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When the catfish awoke: Interview with Tohoku photographer Stephen Vaughan

Meet Mioara Mandea, EGU's new General Secretary

End of EPOCA: Report on the first international large-scale research project on ocean acidification

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EDITORIAL



The General Assembly may be behind us, but the annual conference is never too far from the minds of those working at EGU. The first planning meeting for the 2013 Assembly took place earlier in the summer and, as I write this editorial, the call for session proposals is ongoing. If you are interested in proposing a session for next year's meeting, please check the <u>Call-for-Sessions page on</u> the EGU2013 website and submit your suggestion by 14 September. Other <u>important dates</u> include the deadline for support applications (30 November) for young scientists in need of funding to attend the conference, and the deadline for the receipt of abstracts on 9 January 2013.

While the main focus of this third edition of *GeoQ* is no longer the General Assembly, two of the features in the Articles section reflect back on April's meeting. Tim Middleton asks Stephen Vaughan about his remarkable exhibition at the Assembly, *A Catfish Sleeps* – *Tohoku, photographs in Japan 2009–2011: before and after the Great East Japan Earthquake.* And Mona Behl writes about the Landspotting Project, a programme first presented at the 2012 General Assembly that focuses on an innovative way of collecting geodata for satellite validation.

The External News section features another article of recommended reading. Scientists of the European Project on Ocean Acidification, EPOCA, including the project's coordinator and manager, report on the advances in the scientific understanding of ocean acidification that resulted from the project. EPOCA, which ended in April 2012, was an international effort to further research on 'the other CO₂ problem', comprising over 160 scientists from 10 European countries.

Another highlight is the Education section of this edition. While in previous issues the section featured reports from the EGU Committee on Education (which will return in the next newsletter), in this volume we include two articles focused on educational activities and learning resources in the geosciences. The pieces are especially targeted at teachers, but are a worthwhile read to anyone interested in science education and teaching activities.

GeoQ will come back with a special edition at the end of this year – a volume dedicated to the 10 years of the Union and its General Assembly. Until then, enjoy reading this September issue!

Bárbara Ferreira Chief Editor & EGU Media and Communications Officer

The current and previous editions of the EGU newsletter (GeoQ and The Eggs) are available online at www.egu.eu/newsletter.

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GEO C ARTICLES

When the catfish awoke

An interview with Stephen Vaughan

On 11 March 2011, photographer <u>Stephen Vaughan</u> was standing at the base of the Tokyo Skytree – the world's tallest tower. He had just packed up his camera when the ground started shaking. The buildings began to rattle. People became agitated. The Skytree swayed dramatically. "It took me some time to comprehend what was happening," remembers Vaughan, "it was a strange, disturbing, and unforgettable sensation".

Vaughan's fascination with geological landscapes had begun many years previously, starting with a series of photographs of Iron Age human sacrifices, exquisitely preserved in northern European peat bogs. From there, his exploration of cultural histories and geological phenomena took him to Iceland – a landscape so alien that it was used by NASA astronauts for field training before their first moon landing. In 2009, Vaughan travelled to Japan to continue to make images at the interface between the cultural and the geological; he took photographs at natural locations – sites of geothermal activity and historical seismicity – that have been appropriated as spiritual

pilgrimages and tourist spectacles. He also visited the earthquake simulator at Japan's National Research Institute of Earth Science and Disaster Prevention. The resulting exhibition was called *The Catfish Sleeps* – a reference to the eighteenth century Japanese belief that the deity Kashima held a foundation stone on the head of a giant catfish to protect the population from the terrors of the earthquake when the catfish stirred.

Then, in 2011, Vaughan returned to Japan. His imagination had been sparked by a book called *The Orphan Tsunami*, by Brian Atwater and colleagues, which documents an unexplained tsunami on the northeast coast of Japan and its apparent links to the North American Cascadia earthquake of 1700. "My intention was to make a series of photographs in Iwate prefecture that acknowledged these invisible histories within the coastal landscape," recalls Vaughan. "I had been researching historical seismic events and the probability of future earthquakes. So, for me, earthquakes were imagined but never experienced."



Akahama, Otsuchi, Iwate Prefecture, Japan, 2011 (Credit: Stephen Vaughan)

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It was then - whilst Vaughan was standing in central Tokyo - that the catfish awoke. The magnitude 9.0 Tohoku earthquake struck off the northeastern coast of Honshu and nearly 19,000 people died in the ensuing tsunami. Suddenly, the subject of Vaughan's work became a visible reality. "I knew that I had to follow my original intentions by continuing the work I had planned to make," explains Vaughan. As soon as it became possible, he travelled via the northwest coast of Honshu, then east to the city of Morioka, to those places in Iwate prefecture that had been devastated by the tsunami. He began to make photographs in Kuwagasaki, Tsugaruishi and Otsuchi. "Nothing had prepared me for the overwhelming scale of the disaster in these places," says Vaughan, "The indiscriminate natural forces that created the total destruction that I saw are beyond my ability to comprehend or describe. But I also knew that I must make every effort to create a response to those events that was as accurate a description as I could possibly produce."

In many ways, Vaughan's presence in Japan at the time of the earthquake was the perfect opportunity to pursue his work, but he is also acutely aware of the human side of the catastrophe: "To make photographs within the context of such a disaster without questioning the validity of one's own presence would be very problematic indeed. Parachuting into disaster zones to make images of other people's suffering could be seen as exploitative and voyeuristic. I did not want to be associated with an unjustifiable intrusion of this kind." But Vaughan certainly wasn't an unjustified intruder. "I felt that my presence as an observer was validated by the wider context of my enquiry and the fact that I was personally involved and caught up in the events as a participant," he explains.

"I felt a keen sense of responsibility to bear witness to what had happened there and to create a document that could contribute to an historical understanding of the disaster," he says, "There was an inevitable tension between an urgency to engage with the subject before me, and the need to represent the subject with integrity and respect." Vaughan's overwhelming sense of this need for respect is indicative of his thoughtful and humble approach. After making his photographs, he spent a while volunteering in one of the evacuation centres.

The inherent tension that Vaughan feels in relation to his work is also something that continues as he has to decide how the images should be disseminated. His latest exhibition – *Tohoku*, which was

exhibited alongside *The Catfish Sleeps* at the 2012 EGU General Assembly – includes some remarkable works that bear witness to the scenes of destruction in minute detail. Reams of twisted debris dominate these landscapes and in the middle distance passenger ships are seen balanced atop people's former homes. These busy images are made possible by Vaughan's large-format camera – complete with darkcloth – and individual sheets of film. "I prefer to work slowly with the older technology," he explains.

Vaughan is clearly fascinated by what is possible when photography and geology work in tandem; and nowhere is this more apparent than amongst the geological maps he uses to plan his expeditions. Prior to his work in Japan, he made practical use of a variety of maps - tectonic maps, volcanic maps, maps of historical seismicity and seismic rupture probability maps - to help decide which landscapes to photograph. "The journey that I made from the far north to the far south of Japan in 2009 included landscapes, cities and research facilities that relate directly to the accumulated information from those maps," he explains. But for Vaughan the overlap between the arts and the sciences runs deeper than mere utility. "Many of the maps that I used in preparation for photographing in Japan are incredibly beautiful, graphic objects in their own right," he says, "cartography and the visual arts both produce artifacts that require (or stimulate) complex readings. [Maps] act as shorthand to a more profound understanding of place and process. In this respect, they mirror the ambitions of art-making very closely indeed."

It is Vaughan's hope that his exhibition at the 2012 EGU General Assembly will allow him to continue this interdisciplinary work. "I am seeking ways to bring together my photographic work with physical and graphic artifacts from geoscientific research, and to discover new opportunities for projects in collaboration with geoscientists," he says. And it seems that this sort of relationship could be a symbiotic one: Vaughan's work requires geological knowledge and geology needs people like Vaughan to help explore new forms of geoscience communication for a wider public audience. Working together is clearly the way forward, but, as Vaughan already knows, both parties must be sensitive to the human aspect of disaster when the catfish next awakes.

Freelance science writer and PhD student at the University of Oxford



Otsuchi, Iwate Prefecture, Japan, 2011 (Credit: Stephen Vaughan)

Tim Middleton

Landspotting: A new web tool to improve land cover validation

The rise of user generated media such as blogs, Twitter, Facebook, LinkedIn or Wikipedia, has bridged the gap that existed between the producers and consumers of information. With the advent of Internet technology, ordinary citizens with no scientific training in remote sensing can now contribute to society's overall knowledge base via crowdsourcing, whilst doing something they enjoy. Volunteered Geographic Information (VGI) refers explicitly to geospatial data that are created by participants with an interest in geography, cartography, biodiversity or related fields. Using GPS, mobile devices, photography, textual information or local knowledge, these volunteers are able to submit a variety of information to a website. This resource has already been used in the development of tools such as Wikimapia, Openstreetmap, MapAction, and Google Earth/ Panoramio.

Tapping into the enormous potential that crowdsourcing and VGI have to offer, a team led by Steffen Fritz at the International Institute for Applied Systems Analysis in Austria, developed a <u>Geo-Wiki</u> in 2009. In Fritz' words, "Earth observation derived global land cover data products – for example <u>GLC-2000</u>, <u>MODIS</u>, and <u>GlobCover</u> – provide valuable information about land cover types, such as urban, forested, cropland, wetlands, shrubland, agriculture, conditions of natural resources, quality and quantity of water, snow and ice, etc. However, these land cover data products show a high degree of disagreement when compared with one another, and therefore a high degree of uncertainty in their estimates. The users of these data face many challenges, among other things due to cloud cover and misclassifications."

The Geo-Wiki application provides a web tool for volunteers. It was originally designed to solicit their feedback on whether the data provided by the three land cover types are correct, incorrect, or if the validator is unsure. The application has now moved towards asking volunteers to identify the land cover and other information, such as the degree of human impact that is visible from Google Earth through competitions that are run on a regular basis. This allows users from around the globe to contribute to spatial land cover validation and classification via Google Earth. The application uses a predefined set of criteria to facilitate land cover validation; hence the VGI is more strictly referred to as F-VGI (Facilitated VGI). This package has a variety of research applications such as climate change, food security, monitoring of tropical deforestation, land use monitoring and modelling, etc. and it also allows users to create a validation sample for their own specific applications.

The Geo-Wiki team has now taken their development a step further by creating an innovative Landspotting game.

The Landspotting project

With more than 600 million users around the world, Facebook has become a powerful social networking tool. Within Facebook there are games, such as FarmVille, which encourage communication, social interaction, and the exchange of information. Crowdsourcing offers an enormous opportunity to engage people via 'serious gaming' on Facebook. Foldit is one such game, allowing players to collaborate and compete in predicting the structure of protein molecules.

Developed along similar lines, the Geo-Wiki team has recently launched their new Landspotting game. This game aims to improve land cover data by engaging Internet users and game players in land cover validation exercises using Facebook.

"After a lot of brainstorming, we came up with the idea to develop a strategy game," says Tobias Sturn, the research at the Technical University of Vienna, Austria who built the Landspotting game.



A screenshot of the multiplayer game Landspotting: improving global land cover data via social gaming on Facebook.

Based on concepts similar to those used in the iconic strategy game <u>Civilization</u>, players build (harvest, research, wage war, etc.) in a Stone Age world over thousands of years. Landspotting is similar to Civilization but it is played on Google Earth. The players are directed to certain hotspots of land cover uncertainty (information obtained from a comparison of the GLC-2000, MODIS, and GlobCover data sets), and are asked to enter or record the type of land cover they see. Using the 'Paint' tool, the players can map their territories, and classify Google Earth imagery into different land cover types.

"Motivating people to engage in playing games can sometimes be a tedious task. In order to encourage interaction whilst making it a global endeavour at the same time, we decided to provide rewards to incentivize the game," says Fritz.

The players score points for their entries. The game is particularly useful from a land cover perspective, since users are directed primarily to areas with high disagreement, and where high-resolution scenes are available for validation. In order to control for misuse, and improve the quality of the VGI, there is an overlap between the land cover validation pixels. The game is freely available to Facebook members and can be played anywhere using a web browser (where Flash is supported) without requiring the user to install additional software.

Since all users play the game on a single Google Earth map, the information regarding land cover is recorded and stored in a unique database along with uploaded photos. The data will eventually be used to create a more accurate, hybrid global land cover map that can be used in a number of crucial applications such as food security (especially in developing countries, where high quality datasets available are currently lacking), drought monitoring, forestry applications, carbon sequestration projects, and integrated assessment modelling.

Validation competition

To increase participation, and to raise awareness among a greater number of people, the Geo-Wiki Team is inviting volunteers to participate in a validation competition. Each player is presented with pixels overlaid on Google Earth and is then asked to choose the land cover types up to a maximum of three classes including the percentage of the pixel that each type covers.

"The target is to collect more than 100,000 validation points that will provide valuable information for the future validation of land cover maps, and will also help us understand how much people have modified the landscape," says Fritz.

As an incentive, the top 10 classifiers will be invited to join as coauthors on a scientific publication that will be an extension to the 'human footprint' work done by <u>Sanderson et al. (2002)</u>, and will be entitled: How much wilderness if there left on this planet? Furthermore, the top three classifiers will be awarded Amazon gift certificates of between 20 and 40 Euros.

Earning, learning, and contributing to a global endeavour by engaging in social gaming sounds like an exciting, and intriguing venture. For more information, visit: competition.geo-wiki.org/.

Mona Behl

Visiting Fellow, American Meteorological Society Policy Program

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A frame that shows the user exploring the land to enter/record the type of landcover they see while playing the Landspotting game.

Life & times of granite

How the igneous rock set the stage for the evolution of multicellular life

You may have learnt about life and evolution in a biology class at school, but geology also has a thing or two to say about the evolution of life on Earth. In fact, it can provide answers to some of biology's fundamental questions. Heavy metals, for example, including zinc, copper, and molybdenum, turn out to be exceptionally important for life, since certain proteins require them in their synthesis. Geology may hold the answer as to why life came to be so dependent on these metals: granites.

Or so claims a team of scientists lead by John Parnell of the University of Aberdeen in Scotland, in <u>a recent study</u> published in *Geology*. The researchers suggest that, a couple of billion years ago, metal-rich magmas rose from the planet's interior to the near surface where they were deposited and cooled down to form granites. Weathering then freed up the metals in these rocks, which became available to primitive cells. The rest, as they say, is history.

The insight of Parnell and his collaborators was bringing biology and geology together. The development of sexual reproduction and the onset of the diversification of eukaryotes – organisms made up of nucleated cells – occurred in the Mesoproterozoic, the period in the Earth's history between 1.6 and one billion years ago. At about the same time, granites bearing metals known to have played a critical role in the evolution of complex cells became widely available.

"A lot of us in the community have noted loosely that there's this correlation and we've wondered if there's something to it," <u>said Ariel</u> <u>Anbar</u>, a geologist at the Arizona State University in Tempe who did not take part in the study, to *Inside Science*.

Parnell and his collaborators believe there is. "We propose that metals were delivered [to primitive organisms at the Earth's surface] due to a critical combination of continental growth, near-surface metal concentration, and erosion into the surface environment during the Mesoproterozoic," they write in the paper.

The origin of sexual reproduction, a key event in life's history, was preceded by the formation of a supercontinent known as Nuna, or Columbia, some 1.9 billion years ago in the Palaeoproterozoic – the period just before the Mesoproterozoic. "This was a peak time of mantle-derived magmatism and hydrothermal activity perhaps unique in Earth's history," Parnell said to New Scientist. It was this continent-forming activity that delivered high concentrations of metals, trapped in the magma, from the mantle to just beneath the surface.

The molten material from within the Earth then cooled down and crystallized forming a particular variety of granite – one with a chemical composition that causes the metals to concentrate in ore deposits within, rather than distributed throughout, the rock.

These 'sulfide ore deposits' are readily eroded, and the authors cite a wealth of evidence in the geologic record suggesting this process started almost immediately after the granites formed. <u>Sedi-</u> mentary records, for example, show that certain sulfate minerals



Granite boulders in La Digue, Seychelles (Image by S. Sollberger, distributed by EGU under a Creative Commons licence)

were absent until about 1.7 to 1.6 billion years ago. The researchers believe their appearance resulted from the weathering of the metal sulfides to sulfates. This reaction occurred because the ore deposits were abundant and because the oxygen content of the Earth's atmosphere was by then high enough to weather the sulfides.

(Primitive non-nucleated organisms called cyanobacteria, or bluegreen algae, filled the world with oxygen through photosynthesis in the first billion years of life. They absorbed water, kept the hydrogen for energy, and released oxygen, increasing the concentration of this gas in the atmosphere. Oxygen is thought to have first become a significant atmospheric component about 2.4 billion years ago.)

With the weathering of the ore deposits came the delivery of the precious heavy metals, namely zinc, copper, and molybdenum, to the shallow-water environments where life was thriving. "These metals were used by early cells to develop enzymes that enabled them to carry out a greater diversity of functions and begin to sexually reproduce," said Parnell to New Scientist. "They gave early life the added dimension of natural selection and variability."

Other scientists have called the team's hypothesis "attractive" and the findings "interesting and intriguing". The prevailing consensus, however, is that primitive organisms got their heavy-metal fix due to changes in ocean chemistry resulting from the increased atmospheric oxygenation.

"I think we should all be cautious about saying, 'Oh, this one factor was the key'," Anbar said to *Inside Science*. "There are probably multiple factors."

Either the dominant source of metals or not, granite – Earth's "signature rock" – seems to have played a part in life's development on this planet.

> Bárbara Ferreira EGU Media and Communications Officer

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'Eyes' of Herschel survey enigmatic region beyond Neptune

How trans-Neptunian objects can help us understand our Solar System and its formation

Since its discovery in 1930, Pluto had a special place as one of the planets of the Solar System... until 2006. In August that year, Pluto and other similar objects were the subject of controversy because the term 'planet' was redefined: from then on, only celestial bodies that dynamically dominate their orbital region (among other criteria) would be considered planets. Pluto, in part because of the many small bodies – more than 1,500 were discovered so far – that inhabit the region beyond the orbit of Neptune, lost its planet status. It is now a dwarf planet, part of a group of remote and very cold objects beyond Neptune called trans-Neptunian objects (TNOs).

But these objects also have a special place in the Solar System. They represent the primitive remnants of the disk from which the planets formed, and they inhabit the region where terrestrial water might have originated from. Researchers from the Max Planck Institute for Solar System Research in Germany have recently confirmed that the water of a comet originating in the TNO region has the same composition as the water in our oceans. Scientists are trying to learn about the formation and evolution of the Earth and the Solar System, and TNOs offer several clues.

The physical properties of these TNOs are largely unexplored and the thermal properties are difficult to measure, mainly because these objects are far away. But recent studies, combining new observations carried out with the Herschel Space Observatory and sophisticated models to interpret the data, reported physical and thermal properties of a sample of TNOs. These findings are of significance because they provide unique and important constraints on the almost unprocessed material coming from the frontiers of the Solar System, and on the formation and evolution of the Solar System itself. TNOs represent a fingerprint of the planet-formation era.

Difficulties in determining TNOs thermal properties

The dynamical characteristics of TNOs, such as velocity and orbit, are relatively easy to determine with visible-light telescopes on Earth – and have allowed astronomers to divide TNOs into clubs or dynamic groups. These observations revealed a variety of inclinations of TNOs' orbital planes resulting in a complex orbital architecture, which astronomers cannot yet fully explain. To find out why different groups of TNOs have distinct dynamical properties, scientists need to measure other characteristics of these objects.

Further, measuring physical properties such as size and albedo (percentage of reflected light: low albedo is indicative of a dark surface material like tholin, and high albedo of pure ices) is particularly significant in identifying candidate dwarf planets like Pluto. These Sun-orbiting objects are large enough for their self-gravity to crush them into a nearly round shape but, unlike planets, dwarf planets do not dynamically dominate their orbital region. Objects with more ice (high albedo) become round at smaller sizes than those with more rock – a high-albedo TNO with a diameter larger than about 400 km is considered a strong dwarf planet candidate. However, estimating physical properties of TNOs is considerably harder than measuring their velocities and orbits, since it requires observations in wavelengths other than the visible. Measurements of thermal emissions, which peak at far-infrared wavelengths, offer the best available means to determine those physical properties. But these wavelengths are mostly absorbed by water vapour in the Earth's atmosphere; therefore, they can be best detected from space.

Herschel comes to help

The Herschel Space Observatory, one of the cornerstone missions of the European Space Agency (ESA) with participation from NASA, is delivering a wealth of observations of celestial targets in the farinfrared and sub-millimetre wavelength range, including objects in the region beyond Neptune. Herschel, with its 3.5-m-diameter telescope (the largest infrared telescope in space) and three scientific instruments onboard, is the only space facility ever developed to fully cover these parts of the electromagnetic spectrum.

In the framework of the Herschel Open Time Key Programme <u>TNOs</u> are cool: A survey of the trans-Neptunian region, led by Thomas Müller of the Max Planck Institute for Extraterrestrial Physics in Germany, measurements of around 130 TNOs are being obtained. The team recently reported fundamental properties of TNOs in various studies published in the journal Astronomy & Astrophysics. Astronomers believe different TNO groups are the outcome of the various evolutionary processes that sculpted the Solar System. Therefore, it is crucial to investigate the physical properties of TNOs in the different clubs to grasp these various processes.

Pluto-like bodies

Some TNOs show dynamic behaviour similar to that of the dwarf planet Pluto (i.e., with an orbital velocity 2/3 of Neptune), being called Plutinos. Recently, Mommert and collaborators published sizes and albedos of 18 Plutinos – the largest sample to date – based on dedicated Herschel observations. The sample comprises objects which, with the exception of Pluto, range from 150 to 730 km in diameter and between 0.04 and 0.28 in albedo. Some models predict Pluto-sized objects (~2,000 km in diameter) in this club, but future surveys are needed to discover if such objects do exist or if models need to be revised.

Scattered and detached objects

Other TNOs have highly elliptical orbits and sometimes high orbit inclinations: they are members of the 'scattered disk objects' or SDOs club, and their formation is still poorly understood. Another group of TNOs are well outside Neptune's orbit – beyond 50 times the Earth-Sun distance – and are named detached objects.



Diagram showing relative sizes of the population of TNOs already published, based on Herschel data (Credit: Miriam Rengel)

From Herschel observations, Santos-Sanz and colleagues have recently characterized 15 SDOs and detached objects, measuring their size, albedo, and other properties. Aside from Eris – a large dwarf planet, – diameters of the sample ranged from 100 to 1,280 km, and low albedos (from 0.04 to 0.09).

Interesting objects in this group include 2010 EK₁₃₉, and Sedna. As reported by Pál and collaborators, 2010 EK₁₃₉ turned out to have more than a quarter of Pluto's diameter and an albedo higher than previously believed, indicating that the surface might be covered by a large fraction of ice making the object a plausible candidate for a dwarf planet. Sedna is peculiar because of its orbit: it is the most distant detached TNO known, and is therefore important in determining the edge of the Solar System population with perturbed orbits.

Left out: The classicals

Another study, focusing on TNOs that do not belong to any other club and have nearly circular orbits, found yet other large objects. Vilenius and colleagues measured the diameters and albedos of 19 of these so-called classicals and found large objects, such as 2002 MS_4 and 120347 Salacia, among them. They also found the sample to be diverse in terms of albedo. Curiously, these members represent the superposition of two different subclasses, the cold and hot populations, which have high or low inclinations, respectively. Their study found that these TNOs with high inclinations have higher albedos than the TNOs with low inclinations. Most scenarios suggest that the cold and hot populations may have originally formed in different regions, and migrated during early Solar System evolution.

When size matters: Is Pluto the largest TNO?

Previous direct imaging suggested that Pluto's 'twin' Eris was about 5% larger than Pluto, which itself has a diameter of about 2,000 km. More recently, Eris occulted a faint star and astronomers measured a smaller Eris size than previous measurements, but still in the size-range of Pluto. Since the atmosphere of Pluto prevents accurate measurements of the location of its surface, researchers have not yet been able to confirm whether Eris is larger than Pluto. In the old nomenclature, Eris would clearly be a planet.

Herschel is helping to determine if Pluto is indeed the largest object beyond the orbit of Neptune and find more about Eris and other large TNOs. Further, the growing samples of the various clubs observed with Herschel, and the detailed characterization of these objects, will provide information on the present and the original size distribution of these bodies, remnants of the formation of the Solar System. Herschel results will now be fed into formation and evolution models, which will help scientists draw a more accurate picture of our Solar System, our immense home.

Many large TNOs are worlds of their own. With moons, icy surfaces, and (very likely thin) atmospheres, they would likely have been called planets in former times. They can tell us many things about the early stages of the Solar System, and maybe even about how Earth formed and gained its water and organic materials.

One thing is clear: there is still much to find out about the intriguing, distant, icy bodies beyond Neptune.

Miriam Rengel Astrophysicist at the Max Planck Institute for Solar System Research

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GEO C EGU VOICE

Letter from EGU's new General Secretary

Meet Mioara Mandea

Dear EGU friends,

Since April's General Assembly, thanks to your deep confidence, expressed by your vote, I'm serving as the EGU General Secretary. You know me or maybe you don't... If I would have only one sentence to tell you about my past and current research, I should say I'm a geophysicist, mainly involved in measuring, mapping, and understanding the multitude of magnetic fields encountered in the vicinity of the Earth and Earth-like planets. Understanding our planet, from its deep interior to the nearby space, requires new geophysical measurements and new mathematical tools, to analyze and extract the crucial information from the available data. My research has been continuously influenced by these aspects, which will have an effect on my time as EGU General Secretary. And so will the fact that I have always considered scientific research an activity to be shared with others, mainly with younger scientists.

My great interest in tackling the important subjects posed by understanding the Earth's system has brought me to the EGU, which stands as an ideal environment to address important questions linked to the characterization of parameters governing the Earth's evolution. I believe that my education, my employment background and my personal interests are particularly appropriate for the role of EGU General Secretary. My professional experiences in Romania, France, and Germany, are and will be beneficial for ensuring an appropriate working frame for this new challenge. My broad and diverse range of interests is an effective contribution in developing networks and mechanisms for European and international cooperation, in order to continue to support the geosciences community, from north to south, from east to west. The position of EGU General Secretary asks for some efforts, but doing what you like is a pleasure not a chore - and I feel much enjoyment in being able to work with you and for you! To do this, your comments are continuously needed. As one of the members of the EGU Executive Board, I aim to consider your suggestions and ideas to enhance the work of the Union.

EGU is today the result of a decade of efforts you all have put in. With its 14 Open Access journals, its topical meetings, education and outreach activities, and the new and effective Munich office staff, EGU is one of the youngest and most dynamic structures in the geo-world. Our most prominent event, the annual General Assembly, brings together you all, and now you are over 11,000 scientists. Each meeting is a joy with a lot of interesting new research being presented and discussed – every new Assembly is a new success! I am convinced that 2013 will bring us together again, this time to celebrate a remarkable decade of EGU work!

> Mioara Mandea EGU General Secretary



Mioara Mandea (General Secretary) and Philippe Courtial (Executive Secretary) at the EGU booth at the 2012 Japan Geoscience Union Meeting

Division reports

News brought to you from four of EGU's divisions

In each edition of GeoQ, we select several Division Presidents and Vice-Presidents to contribute reports updating members with news from, or related to the fields covered by, their divisions. Issue 3 gives voice to Stefano Tinti (NH President), Gerrit H. De Rooij (HS President), Henk Dijkstra (NP President), and Athena Coustenis (PS President) and Iannis Dandouras (PS Vice-President).

Natural Hazards

The Natural Hazards (NH) Division covers all the geological and geophysical processes that can be hazardous and can produce damage to the environment and to the society. Therefore it is a place where scientists and researchers of various geo-disciplines meet with sociologists, economists, and people responsible for



One year after the L'Aquila earthquake, a natural hazards that occurred in central Italy in 2009 and killed over 300 people (Image by R. Civico, distributed by EGU under a Creative Commons licence)

territorial and urban defense and planning policies. The aim is to improve the understanding of the evolution of the processes and to discuss new technologies, methods and strategies to mitigate their disastrous effects. NH is structured in nine subdivisions covering specific hazards. Of these, seven are listed here: hydro-meteorological, volcanic, landslide, earthquake, sea and ocean, snowavalanche and glacial, and wildfire hazards. The eighth subdivision covers biological and environmental hazards and, in addition, hazards not included in the previous ones. The ninth (natural hazards and society) focuses on the social aspects of the hazards, including development sustainability, emergency, warning, after-disaster resilience, and others. Most of the topics that are treated in NH are also treated in other EGU divisions, which is expected due to the intrinsic transversal nature of the NH Division. For example, earthquakes are the main interest of the Seismology Division, but they are also of interest here where the chief topics are, among others, how to evaluate vulnerability and risk, how to reduce the earthquake disastrous impact on human lives and society, how geoscientists can contribute to a prompt recovery of a community affected by earthquake sequences, and more.

Traditionally, NH is one of the strongest EGU divisions since many researchers and students share its view of a geoscience aimed at fostering the harmonized development of the human society in the natural environment. As before, in the 2012 EGU General Assembly the participation of scientists to NH initiatives was very active. The Division organized as many as 41 symposia and co-organized 13 more symposia with a total of 1,465 papers, about one third of which were given as oral presentations and the remaining as posters.

The 2012 NH Plinius Medal was awarded to <u>Timothy Sullivan</u> in recognition of his outstanding research achievements in seismic engineering design, seismic assessment, seismic retrofit and mitigation of seismic risk. Further, the Arne Richter Outstanding Young Scientist Award was given to a NH Division scientist, namely <u>Lieven</u> <u>Clarisse</u>, for his outstanding contribution to exploiting remote atmospheric sensing techniques to improve our understanding of emission and transport processes of ash and gases in relation to various natural hazardous processes. (Note that starting from 2013 the <u>Plinius Medal</u> will change significantly since it transforms from a young scientist medal to a mid-career scientist medal.)

For geoscientists interested in natural hazards this is the right time to provide contributions for next year's General Assembly programme, suggesting symposia and conveners, and promoting new ideas. The final decision on the programme will be made by the EGU Council in October.

Of interest to the NH community might be the <u>FP7 two-stage call for</u> research projects published on 10 July by the European Union on the theme 'Environment', more specifically on Protecting Citizens from Environmental Hazards, with deadline 16 October 2012.

The last news is that in November there will be an election for EGU Division Presidents, including NH. Proposals are to be submitted by 15 September.

Stefano Tinti NH Division President

Hydrological Sciences

Hydrological Sciences (HS) are very much in motion. A major driver of this dynamic is the maturing development of versatile sensor networks that record multiple variables with unprecedented frequency and number of observation locations, often deploying wireless technology. Several of this year's sessions at the General Assembly demonstrated that we are witnessing the onset of the ability to monitor large hydrological systems – vegetated soil monoliths, fields, catchments, and landscapes – in real time, and in their entirety. This ability has resulted in the emergence of ambitious monitoring programmes of international significance in several countries.

Kurt Roth touched upon this unprecedented observational capability in his Dalton Medal Lecture. He noted that this development is paralleled by a still continuing increase in computational power. Numerical models will soon be capable not only of solving subsurface flow problems over areas of several square kilometres with a resolution in the order of one metre, but of running in inverse mode (requiring very many model runs). He painted a near-future prospect where the combination of large, diverse data sets and inverse modelling of models with a massive number of nodes will allow model inversion to evolve from a method to fit model parameters to a technique to test various analyzes and competing representations of subsurface processes.

A session dedicated to the hydrological use of commercial equipment and gadgets not at all designed for scientific purposes has testified to the creativity of savvy experimenters for the past two years. Darcy Medallist Tissa Illangasekare championed sophisticated experimentation to develop the process understanding necessary to comprehend what is going on in the subsurface at any relevant scale. Like Kurt Roth and the convenors who dedicated a session to large-scale hydrology, he alluded to the need to practice hydrology across a range of scales. But he also emphasized the need to integrate hydrology with other disciplines: it is not sufficient to understand flow in porous media, we also need to grasp biogeochemical processes and the couplings between the flow below and over the Earth's surface, and the atmosphere above it. The need for this coupling is reflected by the large number of sessions co-organized with such divisions as Atmospheric Sciences, Geomorphology, Soil System Sciences, and Natural Hazards.

> Gerrit H. De Rooij HS Division President

Nonlinear Processes in Geosciences

During the 2012 General Assembly in Vienna, 438 papers were presented within sessions for which the Nonlinear Processes in Geophysics (NP) Division was leading. New in the programme for 2012 were two Short Courses, one on Tipping Points in the Geosciences and one on Nonlinear Time Series Analysis. Both courses attracted a large audience and will again be on the NP programme for the 2013 Assembly. There was also a Townhall Meeting on the topic Complexity Education in the Geosciences, which was interesting, but unfortunately not so well attended.

One of the Union medals, the 2012 Alfred Wegener Medal, was awarded to <u>Michael Ghil</u> (ENS, Paris, France), an active member of the NP community, for "his leading contributions to theoretical climate dynamics, his innovative observational studies involving model assimilation of satellite data in meteorology, oceanography and space physics; the breadth of his interdisciplinary studies, including macroeconomics; and also for his extensive supervision and mentoring of scores of graduate and postdoctoral students". Michael gave a medal lecture with the title The Complex Physics of Climate Change and Climate Sensitivity: A Grand Unification.

The NP Division medal, the 2012 Lewis Fry Richardson Medal, was awarded to <u>Harry Swinney</u> (Center for Nonlinear Dynamics University of Texas at Austin, USA) for "his pioneering experiments on deterministic chaos and highly original laboratory models of geophysical flows". Harry gave a lecture on internal wave turning depths in the oceans.

The NP Division Outstanding Scientist Award was presented to Claudia Cherubini (Politecnico di Bari, Italy) for "valuable contributions to the hydrogeological modelling of groundwater applied to resource management, with specific approaches for coastal fractured aquifers, and for applying advanced geo-statistical techniques to model environmental and anthropogenic variables". She gave a lecture on Experimental Studies of Nonlinear Flow and Solute Transport Dynamics at Different Scales in a Fractured Formation.

Apart from the Lewis Fry Richardson Medal Lecture and the NP Division Outstanding Scientist Lecture, the session (NP1.1) also included invited presentations by 'young stars in the NP field': Freddy Bouchet, Susana Barbosa, Ilan Koren, Ana Mancho, Themis Sapsis, Florian Sevellec, and Michel Crucifix.

