Impact of Microphysics Complexity on Surface Precipitation Characteristics in CCLM

Kwinten Van Weverberg[1], Erwan Brisson[2], Philippe Marbaix[1], Jean-Pascal van Ypersele[1]

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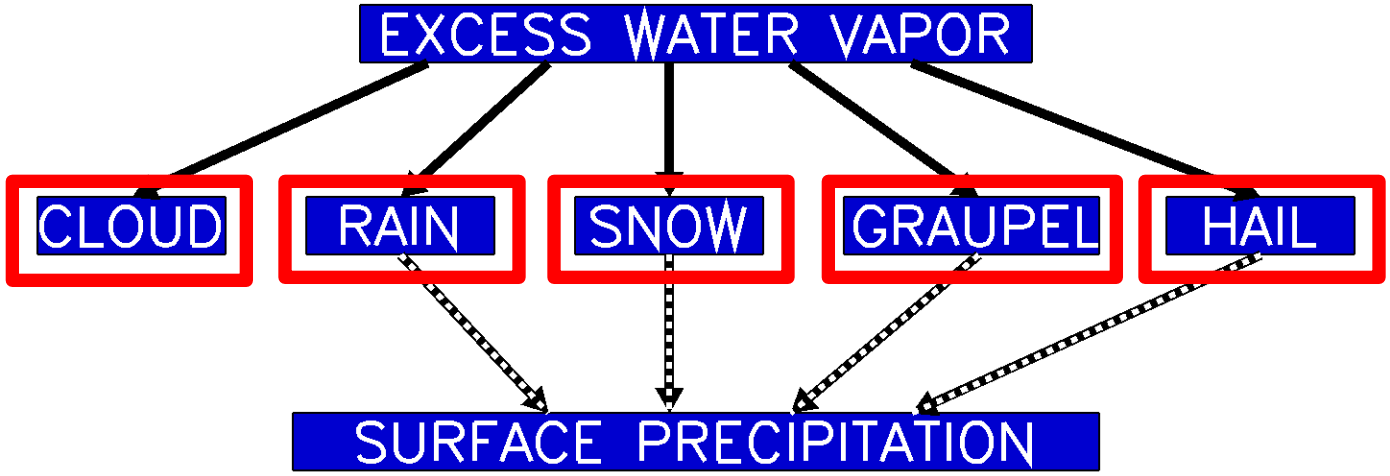
[1]Georges Lemaître Centre for Earth and Climate Research, UCL, Belgium
[2]Earth and Environmental Sciences KULeuven, Belgium

Acknowledgments: Uli Blahak, Axel Seifert, Edouard Goudenhoofdt

Motivation

High resolution climate simulations of deep convection:

- Explicit vertical transport of convective mass and heat
- Increasing importance of microphysics parameterization



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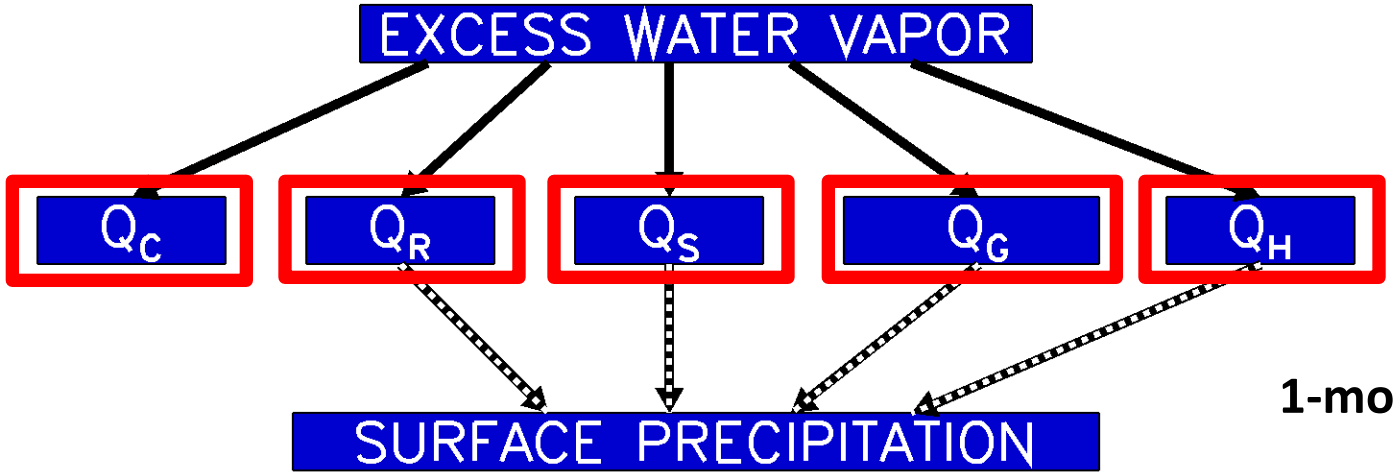

1-moment

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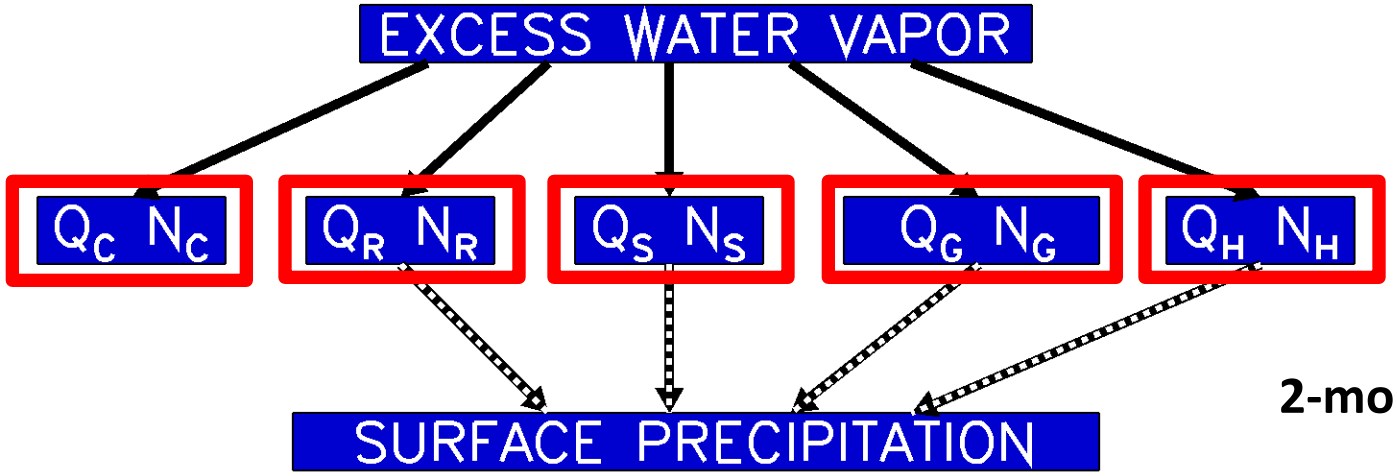

2-moment

Motivation

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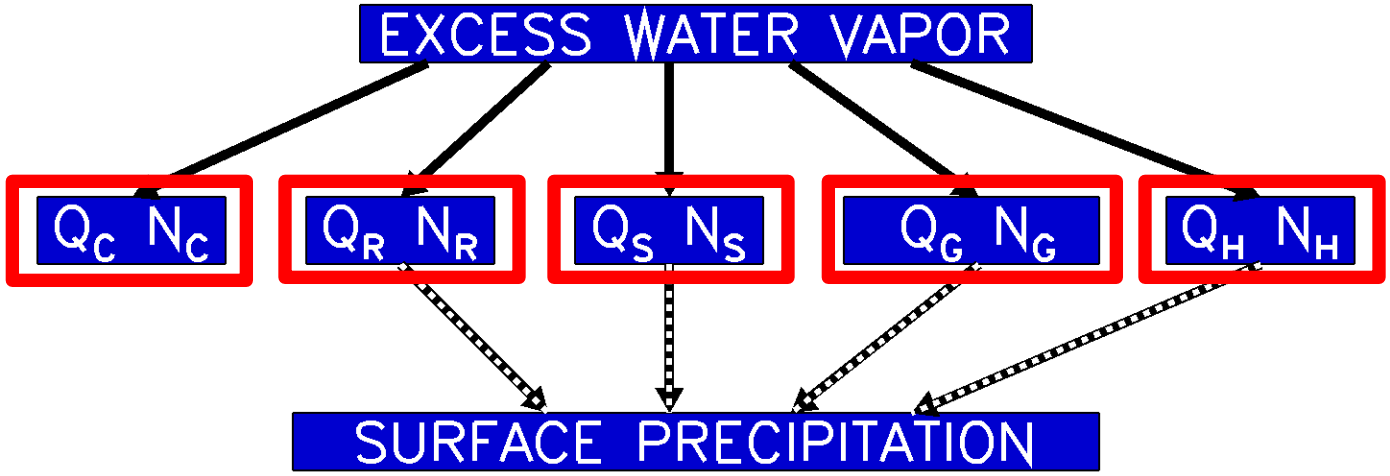


What is the added value of using more complex schemes?

