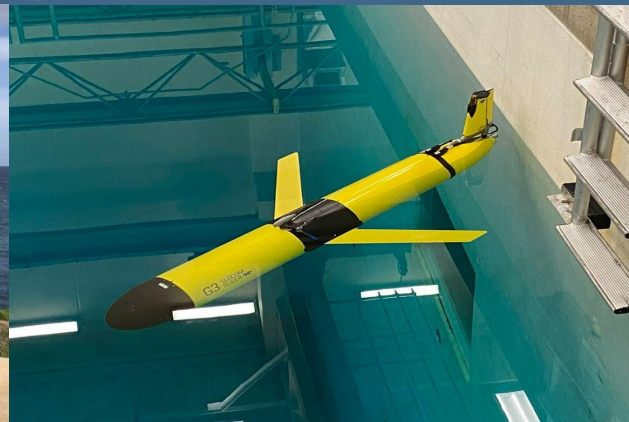


Growing NOAA's Uncrewed Maritime Systems Mission on Mississippi's Gulf Coast

Philip L. Hoffman
NOAA Ocean Exploration



NOAA Line Offices and Missions

National Ocean Service

Hydrography & Nautical Charting
Marine Pollution
Harmful Algal Blooms
Coastal Zone Management

National Marine Fisheries Service

Fish Population Surveys
Habitat Mapping
Marine Mammal/Turtle Surveys
Aquaculture Management

National Weather Service

Provide weather, water and climate data, forecasts and warnings for the protection of life, property and enhancement of the national economy

Office of Marine and Aviation Operations

Operates NOAA's Ships & Aircraft
Operationalize Uncrewed Systems

Office of Oceanic and Atmospheric

"NOAA Research"
provides research foundation
Ocean Exploration

National Environmental Satellite Data and Information Service

Environmental Satellites
Data and Information Services
Retrospective Products



Uncrewed systems (UxS) are vehicles – aerial, terrestrial or marine and associated elements, such as sensors and communications software, that can execute data-collection missions *without a human presence aboard*.

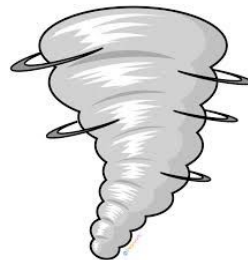




UxS Applications in Oceanic and Atmospheric Research



NOAA
RESEARCH





Broad Application of UxS in NOAA Research



- Extremely broad and extensive use of both aerial maritime systems across OAR
 - Global reach
 - Long-term monitoring and short-term experiments
 - Extreme environments
- Many data acquisition scenarios
 - Government owned and operated platforms
 - Contracted platform activities
 - Data as a service





Partnership is essential to NOAA UxS



- OAR cannot achieve our mission alone
- Cooperative Institutes with USM and MSU
- Cooperative Research and Development Agreements (CRADA)
- Tech transfer - R2O2R
- SBIR
- Investigating lower cost ways to access observations





Aerial Systems Applications



- Imagery
 - Tornado, hurricane, fire or severe event damage
 - Infrastructure assessments
 - Multi and hyperspectral imagery
- Boundary Layer
 - Met data for numerical weather prediction
 - Met observations for targeted events (e.g. severe storm research)
 - Atmospheric chemistry
 - Earth's radiation budget
- Stratospheric
 - Long-term greenhouse gas monitoring
 - Observations and deployment of sensors in severe weather

