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ROLE OF TECH PROVIDERS COMMUNITY REQUIREMENTS CHALLENGES

RENÉ GARELLO
PROFESSOR EMERITUS
LIFE FELLOW IEEE

Marine pollution monitoring, forecasting, and mitigating the impact on marine life and coastal populations

CONTEXT: UN DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT

A clean ocean where sources of pollution are **identified** and **removed**

Marine pollution **monitoring**, **forecasting**, and **mitigating** the impact on marine life and coastal populations

Identified Monitoring	Forecasting Mitigating	Mitigating Removed
“Earth” Observation	Models Information Processing	Actions Citizen science
Sensors Data	Data Storage Data Management	Guidance Data -> AI

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CONTEXT, SCIENCE & TECHNOLOGY

- After "*Future Plan for Ocean Research*" Hitoshi Hotta, Japan Agency for Marine-Earth Science and Technology, Oceans'12 Yeosu Korea

Sensors, on-board systems, drones

Multisource observations, data processing, communications

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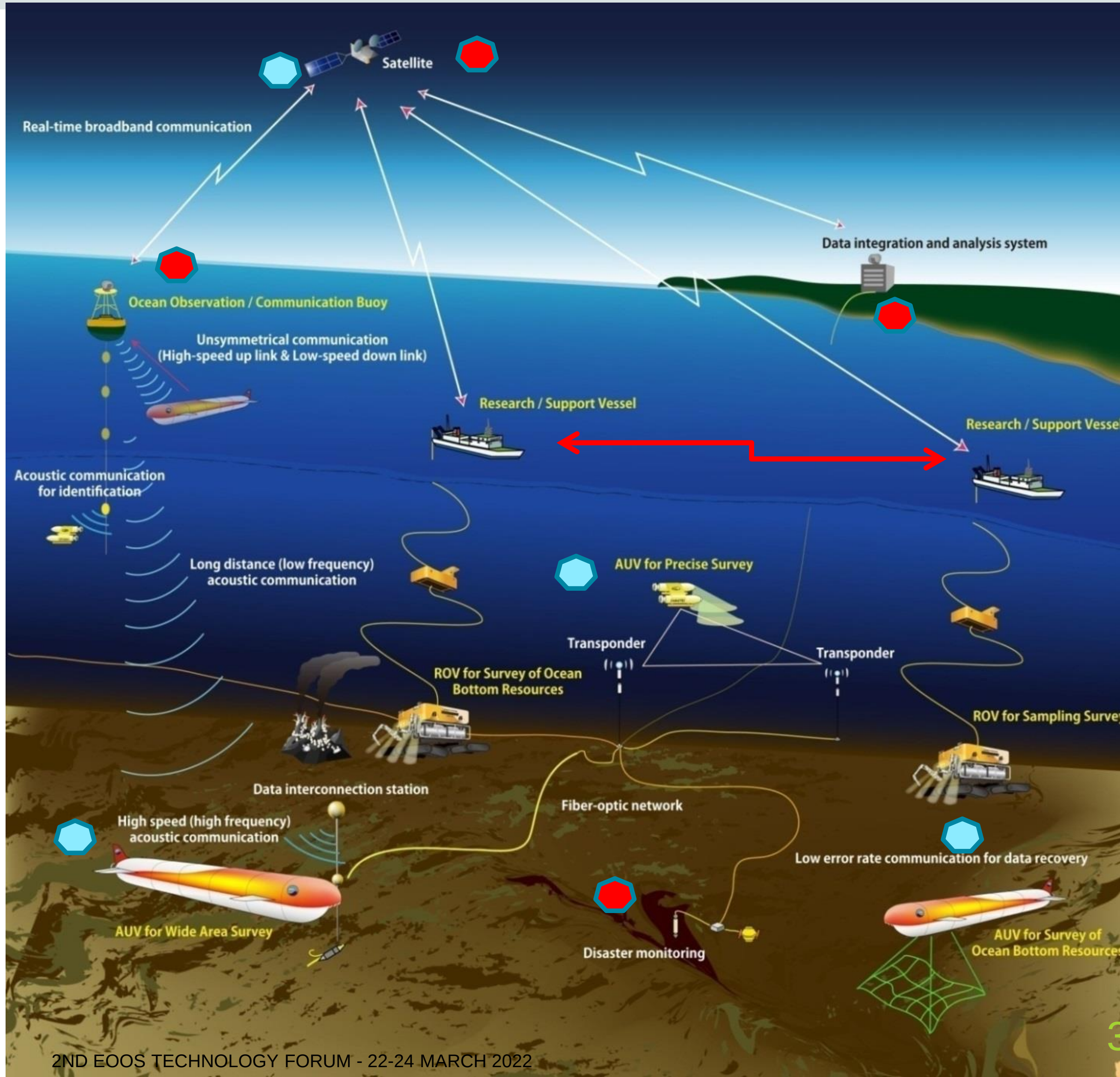
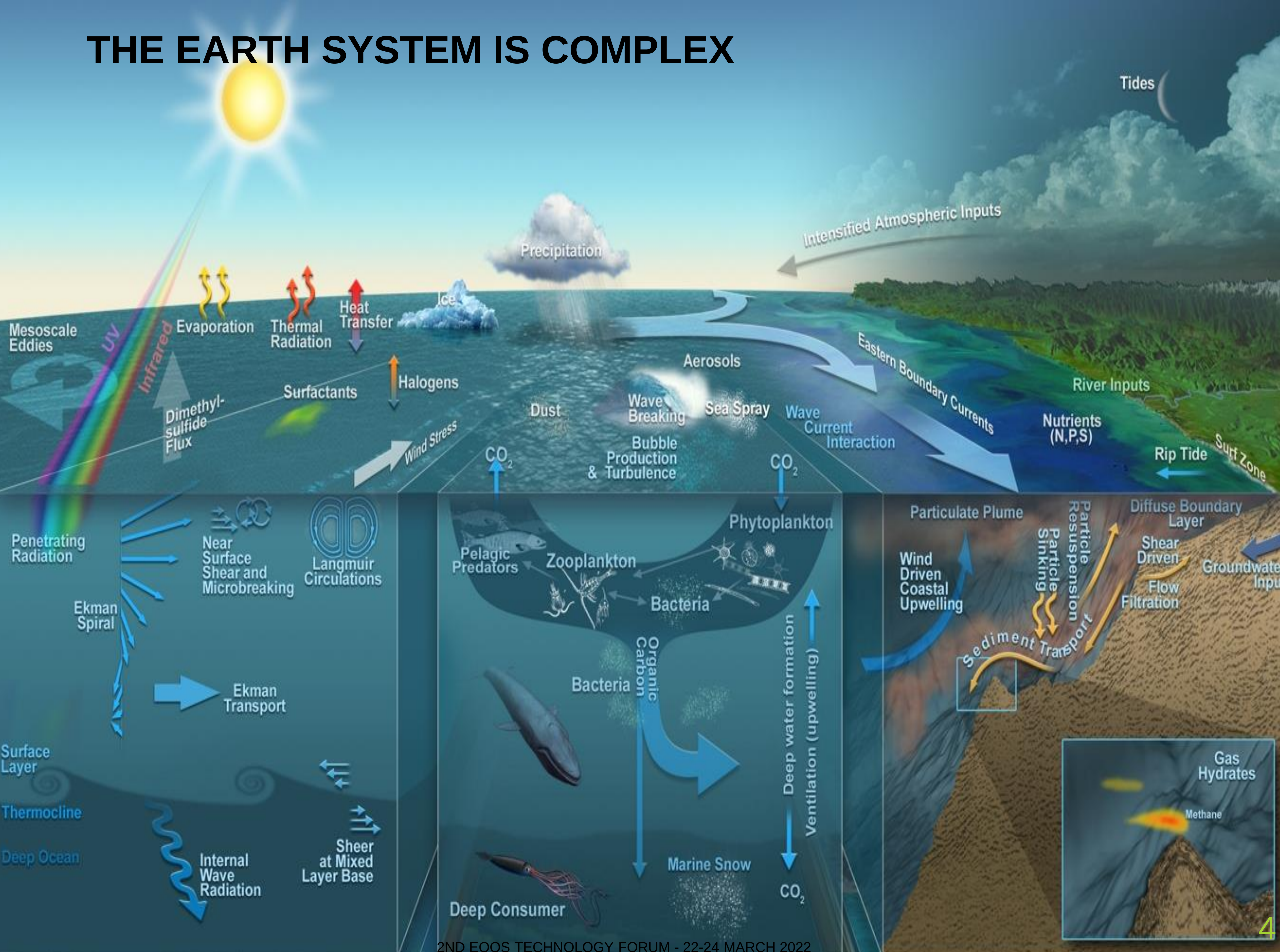


