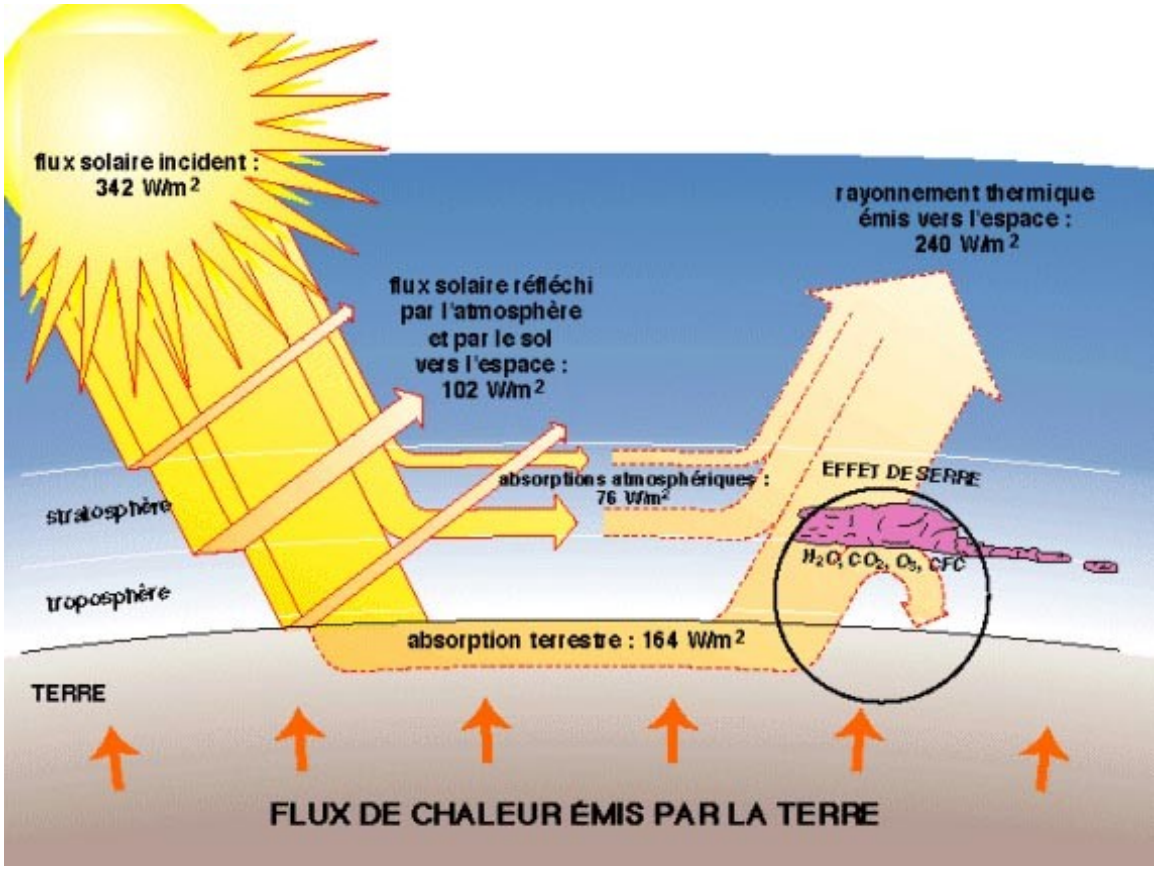
Responsables: gaz « à effets de serre »:

H_2O, CO_2, NH_4, ….

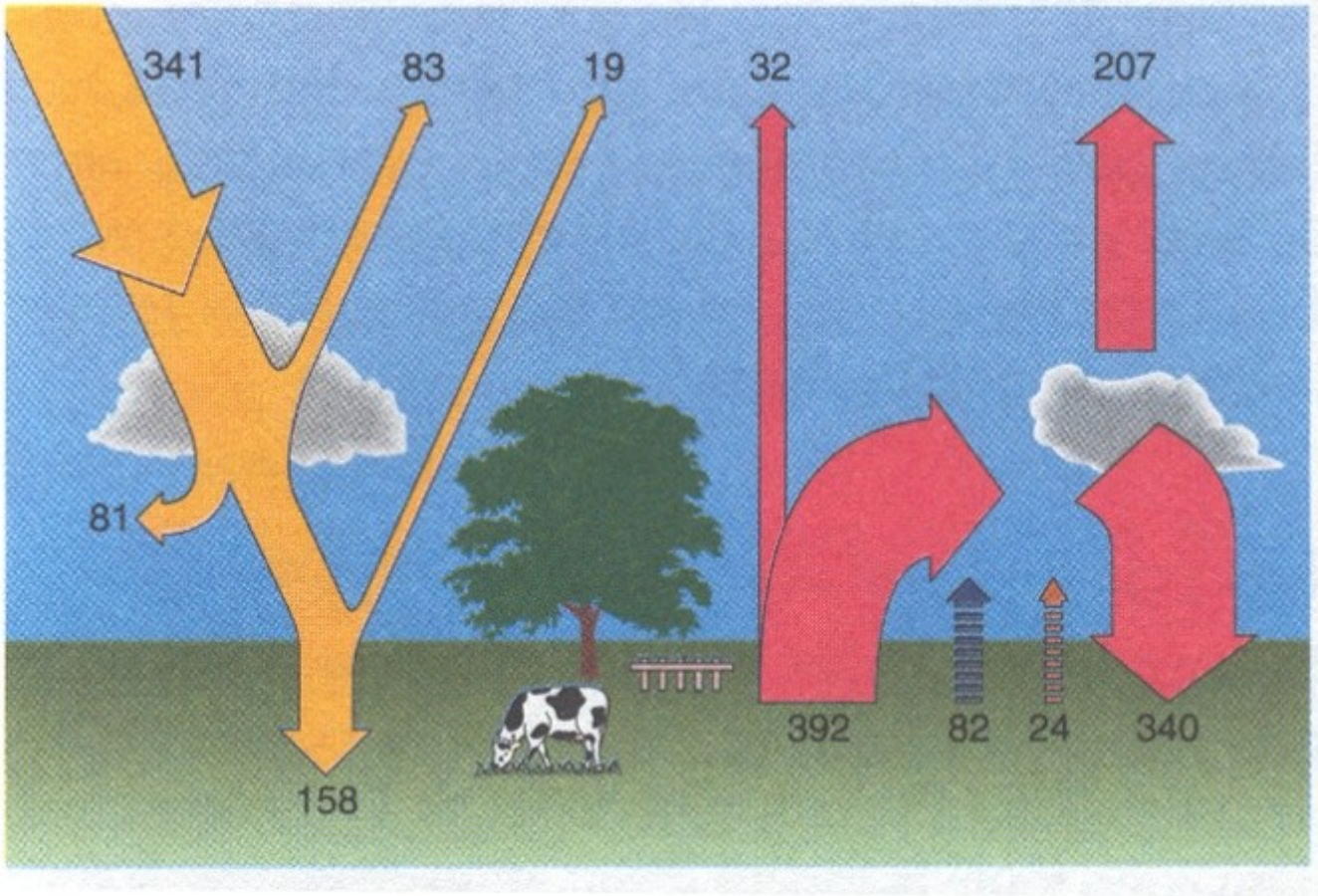
- ***$T_{surf.\ Terre}$:*** ~~-18°C~~ ***15°C***



