Waves and Weather

1. Where do waves come from?

2. What storms produce good surfing waves?

3. Where do these storms frequently form?

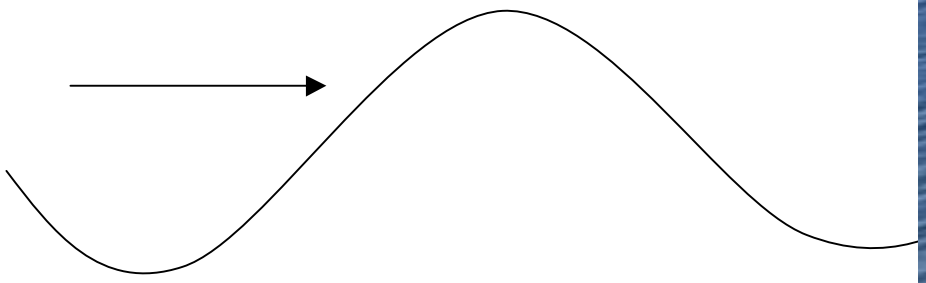
4. Where are the good areas for receiving swells?

Where do waves come from?

==> Wind!

Any two fluids (with different density) moving at different speeds can produce waves.
In our case, air is one fluid and the water is the other.

- Start with perfectly glassy conditions (no waves) and no wind.
- As wind starts, will first get very small capillary waves (ripples).
- Once ripples form, now wind can push against the surface and waves can grow faster.

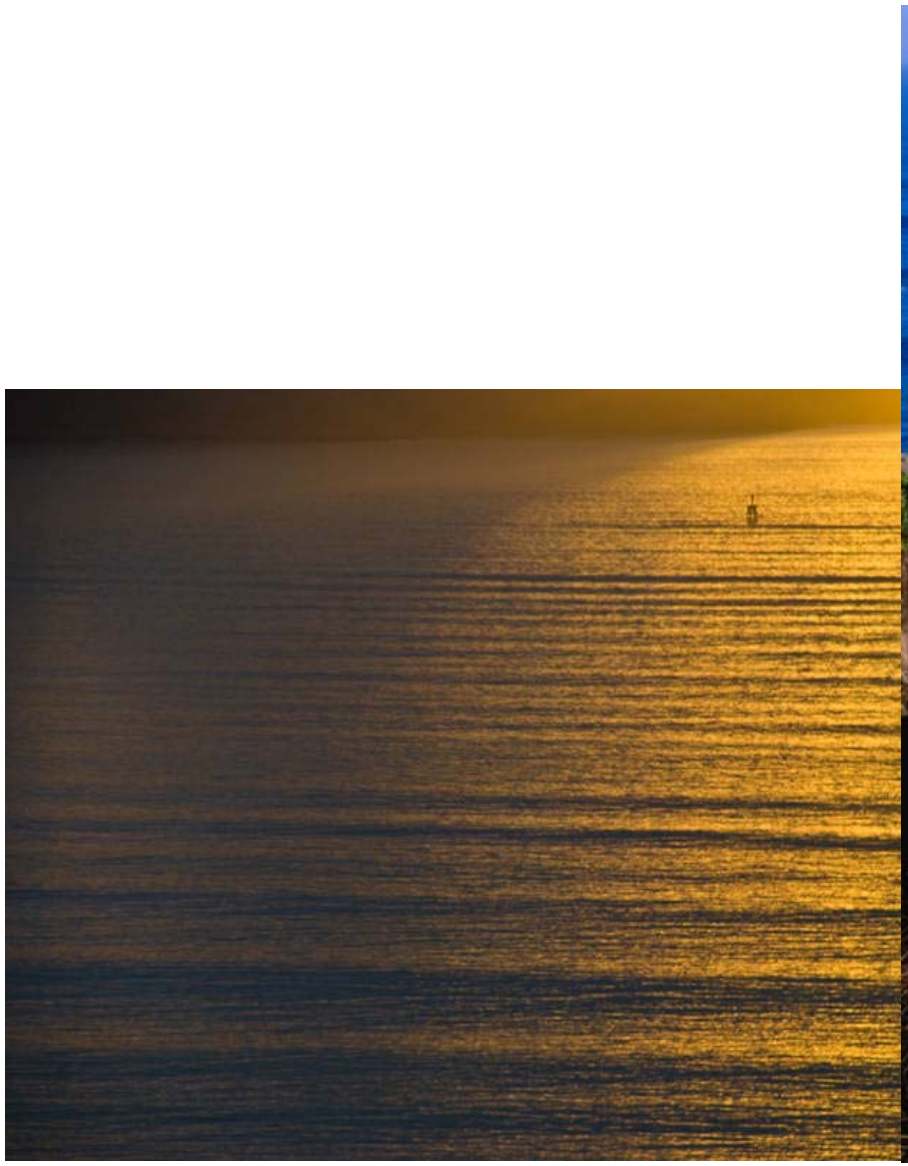


Within Wave Source Region:

- all wavelengths and heights mixed together

- looks like washing machine ("Victory at Sea")

But this is what we want our surfing waves to look like:



How do we get from this

To this ????

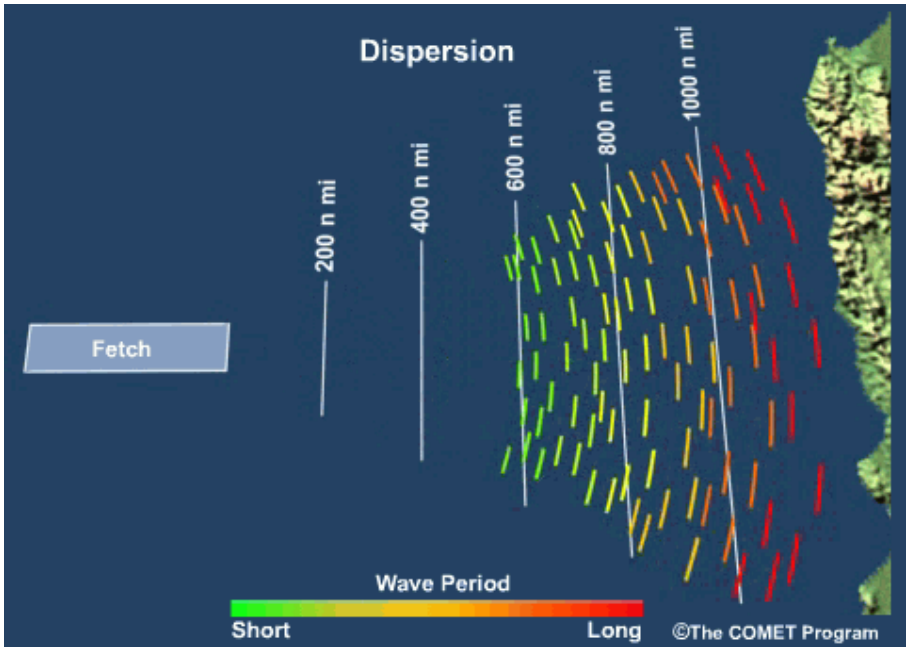
DISPERSION !!

In deep water, wave speed (celerity) $c = gT/2\pi$

Long period waves travel faster. Short period waves travel slower

Waves begin to separate as they move
away from generation area

===> This is Dispersion



How Big Will the Waves Get?

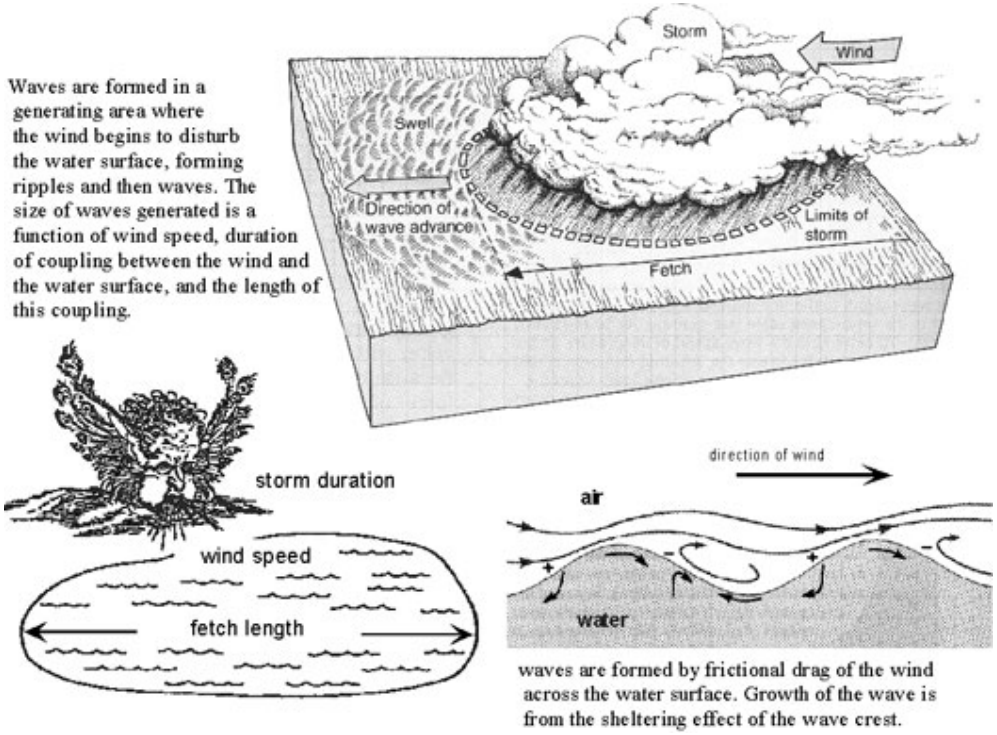
Height and Period of waves depends primarily on:

- Wind speed

- Duration (how long the wind blows over the waves)

- Fetch (distance that wind blows over the waves)

"SMB" Tables



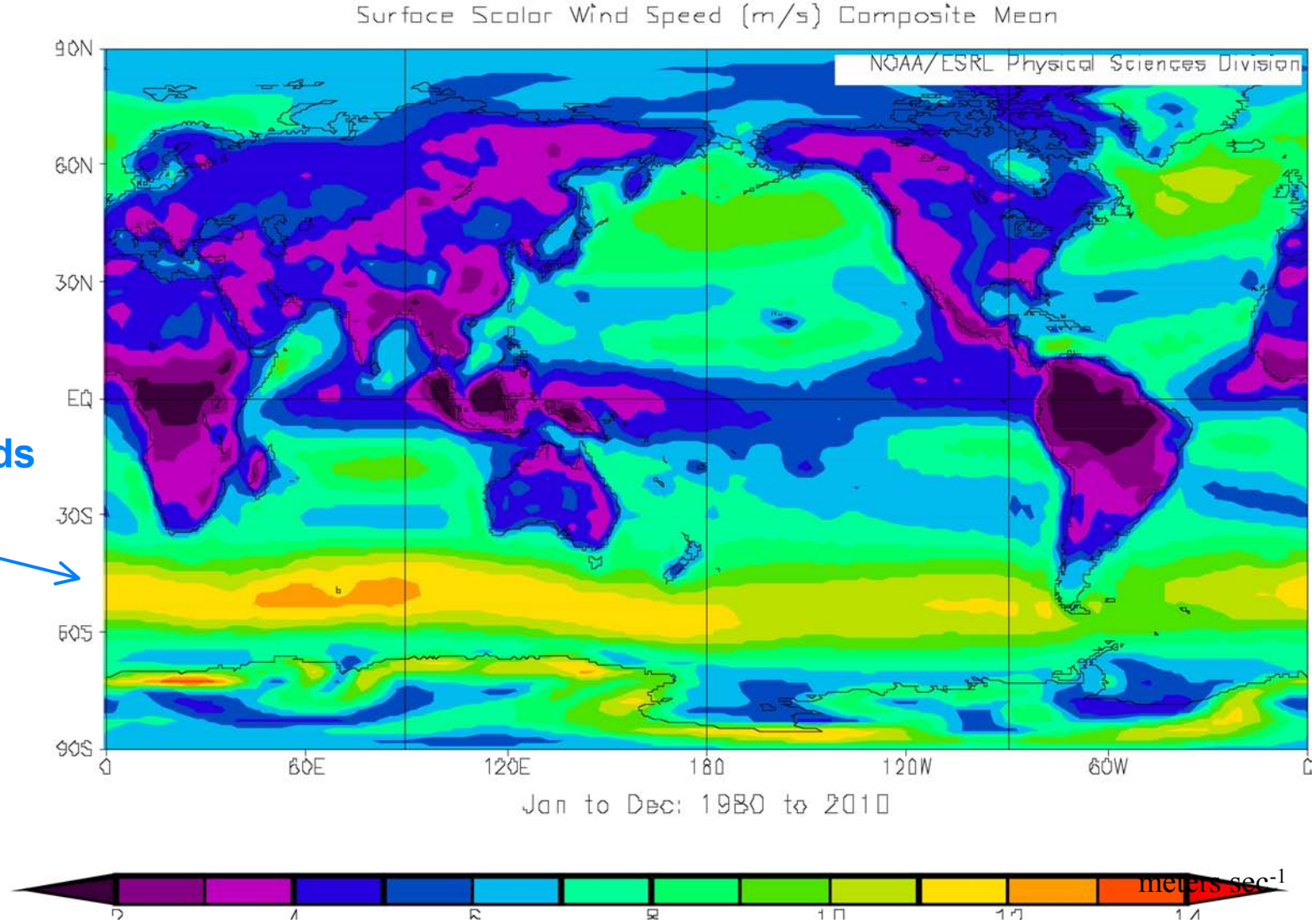
How Big Will the Waves Get?

