Pacific Northwest
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Development and Application of a High-Resolution Global MCS Database on Air-sea Interactions

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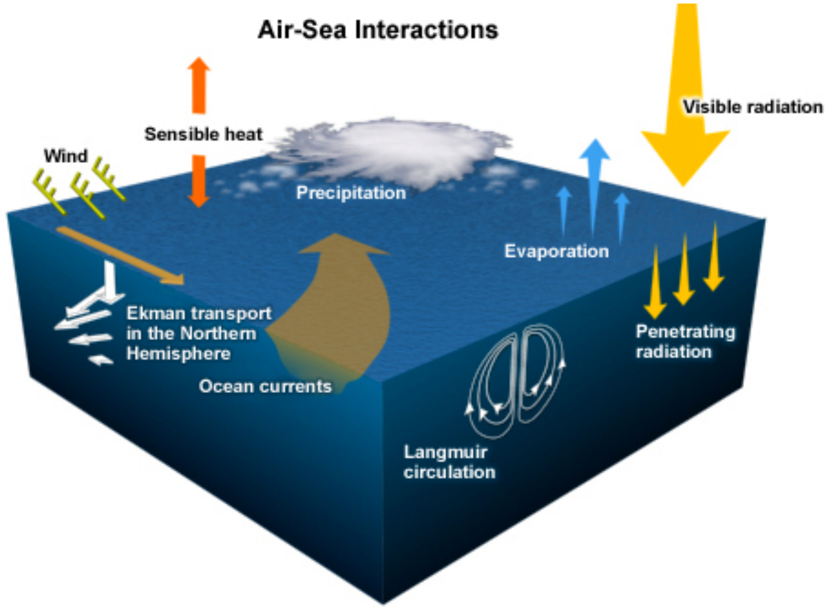
Motivation

- Tropical oceanic MCSs are long-lived and can grow to tremendous horizontal extent
- They interact with the ocean surface to modulate surface fluxes through precipitation and wind gusts
- Air-sea interactions associated with MCSs over tropical oceans have not been systematically quantified due to lack to high-resolution MCS database



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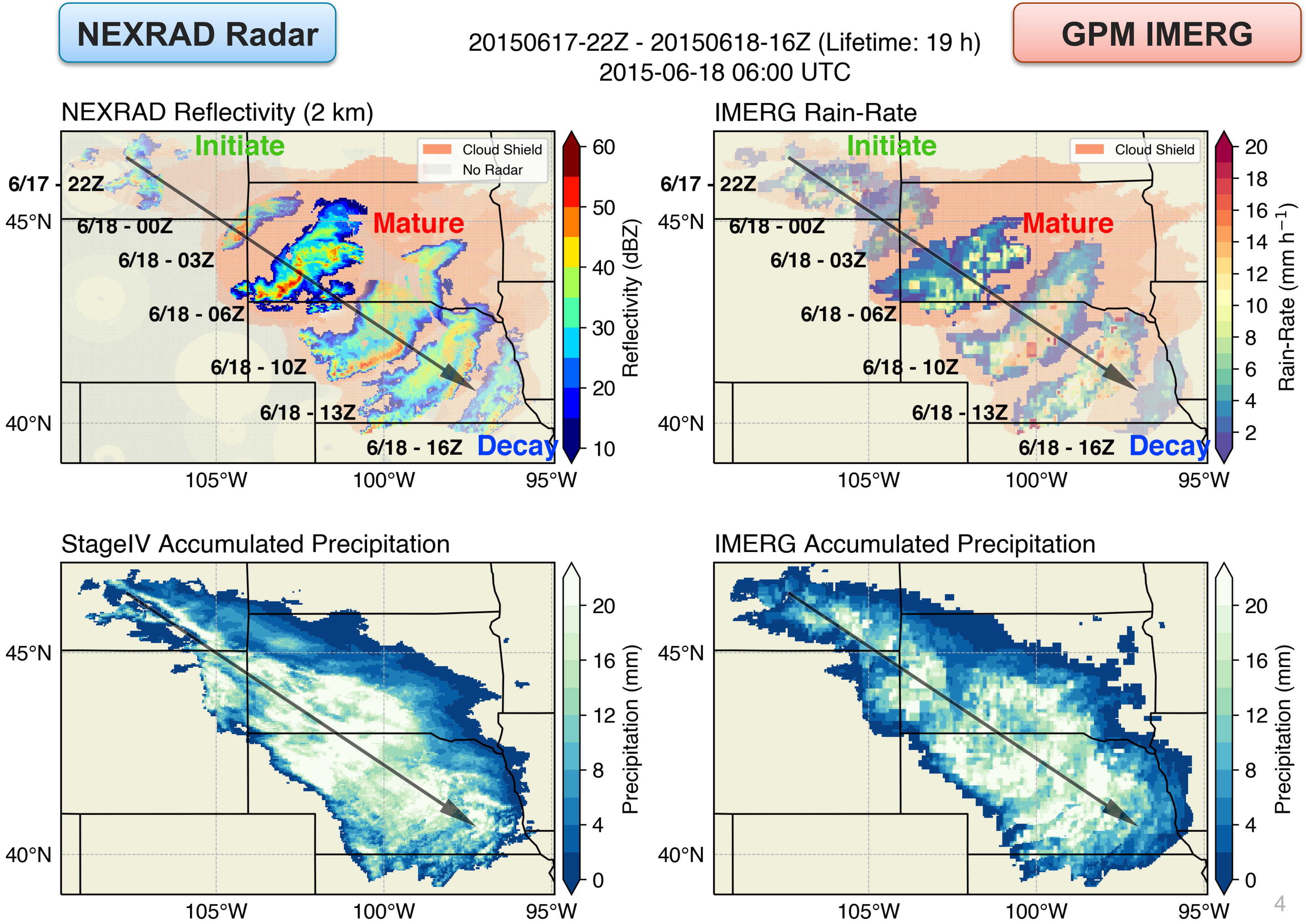
Objectives

- Develop a new algorithm to track long-lived and intense MCSs using global high-resolution satellite datasets
- Evaluate satellite-based MCS database with ground-based radar network observations
- Explore application of the MCS database to tropical convection and air-sea interactions

Adapt FLEXTRKR to Track MCSs using Global GPM IMERG Precipitation Data

- A 13-year MCS database with satellite IR and 3D radar data over the US (Feng et al. 2019) is produced by a new MCS tracking algorithm FLEXTRKR (Feng et al. 2018)
- FLEXTRKR can be applied to radar or precipitation features (PFs)
- GPM IMERG provides global high-res precipitation data
  - Resolution: 10-km, 30min
  - 2014-current (being extended to 1998-current)
- FLEXTRKR uses IMERG PF area and intensity characteristics to identify MCSs



