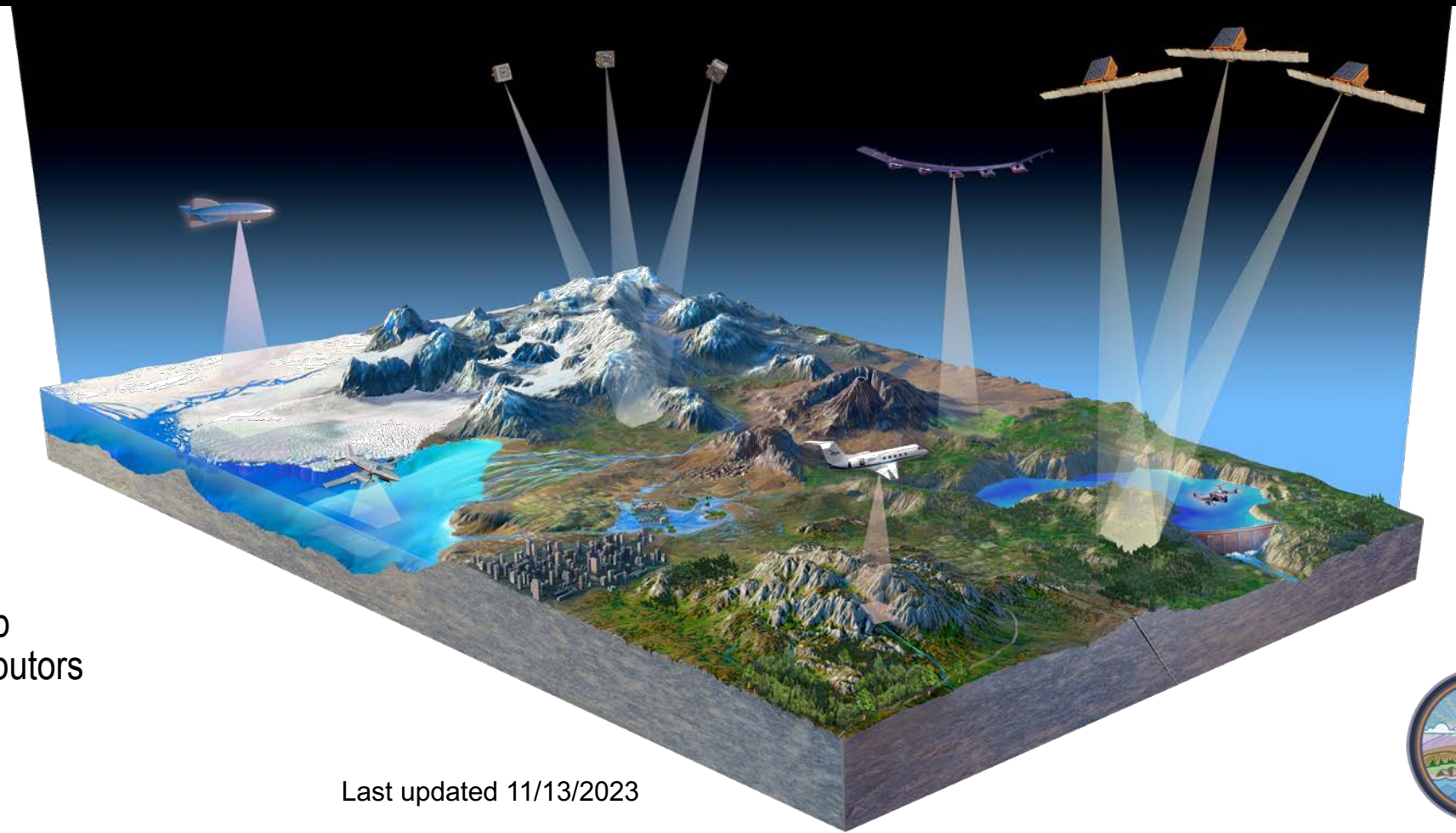
NASA's Surface Topography and Vegetation Study

Cryosphere



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Cryosphere Questions

How are the components of the frozen Earth changing and what are their impacts on the regional and global climate system? [ice sheets, glaciers & ice caps, sea ice, permafrost]

[ice sheets] What are the seasonal to decadal contributions of Earth's ice sheets to sea level, and how do changes in ice-sheet geometry and the influences of the atmosphere and ocean contribute to their mass balance evolution?

