

# Rectification of the Diurnal Cycle of Moist Convection: Implications for Tropical Circulation

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MIT

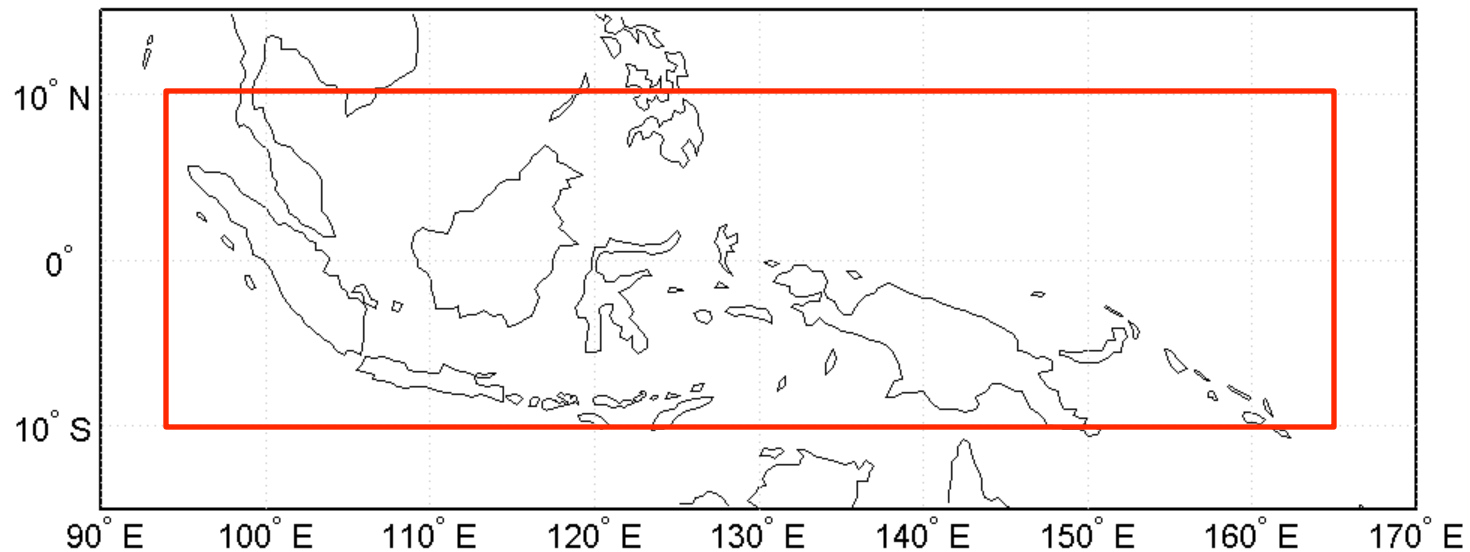
with thanks to Marat Khairoutdinov

# General Questions

- What impact does the diurnal cycle have on the time-averaged climate?
- Might the diurnal cycle be responsible for strong nonlinear behavior in some regions?
- Is the diurnal cycle an *essential* element of the climate system?

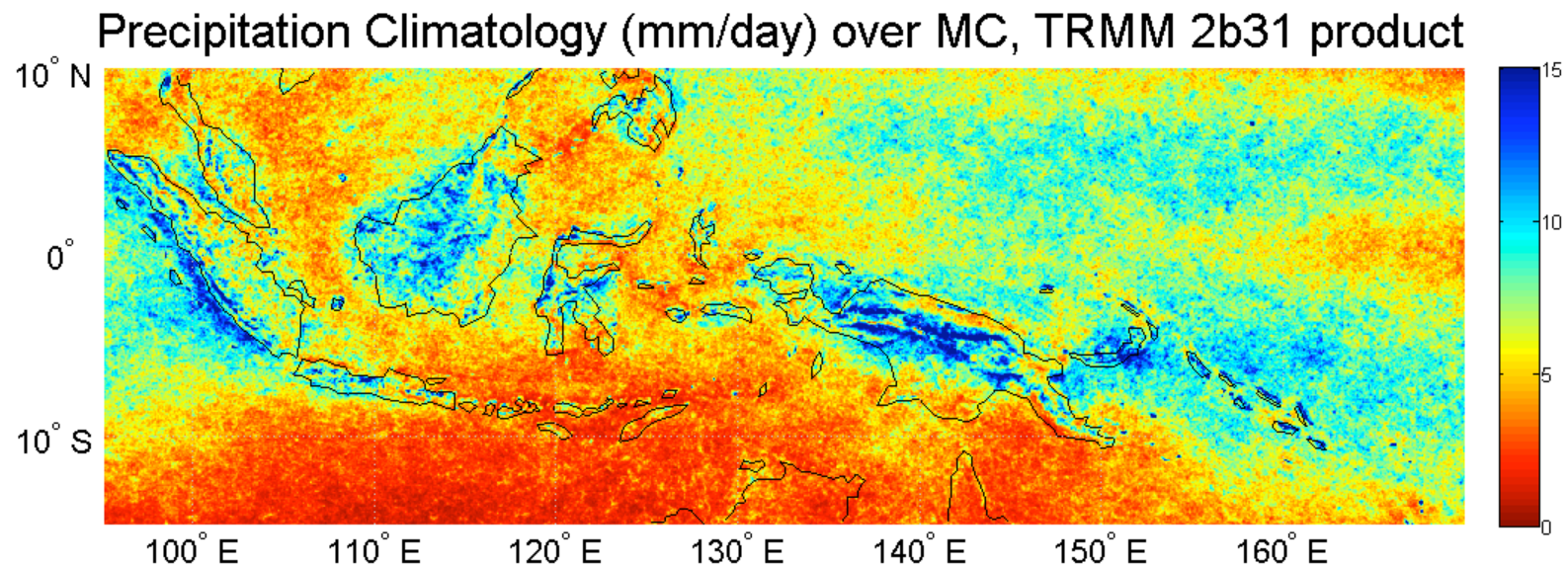
# Diurnal Cycle and the MC

- A good place to look for impacts of the diurnal cycle on the mean climate might be the Maritime Continent (MC)



# Precipitation within the MC

- Does the diurnal cycle play an essential role in the precipitation distribution within the MC?

