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

ESTF 2019

VED CHIRAYATH, ALAN LI, MICHAL SEGAL-ROZENHAINMER, JARRETT VAN DEN BERGH, JUAN TORRES-PEREZ, SAM PURKIS, SYLVIA EARLE

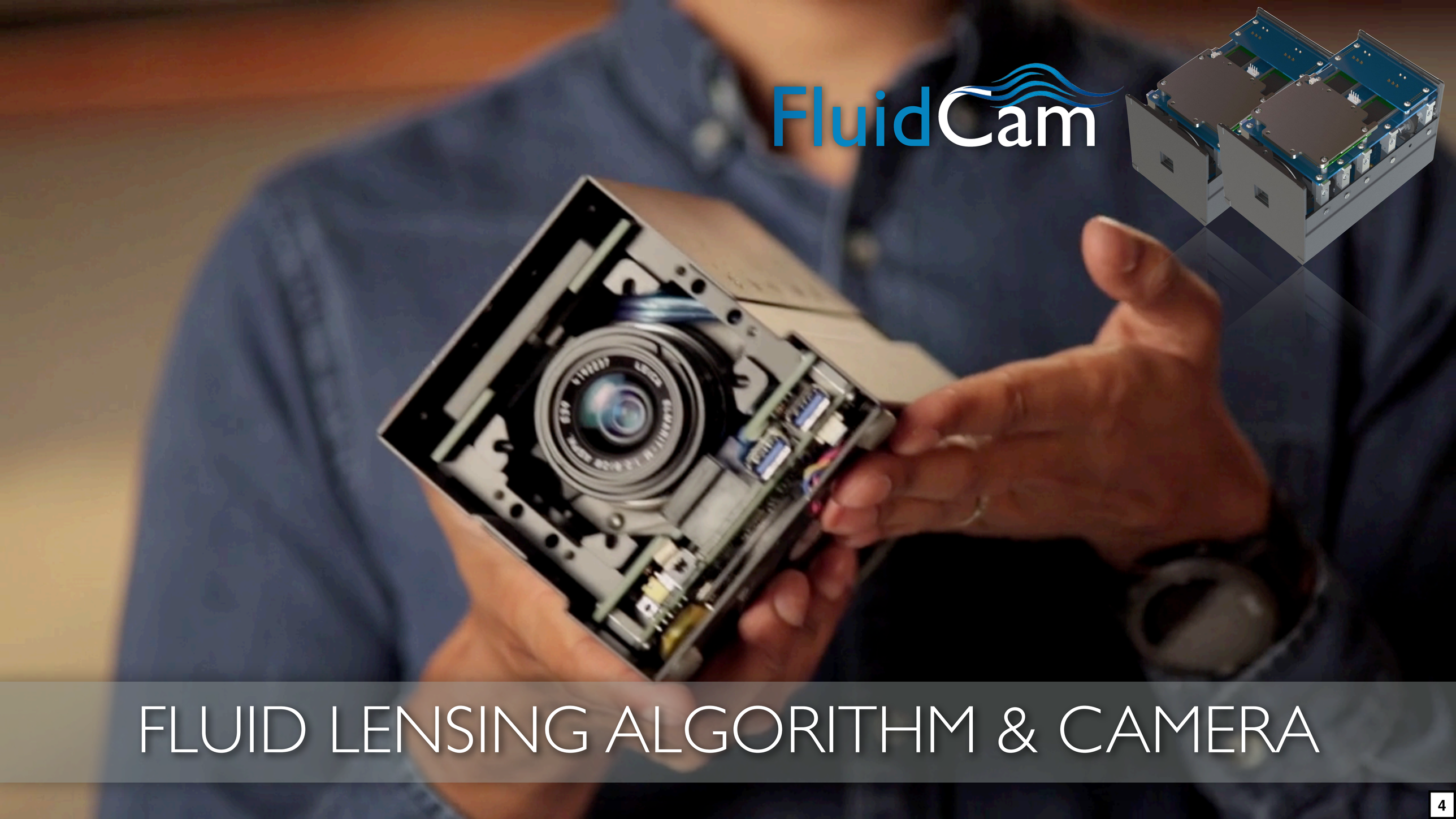
# OCEANS & CLIMATE CHANGE

# NEW MARINE SENSING SYSTEMS & MACHINE LEARNING

FluidCam

MiDAR

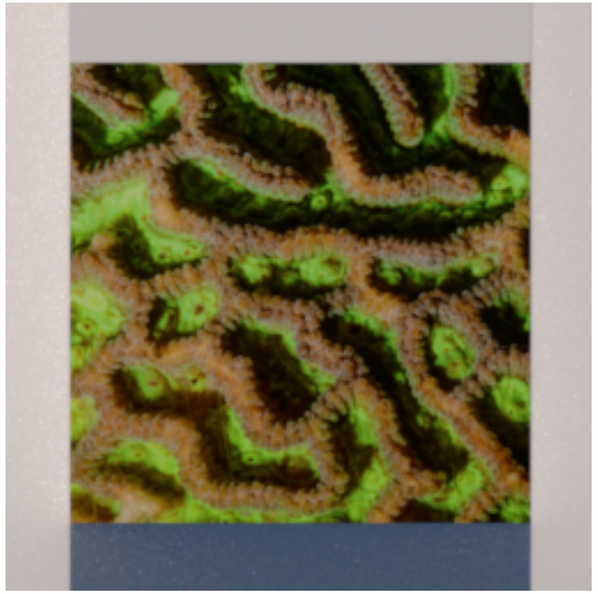
NASA NEMO NET



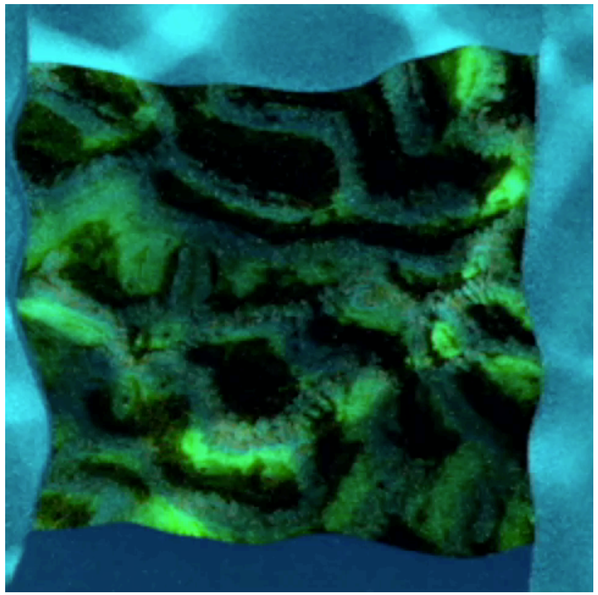

