Ocean impacts on the atmosphere in high-resolution coupled ocean-atmosphere models

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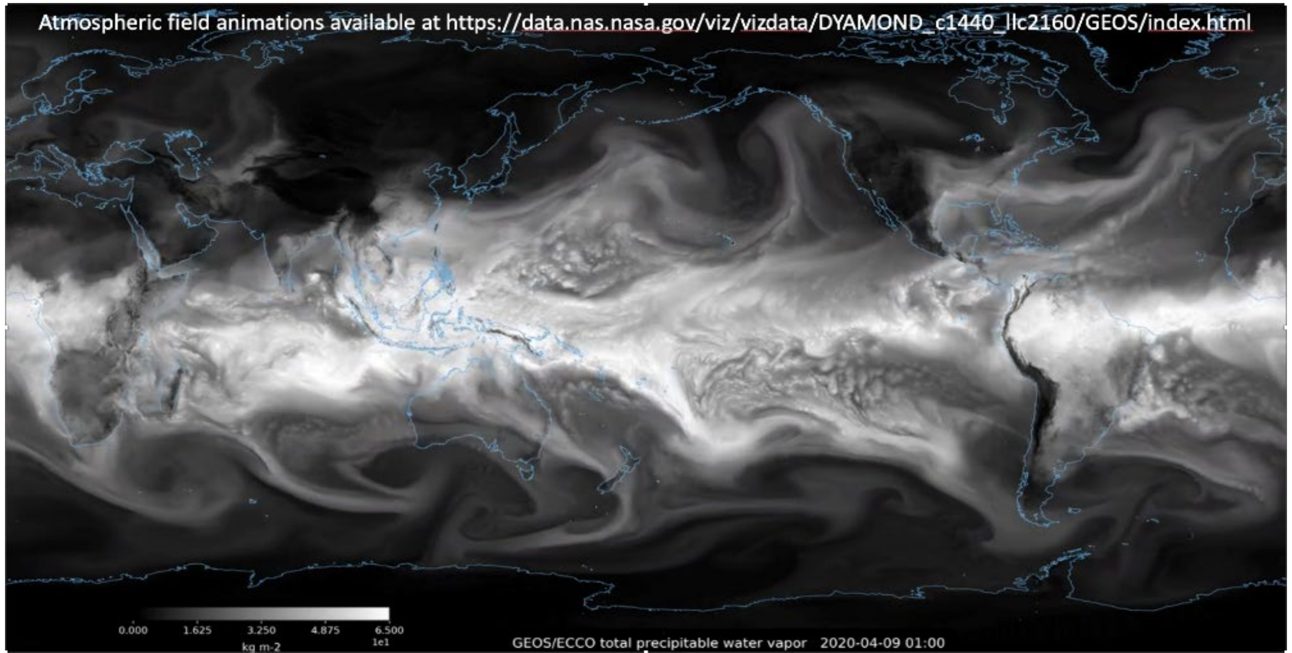
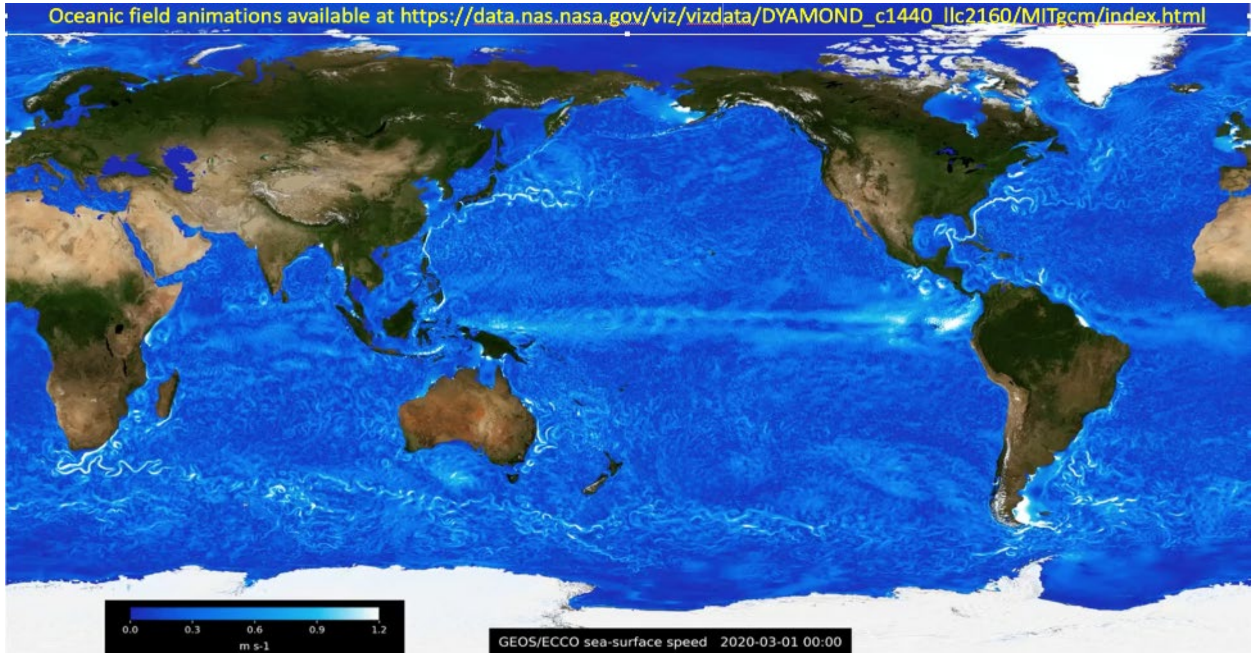
Studying Small-Scale Air-Sea Interactions