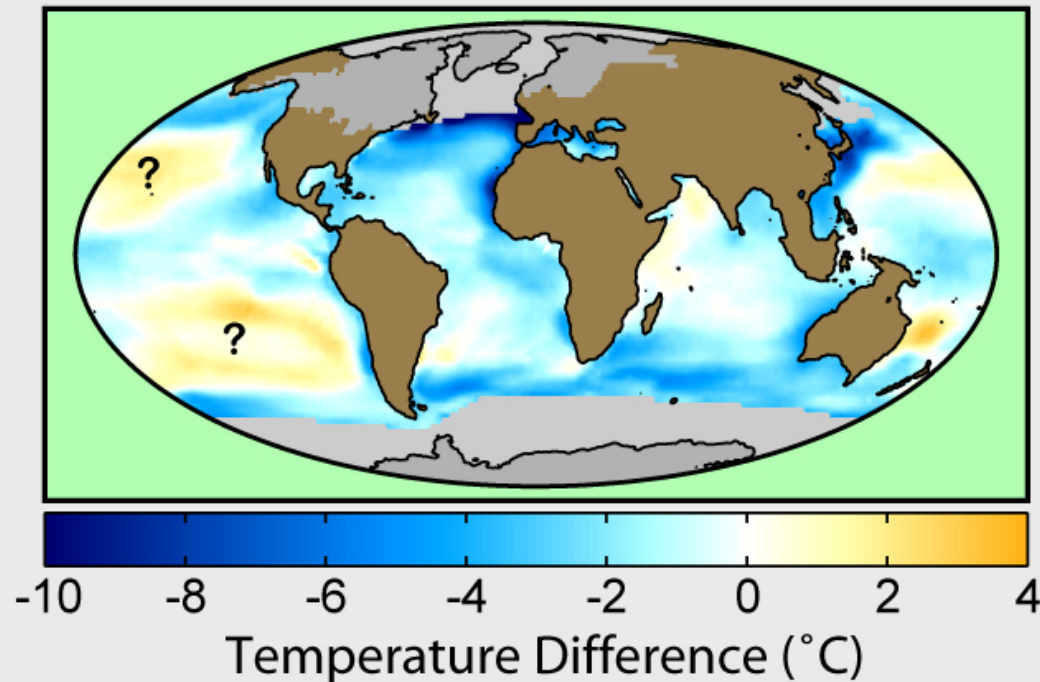


Mulligan, M (2006) Global Gridded 1km TRMM Rainfall  
Climatology and Derivatives. Version 1.0. Database: [http://  
www.ambiotek.com/1kmrainfall](http://www.ambiotek.com/1kmrainfall)

# Changes in MC and Tropical Climate

- Does the diurnal cycle play an essential role in the zonal asymmetry of the tropical Pacific?

CLIMAP: The Last Glacial Maximum

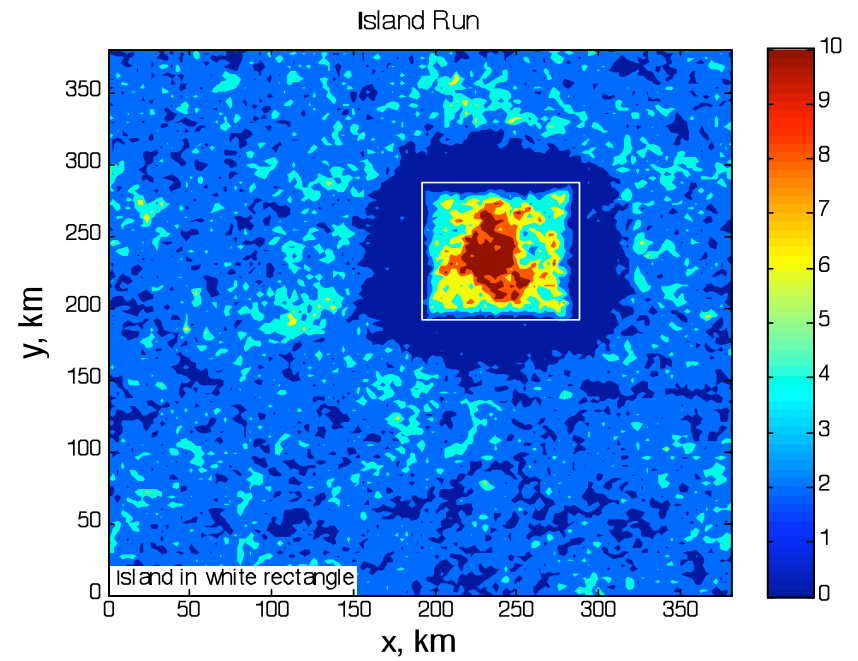
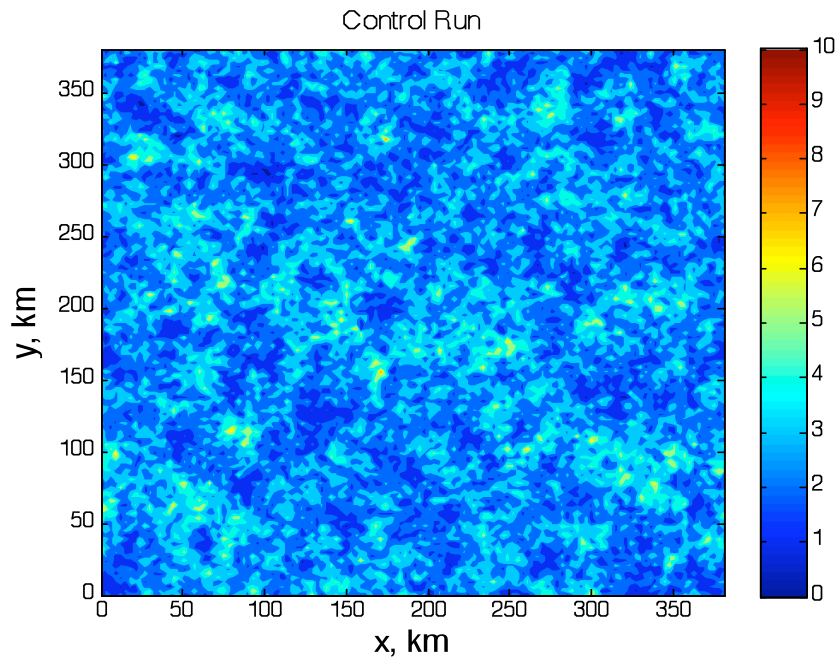


