Let's Read !

■ Interaction Between the Ocean and the Atmosphere (El Niño)

Atmospheric Circulation

Hadley cell

The **general circulation of atmosphere** moves because the rotation of the earth and the differential heating at the surface of the earth. This general circulation of atmosphere helps **transport** heat from the **equator** to the **poles**. Air does not circulate in a single **cell** from the equator to the poles but circulates in each **hemisphere** in three **circulation cells**. The circulation cell nearest the equator is called the **Hadley cell**, as shown in Figure 1. The warm air rises at the equator producing **thunderclouds** and releasing **large amounts of latent heat**. This latent heat produces strong rising **currents**.

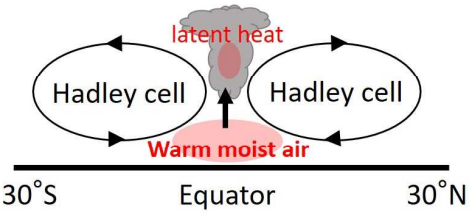


Figure 1. Hadley cell

Trade Winds and Prevailing Westerlies

There are three basic zones, or wind systems, in each hemisphere, as shown in Figure 2. This rising current creates a band of **low pressure** at the equator, and then rises to the **troposphere**, eventually spreading horizontally near the **subtropics**（30 degree **latitude**）where they again sink and a **high-pressure zone** forms with clear skies and little **precipitation**. Therefore, many of the world's deserts are located at these high-pressure zones.

Some of the air that sinks to the surface at a 30 degree latitude returns to the equator, traveling close to the surface of the Earth as **northeasterly trade winds**（in the Northern Hemisphere）.

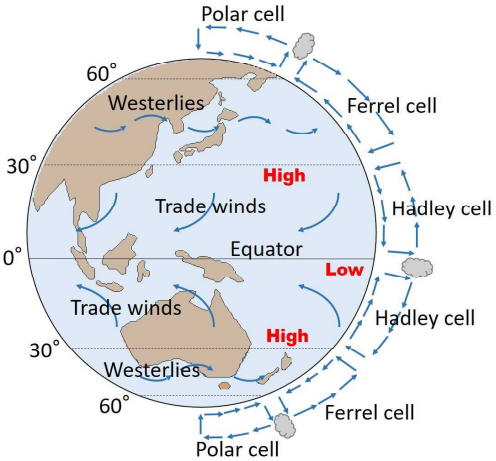


Figure 2. General circulation of atmosphere

The rest of the air sinks to a 30 degree latitude and continues traveling northwards to reach a new cell known as the **Ferrel Cell**. This cell produces **prevailing westerlies** at the surface between a latitude of 30 to 60 degrees.

El Niño

What is El Niño?

El Niño is a climate pattern (weather pattern) at the **Pacific Ocean** which lead to **extreme weather** around the world. El Niño was first observed by Western scientists as unusual ocean warming along the coasts of Peru and Ecuador in South America.

El Niño **events** occur around every two to seven years, and begins when the easterly trade winds become weaker and in some cases blows in the opposite direction.

Causes of El Niño

When the trade winds become weaker, pacific warm surface water starts moving towards the coasts of Peru, thickening the layer of warm surface water, as shown in Figure 3. This **shift** of warm water masses causes a shift in the heavy rain zone from the western Pacific to the central Pacific.

Heavy rain **releases** a lot of latent heat into the middle and upper troposphere. This heat drives the change in global atmospheric circulation, which in turn affects the weather and climate patterns all over the globe.

When El Niño events occur, it can be said that cool summers and warm winters **tend to** occur in Japan.

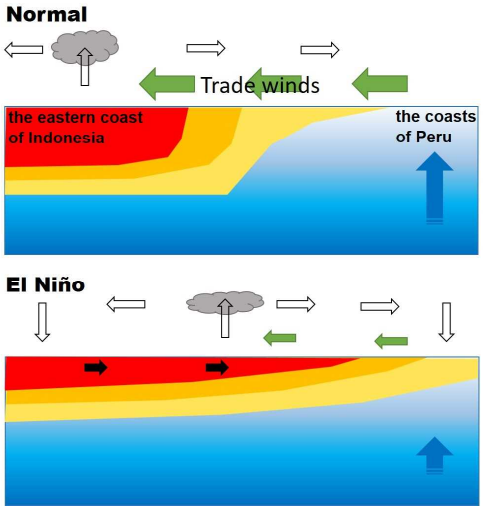


Figure 3. The equator-wide atmospheric circulation

Understanding Main Concepts

1. One of a vertical looping pattern of airflow is known as
   a. the trade winds. **b.** the prevailing westerlies.
   c. North Pacific Current. **d.** the Hadley cell.

