The dark target: studying Earth's oceans @NASA Ames

Dan Whitt

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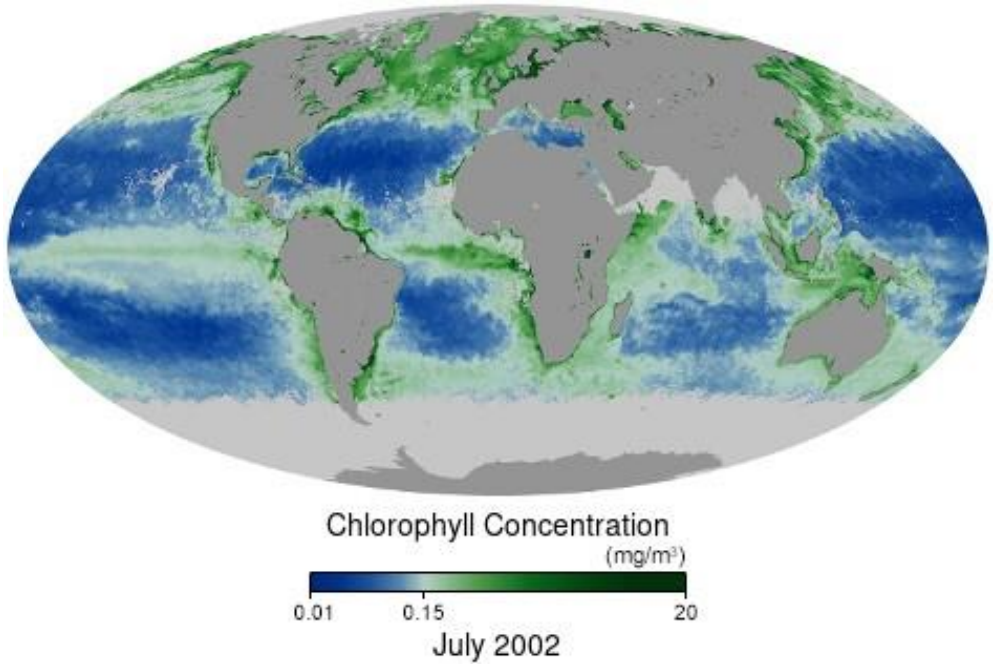
Ocean science on Earth: an exciting frontier

- Water
- Climate
- Life

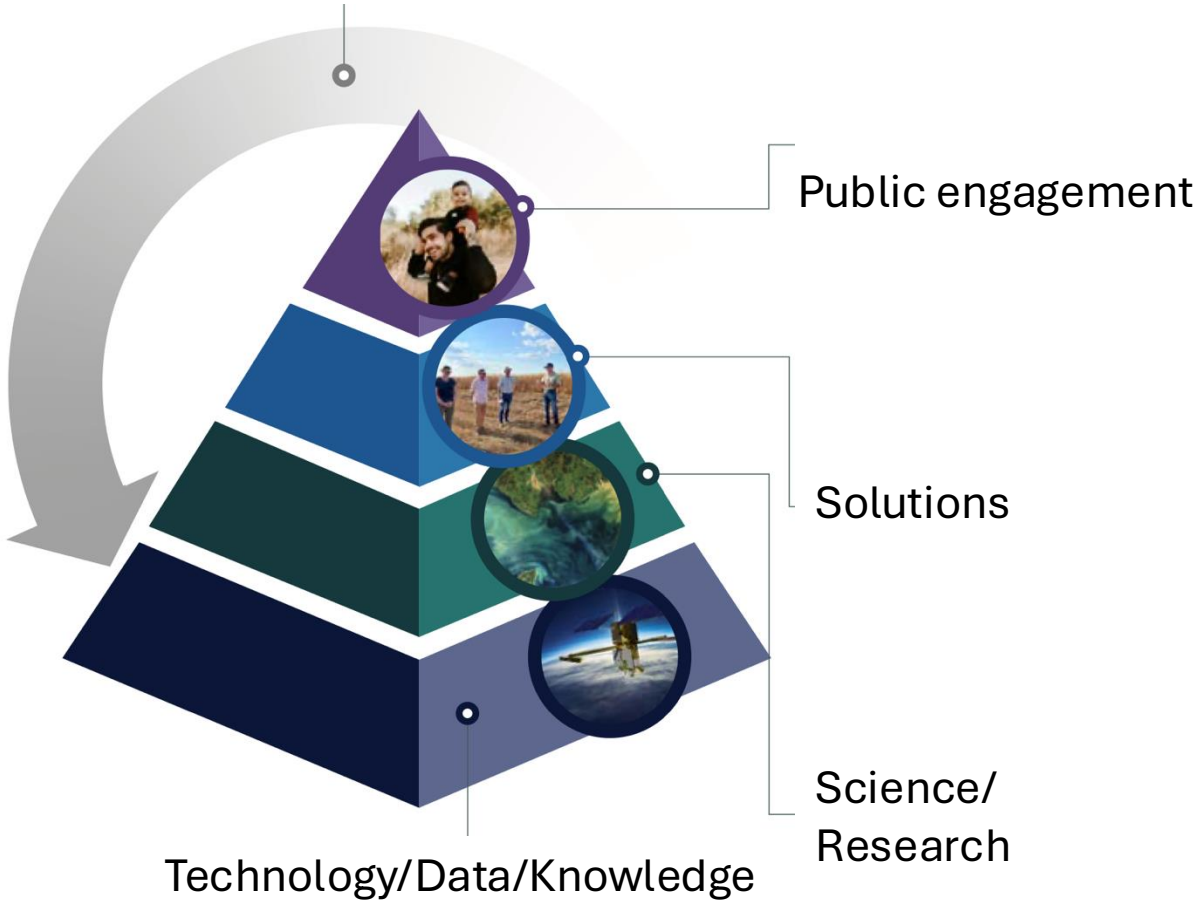


https://earthobservatory.nasa.gov/global-maps/MY1DMM_CHLORA



Ocean science: important for the nation & society

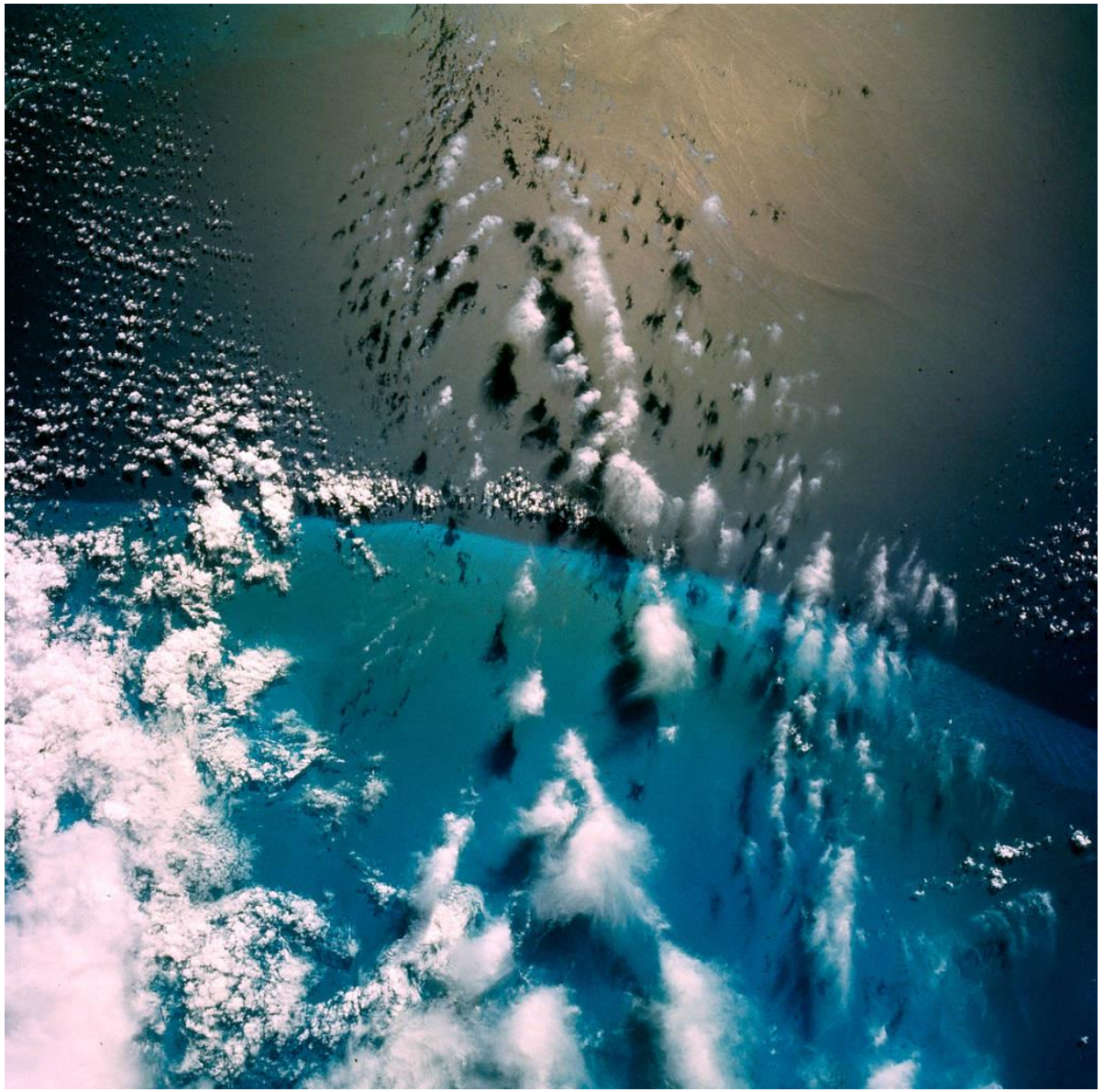
- Weather & climate prediction
  - Sea-level change
  - Building resilience
- Food
  - Fishing and aquaculture
- Culture & recreation
  - Biodiversity and ecological conservation
  - Indigenous people
- Trade & economy
- National security
- Energy & decarbonization
  - Offshore wind
  - Marine carbon dioxide removal



