Presentation on El Nino by TA Diana Zamora Reyes

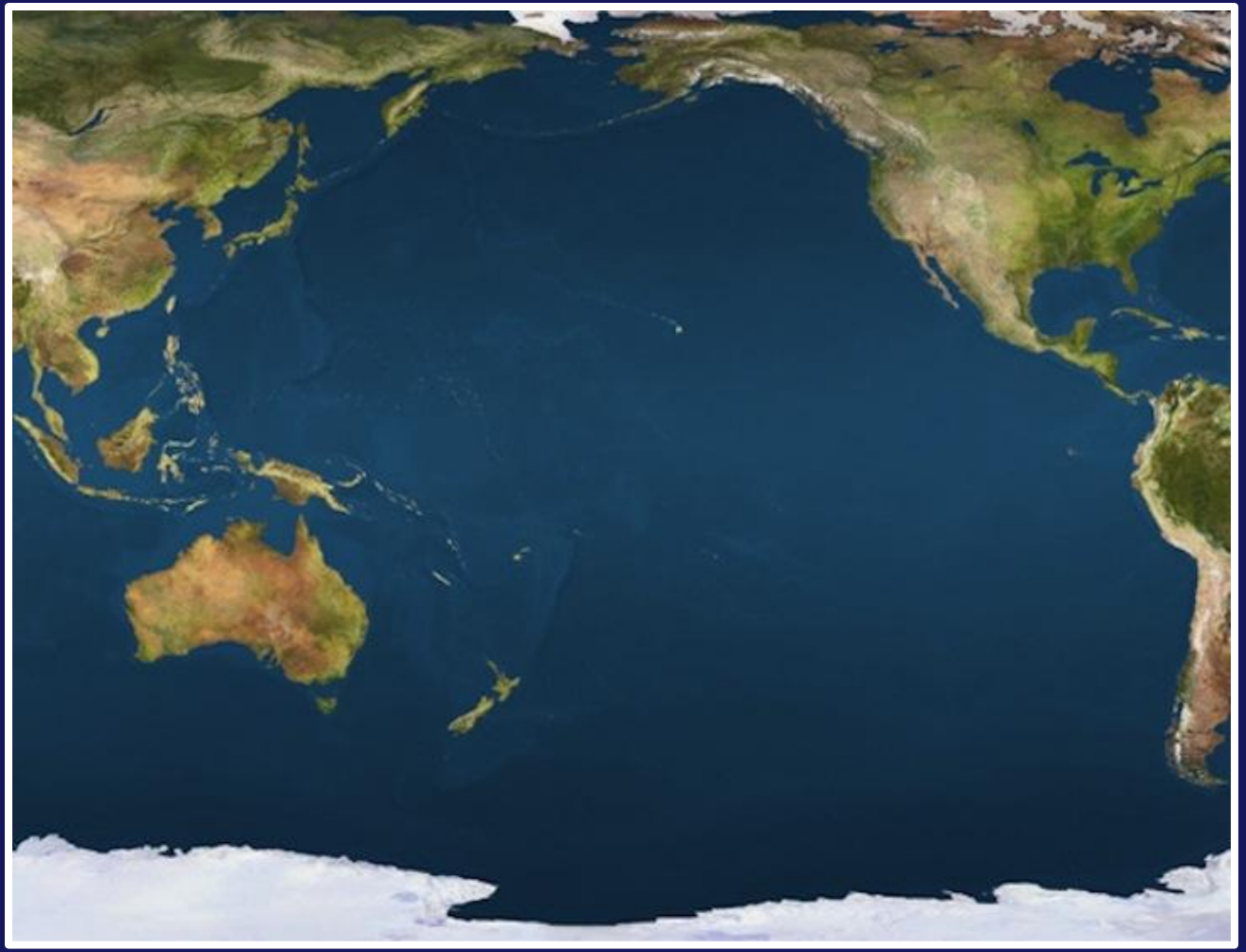
This time draw your map centered on the PACIFIC OCEAN & surrounding continents:

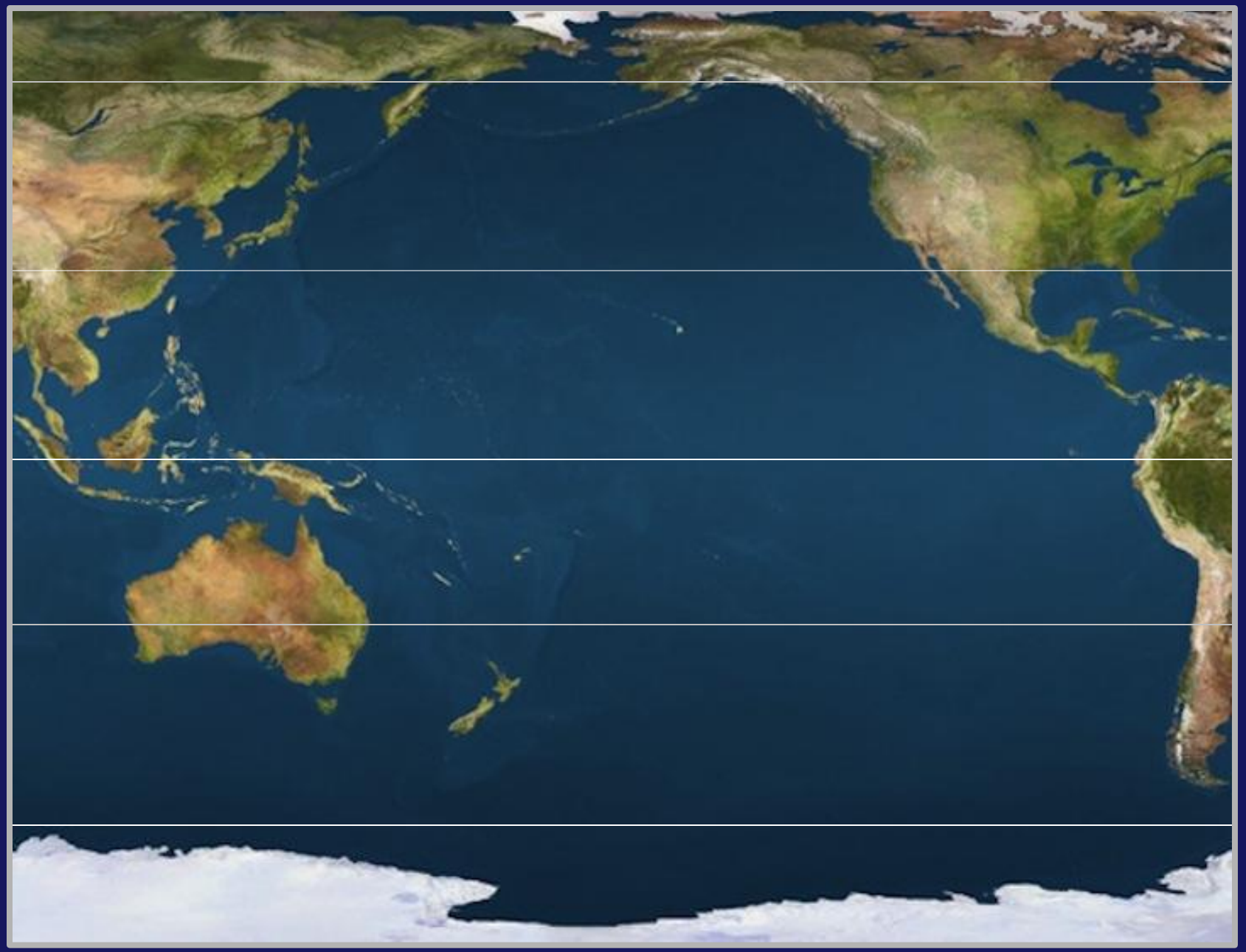
Using CLASS NOTES p 64 to help, draw in these latitudes:

30 ° & 60 ° N

Equator 0 °

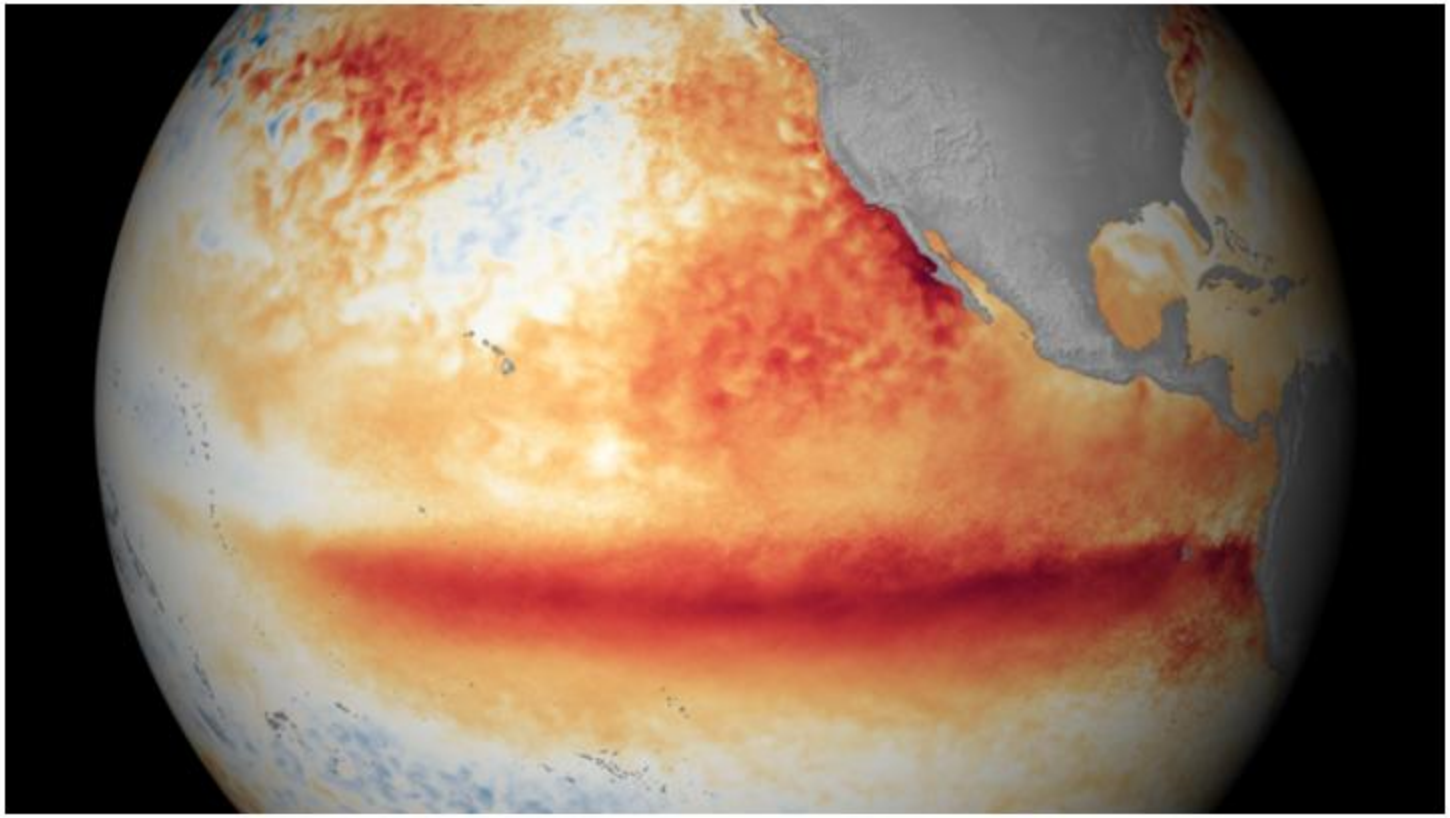
30 ° & 60 ° S




60º N
30º N
0º
30º S
60º S

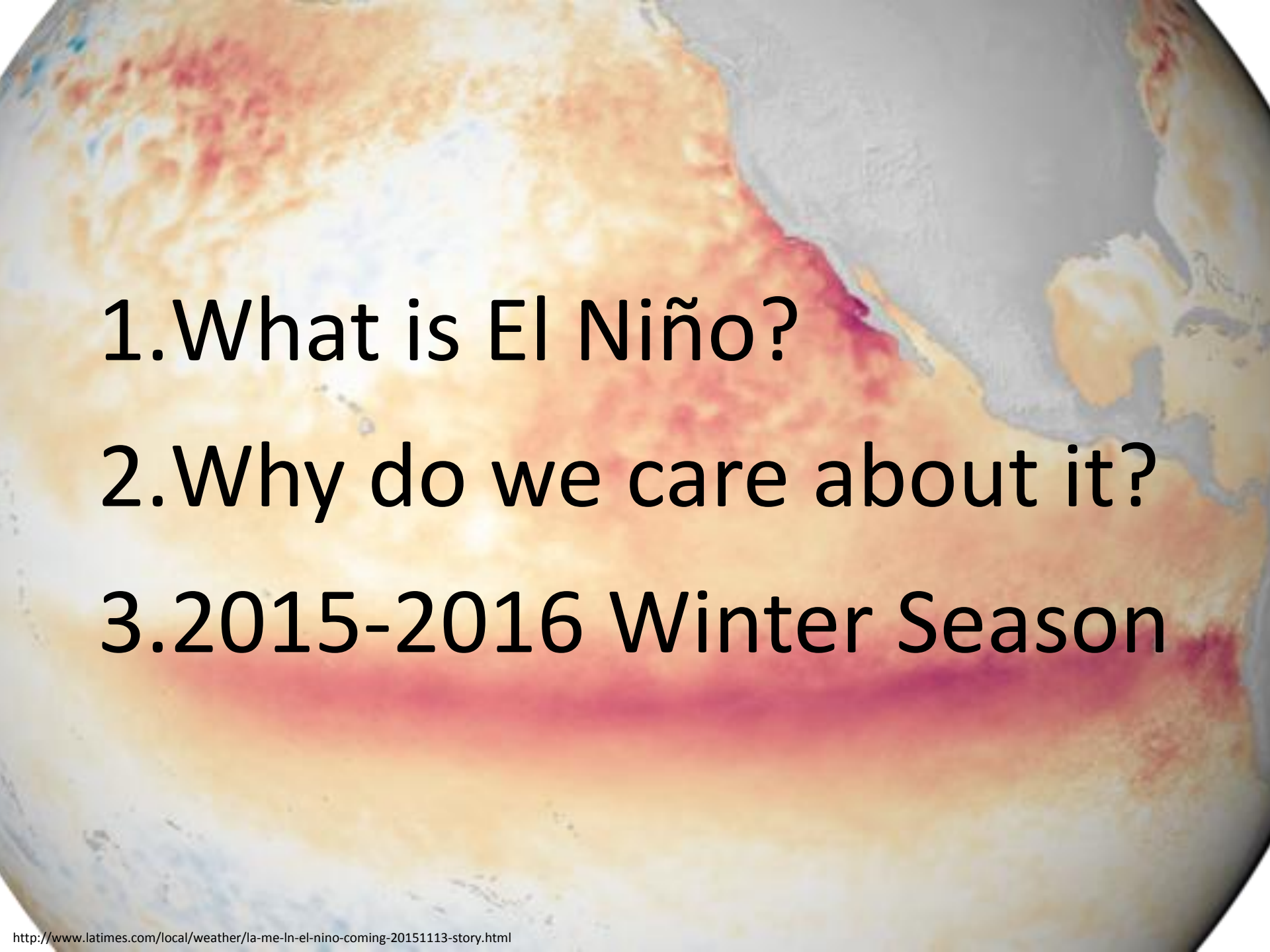
Los Angeles Times Nov 13, 2015

El Niño is here, and it'll be 'one storm after another like a conveyor belt'



A satellite image shows the sea surface temperature in October, with the orange-red colors indicating above-normal temperatures that are indicative of El Niño. (NOAA)

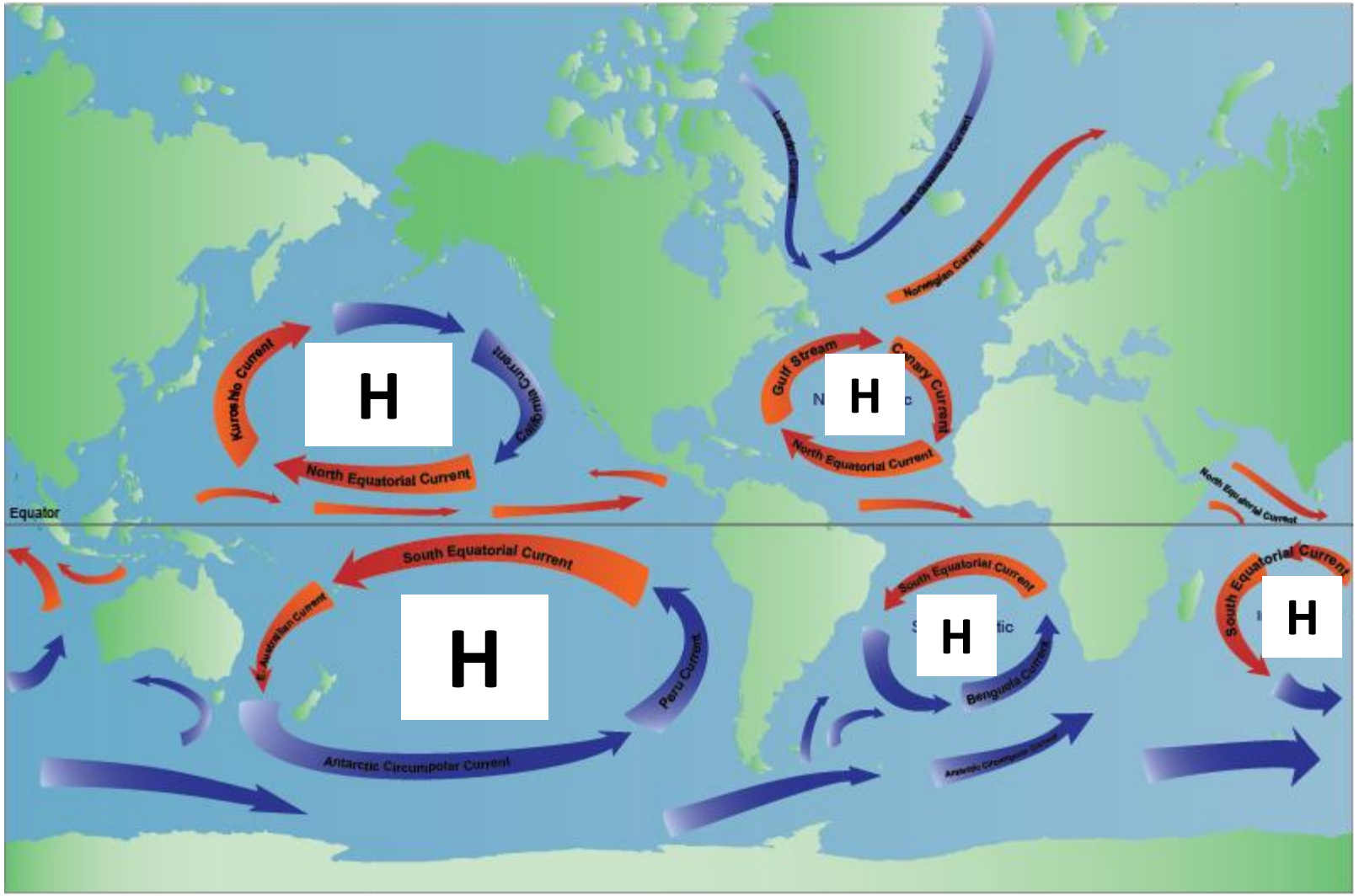
http://www.latimes.com/local/weather/la-me-ln-el-nino-coming-20151113-story.html



1. What is El Niño?
2. Why do we care about it?
3. 2015-2016 Winter Season

http://www.latimes.com/local/weather/la-me-ln-el-nino-coming-20151113-story.html

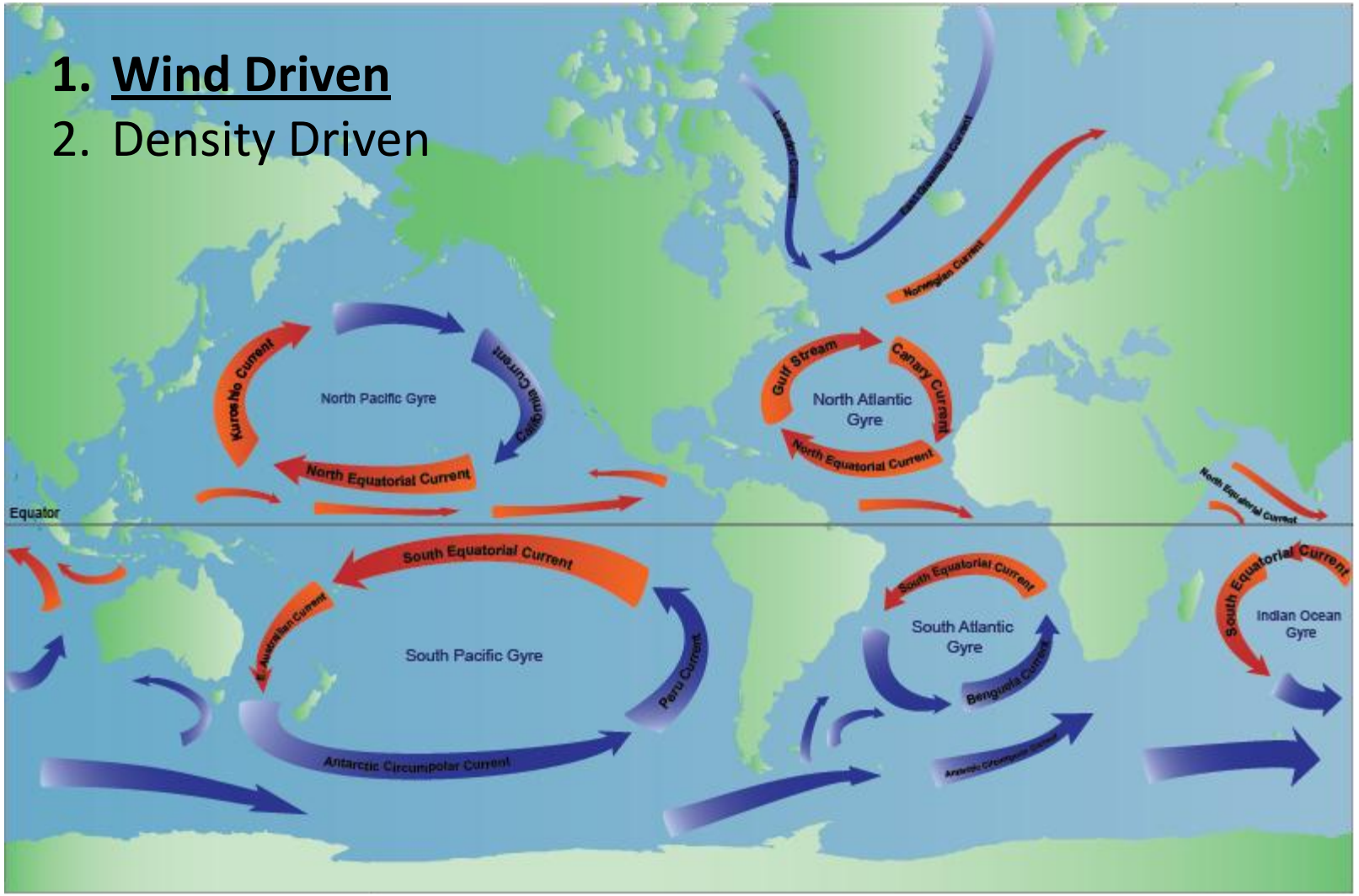
Global Ocean Current Map



http://teachoceanscience.net/teaching_resources/education_modules/observing_the_ocean/explore_ocean_physics/

