

Dirk Werle, Ærde Environmental Research, Halifax, Canada

Health of the environment and the individual – a space perspective

Keynote Lecture 4 at Wonca Europe Conference in Basel, Switzerland, September 16–19, 2009

Thank you for attending this keynote address in this year's Wonca Europe 2009 Special Lecture series. I would like to extend special thanks to Dagmar Haller-Hester and Peter Tschudi of the Organizing Committee for their leadership in taking a broad approach to health and family medicine. Environmental factors (slide 1) in their complexity affect all of us: communities and individuals. Last year, World Health Day proclaimed the close connection of health and climate change. It raised awareness that clean air, safe food and fresh water are all dependent on environmental factors, climate being among the most important ones. You could add that, at a global scale, major public health problems like malnutrition, diarrhea or malaria are all illnesses sensitive to environmental determinants.

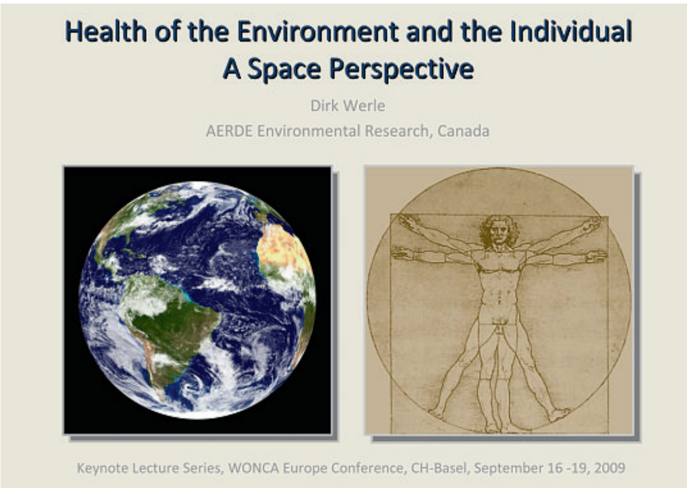
In my presentation this morning, I want to address three issues: the interrelation of the health of planet Earth and the health of the individual and, more to the point, how modern satellite imaging technology can help to survey and monitor environmental conditions and eventually aid decision making; then I will assess some experience to-date and show you recent examples of impacts of environmental change on human health. Finally, I will try to focus on some opportunities and pathways for further work.

What do I, as a geoscientist, know of health and dealing with individuals? Several colleagues were intrigued and said "I'd like to come and hear what you have to say". When one talks about the impact of ideas in one particular discipline on the ideas in another, one has to watch one's step. As Richard Feynman, the renowned physicist, once quipped: "In these days of specialization there are too few people who have such deep understanding of two departments of our knowledge that they do *not* make fools of themselves in one or the other!" I can't count myself into that number of elite experts, but having perhaps foolishly agreed to this talk I shall proceed with caution and with some common ground in mind.

There are indeed striking commonalities when one views the Earth and the human body as functioning organic systems. Just consider commonplace notions such as the tropical rainforests being the 'lungs of the Earth', or large rivers being the 'life blood' of entire nations. It was James Lovejoy, today a leading figure in British science, who first proposed, a couple of decades ago, the idea of our planet acting like a self-regulating organism. His Gaia theory established a useful way of understanding the changes that are happening to the environment of the Earth. Thus, gaining a better understanding of the system at a global scale is a necessity, and using the vantage point of space to deploy satellite-based sensors for Earth observation seems a reasonable idea to improve our understanding and make better decisions. (slide 2) I am sure many of you will recognize this iconic snapshot of Earth taken by the Apollo astronauts in December 1968, iconic in a sense that it reminded us, perhaps for the first time, that we are all sharing this seemingly small and fragile planet.

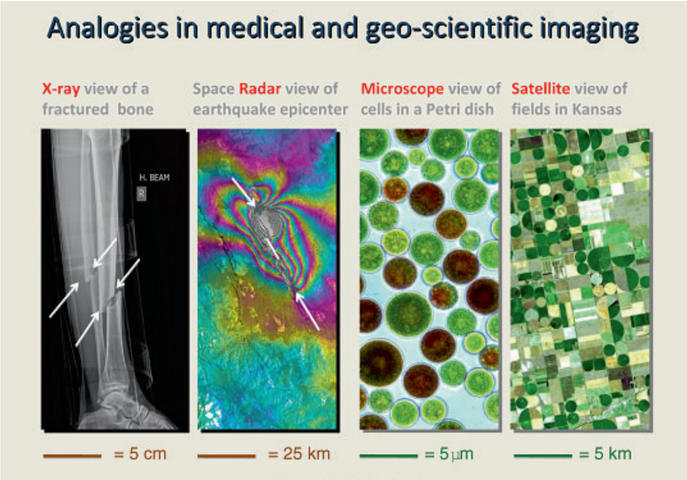
The second commonality that I trust will keep me on fairly solid ground with the medical community is the fact that we both rely on modern imaging systems as tools for study, for examination, and for diagnosis (slide 3). Consider the x-ray machine at the doctor's office to visualize a bone fracture vis-à-vis cloud penetrating space-based radars that record terrain displacement and extent of earthquakes; or the microscope to study individual cells and telephoto lenses aboard orbiting satellites to monitor agricultural fields.

