Understanding weather and the weather forecast

Week 31

Ocean Measurements
Ocean currents

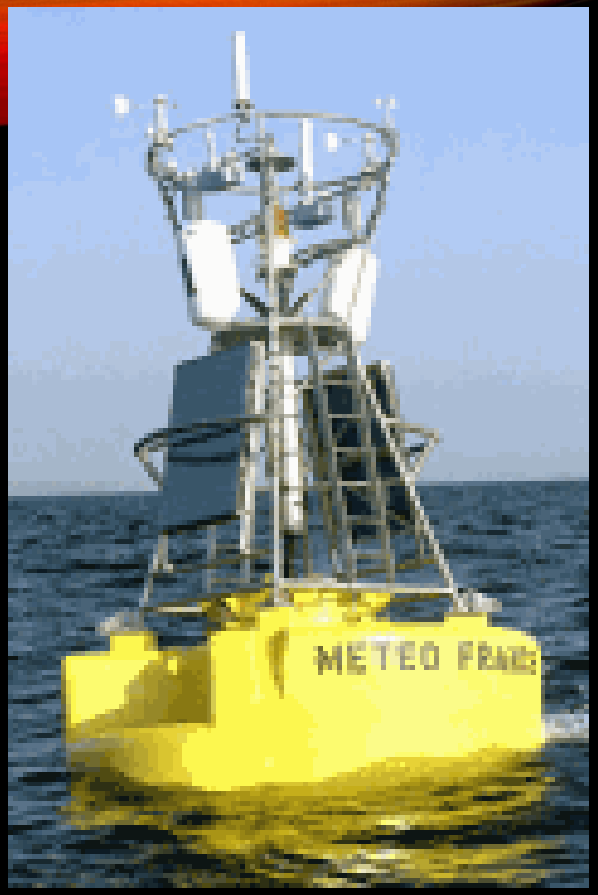
Terry Hart

Measuring pressure over the ocean - buoys

Whether they are drifting or moored, data buoys measure and transmit automatically, in a predictable and controlled way, communicating in real time via satellite telecommunication systems.

Data buoy observations make significant contributions to our ability to model, understand and describe global weather and climate on all time and space scales.

Drifting buoys are generally attached to some form of drogue or sea-anchor, are easy to deploy, relatively inexpensive to operate and reliably measure the atmosphere and ocean surface conditions, for an average of 18 months.

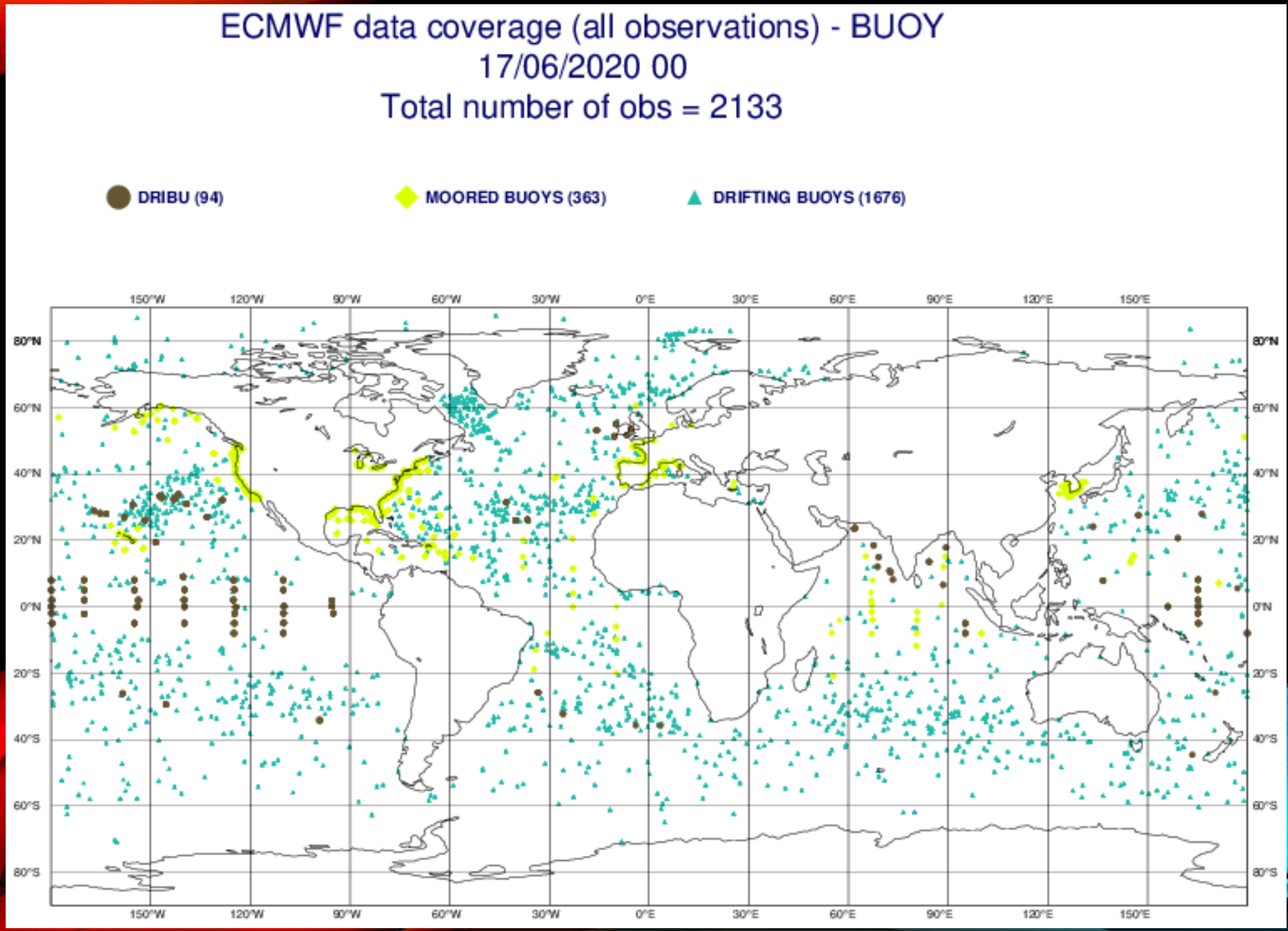


Moored buoys are anchored at fixed locations and regularly collect observations from many different atmospheric and oceanographic sensors. Moored buoys are usually deployed to serve particular forecasting needs such as arrays of moorings in each ocean basin to monitor large scale phenomenon such as El Niño.

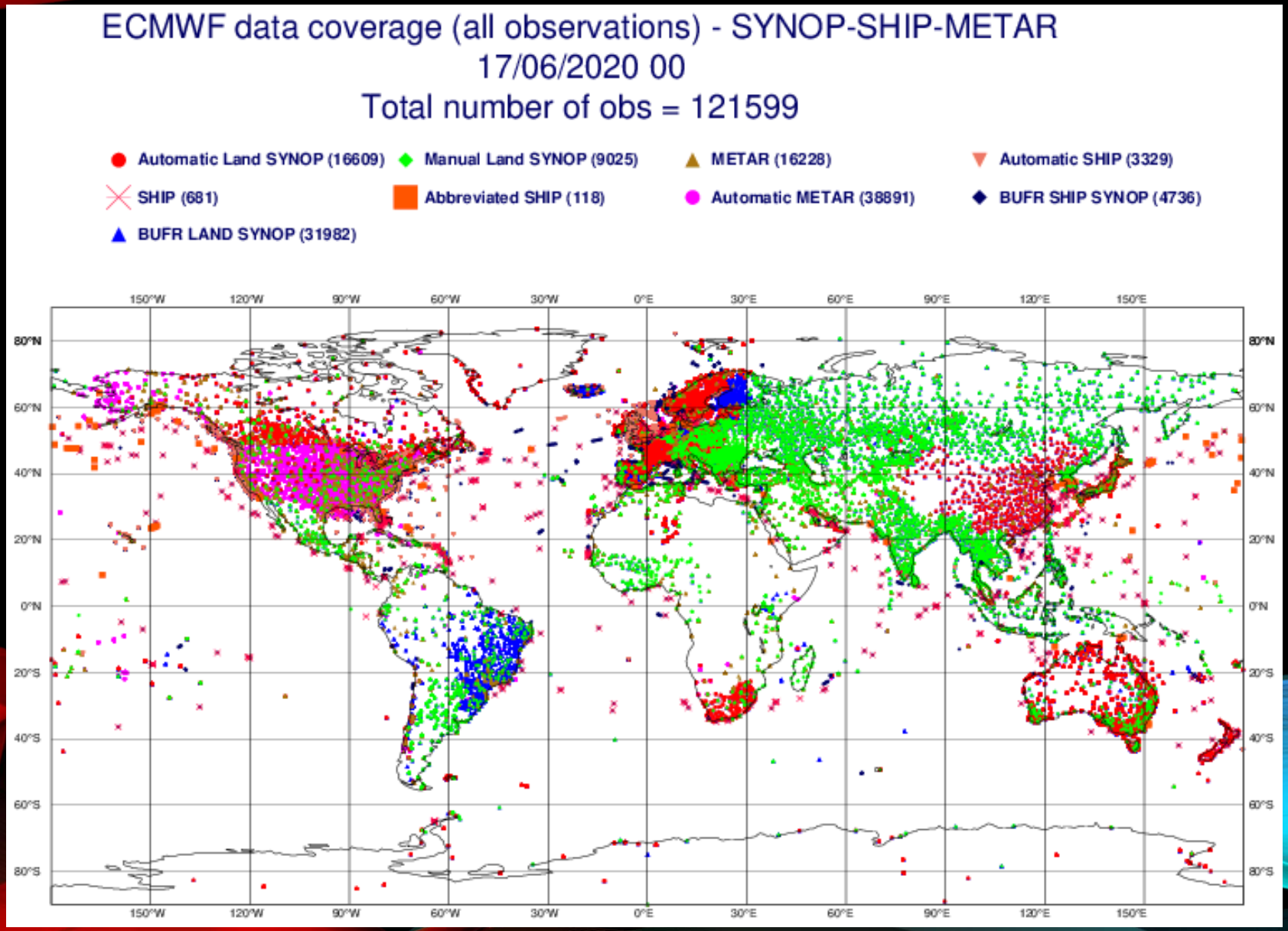
Moored buoys are normally relatively large and expensive platforms. They can vary from a few meters in height and breadth, to over 12 meters. Measurements from the mooring include surface variables (wind, air and sea surface temperature, salinity, air pressure), as well as subsurface temperatures down to a depth of 500 plus metres.

They are generally upgraded or serviced yearly. They need to be constructed of very hardy materials to avoid problems in storms or high seas, the tether line which holds the buoy in the desired location needs to be especially strong. The design also needs to counter intentional vandalism or accidental damage.

Data coverage - buoys



Data coverage - ships and islands only over ocean. The buoys make a big difference to the monitoring of the southern oceans



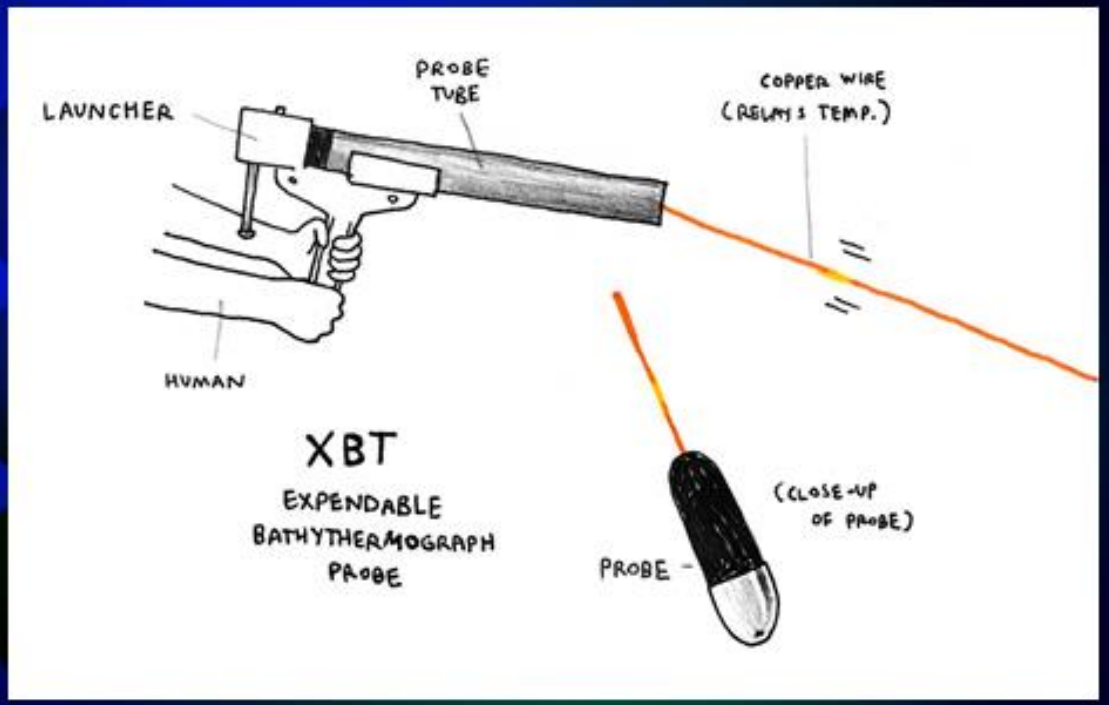
Measuring underwater temperature, depth and salinity

