DOCUMENT
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DOCUMENT TITLE
METEOROLOGY FOR AUSTRALIA

CHAPTER 3 – TEMPERATURE

Version 3.0
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TEMPERATURE

CONVERSIONS

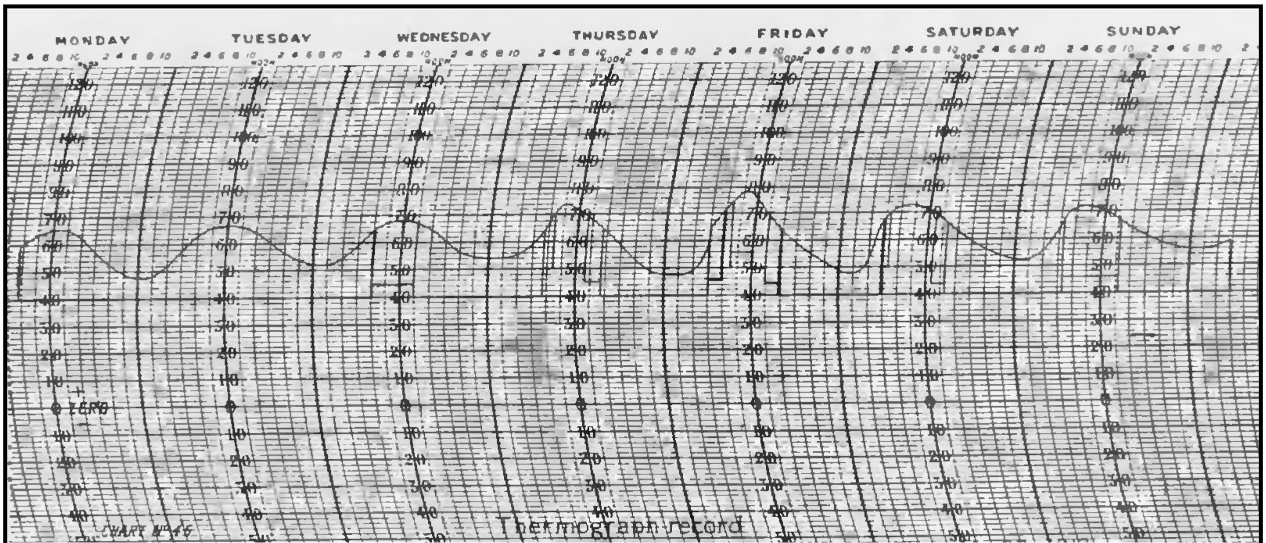
°F = (°C x 9/5) + 32
°C = (°F - 32) x 5/9
K = °C + 273

DEFINITIONS

a) Heat: A form of energy, causing or caused by the vibrations of the molecules of a substance.

b) Temperature: A measure of the degree of hotness or coldness or a measure of an object's heat energy:

- Measured with a thermometer
- Graphed on a thermograph.



This is a chart from a thermograph and shows how the temperature (measured in degrees Celsius °C) changed over a week.

3. a. A Thermograph

c) Specific Heat: The amount of heat (energy) required to raise the temperature of 1 unit of mass by 1°C.

e.g. Water has a high specific heat in that it requires a lot of energy to raise its temperature, hence it heats and cools slowly.

d) A Calorie. The amount of heat required to raise the temperature of 1 gram of water by 1°C.

HEAT EXCHANGE PROCESSES

a) Radiation: Process of heat movement by electromagnetic waves without the help of solid material, e.g. the Earth receiving energy from the sun.

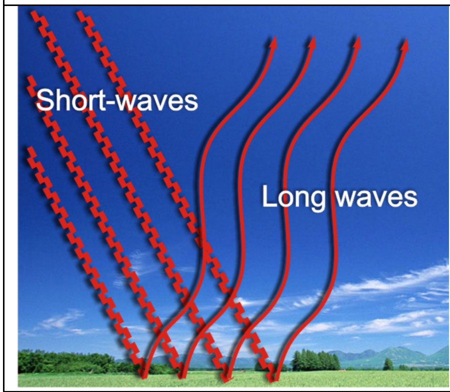
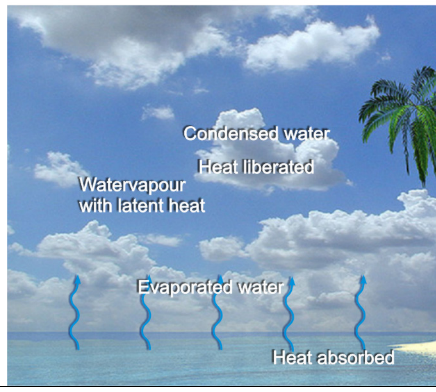
b) Convection: Heat is carried by warm air rising. The air, heated by being in contact with a warm surface, expands, becomes less dense, and rises in convection currents.

