

# The Processes that shape our Weather and Climate

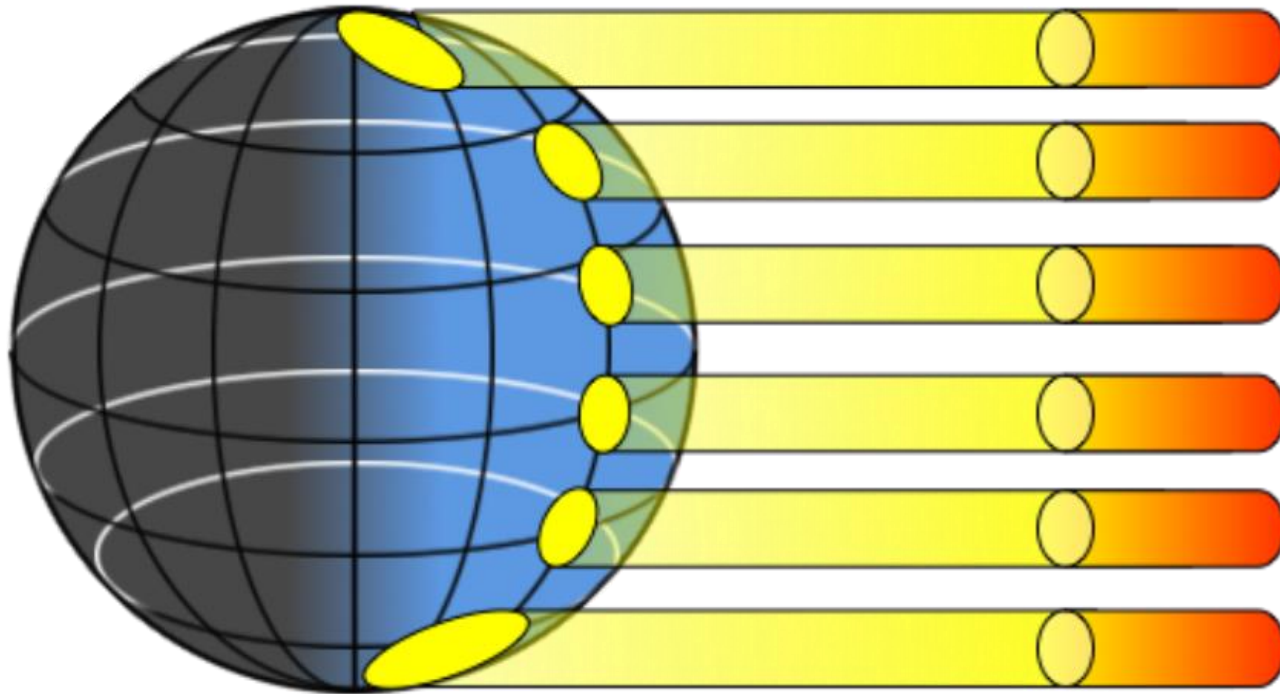


**Geographical Association Talk, 8 October 2024**  
**Donal Mullan, Queen's University Belfast**

# CCEA Unit AS 1: Physical Geography

<p><b>3 (a) The processes that shape our weather and climate</b></p>	<p>(i) demonstrate knowledge and understanding of the global energy balance, including vertical and horizontal heat transfers <b>in the atmosphere</b> and the role of ocean currents;</p> <p>(ii) demonstrate knowledge and understanding of the general circulation of the atmosphere, including surface pressure belts, winds, the tri-cellular model, jet streams and upper <b>westerly winds (in relation to the pressure gradient and Coriolis forces)</b> ; and</p> <p>(iii) explain the factors that influence <b>air</b> temperature, including latitude, <b>distance from the sea/continentality</b>, altitude, <b>ocean currents</b> and seasonality.</p>	<p>For (i) and (ii) study of global patterns of precipitation, surface temperature, pressure and winds</p> <p>For (iii) general reference to places for illustration purposes only</p>
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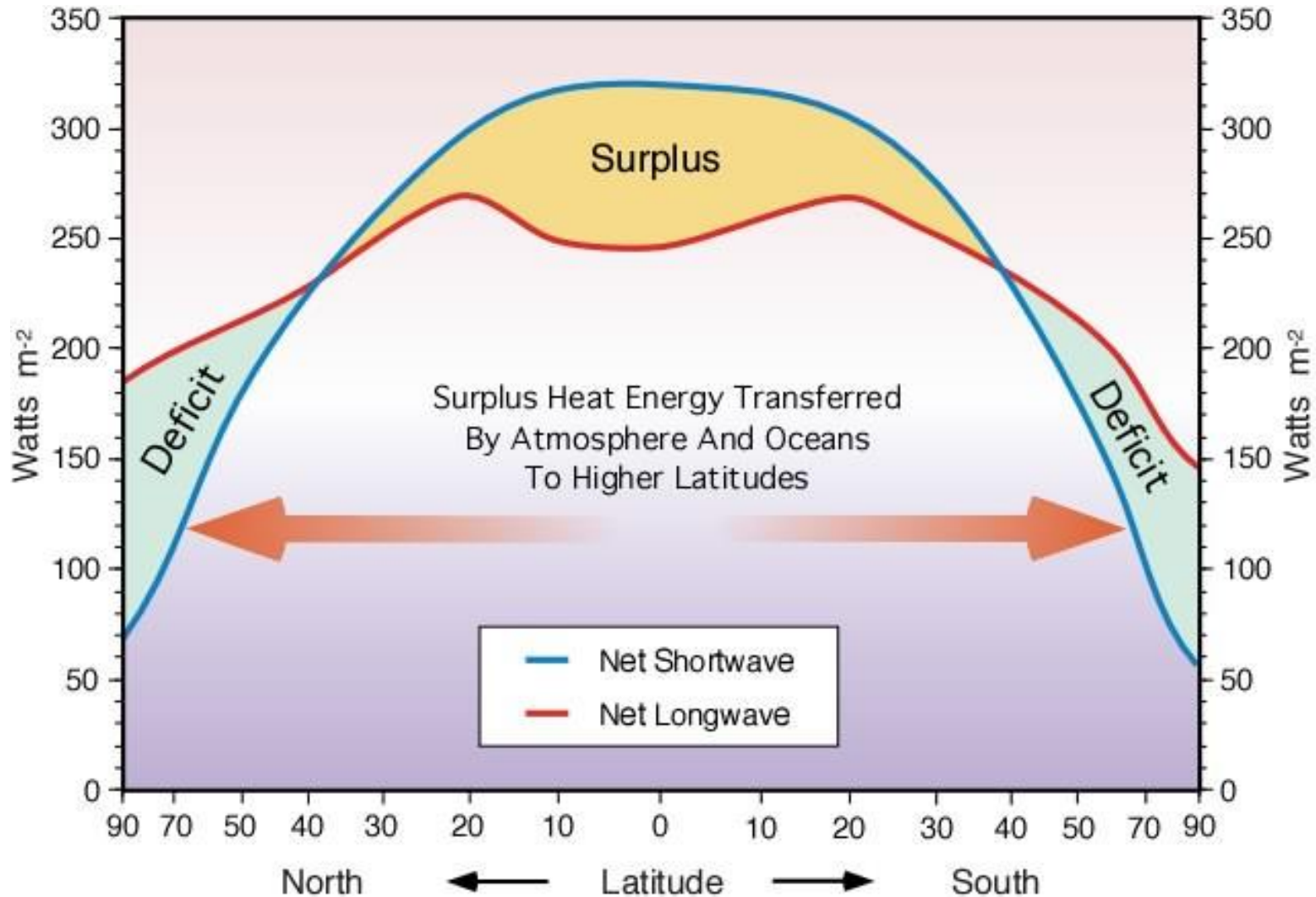
# Why does Earth receive unequal heating?



