Build Your Own Earth:

A Climate and Paleoclimate Tool for Teaching and Research

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eLearning Team, Faculty of Science and Engineering

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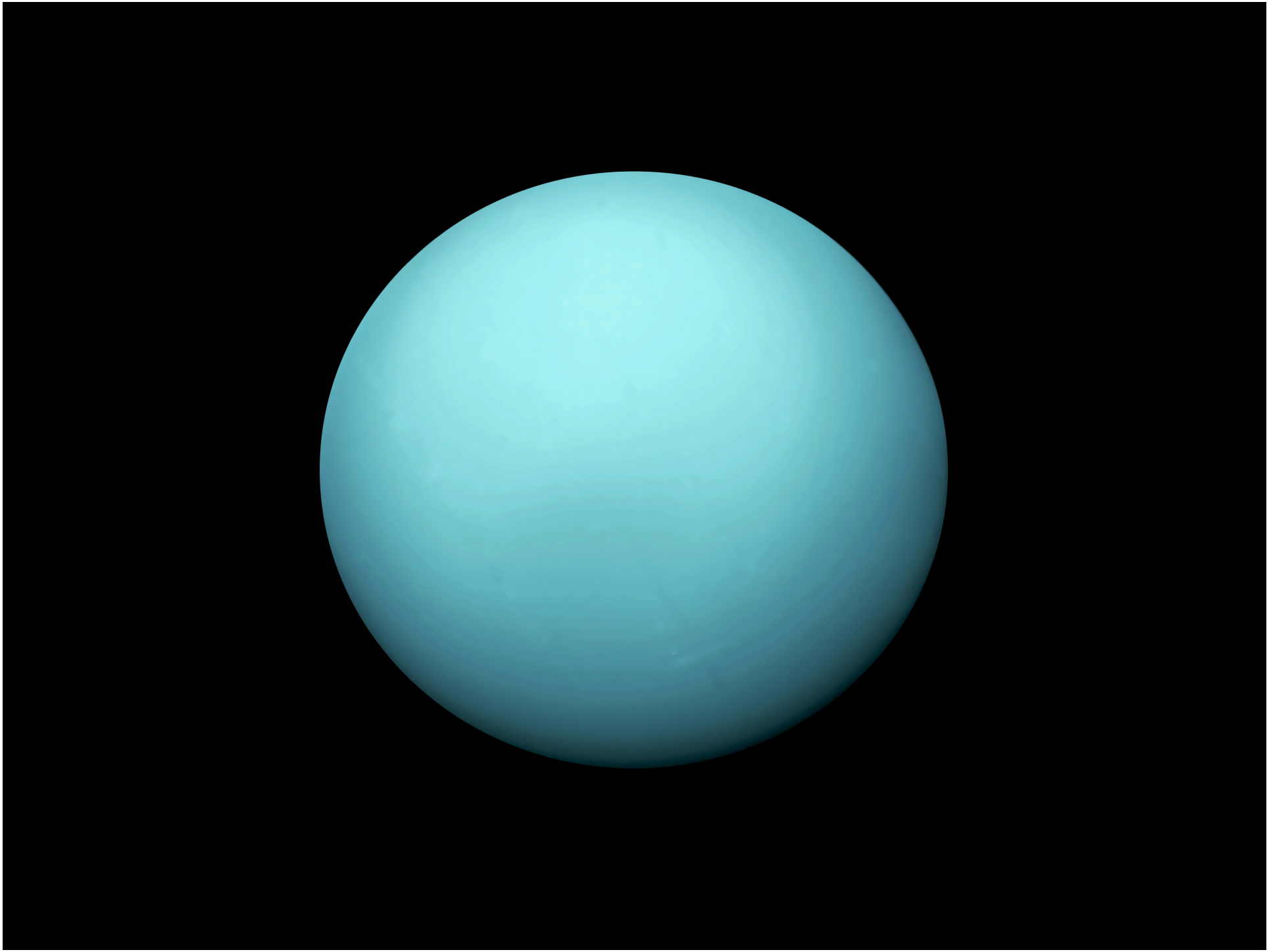
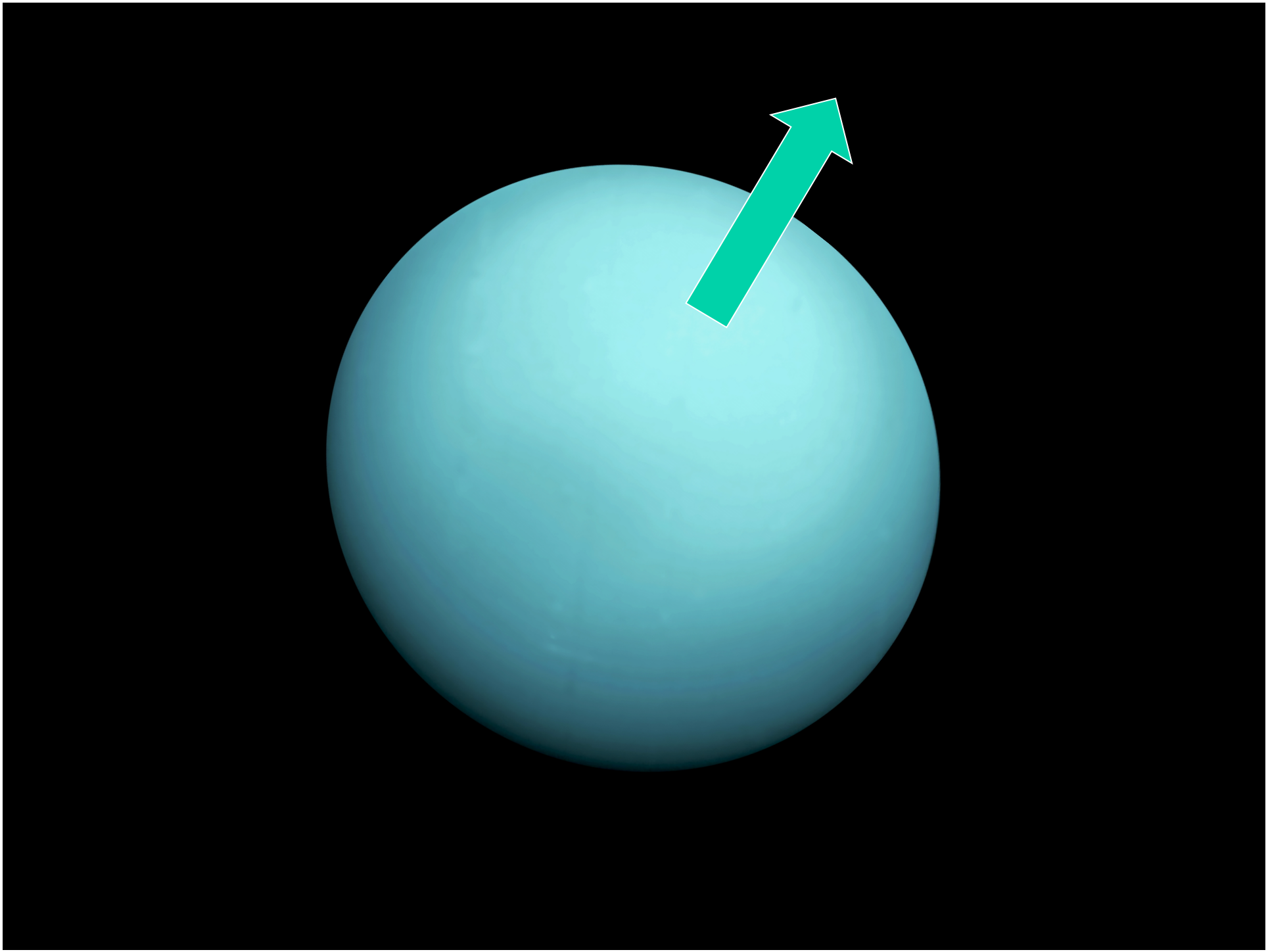
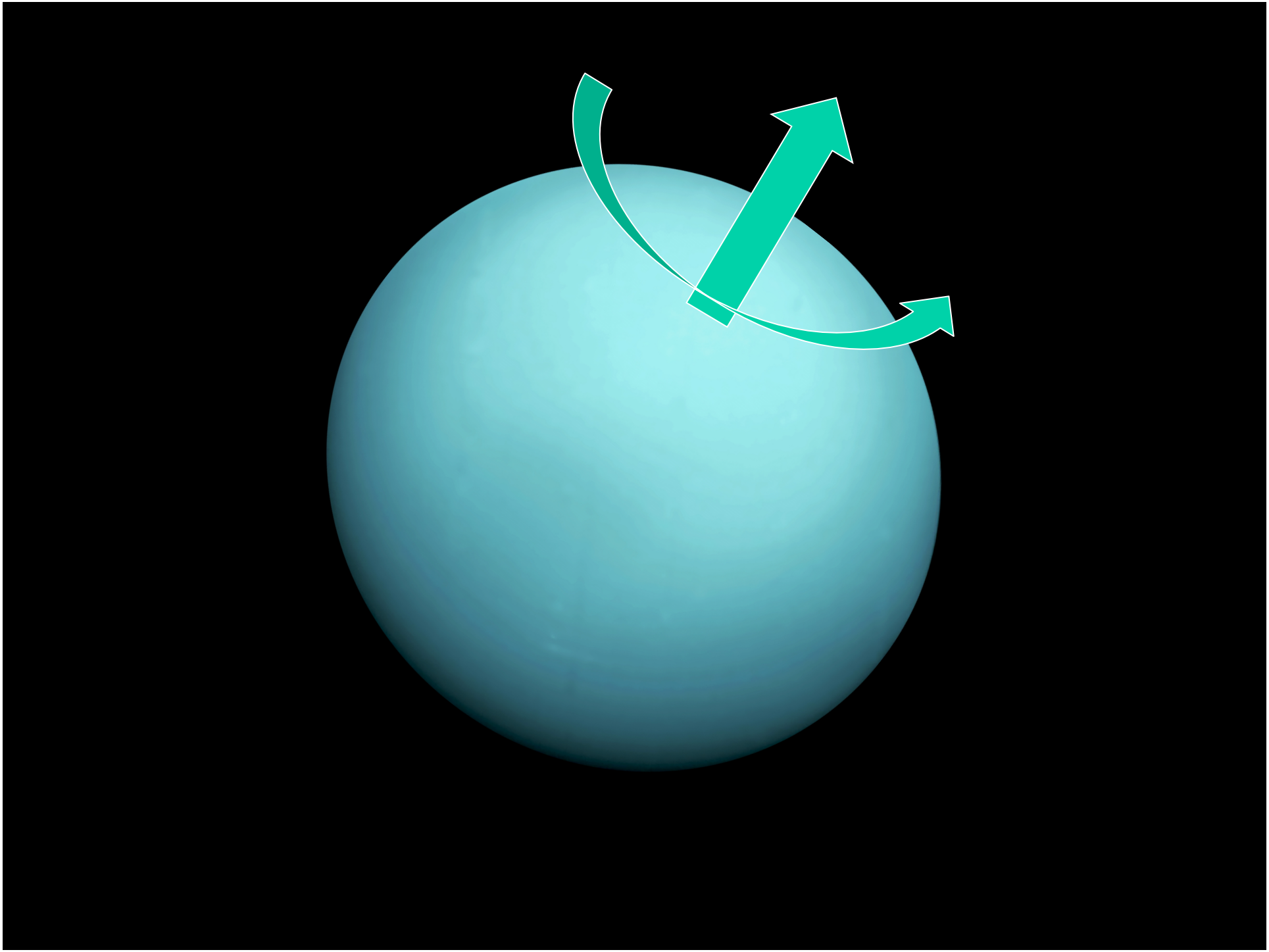
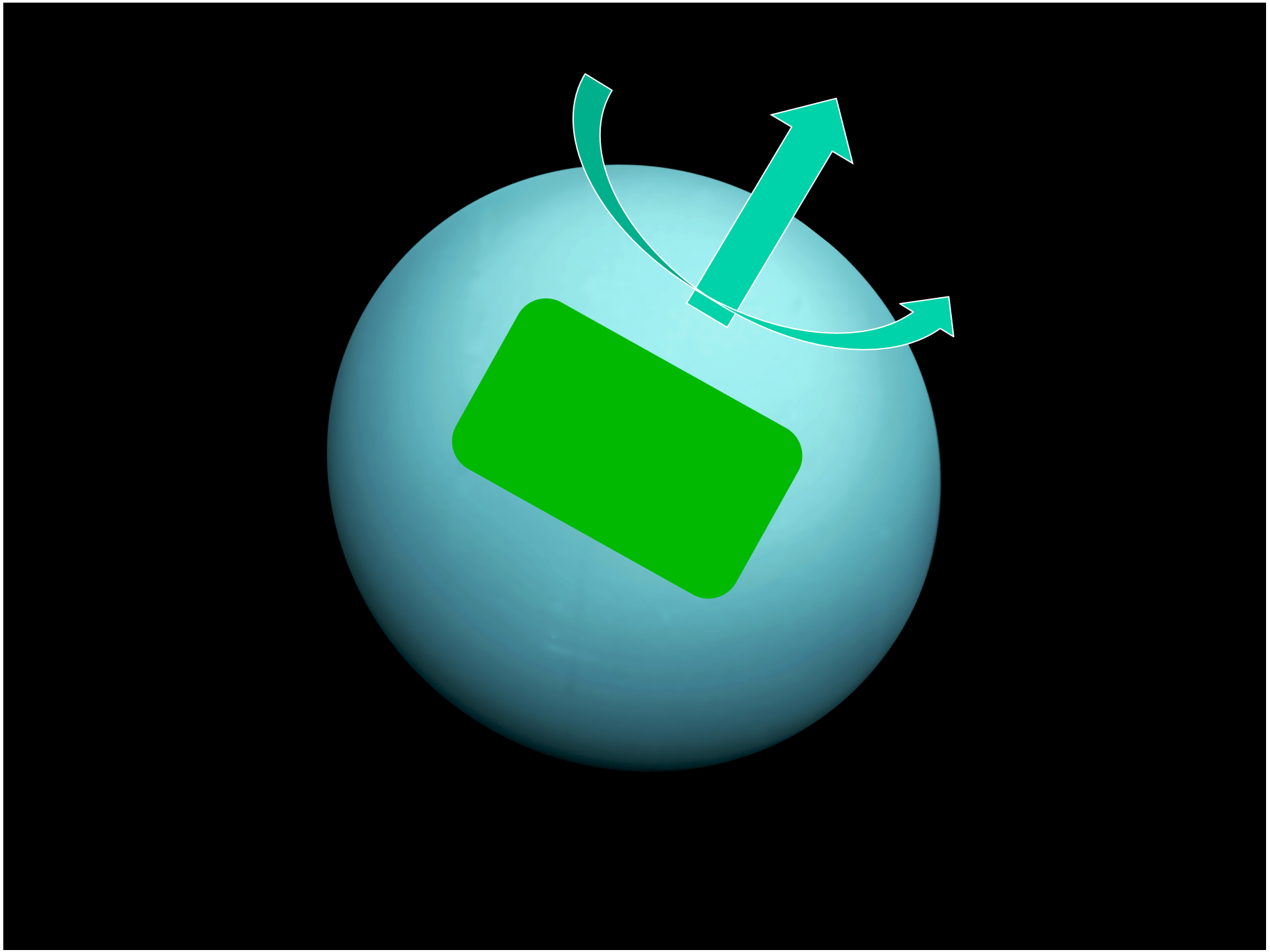
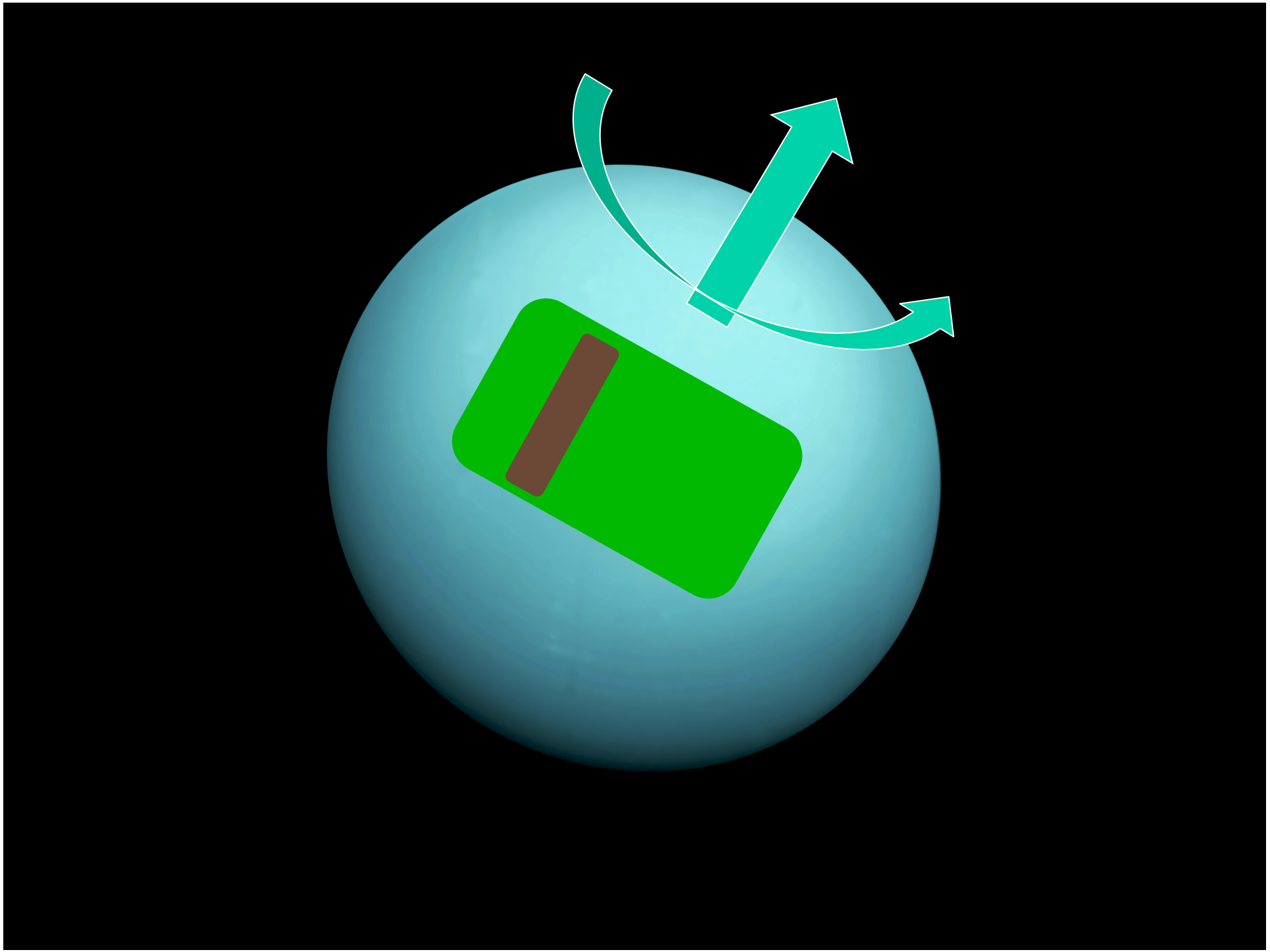
The Vision