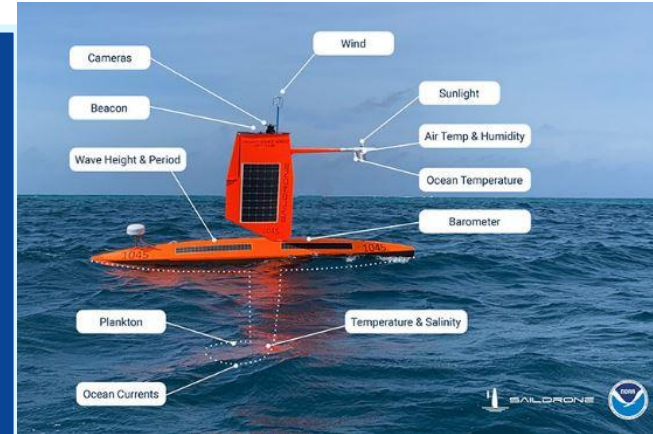




Maritime Systems Applications



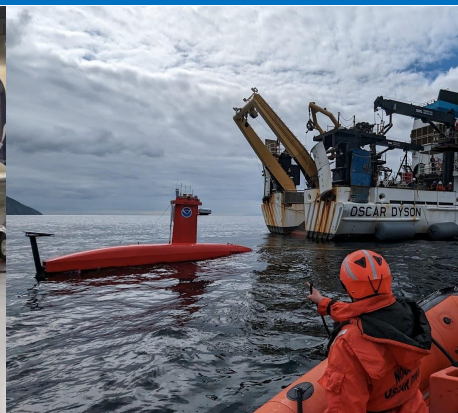
- Surface Vehicles
 - Long-term climate and oceanographic monitoring
 - Bathymetry
 - Ocean biology and chemistry
 - Harmful algal blooms
- Subsurface Vehicles
 - Buoyancy gliders
 - Under ice exploration in Arctic and Great Lakes
- Hurricane and Severe Storm
- Ocean exploration and bathymetry





NOAA

Office of Marine and Aviation Operations (OMAO) and Uncrewed Systems





Mission and Vision



Mission

Optimize NOAA's observational platforms and unique workforce capabilities to meet NOAA's science, service, and stewardship missions.



Vision

Protect environmental security through intelligence and stewardship.





OMAO Uncrewed System Operations Center



- **Development, Transition, and Innovation**
 - Fund R,D,T&E UxS projects to explore new capabilities and mission applications, and transition technologies to regular operations
 - Assess UxS capabilities in relation to NOAA requirements
 - Measurably increase reliability, capacity, efficiency, and safety of NOAA UxS missions
- **Operations and Support**
 - Operationalize UxS corporate assets for use across NOAA missions, or establish other operating models (i.e., industry operated) where fiscally appropriate
 - Provide UxS expertise and associated services
- **UxS Leadership and Collaboration**
 - Inform, coordinate, and implement UxS policies, authorities, and positions
 - Coordinate and collaborate within NOAA and with industry, academia, government, and NGOs
- **Model Workplace**
 - Recruit and develop an expert workforce empowered by a strong culture and infrastructure





Current Corporate UxS Assets



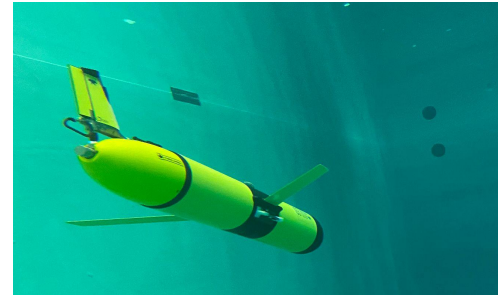
Resources for all of NOAA to use across areas



- Two DriX uncrewed surface vehicles
- Two Slocum underwater buoyancy gliders
- UAS Kickstarter Program
 - Provide Blue Drones and training across NOAA



These assets were realized through partnerships!





Facilitating Data as a Service

Exploring when industry owned and operated UxS is the best operating model

- UMS Services IDIQ Contracts
- Industry owned and operated medium-UAS for complex missions

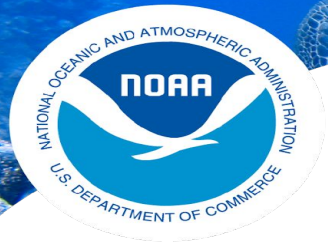




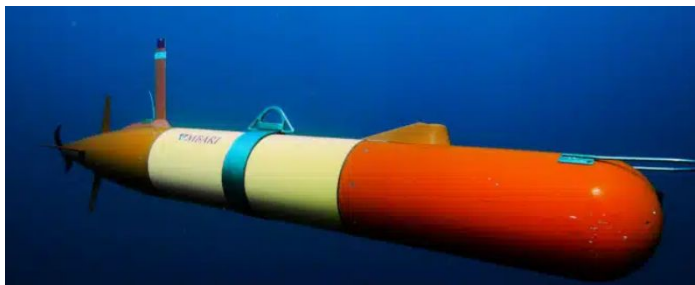
Supporting R&D and Operations with UxS

- **Allocated over \$32.9M to over 60 projects that utilize UxS to meet a NOAA missions since FY20**
 - Typically funded through internal-to-NOAA Requests for Proposals
 - Projects often have partnerships with academia or industry per Congressional direction
- **Enabling other efforts to make substantive advances for NOAA with UxS such as**
 - Beyond visual line of sight UAS operations
 - Underwater buoyancy glider recovery
 - Severe weather UAS
 - NOAA-wide UxS emergency response
 - Trained UxS operators





NOAA
FISHERIES



National Marine Fisheries Service



NMFS Mandates

- Magnuson Stevens Fishery Management and Conservation Act – stewardship of marine fisheries and habitats
- Marine Mammal Protection Act and Endangered Species Act – recovery and conservation of protected species (whales, sea turtles, corals, salmon, etc.)

