Meteorology

Division B

Georgia Tech Event Workshop Series
2024-25

Science Olympiad at Georgia Tech®

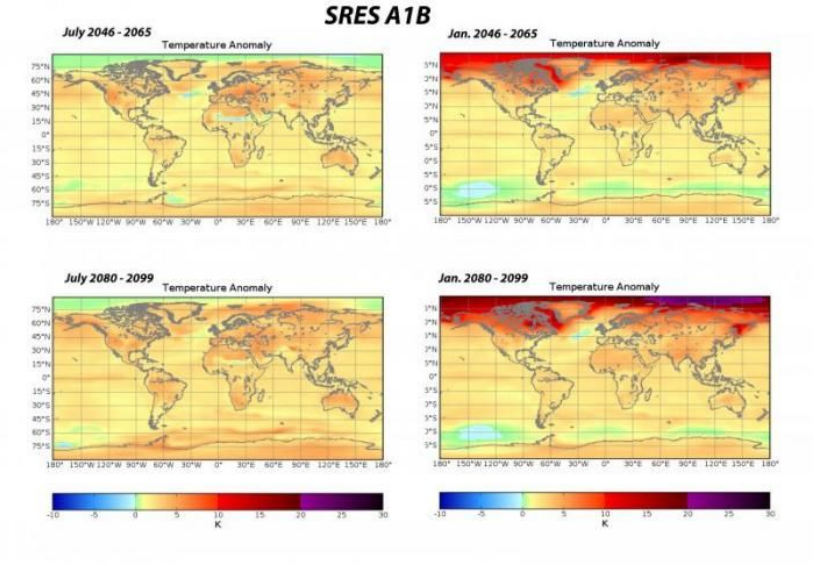
01 RULES SHEET

02 DIFFICULT TOPICS

03 COMMON QUESTIONS

04 TIPS FROM A VETERAN

05 OTHER FREE RESOURCES



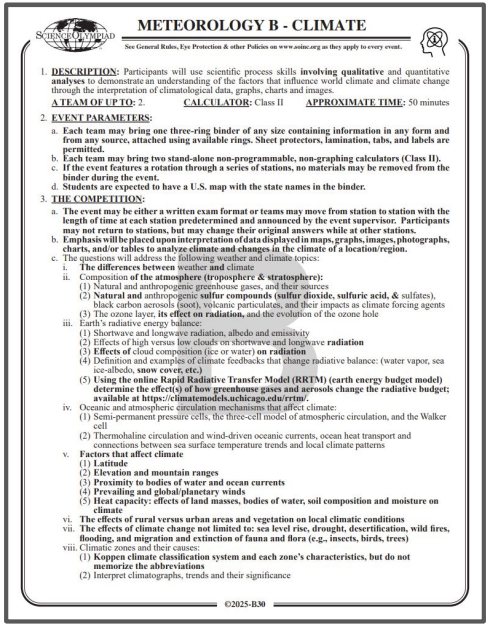
The Rules Sheet

Topics

- Atmospheric structure
- Circulation patterns (ocean & air)
- Energy balance
- Climate zones
- Human impacts
- Climate change – Past, present, and future

Don't Forget!

