

Weak temperature gradient simulations of MJO convection

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Workshop on Tropical Dynamics and the MJO

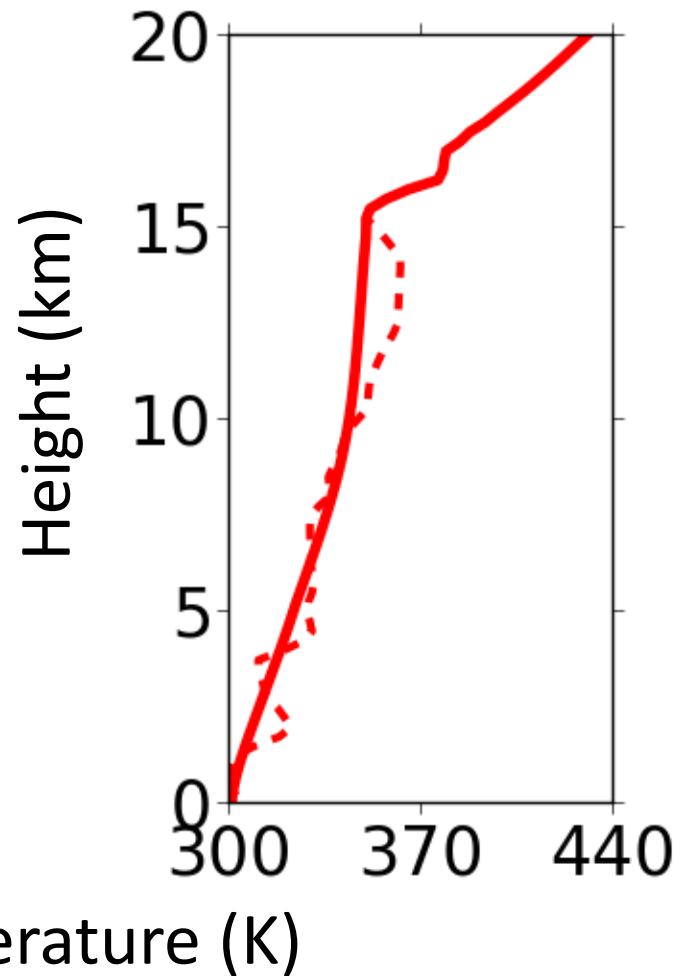
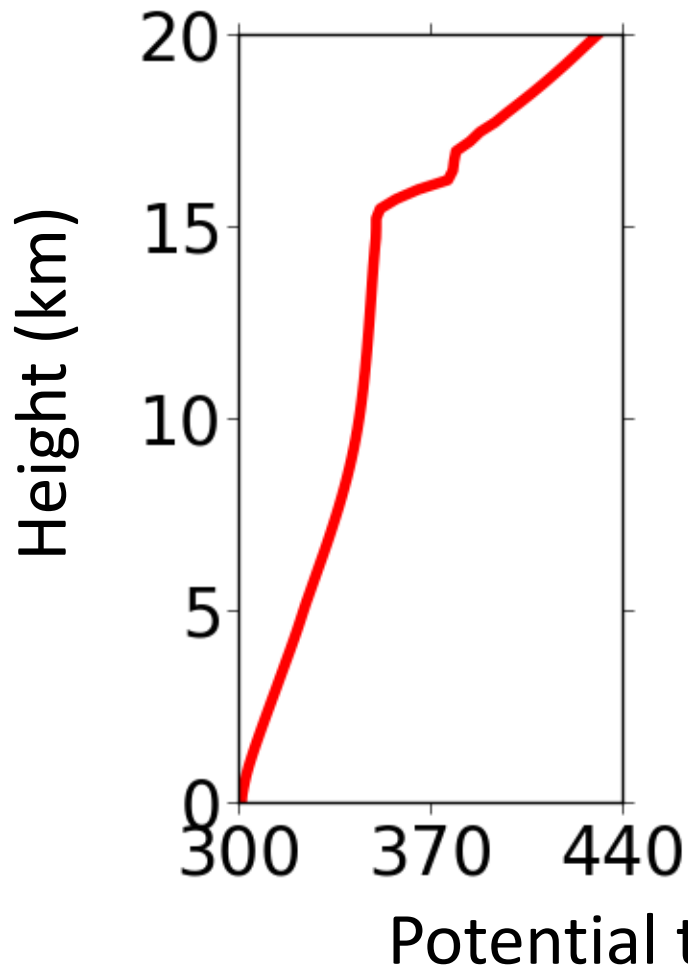
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Main Questions