I am aware that the power of images can have its pitfalls and needs to be treated carefully (slide 4). Let me illustrate this important point, since I intend to make use of images throughout this talk. The slide shows two quite similar looking objects, yet the two are vastly different in terms of location, scale, and origin. The image on the left is part of a large radar satellite image, showing volcanic terrain on the surface of planet Venus; the area covered by this image, in-

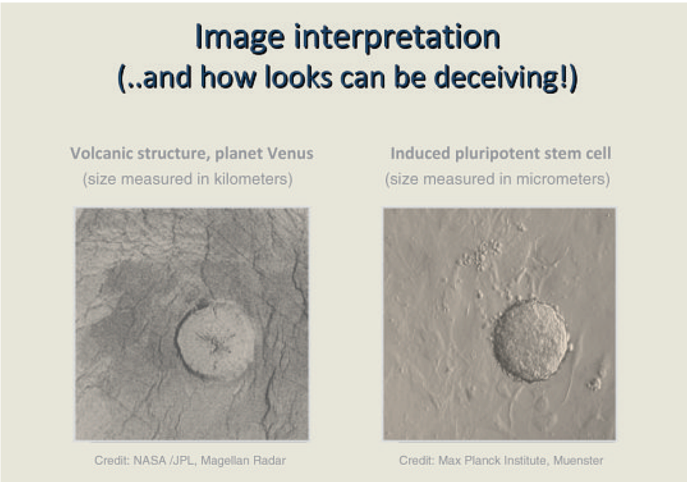


1

2



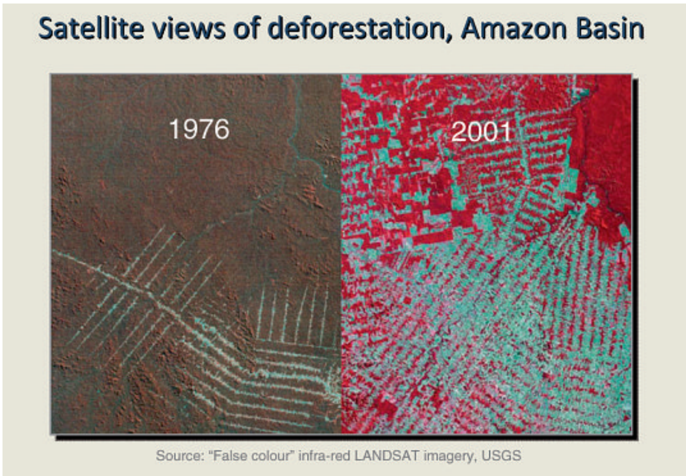
3



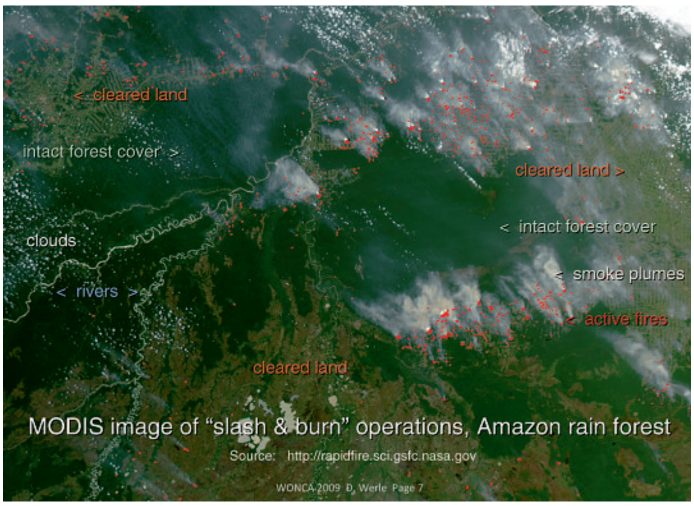
4

cluding the pancake shaped volcanic structure, can be measured in terms of several *kilometers*. The image on the right was taken through a microscope and shows – at the *micrometer*-scale level – a colony of induced pluripotent stem cells.
The old adage that 'A picture is worth more than a thousand words' has been applied very effectively by placing pictures of lung cancer on cigarette packs to illustrate the harmful effects of smoking (slide 5). If one would look for an equivalent in the field of Earth observation, there are plenty of satellite time series to choose from. The adjacent example shows a cancer of a different type: the progression of slash-and-burn colonization in the Amazon Basin; unrelenting population pressure and in-migration of farm workers and their families along the arterial road network accelerates the destruction of primary forest vegetation and the release of enormous amounts of carbon into the atmosphere. The full scale and extent of this landscape transformation becomes even more apparent in this pair of false colour infra-red LANDSAT satellite imagery from 1976 and 2001 (slide 6), covering about a hundred kilometers of tropical forest terrain. It shows that we can, in fact, monitor these land use and land cover changes over the course of a few decades. Moreover, we can now access via the Internet the proverbial 'big picture' (slide 7). This type of satellite imagery covers the globe in long, 1800 km wide swaths and with a spatial detail that is as good as 250 meters. The red dots record actual fire locations where primary forest is being slashed and burned; the large smoke plumes are associated with that activity; intact forest along the rivers is shown in dark green, and land converted to agricultural or pastoral land use appears in shades of brown and light green.
Large-scale environmental problems of this kind are characterized by complexity and uncertainty, entailing time delays and feedback

