Interdisciplinary Science

PA3019

Earth Through Time

University of Leicester

Contents

Welcome

The Earth Through Time module examines our planet in terms of its major systems; the atmosphere, hydrosphere, cryosphere, geosphere and the biosphere, all of which are constantly interacting. The module explores the topic of climate change throughout Earth's history; climate change is not just a contemporary phenomenon, it has happened in the geological past at times abruptly and catastrophically.

In order to understand climate change it is important to understand its history. Ice cores hold key evidence for the Quaternary climate record, whilst isotope and rock records contain relatively less well preserved data for the pre-Quaternary climate. You will also develop an understanding of simple and complex climate models and how they are used to simulate the past and current climate as well as predicting future climatic change.

Module Authors

Prof. Derek Raine, Dr Jörg Kaduk, Dr Jan Zalasiewicz

Problem Statement

Hot Air on Hot Air: Can Technology Fix Global Warming?

By Cameron Scott: July 17, 2007. (http://www.motherjones.com/news/outfront/2007/07/hot_air.html)

Can technology fix global warming? Scientists are starting to pitch some pretty far-out ideas, including these:

1. **PROPOSAL**: Use a fleet of blimps to pour up to 4 million tons of sulphur dioxide, which reflects solar radiation, into the stratosphere each year. **REALITY CHECK**: And you thought weather balloons messed with the UFO crowd.

2. **PROPOSAL**: Position 20 million tons of reflectors between Earth and the sun, 932,000 miles away.
   REALITY CHECK: International Space Station—just 240 miles away—will cost more than $100 billion.

3. **PROPOSAL**: Cover oceans with white Styrofoam beads. **REALITY CHECK**: Marine life and Styrofoam don't mix.

4. **PROPOSAL**: Put anti-gas drugs in cow feed to reduce burps laden with methane, a greenhouse gas 21 times more powerful than CO_2. **REALITY CHECK**: This is actually happening...in Scotland.

5. **PROPOSAL**: Launch fleet of solar-powered satellites that will transform sunlight into electric power to be delivered to Earth as microwaves or laser beams.
   REALITY CHECK: Everything after "solar-powered satellites" sounds really scary.

6. **PROPOSAL**: Cover large swaths of desert with giant sheets of plastic to reflect sunlight back into space.
   REALITY CHECK: Think Laura Palmer.

7. **PROPOSAL**: Send thousands of unmanned yachts to patrol globe and thicken marine clouds by whipping ocean with giant eggbeaters. **REALITY CHECK**: Think Exxon Valdez.

8. **PROPOSAL**: Use large artillery to shoot sulphate into the stratosphere to reflect sunlight and allow Arctic ice to thicken.
   REALITY CHECK: Beware the flight to Reykjavik.

9. **PROPOSAL**: Genetically engineer a creature that would metabolize carbon dioxide.
   REALITY CHECK: They're called trees.

10. **PROPOSAL**: Seed oceans with iron to stimulate growth of phytoplankton, microscopic organisms that convert CO_2 into organic matter. **REALITY CHECK**: Being tested, but other micro-creatures would likely eat phytoplankton and emit carbon, neutralizing effect.

11. **PROPOSAL**: Inject diatomaceous earth, the chalky stuff in cat litter, into the stratosphere above Arctic Circle.
REALITY CHECK: World beholden to Jonny Cat lobby.

Staff

Prof. Derek Raine	Physics
Dr Jörg Kaduk	Geography
Dr Jan Zalasiewicz	Geology

Learning Objectives

Earth Sciences

- Climatology: Evidence preserved within the ice and stratal record, and how to read it and interpret it.
- Geochemistry: Understanding the significance of variations in isotope ratios.
- Geography: Interaction of the various Earth systems.
- Feedback mechanisms and recovery back to a stable climate.
- Major warming events in the Earth's history (Paleocene-Eocene thermal maximum and the Toarcian event).
- Understand the role of mountain belts and ice coverage in climate change.
- Understand the role of methane hydrates; identify current methane hydrate reservoirs and their stability fields.
- Carbon emissions from a variety of sources.
- $\delta\ ^{13}C$ incursions.
- Milankovitch cycles.
- D-O and Heinrich events.
- The greenhouse effect; the link to fossil fuels compared to pre-industrial periods.

Biology

- Understand the chemical reactions involved in photosynthesis and the factors controlling them.
- Understand the importance of photosynthesis and the biosphere as an important carbon sink.
- Be aware of carbon capture and sequestration mechanisms.

