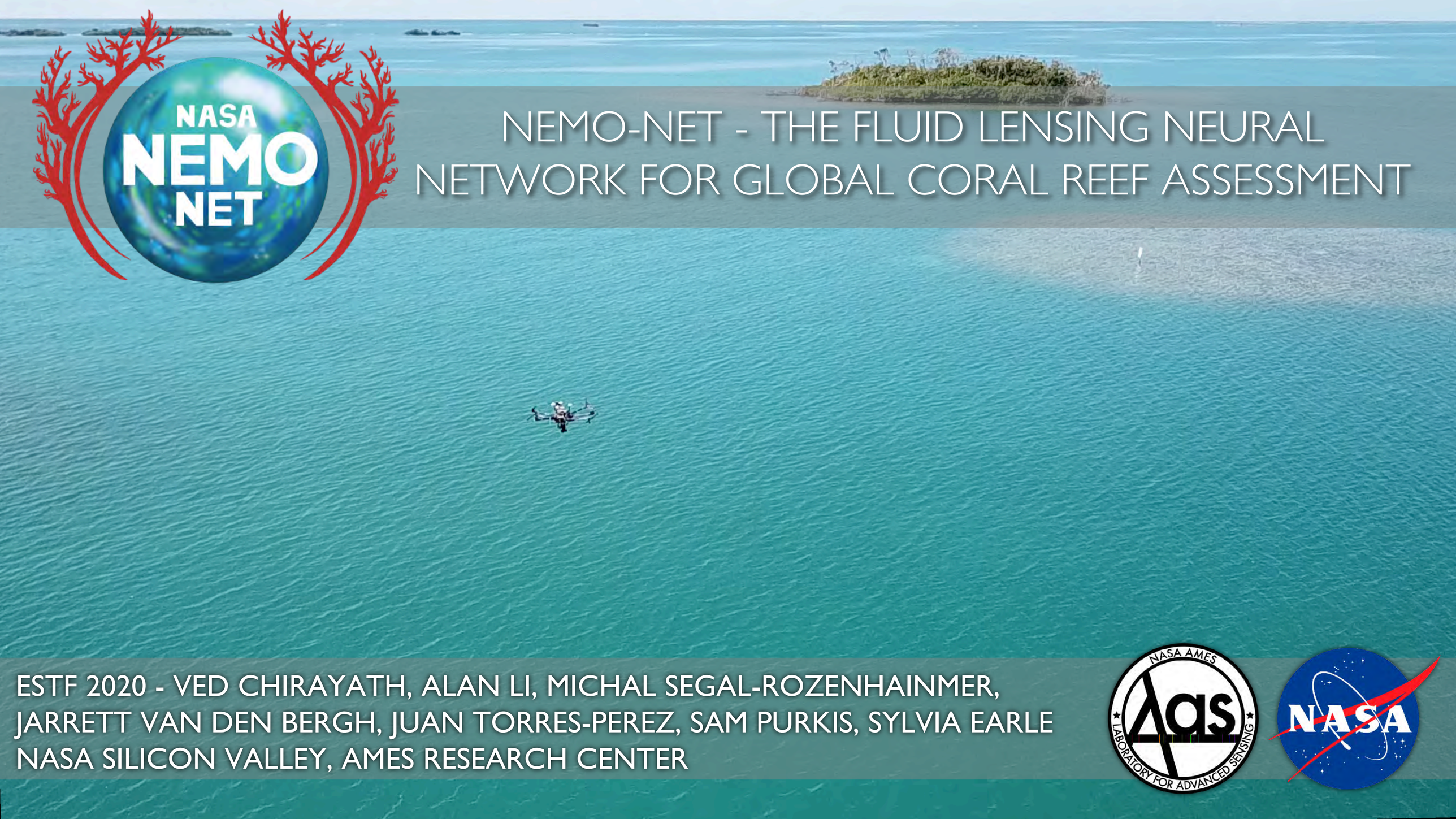


NEMO-NET - THE FLUID LENSING NEURAL NETWORK FOR GLOBAL CORAL REEF ASSESSMENT

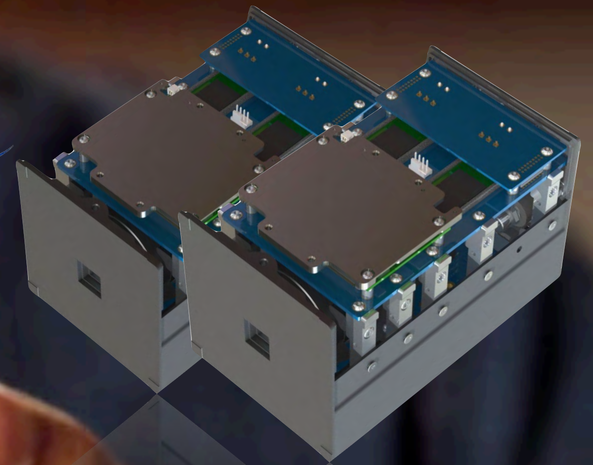
ESTF 2020 - VED CHIRAYATH, ALAN LI, MICHAL SEGAL-ROZENHAINMER, JARRETT VAN DEN BERGH, JUAN TORRES-PEREZ, SAM PURKIS, SYLVIA EARLE
NASA SILICON VALLEY, AMES RESEARCH CENTER

