Air-Sea Flux Activities – Going Forward

Prepared for the 2021 GCOS Joint Panel Meeting
by Meghan Cronin (NOAA PMEL / OOPC)

Looking Back Since April 2019:

Sep 2019 OceanObs19

Mar 2020 COVID19. OOPC meeting canceled.

Sep 2020 Virtual Meeting **Ocean Best Practices Systems "Surface Radiation" Community Consultation Workshop**

Nov 2020 SCOR WG #162 **Observing Air-Sea Interactions Strategy (OASIS)**

Action Items from 2019 Joint Meeting

✓ Caterina Tassone (GCOS) liaison with WCRP to coordinate with existing WCRP ocean & land-base flux groups (WDAC, Surflux Task Team, GEWEX, SOLAS…).

✓ Liz Kent (AOPC) and Rainer Hollman (AOPC) will discuss with AOPC feasibility of remotely-sensed humidity & temperature profiles, optimized for surface boundary layer.

✓ Bob Weller (OOPC) will work with Christian Lanconelli (BSRN) to set up workshop on a global (ocean & land-based) radiation network, and develop best practices for surface radiation.

✓ Matt Palmer (OOPC) will liaison with WMO/WGNE & WCRP/WGCM

✓ Meghan Cronin (OOPC) will help coordinate a vision paper for broader community, beyond OceanObs19.

✓ Scoping of a SCOR Working Group Proposal for organizing/implementing near-term goals?

Slide from Joint Meeting April 2019

Surface Heat Flux Essential Climate Variables (ECVs)

Atmosphere

Surface
- Precipitation
- Pressure
- Radiation budget
- Temperature
- Water vapour
- Wind speed and direction

Upper-air
- Earth radiation budget
- Lightning
- Temperature
- Water vapor
- Wind speed and direction

Atmospheric Composition
- Aerosol and ozone precursors
- Aerosols properties
- Carbon dioxide, methane and other greenhouse gases
- Cloud properties
- Ozone

Land

Hydrosphere
- Groundwater
- Lakes
- River discharge

Cryosphere
- Glaciers
- Ice sheets and ice shelves
- Permafrost
- Snow

Biosphere
- Above-ground biomass
- Albedo
- Evaporation from land
- Fire
- Fraction of absorbed photosynthetically active radiation (FAPAR)
- Land cover
- Land surface temperature
- Leaf area index
- Soil carbon
- Soil moisture

Anthroposphere
- Anthropogenic Greenhouse gas fluxes
- Anthropogenic water use

Ocean

Physical
- Ocean surface heat flux
- Sea ice
- Sea level
- Sea state
- Sea surface currents
- Sea surface salinity
- Sea surface stress
- Sea surface temperature
- Subsurface currents
- Subsurface salinity
- Subsurface temperature

Biogeochemical
- Inorganic carbon
- Nitrous oxide
- Nutrients
- Ocean colour
- Oxygen
- Transient tracers

Biological/ecosystems
- Marine habitat properties
- Plankton

https://gcos.wmo.int/en/essential-climate-variables/ecv-factsheets

For global coverage of air-sea heat fluxes, we must improve satellite measurements

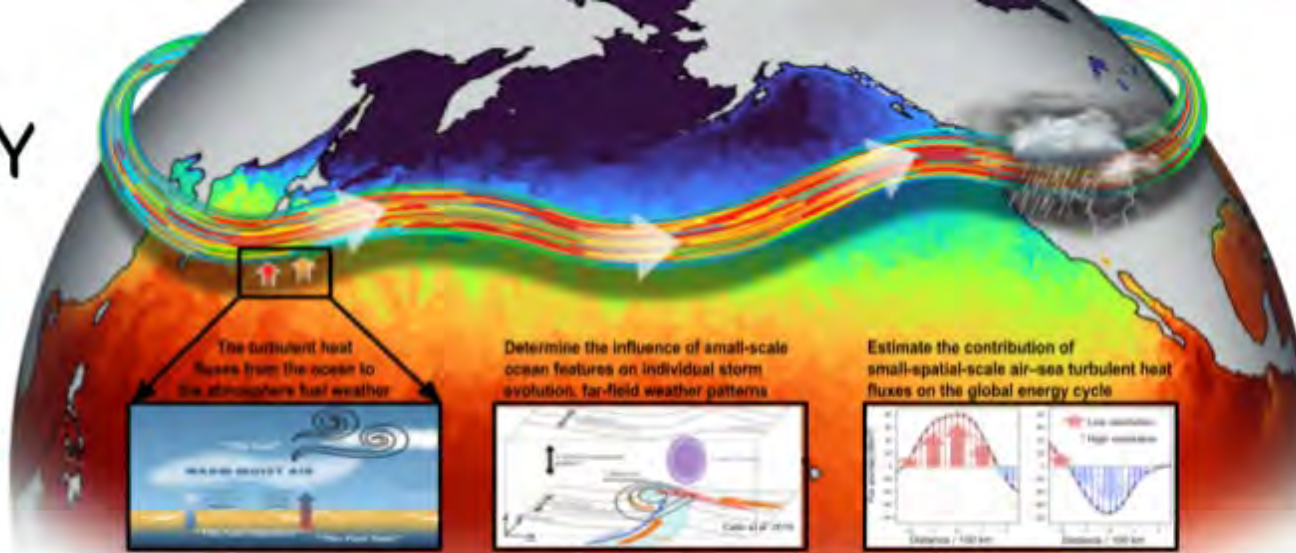| Flux EOV/ECV	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Bulk SST	Partially met												Adequate
Skin Temperature	Partially met												Adequate
Wind Speed and Direction	Partially met												Adequate
Air Temperature	Not met												Adequate
Humidity	Not met												Adequate
Bulk Surface Currents	Partially met												Adequate
Skin Surface Currents	Not met												Adequate
Surface Solar Radiation	Partially met												Adequate
Surface Longwave Radiation	Partially met												Adequate
Albedo	Partially met												Met
Sea State	Requirement Unknown												Requirement Known

