



National Aeronautics and
Space Administration

ESTO: Earth Science Technology Office

NASA Earth

Hydrosphere Meeting
September 2026

Laura Rogers

Earth Science Technology Office (ESTO)

Earth Science Division

NASA HQ

NASA HQ Earth Science Division Leadership



Karen St. Germain
Division Director



Julie Robinson
Deputy Director

ELEMENTS

Earth Science Technology Office



Michael Seablom
Associate Director



Elizabeth Forsbacka
Deputy Associate
Director

Flight Programs



Scott Schwinger
Associate Director



Antonios Seas
Deputy Associate
Director



Beth Weinstein
Deputy Associate
Director

Earth Science Data Systems



Katie Baynes
Earth Data Officer



Jim O'Sullivan
Deputy Earth
Data Officer

Earth System Science Research Program



Barry Lefer
Associate Director



Michelle Hawkins
Deputy Associate
Director

Earth Action



Thomas Wagner
Associate Director



**Emily Sylak-
Glassman**
Deputy Associate
Director

Strategy

ESTO investments inject novel, cost-effective technologies into missions across NASA, other Federal agencies, and the commercial space sector

ESTO executes the nation's premier program for developing Earth observation and intelligent systems technologies.

Widely emulated within NASA and beyond, ESTO's strategy is innovative, analytics-driven, and continually-evolving to retire risk, generate groundbreaking capabilities, and ensure U.S. leadership for science, national security, and commercialization.

Portfolio goal: Critical/Enhancing/Transformational 70% / 20% / 10%

Programs

The Earth Science Technology Office funds new technologies to study Earth. From initial concepts to in-space validation, we work with researchers across industry, academia, and Federal labs to build and develop new ideas that advance science and meet national imperatives.

Advanced Component Technologies (ACT)

Critical components and subsystems for advanced instruments and systems.

Venture Technology Accelerator (VTA) **new**

Spaceborne validation and risk reduction with rapid transition to science operations. Builds on In-Space Validation for Earth Science Technologies (InVEST).

Advanced Modeling Technologies (AMT)

Accelerate AI-enabled, interoperable Earth system models for faster, higher-fidelity prediction

Advanced Information Systems Technology (AIST)

Adaptive, intelligent sensing architectures driven by predictive models

Instrument Incubator Program (IIP)

Innovative remote sensing instrument development from concept through breadboard and demonstration.

Quantum Gravity Gradiometer Pathfinder (QGGpf)

A focused effort to develop and deliver a science-grade QGG for on-orbit testing

FireSense Technology

Innovative observation and information systems to predict and manage wildfires and their impacts.

Crosscutting Programs

Decadal Survey Incubation (DSI)

Accelerating the readiness of Planetary Boundary Layer (PBL) and Surface Topography and Vegetation (STV) observations.

Sustainable Land Imaging Tech (SLI-T)

Legacy Program

New technologies and approaches for reducing costs of future land imaging (Landsat).

Remote Sensing Theory (RST) **co-funded w/ESSRP**

Supports foundational research to advance the fundamental science of remote sensing

Launching the Venture Tech Accelerator

The Venture Technology Accelerator (VTA) program is a new ESTO 'Faster to Science' initiative designed to accelerate transition of next-generation Earth observation technologies to science missions, operational agencies, and/or commercial providers

Building upon the success of the In-Space Validation of Earth Science Technology (InVEST) program model, VTA aims to further accelerate technology impact by:

- Maturing high-potential Earth-observing technologies;
- Identifying transition pathways early;
- Engaging potential end users in targeted flight demonstrations and on-orbit validation planning;
- Serving as a bridge to commercialization, infusion, and operations



FY25 Program Metrics

With over 1,172 technology investments made since 1999 and an active portfolio of 184 projects during FY25, ESTO drives innovation, enables future Earth science observations, and strengthens NASA's capability for developing and advancing leading-edge technologies.

ADVANCEMENT

40% of ESTO technology projects advanced at least one TRL over the course of the fiscal year, and at least 15 projects advanced more than one TRL

INFUSIONS

At least **11 projects** reported infusion into science measurements, airborne campaigns, data systems, or other operational activities.