Robert A. Rohde

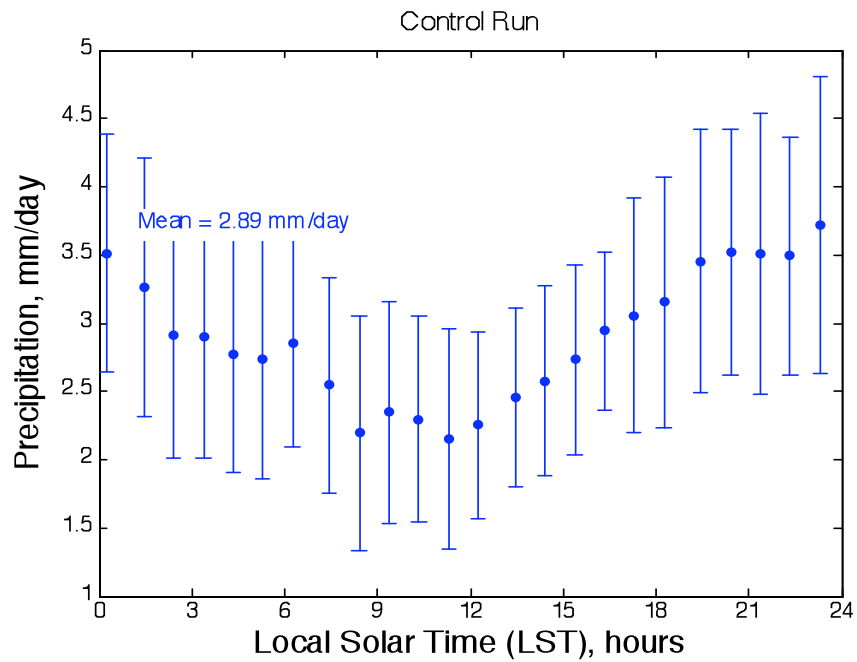
# System for Atmospheric Modeling (SAM) Khairoutdinov and Randall (2003)

- Doubly periodic domain
- 384 x 384 km
- 64 levels
- 3 km horizontal resolution
- Non-rotating
- 1 m deep slab ocean
- 96 X 96 km “island” consisting of 5 cm deep water slab
- Simulations into statistical radiative-convective equilibrium