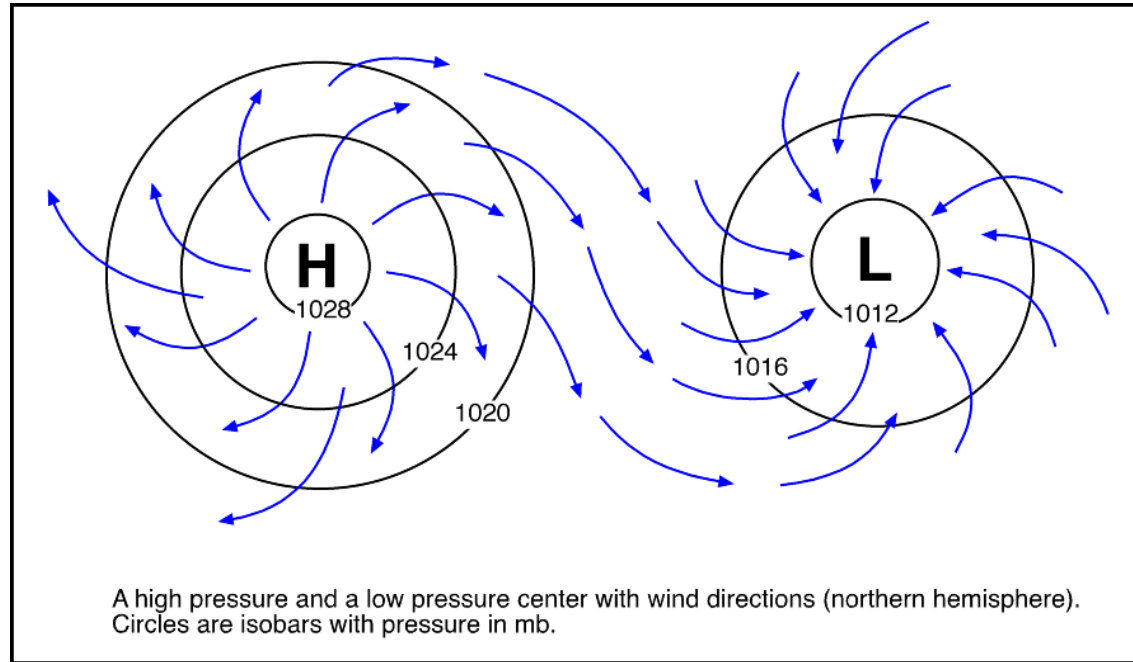
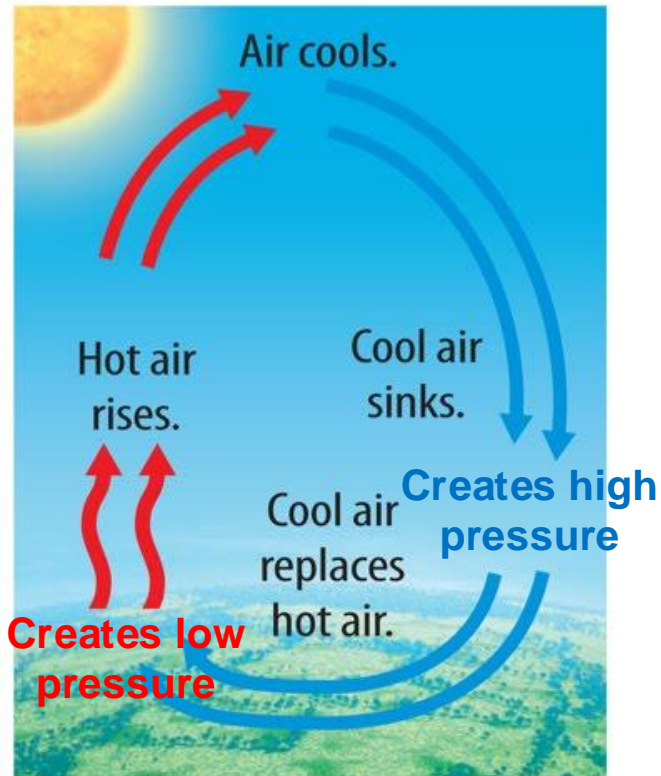
- Due to the curvature of the Earth
- Sun's rays have **less distance to travel near the Equator** and **farther to travel closer to the poles**
- Solar energy **more concentrated near the Equator** and **more dispersed closer to the poles** (beam spreading)



# Global Radiation Balance



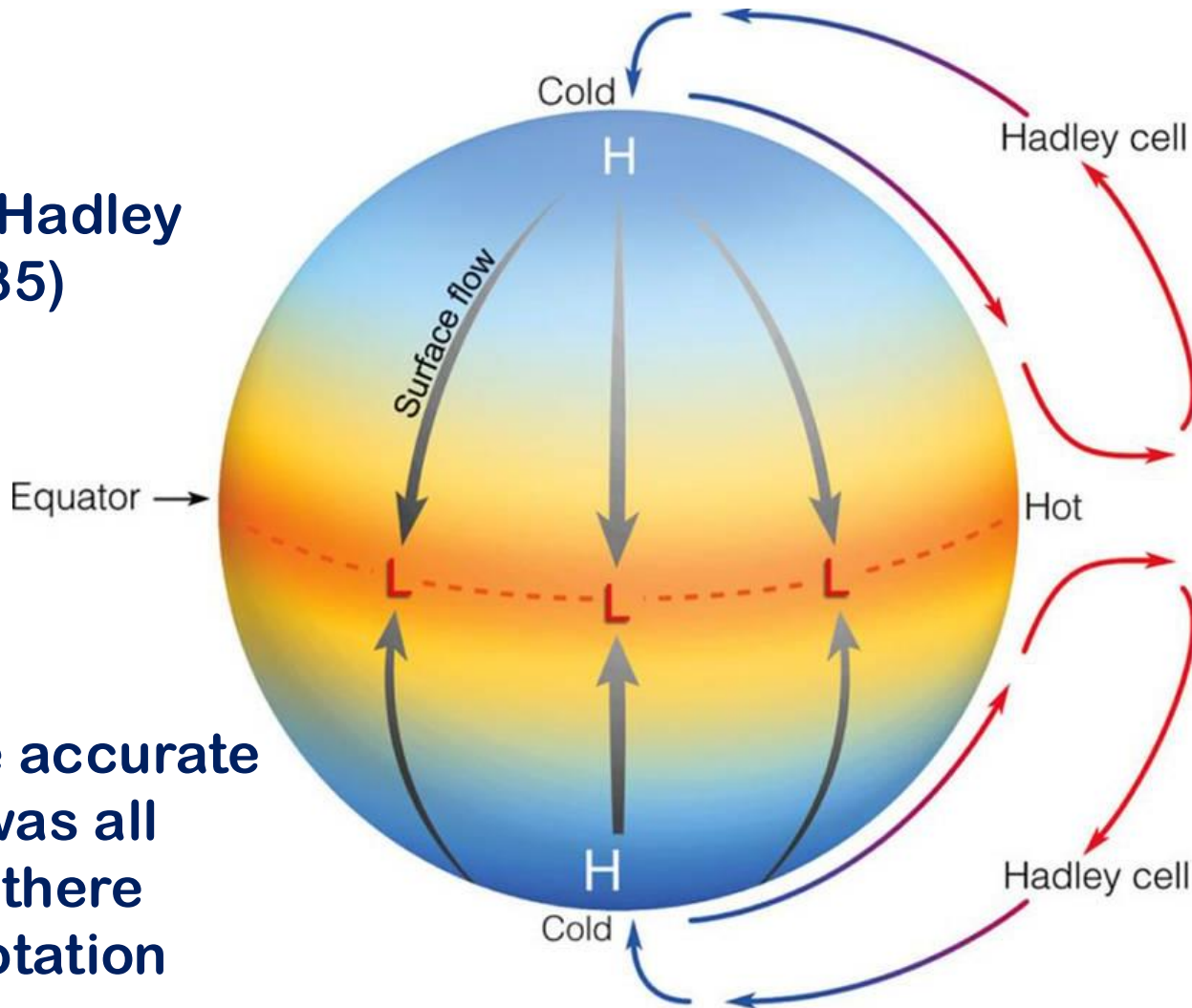
# This causes Atmospheric Motion!



- Differences in **temperature** create differences in **air pressure**
- Differences in **air pressure** drive atmospheric motion (winds)
- Therefore, unequal heating of the Earth causes winds!

# Single-cell Circulation Model

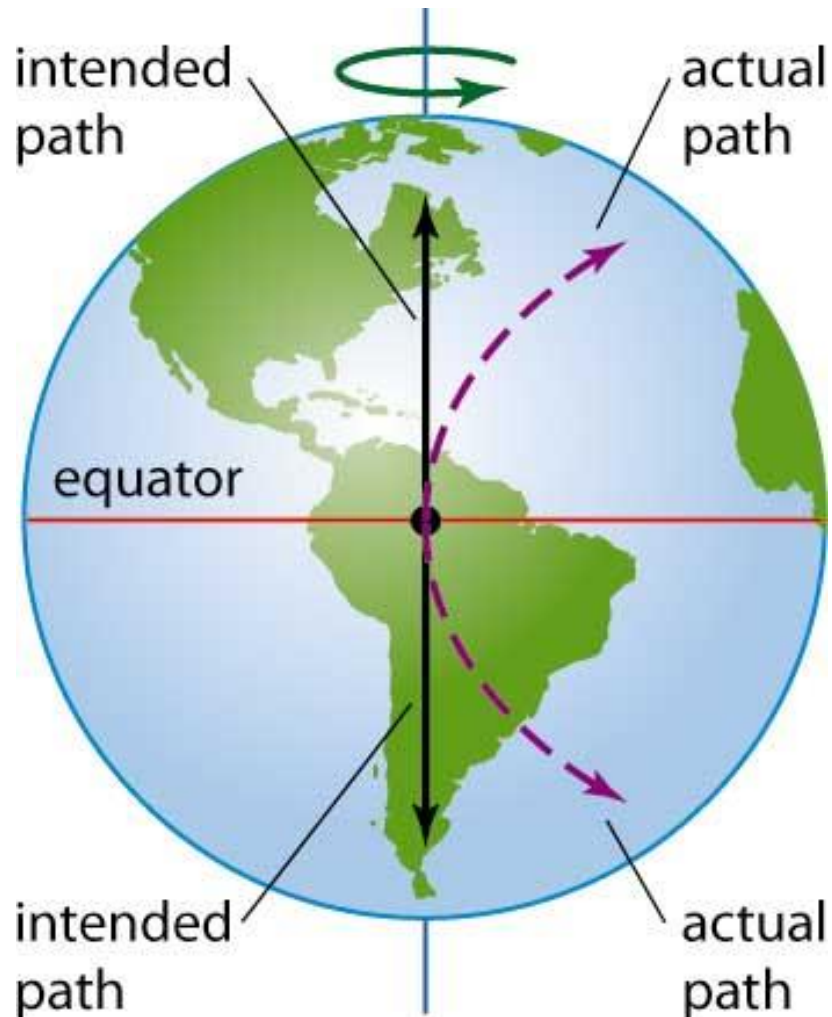
George Hadley  
(1735)



