Impact of addition of mesoscale heating in E3SMv1

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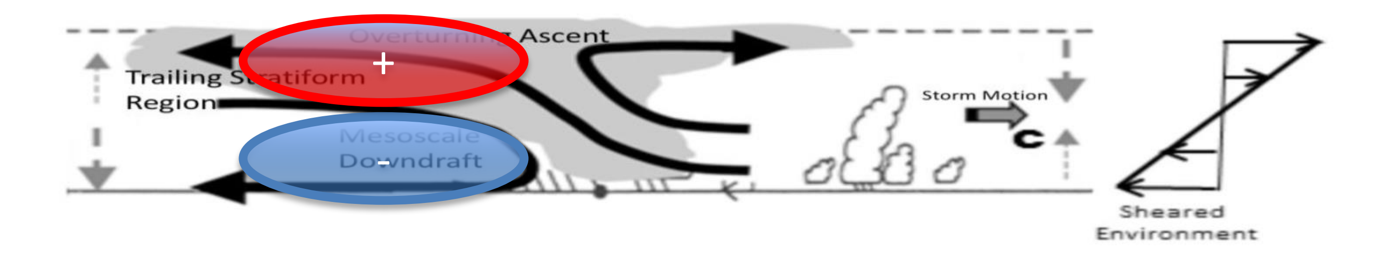
Parameterization of mesoscale convection

Goal: To represent mesoscale organization in E3SM

Multiscale Coherent Structure Parameterization (MCSP)

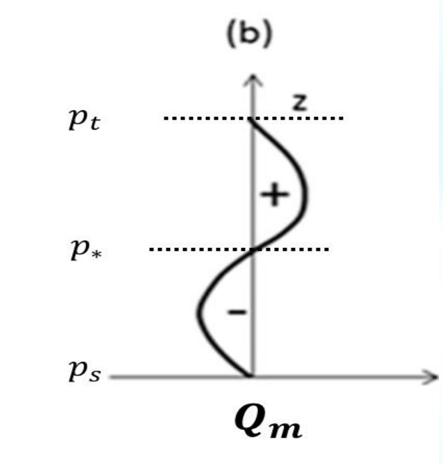


Multiscale coherent structure (MCSP) with a slantwise overturning layer including a trailing stratiform region, an overturning ascent and a mesoscale downdraft.

Added Mesoscale Heating Profile:

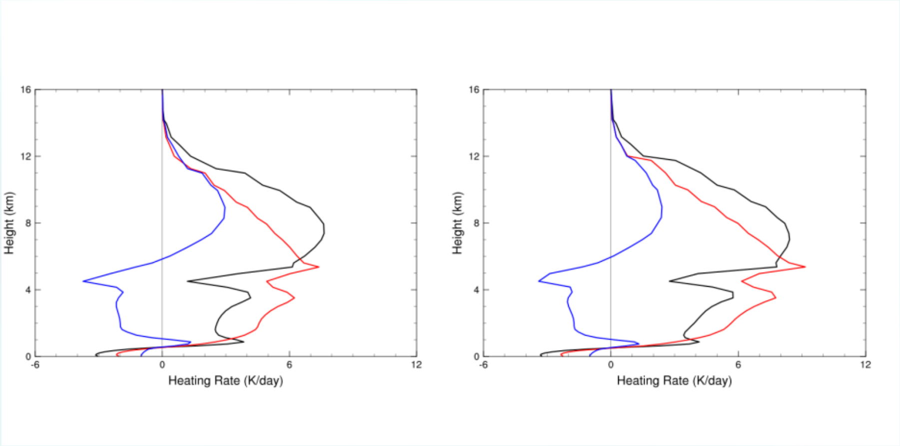
$$Q_m(p,t) = -\alpha_1 Q_c(t) \sin\left(\pi \left(\frac{p_s - p}{p_s - p_*}\right)\right) \quad \text{for } p_* \le p \le p_s$$

$Q_c = Q_{ZM}$ (Zhang McFarlane Heating) integrated between bottom and top of convection