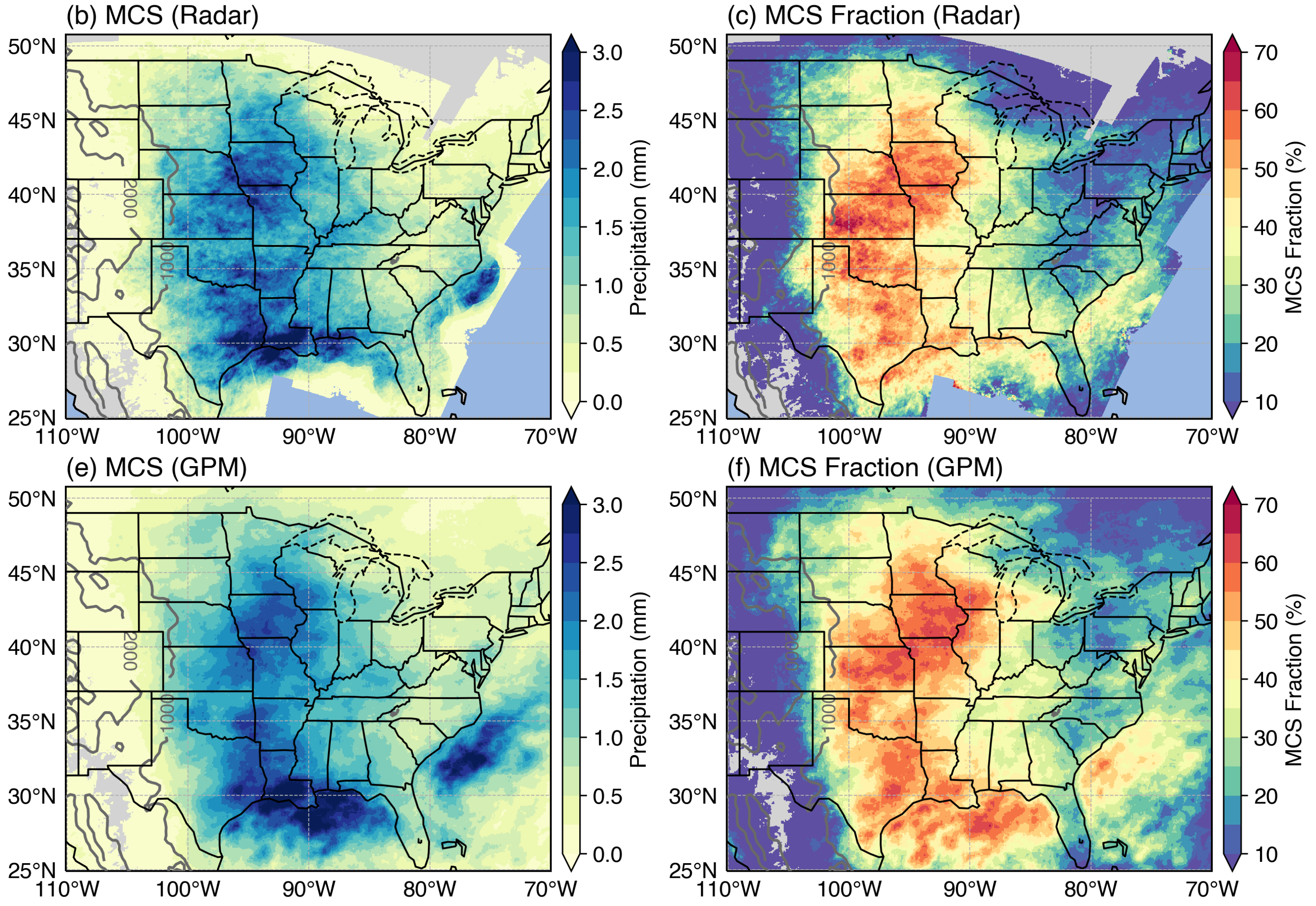
Warm Season MCS Precipitation Tracked by GPM IMERG Data Agree Well with Radar Data

MCS Rain | MCS Rain %

NEXRAD Radar

Period: 2014-2016
Mar-Aug

GPM IMERG

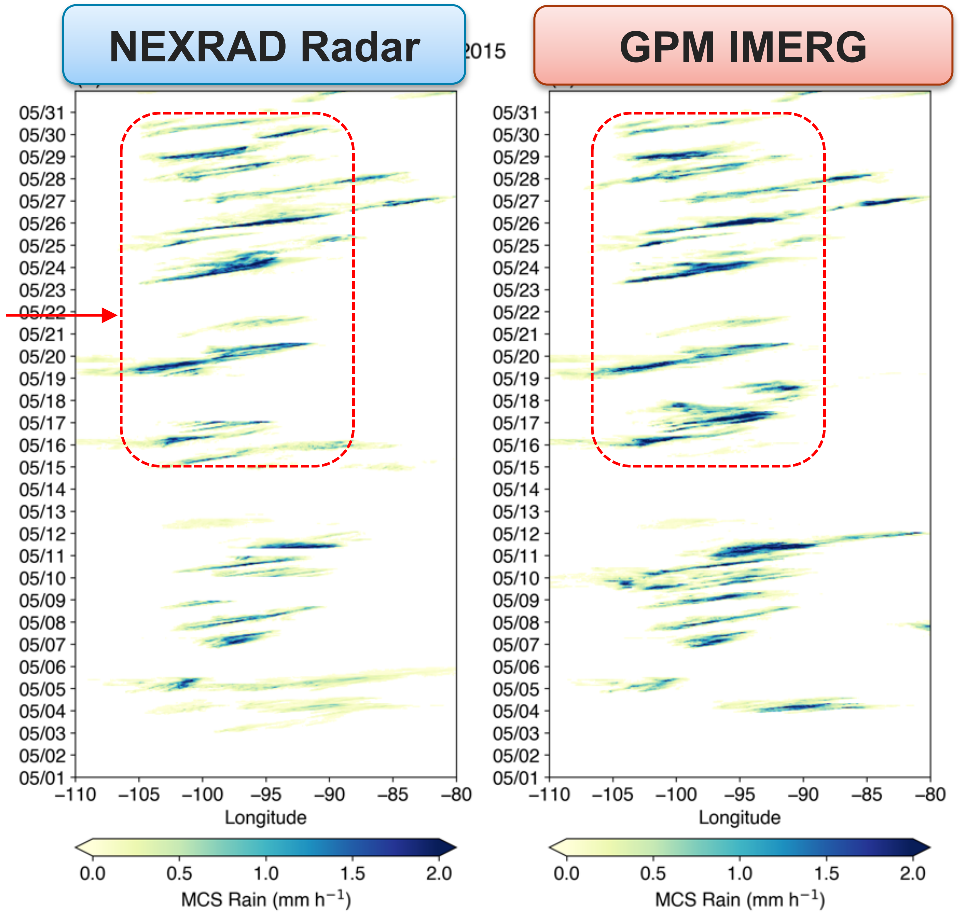


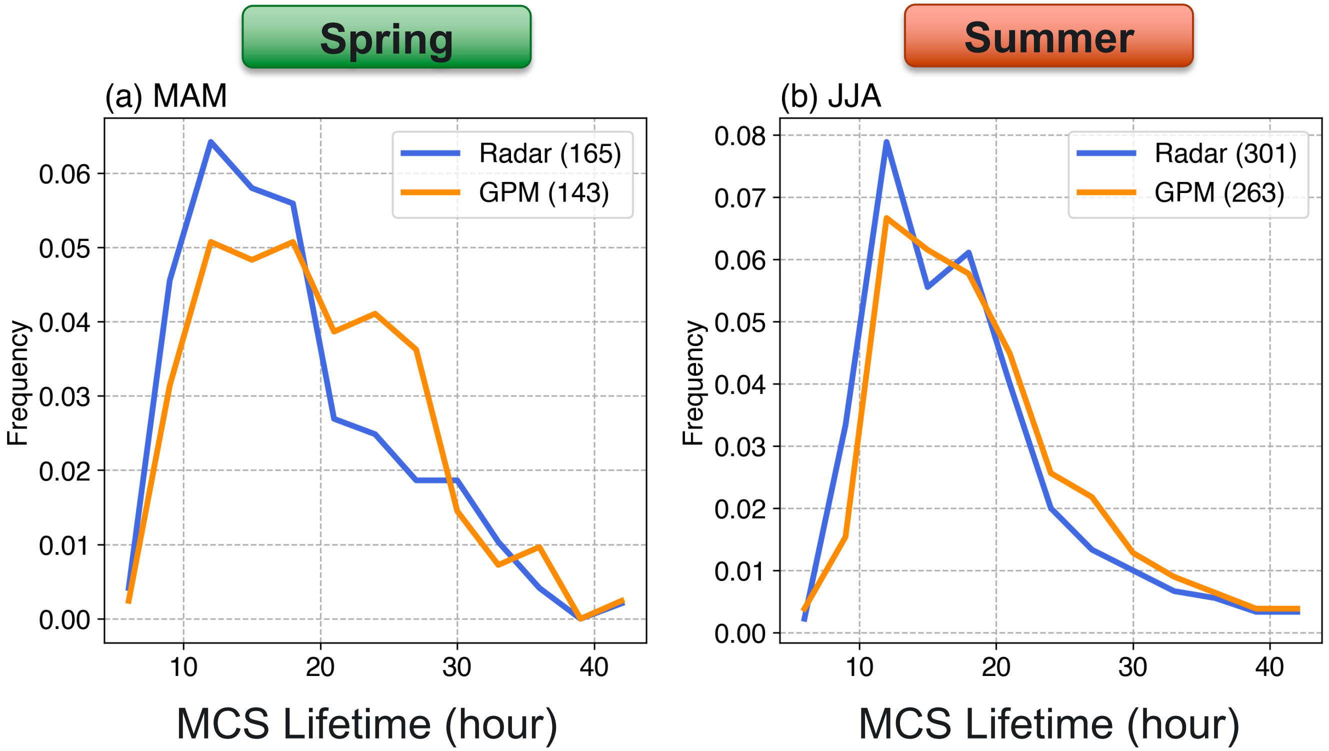
- MCS spatial pattern, precipitation amount and fraction to total precipitation all agree well with radar-based observations

