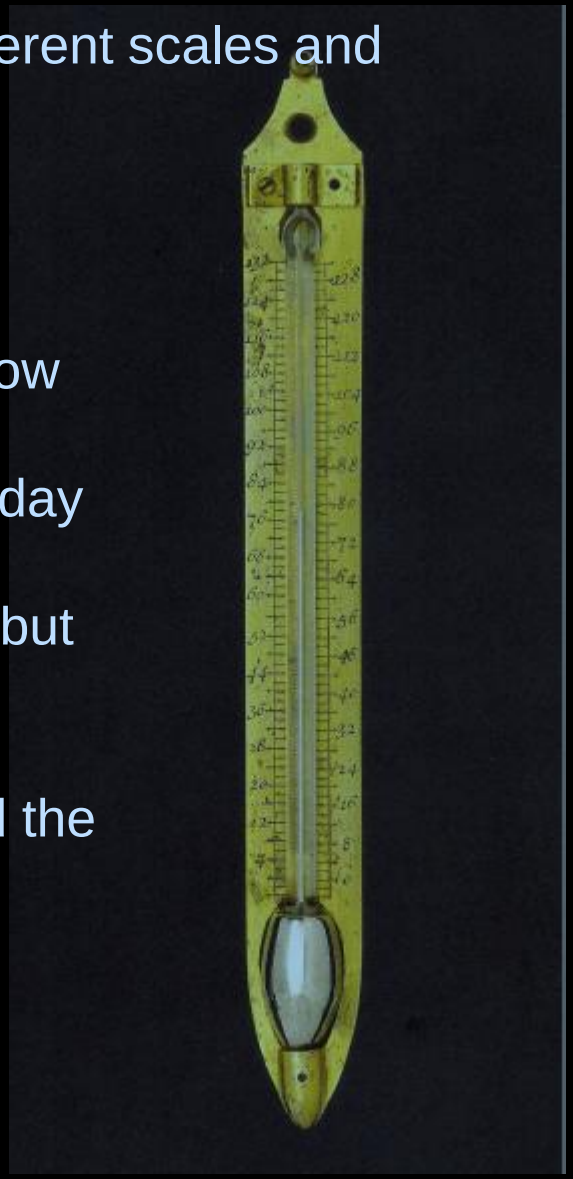
Understanding weather and the weather forecast

Week 10 Observing the Weather

Terry Hart

Temperature measurement

Liquid in glass tubes developed in 1630s with different scales and reference points

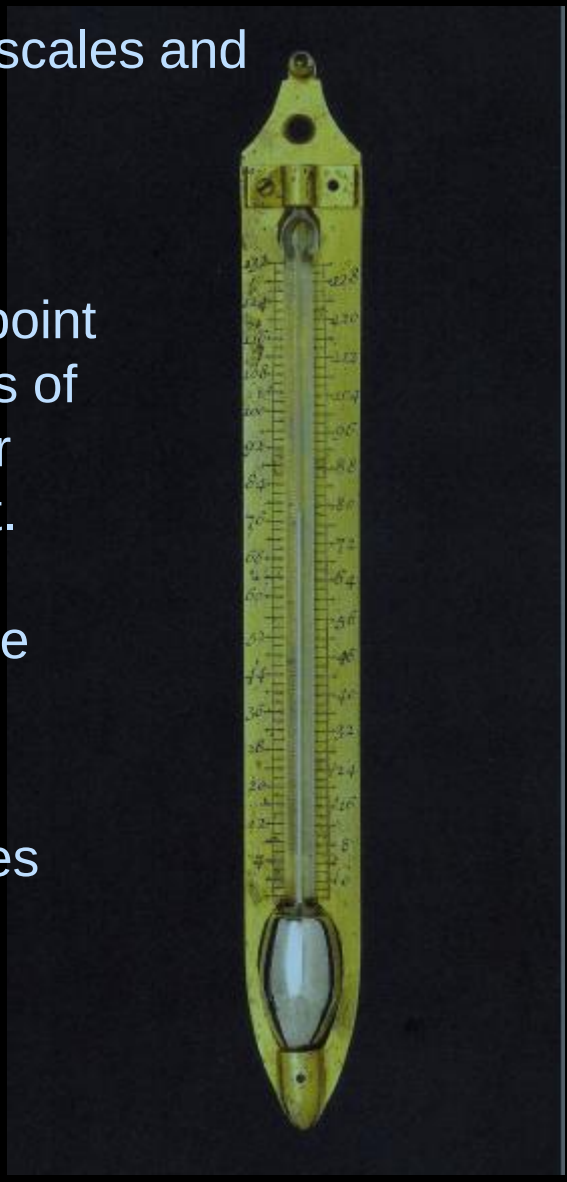


Daniel Fahrenheit (1686-1736)

- son of a wealthy German merchant in Danzig (now Gdansk).
- when he was 16 both parents died on the same day (mushrooms?).
- moved to Amsterdam to work for a shop-keeper but became interested in scientific instruments.
- 1714 Made alcohol in glass thermometers – choosing chilled brine solution for 0 degrees and the boiling point of water as 212.

Temperature measurement

Liquid in glass tubes developed in 1630s with different scales and reference points



Anders Celsius (1701-44) in 1742 decided on a 100-point scale (centigrade) but chose freezing and boiling points of water as the reference points. He initially chose 100 for freezing and 0 for the boiling point, but later reversed it.

1948 – **Celsius scale** adopted by most countries as the standard unit of measurement for temperature

Kelvin scale – the unit in physical sciences as it relates to the absolute lowest temperature (- 273.15) below which there is no molecular movement.

Temperature measurement

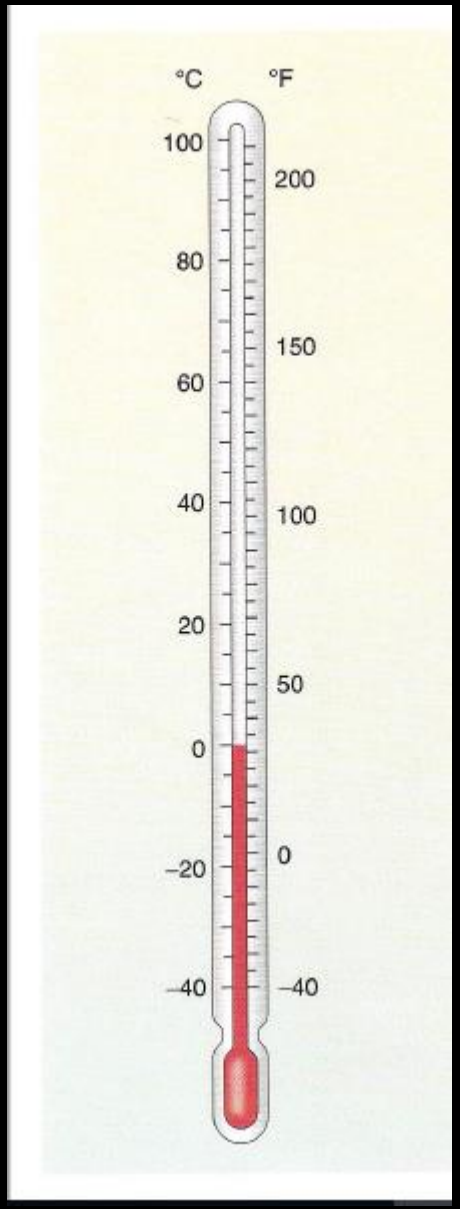
Liquid in glass

- Mercury or alcohol (mercury freezing point – 36 C)
- Special types with needles for recording maximum and minimum temperatures

Bimetallic thermometers

- Two metals with different rates of expansion bonded together so that it bends as temperature changes
- Can be made in the form of a coil for a greater deflection
- Used in mechanical **thermographs**

