The impact of vertical model levels on biases affecting the MJO Teleconnections

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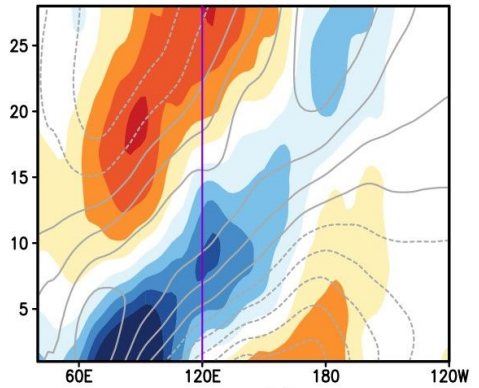
How vertical resolution and location of model top can affect biases with an impact of MJO Teleconnections?

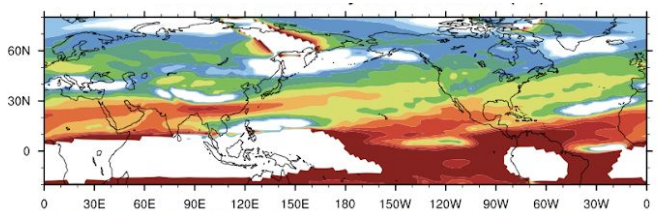
Atmospheric Boundary Layer Biases

MJO



Subtropical Jet Stream Position and Intensity

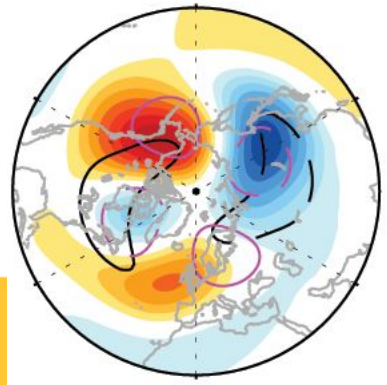
Rossby wave propagation



Stratospheric biases

Polar Vortex

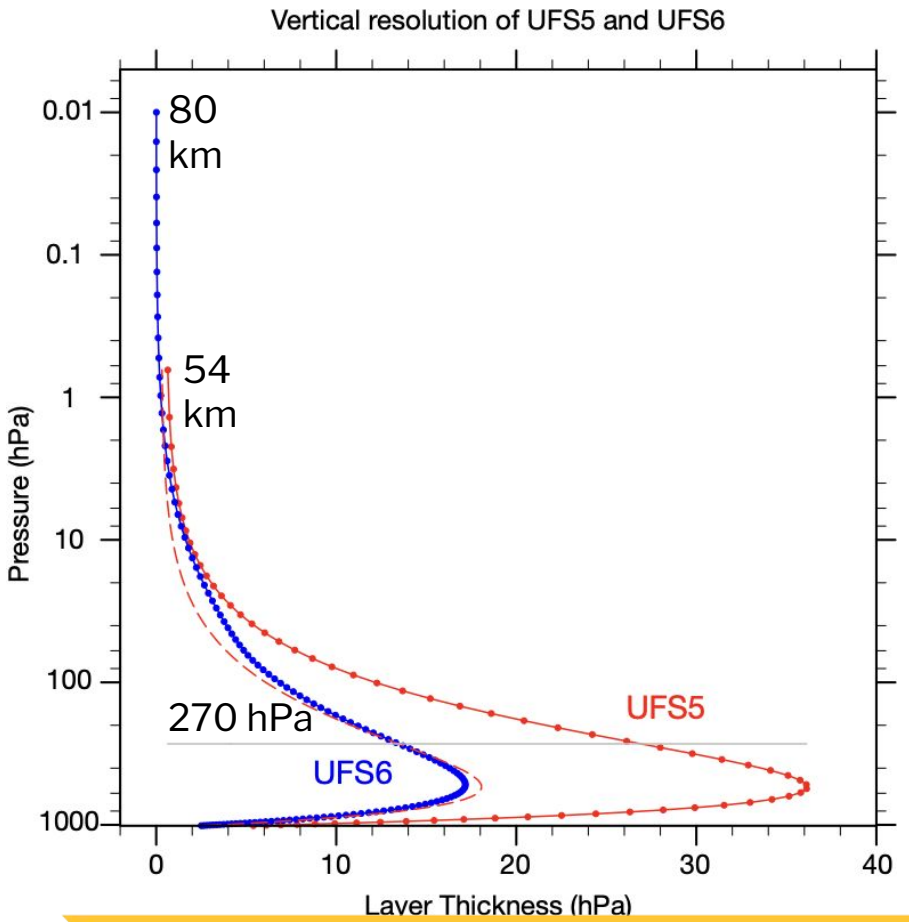
Rossby wave propagation



Model setups

