United Nations Educational, Scientific and Cultural Organization

Earth science education initiative in Africa.

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for tomorrow

GIFT AFRICA

Geosciences Information for Teachers

Climate Change and Human Adaptation

February 26-28th 2014

African Earth Observatory Network
Nelson Mandela Metropolitan University
Port Elizabeth
South Africa

A UNESCO-EGU-ESA collaboration

Introduction

Dear Teachers,

Welcome to the first 2014 UNESCO-EGU-ESA GIFT Africa workshop on Climate Change and Human Adaptation in the framework of Global Change and the publication of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)!

Numerous geological, geophysical and geochemical data acquired over many years have documented that, on geological time-scales, the Earth has continuously undergone large changes. We know that continents have widely moved (plate tectonics), that the chemistry of the atmosphere has changed, that the climate of the Earth has undergone hot and cold periods (even that the Earth has been so cold at some points that the term "Snowball Earth" has been used). The term natural variability is employed to refer to the continuous evolution of our planet.

A new trend in variability has been progressively documented for the last 100-150 years of the Earth's history, since the industrial revolution. Many studies have demonstrated that new factors of anthropogenic origin are starting to govern the environment of the Earth's outer shells, i.e. precisely those where we live. A main, impressive characteristic of these environmental new factors is that changes are occurring at a rate and reach values unprecedented in the Earth's history, to the point that the term "Anthropocene" has been proposed for this new era of the Earth's history. The IPCC's most recent assessment states unequivocally that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

Although Africa has made the smallest continental contribution to the carbon dioxide emissions at the root of this climate change, it is predicted to suffer the severest consequences. The impacts humans may experience in southern Africa range from unusual heat extremes to changing rainfall and water availability to agricultural impacts to shifting terrestrial ecosystem ranges to rising sea-level. The last IPCC report indicated that the climate of Africa is likely to warm more than other parts of the world during this century. Southern Africa occupies a unique geographic position that has played a significant role on the climate of the region which in turn has determined patterns of human evolution and settlement throughout the region. The Agulhas and Benguela currents come together at this southern-most tip of the African climate, driving climate patterns linked to oceanic currents and sea surface temperature, and hosting the tiny fynbos biome. Although changing environments have been drivers of human evolution in the region in the past, the current anthropogenic changes taking places at unprecedented rates will put a major strain on southern African's lifestyles and challenge their ability to adapt.

Given the major importance for human kind, the continuation of so-called "climate skeptics" and the publication of the most recent IPCC report, there is no doubt that these questions will be discussed worldwide, in all media. Therefore, teachers must be provided with sound scientific information in order to answer the questions that, invariably, they will have from their students.

We would like to continue to offer teachers the opportunity to attend GIFT and similar workshops, but this depends upon us being able to show our sponsors that teachers have used what they have learnt at the GIFT workshops in their daily teaching, or as inspiration for new ways to teach science in their schools. Therefore, we would ask you to:

Introduction

1. Fill out the evaluation forms as soon as possible and send them back to us,
2. Make a presentation of your experiences at GIFT to a group of your teaching colleagues soon after you return and
3. Send us reports and photographs about how you have used the GIFT information in your classrooms.

We also encourage you to write reports on the GIFT workshop in publications specifically intended for géosciences teachers.

Information on past and future GIFT workshops are available on the EGU homepage. Go to http://www.egu.eu/media-outreach/gift/gift-workshops.html where you can find brochures (pdf) and also the slides of the different presentations given at the GIFT workshops for the last 8 years. Beginning in 2009, we have also included web-TV presentations, which may be freely used in your classrooms. You can find these at http://www.egu.eu/outreach/egu-tv/.

We hope you enjoy the workshop and your stay in Port Elizabeth!

Carlo Laj
On behalf of the European Geosciences Union Committee on Education

Sarah Gaines
On behalf of UNESCO

Moctar Doucouré
On behalf of AEON-ESSRI (Africa Earth Observatory Network - Earth Stewardship Science Research Institute) and Nelson Mandela Metropolitan University

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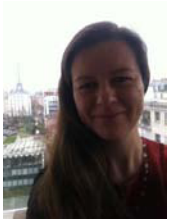

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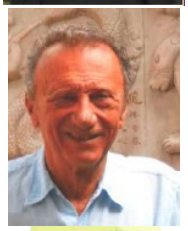

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Programme

UNESCO-EGU-ESA GIFT workshop: Climate change and human adaptation
AEON-ESSRI, Nelson Mandela Metropolitan University
Port Elizabeth, South Africa
26-28 February 2014
Missionvale Conference Centre

Tuesday, 25 Feb

19:00	Icebreaker sponsored by EGU

Wednesday, 26 Feb

9:00-9:15	Welcome from Prof Thoko Mayekiso, Deputy Vice-Chancellor for Research & Engagement, NMMU
9:15-9:30	Greeting from UNESCO and EGU
9:30-9:45	Introduction to the workshop (Moctar Doucouré)
9:45-10:30	Importance of the Geologic perspective for understanding Climate Change (Maarten de Wit)
10:30-11:00	Coffee break
11:00-11:45	The position of Southern Africa in Global Climate Change (Guy Midgely)
11:45-12:30	A space perspective on Climate Change (Michel Verstraete)
12:30-13:30	Lunch
13:30-15:00	Fossil Fuels are they just Dinosaurs? Hands-on teaching practical (Ian McKay)
15:00-15:30	Coffee break
15:30-16:30	Teaching practical continued
16:30-17:00	Discussion panel of day

Thursday, 27 Feb

9:00-9:45	How does climate change affect me? (Carl Palmer)
9:45-10:30	Agriculture (Bernard Seguin)
10:30-11:00	Coffee break
11:00-11:45	Water (Roland Schulze)
11:45-12:15	Educational programmes at the European Geosciences Union (Carlo Laj)
12.15-12.30	An introduction to UNESCO programmes (Sarah Gaines)
12:30-13:30	Lunch
13:30-14:15	Ocean changes – acidification and sea level rise (Jean-Pierre Gattuso)
14:15-15:00	Hands-on teaching practical (Sally Soria Dengg)
15:00-15:30	Coffee break
15:30-16:30	Teaching practical continued
16:30-17:00	Discussion panel of day

19:00	Workshop Dinner sponsored by AEON-ESSRI

Programme

Friday, 28 Feb

9:00-9:45	SA approaches to teaching about climate change (Rob O Donoghue)
9:45-10:30	ACCESS Habitable Planet workshop game – The World Challenge Game (Carl Palmer)
10:30-11:00	Coffee break
11:00-12:30	Hands-on teaching practical (Sally Soria Dengg)
12:30-13:30	Lunch
13:30-15:00	Screening of film 'Thin Ice'
15:00-15:30	Coffee break
15:30-16:00	Discussion of film (moderated by Maarten de Wit)
16:00-17:00	Closure and feedback on Workshop

Maarten de Wit

I was born in Holland (1947), went to school in Holland and Ireland, and completed my BSc/MA in Ireland (Trinity College, Dublin), my PhD in England (Cambridge University), and a postdoctorate at the Lamont Doherty Earth Observatory, Columbia University, USA.

Since 1976, I have held posts with the United Nations in Ethiopia; the Bernard Price Institute of Geophysics, University of the Witwatersrand, South Africa; the Lunar & Planetary Institute, NASA, Houston, USA; Queens University, Canada (where I was awarded an honorary DSc in 1993); Imperial College, London; EAPS MIT, USA; University of Utrecht, Holland; GFZ-Potsdam, Germany; the IPGP-Paris, France; and for 22 years I occupied the Philipson Stow Chair of Geology and Mineralogy at the University of Cape Town, South Africa. Presently I hold a personal chair of Earth Stewardship Science at the Nelson Mandela Metropolitan University in Port Elizabeth. I am the Founding Director of AEON (Africa Earth Observatory Network), a trans-disciplinary research institute (www.aeon.org.za).

My scientific interests lie in complex systems, how the Earth works (particular in its youthful stage); in global tectonics; the evolution of Africa and Gondwana; the origin of continents, life and mineral resources; and in the economics of natural-resources, sharing of the 'commons', and intergenerational equity. I love teaching and interactions with students and have mentored/supervised 67 thesis-based postgraduate students (PhD, MSc)

I have carried out extensive fieldwork in North and South America, Europe, Antarctica, and throughout Africa. I am a founding member of the South Africa Academy of Science; chaired the South African National Committee of IYPE (International Year of Planet Earth); and was a member of the International Continental Drilling Program's Scientific Advisory Board 2007-2012. I serve actively on the editorial boards of 5 international journals. I am an Honory Fellow of the Geological Society of America, and of the Geological Society of London, and serve on the Council of the American Geophysical Union, AGU.

Abstract

Teaching and inculcating *Iphakade* - Earth Stewardship Science using concepts of adaptation and mitigation with a 2020 vision

Maarten de Wit
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Iphakade is an African - isiXhosa - word meaning 'observe the present and consider the past to ponder the future'. Earth Stewardship Science is a close but not synonymous new world equivalent.*

The aim of Earth Stewardship Science (ESS) is to improve engagement, preparedness and motivation: to enable student understanding of being a learner and critical thinker in the 21st century; to promote increased motivation for self-driven engagement and learning; to create spaces for different ways of knowing and doing that are critical to young people; and to explore the essence of consilience – unity of knowledge – and its importance for Africa.

Virtually all of Africa - and the world's - most urgent problems require collective, integrative action – be it environmental protection, energy needs, infrastructure, food security, financial system overhaul, consumer culture, run-away inequality, well-being, data-overload, transition to knowledge-based living or global governance. So, how do we best engage our students to address these increasingly complex problems?

We now live in the Anthropocene Era. We are still only beginning to comprehend how much radical re-thinking we will need to understand the forces with which we are shaping and transforming the planet and how to best to manage them. The scale of the forces ithis time are planetary, the time scale spanning a century or more, the stakes are what we might call civilization and it is all taking place at the headlong speed of self-accelerating human need, greed, technology and environmental turbulence. And it is not the Earth, nor life, but humans that are in trouble, as although we may know what things cost, we mostly have no idea what they are worth.

We need a new holistic approach to stimulate bottom-up inquisitiveness, self-motivation, creativity, knowledge retention and responsibility of learners without compromising their analytical and practical skills. We must therefore challenge teachers to acknowledge the technical, social and environmental challenges young people will face in the next 50 years:

- Demand for their new knowledge and skills will vastly outpace our capacity to teach them
- Half-lives of their skills are shrinking
- There's a difference between knowledge and 'skills', they should take note of it
- Mass unemployment to them seems endemic

Abstract

- Employers will not take on their labour as an act of charity
- Their collective purposes will contain competing objectives
- Their development will be linked to an exponential knowledge-curve based on creativity-technology
- Their communication systems, language and art-forms will metamorphose faster than ours
- Their environments will be metastable

We therefore require education that will excite and inspire learners. At the same time, we need to give all students a coherent view of the processes driving and accelerating changes so that they can tackle interactive and dynamic issues in their own lives and communities before they reach an uncontrollable disequilibrium - for issues such as health, safety and security, inequality and environmental degradation.

We will explore the essence of ESS and how to best inculcate it in a modern school and university curriculum using examples of adaption and mitigation.

*Earth Stewardship – ethical, democratic management of the physical and living systems of our planet. 'Science' is used here in the broadest sense of the word, covering all fields of scientific enquiry: a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions across the natural, social, health and engineering sciences; a body of knowledge of the type that can be rationally explained and reliably applied. Earth Stewardship Science is a new, broad intellectual field in tune with contemporary global perspectives of the world and its complexities; it provides a far broader focus of study than that of 'Climate Change', 'Sustainability Science', 'Development Studies' or 'Earth Systems Science'. Its consilience approach seeks a deeper understanding of people and planet issues of both local and global significance. ESS has the potential to make a major impact on the way Africa manages its resources, how it responds to the many pressures on diversity, environment, and society and how it relates to poverty and well-being.

Sally Dengg

Sally Soria-Dengg was awarded her Bachelor and Master of Science in Zoology from the University of the Philippines in Quezon City. While doing her Masters thesis, she taught undergraduate courses in Vertebrate Anatomy and Physiology at the same university. After her Masters studies she went to Germany to pursue doctoral studies on a scholarship grant from the Konrad-Adenauer-Foundation. She received her Ph.D. in Marine Biology from the Christian-Albrechts University in Kiel with a dissertation on the heavy metal uptake of mussels and oysters.

After her Ph.D. she returned to her old university in the Philippines where she continued research on toxicity of metals on juvenile mussels and on seagrass. While there she also taught graduate and undergraduate courses on marine science. After one and a half years she went back to Kiel to work at the then Leibniz Institut für Meereskunde, now GEOMAR Helmholtz Centre for Ocean Research, Kiel. She did research on the uptake of iron by marine phytoplankton focusing on the role of bacterial siderophores as iron carriers and on phytoplankton-bacteria interactions.

In 1995 she went to the USA and did some research work at the Princeton University. She returned to Germany in 1997 and devoted her time to her two daughters. She resumed her career going into an entirely different field. She is now involved in the school co-operations programme of GEOMAR, acting as a conduit between research and schools in Kiel and neighbouring towns. She worked as the regional coordinator for Kiel in the EU-funded CarboSchools project, where she designed and tested experiments on climate change and ocean acidification for pupils. Presently, she coordinates the school projects of the Collaborative Research Centres, SFB 574 and 754, at GEOMAR dealing with “Volatiles and Fluids in Subduction Zones” and “Climate - Biogeochemistry Interactions in the Tropical Ocean“, respectively.

Sally gives teacher-training courses in Kiel and suburbs regularly and has also classroom experience through the different after-school courses she offers for interested and motivated pupils. She organises and teaches in summer schools on different marine science topics for pupils in the upper level secondary schools. She also supervises different group and individual research projects of pupils and has initiated and taken part in international teacher and school co-operations.

Abstract

Some Experiments on Ocean Acidification and the Role of the Ocean in the Carbon Cycle
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Five experiments concerning the effects of increased atmospheric carbon dioxide on the oceans and an activity showing a quick way to construct a solar cooker will be introduced in the workshop. Most of the experiments are described in a brochure each participant will receive. A lesson plan about the carbon cycle where the experiments are integrated can be found in Soria-Dengg and Jamous (2010).

Experiment 1: How do gases (CO_2) get into the ocean?
With this simple experiment the diffusion of CO_2 into the water from the atmosphere is demonstrated. The pupils will see that this process occurs at the air-water interface and without vertical mixing, dissolved CO_2 remains only on the surface of the water. The experiment will be demonstrated using salad bowls and floating candles, materials which can be easily bought from the supermarket. The diffusion of CO_2 from the air to the water is made visible by using a universal indicator to show the acidification of the water surface. Below is a description of the experiment in pictures (Figure 1-3):

Figure 1. Lighted floating candles are placed in a bowl filled with distilled water with an indicator solution (green- basic; yellow-acidic). The bowl is covered with another bowl with the same diameter.

Figure 2. The burning candles release CO_2 inside the bowl. After some minutes the candles burn out. Take note of the colour of the water at the surface!

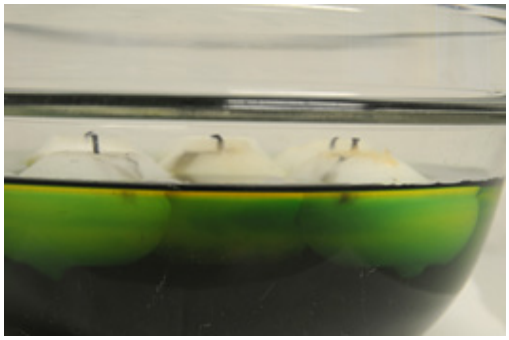

Figure 3. The surface of the water in contact with the air turns yellow, indicating acidification. This layer stays on the surface as long as no mixing occurs.

Experiment 2: How does temperature affect the solubility of gases in liquids?
One of the more relevant factors which influences the solubility of gases is temperature. Gases dissolve better in water at lower than at higher temperatures. This is true for both carbon dioxide and for oxygen. Oceans at higher latitudes have a higher capacity to dissolve gases and this capacity decreases as one nears the equator, where even degassing may occur. In Figure 4 the parts of the world oceans, which act as sinks or sources of CO_2 is shown.

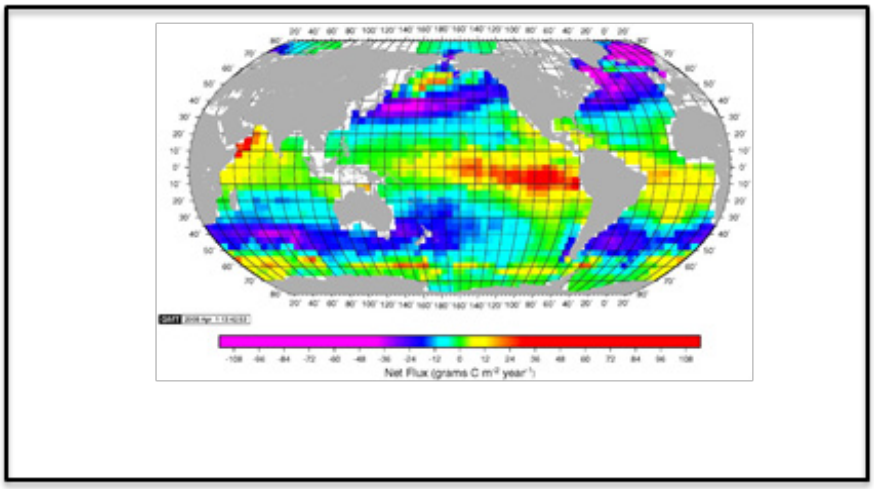

Figure 4. Sea-air CO_2 flux in the world oceans. Sinks (left) to sources (right). (Source: Takahashi et.al. 2009)

Ocean CO_2 "sinks" are the regions where the CO_2 are taken up by the ocean and subsequently transported to the deep, thus effectively removing CO_2 from the atmosphere. CO_2 "sources" are regions where CO_2 is released from the ocean into the atmosphere.

In the following experiment, the volume of carbon dioxide generated by a fizz tablet in warm and cold water is compared. A fizz tablet dissolved in water releases CO_2. A given volume of warm water given to a graduated cylinder is more easily saturated with CO_2 than the same volume of cold water. Once water is saturated with gas, the excess escapes to the overlying air. Using this principle, the following experiment demonstrates how temperature affects the solubility of gases (Figure 5).

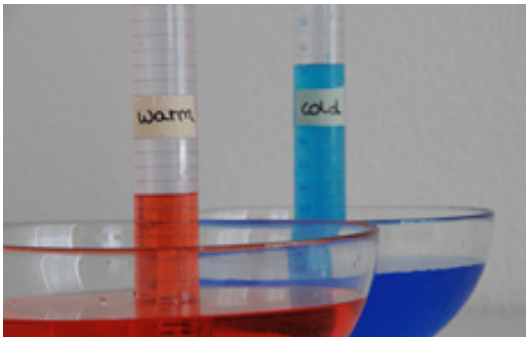

Figure 5. Experimental set-up demonstrating how temperature affects the solubility of gases

Abstract

Experiment 3: How do the oceans act as a sink for CO_2?

In the first experiment it was shown that CO_2 from the atmosphere dissolves only in the water surface and that it stays there if no mixing occurs. According to Henry's Law at a given constant temperature, the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas above the liquid. That means that after sometime, the concentration of CO_2 in the water will equilibrate with that in the air. If that is the case, then the ocean will not be capable of taking up more CO_2 from the atmosphere once equilibrium is attained. However, this is not the case. There are processes in the ocean, which ensure that the CO_2 taken up in the surface is transported to the deep. This is mainly attained by thermal convection, where in specific parts of the oceans CO_2-rich surface waters are transported down. Once the CO_2 is removed from the surface, it is temporarily stored in the ocean (for a period of at least a thousand years), effectively removing this CO_2 from the atmosphere, thus it is a sink for CO_2. However, there are some areas in the oceans where the CO_2-rich bottom waters resurface, and because they have a higher concentration of CO_2 that the atmosphere and because of prevailing temperatures, these areas become "sources" of CO_2 (Figure 4).

In this experiment, the mechanism how CO_2 is transported to the deep by convection will be demonstrated. Carbon dioxide is generated in a test tube connected to another test tube containing water with indicator solution (Figure 6). The CO_2 produced in the right test tube is transferred to the left. The amount of CO_2 produced in the right test tube can be dosed, so that this experiment can also be used to demonstrate how the ocean reacts to increasing CO_2 concentrations in the atmosphere. Once the CO_2 is dissolved in the surface of the water, it is cooled with ice cubes to show how convection occurs and how the CO_2-rich water is transported to the bottom of the test tube (Figure 7).

Figure 6. CO_2 is generated in the right test tube and transferred to the left, which contains water with an indicator solution.

Figure 7. The CO_2-rich surface water starts to be transported to the bottom of the test tube after cooling.

Experiment 4: Where has all the ice gone?

Abstract

Due to increasing atmospheric temperatures the polar ice caps have started to melt. Very dramatic evidence of this is the decreasing size of the Arctic ice and the melting glaciers in Greenland. In this experiment, the pupils will see how the melting of ice leads to a pronounced layering of the ocean, which in turn affects the transport of gases to the deep, influencing the capacity of the ocean to act as a sink for CO_2. Pupils will also see how oxygenation of the oceans occurs.