Assume Duration = 24 hours
Fetch Length = 500 miles

Wind Speed	Significant Wave Height	Significant Wave Period
10 mph	2 ft	3.5 sec
20 mph	6 ft	5.5 sec
30 mph	12 ft	7.5 sec
40 mph	19 ft	10.0 sec
50 mph	27 ft	11.5 sec
60 mph	35 ft	13.0 sec

Wave height will decay as waves move away from source region!!!

Map of Mean Wind Speed (near surface):



Fastest winds in Southern Ocean

==> Average winds would produce relatively small waves

==> Best waves for surfing, usually produced by organized storms

Q? Where are the fastest winds?

Storm Characteristics

Most storms are areas of low pressure:

In Northern Hemisphere, wind flows counter-clockwise around low pressure
In Southern Hemisphere, wind flows clockwise around low pressure

Why doesn't wind flow directly toward low pressure????

Storm Characteristics

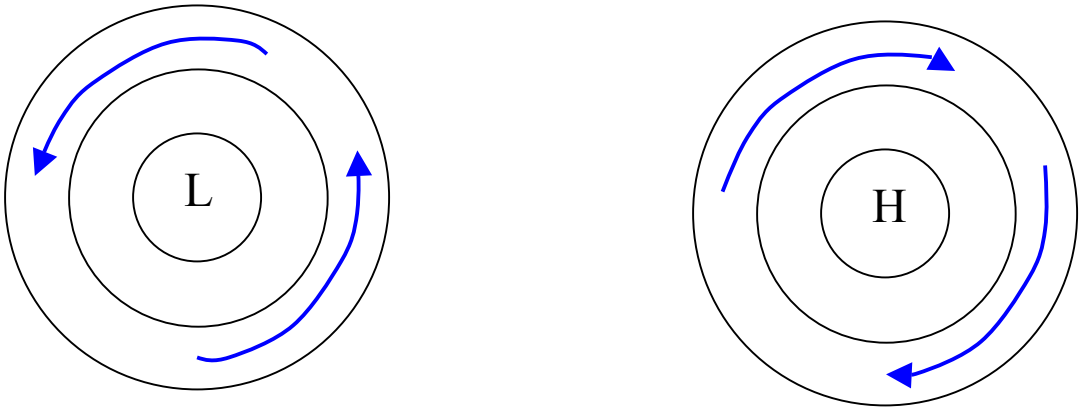
Most storms are areas of low pressure:

In Northern Hemisphere, wind flows counter-clockwise around low pressure
In Southern Hemisphere, wind flows clockwise around low pressure

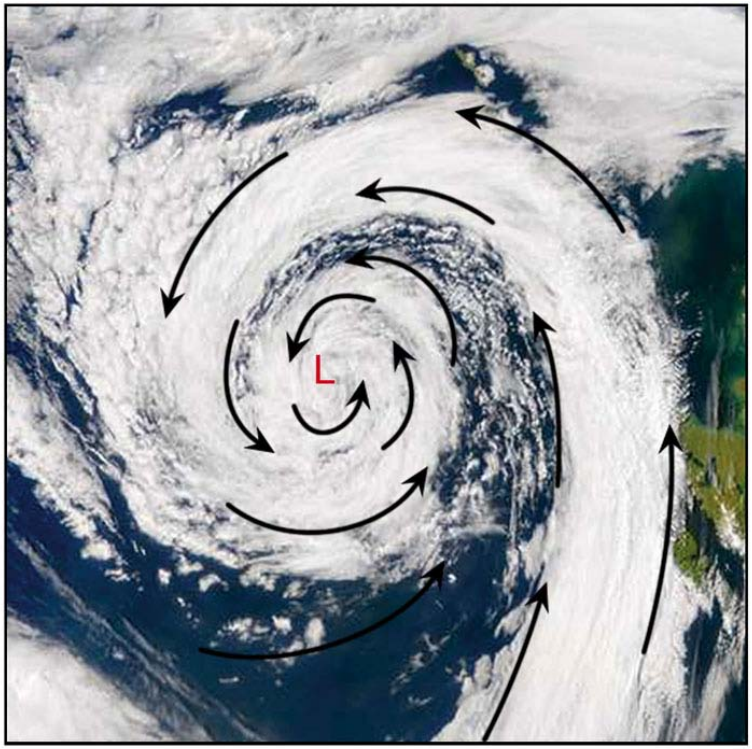
Why doesn't wind flow directly toward low pressure????

===> Because Earth is rotating and we are viewing events from rotating reference frame (Coriolis Force).

In Northern Hemisphere:



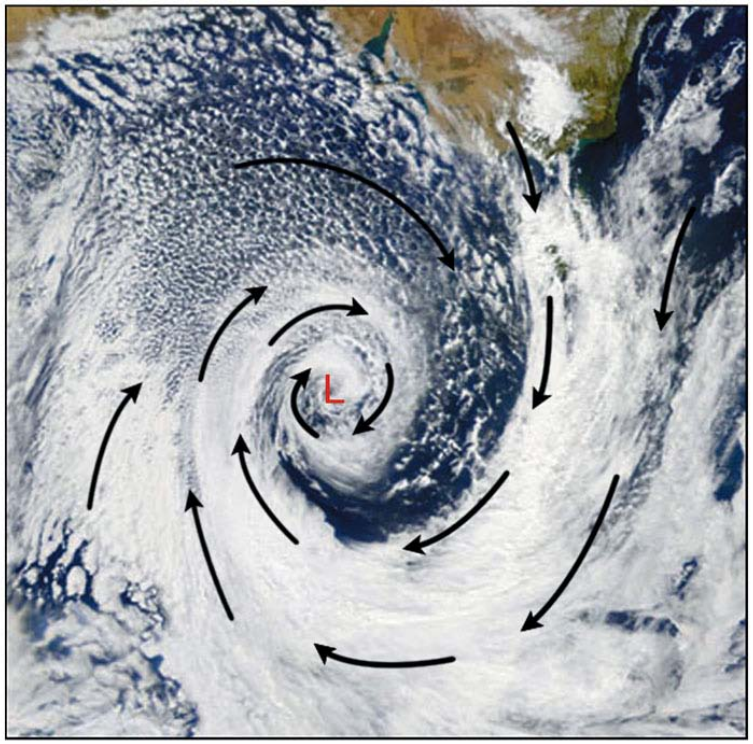
Northern Hemisphere



(a) Northern Hemisphere

© 2007 Thomson Higher Education

Southern Hemisphere



(b) Southern Hemisphere

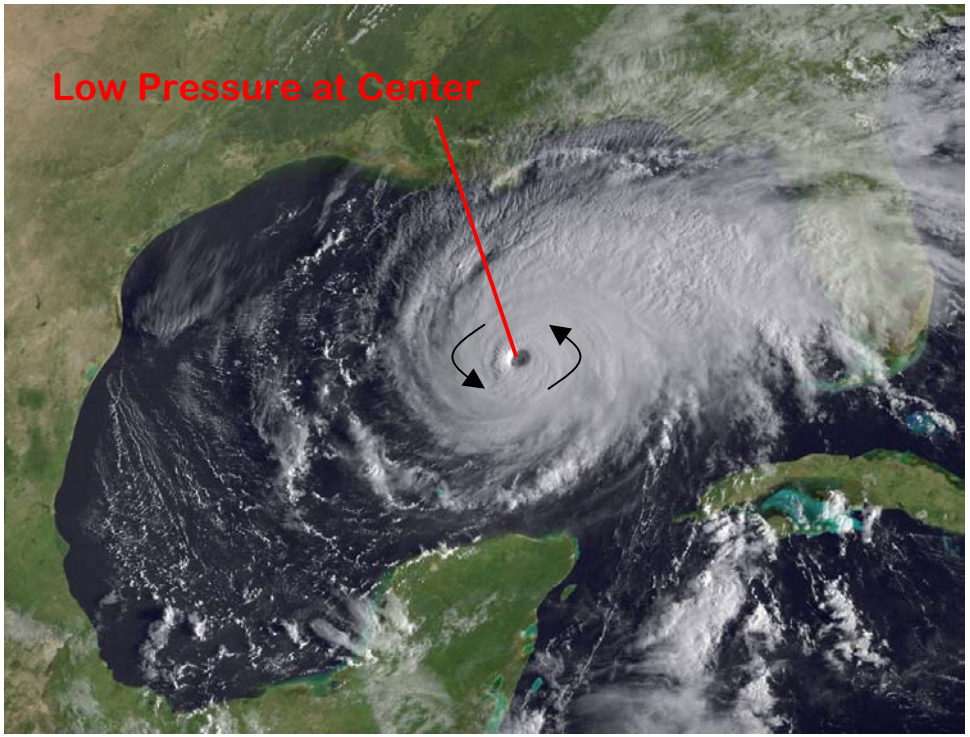
© 2007 Thomson Higher Education

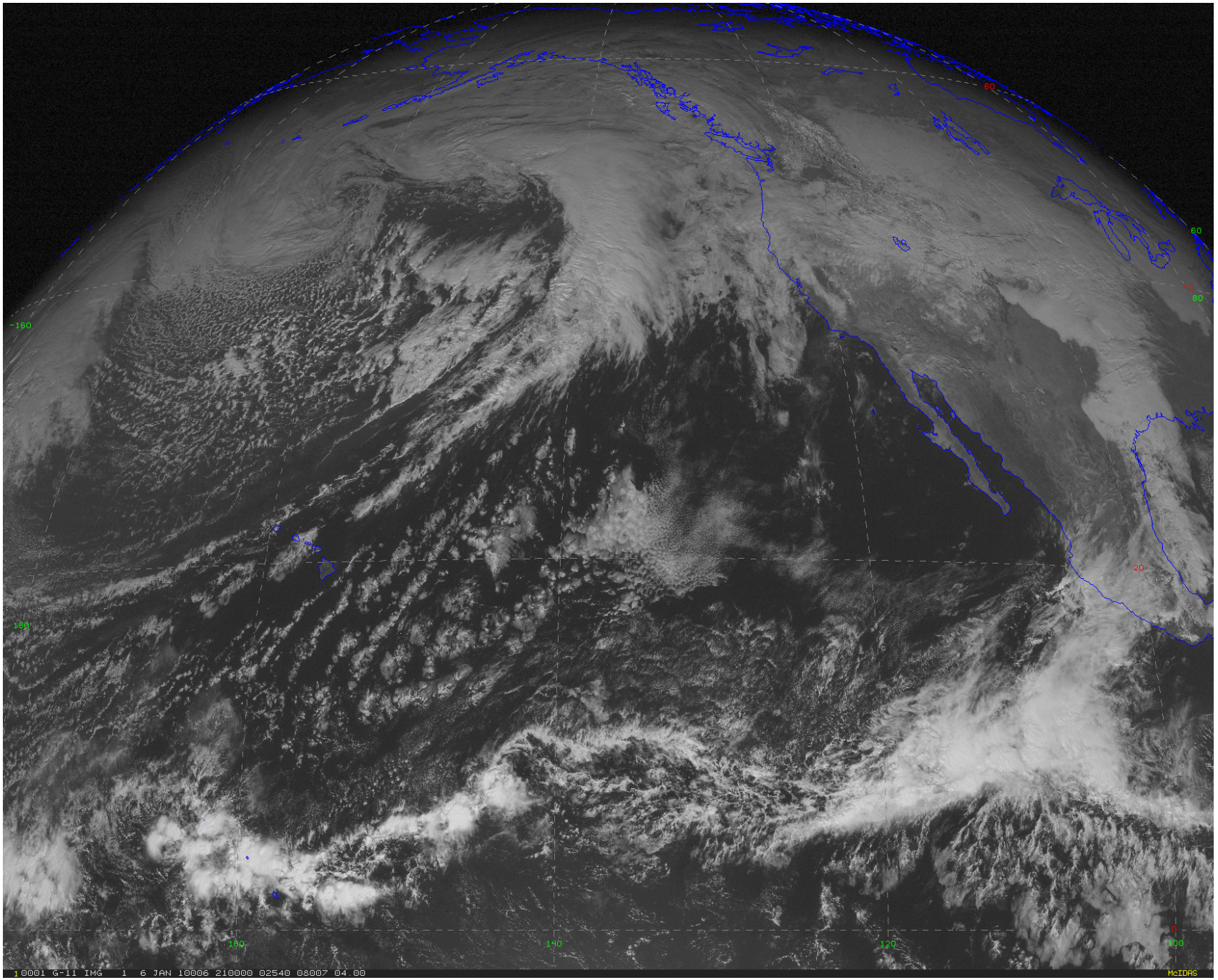
Types of Storms:

- Mid-latitude storm (Winter storms that impact California)

- Tropical Cyclone (aka, Hurricane, Typhoon)

Hurricane Katrina



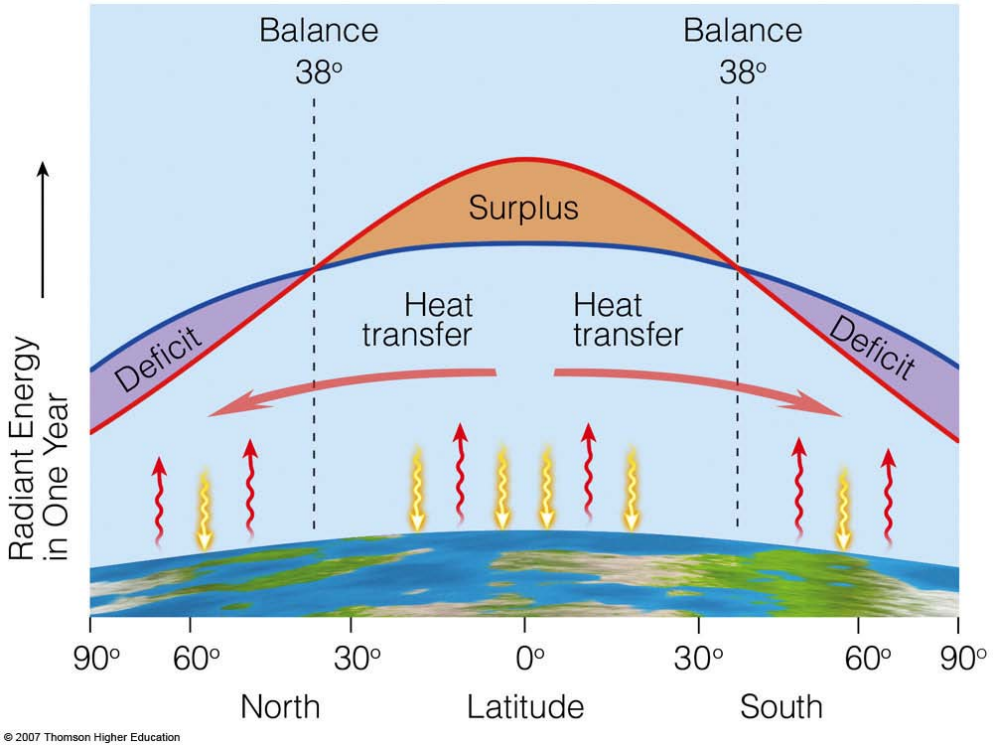

60
60
80
-160
20
160
0
100
140
120
100
1 0001 G-11 IMG 1 6 JAN 10006 210000 02540 08007 04.00
McIDAS

Q: Where do these storms derive their energy?

A: Hurricanes derive energy from warm ocean water and air.

Hurricanes are primarily located in the tropics

Because Earth is a sphere, Solar Energy not distributed equally
Earth also radiates infrared energy ($E=\sigma T^4$) that cools surface

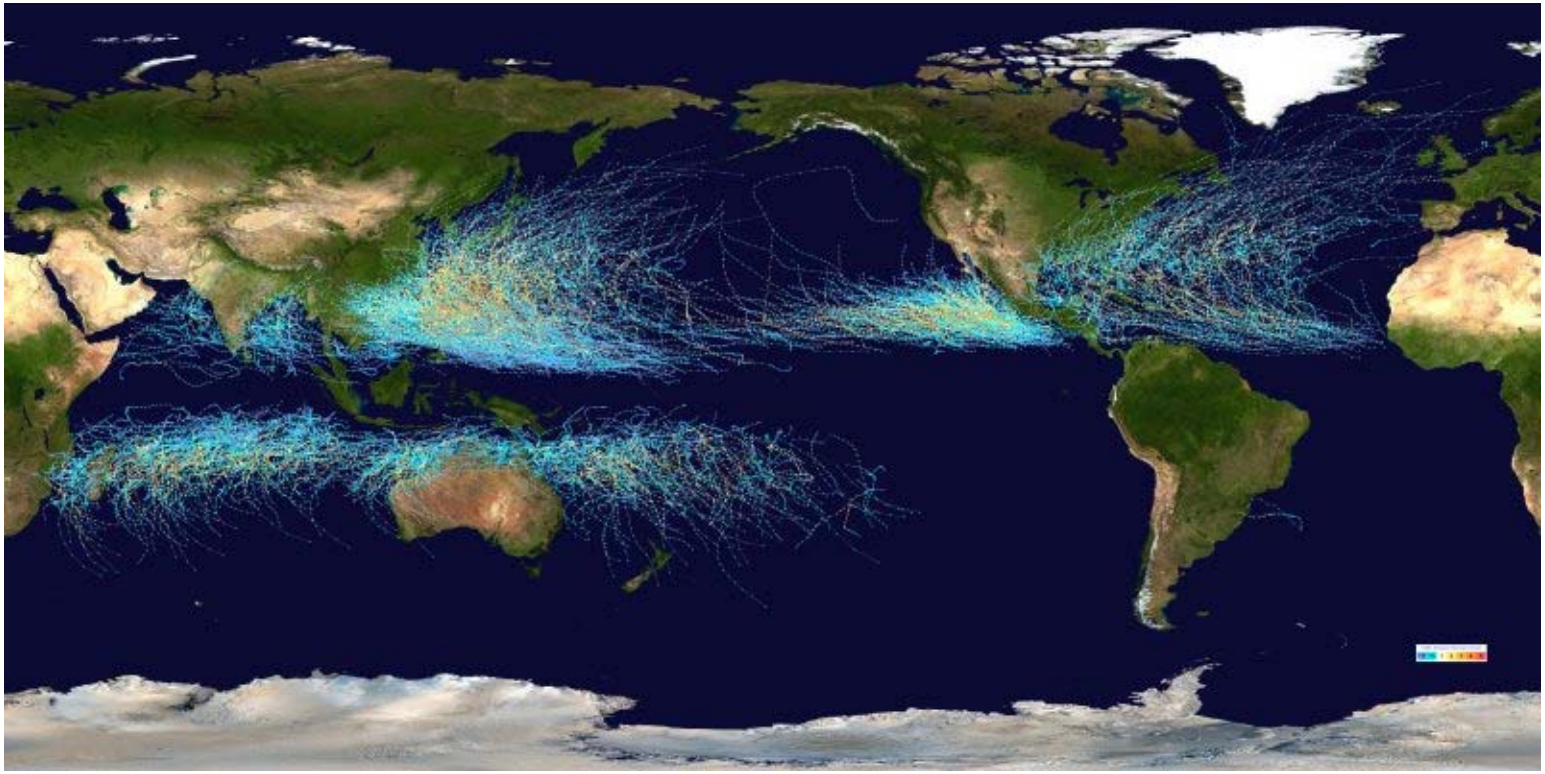


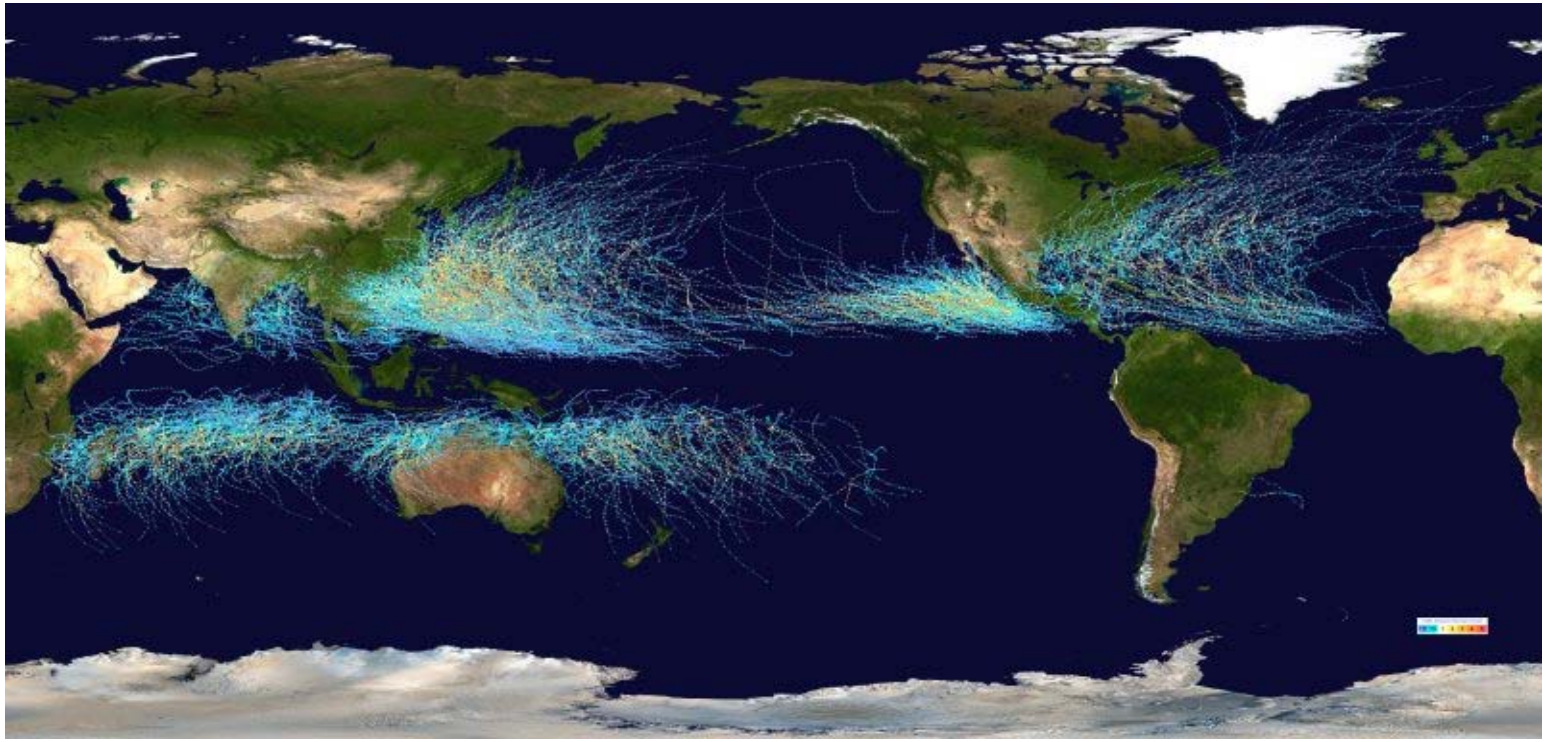
Net effect => surplus of energy in tropics => warmer water and air
Hurricanes are one method that helps to redistribute heat towards the poles