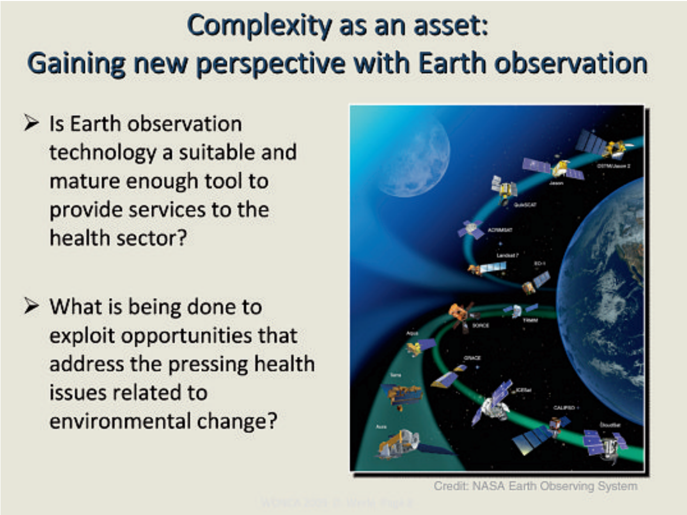
5



6



7



8

loops. Events like the establishment of a farm lot in the Amazon rain forest can have big and multiple effects that are often separated in time and space. Study and analysis of these problems, including those that are health-related, transcend disciplines and pose serious difficulties for predictions and risk management. The information derived from satellite imagery can serve as a powerful decision support tool and reality check, especially in situations where complexity and uncertainty tend to be minimized and may be seen as 'undesirable'.

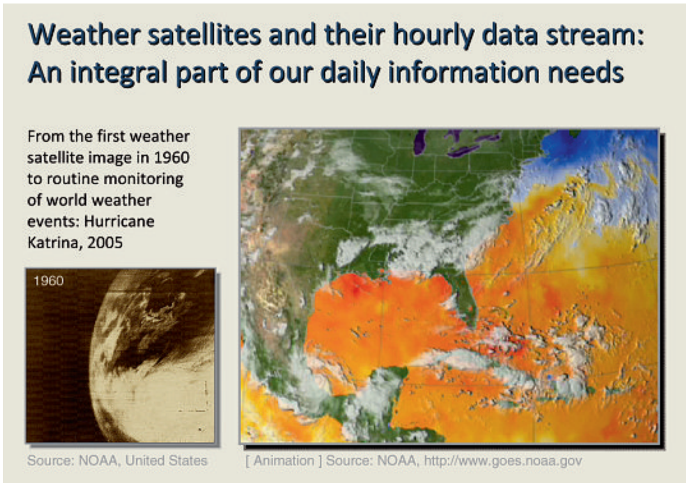
On the other hand, if one would treat complexity as an asset (slide 8) it may then enable us to gain different perspectives, including the one from space, and adopt a more encompassing approach of viewing and understanding systems that affect the environment and human health. But we must ask ourselves: Is Earth observation technology suitable and mature enough to provide not just scientific but also ongoing operational services to the health sector? And, if so, what is being done to exploit opportunities to utilize it?

The first question can be answered in the affirmative. One can point to weather satellites as an early yet still the most functional and widely used application. This animation of the development and track of Hurricane Katrina, in 2005, is an example (slide 9). Weather pictures taken from space were certainly a novelty in the early 1960s when the first satellite of this kind was launched. Now, fifty years later, we have come to rely on an entire fleet of much more sophisticated satellites that constantly observe the global weather pattern. The internet and TV weather channels provide access to the familiar moving pictures of cloud patterns or rainfall events. These satellite systems have become part of our geospatial infrastructure. This doesn't come cheap. Today, civilian Earth observation activities represent an investment of public funds on the order of several billion Euros, more and more driven by the demand for reliable and accurate environmental information. At the highest political level, the (then) G7 Group of Industrialized Nations formed a Committee on Earth Observation Satellites (CEOS) in 1984. Currently more than 20 different space agencies are participating in the coordination and planning of dozens of new and specialized satellite missions.