COMMERCIALIZATION

At least **3 projects** reported new commercialization efforts in FY25



184 projects active in FY25 (58 added / 60 completed)



71 unique PI organizations, in 28 states



162 unique Co-I organizations, in 34 states



282 students from 74 colleges and universities participated in ESTO projects



3 technology demonstrations on orbit



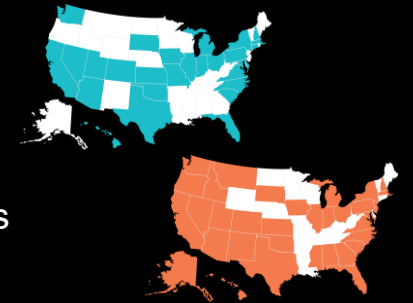
11 projects airborne tested



At least 11 journal articles published, along with more than 370 conference proceedings publications



1 patent granted



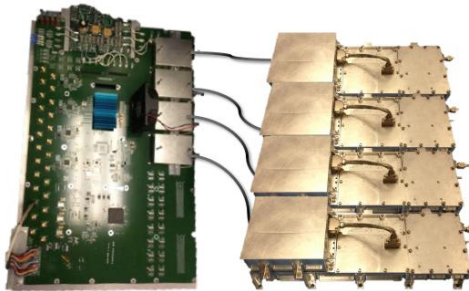
The Early Tech Investments That Enabled NISAR

Several Earth Science Technology Office (ESTO) investments advanced the technologies required for NISAR:



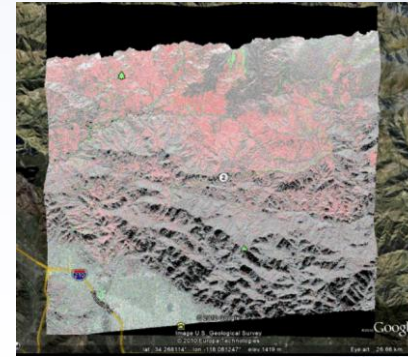
The airborne *Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)* instrument served as a precursor to NISAR and is also producing Cal/Val data for the mission. UAVSAR's L-band radar feed aperture and corresponding RF distribution network informed the NISAR design.

(PI: S. Hensley, JPL, IIP-04)



A series of component technology projects developed the sophisticated *Transmit/Receive (T/R)* modules needed for a spaceborne L-band radar. These efforts produced the overall module design, digital calibration techniques, and the high-power amplifier that were adopted by the NISAR mission.

(PIs: W. Edelstein and J. Hoffman, JPL, ACT-02, 05, 08 & 10)



The *L-Band SAR Onboard Processing* project developed new FPGA-based data processing hardware with autonomy-enabled software to perform data acquisition on-demand. The technology was used by UAVSAR and led to NISAR mission strategies for onboard processing and autonomous data acquisition.

(PI: Y. Lou, JPL, AIST-08)