- U.S. map with state names
- UChicago RRTM



METEOROLOGY B - CLIMATE

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION:** Participants will use scientific process skills **involving qualitative** and quantitative **analyses** to demonstrate an understanding of the factors that influence world climate and climate change through the interpretation of climatological data, graphs, charts and images.
   A TEAM OF UP TO: 2. **CALCULATOR:** Class II **APPROXIMATE TIME:** 50 minutes
2. **EVENT PARAMETERS:**
   a. **Each team may bring one three-ring binder of any size containing information in any form and from any source, attached using available rings. Sheet protectors, lamination, tabs, and labels are permitted.**
   b. **Each team may bring two stand-alone non-programmable, non-graphing calculators (Class II).**
   c. **If the event features a rotation through a series of stations, no materials may be removed from the binder during the event.**
   d. **Students are expected to have a U.S. map with the state names in the binder.**
3. **THE COMPETITION:**
   a. **The event may be either a written exam format or teams may move from station to station with the length of time at each station predetermined and announced by the event supervisor. Participants may not return to stations, but may change their original answers while at other stations.**
   b. **Emphasis will be placed upon interpretation of data displayed in maps, graphs, images, photographs, charts, and/or tables to analyze climate and changes in the climate of a location/region.**
   c. The questions will address the following weather and climate topics:
      i. **The differences between** weather **and** climate
      ii. Composition **of the atmosphere (troposphere & stratosphere):**
         (1) Natural and anthropogenic greenhouse gases, and their sources
         (2) **Natural and** anthropogenic **sulfur compounds (sulfur dioxide, sulfuric acid, &** sulfates), black carbon aerosols (soot), volcanic particulates, and their impacts as climate forcing agents
         (3) The ozone layer, **its effect on radiation,** and the evolution of the ozone hole
      iii. Earth's radiative energy balance:
         (1) Shortwave and longwave radiation, albedo and emissivity
         (2) Effects of high versus low clouds on shortwave and longwave **radiation**
         (3) **Effects of** cloud composition (ice or water) **on radiation**
         (4) Definition and examples of climate feedbacks that change radiative balance: (water vapor, sea ice-albedo, **snow cover, etc.)**
         (5) **Using the online Rapid Radiative Transfer Model (RRTM) (earth energy budget model) determine the effect(s) of how greenhouse gases and aerosols change the radiative budget; available at https://climatemodels.uchicago.edu/rrtm/.**
      iv. Oceanic and atmospheric circulation mechanisms that affect climate:
         (1) Semi-permanent pressure cells, the three-cell model of atmospheric circulation, and the Walker cell
         (2) Thermohaline circulation and wind-driven oceanic currents, ocean heat transport and connections between sea surface temperature trends and local climate patterns
      v. **Factors that affect climate**
         (1) **Latitude**
         (2) **Elevation and mountain ranges**
         (3) **Proximity to bodies of water and ocean currents**
         (4) **Prevailing and global/planetary winds**
         (5) **Heat capacity: effects of land masses, bodies of water, soil composition and moisture on climate**
      vi. **The effects of rural versus urban areas and vegetation on local climatic conditions**
      vii. **The effects of climate change not limited to: sea level rise, drought, desertification, wild fires, flooding, and migration and extinction of fauna and flora (e.g., insects, birds, trees)**
      viii. Climatic zones and their causes:
         (1) **Koppen climate classification system and each zone's characteristics, but do not memorize the abbreviations**
         (2) Interpret climatographs, trends and their significance


DIFFICULT
TOPICS

Topic 1: ENSO

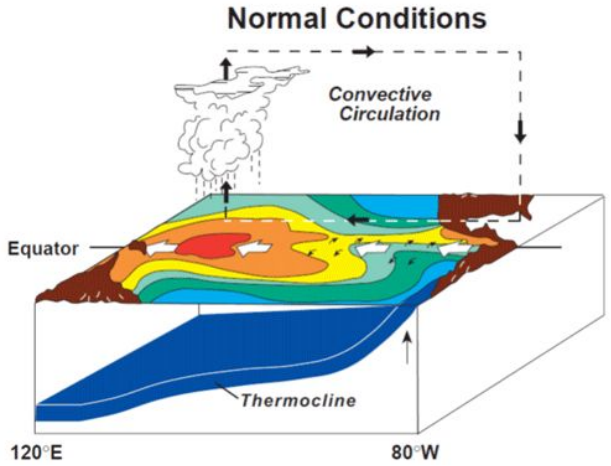
What is the **El Niño/Southern Oscillation** (ENSO)?

- Also called **El Niño/La Niña**
- Recurring climate phenomenon
- Changes **sea surface temperature** (SST), **wind patterns**, and **precipitation** around the Pacific Ocean
- Occurs every **3-7 years**
- Warms or cools by **1-3 °C** (2-6 °F)
- Exact causes are unknown

Topic 1: ENSO

During **neutral** phase:

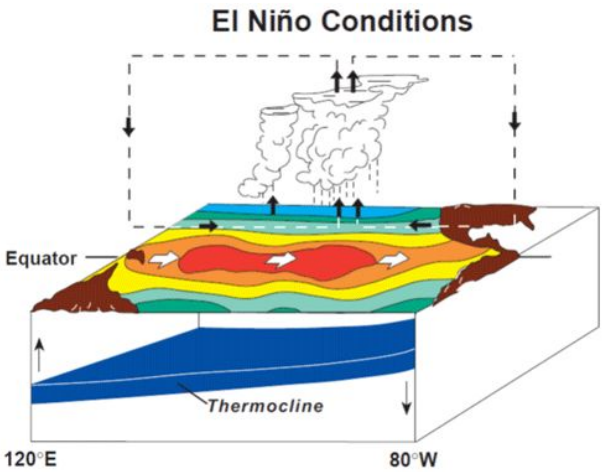
- **SST** is **warmer** in the **west** and **cooler** in the **east**
- Equatorial winds blow east to west (**trade winds**)
- Heavy **precipitation** in the **western** Pacific



Topic 1: ENSO

During an **El Niño** phase:

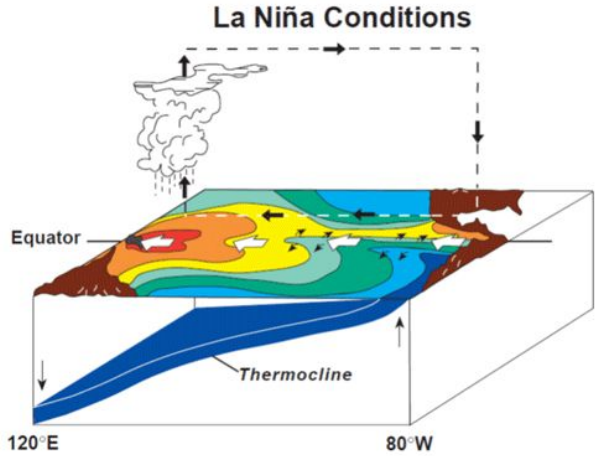
- Eastern Pacific **SST increases**
- Causes air to rise, **changes pressure gradient**
- Pressure change **disrupts trade winds**, can even reverse direction
- **Less rain** over **western** Pacific
- **More rain** over **central & eastern** Pacific



Topic 1: ENSO

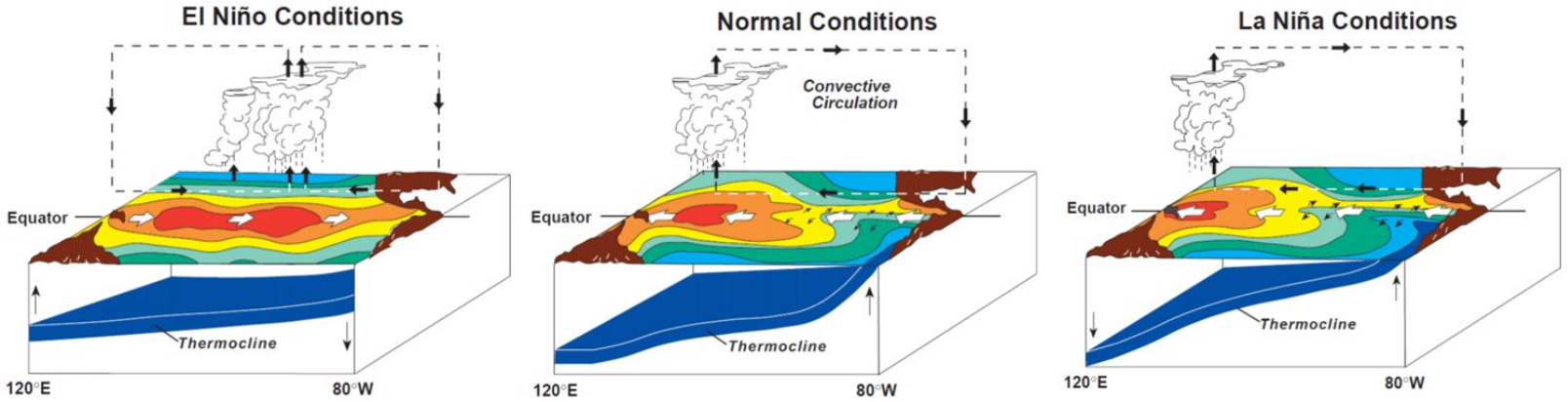
During an **La Niña** phase:

- Eastern Pacific **SST decreases**
- Difference between SST and air pressure in east vs west is even larger than normal
- Trade winds are **stronger** when pressure difference is greater
- **More rain** over **western** Pacific
- **Less rain** over **central & eastern** Pacific



Topic 1: ENSO

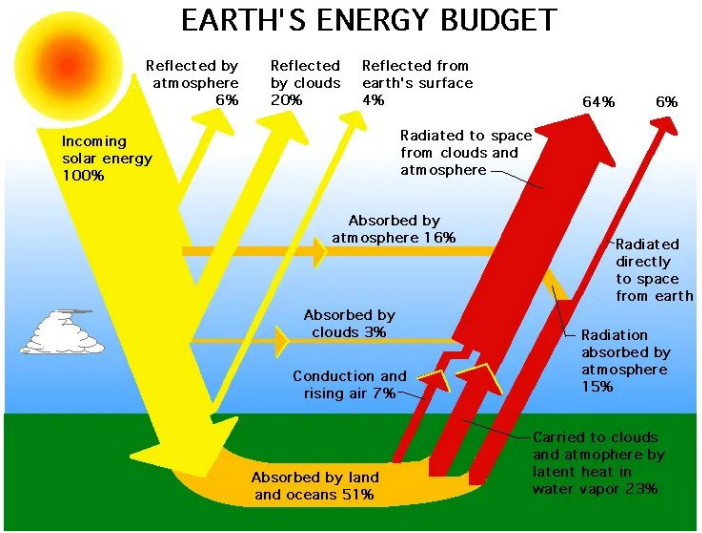
There are **many** other changes associated with ENSO that were not covered here! It is a very big topic!