Would be accurate  
if Earth was all  
land and there  
was no rotation

# Coriolis Effect

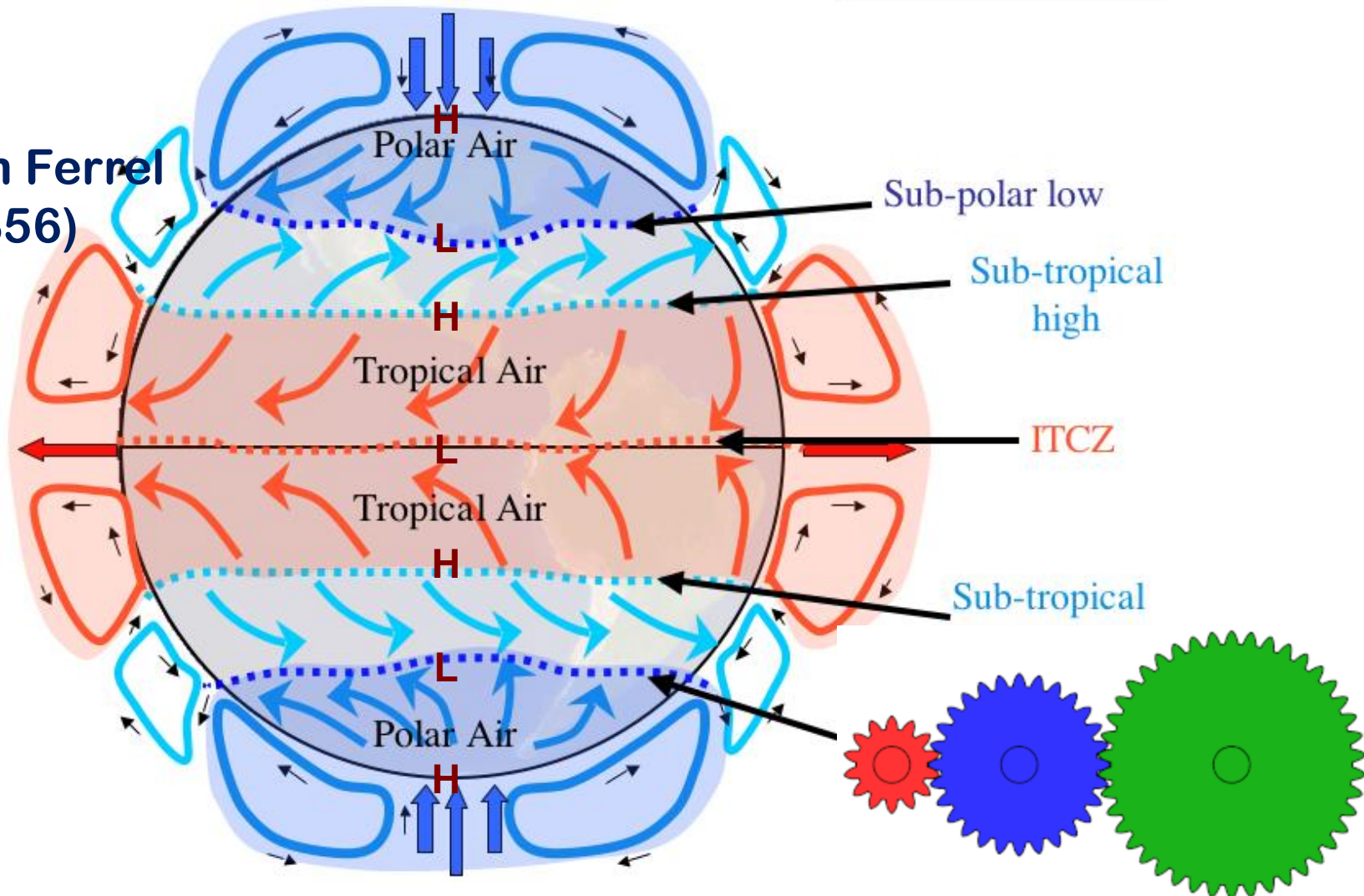
- But the Earth is ~ 71% ocean!
- And it rotates!
- Winds deflected to the right in the northern hemisphere
- Winds deflected to the left in the southern hemisphere





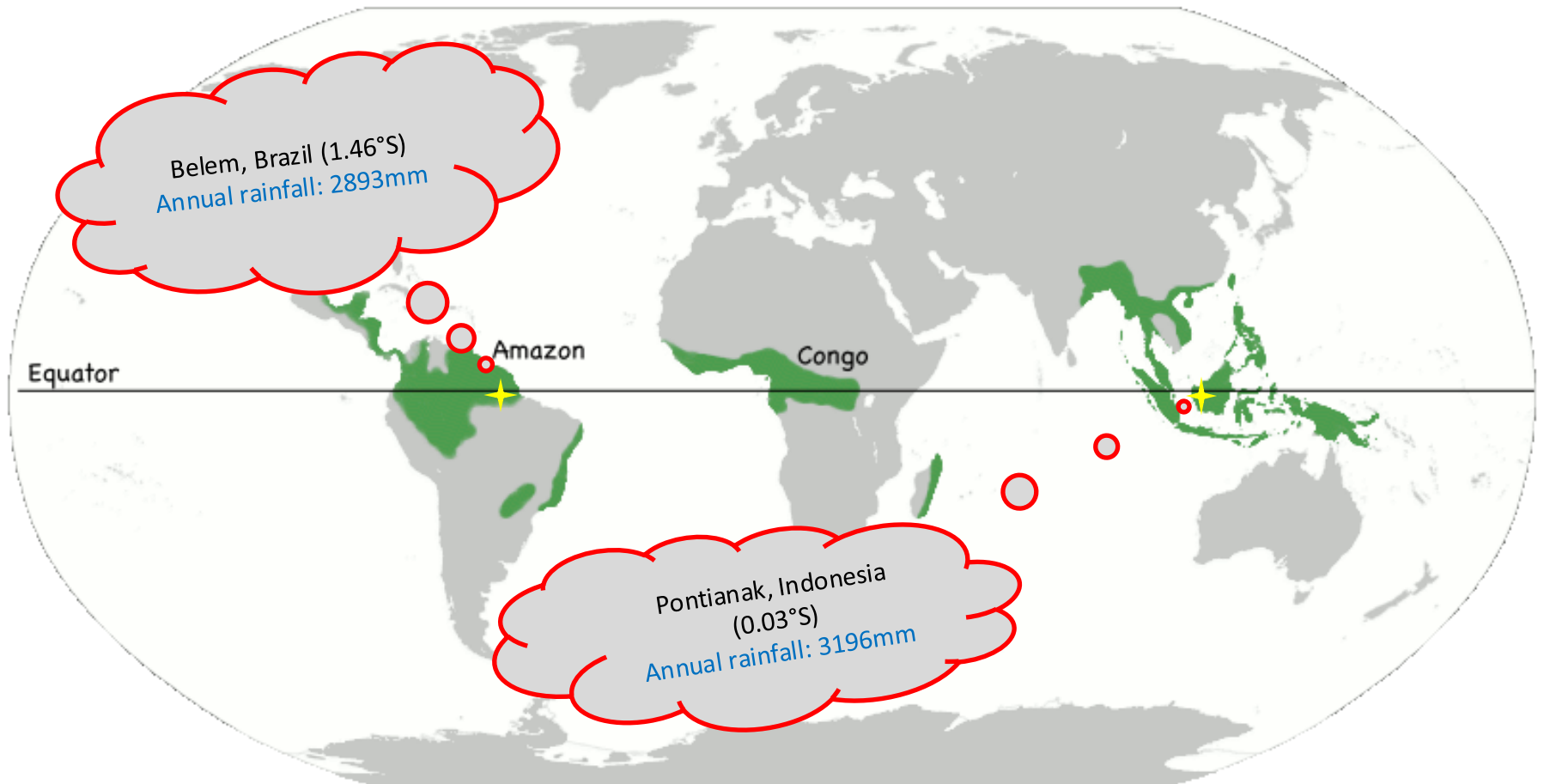
# Three-cell Circulation Model

William Ferrel  
(1856)

