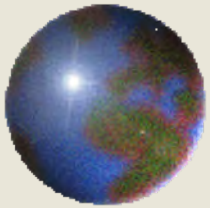
Hurricanes

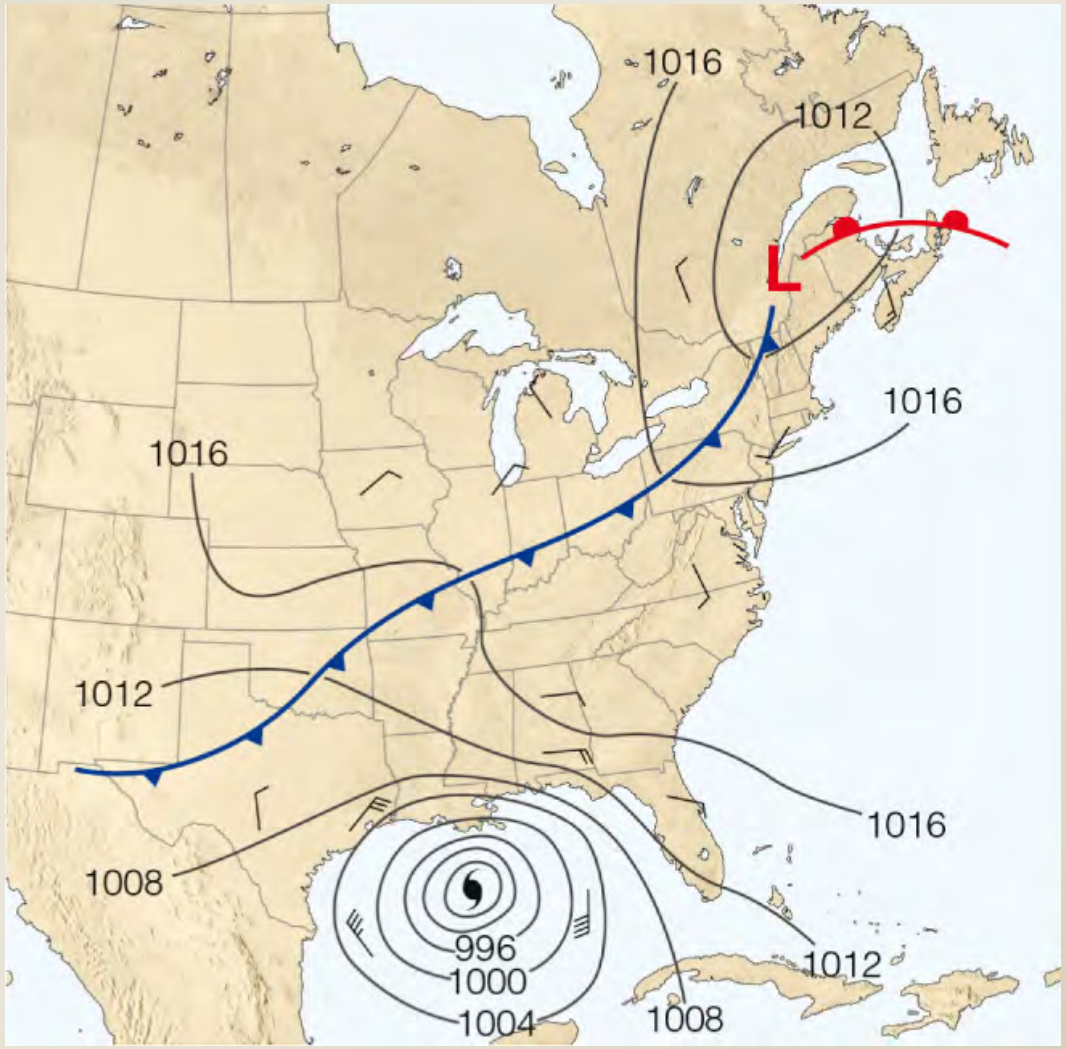


GEOG/ENST 2331
Lecture 17
Ahrens: Chapter 14

Figure to right
Atlantic Hurricanes: 2018

Hurricanes

- Tropical cyclones
- Dynamics
  - Formation
  - Structure
  - Movement
  - Dissipation

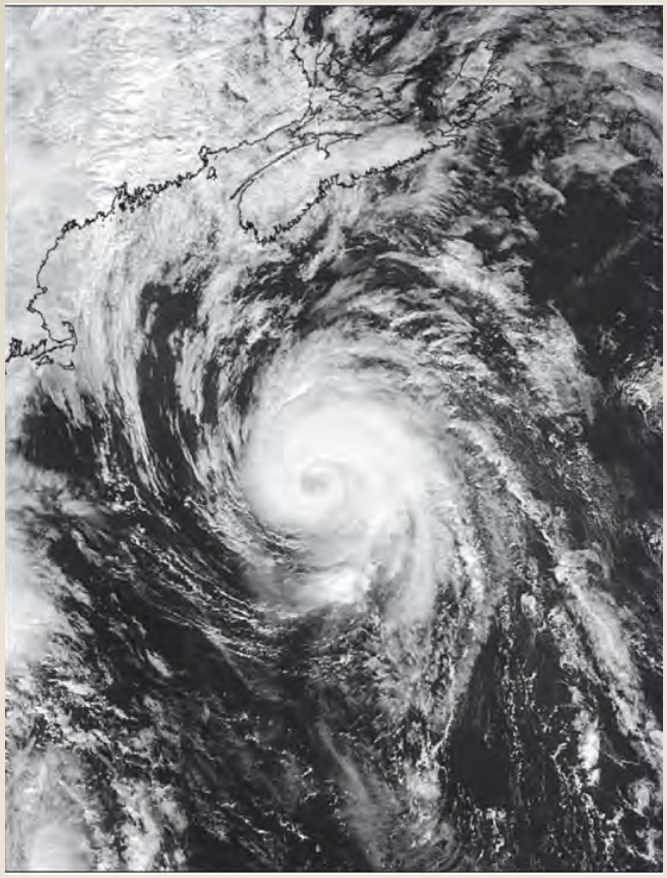


Ahrens: Fig. 1, p. 466
Hurricane Rita (Sept. 2005)