This experiment starts as a guessing game for the pupils. Ice cubes will be left to melt in beakers containing saltwater and tap water (Figure 8.). The pupils will be asked to guess in which beaker the ice cube will melt faster. The ice cube in the beaker with tap water melts faster. The experiment is then repeated using either coloured ice cubes or coloured seawater or tap water in the beakers. After the ice has melted, the students will see a layer of fresh water on top of the seawater (Figure 9) and conversely, no such layer in the beaker containing tap water.

Figure 8. Ice cubes are allowed to melt in beakers containing tap water and seawater (left image). The ice cube melts faster in the beaker with tapwater (right image).

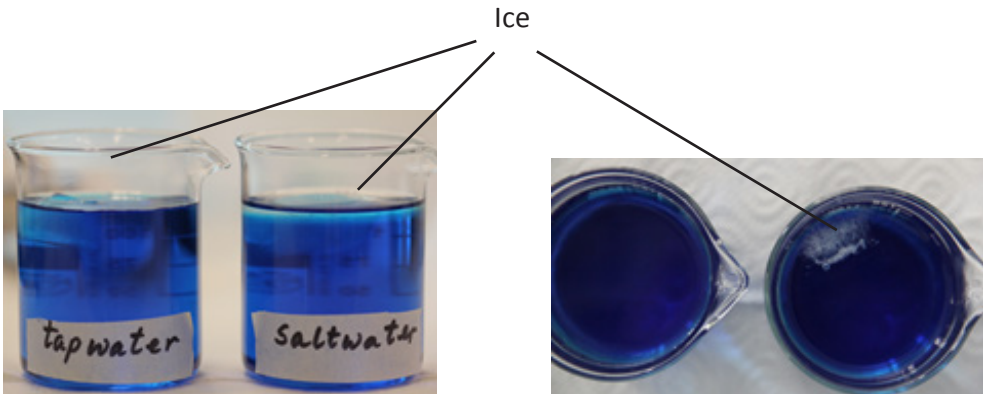

Figure 9. In the beaker containing saltwater, the melt water forms a thin layer on the surface.

If one observes closely and if coloured ice cubes are used in uncoloured water, the cold melt water from the ice cubes in the beaker containing tap water sinks to the bottom. This is due to the higher density of the cold water. The cold melt water mixes with the surrounding warmer water, so the ice

cube melts faster. In the beaker with saltwater, the cold melt water stays at the surface, so that the ice cube melts slower.

The melting of the ice caps and of the Greenland ice leads to the formation of a diluted, less dense layer of water which floats on the surface of the ocean. This results in a decreased capacity of the ocean to transport dissolved CO_2 to the deep. This is reinforced further by increasing atmospheric temperatures causing warming of the ocean's surface and further decreasing the density of the surface water. It should be noted that not only the transport of CO_2 to deeper waters is affected but also of other gases, especially oxygen, leading to de-oxygenation of the oceans (Keeling, et. al. 2010).

Experiment 5: Around the world in a thousand years
The part of the ocean circulation pattern that is driven by density gradients resulting from temperature (thermo) and salinity (haline) differences, is called the thermohaline circulation. This is also termed as the global conveyor belt. This is responsible for the exchange of energy and materials, including gases, between the different ocean basins. In the following experiment, the thermohaline circulation, specifically the Gulf Stream, will be simulated using a 2D tank model (Figure 10).

On its way to the north, the Gulf Stream transports warm salty waters from the subtropics to the sub-polar regions of the Greenland and Labrador seas. When it reaches these regions, the Gulf Stream is cooled, thus increasing in density. It sinks to the bottom and then flows southwards. A detailed description of the experiment can be found in the links below.

Figure 10. Simulating the Gulf Stream with a 2D tank model. The left side of the tank represents the subtropics and the right side the sub-polar regions. The right side is cooled with ice. Due to increased density the Gulf Stream (blue water) sinks to the bottom.

Activity: Constructing a solar cooker in 1 minute
This is a fun activity which teachers can do with their pupils, like staging a lunch cook-out in the school. A solar cooker is easily constructed and can be set-up in a matter of minutes. The solar cooker consists of a windshield sunshade available for a couple of Euros from department stores, a cake rack, a black pot and a transparent plastic bag. The windshield sunshade is shaped into a funnel and placed on a garden chair or on the ground facing the sun. The food is prepared by placing all ingredients in the black pot (with or without

the addition of water depending on the recipe). The pot is covered and placed inside the transparent plastic bag on top of the cake rack (Figure 11). This is then placed in the sun-shade and can be left unattended for the duration of the cooking period. Depending on where you are in Europe, the solar cooker may have to be turned towards the sun every once in a while. The duration of cooking depends on the intensity of the sun.

Figure 11. Different models of solar cookers used in a school lunch cook-out.

References

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Soria-Dengg, S., Jamous, M. 2010. Experiments: A preview to the CarboSchools library. In: Global Change: from research to the classroom. Third educational booklet of CarboSchools. pp. 39-55.

Takahashi, T., Sutherland, S.C., Wanninkhof, R., Sweeney, C., Feely, R.A., Chipman, D.W., Hales, B., Friederich, G., Chavez, F., Sabine, C., Watson, A., Bakker, D.C.E., Schuster, U., Metzl, N., Yoshikawa-Inoue, H., Ishiik, M., Midorikawak, T., Nojiril, Y., Körtzinger, A., Steinhoff, T., Hoppema, M., Olafsson, J., Arnarson, T.S., Tilbrook, B., Johannessen, T., Olsen, A., Bellerby, R., Wong, C.S., Delille, B., Bates, N.R., de Baar. H.J. 2009. Climatological mean and decadal change in surface ocean pCO2, and net sea–air CO_2 flux over the global oceans. Deep-Sea Research II. 56, 554-577.

Links

1. Detailed descriptions for the experiments can be found here:
http://www.bioacid.de/upload/downloads/press/BIOACID_Experiments_en.pdf
2. A detailed description of the tank experiment on Gulf Stream simulation
ftp://ftp.geomar.de/downloads/NaT/Dokumente/ExpDescriptionGulfStream.pdf
3. More experiments on the carbon cycle from the CarboSchools project can be found here:http://www.carboeurope.org/education/libraryHome.php
4. Recipes for the solar cooker can be found in the internet

Sarah Gaines

Sarah Gaines is a programme specialist in Earth sciences at UNESCO headquarters in Paris, France. Starting in 2009, she led the development and scoping of UNESCO's Earth Science Education Initiative which she now implements in close cooperation with colleagues from African UNESCO field offices. As a member of a small team in Earth sciences, she supports the International Geoscience Programme, the development of the Global Geopark Network and various activities on emerging interdisciplinary Earth science topics of relevance to society ranging from geoengineering to best practices in mining and conservation to remote sensing applications for heritage conservation. She was a founding leader of the Young Earth Scientists Network and has served as the VP on the administering council of the French non-profit CIFEG (Centre International pour la Formation et les Echanges en Geosciences).

Sarah has an undergraduate degree in Geology from Princeton University, USA and an MSc in Quaternary Science from the University of Cape Town, South Africa. Her research has focused on paleoclimate reconstructions from various geochemical and geomorphological proxies. She has conducted research at the National Ocean Sciences Accelerator Mass Spectrometer of the Woods Hole Oceanographic Institute. Before coming to UNESCO, she applied this scientific perspective on changing Earth systems as an environmental planner for the Corps of Engineers in San Francisco, USA where she conducted research on remote sensing applications to monitor environmental change.

Of particular relevance to GIFT, Sarah has also taught field-based environmental geology to children at the Woods Hole Children's School of Science in USA and mathematics to college students and adult learners at the University of Cape Town.

Abstract

Partnerships for a relevant Earth Science Education Initiative in Africa

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Taking the opportunity of the launch of the 'International Year of Planet Earth' (IYPE) for Africa in Arusha, Tanzania on 8 May 2008, the Director General of UNESCO announced a new Earth Science Education Initiative for Africa. The overall intention of this Initiative is to support the development of the next generation of Earth scientists in Africa who are equipped with the necessary tools, networks and perspectives to apply sound science to solving and benefiting from the challenges and opportunities of sustainable development. The opportunities in the Earth sciences are great, starting with traditional mineral extraction and extending into environmental management such as climate change adaptation, prevention of natural hazards, and ensuring access to drinking water.

Between 2009 and 2010 the Initiative was scoped through regional workshops in Northern, Central, Western, Portuguese-speaking, and Southern Africa to assess regional capacities and needs in Earth science education, research and industry underlining existing centers of excellence through conversation with relevant regional and international experts including representatives of Universities, Applied Schools, Geological Surveys, Industry and Government and plotting the way ahead for Earth science education.

Based on the recommendations of these workshops, UNESCO has reinforced existing Earth science activities with a renewed focus on and relevance for Africa, namely through the Global Geopark Network (GGN) and the International Geoscience Programme (IGCP). Global Geoparks raise the importance of geological sites, promote Earth science education and develop local tourism which supports community development and pride of place, building an understanding of local geological processes and their relationships with people. Societal understanding and appreciation of Earth sciences is an important element for Earth science education across the continent. In 2014, the UNESCO Secretariat has received its first application for an African Geopark and many aspiring African Geoparks are underway. The 40 year old IGCP has received additional support from the Swedish International Development Cooperation Agency (Sida) to increase the African leadership of IGCP projects through supporting research teams and co-funding workshops on preparing IGCP project proposals. IGCP projects encourage focused international collaboration of societal relevance.

In addition, in order to implement the scoping workshop recommendations, UNESCO has launched three new activities:

- Establish an **African Network of Earth Science Institutions (ANESI)** to foster collaboration between Departments of Earth sciences of universities, Earth science research institutions and related industries. This project was endorsed by the Geo-

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logical Society of Africa and the African Conference of Vice Chancellors and Deans of Science, Engineering and Technology. The network was launched in January 2013 at the 23rd Colloquium of African Geology in Addis Ababa, Ethiopia.

- Develop a **Mobile Geologic Field Mapping School** which will focus on geologic field mapping for early career Earth scientists, as an important geologic tool for their careers and a vital exercise for countries to identify their resources. With the support of UNESCO, the AfricaArray International Geophysical Field Course was organized in South Africa from June-July 2013.
- Look at the **status of Earth Science education at primary and secondary level in schools** to forge the future generation of "Earth Stewards' and give Earth sciences a status that reflects the importance that this discipline plays in the everyday life of African people. Reinforced by UNESCO's findings that investment in teacher training is the most efficient investment in education, UNESCO has partnered with the EGU, following their successful GIFT model, and the Africa Earth Observatory Network's Earth Stewardship Science Institute to hold the current teacher training workshop.

The Africa Earth Observatory Network has been an important partner for UNESCO's Earth Science Education Initiative in Africa. AEON hosted the southern African regional scoping workshop when they were based at the University of Cape Town. Currently based at the Nelson Mandela Metropolitan University as the Earth Stewardship Science Research Institute (AEON-ESSRI), they have again hosted an Initiative workshop, in this case on teacher training. In addition, Prof Moctar Doucouré, the Managing Director of AEON-ESSRI, also serves on the Working Group to prepare the Business Plan of ANESI.