Mandates encompass the U. S. EEZ, with international and high-seas commitments
NMFS Science is performed by six regional science centers; Northeast, Southeast, Southwest, Northwest, Alaska, Pacific Islands

NMFS Missions; turtles, UAS, line of sight

- Sea turtles in known congregations counted and assessed
- Leatherback tagging efforts use boat launched UAS to find turtles and guide tagging boat to animals
- Platforms – low altitude, low endurance VTOL copters and hybrids, beach, hand and boat launch, low disturbance, quiet operation
- Sensors – visual cameras for counts, brand resights, behavior, orthophotos for morphometrics



NMFS Missions; buoyancy gliders

- Cost effective presence in targeted areas (Antarctic, California Current, wind energy areas, right whale habitat)
- Sensors – temperature, salinity, fluorescence, eDNA, broadband water column sonars, optical plankton sensor with taxonomic ID under development, passive acoustic monitors
- Data – PAM and eDNA equipped gliders characterize marine mammal occurrence, gliders with enviro, plankton and sonar sensors for systematic ecosystem observations



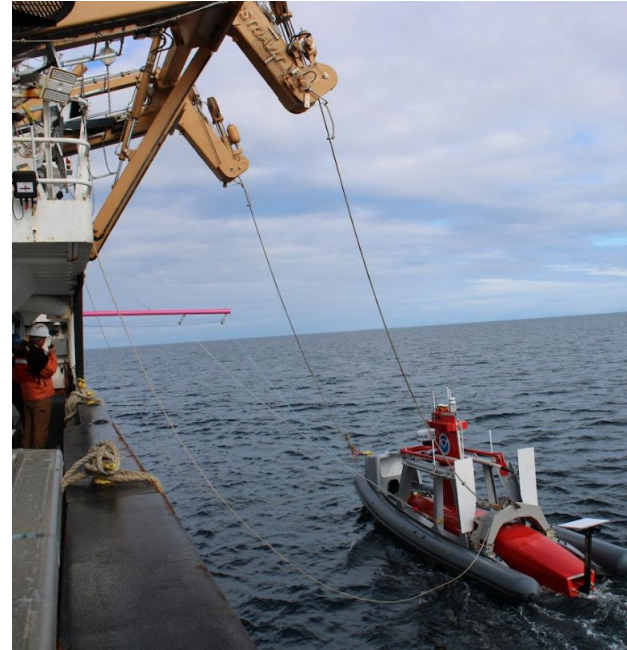
NMFS Missions; LRAUV benthic surveys

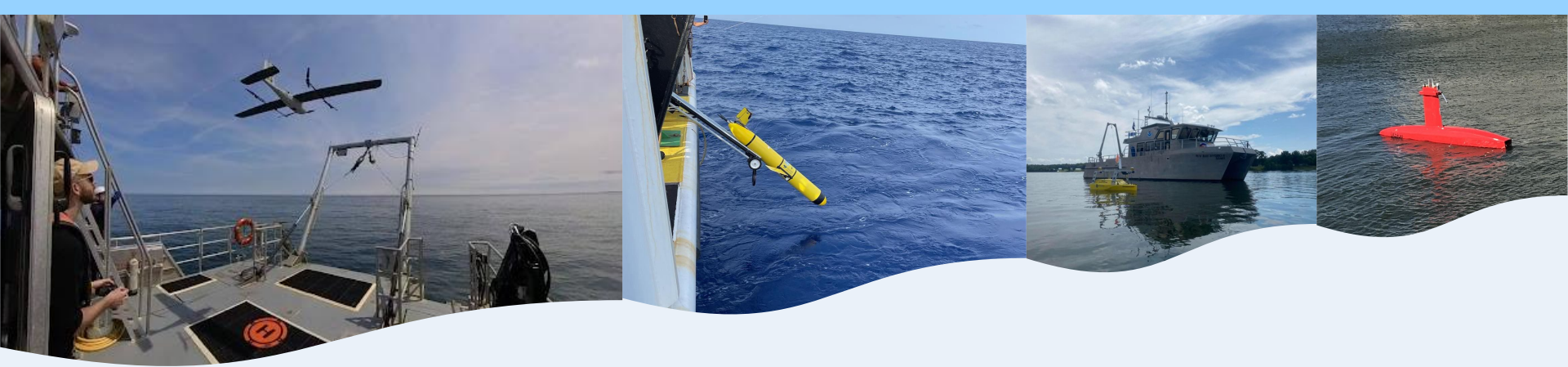
- Benthic surveys in targeted areas (scallops, wind energy areas)
- Platforms – long range AUV, 300m depth rating, one week endurance
- Sensors – stereo camera system with capabilities matching existing HabCAM, ship towed scallop survey sled, environmental sensors
- Data – automated processing of 100,000s images exists for HabCAM