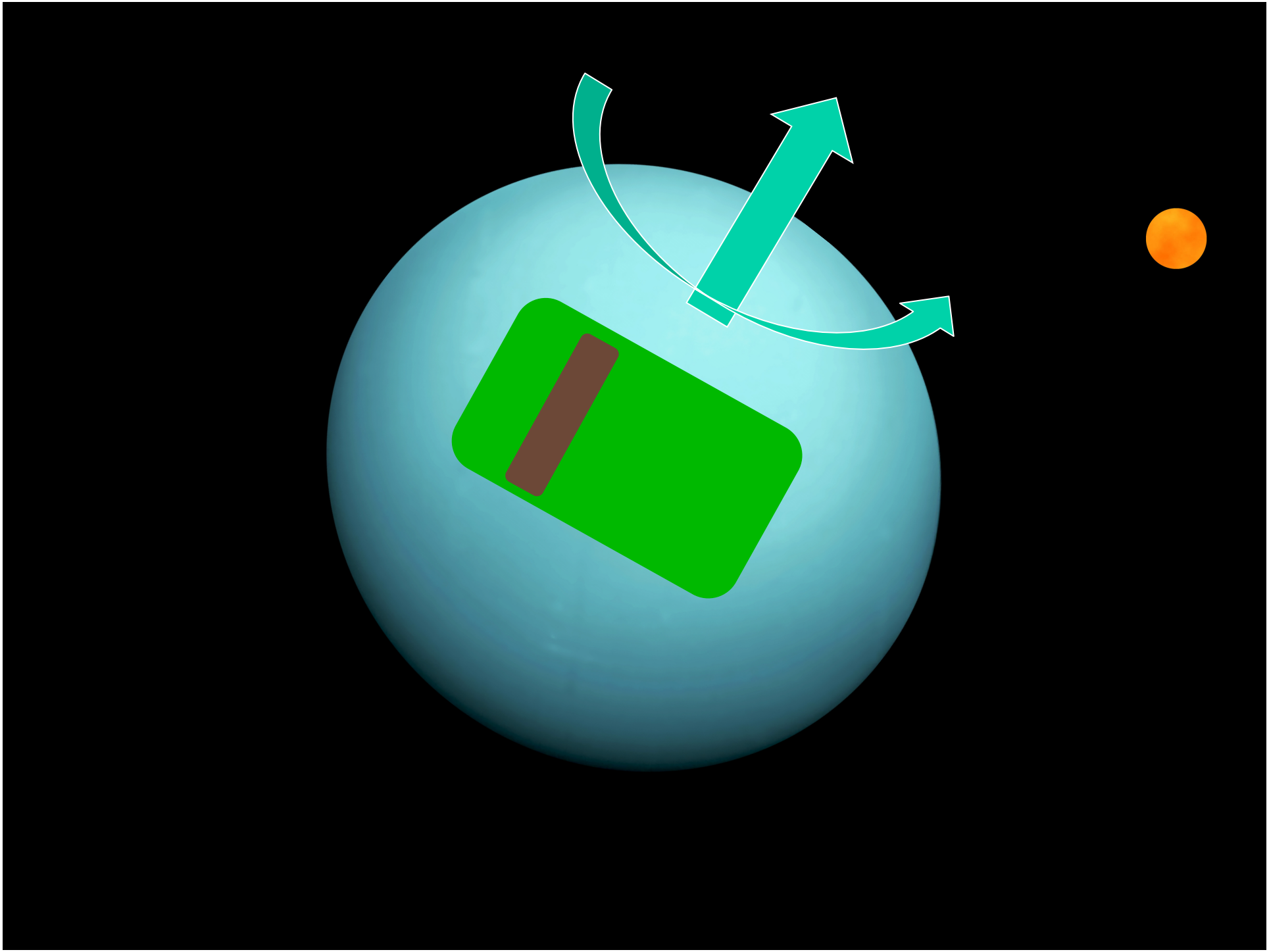


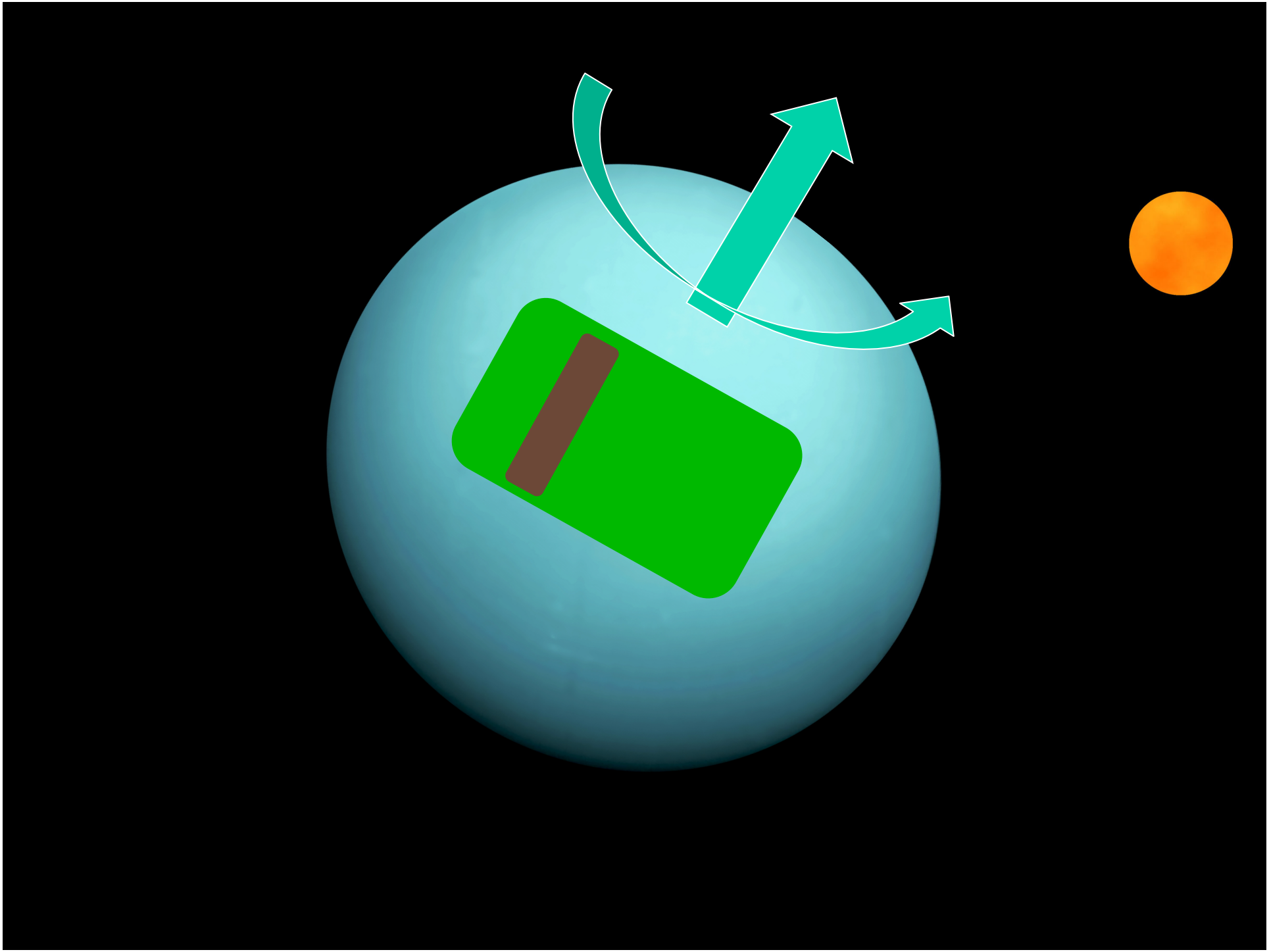


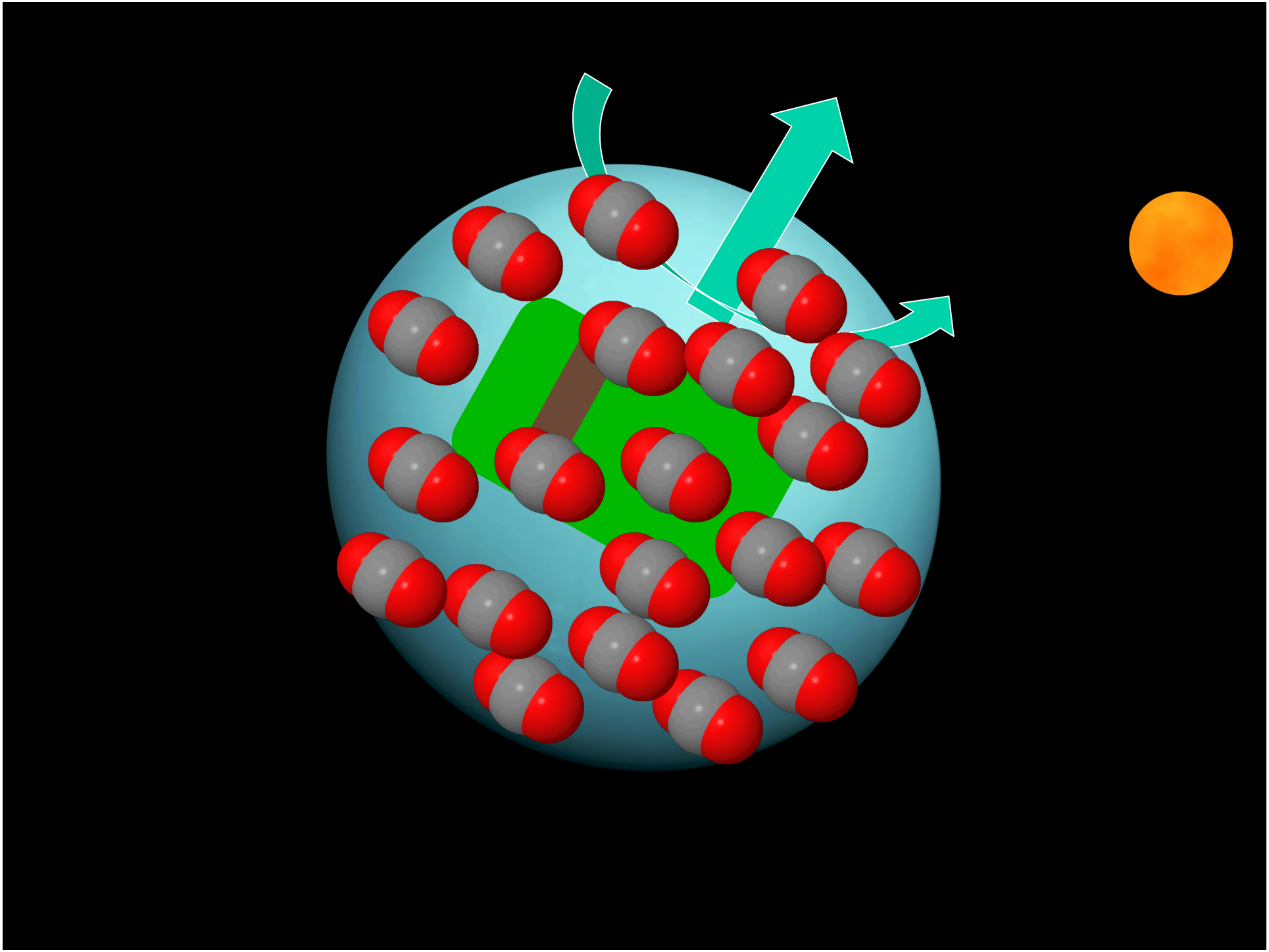


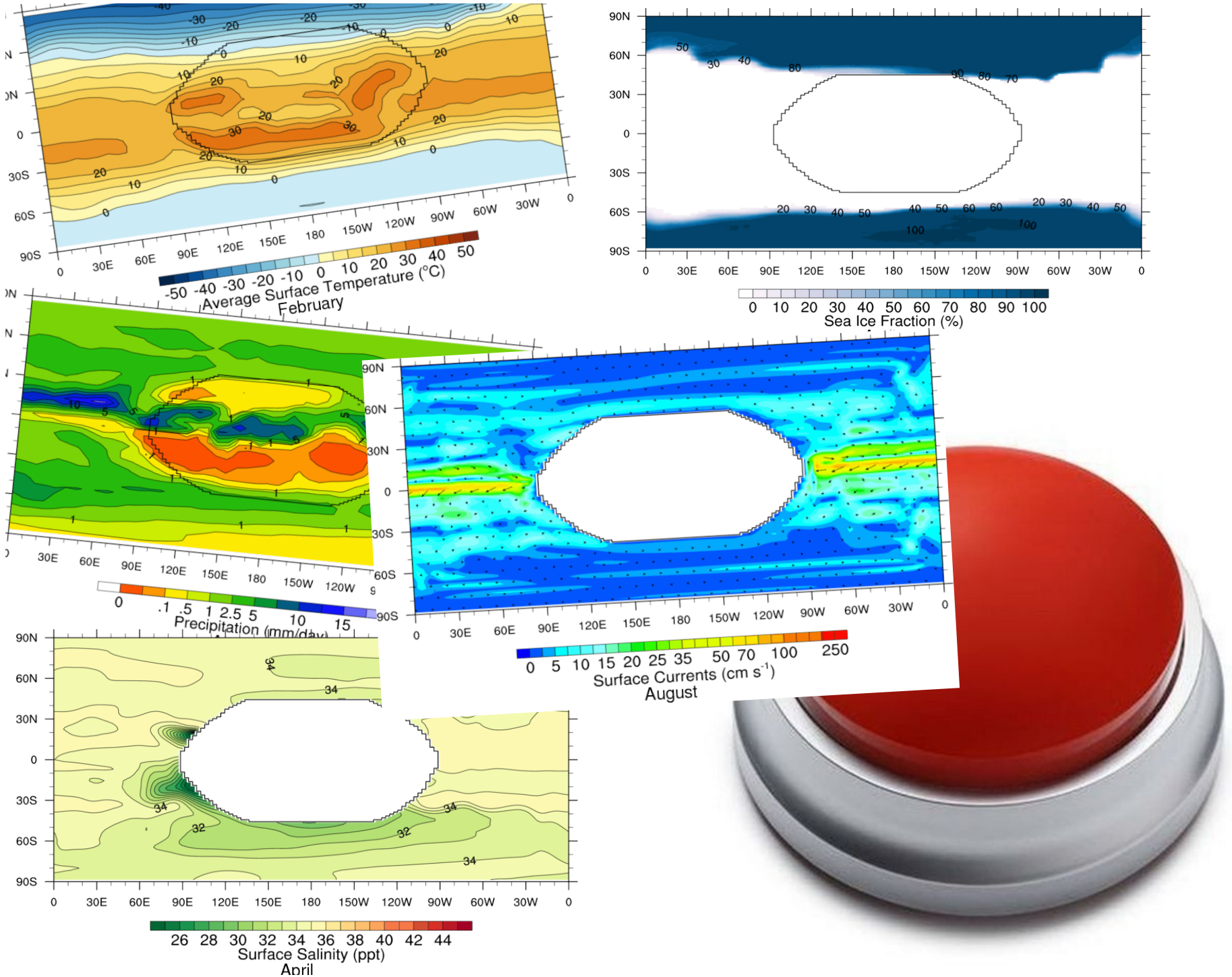











Average Surface Temperature (°C)
February
Sea Ice Fraction (%)
Precipitation (mm/day)
Surface Currents (cm s-1)
August
Surface Salinity (ppt)
April

coursera.org

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Our Earth: Its Climate, History, and Processes

Develop a greater appreciation for how the air, water, land, and life formed and have interacted over the last 4.5 billion years.