Tropical cyclones

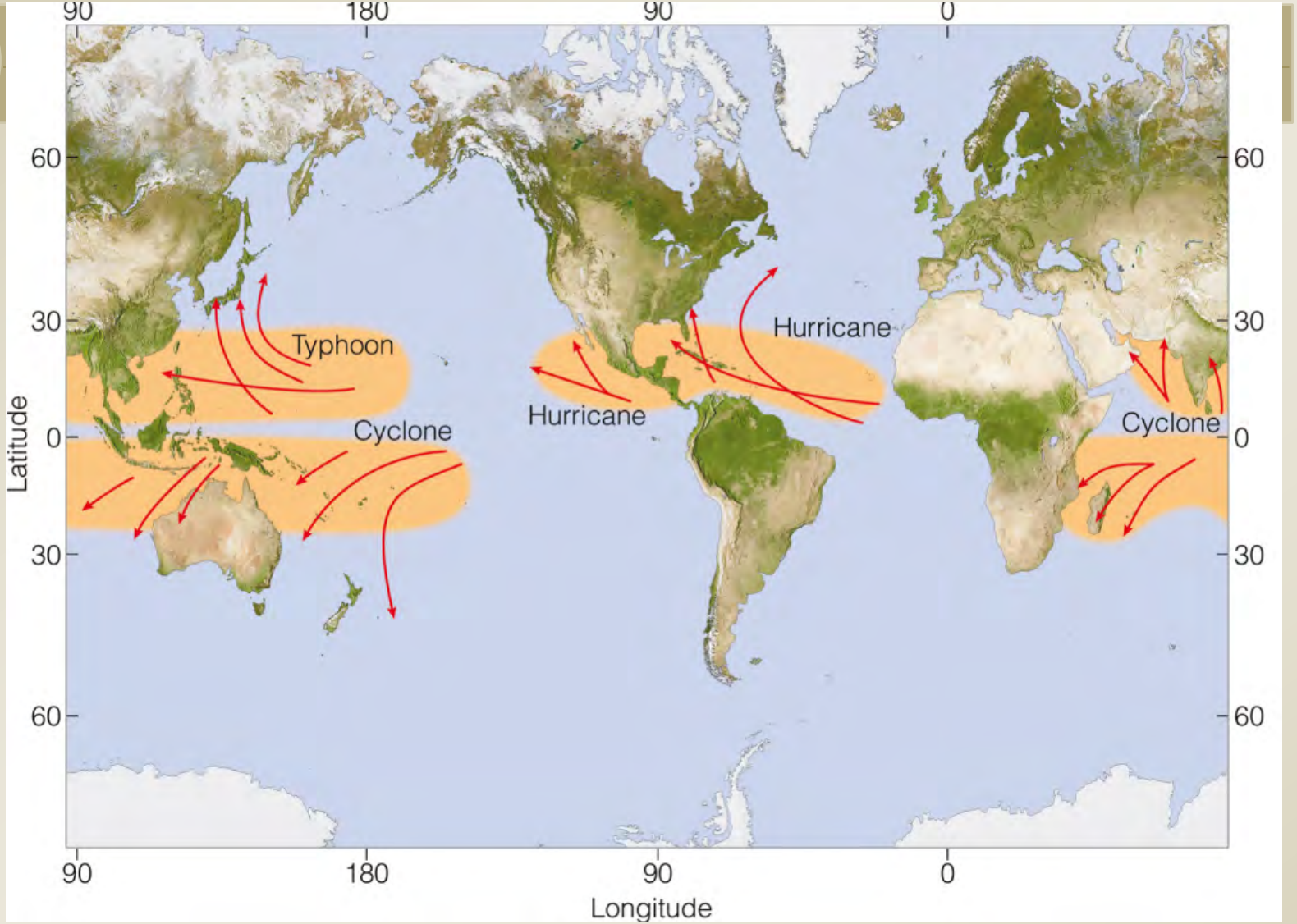
- The most powerful of all storms*
- Lesser intensity than tornadoes but larger size and longer life span makes hurricanes much more devastating
- Average diameters are approximately 600 km and central pressures average about 950 hPa but may be as low as 870 hPa
- Below 920 hPa is a Category 5

Tropical cyclone terminology



Ahrens: Fig. 3, p. 471
Hurricane Juan, 2003

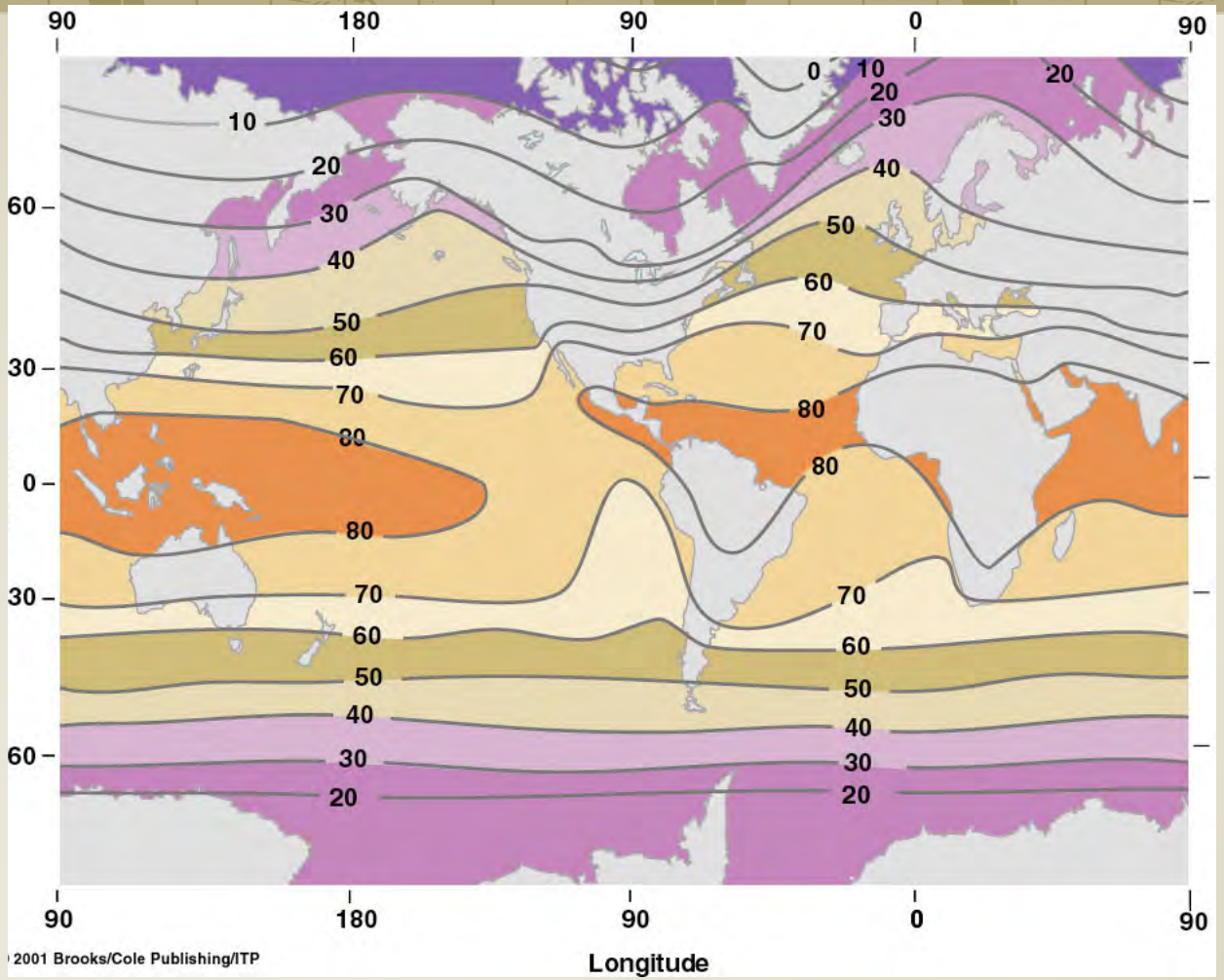
- Hurricane
  - North American term
  - Taino language
  - "god of evil"
- Typhoon
  - Western Pacific term
  - "Tai fung" (Chinese)
  - "Tai-fu" (Japanese)
  - "Great wind"
- Severe Tropical Cyclone
  - Southern Hemisphere and Indian Ocean



Tropical Cyclones

Tropical cyclone genesis areas and storm tracks related to surface sea temperatures

Ahrens: Fig. 14.11



SST Distribution

All regions of tropical cyclone development frequently exceed 27°C (80°F).

