Improved diagnostics for UT cloud assessment in the LMDZ climate model

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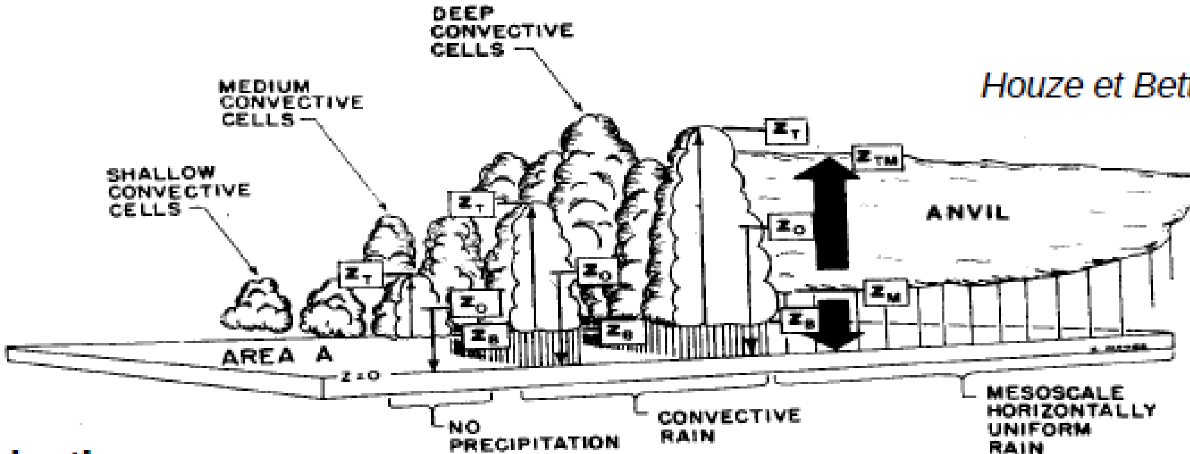
Parameterizations of convective systems in LMDZ

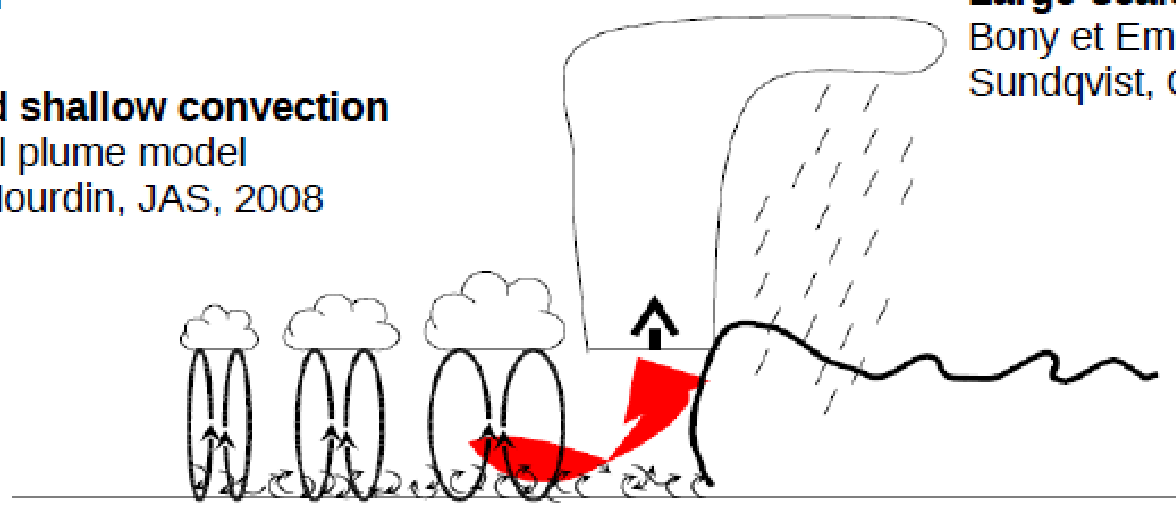


Houze et Betts, RGSP, 1981

Handled by three different parameterizations

Large-scale condensation
Bony et Emanuel, JAS, 2001
Sundqvist, QJRMS, 1978

Dry and shallow convection
Thermal plume model
Rio et Hourdin, JAS, 2008



Deep convection and associated cold pools
Emanuel, JAS, 1991 revisited by
Grandpeix et Lafore, JAS, 2010

