Ensuring Physical Coupling of the Ocean & Atmosphere

PAESCAL Earth System Model Development SciDAC BER/ASCR Partnership

Scientific Achievement

- The atmosphere and ocean exchange heat, water and momentum in such a way that numerical algorithms are required to determine how much was exchanged.
- Criteria were identified that result in the numerical algorithms either failing to find any solution or finding a nonphysical solution.
- From those criteria, two modifications were developed that ensure the numerical algorithm can find the physical solution.

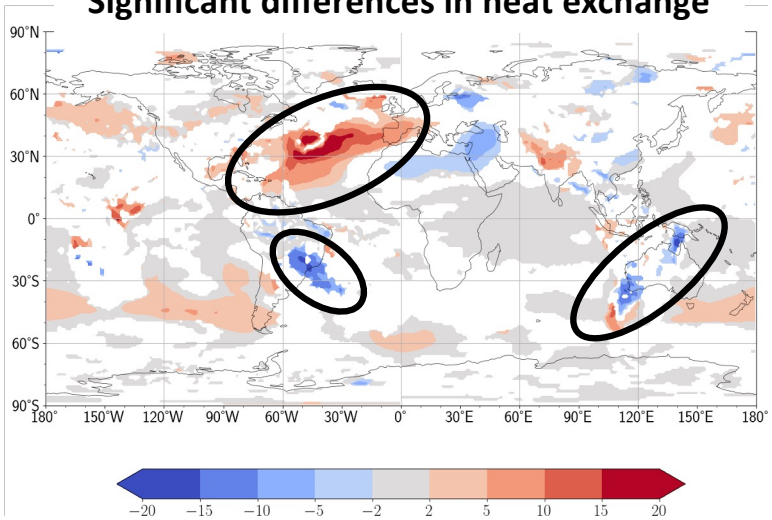
Significance and Impact

- Accurately capturing the exchanges between the ocean and atmosphere is crucial for natural hazard prediction (e.g., hurricanes, droughts, and floods).
- The modifications resulted in different amounts of heat exchanged in long-term global simulations, impacting future natural hazard mitigation strategies.
- Other Earth system models that leverage a similar ocean-atmosphere algorithm stand to immediately benefit from the modifications developed.

Technical Approach

- A separate, more robust (but more expensive) algorithm was leveraged to determine when zero, one, or two solutions can be found.
- Instead of jumping from one value to another, a smooth transition was introduced to the mathematical model to ensure at least one solution can be found.
- Instead of choosing a single parameter value in the model, an adaptive parameter value was introduced to ensure the most physical solution is selected.

Significant differences in heat exchange



The figure shows how using the more accurate algorithm instead of the original one affects the amount of heat exchanged between the ocean and atmosphere. Any statistically insignificant difference is set to no color, i.e., all regions with color are statistically significant. The regions with substantial differences, such as those indicated by ovals, will likely impact future natural hazard mitigation strategies.

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