# FLUID LENSING ALGORITHM & CAMERA

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

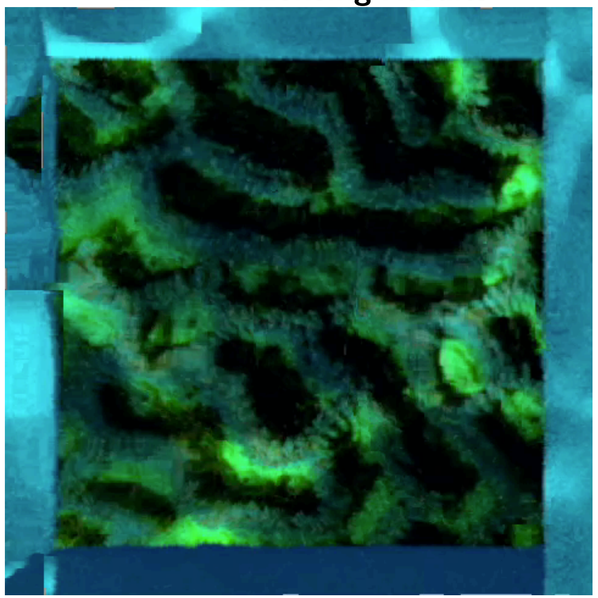
No Fluid



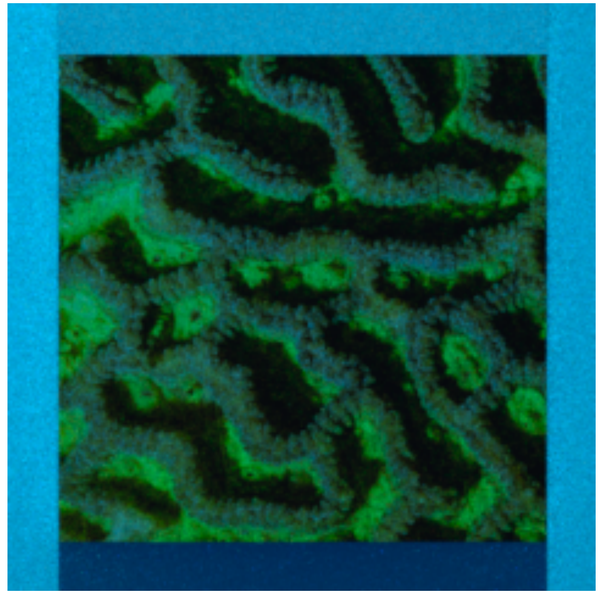
Raw Distorted Frames



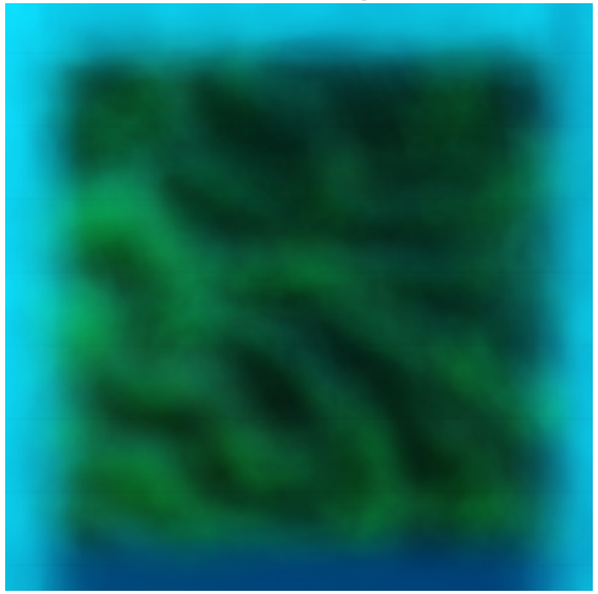
2D Fluid Lensing Results



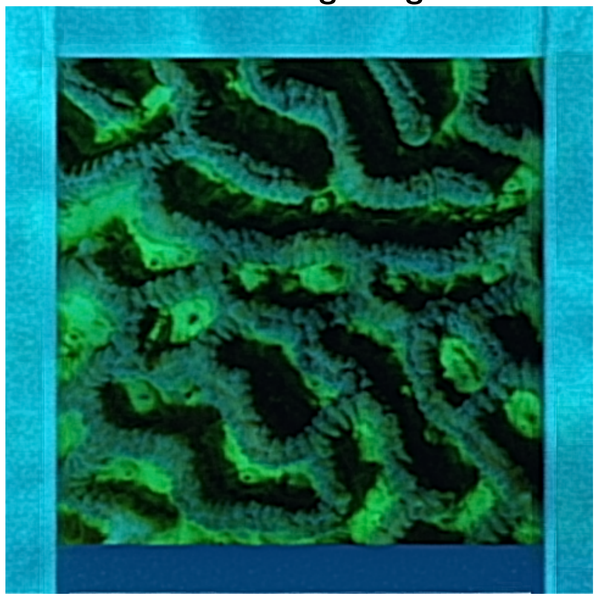
Flat Fluid



Mean Image

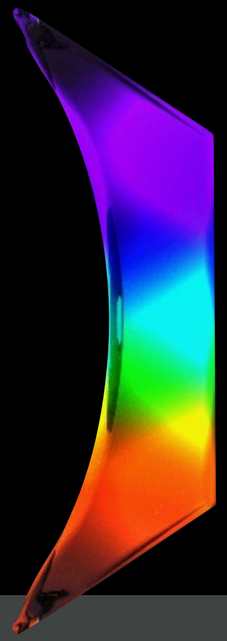


2D Fluid Lensing Integration



