Understanding Global Patterns

Navigating Climate Complexities in the Classroom

Cloud Fraction: January 2007

Biosphere: January 2007

Federica Raia

University California, Los Angeles

Understanding Global Patterns

CLIMATE LITERACY & ENERGY AWARENESS NETWORK

OUTLINE

- **CONTEXT**

- **OBJECTIVES**

- **A GUIDED TOUR OF THE DATA**

- **WORKING WITH PATTERNS**

- **THE ACTIVITIES**

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Context

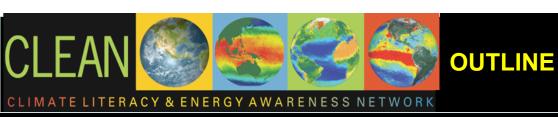Federica Raia

Purpose of the Activity

- Learn to identify global patterns

- Establish connections in Earth Systems climate data

- Develop an understanding of the complex interactions within the Earth System

Audience: Secondary School and Undergraduate college level students

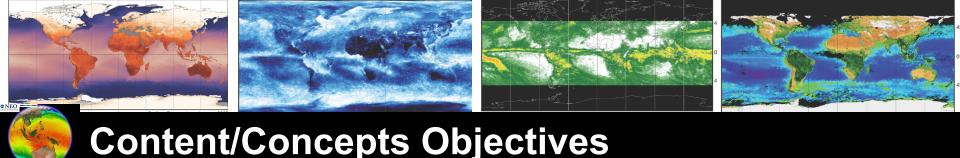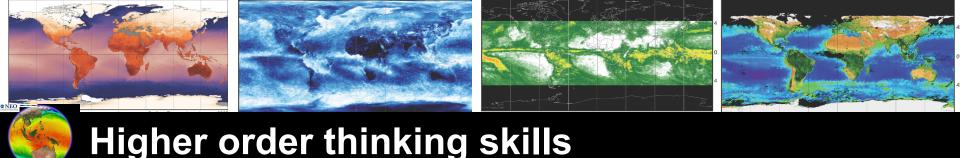**Prerequisites :** Basic map reading skills, and know the names of the continents

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CLEAN — CLIMATE LITERACY & ENERGY AWARENESS NETWORK

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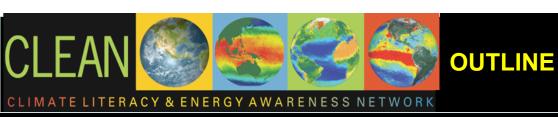
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- Understand the relationship between temporal and spatial distribution of global environmental data

- Recognize patterns and connections among maps containing different environmental data

- Explore concepts of Earth as a System: cycles, feedback mechanisms and their role in the development of patterns

- Establish complex causal relations among system spheres

- Formulate research questions to explore the Earth as a Complex System

Higher order thinking skills

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- Formulate hypotheses

- Formulate the next step to test hypotheses

- Write Scientific papers

- Oral presentation skills

- Work in groups

- Recognize and describe limitations of the data set

- Discuss the concepts of evolutionary cycles vs. cyclicity in the description and interpretation of temporal data sets

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Earth System Science Poster

The Data

NEO NASA
Earth
Observations

Tip: New dataset: Global Temperature Anomaly. See the 'Energy' tab below.

| Ocean | Atmosphere | Energy | Land | Life |

⊞ **Search Parameters** ❓

Download Options ❓

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Get Image ⬇

Analysis   **Matching Datasets**

◯ Blue Marble: Next Generation
+Topo+Bathy (Terra/MODIS)

Select

Blue Marble: Next Generation (Terra/MODIS)
December 1, 2004 00:00-January 1, 2005 00:00
About this dataset

Search Results

⊟ **December 1, 2004 00:00 to January 1, 2005 00:00**
View
Open in Google Earth ❓

⊞ **November 1, 2004 00:00 to December 1, 2004 00:00**

⊞ **October 1, 2004 00:00 to November 1, 2004 00:00**

⊞ **September 1, 2004 00:00 to October 1, 2004 00:00**

Home   News   WMS   Help   About NEO   Subscribe

Tip: New dataset: Global

Color

Ocean

Blue Marble: Next Ge
December 1, 2004 00:00~
About this dataset

Search Results

- ☐ **December 1, 2004 0**
  View
  Open in Google Ear

- ⊞ **November 1, 2004 00:00** to **December 1, 2004 00:00**

- ⊞ **October 1, 2004 00:00** to **November 1, 2004 00:00**

- ⊞ **September 1, 2004 00:00** to **October 1, 2004 00:00**

Datasets

eneration
/MODIS)

