Sensitivity of Mesoscale Convective System Tracking Algorithms to Detection Thresholds and Data Resolution: A Comparison Useful for High Resolution Model Analysis

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NATIONAL SEVERE STORMS LABORATORY NSSL

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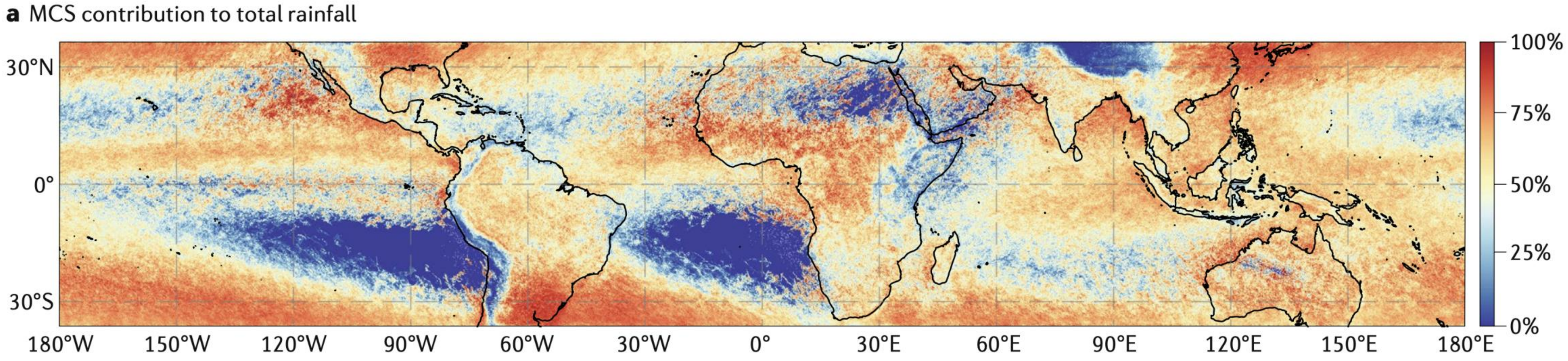
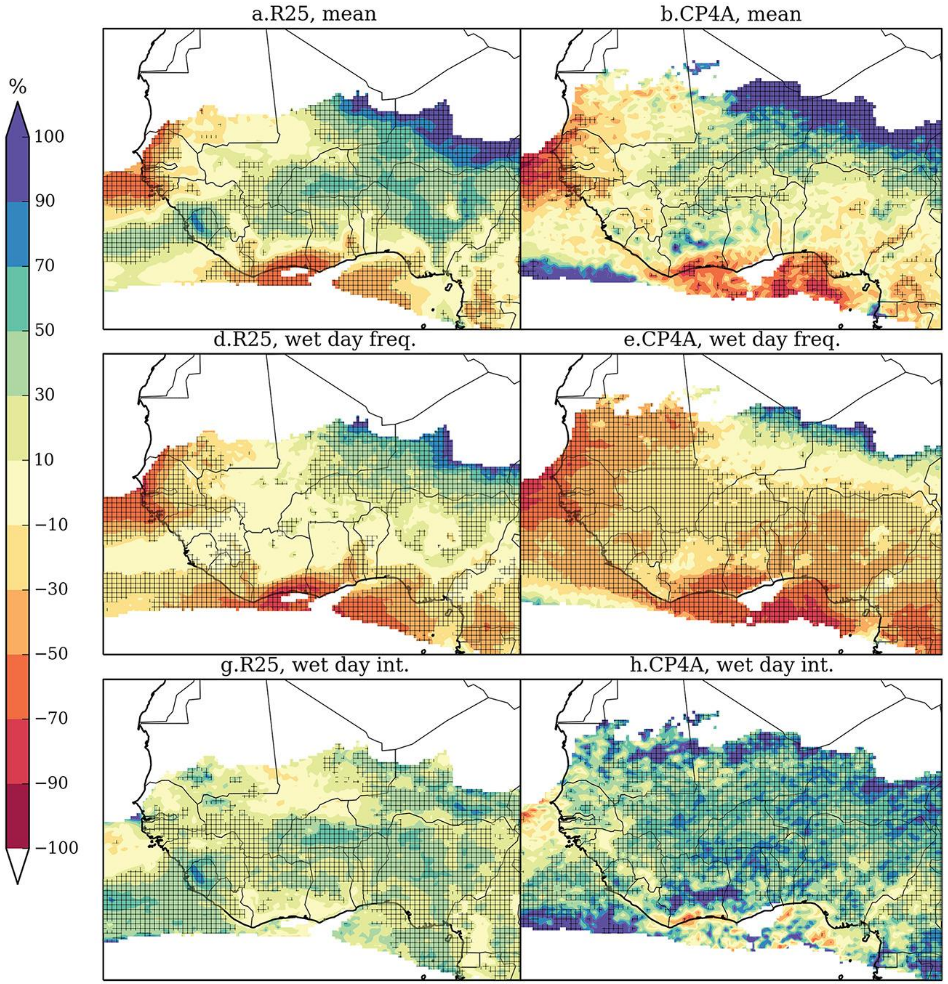
Mesoscale Convective Systems (MCSs)

Mesoscale Convective System: "A complex of thunderstorms which becomes organized on a scale larger than the individual thunderstorms, and normally persists for several hours or more." –NOAA Glossary