AEON-ESSRI aims to provide a research and educational environment to seek consilient knowledge and engagement amongst earth and life sciences, engineering, resource economics, human and cultural sciences through application and dissemination of Earth Stewardship Science. The Insititute fosters cutting-edge, internationally-connected, science and analytical learning using advanced tools and technologies in an environment that nurtures solving complex problems through transdisciplinary science to explore sustainability for people and the planet, particularly in Africa.

Based on a thoroughly participative scoping process, UNESCO is committed to implementing the activities of the Earth Science Education Initiative in Africa in a relevant and effective manner with strong local, regional and international partners.

Jean-Pierre Gattuso

Jean-Pierre completed his studies in 1987 with a PhD in biological oceanography from the University of Aix-Marseille II following an MSc in oceanography.

In 1990, he took on his first research position at the Centre National de la Recherche Scientifique (Perpignan). He followed this with positions leading research projects at Monaco Scientific Centre and Laboratoire d'Océanographie de Villefranche, and as a visiting scientist at Rutgers University and the National Centre for Atmospheric Research.

In 2006, Jean-Pierre took on a visiting professorship at the Marine Biology Institute of Shantou University. He continues to conduct research at the Laboratoire d'Océanographie de Villefranche as senior research scientist.

Since 2001, Jean-Pierre has picked up three awards including the Vladimir Vernadsky Medal and Union Service Award from the EGU. He also edited several journals including acting as the co-founding editor-in-chief for the EGU's peer-reviewed open-access journal Biogeosciences.

Jean-Pierre was the founding president of the Biogeosciences Division of the EGU, and in addition to this has stacked up many other professional achievements including coordinating the European Project on Ocean Acidification (EPOCA) and as a lead and contributing author for Working Group II of the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

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A short summary of the current knowledge on ocean acidification

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Introduction
The oceans have absorbed between 24% and 33% of anthropogenic carbon dioxide (CO_2) emissions during the past five decades. While this uptake provides a valuable service to human societies by moderating the rate and severity of climate change, it comes at a cost for the oceans. The massive input of CO_2 generates sweeping changes in the chemistry of seawater, especially on the carbonate system. These changes are collectively referred to as "ocean acidification" because increased CO_2 lowers seawater pH (i.e. increases its acidity).

Ocean acidification, "the other CO_2 problem", has recently emerged as one of the largest threats to marine organisms and ecosystems. Describing and quantifying the plausible consequences of ocean acidification on societies, however, remains a challenge. Those consequences will depend on interactions among and between species and ecosystems (all reacting at different rates and magnitudes), on the interaction of ocean acidification with other ocean stressors, and on responses of each human group affected. Nevertheless, it is clear that the speed and magnitude of acidification is threatening many marine species and ecosystems. Calcifying organisms such as coral reefs, shellfish and zooplankton are among the first potential victims. Therefore ocean acidification will also impact various economic sectors (e.g. fisheries, aquaculture, tourism) and coastal communities, and may also have heavy indirect effects on much broader segments of the world economy and population. Ocean acidification appeared on the research agenda about two decades ago. It is now an important focal issue for the research community and related societies.

Causes of ocean acidification
There are two main causes of ocean acidification. By far the primary cause is the ocean's uptake of atmospheric CO_2, and there is growing evidence for secondary enhancement of CO_2-driven acidification by other pollutants in coastal regions.

Uptake of atmospheric CO_2
Rising atmospheric CO_2 is the major driver of ocean acidification globally. The increase of CO_2 in the surface ocean resulting from the uptake of anthropogenic CO_2 profoundly affects the seawater carbonate system through well-known chemical reactions. It lowers the pH (increases acidity), increases the concentration of bicarbonate ions (HCO_3^-), decreases the availability of carbonate ions (CO_3^{2-}) and lowers the saturation state of the major shell-forming carbonate minerals such as calcite and aragonite. This process is known as "ocean acidification" because, even though the surface waters remain alkaline, seawater pH is decreasing.

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Average surface water pH values are in an accelerating decline: it was 8.3 during the last glacial maximum, 8.18 just prior to the industrial era, and 8.10 at present. Measured trends agree with those expected from the atmospheric CO_2 increase, with uncertainties larger for the high latitudes, deep ocean, coastal areas, and marginal seas. The basic chemistry of ocean acidification being well understood, future projections are quite reliable for the surface open ocean for a given atmospheric CO_2 trajectory. Those based on the International Panel on Climate Change (IPCC) scenarios give reductions in average global surface pH of between 0.14 and 0.35 units over the 21st century, which means surface pH may reach 7.8 in the year 2100.

Despite anthropogenic CO_2 emissions being the primary driver of acidification, the chemical and biological impacts of ocean acidification would continue to intensify for many years thereafter even if emissions were halted altogether by the end of this century (Joos et al. 2011). Nevertheless, mitigating CO_2 emissions would substantially ease the trajectory of acidification over the course of the 21st century.

Coastal acidification due to inputs from land

Several anthropogenic inputs also exacerbate the effects of ocean acidification at smaller spatial scales. These inputs act disproportionately along coastal margins where anthropogenic stressors are most acute and where oceanographic patterns such as upwelling or incomplete flushing occur, especially in bays and estuaries.

Mechanisms for this locally-intensified acidification are known: there is a negligible equilibrial effect of deposition of atmospheric NO_x and SO_x, but nitrogen and phosphate runoff from agricultural, industrial, urban and domestic sources causes eutrophication, triggering population spikes of algae or heterotrophic plankton. When the algal bloom is over, the organic matter decays, generating CO_2 and acidifying seawater. Understanding and mitigating these secondary causes of acidification is possible at the local and regional scales.

Impacts of ocean acidification on marine organisms and ecosystems

Ocean acidification can have a wide range of biological effects, through two main mechanisms. First, pH plays a key role in several physiological processes and many intracellular enzymes that control cellular physiology are pH-sensitive. The pH of body fluids in animals and the intracellular pH of various organs or unicellular organisms are tightly regulated, but regulatory mechanisms are energetically expensive and can be overwhelmed. The second mechanism occurs through changes in the concentration of molecules that are themselves substrates in key physiological processes. For example, carbon dioxide and bicarbonate are used in photosynthesis and carbonate is a building block of shells and skeletons made of calcium carbonate. Hence, ocean acidification can stimulate primary production since the concentrations of both CO_2 and HCO_3^- are larger at lower pH). It also often decreases calcification (the construction of shells and skeletons), and stimulates nitrogen fixation in some cyanobacteria. This suggests that highly calcium-carbonate-dependent ecosystems—such as coral reefs and oyster and mussel beds—could be particularly vulnerable.

However, the magnitude of species-specific physiological effects is highly variable and,

in few cases, even the sign of the response may vary. For example, there is evidence that the same species may differ in sensitivity among life stages (e.g., with enhanced sensitivity among larval stages), among different strains of the same species, and dependent on their previous exposure (e.g., carry-over effects).

A recent analysis of the rapidly expanding body of research on acidification reveals consistent reductions in calcification, growth, and development of a range of calcified marine organisms despite the variability in their biology (e.g., morphology and life history strategies). It also suggests that some taxa may be predictably more resilient to or may benefit from ocean acidification (e.g. brachyuran crustaceans, fish, fleshy algae, and diatoms). However, this meta-analysis study did not consider all kinds of effects. For example, neurological effects with repercussions for their behavior or the loss of phenolic compounds used as herbivore deterrents by fleshy algae. Furthermore, the potential for acclimation or adaptation in response to acidification could potentially lessen the effects on calcified taxa synthesised here and remain critical areas for future research. While physiological effects on these calcified organisms can result in decreases in their abundance, the higher variability in species responses in multi-species studies indicates that species interactions will also be important determinants of abundance. Furthermore, understanding whether the remaining variation within taxonomic groups and life stages represents real biological differences among species, locally-adapted populations, or acclimatory capacities, rather than experimental error, remains a critical area for future research. Finally, marine organisms of the future will not be subjected to ocean acidification in isolation, and continued research on the concurrent effects of ocean warming and acidification is necessary to forecast the status of marine organisms and communities in the near-future.

Knowledge gaps

Despite very active research on ocean acidification and the considerable increase in the number of papers, there are several key knowledge gaps preventing to assess the full extent of the impacts of ocean acidification with reasonable certainty.

1. Research needs to be scaled up. Most information available on the impacts of ocean acidification was gained from isolated organisms over short periods of time. Little is known about the responses of whole ecosystems, on the impacts of multiple stressors, and on the potential for evolutionary adaptation. These limitations restrict the level of confidence of future projections.
2. Effects of ocean acidification on biogeochemical cycles at a global scale are uncertain. Changing ecosystem composition and the oceans' carbonate chemistry affects biogeochemical cycles in complex ways. Ocean acidification may also affect production of climate-related gases. We need to understand ecosystem responses to the effects of ocean acidification in order to improve how global models simulate and predict biogeochemical changes.
3. Fish and fisheries. It is uncertain how the effects on phytoplankton and zooplankton will propagate through the food web to affect fish and fisheries. Also, very little is known about the direct effects of ocean acidification on fish that are the target of commercial and subsistence fishing.

Carlo Laj

I completed my scientific career, following a PhD in solid state physics at the University of Paris, as an employee of the French Atomic Energy Commission, first as a researcher in the Physics Department than in the field of geophysics.

In 1985, I was appointed as Deputy Director of the Centre des Faibles Radioactivités and Head of the Department of Earth Sciences. I created and directed the Laboratoire de Modélisation du Climat et de l'Environnement, which was later united with the Centre des Faibles Radioactivités to form the present Laboratoire des Sciences du Climat et de l'Environnement (LSCE).

After 3 terms as Head of Department, I stepped down to a researcher position again, until I retired and was made 'emeritus' researcher'. I have since gradually reoriented my activities towards education and have been honoured to receive the Excellence in Geophysical Education Award from the American Geophysical Union.

I founded the Committee on Education of EGU, and have been its Chairman for the past 11 years, for which I have also received a Union Service Award from the EGU.

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THE EDUCATIONAL ACTIVITIES OF THE EUROPEAN GEOSCIENCES UNION
Best practice for the science–teaching interface

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I report on the educational activities of the European Geosciences Union (EGU) that are conducted by its Committee on Education (CoE). They have focused on workshops dedicated to secondary school teachers, mainly high schools. From initial workshops held during the General Assemblies of the EGU, a wider program has been developed with teachers' workshops taking place in different countries in connection with EGU Alexander von Humboldt topical conference series.

More than 1000 teachers have attended these workshops, which are a mixture of presentations by worldwide known scientists, hands-on experiences for the classroom and presentations by the teachers themselves to their fellow teachers.