About the Course

This course focuses on a basic science understanding that demonstrates how the processes on Earth (including biological processes) lead to natural climate changes that have shaped the planet and the path of evolution. Students are challenged to think of the Earth as an integrated system made up of water, air, ice, land, and life.

For example, students learn that the Gulf Stream is not the cause of western Europe's temperate climate. They also learn that the rise of oxygen in the atmosphere 2.5 billion years ago produced massive extinctions of life on Earth that forever altered the dominant types of single-celled life. Students are exposed to how new scientific discoveries are made through the observations that led to plate tectonics, how the Moon formed, and why dinosaurs went extinct.

Course Syllabus

1. **Basics**
   - How science works

Sessions

Jan 19th 2015 - Feb 28th 2015

Go to class

Earn a Verified Certificate

Eligible for

Verified Certificate
Statement of Accomplishment

Course at a Glance

- 5 weeks of study
- 5-8 hours of work / week
- English
- English subtitles

buildyourownearth.com

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Build Your Own Earth

Home | About | Credits

Earth 1

Recent | Ancient | Alien

Current Day 2015

Change climate property

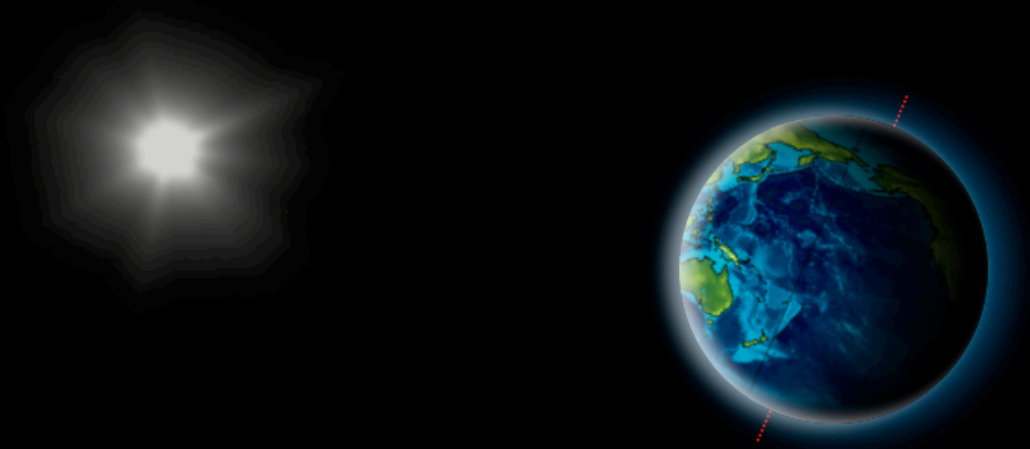
Atmosphere | Ice | Land | Ocean

Mean Temperature

Set analysis level:

Surface

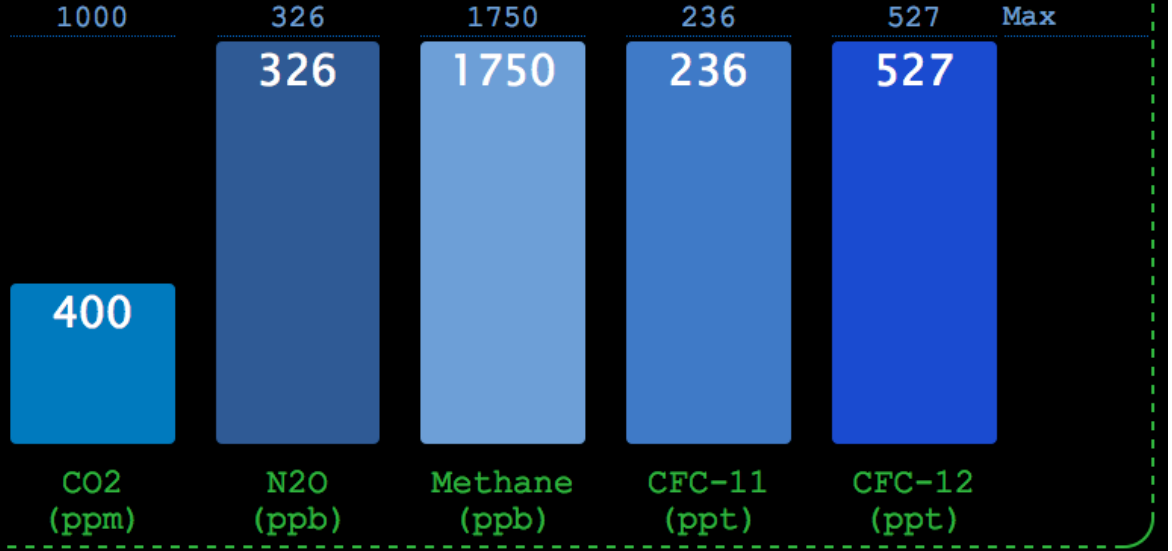
VIEW MODEL



Obliquity: 23.4463°
Eccentricity: 0.016724
Solar Constant: 1367 W/m²

Perihelion Day: 2
mvelp: 77.961°

Gases:



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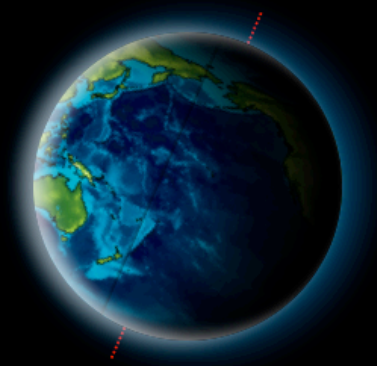

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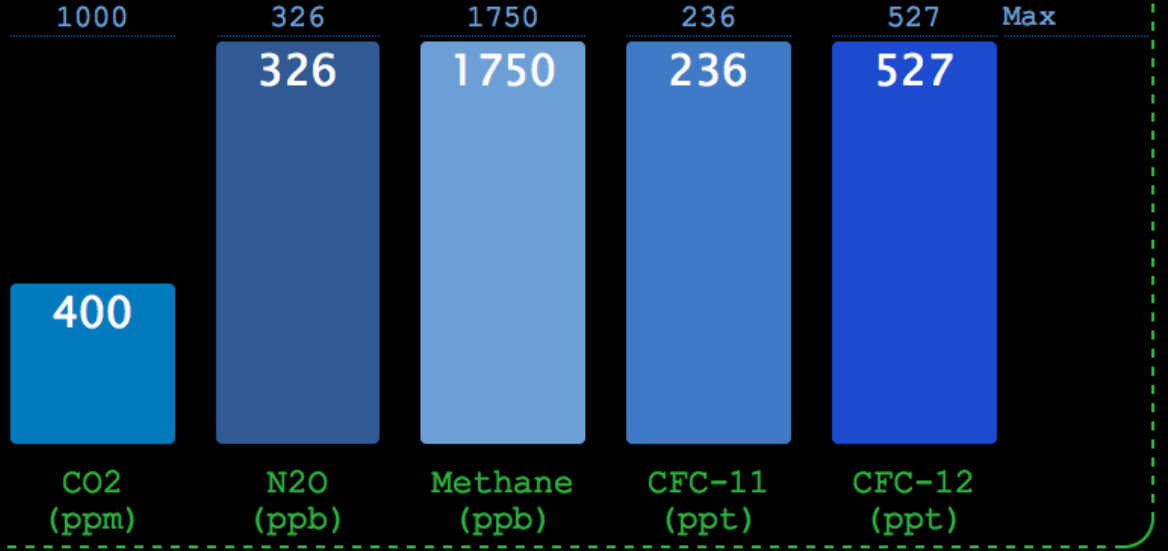

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Build Your Own Earth

Home | About | Credits

Earth 1 view properties

Recent | Ancient | Alien

Current Day 2015

Earth 2 Add Earth 2

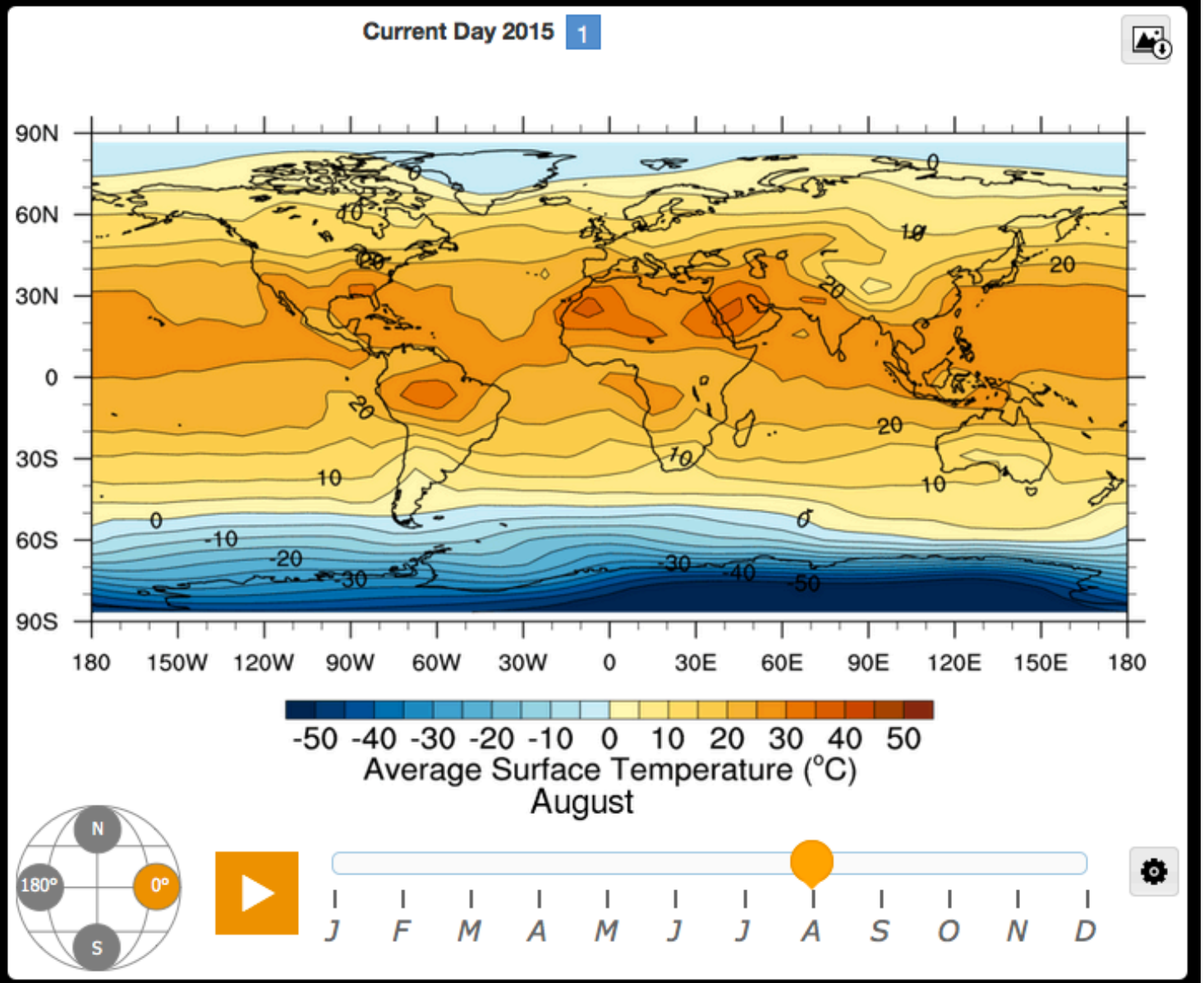
Change climate property

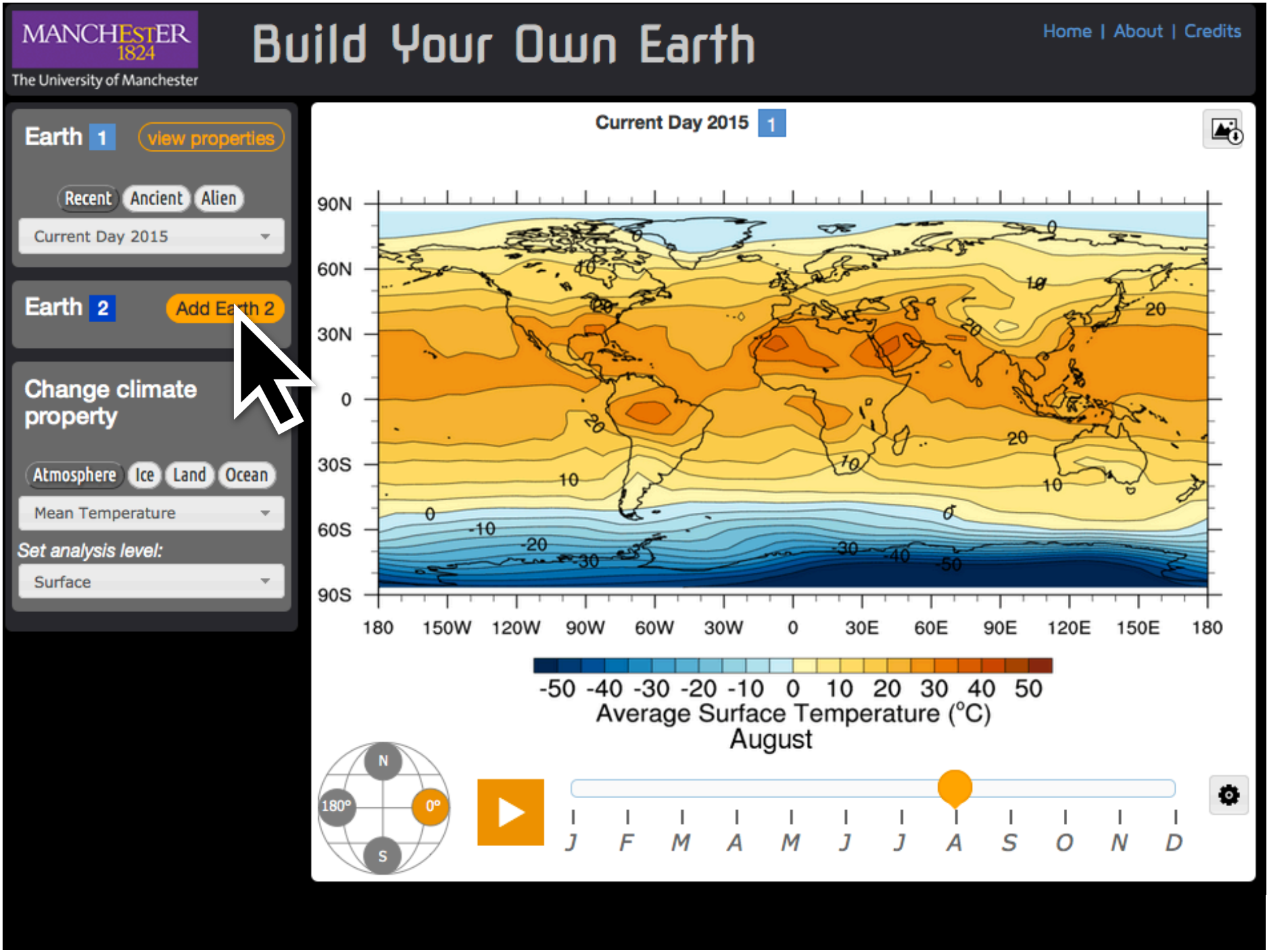
Atmosphere | Ice | Land | Ocean

Mean Temperature

Set analysis level:

