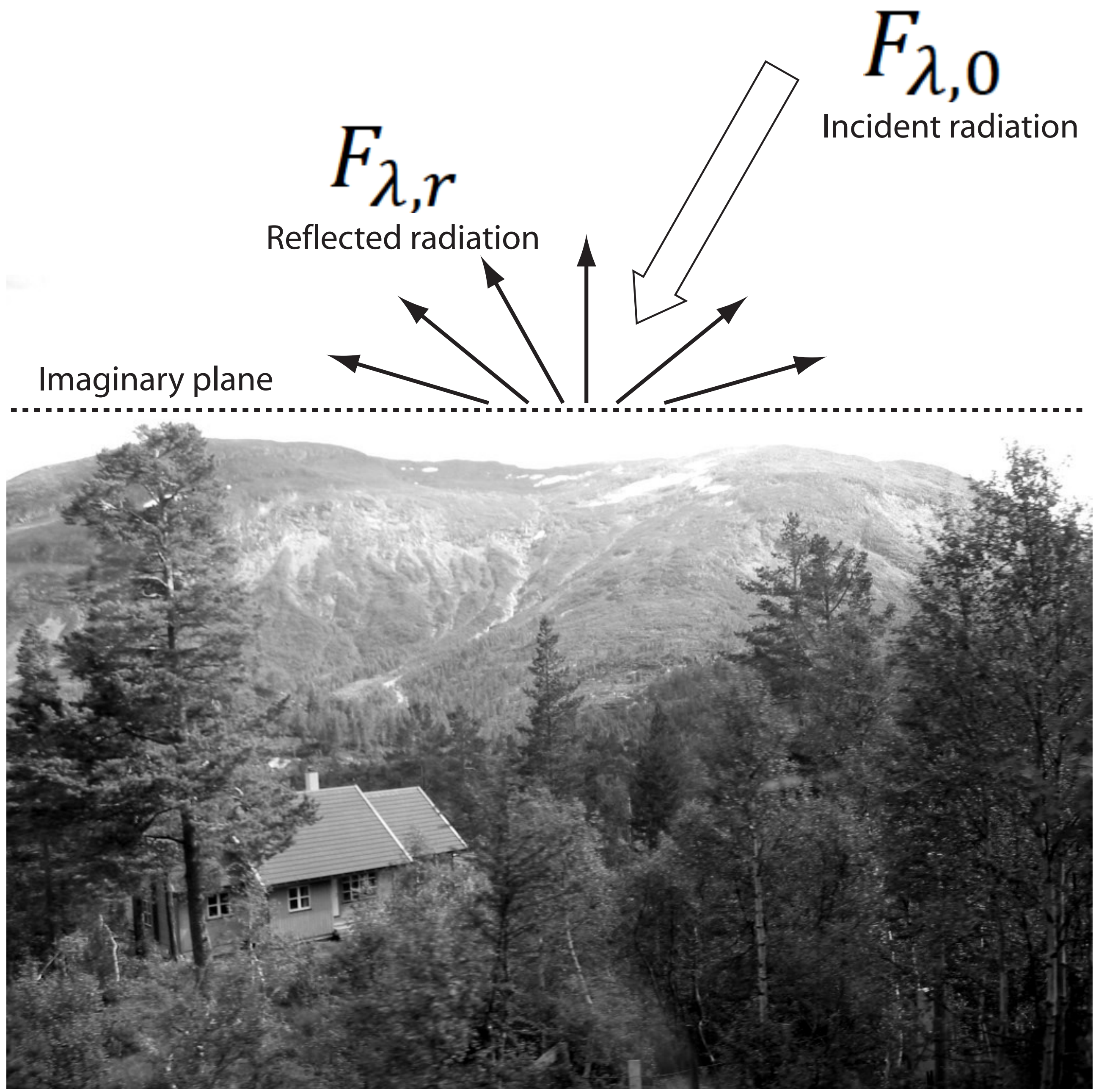
THE UNIVERSITY OF UTAH

ATMOS 5140
Lecture 6 – Chapter 5

- Radiative Properties of Natural Surfaces
- Absorptivity
- Reflectivity
- Greybody Approximation
- Angular Distribution of Reflected Radiances

Natural Surfaces Idealized as Planar Boundaries

Natural Surfaces Idealized as Planar Boundaries



Absorptivity and Reflectivity

$$\alpha_\lambda(\theta, \phi) + r_\lambda(\theta, \phi) = 1$$

Absorptivity and Reflectivity

$$\alpha_\lambda(\theta,\phi) + r_\lambda(\theta,\phi) = 1$$

Natural Surfaces are frequently azimuthally isotropic - then ϕ disappears

Dependence on θ may also be ignored, as an approximation

Then you can relate the reflected monochromatic flux $(F_{\lambda,r})$
to the incident flux $(F_{\lambda,0})$

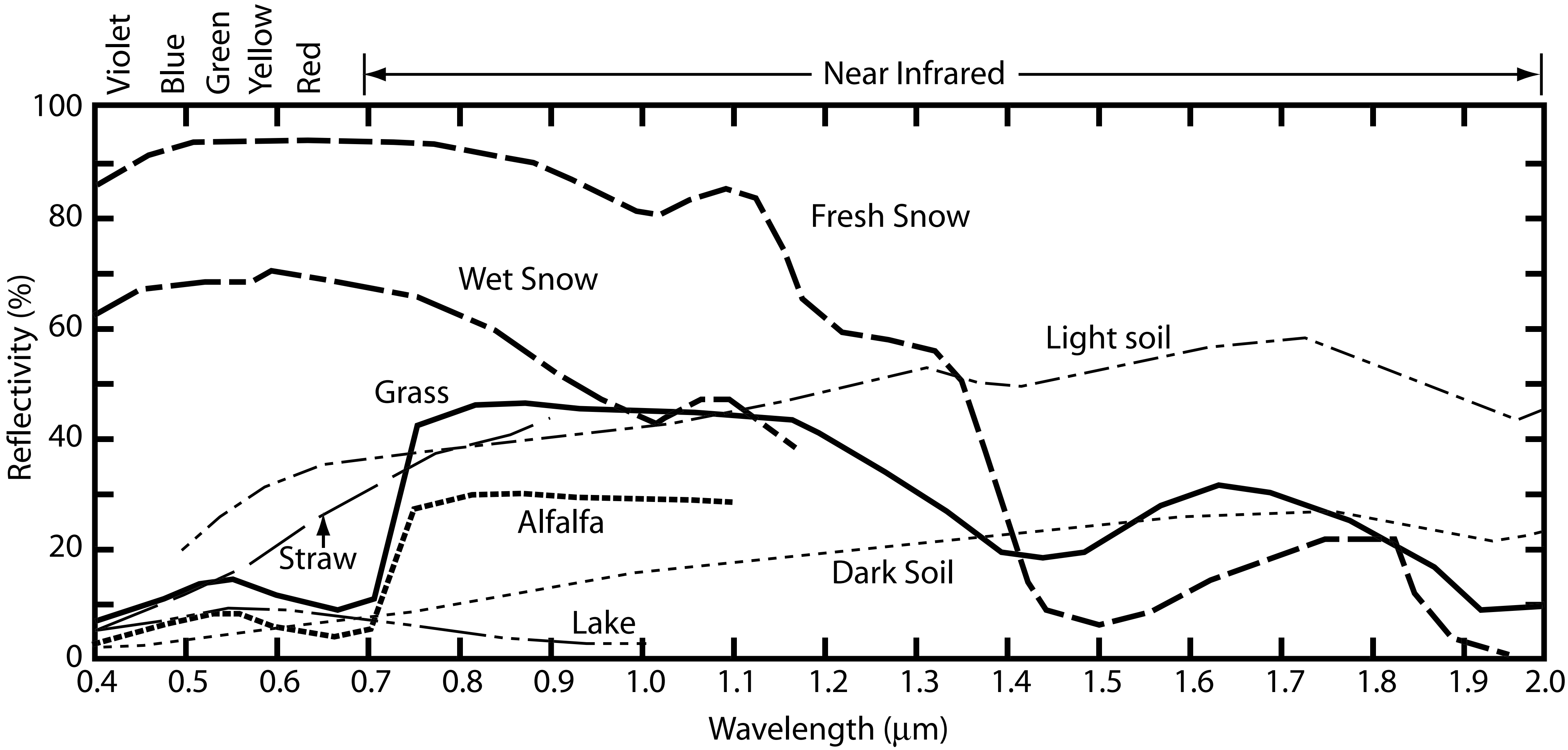
Absorptivity and Reflectivity

Then you can relate the reflected monochromatic flux $(F_{\lambda,r})$
to the incident flux $(F_{\lambda,0})$