NASA Earth Science to Action Strategy

The early legacy in ocean science at NASA 1960s-1980s

- Photography in manned spaceflight
- Gemini (1960s), Skylab (1970s), Shuttle (1980s)



Munk et al. (1987)

STS-61A, October-November 1985. Picture #61A-200-046

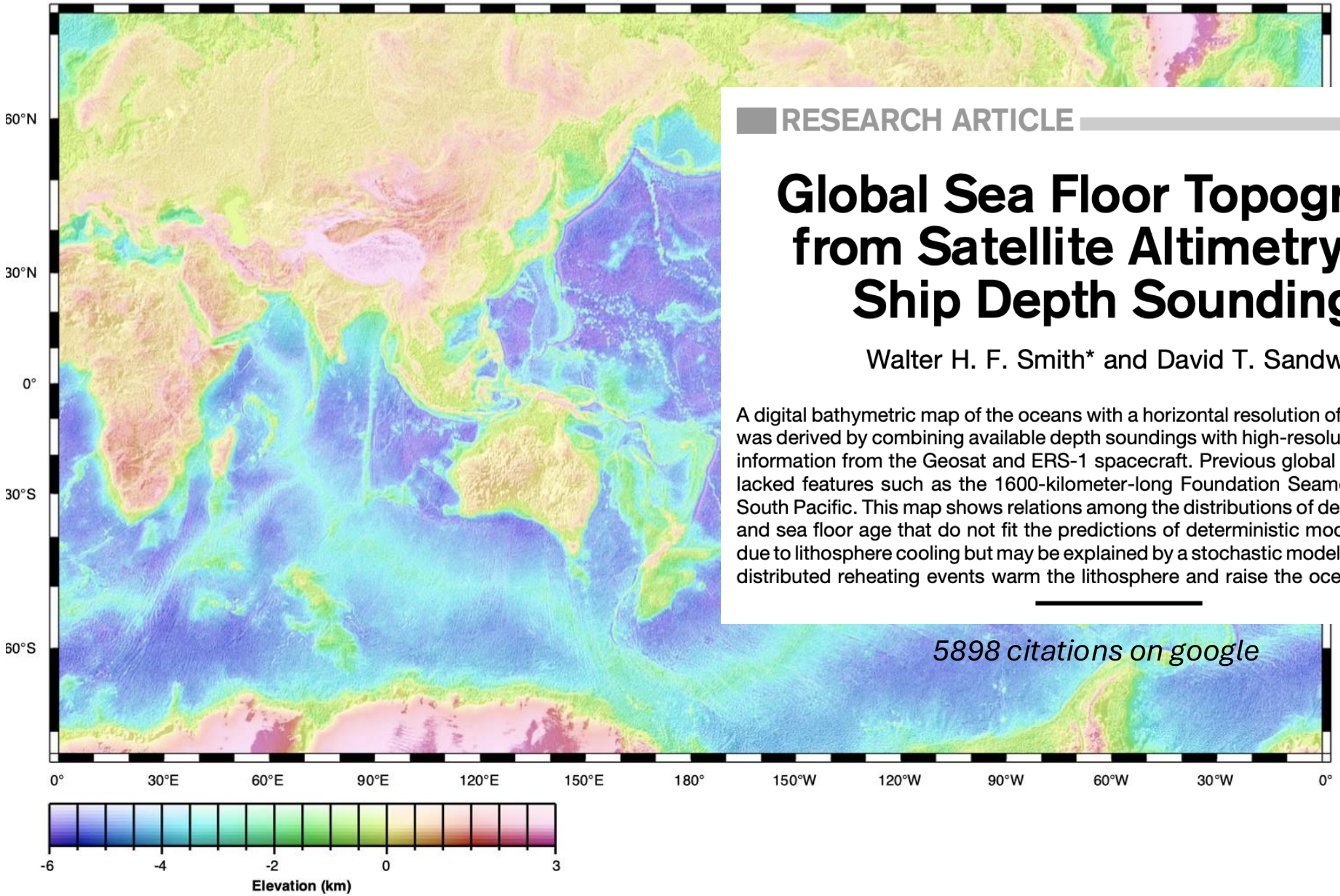
https://www.lpi.usra.edu/publications/slidesets/oceans/oceanviews/slide_09.html



Toward a global space-based interdisciplinary ocean observing system from the 1990s-present

- Dynamics and bathymetry from radar altimetry
- Winds from scatterometers
- Bottom-pressure and circulation from gravimetry
- Sea-surface temperature, salinity and density
- Chlorophyll, primary production, & carbon cycle science from color

