Understanding weather and the weather forecast

Week 18

More on Weather Radar

Ocean - Waves and Swell

Terry Hart

Geophysical Research Letters

RESEARCH LETTER
10.1029/2022GL099381

The Hunga Tonga-Hunga Ha'apai Hydration of the Stratosphere

L. Millán[1], M. L. Santee[1], A. Lambert[1], N. J. Livesey[1], F. Werner[1], M. J. Schwartz[1], H. C. Pumphrey[2], G. L. Manney[3,4], Y. Wang[1,5], H. Su[1], L. Wu[1], W. G. Read[1], and L. Froidevaux[1]

Key Points:

- Following the Hunga Tonga-Hunga Ha'apai eruption, the Aura Microwave Limb Sounder measured

Plain Language Summary The violent Hunga Tonga-Hunga Ha'apai eruption on 15 January 2022 not only injected ash into the stratosphere but also large amounts of water vapor, breaking all records for direct injection of water vapor, by a volcano or otherwise, in the satellite era. This is not surprising since the Hunga Tonga-Hunga Ha'apai caldera was formerly situated 150 m below sea level. The massive blast injected water vapor up to altitudes as high as 53 km. Using measurements from the Microwave Limb Sounder on NASA's Aura satellite, we estimate that the excess water vapor is equivalent to around 10% of the amount of water vapor typically residing in the stratosphere. Unlike previous strong eruptions, this event may not cool the surface, but rather it could potentially warm the surface due to the excess water vapor.

"In comparison with those from previous eruptions, the SO2 and HCl mass injections were unexceptional, although they reached higher altitudes. In contrast, the H2O injection was unprecedented in both magnitude and altitude (penetrating into the mesosphere)."

"It may take several years for the H2O plume to dissipate. This eruption could impact climate not through surface cooling due to sulfate aerosols, but rather through surface warming due to the radiative forcing from the excess stratospheric H2O."

Antarctica bathed in dazzling colours in afterglow of Tonga eruption

The Antarctic sky in the 'afterglow' of the Tongan volcano's January eruption. The colours – seen here from Antarctica's Hut Point, looking north towards McMurdo station – are believed to be caused by a spike in aerosols hurled into the stratosphere. Photograph: Stuart Shaw/Fly on the Wall Images

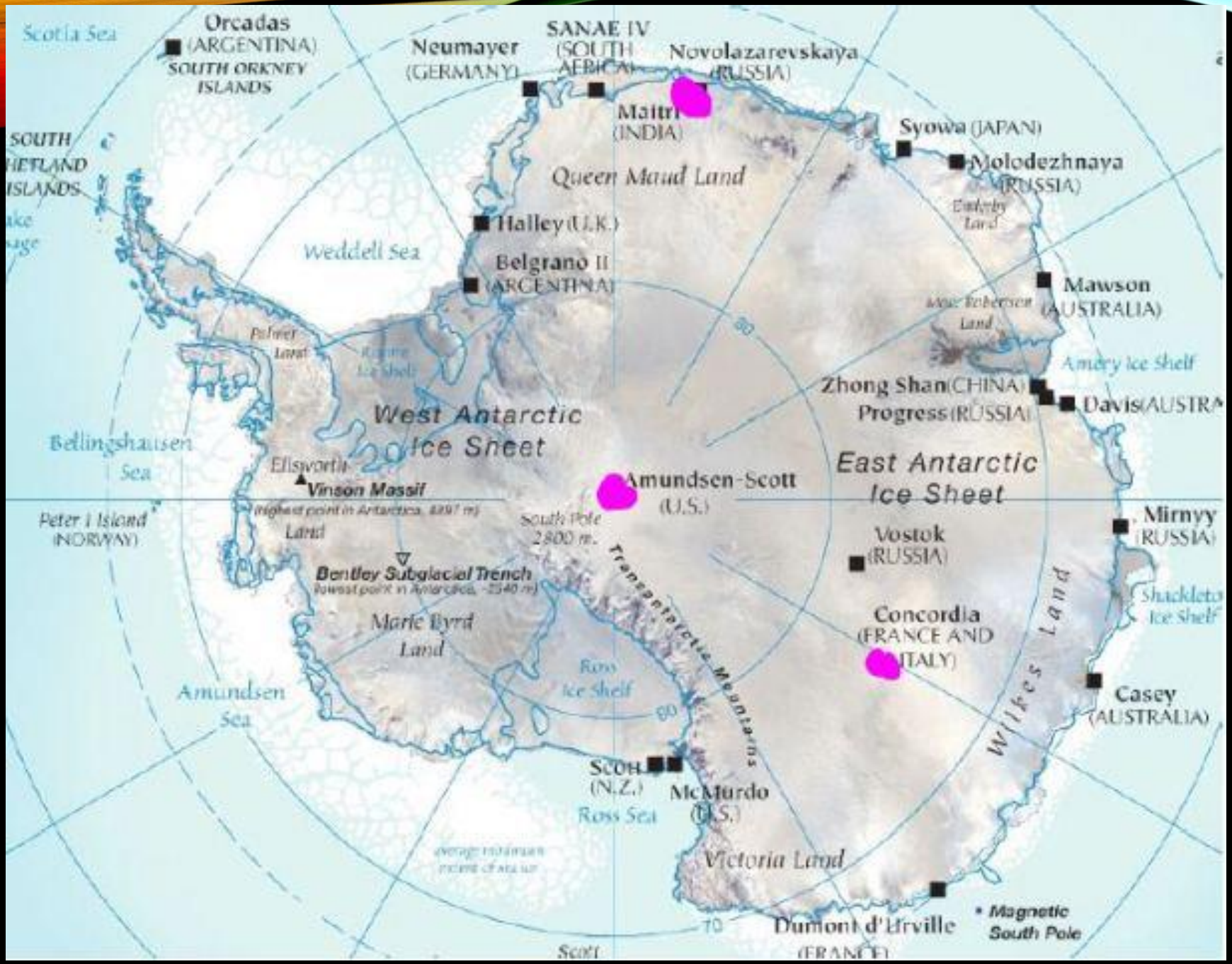
https://www.theguardian.com/world/2022/jul/15/antarctica-bathed-in-dazzling-colours-in-afterglow-of-tonga-eruption

“Usually in mid-winter, Antarctica is nearly continuously dark, except for a slight ‘nautical twilight’ at around midday, which means the horizon is faintly visible in good conditions,” said Stuart Shaw, a science technician with Antarctica New Zealand, who is stationed at **Scott Base** for the winter and who captured stunning images of the blazing skies.

“But this year, we were presented with quite a show, which had most of the station personnel grabbing jackets and running outside with their cameras to look at the awesome colours.

“Believe it or not, I haven’t edited these colours either, they are pretty much as we saw them,” Shaw said. “It’s incredible.”

Data from satellite lidar – a laser radar – shows there is an abundance of aerosols in the stratosphere above Antarctica, which were not there prior to the eruption, said Nava Fedaeff, a forecaster at Niwa.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(SOUTH AFRICA)
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(RUSSIA)
Maitri
(INDIA)
Syowa (JAPAN)
Molodezhnaya
(RUSSIA)
Queen Maud Land
Halley (U.K.)
Weddell Sea
Belgrano II
(ARGENTINA)
Mawson
(AUSTRALIA)
Amery Ice Shelf
Zhong Shan (CHINA)
Progress (RUSSIA)
Davis (AUSTRA
West Antarctic Ice Sheet
East Antarctic Ice Sheet
Bellingshausen Sea
Ellsworth
Vinson Massif
Amundsen-Scott
(U.S.)
South Pole
2800 m.
Peter I Island
(NORWAY)
Bentley Subglacial Trench
Vostok
(RUSSIA)
Mirnyy
(RUSSIA)
Marie Byrd Land
Transantarctic Mountains
Concordia
(FRANCE AND ITALY)
Wilkes Land
Shackleton Ice Shelf
Ross Ice Shelf
Amundsen Sea
Casey
(AUSTRALIA)
Scott Base
(N.Z.)
McMurdo
(U.S.)
Ross Sea
Victoria Land
Dumont d'Urville
(FRANCE)
* Magnetic South Pole

‘Vince’s Cross’, viewed from Hut Point looking north. Photograph: Stuart Shaw/Fly on the Wall Images

Europe battles wildfires in intense heat

Story by Reuters

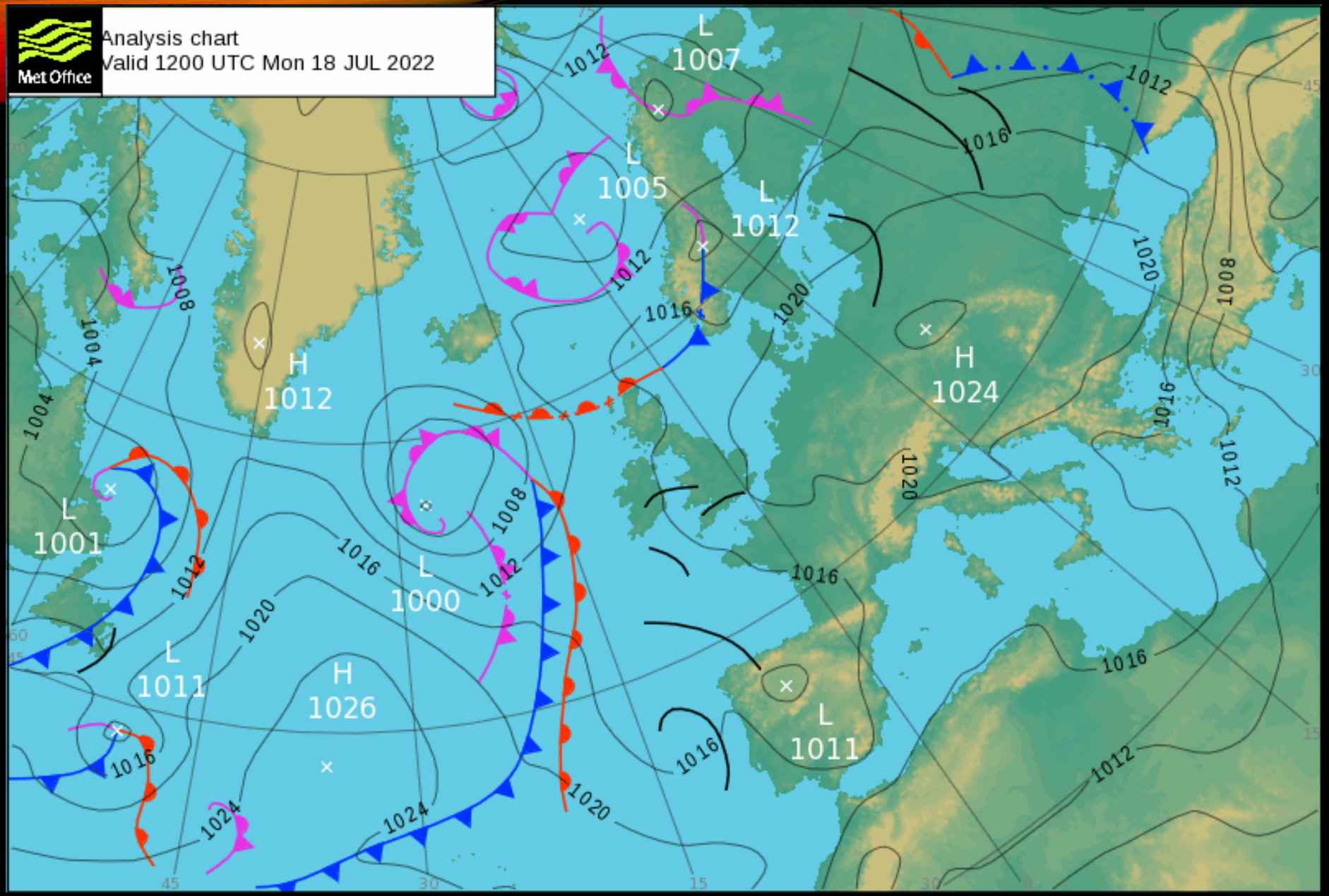
Updated 1145 GMT (1945 HKT) July 18, 2022

Graphic shows all the changes in global temperature since 1850 03:28

(Reuters) — Authorities across southern Europe battled on Sunday to control huge wildfires in countries including Spain, Greece and France, with hundreds of deaths blamed on soaring temperatures that scientists say are consistent with climate change.

In Spain, helicopters dropped water on the flames as heat above 40 degrees Celsius (104 degrees Fahrenheit) and often mountainous terrain made the job harder for firefighters.

Shocked residents watching thick plumes of smoke rising above the central western Jerte valley said the heat was making their previously green and cool home more like Spain's semi-arid south.