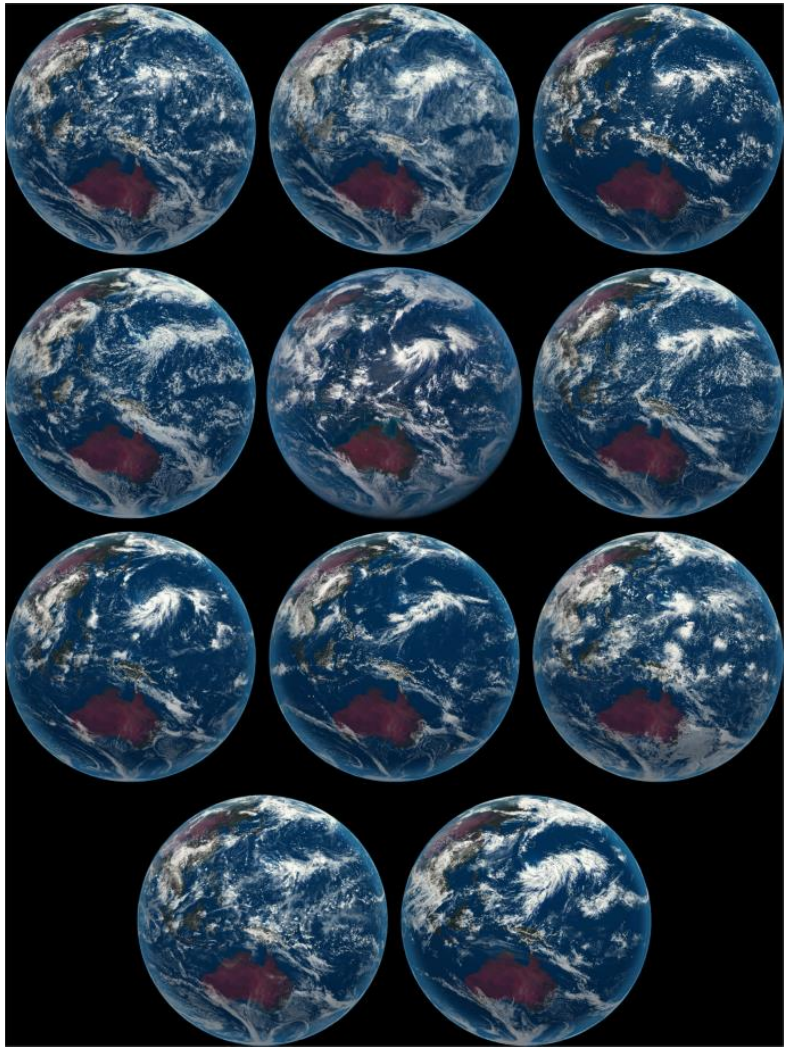


Schumacher and Rasmussen (2020)

Convection Permitting Simulations

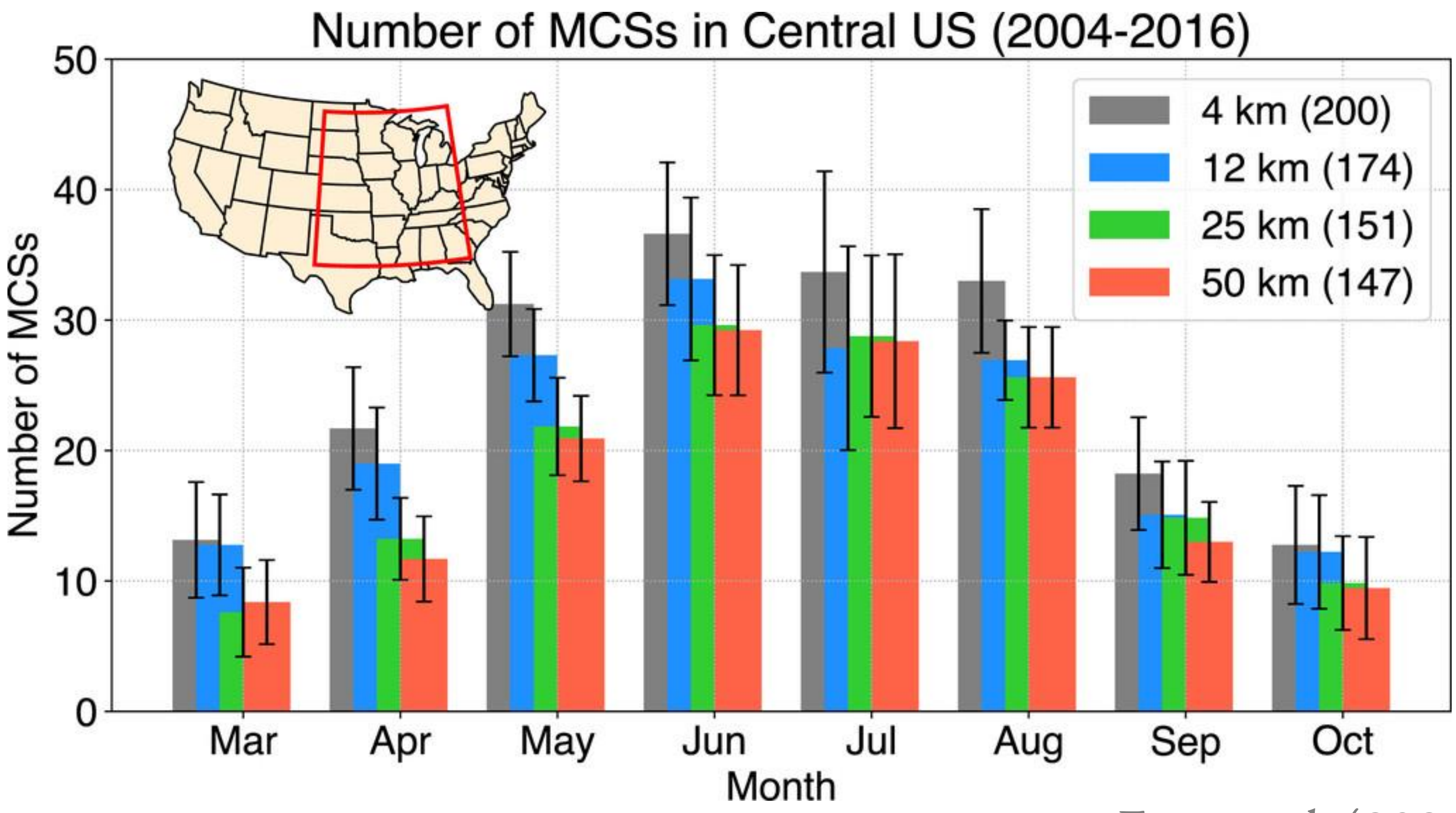


Berthou et al. (2019)



Stevens et al. (2019)

Evaluation of MCS in Climate Simulations



Feng et al. (2021)

Across the global tropics:

How is tracking and identification of MCS clusters sensitive to the resolution of IR dataset?