Thermistors and variable resistance thermometers
e.g. in cars, radiosondes



Temperature measurement

Thermal radiation sensors

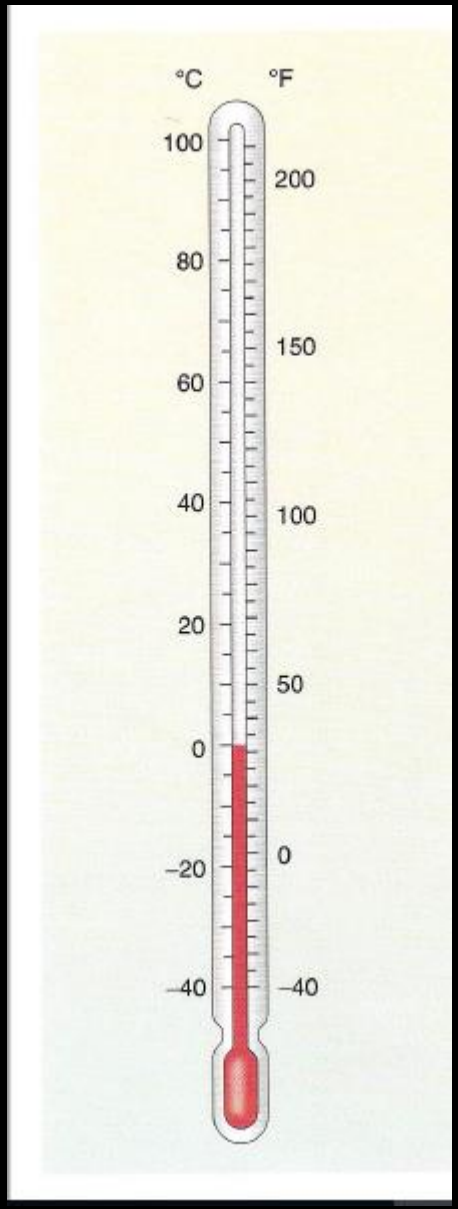
Temperature measurement

Thermal radiation sensors

Temperature measurement

Standards in measurement – *air* temperature

- Height – 1.25 to 2 metres
- Exposure – protected from sun and effects of surrounding objects
- Ventilation – but protected from wind
- Surface – short grass or the natural surface of the district

