2018 Joint ARM User Facility and ASR PI Meeting

Reconstruct Autoconversion and Accretion Enhancement Factors in GCMs using Ground-based Observations at the Azores

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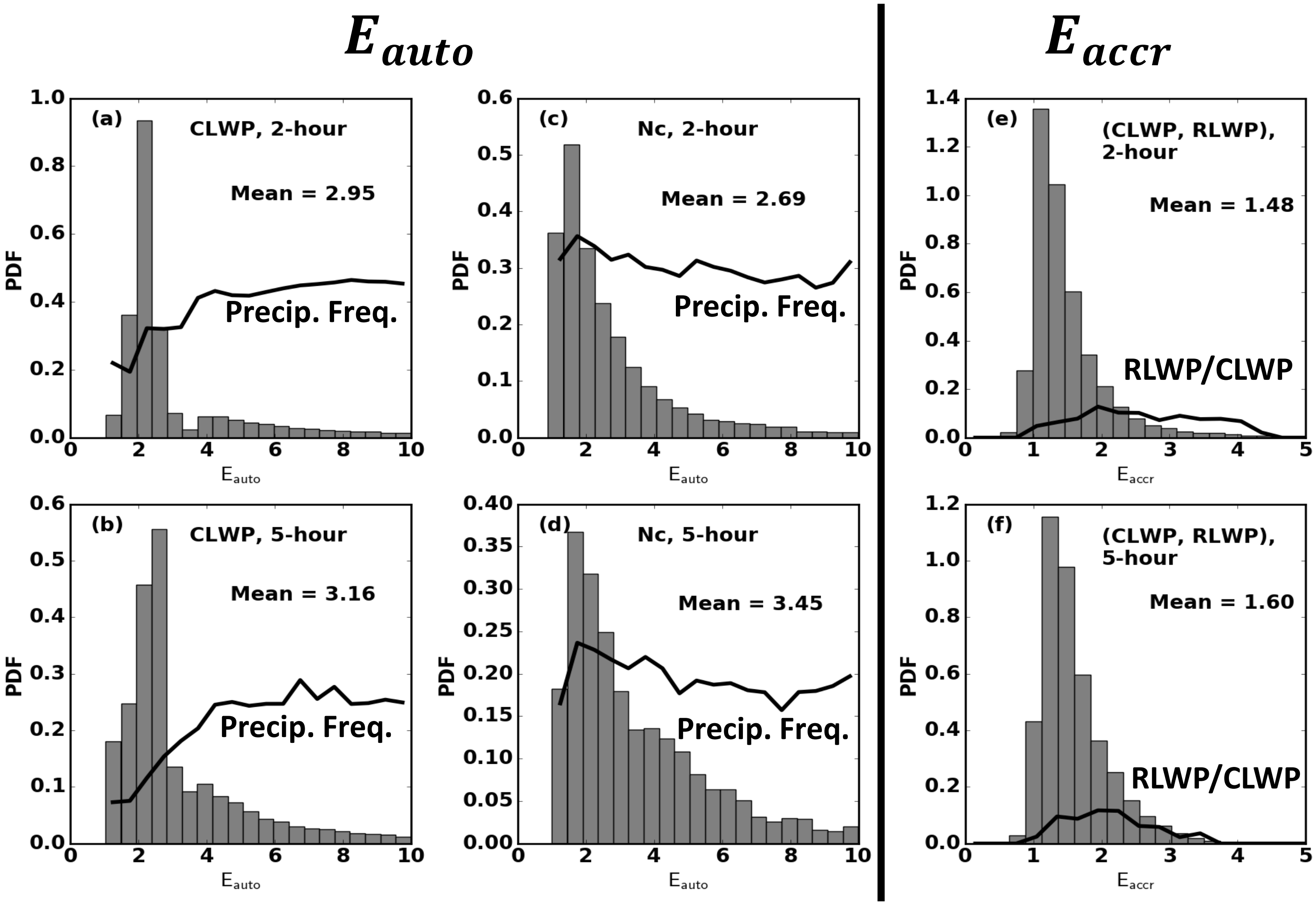
Motivation

