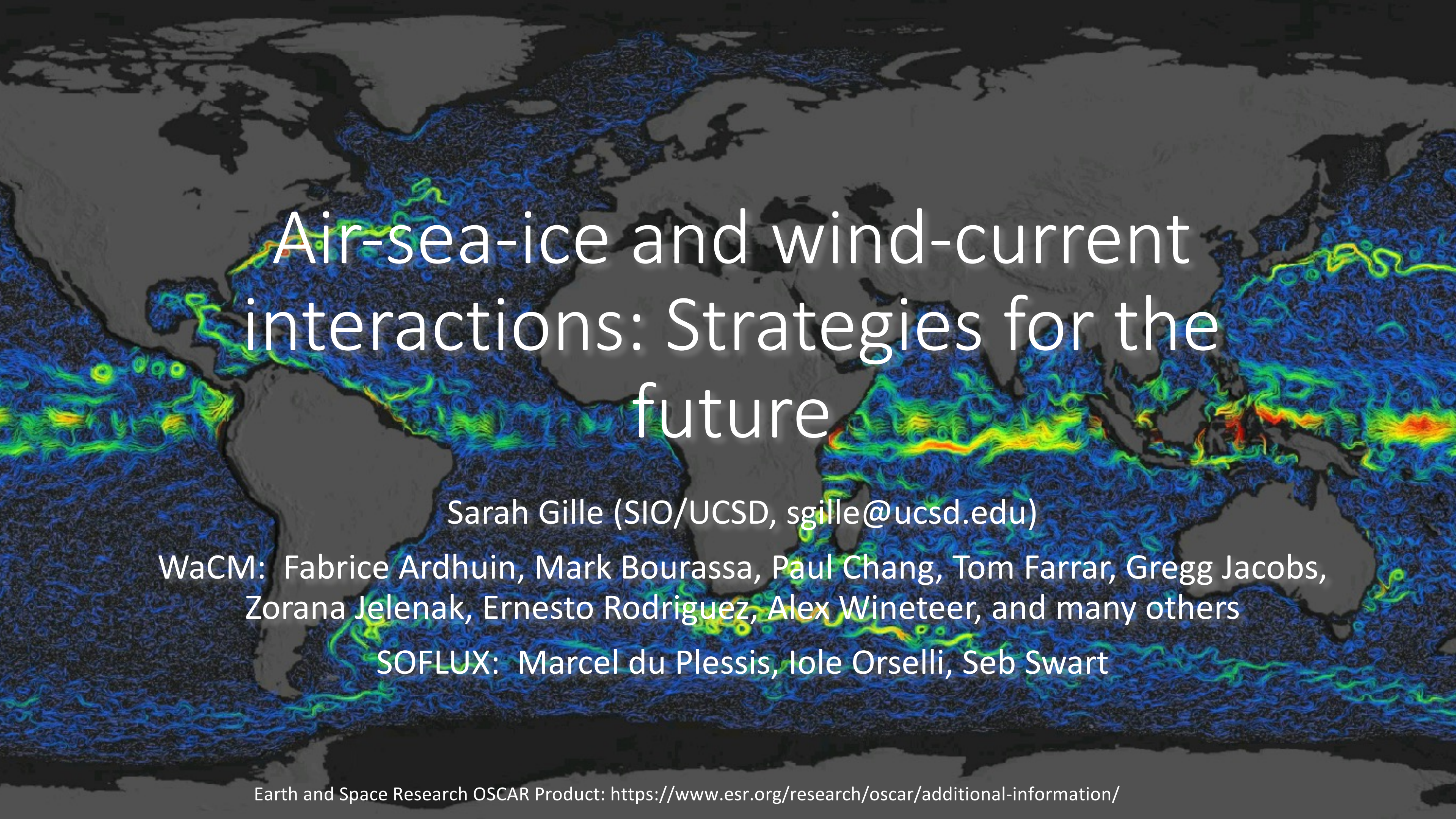
Air-sea-ice and wind-current interactions: Strategies for the future