2. What is El Niño?
   a. a warm wind **b.** a cold wind **c.** a warm ocean current **d.** a cool ocean current

3. El Niño develops because of a weakening of what?
   a. the trade winds **b.** the prevailing westerlies **c.** the jet stream **d.** the Sun's activity

4. Why are many of the world's deserts located around 30 degrees north and south latitude?
   a. Because the air rises forming high presser which brings dry fine weather.
   b. Because the air rises releasing latent heat which brings high temperature on this area.
   c. Because the air sinks forming low pressure which brings dry fine weather.
   d. Because the air sinks forming high pressure which brings dry fine weather.

【Vocabulary】

本文			
circulation	noun	循環	the movement of liquid, air etc in a system
atmosphere	noun	大気	the mixture of gases that surrounds a planet
general circulation of atmosphere	noun	大気の大循環	
transport	verb	輸送する	to take something from one place to another
equator	noun	赤道	an imaginary line drawn around the middle of the Earth that is exactly the same distance from the North Pole and the South Pole
pole	noun	極	the most northern or most southern point on a planet
cell	noun	細胞、区画	
hemisphere	noun	（地球の）半球	a half of the earth
circulation cell	noun	循環流	
Hadley cell	noun	ハドレー循環	
thundercloud	noun	積乱雲	**thunderstorm** 激しい雷雨
a large amount of		大量の	
latent heat	noun	潜熱	energy absorbed or released by a substance during a change in its physical state that occurs without changing its temperature
current	noun	流れ、対流、海流	
low pressure	noun	低気圧	
troposphere	noun	対流圏	the lowest region of the atmosphere
subtropics	noun	亜熱帯地方	
latitude	noun	緯度 longitude 経度	the angular distance of a place north or south of the equator
high-pressure zone	noun	高圧帯	low-pressure zone 低圧帯
precipitation	noun	降水量	the amount of rain, snow etc that falls
northeasterly trade winds	noun	北東貿易風	a tropical wind that blows towards the equator from either the northeast or the southeast
Ferrel Cell	noun	フェレル循環	
prevailing westerlies	noun	偏西風	the winds in the middle latitudes between 30 and 60 degrees latitude.
El Niño	noun	エルニーニョ	
Pacific Ocean	noun	太平洋	
extreme weather	noun	異常気象	
event	noun	出来事、事象	
shift	verb	変化させる	
release	verb	開放する、放出する	
tend to		（の）傾向がある	
授業			
water vapor	noun	水蒸気	the gaseous phase of water
coincide	verb	一致する	to be the same or very similar
surge	verb	打ち寄せる	
upwell	verb	湧昇する、湧き出る	
deep ocean	noun	深海底	in the deeper parts of the sea

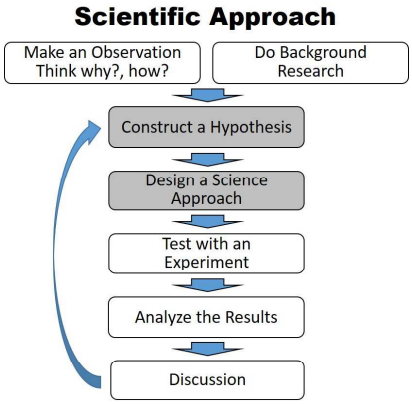
■ El Niño

English Science

Words learned through English Science

Point!