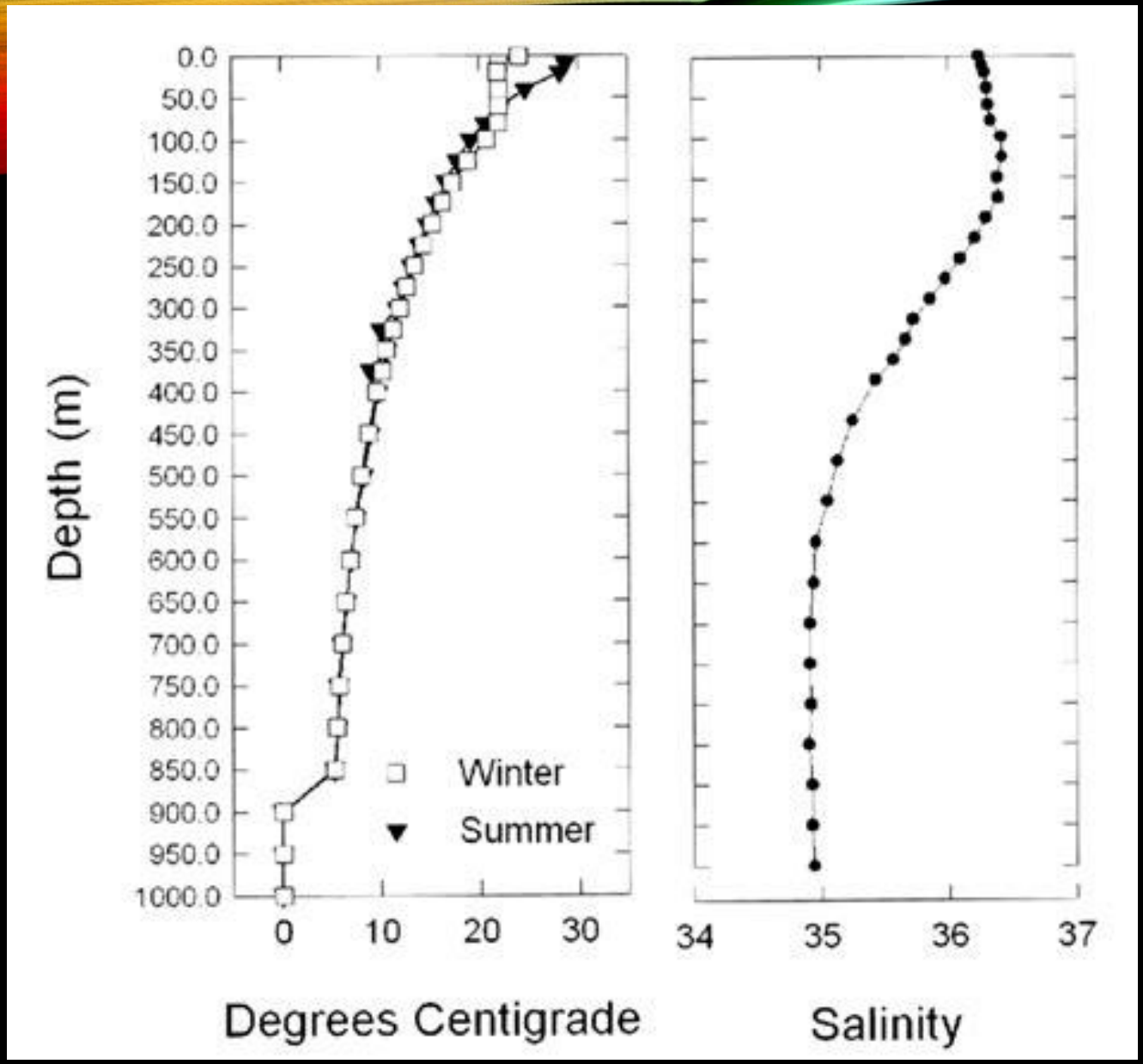
Bathythermograph

- Developed in the 1930s
- a small torpedo-shaped device that holds a temperature sensor to detect changes in water temperature versus depth down to a depth of approximately 300 metres.
- It was lowered by a small winch on the ship into the water. The wire is paid out until it reaches a predetermined depth, then a brake is applied and the BT is drawn back to the surface.

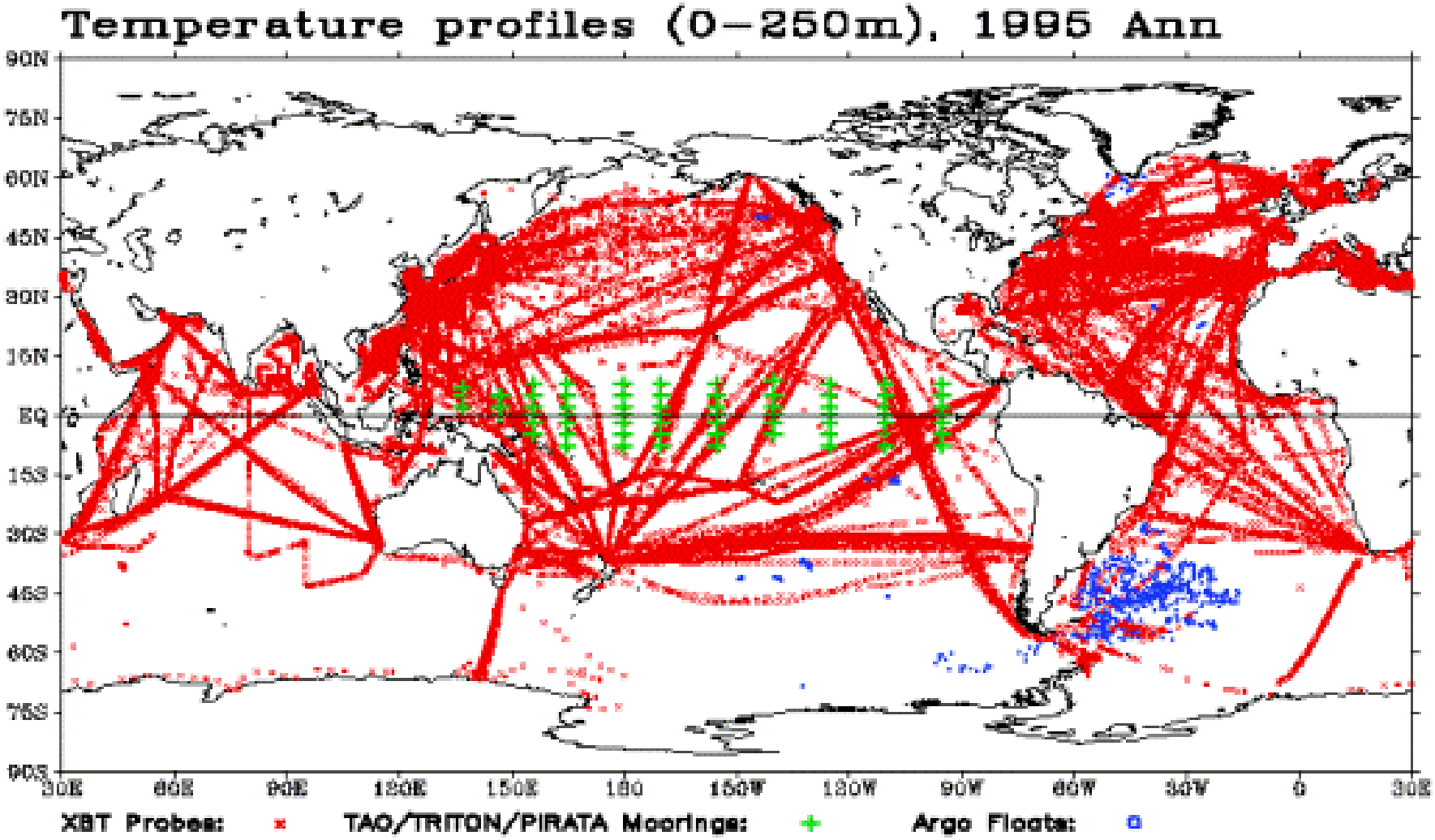
Expendable Bathythermograph

- Developed in the 1960s.
- A probe; a wire link; and a shipboard canister. The probe falls freely at 6 metres per second. A copper wire pays out with the instrument to transfer data to the ship for shipboard recording. Eventually, the wire runs out and breaks, and the XBT sinks to the ocean floor.
- Since the deployment of an XBT does not require the ship to slow down or otherwise interfere with normal operations, XBT's are often deployed from *vessels of opportunity*.

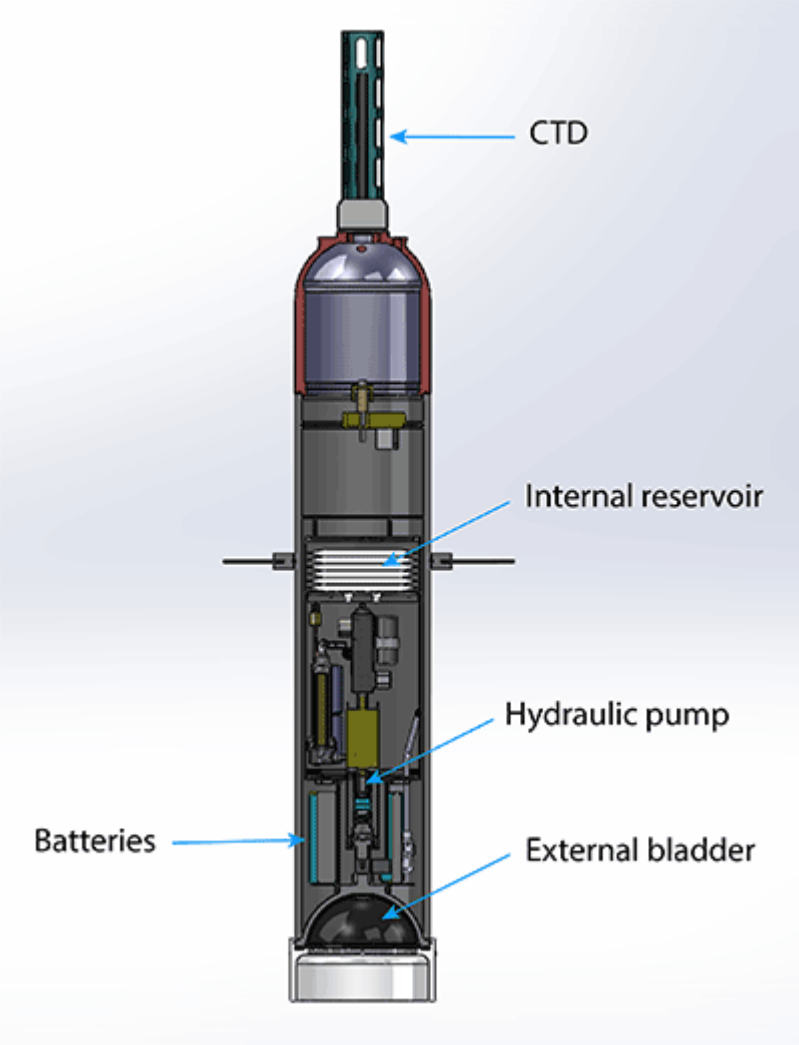

PROBE TUBE
COPPER WIRE (RELAYS TEMP.)
LAUNCHER
HUMAN
XBT
EXPENDABLE BATHYTHERMOGRAPH PROBE
(CLOSE-UP OF PROBE)
PROBE



Temperature and salinity profiles from an expendable bathythermograph (XBT).