THE EARTH SYSTEM IS COMPLEX



OBSERVATIONS MEASUREMENTS

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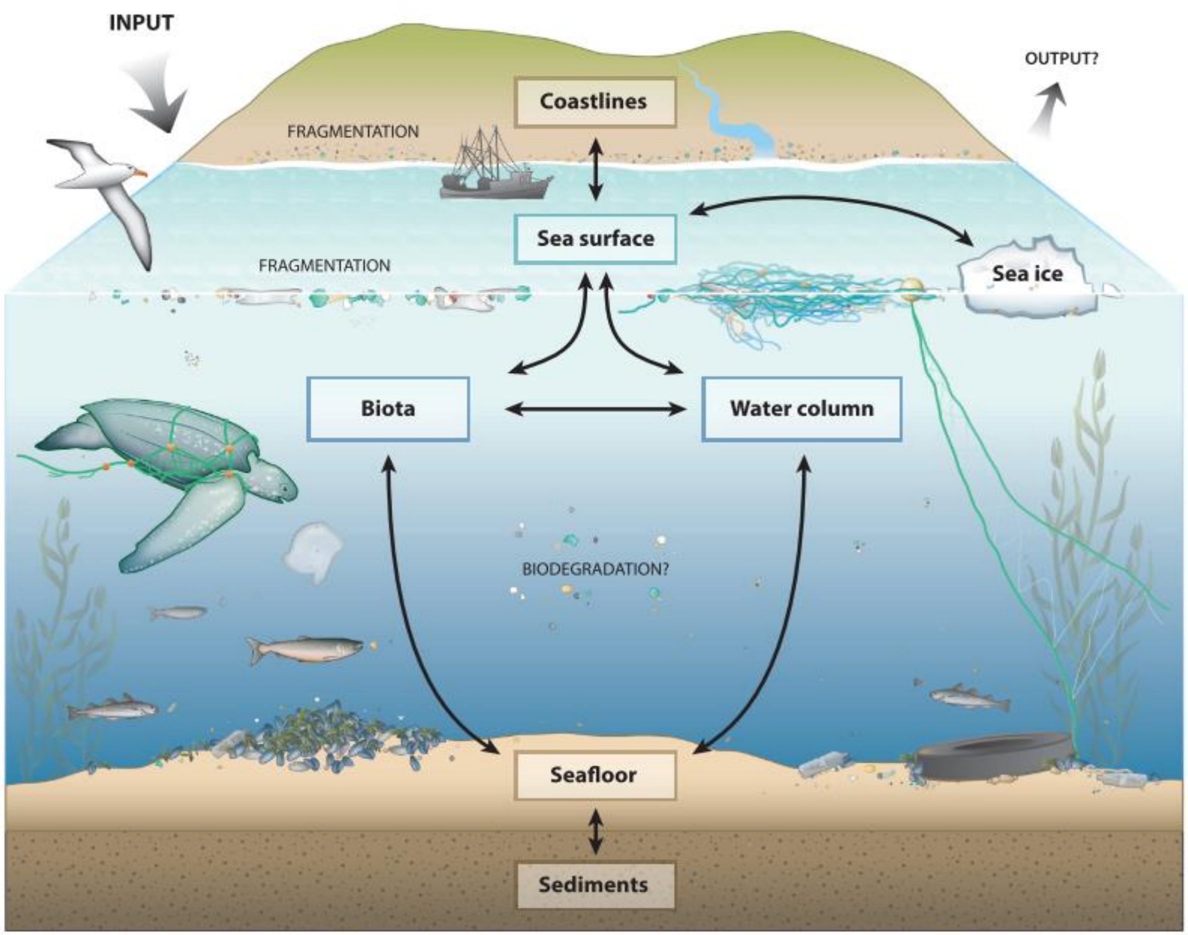
ASSESSMENT OF EXISTING RELEVANT DATA

- Beach/shore line data
- Floating marine litter
- Marine litter in the water column
- Seafloor marine litter
- Ingested marine litter
- Sources of marine litter



Source: Law, K. “Plastics in the marine environment”. 2017. Annual Review of Marine Science.

CHALLENGES / OBSERVATIONS

River mouths: 90% of plastic flow in the ocean.
Direct measuring concentration of plastic particles via in situ samples at water surface.
Direct measurement of movements (remote sensing)

- In situ observations, field surveys, drones, crowdsourcing, webcam, …
- Indirect indicators: Coastal and watershed population, beaches physical characteristics
- Sea-based sources of plastic (ship traffic)
- Automated microplastics sensor for in-situ measurements.
- HF ground-based radar systems (network).
- Potential monitoring via satellites (space/time resolution!)