On other Division news, the NP board for 2012–2014 consists of Stefano Pierini, Reik Donner, Olivier Talagrand, Mickael Chekroun, Vincent Rey, Shaun Lovejoy, Jose Redondo, Daniel Schertzer, and myself. The Lewis Fry Richardson Medal Committee for 2013 consists of Michael Ghil (chair), Harry Swinney, Katy Nicolis, Klaus Fraedrich, and Stefan Fauve.

During the NP Business Meeting at General Assembly, Roger Grimshaw gave, as executive editor, an update on the Division journal Nonlinear Processes in Geophysics. Its current impact factor is 1.6 and increasing! The NP Division community is encouraged to send their best work to this journal to make it the leading journal in the field.

Finally, the autumn 2012 election for EGU Division Presidents, including NP, will take place in November. The NP Division community is encouraged to submit proposals for the next NP Division President by 15 September.

Henk Dijkstra NP Division President

Planetary and Solar System Sciences

The 2012 General Aseembly in Vienna was very successful for the Planetary and Solar System Sciences (PS) Division. The 27 sessions held touched all of the most interesting current science themes in our Division, through 655 papers that were presented concerning current studies from space and ground-based data, laboratory work, and modelling.

The 2012 Jean Dominique Cassini Medal was awarded (posthumously) to <u>Angioletta Coradini</u>, an exceptional colleague, during a very emotional ceremony at the General Assembly, presided by Athena Coustenis. Jonathan Lunine and Jean-Pierre Bibring presented the personality traits of Angioletta and her outstanding contributions to the planetary sciences. The medal was received by her brother, Marcello Coradini.

At the Division level, the Bates Medal – for exceptional contributions to planetary and solar system sciences – was awarded to Hans <u>Rickmann</u>. In addition, the PS Division, together with the Solar-Terrestrial Sciences Division, had an Arne Richter Outstanding Young Scientist Award bestowed to Aikaterini Radioti.

On the science-projects news side, we are glad to announce that the Jupiter Icy Moons Explorer (JUICE) mission was recently selected by ESA for implementation. This L-class mission, planned for launch in 2022, will study in detail the environment of Jupiter and its moons, and the emergence of habitable worlds around giant gas planets. It is characterized by a 7.6 years cruise and 3.5 years of operation in the Jovian system. The call for payload proposals was released recently and is open until 15 October.

The Planetary and Solar System Science community is also excited about the Mars Science Laboratory, the most complex mission in the history of robotic exploration of Mars. The rover landed successfully on Gale Crater, Mars on August 6, 2012.

Finally, on other Division news, the autumn 2012 election for EGU Division Presidents, including PS, will take place in November. The PS community is encouraged to submit proposals for the next Division President by 15 September.

Athena Coustenis and Iannis Dandouras PS Division President and Vice-President

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EGU election for Division Presidents and Treasurer

Propose a candidate by 15 September



The autumn 2012 election, where 2012 EGU members will be able to vote for Division Presidents and EGU Treasurer, is taking place from 1 November to 1 December. Until 15 September, you are kindly asked to propose a candidate to either vacancy by filling in the <u>Candidate Proposal Form</u> on the EGU website.

You are welcome and encouraged to nominate yourself. If you are nominating someone else, please get the candidate's consent.

More information about the elections is available from the Election page on the EGU website.

An earlier version of this article was published on the EGU website

EGU Twitter journal club

The initiative launched on June 12, and two online discussions on papers published in EGU journals followed on 21 June and 12 July. Check <u>GeoLog</u>, the EGU blog, or follow us on <u>Twitter</u>, for information about forthcoming journal club discussions.

How does it work?

Initially, we will present you with a publicly accessible journal article (likely from an <u>EGU publication</u>); you read it, then all of us 'discuss' it on Twitter at a specified time using a specific hashtag (*#egutjc*). The <u>Storify</u> transcript of the event (a story made up of the 'tweets' sent about the paper during the journal club) will subsequently be published on our blog. As the club progresses, you will be asked to recommend articles for discussion based on your own interests and expertise.

How long do we get to read the article?

You will get around a week to read each article before the discussion takes place.

How long is the discussion?

The formal portion of the discussion will last one hour but, if there's more to say, feel free to continue for longer.

Will we be provided with background information?

Yes, we will precede each discussion by tweeting any relevant links and information we can find – and we hope you will do the same. The announcement of the article will be accompanied by a short summary as well as discussion points to get you started.

What if I have more questions?

Please <u>email</u> the EGU's Science Communications Fellow Edvard Glücksman with further questions.

An earlier version of this article was published on the EGU blog



Geotalk: The new monthly column on the EGU Blog

This summer we launched a new monthly blog column on GeoLog, the EGU Blog. Geotalk, featuring short interviews with geoscientists about their research, serves as a platform to promote the Earth, planetary and space sciences and give voice to young scientists and other researchers in all areas represented by EGU divisions.

In the first post of this regular Q&A series, published in July, we talked to Guillermo Rein of Imperial College London about "the

largest fires on Earth" and how they can contribute to greenhouse gas emissions. The <u>August column featured Pedro Jiménez Guer-</u> rero of the University of Murcia and focused on air pollution and its relation with climate change.

If you'd like to suggest a scientist for an interview, please contact Bárbara Ferreira at media@egu.eu.



To the ends of the Earth

To grasp the complexity of the Earth system is both the goal and the greatest challenge of the geosciences, as EGU President Donald Dingwell explains to *Public Service Review*

At the heart of the sciences linking Earth, ocean and atmospheric sciences together, geoscience encompasses a number of disciplines. Geosciences also borders on social sciences, other physical and life sciences and even humanities, and common solutions are often sought.

In an interview with *Public Service Review*, President of the European Geosciences Union (EGU) Donald Dingwell talks about recent breakthroughs in the field, why funding in geoscientific research is still insufficient, and why geoscience should be elevated across the academic and industrial landscape of Europe to enable better knowledge of the Earth to result in improved living conditions for all.

Why is geoscience important?

Geoscience sounds simple enough as a word. It calls to mind an understanding of the geological realm through scientific investigations. That, in and of itself, is more or less accurate. It fails, however, to place geosciences in their vital context of our modern world. Geosciences, and their close allies, the planetary and space sciences, span an astonishingly wide array of disciplines and methods of investigation. Geosciences are also at the core of the Earth



Donald Dingwell, President of the European Geosciences Union president@egu.eu

system sciences that link the Earth, ocean, and atmospheric sciences together.

In addition, geosciences are the direct neighbours to social sciences such as risk analysis and social geography, physical sciences and engineering disciplines, such as physics and chemistry, and geotechnical and other sorts of engineering. The future will likely reveal even more relationships between geosciences and disciplines that, at the moment, are thought to be even further afield, such as humanities, where ancient texts and paintings have been evaluated for their environmental information. The EGU embraces all these aspects in its relation to geosciences.

What are the challenges facing the field of geosciences at present?

Some of the greatest challenges in geosciences come from the complex nature of the field itself. We can perceive the noble challenges of coping with the complexity of the subjects to be understood, and organizational challenges related to the history and current structures of geosciences.

Firstly, to the noble part. Can there be any greater goal than a full understanding of the natural world in which we live? The geosciences stand at the gates of this paradise of investigation. We, ourselves, live in a special period in the history of investigation of the natural world – one in which the actions of man are actually turning the state of the planet into a moving target of challenges and questions. To grasp the complexity of the Earth system and to attempt explanations is the great goal of the geosciences and their greatest challenge.

Secondly, we can observe that the organization of geosciences is anything but simple. Some major international organizations have made great strides in the amplification of our impact and voice regarding the geosciences in our society. However, in many ways, and primarily due to the hybrid nature of methodologies present in the geosciences, the landscape in Europe is characterized by organizational geoscientific structures in teaching and research that, in the past, have detracted from us rising as a community to tackle some of the enormous challenges facing us and, sometimes, the equally enormous opportunities they engender.

Is there currently enough funding for this field?

Let me be clear: there is never enough funding. If you recall that the scientists – who toil away at the problems solvable by geoscientific research – are all motivated entirely by simply getting it right, then what could be a better use of capital? Better knowledge of our world will result in better living conditions for us all.



The Bifertenstock in the Glarus Alps looking east: the region in the middle ground is part of the 'Tectonics Arena Sardona', a UNESCO nature world heritage region (Image by K. Stueve, distributed by EGU under a <u>Creative</u> Commons licence)

In Europe, in particular, geosciences do not have the same voice with regard to scientific infrastructure and large-scale research as their neighbouring domains. Further, the average European (someone whom I have never met) has a far better identification with physics, mathematics, chemistry, biology, etc., than they do with geosciences. In Canada, where I was born and educated, the situation is quite different.

What recent breakthroughs have been made in geosciences?

There are countless examples. Let me commit the sin of naming a few:

- Identification of the acidification of the oceans;
- · Development of forecasting for natural catastrophes;
- · Documentation of global change in the Earth's present and past;
- · The rise of comparative planetology;
- Flood management modelling and strategies;
- · Understanding regional and global impact of volcanic ash;
- Mapping of the history and current state of the Earth's magnetic field intensity – the shield against cosmic radiation to mankind;
- · Powerful rupture models for understanding earthquakes;
- · Coping with the inventory of the cryosphere;
- · The stabilization of mankind's water budget.

And many, many, more...

How is Europe supporting the discipline?

We could be doing much better, but we must admit that the initiatives in European research infrastructure are setting an excellent example of the potential for pooling resources in order to play the research role at a far higher level than is sometimes the case today. Dedicated research institutes in Europe already cover many major themes in a worldwide leading role. Nevertheless, gaps exist in the landscape; too many gaps to be specific here and to lend a priority to some.

What do you hope to see achieved in the future?

I hope, and sincerely believe, that the role of geosciences in the top universities, in the corridors of power in Brussels and the national and regional governments, in the national academies of Europe, including the European academy, in the private philanthropic foundations of Europe, and in the industrial landscape of Europe, will far increase.

To put it simply, 'it is one thing to want to save the world – it is quite another to invest, intellectually and infrastructurally, in the capability to do so'.

> This interview is reproduced with permission from Public Service Review, European Union journal issue 23

Public Service publishes a vast array of publications to suit every professional within the public sector. Contributors include UK and foreign ministers, senior civil servants, experts and academics, discussing the latest initiatives and projects along with case studies and comments on Best Practice.

EGU press release highlights research published in Atmospheric Chemistry and Physics

Most of the world's population will be subject to degraded air quality in 2050 if man-made emissions continue as usual. In this 'businessas-usual' scenario, the average world citizen 40 years from now will experience similar air pollution to that of today's average East Asian citizen. These conclusions are those of a study published today in Atmospheric Chemistry and Physics, an Open Access journal of the European Geosciences Union (EGU).

Air pollution is a major health risk that may worsen with increasing industrial activity. At present, urban outdoor air pollution causes 1.3 million estimated deaths per year worldwide, according to the World Health Organization.

"Strong actions and further effective legislation are essential to avoid the drastic deterioration of air quality, which can have severe effects on human health," concludes the team of scientists, led by Andrea Pozzer of the Abdus Salam International Centre for Theoretical Physics in Italy (now at the Max Planck Institute of Chemistry in Germany), in the new paper.

The researchers studied the impact of man-made emissions on air quality, assuming past emission trends continue and no additional climate change and air pollution reduction measures (beyond what is in place since 2005) are implemented. They point out that, while pessimistic, the global emissions trends indicate such continuation.

"At present the post-Kyoto climate negotiations are progressing slowly, and it is unclear how air quality policies will develop globally," explains co-author Greet Janssens-Maenhout of the European Commission Joint Research Centre in Italy. "In regions with economic growth, it might be less effective to implement emissionreduction measures due to strong growth in activities in particular sectors; in countries suffering from the economic downturn, implementing expensive air-quality measures could prove difficult in coming years," she adds.



A view of Shanghai's polluted sky (Credit: http://www.photoeverywhere.co.uk)

"We show that further legislation to control and reduce man-made emissions is needed, in particular for eastern China and northern India, to avoid hot-spots of elevated air pollution," says Pozzer. Combined with the fact that these are regions of high population density, elevated air pollution here would mean that air quality would worsen significantly for the average world citizen in 2050.

Air pollution would also increase in Europe and North America, but to a much lesser extent than in Asia, due to the effect of mitigation policies that have been in place for over two decades.

Pozzer and his colleagues estimated air quality in 2005, 2010, 2025 and 2050 using an atmospheric chemistry model. "The model uses basic mathematical formulation to predict the meteorology and the chemical composition of the atmosphere," Pozzer explains. "In practice, it is a software used to forecast – or hindcast, for past years – the status of the atmosphere at specific times."

The results show that in 2025 and 2050, under the business-asusual scenario studied, East Asia will be exposed to high levels of pollutants, such as nitrogen dioxide, sulphur dioxide and fine particulate matter (<u>PM2.5</u>). Northern India and the Arabian Gulf region, on the other hand, will suffer a marked increase in ozone levels.

The analysis now published is the first to include all five major air pollutants known to negatively impact human health: PM2.5, nitrogen dioxide, sulphur dioxide, ozone, and carbon monoxide. The scientists considered pollutants released through human activity, as well as those occurring naturally such as desert dust, sea spray, or volcanic emissions.

Taking all pollutants into account, eastern China, northern India, the Middle East, and North Africa are projected to have the world's poorest air quality in the future. In the latter locations this is due to a combination of natural desert dust and man-induced ozone. The effect of anthropogenic pollution emissions are predicted to be most harmful in East and South Asia, where air pollution is projected to triple compared to current levels.

The study aimed to compare the influence of man-made emissions on air quality in different regions, and show how no-further legislation to reduce emissions can result in drastic deterioration of air quality worldwide compared to the present day situation.

Reference

Pozzer, A. et al. (2012): Effects of business-as-usual anthropogenic emissions on air quality, *Atmos. Chem. Phys.*, 12, 6915–6937



Atmospheric Chemistry and Physics

Introduction to the European Monitoring and Evaluation Programme (EMEP) and observed atmospheric composition change during 1972–2009

> K. Tørseth, W. Aas, K. Breivik, A. M. Fjæraa, M. Fiebig, A.
> G. Hjellbrekke, C. Lund Myhre, S. Solberg, and K. E. Yttri NILU – Norwegian Institute for Air Research, Kjeller, Norway

Abstract

European scale harmonized monitoring of atmospheric composition was initiated in the early 1970s, and the activity has generated a comprehensive dataset (available at http://www.emep.int) which allows the evaluation of regional and spatial trends of air pollution during a period of nearly 40 years. Results from the monitoring made within EMEP, the European Monitoring and Evaluation Programme, show large reductions in ambient concentrations and deposition of sulphur species during the last decades. Reductions are in the order of 70-90% since the year 1980, and correspond well with reported emission changes. Also reduction in emissions of nitrogen oxides (NO_x) are reflected in the measurements, with an average decrease of nitrogen dioxide and nitrate in precipitation by about 23% and 25% respectively since 1990. Only minor reductions are however seen since the late 1990s. The concentrations of total nitrate in air have decreased on average only by 8% since 1990, and fewer sites show a significant trend. A majority of the EMEP sites show a decreasing trend in reduced nitrogen both in air and precipitation on the order of 25% since 1990. Deposition of base cations has decreased during the past 30 years, and the pH in precipitation has increased across Europe. Large inter annual variations in the particulate matter mass concentrations reflect meteorological variability, but still there is a relatively clear overall decrease at several sites during the last decade. With few observations going back to the 1990s, the observed chemical composition is applied to document a change in particulate matter (PM) mass even since 1980. These data indicate an overall reduction of about 5 µg/m³ from sulphate alone. Despite the significant reductions in sulphur emissions, sulphate still remains one of the single most important compounds contributing to regional scale aerosol mass concentration. Long-term ozone trends at EMEP sites show a mixed pattern. The year-to-year variability in ozone due to varying meteorological conditions is substantial, making it hard to separate the trends caused by emission change from other effects. For the Nordic countries the data indicate a reduced occurrence of very low concentrations. The most pronounced change in the frequency distribution is seen at sites in the UK and the Netherlands, showing a reduction in the higher values. Smaller changes are seen in Germany, while in Switzerland and Austria, no change is seen in the frequency distribution of ozone. The lack of long-term data series is a major obstacle for studying trends in volatile organic compounds (VOC). The scatter in the data is large, and significant changes are only found for certain components and stations. Concentrations of the heavy metals lead and cadmium have decreased in both air and precipitation during the last 20 years, with reductions in the order of 80-90% for Pb and 64-84% for Cd (precipitation and air respectively). The measurements of total gaseous mercury indicate a dramatic decrease in concentrations during 1980 to about 1993. Trends in hexachlorocyclohexanes (HCHs) show a significant decrease in annual average air concentrations. For other persistent organic pollutants (POPs) the patterns is mixed, and differs between sites and between measurements in air versus precipitation.