NMFS Missions; powered USVs

- Platforms – wind, wave, solar powered USVs for low power/long endurance missions. Diesel powered USV for high speed/high power missions
- Sensors – environmental sensors, water column sonar
- Larger, diesel powered USVs require significant ship capabilities for launch/recovery at sea.





National Ocean Service UxS Operations



NCCOS

Harmful Algal Bloom (HAB) monitoring in coastal marine waters and the Great Lakes

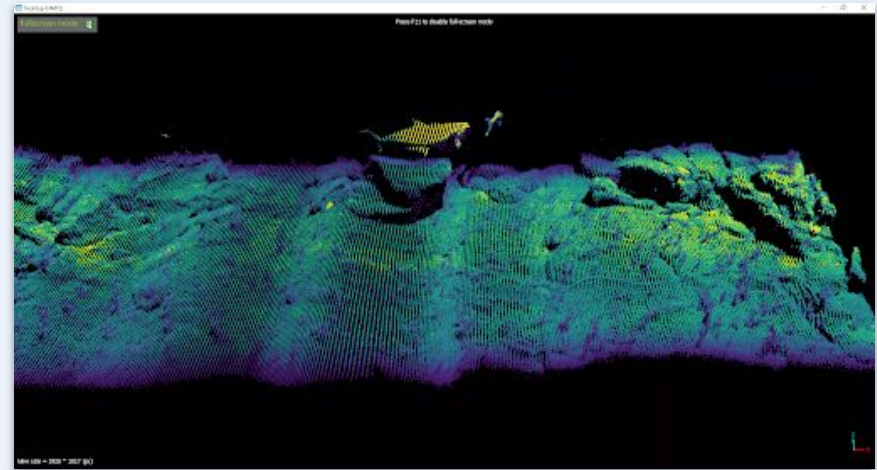
- Long-range AUV gliders & USV
 - Depth range of 10 - 1,500 meters (AUV)
 - CTD
 - Chlorophyll fluorescence/backscatter
 - Dissolved Oxygen (DO)
 - Photosynthetically active radiation (PAR)
 - 3rd Generation Environmental Sample Processor (3G ESP)
 - Algal toxin concentrations, and eDNA sample collection

Shoreline Habitat Monitoring & Characterization

- VTOL - Quadcopter
 - Structure from Motion (SfM)
 - Quantifying biomass of emergent vegetation
 - Digital elevation models
 - Analysis of nearshore vegetative communities