[glaciers & ice caps] How will the seasonal response of mountain glaciers & ice caps in a warming world influence river and stream discharge and sea level, and what are the impacts on the potential for alpine hazards?

[sea ice] How do ongoing and projected declines in global sea ice affect polar and global climate systems as well as local communities, and how predictable are these changes across regions and time-scales?

[permafrost] How will permafrost respond to warming air temperatures, and what are the resulting impacts on the global climate system?

Cryosphere Goals

Improve our ability to measure the current state of the cryosphere and project its future state in a warming world

[ice sheets]

Monitor time-varying: surface mass balance processes (precipitation, compaction, runoff)
fast moving (>50m/yr) glacier processes (outlet glaciers)
slow moving (<50m/yr) glacier processes (interior ice)
ice shelf processes (rifting, calving, etc.)

Generate a (time-varying) high-resolution DEM for ice sheet model initialization

[glaciers & ice caps]

Quantify: seasonal glacier dynamics (topography, 3D velocity, Lagrangian elevation change)
surface mass balance processes (precipitation, compaction, runoff, avalanches)

Cryosphere Goals

Improve our ability to measure the current state of the cryosphere and project its future state in a warming world

[sea ice]

Quantify time-varying: sea ice thickness distribution

snow depth distribution

state of melt (ice, open water, melt ponds etc)

[permafrost]

Quantify seasonal freeze/thaw of the active layer

Monitor secular permafrost degradation and thermokarst evolution

Cryosphere Science Gaps

Needed modeling/simulations/investigations

Development of new OSSE frameworks to assess the impact of candidate STV architecture(s) on model simulations and projections of the various components of the cryosphere

Assessment of the unique spatiotemporal attributes of the various process drivers of height change (e.g., surface mass balance, dynamics, solid Earth)

Evaluation of existing datasets to determine the trade-offs between spatial, temporal resolution, and repeat frequency

Impacts of changing geophysical properties of snow/firn on elevation retrievals

Investigation of the spatiotemporal scales relevant to surface meltwater features

Integration of non-STV related observations to understand spatiotemporal distribution of STV relevant features (e.g., rifts, leads, melt ponds)

…and the list goes on…we will go more in depth in the breakout

Cryosphere Measurement Needs

Based on the STV Study report; Will refine in breakout and as STV experiments conclude

	Aspirational	Threshold
Coverage Area of Interest*	95%	75%
Latency (Applications)	15 days (5 days)	30 days (15 days)
Duration*	120 months	36 months
Repeat Frequency	15 days	45 days
Horizontal Resolution (profile)	4 m (10/1000m)	12 m (50/5000m)
Vertical Accuracy*	0.01 m	0.05 m
Geolocation Accuracy	2.5 m	5 m
Rate of Change Accuracy*	0.01 m/y	0.02 m/y

Cryosphere Needed Experiments

Existing and proposed

[Airborne campaigns]

ARCSIX (summer 2024): Arctic sea ice

SnowEx (2017-2023): Northern hemisphere snow

[Targets]

Temporally dense measurements for selected field sites on ice sheets and glaciers spanning a range of climatic conditions targeted at the assessment of time-scales and rates of firn processes relevant to STV

Repeat surveys using high-resolution, frequent repeat satellite and airborne data for case studies of selected outlet glaciers and ice shelf rifts to identify temporal and spatial scales of calving and rifting rates

Campaigns to better understand spatiotemporal variability in snow-ice formation and snow/ice density evolution, especially in the Southern Ocean

[Data sets]

Operation IceBridge (2009 – 2021): Greenland, Antarctica, Alaska, Arctic/Southern Ocean sea ice

Pre-IceBridge data (prior to 2009)

Summary

- Improve our ability to measure the current state of the cryosphere and project its future state in a warming world
  - Ice sheets, glaciers & ice caps, sea ice, permafrost
- Long duration is important given cryospheric timescales
- Rate of change accuracy: we need to observe very small changes
- At least seasonal repeat; coverage is key: glaciers & permafrost
- Future activities
  - Need for vertical constraint from lidar like accuracy; natural partner with other observation technologies → explore fusion opportunities
  - A lot of IceBridge heritage; partner on CONUS flights; targets?
  - Need for technology demonstration/maturation over snow/ice targets
  - OSSE (or OSSE-lite) development
  - Data fusion with imagery/mass change to help meet need