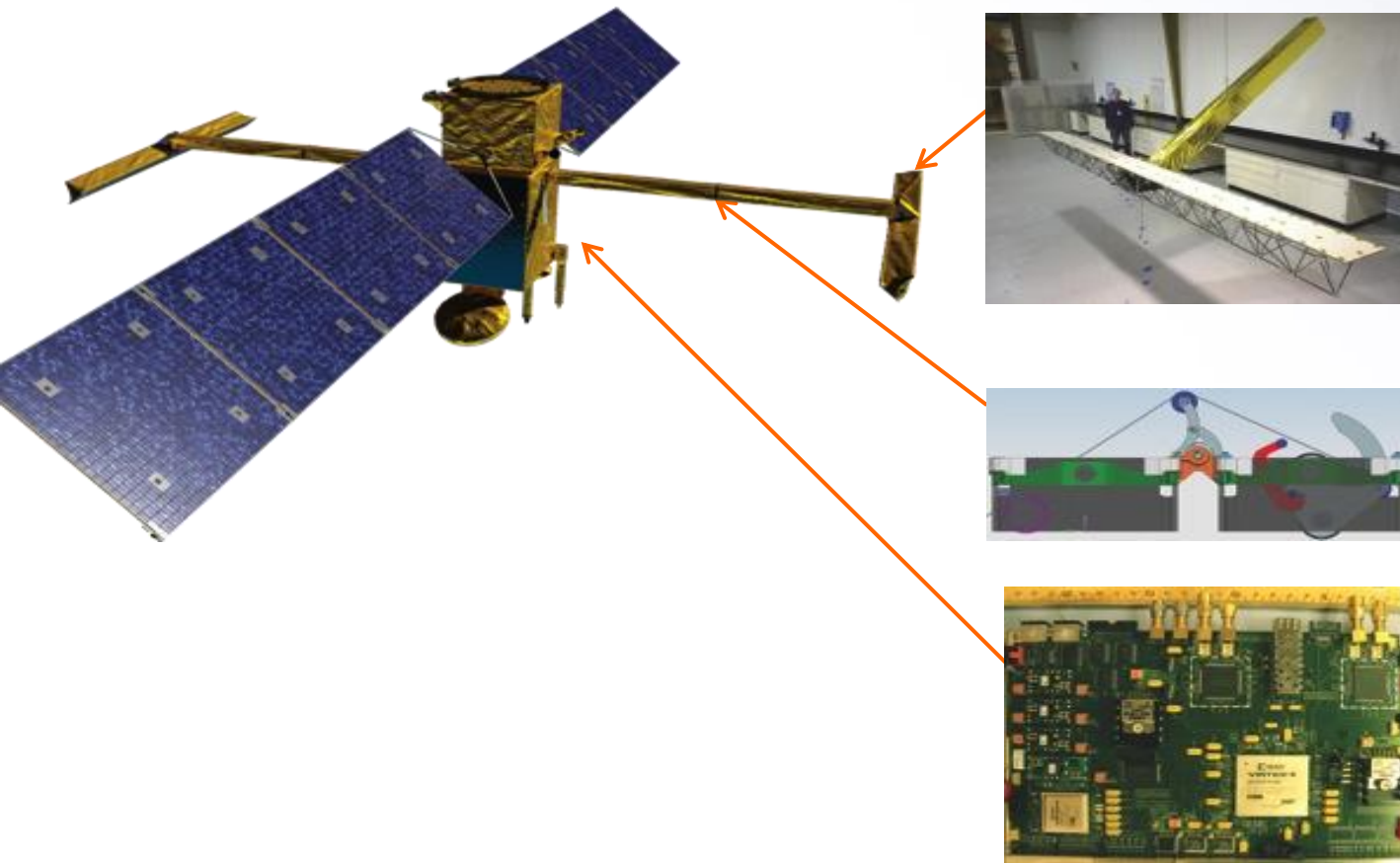
The *Smart Tasking* disaster response system, a prototype for urgent response tasking, was directly adopted by the NISAR Mission System as the interface to monitor rapidly evolving hazards.

(PI: C. Jones, JPL, AIST-19)

Additional examples at: <https://esto.nasa.gov/25years/nisar/>

The Tech Investments That Enabled SWOT

The Surface Water Ocean Topography (SWOT) mission, launched in 2022, is providing the first global survey of ocean topography and terrestrial surface waters at a much higher spatial resolution than previously available. Several Earth Science Technology Office (ESTO) investments advanced the technologies required for SWOT:



SWOT has two deployable, 5-meter, Ka-band reflectarray antennas – part of the Ka-band Radar Interferometer (KaRIn) instrument – that need to be separated by 10 meters, held structurally flat, and thermally stable to meet demanding pointing requirements. This project built and tested a full-scale deployable reflectarray prototype (left) that became the baseline for mission. (PI: M. Thompson, JPL, ACT-08)