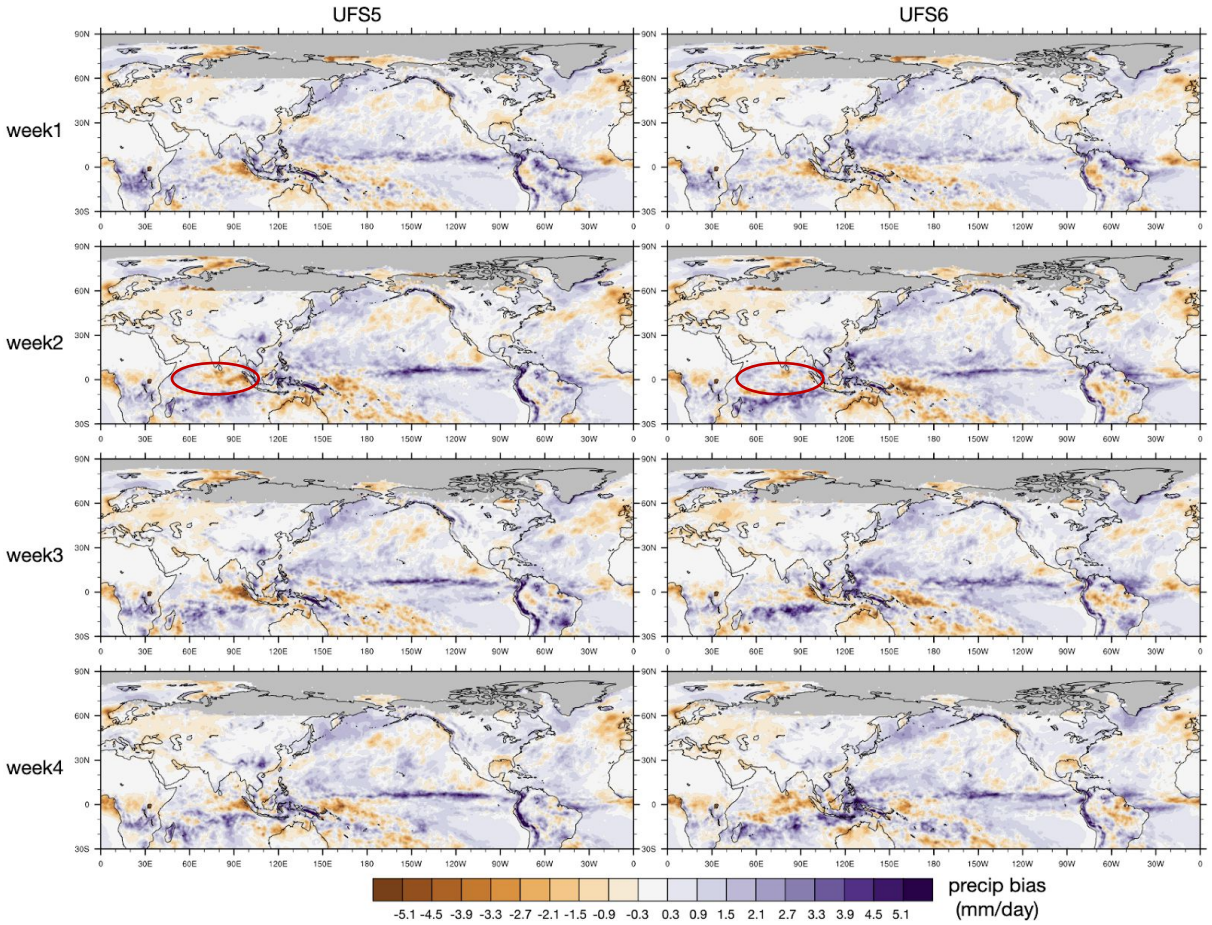
Prototype	**Atmospheric Model** C384 (~0.25 degree) horizontal resolution			**Ocean Model** Tripolar ~0.25 degree horizontal resolution	**Wave Model** Regular lat/lon 0.5 degree grid	**Ice Model** Tripolar ~0.25 degree horizontal resolution	**Mediator**
	Dynamical Model	**Physics Settings & Driver**	**Land Model**				
UFS 5	FV3 **64 layers**, Non-Fractional grid (**model top: 54km**)	GFSv15.2, CCPP driver	Noah LSM	MOM6	Wavewatch III	CICE6 (Mushy thermodynamics not turned on)	CMEPS
UFS 6	FV3 **127 layers**, Fractional grid (**model top: 80km**)	GFSv16, CCPP driver					