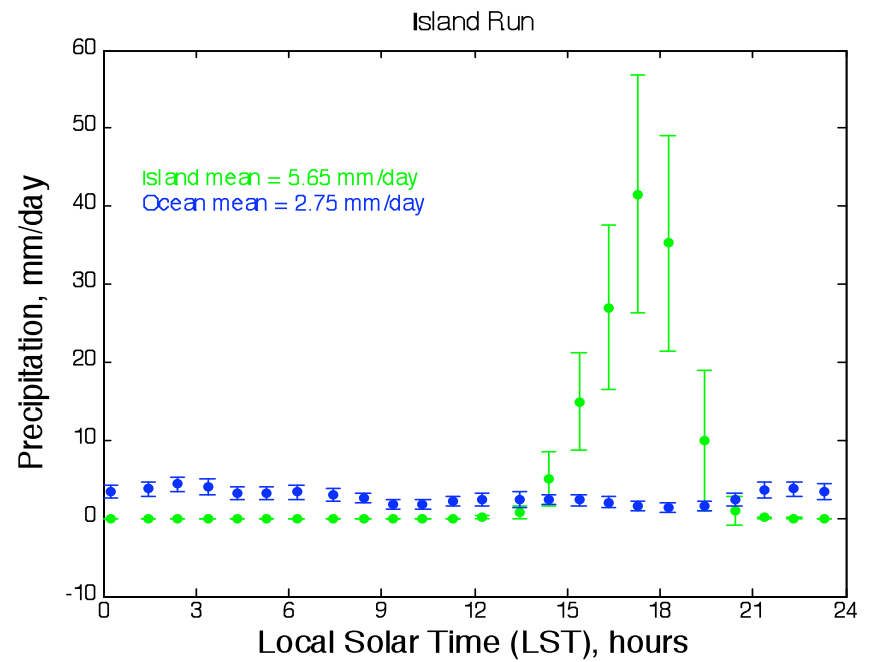
# Precipitation contrast



# Diurnal Cycles



Control

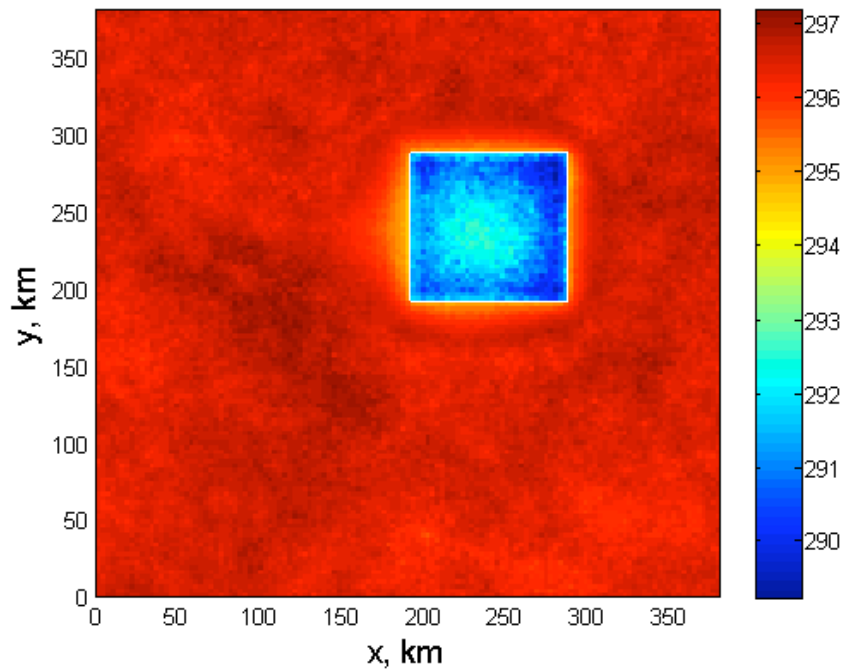


Island

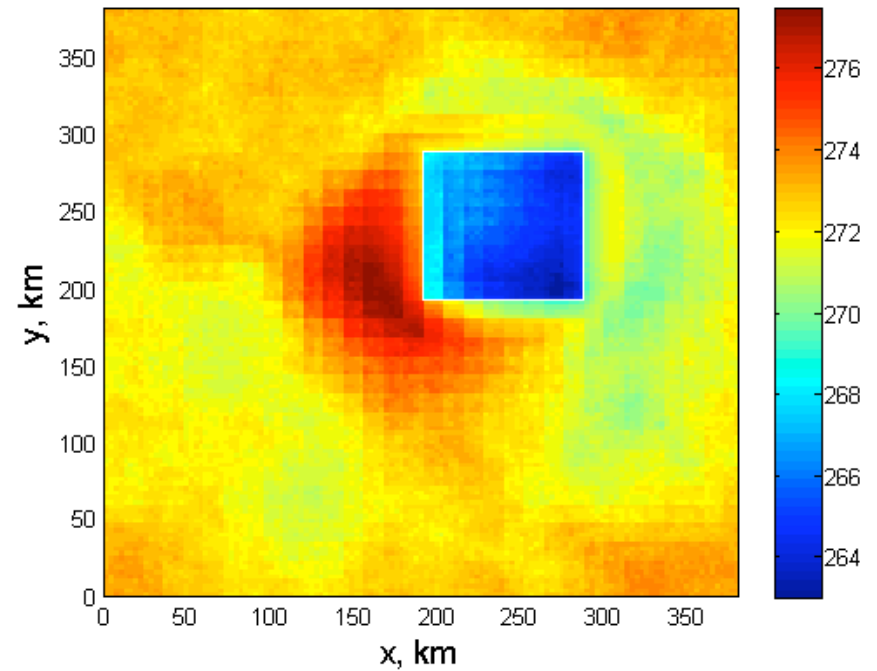


# Rectification Mechanism 1

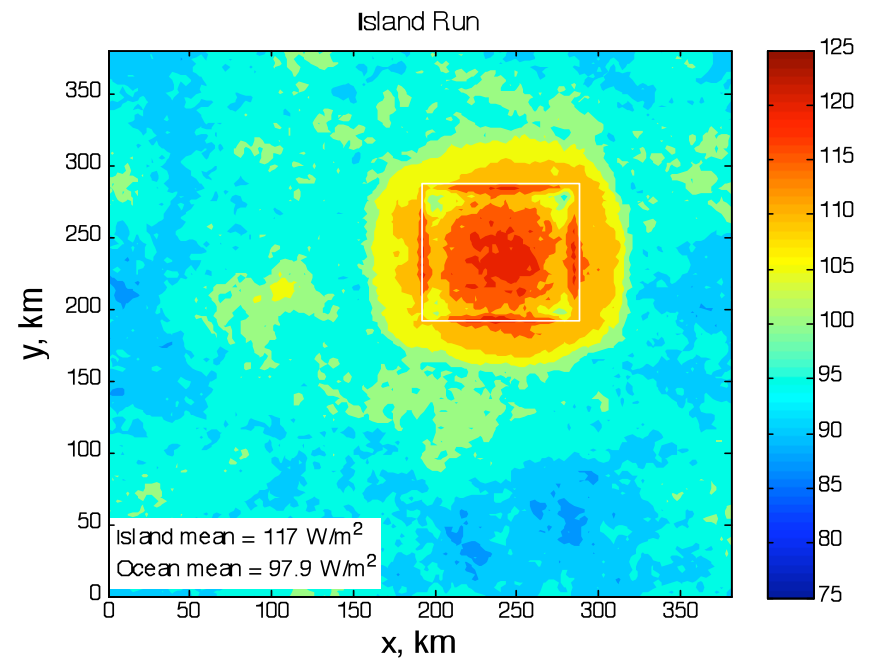
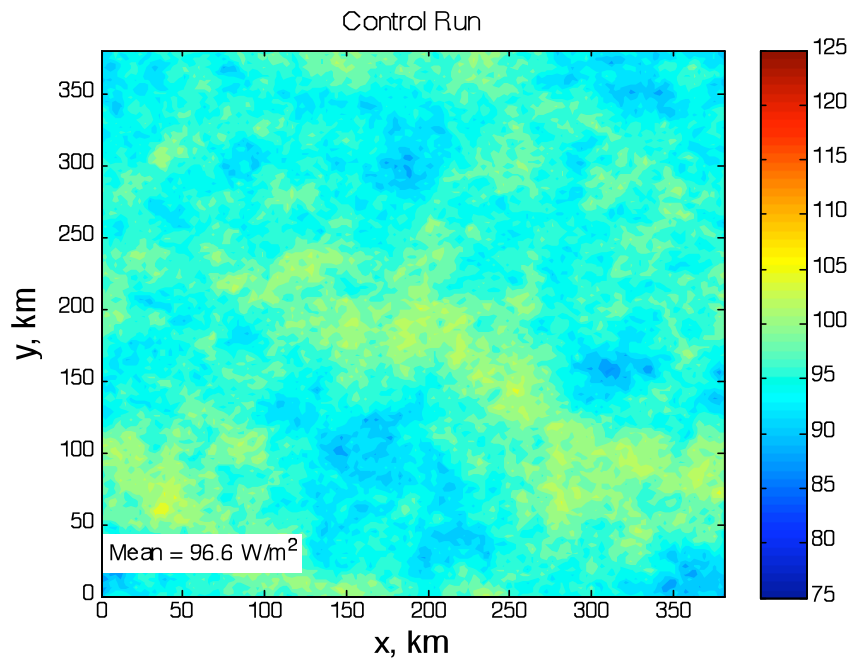
time mean clear-sky surface temperature, K



