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CLIMATE & WEATHER

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CHAPTERS OF CLIMATE & WEATHER

Mid-latitude cyclones

Tropical cyclones

Subtropical anticyclones & associated weather conditions

Valley climates

Urban climates

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REVISION

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AIR MOVEMENT

Sun supplies Earth with heat

Generally hottest at equator, cooling toward poles

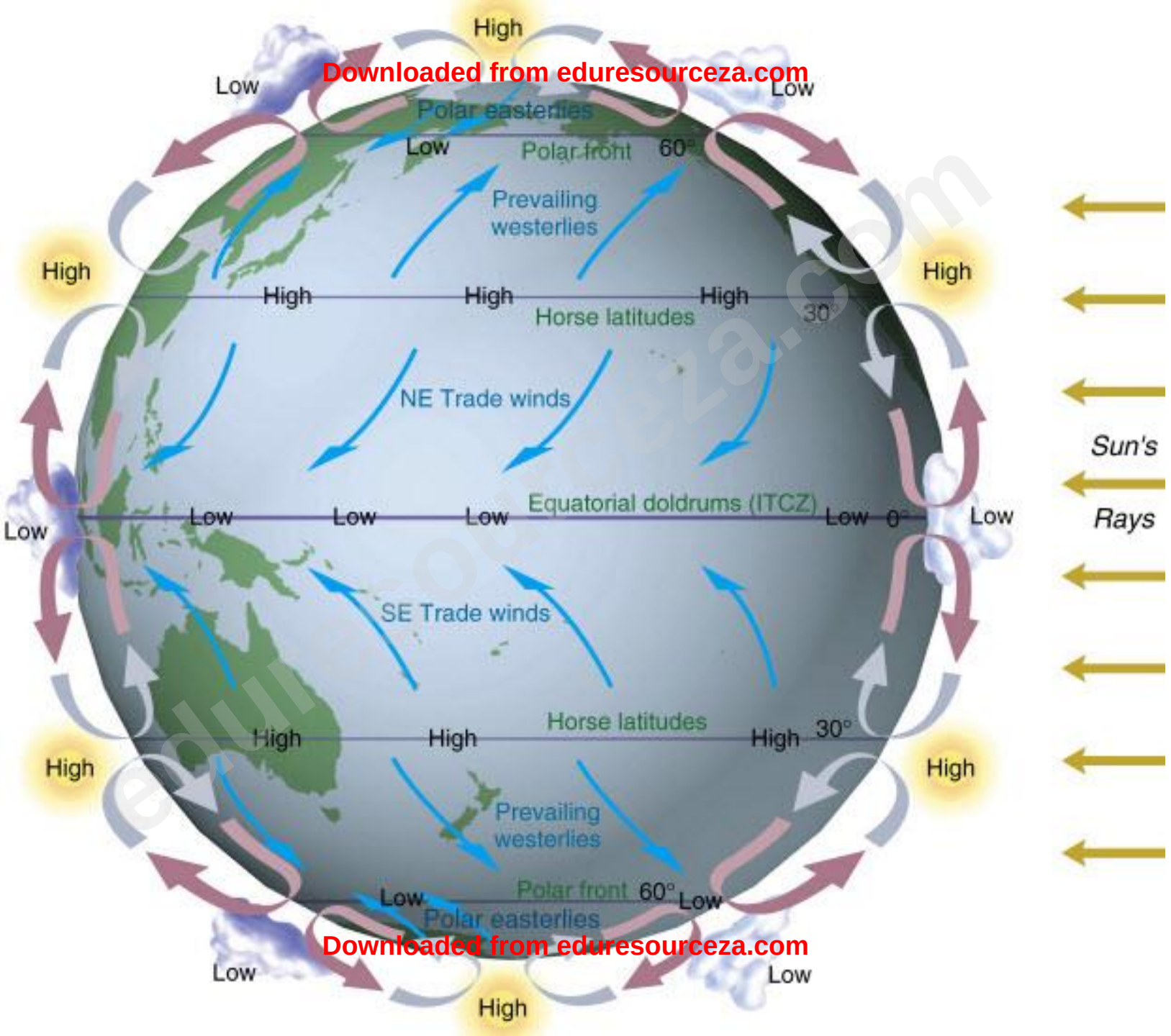
Air is able to move in all directions – always away from a high pressure (HP) toward a low pressure (LP)

Atmospheric pressure = weight of atmosphere on surface of Earth

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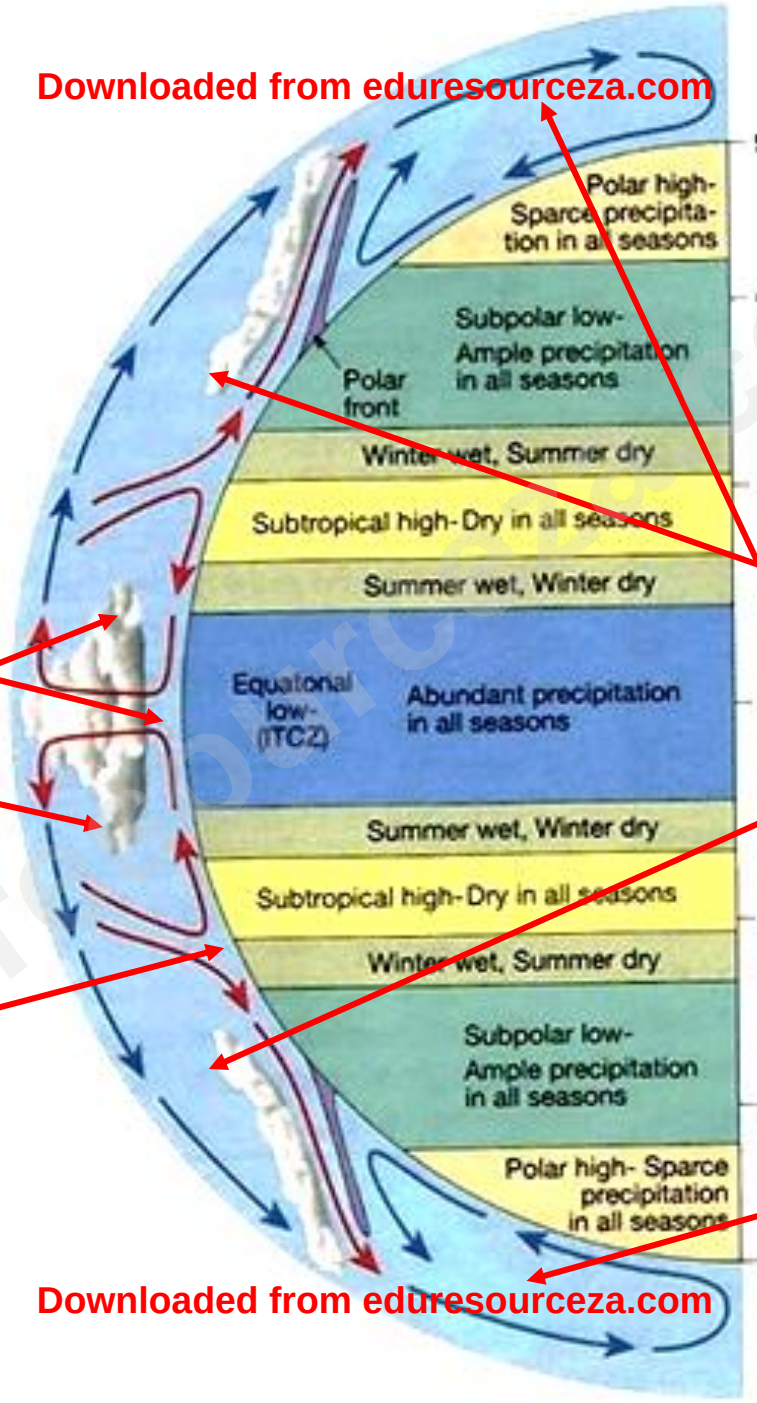
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Convergence; LP; hot air rises

Hadley/tropical cells

Divergence; HP; cool air sinks

Ferrel/midlatitude cells

Polar cells

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CIRCULATION

Primary – circulation on a global scale; horizontal & vertical movement on air

Secondary – within primary circulations on smaller scale e.g. cyclones

Tertiary – most localized e.g. valley & mountain winds

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PLANETARY WINDS

Pressure gradient force = air moving from a high pressure to a low pressure; steeper gradient = stronger wind

Planetary winds = winds that blow all year round over large expanses of the Earth's surface

Speed of rotation varies from 0 kph at poles to 1670 kph at equator

Coriolis force = force acting upon air masses due to the rotation (west to east) of the Earth:

- Does not occur within 5° of the equator
- Is dependent on the strength of the wind
- Deflects winds

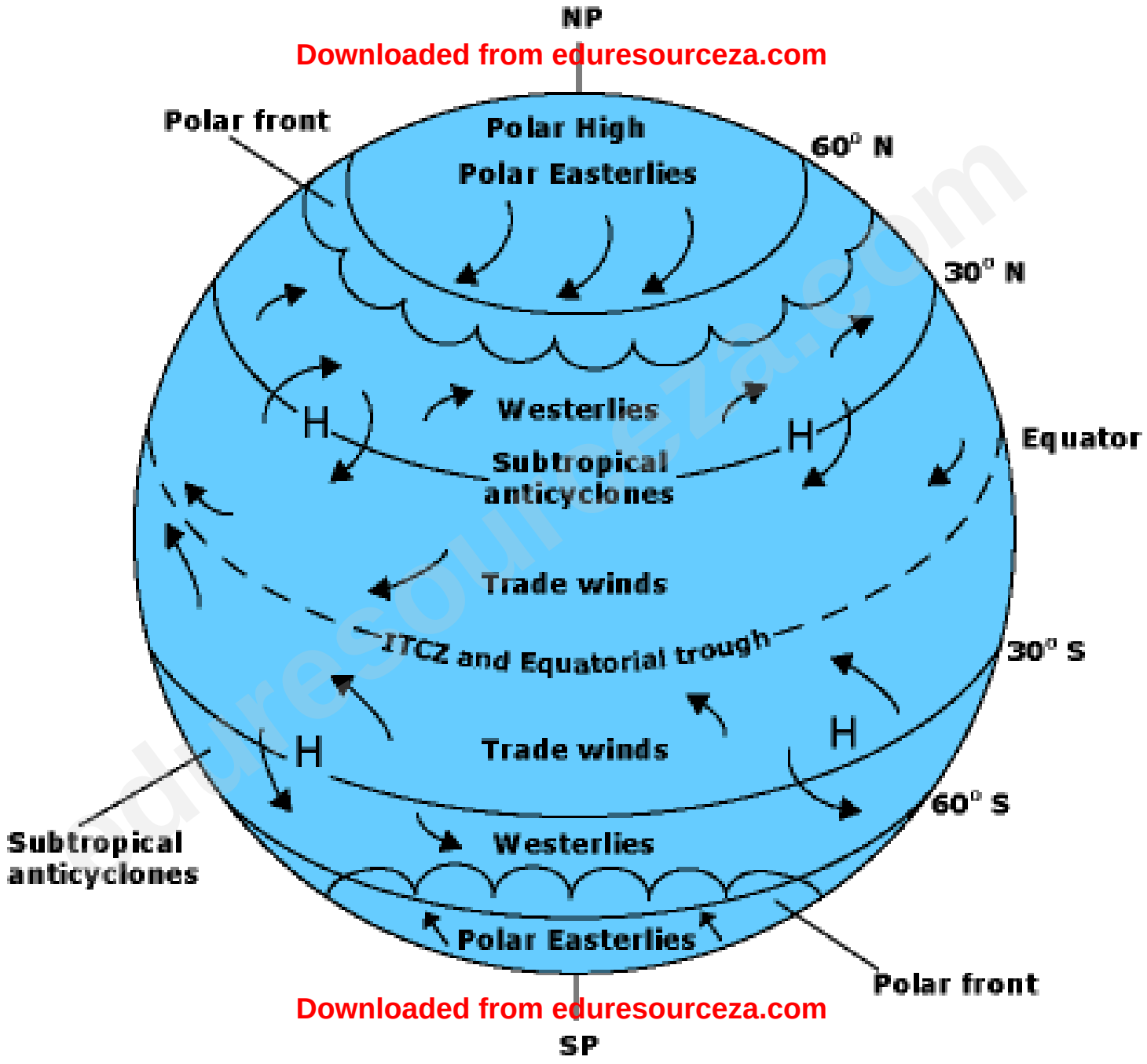
Ferrel's law – winds are deflected to their left in SH & to their right in NH

Differential heating of land & water:

- Land heats & cools quicker
- Quick heating creates LP over land; HP created over oceans

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TRI-CELLULAR MODEL

Consist of:

- tropical/Hadley cell
- mid-latitude/Ferrel cell
- polar cell

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TROPICAL OR HADLEY CELL

Where do they occur?

Rapid uplift due to intense heat resulting in equatorial low

Large cumulonimbus clouds – thunderstorms common

Air diverges at +- 10 km

Subtropical highs (anticyclones) form where air descends – result in warmer, dryer weather

Intertropical Convergence Zone (ITCZ) = zone where tropical easterlies converge (often thunderstorms)

Isobars = lines on a map joining all areas of equal pressure (hPa); average atmospheric pressure = 1000 hPa

HP: winds blow out of it; anticlockwise rotation in SH (vice versa in NH); pressure decreases going out from center

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MID-LATITUDE & POLAR CELLS

Polar front = imaginary zone where polar easterlies (cold) meet subtropical westerlies (warm)

Front = where 2 air masses of different temps meet

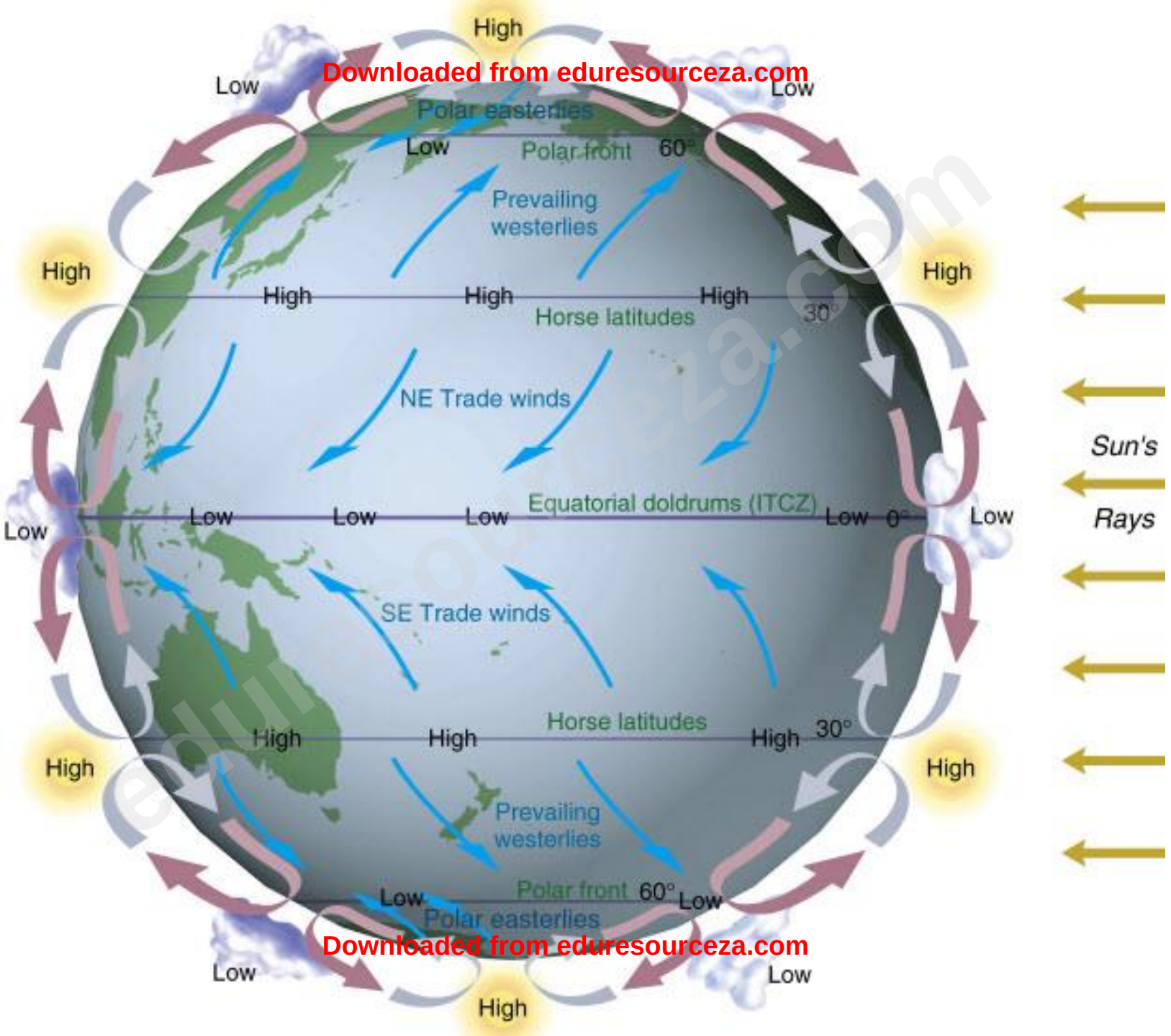
Warm air is pushed up & cold air wedges in beneath

LP: cyclone; clockwise rotation in SH; pressure increases with distance from center

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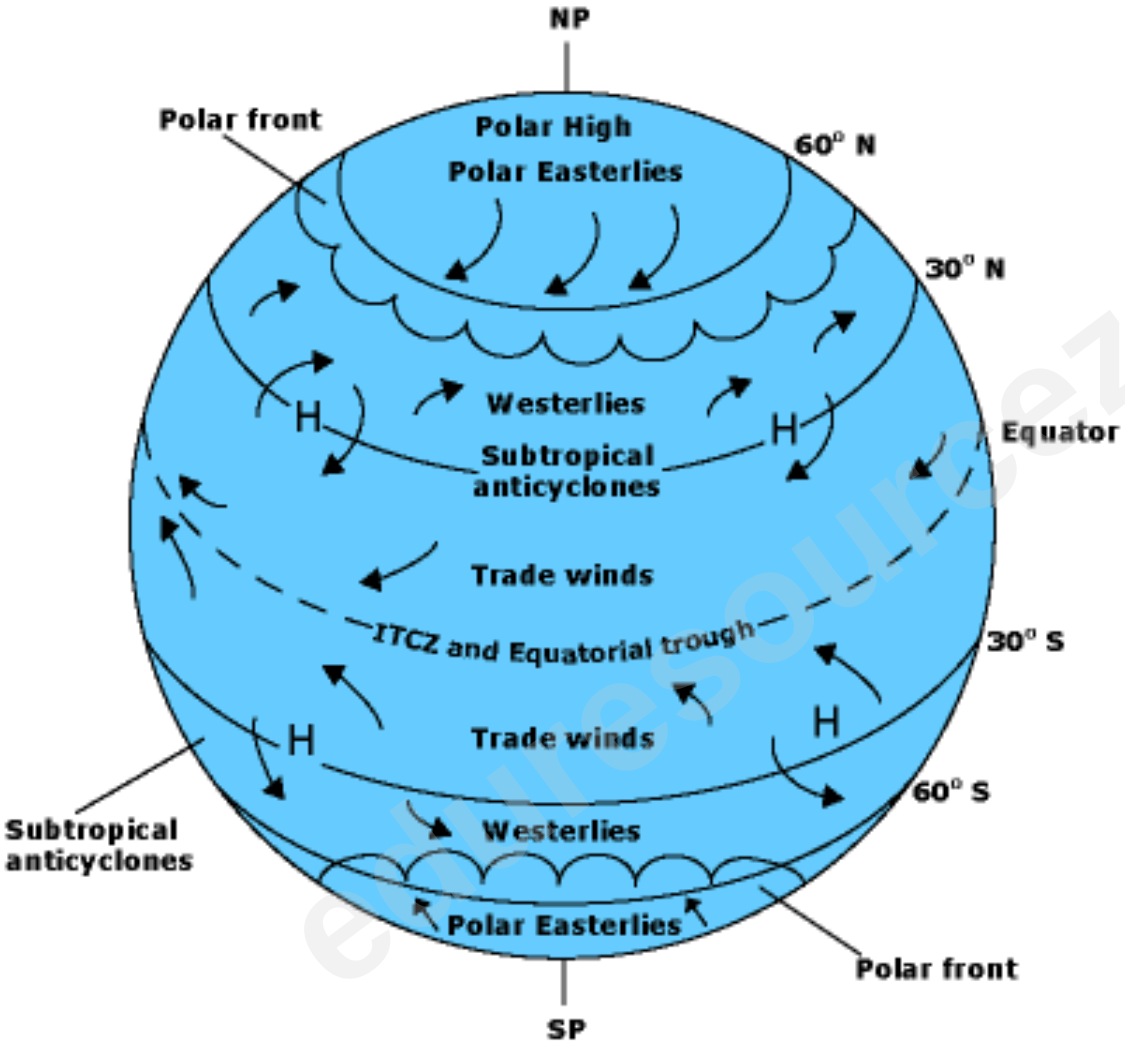
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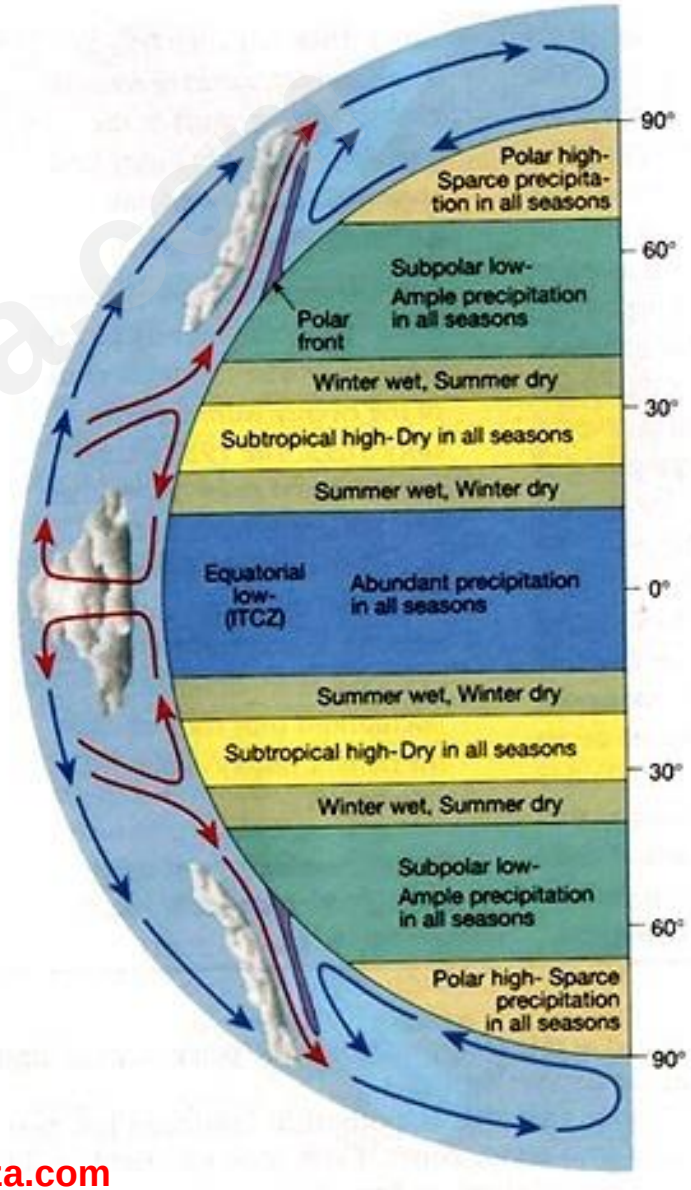
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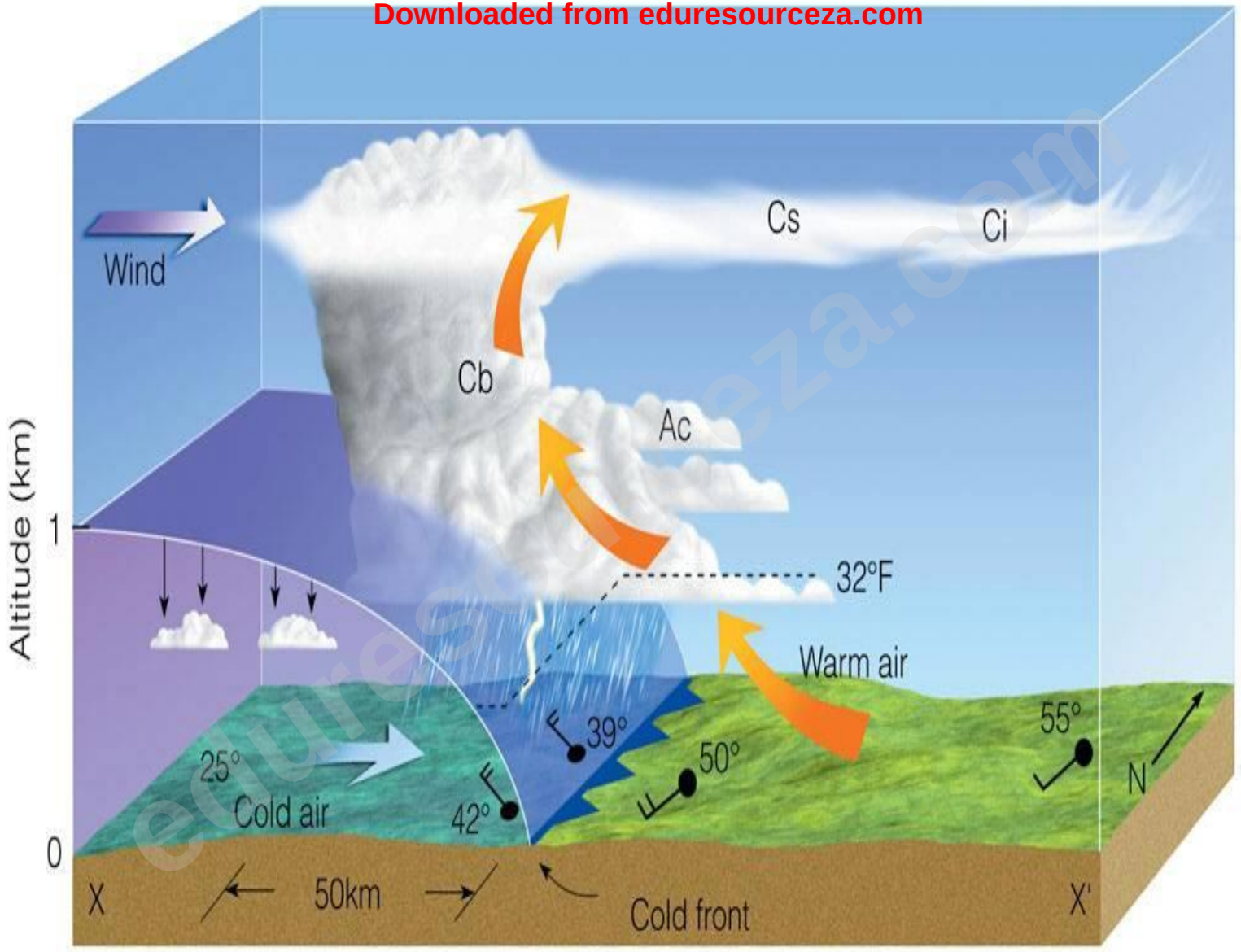
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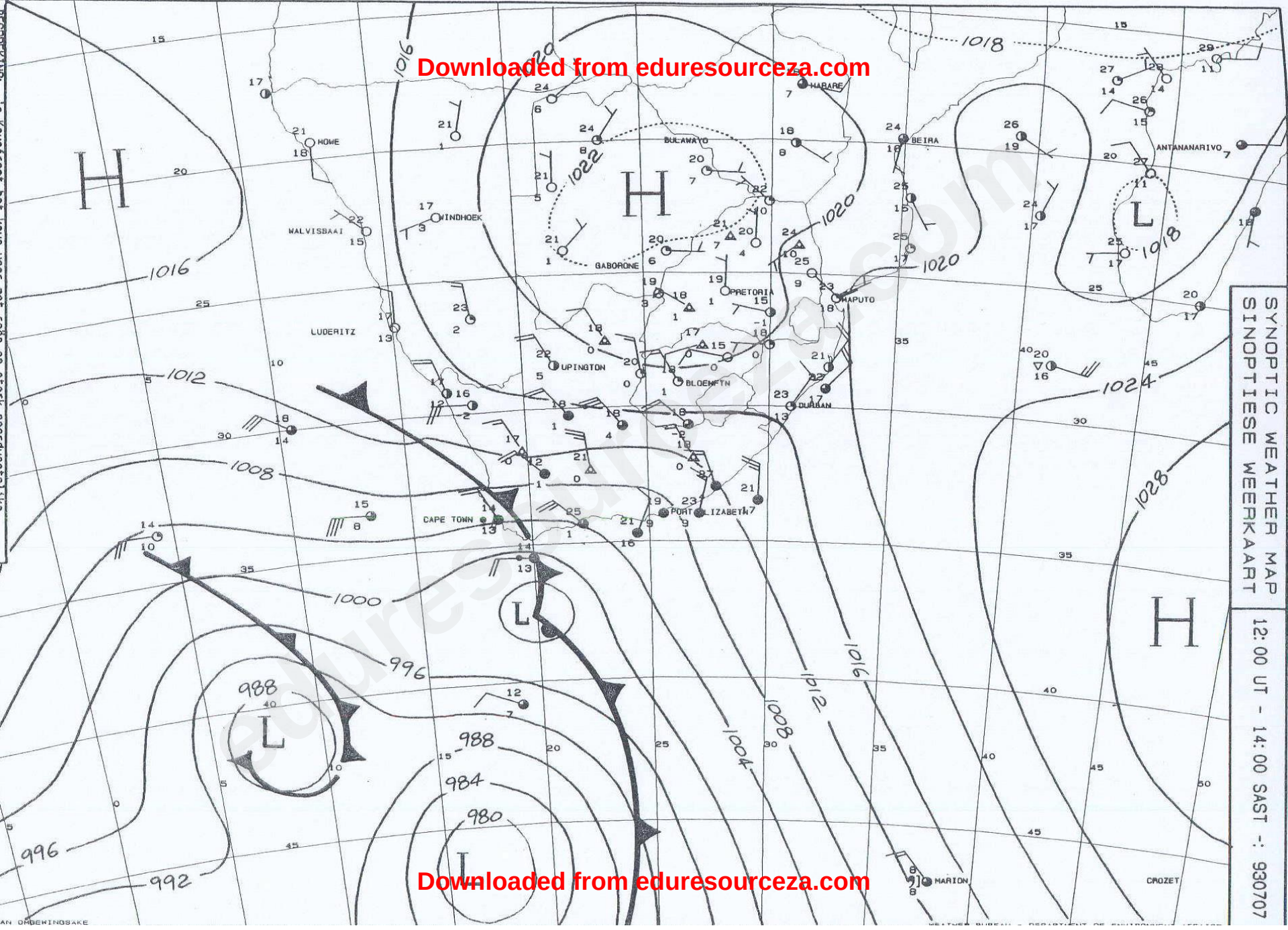
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WHAT ARE CYCLONES?

= a cell or area of LP

2 types:

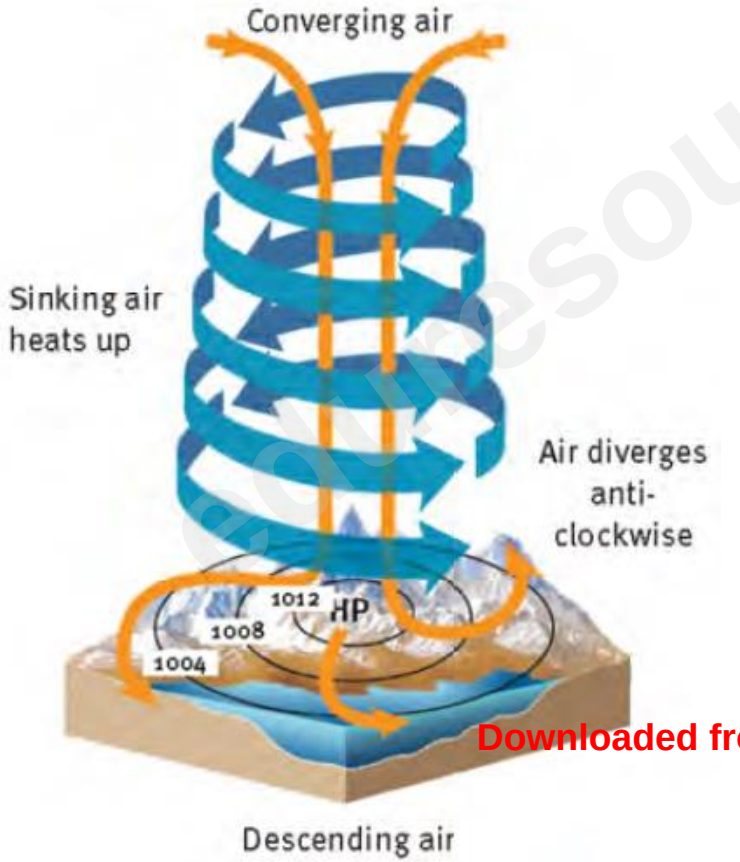
- Tropical – develop over warm oceans btwn tropics (sometimes develop as subtropical cyclones then move to equator & become tropical cyclones)
- Mid-latitude/frontal depressions/temperate cyclones – develop in middle or temperate latitudes (35°- 70°)

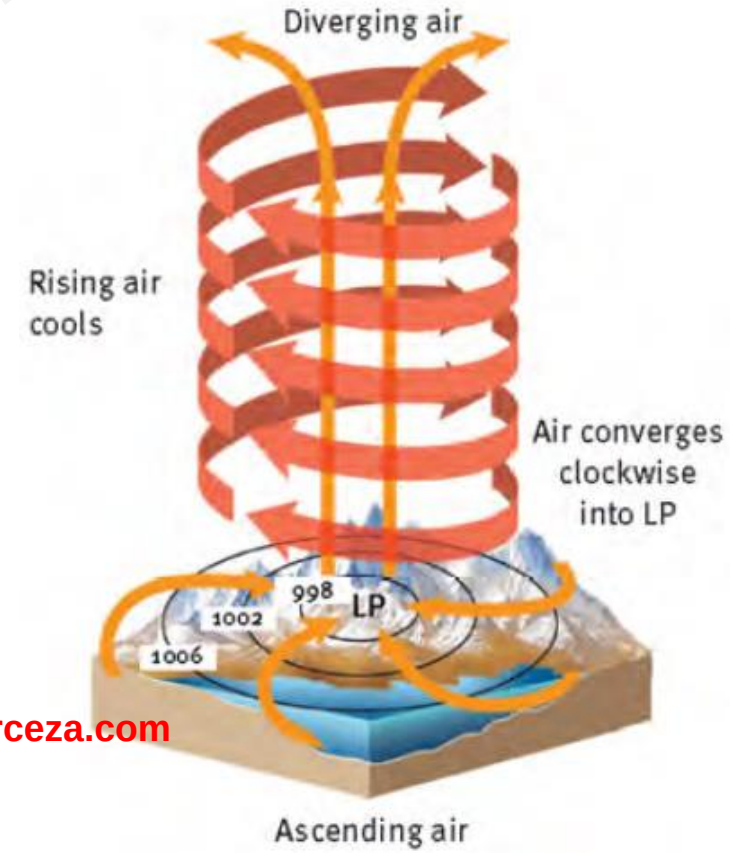
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High pressure	Low pressure
Air sinking anti-clockwise.	Air rising clockwise.
At Earth's surface air moves outwards to areas of lower pressure – outward-blowing surface winds.	At Earth's surface air moves inwards from areas of higher pressure – inward-blowing surface winds.
As it descends, cool air is heated by compression.	As it rises, warm is cooled by expansion.
Associated with calm, fair and dry/hot weather.	Associated with cloudy, rainy and stormy weather.

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MID-LATITUDE CYCLONES

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Cyclogenesis = stages of development of a mid-latitude cyclone

Initial stage

- 50° S; wave forms in polar front due to jet streams high in atmosphere; or mountain range or shape of coastline; wave causes isobars to form a circular pattern

Mature stage

- Air blows clockwise into LP; polar front now forms cold front & warm front; cold front = cold air moving toward warm air & vice versa; so warm sector & cold sector

Occluded stage

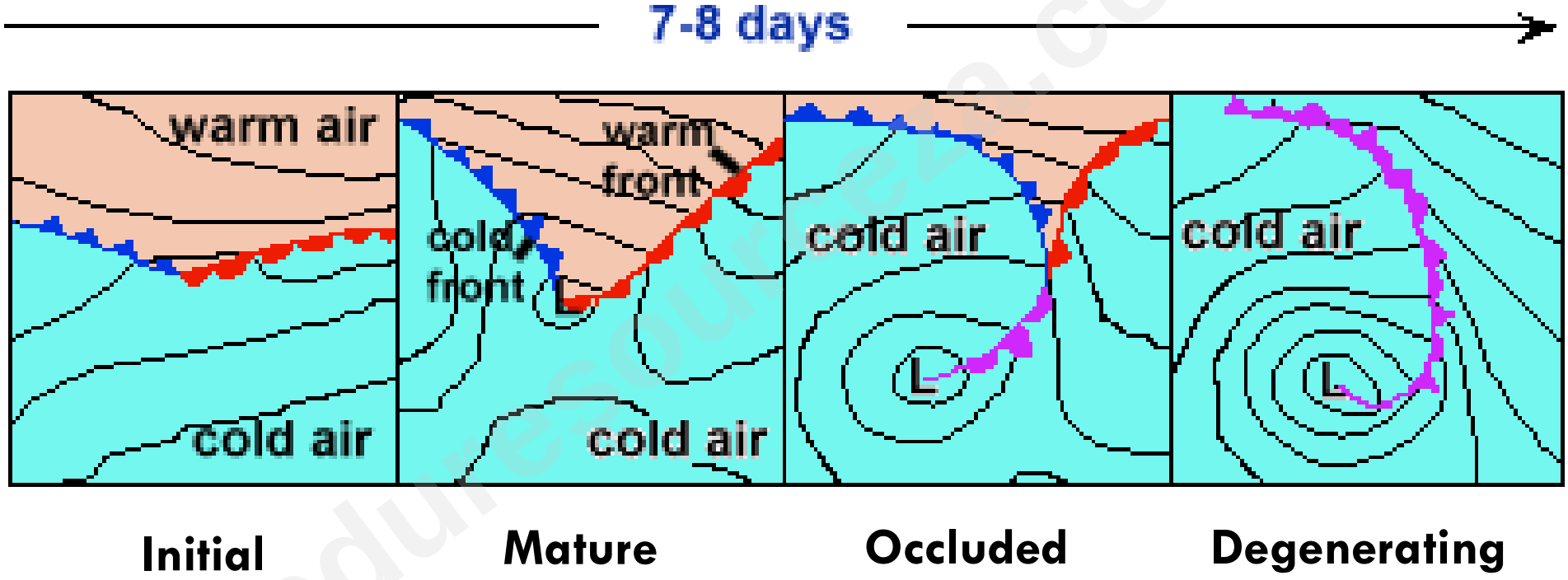
- Warm sector lighter so rises as cold sector wedges beneath; warm sector narrows as cold front overtakes warm front; eventually only cold air is on the ground

Degeneration/dissipating stage

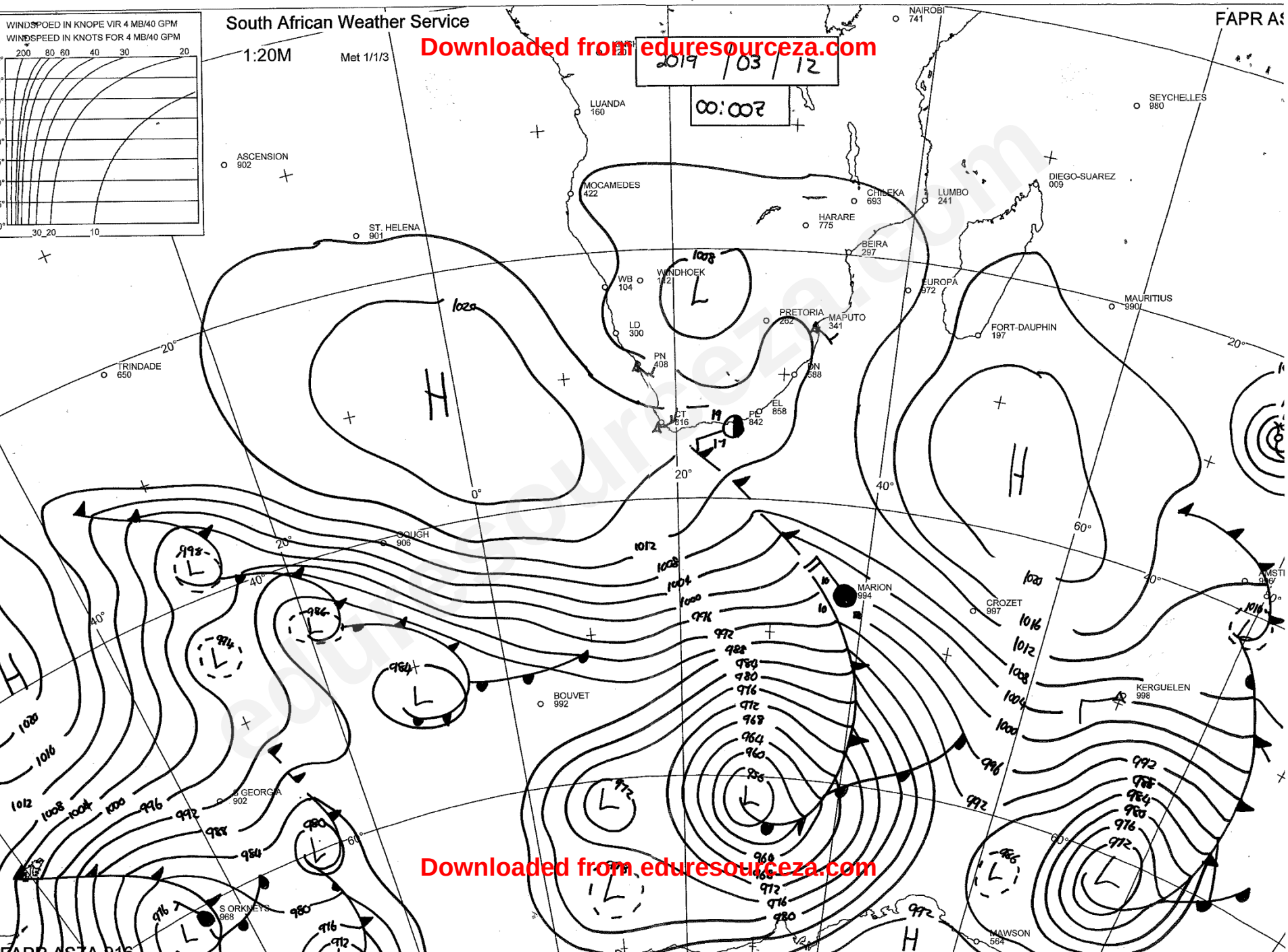
- Ends up as a gust of cold air on ground level; LP cell disappears & isobars even out

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SPOT TEST

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DRAW & LABEL THE FOLLOWING ON YOUR DIAGRAM

Important lines of latitude

Tropical easterlies

Subtropical westerlies

Polar easterlies

Global pressure belts

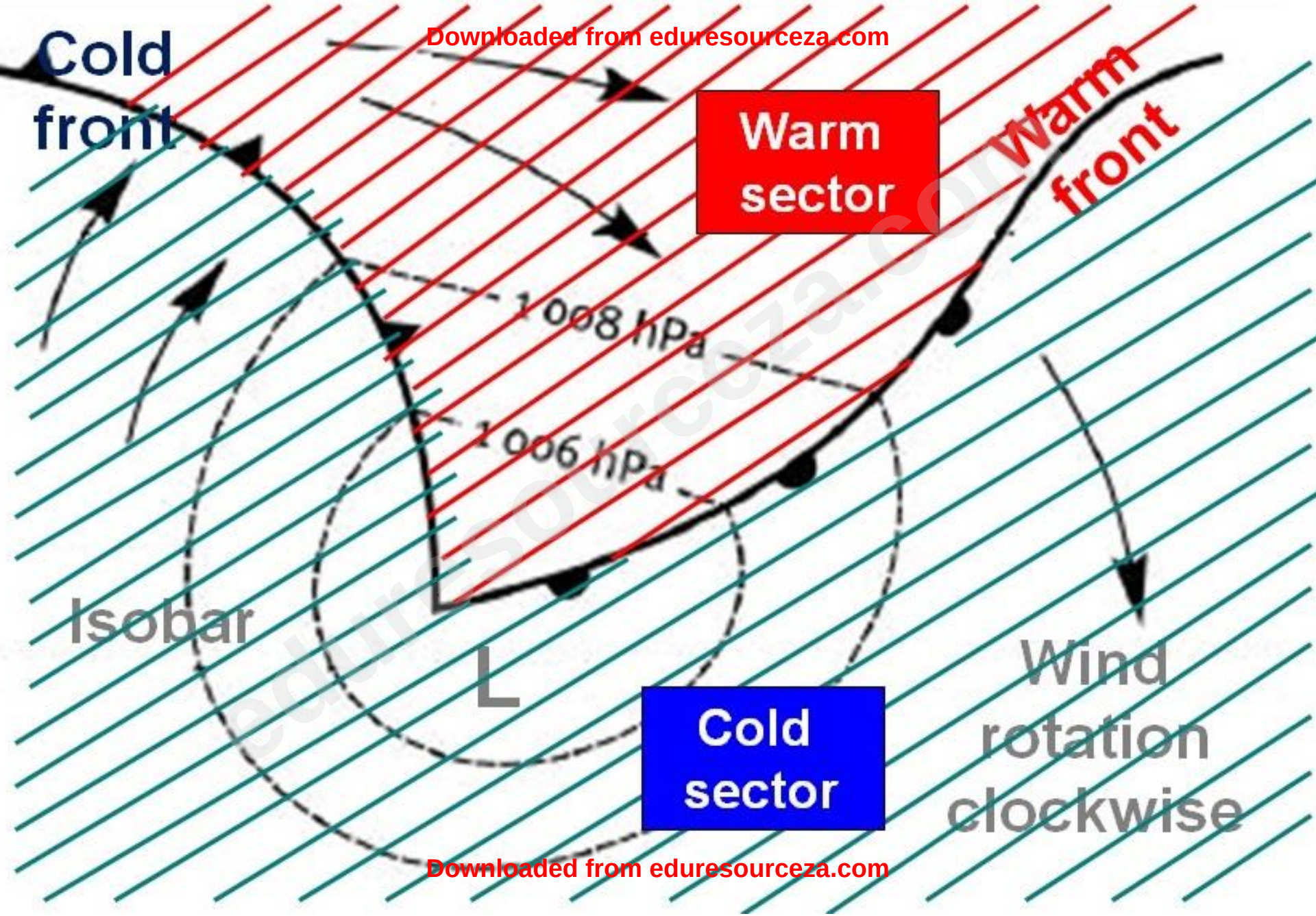
Hadley, Ferrel & Polar cells

Polar front

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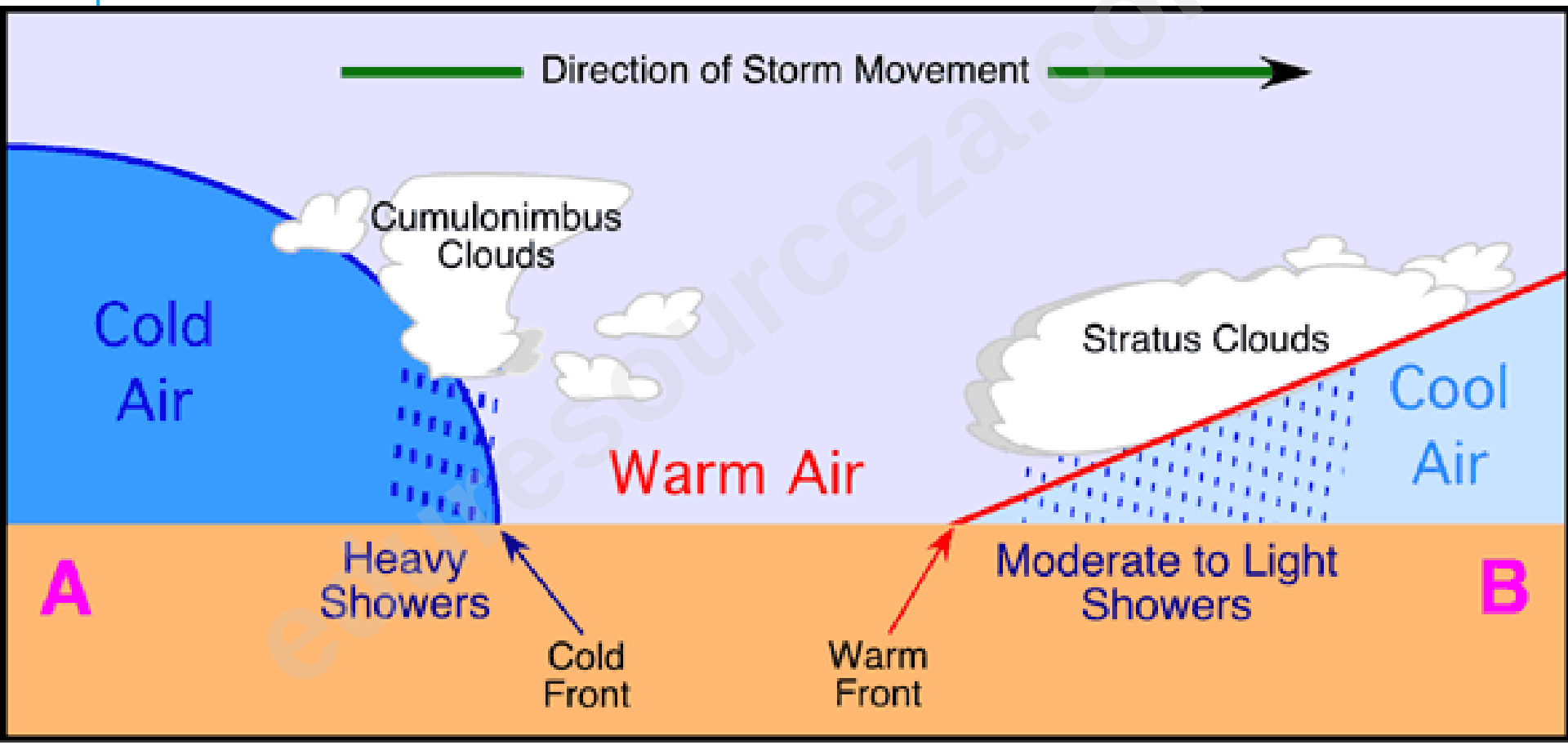
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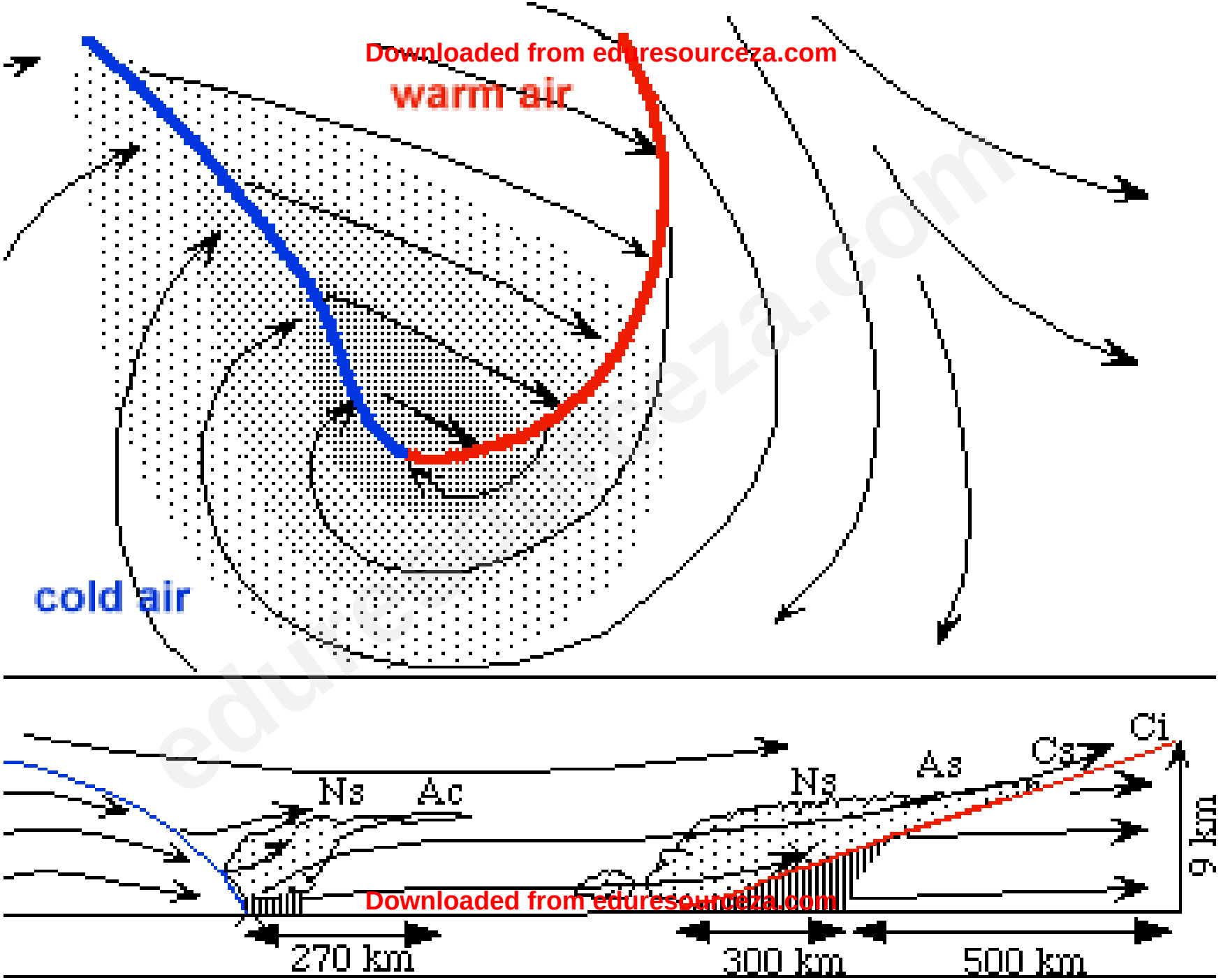
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CS MID LATITUDE CYCLONE



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COLD FRONT CONDITIONS FROM ITS APPROACH

Temp decreases

Pressure decreases on approach then increases as cold sector arrives (pressure increases with a decrease in temp)

Humidity decreases

Moist, warm, unstable air is lifted

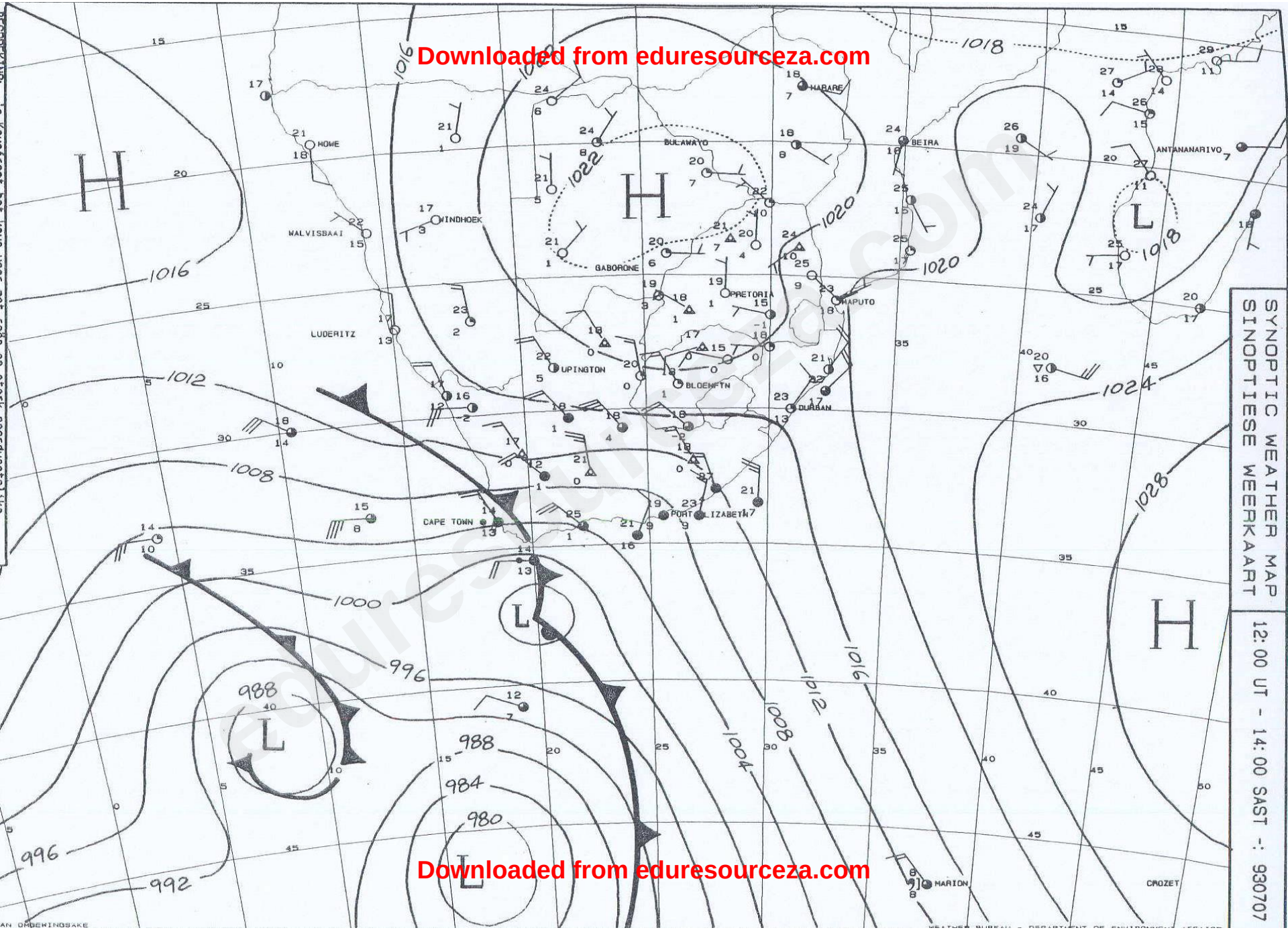
Cumulonimbus clouds due to intense uplift (thunderstorms can occur)

Wind changes (it 'backs' anticlockwise in SH & 'veers' clockwise in NH)

Rainfall!

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WARM FRONT CONDITIONS FROM ITS APPROACH

Temp increases

Pressure decreases on arrival of warm sector

Humidity increases

Warm, moist, unstable air is lifted up the warm front

Clouds not cumulonimbus as gradient is more gentle – cirrus → altostratus → nimbostratus resulting in soft, soaking rain

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OCCLUDED FRONT CONDITIONS

= when cold front catches warm front

Cold front occlusion

Warm front occlusion

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COLD FRONT OCCLUSION

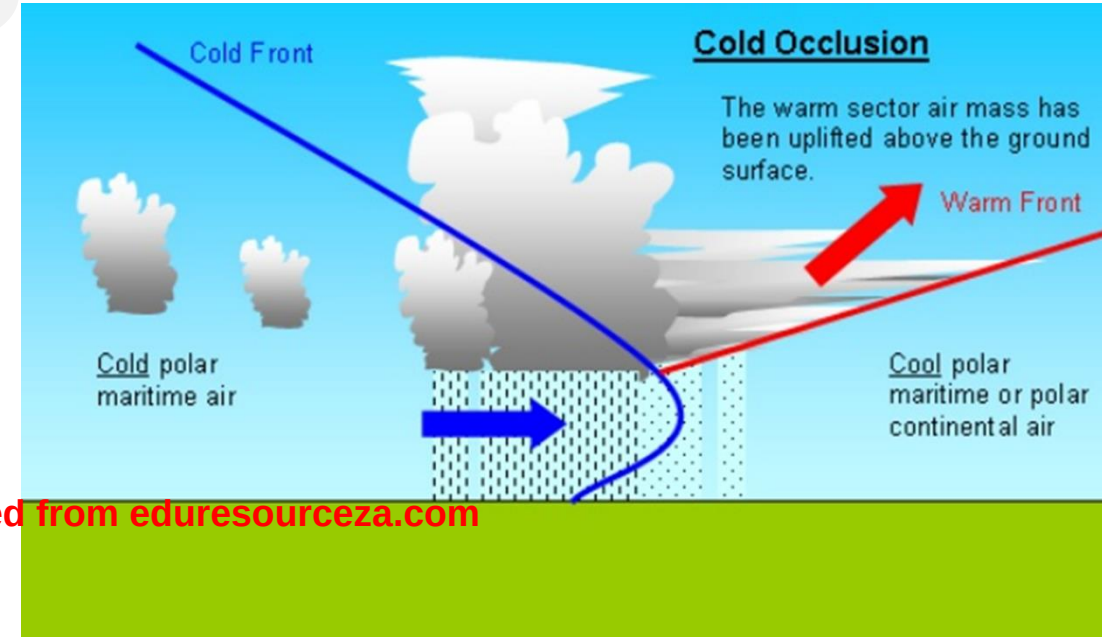
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Air ahead of front is cool

Cold front lifts this air as well as warm air

Air cools & condenses resulting in nimbostratus cloud

Rain falls – weather similar to a cold front



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WARM FRONT OCCLUSION

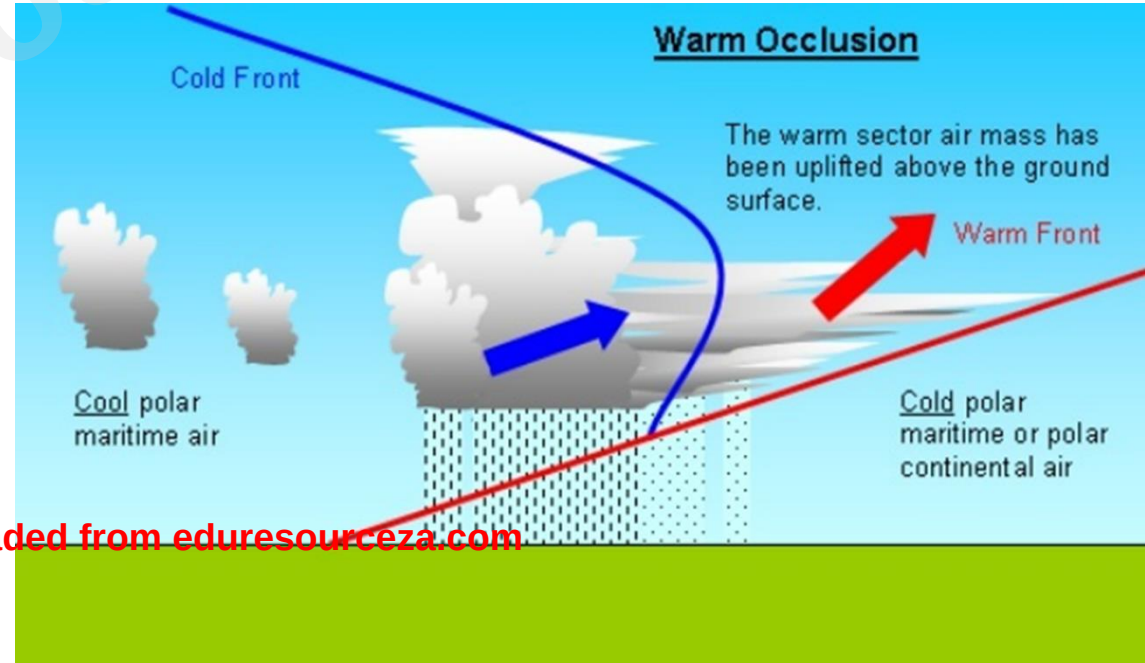
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Air ahead of cold front is colder than air behind

Cool air & warm air in warm sector rise up the occluded front

Nimbostratus cloud results, rain falls

Similar conditions to a warm front



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SA MID-LATITUDE CYCLONES

Southern tip of Africa is 34-35°S

Cold fronts mainly affect southern Cape

Warm fronts are bent southwards away from SA

Cold fronts reach southern Cape more often in winter when pressure belts & wind systems move slightly north (winter rain)

West to East

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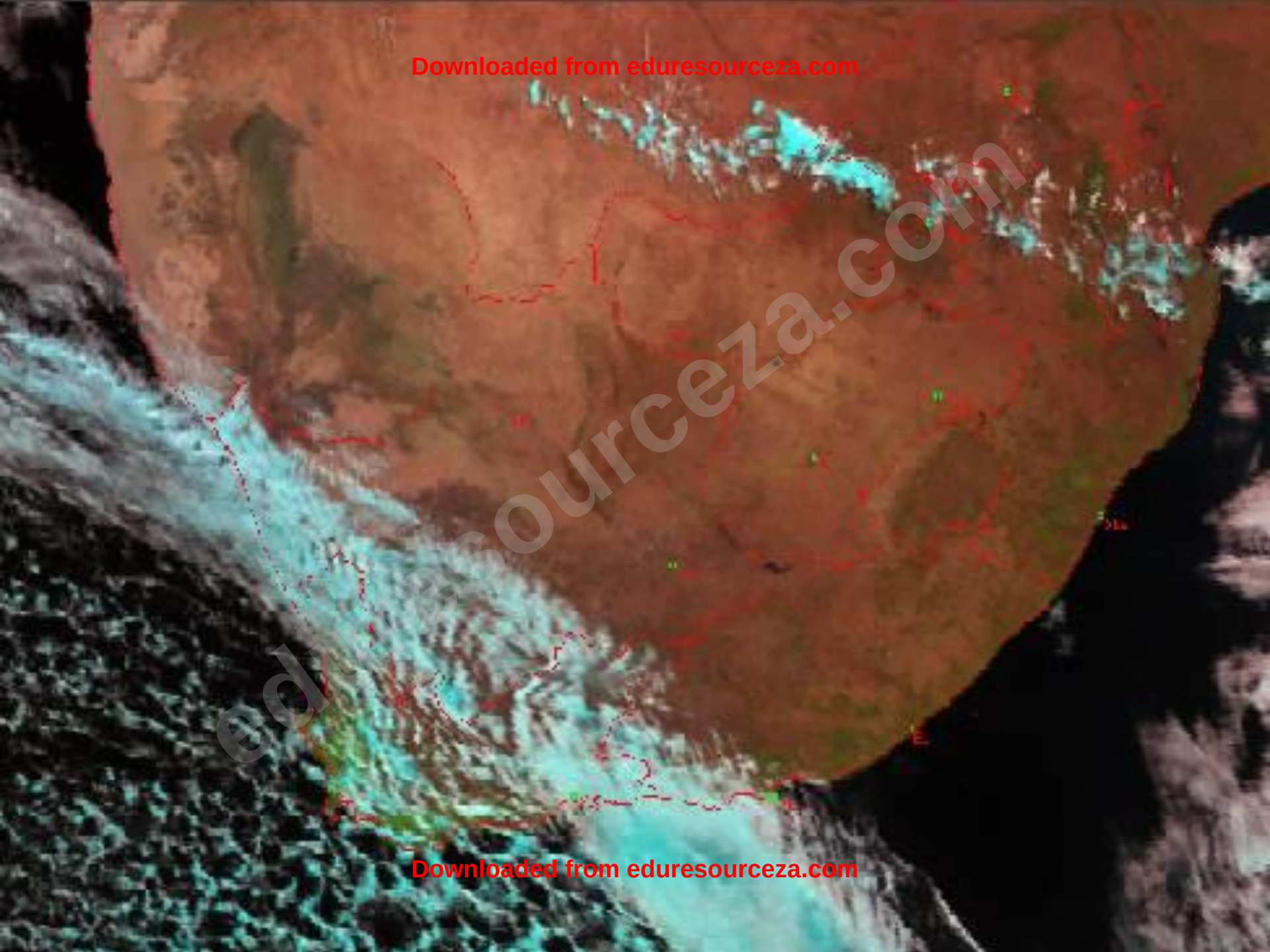
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SYNOPTIC WEATHER MAPS & SATELLITE PHOTOS