EFFET DE SERRE



EFFET DE SERRE



Source: R. Sadourny, 1994

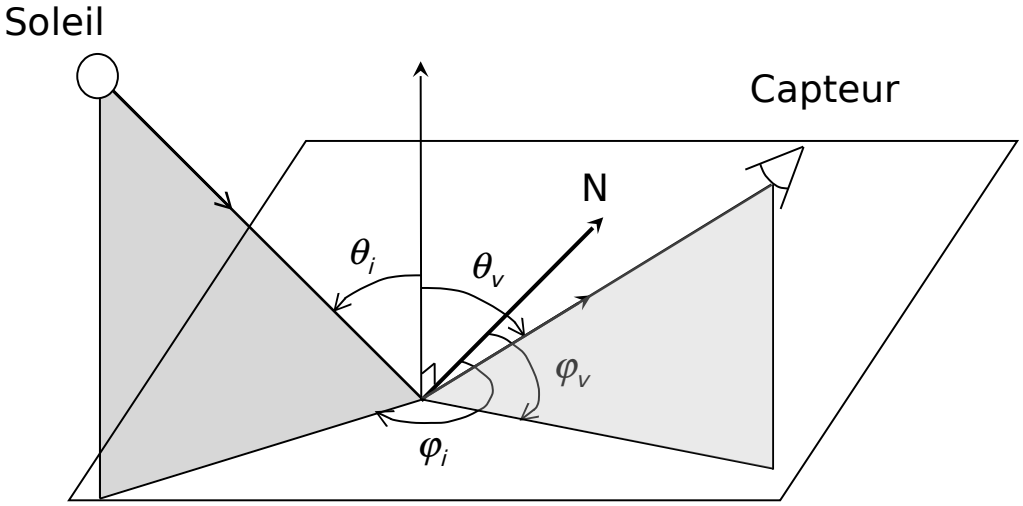
Mesures Optiques (0.4 – 5 µm)

(Réflexion du rayonnement solair

éflectance: caractérise les surfaces étudiées

éflectance bidirectionnelle:

$$\rho(\theta_i,\varphi_i,\theta_v,\varphi_v,\lambda) = \frac{L_r}{E_i} = \frac{L_r}{L_i \cos\theta_i d\Omega_i}$$



Albédo: $a = \dfrac{\int_{hém.} L_r \cos\theta_v d\Omega_v}{\int_{hém} L_i \cos\theta_i d\Omega_i} = \dfrac{M}{E_i}$

Facteur de réflectance:

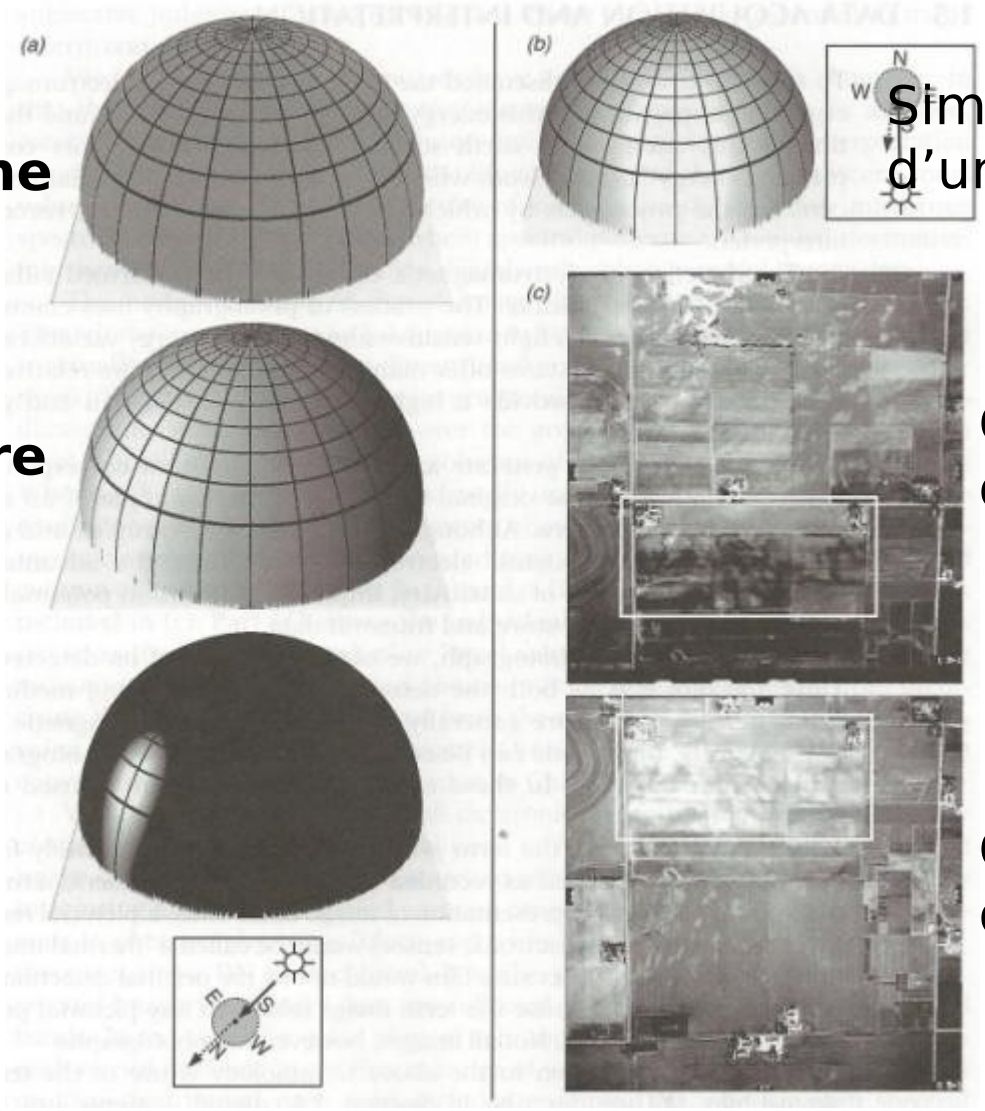
$$\rho_b = \frac{\rho_r}{\rho_r^{ref}} = \frac{L_r}{L_r^{ref}} = \frac{\pi L_r}{E_i} \text{ avec } E_i = L_{sol} \frac{\pi R_{sol}^2}{D_{ST}^2} \cos\theta_i \quad \Rightarrow \quad \boxed{\rho_b = \frac{1}{L_{sol} R_{sol}^2} D_{ST}^2 \frac{L_r}{\cos\theta'}}$$