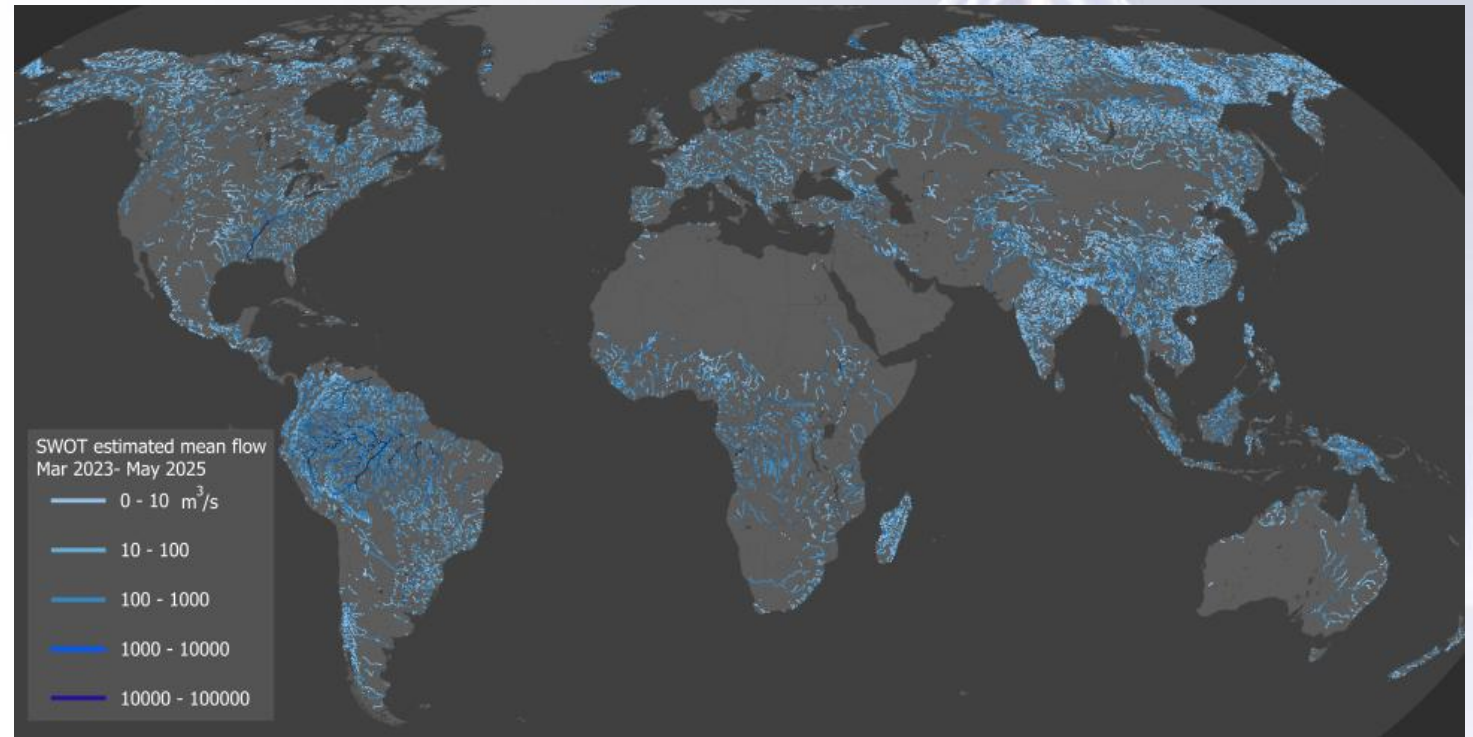
A related project designed and prototyped the precision deployable mast for the two KaRIn antennas, including the hinges and latches needed for precise space deployment. (PI: G. Agnes, JPL, ACT-10)

A third project developed a single-stage Dual Down Converter, a key technology that enabled SWOT to make precision measurements over a wide bandwidth using a low-power, high bandwidth Ka-band receiver. (PI: P. Siqueira, University of Mass, ACT-08)

The Tech Investments That Enabled River Discharge

The open-source framework, Confluence, is the first platform to estimate flow volume together with river sediment on one platform that is freely available to a global community of water resource managers, planners, policy makers, climate scientists and hydrologists:

Application of advanced computer vision and deep learning to hydrology advances the state-of-the-art by replacing traditional, pixel-based hand-engineered algorithms with advanced computer vision techniques. (PI: C. Gleason, UMass Amherst, AIST-21

