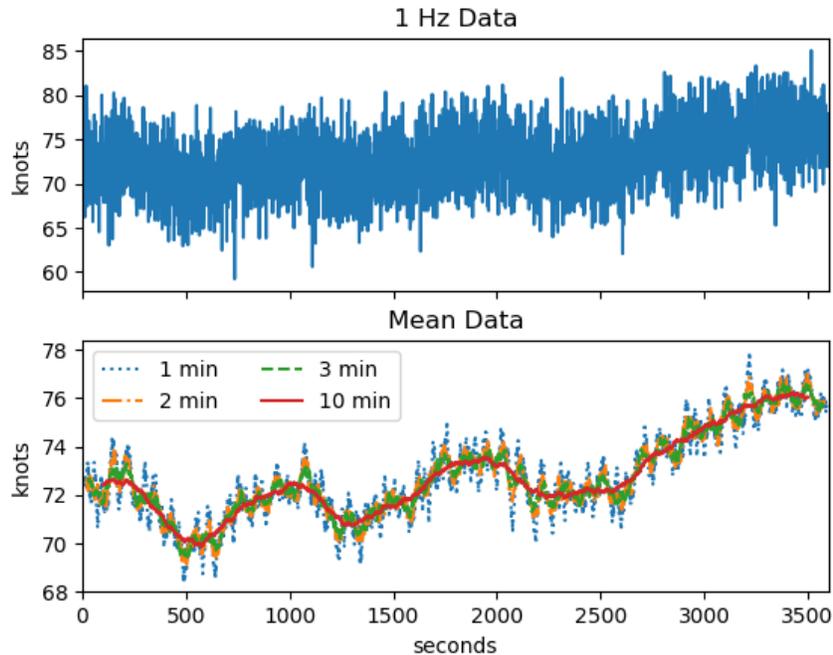


ESCI 344 – Tropical Meteorology
Lesson 2 – Tropical Cyclones: Definitions and Advisory Responsibilities

Reading: *An Introduction to the Meteorology and Climate of the Tropics*, Chapter 9

WIND REPORTING

- **Wind reports are not instantaneous values, but instead are time-averaged values.**
- ***Sustained winds* are those that are averaged over a longer time interval, while *gusts* are averaged over a shorter interval.**
- **There is no global standard for determining the averaging intervals for either sustained winds or gusts.**
 - **The averaging time varies from country-to-country, and within countries it varies by usages.**
 - **A U.S. standard synoptic wind observation is a 2-minute average.**
 - **A U.S. sustained wind for a tropical cyclone report or forecast is a 1-minute average.**
 - **Most other countries use a 10-minute average for tropical cyclone sustained winds, and some even use a 3 minute average.**
- **The averaging used can make a huge difference in reported intensity of a tropical cyclone.**
- **The figure shows some simulated raw 1-Hz (1 second) wind. Also shown are the corresponding 1, 2, 3, and 10 minute-averaged winds that would be obtained from these data. Some features to note:**
 - **The shorter the averaging time, the more variability is present in the observations.**
 - **The peak 1-min averaged wind is greater than the peak 2-min averaged wind.**
 - **The peak 2-min averaged wind is greater than the peak 3-min averaged wind.**
 - **The peak 3-min averaged wind is greater than the peak 10-min averaged wind.**



- Tropical cyclone intensities are given in terms of *maximum sustained winds*, which for the U.S. means the maximum 1-min averaged wind that would be observed within the cyclone (and for most of the rest of the world means the maximum 10-minute averaged wind that would be observed within the cyclone.)
 - This can loosely also be thought of in a temporal sense as the maximum 1-min (or 10-min) averaged wind occurring within some longer time period of observation, say 30 or 60 minutes.
- So, looking again at the figure, we see that a maximum 1-min averaged sustained wind will be greater than a maximum 10-min averaged sustained wind.
- The difference in averaging times for wind observations is why U.S tropical cyclone analyzed and forecast intensities are usually greater than the intensities reported or forecast by other countries.
- As opposed to sustained winds, gusts are shorter term fluctuations.
 - The averaging time for gusts is somewhat relative.
 - Technically a peak 1-min averaged wind is technically a gust with respect to a 10-minute averaged wind.
 - For the U.S., gusts are based on a 2- to 3-second averaged wind.
- Converting maximum sustained winds between two different averaging times is not an easy undertaking.