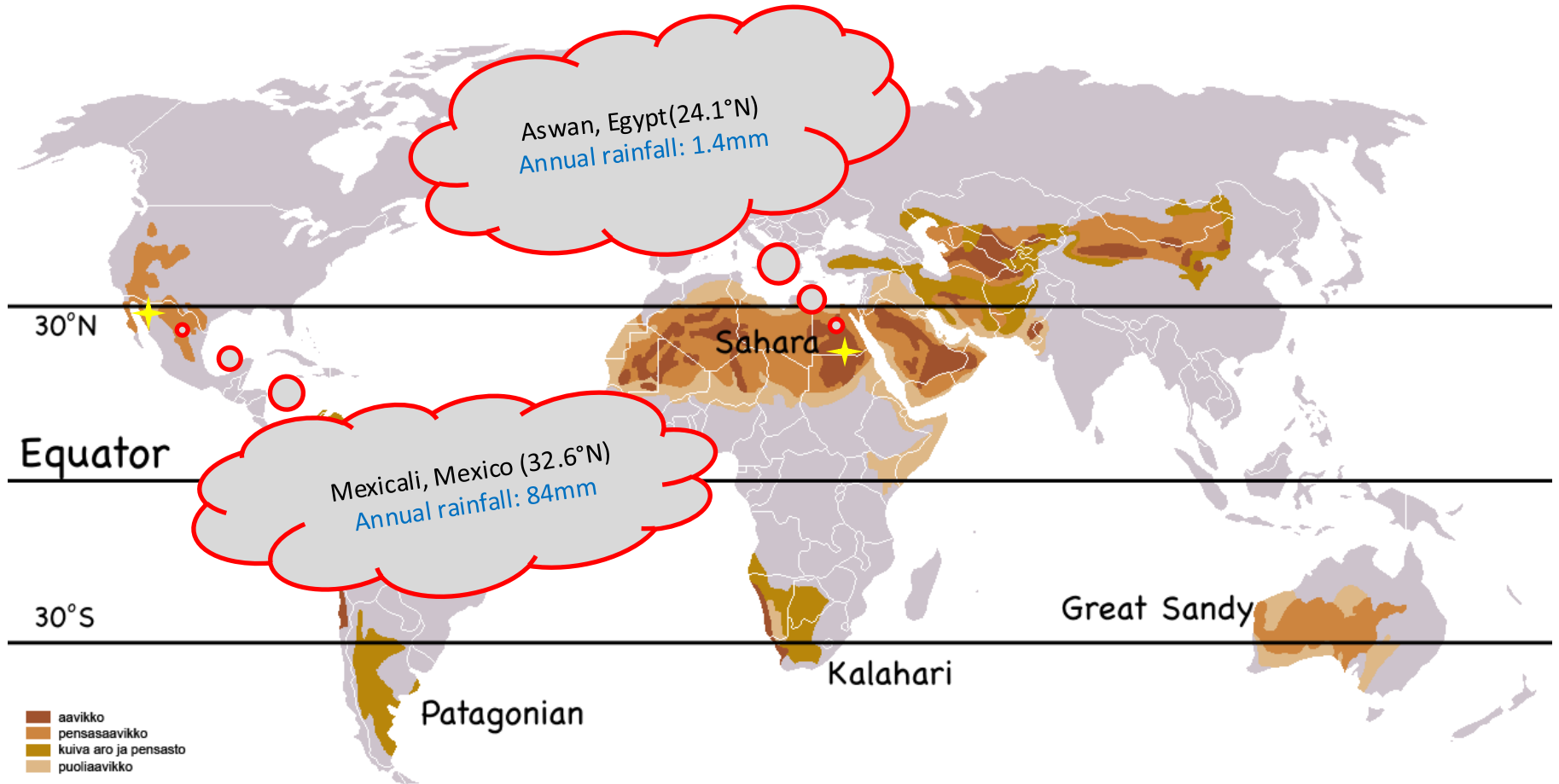




# Explains the geography of rainforests



# Explains the geography of deserts



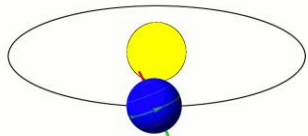
# Shifting Pressure Patterns

Timbuktu, Mali (16.76°N)  
JJA rainfall: 117.6mm  
DJF rainfall: 0.9mm

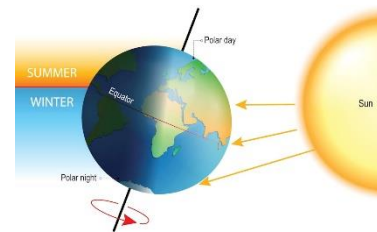
Dodoma, Tanzania (6.2°S)  
JJA rainfall: 0.1mm  
DJF rainfall: 401.1mm