Introduction
In 2002 in Nice, France, EGU Executive Secretary Arne Richter announced a collaboration between scientists and schools all over Europe. The aim was to bring state-of-the-art science via high school teachers into tomorrow's classrooms.

Carlo Laj was appointed chair of the EGU CoE and, in 2003, the first GIFT workshop took place at the General Assembly, featuring 42 teachers from seven European countries.

Since then, the CoE of EGU has progressively developed programmes and educational materials mainly aimed at secondary school teachers and pupils. These programmes have been developed along 5 main axes:

1. Geosciences Information for Teachers (GIFT) workshops at EGU General Assemblies and more recently at Alexander von Humboldt topical conferences
2. Educational sessions at EGU General Assemblies (teachers, scientists and science educators)
3. GIFT Distinguished Lectures series
4. Teachers at sea
5. EGU-UNESCO-ESA Collaboration for GIFT workshops in Africa

These activities are briefly described below.

The GIFT workshops at the EGU General Assemblies
The program of each workshop is focused on a unique general theme, which changes every year, and which combines scientific presentations on current research in the Earth and Space Sciences, given by prominent scientists attending EGU General Assemblies, with hands-on, inquiry-based activities that can be used by the teachers in their classrooms to explain related scientific principles or topics. Also, teachers are wel-

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comed to present to their colleagues some aspects of their own 'out-of-the-programme' classroom activities.

The main objective of these workshops is to spread first-hand scientific information to science teachers of primary and secondary schools, significantly shortening the time between discovery and textbook, and to provide the teachers with material that can be directly transported into the classroom. In addition, the full immersion of science teachers in a truly scientific context (EGU General assemblies) and the direct contact with world leading geo-scientists are expected to stimulate curiosity towards scientific research that the teachers will transmit to their pupils.

The value of bringing teachers from several nations together includes the potential for networking and collaborations, the sharing of experiences, and an awareness of science education as it is presented outside of their own countries. At all previous EGU GIFT workshops teachers mingled with teachers from outside their own country and had lunch together with the scientists, which provided a rich dialogue for all those who participated since the dialogue included ideas about learning, presentation of science content, curriculum ideas etc. We therefore, believe that, in addition to their scientific content, the GIFT workshops are of high societal value.

The workshop quickly became known amongst teachers all over the European continent and, in the following years, the number of participants doubled. Due to the importance of the valuable hands-on activities, which require an intimate setting, and the limited space at the conference venue, the maximum number of participants had to be limited to 85.

Today a GIFT workshop typically includes :

- A two and a half day workshop
- 80 participants from 20 countries (selected from 250-300 applicants)
- 8-9 conferences by worldwide known scientists present at the General Assembly
- 1 half-day practical with specialised educators
- 1 poster session "Science in tomorrow's classroom" where teachers are encouraged to present their 'out-of-the-programme' school activities and which is open to non-teacher participants (in 2012 we have had 50 posters from the teachers attending the GIFT workshop out of a total of 65)
- 1 visit to local institutions in Vienna (UNOOSA, IAEA…)

Each GIFT workshops starts with a visit to and an ice-breaker reception at the Vienna Museum of Natural History on the Sunday preceding the workshop.

In the last 5 years these different themes were addressed: Natural Hazards (2013), Water! (2012), Evolution and Biodiversity (2011), Energy and Sustainable Development (2010) and The Earth from Space (2009) the last one in collaboration with the European Space Agency (ESA).

All the expenses for the selected teachers (travel, lodging and registration at the GA) are met by the EGU.

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Figure 1. Teachers visiting the United Nations Office for Outer Space Activities (UNOOSA)
Figure 2. Experimenting with GPS, during the 2009 GIFT Workshop in Vienna.

The year 2009 brought further additions to the GIFT concept. For the first time, selected lectures were filmed during the workshop. Along with all the other workshop material (programs, brochures, abstracts of presentations) these recordings were made available as web streams and are openly accessible free of charge via the EGU website :(http://www.egu.eu/outreach/gift/workshops/).

Also, in 2010, the CoE decided to hold 'local' GIFT workshops associated with EGU Alexander von Humboldt topical conferences. These are a series of meetings held outside of Europe, in particular South America, Africa or Asia, on selected topics of geosciences with a socio-economic impact for regions on these continents, jointly organised with the scientists and their institutions of these regions.

The first GIFT-AvH took place in Merida (Yucatan), the second in Penang (Malay) the third in Cusco (Peru). Each time we have had a participation of 40-45 'local' teachers. Noticeably, in the three cases it was the first workshop of the kind organised ever.


Figure 3. Teachers during a practical exercise at the GIFT workshop in Merida. *Figure 4.* The Minister of Education of the State of Yucatan, Mr. Raoul Godoy (right) attended the GIFT workshop!

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Figure 5. Sally Soria-Dengg (left) instructs Peruvian teachers during the GIFT workshop in Cusco.

Educational sessions at the EGU General Assembly
We regularly organise 8-10 educational sessions during the General Assembly. On of these sessions, mentioned above, 'Science in tomorrow's classroom' is open to both teachers attending the GIFT workshop and to scientists with an interest in education attending the General Assembly. A growing interest has been shown in Vienna, with over 60 posters presentations, 2/3 by teachers and 1/3 by scientists.

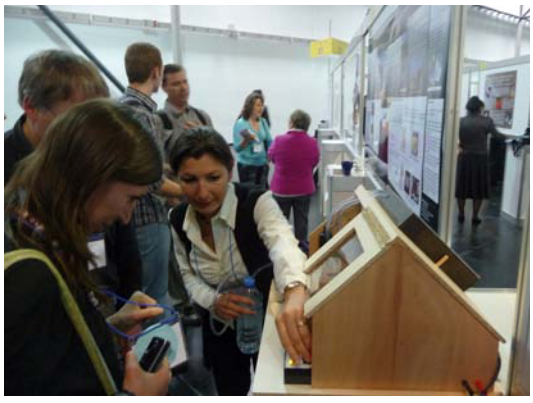

Figure 6. Explaining Energy Saving to fellow teachers! *Figure 7.* Angela (USA) and Hélder (Portugal) in front of their poster

The GIFT Distinguished Lecture Series
In 2011, the EGU CoE has inaugurated an annual series of GIFT Distinguished Lectures, to be given by top scientists who have previously participated as speakers in GIFT workshops during EGU General Assemblies. High school teachers, high school directors and educators for teachers from the European area are welcome to ask for a GIFT Distinguished Lecture. Distinguished Lectures have been given in Spain, Poland and next (2013-2014) in France and Spain.

The Teachers at Sea Programme
'Teachers at sea' is an Educational Programme making it possible for high school teachers to participate to oceanographic cruises together with the scientists. Three editions of this programme have taken place on board the Marion Dufresne during cruises PACHIDERME in 2007 (along the Coast and in the fiords of Southern Chile), AMOCINT in 2008

(in the North Atlantic Ocean) and CIRCEA (in the South China Sea in 2012).

On board, teachers participate in the 'watches' which is really absolutely necessary for them to be in direct contact with the scientists and students and to be totally immersed in the different activities taking place on board, not only for watching the different coring operations, but also to actively participate personally in the first steps of treatment of the cores: cutting, opening, archiving, measurements of their physical properties and

sedimentological description. Some of the sediments are saved for the schools, and can be mailed to the different teachers asking for them.
Figure 8. Teachers on board the Marion Dufresne during the AMOCINT Oceanographic cruise in the North Atlantic (Hélder, Angela, Gertrud, Catalina Jean, and Carlo in the background)

GIFT goes to Africa! (An EGU-UNESCO-ESA Programme)
This year will bring new and fascinating prospects for GIFT. The EGU has teamed up with UNESCO to take the GIFT workshop idea to Africa. ESA has more recently joined this programme. The scope is to disseminate the latest findings in science to the teachers there, to support the development of the next generation of Earth Scientists in Africa. The opportunities and challenges in the Earth Sciences there are great, starting with traditional mineral extraction and extending into environmental management such as climate change adaptation, prevention of natural hazards, and ensuring access to drinking water.

Ian McKay

Ian began his education in 1981 at the University of the Witwatersrand in Zoology, following this with an MSc and PhD in Palaeontology, where he studied a unique fauna of fossil beetles that lived in the time of the dinosaurs in order to reconstruct the prehistoric environment that they lived in.

After his PhD Ian took on a research position at the Onderstepoort Veterinary Institute of the South African Agricultural Research Council where he studied ticks to identify new species that might bring diseases to domestic and wild animals, after which Ian made his switch into more education focused roles. In 1996 Ian took on the role of Science and Environmental Education Specialist at the RADMASTE Centre, a not-for-profit organization associated with the University of the Witwatersrand. Ian focused his work there on research and development of the science, technology and maths curriculum, with particular interest in the field of chemistry and development of 'micro-chemistry' kits for water quality testing in environmental education. During this time Ian also gained an HDipEd in Education from the University of the Witwatersrand, with particular focus on science and biology education.

After some consulting work in the science centre industry, Ian went on to manage the outreach programme of the School of Geosciences and Evolutionary Studies Institute at the University of the Witwatersrand. For a period he was also the Education Officer for the Origins Centre, a modern museum devoted to preserving and explaining the Rock Art of the South African San People. During this time Ian also set up his own science communication company in 2005, ITM Development Education Services, whose mission is 'facilitating development through out-of-the-box thinking, fundraising, conscientious project management, and the communication of technical information in plain language using innovative, entertaining and interactive techniques'.

In addition to his already packed curriculum vitae, Ian convened the 6th quadrennial GeoSciEd conference of the International Geoscience Education organisation in 2010, and has written several chapters of school textbooks published by Macmillan South Africa on biodiversity, palaeontology and Earth history and completed most of an MBA at the University of the Witwatersrand.

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Fossil Fuels: are they just Dinosaurs?

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Evolutionary Studies Institute
University of the Witwatersand

South Africa has consistently underperformed in international science surveys for school goers. Part of the reason for this underperformance may be that most science students get little opportunity for enquiry based experimentation in the classroom. This weakness in basic science conceptual knowledge hinders an understanding of environmental issues such as climate change. For example, the majority of high school pupils attending workshops on climate change at the Grahamstown Science Festival and Sci-Bono Science Centre were unable to name carbon dioxide as the gas produced by the burning of fossil fuels and explain its link to current concerns about climate change.

