Convective invigoration: Untangling CCN impacts on deep convection

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saturation adjustment:
"cold" invigoration?

Untangling Microphysical Impacts on Deep Convection Applying a Novel Modeling Methodology

JAS 2015

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saturation prediction:
"warm" and "cold" invigoration?

JAS 2016

Untangling Microphysical Impacts on Deep Convection Applying a Novel Modeling Methodology. Part II: Double-Moment Microphysics

WOJCIECH W. GRABOWSKI AND HUGH MORRISON

Do Ultrafine Cloud Condensation Nuclei Invigorate Deep Convection?

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JAS 2020

Reply to "Comments on 'Do Ultrafine Cloud Condensation Nuclei Invigorate Deep Convection?'"

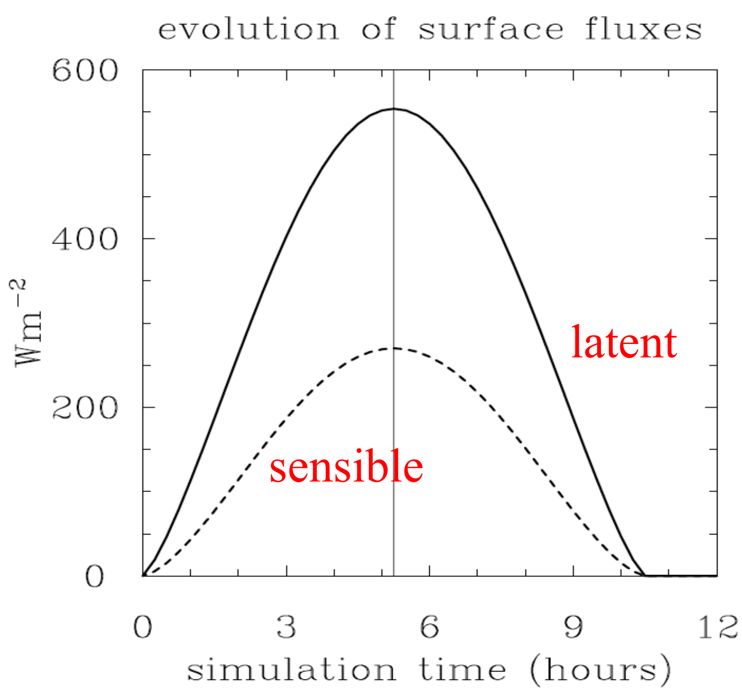
WOJCIECH W. GRABOWSKI[a] AND HUGH MORRISON[a]

JAS 2021

Q. J. R. Meteorol. Soc. (2006), **132**, pp. 317–344 doi: 10.1256/qj.04.147

Daytime convective development over land: A model intercomparison based on LBA observations

By W. W. GRABOWSKI[1]*, P. BECHTOLD[2], A. CHENG[3], R. FORBES[4], C. HALLIWELL[4], M. KHAIROUTDINOV[5], S. LANG[6], T. NASUNO[7], J. PETCH[8], W.-K. TAO[6], R. WONG[8], X. WU[9] and K.-M. XU[3]



Daytime development of scattered ("popcorn") deep convection based on observations in Amazonia…

Adv. Geosci., 49, 105–111, 2019
https://doi.org/10.5194/adgeo-49-105-2019

Advances in Geosciences
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Separating physical impacts from natural variability using piggybacking technique