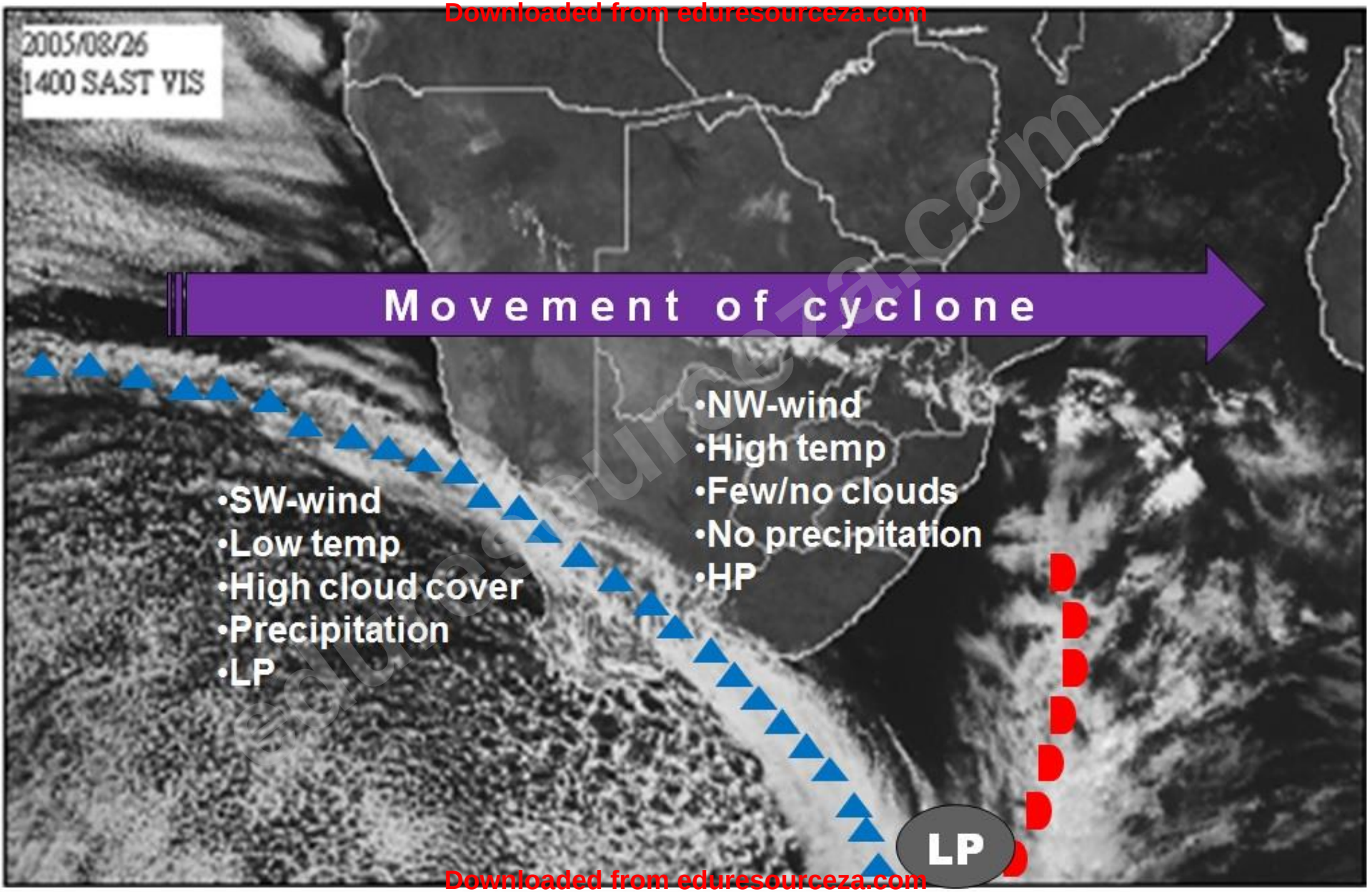
Satellite images show detail of cloud cover

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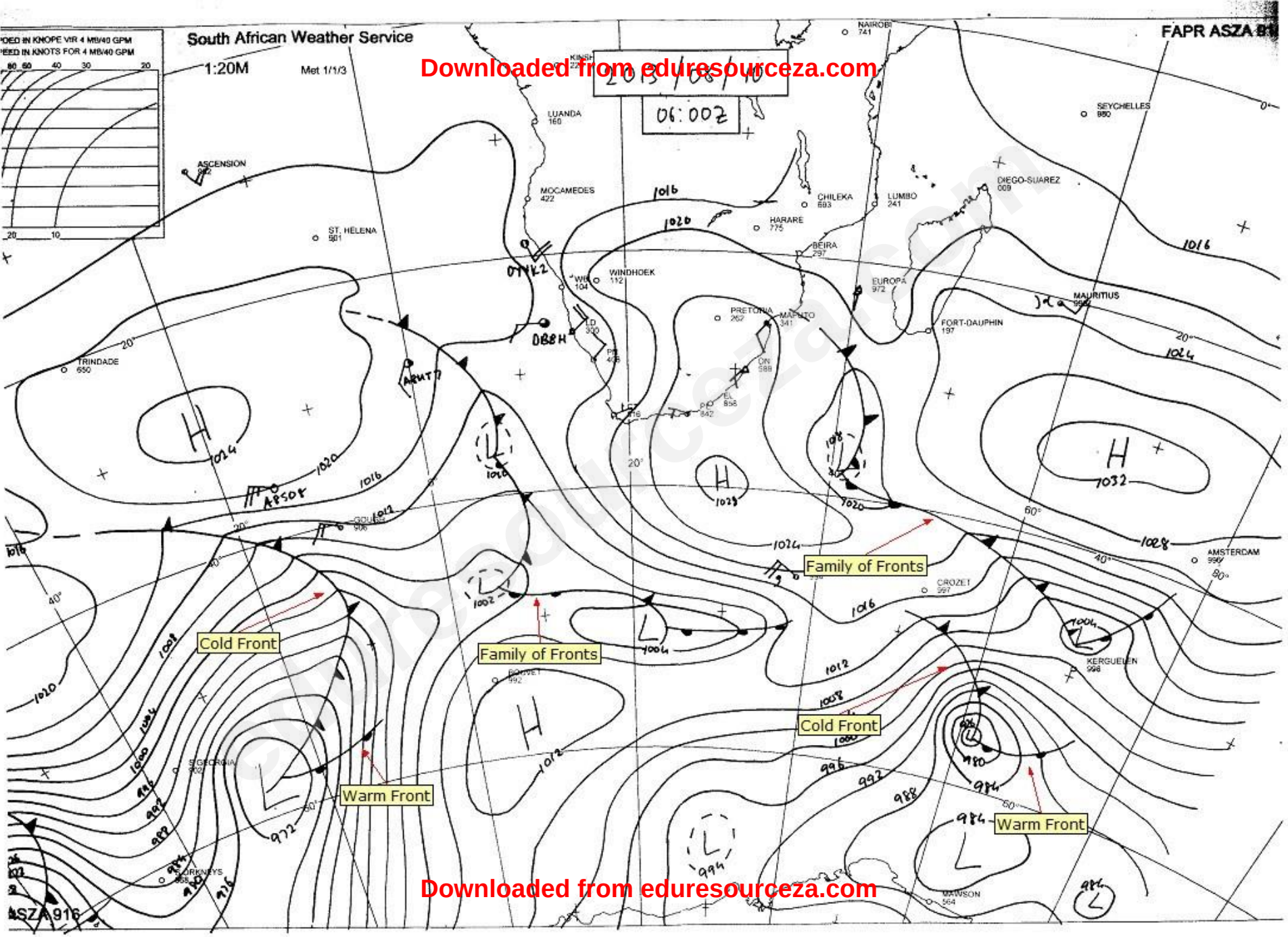
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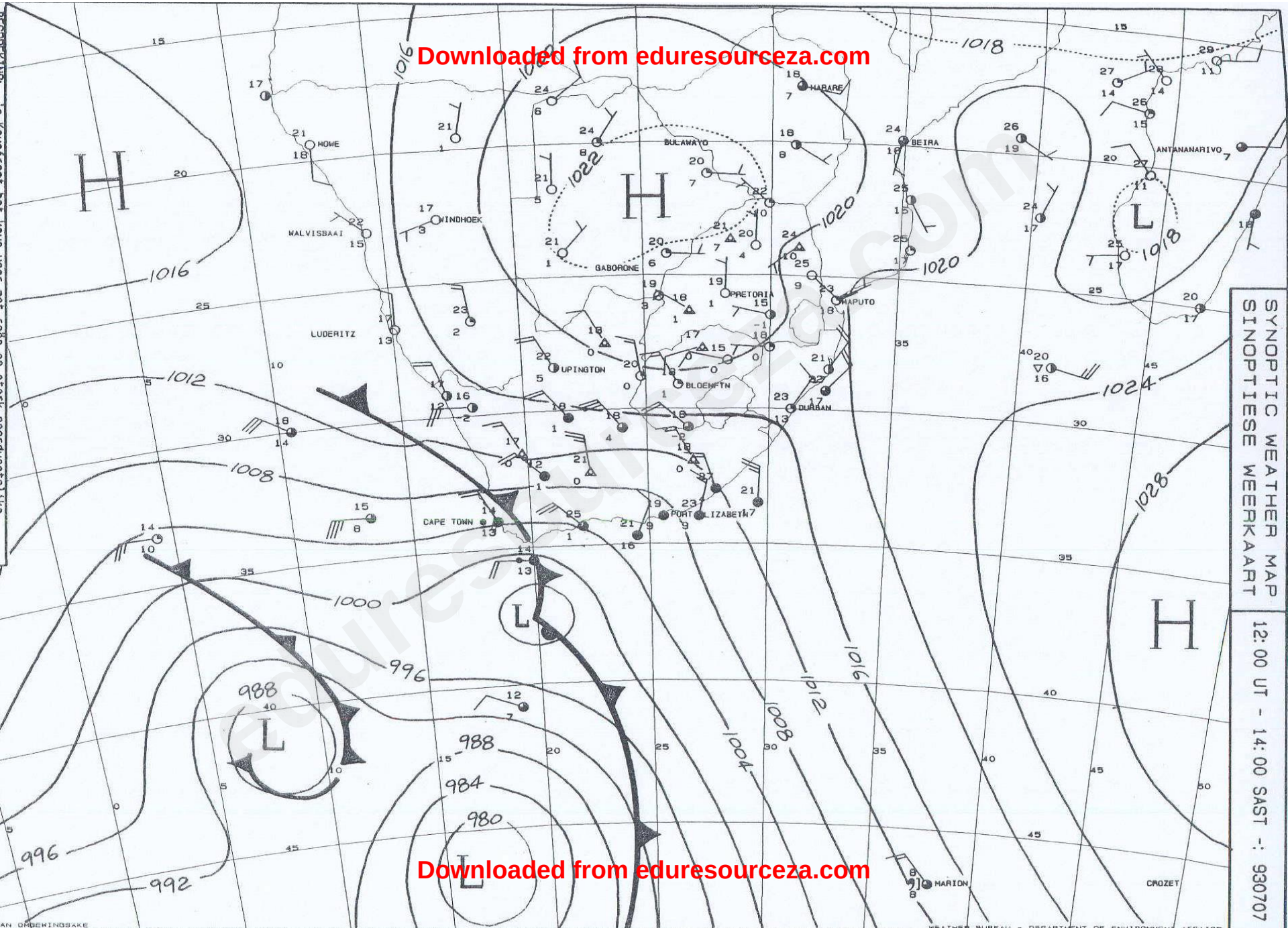
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South African Weather Service
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2013/08/10
01:00Z
Family of Fronts
Cold Front
Family of Fronts
Cold Front
Warm Front
Warm Front
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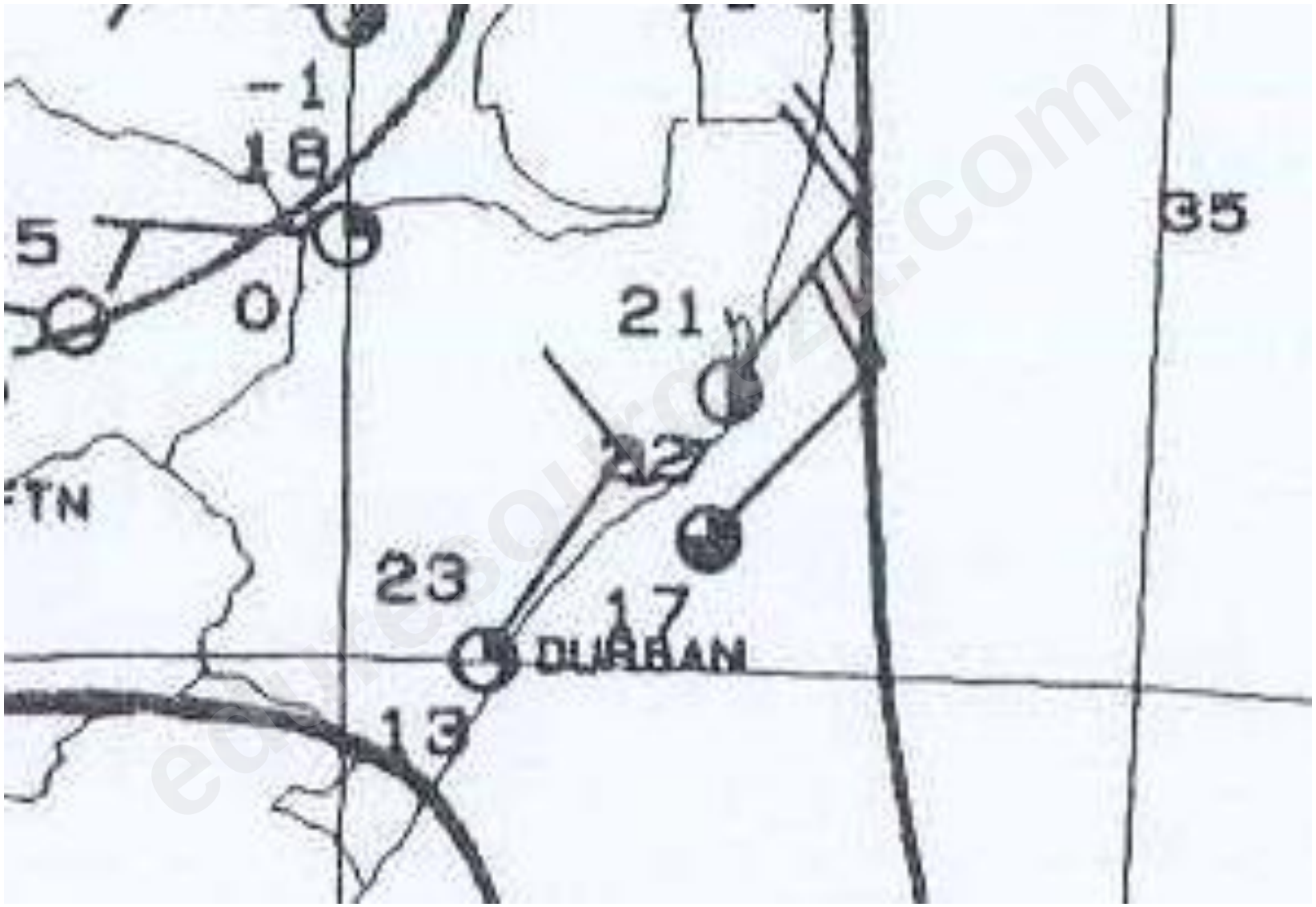
BEAUFORT SCALE

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Force		Anemometer reading mph	kmh	m/s	knts	Description	
0		0-1	<1	<0.3	0-1	Calm; smoke rises vertically.	Calm
1		1-3	1-5	0.3-1.5	1-3	Direction of wind shown by smoke drift, but not by wind vane.	Light air
2		4-7	6-11	1.5-3.3	4-6	Wind felt on face; leaves rustle; ordinary vanes moved.	Light Breeze
3		8-12	12-19	3.3-5.5	7-10	Leaves and small twigs in constant motion; wind extends light flag.	Gentle Breeze
4		13-18	20-28	5.5-8.0	11-16	Raises dust and loose paper; small branches are moved.	Moderate Breeze
5		19-24	29-38	8.0-10.8	17-21	Small trees in leaf begin to sway; crested wavelets form on inland waters.	Fresh Breeze
6		25-31	39-49	10.8-13.9	22-27	Large branches in motion; whistling heard in telegraph.	Strong Breeze
7		32-38	50-61	13.9-17.2	28-33	Whole trees in motion; inconvenience felt when walking.	Near Gale
8		39-46	62-74	17.2-20.7	34-40	Breaks twigs off trees; generally impedes progress.	Gale
9		47-54	75-88	20.7-24.5	41-47	Slight structural damage occurs (chimney-pots and slates removed).	Severe Gale
10		55-63	89-102	24.5-28.4	48-55	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	Storm
11		64-72	103-117	28.4-32.6	56-63	Very rarely experienced; accompanied by wide spread damage.	Violent Storm
12		73-83	≥118	≥32.6	64-71		Hurricane

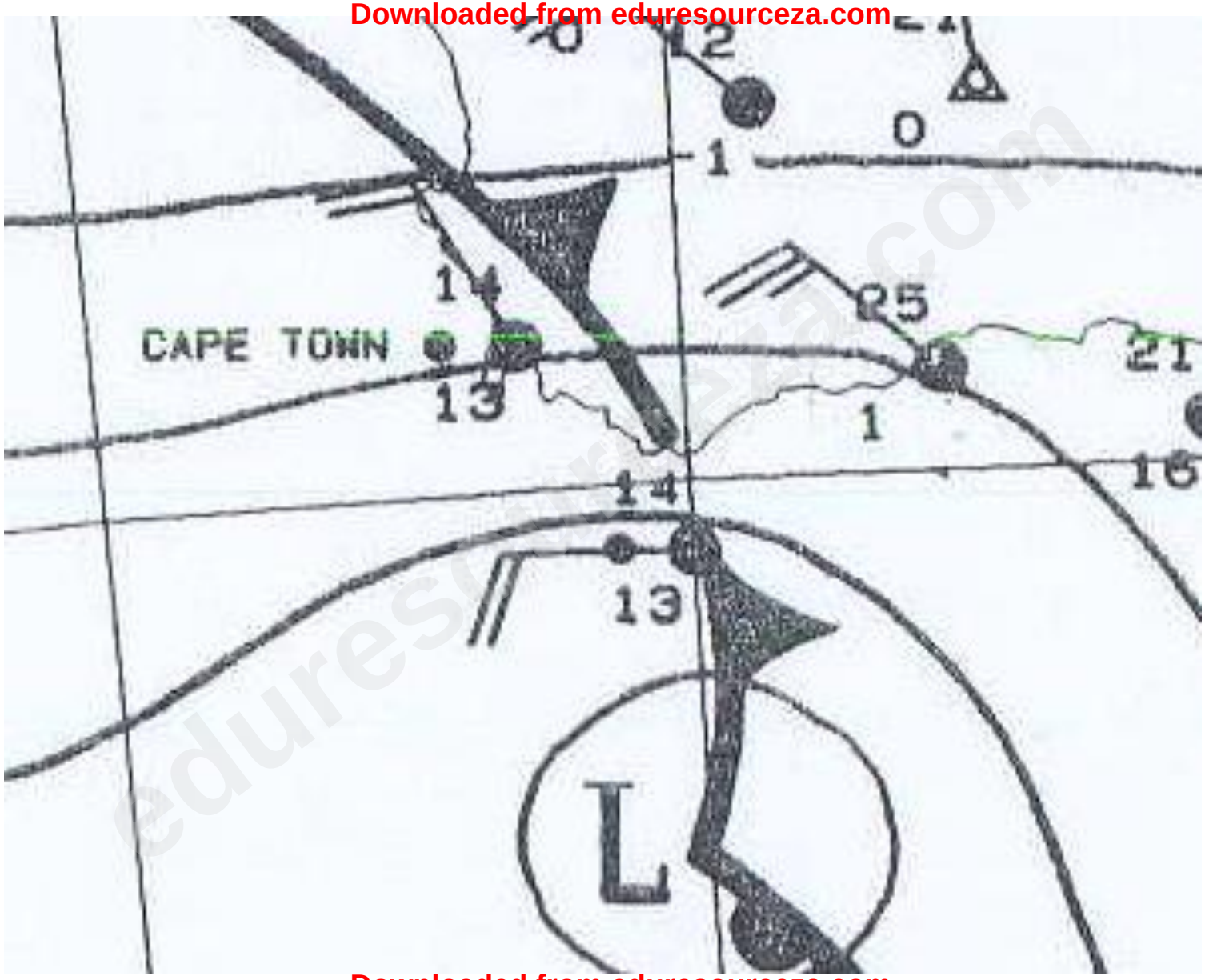
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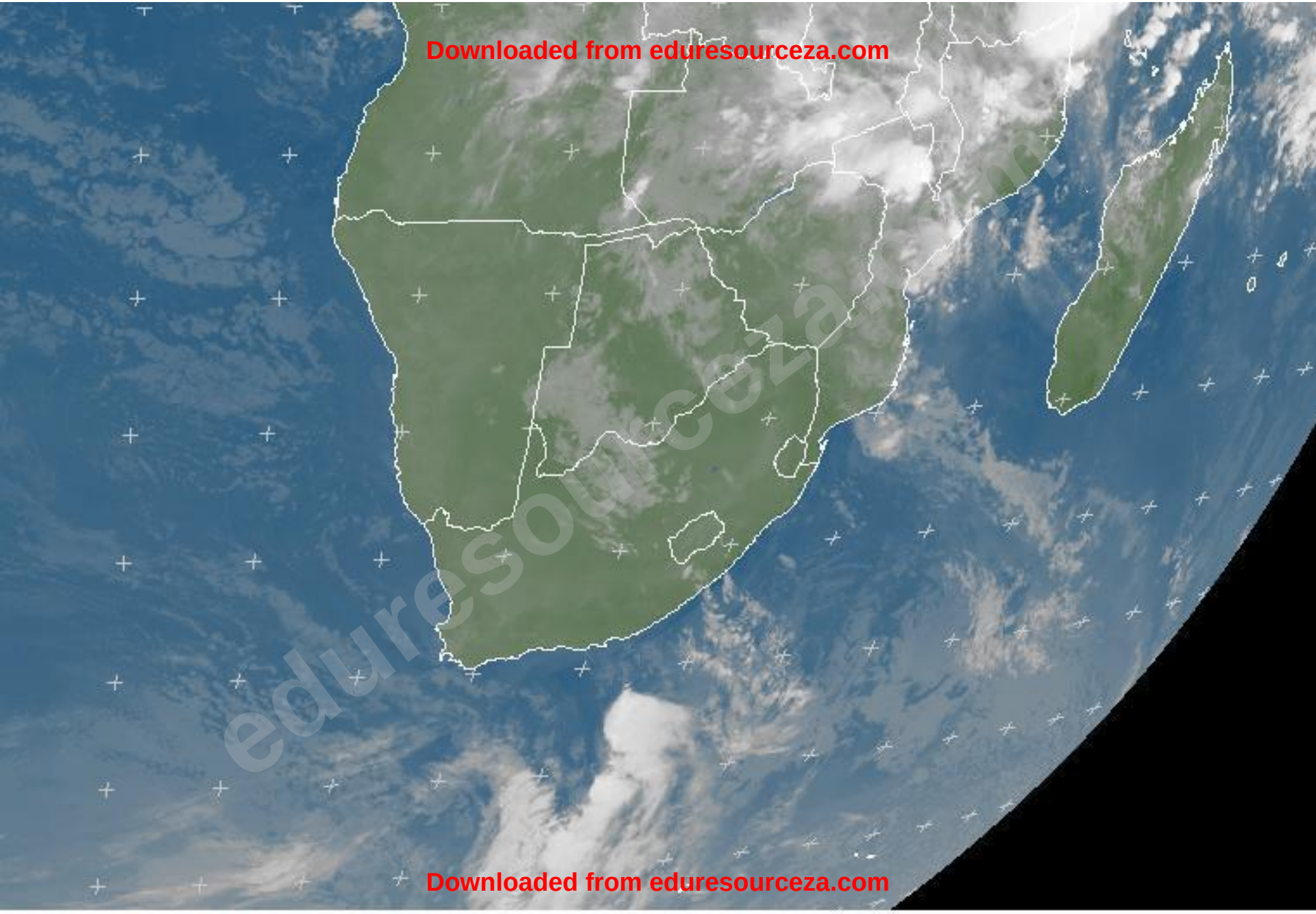


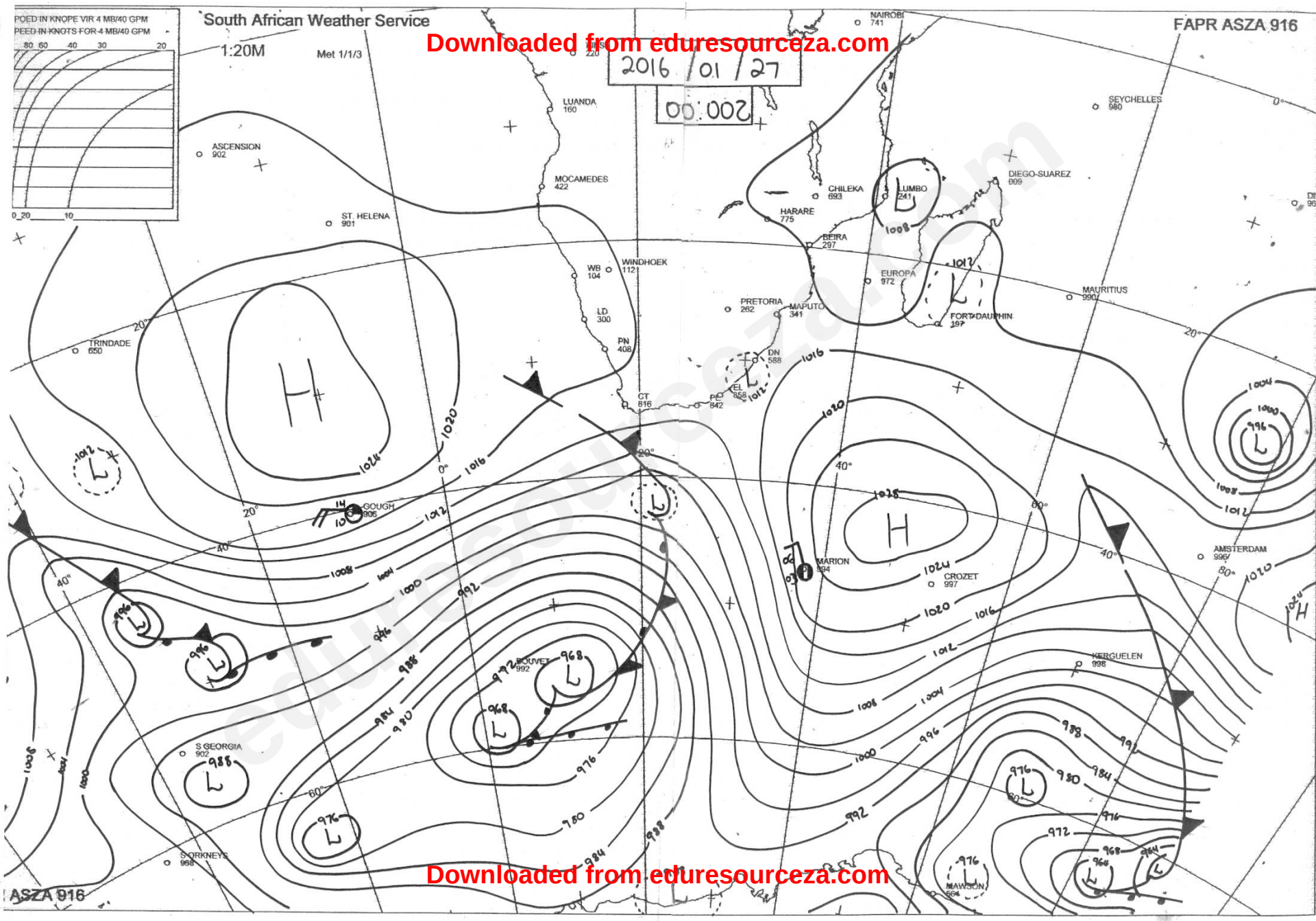
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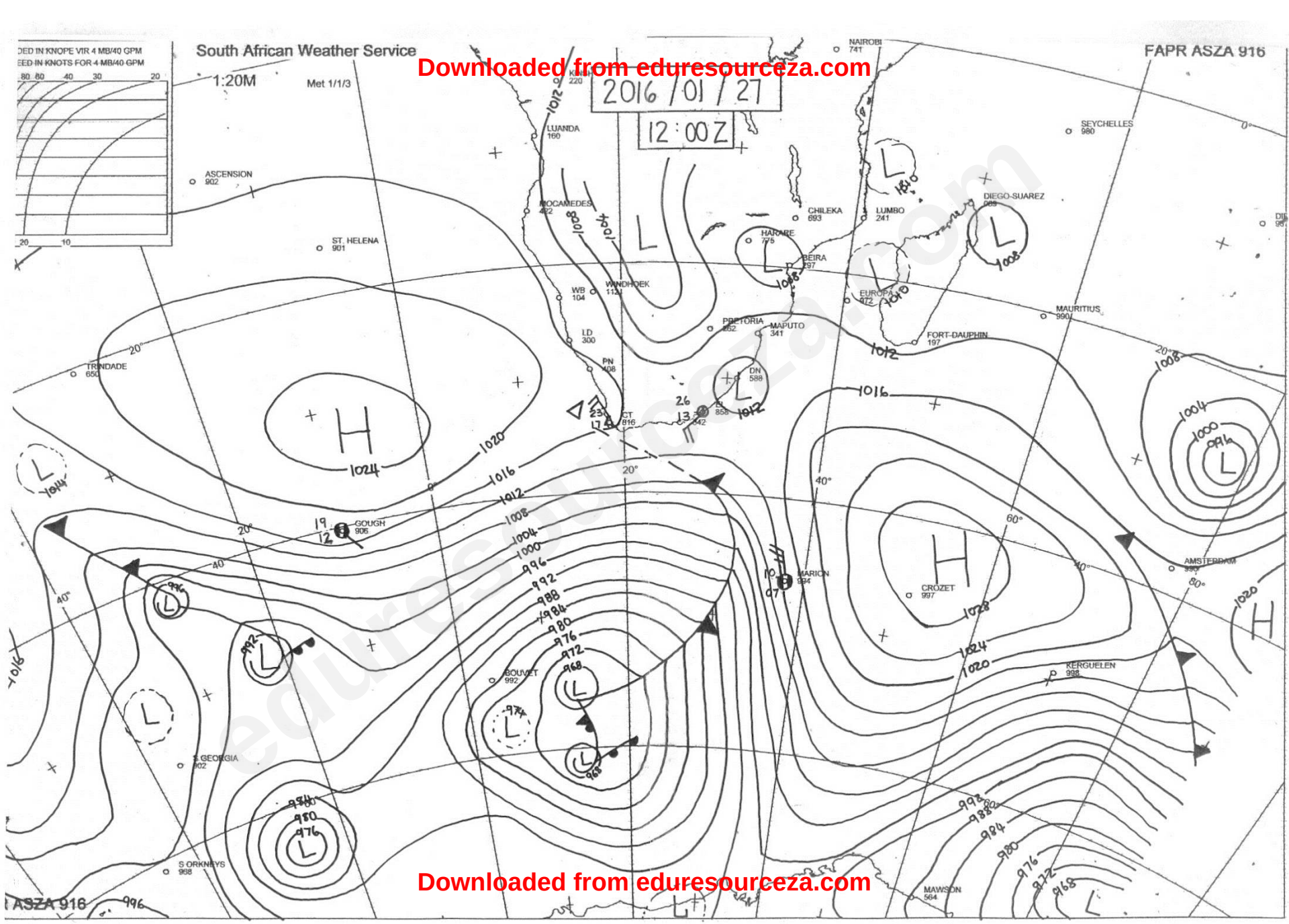
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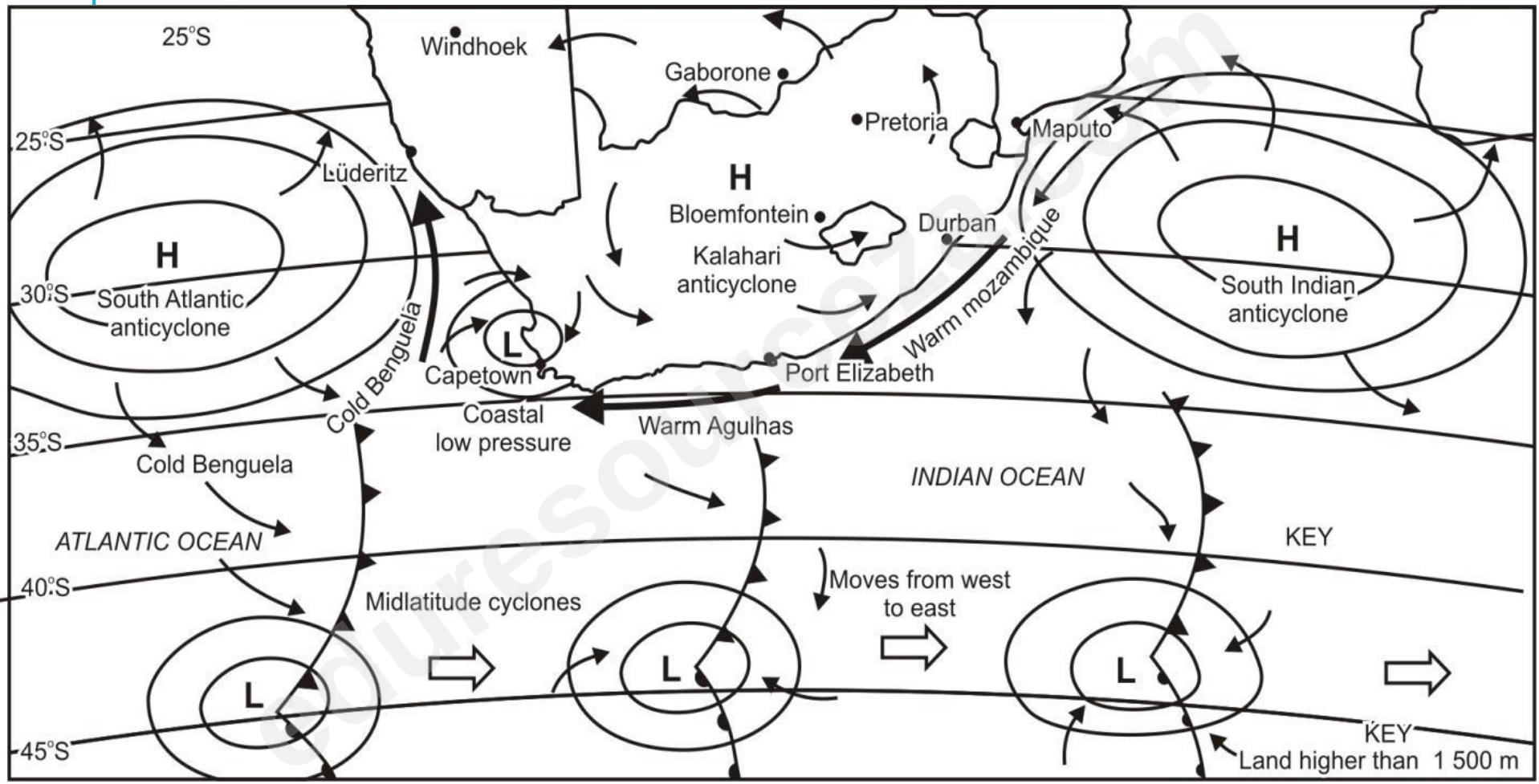
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Low Pressure	High Pressure
Cyclone	Anti cyclone
Air rises	Air subsides
Clockwise in SH	Anticlockwise in SH
Air moves into a LP	Air moves out of a HP
Precipitation	Blue skies

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HOW DOES THIS INFLUENCE SOUTH AFRICAN CLIMATE?

In **S**ummer

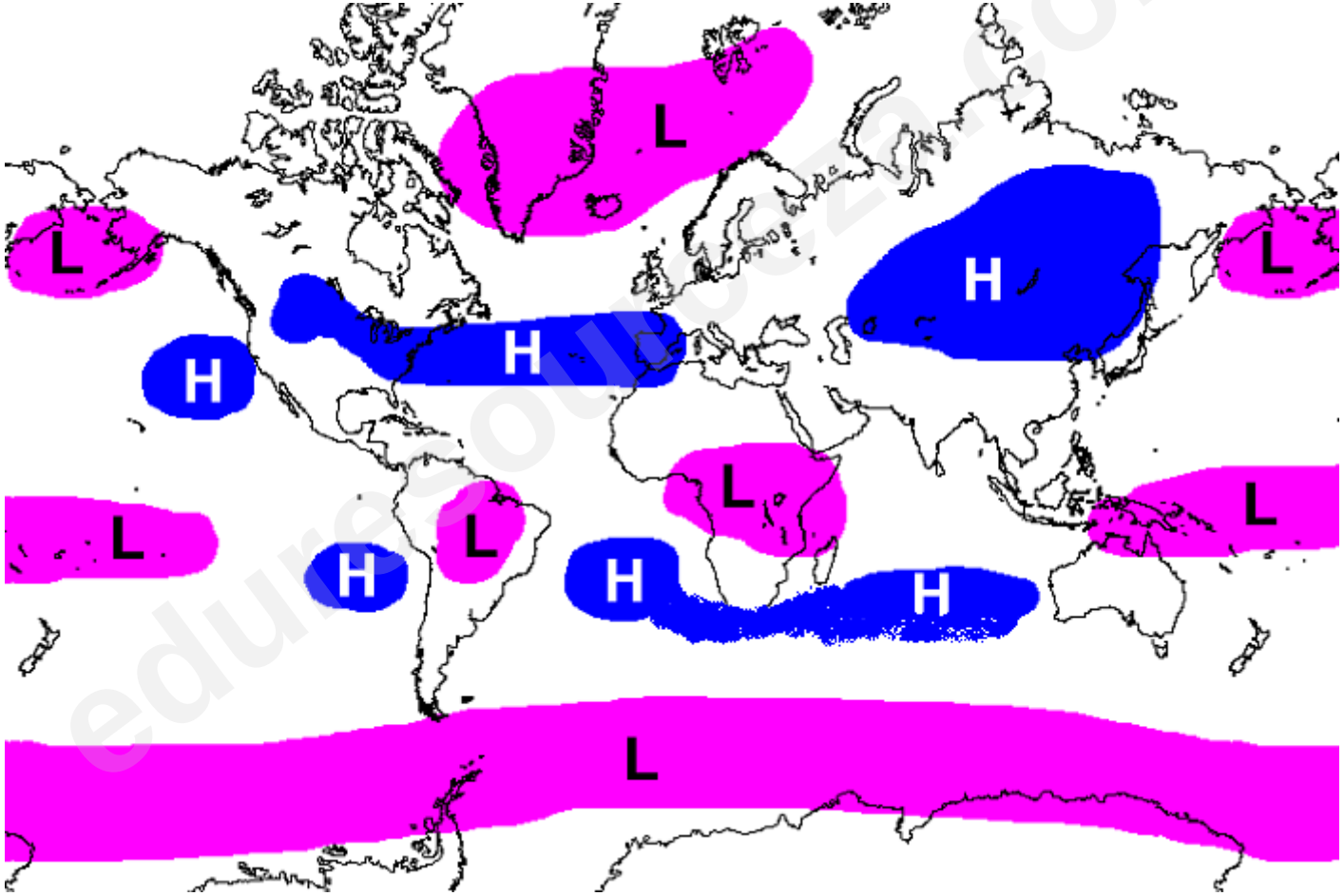
The Subtropical High Pressure Cells (The South Atlantic Anticyclone [SAA] and South Indian Anticyclone [SIA]) migrate **SOUTH** with the heat equator, effectively blocking MLC's from penetrating the interior.

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HOW DOES THIS INFLUENCE SOUTH AFRICAN CLIMATE?



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HOW DOES THIS INFLUENCE SOUTH AFRICAN CLIMATE?

WiNter

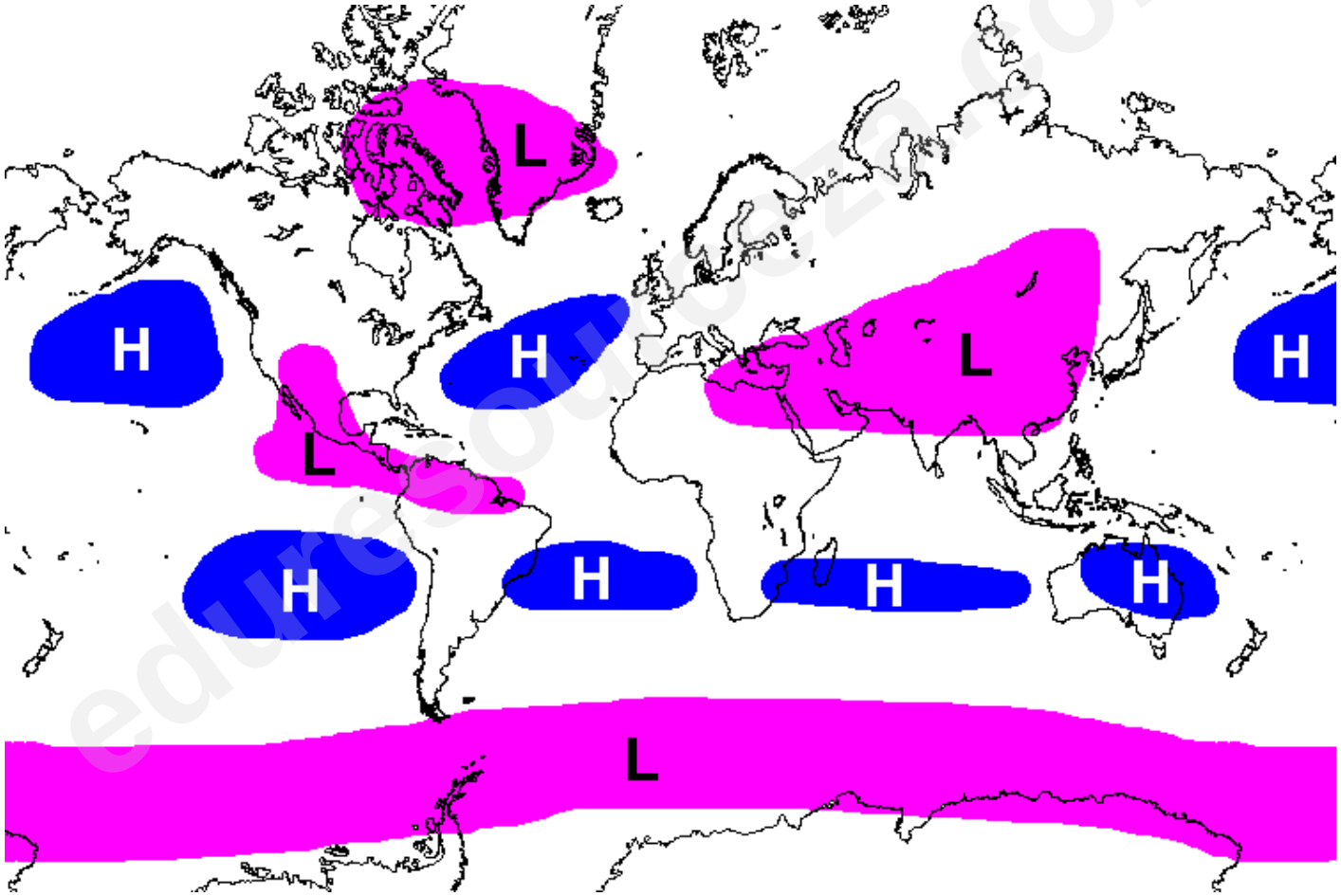
The Sub Tropical High Pressure Cells (The South Atlantic Anticyclone [SAA] and South Indian Anticyclone [SIA]) migrate **NORTH** with the heat equator, effectively allowing MLC's to penetrate the interior.

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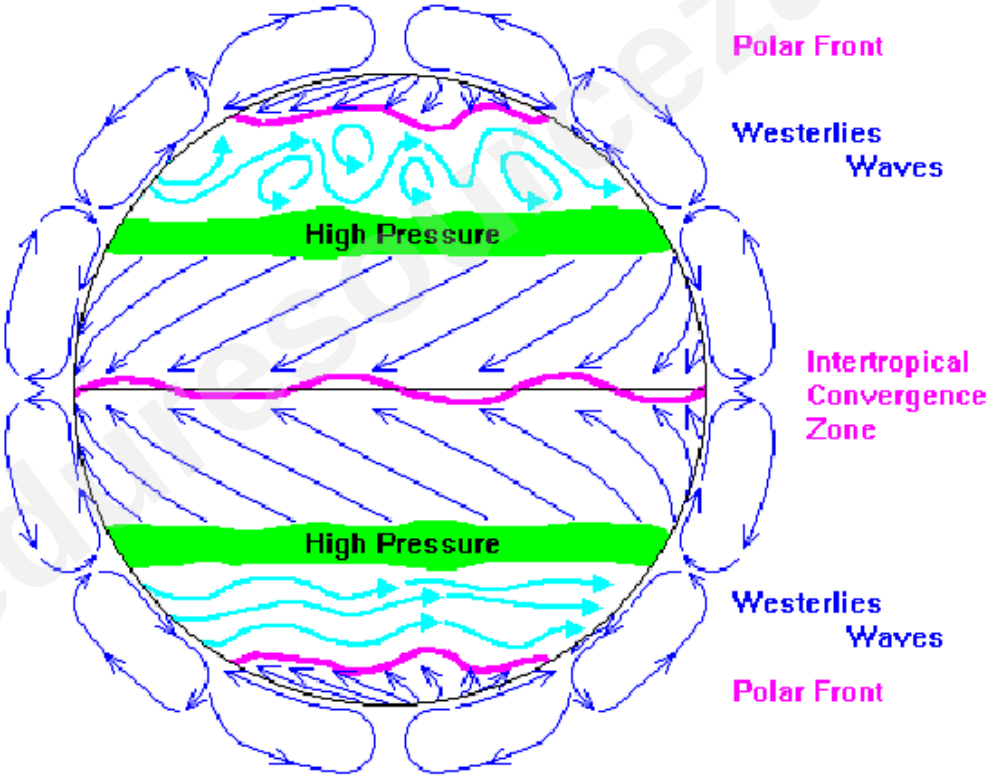
HOW DOES THIS INFLUENCE SOUTH AFRICAN CLIMATE?



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REMEMBER…



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CHARACTERISTICS OF A MLC EVIDENT ON A SYNOPTIC CHART

Low pressure system

Large features approx. 2000 km on average

Travel in Westerly Wind belt

Occur in **families** (if they touching); **groups** if they are not touching

Causes a pre-frontal Low (coastal LP) to develop

Has fronts

Last about 6 days

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STAGES OF DEVELOPMENT

The lifecycle of a MLC is approximately 6 days

STAGES

Initial

Mature

Occluded

Dissipating

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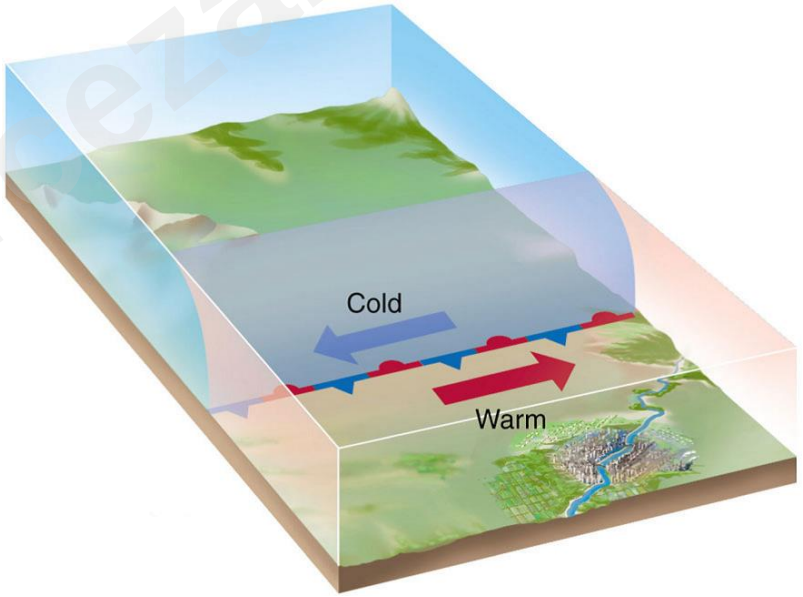
INITIAL STAGE

At approx. 60° S

Friction between the:

- cold polar easterlies (from the polar HP) and
- warm westerlies (from the Sub Tropical HP)

Causes a kink/ discontinuity to develop in the polar front



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MATURE STAGE

Fronts are well developed

Clear warm front

Clear cold front

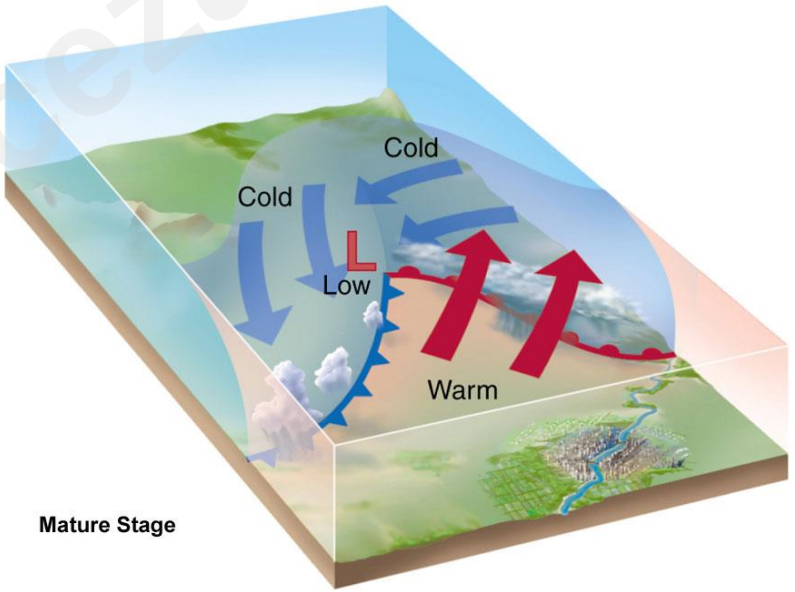
Clockwise airflow (SH)

If warm sector to the north

- southern hemisphere

If warm sector to the south

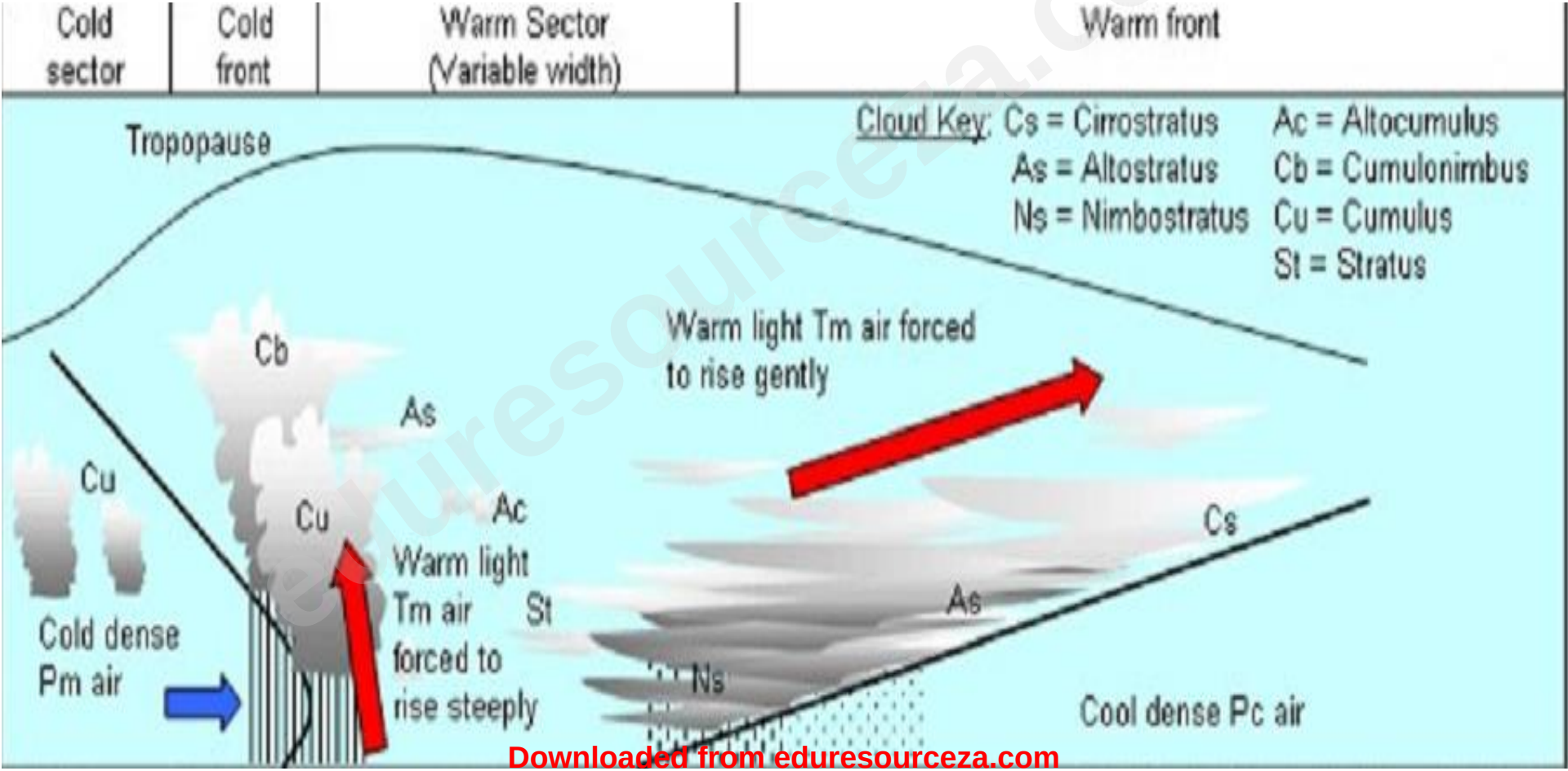
- northern hemisphere



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CROSS SECTION OF A MATURE MLC



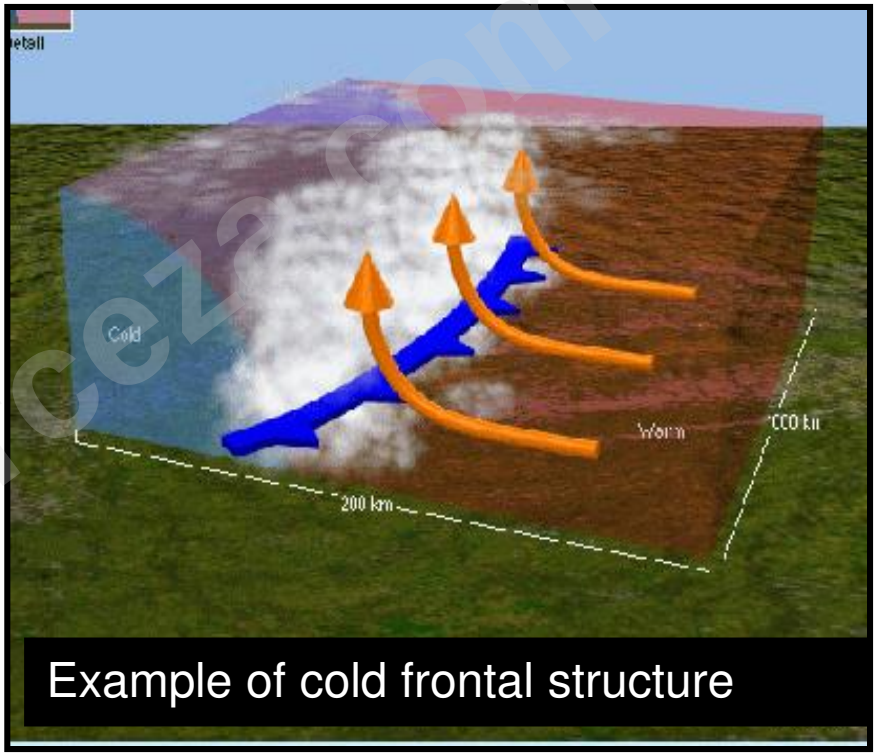
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3D FRONTS

- Precipitation / cloud cover





Example of cold frontal structure

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OCCLUDED STAGE

The Cold Front has caught up with the warm front

This is because;

- it displaces warm air easily

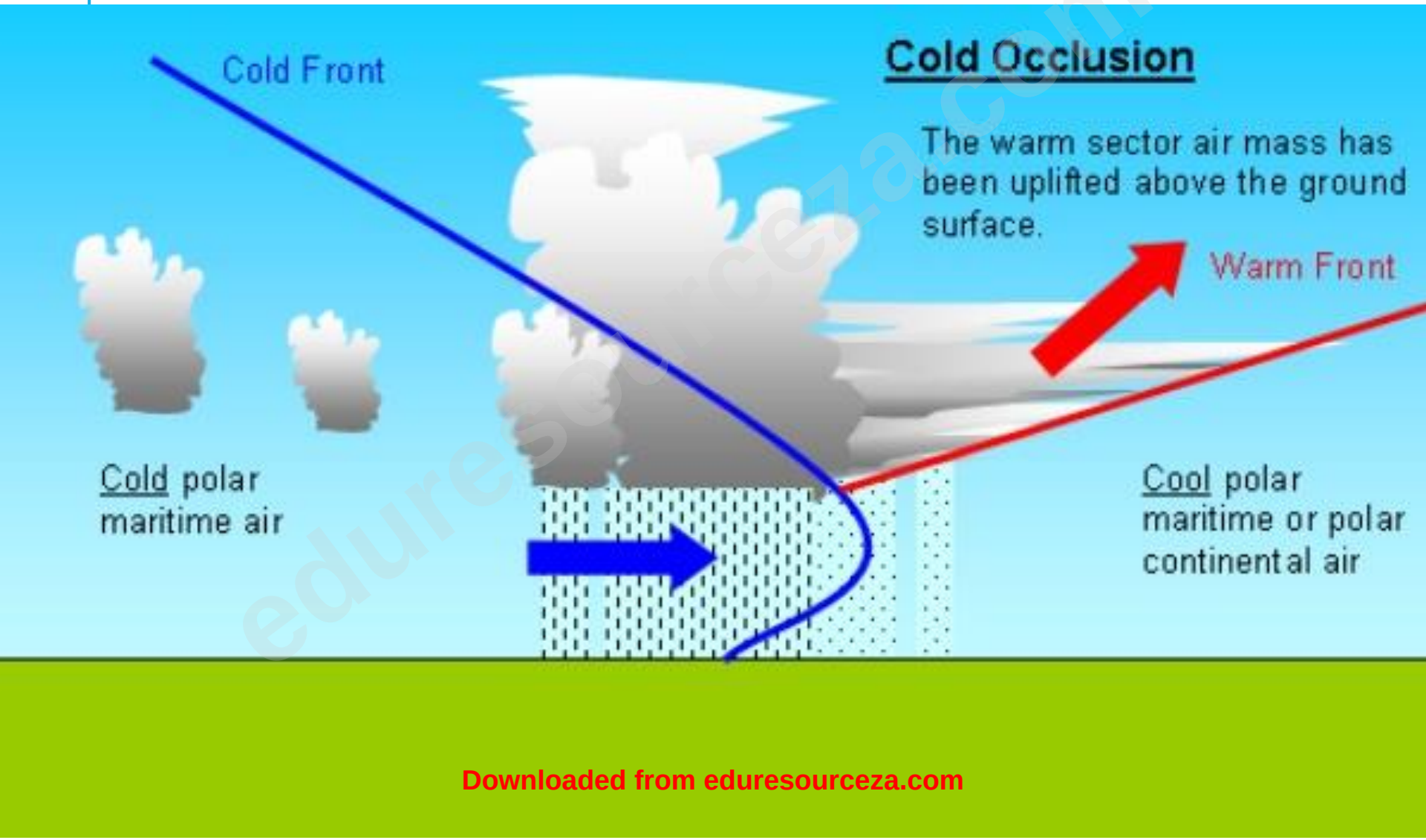
- it travels horizontally and does not use energy to rise

There are two types of occluded fronts, namely cold front and warm front occlusions;

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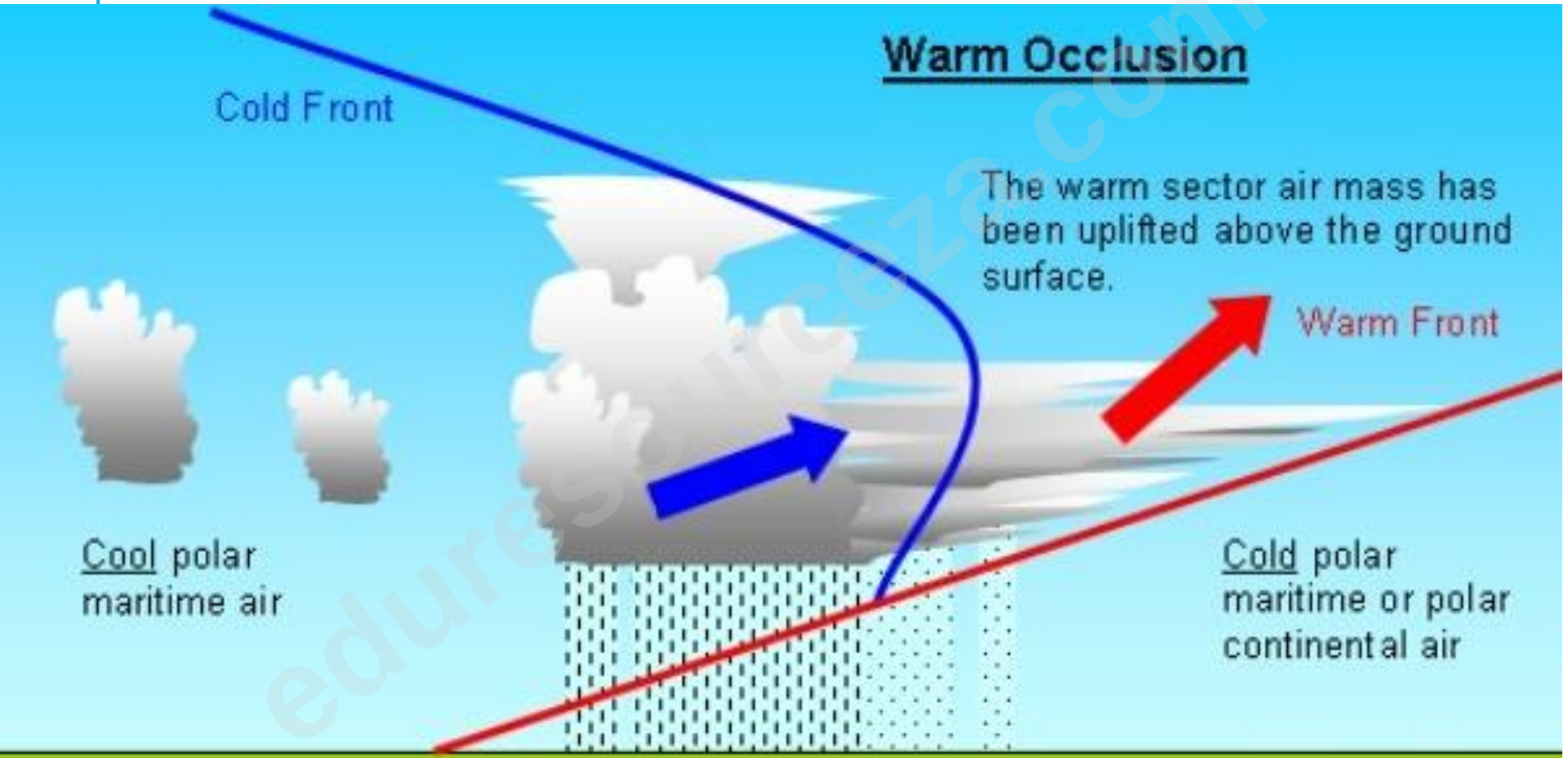
COLD FRONT OCCLUSION



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WARM FRONT OCCLUSION



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DISSIPATING/DEGENERATION STAGE

Vertical mixing of warm and cold air therefore there is no pressure differences and the system “dies”/dissipates.

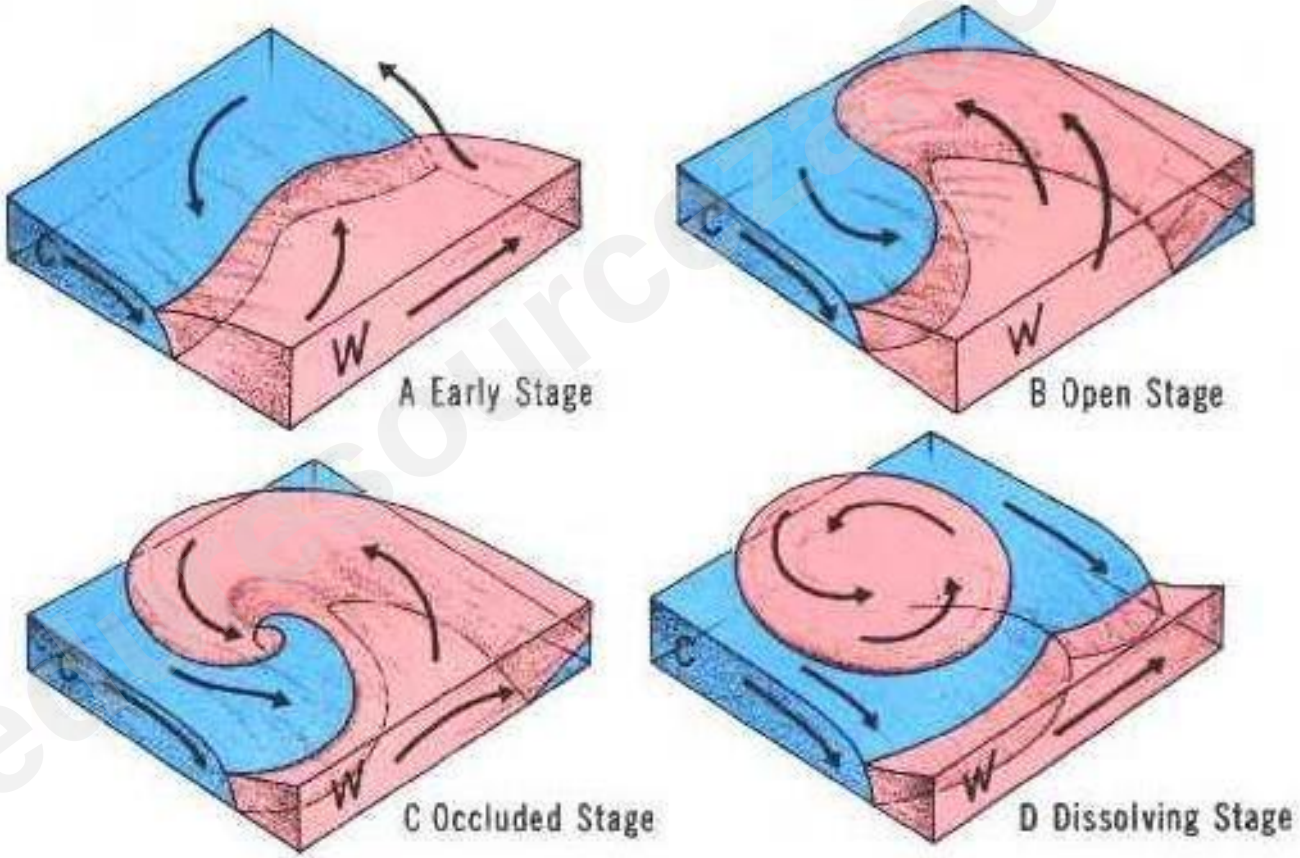
This stage occurs soon after occlusion has occurred.

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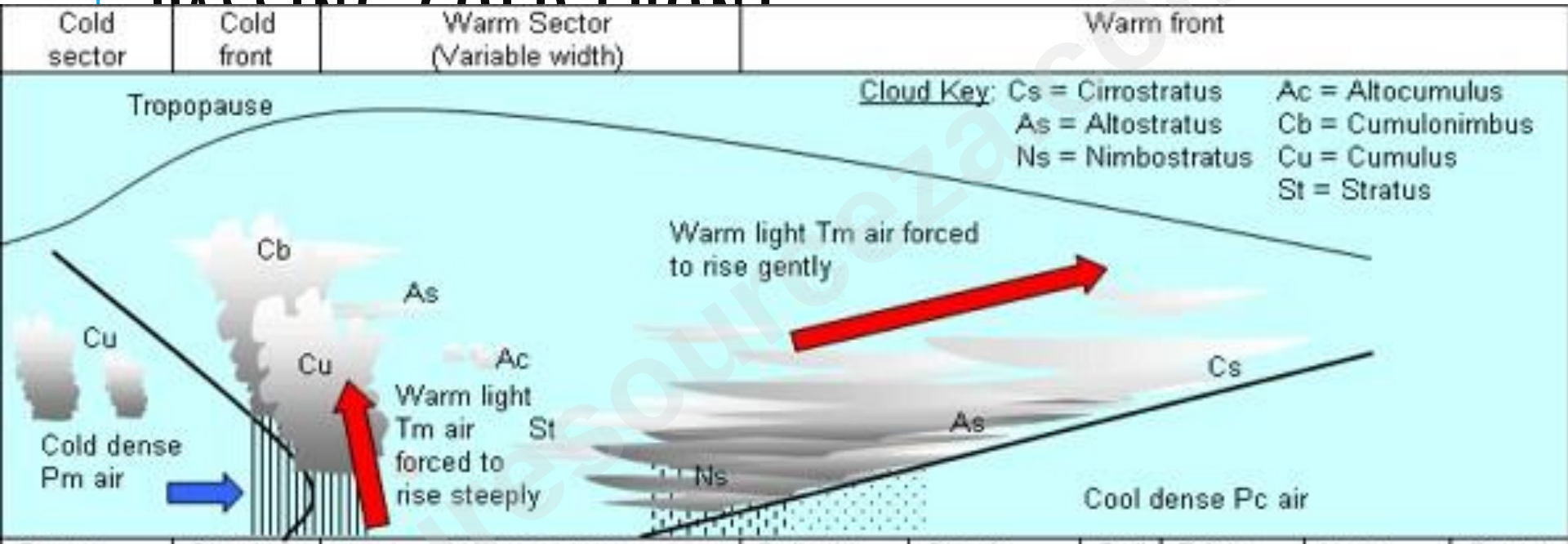
SUMMARY OF STAGES



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WEATHER CHANGES ASSOCIATED WITH A PASSING COLD FRONT



Sunny intervals, possibly showers	Cloudy, bursts of moderate or heavy rain, possible thunder.	Warm sector			Dull with more continuous moderate rain	Cloudy with light intermittent rain and drizzle	Dull	Bright, some watery sunshine	Hazy sunshine	Sunny, cool and dry
		Sunny intervals, increasing cloud.	Sunny, warm and humid	Cloud clearing, warm and humid						
Decreasing wind	Direction change	Wind increasing		Change in wind direction	Increasing wind					

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IDENTIFYING MID-LATITUDE CYCLONES ON SYNOPTIC & SATELLITE MAPS

Always move from W to E

Temp ahead higher than temp behind

Cloud cover increases along & behind cold front

Rain & thunderstorms along front; showers behind front

Wind backs (anticlockwise) as front passes over

Satellite image shows swirl of cloud toward center of LP

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EFFECT ON SA'S WEATHER

They occur throughout the year, but only affect SA in Winter when the sub tropical HP's have moved North - Cold snaps on plateau in Winter

Snow on Cape Fold Mountains

Rain in Western and Southern Cape

Berg Winds

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EFFECT ON SOUTH AFRICA'S ECONOMY

Increased power usage – power cuts

Loss of productivity – illness, power cuts may lead to increase time in traffic, down time at work etc.