Definitions

- Tropical depression
  - Low pressure system in tropical ocean
- Tropical storm (*Named* storm)
  - Sustained winds of 60-120 km/h (18-33 m/s)
- Hurricane/Typhoon/Severe Tropical Cyclone
  - Sustained winds of 120-180 km/h (33-50 m/s)
  - Categories 1-2
- Major Hurricane/Typhoon/Cyclone
  - Sustained winds exceeding 180 km/h (50 m/s)
  - Categories 3-5

Saffir-Simpson Scale for Hurricane Strength

Herbert Saffir and Robert Simpson

Table 12–2 The Saffir-Simpson Scale

Category	Pressure mb	Wind Speed km/hr	Wind Speed mph	Storm Surge m	Storm Surge ft	Damage
1	≥ 980	119–154	74–95	1–2	4–5	Minimal
2	965–979	155–178	96–110	2–3	6–8	Moderate
3	945–964	179–210	111–130	3–4	9–12	Extensive
4	920–944	211–250	131–155	4–6	13–18	Extreme
5	< 920	> 250	> 155	> 6	> 18	Catastrophic

A&B: Table 12-2

Hurricane-strength storms: 2015 compared to average

Basin	1 an 2	3 to 5	Total	Average
Atlantic	2	2	4	5.9
NH East Pacific*	5	10	15	9.0
NH West Pacific*	4	18	22	16.9
NH Indian	0	2	2	2.2
SH Indian	3	2	5	10.3
SH West Pacific	3	2	5	4.8
* **Active TS** **Global**	**17**	**36**	**53**	**48.3**

To Nov. 20, 2015 Sources: Unisys; A&B Table 12-1

Brief history of Hurricane names

Caribbean

Clement Wragge

WW 2 in Pacific

World Meteorological Organization (WMO) in 1953

- tropical storms female names: alphabetical order from the beginning of each year

1978, 1978

- alternately male and female names
- Six semi-permanent lists of names

Retired names

2019
Andrea
Barry
Chantal
Dorian
Erin
Fernand
Gabrielle
Humberto
Imelda
Jerry
Karen
Lorenzo
Melissa
Nestor
Olga
Pablo
Rebekah
Sebasian
Tanya
Van
Wendy

Alvin
Barbara
Cosme
Dalila
Erick
Flossie
Gil
Henriette
Ivo
Juliette
Kiko
Lorena
Mario
Narda
Octave
Priscilla
Raymond
Sonia
Tico
Velma
Wallis
Xina
York
Zelda

Hurricane names

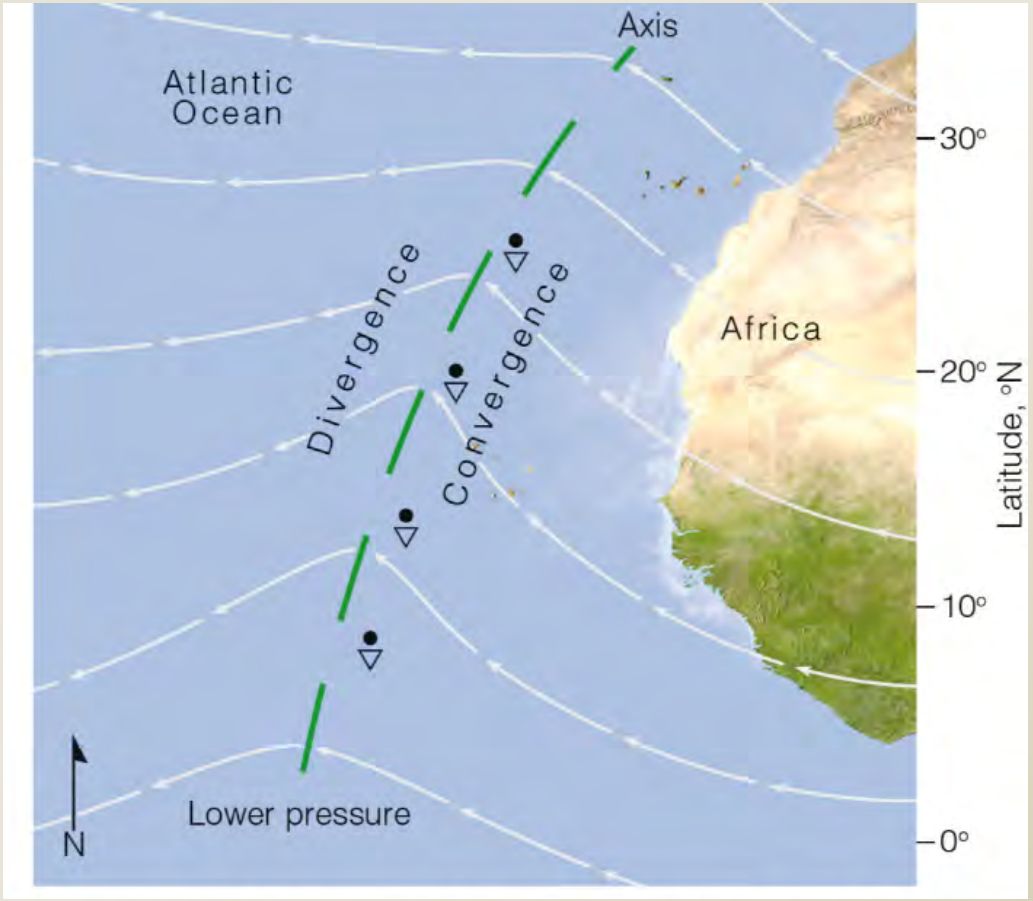
- Six lists a are used in rotation and re-cycled every six years, i.e., the 2015 list will be used again in 2021.
- If 21 named tropical cyclones occur in the Atlantic basin in a season, the Greek alphabet is used for additional storms.
- Grace* (1991) was the hurricane associated with the “perfect storm” and film

Cyclone ingredients

- Hurricanes form only over deep water layers with sea surface temperature (SST) in excess of 27°C
  - Poleward of about 20° (latitude), SSTs are usually too cold
- Coriolis force is an important contributor
  - Hurricanes do not form equatorward of 5°
- An unstable atmosphere necessary
- Strong vertical wind shear must be absent

Atlantic Basin Storm Development

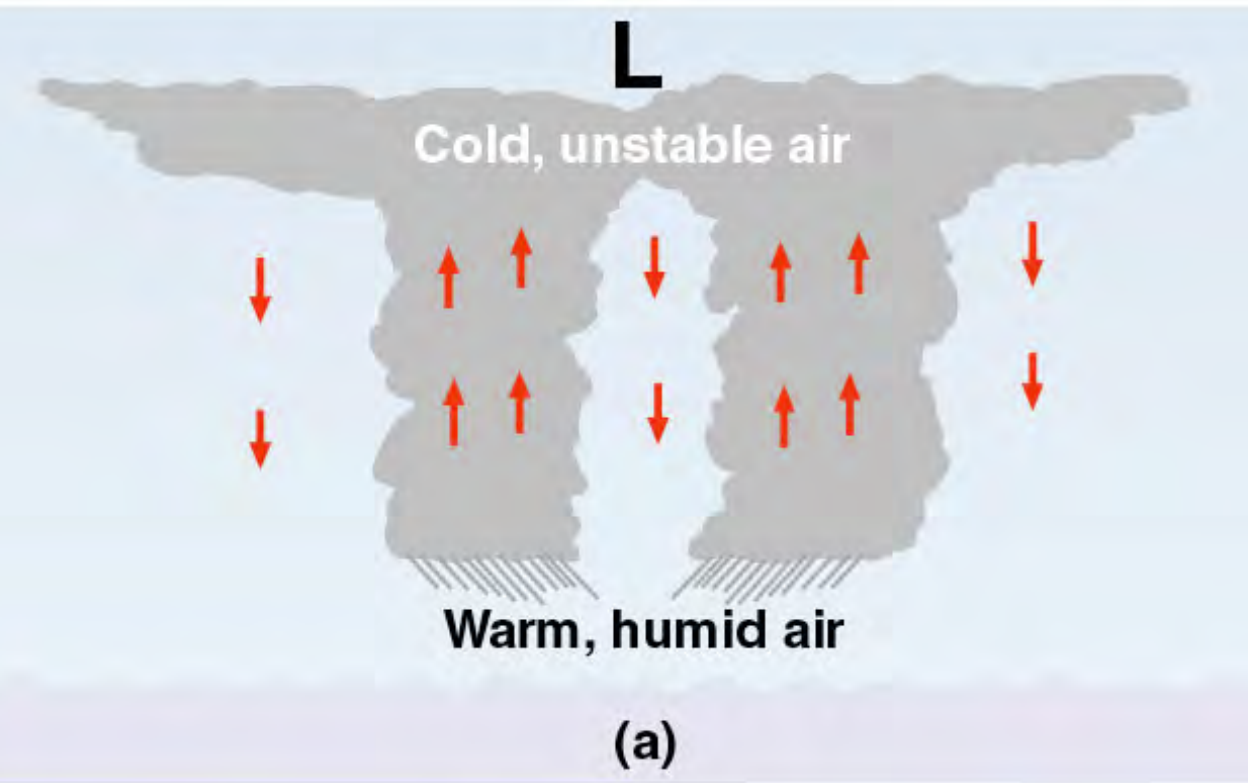
- June through November
- Begins as a tropical wave in the trade winds
  - Originates in East Africa
- One week to cross the Atlantic (15-35 km/h)



