Applications of Satellite Altimetry Observations

Margaret Srinivasan & Vardis Tsontos
Jet Propulsion Laboratory California Institute of Technology

Faisal Hossain
University of Washington

Eldardiry, H., Hossain, F., Srinivasan, M., Tsontos, V. (2021). Success Stories of Satellite Radar Altimeter Applications. BAMS, 1-49. 10.1175/BAMS-D-21-0065.1.

NASA's Ocean Altimetry Missions

Past

- **TOPEX/Poseidon** 1992-2006, NASA/CNES
- **Jason-1** 2001-2013, NASA/CNES
- **Jason-2** 2008, NASA/CNES/NOAA/EUMETSAT

Present

- **Jason-3** 2016, NASA/CNES/NOAA/EUMETSAT
- **Sentinel-6 Michael Freilich** 2020, NASA/CNES/ESA

Future

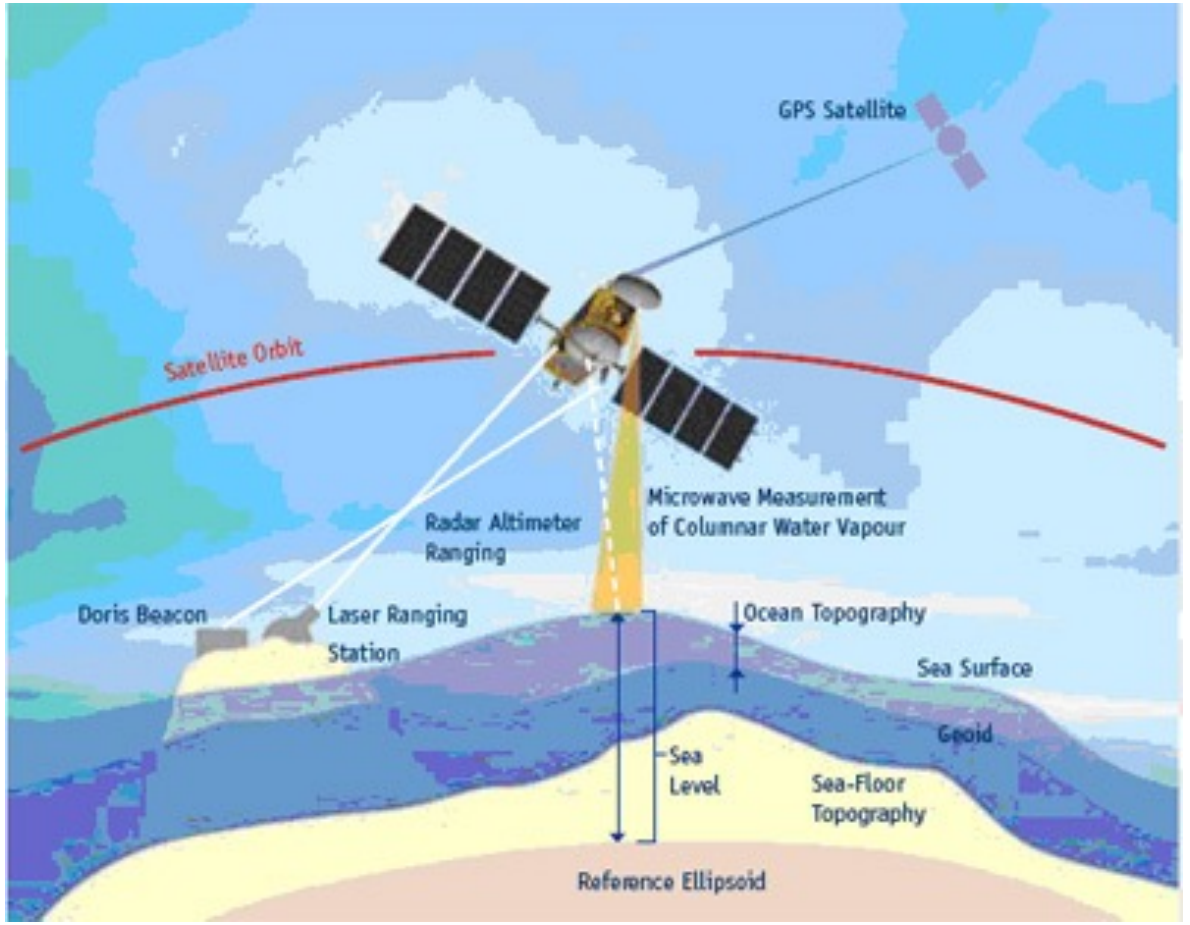
- **SWOT** 2022, NASA/CNES/CSA/UKSA
- **Sentinel-6B** 2025, NASA/CNES/ESA

30 years time series of data – A climate data record.