Sarah Gille (SIO/UCSD, sgille@ucsd.edu)

WaCM: Fabrice Ardhuin, Mark Bourassa, Paul Chang, Tom Farrar, Gregg Jacobs, Zorana Jelenak, Ernesto Rodriguez, Alex Wineteer, and many others

SOFLUX: Marcel du Plessis, Iole Orselli, Seb Swart



Earth and Space Research OSCAR Product: https://www.esr.org/research/oscar/additional-information/

Topics

- Update on US CLIVAR Mesoscale Air-Sea Interactions Working Group (2020-)
- Approaches for improving fluxes at high latitudes (air-sea ice fluxes)
  - US CLIVAR High-Latitude Surface Flux Working Group (2008-2012)
  - Southern Ocean Observing System Working Group on Air-Sea Fluxes (SOFLUX)
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Update on US CLIVAR Mesoscale Air-Sea Interactions Working Group

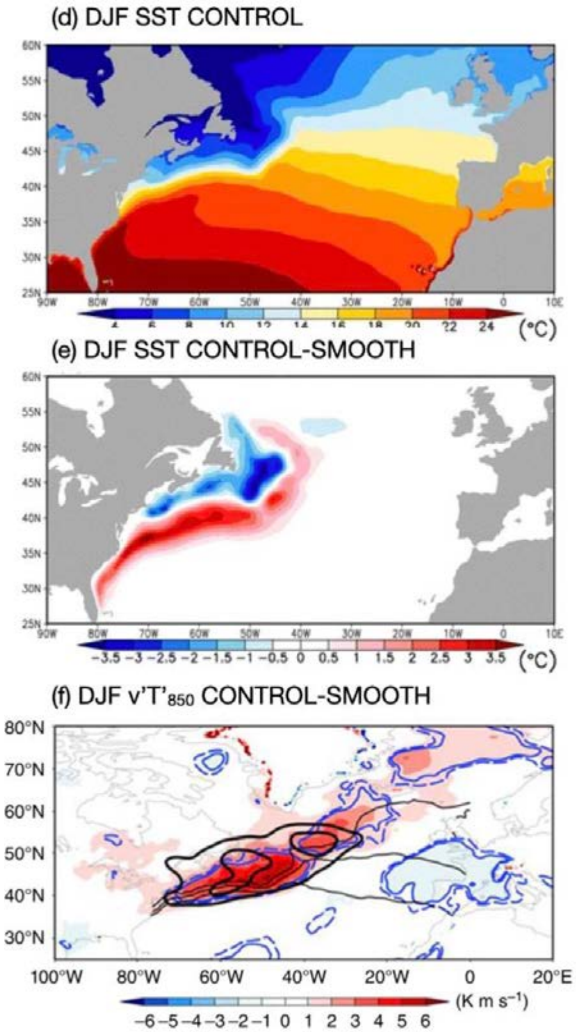
- Co-chairs: Hyodae Seo and Larry O’Neill, initiated in 2020,
  - Members: Mark A. Bourassa, Arnaud Czaja, Kyla Drushka, James B. Edson, Baylor Fox-Kemper, Ivy Frenger, Sarah T. Gille, Benjamin P. Kirtman, Shoshiro Minobe, Angeline G. Pendergrass, Lionel Renault, Malcolm J. Roberts, Niklas Schneider, R. Justin Small, Ad Stoffelen, Qing Wang
- Review paper submitted
- Webinar series ongoing
- Workshop and metrics planned

Review paper submitted in December

Ocean Mesoscale and Frontal-scale Ocean-Atmosphere Interactions and Influence on Large-scale Climate: A Review (to *J. Climate)*

Underscores importance of resolving mesoscale features (fronts and filaments) in order to represent air-sea feedbacks

Example from O'Reilly et al (2016, 2017) shows control vs smoothed fields for Gulf Stream



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US CLIVAR working group on high-latitude surface fluxes