emples de réflectances bidirectionnelles

lambertienne

intermédiaire

Spéculaire²



Simulation de la réflectan
d'un champ agricole

Champs photographié
depuis le nord

Champs photographié
depuis le sud

Source: Lillesand *et al.*, 2

Effet spéculaire sur un surface d'eau

Source: Lillesand *et al.*, 2

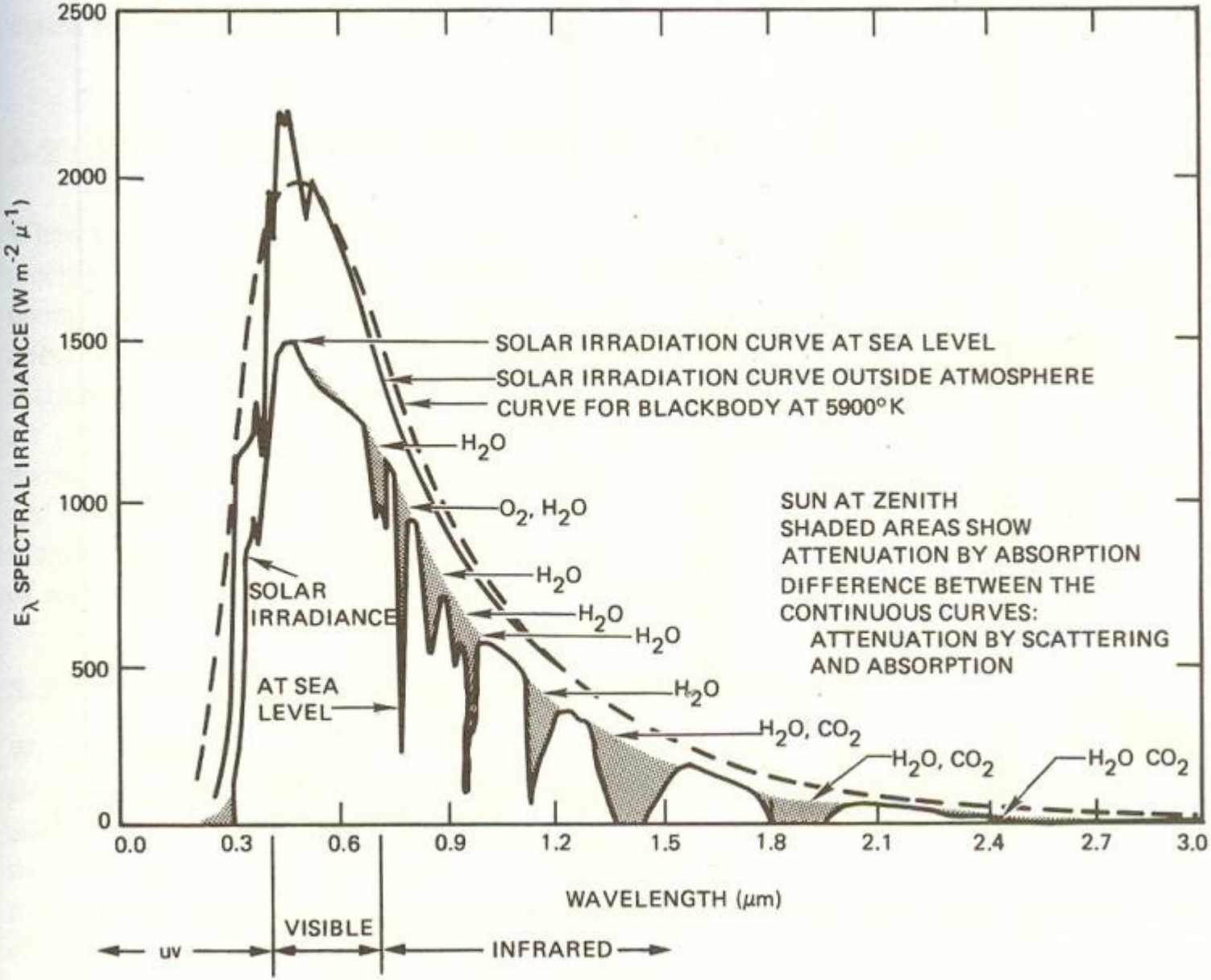
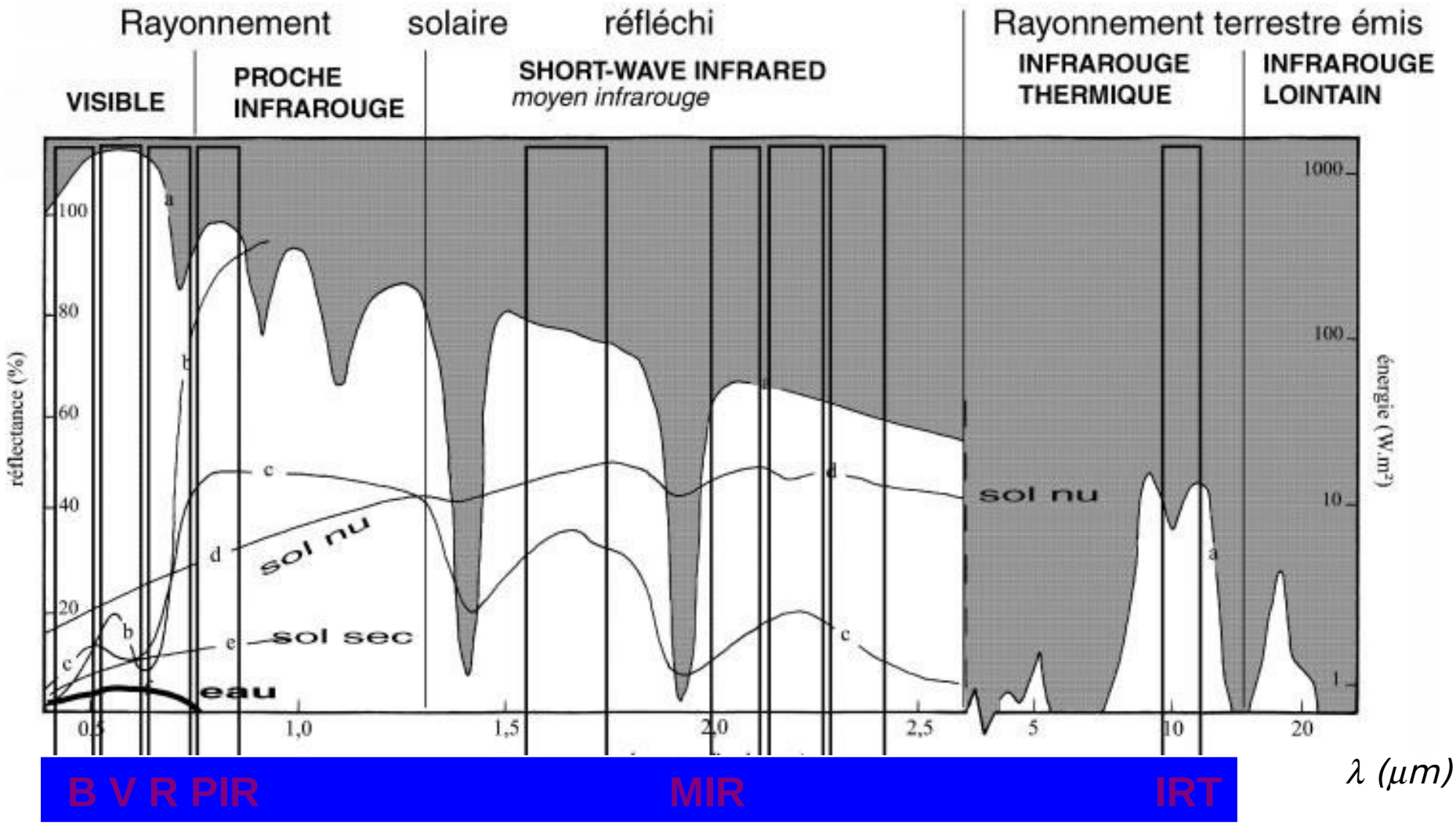


Figure 3-2. Sun illumination spectral irradiance at the Earth's surface. (From Chahine, et al. 1983.)