Video link: http://nemonet.info

FluidCam

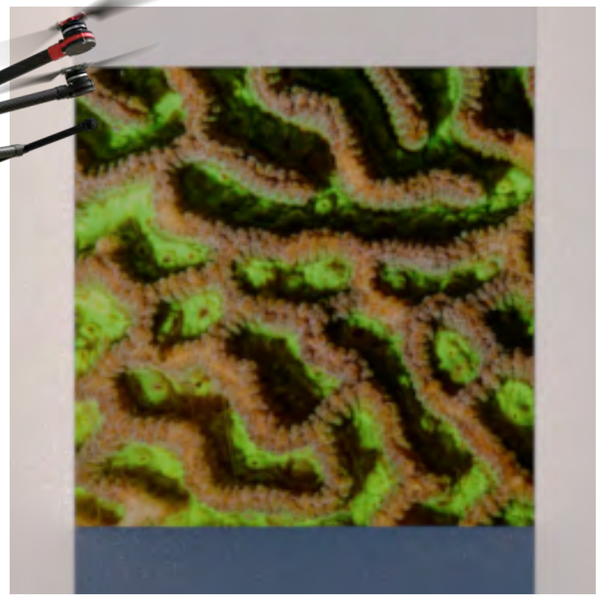
FLUID LENSING CAMERA

FluidCam

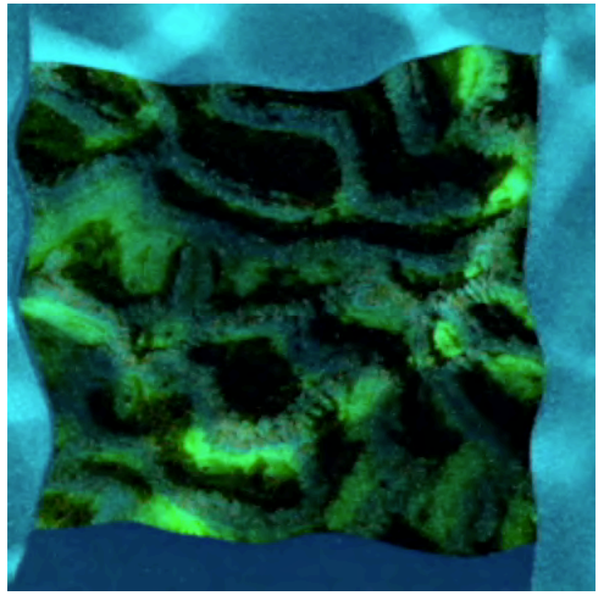


2D Fluid Lensing Algorithm, Coral Test Target, Depth = 4.5m, MSL

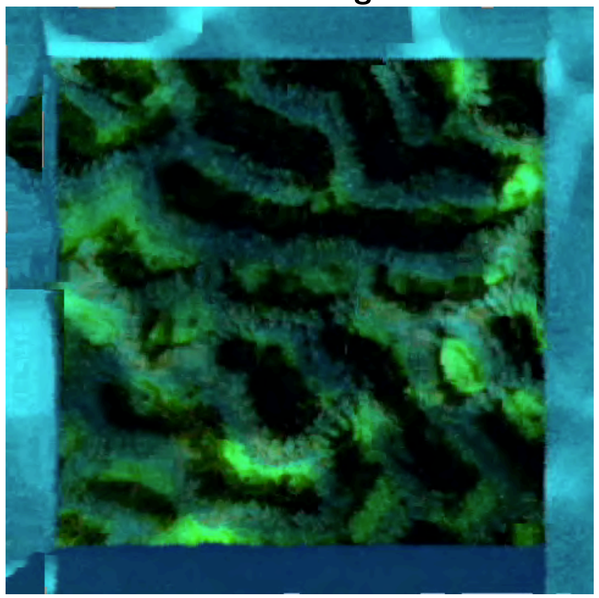
No Fluid



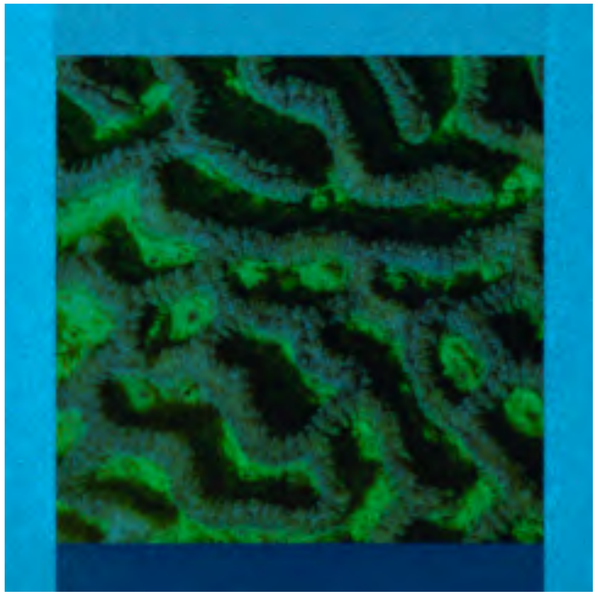
Raw Distorted Frames



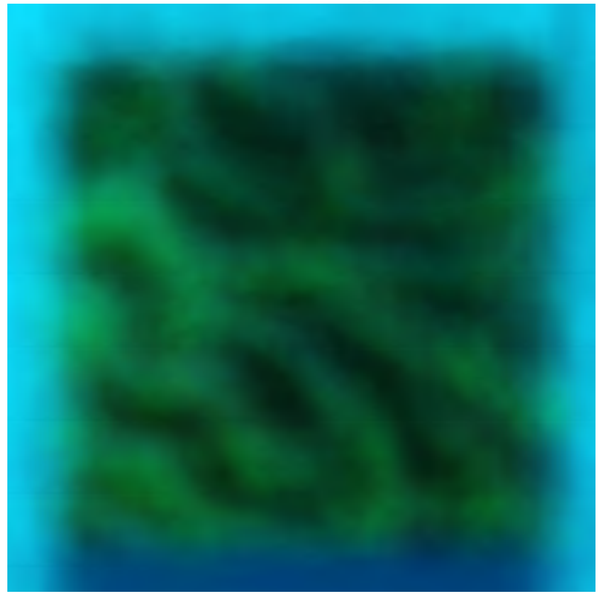
2D Fluid Lensing Results



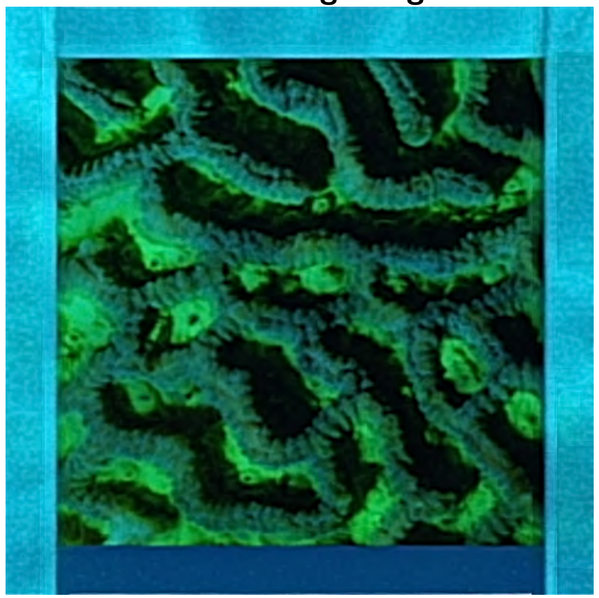
Flat Fluid

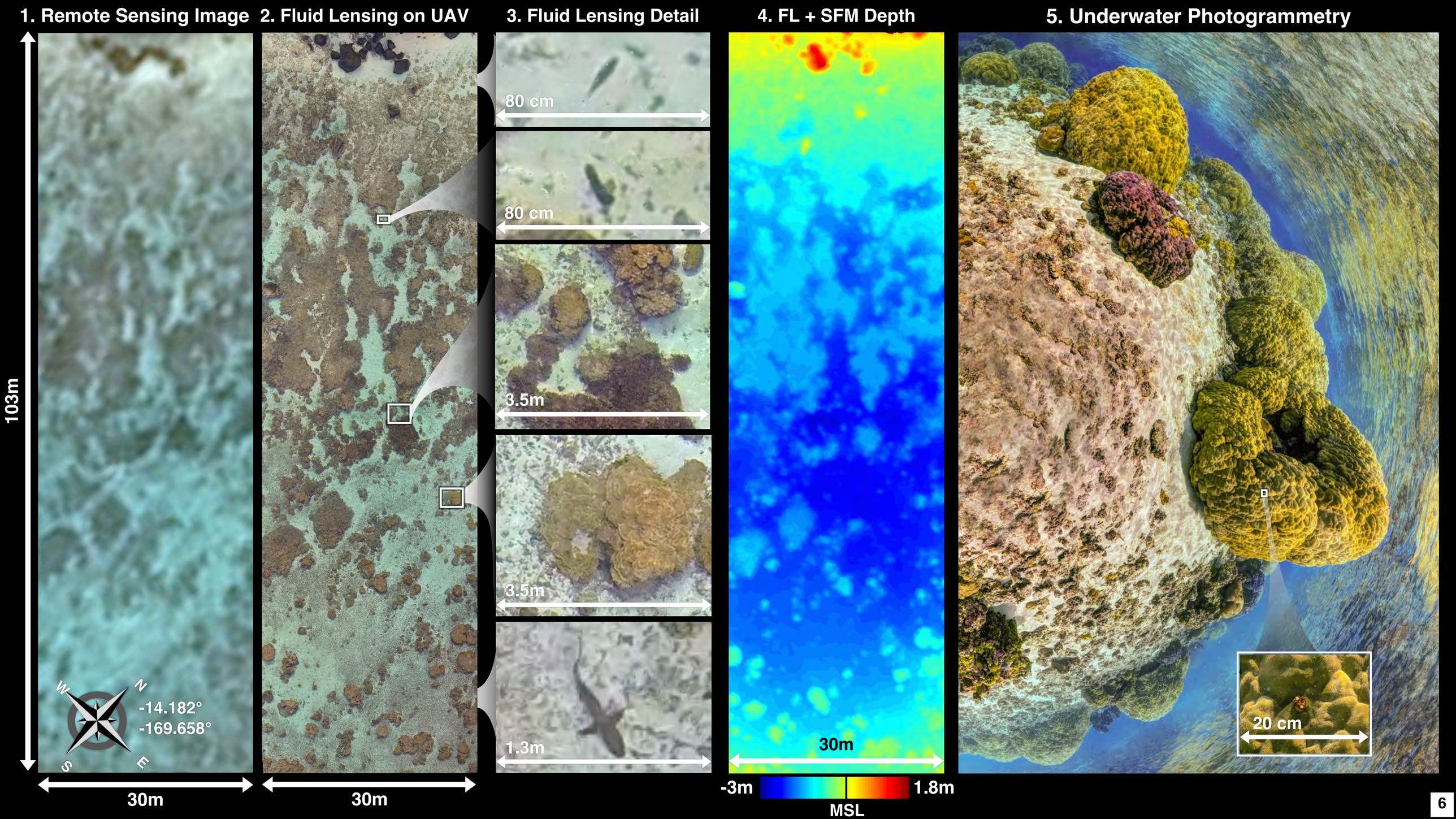


Mean Image



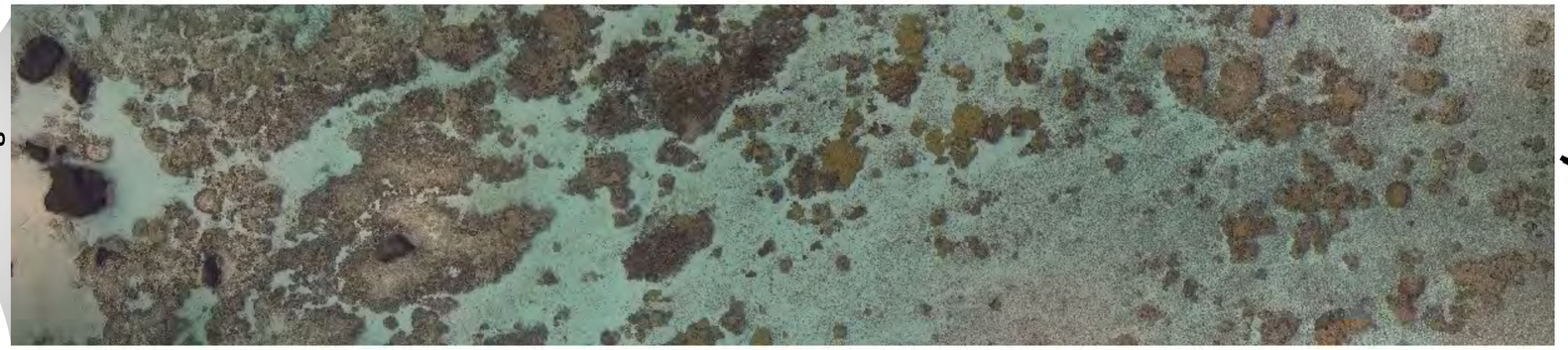
