Weak temperature gradient simulations of MJO convection

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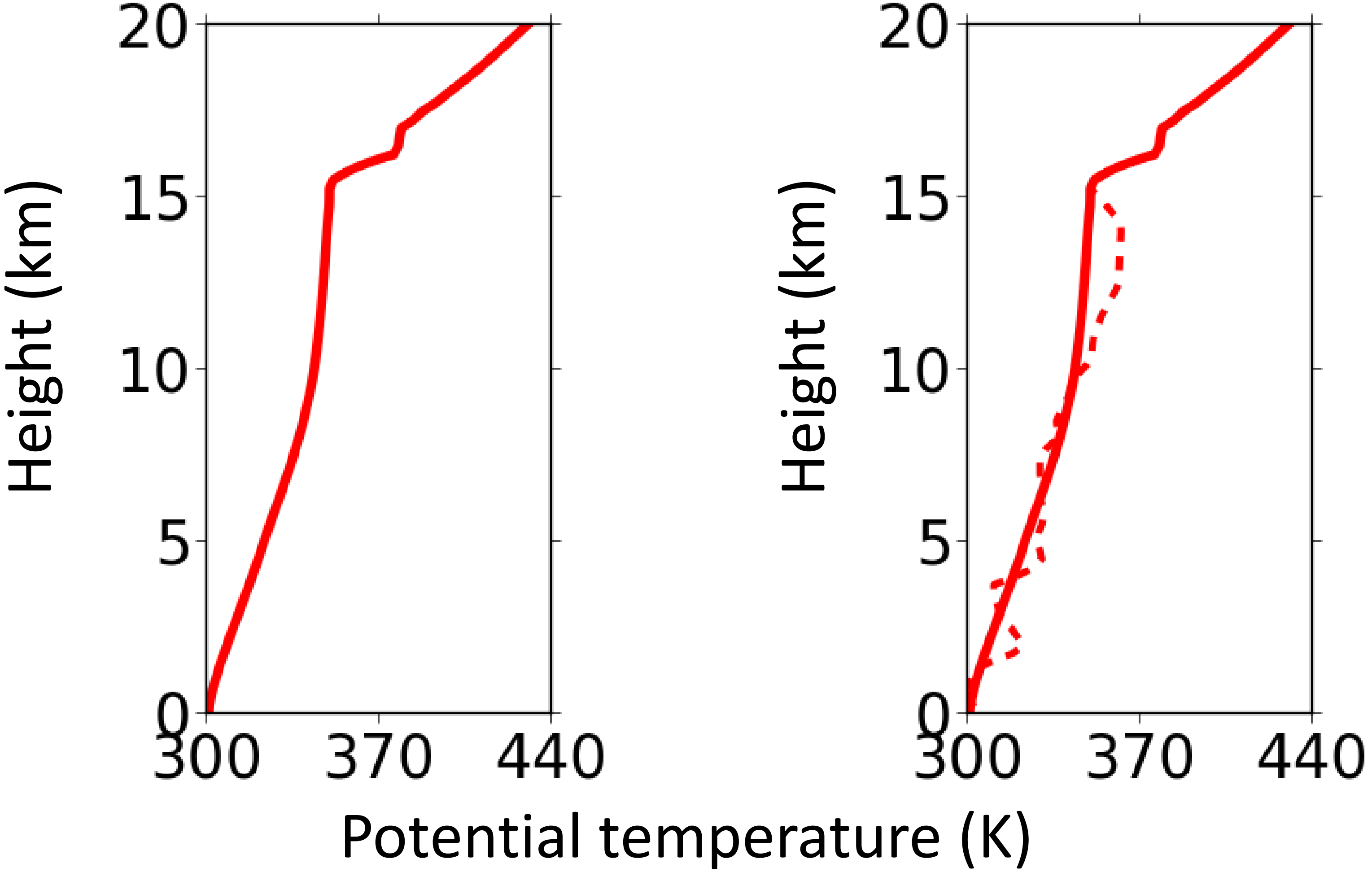
Main Questions