time mean clear-sky OLR,  $W/m^2$



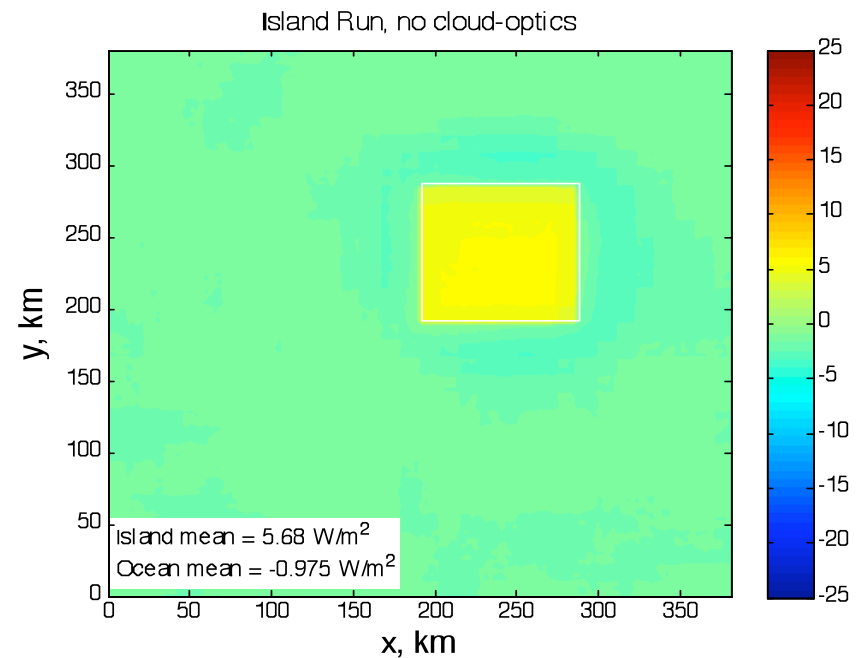
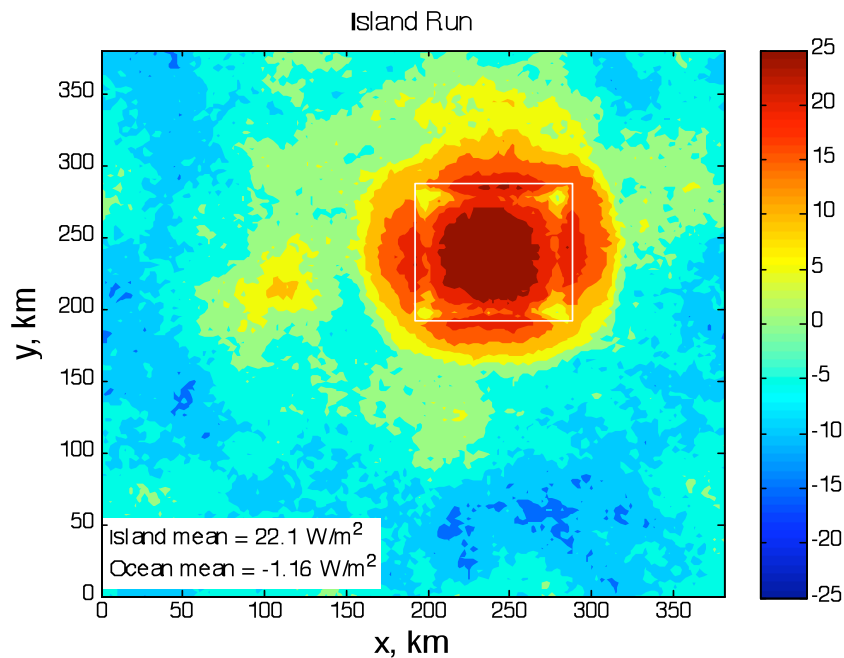
# Surface Enthalpy Fluxes, Time-average Map; $W/m^2$