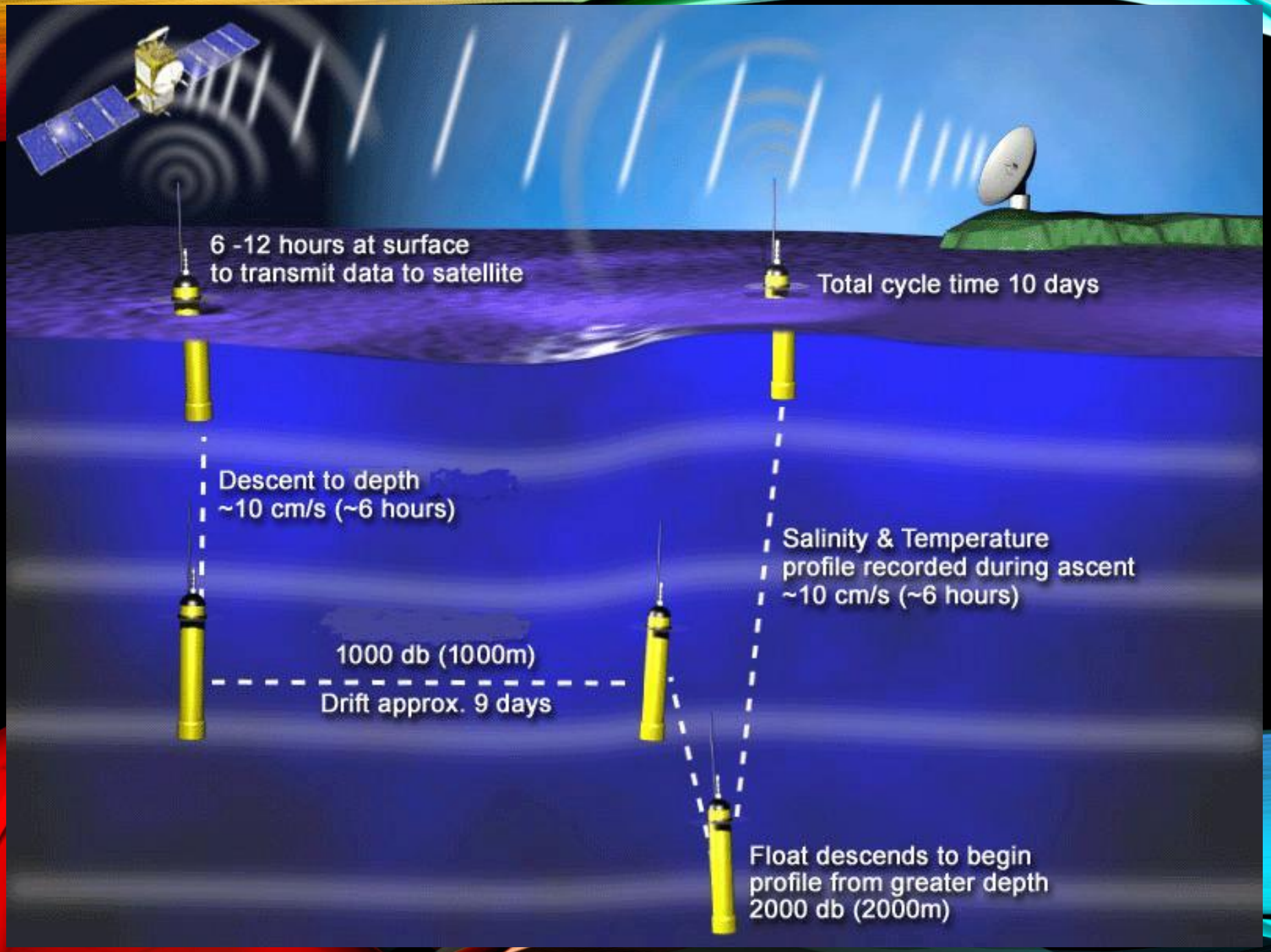

Temperature profiles (0–250m), 1995 Ann
90N
75N
60N
45N
30N
15N
EQ
15S
30S
45S
60S
75S
90S
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
30E
XBT Probes:
TAO/TRITON/PIRATA Moorings:
Argo Floats:

Sub-surface floats Argo Program

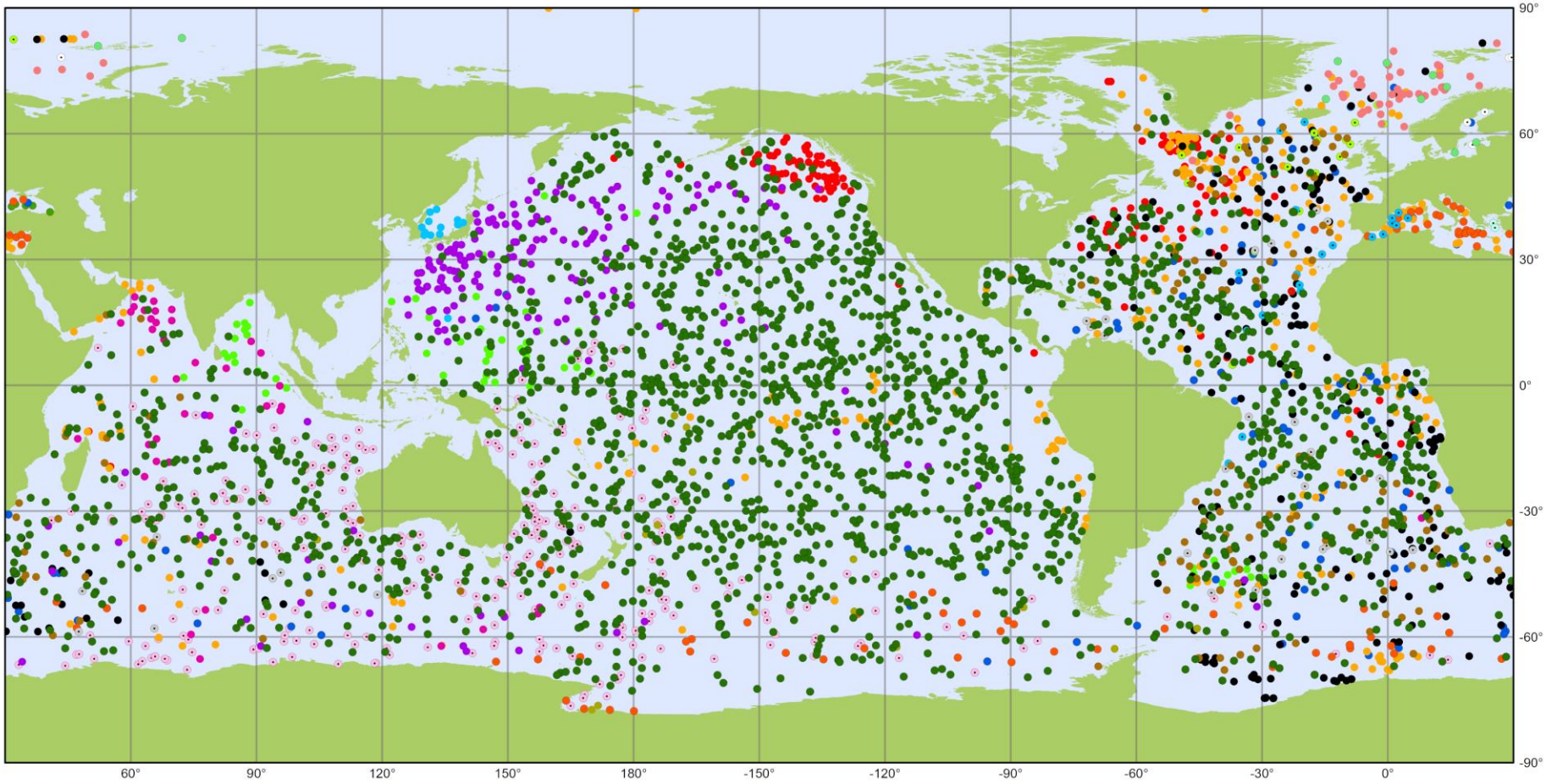


Argo is a global network of more than 3000 free-drifting robots that measure temperature and salinity of the upper 2000 m of the ocean. This allows, for the first time, continuous monitoring of the temperature, salinity, and velocity of the upper ocean, with all data being sent to satellites passing overhead and then made publicly available within hours after collection.

https://youtu.be/PzHZdwaBr_Q


6 -12 hours at surface
to transmit data to satellite
Total cycle time 10 days
Descent to depth
~10 cm/s (~6 hours)
Salinity & Temperature
profile recorded during ascent
~10 cm/s (~6 hours)
1000 db (1000m)
Drift approx. 9 days
Float descends to begin
profile from greater depth
2000 db (2000m)

https://argo.ucsd.edu/about/status/



Argo

National contributions - 3880 operational floats

Latest location of operational floats (data distributed within the last 30 days)

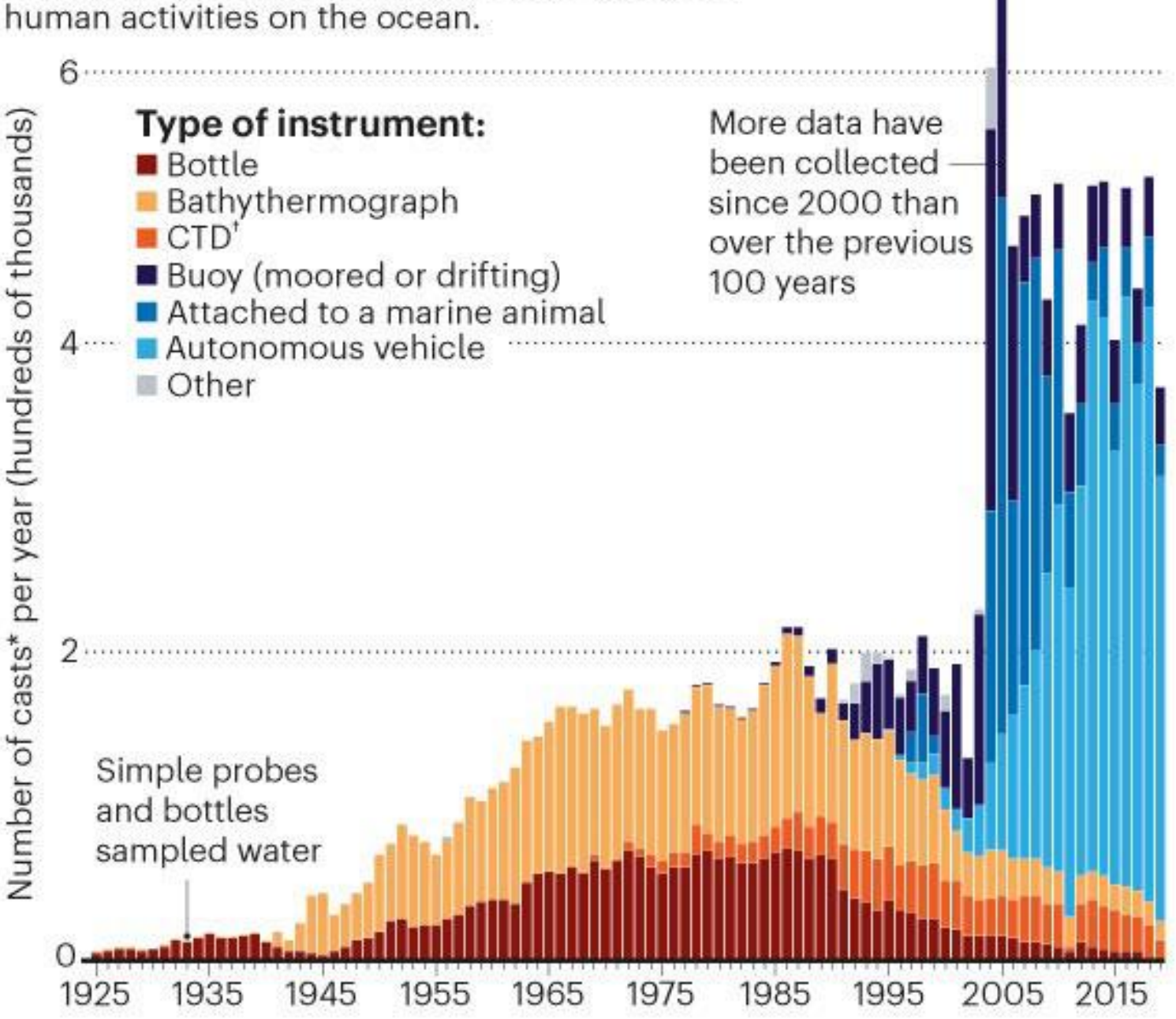
October 2022

AUSTRALIA (313)	FINLAND (6)	IRELAND (17)	NEW ZEALAND (17)	SPAIN (21)
BULGARIA (5)	FRANCE (275)	ITALY (85)	NORWAY (48)	UK (135)
CANADA (152)	GERMANY (226)	JAPAN (204)	PERU (1)	USA (2115)
CHINA (58)	GREECE (3)	MOROCCO (1)	POLAND (11)	
EUROPE (98)	INDIA (41)	NETHERLANDS (34)	KOREA, REPUBLIC OF (14)	