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

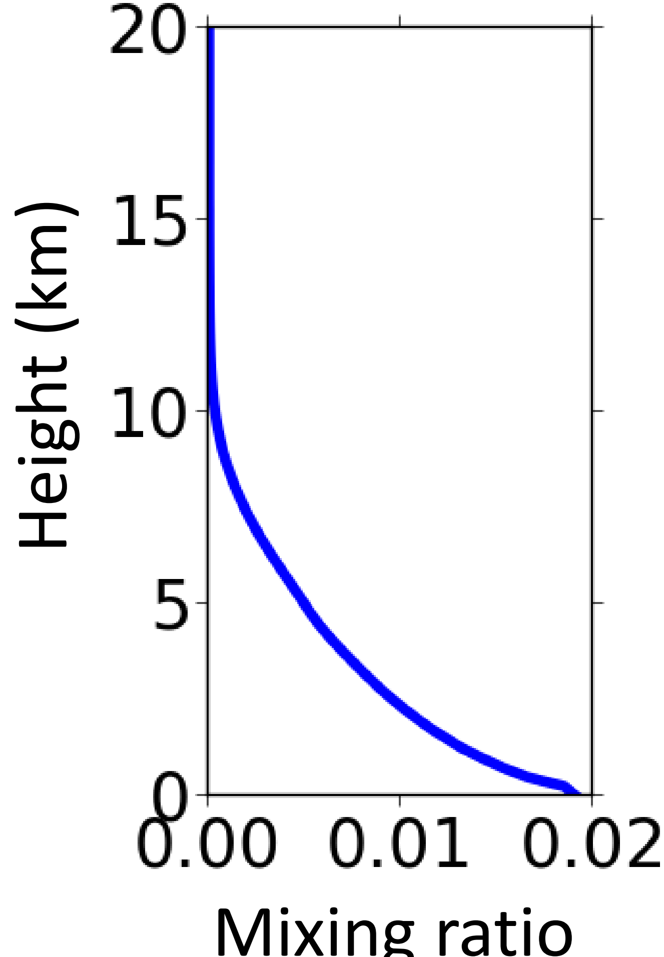
2) Best treatment of environmental moisture for simulating the TOGA-COARE MJO?

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

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

- Instability Index

$$s^*_{1-3\ \mathrm{km}} - s^*_{5-7\ \mathrm{km}}$$

Stage is set!