c) Conduction: Transfer of heat by contact, e.g. the ground heats up by day and the air in contact with it also heats up. The opposite is true at night when the ground cools down.

d) Latent ("hidden") Heat Transfer. This is the heat transferred by the change in state of a substance.

E.g. Evaporation, when latent heat is absorbed by the atmosphere (a cooling process) and Condensation when latent heat is released by the atmosphere (a heating process). (To aid in understanding, it might be useful to consider the water vapour to be separate from the atmosphere. Evaporation would be a cooling process where latent heat is absorbed from the atmosphere by the water vapour and condensation a warming process, when latent heat is released by the water vapour into the atmosphere.)

Latent heat plays a very large part in various meteorological phenomena. If one gram of ice with a temperature of 0°C is heated, the heat supplied (80 calories per gram) will changed the water's state from solid to liquid with **no change in temperature**. The heat has, however, been absorbed as the latent heat of fusion. If more heat is applied to the gram of water, a further 100 calories would raise its temperature to 100°C. Another change of state would now occur (evaporation from water to water vapour) if a further 540 calories of heat were provided. This vapour would be at the same temperature of 100°C. The 'stored' or latent heat is released when the reverse processes occur, e.g. condensation from vapour to liquid when fog or clouds form, and freezing from liquid to ice. **The heat released in the latter process has important implications for aircraft icing, and the much greater latent heat of condensation has similar importance as a source of energy for thunderstorms and hurricanes.**

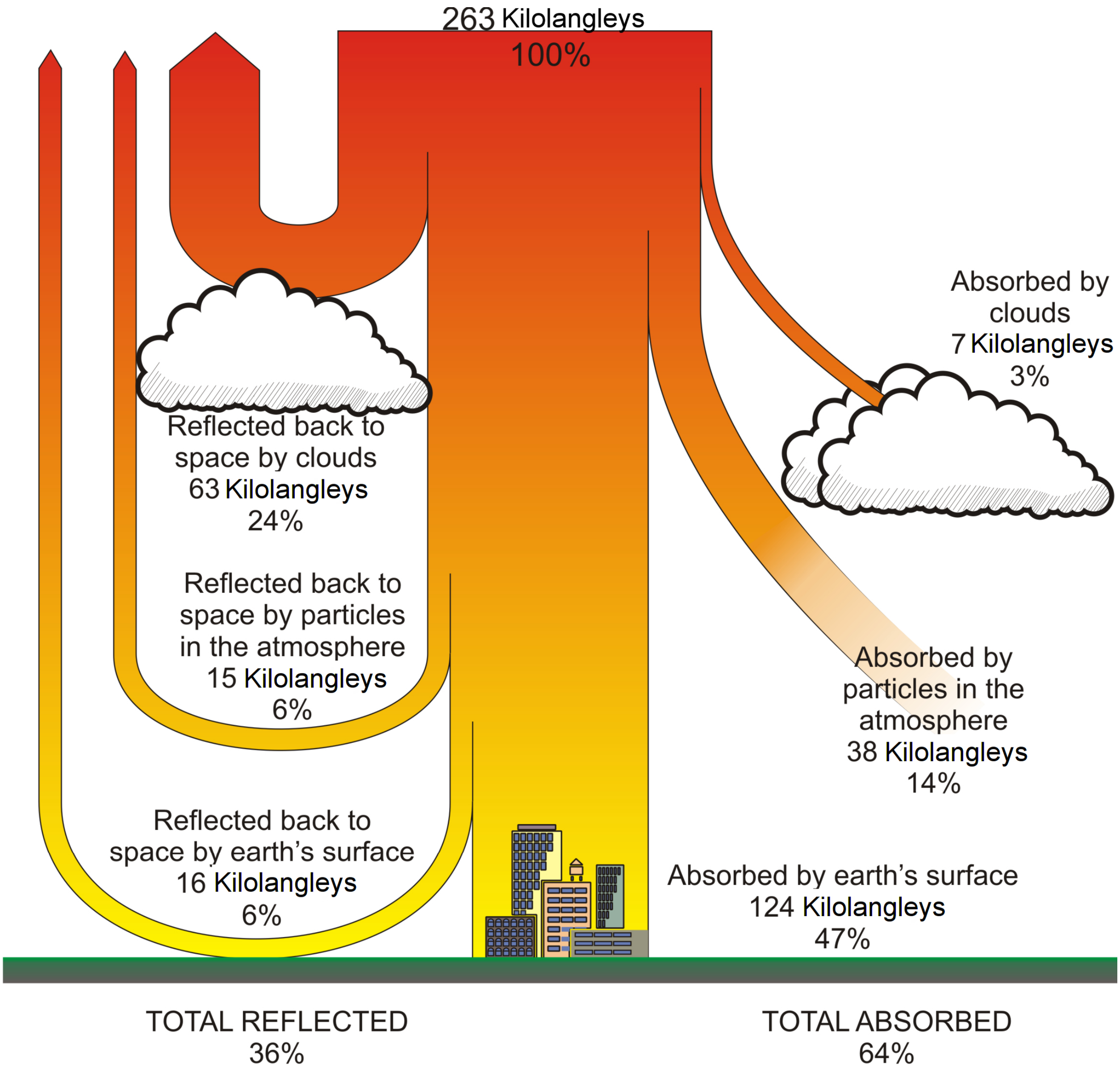
Terrestrial Radiation	Conduction & Convection	Evaporation & Condensation
		
