In The Name Of God

# How the oceans influence climate

*I.R. of IRAN Meteorological organization*

By

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# Presentation structure

- **What is Climate**
- **long time-scale influence**
- **The Ocean Strongly Influence Earth's Present**
- **The ocean stores and transports heat.**
- **Influence of Greenhouse Gases Especially Water Vapor**
- El Niño/Southern Oscillation (ENSO)
- Monsoon
- Guno
- Phet
- conclusions

# Asia continent

# physical map of Iran


ARM.
AZER.
Caspian Sea
UZB.
TURKMENISTAN
Tabrīz
Lake Urmia
Now Shahr
TEHRAN
Kuh-e Damavand
Mashhad
Qom
Kermānshāh
Birjand
AFG.
Dezfūl
Eşfahān
Yazd
IRAQ
Ahvāz
Ābādān
Shīrāz
Kermān
Zāhedān
KUW.
Shatt al Arab
Būshehr
'Asalūyeh
Bandar 'Abbās
SAUDI ARABIA
Persian Gulf
BAHR.
QATAR
Strait of Hormuz
OMAN
PAK.
Chābahār
Gulf of Oman
U.A.E.
0 100 200 km
0 100 200 mi

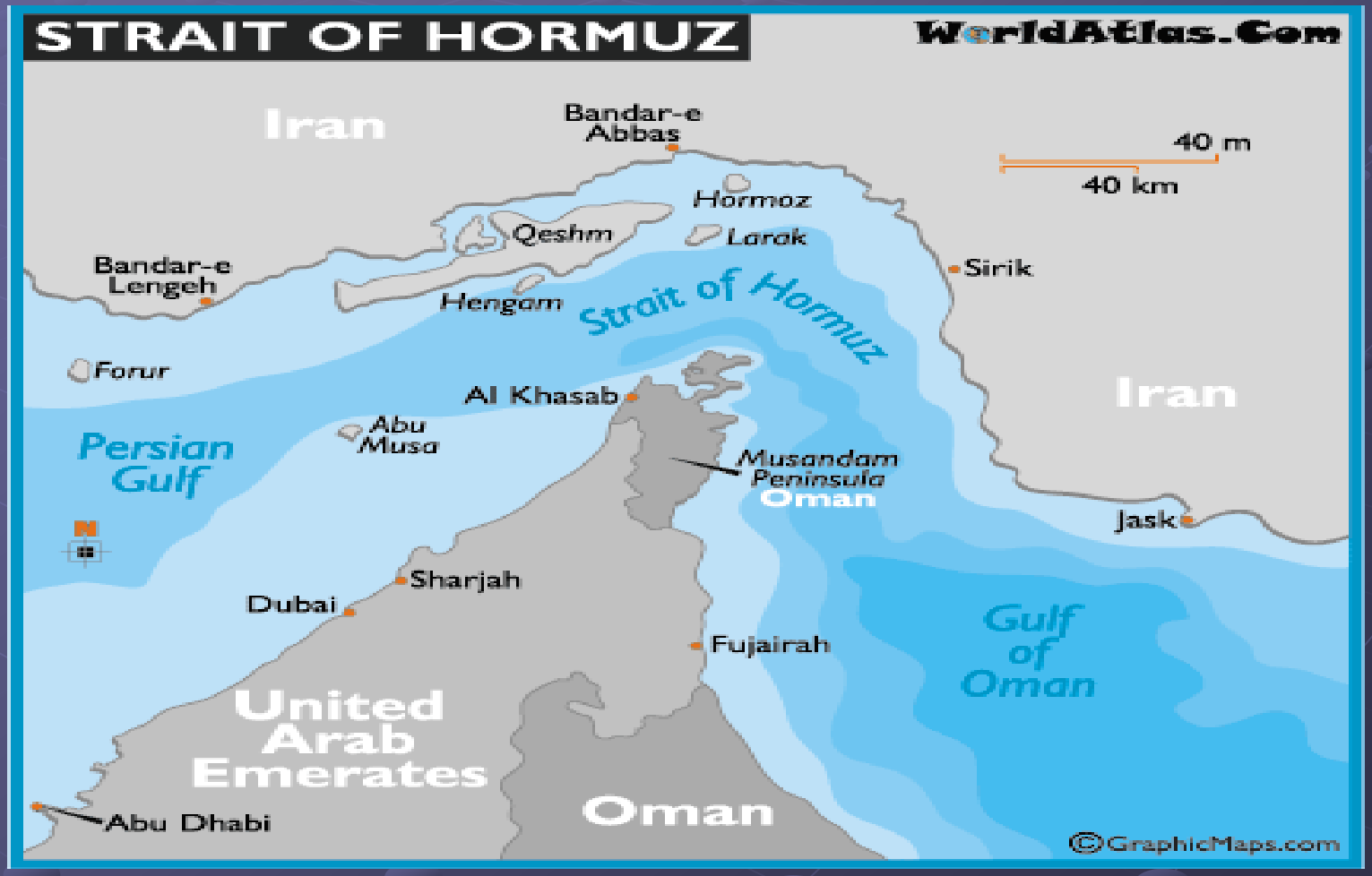

Black Sea
Caspian Sea
Sokhumi
Groznyy
Nukus
Dashhowuz
GEORGIA
Tbilisi
Bat'umi
Samsun
Trabzon
Ankara
ARMENIA
Yerevan
AZERBAIJAN
Baku
Sumqayit
Türkmenbashy
Bukhoro
TURKEY
Erzurum
TURKMENISTAN
Nebitdag
Charjew
GARAGUM
Kayseri
Konya
Van
Ashgabat
Mary
Tabriz
Divarbakir
Adana
Gaziantep
Rasht
Mashhad
Zanjan
Mersin
Irbil
Aleppo
Mosul
Qazvin
Nicosia
Latakia
Tehrān
Karkuk
Hejaz
SYRIA
Qom
Homs
Beirut
Arāk
Damascus
Kermanshah
LEBANON
Baghdad
Haifa
IRAQ
Eşfahān
IRAN
ISRAEL
Port Jerusalem
Said
Amman
Ahvāz
Kermān
Gaza Strip
Suez
JORDAN
An Nāşiriyah
Abādān
Al Başrah
Zāhedān
Al Aqabah
Kuwait
KUWAIT
Shīrāz
Būshehr
Tabūk
Hafar al Bāṭin
Bandar Abbās
Hā'il
Persian Gulf
Al Jubayl
Buraydah
Ad Dammām
Manama
Dhahran
BAHRAIN
QATAR
Doha
Dubai
OMAN
Luxor
Riyadh
Abu Dhabi
Muscat
Aswān
Medina
Gulf of Oman

# Map of Caspian Sea

# Persian Gulf & Gulf of Oman

# Persian Gulf

# Strait of Hormuz



# What is Climate

- Traditionally define:

climate has been defined as the average weather: temperature, precipitation, cloudiness, and how these variables change throughout the year.

- Now, earth-system science define:

it leads to a much broader definition.

*climate is a system consisting of the atmosphere, hydrosphere, lithosphere, and biosphere. Physical, chemical, and biological processes are involved in interactions among the components of the climate system.*

# Inventory of water at the Earth's surface e

- The planetary water supply is dominated by the oceans.
- 97 % of all the water on the Earth is in the oceans.
- The other 3 % is held as freshwater in glaciers an icecaps, groundwater, lakes, soil,the atmosphere, and within life.

| Reservoir | Volume (cubic km x 10,000,000) | Percent of Total |
|---|---|---|
| Oceans | 1370 | 97.25 |
| Ice Caps and Glaciers | 29 | 2.05 |
| Groundwater | 9.5 | 0.68 |
| Lakes | 0.125 | 0.01 |
| Soil Moisture | 0.065 | 0.005 |
| Atmosphere | 0.013 | 0.001 |
| Streams and Rivers | 0.0017 | 0.0001 |
| Biosphere | 0.0006 | 0.00004 |

# long time-scale influence

**The Ocean and Ocean Life Strongly Influenced Earth's Climate Over Billions of Years**

Over millions of years, the concentration of gases in the atmosphere is determined by life. If life did not exist, especially life in the ocean,

On a deeper level, oceanic microbes irreversibly altered the geochemistry of earth and the biogeochemical cycles of H, C, N, O and S.

# Important parameters

1- Carbon dioxide, the most common gas on Venus is rare in earth's atmosphere because oceanic animals have used carbon dioxide to make vast layers of carbonates in the form of limestone, dolomite, and marble. Without life, our atmosphere would be similar to that of Venus. Most sedimentary rocks were laid down in the ocean.