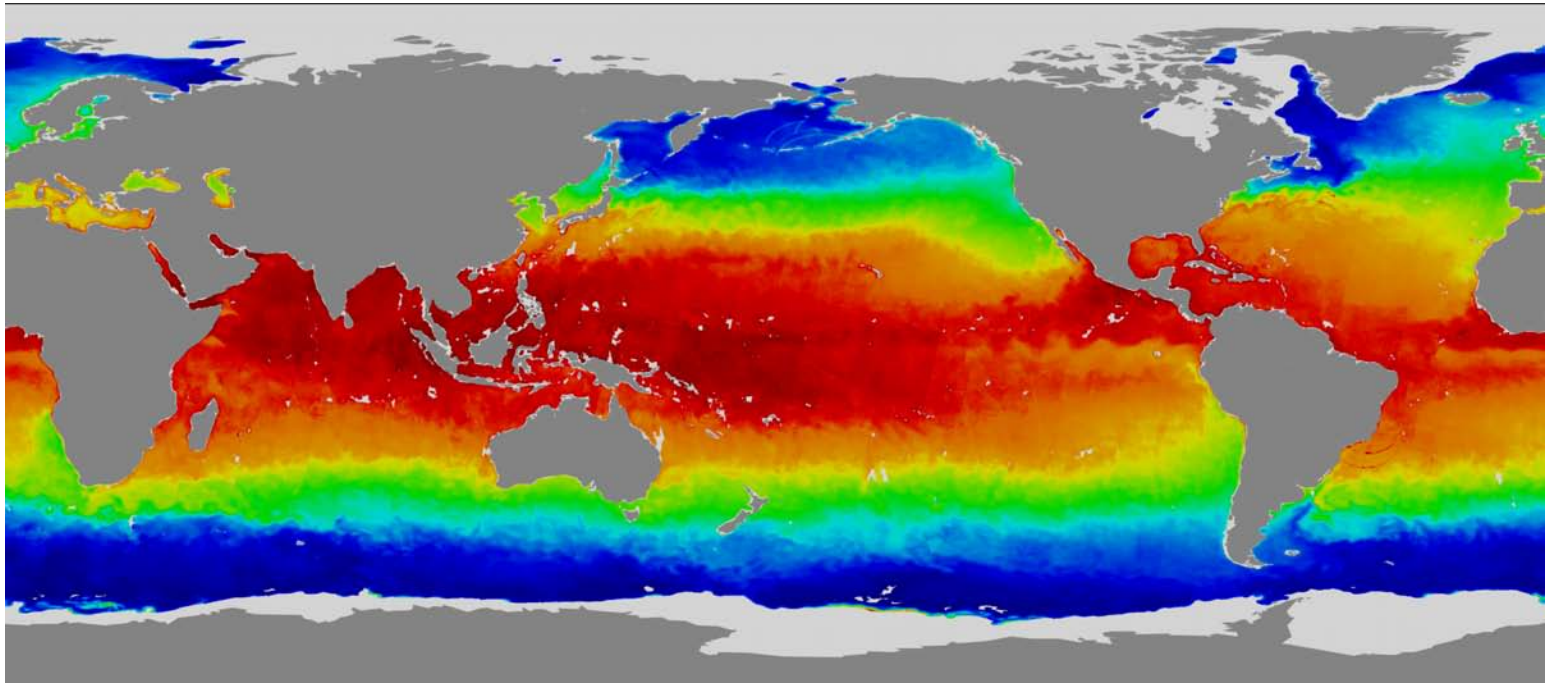
Hurricane Tracks

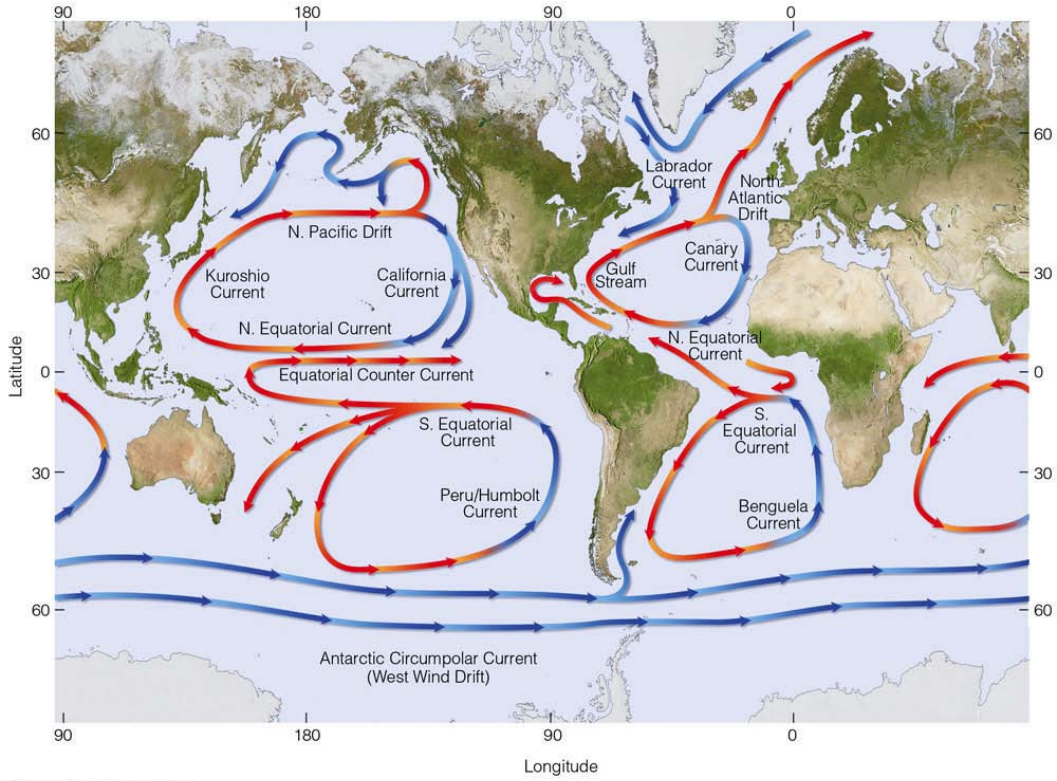
- Generally move from equator towards poles

- No hurricanes in South Atlantic or South Eastern Pacific
  ==> Water temps are too cold for hurricanes to form