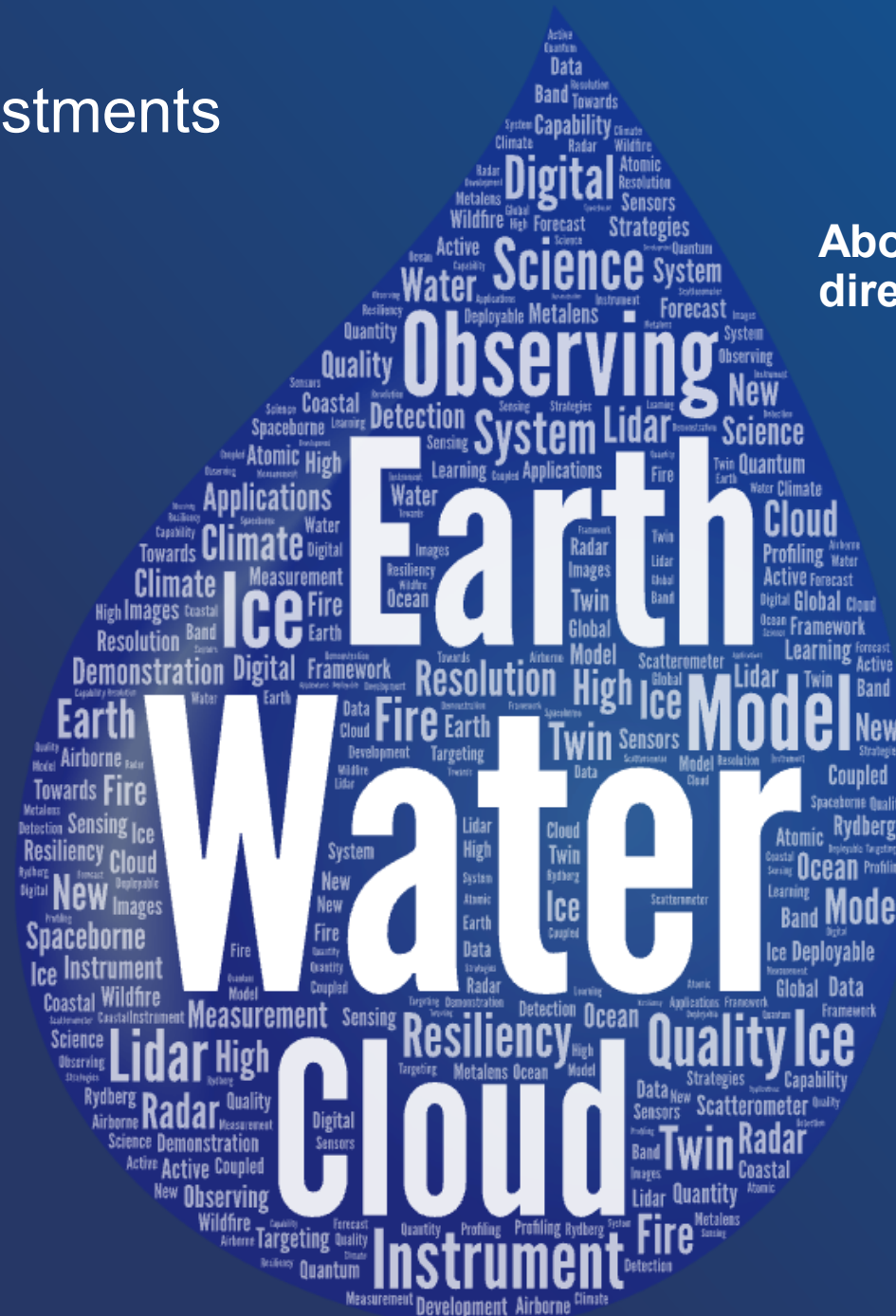


A map made with SWOT data describing estimated discharge for rivers around the world. This information has numerous applications, from freshwater management to flood prediction. Credit: NASA/JPL/UMass Amherst

Technology Investments

Hydrosphere

About 1/2 of the ESTO portfolio has direct relevance to hydrosphere science



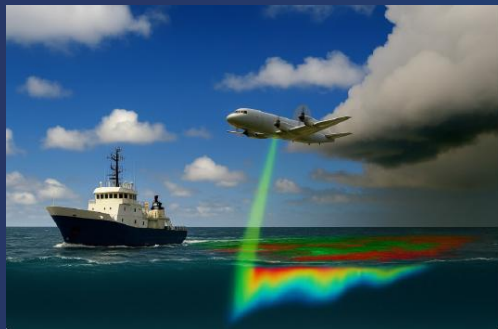
Technology Supporting Hydrosphere Science