Implementation of MCSP in E3SM

From high-resolution WRF simulations

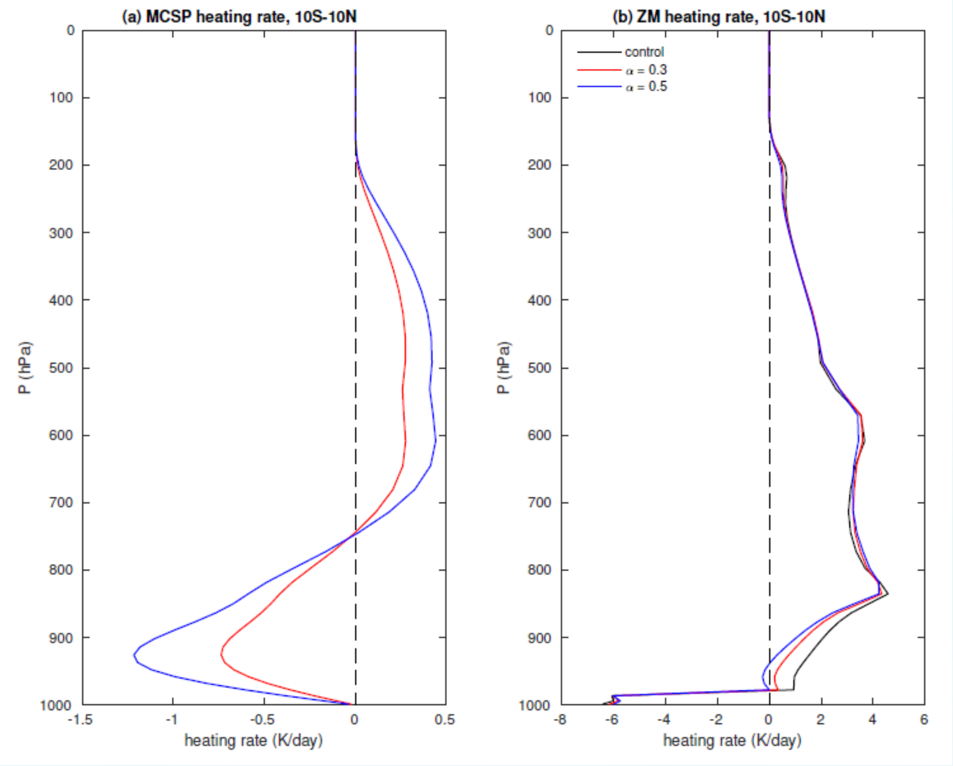


- **More realistic tests**:

  Alpha = 0.3-0.5 (WRF)+ add wind-shear **(WS)** trigger
  Wind-shear is proxy for organized convection
  Three values of wind shear (between surface and 600 hPa) are tried: 3, 5, 7.5 m/s

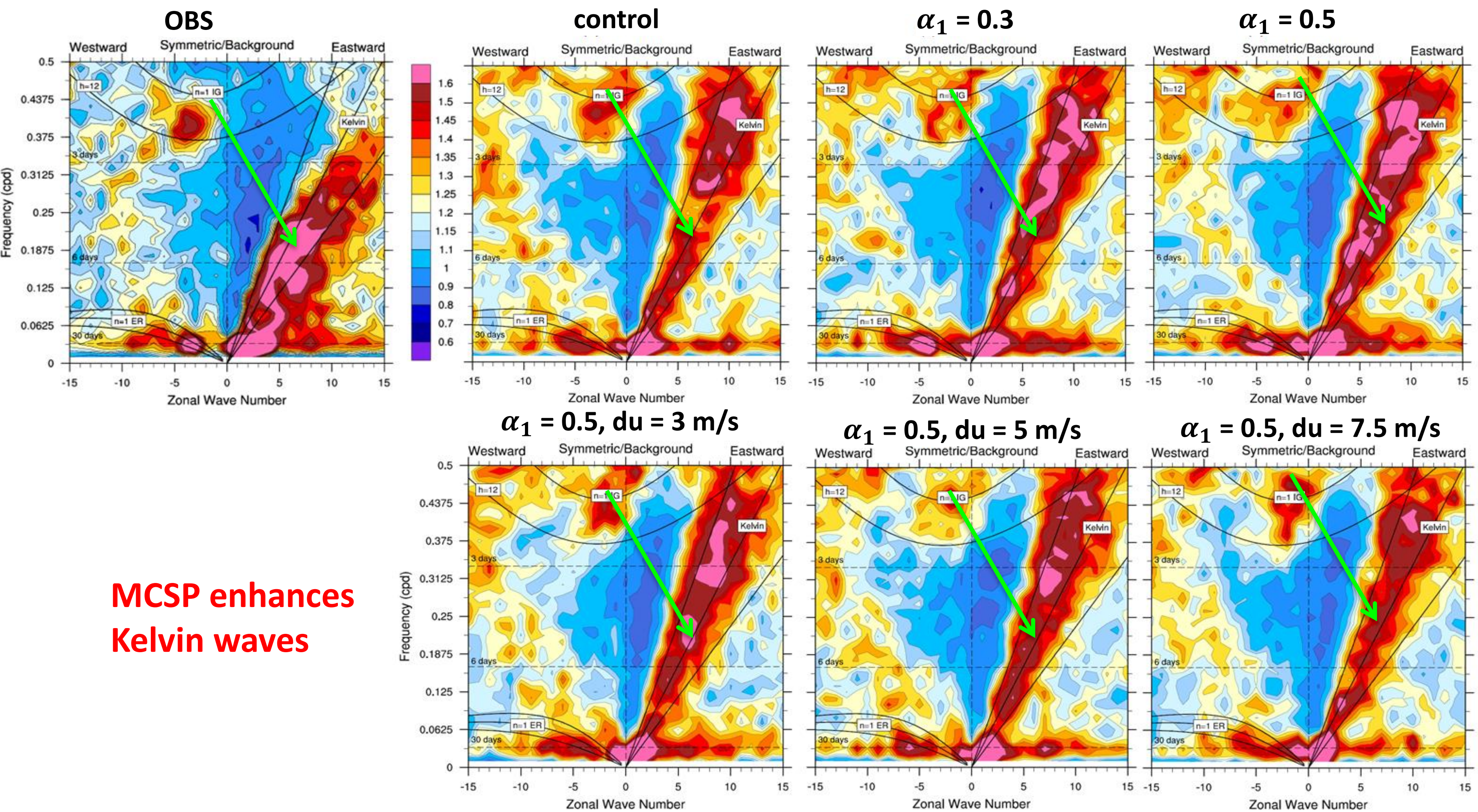
- **AMIP (EAMv1) and Coupled runs (E3SMv1)**