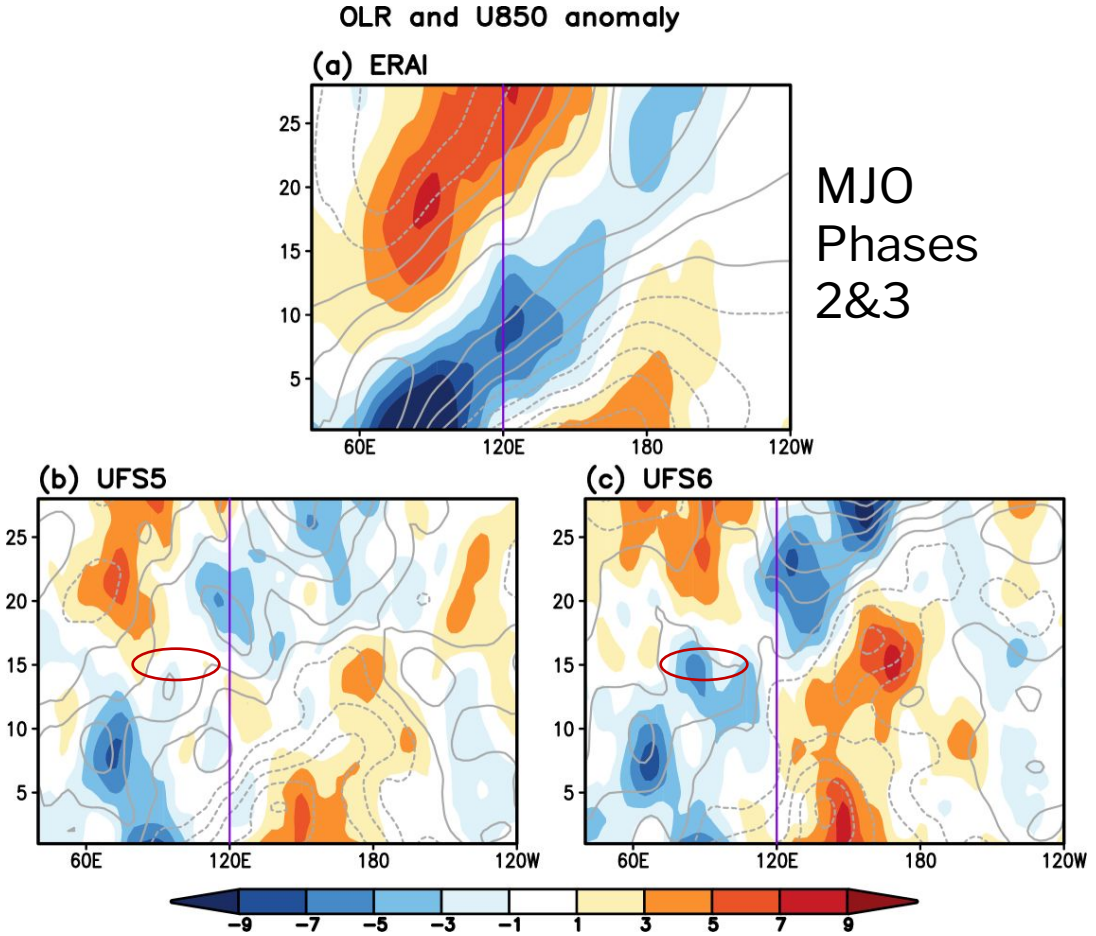
Vertical resolution



- UFS6 has 11 levels above the model top in UFS5
- From the surface to lower stratosphere (~100hPa) UFS6 resolution corresponds to a doubling of UFS5 resolution
- Between 5-50hPa UFS6 resolution is lower than doubling UFS5 resolution
- Below 270hPa UFS6 resolution is slightly higher than doubling UFS5 resolution