Black frost?

Brings rainwater to W. Cape – water for industrial and agricultural use

Pharmaceutical and generator companies love them!

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VIDEOS

A year of weather

19 Sept 2013

Stormy weather & flood warnings for CPT

8 Jan 2015

MLC animation

eNCA tracking winters return

Tech report – eNCA behind the scenes

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ACTIVITIES

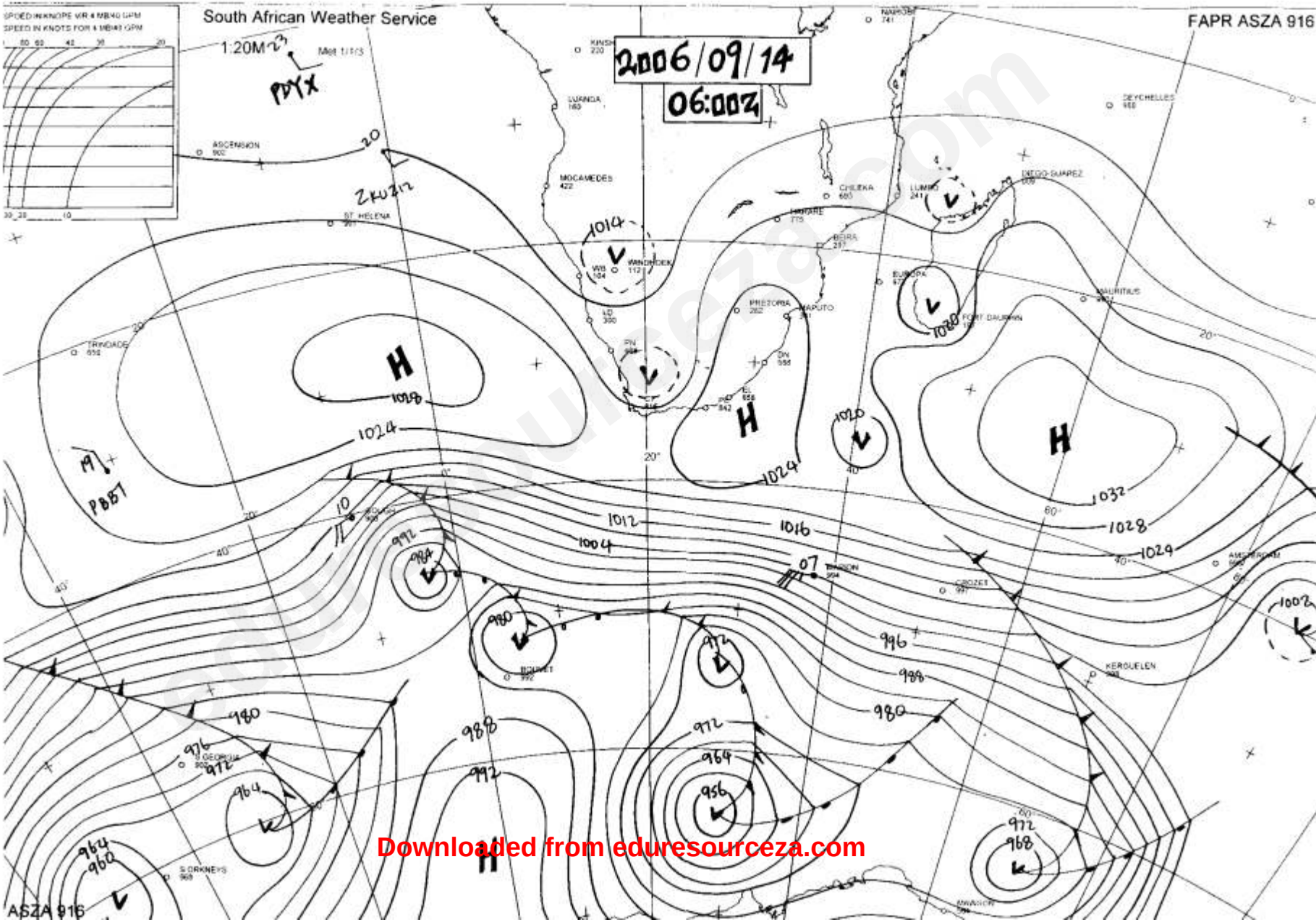
Mid latitude folding model

Activity 6 p 81

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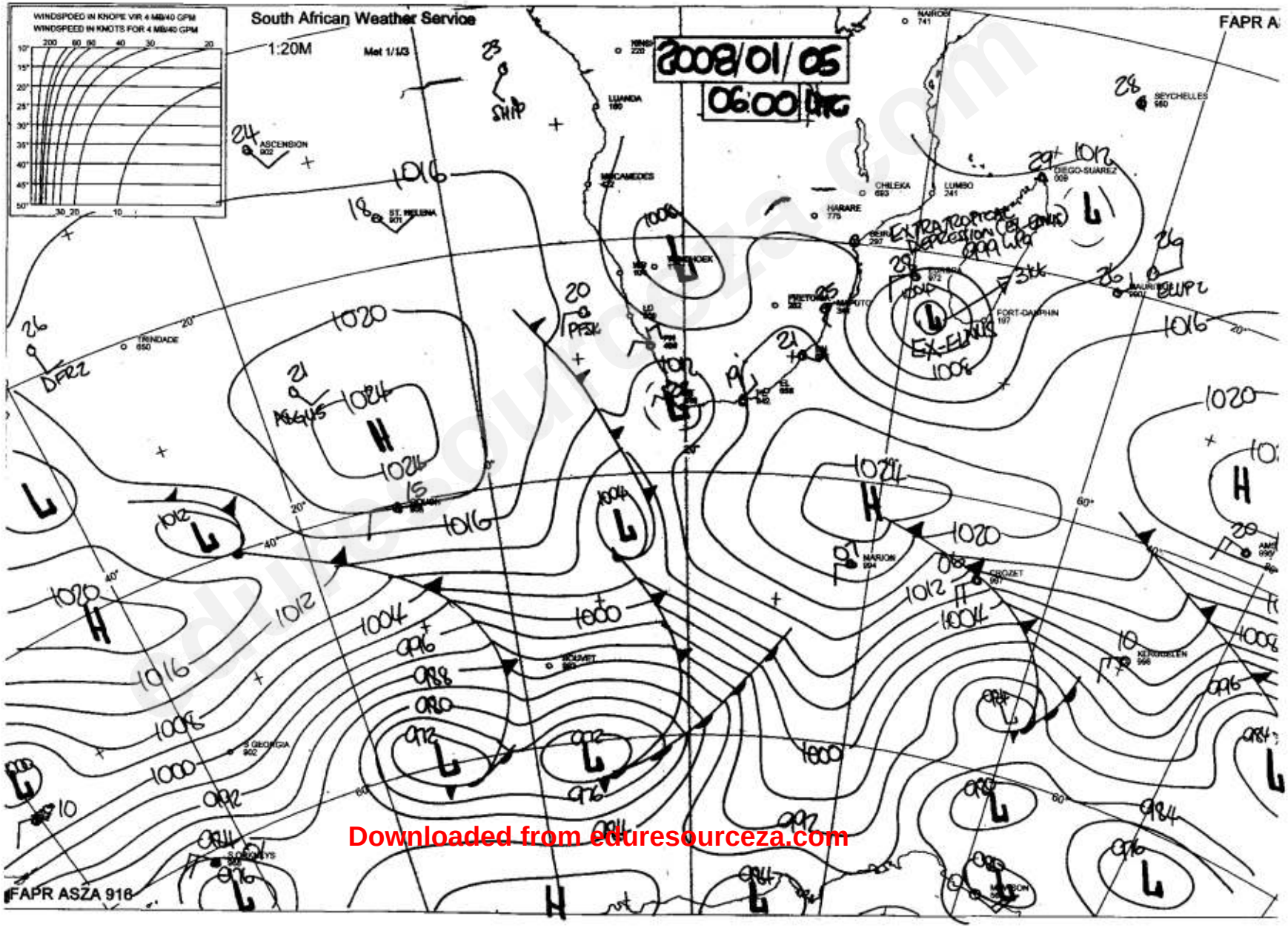
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NB! WHEN A COLD FRONT PASSES…

Temperature decreases

Humidity decreases

Pressure increases

Cb clouds at front, cumulus after

Heavy rain at front, little rain after

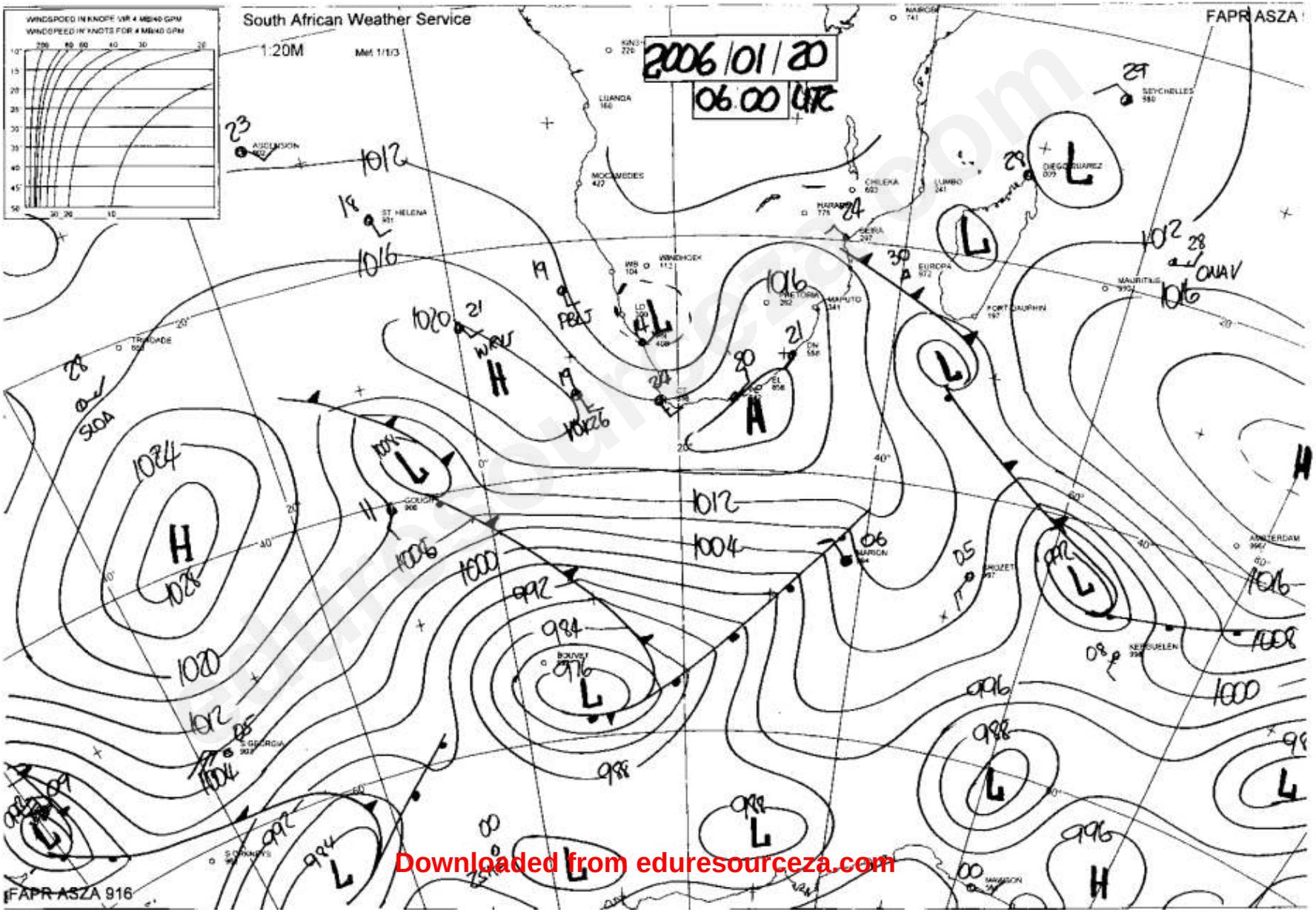
Wind “backs” to SW in S.H. (“veers” in N.H.)

Wind speed increases

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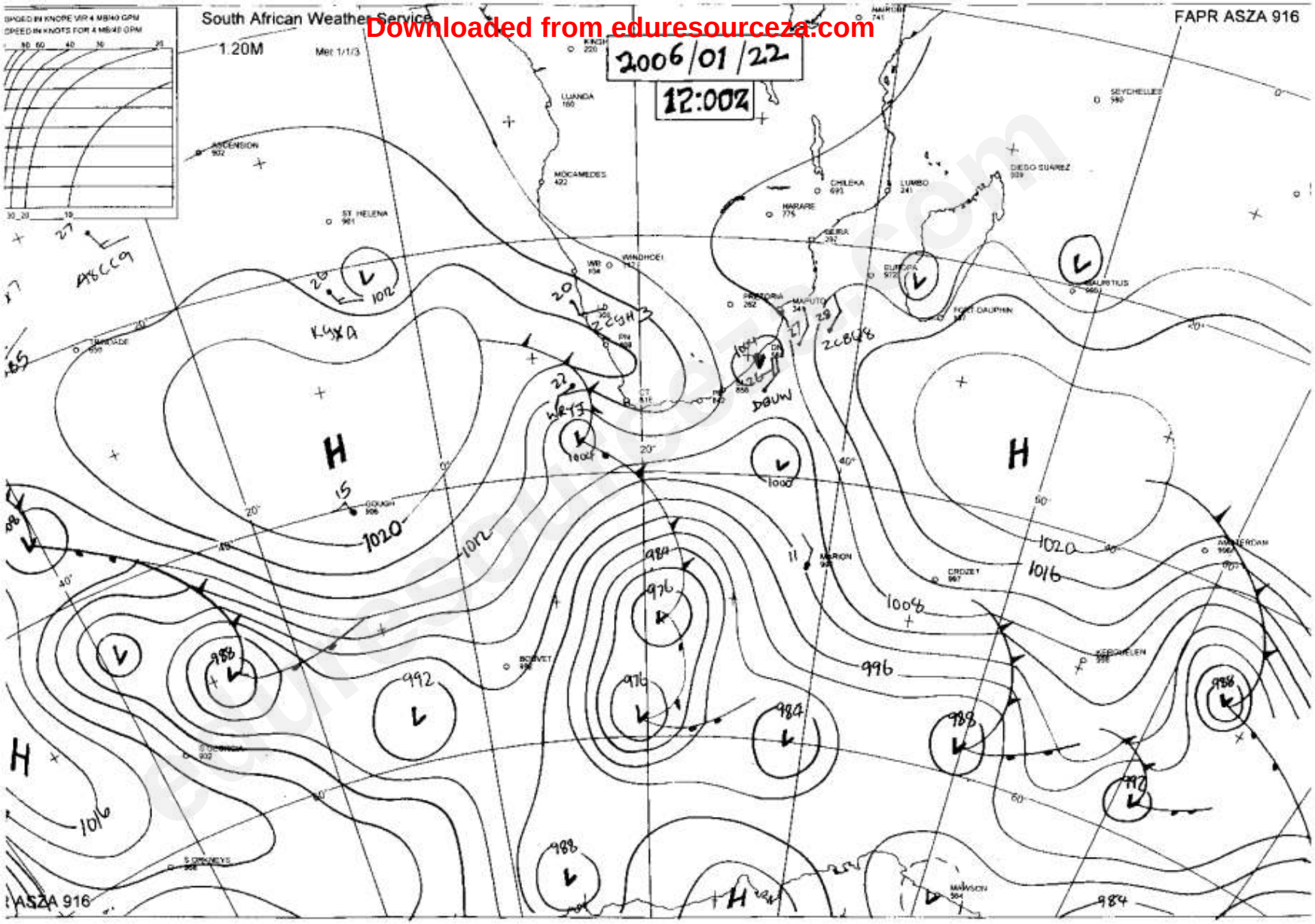
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TYPICAL EXAM QUESTIONS

Label the system - a MLC

Label the parts of a MLC – fronts and sectors

Label warm, cool and cold sectors

Where did system originate – Polar Front

Alternative names for the system

Stage of development system is in

Draw a cross section across mature/occluded stage/cold front

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TYPICAL EXAM QUESTIONS

What are the expected weather changes in PE/CT/Mossel Bay in the next 24 hours?

Typical characteristics of MLC apparent on synoptic chart

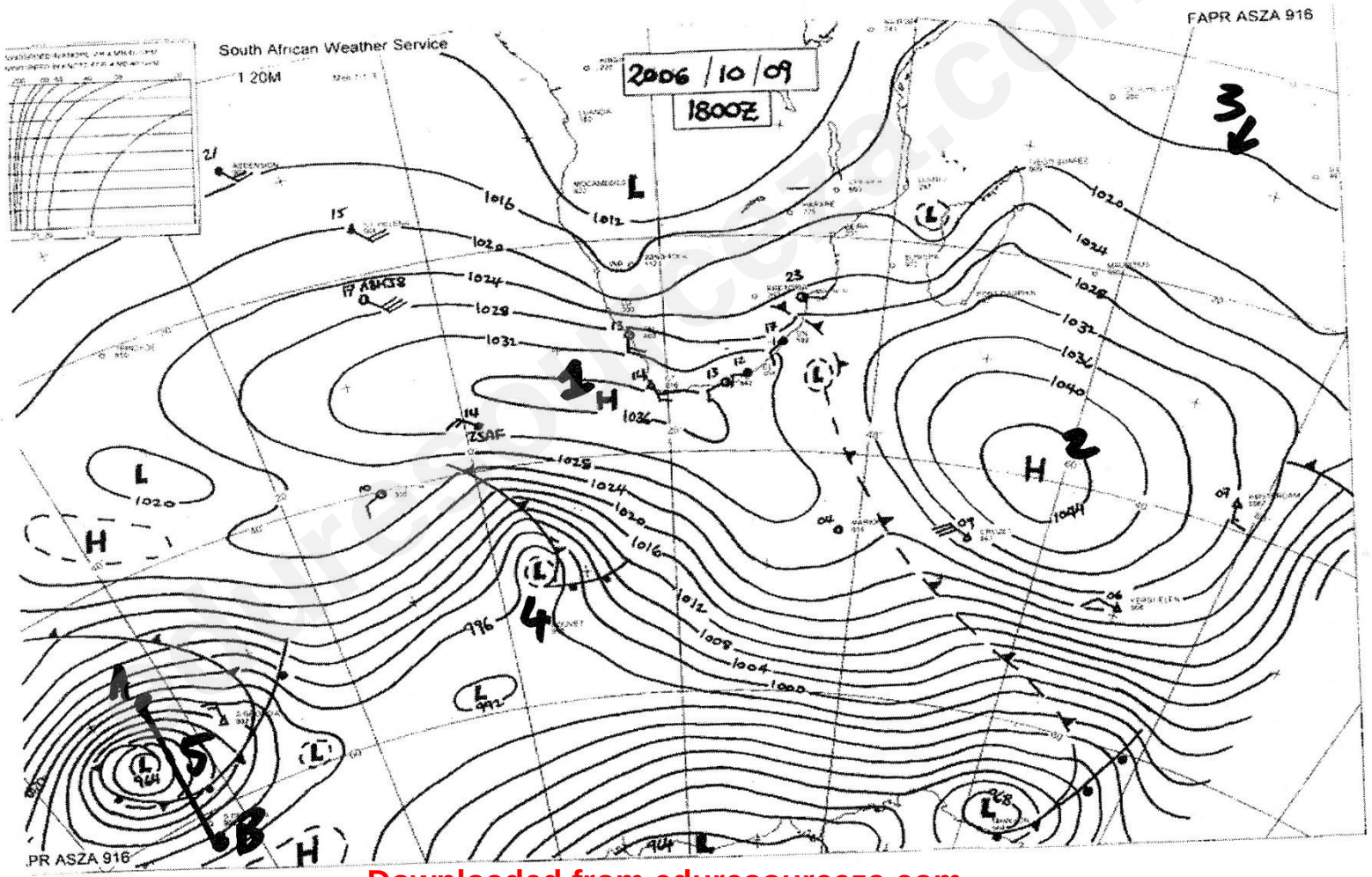
Which MLC is older? – occluded or one further south east.

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SYNOPTIC CHART 2



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MLC EXERCISE

Refer to synoptic chart 1 and answer the following questions;

1. Identify features A, B, D, E and F
2. Provide an alternative name for B
3. List 3 characteristics of B evident on the chart
4. Name the stage of development B is in. Motivate.
5. With the aid of a diagram, explain how B developed to this stage.
6. Predict and explain four likely weather changes CT will experience in the next 24 hours
7. Name and explain the stage of development B will enter into in the next 48 hours.

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ANSWERS TO MLC EXERCISE

1. A - SAA

   B- MLC

   D- Isobar

   E- Cold Front

   F - SIA

2. Temperate Cyclone/depression, Extra Tropical Cyclone
3. LP

   Large (3000km plus)

   Occurs in Westerly Wind belt - latitude

   Has fronts

   Occur in groups

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ANSWERS TO MLC EXERCISE

4. Mature – Fronts are well developed I.e. the cold and warm front are clearly distinguishable

6. Weather changes

Temperature decreases

Humidity decreases

Pressure increases

Cb clouds at front, cumulus after

Heavy rain at front, little rain after

Wind “backs” to SW

Wind speed increases

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ANSWERS TO MLC EXERCISE

Initial Stage

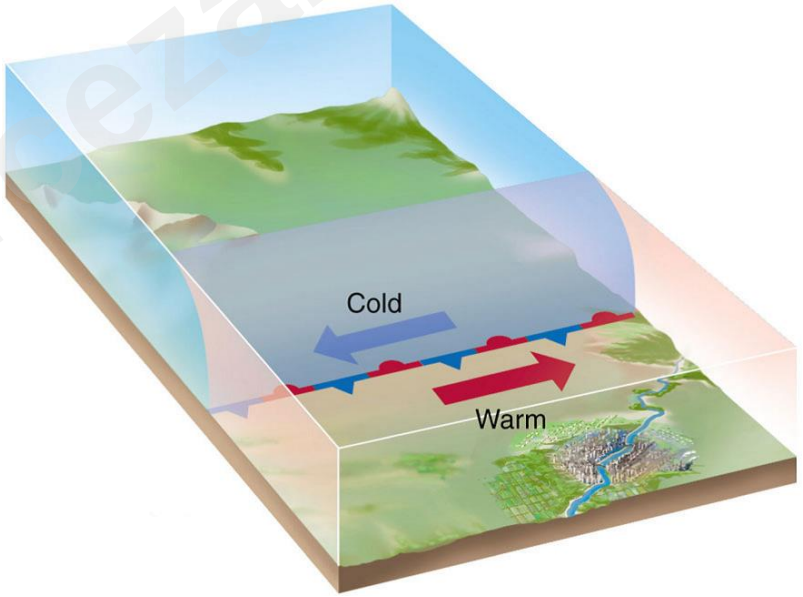
At approx. 60° S

Friction between the

cold polar easterlies (from the polar HP) and

The warm westerlies (from the Sub Tropical HP)

Causes a kink/ discontinuity to develop in the polar front



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ANSWERS TO MLC EXERCISE

7. Occluded Stage

The Cold Front has caught up with the warm front

This is because;

- it displaces warm air easily

- it travels horizontally and does not use energy to rise

There are two types of occluded fronts, namely cold front and warm front occlusions

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TROPICAL CYCLONES

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a.k.a.

Hurricanes – North America

Typhoons - Asia

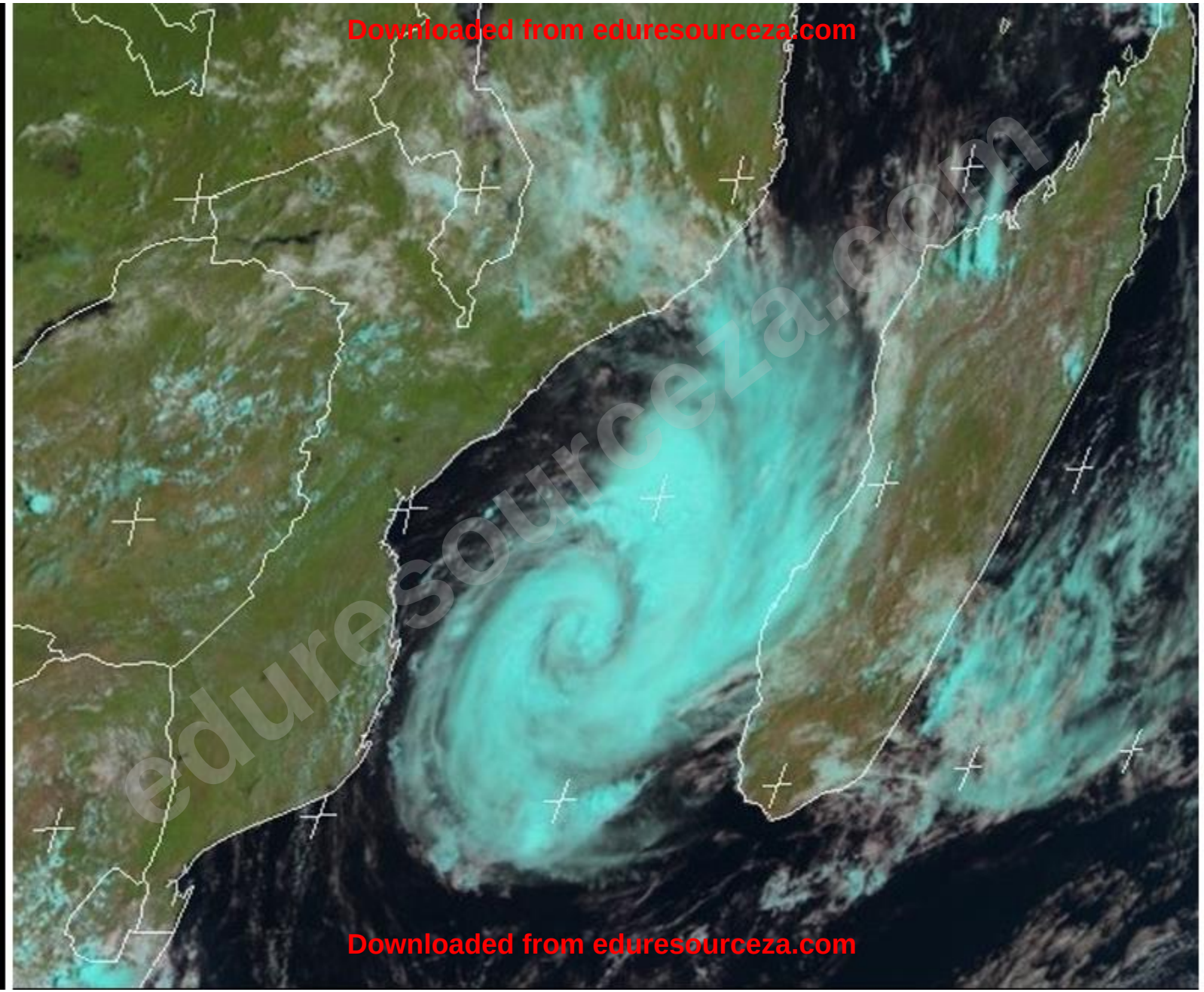
Willy-Willies - Australia

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CASE STUDY OF A TROPICAL CYCLONE – DINEO 2017

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ENCA WARNING!

Tropical storm Dineo has continued to strengthen over the warm waters of the Mozambique Channel overnight.

The storm now has sustained winds of around 90km/h around it's eye with gusts reaching 120km/h.

The only landmass currently experiencing significant effects from Dineo is the tiny uninhabited island of Europa, where average wind speeds of over 80km/h were being reported this morning.

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All available information indicates that Dineo will rapidly intensify into an intense tropical cyclone within the next 24 hours, while moving closer to the southern Mozambique coastline.

The current predicted path shows Dineo making landfall just north of Inhambane on Wednesday evening and at that point Dineo is expected to have average wind speeds of 160km/h, gusting over 200km/h, equivalent to a category 2 hurricane in the north Atlantic.

Along with hurricane force winds, Dineo is expected to produce extremely heavy rainfall over much of southern Mozambique, starting on Wednesday afternoon and becoming heavier into Thursday as the storm moves overland.

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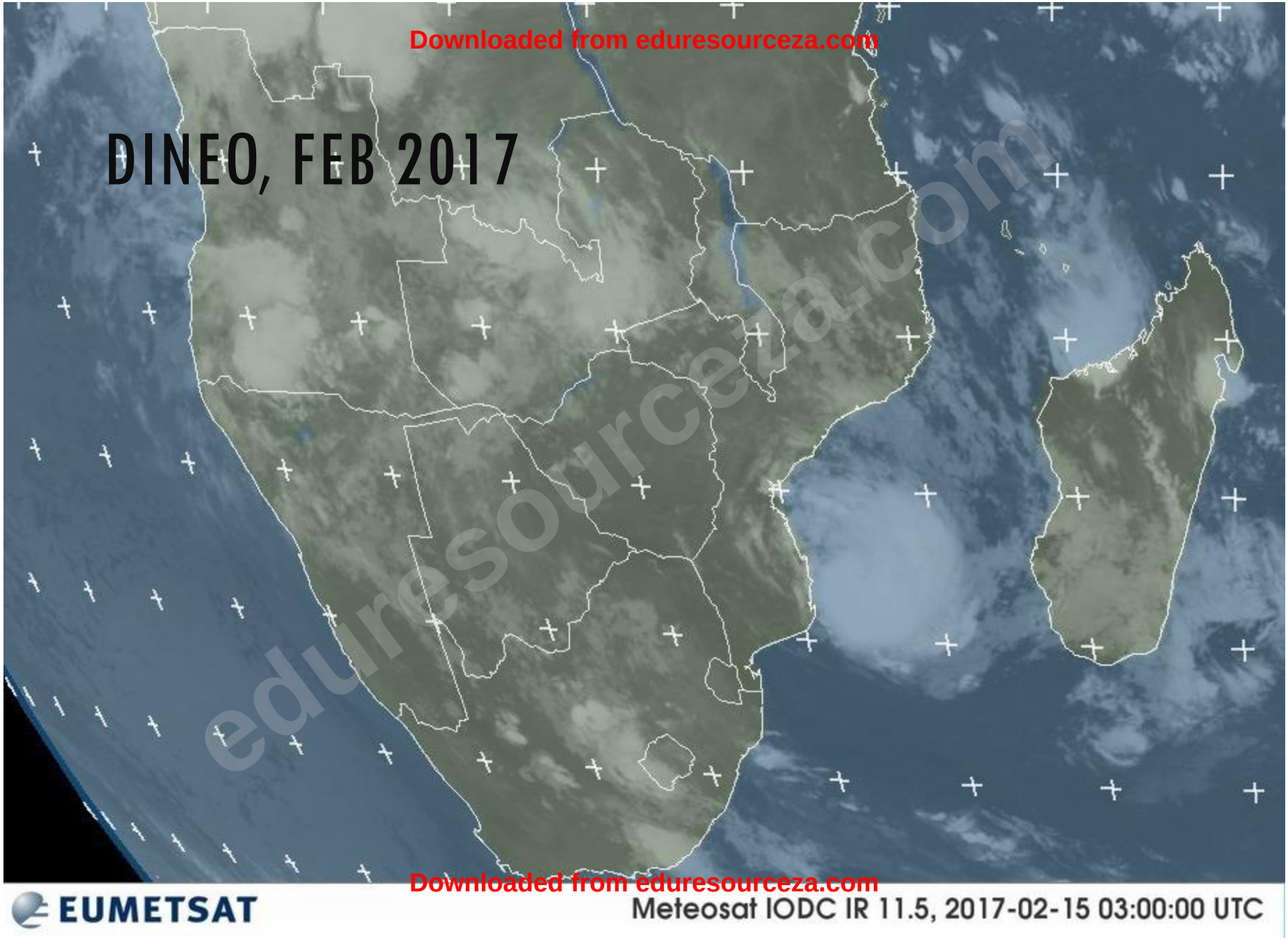
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The risk of flooding in the area will be high and although winds around Dineo will begin to weaken, gale force winds exceeding 70km/h will still lash parts of the Mozambican interior during Thursday.

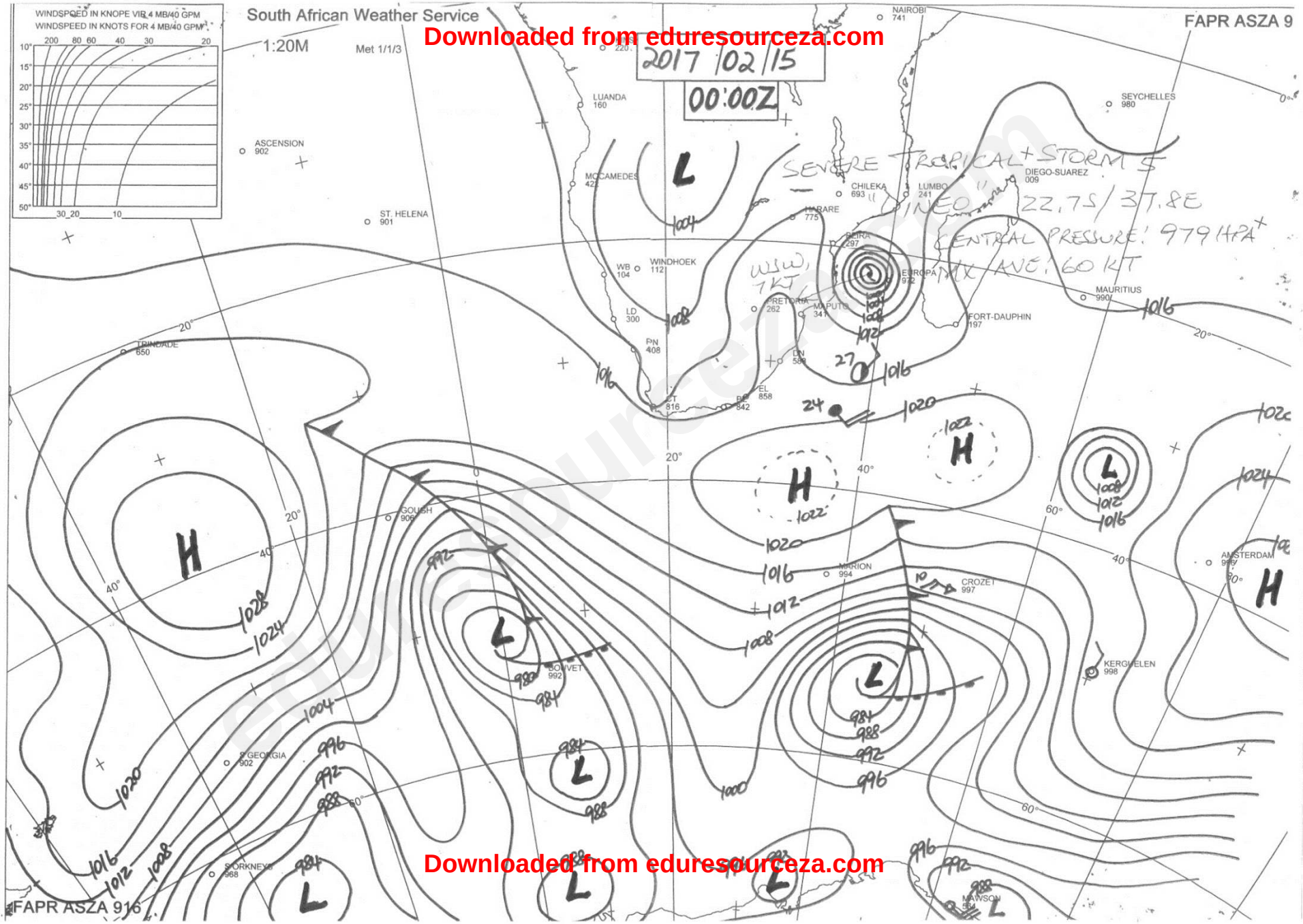
Dineo is then expected to continue moving westwards towards the northern lowveld, bringing strong, gusty winds to eastern Limpopo and Mpumalanga, and heavy rain will begin to affect the area from Thursday evening. Persistent, heavy showers are likely to continue into Friday for these areas, although this is highly dependant on whether Dineo remains on her current forecast track.

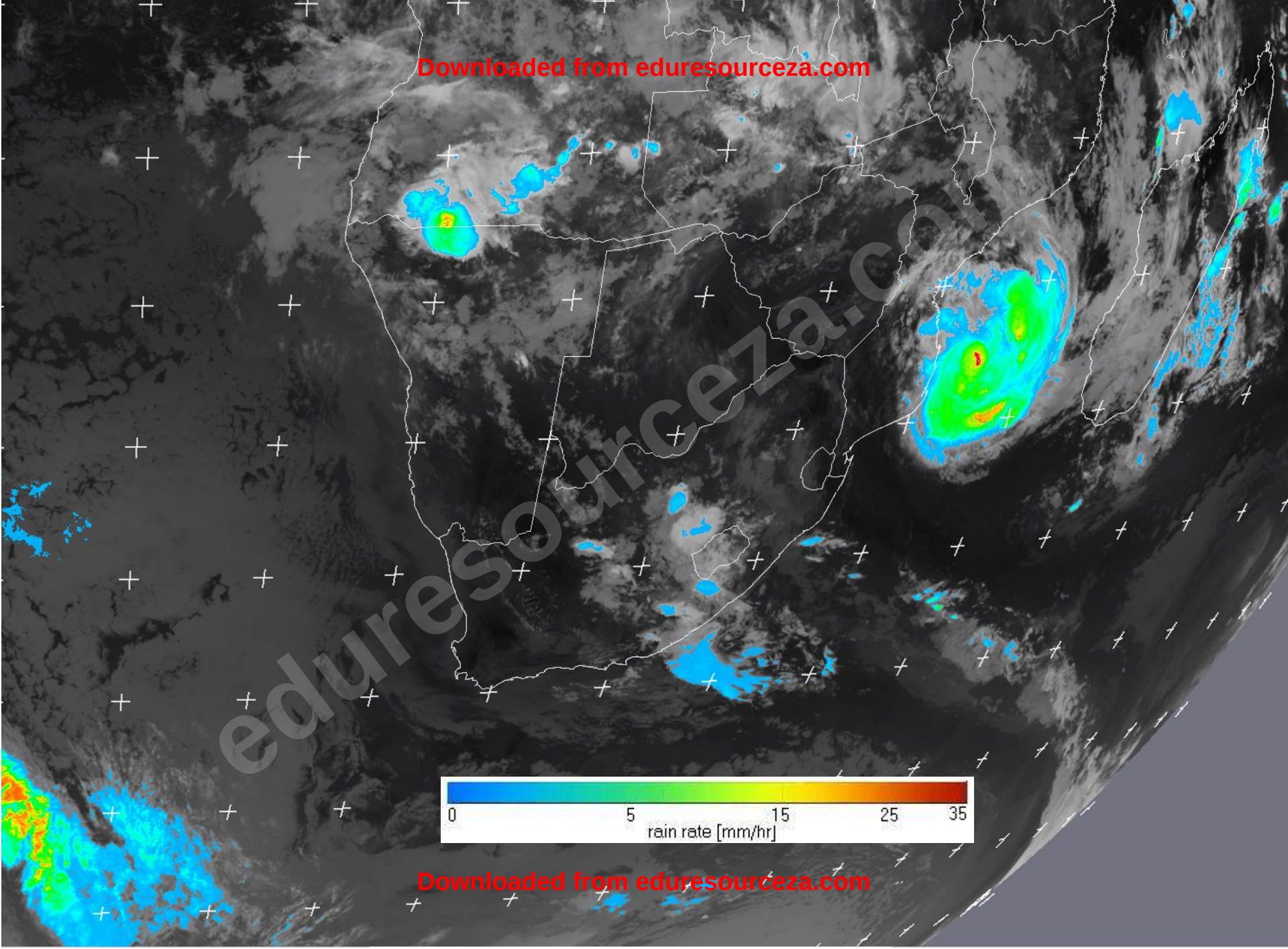
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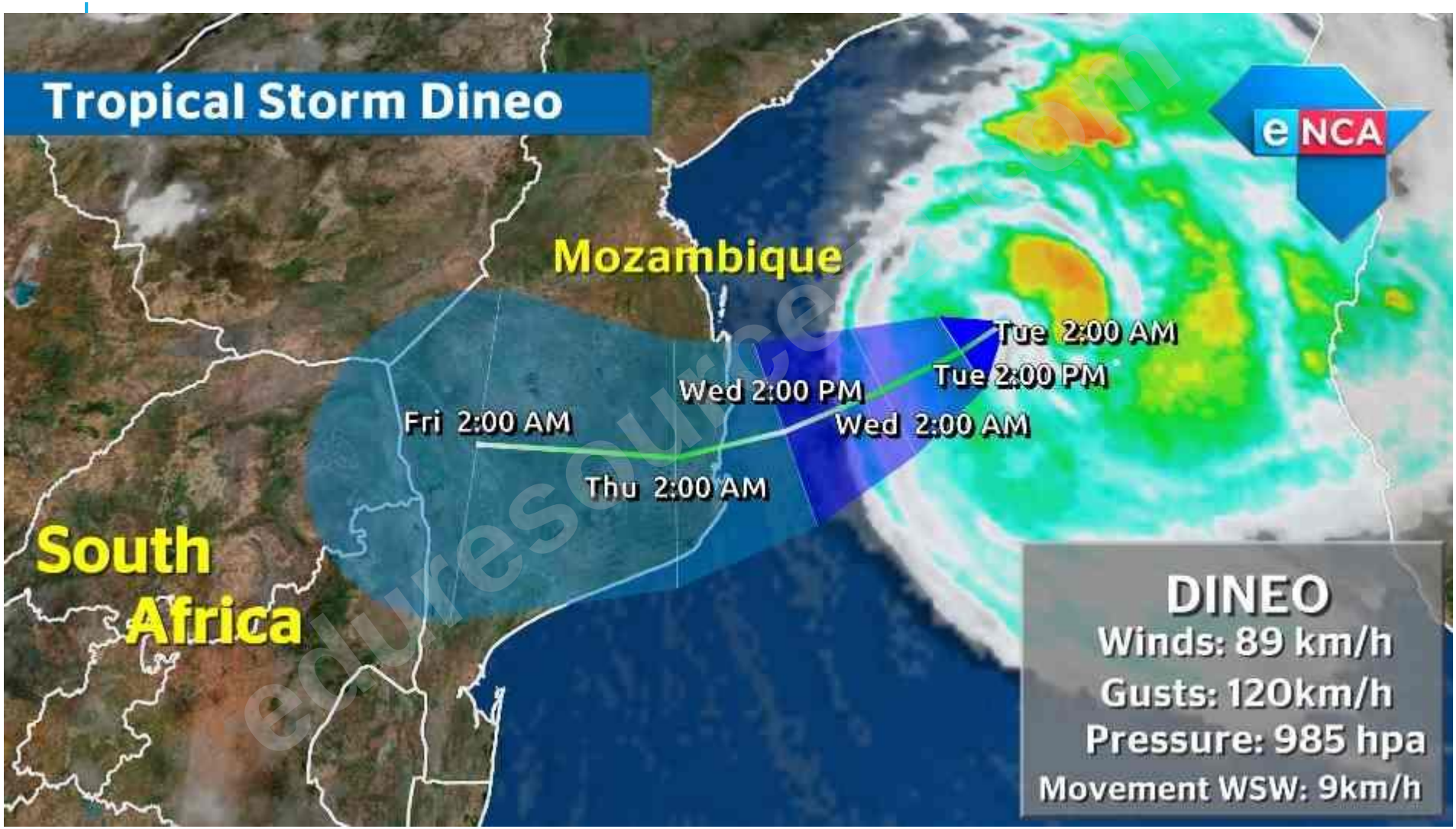


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WINDSPEED IN KNOPE VIB 4 MB/40 GPM
WINDSPEED IN KNOTS FOR 4 MB/40 GPM
South African Weather Service
1:20M
Met 1/1/3
FAPR ASZA 9
2017 /02/15
00:00Z
SEVERE TROPICAL STORM
DINEO
22.7S/37.8E
CENTRAL PRESSURE: 979 HPA
MX WIND AVE: 60 KT
WSW 7KT
LUANDA 160
ASCENSION 902
ST. HELENA 901
MOCAMEDES 422
WINDHOEK 112
WB 104
LD 300
PN 408
TRINIDADE 650
NAIROBI 741
SEYCHELLES 980
CHILEKA 693
LUMBO 241
DIEGO-SUAREZ 009
HARARE 775
BEIRA 297
EUROPA 922
PRETORIA 262
MAPUTS 341
FORT-DAUPHIN 197
MAURITIUS 990
GOUGH 906
MARION 994
CROZET 997
AMSTERDAM 969
KERGUELEN 998
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MAWSON
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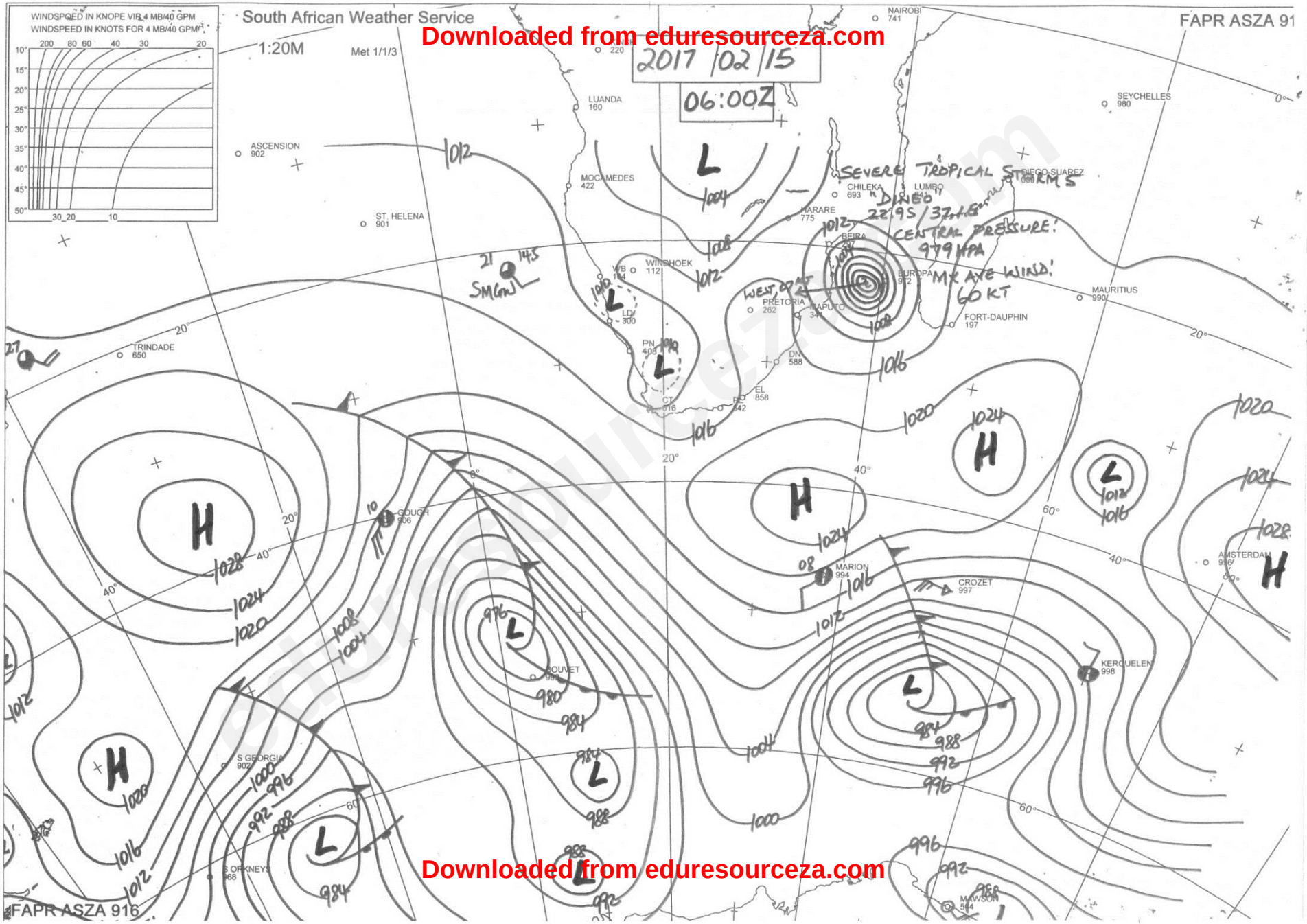

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0
5
15
25
35
rain rate [mm/hr]
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EUMETSAT
MPEF MPE 2017-02-15 05:30

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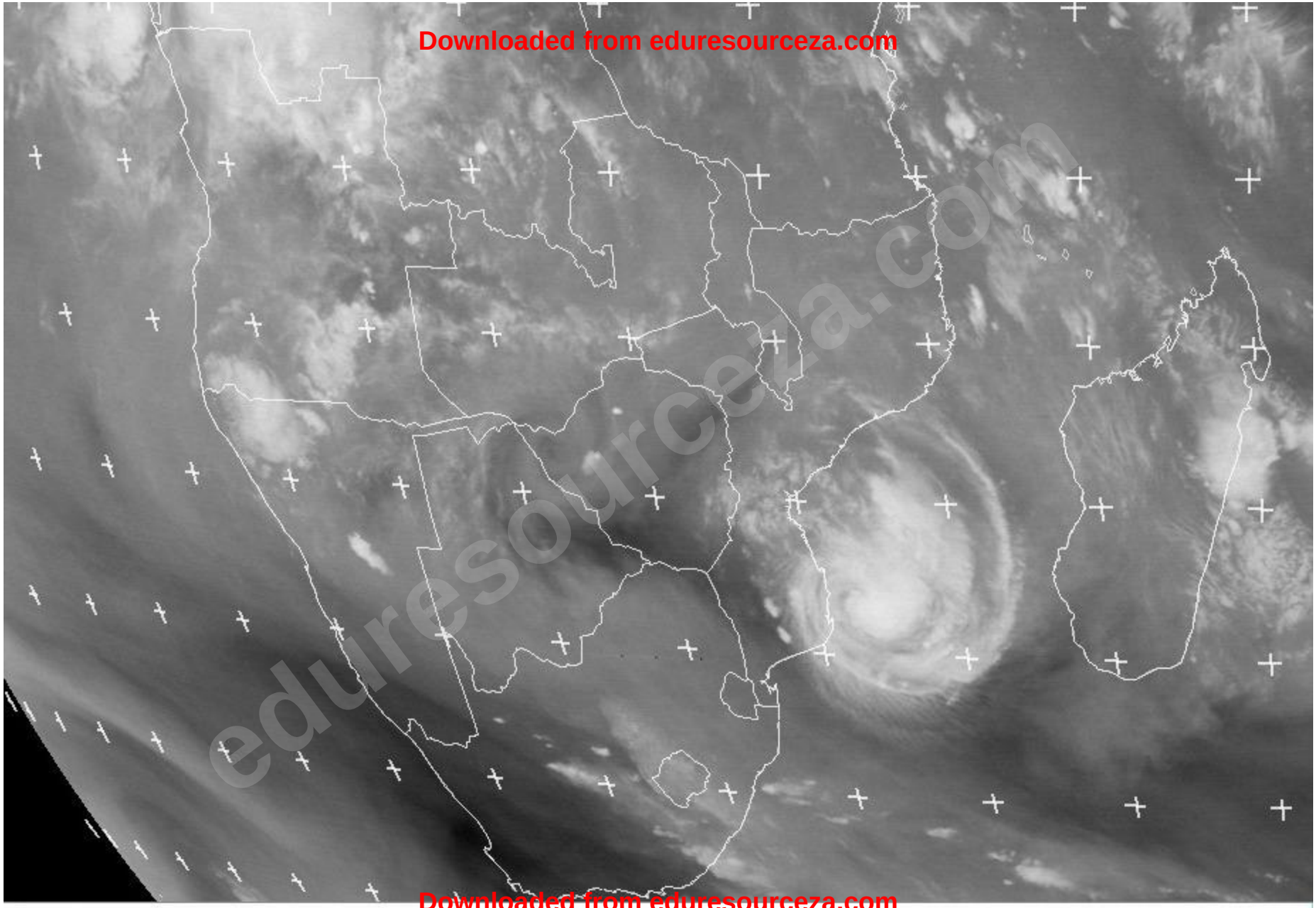
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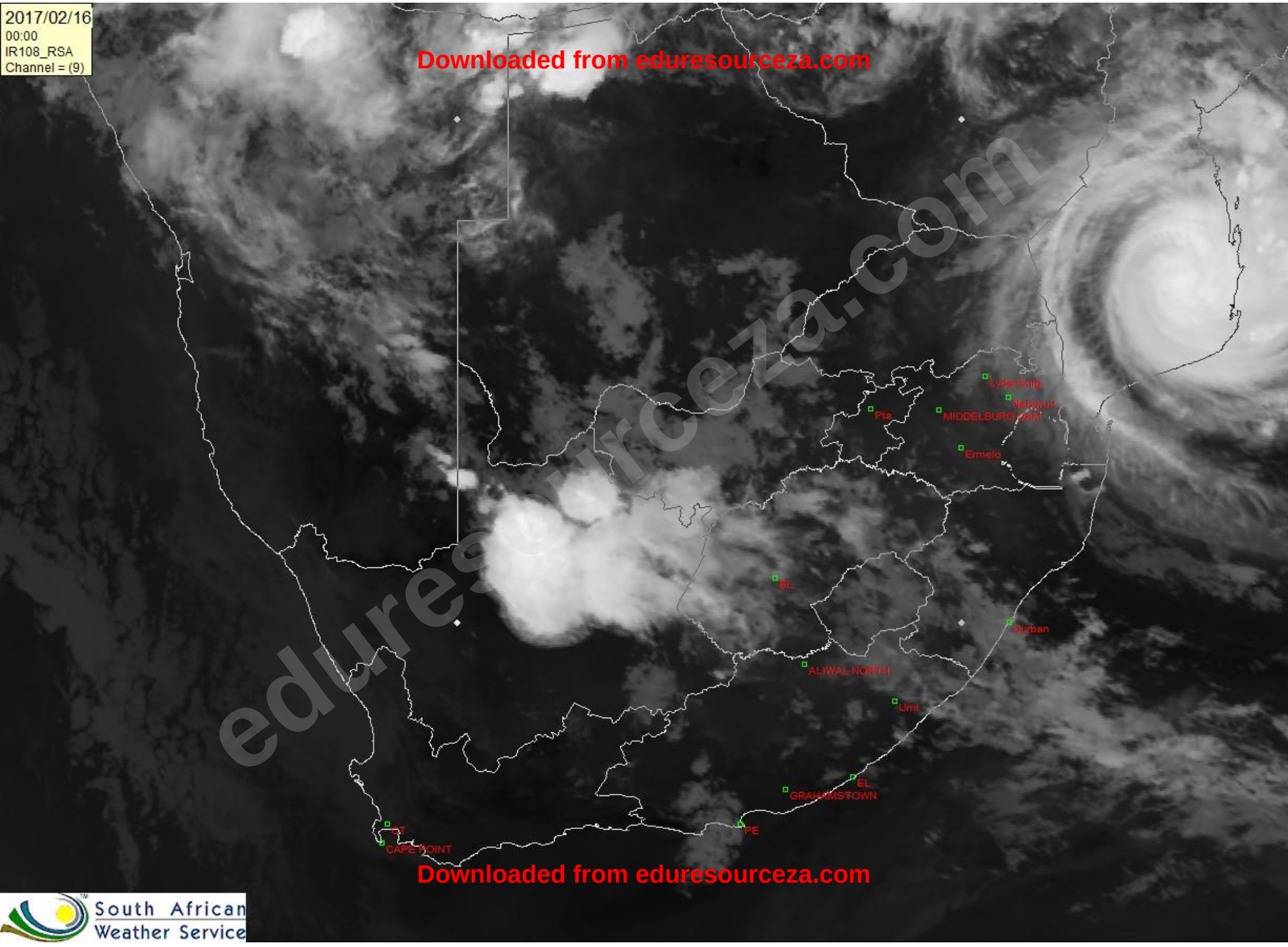


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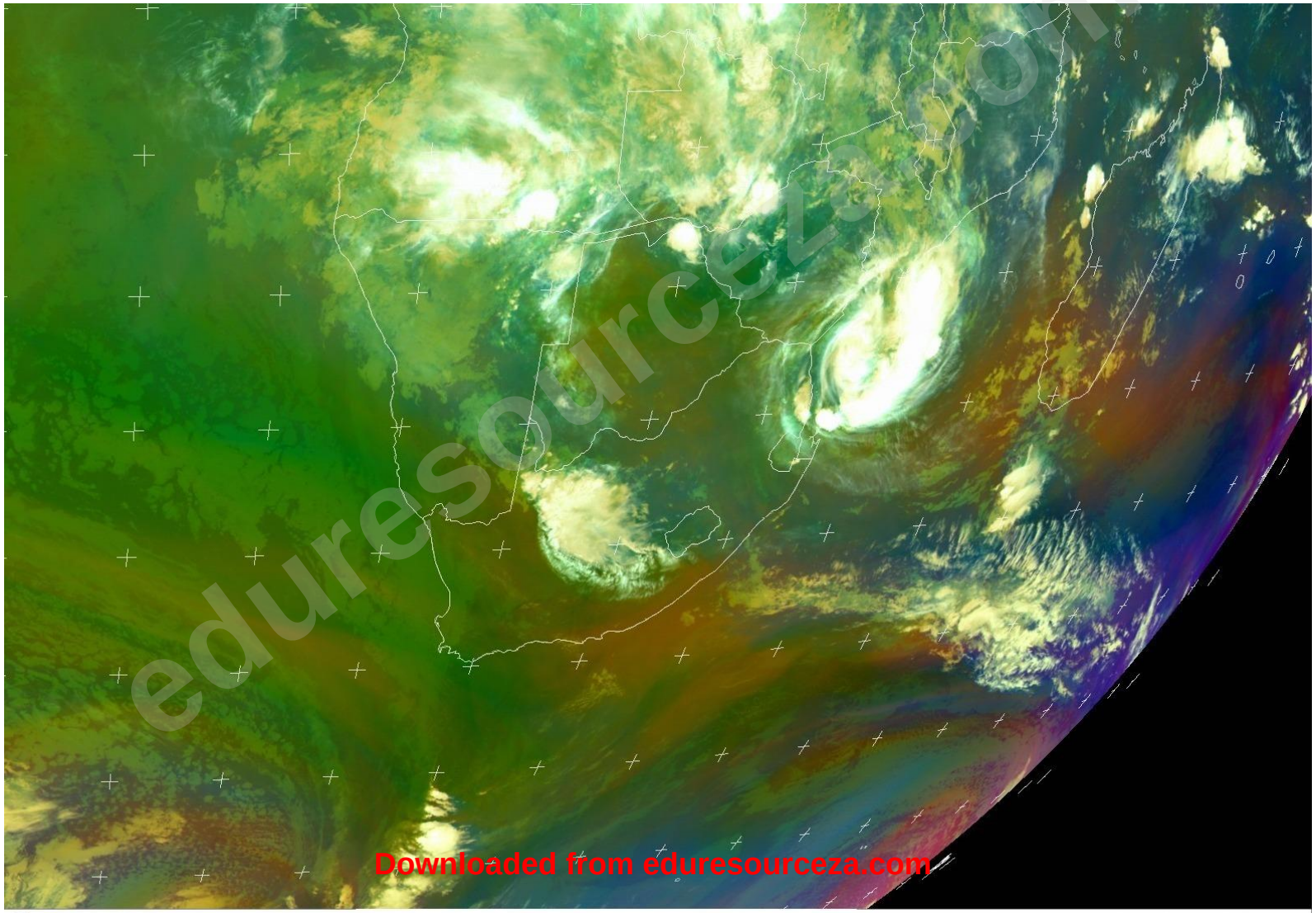
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Meteosat IODC WV 6.4, 2017-02-15 09:00:00 UTC

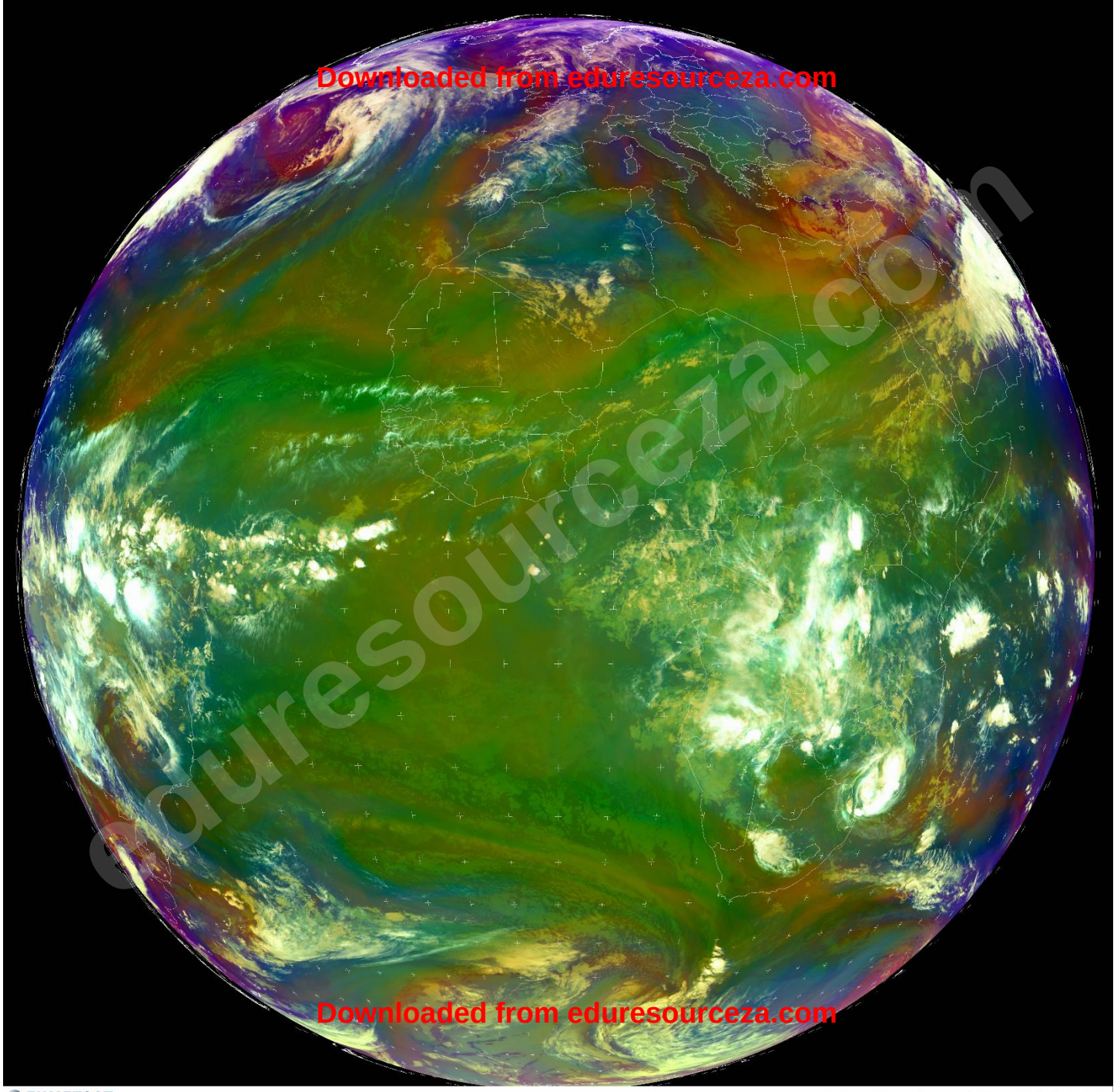

2017/02/16
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Pta
Ermelo
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Durban
ALIWAL NORTH
Umt
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Weather Service

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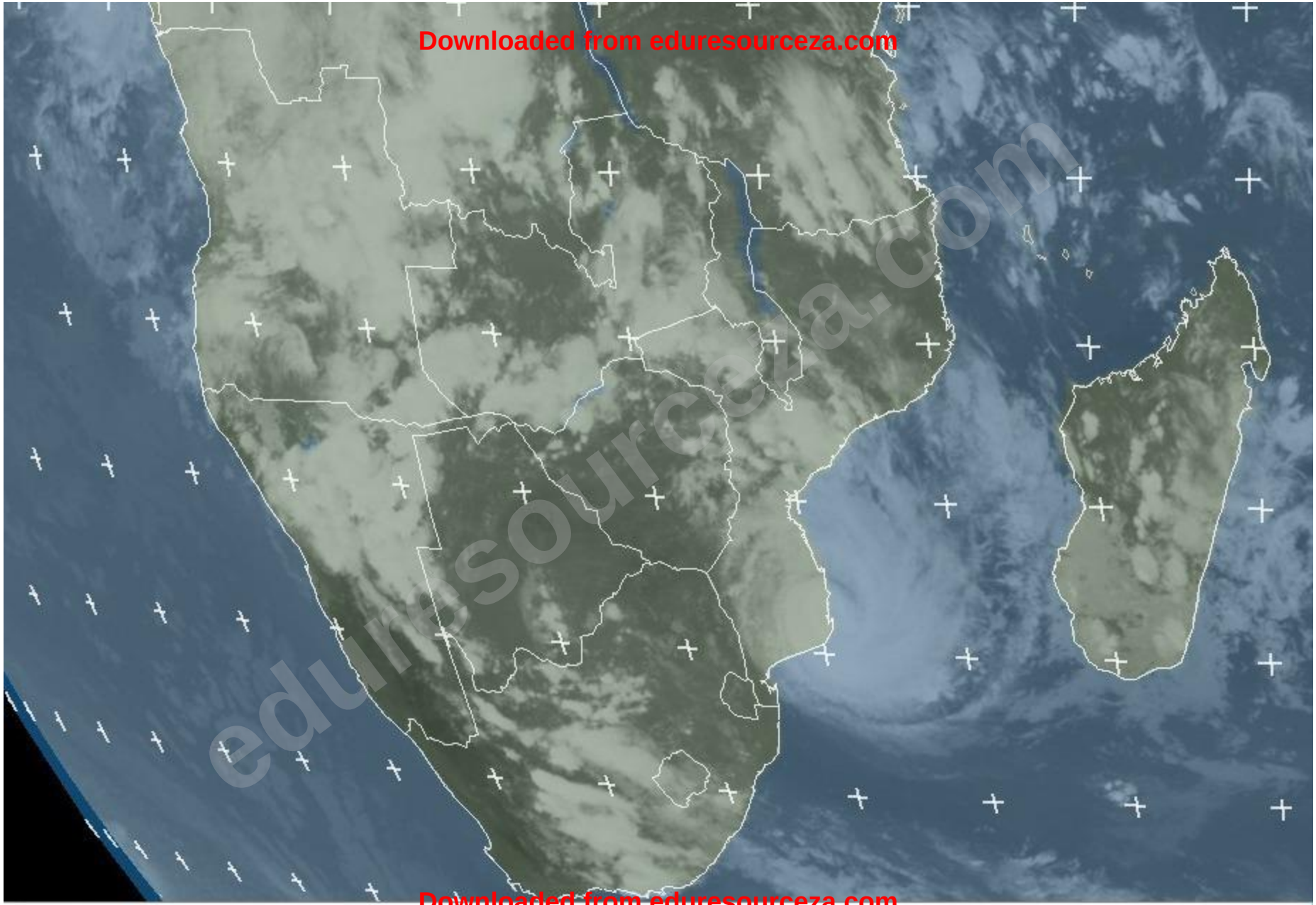
AIR MASS IMAGE