How is tracking and identification of MCS clusters sensitive to the choice of thresholds?

Tracking Methodology:

Cloud Clusters identified following Huang et al. (2018):

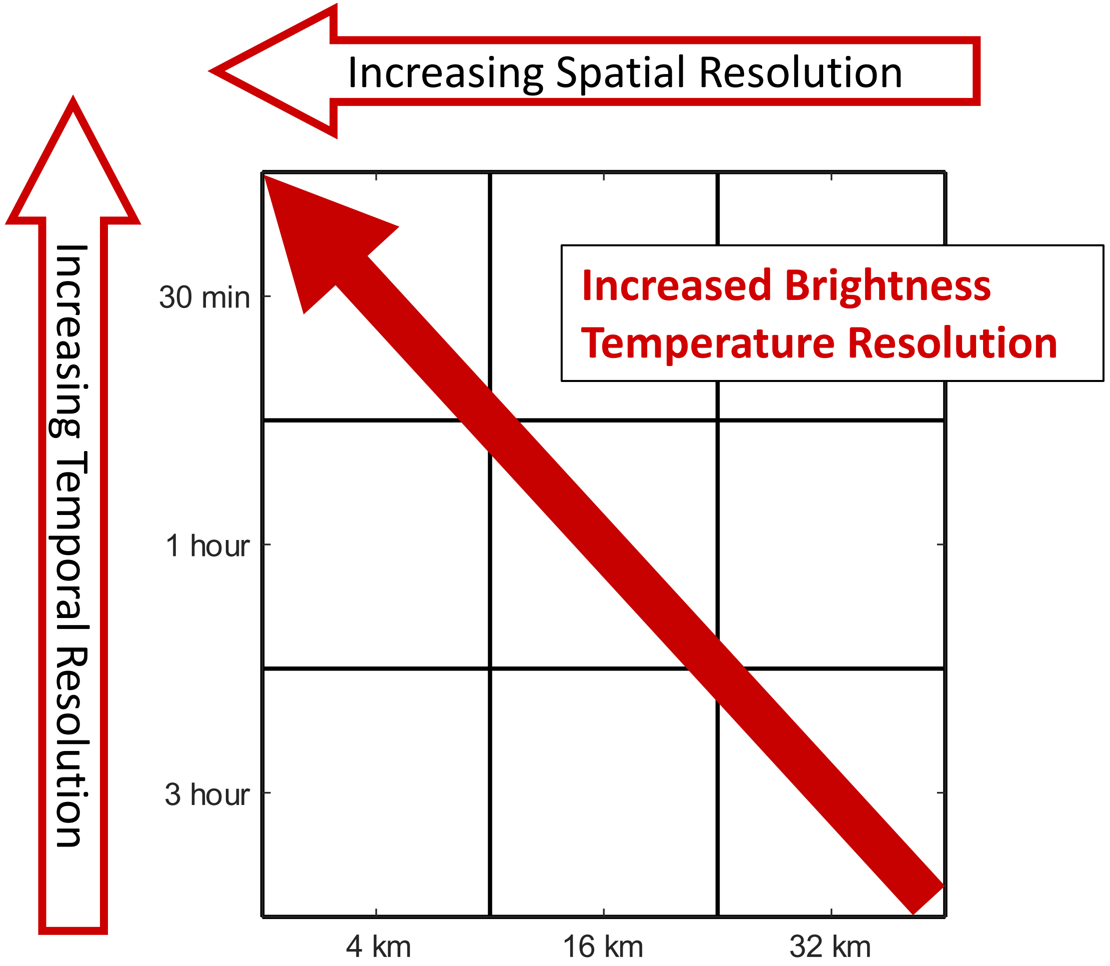
- identifying regions colder than a brightness temperature (BT) threshold and larger than a certain size threshold
- simple area overlap for tracking clusters (instead of a more complex Kalman filter)
- duration over 6 hours

Study region and period:

- Global Tropics (30N – 30S)
- One Month (October 2018)

Brightness Temperature (BT) Data:

- NCEP/CPC L3 Global Merged IR
- Available every 30 mins at 4 km resolution
- Coarsened to 16 km and 32 km



Tracking Methodology:

Large Clusters

- cloud clusters larger than 60,000 km^2
- BT colder than 241K
- cold core identified