GPM IMERG MCS Precipitation Characteristics Agree Well with Radar Data

2015 TX/OK Flood

Most MCS events are captured consistently compared to radar data

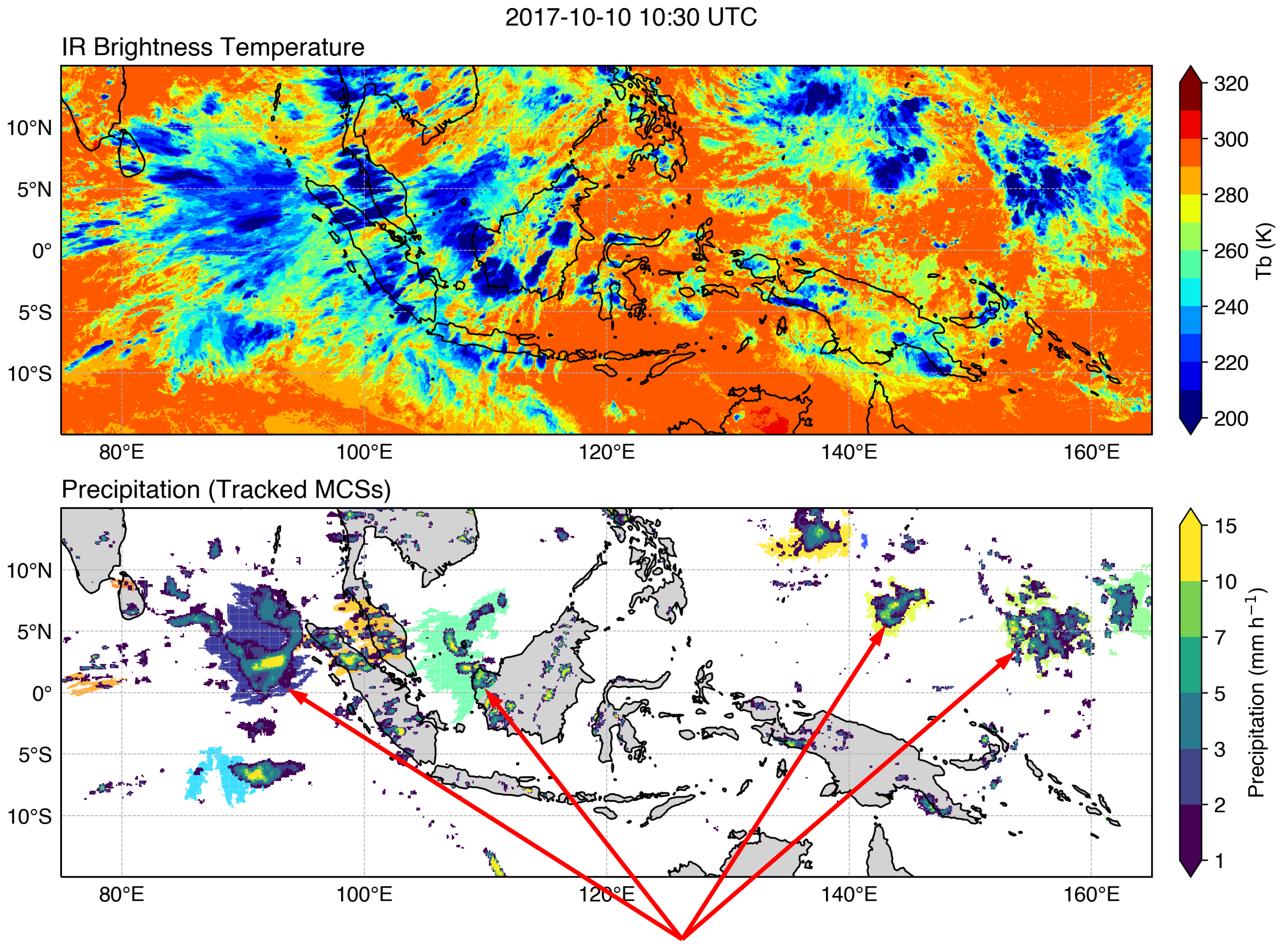




- Majority of individual MCS events are consistently captured by GPM IMERG data
- Warm season MCS statistics agree well with radar data
- GPM IMERG data are of sufficient quality to track MCSs

MCS Tracking over the Tropics

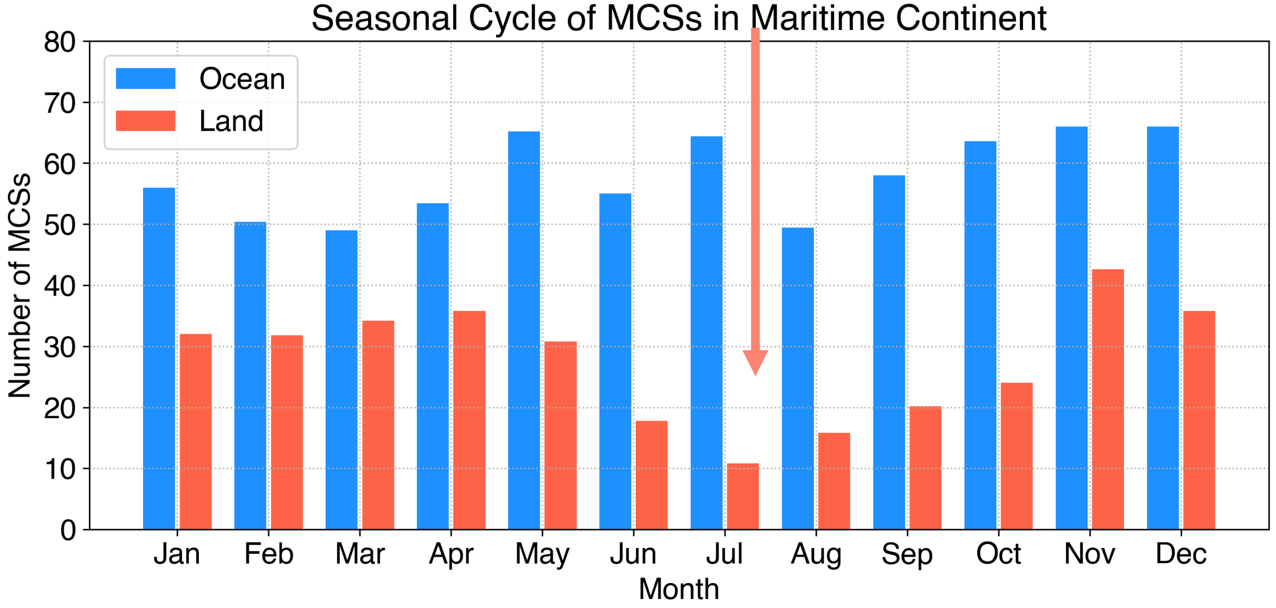
- Regrid GPM IMERG data to match Global IR data (**4 km**)
- Track MCSs from **2014-2018** using **hourly** data
- Initial effort focuses on:
  - Maritime Continent
  - Indian Ocean