Convective heating:



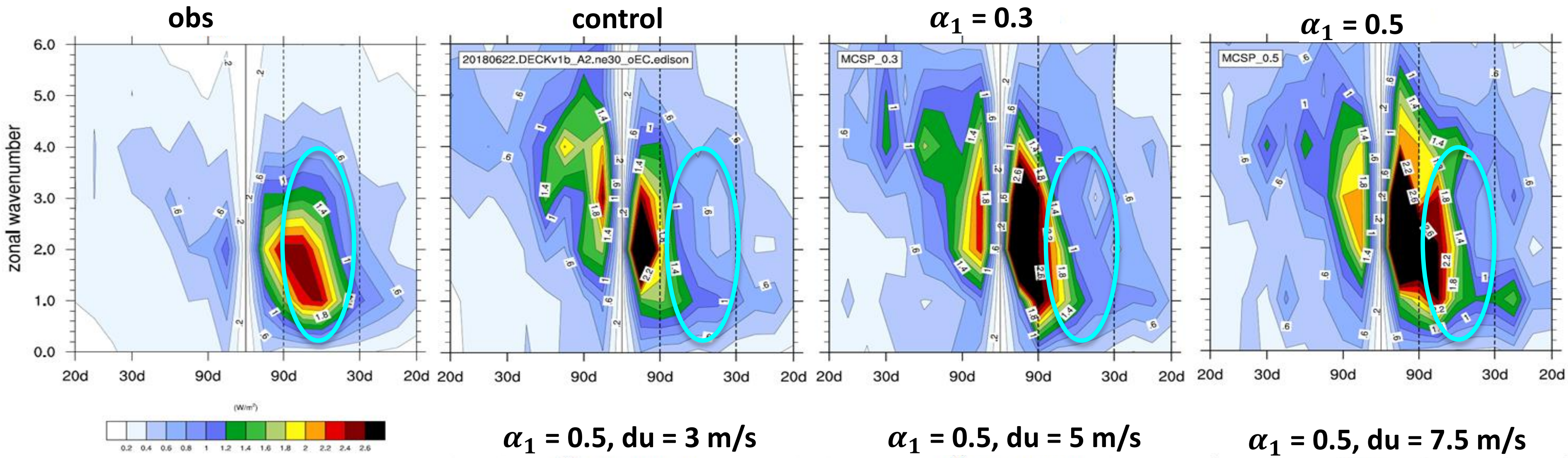
Adding mesoscale convective heating reduces parameterized convective heating