r_t SST

θ U

$\boldsymbol{t_\theta}$

Lateral entrainment

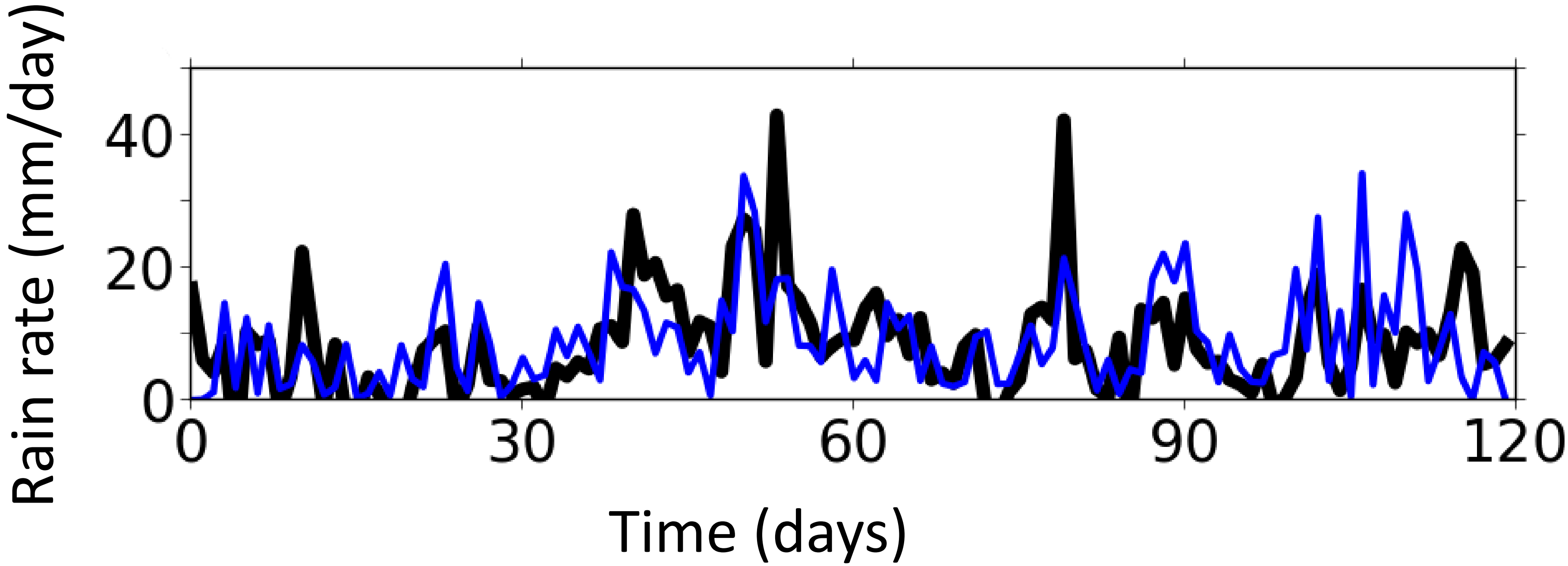
Correlation; t_θ sensitivity