NEO: Blue Marble: Next Generation (Terra/MODIS)

neo.sci.gsfc.nasa.gov/AboutDataset.html?datasetId=BlueMarbleNG

NEO: Blue Marble: Next Generation (Terra/MODIS)

Close Window

Basic Description

Less Detail | More Detail

NASA's Blue Marble: Next Generation images show Earth in true color. The images show how the surface would look to a human in space if our world had no clouds and no atmosphere. NASA's Terra satellite collected these images. There is one Blue Marble image for each month of the year 2004. These images allow us to explore changes on Earth's lands over time. Notice how the patterns of green (trees and plants), brown (exposed land surface), and white (snow) change from winter through spring, summer, and fall.

Website

Blue Marble 🗗

http://earthobservatory.nasa.gov/Newsroom/BlueMarble/BlueMarble_history.html 🗗
Visit NASA's Earth Observatory to read a detailed History of the Blue Marble.
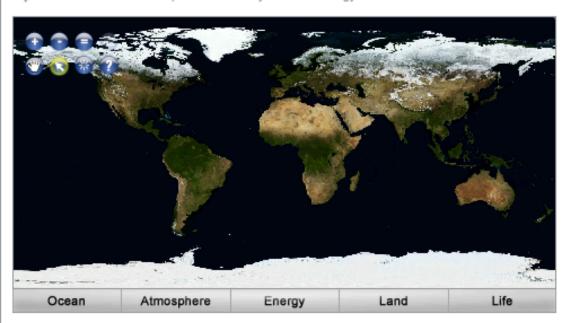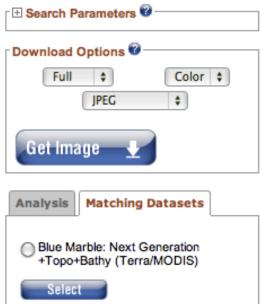
MODIS 🗗

Terra 🗗

Further Reading

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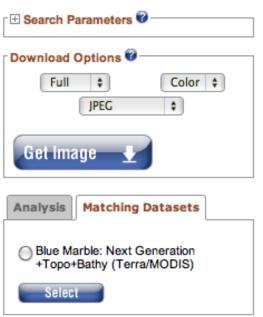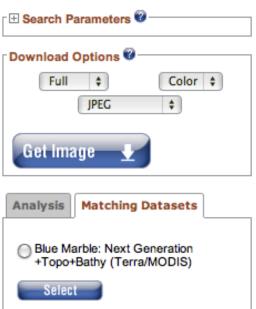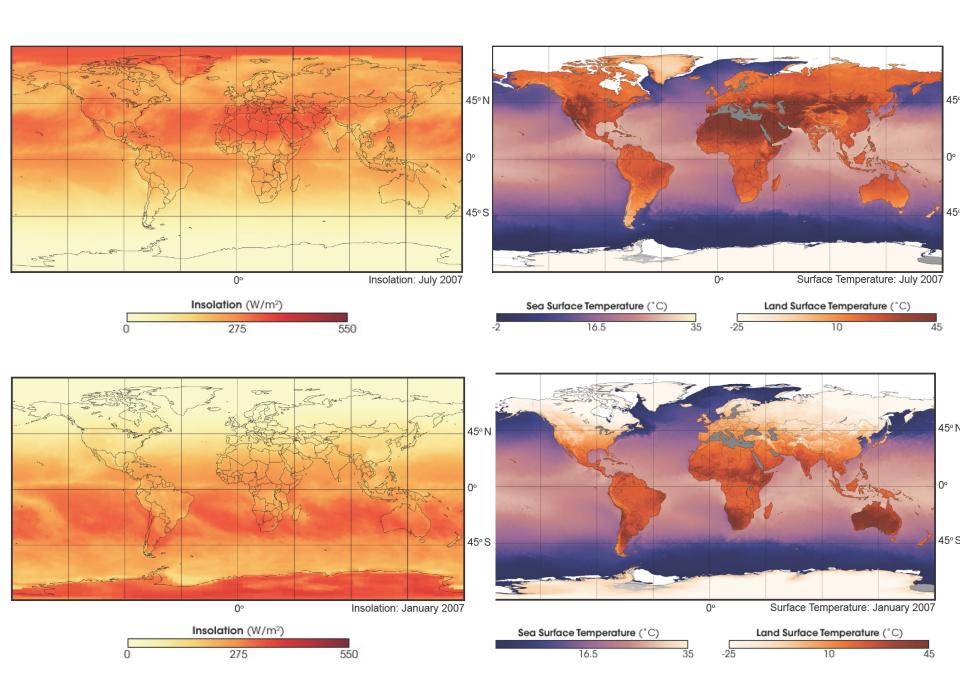**Tip:** New dataset: Global Temperature Anomaly. See the 'Energy' tab below.