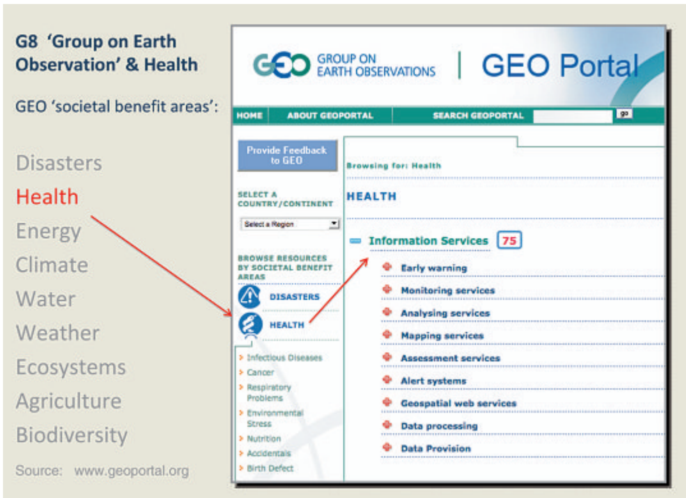
Enter GEO, the Group on Earth Observations (slide 10). GEO was established earlier this decade by the World Summit on Sustainable Development and by the G8 group of countries. The GEO is a voluntary partnership of about 80 governments and a smaller number of international organizations that can help develop new projects and coordinate their strategies and investments. The evolving GEO Internet portal already hosts a plethora of applications in nine so-called societal benefit areas, including Health. There are currently 75 health-related information services listed and these are accessible through GEOSS; topics range from infectious diseases to cancer, respiratory problems, environmental stress, nutrition, accidentals, and birth defects.

Let me now try to answer the second question that I posed earlier, regarding opportunities for using Earth observation to address health-related issues and environmental change (slide 11). In the following, I will show you some examples relating to environmental stress, infectious diseases and respiratory problems. In presenting these cases, I am merely acting as a mediator for the colleagues at various institutions who produced these illustrations based on years of research and development effort. Credit for the satellite data shown here goes to various space agencies, as noted on the slides.

The first example relates to the topic of environmental stress (slide 12). I am sure many of you will remember the hot summer of the year 2003, when Europe experienced a historic heat wave that caused several thousand deaths in France alone. Compared to years prior, temperatures in July and August 2003 were sizzling. Thematic maps of Europe were generated by colleagues at NASA and the ETH