C. Rio, UTCC PROES meeting
16 Nov 2015, Paris

High clouds in LMDZ

(1) Formed by large-scale advection and deep convection (anvils) ; in this latter case they depend on the detrainment of water vapor and maximum precipitation efficiency ε_{max}

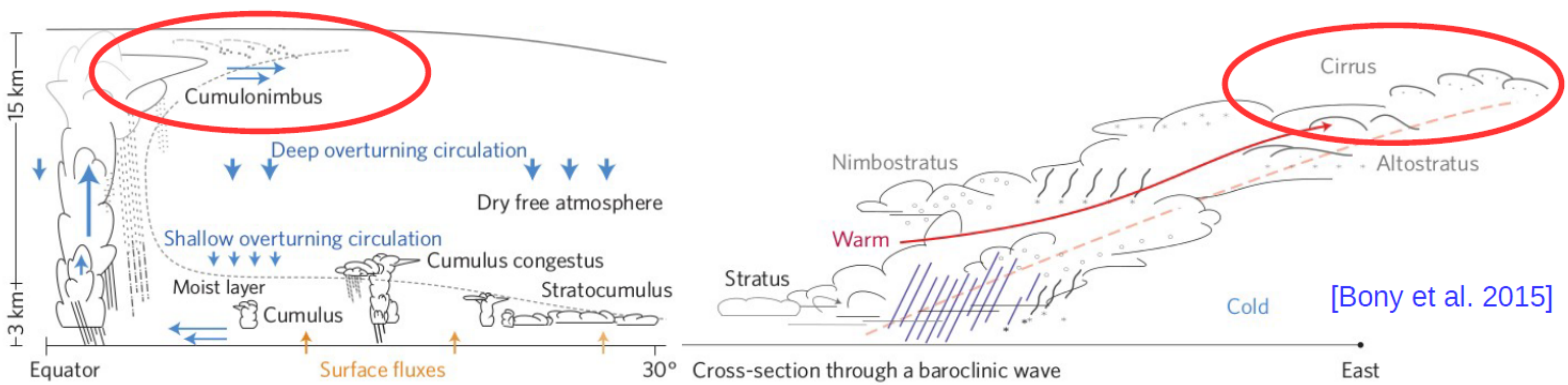
[Emanuel & Živković-Rothman 1999 ; Bony & Emanuel 2001; Rio et al. 2012 ; Grandpeix & Lafore 2010]

(2) Phase based on temperature using $x_{\text{liq}} = \left(\frac{T - T_{\text{ice}}}{T_0 - T_{\text{ice}}}\right)^{n_x}$

(3) Precipitation mass flux $(\rho w_{iw} q_{iw})$ computed using ice particle fall velocity

$w_{iw} = \gamma_{iw} w_0$ with $w_0 = 3.29(\rho q_{iw})^{0.16}$ and γ_{iw} a tuning coefficient

[Zender and Kiehl, 1997 ; Heymsfield and Donner, 1990]



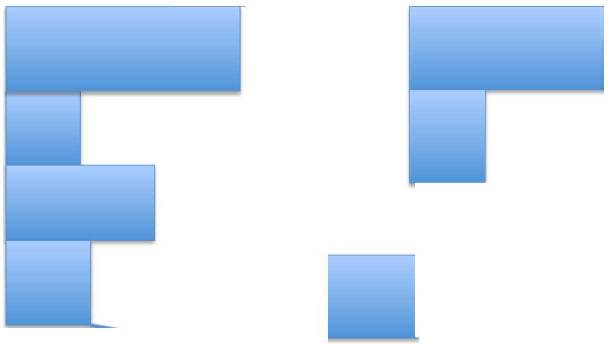
[Bony et al. 2015]