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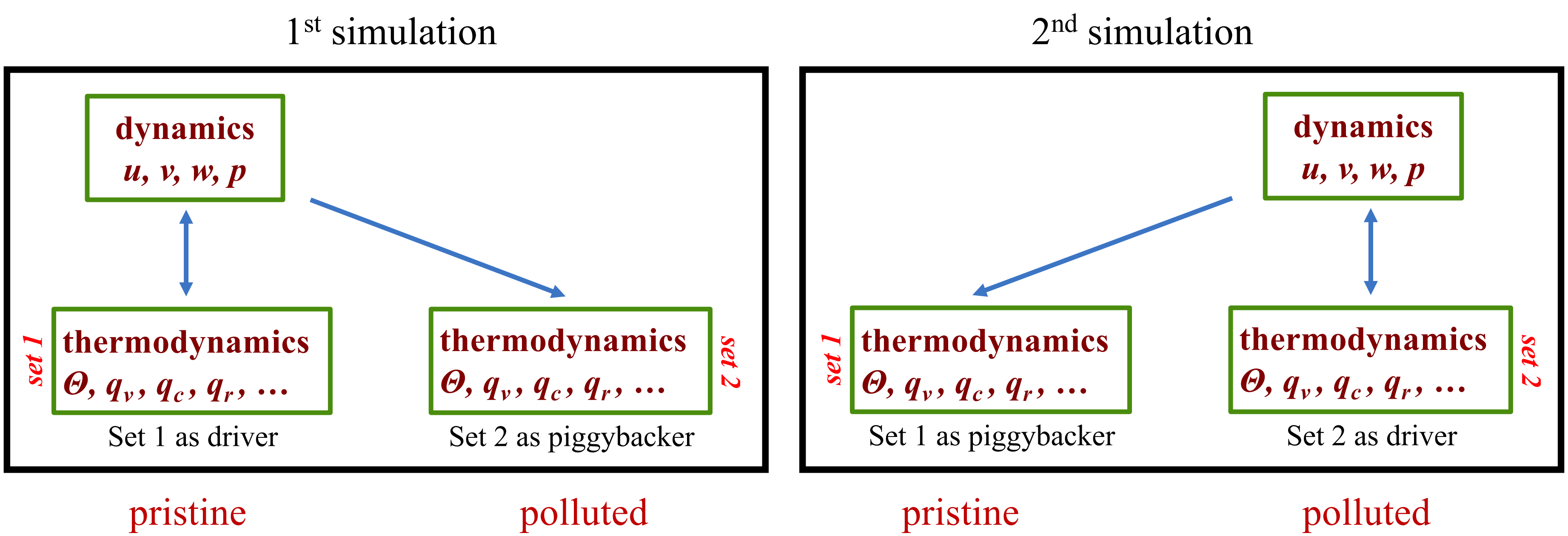
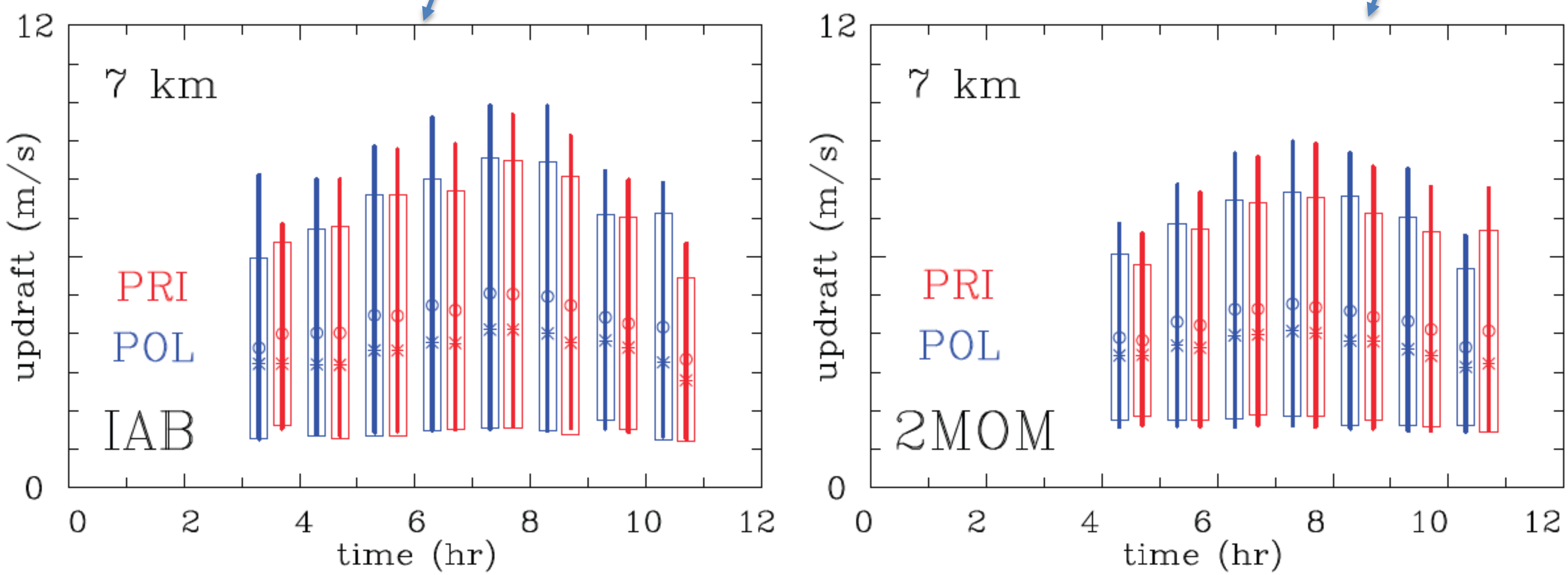


