Fast thermal air-sea coupling: the instantaneous wind response and the role of environmental conditions

A. N. Meroni 1
F. Desbiolles 1,2
C. Pasquero 1,3

1 University of Milano-Bicocca
2 CIMA Research Foundation
3 ISAC CNR

RESEARCH QUESTION

How fast is the atmospheric response to SST structures? Can satellites detect it? How does the environment affect it?

KEY POINTS

- Simultaneous and co-located wind and SST observations reveal a strong air-sea coupling;
- Background wind speed and air-sea temperature difference modulate the DMM mechanism;
- These statistics can be used as a benchmark for air-sea coupling schemes in models.

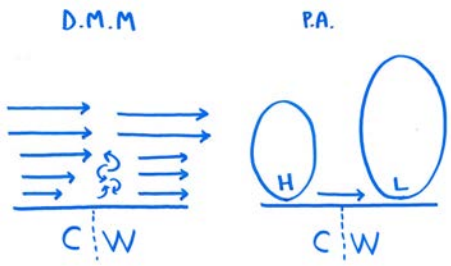
CONTACTS

Agostino Niyonkuru Meroni
agostino.meroni@unimib.it
piazza della Scienza, 4
20126, Milan, Italy

SST AFFECTS THE LOWER ATMOSPHERE

Mesoscale Sea Surface Temperature (SST) structures affect the **surface wind**, the surface **wind convergence**, the **wind in the ABL** (Atmospheric Boundary Layer) and the **low-level clouds** on a wide range of temporal scales (from hours to years) through two main mechanisms:

1. the Downward Momentum Mixing - **DMM**;
2. the Pressure Adjustment - **PA**.



WE USE SATELLITE AND REANALYSIS DATA

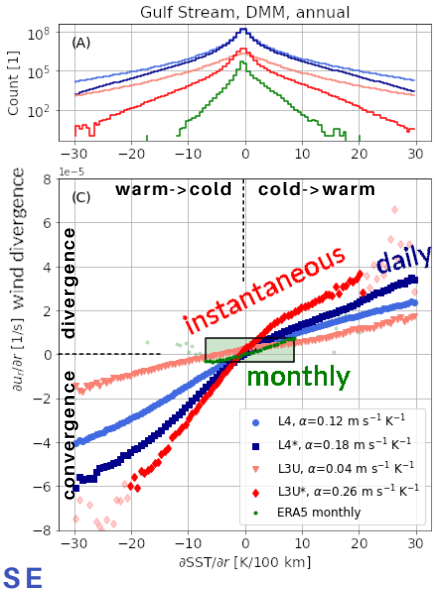
ESA **CCI SST** (both L3U and L4, Metop-A, between January 2007 and March 2014) and **Ascat wind** field (L2, Metop-A, between January 2007 and March 2014) data are used, together with **ERA5** reanalysis daily fields.

The coupling is measured with the slope of binned scatterplots of the relevant variables: along-wind **SST gradient** and along-wind **divergence** for DMM, and across-wind **SST Laplacian** and across-wind **divergence** for PA [Meroni et al., 2022].

The instantaneous coupling is stronger than the daily coupling

[Meroni et al, under review].

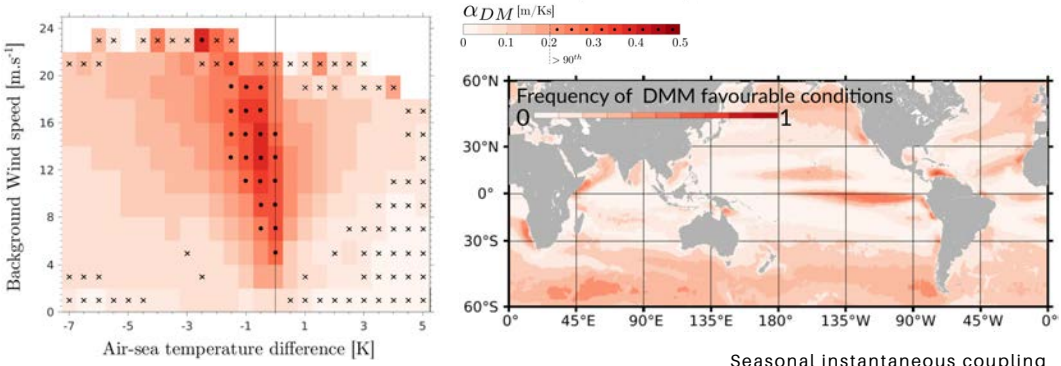
Current **wind data resolution** (Dx~12.5 km) limits the study of such mechanism at the sub-mesoscale, O(1-100) km: future missions like Harmony and Seastar will provide such data!



LARGE-SCALE WIND AND STABILITY MODULATE THE RESPONSE

Five years of global daily ERA5 data are used to evaluate the modulation of **background wind** and **air-sea temperature difference** on the efficiency of the DMM an PA mechanisms [Desbiolles et al., 2023].

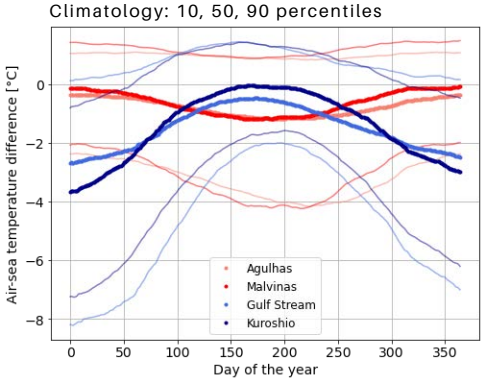
DMM is important for all wind speed in **slightly unstable conditions**. The enhancement and the suppression of the vertical mixing for very unstable and stable conditions weakens the sensitivity to the surface gradients.

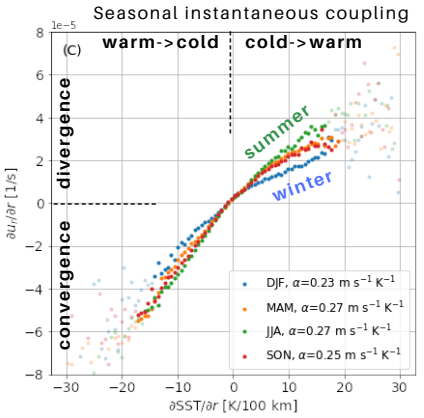


The effects of SST structures on the ABL change in space and time (mainly depending on **air column stability**).

A decrease in the air-sea coupling is observed in winter over Northern Hemisphere WBCs. No such a decrease is found over Southern Hemisphere WBCs.

In the **Northern Hemisphere**, the winter-time unstable conditions due to cold air outbreaks reduce the DMM efficiency.





ALSO CLOUDS RESPOND TBC...

REFERENCES

- Meroni et al. (2022), Introducing new metrics for the atmospheric pressure adjustment to thermal structures at the ocean surface, https://doi.org/10.1029/2021JD035968;
- Desbiolles et al. (2023), Environmental control of wind response to sea surface temperature patterns in reanalysis dataset, accepted, *Journal of Climate*
- Meroni et al. (under review), Satellite signature of the instantaneous wind response to mesoscale oceanic thermal structures, *QJRMS*