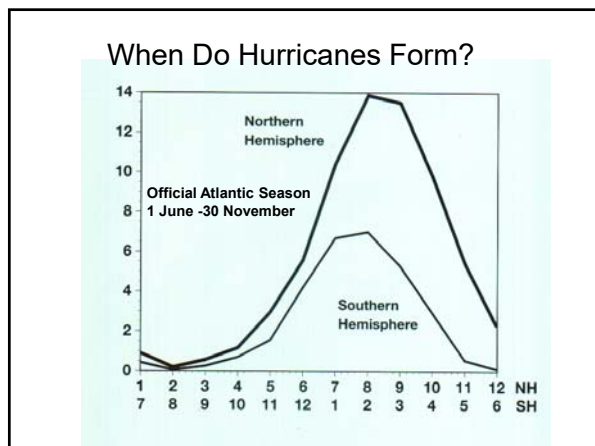


## Worldwide Tropical Cyclone Occurrence

Basin	Named	All Hurricane Strength	Major Hurricane Strength
NW Pacific	26.7	16.9	8.5
S Indian	20.6	10.3	4.3
NE Pacific	16.3	9.0	4.1
N Atlantic	10.6	5.9	2.0
SW Pacific	10.6	4.8	1.9
N Indian	5.4	2.2	0.4

~80 named storms worldwide  
~30 > 33 m s<sup>-1</sup>

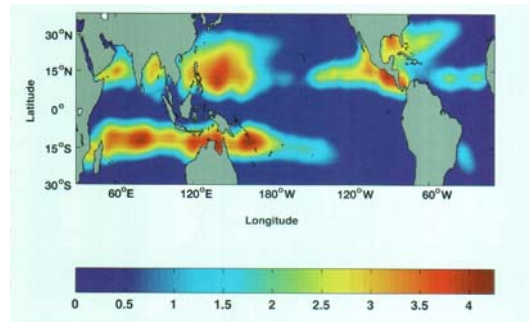


- ## **Hurricane Activity**
- Depends upon the difference in temperature between the air and sea
  - Increases after the Summer Solstice
  - Peaks just before the Autumnal Equinox
  - Continues as the air cools, but the water remains warm
  - Concentrated along the western shores of oceans where wind blowing around the subtropical high brings moist air poleward

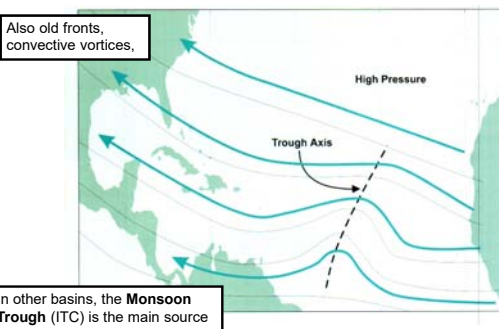
## Necessary Conditions for Tropical Cyclone Formation

- Ocean warmer than 26°C
- Reasonably humid at 2-5 km altitude (~80% RH... under reexamination)
- Rising saturated air is warmer than its surroundings (conditional instability)
- Weak vertical shear ( $< 12.5 \text{ m s}^{-1}$ )
- Pre-existing disturbance
- More than 5° latitude from the Equator

## Hurricane formation Index based upon the 6 necessary conditions



## Atlantic Easterly Waves

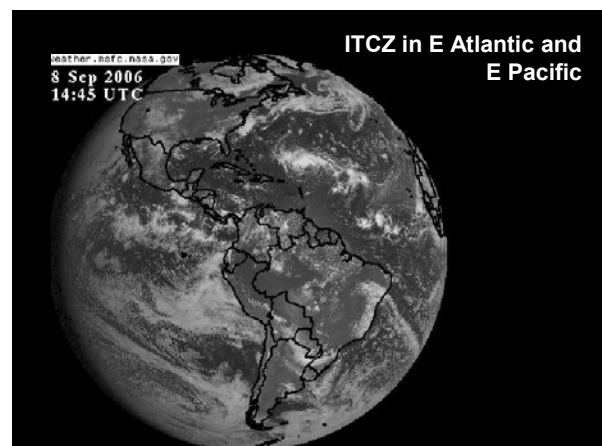
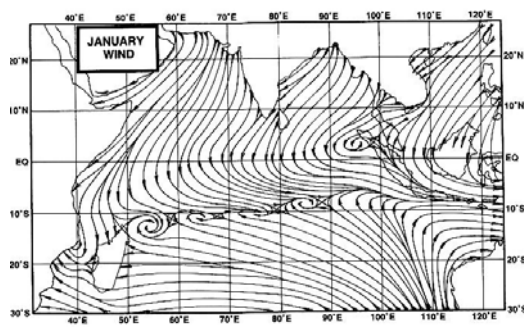


## Easterly Wave Structure

- Form on unstable "Easterly Jet" over Africa
- Generally have SAL behind and/or around their northern side
- Convection is strongest east of the trough
- Clear with scattered clouds to the west
- One every 4 days all summer and into the fall
- 60 during a season
- ~10% become TCs

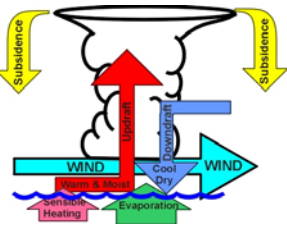


## Cyclonic depressions along the Monsoon Trough in the Southern Indian Ocean

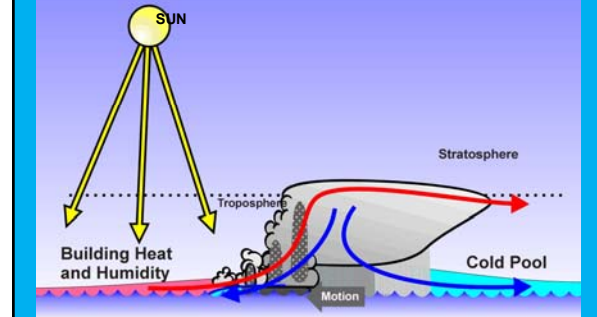


## Role of Humidity

- Sinking in the northern part of the Hadley circulation keeps the subtropics dry
- In the Atlantic the Saharan Air Layer (SAL) is important
- Air is out of thermodynamic equilibrium with the sea
- Evaporation from the sea moistens the air
- Unorganized convection removes vapor & injects cool dry air into the surface layer
- Storms must be "finite amplitude" to intensify
- If the wind is strong enough, evaporation balances downdraft cooling
- Wind-Induced Surface Energy Exchange (WISHE)
- Which brings us to preexisting disturbances



## Role of Squalls in Tropical Heat Balance



## Summary

- 6 TC "Basins" in order of activity
  - NW Pacific, S Indian, NE Pacific, SW Pacific, N Atlantic, N Indian Oceans
- Atlantic Activity:
  - 11 Named Storms
  - 6 Hurricanes, 2 Major
- Conditions for Hurricane Formation: Sea Warmer than 26°C, > 80% RH, Conditional Instability, Pre-existing disturbance, Low Shear, and > 5° from Equator
- Easterly (African) Waves are the pre-existing disturbances in the Atlantic
- Monsoon depressions elsewhere
- Enhanced evaporation due to high winds (WISHE, Wind Induced Surface Energy Exchange)
- Unlike squall lines which live off of the (much lower amount of) energy stored in the air above the sea
  - Rather than the energy stored in the sea itself.
- **For next time: Termination Emanuel 109-115.**
- **Paper Topics Due Monday**