e.g. Feng et al. 2018, 2021

Medium Clusters

- cloud clusters larger than 25,000 km^2
- BT colder than 233K

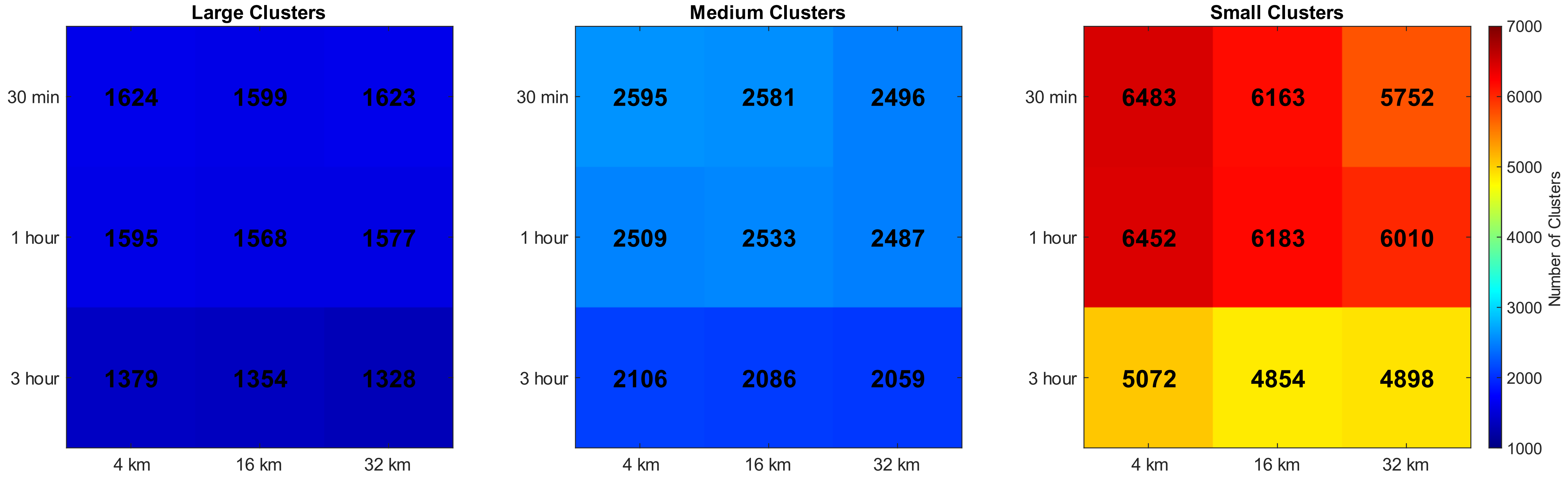
e.g. Taylor et al. 2017

Small Clusters

- cloud clusters larger than 5,000 km^2
- BT colder than 233K

e.g. Huang et al. 2018
Dong et al. 2021

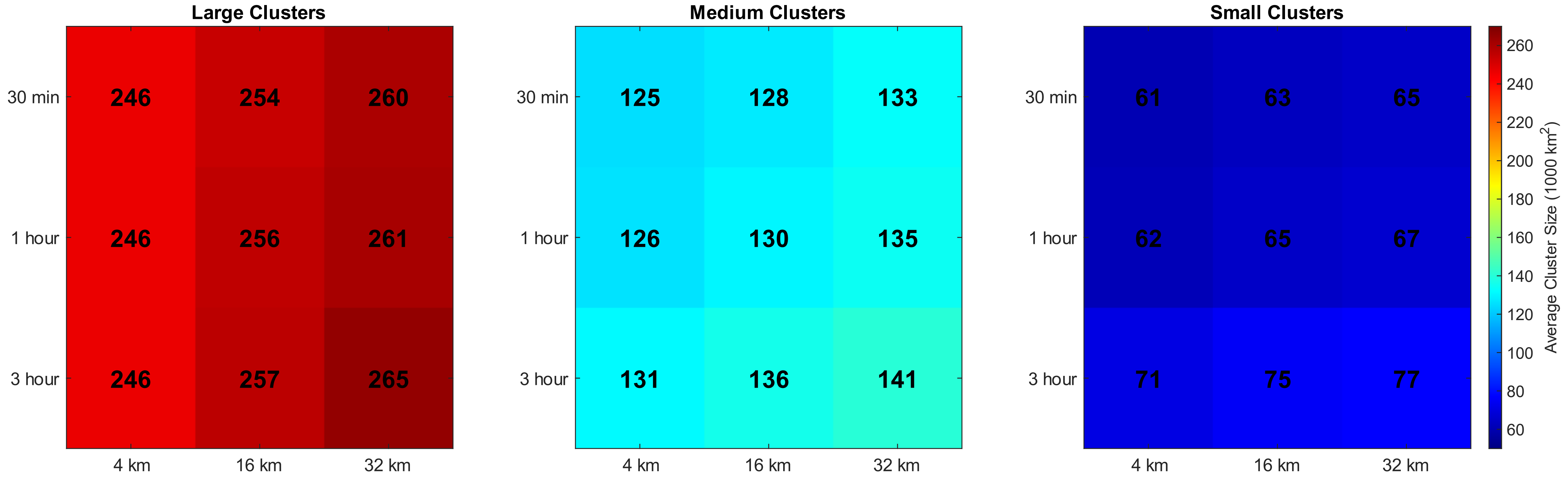
Number of Clusters Identified:



Key Points:

1. As the threshold for cluster size decreases there are **more identified clusters**.
2. There are more clusters identified as the spatial and temporal resolution of the BT database increases.