⊞ Search Parameters ?

Map Widget Help ⊗

➕ Zoom in (keyboard '+')

➖ Zoom out (keyboard '-')

🟰 Zoom out full (keyboard '=')

✋ Drag tool (keyboard 'd')

↖ Selection tool (keyboard 's')

✳ Clear selection (keyboard 'c')

⬛ Display swaths (keyboard 'w')

Download Options ?

Full ⬍   Color ⬍

JPEG ⬍

Get Image ⬇

Analysis | **Matching Datasets**

○ Blue Marble: Next Generation +Topo+Bathy (Terra/MODIS)

Select ▸

Ocean	Atmosphere	Energy	Land	Life

Ocean Datasets

Average Sea Surface Temperature 1985-1997 (AVHRR)
Blue Marble: Next Generation
Chlorophyll Concentration
False Color
Global Bathymetry
Global Temperature Anomaly
Sea Surface Temperature 1981-2006 (AVHRR)
Sea Surface Temperature 2002+ (AMSR-E)
Sea Surface Temperature 2002+ (MODIS)
Sea Surface Temperature Anomaly (AMSR-E)
Snow Cover & Sea Ice Extent
True Color

Blue Marble: Next Generation (Terra/MODIS)
December 1, 2004 00:00-January 1, 2005 00:00
About this dataset

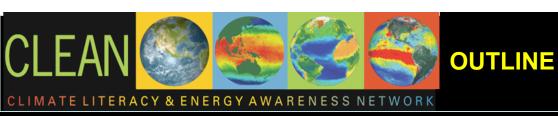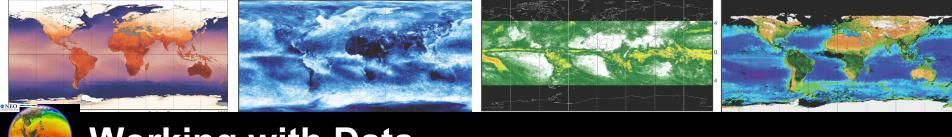**Tip:** New dataset: Global Temperature Anomaly. See the 'Energy' tab below.

Map Widget Help

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- Zoom out full (keyboard '=')
- Drag tool (keyboard 'd')
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- Clear selection (keyboard 'c')
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⊞ **Search Parameters** ?

Download Options ?

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JPEG ▼

Get Image ⬇

| Analysis | **Matching Datasets** |

○ Blue Marble: Next Generation
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Select

| Ocean | Atmosphere | Energy | Land | Life |

Energy Datasets

Albedo
Average Land Surface Temperature [Day]
Average Land Surface Temperature [Night]
Average Sea Surface Temperature 1985-1997 (AVHRR)
Global Temperature Anomaly
Land Surface Temperature Anomaly [Day]
Land Surface Temperature Anomaly [Night]
Land Surface Temperature [Day]
Land Surface Temperature [Night]
Net Radiation
Outgoing Longwave Radiation
Reflected Shortwave Radiation
Sea Surface Temperature 1981-2006 (AVHRR)
Sea Surface Temperature 2002+ (AMSR-E)
Sea Surface Temperature 2002+ (MODIS)
Sea Surface Temperature Anomaly (AMSR-E)
Solar Insolation

Insolation (W/m²)

0   275   550

Insolation: July 2007

Sea Surface Temperature (°C)

-2   16.5   35

Land Surface Temperature (°C)

-25   10   45

Surface Temperature: July 2007

Insolation (W/m²)

0   275   550

Insolation: January 2007

Sea Surface Temperature (°C)

16.5   35

Land Surface Temperature (°C)

-25   10   45

Surface Temperature: January 2007

Cloud Fraction: July 2007

Cloud fraction (%)

0   50   100

Precipitation: July 2007

Rainfall (mm)

1.0   10   100   200   2000

45°

0°

45°

Cloud Fraction: January 2007

Cloud fraction (%)

0   50   100

Precipitation: January 2007

Rainfall (mm)

1.0   10   100   200   2000

45° N

0°

45° S

Ocean: Chlorophyll Concentration (mg/m³)
>0.01   0.05 0.1   0.5   1   5   10   50

Land: Vegetation (NDVI)
-0.05   0.233   0.575   0.912

Biosphere: July 2007

Aerosol Optical Thickness
0   0.5   1.0

Aerosols: July 2007

Ocean: Chlorophyll Concentration (mg/m³)
>0.01   0.05 0.1   0.5   1   5   10   50