2- Free oxygen $O_2$ which is not found in the atmosphere of other planets, is produced by life. It is found in the atmosphere because of production by photosynthesis and the deposition of organic carbon on the the sea floor and the eventual inclusion of the organic carbon into continental rocks by plate tectonics acting over many millions of years.

3- Oxygen in the atmosphere led to the formation of earth's stratospheric ozone layer which protects all life from solar ultraviolet radiation.

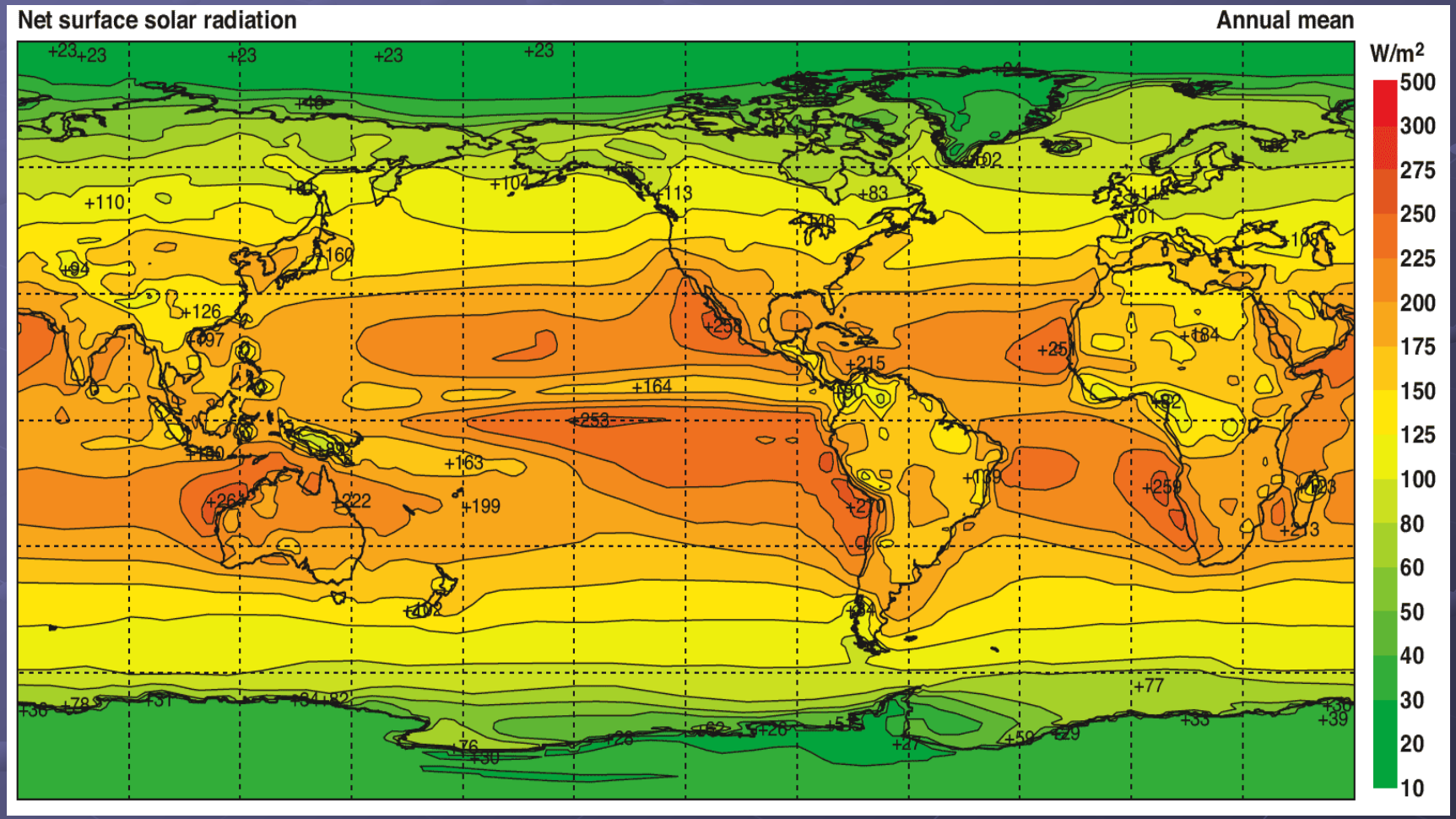
# The Ocean Strongly Influence Earth's Present Climate

**The ocean drives the atmospheric circulation by heating the atmosphere, mostly in the tropics**

1- Most of the sunlight absorbed by earth is absorbed at the top of the tropical ocean.

Most of the ocean is a deep navy blue, almost black. It absorbs 98% of the solar radiation when the sun is high in the sky.

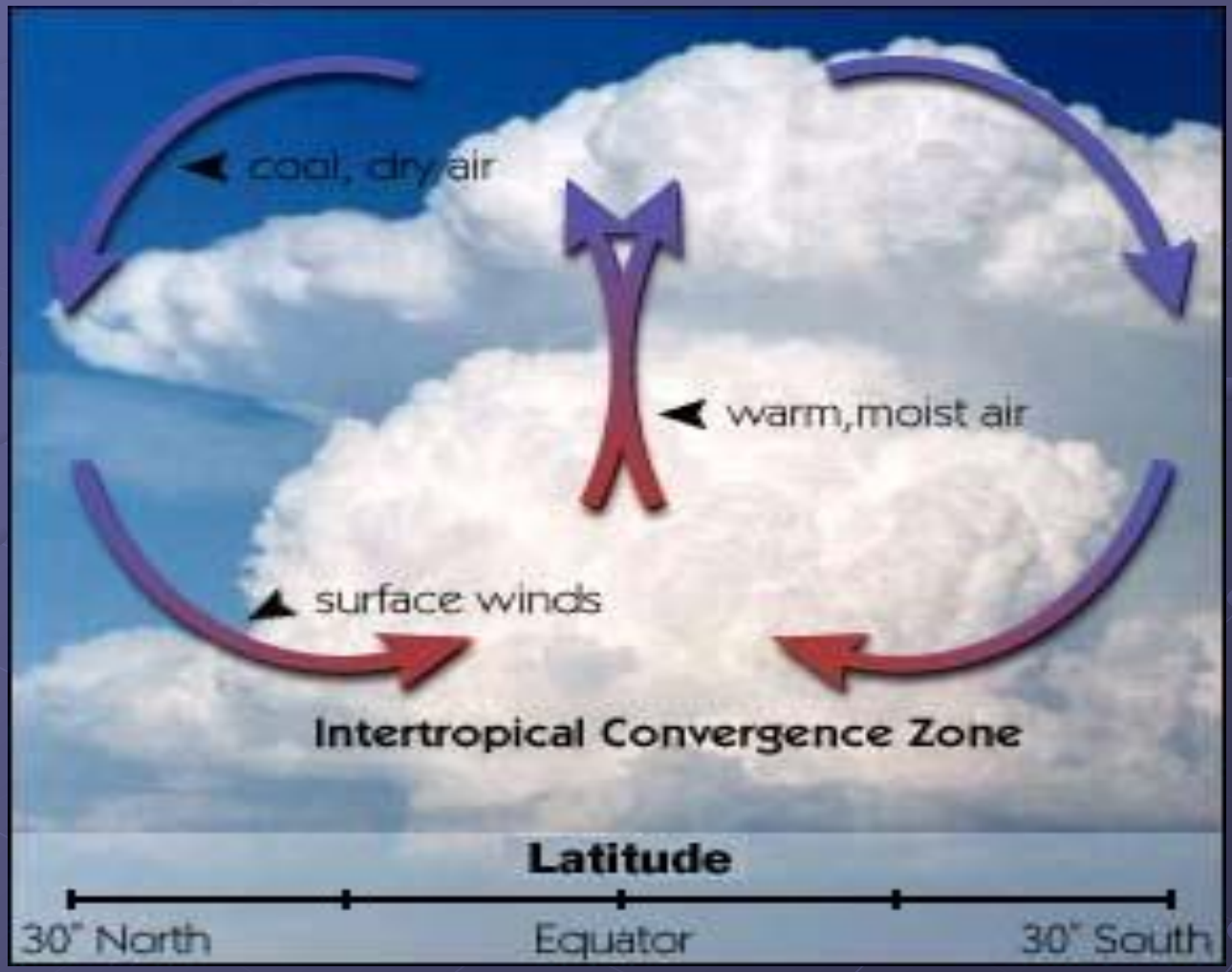
*Heating of earth's surface by solar radiation, in W/m$^2$, calculated from the ECMWF 40-year reanalysis of atmospheric data. Notice that most of the heat absorbed by earth goes into the tropical ocean.*



# The Ocean Strongly Influence Earth's Present Climate

2-The ocean loses heat by evaporation Trade winds carry the evaporated water vapor to the **Inter-Tropical Convergence Zone** where it condenses as rain. Condensation releases the latent heat and warms the air. Warm air rises, further drawing in warm wet air, releasing more heat.