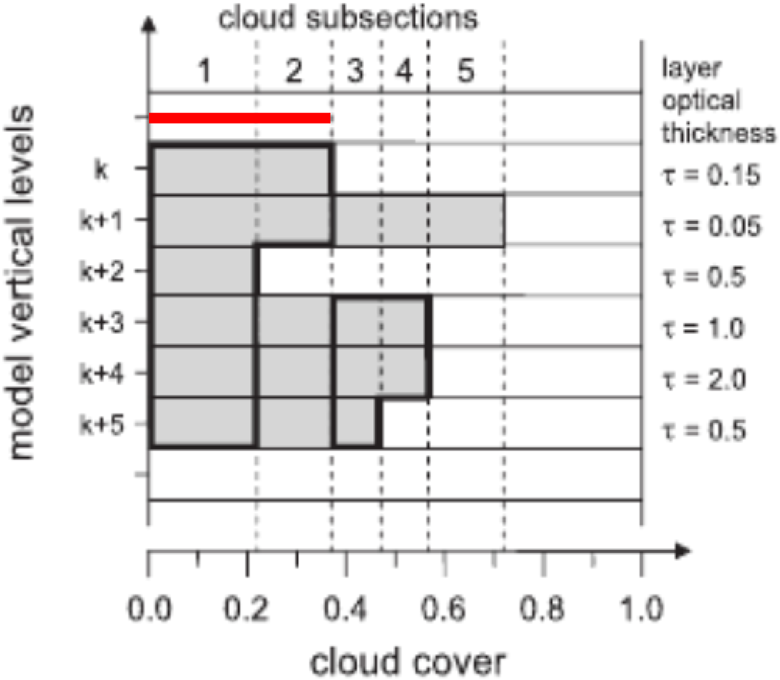
J.-B. Madeleine, UTCC PROES meeting
16 Nov 2015, Paris

Simulator of UT clouds from IR Sounders *(CIRS retrieval)*

(M. Bonazzola, C. Stubenrauch)

adapted from Hendricks et al., Meteorol. Z. 2010, Stubenrauch et al., J. Climate 1997





1) Construct clouds from vertically contigious cloud layers, assuming maximum overlap
2) Assume random overlap for distinct clouds
3) Each cloud divided into sub-sections of similar vertical structure