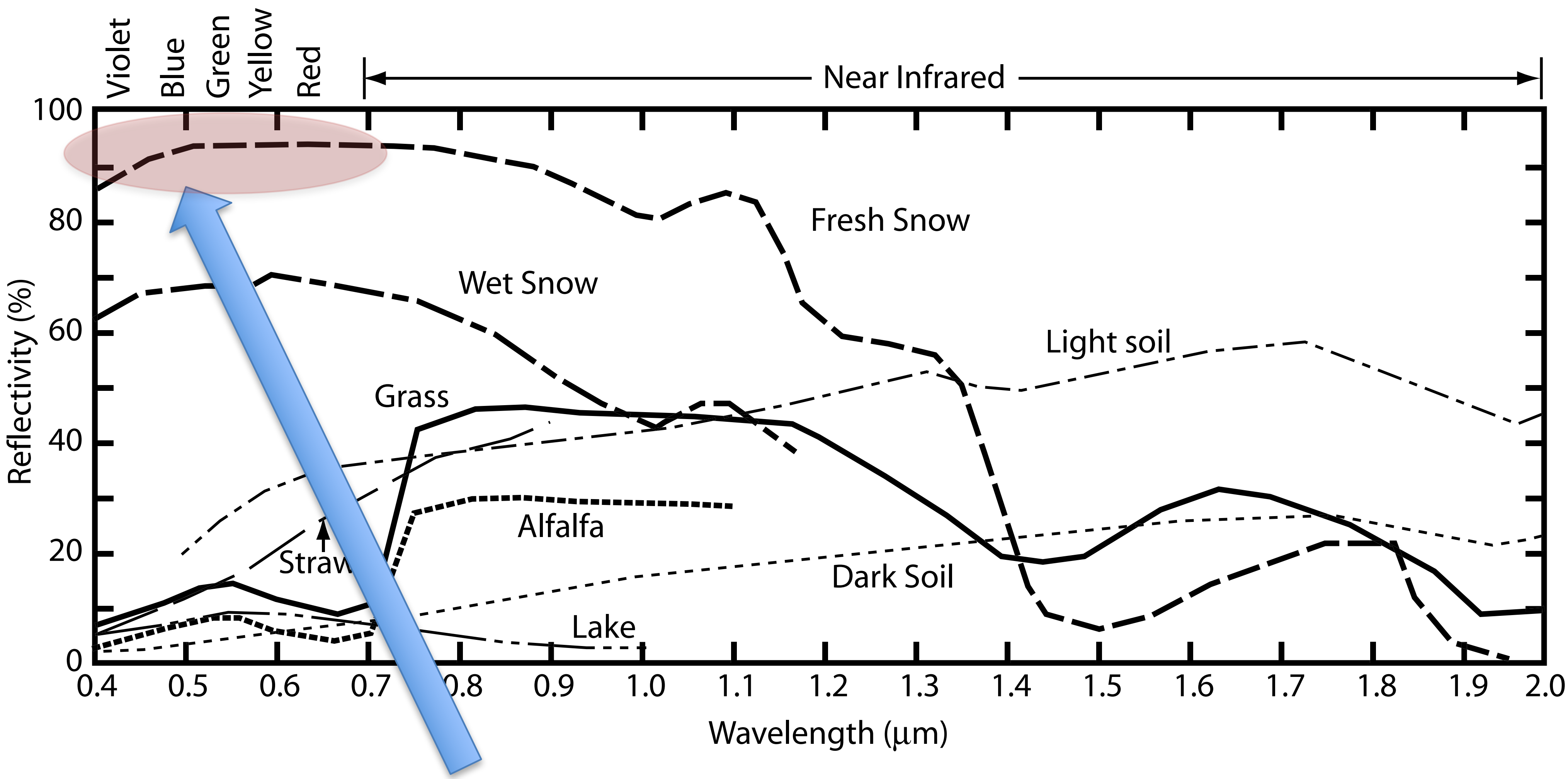
$$F_{\lambda,r} = r_\lambda F_{\lambda,0}$$

$$F_{\lambda,0} - F_{\lambda,r} = (1 - r_\lambda)F_{\lambda,0} = \alpha_\lambda F_{\lambda,0}$$