FluidCam

FluidCam
NASA AMES
LABORATORY FOR ADVANCED SENSING



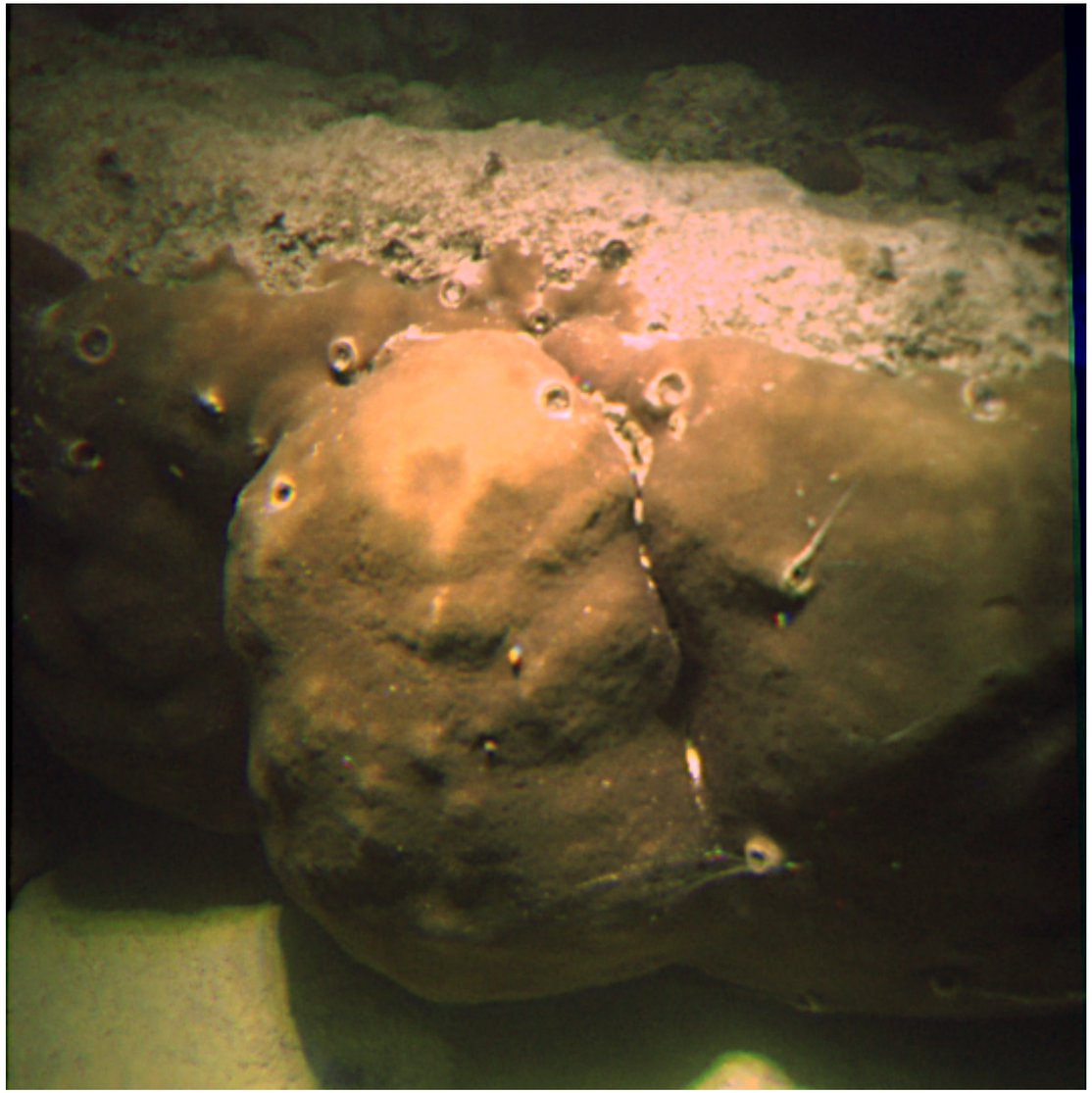
# MiDAR

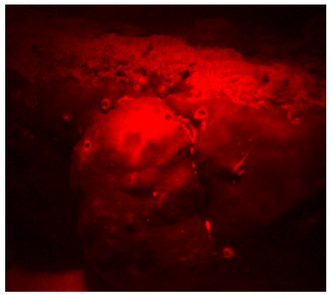
## MULTISPECTRAL IMAGING, DETECTION AND ACTIVE REFLECTANCE INSTRUMENT

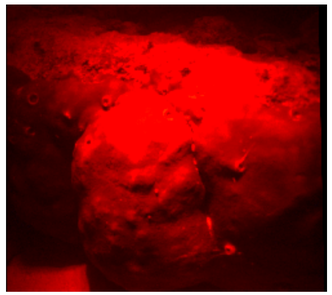
MiDAR

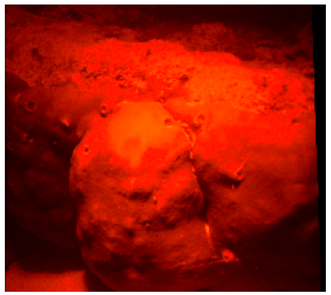
MiDAR

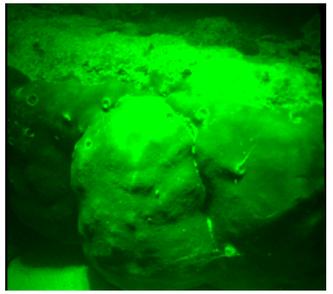
# MiDAR-7 UNDERWATER RESULTS

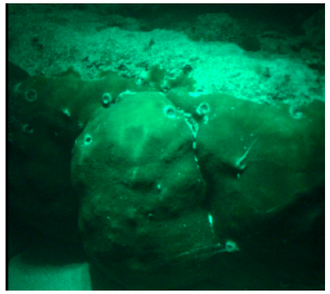