Computing

- Programming: operate a simple climate model that allows alteration of key parameters to show a change in climate.
- Climate modelling: develop a basic/intermediate understanding of the climate modelling software *Ed*GCM. Using the software to simulate climate change.

Additional

- Understand what the Montreal protocol is, when it was signed and what the result was.
- Understand what the Kyoto agreement is, when it was signed, who signed it and who has yet to sign it.

Reading List

Websites

- http://www.ipcc.ch/
- http://www.snowballearth.org/
- *http://education.guardian.co.uk/academicexperts/page/0,1392,1360527,00.html* (Stratigraphy Commission of the Geological Society of London *Global warming: a perspective from earth history.*)
- http://www.biologie.uni-hamburg.de/b-online/e24/24b.htm
- http://homepage.mac.com/uriarte/carbon13.html
- http://wc.pima.edu/~bfiero/tucsonecology/plants/plants_photosynthesis.htm
- http://www.esd.ornl.gov/projects/qen/carbon1.html
- http://www.esd.ornl.gov/projects/qen/nerc.html
- http://www2.ocean.washington.edu/oc540/lec01-20/
- http://tracer.env.uea.ac.uk/esmg/papers/Lenton&Huntingford.pdf
- http://www2.ocean.washington.edu/oc540/lec01-28/
- http://www2.ocean.washington.edu/oc540/lec01-30/

Books

- *Climate Change: Observed Impacts on Planet Earth*. Elsevier.

Scientific Papers

The following may be of interest to you throughout this module:

Note: If you cannot gain access to some of these papers please talk to your facilitator or send a request to iscience@le.ac.uk; we may have them on file or be able to grant you access to them.

- Adams, J.M., et al (1990). *Increases in terrestrial carbon storage from the Last Glacial Maximum to the present*. Nature, **348,** pp 711-714.
- Allen P. A., & Hoffman P. F., (2005) *Extreme winds and waves in the aftermath of a Neoproterozoic glaciation.* Nature, **433,** pp 123-127.
- Alley, R.B. *et al* (2003) *Abrupt Climate Change.* Science, **299,** pp 2005-2010.
- Bard E., (2002) *Climate Shock: Abrupt Changes over Millennial Time Scale.* Physics Today, December.
- Berry, J.A. (1992) *Photosynthesis as a Process Shaping the Global Environment*. Photosynthesis Research, **34**, pp 82.

- Billups K., (2005) *Snow Maker for the Ice Ages*. Nature, **433**, pp 809.
- Blunier T., & Brook E. J., (2001) *Timing of Millennial-Scale Climate Change in Antarctica and Greenland During the last Glacial Period.* Science, **291,** pp 109-111.
- Brook E. J., (2005) *Tiny Bubbles Tell All.* Science, **310**, pp 1285–1286.
- Cohen A. S., et al, (2004) *Osmium Isotope Weathering for the Regulation of Atmospheric CO_2 by Continental Weathering.* Geology **32**, pp 157-160.
- Collatz, G.J., Ribascarbo, M. & Berry, J.A. (1992) *Coupled Photosynthesis-Stomatal Conductance Model For Leaves of C4 Plants*. Australian Journal of Plant Physiology, **19**, pp 519-538.
- Ehleringer J, Bjorkmann O (1977) *Quantum yields for CO_2 uptake in C3 and C4 plants.* Plant Physiol., **59**, pp 86-90.
- Farquhar, G.D., Caemmerer, S.V. & Berry, J.A. (1980) *A biochemical model of photosynthetic CO_2 assimilation in leaves of C3 species*. Planta, 149.
- Ganeshram R. S., (2002) *Oceanic action at a distance.* Nature, **419,** pp 123-125.
- Gribbin J., (1991) *Climate Now.* New Scientist, **44**, pp 1-4.
- Gribbin J., & Gribbin M (1996) *The Greenhouse Effect.* New Scientist, **92**, pp 1-4.
- Hanisch, C. (1998) *The Pros and Cons of Carbon Dioxide Dumping.* Environmental Science & Technology, **32**, 1.
- Haug G. H., et al (2005) *North Pacific seasonality and the Glaciations of North America 2.7 million years ago.* Nature, **433,** pp 821-825.
- Hepple, R.P & Benson, S.M. (2002) *Implications of surface seepage on the effectiveness of geologic storage of carbon dioxide as a climate change mitigation strategy* Earth Sciences Division, Lawrence Berkeley National Laboratory.
- Herzog, J.H. (2001) *What Future for Carbon Capture and Sequestration?* Environmental Science & Technology, **35**, 7, pp. 148–153.
- Holloway, S. (2001) *Storage of Fossil fuel-derived carbon dioxide beneath the surface of the earth.* Annu. Rev. Energy Environ. **26**, pp 145–66.
- Huxman, T. E. & R. K. Monson, (2003). *Stomatal responses of C3, C3-C4 and C4 Flaveria species to light and intercellular CO_2 concentration: implications for the evolution of stomatal behaviour*. Plant, Cell & Env., **26**.
- Hymus, G. J., (2002). *Acclimation of photosynthesis and respiration to elevated atmospheric CO_2 in two scrub oaks*. Global Change Biology, **8**, pp 317-328
- Jackson I., & Stone T., (1999) *Snowball Earth.* New Scientist, pp 29-33
- Kerr R. A., (2004) *Vicissitudes of Ancient Climate*. Science, **303**, pp 307.
- Kovscek A. R. (2002) *Screening criteria for CO_2 storage in oil reservoirs.* Petroleum science and technology, **20**, Nos. 7 & 8, pp. 841–866
- Lambers, H., Chappin, F.S. & Pons, T.L. (1998) *Plant Physiological Ecology*, J. of Agronomy and Crop Science, **184**, pp 143-144.
- Maherali, H. et al., (2003). *Stomatal sensitivity to vapour pressure difference over a subambient to elevated CO_2 gradient in a C3/C4 grassland*. Plant, Cell & Env., **26**, no. 8, pp 1297-1306.
- Medlyn, B.E., Loustau, D. & Delzon, S. (2002) *Temperature response of parameters of a biochemically based model of photosynthesis. I. Seasonal*