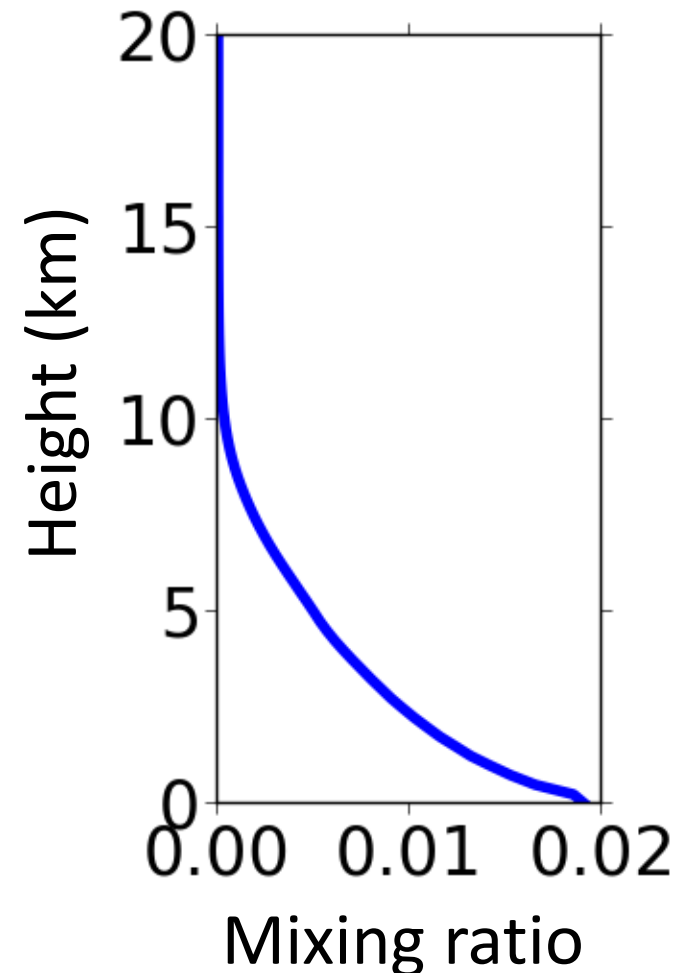
- 1) Thermodynamics (θ , r_t , surface fluxes) sufficient to simulate the TOGA-COARE MJO?
- 2) Best treatment of environmental moisture for simulating the TOGA-COARE MJO?

Weak Temperature Gradient Approximation



WTG Approximation - Moisture

- 1) No communication with environment
- 2) Lateral entrainment; t_θ (Raymond and Zeng, 2005)
- 3) Moisture relaxation (Sobel et al, 2007); t_r



Recent study

- Wang et al. (2013)
- WRF
- TOGA-COARE forcing

- **No communication with observed environmental moisture**
- **Surface fluxes important**

WTG reference profiles

- 1) RCE simulation: 303 K,
5 m/s,
200 x 20 km domain (2D)
1 km resolution
- 2) TOGA-COARE θ and r_t anomalies

WTG reference profiles

- 1) RCE simulation: 303 K,
5 m/s,
200 x 20 km domain (2D)
1 km resolution
- 2) TOGA-COARE θ and r_t anomalies
- 3) *SST* and wind speed
- 4) Radiation fixed in time (from RCE)

