Quick Review of Remote Sensing Basic Theory

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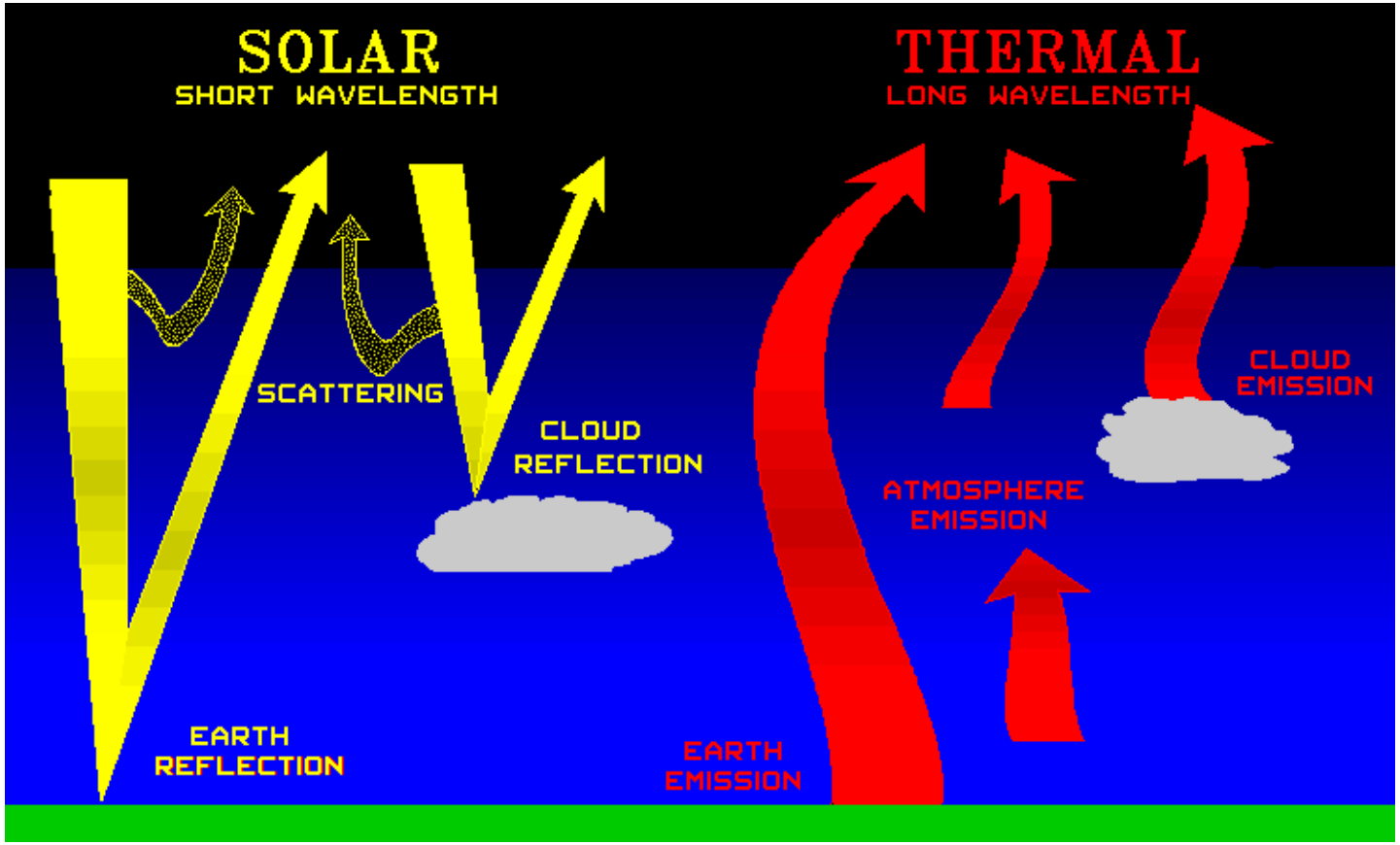
Outline

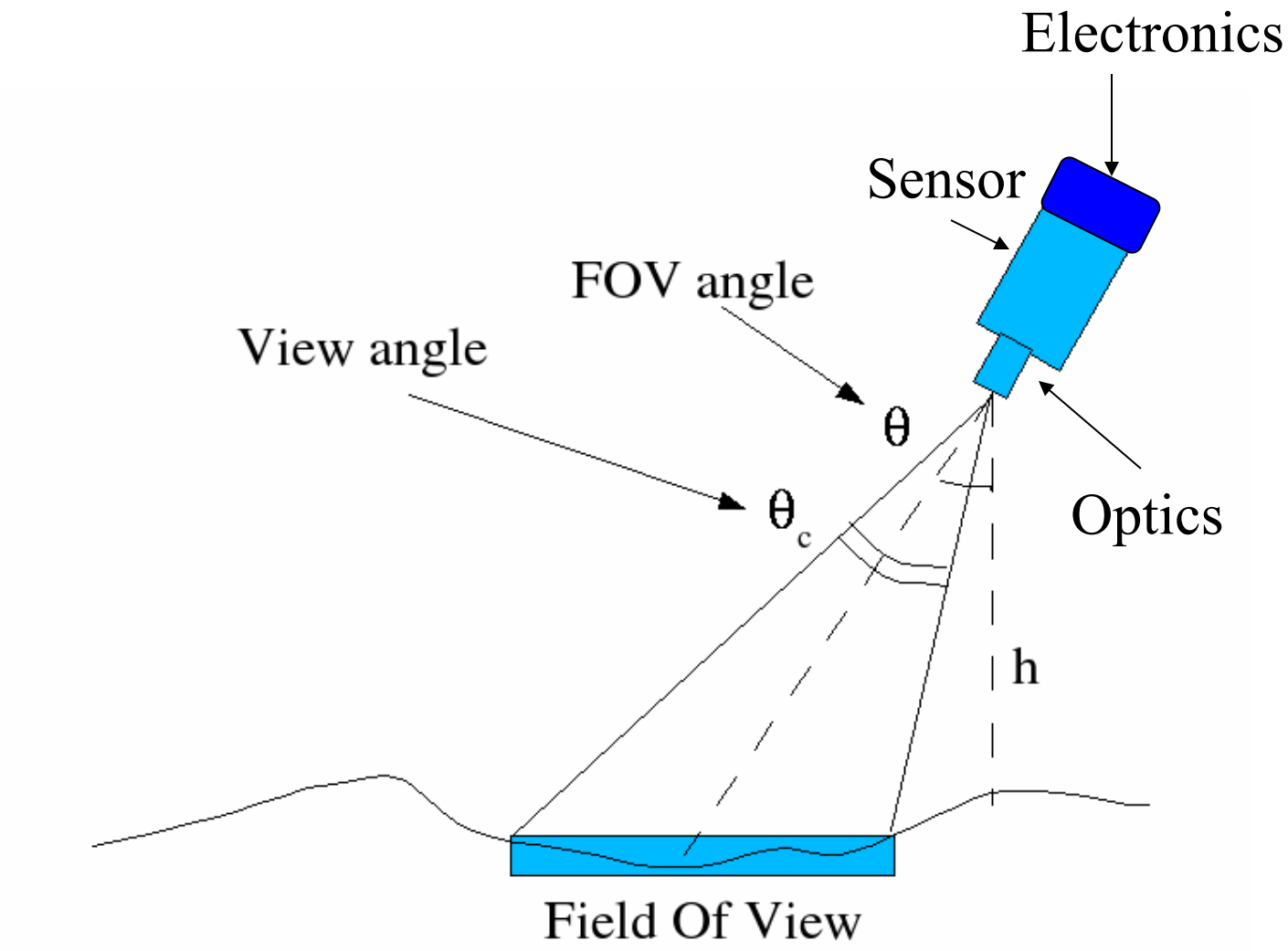
- Visible: RGB, Radiance and Reflectance
- Near Infrared: Absorption
- Infrared: Radiance and Brightness Temperature

Visible
(Reflective Bands)

Infrared
(Emissive Bands)



Sensor Geometry



Terminology of radiant energy

Energy from the Earth Atmosphere

over time is

Flux

which strikes the detector area

Irradiance

at a given wavelength interval

Monochromatic Irradiance

over a solid angle on the Earth

Radiance observed by satellite radiometer

is described by

The Planck function

can be inverted to

Brightness temperature

Definitions of Radiation

QUANTITY	SYMBOL	UNITS
Energy	dQ	Joules
Flux	dQ/dt	Joules/sec = Watts
Irradiance	dQ/dt/dA	Watts/meter^2
Monochromatic Irradiance	dQ/dt/dA/d□	W/m^2/micron
	or	
	dQ/dt/dA/d□	W/m^2/cm^{-1}
Radiance	dQ/dt/dA/d□/d□	W/m^2/micron/ster
	or	
	dQ/dt/dA/d□/d□	W/m^2/cm^{-1}/ster

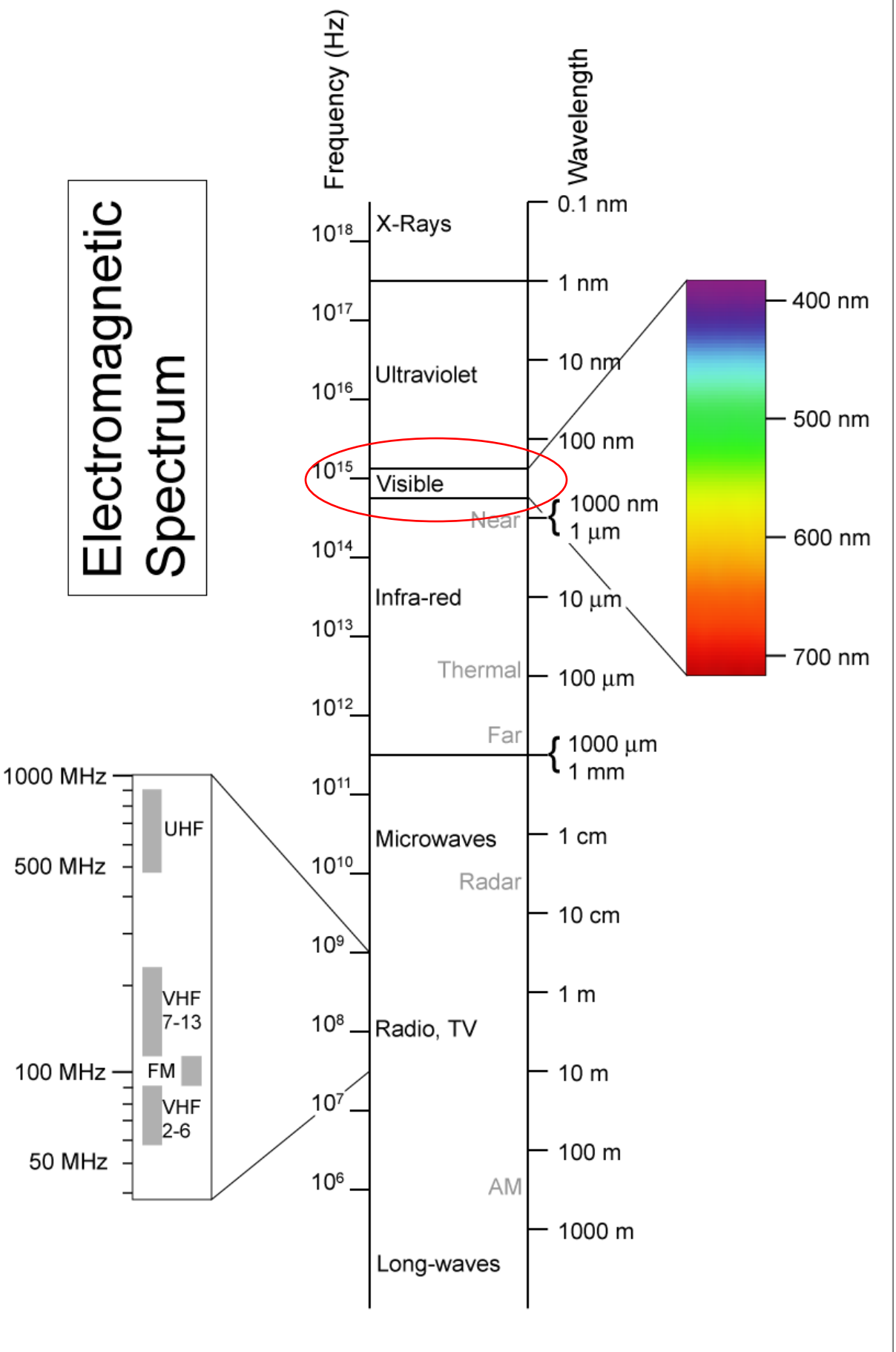
Visible: Reflective Bands

Used to observe solar energy reflected by the Earth system in the:

