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Collaborative Research: Coupled Atmosphere-Ocean Model Study of Wintertime Air-Sea Interaction off the East Coast of North America

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Principal Investigator: Xue, Huijie .
Organization: University of Maine
Title:
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Project Participants

Senior Personnel

Name: Xue, Huijie
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Li, Yongping
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Li worked with the PI to develop a 3D coupled atmosphere-ocean model and applied the model to the coastal cyclogenesis along the east coast of US.

Name: Yan, Yuping
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Yan's work focused on the comparisons between the coupled model simulations and QuikSCAT wind.

Graduate Student

Name: Pan, Ziqin
Worked for more than 160 Hours: Yes
Contribution to Project:
Ziqin worked the PI to develop the concurrent coupling scheme for the project and used the coupled model to examine the air sea interaction processes along the Gulf of Maine front during cold air outbreaks.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

A three-dimensional, regional, coupled atmosphere-ocean model with full physics was developed to study air-sea interactions during winter storms off the U. S. East Coast. The coupled model has been used to simulate the advection of cold air over the Gulf Stream and the rapid development of coastal cyclones. Emphases have been placed on the development of the mesoscale front and local winds in the lower atmosphere due to differential fluxes over the land, the cold shelf water, and the warm Gulf Stream, and on how the mesoscale front and the local winds feed back to the ocean and modify the upper ocean temperature and current fields. Results from this study have been presented at the national and international conferences including three invited talks at Gordon Conference on coastal ocean modeling, SCOR coastal coupling workshop, and 2003 IUGG General Assembly. They have also been incorporated into the teaching material of a course that the PI teaches at the University of Maine..

Findings:

During the cold air advection, a shallow mesoscale atmospheric front is generated over the Gulf Stream and progresses eastward with the prevailing airflow. Behind the front, the wind intensifies and a northerly low-level-jet appears. The low-level northerly winds remain relatively strong even after the front has progresses past the Gulf Stream. The total heat flux in the coupled experiment is about 10 percent less than the total heat flux in the experiment with fixed SST, suggesting that the oceanic feedback to the mesoscale atmospheric features might not be of leading importance. On the other hand, the modification in the atmosphere by air-sea fluxes, which induces the locally enhanced winds, has considerable impact on the ocean.

In the case of coastal cyclogenesis, the simulated atmospheric cyclone evolves in a manner consistent with ETA reanalysis. The maximum ocean-to-atmosphere heat fluxes first appear over the Gulf Stream in the South Atlantic Bight, and this results in rapid deepening of the cyclone off the Carolina coast. As the cyclone moves eastward, the heat flux maximum shifts into the region near Cape Hatteras and later northeast of Hatteras, where it enhances the wind locally. The oceanic response to the atmospheric forcing is closely related to the wind direction. Southerly and southwesterly winds tend to strengthen surface currents in the Gulf Stream, whereas northeasterly winds weaken the surface currents in the Gulf Stream and generate southwestward flows on the shelf. The oceanic feedback to the atmosphere moderates the cyclone strength. The coupled simulation produces higher ocean-to-atmosphere heat flux near Gulf Stream meander troughs, which in turn, enhances the local northeasterly winds. The enhanced northeasterly winds result in stronger southward ocean surface flows on the shelf. Away from the Gulf Stream, the coupled simulation produces surface winds that are 5 ~ 10% weaker.

Training and Development:

We continue to use the synchronized coupling algorithm with concurrent programming in other similar coupled systems. The PI uses the coupled atmosphere-ocean model as one of the modules for a course she teaches at the University of Maine. Mr. Pan was the PI's first graduate student and the experience he gained from this project was helpful to him in securing his first job. Dr. Li is able to extend the experience he gained from this project to develop a coupled system to investigate typhoons over the East China Sea since he returned to China in 2002.

Outreach Activities:

The PI was interviewed by the local National Public Radio station and UMaine Today on research activities and findings related to this project.

Journal Publications

Li, Y., H. Xue, and J. M. Bane, "Air-sea interactions during the passage of a winter storm over the Gulf Stream: A 3D coupled atmosphere-ocean model study", J. Geophys. Res., p. 21-1, vol. 107, (2002). Published

Xue, H., Z. Pan, and J. M. Bane, Jr., "A 2D coupled atmosphere-ocean model study of air-sea interactions during a cold air advection over the Gulf Stream", Monthly Weather Review, p. 973, vol. 128, (2000). Published

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

we conducted numerical studies of rapidly developing winter storms, which represents the foremost effort to examine air-sea interactions between mesoscale atmospheric events and prominent oceanic features using coupled atmosphere-ocean models. The synchronized coupling algorithm, which uses concurrent programming, can also be used in other similar coupled systems.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners
Any Book
Any Web/Internet Site
Any Product
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering