Input to NRC Decadal Survey from NASA SERVIR Central America Hub Region

Q.1 What are the key challenges or questions for Earth System Science across the spectrum of basic research, applied research, applications, and/or operations in the coming decade?

Key challenges/questions identified by approximately 14 respondents living or working in the Central America NASA SERVIR hub region are presented below (not listed in order of priority). Respondents were primarily from academic institutions (5 respondents), but also from federal agencies (4 respondents), global organizations (2 respondents), private or voluntary sector (2 respondents), and state government (1 respondent). Responses are presented verbatim, with minor editing to improve understanding and combine similar comments.

Data Accessibility, Dissemination, and Challenges

1. How do we democratize access to earth science and satellite data, products, and knowledge across various scales, including economic, local to international, and gender boundaries?

Land Surface, Ocean, and Atmospheric Variables

2. Changes in ice cover
3. Changes in biodiversity
4. Changes in important variables: temperature and precipitation
5. Changes in important ocean variables: sea level, salinity, pH, temperature
6. Changes in important surface characteristics: land cover/land use

Climate Change

7. What will be the effects of climate change on human and natural systems?
8. What is the contribution of land use and land cover (LU/LC) change to climate change, and vice versa (the contribution of climate change to LU/LC)?

Food Security

9. Understanding crop mixes and health
10. How do we better monitor global food security and inform policy and economic initiatives to address it?

Energy Balance

11. Understanding the energy balance, evapotranspiration

Sustainable Development

12. How can we inform and educate on sustainable development for environmental, energy, economic, and human capital needs?

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

Respondents were not asked to comment on the timeliness of proposed key questions/challenges. Considering the extended time horizon of the Decadal Survey (2017-2027), timeliness of proposed key questions/challenges was not considered a critical factor.

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

To address proposed key challenges/questions, respondents offered several suggestions for continuing existing satellite observations or implementing new satellite observations, and facilitating the use of satellite data.

Existing observations that should be continued to support decision-making or application development include:

- Landsat must continue as the longest operating mission producing comparable data since the 1970s.
    - Specifically, Landsat images at 7 and 8 pixel to 30 by 30 have been used for decision-making.
    - Landsat-type data are very useful for evaluating and managing natural resources.
- Continue all missions involving the measurement of the variables described in the questions above. For example:
    - Landsat for vegetation, water usage/quality, and fire data related to carbon, agriculture, natural hazards.
    - MODIS/VIIRS for vegetation, water usage/quality, fire, and air measurements, which are relevant to carbon, agriculture, natural hazards, and air quality.
    - Space-based LIDAR and SARs for vegetation, carbon, fire, and soil moisture data, which are relevant to carbon, agriculture, and natural hazards.
    - More hyperspectral capabilities for vegetation, carbon, fire, and soil moisture, which are relevant to carbon, agriculture, and natural hazards.
- Satellite missions such as Landsat and MODIS (Level 1b/2) with free/easy operational subscription access or even access within cloud computing infrastructure for rental for efficient value-added production chains.

Landsat is critically needed to assess LU/LC change. Technological advances in classification of satellite data have made it possible to derive fine-scale annual forest loss maps from Landsat data dating back to 2000 and, for some geographic areas, several years earlier. Longitudinal (time series) LU/LC data is extremely valuable for identifying temporal patterns and drivers of LU/LC change, and for measuring the effectiveness of forest conservation policies. Continued missions are needed to ensure the extension of these longitudinal data.

Suggestions for additional investments include:

- Images of RapidEye 5 by 5 square meter pixel sensor that will allow more details and could be comparable to images of forest cover and land use.
- More frequent medium-resolution data. For example, the resolution level of Landsat and its availability at no cost make it invaluable in environmental studies, but its frequency of 16 days,

with the high probability of cloud cover limitation, reduces its usefulness in monitoring rapidly changing phenomena.

- Higher-resolution images (<30 m), available at lower or no cost, would improve our capability of studying changes at a finer scale.
- High-resolution (<10 m), daily observations with the spectral characteristics of MODIS, VIIRS, and Landsat OLI to improve all application areas and inform all societal, thematic areas.
- High spatial resolution (<1 m).
- Ability to predict extreme weather events over longer periods of time.
- Carbon dioxide and other greenhouse gas monitoring (emission and sequestration).
- Maps of threats and risks to decision-makers at local, regional, and national levels, and dissemination of threats for decision-making.
- Detailed data on the distribution of air contaminants.
- A tool that not only allows users to download data from NASA but also allows users to perform another type of analysis and modeling – to be a "one stop shop."
- Open source coding packages along with raw and science-level data and products so regional analyses could be more rapidly and efficiently completed in R, Python – reducing the need for access to high-power visualizations locally.
- Earth observations – multispectral, including thermal, and 30 m or less resolution, with weekly or more often return.

Moderate resolution (~30 m) LU/LC change maps generated at regular intervals are key to informing many policy decisions, including natural capital accounting, REDD+, and sustainable development. The production of global forest cover maps on a yearly basis has already proven invaluable to REDD+ projects and informing land use and climate mitigation policies. The next step is generating change products for non-forest habitats such as wetlands, grasslands, and agricultural areas. These datasets are key for studies related to water security, food security, health, and sustainable development.

It would be extremely valuable to have an enhanced capability to accurately measure forest disturbance/degradation and forest biomass at a fine spatial and temporal scale. Forest disturbance/degradation is at least as important as forest loss in explaining losses in forest ecosystem services. And biomass is, of course, needed to measure carbon storage and emissions.

To increase the value of data and enable end users to fully understand satellite data and how it can be used, it would be useful to provide:

- Metadata (geographic scope, time series length)
- Information on the uncertainty of satellite data
- A platform that makes it easy to integrate maps, geodata, models, and pictures.
- The ability for users to integrate local layers with satellite information available online.
- The opportunity for users to interact with national and regional experts from NASA.