July ITCZ

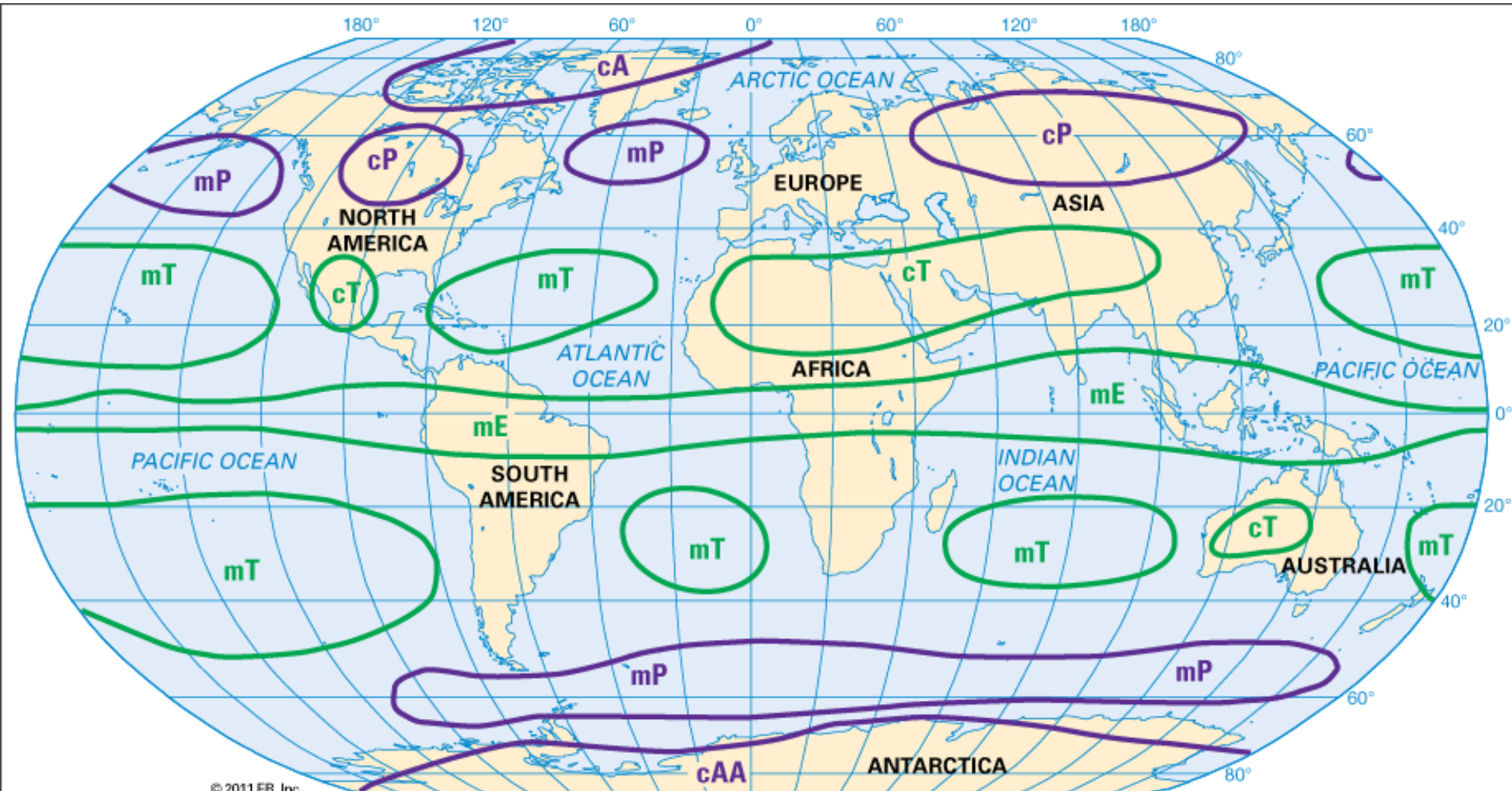
January ITCZ



EARTH'S SEASONS



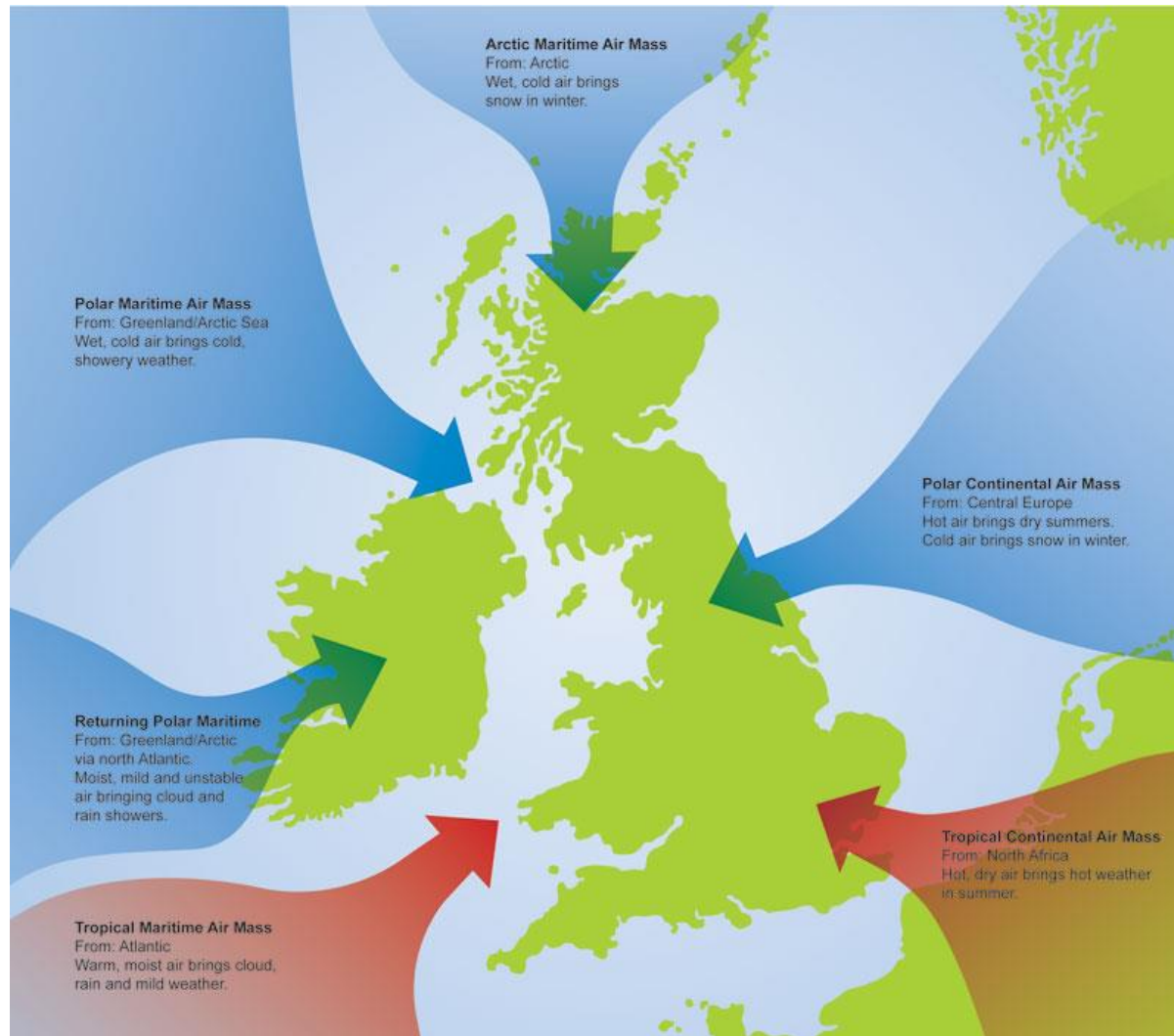
# Global Air Masses



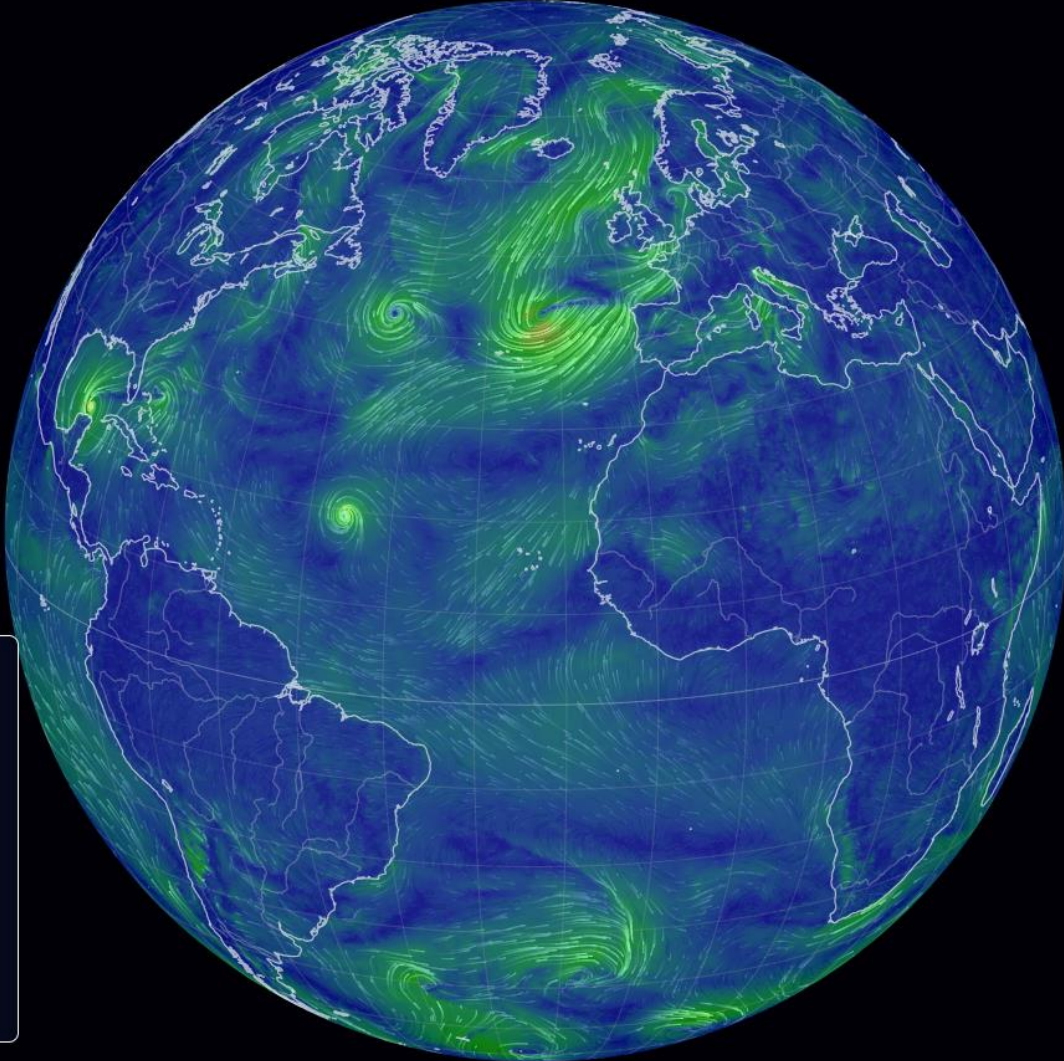
c = continental; m = maritime; P = polar; T = tropical; A = Arctic; AA = Antarctic; E = Equatorial

