- Co-chairs: Mark Bourassa and Sarah Gille
- Objectives: Document understanding of fluxes
- Major activities from 2008 to ~ 2010, regular telecons, plus a one-day meeting following AMS meeting in Phoenix in January 2009.
- BAMS paper summarizing current state of fluxes (published March 2013)
- OceanObs09 contribution
- Newsletter items: US CLIVAR, FluxNews

Photo: 20 m/s winds as seen from ship. Southern Ocean GasEx (Chris Fairall)

Southern Ocean Fluxes Capability Working Group (SOFLUX)

Leadership: **Current c**o-chairs Marcel du Plessis(U. Gothenburg) and Sarah Gille (Scripps Inst. Oceanography, UC San Diego) plus APECS rep (Iole Orselli) and steering committee

Objectives: Coordinate in situ observing plans both for targeted process studies and sustained observation; support satellite air-sea fluxes and reanalysis products; encourage community communication

Achievements: Supported formalizing flux-related variables as ECVs/EOVs, break-out sessions and workshops (pre-pandemic), webinar series (current), community papers for OceanObs'19, and supporting observing system design

Future plans:

- SOFLUX was just renewed for another 5 years
- Intend to continue serving community needs

SOFLUX Priorities for Serving Community Needs

Serve as a forum for discussion of Southern Ocean flux studies

Through newsletters, webinars, workshops, side meetings, etc., build a forum to share news and discuss air-sea and air-sea-ice flux results (e.g. from the US Ocean Observatories Initiative mooring, the Australian SOFS mooring, and the Saildrone Antarctic circumnavigation)

Community interests include heat, momentum, freshwater, and gas fluxes

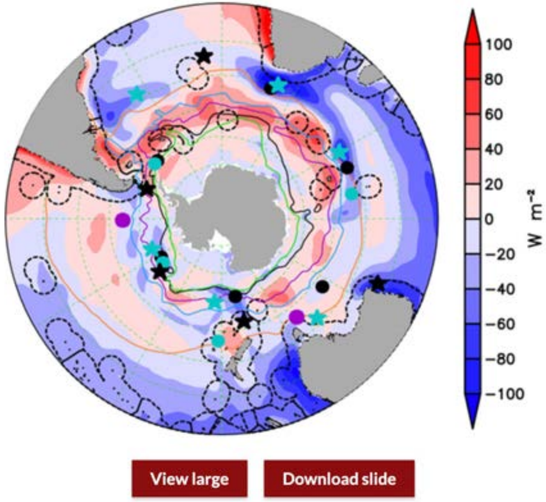
Join us: https://www.soos.aq/activities/cwg/soflux

Flux Moorings Task Team:

Flux Moorings Task Team:
- A joint SOFLUX and OSD effort
- Funded by State Oceanic Admin. China

Project aimed to identify optimal placement of moorings in the Southern Ocean in order to constrain large-scale air-sea fluxes

Wei et al., 2020: DOI 10.1175/JTECH-D-19-0203.1



Locations of OOI and SOFS sites (purple dots), six hypothetical mooring sites (black dots) sited at the extrema of the EOF1 wavenumber-3 pattern of high-frequency Q_{net}, and four hypothetical mooring sites (cyan dots) that can best reflect the ASL and SAM. Additional candidate sites capture the second EOF mode (black stars) and third EOF mode (cyan stars) of low-frequency Q_{net}. EEZs are indicated by black dashed lines. Shading colors indicate the mean of Q_{net} from the JRA data during 1979–2016.

