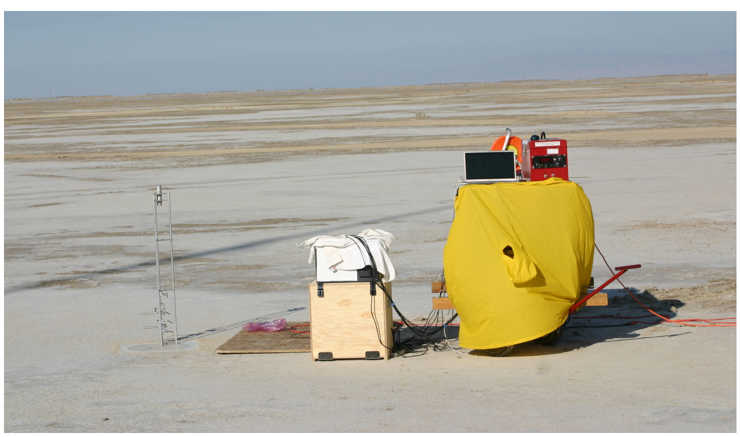
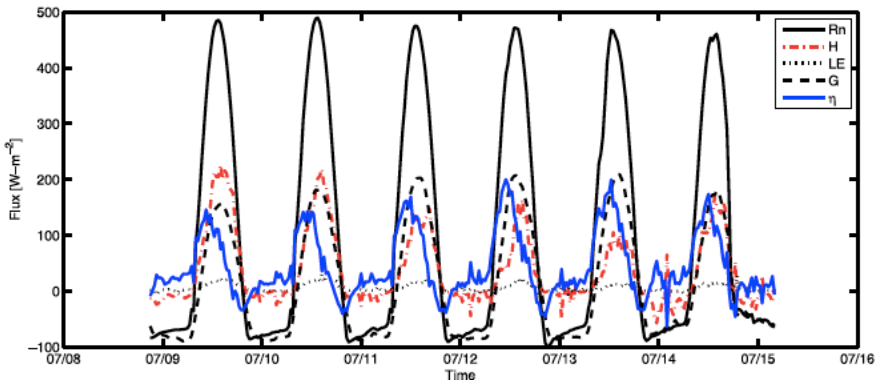
Near Surface Radiation Balance
EFD
ME 7710
Spring 2013

Energy Balance over Salt Flats (Utah's West Desert)

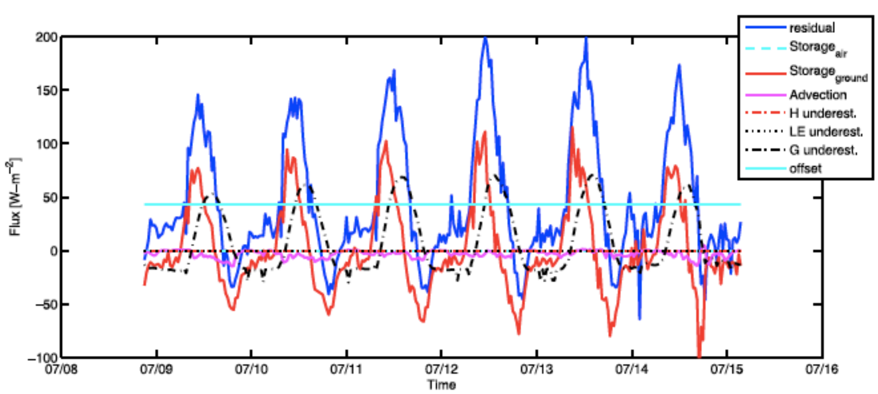


Energy Balance over Salt Flats



$R_N = H + LE + G + \eta$

Energy Balance over Salt Flats
Components of the Residual



$R_N = H + LE + G + \eta$

Electromagnetic Spectrum

Type of change

Orbital changes

Vibration changes

Rotation changes

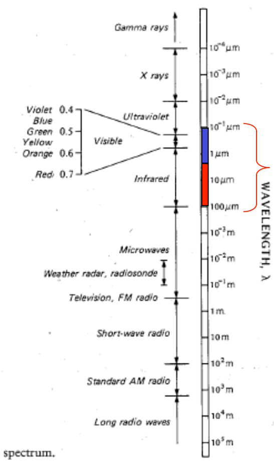


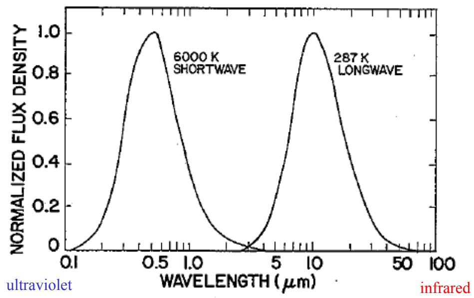
Figure 1.4 The electromagnetic spectrum.

