= Tropical cyclone rainfall climatology =

A tropical cyclone rainfall climatology is developed to determine rainfall characteristics of past tropical cyclones . A tropical cyclone rainfall climatology can be used to help forecast current or upcoming tropical cyclone impacts . The degree of a tropical cyclone rainfall impact depends upon speed of movement , storm size , and degree of vertical wind shear . One of the most significant threats from tropical cyclones is heavy rainfall . Large , slow moving , and non @-@ sheared tropical cyclones produce the heaviest rains . The intensity of a tropical cyclone appears to have little bearing on its potential for rainfall over land , but satellite measurements over the last several years show that more intense tropical cyclones produce noticeably more rainfall over water . Flooding from tropical cyclones remains a significant cause of fatalities , particularly in low @-@ lying areas .

= = Anticipating a flood event = =

While inland flooding is common to tropical cyclones , there are factors which lead to excessive rainfall from tropical cyclones . Slow motion , as was seen during Hurricane Danny (1997) and Hurricane Wilma , can lead to high amounts of rainfall . The presence of mountains / hills near the coast , like across much of Mexico , Haiti , the Dominican Republic , Central America , Madagascar , Réunion , China , and Japan acts to magnify rainfall potential due to forced upslope flow into the mountains . Strong upper level forcing from a trough moving through the Westerlies and its associated cold front , as was the case during Hurricane Floyd , can lead to high amounts even from systems moving at an average forward motion . Larger tropical cyclones drop more rainfall as they precipitate upon one spot for a longer time frame than average or small tropical cyclones . A combination of two of these factors could be especially crippling , as was seen during Hurricane Mitch in Central America . During the 2005 season , flooding related to slow @-@ moving Hurricane Stan 's broad circulation led to 1 @,@ 662 ? 2 @,@ 000 deaths .

= = General distribution within a tropical cyclone = =

Isaac Cline was the first to investigate rainfall distribution around tropical cyclones in the early 1900s . He found that a larger proportion of rainfall falls in advance of the center (or eye) than after the center 's passage , with the highest percentage falling in the right front quadrant . Father Viñes of Cuba found that some tropical cyclones have their highest rainfall rates in the rear quadrant within a training (non @-@ moving) inflow band . Normally , as a tropical cyclone intensifies , its heavier rainfall rates become more concentrated around its center . Rainfall is found to be heaviest in tropical cyclone 's inner core , whether it be the eyewall or central dense overcast , within a degree latitude of the center , with lesser amounts farther away from the center . Most of the rainfall in tropical cyclones is concentrated within its radius of gale @-@ force (34 knots / 39 mph / 63 km / h) winds . Rainfall is more common near the center of tropical cyclones overnight . Over land , outer bands are more active during the heating of the day , which can act to restrict inflow into the center of the cyclone . Recent studies have shown that half of the rainfall within a tropical cyclone is stratiform in nature . The chart to the right was developed by Riehl in 1954 using meteorological equations that assume a gale radius of about 140 miles (230 km) , a fairly symmetric cyclone , and does not consider topographic effects or vertical wind shear . Local amounts can exceed this chart by a factor of two due to topography . Wind shear tends to lessen the amounts below what is shown on the table .

= = Relation to storm size = =

Larger tropical cyclones have larger rain shields , which can lead to higher rainfall amounts farther from the cyclone 's center . This is generally due to the longer time frame rainfall falls at any one spot in a larger system , when compared to a smaller system . Some of the difference seen concerning rainfall between larger and small storms could be the increased sampling of rainfall

within a larger tropical cyclone when compared to that of a compact cyclone ; in other words , the difference could be the result of a statistical problem .

= = Slow / looping motion on rainfall magnitude = =

Storms which have moved slowly , or loop , over a succession of days lead to the highest rainfall amounts for several countries . Riehl calculated that 33 @.@ 97 inches (863 mm) of rainfall per day can be expected within one @-@ half degree , or 35 miles (56 km) , of the center of a mature tropical cyclone . Many tropical cyclones progress at a forward motion of 10 knots , which would limit the duration of this excessive rainfall to around one @-@ quarter of a day , which would yield about 8 @.@ 50 inches (216 mm) of rainfall . This would be true over water , within 100 miles (160 km) of the coastline , and outside topographic features . As a cyclone moves farther inland and is cut off from its supply of warmth and moisture (the ocean) , rainfall amounts from tropical cyclones and their remains decrease quickly .