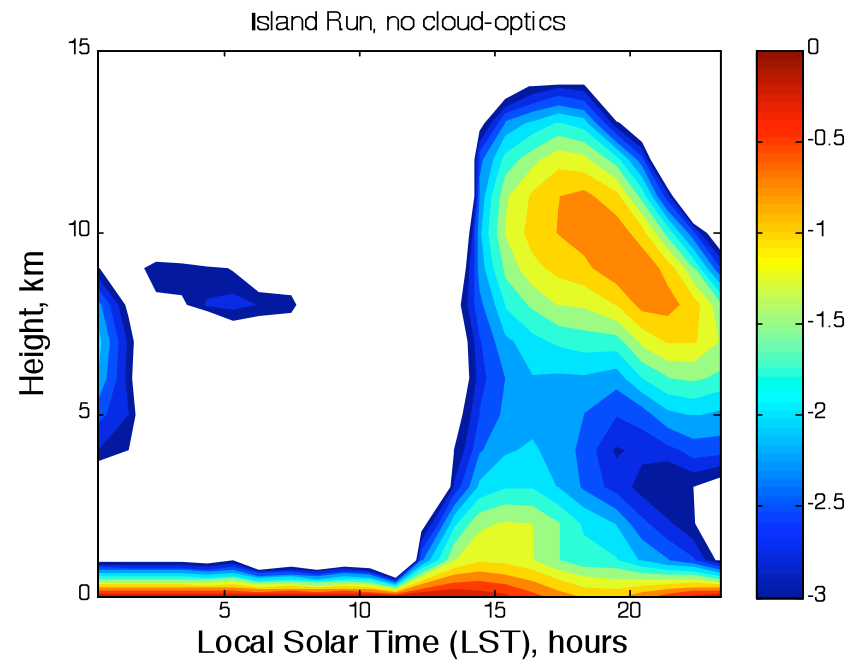
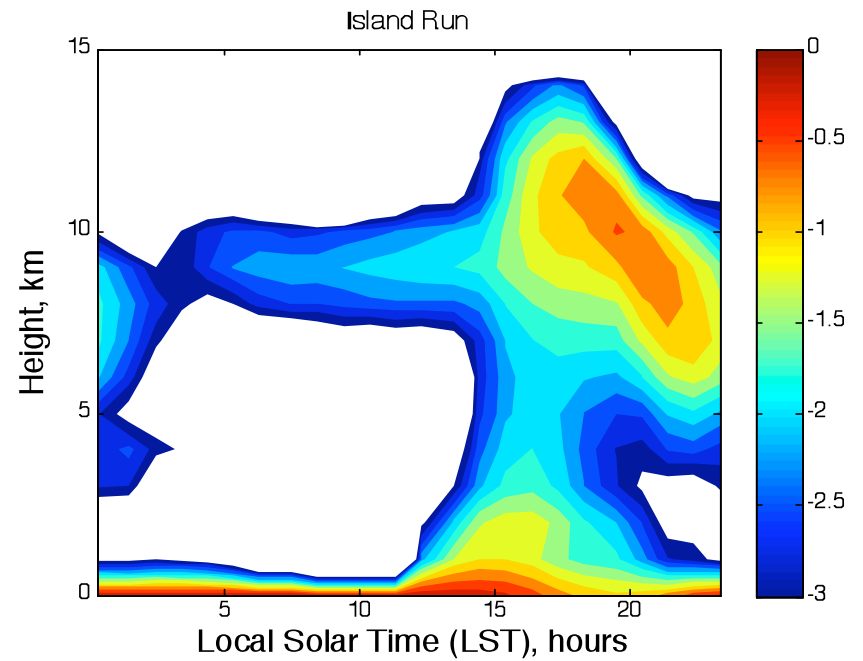
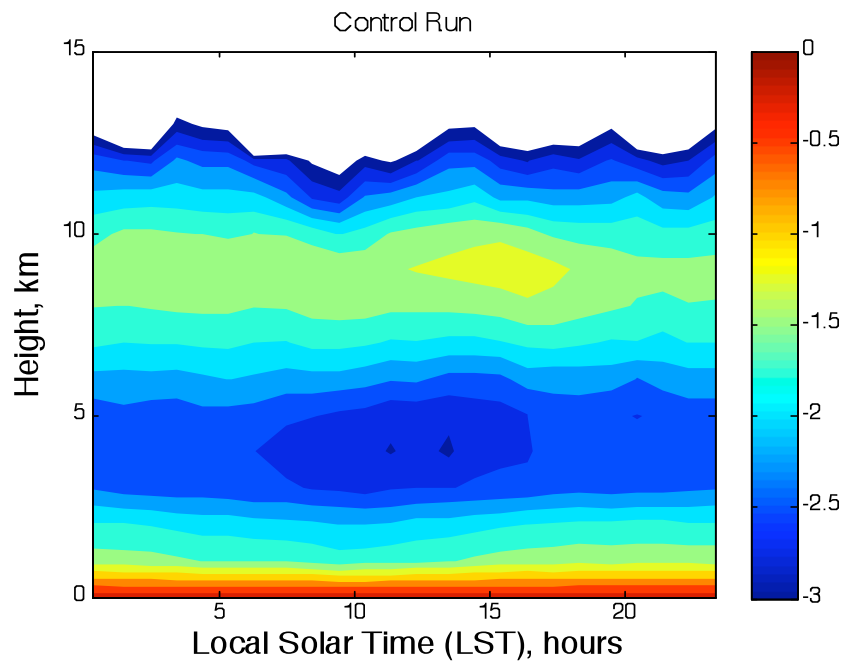
# Rectification Mechanism 2