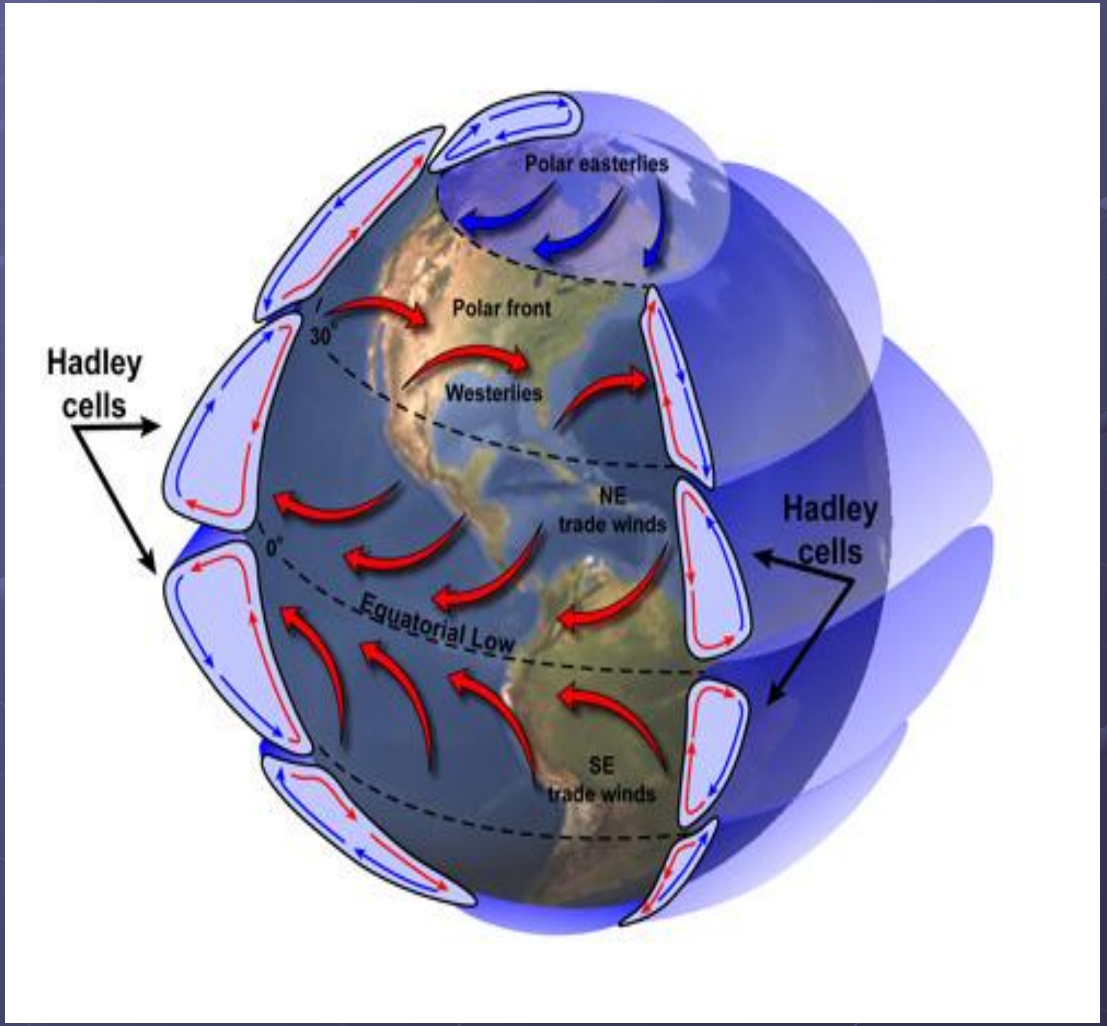
# Intertropical Convergence Zone



# Hadley cells

**Left:** *Rain in the tropics warms the atmosphere and drives the Hadley circulation.*

**Right:** *The Hadley cells (circulation) are a major part of the climate system. Click on image for a zoom.*

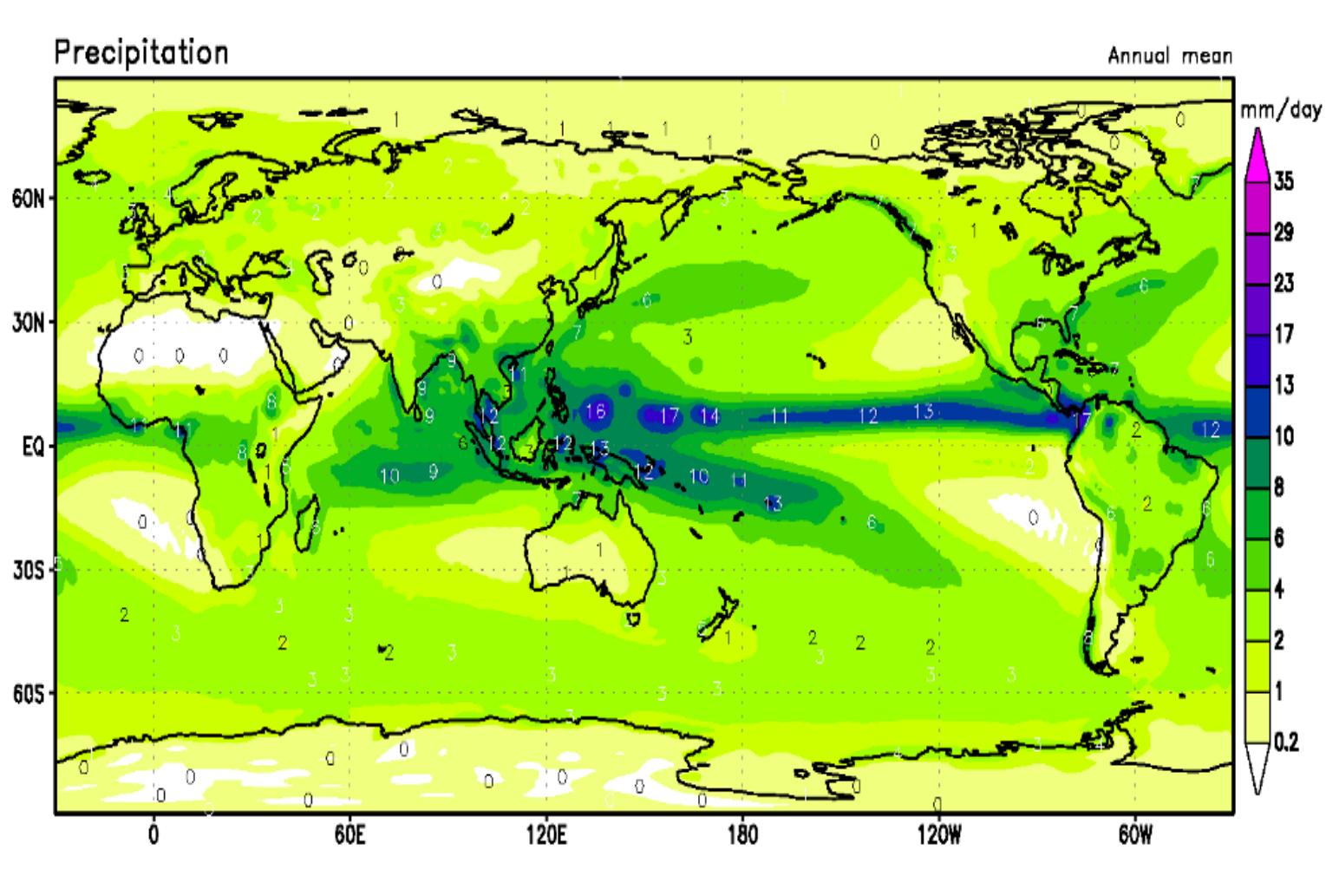


- So much heat is released by rain in the Inter-Tropical Convergence Zone that it drives much of the atmospheric circulation. This circulation is called the Hadley circulation.