= = Vertical wind shear impact on rainfall shield = =

Vertical wind shear forces the rainfall pattern around a tropical cyclone to become highly asymmetric , with most of the precipitation falling to the left and downwind of the shear vector , or downshear left . In other words , southwesterly shear forces the bulk of the rainfall north @-@ northeast of the center . If the wind shear is strong enough , the bulk of the rainfall will move away from the center leading to what is known as an exposed circulation center . When this occurs , the potential magnitude of rainfall with the tropical cyclone will be significantly reduced .

= = = Effect of interaction with frontal boundaries / upper level troughs = = =

As a tropical cyclone interacts with an upper @-@ level trough and the related surface front , a distinct northern area of precipitation is seen along the front ahead of the axis of the upper level trough . This type of interaction can lead to the appearance of the heaviest rainfall falling along and to the left of the tropical cyclone track , with the precipitation streaking hundreds of miles or kilometers downwind from the tropical cyclone . The stronger the upper trough picking up the tropical cyclone , the more significant the left of track shift in the rainfall distribution tends to be .

= = Mountains = =

Moist air forced up the slopes of coastal hills and mountain chains can lead to much heavier rainfall than in the coastal plain . This heavy rainfall can lead to landslides , which still cause significant loss of life such as seen during Hurricane Mitch in Central America .

= = Global distribution = =

Globally , tropical cyclone rainfall is more common across the northern hemisphere than across the southern hemisphere . This is mainly due to the normal annual tropical cyclone distribution , as between half and two @-@ thirds of all tropical cyclones form north of the equator . Rainfall is concentrated near the 15th parallel in both hemispheres , with a less steep dropoff seen with latitude across the northern hemisphere , due to the stronger warm water currents seen in that hemisphere which allow tropical cyclones to remain tropical in nature at higher latitudes than south of the equator . In the southern hemisphere , rainfall impacts will be most common between January and March , while north of the equator , tropical cyclone rainfall impacts are more common between June and November . Japan receives over half of its rainfall from typhoons .

= = United States tropical cyclone rainfall statistics = =

Between 1970 @-@ 2004 , inland flooding from tropical cyclones caused a majority of the fatalities in the United States . This statistic changed in 2005 , when Hurricane Katrina 's impact alone shifted the most deadly aspect of tropical cyclones back to storm surge , which has historically been the most deadly aspect of strong tropical cyclones . On average , five tropical cyclones of at least tropical depression strength lead to rainfall across the contiguous United States annually , contributing around a quarter of the annual rainfall to the southeast United States . While many of these storms form in the Atlantic Basin , some systems or their remnants move through Mexico from the Eastern Pacific Basin . The average storm total rainfall for a tropical cyclone impacting the lower 48 from the Atlantic Basin is about 16 inches (406 mm) , with 70 ? 75 percent of the storm total falling within a 24 @-@ hour period . The highest point total was seen during Amelia 1978 , when 48 inches (1 @,@ 218 mm) fell upon central Texas .

= = = Printed media = = =

Ivan Ray Tannehill . Hurricanes . Princeton University Press : Princeton , 1942 .
Herbert Riehl . Tropical Meteorology . McGraw @-@ Hill Book Company , Inc . : New York , 1954 .
Terry Tucker . Beware the Hurricane ! Hamilton Press : Bermuda , 1966 .

= = Related external links = =

Individual Tropical Cyclone Rainfall Pages for the United States and Mexico
Individual Tropical Cyclone Rainfall Pages for Puerto Rico / U.S. Virgin Islands
Maximum amounts in the lower 48 United States by state
Typhoon Rainfall Statistics and Forecasting (China)
Deadliest , Costliest , and Most Intense United States Tropical Cyclones From 1851 to 2004
Are You Ready ? Hurricanes