- Requirement not met / inadequate
- Requirement partially met / threshold
- Requirement adequately met / breakthrough
- Requirement fully met / ideal goal

Cronin et al. (2019) "Air-sea fluxes with a focus on heat and momentum" OceanObs19 Community Strategy Paper RECOMMENDATIONS:

(1) Optimize satellite-based boundary layer obs for near-surface air temperature & humidity, ...

(2) Expand the global network of *in situ* air-sea interaction observations

OCEAN OBS'19

NASA Earth Venture Missions (EVMs) are science driven, competitively selected, low cost satellite missions

"Butterfly" is a proposed NASA EVM that would lead to significant improvement in satellite-based air-sea heat fluxes by 2027
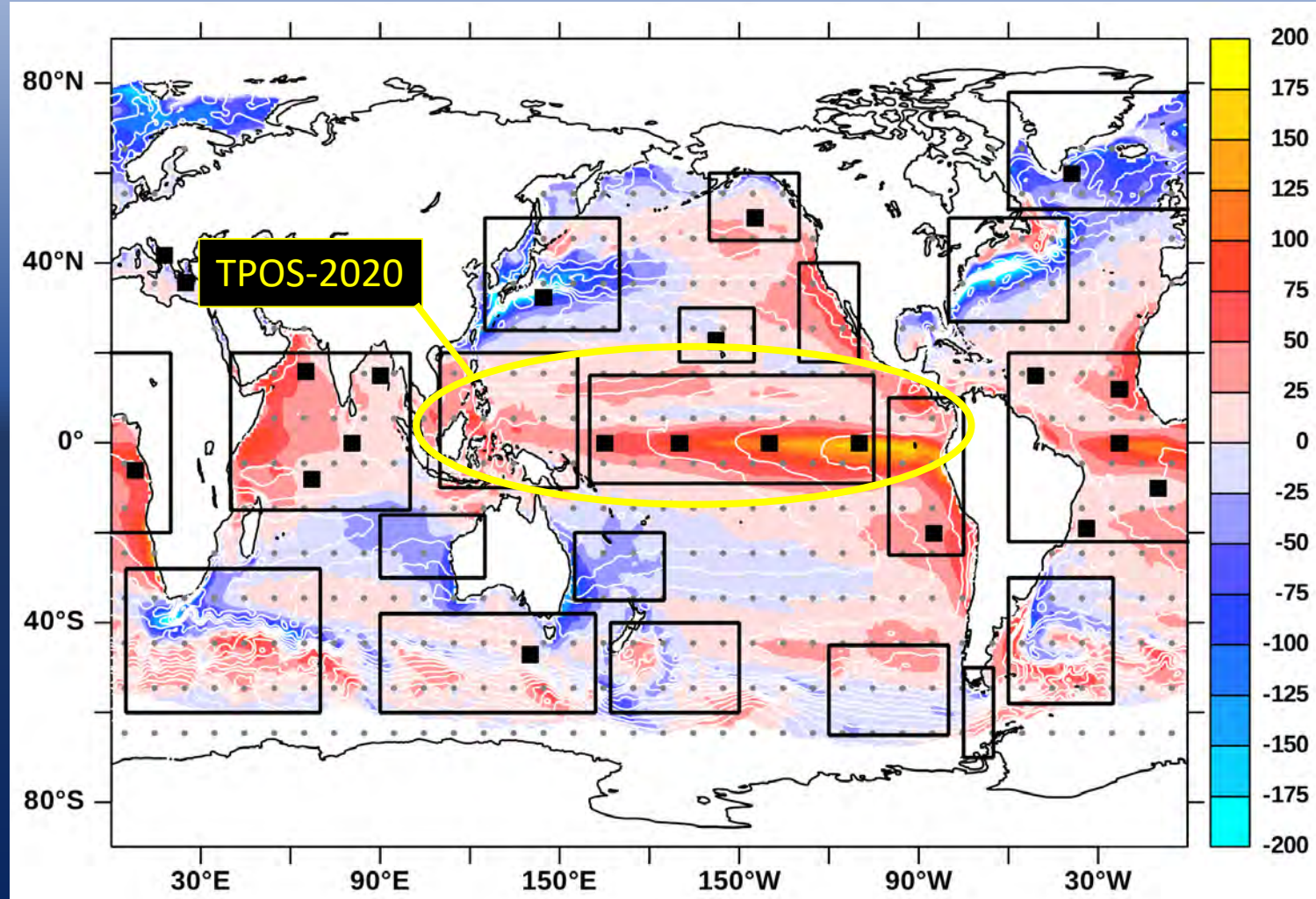
Courtesy Tony Lee