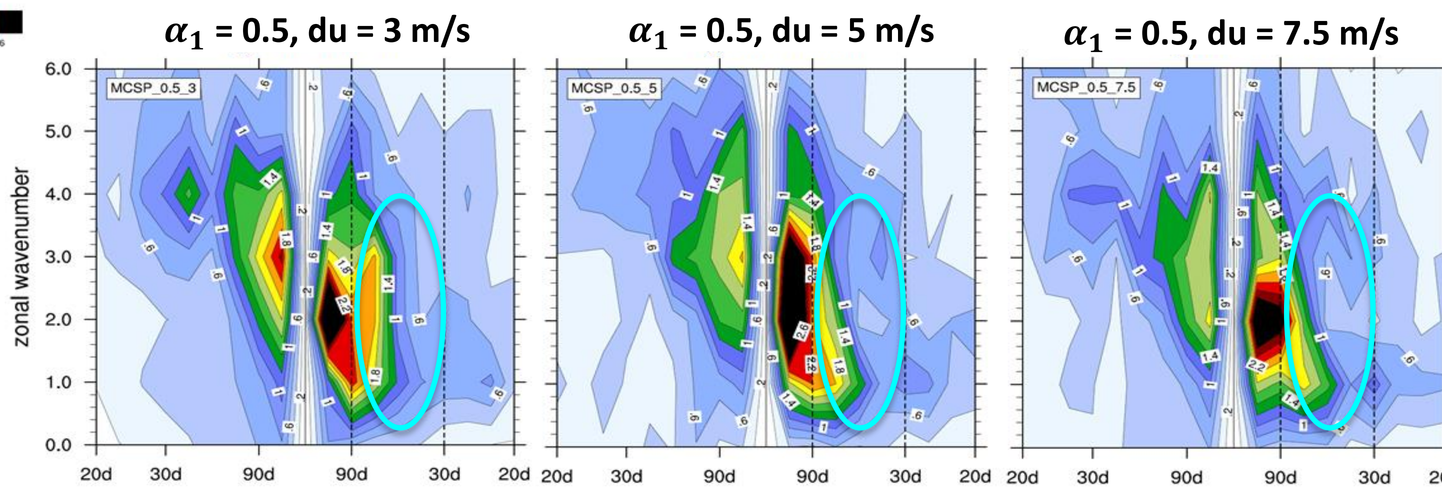
Wheeler-Kiladis Diagrams: EAMv1



MCSP enhances Kelvin waves

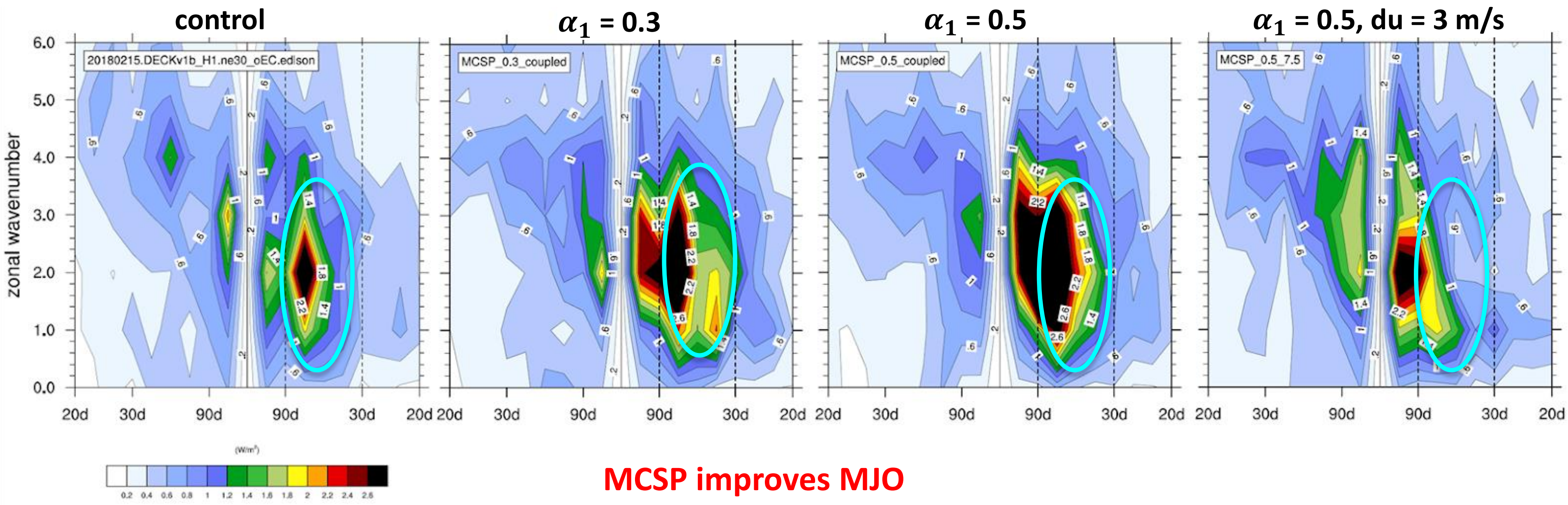