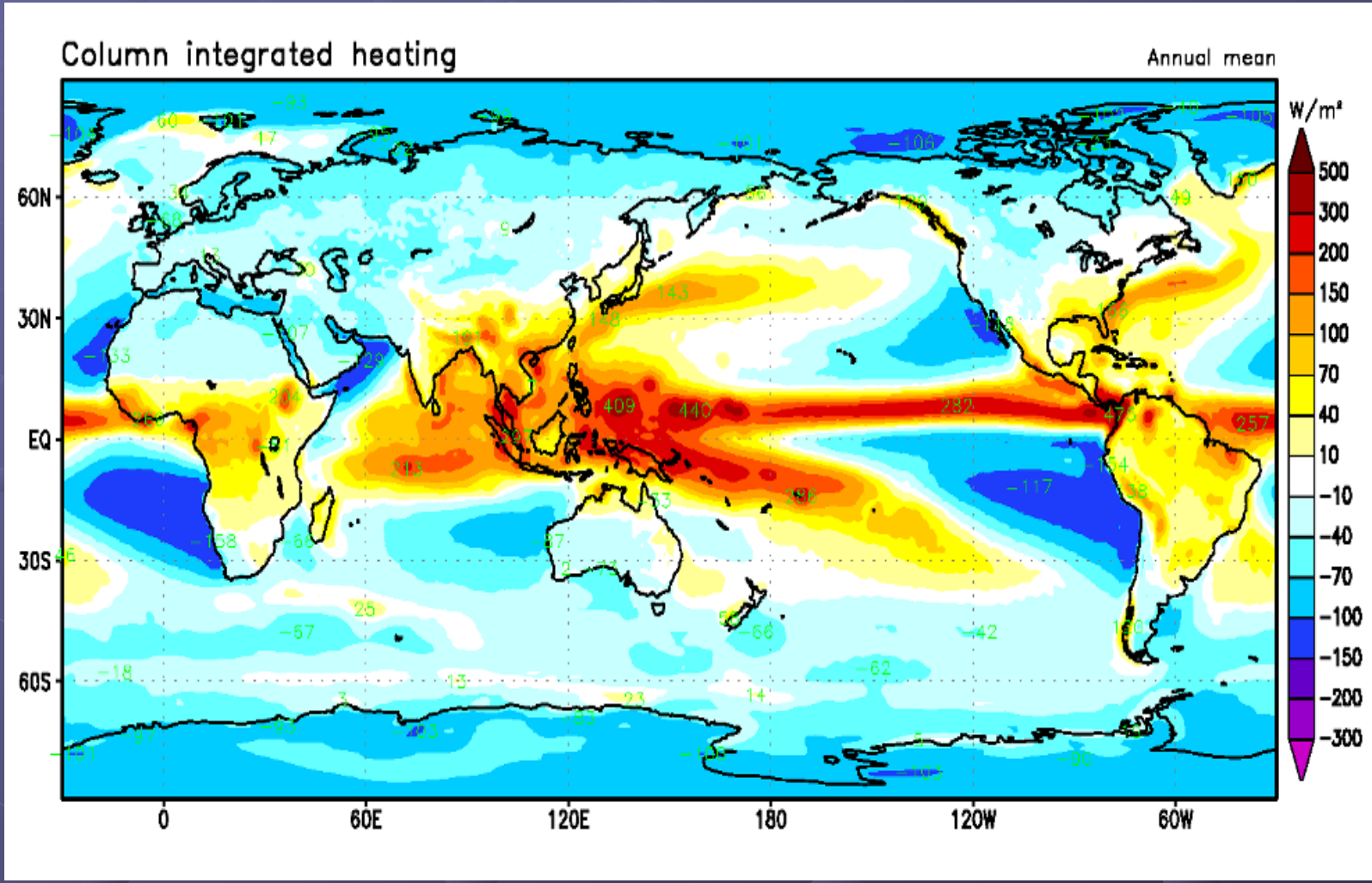
- Heat released by rain in higher latitudes drives storms and winds.

- Heat released by rain in hurricanes and thunderstorms drives these storms.

*25-year average of rain rate.*



*25-year average of heating of the atmosphere. Notice the high correlation with rain rate shown above. Rain and absorption of infrared radiation heats the atmosphere, mostly in the tropics. This heating drives the atmospheric circulation.*



# The Ocean Strongly Influence Earth's Present Climate

3-The ocean also loses heat by sending out infrared radiation (energy), mostly in the tropics. The infrared radiation is absorbed by water vapor in the tropical atmosphere, further heating the atmosphere.

4-The winds drive ocean currents, and together they carry heat from the tropics to the polar regions. See The Climate System below.

# The ocean stores and transports heat.

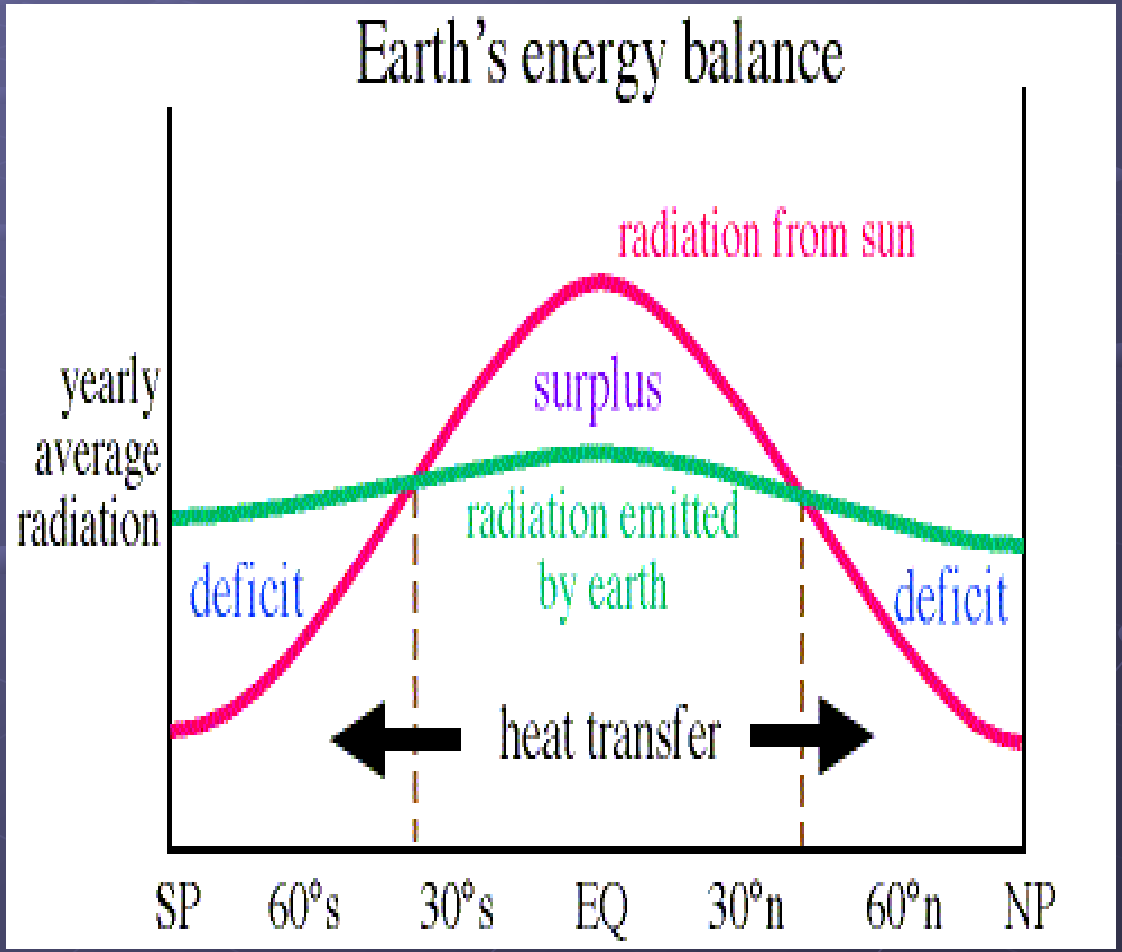
Temperature in the atmosphere, even global changes in temperature are slowed by the exchange of heat with the ocean. Thus, 18 times more heat has been stored in the ocean since the mid 1950s due to global warming than has been stored in the atmosphere. Most of the heat trapped by greenhouse gases has gone into the ocean, not the atmosphere.