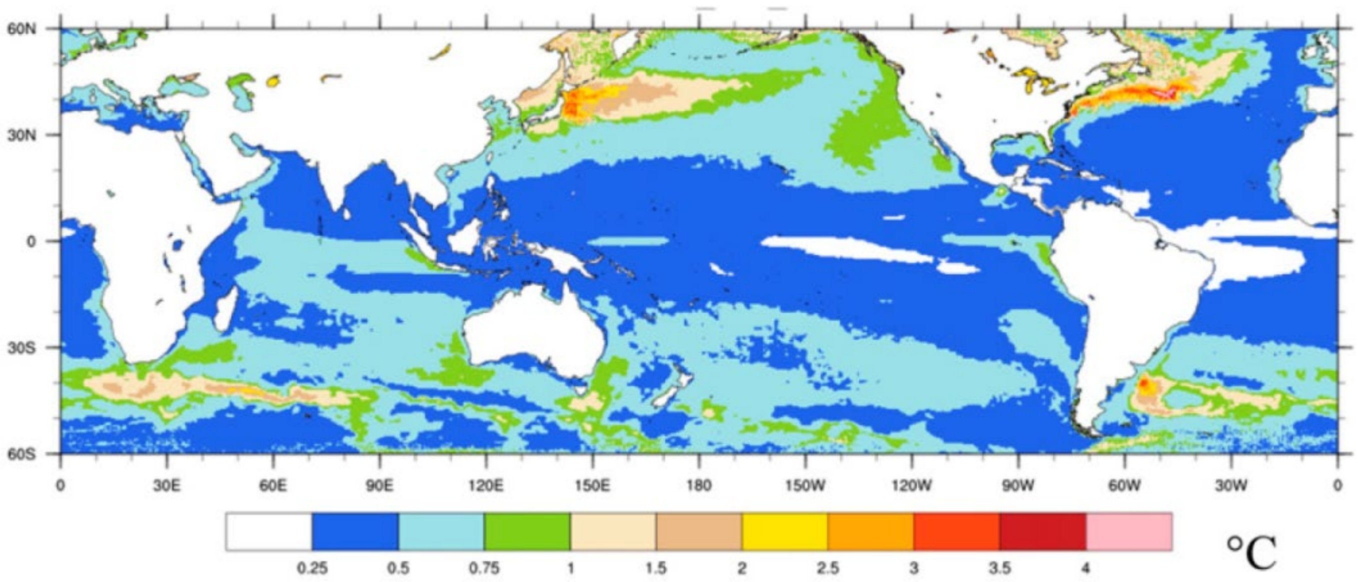
In support of DYAMOND (DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains), we have set-up and integrated a 1/16° atmosphere/land coupled with a 1/24° ocean simulations, which are being used for studying air-sea interactions (Strobach et al. 2022; Torres et al., 2022).

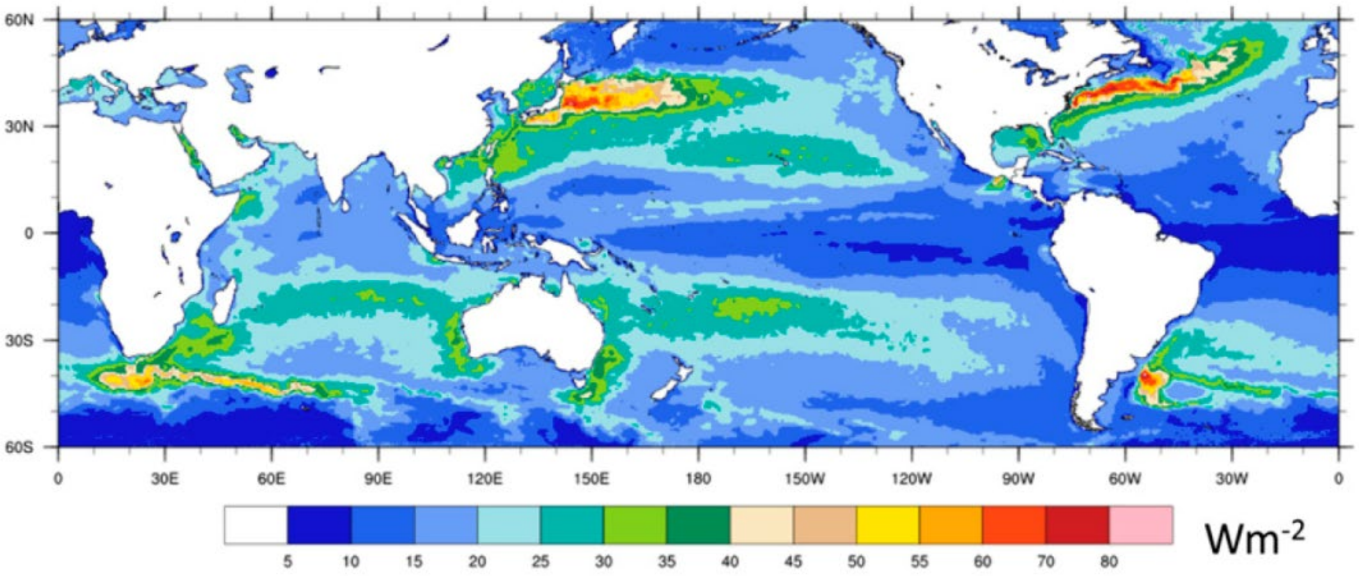
We are now integrating a 1/32° atmosphere/land coupled with a 1/48° ocean simulation.