- Visible between .4 and .7 μm
- NIR between .7 and 3 μm

About 99% of the energy observed between 0 and 4 μm is solar reflected energy

Only 1% is observed above 4 μm



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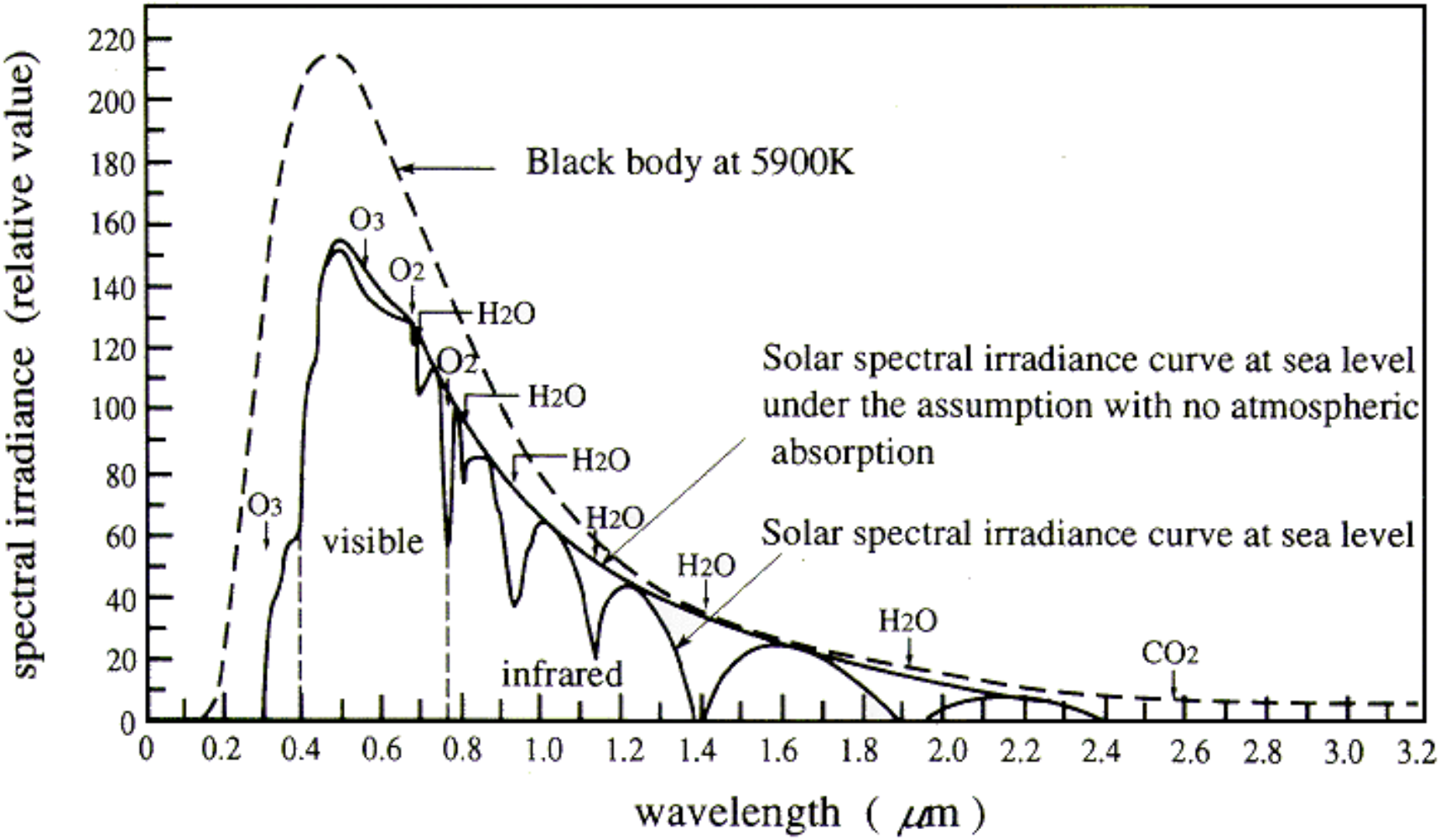


Comparison of spectral irradiance of solar light at sea level with black body radiation

Ocean: Dark

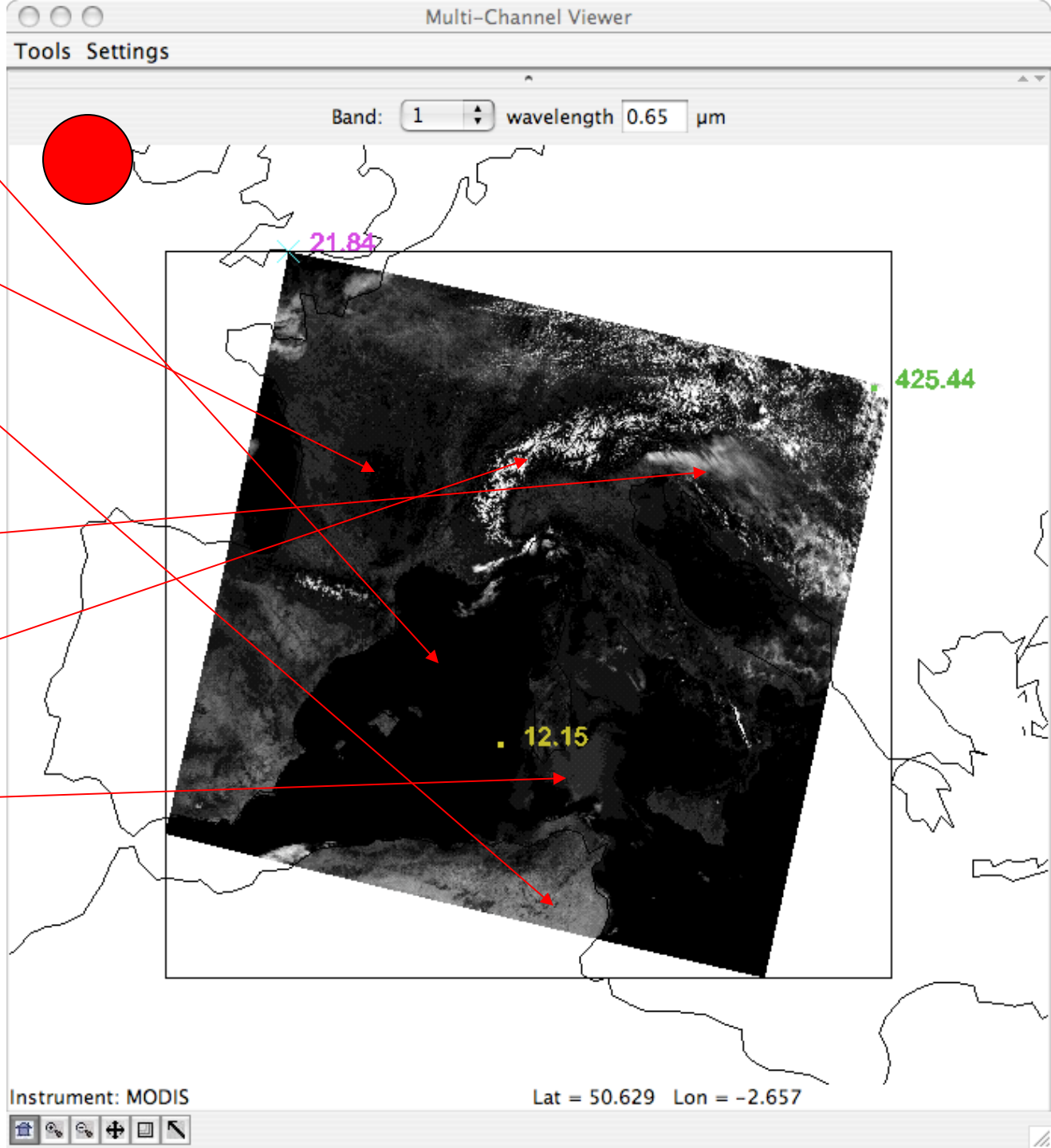
Vegetated Surface: Dark

NonVegetated Surface: Brighter

Clouds: Bright

Snow: Bright

Sunglint



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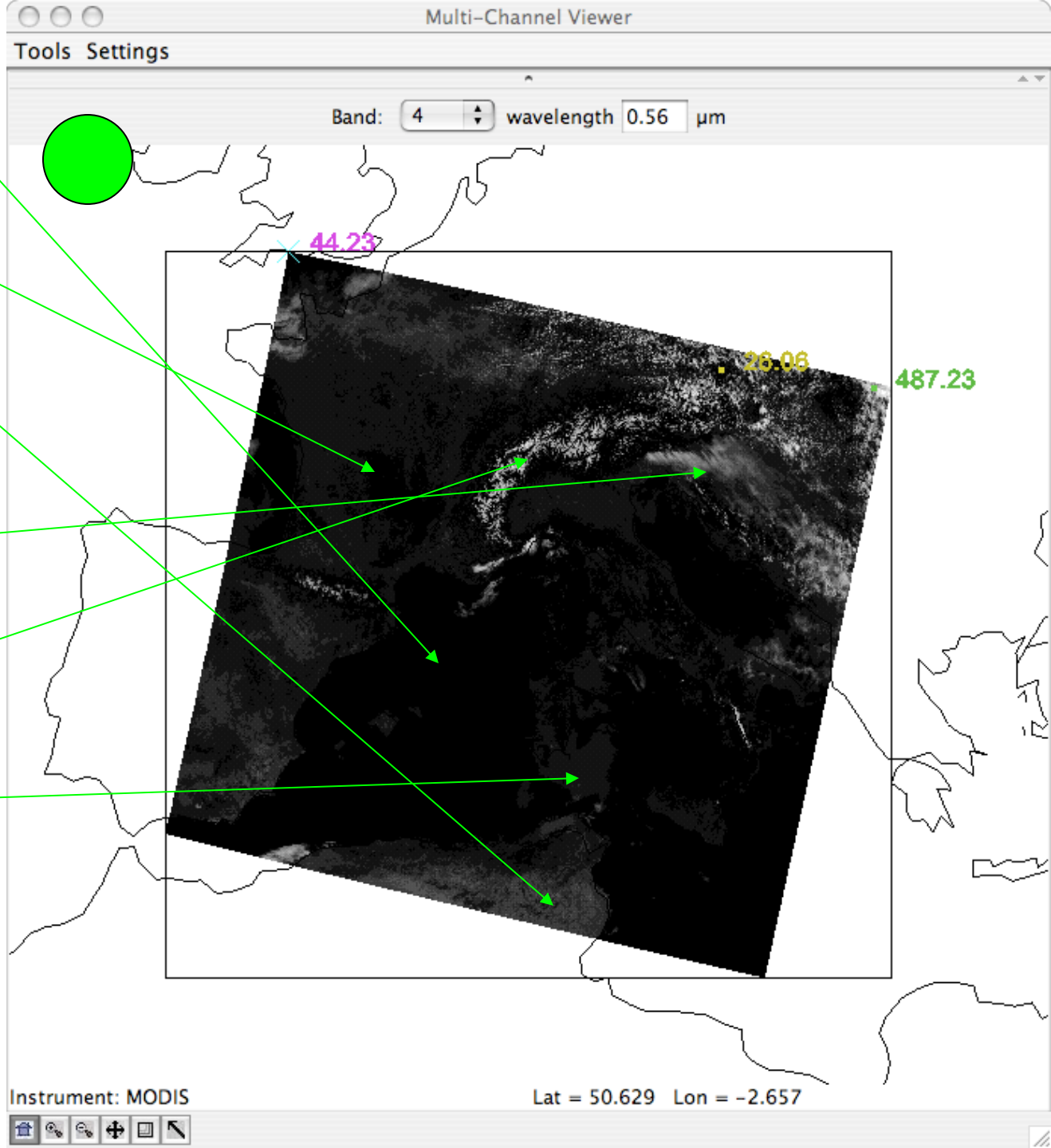

