High Resolution Coastal Surface Temperatures from ECOSTRESS

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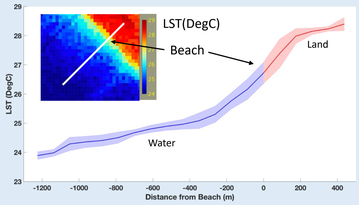
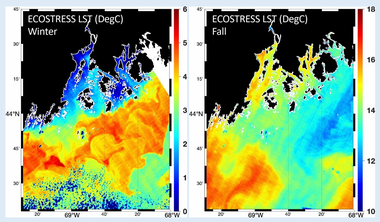
Motivation

- ECOSTRESS was launched in 2018 and is installed on the International Space Station
- Provides a pathfinder for future high-resolution thermal missions like SBG, TRISHNA and LSTM
- High spatial resolution allows sampling where sensors like MODIS and VIIRS are too coarse
- Non-uniform overpass times
- Ability to extract data up to and across the land-water interface

Shore Temperature Profiles (STP) are transects perpendicular to shore where ECOSTRESS data are extracted.

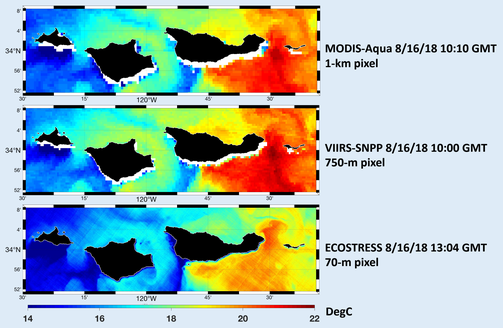


Example ECOSTRESS shore temperature profile from Cape Sable, FL acquired on February 17, 2019.

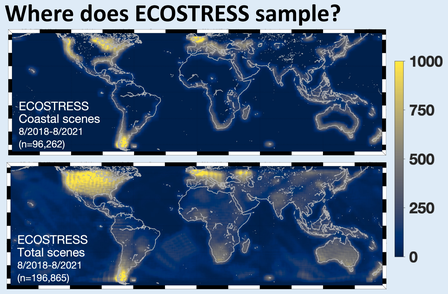


14 JAN 2019 0338 GMT 19 SEP 2021 0558 GMT

The Gulf of Maine is one of the fastest warming water bodies on Earth (GMRI, 2021) and exhibits high temperature variability, particularly in narrow inlets. ECOSTRESS provides data from these areas, while existing SST sensors with 1-km or 750-m resolution cannot reliably sample.



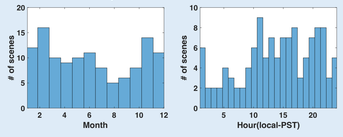
Where does ECOSTRESS sample?



Heatmaps of ECOSTRESS scenes collected from August 2018-August 2021. **A.** ECOSTRESS scenes which intersect the coastline (N=96,262). **B.** Total ECOSTRESS scenes (N=196,865).

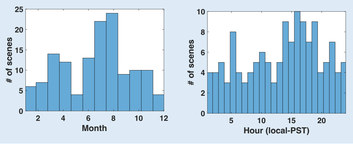
When does ECOSTRESS sample?

Channel Islands, CA



Overpass months and times for cloud-free Channel Island images (n=120)

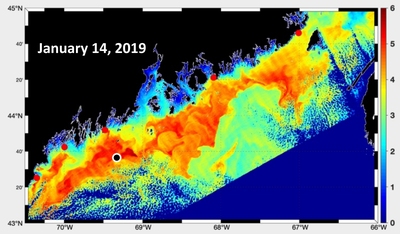
Salish Sea, BC



Overpass months and times for cloud-free Salish Sea images (n=139)

Validation

ECOSTRESS LST values have been validated with two types of in situ sensors, a buoy in the Gulf of Maine maintained by NERACOOS and a set of biomimetic loggers deployed by the Helmuth Lab at Northeastern University.



Composite of two ECOSTRESS scenes acquired over the Gulf of Maine. The location of biomimetic loggers are shown in red and the NERACOOS buoy in black.