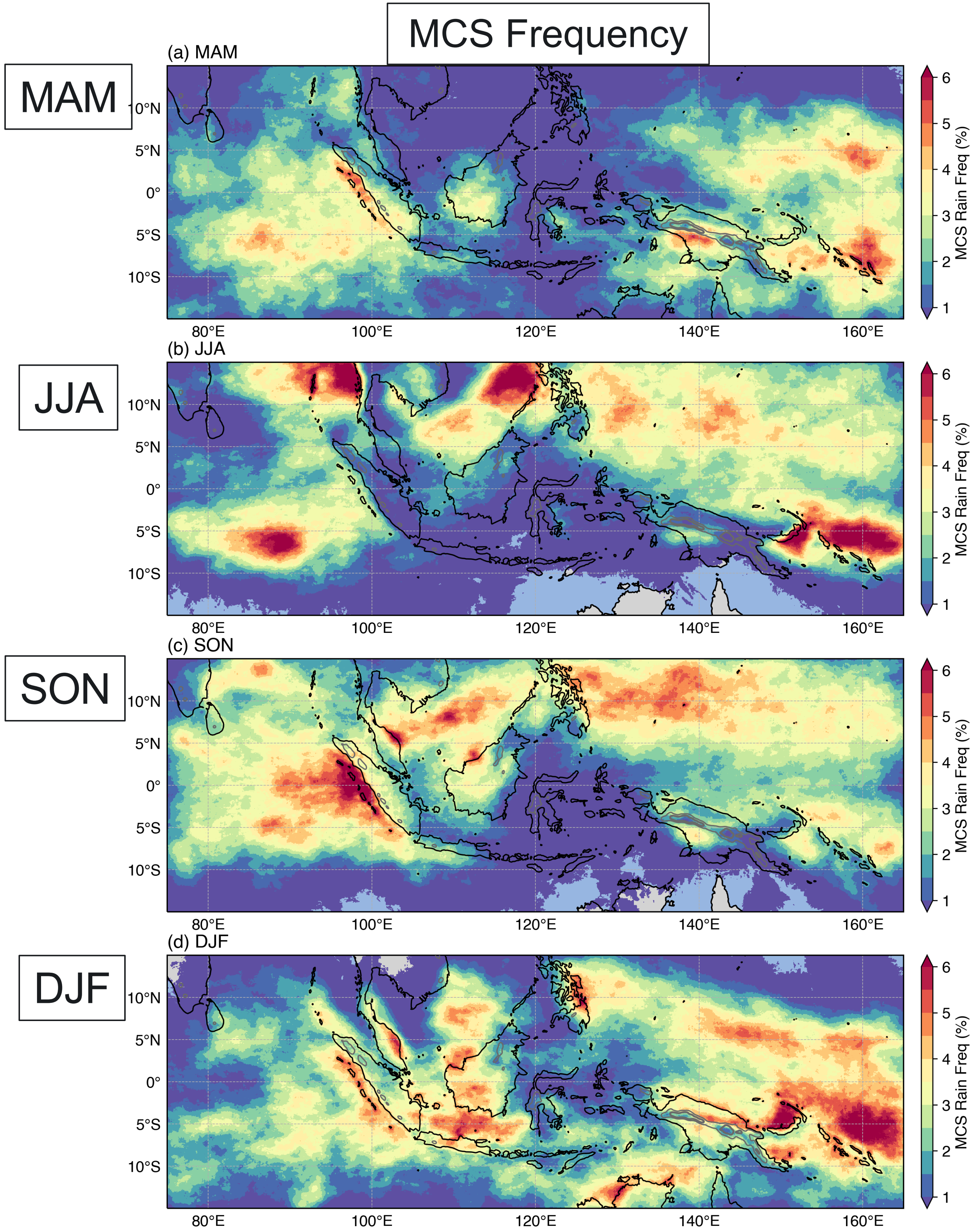
Color shadings are tracked MCS cloud shields

Seasonal Cycle of MCSs Frequency

Fewest land MCSs in JJA

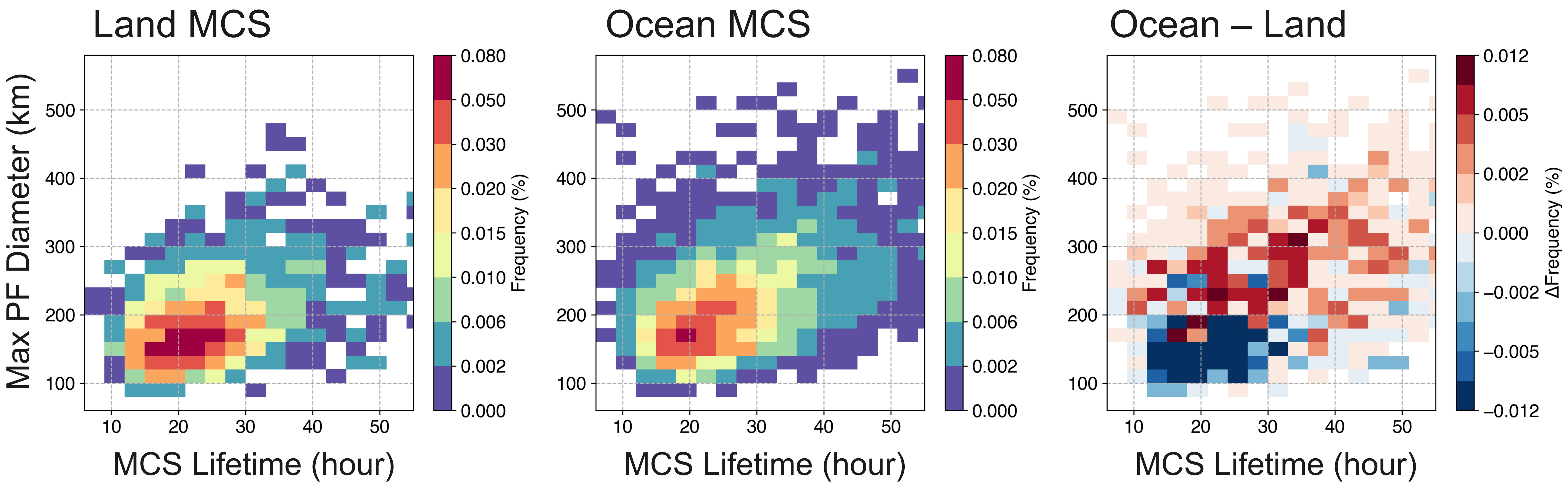


- MCS frequency has clear seasonal cycle:
  - Occurs year round over open ocean
  - Minimum during summer over MC islands and shallow sea