- There is no one-size-fits-all, because the conversion will depend upon atmospheric stability and the frictional properties of the underlying surface.
- A good description of the difficulties, and some guidelines for conversion, are contained in “Guidelines for converting between various wind averaging periods in tropical cyclone condition”, B. A. Harper, J. D. Kepert and J. D. Ginger, 2009 (a report by the WMO).
- Based on the WMO report cited above, the following conversion factors (often called *gust factors*) are recommended for converting a 10-min maximum sustained wind to a 1-min maximum sustained wind, using the formula

$$U_{1\text{-min}} = \alpha U_{10\text{-min}}$$

Condition	α
Over land, away from coast	1.21
Near coast, off-shore wind	1.16
Near coast, on-shore wind	1.11
At sea (>20km from coast)	1.05

- A similar formula, $U_{3\text{-sec}} = \alpha U_{1\text{-min}}$ can be used to estimate 3-sec averaged gusts given a 1-min averaged wind, using the gust factors

Condition	α
Over land, away from coast	1.49
Near coast, off-shore wind	1.36
Near coast, on-shore wind	1.23
At sea (>20km from coast)	1.11

NON-TROPICAL CYCLONE WIND TERMINOLOGY

- In marine meteorology the following terms are in general use for describing high winds that are not the result of tropical cyclones.
 - *Gale* – Sustained winds of 34 – 47 knots.
 - *Storm* – Sustained winds of 48 – 63 knots.

SOME ACRONYMS

- **CPHC – Central Pacific Hurricane Center**
- **JMA – Japan Meteorological Agency**
- **JTWC – Joint Typhoon Warning Center**
- **NHC – National Hurricane Center**
- **RSMC – Regional Specialized Meteorological Center**
- **TCWC – Tropical Cyclone Warning Center**
- **WMO – World Meteorological Organization (part of the United Nations)**

TROPICAL CYCLONES DEFINED

- **Definitions relevant to tropical cyclones vary from region-to-region. For this class, we will use definitions consistent with those of the National Hurricane Center, Central Pacific Hurricane Center, and the Joint Typhoon Warning Center.**
- ***Tropical Cyclone* – A warm-core, non-frontal synoptic scale cyclone that forms over the tropical or subtropical oceans, and having organized deep convection and a closed surface circulation about a well-defined center.**
- ***Tropical Wave* – A trough or area of cyclonic curvature in the trade winds or equatorial westerlies. May be associated with an upper-troposphere cold low or a shear line.**
- ***Tropical Disturbance* – A persistent (24 hours or more) non-frontal system of organized convection forming over the tropical or subtropical oceans.**
- ***Tropical Depression* - A tropical cyclone in the North Atlantic or North Pacific that has maximum sustained surface winds (1-minute mean) of less than 34 knots.**
- ***Tropical Storm* - A tropical cyclone in the North Atlantic or North Pacific that has maximum sustained surface winds (1-minute mean) of 34 knots or greater, but less than 64 knots.**
- ***Hurricane* – A tropical cyclone in the North Atlantic or Eastern North Pacific that has maximum sustained surface winds (1-minute mean) of 64 knots or greater.**

- *Typhoon* - A tropical cyclone in the Northwest Pacific with maximum sustained surface winds (1-minute mean) of 64 knots or greater, but less than 130 knots.
- *Super Typhoon* - A tropical cyclone in the Northwest Pacific that has maximum sustained surface winds (1-minute mean) of 130 knots or greater.
- The table below shows the difference in definitions and nomenclature from region-to-region.