Of the ESTO active technology development projects:

- **Nearly 50% have direct relevancy** to the Hydrosphere focus of improving the observation, understanding, and prediction of how water moves and distributes across land, oceans, and the atmosphere. In general, these projects are developing new measurements, models/algorithms, or instrument concepts to that specifically enable:
 - Oceans: Studies ocean heat, sea level rise, ocean currents, and salinity.
 - Precipitation Science: Monitors rainfall, storms, and global precipitation measurement missions.
 - Terrestrial Hydrology: Tracks soil moisture, snow, groundwater, streamflow, and plant water use.
- **An additional ~20% indirectly enable Hydrosphere-relevant applications**
Technology enablers or platforms commonly used to sense hydrosphere (e.g., radar, radiometer, lidar, hyperspectral microwave, polarimetry, observing strategy/OSSEs, Digital Twins/data assimilation) without an explicit hydrosphere science target.

Active Project Examples – Oceans

(sea state, winds, T/S profiles, coastal water quality)



Lidar Instrument for Salinity and Temperature in the Ocean (LISTO)

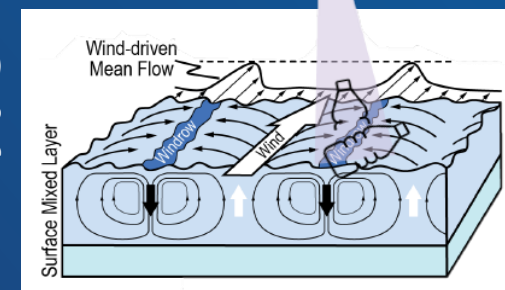
PI: Cecile Rousseaux, NASA GSFC – IIP-QRS-25

Developing a lidar sensor capable of remotely sensing the temperature and salinity of water from spectral characteristics of Brillouin backscatter.

Fluorescence Lidar for Ocean Research - Airborne (FLOR-A)

PI: Madeline Cowell, BAE Systems – IIP-23

Airborne lidar targeting ocean health that vertically resolves the water column for plastics and organic material.



Coastal Zone Digital Twin (CZ-DT)

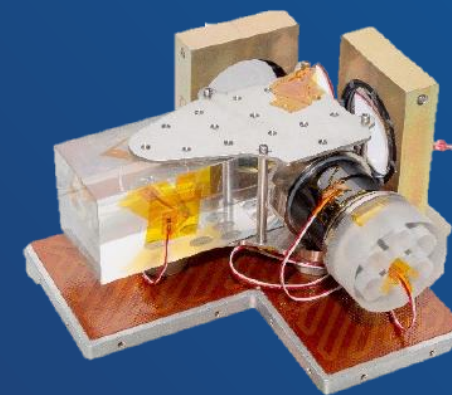
PI: Thomas G. Grubb, NASA GSFC – AIST-24

Dynamic, data-driven virtual replica of interconnected coastal environments to enable scenario based investigations

Blue High Spectral Resolution Lidar for Ocean Profiling

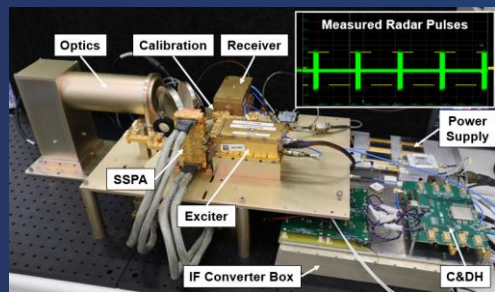
PI: Brian Collister, NASA LaRC – IIP-QRS-25

Developing an airborne, ocean-profiling lidar system using a blue-wavelength (467 nm) laser to measure subsurface ocean optical properties.