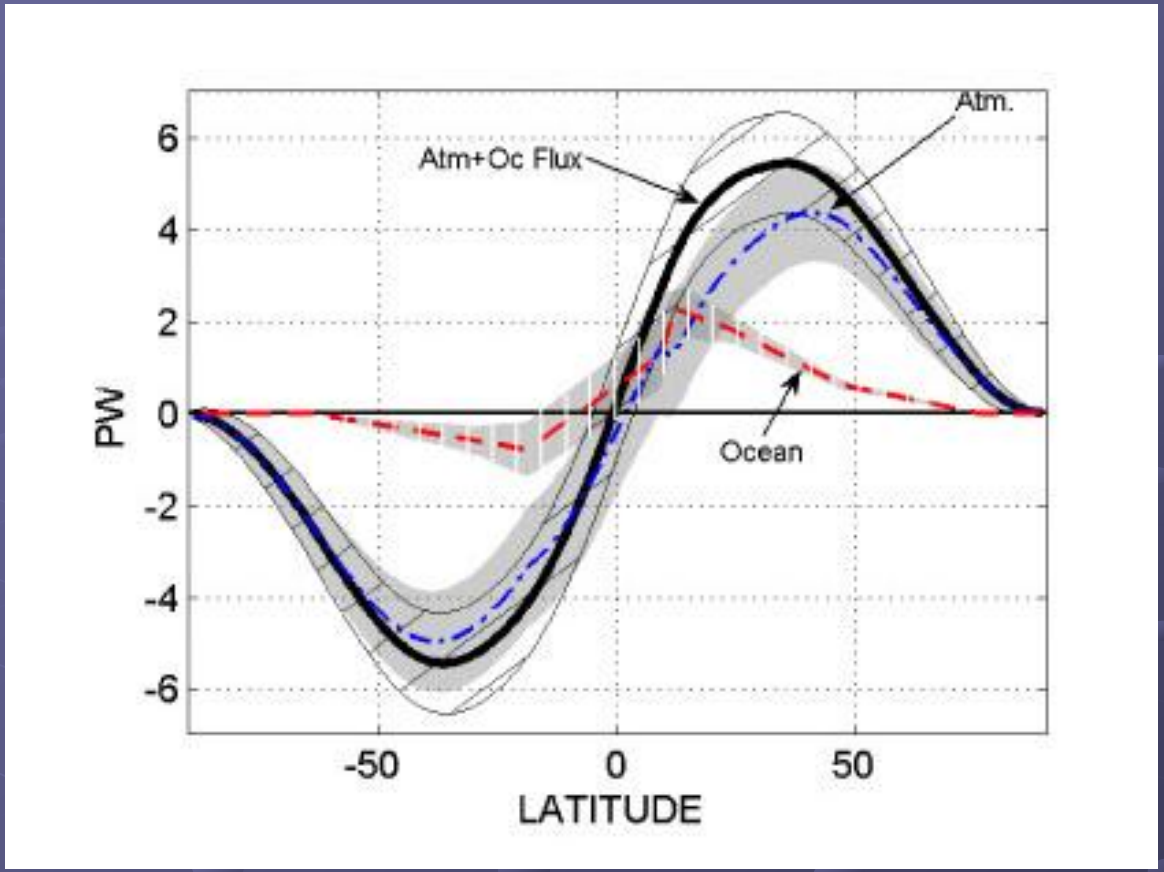
1- The tropics are warm because they receive so much sunlight.

2- The poles are cold because they receive much less sunlight, and because the polar atmosphere is transparent to infrared radiation. They radiate away much more heat than they receive from the sun.

# Earth's Energy Balance

- Zonal average of heat gained from the sun (red line) and lost to space
- by emitted infrared radiation (green line).






*This plot shows the zonal average of heat transported by the atmosphere and the ocean in units of petawatts (PW = $10^{15}$ Watts) (solid black line), by the ocean (red dashed line), and by the atmosphere (blue dashed line), averaged along lines of constant latitude. The ocean is important for carrying heat out of the tropics, and the atmosphere is important at latitudes greater than 20°.*

# Influence of Greenhouse Gases Especially Water Vapor

- how they might cause climate change

There is there ideas for comparing:

1- **Earth with no atmosphere**

If earth had no atmosphere, if it had a land surface that reflected some sunlight like the real earth, and if it were in equilibrium with solar heating, the average surface temperature of earth would be -18°C (0°F), far colder than the average temperature of our earth, which is 15°C (59°F). Worse, the surface would cool down to around -160°C (-250°F) soon after the sun set because the surface would radiate heat to space very quickly, just as the moon's surface cools rapidly as soon as the sun sets on the moon.

## 2- **Earth with a static atmosphere and no ocean**

If the earth had a static atmosphere with the same gases it has now, but with little water vapor and no ocean, the average surface temperature of earth would be 67°C (153°F). This is much warmer than our earth. The planet would be so hot because greenhouse gases in the atmosphere help keep heat near the surface, and because there is no convection, and no transport of heat by winds. Adding winds cools the planet a little, but not enough.

## 3- Earth with an atmosphere and ocean

Earth has an atmosphere and ocean, and the average surface temperature is a comfortable 15°C (59°F). Water evaporates from the ocean and land, cooling the surface. Winds carry the water vapor to other latitudes, and sometimes high up into the air, where heat is released when the vapor condenses to water

*This very large thunderstorm was photographed by astronauts flying over the Indian Ocean, east of Madagascar (25.0N, 56.0E). The storm is about 65 nautical miles on a side and has a top that reaches into the stratosphere at 45,000 to 50,000 ft. and casts long shadows in the low sun. Such storms carry heat from the tropical seas high into the atmosphere, cooling the surface.*

# El Niño/Southern Oscillation (ENSO)

- El Niño is the appearance in the Pacific interior of an anomalously warm tongue of water that changes the convective atmospheric cell above it. In normal conditions, the atmospheric convective loop involves upwelling of warm air over the western Pacific which moves eastward at height and downwells over the eastern Pacific.

During El Niño, due to the warm water pool in the basin interior, two convective loops are produced, with upwelling of warm air over the pool, and two branches moving at height both westward and eastward, finally downwelling over the western Pacific and Central America. El Nino is succeeded by its opposite phase, La Niña, in which the warm pool is replaced by a cold one. This coupled oscillation of the atmosphere-ocean system has an irregular periodicity of a few years and has profound consequences on the fisheries and the economy of central/southern America.