Met Office
Analysis chart
Valid 1200 UTC Mon 18 JUL 2022
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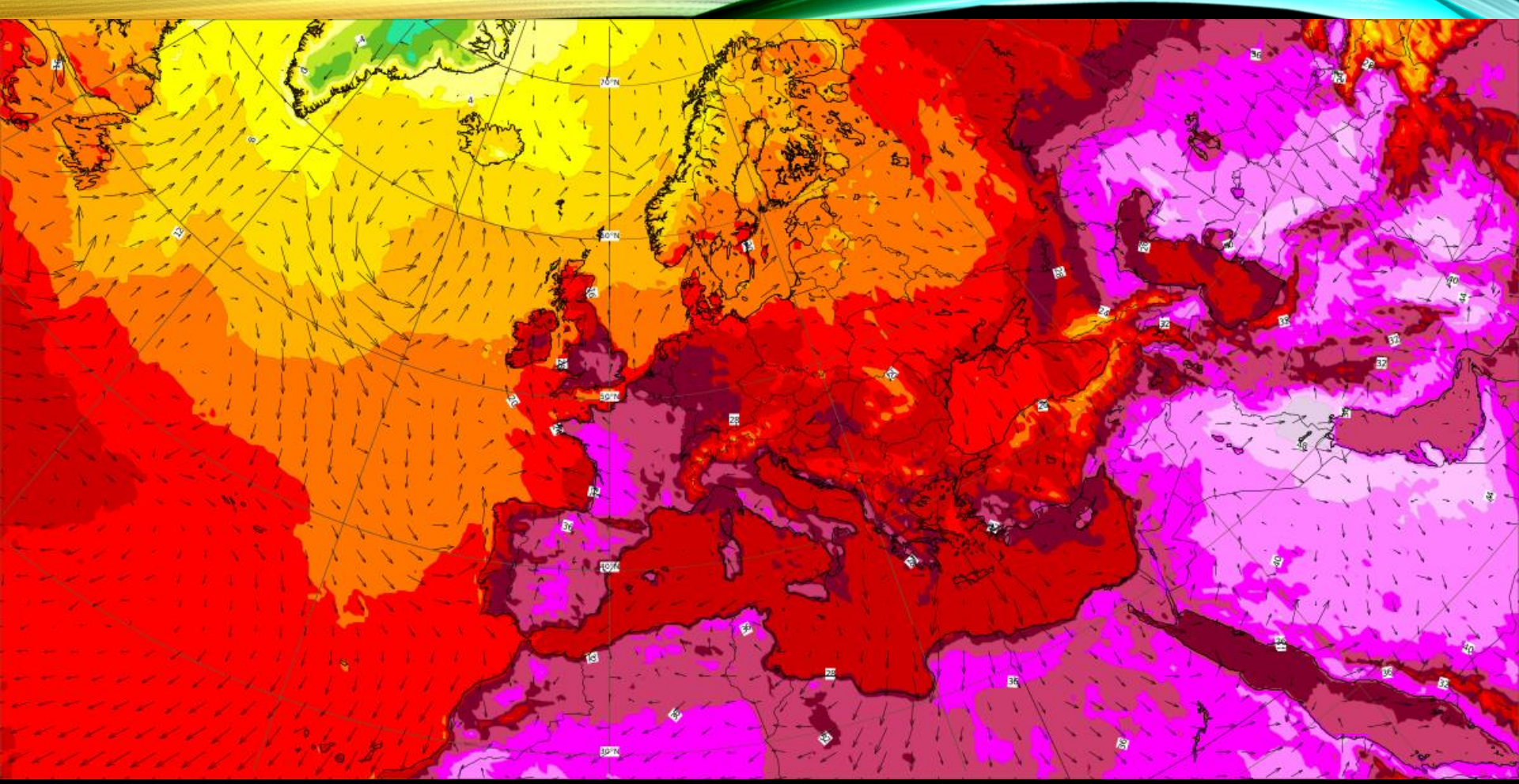
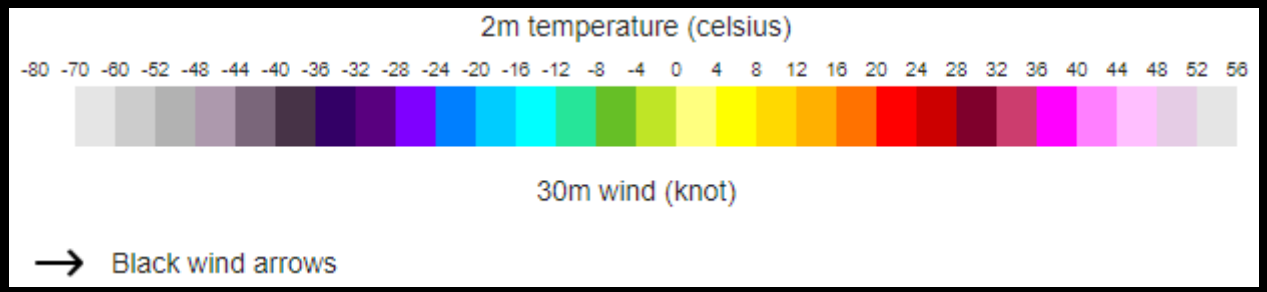
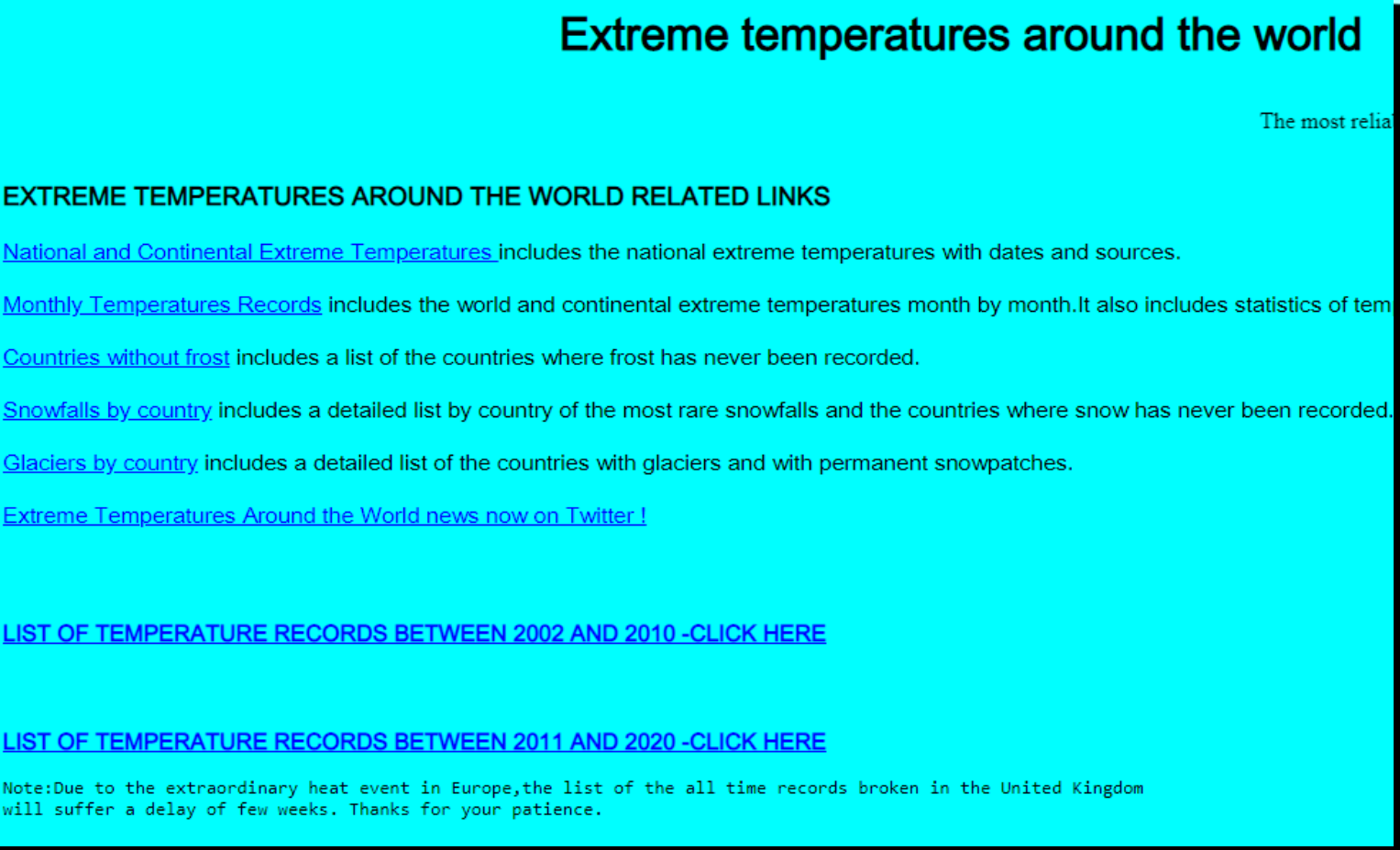


ECMWF Mon 18 Jul 2022 12 UTC (T+0) 2 metre temperature and 10 metre wind.