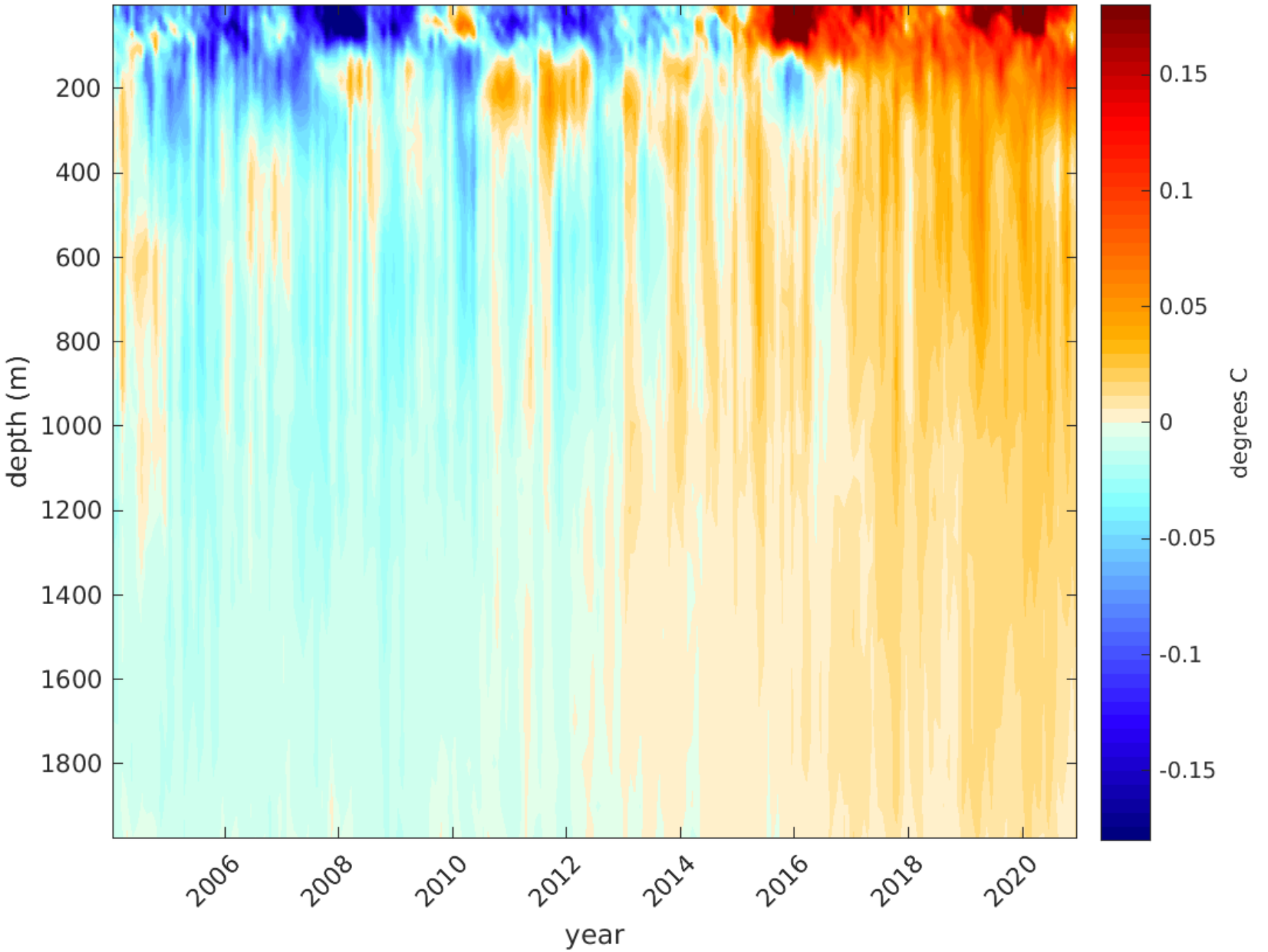
Generated by ocean-ops.org, 2022-11-01

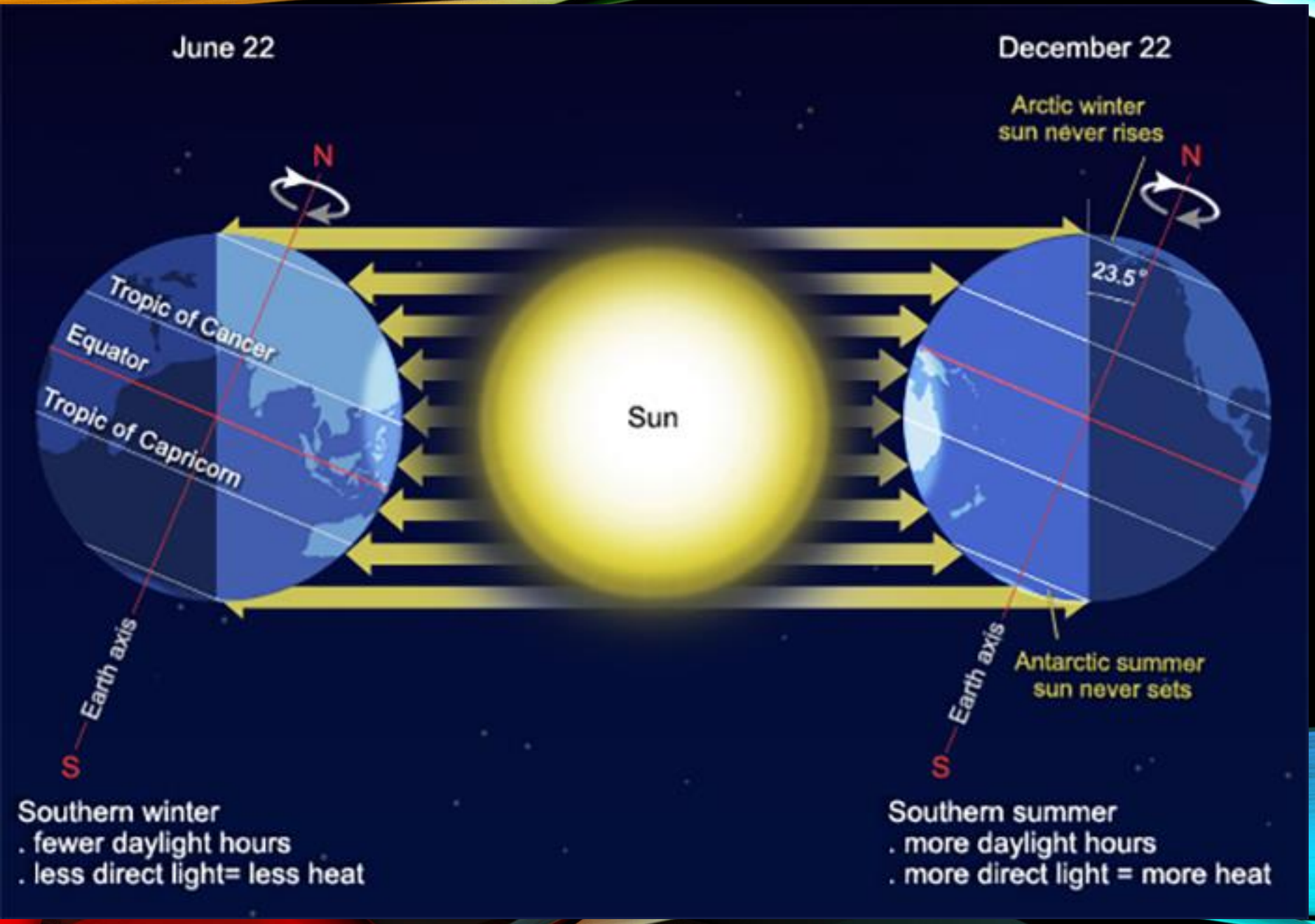
Projection: Plate Carree (-150,0000)

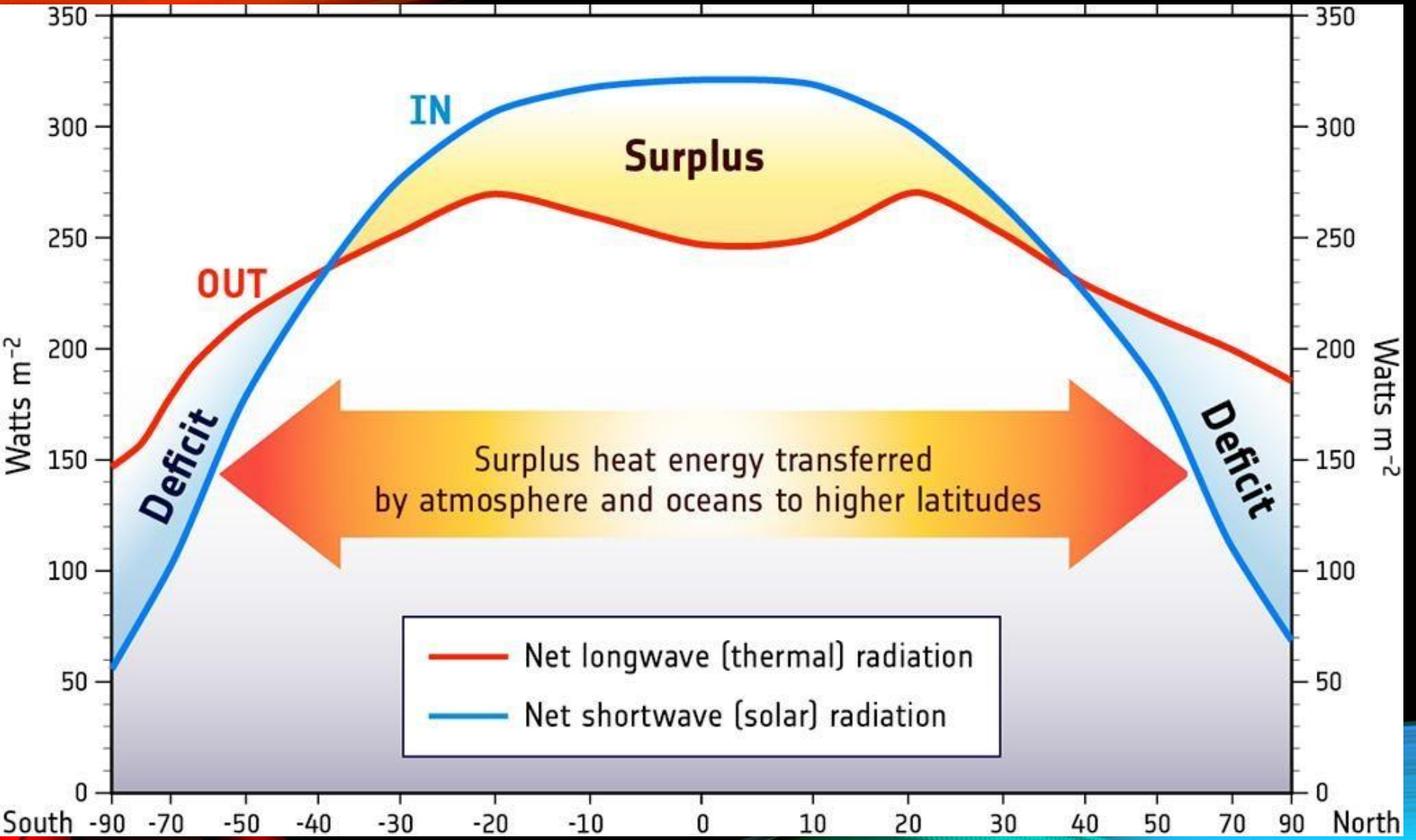
human activities on the ocean.

