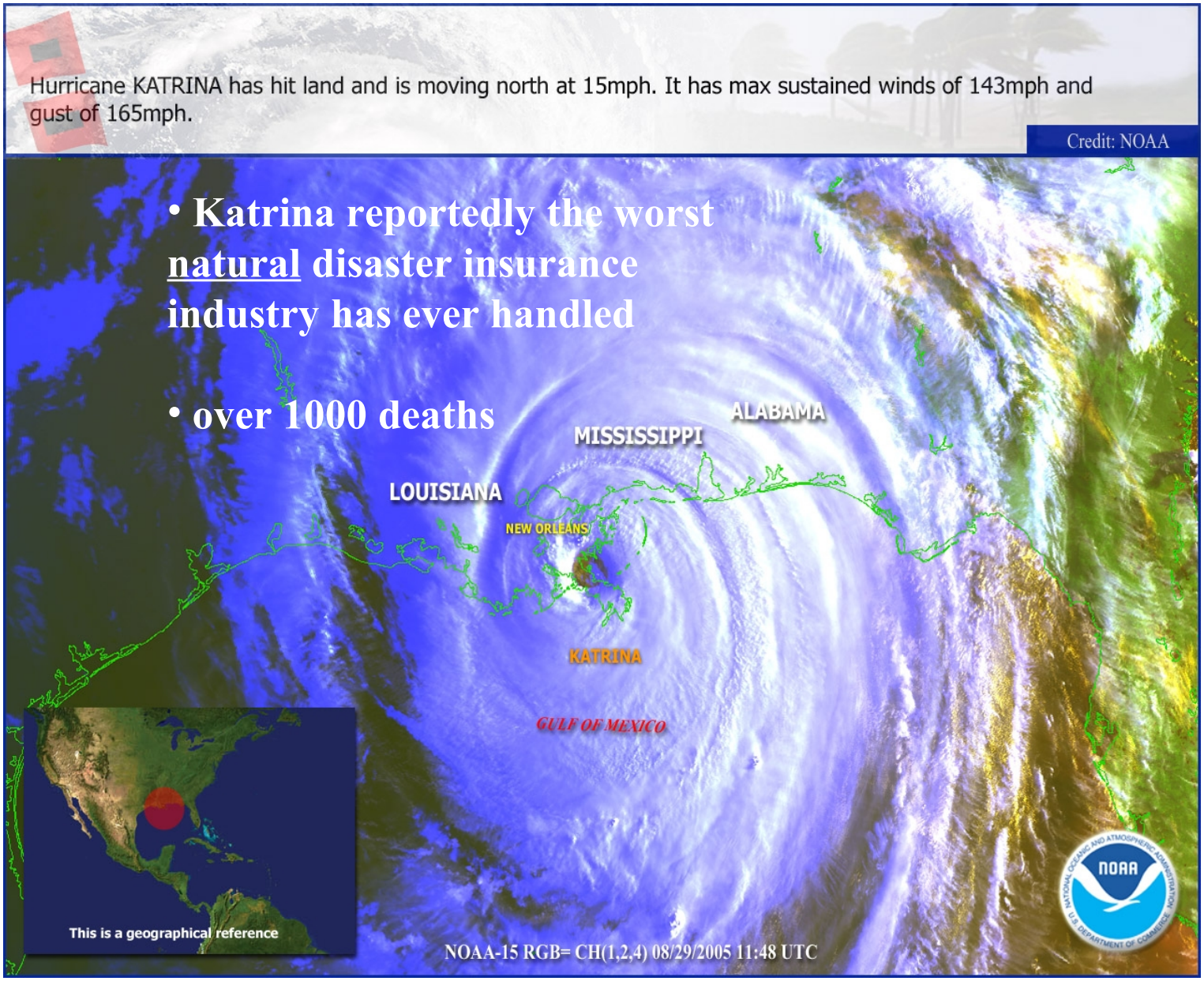
Goals for today:

18 Nov., 2011

- quick overview of Thursday's significant snowfall
- Ch. 12 “Tropical Storms & Hurricanes”



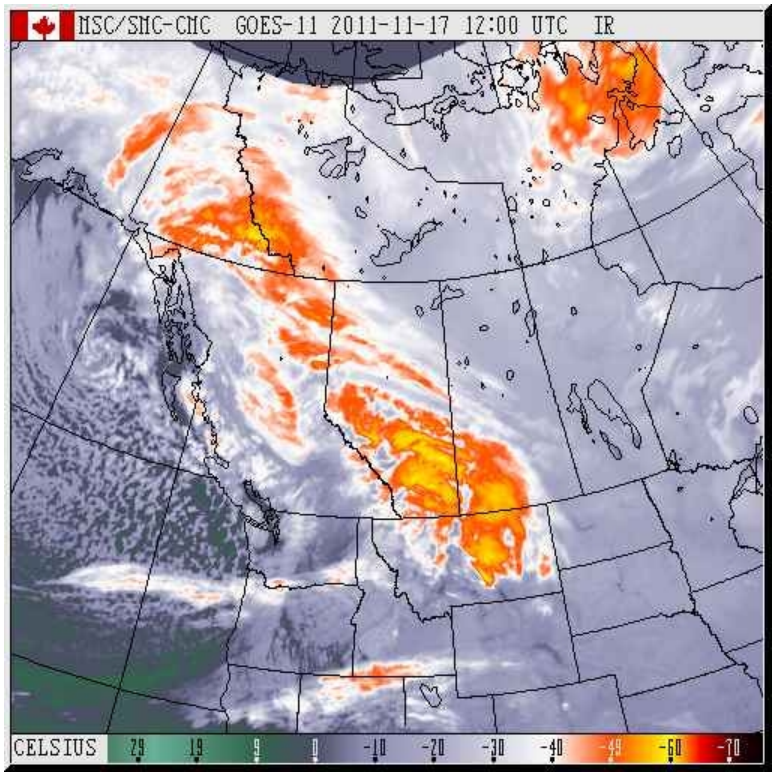
MSC 850 hPa & 700 hPa analyses, 12Z Thurs. 17 Nov. 2011

MSC sfc analysis, 18Z Thurs.

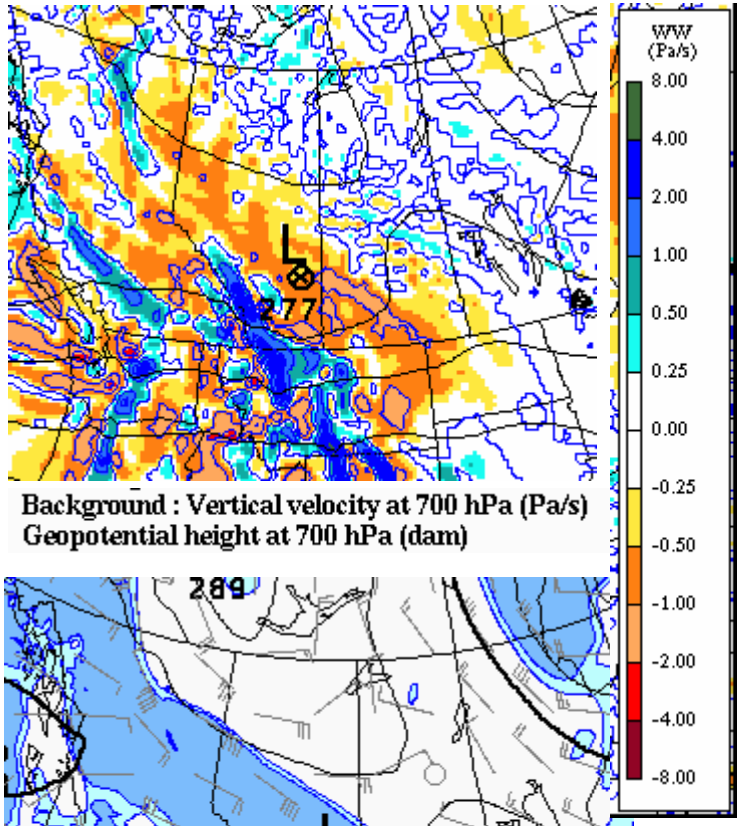
EC 7:00 AM CST FRI. NOV.18 2011... ALBERTA CLIPPER MOVED THROUGH THE PRAIRIES THURS GIVING A SWATH OF 5 CM OF SNOW WITH LOCAL AREAS OF 10 TO 15 CM... WESTERN PRAIRIES...CONDITIONS IMPROVED OVERNIGHT AS THE LOW MOVED OUT OF THE PROVINCE, BUT LIGHT SNOW REMAINS OVER MOST OF ALBERTA. A RIDGE BUILDING IN FROM THE NORTH WILL SUSTAIN UPSLOPE WINDS ALONG THE FOOTHILLS TODAY CAUSING THE STRATUS AND SNOW TO LINGER... IN EXTREME SW ALBERTA THE COLD AIR NEAR THE SURFACE COMBINED WITH UPSLOPE FLOW AND PACIFIC AIR PUSHING IN ALOFT WILL GIVE CONDITIONS PRIME FOR SNOWFALL

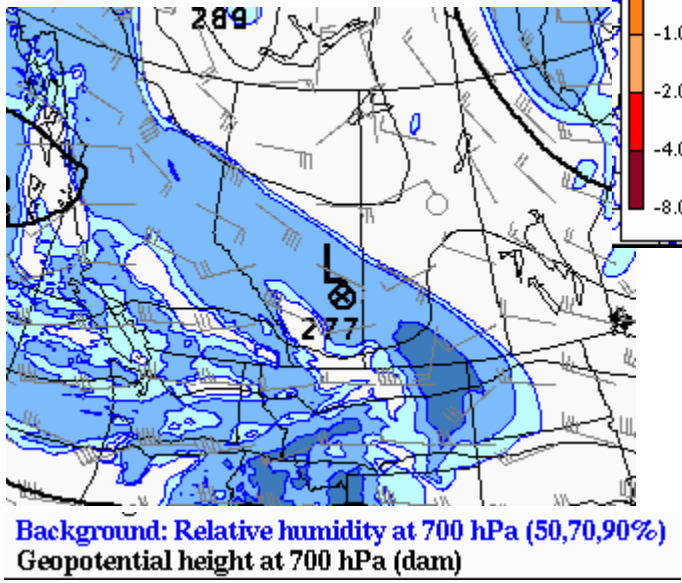
0-hr prog valid 18Z Thurs shows:

- ascent + humidity over C. Alberta
- sink in SW correlates with low RH slot



GEM 0-hr prog valid 18Z Thurs.





Summary: lee low formed beneath 700 hPa trough in region with strong 850 hPa temp. grad. Upslope winds in friction layer, ascent of saturated air over C. Alberta.