OceanOb19 RECOMMENDATION: Global network of 500-1000 drifting or mobile platforms & more reference stations (squares) in key (boxed) regions

Drifting and Mobile Flux Platforms (examples)

Reference Stations (examples)

TPOS-2020

Mean Net Surface Heat Flux (Wm⁻²)

Cronin et al. (2019) **"Air-sea fluxes with a focus on heat and momentum"**

SCOR WG #162 for developing an
Observing Air-Sea Interactions Strategy (OASIS) for 2030
website: airseaobs.org
Expected lifetime as a SCOR Working Group: November 2020 – October 2023

A "system-as-a-whole" approach for making surface and boundary layer observations relevant to the Earth's energy, water, and carbon cycles, including their physical, biological, and geological components

Integrating recommendations from

>40 OceanObs19 community strategy papers &

>400 authors

OASIS SCOR WG #162 DELIVERABLES:

1. Report with consolidated OO19 OASIS recommendations (TOR #1; 6-months)

2. OASIS Strategy Publication & UN Decade action calls (TOR #1-6; 36-months)

   a. OASIS "Programme" for UN Decade (submitted Jan 15, 2021)

   b. OASIS "Ocean Shots" for US Ocean Decade (submitted to NAS Dec 1, 2020)

3. Best practice papers (TOR #2-5; 18-36-months)

4. Air-sea flux toolbox (TOR #2, 4-6; 12-36-months)

5. Air-sea flux curriculum (TOR #2, 4-6; 12-36-months)

6. Website, webinars and newsletter (TOR #1-6; Ongoing)

OBPS Surface Radiation WG Breakout Report

developing best practices for making high quality surface radiation observations from moving platforms

Session Lead: Meghan Cronin (NOAA PMEL)
ECOP Co-lead: Maria Teresa Guerra (Trinity College Dublin)
Co-lead: Laura Riihimaki (NOAA GML)
Co-lead: Elizabeth Thompson (NOAA PSL)

www.oceanbestpractices.org

Surface Radiation OBPS Working Group Strategy

➢ Compile list of papers showing performance statistics for different sensors

➢ Develop Decision Tree for choice of sensors based upon application

➢ Develop best practices for Surface Radiation observations

➢ Propose expanding land-based calibration facilities to handle ocean-based sensor systems

➢ Propose intercomparison experiments at ocean-land testbed sites nearshore & land-based tower references

➢ Write report & peer-review paper

www.oceanbestpractices.org

Bridge ocean & land-based Rad. communities

➤ Compile list of papers showing performance statistics for different sensors … written primarily by land-based networks

➤ Develop Decision Tree for choice of sensors based upon application

➤ Develop best practices for Surface Radiation observations

➤ Propose expanding land-based calibration facilities to handle ocean-based sensor systems

➤ Propose intercomparison experiments at ocean-land testbed sites nearshore & land-based tower references

➤ Write report & peer-review paper

What activities would bring us closer to observing air-sea fluxes globally with accuracies needed for predicting weather & climate influenced by the ocean?