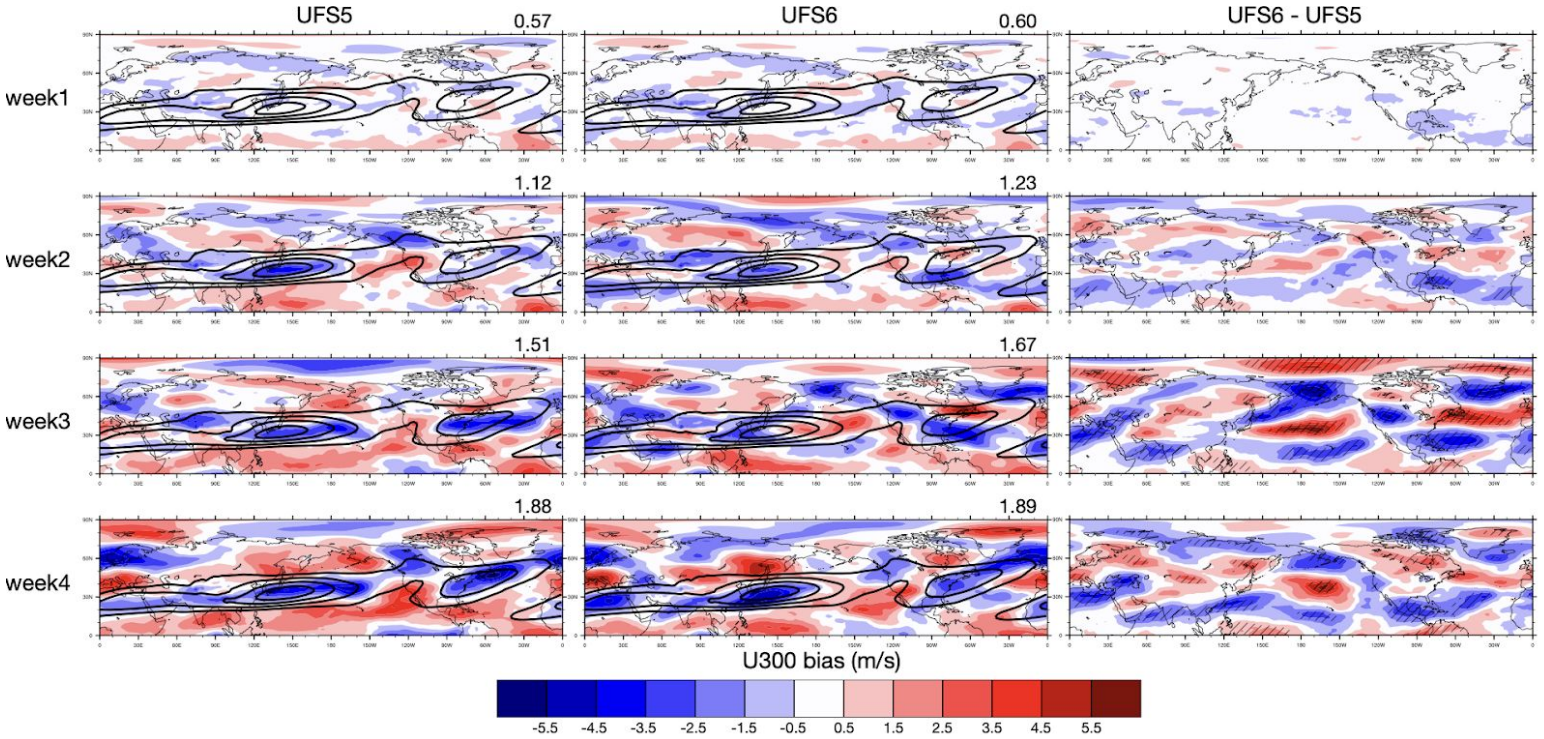
Precipitation Bias and MJO

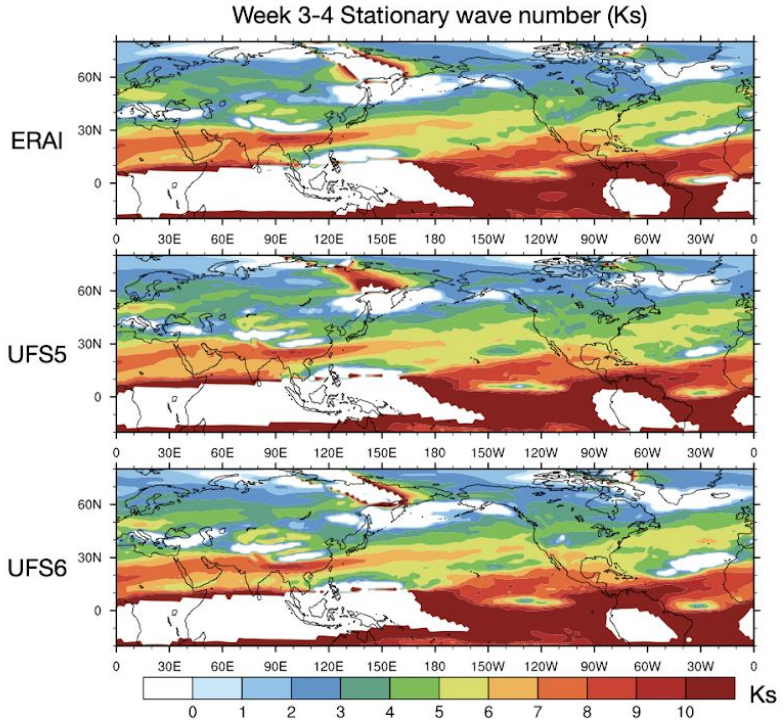




MJO Phases 2&3

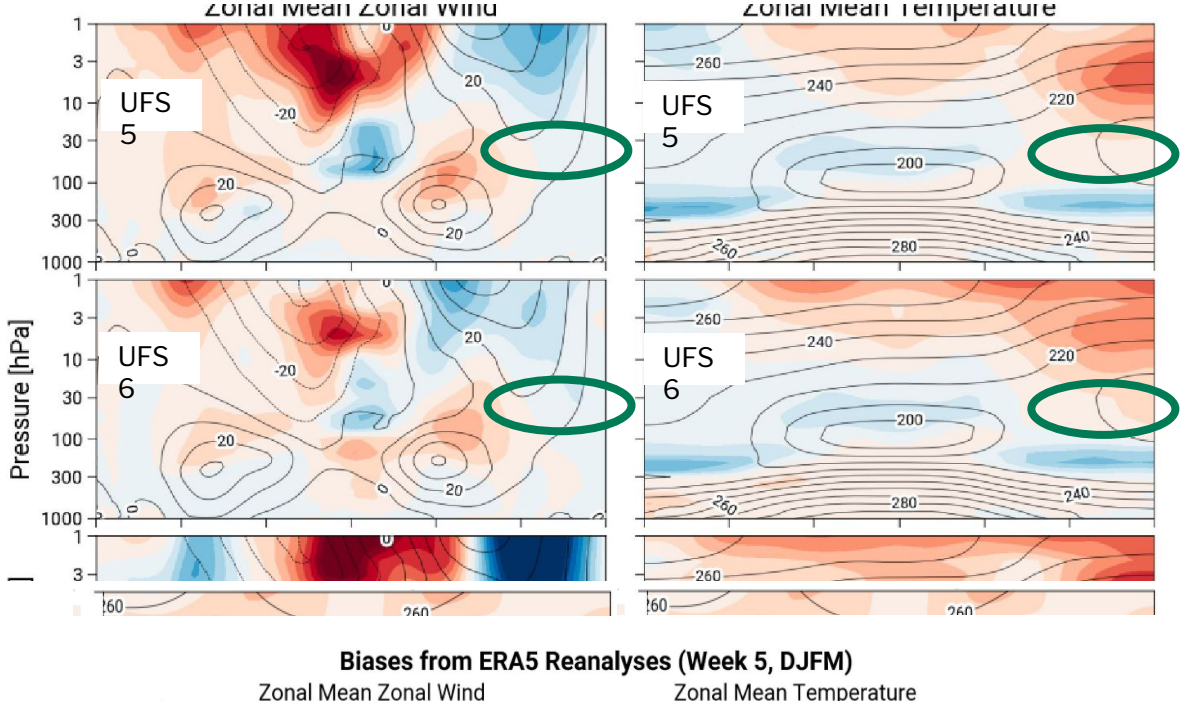