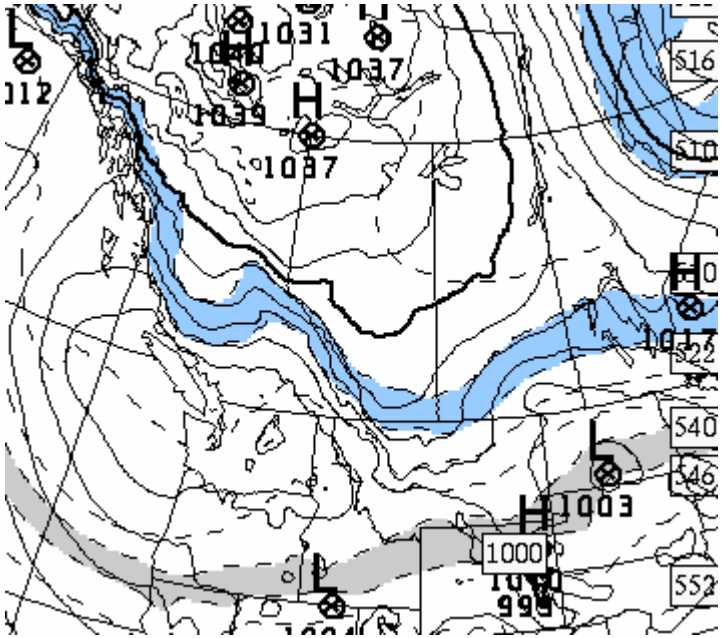
2a

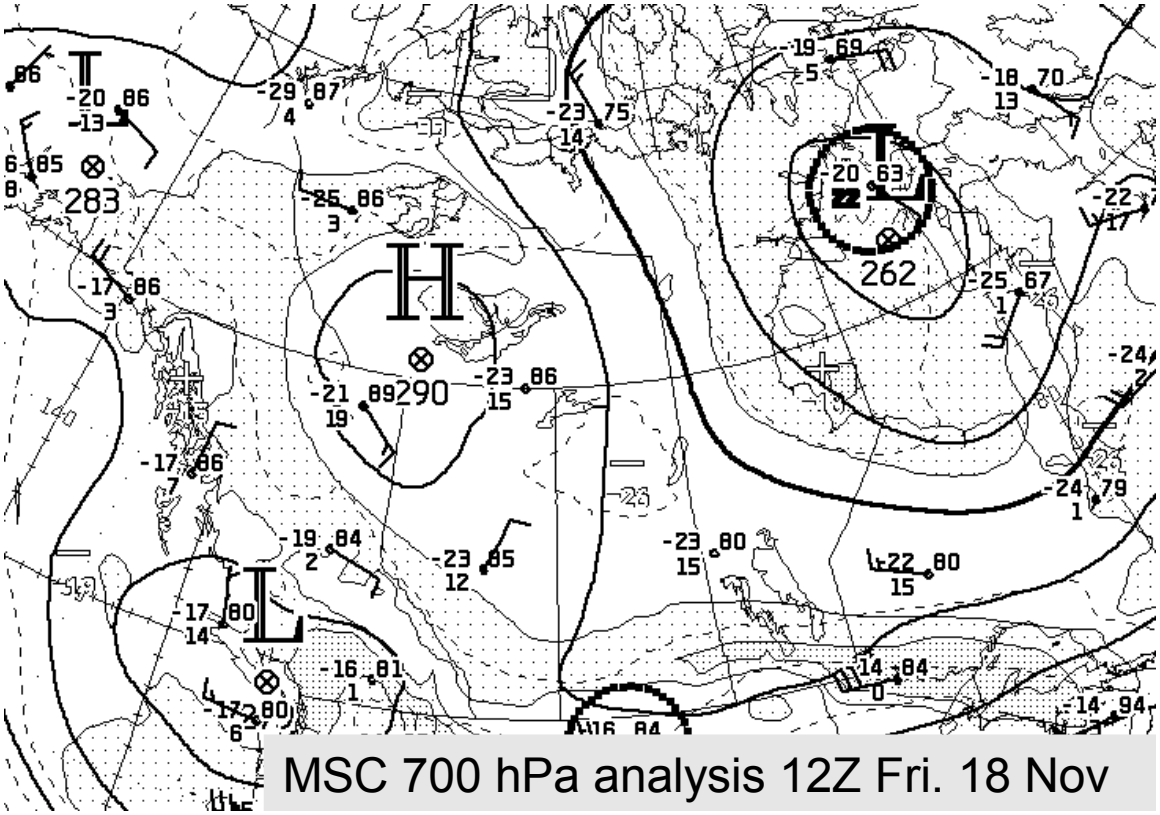
Edmonton City Centre Airport
Past 24 Hour Conditions

18 November 2011		
9:00	Light Snow	-17
8:00	Cloudy	-16
7:00	Cloudy	-17
6:00	Cloudy	-17
5:00	Cloudy	-16
4:00	Cloudy	-16
3:00	Cloudy	-16
2:00	Cloudy	-15
1:00	Cloudy	-15
00:00	Cloudy	-15
17 November 2011		
23:00	Cloudy	-15
22:00	Light Snow	-14
21:00	Cloudy	-13
20:00	Light Snow	-13
19:00	Light Snow	-12
18:00	Light Snow	-12
17:00	Light Snow	-12
16:00	Light Snow	-11
15:00	Light Snow	-11
14:00	Light Snow	-11
13:00	Light Snow	-11
12:00	Light Snow	-11
11:00	Light Snow	-10
0:00	Light Snow	-10

- Ridge of cold air is building down
- flow aloft from N due to midlat. storm over Hudson Bay

GEM 0-hr prog valid 12Z Fri. 18 Nov





MSC 700 hPa analysis 12Z Fri. 18 Nov

2b

What is a HURRICANE / TYPHOON / TROPICAL CYCLONE ?

Mass of thunderstorms (collective diam. typically about 600 km) driven by energy available in very warm, moist tropical surface air and organised in cyclonically spiraling bands ("pinwheel formation") around a low pressure centre

- Sustained wind speed ≥ 120 kph and up to 350 kph; lifetime of days to a week or more

- Cirrus aloft may obscure the pinwheel formation

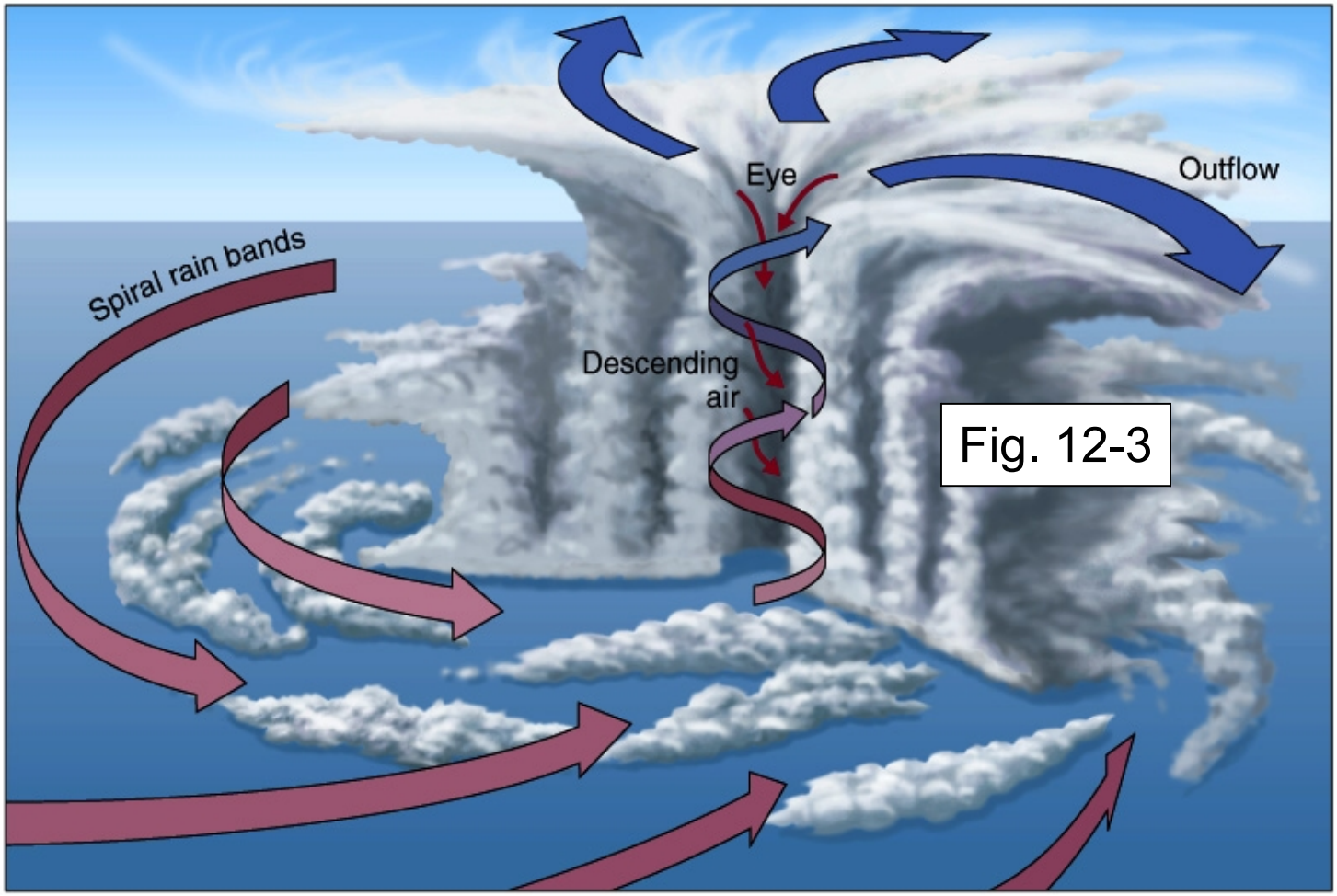


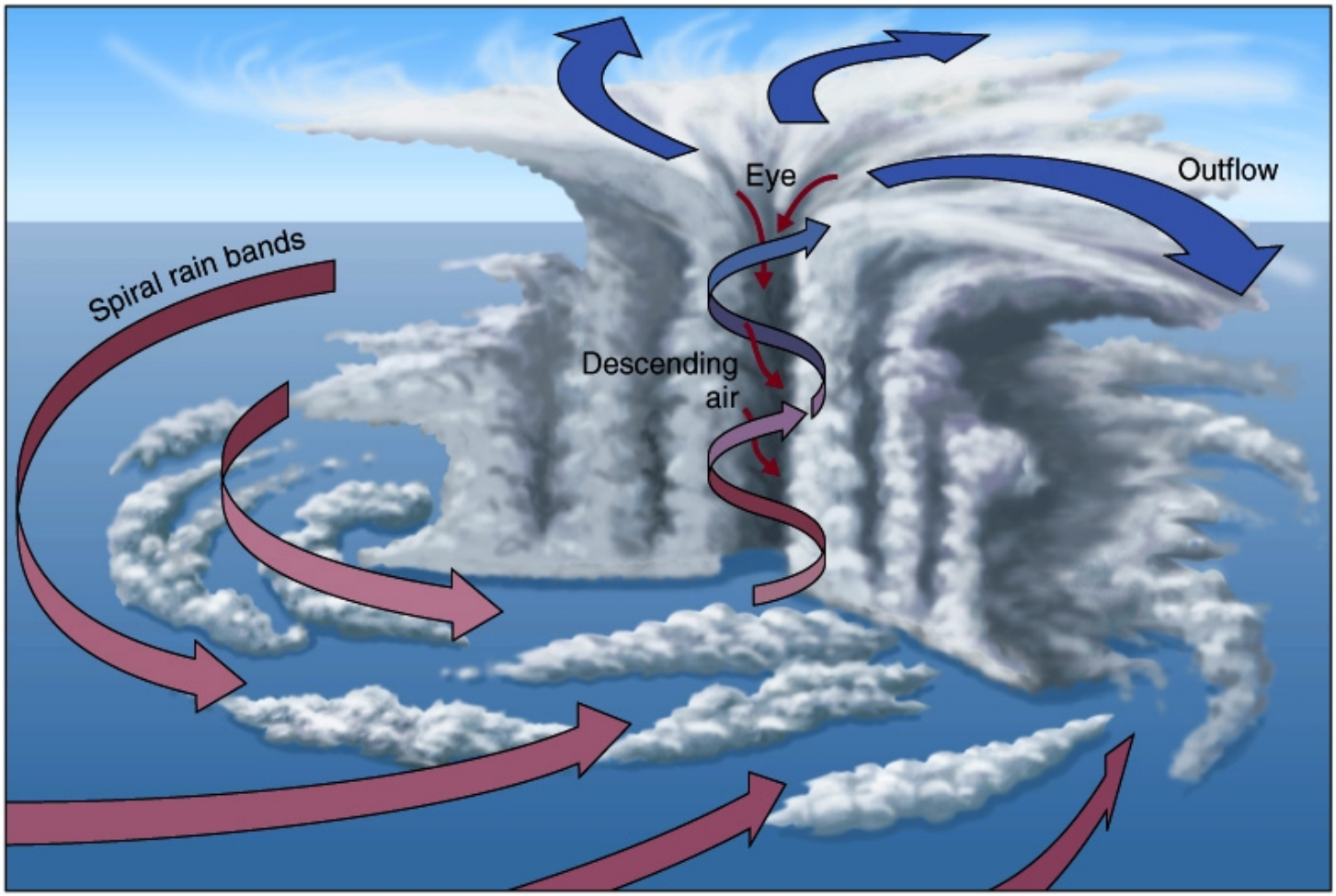
Fig. 12-3

What is a HURRICANE / TYPHOON / TROPICAL CYCLONE ?