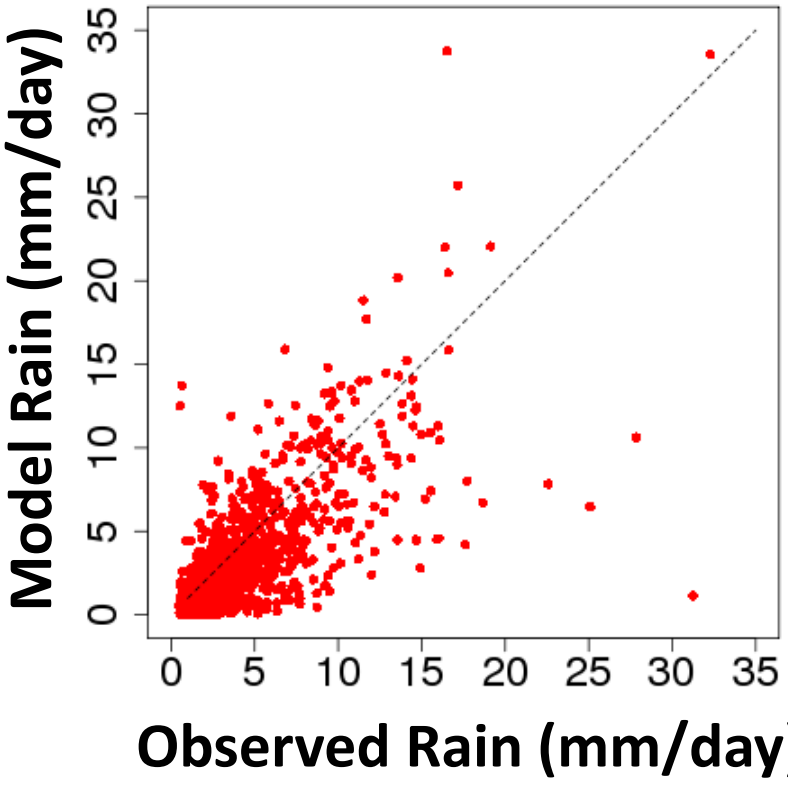
Composite of Representative Cases

Case selection

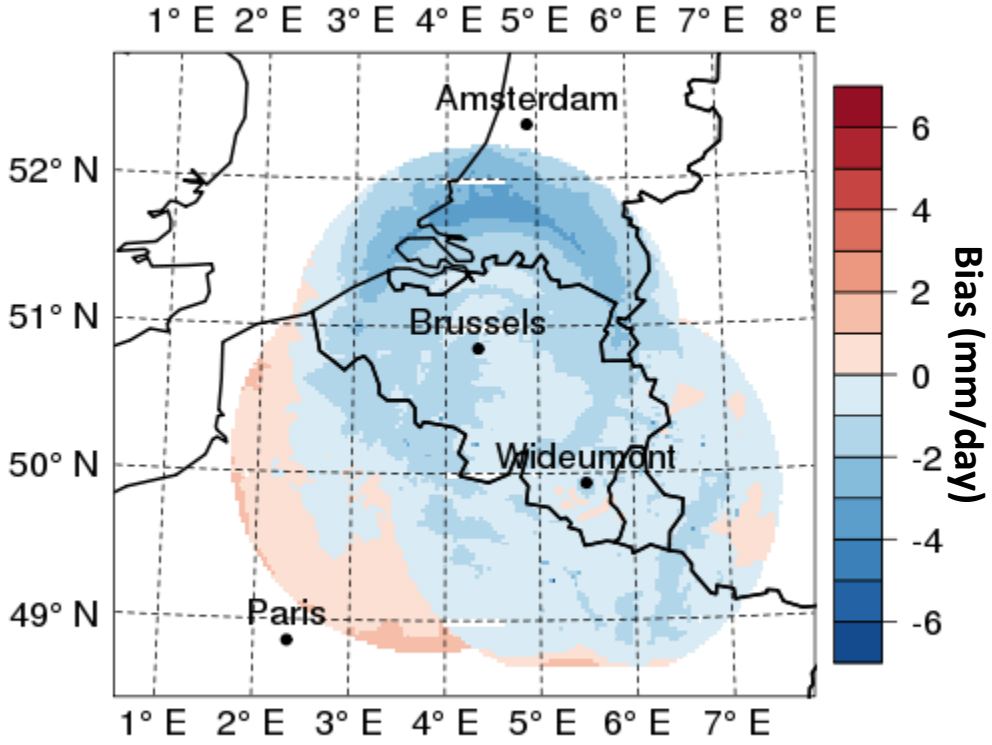
Composite of Representative Cases

10-year climate simulation, driven by ERA-Interim (2000-2010)

Daily Accumulations



Daily Bias (wet days only): -0.8 mm (-20 %)



Data: Brisson (KULeuven) and Goudenhoofdt (RMI)

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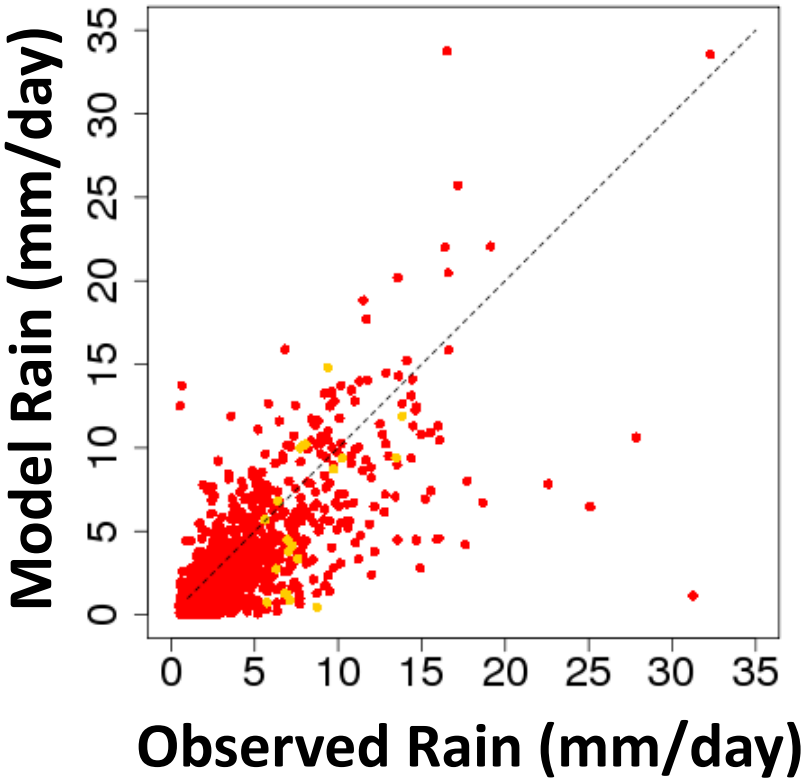


Selection of 20 representative cases of deep convection:

1. Convective:

- **Mean: > 5mm/day**
- **Peak: > 50 mm/day**
- **> 50 different SAL objects ('spotted' precipitation field)**

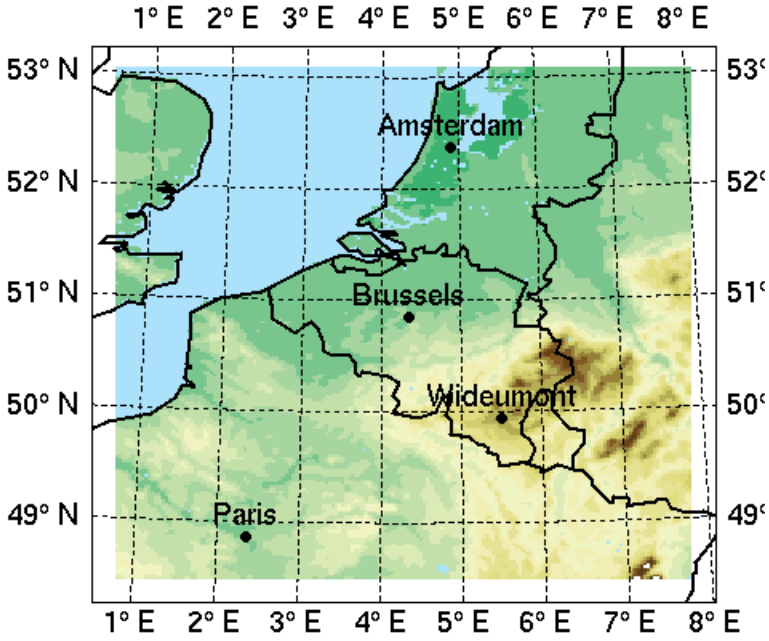
2. Enough Radars available

Data: Brisson (KULeuven) and Goudenhoofdt (RMI)

Model Settings of Representative Cases

Convection Resolving Simulation of 20 cases:

- Cosmo4.8_clm11
- Seifert and Beheng (2006) 2-moment microphysics and 'emulated' 1-moment microphysics scheme
- Two nests, driven by ERA-INTERIM
- Smallest domain: 192 ×175 grid points, 2.8 km grid spacing



