

# Better Metrics for More Effective Decision-making: The Need for Regionally based Environmental Measurement and Monitoring

A Global Initiative of  
The Optical Society and The American Geophysical Union  
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## INTRODUCTION

*Increased climate change and environmental hazards impact regions differently.*

We are facing a tremendous and growing global economic and healthcare burden due to environmental degradation and climate change. Industrial pollution and greenhouse gases currently impact all seven continents, five oceans and 13 climate zones in different ways and with future trajectories that are difficult to predict.

Climate change is impacting regions across the globe in different and widely variable ways. Northern latitudes are beginning to witness the impact of thawing permafrost with buckled roads, destabilized buildings, and unusable runways. Changes in the polar vortex have already begun to generate wildly variable winter temperatures, recently setting record low and high winter temperatures, and anomalous seasons of snow accumulations. Changing precipitation patterns in many countries are causing severe droughts and flooding, challenging existing infrastructures for supplying sufficient water for human consumption, agriculture, and commercial uses. Further south, the changing climate and weather are contributing to the severity of fires in the western United States and increased heat waves throughout Europe. Hazardous air quality due to fossil fuel emissions is an ever-increasing hazard in major cities in Asia and around the globe, impacting the health of urban citizens, particularly young children and older adults. Ocean acidity is rapidly increasing, corresponding to increases in atmospheric CO<sub>2</sub> levels, which affect all levels of the aquatic ecosystem, negatively affecting commercial fishing and destroying coral systems that protect many coastal areas from storm damage and shore erosion.

## NEW OPPORTUNITY FOR BETTER PREDICTIONS

*New sensing technologies generating reliable data sets, combined with big data management tools, will greatly improve regional and local climate change forecasts.*

As the climate changes rapidly, public and private decision-makers around the world are facing an ever-increasing need for more accurate environmental data, improved measurements, and forecasting models to predict the future course of the environment and, where possible, develop strategies to adapt to or mitigate these environmental and climate-change caused disruptions. Developing and deploying new, low-cost and improved measurement instruments in dense networks can provide more precise data and greatly improved models for appropriate

and effective government policies and better evaluation of the risks of public and private investments.

Further investments are needed to validate, design for mass-manufacture, and deploy these new technologies on appropriate measurement platforms, offering important opportunities for improved predictions and understanding of the regional impacts of a changing climate and environment. New measurement capabilities combined with existing sensing systems across ground, ocean, airborne and space platforms will create a more comprehensive picture of the regional impacts of climate change. In addition, “big data” management and machine learning-based modeling tools can now be employed to analyze these regional environmental measurements to interrogate and improve existing models.

For these consolidated datasets to be useful the data must be validated by international standards organizations, made compatible across platforms, and properly referenced, indexed, and collated. Additionally, the emerging field of “climate services” will aid in providing cross-platform compatibility and useful summaries of new climate change predictions, essential for government policy makers and private sector leaders alike.

## **A REGIONALLY BASED SOLUTION**

*Facilitate regionally based centers to identify and address local data gaps under an international umbrella: the Global Environmental Measurement and Monitoring Initiative*

To meet these specific technological and scientific challenges, The Optical Society (OSA) and the American Geophysical Union (AGU) are jointly sponsoring the Global Environmental Measurement and Monitoring (GEMM) Initiative. The GEMM Initiative is engaging universities, research centers, measurement standards agencies, companies, and other scientific societies around the world to form GEMM regional centers and provide a critical focal point for researchers, technology developers and policy makers. These multidisciplinary centers of excellence are focused on developing and sharing new measurement technologies and improved climate models. New regional data will be integrated with data collected from existing environmental and climate networks to improve climate models and the accuracy of specific regional climate change forecasts. With the support of their regional, subnational and national governments these multidisciplinary centers are addressing information gaps to enable more effective government and commercial industry decision-making.