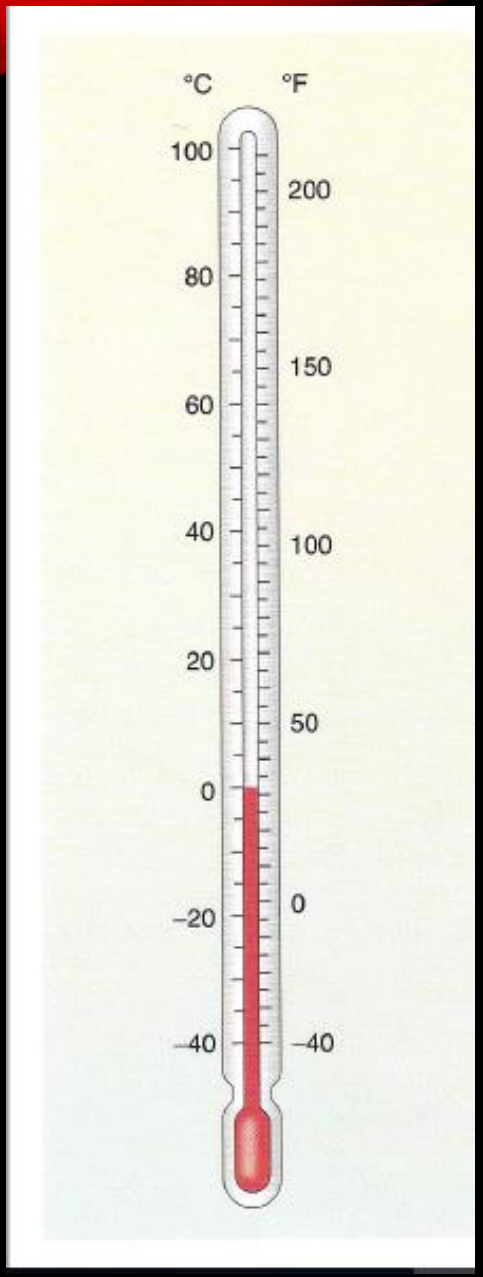


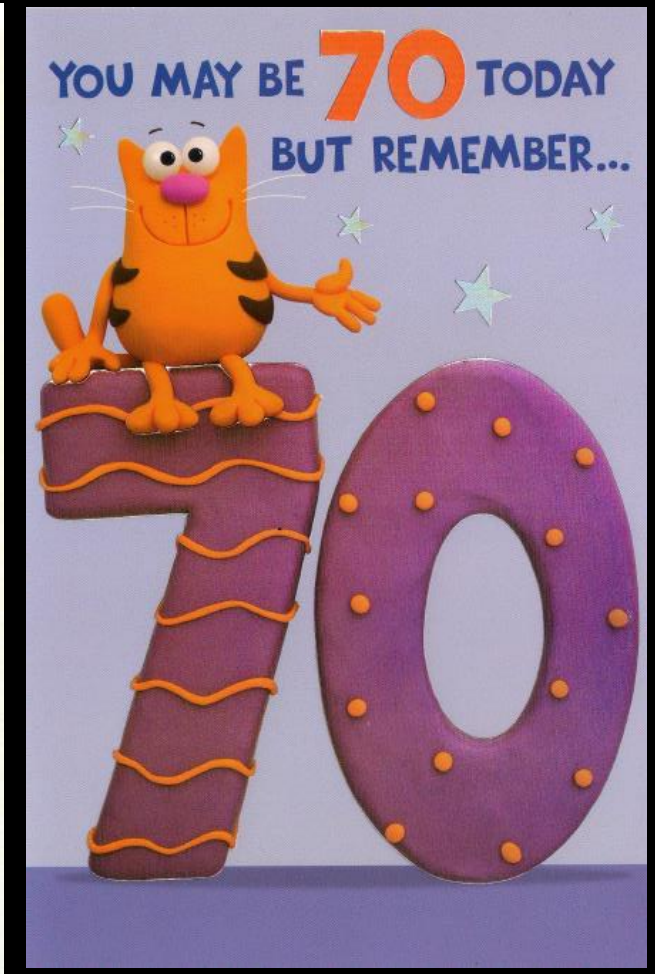
Temperature measurement

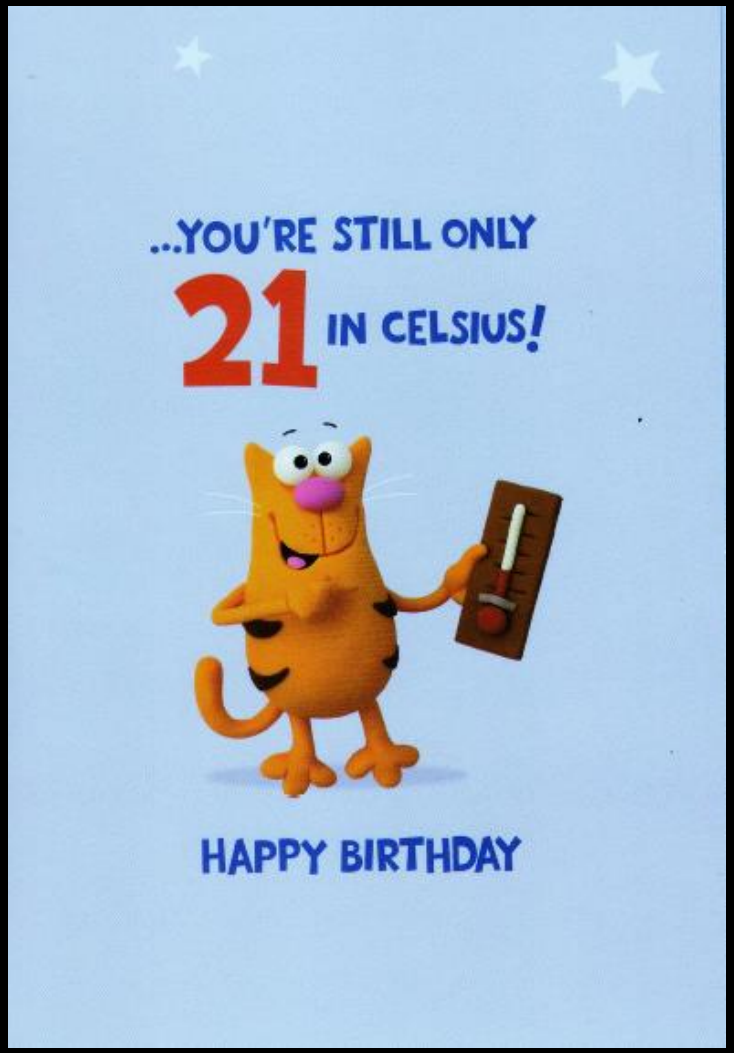
Stevenson screen

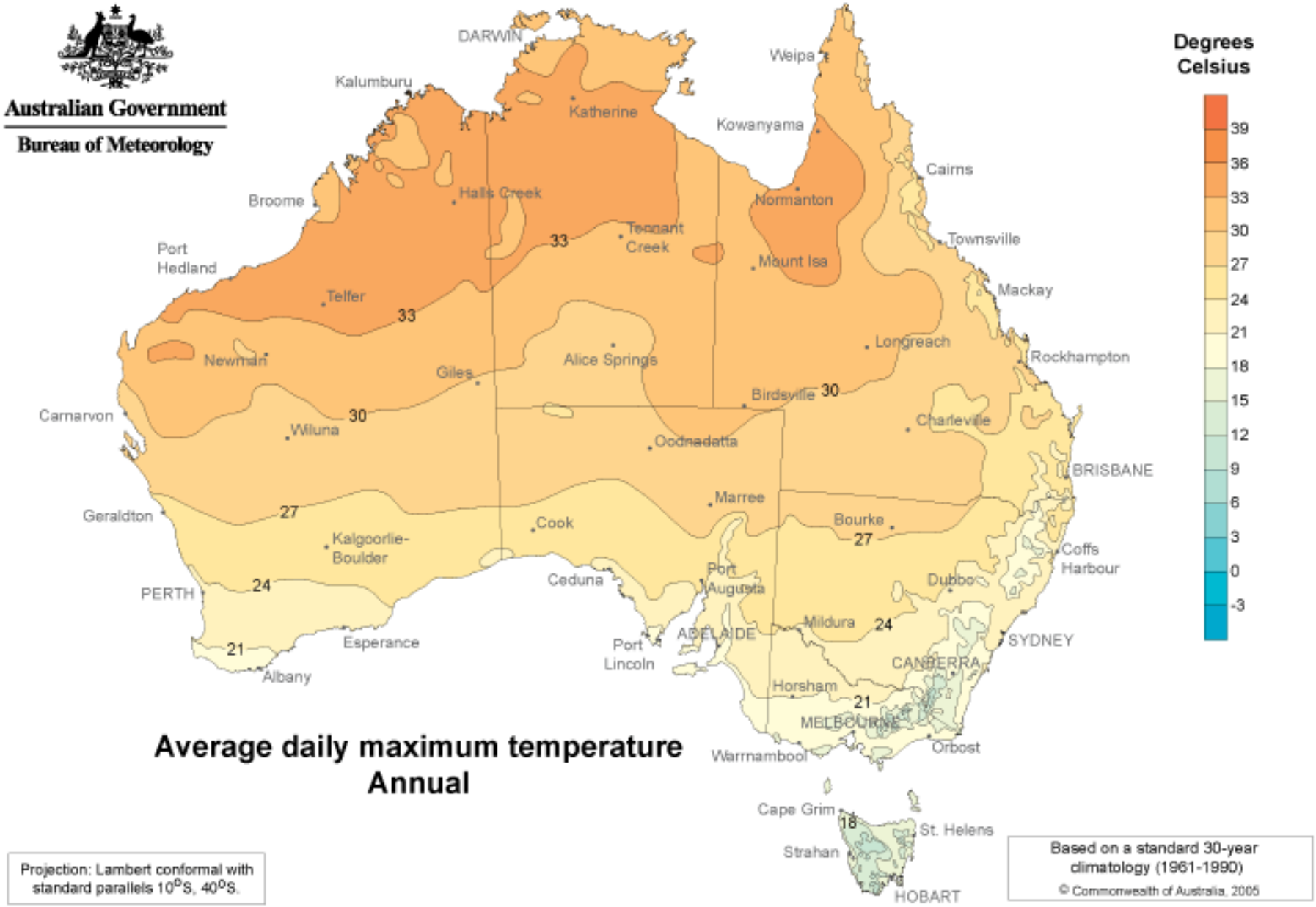
Louvred sides

Temperature measurement








Australian Government
Bureau of Meteorology
Degrees Celsius
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18
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12
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3
0
-3
DARWIN
Kalumburu
Katherine
Weipa
Kowanyama
Cairns
Broome
Halls Creek
Normanton
Tennant Creek
Townsville
Port Hedland
Mount Isa
Telfer
Mackay
Longreach
Newman
Alice Springs
Rockhampton
Giles
Birdsville
Carnarvon
Wiluna
Charleville
Oodnadatta
BRISBANE
Marree
Geraldton
Bourke
Cook
Kalgoorlie-Boulder
Coffs Harbour
Ceduna
Port Augusta
Dubbo
PERTH
Mildura
ADELAIDE
SYDNEY
Esperance
Port Lincoln
CANBERRA
Albany
Horsham
MELBOURNE
Warrnambool
Orbost
Cape Grim
St. Helens
Strahan
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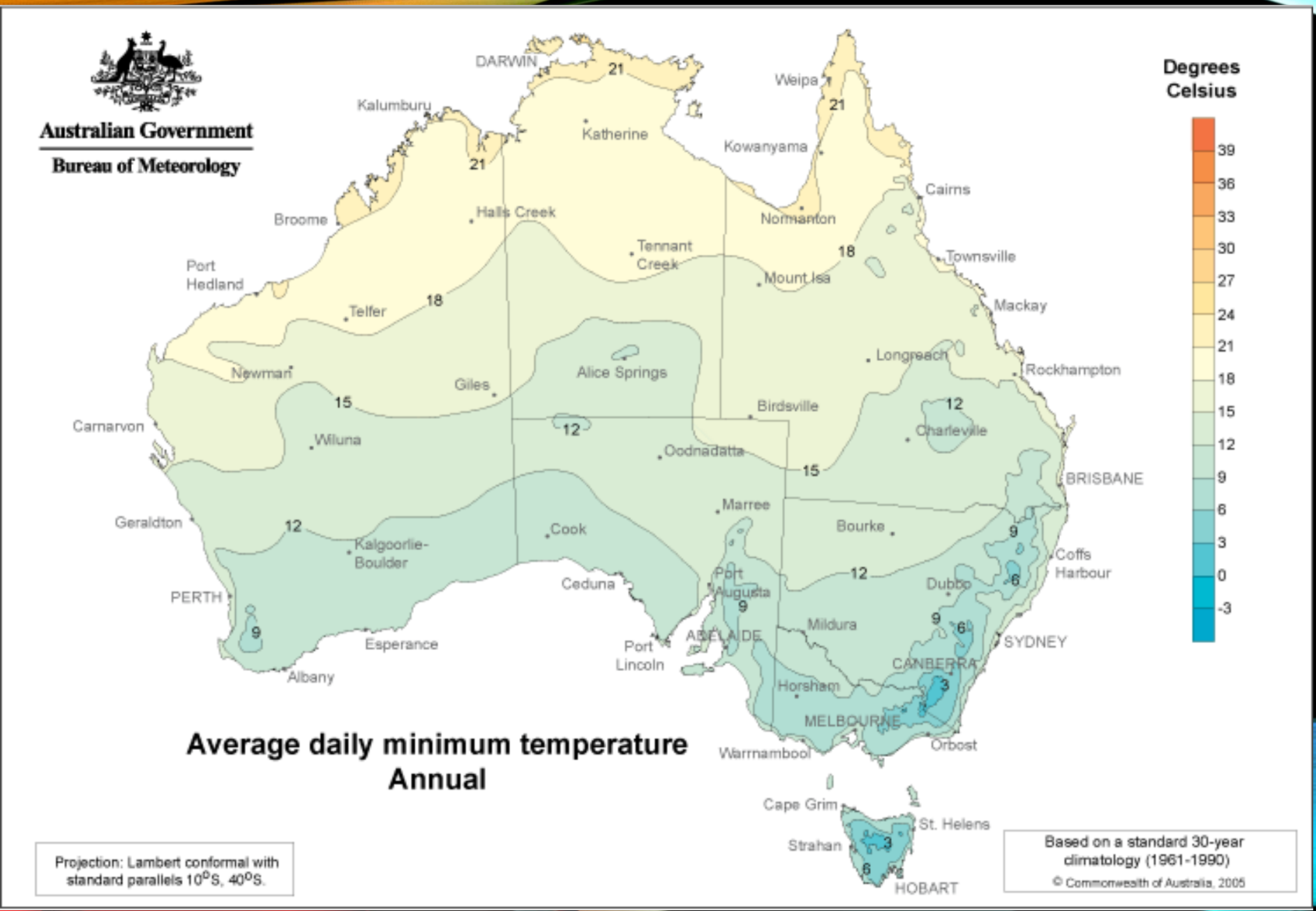
Average daily maximum temperature
Annual
Projection: Lambert conformal with standard parallels 10°S, 40°S.
Based on a standard 30-year climatology (1961-1990)
© Commonwealth of Australia, 2005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HOBART
Average daily minimum temperature
Annual
Projection: Lambert conformal with standard parallels 10°S, 40°S.
Based on a standard 30-year climatology (1961-1990)
© Commonwealth of Australia, 2005