The earth absorbs short-wave solar radiation (insolation) and reradiates long-wave heat energy (thermal radiation) to the atmosphere	The atmosphere is heated by physical contact with warm Earth's surface. Heated air expands, rises and allows cooler air to come into contact with Earth as source of heat.	As water evaporates, heat is absorbed from Earth's surface. It is released into the atmosphere when water vapour condenses

3. b. Heat Exchange Processes

INCOMING SOLAR RADIATION (INSOLATION)

The sun emits short wave (SW) electromagnetic radiation. Approximately 9% is ultra violet, 45% visible light, and 46% is infra red). Of the total insolation, about 43% reaches the Earth's surface, the remainder being reflected or absorbed by ozone, dust, water vapour, clouds etc.

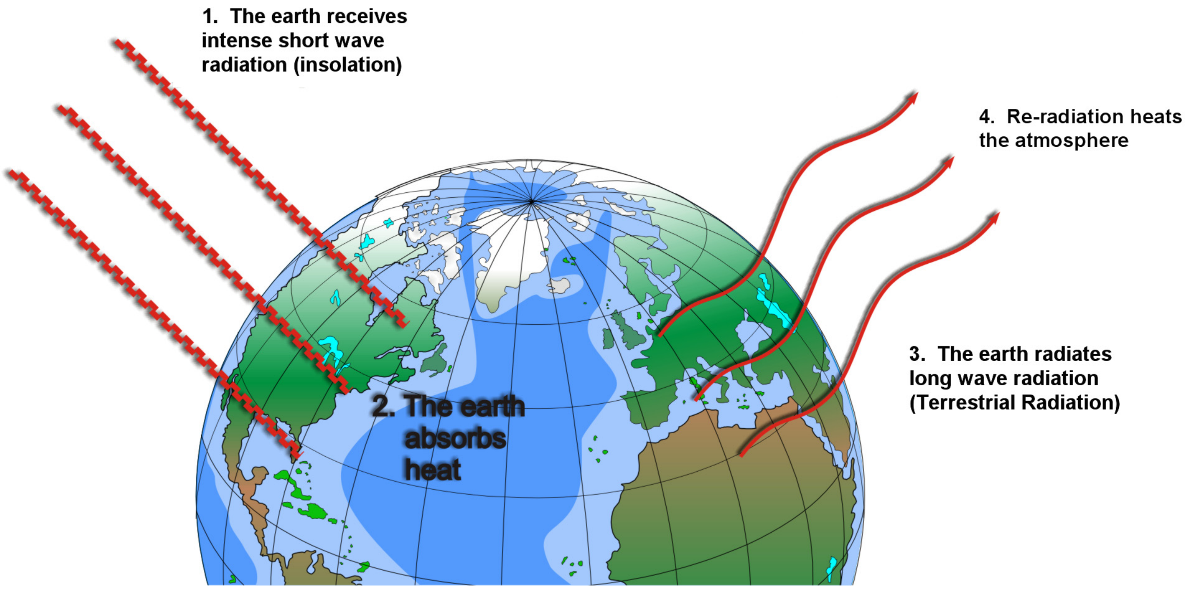
The source of heat for the Earth is the sun, and large amounts of incoming solar radiation are accepted by the Earth as a whole. This Incoming solar radiation (insolation) is short wave. The ozone layer absorbs some of this SW radiation (the harmful ultra-violet) and a little incoming radiation is absorbed by clouds and dust etc. Apart from this, however, the atmosphere is NOT heated by the sun. Instead the atmosphere is heated from below, partly by conduction and convection, partly by the release of latent heat when condensation occurs, and partly by the Earth's long wave (LW) radiation (Terrestrial Radiation) (diag. p5 and p6). The Earth, being at a comparatively low temperature compared to the sun, emits radiation at a longer wavelength. LW radiation is partly absorbed and re-radiated by the carbon dioxide and water vapour in the atmosphere. However, the total outgoing LW radiation must still exactly balance the total incoming SW radiation; otherwise the temperature of the Earth as a whole would rapidly change. Should this balance not exist then global warming would occur.