Land: Vegetation (NDVI)
-0.05   0.233   0.575   0.912

Biosphere: January 2007

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Aerosols: January 2007

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University California, Los Angeles

1.   What kind of data am I looking at?

2.   How the data is represented

3.   What are the units of measurement?

4.   What are the maximum and minimum values in the data set?

Visualizing and Describing Patterns

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1. Spatial distribution: How the data is distributed with longitude and latitude

- o Where are *min* and *Max* values distributed?
- o Is there a pattern of *min* and *Max* distribution along a specific latitude or longitude
- o Is there a pattern such as high or low, symmetric or asymmetric, missing or not missing, varying or constant along the latitude or longitude
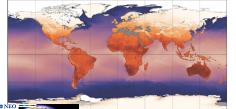
1. Temporal distribution: How the data is distributed over time

- o Do *min* and *Max* values distribution change with time?
- o Is there a pattern of *min* and *Max* distribution change with time
- o Do patterns you recognize change over time?
  Is there a monotonic trend versus time?
  Do there seem to be cycles?
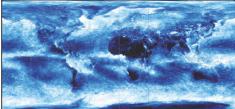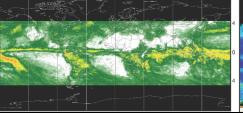
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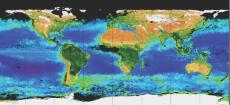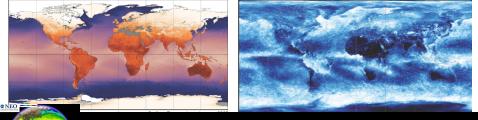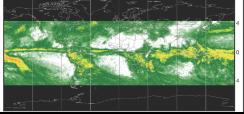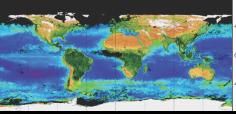
Modified from GLOBE Earth System Sycnece Poster

WORKING WITH GLOBAL DATA		
Specialty Group	Activity 1	Exploring Single Map
	Activity 2	Exploring Annual Changes
Global Climate Experts Group	Activity 3	Exploring Relationships Among Variables for a Particular Month
	Activity 4	Exploring Relationships Among 6 Variables over a year

Spatial distribution   Federica Raia
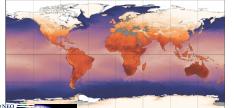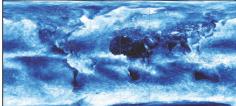
- Students are assembled in 5 specialty groups with their data map
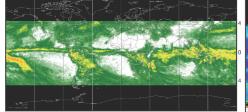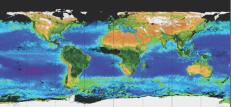
Specialty Group	VARIABLE
Group 1	Insolation
Group 2	Surface Temperature
Group 3	Cloud Fraction
Group 4	Precipitation
Group 5	Biosphere

- They observe and describe data and patterns

- They record all observations and all questions raised
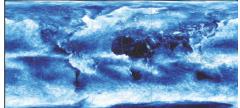
Activity 2 - Exploring Annual Change
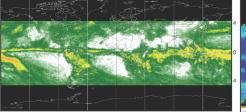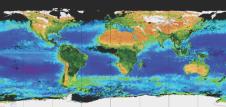
Spatial and Temporal distribution

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- Students are assembled in the same specialty group as in Activity 1
- They are given all the global maps per variable (e.g., all six Insolation maps to Group One; all six Surface Temperature maps to Group Two, etc.
- Students observe the maps as a group, looking for any changes that are occurring throughout the year
- They record all observations, questions raised and possible interpretations
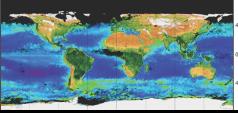
Guiding Questions:

- What changes do you see through the year

- Choose a location or region. During which months do the extreme highs and lows occur?

- Which regions experience both the extreme highs and lows? Which regions don't experience the extremes?

- What differences, if any, do you find between the year's variations over the oceans versus the year's variations over the continents?