Design a Science Approach



●課題を解決するための科学的手法の１つに、「仮説を検証するために適切な実験、観察、調査等を行うこと」、「モデルをつくりシミュレーションを行うこと」があります。仮説の真偽を検証するためには、「何を明らかにするために、何をしたのか（するのか）」、「何と何を測定し」、「何と何の関係に着目し」、「どのように解析すれば」、仮説の証明が可能であるかをデザインすることが重要です。その仮説の真偽を検証するために行うのが実験です。

実験を行う時には、何かの値を変えていくつかの実験を行います。この変える値のことを変数といいます。

・**独立変数**（independent variable）：研究者によって変える値のことで、実験を開始する前にわかっている値です。

・**従属変数**（dependent variable）：実験によって変わる値のことで、研究者が実験を行うまでどのような値になるのかわからない値です。

実験を行うに当たっては、仮説に対応して変数を設定する必要がありますが、実験結果に影響を与える他の要因も十分に注意する必要があります。

・**影響要因**（influence factor）：独立変数以外の従属変数に影響を与える**他の要因**

ここでは、科学的アプローチをデザインすること（変数の設定）に着目して、モデル実験を行いましょう。

It's Your Turn -Activities with TA-

Useful Expression.

influence / affect：影響を与える

【Role play】

A: How does deforestation affect the earth?
How does carbon dioxide affect the earth?
How does the Moon affect the earth?
How does El Niño affect the earth?

B: Deforestation affects biodiversity.
Carbon dioxide affects global warming.
The Moon affects the tides.
El Niño affects climate patterns.

deforestation		the Moon	El Niño
	CO_2		
biodiversity	global warming	the tides	climate patterns

Initial Observation & Information Gathering

Observation 1

Let's observe various extreme weather. Name each locations shown in the pictures below and choose the letter of the locations from the map.

location map (:)

Forest fire along with drought

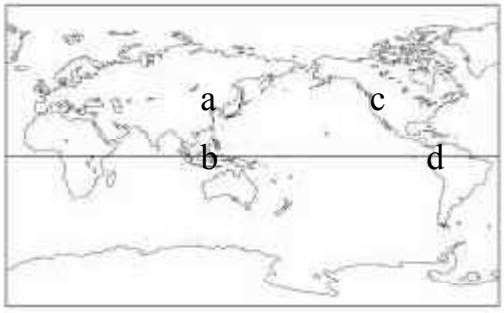
location map (:)

Cherry blossom a month earlier

location map (:)

First deep freeze in 60 years

[location]
Tiananmen
Vancouver
Borneo
Peru



Interpreting Graphics 1

The graph below shows the monthly average sea-surface temperature. Use the graph to answer the questions that follows.

【TAs Question】

Q1.

Q2.

Q3.

Q4.

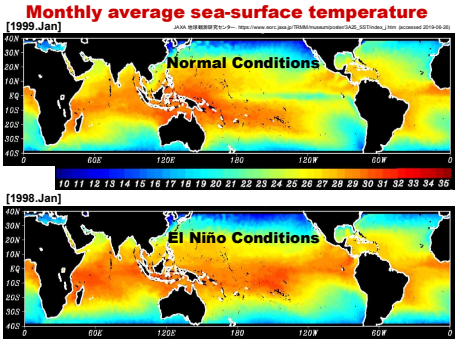
Q5.

Q6.

【Your Answer】

→ reply

Jan. 1999



JAXA 地球観測研究センター. https://www.eorc.jaxa.jp/TRMM/museum/poster/3A25_SST/index_j.htm (accessed 2019-06-26)

→ reply

Jan. 1998

→ reply

→ reply

→ reply

trade winds 貿易風
Westerlies 偏西風

→ reply

During El Niño
the sea-surface
warm along

Exercise 1

Describe what El Niño is and how often it occurs. Fill in the spaces.

El Nino is a climate pattern representing an unusual warming of the eastern tropical Pacific Ocean, from ____ _____ ___ _____ to ____ _____ _____ _____, on average, every three to seven years.

1 Construct a Hypothesis

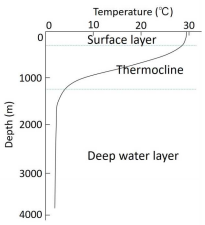
Activity 1

Now you wrote a research question for the initial question about El Niño. What is the answer you expect?

Further big question : Why does various extreme weather occur around the world during El Niño?

Initial Question : What is the cause of El Niño?

What is known :
1. Trade winds are blowing along the equatorial sea-surface.
2. The western tropical Pacific Ocean is warmer than the eastern tropical Pacific Ocean during normal condition.
3. The eastern tropical Pacific Ocean becomes warm during El Niño.
4. Variations in ocean water temperatures.



What is not known : The cause of the change of the sea surface temperature in the eastern tropical Pacific ocean.