Reflectivity as a function of wavelength

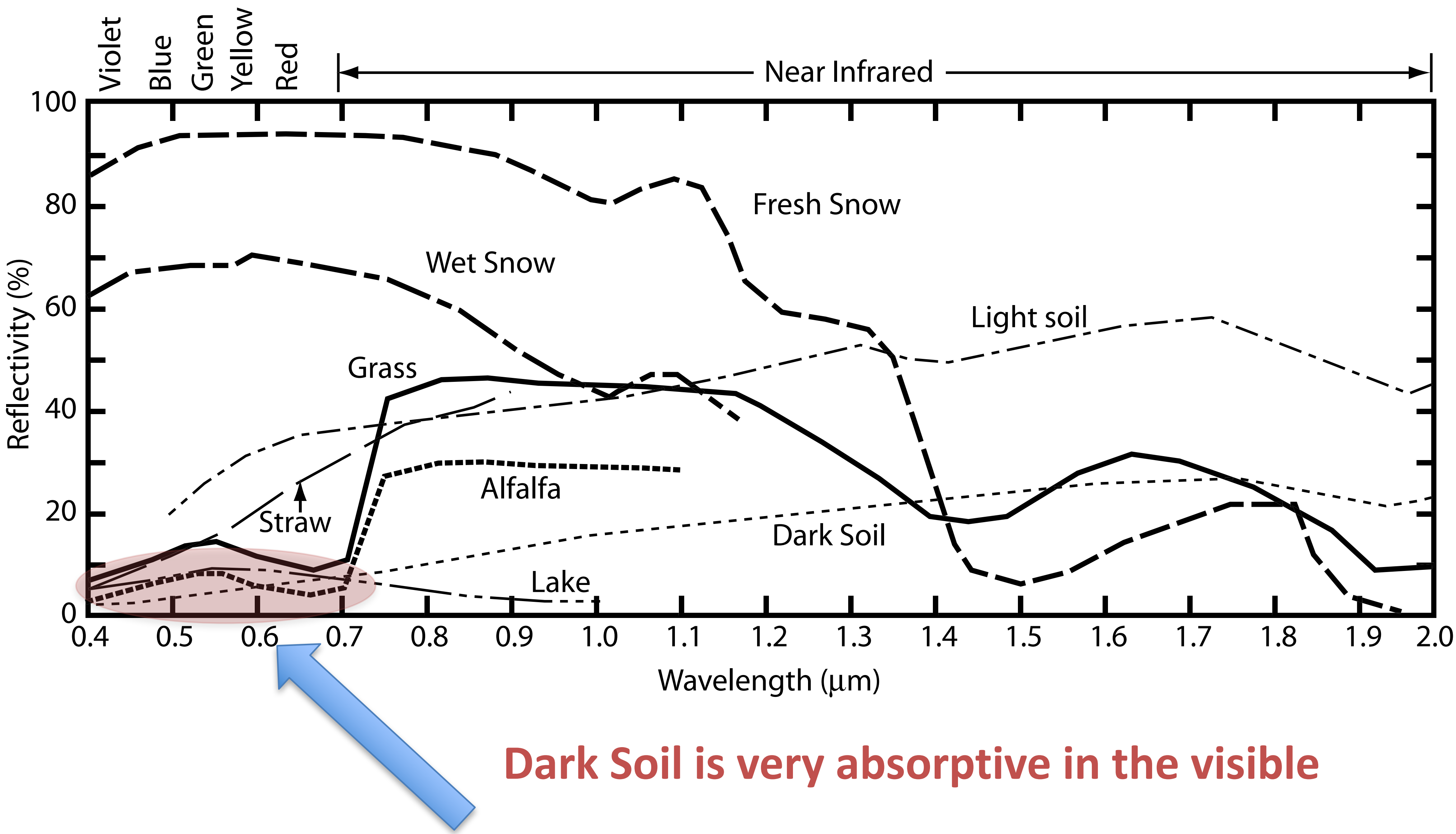


Reflectivity as a function of wavelength



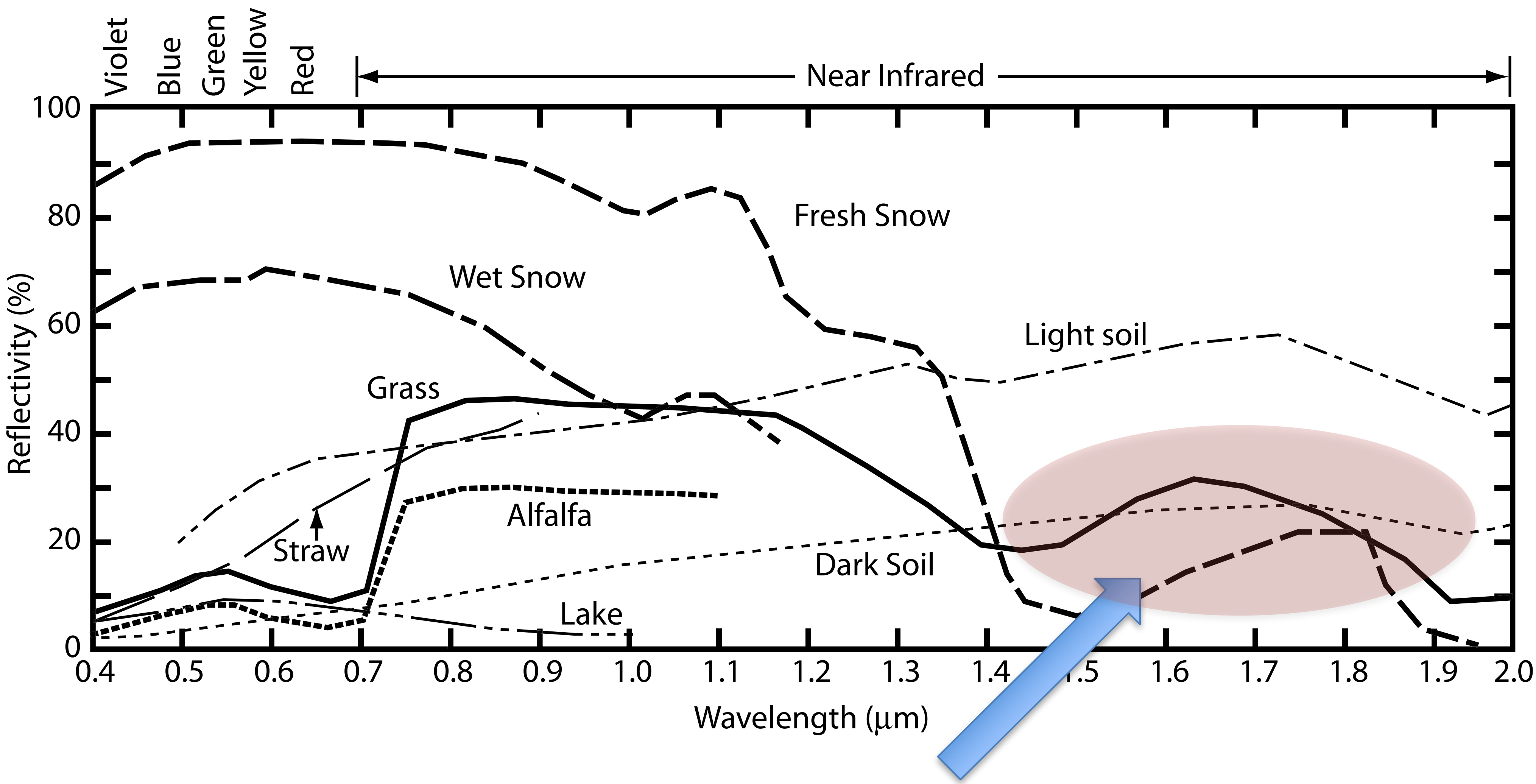
Fresh Snow very reflective in the visible

Reflectivity as a function of wavelength



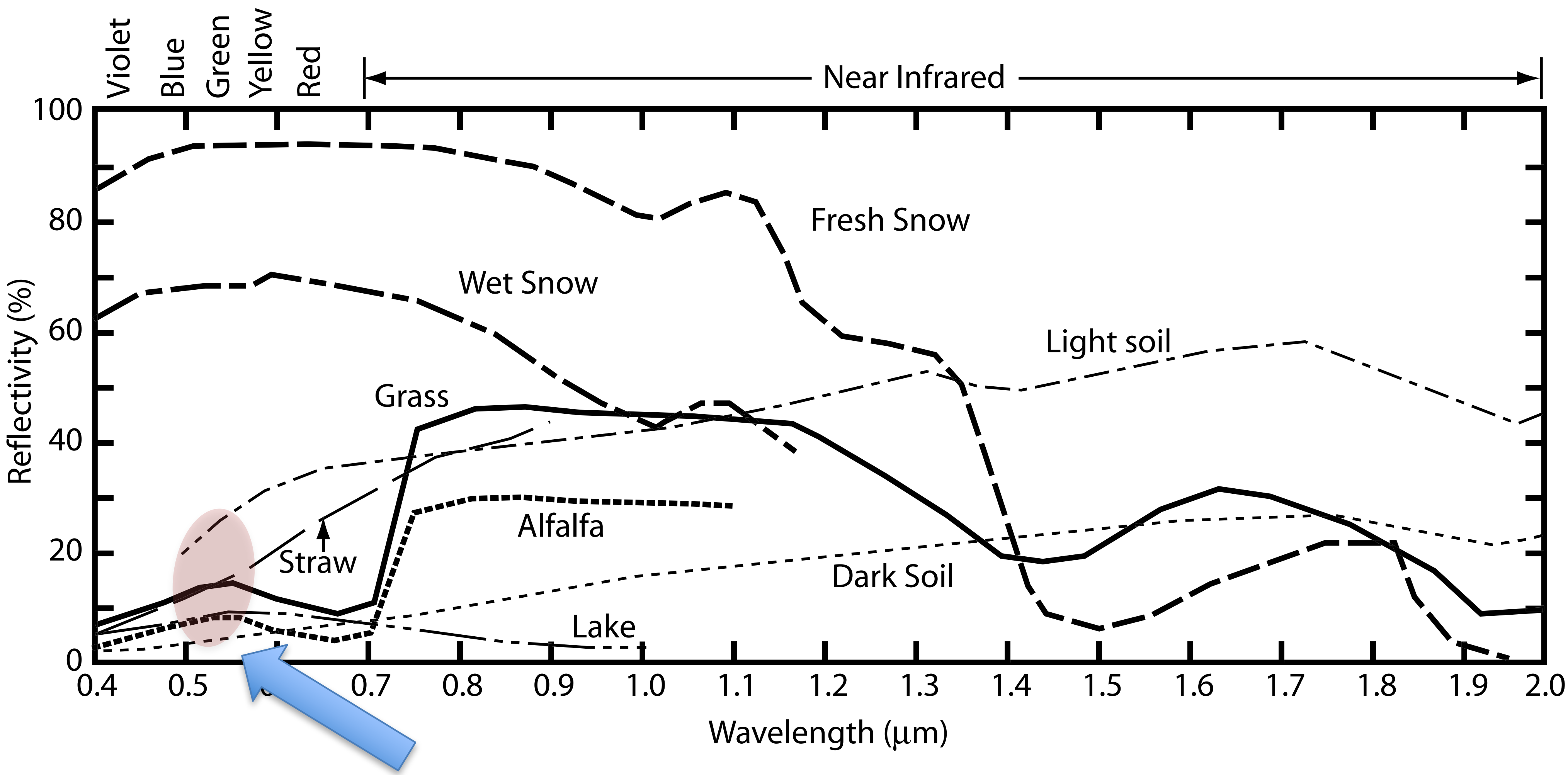
Dark Soil is very absorptive in the visible