Apparent ('feels like') Temperature/Heat Index

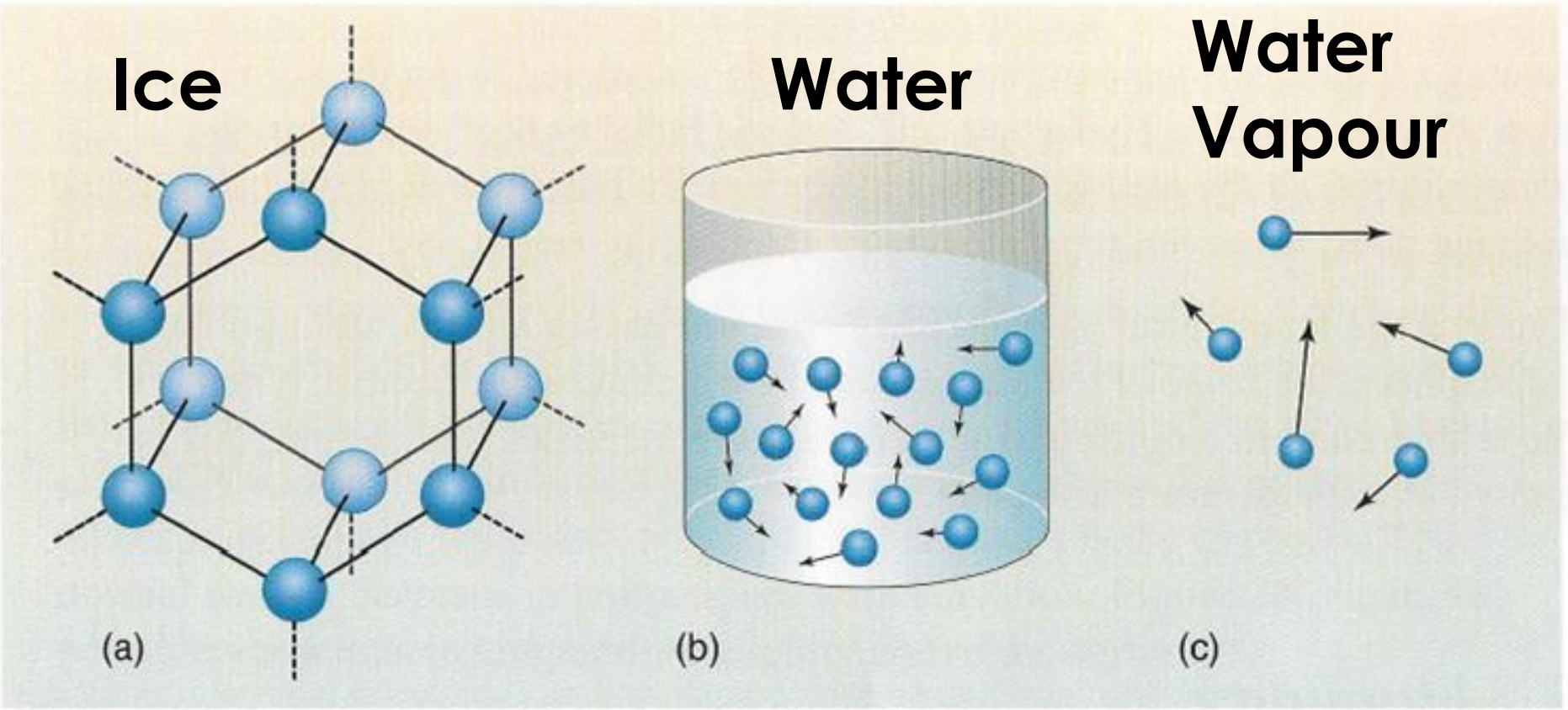
An adjustment to the ambient temperature based on the current humidity and wind speed, designed to be a measure of the discomfort caused to an appropriately dressed adult, walking outdoors, in the shade by the current wind and humidity levels.

For calm wind conditions, if the current humidity is higher than the reference humidity then the Apparent Temperature will be higher than the current Temperature; if the current humidity is lower than the reference humidity, then the Apparent Temperature will be lower than the current Temperature.

In cold, windy conditions, the Apparent Temperature can also be used as a measure of Wind Chill.

The Apparent Temperature used by the Bureau is the Steadman Apparent Temperature.

For more information see http://www.bom.gov.au/info/thermal_stress/



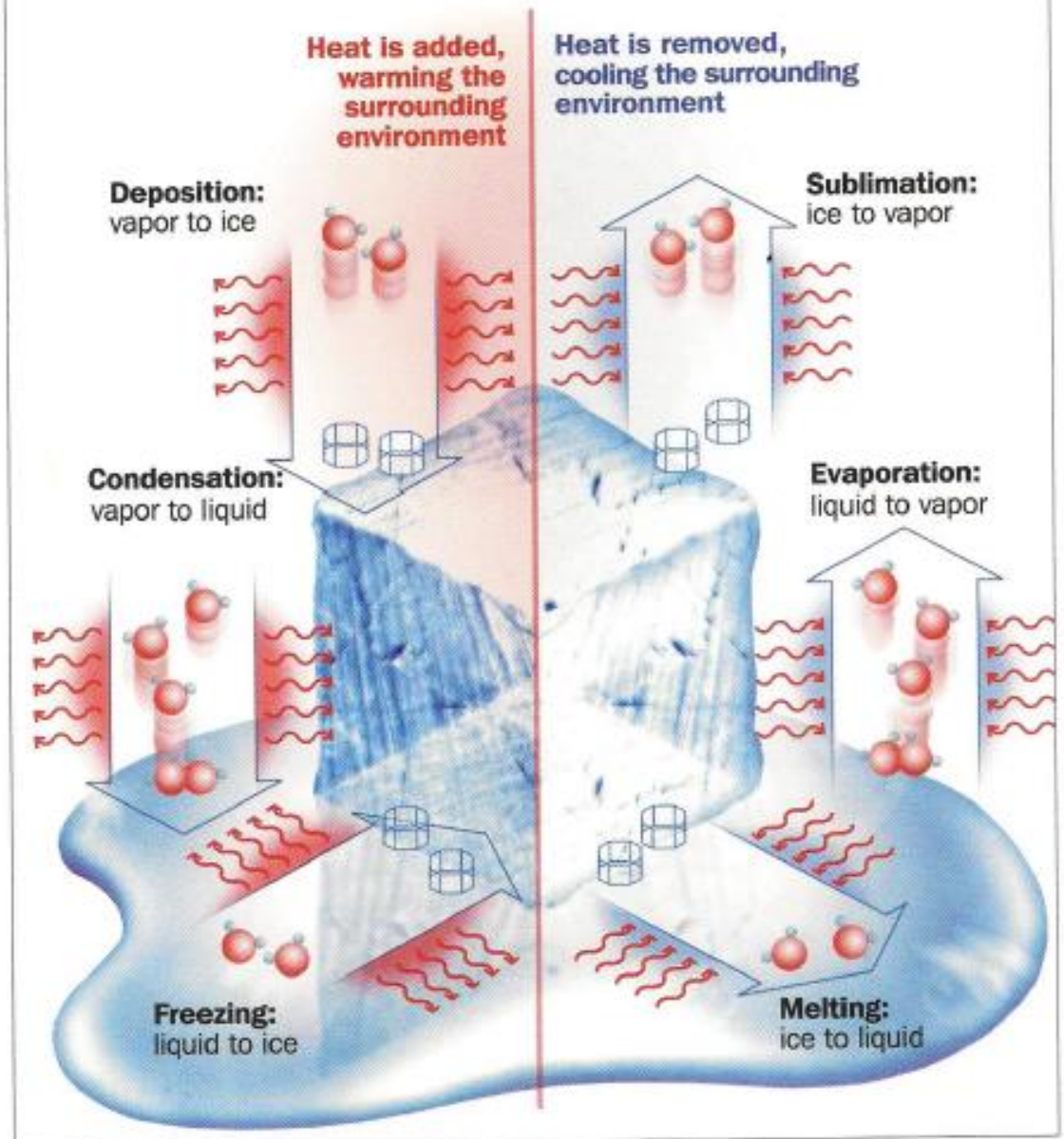
Molecules tightly held in a "crystalline" structure