4) Determine cloud optical depth τ_{cld} per cloud
5) Cloud detection if $\Sigma\, \tau_i > 0.1$
6) p_{cld} corresponds to p_{cld} where τ_{cld} reaches 0.5
7) High-level clouds: $p_{cld} < 440$ hPa

-> total cloud cover, high cloud cover, p_{cld}, T_{cld}, ε_{cld}, z_{cld} (IWP & De)

also allows to distinguish between:

Cb area ($\varepsilon_{cld} > 0.95$)

cirrus (anvil) area ($0.5 < \varepsilon_{cld} < 0.95$)

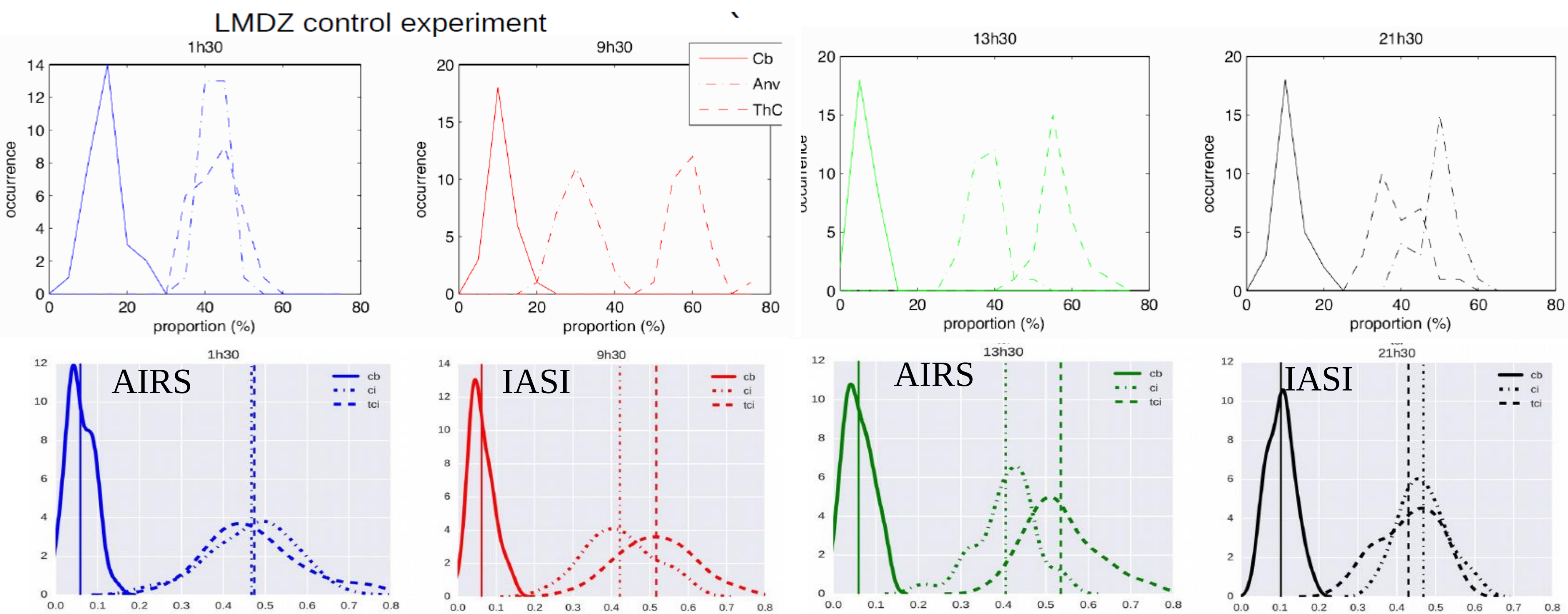
thin cirrus area ($0.1 < \varepsilon_{cld} < 0.5$)

