

ESCI 344 – Tropical Meteorology
Lesson 5 – Tropical Cyclones: Climatology

References: *A Global View of Tropical Cyclones*, Elsberry (ed.)
The Hurricane, Pielke
Tropical Cyclones: Their evolution, structure, and effects, Anthes
Forecasters' Guide to Tropical Meteorology, Atkinson
Forecasters Guide to Tropical Meteorology (updated), Ramage
Global Guide to Tropical Cyclone Forecasting, Holland (ed.)

Reading: *Introduction to the Meteorology and Climate of the Tropics*, Chapter 9
A Global View of Tropical Cyclones, Chapter 3

REQUIREMENTS FOR FORMATION

- **In order for a tropical cyclone to form, the following general conditions must be present:**
 - **Deep, warm ocean mixed layer.**
 - **Sea-surface temperature at least 26.5°C.**
 - **Mixed layer depth of 45 meters or more.**
 - **Relative maxima in absolute vorticity in the lower troposphere**
 - **Need a preexisting cyclonic disturbance.**
 - **Must be more than a few degrees of latitude from the Equator.**
 - **Small values of vertical wind shear.**
 - **Disturbance must be in deep easterly flow, or in a region of light upper-level winds.**
 - **Mean upward vertical motion with humid mid-levels.**

GLOBAL CLIMATOLOGY

Note: Most of the statistics given in this section are from Gray, W.M., 1985:
Tropical Cyclone Global Climatology, WMO Technical Document WMO/TD-72, Vol. I, 1985.

- **About 80 tropical cyclones per year world-wide reach tropical storm strength (≥ 34 kts).**
- **About 50 – 55 each year world-wide reach hurricane/typhoon strength (≥ 64 kts).**
- **The rate of occurrence globally is very steady.**
 - **Global average annual variation is small (about 7%).**

- Extreme variations are in the range of 16 to 22%.
- Variability within a particular region is much larger than global variability.
- Most (87%) form within 20° of the Equator.
 - Those that form farther than 20° from the Equator are usually in the Northern Hemisphere.
- Vast majority form in or near monsoon troughs.
 - Most of the remainder form in tropical waves
 - A few form along old frontal zones or shear lines.
- Cyclogenesis tends to cluster in 2-3 week active periods that occur after 2-3 week inactive periods.

NORTH ATLANTIC

- 11.6% of global total tropical storm strength and higher.
- 12% of global total hurricane strength and higher.
- 97% occur between June 1 and November 30
 - There is no month without at least one tropical cyclone
 - Peak of season is September 10
- Position and strength of subtropical jet is key factor in seasonality, along with variations in SST.
 - Genesis regions migrate throughout season in response to upper-level winds and SST.
- Per year there are on average
 - 10.1 named cyclones
 - 5.9 hurricanes
 - 2.5 category III or greater
- Variability
 - Have been as few as 1, to over 20 cyclones
- Modes of genesis different from global averages
 - More than half form in tropical waves coming off of Saharan Africa.
 - Less than half form along ITCZ, with a few forming in baroclinic zones associated with old fronts or shear lines.

- Possible 25 to 40 year cycle in numbers (not enough data to conclusively determine).
- There have been four hurricanes in recorded history that have made landfall in the U.S. as Category V storms.
 - Labor Day Storm (1935, Florida Keys)
 - Camille (1969, Gulf Coast)
 - Andrew (1992, South Florida)
 - Michael (2018, Florida panhandle)

SOUTH ATLANTIC

- Tropical cyclones are very rare in the South Atlantic.
 - No ITCZ
 - Strong vertical shear
- In satellite era there have been two tropical cyclones in the South Atlantic.
 - One, in March, 2004, becoming a Category I hurricane.
 - Formed from upper-level low.
 - In April, 1991 there was a nominal tropical storm off of Africa.