Resulted in many highly-cited scientific contributions



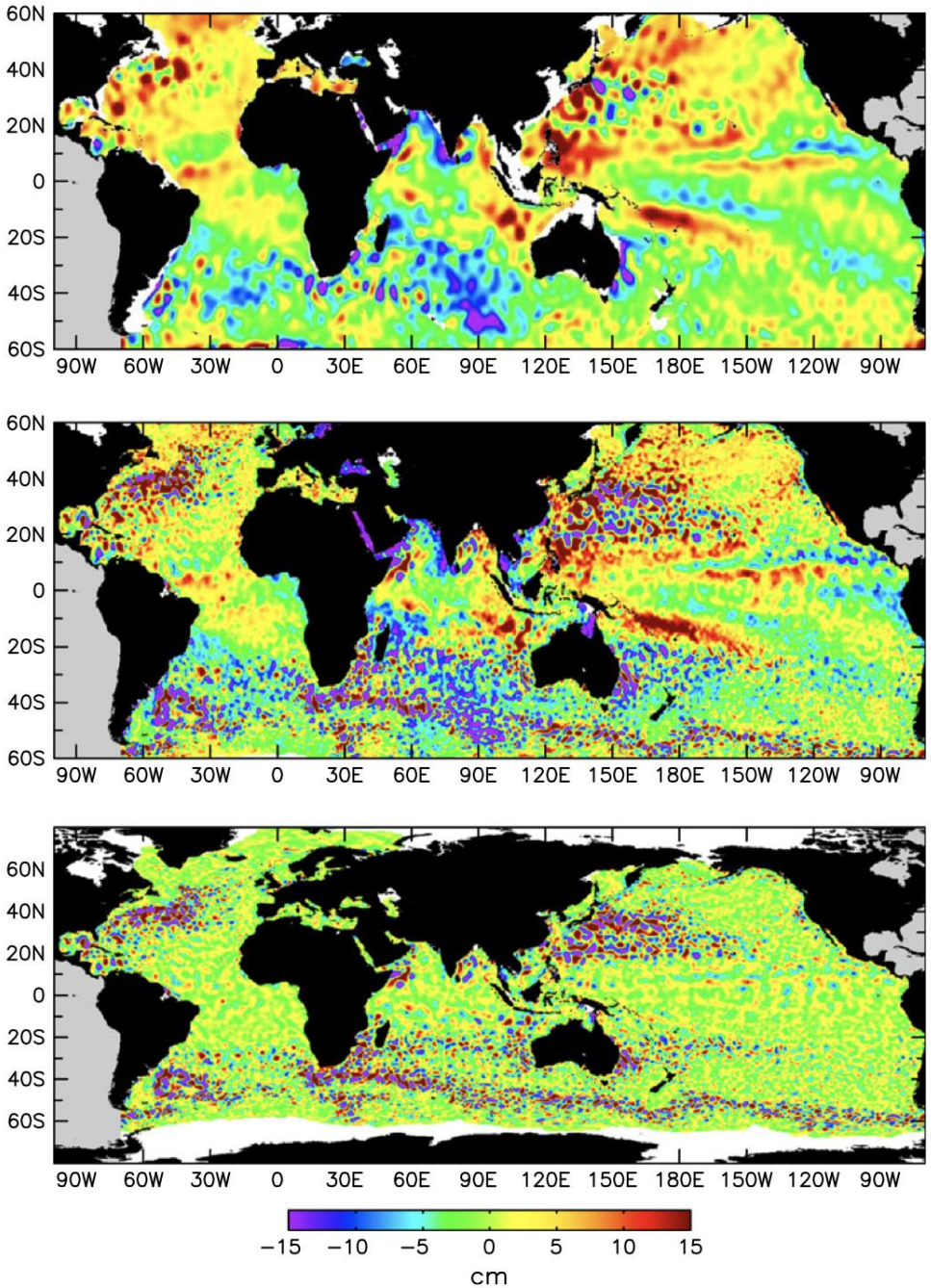
RESEARCH ARTICLE

Global Sea Floor Topography from Satellite Altimetry and Ship Depth Soundings

Walter H. F. Smith* and David T. Sandwell

A digital bathymetric map of the oceans with a horizontal resolution of 1 to 12 kilometers was derived by combining available depth soundings with high-resolution marine gravity information from the Geosat and ERS-1 spacecraft. Previous global bathymetric maps lacked features such as the 1600-kilometer-long Foundation Seamounts chain in the South Pacific. This map shows relations among the distributions of depth, sea floor area, and sea floor age that do not fit the predictions of deterministic models of subsidence due to lithosphere cooling but may be explained by a stochastic model in which randomly distributed reheating events warm the lithosphere and raise the ocean floor.

5898 citations on google



Progress in Oceanography 91 (2011) 167–216

Contents lists available at ScienceDirect

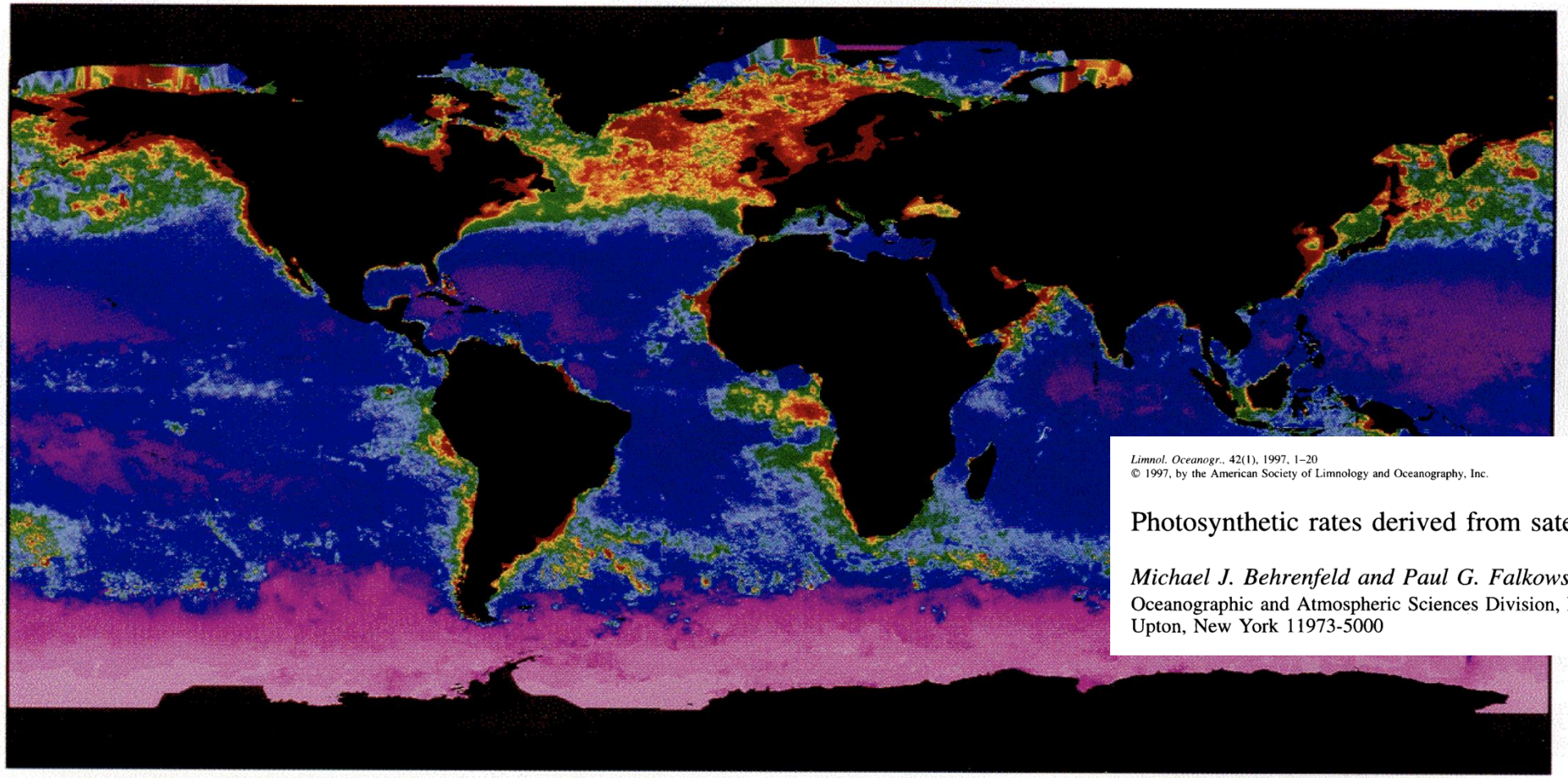
Progress in Oceanography

journal homepage: www.elsevier.com/locate/pocean

Global observations of nonlinear mesoscale eddies

Dudley B. Chelton *, Michael G. Schlax, Roger M. Samelson

2475 citations on google

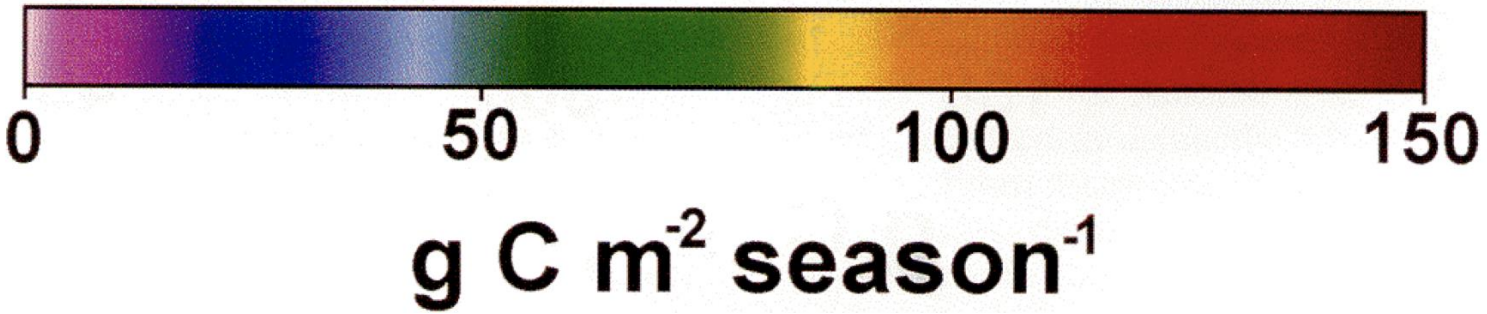


Limnol. Oceanogr., 42(1), 1997, 1–20
© 1997, by the American Society of Limnology and Oceanography, Inc.