Based on “Technologies for Observing and Monitoring Plastics in the Oceans”, René Garello et al, OCEANS 2019 Marseille, June 2019

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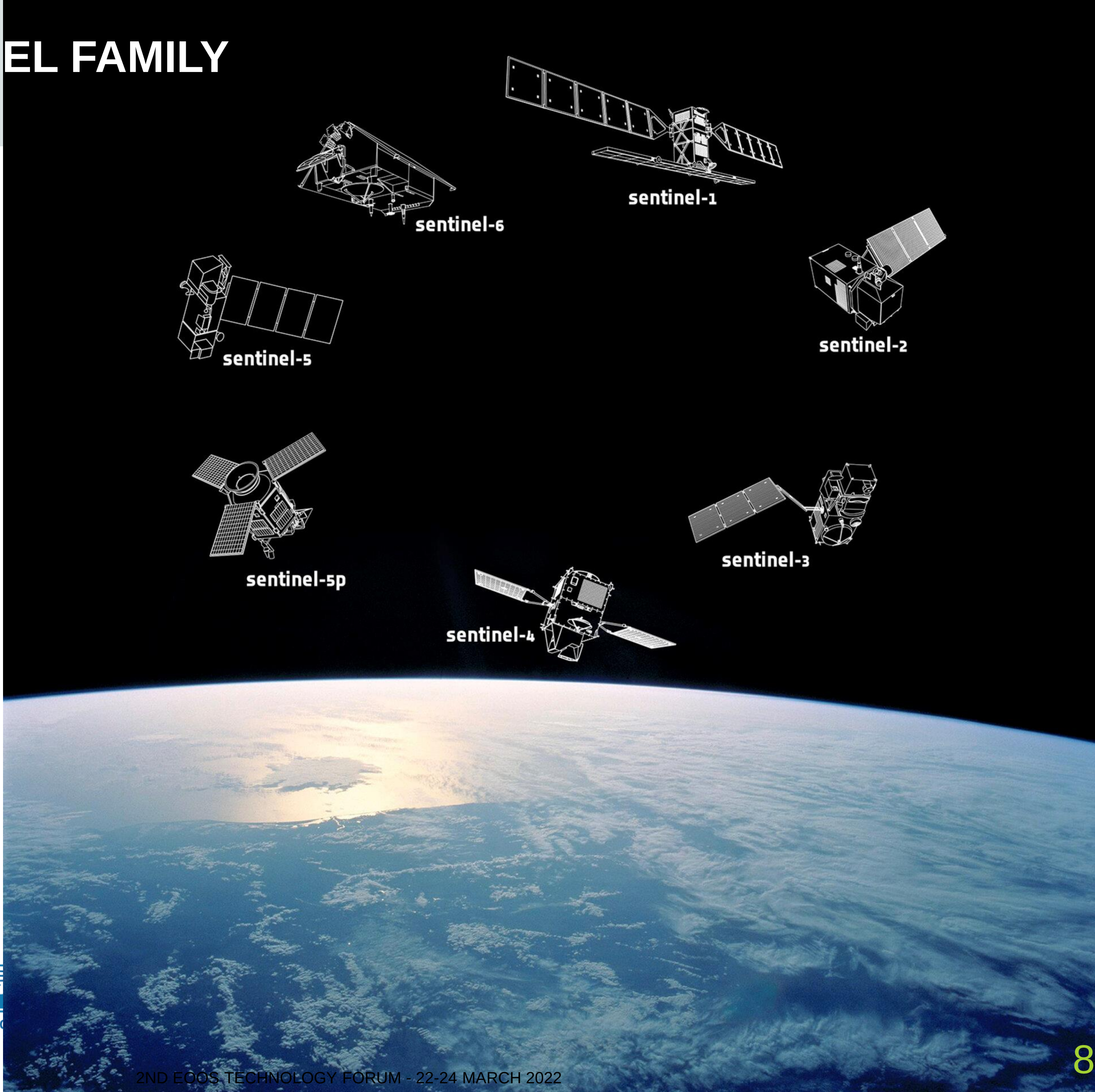
THE SENTINEL FAMILY



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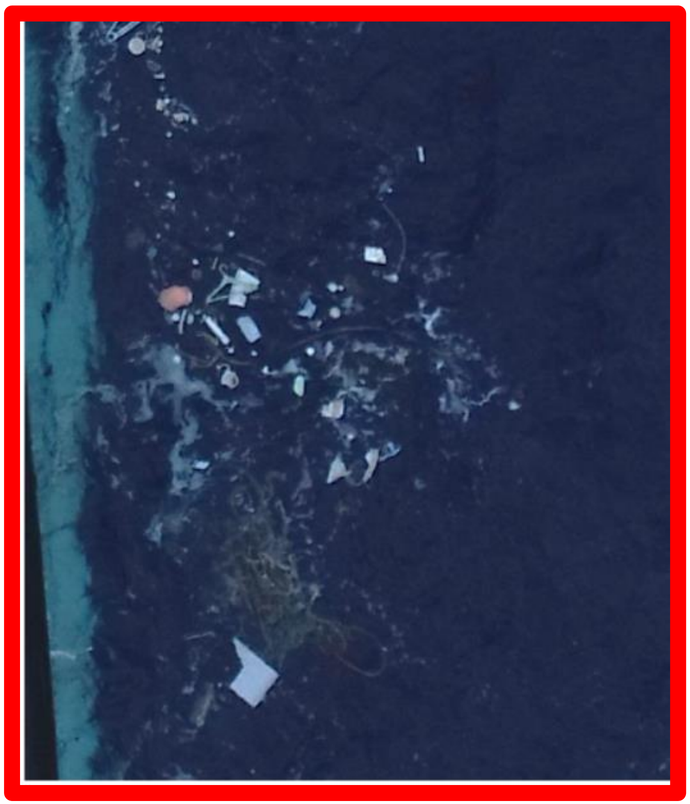
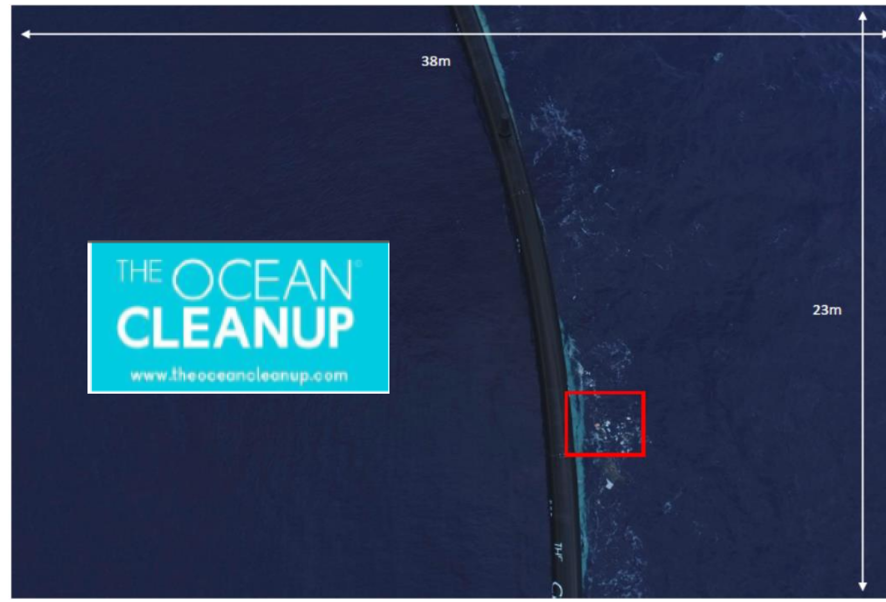
IN SITU PLASTIC MEASUREMENTS