Shallow, Mesophotic and Deep Coral Ecosystem Mapping and Characterization

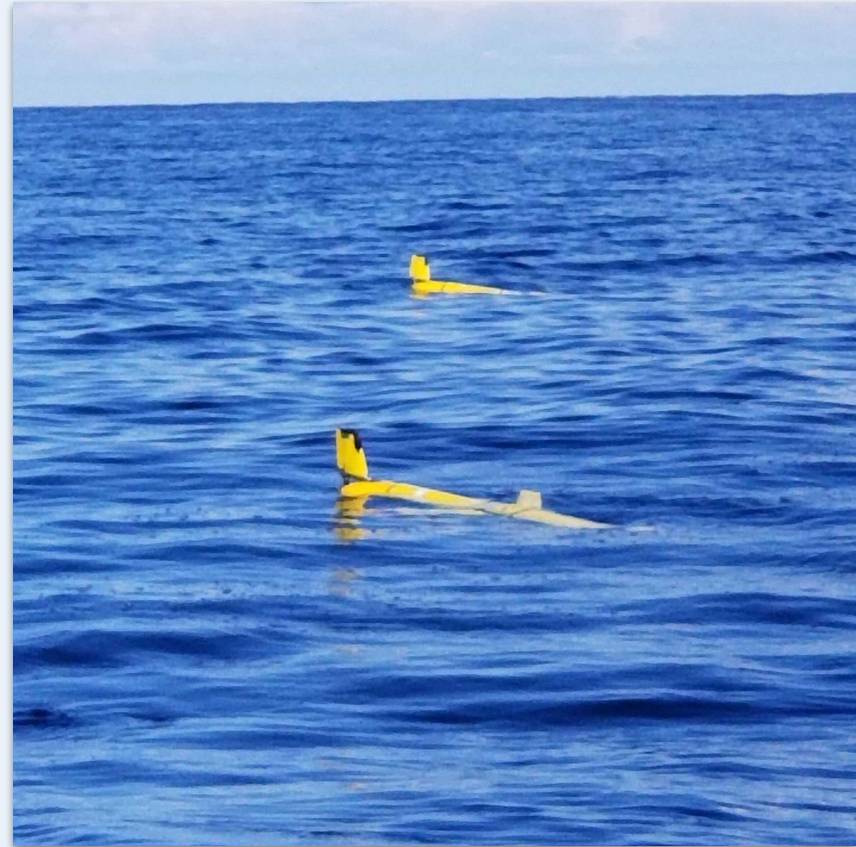
- UUV's - Micro/Small Class (300m)
 - Georeferenced images, SfM image mosaics
- UUV's - Medium Class (600 - 6000m)
 - Large area imaging, mapping and characterization
 - High resolution seabed characterization



IOOS

Coordinates with Regional Associations who deploy AUV's (gliders) in U.S waters for subsurface monitoring.

- Applications
 - Hurricane intensity forecasting
 - Ecosystem dynamics monitoring
 - Fisheries management
 - Impacts of offshore wind development
 - HAB and Hypoxia events
 - Marine heat waves
 - Ocean Acidification
 - Climate monitoring
- Upper ocean environments from surface to ~1000m
- Sensors
 - CTD
 - Physical variables such as pressure, noise (background, ambient, ships, marine mammal, etc), and currents
 - Biological variables related to phytoplankton and zooplankton
 - Ecologically important chemical variables such as DO and Nitrates
 - pH sensors for ocean acidification





NATIONAL
WEATHER
SERVICE

UxS NWS Perspective

#ItStartsWithObs





Examples of Storm Damage Uses



UAS imagery used to survey tornado damage from the remnants of Hurricane Elsa



UAS imagery used to survey flooding along the Ashley River in South Carolina



UAS imagery of EF-3 damage, complete destruction of a mobile home with debris blown downstream



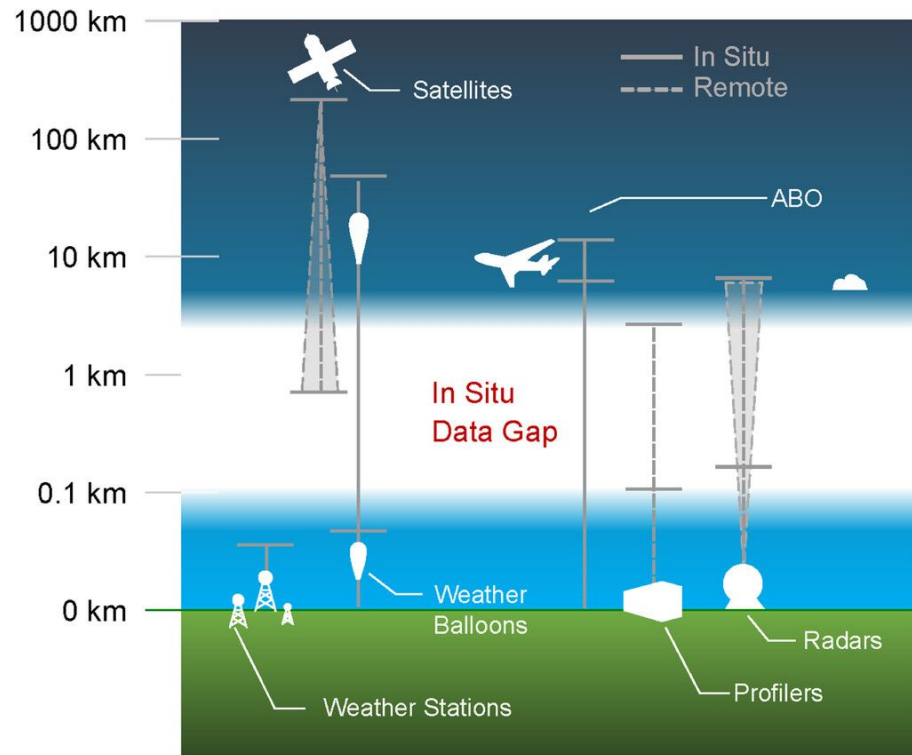
UAS imagery used to observe rip currents on Isle of Palms