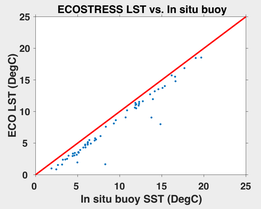
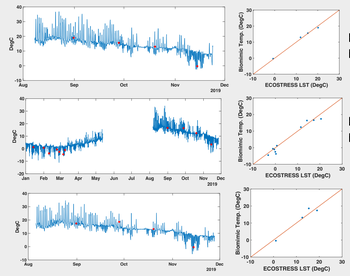


Image courtesy of ElectricBlue.



Rocky shore at Bailey Island, ME
Mid tidal zone, exposed location

Rocky shore at Chamberlain, ME
Mid tidal zone, exposed location

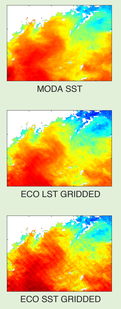
Rocky shore at Biddeford, ME
Mid tidal zone, exposed location

Data courtesy of the Helmuth Lab at Northeastern University

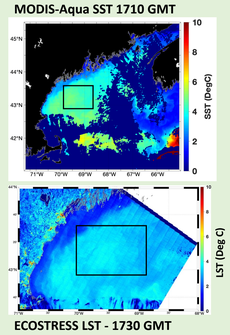
Biomimetic loggers are attached directly to the substrate in intertidal locations and can be encapsulated in housings to mimic mussels, limpets, or rocks. Data is retrieved remotely by holding a phone near the logger.

ECOSST

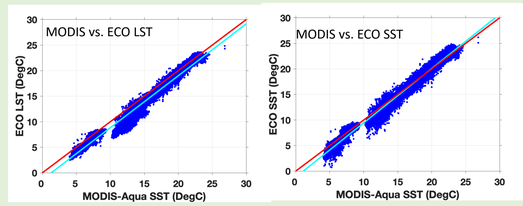
We have developed a split-window SST algorithm for ECOSTRESS (ECOSST) and validated with comparisons to SST data from the Moderate Resolution Imaging Spectroradiometer (MODIS-Aqua) sensor. Coefficients $a_0 - a_5$ were derived for ECOSTRESS from model simulations as in Hulley et al. 2011. T_4 and T_5 are are ECOSTRESS brightness temperatures measured at bands 4 and 5.



Example scenes - 22 FEB 2019 1710 GMT (top) and 1730 GMT (middle and bottom).



$$SST = a_0 + a_1 T_4 + a_2(T_4 - T_5) + a_3(T_4 - T_5)(1 - sec(\theta))$$



Red = 1:1 ; Lt. Blue = Best fit

11 daytime image pairs; ~154,000 pixels

Examples

Vancouver, BC and the Salish Sea

Heatwaves: June 26-29, July 28-30, August 12-13

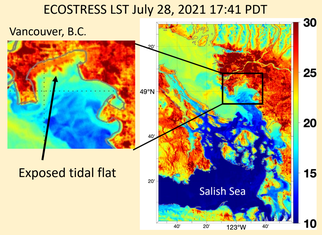
The Washington Post 7/8/2021

Crushing heat wave in Pacific Northwest and Canada cooked shellfish alive by the millions

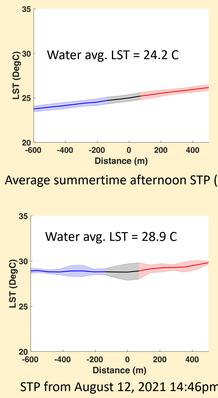
Image courtesy of Hamahama Oysters

Image courtesy of Edward Aites

ECOSTRESS LST July 28, 2021 17:41 PDT



In June, July and August of 2021, beaches here experienced elevated surface temperatures and widespread mortality of mussel beds.