From Garaba, 2018

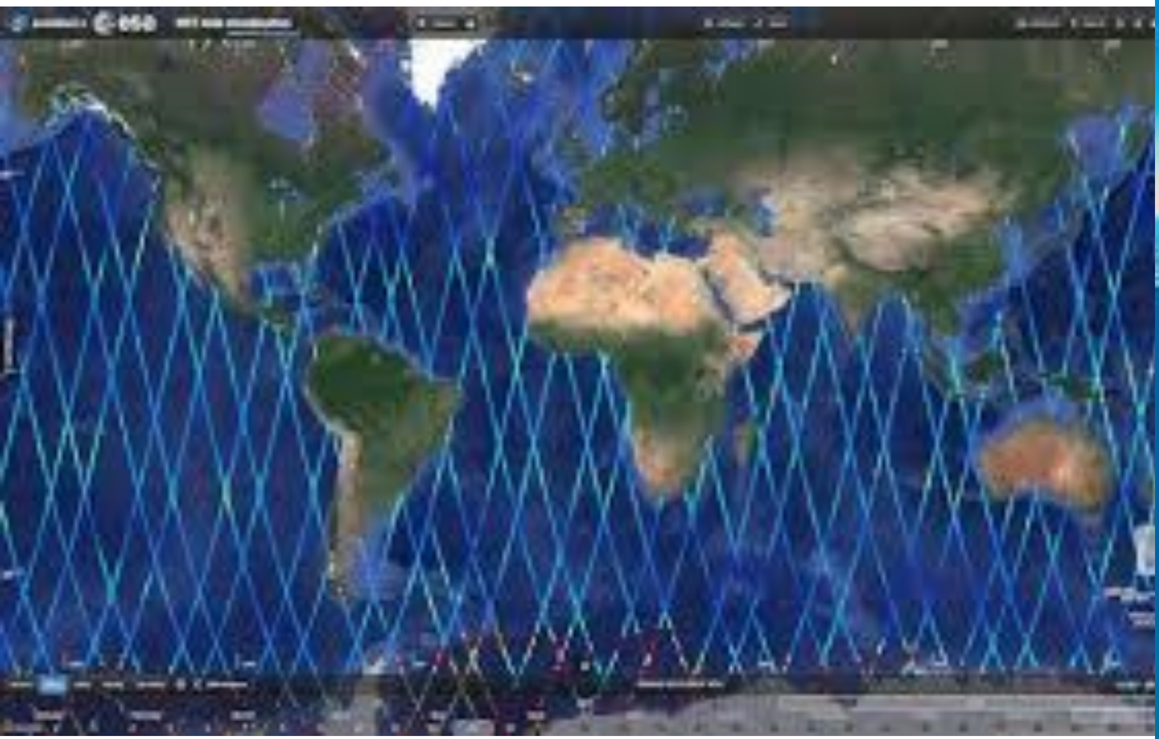
Drones results for measuring plastic patches.

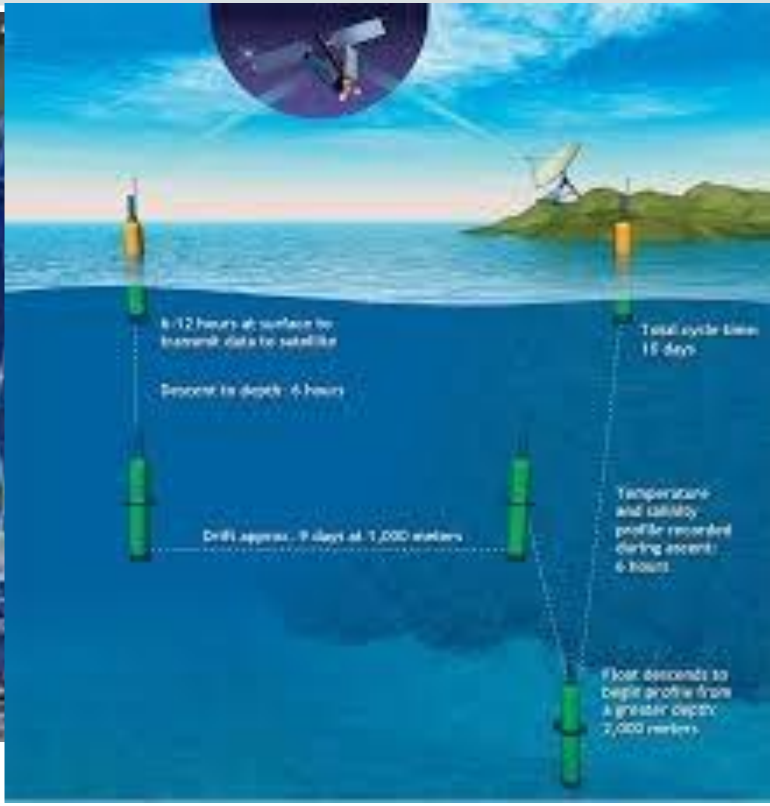




Imagery from a drone at 25m altitude captured around System001 in November 2018 by Robin de Vries

DETECTING, TRACKING, MONITORING





Use of litter-like transmitters for Plastic Marine Debris:

Coupling between global circulation/drift model and argos style positioning system