Topic 2: Energy Budget

Our planet takes in energy from the Sun and also emits its own energy

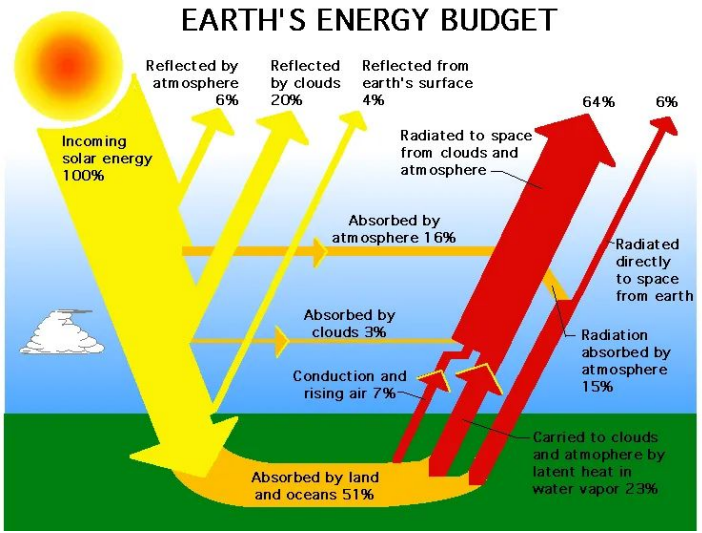
- **All energy** involved in weather comes from **the Sun**
- Sun emits **shortwave** energy (visible, UV)
- Earth absorbs some energy and **re-emits** it as **longwave** radiation (infrared)
- Earth's longwave radiation is **not** the same as light that Earth reflects



Topic 2: Energy Budget

Albedo is how reflective a surface is

- Albedo of 0 absorbs all incoming light
- Albedo of 1 reflects all incoming light
- **Earth** has an average albedo of **0.3**
  - Therefore, about **30%** of all sunlight is reflected back into space!
  - The rest is absorbed



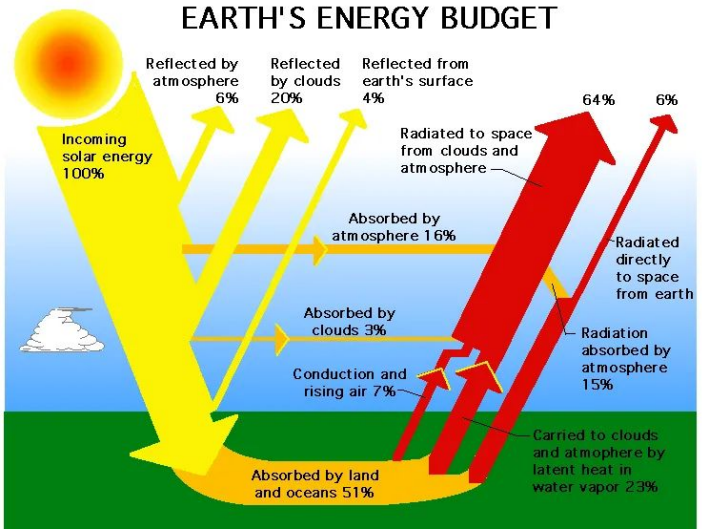
Topic 2: Energy Budget

Absorbed energy is **re-emitted** as longwave radiation

- Not the same as reflected energy
- This energy is heading out to space

Some gases in the atmosphere absorb outgoing longwave radiation

- Some energy is then re-emitted back to Earth's surface as **heat**
- This is the **greenhouse effect**



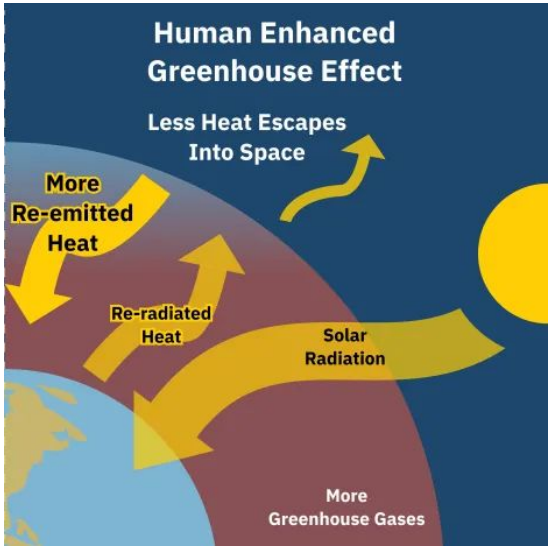
Topic 2: Energy Budget

The **greenhouse effect** is **important** for keeping the planet warm!