2D Fluid Lensing Integration




1. Remote Sensing Image
2. Fluid Lensing on UAV
3. Fluid Lensing Detail
4. FL + SFM Depth
5. Underwater Photogrammetry
103m
30m
30m
N
W
E
S
-14.182°
-169.658°
80 cm
80 cm
3.5m
3.5m
1.3m
30m
-3m
1.8m
MSL
20 cm
6

1 cm

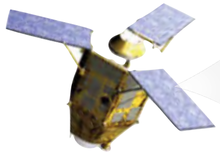
Airborne Fluid Lensing



30 cm

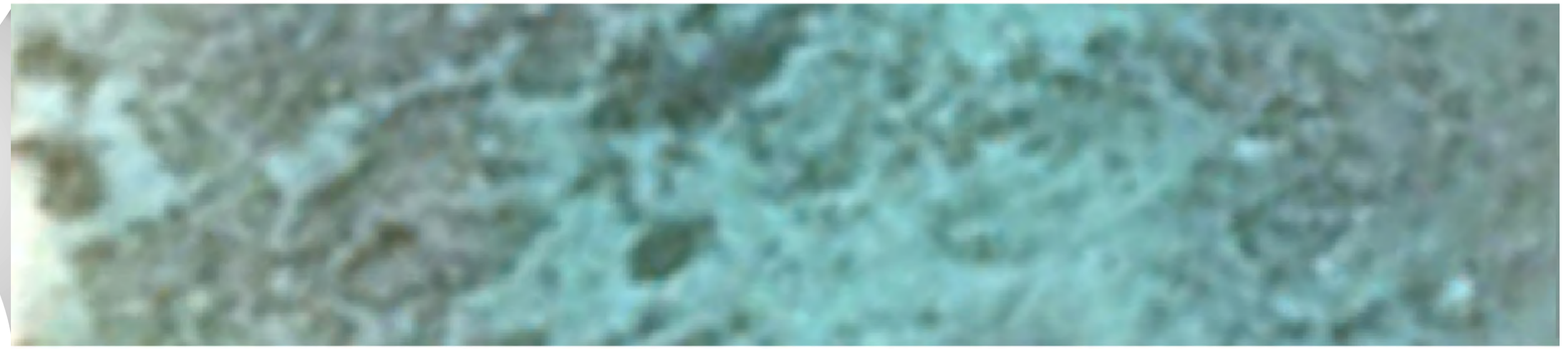
Airborne

?



50 cm

Pleiades 1-A



?

2 m

WorldView-2

?

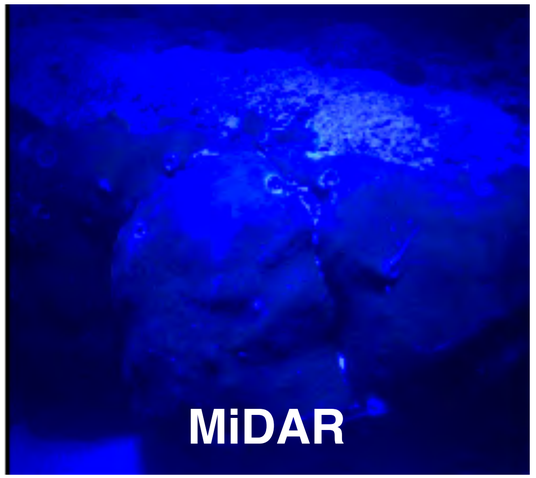
Can FluidCam & MiDAR 3D imagery augment low resolution 2D imagery?