Global Ocean Current Map

1. **<u>Wind Driven</u>**
2. Density Driven



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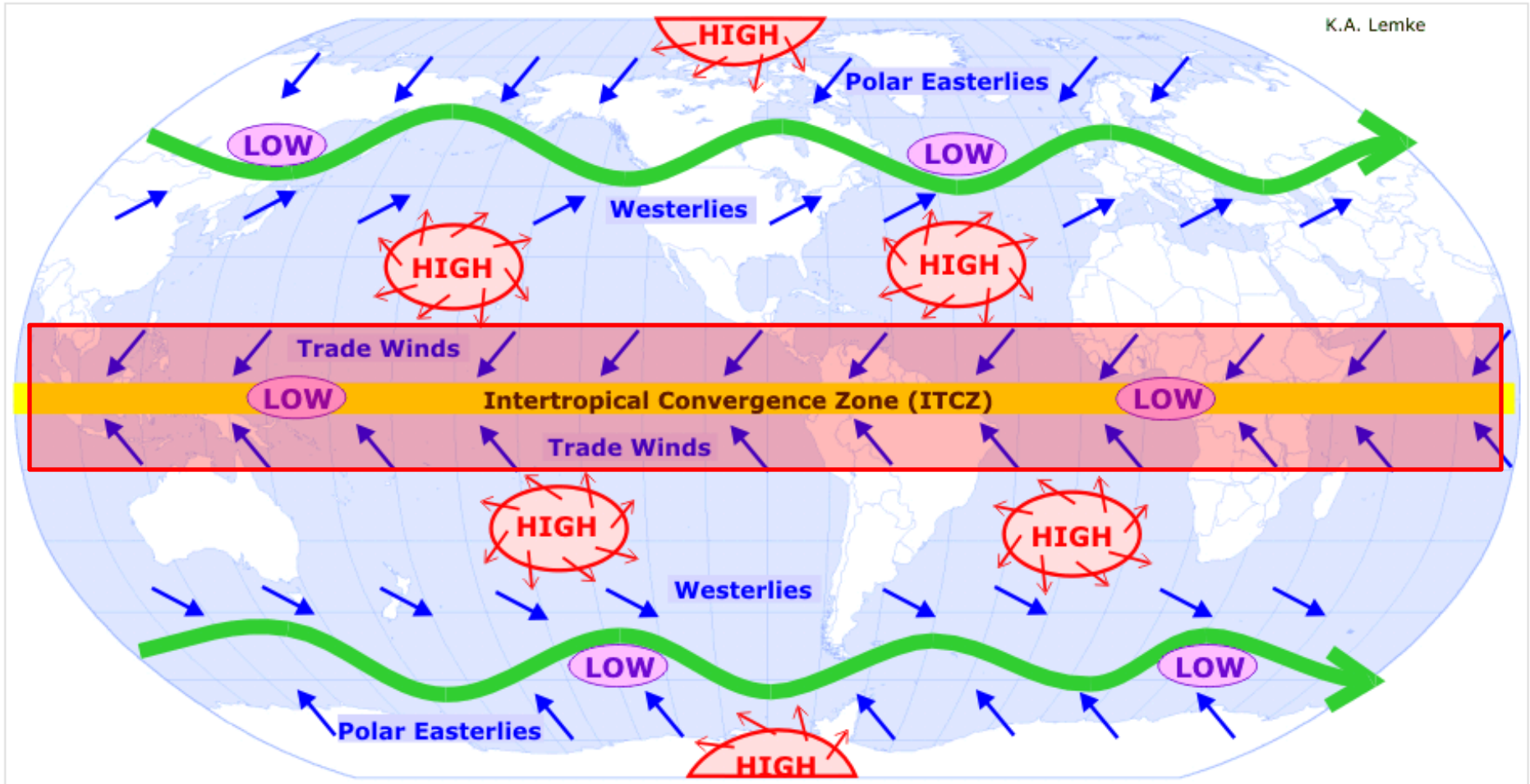
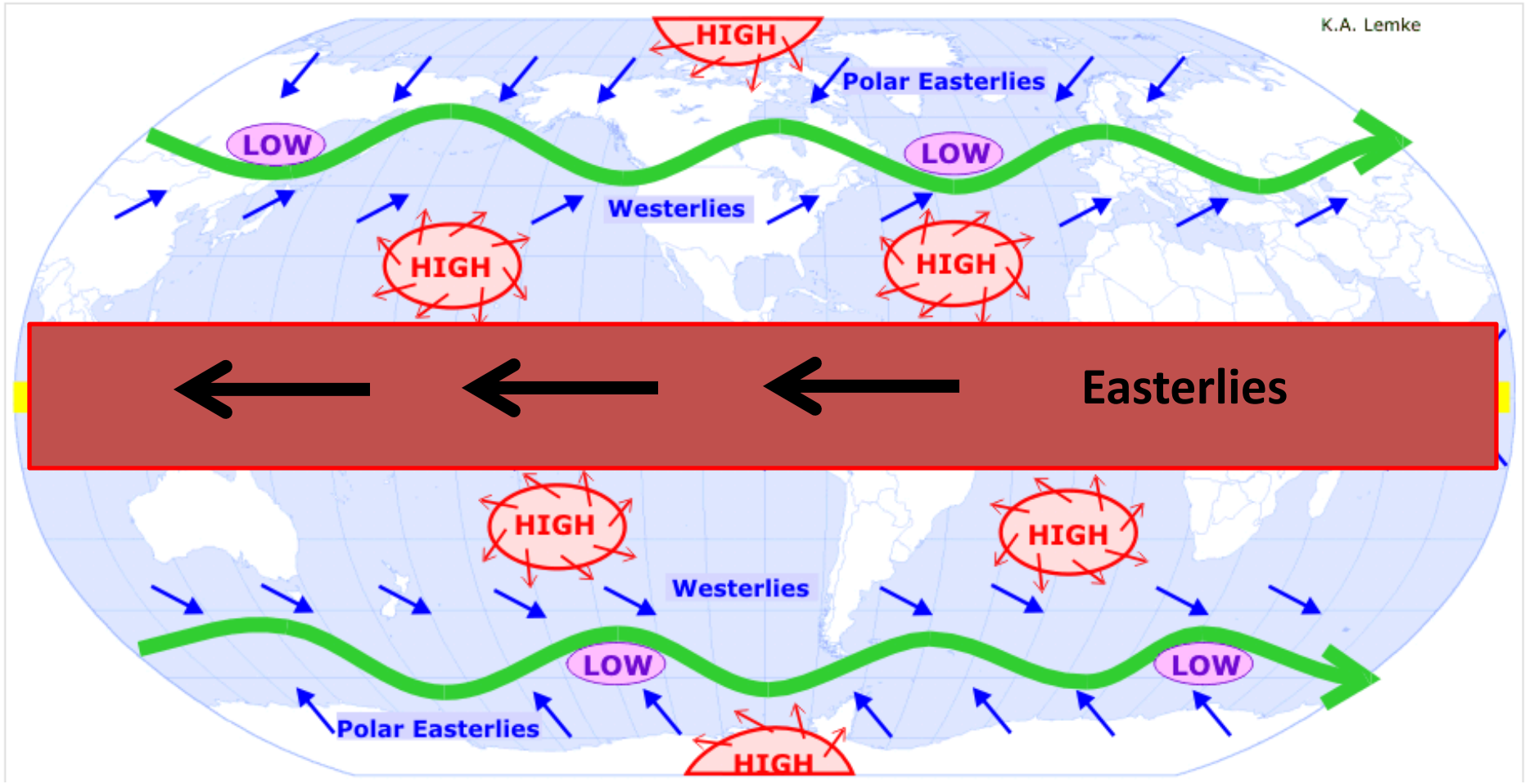
Global Wind Map



From: https://rgreenbergscience.wikispaces.com/EARTH+SCIENCE+IMAGES

Global Wind Map



From: https://rgreenbergscience.wikispaces.com/EARTH+SCIENCE+IMAGES

1. Why do we call it El Niño?

El Niño = Boy child

→Term first coined by Peruvian fishermen when fish stocks would crash due to above-normal ocean temperatures

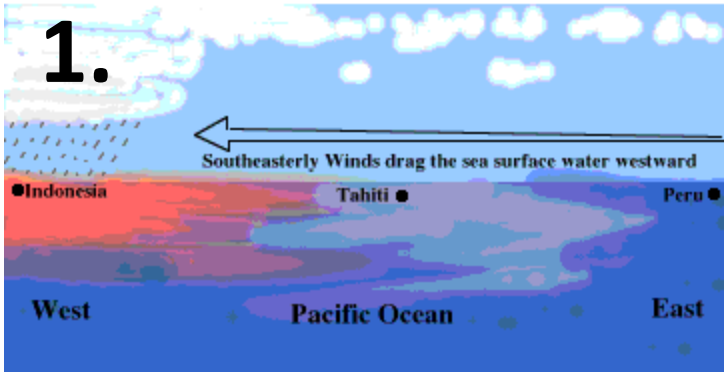
→Opposite of El Niño→ La Niña

2. El Niño Southern Oscillation (ENSO)

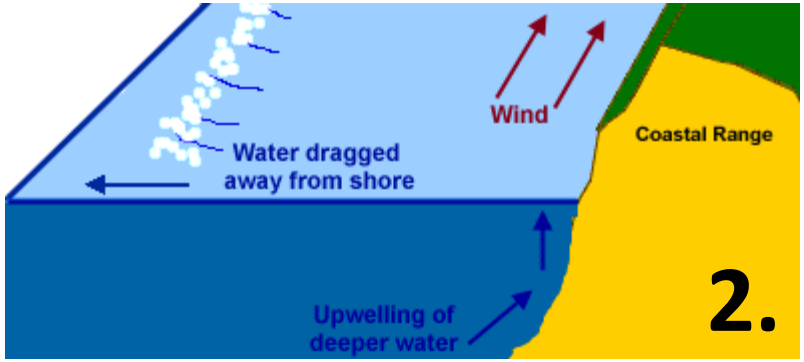
→ Term first used by Jacob Bjerknes in late 1960s unifying both OCEAN and ATMOSPHERE changes

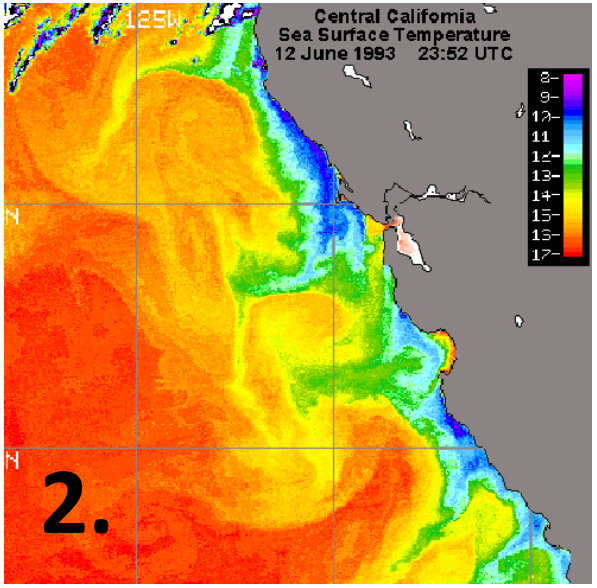
Main point: changing ocean temperatures affect atmosphere

Normal Conditions in S. America



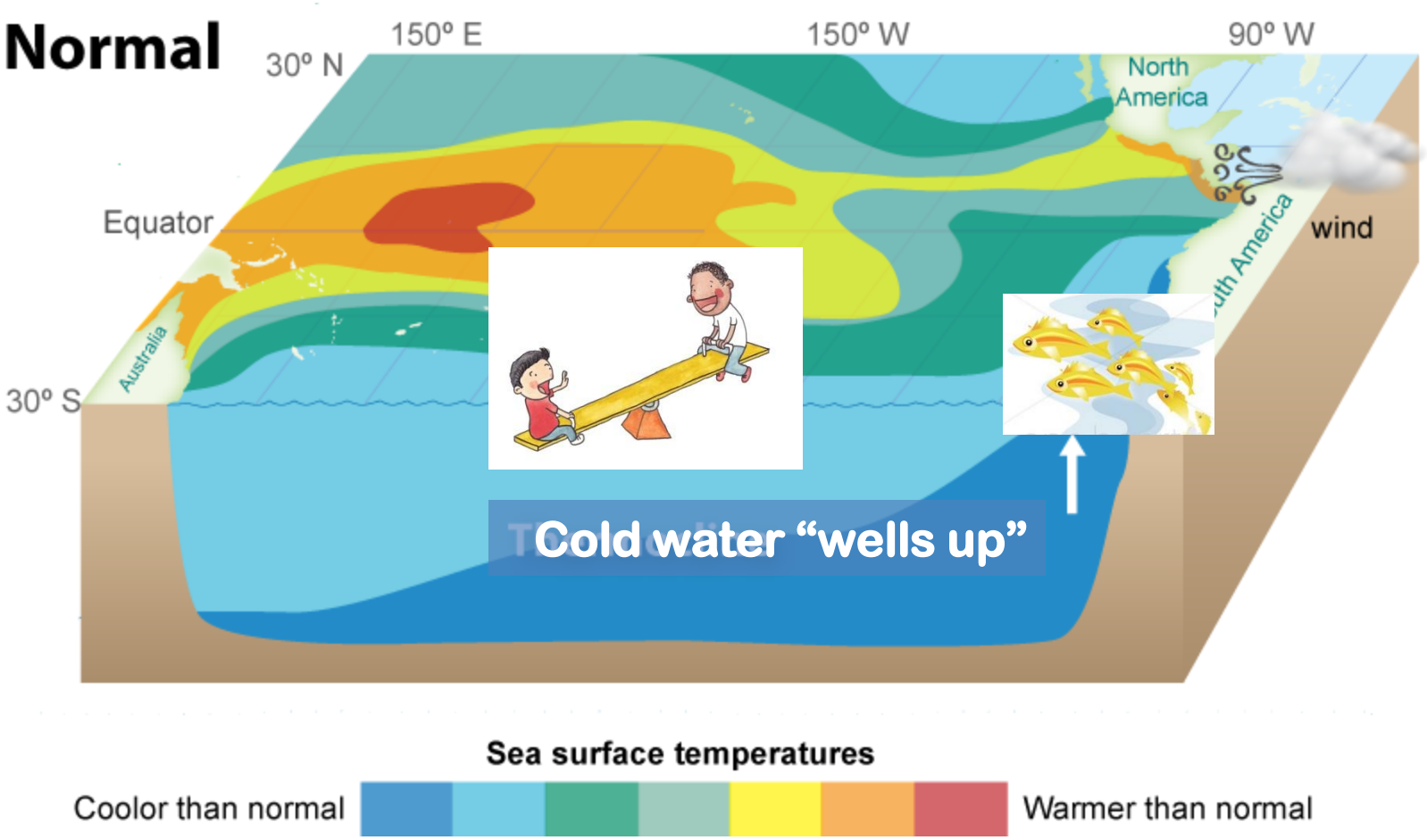
1. Winds “drag” warm water to the west,
2. Cold water is upwelled to the surface
3. Rain in Indonesia





From: https://rgreenbergscience.wikispaces.com/EARTH+SCIENCE+IMAGES
http://judithcurry.com/2013/09/26/shell-game/

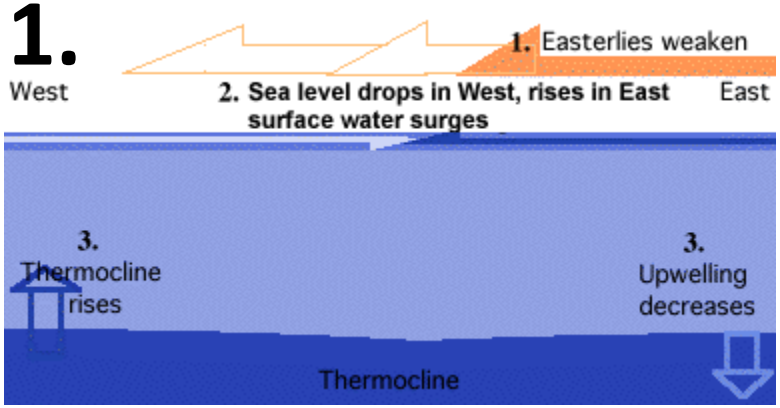
Normal Conditions in S. America



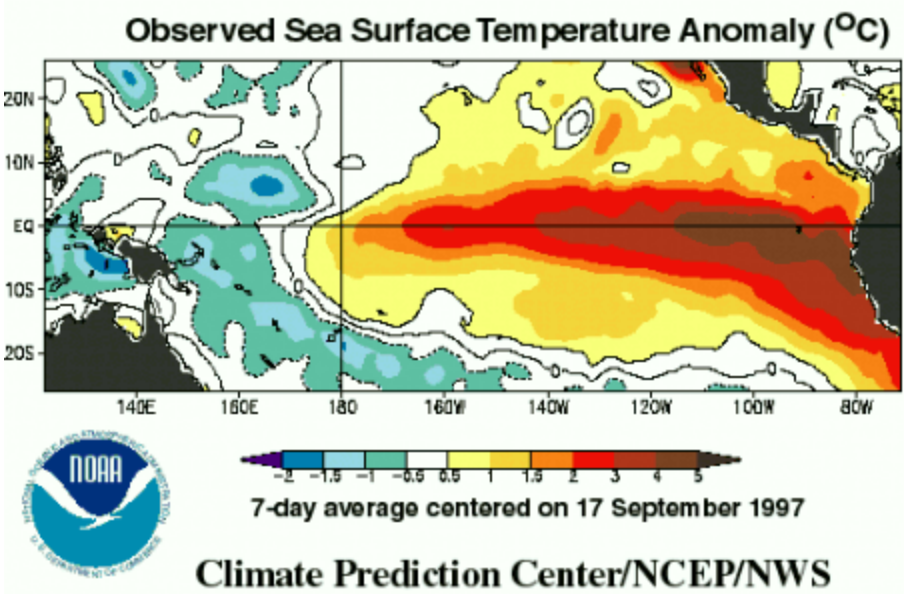
http://teachoceanscience.net/teaching_resources/education_modules/observing_the_ocean/explore_ocean_physics/

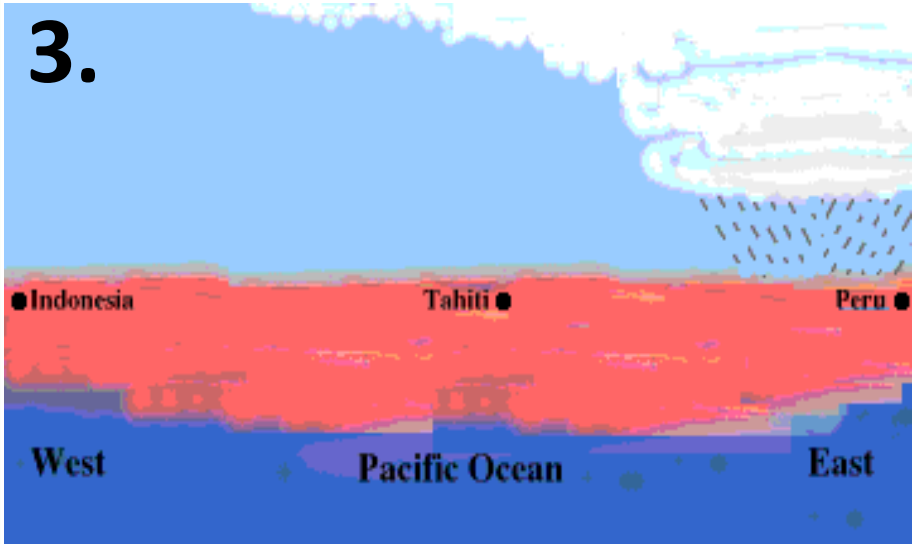
http://nonnativemommy.blogspot.com/2013/05/games-in-playground.html

El Niño Conditions in S. America



1. Winds weaken, and warm water starts to pile up in the east,
2. Cold water cannot be upwelled to the surface
3. Rain over Peru





