

## West African Monsoon and African Easterly Wave Dynamics Investigated Through Moisture Sensitivity Calculations

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#### West African Monsoon (WAM)



Thorncroft et al., 2011, QJRMS



Hourdin et al., 2010, BAMS

# Life Cycle of a Cape Verde Hurricane



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## Questions to be Addressed

- The West African Monsoon System is multi-scale and interconnected
  - land-atmosphere interaction
  - deep moist convection
  - mesoscale convective systems
  - easterly waves (leading to tropical cyclones)
  - monsoon circulations
- Water vapor is an essential aspect of this interconnectedness
- How does the system behave when water vapor is perturbed substantially?
- What can we learn about the multi-scale dynamics through this lens?



### **Numerical Simulation Configuration**



- Model for Prediction Across Scales (MPAS) – limited area 15-3 km grid spacing
- Moisture anomalies: +20% and -50% to initial and boundary conditions
- 5-day integrations during September, 2006, prior to Hurricane Helene
- Small ensembles to assess signal to noise



#### Total Precipitation (5 days)





#### Hovmoller Diagrams of Rainfall and Easterly Wave Tracks

(blue dots denote wave trough location)





#### Zonal Mean Zonal Flow over African Continent



Similar to longterm climatology

## Small differences from ERA5

AEJ intensifies and shifts northward; TEJ intensifies and extends to higher altitude

AEJ weakens, shifts southward and broadens; TEJ weakens and lowers



#### Changes in the Zonal Mean Flow Responsible for Changes in Wave Speed





## Vertical Mass Flux in Different Wave Phases Over Continent

(different dashed curves for ensemble members)





### Wave Grows More Slowly In MOIST (Offshore)





Differences emerging after the wave reaches the coast are likely related to convection over the Guinea Highlands in MOIST.





## Summary

- Moisture perturbations have a large effect across spatial scales in the WAM, even on time scales of a few diurnal cycles
- The zonal mean state changes markedly in response to moisture
  - AEJ pushes northward
  - Monsoon westerlies penetrate farther north
- The above means that easterly wave slows down
- Upon reaching the West African coast, with greater moisture
  - Convection over the Guinea highlands becomes persistent, while wave passes through
  - The wave slows further
  - The wave weakens, with implications for TC genesis
  - Is there evidence of this effect in different waves environments?

Reference: Núñez Ocasio, K. M., Davis, C. A., Moon, Z. L., & Lawton, Q. A. (2024). Moisture dependence of an African easterly wave within the West African monsoon system. *Journal of Advances in Modeling Earth Systems, 16*, e2023MS004070. <u>https://doi.org/10.1029/2023MS004070</u>