Evaluation of UT clouds in LMDZ climate model

'simulator' of UT clouds

for evaluation of convection schemes / detrainment / microphysics in GCMs

comparison of diurnal cycle of Cb / Ci / thin Ci over Africa:



similar behaviour in LMDZ and in observations:
more thin Ci during day than during night

Next step: assess influence of different model parameters

Sensitivity tests on precip eff & ice fall speed

Control: epmax = 0.998, fallv = 0.67

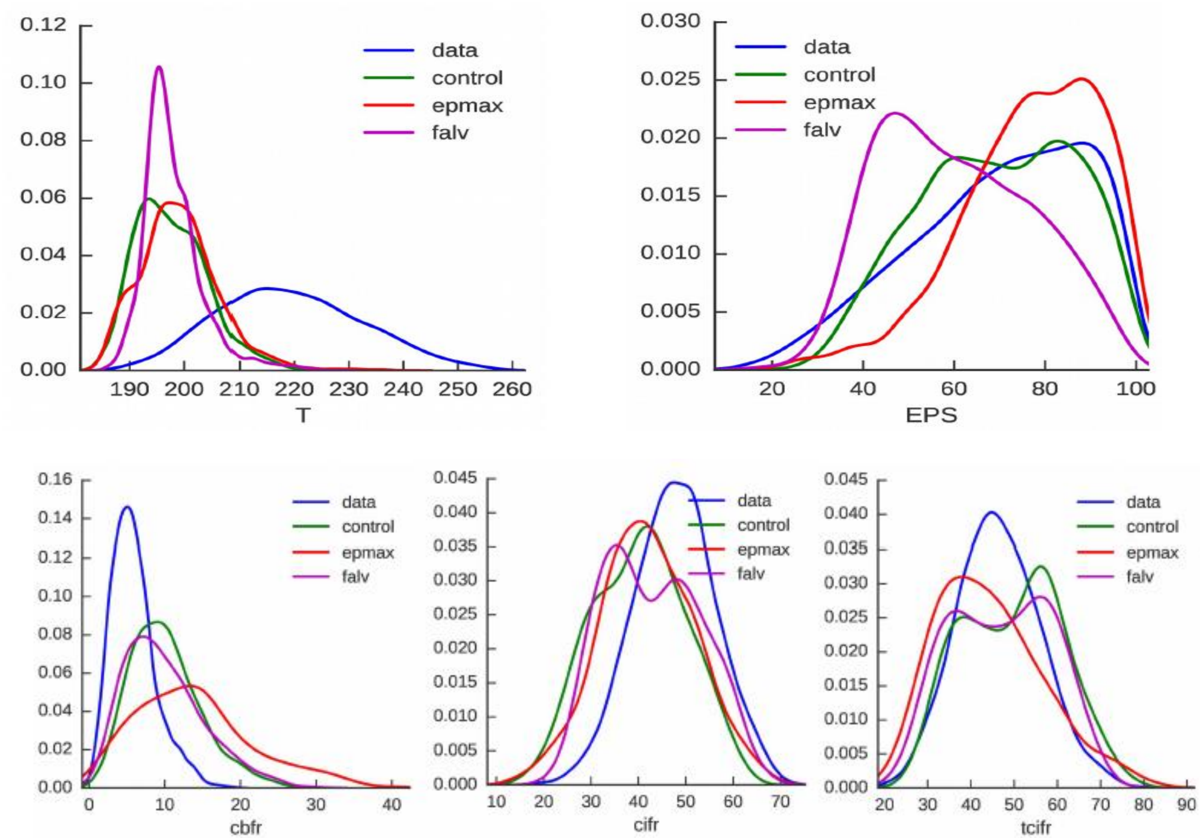
decrease precip efficiency (epmax = 0.995)