“Cold” invigoration test:

Comparing updraft statistics at 7 km for cloud field simulations applying saturation adjustment (i.e., S=0) with similar simulations with S prediction.



Hour-by-hour statistics of convective updrafts:

circle – mean, star – median

box – standard deviation

line – 10 to 90 percentile

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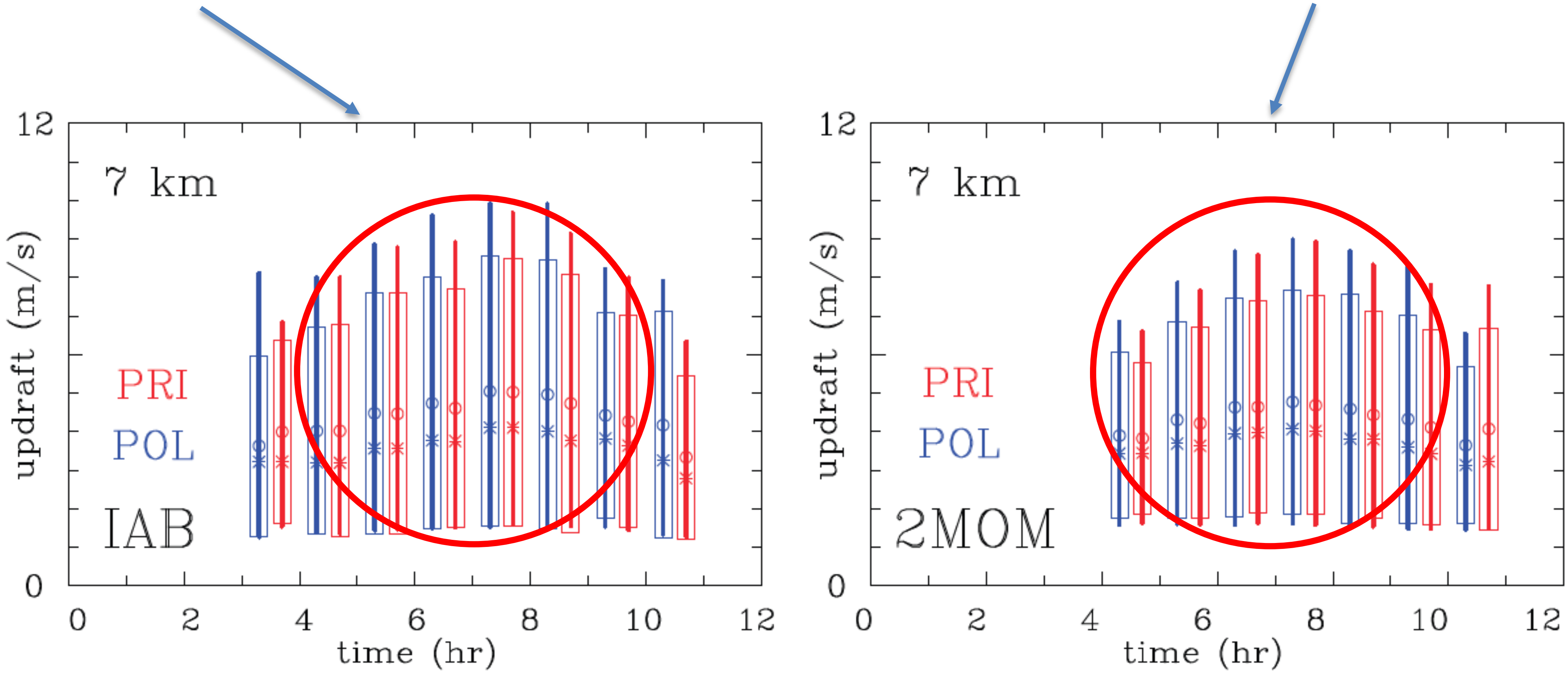
“Cold” invigoration test:

Comparing updraft statistics at 7 km for cloud field simulations applying saturation adjustment (i.e., S=0) with similar simulations with supersaturation prediction.



- small difference for mean updraft statistics and no difference between PRI and POL;
- some impact on the strongest updrafts between saturation adjustment and saturation prediction ensembles…

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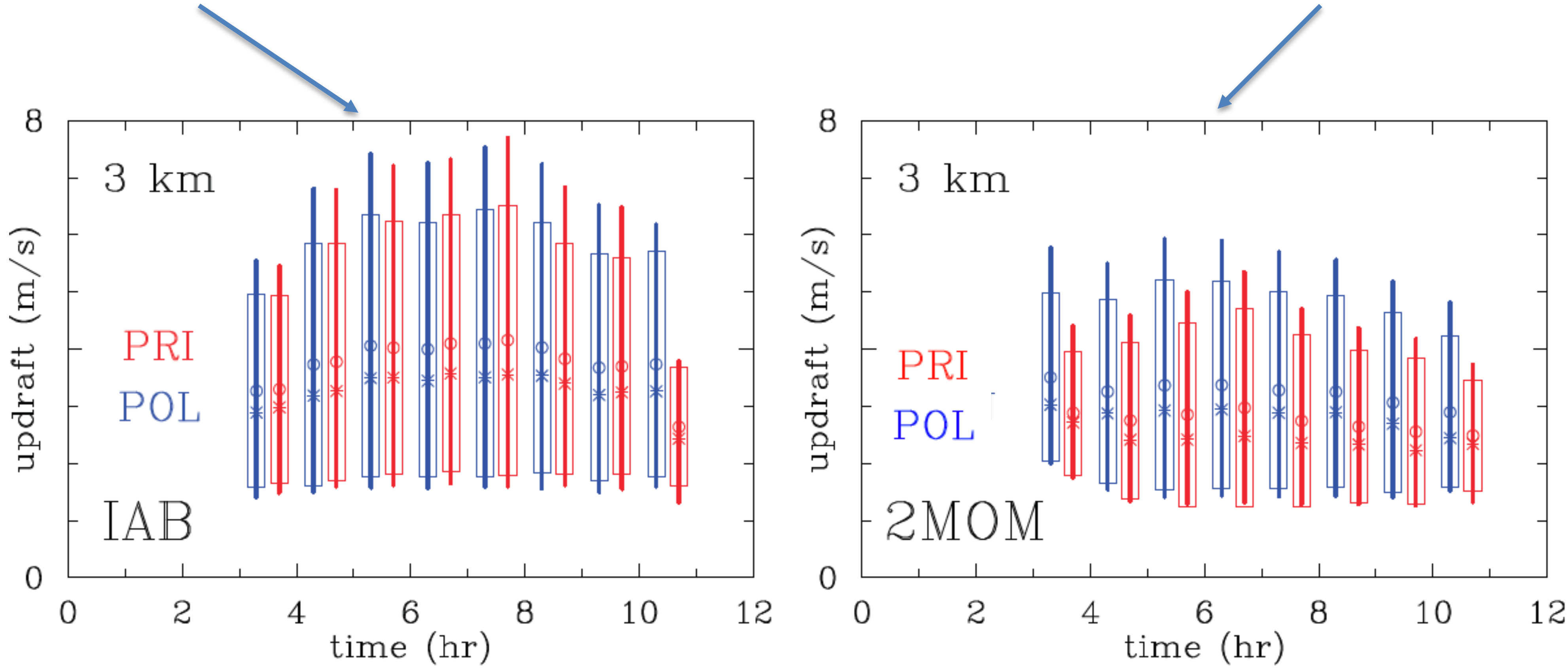
“Warm” invigoration test:

Comparing updraft statistics at 7 km for cloud field simulations applying saturation adjustment (i.e., S=0) with similar simulations with supersaturation prediction.