Reflectivity as a function of wavelength



Dark Soil and light snow absorbs strongly in the near infrared

Reflectivity as a function of wavelength



Grass & Alfalfa Peak at 0.55 microns – green – due to chlorophyll

Grey Body Approximation

$$\bar{r} \equiv \frac{F_r}{F_i}$$

$$\bar{a} = 1 - \bar{r}$$

Assume the absorptivity and reflectivity of a surface does not depend upon wavelength over some broadband (i.e. surface is grey).

Now you can use single average absorptivity to represent band.

Grey Body Approximation

$$\bar{r} \equiv \frac{F_r}{F_i}$$

$$\bar{a} = 1 - \bar{r}$$

Assume the absorptivity and reflectivity of a surface does not depend upon wavelength over some broadband (i.e. surface is grey).

Normally create value for shortwave and longwave

$a_{sw} = 1 - r_{sw}$

$a_{lw} = 1 - r_{lw}$

Grey Body Approximation

$$\bar{r} \equiv \frac{F_r}{F_i}$$

$$\bar{a} = 1 - \bar{r}$$

Assume the absorptivity and reflectivity of a surface does not depend upon wavelength over some broadband (i.e. surface is grey).

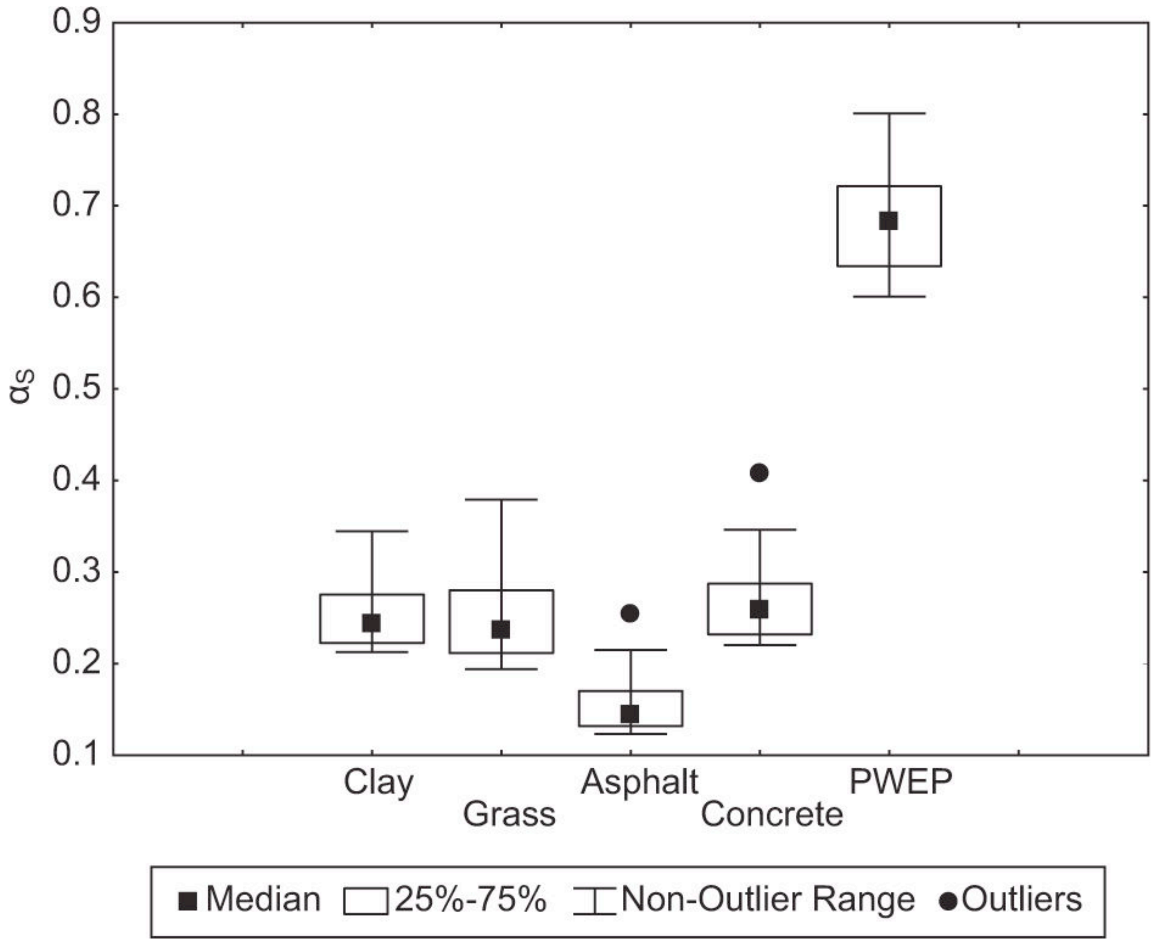
Normally create value for shortwave and longwave