- **Most GCMs simulate precipitation too frequent and too light compared to observations,**
- **Autoconversion and accretion rates :**
  - $\left(\frac{\partial q_r}{\partial t}\right)_{auto} = 1350 q_c^{2.47} N_c^{-1.79}$ **(precip. frequency)**
  - $\left(\frac{\partial q_r}{\partial t}\right)_{accr} = 67 (q_c q_r)^{1.15}$ **(precip. intensity)**
- **Consider *subgrid* variability and covariability of microphysical quantities:**
  - $\left(\frac{\partial q_r}{\partial t}\right)_{auto} = E_{auto} 1350 q_c^{2.47} N_c^{-1.79}$
  - $\left(\frac{\partial q_r}{\partial t}\right)_{accr} = E_{accr} 67 (q_c q_r)^{1.15}$
  - E**: enhancement factor, const. in GCMs.**

Khairoutdinov and Kogan, 2000; Morrison and Gettleman, 2008; Lebsock et al. 2012 and others.



(e), (f)

- E_{accr} has mode~1.5 and right skewed,
- RLWP/CLWP increases with E_{accr} and then decreases, suggesting a possible existence of an optimal state in rain drop collection process.

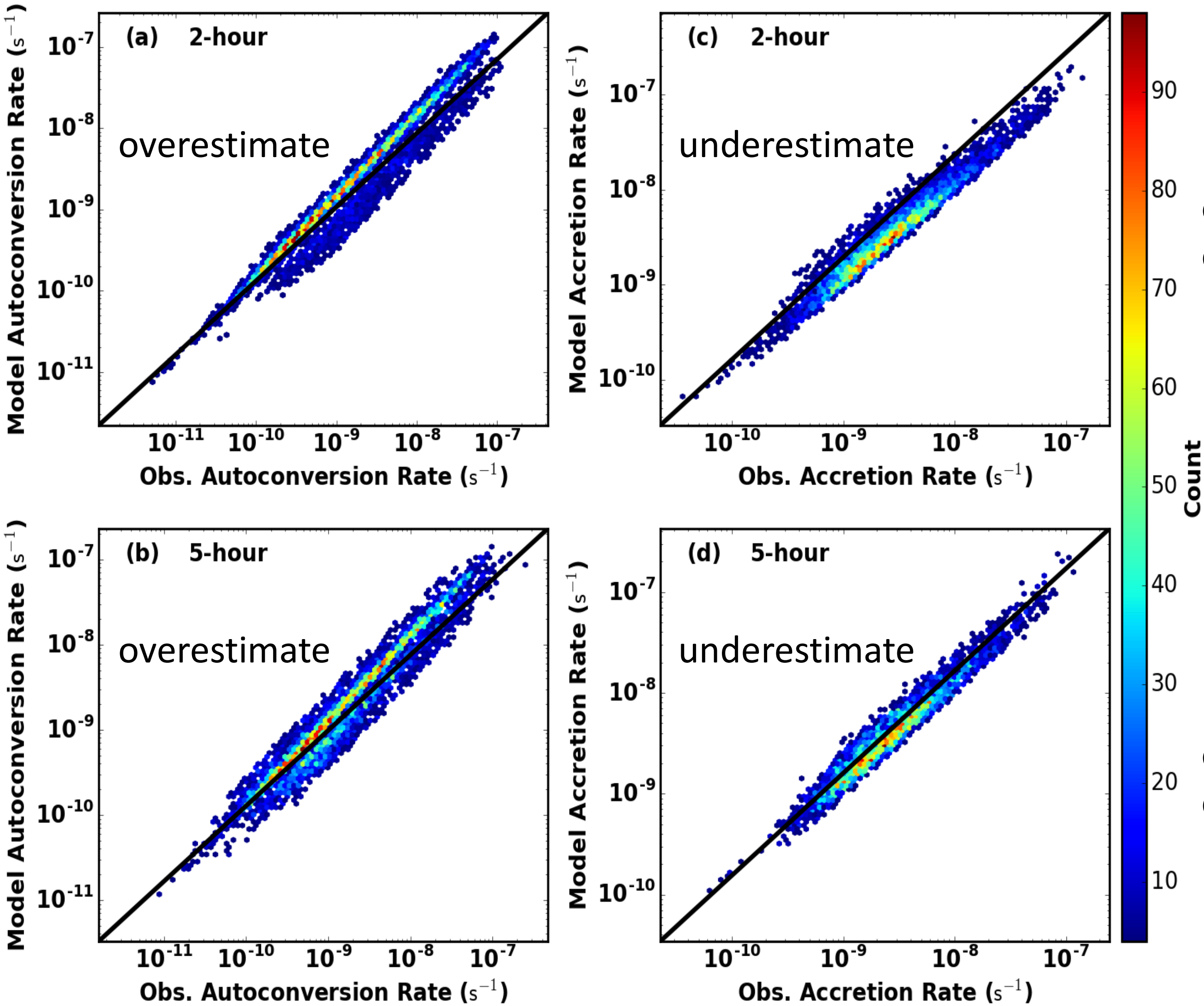
(a), (b)