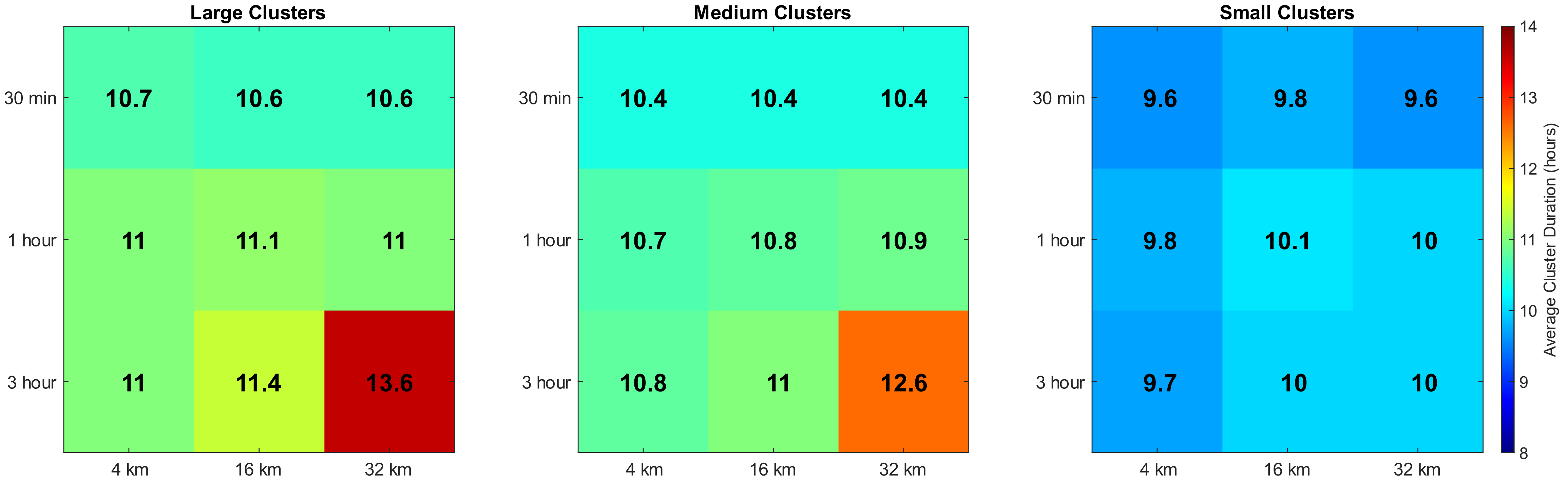
Average Size of Clusters:



Key Points:

1. As the threshold for cluster size decreases the **average cluster size decreases**.
2. There are **smaller clusters** identified as the spatial and temporal resolution of the BT database increases, especially for the **clusters identified using the 5,000 km^2 threshold**.

Average Duration of Clusters:

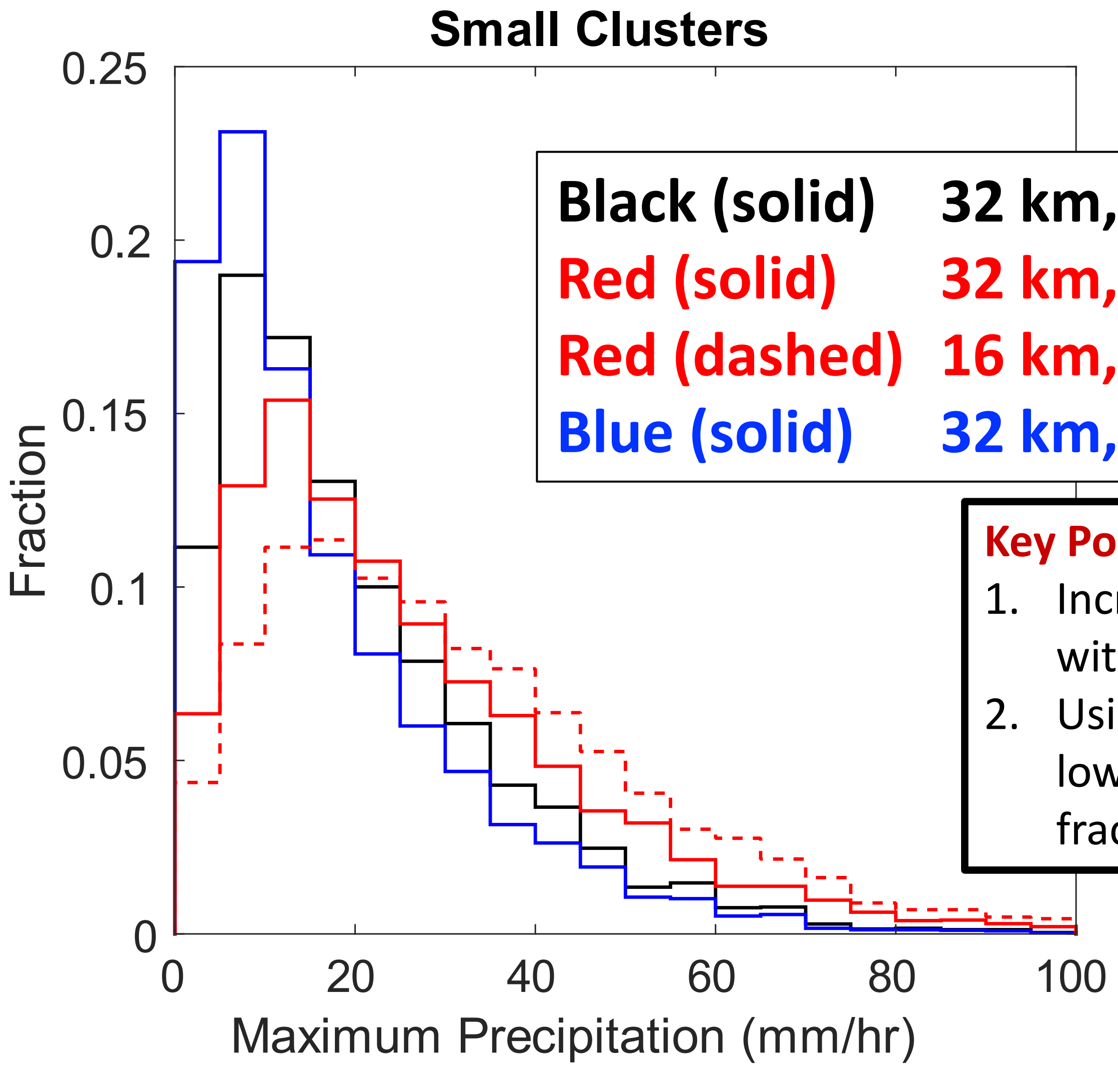


Key Points:

1. As the threshold for cluster size decreases the clusters have **shorter average durations**.
2. There are **shorter duration clusters** identified as the spatial and temporal resolution of the BT database increases.