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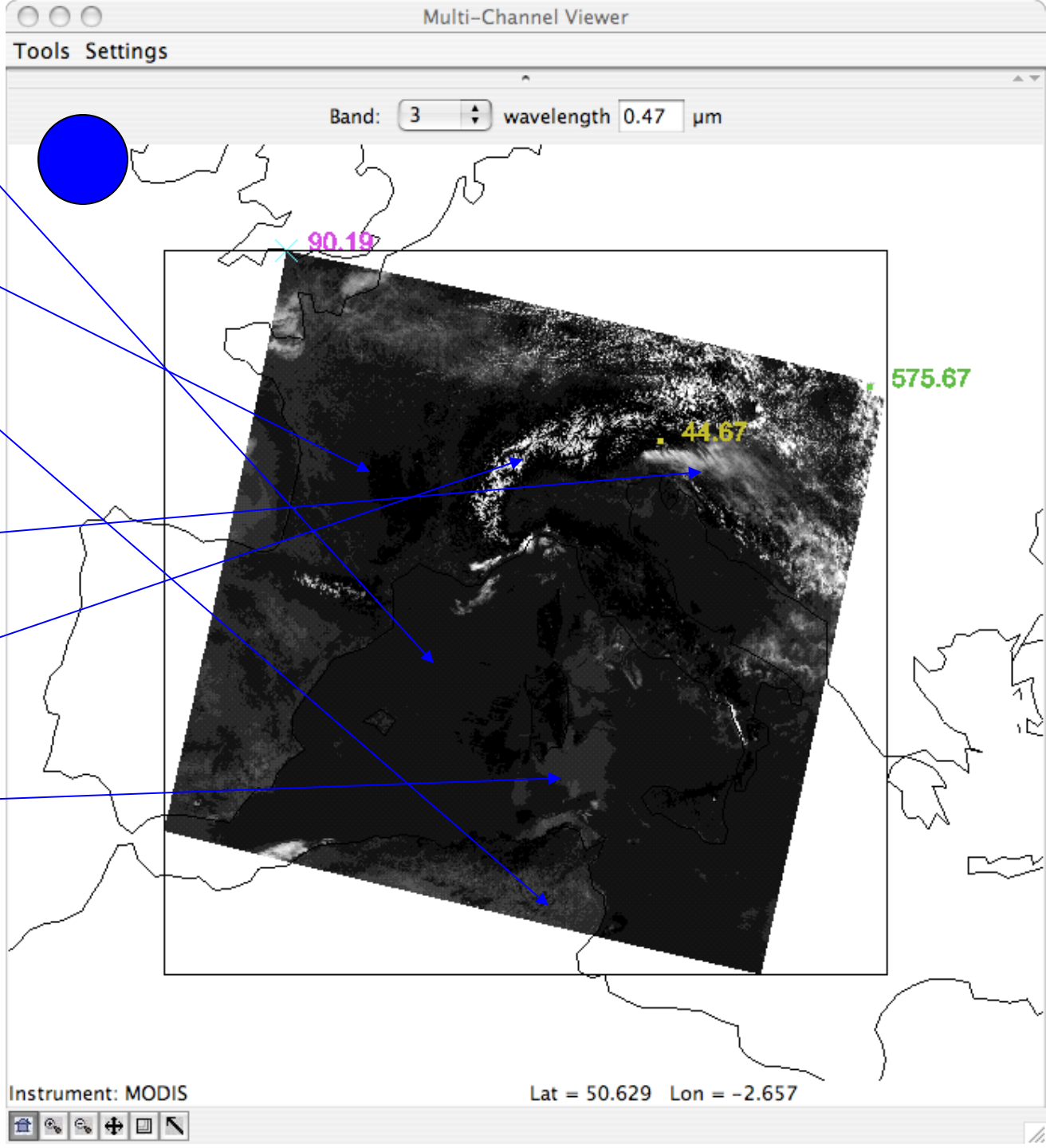
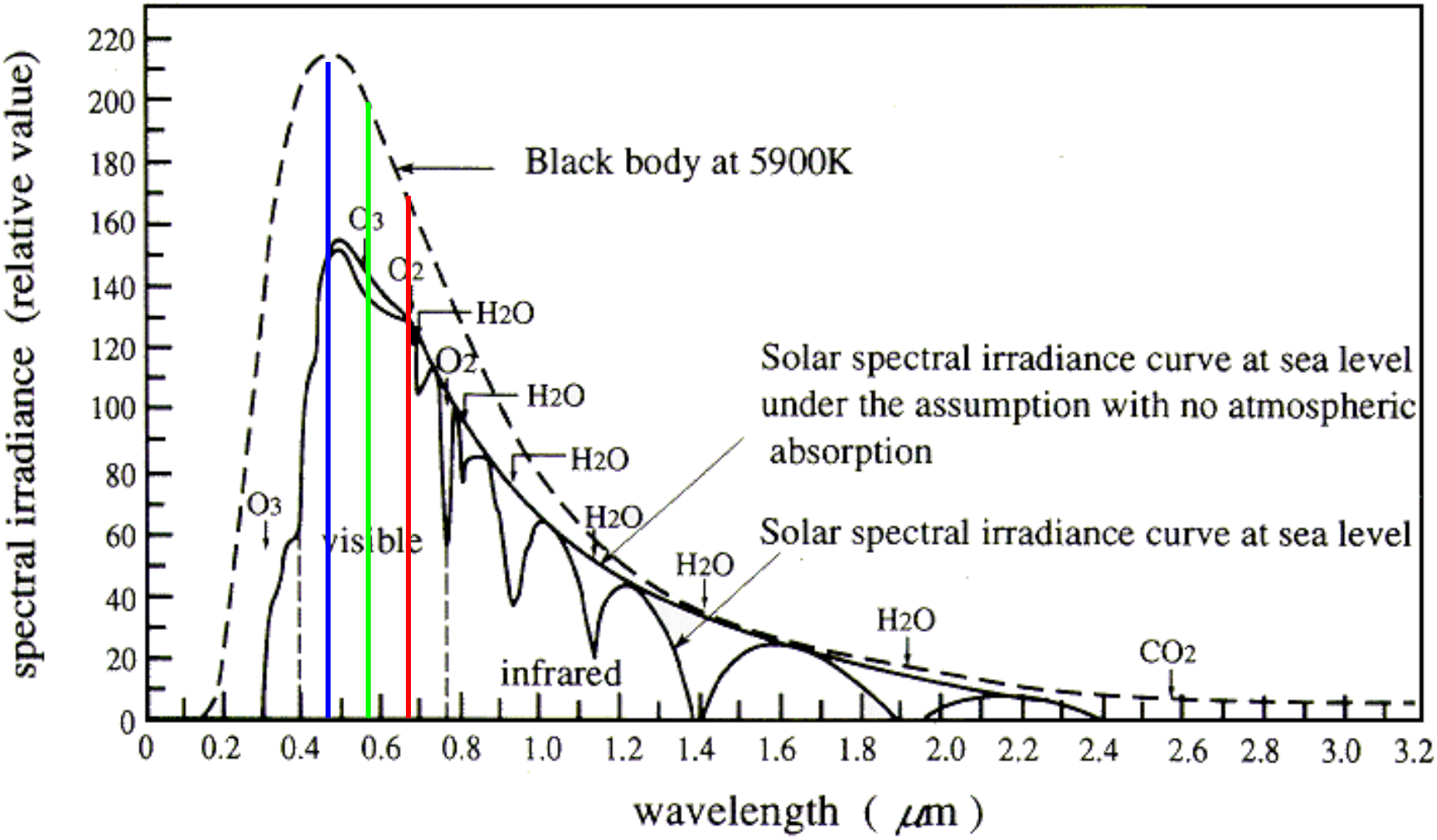




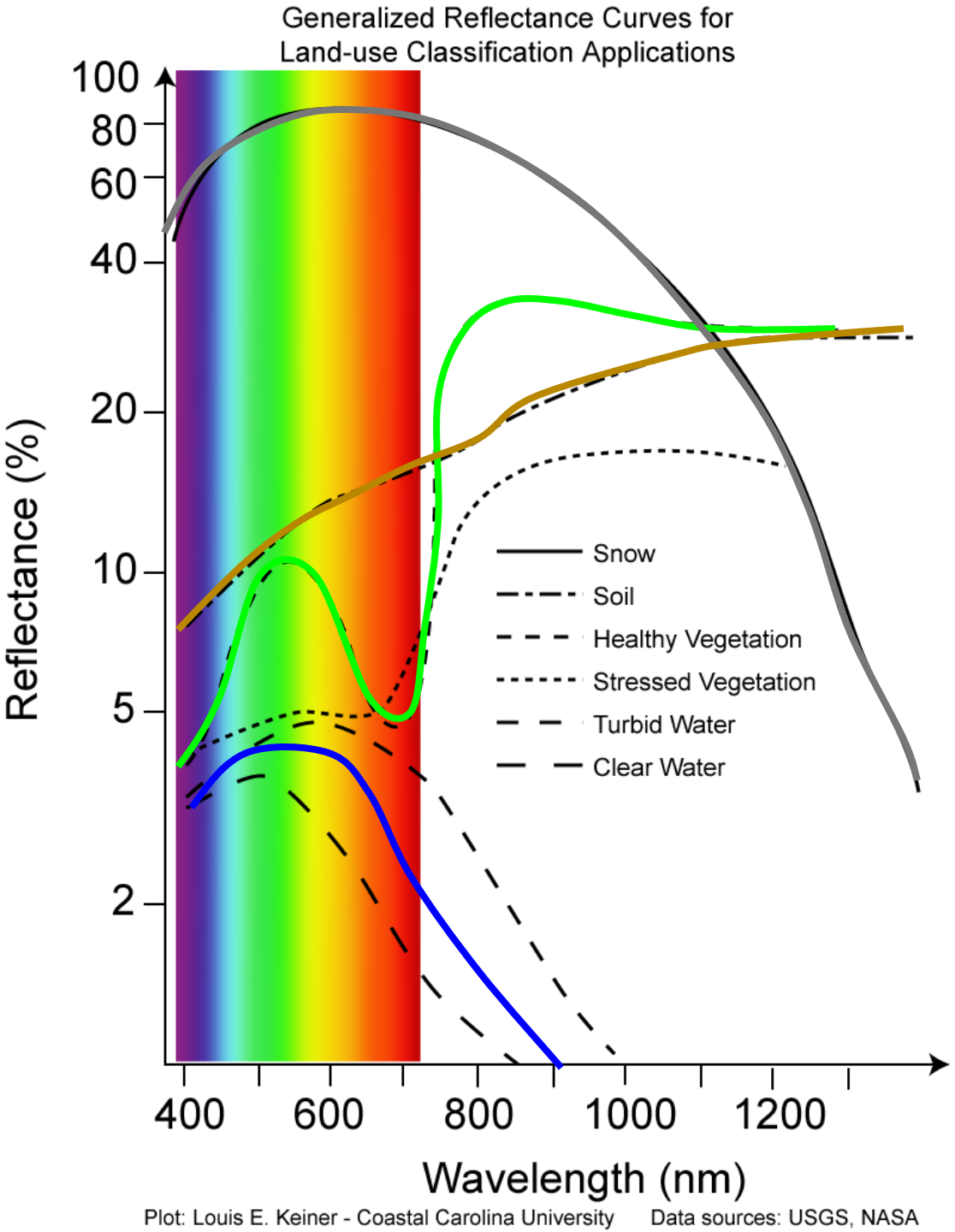
Comparison of spectral irradiance of solar light at sea level with black body radiation