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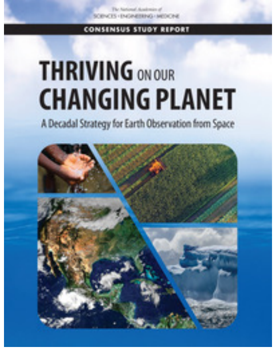


7 Competed Concepts

Recommended NASA Priorities: Explorer

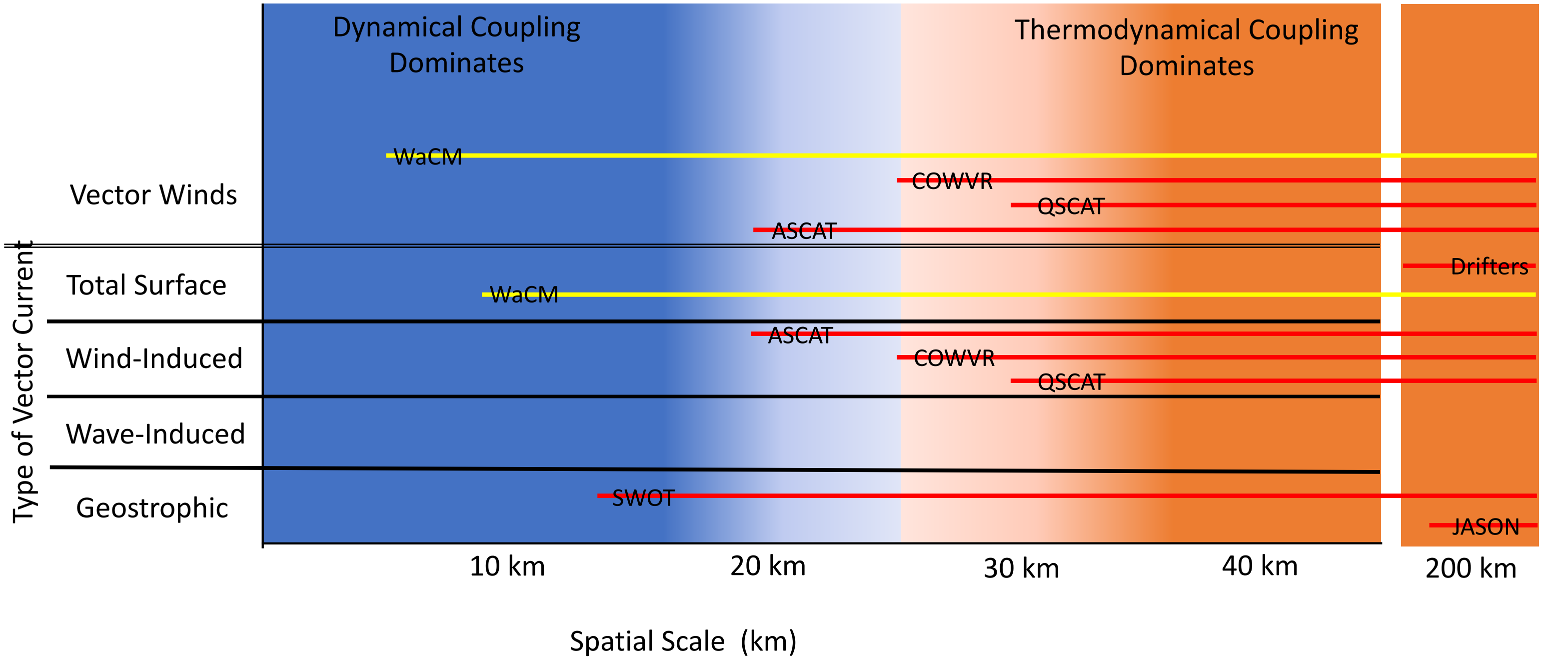
Winds and Currents

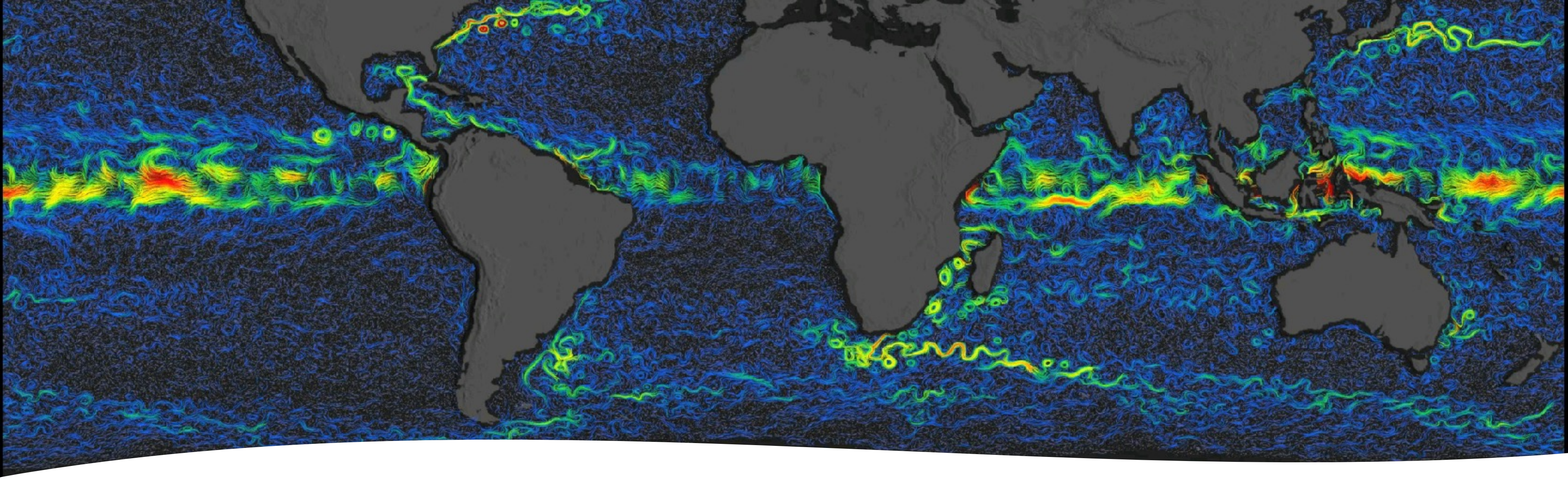
- Opportunities for 3 of ~~6~~7 to be selected in coming decade
- (Atmospheric winds promoted from incubation)
- Call for proposals maybe in July(ish) with proposals due 90 days later

Greenhouse Gases	*CO_2 and methane fluxes and trends*, global and regional with quantification of point sources and identification of sources and sinks	Multispectral shortwave IR and thermal IR sounders; or lidar*	X	
Ice Elevation	*Global ice characterization* including elevation change of land ice to assess sea-level contributions and freeboard height of sea ice to assess sea ice/ocean/atmosphere interaction	Lidar*	X	
Ocean Surface Winds and Currents	*Coincident high-accuracy currents and vector winds* to assess air-sea momentum exchange and to infer upwelling, upper ocean mixing, and sea-ice drift	Doppler scatterometer	X	
Ozone and Trace Gases	*Vertical profiles of ozone and trace gases* (including water vapor, CO, NO_2, methane, and N_2O) globally and with high spatial resolution	UV/VIS/IR microwave limb/nadir sounding and UV/VIS/IR solar/ stellar occultation	X	
Snow Depth and Snow Water Equivalent	*Snow depth and snow water equivalent*, including high spatial resolution in mountain areas	Radar (Ka/Ku band) altimeter; or lidar*	X	
Terrestrial Ecosystem Structure	*3D structure of terrestrial ecosystem* including forest canopy and aboveground biomass and changes in aboveground carbon stock from processes such as deforestation and forest degradation	Lidar*	X	
Atmospheric Winds	*3D winds in troposphere/planetary boundary layer (PBL)* for transport of pollutants/carbon/aerosol and water vapor, wind energy, cloud dynamics and convection, and large-scale circulation	Active sensing (lidar, radar, scatterometer); or passive imagery or radiometry-based atmospheric motion vectors (AMVs) tracking; or lidar*	X	X

New territory with WaCM

- Finer (5 km) spatial resolution than ever before for satellite winds
- Unprecedented 10 km surface current
- Twice daily sampling globally