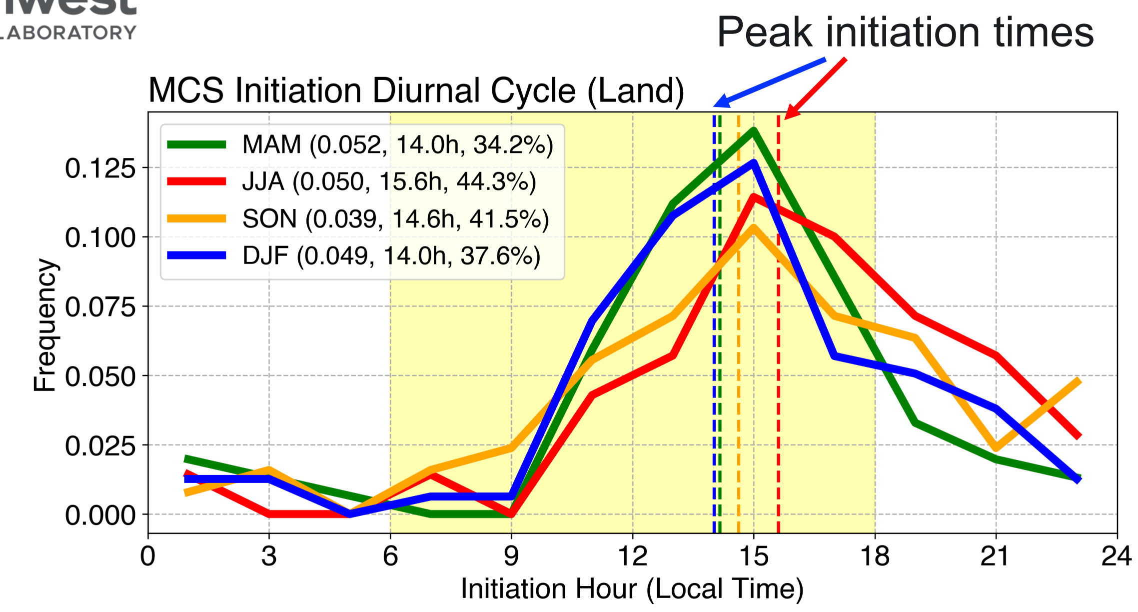


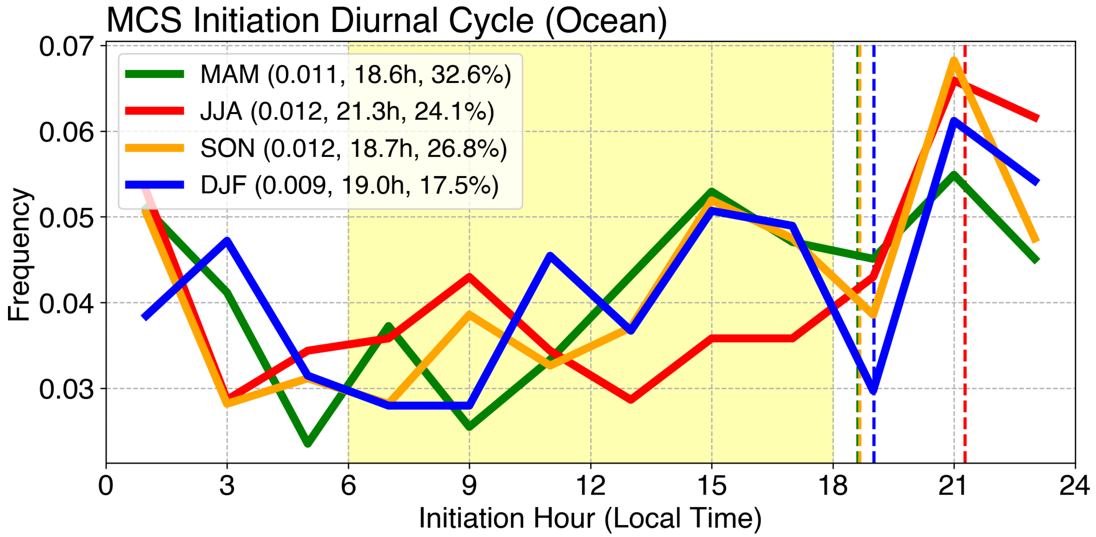
Oceanic MCSs are Longer-lived and Larger

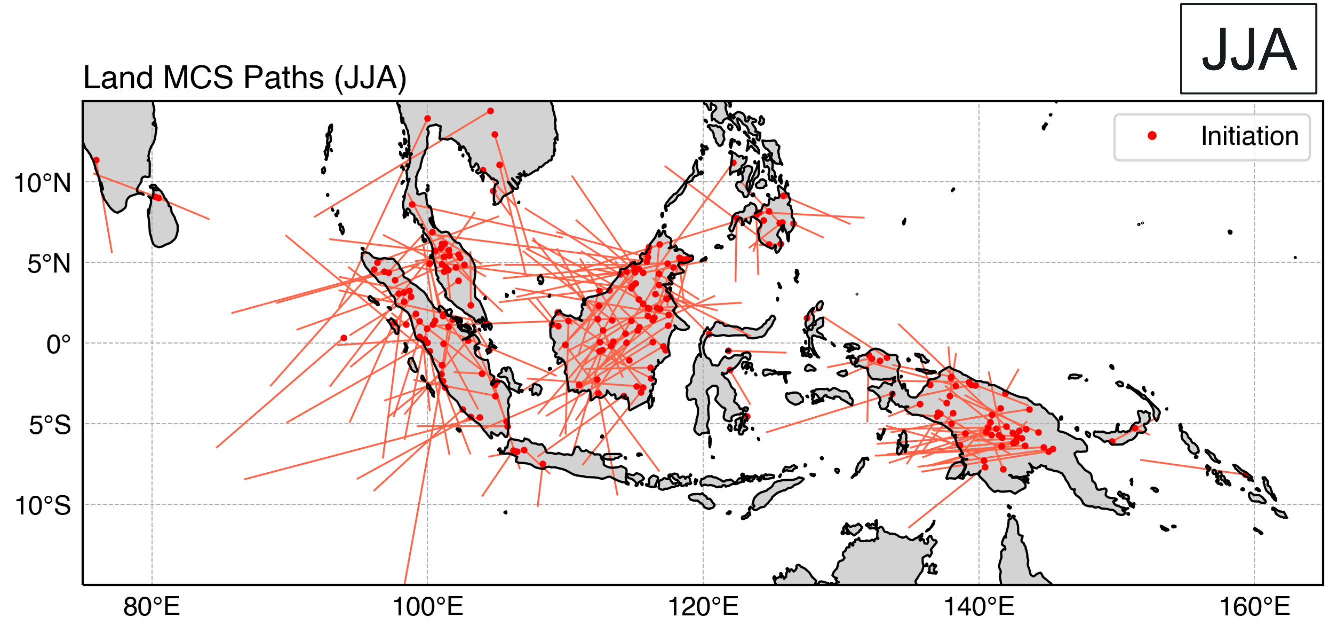
- Oceanic MCSs last significantly longer (up to 2 days) and their PF grow to much larger (up to 500 km)