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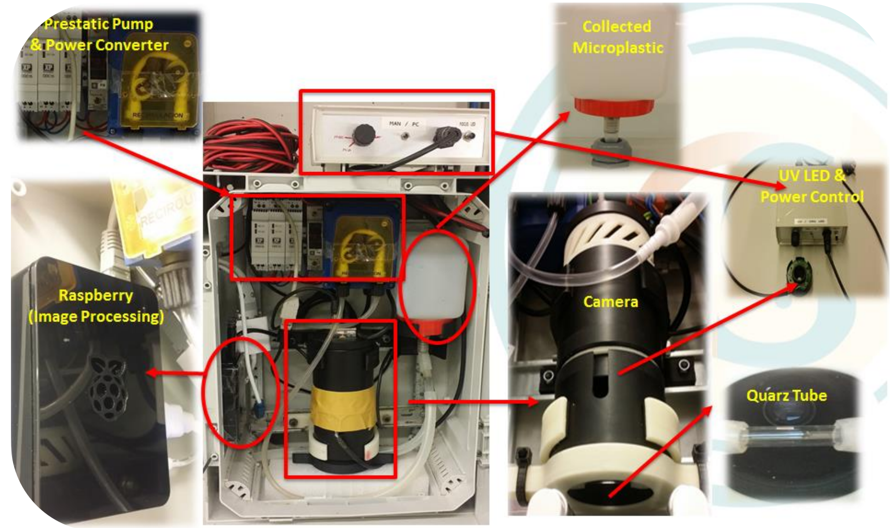
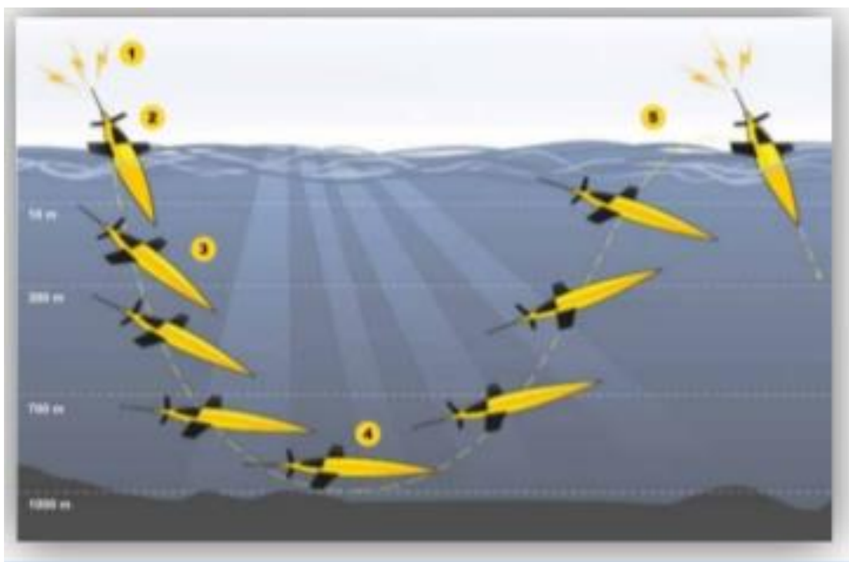
UNDERWATER IN SITU MEASUREMENTS

Common Sense project
(Oceans of tomorrow).





odysseaplatform.eu

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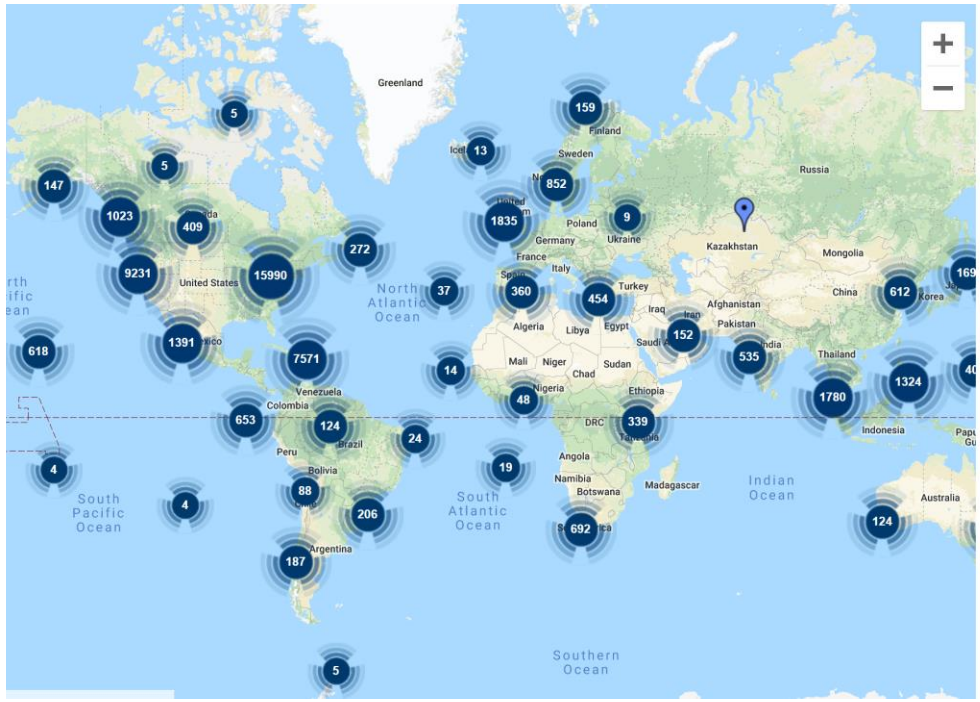
BEACH/SHORELINE DATA

Ocean Conservancy TIDES data system



Collected during the annual International Coastal Cleanup and by users of Clean Swell, Ocean Conservancy's ocean trash data collection app