Wind speed (kts)	Atlantic/Northeast Pacific*	Northwest Pacific		North Indian Ocean	Southwest Indian Ocean	Southeast Pacific	
		JMA	JTWC*				
≤16	Tropical Depression	Tropical Depression	Tropical Depression	Depression	Tropical Disturbance	Tropical Depression	
17-27							Deep Depression
28-33					Moderate Tropical Storm		
34-47	Tropical Storm	Severe Tropical Storm	Cyclonic Storm	Severe Cyclonic Storm		Severe Tropical Storm	Tropical Cyclone (Storm)
47-63					Hurricane		
64-89	Major Hurricane	Typhoon	Typhoon	Super Cyclonic Storm		Intense Tropical Cyclone	Severe Tropical Cyclone
90-96					Very Intense Tropical Cyclone		
97-115							
115-119							
120-129							
≥ 130	Super Typhoon						

* Use 1-minute average winds, instead of 10-minute average winds.

- NOTE: Everywhere except in the Northwest Pacific, JTWC only warns on systems having a sustained wind of 34 knots or greater, and these systems are all designated simply as *Tropical Cyclone* regardless of how intense they are.

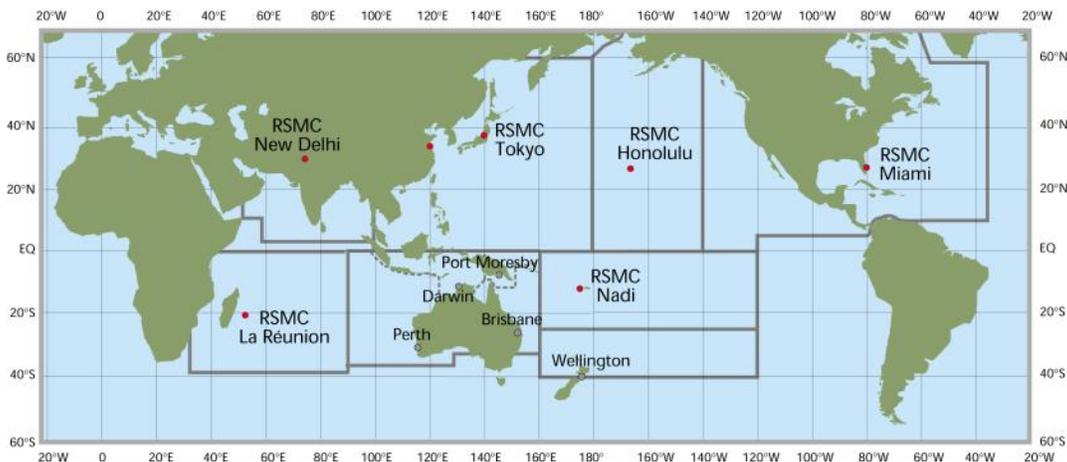
SUBTROPICAL CYCLONES

- Cyclones occasionally form over the tropical ocean that have a mixture of tropical and extratropical characteristics. These are referred to as *subtropical cyclones*.
 - The energetics are a mix of baroclinic instability as well as latent heating from the sea.
- Characteristics of subtropical cyclones are

- **Maximum winds not concentrated near center of storm.**
- **Asymmetric wind distribution.**
- **Asymmetric distribution of convection, not coincident with low center.**
- **Two main types of subtropical cyclones are:**
 - **Those that are surface manifestations of cold-core upper-level lows.**
 - **Those that are mesoscale circulations (cold or warm core) initiated near a frontal zone or shear line.**
- **Subtropical cyclones can transition into tropical cyclones.**

WARNINGS AND WARNING AGENCIES

- **The World Meteorological Organization (WMO), part of the United Nations (UN), coordinates tropical cyclone and high seas warnings.**
- **There are six official WMO Regional Specialized Meteorological Centers (RSMC), and five additional Tropical Cyclone Warning Centers (TCWC).**
- **The map below shows the locations and names of the RSMC's and TCWC's.**



from World Meteorological Organization web site: <http://www.wmo.ch/index-en.html>

- **The RSMC's and TCWC's are operationally run by the respective weather service of the host country. The associations of these centers with the host country's weather service are shown in the table below.**

Center	Organization
RSCM Miami	U.S. National Hurricane Center (NHC)
RSMC Honolulu	U.S. Central Pacific Hurricane Center (CPHC)
RSMC Tokyo	Japan Meteorological Agency (JMA)

RSMC New Delhi	India Meteorological Department
RSMC La Réunion	Météo-France
RSMC Nadi	Fiji Meteorological Service
TCWC Perth	Bureau of Meteorology, Australia
TCWC Darwin	Bureau of Meteorology, Australia
TCWC Brisbane	Bureau of Meteorology, Australia
TCWC Port Moresby	National Weather Service, Papua New Guinea
TCWC Wellington	Meteorological Service of New Zealand, Ltd.

- In addition to the WMO centers, the U.S. Navy and Air Force maintain the Joint Typhoon Warning Center (JTWC) in Pearl Harbor, Hawaii, which provides advisories and forecasts to U.S. government assets in the South Pacific, the Northwest Pacific and Indian Oceans (both hemispheres).
 - JTWC is maintained so that the U.S. government, and U.S. military in particular, do not have to rely on foreign advisories and guidance, which may not be available in times of crisis or conflict.
 - Other than in the North West Pacific, the JTWC only provides warning for tropical cyclones having sustained winds of 34 knots or greater, and refers to these systems generically as “tropical cyclones”.
- Many national weather services also do their own tropical cyclone forecasts and issue their own warnings.
- There is inconsistency in what averaging times are used for reporting sustained winds in tropical cyclones among the various agencies.
 - The U.S. agencies (National Hurricane Center, Pacific Hurricane Center, and the Joint Typhoon Warning Center) use 1-minute average winds
 - Note that standard U.S. surface observations use a 2-minute average wind when reporting wind speed (FMH-1).
 - The difference in averaging explains why sometimes JTWC will sometimes report a stronger intensity than will RSMC Tokyo.
- There is also inconsistency as to the minimum sustained winds required for issuance of tropical cyclone advisories. This varies from region-to-region and agency-to-agency, with some providing advisories at the depression level, while others wait until the winds are 34 knots or greater.

- NHC, CPHC, JMA, and JTWC (Northwest Pacific only) provide advisories on tropical depressions once the sustained winds are 25 to 30 knots.
- In the Indian Ocean and the Southwest Pacific, JTWC provides advisories only for those cyclones with winds 34 knots or greater.
- New Delhi provides advisories only for winds 34 knots or greater.
- In the recent past, names were assigned by regional agencies, and were not necessarily internationally recognized.
 - For example, up through the 1990's, JTWC assigned names to Western Pacific cyclones, while JMA simply referred to them by number.
- However, pretty much all regions now assign names to those cyclones whose winds are 34 knots or greater, and the name lists are coordinated by the WMO member countries in the respective regions.

SAFFIR-SIMPSON SCALE

- The Saffir-Simpson scale is a classification scheme for tropical cyclones based on the maximum sustained wind (1-minute mean) and also type and extent of damage.
- It is mainly used by RSMC Miami, RSMC Honolulu, and JTWC. The wind categories are

Saffir-Simpson Category	Max Sustained Wind (1-min)	
	knots	mph
1	64 - 82	74 - 95
2	83 - 95	96 - 110
3	96 - 113	111 - 130
4	114 - 134	131 - 155
5	135 +	156 +

- The scale used by the Australia Bureau of Meteorology is

Category	Max Sustained Wind (10-min)
1	34 - 47
2	48-63
3	64-85
4	86-107
5	> 107