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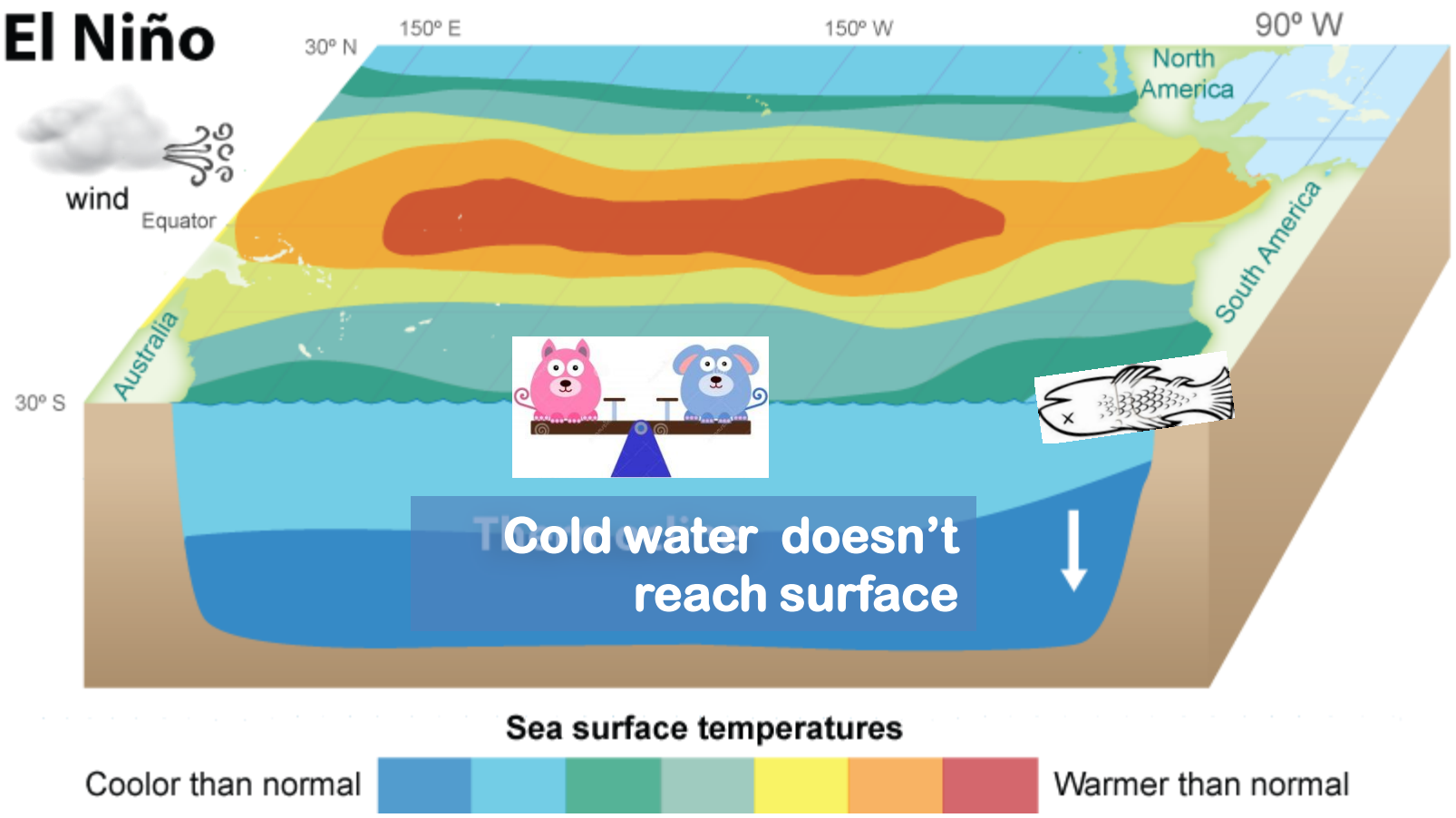
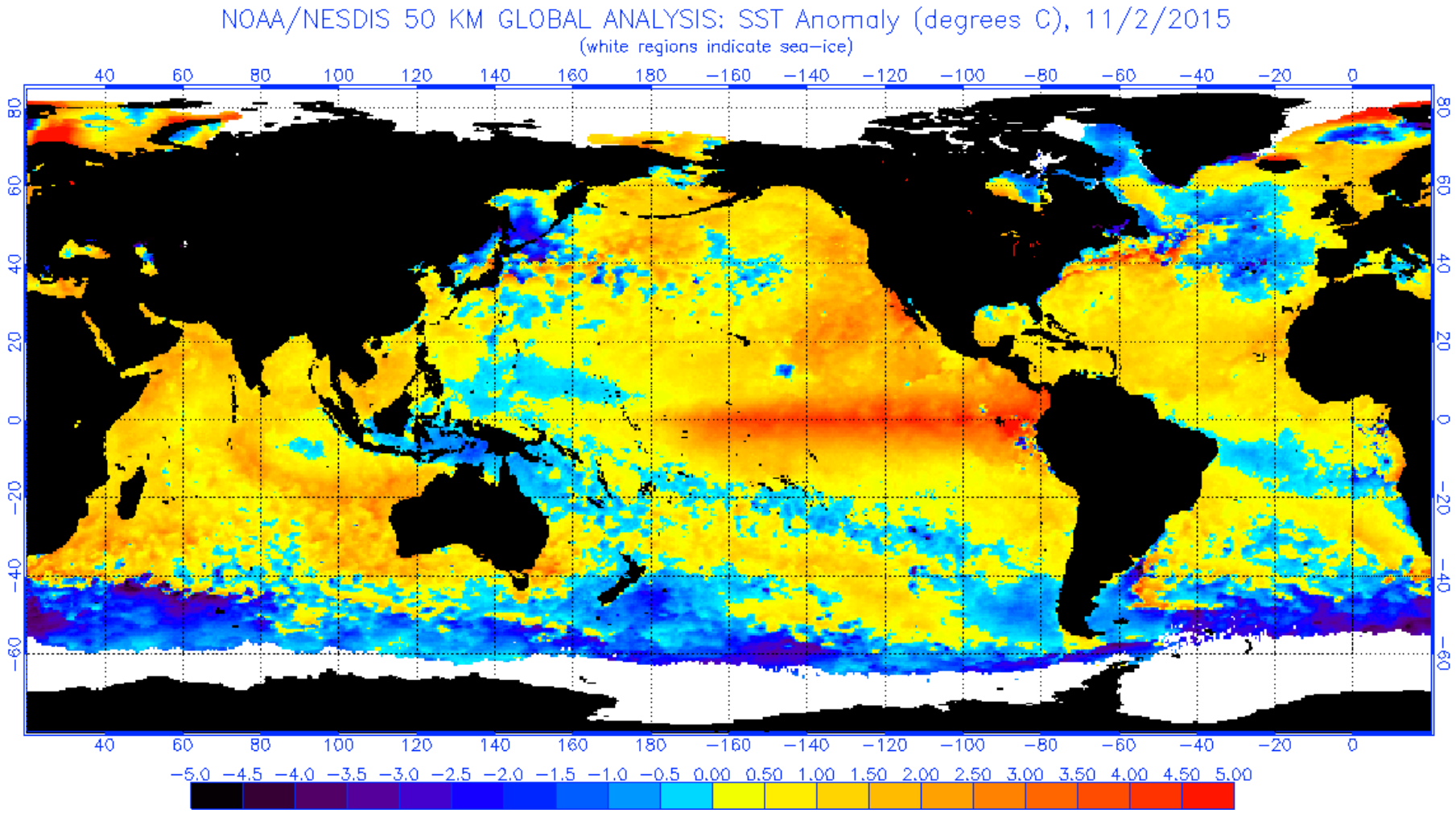
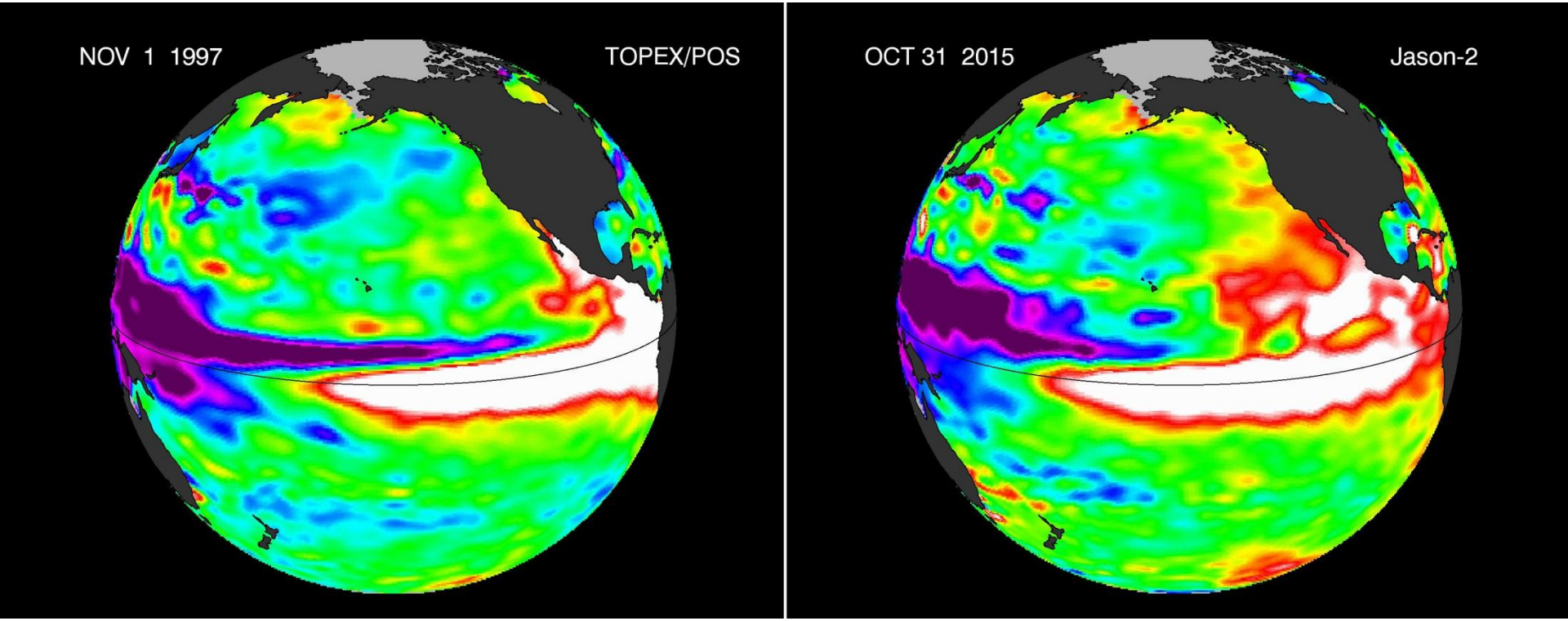


http://teachoceanscience.net/teaching_resources/education_modules/observing_the_ocean/explore_ocean_physics/
http://www.dreamstime.com/stock-photo-equal-animals-cute-illustration-dog-cat-sitting-balanced-seesaw-image33234150

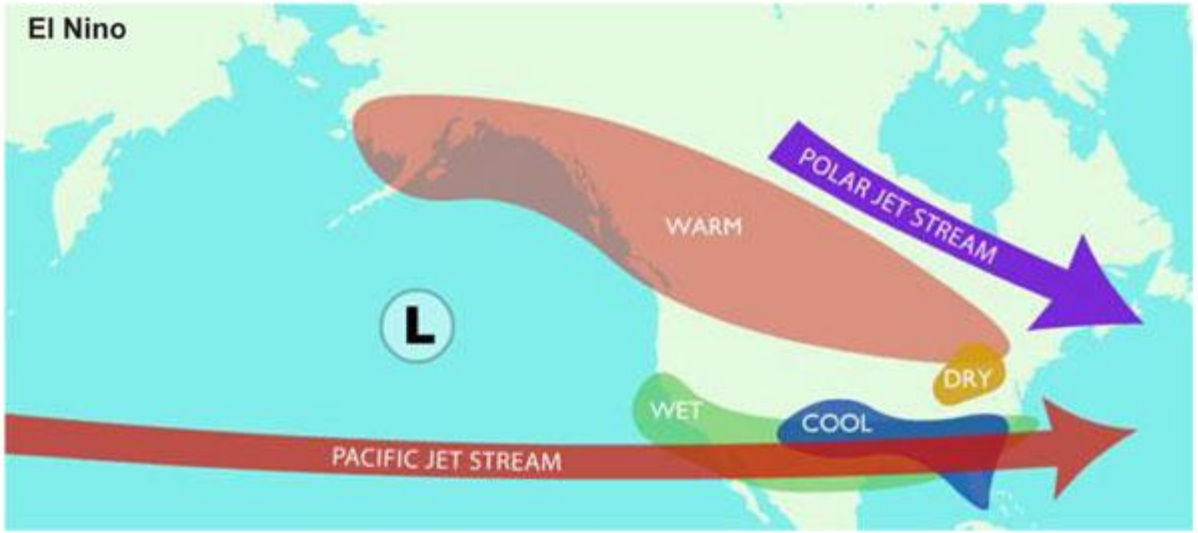
El Niño warming pattern in Nov 2015



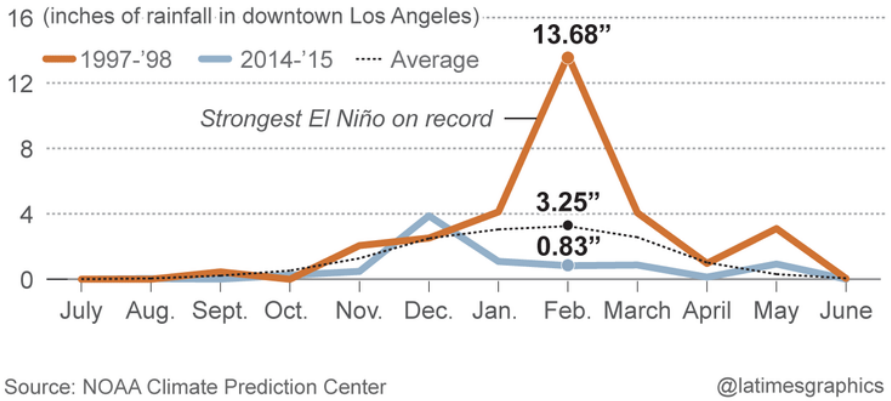
Extent of El Niño
1997 vs. 2015



Why do we even care?!



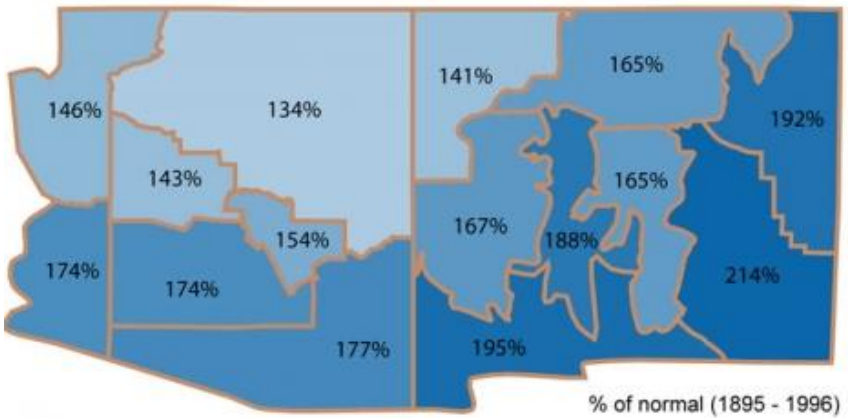
Record El Niño brought more rain to L.A.



Source: NOAA Climate Prediction Center

@latimesgraphics

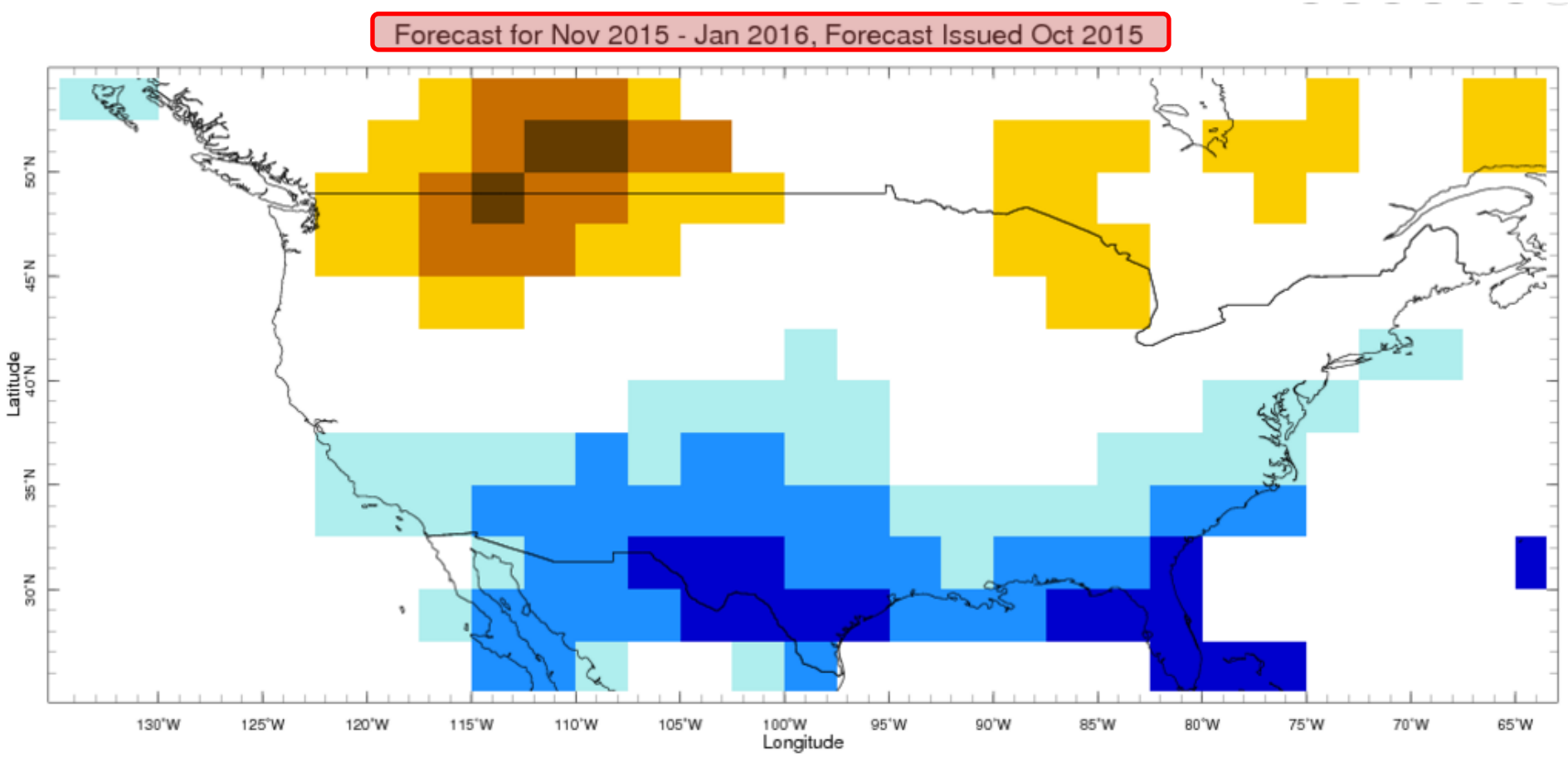
Arizona and New Mexico are Wetter during El Niño Winters



http://www.southwestclimatechange.org/climate/global/enso

http://www.latimes.com/local/lanow/la-me-ln-massive-el-nino-is-now-too-big-to-fail-scientist-says-20151009-story.html

Global Effects caused by El Niño-US



Will this season will be unusually wet?

Wet: **Highly increased** chance (55% or greater)

Wet: **Moderately increased** chance (45-50%)

Wet: **Slightly increased** chance (35-40%)

No new information

Slightly decreased chance of unusually wet or unusually dry

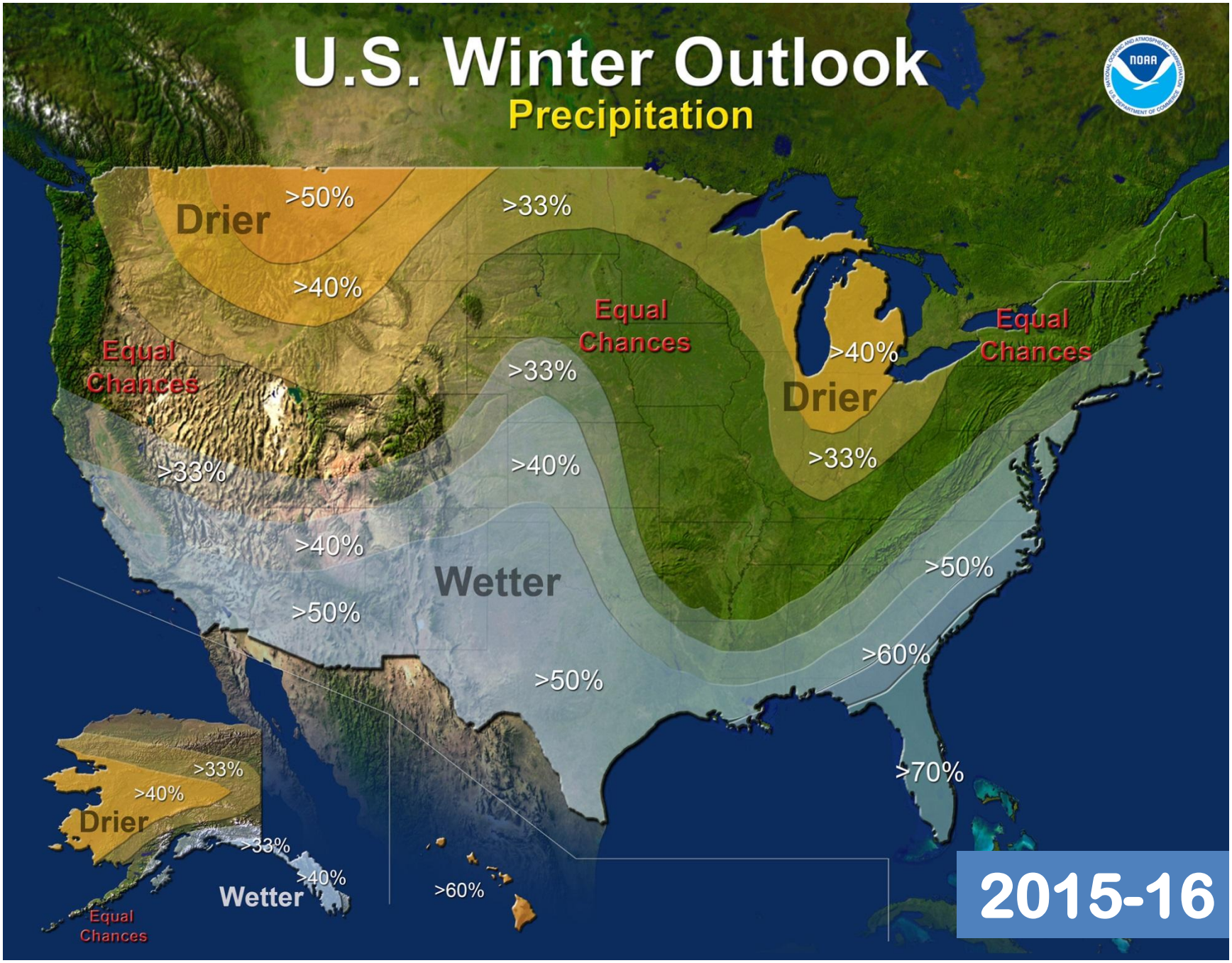
Will this season will be unusually dry?