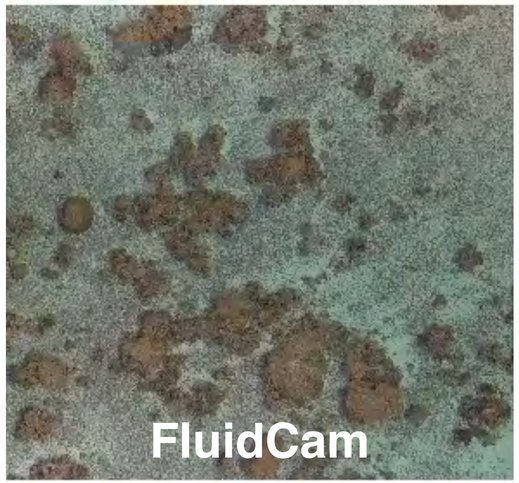
NEMO-NET OBJECTIVES

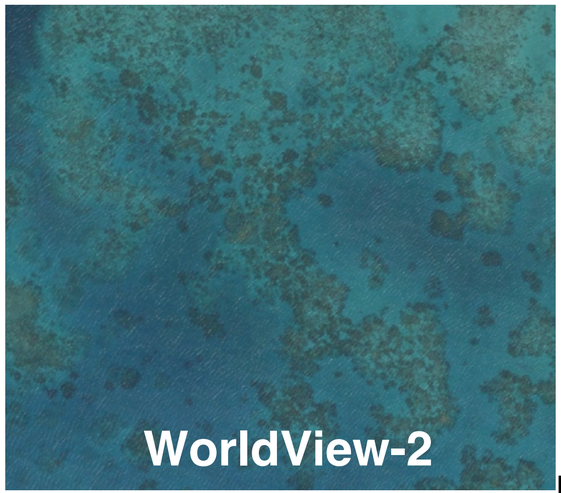
1) *Develop an accurate algorithm for mapping coral reefs with remote sensing at different scales.*
2) *Globally assess the present and past dynamics of coral reef systems through a large-scale active learning convolutional neural network.*
3) *Implement domain transfer learning for spectral and spatial resolution transfer learning (super resolution) across multiple sensors.*
4) *Create 3D active learning CNN training game for data training from multiple sensors.*

NEMO-NET DATA SOURCES

	Sensor	Effective Spatial Resolution	3D	Spectral Bands	Locations
	Underwater AUV	0.1 - 5 cm	YES	3	Australia, Great Barrier Reef, Pacific
	FluidCam & MiDAR (NASA)	**0.1 - 1 cm**	**YES**	**3-7**	American Samoa, Guam, Western Australia, Puerto Rico, Indo-Pacfifc
	QuickBird (USGS)	0.65 m	NO	4	US Territories
	WorldView-2/3	**0.5 - 3 m**	**NO**	**8**	Global
	LandSat (USGS)	**30 m**	**NO**	**11**	Global





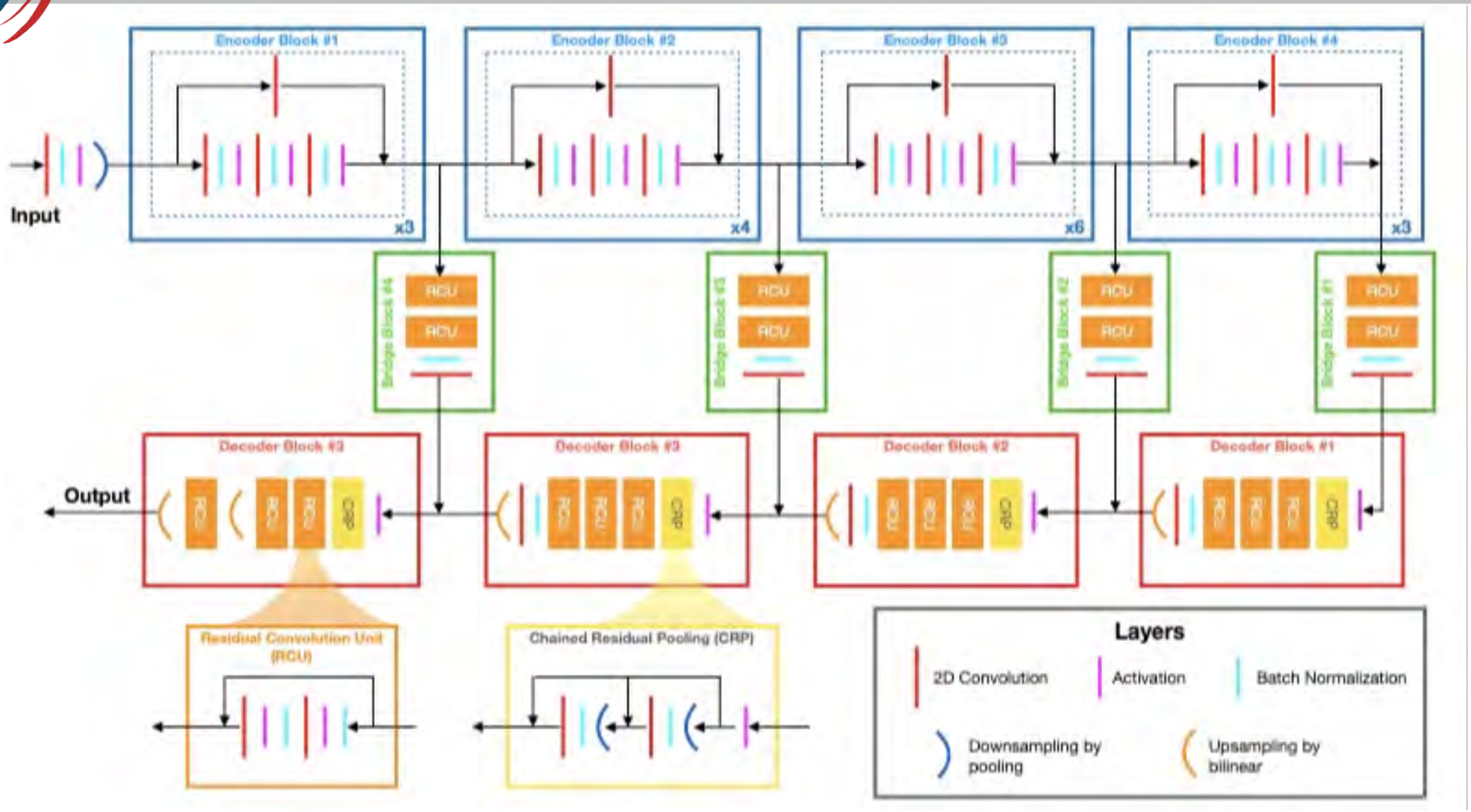


NEMO-NET CLASSIFICATION HIERARCHY

Level 1	Level 2	Level 3	Level 4
Zone	**Biological Cover**	**Biological Morphology**	**Biological Family**
Coral/Algae	Live Coral	Branching Coral	Acroporidae
Bare Substratum	Algae	Massive Coral	Poritidae
Seagrass	Seagrass	Soft Coral	Gorgoniidae
Deep water	Mangrove	Macroalgae	Merulinidae
Clouds	Bare Substratum	Turf algae	Montastraeidae
Breaking Waves	Invertebrate	Seagrass	Mussidae
Beach (Sand, Rock, Dark)	Unknown	Mangrove	Plexauridae
Terrestrial Vegetation		Bare Substratum	Agariciidae
Unknown		Invertebrate	Siderastreidae
		Unknown	Pocilloporidae
			Pectiniidae
			Fungiidae
			Green Algae
			Brown Algae
			Red Algae
			Seagrass
			Mangrove
			Bare Substratum
			Invertebrate
			Unknown

NEMO-NET FCNN ARCHITECTURE

FluidCam, MiDAR, WorldView, Sentinel…



CNN structure of NeMO-Net. The encoder blocks downsamples the data as it extracts deeper and deeper features, the bridge blocks pass the intermediate feature maps to the decoder, and the decoder blocks reconstructs the classification map from the