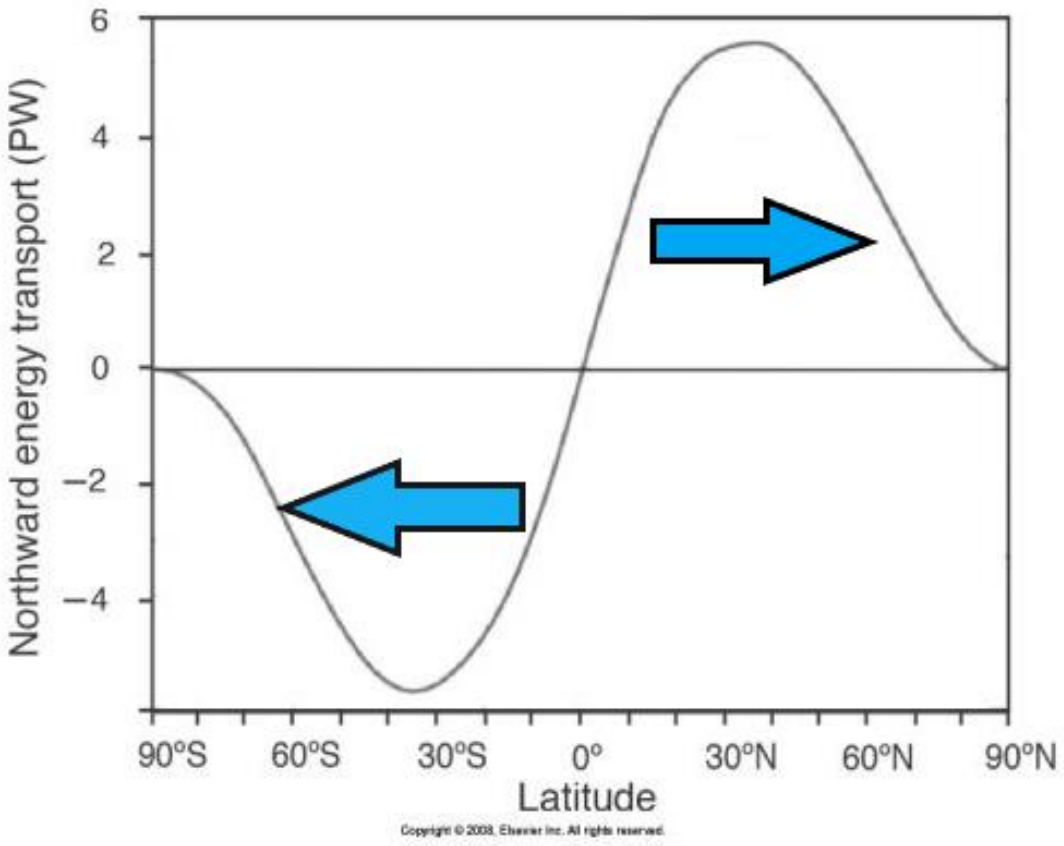


*A cast is a set of measurements for a single variable, such as temperature or salinity at different depths.
†CTD, high-resolution sensor of conductivity, temperature and depth.


Global average ocean temperature anomaly
depth (m)
200
400
600
800
1000
1200
1400
1600
1800
2006
2008
2010
2012
2014
2016
2018
2020
year
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
degrees C

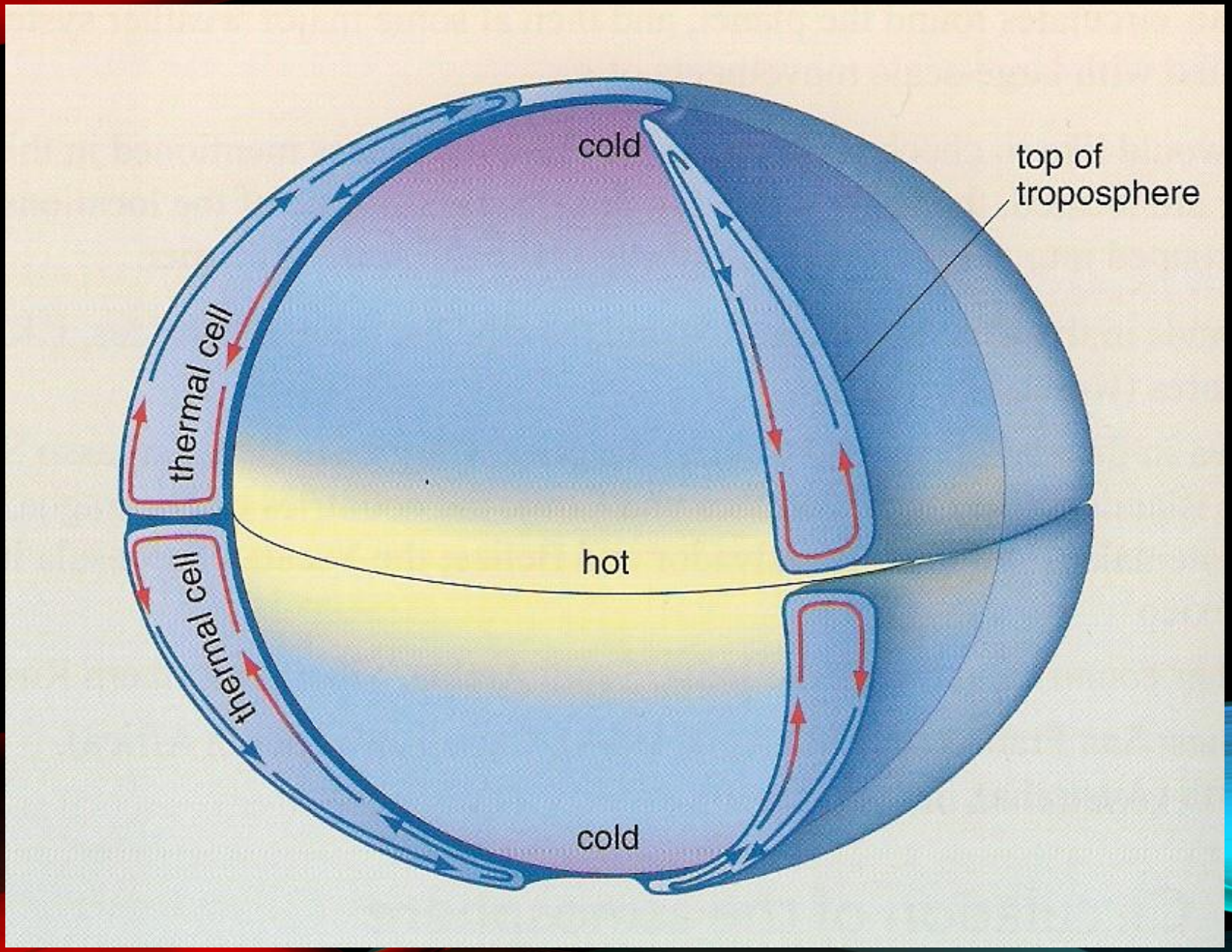

June 22
December 22
Arctic winter
sun never rises
N
N
23.5°
Tropic of Cancer
Equator
Tropic of Capricorn
Sun
Earth axis
Earth axis
S
S
Antarctic summer
sun never sets
Southern winter
. fewer daylight hours
. less direct light= less heat
Southern summer
. more daylight hours
. more direct light = more heat

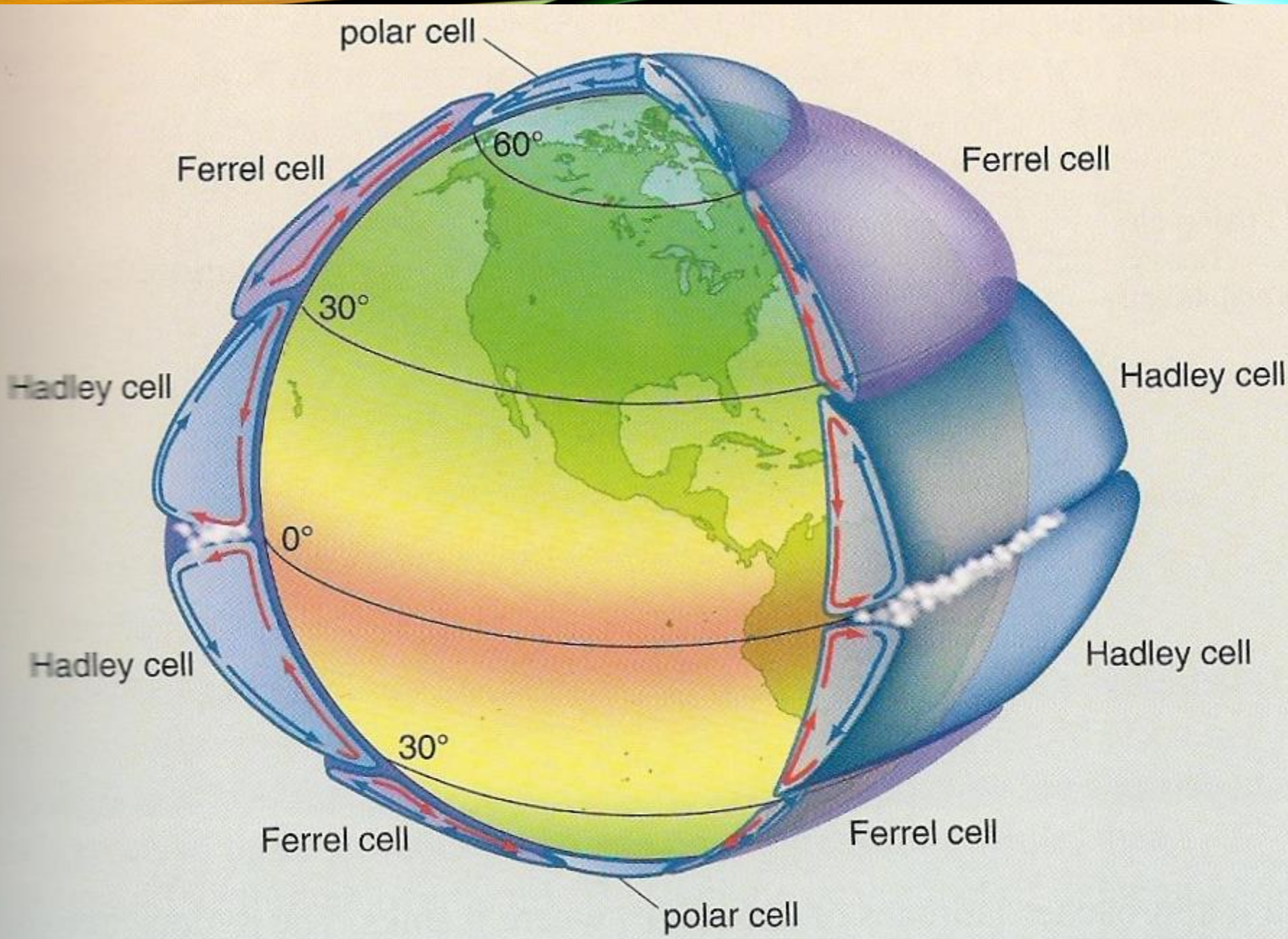

IN
Surplus
OUT
Deficit
Deficit
Surplus heat energy transferred
by atmosphere and oceans to higher latitudes
Net longwave (thermal) radiation
Net shortwave (solar) radiation
Watts m-2
Watts m-2
350
300
250
200
150
100
50
0
South
-90
-70
-50
-40
-30
-20
-10
0
10
20
30
40
50
70
90
North