Dry: **Slightly increased** chance (35-40%)

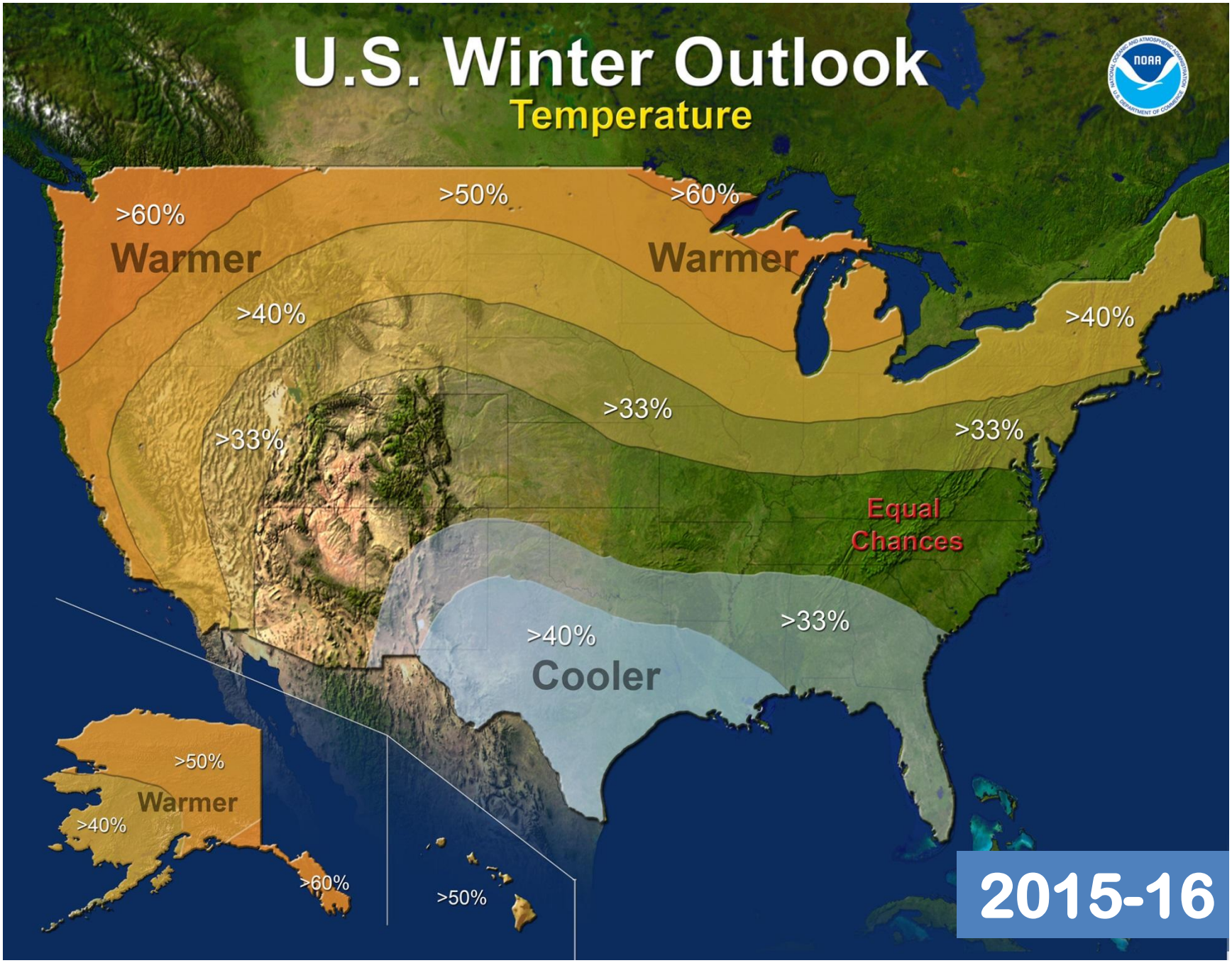
Dry: **Moderately increased** chance (45-50%)

Dry: **Highly increased** chance (55% or greater)

http://iridl.ldeo.columbia.edu



From: NOAA, http://www.noaanews.noaa.gov/stories2015/101515-noaa-strong-el-nino-sets-the-stage-for-2015-2016-winter-weather.html



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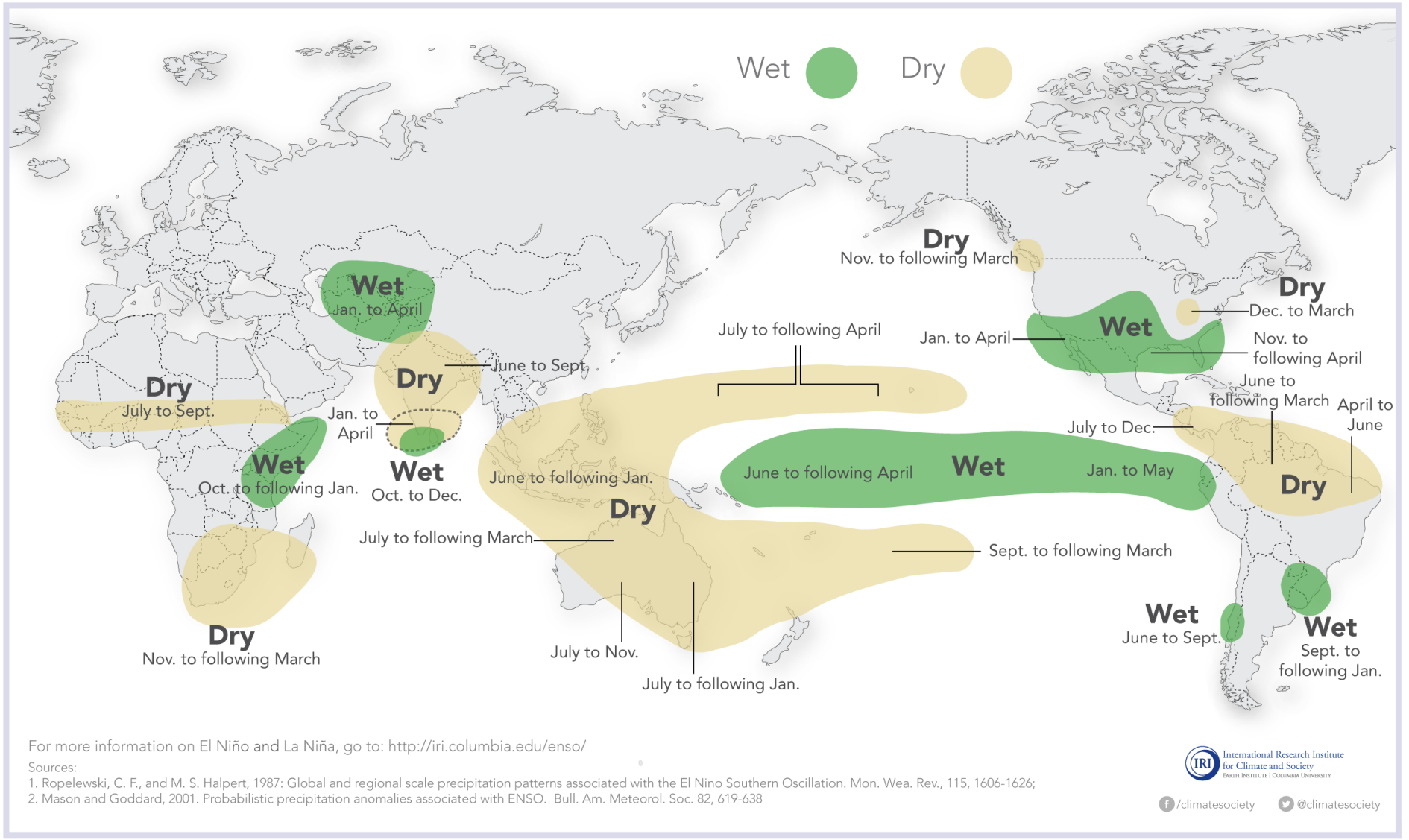
Global Effects caused by El Niño



For more information on El Niño and La Niña, go to: http://iri.columbia.edu/enso/

Sources:
1. Ropelewski, C. F., and M. S. Halpert, 1987: Global and regional scale precipitation patterns associated with the El Nino Southern Oscillation. Mon. Wea. Rev., 115, 1606-1626;
2. Mason and Goddard, 2001. Probabilistic precipitation anomalies associated with ENSO. Bull. Am. Meteorol. Soc. 82, 619-638

International Research Institute for Climate and Society
Earth Institute | Columbia University
/climatesociety @climatesociety

ANNOUNCEMENT:

Teacher Course Evaluations (TCE's)
begin today online and you will be getting email reminders!

Why participate in TCE Course Evaluations?

- Your opinion matters!

- Your evaluations are anonymous.
  (results and comments are not released to instructors until after final grades have been posted.)

- Like the preceptors, who've been providing feedback each week, YOU TOO can help improve this course (and how we use this neat classroom) for future classes!

- When more students participate, we'll get a more diverse and representative evaluation of the course.

- POINTS! If 90% of the class submits a TCE evaluation by midnight Dec 9th, everyone in the class will get 5 pts!

Since we still have some key topics and a couple of assignments to cover, please submit your **ONLINE TCE EVALUATION** after Thanksgiving **during the period Dec 1st – Dec -9th**

I will keep you posted on the class's progress to the 90% goal!

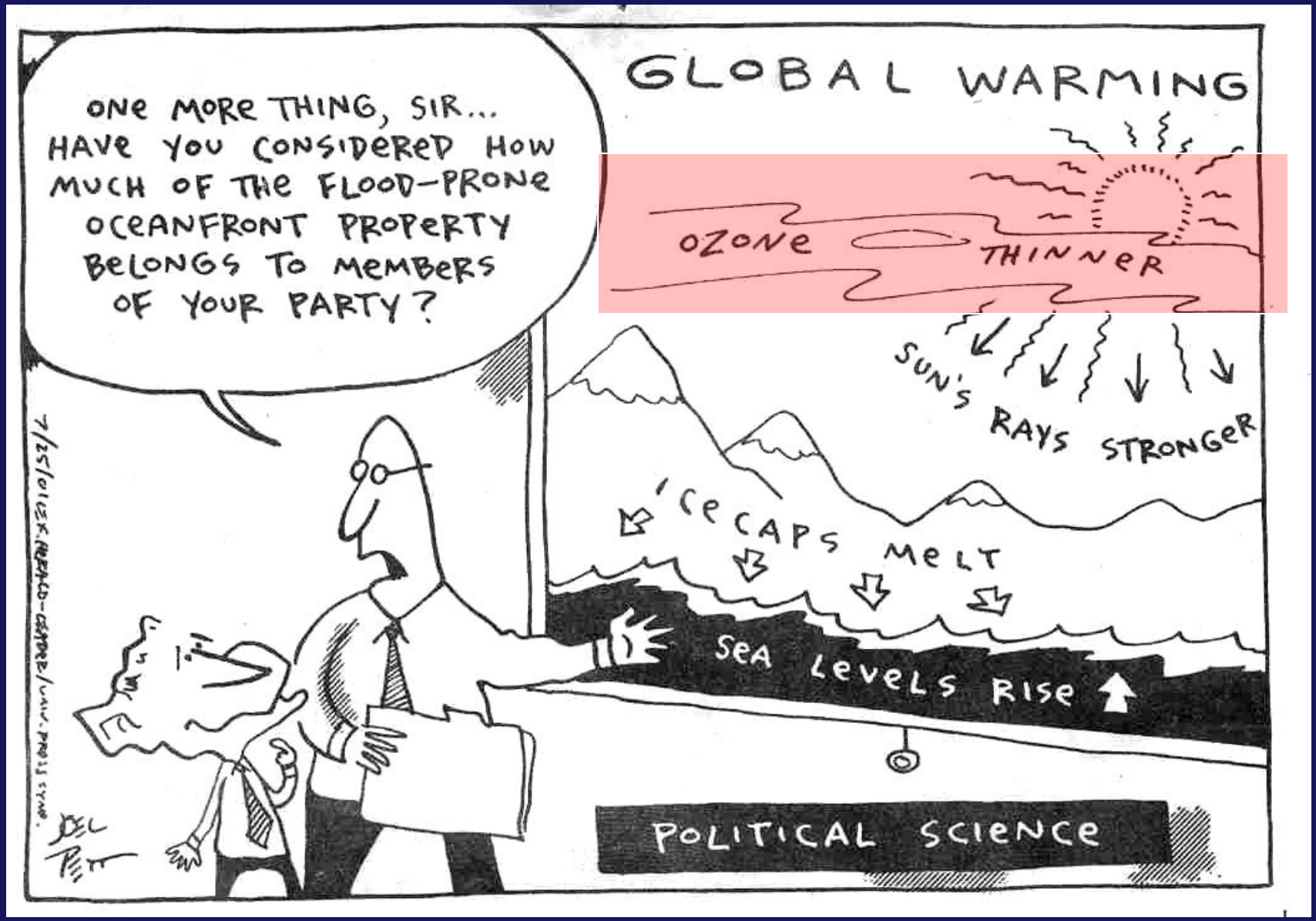
Topic # 12

OZONE DEPLETION IN THE STRATOSPHERE

A Story of Anthropogenic Disruption of a Natural Steady State

p 75 in Class Notes

OZONE's role in Global Warming ? ?



Clicker Q1:

Is the depletion of STRATOSPHERIC OZONE
(in the OZONE HOLE and elsewhere)
an important CAUSE
of GLOBAL WARMING?

1 – YES
2 -- NO

I will ask this again when we complete Topic 12!

“[The Ozone Treaty is] the first truly global treaty that offers protection to every single human being.”

~ Mostofa K. Tolba,
Director of the UN Environment Programme

OZONE STORY = A very interesting illustration of the scientific process!

The **THEORY** that the ozone layer in the stratosphere might be damaged by human intervention **PRECEDED** the actual **OBSERVATION** of the ozone hole.

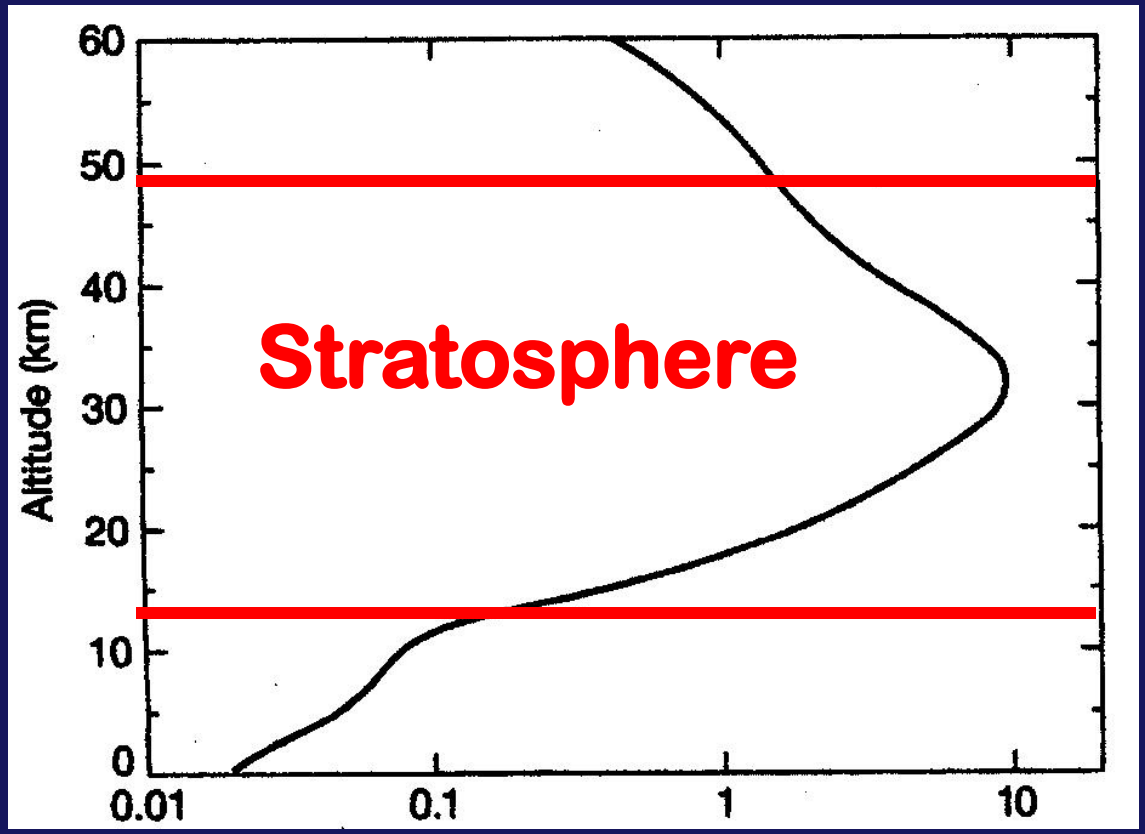
Yet, when the hole **WAS observed** (via satellite) it was **almost "missed"** because it wasn't expected . . .

But let's begin with the stratospheric ozone layer itself . . . . . .

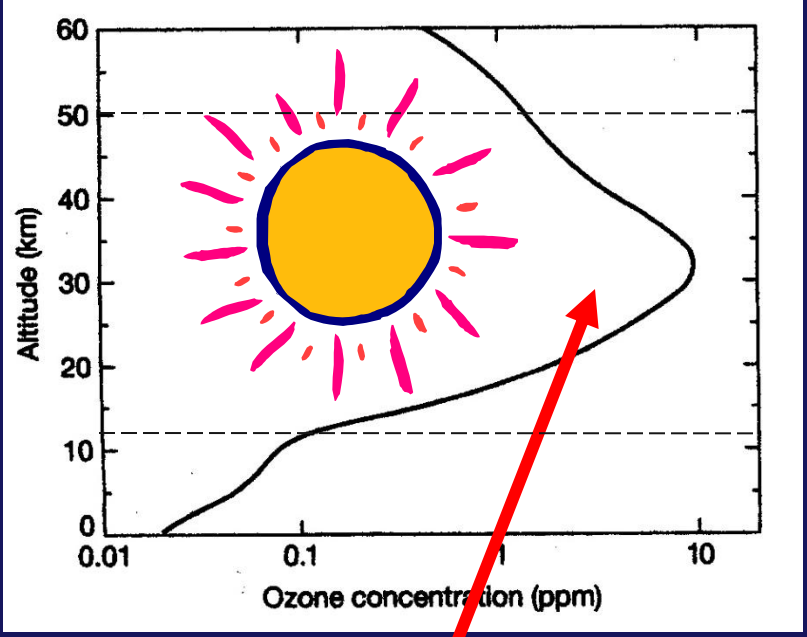
Key Concept

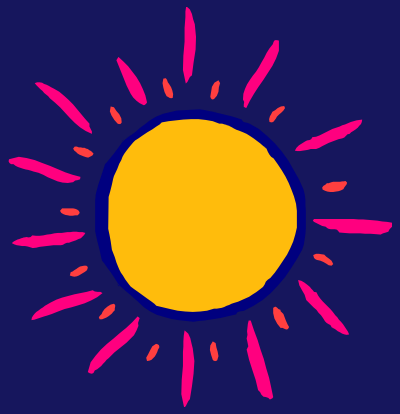
REVIEW: WHERE IS THE OZONE LAYER?

SGC E-Text Fig. 3-11



OZONE: Sources





Ozone is produced naturally in **photochemical reactions** in the stratospheric ozone layer --"good ozone" -- is <u>decreasing</u>!

However, ozone has ***<u>increased</u>*** in troposphere due to photochemical smog reactions -- "bad ozone"

THE OZONE LAYER IN THE STRATOSPHERE -- WHY IT'S THERE

Due to: the natural "Chapman Mechanism"

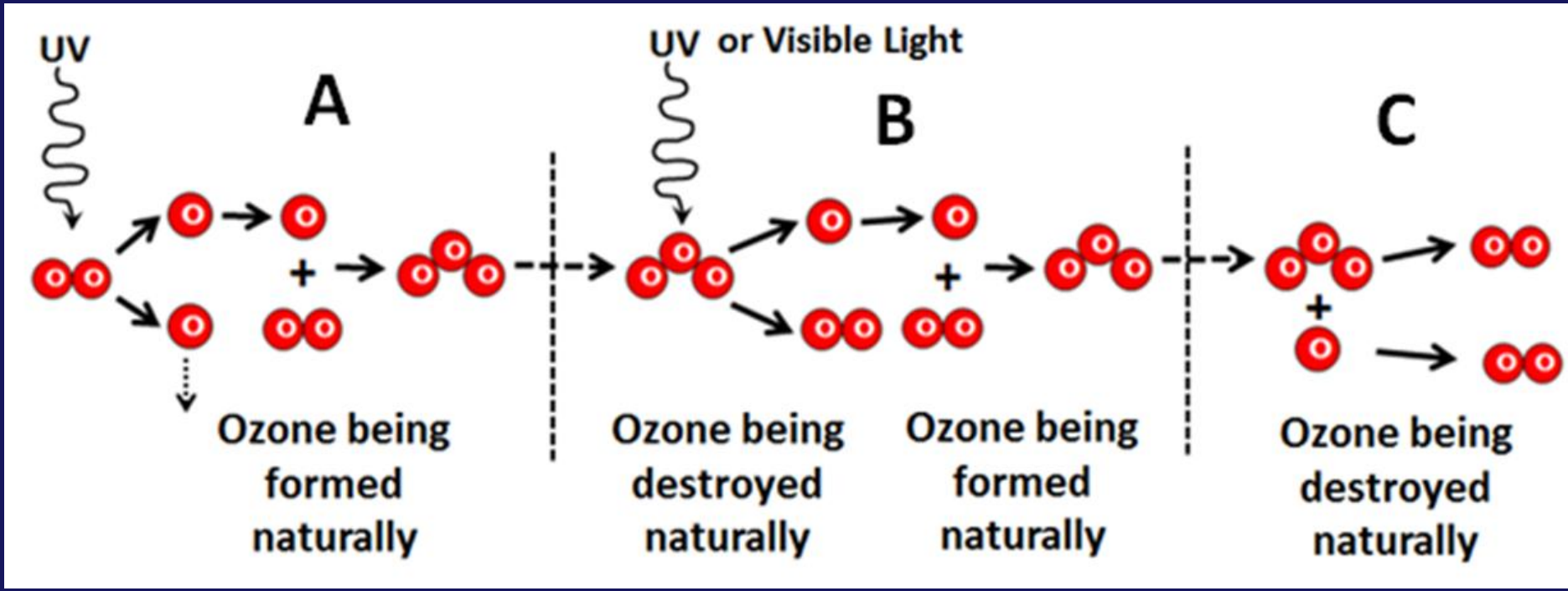
(a series of photochemical reactions)

THE CHAPMAN MECHANISM

(first proposed in 1930s)

- ozone is continuously produced and destroyed
- through **PHOTOCHEMICAL REACTIONS** in the stratosphere
- involves oxygen (O_2), molecular oxygen (O), photons of UV radiation, and OZONE (O_3).