- E_{auto} has a bimodal distribution with mode at ~2 and second peak at ~4,
- Precipitation frequency increases from E_{auto} = 1 to 4 then keep relatively constant.

(c), (d)

- E_{auto} calculated from N_c only has a single mode at ~2. Average values similar as in (a) and (b) ,
- Precipitation frequency does not show similar patterns as in (a) and (b), decrease then increase.

3.2 $\left(\frac{\partial q_r}{\partial t}\right)_{auto}$ **1.07** $\left(\frac{\partial q_r}{\partial t}\right)_{accr}$



From $\left(\frac{\partial q_r}{\partial t}\right)_{auto}$ **:**

Model overestimates precipitation than observation, partially explain why model produce too frequent precipitation.

From $\left(\frac{\partial q_r}{\partial t}\right)_{accr}$ **:**

Model underestimates precipitation than observation, partially explain why model produce too light precipitation.

Regime-Dependent

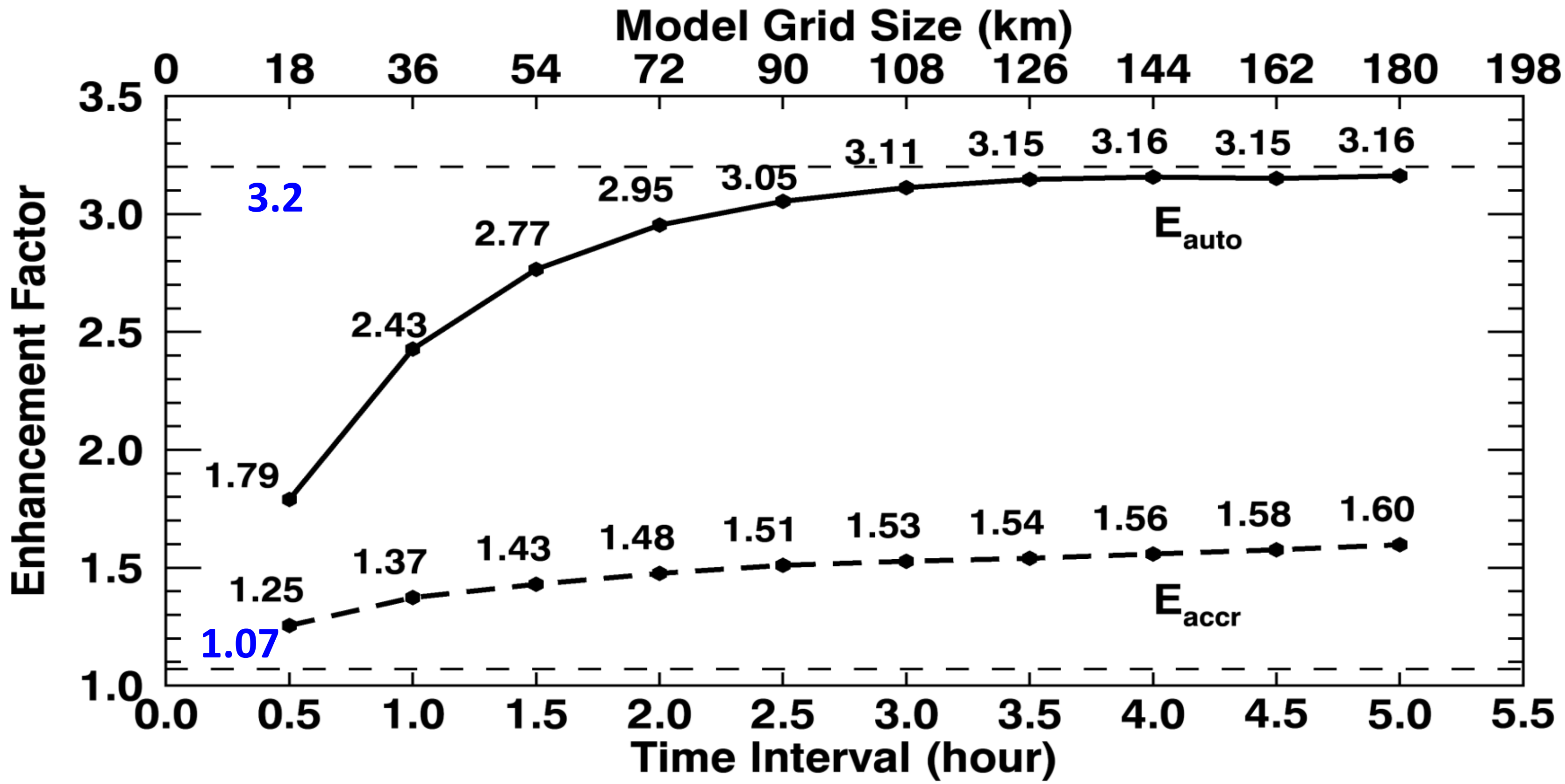
E_{auto}	Non-precip.	Precip.
LTS (K)	LWP ≤ 75 g m^{-2}	LWP > 75 g m^{-2}
> 18	2.31	2.58
(13.5, 18)	2.56	2.98
< 13.5	4.15	6.17

	E_{accr}	Non-precip.	Precip.
	LTS (K)	LWP ≤ 75 g m^{-2}	LWP > 75 g m^{-2}
Stable	> 18	1.40	1.49
Mid-stable	(13.5, 18)	1.43	1.63
Unstable	< 13.5	1.51	1.70

1. **Both enhancement factors increase when the boundary layer becomes less stable (more convections),**
2. **Both enhancement factors are larger in precipitating clouds than those in non-precipitating clouds.**

⇨ **Enhancement factors should be regime-dependent.**

Grid-size-Dependent



- E_{auto} ↑ with grid size till 108 km grid then remain relatively constant,
- E_{accr} keep ↑ from 18 km grid to 180 km grid,
- $E_{auto} < 3.2$ and $E_{accr} > 1.07$ should be used in GCMs.

- For finer resolutions, $E_{accr} \approx$ obs. but E_{auto} is too large → too frequent,
- For coarser resolutions, $E_{auto} \approx$ obs. but E_{accr} is too small → too light.

Summary

- **Too large E_{auto} → too frequent precipitation,**
- **Too small E_{accr} → too light precipitation,**
- **Both enhancement factors are regime-dependent (BL stability, CLWP, etc.),**
- **Values of enhancement factors also depend on model spatial resolution.**

Thank you
and welcome questions!

More details in poster session
Tues. 3:30 – 5:00 pm
 # A1-132