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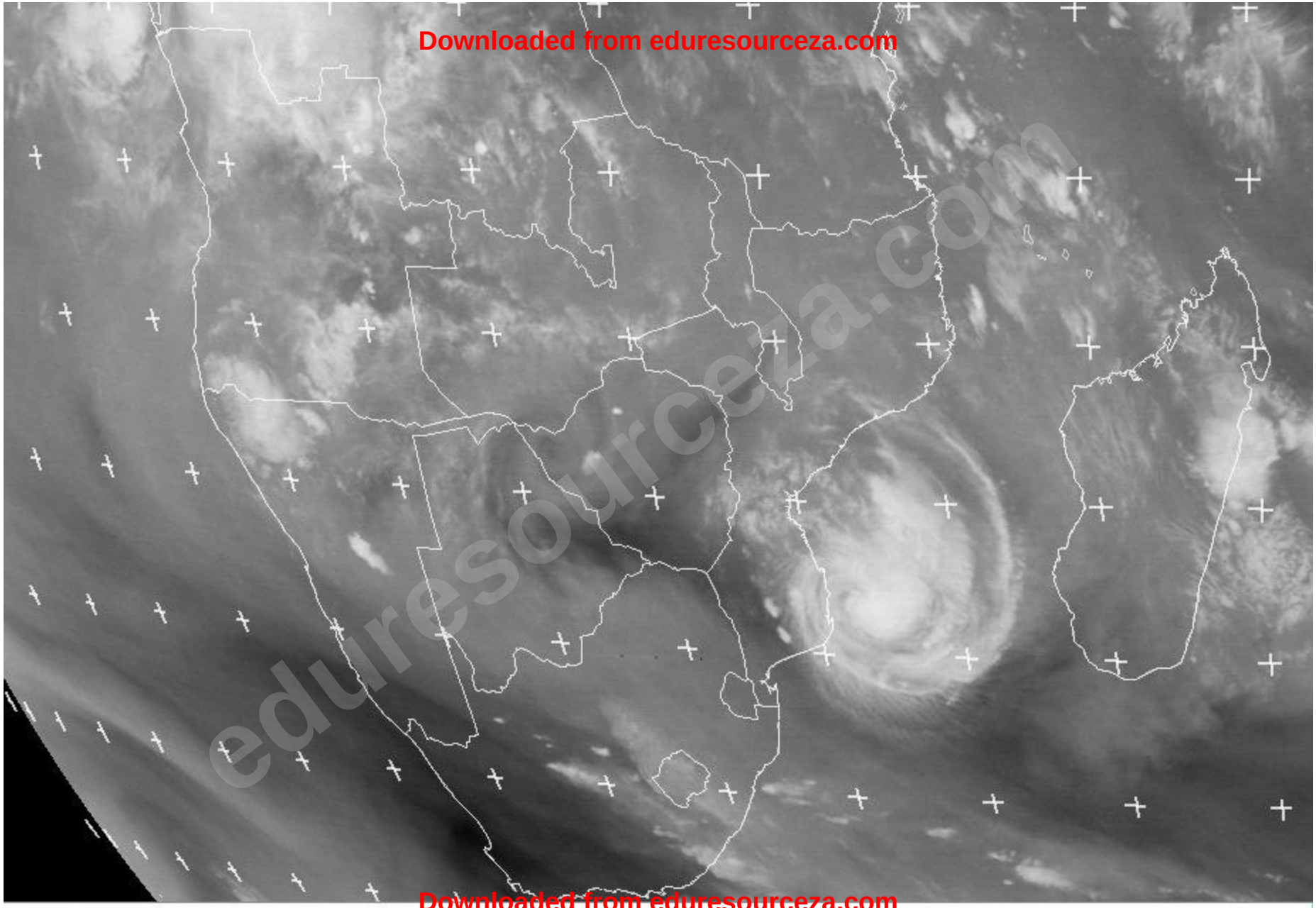

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Meteosat 0deg Airmass, 2017-02-16 05:00:00 UTC

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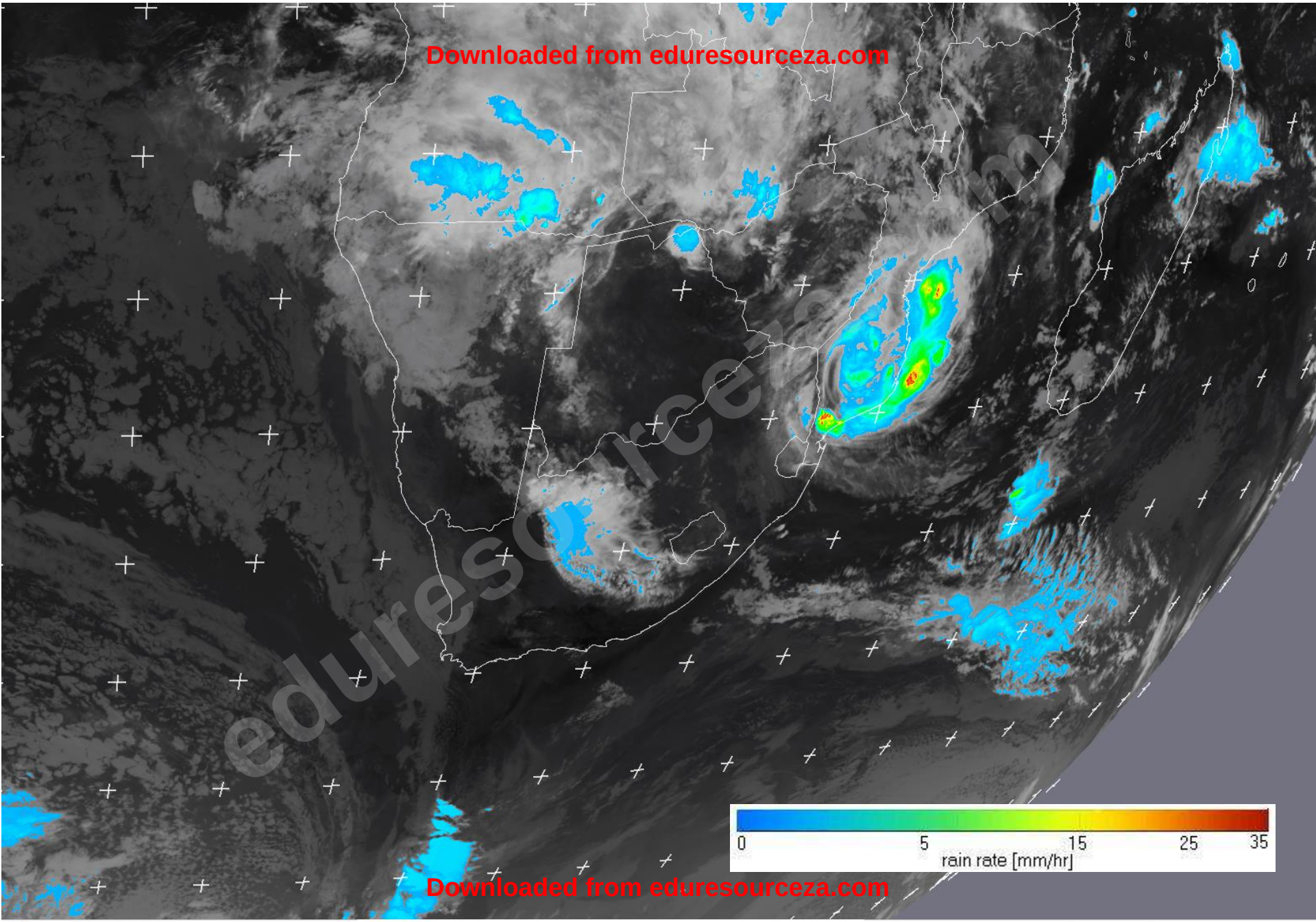
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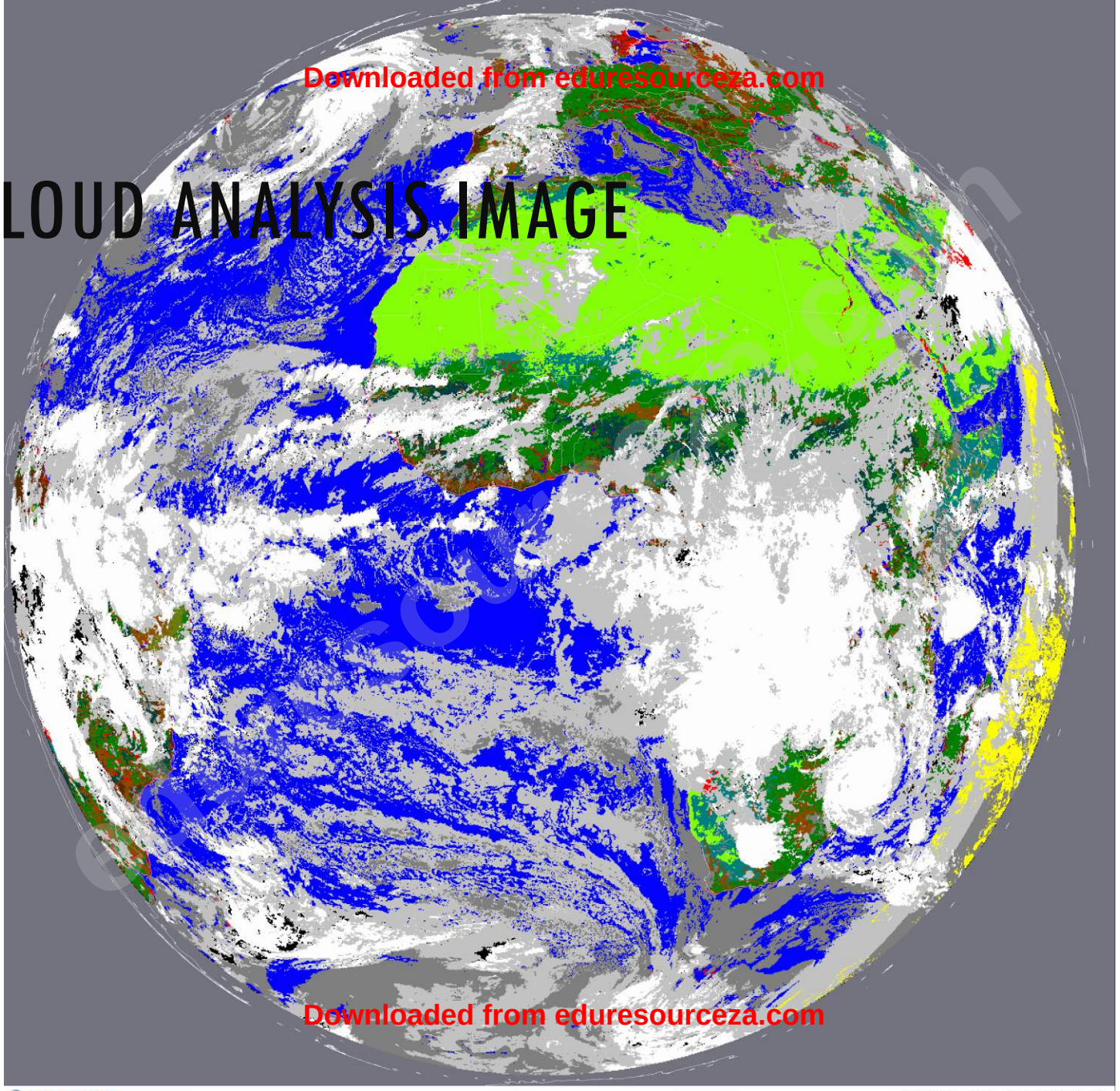
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MPEF MPE, 2017-02-16 05:30:00 UTC

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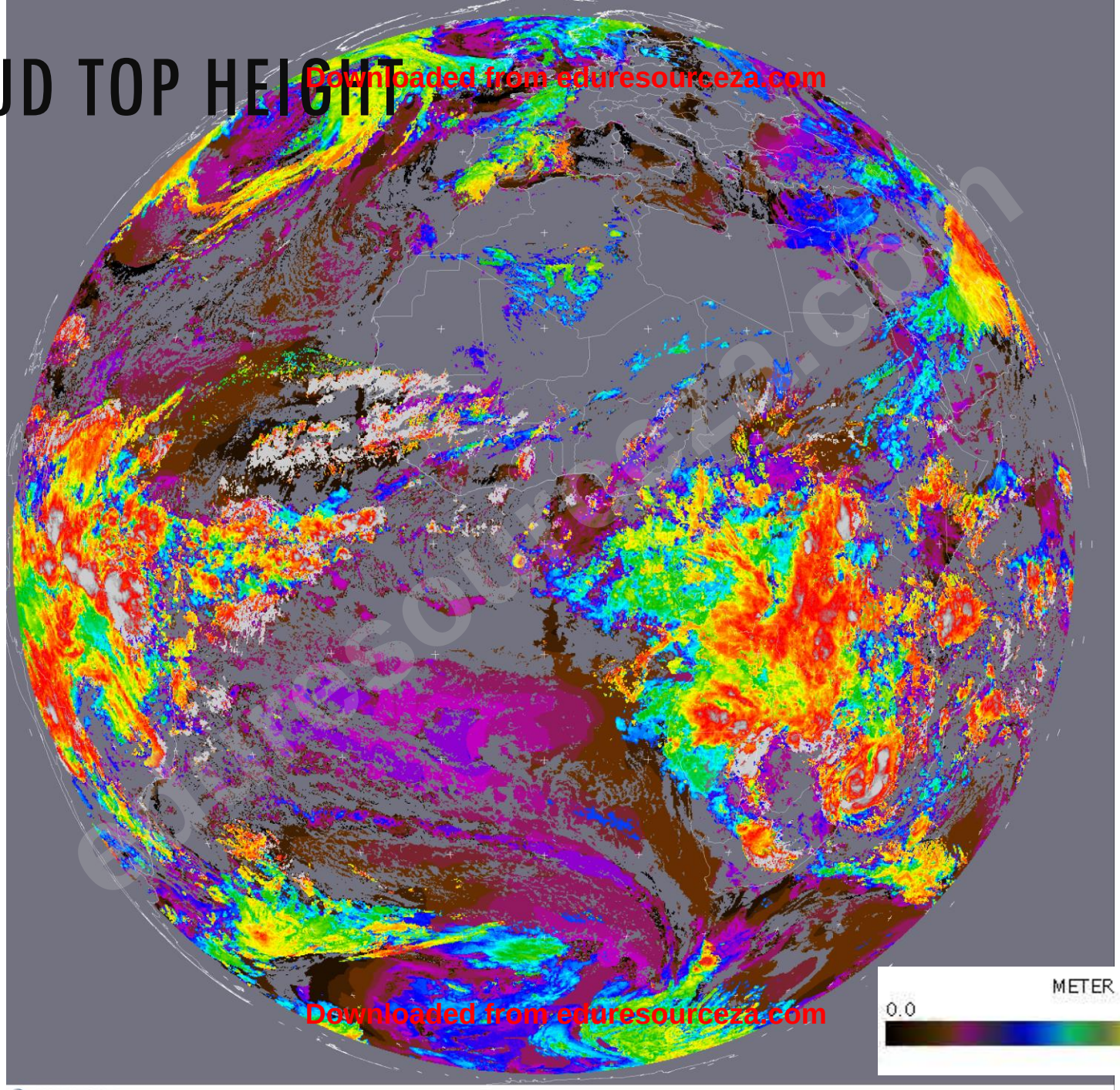
CLOUD ANALYSIS IMAGE



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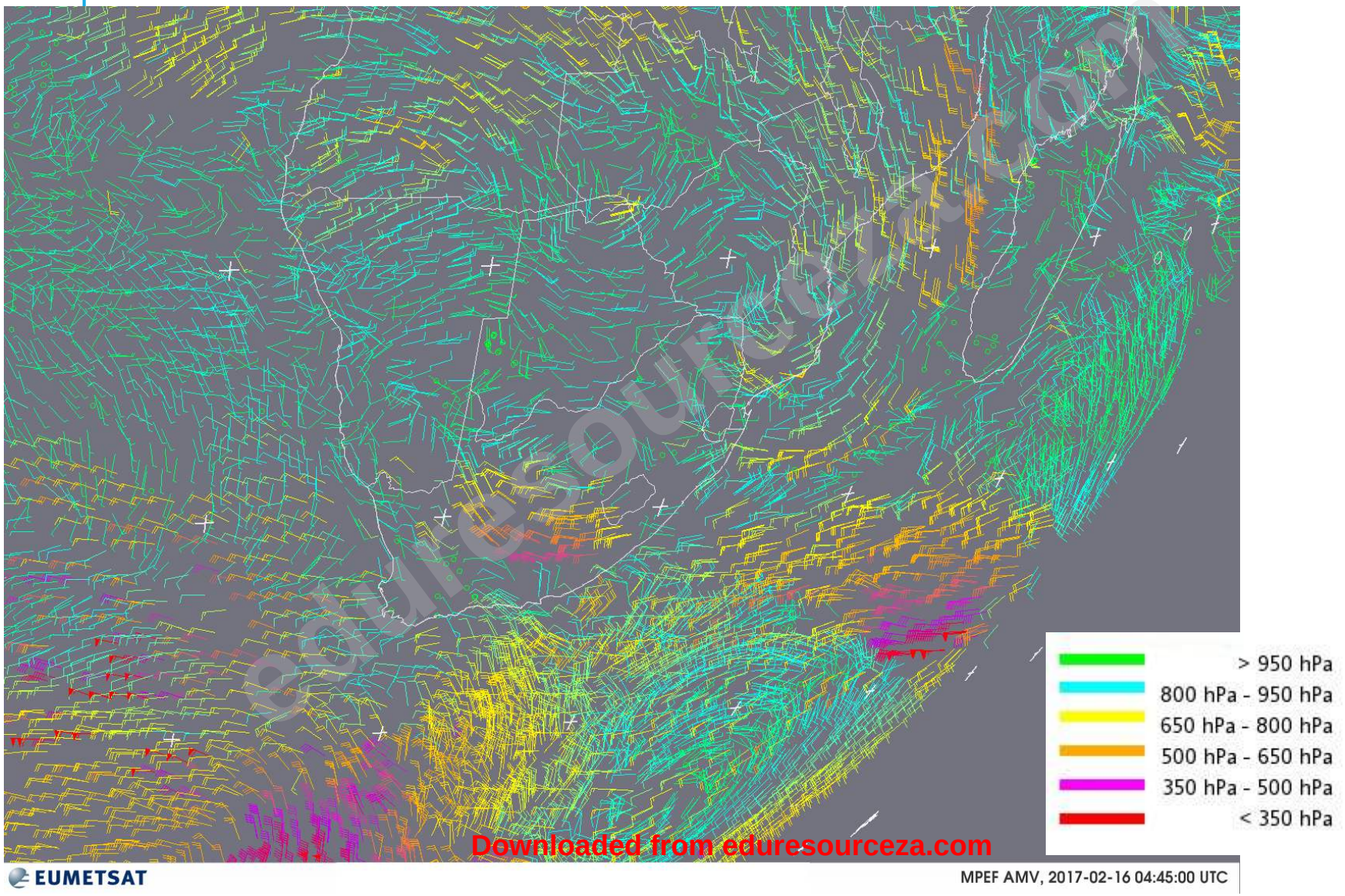
CLOUD TOP HEIGHT

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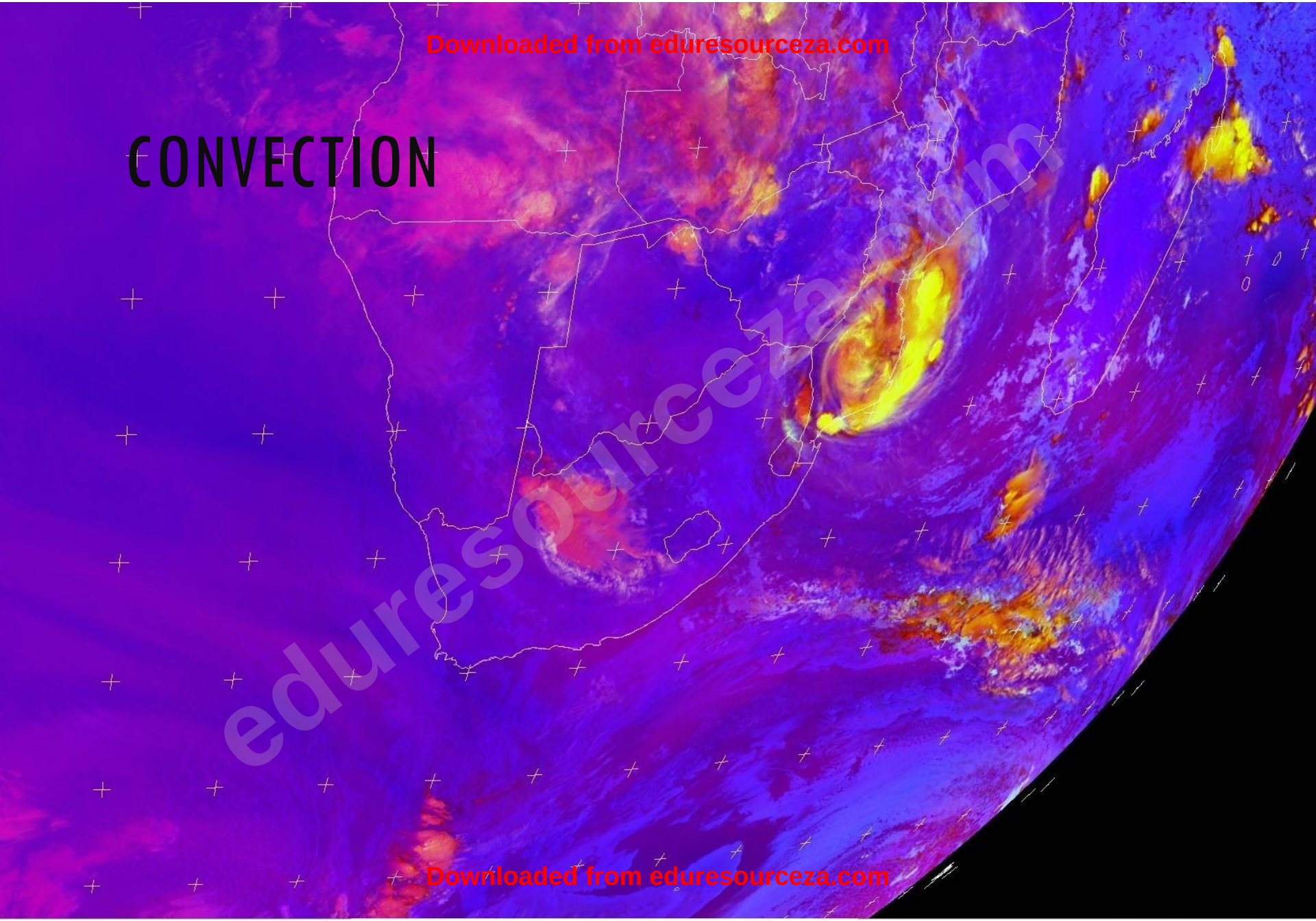
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CONVECTION



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EUMETSAT

Meteosat 0deg Convection, 2017-02-16 05:00:00 UTC

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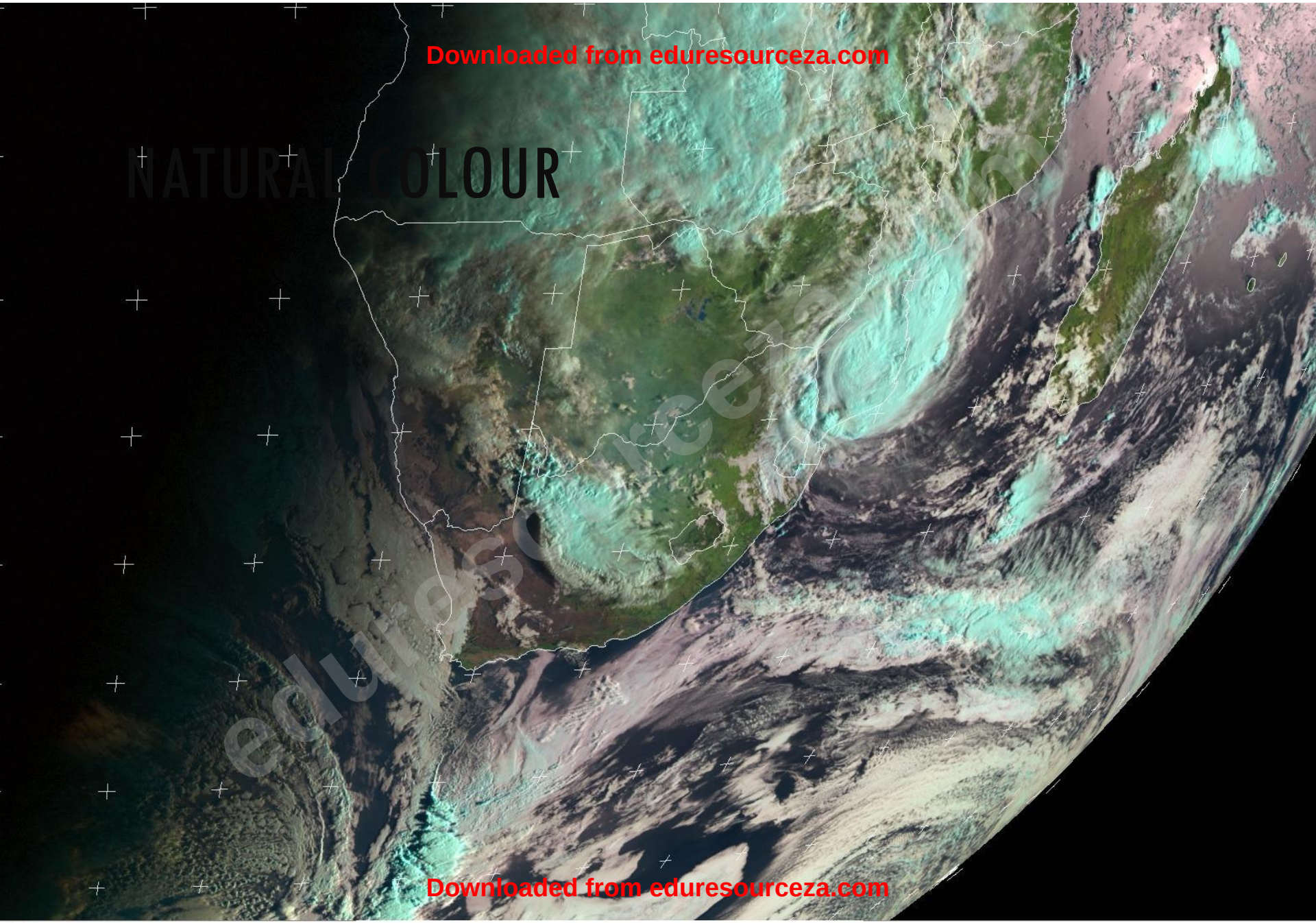
DAY MICROPHYSICS

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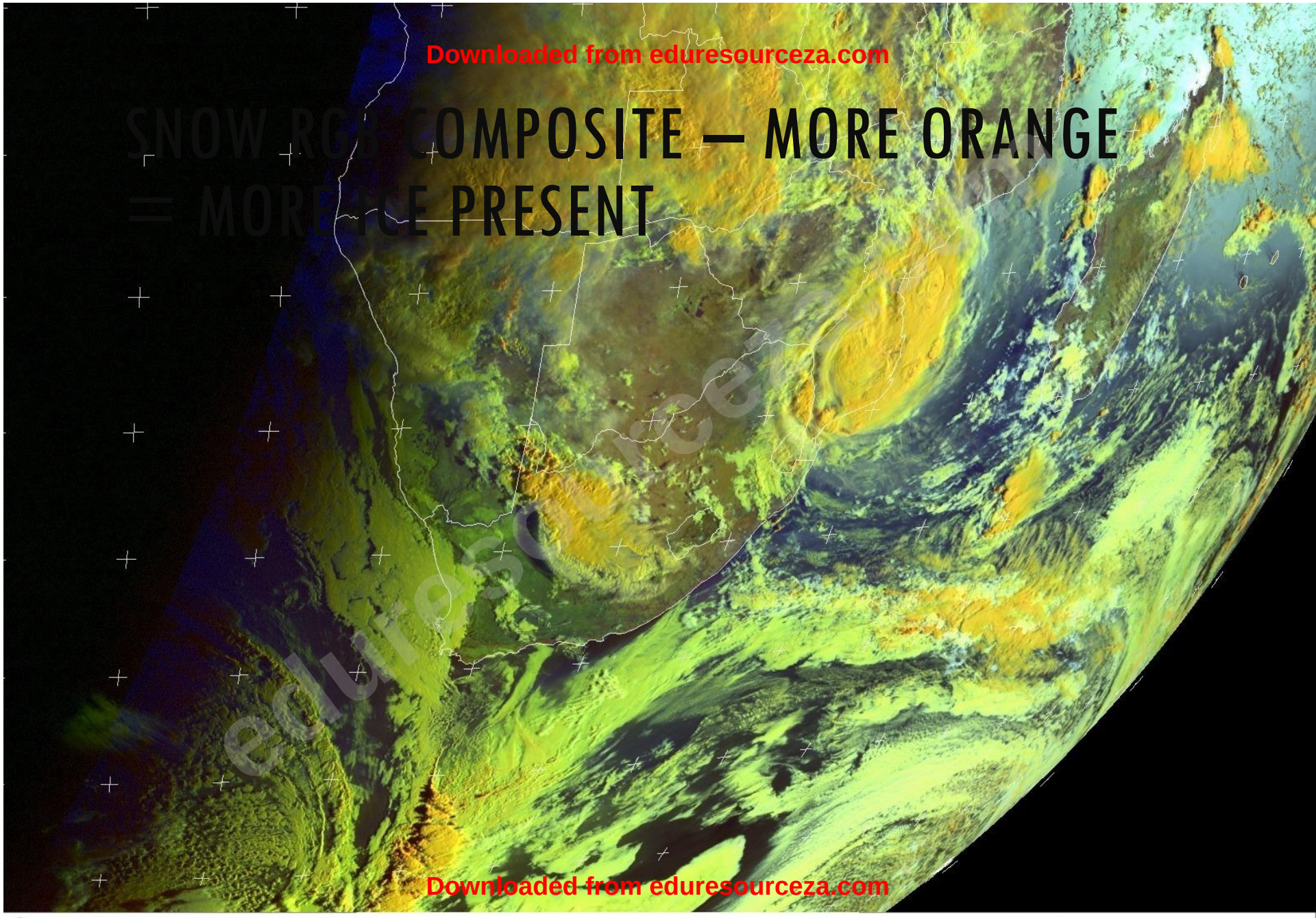
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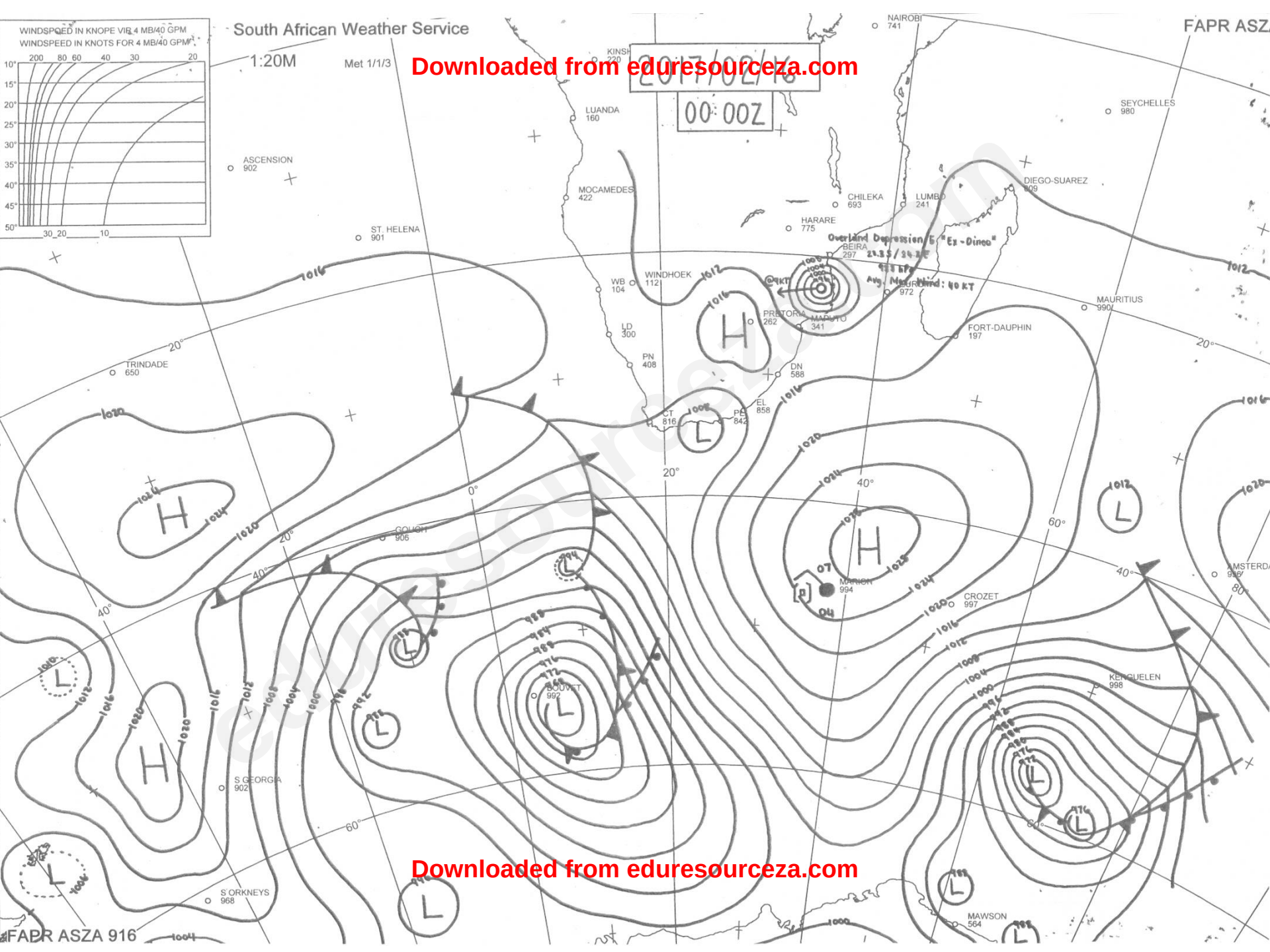
Meteosat 0deg Microphysics, 2017-02-16 05:00:00 UTC


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NATURAL COLOUR
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EUMETSAT
Meteosat 0deg Natural Colour, 2017-02-16 05:00:00 UTC

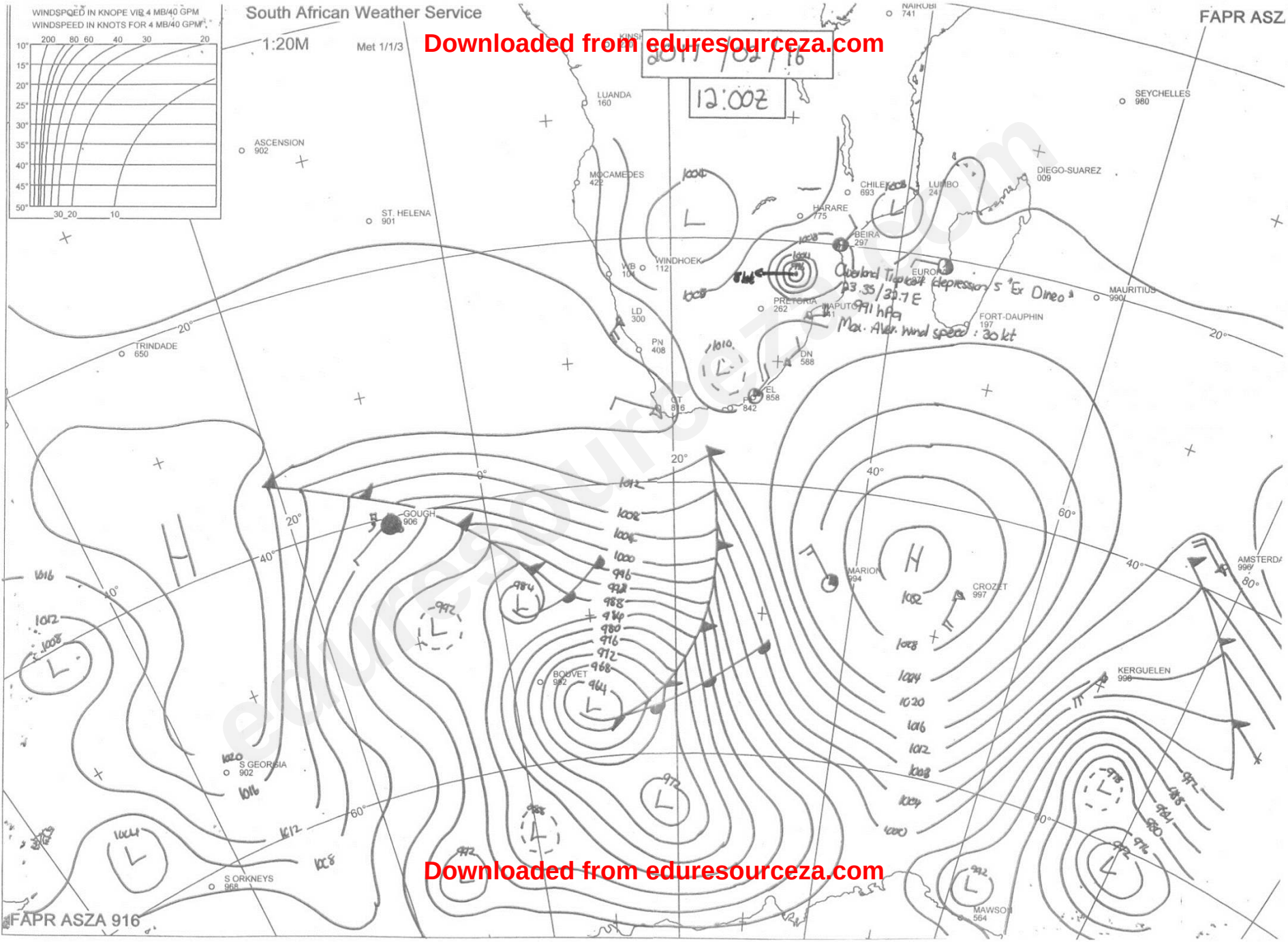
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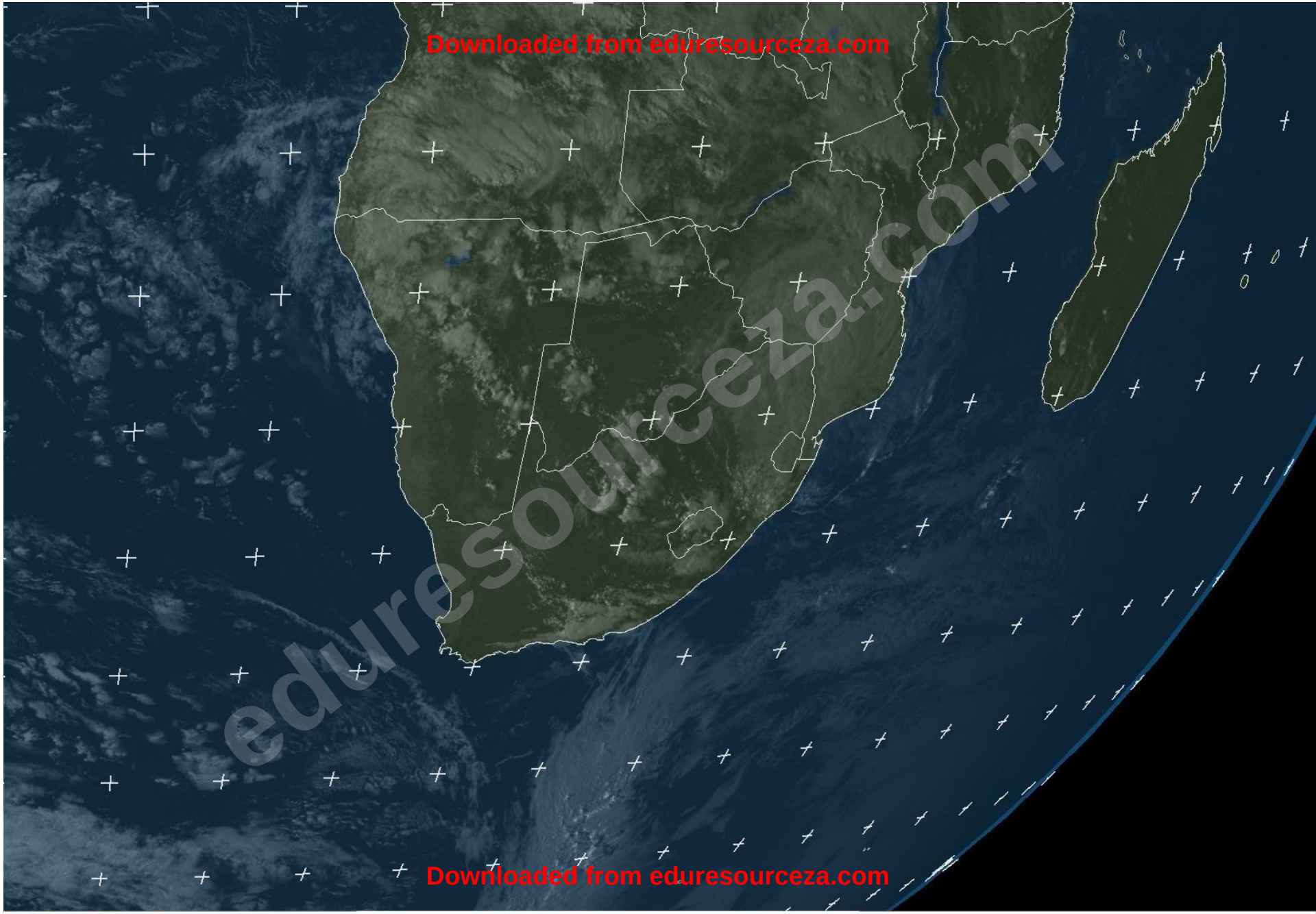


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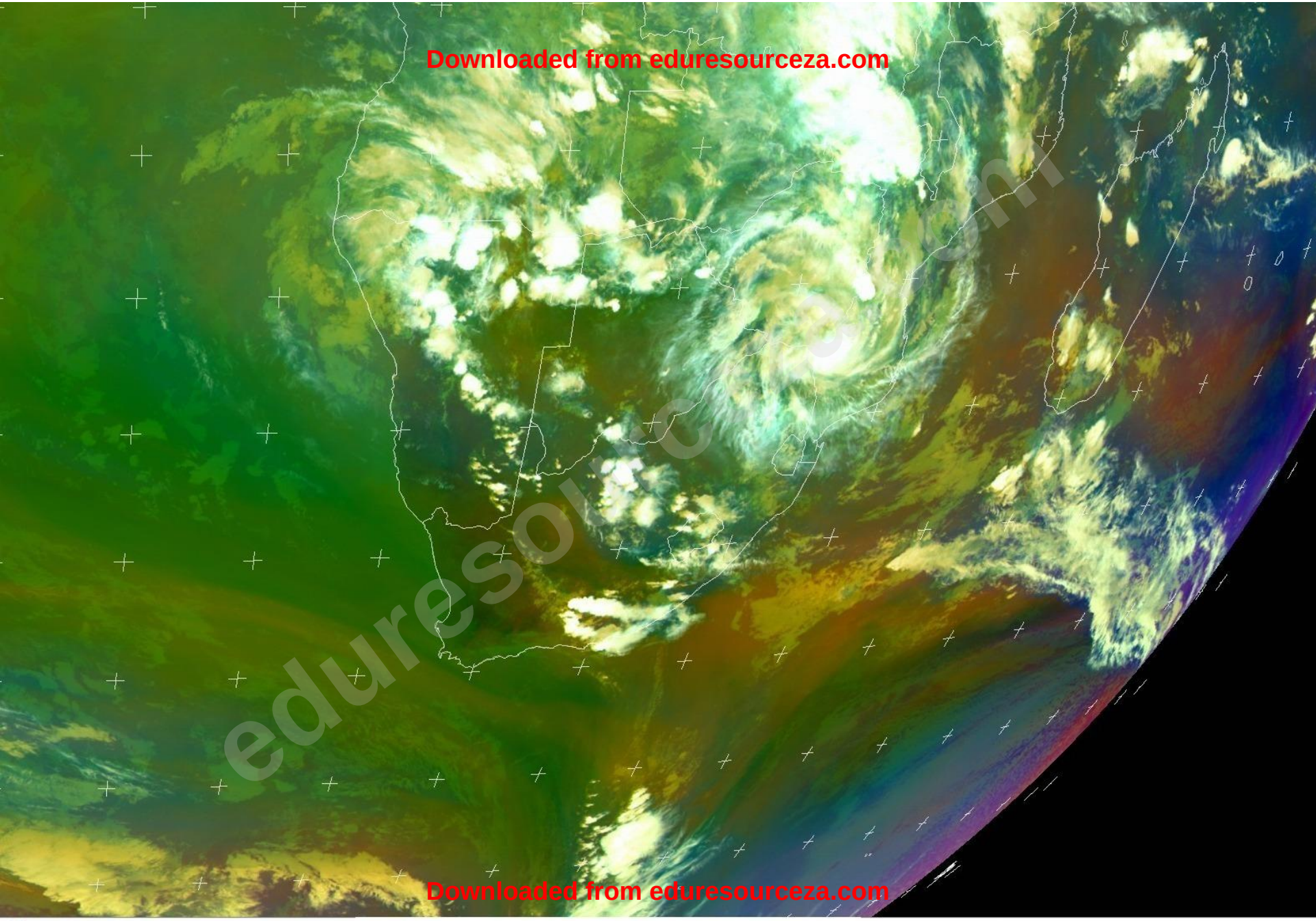


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WINDSPEED IN KNOPE VIB 4 MB/40 GPM
WINDSPEED IN KNOTS FOR 4 MB/40 GPM
South African Weather Service
1:20M
Met 1/1/3
FAPR ASZ
Downloaded from eduresourceza.com
2017/02/16
12:00Z
LUANDA 160
ASCENSION 902
ST. HELENA 901
MOCAMEDES 422
WINDHOEK 112
HARARE 775
CHILEKA 693
LUMBO 241
BEIRA 297
DIEGO-SUAREZ 009
SEYCHELLES 980
EUROA
PRETORIA 262
MAPUTO 741
FORT-DAUPHIN 197
MAURITIUS 990
TRINDADE 650
GOUGH 906
MARION 994
CROZET 997
BOUVET 992
KERGUELEN 996
S GEORGIA 902
S ORKNEYS 968
MAWSON 564
Cyclonic Tropical depression 5 'Ex Dineo'
23.3S/30.7E
991 hPa
Max. Aver. wind speed : 30 kt
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FAPR ASZA 916


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EUMETSAT
Meteosat 0deg VIS 0.6, 2017-02-16 15:00:00 UTC

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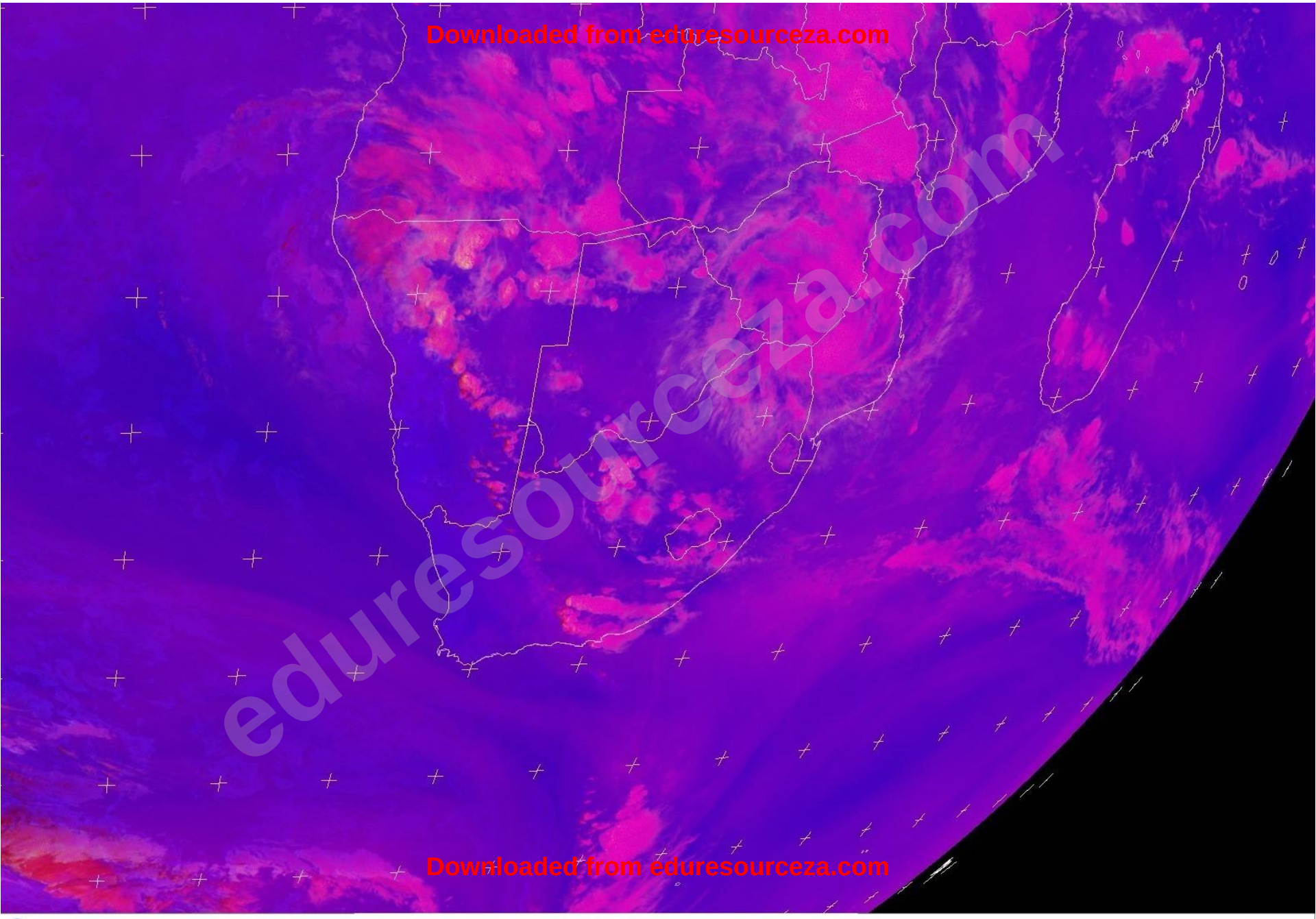
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EUMETSAT

Meteosat 0deg Airmass, 2017-02-16 17:00:00 UTC

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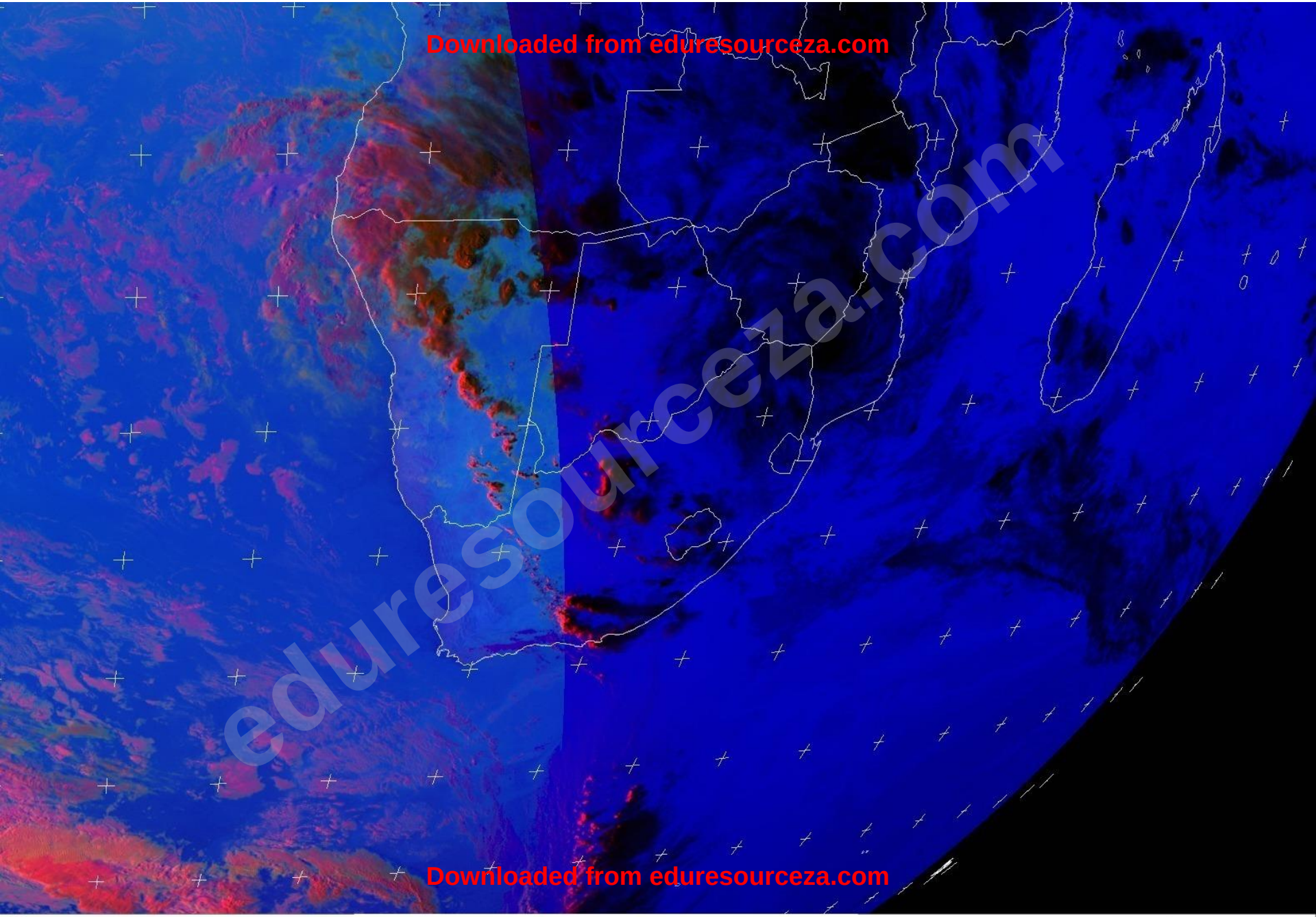


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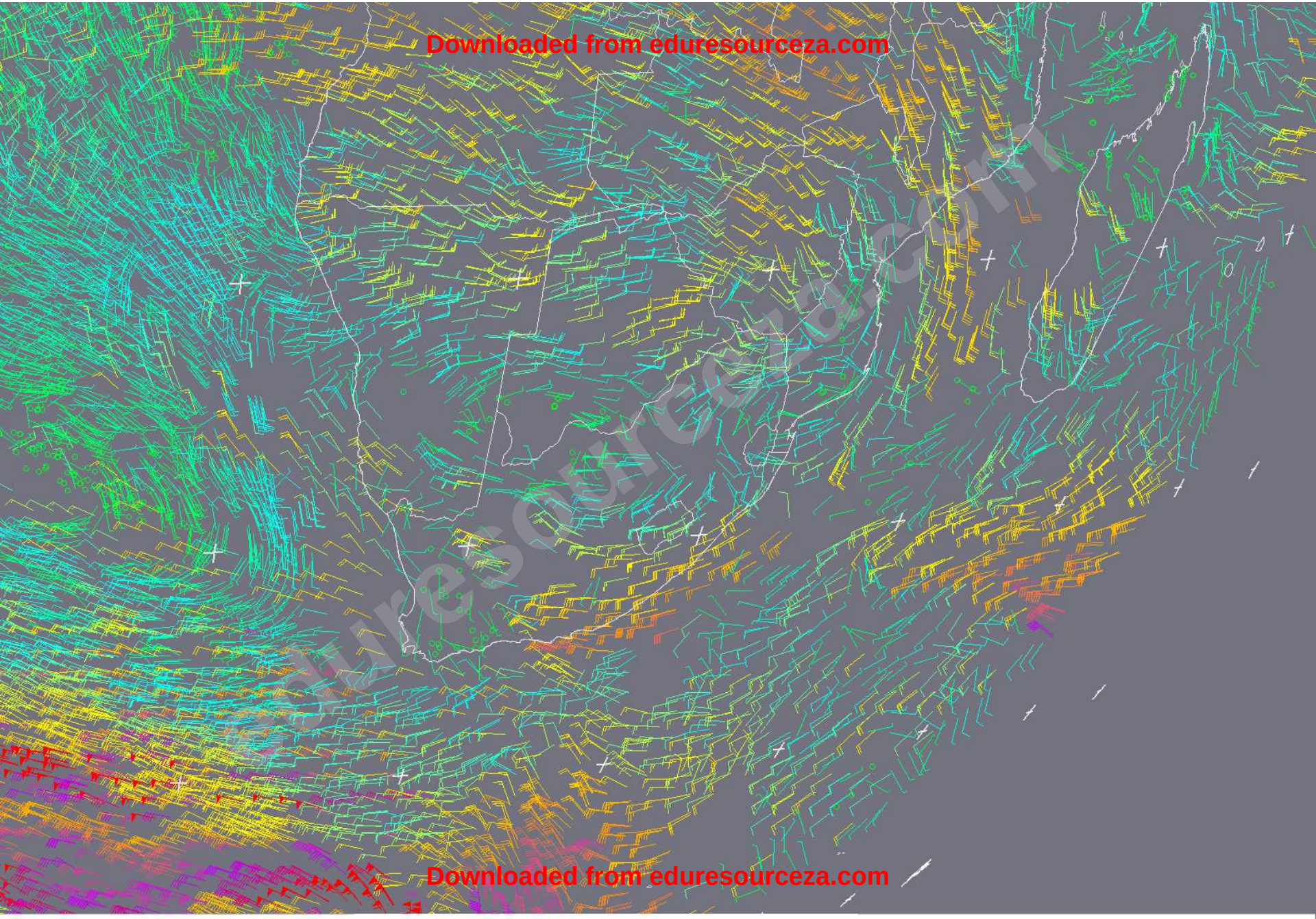
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Meteosat 0deg Convection, 2017-02-16 17:00:00 UTC


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EUMETSAT
Meteosat 0deg Microphysics, 2017-02-16 17:00:00 UTC

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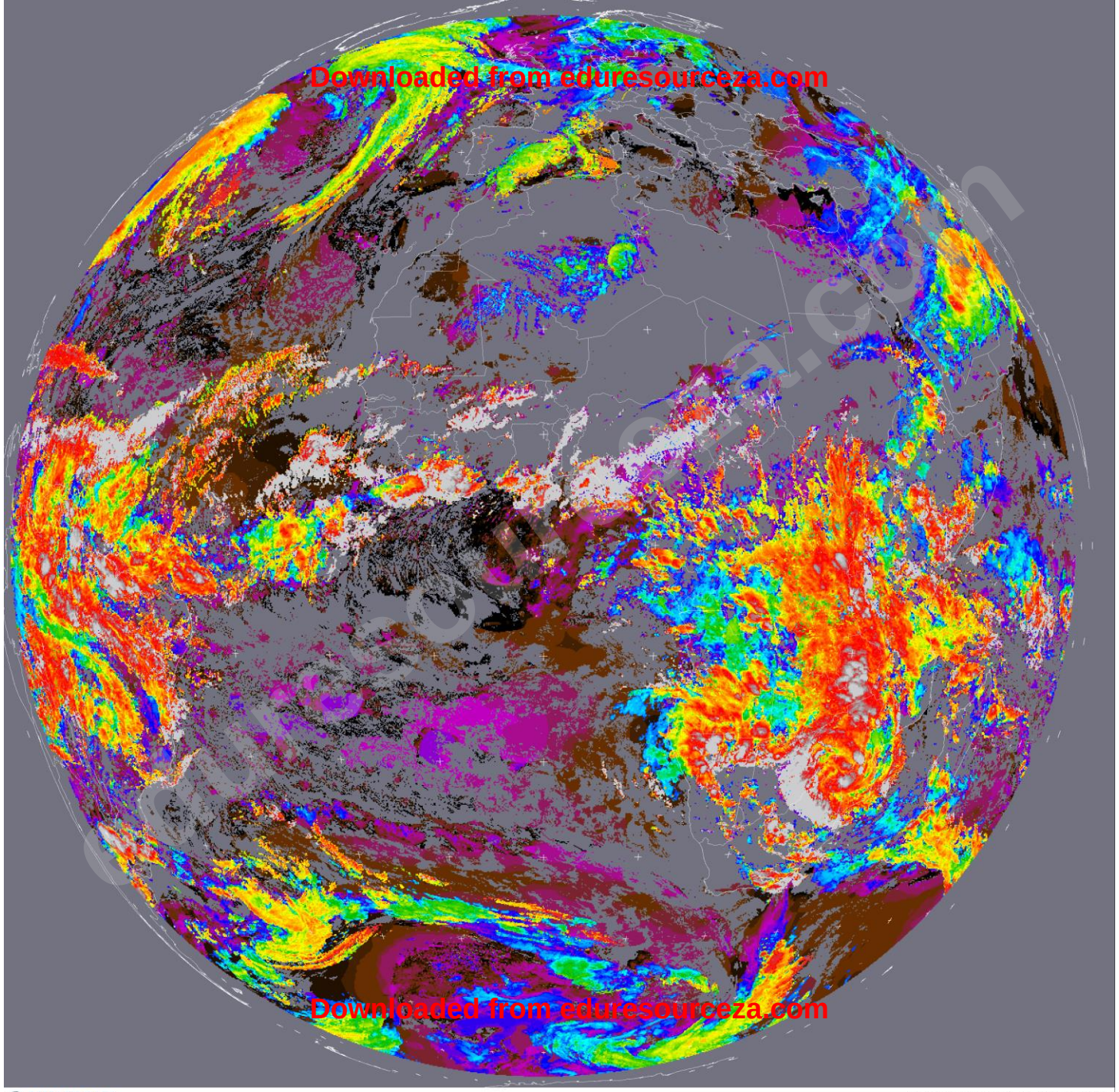


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EUMETSAT

MPEF AMV, 2017-02-16 16:45:00 UTC

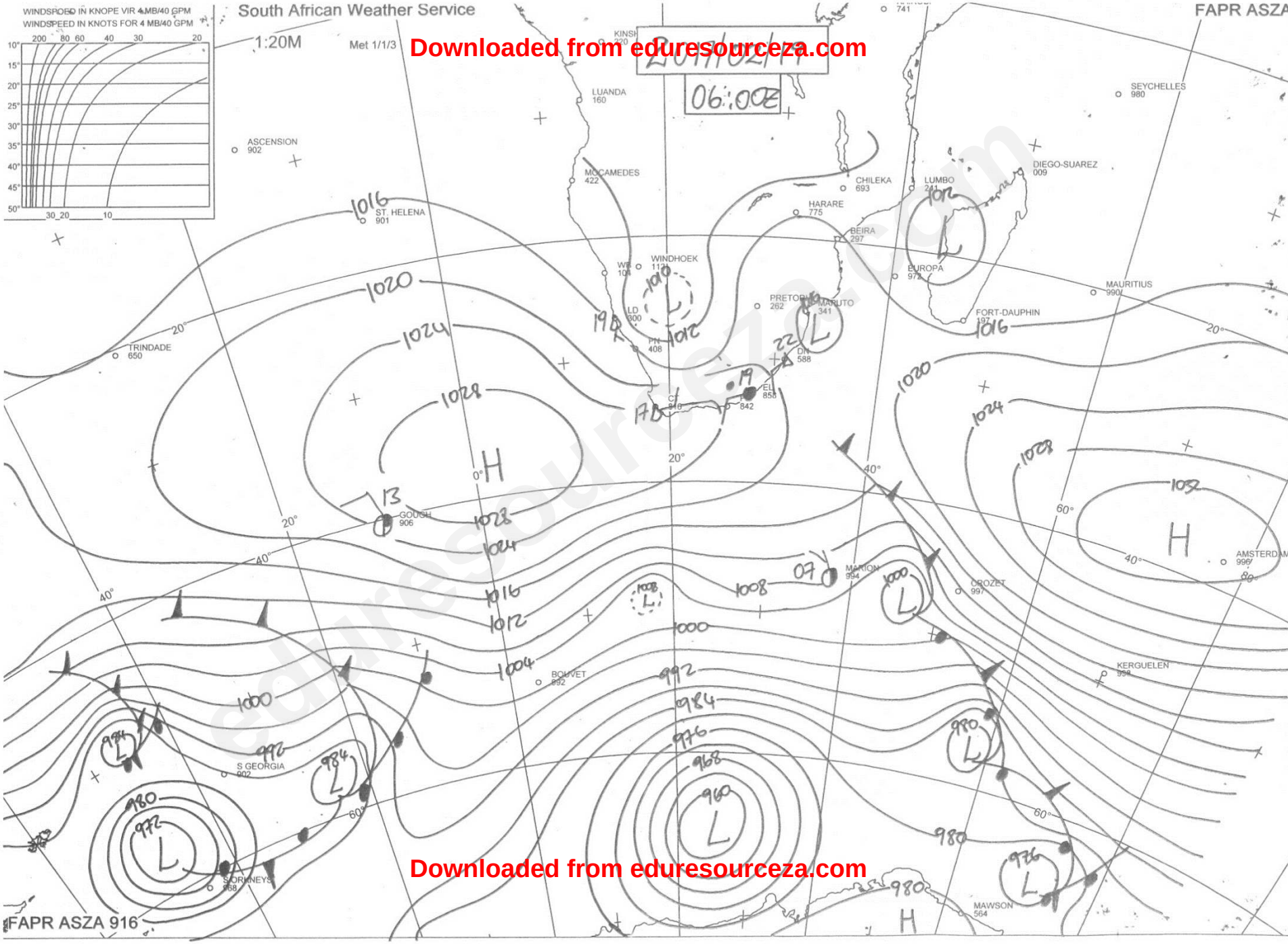
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EUMETSAT

MPEF CTH, 2017-02-16 17:45:00 UTC


WINDSPEED IN KNOPE VIR 4 MB/40 GPM
WINDSPEED IN KNOTS FOR 4 MB/40 GPM
South African Weather Service
1:20M
Met 1/1/3
FAPR ASZA
Downloaded from eduresourceza.com
06:00Z
LUANDA
160
ASCENSION
902
MOCAMEDES
422
ST. HELENA
901
TRINDADE
650
WINDHOEK
CHILEKA
693
HARARE
775
BEIRA
297
LUMBO
DIEGO-SUAREZ
009
SEYCHELLES
980
EUROPA
MAURITIUS
990
FORT-DAUPHIN
PRETORIA
262
MARUTO
341
GOUGH
906
BOUVET
MARION
994
CROZET
997
AMSTERDAM
996
KERGUELEN
S GEORGIA
902
SKORMEYS
MAWSON
564
1016
1020
1024
1028
1012
1008
1004
1000
996
992
988
984
980
976
972
968
960
20°
40°
60°
0°
FAPR ASZA 916

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DINEO IN NUMBERS

The number of people killed by the tropical cyclone - 7

People injured during the cyclone - 14

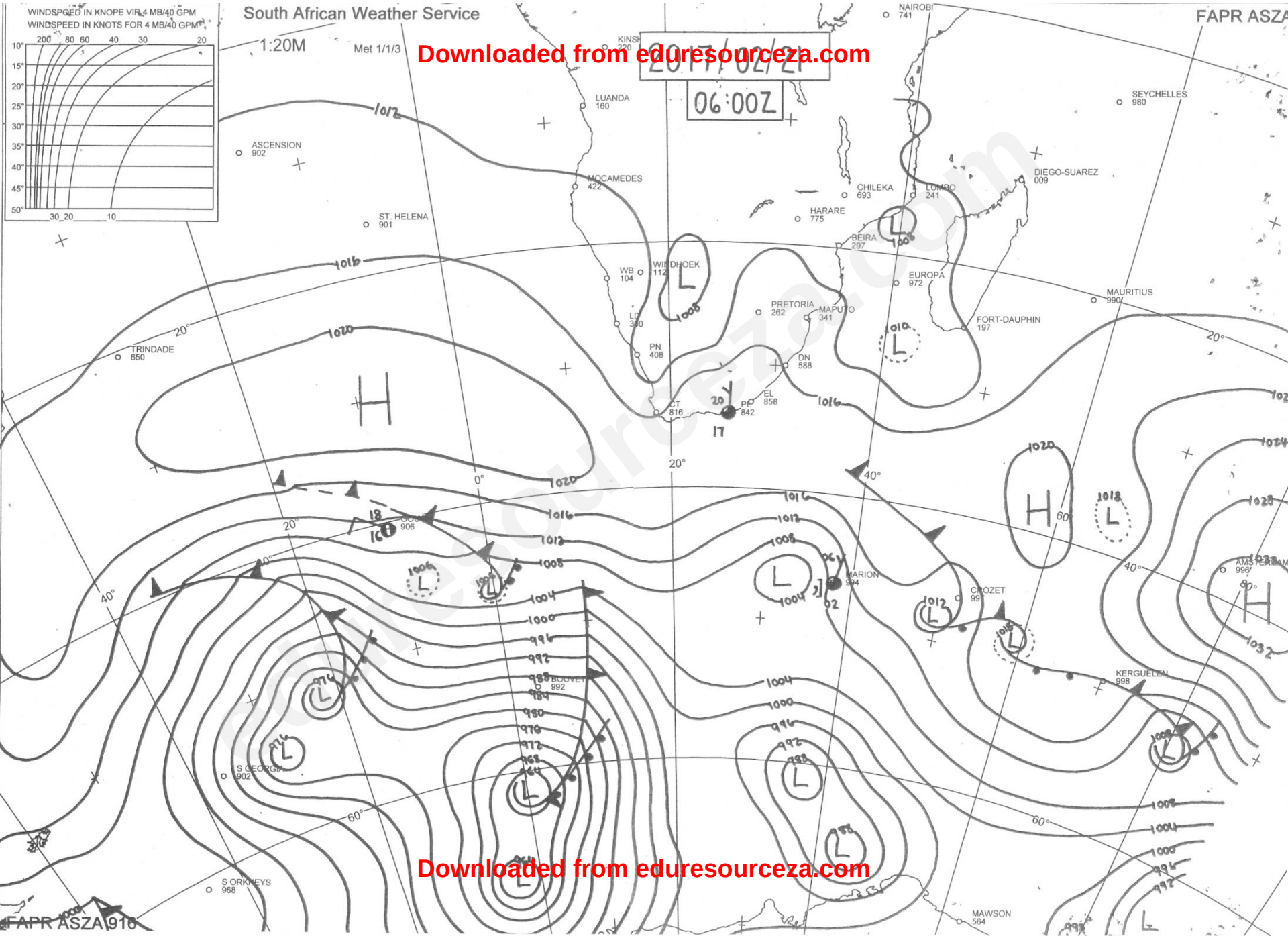
People affected by the storm - 170 000

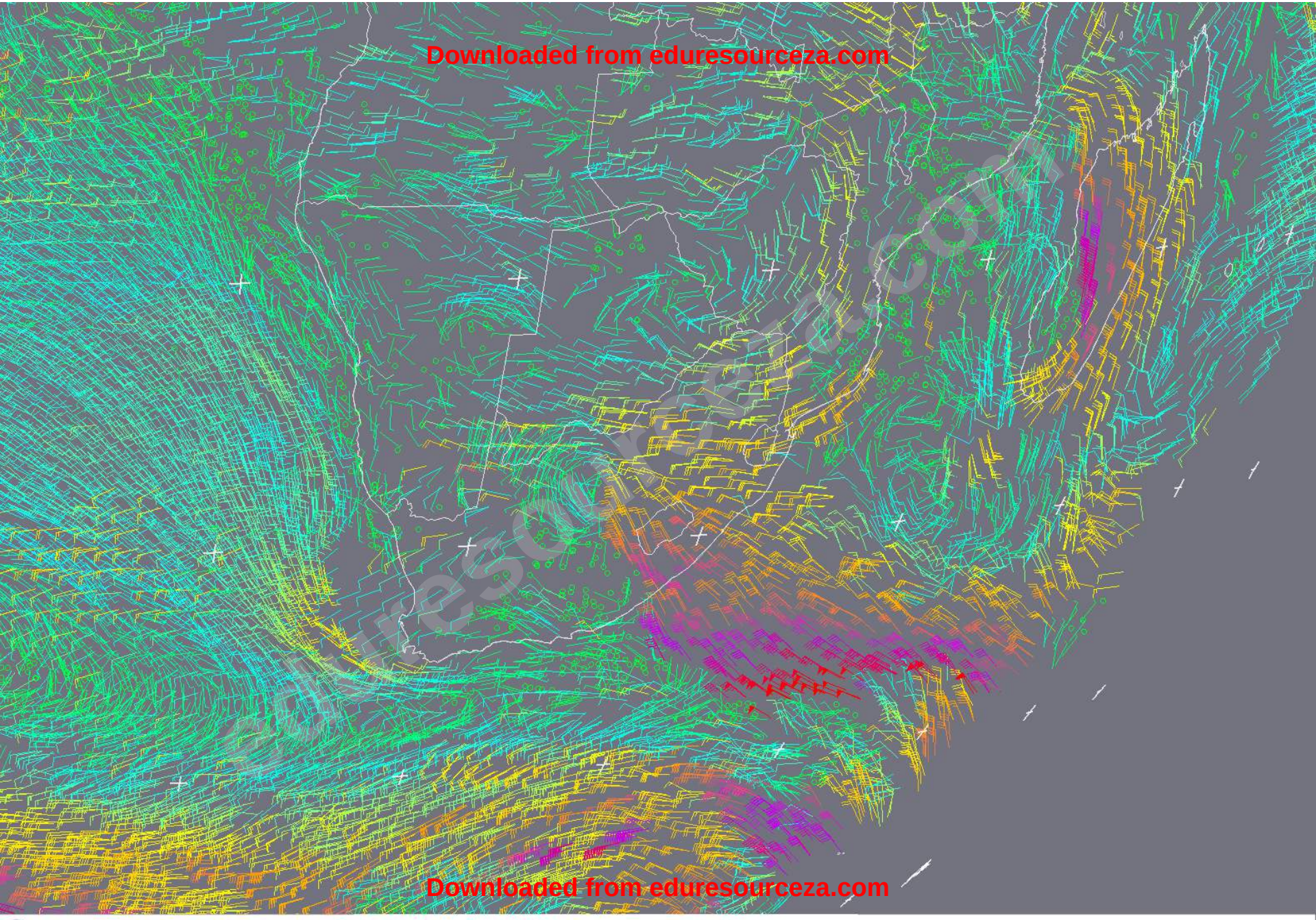
Wind speed during the cyclone - 160km/h

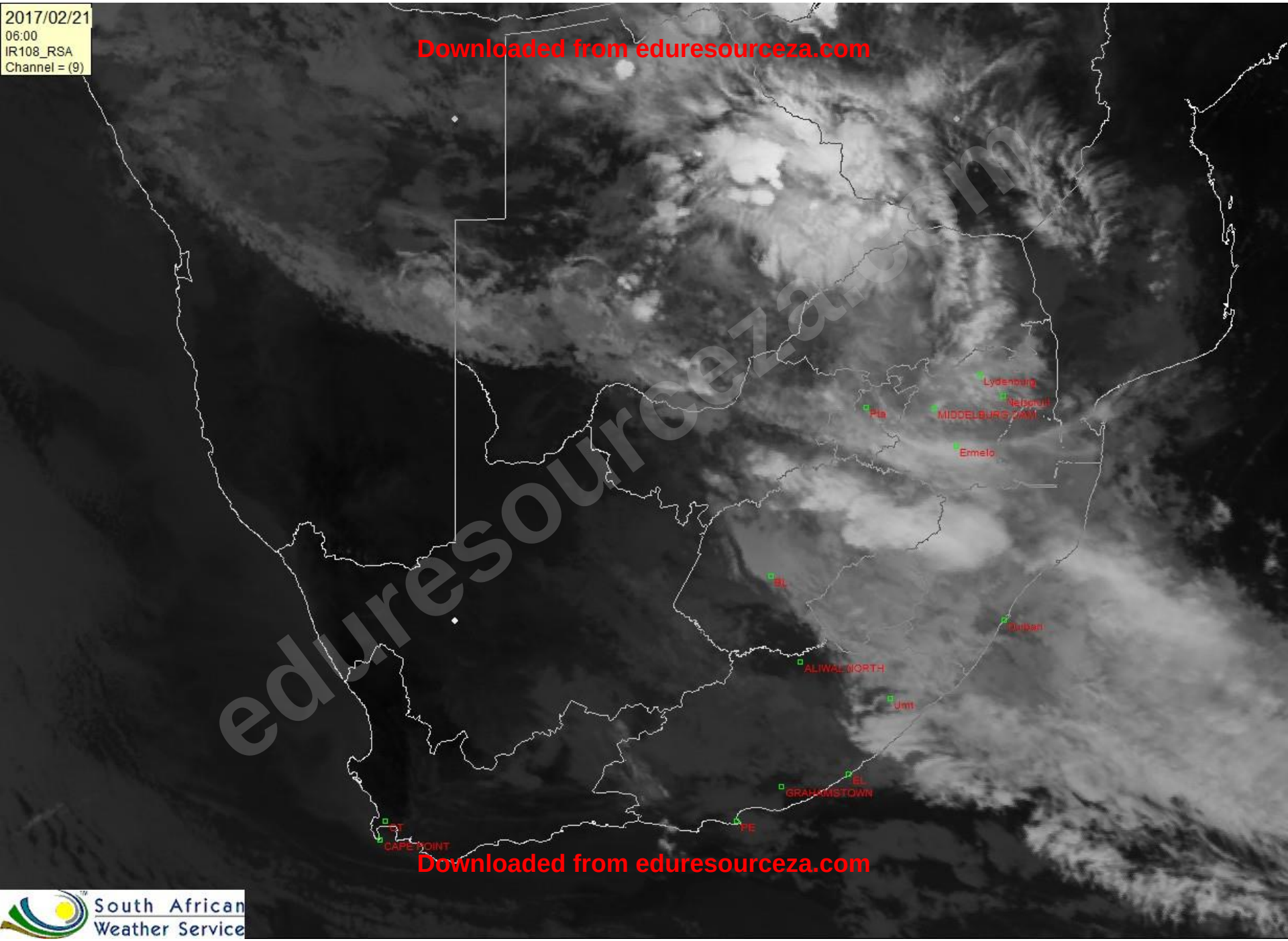
Homes destroyed by Dineo - 20 000

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WINDSPEED IN KNOPE VIR 4 MB/40 GPM
WINDSPEED IN KNOTS FOR 4 MB/40 GPM
South African Weather Service
1:20M
Met 1/1/3
FAPR ASZA
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06:00Z
NAIROBI 741
SEYCHELLES 980
LUANDA 160
ASCENSION 902
MOCAMEDES 422
ST. HELENA 901
CHILEKA 693
HARARE 775
DIEGO-SUAREZ 009
LUMBO 241
BEIRA 297
WB 104
WINDHOEK 112
EUROPA 972
MAURITIUS 990
PRETORIA 262
MAPUTO 341
FORT-DAUPHIN 197
TRINDADE 650
PN 408
DN 588
CT 816
PE 842
EL 858
MARION 994
CROZET 99
KERGUELEN 998
BOUVET 992
S GEORGIA 902
S ORKNEYS 968
MAWSON 564
FAPR ASZA 910


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EUMETSAT
MPEF AMV, 2017-02-21 08:45:00 UTC



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South African Weather Service

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POTENTIALLY DEVASTATING!