The Chapman Mechanism

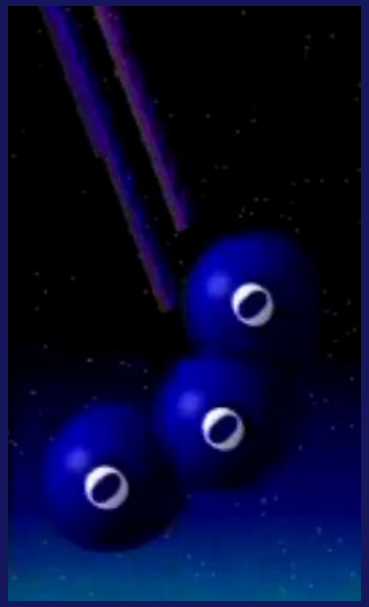


(See explanation in box on top of p 75)

[Go to movie clip]

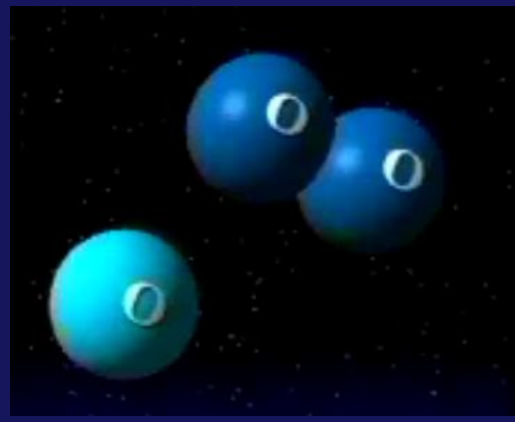
The Natural Chapman Mechanism in the Stratosphere

Breaks down & re-forms ozone naturally



High energy UV splits apart O_3

single O molecule bonds with O_2 to produce new O_3



In theory:

- **a balance of ozone is established over time**

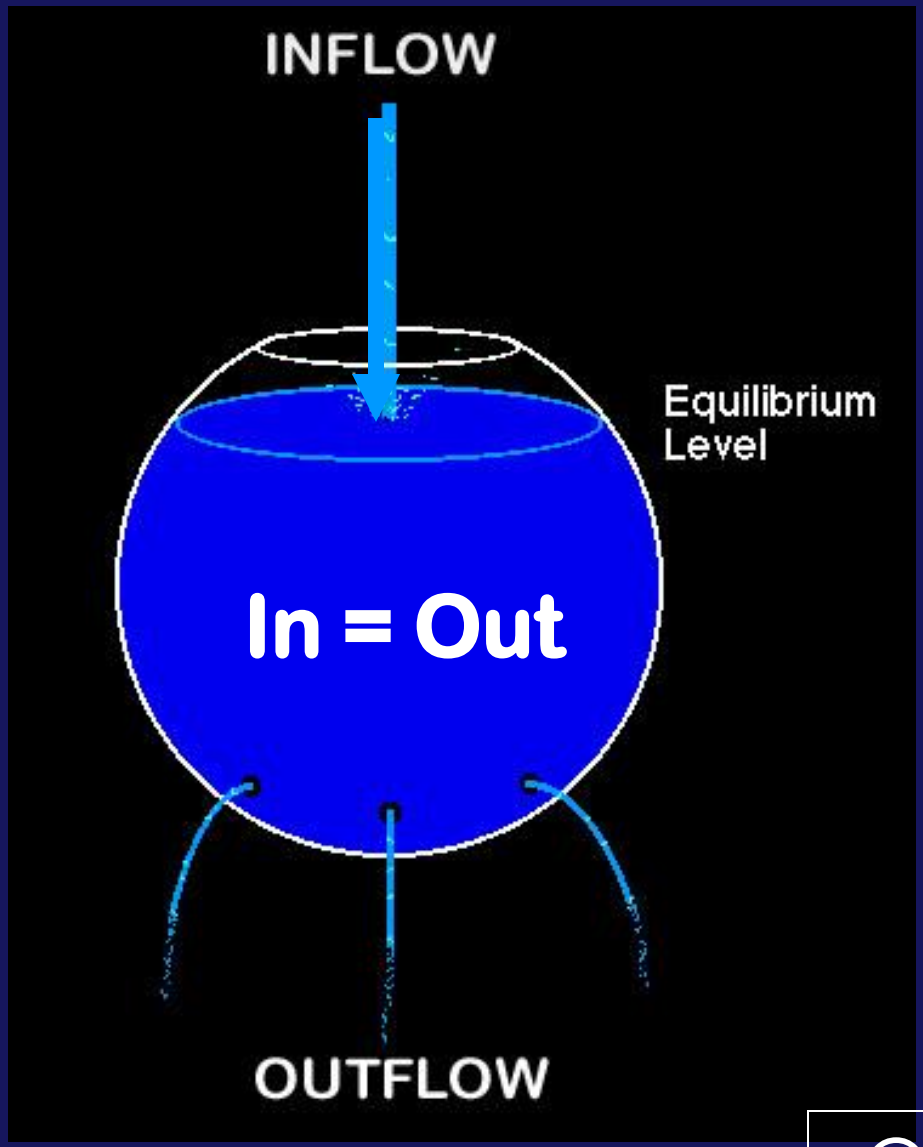
- **prevents much of the harmful UV radiation from reaching the earth's surface.**

Leads to an "Equilibrium" or "Steady State"

STEADY STATE =

a condition in which the STATE of a system component (e.g. reservoir)

is CONSTANT over time.



FLOW DIAGRAM OF A STEADY STATE

Inflow

Ozone **being formed by** natural Chapman mechanism

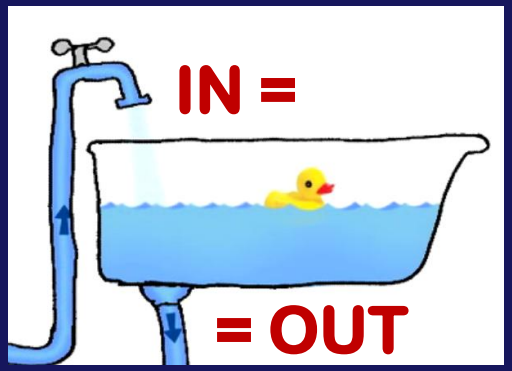
Reservoir of STRATOSPHERIC OZONE

Outflow

Ozone **being destroyed by** natural Chapman mechanism

Where have we seen something like this before?

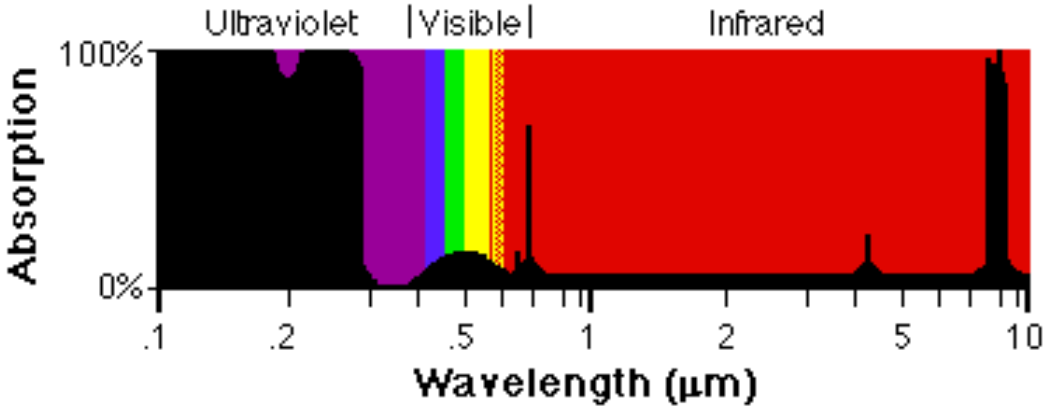
I-1 Lesson 1
Carbon Dioxide in the Atmosphere

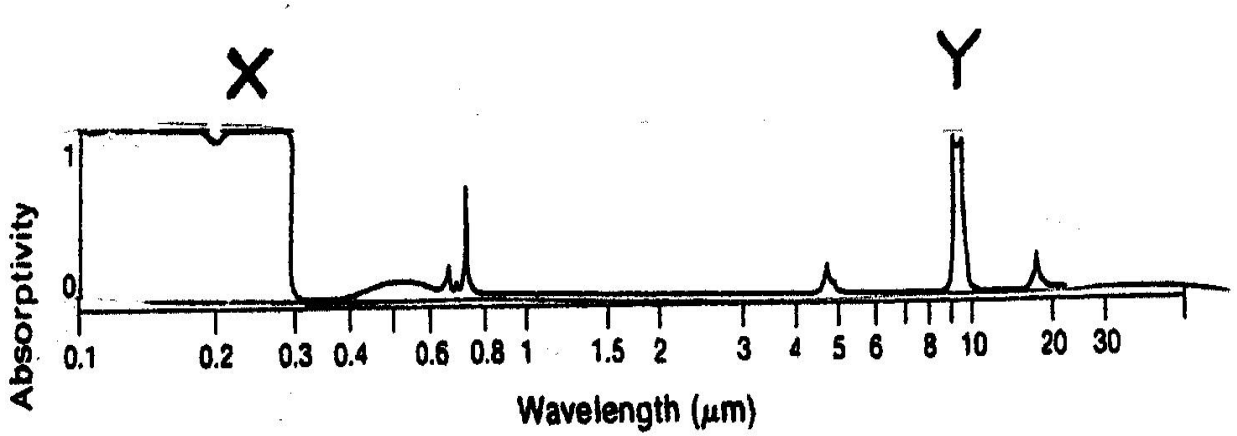


The **NATURAL Carbon Cycle** is in balance!

Review: Why stratospheric ozone is "Good":

Black areas = radiation absorbed

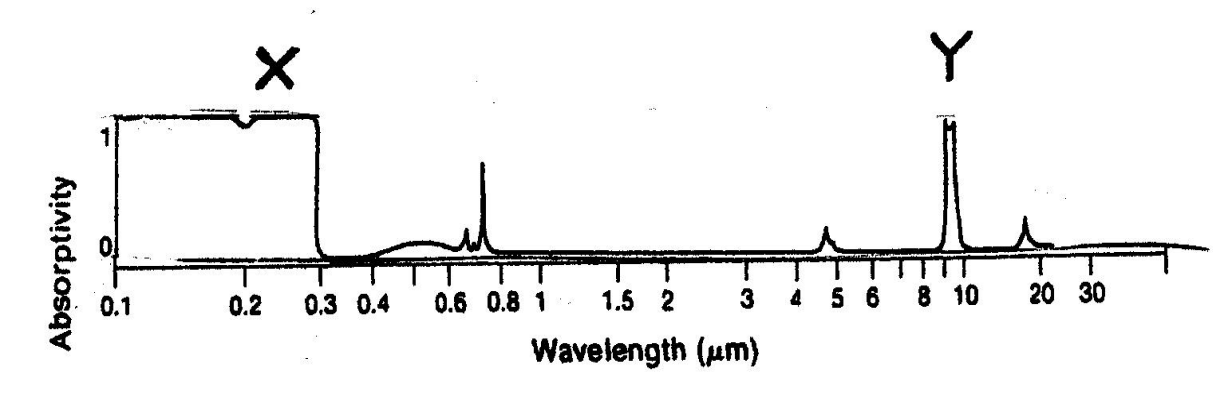




Ozone has the property of being a very strong absorber of ultraviolet radiation → **nearly total absorption of wavelengths less than 0.3 μm**

←remember this absorption curve?

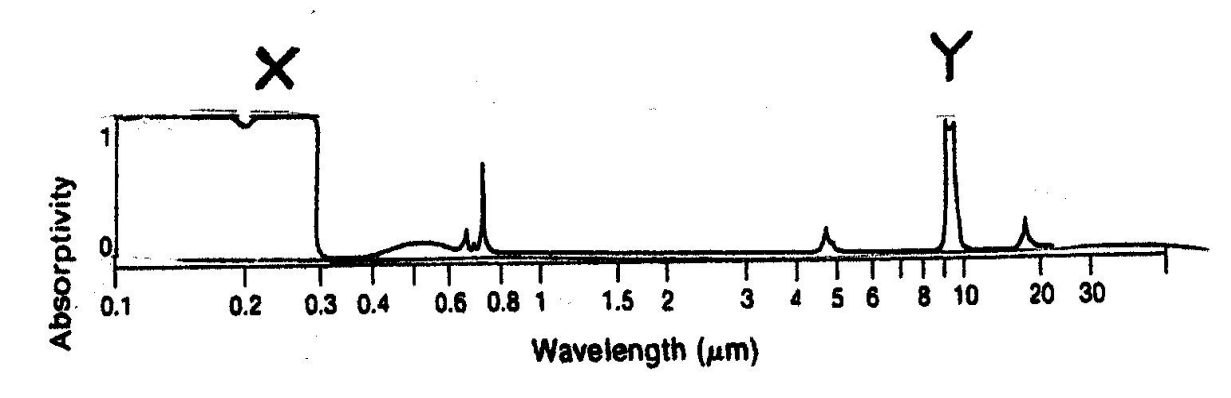
←CLICKER Q coming up!



Class Q: What is the CORRECT completion to this sentence:

The global change issue usually referred to as **Stratospheric Ozone Depletion** is related to the part of the absorption curve that is labeled ____.

(1) X or (2) Y



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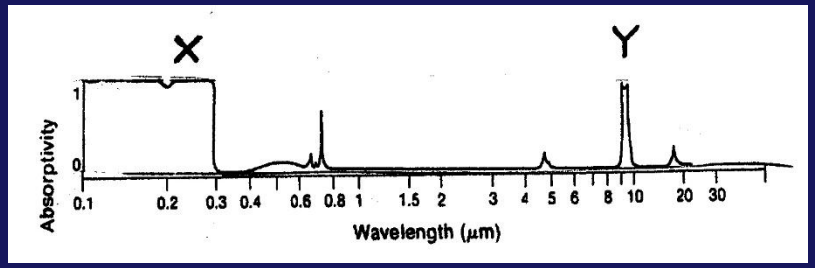
Clicker Q2: Ok, X is right, but Why?

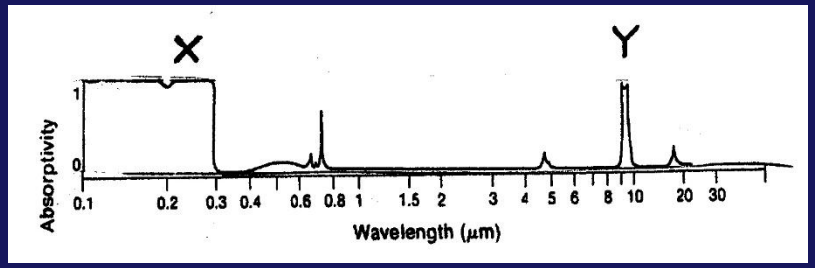


1. . . . because X represents UV radiation being absorbed -- hence if ozone is depleted, MORE ultraviolet radiation will reach the Earth's surface.

2. . . . because X represents terrestrial longwave radiation being absorbed -- and hence serves as a catalyst in the Chapman mechanism.

3. . . .because X represents easy transmission of wavelengths of terrestrial longwave radiation out to space which then disappear through the "atmospheric window" also known as the ozone hole.

Clicker Q2: Ok, X is right, but Why?



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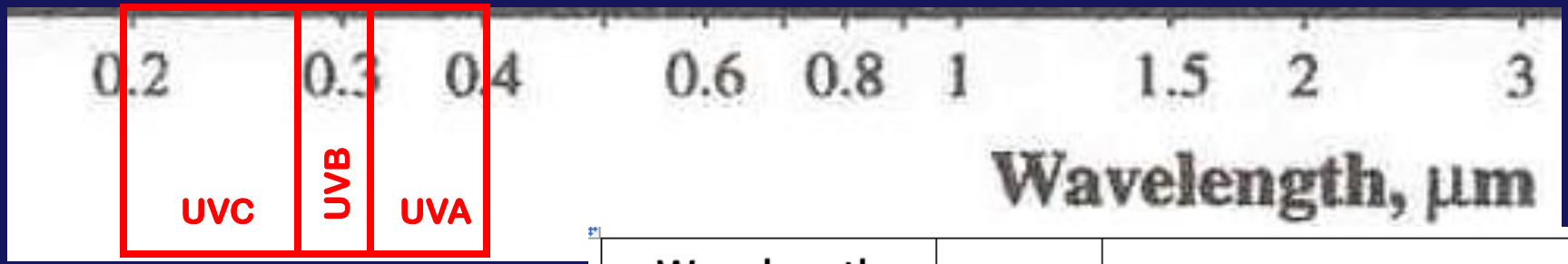
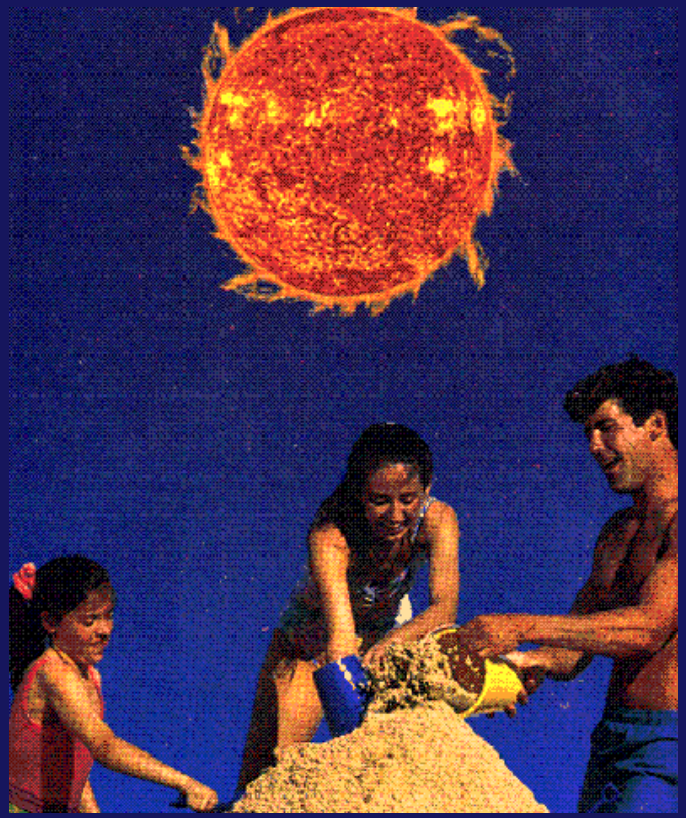
ANOTHER LINK TO EVERYDAY LIFE:

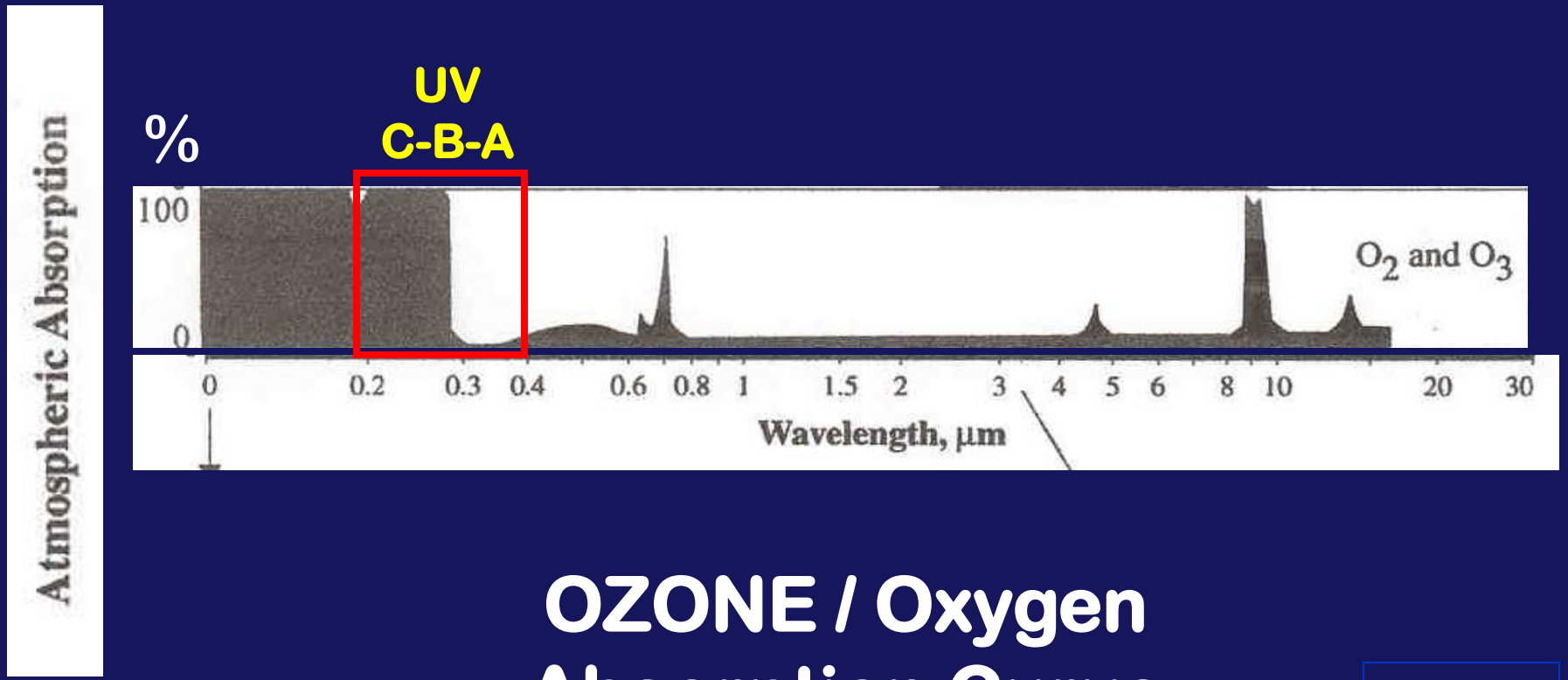
SUN SAFETY!