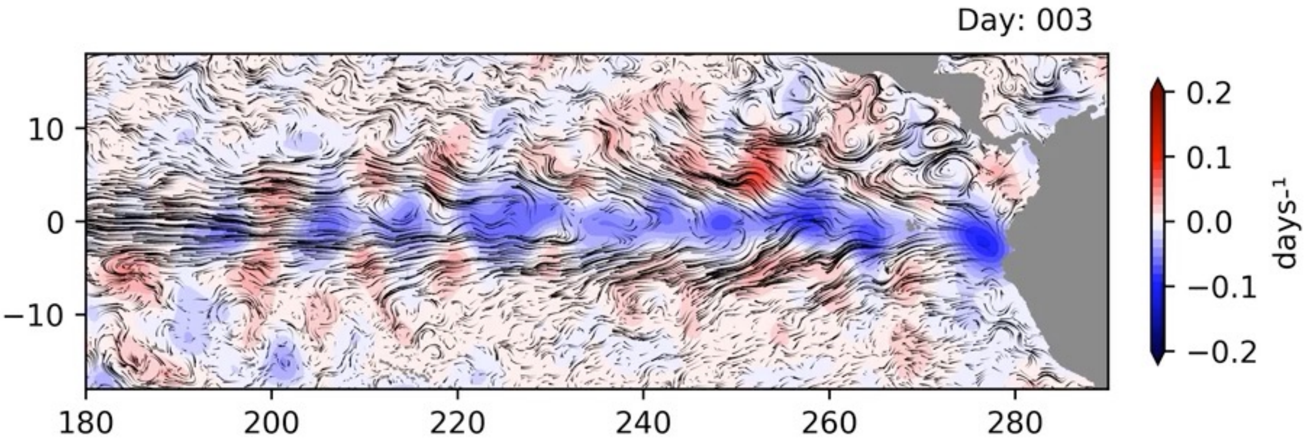
Science objectives:
1. Ocean currents

- What are the relative roles of narrow filaments compared with large-scale flows?
- What are the relative roles of geostrophic and Ekman currents?
- Quantify mechanisms that transport heat, freshwater, nutrients, larvae, and debris within the surface ocean.

Earth and Space Research OSCAR Product: https://www.esr.org/research/oscar/additional-information/

Science objectives: 2. Equatorial divergence

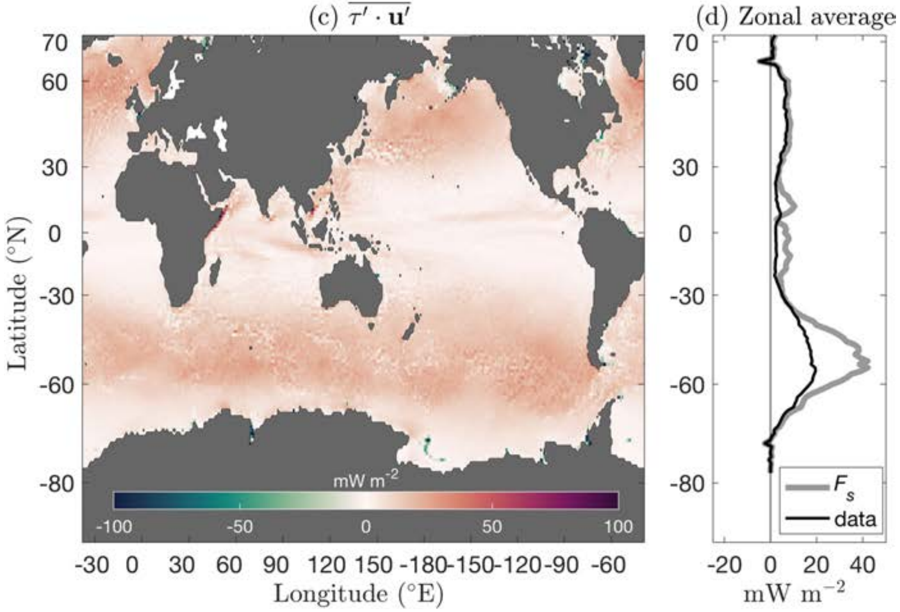
- **Observational gap in the tropics**: Geostrophy breaks down at the Equator and drifters diverge off the equator
- How does wind drive Equatorial circulation?
- What spatial scales matter for off-equatorial divergence?