Flux Accuracies and Processes

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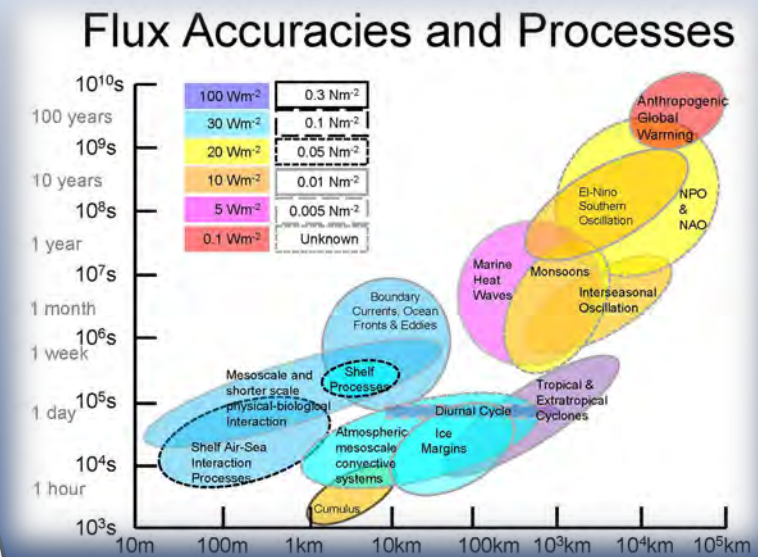
EXTRA Slide

Air-sea exchanges of energy, moisture, and gases drive and modulate the Earth's weather and climate, influencing life, including our own. These air-sea interactions fuel the hydrological cycle and affect precipitation across the globe. Air-sea interactions affect the distribution of carbon dioxide between the atmosphere and ocean, how seawater flows and winds blow, and how pollutants floating on the ocean surface move – information critical to policymakers, industry, and civil society.

The Observing Air-Sea Interactions Strategy (OASIS) PROGRAMME will provide observational-based knowledge to fundamentally improve weather, climate and ocean prediction, promote healthy oceans, the blue economy, and sustainable food and energy.

-- Summary Statement for the UN Ocean Decade OASIS Programme proposal

SCOR WG Member	Institution
Meghan Cronin*	NOAA Pacific Marine Environmental Laboratory, **US**
Sebastiaan Swart*	University of Gothenburg, **Sweden**
Nadia Pinardi	University of Bologna, **Italy**
R. Venkatesan	National Institute of Ocean Technology, **India**
Phil Browne ^	ECMWF, **UK**
Warren Joubert ^	South African Weather Service, **South Africa**
Ute Schuster	University of Exeter, **UK**
Christa Marandino	Geomar, **Germany**
Shuangling CHEN ^	Second Institute of Oceanography, **China**
Clarissa Anderson	Scripps Institution of Oceanography, **US**
Jim Edson	Woods Hole Oceanographic Institution, **US**
Zhaohui CHEN	Ocean University of China, **China**
Juliet Hermes	South African Environmental Observation Network, **South Africa**
Fabrice Ardhuin	University Brest, CNRS, IRD, Ifremer, LOPS, IUEM, **France**
Oscar Alves	Bureau of Meteorology, **Australia**
Hiroyuki Tomita	Institute for Space-Earth Environmental Research (ISEE), Nagoya University, **Japan**

* Cochairs   ^ Early Career

OASIS partnerships for implementing Programme

| Partner Organization	Role of Partner in OASIS Programme	Point of Contact	Contact Info
GOOS Ocean Observations Physics and Climate (OOPC) panel	Help coordinate & integrate air-sea interaction observations within the GOOS for physics and climate	Sabrina Speich & Weidong Yu (co-chairs)	sabrina.speich@lmd.ipsl.fr, yuwd@mail.sysu.edu.cn
GOOS BGC panel / International Ocean Carbon Coordination Project (IOCCP)	Help coordinate & integrate biogeochemical air-sea interaction and carbon flux observations within the GOOS	Kim Currie (co-Chair), Véronique Garçon (co-chair), Rik Wanninkhof (former member)	Kim.Currie@niwa.co.nz, veronique.garcon.legos@gmail.com Rik.Wanninkhof@noaa.gov
GOOS Biology-Ecosystem panel	Help coordinate & integrate OASIS biological and ecosystem observations within the GOOS	Frank Muller-Karger (member), Lavenia Ratnarajah (international project officer)	carib@usf.edu, L.ratnarajah@unesco.org
Ocean Best Practice Systems	Help formalize ocean best practices needed for high-quality observations and interoperability within the OASIS network	Jay Pearlman (co-chair)	jay.pearlman@fourbridges.org
CoastalPredict	Help bridge open ocean and coastal OASIS observations with stakeholders	Nadia Pinardi (co-chair)	nadia.pinardi@unibo.it
Marine Life 2030	Help design and integrate biological and ecosystem observations within the OASIS network	Frank Muller-Karger (co-chair)	carib@usf.edu
Deep Ocean Observing Strategy (DOOS)	Help connect surface OASIS observations with deep ocean observations and processes to inform interaction of the surface and deep ocean (e.g. GHG and elemental fluxes, animal migrations, etc.)	Lisa Levin (co-chair)	llevin@ucsd.edu
Ocean Corps	Help develop OASIS knowledge partners and users in developing countries	Brian Arbic (co-chair)	arbic@umich.edu
EquiSea	Help develop resources and build capacity for OASIS activities in developing countries	Alexis Valauri-Orton (co-chair)	avalauriorton@oceanfdn.org
Consortium for Ocean Leadership	Provides administration and communication support (see airseaobs.org)	Sheri Schwarz (Program Associate)	sschwartz@oceanleadership.org
NSF Regional Coordination Network	Help connect to OceanObs19 community recommendations for ocean observing in 2030	Jay Pearlman (co-chair)	jay.pearlman@fourbridges.org