Molecules free to move but there is still strong attraction among molecules

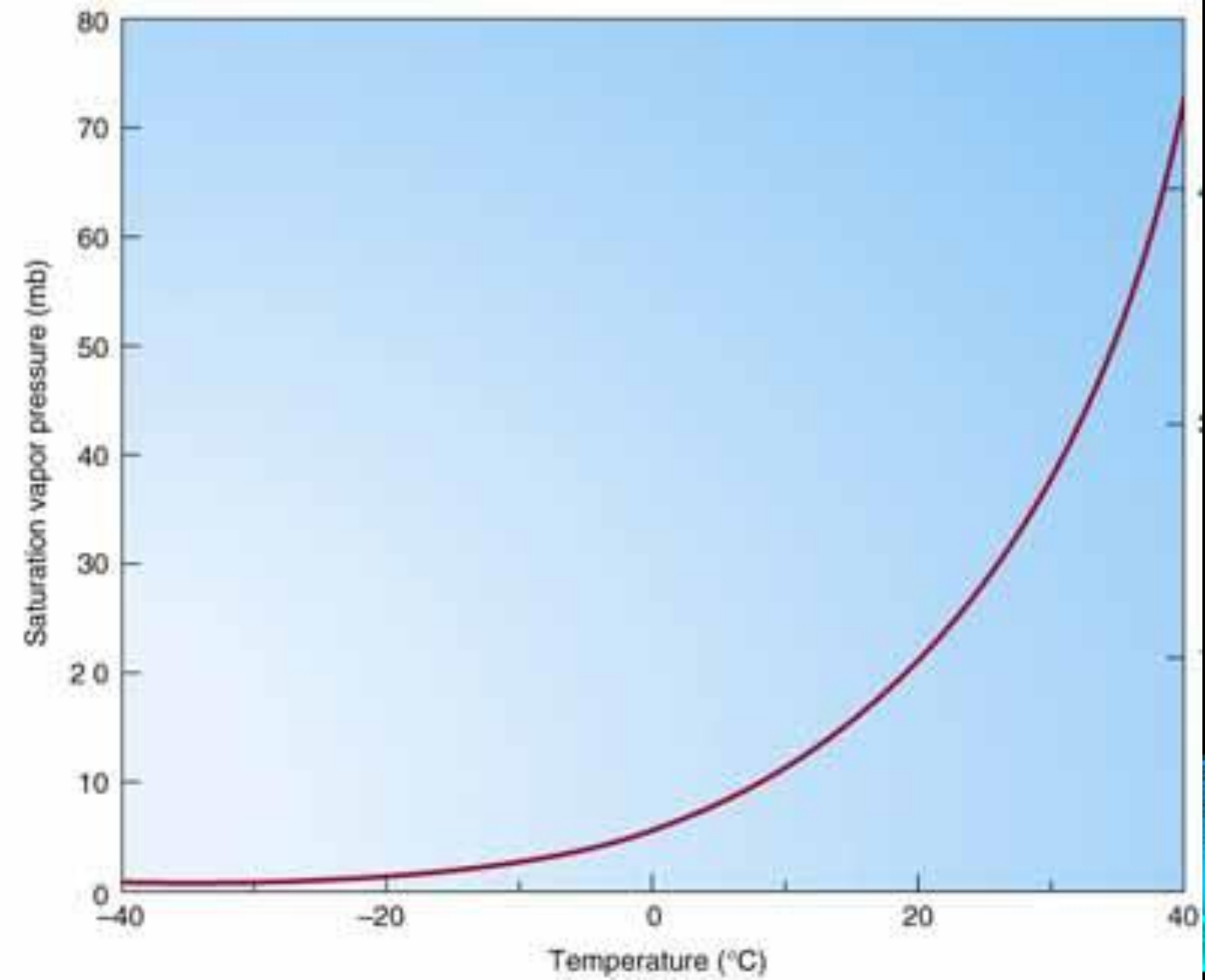
Molecules are further apart and the bonds to other molecules are weak, especially for the faster moving molecules

Water's phase changes

A block of ice sitting in a puddle surrounded by air with water vapor in it helps you see which of water's phase changes add heat to the surroundings, and which cool the surroundings.



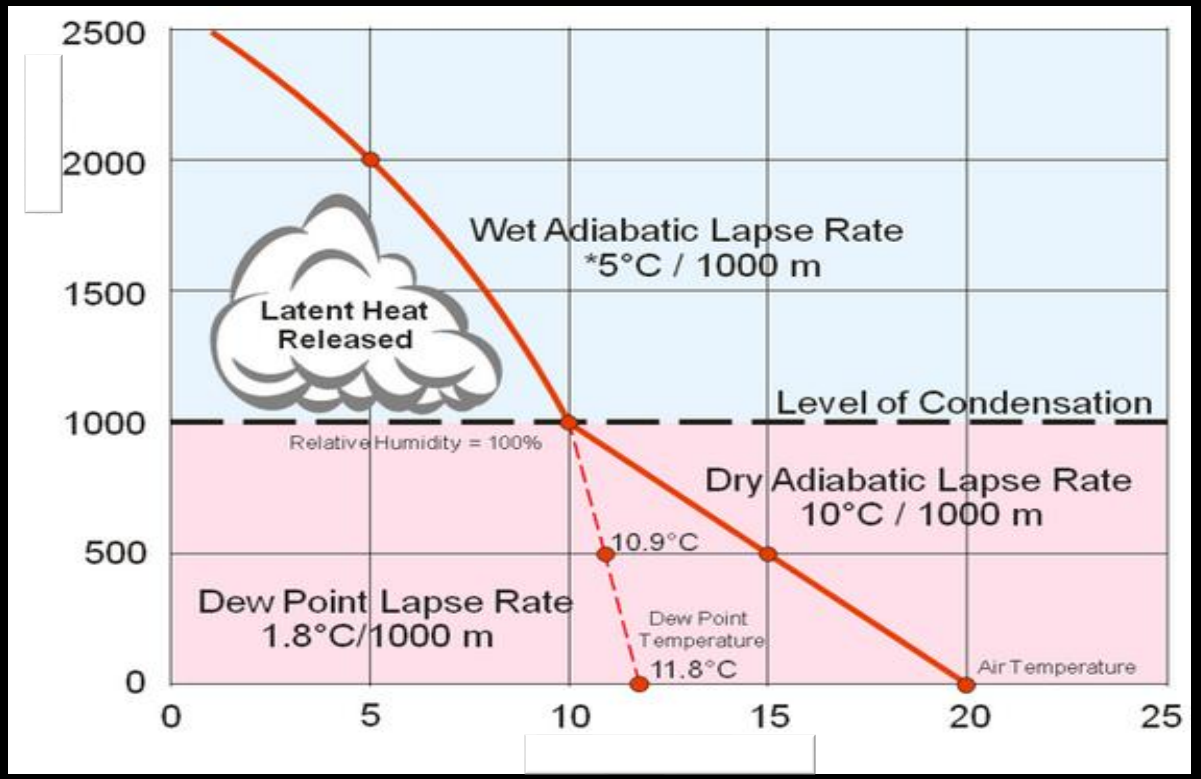
Some interesting facts about the role of water



Phase changes in water

Water vapour is a powerful fuel for the atmosphere

It can make a big difference once condensation starts, particularly in thunderstorms and tropical cyclones.