This workshop provides a basic foundation of science conceptual knowledge for understanding climate change by providing a framework which links concepts such energy, combustion, fossil fuels, hydrocarbons, non-renewable energy sources, and carbon dioxide as a product of combustion and a climate change agent. The concepts are introduced through a series of entertaining, enquiry based demonstrations and hands-on activities including:

- A discussion of energy using a bouncing ball and heavy rock demonstration
- A demonstration of combustion using the classic candle in a saucer of water with an inverted glass experiment (specially adapted for the purpose of the workshop)
- Modelling the combustion reaction using sweets and tooth picks (hydrocarbons and oxygen combust to form carbon dioxide and water)
- A demonstration of the explosive nature of hydrogen using a home-made hydrogen balloon.
- Examination of different types of hydrocarbon: peat, bituminous coal, anthracite, crude oil and ordinary engine oil
- Discussion of the formation of fossil fuels over millions of years and the finite life span of fossil fuels as energy sources
- Concerns about the link between climate change and the combustion of fossil fuels
- Renewable vs non-renewable resources
- Actions that can be taken to reducing our dependency on fossil fuels and reduce CO_2 emissions (discussion via a card game)

The entire workshop (with the exception of the crude oil and peat) is conducted with readily available low cost materials and research has indicated that it provides students with a better understanding of the basic conceptual framework and contemporary concerns about climate change.

Bernard Seguin

Bernard Seguin, now retired, graduated from the Université de Provence in Marseille with a PhD in fluid mechanics and atmospheric physics in 1971. He spent a large part of his professional life working for the Institut National de la Recherche Agronomique (INRA) in France since 1967, beginning in Versailles and then joining Avignon as a researcher in bioclimatology until 1998. Bernard acted as chief of the laboratory (station de bioclimatologie) for 12 years, before becoming involved in the scientific management within INRA as deputy-chief of department Environnement et Agronomie until 2002. Later, Bernard was named coordinator of the INRA research work on climate change and the greenhouse effect, until his retirement in 2011.

Bernard has published 60 papers in international journals concerning micrometeorology, climatology and remote sensing applied to agriculture and continental biosphere and later moving towards the impact of climate change on human and natural services. In addition to numerous scientific actions and contributions to various committees in France, Bernard has participated in European COST (Cooperation in Science and Technology) actions (on agrometeorology, remote sensing, agriculture and climate change). Bernard has also been involved in EU funded projects linking several countries within South America, such as Chile, with the Netherlands, Spain and France on the use of agroclimatology and remote sensing for the monitoring of agriculture and hydrology. On a more international scale, Bernard has been involved in several working groups of the Commission for Agricultural Meteorology of the World Meteorological Organization (WMO).

Bernard has acted as a lead-author for the Intergovernmental Panel on Climate Change's (IPCC) 4th Assessment Report (Working Group II) and as a review editor for the IPCC 5th Assessment Report, for which the Working Group II report is to appear in April 2014. To add to Bernard's already exceptional curriculum vitae, he has also has been honoured by the Nobel Prize for peace in 2007 and contributed to the IPCC as member of the Task Group on Data and Scenario Support for Impact and Climate Analysis (TGICA).

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Impacts of climate change on agriculture
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Climate change will impact and has already impacted a large range of physical/biological systems and sectors of human activity, among them agriculture (including livestock) and its main output as food production. Several other driving forces, especially in the economical and societal domain, will determine the evolution in the present century.

However, climate change has to be considered as a major factor in the context of the enormous challenge of furnishing food for 9 billion people, instead of 6 billion currently. The main lines of foreseen impacts were established in the decade of 1990, when considering the simple assumption of doubling CO_2 concentrations. Recent studies have added more detailed estimates of the consequences for global food production, differing above all by considering a range of emission scenarios (like the new set of RCP trajectories recently proposed for the IPCC 5th Assessment Report), which gives a corresponding range of impacts depending upon the warming hypethesis.

Expected effects on crop functioning
For assessing changes in the eco-physiological functioning of vegetal production, it is firstly necessary to consider the stimulation of photosynthesis by the elevation of atmospheric CO_2 concentration, concering pastures, forests and natural vegetation as annual crops.

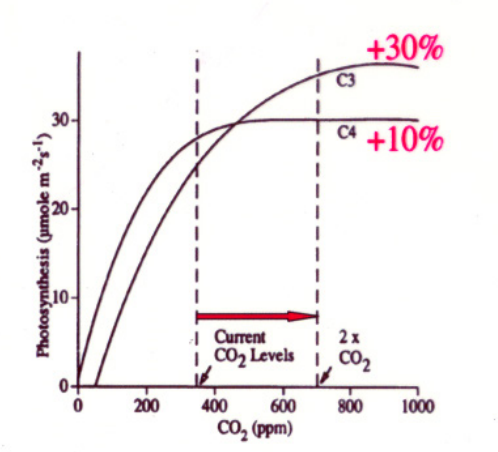

Figure 1. Typical increase of photosynthesis with increase in carbon dioxide concentration .

For these, even if there is some controversy about the results of experiments with free-air enrichment, the well-established curves of photosynthesis enrichment on an instantaneous basis (fig 1) lead to an increase in photosynthesis of 10-20% with 550 ppm

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(parts per million) for C_3 temperate species as wheat, rice, soybean, whilst it seems to be limited to 0-10% for C_4 tropical species as maize and sorghum. This increase of potential production is a first component, on which direct effects of changes in the climatic variables have to be superposed:

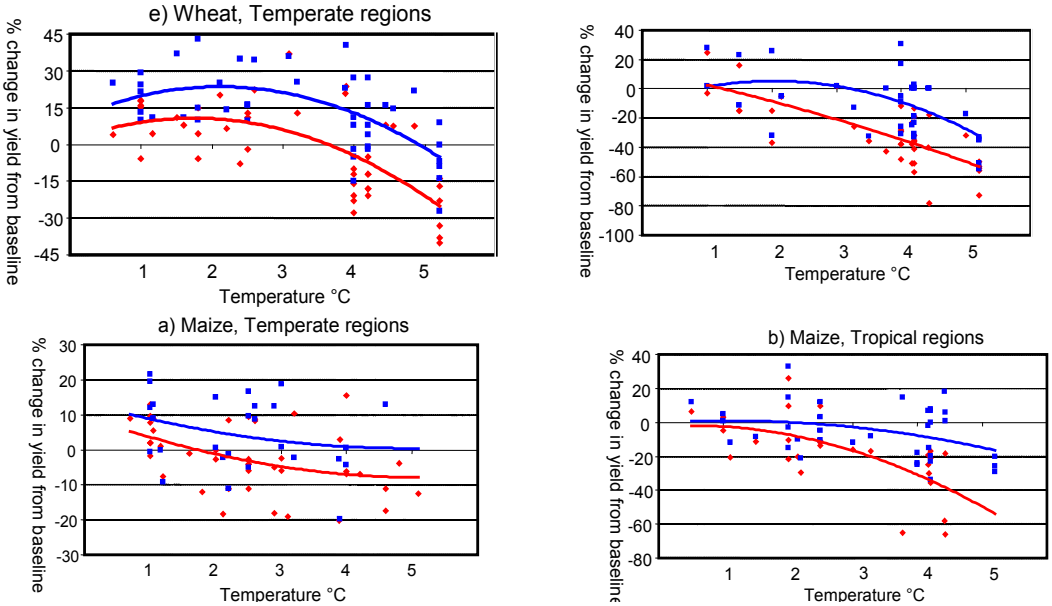

Figure 2. Effects of temperature change on wheat and maize (from Easterling et al 2007)

Firstly temperature, whose effects may be quite variable: higher temperatures are generally favourable for growth in cold and temperate climates, except however when they exceed the optimum and near detrimental thresholds in the case of extreme events. On the contrary, higher temperatures are generally unfavourable for warm areas. For development, the advance in phenology will reduce the duration of the cycle of determinate species, thus the time during which photosynthesis is working. But higher temperatures also shift the periods during which plants are more sensitive to a given factor, for example the flowers of fruit trees, which may result in an increase of spring frost risks, in spite of a reduction of purely climatic frost conditions. For indeterminate cycle species like grass or forests, warmer conditions will speed the budburst at spring and delay the browning in autumn, which on the whole results in a significant increase of the duration of growth season.

Rainfall on a first range and other water balance components like potential evapotranspiration will also seriously modulate the potential changes to plants resulting from the effects of temperature increase. Tendencies towards drier conditions may fully cancel the positive potential impact with higher CO_2 or milder temperatures! More generally, we also have to state that this general figure only considers the continuous effect of mean values for climatic conditions, but that their variability and the occurrence of extreme events (frosts and heat-waves, droughts or torrential rainfall) would totally confirm or inverse this mean tendency. On the whole, the combination of these various influences leads to a variety of contrasted effects, depending upon the type of crop production and the geographical zone.

Abstract

Expected effects on crop production
Resulting effects on crop production may be grossly estimated by setting some in-field experiments or using empirical tools like climatic indices, but there is a general agreement for considering that only the use of well-defined and validated deterministic crop models is able to give valuable predictions. A synthetic view is available from the IPCC 4th Assessment Report, as depicted in fig 2.

The final statement given in the IPCC (2007) states that 'temperate regions, moderate to medium increases in local mean temperature (1° to 3°), along with associated CO_2 increase and rainfall changes, can have small beneficial impacts on crop yields. At lower latitudes, especially the seasonally dry tropics, even moderate increases are likely to have negative yield impacts for major cereals. Further warming has increasingly negative impacts in all regions".

Observed changes in agriculture and livestock resulting from the recent warming are still hardly detectable, except for advances in phenology (i.e flowering of fruit trees, harvest dates of vines and cereals) and the case of wine production in terms of quality, with a noticeable increase in sugar and alcohol content and a simultaneous decrease in acidity. The effect of warming is difficult to isolate from other driving forces in the evolution of regional yield and global production, still primarly sensitive to the climate variability. Among the recent events, both in Europe and in Australia, severe droughts have confirmed the high sensitivity of pasture production, with large-scale losses of 50% and more.

Consequences for global food production
Having a full viewing of the future would also need to incorporate an assessment of the future adaptation by geographical displacement of production zones. It seems easy to give a general idea of possible shifts, like the potential extension of grain maize or vine towards the north or the east in Europe. But it is much more difficult to quantitatively assess the large-scale consequences. Also, the forcing function of the market on the agricultural production is such that it is only possible to give the main tendencies caused by the component of climate change alone. When these are aggregated up to the scale of the global trade market, it is confirmed that most of the increase in production will come from the agriculture of developed countries, which will mostly benefit from climate change. The market will have to compensate for declines projected, for the most part, in developing countries: the reduction of agricultural productivity could approach 20 to 25% for countries like Mexico, Nigeria or South Africa and for some crops like wheat in developing countries. The resulting increase of the number of people at risk of hunger could grow marginally from 380 million up to 1300 million in 2080, depending upon future emission scenarios. It could even be underestimated in the case of unexpected surprises due to increased frequency and severity of extreme events.