Transmission atmosphérique
Signatures spectrales



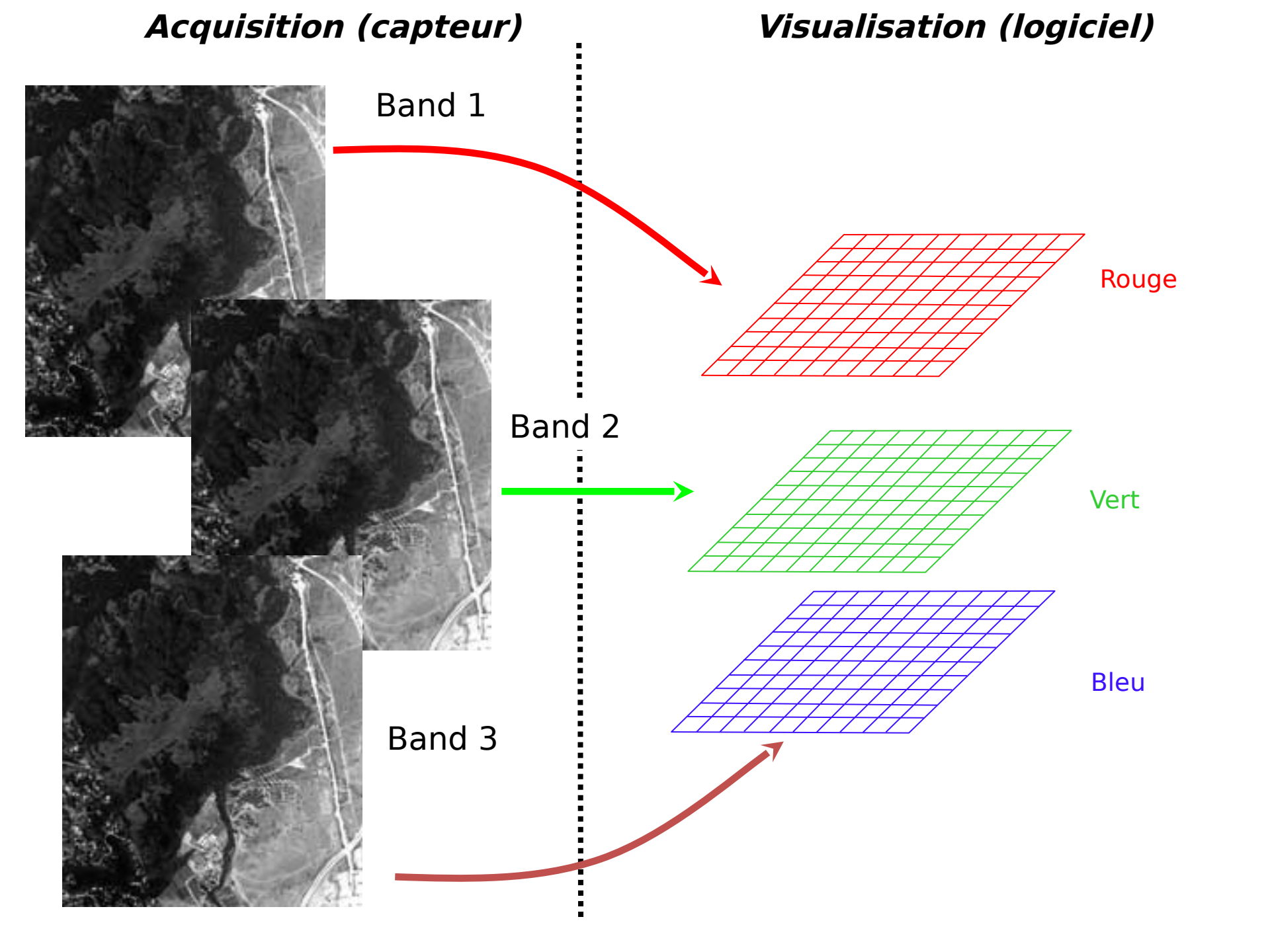
erception humaine

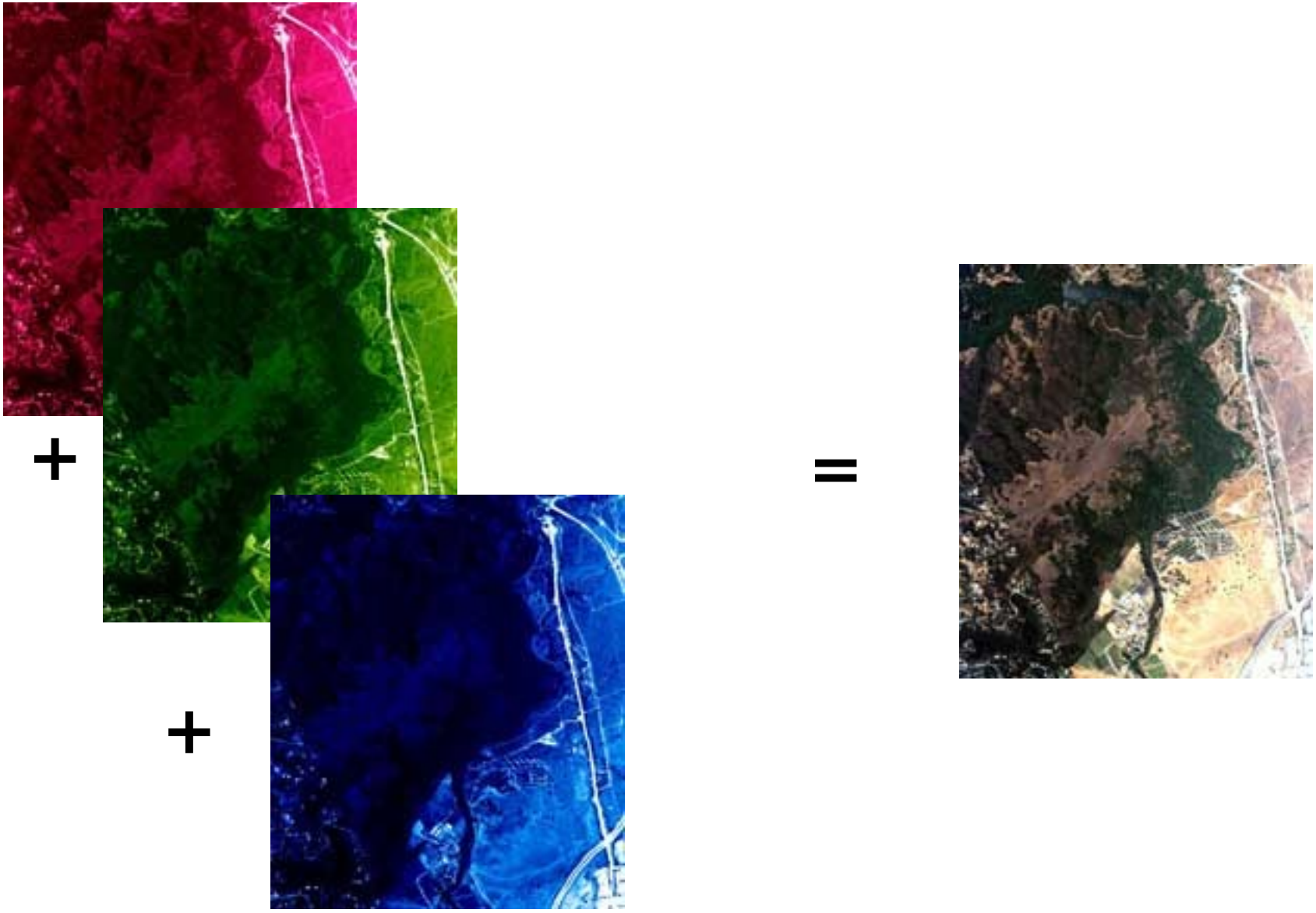
erception humaine

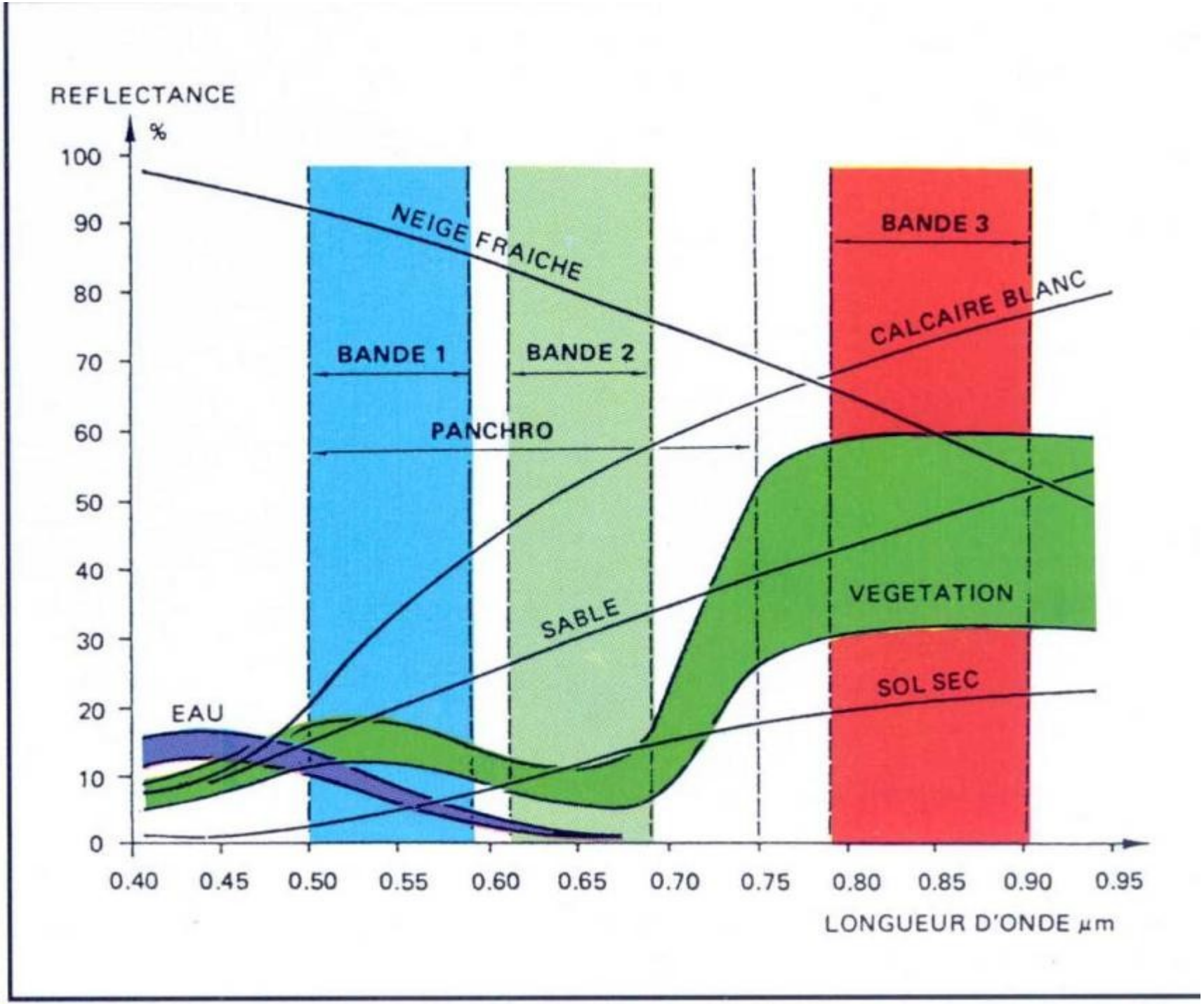
Cône B (5%): λ = 430 nm

Cône V (35%): λ = 530 nm

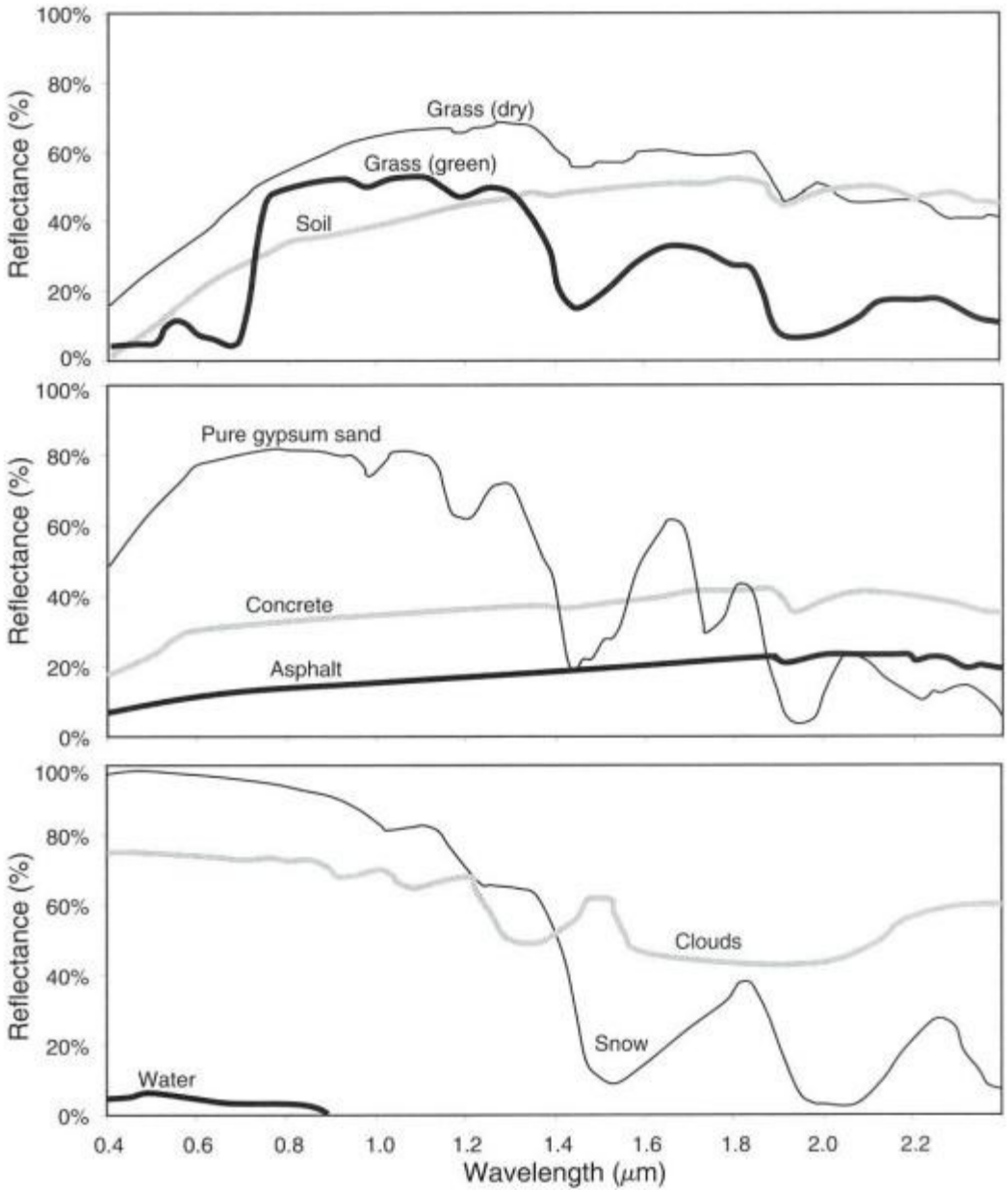
Cône R (60%): λ = 670 nm


Acquisition (capteur)