Maximum Precipitation of Clusters:

Using GPM IMERG Precipitation



Black (solid)	**32 km, 3 hr, Area-Overlap**
Red (solid)	**32 km, 30 min, Area-Overlap**
Red (dashed)	**16 km, 30 min, Area-Overlap**
Blue (solid)	**32 km, 3 hr, Area-Overlap + Kalman Filter**

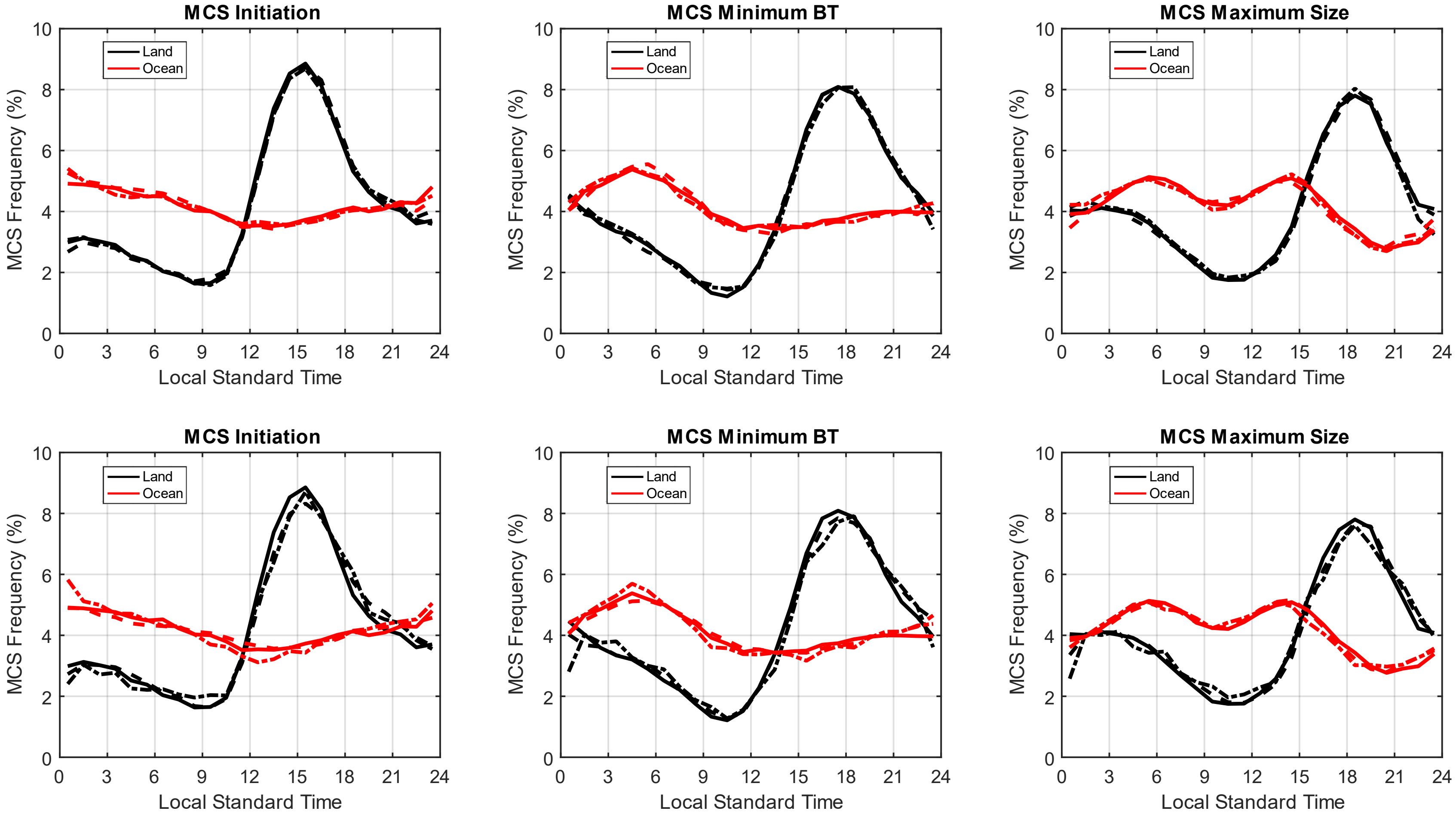
Key Points:

1. Increasing BT resolution decreases the fraction of clusters with weak maximum precipitation (< 10 mm/hr).
2. Using a Kalman filter (as in Huang et al. 2018) with the lower resolution BT data results in an increase in the fraction of clusters with weak precipitation.

Diurnal Cycle of MCS Characteristics:

Vary Horizontal Resolution

Vary Temporal Resolution



Key Point: Diurnal cycle of MCS characteristics is not sensitive to changes in resolution.

In global simulations, how does the representation of the diurnal cycle of MCS characteristics depend on the model resolution?