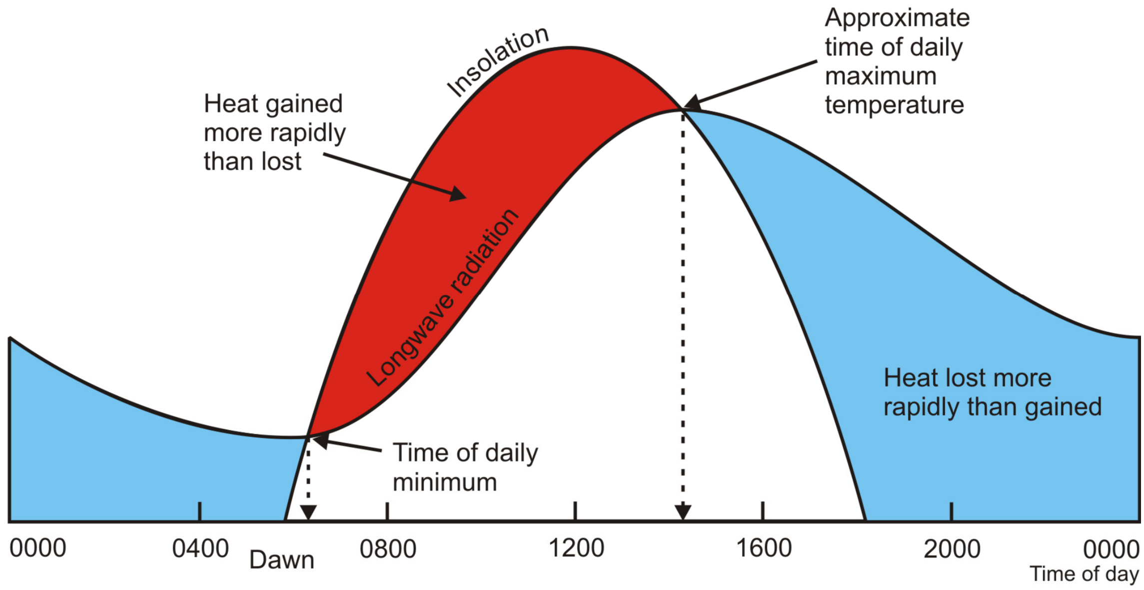
3. c. The Disposal of Insolation in the Latitudes of Sydney

OUTGOING TERRESTRIAL RADIATION (RE-RADIATION)

The Earth absorbs short wave radiation but reflects long wave radiation (Terrestrial Radiation). Terrestrial Radiation is maximum between the hours of 1400 and 1600 Local. Long wave re-radiation heats the atmosphere.



