Coupled ocean-atmosphere research: Questions for the future

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Image credit: NASA

Flux Accuracies and Processes



Air-Sea Related Processes



Cronin et al, *Frontiers in Marine Science*, 2019

Intermittent and extreme events govern air-sea exchange

Deep September mixed layers



- At Southern Ocean flux moorings, highly episodic heat loss from ocean
- Heat loss leads to deep mixed layers, drives airsea exchange with ocean interior
- Heat loss events linked to strong winds from south
- If we want to understand how the ocean sequesters heat or CO₂, need to understand events

Air-Sea Related Processes





C 2021 United Nations Decade of Ocean Science for Sustainable Devaloa

Ardhuin et al. (2019a) Bange et al. (2019) Bax et al. (2019) Canonico et al. (2019) Domingues et al. (2019) Estes et al. (2021) Penny et al. (2019) Pinardi et al. (2019) WEATHER Powers et al. (2019)

Arico et al. (2021

Foltz et al

Speich et al. (201) Wanninkhof et al. (2019)

Groom et al. (2019

Jarnet et al. (2019

Muelbert et al. (2019)

Muller-Karger et al. (2018) Newman et al. (2019

Lombard et al. (2019) Marandino et al. (2022 Kent et al. (2019) O'Carroll et al. (2019

Anderson et al. (2019)

Improved Earth system (including ecosystem) forecasts for a predicted, clean, accessible, healthy, safe & productive ocean

CUMATE

Improved ocean information serving stakeholders around the world

Grand Idea #3 Improved models & understanding of air-sea interaction processes

Observing Air-Sea Interactions Strategy (OASIS) is harmonizing community recommendations from OceanObs'19 and UN Decade Laboratories... NSF Harcourt et al. (2019

... into three Grand Ideas



OceanObs'19 vision for a flux observing system

Infrastructure wish list:

- Maintain Argo array to capture ocean's evolving reservoir of heat, freshwater, etc.
- 2. Flux moorings---especially in Southern Ocean. Lack of observations in Southern Ocean high wind/high fetch conditions.
- 3. Process studies to unravel physics

OASIS Grand Idea #1: Implicit inclusion of NOAA buoys and NSF Ocean Observatories Initiative sites, as well as contributions from international partners



2019

Frontiers in Marine Science,

Cronin et al,

Mean Net Surface Heat Flux (Wm^{-2})



NSF and potential satellite missions



What's coming?

- Momentum fluxes (winds and currents):
 - Harmony (European Space Agency, 2029 launch)
 - ODYSEA (Ocean Dynamics and Surface Exchange with the Atmosphere, JPL-CNES Phase A proposal due March 20, 2025. Doppler scatterometer, proposed for 2030 or 2032 launch)
- Turbulent heat fluxes (plus latent heat)
 - CIMR (European Space Agency, 2025 launch, high-res all-weather SST)
 - Butterfly (near surface temperature, humidity, + SST, wind) to be re-proposed to NASA

Partnership opportunities



- Calibration and validation phase
 - Model of SWOT satellite Adopt-A-Crossover program which mobilized ~20-30 research groups to carry out observations coordinated with satellite cal/val
 - Validation across a range of conditions
- Process studies coordinated with new satellite observations
- Early adopter initiatives

Final comments

- Multi-scale observations and analysis needed to cover full range of processes (and interplay between scales)
- Importance of full transition zone, from base of mixed layer to top of marine atmospheric boundary layer