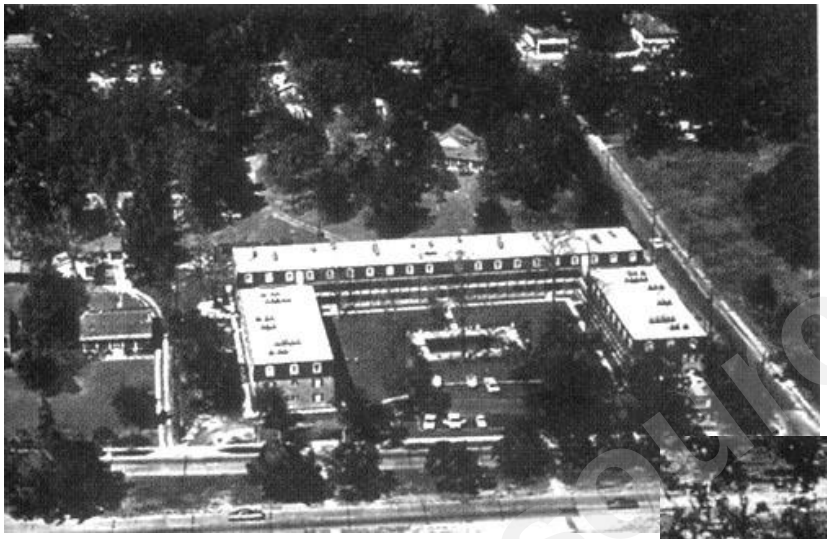




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HURRICANE PARTIES





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REQUIREMENTS FOR FORMATION

Sea 27°C plus

High humidity

Unstable air

Very low pressure

(steep pressure gradient)

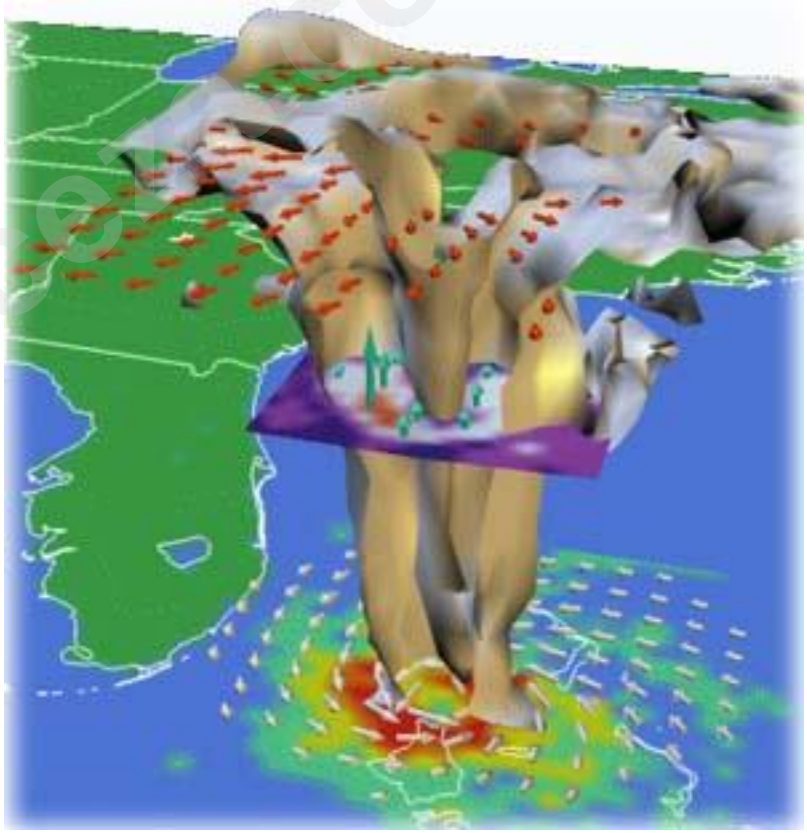
Coriolis force

5°-25° N/S of equator

Strong upper air

divergence/Jet stream

Very little surface friction



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CHARACTERISTICS

Form over tropical oceans except South Atlantic – too cold

Occur in late Summer to early Autumn. In SA November to April

Move in Tropical Easterlies –

In S.H. move east to west, South and then back East although paths can be erratic

Occur on Eastern side of continents

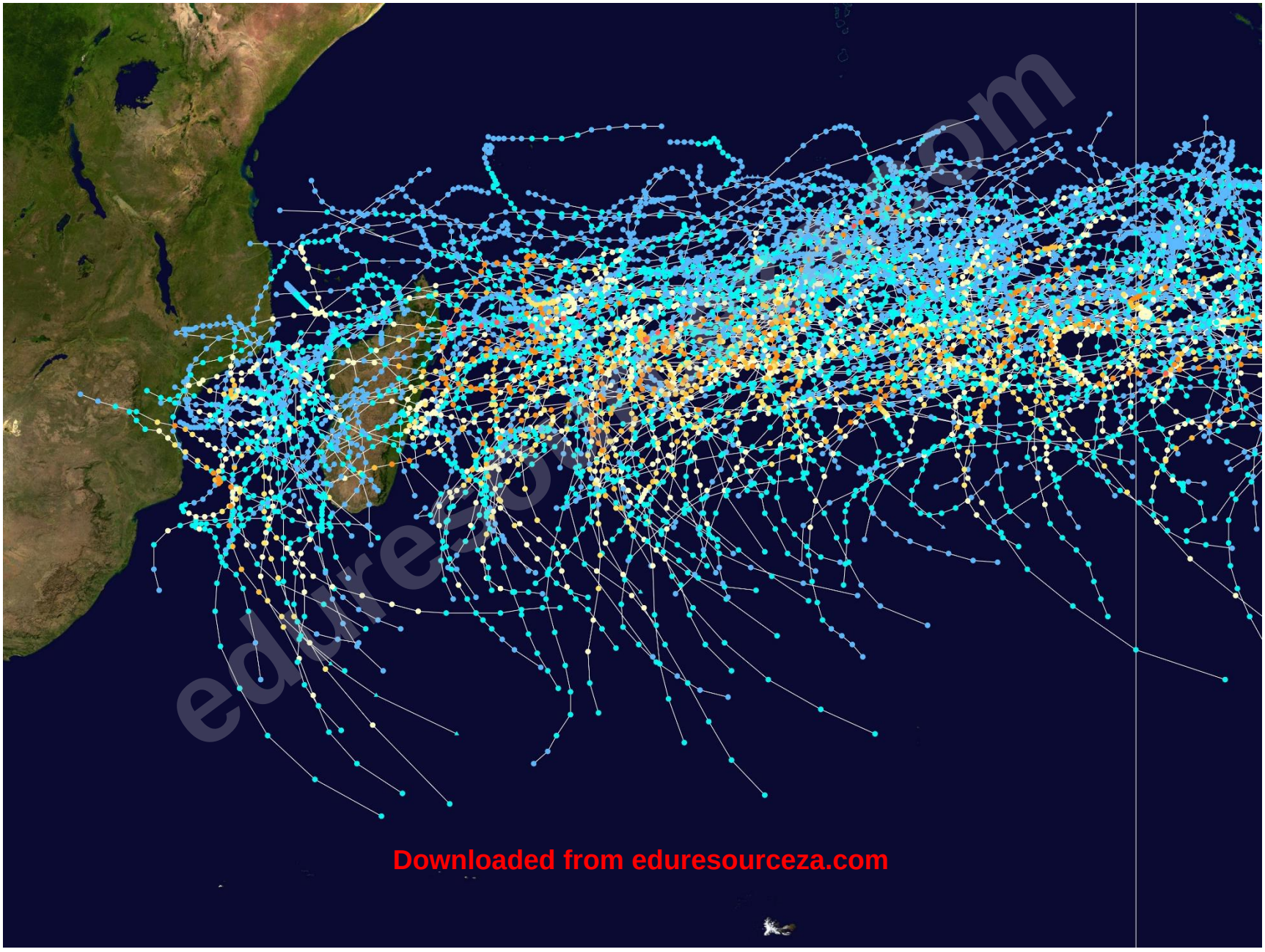
Very low pressure, clockwise airflow, Eye center

Named alphabetically

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STORM TRACKS 1980-2005 (ERRATIC)

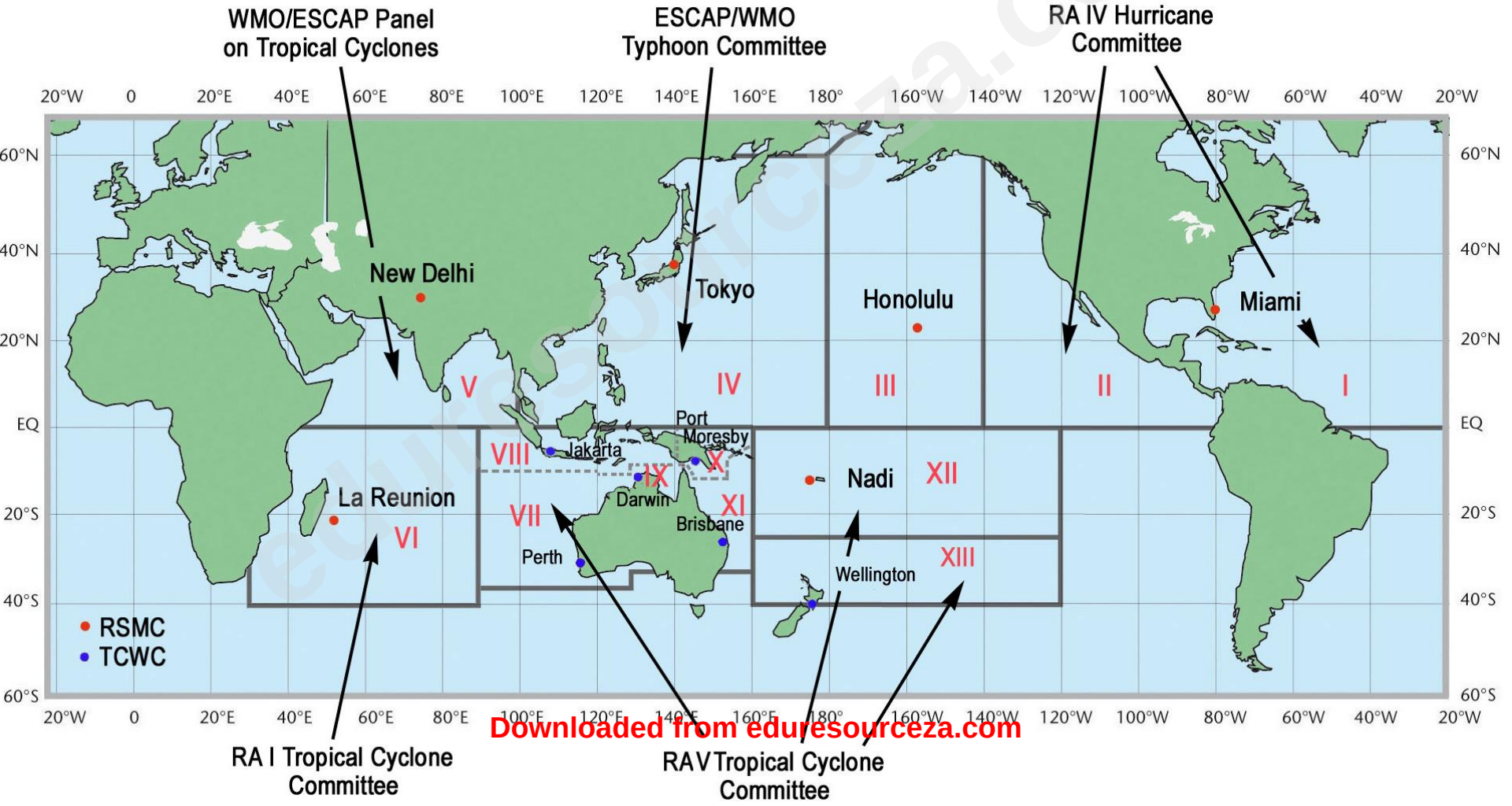
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TROPICAL CYCLONE WARNING CENTERS & REGIONAL SPECIALIZED METEOROLOGICAL CENTERS & REGIONAL ASSOCIATIONS

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STORM CLASSIFICATION

Tropical disturbance = a low pressure area with organized convection & definite cyclonic surface wind circulation with the average wind speed estimated to be not exceeding 27 knots (50 km/h)

Tropical depression = when it reaches wind speeds above 28 knots (50 km/h, 32 mph)

Moderate tropical storm = wind speeds of 35 knots (65 km/h, 40 mph); assigned a name by either the Sub Regional Center in Mauritius or Madagascar

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Severe tropical storm = winds speeds of 48 knots (89 km/h, 55 mph)

Tropical cyclone = wind speeds of 64 knots (118 km/h, 74 mph) (Dineo – 160 km/h)

Intense tropical cyclone = wind speeds of 90 knots (166 km/h, 103 mph), it will be classified as an intense tropical cyclone

Very intense tropical cyclone = winds of over 115 knots (212 km/h, 132 mph)

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TROPICAL CYCLONE INTENSITY SCALE

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Category	Sustained winds
Very Intense Tropical Cyclone	>115 kt > 212 km/h
Intense Tropical Cyclone	90–115 kt 166–212 km/h
Tropical Cyclone	64–89 kt 118–165 km/h
Severe Tropical Storm	48–63 kt 89–117 km/h
Moderate Tropical Storm	34–47 kt 63–88 km/h
Tropical Depression	28–33 kt 51–62 km/h
Tropical Disturbance	<28 kt < 50 km/h

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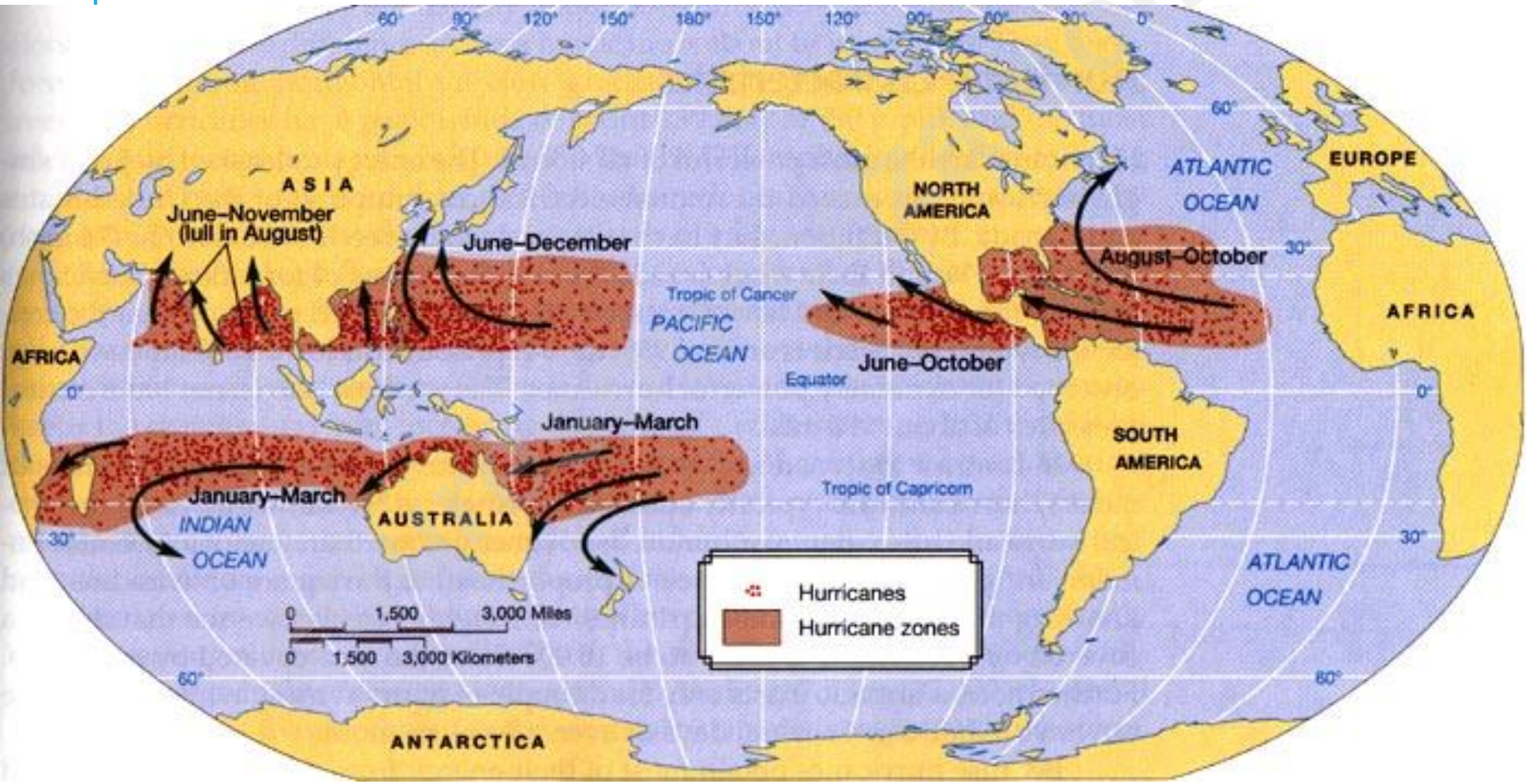
NAMING SOUTH INDIAN OCEAN STORMS

The Sub-Regional Tropical Cyclone Advisory Centers in Mauritius and Madagascar name the systems. The Sub-Regional Tropical Cyclone Advisory Center in Mauritius names a storm should it intensify into a moderate tropical storm between 55°E and 90°E. If instead a cyclone intensifies into a moderate tropical storm between 30°E and 55°E then the Sub-Regional Tropical Cyclone Advisory Center in Madagascar assigns the appropriate name to the storm. Beginning from the 2016–17 season, name lists within the South-West Indian Ocean will be rotated on a triennial basis. Storm names are only used once, so any storm name used this year will be removed from rotation and replaced with a new name for the 2020–21 season. The unused names are expected to be reused in the list for the 2020–21 season.

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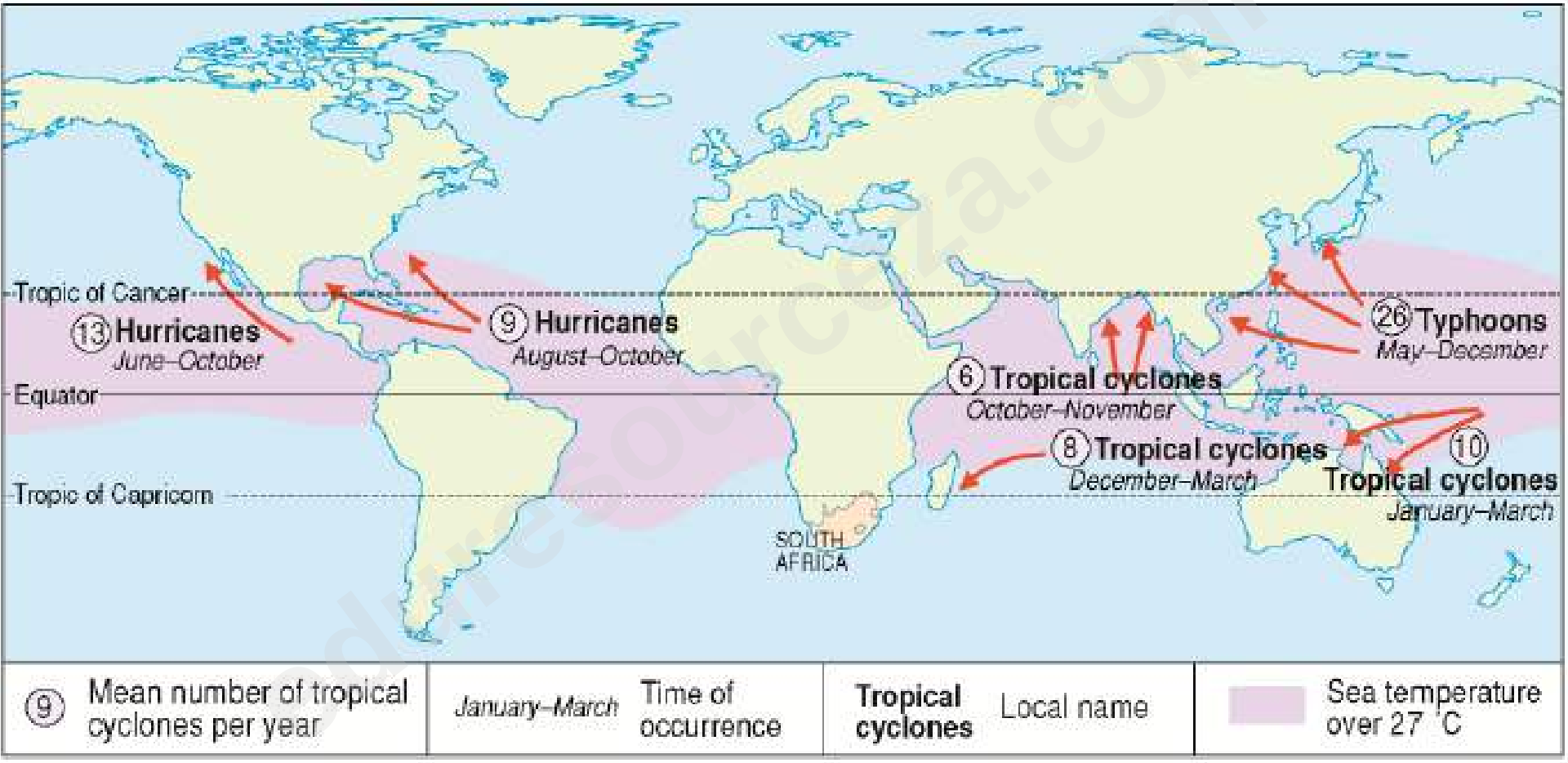
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OCCURRENCE



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CLASS & PREP WORK

Activity 7 p 83

Activity 8 p 84

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STAGES OF DEVELOPMENT

Initial or Formative

Immature

Mature

Dissipating

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INITIAL OR FORMATIVE

Easterly wave deepens

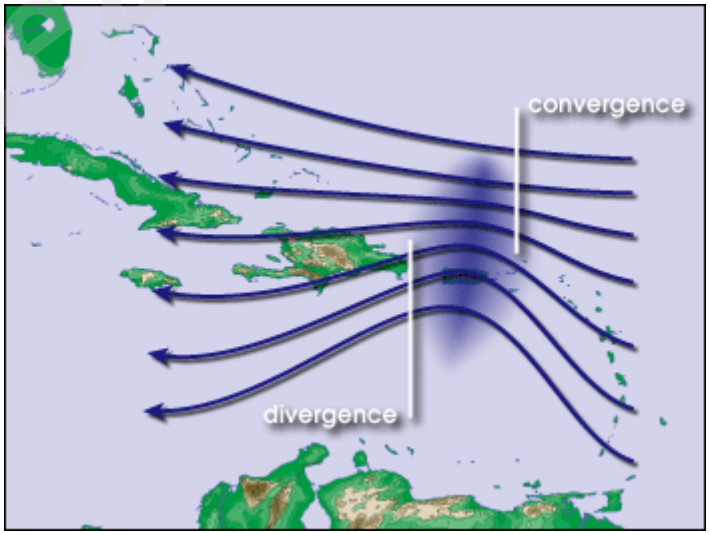
Pressure drops to just above 1000 hPa

Convergence and vortex develops

Light rain

Gales

Easterly wave



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IMMATURE

Pressure below 1000 hPa

Weak upper air divergence

Spiral bands and light rains

Hurricane speed winds close to eye

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MATURE

Named

Pressure in eye approx 940 hPa

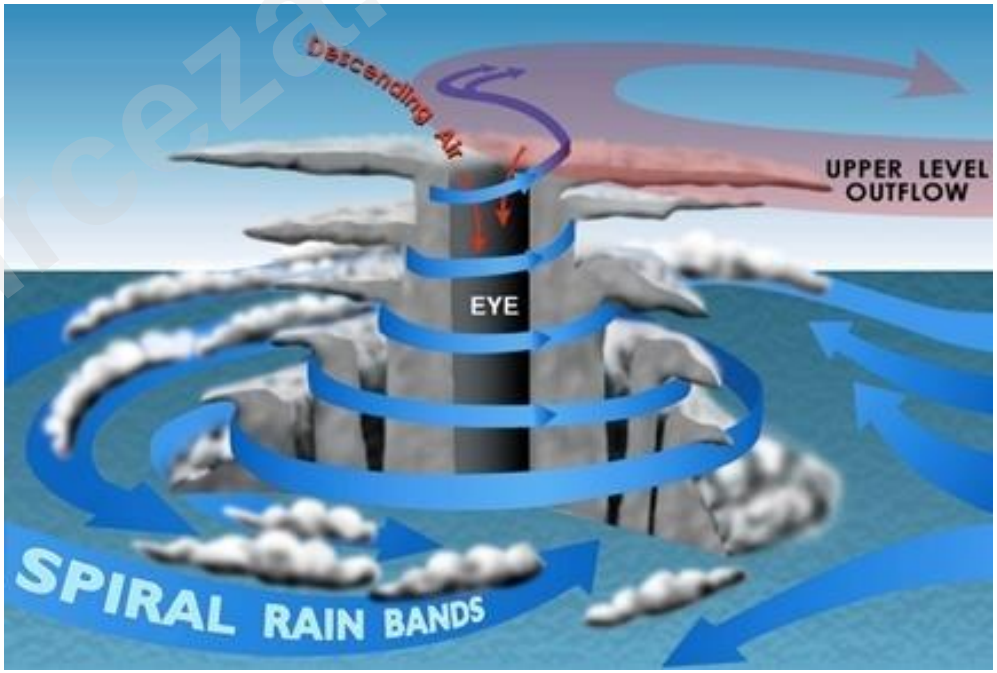
Cb Clouds, heavy rain

Strong upper air divergence

Air subsides in eye – warming adiabatically

Gales on edge, hurricanes near eye

Dangerous semi circle



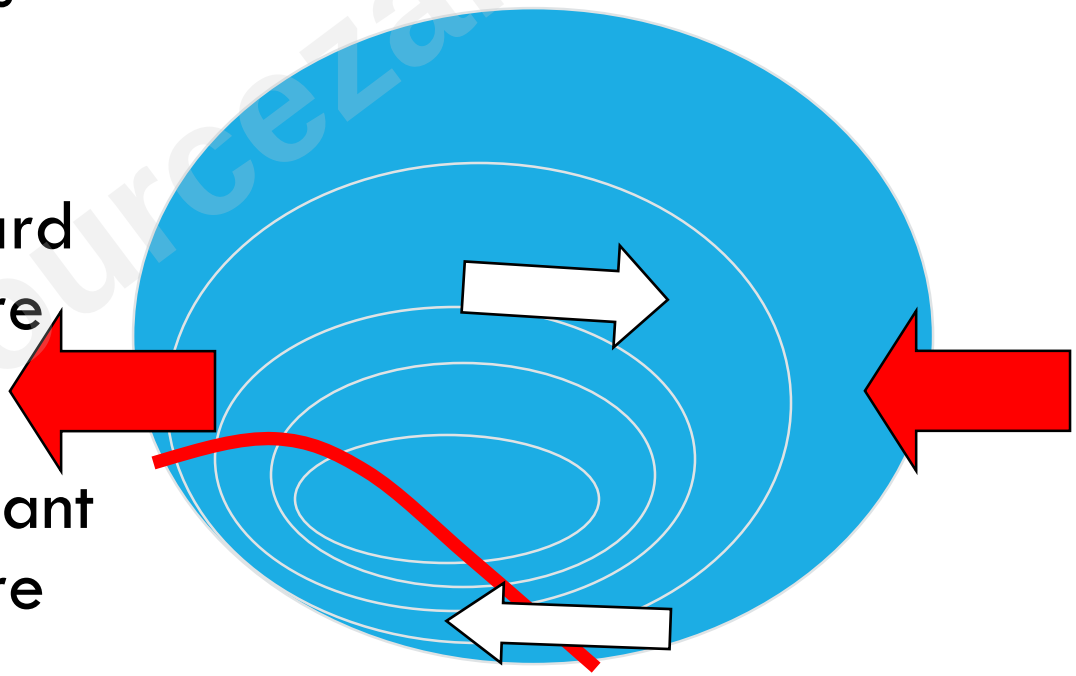
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DANGEROUS SEMI CIRCLE

The direction of winds within the cyclone coincide with the direction of the forward movement of the entire cyclone

Front left hand quadrant in Southern hemisphere



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DISSIPATION

Cut off from heat source e.g. moves into the higher latitudes which is cooler

Cut off from moisture source e.g. the system moves over land – therefore has less latent heat as less condensation occurs

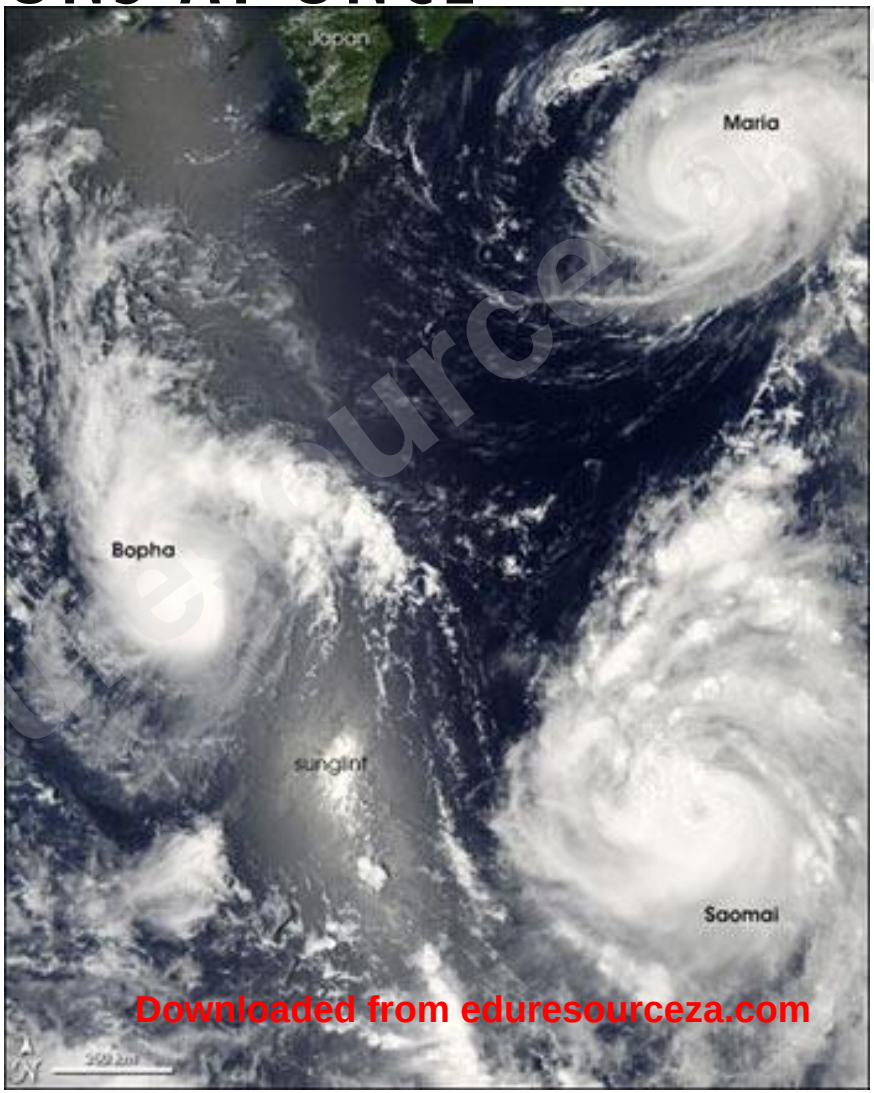
Friction increases as it travels over land

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3 TYPHOONS AT ONCE



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CRUISE SHIP CAPSIZED - TYPHOON



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THE EYE



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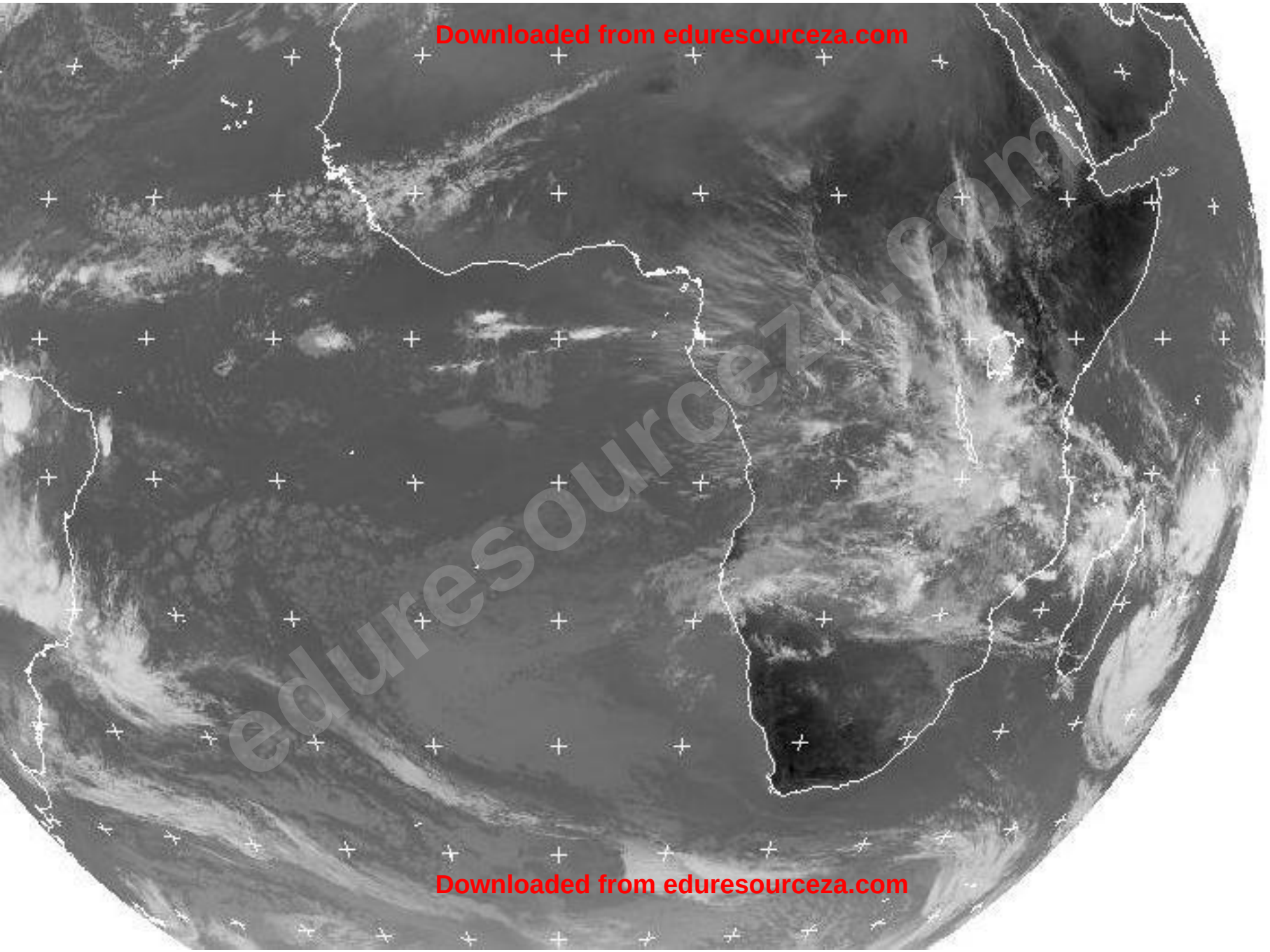
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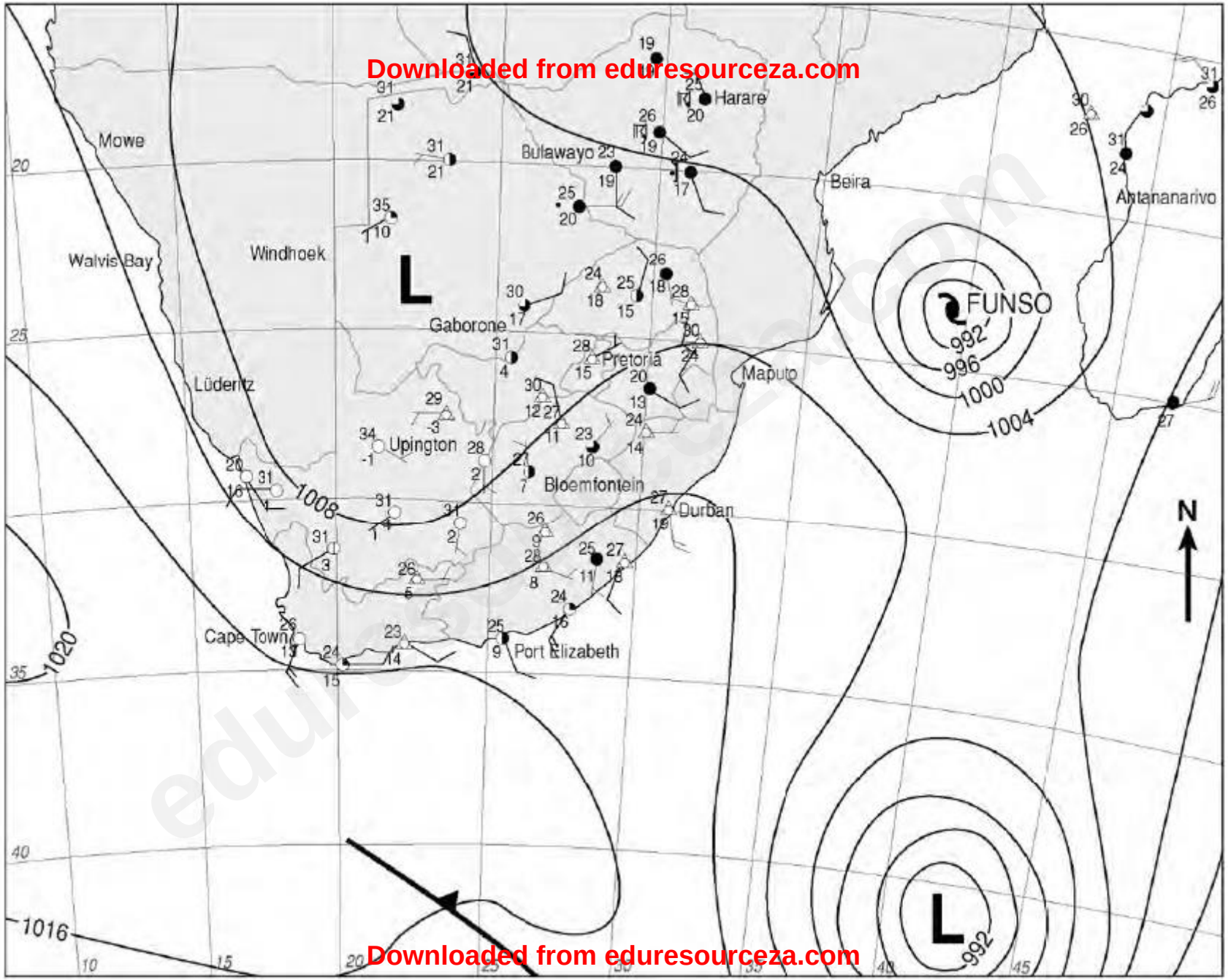
WALLS OF THE EYE



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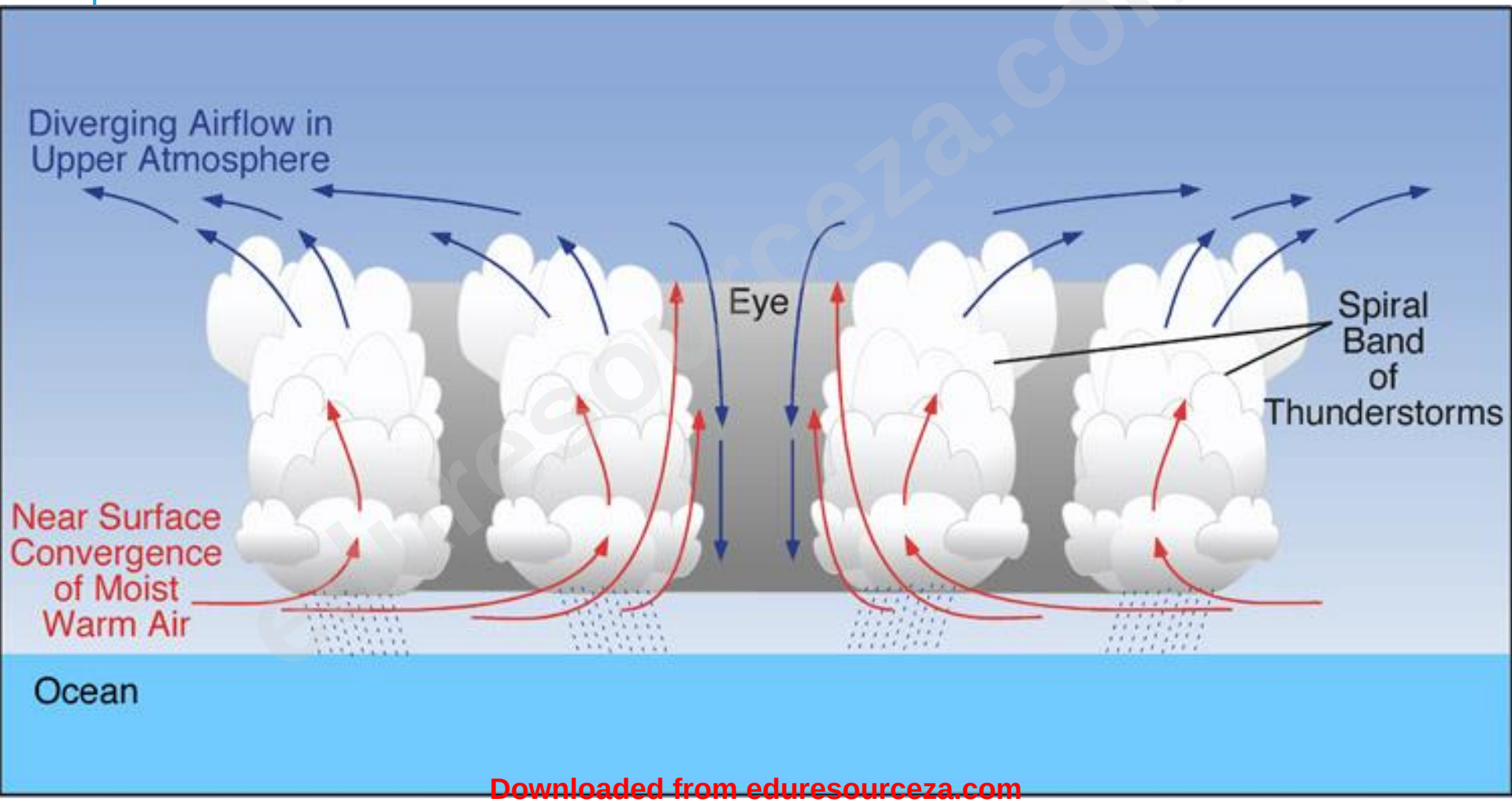


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Figure 21 Synoptic weather map of 25 January 2012

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CS THROUGH A MATURE CYCLONE



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ASSOCIATED WEATHER PATTERNS

As the cyclone approaches	As the eye is overhead	As the cyclone moves away
• Temperature rises • Calm though there is a sea swell which begins to increase • High cirrus clouds on the horizon • Pressure begins to fall • Wind strength increases • Cumulonimbus clouds approach • Torrential rain • Storm surge swamps low lying areas • Temperatures drop.	• Temperatures increase slightly • Wind drops suddenly • Pressure is at its lowest • Light scattered cloud • Sunshine • Calm conditions for an hour or two	• First set of conditions repeated • Winds have reversed their direction • Conditions gradually improve until the cyclone has passed

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WEATHER IN THE EYE

Air pressure decreases

Sinking air

Wind is calm (except sea may be violent)

Free of clouds

Little, if any, rain

At surface coldest part of storm

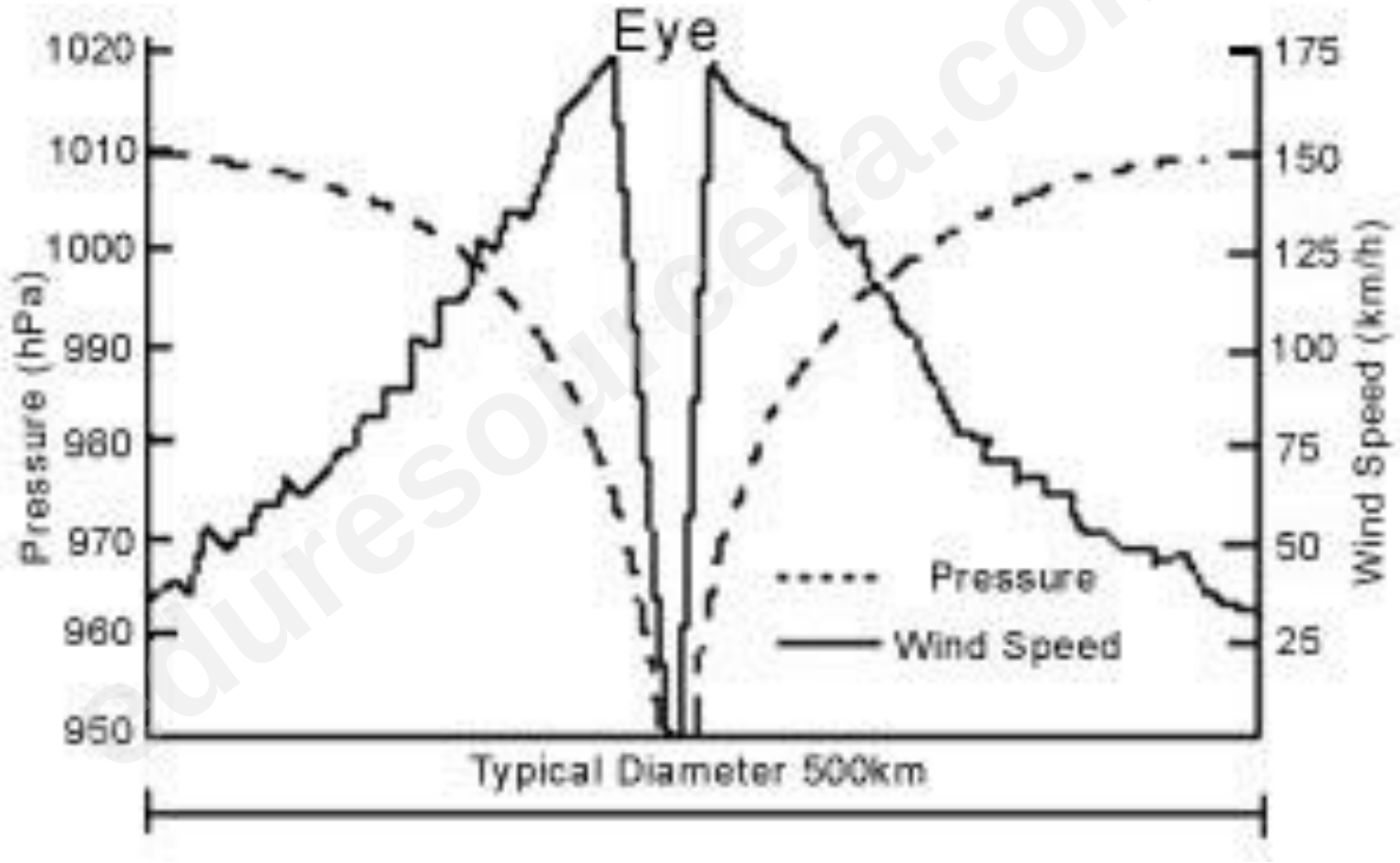
At upper levels the warmest part of the storm

Storm surge on ocean

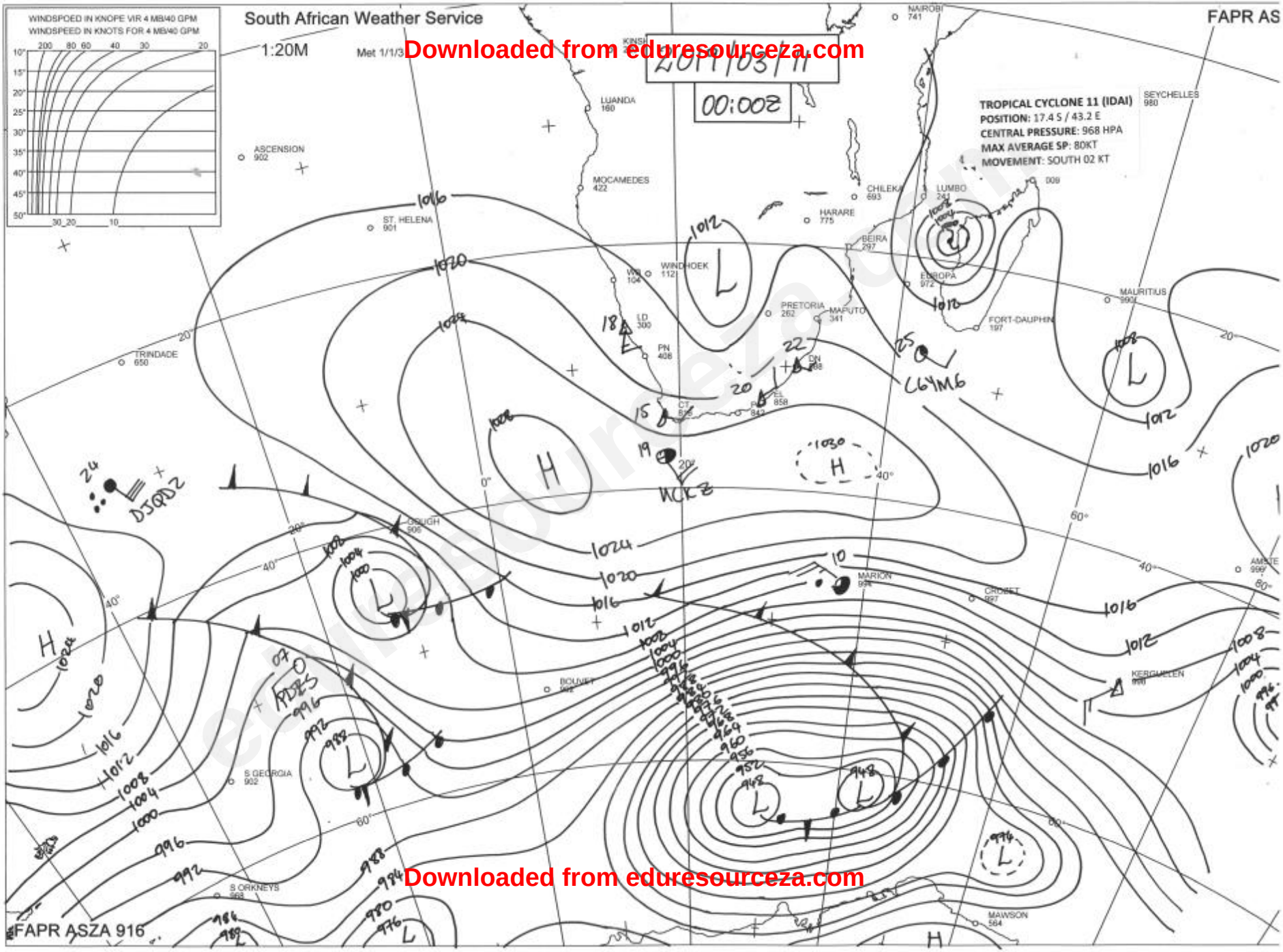
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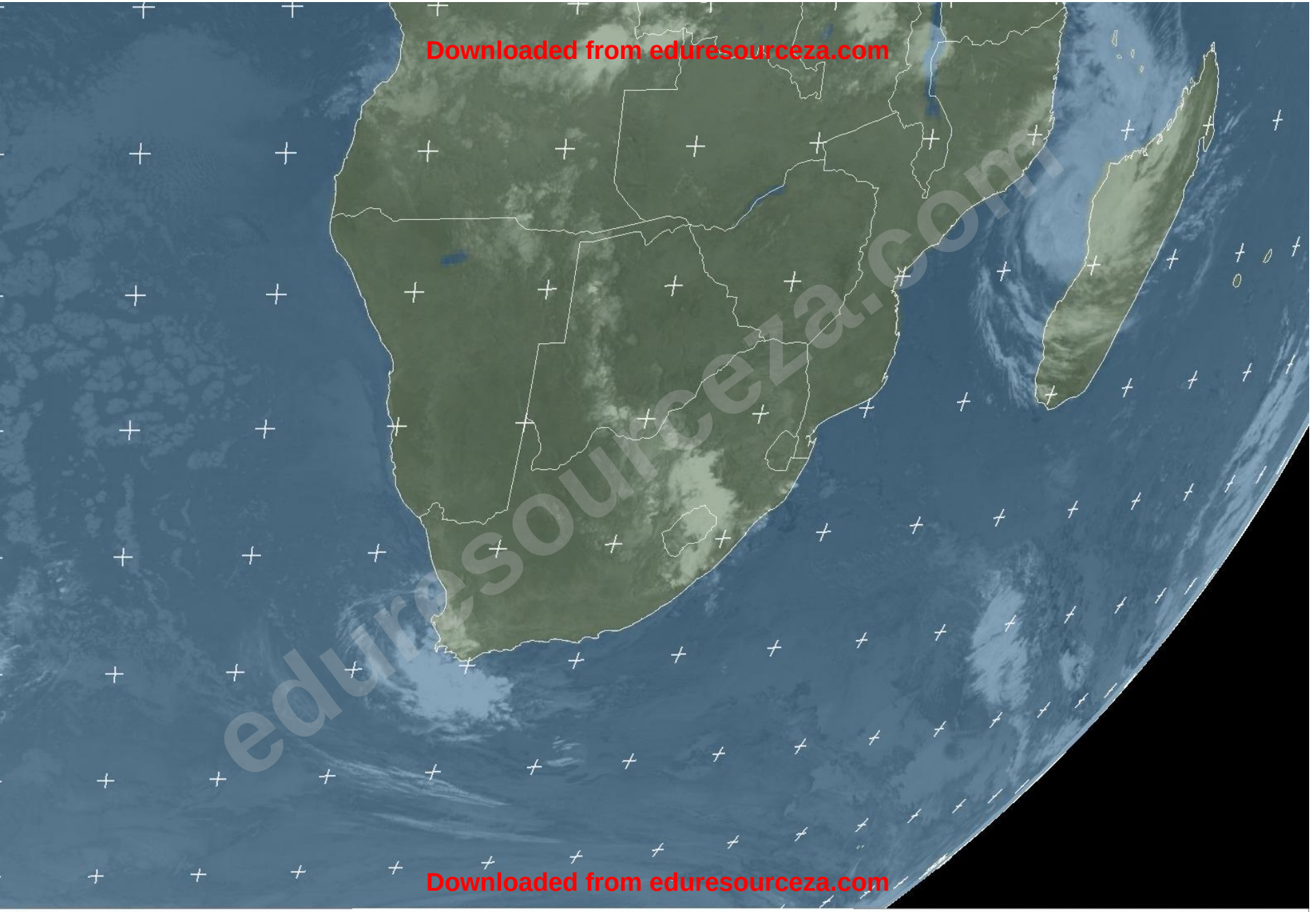
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WEATHER IN EYE

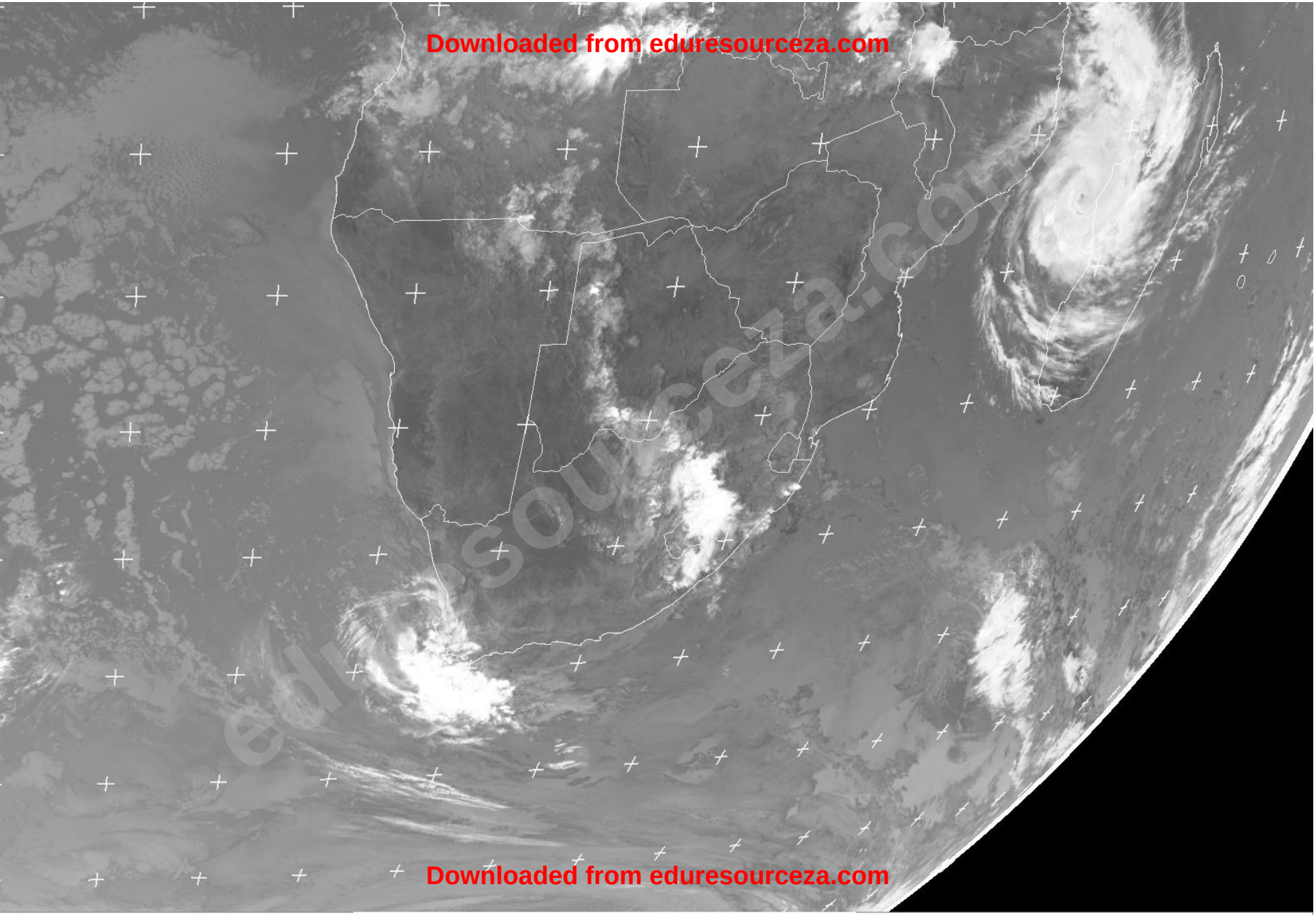


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WINDSPEED IN KNOPE VIR 4 MB/40 GPM
WINDSPEED IN KNOTS FOR 4 MB/40 GPM
South African Weather Service
1:20M
Met 1/1/3
2011/03/11
00:00Z
TROPICAL CYCLONE 11 (IDAI)
POSITION: 17.4 S / 43.2 E
CENTRAL PRESSURE: 968 HPA
MAX AVERAGE SP: 80KT
MOVEMENT: SOUTH 02 KT
FAPR AS
FAPR ASZA 916
NAIROBI 741
LUANDA 160
ASCENSION 902
MOCAMEDES 422
ST. HELENA 901
CHILEKA 693
HARARE 775
LUMBO 241
BEIRA 297
WINDHOEK 112
PRETORIA 262
MAPUTO 341
EBOPA 972
MAURITIUS 990
FORT-DAUPHIN 197
SEYCHELLES 980
TRINDADE 650
GOUGH 905
MARION 934
CROZET 927
KERGUELEN 990
AMSTE 999
BOUVET 902
S.GEORGIA 902
S.ORKNEYS 968
MAWSON 564
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EUMETSAT
Meteosat 0deg IR 3.9, 2019-03-11 07:00:00 UTC