Conclusion
Even if there are large uncertainties existing, if we consider the addition of those dealing with climate scenarios and those linked with the answer of cultivated crops, we may consider that there is a sufficient amount of work and knowledge for starting the adaptive process. There is less urgency than for the forest sector, for which decisions to be taken now will determine the growth characteristics of trees for the next 50 to

Abstract

100 years. But some productions like fruit-trees and vine need at least 20 to 40 years of anticipation, due to the duration life of planting and the corresponding delay in plant breeding. For annual crops, the time scale seems to be less constrained, but there are many questions about the medium-term (2020-2040).

Adaptation may be thought of in terms of genetics or cultural practices, but it will also include geographical movements along the European landscape, both in latitude and altitude. Potential changes are significant, as illustrated by studies delimitating the northern expansion of grain maize, sunflower or soybean. They will raise specific questions for the productions directly linked, generally in terms of quality, to local specificities, as in the well-known case of 'terroirs' for the wine production. In any case, we have to underline that these climate change impacts will be combined with other significant drivers, some being of technical character but others surely predominant concerning the economic and sociological aspects. Inversely however, these drivers will also have to cope with climate change as a possible first-order factor in the future.

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Carl Palmer

Carl began his education at the University of York with a MChem followed by a PhD in atmospheric chemistry, completed in 2006.

Carl then went on to a postdoctoral position at the University of Cape Town in ocean-climate biogeochemistry, where he developed a climatology of bromoform in the marine boundary layer via parameterisation of collated archive data.

Since then, Carl has been the education and training manager at the Applied Centre for Climate and Earth Systems Science (ACCESS) where he is responsible for curriculum development, teaching and implementation of the undergraduate training programme Habitable Planet. Carl has a specific interest in modeling methods and development of African appropriate laboratory techniques to investigage the distribution and fluxes of halocarbons in the marine boundary layer.

Abstract

“Open your mind, o!” Making sense of climate change education: challenges and opportunities in southern Africa

Carl Palmer, Applied Centre for Climate and Earth Systems Science (ACCESS)

Climate change is one of the most pressing issues facing humankind and as such an understanding of the Earth’s systems is essential for educators and children alike, in order for them to engage meaningfully with such a critical issue. Interventions to educate teachers and children on the topic have a tendency to start with the problem itself and what we must do about it, without first referencing the knowledge tools needed to engage with this new kind of problem. A systems level (cf. discipline specific) understanding of how the Earth functions, as well as knowing how to evaluate scientific information using critical thinking, are, for example, two such tools which are just as important as the message itself. Another challenge in teaching about climate change in schools is that often the political and ethical aspects pertaining to the issues are neglected, and the respective roles of science and politics are conflated with each other (as in “science prescribes the solutions”).

Although the scientific questions of ‘is climate change man made?, is it a severe problem? and is it really happening?” have all been answered with a resounding “yes” (with appropriate scientific confidence limits), the political questions about what a specific society’s response should be has no “correct” answer and should definitely not be dictated by scientists. The resulting myopic view, often results in practitioners taking a solely global perspective in teaching about climate change, which is insensitive to regional local and domestic differences, politics and priorities (e.g. Figure 1). The outcome of this is that the narrative on the issues emerges as uninspiring, inaccessible and instils pessimism and despondency among learners. ACCESS have demonstrated that an alternative approach, whereby an appreciation of the Earth’s systems, and why South Africa is a unique place to study them (see Figure 2), promotes fascination, pride and a sense of ownership among learners. From this platform it is easier, and arguably more effective, to convey the knowledge that the learners require in order to become active science researchers (the paucity of which is hindering the South African economy) or environmental ambassadors.

In this contribution we demonstrate that by thinking outside the box, the threat of climate change, can also be viewed as an exciting opportunity. We examine how: (i) an appreciation of the local context, (ii) A systems understanding, (iii) some critical thinking and (iv) a better understanding of the roles of science and politics can add value to climate change education in southern Africa. Using this approach we developed an exciting and progressive curriculum with a programme of teaching events that has inspired students and learners all over Africa. We show that this intervention is helping to train more scientists and instilling a love of the environment in many people who may otherwise not consider either. Together we contend that this delivers material benefits to the learners themselves, the economy, and most of all, the environment.

Abstract

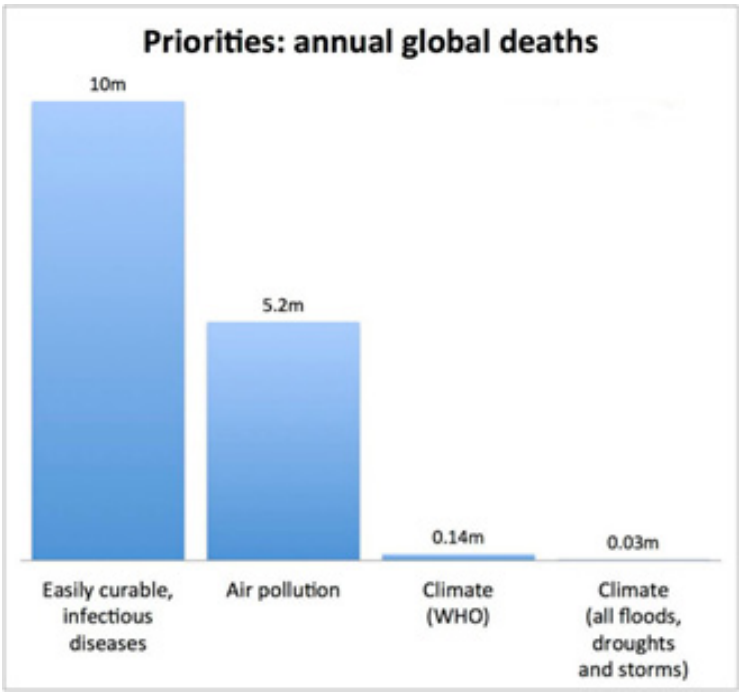

Figure 1. A comparison of global mortality from a variety of causes. Two estimates of climate mortality are given, the WHO estimate includes many indirect effects of climate and 141,000 deaths (http://www.who.int/mediacentre/factsheets/fs266/en/), whereas the lower estimate is just 28,266/year for the past decade, this using estimates of deaths from flooding, droughts, heatwaves and storms, and assuming every single extreme event is a result of climate change (http://www.csccc.info/reports/report_23.pdf). Most of the deaths on the left had side are in developing countries like South Africa. The majority of deaths from air pollution are due to indoor wood burning in homes that do not have, or cannot afford, electricity.* The logical solution to this in a coal rich country like South Africa is to burn fossil fuels. Or is it? What policy should we adopt, and why? Figure adapted from https://www.facebook.com/bjornlomborg.

*Bruce, Nigel, Rogelio Perez-Padilla, and Rachel Albalak. “Indoor air pollution in developing countries: a major environmental and public health challenge.” Bulletin of the World Health Organization 78.9 (2000): 1078-1092.

Guy Midgley

Guy Midgley obtained his BSc in plan physiology from the University of Stellenbosch, going on to obtain an MSc in Botany from the University of Cape Town and his PhD in biology from the University of Natal. Since then Guy has published more than 160 peer-reviewed papers, many in leading journals. Guy is an internationally renowned expert in several academic fields including biodiversity and global change science, bioclimatic and mechanistic niche modelling applications, evolutionary ecology and plant ecophysiology.

Guy has collaborated with a wide range of scientists around the world including ecological work on the Kalahari Transect Program; estimating species risk with York University, and biodiversity risk assessment and conservation planning with scientists of the Department of Environment and Conservation in Western Australia.

Guy has accumulated more than fifteen years of experience in leading and managing policy-relevant research, filling the role of lead scientist and group leader of the Global Change Research Group at SANBI (South African National Biodiversity Institute) since the late 1990s and leading an expanded Global Change and Biodiversity Program since 2005. Part of his work has included leading national and international meetings, including the May 2008 4th International Geosphere-Biosphere Program “Sustainable Livelihoods in a Changing Earth System” (Cape Town Convention Center), the National Global Change and Regional Sustainability Symposium (Kirstenbosch Center, October 2003) and the National Climate Change Symposium (Midrand, October 2005), co-organised with DEAT. As co-ordinating lead author of the Intergovernmental Panel on Climate Change (IPCC),and the CBD Technical Expert Group for Biodiversity and Climate Change, Guy defended IPCC science findings in plenary negotiations between 2007 and 2010, and locally led impacts and adaptation assessment syntheses for South African (South African Country Study on Climate Change, 2000) and Western Cape Government policy development purposes (in 2006).

In addition to his impressive academic and professional achievements, Guy has been engaged in numerous television and radio programmes, including live debates and interviews on national television and radio including National Geographic and the BBC as well as having produced several popular booklets, pamphlets and posters on climate change.

Abstract

The position of Southern Africa in Global Climate Change

Prof GF Midgley

South African National Biodiversity Institute, Kirstenbosch Research Center, Claremont, South Africa

Southern Africa stands to face significant adverse impacts from climate change in the long term, while the countries of southern Africa have historically contributed little to the causes of climate change (with the notable exception of South Africa). Emissions from countries north of South Africa's border are dominated by those from land cover and land use change, orders of magnitude lower than South Africa's emissions that are predominantly from coal-fired power stations. South Africa was one of the first developing country nations to announce their aspirations for tackling emissions reductions through the strategy of "peak, plateau and decline", supported by international assistance. This announcement was made prior to the 2008 United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties in Copenhagen, and is reflected in the Copenhagen Accord.

Only recently has the focus in southern Africa shifted from the potential benefits that might flow from climate mitigation actions carried out domestically, to the potential benefits from planning and implementing adaptation responses. Internationally, the incomplete adoption of the Kyoto Protocol (KP) by developed countries, and the vacillation by some leading global emitters due to political changes, has resulted in a collapse of the carbon price. This highlighted the weakness in the assumption made by developing countries in negotiating the KP under the UNFCCC that adaptation could be financed from 2% of the proceeds of international carbon trading. The weak carbon price has limited the potential of the Adaptation Fund of the UNFCCC. As a result, developing countries have endeavoured to establish a strong basis for adaptation finance through subsequent UNFCCC negotiations. At this time, developing countries are able to access adaptation finance from the UNFCCC Adaptation Fund via National Implementing Entities, but this should be seen as a learning-by-doing effort that would guide and inform more ambitious responses into the future.

I will reflect on the science of climate change and the related uncertainties, risks and opportunities that are relevant for southern Africa, the policy situation with regard to mitigation and adaptation, and future efforts that may be beneficial for the region. I will specifically reflect on South Africa's experience with their National Implementing Entity, which addresses action on the ground, and the development of Long Term Adaptation Scenarios to guide adaptation planning at a high level.

Roland Schulze

Roland Schulze began his education at the University of Natal, graduating with a BSc Hons in 1964. He then went on to achieve an MSc and PhD at the same institution in 1975.

In the year he finished his PhD, Roland took on a visiting scientist role at Hull University in the UK, followed by several other visiting scientist and professorships throughout his professional career at various universities across the world including the UK, USA, Germany, Sweden, and the Netherlands. In addition to his visiting roles in universities, Roland has also been a research partner and consultant for European and UK Department for International Development projects across the world. In South Africa, Roland is the project leader of a team of agrohydrological research scientists and engineers and a consultant.