Typical central pressure about 950 hPa, extreme cases <900 hPa, eg.

- Gilbert, 14 Sept. 1988, “atlantic storm of century”, 888 hPa
- Wilma, 18 Oct. 2005, 882 hPa
- Katrina, 902 hPa

Wind drag piles up water on a coast (“storm surge”) & the low central pressure also contributes to sea-level rise/swell, typically 1-2 m but up to 7 m



Where/under what conditions do they form ?

• ***Requires*** ocean surface layer temperature > 27°C (in layer tens of metres deep - favouring tropics in late summer/early fall). Vital role of Coriolis force (prevents filling of central Low) prohibits formation below about 5° latitude

• energy supply? latent heat evaporated off ocean… thus...

• peak season in late summer/early fall, when ocean temps highest

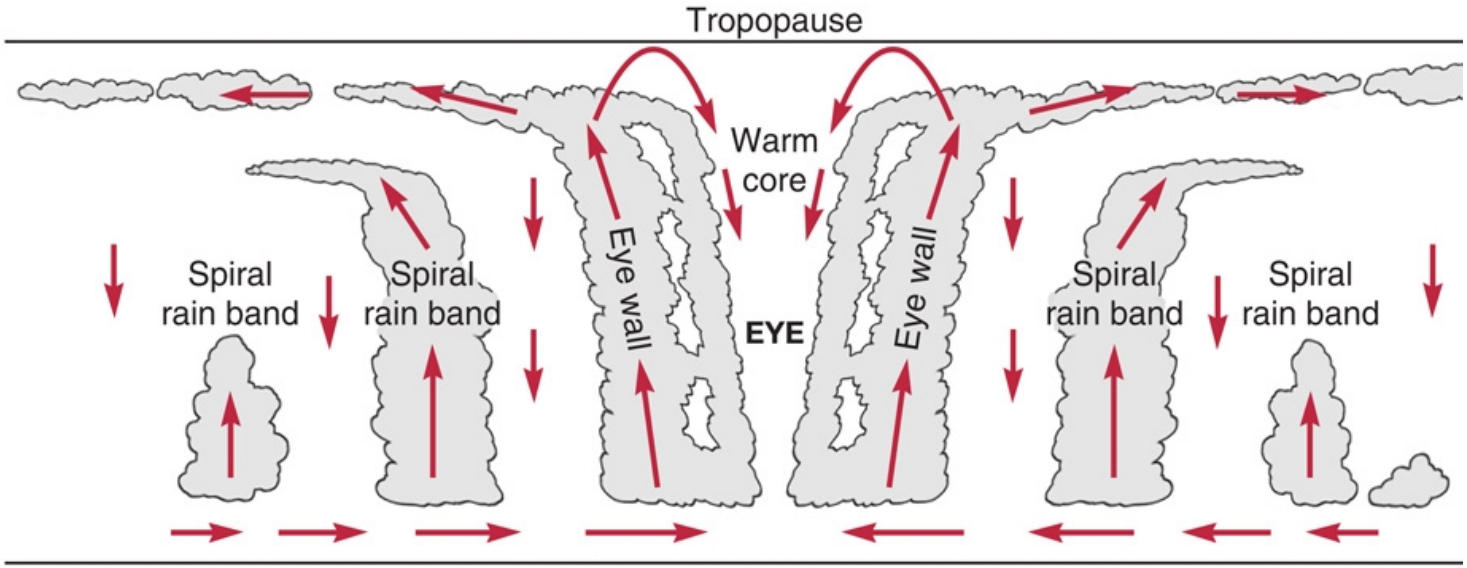
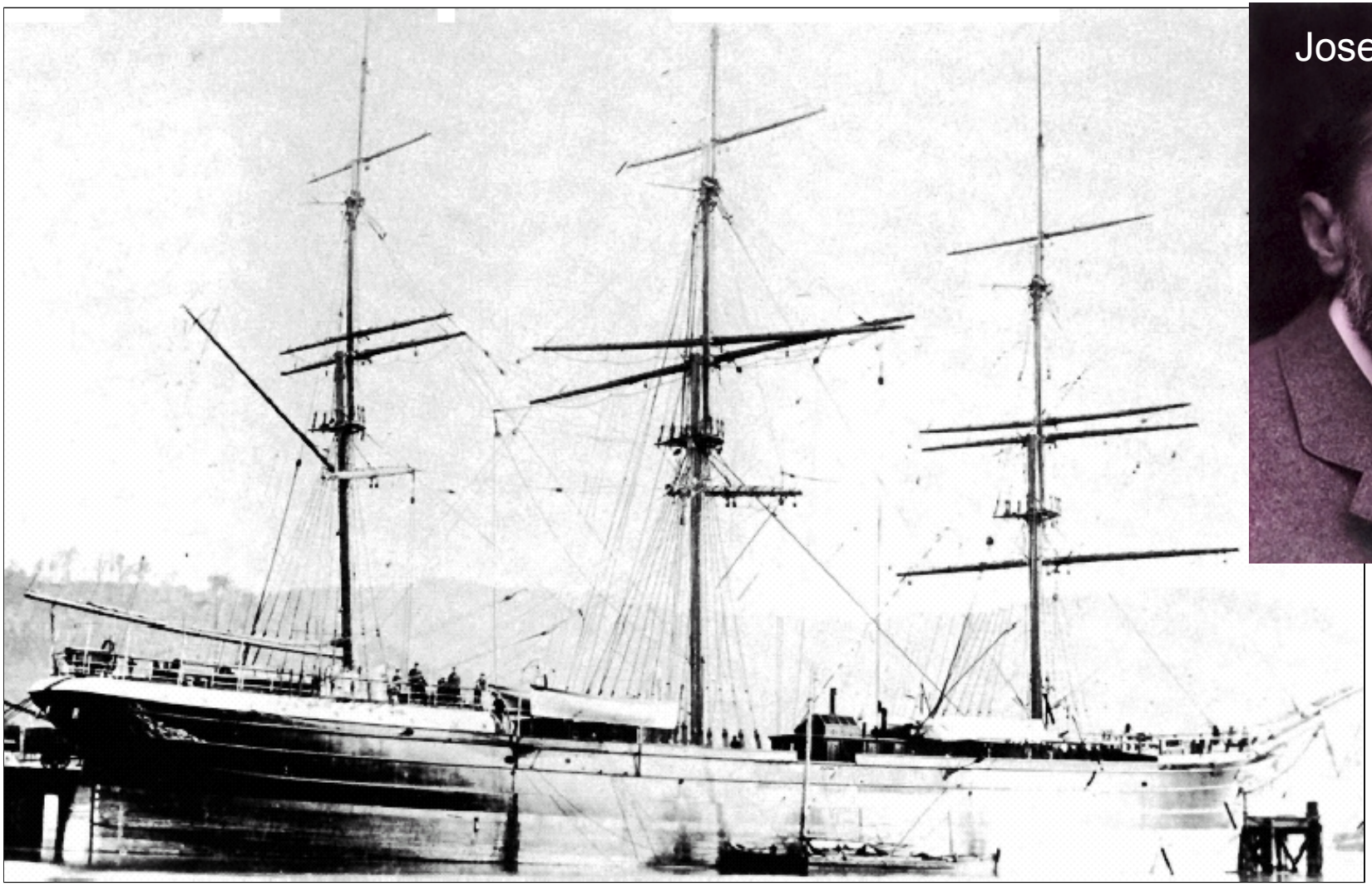
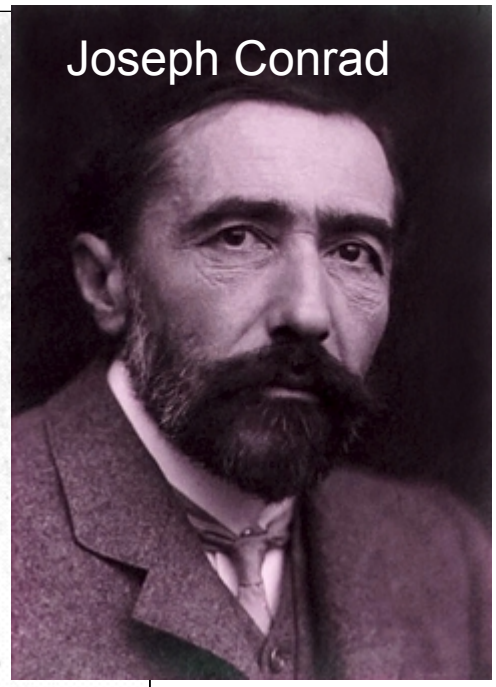