Reference

Tørseth, K. et al. (2012): Introduction to the European Monitoring and Evaluation Programme (EMEP) and observed atmospheric composition change during 1972–2009, *Atmos. Chem. Phys.*, 12, 5447–5481

Summer ammonia measurements in a densely populated Mediterranean city

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Left panels: Average concentrations of Pb in aerosols in 1990 and 2009 in ng Pb m⁻³; Right panels: Average concentrations of Cd in aerosols in 1990 and 2009 in ng Cd m⁻³. (From Tørseth, K. et al, 2012)

Abstract

Real-time measurements of ambient concentrations of gas-phase ammonia (NH₃) were performed in Barcelona (NE Spain) in summer between May and September 2011. Two measurement sites were selected: one in an urban background traffic-influenced area (UB) and the other in the historical city centre (CC). Levels of NH₃ were higher at CC (5.6 \pm 2.1 µg m⁻³ or 7.5 \pm 2.8 ppbv) compared with UB $(2.2 \pm 1.0 \ \mu g \ m^{-3} \text{ or } 2.9 \pm 1.3 \text{ ppbv})$. This difference is attributed to the contribution from non-traffic sources such as waste containers, sewage systems, humans and open markets more dense in the densely populated historical city centre. Under high temperatures in summer these sources had the potential to increase the ambient levels of NH₃ well above the urban-background-traffic-influenced UB measurement station. Measurements were used to assess major local emissions, sinks and diurnal evolution of NH₃. The measured levels of NH₃, especially high in the old city, may contribute to the high mean annual concentrations of secondary sulfate and nitrate measured in Barcelona compared with other cities in Spain affected

by high traffic intensity. Ancillary measurements, including PM10, PM2.5, PM1 levels (Particulate Matter with aerodynamic diameter smaller than 10 μ m, 2.5 μ m, and 1 μ m), gases and black carbon concentrations and meteorological data, were performed during the measurement campaign. The analysis of specific periods (three special cases) during the campaign revealed that road traffic was a significant source of NH₃. However, its effect was more evident at UB compared with CC where it was masked given the high levels of NH₃ from non-traffic sources measured in the old city. The relationship between SO₄²⁻ daily concentrations and gas-fraction ammonia (NH₃/(NH₃ + NH₄⁺)) revealed that the gas-to-particle phase partitioning (volatilization or ammonium salts formation) also played an important role in the evolution of NH₃ concentration in summer in Barcelona.

Reference

Pandolfi, M. et al. (2012): Summer ammonia measurements in a densely populated Mediterranean city, *Atmos. Chem. Phys.*, 12, 7557–7575

Atmospheric Measurement Techniques

Comparison of OH concentration measurements by DOAS and LIF during SAPHIR chamber experiments at high OH reactivity and low NO concentration

> H. Fuchs, H.-P. Dorn, M. Bachner, B. Bohn, T. Brauers, S. Gomm, A. Hofzumahaus, F. Holland, S. Nehr, F. Rohrer, R. Tillmann, and A. Wahner Institute of Energy and Climate Research, IEK-8: Troposphere, Forschungszentrum Jülich GmbH, Germany

Abstract

During recent field campaigns, hydroxyl radical (OH) concentrations that were measured by laser-induced fluorescence (LIF) were up to a factor of ten larger than predicted by current chemical models for conditions of high OH reactivity and low NO concentration. These discrepancies, which were observed in forests and urbaninfluenced rural environments, are so far not entirely understood. In summer 2011, a series of experiments was carried out in the atmosphere simulation chamber SAPHIR in Jülich, Germany, in order to investigate the photochemical degradation of isoprene, methyl-vinyl ketone (MVK), methacrolein (MACR) and aromatic compounds by OH. Conditions were similar to those experienced during the PRIDE-PRD2006 campaign in the Pearl River Delta (PRD), China, in 2006, where a large difference between OH measurements and model predictions was found. During experiments in SAPHIR, OH was simultaneously detected by two independent instruments: LIF and differential optical absorption spectroscopy (DOAS). Because DOAS is an inherently calibration-free technique, DOAS measurements are regarded as a reference standard. The comparison of the two techniques was used to investigate potential artifacts in the LIF measurements for PRD-like conditions of OH reactivities of 10 to 30 s⁻¹ and NO mixing ratios of 0.1 to 0.3 ppbv. The analysis of twenty experiment days shows good agreement. The linear regression of the combined data set (averaged to the DOAS time resolution, 2495

data points) yields a slope of 1.02 ± 0.01 with an intercept of $(0.10 \pm 0.03) \times 10^6$ cm⁻³ and a linear correlation coefficient of R² = 0.86. This indicates that the sensitivity of the LIF instrument is well-defined by its calibration procedure. No hints for artifacts are observed for isoprene, MACR, and different aromatic compounds. LIF measurements were approximately 30–40% (median) larger than those by DOAS after MVK (20 ppbv) and toluene (90 ppbv) had been added. However, this discrepancy has a large uncertainty and requires further laboratory investigation. Observed differences between LIF and DOAS measurements are far too small to explain the unexpected high OH concentrations during the PRIDE-PRD2006 campaign.

Reference

Fuchs, H. et al. (2012): Comparison of OH concentration measurements by DOAS and LIF during SAPHIR chamber experiments at high OH reactivity and low NO concentration, *Atmos. Meas. Tech.*, 5, 1611–1626

Aerosol information content analysis of multi-angle high spectral resolution measurements and its benefit for high accuracy greenhouse gas retrievals

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Abstract

New generations of space-borne spectrometers for the retrieval of atmospheric abundances of greenhouse gases require unprecedented accuracies as atmospheric variability of long-lived gases is very low. These instruments, such as GOSAT and OCO-2, typically



Artist Rendition of the Orbiting Carbon Observatory, OCO-2 (Credit: John Howard/JPL)

use a high spectral resolution oxygen channel (O_2 A-band) in addition to CO_2 and CH_4 channels to discriminate changes in the photon path-length distribution from actual trace gas amount changes. Inaccurate knowledge of the photon path-length distribution, determined by scatterers in the atmosphere, is the prime source of systematic biases in the retrieval. In this paper, we investigate the combined aerosol and greenhouse gas retrieval using multiple satellite viewing angles simultaneously. We find that this method, hitherto only applied in multi-angle imagery such as from POLDER or MISR, greatly enhances the ability to retrieve aerosol properties by 2–3 degrees of freedom. We find that the improved capability to retrieve aerosol parameters significantly reduces interference errors introduced into retrieved CO_2 and CH_4 total column averages. Instead of focussing solely on improvements in spectral and spatial resolution, signal-to-noise ratios or sampling frequency, multiple angles reduce uncertainty in space based greenhouse gas retrievals more effectively and provide a new potential for dedicated aerosols retrievals.

Reference

Frankenberg, C. et al. (2012): <u>Aerosol information content analysis of</u> multi-angle high spectral resolution measurements and its benefit for high accuracy greenhouse gas retrievals, *Atmos. Meas. Tech.*, 5, 1809–1821

Biogeosciences

2509-2522

Detecting anthropogenic carbon dioxide uptake and ocean acidification in the North Atlantic Ocean

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Abstract

Fossil fuel use, cement manufacture and land-use changes are the primary sources of anthropogenic carbon dioxide (CO₂) to the atmosphere, with the ocean absorbing approximately 30% (Sabine et al., 2004). Ocean uptake and chemical equilibration of anthropogenic CO₂ with seawater results in a gradual reduction in seawater pH and saturation states (Ω) for calcium carbonate (CaCO₃) minerals in a process termed ocean acidification. Assessing the present and future impact of ocean acidification on marine ecosystems requires detection of the multi-decadal rate of change across ocean basins and at ocean time-series sites. Here, we show the longest continuous record of ocean CO₂ changes and ocean acidification in the North Atlantic subtropical gyre near Bermuda from 1983–2011. Dissolved inorganic carbon (DIC) and partial pressure of CO₂ (pCO₂) increased in surface seawater by ~40 µmol kg⁻¹ and ~50 μatm (~20%), respectively. Increasing Revelle factor (β) values imply that the capacity of North Atlantic surface waters to absorb CO₂ has also diminished. As indicators of ocean acidification, seawater pH decreased by ~0.05 (0.0017 yr⁻¹) and ω values by ~7–8%. Such data provide critically needed multi-decadal information for assessing the North Atlantic Ocean CO₂ sink and the pH changes that determine marine ecosystem responses to ocean acidification.

Reference

Bates, N. R. et al. (2012): Detecting anthropogenic carbon dioxide uptake and ocean acidification in the North Atlantic Ocean, *Biogeosciences*, 9, A synthesis of carbon in international trade

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Abstract

In a globalized world, the transfer of carbon between regions, either physically or embodied in production, represents a substantial fraction of global carbon emissions. The resulting emission transfers are important for balancing regional carbon budgets and for understanding the drivers of emissions. In this paper we synthesize current understanding in two parts: (1) CO2 emissions embodied in goods and services that are produced in one country but consumed in others, and (2) carbon physically present in fossil fuels, petroleum-derived products, harvested wood products, crops, and livestock products. We describe the key differences between studies and provide a consistent set of estimates using the same definitions, modelling framework, and consistent data. We find the largest trade flows of carbon in international trade in 2004 were fossil fuels (2673 MtC, 37% of global emissions), CO₂ embodied in traded goods and services (1661 MtC, 22% of global emissions), crops (522 MtC, 31% of total harvested crop carbon), petroleum-based products (183 MtC, 50% of their total production), harvested wood products (149 MtC, 40% of total roundwood extraction), and livestock products (28 MtC, 22% of total livestock carbon). We find that for embodied CO2 emissions, estimates from independent studies are robust, and that differences between individual studies are not a reflection of the uncertainty in consumption-based estimates, but rather these differences result from the use of different production-based emissions input data and different definitions for allocating emissions to international trade. After adjusting for these issues, results across independent studies converge to give less uncertainty than previously

assumed. For physical carbon flows there are relatively few studies to be synthesized, but differences between existing studies are due to the method of allocating to international trade, with some studies using 'apparent consumption' as opposed to 'final consumption'. While results across studies are sufficiently robust to be used in further applications, more research is needed to understand differences and to harmonize definitions for particular applications.

Reference

Peters, G. P., Davis, S. J., and Andrew, R. (2012): A synthesis of carbon in international trade, *Biogeosciences*, 9, 3247–3276

Novel water source for endolithic life in the hyperarid core of the Atacama Desert

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Abstract

The hyperarid core of the Atacama Desert, Chile, is possibly the driest and most life-limited place on Earth, yet endolithic microorganisms thrive inside halite pinnacles that are part of ancient salt flats. The existence of this microbial community in an environment that excludes any other life forms suggests biological adaptation to high salinity and desiccation stress, and indicates an alternative source of water for life other than rainfall, fog or dew. Here, we show that halite endoliths obtain liquid water through spontaneous capillary condensation at relative humidity (RH) much lower than the deliguescence RH of NaCl. We describe how this condensation could occur inside nano-pores smaller than 100 nm, in a newly characterized halite phase that is intimately associated with the endolithic aggregates. This nano-porous phase helps retain liquid water for long periods of time by preventing its evaporation even in conditions of utmost dryness. Our results explain how life has colonized and adapted to one of the most extreme environments on our planet, expanding the water activity envelope for life on Earth, and broadening the spectrum of possible habitats for life beyond our planet.

Reference

Wierzchos, J. et al. (2012): Novel water source for endolithic life in the hyperarid core of the Atacama Desert, *Biogeosciences*, 9, 2275–2286



The Atacama in northern Chile is the driest desert in the world (Credit: ESO)

Bioerosion by euendoliths decreases in phosphate-enriched skeletons of living corals

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Abstract

While the role of microboring organisms, or euendoliths, is relatively well known in dead coral skeletons, their function in live corals remains poorly understood. They are suggested to behave like ectosymbionts or parasites, impacting their host's health. However, the species composition of microboring communities, their abundance and dynamics in live corals under various environmental conditions have never been explored. Here, the effect of phosphate enrichment on boring microorganisms in live corals was tested for the first time. Stylophora pistillata nubbins were exposed to three different treatments (phosphate concentrations of 0, 0.5 and 2.5 µmol I⁻¹) during 15 weeks. After 15 weeks of phosphate enrichment, petrographic thin sections were prepared for observation with light microscopy, and additional samples were examined with scanning electron microscopy (SEM). Euendoliths comprised mainly phototrophic Ostreobium sp. filaments. Rare filaments of heterotrophic fungi were also observed. Filaments were densely distributed in the central part of nubbins, and less abundant towards the apex. Unexpectedly, there was a visible reduction of filament abundance in the most recently calcified apical part of phosphate-enriched nubbins. The overall abundance of euendoliths significantly decreased, from $9.12 \pm 1.09\%$ of the skeletal surface area in unenriched corals, to 5.81 ± 0.77% and 5.27 ± 0.34% in 0.5 and 2.5 µmol I⁻¹-phosphate enriched corals respectively. SEM observations confirmed this decrease. Recent studies have shown that phosphate enrichment increases coral skeletal growth and metabolic rates, while it decreases skeletal density and resilience to mechanical stress. We thus hypothesize that increased skeletal growth in the presence of phosphate enrichment occurred too fast for an effective expansion of euendolith growth. They could not keep up with coral growth, so they became diluted in the apex areas as nubbins grew with phosphate enrichment. Results from the present study suggest that coral skeletons of S. pistillata will not be further weakened by euendoliths under phosphate enrichment.

Reference

Godinot, C. et al. (2012): Bioerosion by euendoliths decreases in phosphateenriched skeletons of living corals, *Biogeosciences*, 9, 2377–2384

Organic matter dynamics and stable isotope signature as tracers of the sources of suspended sediment

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Abstract

Suspended sediment (SS) and organic matter in rivers can harm brown trout *Salmo trutta* by affecting the health and fitness of free

swimming fish and by causing siltation of the riverbed. The temporal and spatial dynamics of sediment, carbon (C), and nitrogen (N) during the brown trout spawning season in a small river of the Swiss Plateau were assessed and C isotopes as well as the C/N atomic ratio were used to distinguish autochthonous and allochthonous sources of organic matter in SS loads. The visual basic programme IsoSource with ¹³Ctot and ¹⁵N as input isotopes was used to quantify the temporal and spatial sources of SS. Organic matter concentrations in the infiltrated and suspended sediment were highest during low flow periods with small sediment loads and lowest during high flow periods with high sediment loads. Peak values in nitrate and dissolved organic C were measured during high flow and high rainfall, probably due to leaching from pasture and arable land. The organic matter was of allochthonous sources as indicated by the C/N atomic ratio and δ¹³C_{org}. Organic matter in SS increased from up- to downstream due to an increase of pasture and arable land downstream of the river. The mean fraction of SS originating from upper watershed riverbed sediment decreased from up to downstream and increased during high flow at all measuring sites along the course of the river. During base flow conditions, the major sources of SS are pasture, forest and arable land. The latter increased during rainy and warmer winter periods, most likely because both triggered snow melt and thus erosion. The measured increase in DOC and nitrate concentrations during high flow support these modelling results. Enhanced soil erosion processes on pasture and arable land are expected with increasing heavy rain events and less snow during winter seasons due to climate change. Consequently, SS and organic matter in the river will increase, which will possibly affect brown trout negatively.

Reference

Schindler Wildhaber, Y., Liechti, R., and Alewell, C. (2012): Organic matter dynamics and stable isotope signature as tracers of the sources of suspended sediment, *Biogeosciences*, 9, 1985–1996

Photoproduction of ammonium in the southeastern Beaufort Sea and its biogeochemical implications

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Abstract

Photochemistry of dissolved organic matter (DOM) plays an important role in marine biogeochemical cycles, including the regeneration of inorganic nutrients. DOM photochemistry affects nitrogen cycling by converting bio-refractory dissolved organic nitrogen to labile inorganic nitrogen, mainly ammonium (NH₄⁺). During the August 2009 Mackenzie Light and Carbon (MALINA) Program, the absorbed photon-based efficiency spectra of NH₄⁺ photoproduction (i.e. photoammonification) were determined using water samples from the SE Beaufort Sea, including the Mackenzie River estuary, shelf, and Canada Basin. The photoammonification efficiency decreased with increasing wavelength across the ultraviolet and visible regimes and was higher in offshore waters than in shelf and estuarine waters. The efficiency was positively correlated with the molar nitrogen:carbon ratio of DOM and negatively correlated with the absorption coefficient of chromophoric DOM (CDOM). Combined with collateral measurements of CO₂ and CO photoproduction, this study revealed a stoichiometry of DOM photochemistry with a CO₂ : CO : NH₄⁺ molar ratio of 165 : 11 : 1 in the estuary, 60 : 3 : 1 on the shelf, and 18 : 2 : 1 in the Canada Basin. The NH4⁺ efficiency spectra, along with solar photon fluxes, CDOM absorption coefficients and sea ice concentrations, were used to model the monthly surface and depth-integrated photoammonification rates in 2009. The summertime (June-August) rates at the surface reached 6.6 nmol I⁻¹ d⁻¹ on the Mackenzie Shelf and 3.7 nmol I⁻¹ d⁻¹ further offshore; the depth-integrated rates were correspondingly 8.8 µmol m⁻² d⁻¹ and 11.3 µmol m⁻² d⁻¹. The offshore depth-integrated rate in August (8.0 µmol m⁻² d⁻¹) was comparable to the missing dissolved inorganic nitrogen (DIN) source required to support the observed primary production in the upper 10-m layer of that area. The yearly NH4+ photoproduction in the entire study area was estimated to be 1.4 × 108 moles, with 85% of it being generated in summer when riverine DIN input is low. Photoammonification could mineralize 4% of the annual dissolved organic nitrogen (DON) exported from the Mackenzie River and provide a DIN source corresponding to 7% of the riverine DIN discharge and 1400 times the riverine NH4⁺ flux. Under a climate warming-induced ice-free scenario, these quantities could increase correspondingly to 6%, 11%, and 2100 times. Photoammonification is thus a significant nitrogen cycling term and may fuel previously unrecognized autotrophic and heterotrophic production pathways in the surface SE Beaufort Sea.