Visualisation (logiciel)
Band 1
Band 2
Band 3
Rouge
Vert
Bleu

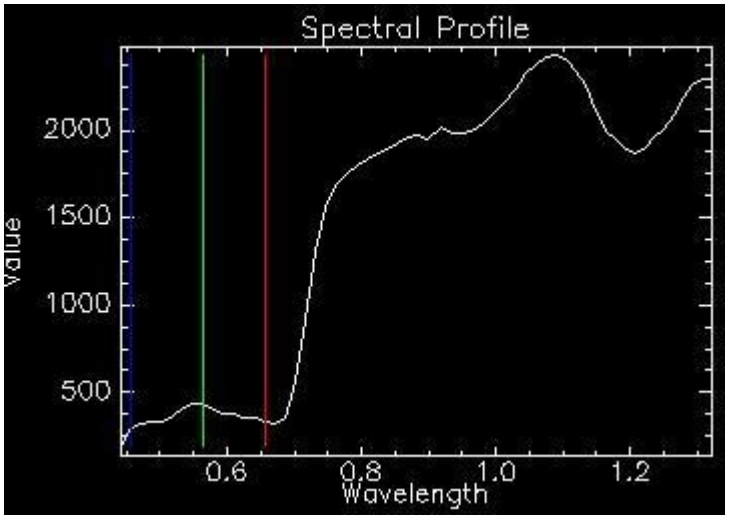


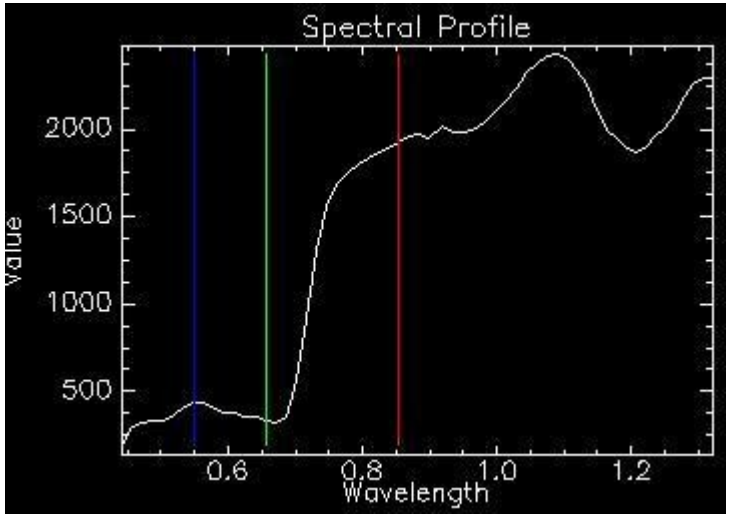

REFLECTANCE
%
100
90
80
70
60
50
40
30
20
10
0
NEIGE FRAICHE
CALCAIRE BLANC
BANDE 1
BANDE 2
BANDE 3
PANCHRO
VEGETATION
SABLE
SOL SEC
EAU
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
LONGUEUR D'ONDE µm