Aim of your research : To clarify the relationship between the change of the sea surface temperature and the trade winds.

Research question : Does the strength of the trade winds change the temperature of the surface water of the Pacific Ocean?

The answer I will expect **(Construct a Hypothesis):**

2 Design a Science Approach -Independent variable & Dependent variable-

If you construct a hypothesis, the next step is to test the hypothesis through an experiment. In this section, let's try to design model experiment to test our hypothesis.

Activity 2

Fill in brackets.

Step 1 What is the Independent variable and the Dependent variable in this case?

Independent variable

Dependent variable

Step 2 Design an experiment to test this hypothesis. Be specific.

Strategy : Model experiment
Material : Container ⇒ ( )
20 ℃ Blue color water ⇒ (Surface Water / Deep Water)
40 ℃ Red color water ⇒ (Surface Water / Deep Water)
Hair dryer ⇒ (Trade Winds / Westerlies)
Independent variable : ⇒ ( )
Dependent variable : ⇒ ( )

* Consider how the temperature of surface water changes according to the strength of the blow of hair dryer.

Prediction:

The air from the hair dryer push surface warm water to the _____.
When the air from the hair dryer weakens, red color water from the west surges _____.

Experiment & Results

Constructing Charts

Activity 3

Let's try a model experiment! Draw the experimental results.

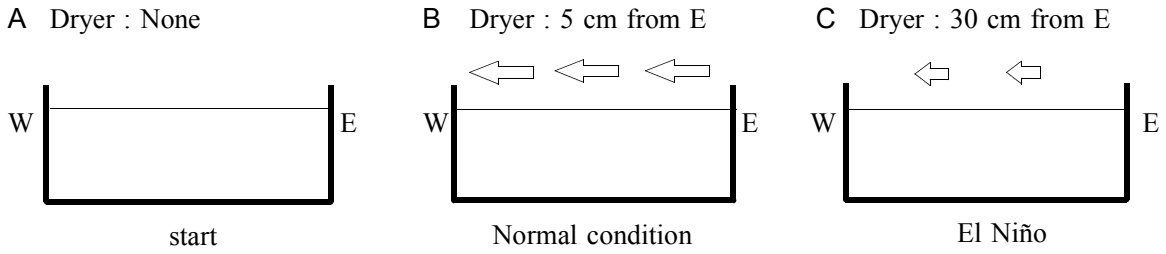


Figure 1. Relationship between strength of the air from the hair dryer and distribution of red color water

Describing Events

Activity 4

Describe the experimental results and fill the spaces.

1. When the dryer was put 5 cm from E,
   around point W : the thickness of _____ color water became _____ _____ as much as before (Figure 1. B),
   around point E : _____ color water moved up and the color of surface water changed to _____ (Figure 1. B).
2. When the dryer was put 30 cm from E,
   _____ color water around point W moved back to point E and the thickness of red color water became almost _____ _____ as point W (Figure 1. C)..

Discussion

Interpreting Results -Critical Thinking-

Exercise 2

Interpret and explain the results in the context of your hypothesis. Write down the appropriate words to complete the brackets.

- Distribution of color water of Figure 1. B and C correspond to the real distribution of the sea surface temperature during normal condition and El Niño respectively.
- The result of Figure 1. B shows that the western tropical Pacific Ocean becomes warmer than the eastern tropical Pacific Ocean during normal condition because ____ _____ _____ push surface warm water to the _____ from the coasts of Peru and around there _____ _____ upwells in order to cover the shortage of the surface water.
- The result of Figure 1. C shows that the eastern tropical Pacific Ocean becomes warm during El Niño because surface warm water from the west surges _____ when ____ _____ _____ weaken.

Drawing Conclusions

From our model experiment, it has been demonstrated that the strength of the trade winds change the sea surface temperature of the eastern tropical Pacific Ocean.

Future directions

In addition, the finding of this model experiment provides additional information that the change of the sea surface temperature changes where the rising current of air is formed; this leads to the change of equator-wide precipitation, because warm air contains a lot of water vapor. The change of this rising current leads to the vertical circulation of atmosphere. Further studies should investigate the relationship between the change of the sea surface temperature and the precipitation in order to clarify the relationship between El Niño and extreme weather.