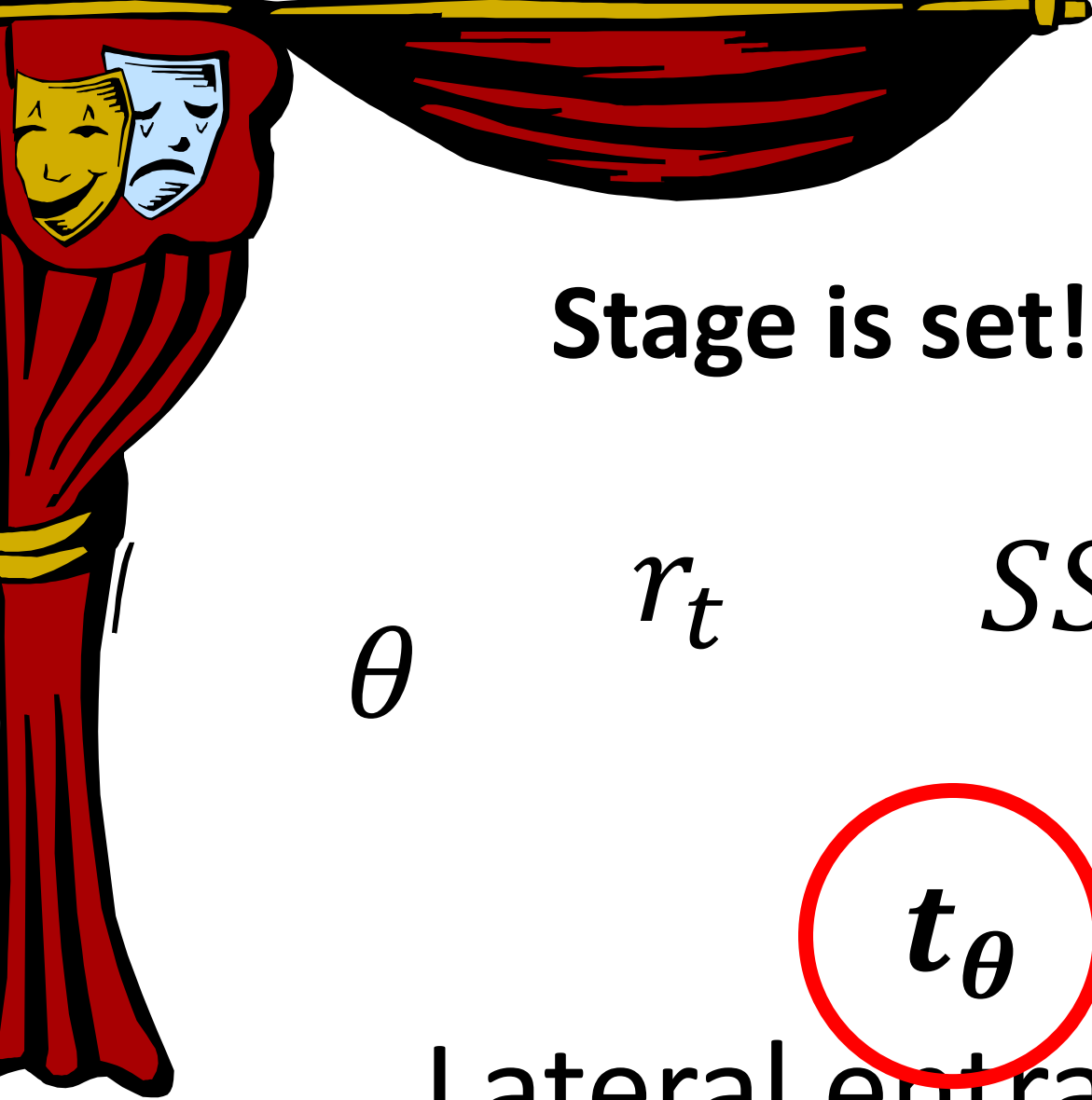
Diagnostics used

- Rain rate
- Saturation fraction

$$\frac{\textit{precipitable water}}{\textit{saturated precipitable water}}$$

- Instability Index

$$S_{1-3 \text{ km}}^* - S_{5-7 \text{ km}}^*$$



Stage is set!