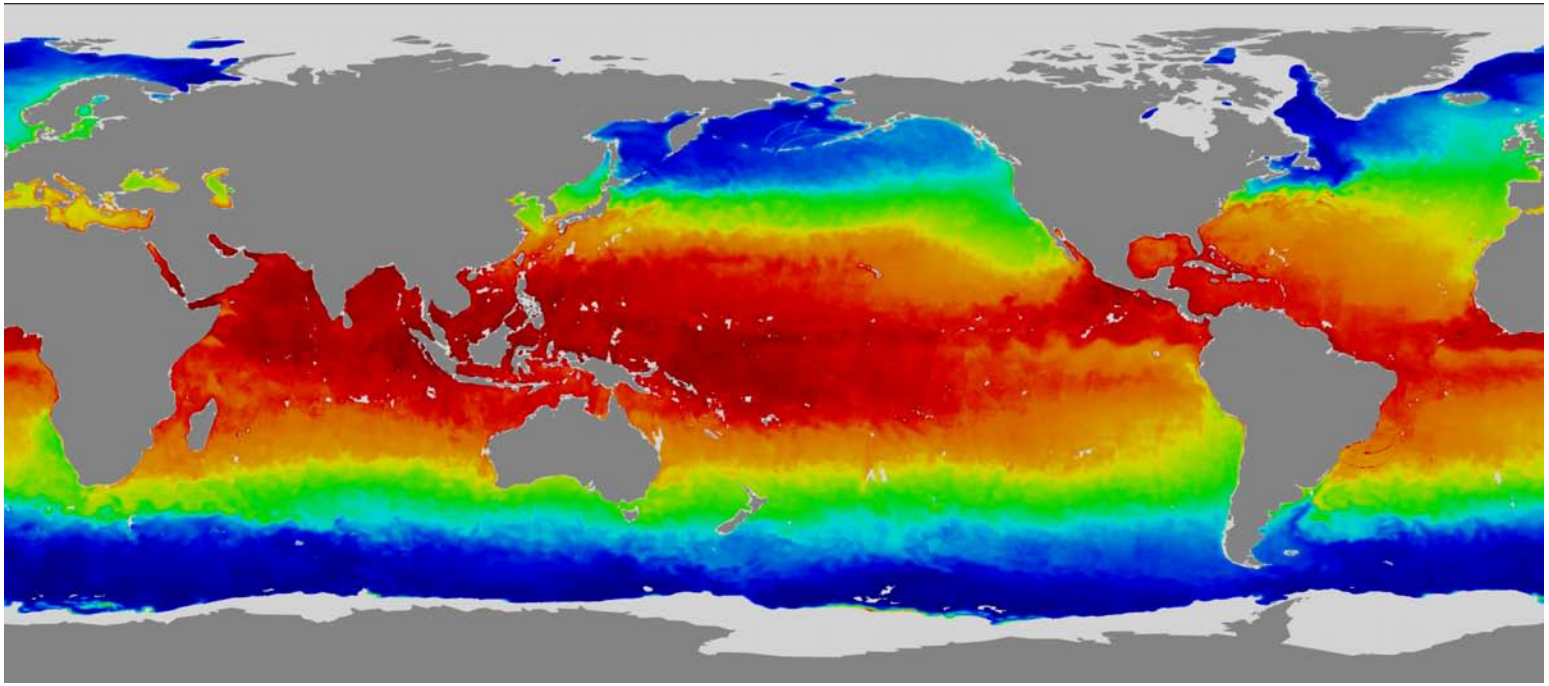






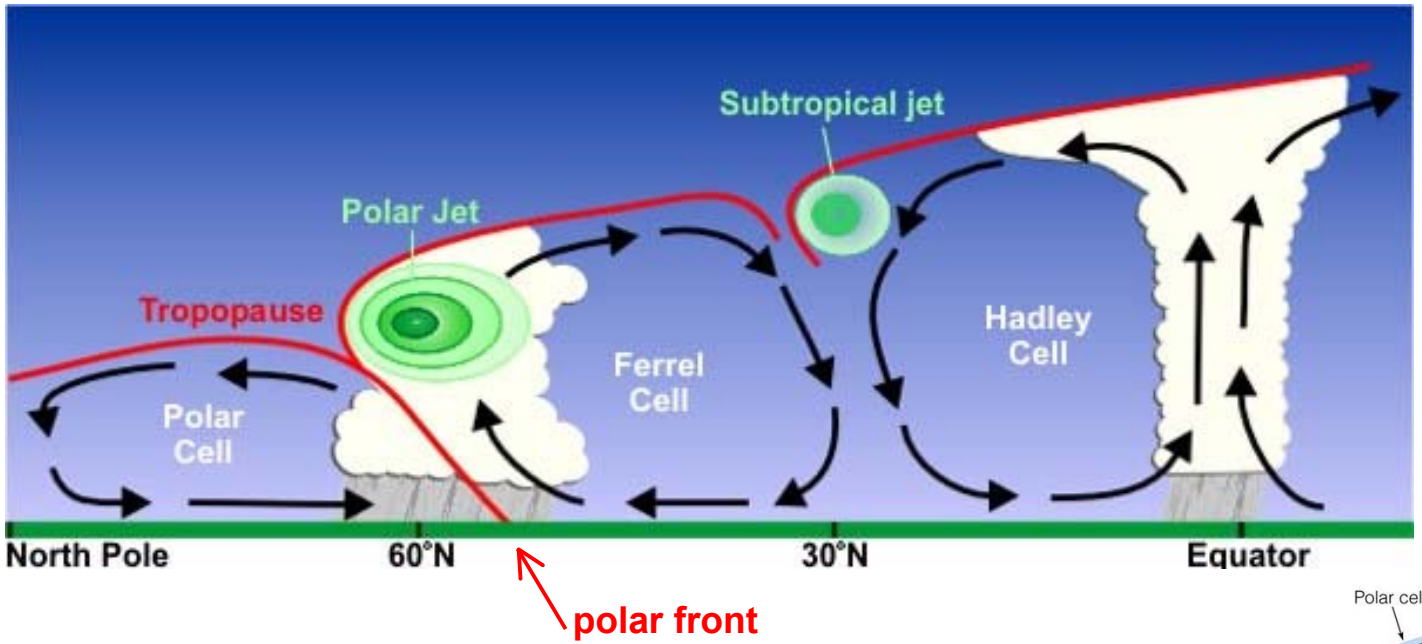


© 2007 Thomson Higher Education

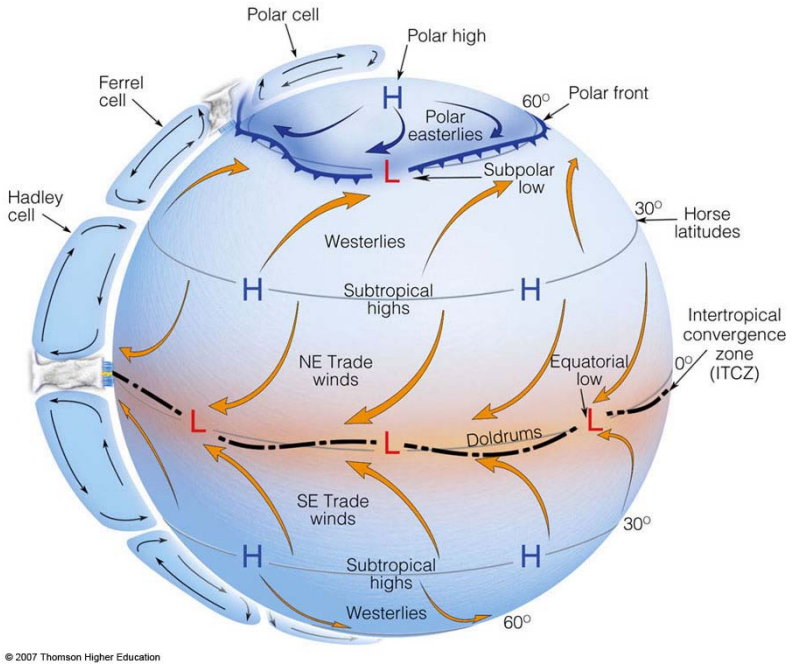


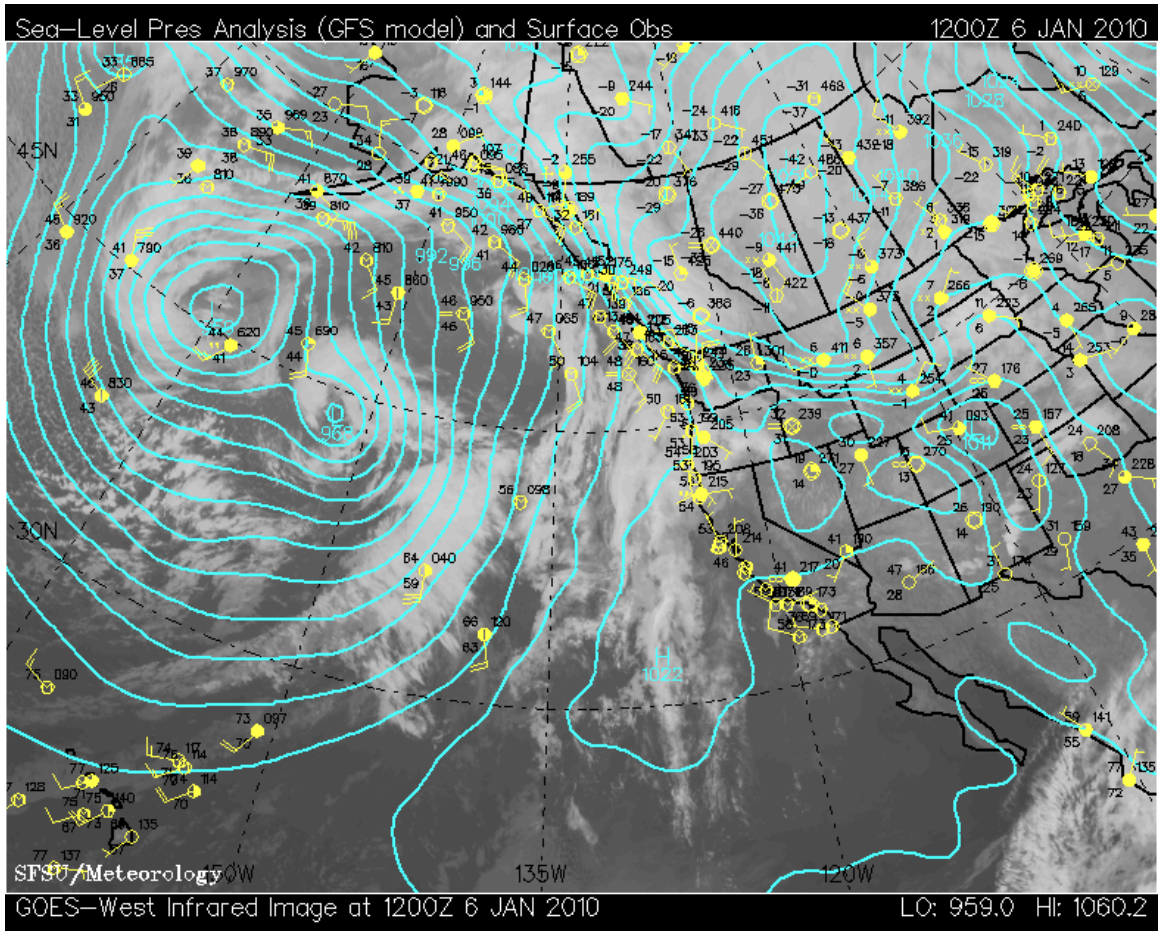
Q: Where do these storms derive their energy?

A: Mid-latitude storms derive most of their energy from the contrast between warm and cold temperature along polar front.



Circulation Cells develop due to unequal heating of Earth's surface

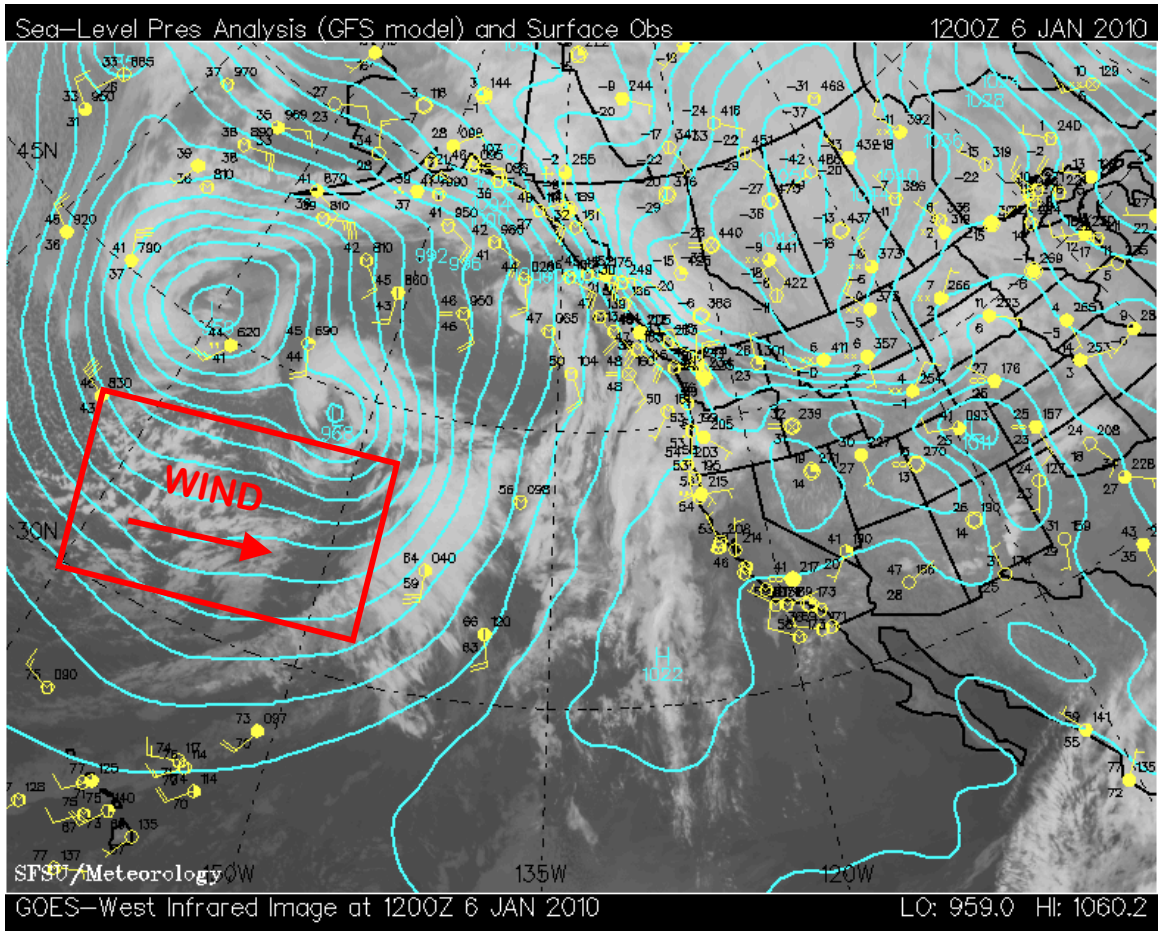




Blue lines are "isobars" = lines of equal pressure

Wind is close to parallel to isobars

Wind inversely proportional to isobar spacing
(close isobars = fast winds)