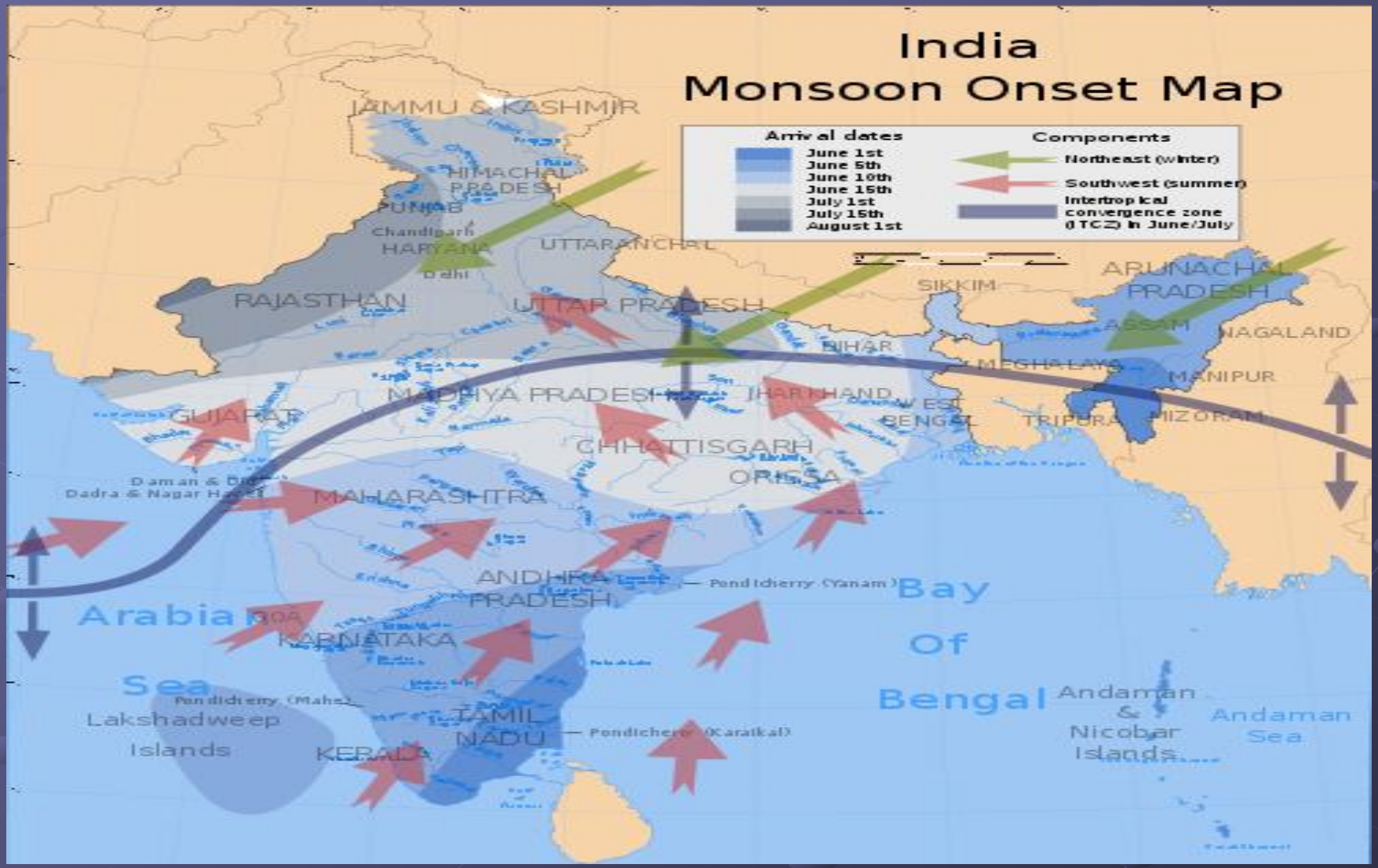
# Monsoon

The Asian monsoons may be classified into a few sub-systems, such as the South Asian Monsoon which affects the Indian subcontinent and surrounding regions, and the East Asian Monsoon which affects southern China, Korea and parts of Japan.

# South Asian Monsoon

The southwestern summer monsoons occur from June through September. The Thar Desert and adjoining areas of the northern and central Indian subcontinent heats up considerably during the hot summers, which causes a low pressure area over the northern and central Indian subcontinent.

# Onset dates and prevailing wind currents of the southwest summer monsoons in India.



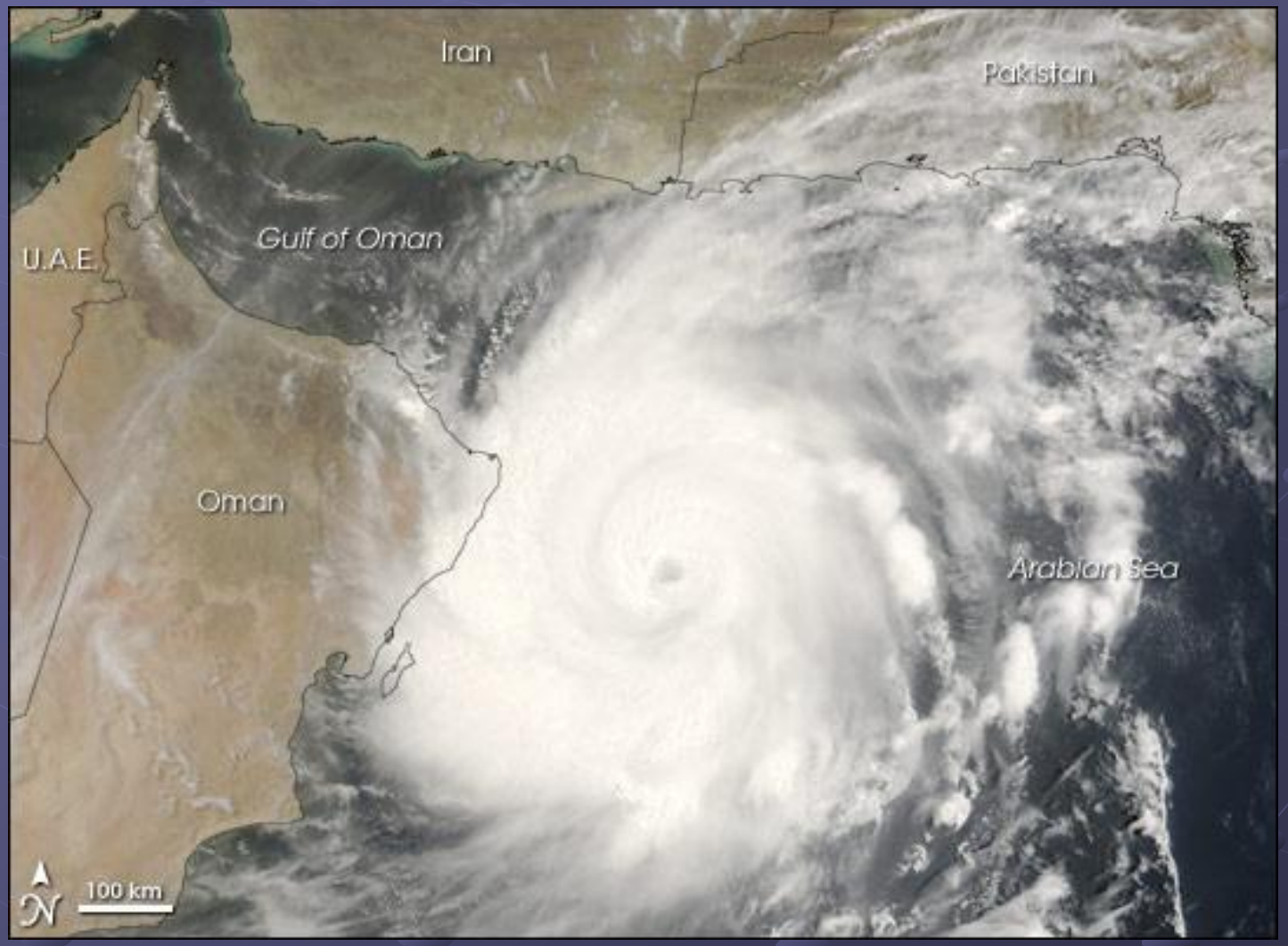
The southwest monsoon is generally expected to begin around the start of June and fade down by the end of September. The moisture-laden winds on reaching the southernmost point of the Indian Peninsula, due to its topography, become divided into two parts: the *Arabian Sea Branch* and the *Bay of Bengal Branch*

# East Asian Monsoon

The East Asian monsoon affects large parts of Indo-China, Philippines, China, Korea and Japan. It is characterised by a warm, rainy summer monsoon and a cold, dry winter monsoon. The rain occurs in a concentrated belt that stretches east-west except in East China where it is tilted east-northeast over Korea and Japan. The seasonal rain is known as *Meiyu* in China, *Changma* in Korea, and *Bai-u* in Japan, with the latter two resembling frontal rain.

The onset of the summer monsoon is marked by a period of premonsoonal rain over South China and Taiwan in early May. From May through August, the summer monsoon shifts through a series of dry and rainy phases as the rain belt moves northward, beginning over Indochina and the South China Sea (May), to the Yangtze River Basin and Japan (June) and finally to North China and Korea (July). When the monsoon ends in August, the rain belt moves back to South China.