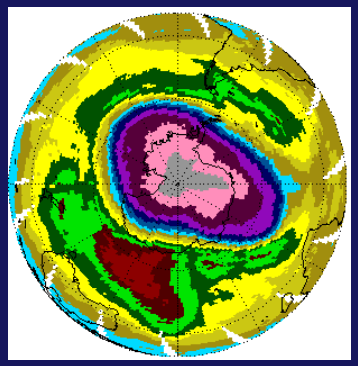
Wavelength Range	Name	Biological Effect
.32 to .4 µm (320-400 nm)	UVA	once thought to be relatively harmless, **BUT causes wrinkles, premature aging** and associated sun-related skin damage; **new research indicates possible skin cancer link**
29 to .32 µm (290-320 nm)	UVB	**harmful**, causes sunburn, skin cancer, and other disorders
.20 to .29 µm (200 - 290 nm)	UVC	**extremely harmful, damages DNA** -- but almost completely absorbed by ozone

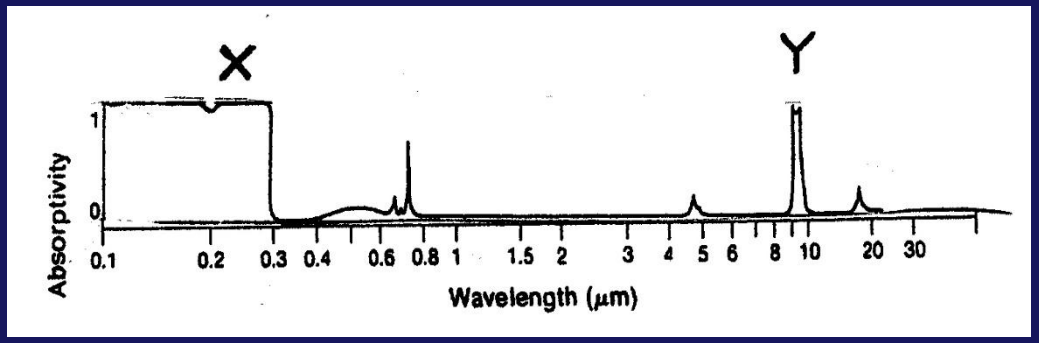
FULL SPECTRUM PROTECTION NEEDED!!



OZONE / Oxygen Absorption Curve

OZONE'S DUAL PERSONALITY!



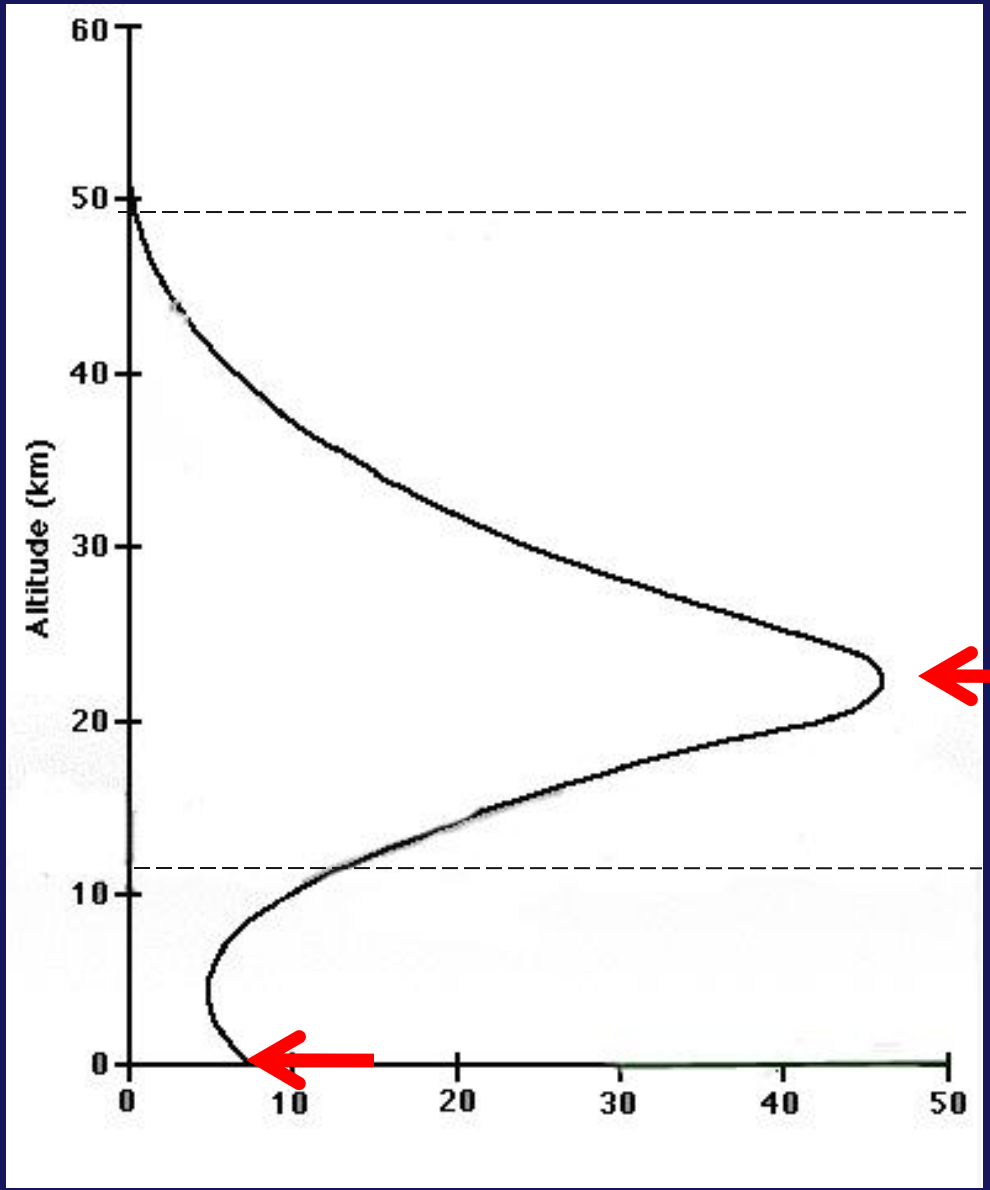


Important as an absorber of harmful UV in the **STRATOSPHERE**

Important as a GH Gas = absorber of IR in the **TROPOSPHERE**

Here's a different version of the figure ➔

Shows 2 peaks, a major peak in O_3 density in the **stratosphere**, a smaller secondary peak in the **lower troposphere**

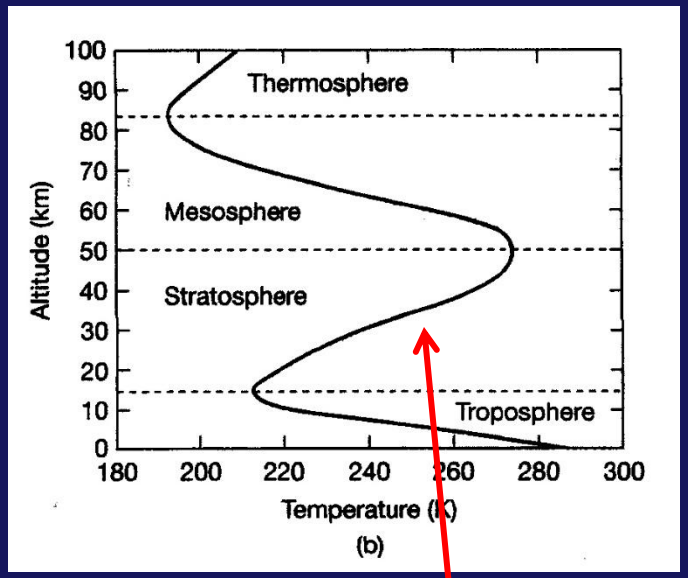


Ozone Density

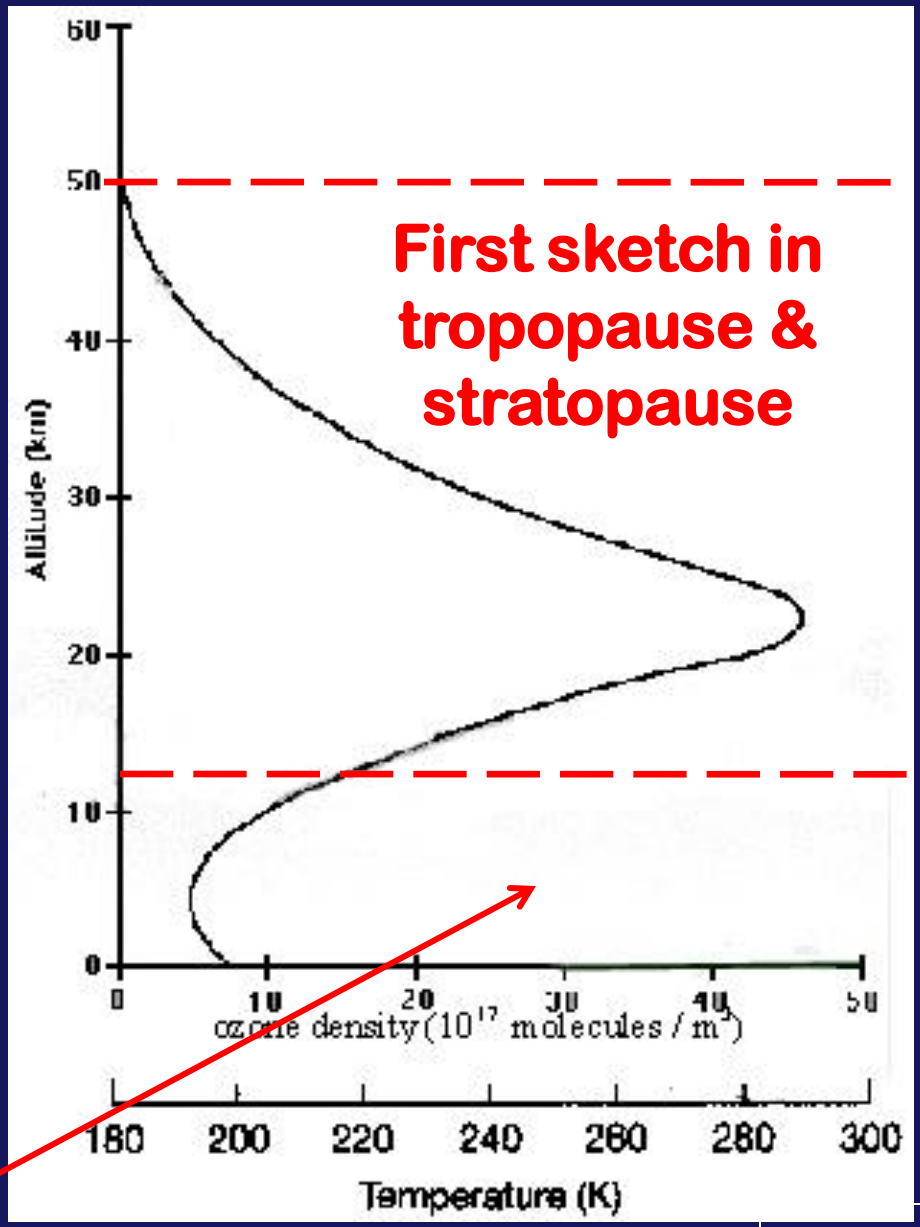
(10^{17} molecules / m^3)

Hands on – sketch this in on p 76:

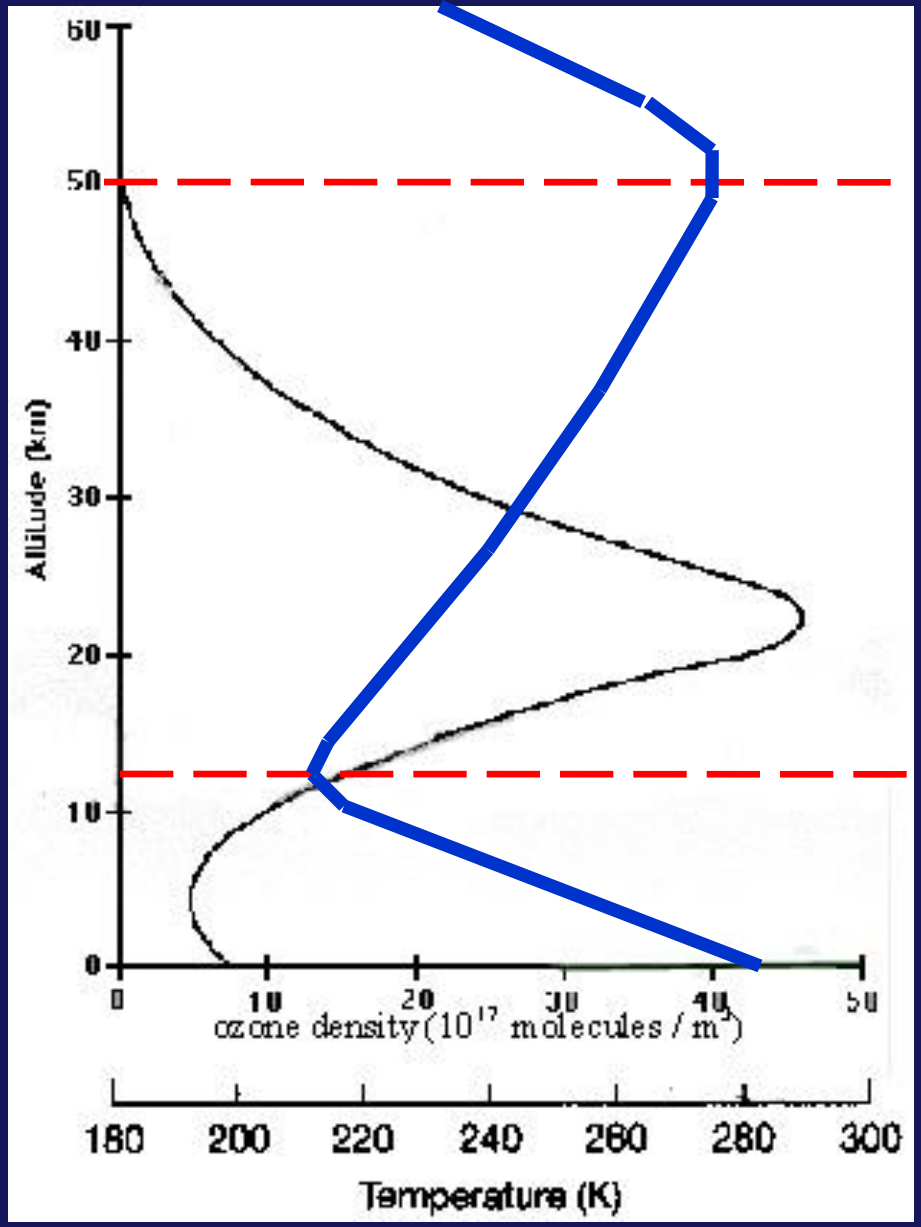
Temperature graph



Ozone Density graph



Now roughly sketch the <u>temperature</u> line from this graph onto the ozone graph



Fill in the Q on p 76:

Q. Does the temperature of the atmosphere INCREASE or DECREASE with increasing altitude in t the Stratosphere?

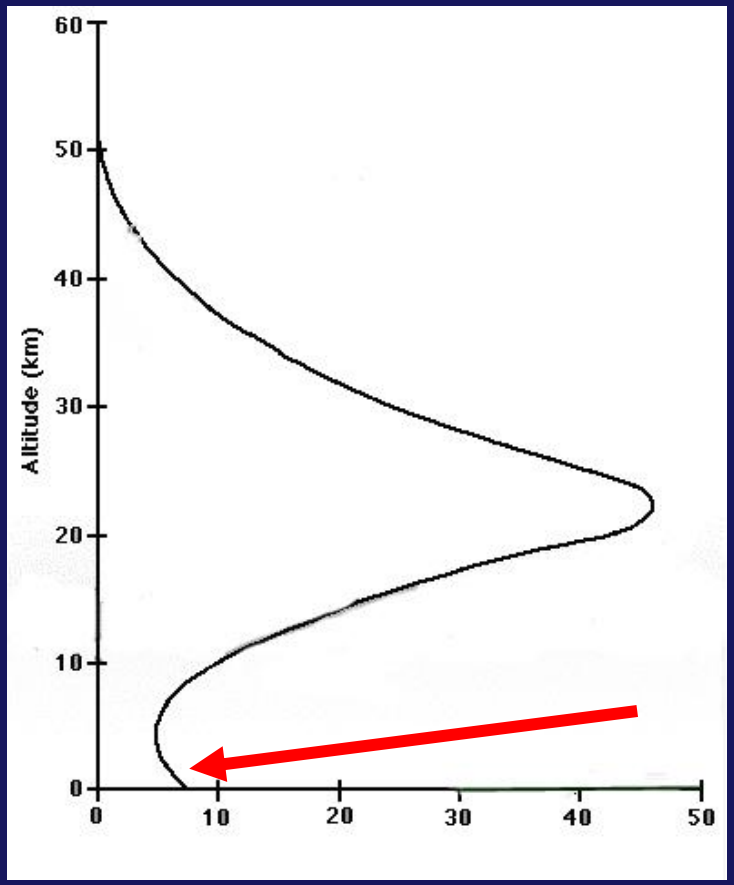
TEMPERATURE

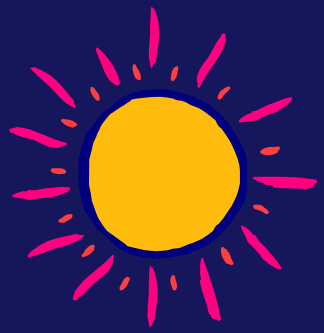
[increases / decreases]

with increasing altitude in the stratosphere

WHY???

What about the "BAD" ozone located in the troposphere?





Ozone has *increased* in troposphere due to photochemical smog reactions ➔ "bad ozone"

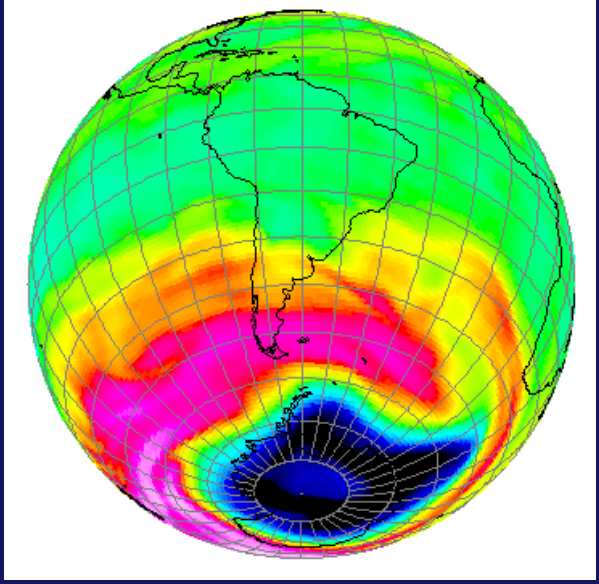
HEALTH AND ENVIRONMENTAL EFFECTS OF GROUND-LEVEL OZONE

Why are We Concerned about Ground-Level Ozone?

