**ICESat-2 Applications Traceability Matrix - entries are based on ICESat-2 Early Adopter research and are listed for each of the NASA Applied Sciences Program application areas**

| Application Question | Application Concept | Application Measurement Goals | Applied Sciences Category | Host agencies and Potential end-users | Mission Data Product | Projected Mission Performance | ARL | Ancillary Measurements |
|---|---|---|---|---|---|---|---|---|
| **Are ships able to navigate through the Arctic in current conditions?** | Dramatic changes of the Arctic climate system demand high resolution and accurate sea ice forecasts in the Marginal Ice Zone (MIZ) for a number of operational applications, including Arctic shipping. Successful implementation of new data sources is expected will lead to significant improvements in ice edge forecasts for the entire Arctic MIZ, resulting in operational and societal benefit. | Sea ice thickness and/or freeboard observations that cover the full Arctic region. There is a 72 hour latency requirement for data to be incorporated into the Navy's Arctic Cap Nowcast Forecast System (ACNFS). Very high precise geolocation of sea ice, open water and leads in MIZ. ACNFS resolution is ~ 3.5 km near the North Pole and 6.5 km near 40° North. | **Climate** | **Early Adopter: U.S. Naval Research Laboratory**<br>**PI: Pamela G. Posey**<br><br>U.S. Navy; U.S. National/Naval Ice Center and other external customers of the ACNFS products | Global geolocated photon data; Sea ice height; Sea ice freeboard; Gridded sea surface height - open ocean; Gridded sea ice freeboard; Gridded sea surface height - ice covered ocean | Monthly surface elevation products to enable, when sea surface height references (leads) are available and under clear sky conditions, the determination of sea-ice freeboard to an uncertainty of less than or equal to 3 cm along 25 km segments for the Arctic and Southern Oceans; track spacing should be less than or equal to 35 km at 70 degrees latitude on a monthly basis. | 3 | Ice thickness observation sources such as ice mass balance buoys, synoptic airborne thickness surveys, and upward sonar observations. IR temperature data from MODIS/VIIRS and microwave ice concentration data from AMSR-2. NRL airborne surveys and NASA Ice Bridge measurements of sea ice thickness and snow depth |
| **Where and how connected are the Sage Grouse habitat corridors?** | In the semiarid western US, the distribution of species and vegetation types are expected to shift in response to climate change and other stressors. Sagebrush ecosystems are vulnerable to change in composition and structure from fire-grass recurring cycles that transform the landscape from intact to invasive annuals. | Extend scales of semiarid environments derived from full-waveform terrestrial laser scanning and airborne laser scanning to scales derived from satellite-based laser altimetry. Quantify shrubland vegetation structure (height at a minimum, shape if possible) and derivatives such as vegetation roughness. Height of low-lying vegetation in semiarid ecosystems (example): low sage species (30 cm in height), sagebrush (~2m) and average sage brush height (~1m). | **Ecological Forecasting** | **Early Adopter: Boise Center Aerospace Laboratory**<br>**PI: Nancy F. Glenn**<br><br>USDA (U.S. Forest Service and Agricultural Research Service); DOI (BLM, including Great Basin Landscape Conservation Cooperative, and USGS); DOD and regional partners (Great Basin Research and Management Partnership and Join Fire Sciences Program) | Land ice height, Land-vegetation height, Land-vegetation gridded height | ICESat-2 is expected to produce high precision (cm) elevation measurements over land that enable scientists to determine global vegetation height with a ground track spacing of less than 2 kilometers over a 2-year period. | 3 | Field-based spectroscopy and ground-based terrestrial laser scanning. MABEL/SIMPL data. |
| **Is there a potential for volcanic mass flows and what are impending dangers, if any, to population centers?** | Volcanic mass flows are among the most deadly volcanic phenomena, causing most of the deaths in the cases of Mt. St. Helens, Pinatubo, Soufriere Hills Volcano, Merapi, to name a few. Monitoring surface changes during the effusive phase of eruption can hopefully yield information to determine potential hazards in mass flows down the flanks of a volcano. | ICESat-2 data could be used to generate high spatial and temporal resolution digital elevation models (DEMs) to be used as model inputs for the prediction of evolving pyroclastic flow hazards and to further the understanding of physical volcanic processes. Repeat track and crossover analysis, combined with DEMs, will be used to monitor volcanic lava dome volume changes and flank deformation. | **Disasters** | **Early Adopter: SUNY at Buffalo**<br>**PI: Greg Babonis**<br><br>Volcano Observatories, Vhub user group, UB Geophysical Mass Flow Group; US Geological Survey | Science unit converted telemetry, Global geolocated photon data, Land ice height, Land-vegetation height | ICESat-2 is expected to produce high precision (cm) elevation measurements over land that enable scientists to determine global vegetation height with a ground track spacing of less than 2 kilometers over a 2-year period. | 3 | Field experiments for volcanic processes and geohazard studies. High resolution (1m) LiDAR DEM available for Montserrat. |