MJO OLR Spectra: EAMv1





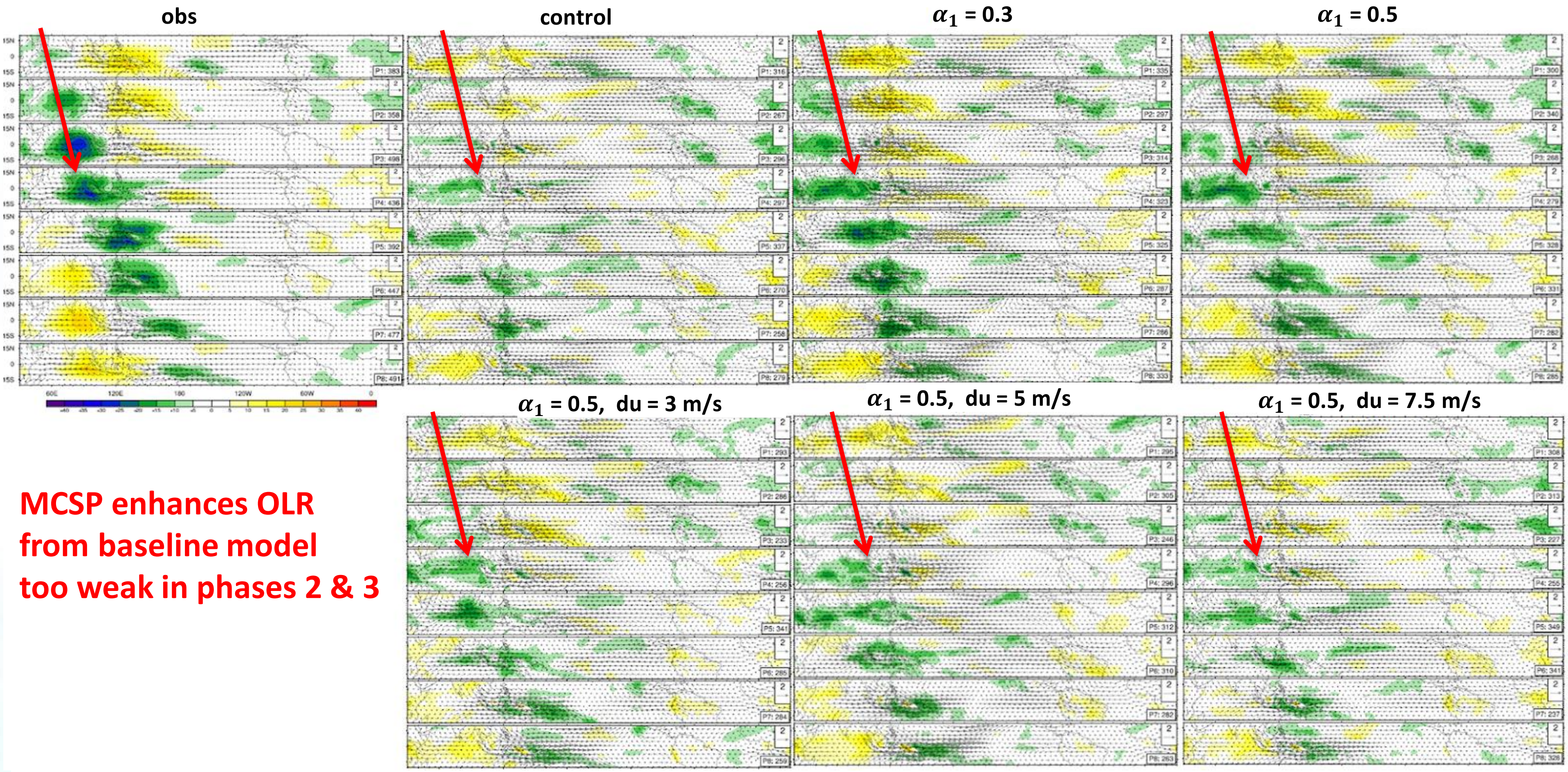
MCSP improves MJO
higher spectra
Between 30-90 days