Moisture in the atmosphere

Several quantities are used to report the amount of water vapour in the air:

(a) Wet bulb depression:

- wet muslin over the bulb of the thermometer
- air flow leads to a lower temperature called the wet bulb depression
- **from the wet bulb depression other measures of water vapour content can be calculated**

(b) Dew point

- the temperature to which air would need for it to become saturated, and dew to start forming

Moisture in the atmosphere

(c) Mixing ratio

- the ratio of the mass of water vapour in the air to the mass of dry air expressed as gm/gm or gm/kg

  (specific humidity – ratio of water vapour to moist air)

(d) Relative humidity

- the ratio (expressed as a percentage) of the water vapour in the air to the amount of water vapour necessary for the air to be saturated

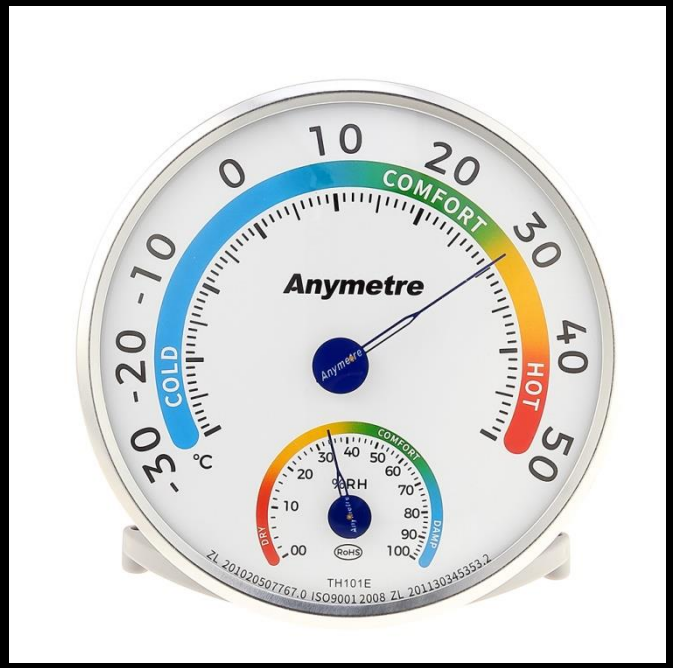
(e) Absolute humidity

- water vapour in a given volume of air ($gm/m^{3)}$

Note: As the molecular weight of water is less than the other major constituents of air (oxygen and nitrogen) moist air is actually less dense than dry air.

Humidity measurement - hygrometers

Humidity measurement - hygrometers



Measurement of wind speed and direction

- Surface wind speeds and directions are measured by an anemometer (propeller, cup, ultrasonic, pressure tube).
- a continuous record of wind speed and direction is recorded on an anemograph