Reference

Xie, H. et al. (2012): Photoproduction of ammonium in the southeastern Beaufort Sea and its biogeochemical implications, *Biogeosciences*, 9, 3047–3061

Towards a merged satellite and in situ fluorescence ocean chlorophyll product

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Abstract

Understanding the ocean carbon cycle requires a precise assessment of phytoplankton biomass in the oceans. In terms of numbers of observations, satellite data represent the largest available data set. However, as they are limited to surface waters, they have to be merged with in situ observations. Amongst the in situ data, fluorescence profiles constitute the greatest data set available, because fluorometers have operated routinely on oceanographic cruises since the 1970s. Nevertheless, fluorescence is only a proxy of the total chlorophyll *a* concentration and a data calibration is required. Calibration issues are, however, sources of uncertainty, and they have prevented a systematic and wide range exploitation of the fluorescence data set. In particular, very few attempts to standardize the fluorescence databases have been made. Consequently, merged estimations with other data sources (e.g. satellite) are lacking.



We propose a merging method to fill this gap. It consists firstly in adjusting the fluorescence profile to impose a zero chlorophyll *a* concentration at depth. Secondly, each point of the fluorescence profile is then multiplied by a correction coefficient, which forces the chlorophyll *a* integrated content measured on the fluorescence profile to be consistent with the concomitant ocean colour observation. The method is close to the approach proposed by Boss et al. (2008) to correct fluorescence data of a profiling float, although important

differences do exist. To develop and test our approach, in situ data from three open ocean stations (BATS, HOT and DYFAMED) were used. Comparison of the so-called 'satellite-corrected' fluorescence profiles with concomitant bottle-derived estimations of chlorophyll a concentration was performed to evaluate the final error (estimated at 31%). Comparison with the Boss et al. (2008) method, using a subset of the DYFAMED data set, demonstrated that the methods have similar accuracy. The method was applied to two different data sets to demonstrate its utility. Using fluorescence profiles at BATS, we show that the integration of 'satellite-corrected' fluorescence profiles in chlorophyll a climatologies could improve both the statistical relevance of chlorophyll a averages and the vertical structure of the chlorophyll a field. We also show that our method could be efficiently used to process, within near-real time, profiles obtained by a fluorometer deployed on autonomous platforms, in our case a bio-optical profiling float. The application of the proposed method should provide a first step towards the generation of a merged satellite/ fluorescence chlorophyll a product, as the 'satellite-corrected' profiles should then be consistent with satellite observations. Improved climatologies with more consistent satellite and in situ data are likely to enhance the performance of present biogeochemical models.

Reference

Lavigne, H. et al. (2012): Towards a merged satellite and in situ fluorescence ocean chlorophyll product, *Biogeosciences*, 9, 2111–2125

Hydrology and Earth System Sciences

Climatic and geologic controls on suspended sediment flux in the Sutlej River Valley, western Himalaya

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Abstract

The sediment flux through Himalayan rivers directly impacts water quality and is important for sustaining agriculture as well as maintaining drinking-water and hydropower generation. Despite the recent increase in demand for these resources, little is known about the triggers and sources of extreme sediment flux events, which lower water quality and account for extensive hydropower reservoir filling and turbine abrasion. Here, we present a comprehensive analysis of the spatiotemporal trends in suspended sediment flux based on daily data during the past decade (2001–2009) from four sites along the Sutlej River and from four of its main tributaries. In conjunction with satellite data depicting rainfall and snow cover, air temperature and earthquake records, and field observations, we infer climatic and geologic controls of peak suspended sediment concentration (SSC) events. Our study identifies three key findings: First, peak SSC events (\geq 99th SSC percentile) coincide frequently (57–80%) with heavy rainstorms and account for about 30% of the suspended sediment flux in the semi-arid to arid interior of the orogen. Second, we observe an increase of suspended sediment flux from the Tibetan Plateau to the Himalayan Front at mean annual timescales. This sediment-flux gradient suggests that averaged, modern erosion in the western Himalaya is most pronounced at frontal regions, which are characterized by high monsoonal rainfall and thick soil cover. Third, in seven of eight catchments, we find an anticlockwise hysteresis loop of annual sediment flux variations with respect to river discharge, which appears to be related to enhanced glacial sediment evacuation during late summer. Our analysis emphasizes the importance of unconsolidated sediments in the high-elevation sector that can easily be mobilized by hydrometeorological events and higher glacial-meltwater contributions. In future climate change scenarios, including continuous glacial retreat and more frequent monsoonal rainstorms across the Himalaya, we expect an increase in peak SSC events, which will decrease the water quality and impact hydropower generation.

Reference

Wulf, H., Bookhagen, B., and Scherler, D. (2012): Climatic and geologic controls on suspended sediment flux in the Sutlej River Valley, western Himalaya, *Hydrol. Earth Syst. Sci.*, 16, 2193–2217

Value of medium range weather forecasts in the improvement of seasonal hydrologic prediction skill

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Abstract

We investigated the contribution of medium range weather forecasts with lead times of up to 14 days to seasonal hydrologic prediction skill over the conterminous United States (CONUS). Three different Ensemble Streamflow Prediction (ESP) based experiments were performed for the period 1980–2003 using the Variable Infiltration Capacity (VIC) hydrology model to generate forecasts of monthly runoff and soil moisture (SM) at lead-1 (first month of the forecast period) to lead-3. The first experiment (ESP) used a resampling from the retrospective period 1980–2003 and represented full climatological uncertainty for the entire forecast period. In the second and third experiments, the first 14 days of each ESP ensemble

member were replaced by either observations (perfect 14-day forecast) or by a deterministic 14-day weather forecast. We used Spearman rank correlations of forecasts and observations as the forecast skill score. We estimated the potential and actual improvement in baseline skill as the difference between the skill of experiments 2 and 3 relative to ESP, respectively. We found that useful runoff and SM forecast skill at lead-1 to -3 months can be obtained by exploiting medium range weather forecast skill in conjunction with the skill derived by the knowledge of initial hydrologic conditions. Potential improvement in baseline skill by using medium range weather forecasts for runoff [SM] forecasts generally varies from 0 to 0.8 [0 to 0.5] as measured by differences in correlations, with actual improvement generally from 0 to 0.8 of the potential improvement. With some exceptions, most of the improvement in runoff is for lead-1 forecasts, although some improvement in SM was achieved at lead-2.

Reference

Shukla, S., Voisin, N., and Lettenmaier, D. P. (2012): <u>Value of medium range</u> weather forecasts in the improvement of seasonal hydrologic prediction skill, *Hydrol. Earth Syst. Sci.*, 16, 2825–2838

Natural Hazards and Earth System Sciences

Building an 18,000-year-long paleo-earthquake record from detailed deep-sea turbidite characterization in Poverty Bay, New Zealand

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Abstract

Two ~20-m-long sedimentary cores collected in two neighbouring mid-slope basins of the Paritu Turbidite System in Poverty Bay, east of New Zealand, show a high concentration of turbidites (5 to 6 turbidites per meter), interlaid with hemipelagites, tephras and a few debrites. Turbidites occur as both stacked and single, and exhibit a range of facies from muddy to sandy turbidites. The age of each turbidite is estimated using the statistical approach developed in the OxCal software from an exceptionally dense set of tephrochronology and radiocarbon ages (~1 age per meter). The age, together with the facies and the petrophysical properties of the sediment (density, magnetic susceptibility and P-wave velocity), allows the correlation of turbidites across the continental slope (1400-2300 m water depth). We identify 73 synchronous turbidites, named basin events, across the two cores between 819 ± 191 and 17729 ± 701 yr BP. Compositional, foraminiferal and geochemical signatures of the turbidites are used to characterize the source area of the sediment, the origin of the turbidity currents, and their triggering mechanism. Sixty-seven basin events are interpreted as originated from slope failures on the upper continental slope in water depth ranging from 150 to 1200 m. Their earthquake trigger is inferred from the heavily gullied morphology of the source area and the water depth at which slope failures originated. We derive an earthquake



Earthquakes in New Zealand are common since the country is part of the Pacific Ring of Fire, which is geologically active. Poverty Bay is one of several bays on the east coast of the North Island. (Credit: NASA)

mean return time of ~230 yr, with a 90% probability range from 10 to 570 yr. The earthquake chronology indicates cycles of progressive decrease of earthquake return times from ~400 yr to ~150 yr at 0–7 kyr, 8.2–13.5 kyr, 14.7–18 kyr. The two 1.2 kyr-long intervals in between (7–8.2 kyr and 13.5–14.7 kyr) correspond to basin-wide reorganizations with anomalous turbidite deposition (finer deposits and/or non-deposition) reflecting the emplacement of two large mass transport deposits much more voluminous than the 'classical' earthquake-triggered turbidites. Our results show that the progressive characterization of a turbidite record from a single sedimentary system can provide a continuous paleo-earthquake history in regions of short historical record and incomplete onland paleo-earthquake evidences. The systematic description of each turbidite enables us to infer the triggering mechanism.

Reference

Pouderoux, H., Lamarche, G., and Proust, J.-N. (2012): <u>Building an</u> 18,000-year-long paleo-earthquake record from detailed deep-sea turbidite characterization in Poverty Bay, New Zealand, Nat. Hazards Earth Syst. Sci., 12, 2077–2101

The spatial structure of European wind storms as characterized by bivariate extreme-value Copulas

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Abstract

The winds associated with extra-tropical cyclones are amongst the costliest natural perils in Europe. Re/insurance companies typically have insured exposure at multiple locations and hence the losses they incur from any individual storm crucially depend on that storm's spatial structure. Motivated by this, this study investigates the spatial structure of the most extreme windstorms in Europe. The data consists of a carefully constructed set of 135 of the most damaging storms in the period 1972–2010. Extreme value copulas are applied to this data to investigate the spatial dependencies of gusts.

The copula method is used to investigate three aspects of windstorms. First, spatial maps of expected hazard damage between large cities and their surrounding areas are presented. Second, we demonstrate a practical application of the copula method to benchmark catalogues of artificial storms for use in the re/insurance sector. Third, the copula-based method is used to investigate the sensitivity of spatially aggregated damage to climate variability. The copula method allows changes to be expressed in terms of storm frequency, local intensity, and storm spatial structure and gives a more detailed view of how climate variability may affect multi-location risk in Europe.

Reference

Bonazzi, A. et al. (2012): <u>The spatial structure of European wind storms as</u> <u>characterized by bivariate extreme-value Copulas</u>, *Nat. Hazards Earth Syst. Sci.*, 12, 1769–1782

Enhancing flood resilience through

improved risk communications

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Abstract

A framework of guiding recommendations for effective pre-flood and flood warning communications derived from the URFlood project (2nd ERA-Net CRUE Research Funding Initiative) from extensive quantitative and qualitative research in Finland, Ireland, Italy and Scotland is presented. Eleven case studies in fluvial, pluvial, coastal, residual, and 'new' flood risk locations were undertaken.

The recommendations were developed from questionnaire surveys by exploring statistical correlations of actions and understandings of individuals in flood risk situations to low, moderate and high resilience groupings. Groupings were based on a conceptual relationship of self-assessed levels of awareness, preparedness and worry. Focus groups and structured interviews were used to discuss barriers in flood communications, explore implementation of the recommendations and to rank the recommendations in order of perceived importance. Results indicate that the information deficit model for flood communications that relies on the provision of more and better information to mitigate risk in flood-prone areas is insufficient, and that the communications process is very much multi-dimensional. The recommendations are aimed at addressing this complexity and their careful implementation is likely to improve the penetration of flood communications. The recommendations are applicable to other risks and are transferable to jurisdictions beyond the project countries.

Reference

O'Sullivan, J. J. et al. (2012): Enhancing flood resilience through improved risk communications, Nat. Hazards Earth Syst. Sci., 12, 2271–2282

Severe wind gust thresholds for Meteoalarm derived from uniform return periods in ECA&D

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Abstract

In this study we present an alternative wind gust warning guideline for Meteoalarm, the severe weather warning website for Europe. There are unrealistically large differences in levels and issuing frequencies of all warning levels currently in use between neighbouring Meteoalarm countries. This study provides a guide for the Meteoalarm community to review their wind gust warning thresholds. A more uniform warning system is achieved by using one pan-European return period per warning level. The associated return values will be different throughout Europe because they depend on local climate conditions, but they will not change abruptly at country borders as is currently the case for the thresholds. As return values are a measure of the possible danger of an event and its impact on society, they form an ideal basis for a warning system. Validated wind gust measurements from the European Climate Assessment and Dataset (ECA&D, http://www.ecad.eu) were used to calculate return values of the annual maximum wind gust. The current thresholds are compared with return values for 3 different return periods: 10 times a year return periods for yellow warnings, 2 yr periods for orange and 5 yr periods for red warnings. So far 10 countries provide wind gust data to ECA&D. Due to the ECA&D completeness requirements and the fact that some countries provided too few stations to be representative for that country, medians of the return values of annual maximum wind gust could be calculated for 6 of the 10 countries. Alternative guideline thresholds are presented for Norway, Ireland, The Netherlands, Germany, the Czech Republic ,and Spain and the need to distinguish between coastal, inland and mountainous regions is demonstrated. The new thresholds based on uniform return periods differ significantly from the current ones, particularly for coastal and mountainous areas.

We are aware of other, sometimes binding factors (e.g. laws) that prevent participating counties from implementing this climatology based warning system.

Reference

Stepek, A. et al. (2012): Severe wind gust thresholds for Meteoalarm derived from uniform return periods in ECA&D, Nat. Hazards Earth Syst. Sci., 12, 1969–1981



weather alerts in Europe on 9 August 2012, according to the Meteoalarm website. (Credit: http://www.meteoalarm.eu/)

Risk perception – issues for flood management in Europe

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Abstract

Public perception of flood risk and flood risk information is often overlooked when developing flood risk management plans. As scientists and the public at large perceive risk in very different ways, flood risk management strategies are known to have failed in the past due to this disconnect between authorities and the public. This paper uses a novel approach in exploring the role of public perception in developing flood risk communication strategies in Europe. Results are presented of extensive quantitative research of 1375 questionnaire responses from thirteen communities at risk across six European countries. The research forms part of two research projects funded under the 2nd ERA-Net CRUE Funding Initiative: URFlood and FREEMAN. Risk perception is conceptualized as a pillar of social resilience, representing an innovative approach to the

issue. From this process recommendations are identified for improving flood risk management plans through public participation.

Reference

Bradford, R. A. et al. (2012): Risk perception – issues for flood management in Europe, Nat. Hazards Earth Syst. Sci., 12, 2299–2309

Searching for the seafloor signature of the 21 May 2003 Boumerdès earthquake offshore central Algeria

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Abstract

Shaking by moderate to large earthquakes in the Mediterranean Sea has proved in the past to potentially trigger catastrophic sediment collapse and flow. On 21 May 2003, a magnitude 6.8 earthquake located near Boumerdès (central Algerian coast) triggered large turbidity currents responsible for 29 submarine cable breaks at the foot of the continental slope over ~150 km from west to east. Seafloor bathymetry and backscatter imagery show the potential imprints of the 2003 event and of previous events. Large slope scarps resulting from active deformation may locally enhance sediment instabilities, although faults are not directly visible at the seafloor. Erosion is evident at the foot of the margin and along the paths of the numerous canyons and valleys. Cable breaks are located at the outlets of submarine valleys and in areas of turbiditic levee overspilling and demonstrate the multi-source and multi-path character of the 2003 turbiditic event. Rough estimates of turbidity flow velocity are not straightforward because of the multiple breaks along the same cable, but seem compatible with those measured in other submarine cable break studies elsewhere.

While the signature of the turbidity currents is mostly erosional on the continental slope, turbidite beds alternating with hemipelagites accumulate in the distal reaches of sediment dispersal systems. In perspective, more chronological work on distal turbidite successions offshore Algeria offers promising perspectives for paleoseismology reconstructions based on turbidite dating, if synchronous turbidites along independent sedimentary dispersal systems are found to support triggering by major earthquakes. Preliminary results on sediment core PSM-KS23 off Boumerdès typically show a 800-yr interval between turbidites during the Holocene, in accordance with the estimated mean seismic cycle on land, even if at this stage it is not yet possible to prove the earthquake origin of all the turbidites.

Reference

Cattaneo, A. et al. (2012): Searching for the seafloor signature of the 21 May 2003 Boumerdès earthquake offshore central Algeria, Nat. Hazards Earth Syst. Sci., 12, 2159–2172

Impact of heat and drought stress on arable crop production in Belgium

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Abstract

Modelling approaches are needed to accelerate understanding of adverse weather impacts on crop performances and yields. The aim was to elicit biometeorological conditions that affect Belgian arable crop yield, commensurate with the scale of climatic impacts. The regional crop model REGCROP (Gobin, 2010) enabled to examine changing weather patterns in relation to the crop season and crop sensitive stages of six arable crops: winter wheat, winter barley, winter rapeseed, potato, sugar beet and maize. The sum of vapour pressure deficit during the growing season is the single best predictor of arable yields, with R² ranging from 0.55 for sugar beet to 0.76 for wheat. Drought and heat stress, in particular during the sensitive crop stages, occur at different times in the crop season and significantly differ between two climatic periods, 1947–1987 and 1988–2008. Though average yields have risen steadily between 1947 and 2008, there is no evidence that relative tolerance to stress has improved.