MJO OLR Spectra: E3SMv1



MCSP improves MJO
higher spectra
Between 30-90 days

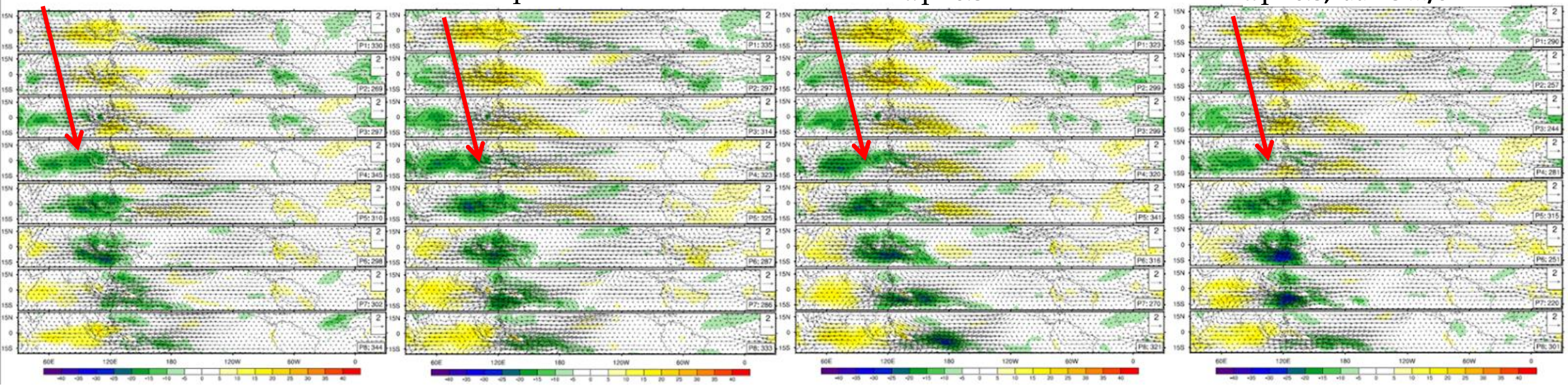
MJO life cycle composite: EAMv1



MCSP enhances OLR from baseline model too weak in phases 2 & 3