Subtropical Jet Stream Bias

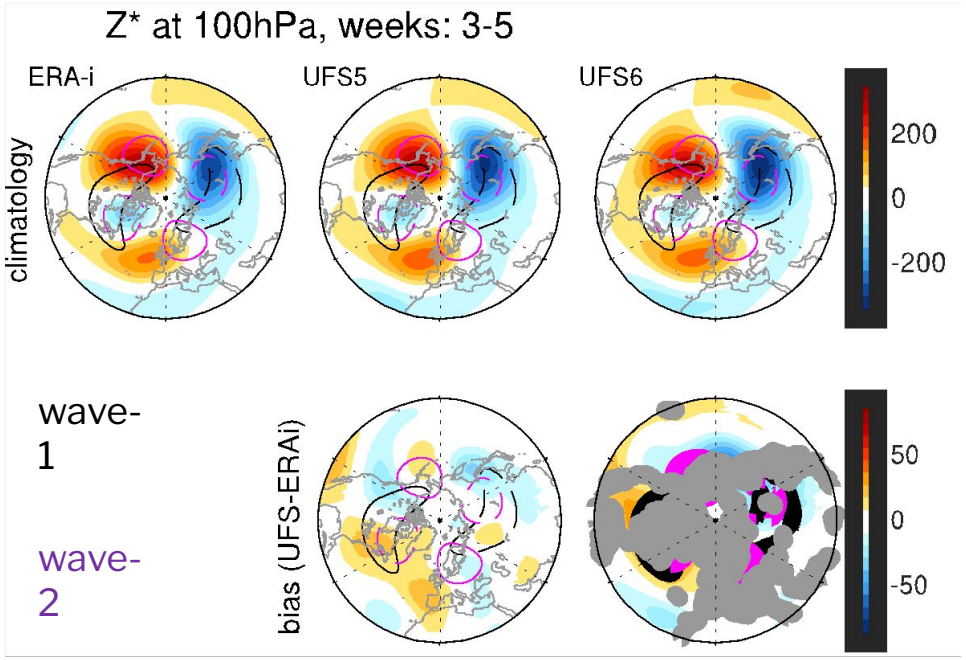




Both prototypes underestimate the magnitude of the jet over the jet core regions of the North Pacific and North Atlantic jet and overestimate the magnitude of the jet over the flanks of the North Pacific jet.