θ r_t SST U

t_θ

Lateral entrainment

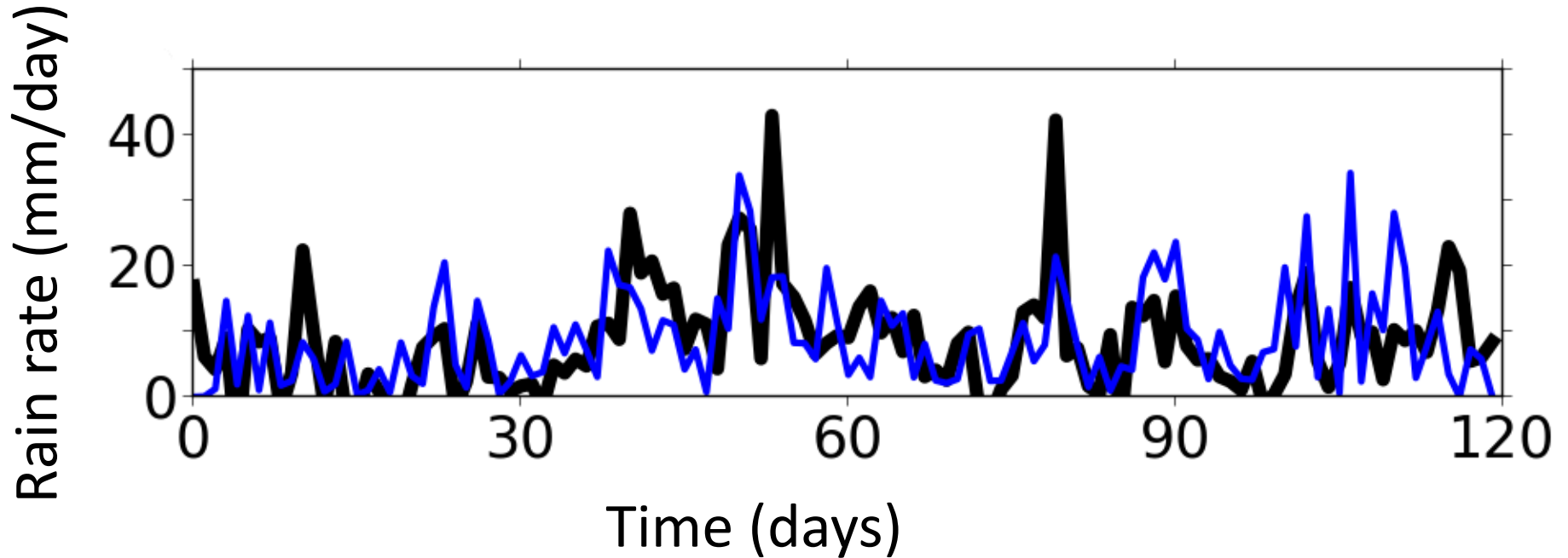
Correlation; t_θ sensitivity

t_θ	Rain	SF	II
22 min	0.56	0.83	0.82
1 h	0.48	0.81	0.65
2 h	0.48	0.73	0.33
4 h	0.33	0.64	0.17

Rain rate (mm/day)

t_θ	Corr	Mean	Std
22 min	0.56	11.4	11.2
1 h	0.48	8.8	7.5
2 h	0.48	7.9	5.9
4 h	0.33	7.4	4.9
OBS	1.00	8.5	8.3