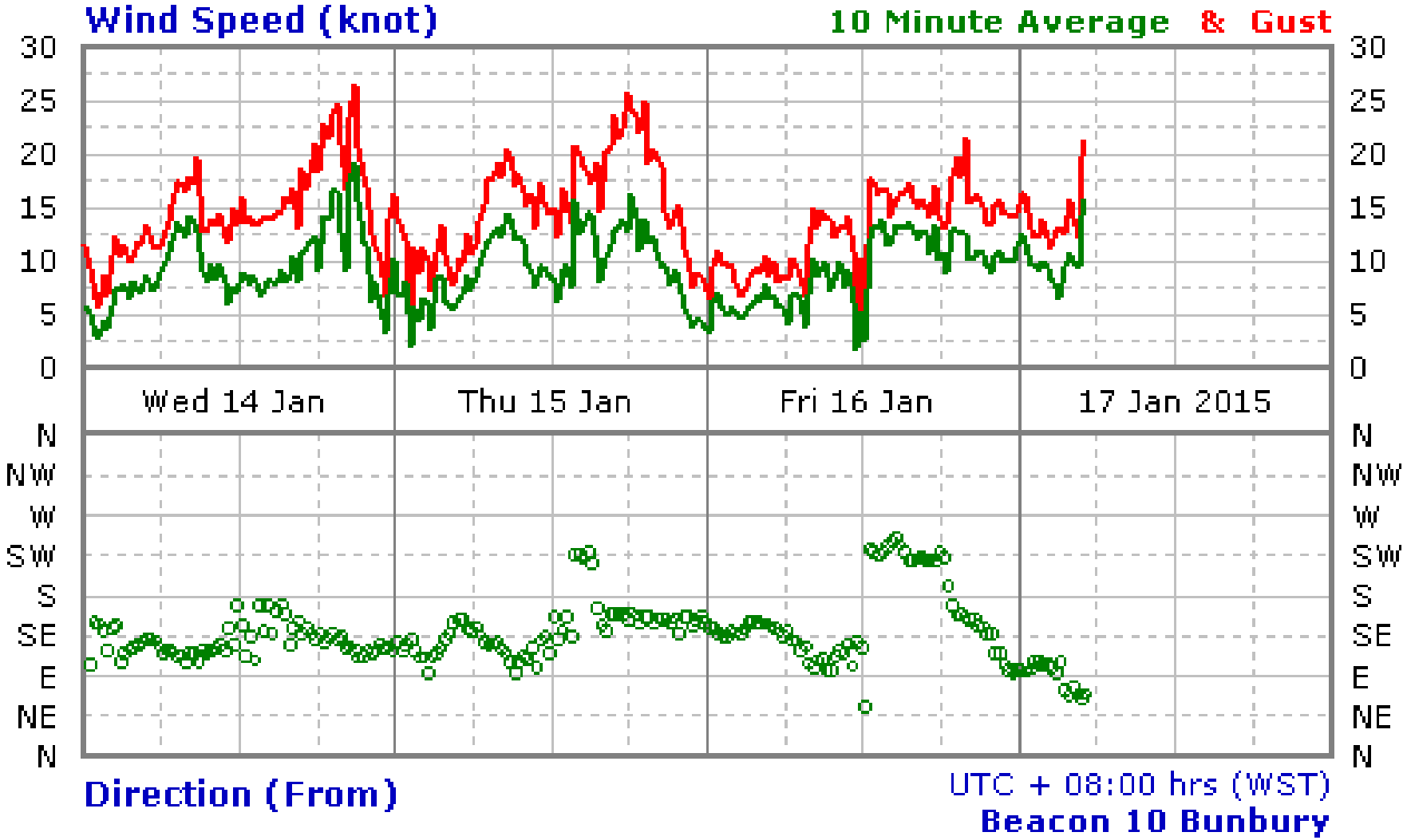
Propeller anemometer

Cup anemometer

Ultrasonic

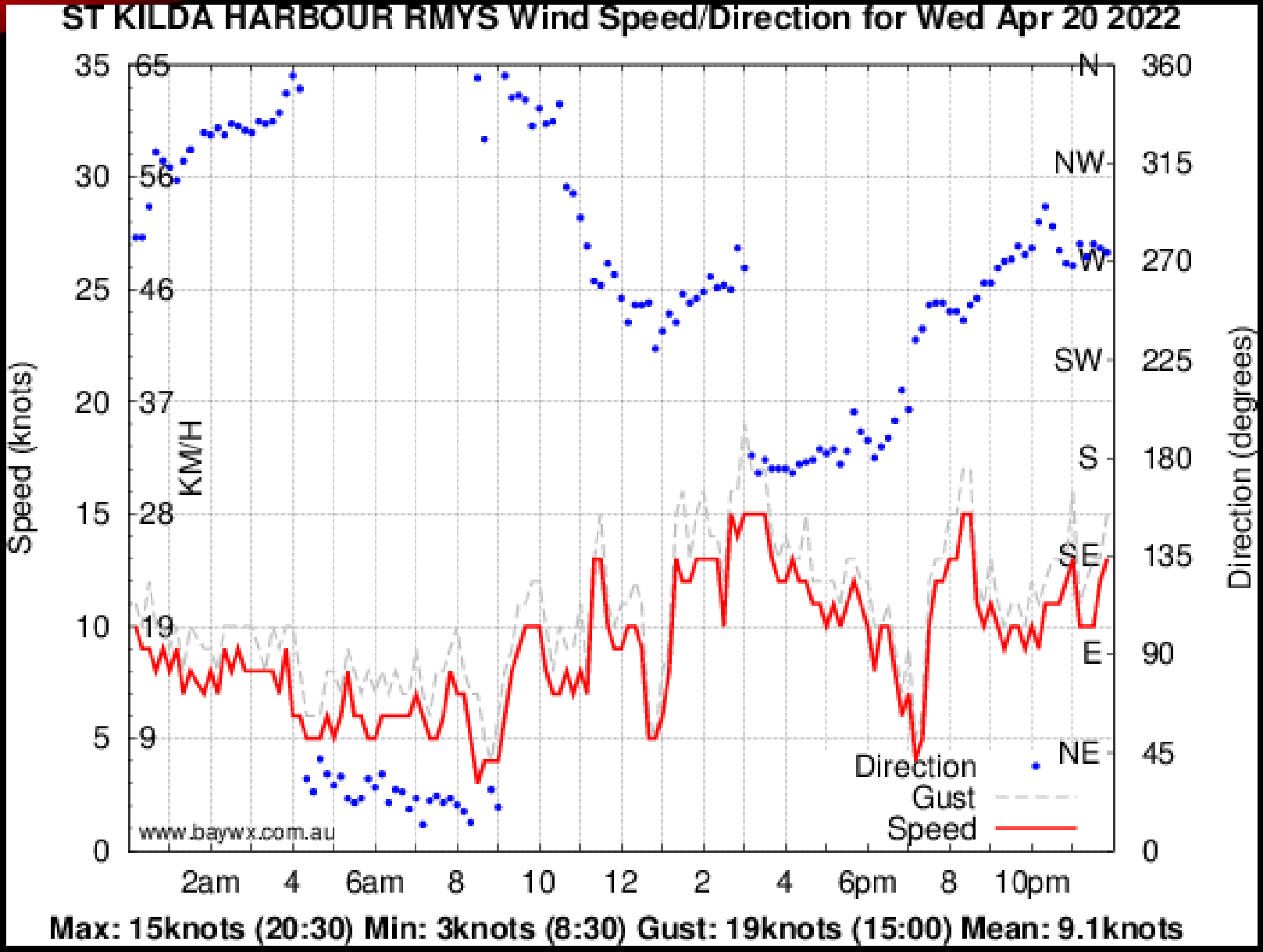
Cup and pressure tube (Dines) anemometer

Measurement of wind speed and direction



Anemograph trace

Wind speed and direction



Measurement of wind speed and direction

Wind Direction	Direction from which the wind is coming, relative to true North	16 compass points
(Average) Wind speed	Wind observations averaged over 10 minutes	Knots (marine) Kilometres per hour (km/h) for land purposes
Wind Gust	Wind observations averaged for 3 seconds	Knots (marine) Kilometres per hour (km/h) for land purposes

For marine users wind is usually expressed in knots

(1 knot = 1.85 kilometer/hour)

http://www.bom.gov.au/cyclone/history/tracy.shtml

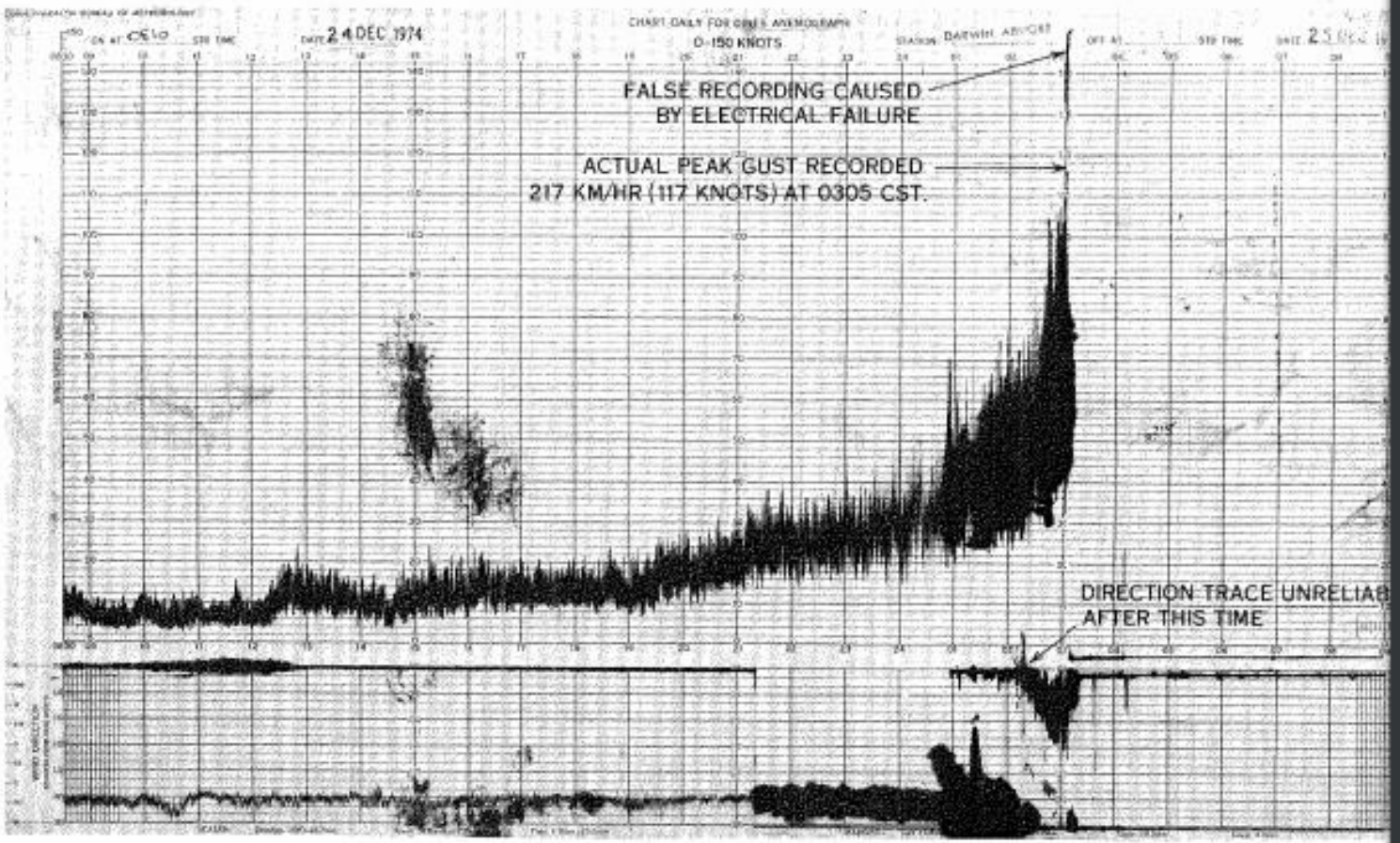


Fig 25 Dines anemograph trace at Darwin Airport, 24–25 December 1974.

Wind trace from the Darwin Airport 24-25 December 1974. Winds rapidly increased after 2:30am as the powerful eyewall came shore. A peak gust of 217 km/h was recorded just before the anemometer failed at 3:10am. The failure likely coincided with the commencement of the storm's highest winds, which likely intensified before the calm of the eye reached the area 40 minutes later.