$a_{sw} = 1 - r_{sw}$

$a_{lw} = 1 - r_{lw}$

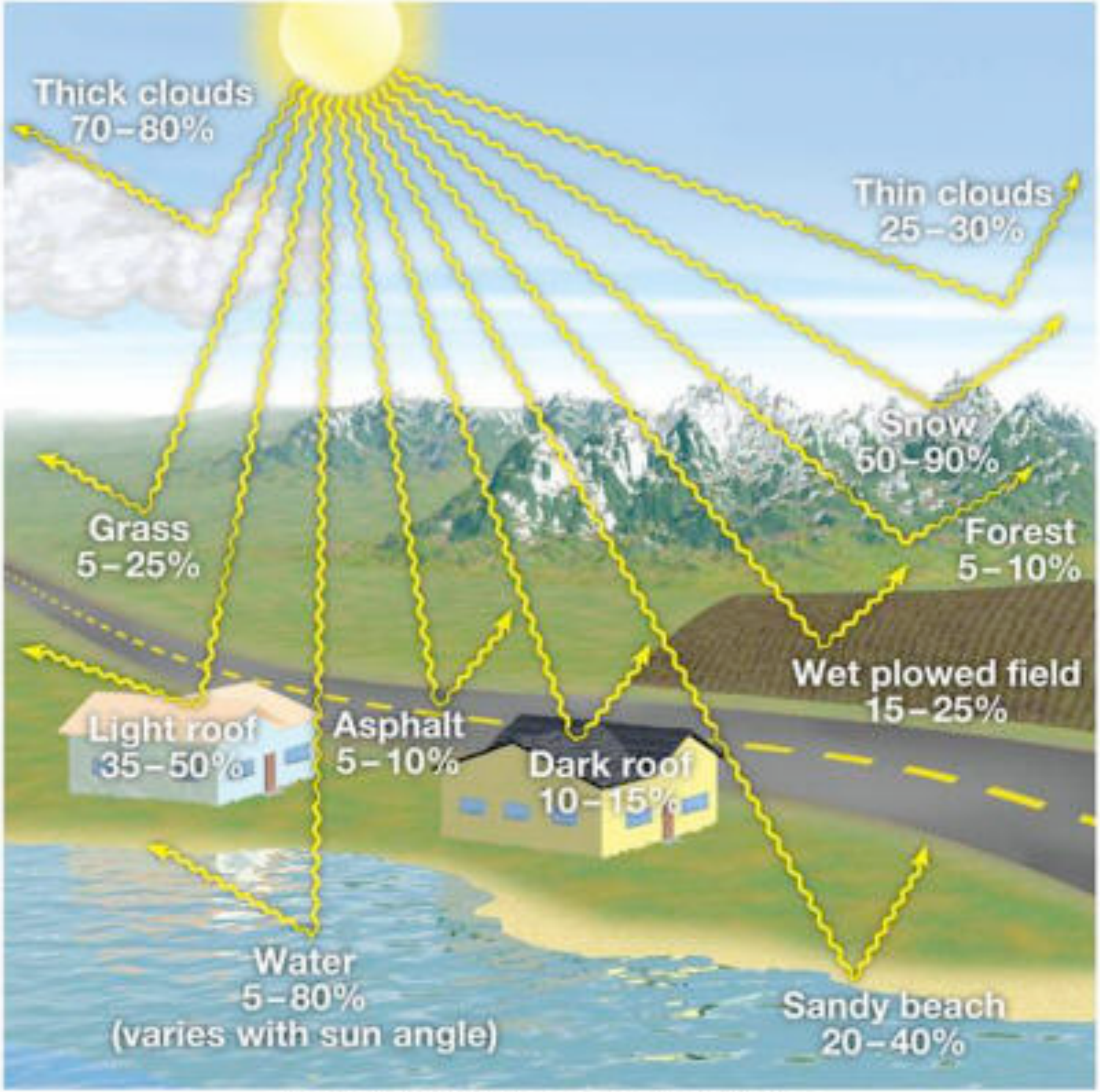
Shortwave albedo

Shortwave Albedo



Great deal of current research considering albedo with regard to solar panels, heating island etc.

polystyrene painted with white elastomeric paint

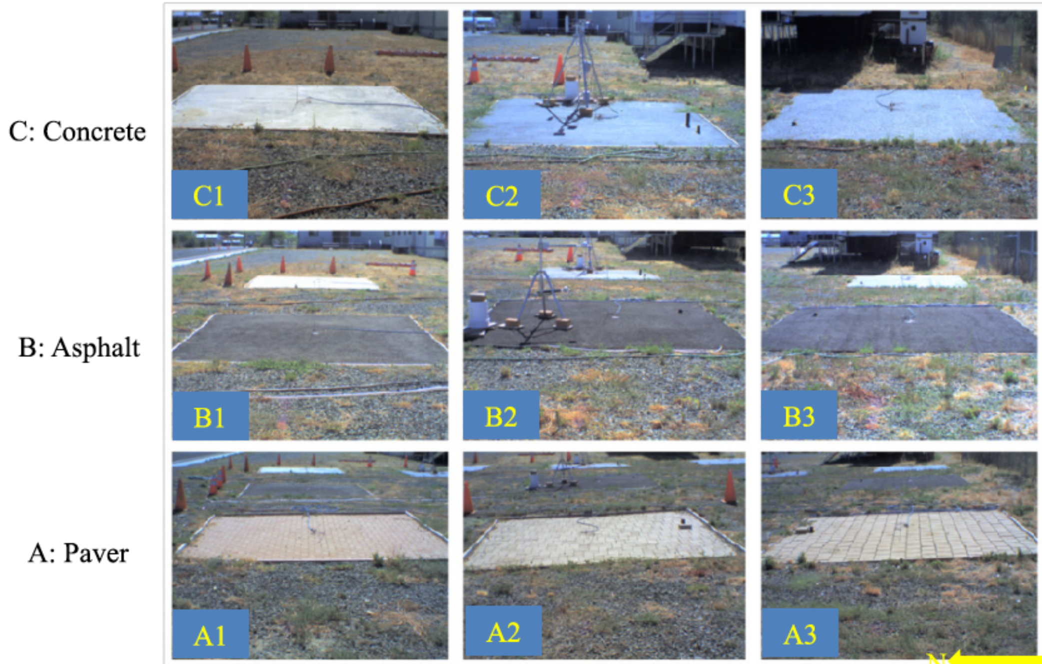

Thick clouds
70–80%
Thin clouds
25–30%
Snow
50–90%
Forest
5–10%
Grass
5–25%
Wet plowed field
15–25%
Light roof
35–50%
Asphalt
5–10%
Dark roof
10–15%
Water
5–80%
(varies with sun angle)
Sandy beach
20–40%

OPEN ACCESS
IOP PUBLISHING ENVIRONMENTAL RESEARCH LETTERS
Environ. Res. Lett. **8** (2013) 015023 (14pp) doi:10.1088/1748-9326/8/1/015023

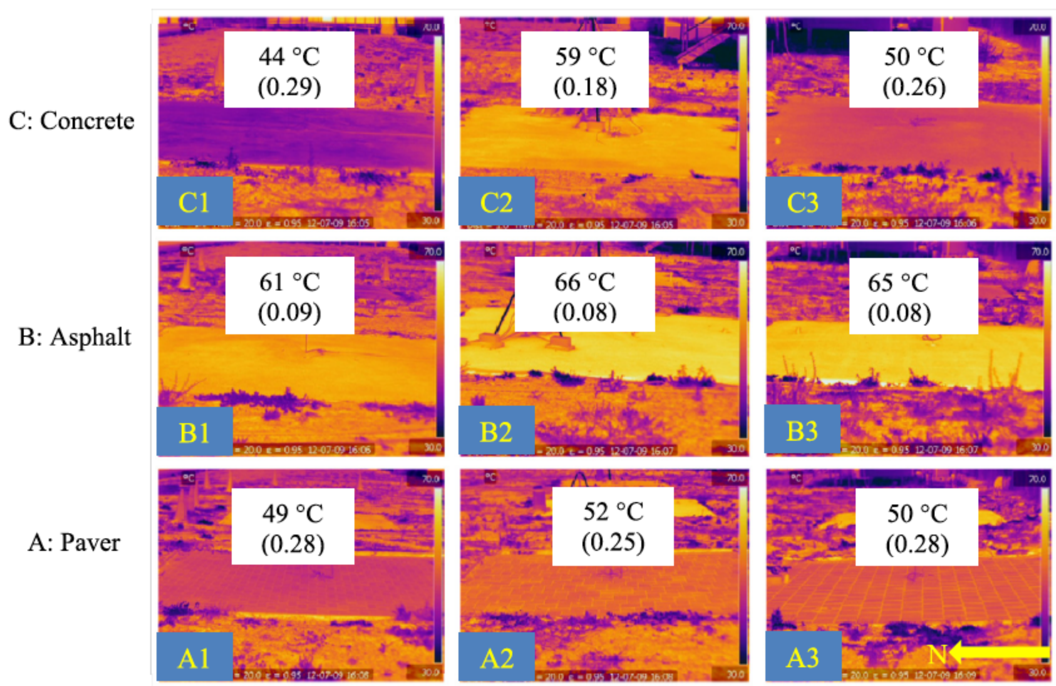
The use of reflective and permeable pavements as a potential practice for heat island mitigation and stormwater management