Signatures spectrales de différents types de surfaces



Source: Lillesand *et al.*, 2


Spectral Profile
2000
1500
1000
500
value
0.6
0.8
1.0
1.2
Wavelength


Spectral Profile
2000
1500
1000
500
value
0.6
0.8
1.0
1.2
Wavelength

DISCRIMINATION DE LA VEGETATION avec l'InfraRouge

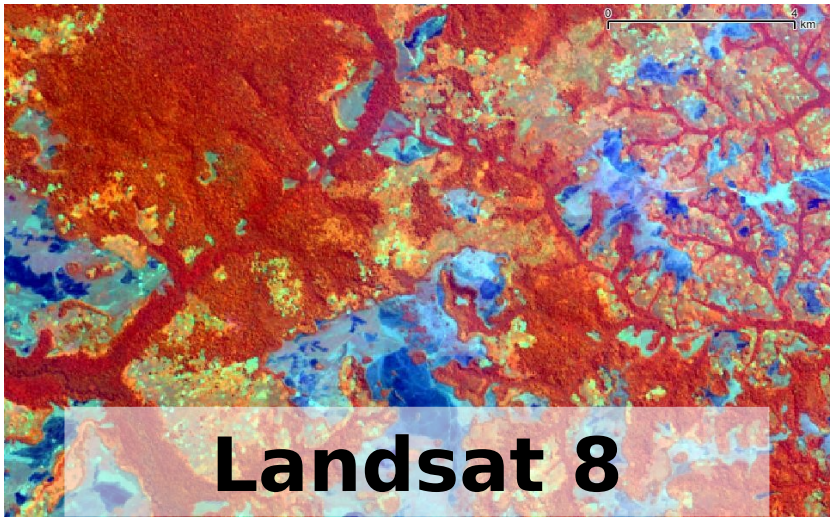
Source: Lillesand *et al.*, 2

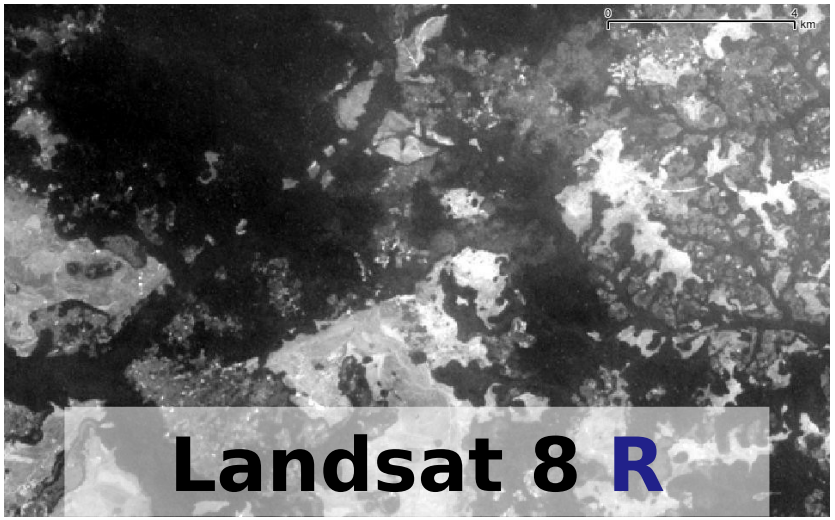
DISCRIMINATION DE LA VEGETATION avec l'InfraRouge