- However, too much can be **harmful**
- If Earth **keeps more energy than it receives** from the Sun, the planet will warm up

Common **greenhouse gases** include:

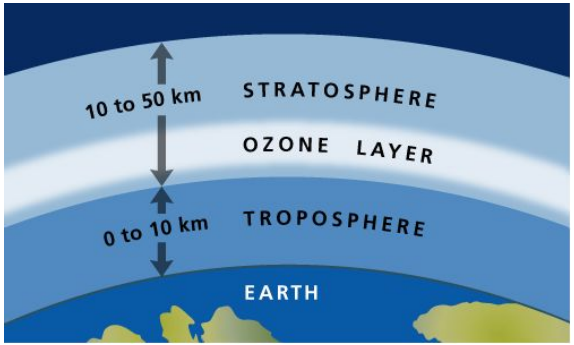
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Water (H_2O)
- Nitrous oxide (N_2O)



Topic 3: Ozone (O_3)

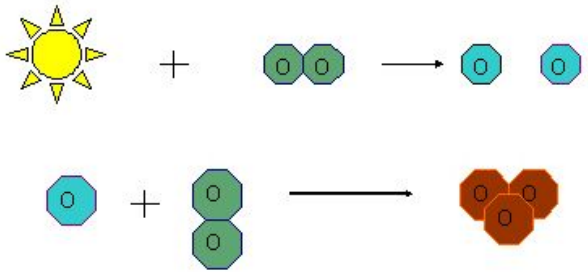
What is **ozone**?

- Ozone is triatomic oxygen (O_3)
- It is formed naturally in the **stratosphere**
- Forms a protective layer that **absorbs harmful UV radiation**



Topic 3: Ozone (O_3)

- Stratospheric ozone is formed in the **Chapman cycle**
- Ozone is formed when **oxygen (O_2)** is broken apart into **two separate oxygen atoms (O)** by **UV radiation**
- O combines with O_2 to form **ozone (O_3)**

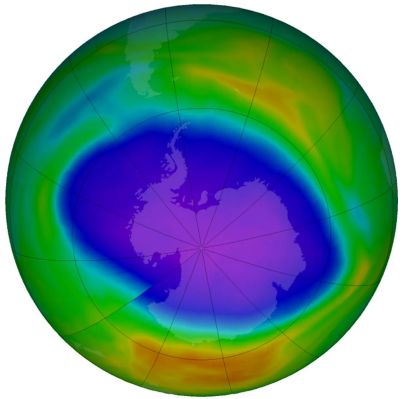


Topic 3: Ozone (O_3)

The **Ozone hole** is the most important application of ozone chemistry

- Man-made chemicals called **chlorofluorocarbons** (**CFCs**) can destroy ozone
- When CFCs are hit by UV radiation, a free chlorine atom (Cl) is released
- Cl can **break apart O_3** by stealing an oxygen atom
- The Cl atom can be **reused** for a long time, destroying lots of ozone!
- Ozone hole **exposes us** to **dangerous UV** rays

- CFCs were regulated by the **Montreal Protocol**
- Ozone hole is healing, but slowly



COMMON QUESTIONS

All of the following questions have been pulled from past YJI exams (which can be found on our website) or the Text Exchange on SciOly Wiki

Question 1

What is the difference between weather and climate?

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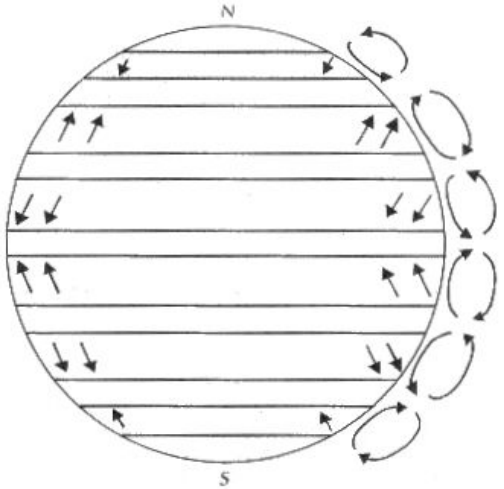
What is the difference between weather and climate?