changes in mature maritime pine (Pinus pinaster Ait.) Plant, Cell and Environment, **25**, pp 1155-1165.

- Medlyn, B.E., et al (2002) *Temperature response of parameters of a biochemically based model of photosynthesis. II. A review of experimental data.* Plant, Cell and Environment, **25**, pp 1167-1179
- Lyons T. W., (2004) *Warm Debate on Early Climate*. Nature, **429**, pp 359-360.
- Schrag, D. P., & Alley R. B., (2004) *Ancient Lessons for Our Future Climate*. Science, **306**, pp 821-822.
- Schwarzschild B., (2001) *Isotopic Analysis of Pristine Microshells Resolves a Troubling Paradox of Paleoclimatology.* Physics Today, **54,** pp 16-18.
- Shackleton N., (2001) *Climate Change Across the Hemispheres.* Science, **291,** pp 58-59.
- Siegenthaler U., et al (2005) *Stable Carbon Cycle-Climate Relationship During the Late Pleistocene.* Science, **310,** pp 1313-1317.
- Spahni R., *et al* (2005) *Atmospheric Methane and Nitrous Oxide of the Late Pleistocene from Antarctic Ice Cores.* Science, **310,** pp 1317-1321.
- Takahashi, T., et al (2002). *Global sea-air CO_2 flux based on climatological surface ocean pCO_2, and seasonal biological and temperature effects*. Deep-Sea Res. Pt. II **49**, pp 1601-1622.
- Thomas D. J., et al, (2002) *Warming the Fuel for the Fire: Evidence for the Thermal Dissociation of Methane Hydrate During the Paleocene-Eocene Thermal Maximum.* Geology, **30**, pp 1067-1070.
- Walker, G (2004) *Frozen Time*. Nature, **429**.
- Zachos J. C., et al, (2003) *A Transient Rise in Tropical Sea Surface Temperature During the Paleocene-Eocene Thermal Maximum.* Science, **302**, pp 1551-1554.