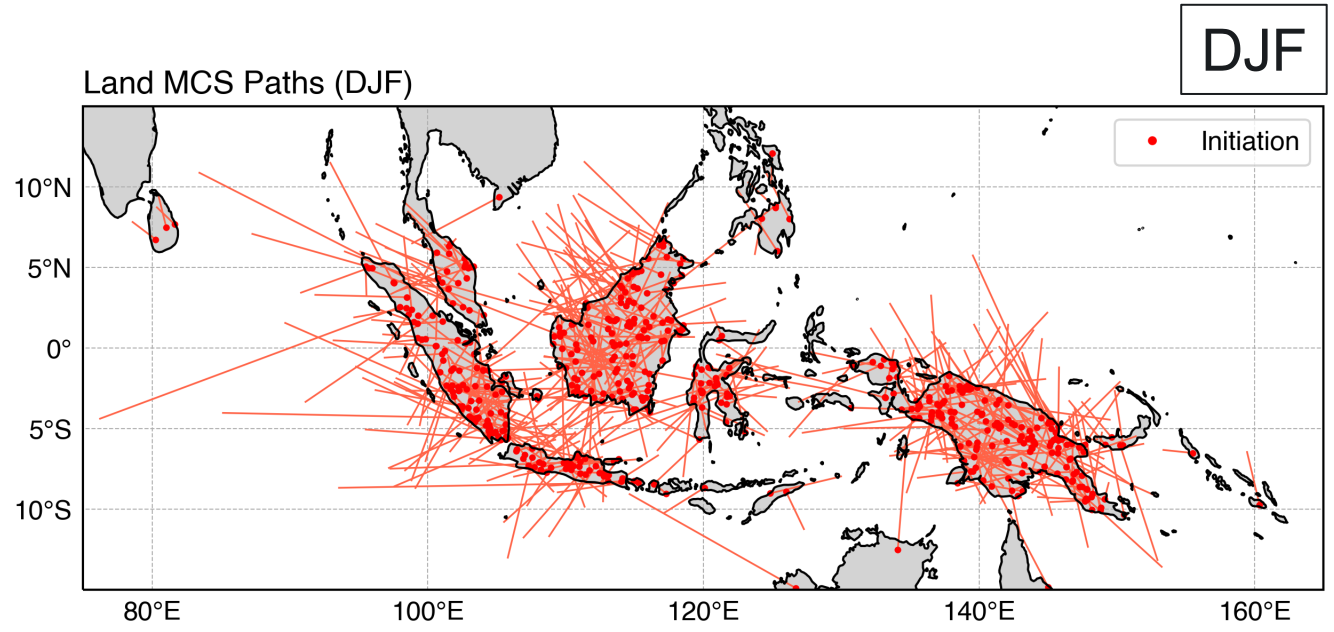


MCSs Initiated Over Land Propagate into Ocean



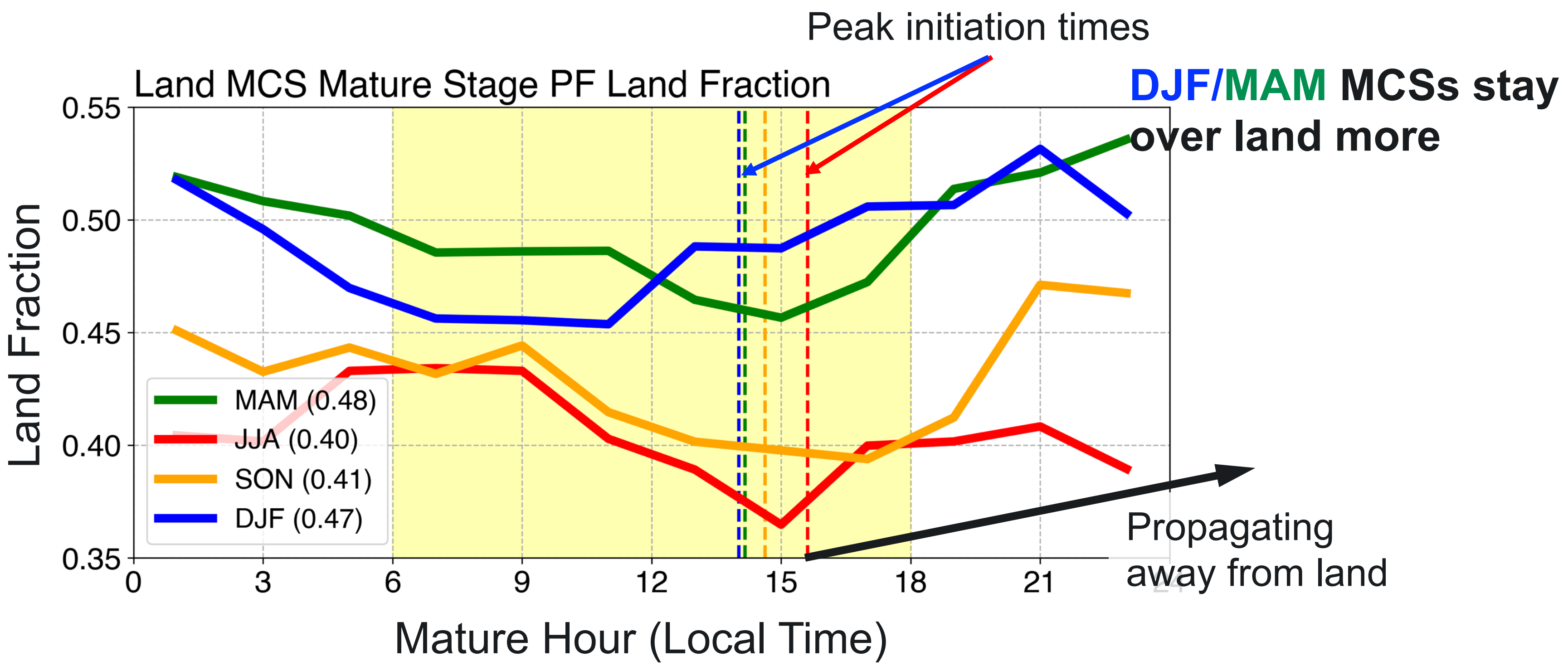


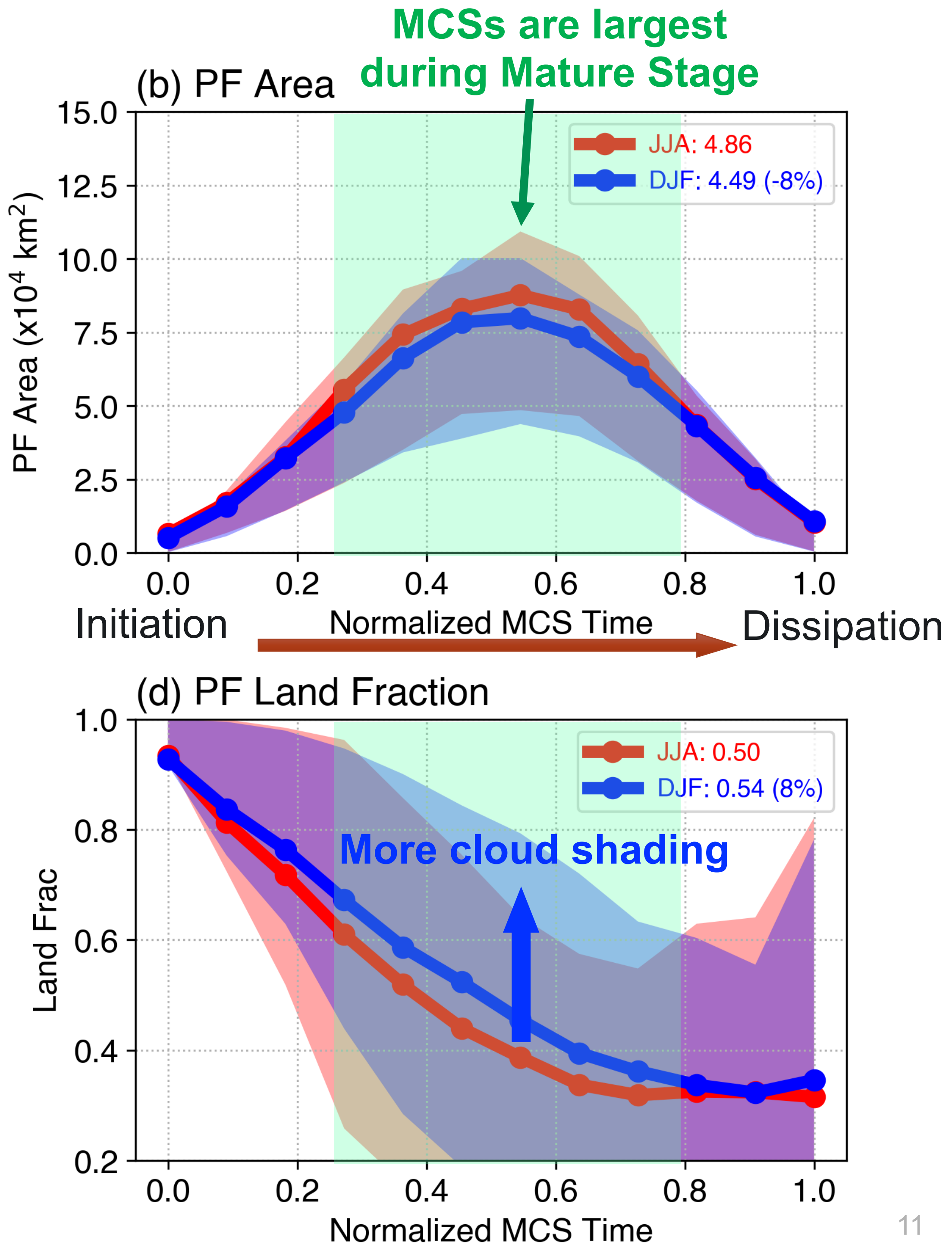




- DJF/MAM land MCSs initiate ~2h earlier than JJA
- After initiation, MCSs often propagate away from land into the ocean

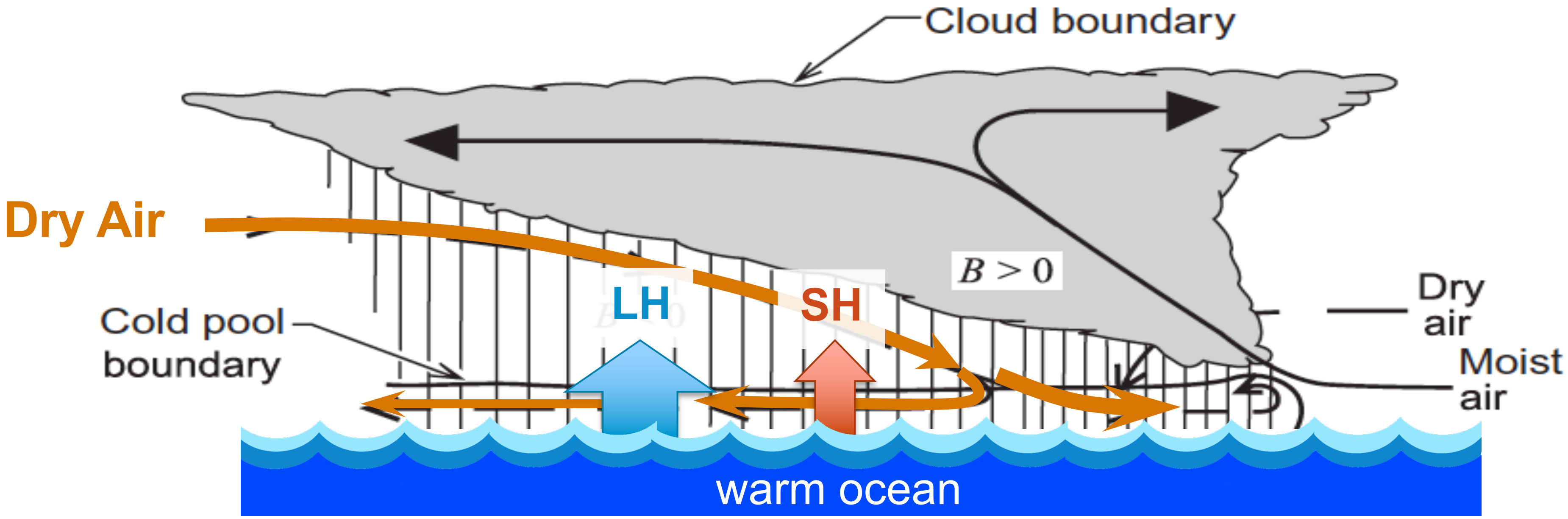
DJF MCSs Shields the Land from Solar Radiation More than JJA MCSs





- DJF/MAM MCSs stay over land in the afternoon more than JJA MCSs, particularly during the mature stage when they are the largest