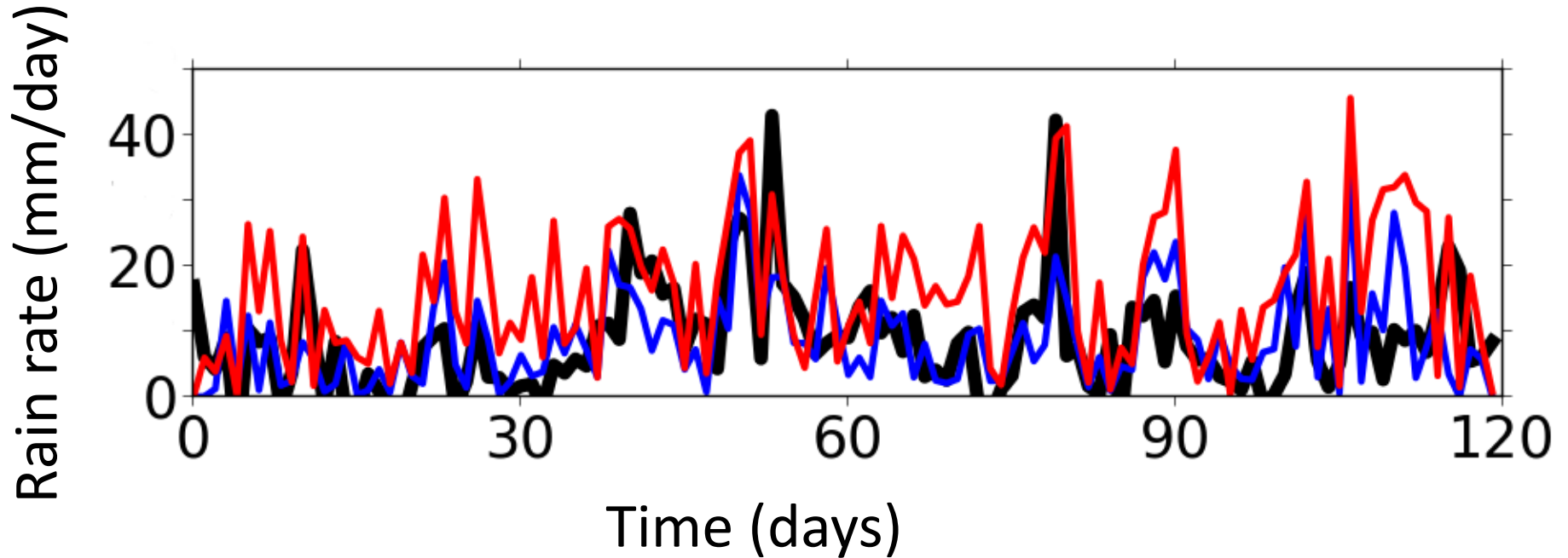
$$t_{\theta} = 1 \text{ h}$$



— Observations

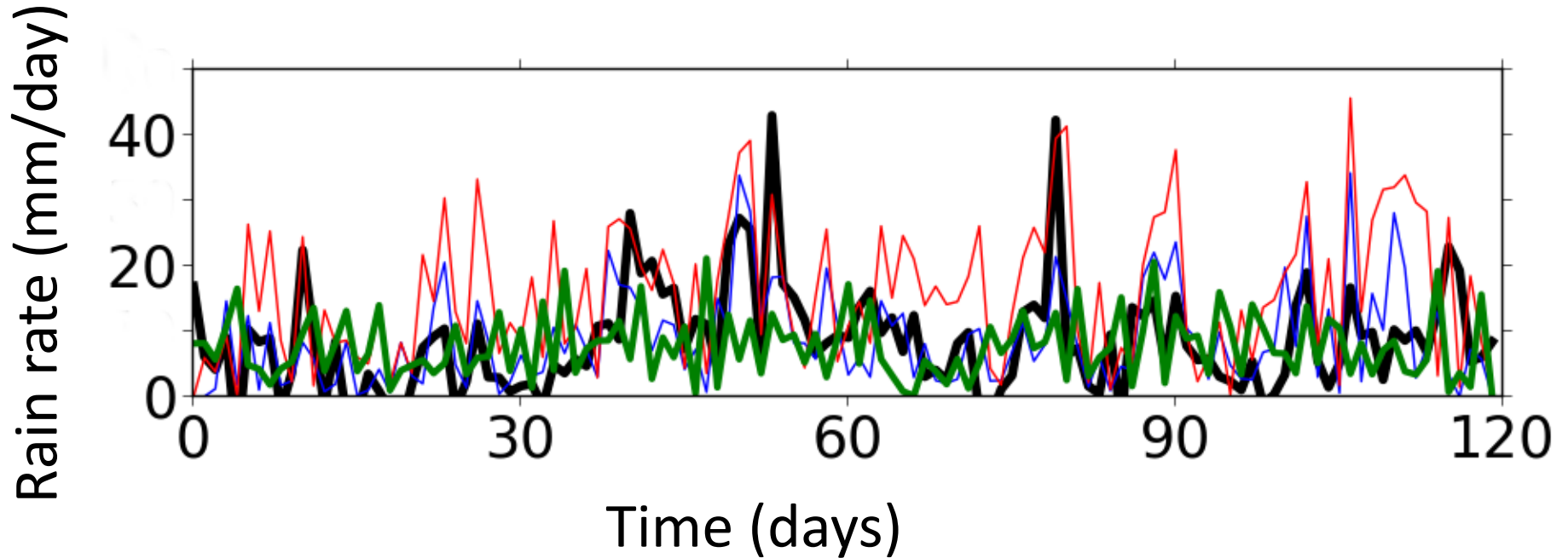
— θ , r_t , SST and U vary

$$t_{\theta} = 1 \text{ h}$$



- Observations**
- θ , r_t , SST and U vary***
- θ and r_t vary***

$$t_{\theta} = 1 \text{ h}$$