# Air Masses affecting UK & Ireland

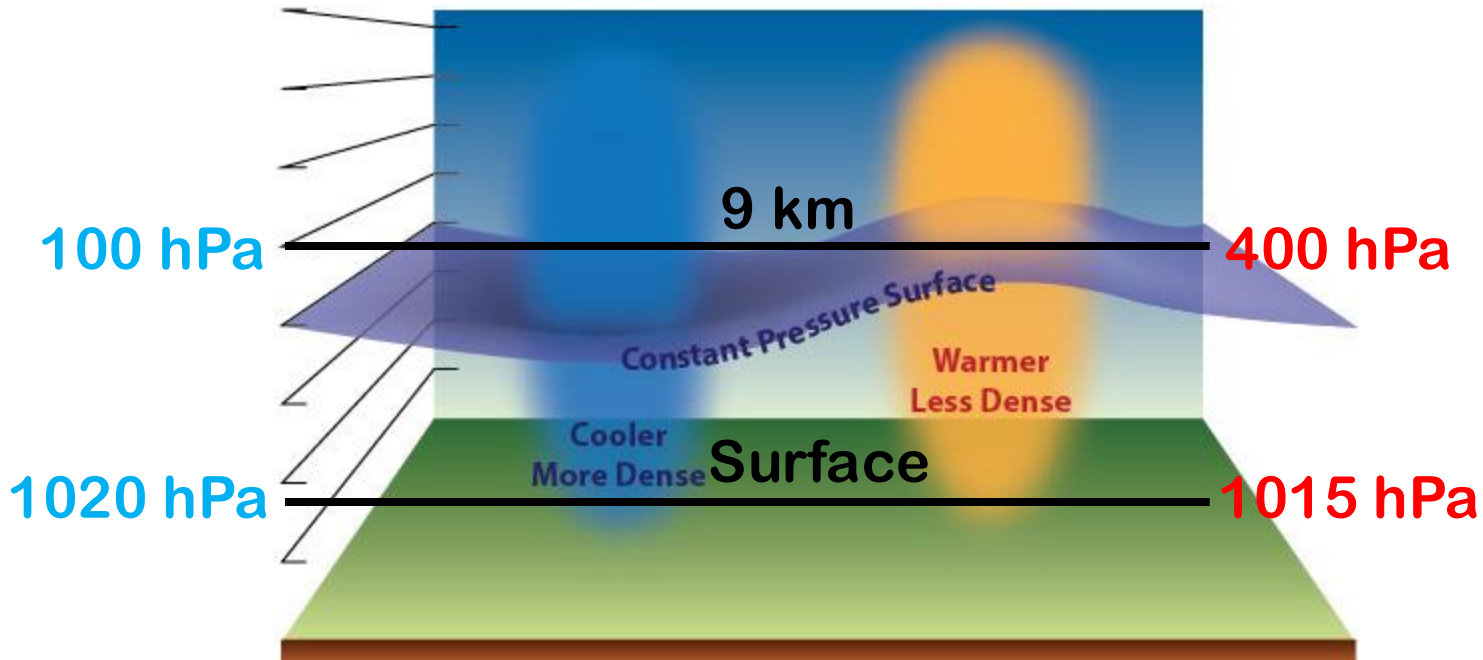


# Surface winds right now!



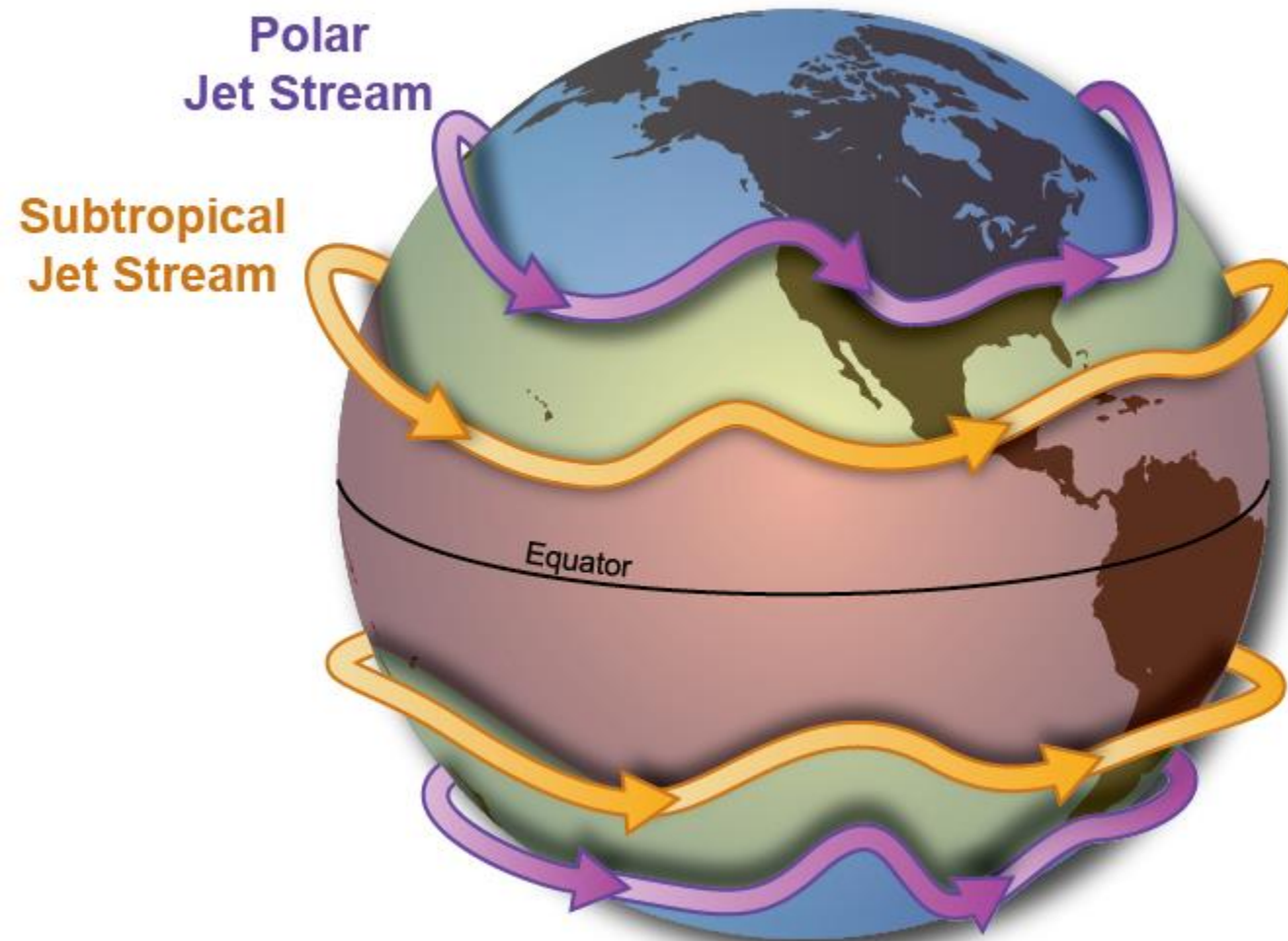
Data | Wind @ Surface  
Date | 2024-10-08 17:00 Local  $\approx$ UTC  
Source | GFS / NCEP / US National Weather Service  
Scale |   
Control | Now      Grid  HD   
Mode | Air Ocean Chem Particulates Space Bio  
Animate | Wind Currents Waves  
Height | Sfc 1000 850 700 500 250 70 10 hPa  
Overlay | Wind Temp RH Dew WBT 3HPA CAPE  
TPW TCW MSLP MI UVI WPD None  
Projection | A CE E  P S WB W3  
about      feedback 

# Wind speeds are much faster higher up!



- Less obstacles higher up in the atmosphere
- Huge differences in air pressure with height
- Differences highest between warm and cold air
- Creates huge **pressure gradient force**

# This explains the Jet Streams



- Core of strong winds 5-7 miles high, blowing W to E
- Strongest in winter with higher temp. contrast between Equator and poles
- Wind speeds 275 mph
- Meandering pattern based on land/ocean temperature contrast
- Steers weather systems and controls weather at the surface

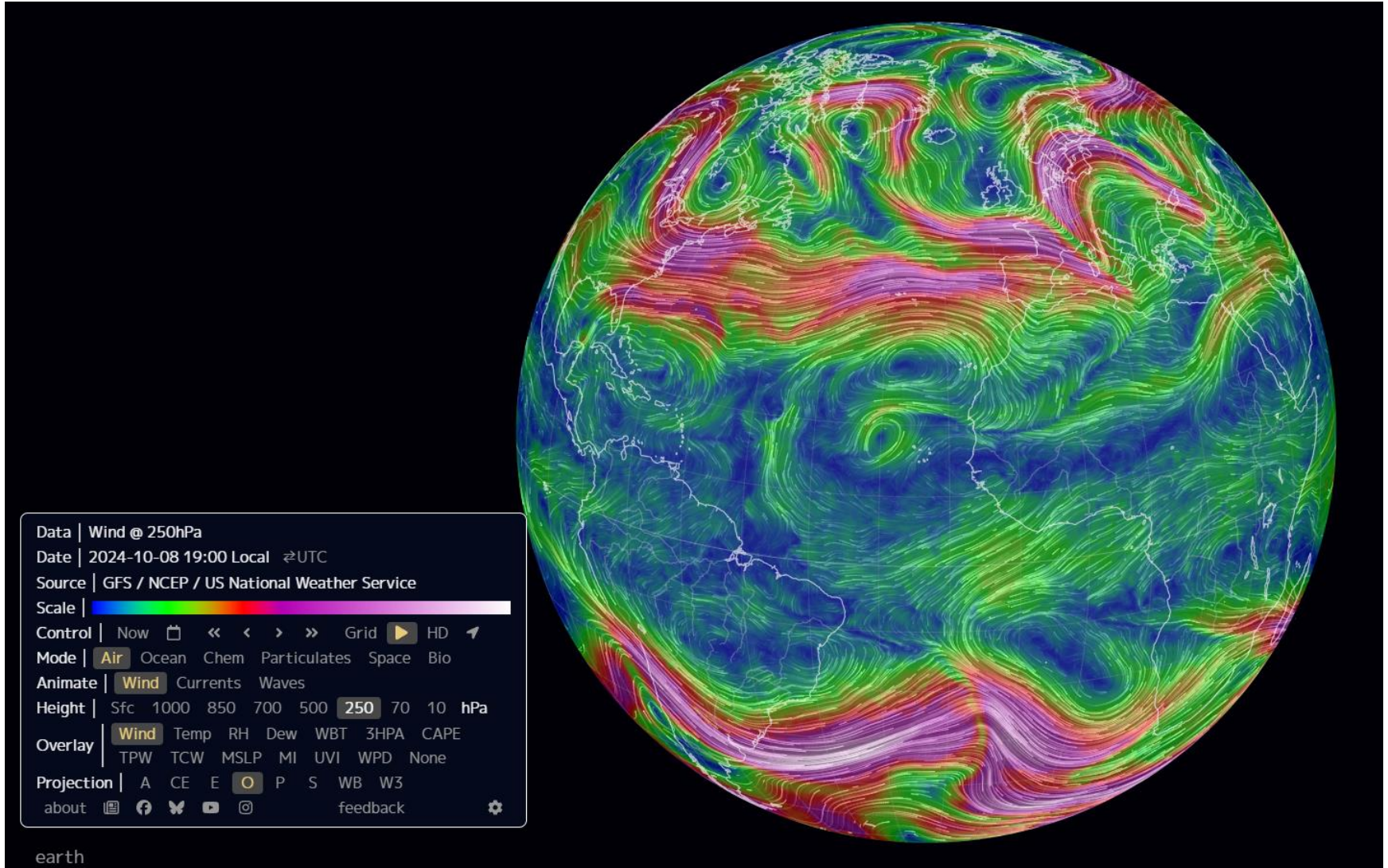


# They strongly influence our weather

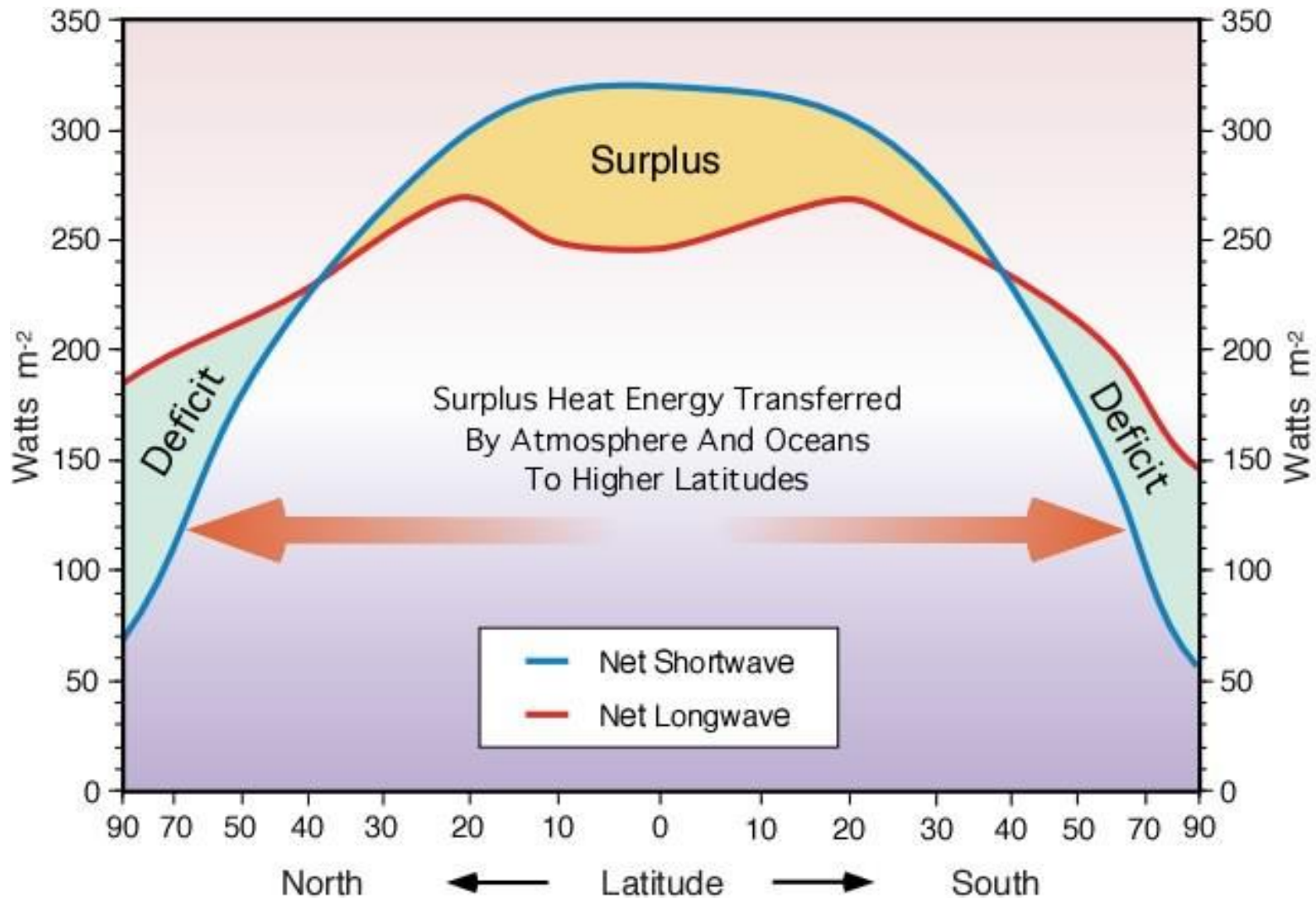


- Normally moves N of UK/Ireland in summer due to tilt of the Earth's axis and warm air reaching higher latitudes
- Sometimes it sits stuck in the same place, bringing frequent and repeated depressions and wet weather