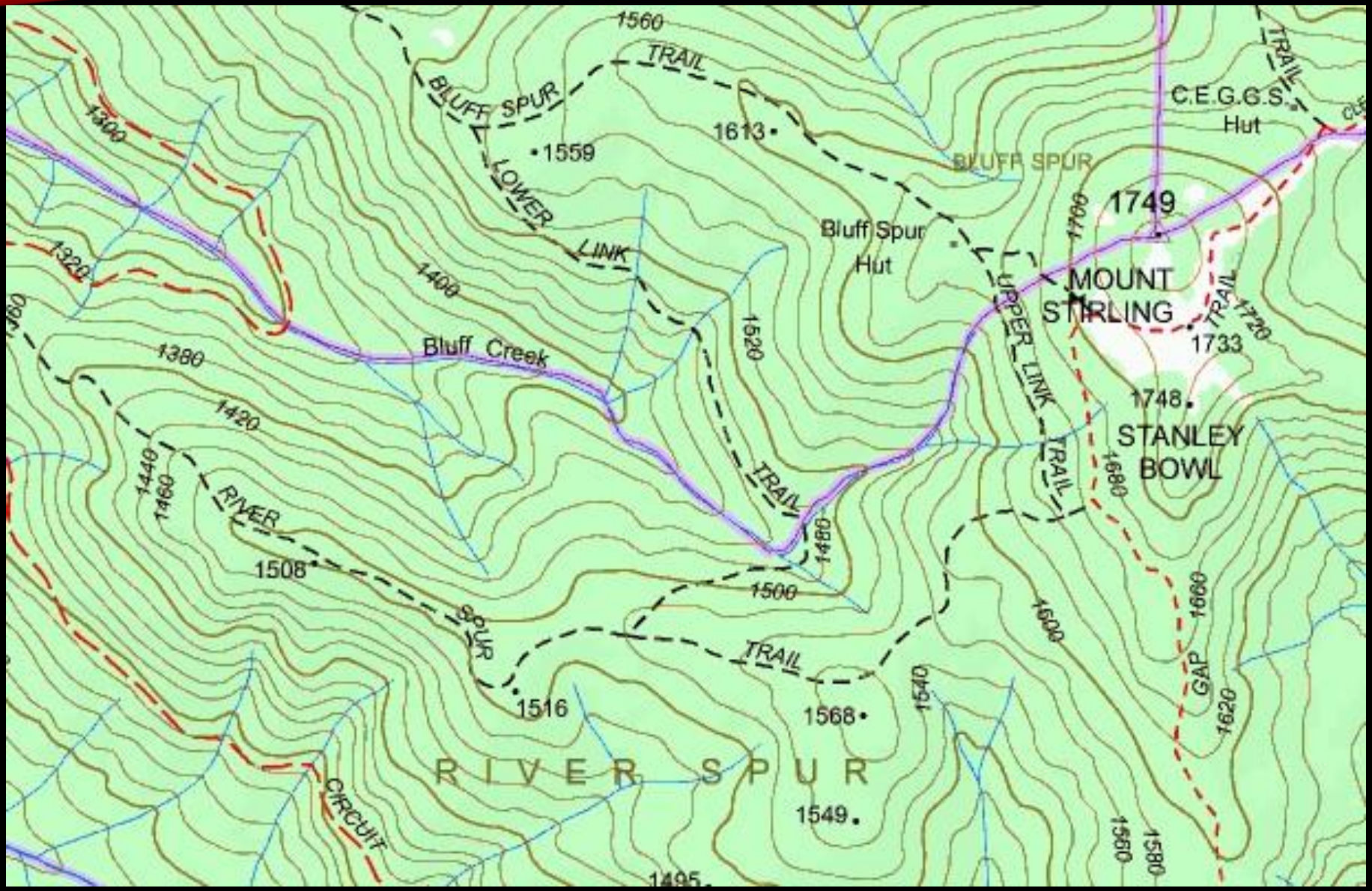


https://www.mherrera.org/temp.htm

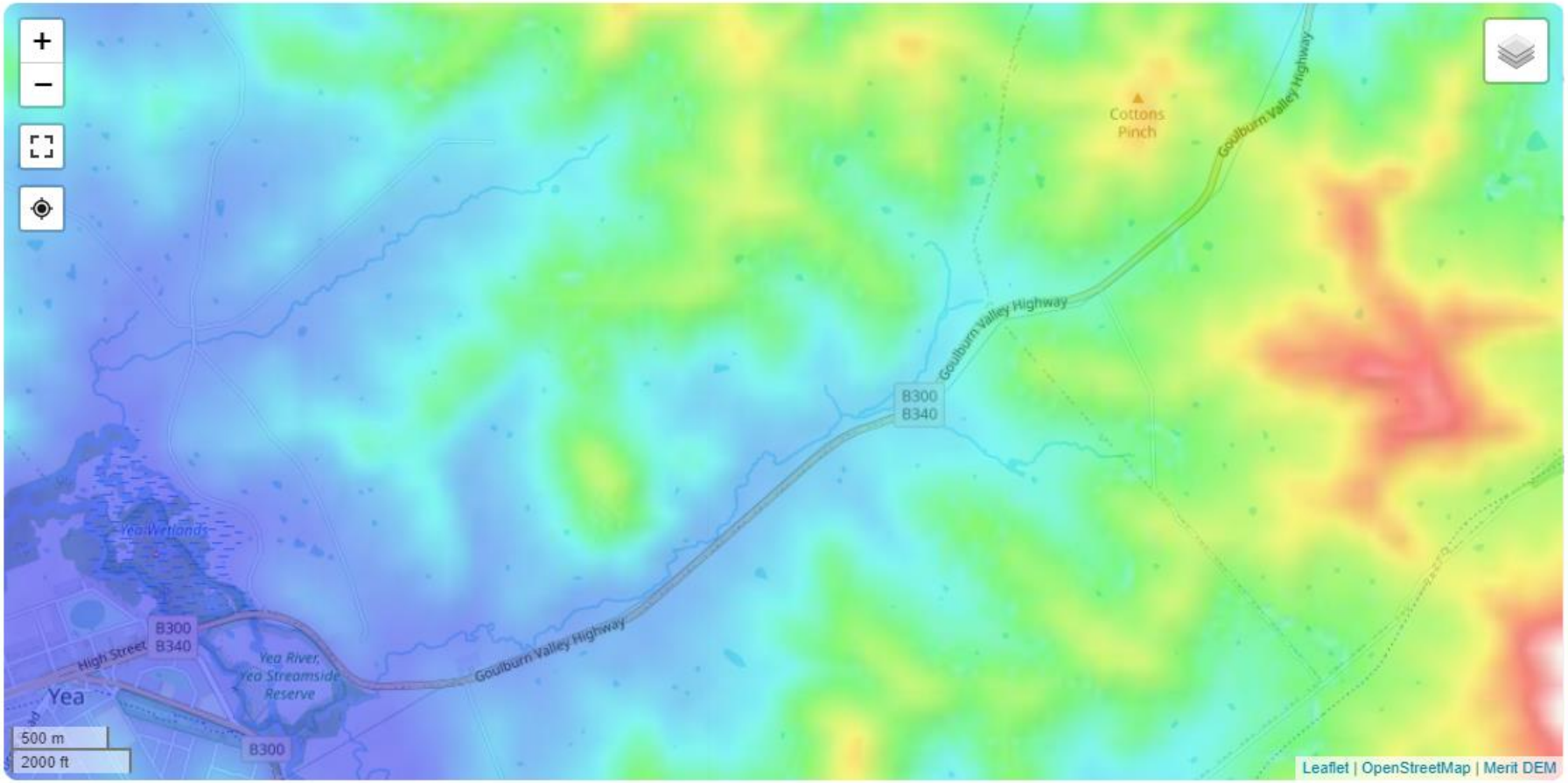
"So far in 2022 (NOT including the recent heatwave in the UK) 287 stations around the world have broken their all-time highest temperature record; two stations have broken their all-time lowest temperature record."

Courtesy of Neville Nicholls (formerly Bureau of Met., now at Monash Uni.)

Topographic map with elevation contours (metres)



Topographic map with elevation coloured

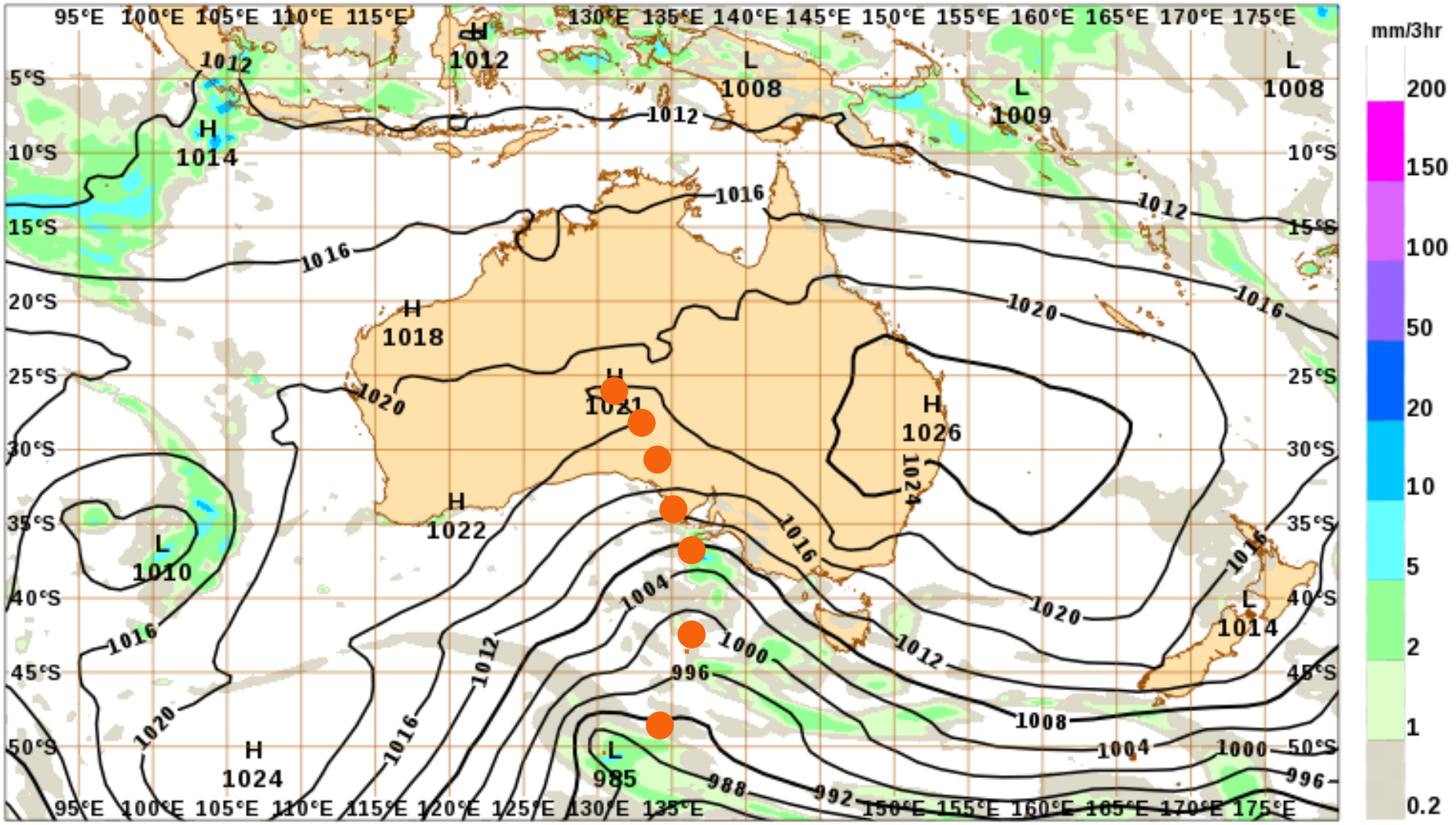


Yea, Shire of Murrindindi, Victoria, 3717, Australia (-37.21305 145.42247)

https://en-au.topographic-map.com/maps/ja85/Yea/

MSLP / Precip (03 hourly)
Valid 03UTC Sat 16 Jul 2022

ACCESS-G3
t+009



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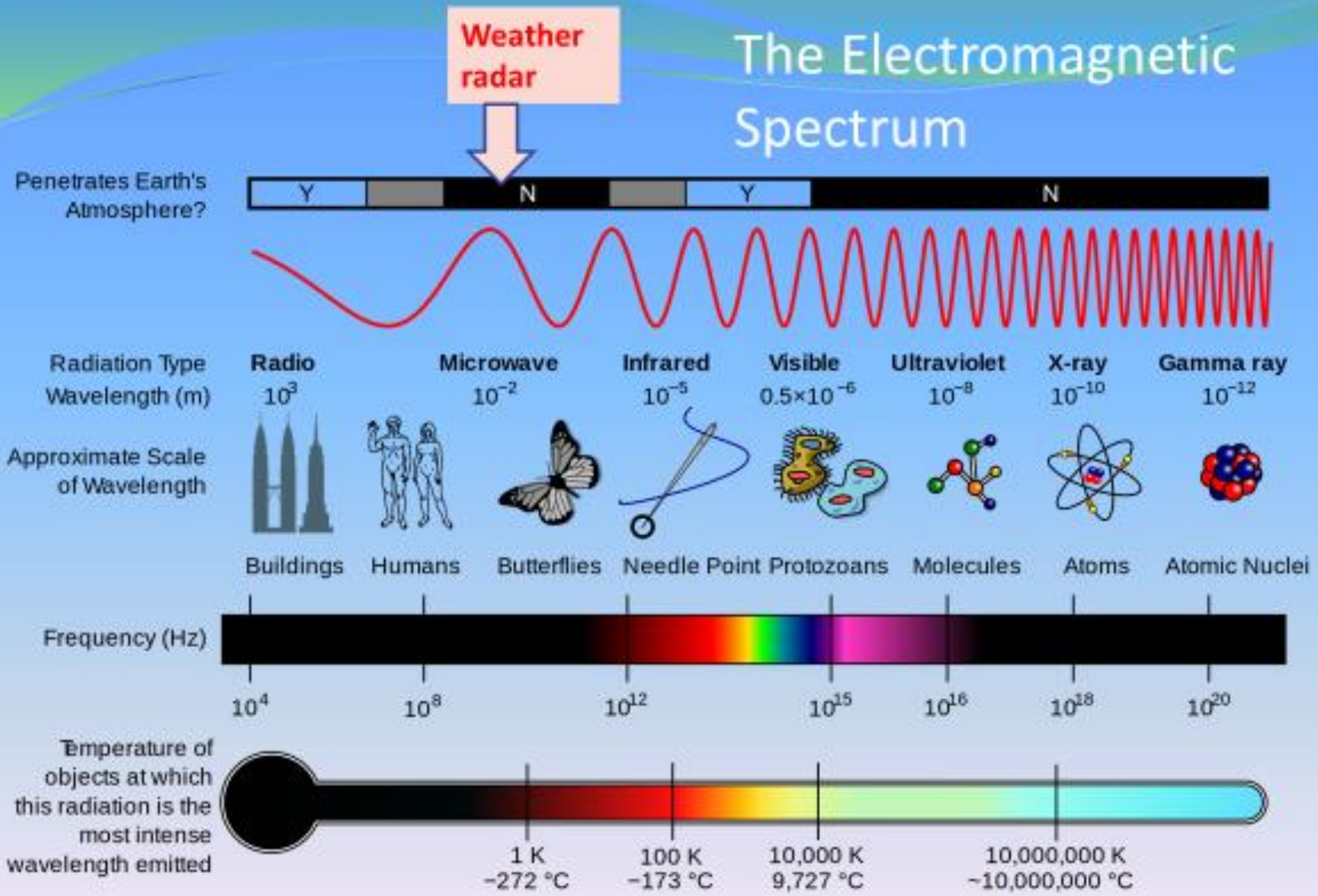
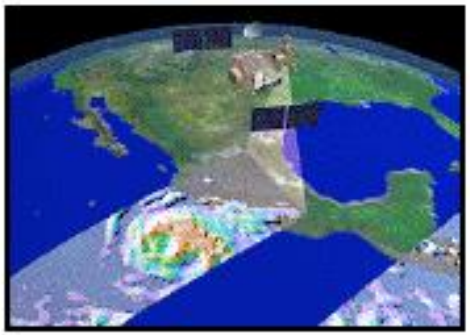
The Electromagnetic Spectrum