Surface

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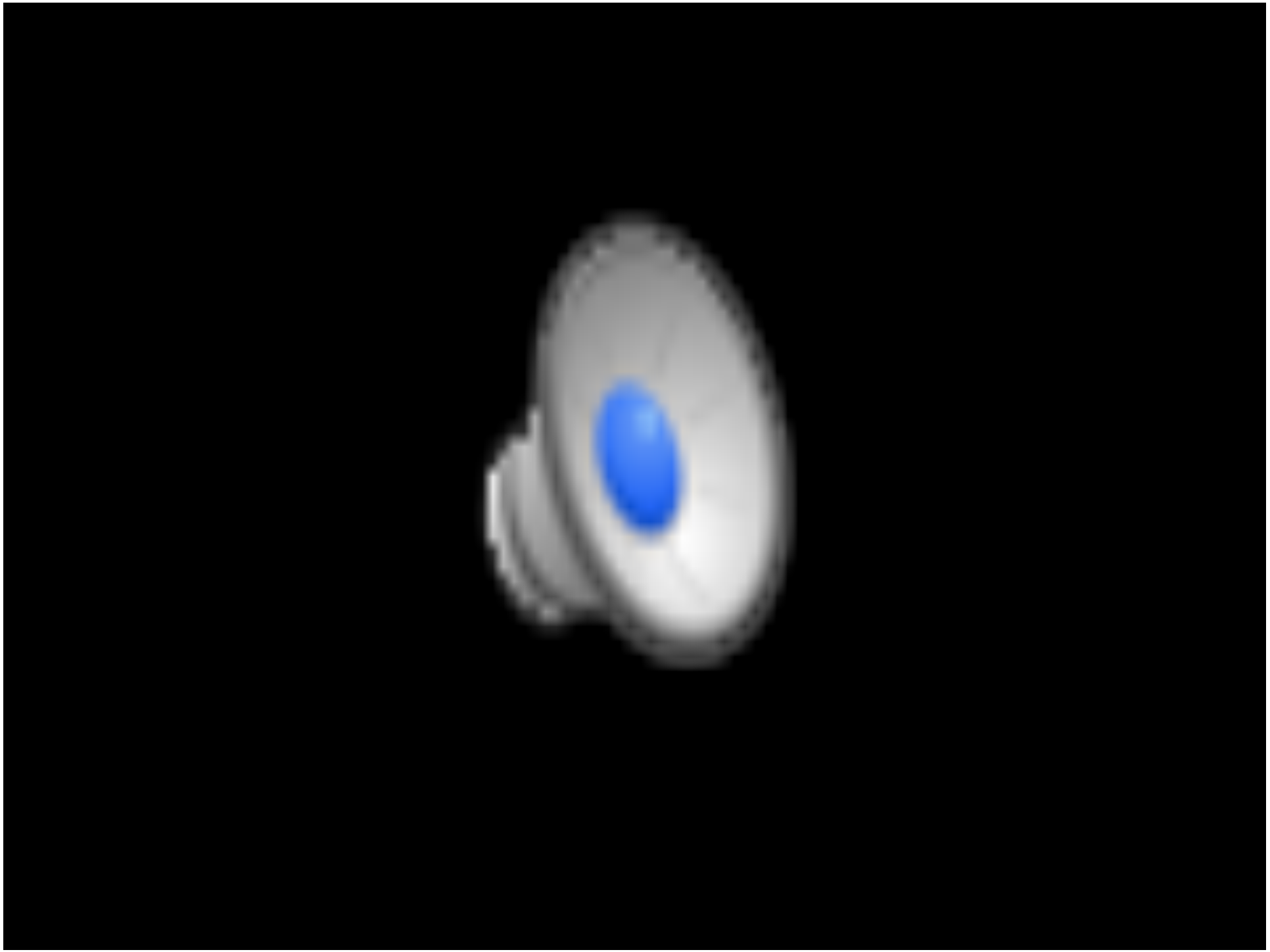
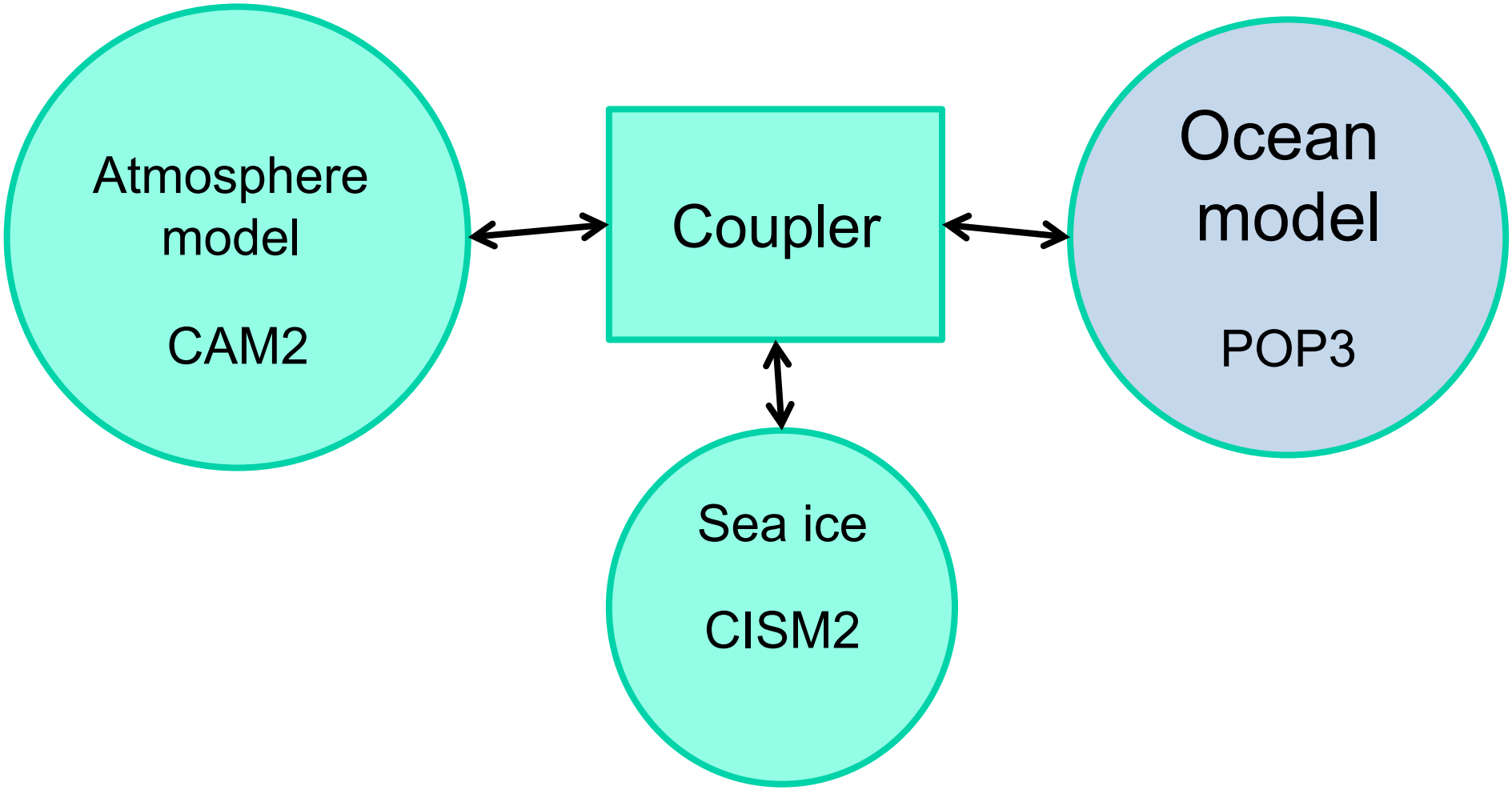
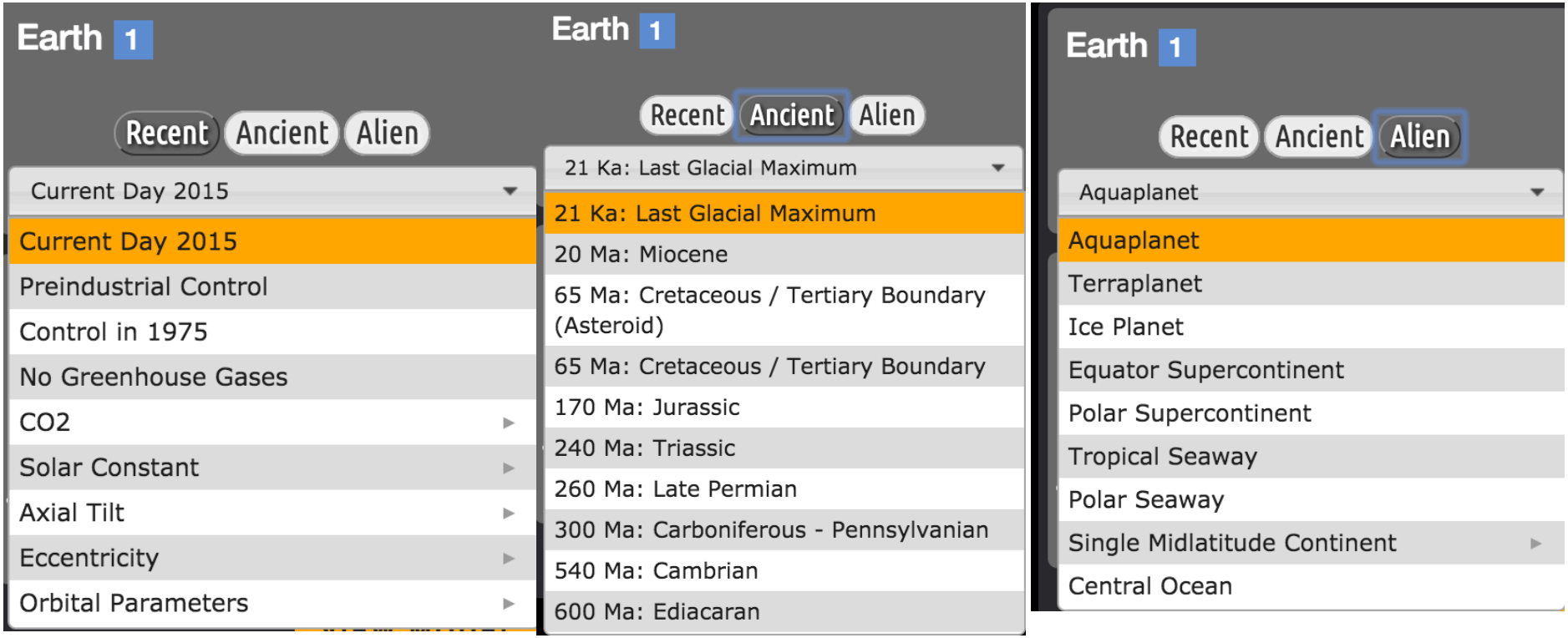
Build Your Own Earth
Home | About | Credits
Earth 1
view properties
Recent
Ancient
Alien
Current Day 2015
Earth 2
Add Earth 2
Change climate property
Atmosphere
Ice
Land
Ocean
Mean Temperature
Set analysis level:
Surface
Current Day 2015 1
90N
60N
30N
0
30S
60S
90S
180
150W
120W
90W
60W
30W
0
30E
60E
90E
120E
150E
180
-50 -40 -30 -20 -10 0 10 20 30 40 50
Average Surface Temperature (°C)
August
N
180°
0°
S
J F M A M J J A S O N D



Fast Ocean–Atmosphere Model (FOAM) 1.5



FOAM model run on the



About 50 total simulations

How is BYOE used for teaching?

What do the students think?

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Build Your Own Earth: Information Sheet and Assignment

Our Earth: Its Climate, History and Processes: June 2015

Information Sheet

Build Your Own Earth (BYOE) was a vision that we had to engage students in understanding the controls on Earth's climate. The vision was for you to selecting the features you wanted: distance from the Sun, tilt of the axis, location of continents, oceans and mountains, rotation rate, atmospheric composition, etc. You would enter these characteristics on a web page, and push the "Go" button. A climate model would run in the background and produce the climate on that world for you. Sounds fun, huh?

Unfortunately, such a vision is not currently possible with the speed of today's computers. Even using a simplified climate model that is built for speed (FOAM: the Fast Ocean–Atmosphere Model), our supercomputer will only run about 480 years of model climate in one day. That's even with our model having fairly coarse grid spacing. Each atmospheric grid box is 4.5° in latitude and 7.5° in longitude (about 500 km by 800 km near the equator), which would mean that there are around 4 grid points representing all of the UK and Ireland. Even at this coarse grid spacing, you'd need about 50–300 years of simulations to obtain a stable climate! Plus, with thousands of students submitting simulations in real time, our supercomputer would be inundated with

Asking Your Own Research Question

26. Pick a scientific question that you could answer with simulations that are not currently in BYOE. Design a simulation or series of simulations that you would like to perform. Hypothesize what results that you might expect. Explain the simulation and the hypothesized results. Explain your answer.

Asking Your Own Research Question

26. Pick a scientific question that you could answer with simulations that are not currently in BYOE. Design a simulation or series of simulations that you would like to perform. Hypothesize what results that you might expect. Explain the simulation and the hypothesized results. Explain your answer.

"The BYOE made you think for yourself and explain your reasoning, showing innovation and meaning the answers were not just on the internet. .... This was a very good assignment because it made people think for themselves and make their own hypotheses and assumptions. Plus, the last question is really what I want to be asked at University. I want to write innovatively and not just the right answer in a textbook."

What to take away from this assignment:

1. Although the global average temperature has undergone large variations over geological time, the patterns of moist tropics and dry subtropics with polar jet streams are consistent. Details about these features change, but the planetary-scale circulation (Hadley cells, polar jet streams) is a consistent feature.

2. The global average temperature is a relatively simple metric for the global climate that fails to illustrate the wonderfully rich patterns associated with the planetary-scale circulation and annual cycle.

3. These rich patterns control the local climate (temperature, precipitation, wind), which then determine various ecosystems for plant and animal life.

What students in Planet Earth think

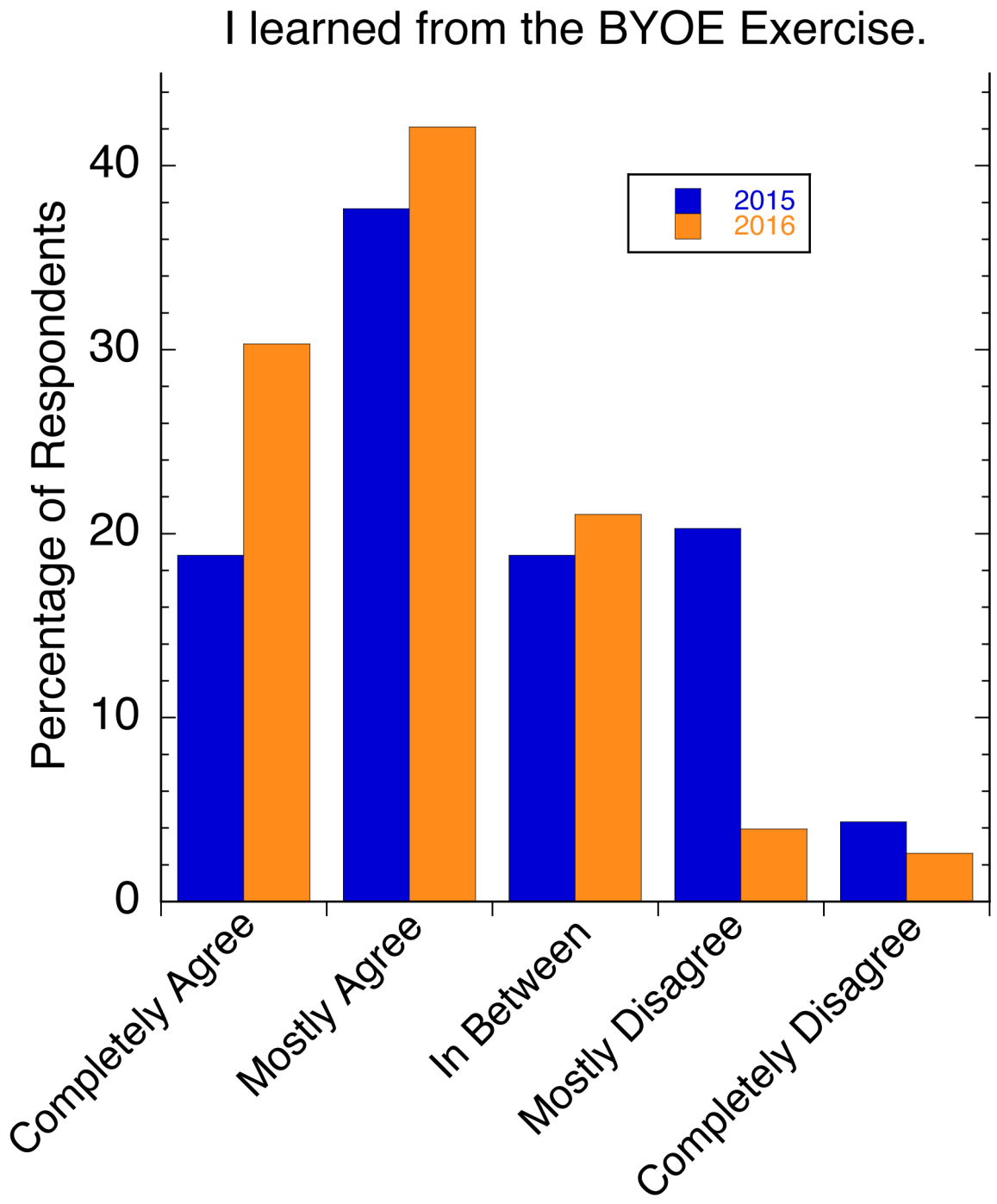
“Already knew quite a lot about climate from A-level but the BYOE assignment was good at applying my knowledge and thinking beyond what I had been taught.”