Reflectance

- To properly compare different reflective channels we need to convert observed radiance into a target physical property

- In the visible and near infrared this is done through the ratio of the observed radiance divided by the incoming energy at the top of the atmosphere

- The physical quantity is the Reflectance i.e. the fraction of solar energy reflected by the observed target



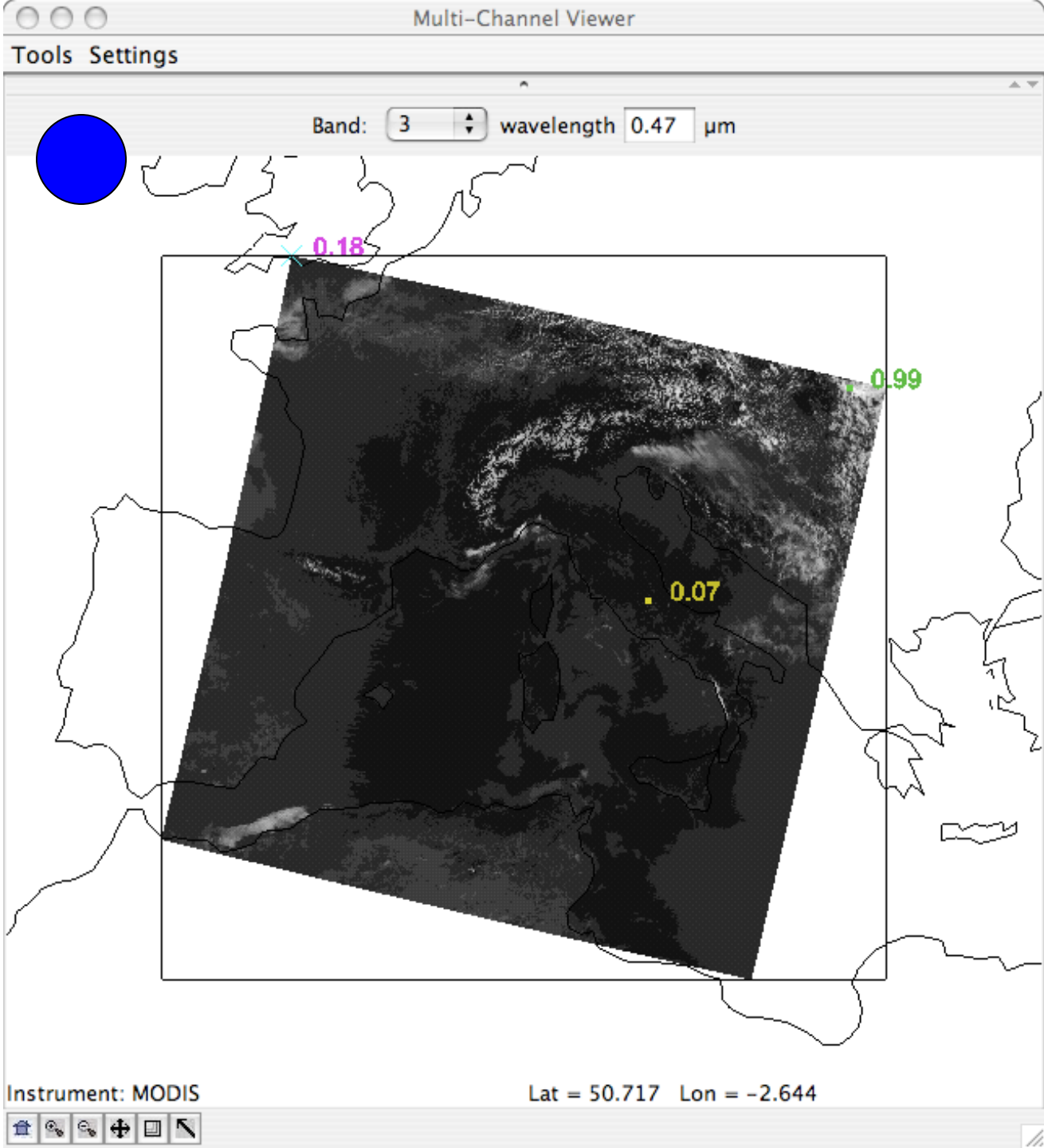
Soil

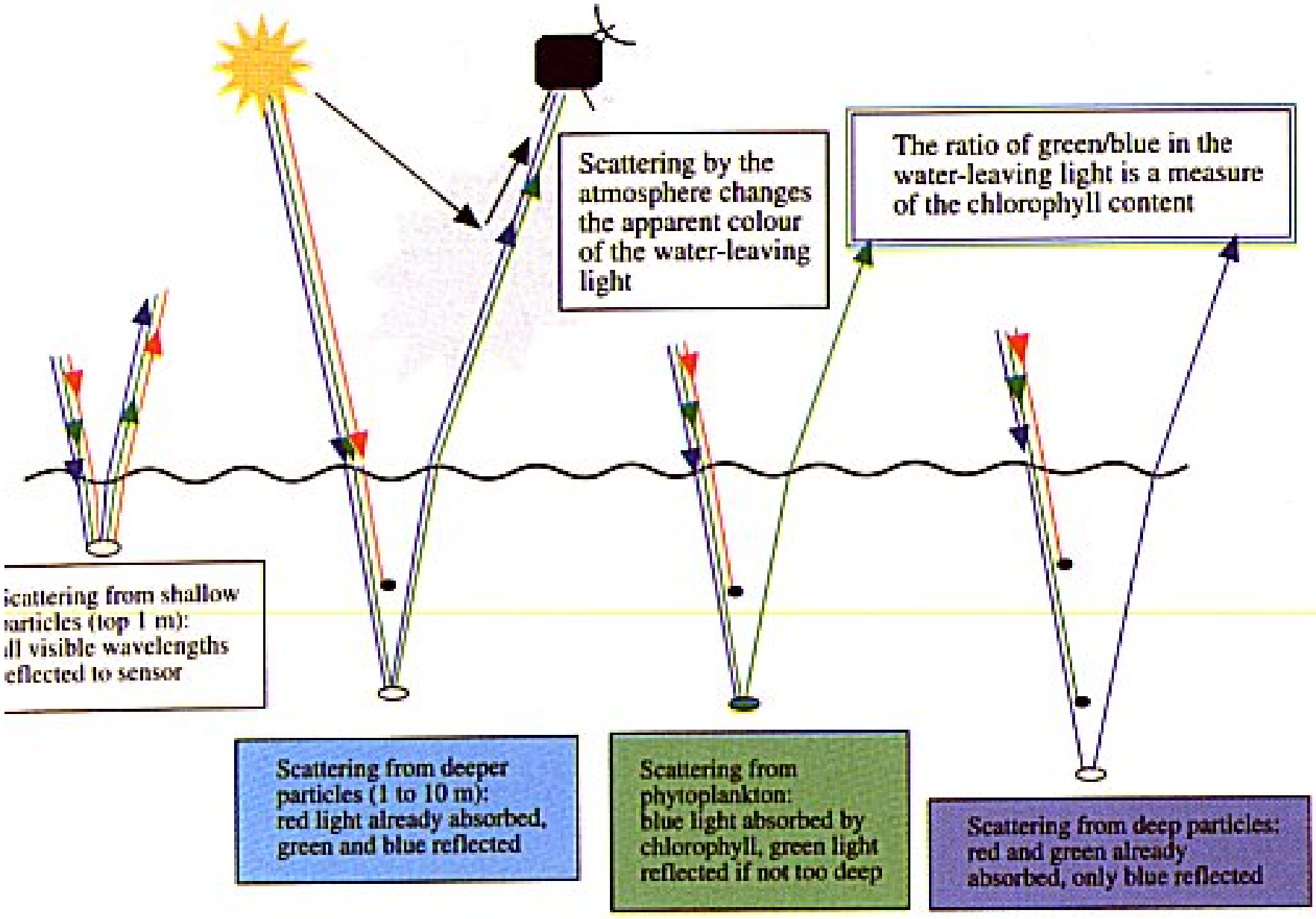
Vegetation

Snow

Ocean

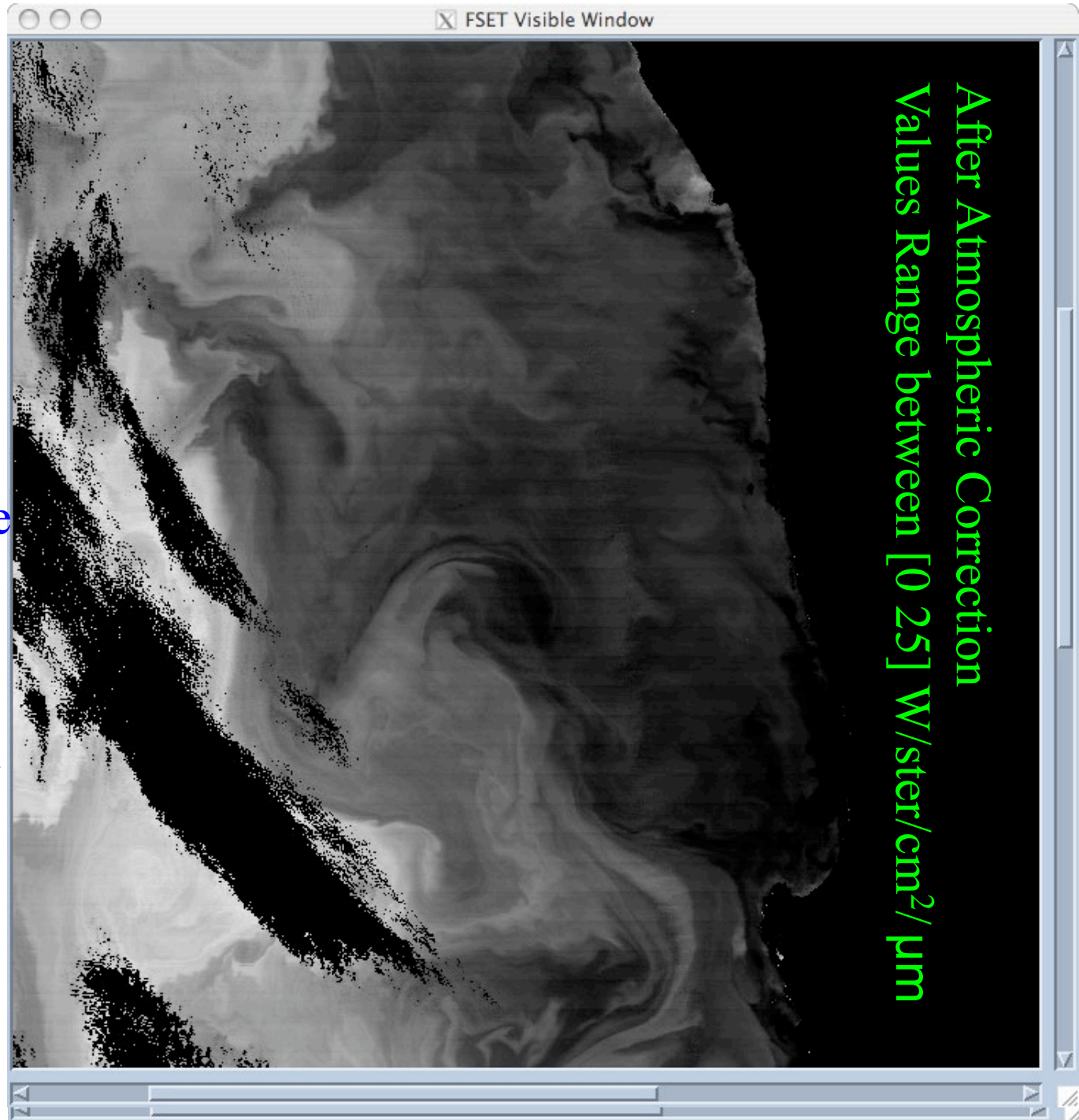
Reflectances
On Same
Color Scale



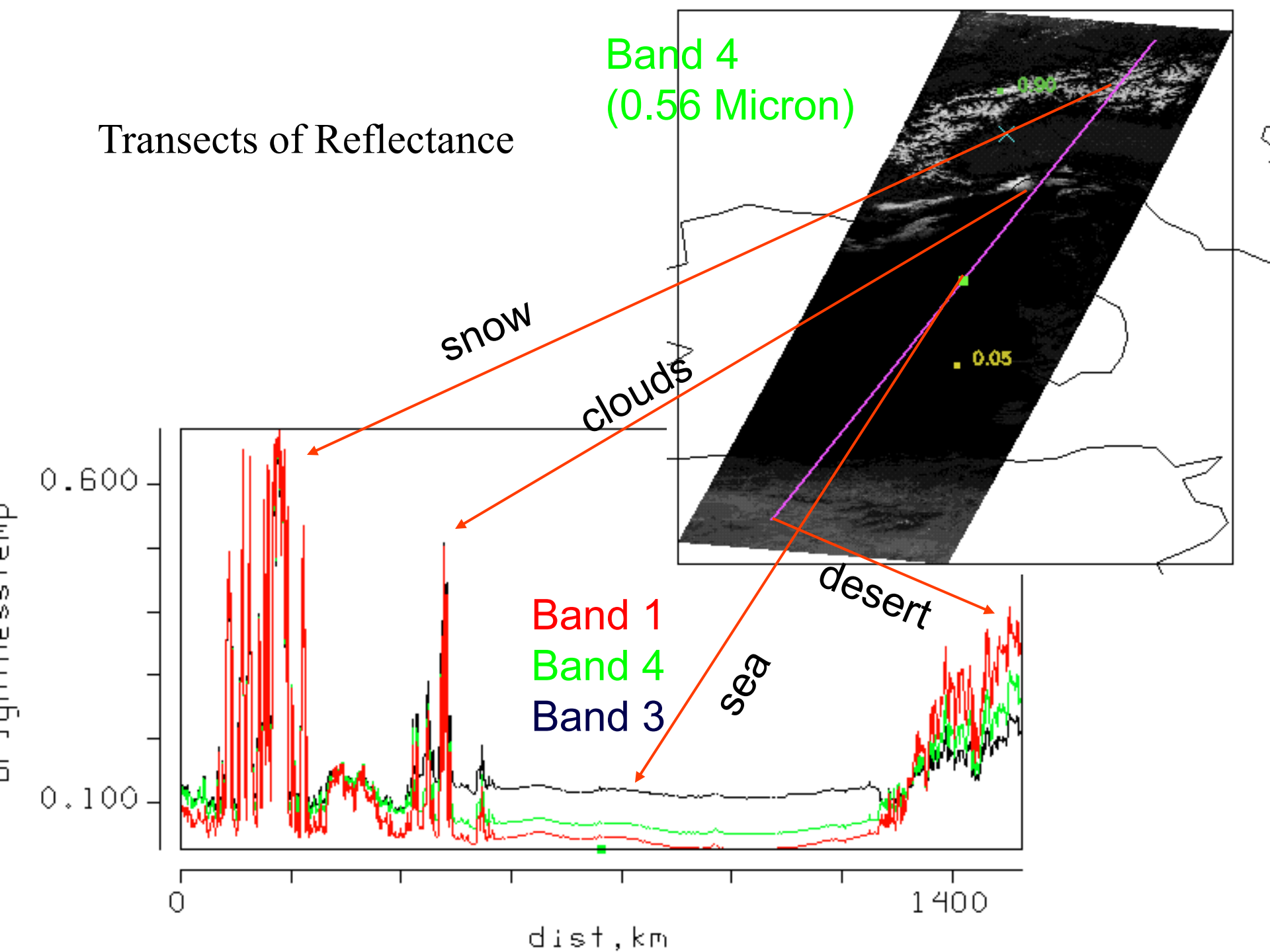

Scattering by the atmosphere changes the apparent colour of the water-leaving light