Blue lines are "isobars" = lines of equal pressure

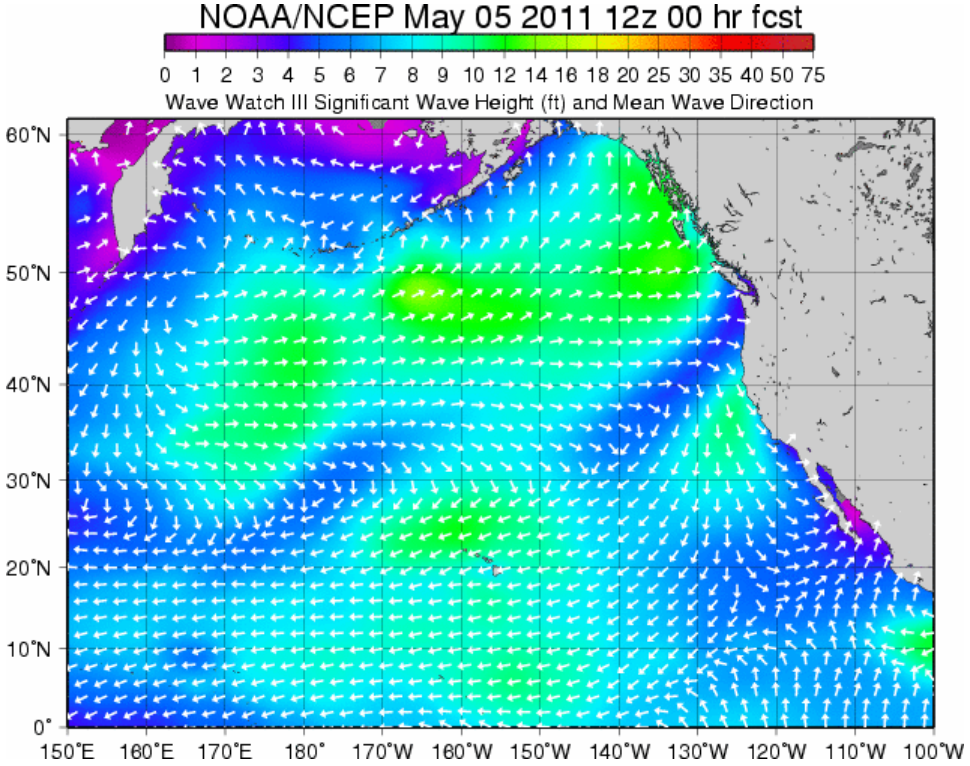
Wind is close to parallel to isobars

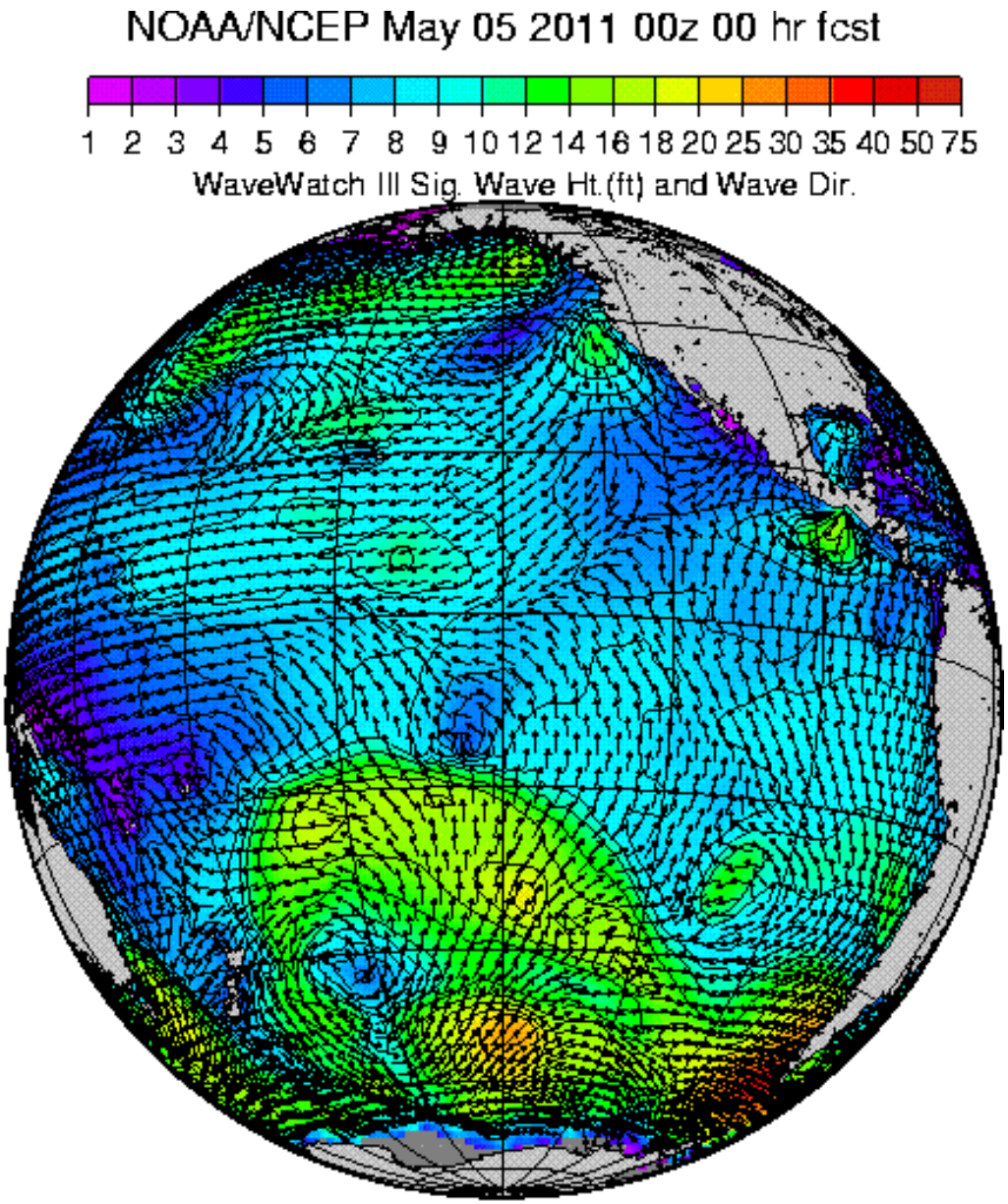
Wind inversely proportional to isobar spacing
(close isobars = fast winds)

Geostrophic wind $U_g = (1/\rho f)(\Delta p/\Delta d)$
Surface wind speed ~ 0.6 * U_g (due to friction)

f = coriolis parameter ($2\omega\sin\phi$)
ϕ=latitude
ω=rotation rate = 2π/24hr)
$\Delta p/\Delta d$ = horizontal pressure gradient

Navy Models Forecast Wave Heights and Direction:





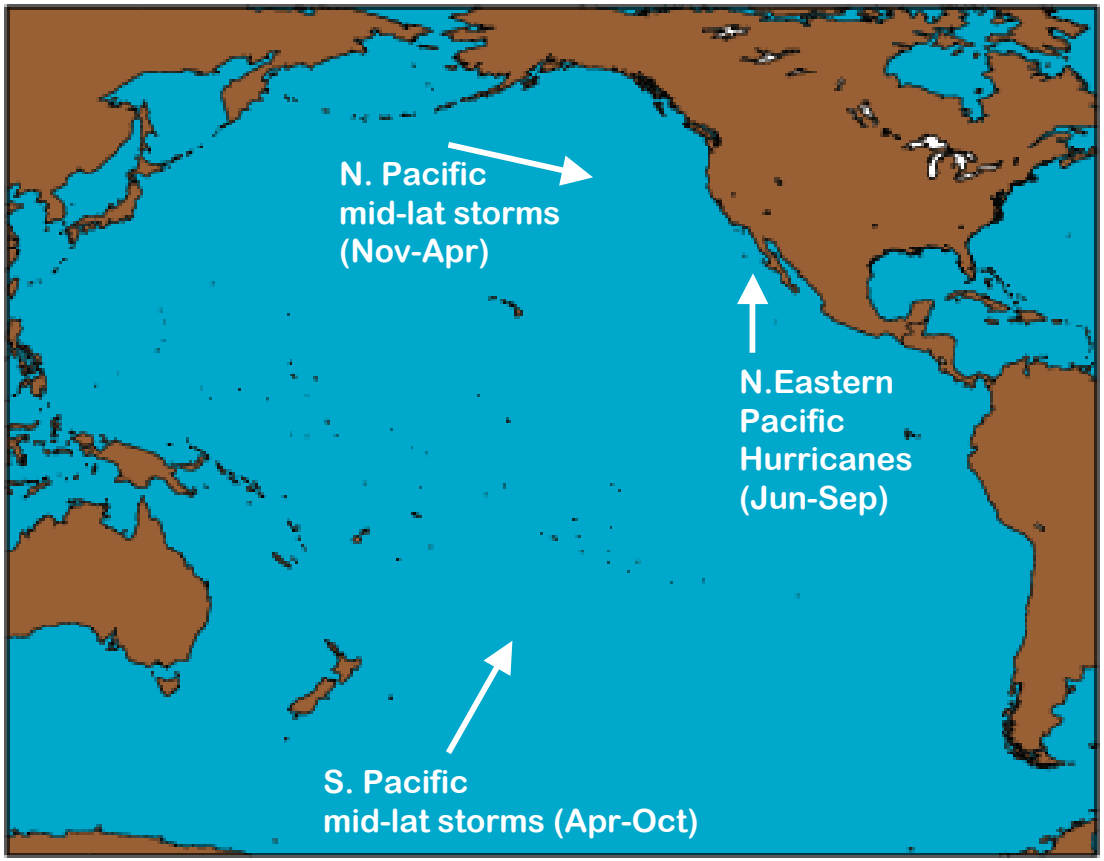
GMT May 6 03:41 La Jolla Surfing - http://www.lajollasurf.org/surf/

California Wave Sources

Winter: Mid-latitude storms in North Pacific

Summer: Mid-latitude storms in South Pacific (surfing slang = Southern Hemis)
Hurricanes off west coast of Mexico

All Seasons: Local wind swell
This is usually moderate winds close to California
Produces short interval swell



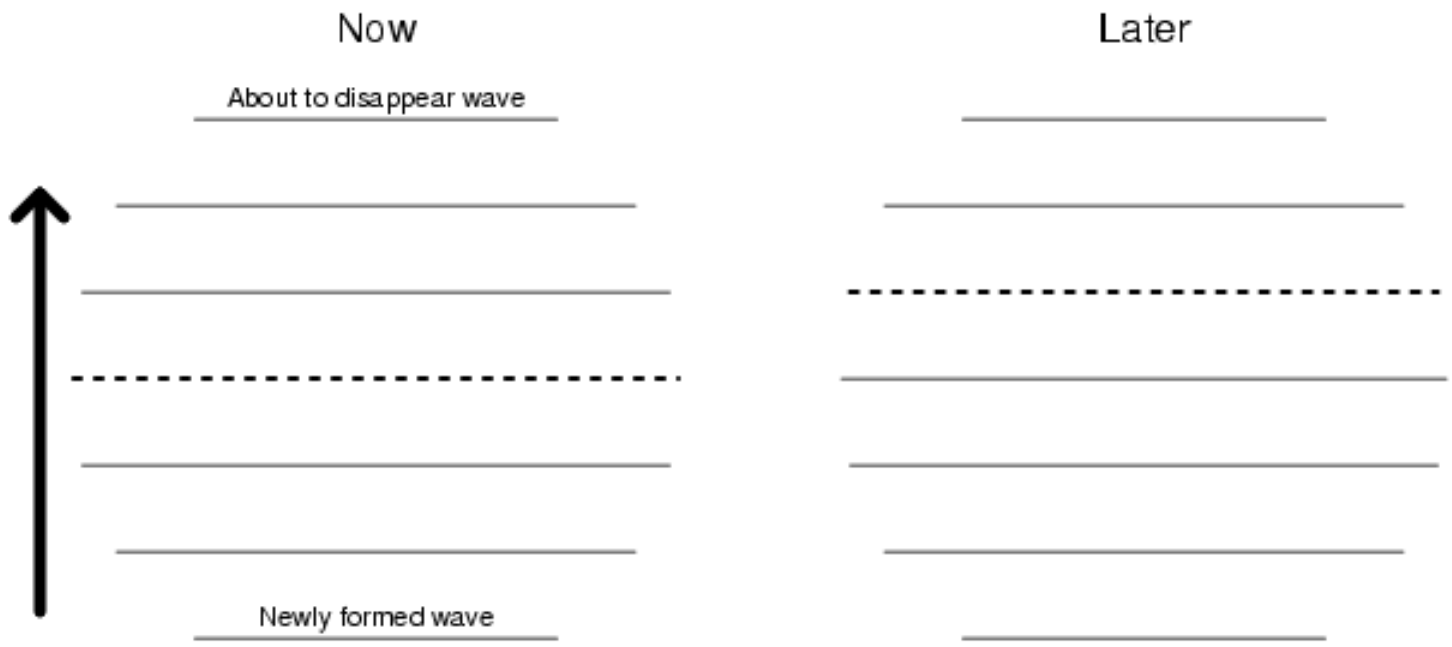
California Wave Sources

Travel Time for 15 second period wave

- in deep water, $C = gT/2\pi$
  BUT, this is the "wave speed", the speed that the wave form travels.