H Li[1], J T Harvey[1], T J Holland[2] and M Kayhanian[3]

[1] University of California Pavement Research Center, Department of Civil and Environmental Engineering, University of California, Davis, CA 95616, USA
[2] California Department of Transportation, Sacramento, CA 95814, USA
[3] Department of Civil and Environmental Engineering, University of California, Davis, CA 95616, USA

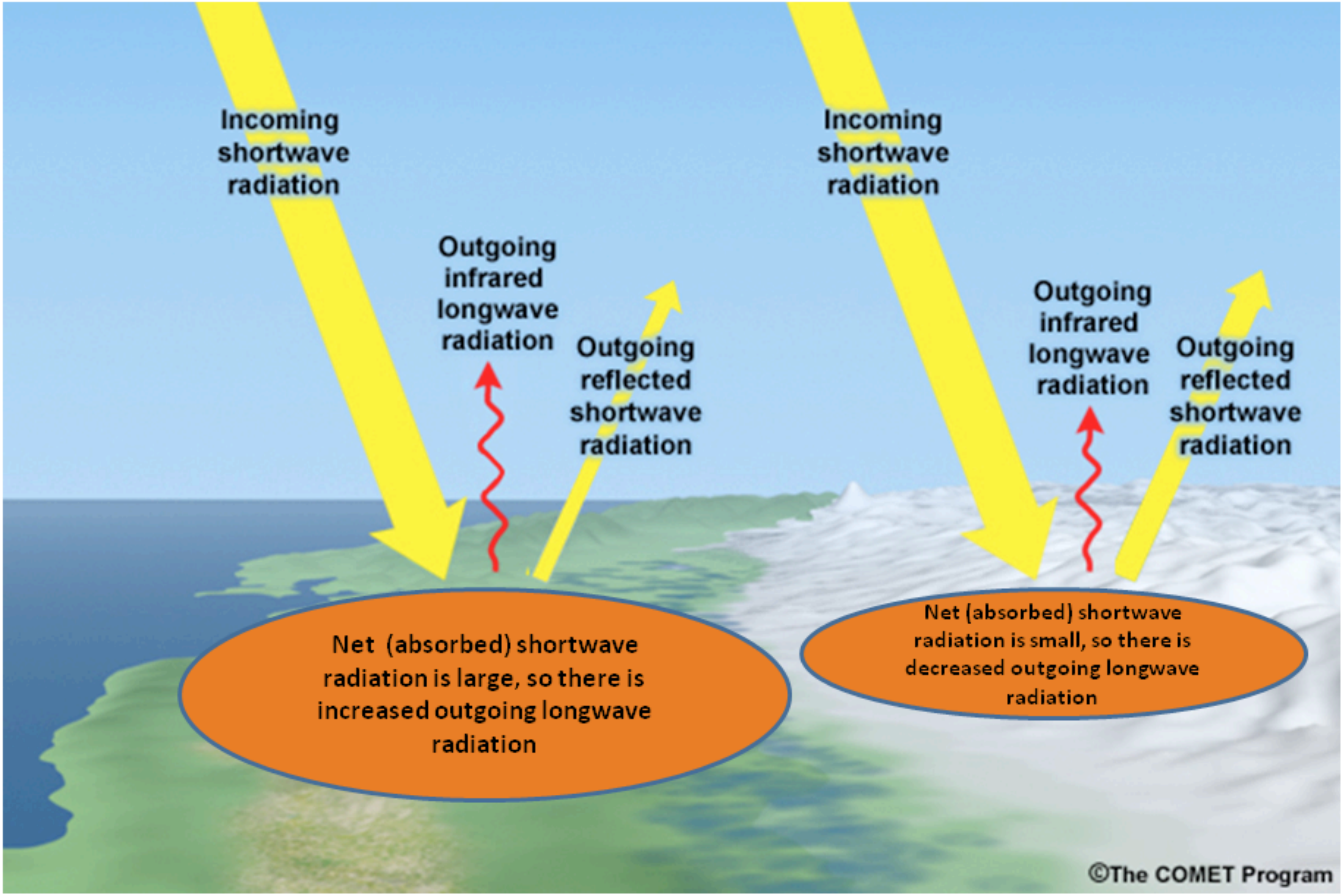


(a)



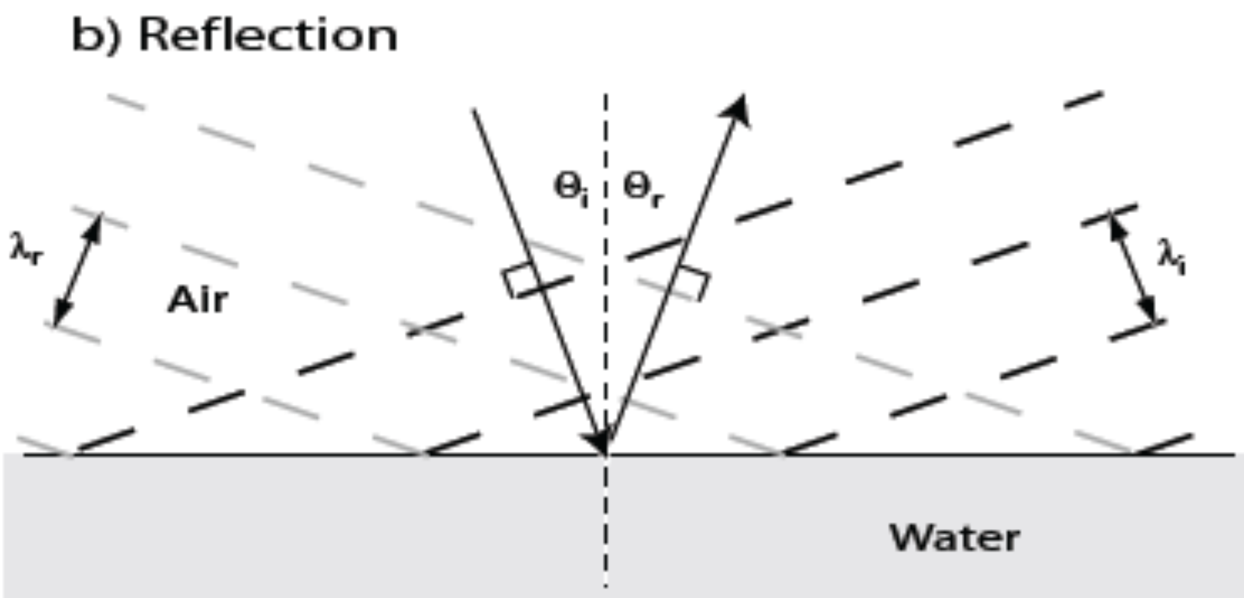
(b)

Figure 5. Optical and thermal images of experimental test sections on 9 July 2012. (a) Optical images. (b) Infrared thermal images under dry condition (16:00) (lighter is hotter, average surface temperatures are listed with albedo in parentheses).