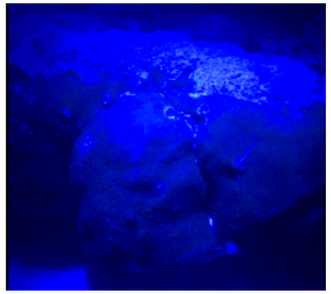


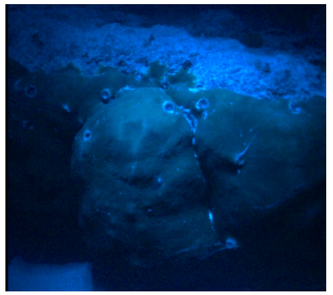


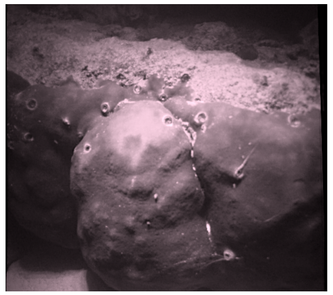












# NEMO-NET - THE FLUID LENSING NEURAL NETWORK FOR GLOBAL CORAL REEF ASSESSMENT

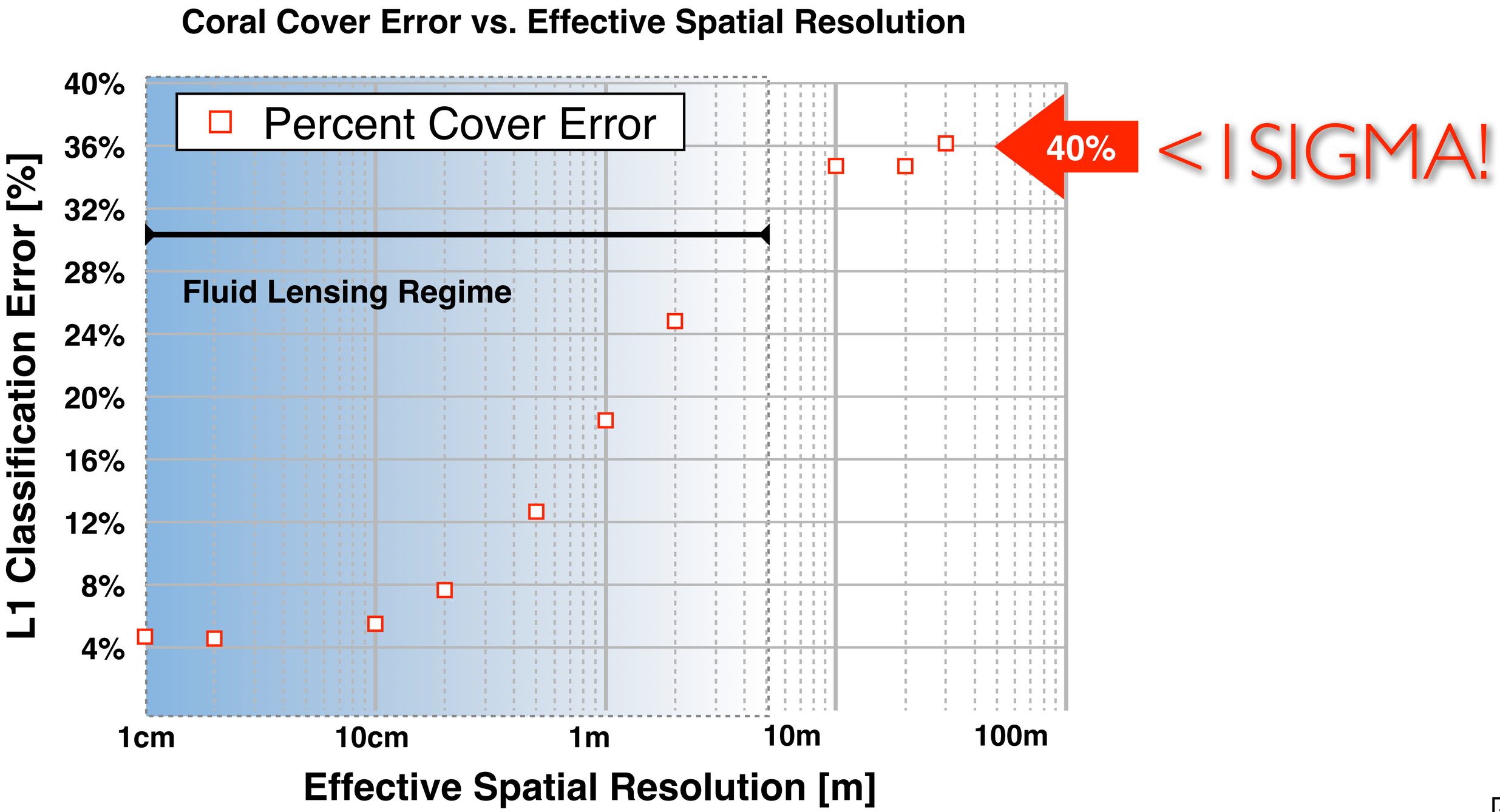
VED CHIRAYATH, JUAN TORRES-PEREZ, SAM PURKIS, ALAN LI, MICHAL SEGAL-ROZENHAINMER, JARRETT VAN DEN BERGH, SYLVIA EARLE