Reference

Gobin, A. (2012): Impact of heat and drought stress on arable crop production in Belgium, Nat. Hazards Earth Syst. Sci., 12, 1911–1922

The Cryosphere

Statistical adaptation of ALADIN RCM outputs over the French Alps – application to future climate and snow cover

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Abstract

In this study, snowpack scenarios are modelled across the French Alps using dynamically downscaled variables from the ALADIN Regional Climate Model (RCM) for the control period (1961–1990) and three emission scenarios (SRES B1, A1B and A2) for the midand late 21st century (2021-2050 and 2071-2100). These variables are statistically adapted to the different elevations, aspects and slopes of the Alpine massifs. For this purpose, we use a simple analogue criterion with ERA40 series as well as an existing detailed climatology of the French Alps (Durand et al., 2009a) that provides complete meteorological fields from the SAFRAN analysis model. The resulting scenarios of precipitation, temperature, wind, cloudiness, longwave and shortwave radiation, and humidity are used to run the physical snow model CROCUS and simulate snowpack evolution over the massifs studied. The seasonal and regional characteristics of the simulated climate and snow cover changes are explored, as is the influence of the scenarios on these changes. Preliminary results suggest that the snow water equivalent (SWE) of the snowpack will decrease dramatically in the next century, especially in the Southern and Extreme Southern parts of the Alps. This decrease seems to result primarily from a general warming throughout the year, and possibly a deficit of precipitation in the autumn. The magnitude of the snow cover decline follows a marked altitudinal gradient, with the highest altitudes being less exposed to climate change. Scenario A2, with its high concentrations of greenhouse gases, results in a SWE reduction roughly twice as large as in the low-emission scenario B1 by the end of the century. This study needs to be completed using simulations from other RCMs, since a multi-model approach is essential for uncertainty analysis.

Reference

Rousselot, M. et al. (2012): Statistical adaptation of ALADIN RCM outputs over the French Alps – application to future climate and snow cover, The Cryosphere, 6, 785–805

Extrapolating glacier mass balance to the mountainrange scale: the European Alps 1900–2100

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Abstract

This study addresses the extrapolation of in-situ glacier mass balance measurements to the mountain-range scale and aims at deriving time series of area-averaged mass balance and ice volume change for all glaciers in the European Alps for the period 1900-2100. Long-term mass balance series for 50 Swiss glaciers based on a combination of field data and modelling, and WGMS data for glaciers in Austria, France and Italy are used. A complete glacier inventory is available for the year 2003. Mass balance extrapolation is performed based on (1) arithmetic averaging, (2) glacier hypsometry, and (3) multiple regression. Given a sufficient number of data series, multiple regression with variables describing glacier geometry performs best in reproducing observed spatial mass balance variability. Future mass changes are calculated by driving a combined model for mass balance and glacier geometry with GCM ensembles based on four emission scenarios. Mean glacier mass balance in the European Alps is -0.31 ± 0.04 m w.e. a^{-1} in 1900–2011, and -1m w.e. a⁻¹ over the last decade. Total ice volume change since 1900 is -96 ± 13 km³; annual values vary between -5.9 km³ (1947) and +3.9 km³ (1977). Mean mass balances are expected to be around -1.3 m w.e. a⁻¹ by 2050. Model results indicate a glacier area reduction of 4–18% relative to 2003 for the end of the 21st century.

Reference

Huss, M. (2012): Extrapolating glacier mass balance to the mountain-range scale: the European Alps 1900–2100, *The Cryosphere*, 6, 713–727

GEO CEXTERNAL NEWS

End of first international large-scale research project on ocean acidification

Over the past 250 years, the ocean has absorbed about one third of the carbon dioxide released as a result of human activities. The process results in ocean acidification, often referred to as 'the other CO_2 problem'. Whereas the chemical consequences of this CO_2 uptake are well known (decrease in pH and shifts in sea-water carbonate chemistry), the biological impacts are poorly understood.

The European Project on Ocean Acidification (EPOCA) was the first international project that focused on ocean acidification and its consequences. It comprised over 160 scientists from 32 institutions in 10 European countries. Partly funded by the European Commission (6.5 M€ for a total budget of 16 M€), the project began in May 2008 and ended in April 2012.

EPOCA research was structured around four themes, some highlights of which are provided below.

Theme 1: Changes in ocean chemistry and biogeography

Within theme 1, paleo-reconstruction methods were used to investigate the response of organisms, particularly calcifiers, to past changes in ocean acidification and to assess past variability in ocean carbonate chemistry, nutrients, and trace metals. Observational data were also collected to improve understanding of modern-day carbonate chemistry and the distribution and abundance of calcifiers.

Highlights include results from the Arctic Ocean near Iceland where acidification is occurring faster and is more severe than expected, based on data from a 25-year Iceland Sea time-series station (1984–2008). The decline in surface water pH is 50% faster than average annual rates at subtropical time-series stations in the North Atlantic and Pacific Oceans. The aragonite saturation horizon is shoaling at a rate of four metres per year, encroaching on an additional 800 km² of ocean floor every year (Olafsson et al., 2009).

EPOCA also showed that some coastal waters of the Arctic Ocean are now extremely undersaturated with respect to aragonite owing to organic carbon input from thawing permafrost, the plumes of which flow off the shelf into the deep central Arctic Ocean (Anderson et al., 2011).

For the western Arabian Sea, <u>de Moel et al. (2009)</u> found that light, thin-walled shells of the surface-water dwelling planktic foraminifer *Globigerinoides ruber* from the surface sediment are younger (based on ¹⁴C and ¹³C measurements) than heavier, thicker-walled shells, concluding that the age difference was indicative of ocean acidification on top of seasonal upwelling. Contrasting results were found for the response of the coccolithophorid *Emiliania huxleyi* to ocean acidification. Higher percentages of over-calcified morphotypes were measured in the Bay of Biscay during winter, when conditions for calcification should be less favourable (<u>Smith et al., 2012</u>; see Fig. 1). Conversely, <u>Beaufort et</u> <u>al. (2011)</u> reported a substantial decline in coccolith mass and a decrease in coccolith flux since the 1940s in sediment cores collected in the Western Pacific.



black line shows the seasonal changes in the proportion of 'overalcified' (more heavily calcified) *Emiliania huxleyi* cells; the blue lines shows the saturation state of surface seawater with respect to calcite CaCO₃ (Ω); the red line shows pH (red line); the green dashed line shows bicarbonate ion (HCO₃··)concentration (µmol/kg). (Bottom left) the two main morphotypes of *Emilania huxleyi* observed in the water samples: the left-hand cell is Type A overcalcified; the right-linand cell is standard Type A. (Bottom right) two individual coccoliths (calcium carbonate plates), one from each morphotype, that happened to lie next to each other in an SEM image. More calcium carbonate is used to build each Type A overcalcified coccolith (left), as evidenced by infilling of the central area and thicker spokes. (From <u>Smith et al.</u>, 2012, reprinted with permission from PNAS)

Theme 2: Biological and ecosystem responses, acclimation and adaptation

EPOCA researchers studied a broad range of taxonomic groups, communities, habitats, and processes, with a regional focus on the European shelf seas and the high Arctic Ocean. This was achieved through a multidisciplinary approach that combined laboratory studies, field experiments, and observations with a suite of model studies that focused on processes from the cellular and organismal level up to ecosystems and ranging in complexity from 0- and 1-D up to Earth system models. Major field activities included research cruises from the NW European continental shelf up to the Arctic, two joint mesocosm experiments in Svalbard that focused on bottom-dwelling organisms and processes influenced by them in 2009 and on the plankton community and elemental fluxes in the water



Fig. 2: Mesocosm facilities developed at the GEOMAR | Helmholtz Centre for Ocean Research Kiel, used during the second EPOCA campaign in Svalbard, summer 2010.

column in 2010 (Fig. 2), and extensive studies at a natural CO_2 venting site in the Mediterranean Sea.

EPOCA has helped to clearly demonstrate that many calcifying organisms are adversely affected by ocean acidification, while also revealing considerable variability in sensitivity between closely related species and even between different strains of the same species; some species appear tolerant to ocean acidification in the range of pCO₂ levels projected until the end of this century. Observed variability was shown to reflect the genetic diversity within populations (Langer et al., 2011; Hagino et al., 2011) or to be related to regional differences between populations (Thomsen et al., 2010). In several groups, early life stages were particularly sensitive to ocean acidification (e.g. Gazeau et al., 2010). High CO₂ resulted in delayed larval development of crustaceans, bivalves, and echinoderms.

Several EPOCA studies highlighted the importance of long-term exposure to allow for proper acclimation. Some species that were sensitive to ocean acidification in short-term incubations became insensitive when kept under high pCO₂ for extended periods of time (Form & Riebesell 2011, Dupont et al., 2012). Reduced fitness of sea urchins was observed when consecutive life-stages were exposed to high CO₂.

EPOCA also made considerable progress concerning the mechanisms underlying the observed responses for some taxonomic groups. For coccolithophores, some of the transporters involved in calcium and carbon acquisition were identified (Mackinder et al., 2011; Richier et al., 2011). Very efficient mechanisms to regulate internal pH using proton pumps were identified in echinoderm larvae. A decapod crab was capable to compensate for ocean acidification by acid-base regulation, however, at the expense of metabolic repression.

As ocean acidification occurs with changes in other environmental stressors, such as ocean warming, deoxygenation, and eutrophication, EPOCA research examined possible interactive effects of multiple stressors (Pörtner, 2010). Several EPOCA studies indicated that ocean acidification narrows the thermal tolerance of many organisms (e.g. Walther et al., 2009), while another showed that interacting effects of warming and acidification are expected to alter community structure and biodiversity (Hale et al., 2011).

Studies of natural communities along CO₂ gradients (<u>Charalampo-poulou et al., 2011</u>) and at CO₂ venting sites proved to be a powerful test bed to assess results obtained in previous laboratory-based studies. Relating coccolith mass to seawater carbonate chemistry in different oceanographic regions as well as in sediment cores suggested much stronger sensitivities in coccolithophores than obtained in the laboratory (Beaufort et al., 2011). Drastic changes in benthic community composition and biodiversity were observed at volcanic CO₂ vents (Barry et al., 2011; in *Ocean Acidification*).

EPOCA research found several key processes driving biogeochemical cycling in the ocean to be sensitive to ocean acidification. This includes phytoplankton photosynthesis, nitrogen fixation by diazotrophic cyanobacteria, and calcium carbonate (CaCO₃) production by calcifying plankton organisms. These responses cause changes in ocean biogeochemistry, including the C:N:P composition of organic matter and the ratio of CaCO₃ to organic matter in the export flux (the rain ratio) as well as associated ballasting of the organic matter flux to the deep ocean (Gehlen et al., 2011; in <u>Ocean Acidification</u>). Changes in these processes affect storage of carbon in the deep ocean, which feeds back on the climate system.

EPOCA research has substantially improved our understanding of biological sensitivities to ocean acidification, but major questions remain. Little is known about how biotic responses will affect competitive and trophic interactions. Will marine food webs differ in a warmer, more acidified ocean? Will organisms be able to adapt to ocean acidification?

Theme 3: Biogeochemical impacts and feedbacks

In theme 3, EPOCA modellers used coupled Earth system models (ESMs), forced global and regional ocean models, and a sediment model to project how ocean acidification will alter ocean biogeochemistry. Results from <u>seven IPCC AR4-era ESMs</u> were stored in a central, publicly available <u>archive</u>. The same interface was extended to allow comparison with the ESMs from the Coupled Model Intercomparison Project, part of the ongoing assessment of the Intergovernmental Panel on Climate Change (IPCC AR5).

One ESM projects that around 10% of Arctic surface waters will become undersaturated within 10 years during summer, and that climate change has little effect on acidification except in the Arctic where it is exacerbated, mainly from freshening due to ice melt (Steinacher et al., 2009). Model formulations of CaCO₃ production and dissolution as well as the particulate organic-to-inorganic carbon ratio were made to depend on CO₂ levels, but there was little sensitivity in resulting air-sea CO₂ fluxes. Similarly, explicitly modeling aragonite makes little difference (Gangstø et al. 2009).

New forced ocean model simulations with variable C:N:P composition suggest that acidification-induced changes in primary productivity and carbon export (Tagliabue et al., 2011) will counter general reductions from climate change (Steinacher et al., 2010). New sensitivity tests indicate that coarse-resolution global models may generally underestimate the magnitude of variability of surface pH, saturation states, and air-sea CO_2 flux by a factor of two or more.

New regional model simulations have demonstrated the high vulnerability of some nearshore regions. In the Northwestern European Shelf Seas, simulations indicate large spatiotemporal variability, sometimes locally dominated by effects from river input and organic matter degradation, exacerbating acidification (<u>Artioli et al., 2012</u>). In the California Current System, an eastern boundary upwelling system (EBUS), there is a strong seasonal upwelling of undersaturated waters and a trend that will cause half the waters above 250 metres



Fig. 3: Acidification of the California Current System in 1750–2050 under the A2, IPCC scenario. (A to C) Maps of annual mean surface pH, illustrating its decline. (D to F) Offshore depth sections reveal the corresponding decline in annual-mean saturation state of seawater with respect to aragonite, Ω_{arag} , and the shoaling of the saturation horizon, $\Omega_{arag} = 1$. White lines in (A) to (C) indicate the position of the offshore section (From Gruber et al., 2012, reprinted with permission from AAAS).

to become undersaturated by year 2050 (<u>Hauri et al., 2009;</u> <u>Gruber et al., 2012</u>; Fig. 3). Two other EBUS systems (Humboldt and Canary) also reveal heightened vulnerability.

Projections from a global coastal sediment model indicate that alkalinity generation from benthic carbonate dissolution provides a negligible feedback against ocean acidification in coming centuries (Krumins et al., 2012, submitted).

Some of the advances from EPOCA's modelling initiative are detailed in three chapters of the book *Ocean Acidification* and focus on recent and future changes in ocean carbonate chemistry, bioge-ochemical impacts, and effects from climate-change mitigation (Orr, 2011; Gehlen et al., 2011; Joos et al., 2011; in *Ocean Acidification*).

Theme 4: Synthesis, dissemination and outreach

EPOCA has helped to raise awareness of ocean acidification worldwide through its contributions to major policy activities, scientific assessments (e.g. IPCC AR5), and reports for policy-makers and other research users, all available on the <u>EPOCA website</u> (Fig. 4). The <u>EPOCA blog</u> has been the first point of call for researchers and policy-makers for new science, policy and media information on ocean acidification with almost 4000 posts and more than 500,000 visits during the duration of the project.

The EPOCA Ocean Acidification Reference User Group (OA-RUG), formed in 2008, rapidly evolved to incorporate UK, German, and

Mediterranean research programmes and recently other countries to form the International Ocean Acidification Reference User Group (*i*OA-RUG). Its many outreach products include three multilingual guides that outline the essential facts for policy-makers and decision-makers on ocean acidification and have been scrutinized by the scientific members of the RUG to ensure scientific integrity.

EPOCA joined with a range of partners on outreach. Examples are, <u>Ocean Acidification: Frequently Asked Questions</u> in response to the growing research across disciplines and the increasing need for clear answers by experts, a range of other policy documents including <u>Hot</u>, <u>Sour and Breathless: Ocean Under Stress</u> and side- and media-events and exhibition stands at the United Nations Framework Convention on Climate Change Congress of Parties, the Planet Under Pressure Symposium, and the Rio+20 Earth Summit.

EPOCA worked with 11–15 year old students from Ridgeway School in Plymouth, who made their concerns about the state of the world's oceans clear through the award winning animation <u>The Other CO₂</u> <u>Problem</u>, suitable for children and policy-makers alike and now available in several languages. The movie <u>Tipping Point</u> mostly describes EPOCA research and has received three awards including 'Best Scientific Movie' at the Mediterranean film festival. Both have been shown at science and policy meetings around the world with copies distributed worldwide.

An editorial, <u>The Societal Challenge of Ocean Acidification</u>, addressed for the first time the issue of vulnerable regions and biodiversity and how this would be a challenge for policy makers. The

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Guide to Best Practices for Ocean Acidification Research and Data

Reporting regroups standards and guidelines on ocean acidification research and has been widely distributed to the international scientific community. <u>Ocean Acidification</u>, edited by the EPOCA coordinator and manager, is the first book on ocean acidification with the majority of the synthesis chapters written by EPOCA experts.

Conclusion

EPOCA advanced scientific understanding of ocean acidification and its impact on marine organisms and ecosystems, while providing a new paradigm for outreach. It produced 21% of the research articles on ocean acidification published during the period 2009– 2012, more than 200 papers. It has provided key products that will be used by the research community and policy-makers. Results from EPOCA will influence the IPCC's Fifth Assessment Report as well as new studies on socio-economic impacts of ocean acidification.

European research on ocean acidification continues through the EU project MedSeA, the German project BIOACID, the UK project UKOA, and the project eFOCE. But ocean acidification research remains in its infancy, so it is essential that new projects emerge in the near future. It is vital that these projects be coordinated at the international level, as emphasized by the SOLAS-IMBER Working Group on Ocean Acidification and the *i*OA-RUG.