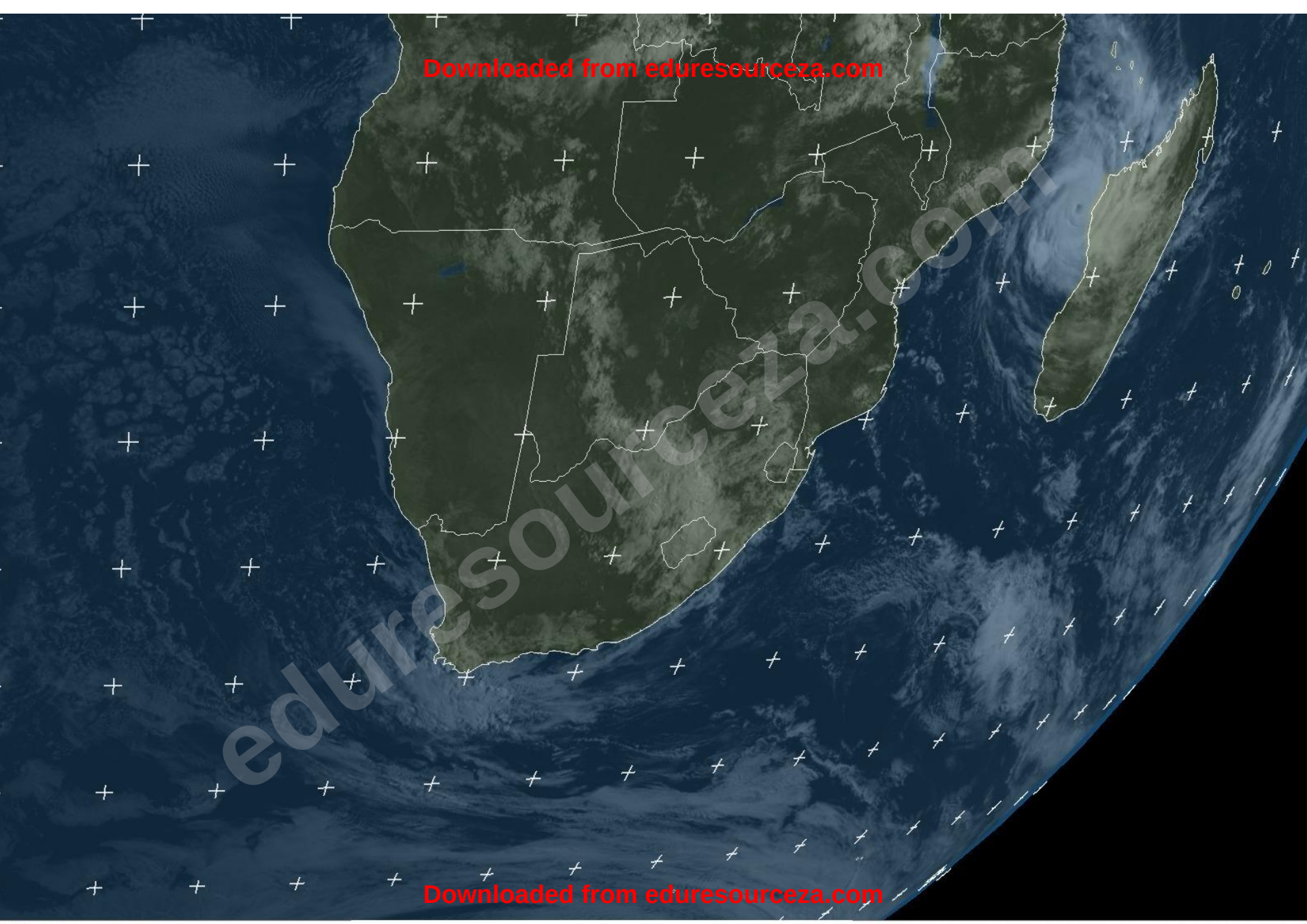
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EUMETSAT

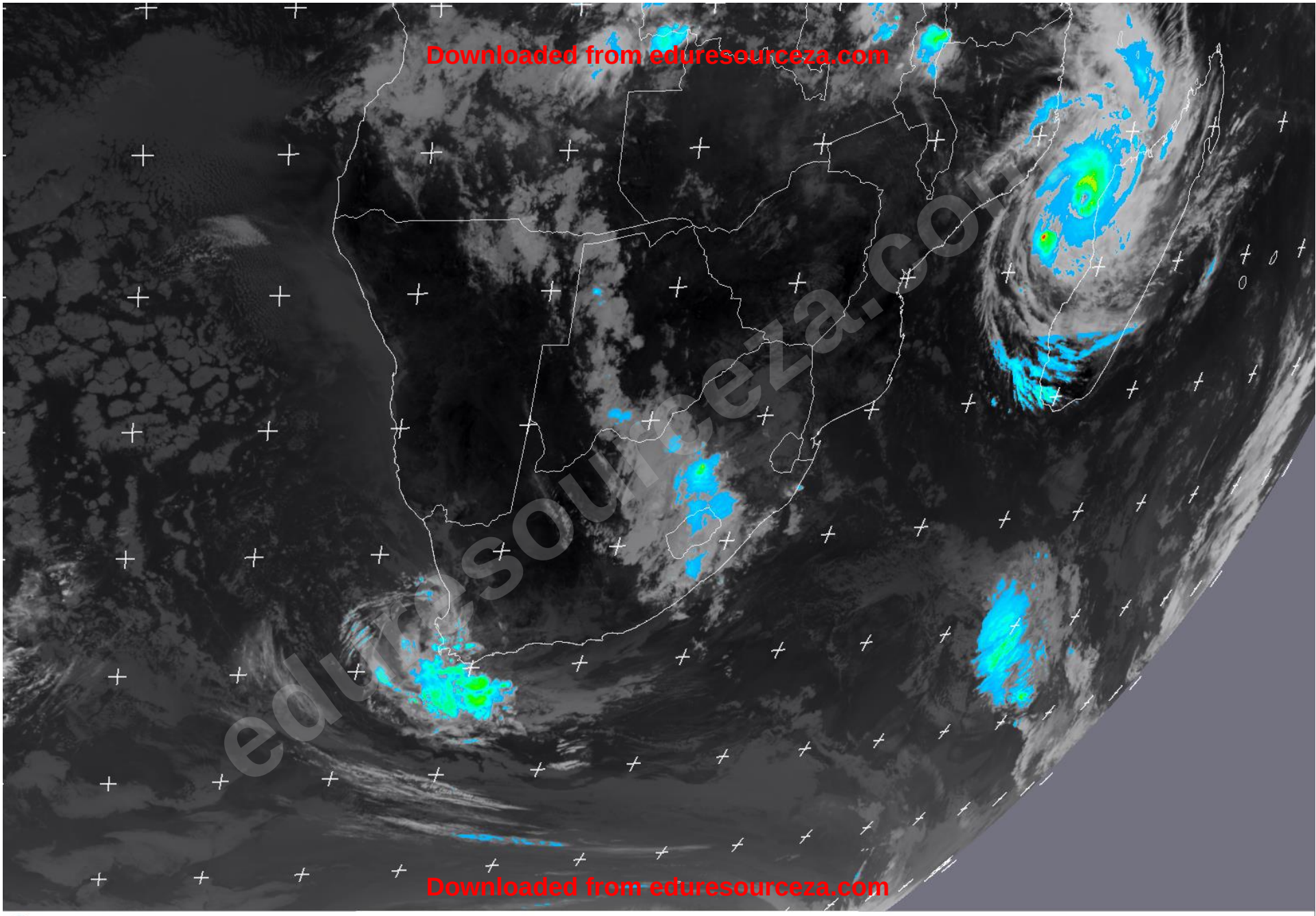
Meteosat 0deg IR 3.9, 2019-03-11 07:00:00 UTC


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EUMETSAT
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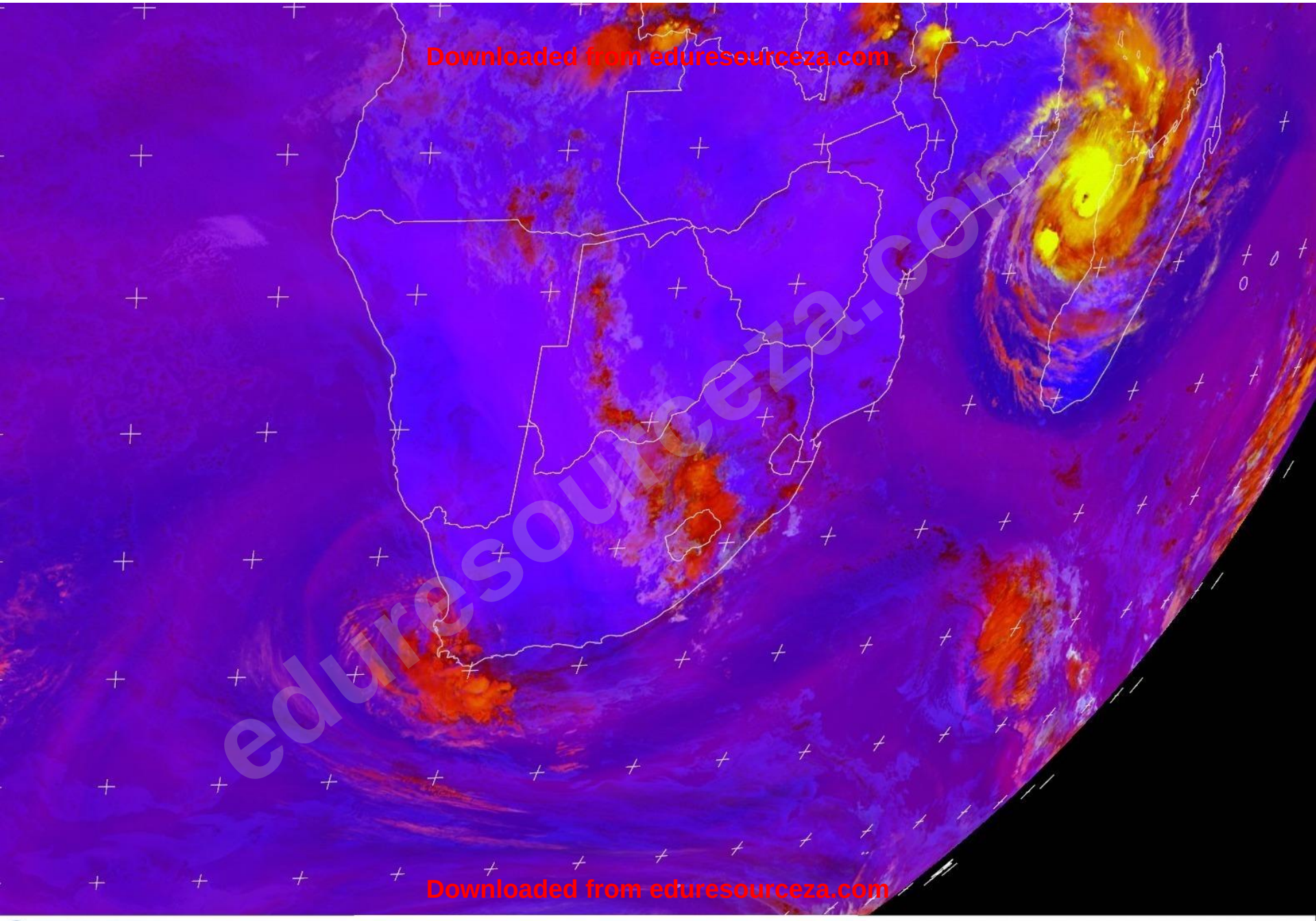
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MPEF CTH, 2019-03-11 07:00:00 UTC


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EUMETSAT
MPEF MPE, 2019-03-11 07:00:00 UTC

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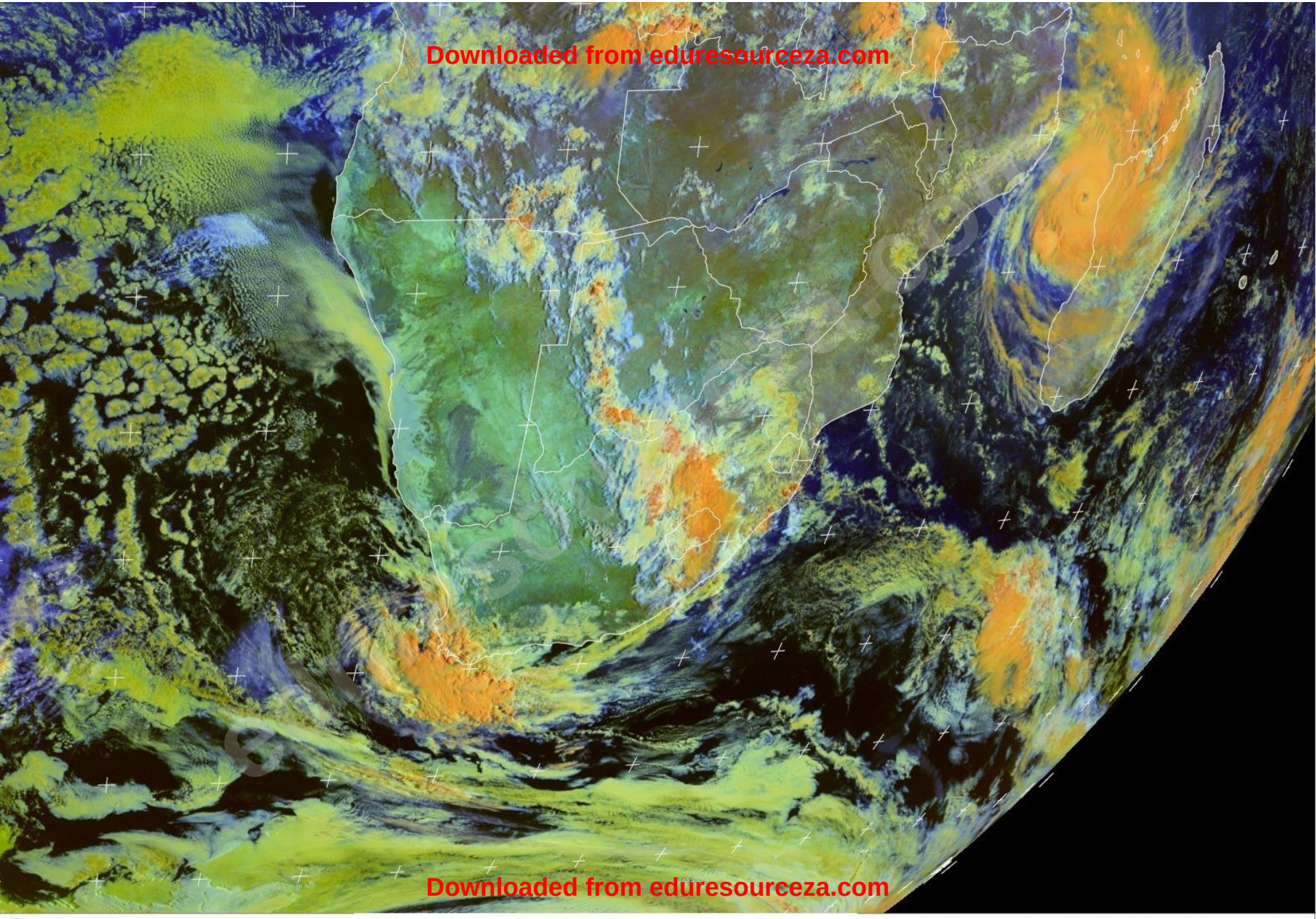


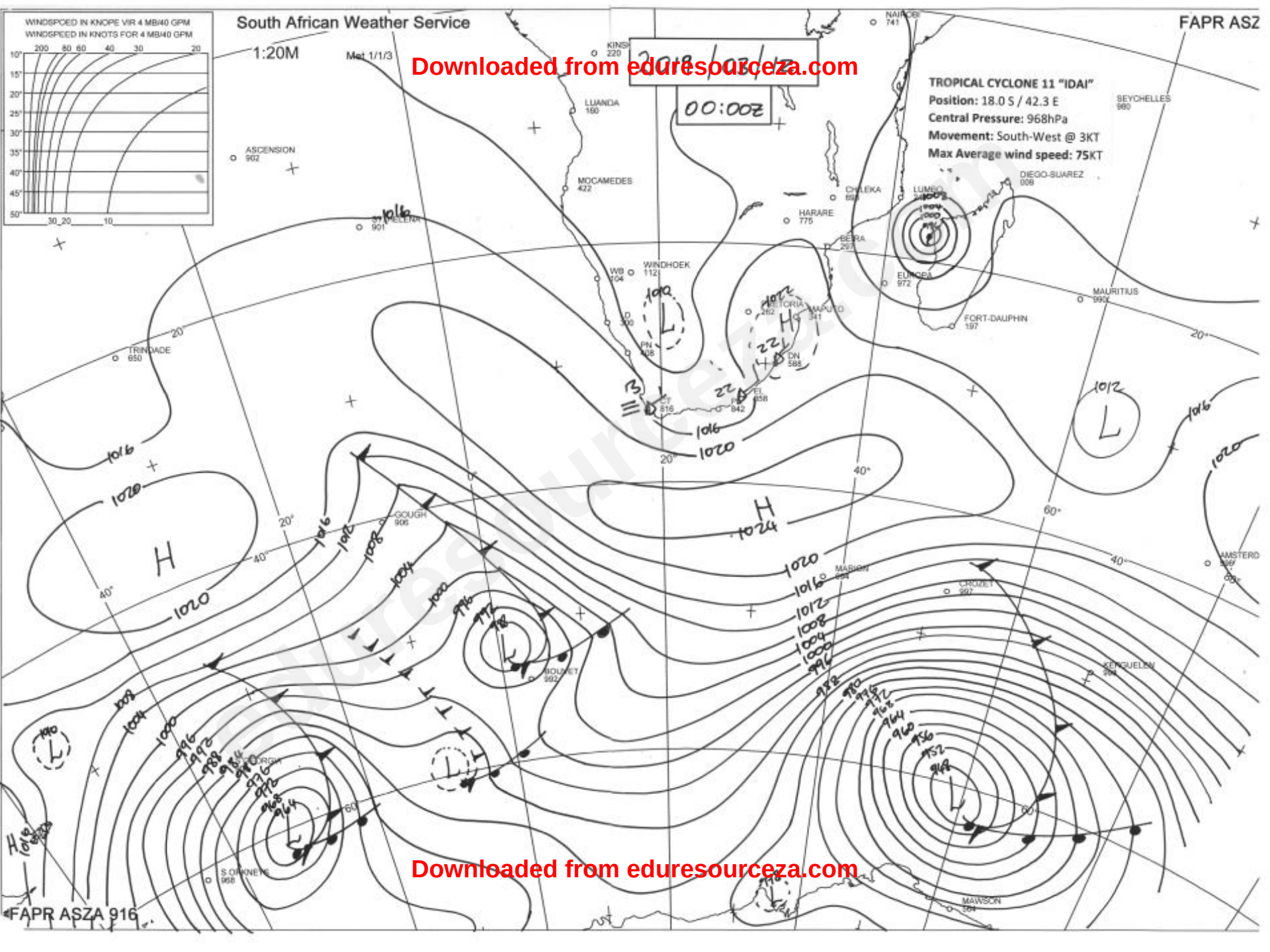
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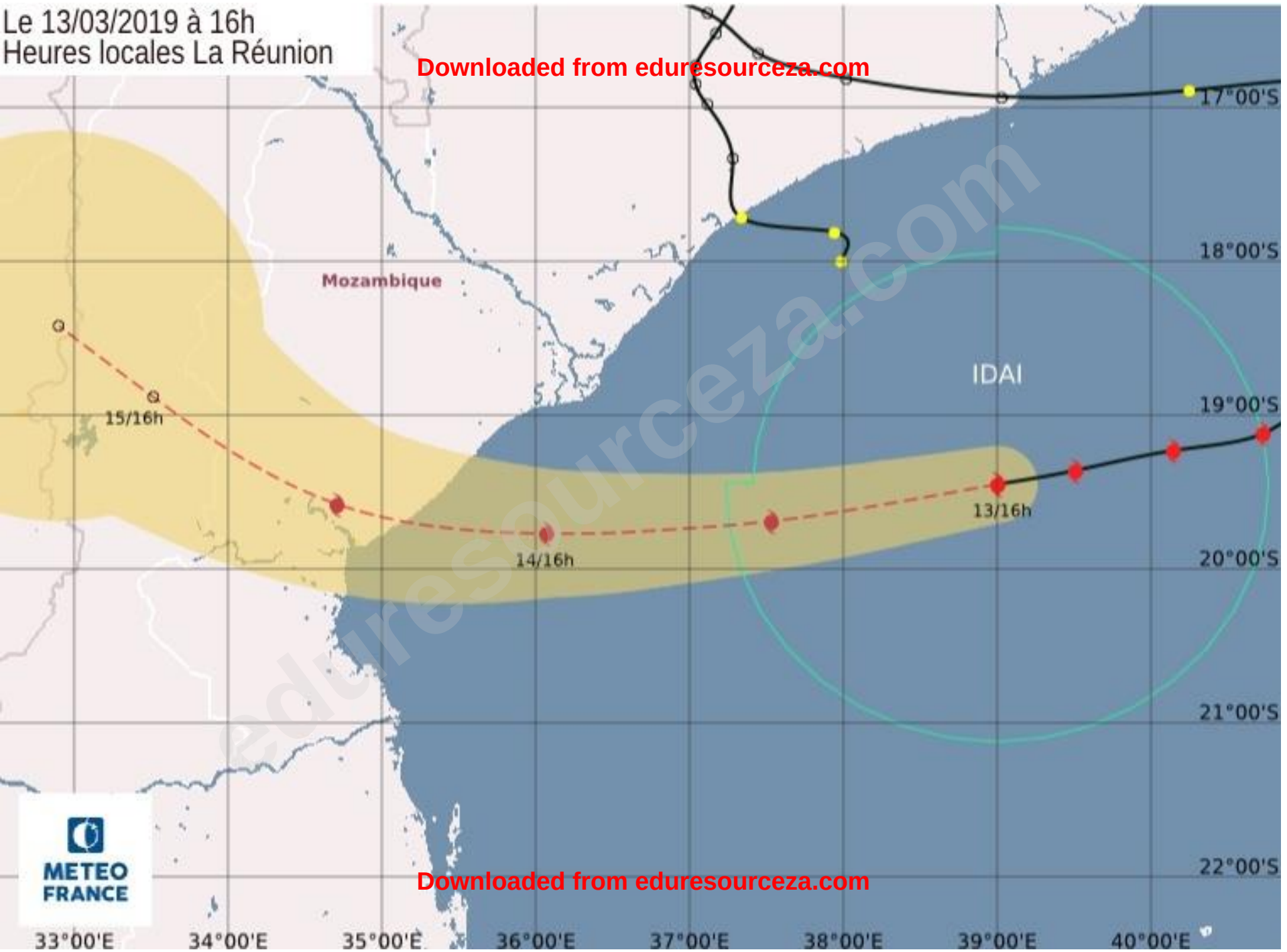
EUMETSAT

Meteosat 0deg Convection, 2019-03-11 07:00:00 UTC


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EUMETSAT
Meteosat 0deg Snow, 2019-03-11 07:00:00 UTC

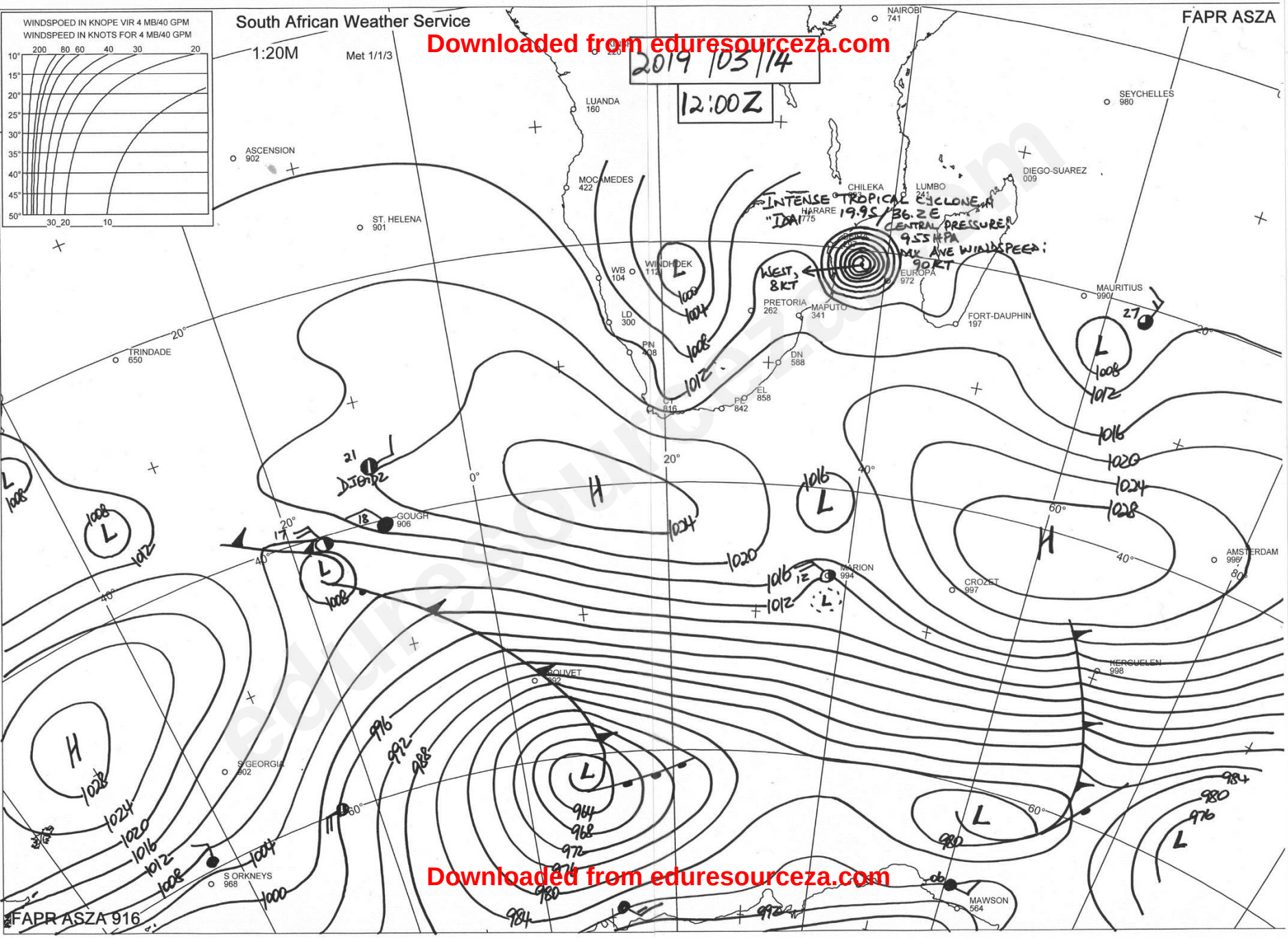


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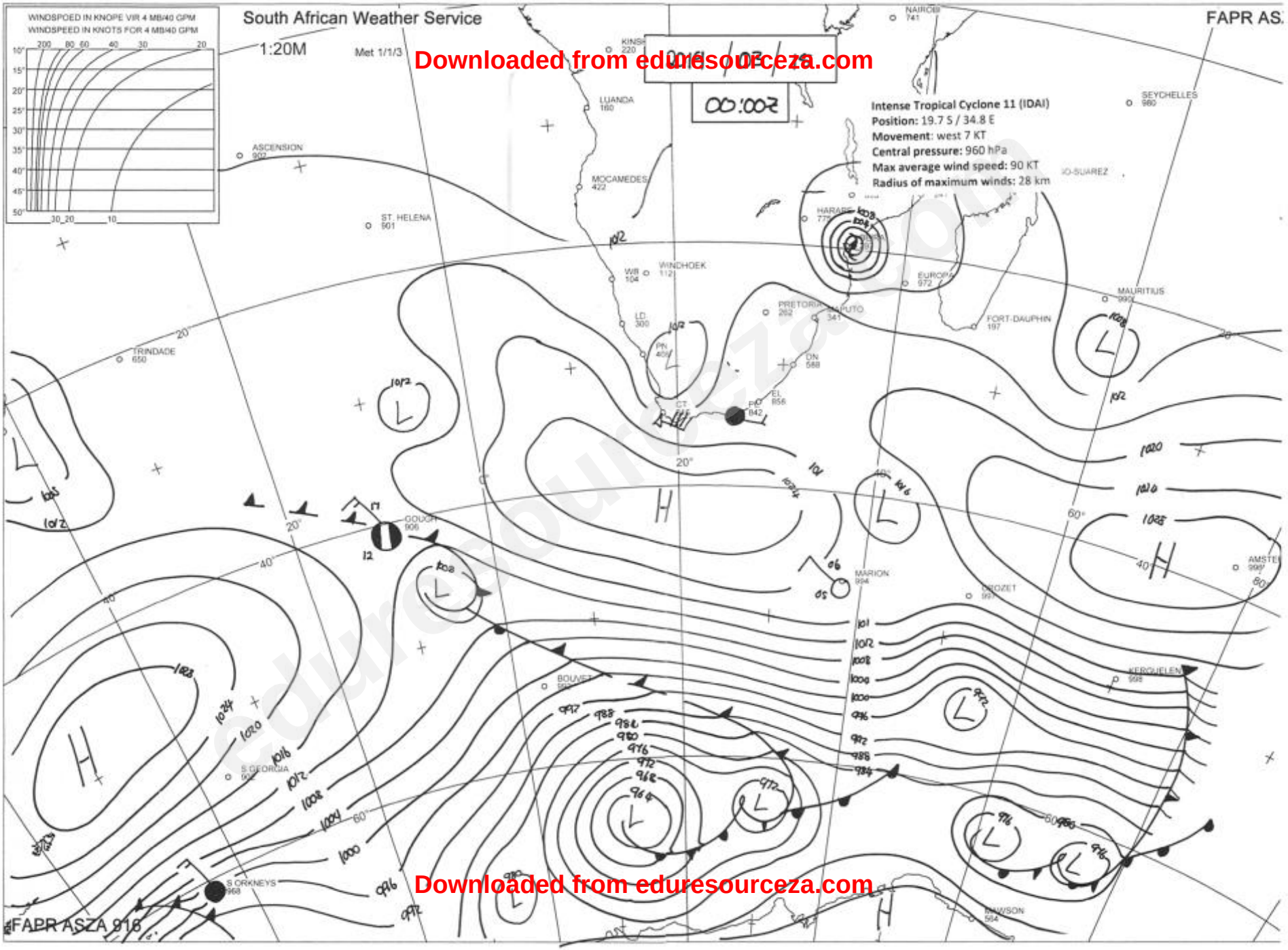


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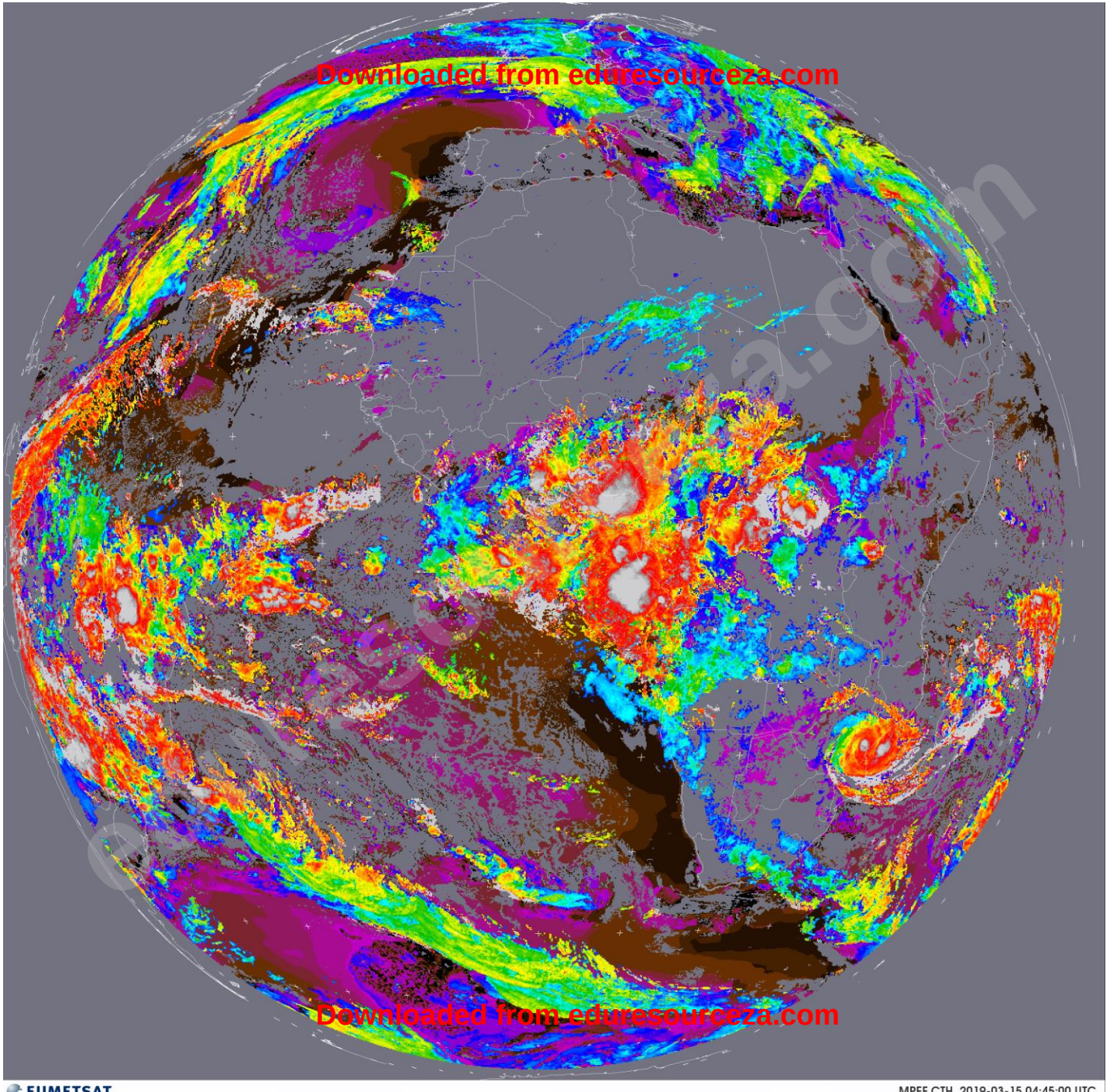
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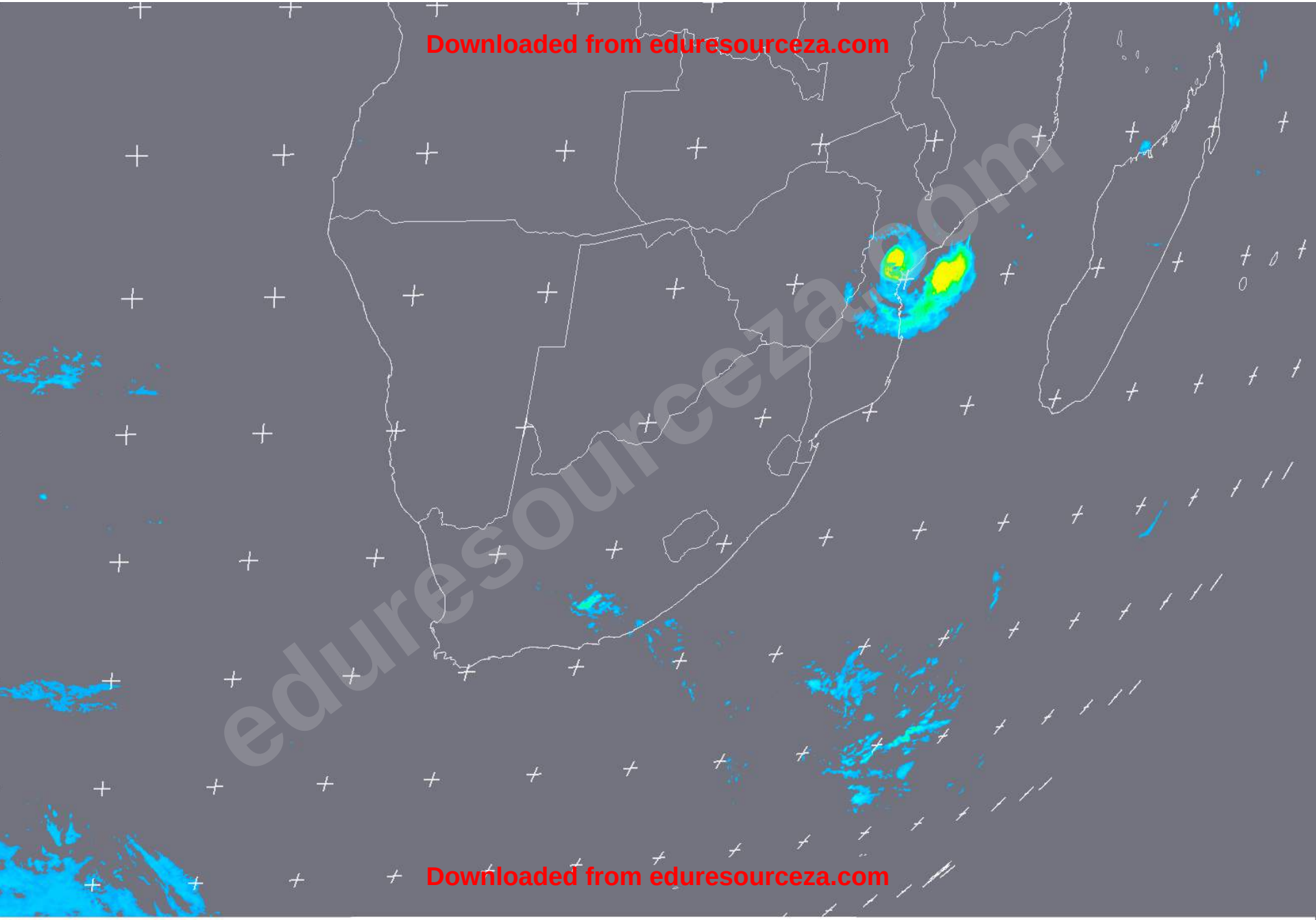
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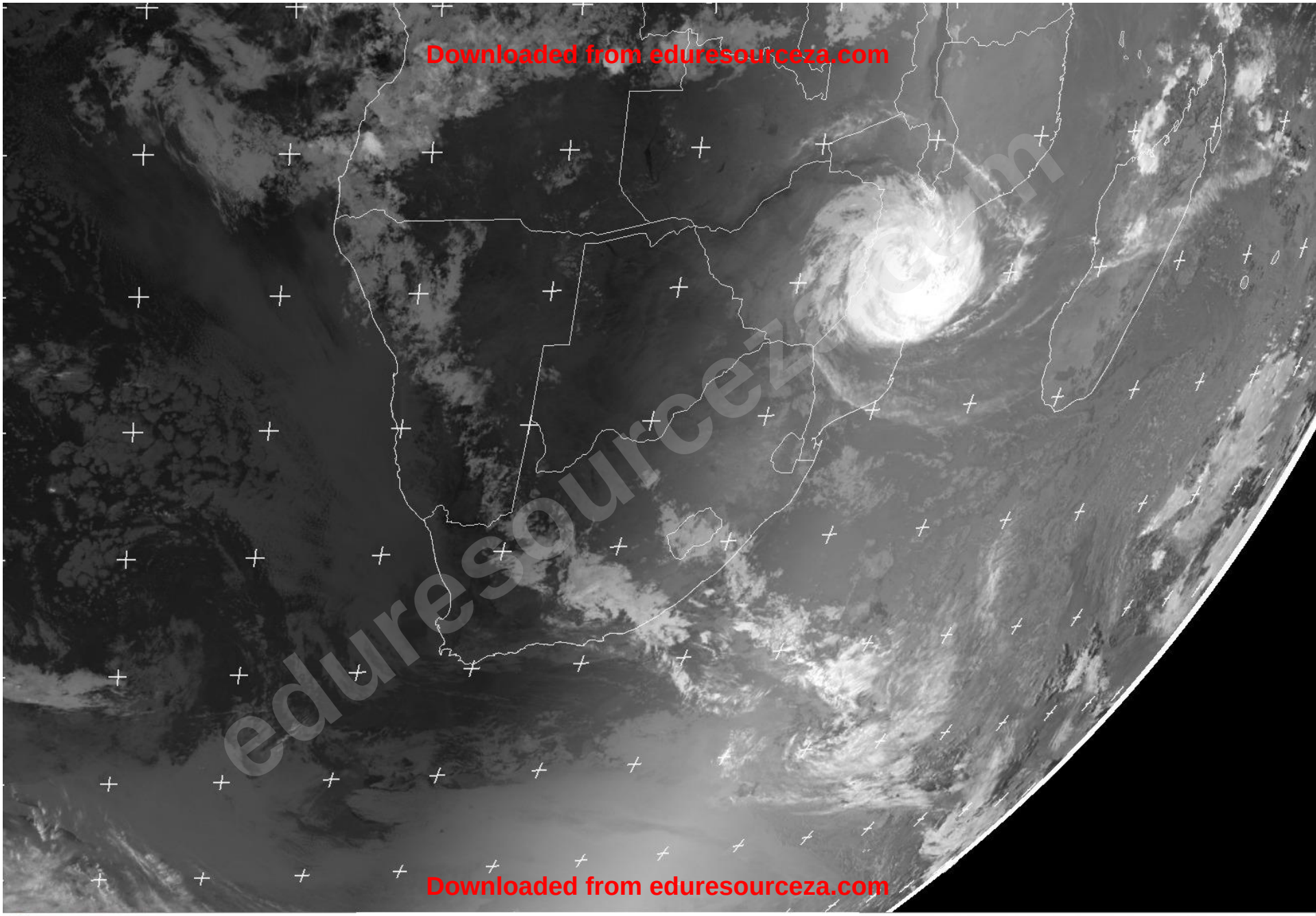


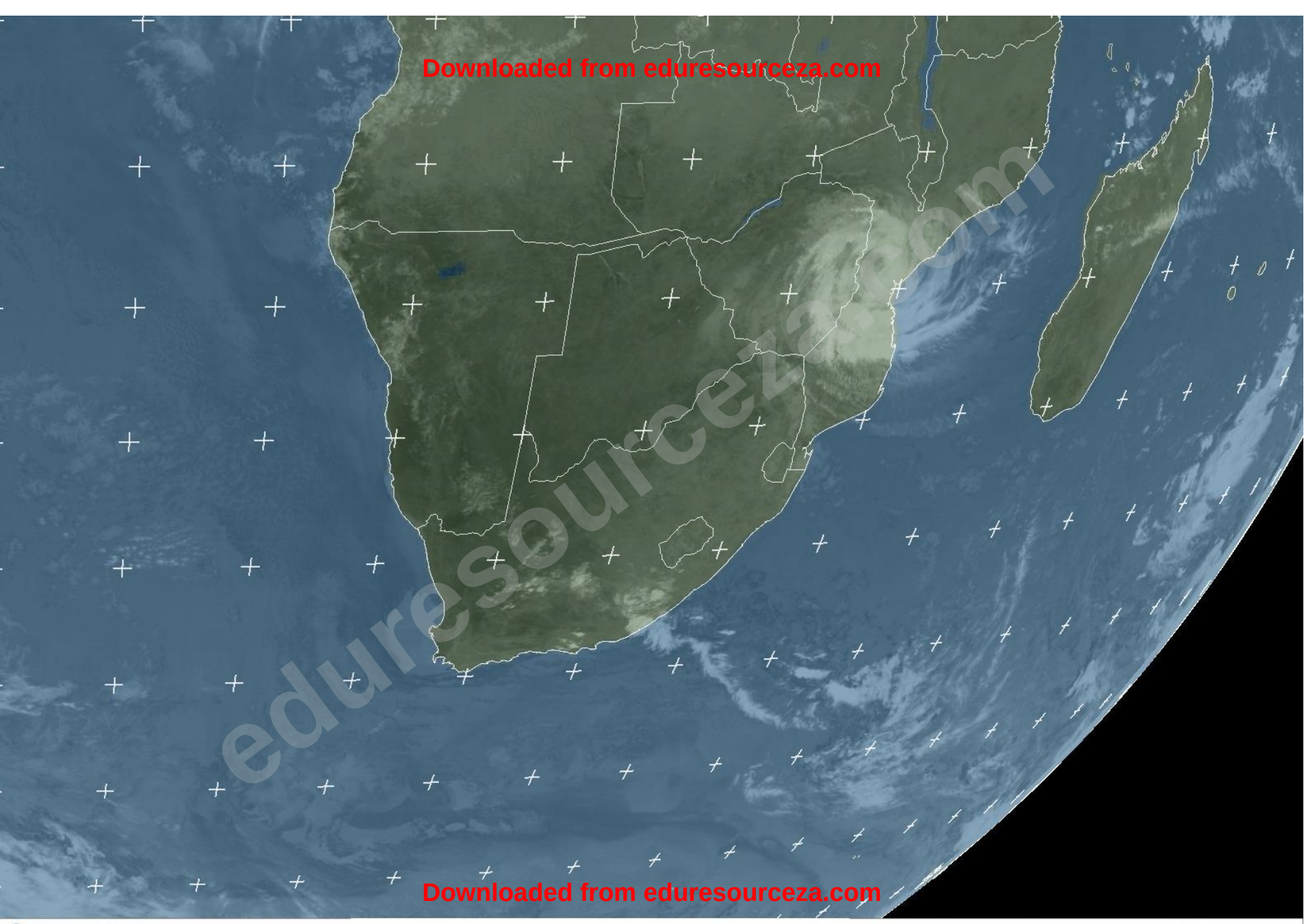
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EUMETSAT

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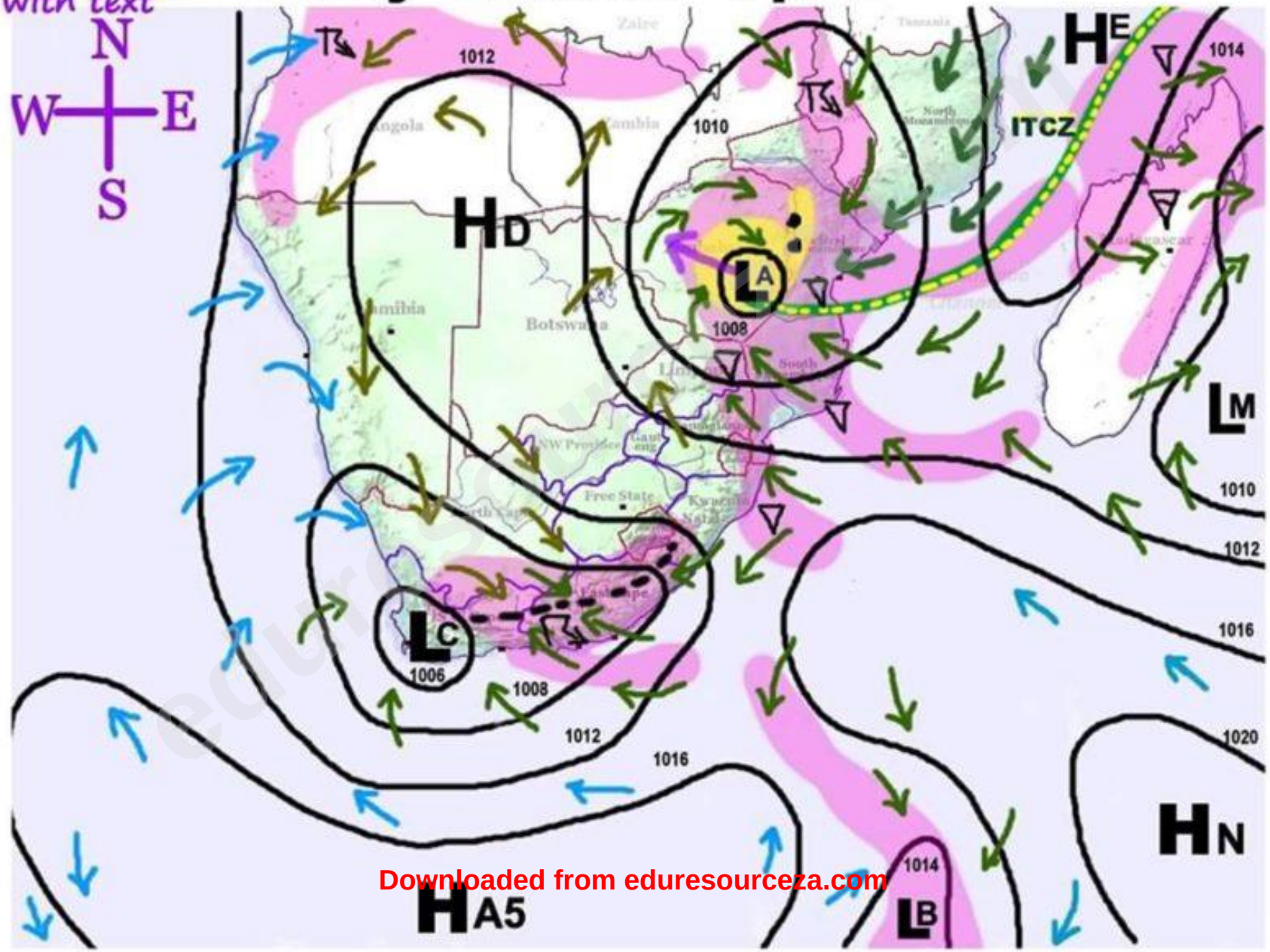

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Weather Today - Southern Africa

Friday 13 March 4 p.m.

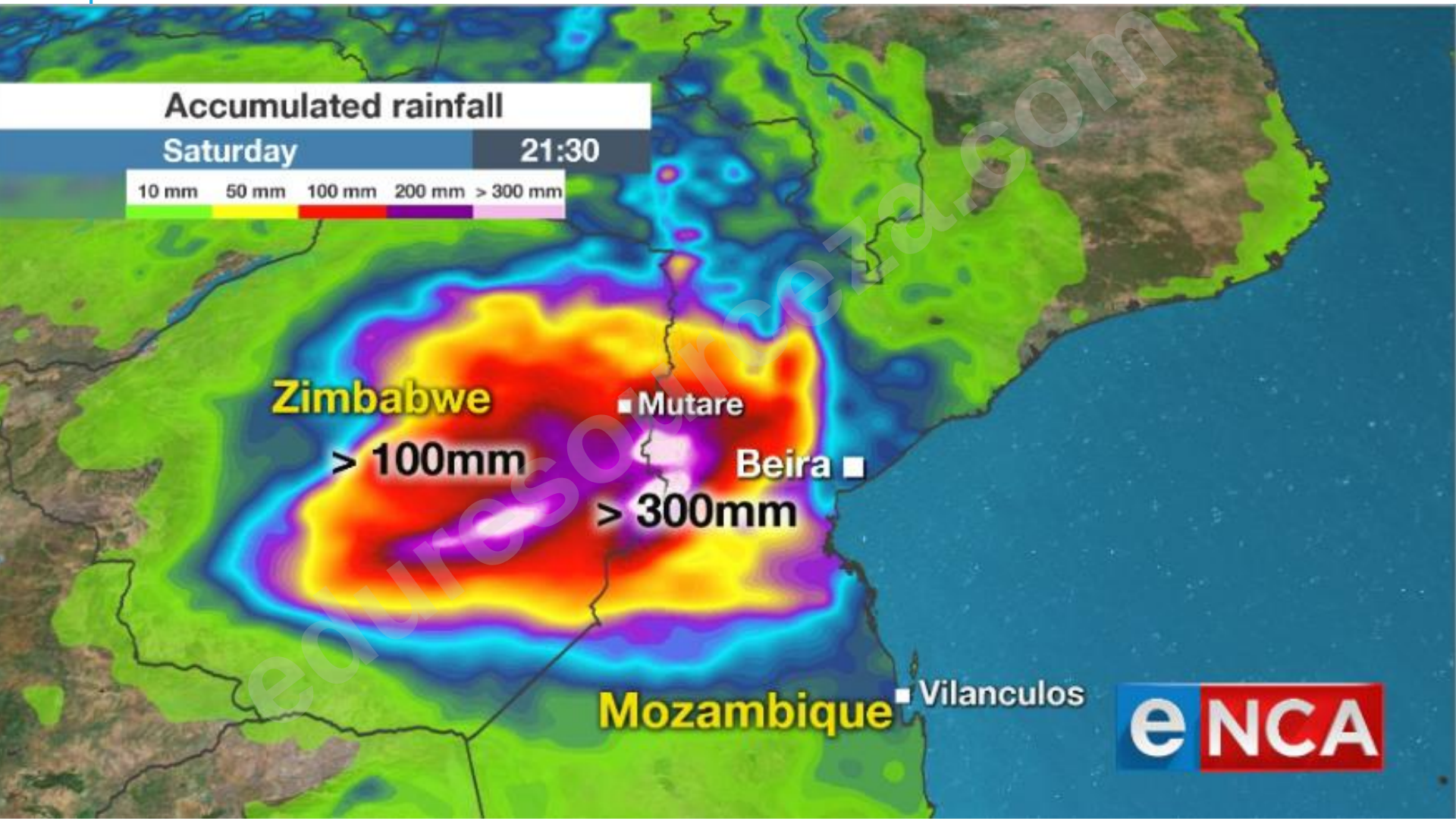
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m j berridge with text



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CLASS & PREP WORK

Activity 9 p 87

Activity 10 p 89

Activity 11 p 91

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VIDEO

Super hurricanes & typhoons

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PRECAUTIONARY STRATEGIES

Research development & typical paths more accurately

Better meteorological warning systems

Don't build below the flood line

Have proper, well-practiced disaster management plans in place

Have a good warning system in place – buy-in from local radio stations

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PRECAUTIONARY STRATEGIES

Preserve sand dunes and wetlands

Don't build right on the shoreline

Strengthen building structures

Flood-proof homes

Limit the construction of infrastructure in hazard prone areas

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DISASTER MANAGEMENT

4 aspects to a proper DM plan:

Planning

Evacuation after storm warning

Emergency aid immediately after storm

Restoration of community

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THE EFFECT OF TROPICAL CYCLONES ON SOUTH AFRICA

Peak frequency of TC's in January & February (Late Summer).

Only tropical cyclones moving into the Mozambique channel influence South Africa's weather, then…

The Limpopo Province, Mpumalanga and KwaZulu-Natal may experience destructive winds & the risk of flooding, & …

Dry weather over the interior because of the subsiding air surrounding a tropical cyclone.

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THE EFFECT OF TROPICAL CYCLONES ON SOUTH AFRICA

Significant tropical cyclones that had an effect on South Africa were:

"Domoina" January 1984

"Imboa" in February 1984

"Eline" in February 2000

"Dineo" in February 2017

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Saffir–Simpson hurricane wind scale

Category	Wind speeds
Five	≥70 m/s, ≥137 knots ≥157 mph, ≥252 km/h
Four	58–70 m/s, 113–136 knots 130–156 mph, 209–251 km/h
Three	50–58 m/s, 96–112 knots 111–129 mph, 178–208 km/h
Two	43–49 m/s, 83–95 knots 96–110 mph, 154–177 km/h
One	33–42 m/s, 64–82 knots 74–95 mph, 119–153 km/h
Additional classifications	
Tropical storm	18–32 m/s, 35–63 knots 39–73 mph, 63–118 km/h
Tropical depression	<17 m/s, <34 knots <38 mph, <62 km/h

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CYCLONE DIFFERENCES

	Tropical cyclones	Mid-latitude cyclones
Names	Typhoons (China, Japan) Hurricanes (America)	Extra-tropical cyclones, mid-latitude cyclones, depressions
Origin	Tropical oceans 5–30° N and S	At polar front 40–60° N and S
Pressure	Very low	Low
Pressure gradient	Very steep	Less steep
Movement	East to west carried by tropical easterlies	West to east carried by the westerlies
Wind speed	Very fast	Not as fast
Size	250–500km diameter	1000–3500 km diameter
Weather	Hot, destructive winds, heavy rain	Cool, cloudy and rainy

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CLASS & PREP WORK

Activity 12 p 92

Activity 13 p 94

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TYPICAL EXAM QUESTIONS

Identify the feature – TC

Explain requirements for TC development

List typical features of the TC as evident on the synoptic chart

Identify dangerous quadrant/semi-circle AND explain the reason why it is the most dangerous – isobars tightly packed and the direction of airflow within the system coincides with the direction of travel of the entire system.

Identify the stage of development the TC is in.

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TYPICAL EXAM QUESTIONS

Explain the wind direction at a certain weather station

Draw cross section of mature stage

Describe conditions in “the eye”

Reasons for dissipation

Relevance to SA

How many cyclones before “Fred”?

Environmental (human/nature) damage caused

Precautions

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TROPICAL CYCLONE EXERCISE

Refer to Synoptic chart 1 and answer the following questions;

1. Identify feature C. Provide an alternative name.
2. How many cyclones have occurred before "Cynthia" this season?
3. List 3 conditions necessary for the development of C.
4. List 3 characteristics of C evident from the chart.
5. What stage of development is "Cynthia" in?
6. Where could C be the most destructive? Motivate
7. How likely is it that C will recurve?
8. Draw a fully labeled cross section of C. Indicate the weather conditions that will be found in the eye.

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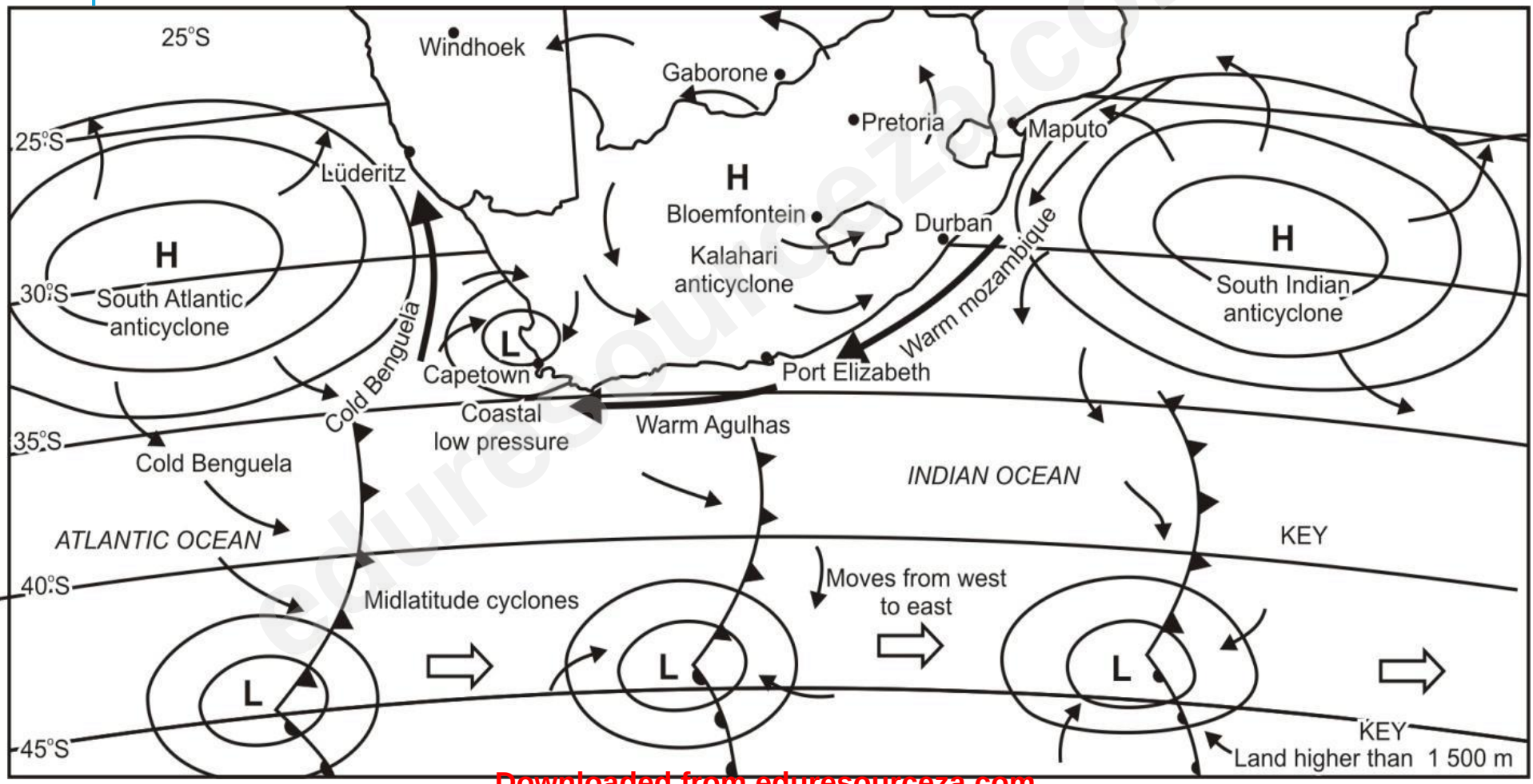
REGIONAL CLIMATOLOGY

Typical Features of Southern Africa's Climate

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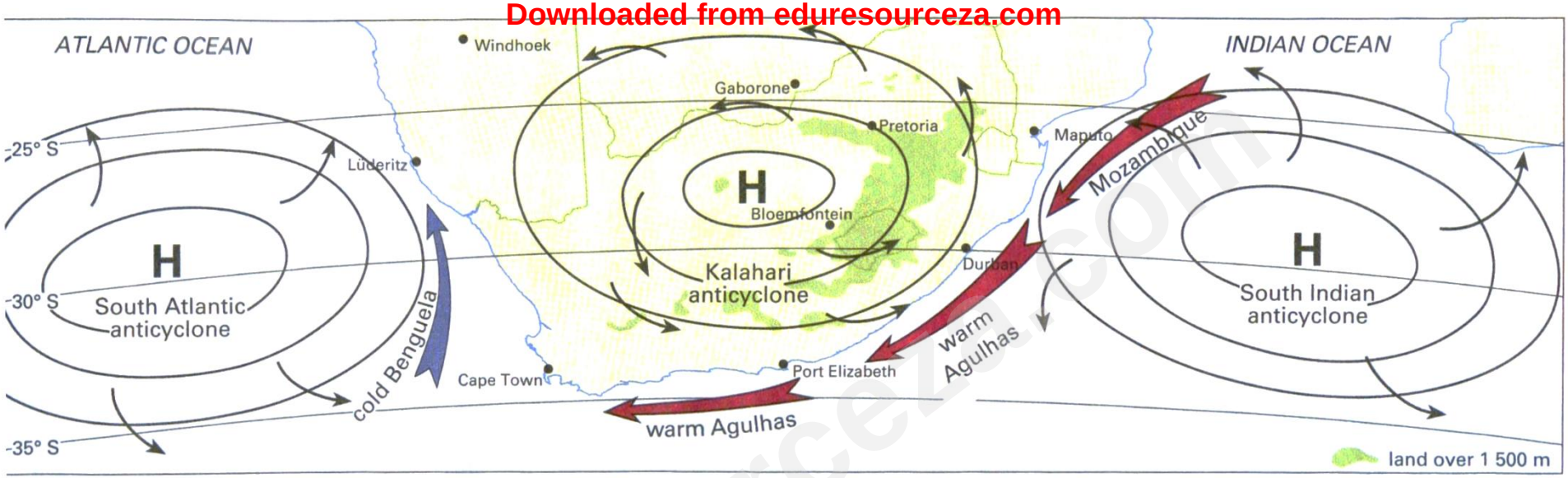
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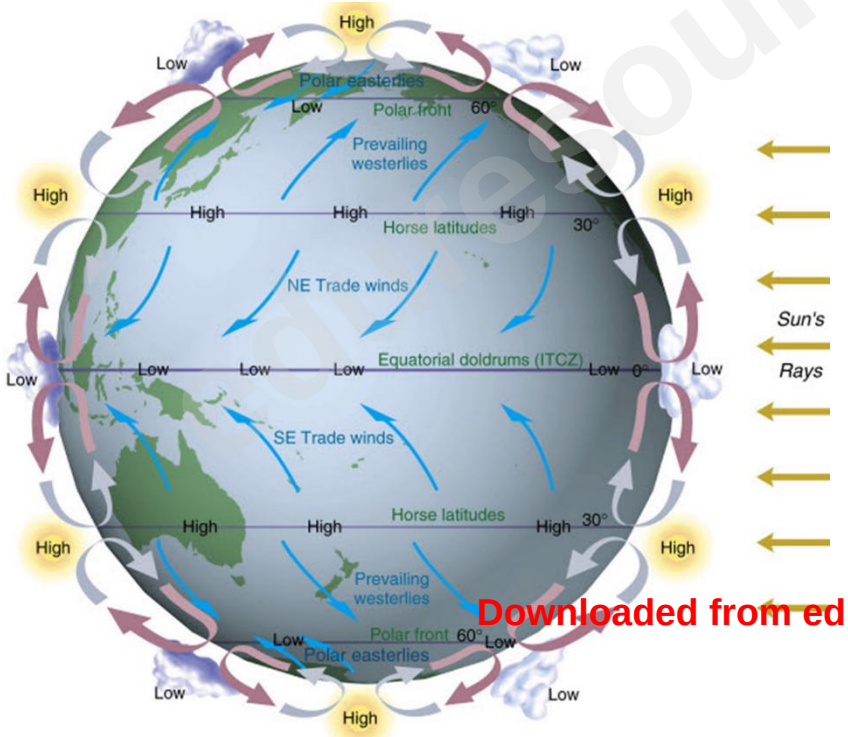
SUBTROPICAL ANTICYCLONES



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IT IS A WINTER CHART IF…

Date (April – August)

Low temperatures over interior (use examples)

Low dew point temperatures in interior – dry air

Little or no cloud cover over interior

Cloud cover and rain over Cape Town – Mediterranean Climate

Berg wind conditions – Pre frontal/coastal LP

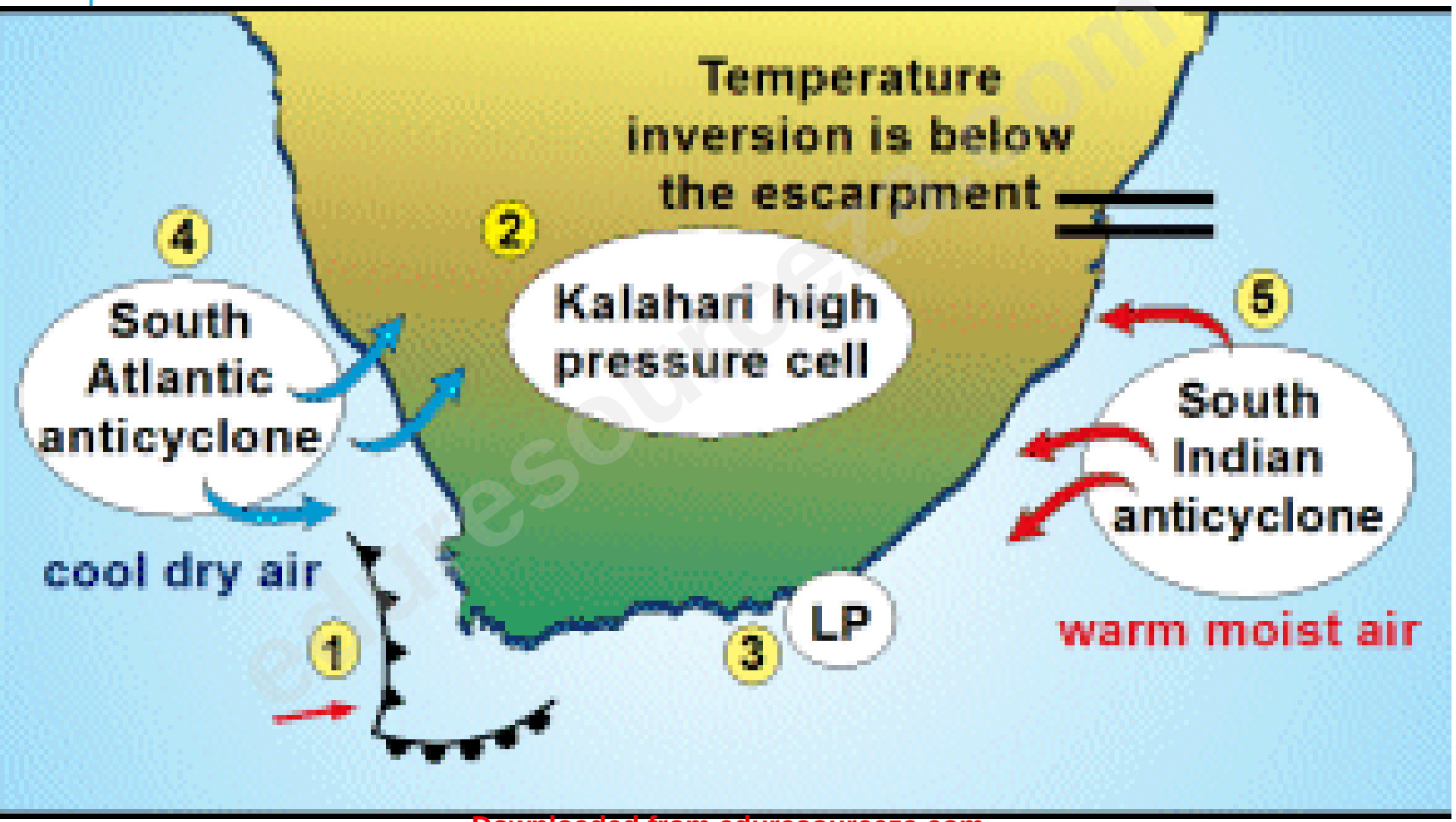
Cold front over Western Cape

No Tropical Cyclones

High Pressure over interior

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IT IS A SUMMER CHART IF…

Date (October – February)

High temperatures over interior

Dew point and maximum temperatures in interior within 5 degrees of each other – moist air