Photosynthetic rates derived from satellite-based chlorophyll concentration

Michael J. Behrenfeld and Paul G. Falkowski
Oceanographic and Atmospheric Sciences Division, Brookhaven National Laboratory,
Upton, New York 11973-5000

3308 citations on google



NPP ~ 100 Pg C/yr, about even between the ocean and terrestrial biosphere

Coastal Zone Color Scanner

Today's ocean science builds on our legacy

Paul Scully-Power Photos

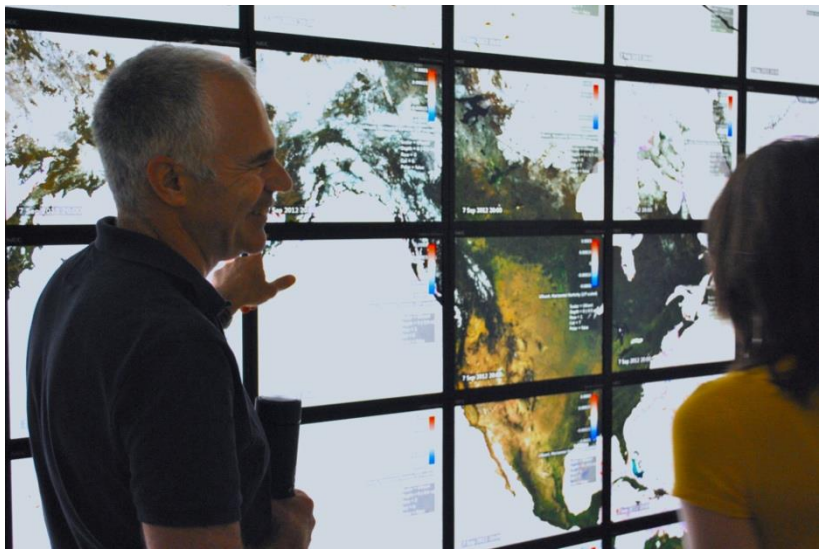


Observation of ubiquitous submesoscale eddies
1980s-1990s

Modeling And Process Studies



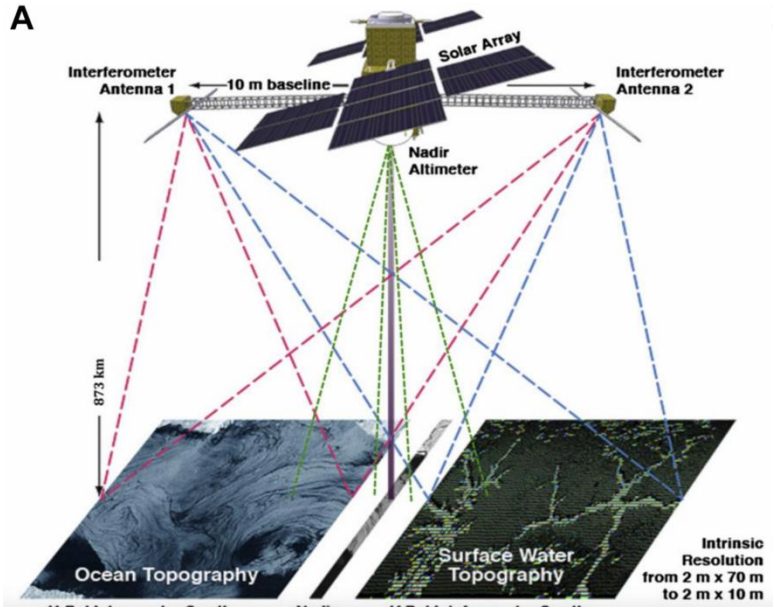




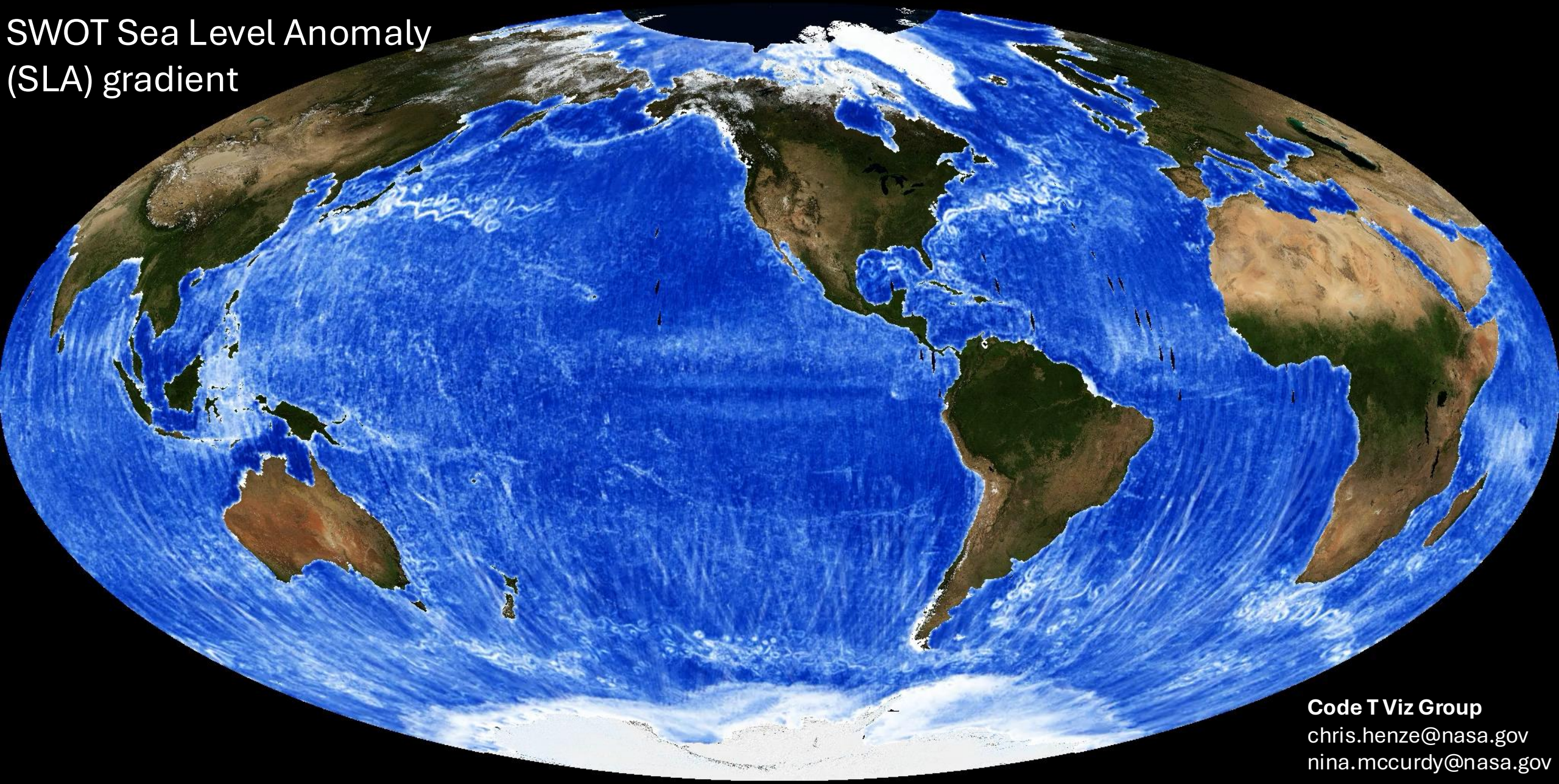
Submesoscales scale up to impact biogeochemical/climate dynamics
2000s-2010s

S-MODE EVS-3 (2018-2024)

SWOT launched Dec 2022



SWOT Sea Level Anomaly (SLA) gradient



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nina.mccurdy@nasa.gov

NASA Ames Pleiades mirror of L2 and L3 SWOT ocean data: /export1/nmccurdy/public/swot

A unique opportunity to: develop & use new technology, make discoveries, forge new collaborations, and create solutions for society