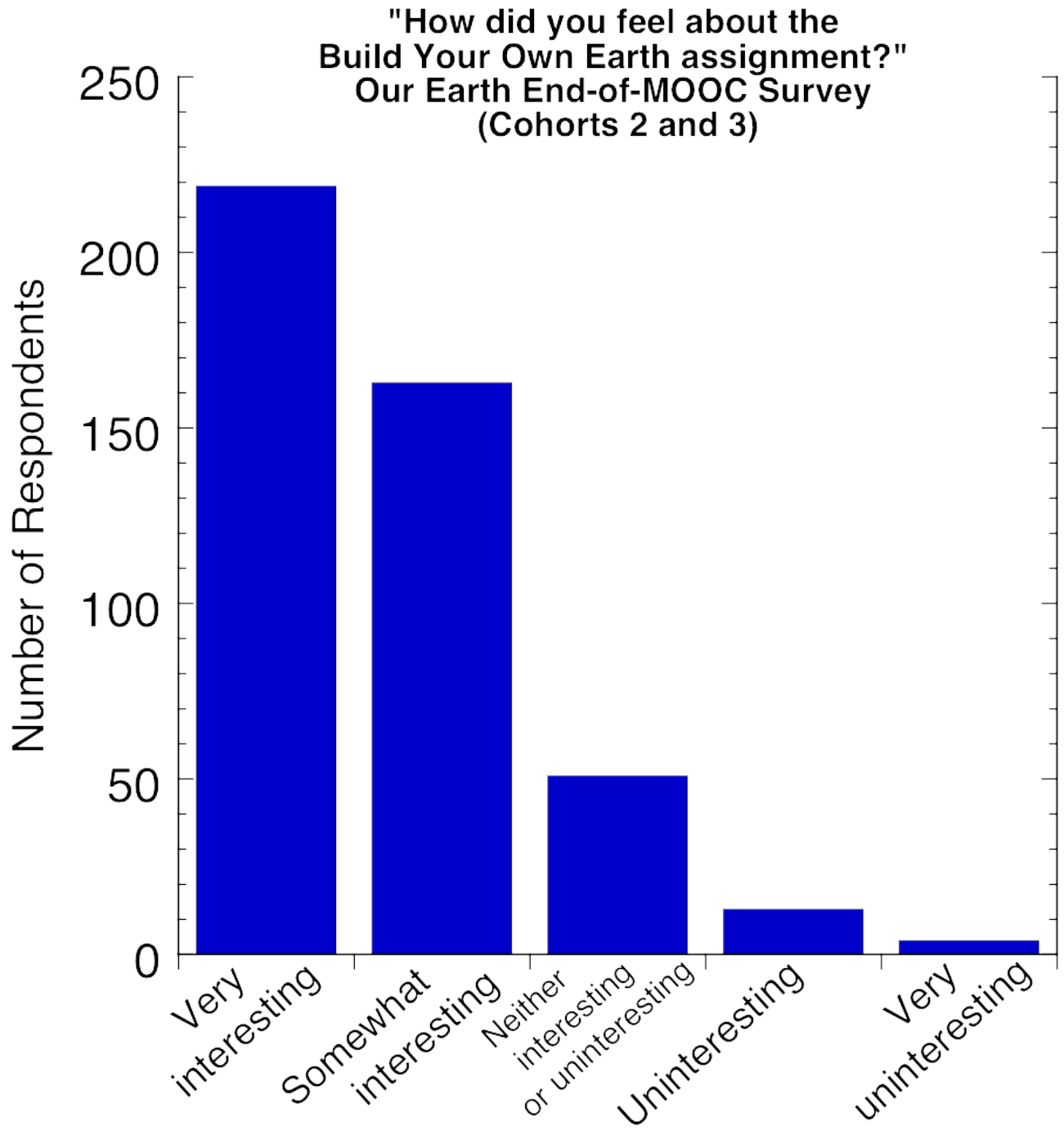
“Helped me understand the processes on Earth better because some research had to be done.”

“The assignment put interacting elements of the climate into better context for me.”

What students in the MOOC think

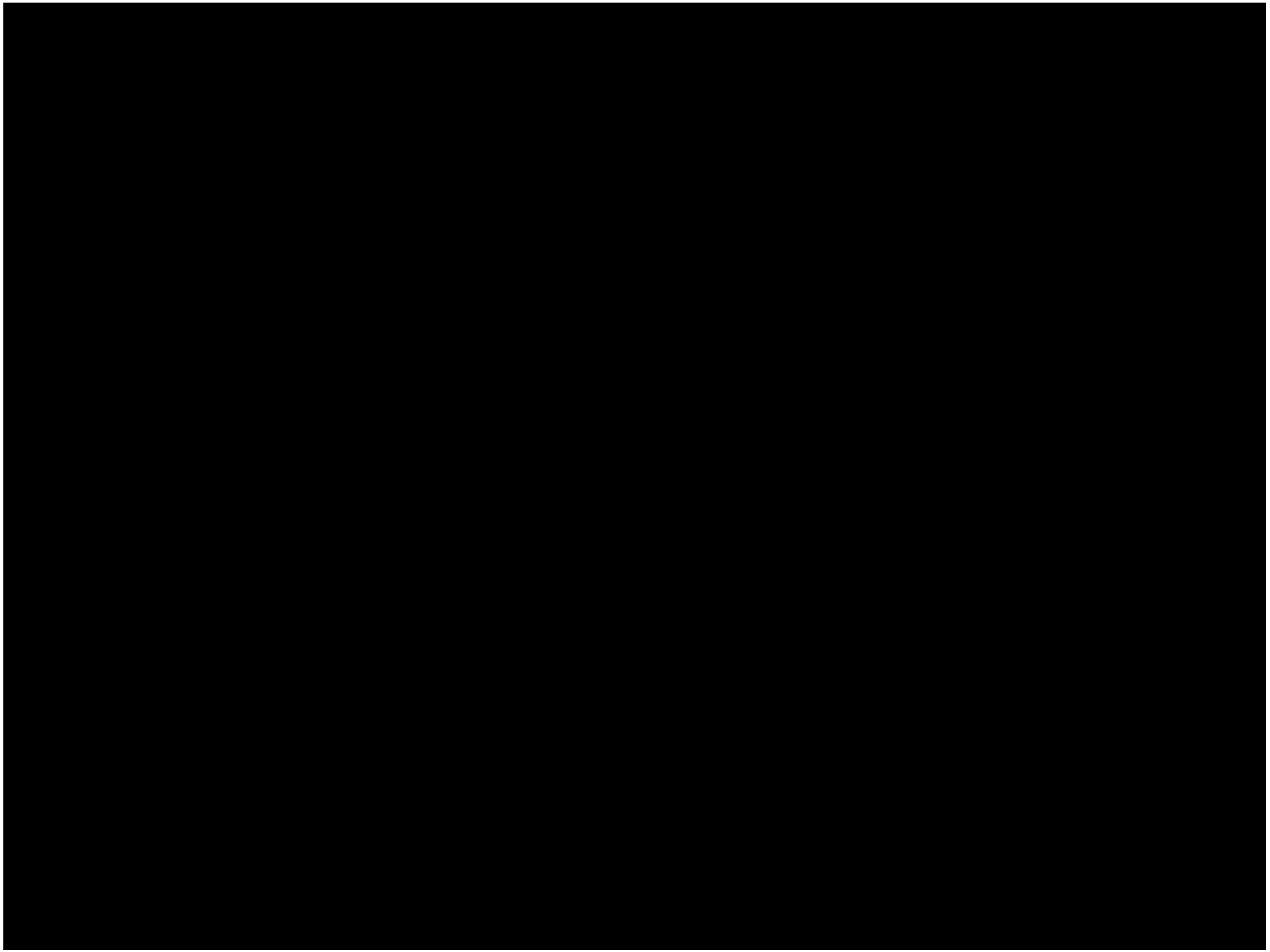
"This is the first time in over 50 years that I've even looked at Earth Science. I'm literally "blown away" by the power of the simulation for gaining an understanding of how the earth works now and in the past. I'm hooked!"


I learned from the BYOE Exercise.
Percentage of Respondents
0
10
20
30
40
2015
2016
Completely Agree
Mostly Agree
In Between
Mostly Disagree
Completely Disagree

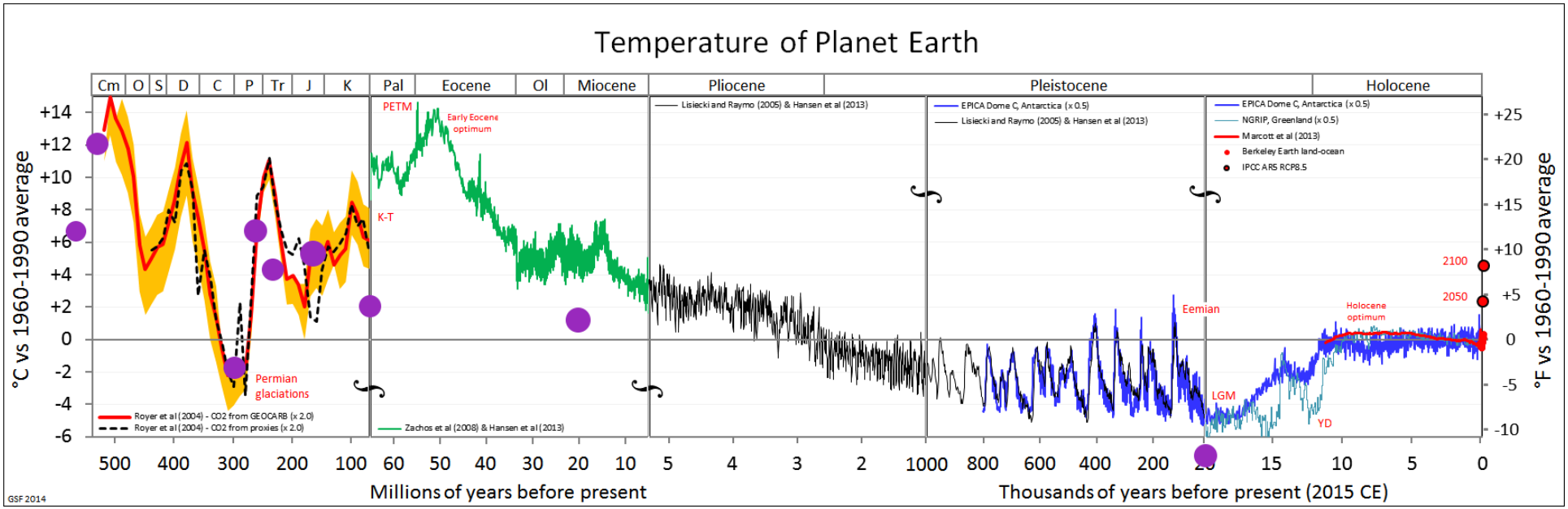

"How did you feel about the
Build Your Own Earth assignment?"
Our Earth End-of-MOOC Survey
(Cohorts 2 and 3)
Number of Respondents
250
200
150
100
50
0
Very interesting
Somewhat interesting
Neither interesting or uninteresting
UnInteresting
Very uninteresting

buildyourownearth.com

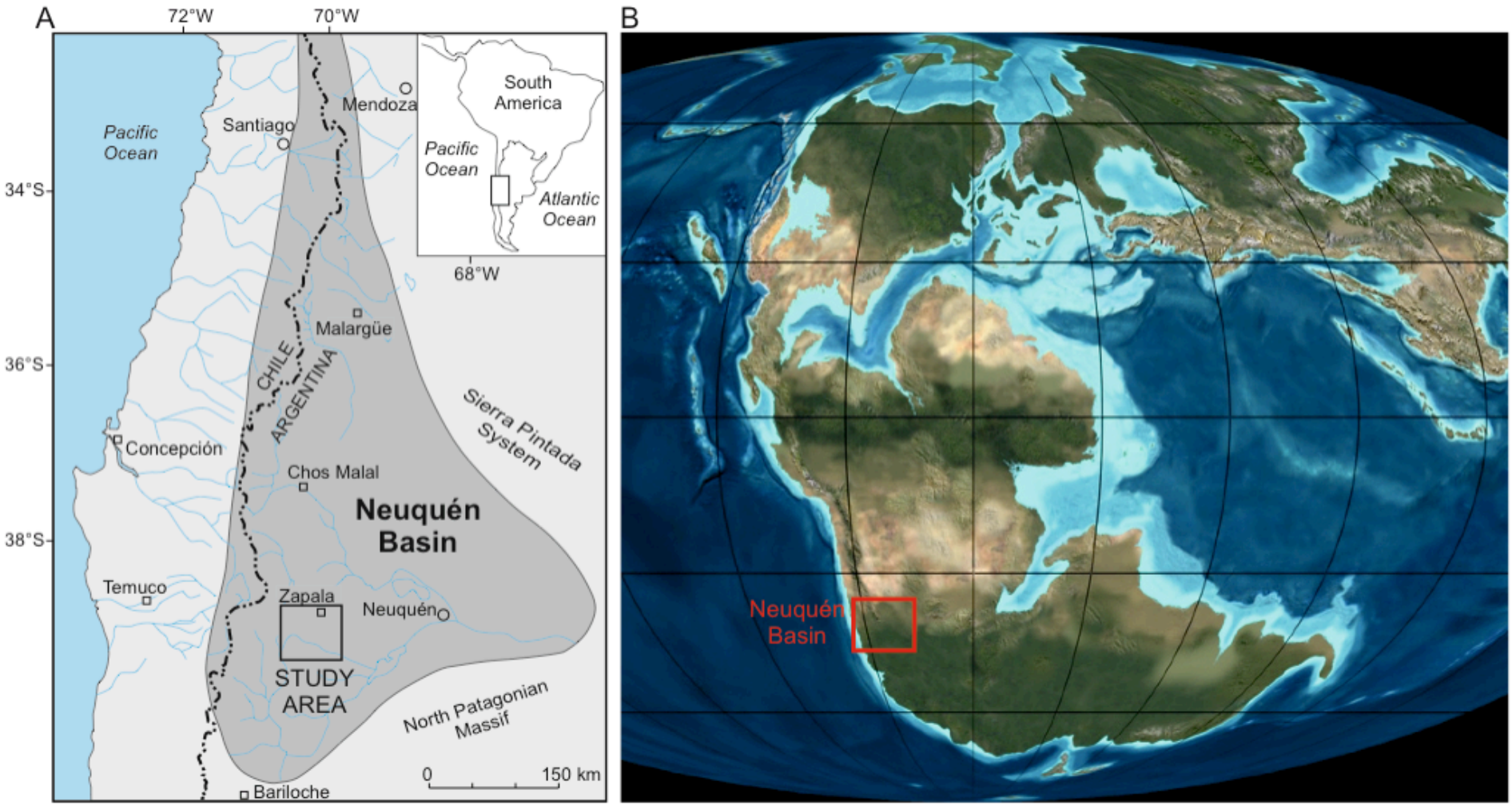
David.Schultz@manchester.ac.uk
Jonathan.Fairman@manchester.ac.uk



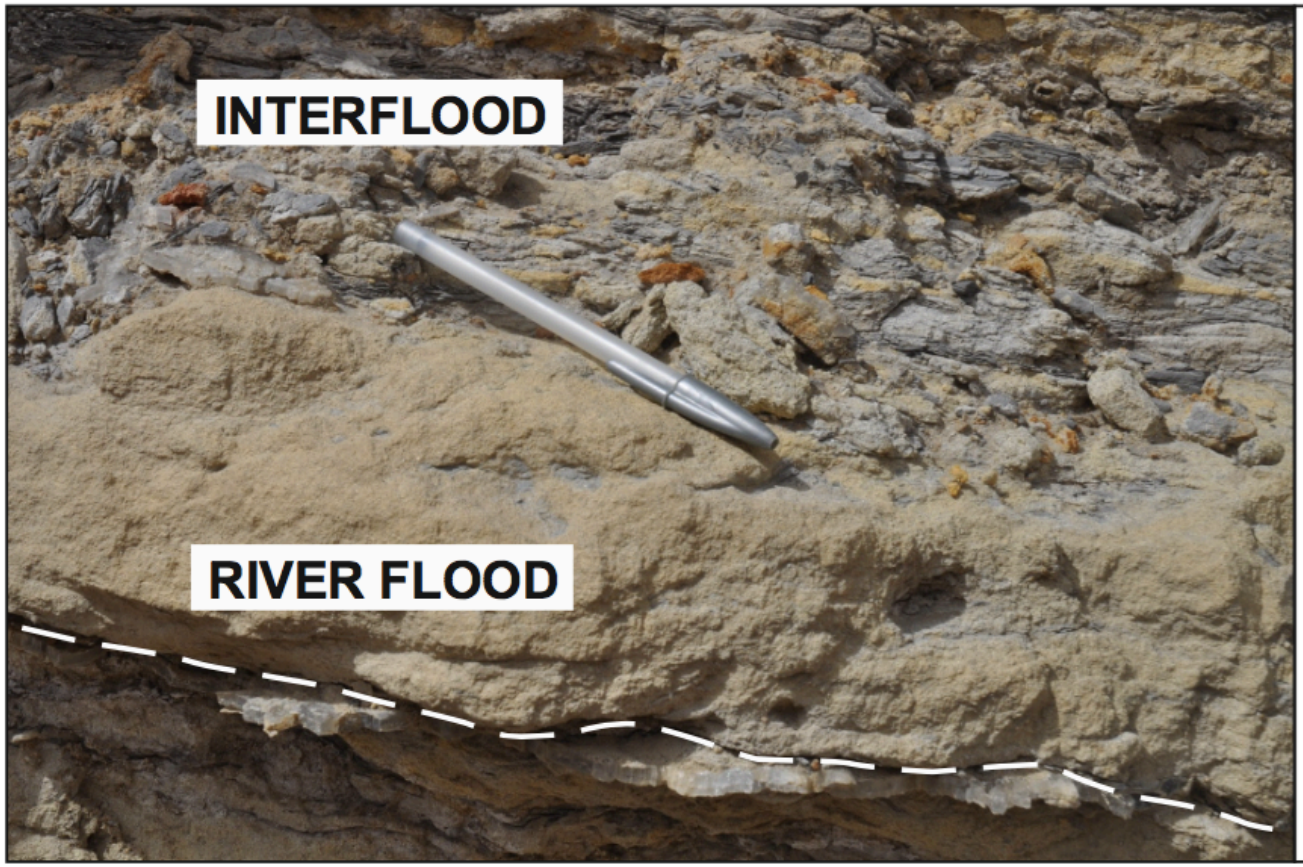
How well does BYOE do?