increase ice fall speed (fallv = 0.95)

AIRS/IASI

3 months statistics

very preliminary

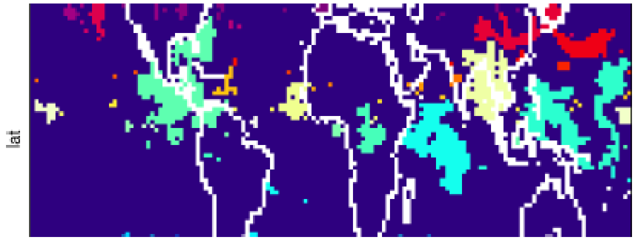


Model: T_{cld} smaller than data, average ε_{cld} in agreement

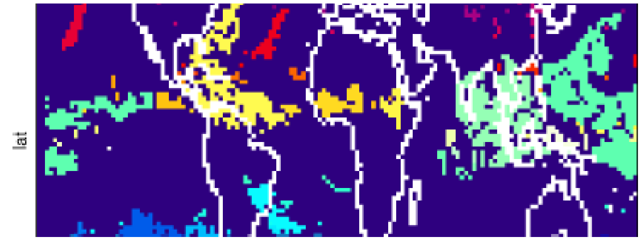
ε_{cld} increases / ε_{cld} decreases

UT cloud system approach

data

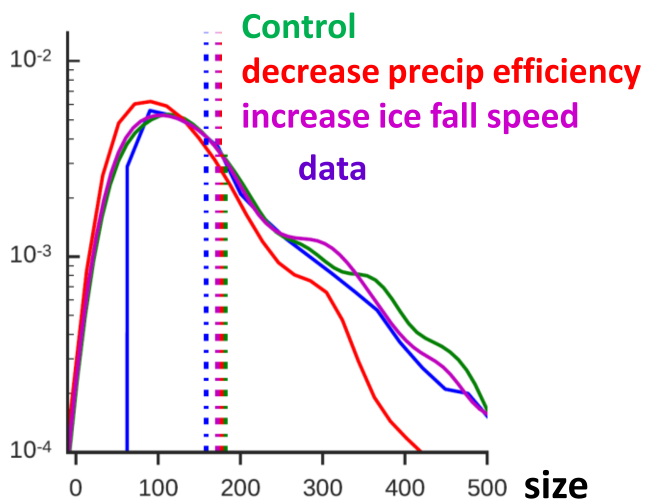


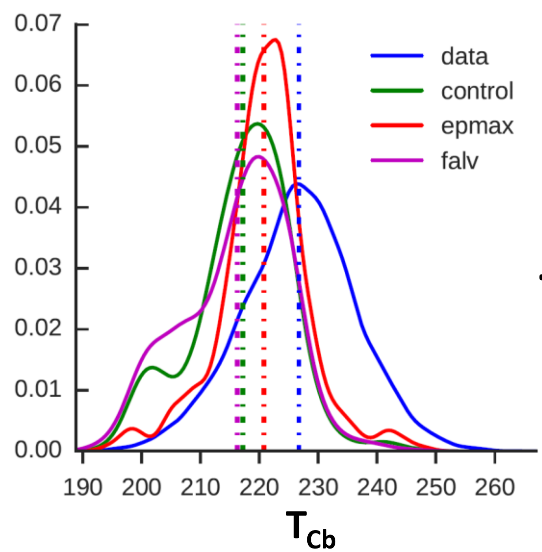
model

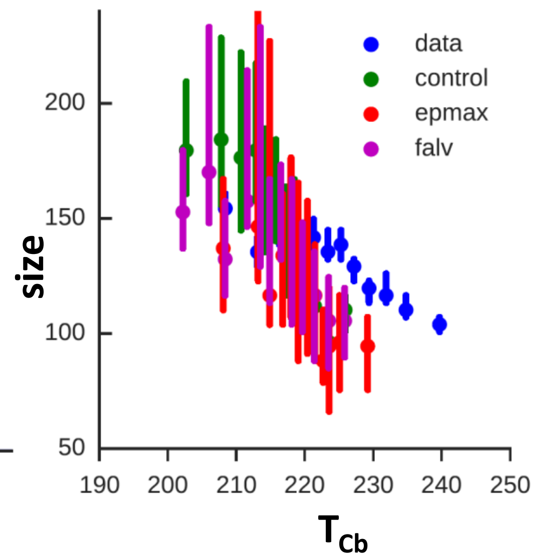


very preliminary
only 3 months statistics

Challenge: adapt approach to coarser spatial resolution (2.5° x 1.25°)







mature UT cloud systems

system size similar; system size decreases / increases

T_{cld} is smaller, a preliminary study also shows an increase of thin Ci/tot anvil when convection gets deeper

Conclusions & Outlook

- AIRS / IASI cloud simulator has been developed for LMDZ
  including partitioning of Cb / Ci / thin Ci
- Diurnal evolution of Cb / Ci / thin Ci can be evaluated with AIRS / IASI
- AIRS / IASI simulator will be integrated into COSP
- UT cloud system simulator has to be adapted to spatial resolution
- First preliminary results promising