<u>Observation</u>: NCEP/CPC L3 Global Merged IR

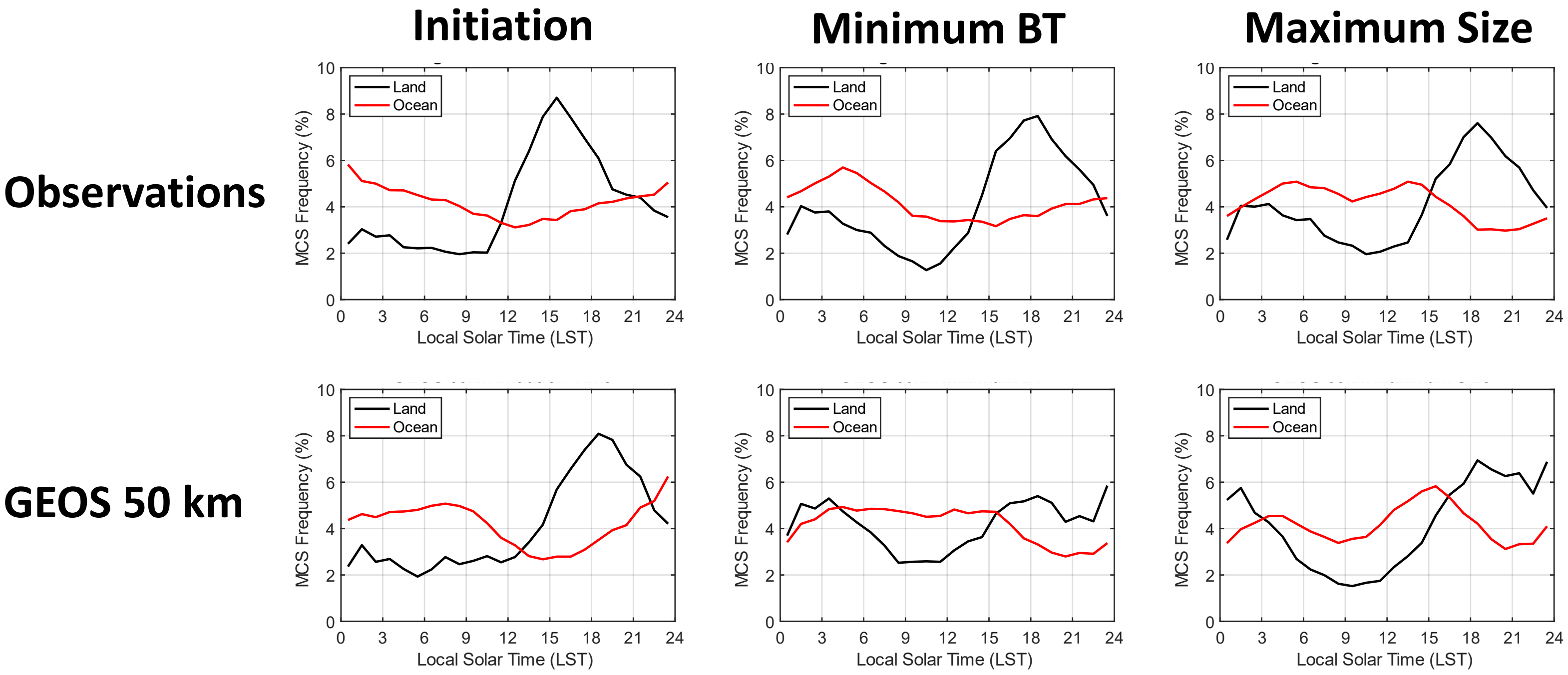
Spatial: 16 km

Temporal: 3 hr

<u>Model</u>: Goddard Earth Observing System (GEOS)