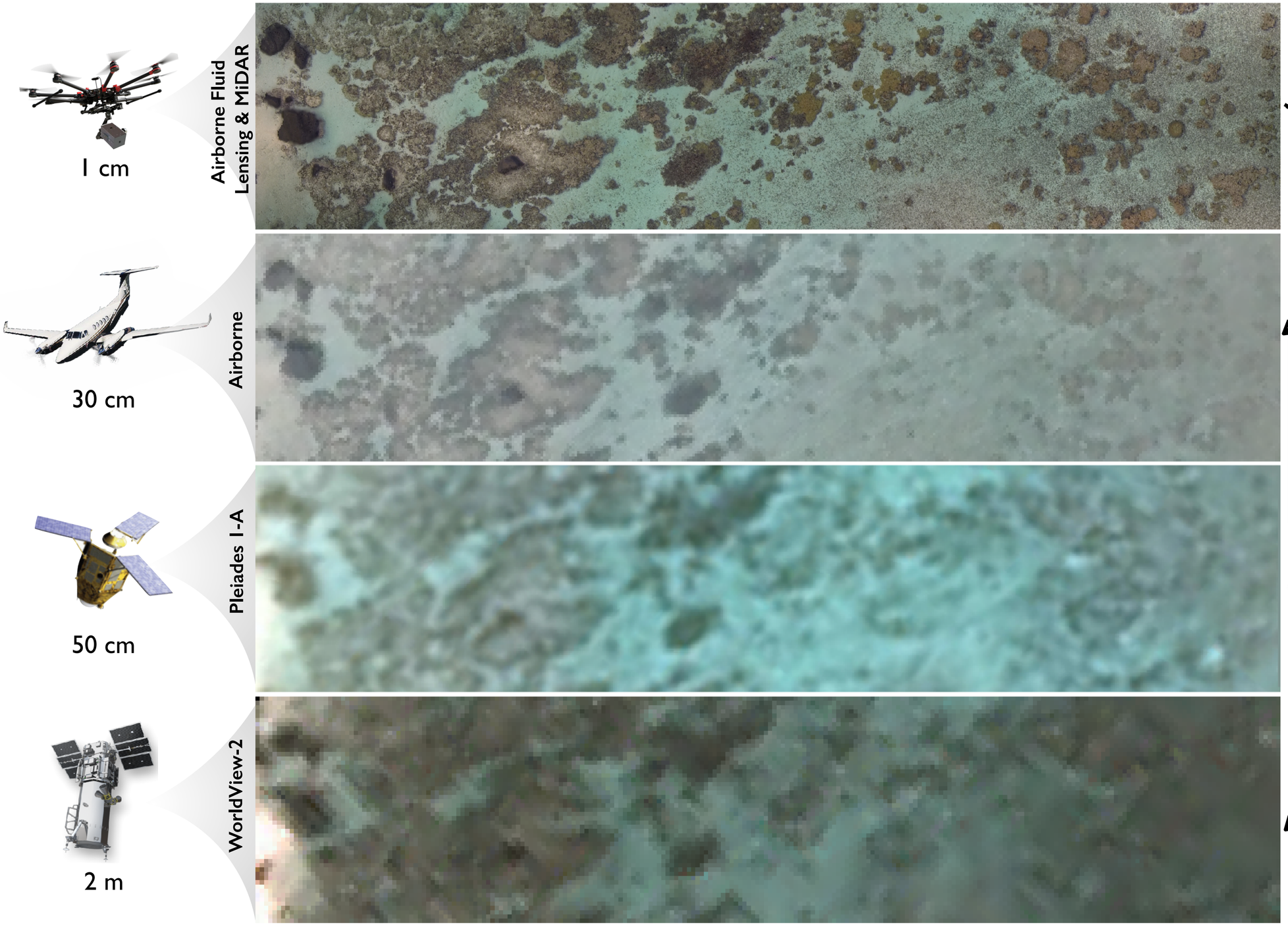
# NEMO-NET OBJECTIVES

1) *Develop the most 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 GLOBAL BENTHIC CLASSES

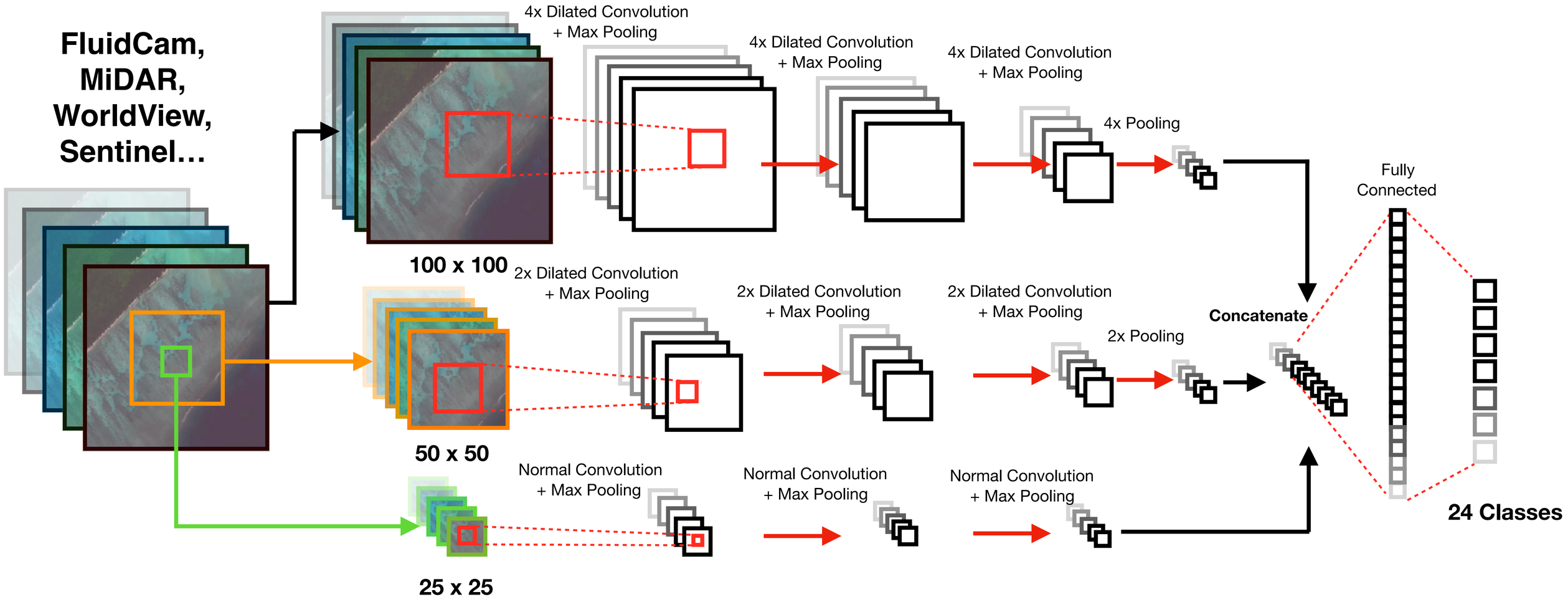
| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|---|---|---|---|---|---|
| **Zone** | **Major Geomorphological Structure** | **Detailed Geomorphological Structure** | **Biological Cover** | **Biological Morphology** | **Family** |
| Land | Coral Reef and Hardbottom | Rock Outcrop | Live Coral | Branching Coral | Acroporidae |
| Salt Pond | | Boulder | Algae | Massive Coral | Agariciidae |
| Inland water | | Aggregate Reef | Seagrass | Macroalgae | Astrocoeniidae |
| Shoreline intertidal | | Bommies | Coralline Algae | Turf algae | Gorgoniidae |
| Lagoon | | Individual Patch Reef | Cyanobacteria | Unknown | Merulinidae |
| Reef flat | | Aggregated Patch Reefs | Mangrove | | Montastraeidae |
| Back reef | | Pinnacles | No cover | | Mussidae |
| Reef crest | | Spur and Groove | Unknown | | Plexauridae |
| Fore reef | | Pavement | | | Poritidae |
| Bank / Shelf | | Pavement with Sand Channels | | | Siderastreidae |
| Escarpment | | Reef Rubble | | | Pocilloporidae |
| Channel | | Rhodoliths | | | Pectiniidae |
| Dredged | | Unknown | | | Fungiidae |
| Unknown | Unconsolidated Sediment | Sand | | | Caryophyliidae |
| | | Mud | | | Dendrophyliidae |
| | | Sand with Scattered Coral and | | | Phylum Chlorophyta |
| | | Unknown | | | Phylum Cyanophyta |
| | Other | Land | | | Phylum Phaeophyta |
| | | Artificial | | | Phylum Rhodophyta |
| | | Unknown | | | Angiospermae |


Coral Cover Error vs. Effective Spatial Resolution
Percent Cover Error
40%
36%
32%
28%
24%
20%
16%
12%
8%
4%
L1 Classification Error [%]
Fluid Lensing Regime
40%
<1SIGMA!
1cm
10cm
1m
10m
100m
Effective Spatial Resolution [m]