3. d. Terrestrial Radiation



3. e. Diurnal Temperature Variation

FACTORS AFFECTING TEMPERATURE

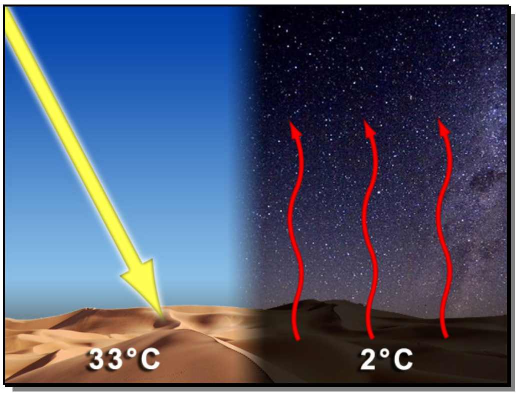
a) Length of Day and Night

The more hours of daylight there are, the more time there is for insolation and the longer the night is, the more hours there are for re-radiation. The longer the day, the warmer the temperature. The longer the night, the cooler the temperature

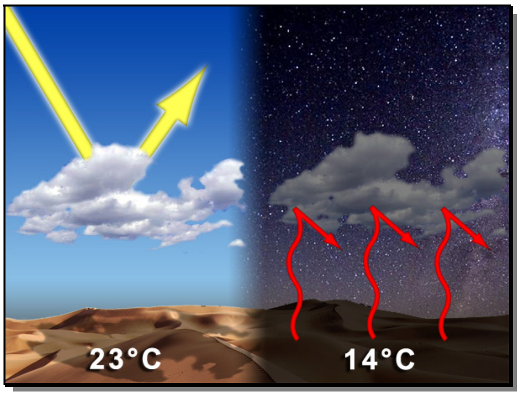
3. f. Length of Day and night

b) Cloud Cover

Cloud cover lowers the daytime temperature by filtering the insolation but increases the night time temperature by trapping the LW radiation beneath it. Clear skies give hot days but cold nights (desert areas). Cloudy skies give smaller diurnal temperature variations (tropical areas).



3. g. Clear Skies



3. h. Cloudy Skies

c) Surface Reflectivity (Albedo)

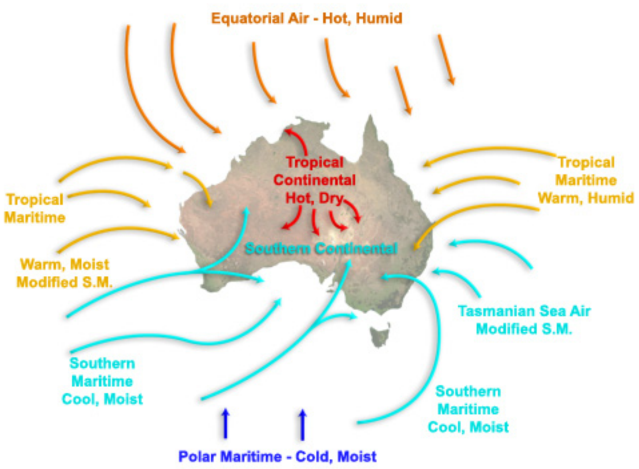
Albedo is a measurement of a material's reflectivity. Dark surfaces absorb heat (low albedo) and shiny or white surfaces reflect heat (high albedo).

Surface	Percentage
fresh snow	80 to 90
old snow	40 to 80
sea and glacial ice	30 to 50
light dry sands	35 to 50
bare dark soil	5 to 15
field crops	10 to 20
dry concrete	15 to 30
bitumen roads	5 to 10
clouds	60 to 90
desert lands	25 to 30
savanna lands:	
wet season	15 to 20
dry season	25 to 30
temperate grasslands	10 to 20
temperate forestlands	10 to 20
tropical forestlands	5 to 15
coniferous forestlands	10 to 15
tundra	15 to 20
oceans (with sun near horizon)	about 40
oceans (with sun nearly overhead)	about 5

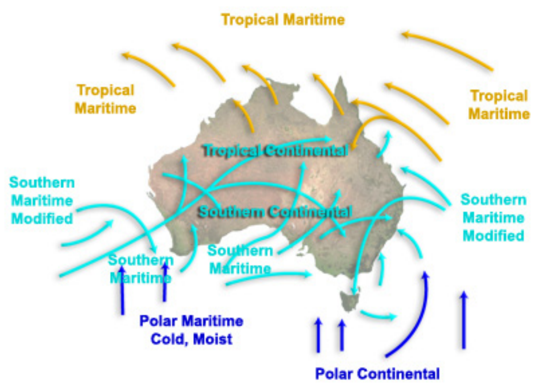
3. i. Albedo for Short Wave Radiation

d) Movement of Air Masses

An air mass is a large body of air with uniform characteristics of temperature and humidity and stability throughout (See Chapter 15). Advection is the horizontal movement of air. Cold air masses bring cold conditions. Warm air masses bring warm conditions (see Chapter 15 on European air masses.).