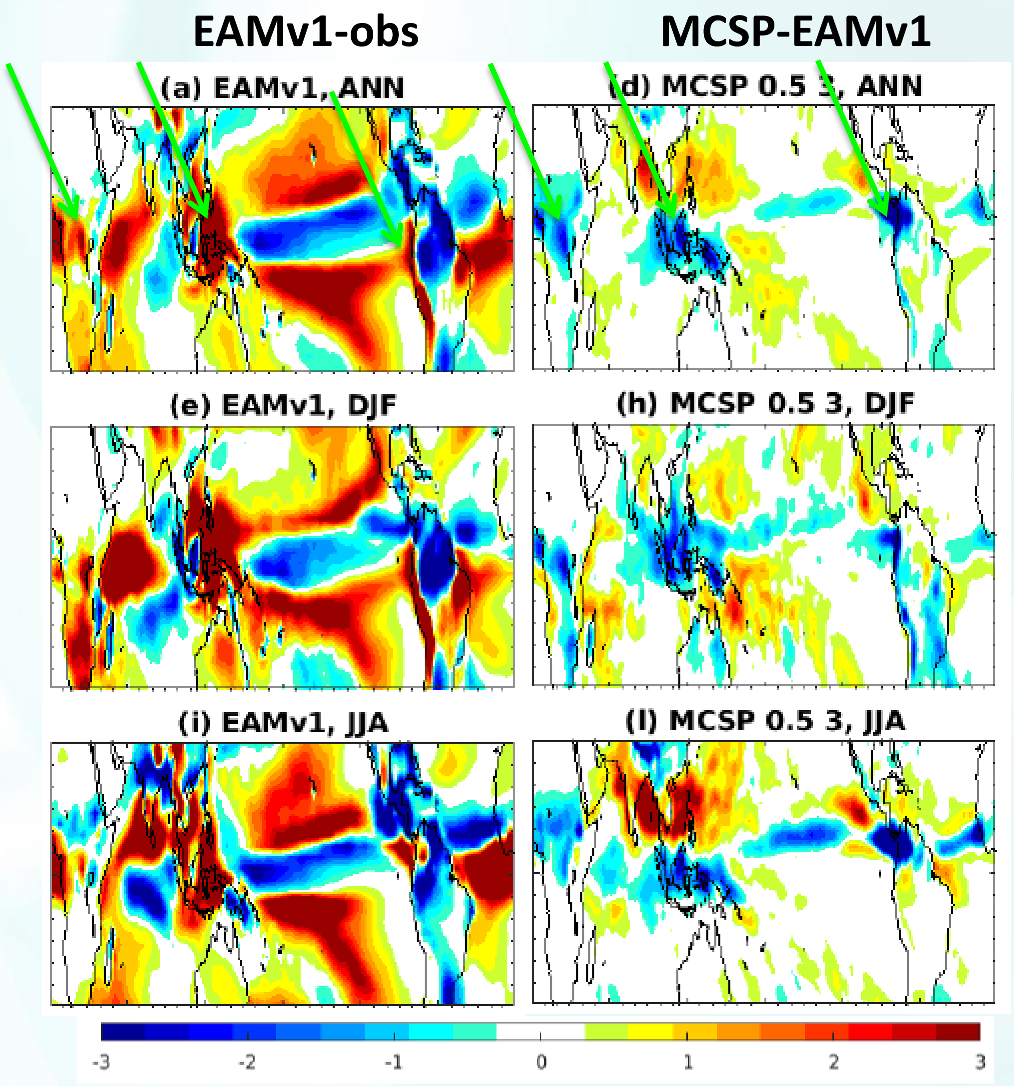
MJO OLR Life cycle composite: E3SMv1

control | α_1 = 0.3 | α_1 = 0.5 | α_1 = 0.5, du = 3 m/s



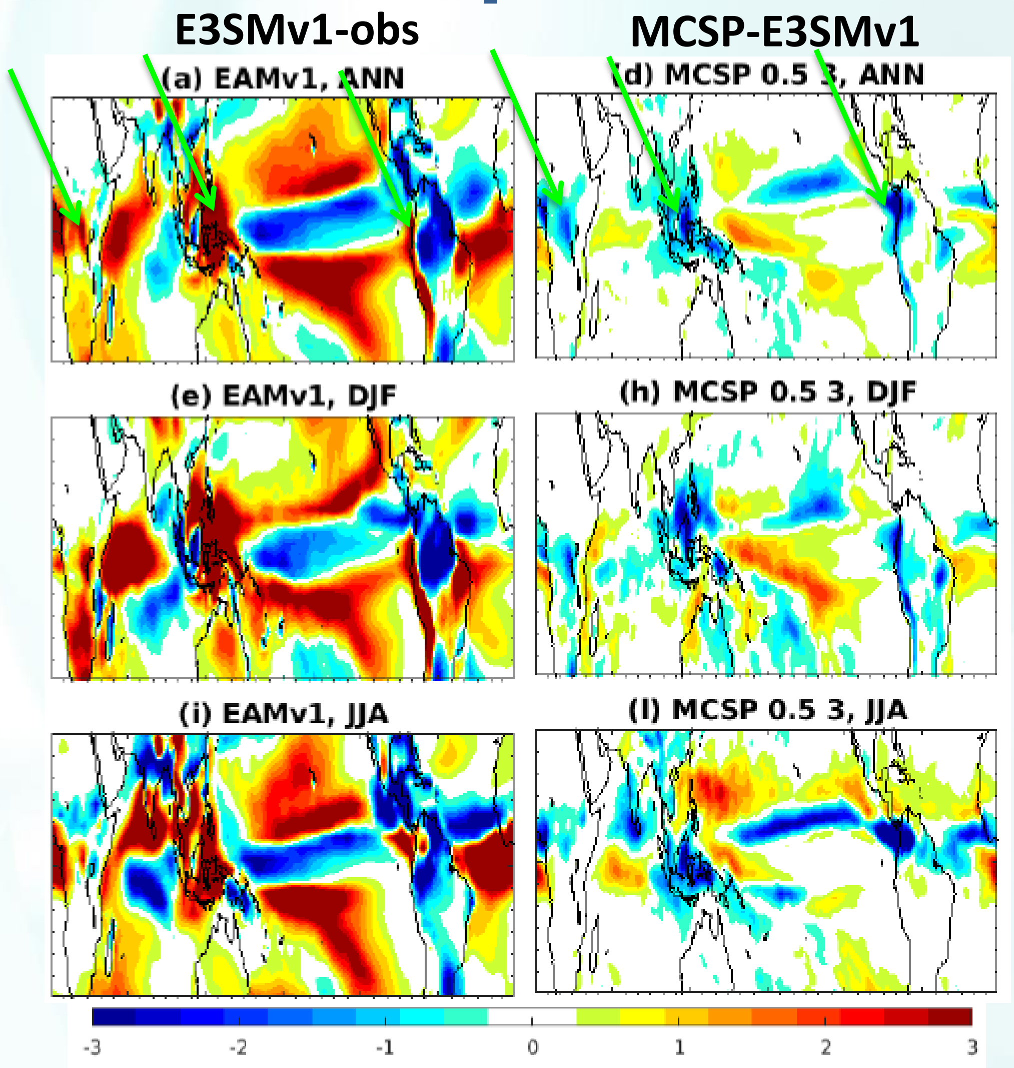
MCSP enhances OLR from baseline model

Precipitation biases EAMv1:



MCSP reduces positive biases around
1) central Africa
2) tropical western Pacific
3) tropical eastern Pacific

Precipitation biases E3SMv1:



Control-OBS

MCSP reduces positive biases around
1) central Africa
2) tropical western Pacific
3) tropical eastern Pacific

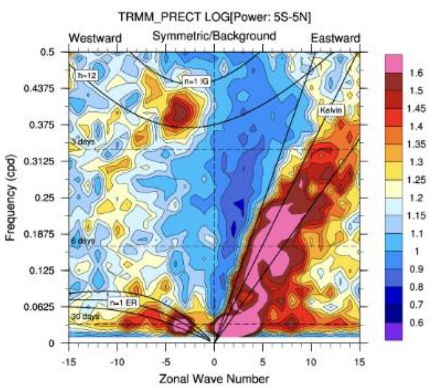
Summary and Next Steps

Summary:

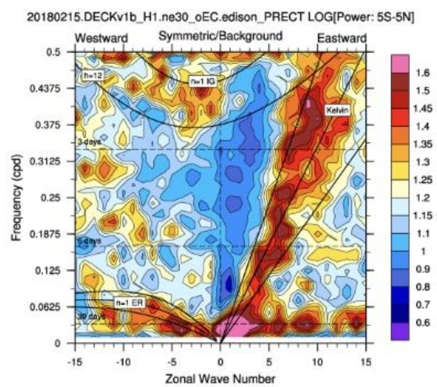
- We have implemented a parameterization of mesoscale convective heating
- High-resolution WRF simulations are used to determine mesoscale heating tendencies
- Implementation of the mesoscale heating improves Kelvin wave generation and strengthens the MJO
- MJO propagation is significantly improved in coupled runs
- The parameterization of mesoscale heating enhances the stability of the atmosphere and thus make convection less intense/persistent
- The new parameterization reduces positive precipitation biases of the baseline model in the Eastern and Western tropical Pacific, by making deep convection less persistent
- A manuscript will be submitted soon.
- We will implement momentum transfer on top of the current parameterization

Wheeler-Kiladis Diagrams: E3SMv1

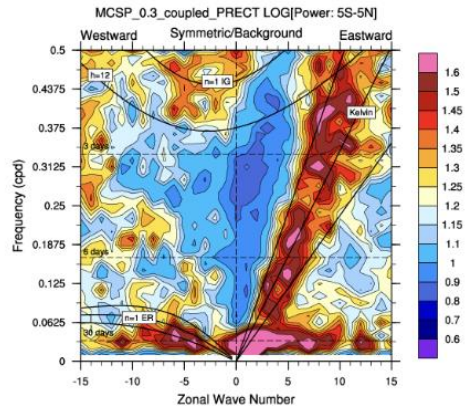
OBS



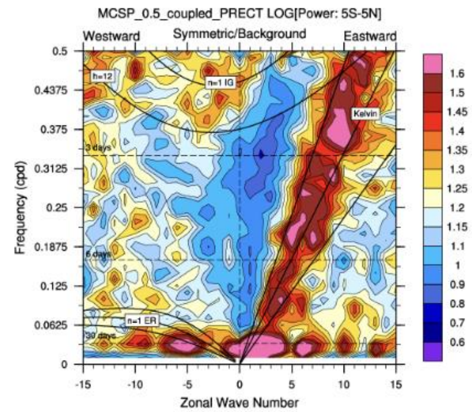
CONTROL



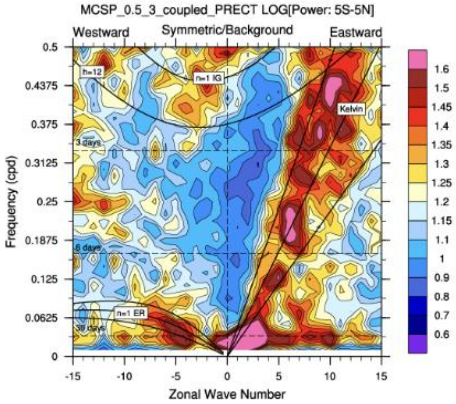
α_1 **= 0.3**



α_1 **= 0.5**



α_1 **= 0.5 + WS 3 m/s**



Increased in Kelvin wave activity is less pronounced than in AMIP runs; MJO activity is much stronger than in control