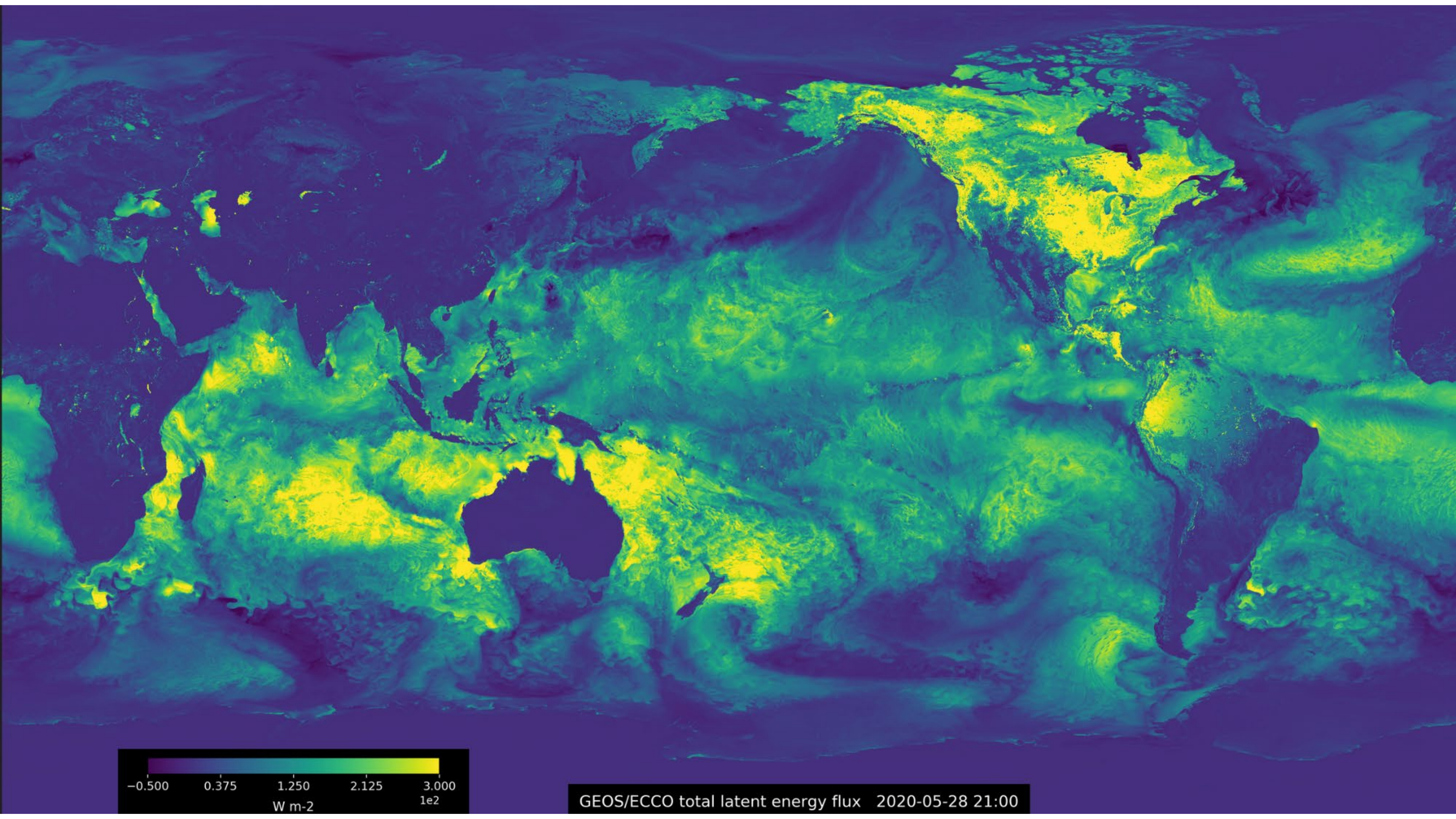
SST and Latent Heat Variability

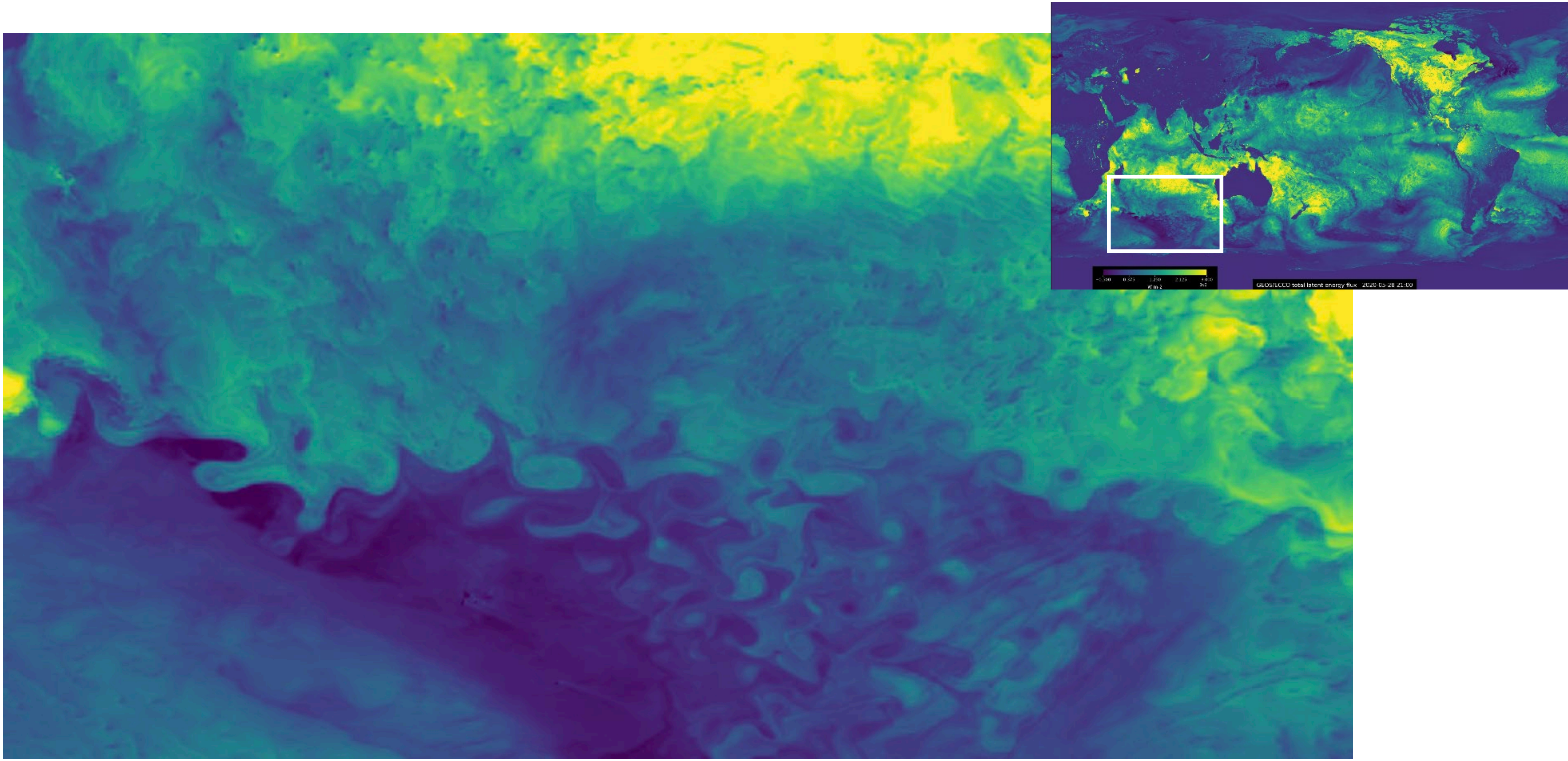




The contribution of SST to the LHF variance is over 50% in much of the **WBC regions,** eastern equatorial Pacific and Atlantic Oceans (Small et al., 2019)