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**

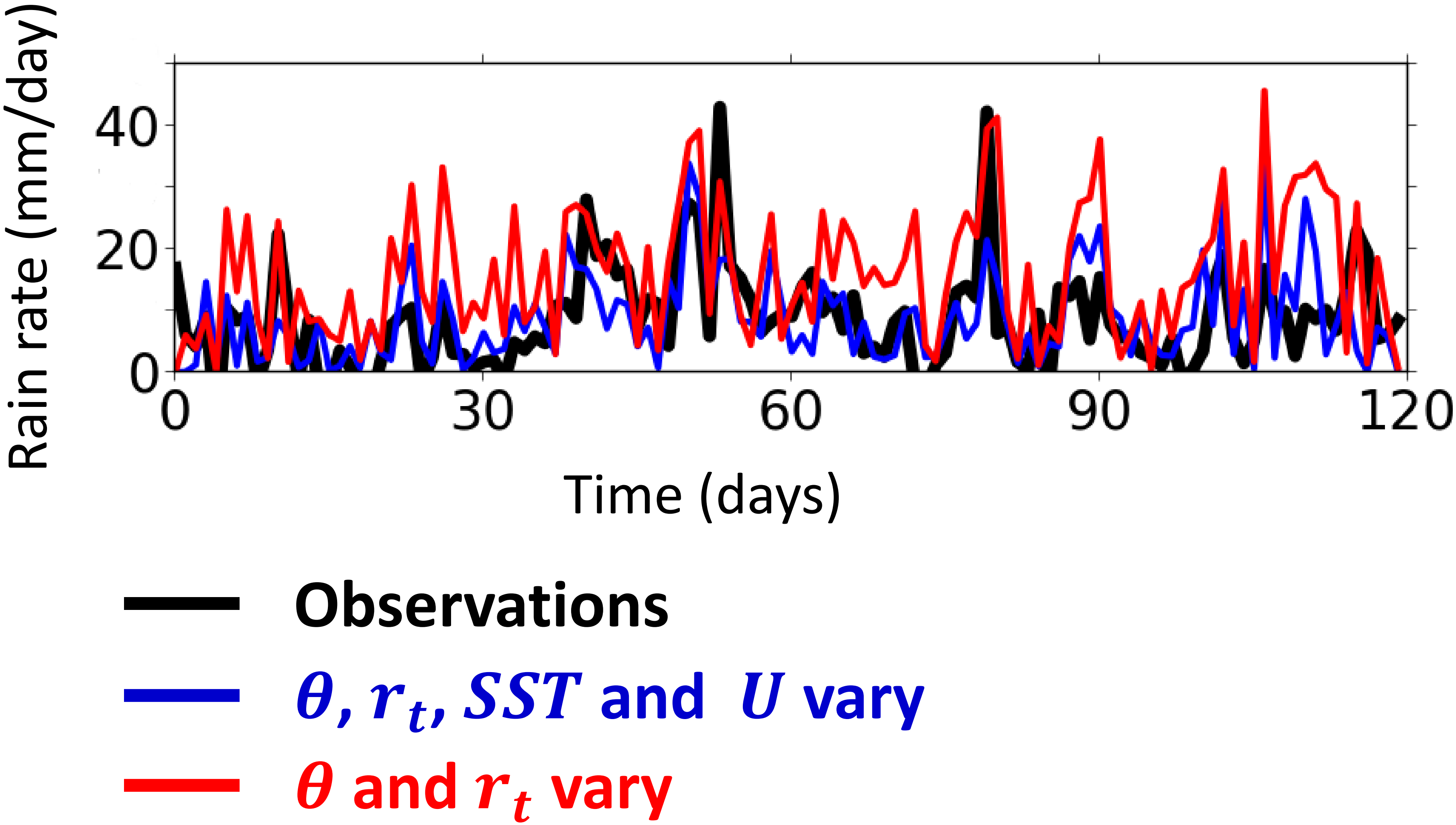
t_θ = 1 h



Observations

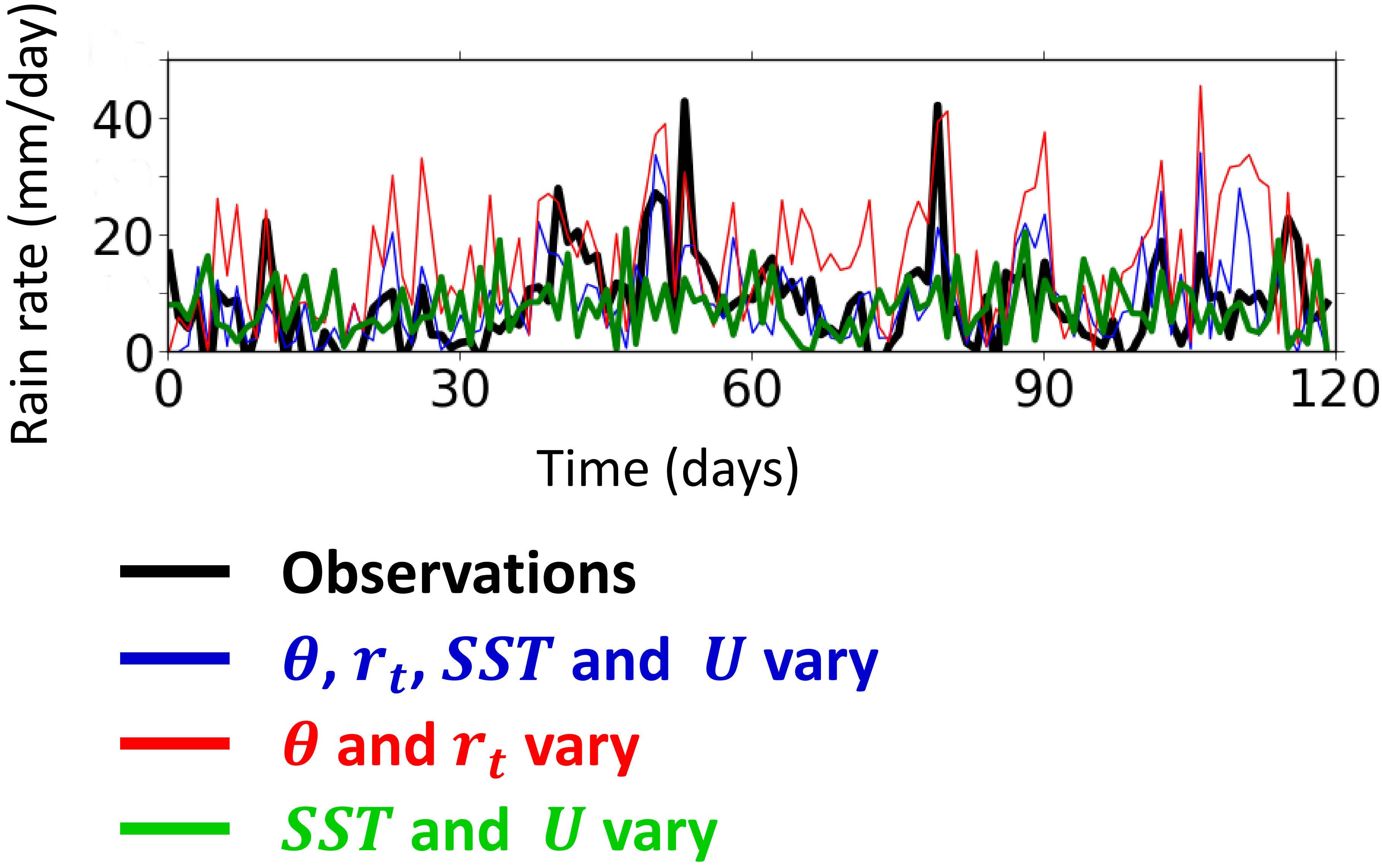
θ, r_t, SST **and** U **vary**

t_θ = 1 h



Rain rate (mm/day)
0
20
40
0
30
60
90
120
Time (days)
Observations
θ, r_t, SST and U vary
θ and r_t vary