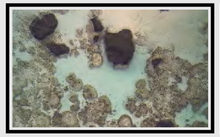
CLASSIFICATION IS HARD & CNNS NEED TRAINING DATA

Chihuahua vs. Blueberry Muffin

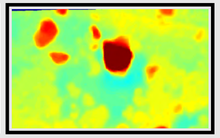
Bagel vs. Sleeping Dog

Mop vs. Hungarian Sheepdog

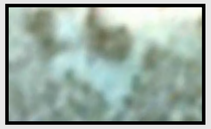
MM-Scale Airborne Fluid Lensing



MM-Scale Airborne Fluid Lensing DEM



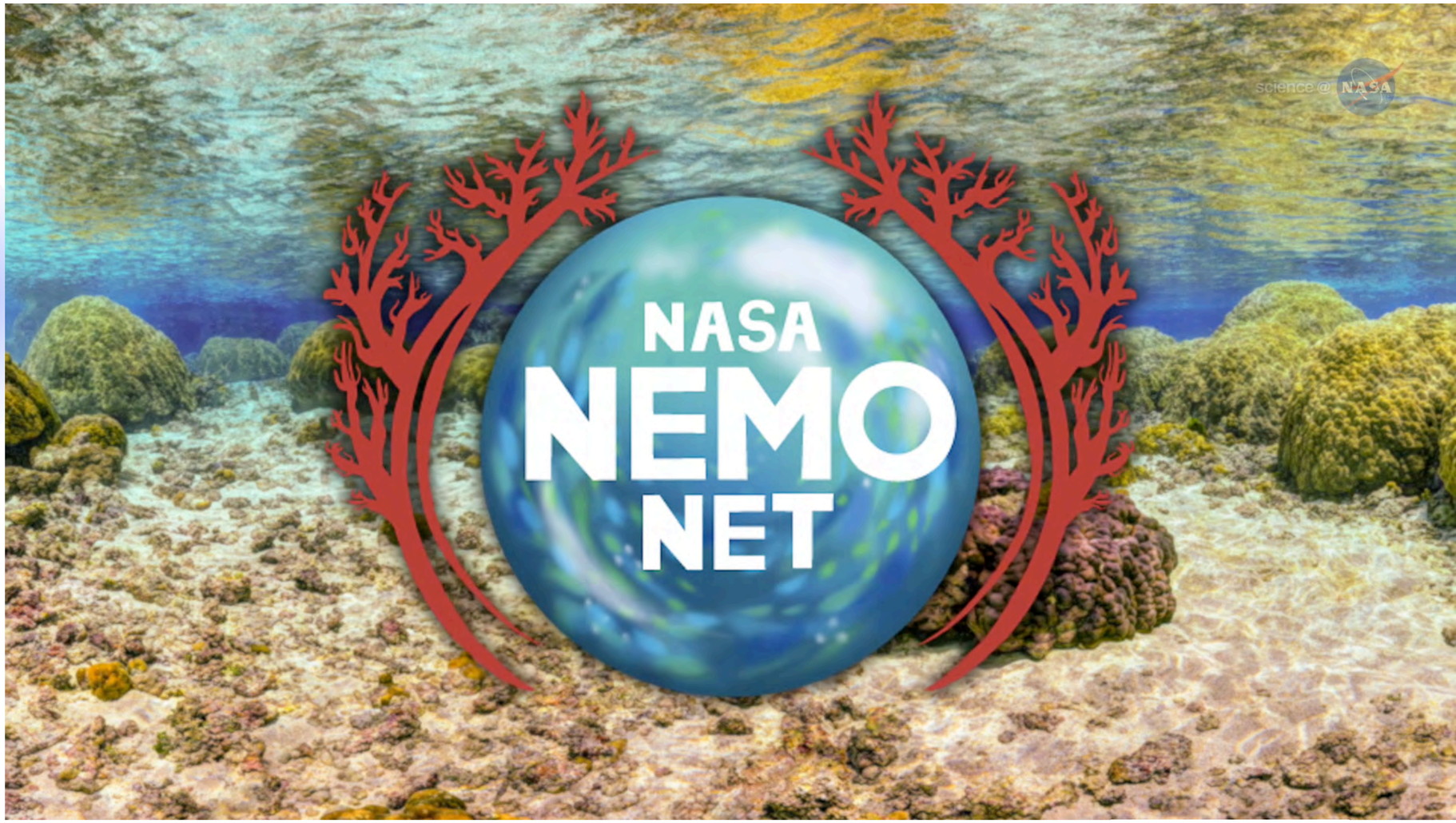
M-Scale Airborne & Satellite Data



VR & App-based Active Learning & Interactive Training through IUCN, Mission Blue, & Partners

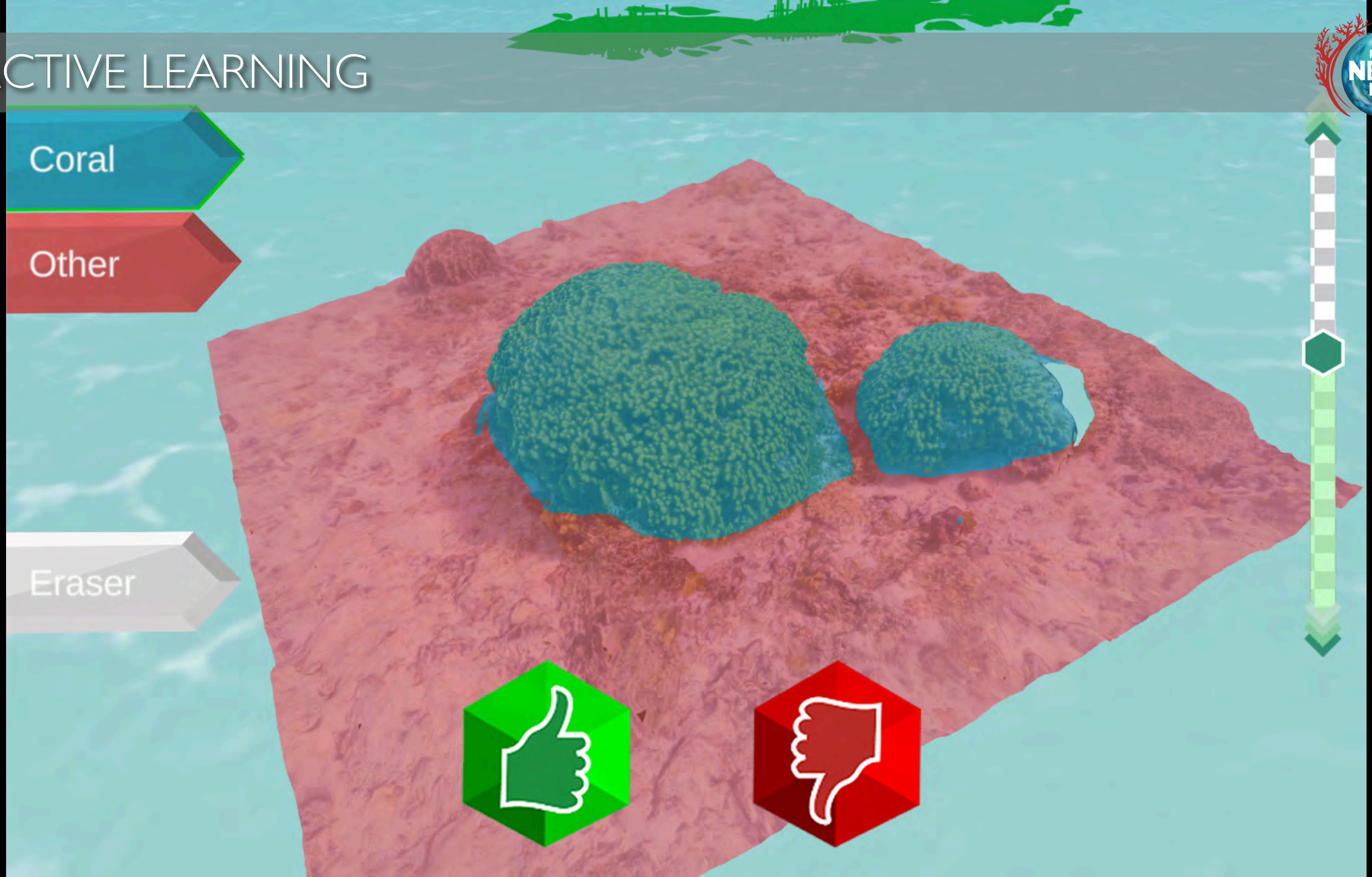
Level 1 Data & Existing Training Data Analysis