Surface ocean CO_2 flux: all seawater pCO_2 measurements collected since 1957

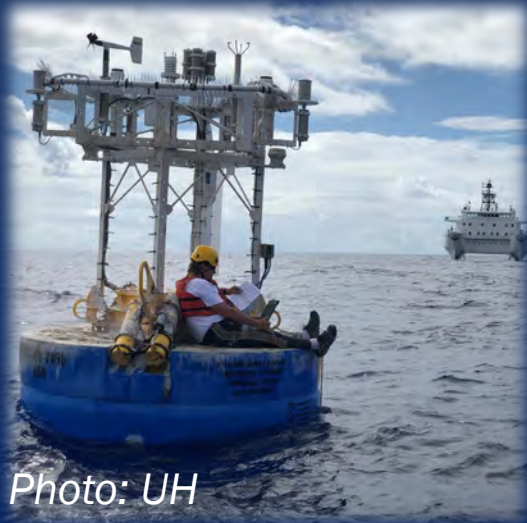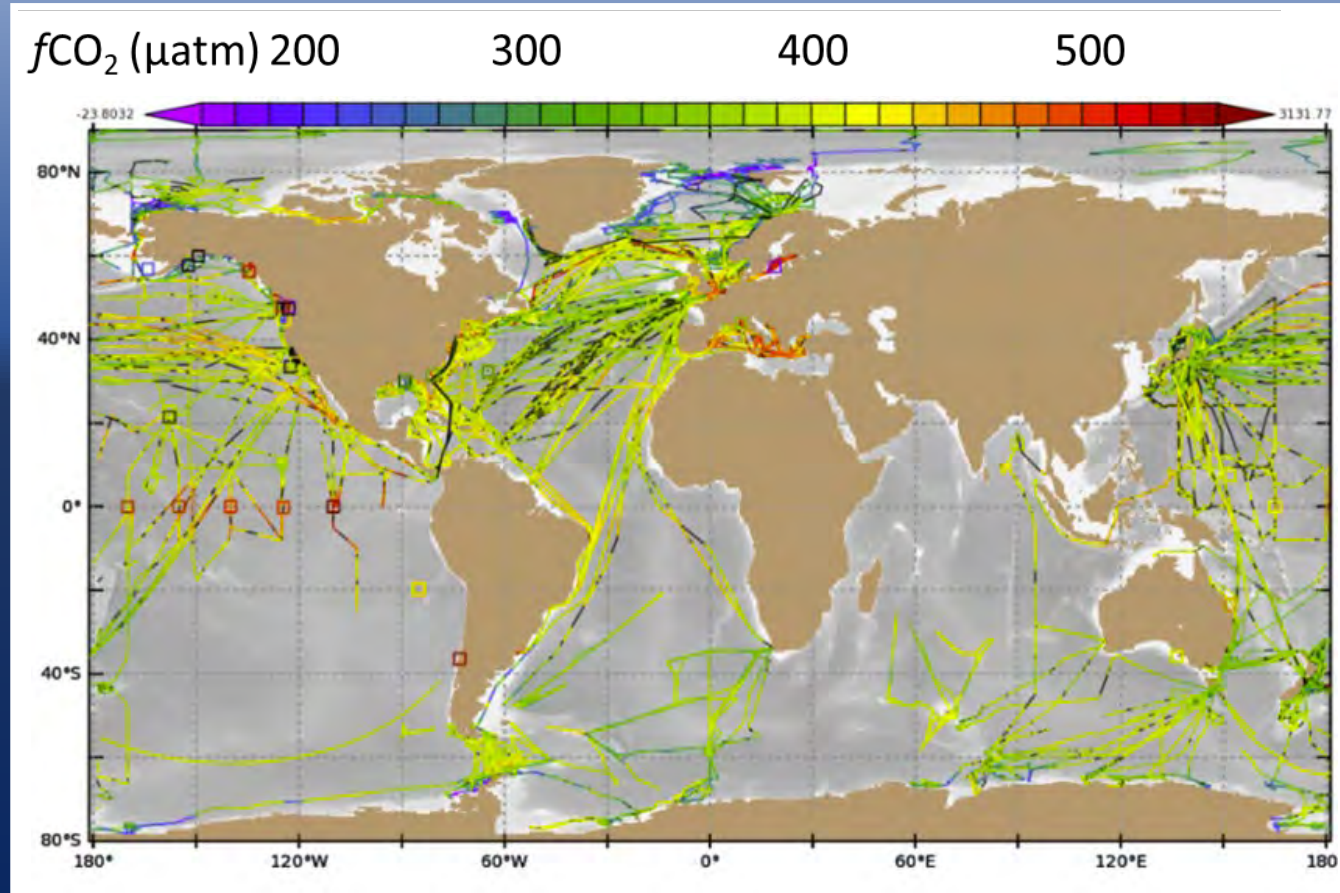**Established Platforms:**