170 Ma – Middle Jurassic

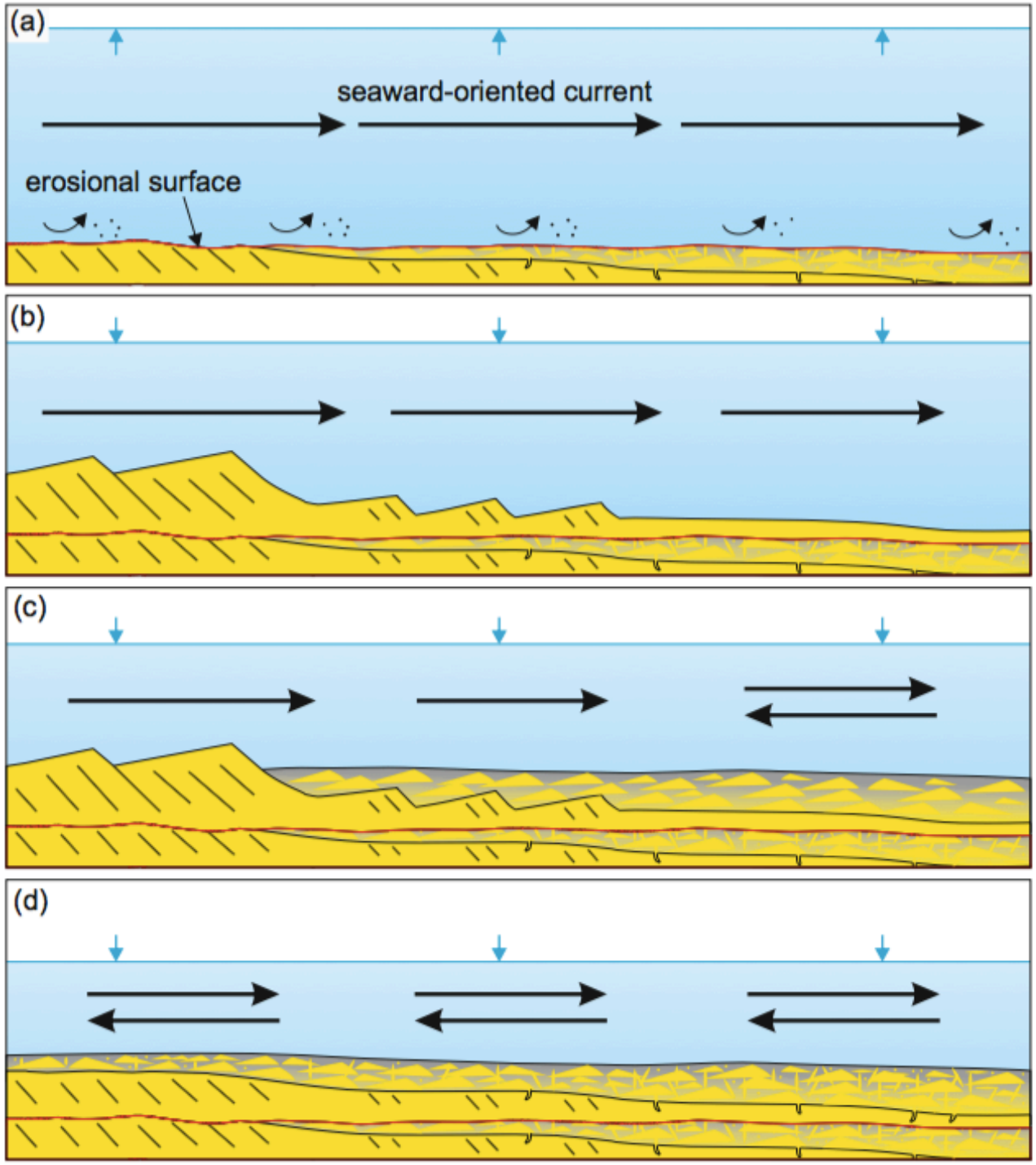


Marcello Gugliotta and Stephen Flint



INTERFLOOD BEDS
- finer-grained
- heterolithic
- gradational base
- mm-scale rhythmites
- mud drapes
- bidirectional ripples
- BI up to 6

RIVER FLOOD BEDS
- coarser-grained
- sandstone
- erosional base
- mudstone clasts
- structureless or cross-stratified
- rare rhythmites
- rare drapes
- rare bidirectional ripples
- BI 0-1



RIVER FLOOD
(WAXING STAGE)

early stage of the river flood
mainly producing erosion

RIVER FLOOD
(WANING STAGE)

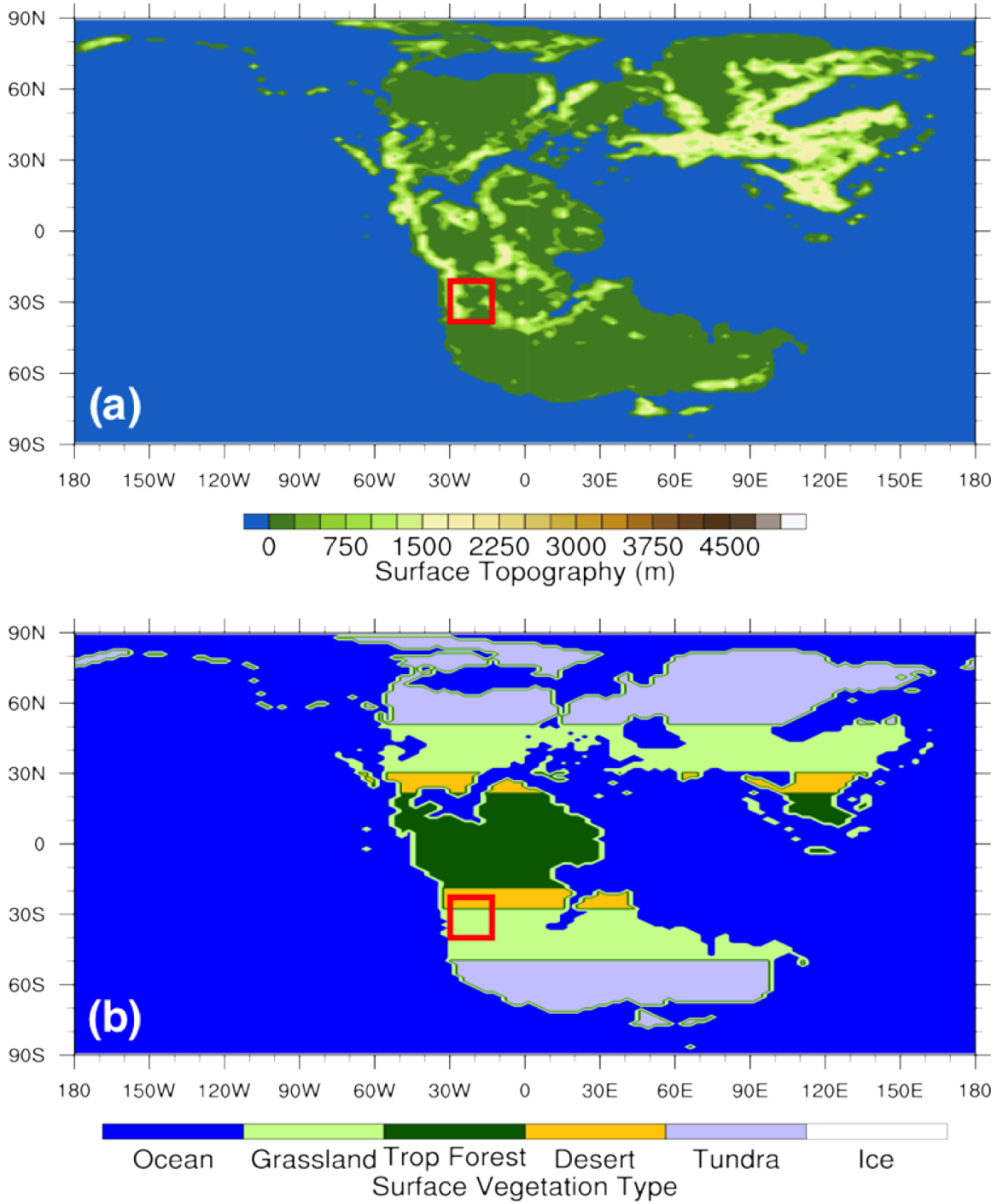
sedimentation under fluvial
dominance

RIVER FLOOD
(LATE STAGE)

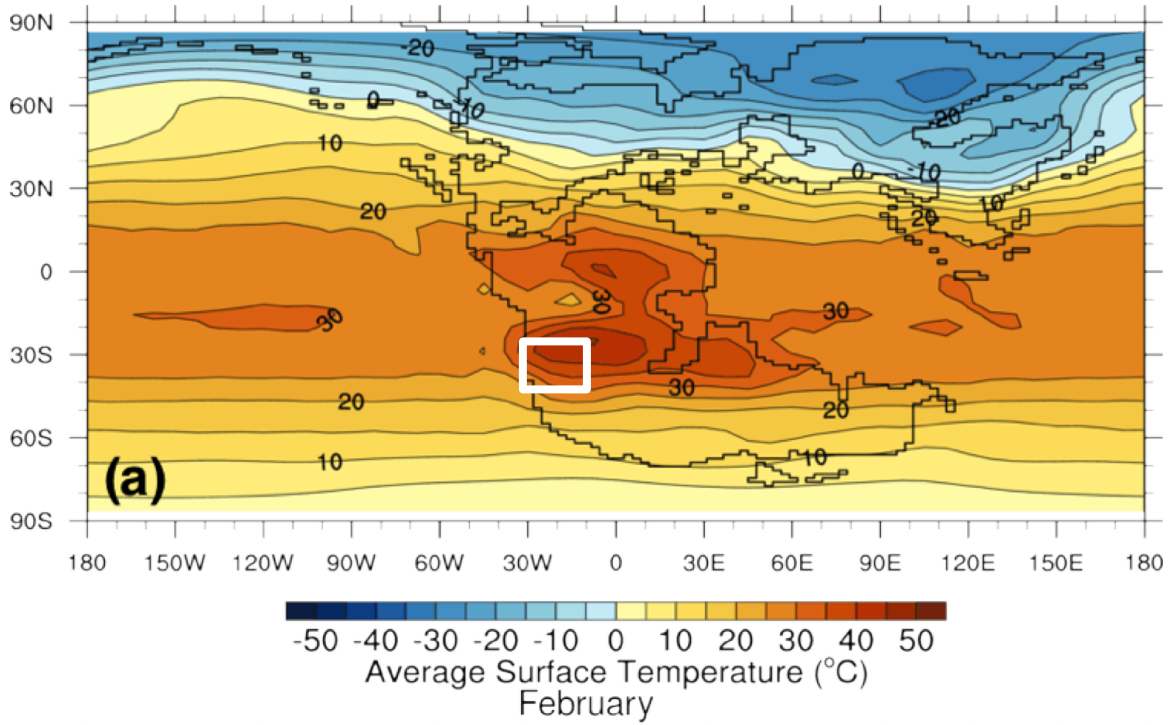
sedimentation under fluvial
dominance and minor
influence of tides

INTERFLOOD

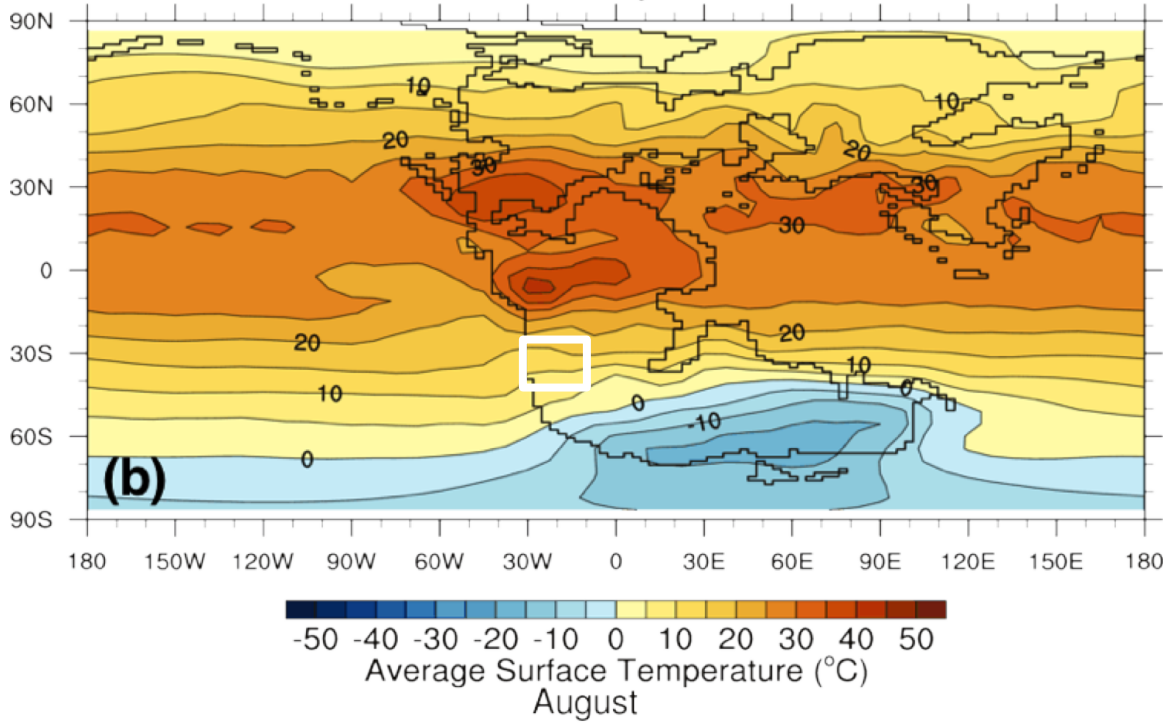
tidal and biological reworking
and minor fluvial influence


90N
60N
30N
0
30S
60S
90S
(a)
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
0 750 1500 2250 3000 3750 4500
Surface Topography (m)
90N
60N
30N
0
30S
60S
90S
(b)
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
Ocean Grassland Trop Forest Desert Tundra Ice
Surface Vegetation Type

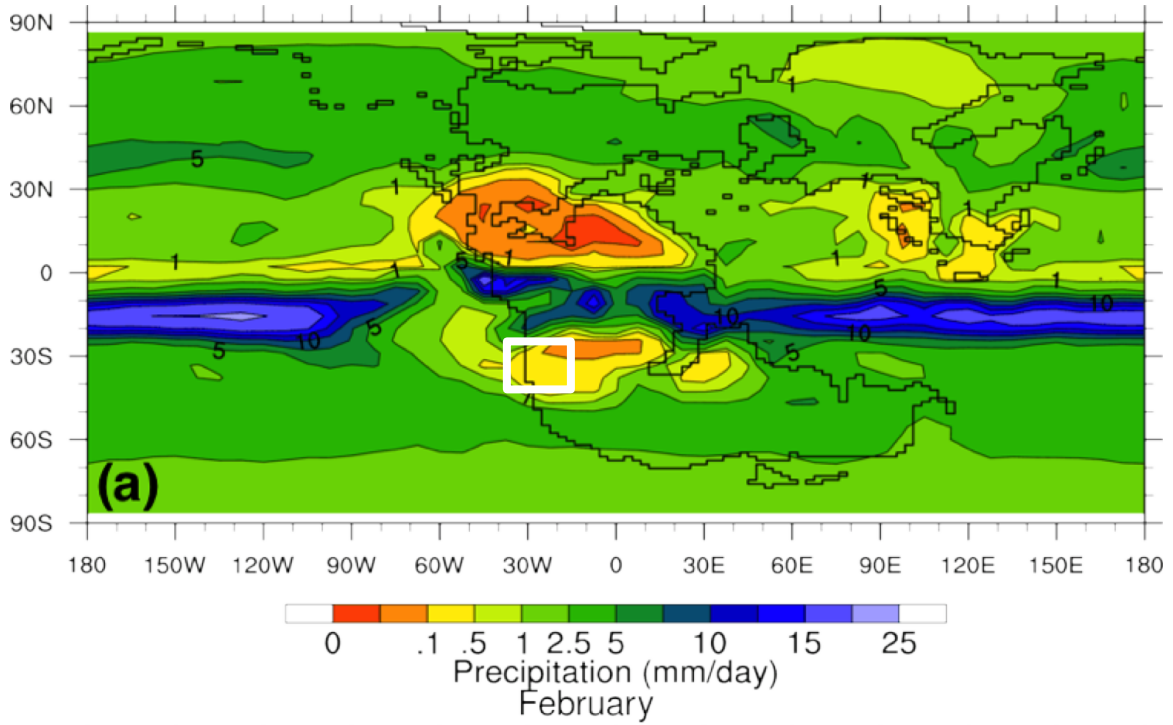
Feb


90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
(a)
-50 -40 -30 -20 -10 0 10 20 30 40 50
Average Surface Temperature (°C)
February