Polar vortex biases



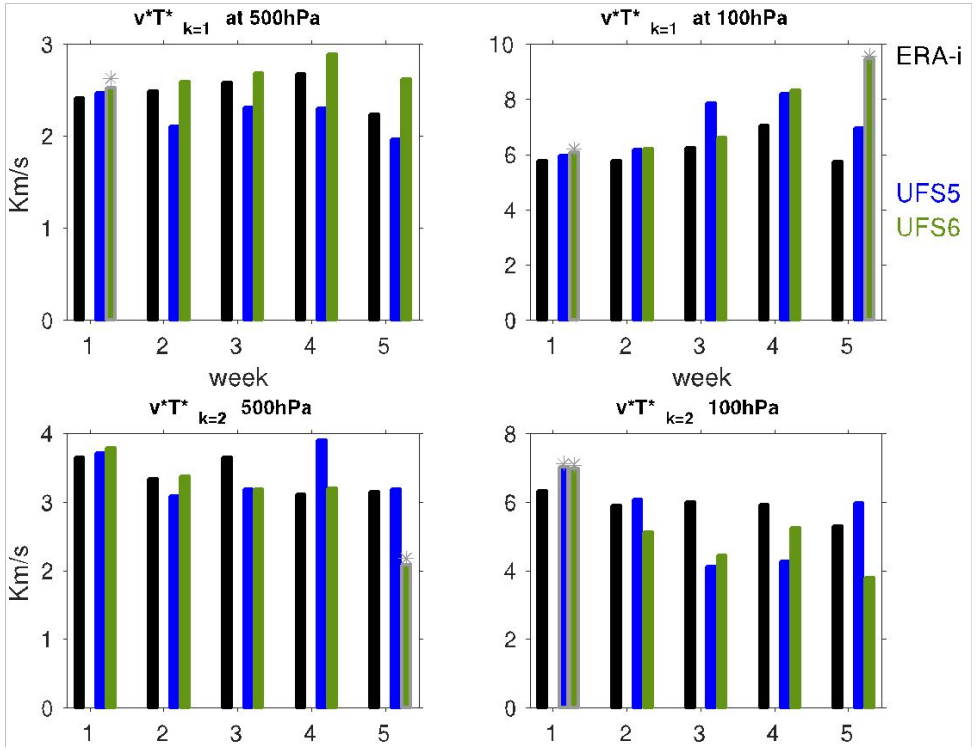


In UFS6, the warm bias is slightly reduced and the
vortex strength is reduced.

Curtesy of Zachary D. Lawrence

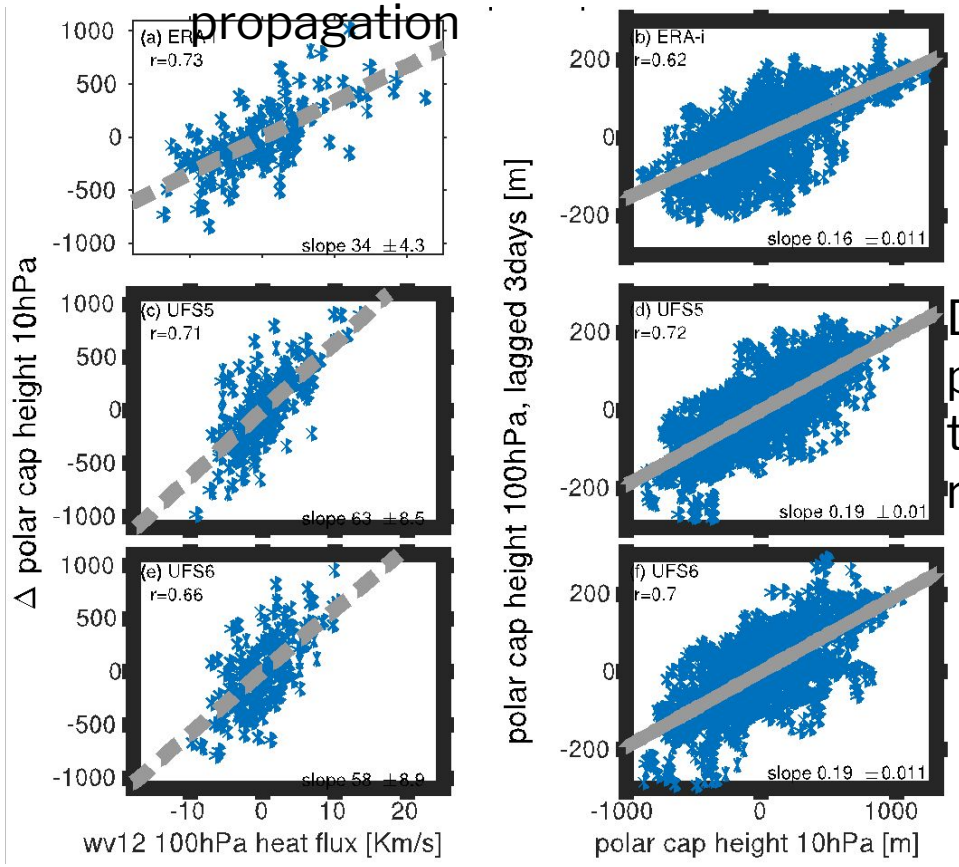
The quasi-stationary wave biases in the lower stratosphere are smaller in UFS5 than in UFS6.

Heat flux biases



At both levels, UFS6 has too much wave-1 heat flux and too little wave-2 heat flux.

Downward propagation



Downward propagation within the stratosphere is realistically predicted

Conclusions: Changing the vertical resolution and model top …

- Improves
  - precipitation bias over the Indian Ocean
  - bias in the subtropical jet
  - warm bias in the polar vortex
  - vortex strength
- Degrades
  - biases in the quasi-stationary waves in the lower stratosphere
- Does not impact
  - stratosphere-troposphere coupling