Fig. 12-4

5

• bands of heavy convection separated by areas of weaker lift &precip



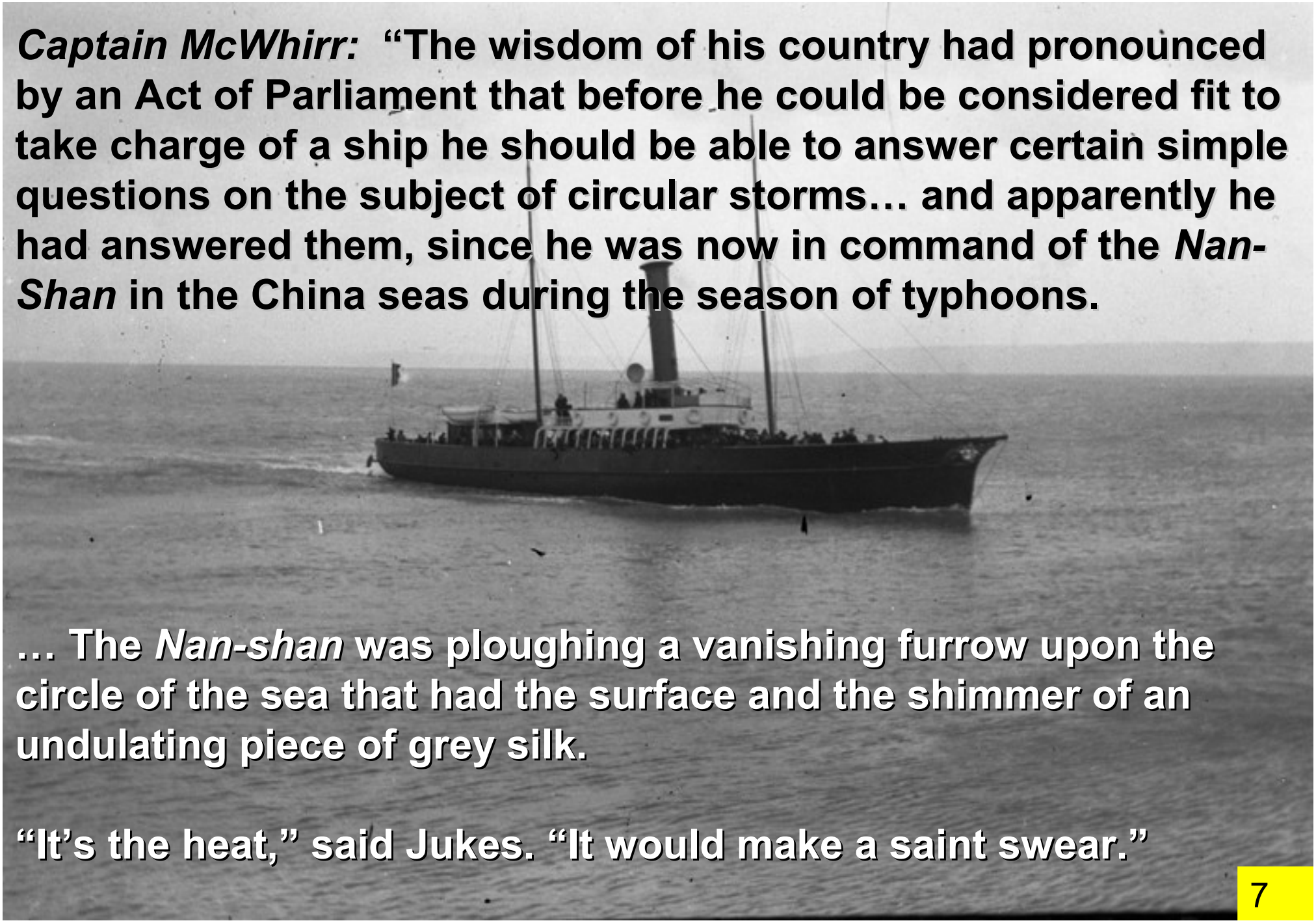


Wikipedia

Joseph Conrad** was captain of this vessel, the barque “Otago” seen here moored at Port Chalmers (Dunedin, New Zealand). Photo from N.Z. Geographic No.78, 2006.

**Józef Teodor Konrad Korzeniowski, author of *Lord Jim, The Secret Agent, An Outcast of the Islands, The Rover, The Shadow Line, Heart of Darkness, Nostromo, Almayer's Folly...*

Joseph Conrad: "Typhoon" (short story, published 1904)



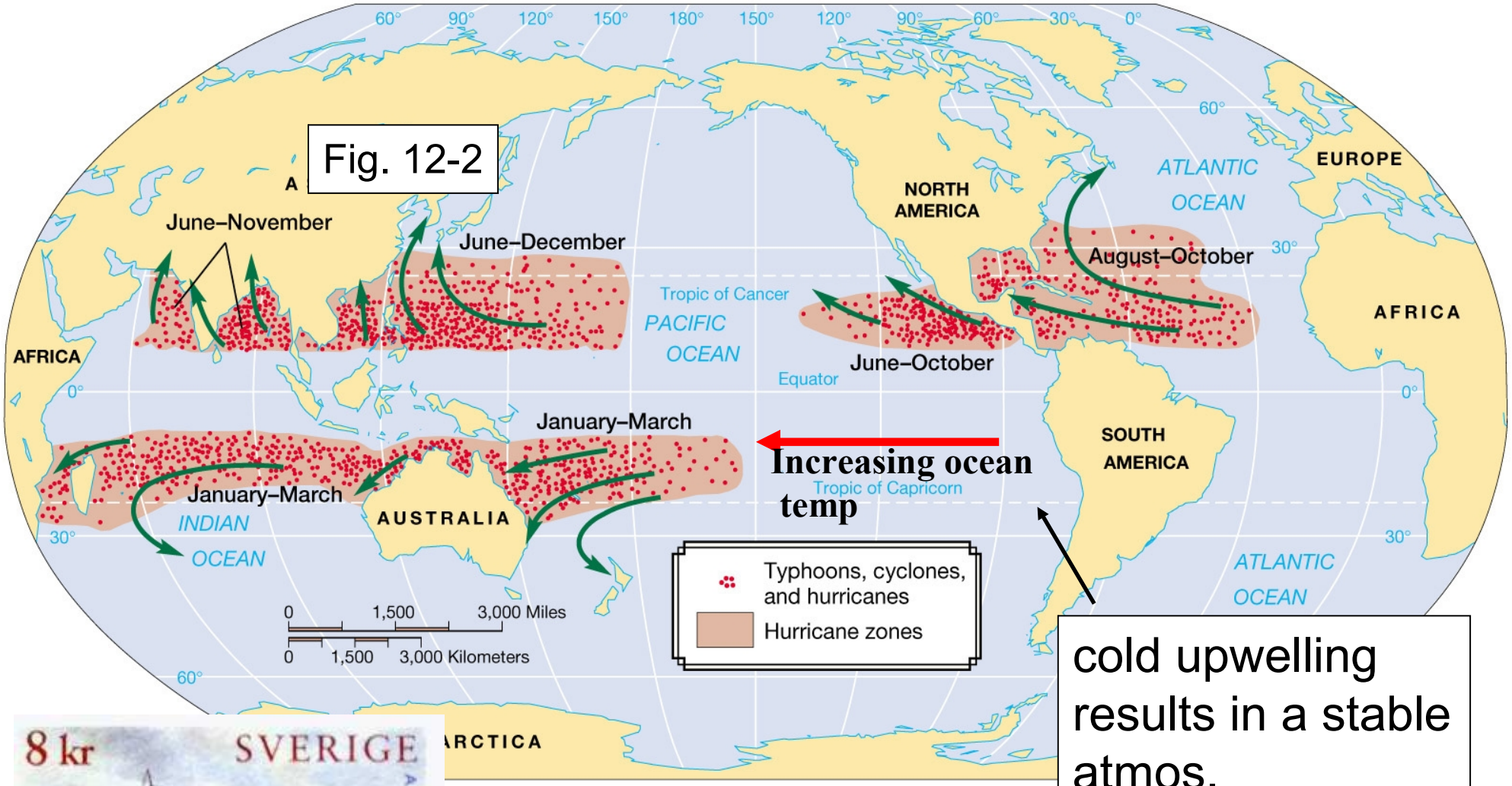
Captain McWhirr: **"The wisdom of his country had pronounced by an Act of Parliament that before he could be considered fit to take charge of a ship he should be able to answer certain simple questions on the subject of circular storms… and apparently he had answered them, since he was now in command of the *Nan-Shan* in the China seas during the season of typhoons.**

… The *Nan-shan* was ploughing a vanishing furrow upon the circle of the sea that had the surface and the shimmer of an undulating piece of grey silk.

"It's the heat," said Jukes. "It would make a saint swear."

Fuzhou is the capital and one of the largest cities in Fujian Province, People's Republic of China... the name "Fuzhou" was variously romanized as Foochow, Fuchow, Fuh-chau, Fuh-Chow, Hock Chew or Hokchew.

Where/under what conditions do they form ?



cold upwelling results in a stable atmos.

"I wonder where that beastly swell comes from," said Jukes aloud, recovering himself from a stagger.

Development...

Small cluster of thunderstorms known as “tropical disturbance” forms in convergence zone of an “easterly wave” at low latitude