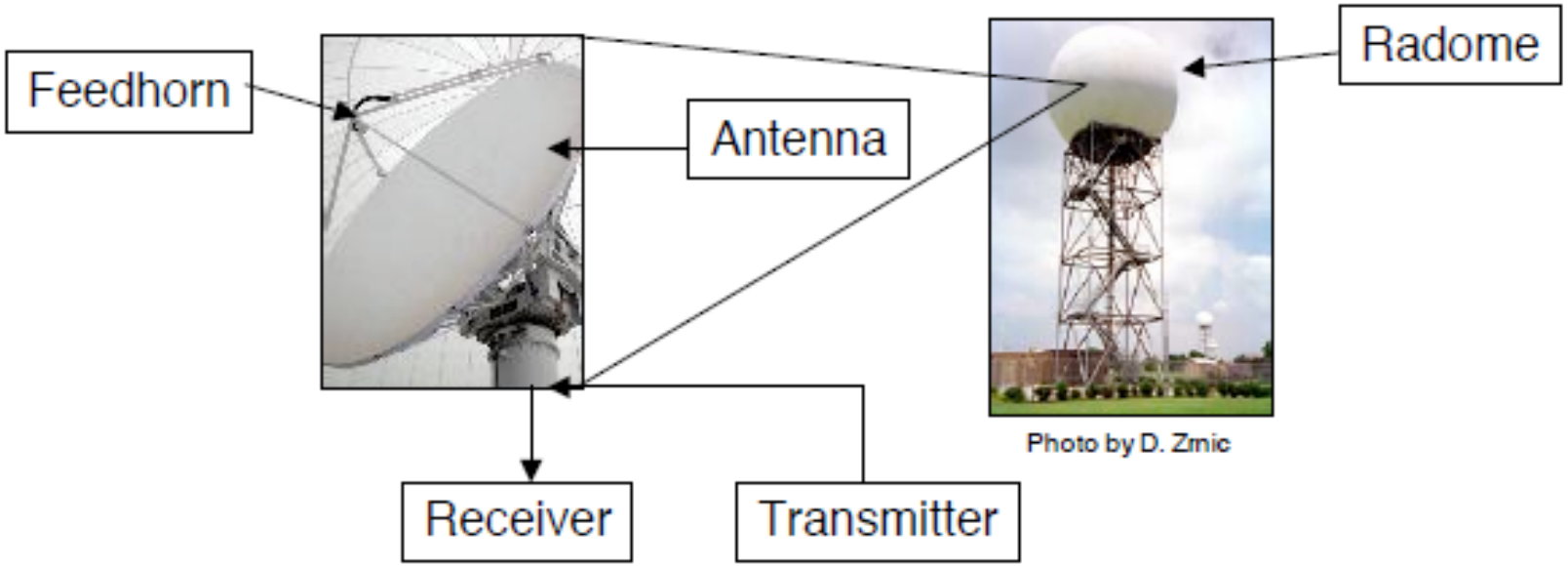
RADAR: Radio Detection And Ranging



- Developed during World War II as a method to detect the presence of ships and aircraft (*the military considered weather targets as noise*)

- Since WW II, there have been many advances in radar technology (e.g., Doppler techniques) and it's used on land, sea, and in space for both research and operational needs

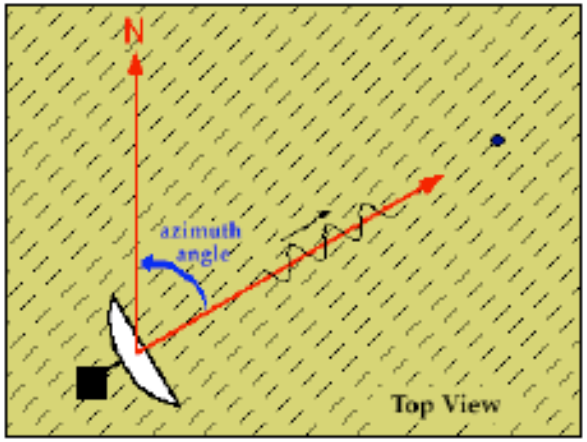
Anatomy of a Weather Radar



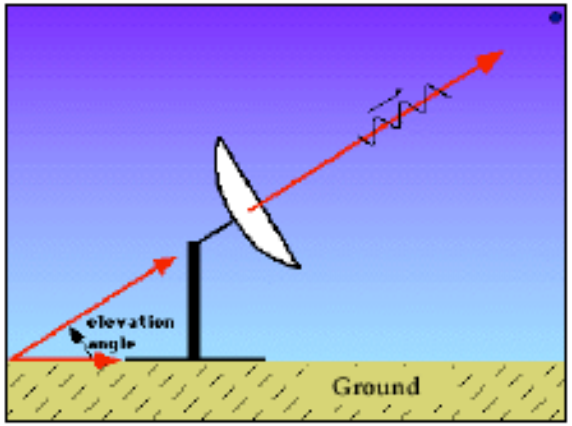
- **Transmitter** - generates the microwave signal of the correct phase and amplitude. For a weather radar, the wavelength of the signal is ~ 10cm
- **Antenna** - the main purpose of the antenna (also called the "dish") is to focus the transmitted power into a small beam and also to listen and collect the returned signal
- **Feedhorn** - directs the signal from the transmitter onto the antenna (also directs the return signal from the antenna to the receiver)
- **Receiver** - detects the signal returned from a target
- **Radome** - protects the antenna from high winds

Weather Radar Scanning

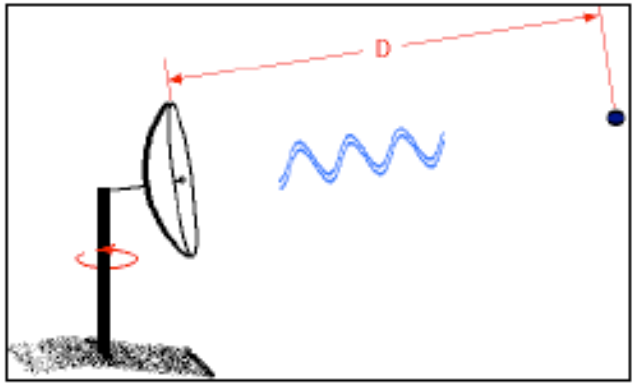
For a radar to find a target of interest (e.g., a cloud), 3 pieces of information are needed:



- *Azimuth angle (direction relative to north)*



- *Elevation angle (angle above the ground)*



- *Distance to the target of interest*

Images on this page made available from the University of Illinois WW2010 Project

The microwave radiation (which travels at the speed of light) has to travel from the transmitter to the weather target and back again, a distance which could be several hundred kilometers.

Horizontal distance from station to target - from the time delay between the transmitted and the return signal

The radar makes a scan around 360 degrees at a low elevation angle, then tilts up a few degrees and makes another scan. The process is repeated until the full volume has been scanned.

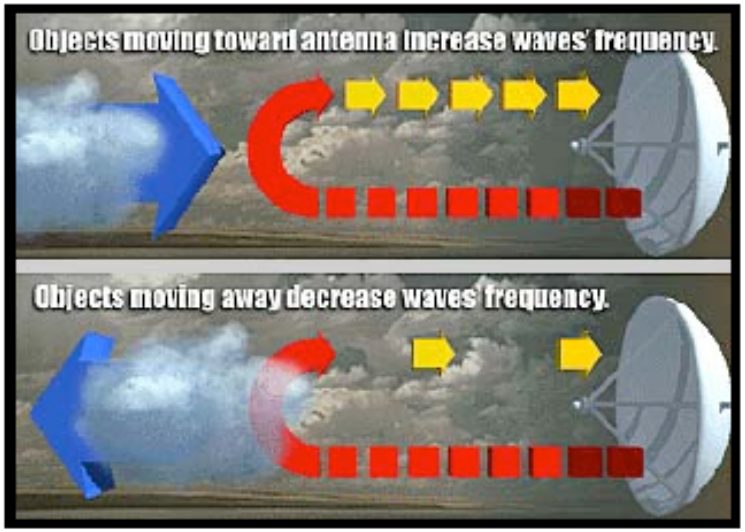
That can take at least 5 minutes. That is why the Bureau radar images are 6 minutes apart for the main radars, and 10 minutes for others.

The standard radar image shows the **reflectivity**.
An estimate can be made of the **rainfall rate**.

Doppler Radar

Measuring Air Motion with Radar

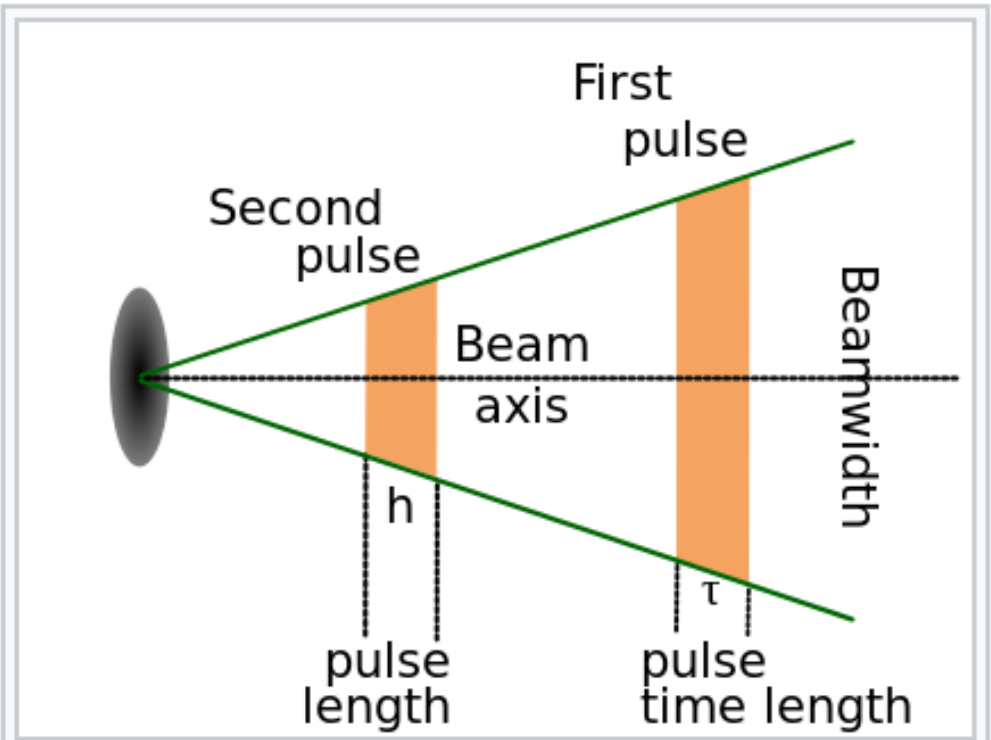
In addition to measuring the amount of signal returned from targets, *NEXRAD* radar has the added capability of being able to measure a frequency shift that is introduced into the reflected signal by the motion of the precipitation particles. This frequency shift is then used to determine wind speed (*we assume that the particles are instantaneously moved around by the wind*).



Images from The USA TODAY Weather Book *by Jack Williams*

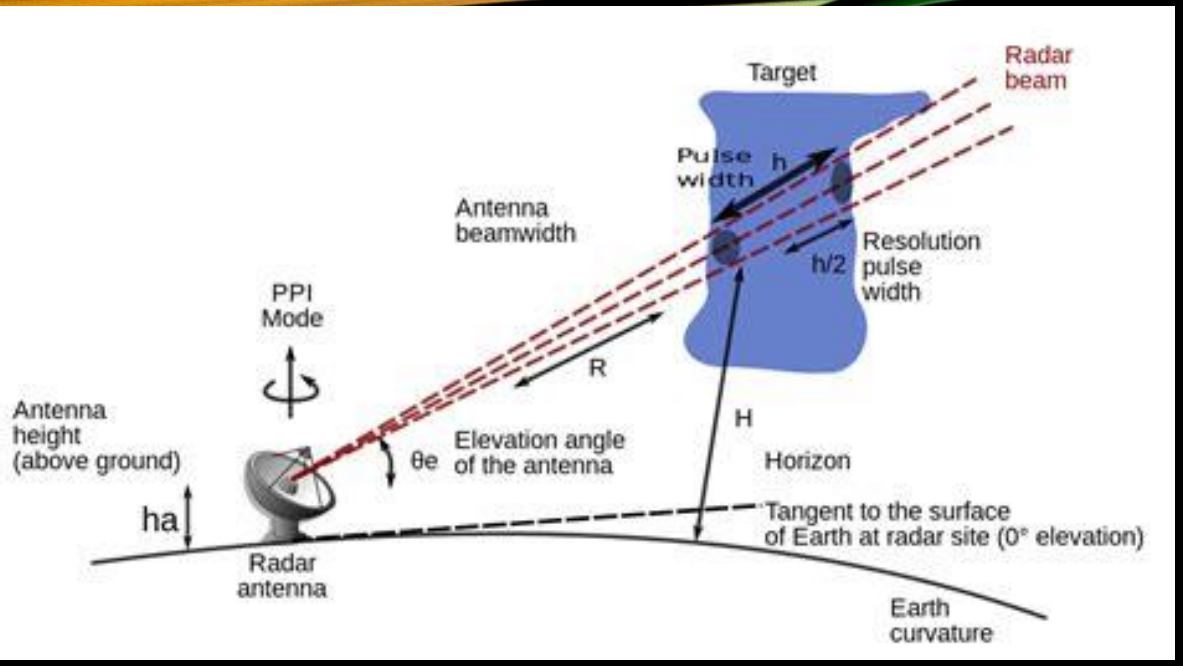
- The amount of "shift" can be determined by comparing the frequency of the transmit pulse with the frequency of the reflected pulse
- Particles moving toward the radar are shifted to higher frequency
- Particles moving away from the radar are shifted to lower frequency

Some problems with weather radar



A radar beam spreads out as it moves away from the radar station, covering an increasingly large volume.

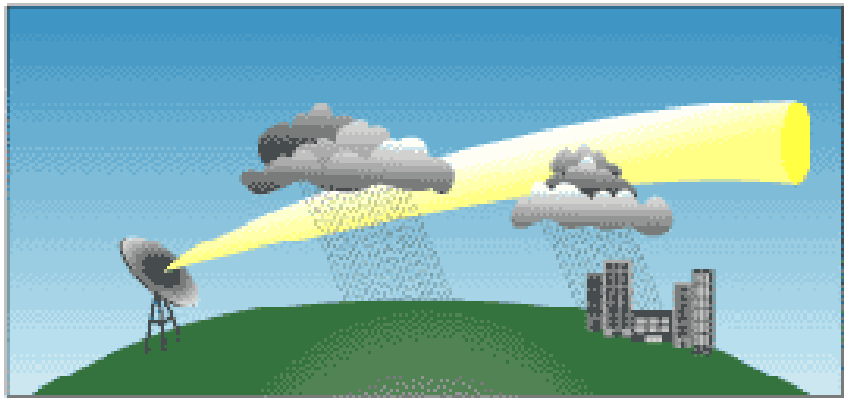
As you move further away from the radar, the radar beam broadens. So, the proportion of the beam that is filled with rain lessens and reduces the echo intensity.