Surface Water and Ocean Topography
Launched December 2022



Plankton, Aerosol, Clouds, and Ocean Ecosystems
Launched February 2024

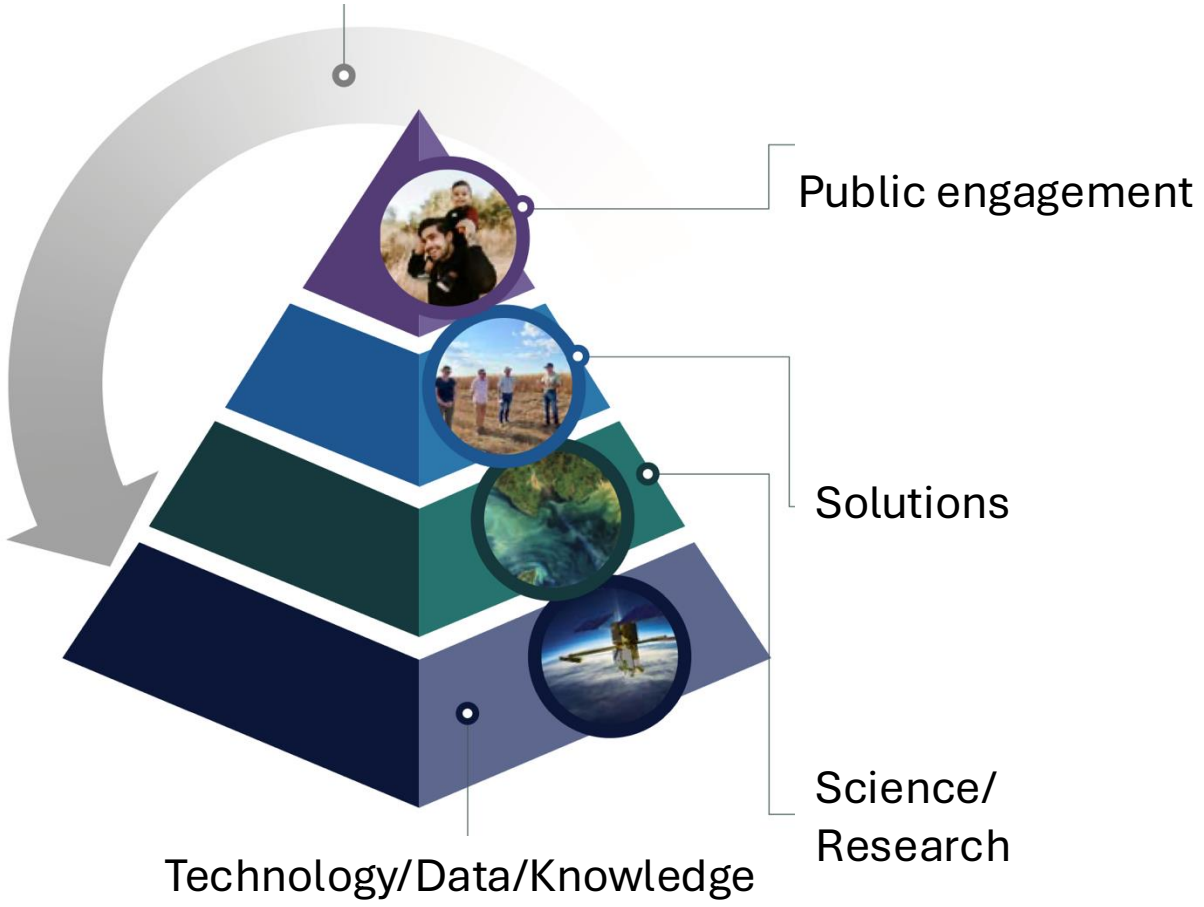


Missions designed for multi-disciplinary Earth system science and solutions:

- Terrestrial and marine surface water
- Atmospheric composition & ocean biology and biogeochemistry

Ames has a growing legacy of contributions to ocean science

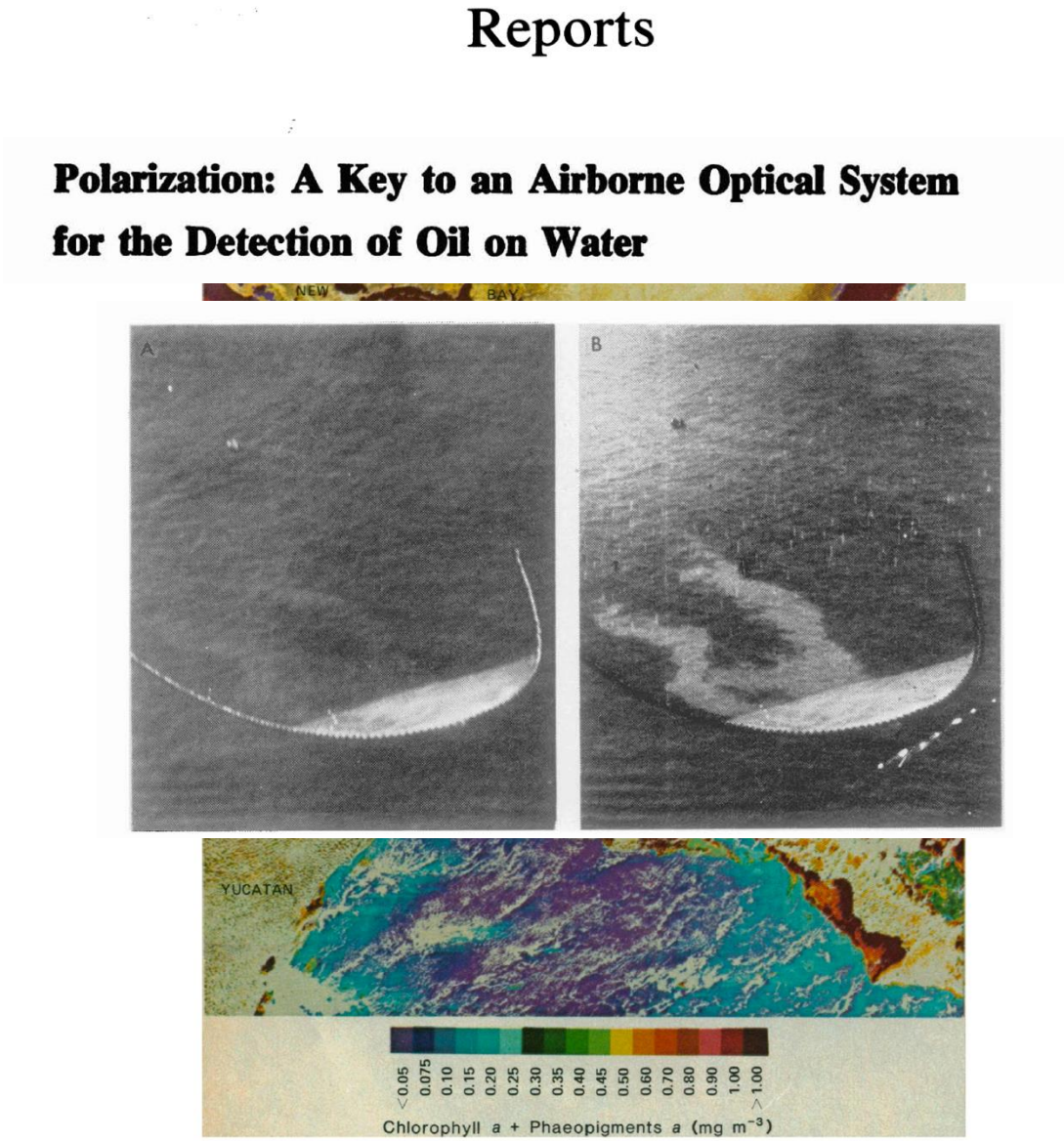
- Airborne/suborbital technology & field work
- Computing/analysis
- Science & Applications
  - Interdisciplinary science to solutions
  - Engagement & capacity building