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European Forest Fire Information System: Current situation in Europe

13 August 2012 – The 2012 fire season has been characterized by a high number of fires in the early season. Over 100,000 hectares had already been consumed by fire at the end of March. July brought critical fire episodes in Spain and Portugal, which led to a number of human casualties.

Fire danger has been very high in southern Europe during the last weeks, in particular in Portugal, Spain, southern France, central and southern Italy (where a large number of fires are still active), the Balkan region, Greece and Turkey. The current fire danger forecast provided by the European Forest Fire Information System (EFFIS) confirms a slight improvement in the situation at the beginning of this week as forecast end of last week.

However, fire danger conditions remain very high in the western part of the Mediterranean region, in Portugal, Spain and France, and will return to a situation of critical fire danger in the overall Mediterranean region by the end of this week.

The forest fire situation in Europe is constantly monitored by EFFIS, a system developed and run by the European Commission's inhouse science service, the Joint Research Centre (JRC) in collaboration with the Directorate General for Environment (DG ENV) and

the Directorate General for Humanitarian Aid and Civil Protection (DG ECHO).

EFFIS provides updated and reliable information on wild land fires in Europe supporting forest fire prevention and fire-fighting services in the European countries, the European Commission's Monitoring and Information Centre (ECHO MIC), based in Brussels, and other organizations in the field.

EFFIS provides fire danger forecast up to six days in advance, enhancing the preparedness of the countries at risk of fire. Furthermore, fires are monitored and mapped by EFFIS, providing near-real time estimates of fire damages across Europe. Maps and key data on fire danger and individual fire effects can be consulted at <u>http://</u> effis.jrc.ec.europa.eu/current-situation.

Up to now, approximately 580,000 hectares have been burnt this year in the area monitored by EFFIS, which includes Europe, Middle East and North African countries.

Release published by the European Commission, Joint Research Centre (JRC)



Building a seismograph from scrap

Did you know that you can use old hi-fi speakers to detect earthquakes? And also carry out some simple earthquake experiments in the classroom? Here's how.

Earthquakes occur around the world all the time. In 2011, the earthquakes that caused the Fukushima disaster in Japan killed thousands in Turkey and devastated New Zealand's second-largest city made the headlines. But did you know that 2011 also saw earthquakes in Finland, Belgium, and the Czech Republic?

Some earthquakes may be so slight as to be practically unnoticeable, but they can still be recorded. Each tremor produces different types of vibration, or seismic waves, which travel through Earth's interior with different velocities. These waves can be detected and recorded by instruments called seismographs, which are often sited at great distances from the earthquake. By measuring the time that the seismic waves take to arrive at seismographs, as well as recording the amplitude and duration of the waves, we can calculate the magnitude of the earthquake and determine its epicentre.

Monitoring local earthquakes

Earthquakes are a daily occurrence in Greece, sitting as it does at the boundary of two tectonic plates. The district of Messinia, where our school is located, has a history of major earthquakes. In 1886, a severe earthquake of magnitude 7.5 on the Richter scale struck Filiatra. A century later, Kalamata was hit by another strong earthquake, this time of magnitude 6.0. Within the next 100 years, it is predicted that <u>Sparta will be struck by an earthquake</u> of at least magnitude 7.0.

To encourage my students to learn about earthquakes, I acquired and set up a commercial, educational seismograph in our school (Figs. 1 and 2a), the General Lyceum of Filiatra. The seismograph is based on an array of three geophones – devices that respond to the seismic waves and convert them to electrical signals. Each of the three geophones monitors waves in the up-down, east-west or north-south directions. The three signals are then processed by computer, allowing the magnitude of the earthquake and the distance from the epicentre to be calculated (Fig. 1).

Building a seismograph

I also wanted to encourage the students to think about the technology that is used to detect and measure earthquakes and to understand what each component does, rather than viewing a seismograph as a 'black box'. To this end, we build our own seismograph, with which we can detect local earthquakes – up to 100–200 km away, depending on their magnitude.

At the heart of any seismograph are the geophones. They convert the ground vibrations into electrical signals using a coil that moves



Fig. 1: A 3-channel seismogram from our commercial seismograph, showing the start times of the primary (P) and secondary (S) waves and the vibration end time (C). Primary waves are compressional longitudinal waves that are the first to arrive at the seismograph. They can travel through solids or fluids – in air they take the form of sound waves, travelling therefore at the speed of sound (340 m/s). In water they travel at about 1450 m/s and in granite at about 5000 m/s. Secondary waves are shear transverse waves, arriving at the seismograph after the primary waves and displacing the ground in a direction perpendicular to the direction of propagation. They do not travel through liquids or gases, travelling through solids at speeds of about 60% of those of primary waves. The epicentre distance (in km) and the earthquake magnitude (measured on the Richter scale) are calculated according to the formulae

distance = $p_1 \cdot (t_s - t_p)$, and magnitude = $p_2 \cdot log_{10} (t_c - t_p) + p_3 \cdot distance - p_4$,

where p_1, p_2, p_3, p_4 are constants that depend on the types of rock that the earthquake passed through. Default values are p_1 = 7.6, p_2 = 2.31, p_3 = 0.0012, p_4 = 1.0. Three time measurements (in seconds) are needed: the time that P waves arrive (tp), the time that S waves arrive (ts) and the time that vibrations end (t_c). (Credit: Panteleimon Bazanos; image source: Seismic Logger, Helicorder and Dataviewer software, Seismology Laboratory of the University of Patras)

relative to a magnet, producing an electrical voltage at the end of the coil (Faraday's law; Fig. 2a). To build our seismograph, we used everyday technology as the geophone: a loudspeaker. Normally, loudspeakers operate by converting an electrical signal into the relative movement of a coil and a magnet, which causes the cone to move in and out, thus generating vibrations: sound waves (Fig. 2b). By making them operate the other way round – turning vibrations into electrical signals – they can be made to function as geophones.

To make our geophone, we used a 'woofer' – a speaker for lowpitched sounds – because woofers are designed to work well for low frequencies, and seismic waves are of course low-frequency vibrations. To minimize interference from sound vibrations, we removed the cone of the loudspeaker.

To complete our geophone (Fig. 3), we also used a weight, a spring and the lid of a spray can. The weight serves to increase the inertia, as the loudspeaker coil itself is very light. Placing a weight directly onto the coil would damage it, so we used the spring to hold the weight over the coil, allowing it to oscillate. The lid protected the coil. We then plugged our woofer geophone into the sound-card port of a computer, and recorded the signals using sound-editing



Fig. 2: a (left): How a geophone works. When the ground vibrates, the mass with the coil attached to it moves relative to the magnet. The potential difference produced in the connectors depends on the way the ground vibrates. (Credit: Panteleimon Bazanos) b (right): How a loudspeaker works. As the function of loudspeakers is based on the relative movement of coil and magnet, we can use them to detect ground vibrations. These vibrations move the coil relative to the magnet, producing a potential difference between the coil's connectors. This electrical signal is recorded by the computer via the sound card, in the same way as input from a microphone would be. (Credit: lain Fergusson; image source: Wikimedia Commons)

software, creating a working seismograph. Detailed instructions for building our seismograph can be <u>downloaded from the Science in</u> School website.

Now it's your turn

If you are interested in monitoring and investigating seismic activity in the classroom, you could:

1. Monitor and analyze data from existing seismographic stations.

- 2. Use a commercial, educational seismograph.
- 3. Construct your own seismograph, using the <u>downloadable</u> instructions.
- Carry out some simple experiments (detailed below) to simulate and investigate the physics of earthquakes.

To record earthquakes with either a commercial or a homemade seismograph, you will need to be relatively close to their epicentres. Our homemade seismograph detected earthquakes up to 100–200 km away, depending on magnitude. With our <u>commercial seismograph</u>, we detected earthquakes of 4.0 on the Richter scale from 500 km away.

Options 1 and 4 have the advantage of being feasible even in regions with very little seismic activity.

Looking for earthquakes

The coil of the homemade seismograph is very sensitive, so the geophone must be handled with great care. For the best measurements, set up the seismograph somewhere quiet and free from vibrations, perhaps in the school cellar. However, to encourage student participation, I set mine up in the classroom.

Once you have set up your seismograph, let it record continuously for one or two days, then save the data in a file. Before you can search for earthquakes in the data, you will need to do some processing. The exact details of the processing will depend on the software you use, but it should be fairly straightforward.



Fig. 3: Our homemade geophone (Credit: Panteleimon Bazanos)

- Remove any DC offset, to remove the contribution of any DC current to the signal.
- 2. Amplify the low frequencies (below 100 Hz). This is the range in which you will detect earthquakes.
- Remove background 'noise' (thermal noise, electronic noise, etc.) to make the signal clearer.
- After that, you can search the data for patterns that indicate an earthquake.

Not all signals recorded by seismographs are earthquakes. Other, more local sources, including traffic, wind, explosions, and opening and closing doors, can cause confusion. Earthquakes often have a characteristic pattern: a small waveform followed by a large one (Fig. 1). Because this is not always the case, however, you and your students may sometimes be unsure if what you have detected really is an earthquake. The only way to be certain is to do what professional seismologists do and compare your data with the recordings made at other seismographic stations.

When you are confident that you have detected an earthquake, you can calculate its magnitude (on the Richter scale) and your distance (in km) from the epicentre (Fig. 4). For that, you need only three measurements: the arrival time (in seconds) of the P and S waves, and the time at which the vibrations stop (Fig. 1). For more details, download the instructions from the *Science in School* website.



Fig. 4: Earthquake signals recorded with our homemade seismograph. The values in the yellow boxes were calculated from the homemade seismograph data, while the values under the signals are from the reports of the Institute of Geodynamics of National Observatory of Athens. ML stands for local magnitude (ML) on the Richter scale. (Credit: Panteleimon Bazanos)

Vibration experiments using computer speakers

I also devised experiments to simulate some aspects of earthquakes and the signals they produce – for example, how the energy of the earthquake decreases as it passes through different materials.

To do this, we used speakers and a computer equipped with a sound card and audio processing software, as before. But in place of geophones you can use old computer speakers (again with the cone removed), which can be moved around as needed in the experiments. You can use 100W / 8 Ω woofers, as in the construction of our seismograph, or 3W / 8 Ω computer speakers, plus the <u>soundediting software Audacity</u>. For more details, see steps 1, 8 and 9 in the downloadable instructions.

The experiments involved dropping balls from different heights (representing different energies), at different distances from the detectors (the speakers), onto surfaces made from various solid materials.

When the ball strikes the hard surface, it produces vibrations that travel through the solid – just as an earthquake produces waves that travel through Earth.

Experiment 1: The power of a shake

This activity demonstrates the relationship between earthquake power and ground movement. We caused vibrations on a piece of marble (or wood, plastic or even the ground) by dropping a mouse ball (from a computer mouse) from different heights, producing different ground-shaking powers. The amplitude of the signal depends on the power of the shake.

- 1. Set up the equipment as shown in Fig. 5a.
- Drop the ball from different heights, recording the signal amplitude (Fig. 6a) in Tab. 1. It is not important exactly what distance from the speaker you drop the ball, but make sure you drop it onto the same spot each time.
- 3. Plot a graph of amplitude against height.
- 4. Discuss the graph. Your students should conclude that the more energy is released, the more the ground vibrates.



Experiment 2: Energy attenuation

This activity demonstrates the energy attenuation (decrease) as seismic waves travel through Earth's crust. We produced vibrations by dropping a 4 kg shot put (metal ball) on the ground from the same height but at different distances from the woofer geophone or loudspeaker. As the waves travel, they lose energy and the ground vibrates less. This is reflected in the amplitude of the signals.

- 1. Set up the equipment as shown in Fig. 5a.
- Mark 5 distances of 1 m intervals from the woofer geophone or loudspeaker along the ground.
- 3. Let the ball fall from the same height (e.g. 1 m) onto the ground at each marked distance, recording the results (Fig. 6b) in Tab. 2.
- Plot a graph of amplitude against distance.
- Discuss the graph. Your students should conclude that the farther away the 'earthquake' is, the less the ground vibrates.

Experiment 3: Wave velocity in different media

In this activity, we investigate wave velocities in different media. As seismic waves travel through Earth, their velocity differs depending on the composition of the rocks they are travelling through. This gives seismologists and geologists important information about Earth's interior. Here, we investigate how fast vibrations travel through different solid materials.



We used wood, iron and marble as the materials, but any hard solid can be used. Just make sure you have the various materials available in a size suitable for the activity.

- 1. Set up the equipment as shown in Fig. 5b. We used a distance (x) of 80 cm between the speakers.
- Drop a mouse ball (or other suitable object) onto the first solid material, close to one speaker, but not between the speakers. Record the times for the signal to reach each speaker (t1, t2).
- Repeat with the other materials, entering each result in Tab. 3.
 Work out the wave velocities using the formula: v = x / (t2-t1)
- 4. Discuss the results. In which material do the waves travel fastest?

Panteleimon Bazanos General Lyceum of Filiatra, Greece

Images and text reproduced with permission from Issue 23 (May 2012) of Science in School

Resources

On the website of Natural Resources Canada, there is a brief introduction to seismographs and how they function.

Learn about earthquake-measuring scales on About.com.

The website of Michigan Technological University has a compact and comprehensive guide for budding seismologists.

The world seismic monitor has a visual representation of recent earthquakes.

For another seismograph to build at school, this one based on an ancient Chinese design, see: Kirschbaum, T. and Janzen, U. (2006): Tracing earthquakes: seismology in the classroom, *Science in School* 1, 41–43

See the website of the UK's National STEM Centre for a <u>collection of</u> <u>teaching ideas for seismology</u>. The materials are free but you need to register on the website to download them.

To learn how to use geographical information systems to analyze earthquakes, see: Kerski, J. (2010): <u>GIS: analysing the world in 3D</u>, *Science in School* 15, 34–38

Marazzi, F. and Tirelli, T. (2010): Combating earthquakes: designing and testing anti-seismic buildings, *Science in School* 15, 55–59

Height (cm)	10	15		20		25		30
Signal amplitude								
Distance from geophone (m)	1	2		3		4		5
Signal amplitude								
Material	t1	t2	t	2-t1	x		v = x / (t2-t1)	
Wood								
Iron								
Marble								

Tabs. 1 (top), 2 (centre), and 3 (bottom): Enter your results for experiments 1, 2, and 3, respectively

See the education web pages of the Incorporated Research Institutes for Seismology for more teaching ideas about earthquakes.

For further teaching ideas about earthquakes, see <u>How to teach natural</u> <u>hazards in school: raising awareness on earthquake hazard</u> from the EUfunded Eduseis project.

Increasing numbers of schools are becoming involved in recording seismic data themselves. To strengthen the links between such schools in Europe, teachers are invited to apply for the second European summer school in school seismology. To be held in Summer 2013 in France, it is funded by EU Comenius grants to teachers.

If you found this article inspiring, why not browse all the science education projects in *Science in School*.

Jean-Luc Berenguer of the EGU Committee on Education, and an expert in teaching natural hazards in school, comments:

"Feeling the Earth shake in the classroom is now possible by way of seismometers installed in schools. In the past couple of years, teachers have been able to bring seismology into the classroom with a lot of data in real time. This experience, beginning in the US and then in France, is spreading quickly in Europe. The development of simple devices and the design of concrete experiments, associated with an investigative approach, make it possible to instil the students, the professionals of the future, with high-quality scientific culture and education about risks. In this article, Sir Panteleimon Bazanos, shows us how teachers can motivate 'seismology in school' with simple and effective tools."

Additional resources

'Sismos à l'école', the French seismological educational network (in French)

UK School Seismology Project: 'real science with real data'

Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation – NERA project

The 2013 Geosciences Information For Teachers (GIFT) Workshop, taking place in April in Vienna, is dedicated to Natural Hazards. For more information, check the application form and preliminary programme.

Remote sensing, e-learning and scientific literacy

A new learning portal for schools using satellite images

German researchers have created a new portal to help school students learn about remote sensing. In this article, they introduce the website and its teaching activities.

The project <u>FIS</u> – *Fernerkundung in Schulen* (German for 'Remote Sensing in Schools') – aims at a better integration of remote sensing in school lessons. In addition to the strengthening of natural science education and working on present questions, the use of satellite images in classrooms offers further advantages. These include a high degree of descriptiveness, a motivating effect of the imagery, as well as ways for problem-oriented working, the strengthening of spatial orientation competence, method competence, and evaluating and practice skills. Respectively, the overall objective is to teach pupils from primary school up to high-school graduation all basics and fields of application of remote sensing. For this reason, we developed a comprehensive and well-structured learning portal on the subject of remote sensing, which will facilitate teachers' and pupils' entry to the topic.



Teaching materials

The learning portal's development is based on the didactic principles of moderate constructivism. Accordingly, all different learning materials of the portal are multimedia applications, thus the contents are provided through different means of coding.

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The three main sections of teaching materials that form the backbone of the developed learning portal are:

Learning modules

The heart of the learning portal consists of digital and interactive learning modules that teach remote sensing topics following the curriculum for specific school grades. To cover different aspects of remote sensing, we developed learning modules for the subjects of geography, biology, physics, maths, and informatics. The design of the learning modules enables the user to conduct classical remote sensing analysis by using interactive tools (see figure). The

analyzes' complexity is lower than in conventional remote sensing software, thus usability as well as functionality of the digital learning modules is adapted to a pupil-friendly standard.