An easterly wave in surface winds
Ahrens: Figure 14.1

Hurricane structure

- 10% of 'seedlings' develop into **rotating storms**
- Growth fuelled by rising warm, saturated air
- Group of thunderstorms becomes organized and self-sustaining

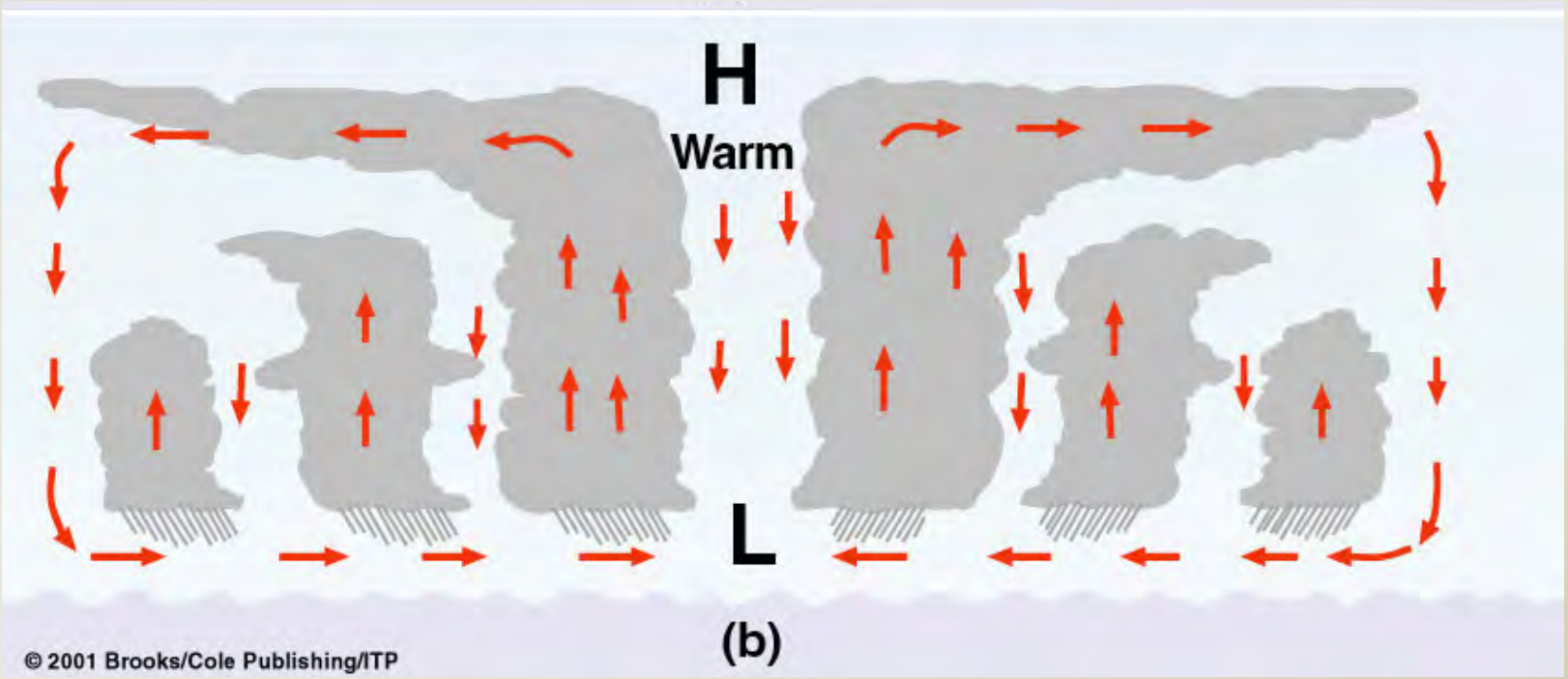


Hurricane dynamics

Rising air

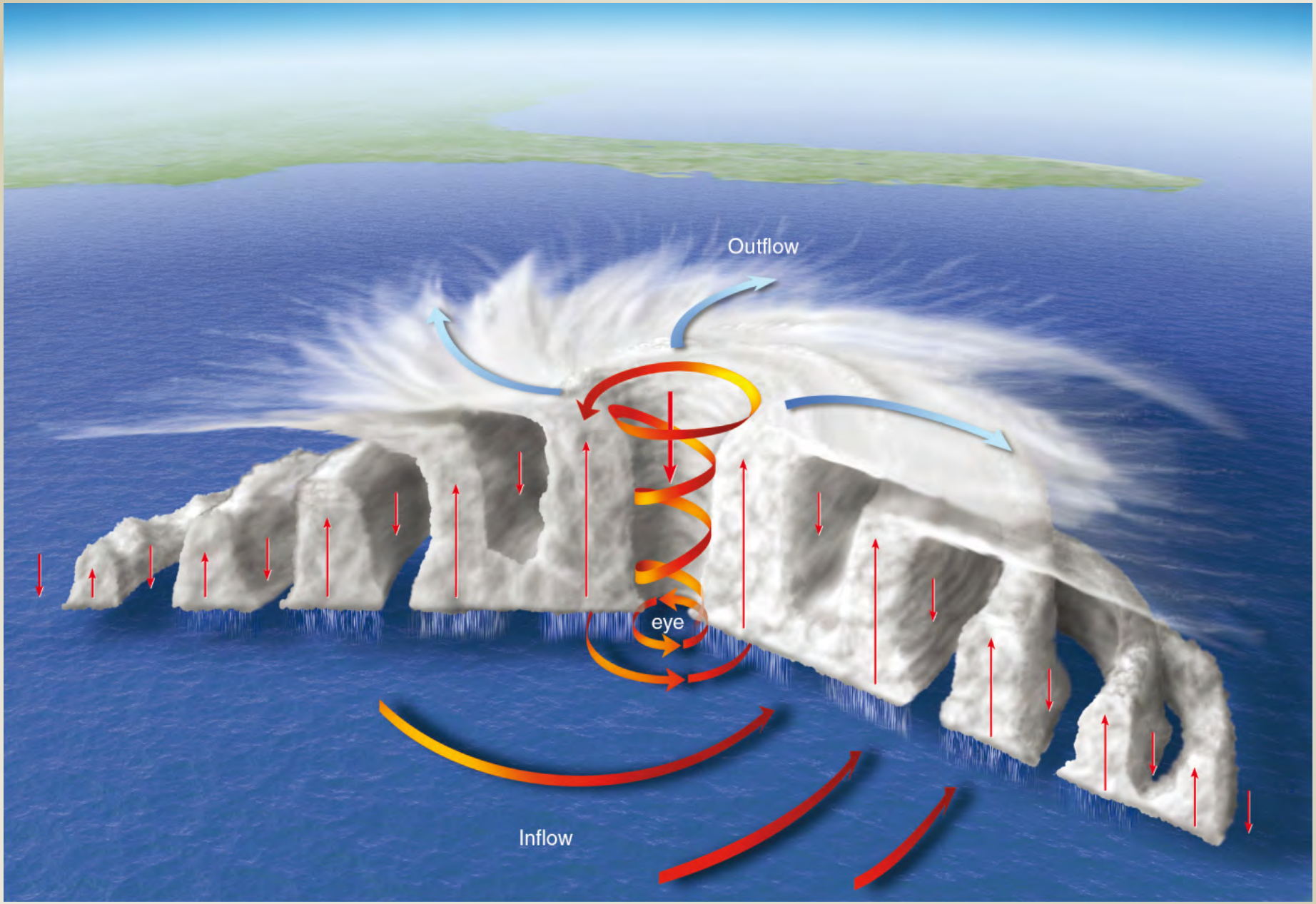
- Releases latent heat
- Warms upper atmosphere
- Causes upper air to diverge