Sensitivity tests on precip eff & ice fall speed

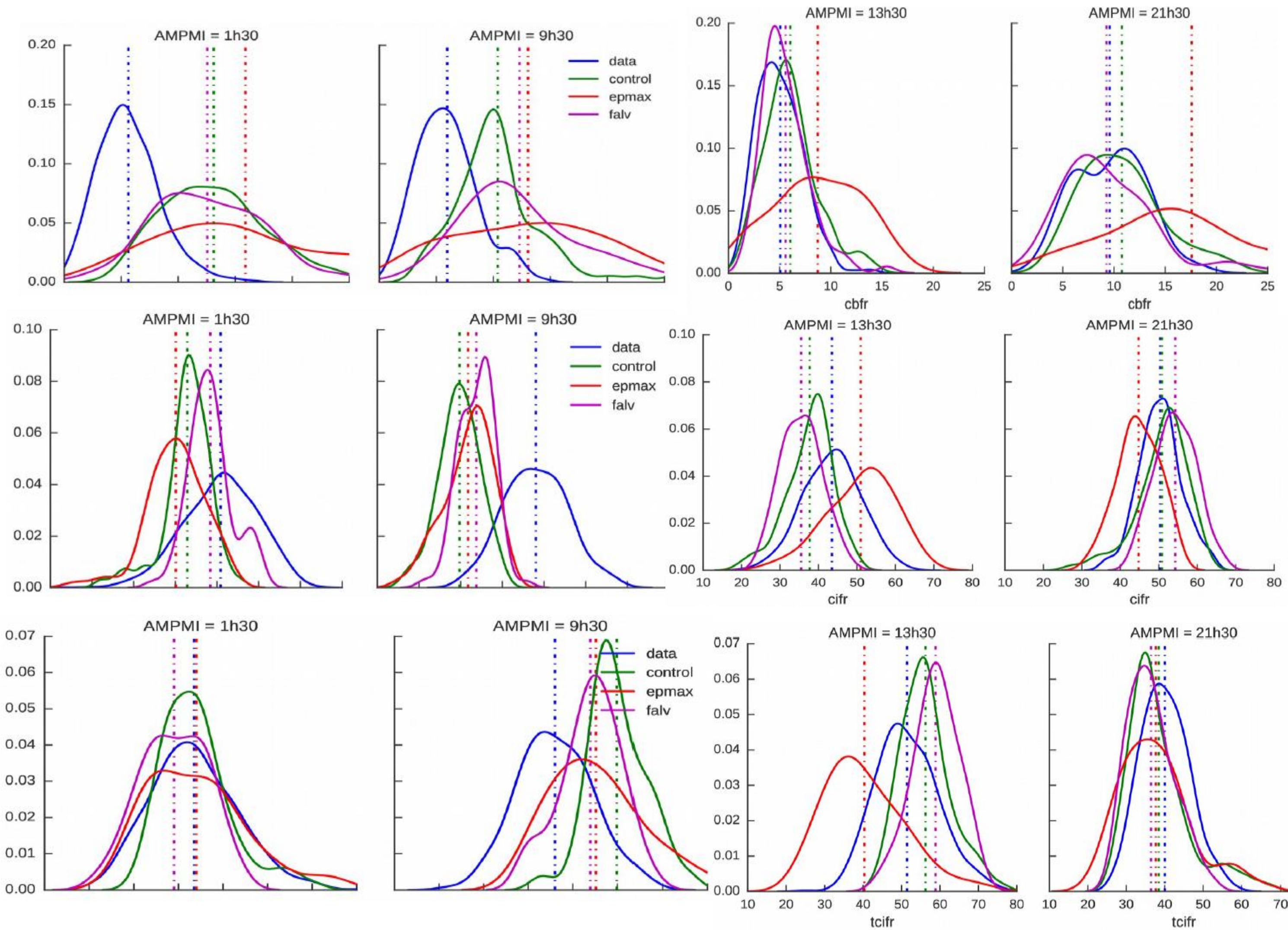
Control: epmax = 0.998, fallv = 0.67

Control1: **decrease precip efficiency** (epmax = 0.995)

Control2: **increase ice fall speed** (fallv = 0.95)

AIRS/IASI

3 months statistics



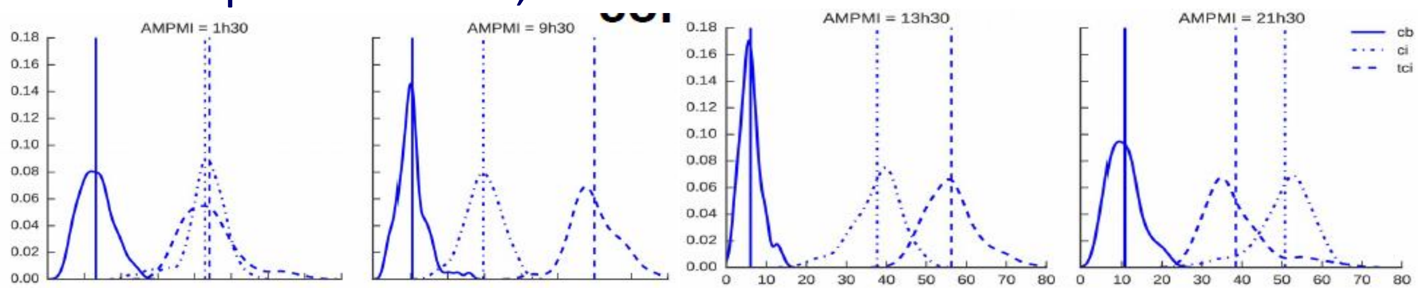
during day slightly less Ci & more thin Ci

increase of Cb, afternoon: increase of Ci & decrease of th Ci (more ice in UT)

