Input to the NRC Decadal Survey for Earth Science and Applications from Space

Health and Air Quality Applications

Abstract:

This paper is submitted to provide key inputs to inform health and air quality applications recommendations for the upcoming 2017-2027 NRC Decadal Survey. A session of the NASA Health and Air Quality Applications Team Meeting held in Park City, Utah, from September 16-17, 2015, was dedicated to addressing this survey. The meeting brought together health and air quality experts who are project investigators for the NASA Applied Sciences Program (ASP), NASA Health and Air Quality personnel, and stakeholder agencies that use Earth observation data and systems. The objective of the Decadal Survey session was to develop recommendations for a balanced program that would advance the understanding of Earth system processes that affect public health and air quality and identify how this information could be harnessed for the benefit of society.

Description:

Domestic and international officials have increasingly recognized links between environment and health. The World Health Organization (WHO) states "environmental hazards are responsible for as much as a quarter of the total burden of disease worldwide."[1] Recognizing such links, the 2007 report *Earth Science and Applications from Space: National Imperatives for the Next Decade* (commonly referred to as the first Decadal Survey) in its "vision for the future" of Earth Science and applications, specifically called for "a vision that includes advances in fundamental understanding of the Earth system and increased application of this understanding to serve the nation and the people of the world." The report also highlighted the use of satellite data for "targeted interventions to reduce vulnerability to health risks, and enhanced knowledge of human health-environment interactions".[2] NASA maintains a diverse constellation of Earth observing research satellites and sponsors research in developing satellite data applications across a wide spectrum of areas including environmental health; infectious disease; air quality standards, policies, and regulations; and the impact of climate change on health and air quality. Successfully providing predictions with the accuracy, latency, and specificity required by decision makers will require advancements over current capabilities in a number of interrelated areas. These areas include observations, modeling systems, forecast development, application integration, and the research to operations transition process. NASA has been a primary partner with operational agencies over the past fifteen years in these areas.

[1] http://www.who.int/phe/en/.

[2] NRC (2007): **Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond:** Committee on Earth Science and Applications from Space: A Community Assessment and Strategy for the Future, National Research Council ISBN: 978-0-309-10387-9, 456 pages, 8 1/2 x 11, paperback (2007); http://www.nap.edu/catalog/11820.html

Participants Input and Recommendations for the Decadal Survey:

The group of experts and stakeholders referenced above convened in Park City to identify and prioritize future needs and to identify potential questions that may be included in the new Decadal Survey. The interim report, *Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey*, framed the group's discussion. Participants discussed key issues towards fostering the Earth observations-based applications community in the coming decade. The key discussion points of this session were:

- *What has worked and what hasn't in the health and air quality applications community since the first Decadal Survey?*
- *How do we fix what is not working while scaling up what is working well in order to develop productive societal applications?*

In accordance with this RFI, the paper is organized around the following questions:

1. *What are the key challenges or questions for health and air quality applications in the coming decade?*

Earth observations from satellites and *in situ* collection sites are critical for an ever-increasing number of applications related to the health and well-being of society. Fundamental improvements are needed in existing observation and information systems in the following three areas: 1) collection of raw observations with improved spatial and temporal accuracy; 2) analyses, forecasts, and model/product developments to provide timely and coherent syntheses of otherwise disparate information; and 3) outreach and capacity building for decision-makers who use these analyses and forecasts to produce actions for direct societal benefit.

Key space-based observational and informational needs by the community include:

- Growth in near real-time satellite products, as these often produce immediate societal impact.

- Wider availability and ease of data accessibility for researchers with limited time or capacity to learn new processes (*e.g.,* more products that are easily compatible with GIS systems). The establishment of an Applications Distributed Active Archive Center (DAAC) was recommended.

- Clear documentation and availability of related publications and metadata to validate research processes. This includes documentation of model development and validation with associated estimations of uncertainty.

- Balance between rapid delivery of near-ready ("beta test") models in matters of time-sensitivity and models of longer-term testing and validation.