Roland has also been on many national and international committees including an author (in 2004-2006) and reviewer (2013) for the Intergovernmental Panel on Climate Change, on the advisory board of UNESCO's International Hydrological programme, the steering committee for UNESCO's Hydrology for the Environment, Life and Policy and co-chair on indicators for UNESCO's World Water Assessment Programme.

In addition to the packed curricula above, Roland has also authored well over 500 academic papers, books and chapters, and served on the editorial board of several journals.

Abstract

Reflections on Climate Change Impacts over South Africa: Why Focus on Water?
Roland Schulze, Professor Emeritus of Hydrology
University of KwaZulu-Natal, Pietermaritzburg Campus

South Africa's water resources, already subjected to high hydro-climatic variability both over space and over time, are a key constraint to the country's continued economic development and the sustainable livelihoods of its people.

In regard to climate change it should be stressed that because:

- water is arguably the primary medium through which early (and subsequent) climate change impacts will be felt by people, ecosystems and economies,
- a large proportion of South Africa's population is impoverished (thus rendering them particularly vulnerable to impacts of climate change),
- many of the fragile ecosystems in South Africa (both terrestrial and aquatic) are implicitly or explicitly water dependent,

It has become urgently necessary to gain a comprehensive understanding of the physical drivers and the hydrological responses of climate change in a South African water sector context in order to develop science based strategies and plans of action to adapt to climate change through an integrated approach to land and water management as the cornerstone to establishing effective resilience to the projected impacts of climate change.

In addition to the above, it should be noted that:

- water-related infrastructure (e.g. dams, irrigation projects, inter-basin transfers, storm-water drains etc) is typically a long term investment with a design life of 50 - 100 years, is very expensive, essentially irreversible once constructed and is designed to cope with currently (but not necessarily future) expected extremes of floods and droughts,
- any changes in rainfall, be they up or down, are amplified in changes of hydrological responses (in the case of year-to-year variability the amplification from rainfall to runoff can be 2 - 5 fold),
- climate change is not going to be experienced evenly throughout the country, with some areas "winners", other areas "losers" and others still are likely to become real "hotspots of concern",
- climate change does not occur on a "clean sheet" of virgin catchments not yet impacted upon by human interventions on the land and in the channel, but will rather be superimposed onto already water stressed catchments with complex land uses, water engineered systems and a strong socio-political as well as economic historical footprint, and that symbiotic links exist between water and:

1. human and animal health
2. disaster risk management
3. agriculture – both rainfed and irrigated
4. commercial production forestry
5. many coastal zone processes
6. biodiversity
7. mountain zones – as the water generating zones of South Africa

8. the transport sector
9. the insurance industry
10. the tourist industry
11. the energy sector
12. our neighbouring countries through transboundary waters in the sense of either water flowing from other countries into South Africa (e.g. Lesotho) or water flowing from South Africa into other countries (e.g. Mozambique) or rivers forming international boundaries (e.g. with Namibia, Zimbabwe, Lesotho).

The above factors render the in-depth understanding of the ramifications of projected climate change on the one hand, and the development of a dynamic, water related adaptation response strategy to climate change on the other, imperatives for South Africa. Many of the issues alluded to above are contained in a book titled "A 2011 Perspective on Climate Change and the South African Water Sector" (pp 366) and a companion document titled "Atlas of Climate Change and the South African Agriculture Sector: A 2010 Perspective" (pp 388).

Abstract

In addition to the above, it should be noted that:

- climate change from a water viewpoint also has to be considered from a perspective of broader development national agendas (e.g. National Planning Commission; the Presidential Outcomes) in emphasising adaptive land and water management in a holistic, integrative manner,
- the latest (2013) Department of Water Affairs' National Water Resource Strategy 2 has placed heavy emphasis on climate change by committing itself to a set of principles, objectives and key issues.

Overarching all of the above are the recent (2013) updates from the Intergovernmental Panel on Climate Change confirming, inter alia, that:

- there is new and stronger evidence than before (at very high confidence) of observed impacts of climate change on vulnerable systems such as water, with increasing levels of adverse impacts as temperatures increase,
- there is new evidence that observed climate change is likely to have already increased the risk of certain extreme events such as floods and droughts (very high confidence), and it is more likely than not that warming has contributed to the intensification of some tropical cyclones, with increasing levels of adverse impacts as temperatures increase,
- the distribution of impacts and vulnerabilities is still considered to be uneven, with less-developed areas (such as large parts of South Africa) generally at greatest risk due to both higher sensitivity and lower adaptive capacity, but with evidence also that vulnerability to climate change is highly variable within countries,
- adaptation can significantly reduce many potentially dangerous impacts of climate change and reduce the risk of many key vulnerabilities.

Rob O'Donoghue

After 7 years as a primary school teacher Rob O'Donoghue joined Ezemvelo KZN-Wildlife where he coordinated Environmental Education services and research as Senior Professional Officer supporting activities in park, school and local community settings for just under 20 years. During this time he established the Share-Net low-cost printing initiative with The Wildlife and Environment Society of South Africa and WWF-SA, publishing numerous open access 'Hands-on field guides' and practical environmental learning materials for use in classroom and fieldwork settings. He completed a MEd at University of Natal on 'participatory curriculum development in the sciences' in 1990 and a PhD at Rhodes on 'the emergence of environmental education in eastern southern Africa' in 1997.

He is now an Associate Professor in the Environmental Learning Research Centre at Rhodes University. Rob has published numerous papers in internationally peer-reviewed journals and has recently given close attention to indigenous knowledge practices, social theory and environmental learning in post-colonial curriculum and community contexts. His work on the intermeshed bio-physical, social, economic and political dimensions of environment and environmental issues like biodiversity and climate change is a key orientating perspective in environment and sustainability education today, and his text on 'active learning processes' is a guidelines document for environmental learning in the revised South African national curriculum. His recent work has been on scientific knowledge acquisition and social change draws on historical sociology after Norbert Elias, the communities of practice work of Lave and Wenger, CHAT after Engestrom and the social realism of Archer.

His most recent work, edited with two of his students Dr Clayton Zazu and Dr Soul Shava, is on "African Heritage Knowledge and Social Innovation," an e-book launched at the World RCE Congress in Nairobi in November 2013 and available from the United Nations University web site http://www.ias.unu.edu/resource_centre/UNU_Booklet_MB2013_FINAL_Links_v12.pdf.

Abstract

What, along with the science, is also important for teaching climate change?
Rob O'Donoghue
Environmental Learning Research Centre
Rhodes University

This presentation suggests that not only must teachers, "be provided with sound scientific information in order to answer the questions that, invariably, they will have from their students" (GIFT, 2014) but with materials that allow a grasp of why local climatic and social-ecological contexts are special and what might be practical responses to the climate change of our modern times.

Climate change is now a clear topic in the CAPS curriculum. The Fundisa for Change, Habitable Planet (ACCESS) and the UNESCO international materials are all excellent for teacher professional development. These and other informative scientific materials provide useful support for teachers to tackle this new curriculum topic. With so much compelling scientific material available to teachers, it may appear strange to note that there are still surprising anomalies and omissions that can be easily overlooked.

A surprising anomaly is that climate science has produced compelling evidence for the emergence of human influenced climate change on a global scale but this is still notoriously difficult to reliably translate into the changes that will play out in most regional contexts across the globe. This workshop notes that teachers as mediating social translators of the issues of the day, need sound scientific information, as mentioned above, but this is not enough. A necessary addition here might be materials that allow a grasp of the issues in their regional contexts and a sense of the practical responses to these issues of our times. This is an issue that takes us beyond simply teaching scientific facts that do not currently translate with sufficient reliability for an area of high climate variability like the Eastern Cape.

Exploring interesting anomalies and omissions like these might make climate change one of the most exciting and engaging topics in the curriculum if only we had a better idea of how to teach it in ways that might best inform positive change. In the Eastern Cape, for example, there is knowledge on how the early peoples not only shaped regional habitats and their micro-climates but also learned to successfully live in a region of high climatic variability that is now better understood with climate science today. To this end the presentation explores:

- How climate and social-ecological processes make the macro, socio-cultural landscape of the Eastern Cape special
- Evidence of early climate migration in response to regional climatic variability
- Evidence of a regional, village-level innovation for mitigating the risk of seasonal climate variability
- Evidence of the garden-level mediation of food production in an area of high climate variability.

This paints the Eastern Cape as a special social-ecological landscape that is not only ideal for teaching what is now known about climate change but also for contemplating things that we can change and things that we can do to live in better alignment with a planet that is in the midst of profound climate change that we need to both understand and respond to as teachers.

Michael Verstraete

Michael Verstraete began his scientific career in the National Centre for Atmospheric Research in Boulder, USA, after obtaining his PhD at Massachusetts Institute of Technology (MIT) in 1985. From there until 1990, Michael served as staff scientist and later visiting and adjunct professor at the Office for Interdisciplinary Earth Studies in Boulder and the University of Michigan, USA. From 1990 until 2011, Michael worked in Italy with several research institutes as a researcher and senior scientist, mainly working in terrestrial environment and atmospheric modelling, and later moving to remote sensing of the land and ocean.

In 2011 Michael made his move to South Africa, initially on sabbatical at the Council for Scientific and Industrial Research in Pretoria. In 2013, Michael received a distinguished scholarship from the University of the Witwatersrand in Johannesburg while working as a senior scientist in the Climate Risk Management Unit of the Institute for Environment and Sustainability at the European Commission Joint Research Centre, Italy. In October 2013 Michael moved back to South Africa to take on his current role as chief scientist at the Earth Observation Directorate at the South African National Space Agency, Pretoria.

In addition to his scientific appointments, Michael has received the ENVISAT Medal of the European Space Agency, co-authored over 220 scientific publications and served on the editorial boards of the journal Environmental Science and Policy and the Advances in Global Climate Change Research book series.

Abstract

Opportunities for science teaching arising from Earth Observation

Michel M. Verstraete

Chief Scientist, SANSA Earth Observation Directorate

Climate variability and change, as well as environmental degradation, have been identified as some of the most critical issues facing humanity, as they could threaten the habitability of the planet and the survival of humanity. These issues are particularly relevant for the current and upcoming generations of students, as they will have to deal with the consequences of these processes throughout their life. Earth Observation, and in particular remote sensing from space, offers a powerful set of technologies to monitor relevant processes and changes, to plan economic development and manage natural resources, as well as to assess the effectiveness of mitigation and adaptation measures. This lecture will discuss some of the current challenges in this field, focusing on opportunities to teach basic science (in particular physics, but also other sciences, engineering and computing) in secondary schools as well as highlighting job opportunities that will likely be open in these and related fields in years to come.


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