

## EARTH OBSERVATIONS AND HEALTH DECISIONS

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### ABSTRACT:

Earth observations can provide a wealth of information for making informed societal decisions. The Group on Earth Observations (GEO) integrates a variety of organizations interested in environmental data and/or decision-making to create a sound technical platform for information-sharing and collaboration. The Global Earth Observation System of Systems (GEOSS) facilitates the use of Earth observations in decisions by making decision-support tools and information publically available.

The main principle of GEOSS is to benefit society. The Health Societal Benefit Area (SBA) spans the science-to-decision-making continuum through three tasks: Information Systems for Health, Monitoring and Prediction Systems for Health, and End-to-End Projects for Health. Projects within each overarching task focus on building connections between basic research, tools, and tangible decisions. Current foci within the Health SBA include: aerosol impacts on health, air quality forecasting, global monitoring of persistent organic pollutants and mercury, meningitis in Africa, developing malaria early warning systems, and decision support tools for ecosystems, biodiversity and health.

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## INTRODUCTION

Well-informed decision-making is a multi-dimensional task requiring data from disparate disciplines such as economics, biology, geography, social sciences, engineering, and others. However, often information is missing, leading to uncertainty and sub-optimal conditions for decision-makers.

The Group on Earth Observations (GEO) is a voluntary partnership of governments and international organizations which provides a framework to support Earth observations for decision-making. The Global Earth Observation System of Systems (GEOSS) is a platform through which Earth observation data and tools are made publically available. GEOSS supports data accessibility by linking together existing and planned observing systems and supporting the development of new systems where gaps occur. It provides an integrated framework of organizations, data, and technology to support environmental decisions.

GEOSS focuses its efforts to benefit society through nine major themes, or Societal Benefit Areas (SBAs). The Health SBA is structured around the three overarching principles of GEOSS: collecting spatial and temporal environmental data; applying monitoring data to develop decision support tools; and publically sharing data and tools. These principles span the spectrum of data collection, transforming it into tools, and applying it to solving health problems. This paper is a synopsis of a range of health-related activities under the framework of the science-to-decisions continuum.

## MAIN BODY

### **Monitoring and Prediction Systems for Health**

This Task 1) supports the development of operational health applications; and 2) connects established and emerging Earth observation systems to health monitoring and prediction systems.

**Aerosol Impacts on Health and Environment: Research, Monitoring and Prediction:** This subtask is developing new atmospheric aerosol services and improving forecasting systems. Small scale events (down burst of cold air, etc.) are not easily predicted but are important parts of the dust cycle. This project focuses on: sand and dust forecasting, aerosol effects on the ocean, and societal effects of bioaerosols.

The World Meteorological Organization (WMO) has implemented an international Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) (<http://www.wmo.int/sdswas>). The system brings together research and operational sand and dust forecasts and atmospheric dust observations to support a better understanding sand and dust effects on health. Technical components include: 1) enhanced use of surface-based in situ (e.g. IMPROVE, EUSAAR), remote sensing (e.g. AERONET, GALION), aircraft (e.g. IAGOS) and satellite (e.g. NASA CALIPSO and ESA MSG) observations relevant to dust; 2) re-analyses using atmospheric models of sand and dust and meteorological re-analyses (some have supported the Implementation of a Meningitis Decision-Support Tool

project); and 3) building monitoring capacities in developing countries through the WMO Global Atmosphere Watch program.

Oceanic dust deposition is a significant resource for marine organisms; much of the iron and phosphorous available in the oceans is from atmospheric dust. The WMO is leading the Group of Experts on Marine Pollution on an assessment of how dust deposits in the ocean affect marine ecosystems. This project aims to better coordinate atmosphere and oceanic dust impact research and is connected to the SDS-WAS. Upon completion of the assessment, a report emphasizing the key critical issues of the study will be produced and directed at policy-makers.

Bioaerosols can be composed of bacteria, viruses, toxins, spores, and other biological entities that cause disease in humans or animals. Adverse effects of bioaerosols may be reduced with reliable dust forecast and prediction tools. WMO will investigate the current status of bioaerosol monitoring and modeling capabilities and practices, and evaluate how they could be improved to benefit health. Recommendations will include considerations of international partnerships and collaborations with modeling, monitoring, and public health communities.