Eye forms in the middle where air is sinking



Hurricane dynamics

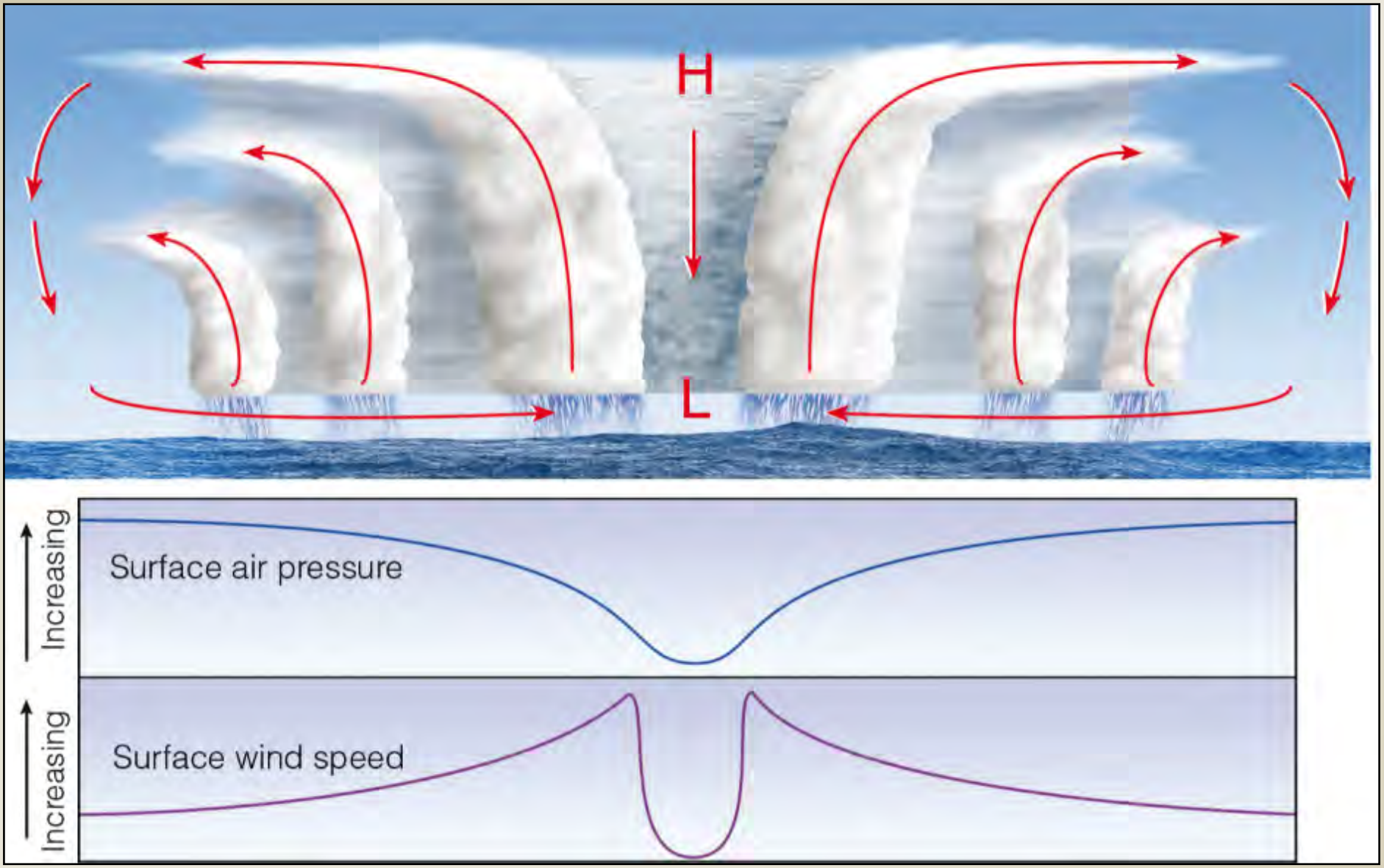
- The horizontal pressure gradient changes with altitude
  - At about 7.5 km, pressures are equal inside and outside
  - From 7.5 km to the tropopause, pressures within the storm *exceed* those outside the storm
- Lower portion of the storm rotates cyclonically
- Upper portion rotates anticyclonically



Ahrens: Figure 14.3

The Eye and Eye Wall

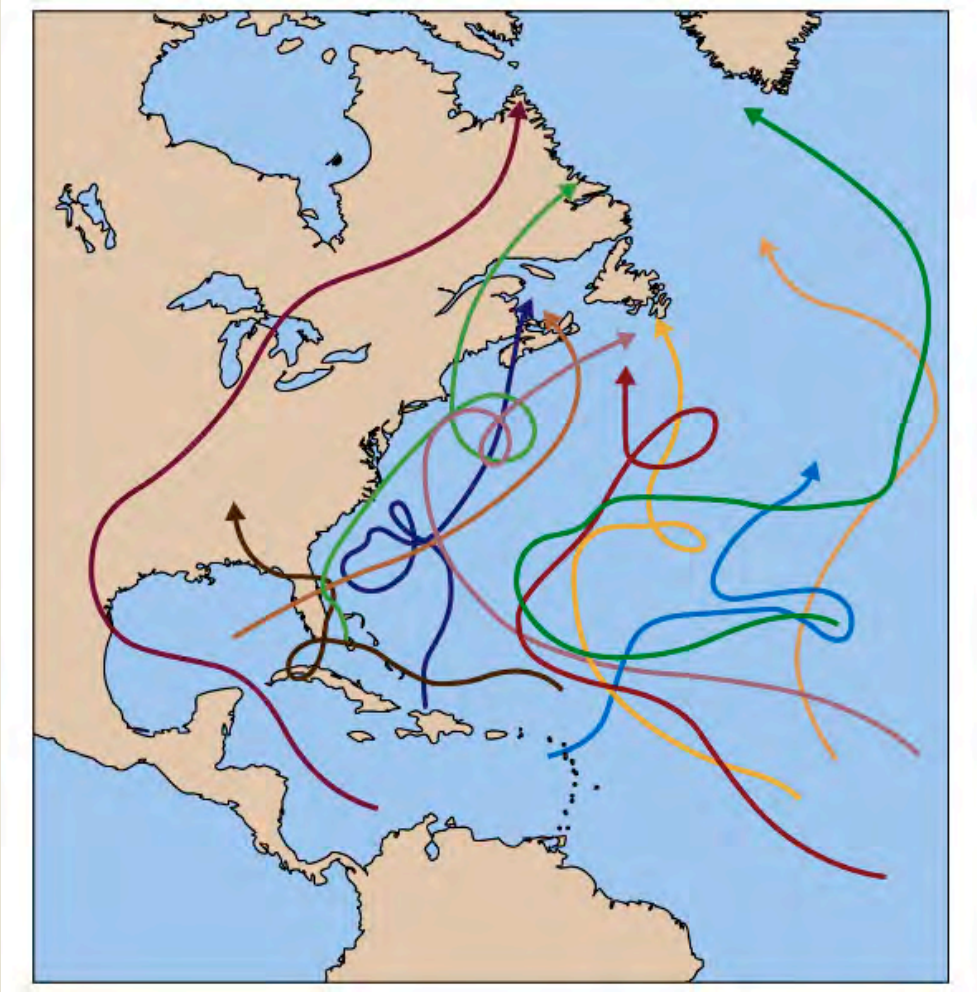
- The **eye** is an area of descending air and light winds
  - Average 25 km in diameter
  - A shrinking eye indicates storm intensification
- The **eye wall** is comprised of the strongest winds, the largest clouds, and the heaviest precipitation
  - Rainfall rates as high as 2500 mm/day