Animation by Clément Ubelmann using Mercator Glorys 1/12 simulation

Science objectives: 3. Coupled winds and currents

- What governs the momentum exchange between the atmosphere and the ocean?
- When do winds drive the ocean? Can wind "kill" eddies?
- When does the ocean drive the atmosphere? Do surface currents shape the profile of winds in the atmospheric boundary layer?
- What scales matter?



Transient component of "wind work".
(Flexas et al, JGR-Oceans, 2019)

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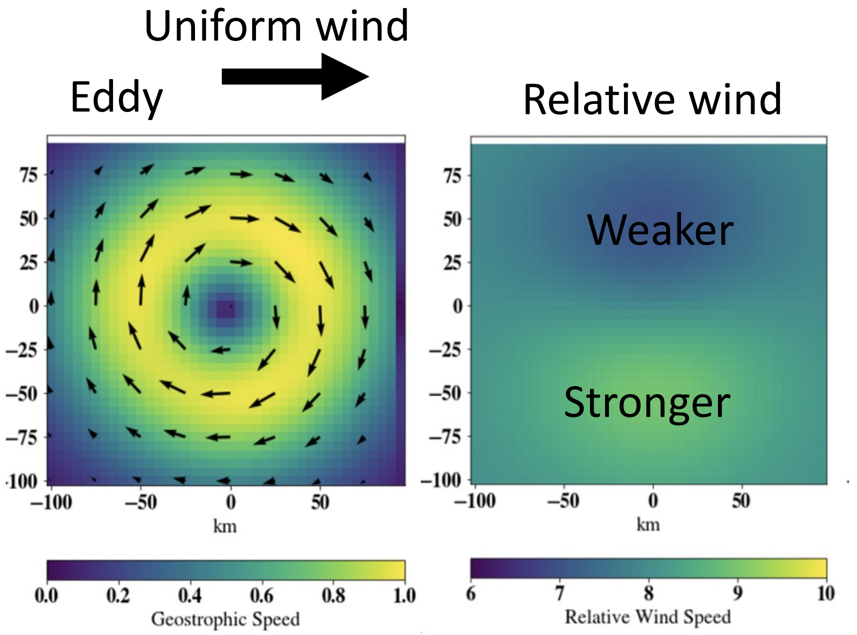
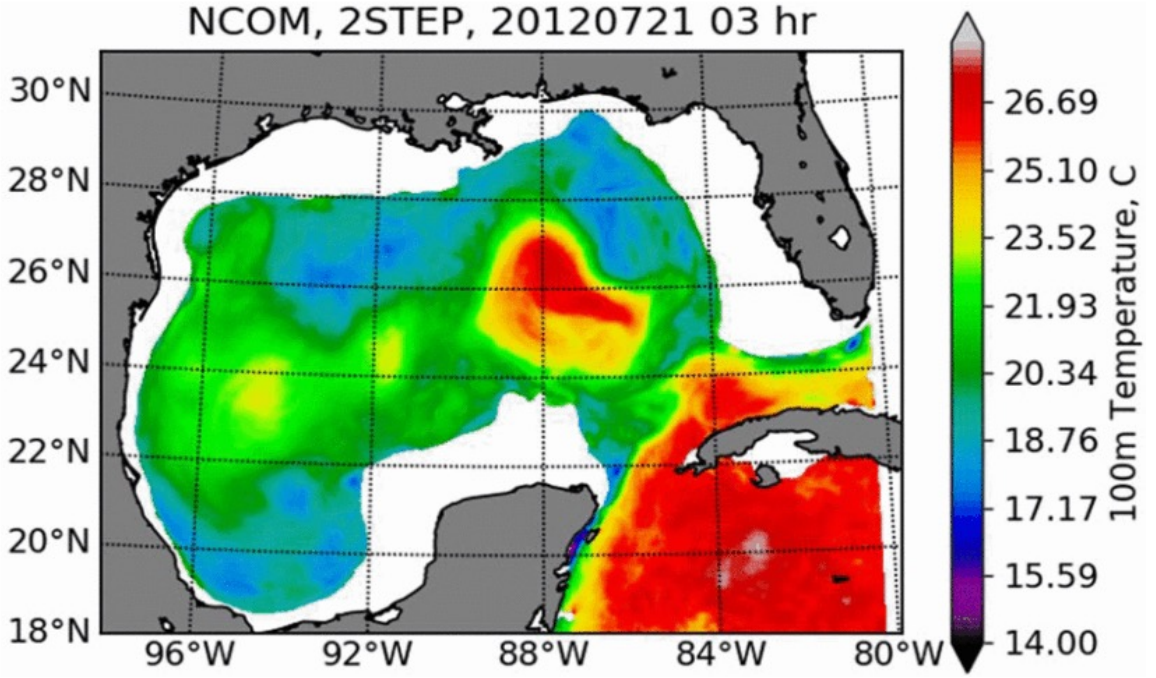