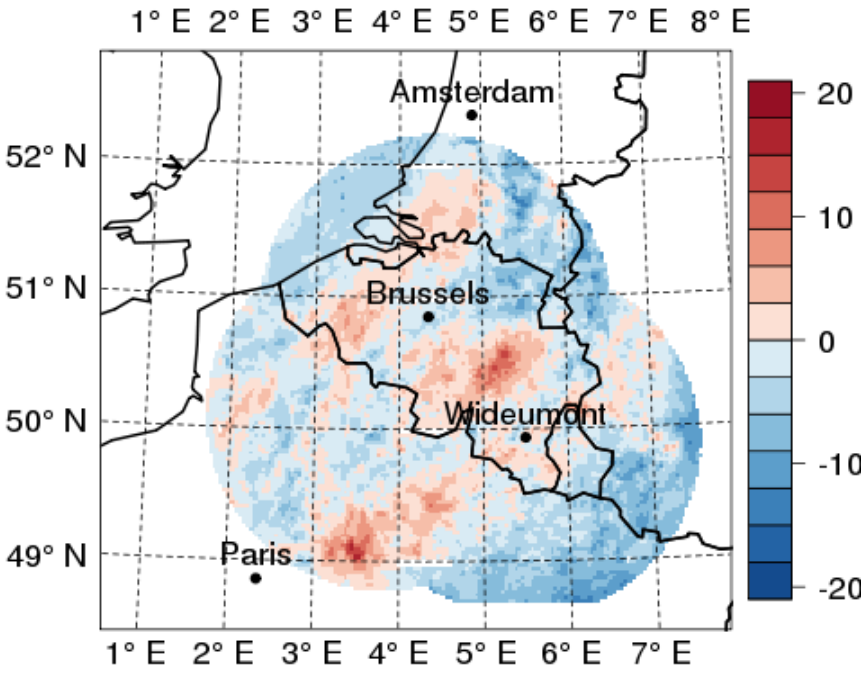
Number of Prognostic Moments

1-moment versus 2-moment scheme

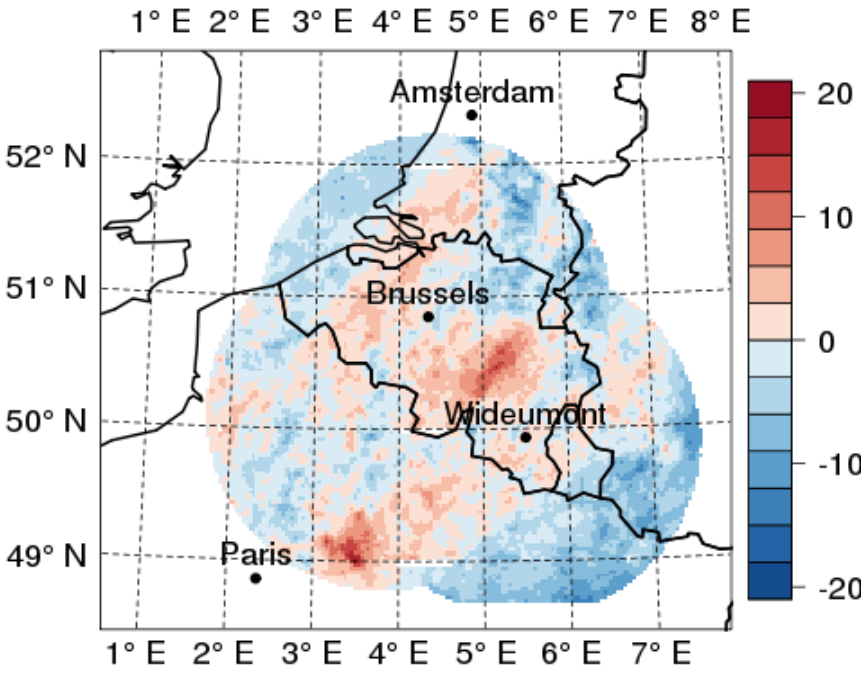
Number of Prognostic Moments

2 experiments: 1- and 2-moment scheme: Daily mean bias

1-moment: -1.7 mm (-22%)



2-moment: -1.2 mm (-16%)

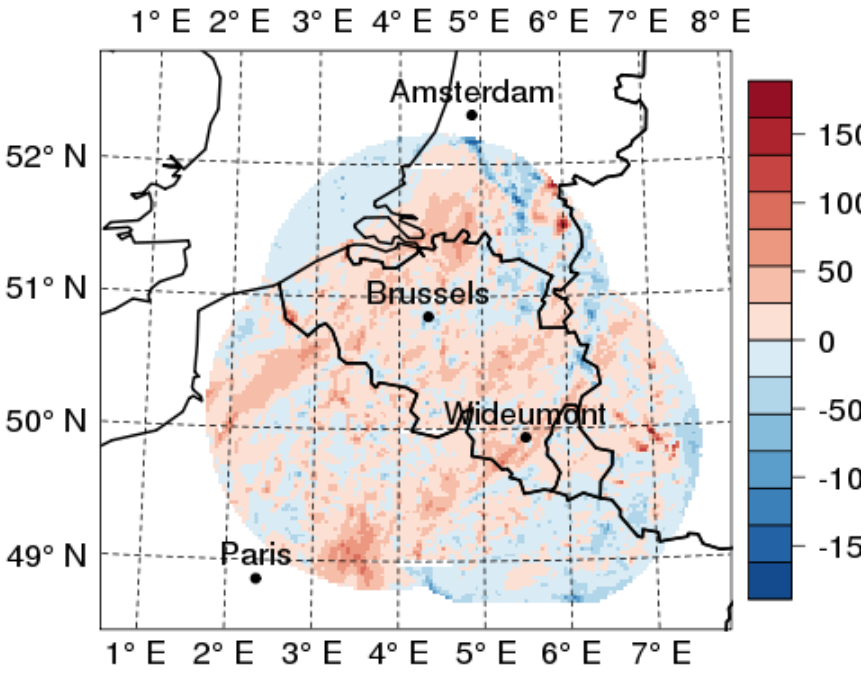


All cases

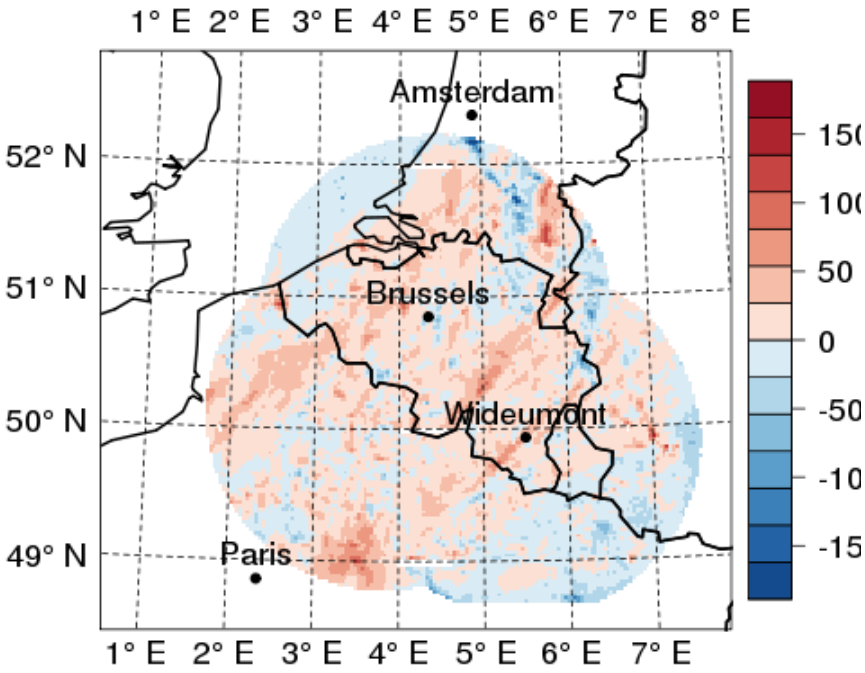
Number of Prognostic Moments

2 experiments: 1- and 2-moment scheme: Daily maximum bias

1-moment: +6.1 mm (+20%)



2-moment: +6.6 mm (+22%)