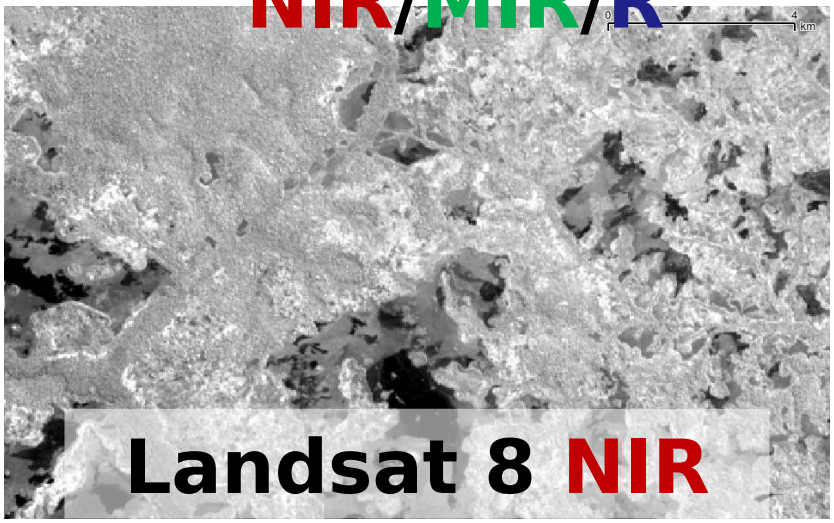
Source: Lillesand *et al.*, 2

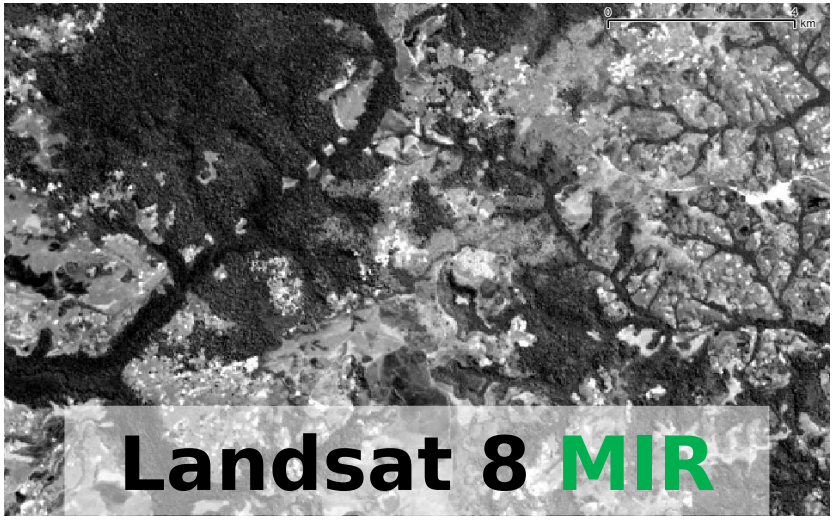
Introduction à la télédétection

Bande spectrale







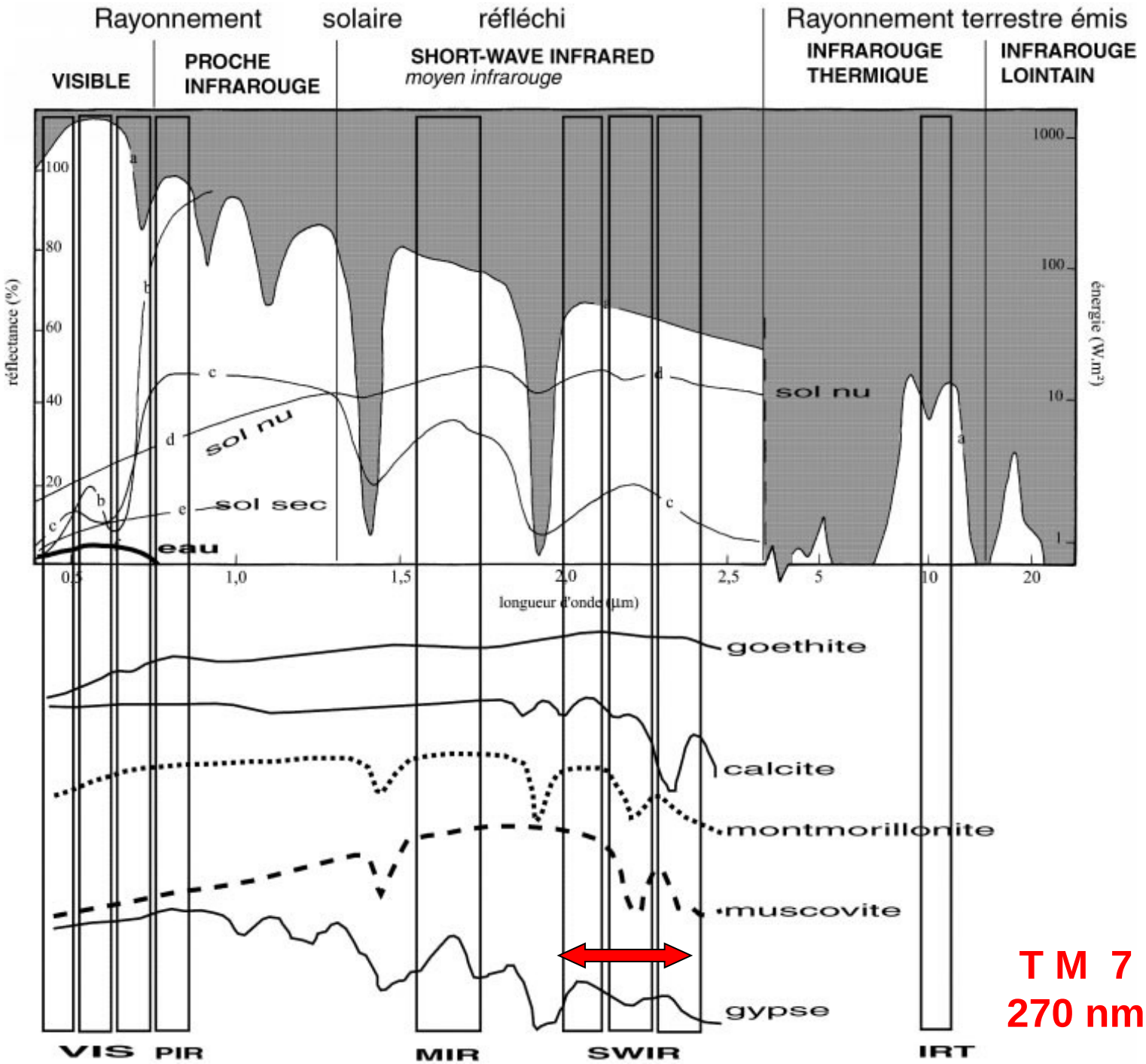


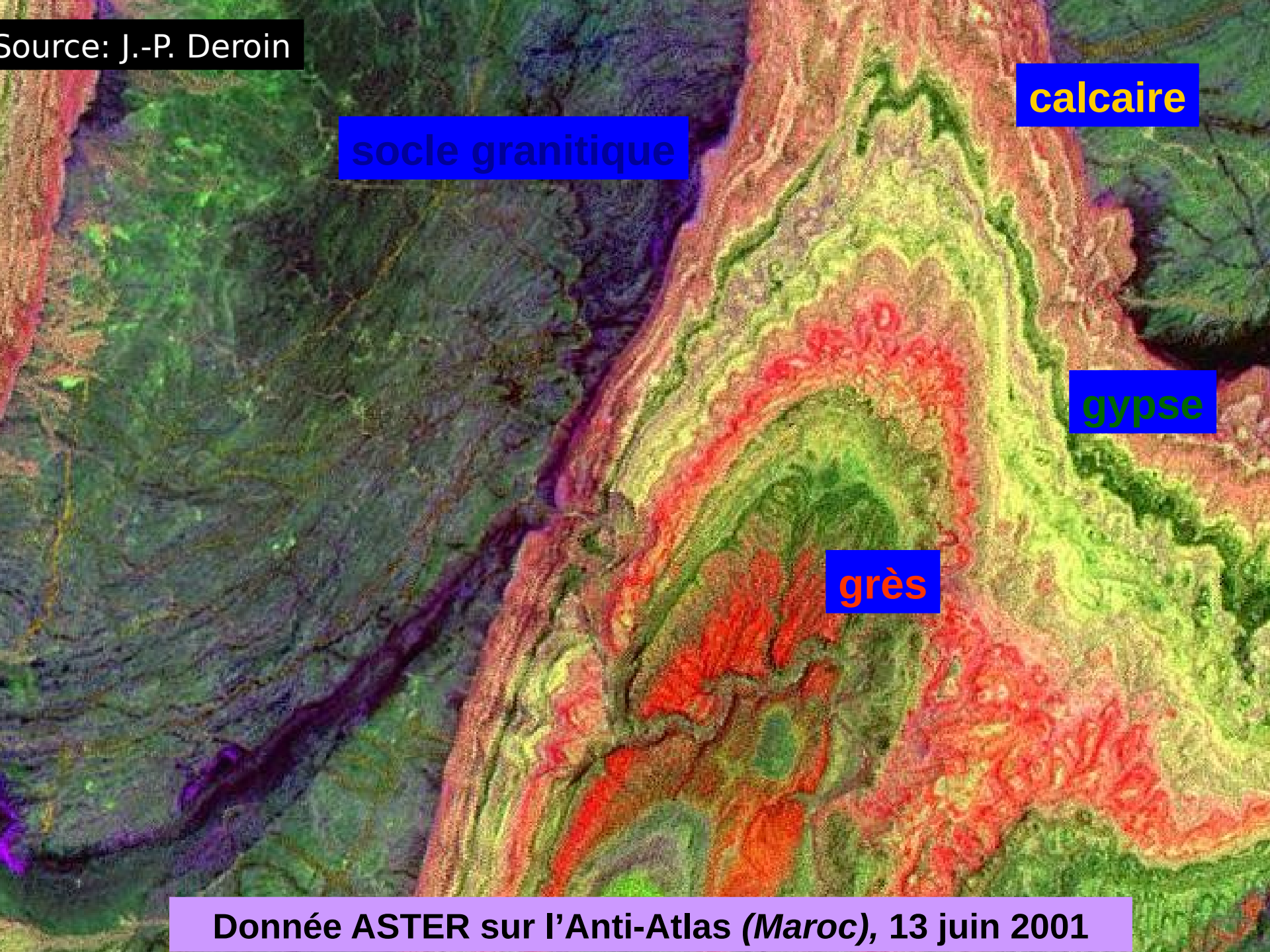
DISCRIMINATION Feuillus / conifères avec l'InfraRouge

nal panchromatique
(*0.4 – 0.7 μm*)

al Proche-InfraRouge
(*0.7-0.9 μm*)