- More solar radiation are blocked by the MCS anvil clouds during DJF, hence weakening the diurnal cycle of the MC islands

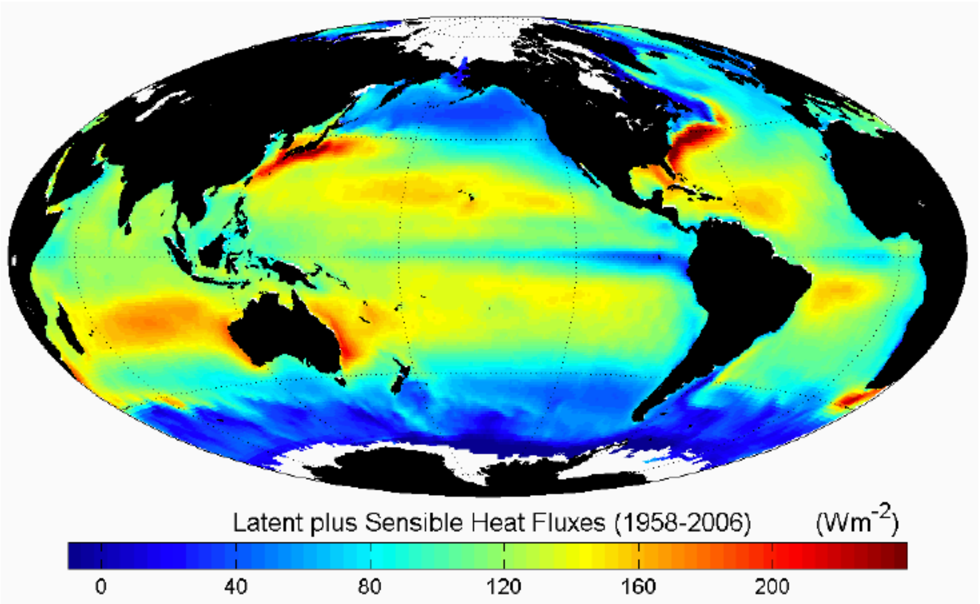
MCS Impacts on Surface Fluxes



- MCSs produce organized **mesoscale downdrafts**, effectively bringing mid-level dry air down to the surface
- Increased surface **gustiness**, **drier** and **cooler air** promote enhanced ocean surface evaporation and heat flux
- Previous work suggests mature MCSs with large stratiform area produce strongest LH, SH flux enhancements (Saxen & Rutledge 1998)