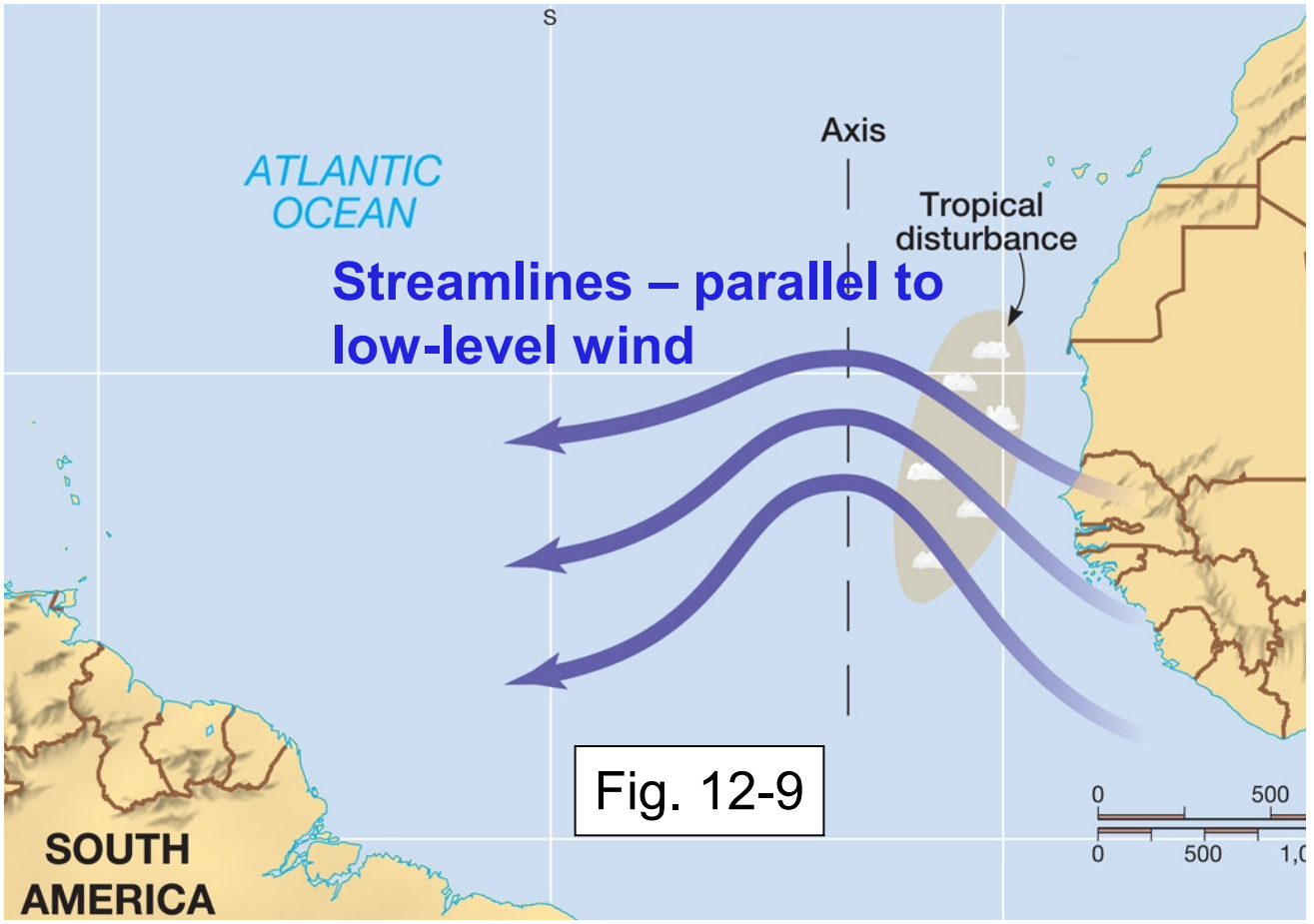


Fig. 12-9

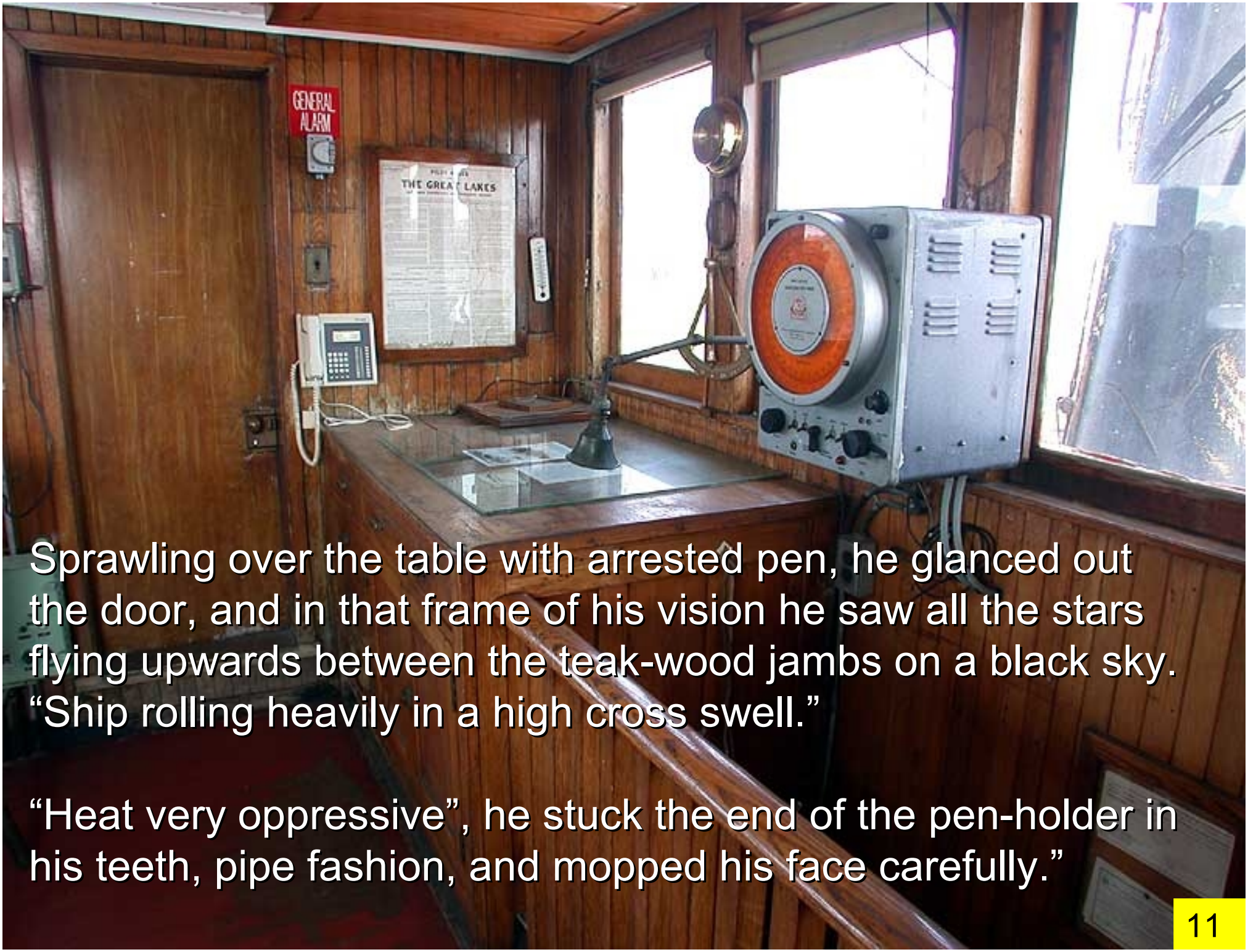
Tropical disturbance migrates slowly westward

< 10%

Tropical depression (at least one closed surface isobar)

Tropical storm (sustained winds > 60 kph)

Hurricane (sustained winds > 120 kph)



Sprawling over the table with arrested pen, he glanced out the door, and in that frame of his vision he saw all the stars flying upwards between the teak-wood jambs on a black sky. “Ship rolling heavily in a high cross swell.”

“Heat very oppressive”, he stuck the end of the pen-holder in his teeth, pipe fashion, and mopped his face carefully.”

- paths can be “wildly erratic”
- precursor disturbances move westward in trade winds
- tendency to move to (or develop towards) warmer water
- often turn poleward
- dissipate when move over land or cooler water
- preferred path varies across Aug/Sep/Oct

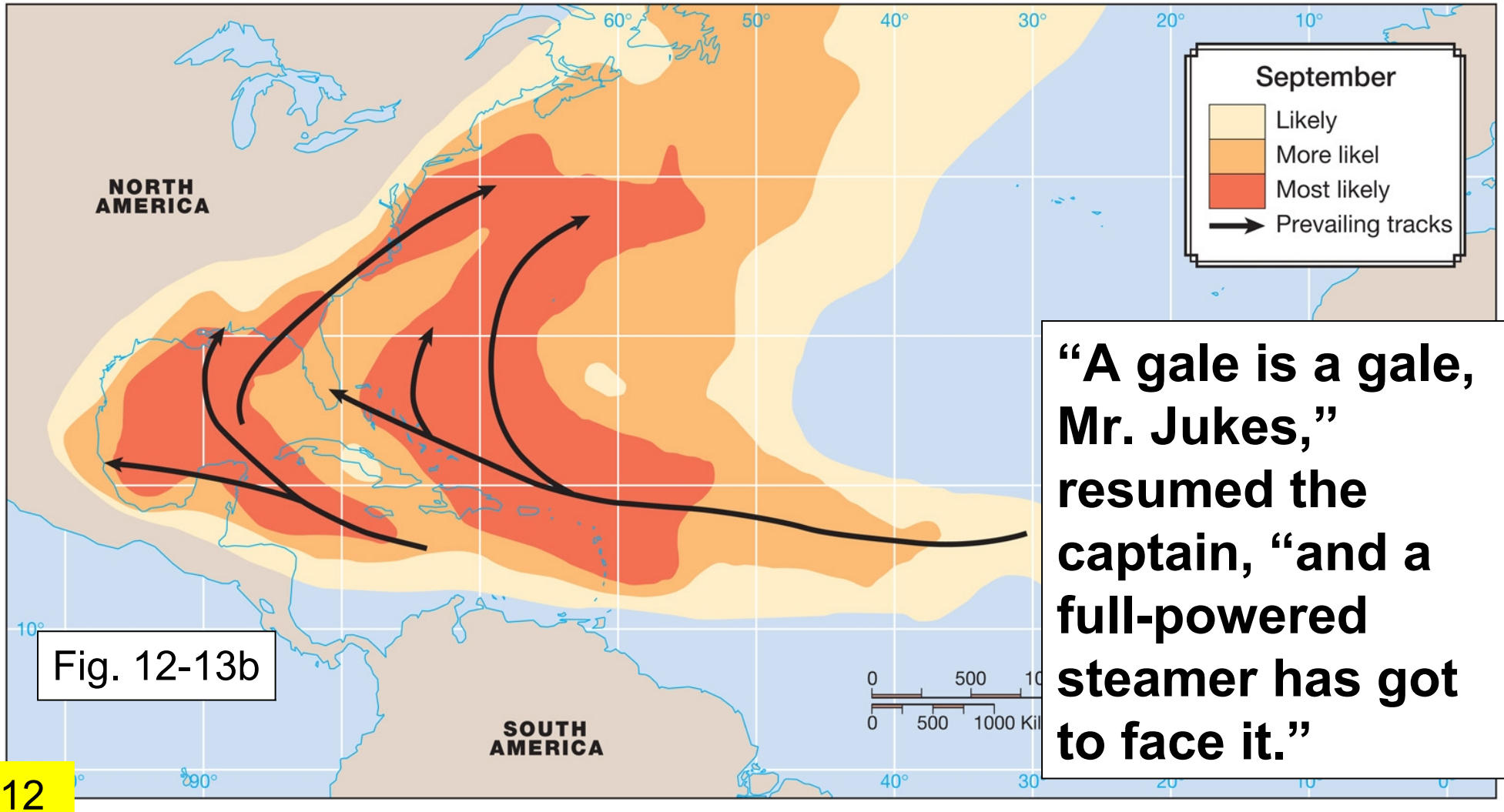
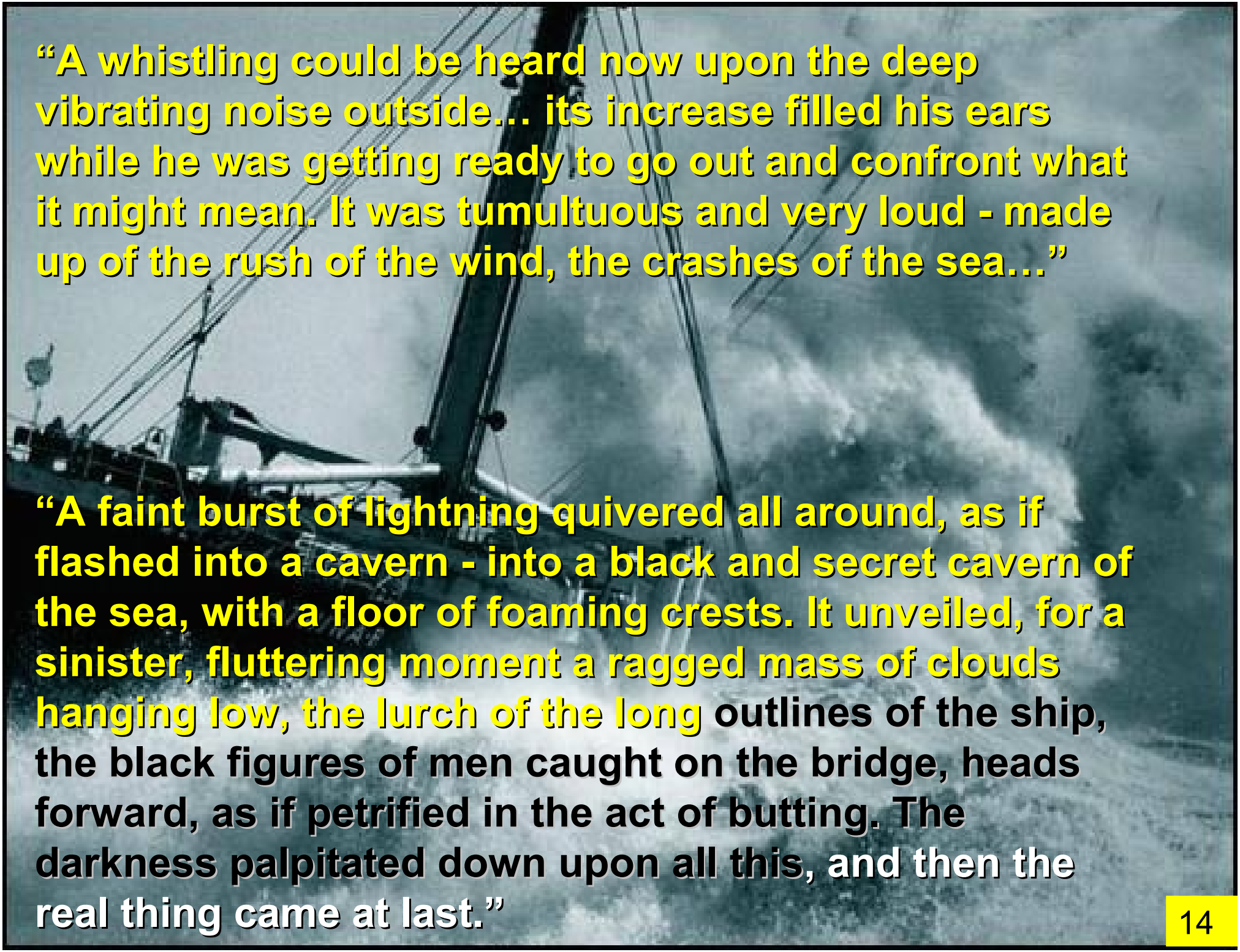


Fig. 12-13b

“A gale is a gale, Mr. Jukes,” resumed the captain, “and a full-powered steamer has got to face it.”