Active Learning Training of Coral Cover & Morphology Type



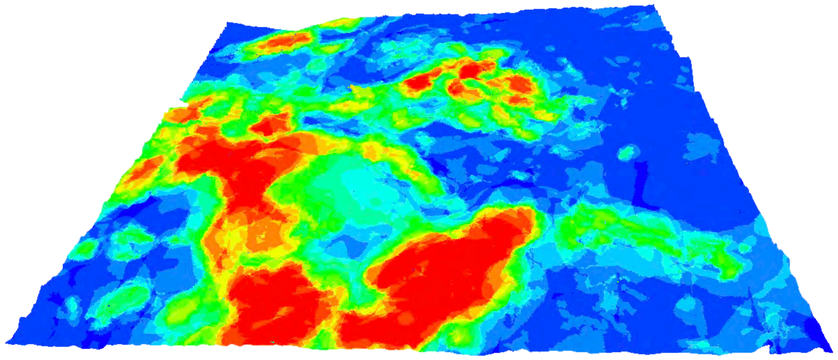
NEMO-NET GAME

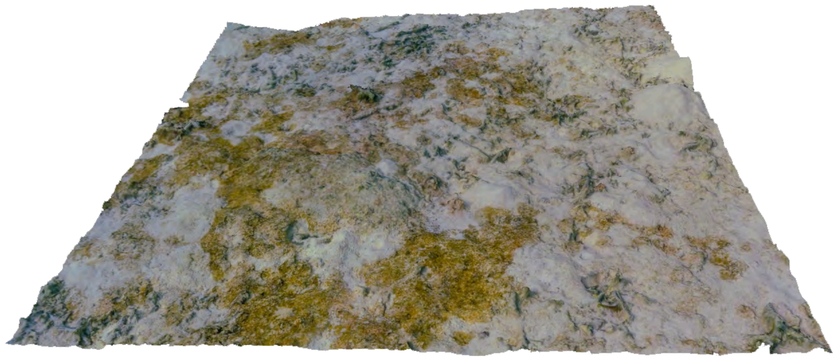
ACTIVE LEARNING



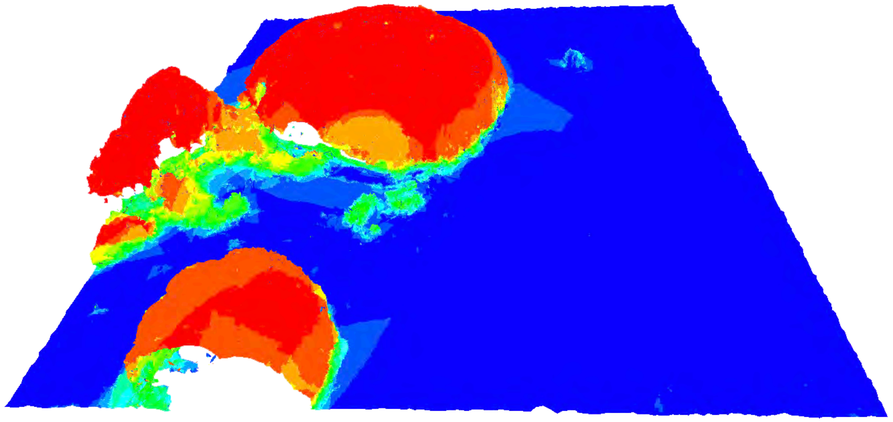
CLASSIFICATION CONVERGENCE

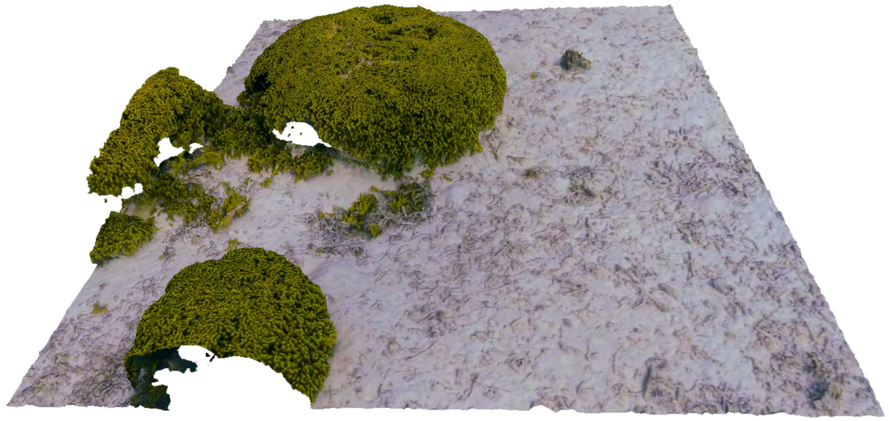
Heat Map of Algae





Heat Map of Coral



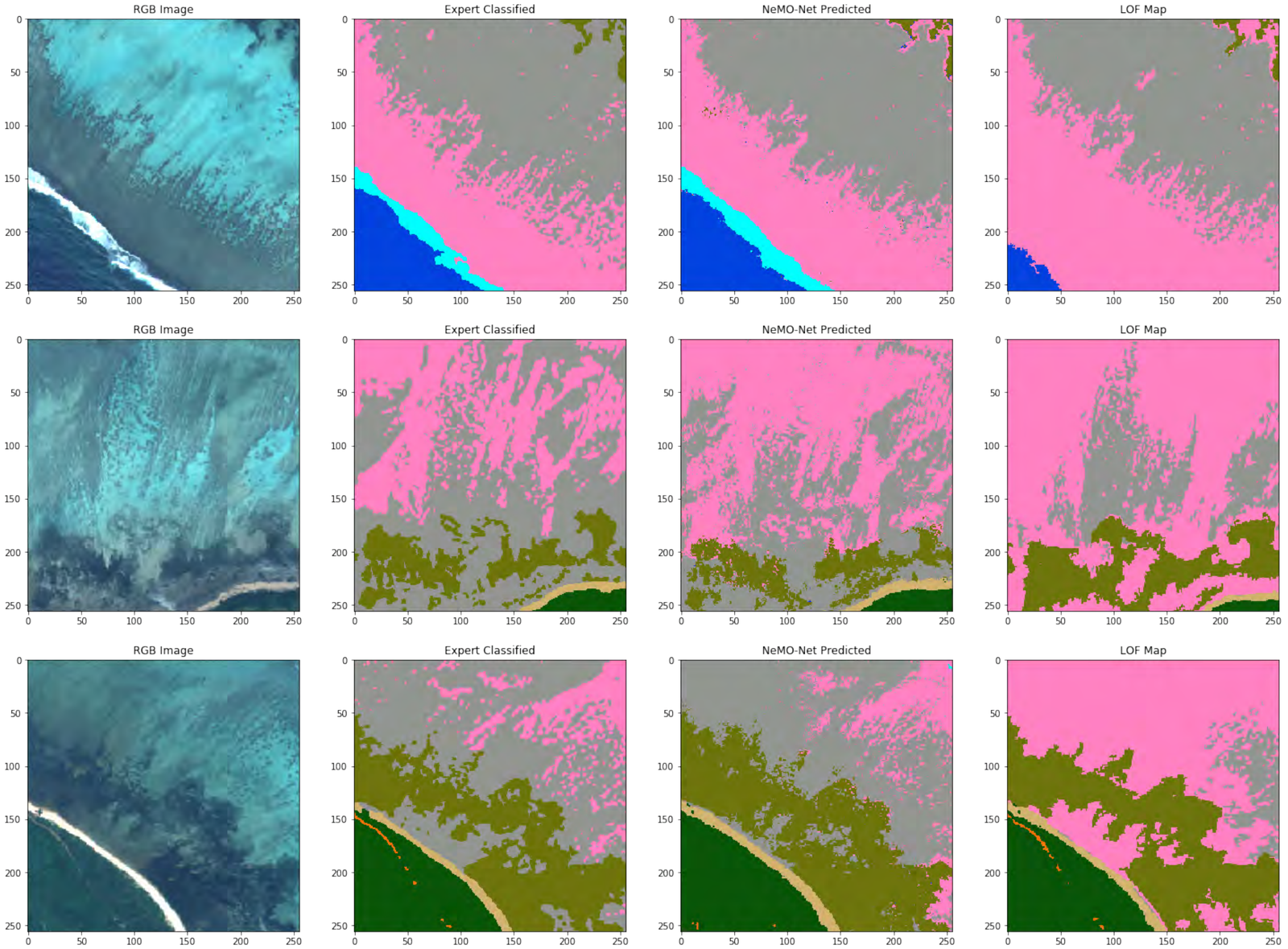


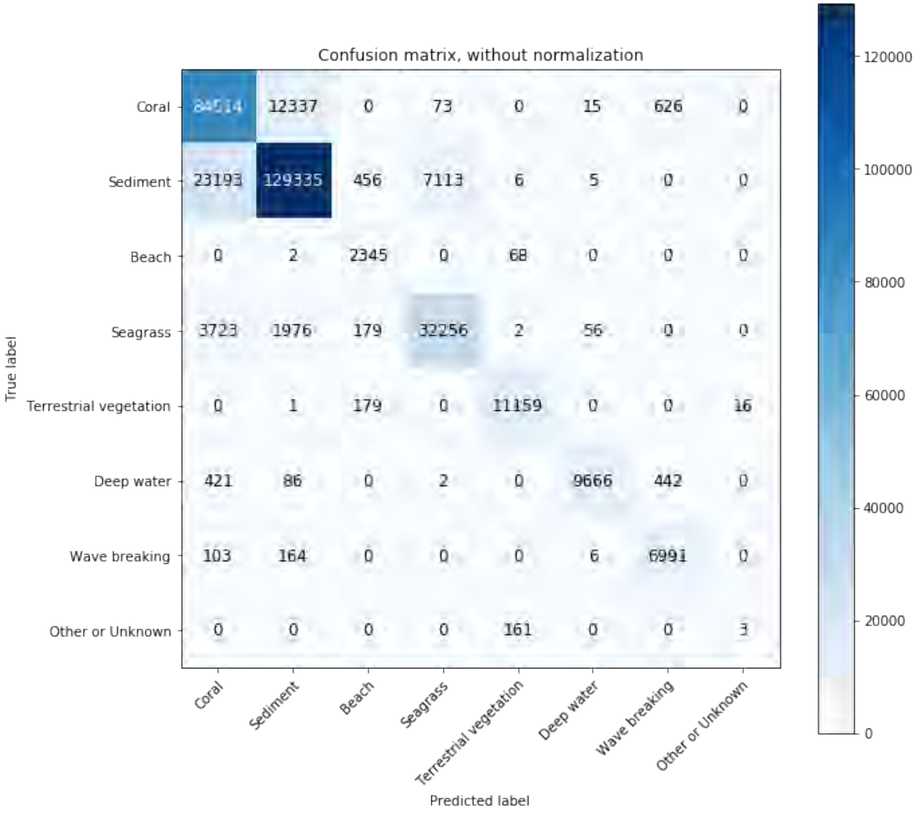
0% of Users Classified as Algae / Coral

100% of Users Classified as Algae / Coral

NEMO-NET PROTOTYPE DATA PRODUCTS

PERFORMANCE METRICS: WV-2



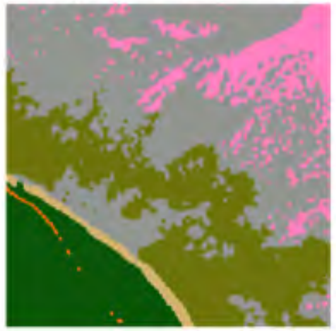


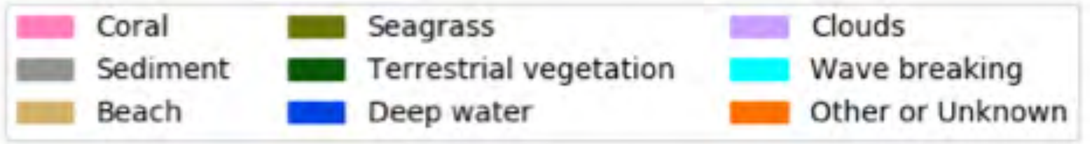
Total Accuracy: 84.3%

COMPARISON TO OTHER CNNS

RGB Image

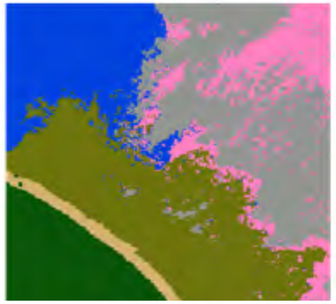
Expert Classified