*Weather follows **short-term** changes in the atmosphere, while climate focuses on **long-term** averages (typically >30 years).*

Question 2

Label circulation cells, pressure belts, and prevailing winds on a diagram:

Hadley cell
Ferrel cell
Polar cell
ITCZ
Subtropical high
Subpolar low
Trade winds
Westerlies
Polar easterlies



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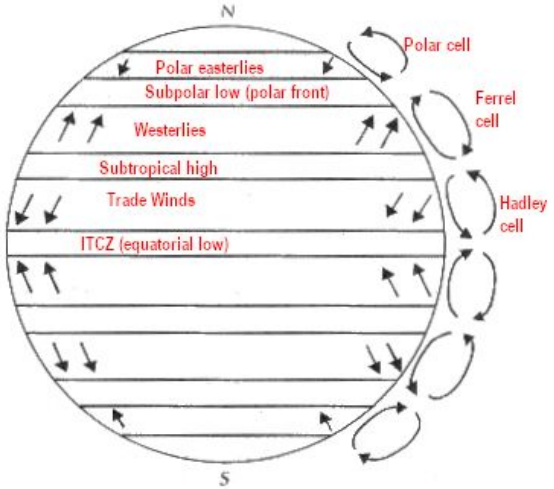
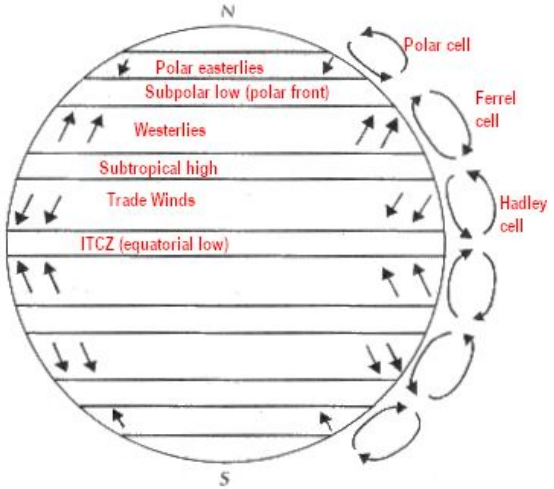


Question 2

Label circulation cells, pressure belts, and prevailing winds on a diagram:

Which of these items is also called the Doldrums?
The Horse Latitudes?

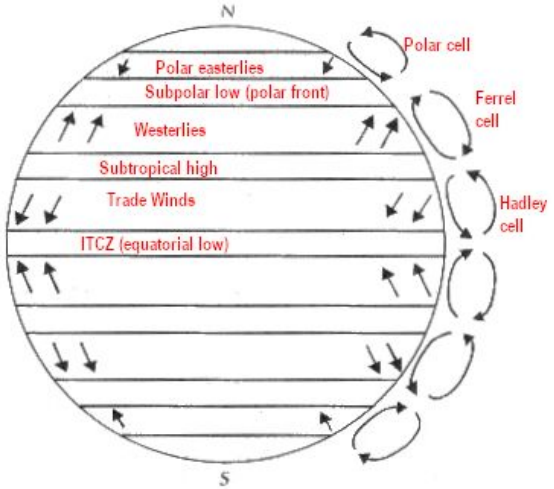


Question 2

Label circulation cells, pressure belts, and prevailing winds on a diagram:

Which of these items is also called the Doldrums?
The Horse Latitudes?

Doldrums – ITCZ
Horse Latitudes – Subtropical high



Question 3

The sun emits [shortwave **/** longwave **] radiation, while Earth emits [**shortwave **/** longwave **] radiation.**

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The sun emits [shortwave **/** longwave **] radiation, while Earth emits [**shortwave **/** longwave **] radiation.**

*Most of the light from the **Sun** is **visible light and UV**, which has a short wavelength (100-780 nm). Most of the light that **Earth** emits is **infrared** radiation, which has a longer wavelength (>780 nm).*

Question 4

Which of the following generally has the highest albedo?

a) Fresh snow
b) Ocean
c) Grass
d) Concrete
e) Forest
f) Clouds

Question 4

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a) Fresh snow
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Fresh snow *has an albedo of* ***0.9****, which means it* ***reflects 90%*** *of incoming light.*

Question 4

Which of the following generally has the highest albedo?

a) Fresh snow
b) Ocean
c) Grass
d) Concrete
e) Forest
f) Clouds

Follow-up: Which surface generally has the lowest albedo?

Question 4

Which of the following generally has the highest albedo?