NASA Earth Science to Action Strategy

Building on a quiet legacy in ocean sensing

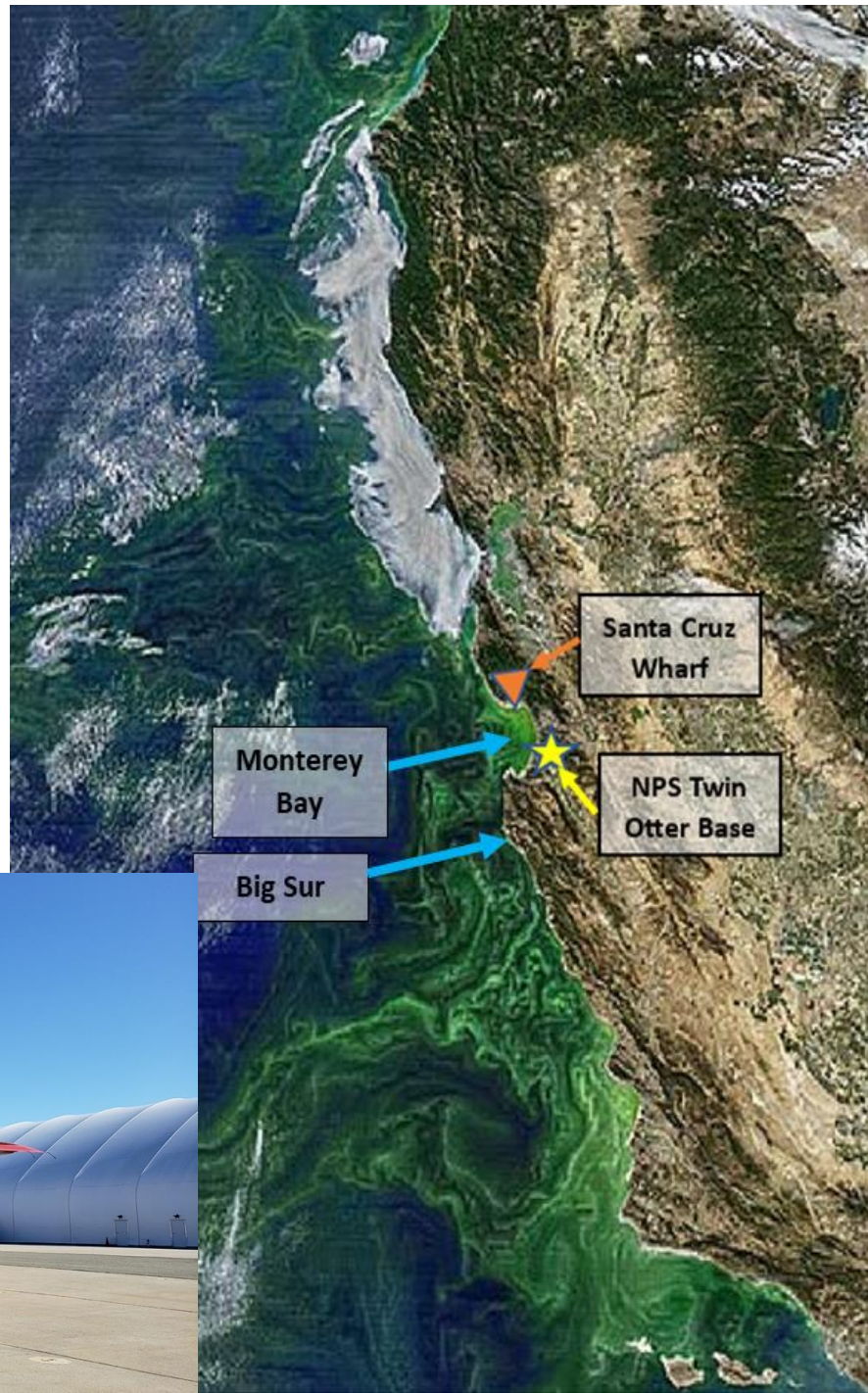
- Submarine hunting at Moffett Field.
- Airborne remote sensing of the ocean physics and biology and atmospheric correction in the 1970s-1980s
- Aircraft and support contributions for many field campaigns
  - Today ESPO @ Ames manages many NASA suborbital campaigns, such as S-MODE



PACE Validation with suborbital observations

- AirSHARP high resolution spatial and spectral data for validation of PACE Ocean Color Instrument
- SeaSTAR ship based sun photometer and sky polarimeter

Liane Guild (liane.s.guild@nasa.gov)
Stephen Broccardo (Stephen.p.broccardo@nasa.gov)







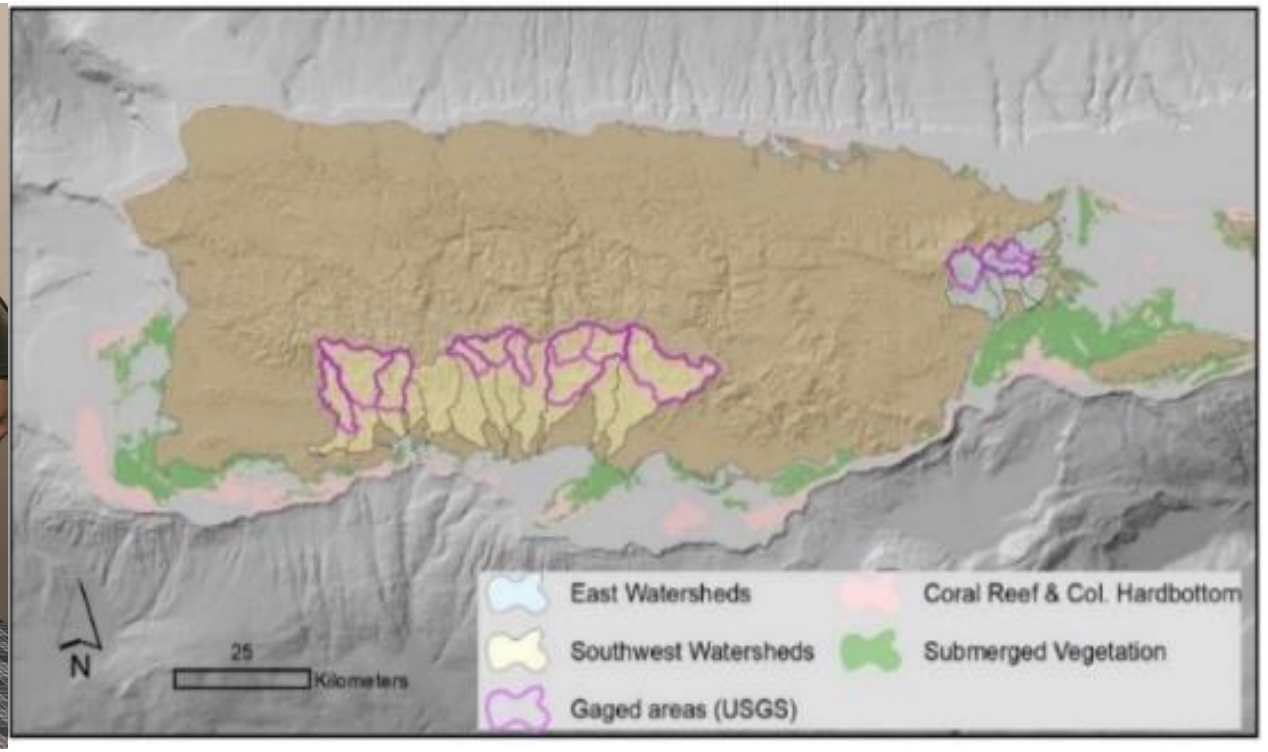
IDS: Interdisciplinary watershed to coastal science in Puerto Rico

Characterize river pollution in Puerto Rico and determine dynamics/causes and societal impacts/vulnerability

Juan Torres-Perez & Liane Guild

(juan.l.torres-perez@nasa.gov)





Ocean Community Engagement and Awareness using NASA Observations and Science for Hispanic/Latino Students (OCEANOS)

Juan Torres-Perez
(juan.l.torres-perez@nasa.gov)

- Capacitate low-income Hispanic/Latino high schoolers and 1st generation undergraduates on ocean color analysis with remotely-sensed imagery



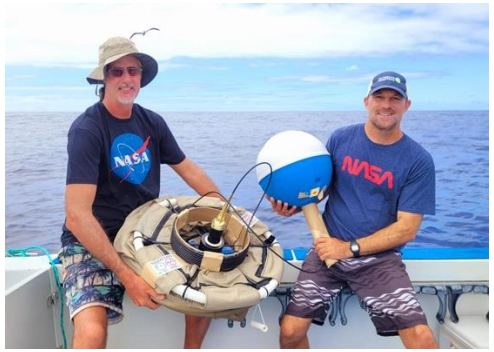
www.nasa.gov/oceanos

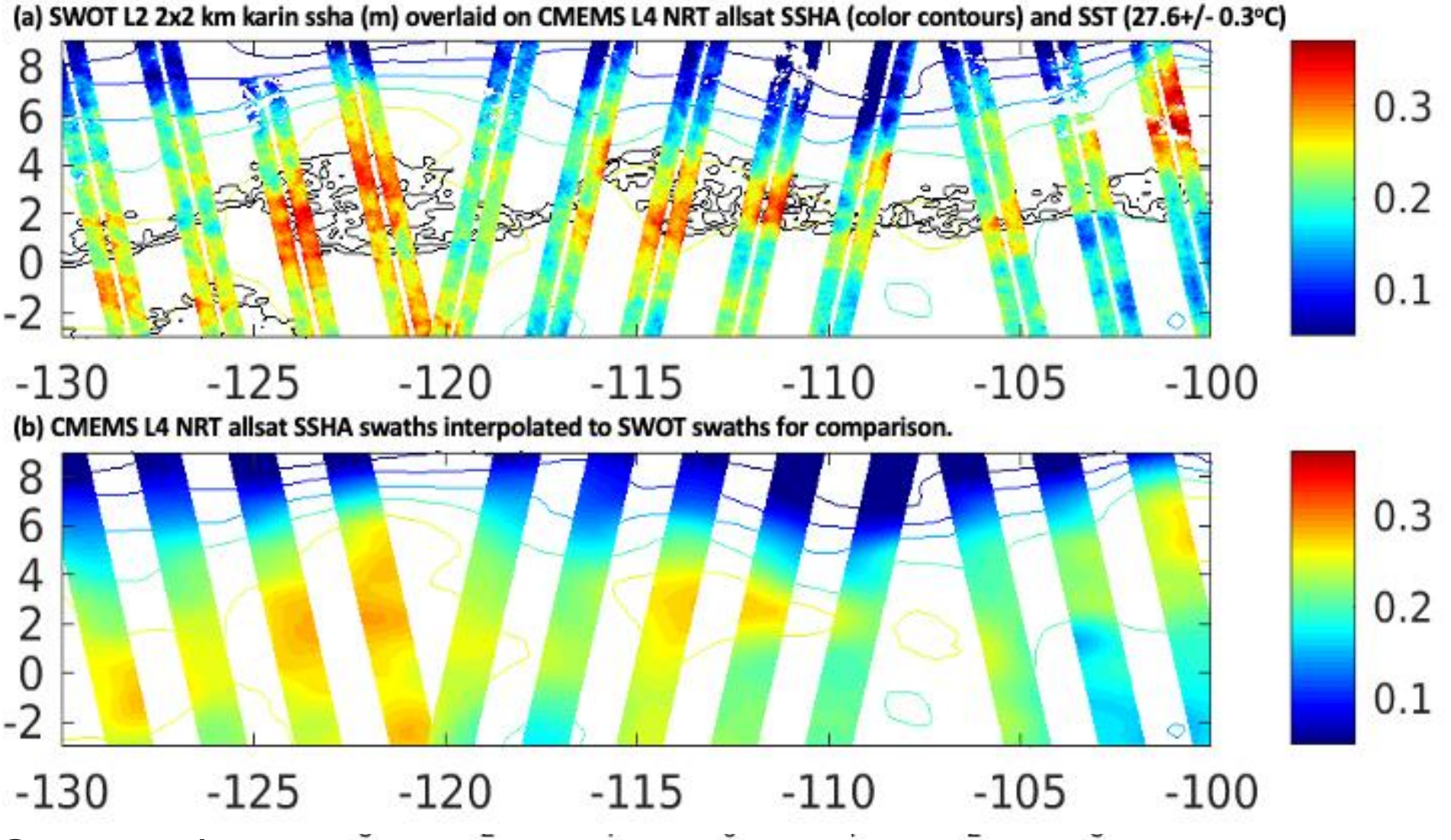
Using SWOT to quantify how small ocean eddies participate in El Niño/La Niña

Numerical simulations



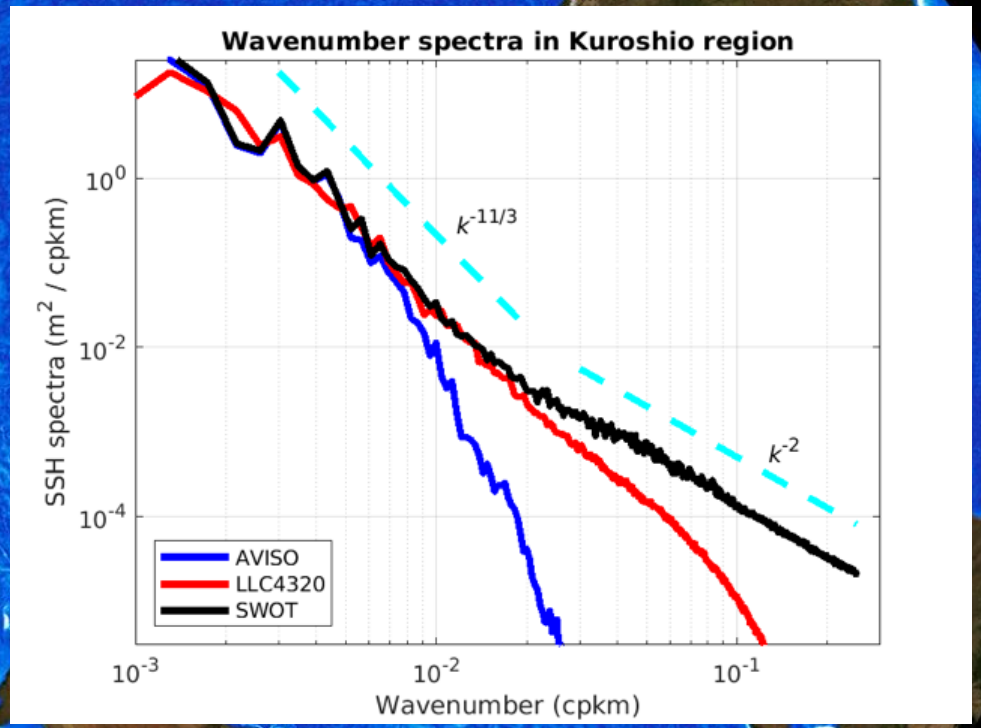
Lagrangian drifters

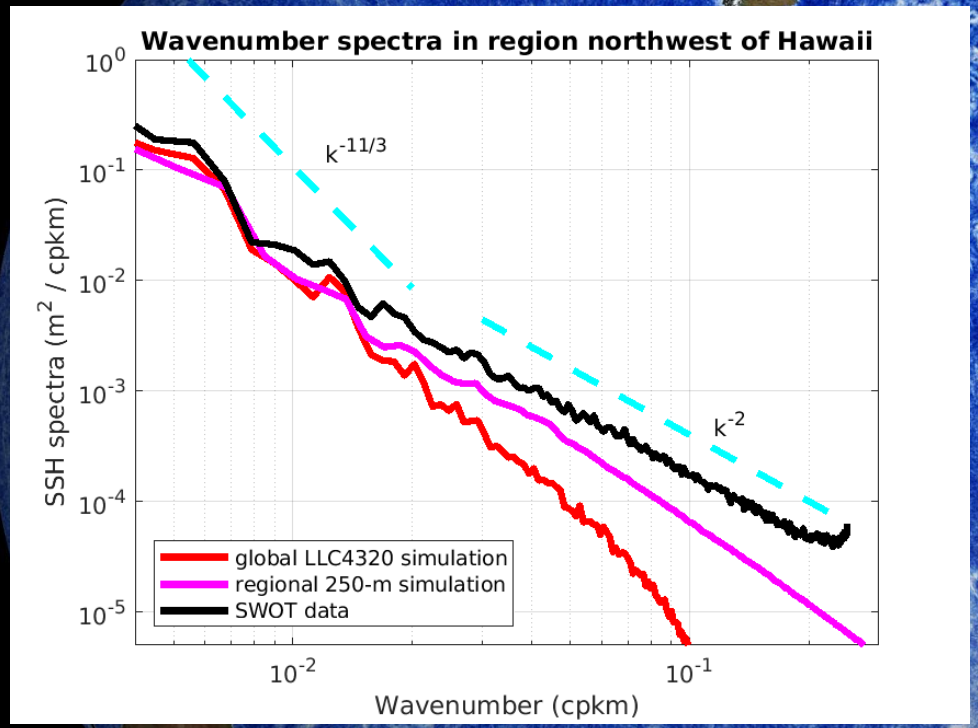




Dan Whitt (daniel.b.whitt@nasa.gov)

MAP: Using Ames supercomputers+SWOT to advance ultra-high resolution global ocean and climate simulation





ECCO
surface speed

SWOT
SLA gradient

Dimitris Menemenlis (JPL)