# Jet Streams right now!

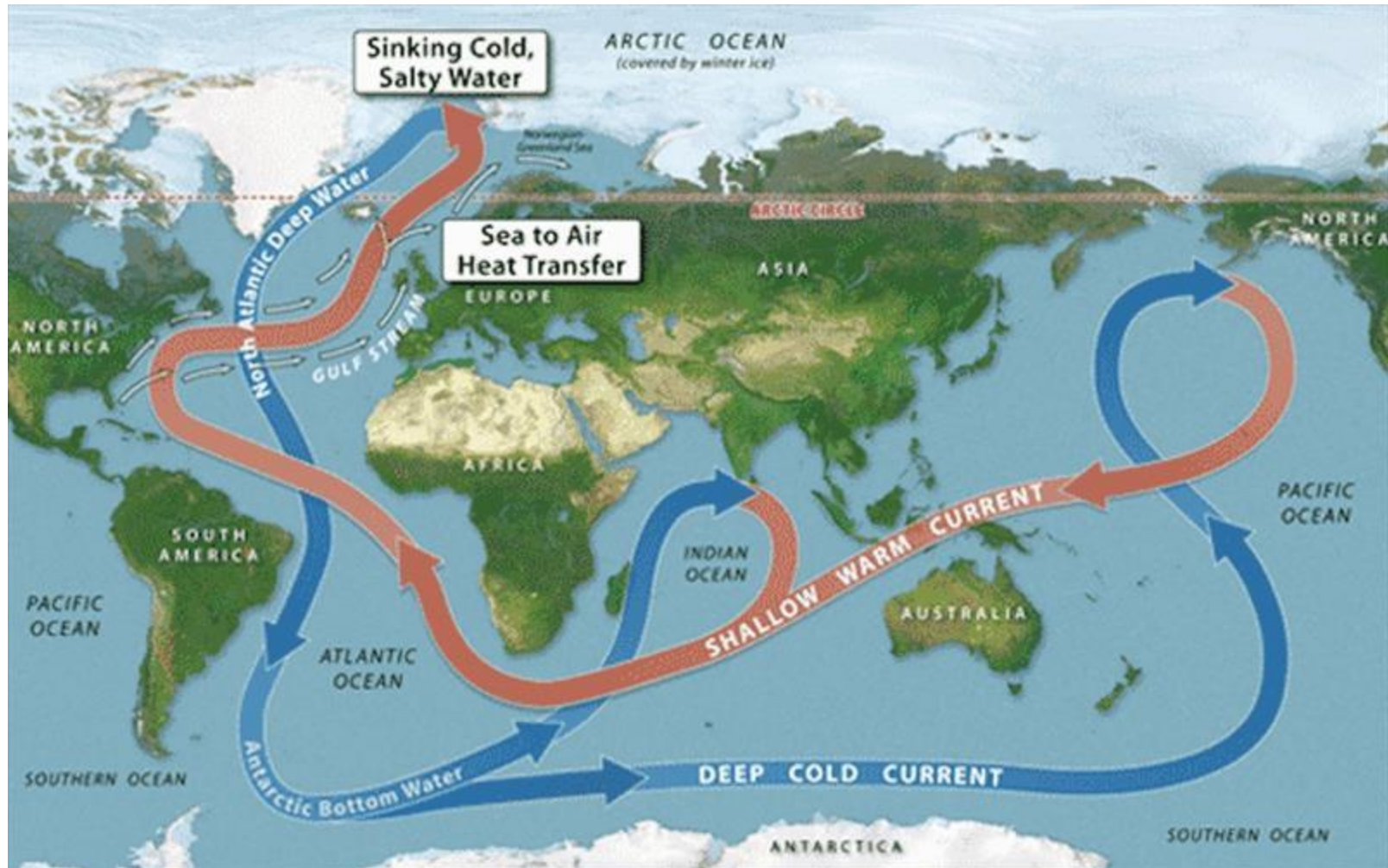


# Recap: Global Radiation Balance



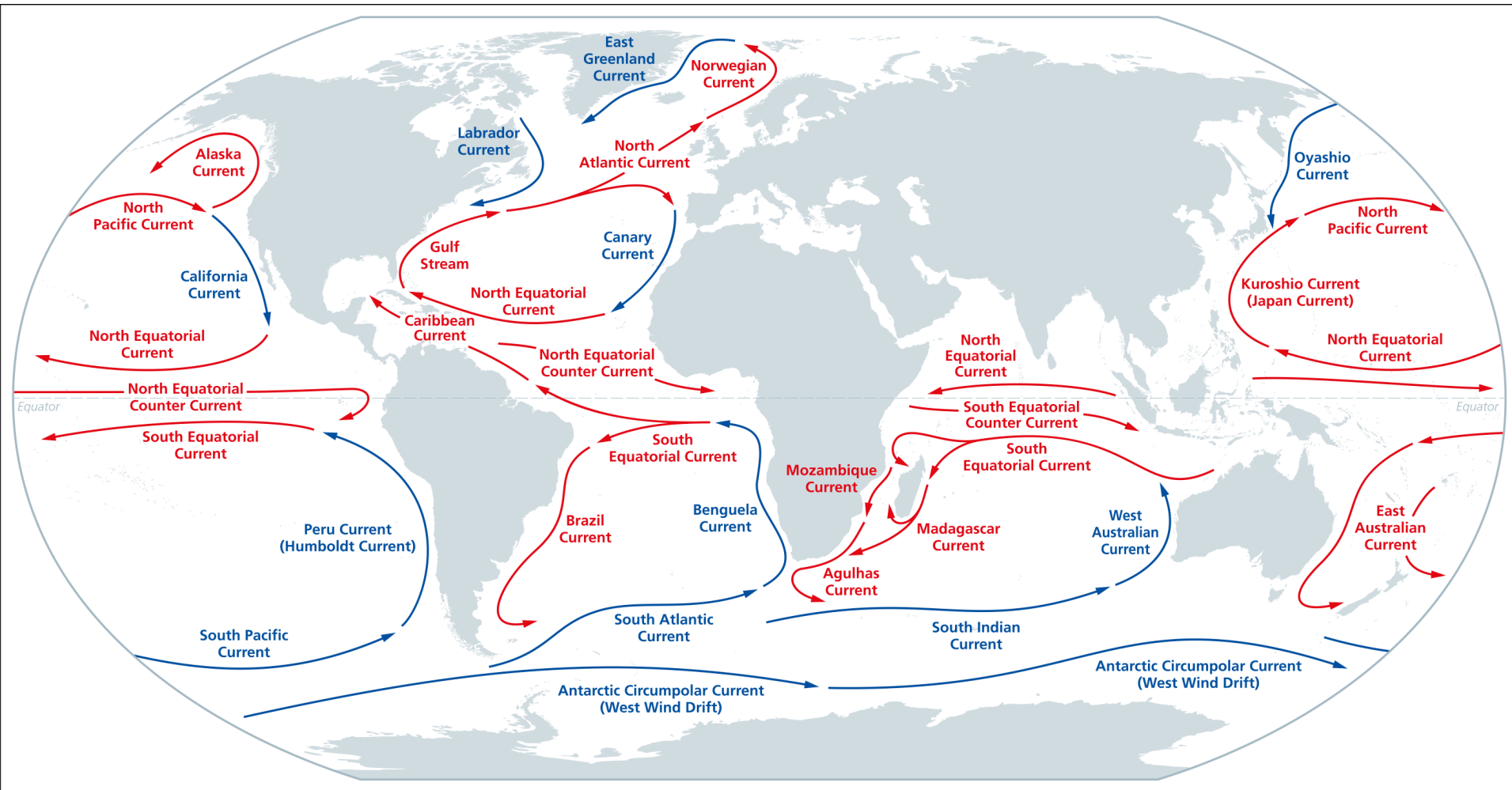


# Ocean Currents





# Ocean Currents



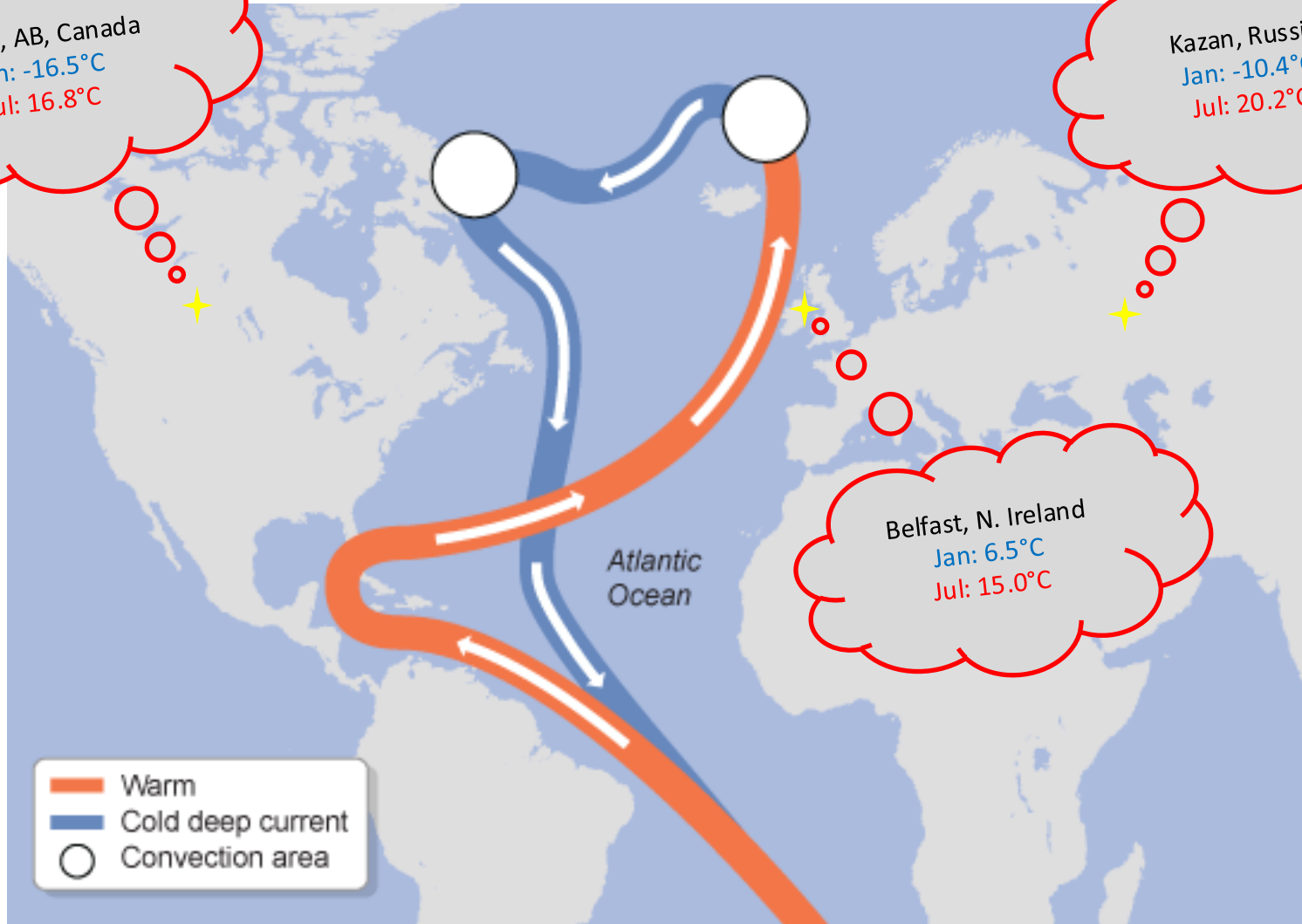
# North Atlantic Drift

Tulliby, AB, Canada  
Jan: -16.5°C  
Jul: 16.8°C

Kazan, Russia  
Jan: -10.4°C  
Jul: 20.2°C

Belfast, N. Ireland  
Jan: 6.5°C  
Jul: 15.0°C

- Warm
- Cold deep current
- Convection area



# Useful Resources



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## Global circulation patterns

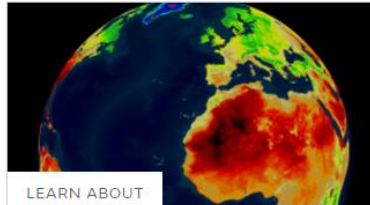
Explore



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## Air masses

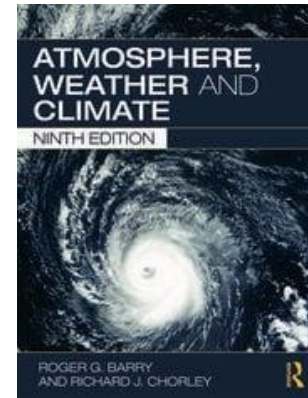
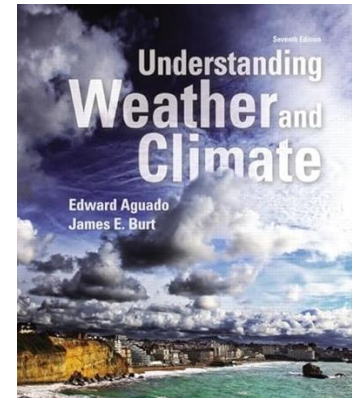