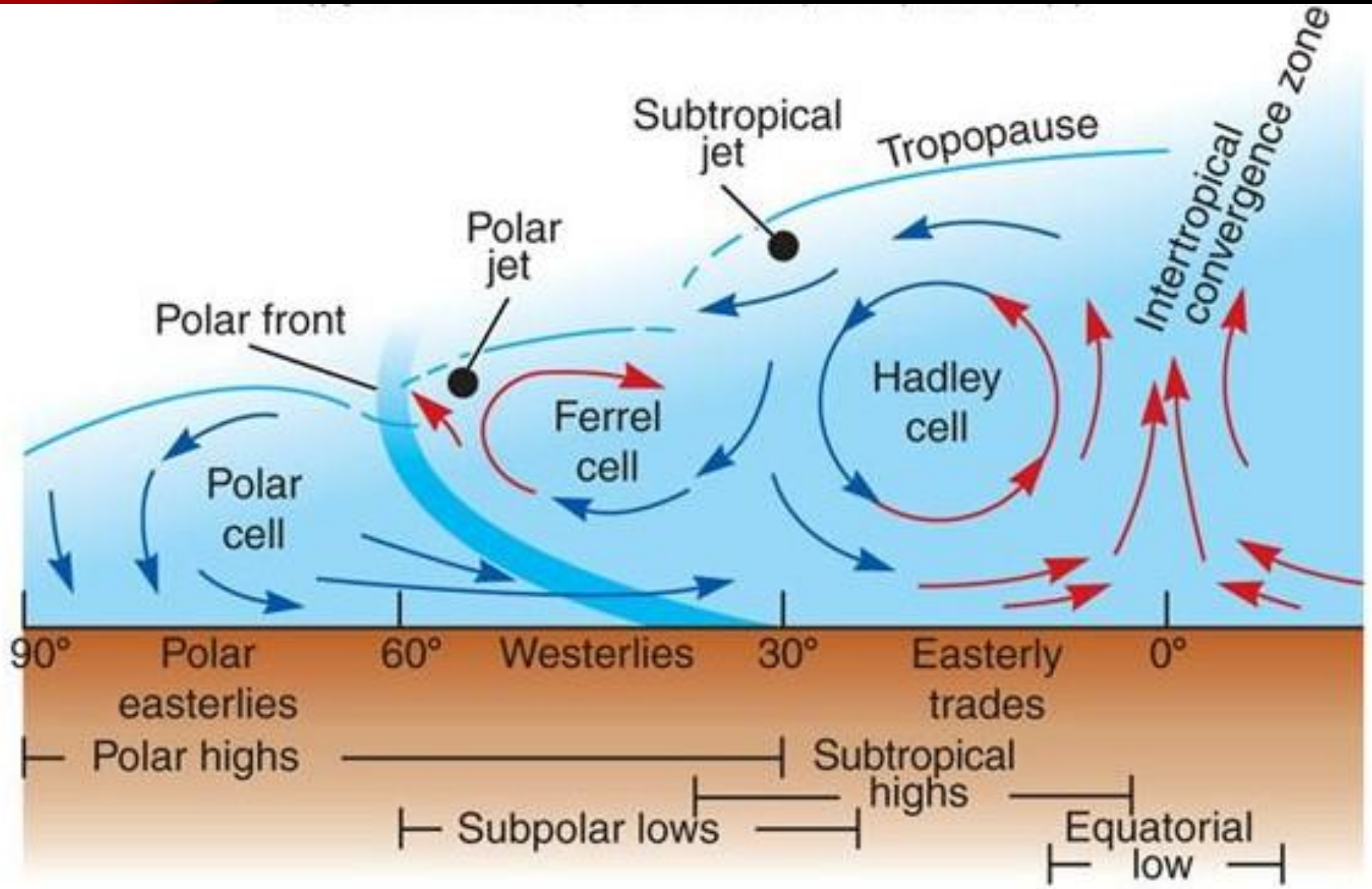


Heat transport is poleward

The Circulation Concept proposed by Hadley

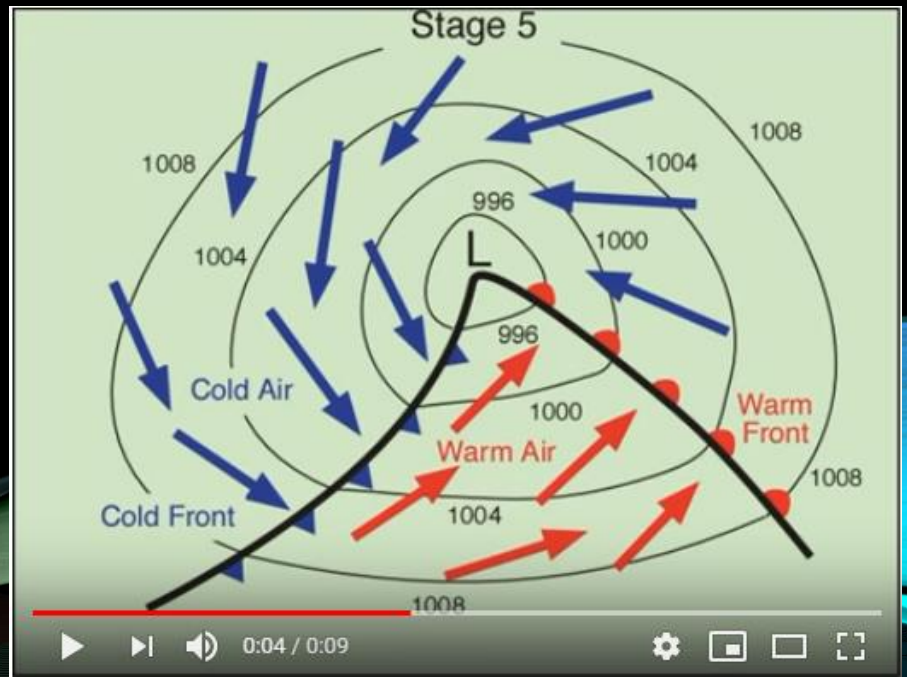



polar cell
60°
Ferrel cell
Ferrel cell
30°
Hadley cell
Hadley cell
0°
Hadley cell
Hadley cell
30°
Ferrel cell
Ferrel cell
polar cell


Subtropical jet
Tropopause
Intertropical convergence zone
Polar jet
Polar front
Hadley cell
Ferrel cell
Polar cell
90°
Polar easterlies
60°
Westerlies
30°
Easterly trades
0°
Polar highs
Subtropical highs
Subpolar lows
Equatorial low

Ferrel Cell

- Not a continuous cell, rather it is the nett effect of the various fronts and lows
- Look at weather map – and what happens with fronts (e.g. summer in Melbourne)
- Warm tropical air brought polewards and cold polar air moved northwards
- This evens out the differences in temperature – and explains why the temperature in the mid-latitudes (e..g. Melbourne) can vary so much from day to day.



California Academy of Sciences – why we have seasons
https://youtu.be/WgHmqv_-UbQ

Understanding global atmospheric circulation (Clickview)
https://youtu.be/PFxpJkMXhwg

Other videos:

Met Office - How does the climate system work?
https://youtu.be/lrPS2HiYVp8

Met Office - What is the global circulation – 1 differential heating
https://youtu.be/7fd03fBRsuU

Met Office – What is the Global Circulation?
Part 2 The Three Cell Model
https://www.youtube.com/watch?v=xqM83_og1Fc

- Atmosphere: 4 PW
- Ocean 2 PW.

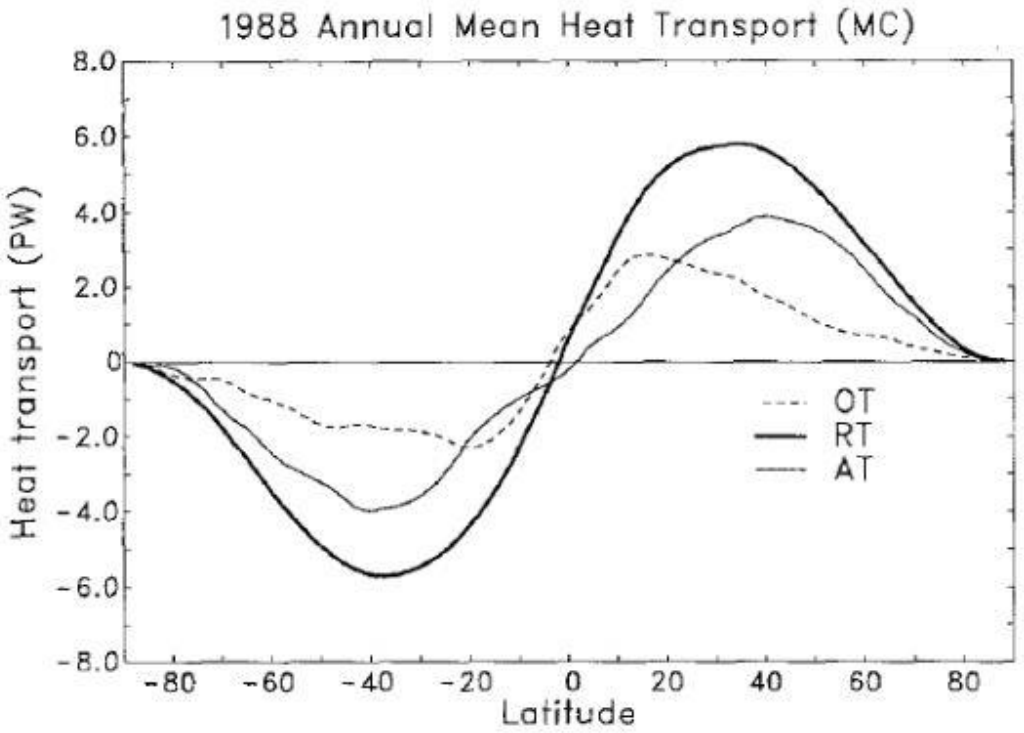
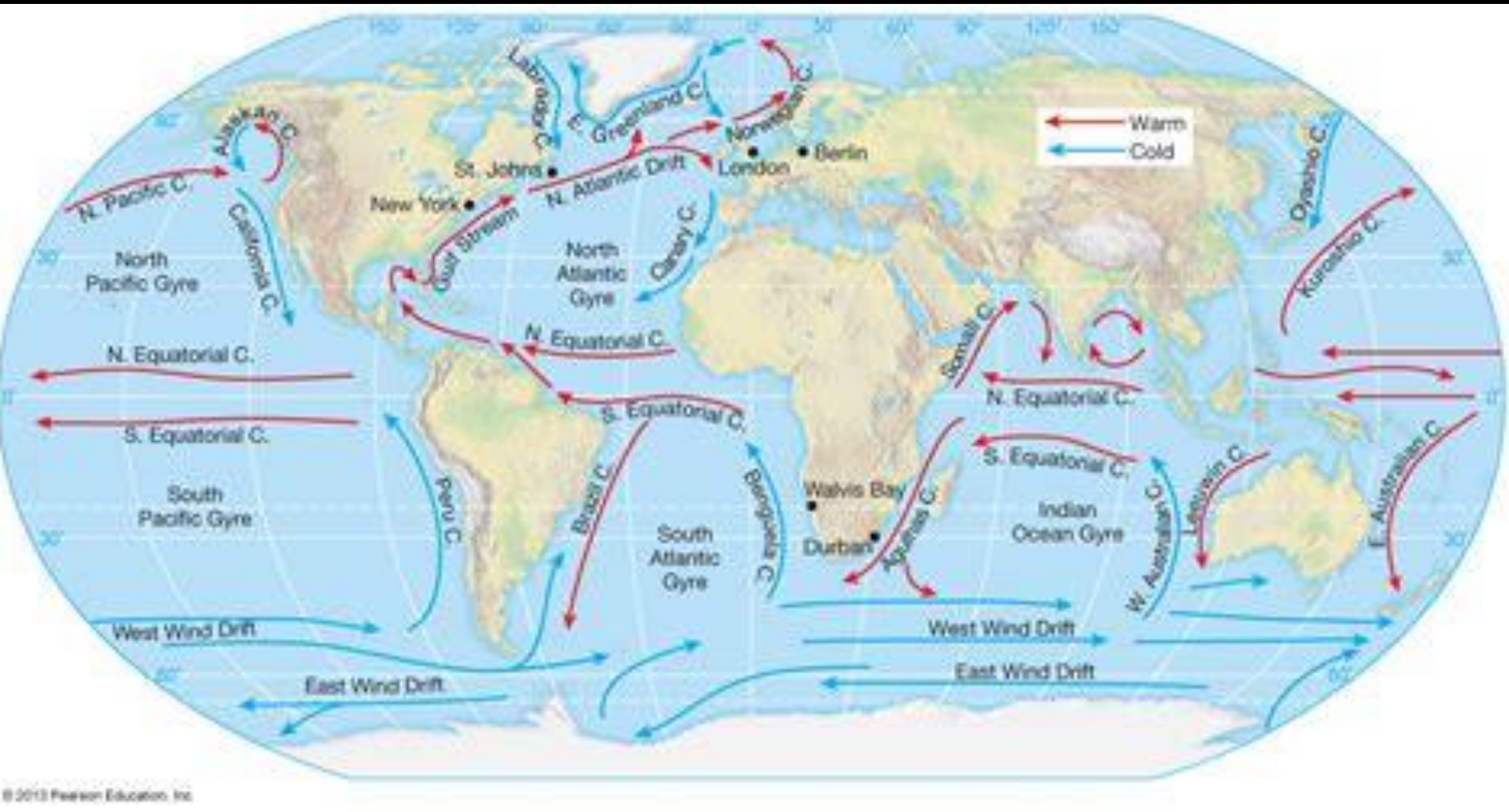
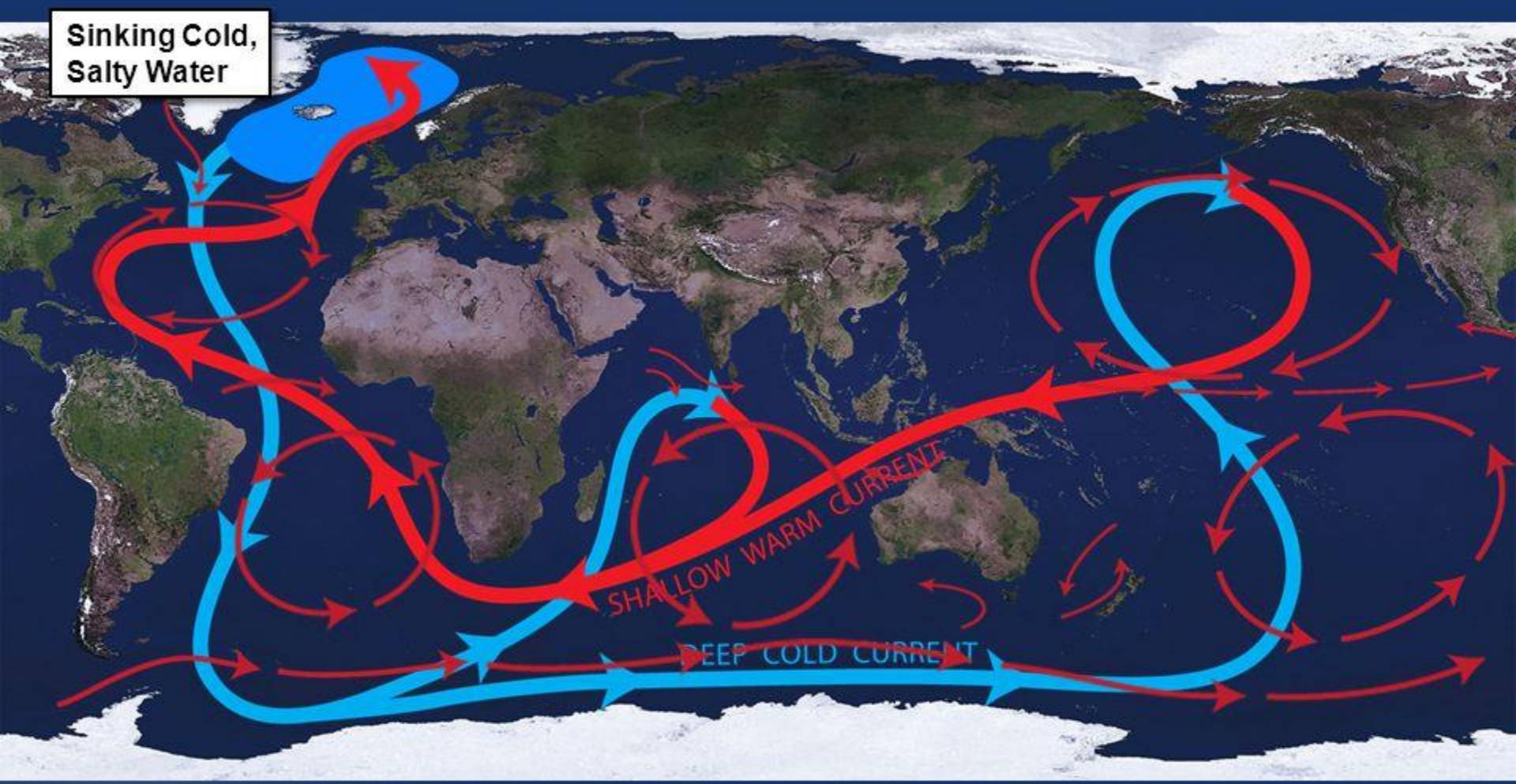