Ahrens: Fig. 14.9

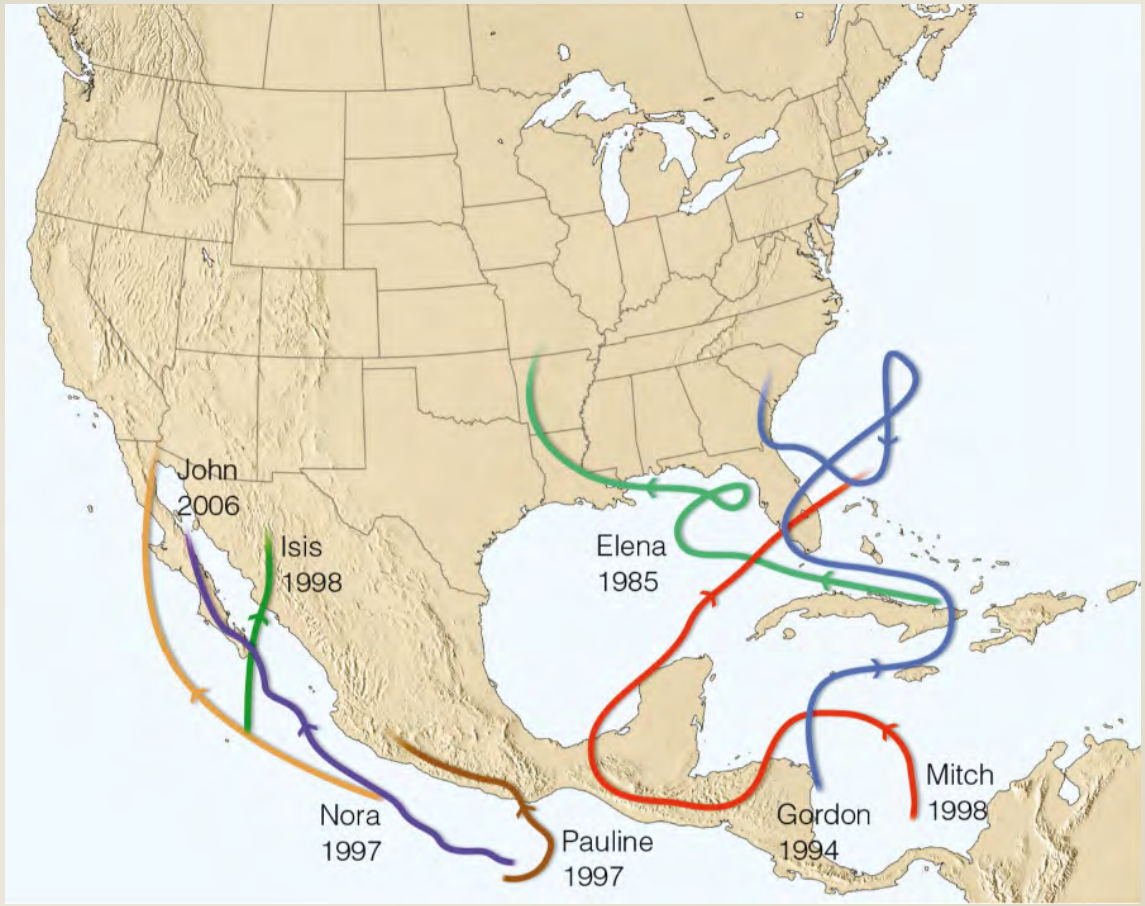
Atlantic Hurricane Movement

- Movement is dependent upon the stage of development
- In the Atlantic, storms that gain latitude usually ***curve back*** **toward the northeast** due to the influence of surface and upper-level westerlies



A&B: Figure 12-12

Hurricane Movement

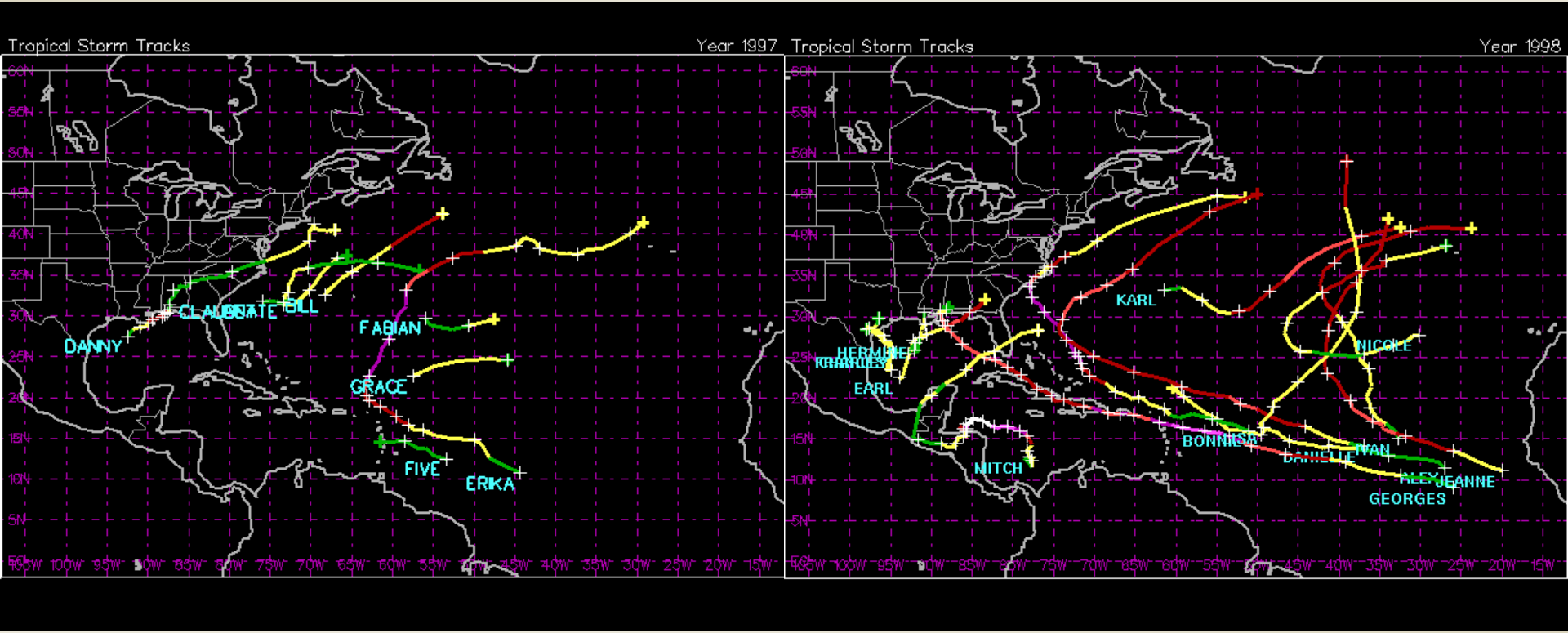


Ahrens: Fig. 14.13

Lifespan of a tropical cyclone

- SST – warmer water means more energy
- Upper wind structure – strong upper level winds inhibit tropical cyclone longevity
  - El Niño – more Pacific hurricanes, fewer Atlantic hurricanes
  - QBO – quasi-biennial oscillation of the winds in the tropical stratosphere
- Landfall