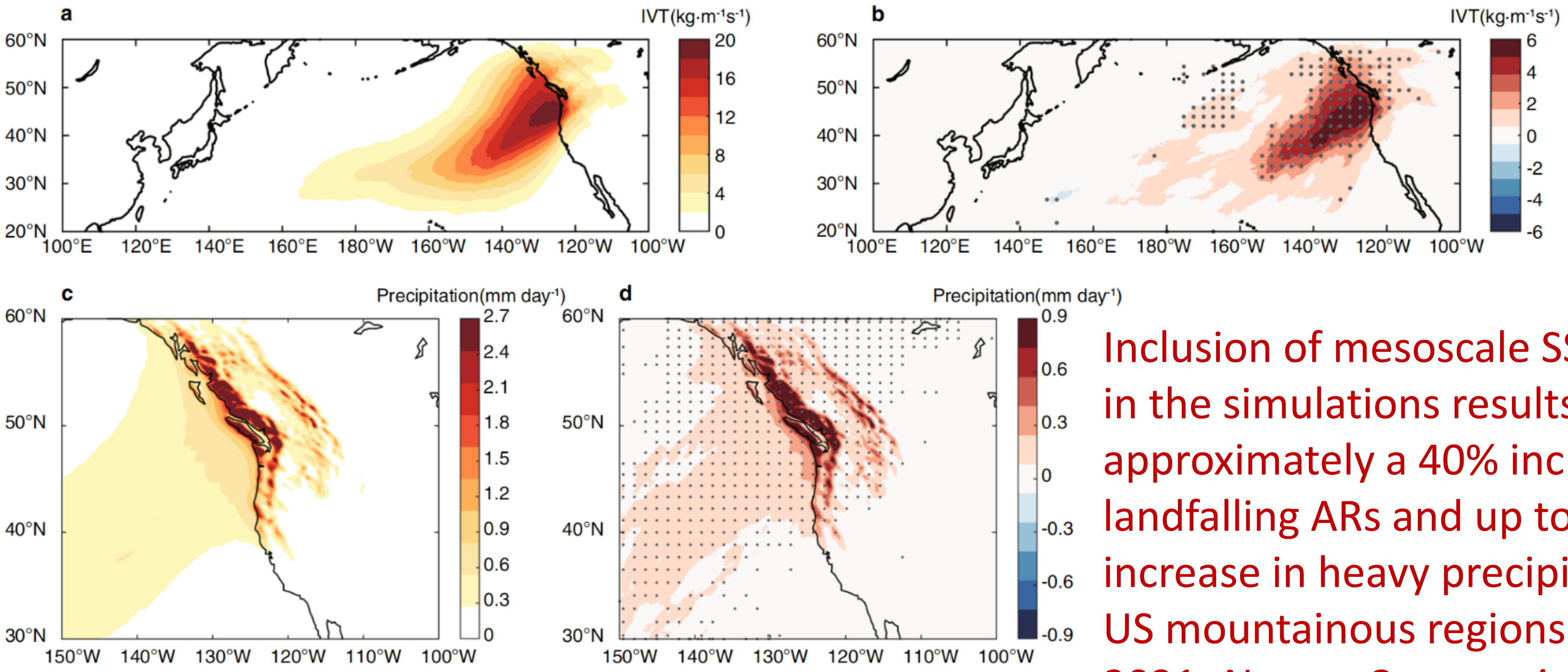
Context: «**Ocean mesoscale eddies impact atmospheric storm tracks (through air-sea moisture exchanges) and the global water cycle**»


−0.500
0.375
1.250
2.125
3.000
1e2
W m-2
GEOS/ECCO total latent energy flux 2020-05-28 21:00



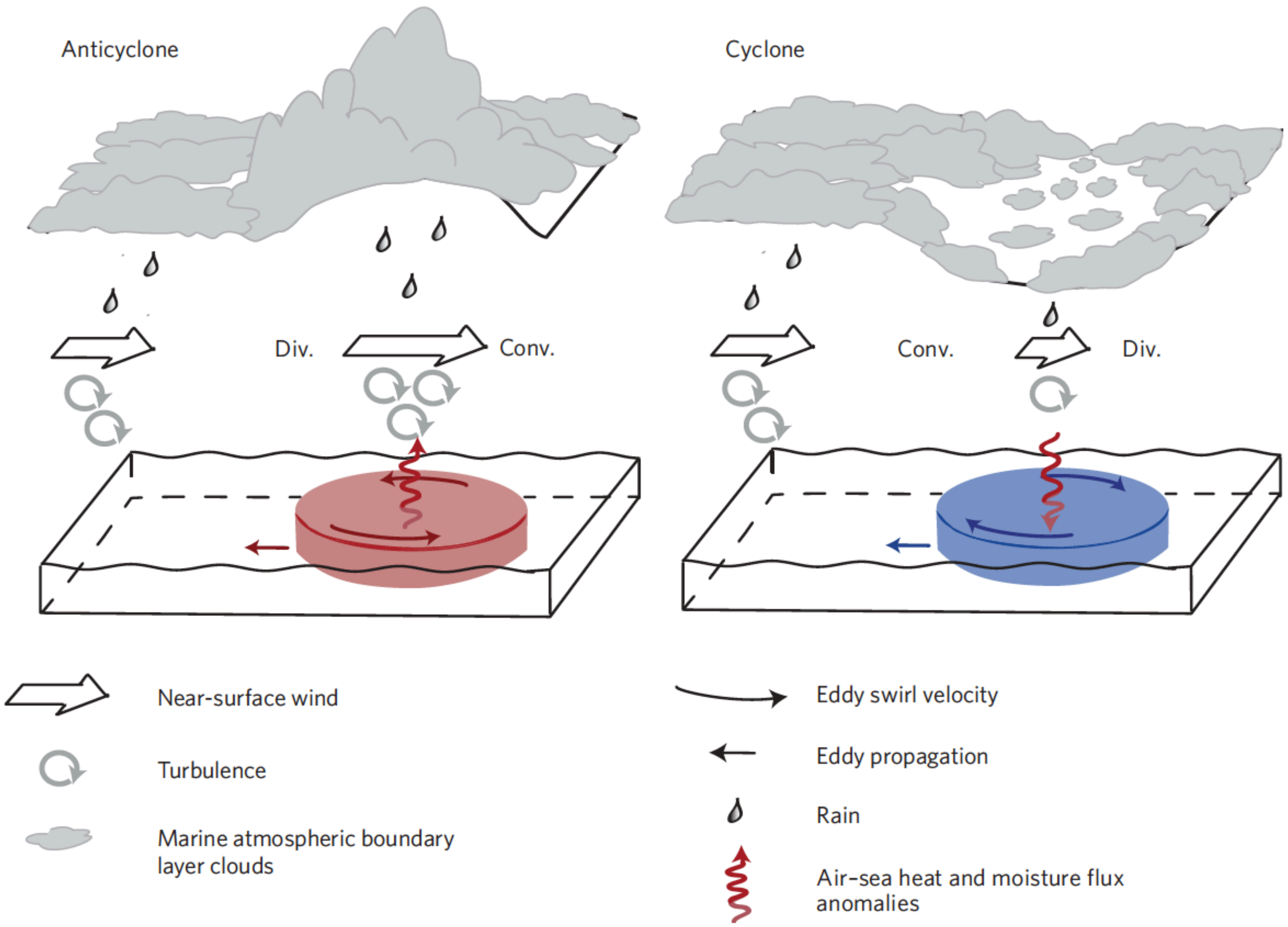
=> Ocean at mesoscale significantly affect latent heat flux to the atmosphere