The radar beam gets further from the ground with distance because of the Earth's curvature.

So, lower parts of the rain can be missed.

For example, a horizontal radar beam detects raindrops at about 1 kilometre above the ground when it is 100 kilometres away from the radar. Rain that is 200 kilometres away from the radar will be detected at a height of 3 km.



The effects of the curvature of the earth on weather radar.

There is some refraction of the beam towards the earth.

Non-weather targets

Some things can be misinterpreted as rain or snow by radars:

- Insects
- Birds
- Solid obstacles such as mountains, buildings, and aircraft
- Wind farms
- Dust and smoke
- Ground and sea clutter.

Some can be removed by various processing techniques. E.g. the pattern of “permanent” echoes can be removed, although it does affect the radar image in those areas.

The rotating blades of **wind farms** can return the radar beam to the radar if they are in its path. Since the blades are moving, the echoes can be mistaken for real precipitation.

To explore some past cases:
http://www.theweatherchaser.com/radar-loop/

Some examples:

- Thunderstorms in Melbourne : 22 March 2019 02-11 UTC
- Tropical Cyclone Debbie: Bowen or Mackay radars: 01 UTC 27 March - 15 UTC 1 April 2017
- Rain in Sydney 01 UTC 1 July – 01 UTC 4 July 2022
- Black Saturday, Melbourne: 7 February 2009 02-15 UTC
  - both the standard images and the Doppler view
- Hail in Brisbane: 27 November 2014 03-09 UTC.

Ocean Waves and Swell

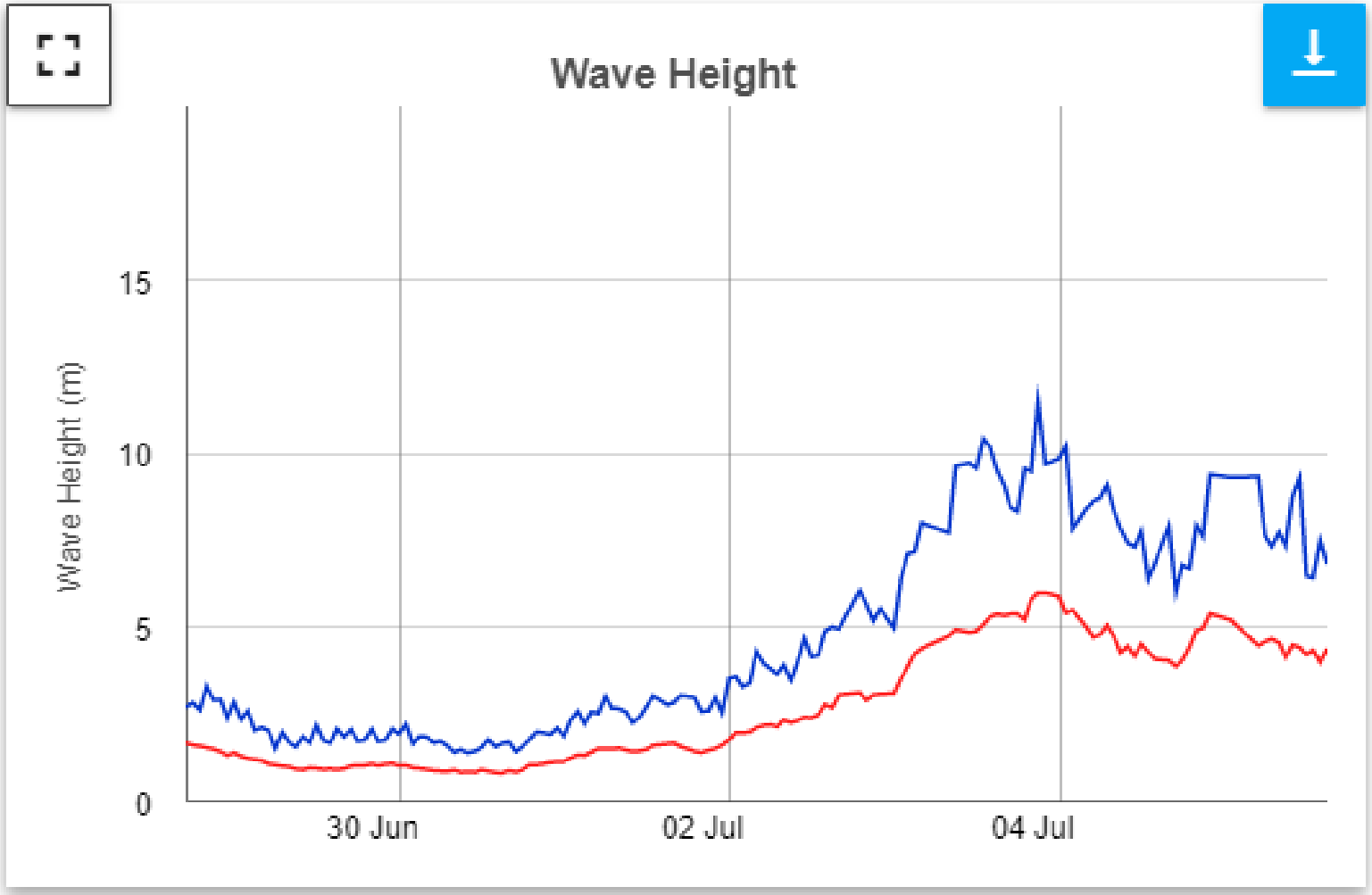
Stranded bulk carrier with 21 crew members on board drifts further north after tugboat cable snaps

Poor conditions overnight have thwarted rescue attempts as MV Portland Bay is anchored off Cronulla. Rescuers hope the ship can be towed in to nearby Port Botany once conditions ease, possibly on Wednesday.

NSW GOVERNMENT | Manly Hydraulics Laboratory

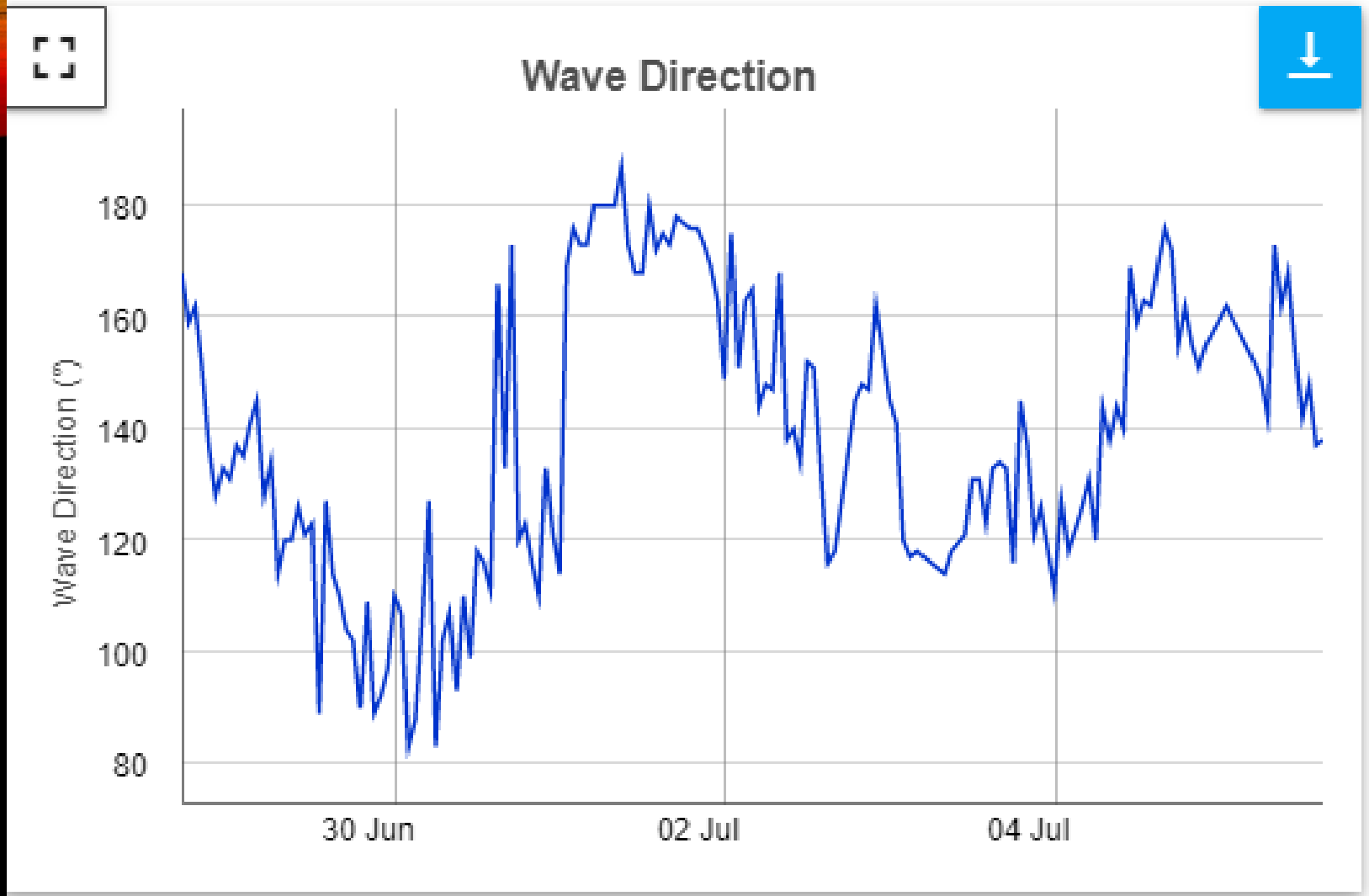
https://www.mhl.nsw.gov.au/Station-SYDDOW

Sydney (SYDDOW)



Legend:

- [x] Sydney (Hs)
- [x] Sydney (Hmax)