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## Weather fronts

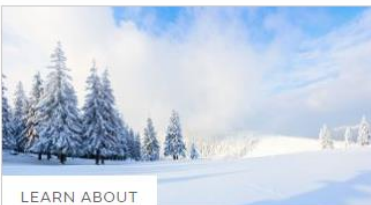
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## Polar Vortex

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## Albedo

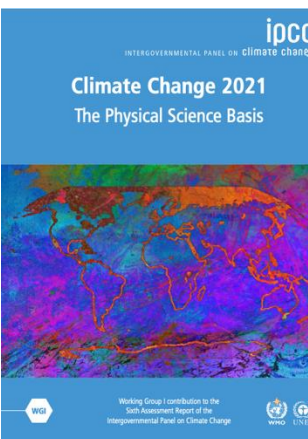
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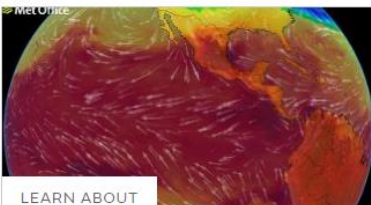
## Intertropical Convergence Zone (ITCZ)

Explore



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## North Atlantic Oscillation



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## Quasi-Biennial Oscillation (QBO)

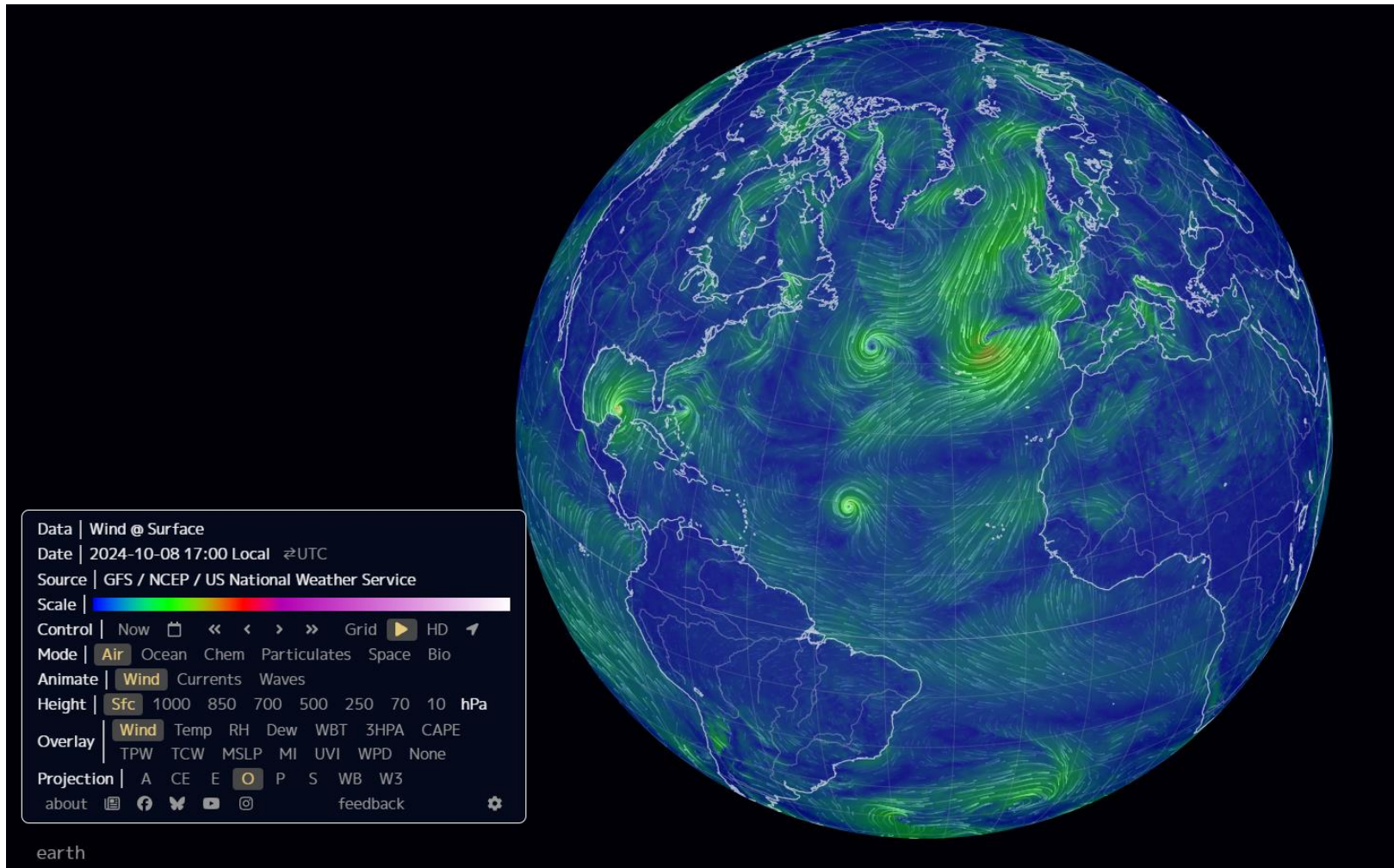


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## What is the Madden-Julian Oscillation?



# Useful Resources



<https://earth.nullschool.net/>