The ratio of green/blue in the water-leaving light is a measure of the chlorophyll content
icattering from shallow
articles (top 1 m):
ll visible wavelengths
eflected to sensor
Scattering from deeper particles (1 to 10 m): red light already absorbed, green and blue reflected
Scattering from phytoplankton: blue light absorbed by chlorophyll, green light reflected if not too deep
Scattering from deep particles: red and green already absorbed, only blue reflected

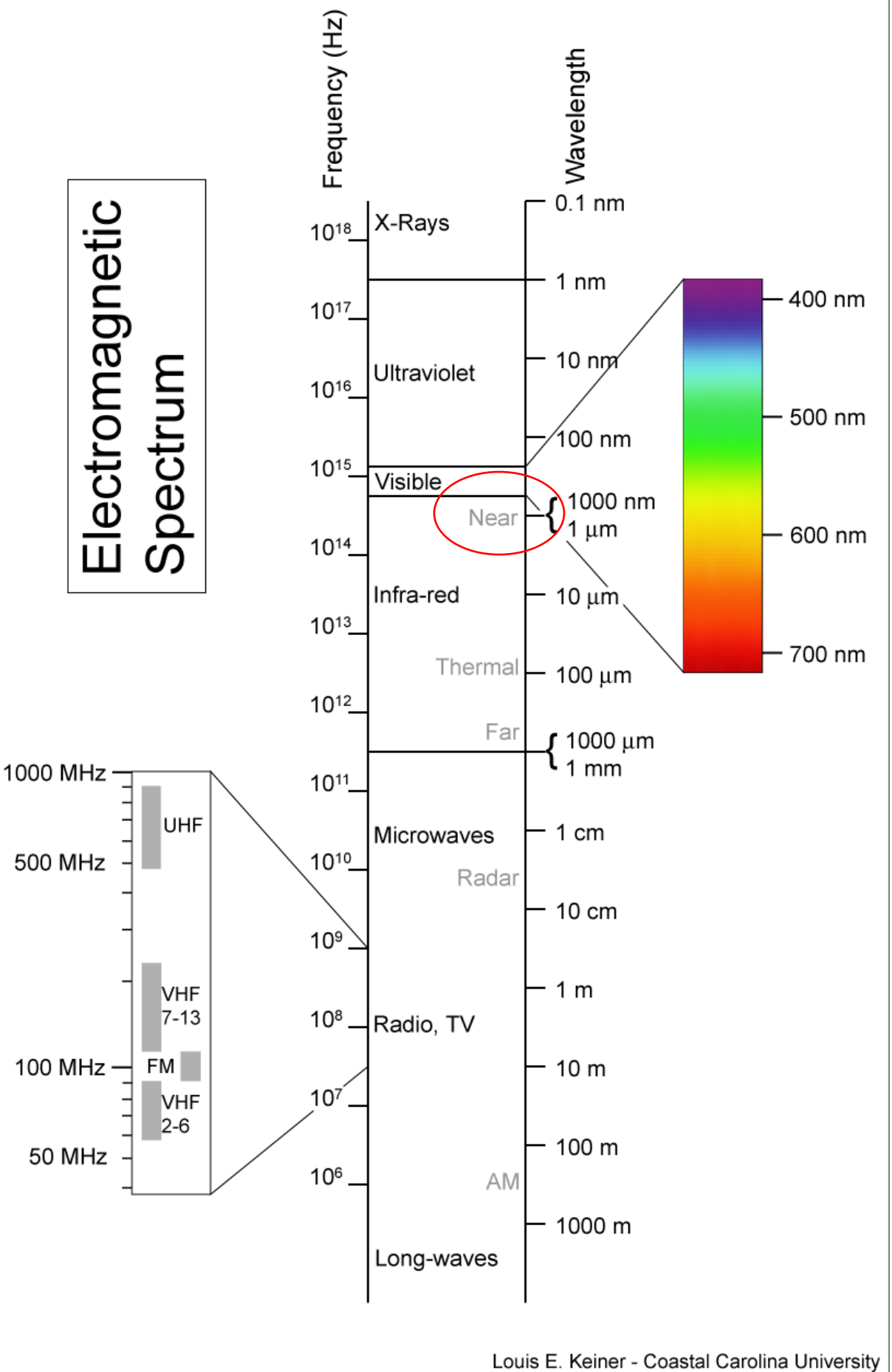
Radiance observed
In the Blue Band
At 0.41 μm

More than 75% of the
Observed energy
Over Ocean
In the blue bands
Is due to atmospheric
Scattering.
Less than 25% is due
to Water
Leaving Energy