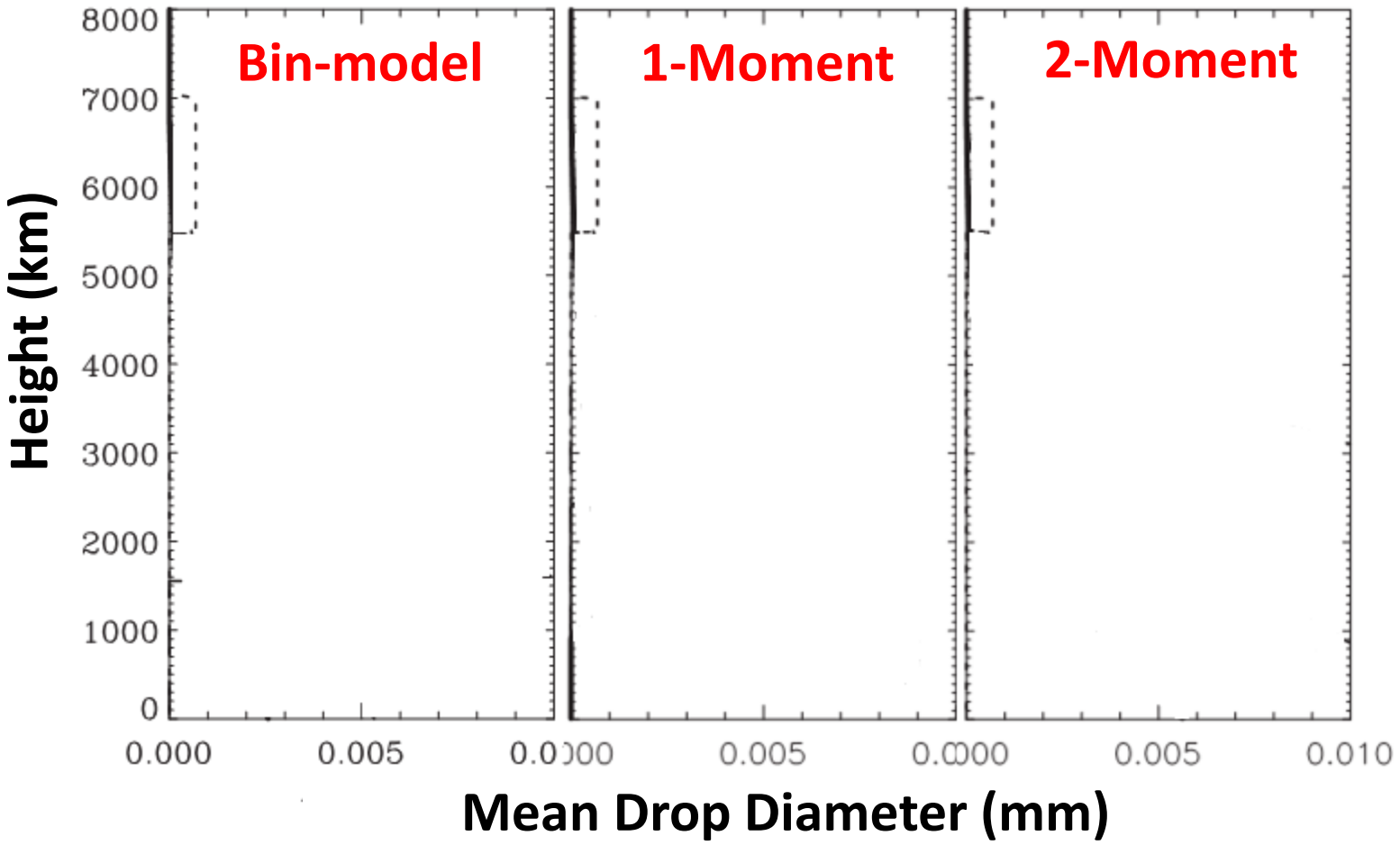
All cases

Number of Prognostic Moments

2 experiments: 1- and 2-moment scheme: Theory on size sorting

Time = 0

Milbrandt and McTaggert-Cowan 2010

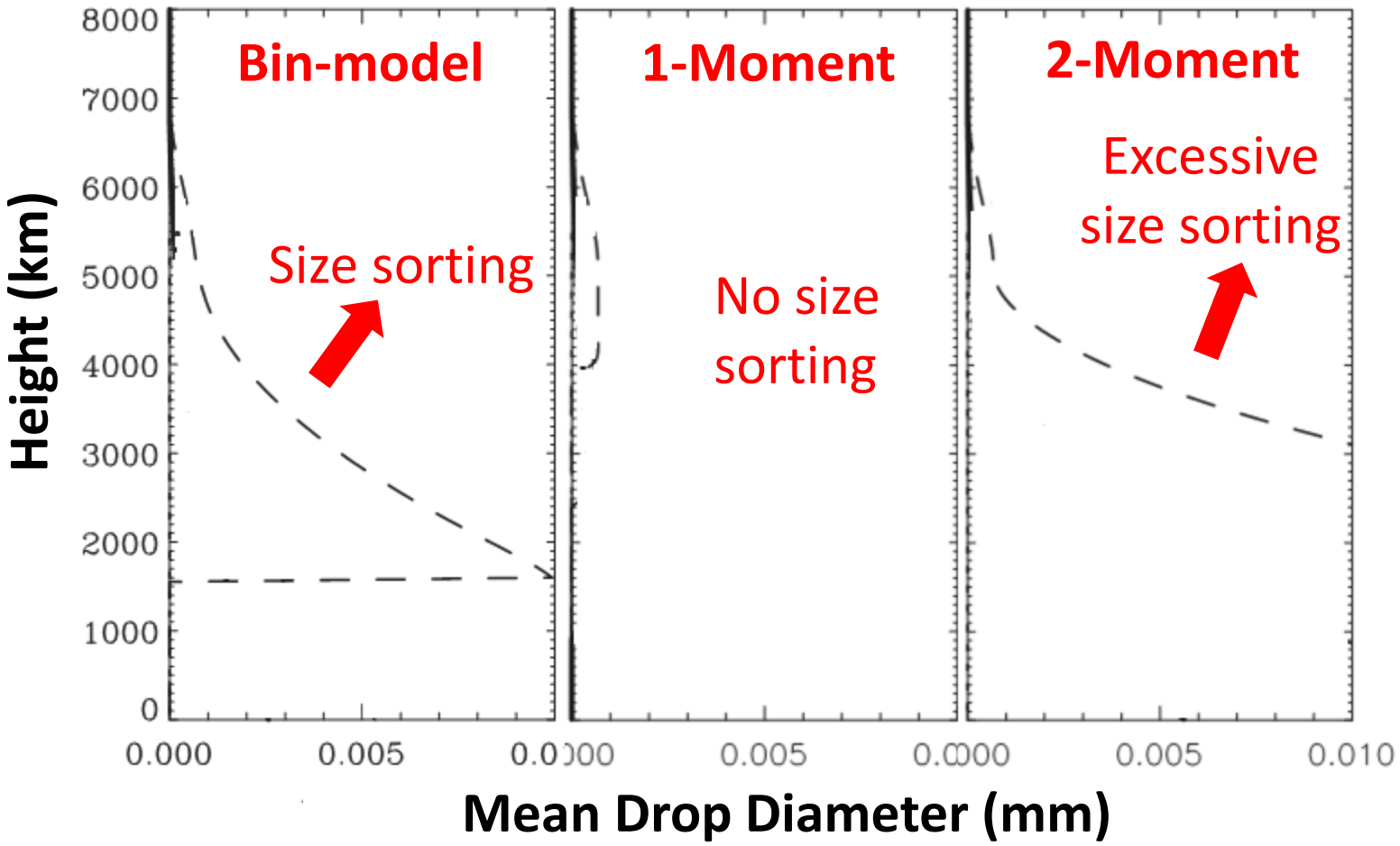


Number of Prognostic Moments

2 experiments: 1- and 2-moment scheme: Theory on size sorting

Time = 1

Milbrandt and McTaggert-Cowan 2010

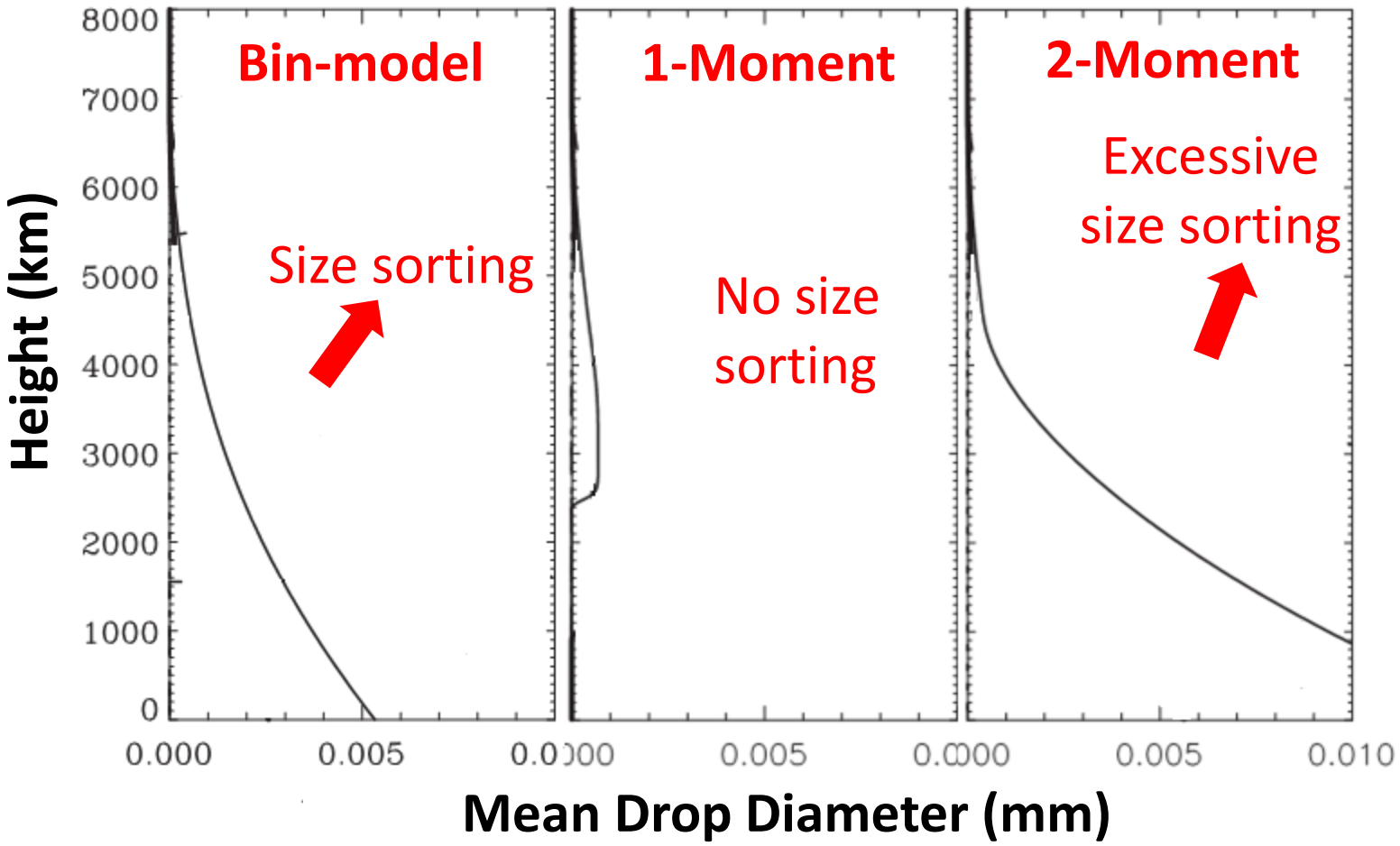


Number of Prognostic Moments