Cloud cover over interior

Little or no cloud cover and rain over Cape Town – Mediterranean Climate

No cold front over interior

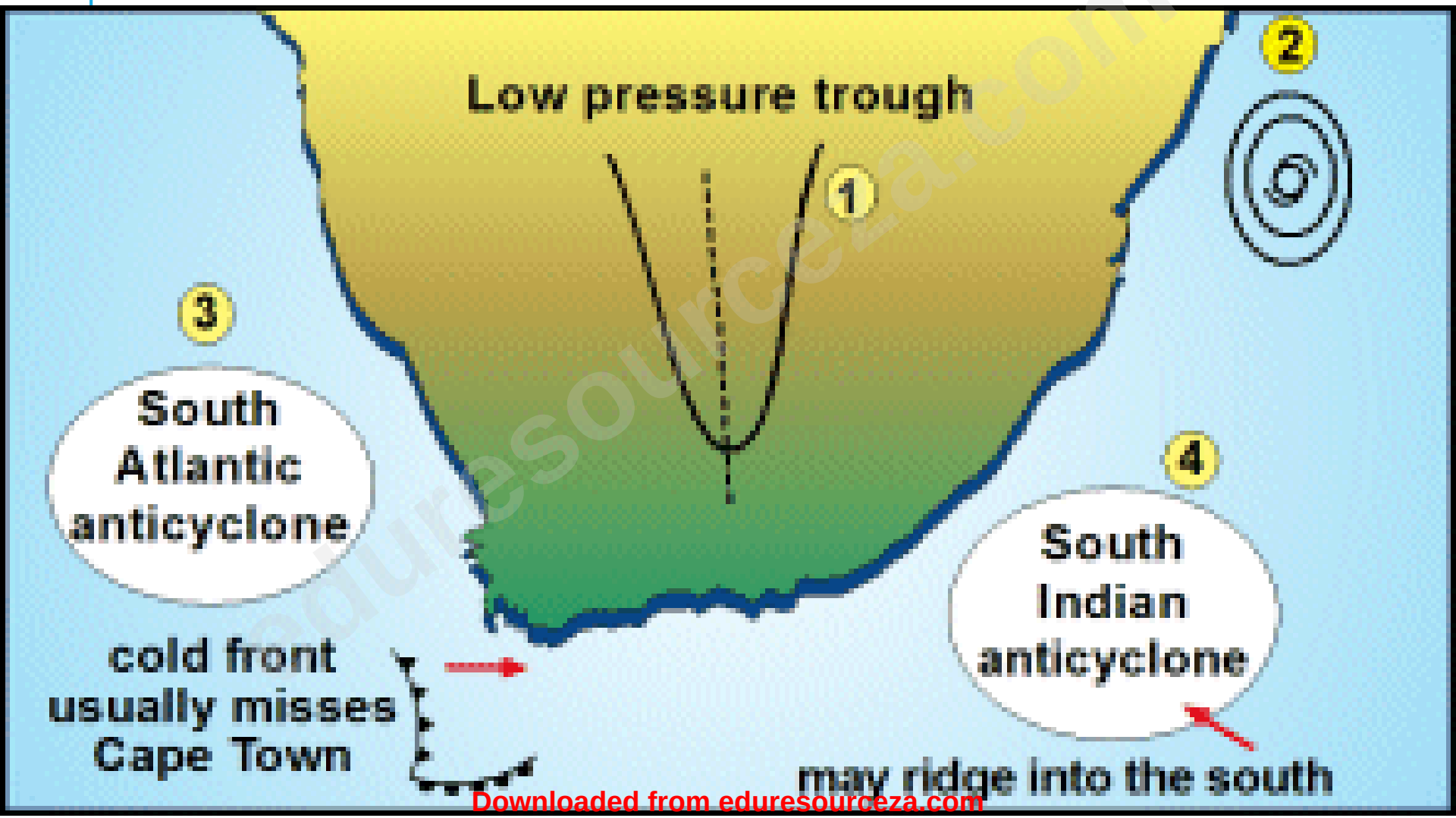
Presence of a tropical cyclone

Low Pressure over interior

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SUMMER



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CLASS & PREP WORK

Activity 15 p 100

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MAJOR FACTORS INFLUENCING SOUTH AFRICA'S CLIMATE

1. Ocean currents
2. Altitude of the plateau
3. High pressure systems
   - SAA
   - SIA
   - KA

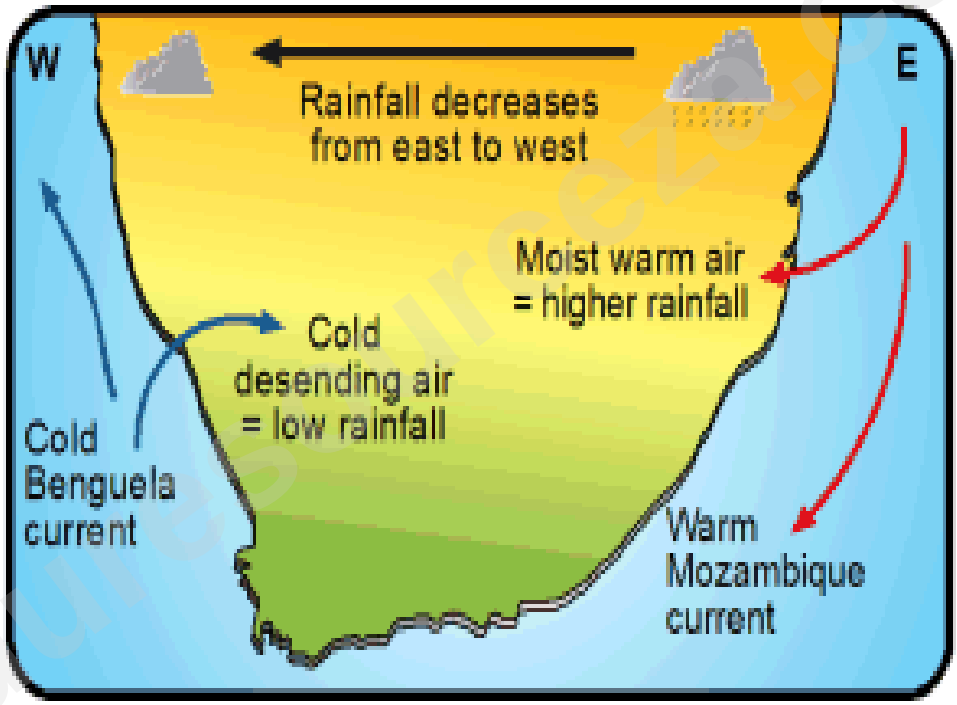
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1. OCEAN CURRENTS

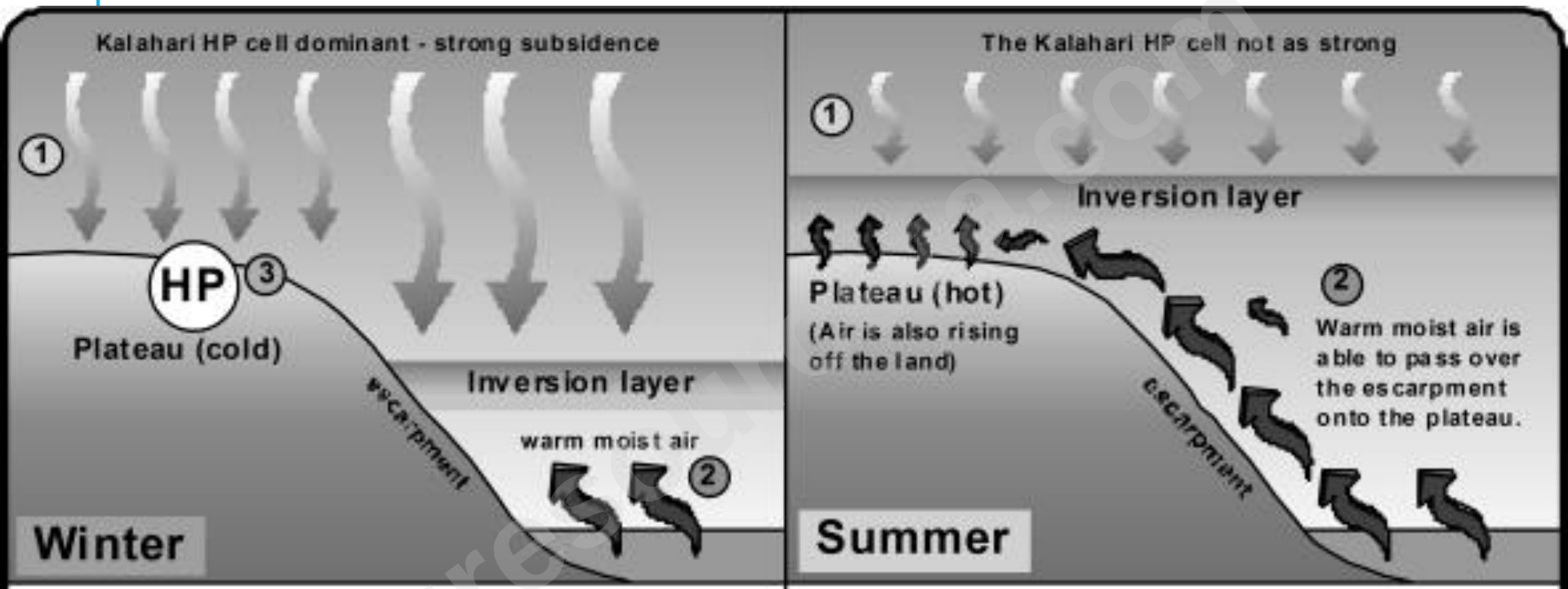
The cold current causes lower temperatures and **low rainfall** on the West Coast



The warm current results in warmer temperatures and **higher rainfall** on the East Coast

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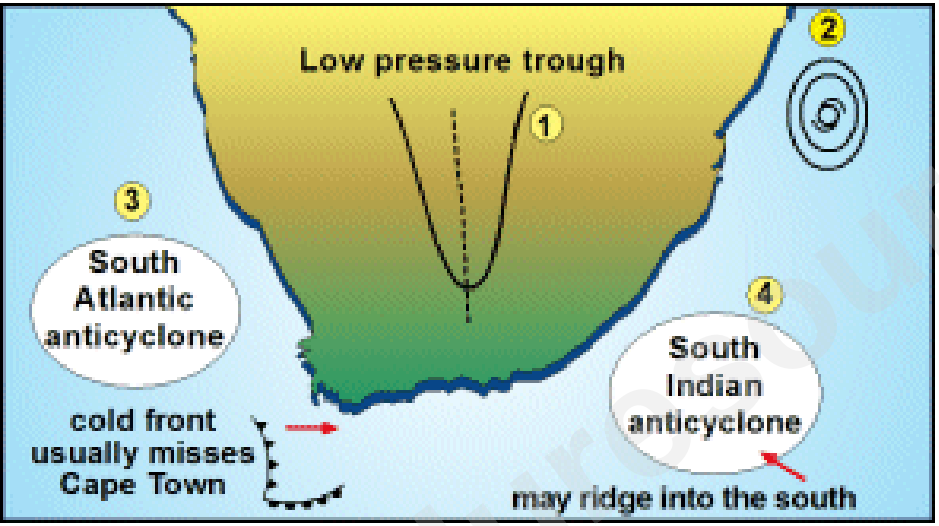
1. Because the influence of the Kalahari high is strong (coupled with the fact that the land is cold – no rising air), the sinking air forms an inversion layer below the escarpment.
2. This layer **blocks** warm, moist air from reaching the interior.
3. This results in **dry winters** over the interior (no rain, clear skies, warm days and cold nights).

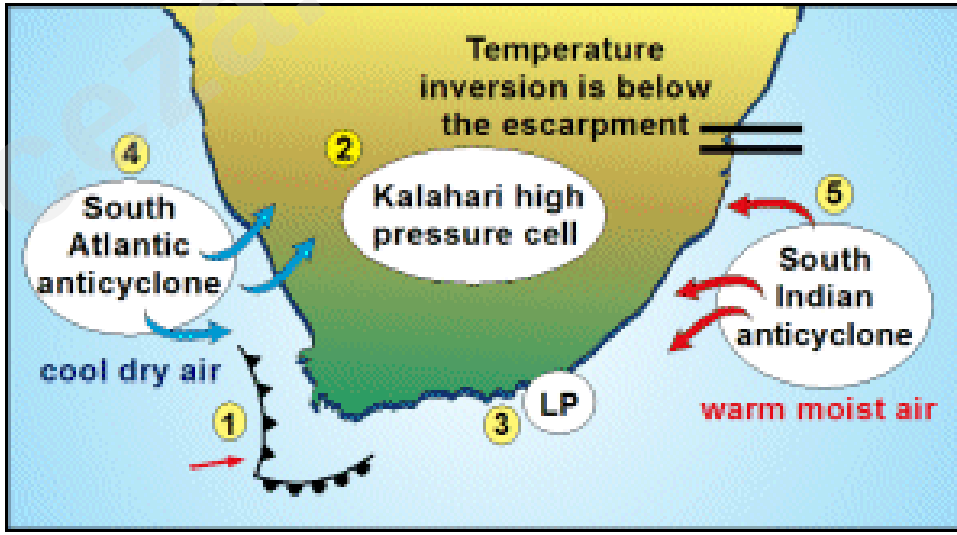
1. During the summer the land is hot and air rises. The sinking air from the Kalahari HP cell is weaker.
2. Now the **inversion** layer is **above** the escarpment, and warm, moist air is **able** to get over into the interior.
3. This can result in summer rainfall over the interior.

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3. HIGH PRESSURE SYSTEMS





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CAPE TOWN'S SOUTH EASTER

Also called the Cape Doctor

SAA ridges south of SA causing SE wind (summer)

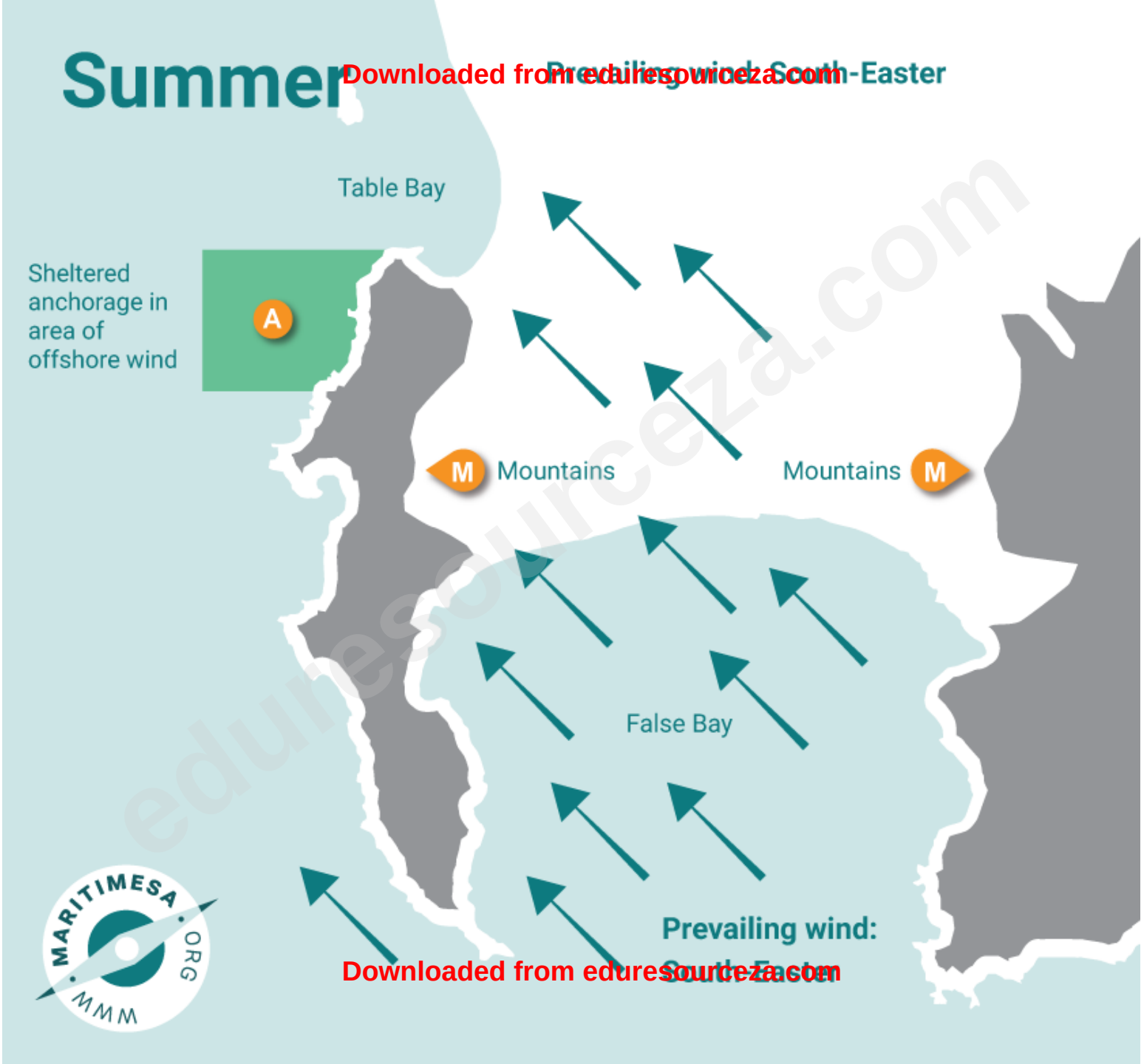
Wind funnels btwn mtn ranges

Blows out pollution & may be gale force at times

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TRAVELLING DISTURBANCES ASSOCIATED WITH ANTICYCLONIC CIRCULATION

= weather patterns that arise from anticyclones that occur at certain times of the year that travel from one area to another

1. Moisture front & line thunderstorms
2. Coastal low pressure
3. Berg winds
4. Cut-off low

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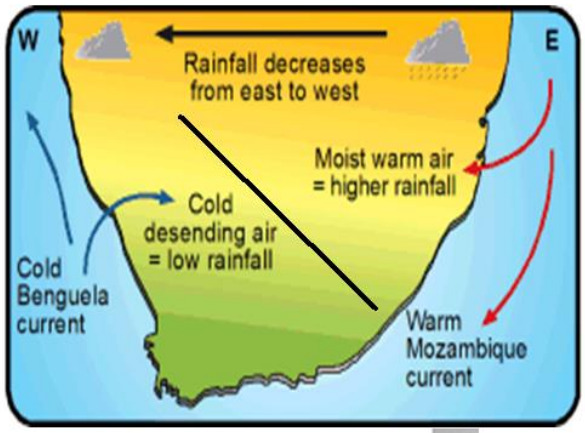
TRAVELLING THUNDERSTORMS, MOISTURE FRONTS OR SQUALL LINE THUNDERSTORMS

In summer a trough of LP exists over the interior of SA

Occur along a moisture front running from NW to SE of SA

Warm air from NE rises above cold air from SW

Accounts for much of SA's summer rain



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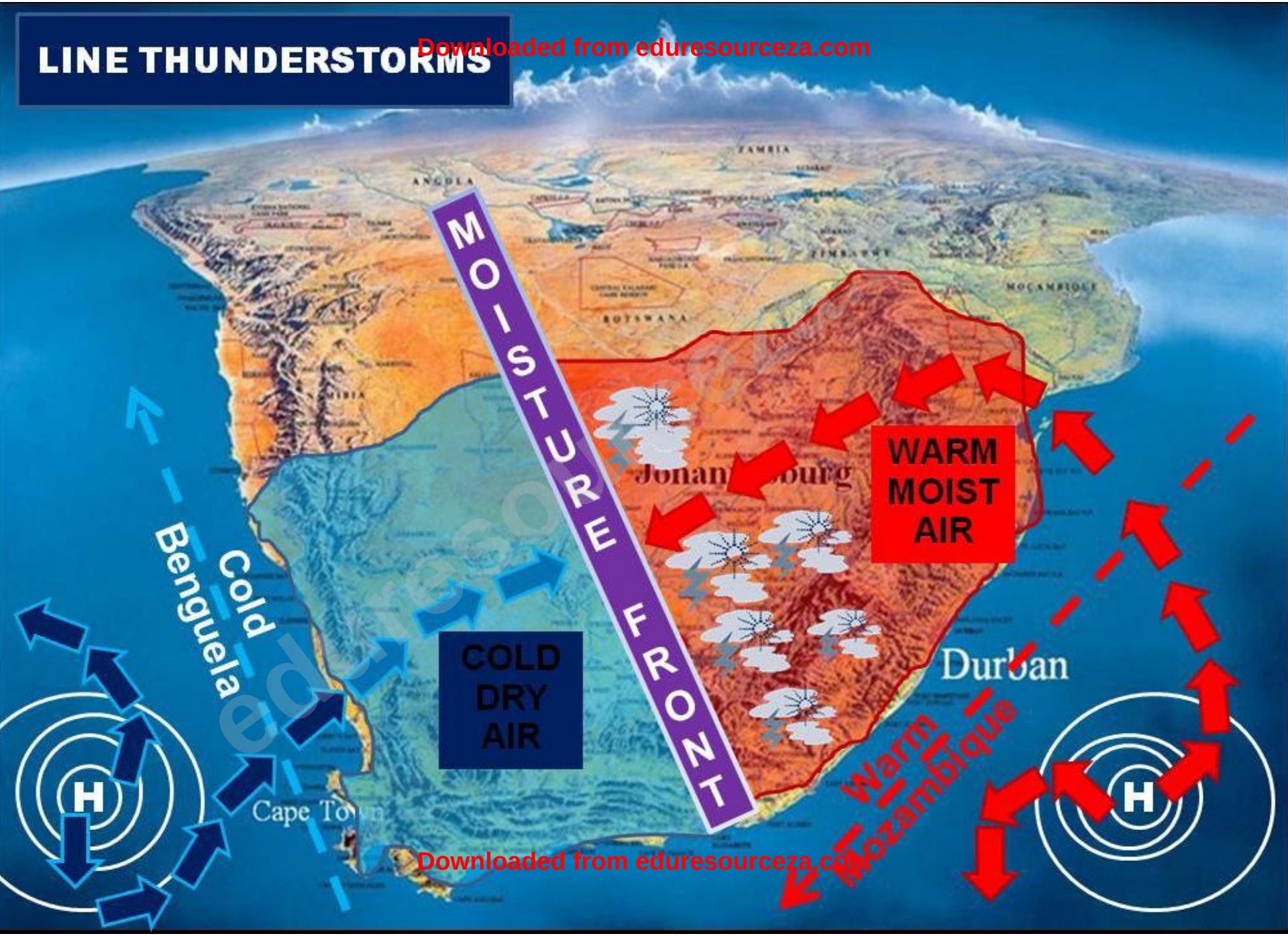
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LINE THUNDERSTORMS

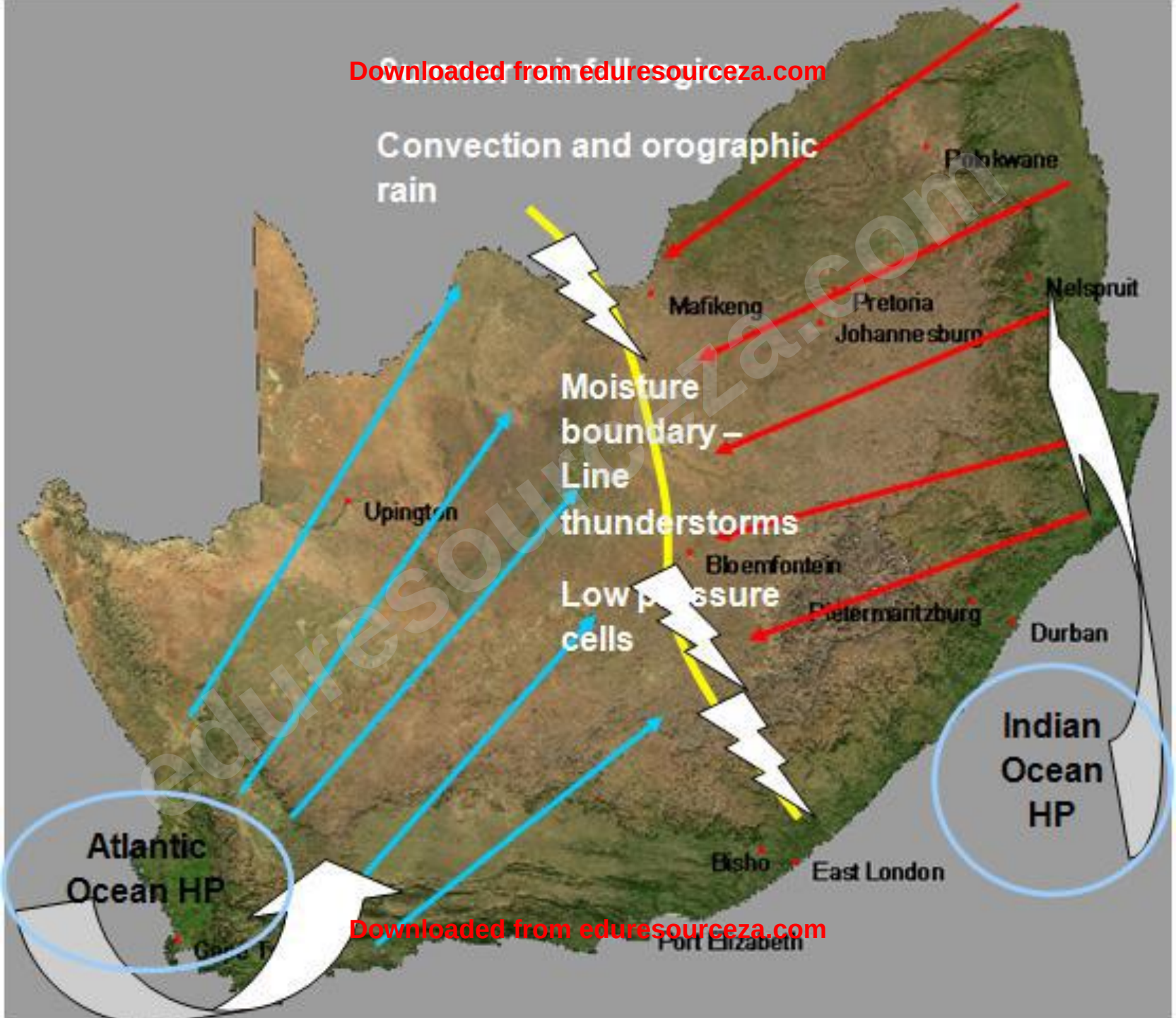


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LINE THUNDERSTORMS
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ZAMBIA
ANGOLA
ZIMBABWE
MOÇAMBIQUE
BOTSWANA
NAMIBIA
MOISTURE FRONT
WARM MOIST AIR
COLD DRY AIR
Cold Benguela
Warm Mozambique
Durban
Cape Town
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COASTAL LOWS

Develop during summer & winter in SA, mostly during winter

LP system – clockwise air flow

On one side, air moves from land to sea (offshore) creating dry, warm conditions

On the other side, air moves from sea to land (onshore) bringing moist, cloudy, rainy conditions (particularly on the E coast); fog may develop on the W coast

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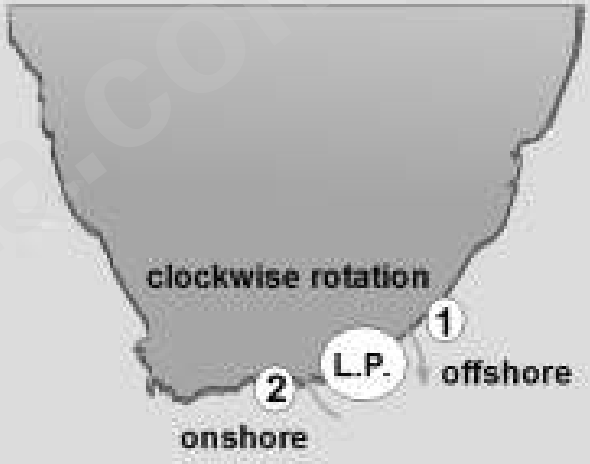
Moves from W to E along the coast

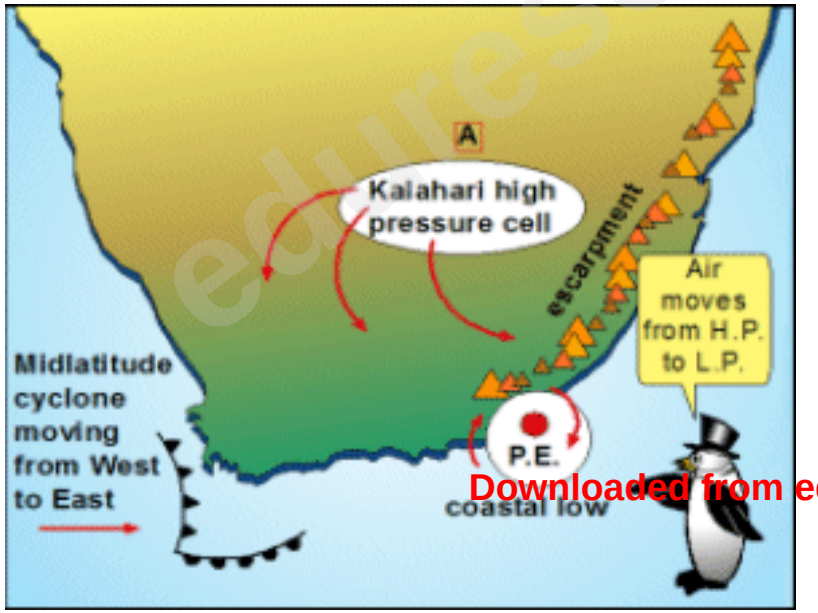
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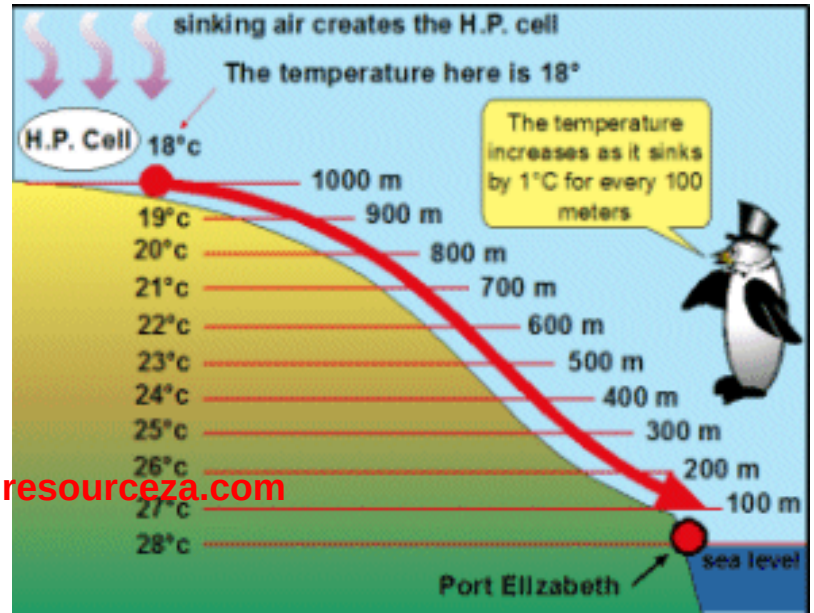
COASTAL LOWS & BERG WINDS

1. Ahead of the coastal low, offshore winds will blow. These are **dry** and hot (called berg winds).

2. Behind the coastal low, there is an onshore wind (**from** the sea **onto** the land). The moist air from the sea results in fog or light drizzle or rain, depending on the position of the coastal low.







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CUT-OFF LOW

Forms when the SAA forms a strong ridge behind a cold front, 'cutting it off'

Cold, moist air blows in behind the cold front from the SW

Very cold weather, heavy rain & snow may be experienced across SA

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VIDEO

Cut-off low this weekend

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CLASS & PREP WORK

Activity 16 p 102

Activity 17 p 104

Activity 18 p 104

Subtropical anticyclones crossword

Data handling activity p 105-106

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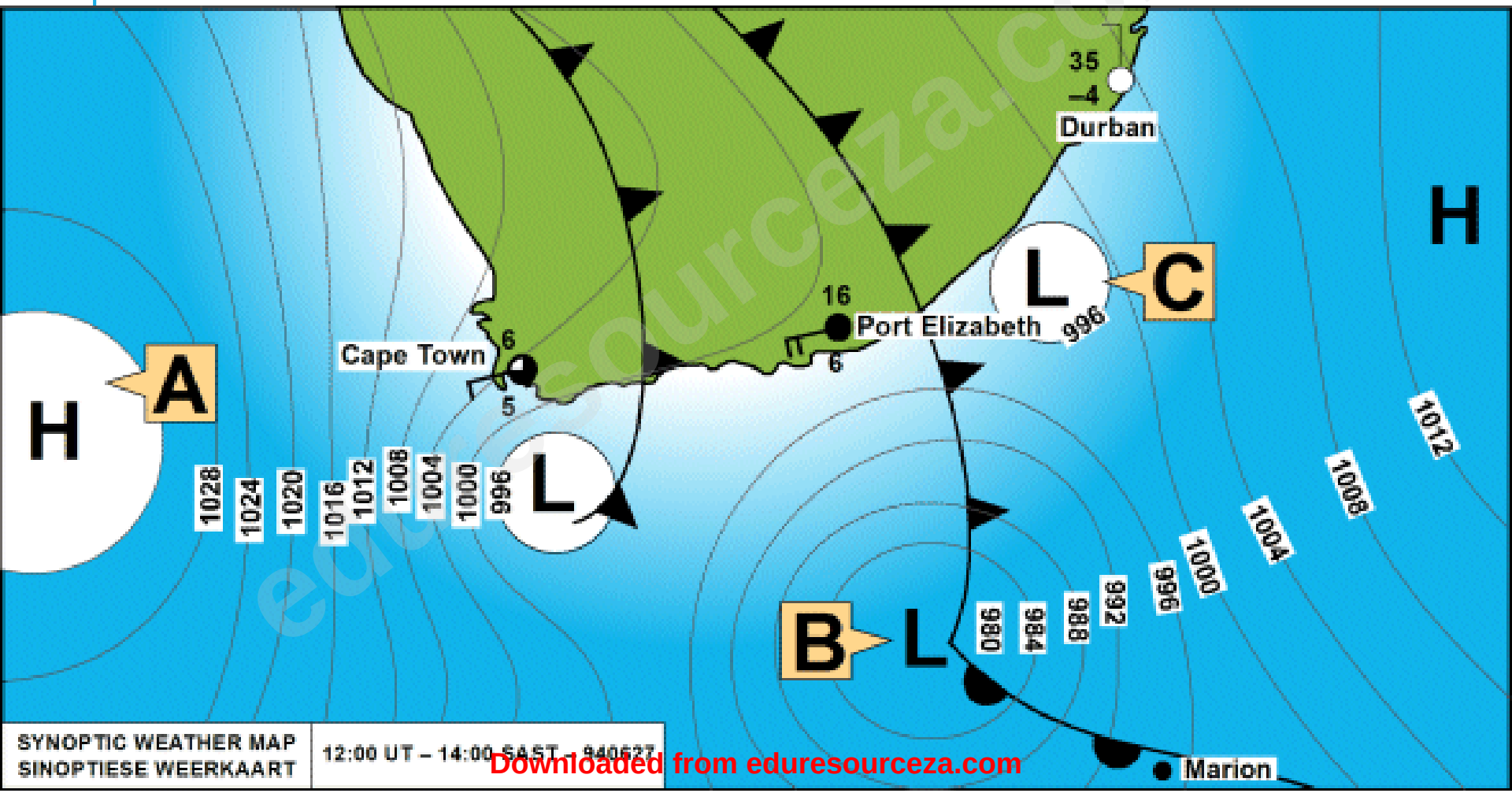
SPOT TEST

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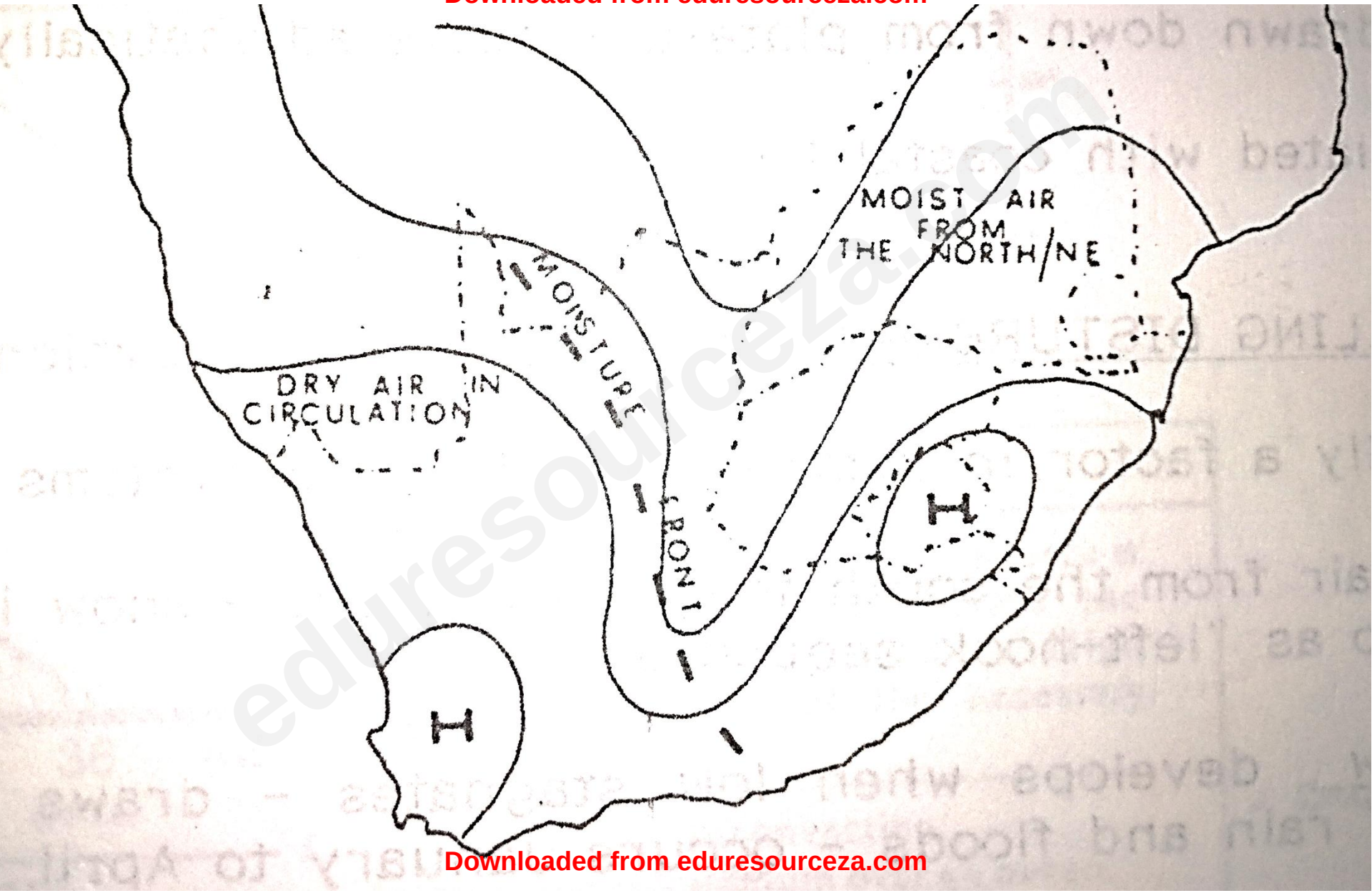
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SPOT TEST



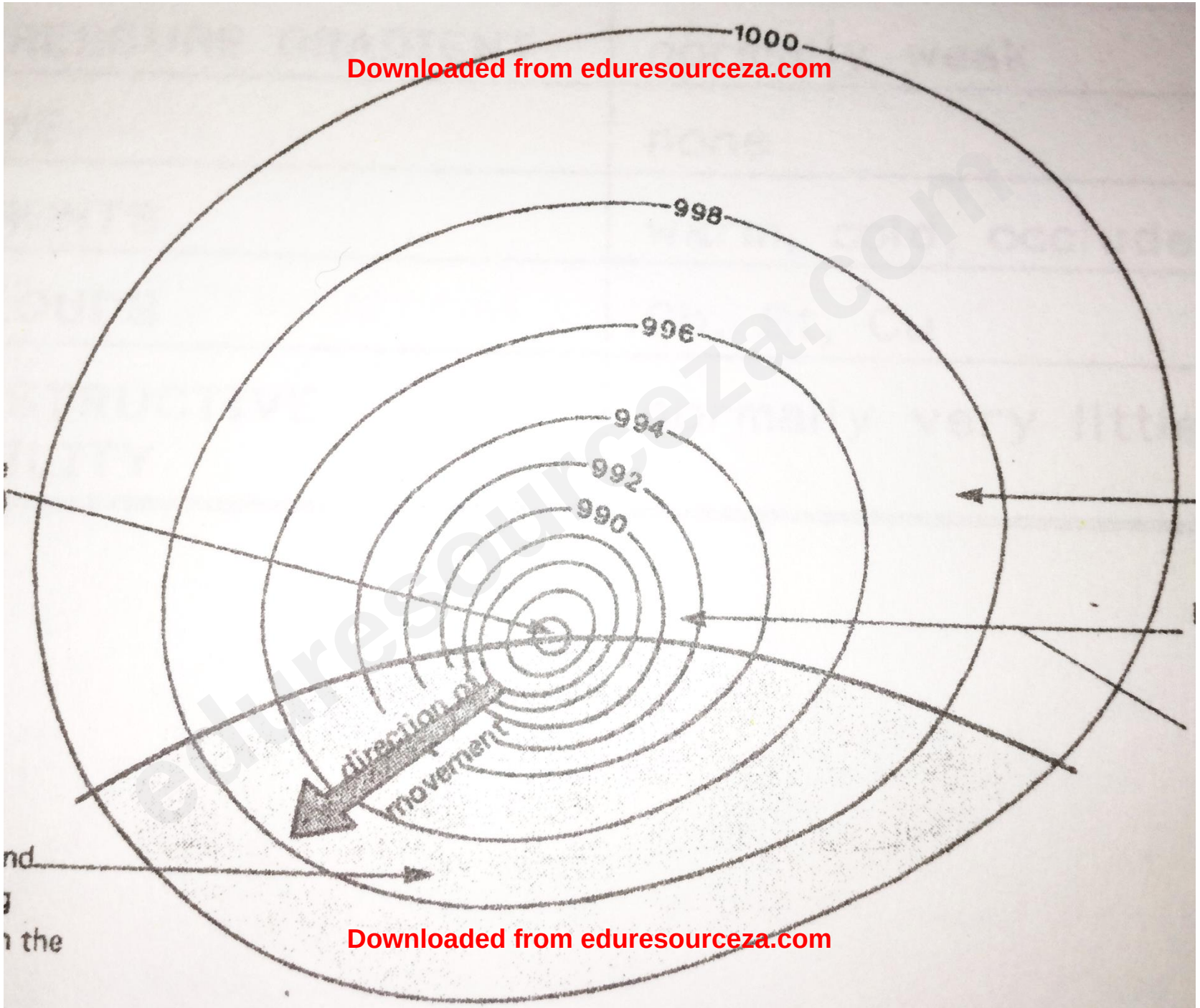
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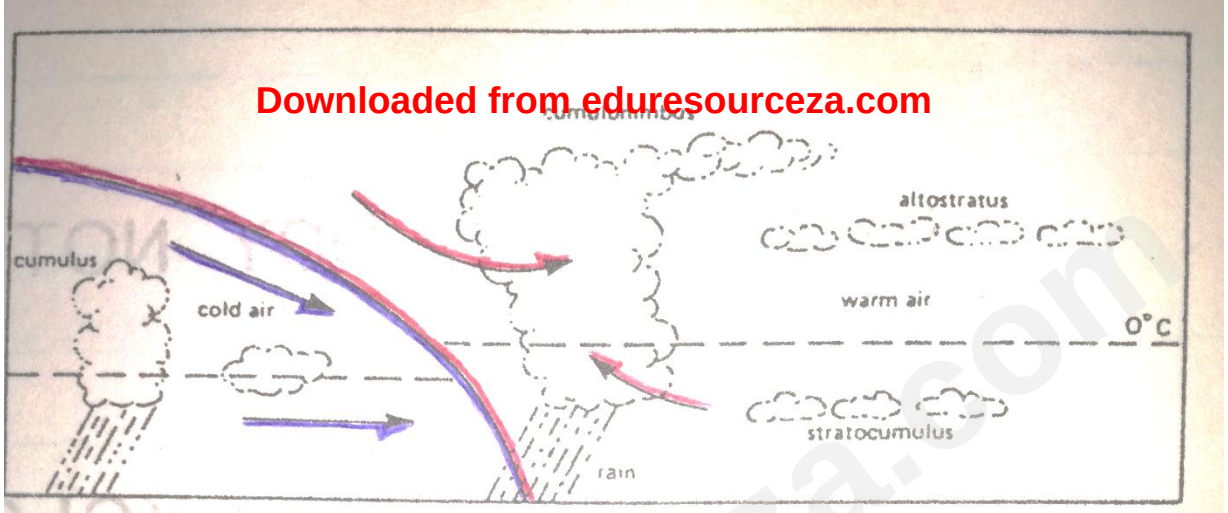


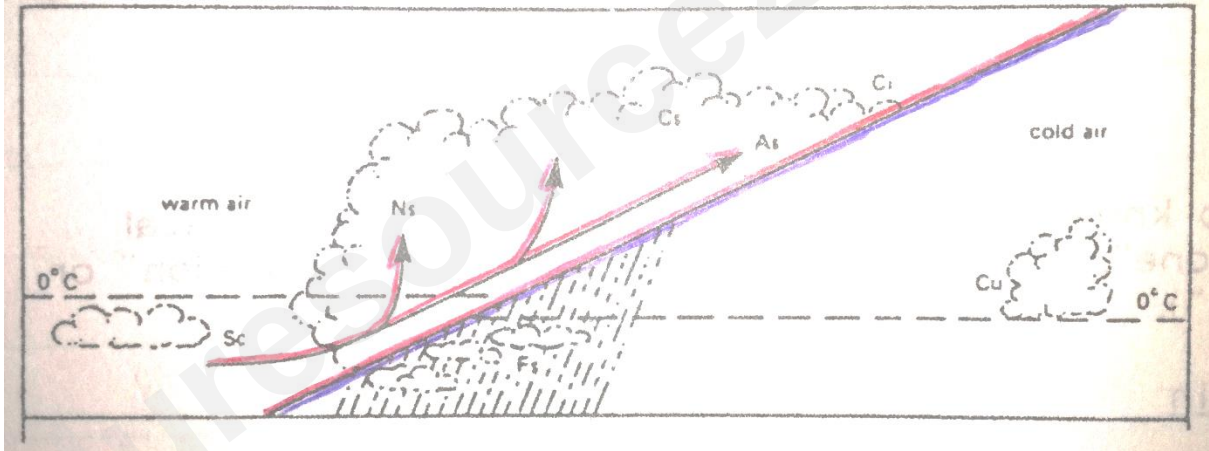
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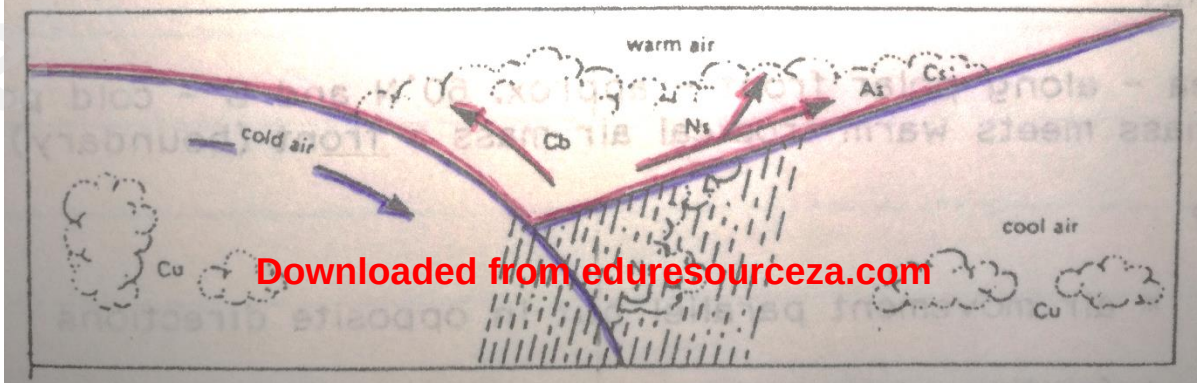
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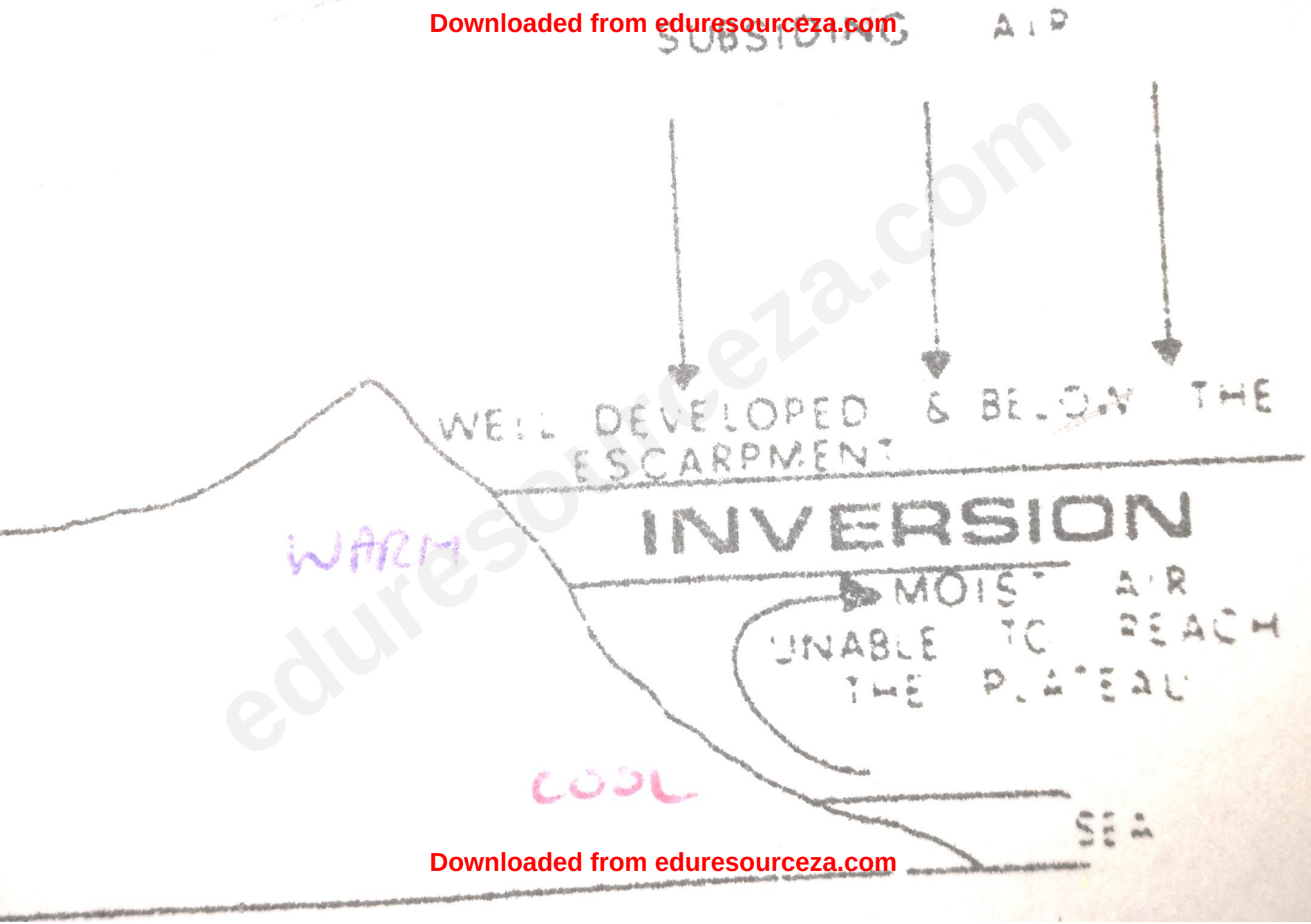






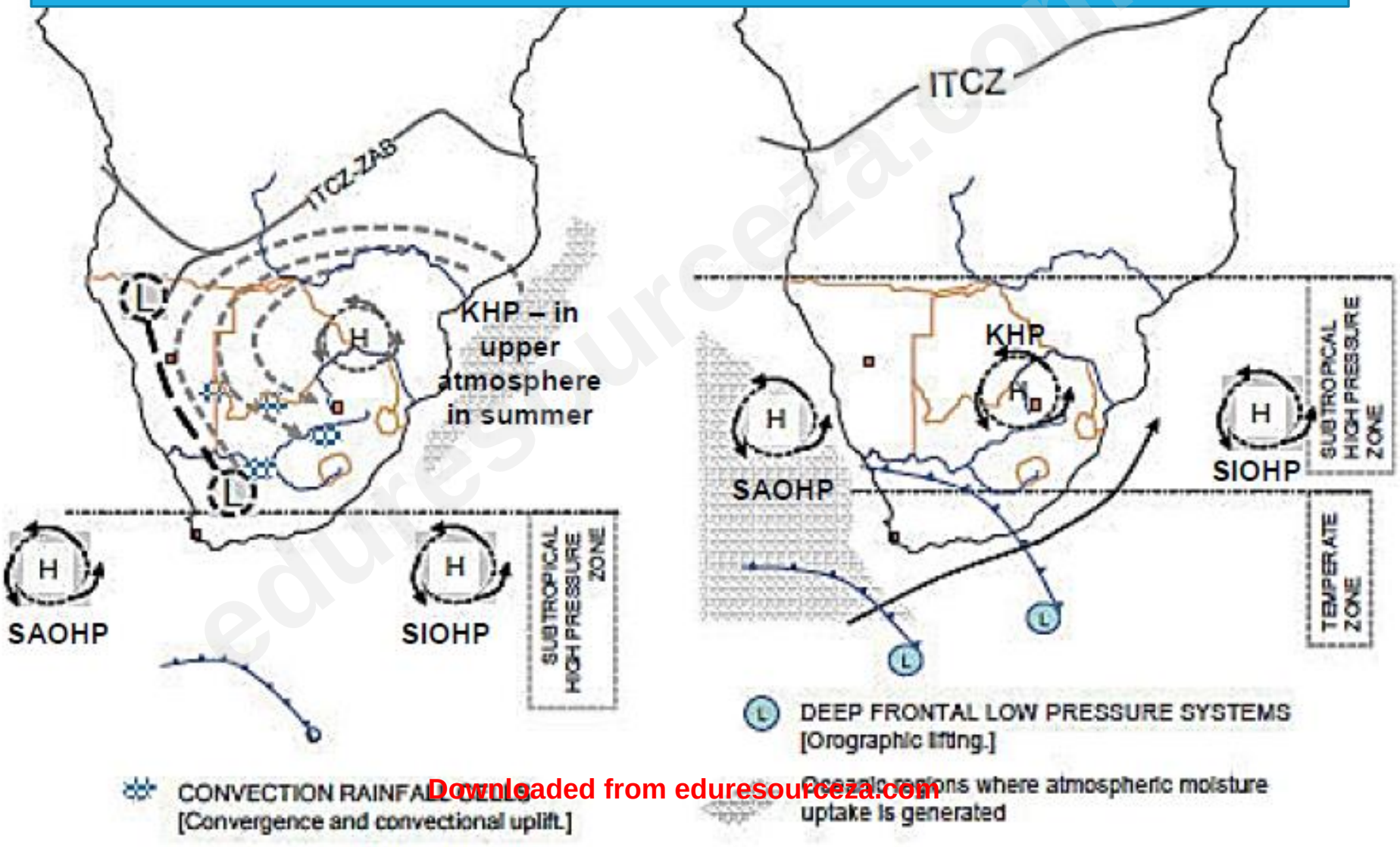
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MICRO CLIMATE

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- Valley climates
- Urban Climates

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VALLEY CLIMATES

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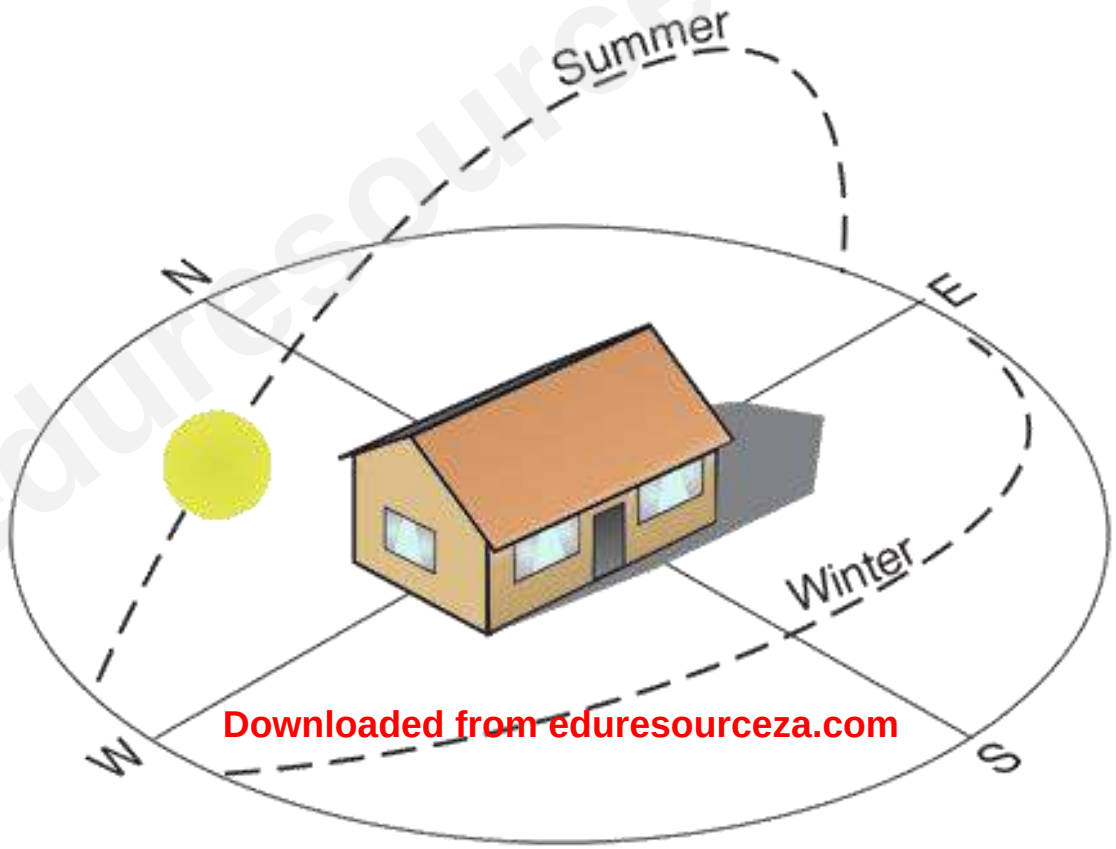
1. Aspect
2. Valley Inversions
3. Air flow in valleys

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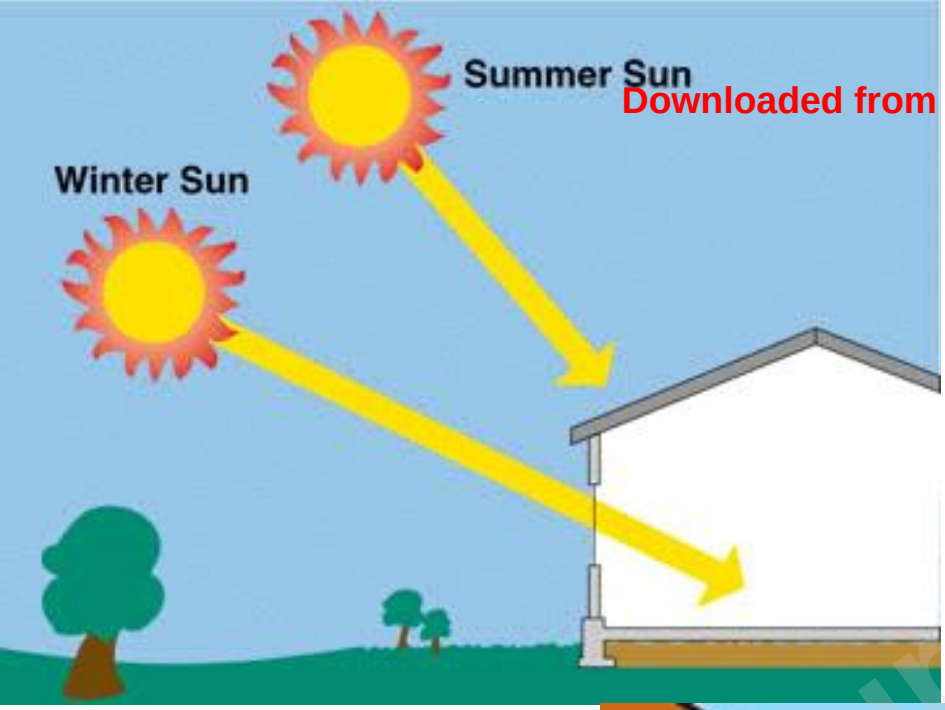
1. SLOPE ASPECT

= the angle at which the sun's rays strike a slope

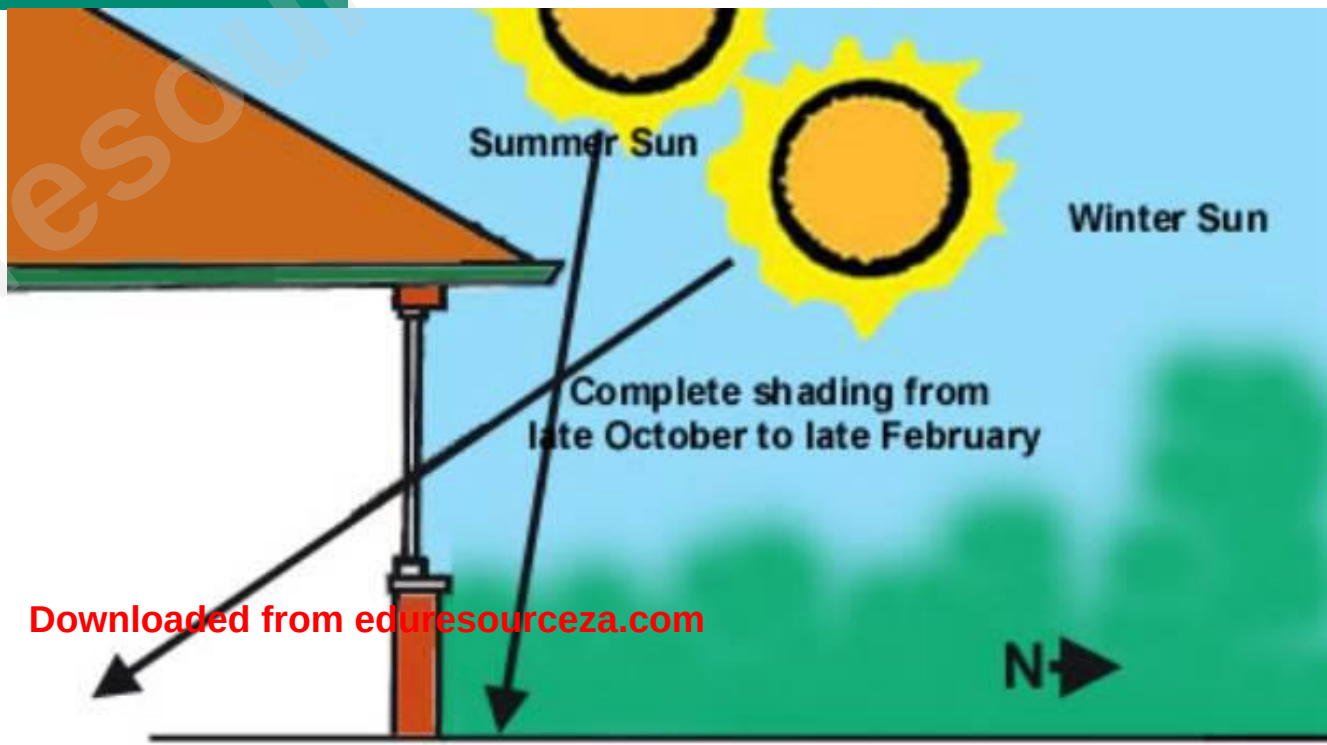
Shadow zone = an area that does not receive any direct sunlight



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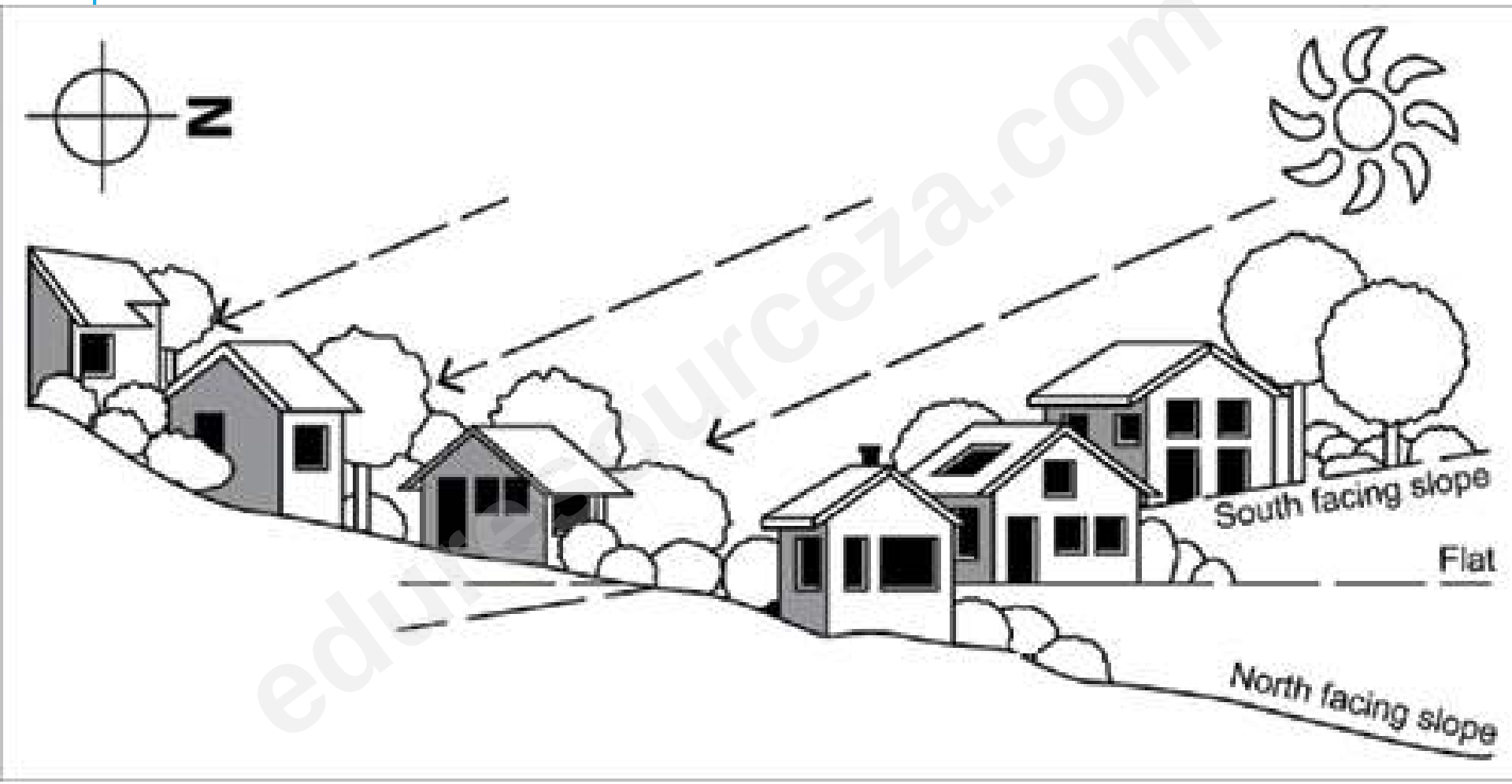


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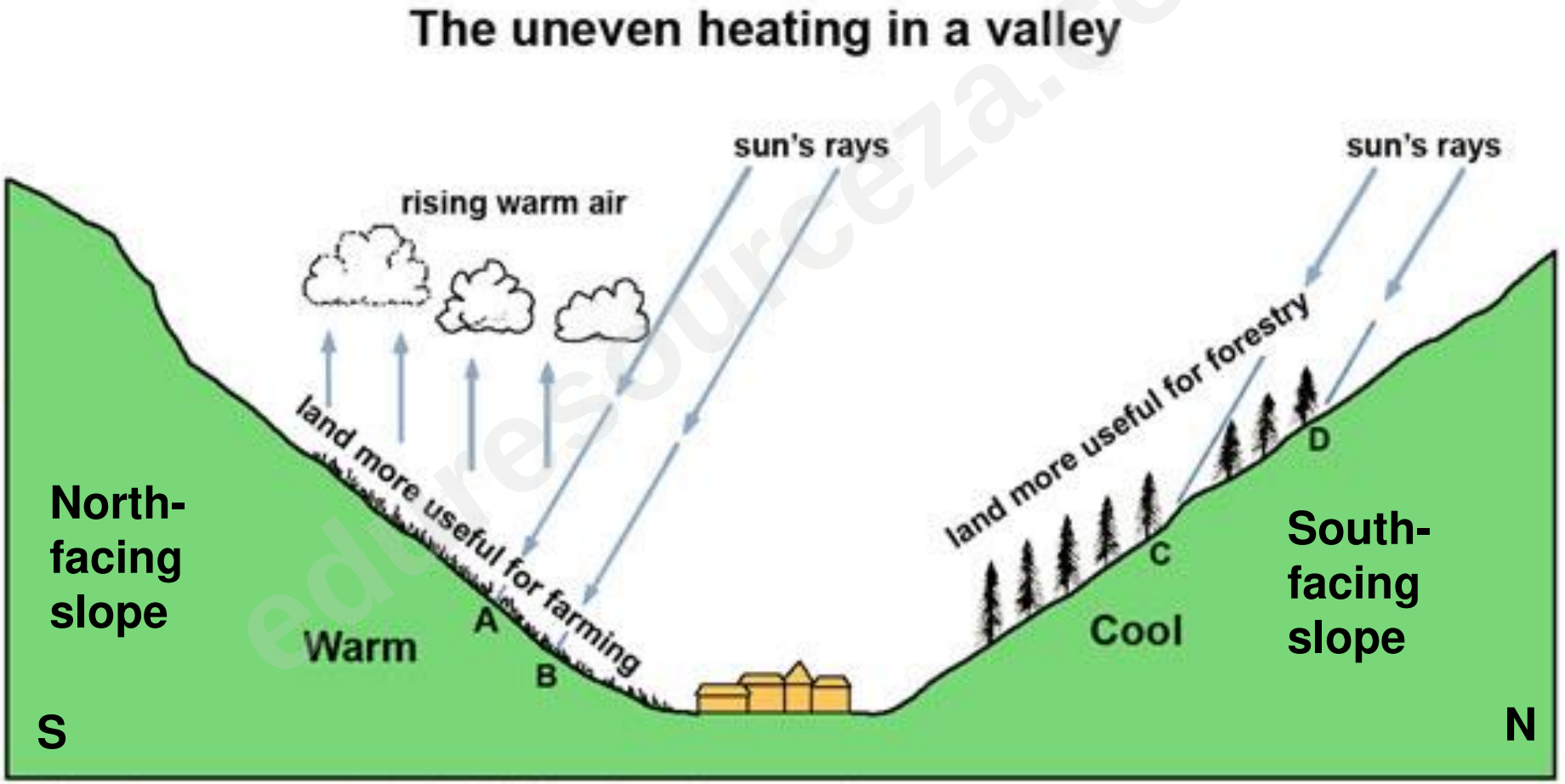
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SOUTHERN HEMISPHERE



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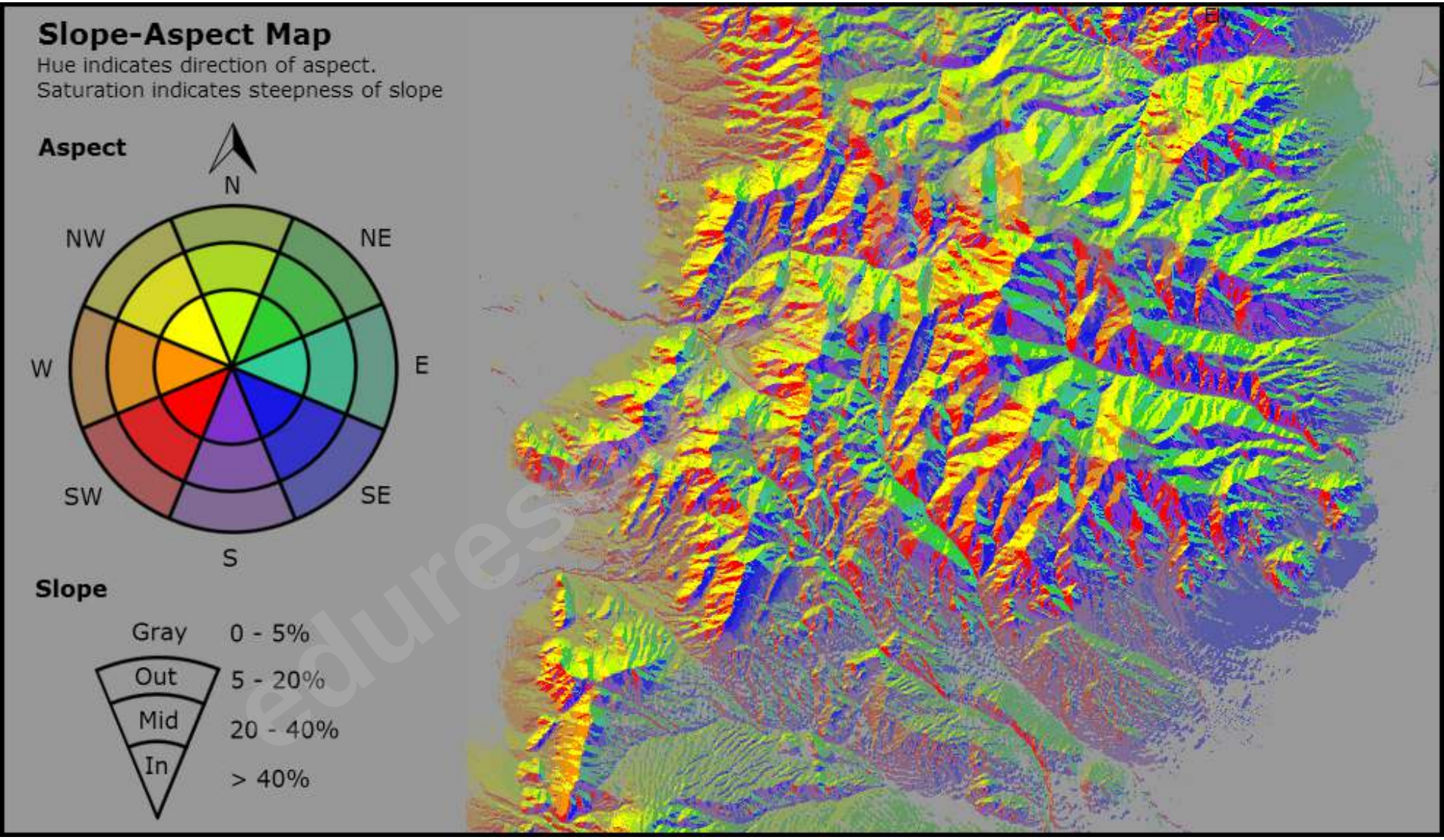
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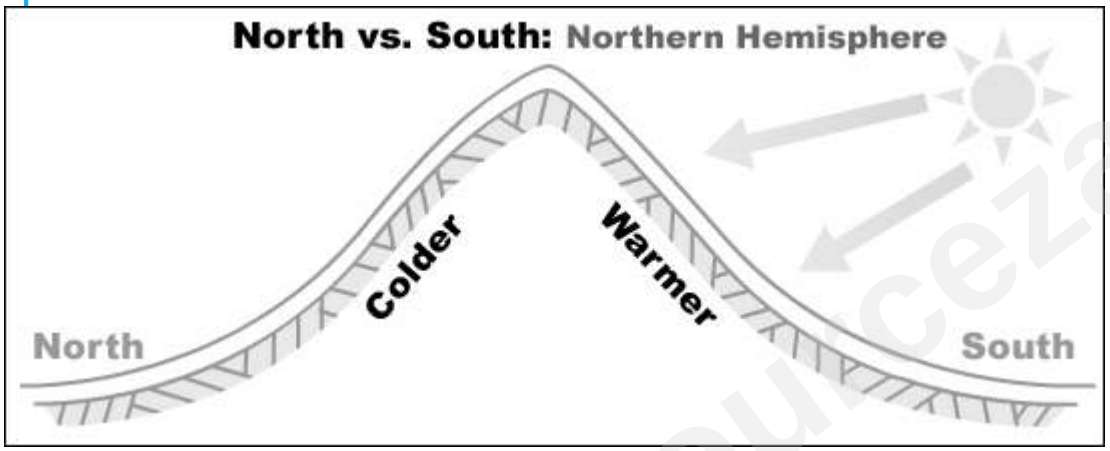
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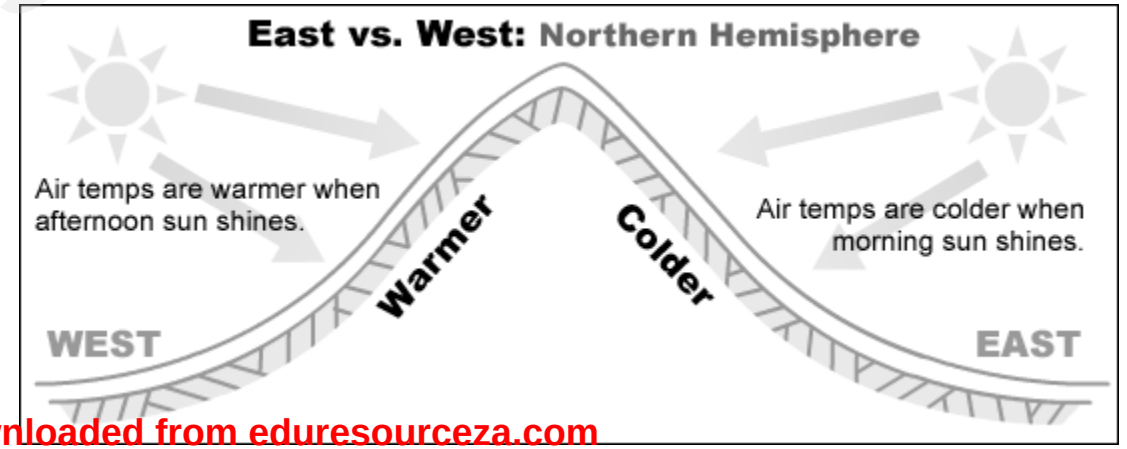


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ASPECT





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MOSS ON THE SOUTH-FACING SIDE (S HEM)



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ASPECT

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- In the northern hemisphere, a southerly aspect gives effectively a higher angle of sun in the sky, and longer days.
- In the southern hemisphere, a northerly aspect is warmer
- The growing season is longer (by about a month for each 1°C higher in annual average temperature),
- Frosts are less frequent, less severe
- Maximum temperatures are higher.