FluidCam & MiDAR 3D imagery can augment low resolution 2D imagery

# NEMO-NET CNN ARCHITECTURE




**Domain Adaptation, Transfer Learning & Lap SuperResolution**

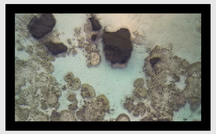
# CLASSIFICATION IS HARD & CNNS NEED TRAINING DATA

Chihuahua vs. Blueberry Muffin

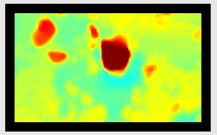
Bagel vs. Sleeping Dog

Mop vs. Hungarian Sheepdog

MM-Scale Airborne Fluid Lensing



MM-Scale Airborne Fluid Lensing DEM

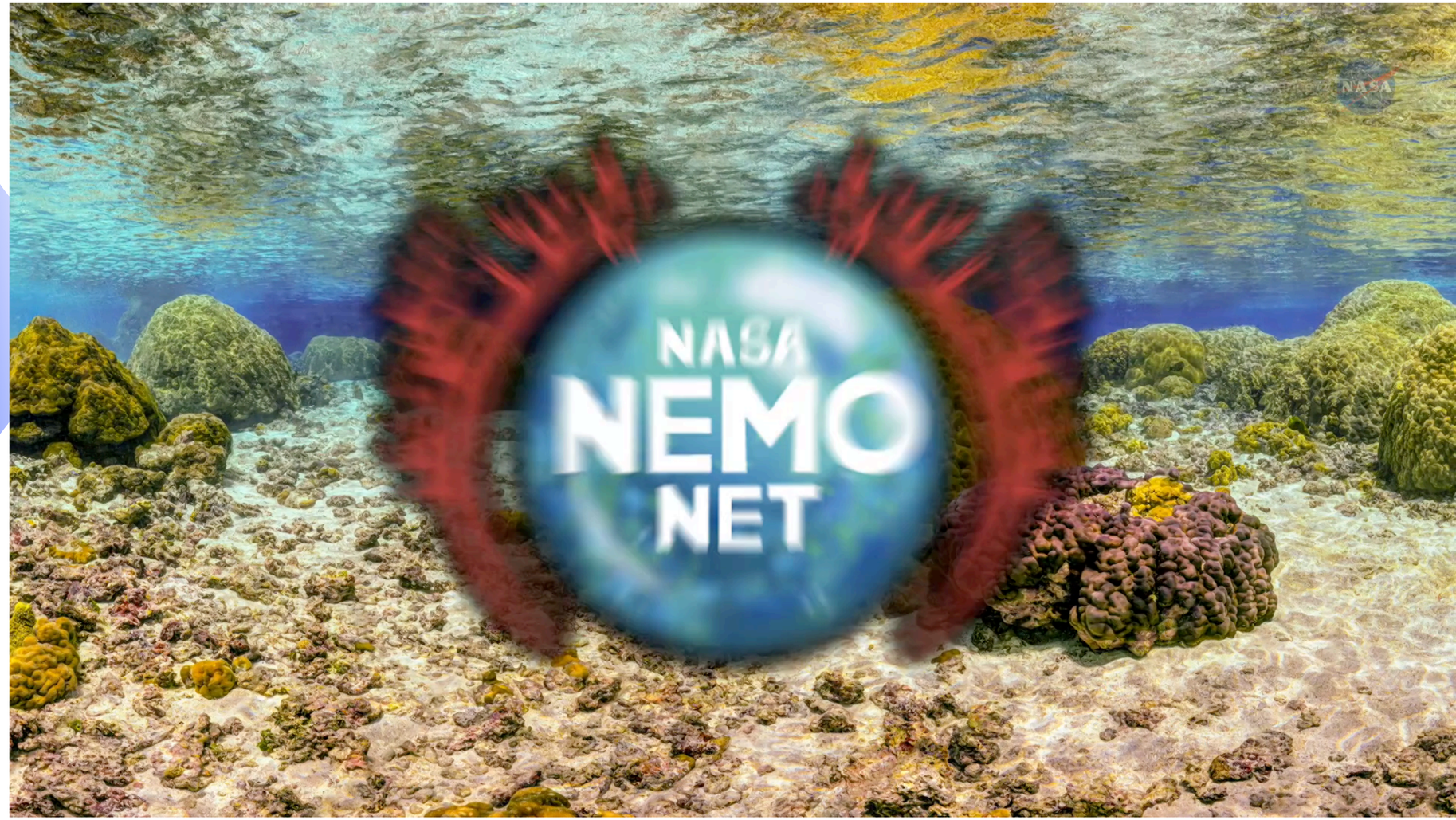


M-Scale Airborne & Satellite Data

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

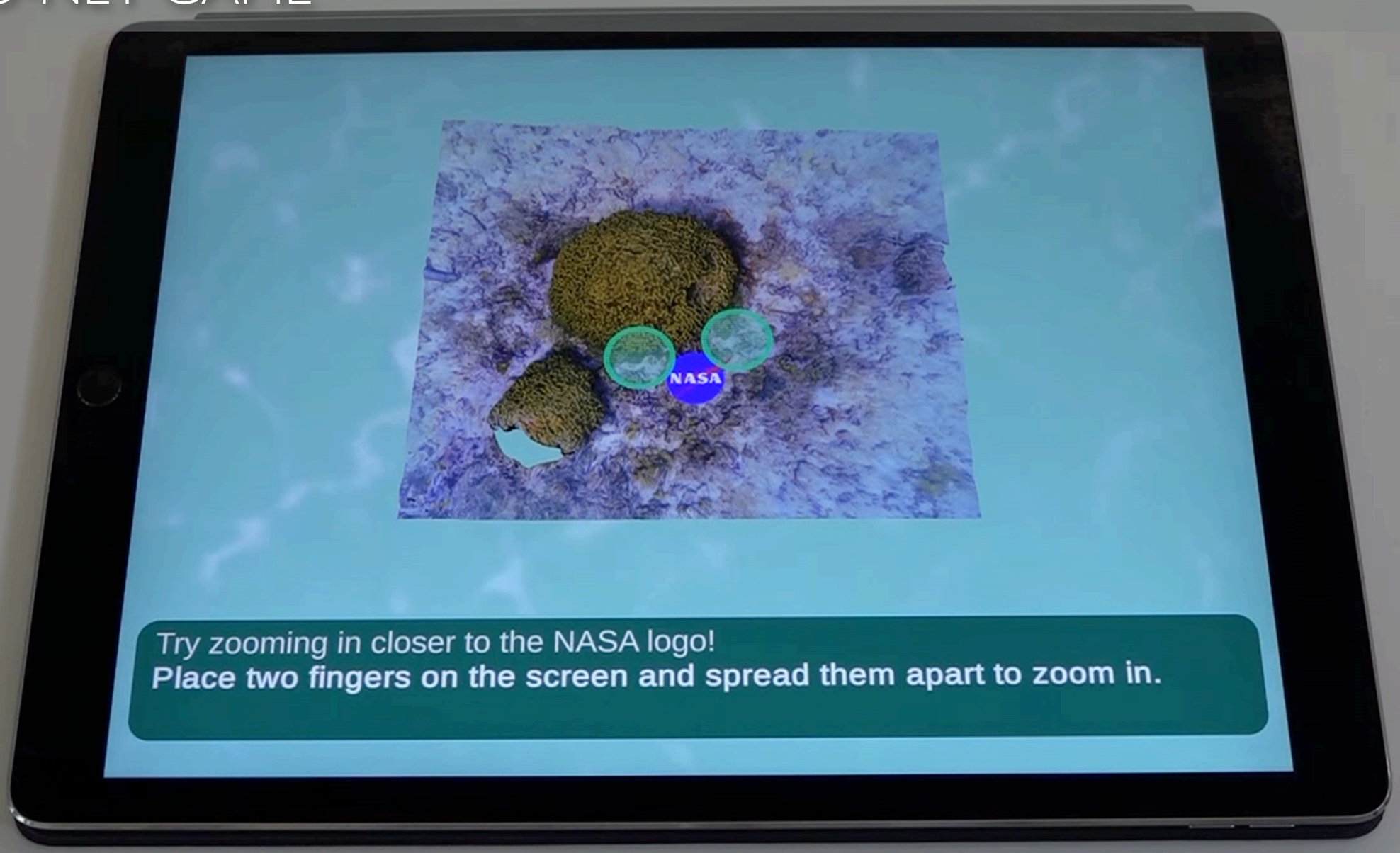
Level 1 Data & Existing Training Data Analysis