2 experiments: 1- and 2-moment scheme: Theory on size sorting

Time = 2

Milbrandt and McTaggert-Cowan 2010

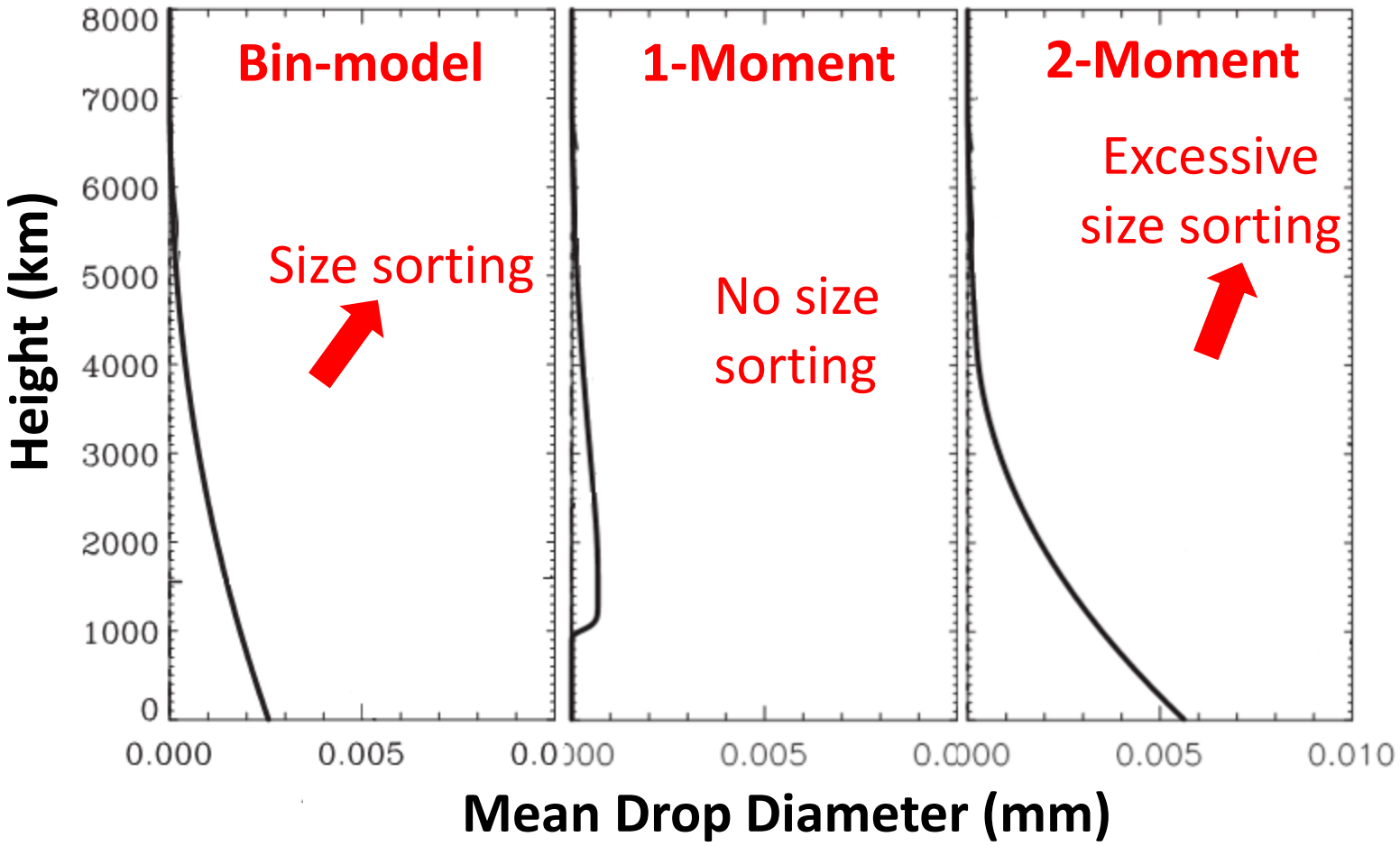


Number of Prognostic Moments

2 experiments: 1- and 2-moment scheme: Theory on size sorting

Time = 3

Milbrandt and McTaggert-Cowan 2010



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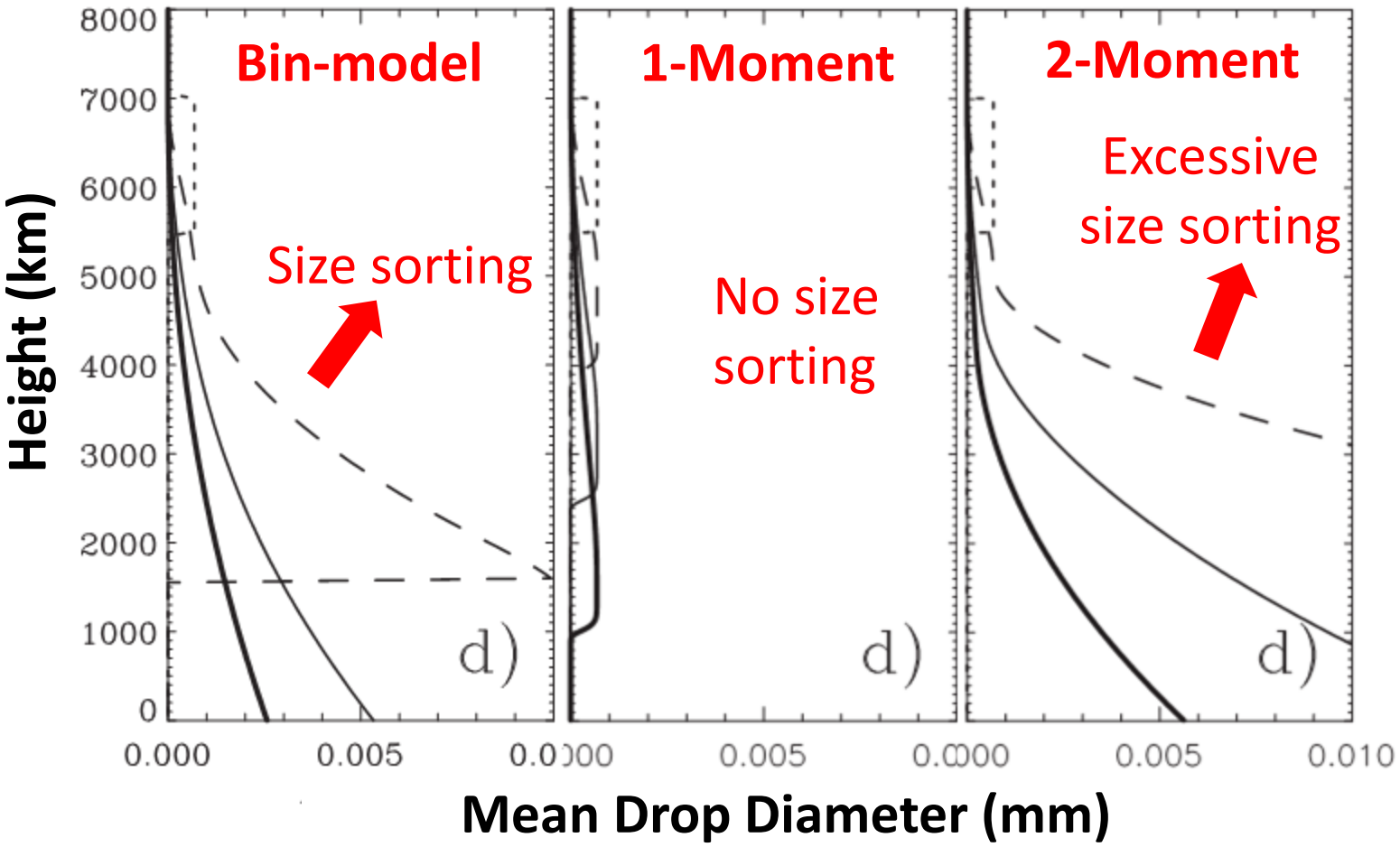
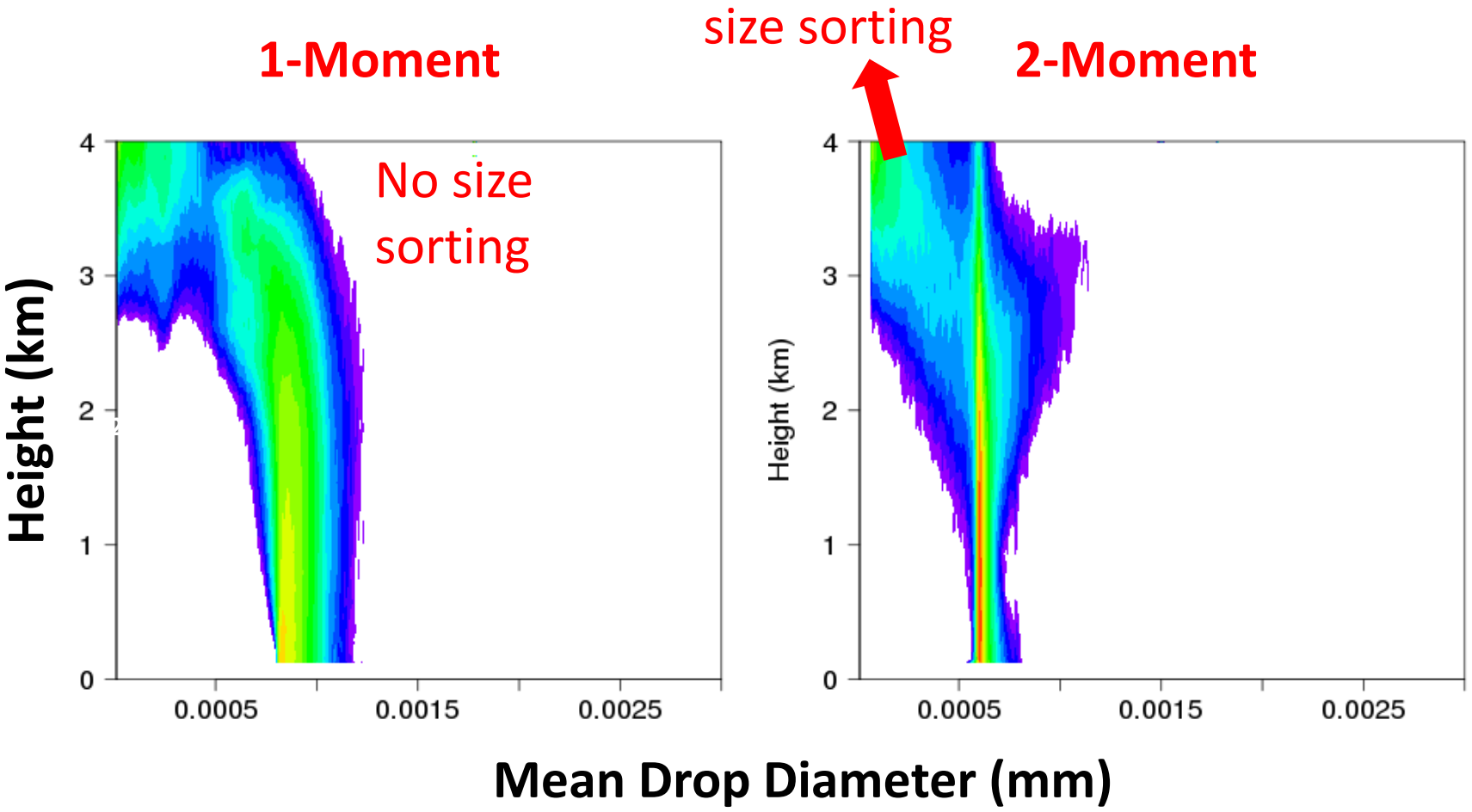