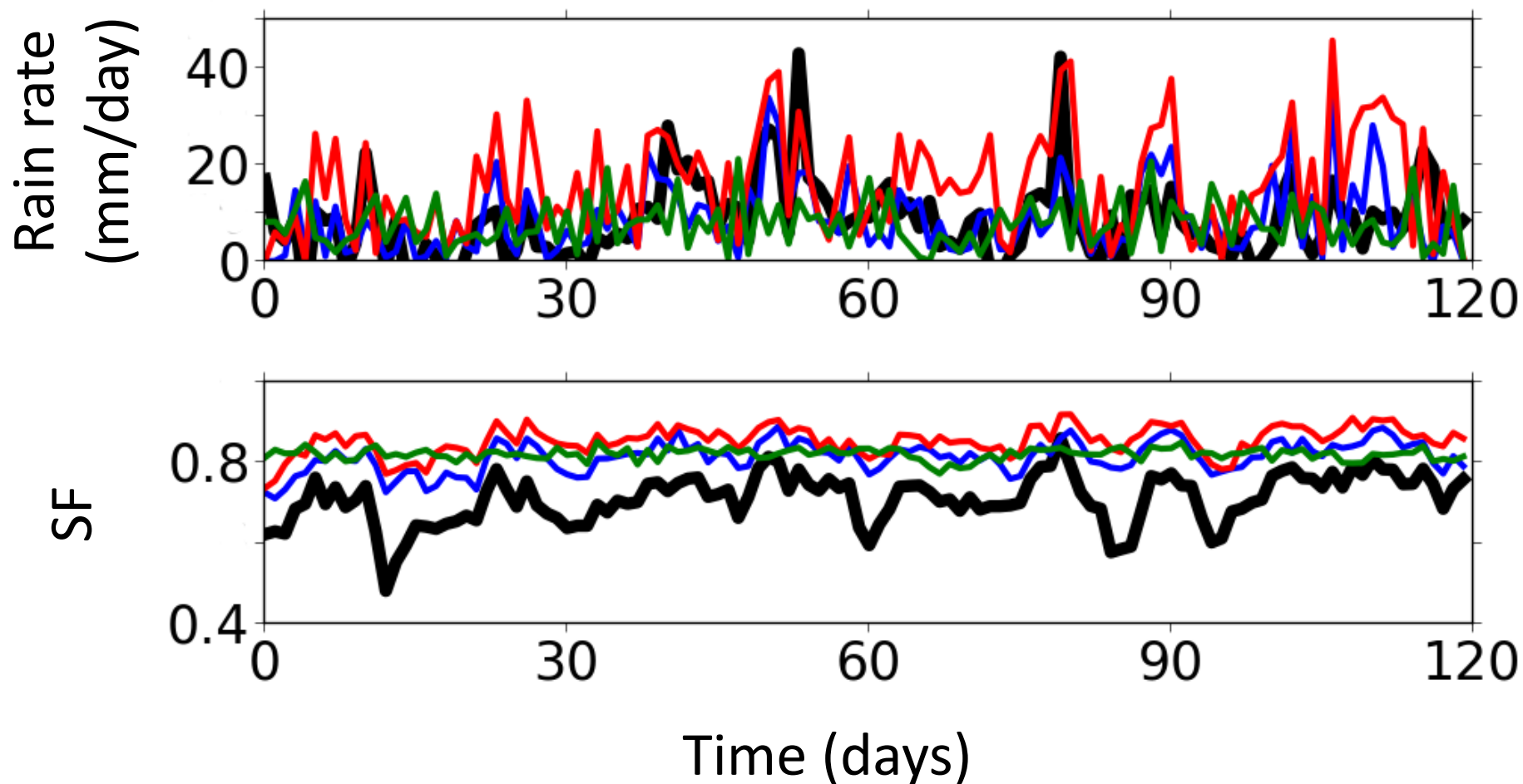


- Observations**
- θ , r_t , SST and U vary***
- θ and r_t vary***
- SST and U vary***

Rain rate (mm/day)

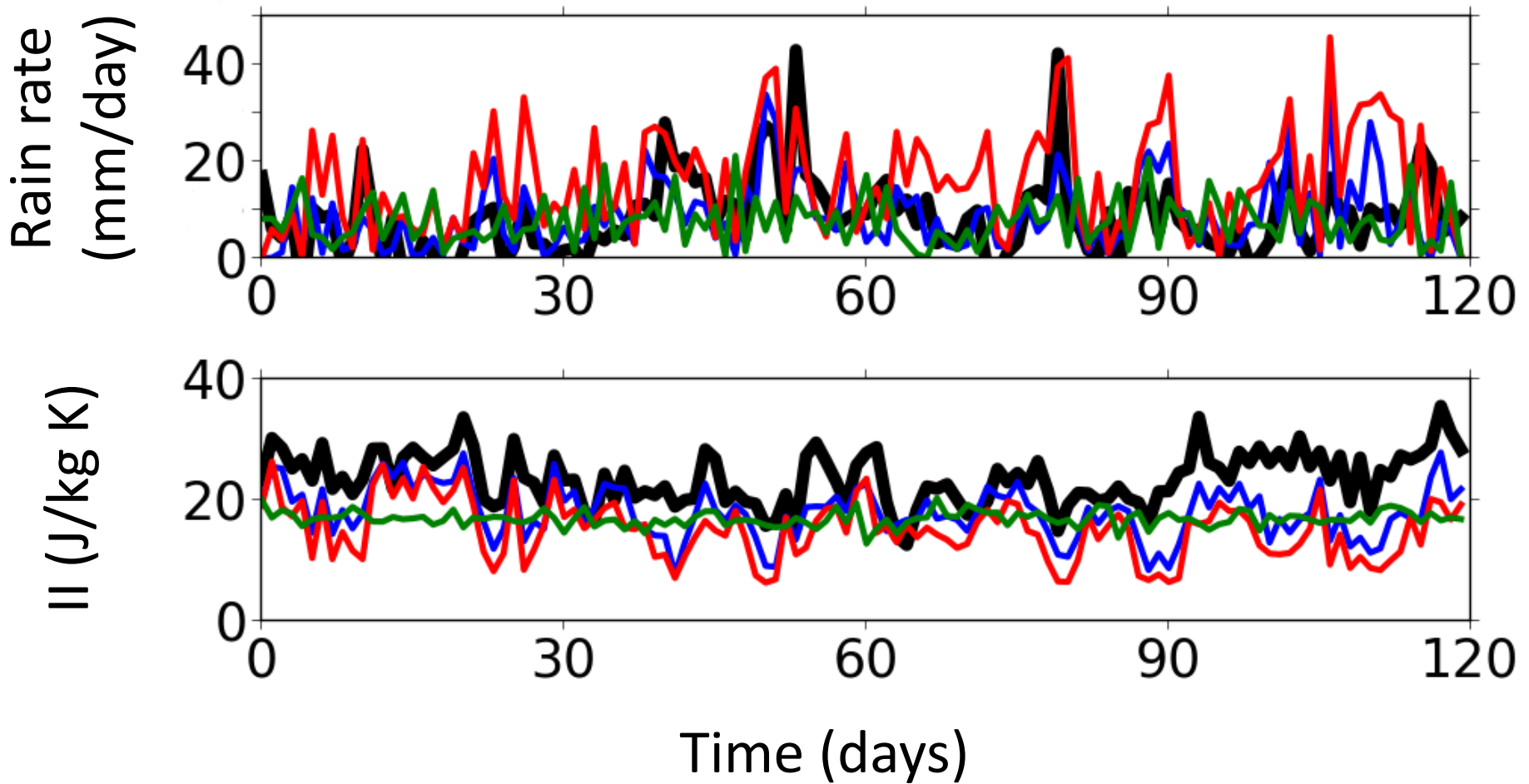
t_θ	Corr	Mean	Std
OBS	1.00	8.5	8.3
θ, r_t, SST and U vary	0.48	8.8	7.5
θ and r_t vary	0.48	15.9	10.7
SST and U vary	0.09	7.9	5.9