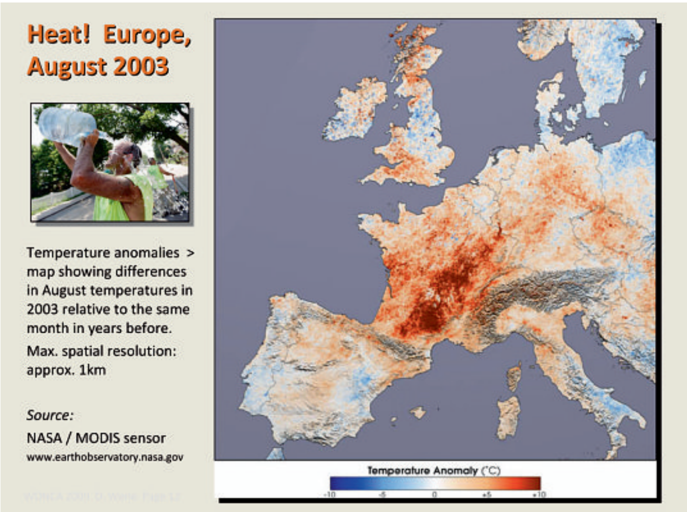


9



10

11

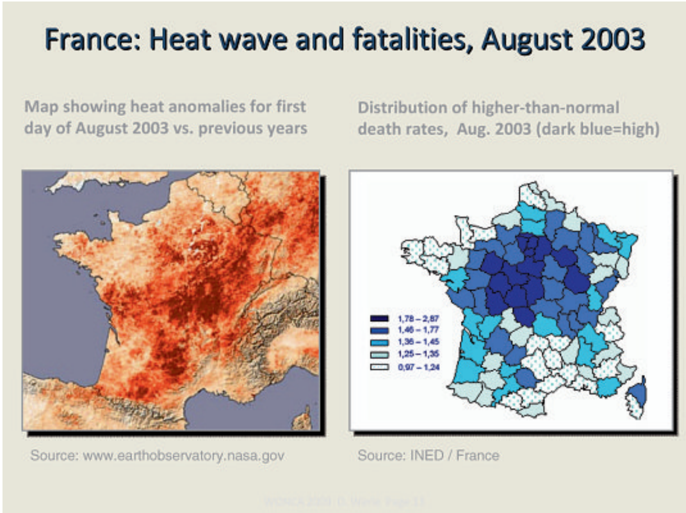


12

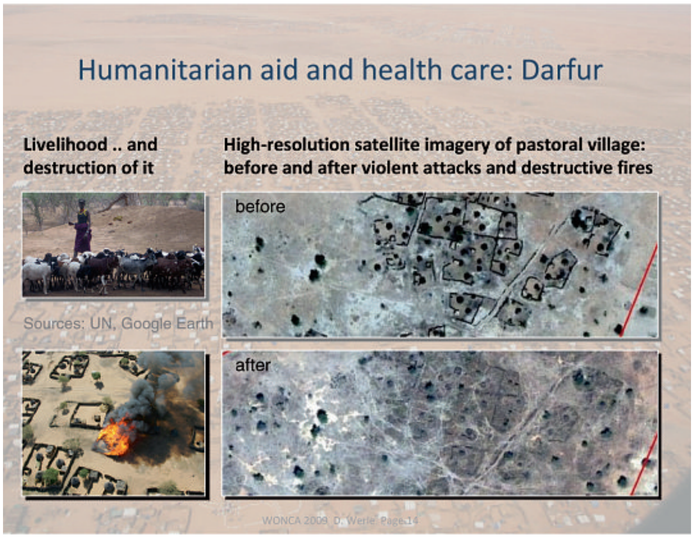
Zuerich from imagery collected by the MODIS sensor. These images are publicly available at the NASA Earth Observatory web site. The slide shows the differences in July/August daytime land surface temperatures collected in years 2000 to 2002 and 2004, relative to the records for 2003. Deep red signatures across southern and eastern France suggest that temperatures were significantly hotter in 2003 than in 2001. White areas show where temperatures were similar, and blue shows where temperatures were cooler in 2003 than 2001.

A more in-depth look at the dramatic situation in France shows that the geographic distribution of fatalities (by *Department*) is in fairly good agreement with the satellite data (slide 13). As a consequence of the events of the summer of 2003, *Meteo France* is now providing, for extreme weather situations, a daily "weather watch vigilance map" service which, in part, relies on satellite-based measurements.

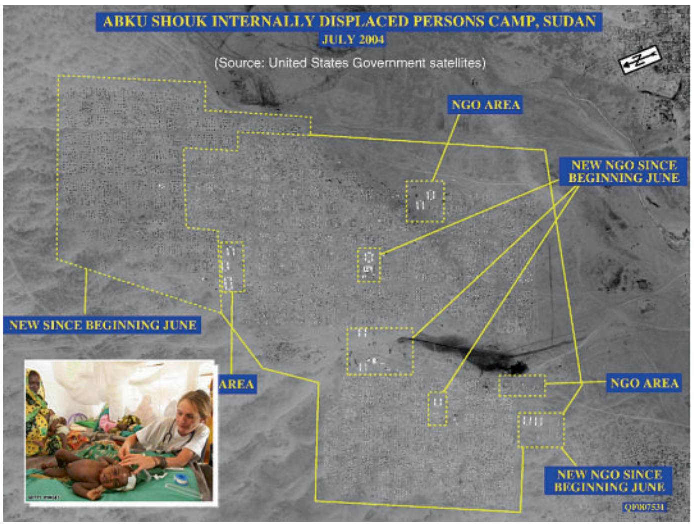
I also want to bring to your attention the use of satellite imagery in hot spots of a very different kind (slide 14), where humanitarian aid and health care are in strong demand, like the Darfur region in Sudan. Your colleagues of Medecins Sans Frontiers are actively involved and use very detailed Earth observation data that have brought the violence and destruction in the rural villages of the region to the attention of the outside world. Other high-resolution satellite data show the enormous extent of the various refugee camps and the location of the NGO support facilities (slide 15). Such imagery can be useful for risk evaluation, preparedness measures, rescue operations, and post-event evaluation. Satellite data can



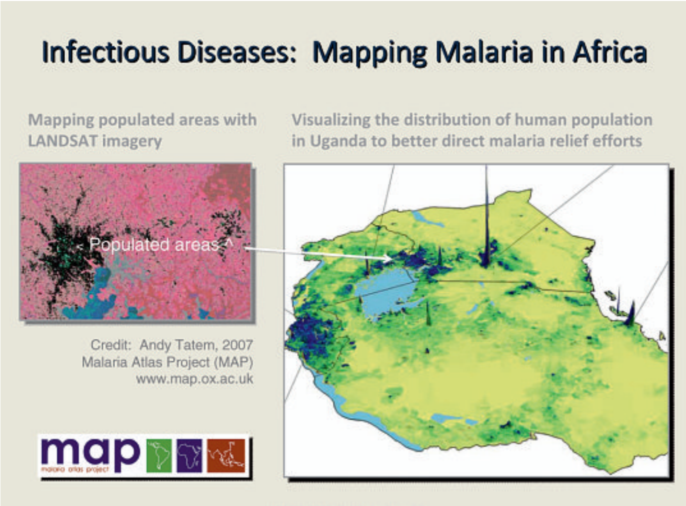
13



14



15



16

play a supporting role at the evaluation stages and offers potential at the warning stage as well.