Fig. from Trenberth and Solomon (1994)

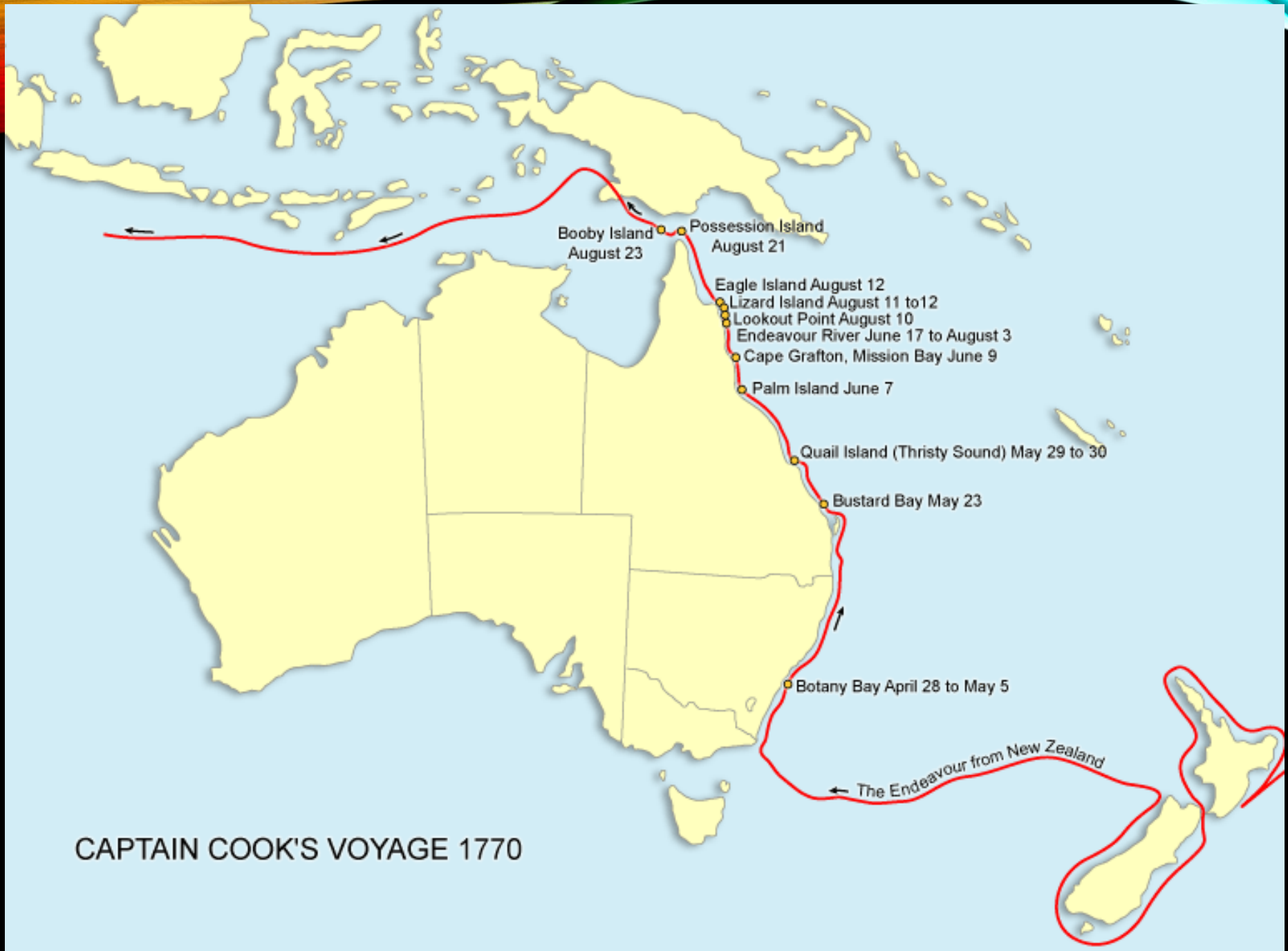
Wind driven ocean currents

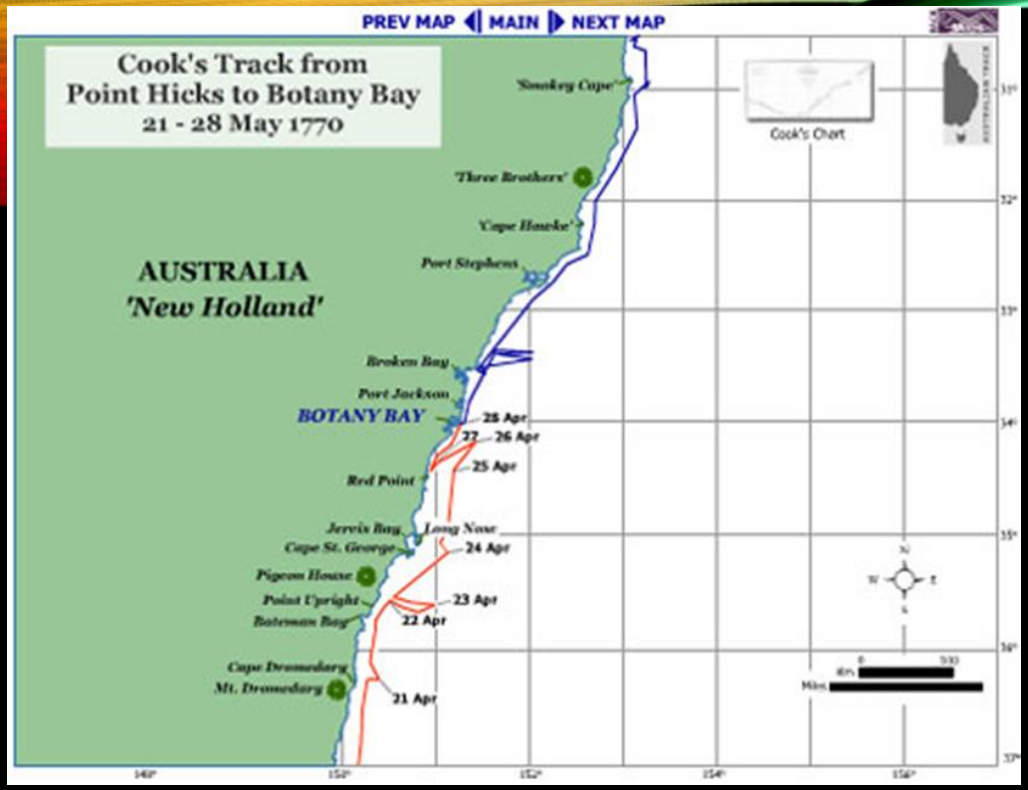


Global Conveyor Belt



Deeper ocean circulations – driven by heat and salinity

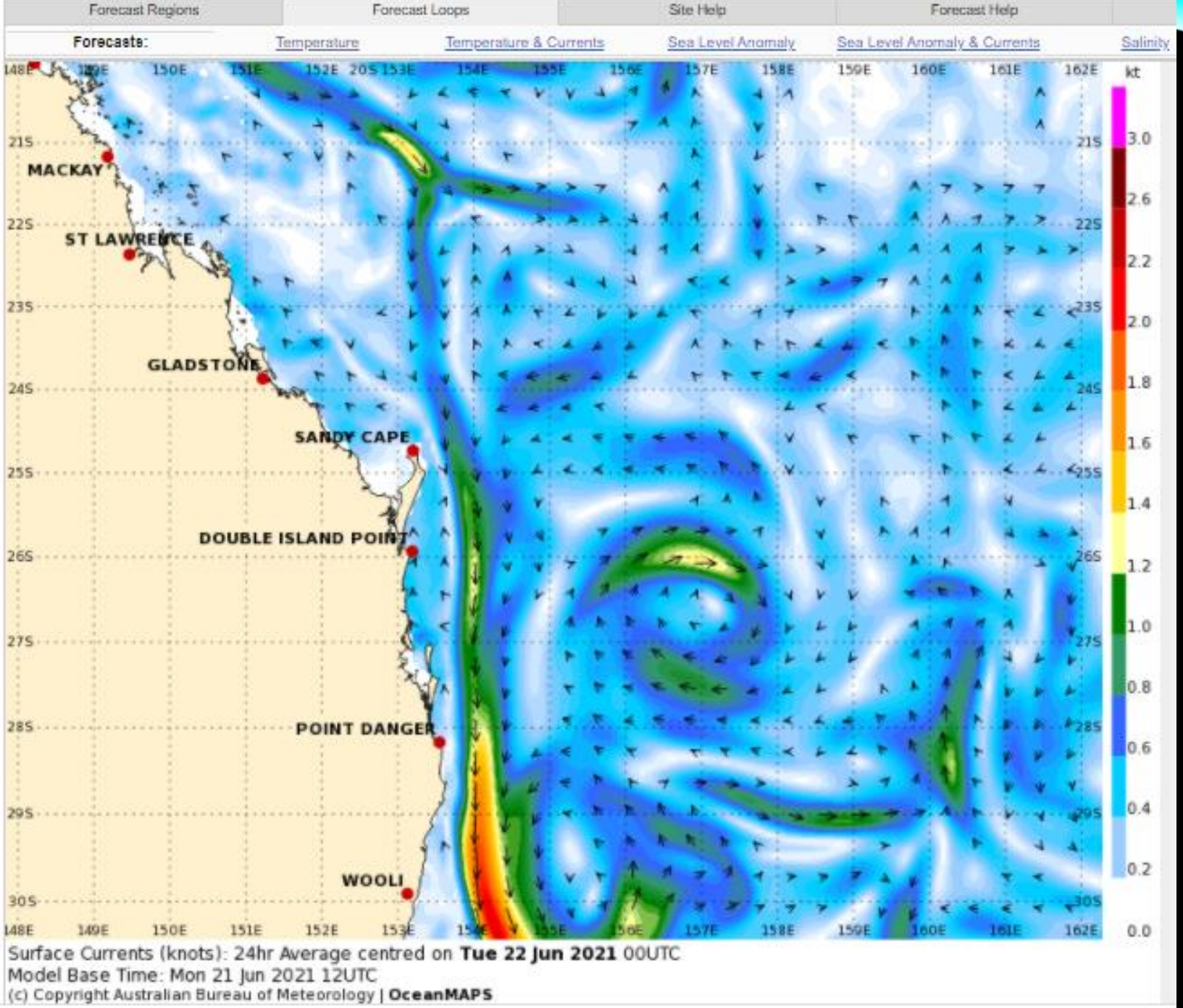

Booby Island
August 23
Possession Island
August 21
Eagle Island August 12
Lizard Island August 11 to12
Lookout Point August 10
Endeavour River June 17 to August 3
Cape Grafton, Mission Bay June 9
Palm Island June 7
Quail Island (Thristy Sound) May 29 to 30
Bustard Bay May 23
Botany Bay April 28 to May 5
The Endeavour from New Zealand
CAPTAIN COOK'S VOYAGE 1770