Saturation fraction



- Observations
- θ and r_t vary
- θ, r_t, SST and U vary
- SST and U vary

Instability Index



Observations



θ and r_t vary



θ , r_t , SST and U vary



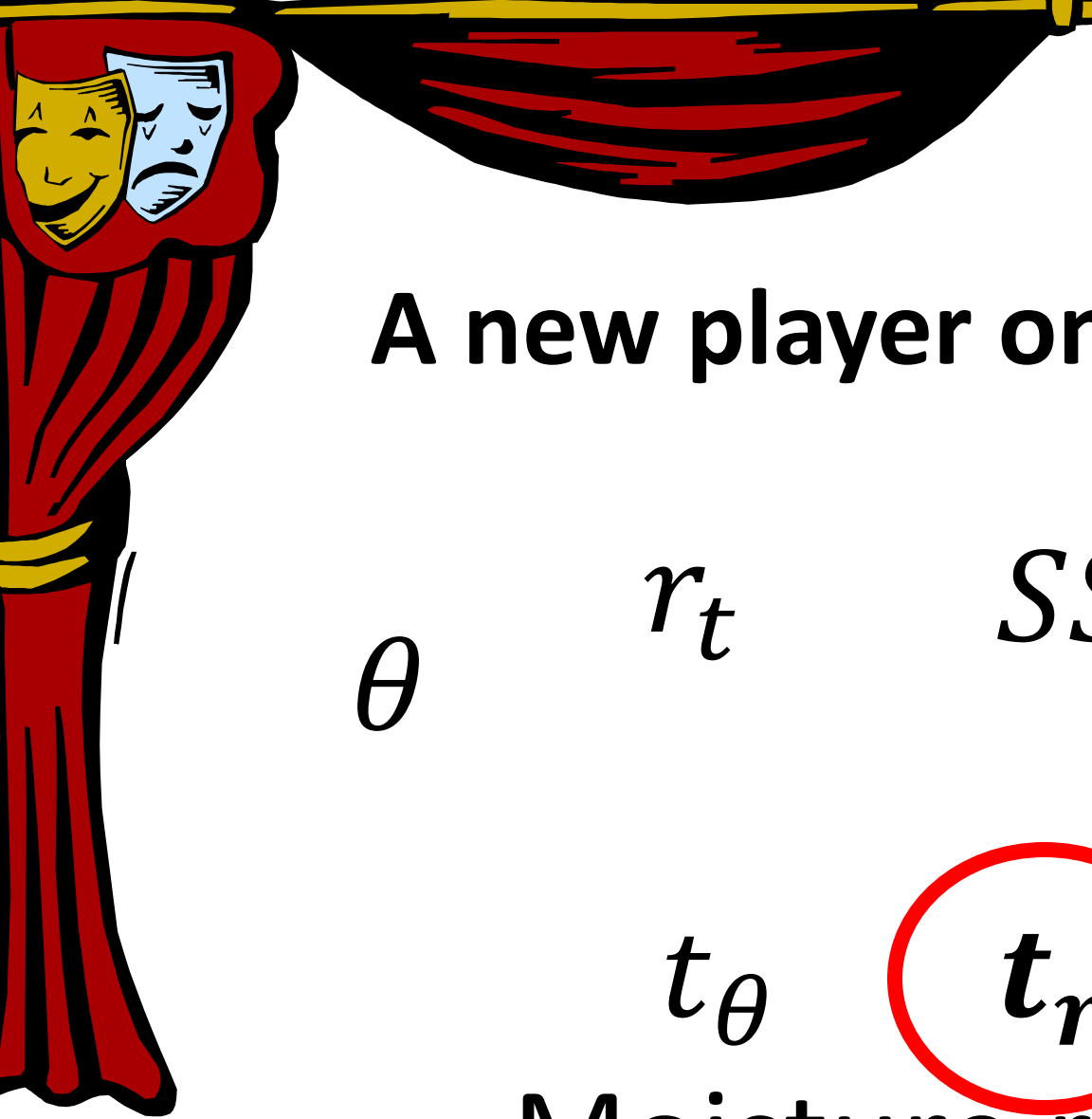
SST and U vary

Main Question #1

1) Thermodynamics (θ , r_t , surface fluxes) sufficient to simulate the TOGA-COARE MJO?