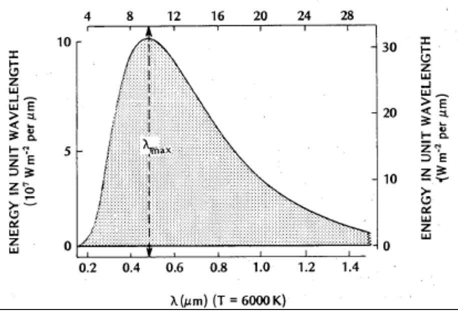
Range of Interest for Atmospheric Radiative Transfer
Solar ~ 0.15-4 mm (Short wave)
Terrestrial ~ 3-100 mm (Long wave)

EPFL Raman Lidar

Discuss on Whiteboard

Shortwave & Longwave Radiation





Wien's Law – Wavelength of maximum spectral emissive power

$$\lambda_{\max} = \frac{2897}{T_{abs}}$$

Average Global Radiation Balance

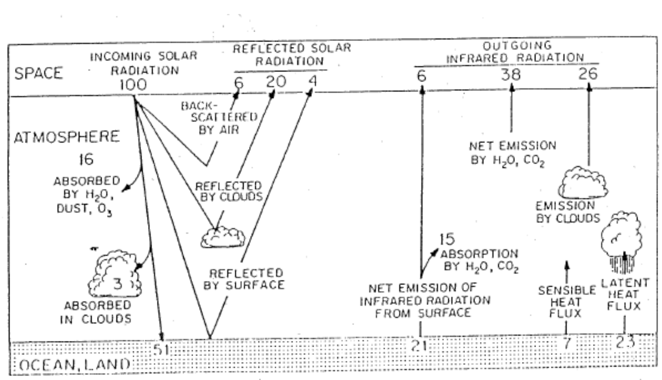


Fig. 1.3 Radiation balance for the atmosphere. [Adapted from "Understanding Climate Change", U.S. National Academy of Sciences, Washington, D.C., Fig. 1.6 on p. 10 of Gill (1982)].

Radiative Properties of Surfaces

Table 1.1 Radiative properties of natural materials.

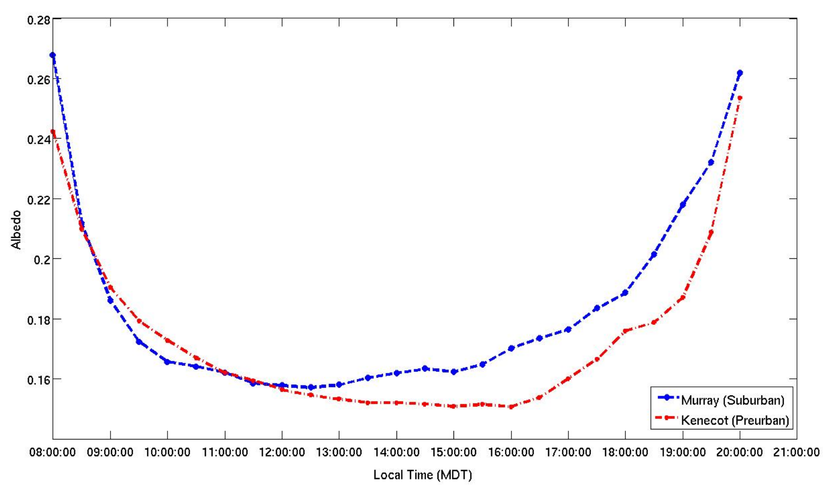
Surface	Remarks	Albedo α	Emissivity ε
Soils	Dark, wet Light, dry	0·05– 0·40	0·98– 0·90
Desert		0·20–0·45	0·84–0·91
Grass	Long (1·0 m) Short (0·02 m)	0·16– 0·26	0·90– 0·95
Agricultural crops, tundra		0·18–0·25	0·90–0·99
Orchards		0·15–0·20	
Forests			
Deciduous	Bare Leaved	0·15– 0·20	0·97– 0·98
Coniferous		0·05–0·15	0·97–0·99
Water	Small zenith angle Large zenith angle	0·03–0·10 0·10–1·00	0·92–0·97 0·92–0·97
Snow	Old Fresh	0·40– 0·95	0·82– 0·99
Ice	Sea Glacier	0·30–0·45 0·20–0·40	0·92–0·97

Sources: Sellers (1965), List (1966), Paterson (1969) and Monteith (1973).