Mesoscale Eddies Remote Effects



Inclusion of mesoscale SST forcing in the simulations results in approximately a 40% increase in landfalling ARs and up to a 30% increase in heavy precipitation in US mountainous regions (Liu et al. 2021, *Nature Communications*).

=> Importance of the mechanisms associated with LHF over mesoscale eddies

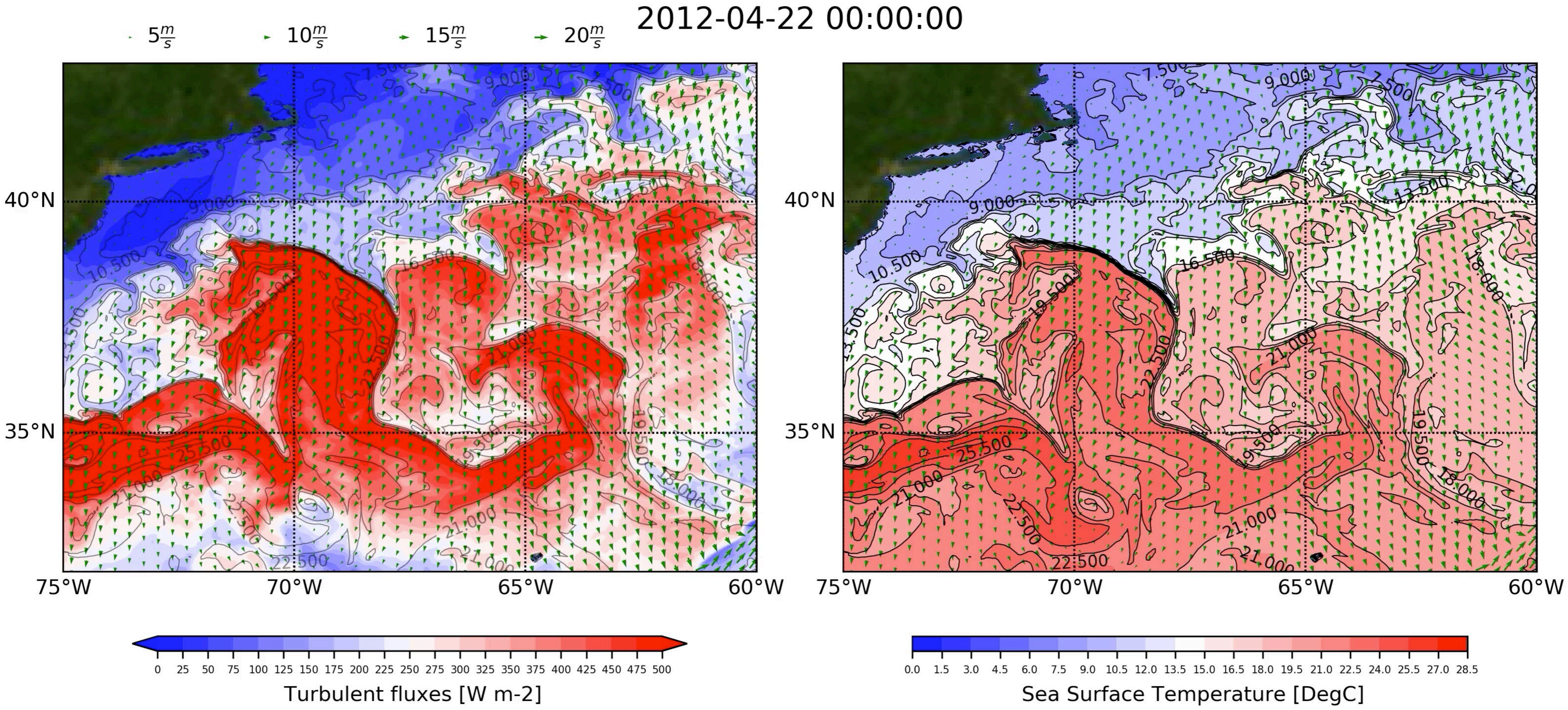


Frenger et al. *(2013), Nature Geoscience*

Classical paradigm: **intensified mixing** over warm SST leads to increase latent heat fluxes