- Energetic contrast: Cloud Radiative Forcing

TOA Net Radiation, Time-average Maps;  $\text{W/m}^2$

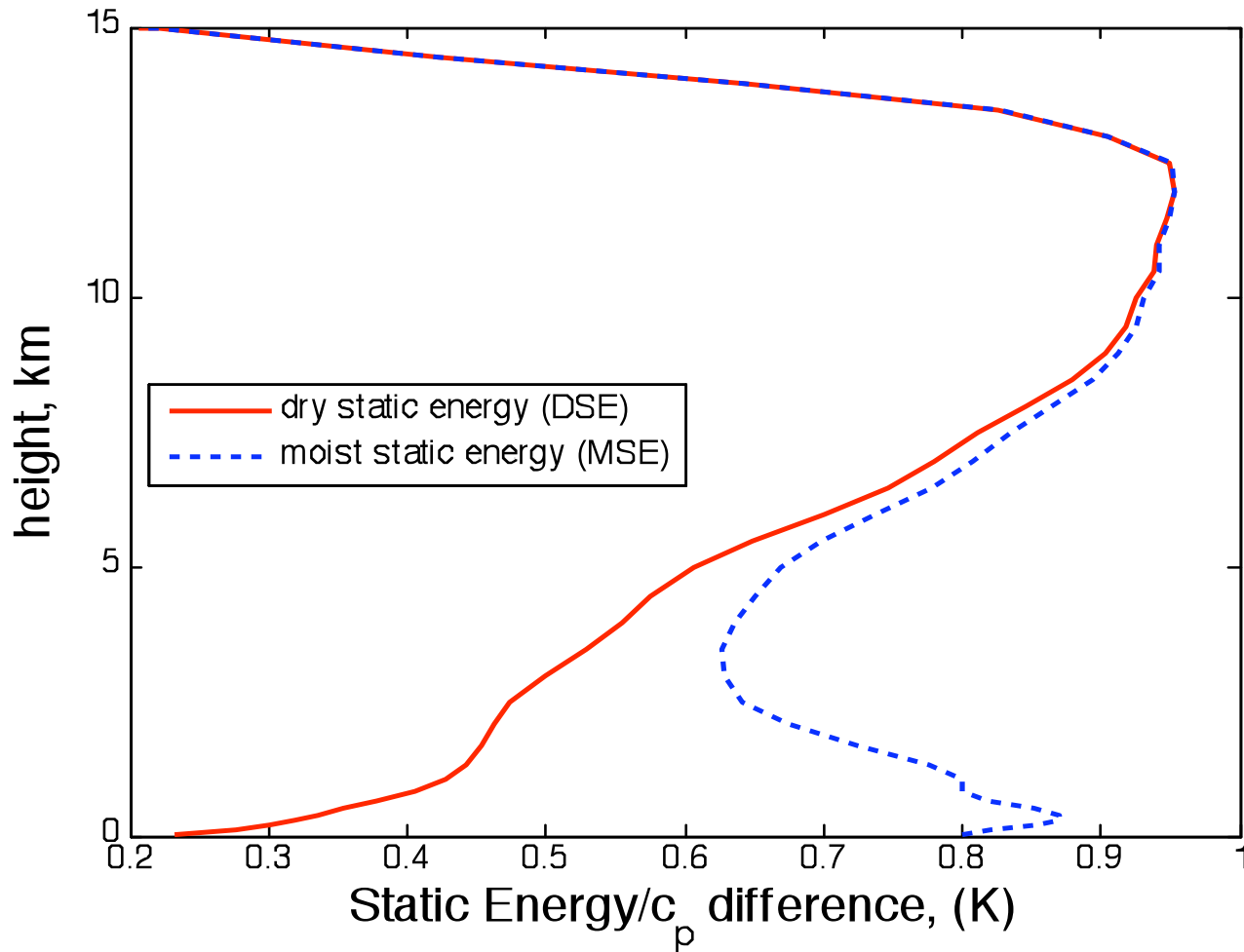


# Log<sub>10</sub> of Cloud-top height PDF over island region (column integral=1 at each LST)



# Domain with Island is Warmer than All Ocean Domain

Island minus Ocean Run: DSE and MSE differences

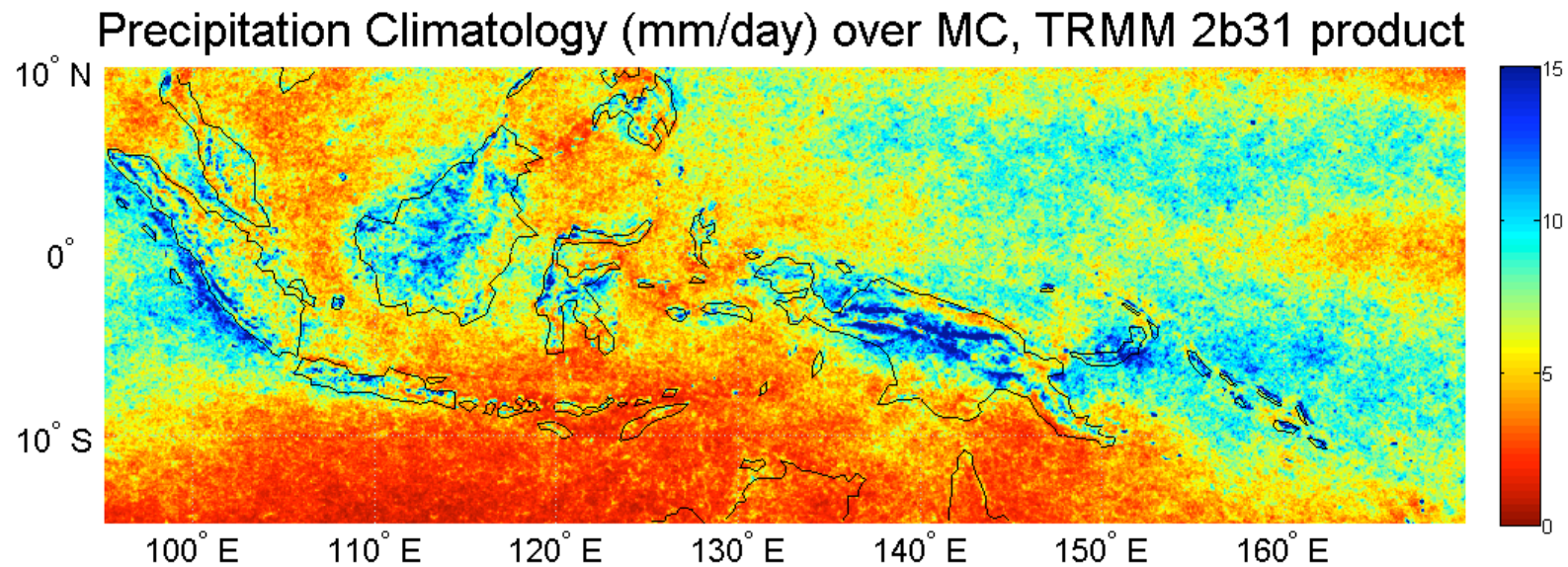


# Expand to General Circulation Scale

- GCM (or SAM) with modified parameterized convection
- GCM with superparameterized convection
- SAM (or other CRM) simulations with rescaled parameters (or expensive runs with quasi-3D geometry)

# Comparisons of Observations to Theory

- E.g. – what is land/ocean precip ratio observed over maritime continent?