➔ **Ozone is the prime ingredient of smog in our cities and other areas of the country.**

Phoenix smog !! ➔

THE DESTRUCTION OF STRATOSPHERIC OZONE



The ozone hole is:

-- a depletion of ozone in the lower stratosphere

-- that has occurred with increasing severity each spring (since measurements begin in 1970s)

NOTE: this and other "bullet" items from today's lecture are in the box on p 77

FLOW DIAGRAM OF A STEADY STATE

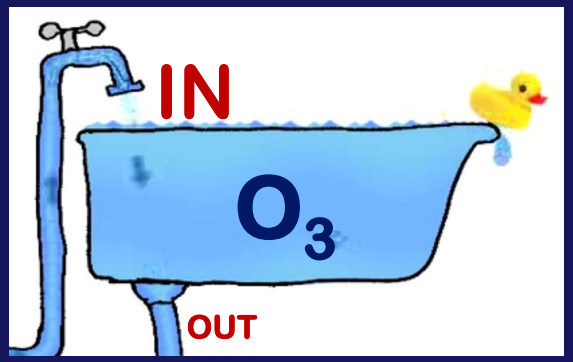
Inflow

Ozone being formed via natural Chapman mechanism

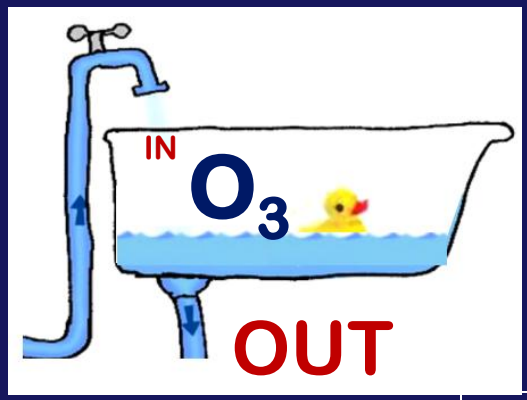
Reservoir of STRATOSPHERIC OZONE

Outflow

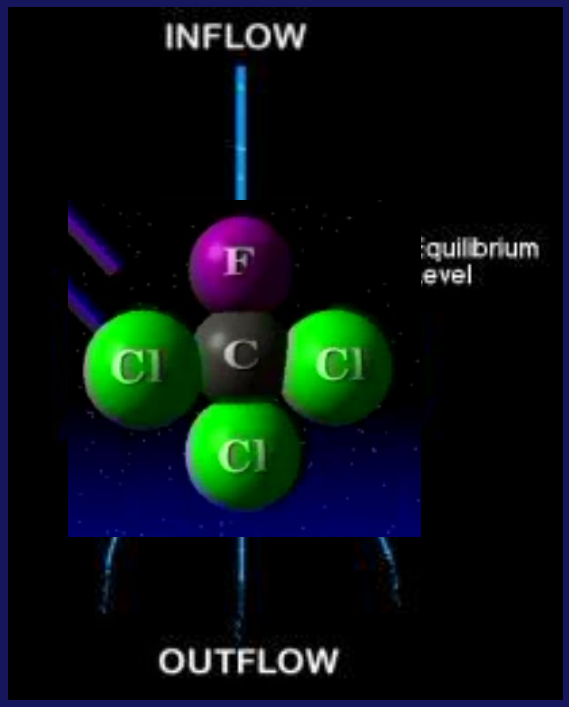
Ozone being destroyed via natural Chapman mechanism



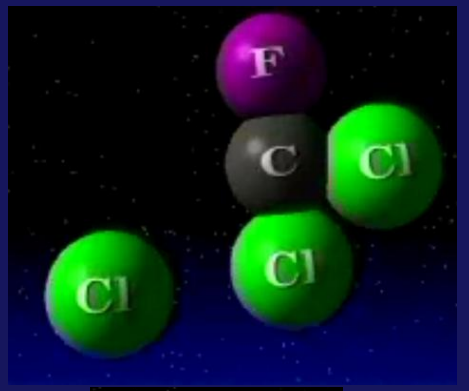
← 2 ways to get out of balance →



The Chapman Mechansim “balance” is being **disrupted** by the introduction of **CFC's** and other similar gases into the stratosphere:



> CFCs are photo-dissociated into **FREE CHLORINE ATOMS (Cl)** and other molecular fragments by UV ray



> **Chlorine** ➔ acts as **catalyst** in ozone loss reactions

CATALYST =

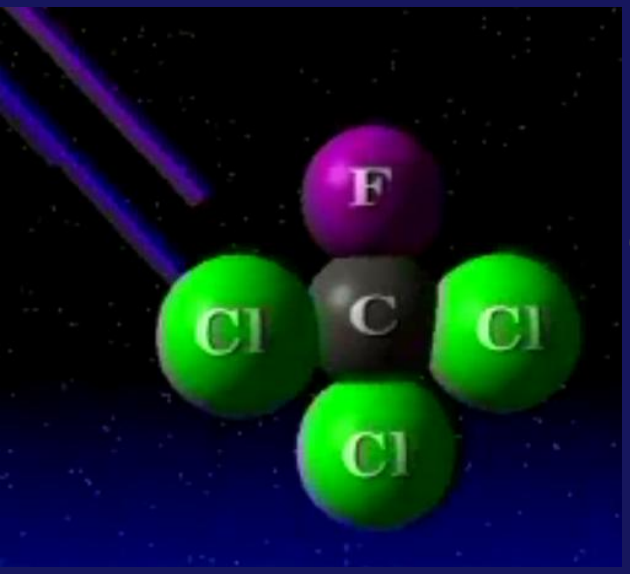
A compound that increases the rate of a chemical reaction and is itself unchanged by the reaction

Through chemical reactions:

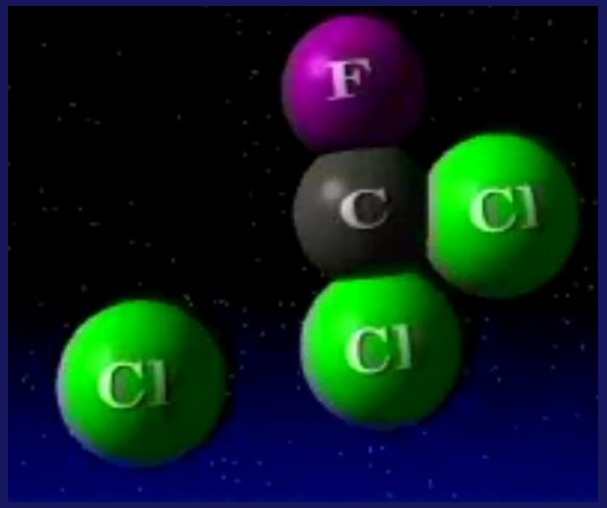
- **the chlorine removes ozone from the stratosphere**
- **and also frees more chlorine atoms to begin the process all over again**

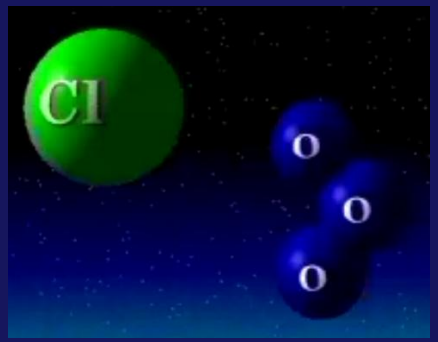
[Go to movie clip]

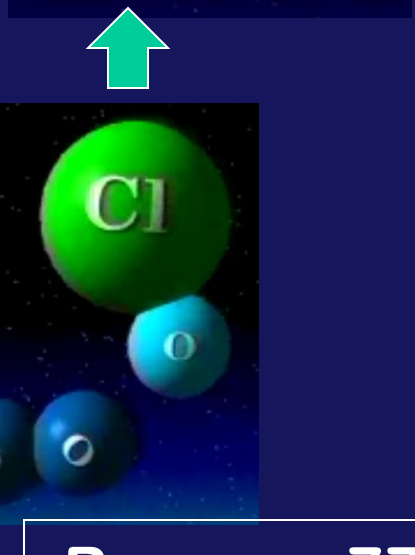
DESTRUCTION OF OZONE BY CFC's & CHLORINE CATALYST

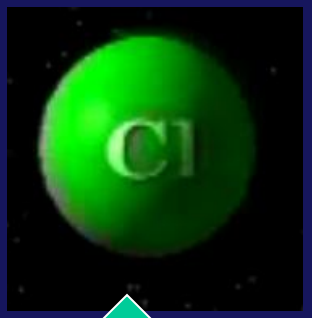


A single Cl atom destroys 100,000s of O_3 but is not itself destroyed

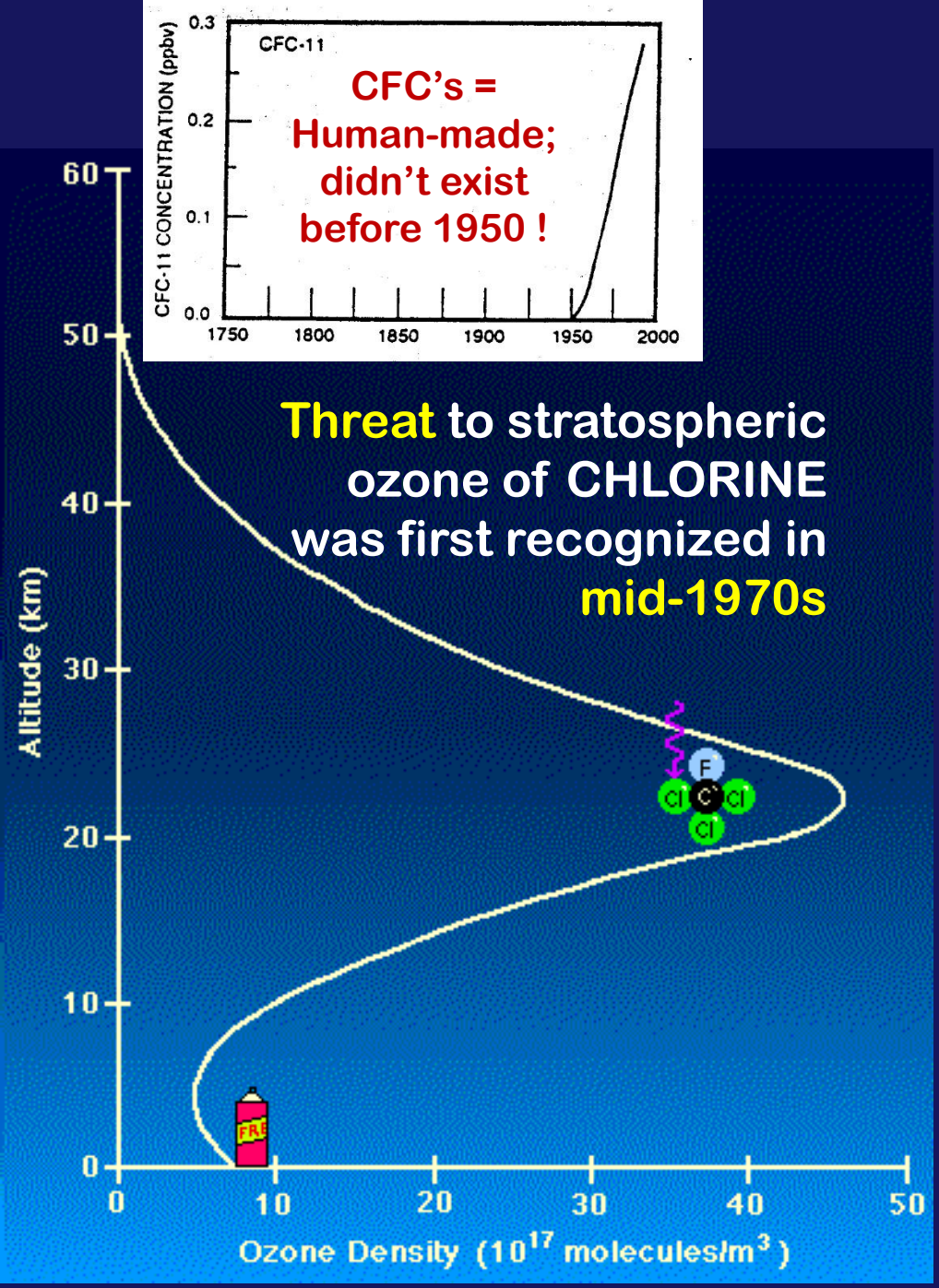








Box on p 77



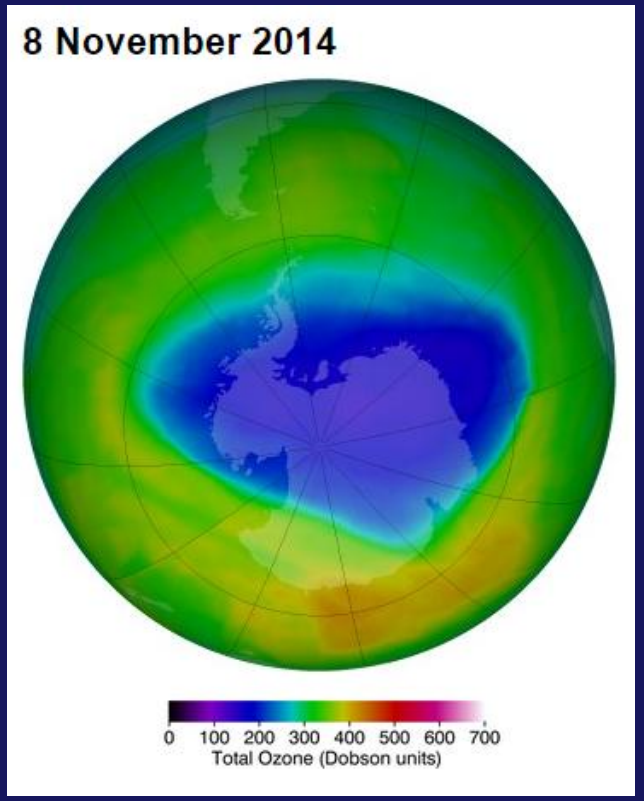
CFC compounds: Chlorofluorocarbons

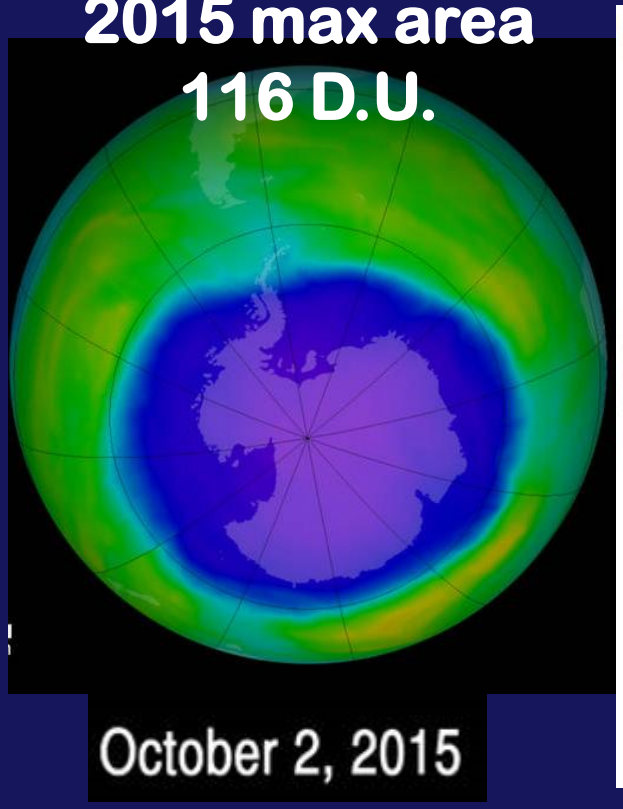
are unreactive at Earth's surface,

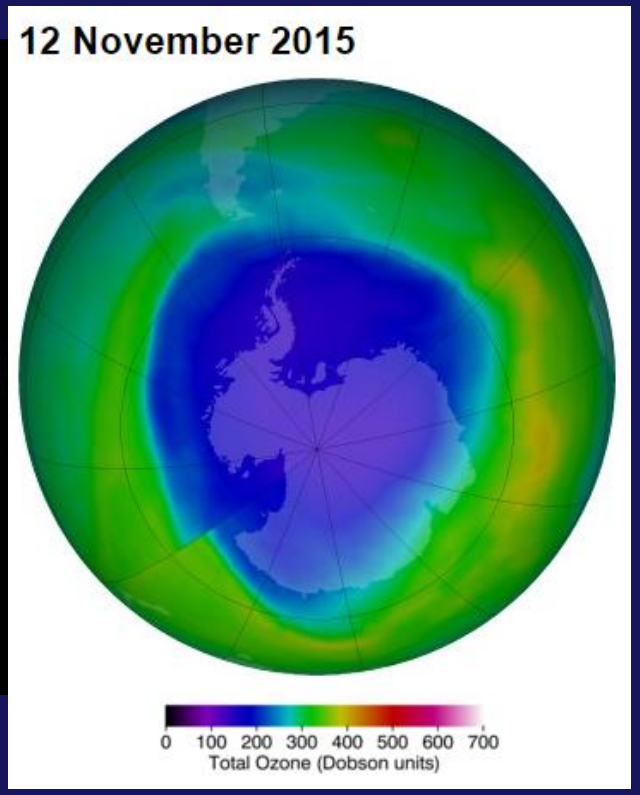
but if they get into the stratosphere . . .

they can be broken down by high energy UV → highly reactive CHLORINE atoms (Cl)

THE ANTARCTIC OZONE HOLE





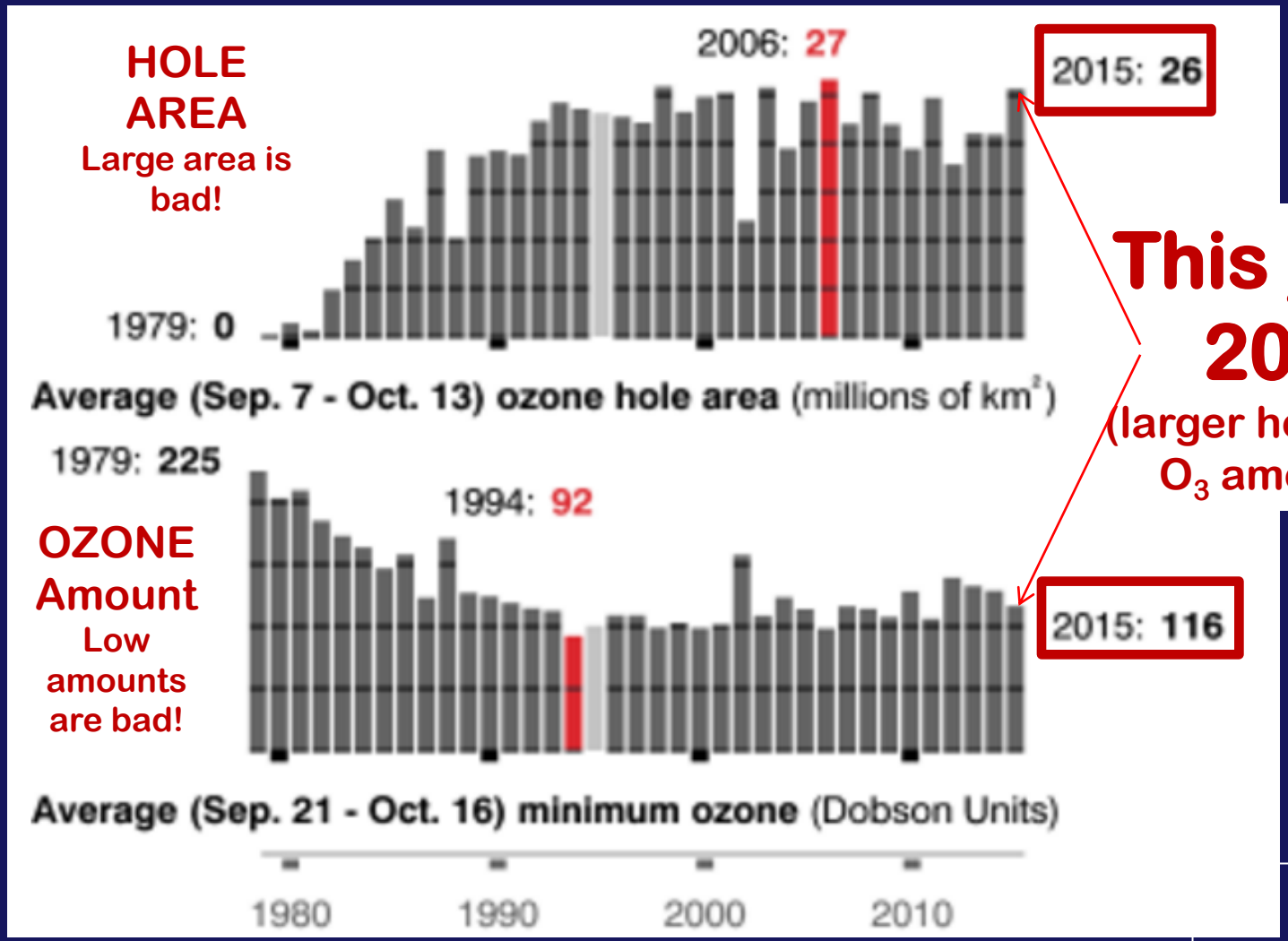


http://ozonewatch.gsfc.nasa.gov/

http://ozonewatch.gsfc.nasa.gov/

OZONE HOLE WATCH
images, data, and information; updated daily

Annual Ozone Hole Variations (since 1979)



This year: 2015
(larger hole, lower O_3 amounts!)

from: http://ozonewatch.gsfc.nasa.gov/

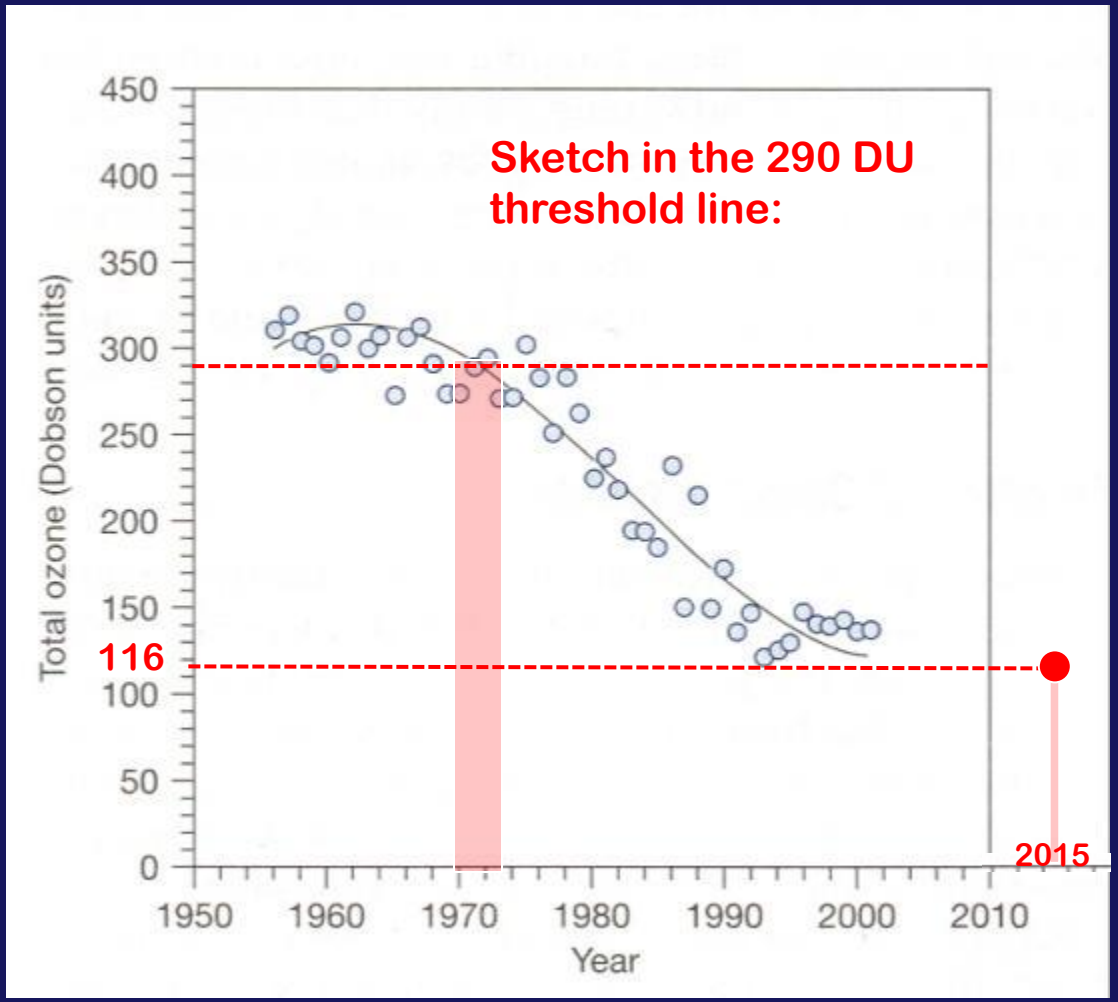
UPDATE

RATE OF OZONE DEPLETION

in DOBSON UNITS (DU)

<u>When</u> did the Hole begin forming?