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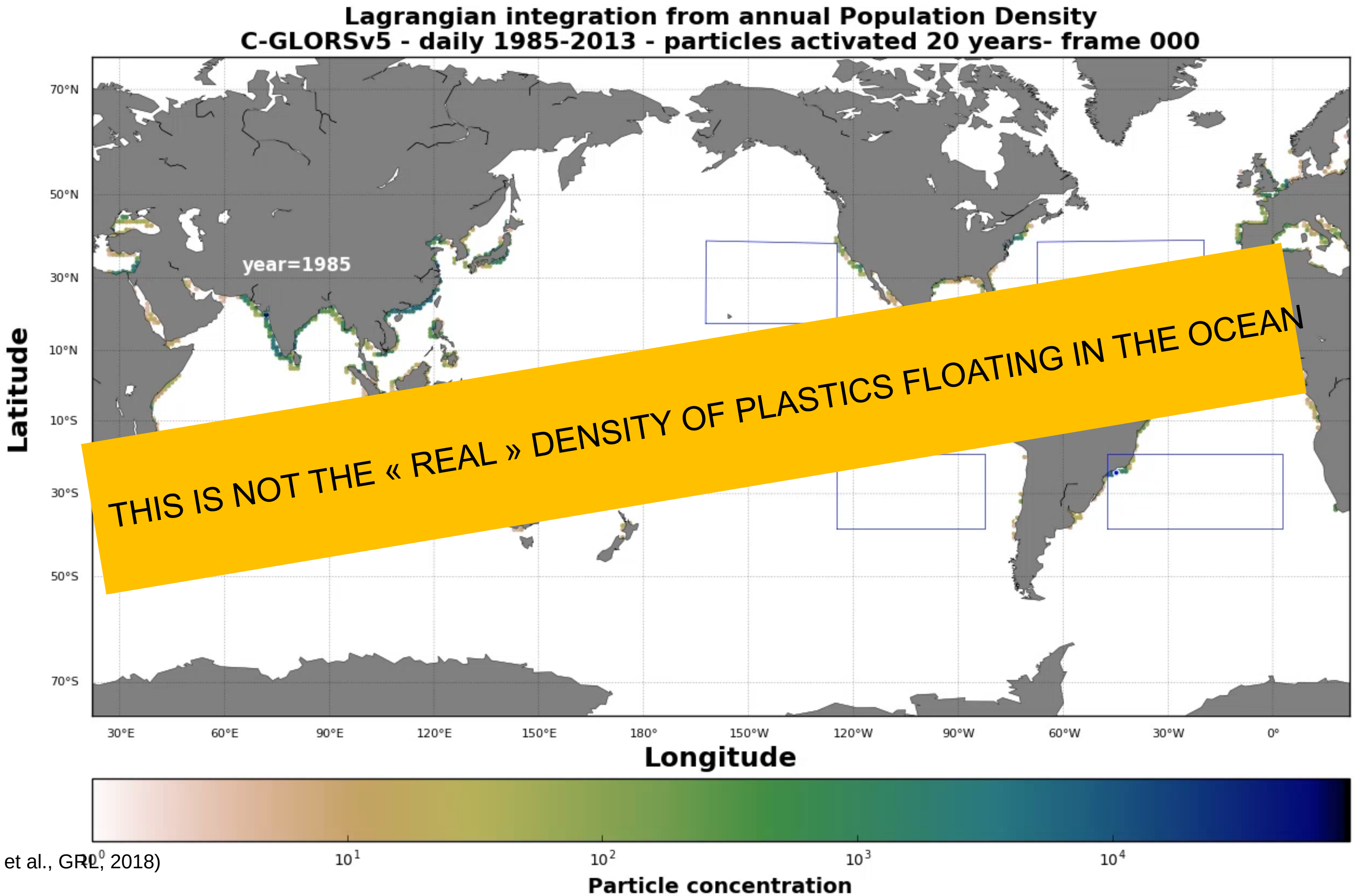
NUMERICAL MODELS



(From Maes et al., GRL, 2018)

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MONITORING
UNDERSTANDING
MITIGATING

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CHALLENGES

- How do we observe?
- How do we integrate?
  - ➢ Diversity of sources (above and below the surface, on the beach, models, …)
  - ➢ Diversity of communities (science, technology, citizens, regionally oriented, …)
  - ➢ Diversity of « data processing » (platforms, pre vs post processing, calibration, …)

- How do we manage?

➢ Role of AI

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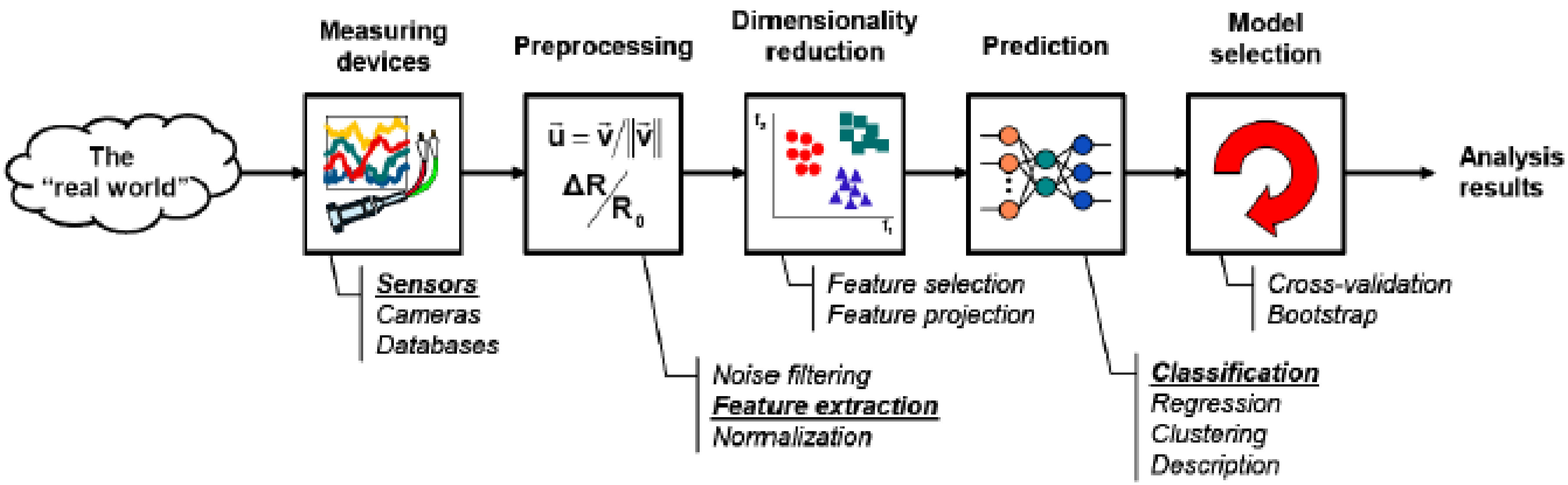
MACHINE LEARNING – DEEP LEARNING



Example for "marine debris":
TOWARDS DETECTING FLOATING OBJECTS ON A GLOBAL SCALE WITH LEARNED SPATIAL FEATURES USING SENTINEL 2
Jamila Mifdal et al, ϕ-lab, European Space Agency, ESRIN