Active Project Examples – Precipitation Science

(clouds, storms, hydrometeors, PBL water vapor)



Smart Ice Cloud Sensing (SMICES)

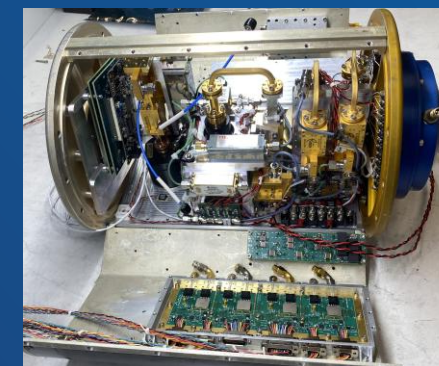
PI: Bill Deal, Northrop Grumman Corp – IIP-19

Low-power, reconfigurable, millimeter-wave active and passive instrument to provide multi-angle and multi-resolution measurements of tropospheric cloud ice

Hyperspectral Capability for CoSMIR (CoSMIR-H)

PI: Rachael Kroodsma, NASA GSFC – DSI-21

Hyperspectral capability for high-resolution vertical profiles of atmospheric temperature, water vapor, cloud microphysics, and precipitation rates



CloudCube

PI: Raquel Rodriguez Monje, JPL – IIP-19

A compact, multi-frequency radar system to study cloud microphysics, convection, and precipitation dynamics from resource-limited small satellites or airborne platforms

Vapor In-cloud Profiling Radar (VIPR)

PI: Ken Cooper, JPL – DSI-24

Upgrades to pioneering airborne radar system that measure absolute water vapor and humidity directly inside clouds and precipitation



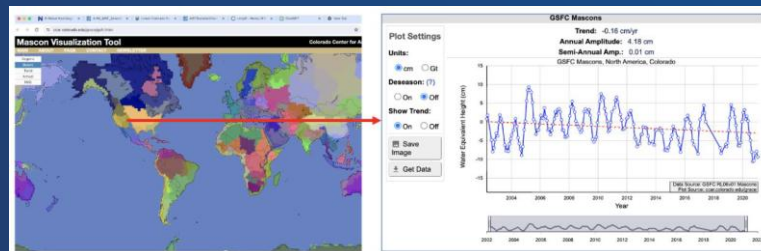
Active Project Examples – Terrestrial Hydrology

(soil moisture, snow, groundwater, streamflow, plant water use)

Mapping anthropogenic water cycle impacts

PI: Sujay Kumar, GSFC – AMT-23

Forecasts and future projections of terrestrial water cycle inclusive of human management influences



A Terrestrial Water Budget Digital Twin

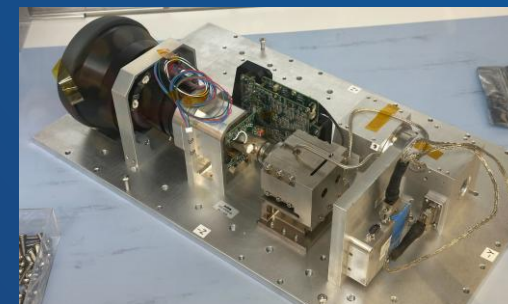
PI: Fritz Policelli, GSFC – AMT-23

Monthly water budget data for the global set of major water basins

Hyperspectral Thermal Imager (HyTI-2)

PI: Robert Wright, University of Hawaii at Mānoa – InVEST/VTa

Next-generation long-wave infrared (LWIR) for land surface temperature and soil moisture. HyTI-2 small satellite payload aims to fly in 2027.



TERRAHydro: Terrestrial Environmental Rapid-Replication and Assimilation Hydrometeorological System

PI: Craig Pelissier, SSAI – AMT-23

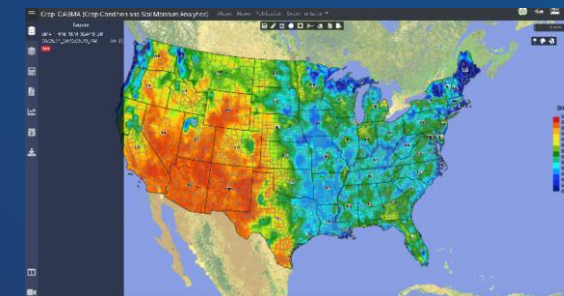
Couple AI-driven and traditional physics-based hydrology models into a single, unified system