# Super cyclonic storm (IMD) Category 5 cyclone (SSHS)



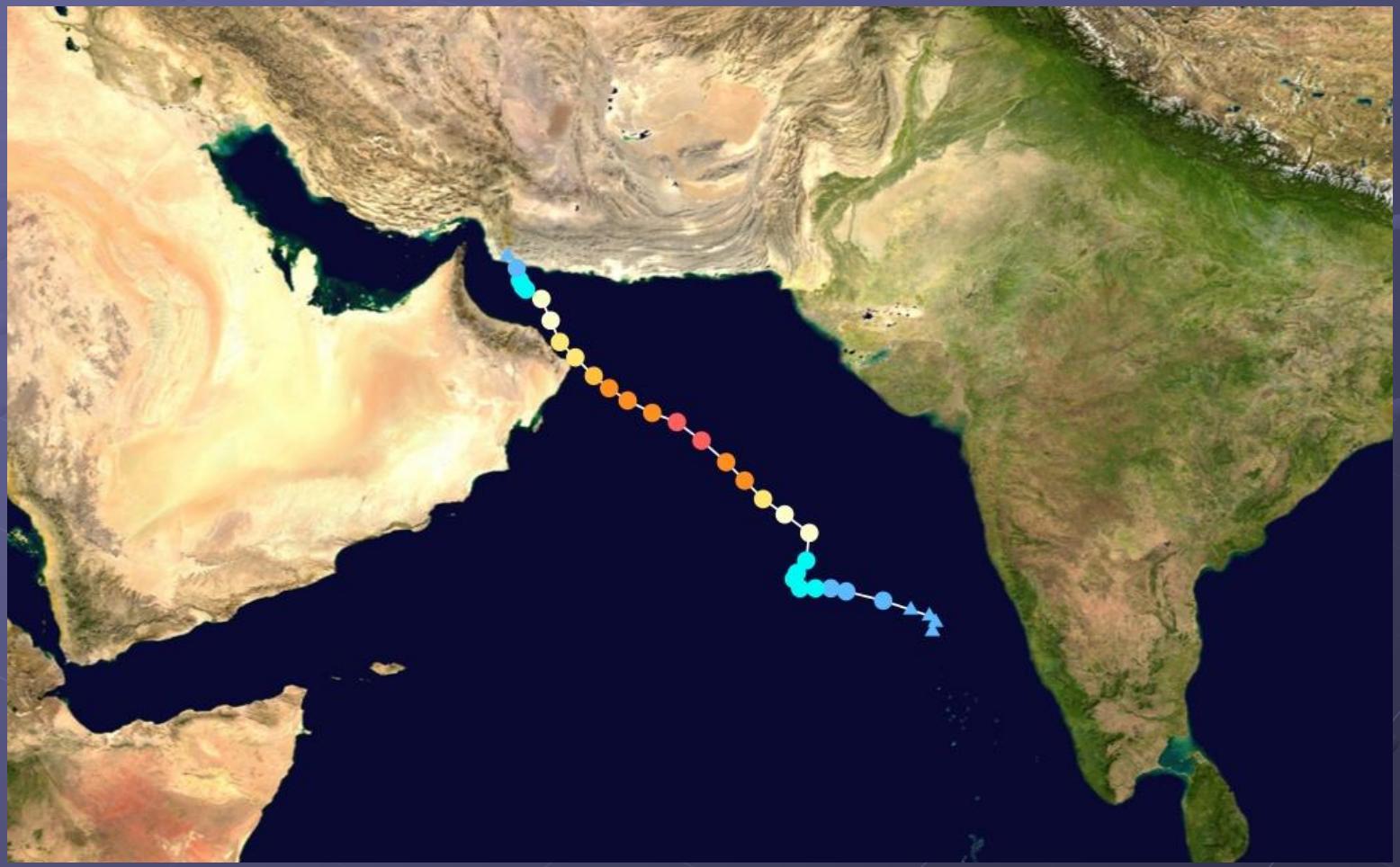
- A storm with near-perfect symmetry and a well-defined eye hovering over the warm waters of the Caribbean or in the South Pacific is not unusual, but Tropical Cyclone Gonu showed up in a rather different place: the Arabian Sea. Though rare, cyclones like Gonu are not unheard of in the northern Indian Ocean basin.

Most cyclones that form in the region form over the Bay of Bengal, east of India. Those that take shape over the Arabian Sea, west of the Indian peninsula, tend to be small and fizzle out before coming ashore. Cyclone Gonu was a rare exception.

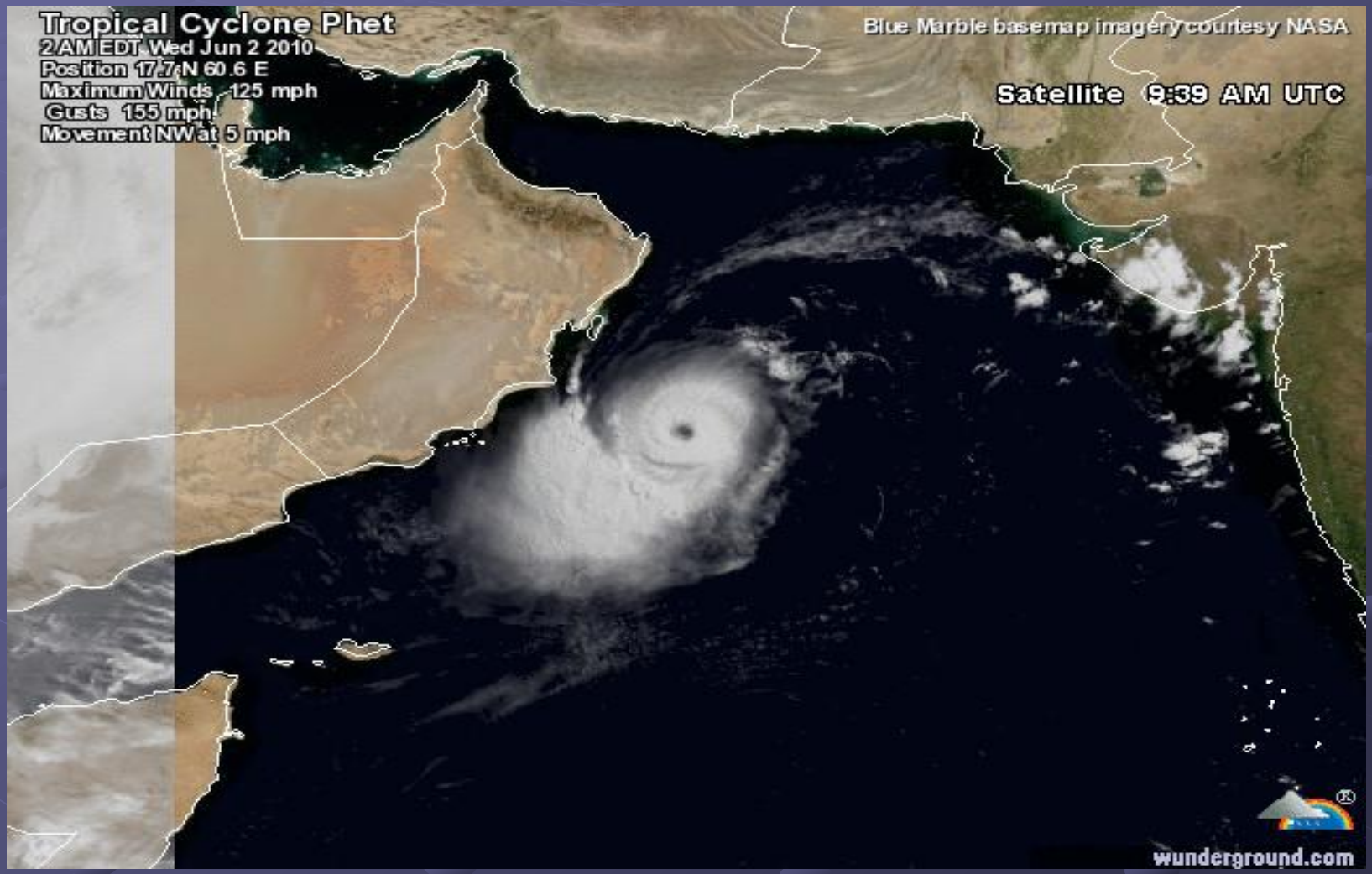
# Cyclone Gonu

**Cyclone** known as **Super Cyclonic Storm Gonu** was the strongest tropical cyclone on record in the Arabian Sea, and was also the strongest named cyclone in the northern Indian Ocean.The second named tropical cyclone of the 2007 North Indian Ocean cyclone season, Gonu developed from a persistent area of convection in the eastern Arabian Sea on June 1. With a favorable upper-level environment and warm sea surface temperatures, it rapidly intensified to attain peak winds of 240 km/h (150 mph) on June 3, to the India Meteorological Department

. Gonu weakened after encountering dry air and cooler waters, and early on June 6, it made landfall on the eastern-most tip of Oman, becoming the strongest tropical cyclone to hit the Arabian Peninsula. It then turned northward into the Gulf of Oman, and dissipated on June 7 after making landfall in southern Iran.