Transects of Reflectance





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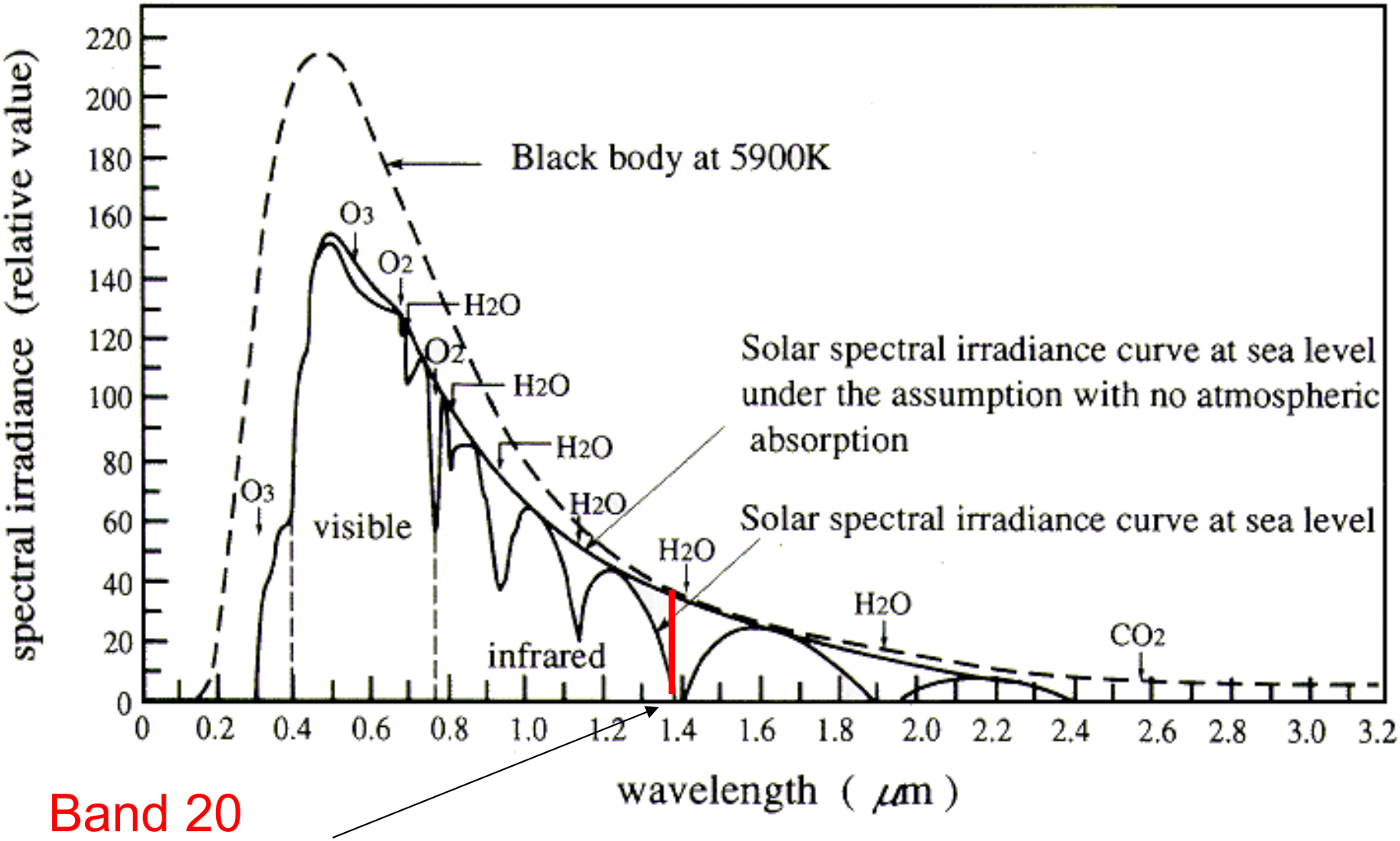
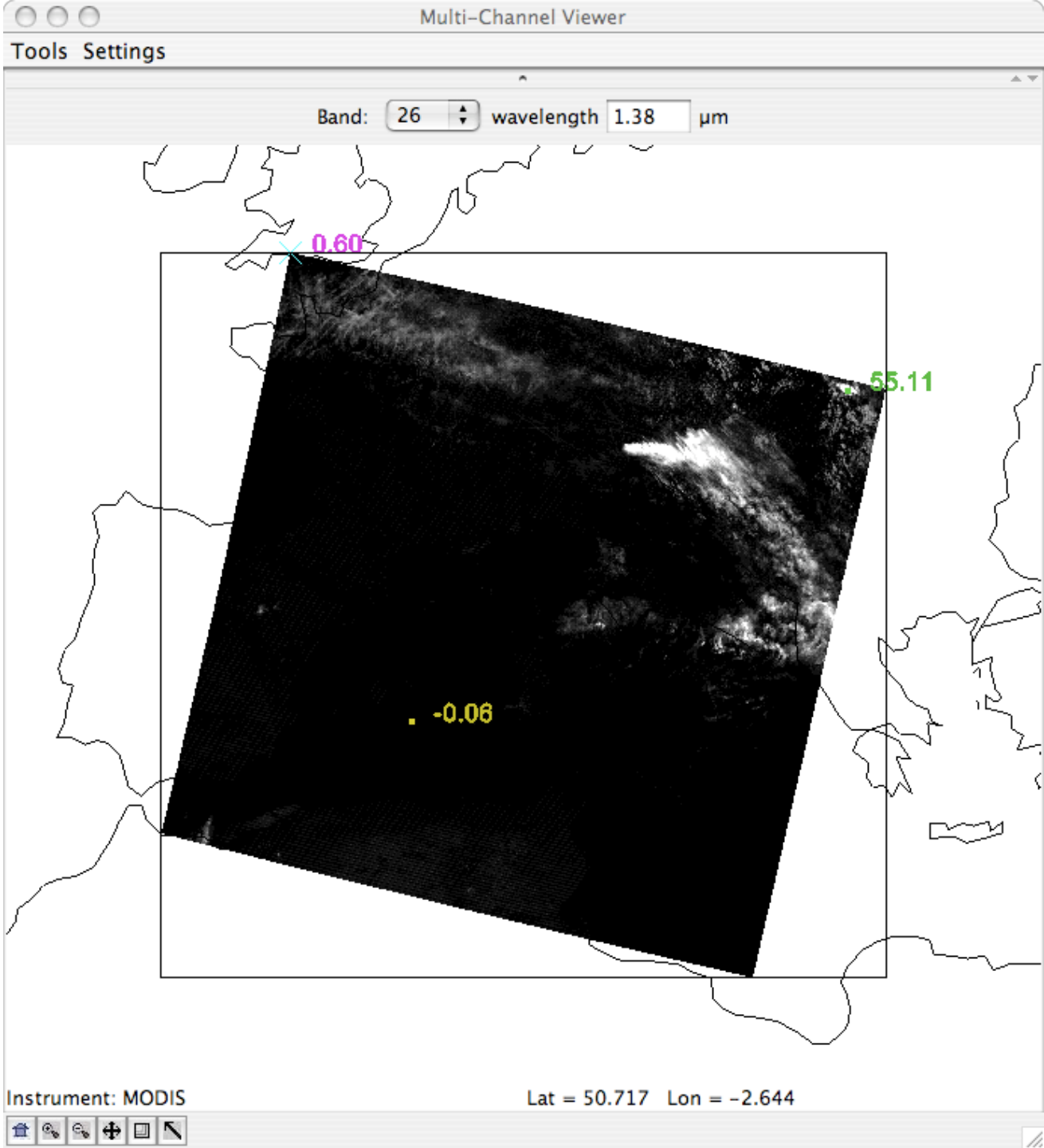


Band 20
1.38 micron
Strong H_20

Comparison of spectral irradiance of solar light at sea level with black body radiation

Only High Clouds Are Visible



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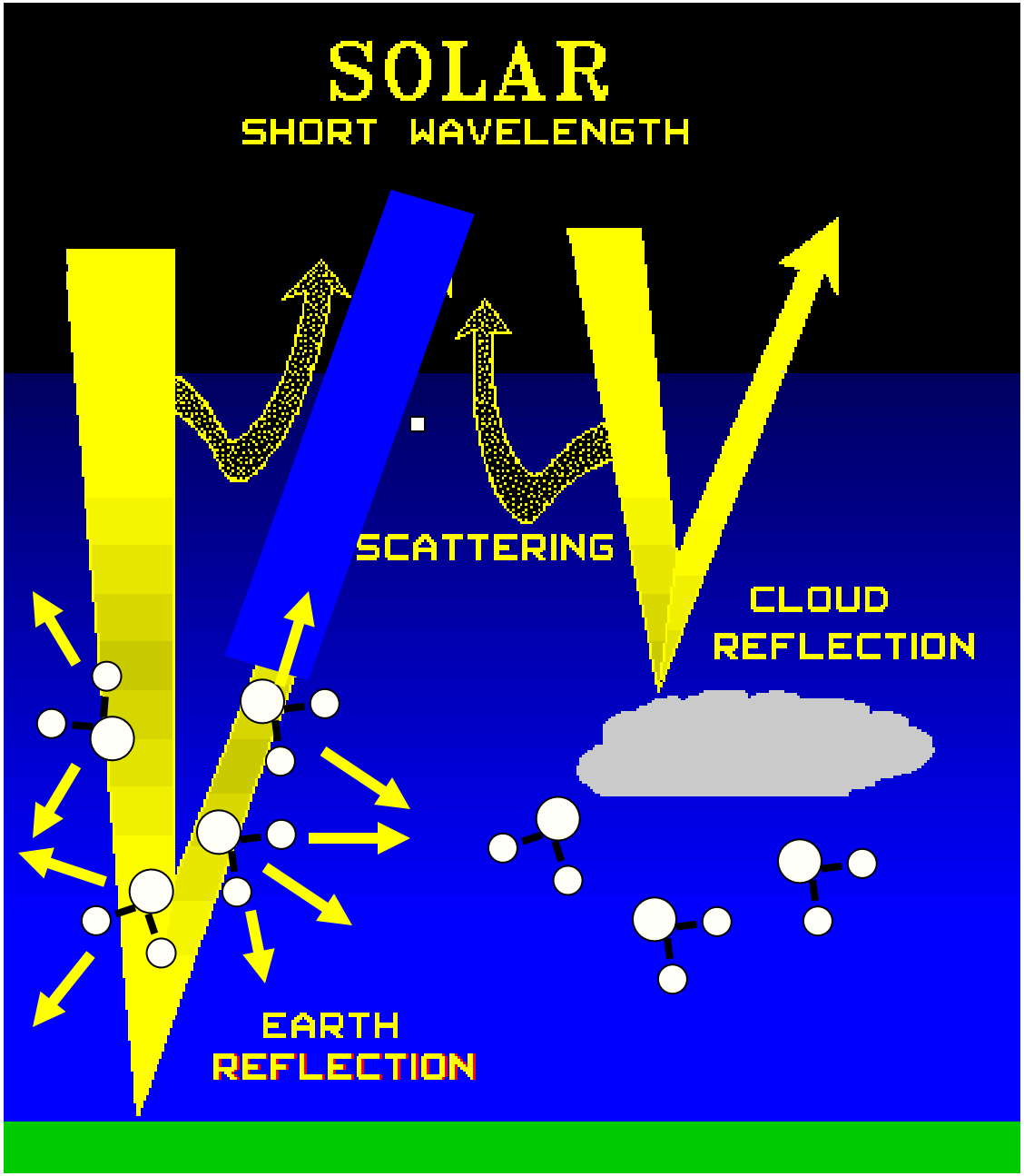
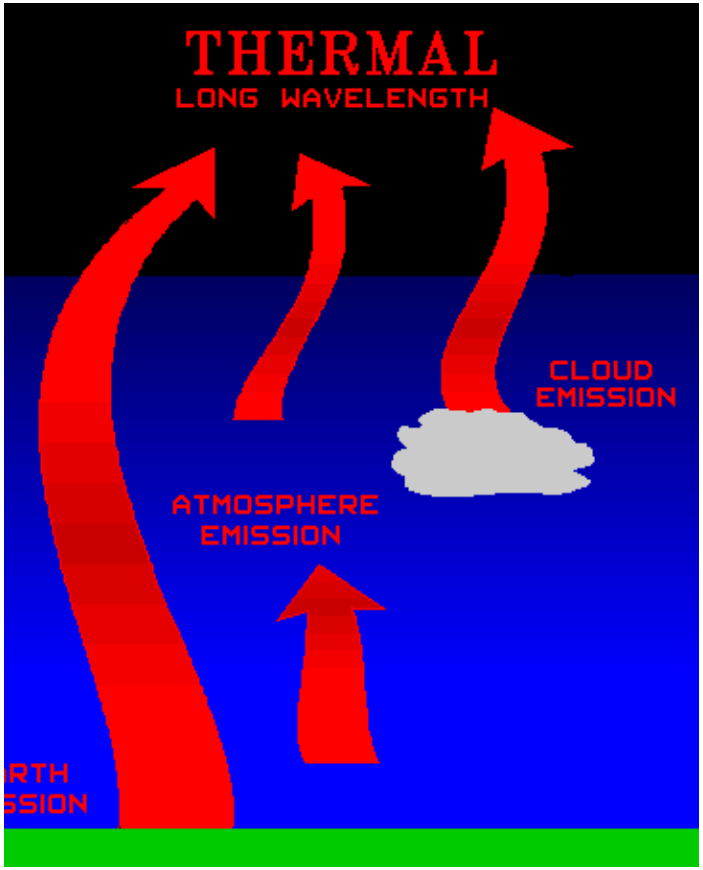