Atlantic Hurricanes and ENSO



1997 – El Niño year

1998 – Non-El Niño year

Cyclone dissipation

- Continuous supply of warm, moist air necessary to maintain intensity
  - Weakens over colder water
  - Weakens rapidly after landfall
- Reverts to tropical storm status
  - Still carries a lot of rain

Hurricane hazards

- High winds
- Storm surge
- Flooding

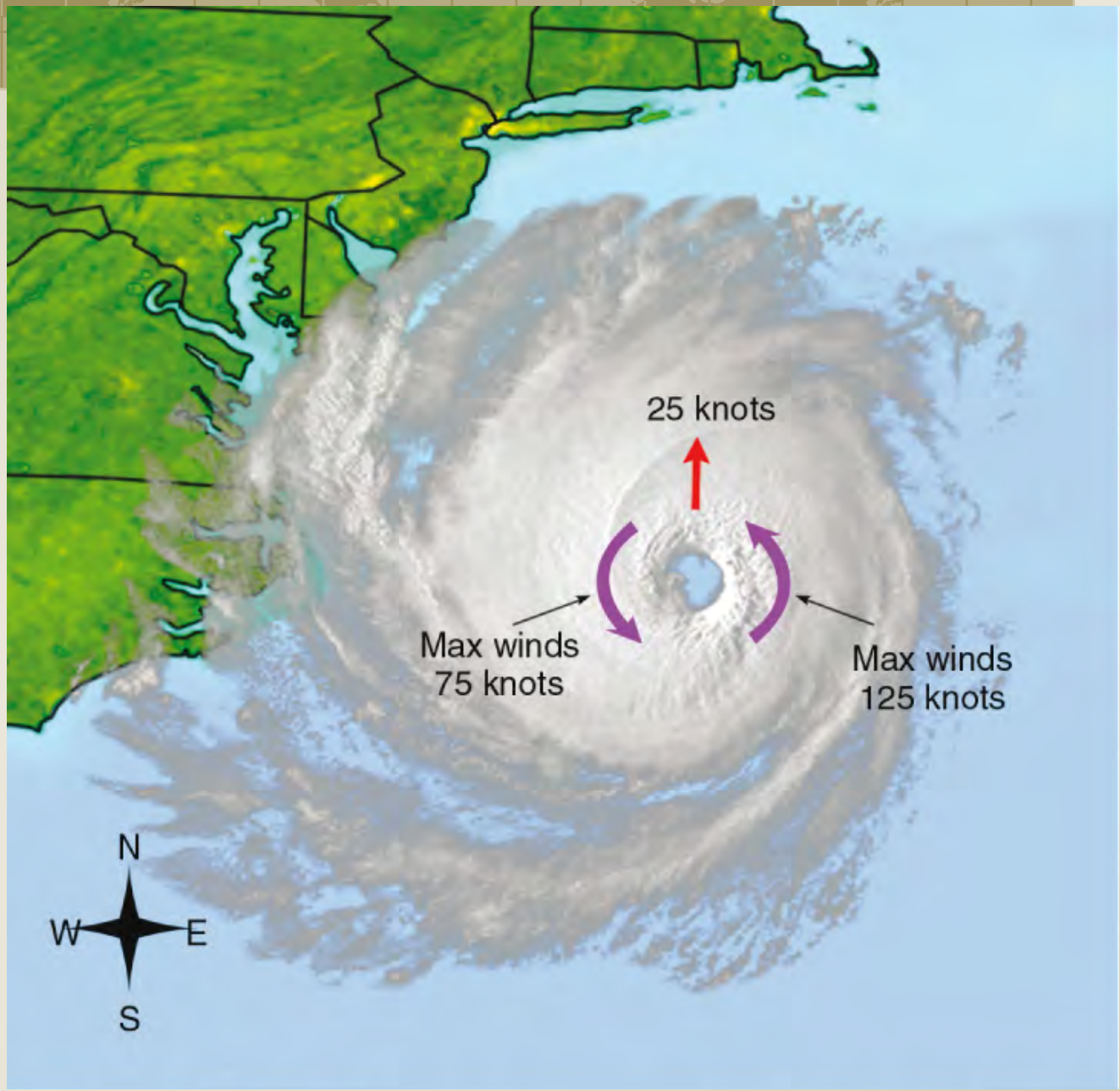
High winds

Excess of 120 km/h

Category 4
(>210 km/h)
- can blow the roofs off of houses

Category 5
(>250 km/h)
- can destroy houses

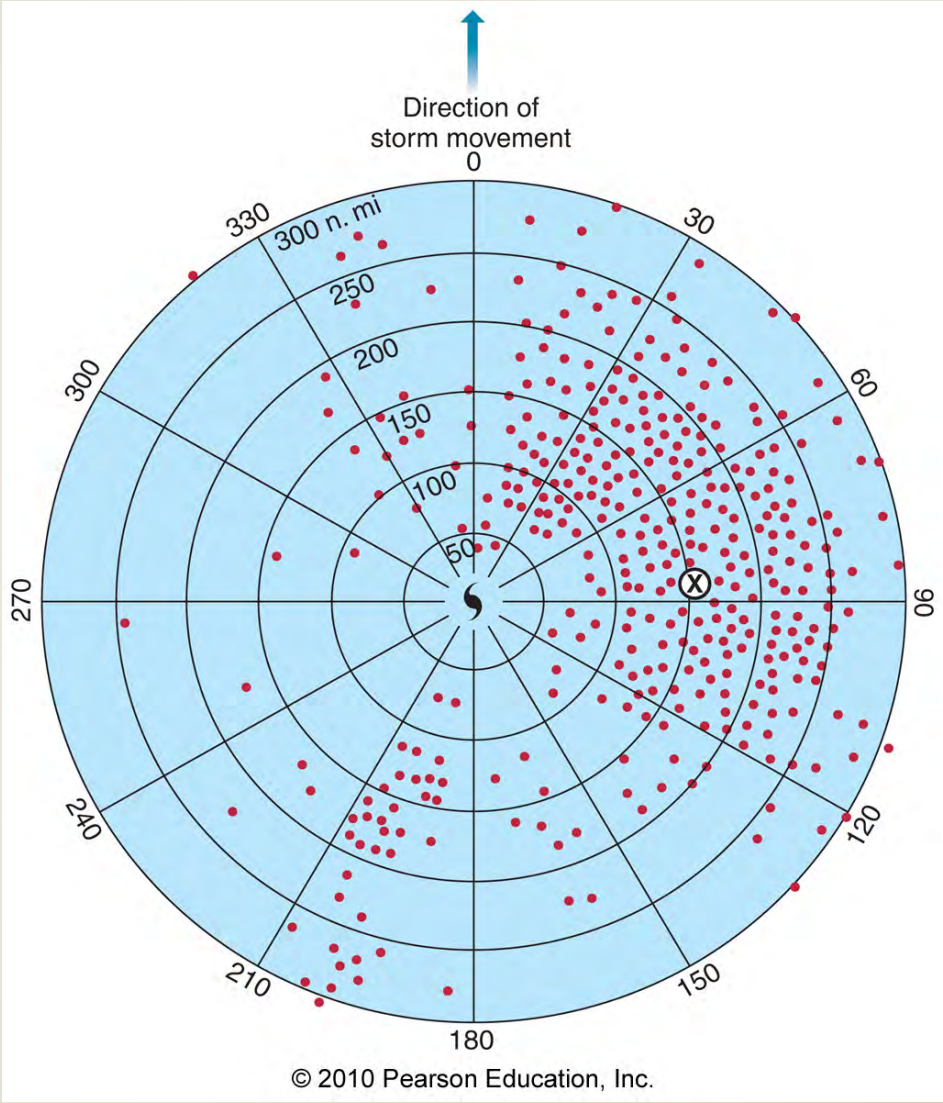
Ahrens: Fig. 14.14



Tornadoes

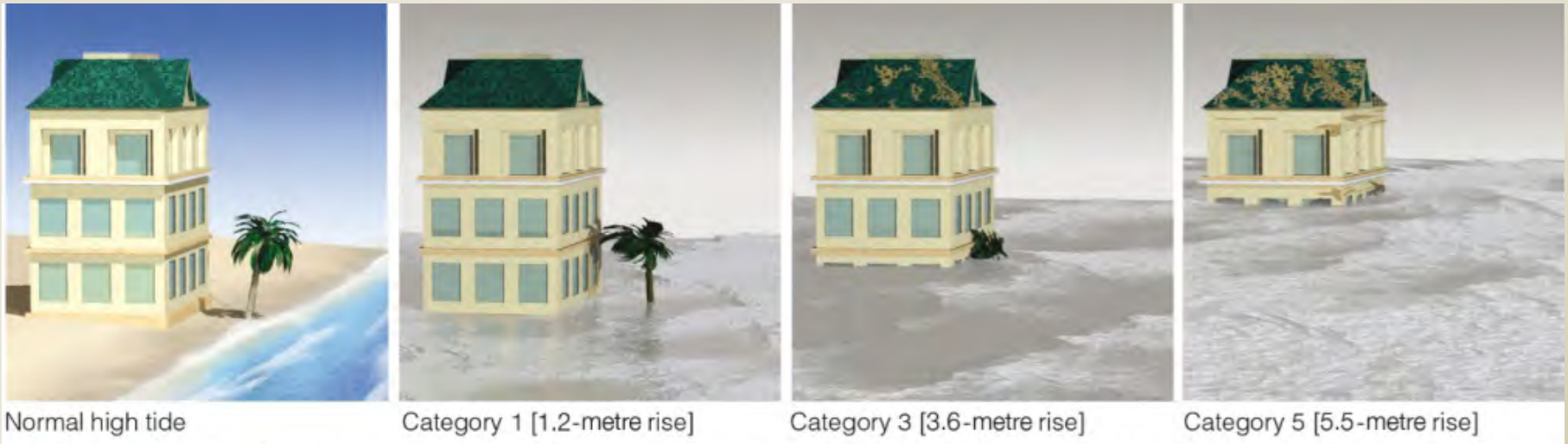
- Frequent feature of hurricanes
- Short duration
- May be triggered by landfall

A&B: Figure 12-15



Storm surge

- Rise in sea level
  - Piled up by heavy winds
  - Low pressure also produces a bulge
- Greatest potential for damage



Ahrens: Figure 14.15

Heavy rain

- 250 mm/day under a passing storm
- Floods, landslides