Number of Prognostic Moments

2 experiments: 1- and 2-moment scheme: Raindrop sizes



All cases, Surface rain > 10 mm/h!

Number of Prognostic Moments

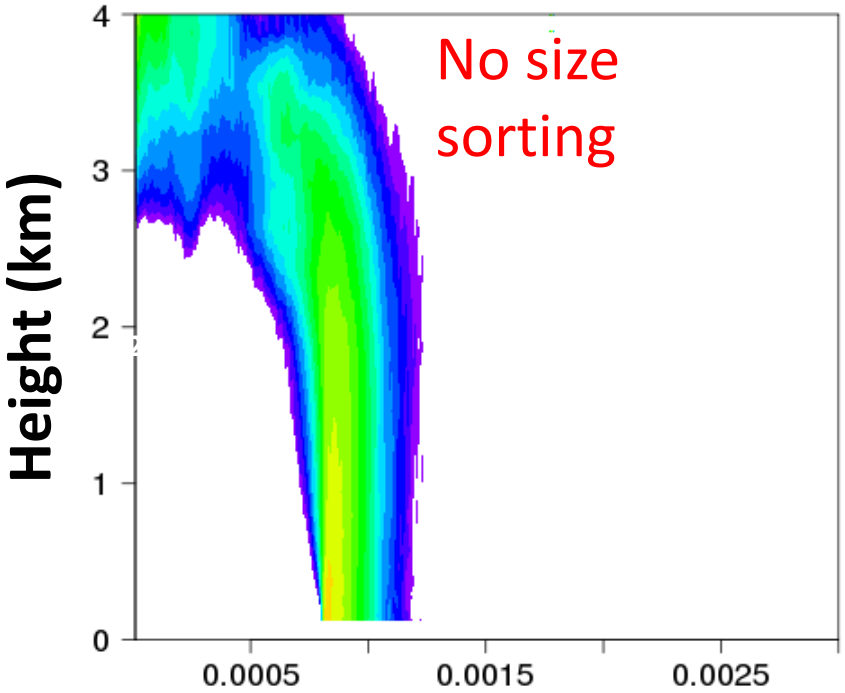
2 experiments: 1- and 2-moment scheme: Raindrop sizes

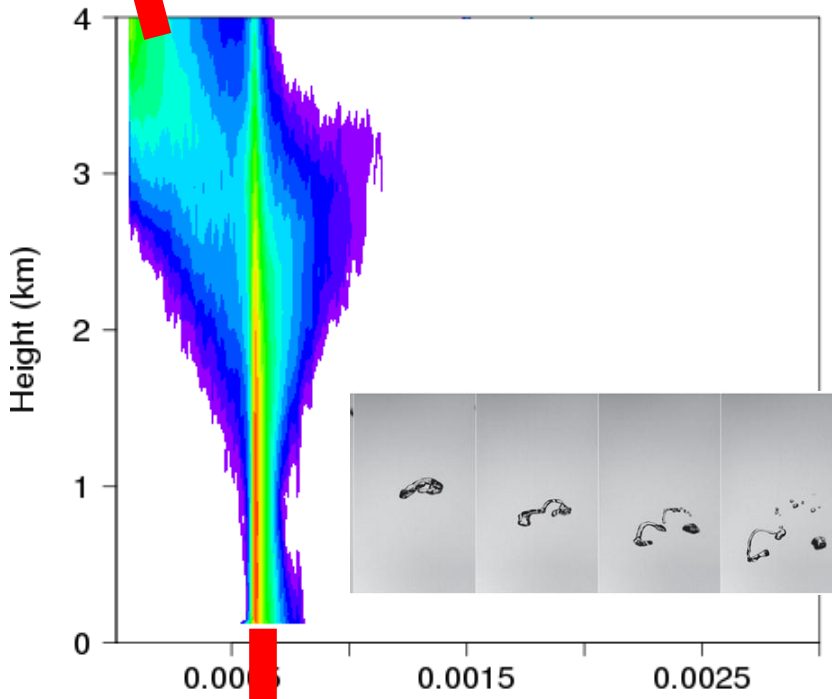
size sorting

1-Moment

No size sorting

2-Moment





Mean Drop Diameter (mm)

Breakup Threshold: 0,6 mm

All cases, Surface rain > 10 mm/h!