$t_\theta = 1$ h

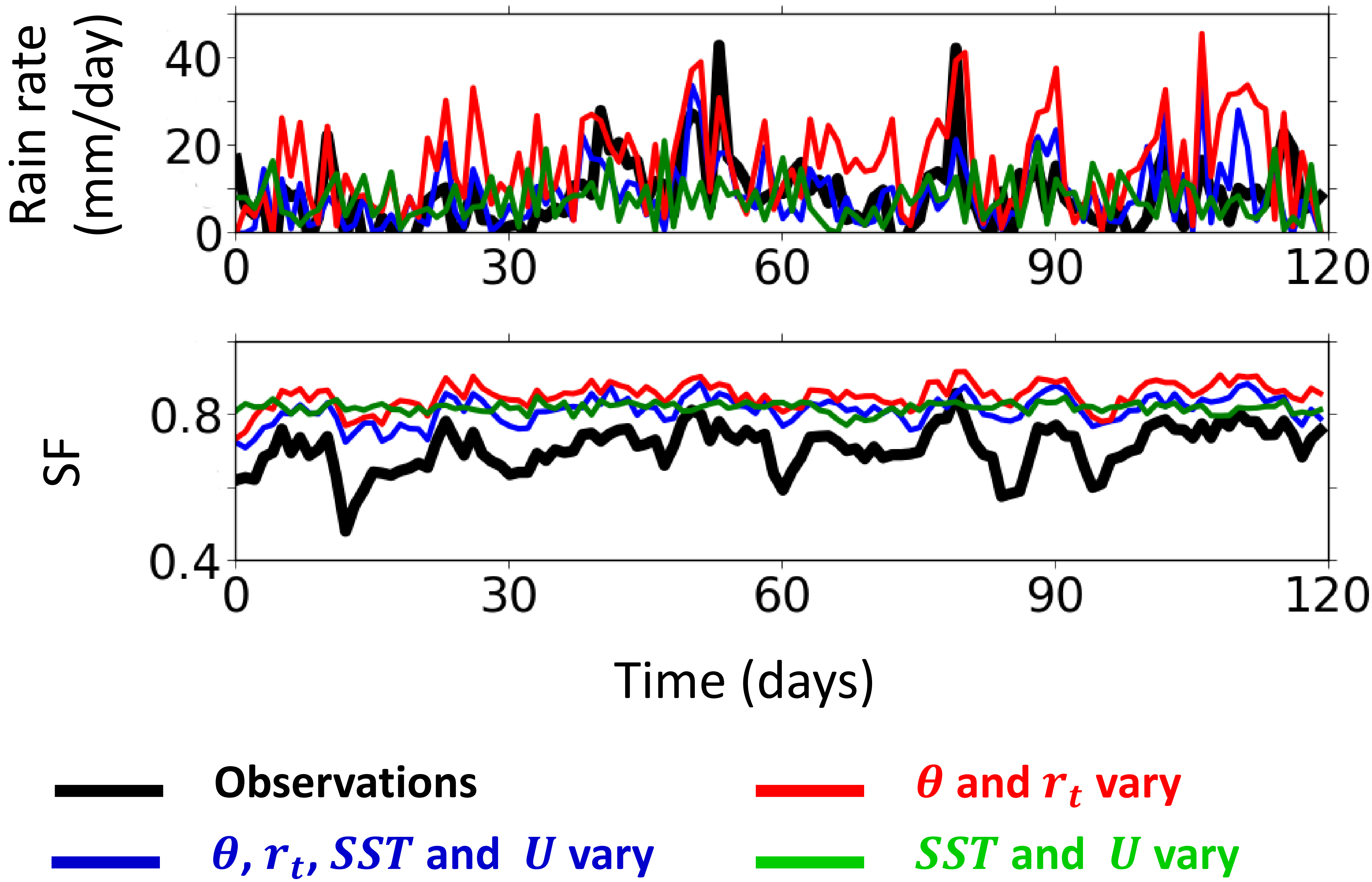


Rain rate (mm/day)
0
20
40
0
30
60
90
120
Time (days)