Hole generally defined as < 290 DU



~ 1969 to 1970

RECIPE FOR THE OZONE HOLE

http://www.youtube.com/watch?v=qUfVMogIdr8

WHY ANTARCTICA?

The ozone "hole(s)" have a unique REGIONALITY and SEASONALITY :

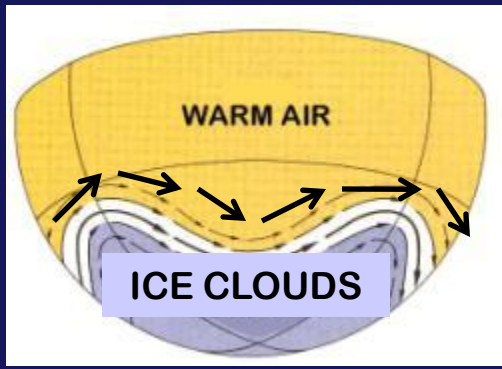
> it is most severe over Antarctica in S.H. spring (Sep, Oct);

> a less severe depletion (not a true hole) occurs over the Arctic in N.H. spring (Feb, Mar)

Key Concept

The special conditions that make ozone depletion most severe over polar regions (esp. Antarctica) are:

(1) the unique **CIRCUMPOLAR CIRCULATION PATTERN** over Antarctica in winter which isolates the stratosphere inside a vortex and acts like a "containment vessel" in which chemical reactions may occur in near isolation;



(2) The presence of **POLAR STRATOSPHERIC ICE CLOUDS** -- on the surfaces of these extremely cold cloud particles certain chemical reactions are more efficient and faster.

Key Concept

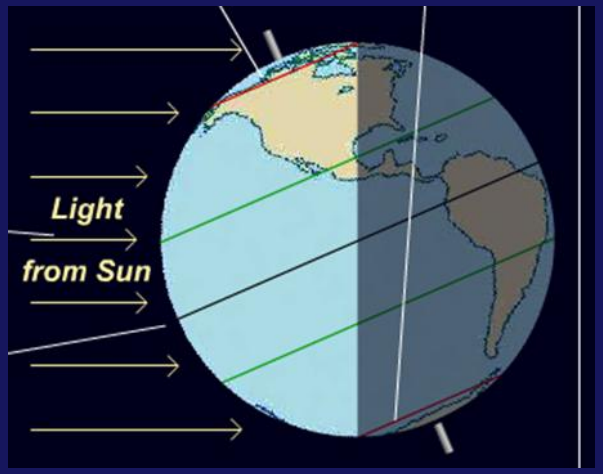
POLAR STRATOSPHERIC CLOUDS OVER ANTARCTICA

[Go to movie clip]

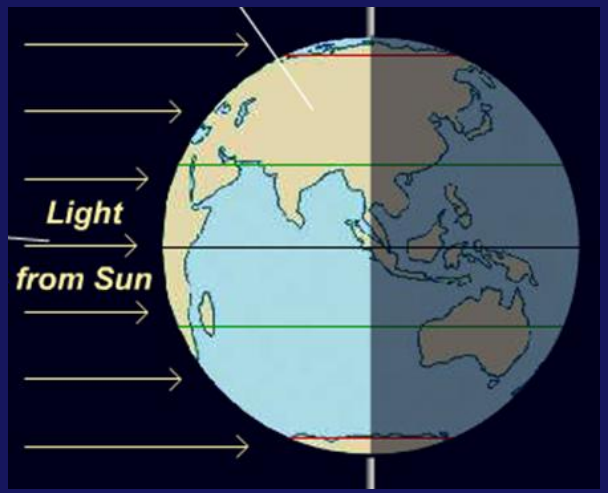
LAST INGREDIENT:

SUNLIGHT + UV PHOTONS

June



Sept



Only after well after the June Solstice and esp. the September Equinox, does the South Pole & Antarctic Circle receive sufficient sunlight!

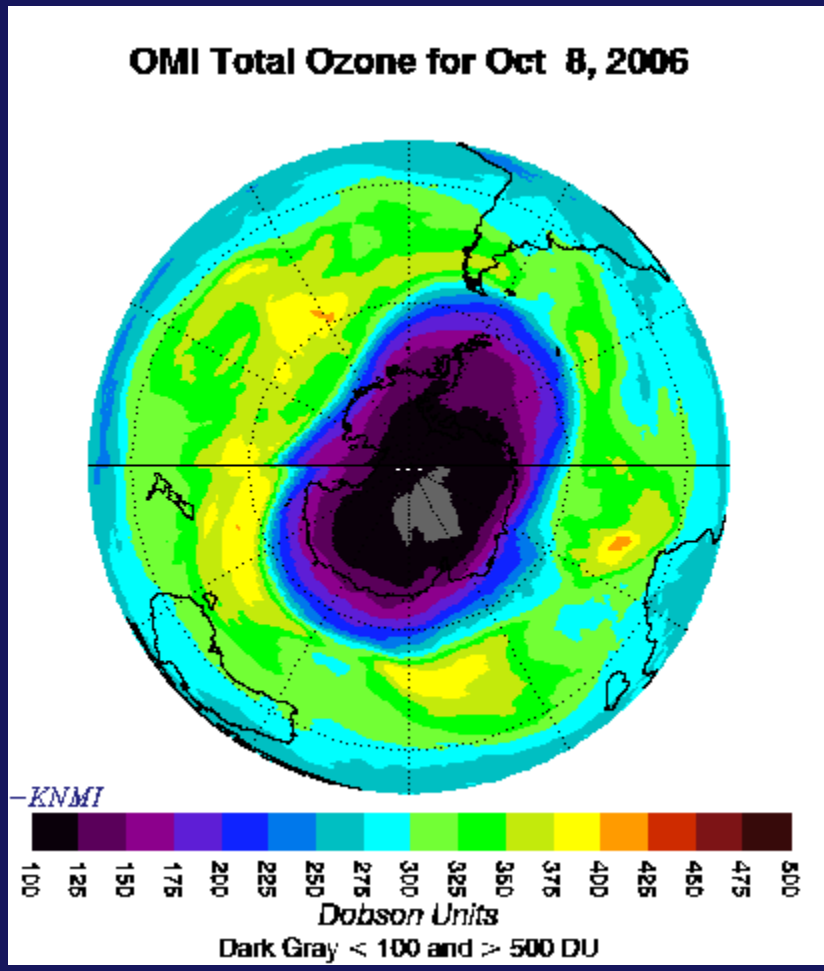
HOW DEEP DOES THE HOLE GET?

The intensity of ozone depletion varies from year to year.

The value of **85 Dobson Units** on October 8, 2006 was the second lowest ever recorded by satellite measurements.

Nearly ALL of the ozone in the layer 8-13 miles above the Earth's surface was destroyed!

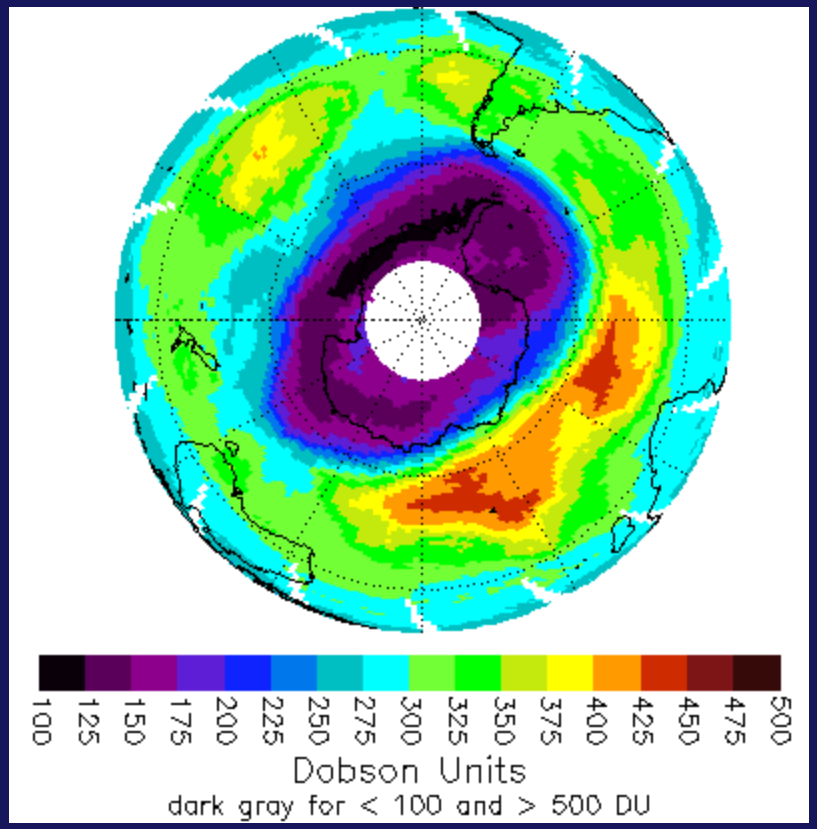
In this critical layer, the instrument measured a record low of only 1.2 DU!

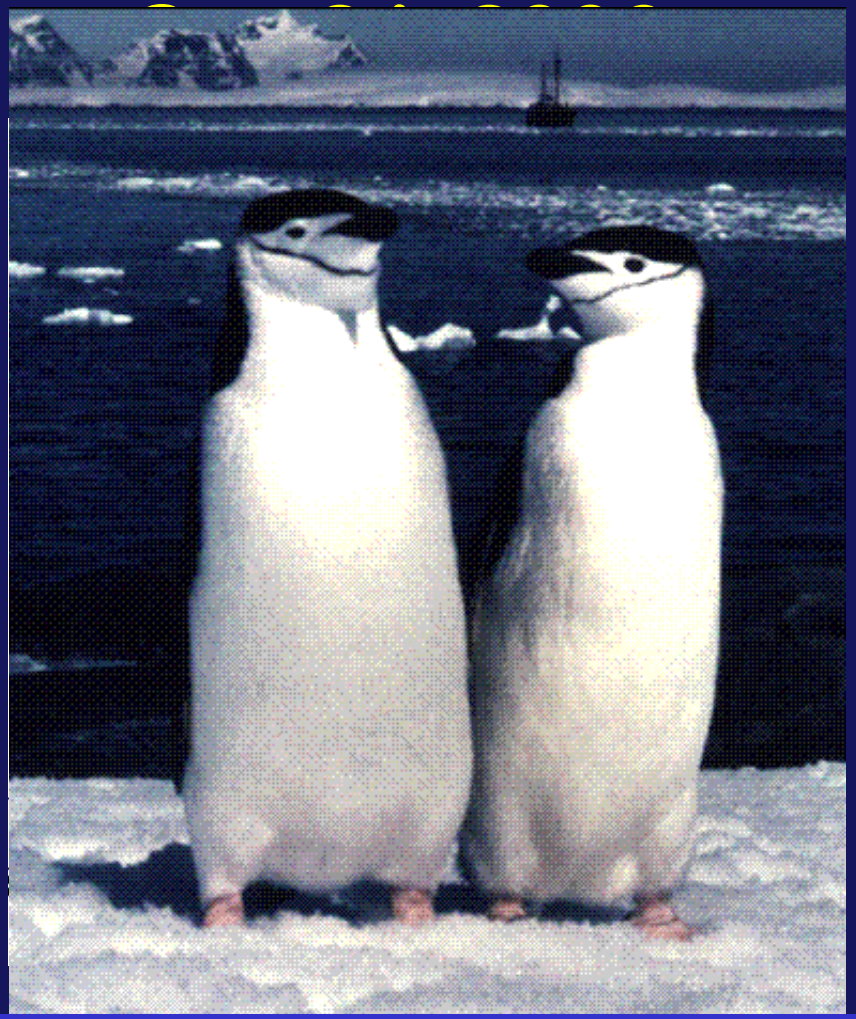


2006 also saw the second LARGEST sustained ozone hole.

http://www.sciencedaily.com/releases/2006/10/061019162053.htm

Sep 9, 2000





Here are some inhabitants with strong cause for concern about the Ozone Hole!

But what about the rest of us?

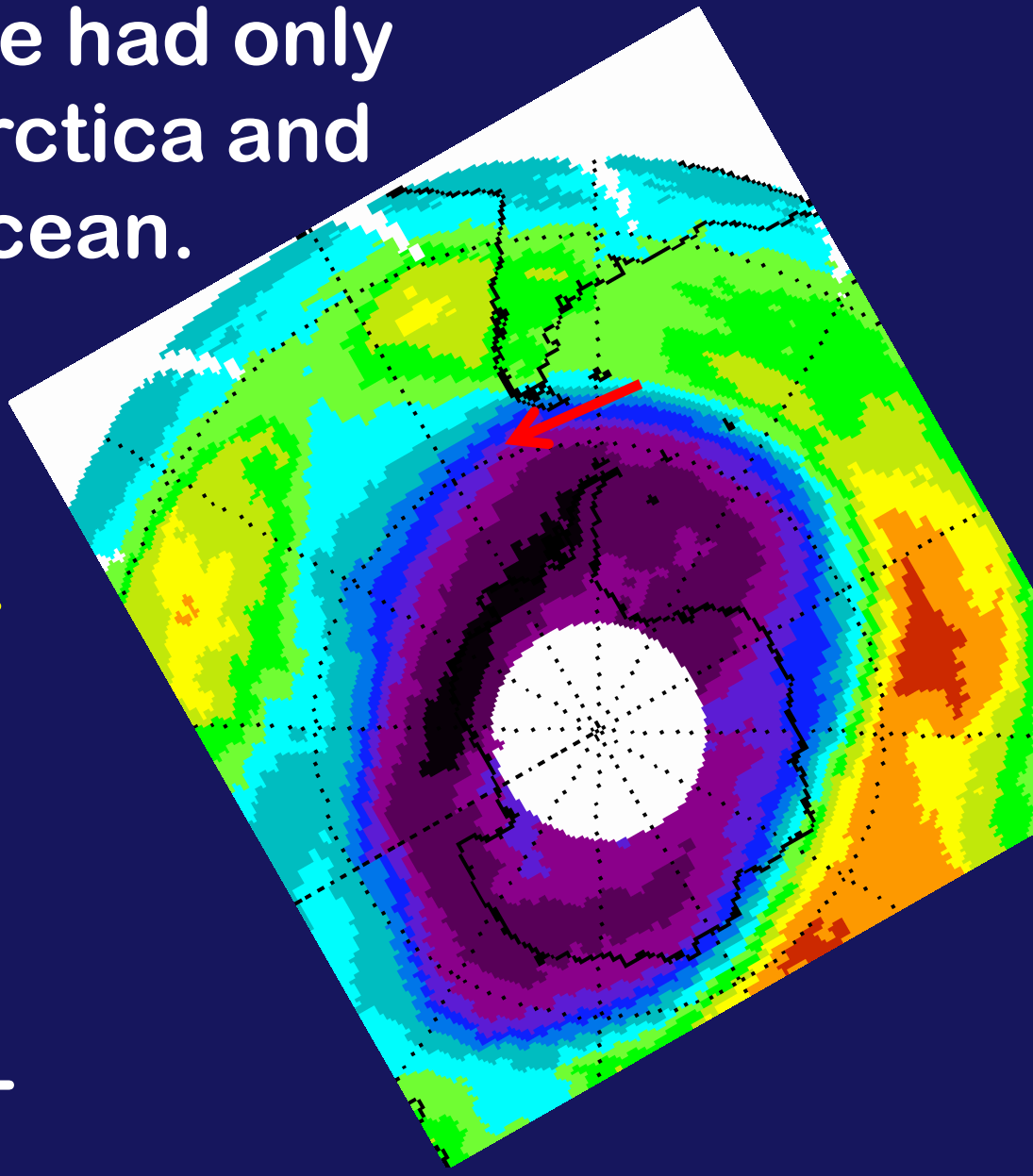
HOLE IN OZONE LAYER EXPOSED A CITY

THE ASSOCIATED PRESS 10-6-00

WELLINGTON, New Zealand –

The hole in the ozone layer over Antarctica stretched over a Chilean city when it ballooned to a record size on Sep 9 & 10, 2000

Previously, the hole had only opened over Antarctica and the surrounding ocean.



Hole covered 11.4 million square miles - an area more than three times the size of the United States -

A "solar stoplight" in Punta Arenas announces an orange alert

a woman and her child are bundled up against the sun in mid-day

For those two days, the hole extended over Punta Arenas, a southern Chilean city of about 120,000 people, exposing residents to very high levels of ultraviolet radiation.

. . . findings showed a city being exposed to the ozone hole for the first time!

What about other parts of the globe?

- *DECREASES* have been observed in nearly all latitude zones:
  - 1.1 - 9% in Southern Hemisphere
  - 1.1 - 3.7% in Northern Hemisphere

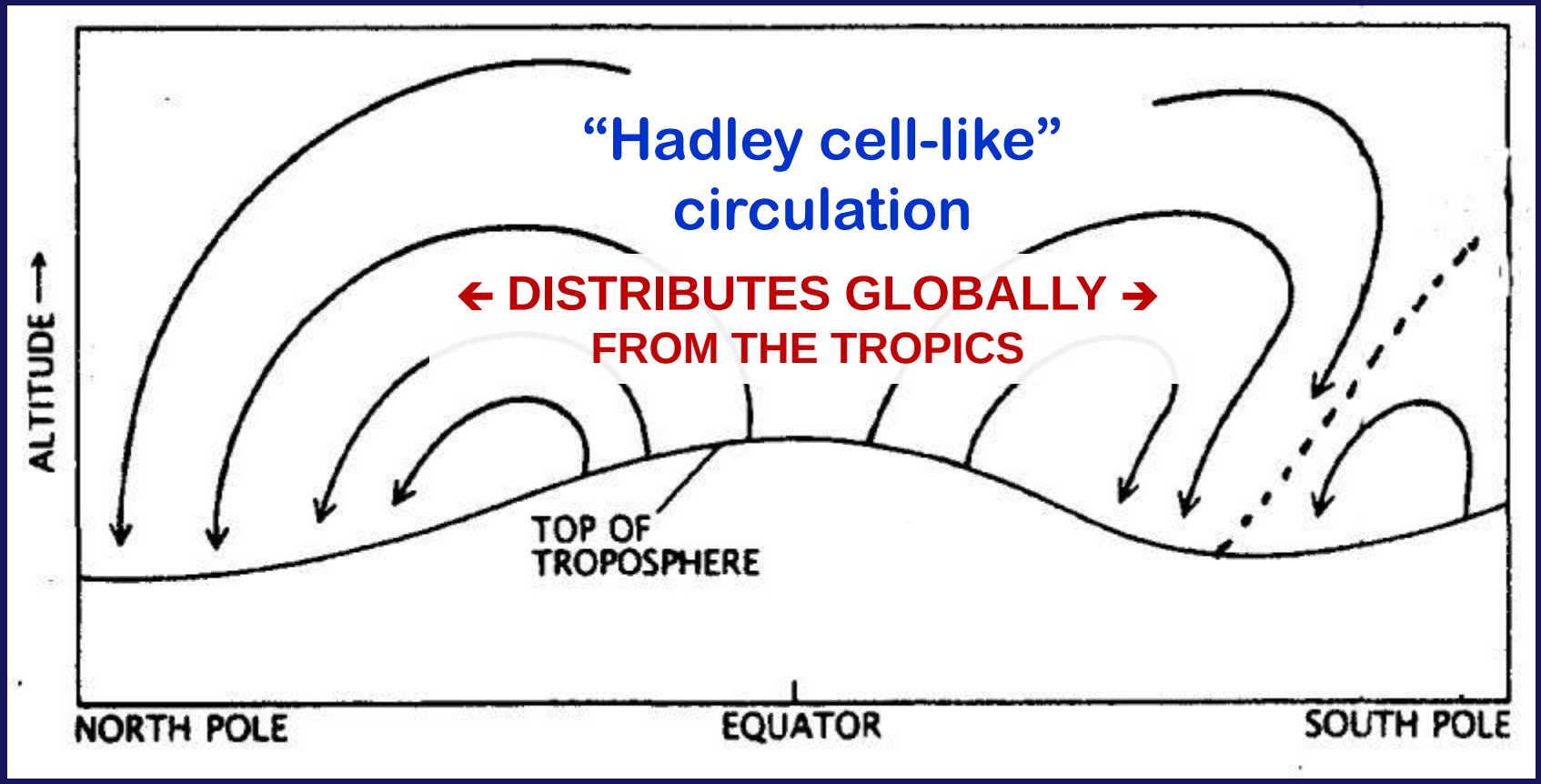
- **Mid-latitude ozone** has been decreasing by ~ 4% per decade in both hemispheres

- **Tropical ozone** has remained more or less constant.

http://www.theozonehole.com/arcticozone.htm

Key Concept

Stratospheric Atmospheric Circulation Determines this Distribution



Ozone production is *highest in tropics*
but stratospheric circulation distributes it poleward

GROUP CHALLENGE QUESTION:

Q: Why do you think ozone production in the stratosphere is highest over the TROPICS?

Hint: Chapman Mechanism

SEE YOU WEDNESDAY
for Wrap -Up!