- Are there regions that remain relatively unchanged over the year?
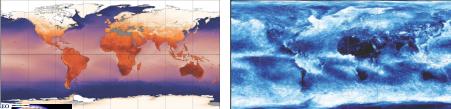
Federica Raia
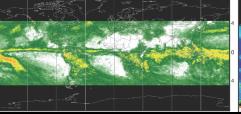
Guided question to write an Explanation/Interpretation:
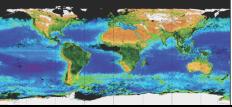
a) What explanations can you suggest for the emergence of these patterns */* the timing of those extremes?

b) Record your interpretations with a separate heading just below each of the corresponding observations

Developing a hypothesis:

c) Based on the process(s) you recorded in (a) –develop a hypothesis of what pattern you would find in one of the other 6 specialty maps

Write your hypothesis in the following form:

     1) the answer to the question "what kind of pattern

    do you expect?" and

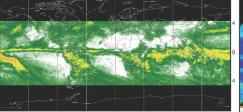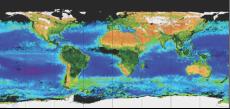   2) the reason why you would expect that pattern
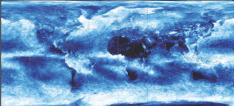
- Students are assembled in new Global Climate groups
- Each group consists of 5 students, each expert in one specialty
- Each specialty expert presents to the rest of the new group peers her/his discovery of patterns/relationships and interpretations
- Students are asked to identify the changes that occur in the 5 variables thought out the year
- They are also asked to observe and make sense of the Aerosol maps –new to them
- Students choose a pattern they recognized to be presented
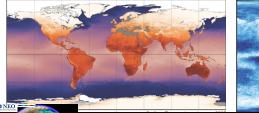
Guiding questions:

- Which variables change the most over the six-month period? Which variables change the least?

- How the variables change over a year ?

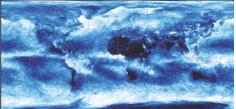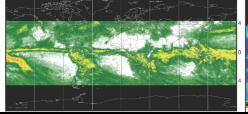- Do you see any relationships among the variables that you didn't see previously?
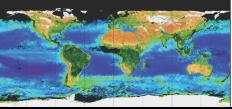
Our research shows that the proposed activity supports students' understanding of complex dynamic system (e.g the climate system, Earth system), specifically:

1) contrary to experts, when presented with data distribution and spatio-temporal patterns, students' first step is to consider or search for a unique cause without describing the distribution or a recognized pattern, and consequently to ask questions that presuppose a linear causal relation between a possible cause and the pattern observed;

2) students do not consider a pattern observed as an emergent phenomenon influencing and mediating the evolution of the system;

3) when students are iteratively asked to recognize and describe patterns in data distribution, novel type of questions and changes in reasoning emerge. Students start learning to identify these patterns as emergent phenomena and as fundamental controls over system evolution and behavior (Raia, 2005, 2008, 2010, Raia and Patel 2011)
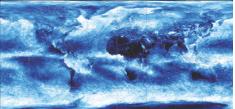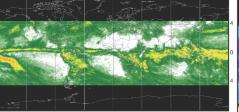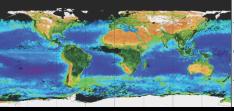
References & On-line Resources

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- GLOBE *www.globe.gov.*
- NASA Earth Observations (NEO) *http://neo.sci.gsfc.nasa.gov*
- NASA Earth Observatory Web http://earthobservatory.nasa.gov Cloud Fraction information can be found at *http://earthobservatory.nasa.gov/Observatory/Datasets/cldfrc.isccp_c2.html*
- NASA IMAGERS -Remote Sensing to explore remote sensing and satellite imagery at: *http://science.hq.nasa.gov/kids/imagers/teachersite/RSi.htm*
- NASA Goddard Institute for Space Studies -lesson on Studying Clouds from Space *http://icp.giss.nasa.gov/education/cloudintro/page6.html*
- NOAA Sea Surface Temperature Data: *www.csc.noaa.gov/crs/cohab/hurricane/sst.htm*
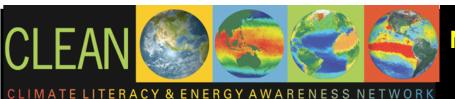
Federica Raia

Raia F., Patel N. 2011. Questions and Explanations –Students' Understanding of Complex Systems paper presented at the Eighth International Conference on Complex Systems. New England Complex Systems Institute.

Raia F., 2010. Complexity: Pattern Recognitions, Emergent Phenomena and Causal Coupling-paper presented at the American Geophysical Union Fall meeting 2010. In prep for publication for Journal of Geoscience Education

Raia F., 2008. Causality in Complex Dynamic Systems: A Challenge in Earth Systems Science Education.Journal of Geoscience Education – 56, 81-94

Raia F,. 2005. Students' understanding of complex dynamic systems. Journal of Geoscience Education. 5 53, 297-309

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Navigating Climate Complexities in the Classroom

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