I've been reading the chapter on the storms there… you would think an old woman had been writing this. It passes me. If that thing means anything useful, then it means that I should at once alter the course away, and come booming down on Fu-chau from the northward at the tail of this dirty weather that's supposed to be knocking about in our way. From the north. Do you understand, Mr. Jukes? Three hundred extra miles to the distance, and a pretty coal bill to show…

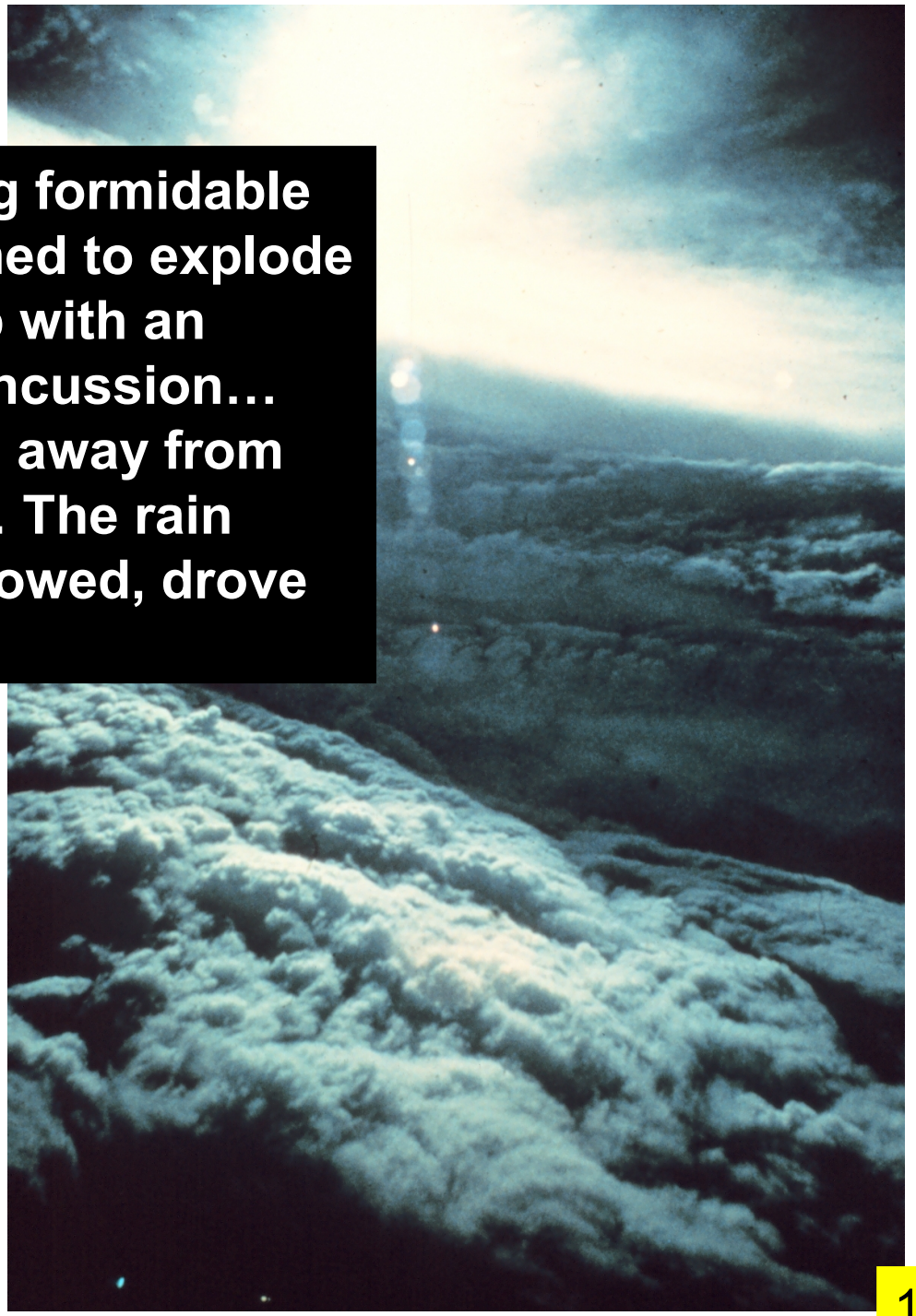
Suppose I went swinging off my course and came in two days late and they asked me: 'Where have you been all that time Captain?' What could I say to that? 'Went round to dodge the bad weather,' I would say. 'It must've been damn bad,' they would say. 'Don't know,' I would have to say; 'I've dodged clear of it.' See that, Jukes?



“A whistling could be heard now upon the deep vibrating noise outside… its increase filled his ears while he was getting ready to go out and confront what it might mean. It was tumultuous and very loud - made up of the rush of the wind, the crashes of the sea…”

“A faint burst of lightning quivered all around, as if flashed into a cavern - into a black and secret cavern of the sea, with a floor of foaming crests. It unveiled, for a sinister, fluttering moment a ragged mass of clouds hanging low, the lurch of the long outlines of the ship, the black figures of men caught on the bridge, heads forward, as if petrified in the act of butting. The darkness palpitated down upon all this, and then the real thing came at last.”

In the eyewall intense Cb…
up to 25 cm/hour rain rate



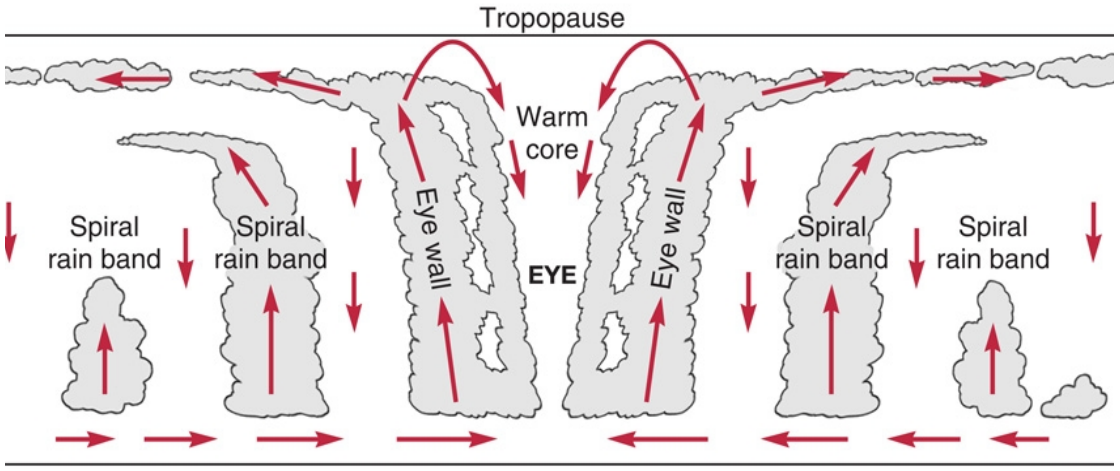
"It was something formidable and swift. It seemed to explode all round the ship with an overpowering concussion… Jukes was driven away from his commander… The rain poured on him, flowed, drove in sheets…"

Structure/mechanism?

Intense cyclonic low-level winds result from the strong radial pressure gradient…

• winds whip up the ocean surface, resulting in huge sea-air fluxes of vapour and sensible heat

• adiabatic expansion as parcels spiral to centre, so relatively weak temperature gradient at low levels… but



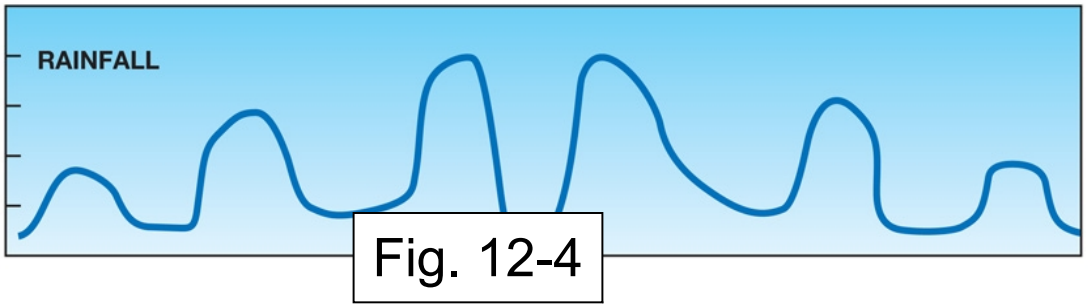
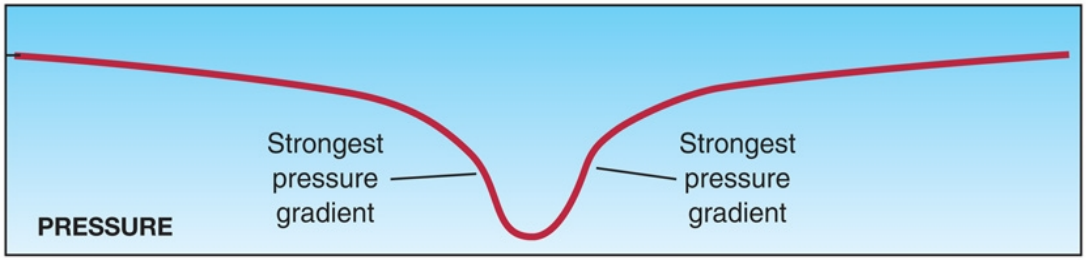
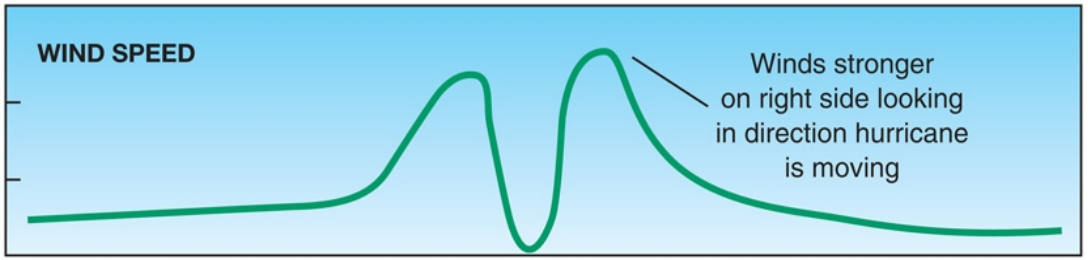