Wave Direction
Wave Direction (°)
180
160
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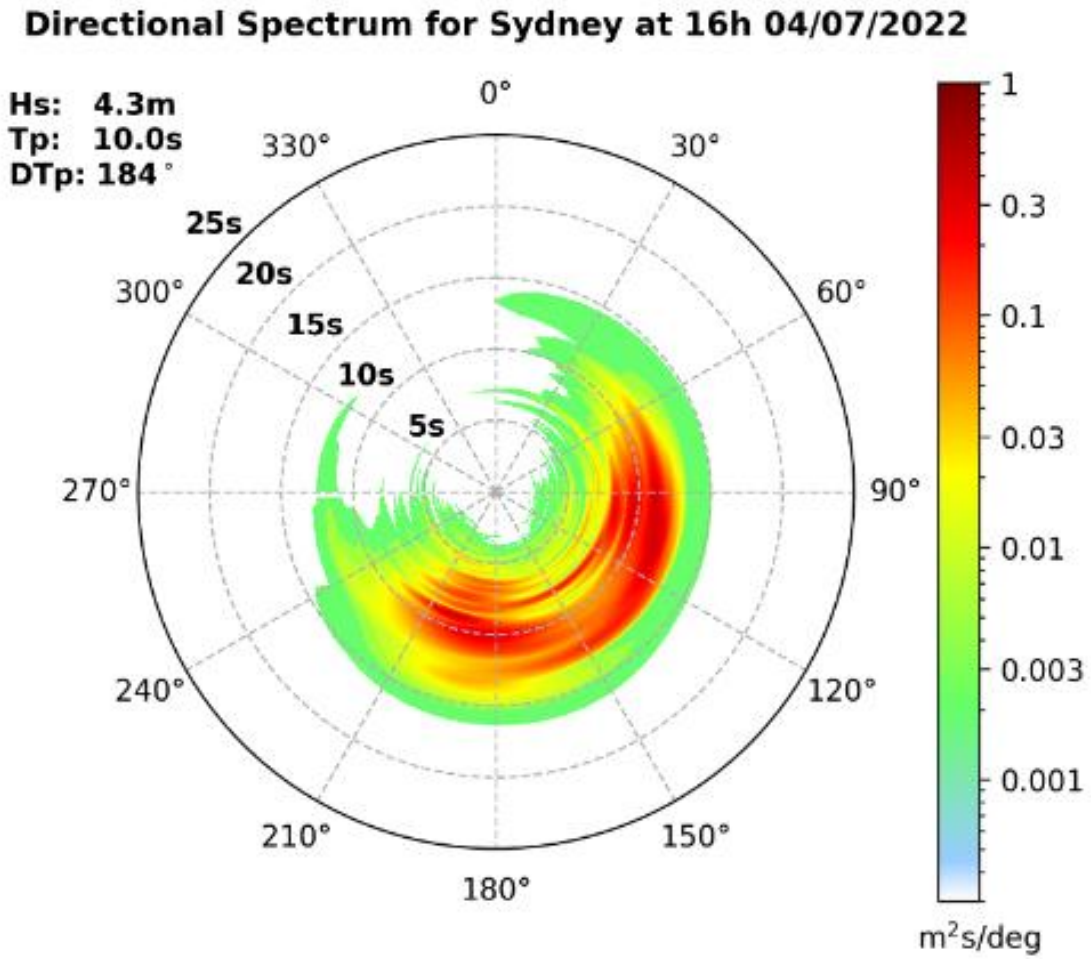
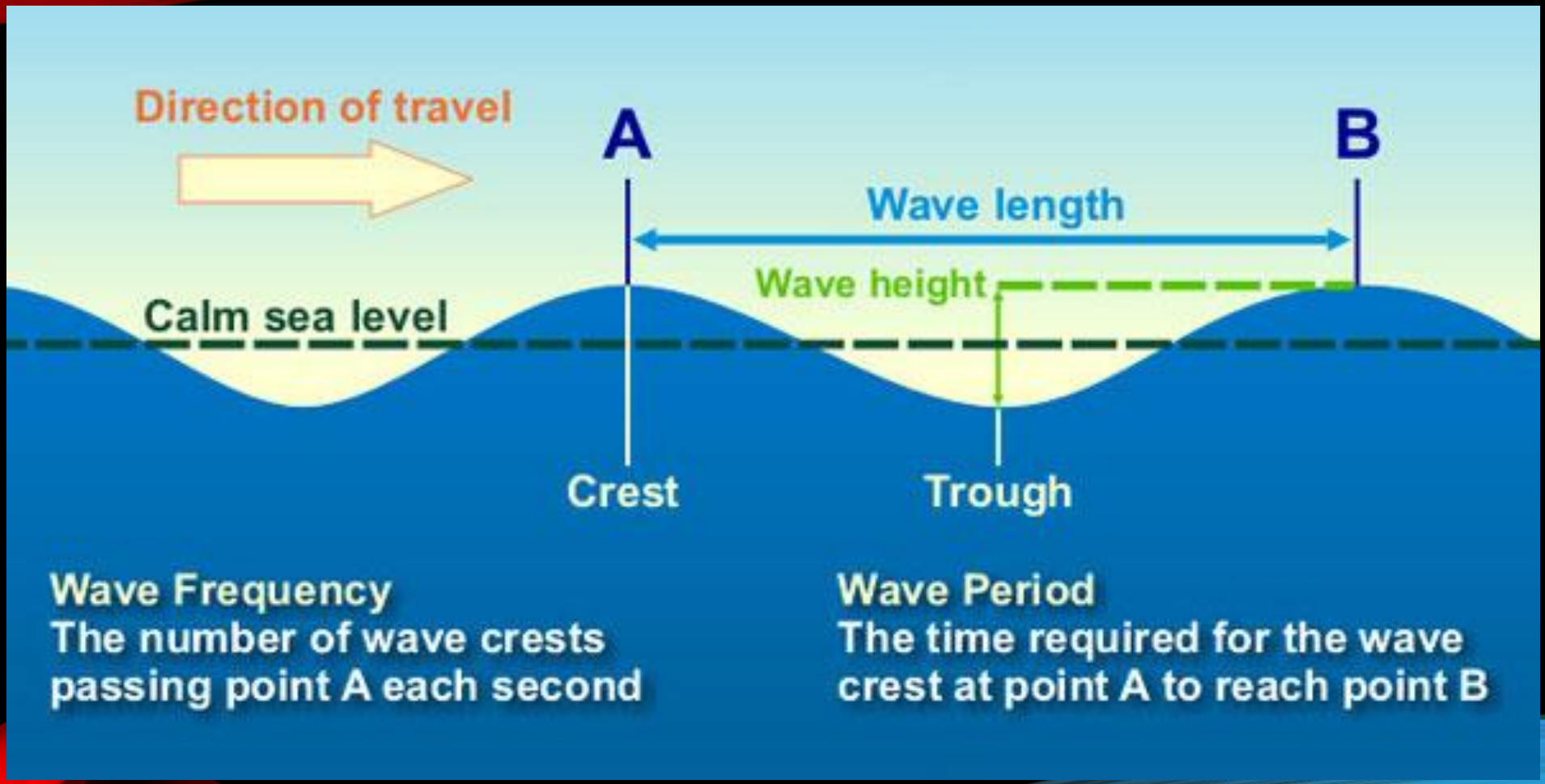
80
30 Jun
02 Jul
04 Jul
Legend:
Sydney (Wave Direction)

Sydney Spectral Plots



RESTART BACK PLAY FWD STOP

Winds and waves



Winds and Waves

Sea state refers to the combination of **sea** and **swell** waves.

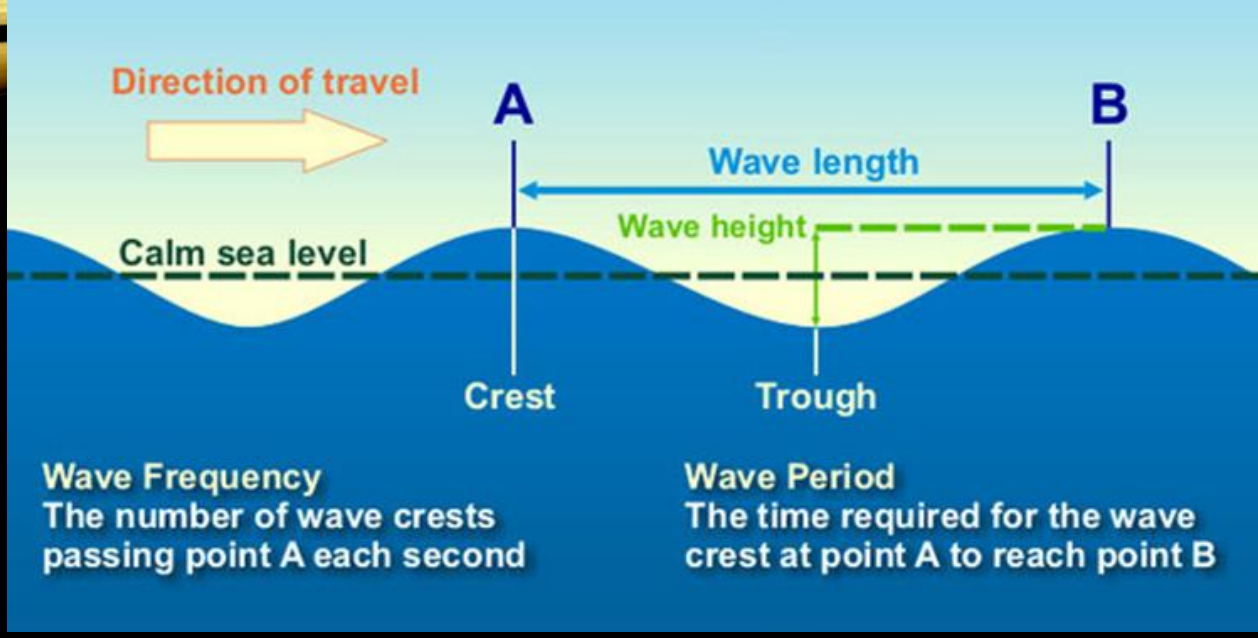
Sea waves are generated by the **local wind**.

Swell waves are the regular, longer period waves generated by distant weather systems. They may travel over thousands of kilometres.

Significant Wave height describes the average height of the highest third of the waves. It seems to be the value a "trained observer" (e.g. from a ship's crew) would estimate from visual observation of a sea state

The **maximum wave height** can be up to twice the significant wave height.

Winds and waves

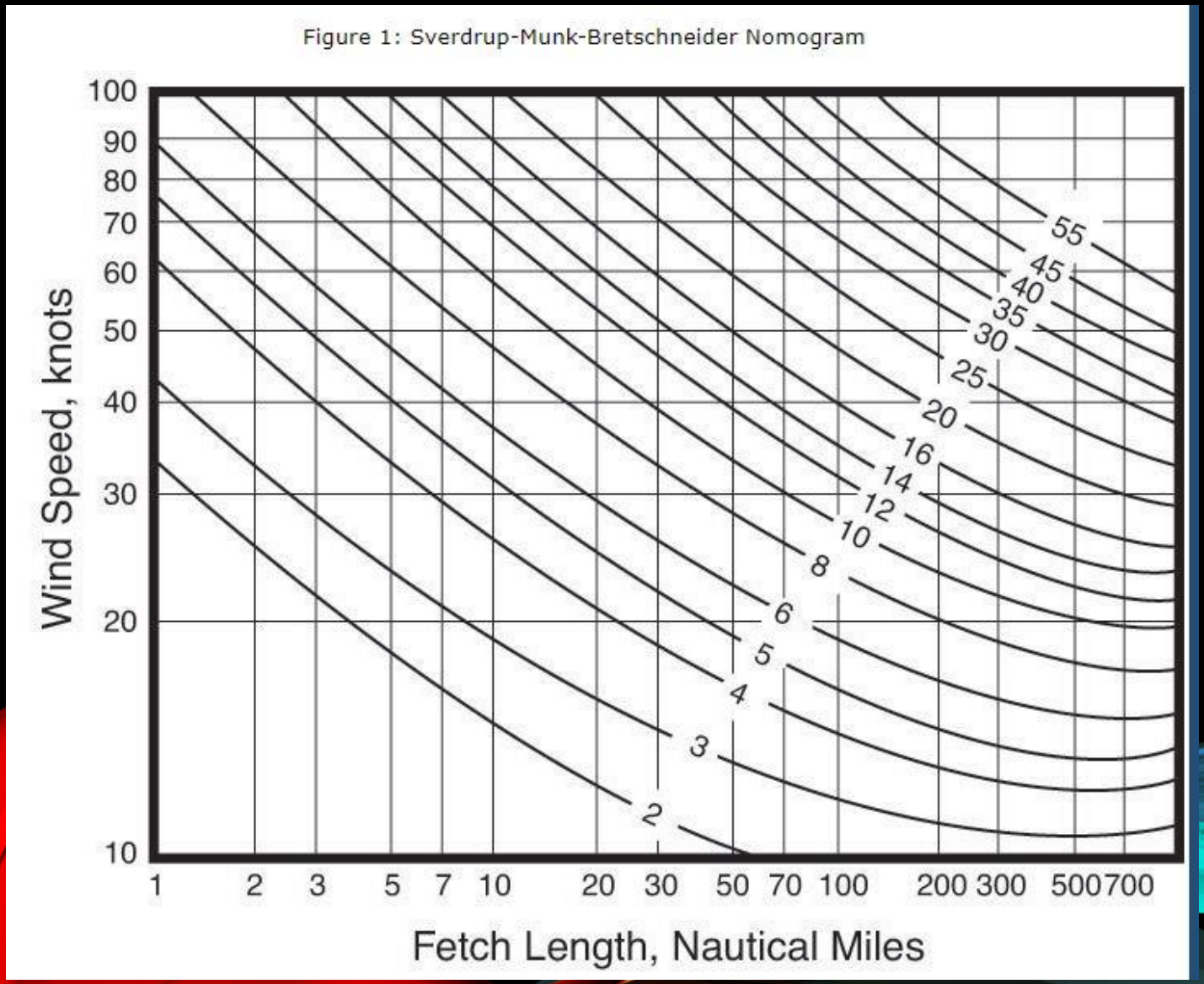


Three factors influence the formation of wind waves:

- **Wind speed relative to the water** - the wind must be moving faster than the water for energy transfer
- The uninterrupted **distance of open water** over which the wind blows without significant change in direction (called the ***fetch*****)**
- Wind **duration** — the time for which the wind has blown over the water.