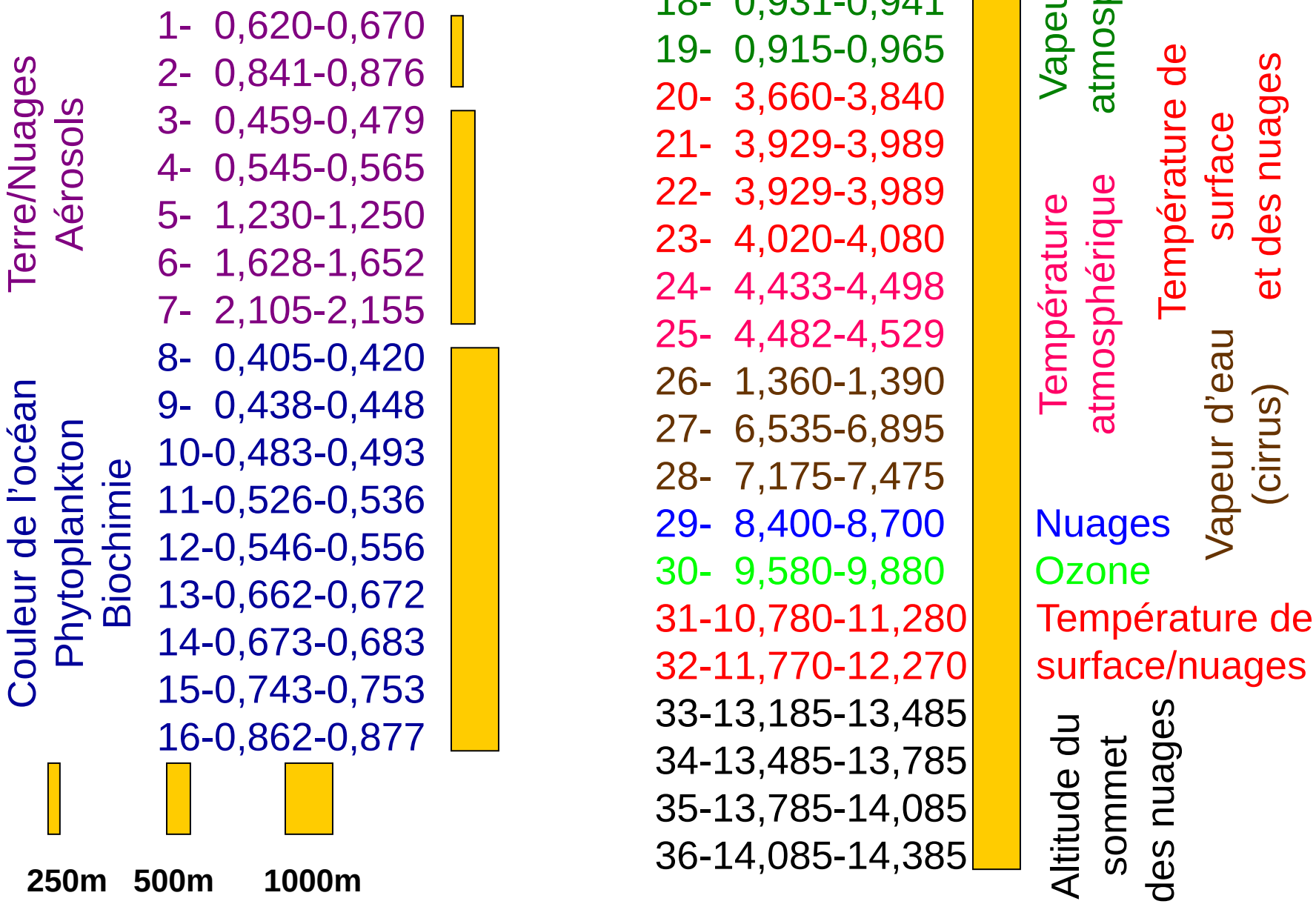
Source: Lillesand *et al.*, 2


Rayonnement solaire réfléchi
Rayonnement terrestre émis
VISIBLE
PROCHE INFRAROUGE
SHORT-WAVE INFRARED
moyen infrarouge
INFRAROUGE THERMIQUE
INFRAROUGE LOINTAIN
réflectance (%)
énergie (W/m²)
sol nu
sol sec
eau
longueur d'onde (µm)
goethite
calcite
montmorillonite
muscovite
gypse
VIS
PIR
MIR
SWIR
IRT
T M 7
270 nm

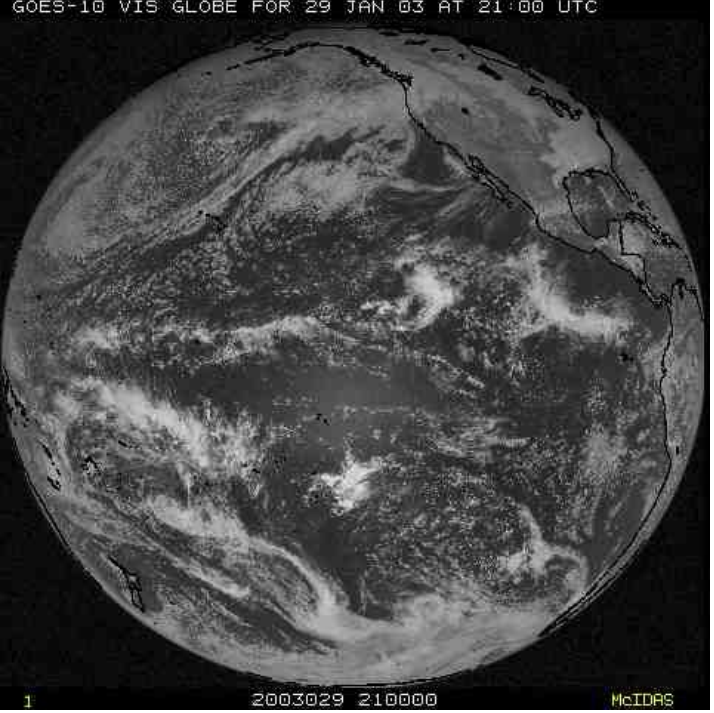


Donnée ASTER sur l'Anti-Atlas *(Maroc)*, 13 juin 2001

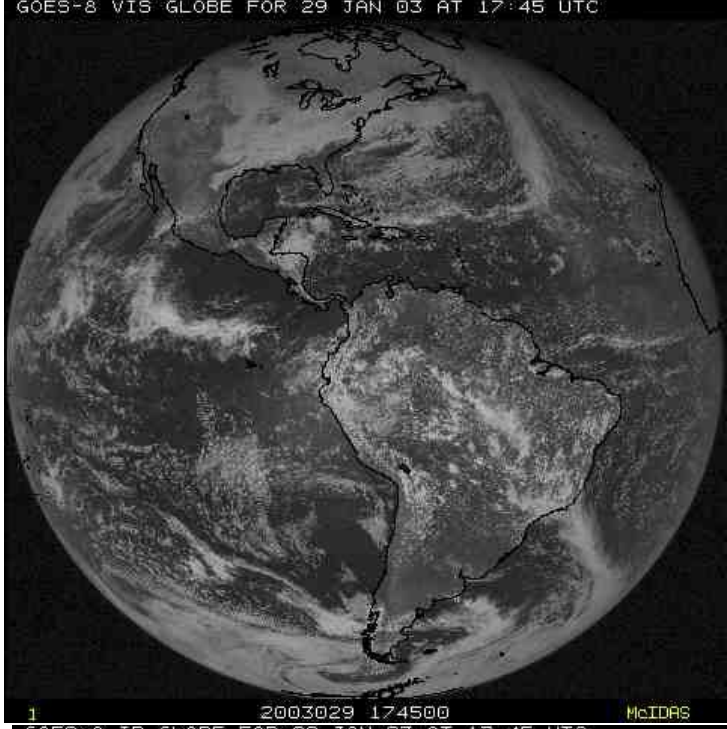
Multispectral : Exemple de MODIS (36 canaux [µm])

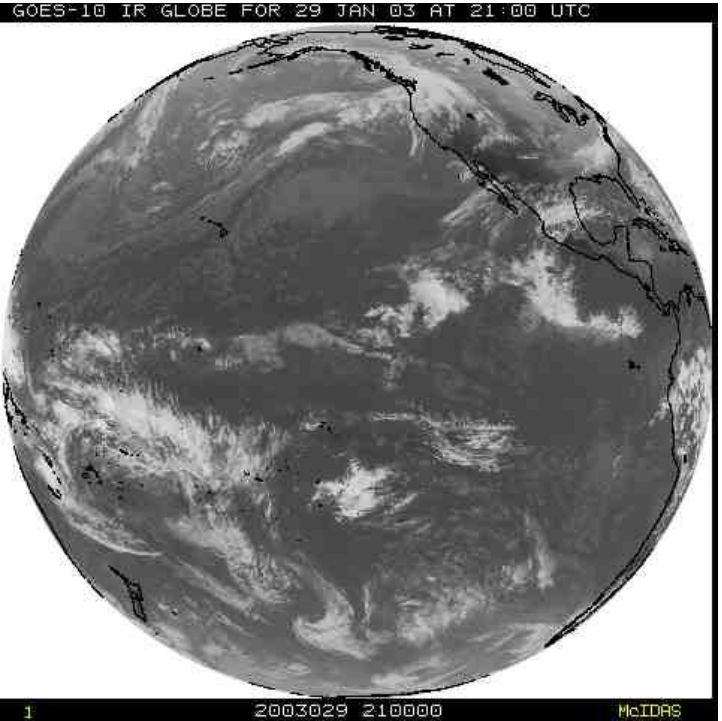


Satellites GOES



Visible





Infra-Rouge