The right hand slope (above) is facing the sun, keeping it free of snow for longer.



Isolated snow patches are likely to remain in spring on north facing slopes (in Britain) where the sun takes longer to melt the snow.



In some arid environments, shade is important, reducing temperature, humidity and evaporation rates.



Shaded areas, especially if north facing, remain damper with reduced temperatures, evaporation and humidity. This also affects vegetation, soil moisture which may, in turn, affect frosts and temperature variations

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Sensitive crops may only be possible on south-facing slopes in Europe (e.g. vines below); the opposing slope is pasture alone.



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CLASS & PREP WORK

Activity 19 p 107

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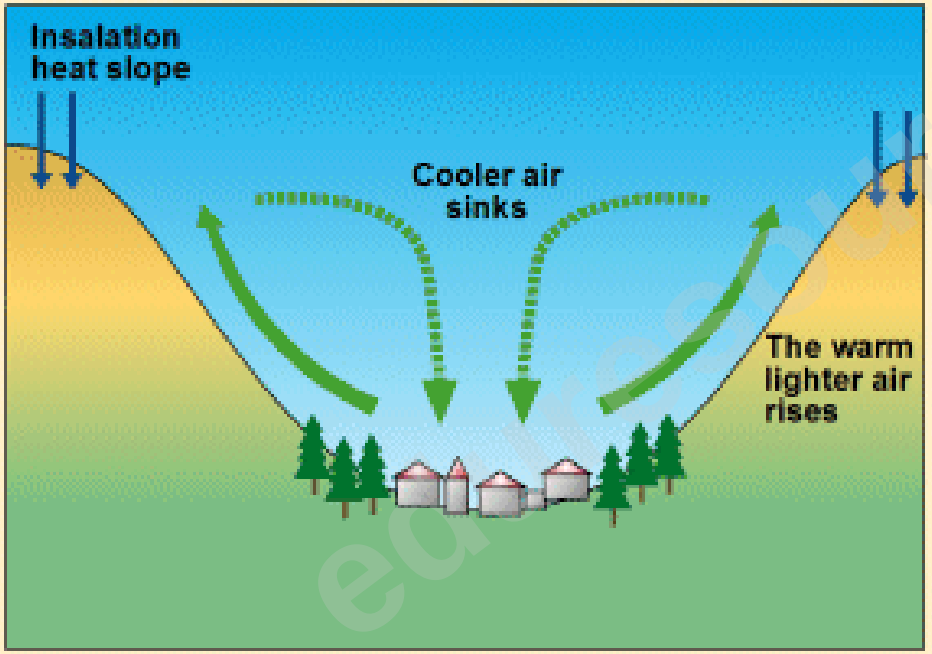
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2. VALLEY AIR FLOW

Day = anabatic = valley wind = upslope

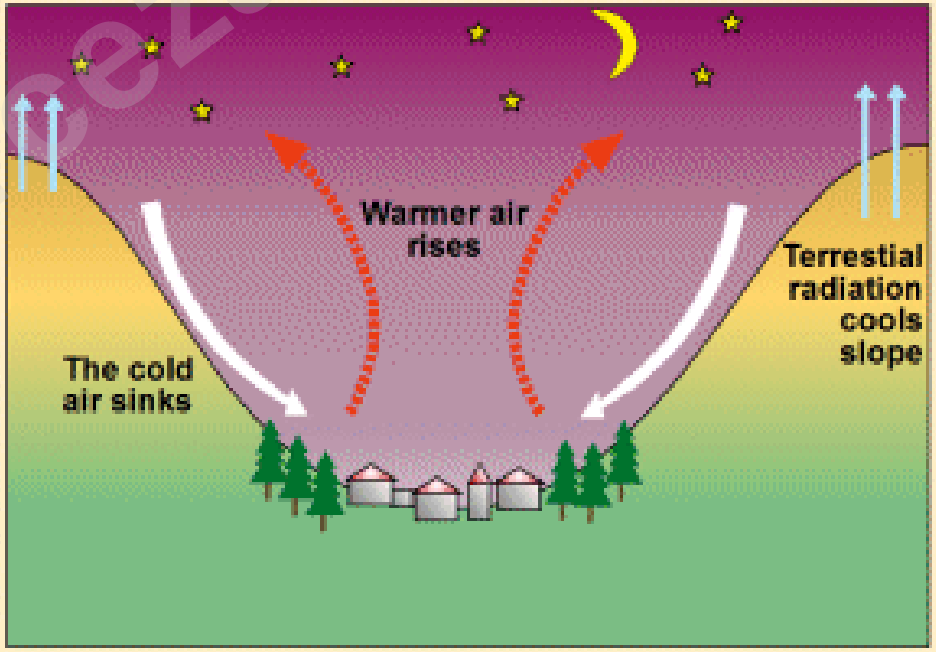
During the day the sun's rays warm the top of the slopes and the warm air **rises upslope**.



You can see this valley experiences winds that **reverse** daily: upslope during the day, downslope at night.

Night = katabatic = mountain wind = downslope

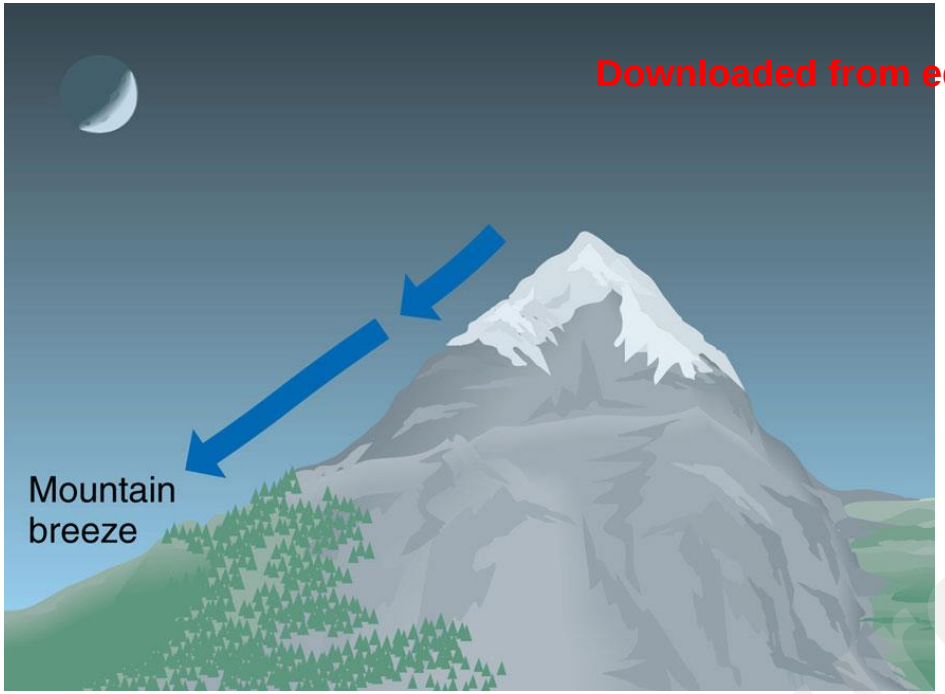
At night the slopes cool; the air in contact with the slopes cools and **sinks downslope**.

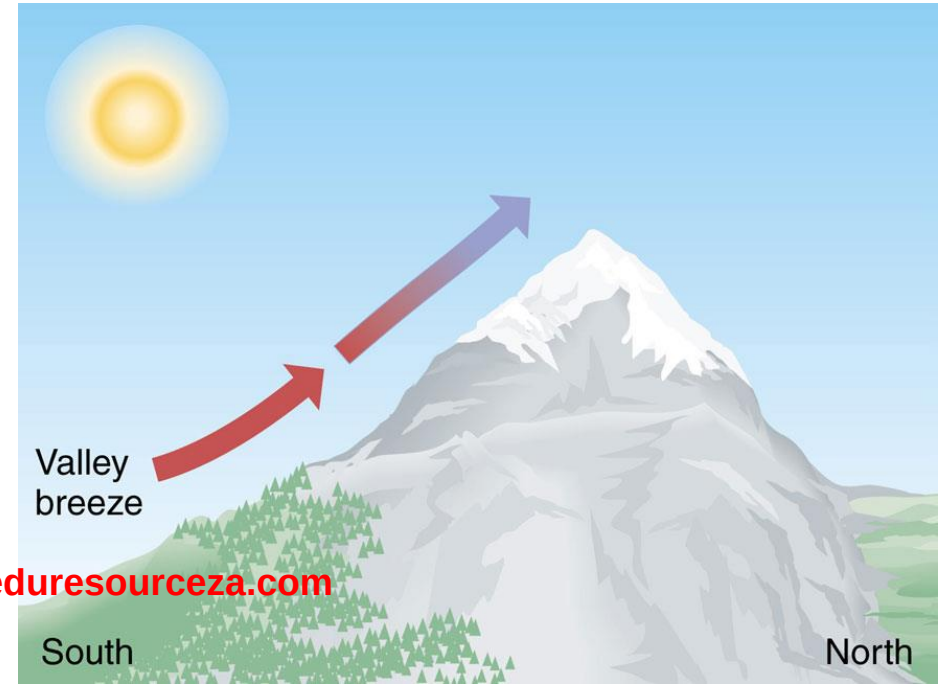


See the link between this diagram and the one on temperature inversions: during winter the cold air collects in the bottom of the valley, which could result in a frost pocket.

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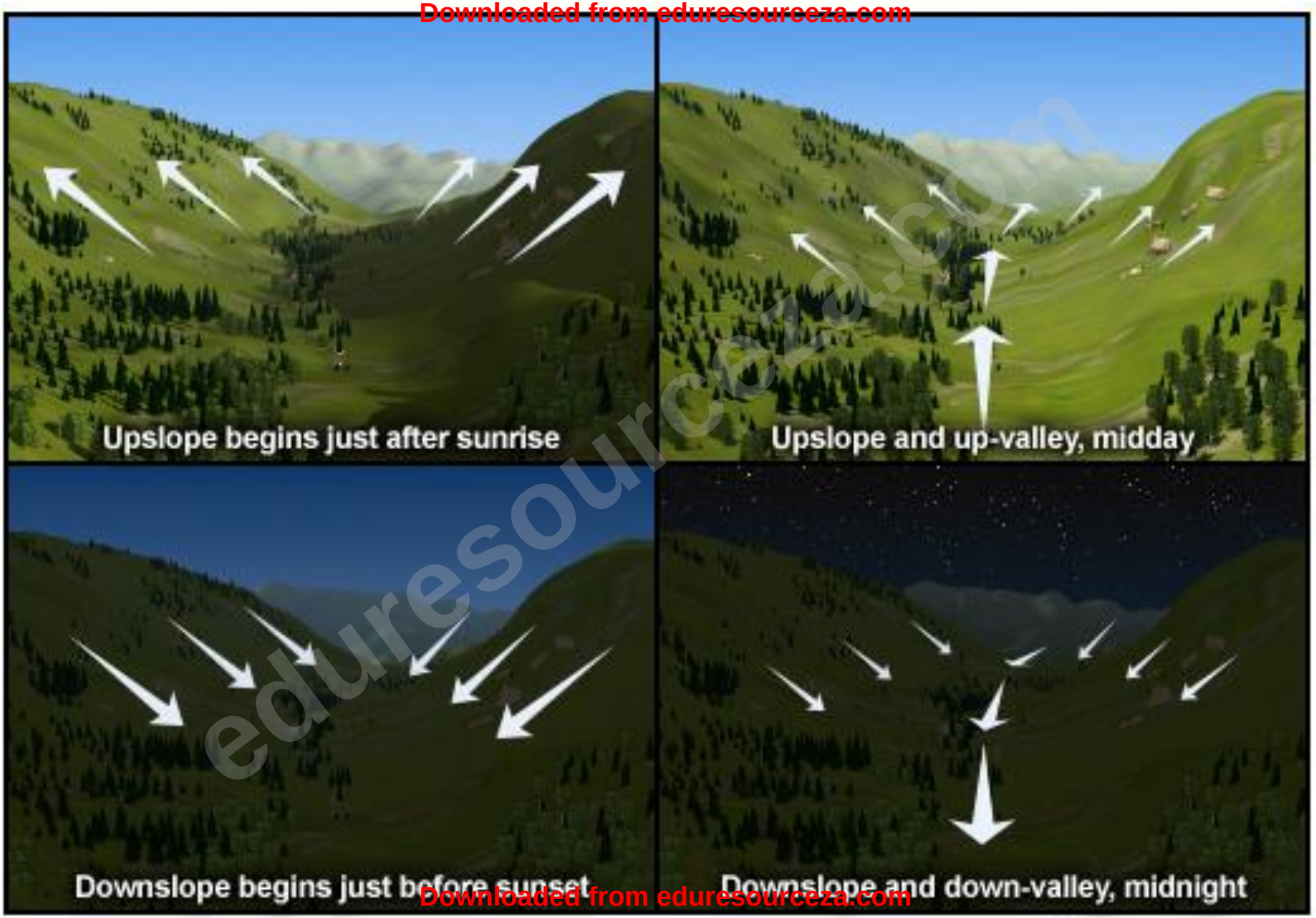
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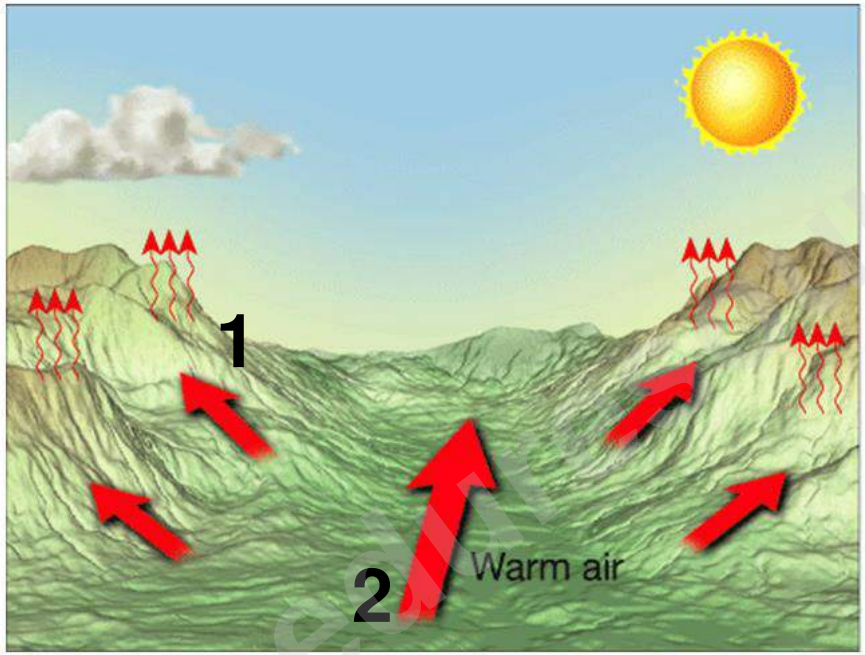
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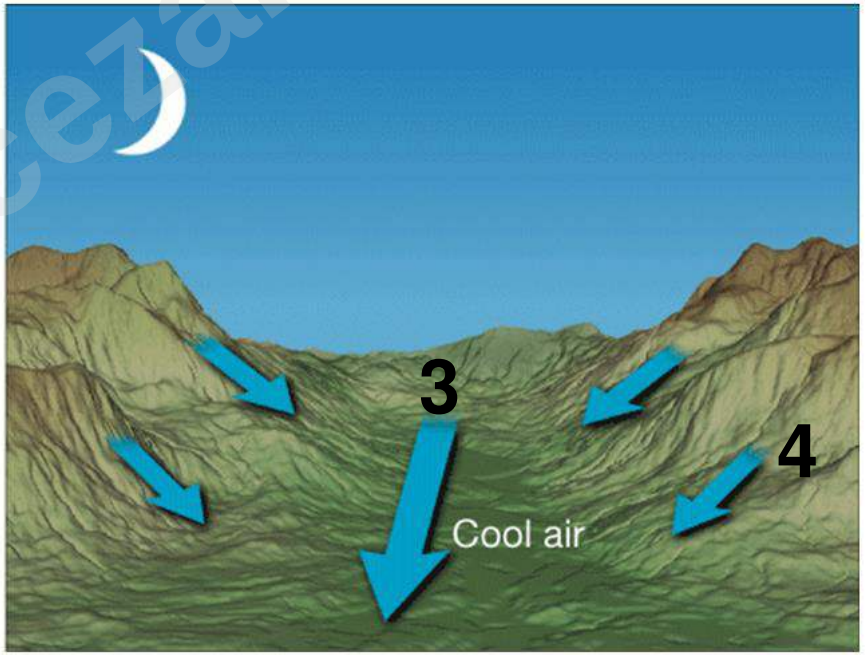
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SPOT TEST





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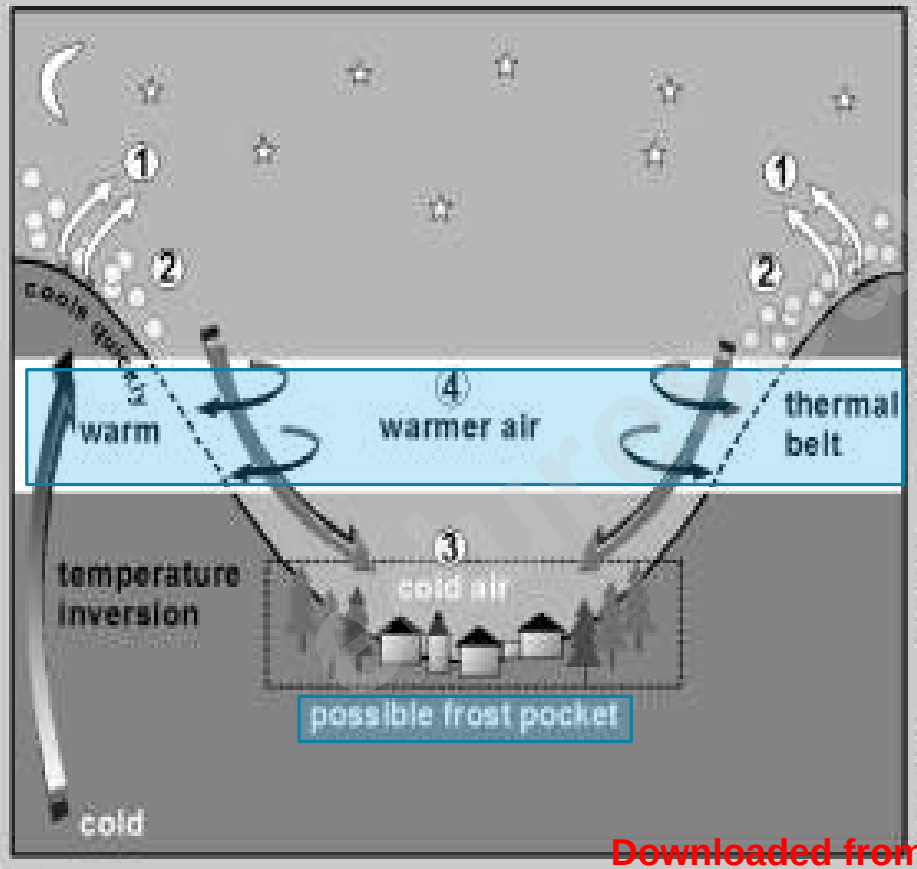


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3. VALLEY INVERSIONS

Look at the diagram and follow the numbered explanations step by step:



1. At night the top of the mountain loses heat quickly. No clouds to block re-radiation. Thus the top slopes get cold.
2. Air molecules touching the cold slope get cool – cool air sinks.
3. These molecules are heavy and dense and sink to the bottom of the valley = a pocket of cold air.
4. The air in the middle of the valley remains warmer (because it is not touching the cold slope). The warmer air moves in to replace the colder sinking air, creating a thermal belt. (This is a warmer section midway up the slope.)
5. Now you can see there is cold air at the bottom, and warmer air higher up, so along the vertical there is a temperature inversion. You can see temperature increases with height.

Results of inversion:

- Rural settlements halfway up the slope in thermal belts (on north-facing slopes).
- Crops that are not frost-resistant cannot be grown on the valley floor.
- Pollution in valleys is dangerous as it gets trapped by the inversion.

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CROPS

So where would you plant:

Frost sensitive crops e.g. grapes?

Frost resistant crops e.g. potatoes?

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RADIATION FOG

Air at base of valley drops below dew point

If DPT is above freezing, fog forms

Because cold air in the valley is caused by terrestrial radiation from the higher sides of the valley, it is known as radiation fog

The fog 'lifts' as the sun penetrates & warms lower layers of air, causing the fog to evaporate

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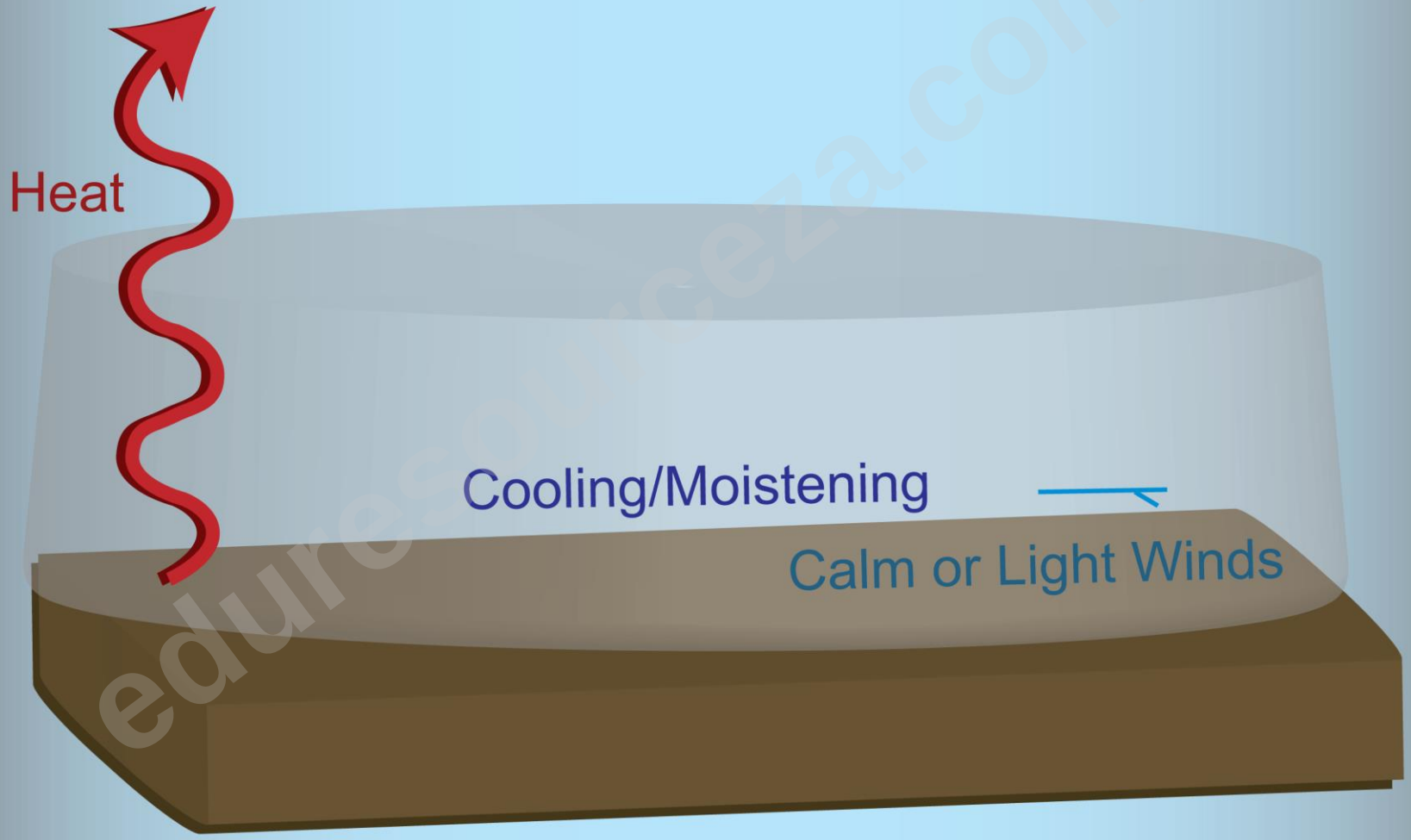
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Radiation Fog



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FARMING CONSIDERATIONS

Aspect

Frost pocket

Thermal belt

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CLASS & PREP WORK

Activity 20 p 109

Activity 21 p 110

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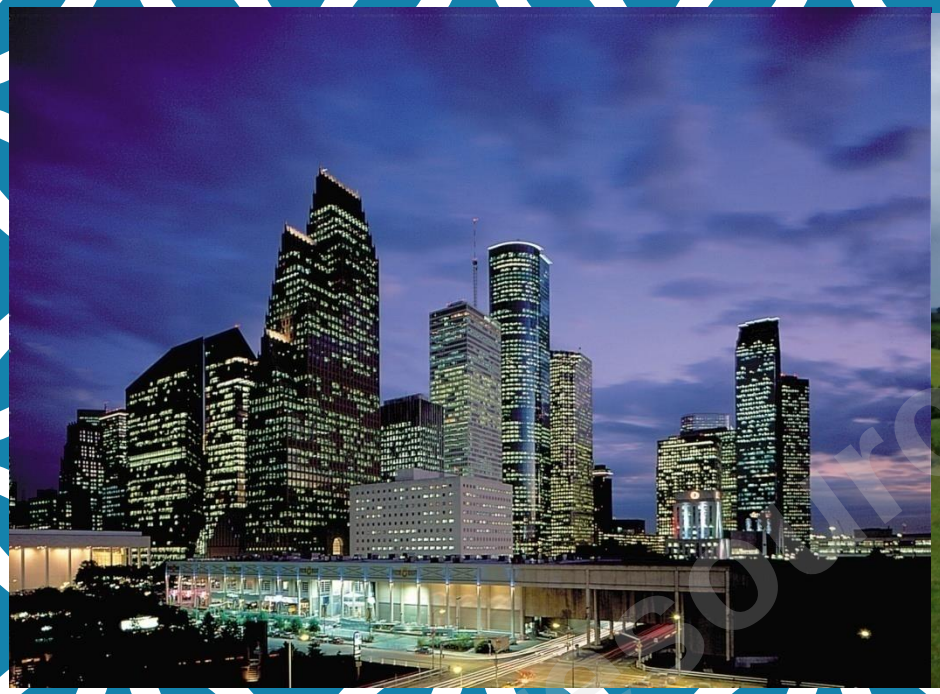
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MICRO CLIMATE

- Valley climates
- Urban Climates

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URBAN CLIMATES

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1. Rural vs Urban
2. Urban heat islands
3. Pollution domes
4. Reducing city temperatures

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URBAN VS RURAL

Urban

- Artificial substances absorb heat
- Domestic & industrial heating, power stations, car engines, air conditioners, people etc.
- High-rise buildings with large surface area
- Polluted air acts like a blanket

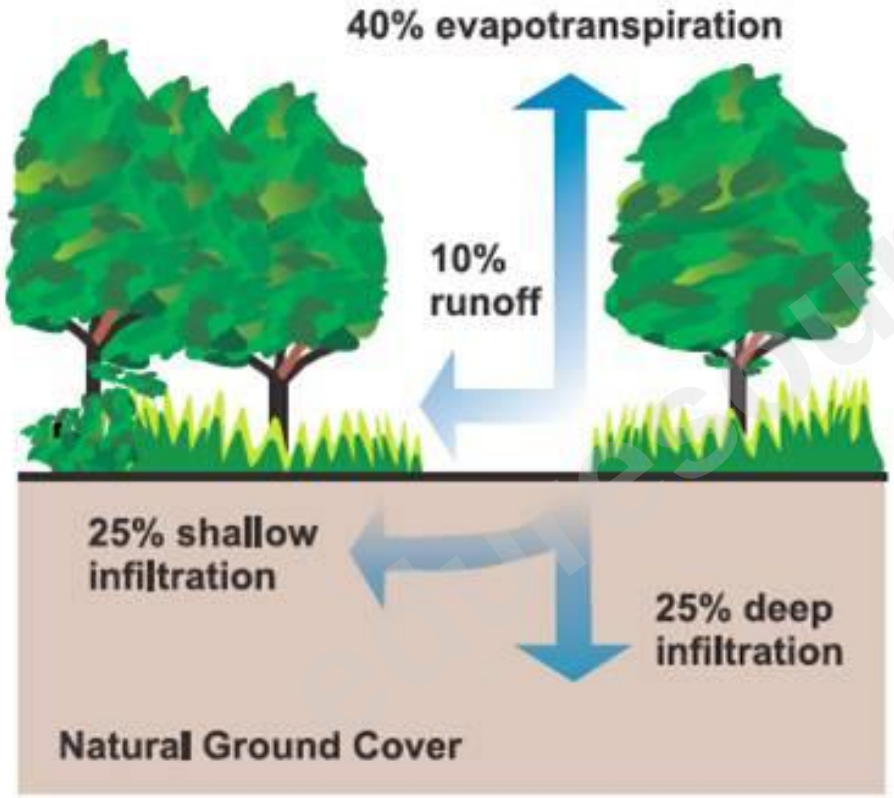
Rural

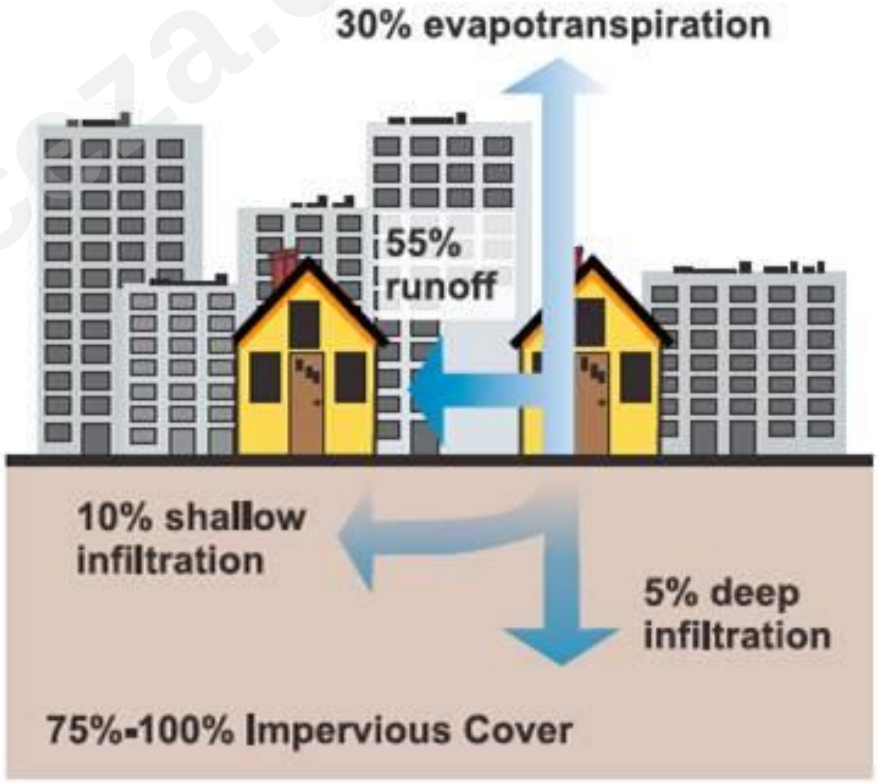
- Heat used in evaporation & transpiration

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PROCESSES: RURAL VS URBAN





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HUMIDITY & PRECIPITATION IN CITIES

Cities are usually **less humid** than surrounding areas – water carried away in drains; less transpiration

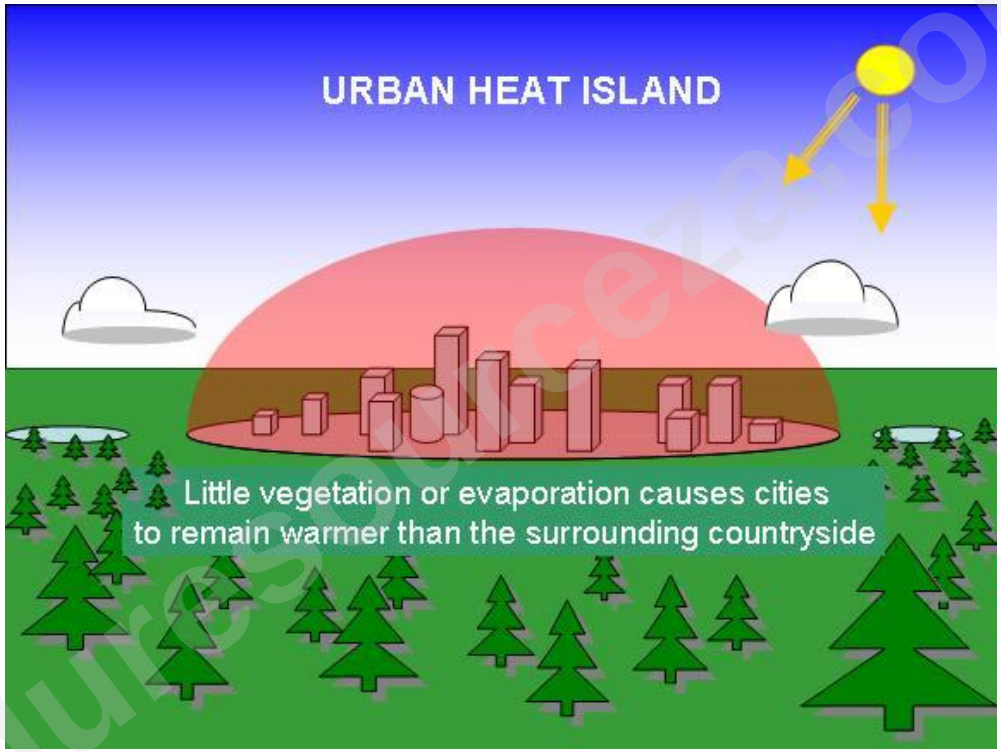
Precipitation is greater over city areas – more **hygroscopic nuclei** upon which water vapour can condense

Thunderstorms are more common over cities, resulting from convectional uplift

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URBAN HEAT ISLAND

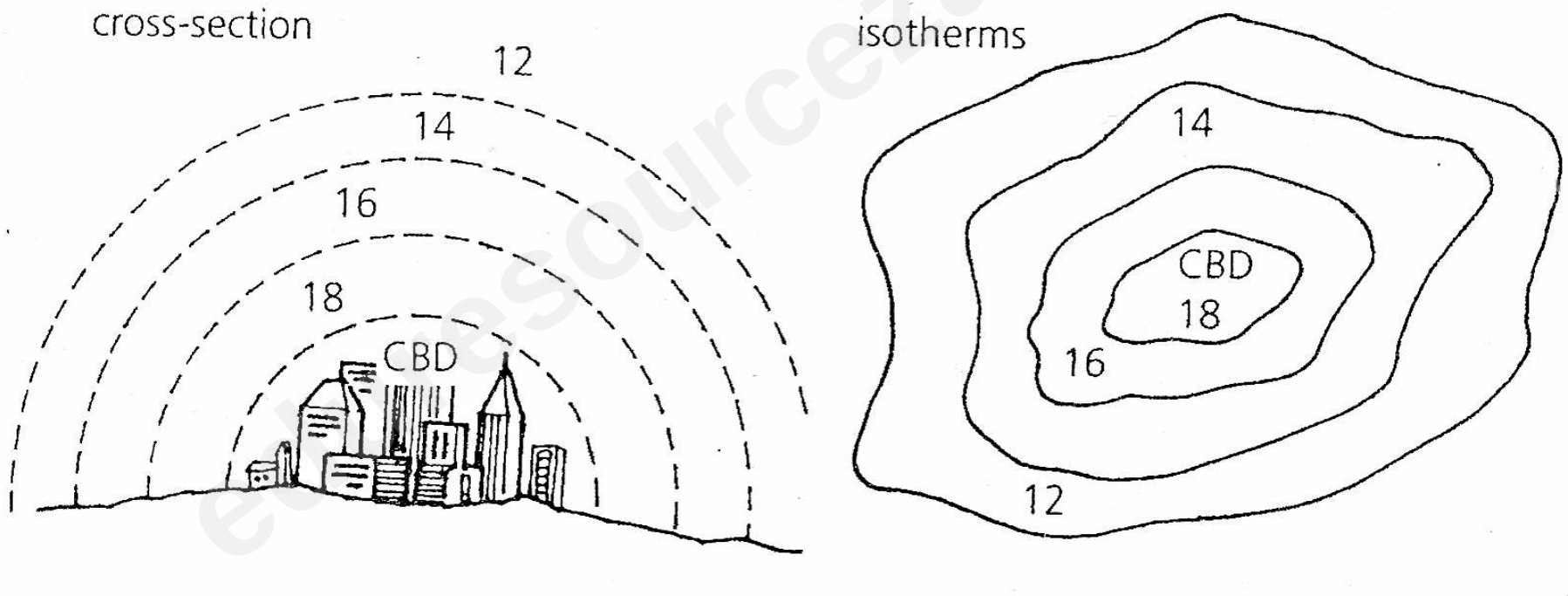


An island of warmer urban air surrounded by a sea of cooler, rural air; the central part of a city is warmer than surrounding suburban & rural areas

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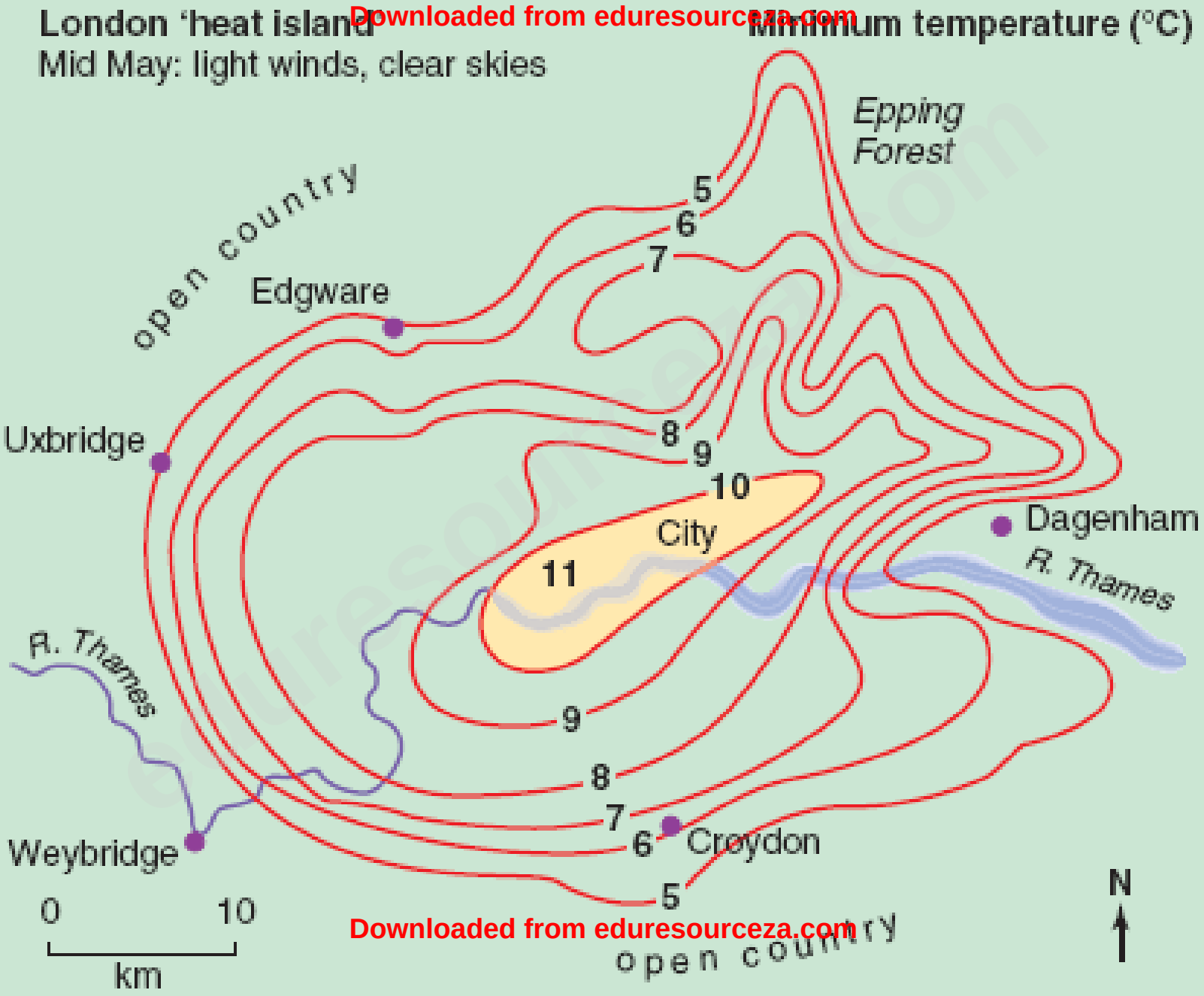
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WHAT IS THIS ATMOSPHERIC PHENOMENON CALLED?



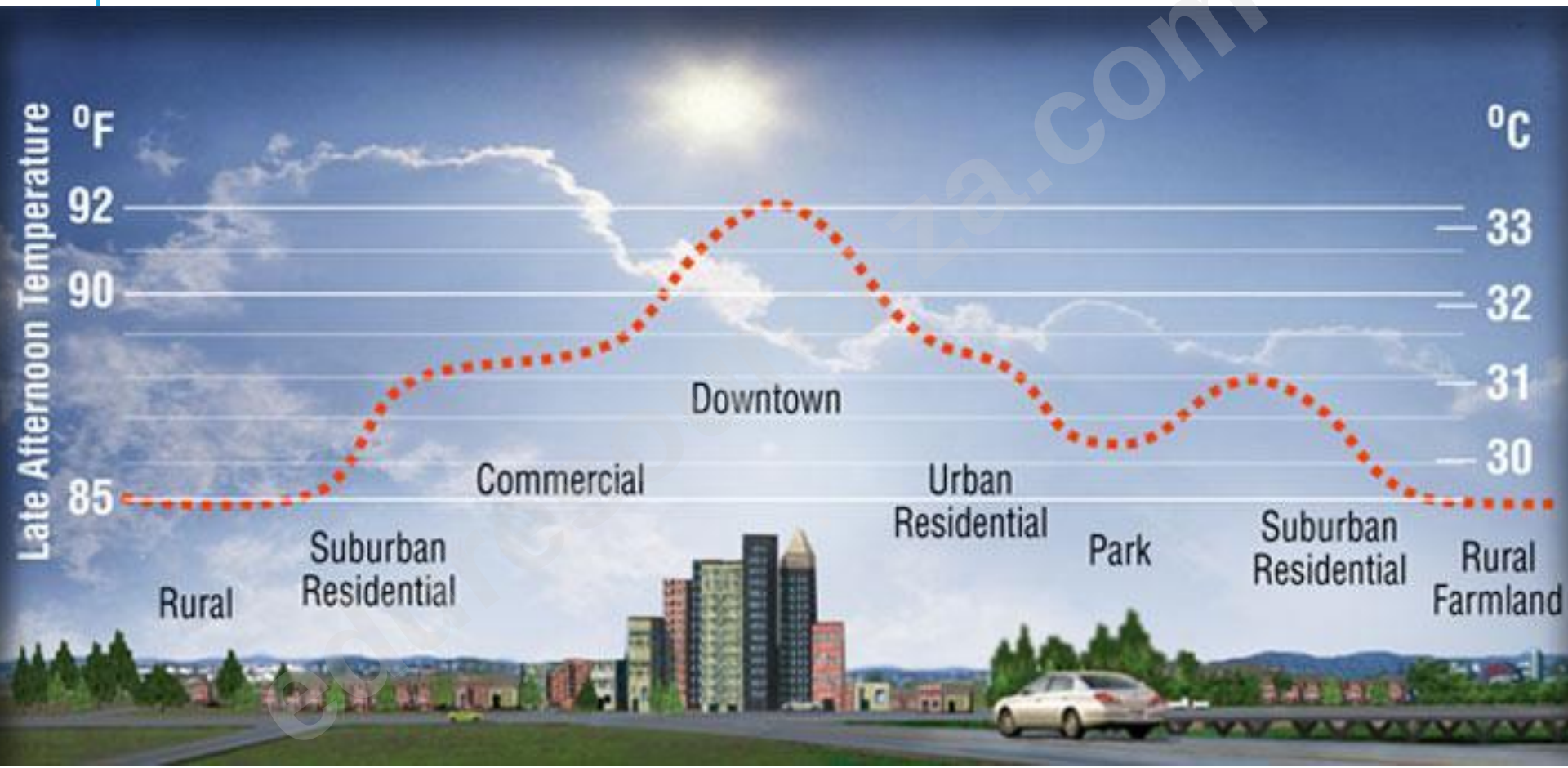
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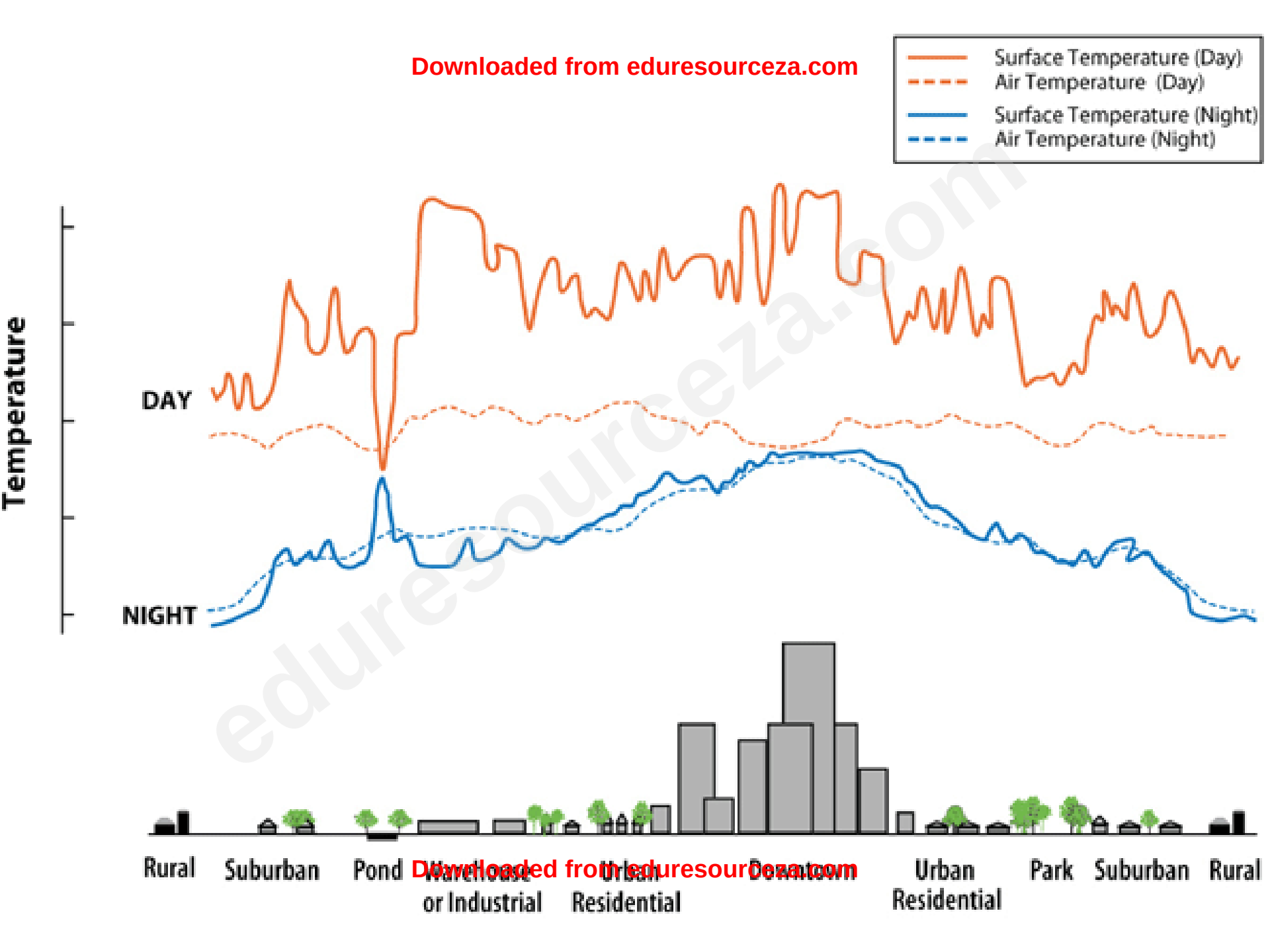
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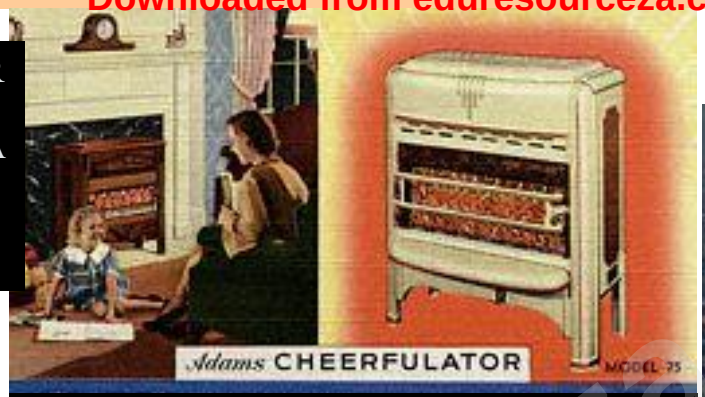
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URBAN HEAT ISLAND CAUSES

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RUSH HOUR TRAFFIC THROUGH A HAZE OF FUMES



DOMESTIC HEATING

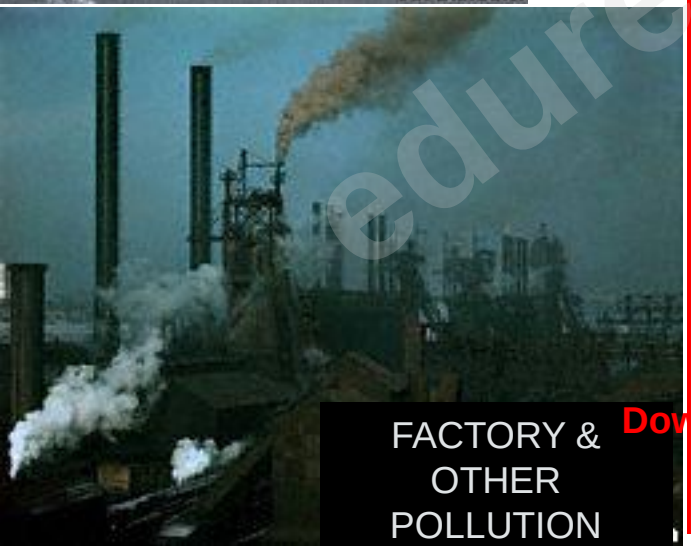


DARK AND DRY TARMAC SURFACES



MOTOR EXHAUSTS

Human heat sources (domestic heating, cars, factories) all warm the air. Pollution by exhausts, factories and other dusts absorb radiation and prevent heat loss during the night. Dark surfaces have a low albedo. Dry surfaces **reduce latent heat loss by evaporation**



FACTORY & OTHER POLLUTION

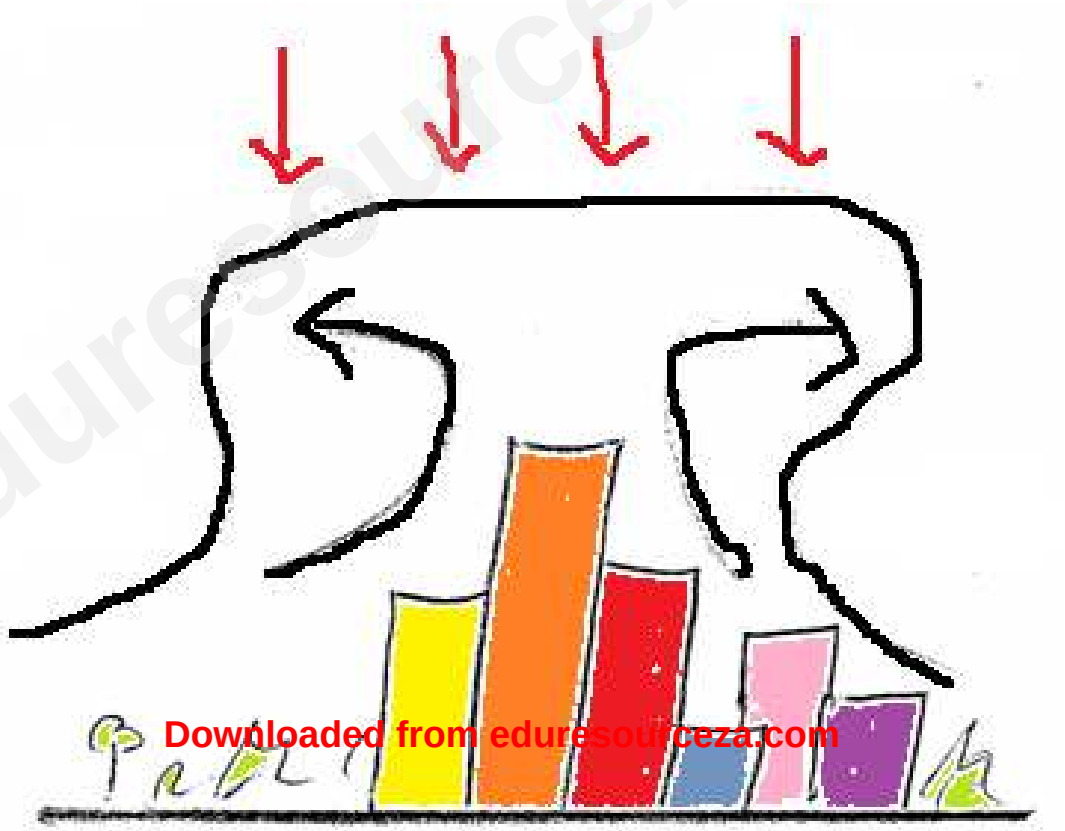


SMOG RESULTS FROM POLLUTION

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DAYTIME/SUMMER CONDITIONS

Warm air rises, pushing against the anticyclone; dome tall



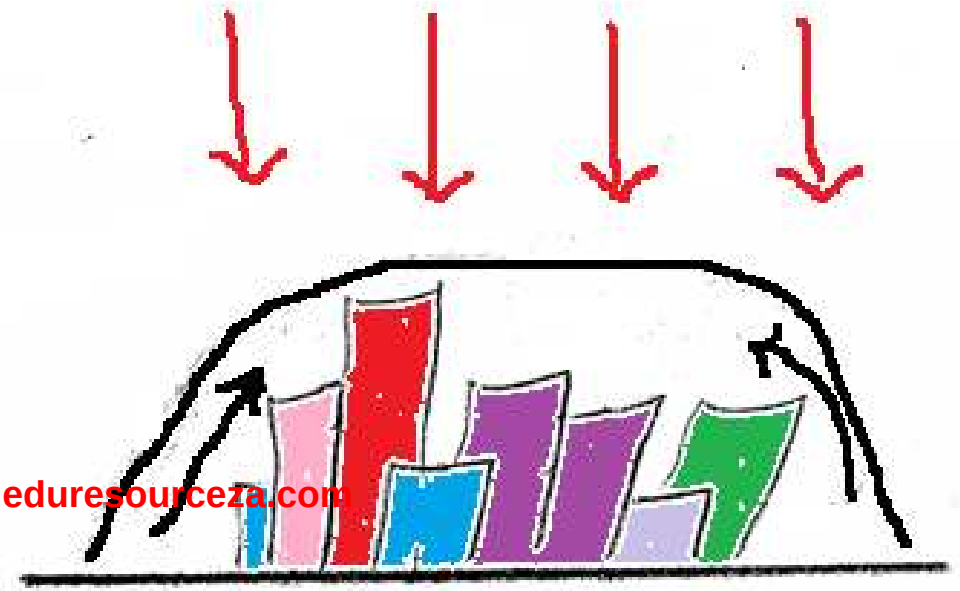
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NIGHT-TIME/WINTER CONDITIONS

Cooler air does not rise as much; dome compressed; inversion layer prevents pollution escaping; concentrated pollution; more health problems

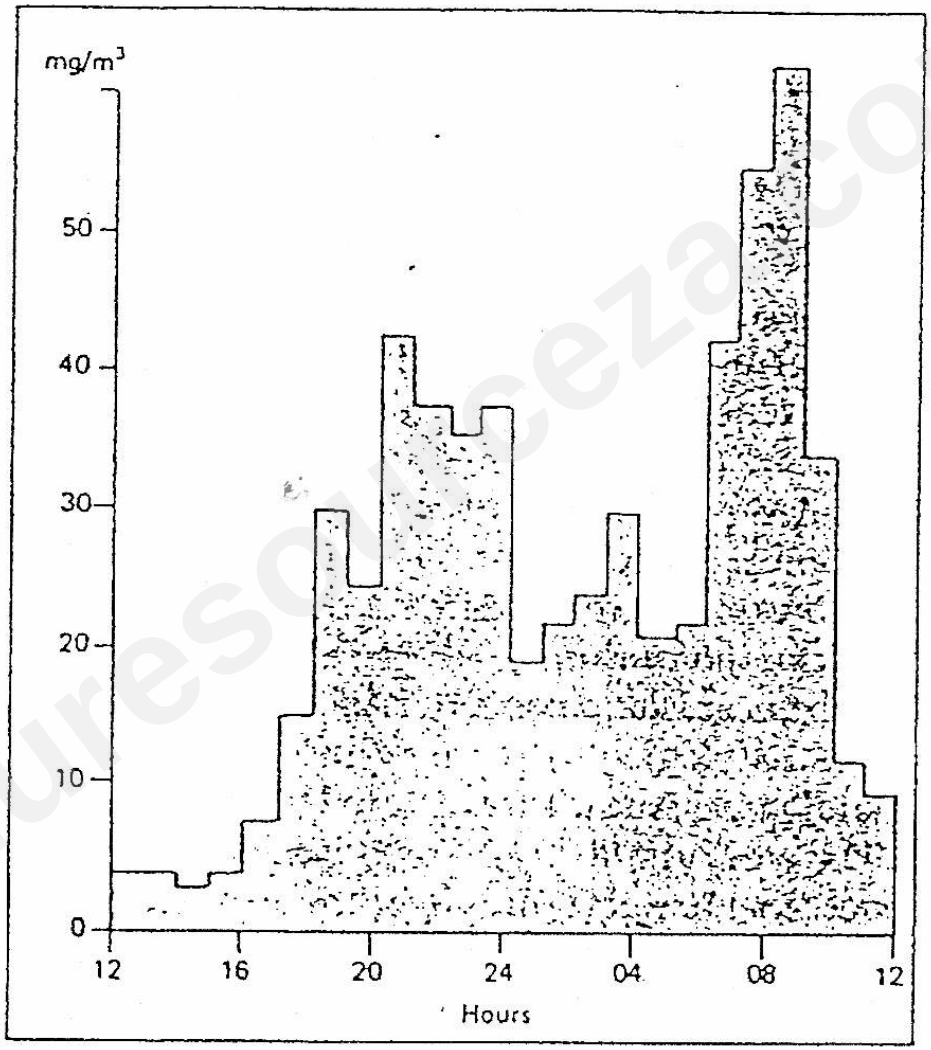
Hygroscopic pollution particles nuclei + water vapour = smog



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POLLUTION CONCENTRATION

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Smoke concentration for a period of 24 hours during winter in Pretoria, expressed in milligrams per cubic metre (mg/m³).

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COOLING STRATEGIES

Make surfaces more reflective – higher albedo

Greening cities – planting trees

- Reduces energy costs for cooling by 10-20 %
- Planted on E & W side of buildings they are most effective
- Roof gardens cool the inside of buildings

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rethink / SUSTAINABILITY CITY OF AUSTIN

www.austintexas.gov/coolspaces





1 Shade Structures



2 Light Colored, Reflective Roof



3 Green Roof



4 Green Wall



5 Light Colored, Permeable Pavement



6 Trees and Leafy Vegetation

Cool Spaces - Hot Property

Cooling strategies for an increasingly hot sun-belt city.

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CHICAGO'S CITY HALL



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CLASS & PREP

Exam Practice p 118-119

Practise geographical skills & techniques p 120-121

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CLASS & PREP WORK

Units 1 – 5 (Via Afrika)

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