A Study of the Large-Scale Impact of Cloud-Scale Interactions Using a Cloud-System Resolving Model

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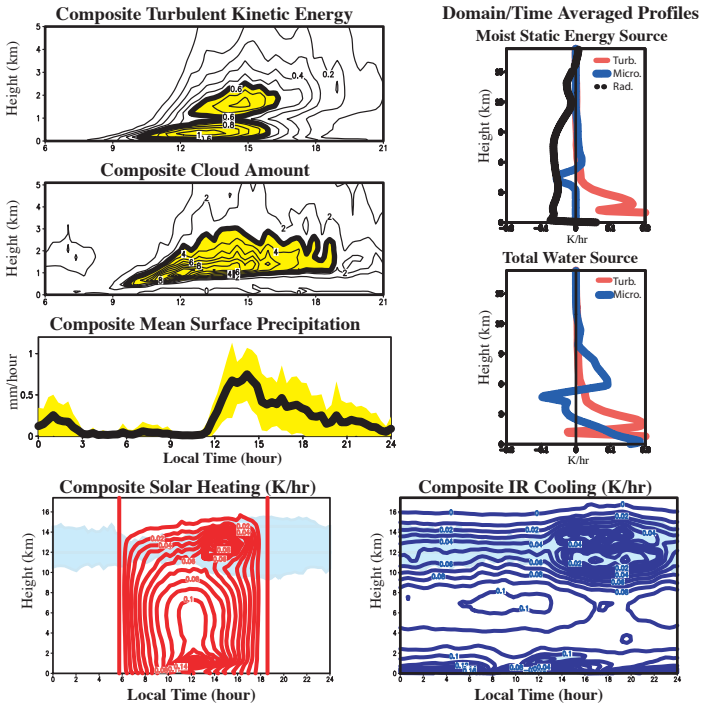
Introduction

Through the use of a modular structure for model physics, conventional general circulation and numerical weather prediction models are designed to focus on the coupling of each physical process with the dynamics core for resolved motion. In this way, most of the cloud-scale direct interactions between those processes are missing. In this paper, we use a cloud-system resolving model (CSRM), in which cloud-scale modulations of turbulence, microphysics and radiation processes are explicitly calculated.

Control

Simulation for an idealized domain over land with diurnally-varying solar insolation with full cloud-scale interactions.



- Clouds strongly influence turbulence and its flux convergence.
- Existence of clouds modulates radiative heating profiles as expected.

Experiment Setup

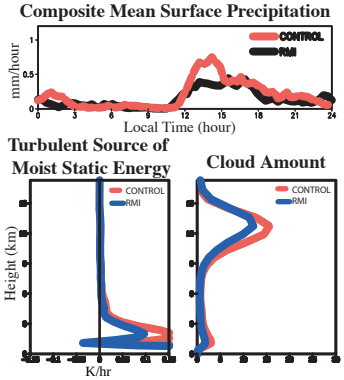
- **MI (Mean Input) experiments:**

  Input to a physics subroutine is horizontally averaged to eliminate *the cloud-scale modulation of the process in question entirely.*

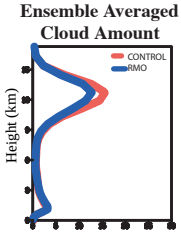
- **MO (Mean Output) experiments:**

  Output from a physics subroutine is horizontally averaged to eliminate

Radiation with Mean Input (RMI)

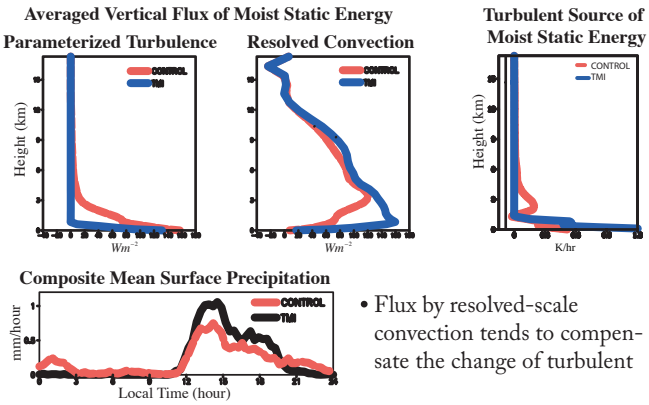


Radiation with Mean Output (RMO)



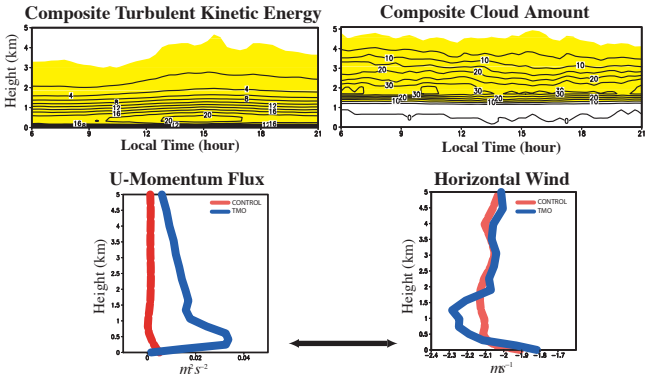
- Weaker diurnal cycle in RMI.
- Less cirrus in RMO.

Turbulence with Mean Input (TMI)



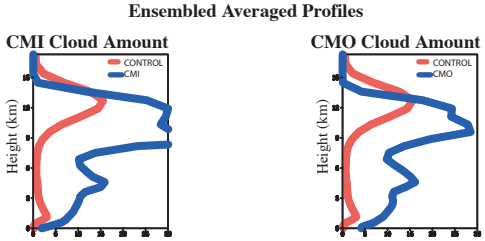
- Flux by resolved-scale convection tends to compensate the change of turbulent

Turbulence with Mean Output (TMO)



- Since the environmental wind has no direct feedback on local clouds, the downgradient momentum flux near the surface causes spurious shear generation of TKE.

Cloud Microphysics with Mean Input/Output (CMI/CMO)



- Extremely unrealistic results.

Conclusion

- **RMI and RMO suggest the importance of including the feedback of local radiative heating/cooling on fractional cloudiness.**
- **TMI suggests that it is crucial to consider cloud-scale enhancement of turbulence to correctly simulate the partition between resolved convection and parameterized turbulence.**
- **TMO suggests that local effects such as cloud-scale advection may balance the turbulence/microphysics processes within and/or below clouds.**
- **Due to the existence of cloud-scale interactions, the effects of individual physical processes should not be separately averaged for predicting the averaged field.**