GEOS/ECCO animations available at https://data.nas.nasa.gov/geoseccoviz

Code T Viz Group
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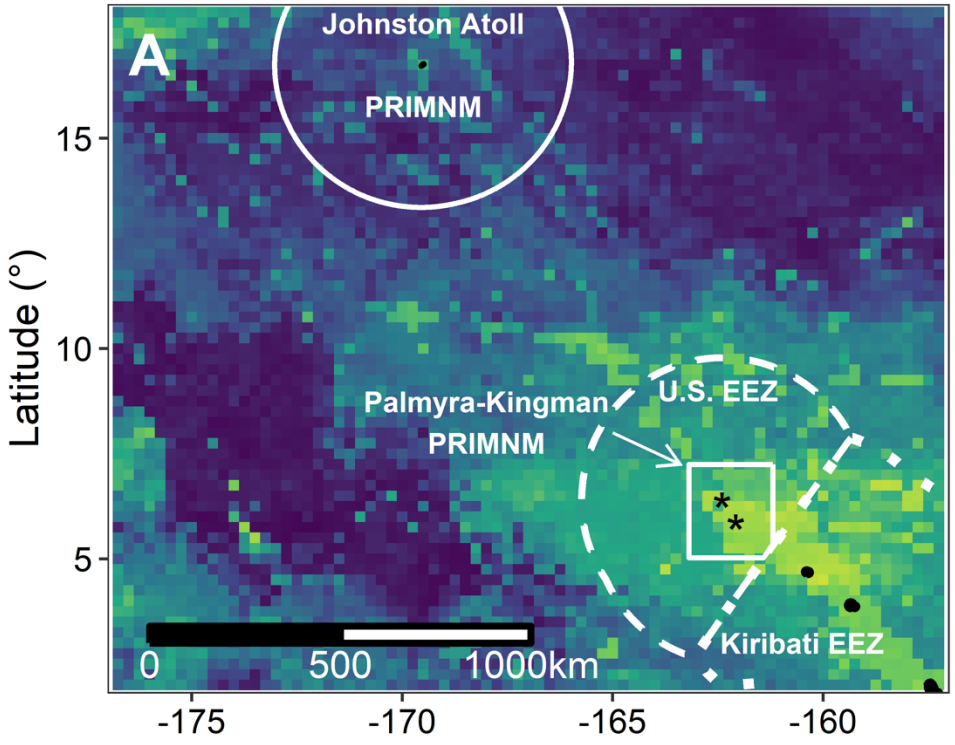
nina.mccurdy@nasa.gov
david.ellsworth@nasa.gov

How well do Marine Protected Areas protect species?

NASA Internet of Animals -- Palmyra Bluewater Research

Animal telemetry + Earth Observations + Modeling



In 2022, the MPA encompassed:

- 39% of tracks
- 73% of habitats

Under climate change scenarios:

- 52% of habitats



Morgan Gilmour
(morgan.e.gilmour@nasa.gov)










Collaborative project with: The Nature Conservancy, USGS, NOAA, & university partners

Ecological Conservation: Modeling drifting Fish Aggregating device (dFAD) TrajEctories

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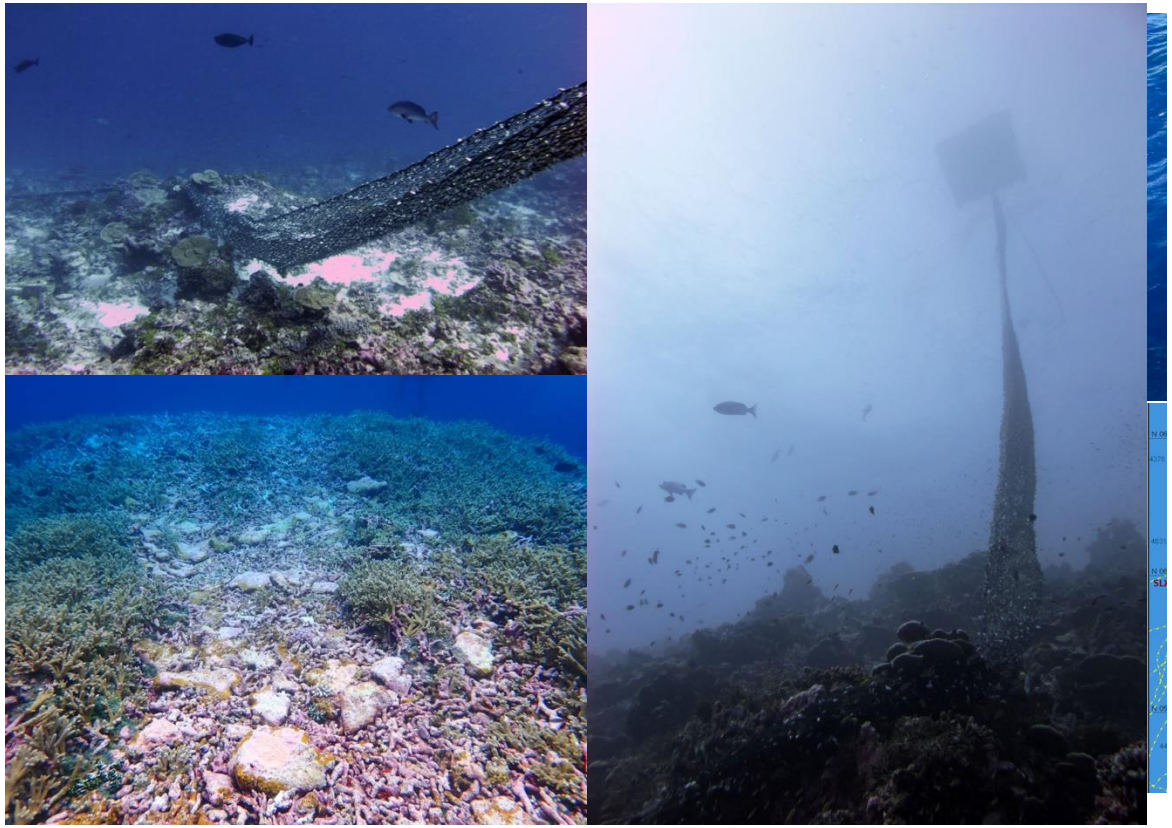
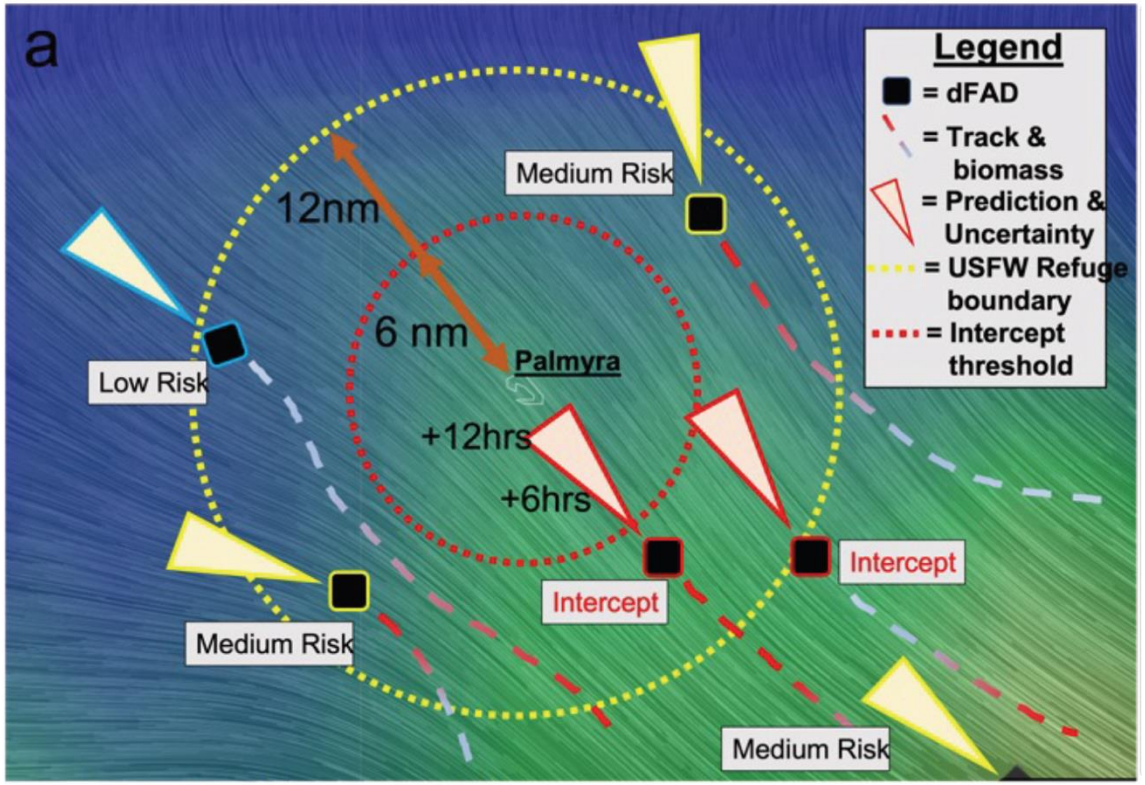
Ian Brosnan (ian.g.Brosnan@nasa.gov)
Dan Whitt (daniel.b.whitt@nasa.gov)





Looking to the future of ocean science at Ames…

- Advance ocean science by building on existing strengths
  - Suborbital & computing technology, interdisciplinary and actionable ocean science & engagement
  - Collaboration across disciplines, directorate, center and beyond
- Capitalize on the new space missions! Foster collaborations that make the most of and bridge SWOT, PACE, and Europa Clipper!





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