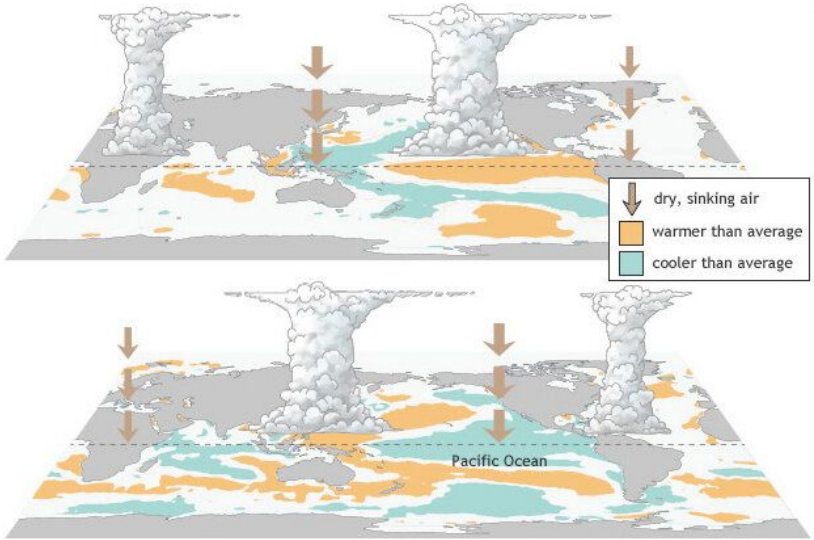
a) Fresh snow
b) Ocean
c) Grass
d) Concrete
e) Forest
f) Clouds

Follow-up: Which surface generally has the lowest albedo?

*The **ocean** has an albedo of around **0.1**, meaning it **absorbs 90%** of incoming light.*

Question 5

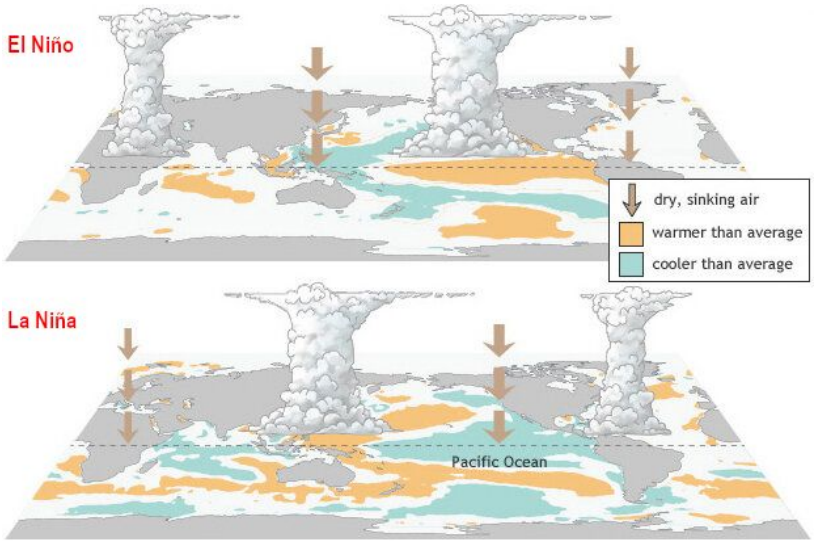
Which diagram represents El Niño, and which diagram represents La Niña?



Question 5

Which diagram represents El Niño, and which diagram represents La Niña?

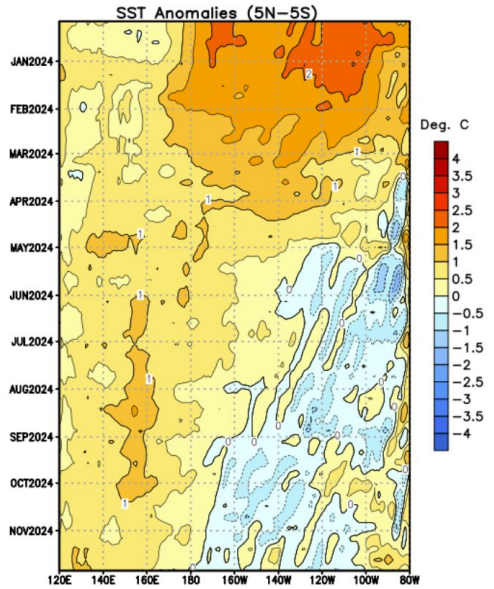
El Niño:
Warmer SST
↑ rain in east Pacific
↓ rain in west Pacific



La Nina:
Cooler SST
↓ rain in east Pacific
↑ rain in west Pacific

Question 6

What phase of ENSO are we currently in? What phase is predicted to occur next?