NORTHEAST AND NORTHCENTRAL PACIFIC

- 19.8% of global total tropical storm strength and higher.
- 19.9% of global total hurricane strength and higher.
- Numbers undercounted in pre-satellite era (not many ships in this area compared to Atlantic).
- Season similar to Atlantic.
 - Peak in late-August
- Per year there are on average
 - 16.4 named cyclones
 - 9.2 hurricanes
 - 4.0 category III or greater
- Region off of Central America has highest density of genesis points on the globe.
- Little genesis south of 10° due to cold upwelling of ocean waters.
- Modes of genesis not well documented.

- Controversy concerning whether “African” waves propagate across Central America and spawn Pacific cyclones.

WESTERN NORTH PACIFIC

- **Granddaddy of all basins**
 - **30.7% of global total tropical storm strength and higher.**
 - **35.7% of global total hurricane strength and higher.**
- **Noted for high occurrence of very large and very intense storms.**
 - **Lowest SLP on record was 870 mb in Super Typhoon Tip (October, 1979).**
- **Only basin that is active throughout the year.**
- **Highly seasonal, with peak in late-July/early-August**
 - **Can occur in any month**
- **Per year the average is**
 - **26 named storms**
 - **16 typhoons**
- **Genesis regions migrate seasonally with position of monsoon trough.**
- **Vast majority of cyclones form in monsoon trough, with a small minority forming in tropical waves.**
- **Tropical upper-tropospheric trough (TUTT) can play significant role in genesis and development.**

NORTH INDIAN OCEAN

- **6.5% of global total tropical storm strength and higher.**
- **5.6% of global total hurricane strength and higher.**
- **Deadliest in world.**
 - **Low-lying, flood prone areas of Bangladesh with large population density.**
 - **1970 cyclone killed over 300,000 people.**
 - **Several cyclones have killed 100,000 to 200,000 people each.**
 - **Most recently, Tropical Cyclone Nargis (May 2008) killed up to 150,000 in Myanmar (Burma).**
- **Highly seasonal, with two peaks in May and November.**

- The bimodal distribution is associated with the transition seasons of the monsoon, as the monsoon trough is over water during these times.
- During height of summer monsoon, the monsoon trough is well inland, and there is also strong vertical shear due to the Tropical Easterly Jet, which suppresses cyclogenesis.
- November peak is more pronounced than May peak.
- Majority occur in the Bay of Bengal, with far fewer in the Arabian Sea.
- Per year there are on average
 - 5 – 6 tropical storm strength cyclones per year
 - Range is 1 – 10
 - 2 to 3 hurricane strength cyclones per year

SOUTHWEST INDIAN OCEAN (West of 100°E)

- 12.4% of global total tropical storm strength and higher.
- 9.9% of global total hurricane strength and higher.
- Seasonal (October through May)
 - Peaks in January and February/March
 - Can get off-season genesis.
- Per year the average is
 - 10.4 tropical storm strength cyclones
 - 4.4 hurricane strength cyclones
- Monsoon trough is important genesis feature.

SOUTHEAST INDIAN OCEAN (100°E to 142°E)

- 8.2% of global total tropical storm strength and higher.
- 7.6% of global total hurricane strength and higher.
- Seasonal (October through May)
 - Peaks in January and February/March
- Per year the average is
 - 6.0 tropical storm strength cyclones
 - 3.4 hurricane strength cyclones
- Monsoon trough is important genesis feature.

SOUTHWEST PACIFIC OCEAN (East of 142°E)

- **10.8% of global total tropical storm strength and higher.**
- **9.5% of global total hurricane strength and higher.**
- **Seasonal (October through April)**
 - **Peak in February/March**
- **Per year the average is**
 - **9.0 tropical storm strength cyclones**
 - **4.3 hurricane strength cyclones**
- **Monsoon trough and SPCZ are important genesis features.**
- **Twin cyclones (one on each side of the Equator) sometimes form in early and late season, often in conjunction with westerly wind burst along the Equator.**