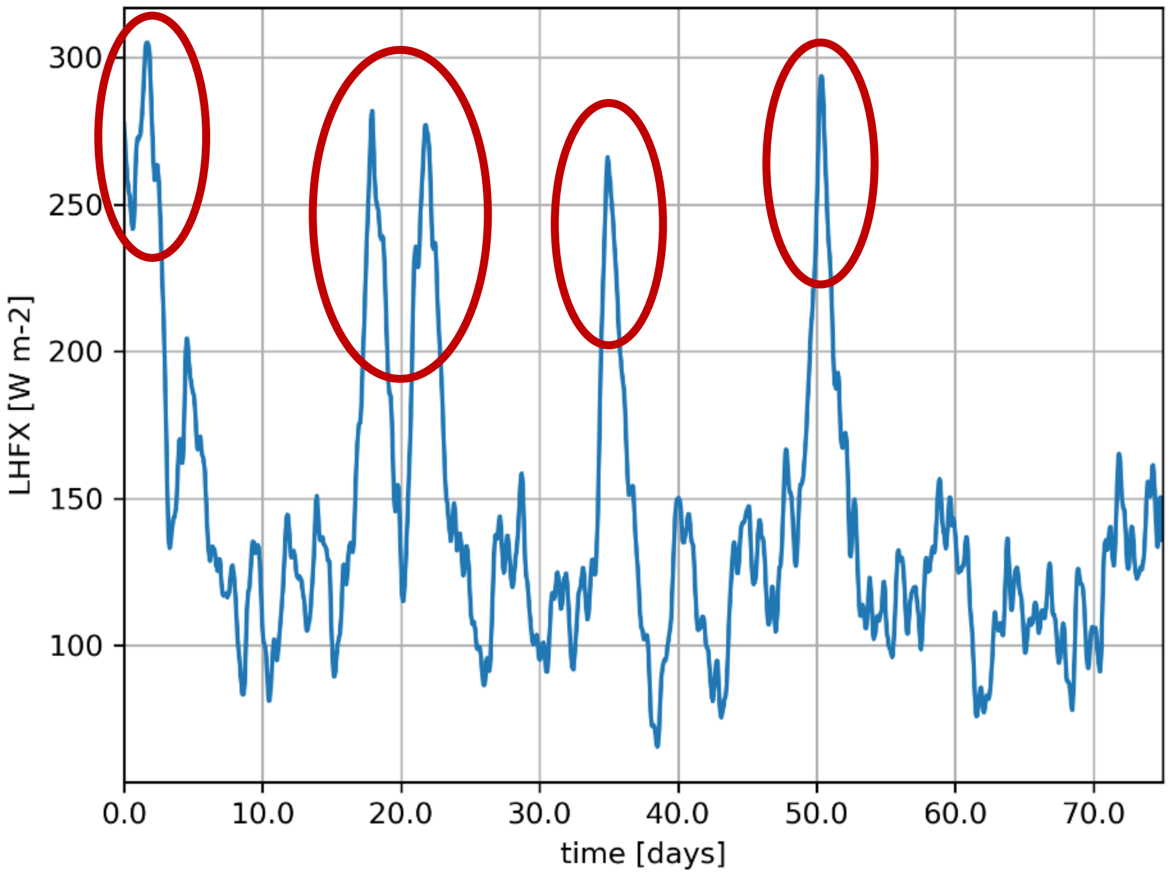
New paradigm: **Wind divergence explained by submesoscale SST fronts** trigger a secondary circulation that transfers dry air and momentum down to surface. Which **leads to intensify latent heat fluxes by ~30%.**
(Strobach et al. 2022, *Geophysical Research Letters)*