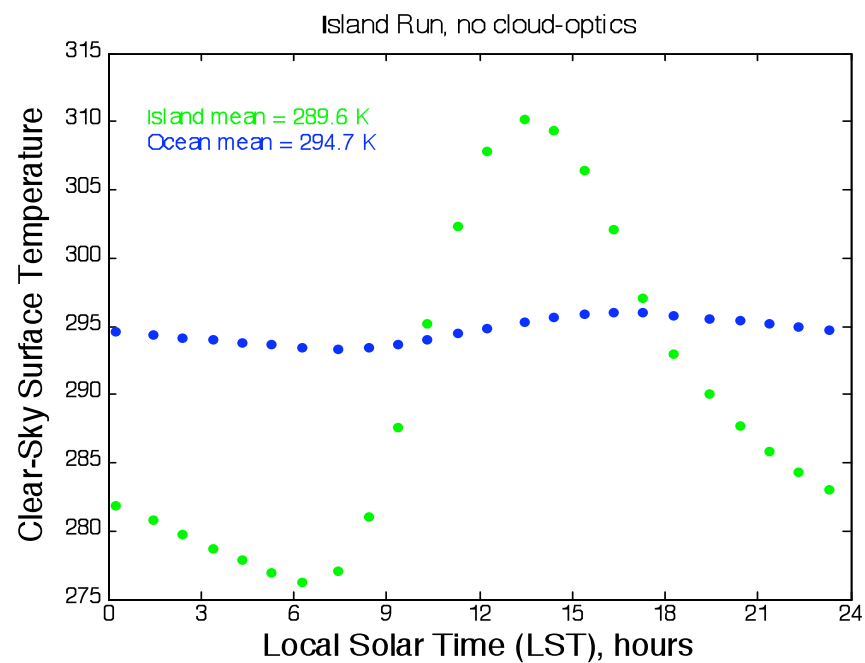
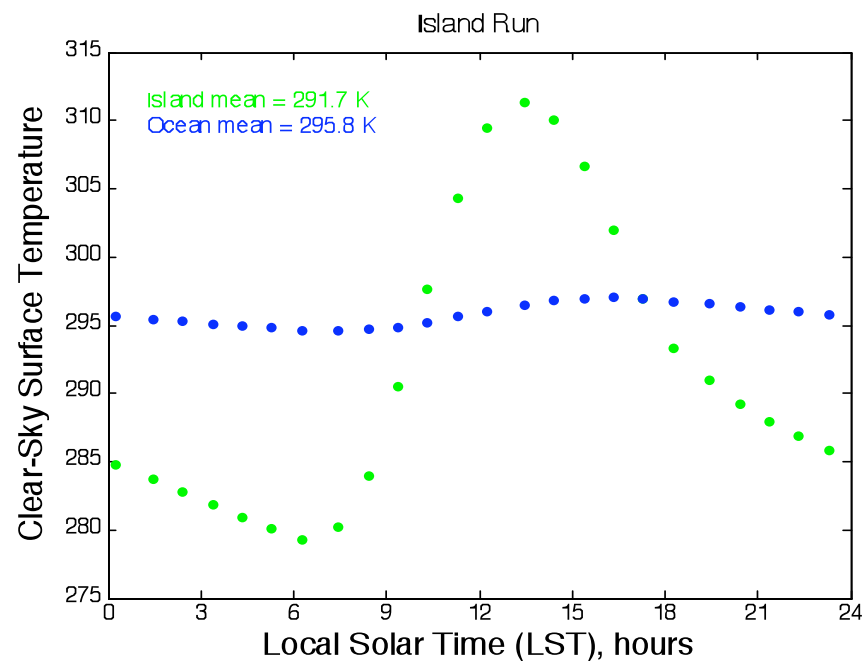
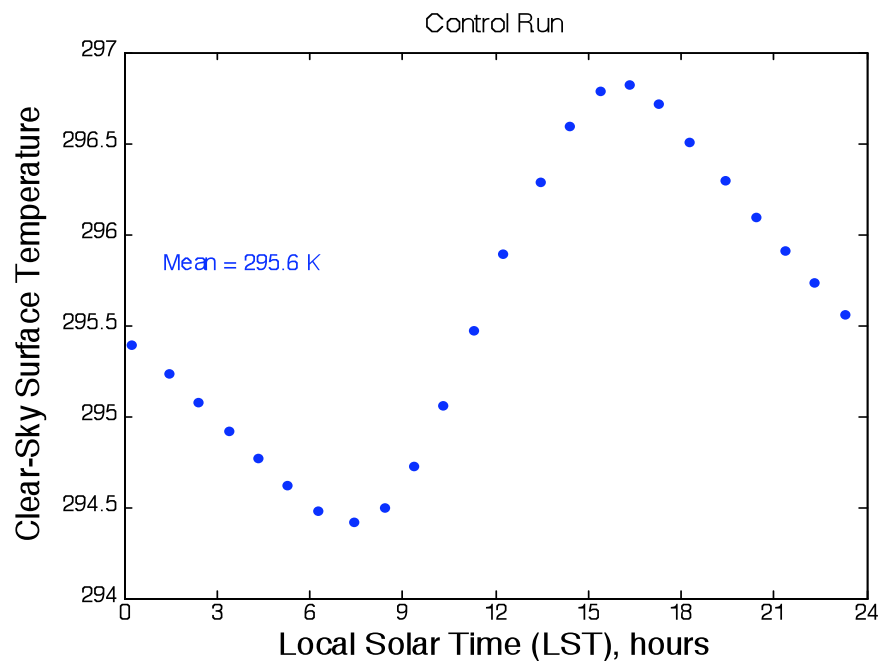
# Summary/Discussion

- There appear to be at least two mechanisms that rectify the diurnal cycle
- Atmosphere is, in the mean, warmer when a diurnal cycle is present
- Research Goals:
  - Better understanding of mechanisms that can rectify diurnal cycle
  - Better understanding of whether tropical islands can influence the zonal symmetry of the tropical climate





# Clear-Sky Surface Skin Temperature, Diurnal Composite, K



# Precipitation Rate, Time-average Map, mm/day