  - Freshwater flooding is the deadliest aspect of hurricanes
- Hurricane Mitch (1998):850 mm over a few days in Honduras and Nicaragua
  - Over 19 000 deaths
  - Deadliest hurricane in last 200 years in Western Hem.
- Bangladesh 1970 Bay of Bengal
  - 300,000 - 500,000 deaths

Canadian Weather Service

1873

- "Great Nova Scotia Cyclone"
- Category 2 hurricane off the Nova Scotia coast
- Over 500 people killed

1876

- Telegraph lines set up to every major city in Eastern Canada.

Canadian Hurricanes

- Eastern provinces occasionally are hit by tropical storms – as far west as the Great Lakes
  - Great Lakes – 1 in 5 years
- Not an issue in the Western provinces
- Canadian Hurricane Centre
  - Halifax
  - Founded in 1986

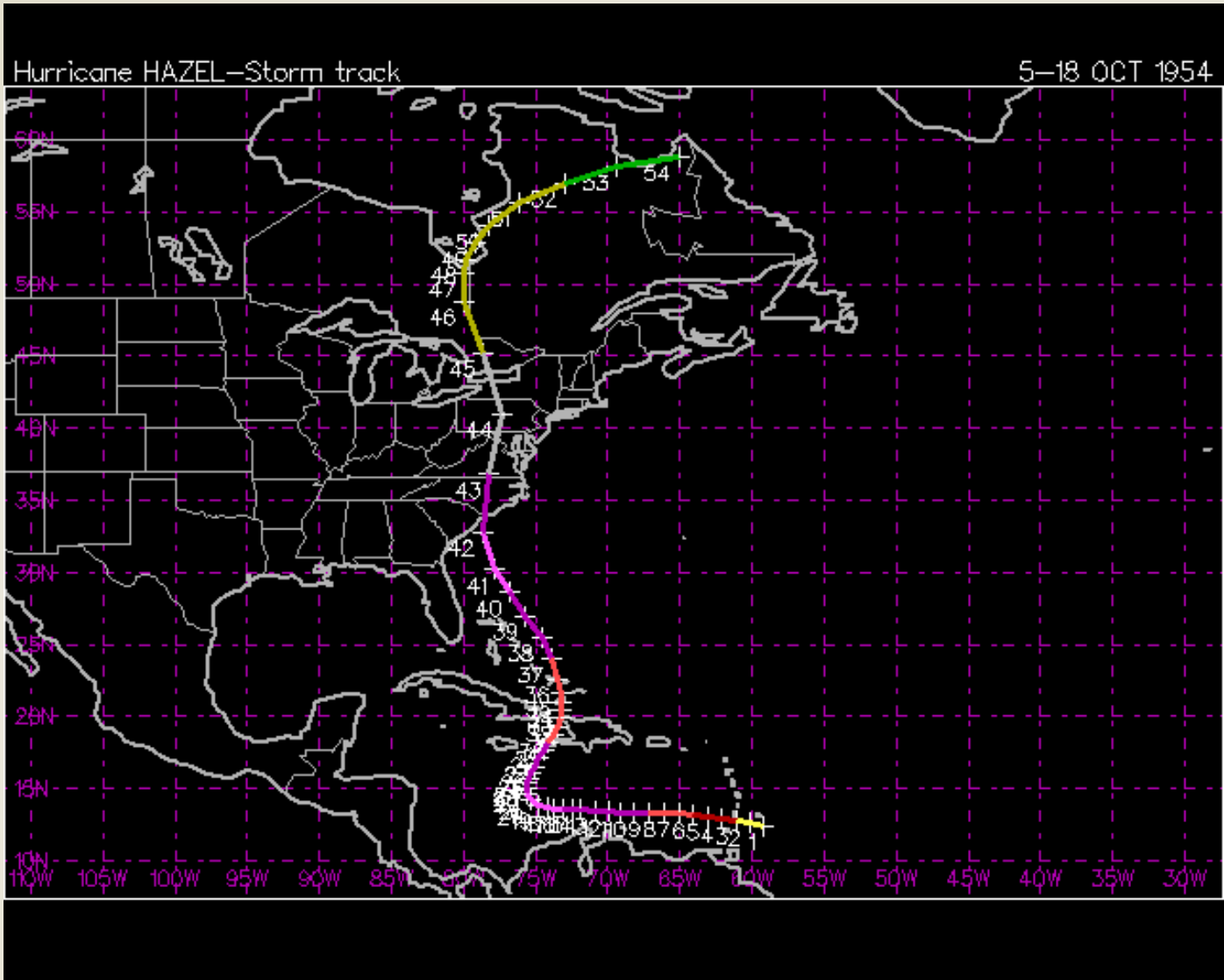
Igor floods Newfoundland
Source: CTV

Hurricane Hazel (1954)

October 15, 1954

121.4 mm at Toronto International Airport

Transitioned storm



Coming up

- Hurricane forecasting
  - More from Ahrens: Chapter 15
- Weather forecasting