- the wave energy travels at C_g (also known as "group" speed),
  where $C_g = 0.5\ C$

- so, the energy travels slower than the waves themselves.



California Wave Sources

Travel Time for 15 second period wave

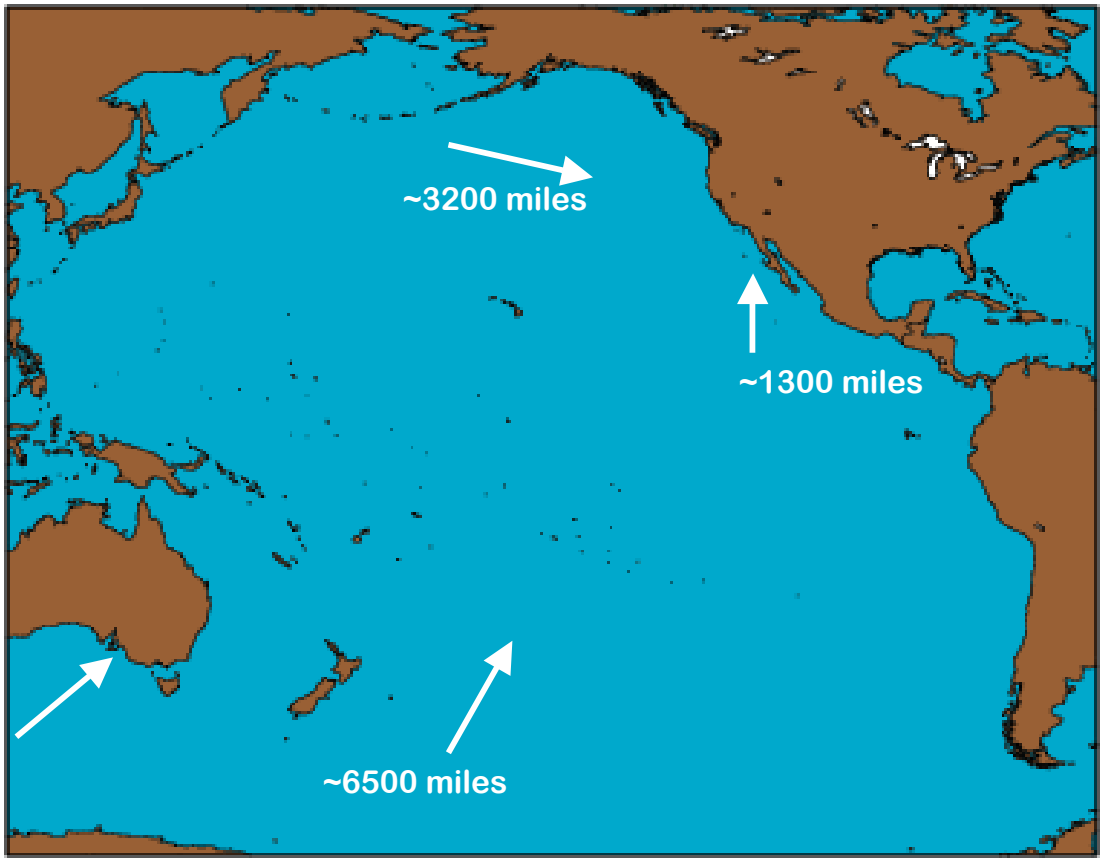
in deep water, $C = gT/2\pi$ BUT, this is the "wave speed", the speed that the wave form travels.

The wave energy travels at C_g (also known as "group" speed), where

$C_g = 0.5\ C$

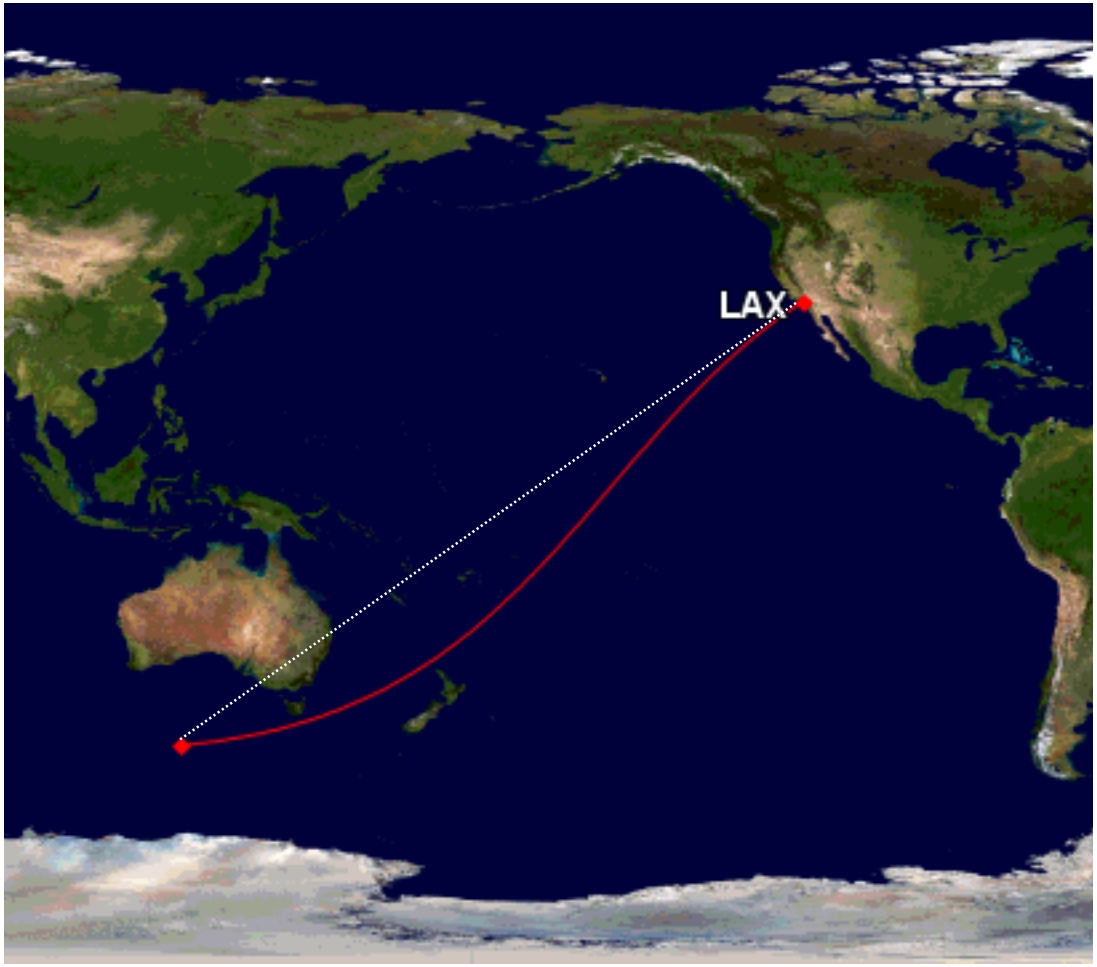
If T=15, C = 23m/sec = 52 mph
So, Cg = 26 mph

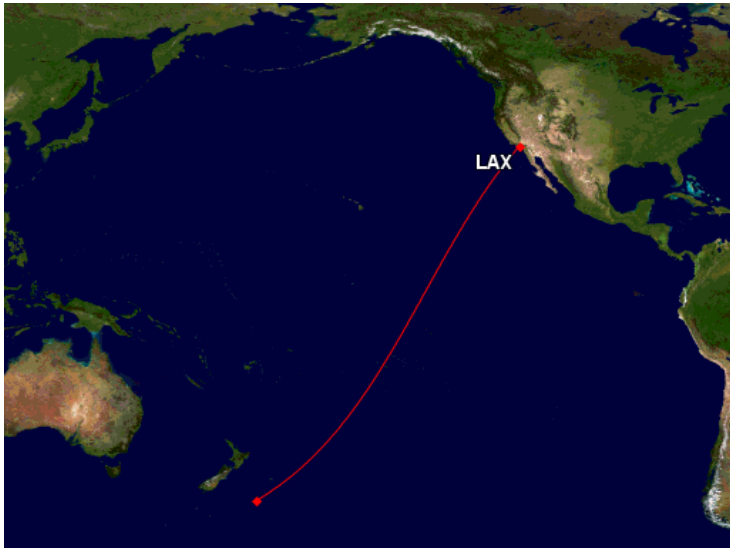
Source	**Travel Time**
North Pacific	~ 5 days
Mex. Hurricanes	~ 2 days
South Pacific	~ 10 days

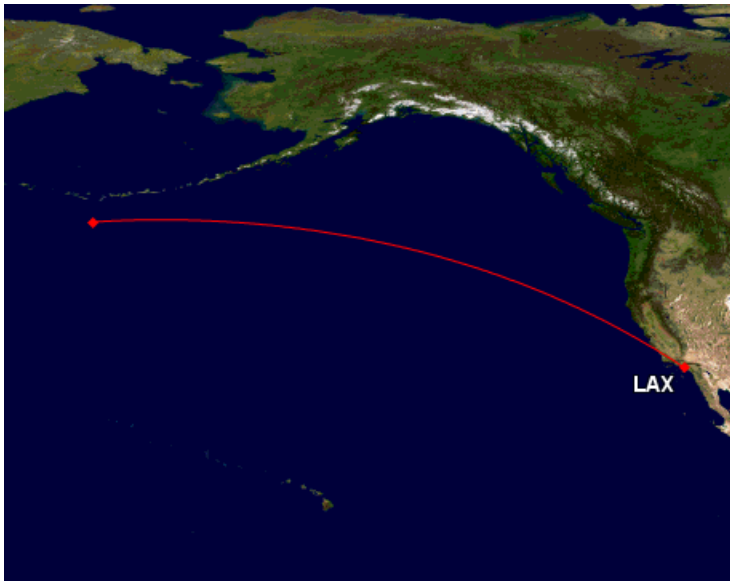


Great Circle Paths

maps are flat, but Earth is a sphere!







What areas are best for surfing?