A Guide to Module Pacing

Session	Preparation	Learning
FS01	Revise previous work on the environment from earlier modules.	Introduction to the Module and Problem Statement
ES01	Support for EdGCM software	
FS02	Allen P. A., & Hoffman P. F., (2005) Extreme winds and waves in the aftermath of a Neoproterozoic glaciation. Jackson I., & Stone T., (1999) Snowball Earth.	Snowball Earth
ES02	Support for EdGCM software	
ES03	Open discussion with Jan	
FS03	Cohen A. S., et al, (2004) Osmium Isotope Weathering for the Regulation of Atmospheric CO2 by Continental Weathering. Kerr R. A., (2004) Vicissitudes of Ancient Climate. Lyons T. W., (2004) Warm Debate on Early Climate. Schrag D. P., & Alley R. B., (2004) Ancient Lessons for Our Future Climate. Schwarzschild B., (2001) Isotopic Analysis of Pristine Microshells Resolves a Troubling Paradox of Paleoclimatology. Thomas D. J., et al, (2002) Warming the Fuel for the Fire: Evidence for the Thermal Dissociation of Methane Hydrate During the Paleocene-Eocene Thermal Maximum. Zachos J. C., et al, (2003) A Transient Rise in Tropical Sea Surface Temperature During the Paleocene-Eocene Thermal Maximum.	Severe Climate Disruptions: PETM and Toarcian Event
FS04	Alley, R.B. et al (2003) Abrupt Climate Change. Bard E., (2002) Climate Shock: Abrupt Changes over Millennial Time Scale. Billups K., (2005) Snow Maker for the Ice Ages. Blunier T., & Brook E. J., (2001) Timing of Millennial-Scale Climate Change in Antarctica and Greenland During the last Glacial Period. Brook E. J., (2005) Tiny Bubbles Tell All. Haug G. H., et al (2005) North Pacific seasonality and the Glaciations of North America 2.7 million years ago. Ganeshram R. S., (2002) Oceanic action at a distance. Gribbin J., (1991) Climate Now. Gribbin J., & Gribbin M (1996) The Greenhouse Effect. Shackleton N., (2001) Climate Change Across the Hemispheres. Siegenthaler U., et al (2005) Stable Carbon	Glaciation

	Cycle-Climate Relationship During the Late Pleistocene. Spahni R., et al (2005) Atmospheric Methane and Nitrous Oxide of the Late Pleistocene from Antarctic Ice Cores. Walker, G (2004) Frozen Time.	
ES04	Open discussion with Jan	
FS05	Gribbin J., (1991) Climate Now. Gribbin J., & Gribbin M (1996) The Greenhouse Effect.	Global warming – human effects
FS06	Gribbin J., (1991) Climate Now. Gribbin J., & Gribbin M (1996) The Greenhouse Effect.	Global warming – natural cycles
ES05	Open discussion with Joerg	
FS07	You will be expected to discuss your own research.	Consolidate work on deliverables
FS08	You will be expected to discuss your own research.	Consolidate work on deliverables
ES06	Open discussion with Jan	
FS09	Revise previous work on photosynthesis from earlier modules. Berry, J.A. (1992) Photosynthesis as a Process Shaping the Global Environment. Collatz, G.J., Ribascarbo, M. & Berry, J.A. (1992) Coupled Photosynthesis-Stomatal Conductance Model For Leaves of C4 Plants. Ehleringer J, Bjorkmann O (1977) Quantum yields for CO2 uptake in C3 and C4 plants. Farquhar, G.D., Caemmerer, S.V. & Berry, J.A. (1980) A biochemical model of photosynthetic CO2 assimilation in leaves of C3 species. Huxman, T. E. & R. K. Monson, (2003). Stomatal responses of C3, C3-C4 and C4 Flaveria species to light and intercellular CO2 concentration: implications for the evolution of stomatal behaviour. Hymus, G. J., (2002). Acclimation of photosynthesis and respiration to elevated atmospheric CO2 in two scrub oaks. Lambers, H., Chappin, F.S. & Pons, T.L. (1998) Plant Physiological Ecology. Maherali, H. et al., (2003). Stomatal sensitivity to vapour pressure difference over a subambient to elevated CO2 gradient in a C3/C4 grassland. Medlyn, B.E., Loustau, D. & Delzon, S. (2002) Temperature response of parameters of a biochemically based model of photosynthesis. I. Seasonal changes in mature maritime pine (Pinus pinaster Ait.) Medlyn, B.E., et al (2002) Temperature response of parameters of a biochemically based model of photosynthesis. II. A review of experimental data.	Photosynthesis C3 & C4 plants Cam adaptation

ES07	Open discussion with Joerg	
FS10	You will be expected to discuss your own research.	Box models Field trip preparation
ES08	Open discussion with Joerg	
Field Trip	Stratification	
FS11	You will be expected to discuss your own research.	Box models
ES09	Open discussion with Joerg	
FS12	Revise previous work on the carbon cycle from earlier modules. The following papers may be useful: Kovscek A. R. (2002) Screening criteria for CO2 storage in oil reservoirs. Hepple, R.P & Benson, S.M. (2002) Implications of surface seepage on the effectiveness of geologic storage of carbon dioxide as a climate change mitigation strategy. Herzog, J.H. (2001) What Future for Carbon Capture and Sequestration? Holloway, S. (2001) Storage of Fossil fuel-derived carbon dioxide beneath the surface of the earth. Hanisch, C. (1998) The Pros and Cons of Carbon Dioxide Dumping.	Carbon cycle Carbon sequestration
ES10	Open discussion with Jan	
FS13	You will be expected to discuss your own research.	Continue to work on the deliverables
FS14	You will be expected to discuss your own research.	Continue to work on the deliverables

Facilitation Sessions

Facilitation Session 01

Pre Session Preparation

Revise previous work on the environment from earlier modules.