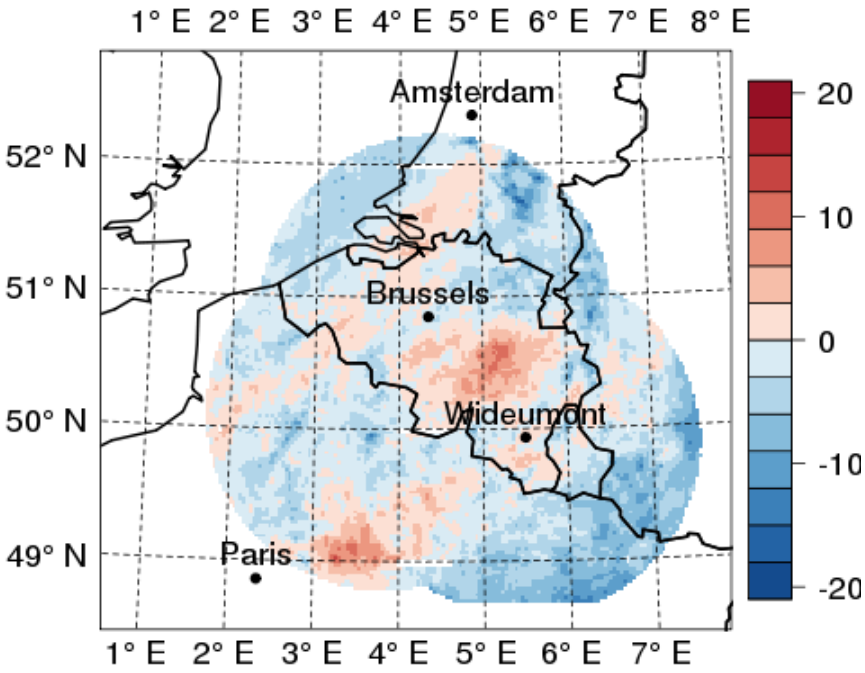
Raindrop Breakup Threshold

intense breakup versus weak breakup

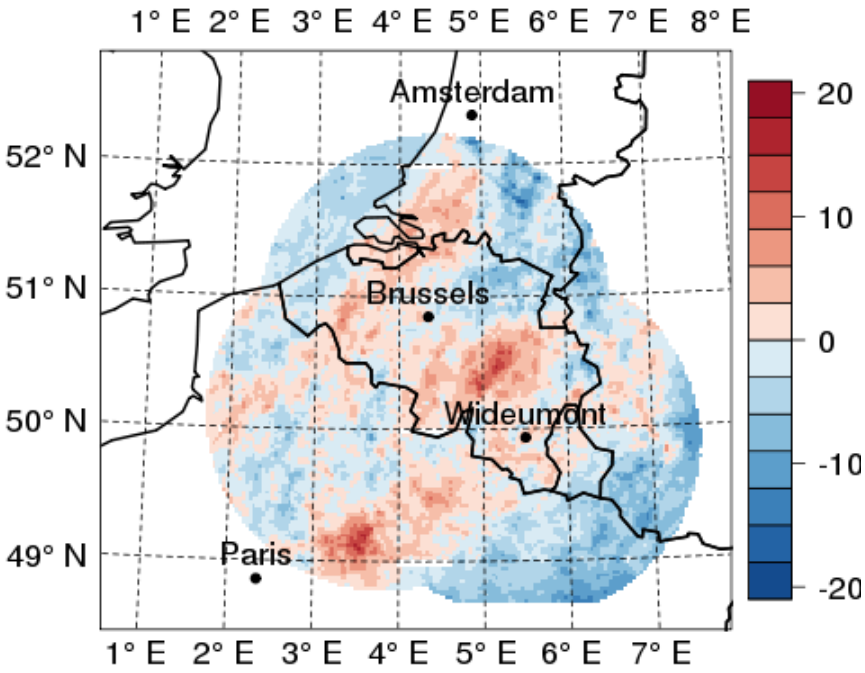
Raindrop Breakup Threshold

2 experiments: 2-moment, 2 different breakup thresholds: Daily bias

Intense breakup: -1.9 mm (-24%)



Weak breakup: -1.1 mm (-13%)

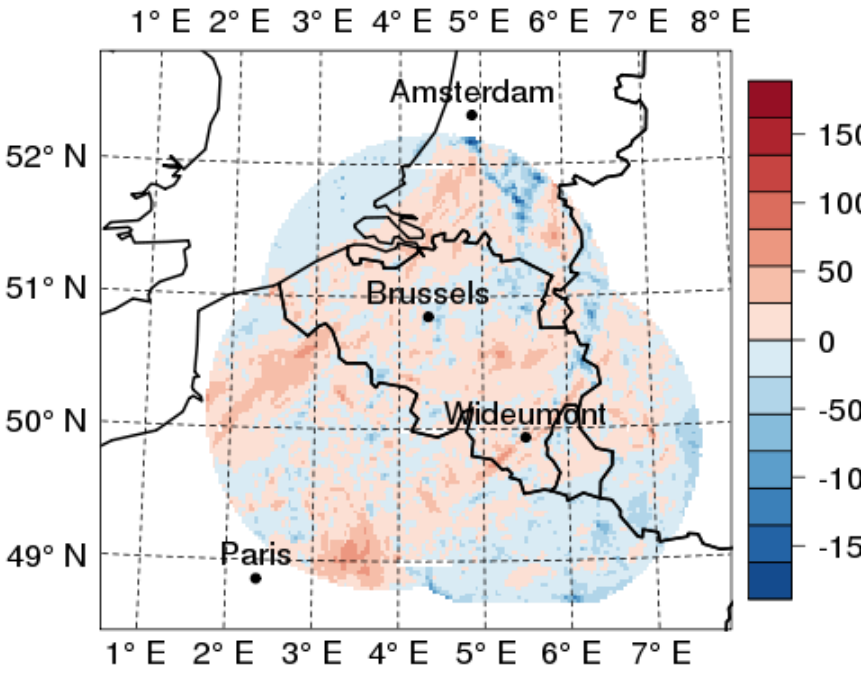


All cases (breakup parameterization by Verlinde and Cotton 1993)

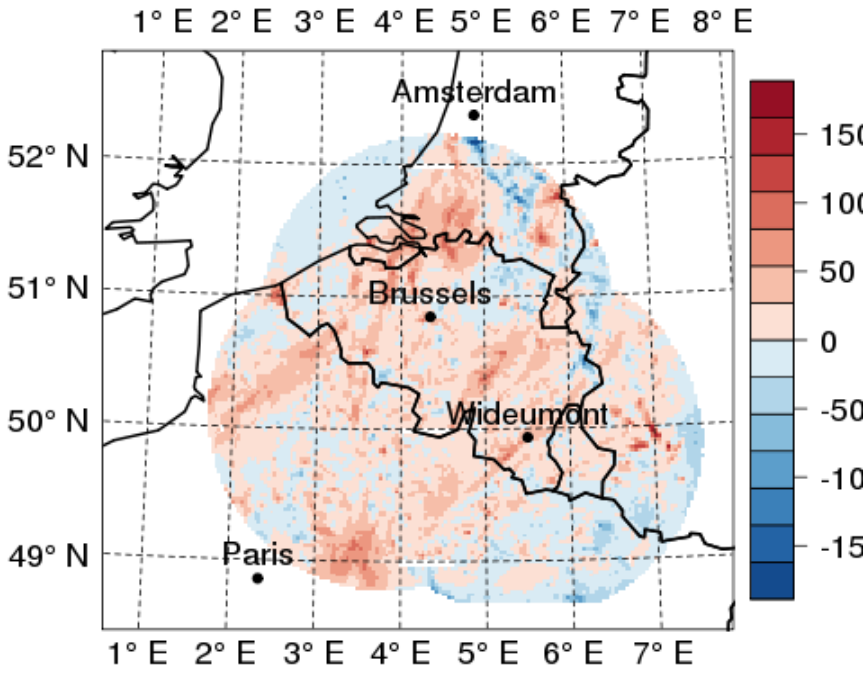
Raindrop Breakup Threshold

2 experiments: 2-moment, 2 different breakup thresholds: Daily max

Intense breakup: +1.5 mm (+5%)



Weak breakup: +9.6 mm (+32%)