Incoming shortwave radiation
Outgoing infrared longwave radiation
Outgoing reflected shortwave radiation
Net (absorbed) shortwave radiation is large, so there is increased outgoing longwave radiation
Incoming shortwave radiation
Outgoing infrared longwave radiation
Outgoing reflected shortwave radiation
Net (absorbed) shortwave radiation is small, so there is decreased outgoing longwave radiation
©The COMET Program

Reflection

REVIEW



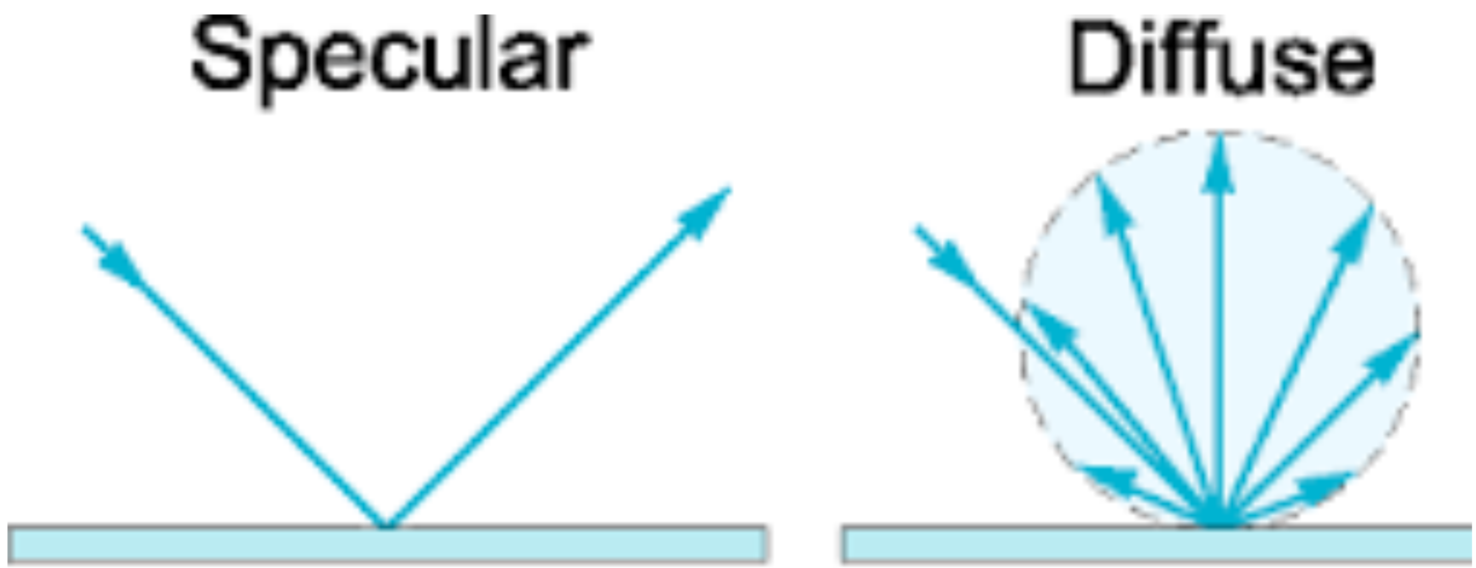
When

$$\Theta_i = \Theta_r$$

Specular reflection

Smooth surface in comparison to wavelength of light

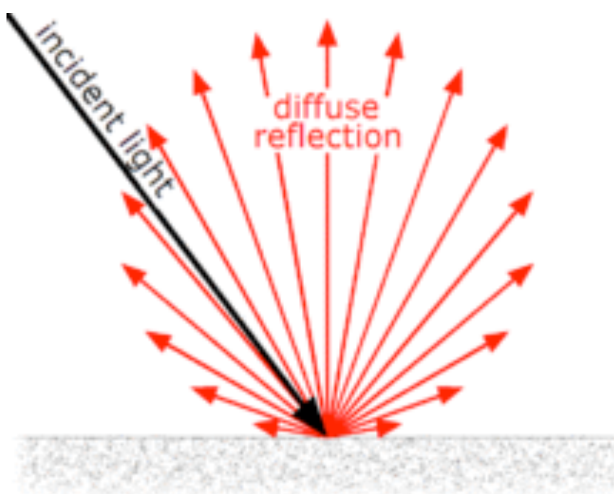
Reflection



$$F_r = rF_i$$

Lambertian Reflectance

- property that defines an ideal "matte" or diffusely reflecting surface
- apparent brightness of a Lambertian surface to an observer is the same regardless of the observer's angle of view
- surface's luminance is isotropic, and the luminous intensity obeys Lambert's cosine law.