After "Machine Learning", Dr. Lior Rokach, Ben-Gurion University

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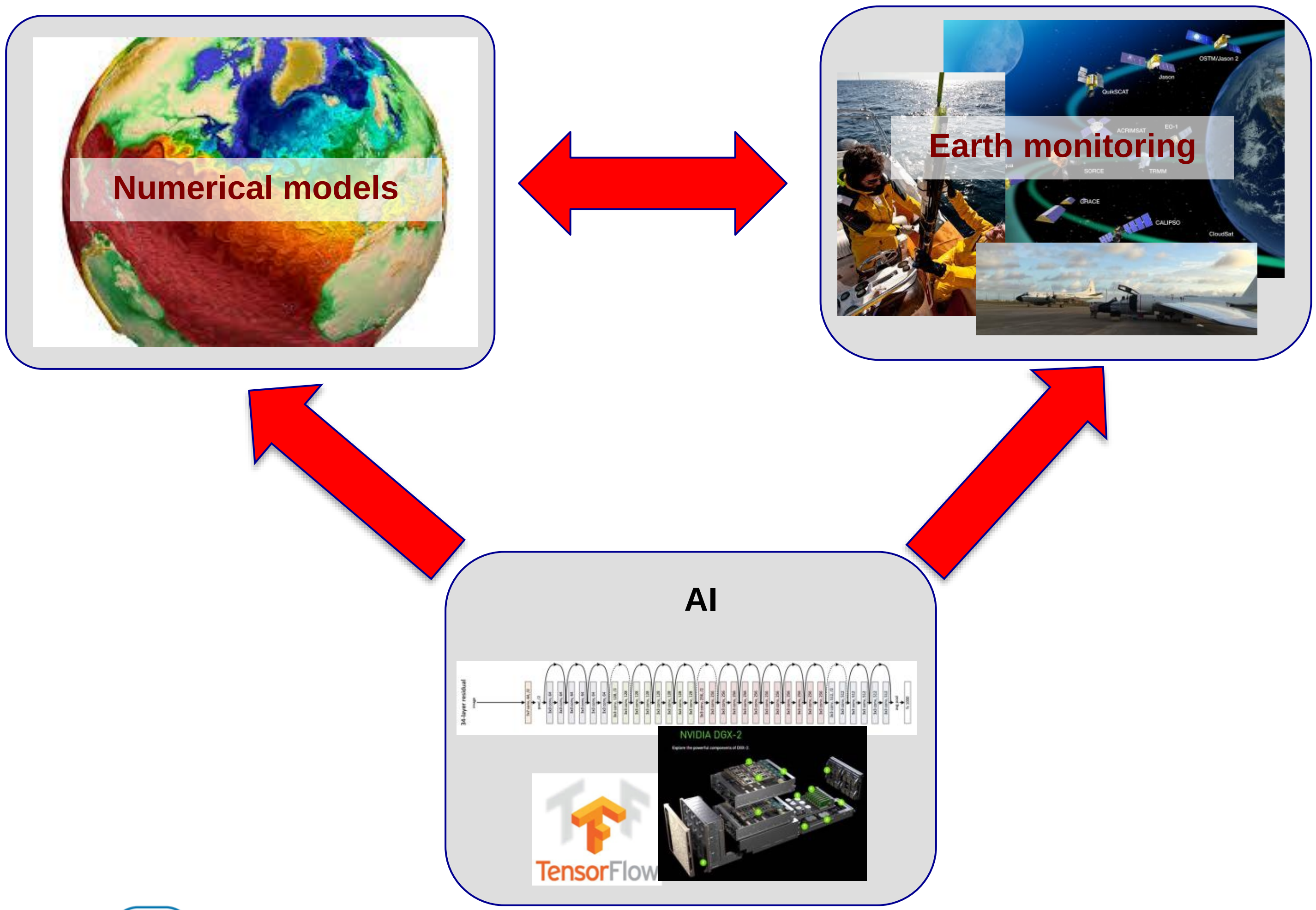
AI SUPERVISING THE LOOP



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APPLICATION: SEA CLEANING «GUIDE»

Floating marine debris along Indonesian coasts An atlas of strandings based on Lagrangian modelling ; Dobler et al, IRD

Manta project

The SEA CLEANERS

https://www.theseacleaners.org/

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PARTNERS

- Under GEO Blue Planet, an IEEE/OES funded working group on marine litter is investigating the sources, distribution and impact of marine debris, and supporting mitigation measures, policies and regulations to reduce it.

ACTIONS

GLOBAL PARTNERSHIP ON MARINE LITTER

GEO BLUE PLANET

DRAFT

A Global Platform for Monitoring Marine Litter and Informing Action

Draft version: 7 March 2020

Emily Smail, Jillian Campbell, Daniel Takaki, Hans-Peter Plag, René Garello, Samy Djavidnia, José Moutinho, Ghada El Serafy, Alessandra Giorgetti, Matteo Vinci, Maria Eugenia Molina Jack, Kate Larkin, Dawn J. Wright, Francois Galgani, Konstantinos Topouzelis, Stewart Bernard, Anne Bowser, Guido Colangeli, Linwood Pendleton, Leah Mupas Segui, Llorenç Milà i Canals, Morgan Simpson, Armando Marino, Imanol Zabaleta

IMDOS

Toward the Integrated Marine Debris Observing System, Front. Mar. Sci., 28 August 2019