Introduction to Module

An introduction to the module as a whole with a brief overview of the various topics that will be covered over the following weeks. The Problem Statement and deliverables will be introduced and initial thoughts will be discussed as a class.

Group Discussion: Problem Statement

In your groups read through the problem statement and highlight the important terms/phrases. Locate useful triggers within the document that will help you to start planning your responses to the deliverables.

Facilitation Session 02

Pre Session Preparation

The following papers may be useful:

- Allen P. A., & Hoffman P. F., (2005) *Extreme winds and waves in the aftermath of a Neoproterozoic glaciation.* Nature, **433,** pp 123-127.
- Jackson I., & Stone T., (1999) *Snowball Earth.* New Scientist, pp 29-33

Group Discussion: Snowball Earth

Within your groups discuss the topic of Snowball Earth using the following questions as a starting point:

- What is it?
- What were the contributing factors/ what was it caused by?
- What happened during this event?
- What evidence do we have for it?
- Is it possible to simulate this event using the EdGCM software?

If you attempt to simulate this event using the EdGCM software consider the following:

- What happens when ice sheets are added/lost?
- What happens during tectonic uplift (i.e. more mountains are present)?

Throughout this discussion you should make sure you understand the concepts being discussed as well as considering how this topic ties into the module deliverables.

Facilitation Session 03

Pre Session Preparation

The following papers may be useful:

- Cohen A. S., et al, (2004) *Osmium Isotope Weathering for the Regulation of Atmospheric CO_2 by Continental Weathering.* Geology **32**, pp 157-160.
- Kerr R. A., (2004) *Vicissitudes of Ancient Climate*. Science, **303**, pp 307.
- Lyons T. W., (2004) *Warm Debate on Early Climate*. Nature, **429**, pp 359-360.
- Schrag D. P., & Alley R. B., (2004) *Ancient Lessons for Our Future Climate*. Science, **306**, pp 821-822.
- Schwarzschild B., (2001) *Isotopic Analysis of Pristine Microshells Resolves a Troubling Paradox of Paleoclimatology.* Physics Today, **54,** pp 16-18.
- Thomas D. J., et al, (2002) *Warming the Fuel for the Fire: Evidence for the Thermal Dissociation of Methane Hydrate During the Paleocene-Eocene Thermal Maximum.* Geology, **30**, pp 1067-1070.
- Zachos J. C., et al, (2003) *A Transient Rise in Tropical Sea Surface Temperature During the Paleocene-Eocene Thermal Maximum.* Science, **302**, pp 1551-1554.

Group Discussion: Severe Climate Disruptions

Within your groups discuss the topic of Severe Climate Disruptions paying particular attention to the “Paleocene-Eocene thermal maximum” and the “Toarcian Event”. Summarise these events (and any other notable events) and assess the likely occurrence of a repeat event. Are there any parallels with the current output of fossil fuel emissions?

Throughout this discussion you should make sure you understand the concepts being discussed as well as considering how this topic ties into the module deliverables.

Facilitation Session 04

Pre Session Preparation

The following papers may be useful:

- Alley, R.B. *et al* (2003) *Abrupt Climate Change.* Science, **299,** pp 2005-2010.
- Bard E., (2002) *Climate Shock: Abrupt Changes over Millennial Time Scale.* Physics Today, December.
- Billups K., (2005) *Snow Maker for the Ice Ages*. Nature, **433**, pp 809.
- Blunier T., & Brook E. J., (2001) *Timing of Millennial-Scale Climate Change in Antarctica and Greenland During the last Glacial Period.* Science, **291,** pp 109-111.
- Brook E. J., (2005) *Tiny Bubbles Tell All.* Science, **310**, pp 1285–1286.
- Haug G. H., et al (2005) *North Pacific seasonality and the Glaciations of North America 2.7 million years ago.* Nature, **433,** pp 821-825.
- Ganeshram R. S., (2002) *Oceanic action at a distance.* Nature, **419,** pp 123-125.
- Gribbin J., (1991) *Climate Now.* New Scientist, **44**, pp 1-4.
- Gribbin J., & Gribbin M (1996) *The Greenhouse Effect.* New Scientist, **92**, pp 1-4.
- Shackleton N., (2001) *Climate Change Across the Hemispheres.* Science, **291,** pp 58-59.
- Siegenthaler U., et al (2005) *Stable Carbon Cycle-Climate Relationship During the Late Pleistocene.* Science, **310,** pp 1313-1317.
- Spahni R., *et al* (2005) *Atmospheric Methane and Nitrous Oxide of the Late Pleistocene from Antarctic Ice Cores.* Science, **310,** pp 1317-1321.
- Walker, G (2004) *Frozen Time*. Nature, **429**.