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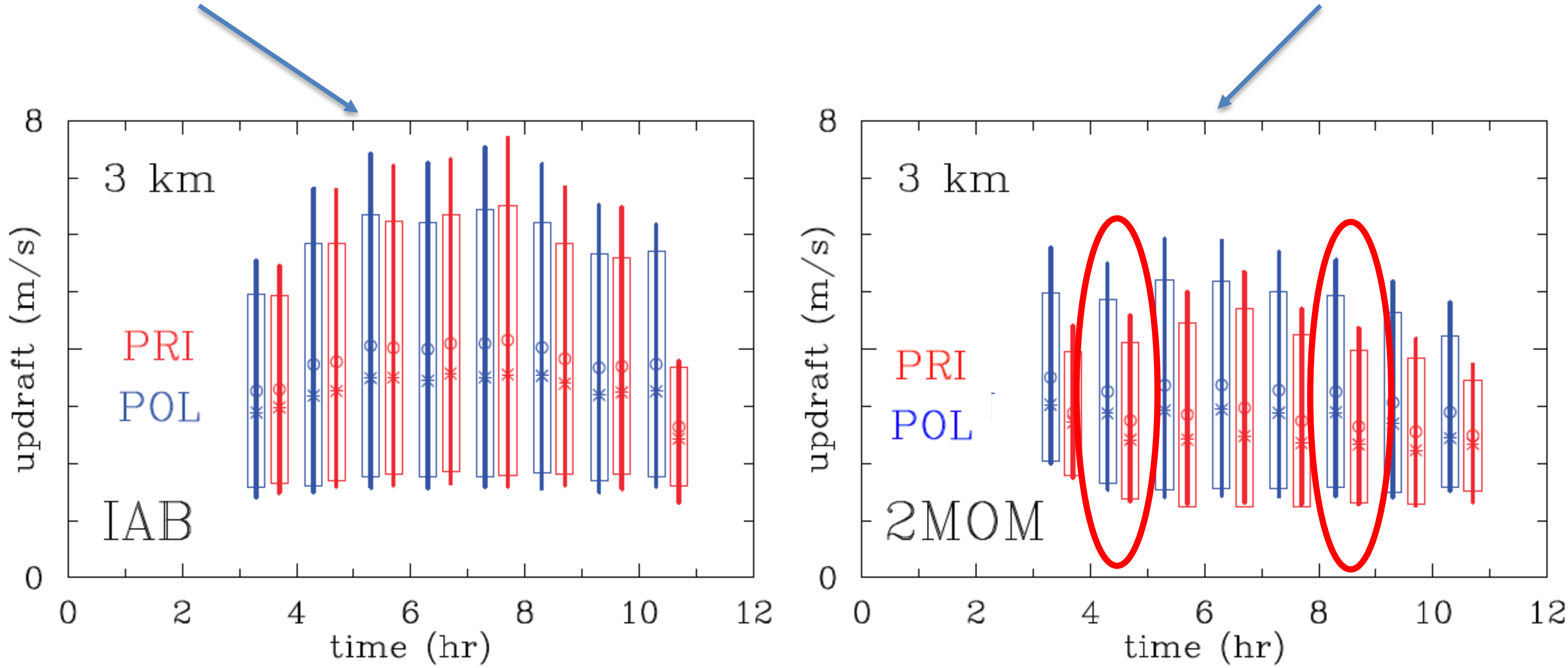

- weaker updrafts with supersaturation prediction;
- pristine (higher S) have noticeable weaker updrafts compared to polluted (lower S).

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PRI vs POL simulations in Grabowski and Morrison (2016) and PRIS vs ADCN in Grabowski and Morrison (2020) with double-moment bulk scheme:

- **small modification of the cloud dynamics in the warm-rain zone due to differences in the supersaturation field;**

- **no invigoration above the freezing level;**

- **significant *microphysical* impact on convective anvils: higher droplet concentrations leading to higher ice concentrations, small ice terminal velocities and longer anvil life times.**