Research tools

To improve individual and discovery-based learning, the pupils find extensive background information provided by research tools in terms of a digital glossary (Info-Box) and an image gallery. The **Info-Box** is a digital encyclopaedia for terms and basics of remote sensing. Paying attention to the pupils' different levels of knowledge, the Info-Box is presented in two versions: beginner and professional. Additionally, the pupils can search pointedly for supplementary visual material. Searching options exist for images regarding specific regions or matching specific keywords.

Analysis tools

Individual learning is put forward by different analysis tools. The pupils have the chance to analyze single images directly. The **Sat-Calculator** helps to perform simple arithmetic calculations on digital images, for example the Normalized Difference Vegetation Index NDVI. Another analysis tool is the **RGB Classifier** – the pupils use this tool to learn that digital images consist of raster cells which all have characteristic colours. This colour information can be used to derive a thematic map from a satellite image. In addition to static analyzes of the land surface, we developed a tool to observe current processes of the atmosphere, the **MeteoViewer**. It shows images of the MeteoSat satellite on a daily basis, which are reloaded automatically every 15 minutes. The pupils have the option to watch the latest image or a 3- or 24-hour loop, covering either the whole Earth or Europe, to draw conclusions regarding present weather conditions.

The digital learning materials integrated into the platform allow, therefore, a high degree of interaction. Moreover, independent working and discovery-based learning is encouraged in terms of a practice-oriented approach. That way students use the added value of geodata as well as geographic-information-system and remote-sensing technology while answering specific research questions – and they communicate their hypotheses using these data and technologies as an argumentation basis to defend their decisions.

Kerstin Voß¹, Andreas Rienow², Roland Goetzke², and Henryk Hodam² ¹University of Education Heidelberg ²University of Bonn

The FIS-project is funded by the Federal Ministry of Economics and Technology through DLR, German Aerospace Centre (project no. 50EE0615). The online portal (in German) can be accessed at <u>http://fis.uni-bonn.de</u>. Teaching materials are available in English at <u>http://www.fis.uni-bonn.de/EnglishMaterial</u>.

Reference

Voß, K., et al. (2011): Remote sensing, new media and scientific literacy – A new integrated learning portal for schools using satellite images; in *Learning* with GI 2011 – Implementing Digital Earth in Education, Wichmann, pp. 172–180.



GEO C BOOKS

Geographic Information Analysis for Sustainable Development and Economic Planning: New Technologies



By Giuseppe Borruso, Stefania Bertazzon, Andrea Favretto, Beniamino Murgante and Carmelo Maria Torre

IGI GLOBAL

434 pages | Hardback 1st edition | July 2012 ISBN 978-1-46-661924-1

Price: \$136 (~€110)

Publisher's summary

Spatial analytical techniques and geographical analysis and modelling methods are required in order to analyze data and to facilitate the decision process at all levels. Old geographical issues can find an answer thanks to new methods and instruments, while new issues are developing, challenging the researchers for new solutions.

Geographic Information Analysis for Sustainable Development and Economic Planning: New Technologies tackles topics related to, to-date development of Geographic Information in terms of the technologies available for retrieving, managing, and analyzing geographical data. This book is useful for academic staff, as well as postgraduate students (MSc, PhD levels) in GIS, remote sensing, economic geography, spatial planning, geostatistics, and related fields.and geology and a beneficial tool for professional scientists seeking a better understanding of the mathematics and physics within Earth sciences.

Crustal Evolution and Metallogeny in India





By Sanjib Chandra Sarkar and Anupendu Gupta

CAMBRIDGE UNIVERSITY PRESS

912 pages | Hardback 1st edition | April 2012 ISBN 978-1-10-700715-4

Price: £90 (~€114)

Publisher's summary

Crustal evolution means the resultant changes that the Earth's crust has gone through in its geologic past affected by changes in the mantle-crust system, the atmosphere, the hydrosphere, and the biosphere. Metallogeny is the genesis of metallic mineral deposits. Both the terms are used in the book in their conventional sense, but keeping in mind an Indian context. This book is the first of its kind to document in detail the nature, origin and evolution of mineral deposits in India and is contextualized in local, regional and global geology. The book is unique in that it combines both metallogeny and crustal evolution that were hitherto treated as stand-alone topics. The exhaustive chapters in the book carry detailed case studies of the distribution and occurrence of ores. The book would be useful to students of advanced geology, researchers, teachers, planners, and global metallogeneticists around the world.

Geophysical Data Analysis: Discrete Inverse Theory, MATLAB edition



By William Menke

ACADEMIC PRESS (ELSEVIER)

348 pages | Hardcover 3rd edition | June 2012 ISBN 978-0-12-397160-9

Price: € 64.95

Publisher's summary

Since 1984, Geophysical Data Analysis has filled the need for a short, concise reference on inverse theory for individuals who have an intermediate background in science and mathematics. The new edition maintains the accessible and succinct manner for which it is known, with the addition of: MATLAB examples and problem sets; advanced colour graphics, coverage of new topics, including Adjoint Methods, Inversion by Steepest Descent, Monte Carlo and Simulated Annealing methods, and Bootstrap algorithm for determining empirical confidence intervals; online data sets and MATLAB scripts that can be used as an inverse theory tutorial.

This book is suited for graduate students and researchers in solid earth geophysics, seismology, atmospheric sciences and other areas of applied physics (e.g. image processing) and mathematics.

Practical Chemical Thermodynamics for Geoscientists



By Bruce Fegley, Jr.

ACADEMIC PRESS (ELSEVIER)

696 pages | Hardback 1st edition | July 2012 ISBN 978-0-12-251100-4

Price: €89.95

Publisher's summary

Practical Chemical Thermodynamics for Geoscientists covers classical chemical thermodynamics and focuses on applications to practical problems in the geosciences, environmental sciences, and planetary sciences. This book will provide a strong theoretical foundation for students, while also proving beneficial for earth and planetary scientists seeking a review of thermodynamic principles and their application to a specific problem.

This book is suited for students and researchers in earth sciences and related fields, including astronomy and physics.

Soil Ecology and Ecosystem Services



Edited by Diana H. Wall, et al.

OXFORD UNIVERSITY PRESS

424 pages | Hardback 1st edition | June 2012 ISBN 978-0-19-957592-3

Price: £75 (~€95)

Publisher's summary

This multi-contributor, international volume synthesizes contributions from the world's leading soil scientists and ecologists, describing cutting-edge research that provides a basis for the maintenance of soil health and sustainability. The book covers these advances from a unique perspective of examining the ecosystem services produced by soil biota across different scales – from biotic interactions at microscales to communities functioning at regional and global scales. The book leads the user towards an understanding of how the sustainability of soils, biodiversity, and ecosystem services can be maintained and how humans, other animals, and ecosystems are dependent on living soils and ecosystem services.

Orogenesis: The Making of Mountains

A book review



By Michael R. W. Johnson and Simon L. Harley

CAMBRIDGE UNIVERSITY PRESS

398 pages | Hardback 1st edition | March 2012 ISBN 978-0-52-176556-5

Price: £45.00 (~€55.00)

Mountains have always attracted the attention of humanity because, as natural barriers for trade, they played a vital role in its history. Moreover, they have a strong influence in the culture and the way of life of people residing next to them.

Orogenesis, a Greek term used to describe the process of mountain building, is the title of a recently published Cambridge University Press book. The term refers to the collision of two tectonic plates, which either forces material upwards and creates mountain belts or causes a plate to be subducted below the other creating volcanic mountain chains. A great majority of orogens – belts of rocks involved in the formation of mountains – mark the sites of ancient oceans, which have closed completely. Examples include the Alps and the Caledonian orogens, which represent the closure of the Tethys and lapetus oceans, respectively. The study of mountains therefore reveals the history of the Earth, concerning the growth and closure of oceans, the formation of its continents, and its geomorphologic features.

The new book is edited by two internationally recognized academics from the University of Edinburgh. Michael R. W. Johnson, a veteran of geology, and Simon L. Harley, a specialist in metamorphism, have carried out research on orogens worldwide and synthetize their knowledge in an up-to-date overview of orogenic research. The book provides the necessary background knowledge on 'the making of mountains', and presents the major features of selected orogenic belts of the Earth, ranging from the Alps to the Himalayas and the Andes. It offers particularly detailed information on the formation of the Himalayas.

The book is structured in 12 chapters. The first three chapters deal with the basics of mountain building processes, such as plate tectonics, the driving mechanisms, and mass and heat transfer issues in the lithosphere.

The following chapter covers the essential characteristics of orogens giving examples from major mountain belts.

Chapters five to nine mainly focus on the evolution of orogens and the mechanisms that take place during it. They make an extensive analysis of the metamorphism, erosion, exhumation, and sedimentation processes that occur during the evolution of orogens.

The book ends with two chapters dedicated to topics that have been subject of debate in recent years. One focuses on the impact of mountain building on climate and climate change. Mountains affect climate because they obstruct air circulation, but the jury is still out on the exact role of orogenesis in climate change. The final chapter looks into the question of secular change in the formation of mountains.

The book suits the role of textbook for undergraduate and graduate students of structural geology and plate tectonics. But *Orogenesis* is also recommended to researchers of geodynamics or related fields such as petrology geochemistry and sedimentology.

Overall, *Orogenesis* is a must for those who have a keen scientific interest in mountains and want to deepen their knowledge in this exciting topic.

Lida Maria Soukouli, engineering geologist based in Greece



The Open Access Journals of the European Geosciences Union

GEO **Q** ON THE WEB

Featured website: Minigeology.com

Interviews with famous geologists

Minigeology.com is dedicated to the human side of the geological sciences, featuring dozens of video interviews of scientists speaking about geology, their work, and their human side. The site is updated several times monthly with videos done by Daniel Minisini, the website's manager, or submitted by the general public, representing a compelling attempt to add spontaneity and candour to scientists otherwise known mostly by their peer-reviewed academic papers. This website has the feel of a work of art in progress, fitting loosely into the boundaries of its listed 15 geological disciplines, from geoarchaeology to vulcanology. The topics discussed range from religion in science to the role of serendipity within the scientific method, providing the user with a patchwork of themes from which to draw inspiration either as an aspiring scientist or admirer of the diversity of distinct personalities involved within the geosciences.

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Social media: Who should you follow?

In this issue of GeoQ, we highlight individuals and organizations who regularly post interesting updates in the geosciences on Twitter or Facebook. If you have accounts on these networks, why not also follow EGU at @Eurogeosciences (on Twitter) and European Geosciences Union (on Facebook)?

The Earth Story (Facebook): this excellent page covers all Earth sciences. Its contributors are dedicated to "bringing you original articles, stunning photography and plenty of fascinating information about the amazing planet we live on."

<u>@eruptionsblog (Twitter)</u>: Erik Klemetti, assistant professor of geosciences at Denison University, tweets about what he blogs in his brilliant <u>Eruptions Blog</u>, hosted by Wired Science, and other volcano news.

<u>@Earth_News (Twitter)</u>: "Wildlife, Nature, Science & Environment news from around the world".







GEO CEVENTS

Floods and climate: Understanding and exploiting the link between floods and climate

04-05 October 2012, Potsdam, Germany

This EGU Topical Meeting is aimed at discussing (1) the current state of our understanding of the link between floods, meteorological processes and climate, and (2) novel research and management options for quantifying and exploiting the climate-flood link. We bring together scientists from different disciplines, e.g. hydrology, water resources management, meteorology, climatology, paleo-climatology, paleo-hydrology, to have a broader perspective on floods.

Website: http://bit.ly/TUdM3d

PANAF 2012 – Paleoseismology Along the North Anatolian Fault

08-12 October 2012, Istanbul, Turkey

The Paleoseismology along the North Anatolian Fault (PANAF) meeting aims to gather Earth scientists who are interested on the paleoseismicity and recent earthquake activity of the North Anatolian Fault.

Website: http://www.panaf.itu.edu.tr/

International Symposium on Properties and Functions of Biogeochemical Interfaces in Soil

08–10 October 2012, Dornburg, Germany

The symposium aims to raise interdisciplinary dialogue between specialists from the fields of advanced instrumental analysis techniques and experts from the field of theoretical, physically based modelling and computational chemistry. The goal is to discuss the limits and prospects of the joint application of these two complementary scientific approaches to gain a mechanistic understanding of the controlling role of BGI (Biogeochemical Interfaces) for the fate of organic chemicals in soil.

Website: http://www.spp1315.uni-jena.de/

Land atmosphere interactions at the regional scale

08–10 October 2012, Madrid, Spain

This workshop will revise the state-of-the art of land-atmosphere interactions encouraging to establish future links between atmospheric process to the ones that occur at the vegetation and soil level. Invited lecturers with different background will present how the combination of experiments and process studies can improve the representation of the land-atmosphere at different spatial and temporal scales and unravel the feedbacks between land and atmosphere, including cloud effects.

Website: http://events.ciemat.es/web/egu

FuegoRED IV. Forest fires effects on soils

24–27 October 2012, Tenerife, Canary Islands

The main targets of the meeting are intended to be the establishment of further links between fire scientists on the one hand and environmental managers, on the other, as well as to show new perspectives of study about problematic issues related to forest fires.

Website: http://jnotario.webs.ull.es/FuegoRED12/index.htm

3rd Conference on Terrestrial Mars Analogues

25–27 October 2012, Marrakech, Morocco

The analysis of Mars analogue environments on Earth is of paramount importance for the interpretation of the data from past, present, and future orbital and landed missions, as well as mission planning (both robotic and human). Sedimentary environments in particular attract strong interest because they can retain the palaeoclimatic and palaeoenvironmental history of the planet and under the right conditions may harbour fossil or present life signatures. The participation of terrestrial geologists is particularly encouraged, in order to identify and promote the many synergies between Martian and terrestrial science.

Website: http://www.ibnbattutacentre.org/conf/mars2012/

GSA Annual Meeting & Exposition

04-07 November 2012, Charlotte, USA

The Annual Meeting & Exposition of the Geological Society of America will count with a broad array of field trips, technical sessions, and short courses. The meeting is typically attended by some 6,000 people from every geoscience discipline and every stage of career development.

Website: http://www.geosociety.org/meetings/2012/

9th European Space Weather Week . . .

05–09 November 2012, Brussels, Belgium

Now in its 9th year, the ESWW has grown into the main annual event in the European Space Weather calendar. This year's event will highlight key innovations in space weather research, applications and services. The meeting will also focus on current challenges and actions necessary in moving towards a sustainable Space Weather Infrastructure able to meet the requirements of a diverse end-user community. The final session of the week will present the final results of the COST Action ES0803 Developing Space Weather Products and Services in Europe.

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Website: http://stce.be/esww9/

8th Alexander von Humboldt International Conference on Natural Disasters, Global Change, and the Preservation of World Heritage Sites

12–16 November 2012, Cusco, Peru

The aim of this conference is to bring together geoscientists, engineers, seismologists, geologists, architects, and other specialists, to discuss natural disasters and their prevention, with particular emphasis on World Heritage sites. A special session will be devoted to Inca ruins, in particular those of Macchu Picchu (celebrating the 100 years anniversary of their rediscovery in 1911).

Website: http://meetings.copernicus.org/avh8/

ESA-CliC-EGU Topical Conference on Earth **Observation and Cryosphere Science**

13–16 November 2012, Frascati, Italy

This conference, a joint venture between the Climate and Cryosphere (CliC) Project of the World Climate Research Program, the European Geosciences Union (EGU) and the European Space Agency (ESA), aims to provide a forum for world-class scientists to present new research results and focus on and discuss future challenges on EO technology for cryosphere science.

Websites: http://eo4cryosphere.info/

14th Plinius Conference on Mediterranean Storms and Final MEDEX Conference _____

13–16 November 2012, Palma de Mallorca, Spain

The Plinius Conferences are interdisciplinary meetings in which the exchange of new ideas and results about the Mediterranean Storms and their hydrological, geological, marine or social consequences takes place. The topics foreseen for this 14th edition are: Social impacts of the Mediterranean storms; Mediterranean storms monitoring; Diagnosis and prediction of the Mediterranean storms; Hydrometeorology and hydrology of the Mediterranean storms; Geological and marine consequences of the Mediterranean storms.

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Website: http://www.plinius14.eu/

4th EGU Leonardo Conference:

Hydrology and Society

14–16 November 2012, Torino, Italy

The EGU Leonardo Topical Conference Series on the Hydrological Cycle is a cycle of conferences taking places every year in Europe to host scientific discussions focused on specific topics around the hydrological cycle. This year's topic is directed also to non-hydrologists, trying to bridge issues coming from themes that are relevant for the society to solutions possibly coming from the scientific research in hydrology.

Website: http://www.eguleonardo2012.polito.it/

AGU Fall Meeting

03-07 December 2012, San Francisco, USA

The American Geophysical Union's 45th annual Fall Meeting will count with the presence of more than 20,000 Earth and space scientists, educators, students, and other leaders who will gather in San Francisco to present groundbreaking research and connect with colleagues.

Website: http://fallmeeting.agu.org/2012/

Annual International Conference on Geological & Earth Sciences (GEOS 2012)

03–04 December 2012, Singapore

A major role of Earth science scholars is to examine the delicate balance between the Earth's resources and the growing demands of industrialization. Through research and development, earth scientists have the power to preserve the planet's different resource domains by providing expert opinion and information about the forces which make life possible on Earth. This is the theme of GEOS 2012.

Website: http://www.geoearth.org/