Group Discussion: Glaciation

Within your groups discuss the topic of Glaciation and its cyclic nature. What processes are important for glaciation and which factors are the most important in the onset of such periods? Throughout this discussion you should make sure you understand the concepts being discussed as well as considering how this topic ties into the module deliverables.

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Facilitation Session 05

Pre Session Preparation

The following papers may be useful:

- Gribbin J., (1991) *Climate Now.* New Scientist, **44**, pp 1-4.
- Gribbin J., & Gribbin M (1996) *The Greenhouse Effect.* New Scientist, **92**, pp 1-4.

Group Discussion: Global Warming – Human Effects

Within your groups discuss the topic of Global Warming paying special attention to the effect that humans are having on the environment; natural cycles of warming and cooling will be considered in the next session. This is a contentious issue and care must be taken to extract solid scientific theories from media distortion.

You may like to consider the following questions:

- What is the Greenhouse Effect and what likely changes will it bring about to the global climate?
- How could international treaties, such as the Kyoto Agreement and Montreal Protocol, affect his phenomenon?

Throughout this discussion you should make sure you understand the concepts being discussed as well as considering how this topic ties into the module deliverables.

Facilitation Session 06

Pre Session Preparation

The following papers may be useful:

- Gribbin J., (1991) *Climate Now.* New Scientist, **44**, pp 1-4.
- Gribbin J., & Gribbin M (1996) *The Greenhouse Effect.* New Scientist, **92**, pp 1-4.

Group Discussion: Global Warming – Natural Cycles

Within your groups discuss the topic of Global Warming paying special attention to natural cycles of warming and cooling.

You may like to consider the following questions:

- What is the Quaternary climate and how has it changed over time?
- Are there any natural cycles that cause the global climate to change over time?

Throughout this discussion you should make sure you understand the concepts being discussed as well as considering how this topic ties into the module deliverables.

Facilitation Session 07

Pre Session Preparation

Continue with your own research.

Group Work: Deliverables

Within you groups work on your deliverables, consolidating all of the information you have researched so far. Ideally by this stage of the module you should have at least a draft outline for the whole series of vidcasts with a good overall idea of the theme and narrative pacing.

You should be starting to consider which of the vidcasts you wish to develop in more detail; by the next facilitation session you should have a more detailed plan (still in note form) for this session.

Facilitation Session 08

Pre Session Preparation

Continue with your own research.

Group Work: Deliverables

In this session you should continue working on your deliverables. It is advised that you work on the vidcast episode that you intend to produce by fleshing out the plan you produced in the previous facilitation session. What materials are you going to include? (Animations, narrative, images, simulations etc). What additional topics do you need to research?

Facilitation Session 09

Pre Session Preparation

Revise previous work on photosynthesis from earlier modules.

The following papers may be useful:

- Berry, J.A. (1992) *Photosynthesis as a Process Shaping the Global Environment*. Photosynthesis Research, **34**, pp 82.
- Collatz, G.J., Ribascarbo, M. & Berry, J.A. (1992) *Coupled Photosynthesis-Stomatal Conductance Model For Leaves of C4 Plants*. Australian Journal of Plant Physiology, **19**, pp 519-538.
- Ehleringer J, Bjorkmann O (1977) *Quantum yields for CO_2 uptake in C3 and C4 plants.* Plant Physiol., **59**, pp 86-90.
- Farquhar, G.D., Caemmerer, S.V. & Berry, J.A. (1980) *A biochemical model of photosynthetic CO_2 assimilation in leaves of C3 species*. Planta, 149.
- Huxman, T. E. & R. K. Monson, (2003). *Stomatal responses of C3, C3-C4 and C4 Flaveria species to light and intercellular CO_2 concentration: implications for the evolution of stomatal behaviour*. Plant, Cell & Env., **26**.
- Hymus, G. J., (2002). *Acclimation of photosynthesis and respiration to elevated atmospheric CO_2 in two scrub oaks*. Global Change Biology, **8**, pp 317-328
- Lambers, H., Chappin, F.S. & Pons, T.L. (1998) *Plant Physiological Ecology*, J. of Agronomy and Crop Science, **184**, pp 143-144.
- Maherali, H. et al., (2003). *Stomatal sensitivity to vapour pressure difference over a subambient to elevated CO_2 gradient in a C3/C4 grassland*. Plant, Cell & Env., **26**, no. 8, pp 1297-1306.
- Medlyn, B.E., Loustau, D.& Delzon, S. (2002) *Temperature response of parameters of a biochemically based model of photosynthesis. I. Seasonal changes in mature maritime pine (Pinus pinaster Ait.)* Plant, Cell and Environment, **25**, pp 1155-1165.
- Medlyn, B.E., et al (2002) *Temperature response of parameters of a biochemically based model of photosynthesis. II. A review of experimental data.* Plant, Cell and Environment, **25**, pp 1167-1179