Extensions -The Relationship between El Niño and various extreme weather-

Organizing Data

Exercise 3

Why does El Niño relate to forest fires? What data will help your discussion? (e.g., Population map, Forest map or Precipitation map)

Interpreting Graphs

Exercise 4

Use the given graph to answer the questions that follows.

1. Where is the heavy precipitation area?
   ⇒ In the normal conditions: ( )
   In the El Niño conditions: ( )
2. Give the reason for the above.
   ⇒ The reason is that the sea-surface temperature of the heavy precipitation area is ( ).

Making Predictions -Critical Thinking-

Exercise 5

Discuss in groups and write down the appropriate words to complete the blanks.

1. Why does El Niño relate to forest fires?

When El Niño events occur, the area of the warm water is changed from ____ _____ ____ _____ to ____ _____ _____ _____. This leads to the change of the area where the rising current of air formed. This Changing of the equator-wide atmospheric circulation leads to the decrease of the _____ of the island Borneo.

2. Why does El Niño influence extreme weather around the globe?

El Niño ⇒ Changes the equator-wide atmospheric circulation

⇒ Changes subtropical atmospheric circulation by ( )

⇒ Extreme weather around the globe

e.g., Japan ⇒ Summer: (Cold / Warm, Heavy rainfall / Dry)
Winter: (Cold / Warm)

仮説の設定（Hypothesis Construction）で使う英語表現

1　研究デザインを説明する表現

Our hypothesis is that（if）..., ... will ... ., We measured ... using a ..., We controlled［dependent variable］so as not to influence the result of this experiment., The general procedure is as follows: First,　Then,

2　実験の目的を説明する表現

Example 1: In order to / To + test / clarify / measure / investigate + the effect / influence of［independent variable］ on［dependent variable］, ...

Example 2: In order to / To + test / measure / examine / investigate + whether［independent variable］affected / influenced［dependent variable］, this study tested ...

Exercise 1

Use the underlined phrases above, explain the model experiment of El Niño to a partner of your group. Then write down the sentences.

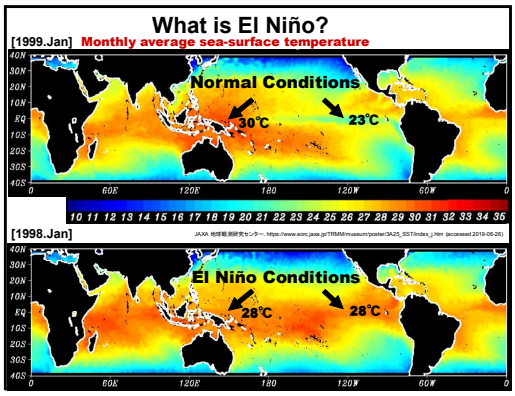
_____the strength of the trade winds change, the temperature of the surface water ___ change. In order to clarify the influence of _____ on _____, we planned to conduct a model experiment.

Home Work　Using the form below, design an experiment to test your hypothesis.

Name	**Class**
Research question and/or hypothesis（仮説）	
Design of a science approach	
Variables -Independent（独立変数） -Dependent（従属変数） -Controlled（制御変数） **Materials**（必要なもの）	**Methods** -What kind of data/information should you collect?（どんなデータ・情報が必要か） -How will it be analyzed?（どのように分析するか） -How long will the experiment take?（研究期間）

Exercise 1

You are going to explain about El Niño by using the slide and the script below. Choose the most suitable sentence to fill the blank from the following ①～④.



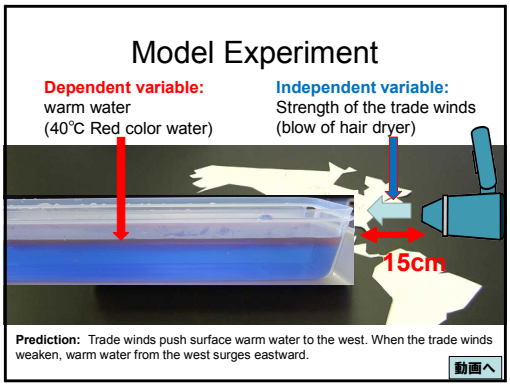
Script

・This diagram shows monthly average sea-surface temperatures.
・El Niño is a phenomenon, _____

① the sea-surface becomes cold along the coasts of Peru all the way to the central Pacific Ocean.
② the sea-surface becomes cold along the coasts of Indonesia all the way to the central Pacific Ocean.
③ the sea-surface becomes warm along the coasts of Peru all the way to the central Pacific Ocean.
④ the sea-surface becomes warm along the coasts of Indonesia all the way to the central Pacific Ocean.

