Near Surface Radiation Balance
EFD
ME 7710
Spring 2013

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

Components of the Residual

\[ R_N = H + \text{LE} + G + \eta \]
Electromagnetic Spectrum

Type of change
- Orbital changes
- Vibration changes
- Rotation changes

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

Figure 2.4: The electromagnetic spectrum.

EPFL Raman Lidar

Discuss on Whiteboard
Shortwave & Longwave Radiation

Wien’s Law – Wavelength of maximum spectral emissive power

\[ \lambda_{\text{max}} = \frac{2897}{T_{\text{abs}}} \]

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 GSR (1982)].
Radiative Properties of Surfaces

Table 1.1 Radiative properties of natural materials.

<table>
<thead>
<tr>
<th>Surface</th>
<th>Remarks</th>
<th>Albedo α</th>
<th>Emittance ε</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soils</td>
<td>Dark, wet Light, dry</td>
<td>0.05–0.95</td>
<td>0.98–0.99</td>
</tr>
<tr>
<td>Desert</td>
<td></td>
<td>0.20–0.45</td>
<td>0.84–0.91</td>
</tr>
<tr>
<td>Grass</td>
<td>Long (1-0 m) Short (0-02 m)</td>
<td>0.16–0.95</td>
<td>0.90–0.95</td>
</tr>
<tr>
<td>Agricultural crops, tundra</td>
<td></td>
<td>0.10–0.25</td>
<td>0.90–0.99</td>
</tr>
<tr>
<td>Forests</td>
<td>Deciduous Bare</td>
<td>0.15–0.87</td>
<td>0.97–0.99</td>
</tr>
<tr>
<td></td>
<td>Leaved</td>
<td>0.20–0.98</td>
<td>0.97–0.99</td>
</tr>
<tr>
<td></td>
<td>Coniferous</td>
<td>0.05–0.11</td>
<td>0.92–0.97</td>
</tr>
<tr>
<td>Water</td>
<td>Small shrub angle</td>
<td>0.03–0.10</td>
<td>0.92–0.97</td>
</tr>
<tr>
<td></td>
<td>Large shrub angle</td>
<td>0.10–0.30</td>
<td>0.92–0.97</td>
</tr>
<tr>
<td>Snow</td>
<td></td>
<td>0.02–0.95</td>
<td>0.92–0.97</td>
</tr>
<tr>
<td>Ice</td>
<td>Sea</td>
<td>0.02–0.45</td>
<td>0.92–0.97</td>
</tr>
<tr>
<td></td>
<td>Glacier</td>
<td>0.20–0.49</td>
<td>0.92–0.97</td>
</tr>
</tbody>
</table>

Source: Sellers (1965), Lit (1964), Peterson (1964) and Memon (1973).

\[ \alpha = \frac{R_S}{R_S} = \int_{0.15 \mu m}^{4 \mu m} \alpha_\lambda d\lambda \]

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

Albedo Variability

Murray Utah
Clear Atmospheric Flux Density of Solar Radiation

Energy depletion due to scattering

\(~97\%\) of total irradiance

Cloudless Absorption Spectra
Surface Irradiance

Radiation Balance
(Clear Diffuse Component)

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

From Boundary Layer Climate, Oke 1987

Solar Constant

Radiation Balance

Table 3.9: Radiation budget components for 30 July 1974, at Matsukawa, Suzuki, and Miyazawa (SSM) over a 9.4 m stand of tamarisk grass. Clear-sky data in the morning, increasing cloud in the late afternoon and evening (after Nishi and Rind, 1976). Note: In the text no units have been given as individual radiation fluxes, only to net fluxes ($K_{s}$, $L_{a}$, and $Q_{c}$). However, in figure such as this radiative input to the surface ($K_{s}$, $L_{a}$) have been placed as positive, and negative ($K_{r}$, $L_{r}$) as negative to all instruments. The following table gives the radiation needs for the day (MJ m$^{-2}$ day$^{-1}$):

<table>
<thead>
<tr>
<th></th>
<th>$K_{s}$</th>
<th>$L_{a}$</th>
<th>$Q_{c}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27.5</td>
<td>11.2</td>
<td>6.8</td>
</tr>
<tr>
<td>$K_{r}$</td>
<td>4.6</td>
<td>1.7</td>
<td>-0.8</td>
</tr>
<tr>
<td>$L_{r}$</td>
<td>0.46</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* Uncertainty

K – Shortwave (Solar)
L - Longwave
Solar declination $d_s$

Solar altitude $y$

Local Azimuth Angle $\alpha$

Equator

Ecliptic

Latitude $f$