**Air Quality Observations, Forecasting and Public Information:** The goal of this subtask is to produce portable, low-cost, standards-based software that delivers near real-time air quality observations and forecasts to the public. The state of the art is hourly real-time air quality data made available via the internet or other sources; however, few

countries have such capabilities and air quality monitoring data is scarce or not publically available in many parts of the world. This subtask is expanding a public information tool, AIRNow ([www.airnow.gov](http://www.airnow.gov)), which makes near real-time air quality data; forecasts for particulate matter, ozone and other pollutants; and tools openly available on the internet. AIRNow is operational in the United States and recently launched AIRNow-International in Shanghai at the 2010 World Expo. In addition, Mexico has agreed to pursue a pilot AIRNow-International project and a workshop is anticipated for 2010.

The GEMS/MACC is an effort to deliver near real-time air quality data to numerical weather prediction models in Europe. It is based in the European Centre for Medium Range Forecast and relies upon the coordination and cooperation of a number of regional air quality models and monitoring networks in Europe (e.g. environmental agencies, EMEP, and GAW). An air quality community of practice has been established within GEO and will provide the framework for further international collaborations and information sharing.

**Global Monitoring Plan for Persistent Organic Pollutants (POPs):** This subtask is developing and implementing a global monitoring plan for tracking changes in levels of POPs. The Stockholm Convention has identified a number of POPs and established a 5-year monitoring and evaluation period for the concentrations of these chemicals in the environment and human tissues (blood, breast milk). This subtask is evaluating the current worldwide POPs network and filling in surveillance and technical analysis gaps. It is overseeing the

publication of five monitoring reports which correspond to the first ten-year period of data collection. The reports are expected to act as a baseline for future evaluation periods. One challenge has been to develop sampling and analytical methods for detecting newly designated POPs in humans and the environment. In particular, PFOS (perfluorooctanate sulfonic acid), and its salts, were adopted as POPs during the 4<sup>th</sup> meeting of the Conference of Parties to the Stockholm Convention and new sampling and detection methods are needed. This subtask will continue to identify, fill monitoring and analytical gaps, and build international capacity for a sustained worldwide evaluation of POPs.

**Global Monitoring Plan for Atmospheric Mercury:** This subtask is creating a global monitoring system (25–50 sites worldwide) of environmental mercury data and establishing forecast systems for mercury-related health effects. The current limitation of a mercury forecasting system is lack of coordination among global monitoring sites. Standard operating procedures need to be harmonized to ensure high quality data from monitoring stations. In addition, regional and global atmospheric mercury models will be validated so they can be used to evaluate policy options. Currently, efforts are focused on training local people across the globe who will be collecting mercury monitoring data.

#### **End-to-End Projects for Health (Applying Decision-Support Tools)**

This Task advances the application of observation, monitoring, and forecasting systems to health decision-making processes.

**Implementation of a Meningitis Decision-Support Tool:** This subtask is building and applying a model to predict meningitis outbreaks in sub-Saharan Africa. A new long term vaccination will be deployed across the meningitis belt over the next ten years. A meningitis outbreak model will help to prioritize vaccination efforts to those areas most immediately at risk.

Meningitis epidemics occur in the winter when the environment is dry and dusty. Dust appears to be related to disease outbreaks, although the exact mechanism (or combination) is unclear: abrasive dust particles increase susceptibility to disease, dust supplies iron for bacterial growth, dust carries the bacteria. The meningitis prediction model incorporates surface-based in situ observations, remote sensing, and satellite aerosol observations (provided by the SDS-WAS project described earlier) with in situ epidemiological data. The SDS-WAS research modeling community is working on models that accurately predict outbreaks up to two weeks in advance so that vaccination and medical resources can be deployed.

**Implementation of a Malaria Early Warning System:** This subtask uses satellite data to support the identification of habitats conducive to mosquito development, link this information to the spread of malaria, and create a prediction tool for decision-makers. Specific project goals include: 1) develop country-specific techniques to use satellite data for early malaria detection and monitoring paired with *in situ* validation; 2) integrate vector risk products with local mitigation and prevention efforts; and 3) integrate best