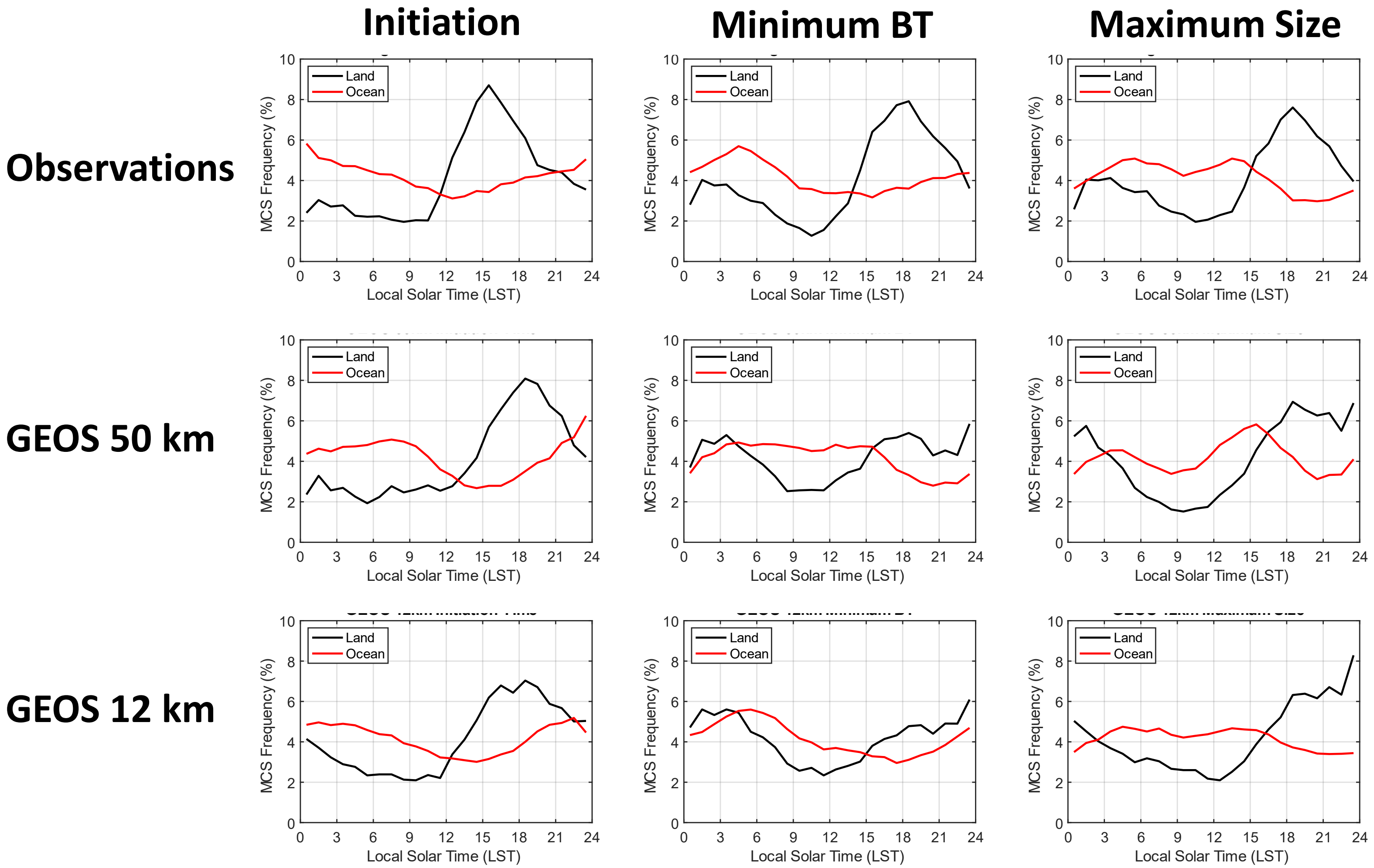
Spatial: 50 km, 12 km, 3 km

Temporal: 3 hr



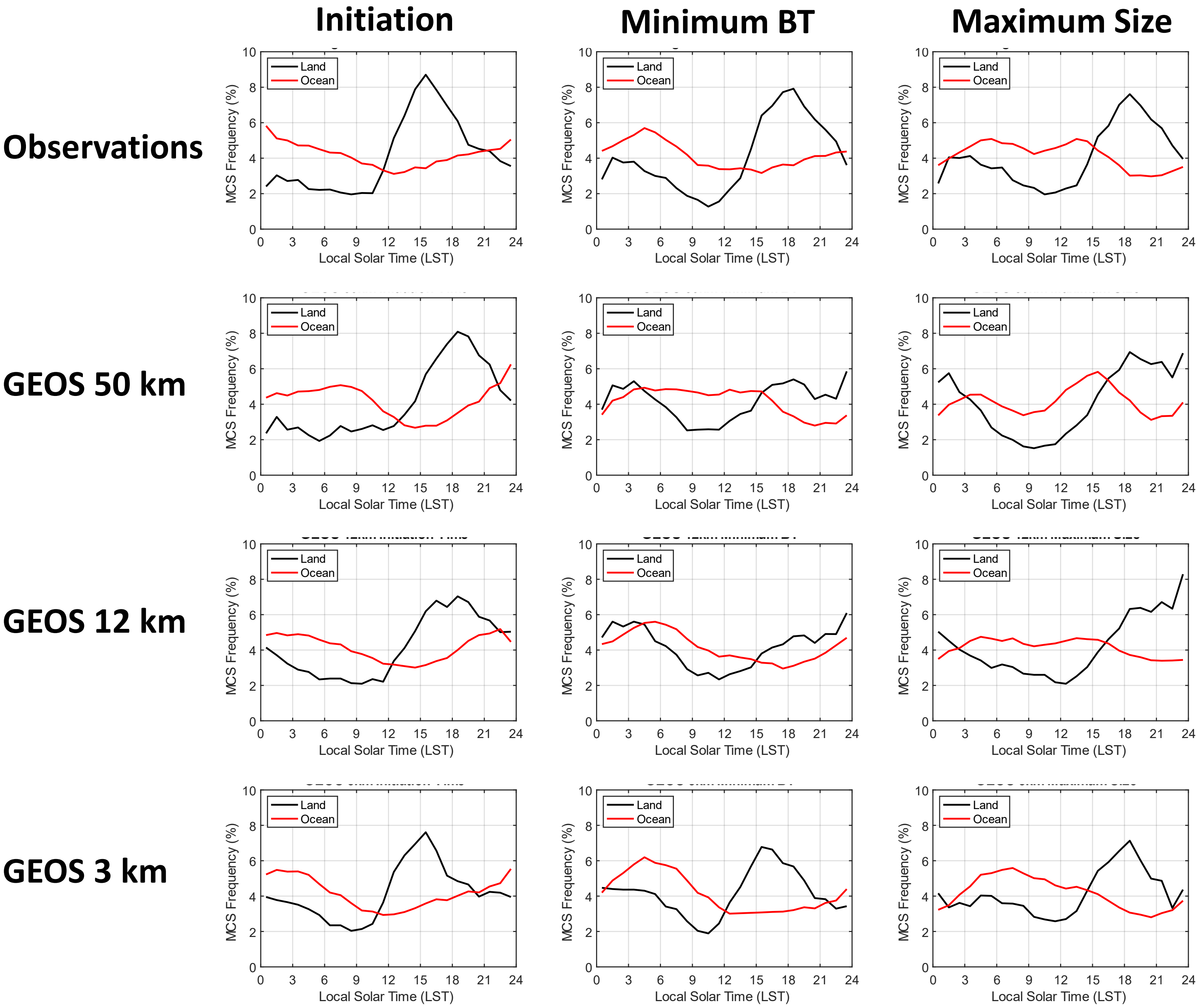
The 50 km simulation:

- initiates MCSs later in the day than observations
- unable to produce the strong signal of MCS intensification
- occurrence time of the maximum size of MCSs is slightly delayed
- produces double peak in oceanic MCS maximum size



The 12 km simulation:

- delay in MCS initiation not as strong as at 50 km
- unable to produce the strong signal of MCS intensification
- occurrence time of the maximum size of MCSs is delayed



The 3 km simulation:

- produces timing of initiation, minimum BT, and maximum size closer to observations
- produces the strong signal of MCS intensification
- does not produce double peak in oceanic MCS maximum size

The tracking of MCSs across the global tropics is sensitive to the choice of brightness temperature data & choice of thresholds.

High-resolution GEOS simulations produce the diurnal cycle of MCS characteristics better than coarser simulations, an example of exciting work that can be done with DYAMOND output.

There is a central role for both observations and modeling experiments to better understand mechanisms that lead to the organization of convection and upscale growth.

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