Key Satellite Radar Altimeter Measurements

- **Water surface heights – ocean & land**
- **Significant wave heights**
- **Sea surface wind speeds**
- **Topography of land, sea ice, and ice sheets**

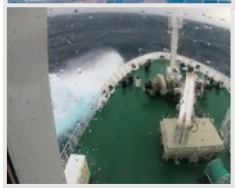
More information: sealevel.jpl.nasa.gov



After 30 years, what are some of the success stories of satellite altimeter applications?

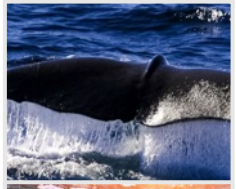
Key Applications Areas & Example Users/Types

Water Cycle

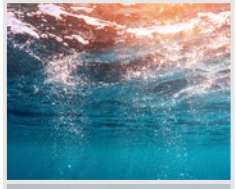


Operational

Coastal



Biological



Climate

Hazards

Surface Water

- Global lake & reservoir monitoring; water managers, USDA Foreign Agricultural Service (FAS); SWOT Early Adopters
- River heights (real & "virtual"); flood forecasting, i.e., Bangladesh Water Development Board

Ocean

- Operational ocean forecasting; naval operations, safety at sea, environmental monitoring
- Marine operations; sea state for ship routing, offshore infrastructure, hazards assessment
- Environmental tracking; marine debris, oil spill discharge forecast (ocean currents)

Climate

- Modeling changes in heat distribution provides insights into the evolution of weather patterns from the ocean system.

Coastal

- Coastal impacts of sea level rise; coastal managers, decision makers
- Storm surge forecasting; coastal communities, infrastructure planning
- Hurricanes; coastal impacts of wind & waves, intensity monitoring and forecast

Global Lakes & Reservoir Monitoring

Summary: USDA-FAS, with NASA & University of Maryland—routine monitoring of global lake and reservoir height variations.

- 30 years of NASA/CNES/ESA/ISRO radar altimeter data
- Surface elevation products for USDA and public access
- Real-time products from this project have been in operation since December 2003.