The GEMM Initiative has convened several multidisciplinary meetings throughout Europe, the United States, Canada, Singapore and New Zealand. Launched in September 2018, the GEMM Initiative is working with in-country scientific, government and industry leaders, and is facilitating creating centers of excellence. On 13 September 2019, the University of Strathclyde, Glasgow launched its GEMM Centre and announced a new Centre for Doctoral Training in Global Environmental Monitoring and Policy. Currently, the GEMM Initiative also is working with institutions in three additional regions: Université Laval in Québec; University of Otago in Dunedin;

and University of California, Berkeley and Stanford University in Northern California. These initial GEMM centers are identifying and beginning to address measurement needs in their specific regions, sharing technology, data, and insights to provide for informed decision-making in priority environmental issues worldwide, and are serving as models for additional regions under discussion.

The GEMM Initiative also helps to identify priority issues common to the GEMM centers across the globe and facilitate the development and deployment of joint pilot projects. Initial issues include developing reliable and cost-effective technologies for mapping air quality in dense urban areas over time and distance; tracking the incursion of saltwater into fresh ground-water sources; predicting the changing seasonal availability of fresh water; and monitoring the rapid and complex changes in the polar environments.

The use of new sensing technologies to address specific regional data gaps include the following projects currently under discussion:

- Mapping the highly variable demographic burden of air pollution effects in cities in real-time using cost-effective pollution gas sensors; and
- Monitoring greenhouse gas emissions from regions directly using dense arrays of GHG sensors, for compliance with cap and trade policies.
- Mapping saltwater and fresh ground water resources in California using advance electromagnetic sensing;
- Measuring and predicting the melt points of the Sierra Nevada snowpack to guide new reservoir construction through advances in atmospheric models;
- Monitoring methane emissions from thawing permafrost through satellite observations and dense ground-based sensor networks;
- Measuring strain and potential rupture points in roadways and airport runways using long-base line fiber optic sensors;
- Determining the sources and magnitudes of methane emissions and agricultural run-off pollution from farms;
- Mapping the changes in ocean chemistry affecting the fishing industry and coral reef structures using autonomous floats measuring ocean, pH, organic materials, O<sub>2</sub> and CO<sub>2</sub> levels, and ocean chemistries;

The focus of each regional GEMM center is determined by an ongoing dialogue with a suite of experts that bridge multiple research disciplines, government policy makers and private interests. A regionally based and multidisciplinary approach will better ensure public and private investments in developing and deploying new measurement technology are undertaken in a relevant timeframe; provide more information guiding infrastructure investments; and create new commercial opportunities.

GEMM regional centers are reaching out, consolidating expert input from a variety of different sources such as the following:

- *Climate and environment modeling scientists* who determine what to measure to develop better regional forecasting capabilities.
- *Climate and environmental scientists ‘out in the field’* who advance and create the design and deploy the instruments on cost effective and accurate measurement platforms, e.g., ground-based stations, subterranean monitors, ocean floats, aircraft, drones, satellites.
- *Equipment and device engineers* who provide new instrumentation to improve measurement accuracy and precision.
- *Measurements and standards meteorologists* who provide internationally accepted measurement protocols and standard reference materials.
- *‘Big Data’ experts* who coordinate the collection and processing of and access to critical measurement data and analysis tools.
- *‘Climate services’ experts* who focus on outcome-oriented research, engage private and public sector end-users throughout the development of data application tools, and provide ongoing guidance in the interaction between scientists gathering and modeling data and local practitioners using the tools to make needed decisions.
- *Government, economic and legal experts* to assess the societal impact of implementing specific adaptation and mediation efforts.

By integrating input from these regional centers GEMM will provide more accurate forecasts of the impacts of climate change globally as well as within their locales.

## NEXT STEPS

The GEMM Initiative is exploring additional regional centers to improve data availability, forecasting, instrumentation, and ultimately, policy decisions. The initiative welcomes discussions with interested parties around the world.

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