Input to NRC Decadal Survey from NASA SERVIR Eastern and Southern Africa 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 12 respondents living or working in the Eastern and Southern Africa NASA SERVIR hub region are presented below (not listed in order of priority). Respondents represented intergovernmental organizations (5 respondents), academic institutions (2 respondents), federal agencies (2 respondents), and other sectors (3 respondents). Responses are presented verbatim, with minor editing to improve understanding and combine similar comments.

Data Accessibility, Dissemination, and Challenges

1. How can scientists access free, higher resolution satellite datasets?
2. Are key research findings being consumed sufficiently?
3. What information can we obtain from Earth Observation data to inform policy?
4. How can satellite data and methods for analysis be easily integrated into a country's monitoring strategy?
5. 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?
6. How can we utilize private satellite companies' technologies to enhance our monitoring and modeling capabilities?
7. How to foster demand and market driven innovation, reflecting proprietary technology development?

Water Resources

8. What is the situation (quality and quantity) of our fresh water resources, including surface and underground water?
9. What is/would be the impact of climate change on water availability?

Climate Change

10. Is the war against climate change being won?
11. What is the impact of industrial agriculture on local and global climate variability?
12. Can integration of near-real time monitoring tools into national climate adaption plans and climate mitigation strategies help achieve better outcomes?
13. Will severe weather events become more frequent and more intense?
14. Human health with respect to the penetration of harmful radiation (UV) into the atmosphere.

Food Security

15. What will drought patterns be in the upcoming decade, and what will be their impact on wildlife and agriculture production?
16. Can near-term forecasting using satellite data be an effective tool to avoid crop failure, pest outbreaks, and disease for small-holder farms?

Disasters

17. Are existing Disaster Early Warning Systems sufficient?
18. Are earthquake losses preventable?

Sustainable Development

19. Sustainability of hydropower
20. 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:

- Icesat-using GLAS on Icesat and Icesat-2 for measuring vegetation structure and biomass for climate mitigation policy
- Landsat for vegetation, water usage/quality, and fire data related to carbon, land cover, land use/land cover (LU/LC) change, agriculture, and natural hazards. Landsat offers comprehensive spatio-temporal advantages.
- MODIS/VIIRS for vegetation, water usage/quality, fire, and air measurements, which are relevant to carbon, agriculture, natural hazards, and air quality.
- MODIS/AVHRR – have a long record of vegetation indices for monitoring phenology, climate change, and landscape changes to inform climate policy and sustainable development.
- 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, soil moisture, which are relevant to carbon, agriculture, and natural hazards.
- Rosetta – Studying the solar system and comets in particular is increasingly important
- Aqua – Ocean behavior is important in aviation and needs to be further studied
- APM – for NRT forecasting—water and disasters
- SMAP – soil moisture, drought monitoring, and food security
- CO_2 measurements
- Sea level instrument
- Climate meteorological satellites – precipitation, temperature, soil moisture, humidity, ocean color, winds – are all important for tracking climate/human footprints
- Monitoring of environmental gases and incoming radiation in the atmosphere

- Population distribution
- Land use, land morphology
- High temporal and spatial resolution measurements of NDVI worldwide
- TRMM/GPM – Rainfall data are critical for areas that have unreliable station data. Can provide a climatology record for rainfall and is critical to monitoring and forecasting droughts and floods for disaster risk mitigation.
- GPM – Provides critical precipitation data useful for weather prediction, disaster risk assessments, agriculture, ecosystems, hydrology models, and in fact all societal benefit areas.
- Jason-1 to monitor water surface height
- SeaWIFS – To improve the accuracy of ocean-water quality measurements
- SRTM – Accurate and high-resolution elevation data are a universal input to improve understanding of hydrological models

Suomi NPP-VIIRS-MODIS and VIIRS derived measurements are used worldwide by decision makers to monitor forest fires, land cover, vegetation indices, and monitor air and water quality. Continuous measurements of surface reflectance that help to generate other products are critical to monitor ecosystems.

Suggestions for additional investments include:

- A tool that takes inputs and predicts crop harvests in Africa – to support food security efforts in the advent of a changing climate system
- A one-stop-shop for all satellite observed or computed data for weather monitoring
- Towards a safer world, a tool that can monitor terrorist groups and advise governments
- Higher resolution data that can be freely distributed
- 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
- Cloud-free data for coastal areas – overcoming the challenge of obtaining good datasets for these areas
- Biodiversity and Habitat Measurement required as an essential climate variable (ECV)
- Evapotranspiration to be included as an ECV
- Forecasted rainfall for flood forecasting and water resources forecasting
- Groundwater monitoring/groundwater level datasets
- Soil quality/fertility
- In terms of new sensors, hyperspectral and radar sensors
- In terms of products, surface reflectance products from the multispectral and hyperspectral sensors
- Radar data and technology
- 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
- New-NISAR – to obtain measurements on biomass
- New-SWOT – to survey Earth's surface water
- LIDAR – for vegetation structure and biomass to monitor forest degradation and inform land use policy, mitigation policies, and protected area enforcement

- Vegetation indices, rainfall estimates, radiation, atmospheric gases. These will guide decision making in various sectors: Food security, health, power generation, etc.

A one-stop-shop for all satellite observed or computed data for weather monitoring would be ideal, especially for Africa, where weather observations have been reduced and continue to decline. Besides the minimal upper air observation equipment (the radiosonde), surface stations are also in a free-fall mode.

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.

The phenology of NDVI is one of the most basic and important products that satellites provide to the agriculture industry. MODIS is the only product with sufficient temporal resolution to be useful to understanding plant growth phenology (central to understanding influence of climate change on agriculture), but its spatial resolution is too low to be useful to most field/pasture-scale analyses.

In terms of new measurements, NISAR and SWOT will provide new understanding of our forests (NISAR) and water resources (SWOT).

Climate change and people/demographers will affect development objectives. Products that can track the interactions of climate and inconsistent population growth (spatially) will be critical.

In relation to food security, it is becoming increasingly important to monitor groundwater reservoirs and soil fertility.

In the case of hyperspectral technology, such satellite capacity is needed on an operational basis to continue the legacy of EO-1 Hyperion. Hyperspectral data can be used for a variety of applications; in biodiversity and ecology a good signal to noise ratio product will support analyses to discriminate species of interest from the surface coverage.

Radar is critically needed to acquire useful and timely, post-event data in water-related disasters. In addition, radar technology is also needed to improve biomass estimations.

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
- Byproducts, such as flood maps
- A better understanding of product applications and limitations