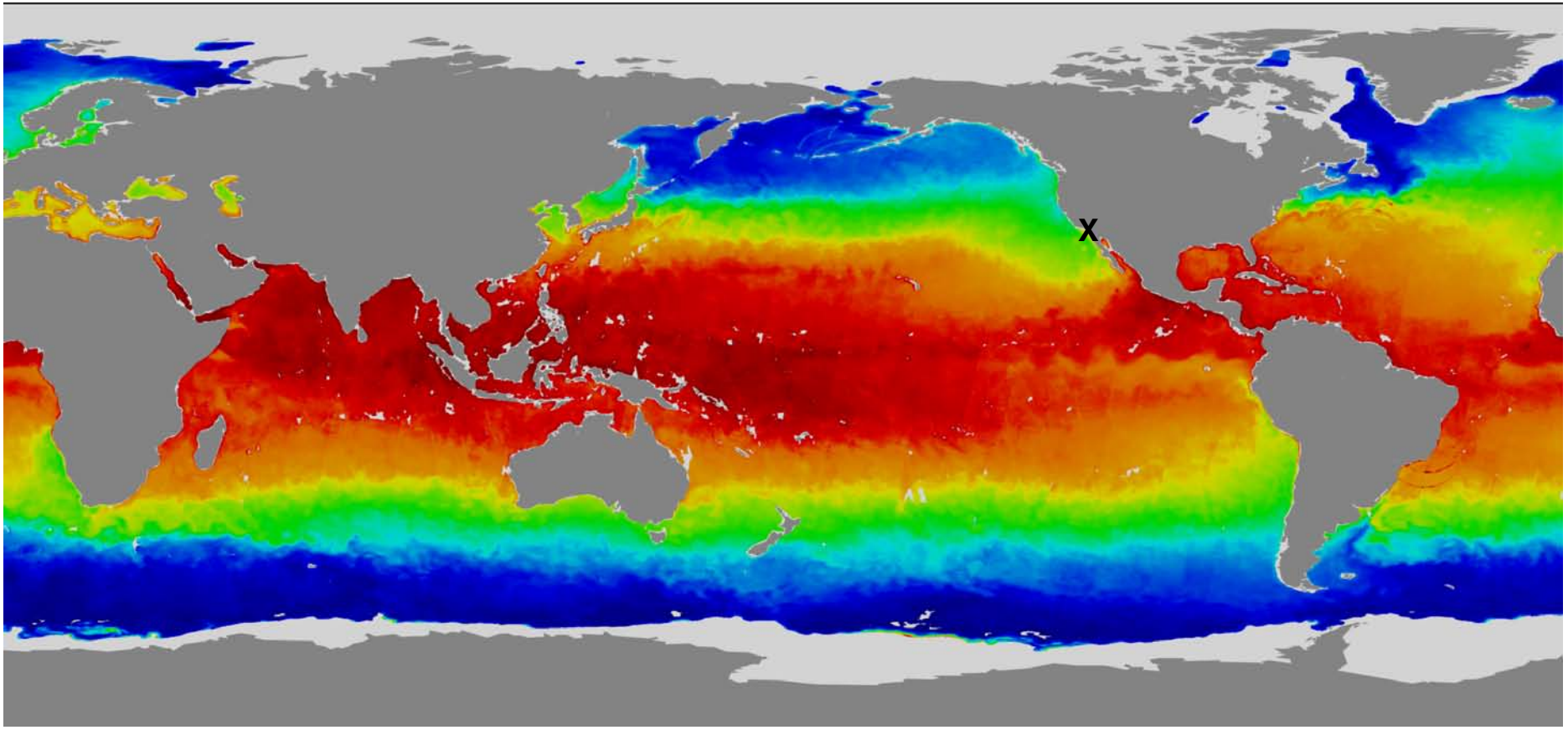
- Need exposure to good swell generating regions

- Generally on west coasts of continents better than east coasts
  - mid-latitude storms move west-to-east => usually stronger winds aimed at west coasts

- Islands
  - Coasts facing all directions - can pick up swells from many different sources

- Areas away from storm regions
  - at least areas with normally light winds

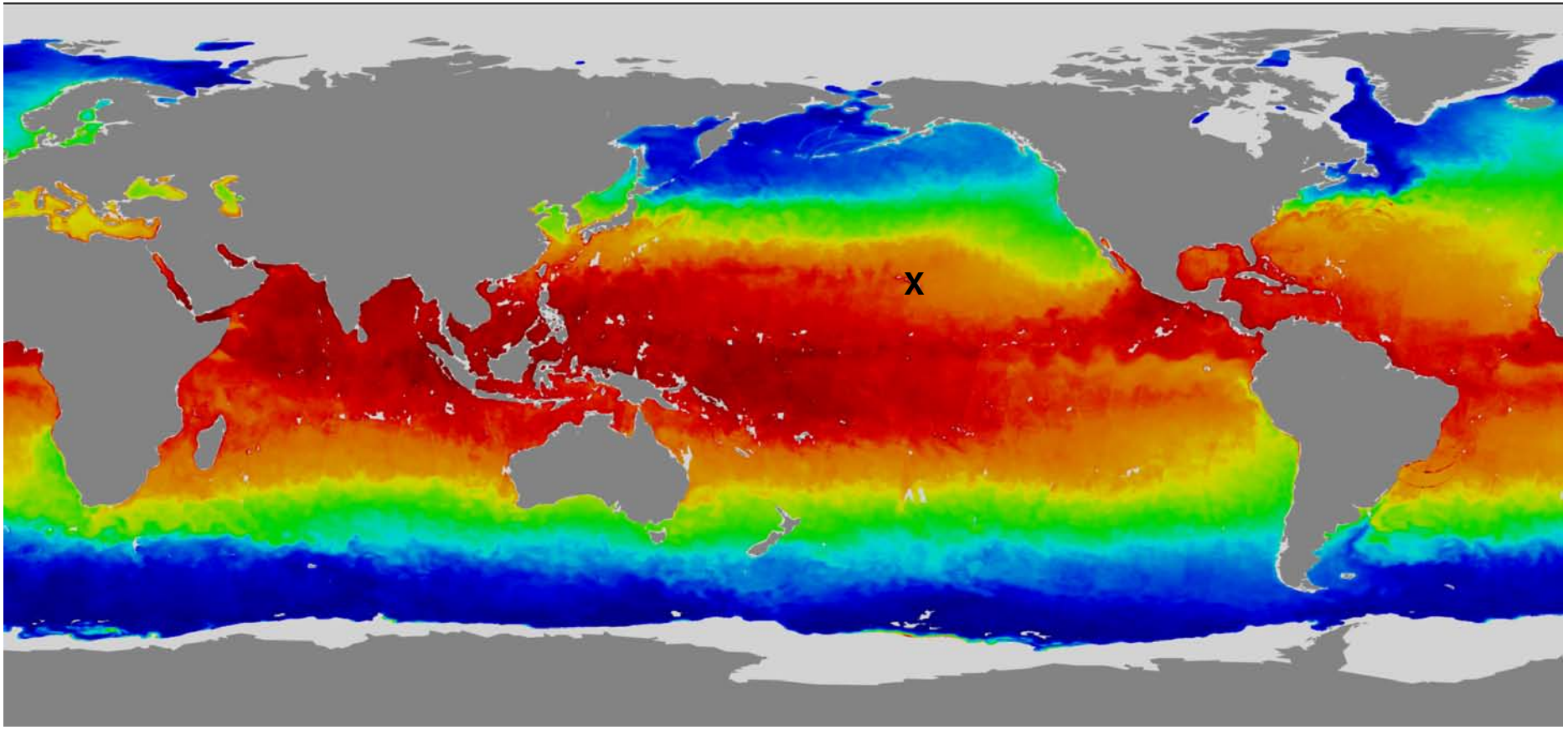
- Warm water
  - not necessary, but nice



X = San Diego

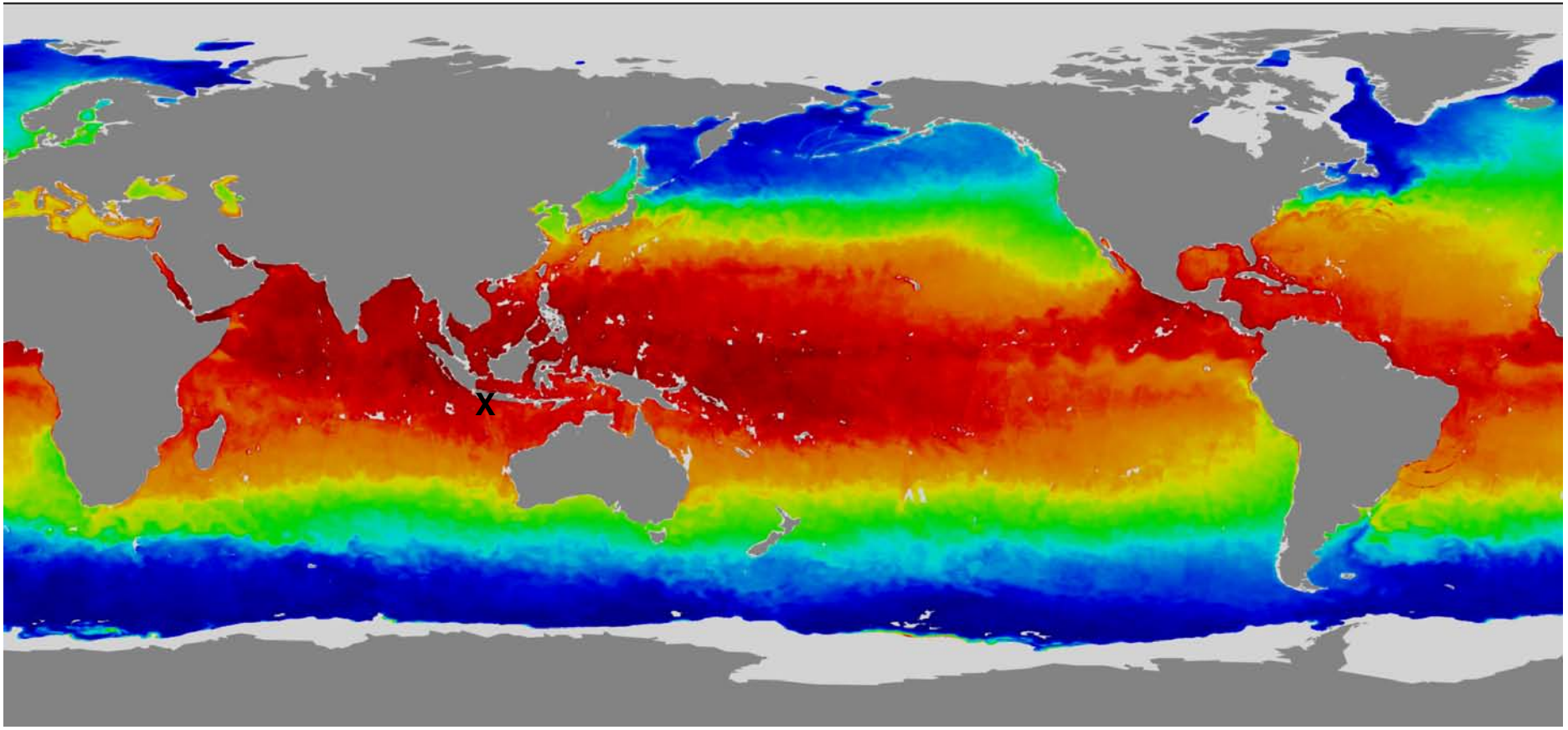
- Exposure to N. Pacific storms, S. Pacific storms, and Mex. hurricanes
- generally light winds (sea-breeze in summer not great)
- cold-warm water (~58-72°F)

- also, waves often wrap around (refraction) Point Conception and Channel Islands
  ==> some energy loss



X = Hawaii

- Exposure to N. Pacific storms, S. Pacific storms, and some Mex. hurricanes
- light-moderate tradewinds (consistent direction year round)
- warm water (~75°F)



X = Indonesia

- Exposure to S. Pacific storms, and some hurricanes
- light-moderate winds (monsoonal circulation = direction changes seasonally)
- very warm water (~85°F)