MMM SEMINAR SERIES

Mesoscale Sea Surface Temperature Anomalies Excite Trade Cumulus Generation in North Atlantic Trades: Satellite Observations and Large Eddy Simulations

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Trade-wind cumuli play a crucial role in Earth's energy budget due to their prevalence and net cooling effect. How these shallow clouds respond to a warming climate remains a key uncertainty for climate projections. The Atlantic Tradewind Ocean-Atmosphere Mesoscale Interaction Campaign (ATOMIC) provided a unique opportunity to investigate how relatively weak yet ubiquitous mesoscale sea surface temperature (SST) variations impact trade cumulus cloudiness. This talk will present complementary investigations using ATOMIC-validated satellite observations and a cloud-resolving Large Eddy Simulation (LES) Model.

Using a coordinate system aligned with the large-scale background surface wind, we composite satellite cloud fraction, 10-m neutral wind speed, and 10-m wind convergence anomalies over daily spatial SST anomalies in the ATOMIC region during January and February 2020. The analysis shows in-phase modulations of daily mean cloudiness over weak sea surface temperature anomalies (0.25 K on average). These daily cloudiness anomalies are positively correlated with the 10-m neutral surface wind speed but are offset from the near-surface wind convergence. These results indicate that the response of daily cloudiness is more likely generated by spatial variability of surface-driven turbulence and surface fluxes rather than that of surface or boundary layer convergence.

To further our process-level understanding of the satellite composite results, idealized LES experiments are conducted with the System for Atmospheric Modeling (SAM) in a 102.4 km x 102.4 km x 10 km domain. The marine atmospheric boundary layer response to a prescribed SST warm anomaly of 0.5 K is examined in an ensemble manner to reduce the influence of atmospheric variability associated with shallow cumulus organization. The difference between the perturbation and control experiments qualitatively reproduces the surface wind and cloud responses seen in our satellite composites. LES further shows that the peak of the enhanced cloud fraction is located near the lifting condensation level. The core of the enhanced cloud fraction is aligned with that of the surface-driven turbulence instead of the surface convergence-induced upward motions. We conclude with a discussion of the relative roles of surface sensible and latent heat flux in initiating trade cumulus generation based on mechanism denial experiments.

Thursday, 25 April 2024, 2:00PM
Refreshments 1:45PM
Please also join colleagues for refreshments and informal discussion after the seminar until 3:30pm
NCAR-Foothills Laboratory, 3450 Mitchell Lane
FL2-1022, Large Auditorium
Seminar will also be live webcast
https://operations.ucar.edu/live-mmm
Participants may ask questions during the seminar via Slido.