Global ~5 km Atmosphere-Ocean Simulation

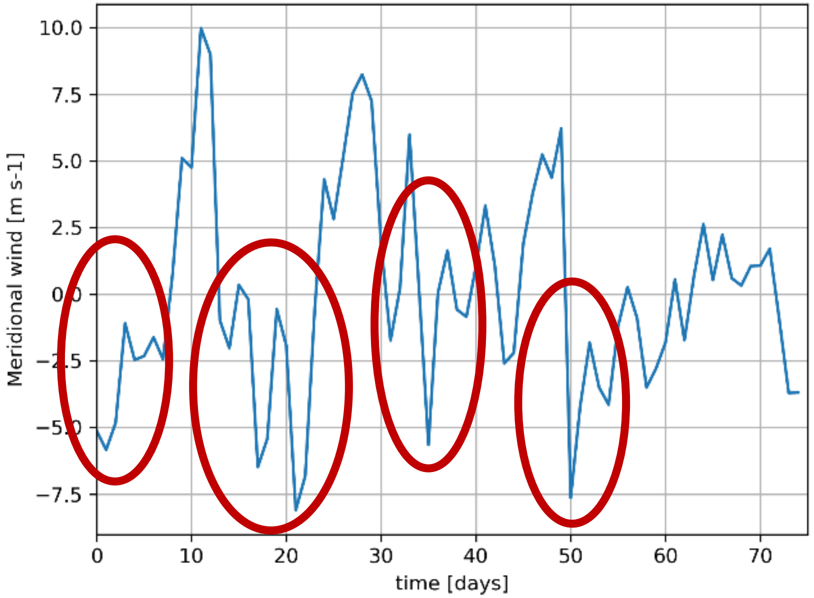


Latent Heat Bursts

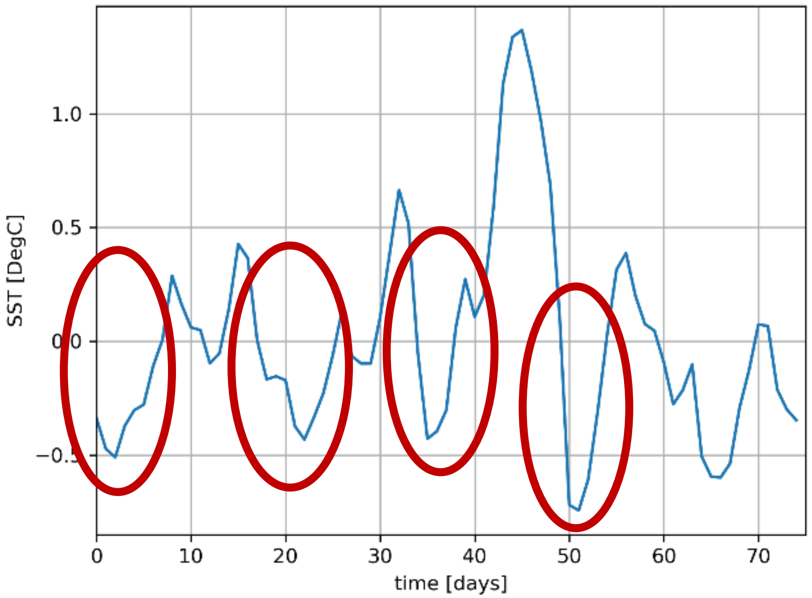
Latent heat flux



Meridional wind



SST

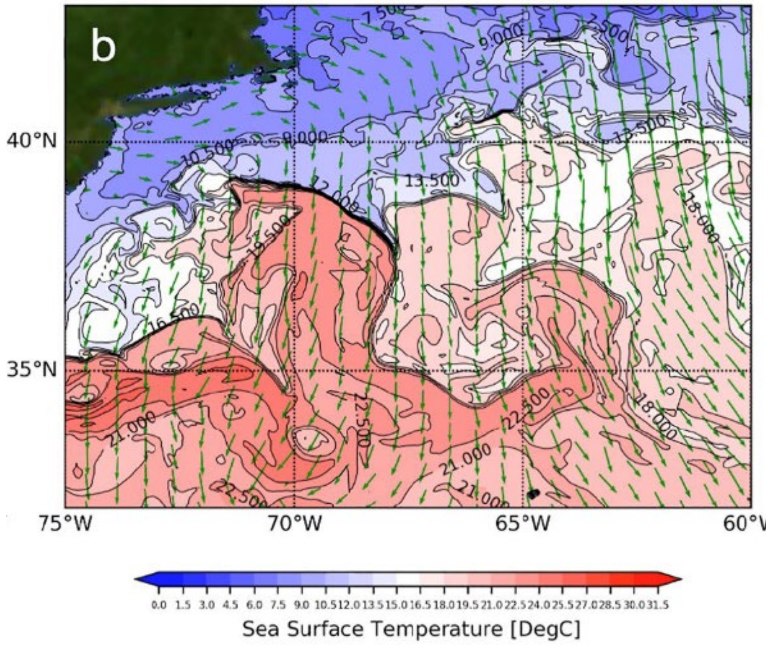


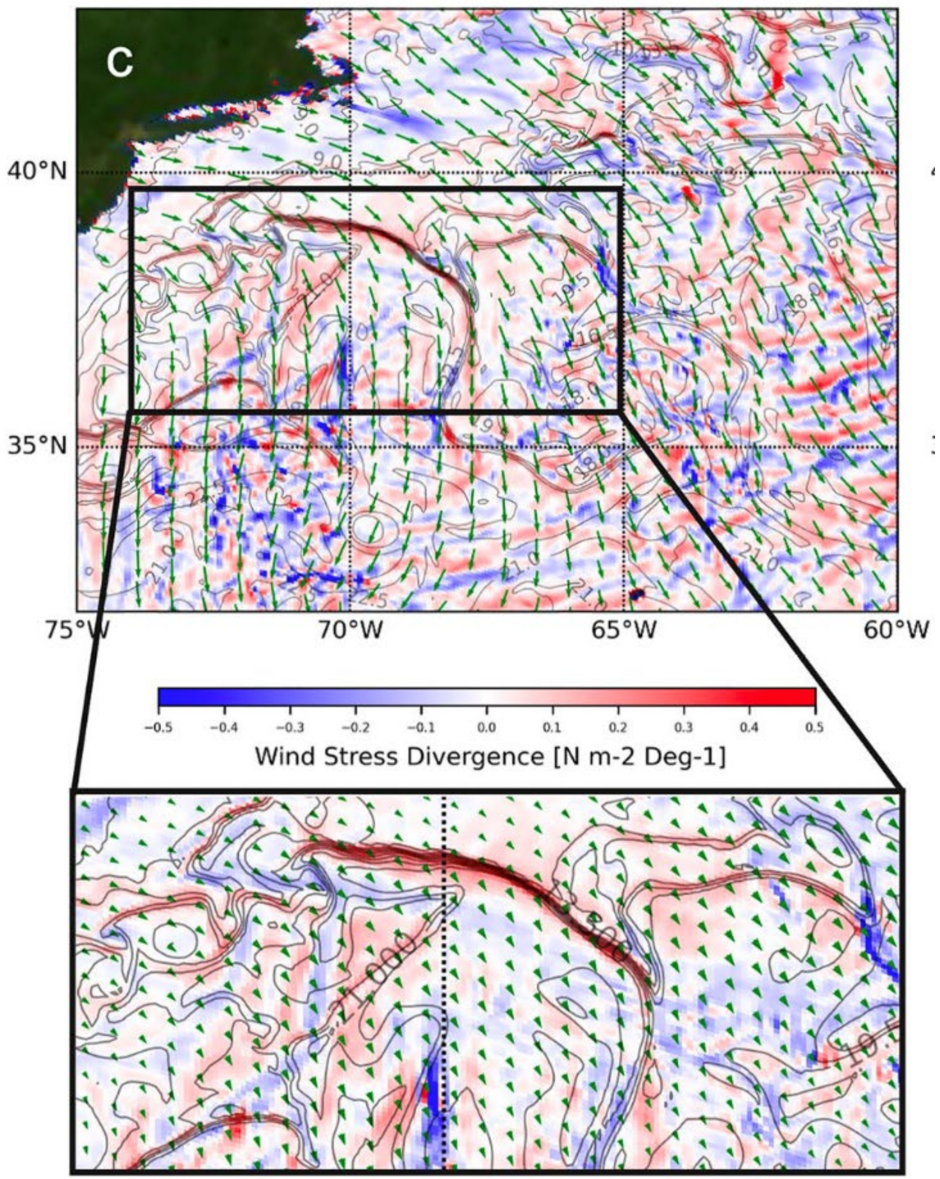
Intense latent heat flux is asossiated with strong North to south winds

Vertical Velocity Field in the Atmosphere

Submesoscale fronts have a strong signature at surface with fronts usually found at the edges of mesoscale eddies. They are closely associated with windstress divergence with the same scales that triggers intense vertical velocity in the atmosphere up to the tropopause level

The resulting vertical velocity in the atmosphere is one order of magnitude larger than found in recent studies at lower resolution (e.g., Foussard et al., 2019).