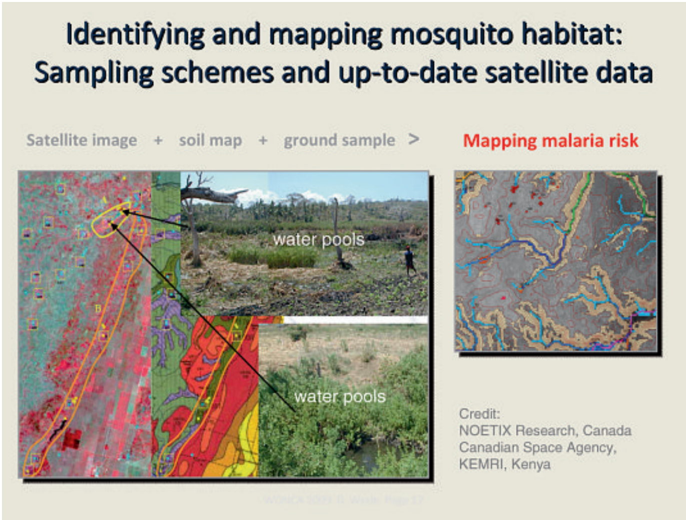
The next example of Earth observation focuses on infectious diseases. I am going to highlight the Malaria Atlas Project (MAP), malaria being the ninth most significant cause of death and disability globally. MAP has been funded by the Welcome Trust since 2002 and relies on collaboration between malaria scientists in the UK, Kenya, Vietnam, Indonesia, Ecuador and the USA. Their goal is to assemble medical intelligence and satellite derived survey data to provide evidence-based maps on the distribution of malaria risk, human population, disease burdens, mosquito vectors, inherited blood disorders and, malaria financing and control worldwide (slide 16). It is a timely and overdue effort, too, as the last global malaria map dates back to the early 1960.

Reliable information on human population numbers and their geographic distribution is notoriously hard to come by in some countries. In areas of East Africa, MAP team member, Andrew Tatem, used a combination of satellite imagery, land use information and sparse amount of census data to derive, at very low cost, some very valuable population maps. An example of his work is shown in the slide. Accurate and up-to-date population information can be key to effective malaria prevention and relief efforts.

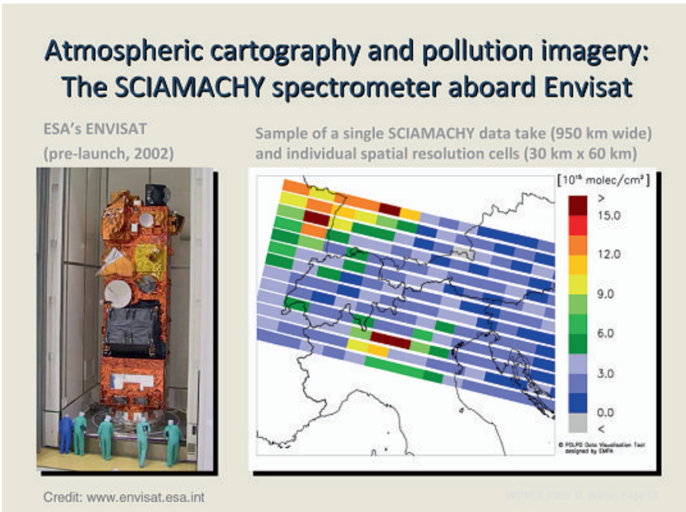
The identification of mosquito vectors and their habitat and risk prediction of malaria pose another challenge. In fact, this task is one where satellite imagery has limited usefulness when it comes to actually pinpointing individual sources, like small areas of pond water close to areas of human habitation (slide 17). Yet, this realization has not discouraged colleagues from KEMRI in Kenya and Noetix Research in Canada to use radar and infrared satellite imagery, plus soil maps and digital terrain models, in their larvae data collection and habitat evaluation program in the Kilifi District of Kenya. Incidentally, much of this particular work was not funded by health organizations but by the Canadian Space Agency, also assisting MAP with large RADARSAT data sets for population mapping in the malaria affected regions of Africa. MAP is well on its way to complete the initial goal to offer a comprehensive map database of malaria-prone regions of the world and thus update its 50-year old predecessor.

Given the rate of global environmental change and population growth, it seems unlikely though that the next revision of MAP can wait for another half century. What changes in vector borne transmissions may be in store? Some regions may experience increases or decreases in the incidence rate and length of the transmission season. The geographic distribution of vectors may change as a result of changing climatic conditions; vectors may migrate into areas and survive long enough for disease transmission to take place, affecting a population that lacks immunity. The outlook is uncertain.