| **How are aerosols in the Arctic transported from lower latitudes affecting ecosystems in Alaska's national parks?** | Airborne contaminants, including trans-pacific and trans-polar global pollution sources, have the potential to negatively impact the national park's ecosystem through its adverse affects on biota and visibility. Park managers are concerned with monitoring air quality to measure the contaminants deposited on the earth's surface. | Improved temporal and spatial coverage of aerosol data in Polar regions. The availability of aerosol optical properties vertical profiles over Polar Regions by ICESat-2 and CALIOP (and then JAXA EarthCARE) could provide a long-term data record of aerosol content over polar regions for air quality applications. | **Health & Air Quality** | **Early Adopter: National Research Council of Italy - Institute of Methodologies for Environmental Analysis (CNR-IMAA)**<br>**PI: Lucia Mona**<br><br>National Park Service | Normalized relative backscatter, ATLAS atmosphere cloud layer characteristics, Sea ice freeboard, Land ice H(t) | During the day thin cloud and aerosol will be detectable, probably, only after a large amount of averaging (at least 40,000 lidar pulse, i.e. about 28 km horizontal resolution) | 2 | MABEL data; CALIOP aerosol/cloud optical properties; aerosol extinction-to-backscatter ratio (namely, lidar ration S) estimated from AERONET data |

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| **What should be the rescue mission plan after a flood event? What is the flood damage?** | Flood mapping and forecasts are used to inform decisions made by international aid and development organizations (e.g., decisions made by United Nations rescue mission after flood events). To date, flood inundation models at large scales are not really routinely applied and the data used to calibrate and validate those models are extremely limited; in addition, often, particularly in data sparse regions, only remotely sensed flood maps from low-resolution optical or radar imagery exist. | Water levels, such as provided by ICESat-2, may prove to be invaluable for model calibration/validation at scales ranging from regional to global. While flood event and near real time river monitoring have a latency requirement of 24 hours or less; archiving for historic analysis/re-analysis and cal/val studies can use any latency. | **Water Resources** | **Early Adopter: Joint Institute for Regional Earth System Science & Engineering, University of California, Los Angeles**<br>**PI: Dr. Guy J-P. Schumann**<br><br>Global Flood Partnership | Inland water body height | ICESat-2 will offer high resolution inland water and near shore surface heights ~O[100-1000m] along multibeam, non-imaging transects. | 3 | Pre-launch data over California Bay area or Niger Inland Delta, if feasible; simulated inland water body height data over Niger Inland Delta; gauged records over California Bay Delta. |
| **What are current regional droughts? What is irrigation potential for a particular region and associated crop estimates?** | The U.S. Department of Agriculture (USDA) Foreign Agricultural System (FAS) uses archival and operational information on global lake level variation to assess the hydrological drought for a particular lake basin and to assess the agricultural drought situation within a lake basin, respectively, for its Crop Explorer operational system. | ICESat-2 is expected to both improve the height measurements of lake levels during winter and provide a global picture. ICESat-2's low (seasonal) temporal resolution compared to the monthly resolution required to assess agricultural drought, means that ICESat-2 can only be used by the USDA FAS as an archival validation source. | **Food Security** | **Early Adopter: Earth System Science Interdisciplinary Center, University of Maryland**<br>**PI: Charon Birkett**<br><br>USDA/FAS; Other stakeholders (TBD) that have requirements for very high-latitude lakes and reservoirs | Inland water body height | ICESat-2 will offer high resolution inland water and near shore surface heights ~O[100-1000m] along multibeam, non-imaging transects. | 3 | MABEL data over lakes/reservoirs |
| **What are current wildland fire dangers? What firefighting resources need to be mobilized?** | The ability to capture the 3D arrangement of canopy elements (vertical and horizontal arrangement) is critical to modeling fire behavior. For example, the heterogeneity of canopy heights influences wind-reduction factors which, in turn, affect fire spread rates. Fire managers will benefit from spatial extrapolation of fire-relevant canopy structure and fuel metrics (e.g. canopy height, canopy cover, and canopy base height) with newer data. | Allow land managers to easily derive fire behavior modeling variables from lidar. Maintain the relevancy and currency of mapped structure and fuels products within existing mapping efforts (e.g. LANDFIRE program). Ensure that structure and fuels can be mapped consistently at the regional-to-national scale using the spatial coverage offered by ICESat-2. | **Wildfires** | **Early Adopter: US Geological Survey Earth Resources Observation and Science Center**<br>**PI: Birgit Peterson**<br><br>U.S. Forest Service's Wildland Fire Assessment System | Global geolocated photon data; Land-vegetation height | ICESat-2 is expected to produce high precision (cm) elevation measurements over land that enable scientists to determine global vegetation height with a ground track spacing of less than 2 kilometers over a 2-year period. | 3 | MABEL campaigns focused on the Sierras, New England, the mid-Atlantic and Southeast, as well as vegetation night flights. |