Photo: UH
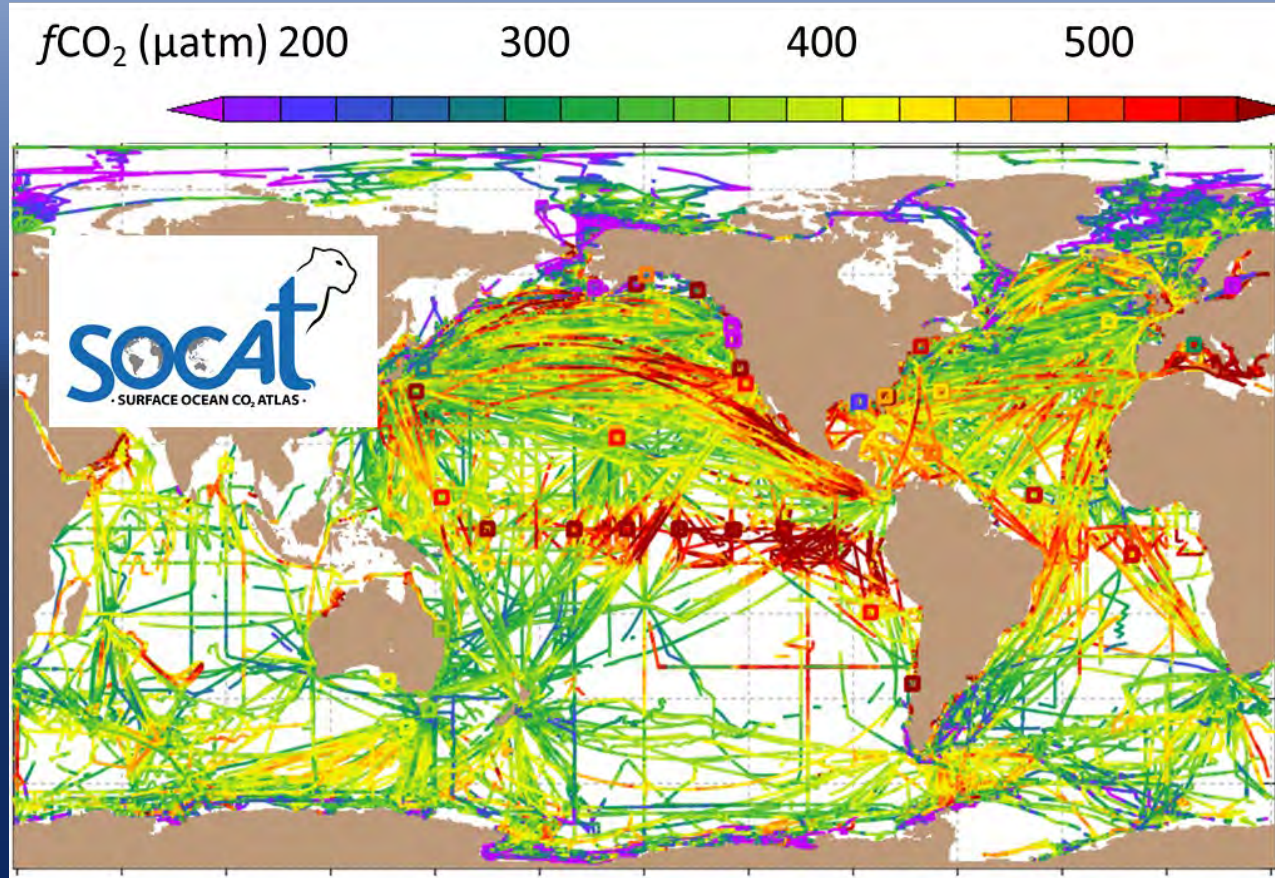
New Technology:

Photo: Saildrone

Wanninkhof et al. (2019) **"A Surface Ocean CO_2 Reference Network, SOCONET and Associated Marine Boundary Layer CO_2 Measurements"**

Surface ocean CO$_2$ flux: all seawater pCO$_2$ measurements collected in 2015

Established Platforms:

New Technology:

Photo: Saildrone

Photo: UH

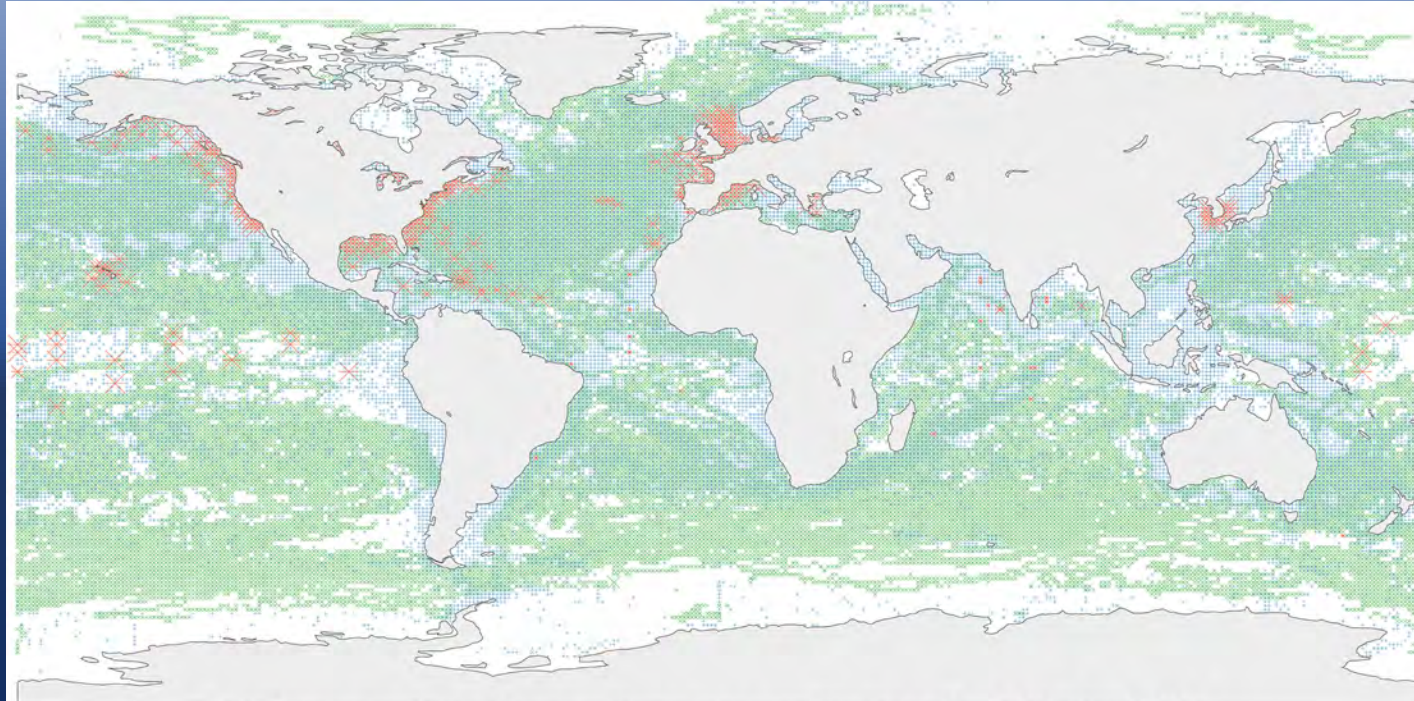Wanninkhof et al. (2019) **"A Surface Ocean CO$_2$ Reference Network, SOCONET and Associated Marine Boundary Layer CO$_2$ Measurements"**