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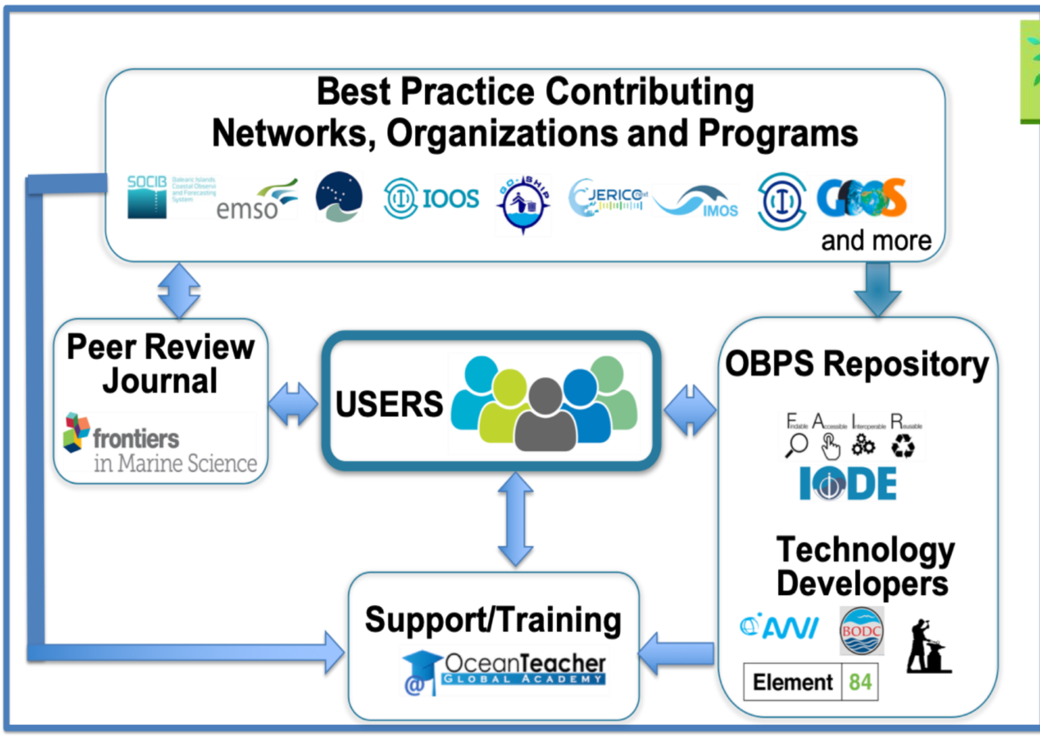
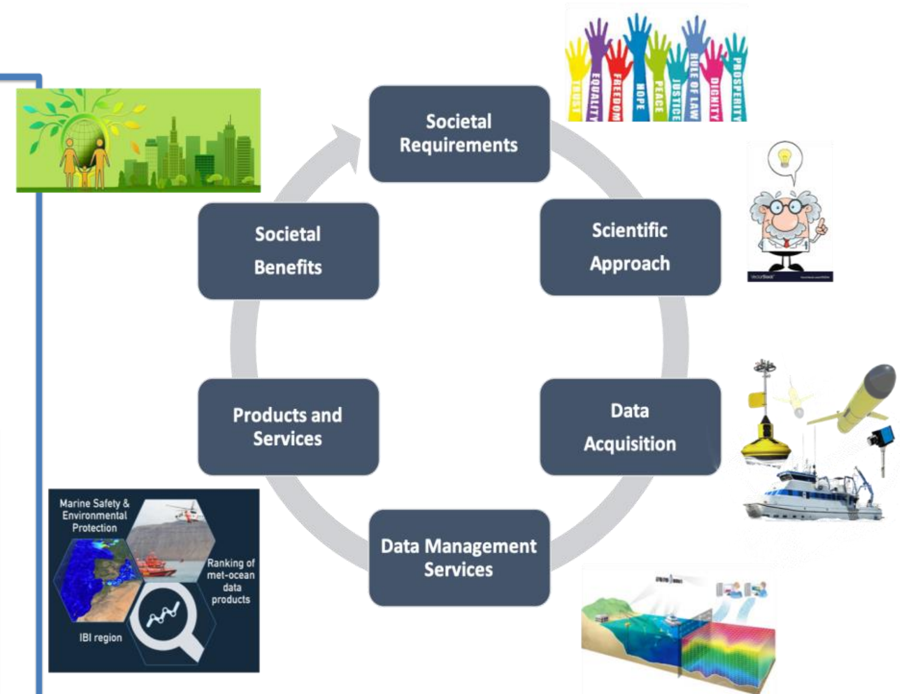
ACTIONS: THE OCEAN BEST PRACTICES SYSTEM

Ocean best practices





Supporting the entire value chain

Over 1500 practices in the repository

Provides long-term sustainable BP access

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SENSORS ON-BOARD

- Sentinel 1: imaging radar
- Sentinel 2: multispectral high-resolution imaging
- Sentinel 3: SST, SSH, ocean color
- Sentinel 4 & 5: atmosphere/ Met (aerosol, gases, …)
- Sentinel 6: Altimeter

- See at: https://sentinels.copernicus.eu/web/sentinel/missions

SATELLITE SENSORS CHARACTERISTICS

Satellite remote sensing is only applicable for floating debris close to the surface

Imaging radars (SAR)
Provide high-resolution information on parameters of the ocean surface (topography, roughness, surface waves, winds and currents). Correlates with the movement of marine debris, or identification of convergent fronts where floating debris collects.

-> Coupling with Ocean General Circulation Models.

Altimeters
Reconstructing the path of plastic from source to fate. Combined with auxiliary datasets such as currents, wind & waves

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SATELLITE SENSORS CHARACTERISTICS

Multi/Hyper spectral and Ocean Color
Looking at anomalies or particular signatures to identify ocean plastics and large agglomerations of plastic. Problem: resolution.

Combine with airborne sensors or drones. Hyperspectral sensors such as HyMap may be more suited to detecting plastics, these are available commercially.

Direct tracking of plastic or floating pieces (GPS tags or transmitters).

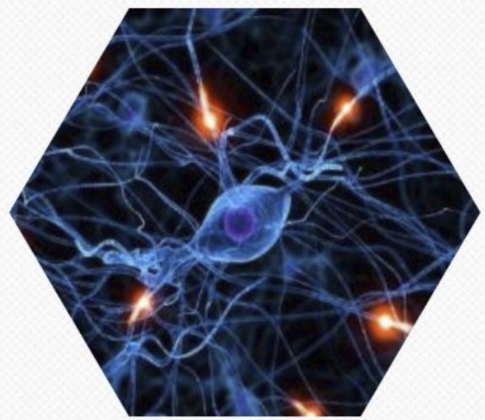
-> KINEIS constellation (IoT technology, see at https://www.kineis.com/en/homepage/).
Problem: the caveat of introducing electrical trash into the environment.

THREE MAIN DRIVERS FOR AI

More Data

Better Models

and Algorithms



Powerful GPU Accelerators

Especially for Deep Learning

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THE FOURTH DRIVER

The designer

- A priori knowledge
- Data selection
- Data Filtering and Enhancing
- Model selection
- Learning technique choice
- Experiment Design
- Avoid brute force
- Hybrid systems
  - Divide et impera

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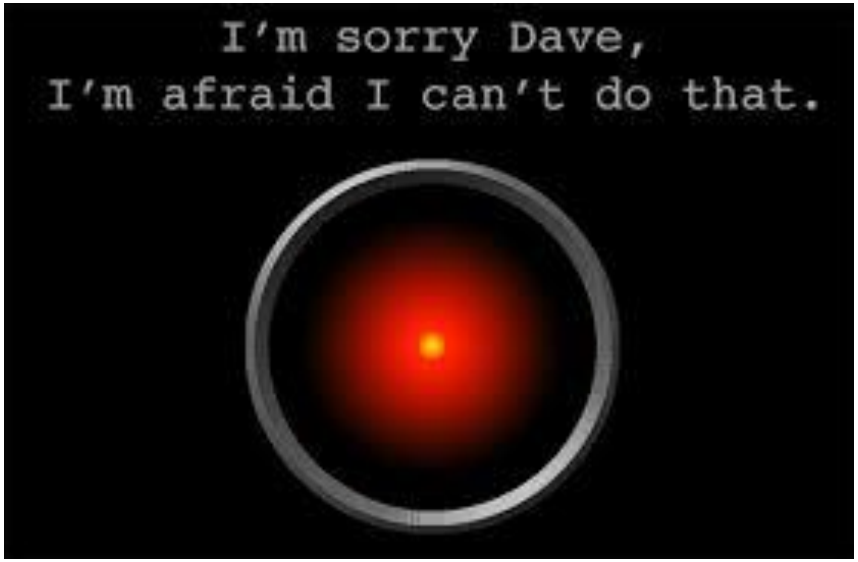
WHAT AI IS NOT

Autonomous machine



"Intelligent" machine