Atmospheric Measurements



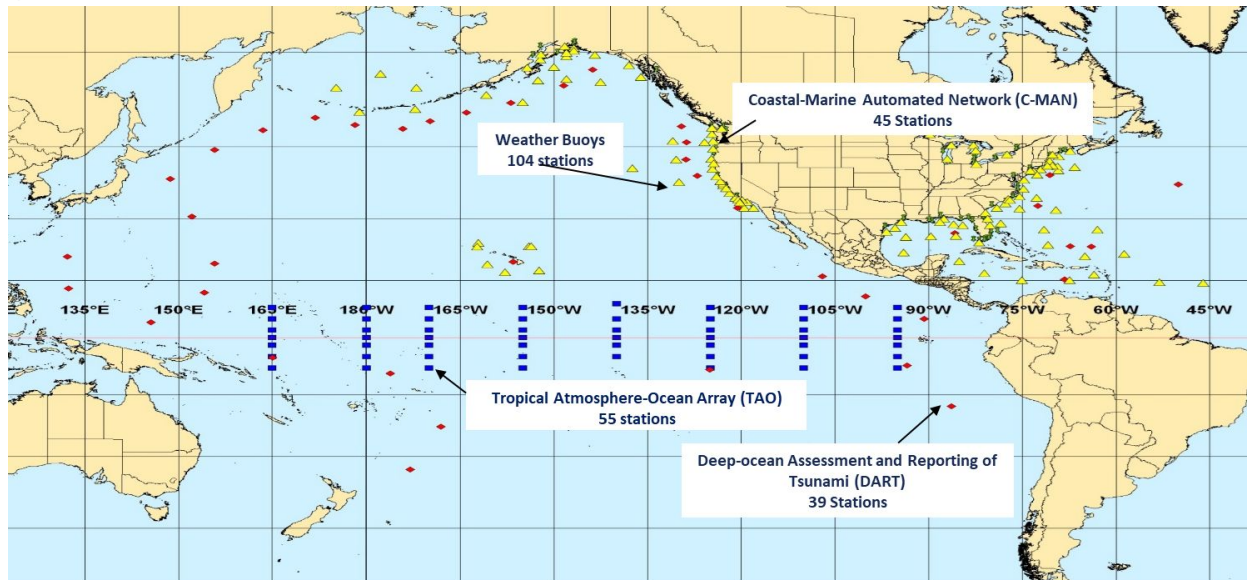
- The radiosonde network (aka weather balloons) has been in existence since the early 1930s.
 - Launch sites are sparse (92)
 - Launches occur twice per day (up to 4 times per day for extreme weather)
 - Can be costly to operate (time and money)
- Data from this network is coupled with aircraft, radar and satellite data, but still limited.
- Seek new ways to obtain vertical profiles of temperature, moisture and pressure to supplement the current network, or to provide gap mitigation (e.g., combo of low-level and hi-level UAS)



Source: Bulletin of the American Meteorological Society 102, 11; [10.1175/BAMS-D-20-0138.1](https://doi.org/10.1175/BAMS-D-20-0138.1)

Oceanic Measurements

- Ocean data is largest gap in observing capabilities for:
 - Atmospheric information over water
 - Ocean information (temp, salinity, wave info, etc.)
- Important for global and for atmosphere/ocean-coupled forecast models



NWS Marine Network



NESDIS - NCEI NOAA Uncrewed Systems Data Management

**National Oceanic and
Atmospheric Administration**