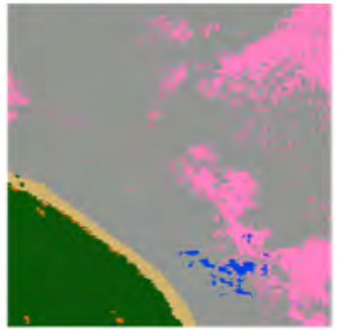


VGG16-FCN

DeepLab v2



SharpMask



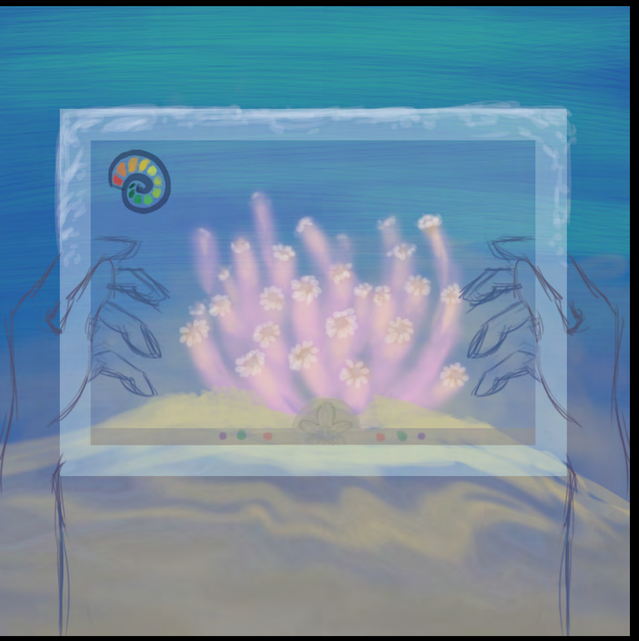
NeMO-Net RefineNet

Method	Accuracy	Mean Precision	Mean Recall	Frequency-weighted IoU
All Classes				
VGG16-FCN	79.0%	67.4%	70.0%	66.0%
DeepLab	73.4%	55.2%	54.7%	59.4%
SharpMask	73.2%	57.4%	54.1%	60.2%
NeMO-Net (RefineNet)	**83.3%**	**64.9%**	**65.8%**	**71.5%**
Coral, sediment, and seagrass only				
VGG16-FCN	82.8%	80.1%	85.4%	70.7%
DeepLab	77.4%	68.5%	82.2%	64.1%
SharpMask	81.6%	77.9%	81.9%	69.1%
NeMO-Net (RefineNet)	**85.1%**	**86.8%**	**87.9%**	**74.0%**
KSLOF Ecognition Prediction	*48.9%*	*56.9%*	*44.5%*	*26.2%*

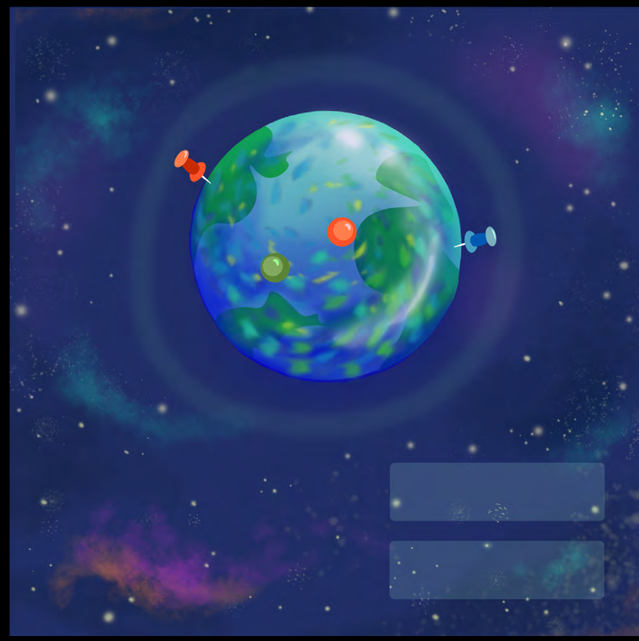
NEW PUBLICATIONS