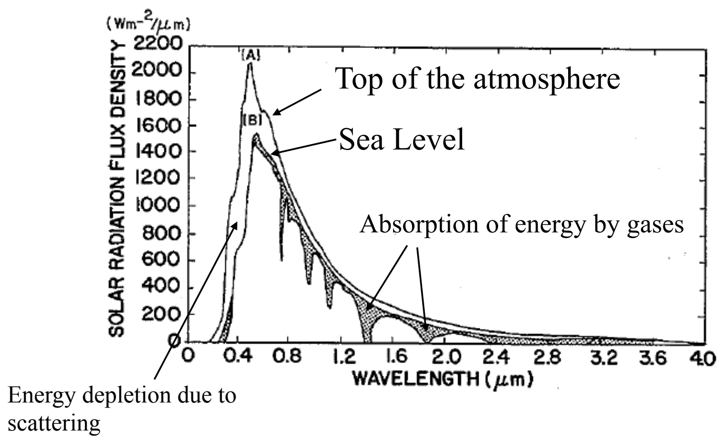
$$\alpha = \frac{R_S \uparrow}{R_S \downarrow} = \int_{0.15\mu m}^{4\mu m} \alpha_\lambda d\lambda$$

$$\varepsilon = \int_{3\mu m}^{100\mu m} \varepsilon_\lambda d\lambda$$

Albedo Variability
Murray Utah

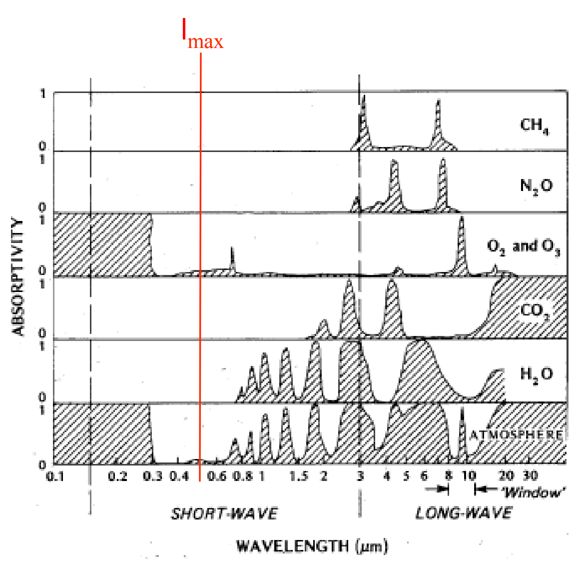


Clear Atmospheric Flux Density of Solar Radiation



~97% of total irradiance

Cloudless Absorption Spectra



Surface Irradiance

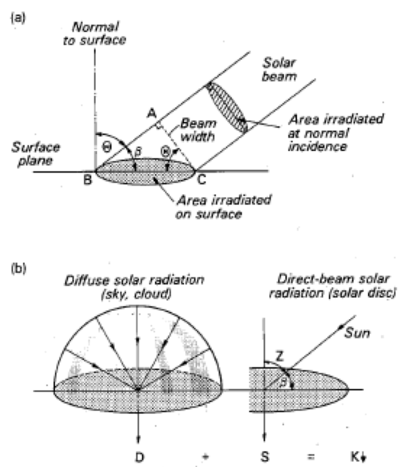


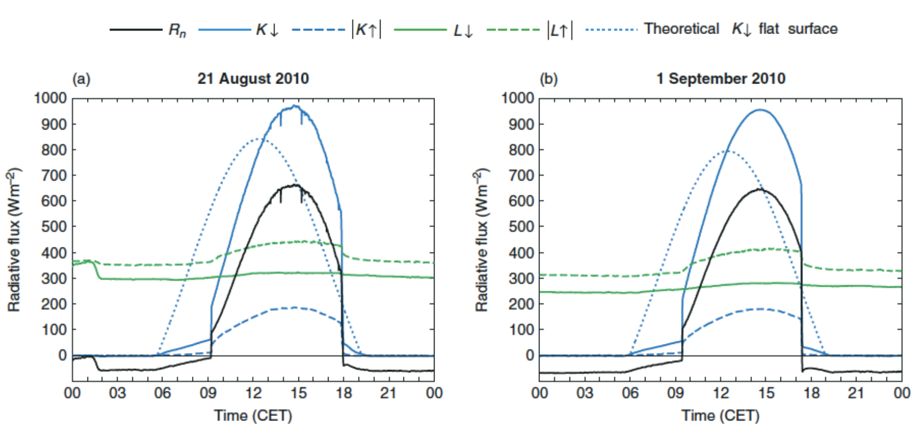
Figure 1.7 (a) Illustration of the areas irradiated by a circular beam on planes placed normal to, and at an angle Θ to, the beam. The radiant energy flux ($J\ s^{-1}$) is spread over unit area ($= \pi(0{\cdot}5AC)^2$) at normal incidence but over a larger area ($= \pi(0{\cdot}5BC)^2$) on the surface. The flux density ($W\ m^{-2}$) on the surface (S) is less than that at normal incidence (S_i) by the ratio $AC/BC = \cos\Theta$ or $\sin\beta$. Therefore, $S = S_i \cos\Theta$ and when $\Theta = 0°$ $\cos\Theta = 1$ and $S = S_i$. For a horizontal surface $\Theta = Z$ the zenith angle of the Sun. (b) The components of incoming solar radiation at the Earth's surface (modified after Monteith, 1973).

Direct Solar Radiation
Diffuse Solar Radiation – scatter radiation
Global = Direct + Diffuse

From Boundary Layer Climate, Oke 1987

Radiation Balance (Clear Diffuse Component)

K – Shortwave; L – Longwave; Rn – Net Radiation



From Nadeau et al., Q. J. R. Meteorol. Soc. (2012)

Solar Constant

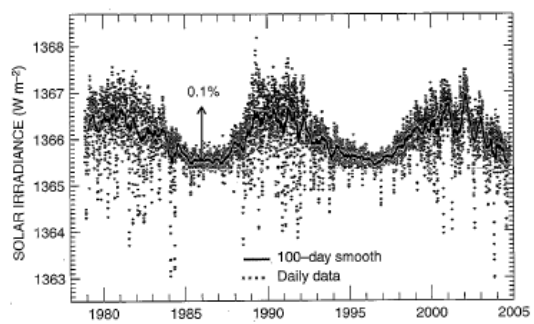


FIGURE 5.1 Composite record of Total Solar Irradiance (the 'Solar Constant') from 1978 to 2005 compiled from satellite radiometric measurements adjusted to a standard reference scale. (data courtesy of Dr. Judith Lean)

From Principles of Environmental Physics, Monteith & Unsworth

Radiation Balance

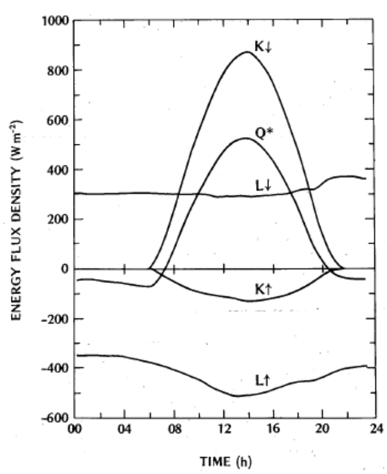
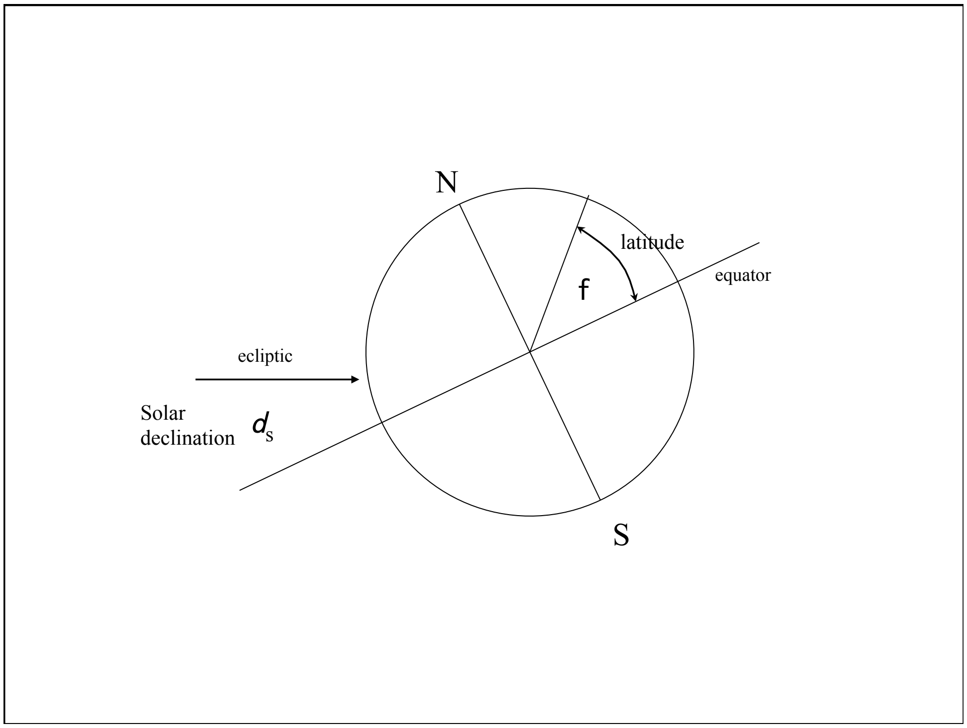