Global Objectively Analyzed Air-sea Fluxes

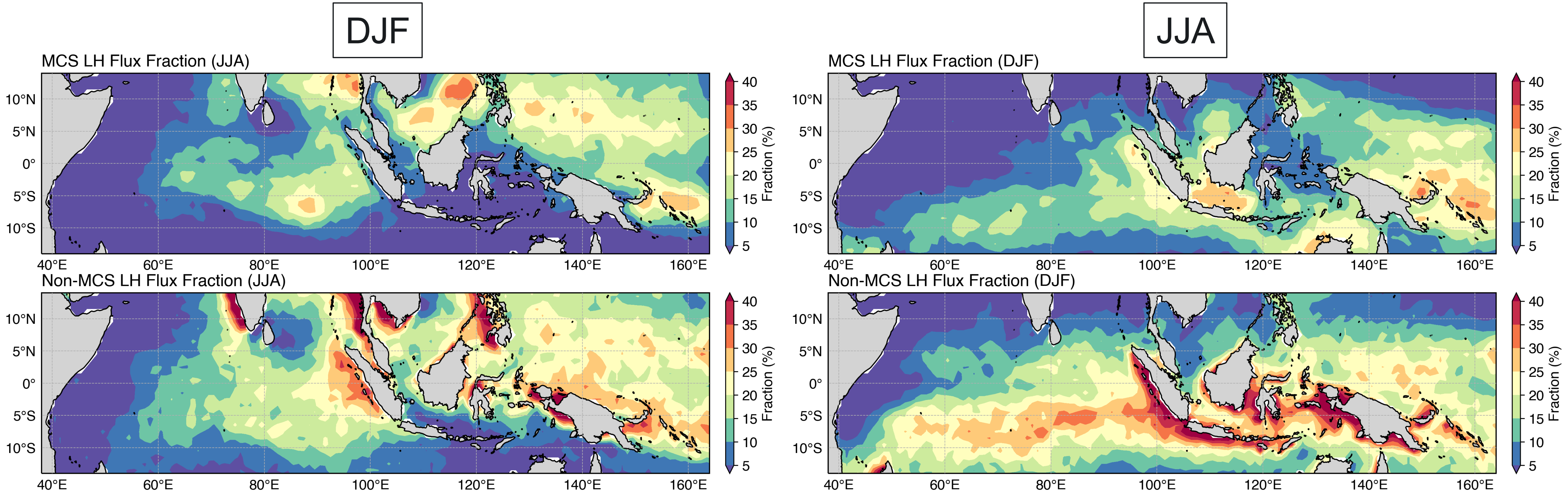
- Global OAFlux dataset (1958-current)
  - LH, SH, SST, T_{2m}, Q_{2m}, $wind_{10m}$
  - **1° x 1°, daily**
- Objectively synthesize satellite observations and NCEP, ECMWF reanalysis
  - Satellite: $wind_{10m}$, SST, Q_{2m}
  - Reanalysis: T_{2m}, fill gaps in satellite data
  - Error estimates for each variable
- Flux calculation uses COARE 3.0 algorithm
  - $Q_{LH} = \rho L_e c_e U(q_s - q_a)$
  - $Q_{SH} = \rho c_p c_h U(T_a - \theta)$



MCS and non-MCS Contributions to Total Turbulent Fluxes

MCS

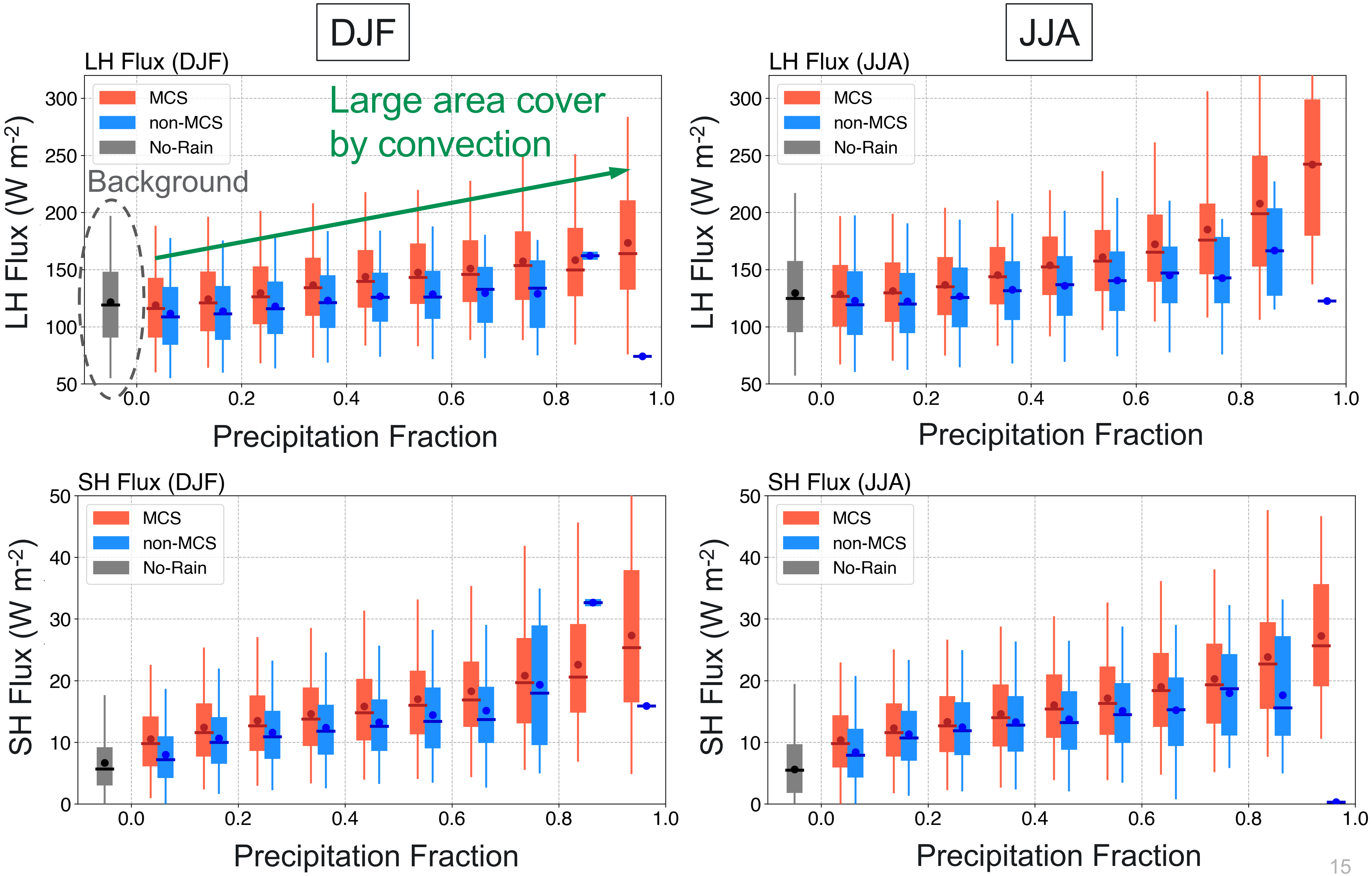
Non-MCS



- Over tropical Indian Ocean and Western Pacific:
  - **MCSs** contribute to **15-25%** total LH, SH fluxes
  - **Non-MCSs** contribute to **15-40%** total LH, SH fluxes (non-MCSs are more frequent)
- Non-MCS contribution are higher near coastal area

Impact of MCS Fractional Area to Fluxes

- LH flux increases more significant when MCS fraction > 0.3
  - Up to **40%**
  - Stratiform downdrafts?
- SH flux increases occur more immediately with MCSs
  - Up to **3X**
  - Cold pools?



Summary and Discussions

- Preliminary findings:
  - **MCSs** accounts for **15-25%** of total oceanic LH, SH fluxes
  - Compared to no precipitation, MCSs enhances **LH flux** by up to **40%**, **SH flux** by up to **3 times**
  - Primary reason is due to enhanced surface wind speed (gustiness)

- **Science Questions** the MCS database may help address:
  - How do seasonal and intra-seasonal variability affect MCS properties?
  - How does MCSs interact with the MC diurnal cycle?
  - What role do MCSs play in air-sea interactions during MJO?

- Contact me for the MCS database: Zhe.Feng@pnnl.gov

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Thank you