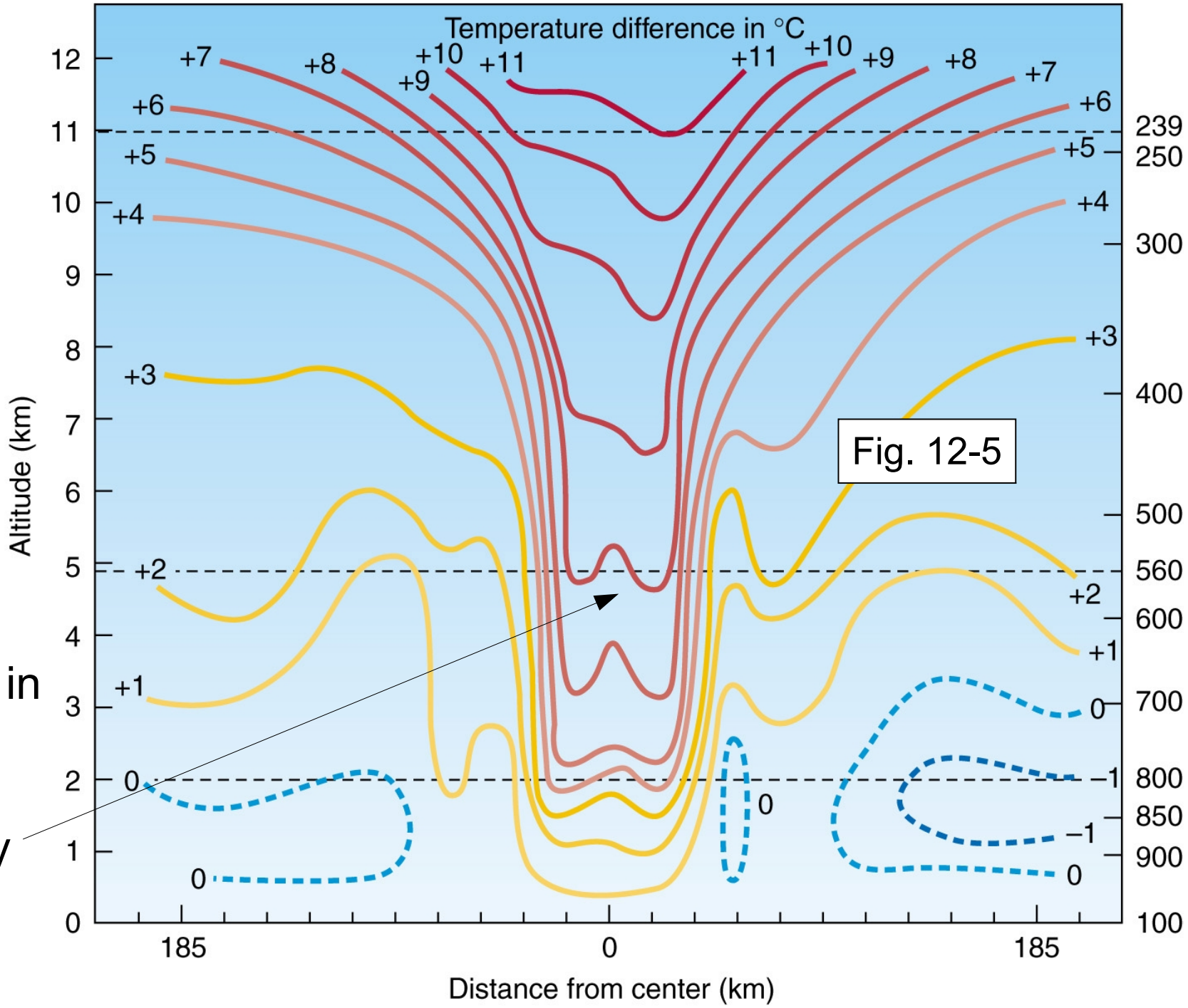
Fig. 12-4



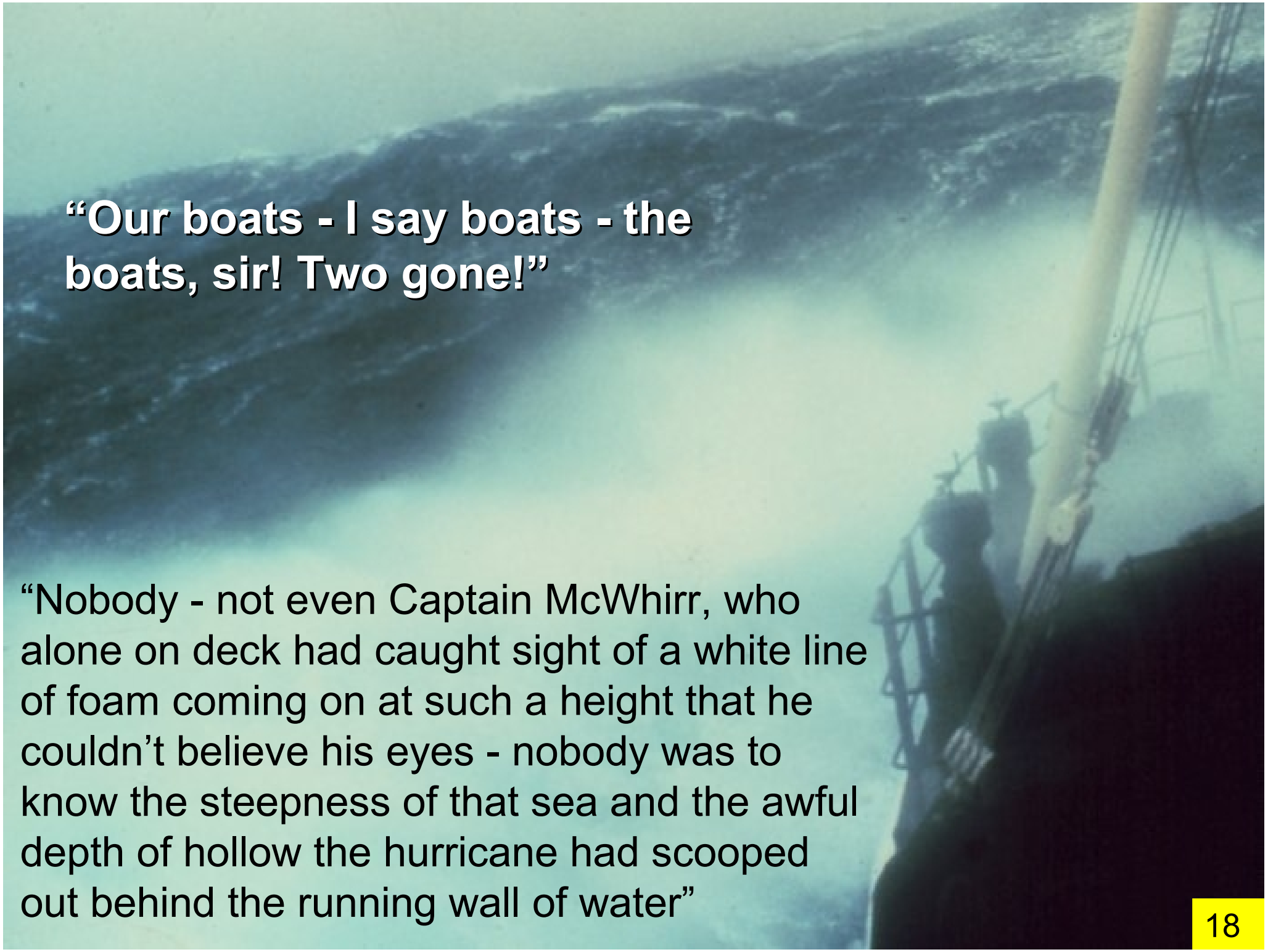


Structure/mechanism?

... warm central core



• air descending in the core warms adiabatically

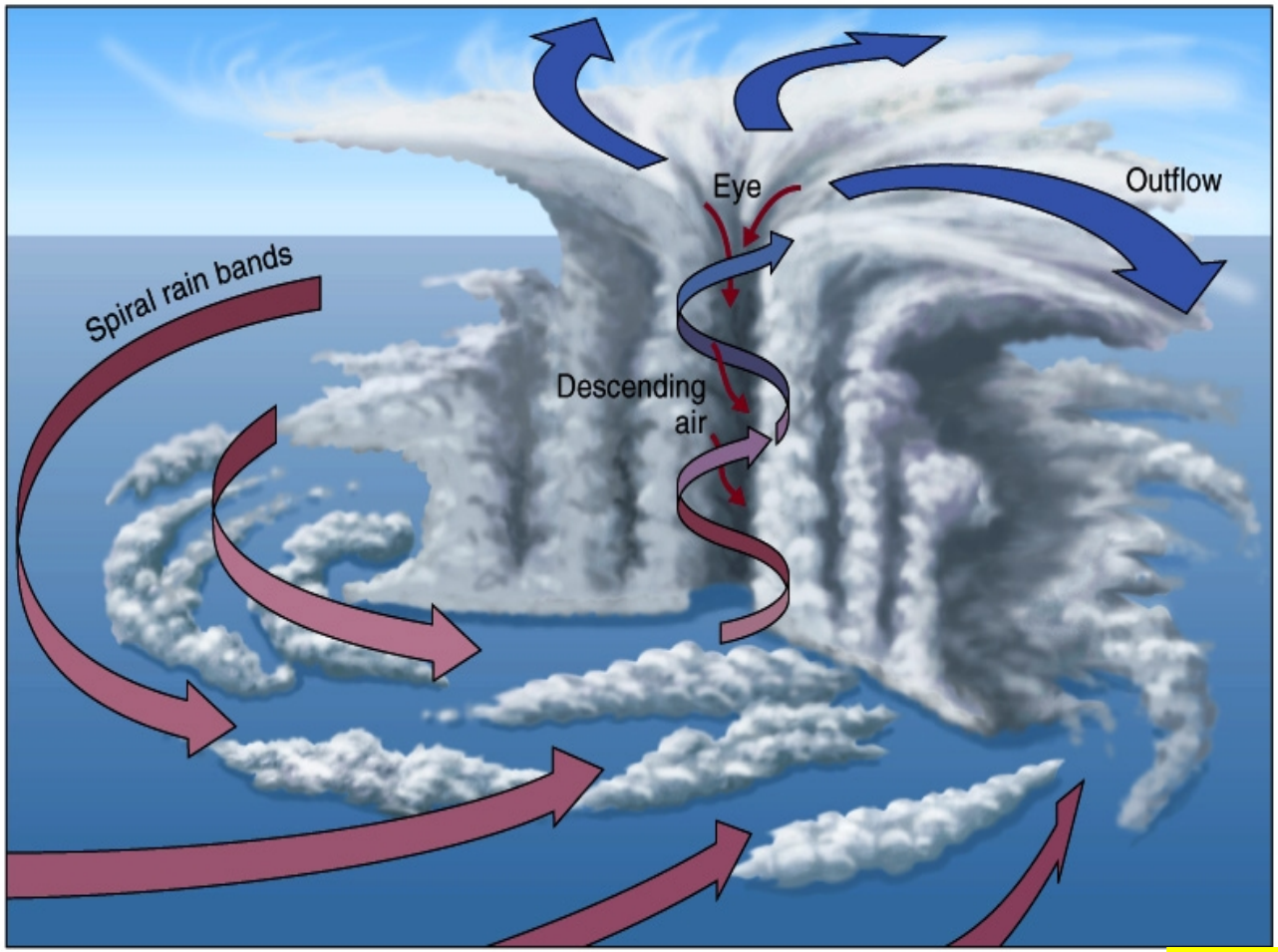


“Nobody - not even Captain McWhirr, who alone on deck had caught sight of a white line of foam coming on at such a height that he couldn’t believe his eyes - nobody was to know the steepness of that sea and the awful depth of hollow the hurricane had scooped out behind the running wall of water”

Structure/mechanism?