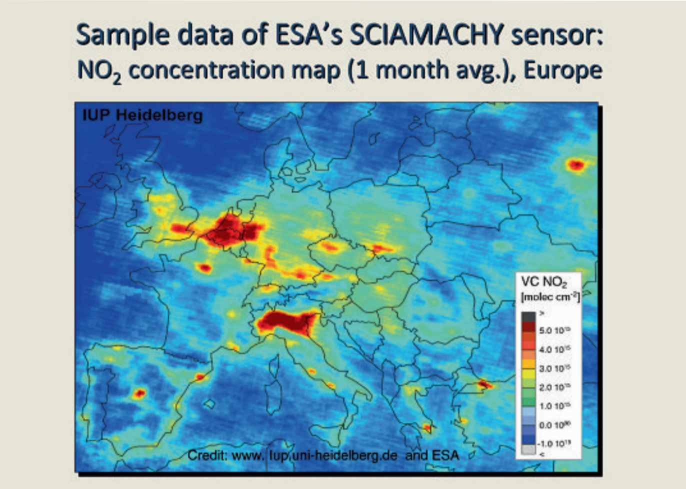
I now come to the last example with focus on air quality measurements in Europe and in East Asia (slide 18). Major strides have been made in this area of Earth observation. Sensor systems, with such curious names as SCIAMACHY and MOPITT, can detect trace gases, ozone and related gases, clouds and dust particles throughout the atmosphere, thus adding strength to scientific data collections, analyses and climate assessments. These instruments record the spectrum of sunlight that is shining through the atmosphere. The results are then finely sifted in search of spectral absorption 'fingerprints' of trace gases in the air. The SCIAMACHY instrument aboard the "Envisat" satellite is capable of covering key spectral regions over a 900 km wide swath, with spatial resolution cells of approximately 30 km by 60 km. This may not yield as detailed an image record as several of the previous shown satellite images, but repet-



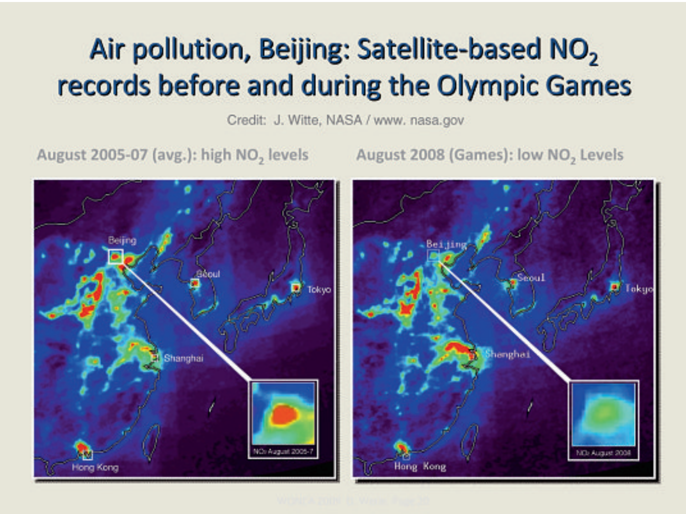
17



18



19



20

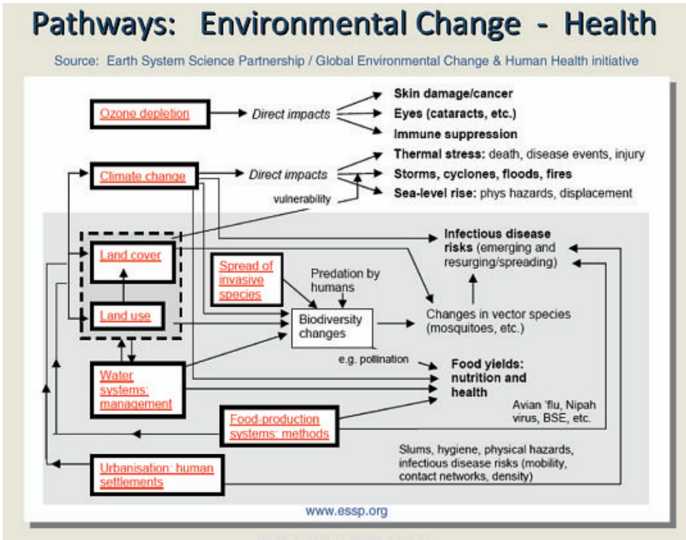
itive measurements taken about every six days reveal some remarkable insights regarding location, distribution and severity of atmospheric pollution.

What does the situation closer to home look like (slide 19)? Here is the result of tropospheric nitrogen dioxide (NO_2) measurements over Europe, averaged by researchers at the Institute for Environmental Physics in Heidelberg over the period of one month. NO_2 is a mainly man-made gas, excess exposure to which causes lung damage and respiratory problems. Low concentrations are depicted in blue, higher concentrations in yellow and red, coinciding with the location of major cities and highly industrialized regions. Concentrations and extent vary seasonally and their area extent may shift depending on prevailing wind and weather conditions. From a very practical perspective, it would be exciting to learn if this type of data could assist the Swiss Study on Air Pollution and Lung Disease In Adults (SAPALDIA) which studies the effects of air pollution on respiratory and cardiovascular health.