TERRAHydro.org is live

AgLIS: Digital Twin Infrastructure Model for Agricultural Applications

PI: Rajat, Bindlish, GSFC – AIST-21

Coupled hydrology and crop models for “what-if” crop yield scenarios (partner with EA)



Selected Highlights

Airborne SNOWWI Radar Deployed for Science Flights

- Snow Water Equivalent Wide Swath Interferometer and Scatterometer (SNOWWI) instrument was deployed onboard a Twin Otter for one week of flights in January–February 2026.
- SNOWWI is a three-frequency (5.4, 13.6, and 17.2 GHz), dual-polarized (VV and VH), interferometric instrument designed to advance remote-sensing science of the volume-scattering signature of snow.
- Snow water equivalent (SWE) is critical measurement for hydrology and freshwater management.
- SNOWWI Overflow snow-covered regions near Boise, Idaho, and at Grand Mesa in Colorado.
- Collected over 10 TB of three-frequency data, along with lidar measurements in Idaho and ground-validation data at several sites. Initial data processing looks promising.



Right: Installation on the aircraft at Twin Otter International in Grand Junction, CO.

Below: C-Band SNOWWI data collected on 1/27/26 over Colorado's Grand mesa region. Horizontal lines are artifacts from the patch processor (500 m) and are removed in post processing.

(All images credit: P. Siqueira)



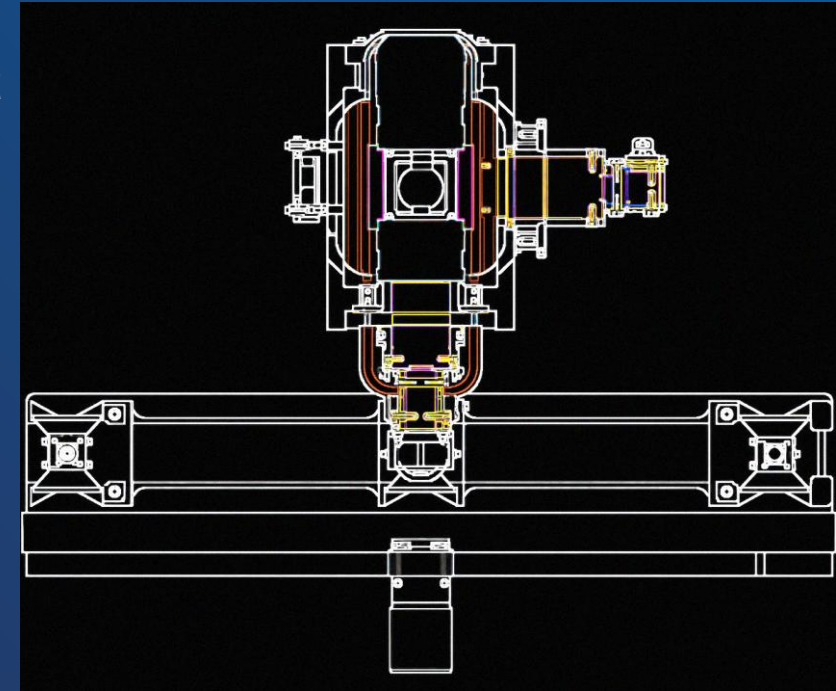
PI: Paul Siqueira, University of Massachusetts, IIP

Quantum Gravity Gradiometer Pathfinder (QGGPf) Mission and Technology Objectives

QGGPf mission objectives:

- QGGPf is a technology demonstration project requiring flight demonstration of a new quantum sensor system capable of measuring Earth's gravity gradient from a free-flying spacecraft in LEO.
 - Two source Rb QGG using super cooled Bose Einstein Condensate
 - Test QGGPf EDU at the Einstein Elevator in July-September of 2027
 - Launch QGGPf in 2030
 - Will enable the future gravity measurements by an order of magnitude better sensitivity than current GRACE-FO mission

QGGPf Project is working to demonstrate and validate key quantum and supporting technologies essential to gravity gradient missions in space



Strategic Directions

ESTO is pursuing several emergent technology areas, such as:

- Quantum Sensing/Computing
- Digital Twin Architectures
- Metamaterials
- Freeform Optics
- Deployable Structures (antennas, telescopes)
- Intelligent Observing Strategies
- Artificial Intelligence