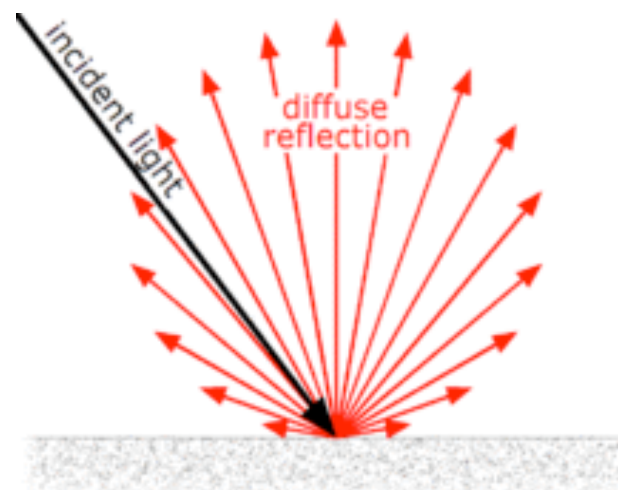


Lambertian Reflectance

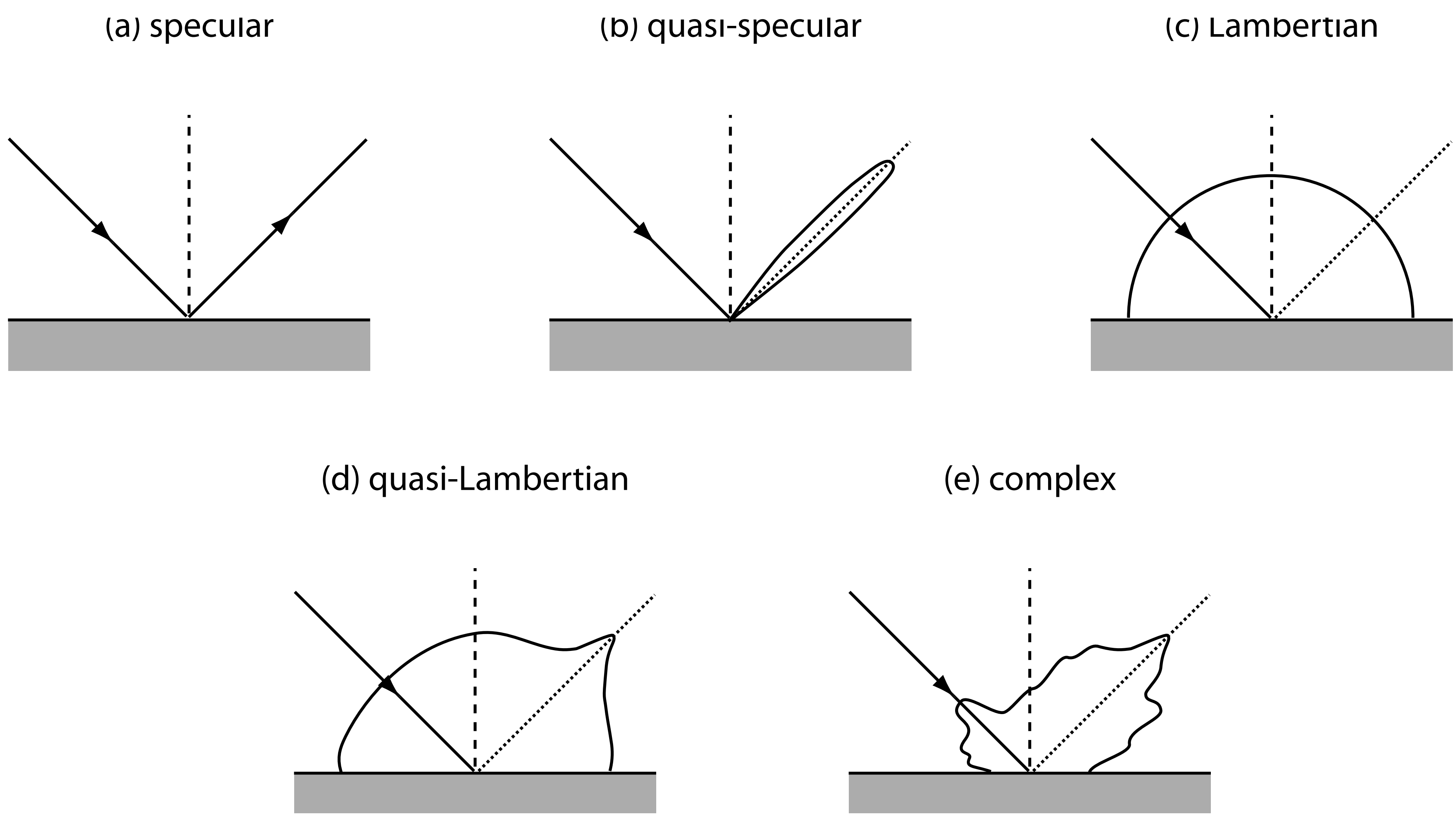
$$F_r = \pi I_r$$

$$I^{\uparrow} = \frac{rF_i}{\pi}$$

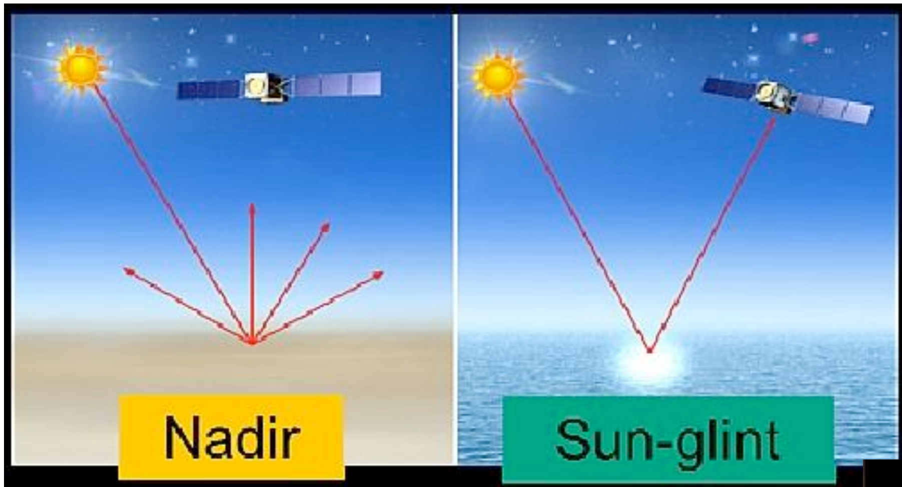
$$I^{\uparrow} = \frac{rS_0 \cos\theta_i}{\pi}$$



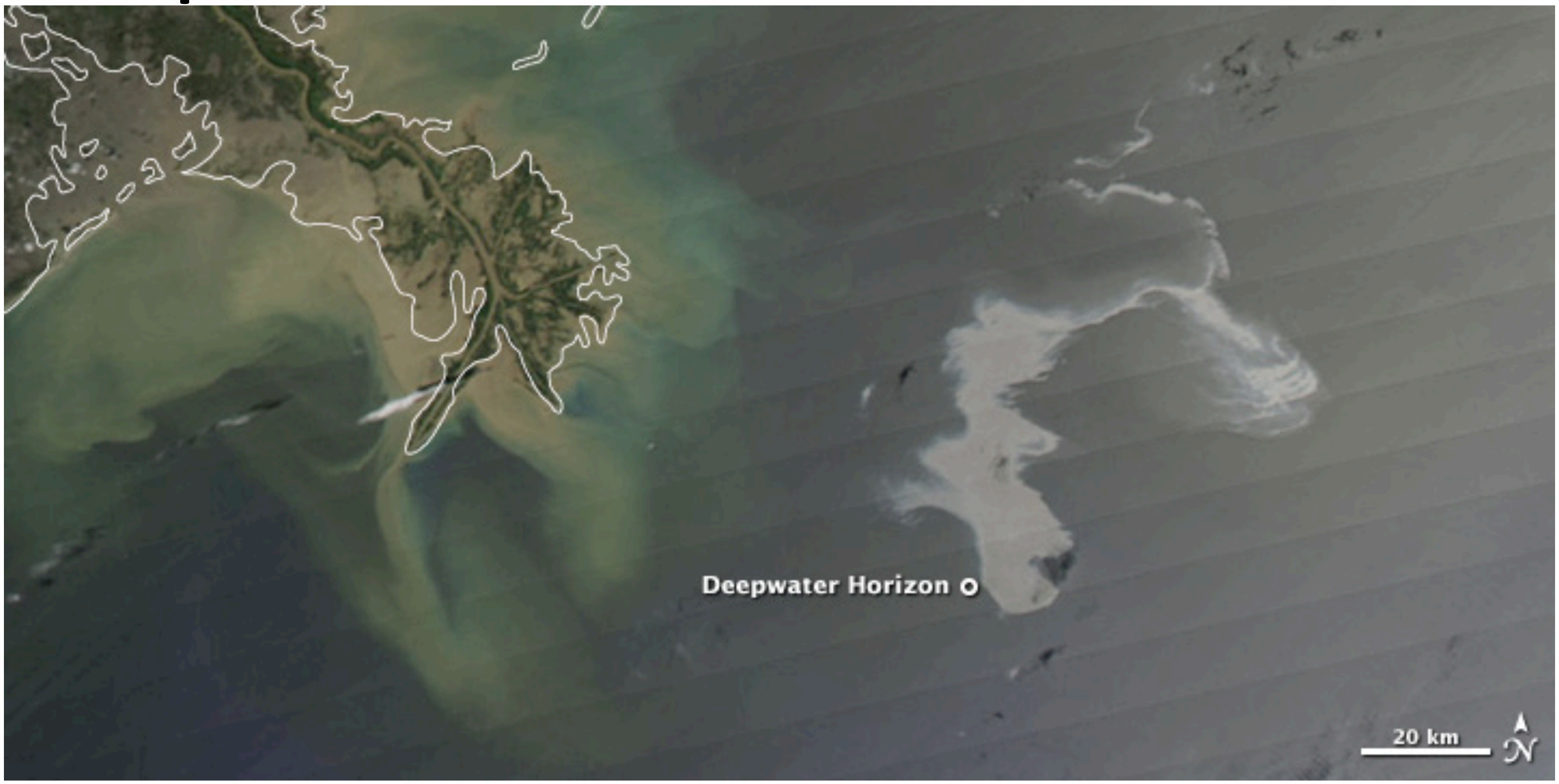
Surface Reflection



Sun Glint



Deep Water Horizon and Reflection



If the oil is located very close to the spot where the Sun's reflection would appear, it usually looks brighter than nearby clean water in the MODIS images

https://earthobservatory.nasa.gov/Features/OilSlick/