Observations
θ, r_t, SST and U vary
θ and r_t vary
SST and U vary

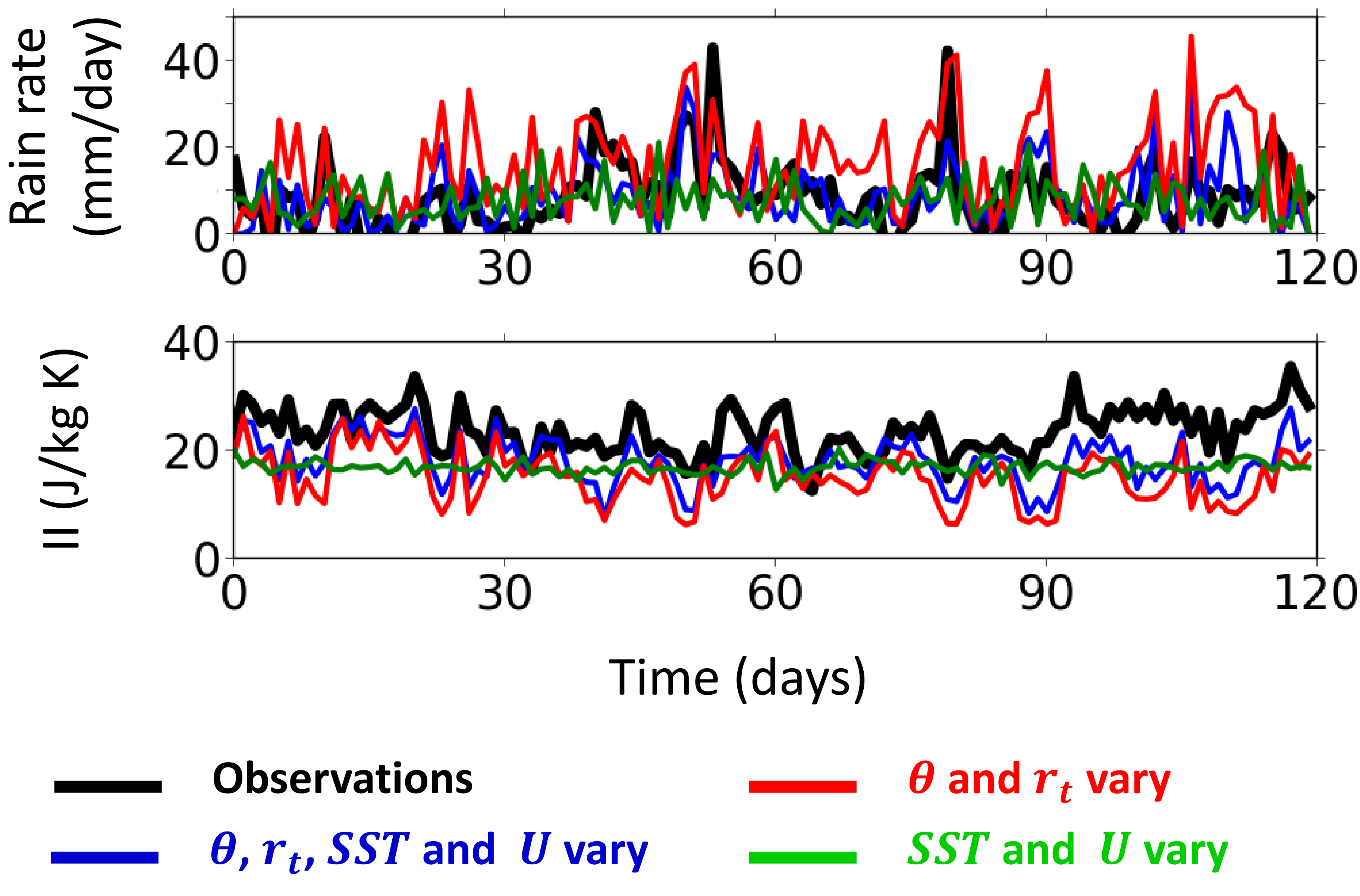
Rain rate (mm/day)