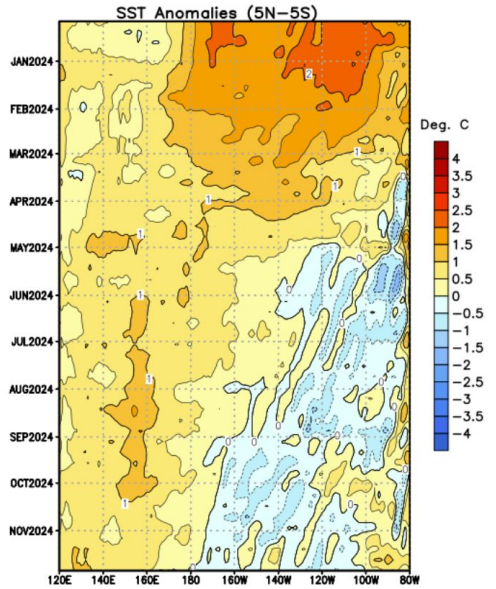


Question 6

What phase of ENSO are we currently in? What phase is predicted to occur next?

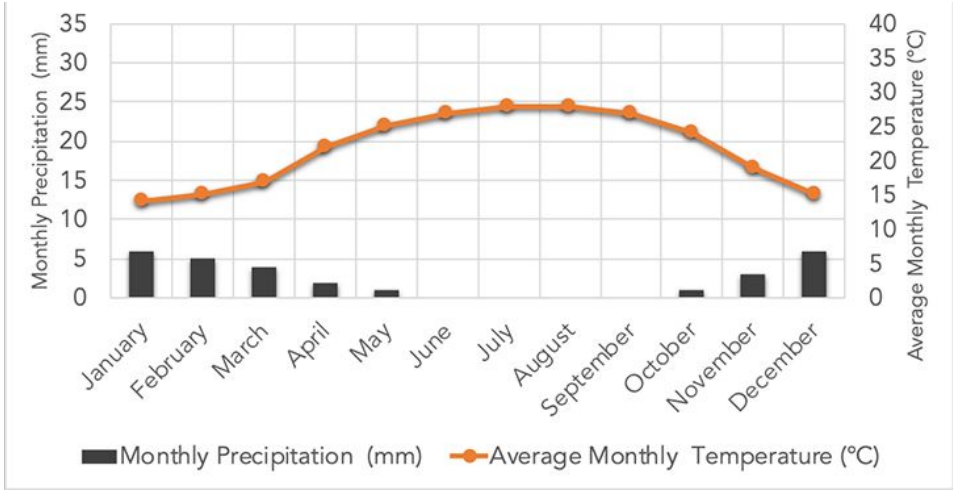
Current – neutral
Upcoming – La Niña

*SSTs are close to average (**SST anomaly** is close to **0**).*
*Overall trend of **decreasing SST**, suggesting La Niña.*



Question 7

What type of environment would produce this climatograph?

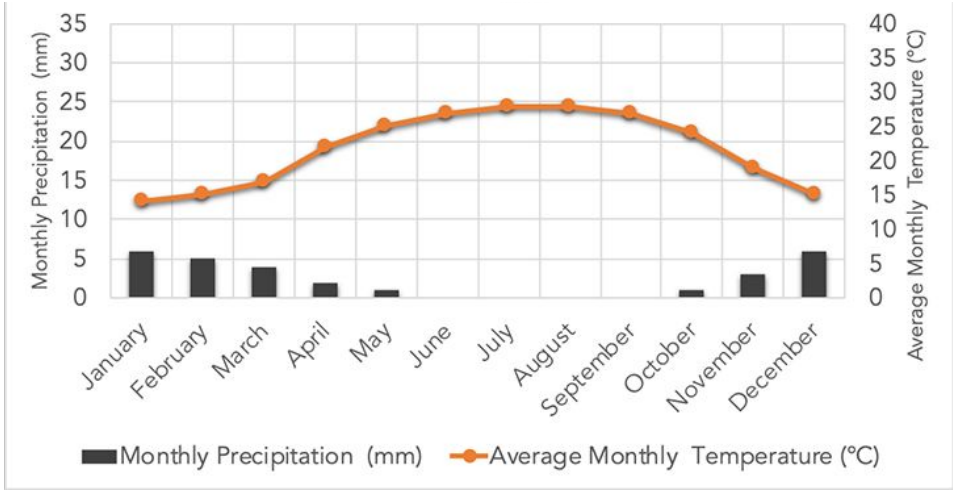


Question 7

What type of environment would produce this climatograph?

*Hot **desert***
(Köppen - BWh)

Defined by
low rainfall and
high temperature



Tips from a Veteran

- If you get stuck on a tough conceptual question, try to break it into the core concepts
  - For example, the **direction of flow** is useful for questions that involve air or ocean circulation
- **Organize** your notes! Being able to know exactly where to look for information will save valuable time
- Learn **vocabulary** – a lot of questions will use specific climatology terms!
- Be careful when using **past tests** to study because Meteorology **rotates topics**, so not all of them have the right content!

Additional Resources

NOAA JetStream

Introduction to Climate Science

UIUC Online Meteorology Guide

NASA Climate Change

THANKS!