Figure 1.9 Radiation budget components for 30 July 1971, at Matador, Saskatchewan (50°N) over a 0·2 m stand of native grass. Cloudless skies in the morning, increasing cloud in the later afternoon and evening (after Ripley and Redmann, 1976). (*Note* – In the text no signs have been given to individual radiation fluxes, only to net fluxes (K^*, L^* and Q^*). However, in figures such as this radiative inputs to the surface ($K\downarrow$, $L\downarrow$) have been plotted as positive, and outputs ($K\uparrow$, $L\uparrow$) as negative to aid interpretation.) The following table gives the radiation totals for the day (MJ m^{-2} day^{-1}).

$K\downarrow$	27·3	$L\downarrow$	27·5
$K\uparrow$	4·5	$L\uparrow$	36·8
K^*	22·7	L^*	−9·3
$a^\dagger$	0·16	Q^*	13·4

† Dimensionless

K – Shortwave (Solar)
L - Longwave


N
latitude
f
equator
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Solar
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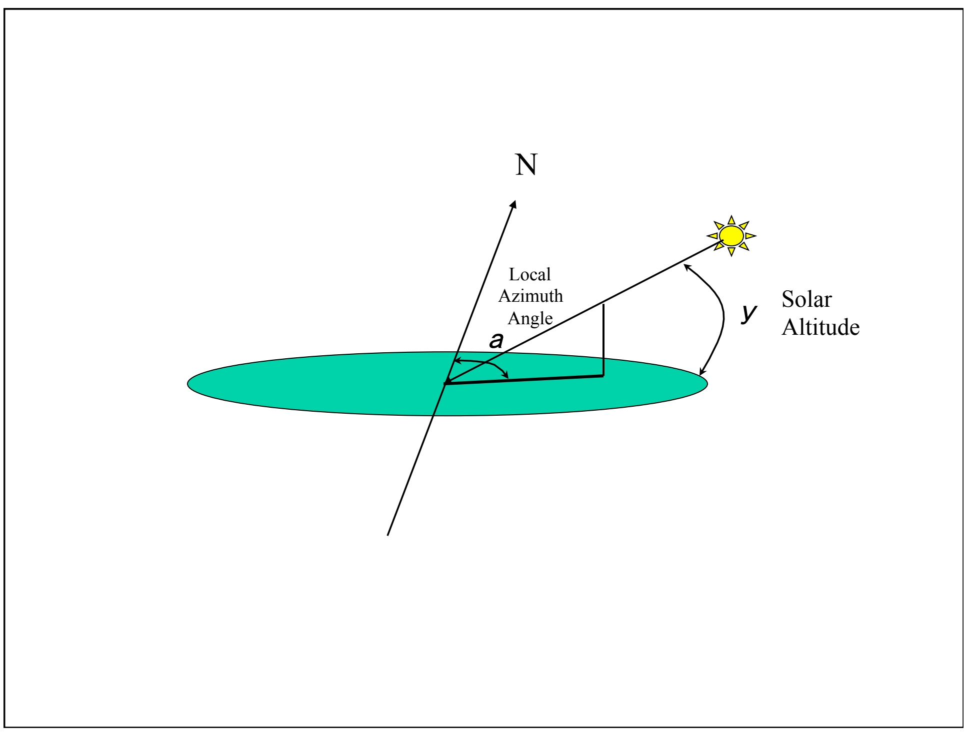
N
Local
Azimuth
Angle
a
y
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