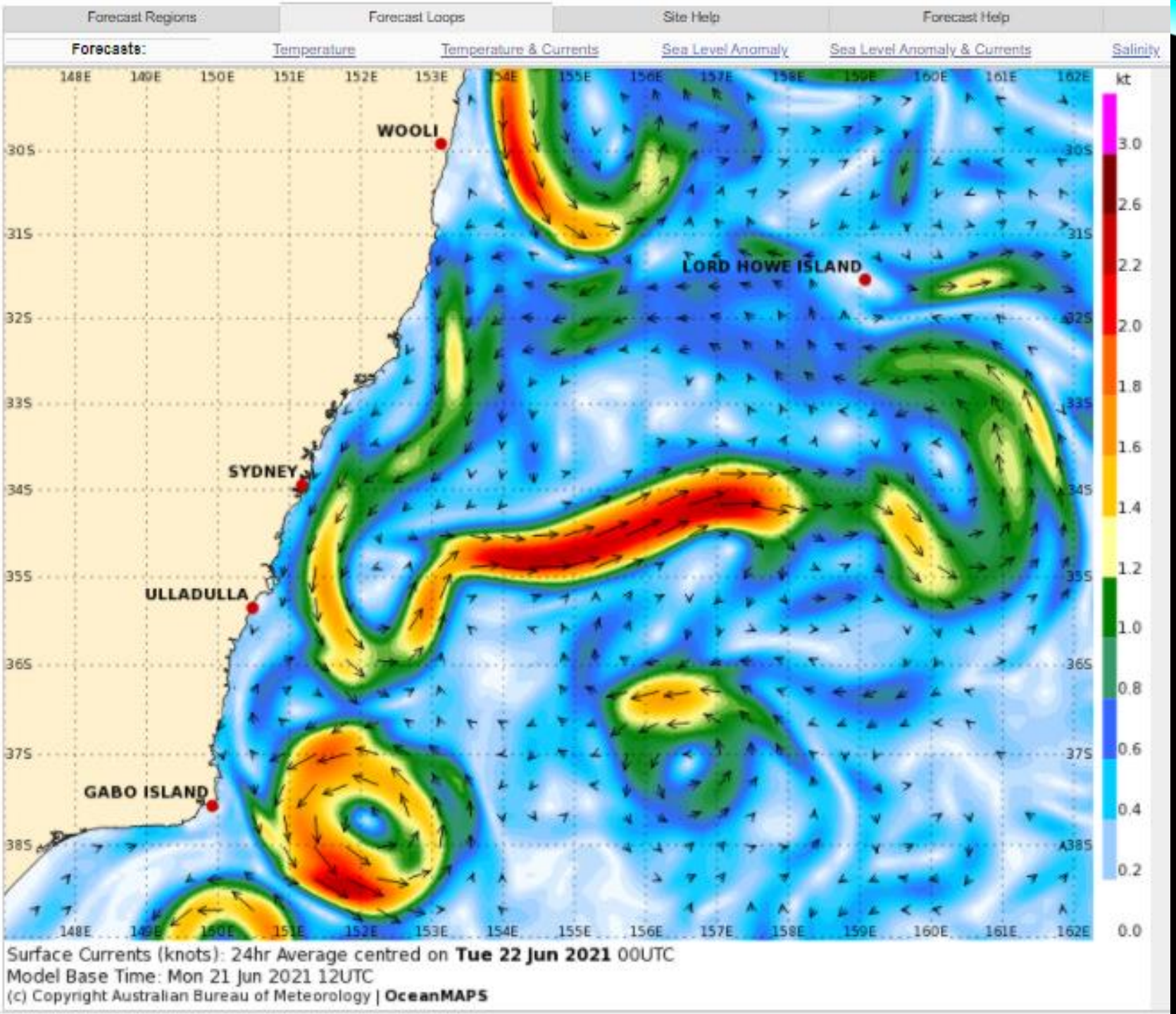


Discovery of East Australian Current

Cook's journal for 22 April in the Jervis Bay region:
"At midnight being in 70 fathom water we brought too until 4 AM at which time we made sail in for the land and at daylight found ourselves nearly in the same place we were at 5 o'Clock in the evening by which it was apparent we had drove about 3 leagues to the southward by a tide or current in the night.

For these two days the observed latitude has been 12 or 14 miles to the southward of the ships account given by the Log ***which can be owing to nothing but a current setting to the Southward.*** "


Forecast Regions
Forecast Loops
Site Help
Forecast Help
Forecasts:
Temperature
Temperature & Currents
Sea Level Anomaly
Sea Level Anomaly & Currents
Salinity
MACKAY
ST LAWRENCE
GLADSTONE
SANDY CAPE
DOUBLE ISLAND POINT
POINT DANGER
WOOLI
kt
3.0
2.6
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Surface Currents (knots): 24hr Average centred on Tue 22 Jun 2021 00UTC
Model Base Time: Mon 21 Jun 2021 12UTC
(c) Copyright Australian Bureau of Meteorology | OceanMAPS


Forecast Regions
Forecast Loops
Site Help
Forecast Help
Forecasts:
Temperature
Temperature & Currents
Sea Level Anomaly
Sea Level Anomaly & Currents
Salinity
WOOLI
LORD HOWE ISLAND
SYDNEY
ULLADULLA
GABO ISLAND
kt
3.0
2.6
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Surface Currents (knots): 24hr Average centred on Tue 22 Jun 2021 00UTC
Model Base Time: Mon 21 Jun 2021 12UTC
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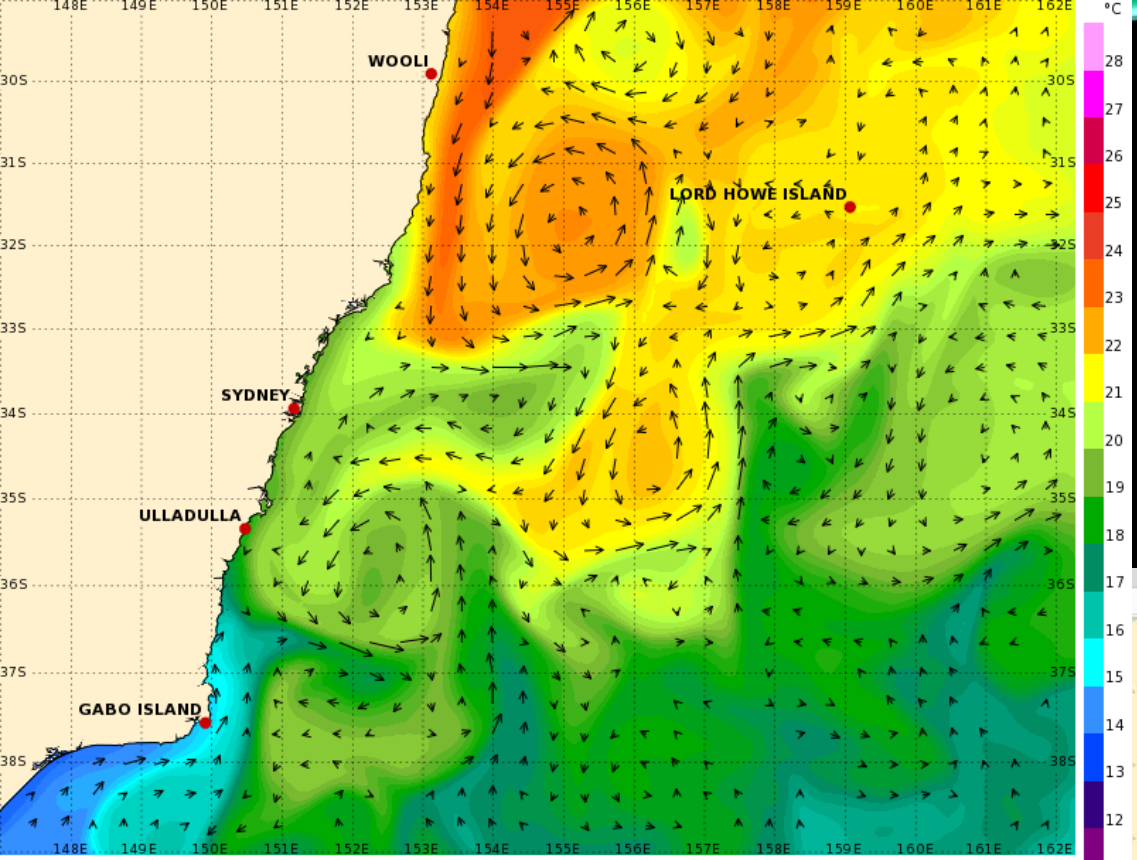
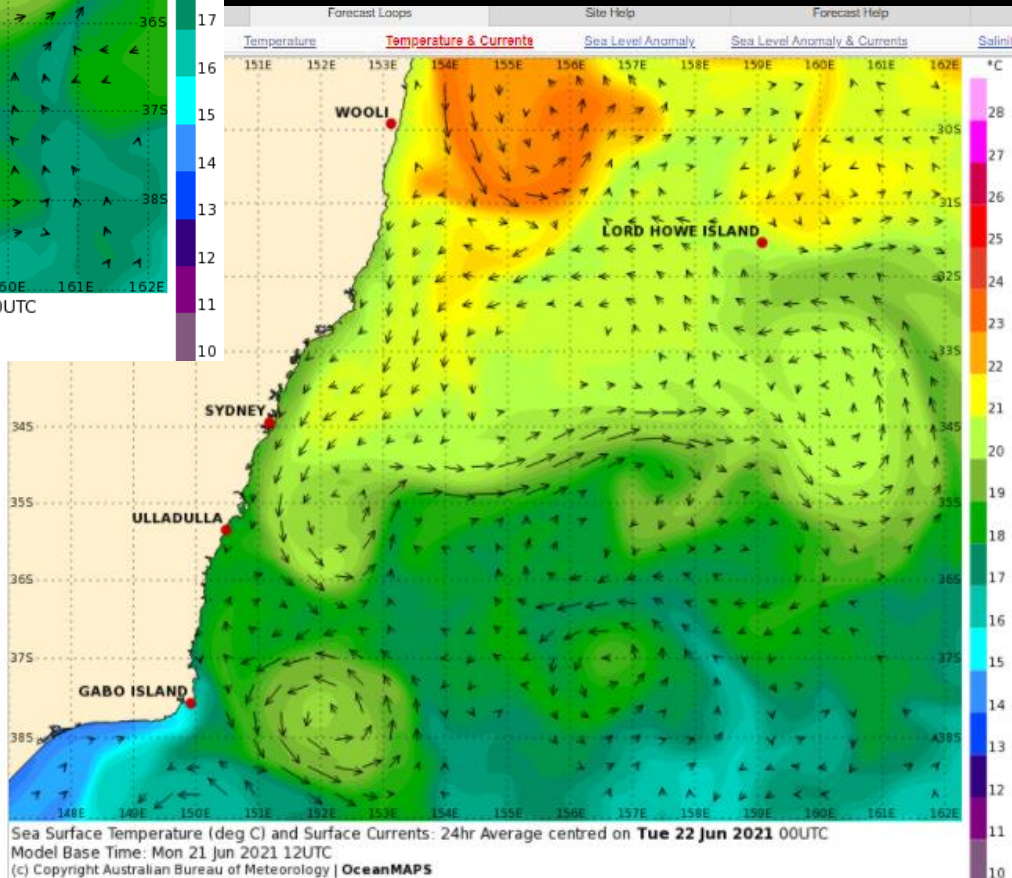


Sea Surface Temperature (deg C) and Surface Currents: 24hr Average centred on **Wed 17 Jun 2020** 00UTC
Model Base Time: Tue 16 Jun 2020 12UTC
(c) Copyright Australian Bureau of Meteorology | **OceanMAPS**

17 June 2020

22 June 2021



Sea Surface Temperature (deg C) and Surface Currents: 24hr Average centred on **Tue 22 Jun 2021** 00UTC
Model Base Time: Mon 21 Jun 2021 12UTC
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