Affirmative

Surface fluxes modulate it



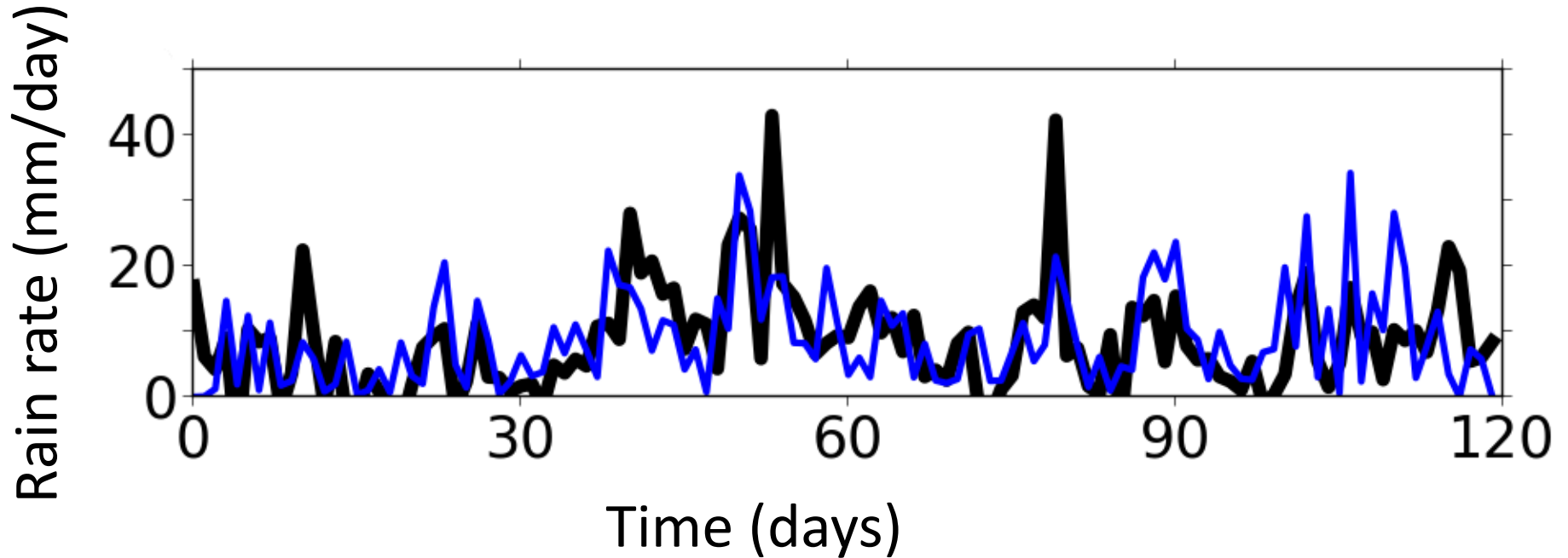
A new player on the stage!

θ r_t SST U

t_θ t_r

Moisture relaxation

$$t_{\theta} = 1 \text{ h}$$



— Observations

— θ , r_t , SST and U vary

Moisture treatment sensitivity

- θ , r_t , SST and U vary in time
- Fixed in time: radiation
- $t_r = 1$ day

Env. moisture	Rain	SF	II
None	0.15	0.29	0.60
Lateral entrainment	0.48	0.81	0.65
Relaxation	0.49	0.91	0.60

Rain rate (mm/day)

- θ , r_t , SST and U vary in time
- Fixed in time: radiation
- $t_r = 1$ day

Env. moisture	Corr	Mean	Std
None	0.15	17.0	14.0
Lateral entrainment	0.48	8.8	7.5
Relaxation	0.49	11.3	10.7
Observations	1.00	8.5	8.3

Main Question #2

2) Best treatment of environmental moisture for simulating the TOGA-COARE MJO?

Lateral entrainment

Summary

1) Thermodynamics (θ , r_t , surface fluxes) sufficient to simulate the TOGA-COARE MJO?

Yes

2) Best treatment of environmental moisture for simulating the TOGA-COARE MJO?

Lateral entrainment