1) *Chirayath, Ved, and Alan Li. "Next-Generation Optical Sensing Technologies for Exploring Ocean Worlds-NASA FluidCam, MiDAR, and NeMO-Net." **Frontiers in Marine Science** 6 (2019): 521.*
2) *Segal-Rozenhaimer, Michal et al. "Cloud detection algorithm for multi-modal satellite imagery using CNNs." **Remote Sensing of Environment** 237 (2020).*
3) *"Drone takes to the skies to image offshore reefs." **Nature** (2019) Vol 570. 545.*
4) *Chirayath, Ved and Instrella, Ron. "Fluid lensing and machine learning for centimeter-resolution airborne assessment of coral reefs in American Samoa." **Remote Sensing of Environment** 235 (2019): 111475.*

NEMO-NET LAUNCH - EARTH DAY 2020

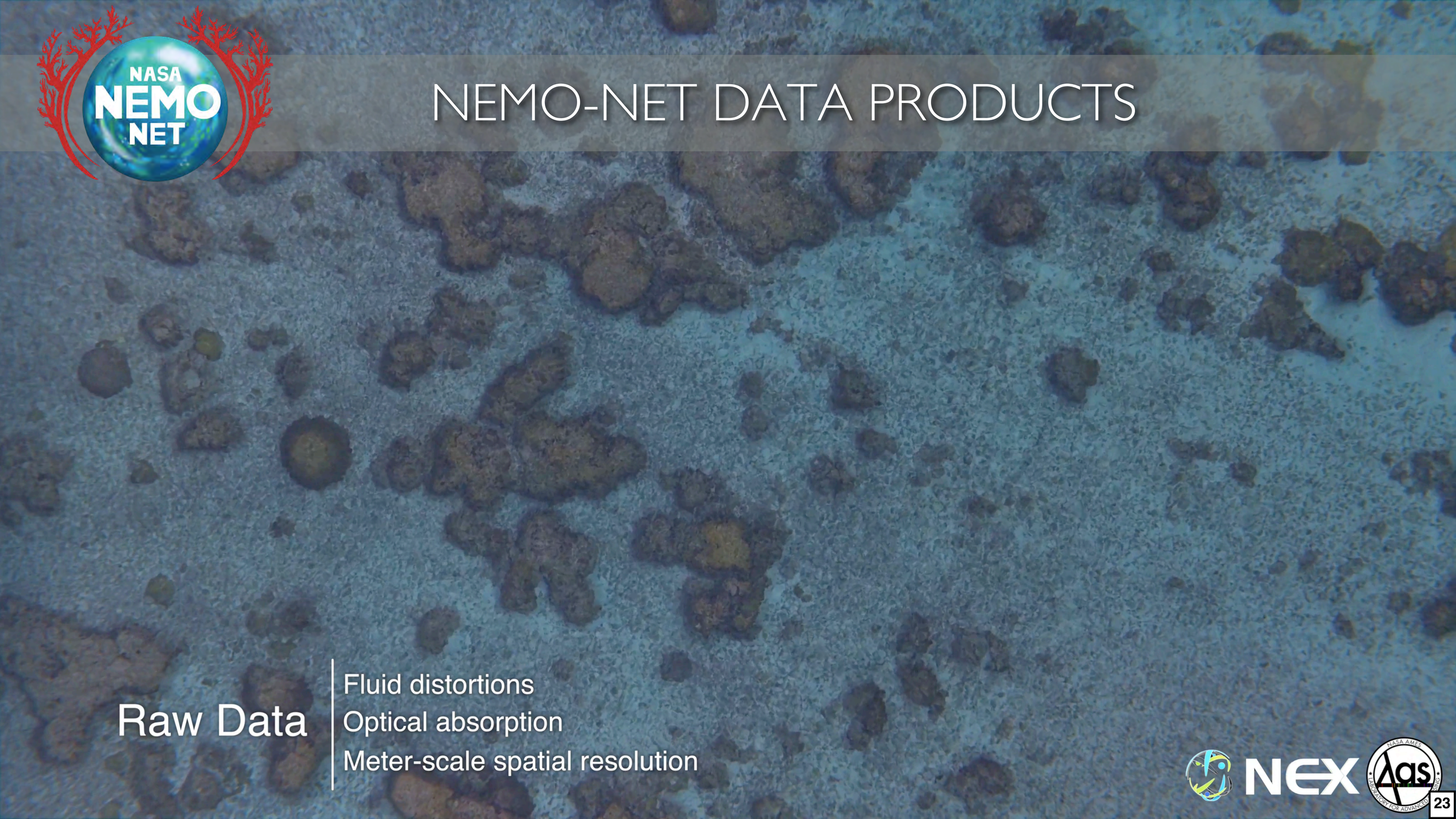


nemonet.info



THANK YOU!

NEMO-NET DATA PRODUCTS



Raw Data

- Fluid distortions
- Optical absorption
- Meter-scale spatial resolution