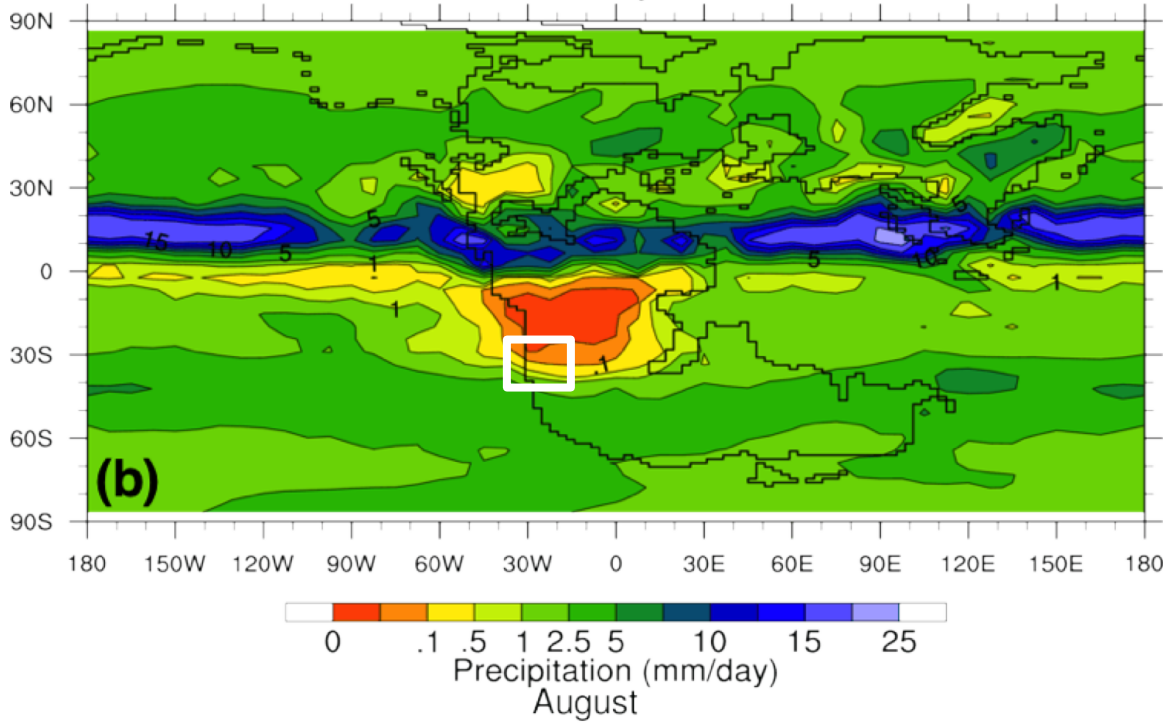
Aug


90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
(b)
-50 -40 -30 -20 -10 0 10 20 30 40 50
Average Surface Temperature (°C)
August

Feb


90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
(a)
0 .1 .5 1 2.5 5 10 15 25
Precipitation (mm/day)
February

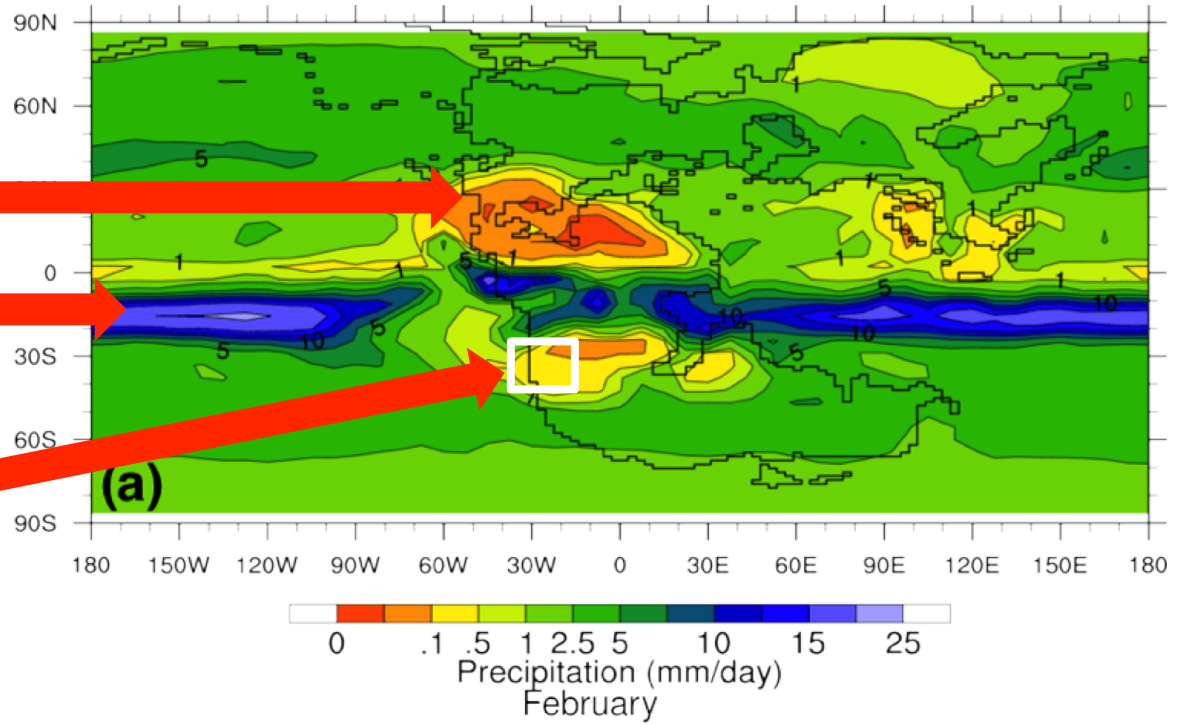
Aug


90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
(b)
0 .1 .5 1 2.5 5 10 15 25
Precipitation (mm/day)
August

Subtropical deserts

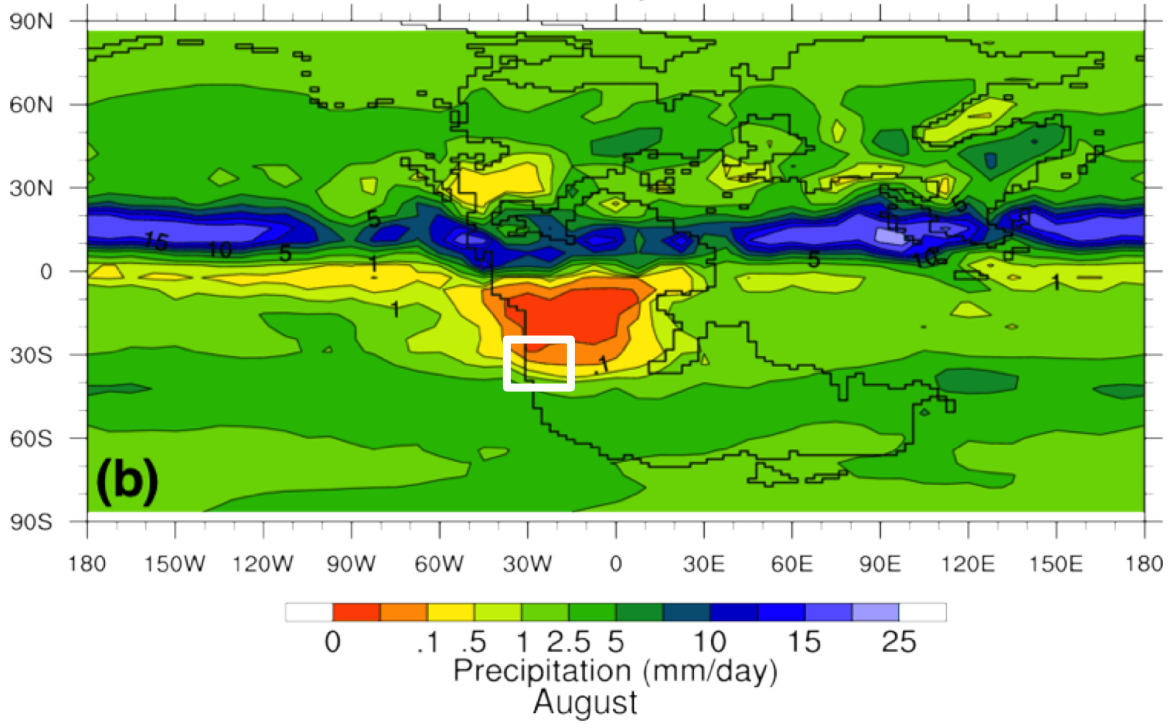
Intertropical Convergence Zone

Subtropical deserts



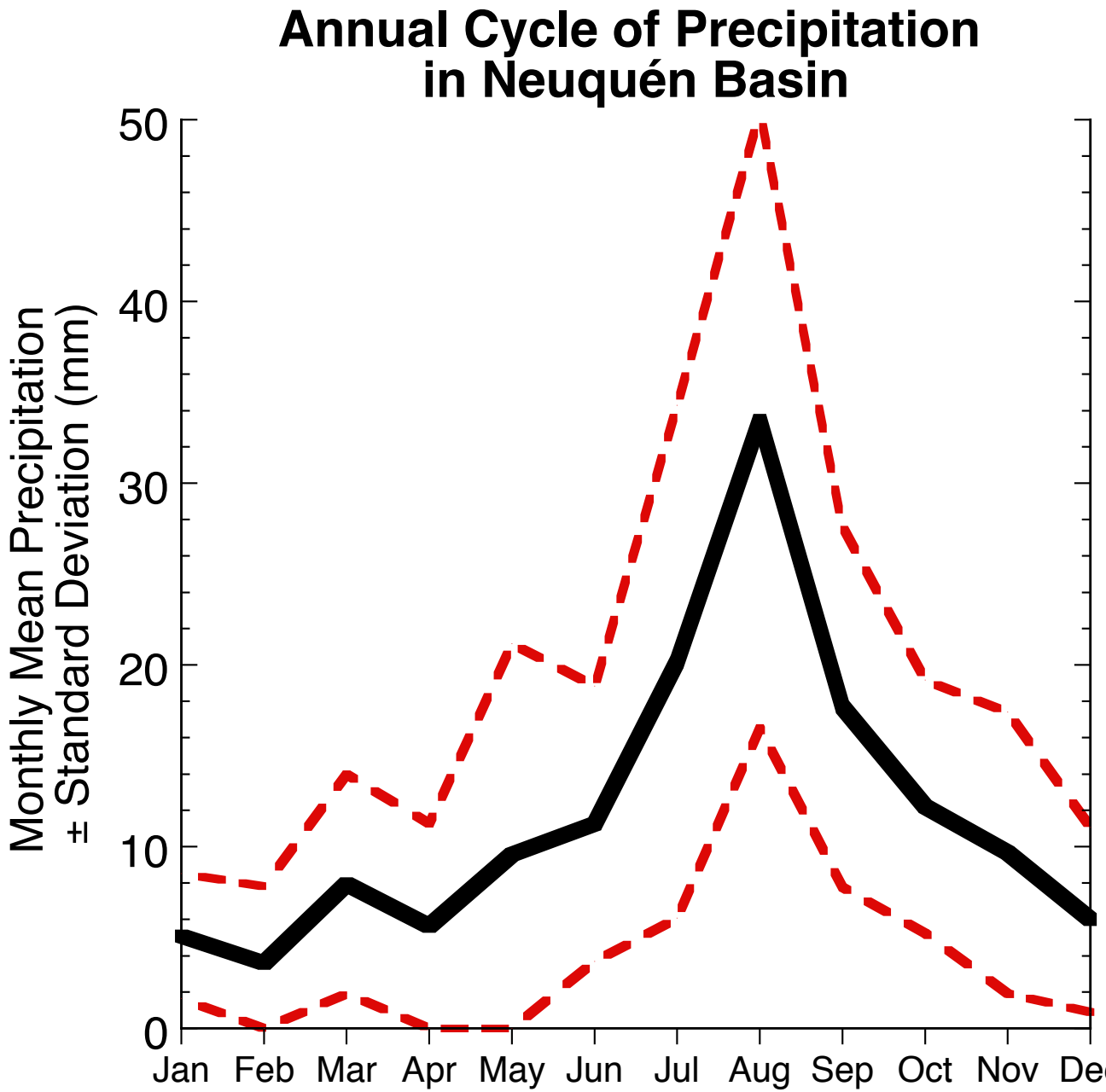
NH winter

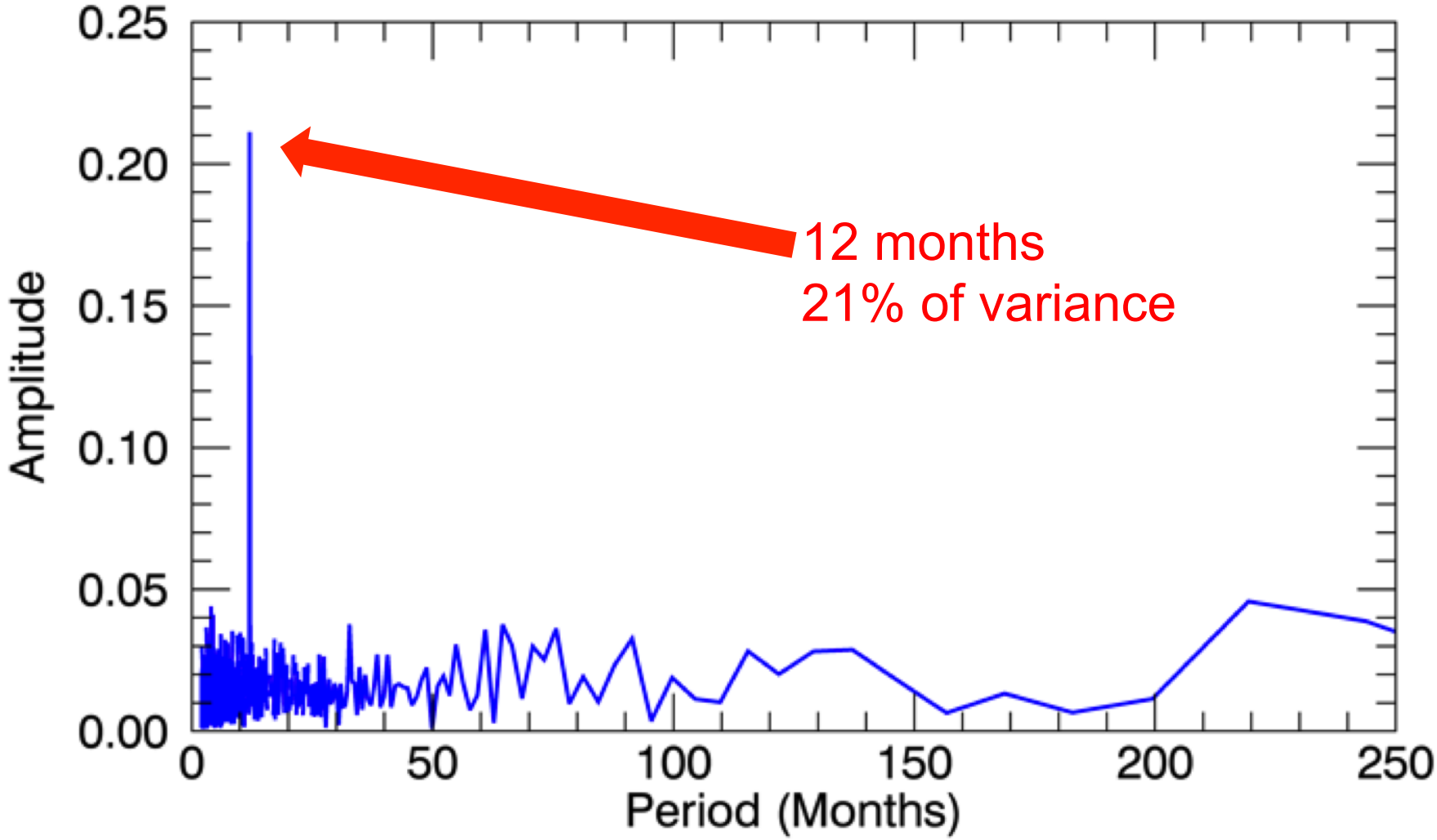
Feb



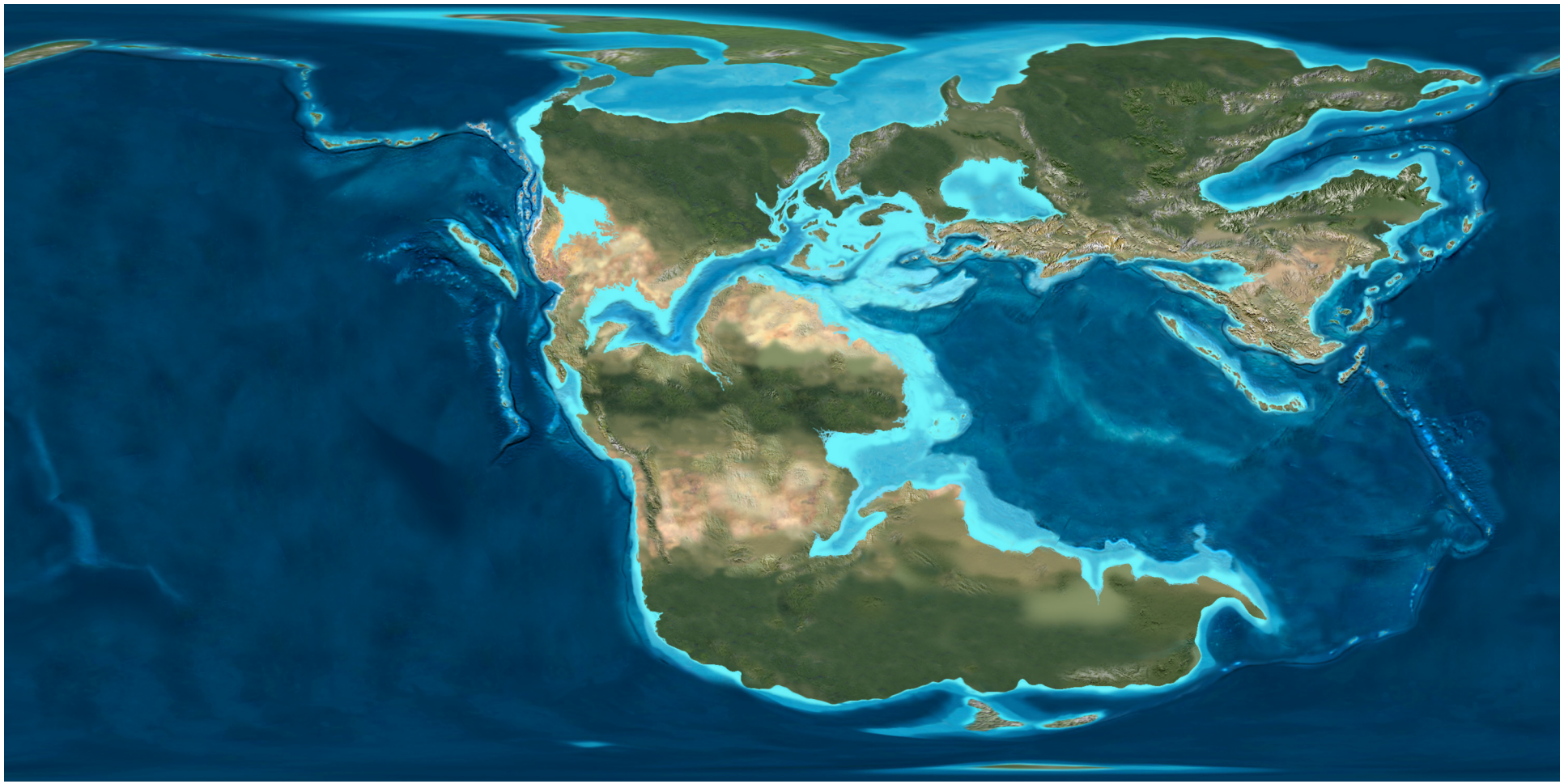
NH summer

Aug


Annual Cycle of Precipitation
in Neuquén Basin
Monthly Mean Precipitation
± Standard Deviation (mm)
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