Infrared
(Emissive Bands)

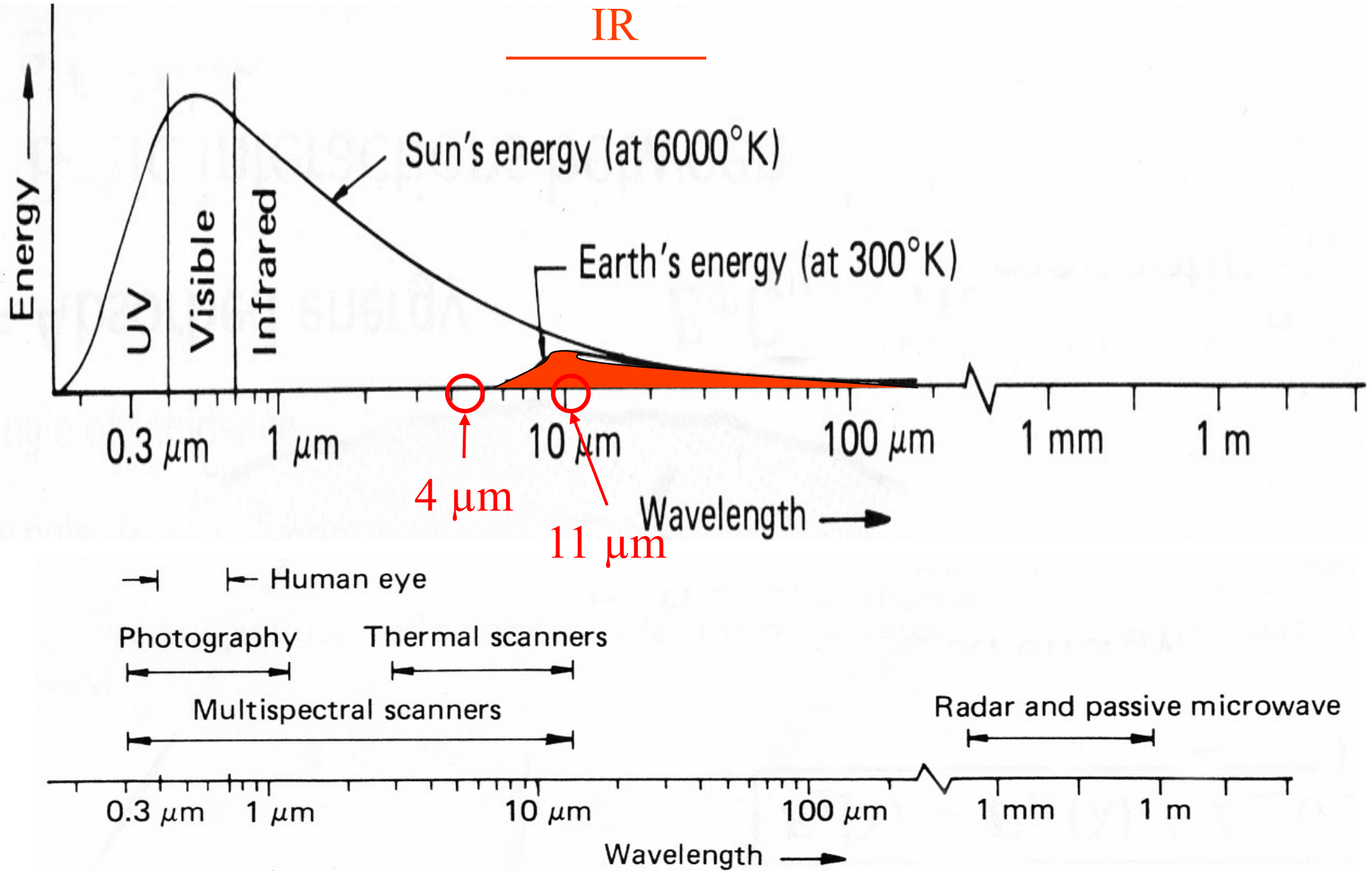


Emissive Bands

Used to observe terrestrial energy emitted by the Earth system in the IR between 4 and 15 μm

- About 99% of the energy observed in this range is emitted by the Earth
- Only 1% is observed below 4 μm
- At 4 μm the solar reflected energy can significantly affect the observations of the Earth emitted energy

Spectral Characteristics of Energy Sources and Sensing Systems



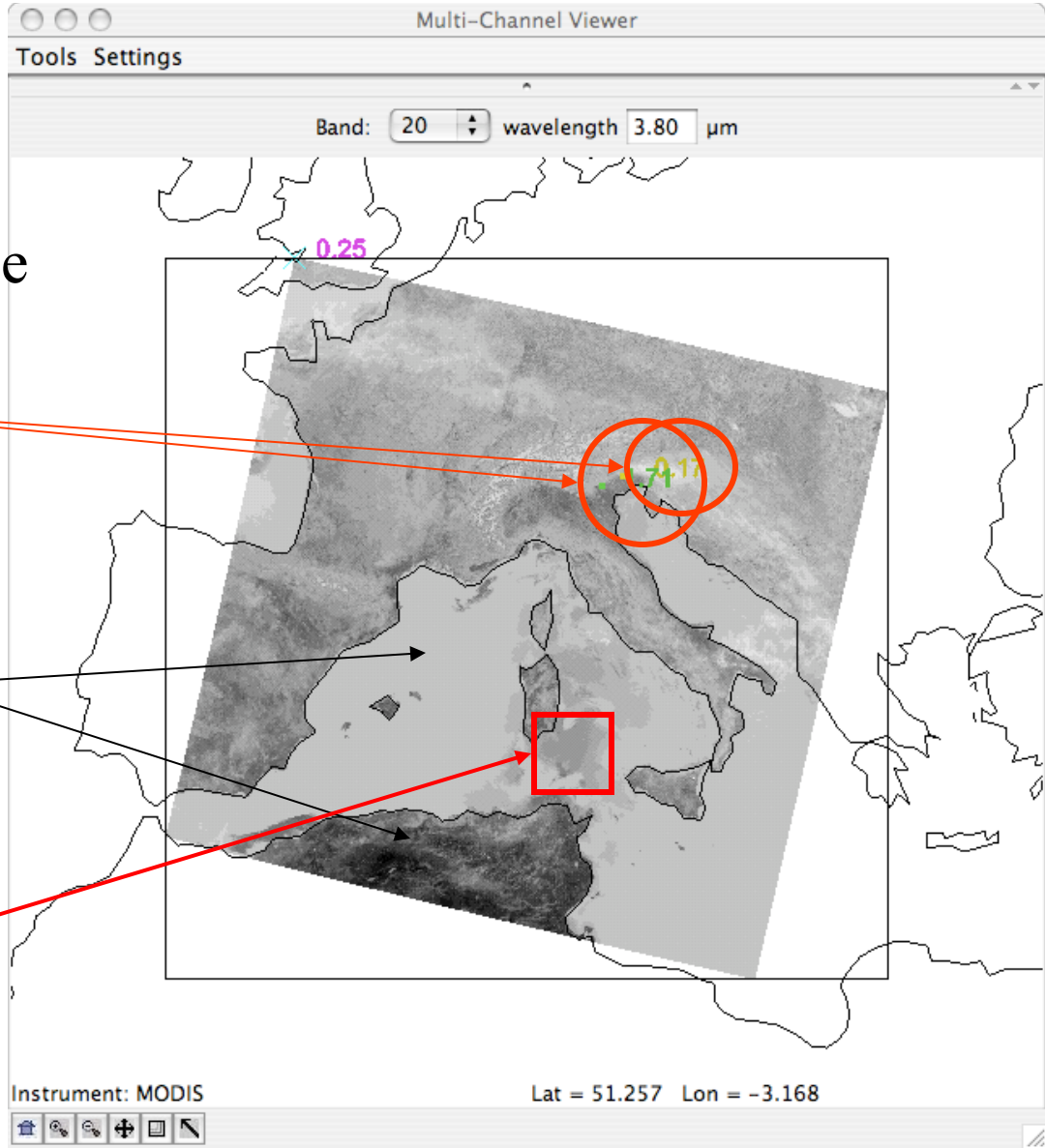
Observed Radiance at 4 micron

Window Channel:
- little atmospheric absorption
- surface features clearly visible

Range [0.2 1.7]