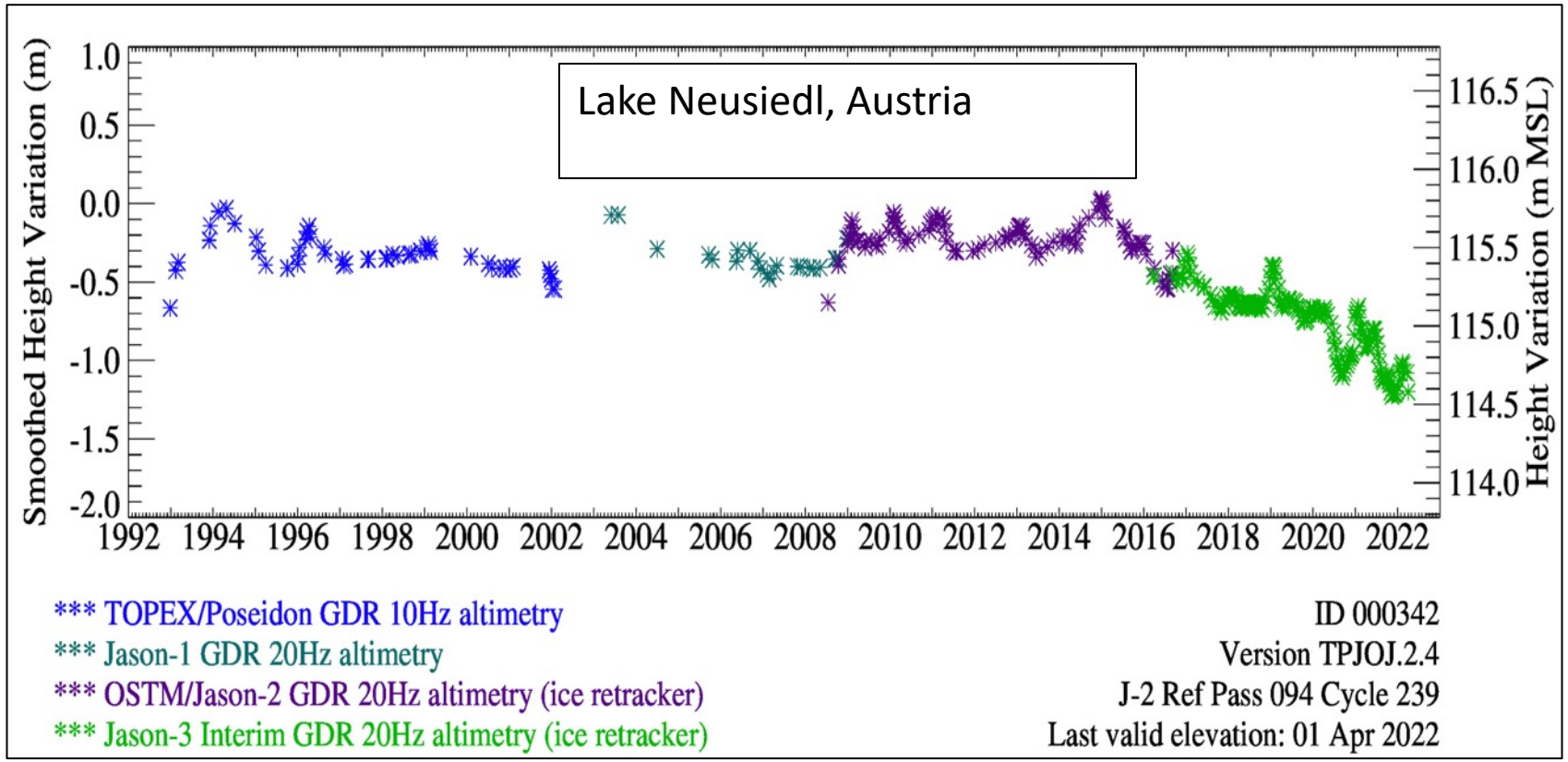
Users:

- USDA FAS, farmers, water managers - quickly locate regional droughts, as well as improve crop production estimates for irrigated regions located downstream from lakes and reservoirs.
- Reservoir operators, decision makers

USDA FAS; https://ipad.fas.usda.gov/cropexplorer/global_reservoir/
Charon Birkett; https://sealevel.jpl.nasa.gov/documents/1694/?list=projects