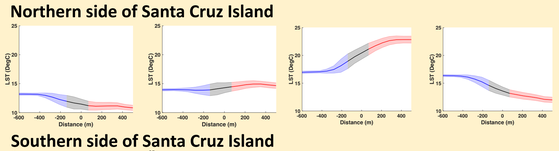
Average summertime afternoon STP (n=23)

STP from August 12, 2021 14:46pm PDT

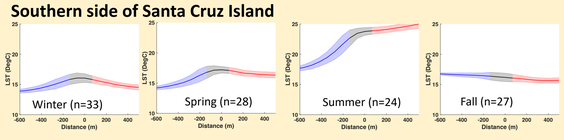
Shore Temperature Profiles from Santa Cruz island in the Channel Islands, CA

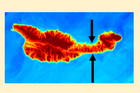
Shore Temperature Profiles (STP) from the northern and southern fa80NSSC20K0075cing shorelines of Satna Cruz Island show markedly different patterns over the year. Water, swash zone (gray region of STP) and land temperatures are higher on the southern facing side. In the swash zone, temperature ranges which organisms living on the beach are exposed to are also markedly higher on the southern facing side (red rectangle).

Northern side of Santa Cruz Island



Southern side of Santa Cruz Island





Comparison of north and south sides of Santa Cruz Island

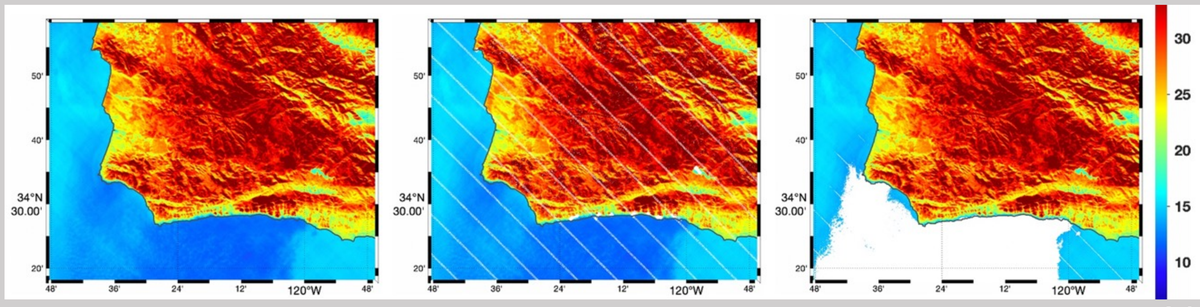
Season	Site	Water Temp.	Swash Temp.	Swash Range	Land Temp.
Winter	North	13.2	**12.8**	**6.2**	11.4
	South	14.0	**15.2**	**16.5**	15.3
Spring	North	13.9	**13.9**	**7.6**	14.5
	South	14.4	**15.9**	**15.9**	16.7
Summer	North	16.9	**17.5**	**9.3**	21.4
	South	17.9	**20.7**	**13.9**	24.12
Fall	North	16.3	**15.7**	**10.1**	13.0
	South	16.7	**16.5**	**13.3**	15.9

Average surface temperature values and ranges calculated from STPs in degrees C.

ECOSTRESS Collection 2

The ECOSTRESS program is undergoing major revisions in 2022, with Collection 2, which began with Science Data System (SDS) Build 7.0 (B7.0) provisional products in March 2022, to be followed by a public release of Build 7.1 in the fall of 2022. Specific improvements include:

- Level 1B Calibration and geo-location improvements
- Streamlined, cloud-enabled file formats (including tiled products matching Sentinel-2 tiles)
- Improved cloud and land masking



ECOSTRESS LST (degC) collected over Pt. Conception on the California Coast on November 30th, 2021 with no cloud mask applied (left), with the Version 1 Cloud Mask (center) and with the Version 2 Cloud Mask in Collection 2 (right).

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References: Gulf of Maine Research Institute. 2022. Gulf of Maine Warming Update: 2021 the Hottest Year on Record. https://gmri.org/stories/warming-21

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Hulley, G. C., Hook, S.J., and Schneider, P. (2011). Optimized split-window coefficients for deriving surface temperatures from inland water bodies. *Rem. Sens. Env., 115*(12), 3758-3769. doi:doi:10.1016/j.rse.2011.09.014

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