Beaufort Scale

Beaufort Force	Wind Speed (kts)	Description	Sea Condition
0	0	Calm	Sea is like a mirror
1	1 – 3	Light air	Ripples but without foam crests
2	4 – 6	Light breeze	Small wavelets. Crests do not break
3	7 – 10	Gentle breeze	Large wavelets, perhaps scattered white-caps
4	11 – 16	Moderate breeze	Small waves. Frequent white-caps
5	17 – 21	Fresh breeze	Moderate waves. Many white-caps
6	22 – 27	Strong breeze	Large waves begin to form. White foam crests, perhaps some spray
7	28 – 33	Near gale	Sea heaps up. White foams blown in streaks along wind
8	34 – 40	Gale	Moderately high waves. Crests begin to break into spindrift
9	41 – 47	Strong gale	High waves. Dense foam along the direction of the wind. Crests of waves begin to roll over. Spray may affect visibility
10	48 – 55	Storm	Very high waves with long overhanging crests. The surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock like. Visibility affected
11	56 – 63	Violent storm	Exceptionally high waves. The sea is completely covered with long white patches of foam lying in the direction of the wind. Visibility affected
12	64+	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray. Visibility very seriously affected.

Defined by Admiral Sir Francis Beaufort (1774-1857)

Force 0: Wind Speed less than 1 knot
Sea: Sea like a mirror

Force 1: Wind Speed 1-3 knots
Sea: Wave height .1m (.25ft); Ripples with appearance of scales, no foam crests

Force 2: Wind Speed 4-6 knots
Sea: Wave height .2-.3m (.5-1 ft); Small wavelets, crests of glassy appearance, not breaking

Force 3: Wind Speed 7-10 knots
Sea: Wave height .6-1m (2-3 ft); Large-wavelets, crests begin to break, scattered whitecaps

Force 4: Wind Speed 11-16 knots
Sea: Wave height 1-1.5m (3.5-5 ft); Small waves becoming longer, numerous whitecaps

Force 5: Wind Speed 17-21 knots
Sea: Wave height 2-2.5m (6-8 ft); Moderate waves, taking longer form, many whitecaps, some spray

Force 6: Wind Speed 22-27 knots
Sea: Wave height 3-4m (9.5-13 ft); Larger waves forming, whitecaps everywhere, more spray

Force 7: Wind Speed 28-33 knots
Sea: Wave height 4-5.5m (13.5-19 ft); S heaps up, white foam from break-ing waves begins to be blown in streaks along direction of wind

Force 8: Wind Speed 34-40 knots
Sea: Wave height 5.5-7.5m (18-25 ft):

Force 9: Wind Speed 41-47 knots
Sea: Wave height 7-10m (23-32 ft); High

Force 10: Wind Speed 48-55 knots (storm)
Sea: Wave height 9-12.5m (29-41 ft); Very

Force 11: Wind Speed 56-63 knots
Sea: Wave height 11.5-16m (37-52 ft);

BEAUFORT FORCE 12
WIND SPEED: 64 KNOTS

SEA: SEA COMPLETELY WHITE WITH DRIVING SPRAY, VISIBILITY VERY SERIOUSLY AFFECTED. THE AIR IS FILLED WITH FOAM AND SPRAY

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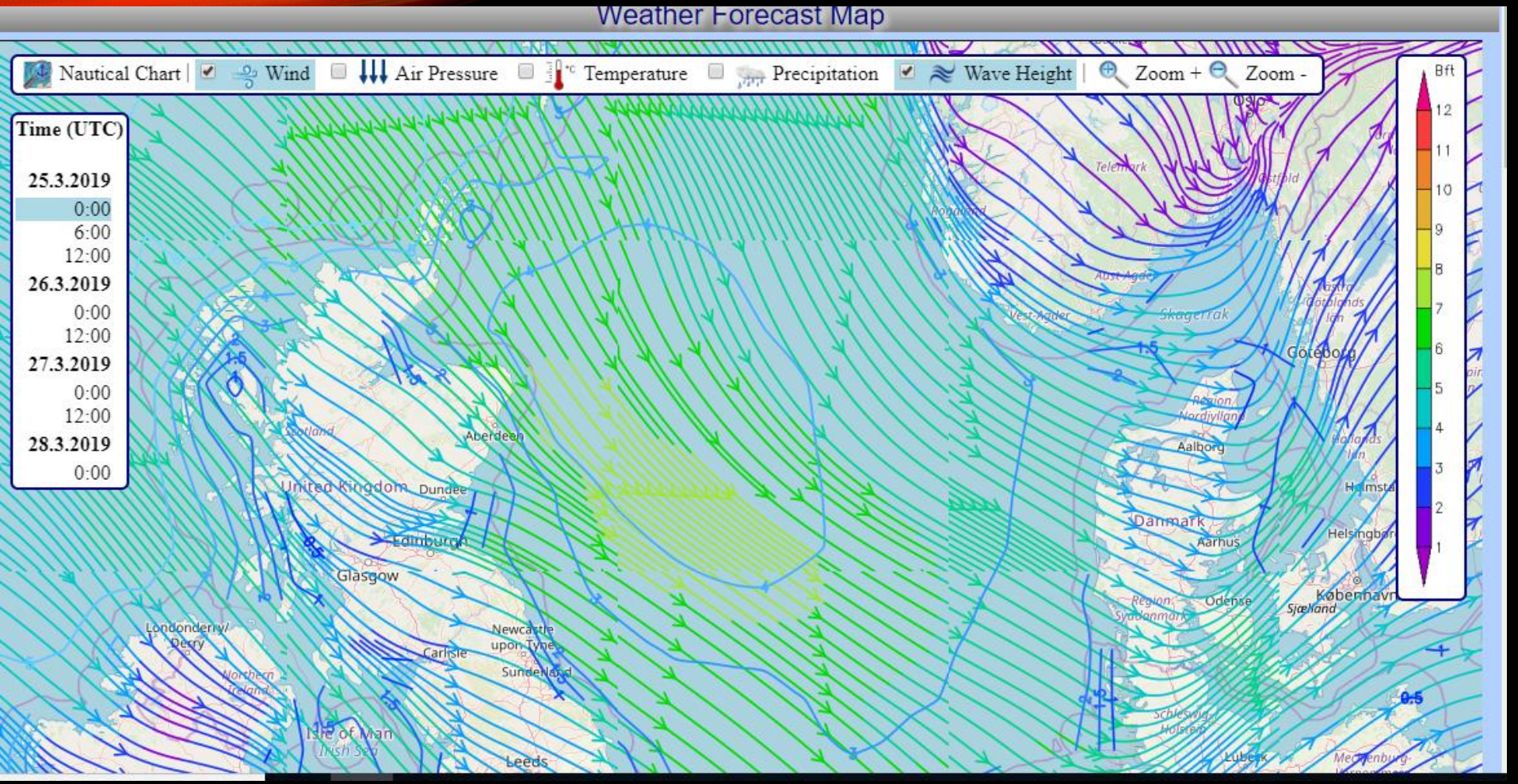

http://www.shiptraffic.net/2016/04/Weather-Forecast-Map.html

A change in the wind

What a gale meant to Handel, Cook and Beaufort

Terry Hart
Email: terryhart27@hotmail.com

In Handel's opera *Semele* first performed in 1744, Jupiter, king of the gods, sings to reassure his mortal lover Princess Semele:

> Where'ere you walk cool gales shall fan the glade
>
> Trees where you sit shall crowd into a shade.

It is an exquisitely beautiful song to words from the poem *Summer* by Alexander Pope. From the context and the setting, it is clear that the words do not mean that the heroine is likely to have trouble standing in the wind or fear branches from the glade crashing down on her.

Rear-Admiral Sir Francis Beaufort in 1855.

Bulletin of the Australian Meteorological and Oceanographic Society
Quarter 3 2020

https://drive.google.com/drive/folders/0B_V-fcpNMrJjOTlPSi11dVdzMlk