Lecture 4: Radiation/Energy Balance

[Graph showing daily insolation in W m⁻² day with contour lines indicating variations across latitudes and dates from 21 February to 21 December.]
Insolation vs. Latitude

The graph shows the insolation (W/m²) plotted against latitude. There are three curves:

- **21 December**: The curve reaches its minimum at the equator and increases towards the poles.
- **21 June**: The curve reaches its maximum at the equator and decreases towards the poles.
- **Annual**: The curve is intermediate between the two, showing a continuous increase or decrease depending on latitude.

The insolation values range from 0 to 600 W/m², and the latitude spans from -90° to 90°.
Albedo Maps

Figure 2.9 Global maps of planetary albedo in a Hammer equal-area projection averaged for (a) annual mean, (b) JJA season, and (c) DJF season. Values are given as fractions. Contour interval is 0.05. Values greater than 0.4 are heavily shaded; values less than 0.2 are lightly shaded.
OLR Maps

Fig. 2.10  Global maps of outgoing longwave radiation for (a) annual mean, (b) JJA (June–July–August) season, and (c) DJF (December–January–February) season. Contour interval is 10 W m$^{-2}$. Values greater than 280 W m$^{-2}$ are lightly shaded, and values less than 240 W m$^{-2}$ are heavily shaded.
Net Radiation Map

Fig. 2.11 Global maps of net incoming radiation at the top of the atmosphere for (a) annual mean, (b) JJA season, and (c) DJF season. Contour interval is 20 W m$^{-2}$. Values greater than 80 W m$^{-2}$ are lightly shaded, and values less than zero are heavily shaded.
Movies of Energy Balance

- Planetary Albedo
- Outgoing Longwave Radiation (OLR)
- Net Radiation Balance
- Cloud Forcing
Annual Energy Fluxes

![Graph showing annual energy fluxes with lines for Absorbed Solar, Emitted Longwave, and Net Radiation against Latitude.](graph.png)
Atmospheric vs. Oceanic Heat Transport

Northward heat transport in PW ($10^{16}$ W), Northern hemisphere

Cloud Coverage Map

p < 440 mb

p < 680 mb

All clouds
Cloud Forcing Map

OLR Reduction

Solar Absorption

Net change
Cloud Radiative Forcing

\[ F_{net,TOA} = F_{cloudy} - F_{clear} = -\frac{S_0}{4} (\alpha_{cloud} - \alpha_{planet}) + F_{LW,clear} - \varepsilon\sigma T_z^4 \]

“Albedo Effect”

“Greenhouse Effect”