Winds and waves

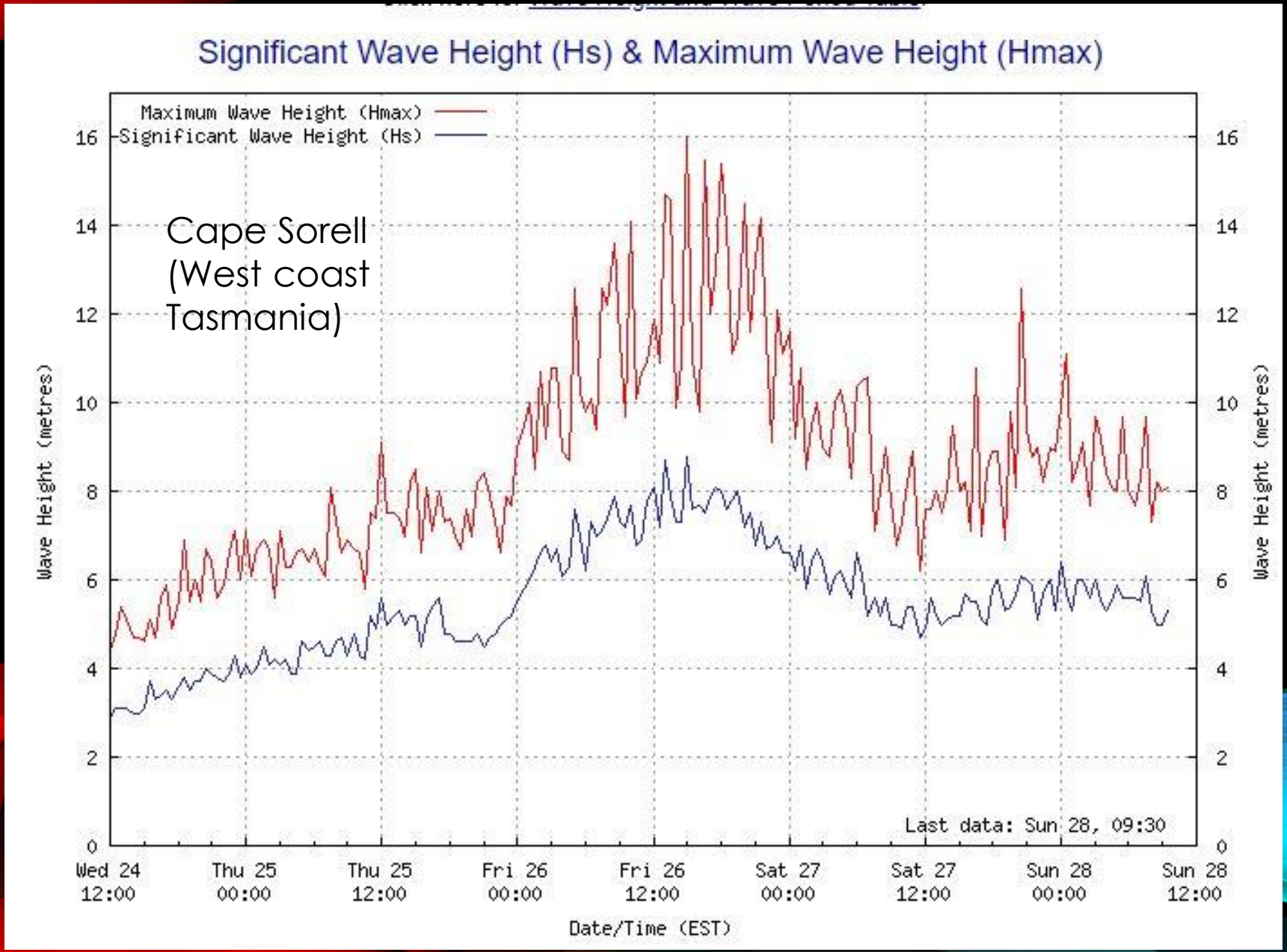
A famous early diagram used to calculate the height of waves.

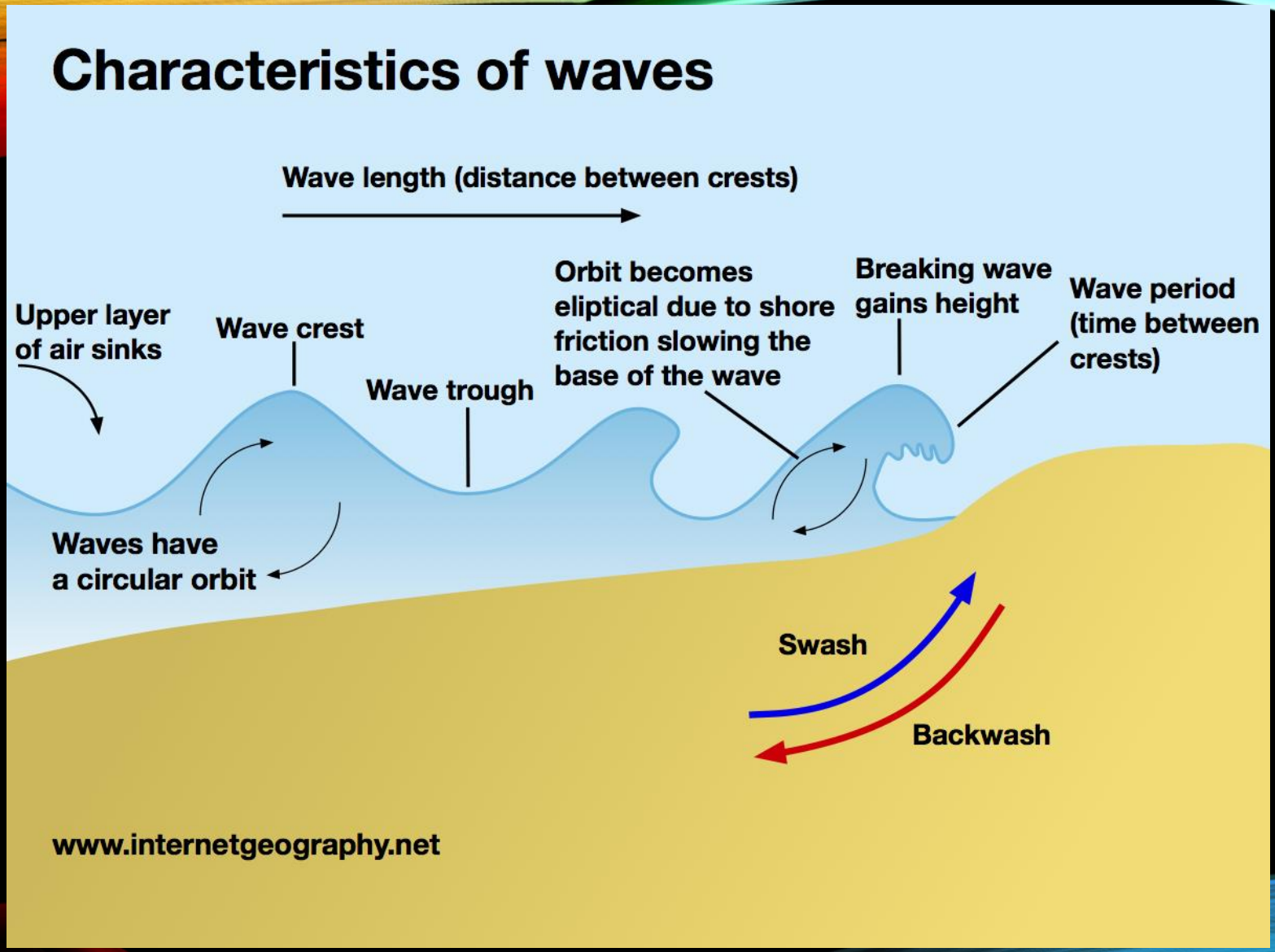


From the wind speed and fetch you can read off the wave height (in feet).

Surf at Bells Beach

26-27 April 2019



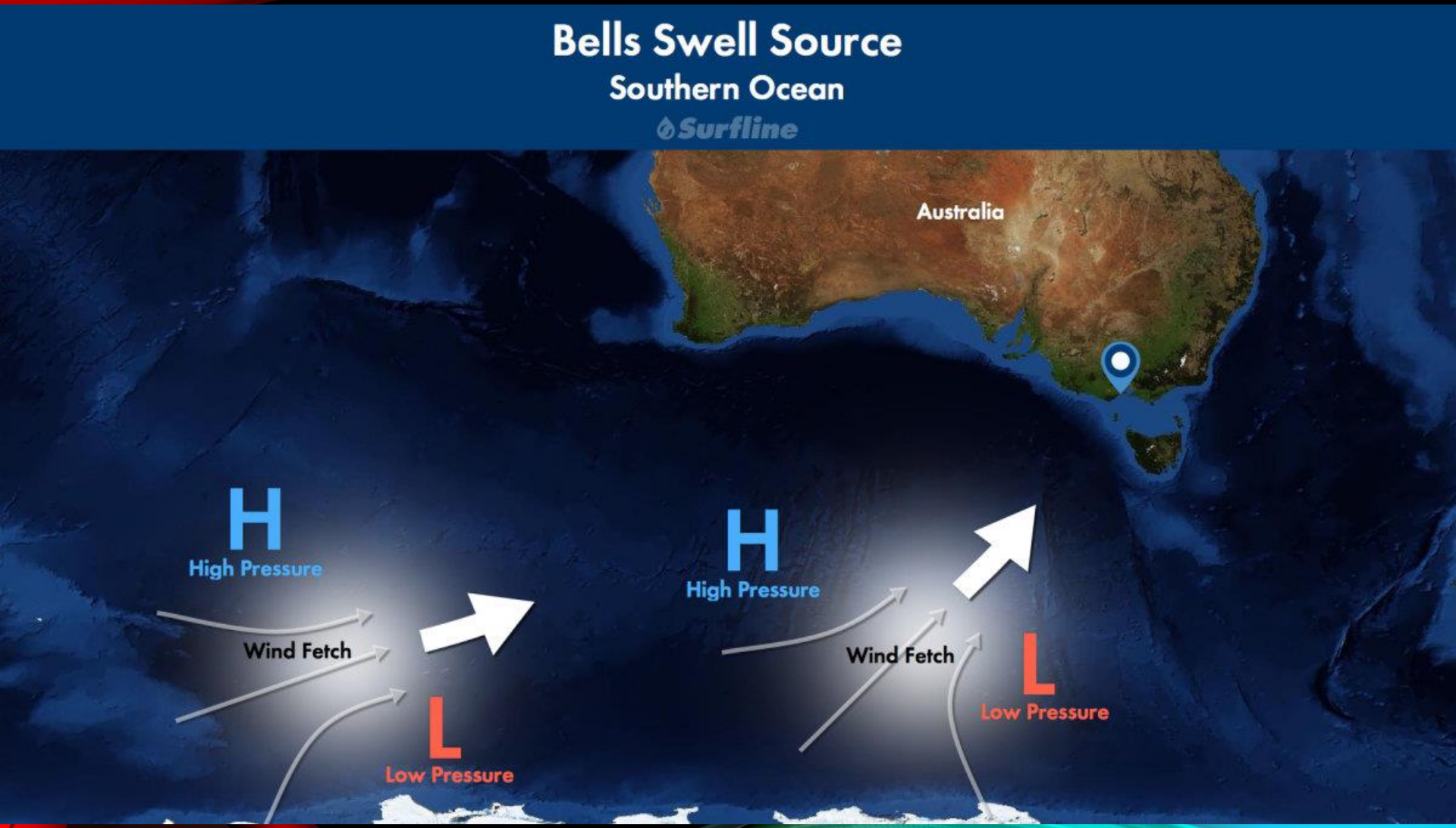


Surf can be higher:

- water depth decreases quickly
- offshore wind

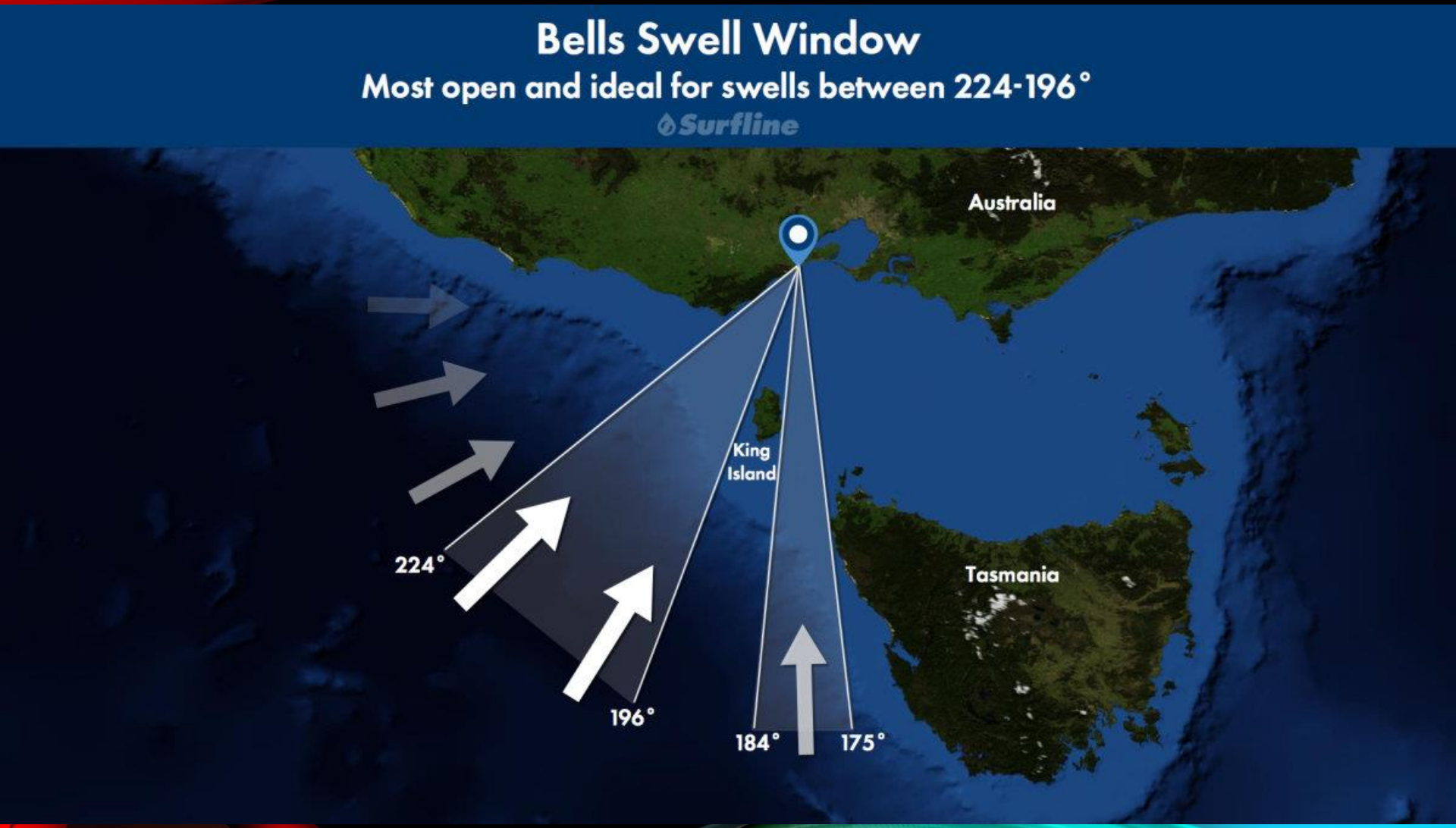
Surf at Bells Beach

26-27 April



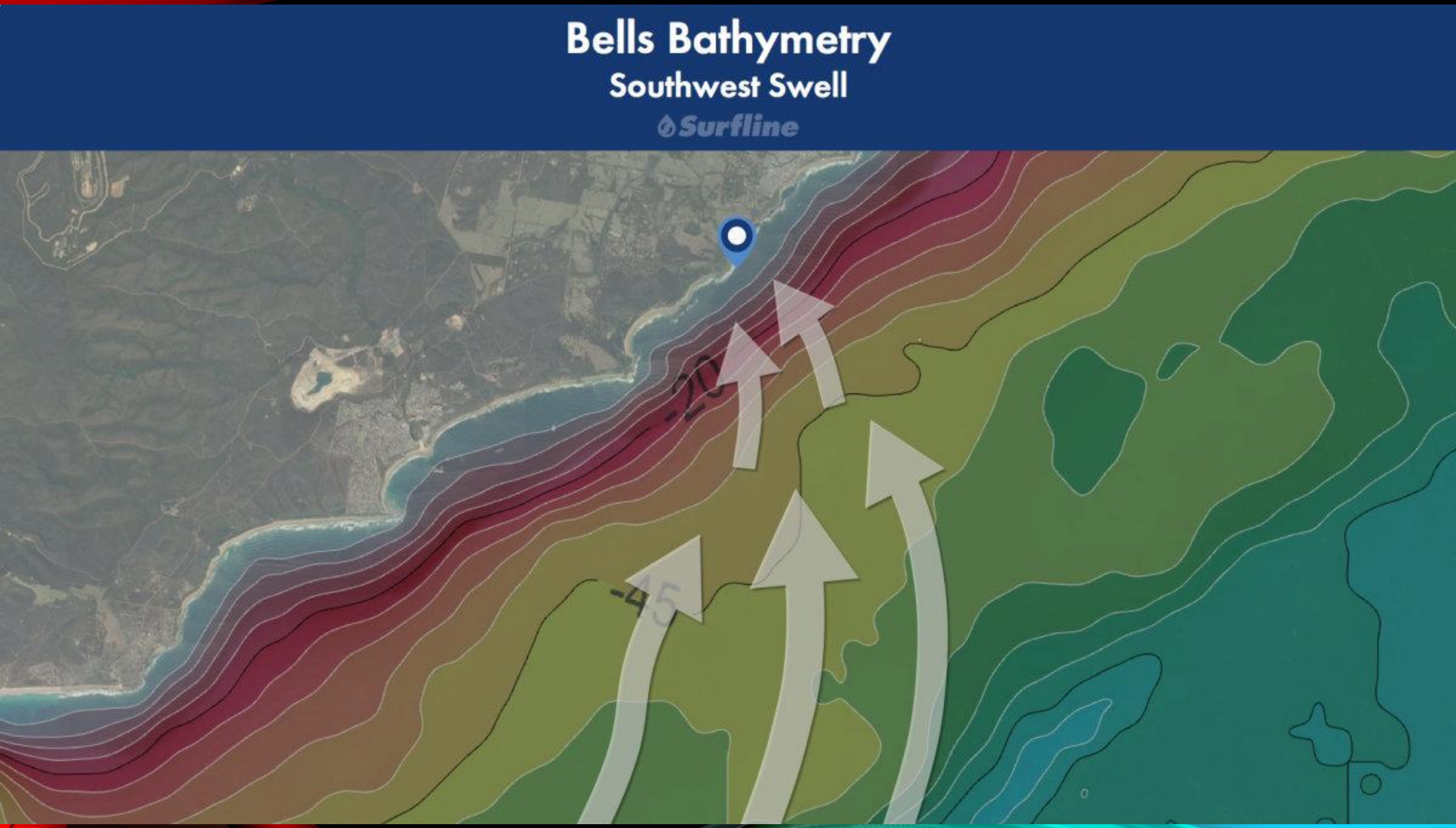
Surf at Bells Beach

26-27 April

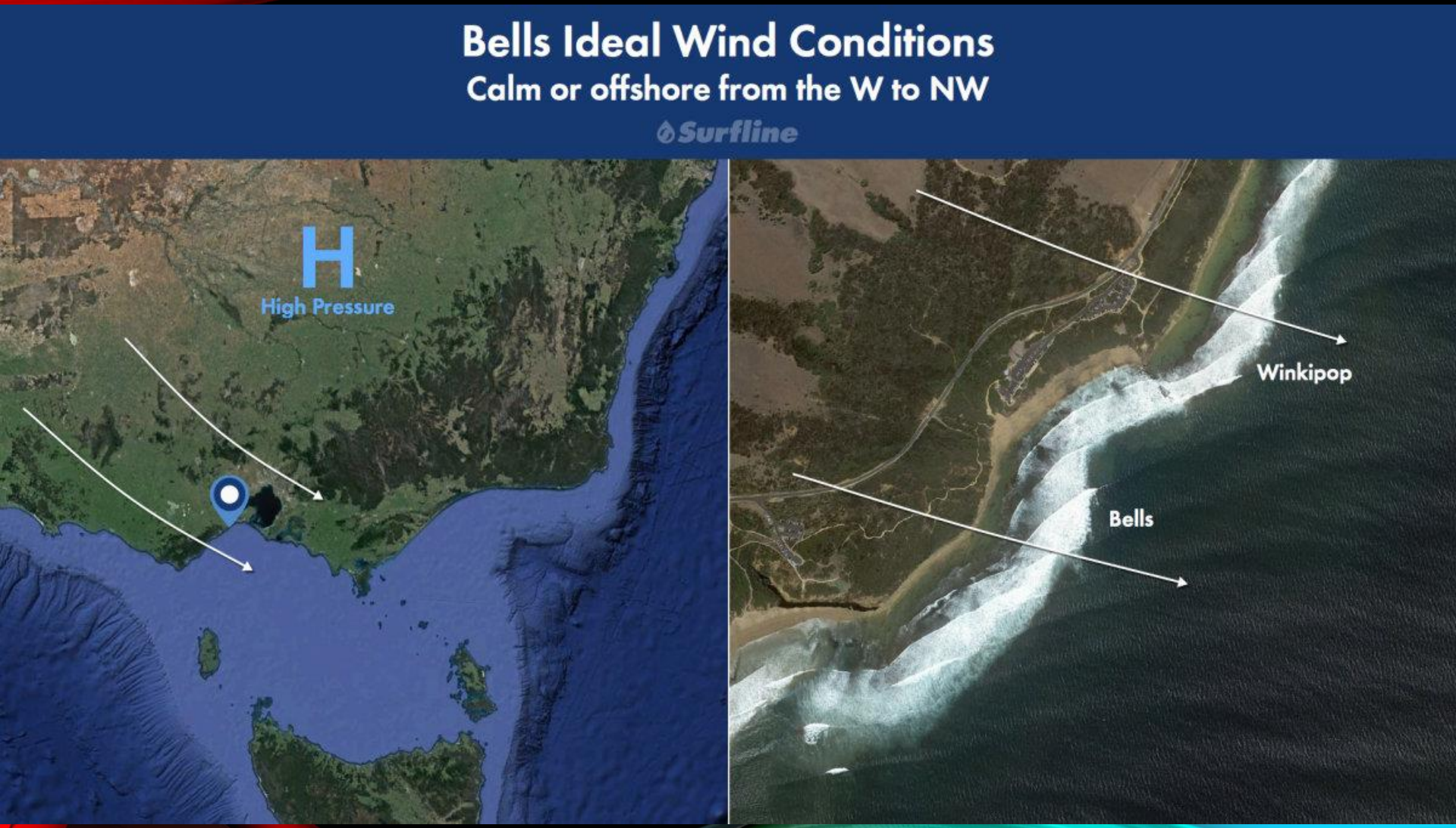


Surf at Bells Beach

26-27 April



Surf at Bells Beach



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Home > Community & bay users > Waves, wind & weather

Waves, wind & weather

Point Nepean updated 08:00 10/06/2021 Melbourne time

Point Nepean

Latitude: -38° 21' 36" Longitude: 144° 41' 14"

https://www.vicports.vic.gov.au/community-and-bay-users/Pages/Waves-wind-weather.aspx

Point Nepean wave data

Significant height	3.57 m
Maximum height	5.84 m
Significant period	8.8 s
Peak period	10.5 s
Wave direction	159 °
Water temperature	14.3 °C
Last reading	8:00
Melbourne time	10/6/2021

Detailed wave data

Tide

N/A

Next high tide	N/A
Next low tide	N/A

Detailed tide data

Wind

N/A

Current gust	N/A
Wind direction	N/A

Detailed wind data

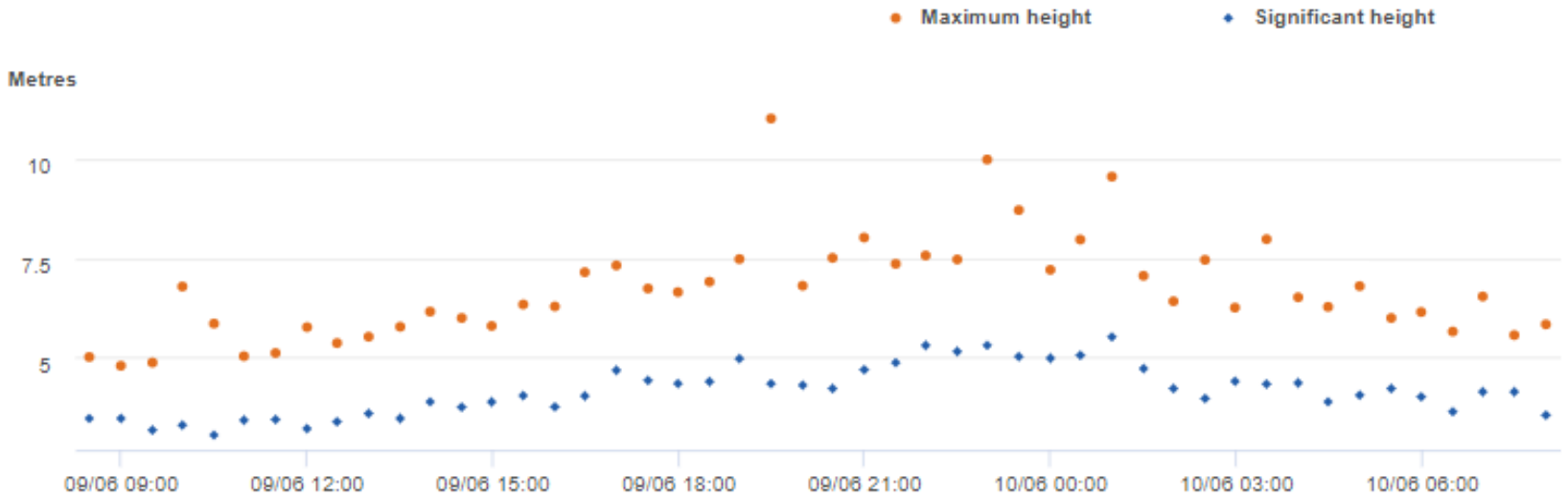
Weather

N/A

Humidity	N/A
Air pressure	N/A

Detailed weather data

Wave height



https://www.vicports.vic.gov.au/community-and-bay-users/Pages/Waves-wind-weather.aspx

Not secure | bom.gov.au/tas/observations/

BoM | ABC News Homepa... | Bookmarks | Hotmail | Google Maps | Phil's Weather | Phil... | MetEye_PortPhillip

Hobart observations
via clickable map

Land areas

- TAS latest observations
- Tasmania observations
  via clickable map
- Latest weather graphs
  via clickable map
- Thermal comfort

Marine areas

- Latest coastal observations
- Coastal observations
  via clickable map
- Wave observations (Cape Sorell)
  - Graph
  - Table
- Wave observations (Maria Island)
  - Graph
  - Table

(by catchment)

including all Daily and Weekly Rainfall bulletins

- Rainfall overview maps
  General overview of rainfall across Tasmania (day, month or year)
- Tasmanian River Report

Radars

- Hobart radar

Select location to see its image.

- All radar sites for Tasmania

Agriculture

- Daily weather observation tables
  (via location then date)
- Rainfall and temperature records

Climate Data Online

Access a range of statistics, historical weather observations, climatology maps, and other Australian climate data.

Severe Weather

- Severe storms archive
- Severe weather events

om.gov.au/watl/weather/observations/tas-latest-weather-graphs.shtml