Warm core results in weaker dp/dz than environment… thus central pressure aloft is a ***High***… result is diverging anticyclonic winds aloft. In the **eye** of the storm (diam 20-50 km) air is sinking… less cloud. Wind is light.

"There was no wind, not a breath, except the faint currents created by the lurches of the ship. The smoke tossed out of the funnel was settling down upon her deck.
"We have done it, sir," he gasped."



“On a bright, sunshiny day, with the breeze chasing her smoke far ahead, the *Nan-Shan* came into Fu-chau”. Her arrival was at once noticed on shore, and the seamen in harbour said: "Look! Look at that steamer. Siamese -- isn't she? Just look at her!

She seemed, indeed, to have been used as a running target for the secondary batteries of a cruiser.”

Summary:

Feedback: **warm, moist** surface air, gaining latent heat and ***converging*** due to cross-isobar flow (***friction*** of rough, wind-driven ocean)→ ***lift*** → release latent heat aloft → warming air aloft (warm core of air aloft) → slow $\Delta p/\Delta z$ so that upper region of hurricane has HIGH ***p*** relative to same level outside storm → anticyclonic winds & ***divergence aloft*** → reduce central surface pressure (***L***) → increase surface ***winds*** → increase surface Q_H + Q_E and increase surface convergence

Modelling the HURRICANE at high resolution

A Multiscale Numerical Study of Hurricane Andrew (1992). Part II: Kinematics and Inner-Core Structures

Monthly Weather Review

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5) The total generation estimate for Hilda using a sea surface temperature of 28°C. is 10.3×10^{12} watts with approximately 6 percent being contributed by direct solar absorption, 17 percent by infrared cooling, and 77 percent by the release of latent heat.

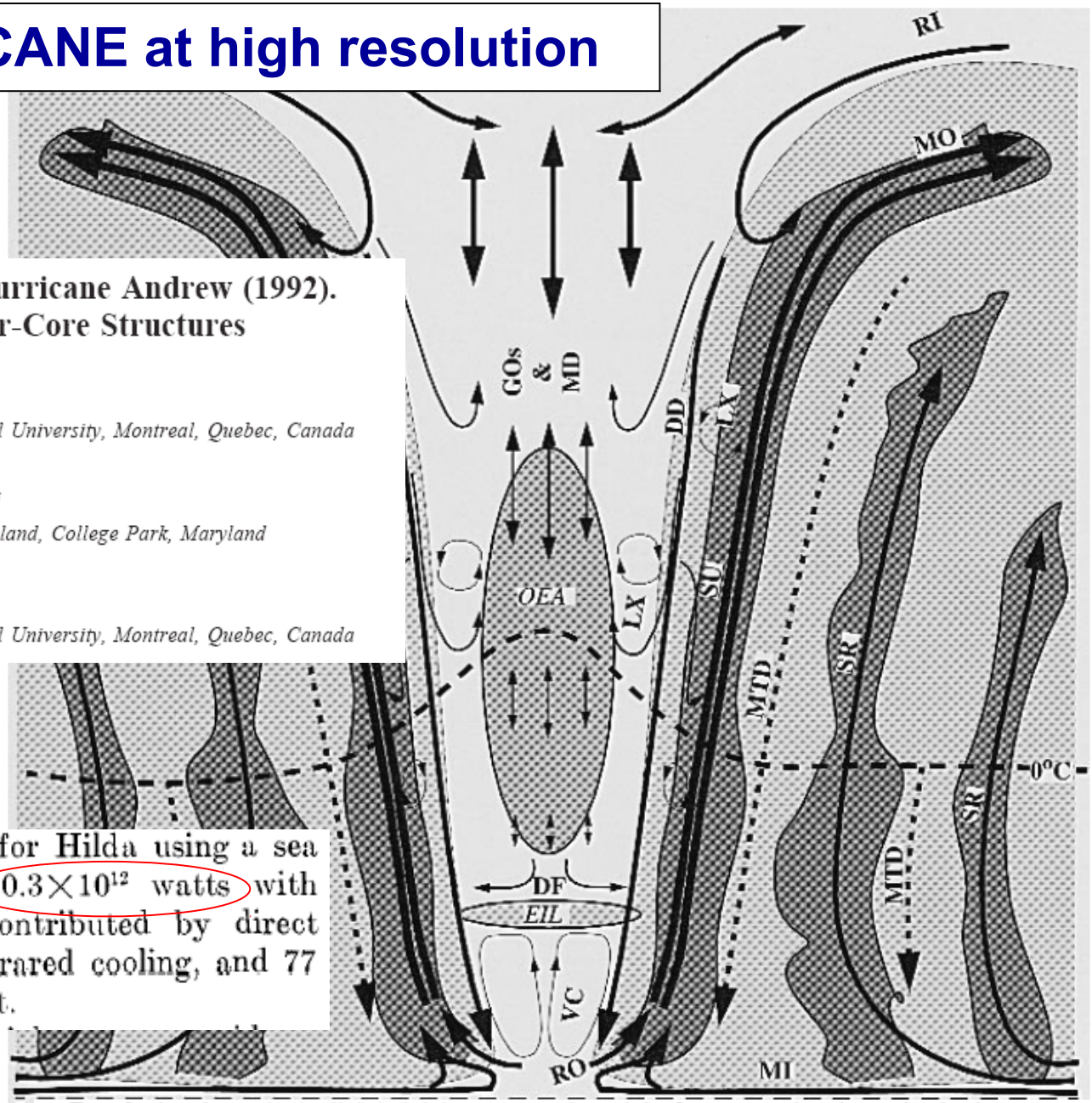
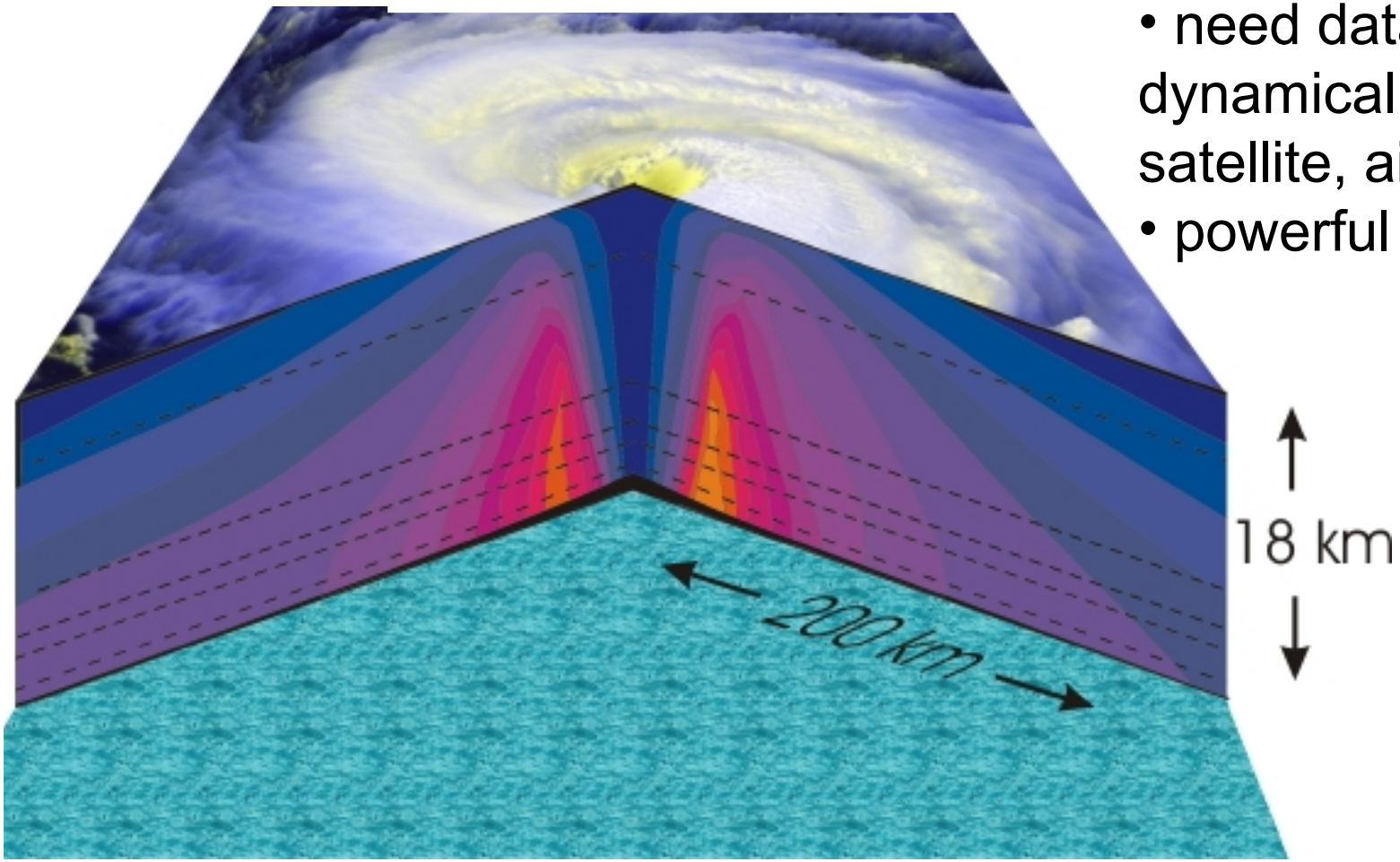


FIG. 9. A schematic (radial–height) conceptual model of a mature hurricane in the inner-core region. The light-shading areas indicate regions with cloud and precipitation. The dark regions represent the convective eyewall and spiral rainbands. The slash-hatched areas represents the eye inversion layer (EIL) and the cross-hatched regions is the occluded eye air (OEA) with low θ_e. The freezing level is marked with a dashed line. MTD and SR stand for moist downdrafts between the convective bands and spiral rainband updrafts, respectively. Refer to the text for the meaning of other symbols.

In recent years, one of the techniques used by hurricane forecasting models is to initialize with an axisymmetric vortex. The large scale flow is taken from a conventional analysis or forecast and a symmetric idealized vortex is superimposed upon this flow. Once such a well defined vortex is implanted, the fine mesh, primitive equation model can then forecast the motion of the storm.



- need data to initialize dynamical model; satellite, aircraft,…
- powerful computers

- 1992-2001 average error in 24 hr forecast of hurricane landfall position was 150 km

"ARCTIC HURRICANE"

• evolves from a *Polar Low*

• extremely cold (eg. -30°C) & dry continental air moves off the icepack onto open water (0°C). Huge sea-air heat & moisture flux Q_H + Q_E results in vigorous cumulonimbus

• deepening *Low* travels parallel to ice edge

• spiral cloud bands, about cloud-free eye

• strong surface winds close to centre result in rough ocean surface

Marine Icing Gallery
Dr. E. Lozowski
(Prof emeritus)
EAS, U. Alberta

HURRICANE versus MID-LATITUDE STORM

	Hurricane	Mid-latitude storm
Energy Source	Q_H+Q_E off very warm ocean	Grav. pot'l energy due to horiz temp gradient
Low level Rotation	cyclonic	cyclonic
Vertical motion in core	downdraft	updraft
Frontal structure	no	yes
Surface isobar pattern	tightly- packed, circular contours	weaker contour packing, usually asymmetric
Core	warm	cold
Strongest winds	surface	aloft