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



Instability Index

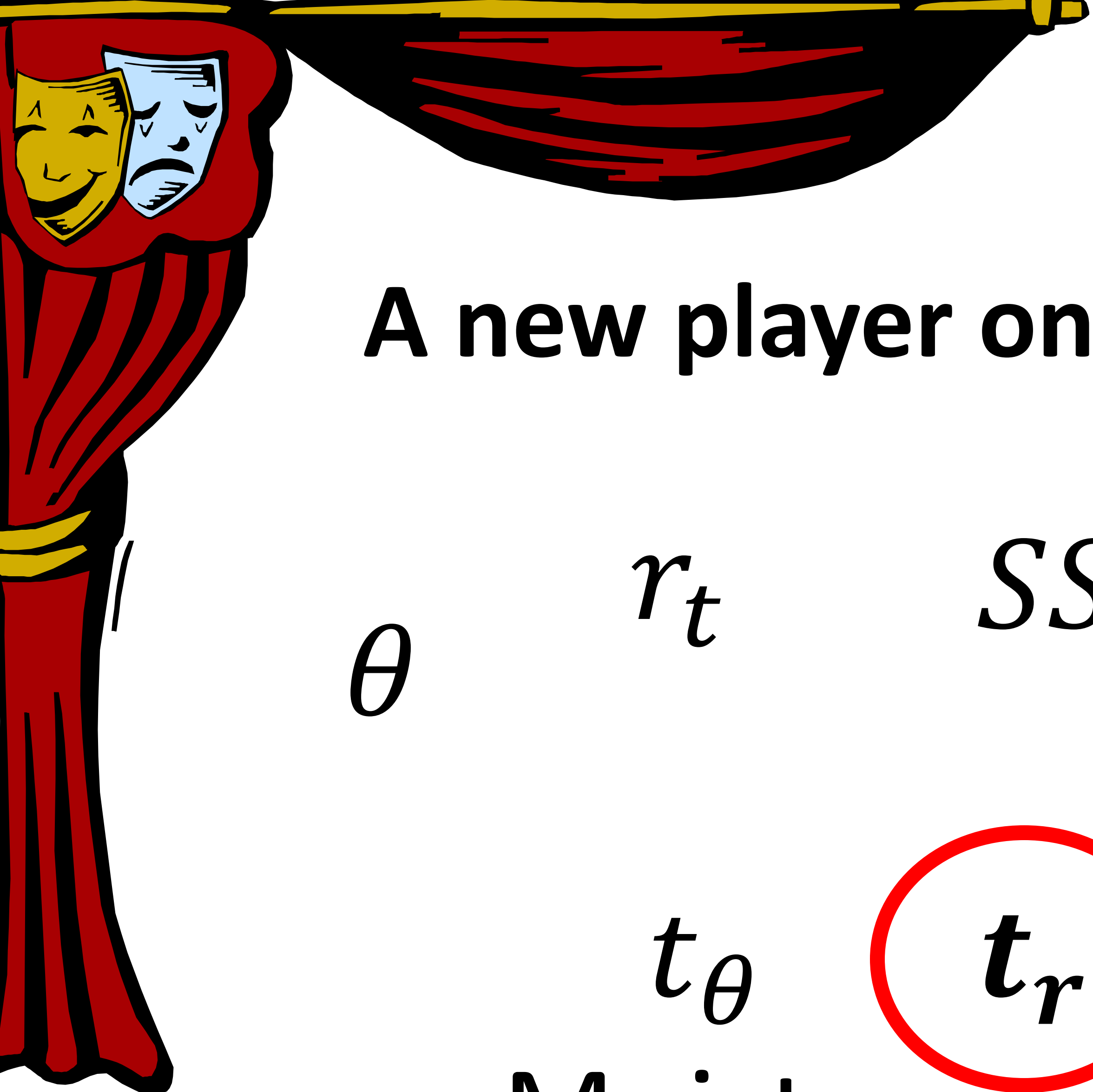


Main Question #1

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!

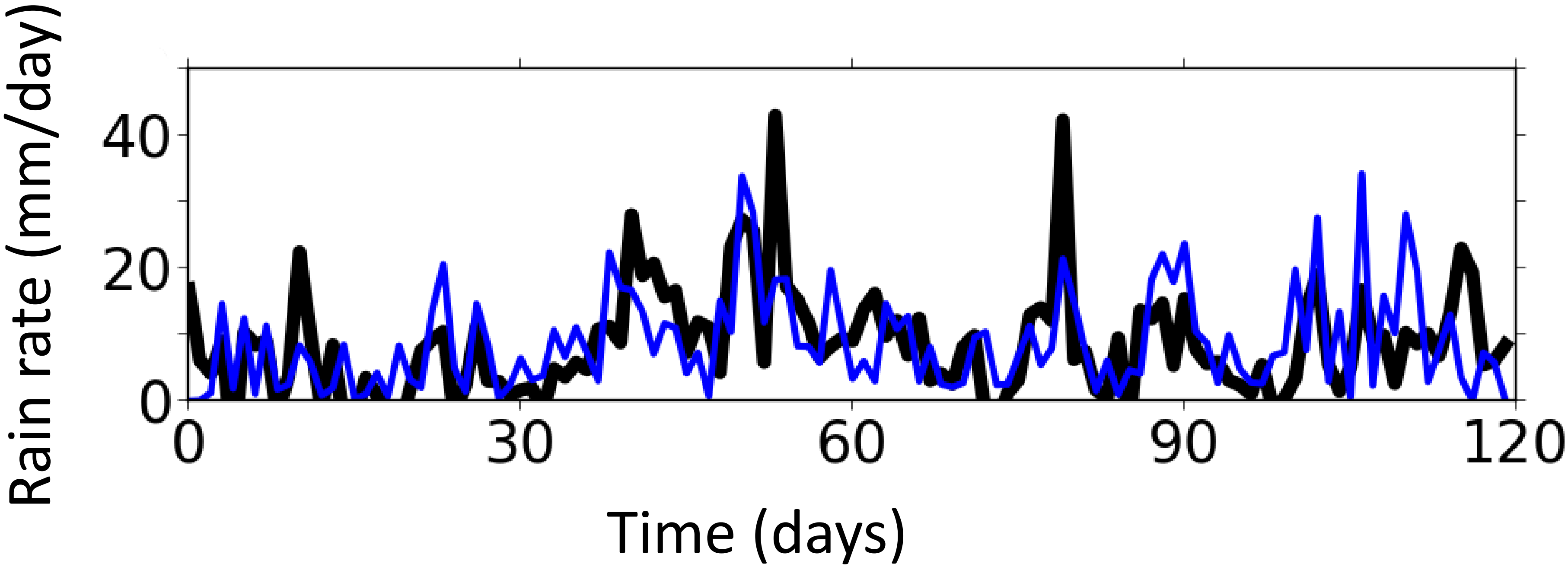
r_t SST

θ U

t_θ $\boldsymbol{t_r}$

Moisture relaxation

t_θ = 1 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