# Cyclone Phet



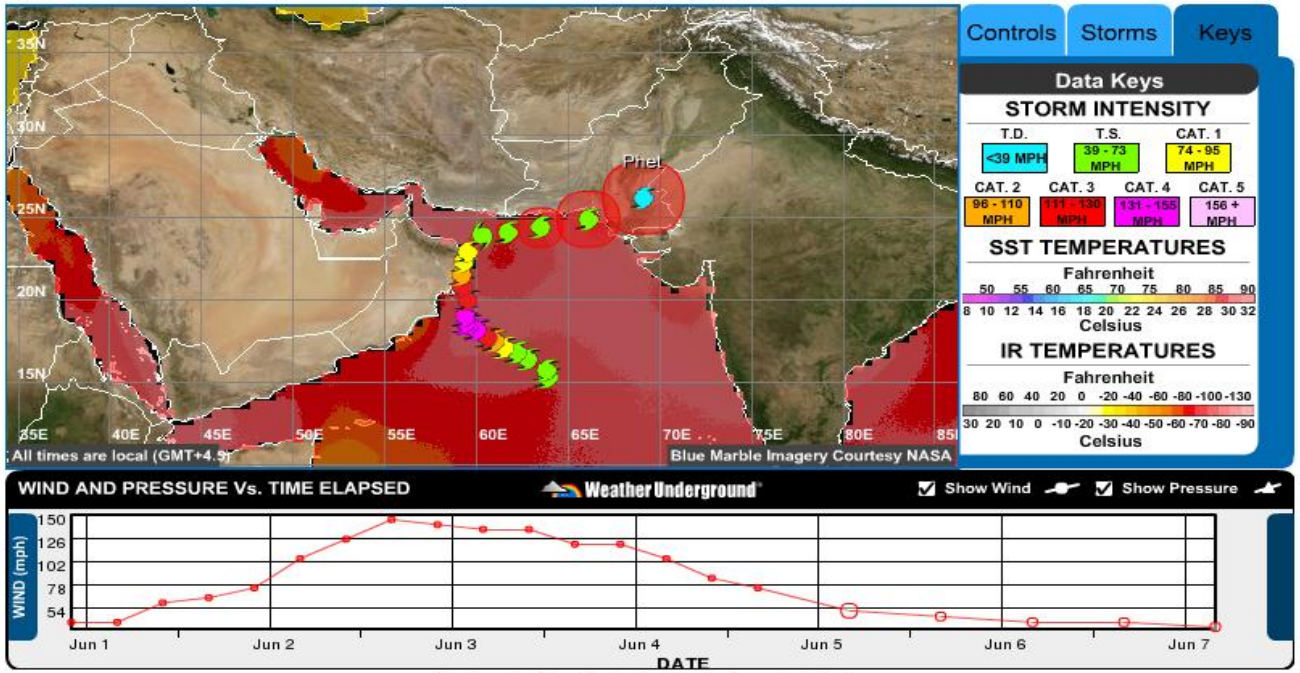
**Cyclone Phet** (IMD Designation:**ARB 02**, JTWC designation:**03A**) is the second-strongest tropical cyclone on record to develop within the Arabian Sea; only Cyclone Gonu in 2007 was more intense. It initially moved to the northwest direction near Oman but is forecasted to turn more to the North before reaching the Arabian Peninsula and later to a northeastern track onto Pakistan and the Indian state of Gujarat. "Phet" is a Thai word, it means Diamond.

http://www.wunderground.com/tropical/tracking/na201003_flashtool.html?extraprod=fl

Text Information: Public Advisory Coordinates

Tracking | 5 Day Forecast | Storm History | Satellite | Flash Tracker | WunderMap™

## Tropical Storm Tracking Map







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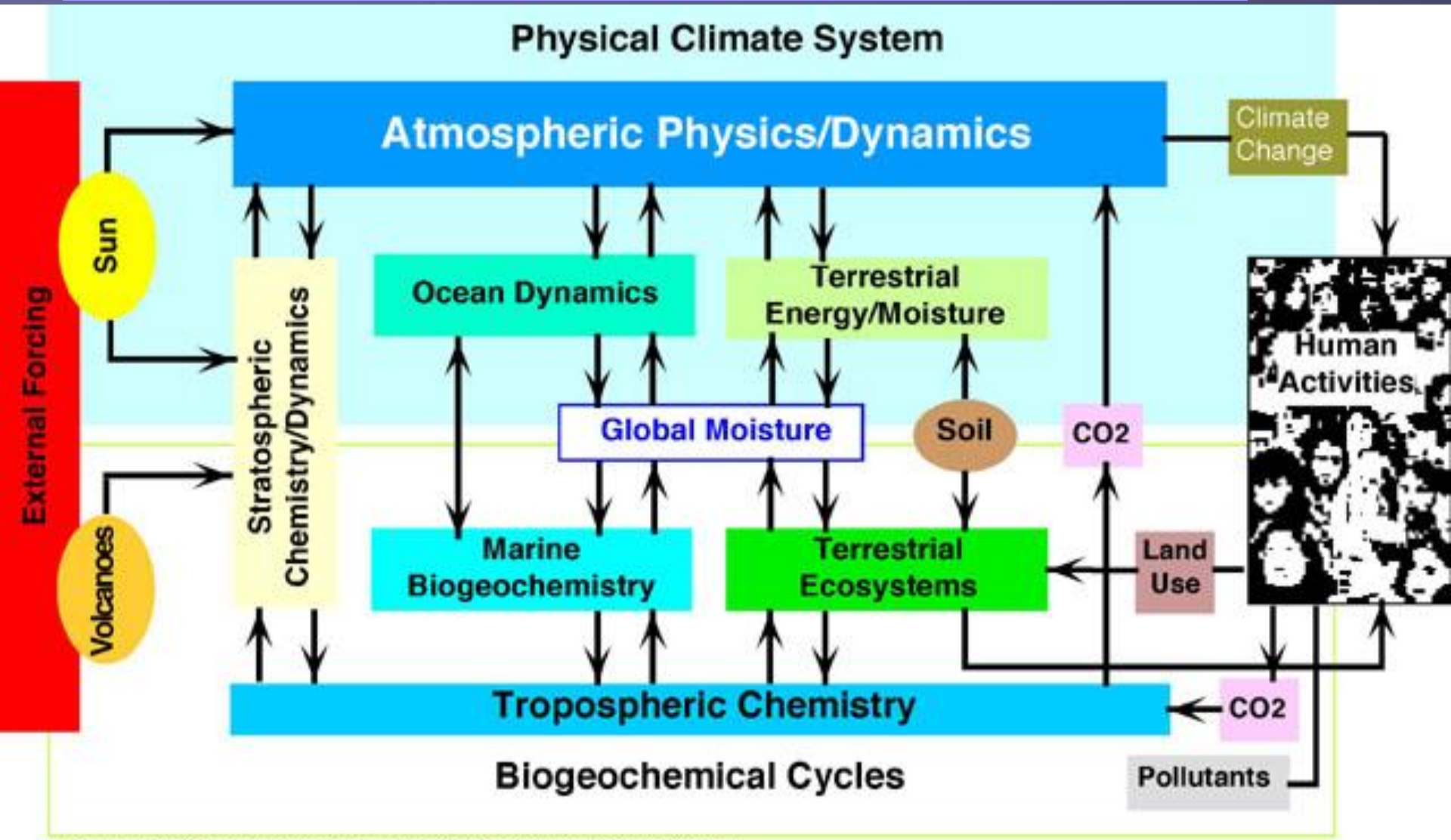
# conclusions

From this simple discussion we can conclude:

- we must understand how earth, with its atmosphere, greenhouse gases, ocean, life, winds, and currents all interact to produce our climate. The ocean is one big part of the earth system. The ocean, atmosphere,and land are connected through the climate system. Changes in one area cause changes everywhere else. Everything is connected, and everything influences everything else.

# One Example:




(from Earth System Science: An Overview, NASA, 1988)

# As a result of these connections

- Earth has a surface temperature that is just right for life. Water vapor from the ocean is essential for setting the earth's temperature.
- The tropical ocean supplies almost all the water that falls on land.
- The ocean absorbs half of the carbon dioxide released by our burning of fossil fuels. This reduces global warming caused by carbon dioxide.

- So much heat is absorbed by the oceans, that the the warming of earth's surface by greenhouse gases is slowed down. 84% of the energy available to warm earth's surface has gone into the ocean during the 48 years from 1955 to 2003; 5% has gone into the land; 4% has gone into the atmosphere; and the remainder has gone into melting ice

*Thanks a lot for your attention*