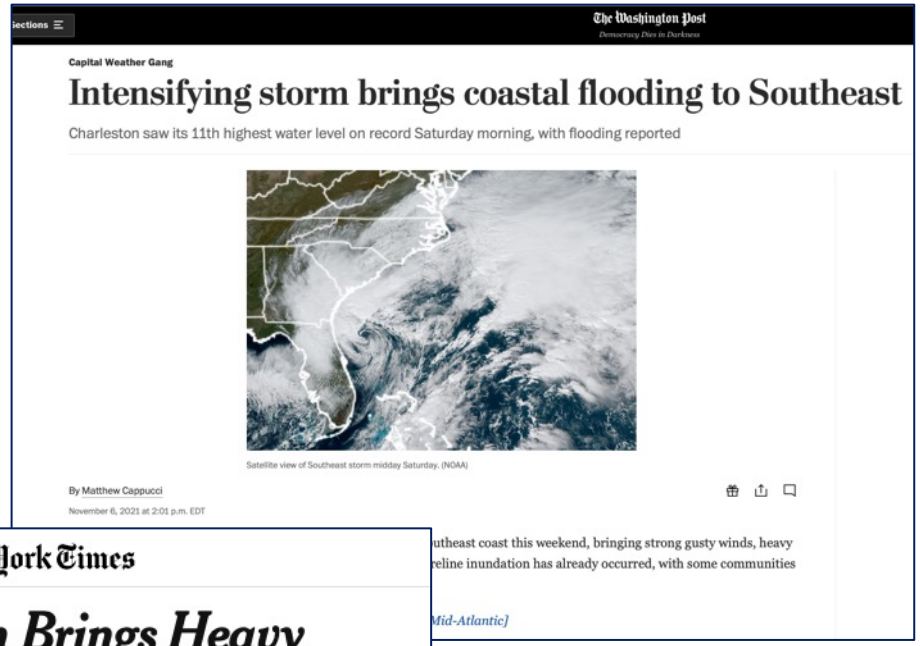
Lake Neusiedl, Austria

- Accurate estimation of reservoir storage levels
- Most reservoir operations carried out at weekly or bi-weekly timescales.



Coastal Impacts

- Sea level rise
- High tide flooding (nuisance flooding)
- Coastal erosion, ecosystem deterioration (marshes, wetlands)
- Infrastructure risks (e.g. military installations, power plants, roads)
- Significant impacts to coastal communities


The Washington Post

Capital Weather Gang

Intensifying storm brings coastal flooding to Southeast

Charleston saw its 11th highest water level on record Saturday morning, with flooding reported

Satellite view of Southeast storm midday Saturday. (NOAA)

By Matthew Cappucci

November 6, 2021 at 2:01 p.m. EDT

utheast coast this weekend, bringing strong gusty winds, heavy
reline inundation has already occurred, with some communities

Mid-Atlantic]