To what extent can changes be detected and then visualized? The 2008 Olympic Games in Beijing gave occasion for an interesting comparison using NASA satellite measurements of air pollution levels before and during the games (slide 20). The Chinese authorities are well aware of the large amount of air pollution in the capital region and sought to improve air quality during the games through stringent restrictions. The satellite images are revealing. According to NASA scientist Jacqueline Witte, NO_2 output during the month of August, 2008, was quite noticeably lower compared to the same month in years prior and plunged almost 50 percent. This is a good indication that pollution restriction can have an effect and that they can be measured over very large areas from space. Alas – the restrictions were lifted after the games were over and the level of pollution shot right back up ...

When compared to impact studies in ecology, the economy or geography there is surprisingly little in the way of formal study and analysis concerning the relationship between human health and (global) environmental changes. Monitoring the environment from space started as a scientific endeavour, but it has also obtained significant political clout – witness the reports of Intergovernmental Panel on Climate Change – and is likely to have economic, legal and, most certainly, a human health dimensions as well.

One of the promising developments recently has been the work of the Earth System Science Partnership and its "Global Environmental Change and Human Health" initiative. This group has prepared



21

22

a formal science plan and implementation strategy to support and coordinate the slowly evolving international research network (slide 21). Their preparatory work confirms the assumption that, and I quote, "there has been relatively little recognition that ecosystem disruptions, species extinctions, degradation of food-producing systems, perturbation of nutrient cycles and the sprawl of cities pose risks to the well-being and health of human populations".

The science plan has summarized, in a schematic format, the various pathways by which global environmental change can affect human health. Note that the shaded area on the slide includes those pathways that are more complex and multivariate than the direct impacts listed at the top. I admit that I was a bit apprehensive at first to include a fairly complex "wire-diagram" in this talk. But then 'complexity' is part of the theme at this conference, and I think this is an informative conceptual diagram. One could point out though, that pathways need not be one-directional, as the many arrows pointing toward the human health issues on the right-hand side of the diagram suggest. So, if a practitioner in the health sector would want to find out from which corner of the environmental change side "trouble" is coming from, one could follow the respective pathways with the arrows pointing in the opposite direction. Also, take note of the fact that a lot of up-to-date measurements regarding the categories on the left, ranging from "ozone depletion" to "urbanization" can be derived from Earth observation satellite data. Overall, the plan offers useful orientation and contains some much-needed guidance.

Let me conclude by saying that Earth observation comprises of essential technology capable of measuring the pulse of Mother Earth (slide 22). It can be applied in many fields, including the health profession when it comes to assessing environmental changes. Satellite systems around the world represent a substantial public investment that should be widely utilized. The reach is global, regional and, as Google Earth shows in its omni-present ways, even local.

The information derived from satellite imagery can reveal spatial and temporal differences in health risks; in vulnerability areas, and in priority areas for intervention. It informs high-level decision makers, notably with regard to climate change. But in order to be effective and far reaching, it has to be relevant and accessible to the individual as well, whether this is the citizen, the family doctor or the patient. However, stronger linkages and networks are urgently needed between Global Environmental Change, Earth Observation and Health, if problems are to be addressed effectively and in a comprehensive manner.

Environmental change will be a driving force, if not a catalyst, and changes may come faster than we think. This will inevitably lead to calls for action. Timely and accurate geospatial health information will likely be in demand for impact adaptation, mitigation and education to maintain physical health, and one might well add mental health. There is plenty of opportunity, if not outright necessity, for practitioners in the environmental field, Earth observers, and health professionals to engage and cooperate.

Correspondence:
Dirk Werle
Ærde Environmental Research
P.O Box 1002
Halifax B3J 2X1, Canada
dwerle@ca.inter.net

PrimarySpots

Das BIHAM gratuliert Frank Locher zum «GP Teacher of the Year 2011»

Anlässlich des Hausärztetages des Berner Instituts für Hausarztmedizin (BIHAM) vom 10. Februar 2011 wurde **Frank Locher, Facharzt für Allgemeinmedizin FMH,** zum «GP Teacher of the Year 2011» ernannt und durfte das von der Ärztekasse alljährlich gestiftete Preisgeld von 1000 Franken entgegennehmen.

Frank Locher ist für sein langjähriges Engagement in der Ausbildung von Studierenden geehrt worden: Während 13 Jahren beteiligte er sich am Gruppenunterricht von Studierenden in der Hausarztpraxis und seit Beginn der neuen Hausarztpraktika ist er als Lehrbeauftragter der Medizinischen Fakultät der Universität Bern tätig. Daneben engagiert er sich seit mehreren Jahren als Tutor im «Erste-Hilfe-Kurs» für Studierende der Humanmedizin. Am Staatsexamen wirkte er mehrmals als Co-Examinator mit. Er ist vielen unter uns auch als aktives Mitglied der legendären Big-BEGAM-Band bekannt.

Das BIHAM-Team gratuliert Frank Locher zu diesem Titel und dankt ihm für seine wertvolle Mitarbeit!