Group Discussion: Photosynthesis

Within your groups discuss the topic of Photosynthesis. You may like to consider the following questions:

- How does the rate of photosynthesis change with temperature?
- What other factors contribute to the rate of photosynthesis?
- What was the rate of photosynthesis in the last glacial maximum; what is it now?
- What are C_3 and C_4 plants?
- What is CAM and how does it relate to photosynthesis?

Throughout this discussion you should make sure you understand the concepts being discussed as well as considering how this topic ties into the module deliverables.

Facilitation Session 10

Pre Session Preparation

Continue with your own research.

Group Discussion: Modelling Climate Change

Climate change is modelled in a variety of ways; you have already encountered the EdGCM software. What other methods of modelling are available? Specifically what are Box Models and how are they used? What are the drawbacks of various different methods of climate modelling?

Throughout this discussion you should make sure you understand the concepts being discussed as well as considering how this topic ties into the module deliverables.

Group Discussion: Field Trip

Prepare for the field trip by researching the site you will be visiting and make sure that you are familiar with the Health and Safety aspects of University Fields trips; see your Laboratory Safety Handbook.

Facilitation Session 11

Pre Session Preparation

Continue with your own research.

Group Work: Box Models

Within your group use Box Models to explore climate change. These models should provide useful information for your deliverables.

Facilitation Session 12

Pre Session Preparation

Revise previous work on the carbon cycle from earlier modules.

The following papers may be useful:

- Kovscek A. R. (2002) *Screening criteria for CO_2 storage in oil reservoirs.* Petroleum science and technology, **20**, Nos. 7 & 8, pp. 841–866
- Hepple, R.P & Benson, S.M. (2002) *Implications of surface seepage on the effectiveness of geologic storage of carbon dioxide as a climate change mitigation strategy* Earth Sciences Division, Lawrence Berkeley National Laboratory.
- Herzog, J.H. (2001) *What Future for Carbon Capture and Sequestration?* Environmental Science & Technology, **35**, 7, pp. 148–153.
- Holloway, S. (2001) *Storage of Fossil fuel-derived carbon dioxide beneath the surface of the earth.* Annu. Rev. Energy Environ. **26**, pp 145–66.
- Hanisch, C. (1998) *The Pros and Cons of Carbon Dioxide Dumping.* Environmental Science & Technology, **32**, 1.

Class Discussion: Field Trip

As a class discuss the field trip. What did you learn? How can you usefully tie your experiences and results into your deliverables? Did the trip raise any interesting questions?

Group Discussion: Carbon Cycle and Sequestration

Within your groups discuss the topic of the carbon cycle and carbon sequestration. You may like to consider the following questions:

- What are the major natural carbon sources/sinks?
- What are the major man-made/influenced carbon sources?
- What is carbon sequestration?
- Can you find any modern case studies of carbon sequestration? Could similar projects be carried out in the UK?

Facilitation Session 13

Pre Session Preparation

Continue with your own research.

Group Work: Deliverables

In this session you should continue working on your deliverables.

Facilitation Session 14

Pre Session Preparation

Continue with your own research.

Group Work: Deliverables

In this session you should continue working on your deliverables.

Deliverables

Please name your deliverables in accordance with the standard naming convention (see the handbook for details). A sample filename is provided for you to cut and paste - please complete with submission date and username/group letter as appropriate.

All deliverables to be submitted to iscience@le.ac.uk

Please note that although deliverable deadlines (except for CLEs) are at the end of the module, you are strongly urged not to leave all work on the deliverables until the final weekend! In particular, if you would like formative feedback on your works-in-progress from your facilitator and/or experts, please provide them with draft copies in good time.

