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2.19 Surface reflectance - Albedo

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Surface reflectance – Albedo	**Climate resilience**
Description and justification	Radiation balance at the Earth's surface consists of net short-wave radiation and net long-wave radiation. Long-wave radiation (wavelength 3 to 100 µm) is an energy exchange between the Earth's surface and the atmosphere. Short-wave radiation (wavelength 0.3 to 3 µm) coming from the sun can be reflected back or scattered by air molecules or clouds when they are present, although part of it reaches the ground. Albedo is a portion of short-wave radiation that is reflected back once it reaches the ground, and it varies with the land cover (Shuttleworth, 1993).
Definition	Short-wave radiation reflectance coefficient of a surface (0-1, unitless), where 1 denotes full reflection and 0 denotes full absorption. Surface albedo is defined as the instantaneous ratio of surface-reflected radiation flux to incident radiation flux over a given spectral interval (dimensionless) (Wang *et al.*, 2019)
Strengths and weaknesses	+ Surface reflectance can be measured directly + Directly comparable to other variables such as cooling and greenhouse gases emissions + Albedo values for various known surfaces and land-uses already exist - Requires advanced equipment and judgment

Measurement procedure and tool

Surface reflectance can be measured in the laboratory, in the field, and via remote sensing.

a. In the laboratory, surface reflectance can be measured using spectrophotometers equipped with integrating spheres over wider spectral ranges than the photopic vision (well-lit conditions) response of a human eye, and using light sources other than natural light (ASTM, 2012). Since the beam illuminates only part of a sample, a spatially uniform sample will yield the most fast and accurate results (Levinson, Akbari & Berdahl, 2010).

b. In the field, surface reflectance is typically measures using a pyranometer, a solar radiation meter, which measures the reflected solar irradiance (ASTM, 2016). This method requires a portable and relatively inexpensive equipment and it can be applied to flat and curved surfaces. However, the limitations include the necessity of a clear sky as clouds can lead to erroneous results, and a relatively large size of the surface to prevent the radiation collections from the object's surroundings (Levinson, Akbari & Berdahl, 2010). Ideally, the *in situ* albedo measurements are continuous ahd have temporal resolution of less than 30 minutes (Wang *et al*., 2019).

c. Remote sensing options utilise the satellite or aerial systems that that record albedo of larger surfaces (Ban-Weiss, Woods & Levinson, 2015), or the Earth such Clouds and the Earth's Radiant Energy System, or CERES (NASA, 2019). While remote sensing is feasible for measuring albedo at larger scales, this method is nor suitable for finer scale applications, and validations in the filed may be necessary (Wang *et al*., 2019; Williamson, Copland & Hik, 2016).

Reference tables exist for certain surfaces and land covers:

Land cover	Albedo
Grass and pasture	0.2 – 0.26†
Snow and ice	0.2 (old) – 0.8 (new)†
Bare soil	0.1 (wet) – 0.35 (dry)†
Asphalt	0.05 – 0.2‡
Red/Brow roof tile	0.1 – 0.35‡

	Open water	0.08[†]	
	[†]Shuttleworth (1993) [‡]US EPA (1992)		
Scale of measurement	Plot scale		
Data source			
Required data	Albedo of various surfaces and land covers		
Data input type	Quantitative		
Data collection frequency	Annually		
Level of expertise required	High when applying direct measurements Low when using reference tables		
Synergies with other indicators	Direct relation to *Rate of evapotranspiration*, *Land surface temperature* and *Urban Heat Island incidence* indicators		
Connection with SDGs	SDG 13 Climate action, SDG 15 Life on land		
Opportunities for participatory data collection	No opportunities identified		
Additional information			
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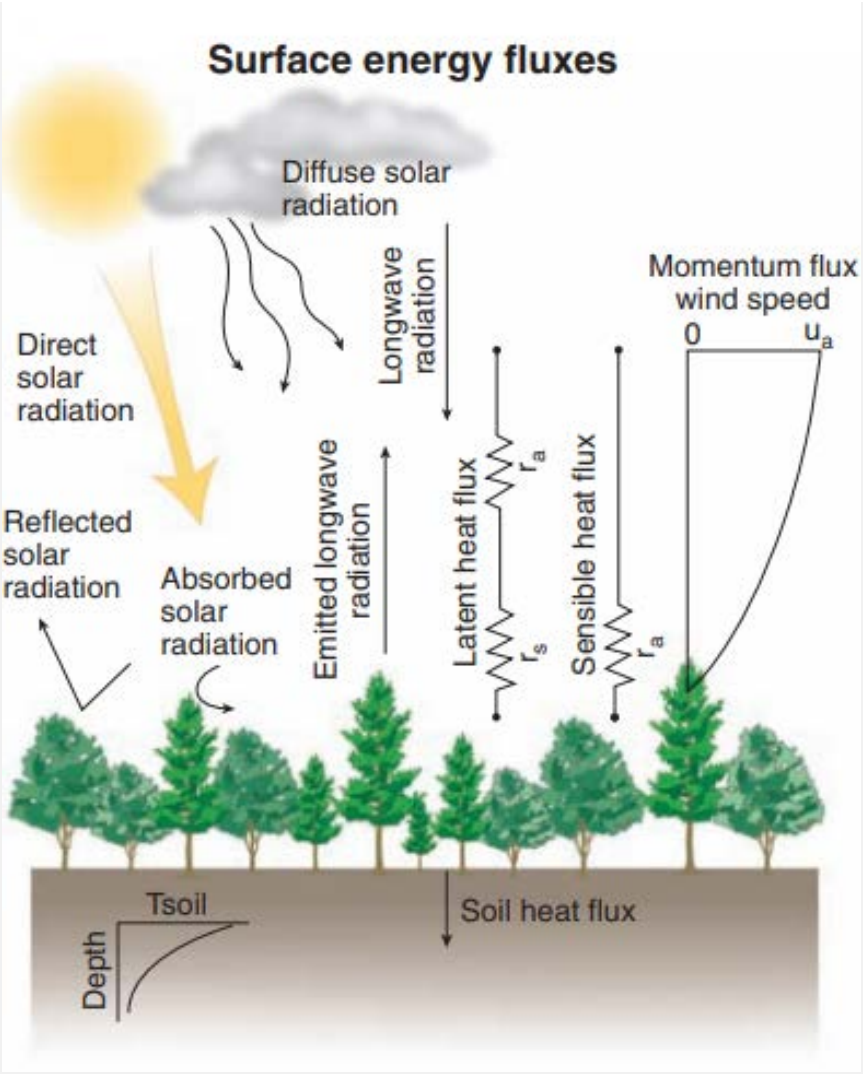

Figure: Surface energy fluxes (adapted from Bonan, 2008)