Exercise 2

Let's try to give a presentation using the following slide in order to explain your research question.



【Presentation Exercise】 Let's try to have a presentation using the following slides and script.

Introduction

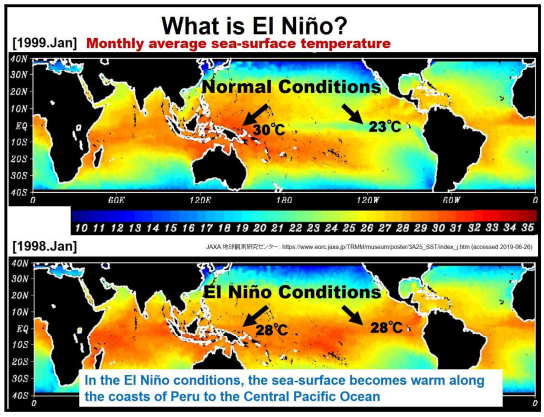
Interaction between the ocean and the atmosphere (El Niño)

・My name is …

・I'm going to talk about ….

・Do you know about El Niño?

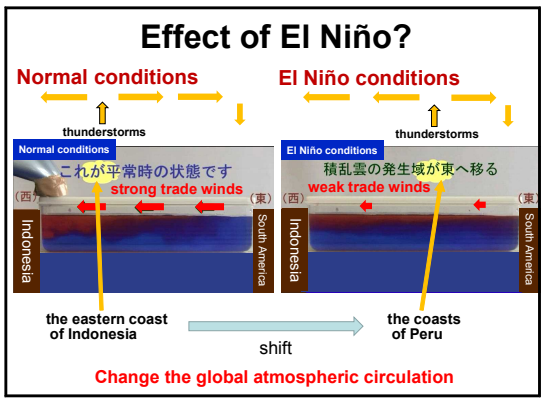
Body 1



・This diagram shows monthly average sea-surface temperatures.

・El Niño is a phenomenon, the sea-surface becomes warm along the coasts of Peru all the way to the central Pacific Ocean.

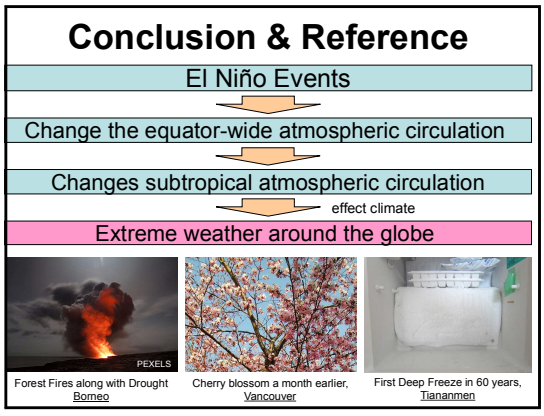
Body 2



・When El Niño events occur, an area of thunderstorms shift from the eastern coast of Indonesia to the coasts of Peru.

・This shift changes the global atmospheric circulation, which affects climate patterns all over the globe.

Conclusion & Reference



・In this way, El Niño is a good example of the interaction between the ocean and the atmosphere, and how these interactions effect climate.

・Thank you for listening.

Research Plan

Name	Class
Background research -What you want to investigate（何をしたいか、問題は何か） -What is known（今までの結果、わかっていることは何か） -What is not known/Current status of issues/Why is it important?（わかっていないこと、課題の現状、なぜ問題なのか） -Ideas to solve the question（何をしたら解決できそうか、課題を乗り越えるアイディア）	
Aim of research（研究の目的）	
Research question and/or hypothesis（仮説）	
Design of a science approach	
Variables -Independent（独立変数） -Dependent（従属変数） -Controlled（制御変数） **Materials**（必要なもの）	**Methods** -What kind of data/information should you collect?（どんなデータ・情報が必要か） -How will it be analyzed?（どのように分析するか） -How long will the experiment take?（研究期間） -Costs（予算）
Figure (Rough diagram of the experiment)（実験の設計図）	
Prediction (Expected answer)（予想される結果）	