Values over land
Larger than over water

Reflected Solar everywhere
Stronger over Sunglint



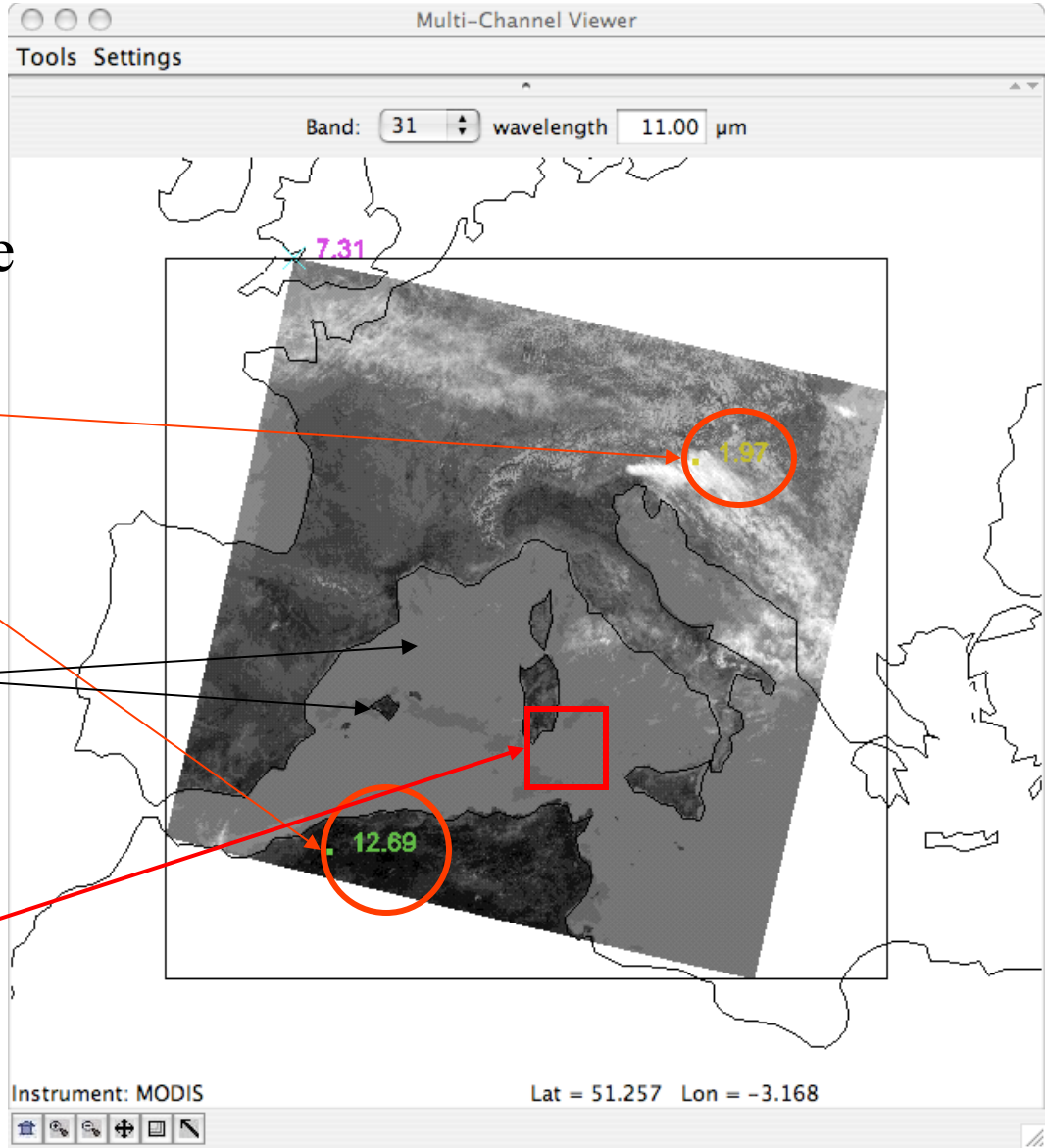
Observed Radiance at 11 micron

Window Channel:
- little atmospheric absorption
- surface features clearly visible

Range [2 13]

Values over land
Larger than over water

Undetectable Reflected Solar
Even over Sunglint



Brightness Temperature

- To properly compare different emissive channels we need to convert observed radiance into a target physical property
- In the Infrared this is done through the Planck function
- The physical quantity is the Brightness Temperature i.e. the Temperature of a black body emitting the observed radiance

Observed BT at 4 micron

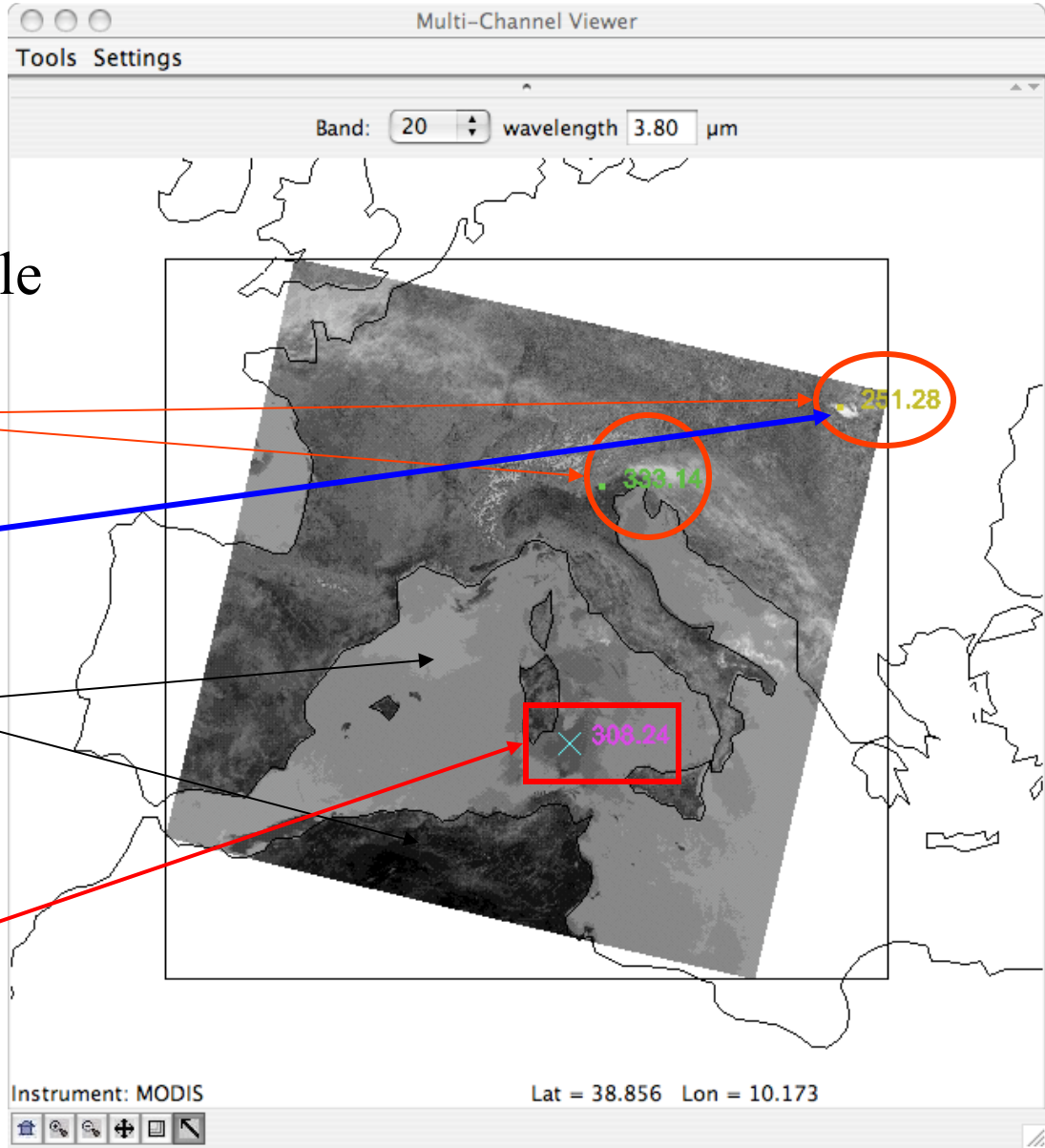
Window Channel:
- little atmospheric absorption
- surface features clearly visible

Range [250 335]

Clouds are cold

Values over land
Larger than over water

Reflected Solar everywhere
Stronger over Sunglint



Observed BT at 11 micron

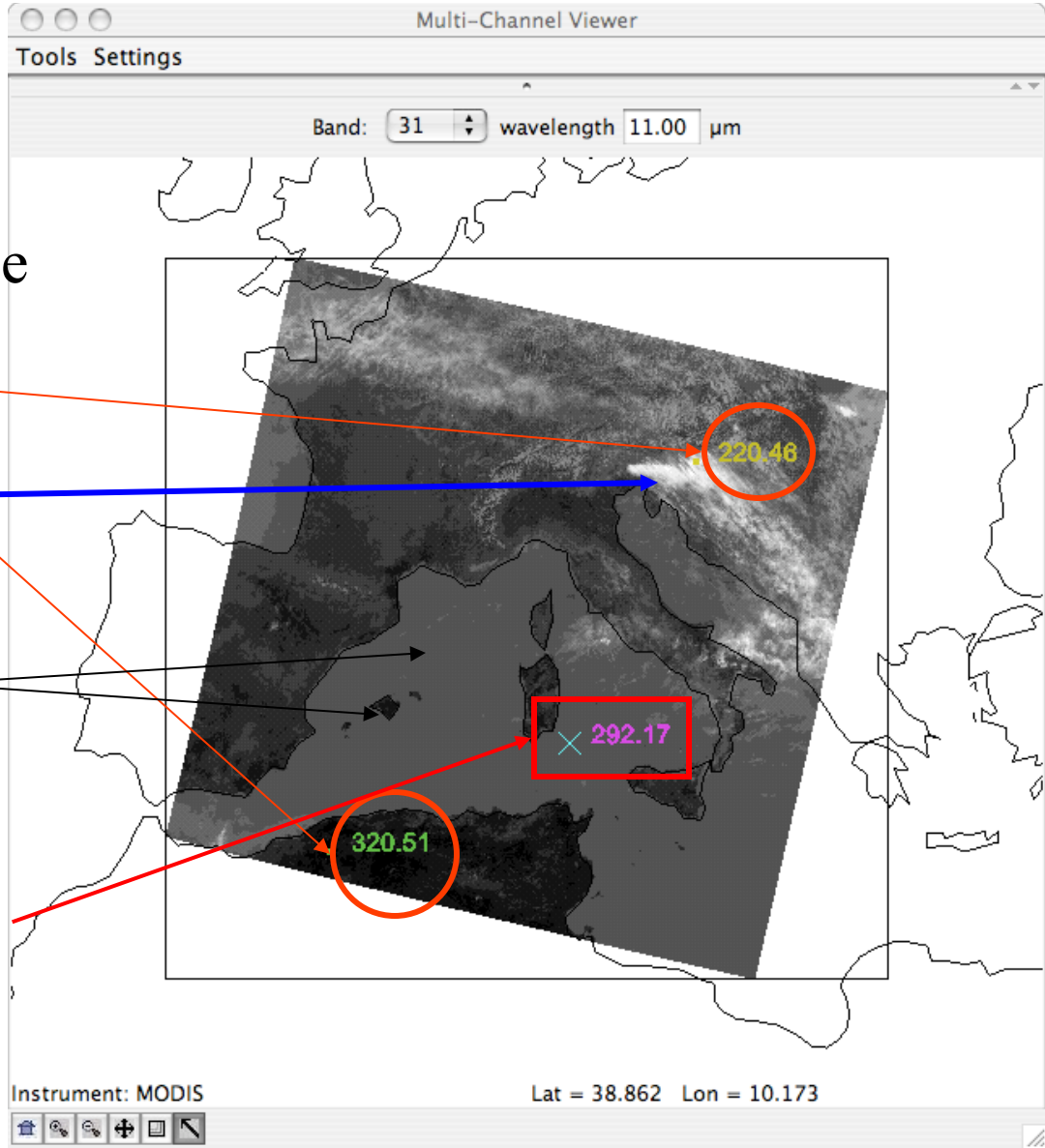
Window Channel:
- little atmospheric absorption
- surface features clearly visible

Range [220 320]

Clouds are cold

Values over land
Larger than over water

Undetectable Reflected Solar
Even over Sunglint



Conclusions

- Radiance is the Energy Flux (emitted and/or reflected by the Earth) which strikes the Detector Area at a given Spectral Wavelength (wavenumber) over a Solid Angle on the Earth;
- Reflectance is the fraction of solar energy reflected to space by the target;
- Given an observed radiance, the Brightness Temperature is the temperature, in Kelvin, of a blackbody that emits the observed radiance;
- Knowing the spectral reflective (Vis) and emissive (IR) properties (spectral signatures) of different targets it is possible to detect: clouds, cloud properties, vegetation, fires, ice and snow, ocean color, land and ocean surface temperature ……