OceanObs'19 Recommendation: Create an Integrated Surface Ocean Observing System

Surface marine observations transmitted on the GTS in 2018
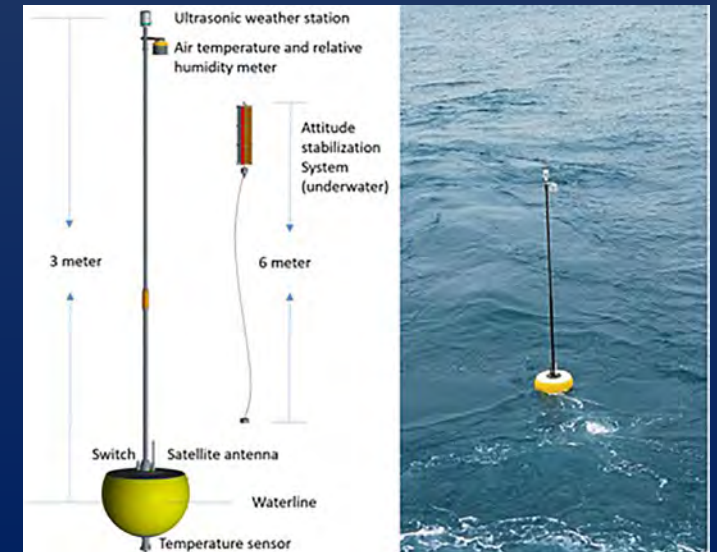Ships (+)   Drifting buoys (x)   Moored buoys (✳)
Symbol size indicates number of days in 2018 when the 1°x1° cell was observed
from   · : 30 days or less, to   X: 335 days or more

Centurioni et al. (2019) **"Global in situ Observations of Essential Climate and Ocean Variables at the Air-Sea Interface"**
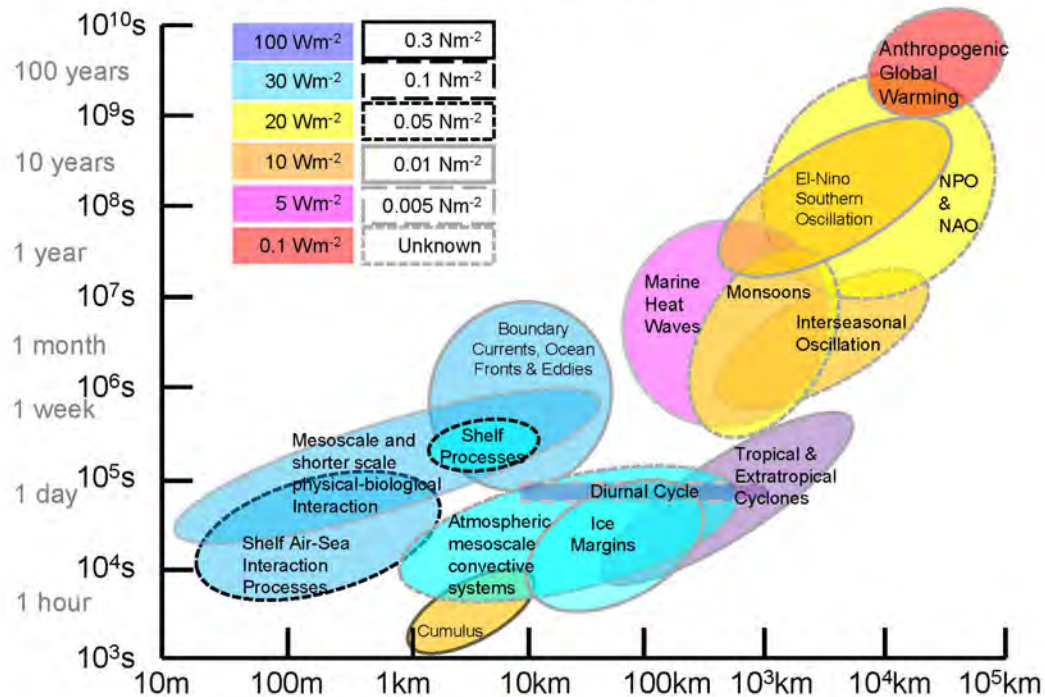
New technology for measuring directional waves
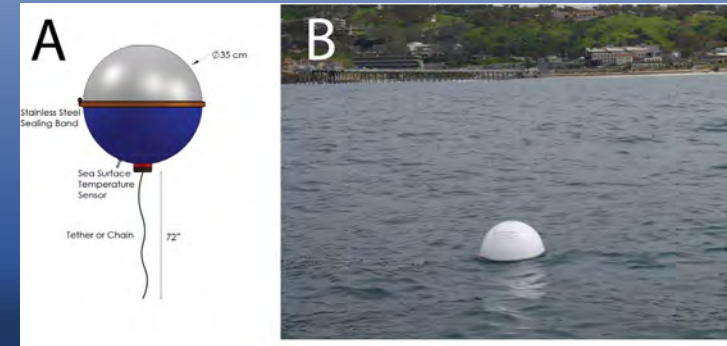
... and meteorological variables

To predict weather and climate influenced by the ocean, we must accurately resolve air-sea heat fluxes

Cronin et al. (2019) **"Air-sea fluxes with a focus on heat and momentum"**

How accurate?
What resolution?
Where are these observations needed?
How can this be done?

An Observing Air-Sea Interactions Strategy (OASIS) for 2030