Active Learning Training of Coral Cover & Morphology Type

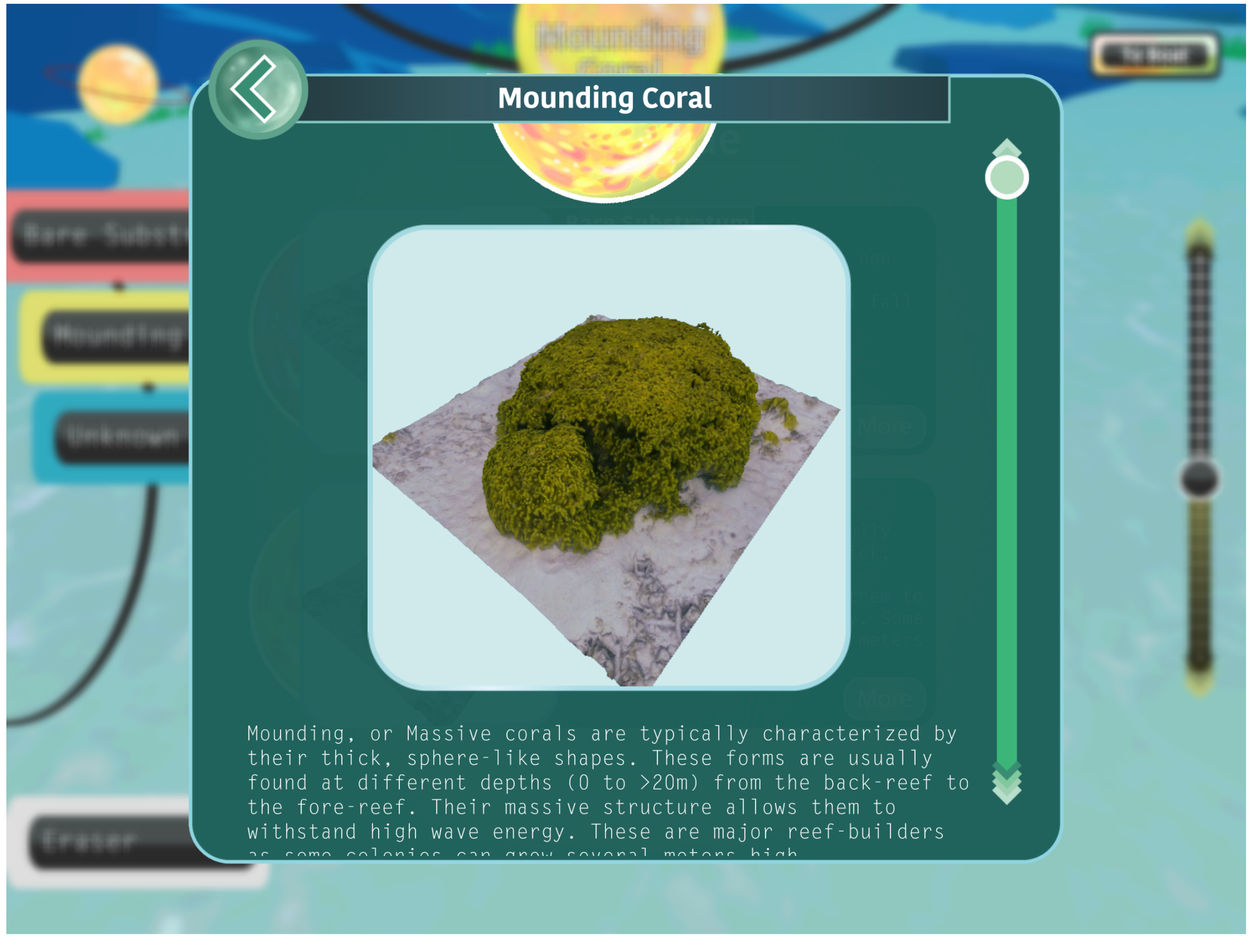


# NEMO-NET GAME

# NEMO-NET GAME



# NEMO-NET TRAINING & LEVELS



# NEMO-NET GAME

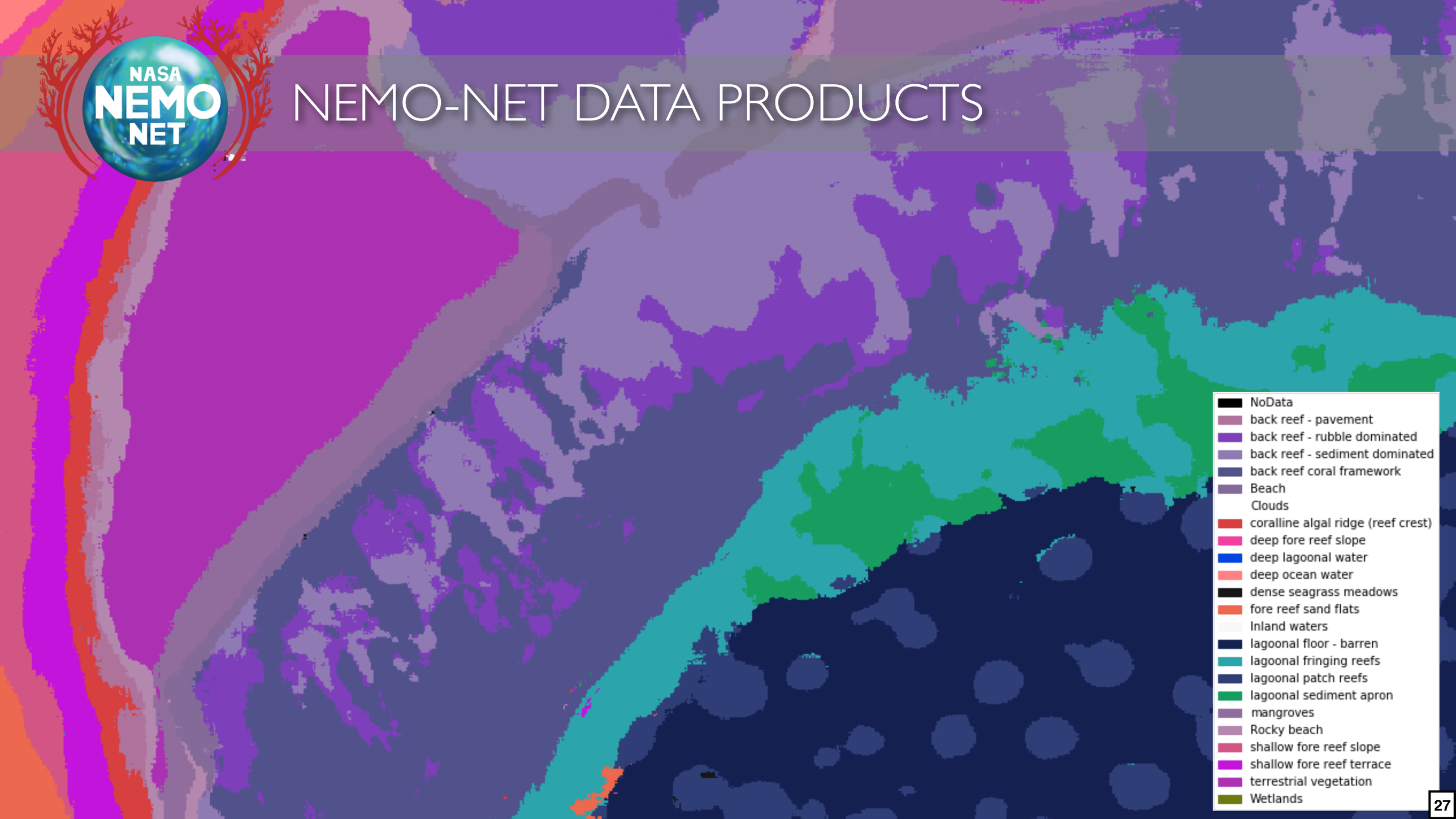
Players are required to classify coral at a minimum accuracy before sending data to the neural network

# NEMO-NET GAME

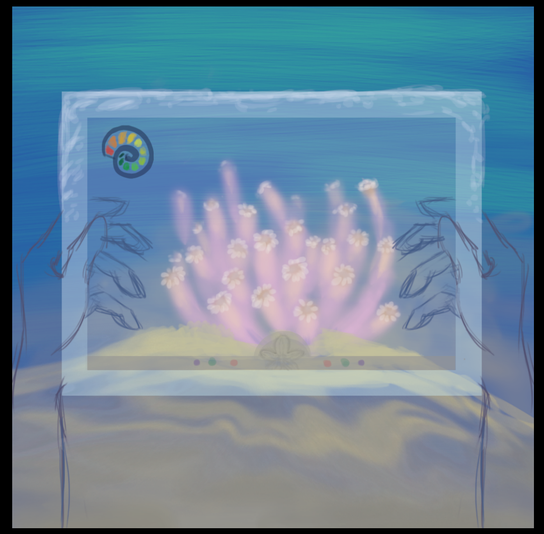