2. *Why are these challenges/questions timely to address now especially with respect to readiness?*

Environmental health risks are a major concern. Particulate matter in the lower troposphere can cause or exacerbate cardiovascular and respiratory diseases and cause heart attacks, decreased lung function, and asthma. According to Environmental Protection Agency's (EPA) Integrated Science Assessment (ISA) for Particulate Matter (PM) released in 2009, visits and hospital admissions for heart diseases reported consistent positive associations, with the majority of epidemiological studies reporting increases ranging from 0.5 to 3.4% per 10 $\mu g/m^3$ increase in $PM_{2.5}$.[3] Based on the 2009 National Health Interview Survey (NHIS), it was estimated that 39.9 million Americans had been diagnosed with asthma within their lifetime.[4]

Research has shown that environmental factors such as water temperature, land surface temperature, soil moisture, and precipitation contribute to infectious disease outbreaks. Changes in weather and climate conditions can affect infectious diseases such as malaria, dengue fever, and Rift Valley Fever. Changes in temperature, humidity and habitat affect the lifecycle and transmission effectiveness of disease vectors. These parameters also affect vector interaction with humans. Changes in climate and weather can affect the distribution of some mosquito and rodent habitats, particularly in mountainous regions.[5]

"Grand challenges" identified for the community included:

- *Malaria:* Risk characterization models are currently deployed regionally. A unified dynamic malaria risk model would be a major achievement for end-users worldwide and would provide economic savings by scale and through elimination of redundant, competing models.

- *Air Quality*: Accurate ground-level aerosol and constituent measurements from remotely-sensed columnar values are critical. While progress has been made in this area thanks to investments in algorithm development and targeted field campaigns, large discrepancies still remain. Ozone is a critical issue in this regard; aerosols over land areas with high albedo also have large discrepancies. Even developed countries, such as the USA, have relatively sparse ground level aerosol networks – with remotely sensed observations providing critical data to fill coverage gaps. Developing countries have even fewer ground sensors – and sometimes none at all.

- *"One Health" Community of Practice*: It has become clear that human health, animal health, and ecosystem health are inextricably linked, yet these disciplines have often worked as completely separate entities. The integration of human medicine, veterinary

[3] http://www.epa.gov/ncea/pdfs/partmatt/Dec2009/PM_ISA_full.pdf
[4] http://www.lung.org/finding-cures/our-research/trend-reports/asthma-trend-report.pdf
[5] http://csis.org/files/publication/110927_Wigbels_UsingEarthObserHealth_WEB.pdf

medicine and environmental science is now seen as crucial in tackling the health and air quality challenges facing the planet.

3. *Why are space-based observations fundamental to addressing these challenges/questions?*

Space-based observations provide a unique vantage point to address health and air quality applications, particularly in the developing world where only sparse *in situ* coverage exists. Remotely sensed observations provide critical components for integration with various forecasts, models, and decision support systems. These observations are key in addressing the complexity associated with health and environment relationships due to the diversity and number of potentially confounding variables. Research is needed on integrating climate science with health and air quality science; integrating environmental, public health, and marine and wildlife surveillance; integrating socio-economic data; applying climate and meteorological observations to real-time issues; and the down-scaling of long-term climate models.

In many cases, space-based observations are beneficial to both fundamental research and applications that benefit society, albeit at different latency and spatial/temporal resolution requirements. For example, for many years while climate has been the main focus of aerosol research at NASA, aerosols are an important component of the air quality health index through their effects on human health, biological productivity, visibility, and boundary layer chemistry. Therefore, it is imperative that future science missions maximize the science and applications return on the nation's investment by designing missions that will deliver products at a latency and spatial/temporal resolution that can be used for applications.

Future highly desirable measurements were addressed by the session. For example, thermal imagery is important for urban heat island studies, prediction of episodes of harmful algal blooms (HABs), prediction of outbreaks of vector-borne diseases, carbon fixation, etc. Currently there are no high spatial and temporal resolution thermal imagery products available except for a few isolated aircraft measurements.

Additionally, many session participants stated that the next generation of space lidar (*e.g.,* ACE) must be a significant improvement over CALIPSO. A pointing capability, though more expensive and a higher risk to operate, could provide a significantly higher return in benefits to society. During disasters such as a volcanic eruption, intentional or accidental catastrophic emission of hazardous gases or particles, or wildfires, knowledge of the horizontal extent, altitude, and concentration of the emissions plume would be critical for public health or aviation safety policy. A pointing lidar could also profile tropical cyclones to improve estimates of storm dynamics, amount of precipitable water, cloud-top height, and potential landfall impacts to inform public health decisions and risk avoidance.

Additionally, the group discussed the future use of small satellites, cube satellites, and well-designed applications for mobile devices which could enable the combination of Earth observing

satellite measurements and citizen-science to increase available data, public participation, and number and use of products.

Conclusion:

The health and air quality community was appreciative of the opportunity to provide inputs for the Decadal Survey during the NASA Health and Air Quality Applications Team Meeting in September 2015 at Park City, Utah. The participants provided many useful suggestions for consideration over the next ten years ranging from desired measurements, to public-, private-sector and citizen engagement, to strategies for increasing the sustained use of applications products. The meeting underscored the importance of Earth observations for applications and the reliance on these measurements from several stakeholder communities.