3. j. Air masses over Australia in Summer

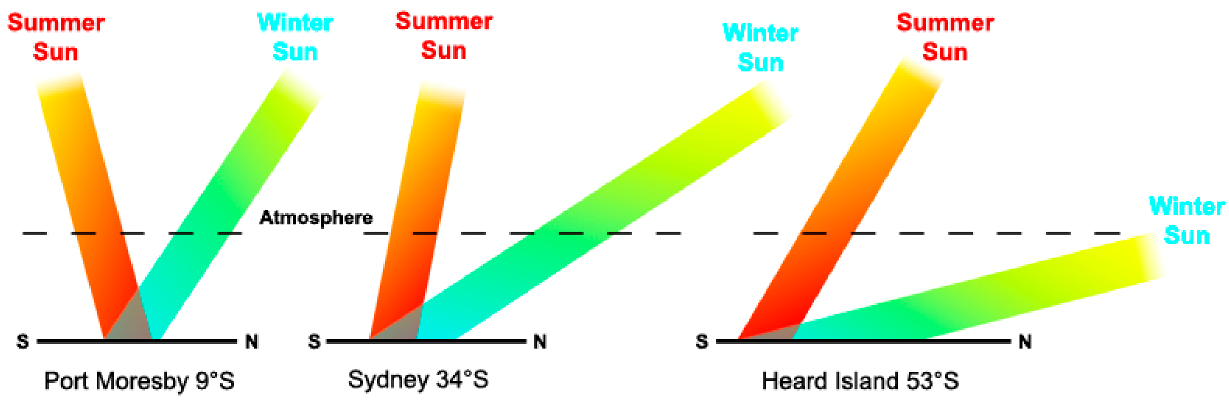


3. k. Air masses over Australia in Winter

e) Season

Meridian Altitude is defined as the angle the sun makes with the horizon at midday.

Due to the Earth's revolution around the sun, and also due to the tilt of its axis, the sun's relative position migrates north and south. In June, the sun is directly over the Tropic of Cancer and in December over the Tropic of Capricorn. The closer to the sun, the warmer that part of the Earth's surface will be. Below are diagrams showing the effect of the seasonal variation on the incidence of the sun's rays at selected localities in the southern hemisphere. They show equal amounts of insolation at summer and winter solstice. Note the variations in (a) the size of the areas of the Earth which have to be heated, and (b) the distances through the atmosphere which the sun's rays have to pass.



3. I. Seasonal Variation on Sun's Incidence

f) Location

Incoming radiation which is reflected by clouds, or by a reflective surface such as water, snow or ice, plays no part in raising the Earth's surface temperature. At high latitudes the general nature of the surface and the small angle of incidence of the sun's rays both contribute to a small intake of heat. Over a snow or ice surface, much of the heat which is absorbed is expended in providing the latent heat of melting, so that there is little if any increase in temperature. Over the sea, reflection is a major loss, and latent heat consumes a large proportion of the remaining energy. In addition, the incoming radiation penetrates to a depth of several metres, and ocean mixing then spreads the heating effect through a much greater depth. The net effect is that the increase in sea temperature due to solar radiation is very small. The sea is of course a source of heat loss, owing to the Earth's LW radiation, but water vapour, which is in plentiful supply over the sea, absorbs much of the outgoing LW radiation, and re-radiates it. The heat loss is therefore also fairly small. The sea temperature therefore varies very little day or night. It increases very slowly throughout the summer but similarly decreases very slowly during the winter. Land surfaces vary, but they tend to respond quite rapidly to diurnal and seasonal changes in solar radiation.

Overall, land is a good absorber of SW radiation during the day, and a good radiator of LW radiation both by day and by night. **Therefore diurnal variation of temperature over land is much greater than over the sea.** Seasonally, especially in the centre of large continents away from the moderating effects of the sea, there is an extreme range of temperature from summer to winter.

Coastal locations are warmer in winter and cooler in summer than inland areas and diurnal extremes are moderated as the table below illustrates.

	Adelaide °C	Renmark °C
Summer (January)		
Average maximum	29.7	32.5*
Average minimum	16.4	16.6
Range	13.3	15.9
Winter (July)		
Average maximum	14.9	16.1
Average minimum	7.2	5.1*
Range	7.7	11.0
Adelaide is a coastal city; Renmark is at approximately the same latitude but is 200 km from the sea. (* note: High average maximum and low average minimum.)		

3. m. Diurnal Variation in South Australia