# ACTIVE LEARNING

# NEMO-NET DATA PRODUCTS

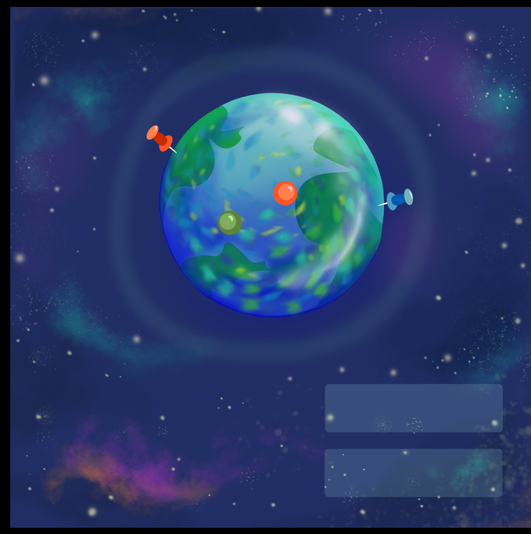
# NEMO-NET DATA PRODUCTS



# NEMO-NET BETA LIVE TODAY!

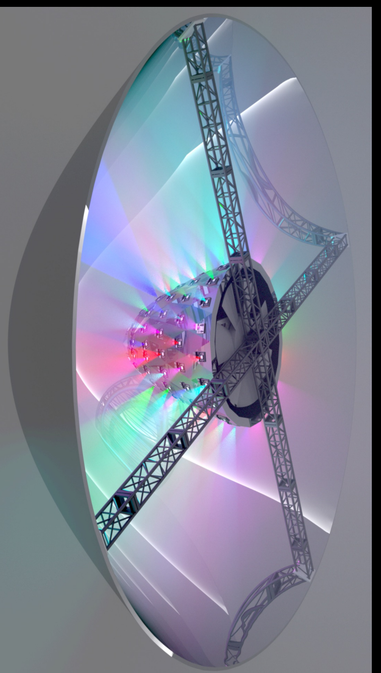


nemonet.info/beta



# UPCOMING & FUTURE WORK

1) Guam - MiDAR & FluidCam May 2019
2) Palau - MiDAR & FluidCam September 2019
3) NASA NeMO-Net Global Coral Reef Map - Dec 2019



# THANK YOU!