morning: increase of Ci, decrease of th Ci afternoon opposite

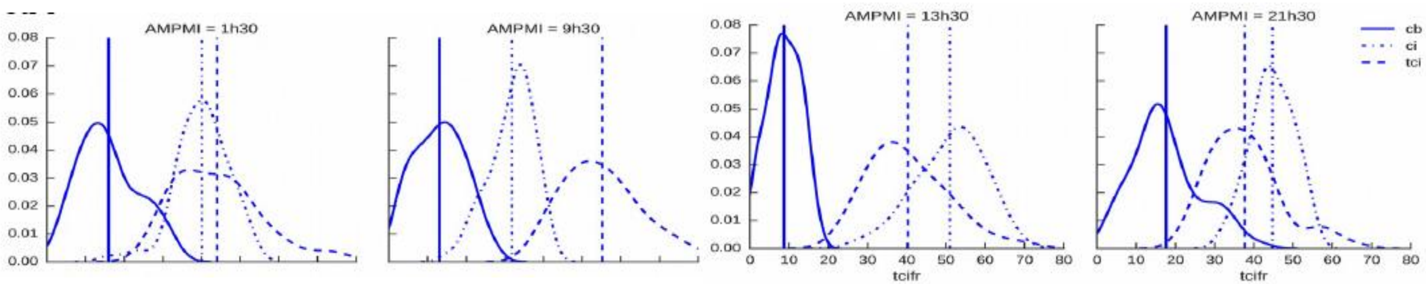
Sensitivity tests on precip eff & ice fall speed

Control: epmax = 0.998, fallv = 0.67



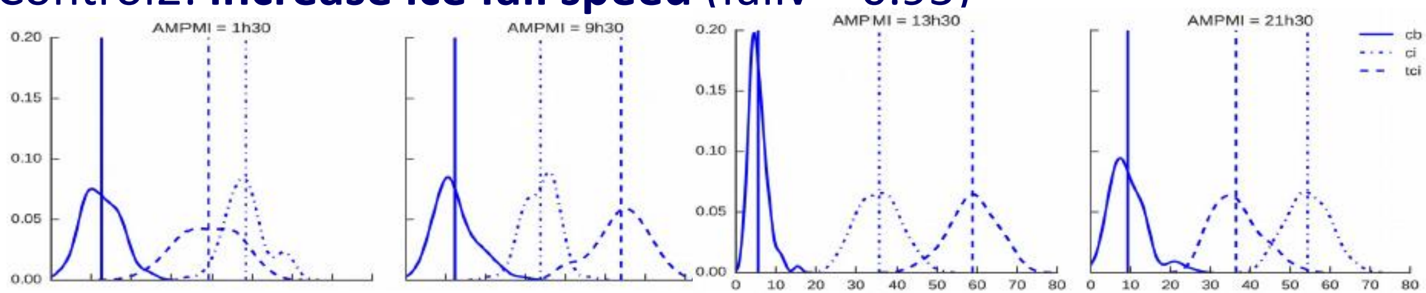
during day slightly less Ci in model compared to data

Control1: **decrease precip efficiency** (epmax = 0.995)

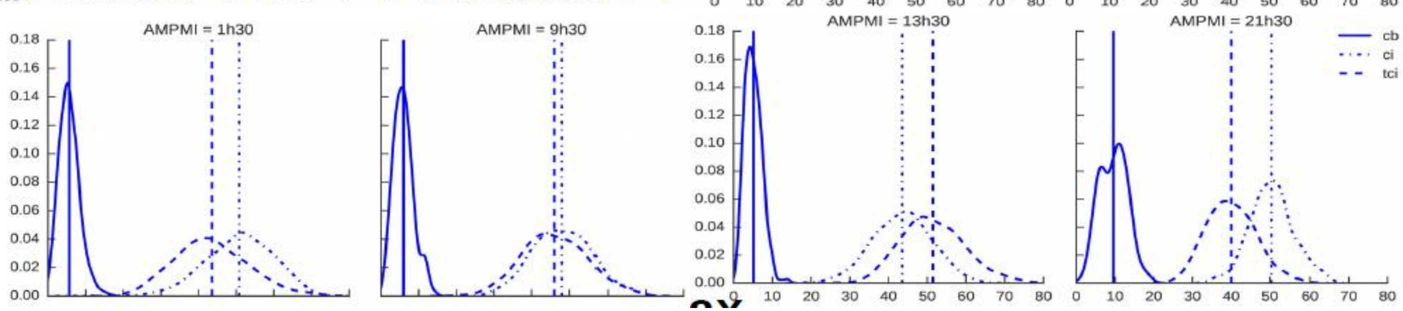


increase of Cb (more ice in UT)

Control2: **increase ice fall speed** (fallv = 0.95)



increase of th Ci, decrease of Cb



AIRS/IASI

3 months statistics