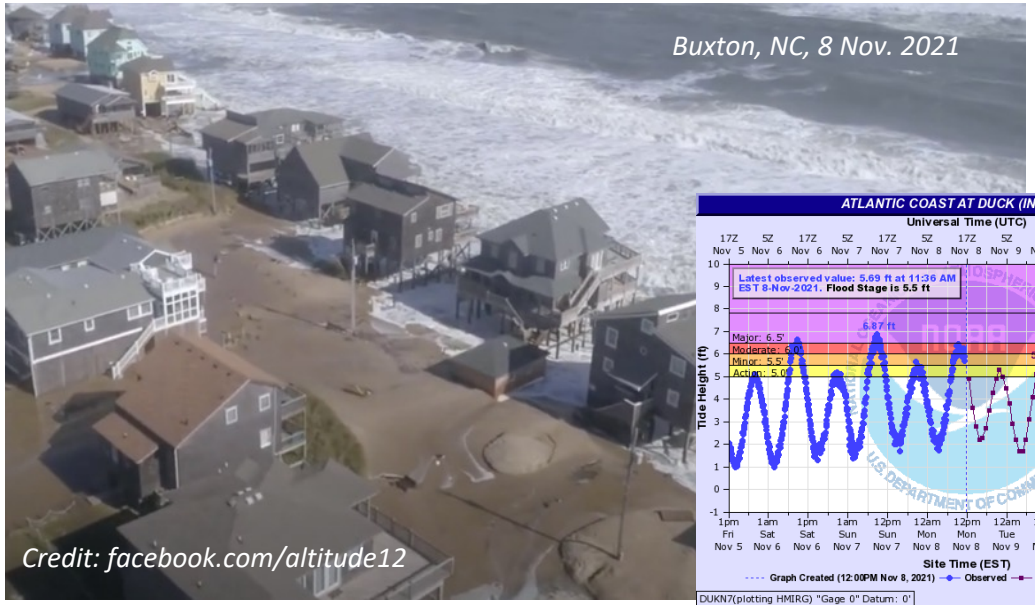

The New York Times

Slow-Moving Storm Brings Heavy Flooding to Mid-Atlantic

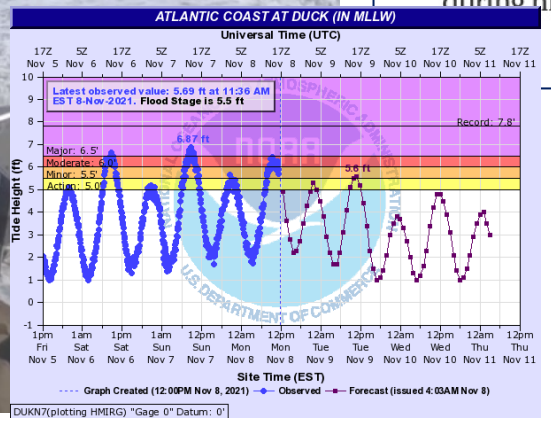
A National

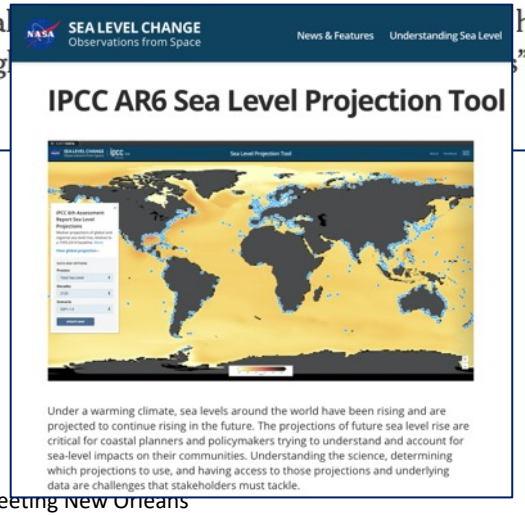
heavy rain

during hig


Buxton, NC, 8 Nov. 2021

Credit: facebook.com/altitude12




SEA LEVEL CHANGE
Observations from Space

News & Features

Understanding Sea Level

IPCC AR6 Sea Level Projection Tool

Under a warming climate, sea levels around the world have been rising and are projected to continue rising in the future. The projections of future sea level rise are critical for coastal planners and policymakers trying to understand and account for sea-level impacts on their communities. Understanding the science, determining which projections to use, and having access to those projections and underlying data are challenges that stakeholders must tackle.


WJCT News

NEXT UP: 8:00 PM First Coast Connect With Melissa Ross

STORIES

SPECIAL SECTIONS

SHOWS & PODCASTS

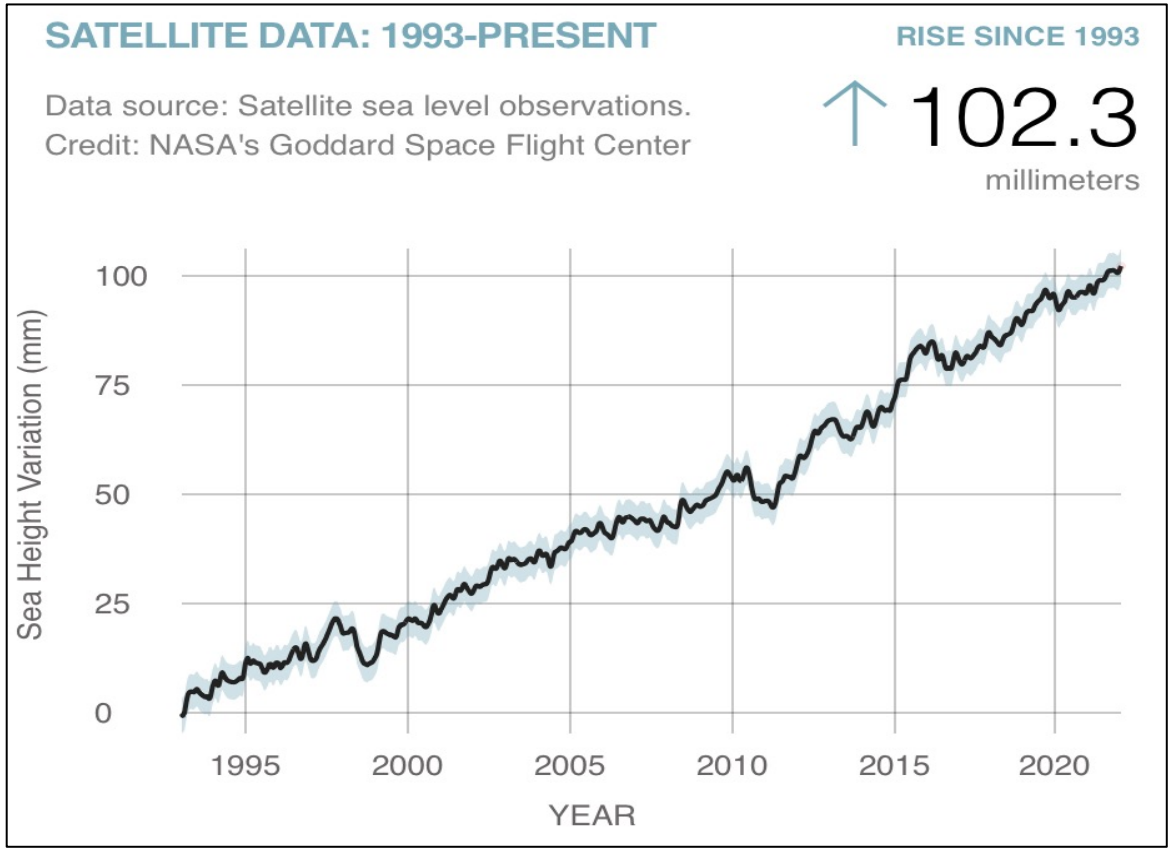
ABOUT

NOAA: 'Sunny Day Flooding' Becoming More Common Across Fla. As Sea Levels Rise

WJCT News | By Brendan Rivers

Published July 15, 2021 at 4:58 PM EDT

Operational Ocean Forecasting



Summary: Multiple satellite altimeters/ 30 years and data merging techniques –> unique capabilities to observe the dynamic oceanography

- NRT high-res global sea level anomaly maps (SSALTO/DUACS system).
- Altimetry + in situ ocean observation systems (Argo) provide measurements of global SLR (~3 mm/yr).
- Ocean analysis and forecasting models are strongly dependent on multiple altimeter data and Argo observations.

Users: Products & services for a wide range of applications:

- Marine environment monitoring – marine debris, oil spills
- Coastal managers, ocean biologist, marine mammal monitoring organizations
- Weather & event forecasting, seasonal and climate prediction; NOAA (CoastWatch, OceanWatch, National Hurricane Center)
- Maritime safety and pollution forecasting, national security, the oil and gas industry, fisheries management and coastal and shelf-sea forecasting: Mercator Ocean, NOAA, US Navy

Conclusion: Building on the Success of Altimeter Applications

Summary

- Multi-decadal heritage, international collaborations
- Applications span multiple sectors of the economy
- Advancements in information technology → more accessible data
  -Publicly-accessible data portals -Training -Cloud access

Sustained outreach by space agencies beginning in the early 2010s, and the increased collaboration between scientists and data experts have played a role in recent acceleration of altimeter applications.

Challenges

- SWOT can mitigate altimeter's limited footprint, but as a research mission with a nominal life span of 3-5 years – no improvement in temporal sampling, particularly in the tropics.
- Further investments in altimeter missions will be required to address current temporal sampling limitations.

Current altimeter constellation, with limited design span, remains vulnerable to discontinuity in data record. The International Altimetry Team (2021) reports that "today we are just one satellite-failure away from a gap in the 30+ year record that has, so far, been accumulated on sea level rise."

Recommendations

- Continue public outreach & delivery of training programs on to demonstrate value for decision-making
- Workshops to feature relevant studies in altimetry, provide training for ECSs & potential stakeholders.

Scale up outreach to more users by the scientific community, promote the use of data and information products of all missions to synergistically address unsolved global to regional environmental challenges.

More Information

- Eldardiry, H., Hossain, F., Srinivasan, M., & Tsontos, V. (2021). Success Stories of Satellite Radar Altimeter Applications. *Bulletin of the American Meteorological Society,* 1-49. https://doi.org/10.1175/BAMS-D-21-0065.1
- SWOT mission; swot.jpl.nasa.gov
- Jason-series missions; sealevel.jpl.nasa.gov
- margaret.srinivasan@jpl.nasa.gov

Acknowledgement

The work was carried out, in part, at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004). First two authors of this work were supported by a Jet Propulsion Laboratory, California Institute of Technology subcontract to University of Washington "Jason-3 Altimetry Missions Applications Activities" (Subcontract No. 1656043).