DELIVERABLES	TYPE	FILENAME	DUE	WEIGHTING
CLE01:	I	PA3019_I_CLE01_*username_date*.pdf	Week 2, Day 1	30%
CLE02:	I	PA3019_I_CLE02_*username_date*.pdf	Week 3, Day 1	
CLE03:	I	PA3019_I_CLE03_*username_date*.pdf	Week 4, Day 1	
CLE04:	I	PA3019_I_CLE04_*username_date*.pdf	Week 5, Day 1	
D01: Vidcast Series Outline	G	PA3019_G_D01_SeriesOutline_*groupletter_date*.pdf	Week 5, Day 2	20%
D02: Support Pack	G	PA3019_G_ D02_SupportPack_*groupletter_date*.pdf	Week 5, Day 2	20%
D03: Vidcast Episode	G	PA3019_G_ D03_Vidcast_*groupletter_date*	Week 5, Day 3	30%

Core Learning Exercise 01

Snowball Earth

1. What is “Snowball Earth”? [5]

2. When did “Snowball Earth” occur? [2]

3. What caused “Snowball Earth”? [5]

4. What is the evidence for this climatic event? [20]

5. What is the evidence against “Snowball Earth”? [20]

6. What is the effect of mountains and ice on the climate? [10]

Paleocene-Eocene thermal maximum

7. a) When did the Paleocene-Eocene thermal maximum event occur? [1]
   b) What is the evidence for this event? [2]
   c) What does the nature of this evidence suggest? [2]

8. What was the nature of the biotic response to the Paleocene-Eocene thermal maximum? [5]

9. How much did the surface sea and the deep-sea temperature rise by?[2]

10. What might have caused the isotope excursion? [5]

Core Learning Exercise 02

1. What is a methane hydrate? [5]

2. How are methane hydrates destabilised? [5]

3. What is the main source of evidence for the Quaternary Climate change, and how many years are recorded? [5]

4. Climate changes occurs in cycles; what are the cycles? [15]

Core Learning Exercise 03

1. What is the structural difference between C_3 and C_4 plants? [5]

2. Which type of plant would be more advantageous at high light intensity and high temperature? [5]

3. Why are C_3 plants adapted to low temperature conditions? [5]

4. What are CAM plants and why are they so successful with extreme conditions? [10]

Core Learning Exercise 04

1. What is the evidence that links burning fossil fuels and climate change? [10]

2. What is a natural sink? Which natural sinks remove carbon? [5]

Deliverable 01: Vidcast Series Outline

Within your group produce an outline plan for a series of 5 vidcasts discussing the important issues covered within this module. The series should be suitable for hosting on a University UTunes channel, with episodes that should be between 5-10 minutes long.

The plan for each vidcast should be approximately one side of A4. You should include notes on the topics you would discuss, any animations/images you would use to illustrate your points and any significant conclusions or arguments you would put across. It must be more than a series of bullet points. You are not expected to produce a full script for each vidcast.

In addition you need to provide an outline plan of supporting materials that go with each vidcast in the series; the plan for each set of supporting materials should be approximately one side of A4.

Deliverable 02: Support Pack

For the vidcast you have chosen in Deliverable 02 produce the supporting material for it. These materials should cover ~5 sides of A4 and should be accessible to a range of age groups (GCSE students, A-Level students and undergraduates).

Deliverable 03: Vidcast Episode

Pick one of vidcasts in the series you have outlined and create it. The episode should be between 5-10 minutes long, depending on the number of animations you use.

The video may be created in any software you like; however, the AV suite and software will be made available for your use during this module. If you choose to use alternative equipment/software please submit the vidcast in a format that can be view on a standard Windows operating system (.mp4, .wmv, .flv etc).

Meta tags

Author: Kaduk, J.; Raine, D.; Zalasiewicz, J.

Owner: University of Leicester

Title: Interdisciplinary Science Earth Through Time Student Document

Classification: PA3019 / Earth Through Time

Keywords: Earth Sciences; Geology; Geography; Problem-Based Learning; Systems; sfsoer; ukoer

Description: The Earth Through Time module examines our planet in terms of its major systems; the atmosphere, hydrosphere, cryosphere, geosphere and the biosphere, all of which are constantly interacting. The module explores the topic of climate change throughout Earth's history; climate change is not just a contemporary phenomenon, it has happened in the geological past at times abruptly and catastrophically.

Language: English

File Size: 1.9MB

File Format: PDF

Version: 1.0

Additional Information

This module pack is the open student version of the teaching material. An expanded module pack for facilitators and additional information can be obtained by contacting the Centre for Interdisciplinary Science at the University of Leicester. http://www.le.ac.uk/iscience

This pack is the Version 1.0 release of the module.