Applications: Better atmosphere and ocean predictions

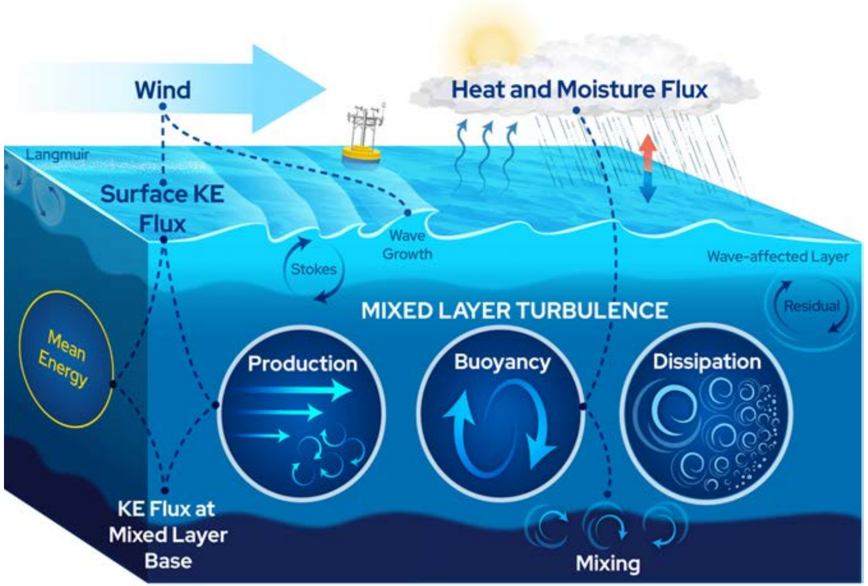
- Assimilation to improve knowledge of current state
- **Ocean currents:** search and rescue, tracking oil spills, fisheries management, Navy operations,
- **Atmosphere:** sub-seasonal to seasonal weather forecasts



Helber et al, 2020, DOI: 10.1109/IEEECONF38699.2020.9389362

Join the discussion

- SOFLUX
  - Join the distribution list: https://www.soos.aq/activities/cwg/soflux
  - Next webinar: Wednesday April 27 (Dorothee Bakker, UEA, SOCAT)
- WaCM
  - Webinar Tuesdays at 8 am Pacific time/11 am Eastern
  - Next talk will be after Ocean Sciences, Tuesday March 15th (Hector Torres, JPL)
  - Informal format: one talk plus discussion
  - Sign up with our form: https://forms.gle/WBzfZh1Y2mFKgPmx6
  - Help choose a better name
- OASIS (SCOR working group) serves as a clearing house and information exchange for much of this



Parsing the kinetic energy budget of the ocean surface mixed layer *(Zippel et al, GRL, 2022)*