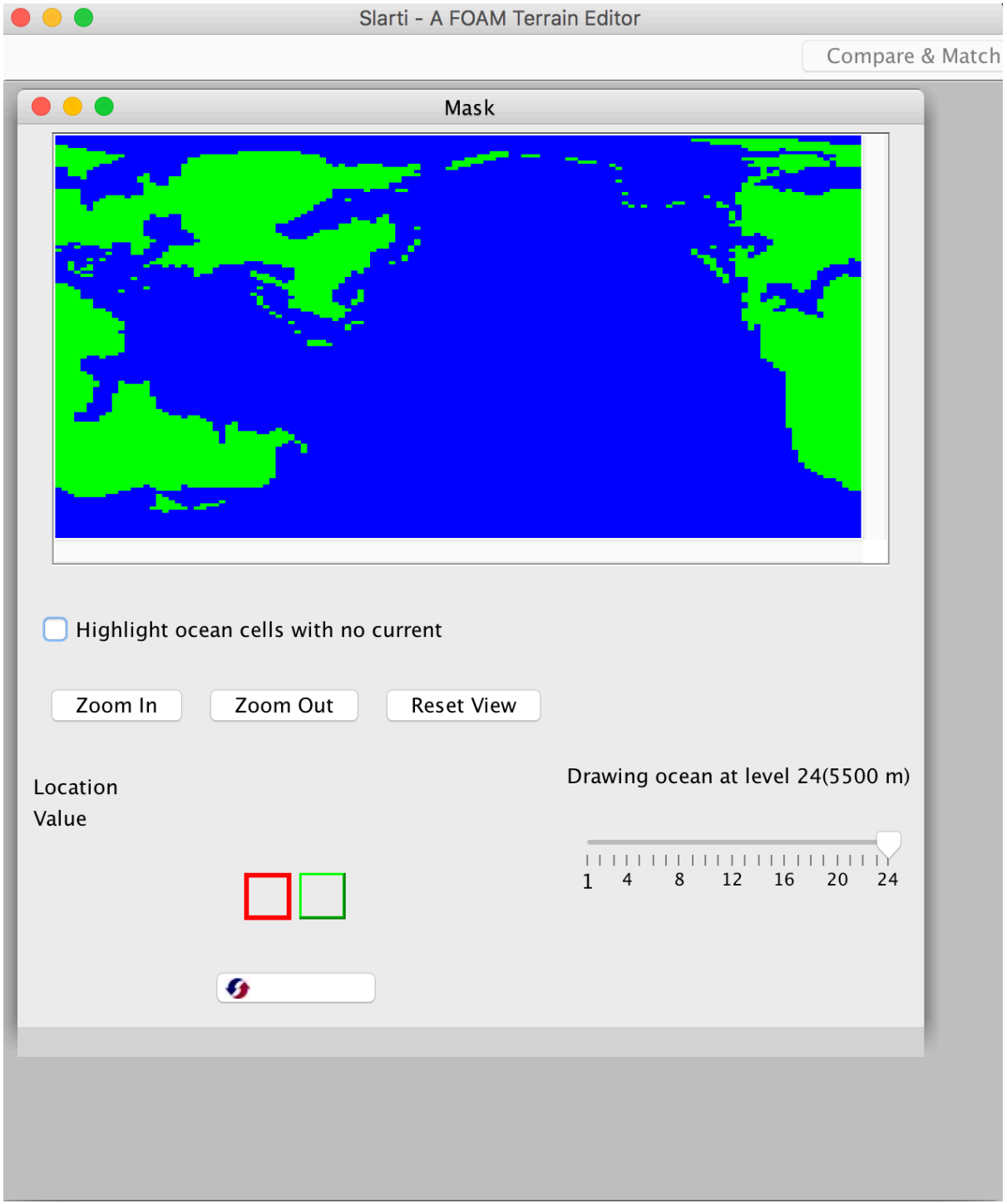

0.25
0.20
0.15
0.10
0.05
0.00
Amplitude
0
50
100
150
200
250
Period (Months)
12 months
21% of variance

Jurassic reconstruction – 170 Ma

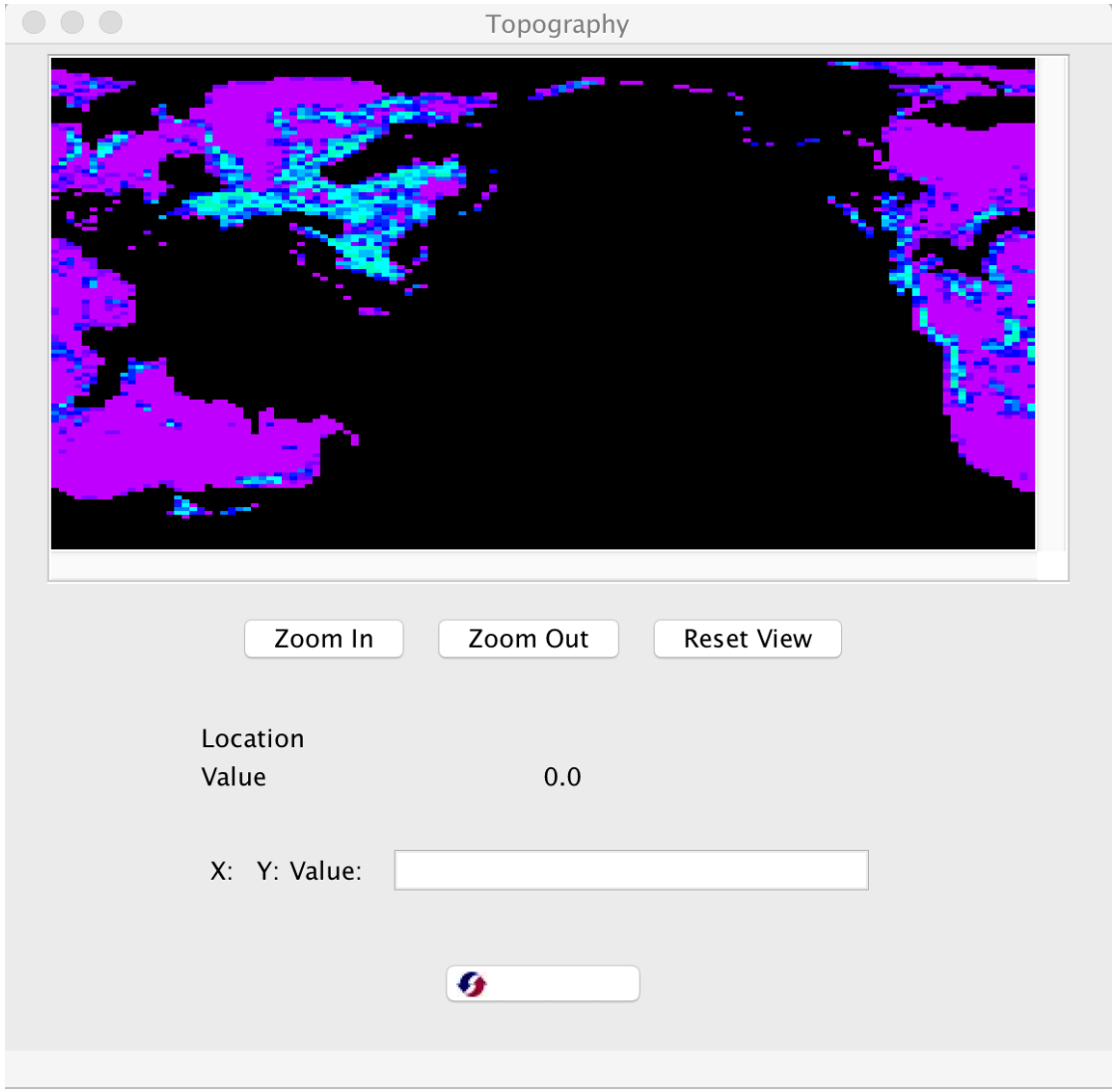


Ron Blakey, Colorado Plateau Geosystems

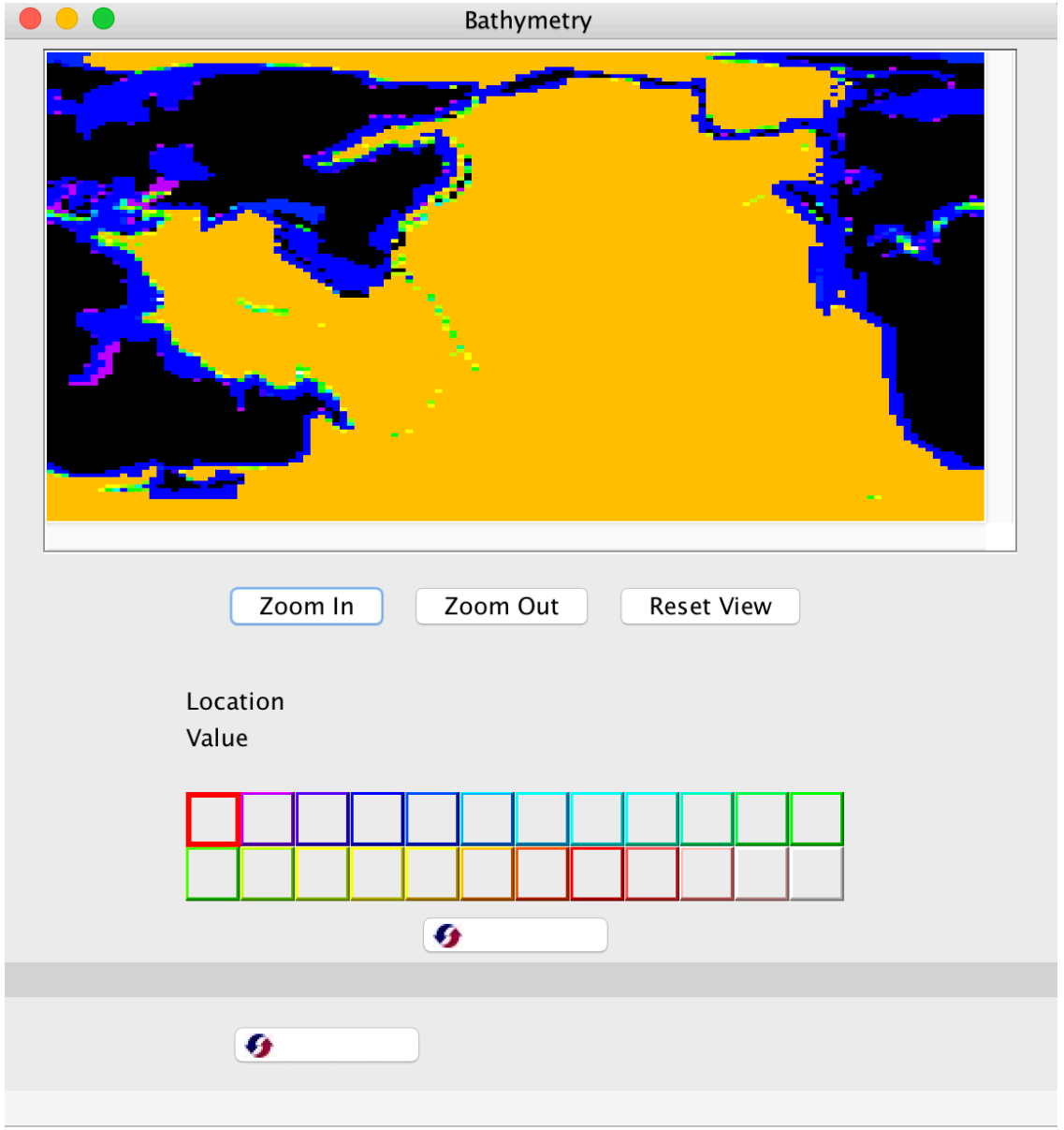
Put them through Slarti – the FOAM editor to form land/ocean masks



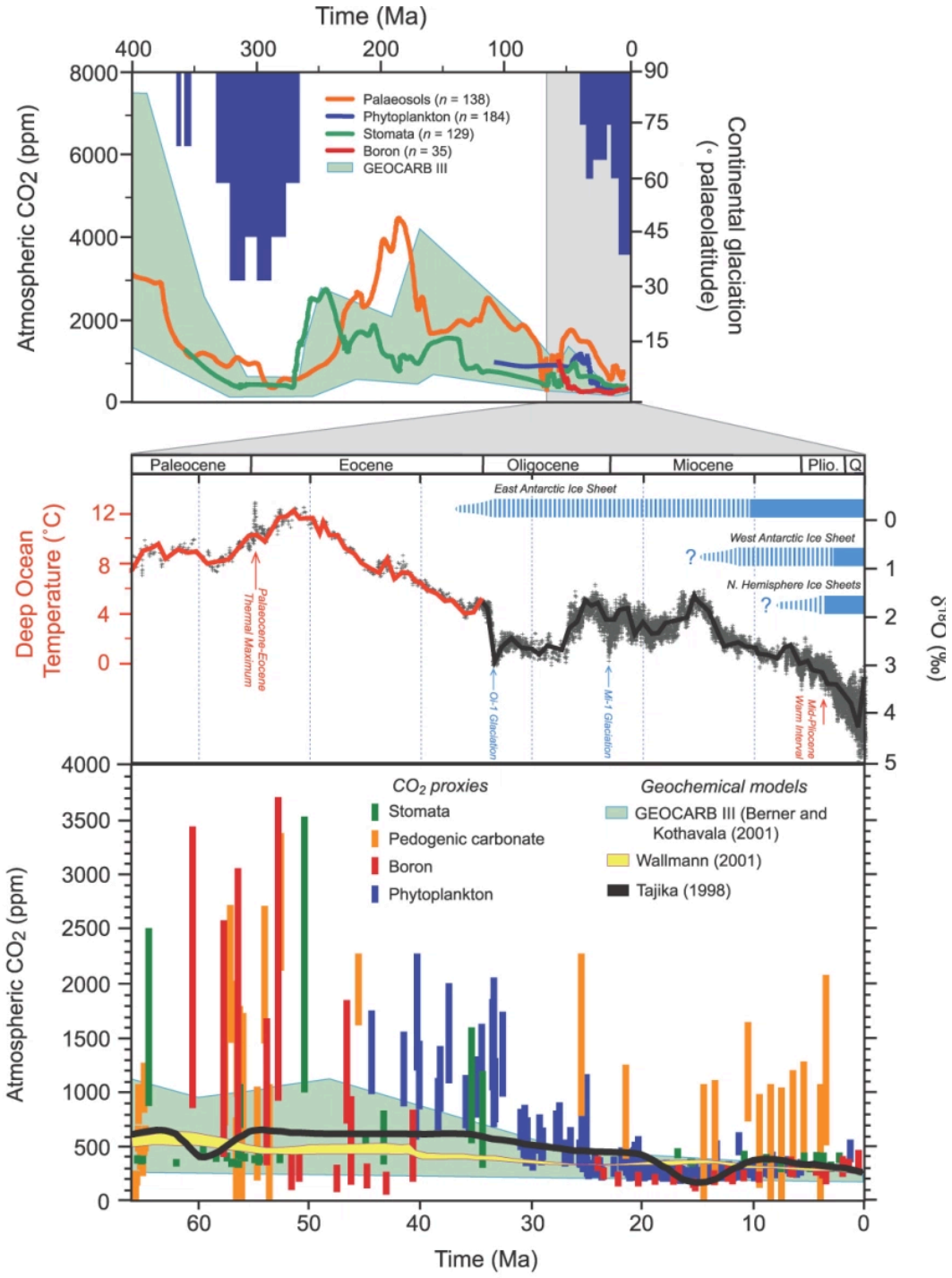
Estimate topography



Simplify bathymetry



Estimate GHGs



IPCC AR4

Run to equilibrium