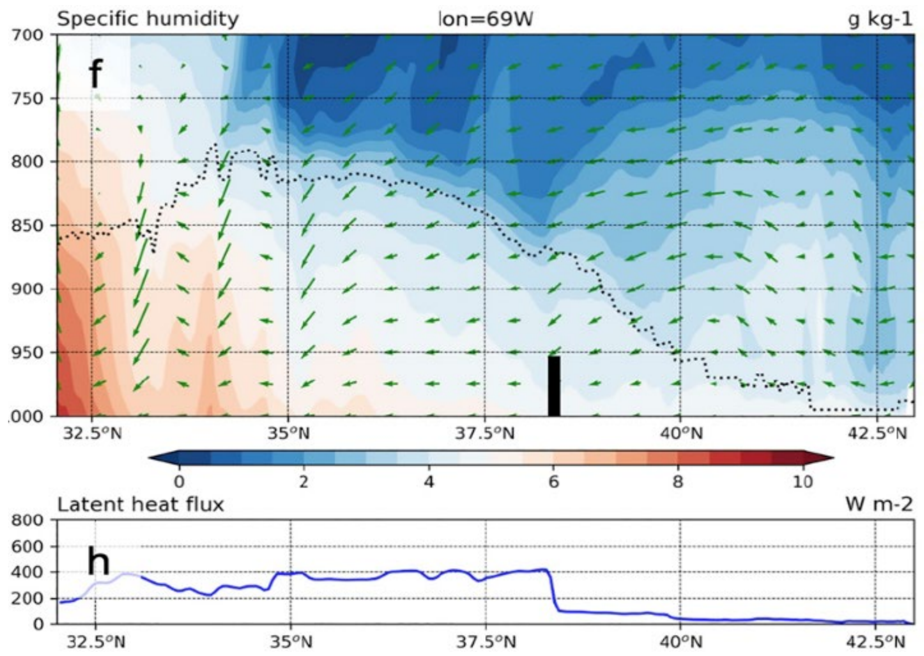


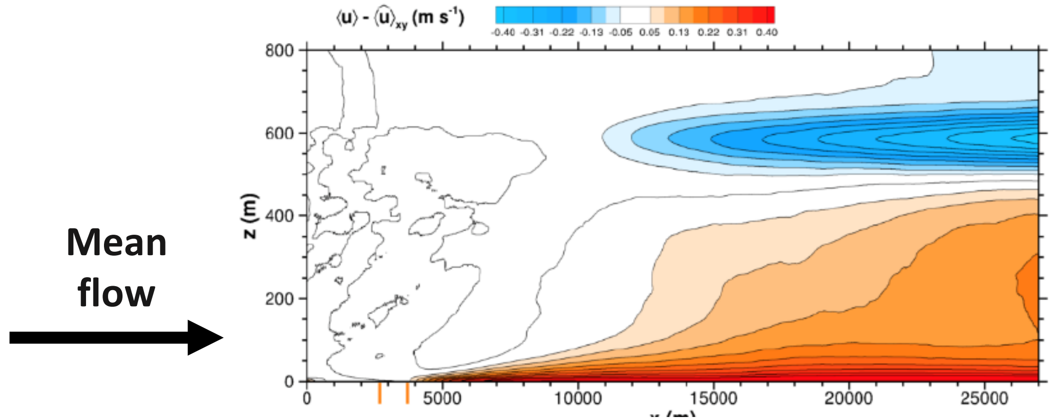


Secondary Circulation

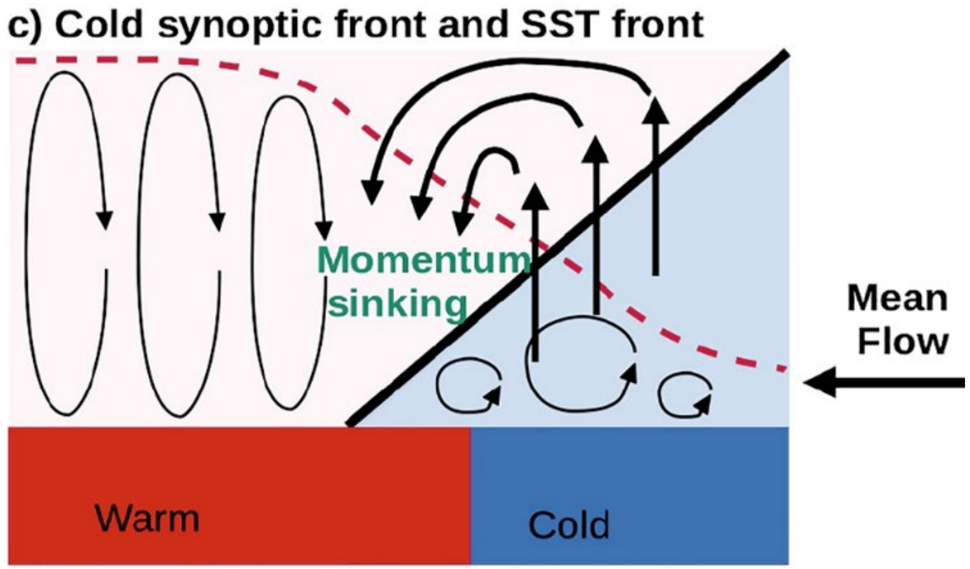
Wind stress divergence triggers a secondary circulation in the lower atmosphere that brings momentum and dry air above warm SST. This secondary circulation increase the latent heat fluxes by 30% compared with a situation when the wind stress divergence is ten times smaller.

Strobach, E., Klein, P., Molod, A., Fahad, A. A., Trayanov, A., Menemenlis, D., & Torres, H. (2022). Local Air-Sea Interactions at Ocean Mesoscale and Submesoscale in a Western Boundary Current. *Geophysical Research Letters*, *49*(7), 1–10. https://doi.org/10.1029/2021GL097003





Sullivan *et al. (2020), Journal of the Atmospheric Sciences*



In summary:

SST fronts trigger a strong wind stress divergence when combined with a synoptic atmospheric system

The resulting atmospheric vertical velocity has a magnitude 10 times higher than reported in previous studies and can reach the atmospheric tropopause

A non-local secondary circulation which acts to transfer dry air from the upper levels into the surface may explain the latent heat bursts events