practices in satellite use and other observations for malaria risk prediction to develop pilot projects (including training and capacity building). The National Ocean and Atmospheric Administration (NOAA), the French Centre National d'Etudes Spatiales (CNES), and the GEO-Informatics and Space Technology Development Agency of Thailand (GISTDA) are using satellite observations to predict malaria outbreaks and pinpoint areas of risk for disease transmission. For example, NOAA uses vegetation health indices from the NOAA POES AVHRR instrument to produce weekly malaria risk maps for Africa, some of which are validated with epidemiological data. Using a variety of satellite data (SPOT5, Quickbird, TerraSarX images, TRMM data) and in situ measurements (entomology, environment, epidemiology, climate), CNES is developing rural and urban risk maps of zones potentially occupied by mosquitoes (ZPOM) for malaria to better understand the mechanisms for malaria vector outbreak, contributing factors to outbreaks, and environmental conditions that could act as sentinels of impending outbreaks. The "tele-epidemiology" conceptual approach, developed by CNES, has been applied in North Africa with ASAL (Algerian Space Agency) and in South America with CONAE (Argentinean Space Agency). In Thailand, GISTDA is using LANDSAT 5TM satellite imagery, spatial analyses, and time series analyses to determine malaria distribution patterns. They found their 2004 – 2008 data predicted the malaria distribution and morbidity rate during the 2009 season. The ultimate goal of this subtask is to link satellite and climate data to predict malaria outbreaks so that spraying, treatment,

and other prevention efforts can be targeted towards the regions most at risk.

#### **Ecosystems, Biodiversity, and Health: Decision-Support Tools and Research:**

This subtask is developing integrated pest management (IPM) strategies to reduce and prevent infectious disease transmission to humans. The focus is on understanding the connection between biodiversity, animal hosts and vectors, and human infectious disease, and using this knowledge to develop tools to prevent and reduce the risk of infectious disease transmission. The rate of biodiversity decline worldwide has accelerated over the past 50 years. At the same time, infectious diseases appear to be emerging and re-emerging at a faster rate. There is scientific evidence to support a relationship between biodiversity loss and increased risk of infectious disease in humans.

This subtask covers a number of disease systems including: Lyme disease ecology in disrupted landscapes; West Nile Virus ecology/bird diversity and human behavior; demonstration of environmentally-based integrated pest management strategies; and a baseline study of Panamanian mosquito and sandfly diversity and its relationship to human disease prevalence. For example, studies on Lyme disease ecology suggest that changes in landscape, such as forest fragmentation, affect the community of animal hosts that are important in the Lyme disease transmission cycle. Forest fragmentation leads to decreases in animal host diversity, leaving habitat that is predominantly occupied by animal hosts that are efficient carriers of the Lyme disease pathogen. This decrease in animal diversity, in turn,

facilitates the risk of transmission to humans. The goal of this subtask is to develop environmentally-based and behavioral strategies to prevent risk of human disease and loss of biodiversity.

### **Information Systems for Health**

This task is developing a global public health information database which incorporates earth observations with health data to improve decision-making. An important aspect of improving predictive and decision support tools for human diseases with environmental drivers (e.g. malaria, meningitis) is validation with epidemiological and observation data. The World Health Organization is bringing together datasets, tools, and other information developed in other venues (e.g. IRI, WMO) in a Global Health Observatory web-portal. The portal will cover a wide range of topics including a “Health and Environment” button which will provide access to data on disease risk related to environmental indicators.

### **CONCLUSIONS**

GEO adds value to environmental decision-making by providing a platform for integrated multidisciplinary science and decision-making collaborations. GEOSS SBAs focus the advancement of science-for-decision-making on internationally important issues. Working within the context of an SBA creates a setting for new collaborations and connections among activities. For example, the Sand and Dust Storm Warning Advisory and Assessment System is supporting the development of meningitis outbreak models in Africa. As the Health SBA matures, greater interconnectivity and natural linkages

among the activities will be furthered. Many environmental drivers for health (e.g. climate, land-use, natural disasters) are linked to multiple adverse health effects and a decision-support tool for one disease may be applicable to others as well (e.g. a malaria warning system in Africa may be relevant for Asia).

GEO directly benefits health. For example, AIRNow demonstration projects in the United States and China produce near real-time air quality information, allowing governments and individuals to make decisions about health risks and take precautions when necessary. The meningitis prediction model in Africa has the potential to focus vaccination and treatment efforts in regions at risk for outbreaks. Bringing together worldwide health concerns under the GEO framework fosters the efficient exchange of information, benefiting multiple health problems with minimal effort. The impact of the sum of the GEO Health projects is greater than their individual efforts.

Finally, the Health SBA spans the continuum of basic research to health decision-making with the flexibility to add projects and expand upon activities already in progress. New environmental health issues can be easily incorporated into the GEO framework, reaping the benefits of work already accomplished from other projects while making their own contributions to the wealth of knowledge and tools for health decision-making.

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