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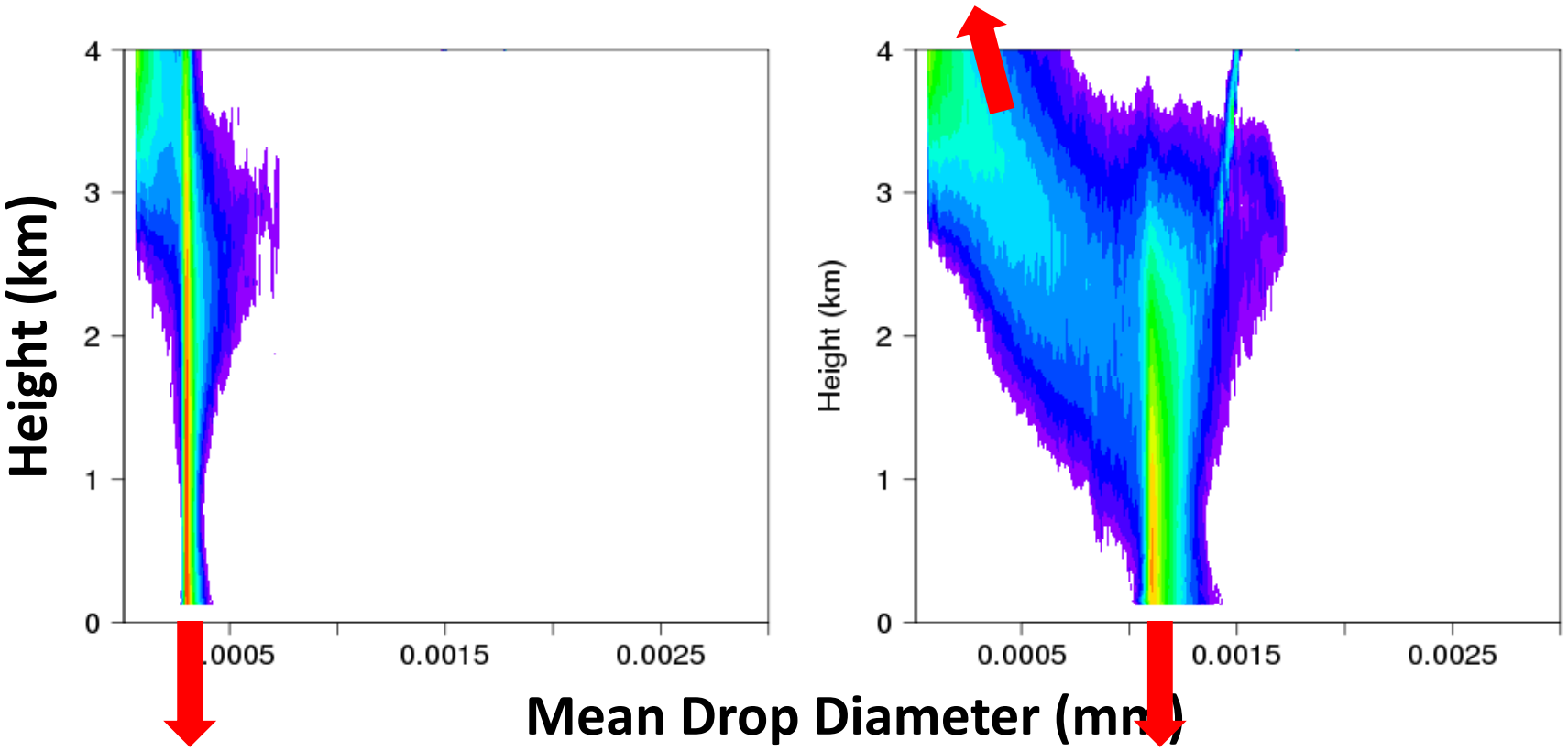
Raindrop Breakup Threshold

2 experiments: 2-moment, 2 different breakup thresholds: Drop sizes

Intense breakup size sorting **Weak Breakup**



Breakup Threshold: 0,3 mm

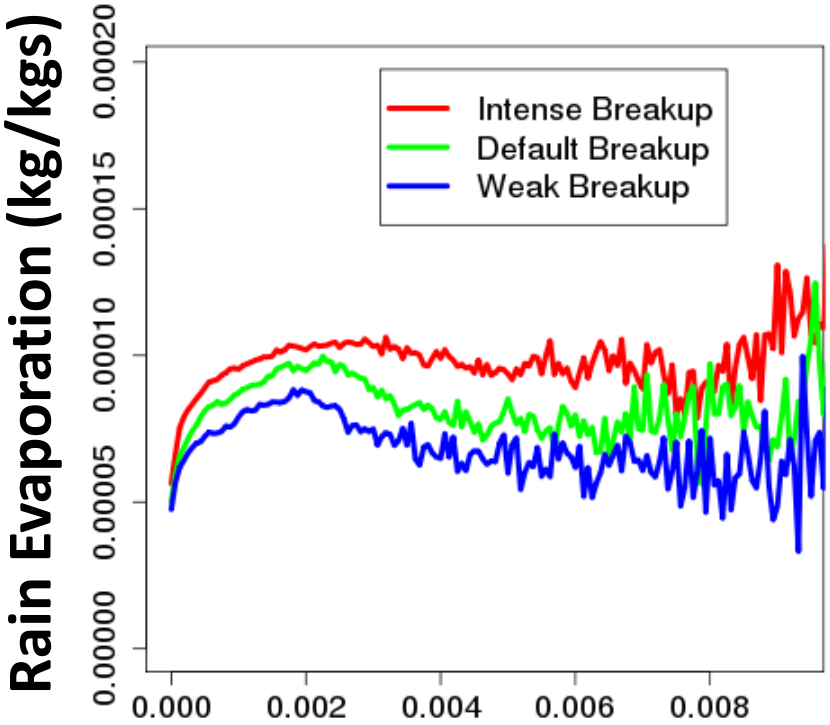
Breakup Threshold: 1,2 mm

All cases, Surface rain > 10 mm/h!

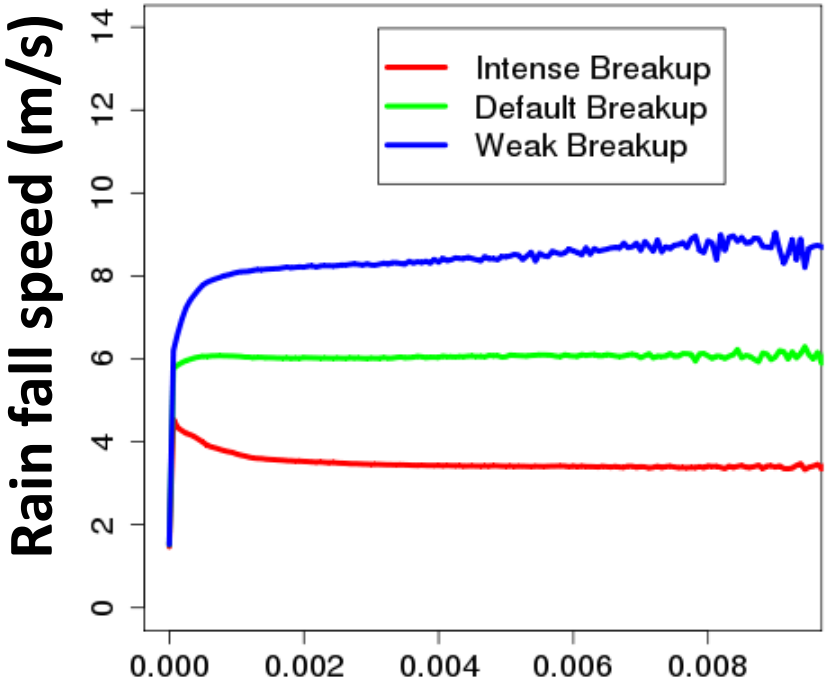
Raindrop Breakup Threshold

2 experiments: 2-moment, 2 different breakup thresholds:

Rain Evaporation



Rain Fall Speed



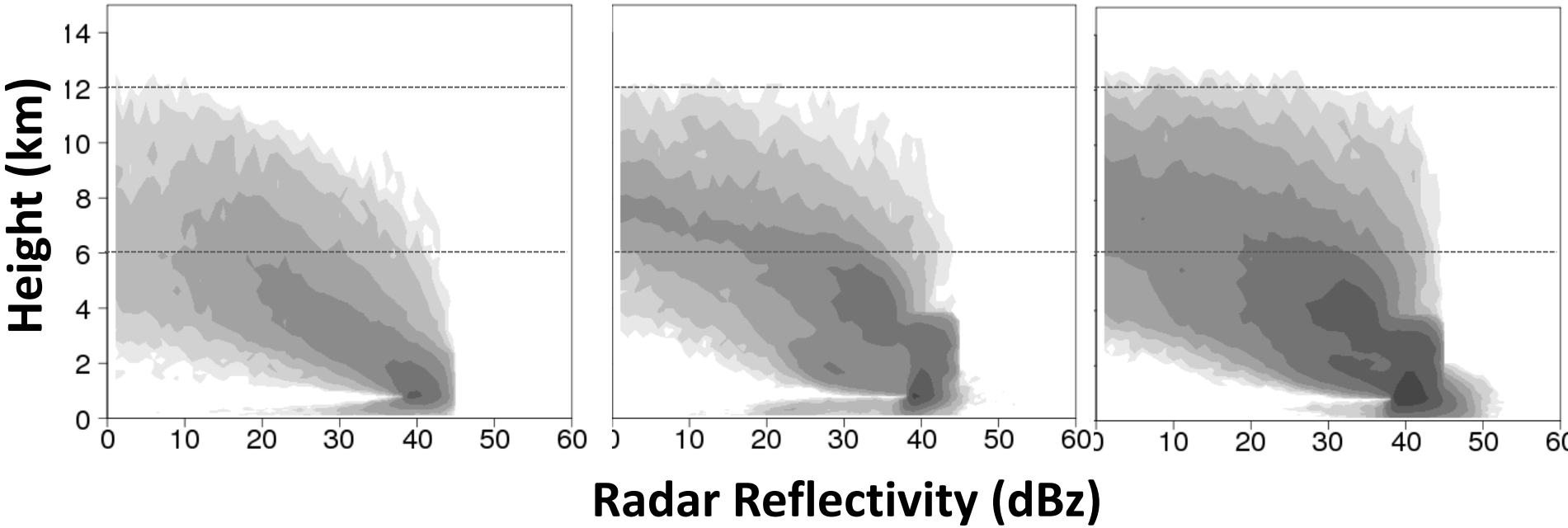
Rain Mixing Ratio (kg/m^3)

All cases, Surface rain > 10 mm/h!

Raindrop Breakup Threshold - Reflectivity

Radar reflectivity to evaluate rain size distributions? CFADs

Observed **Intense Breakup** **Weak Breakup**



All cases, Surface rain > 10 mm/h, filtered for hail occurrence

Raindrop Breakup Threshold - Reflectivity

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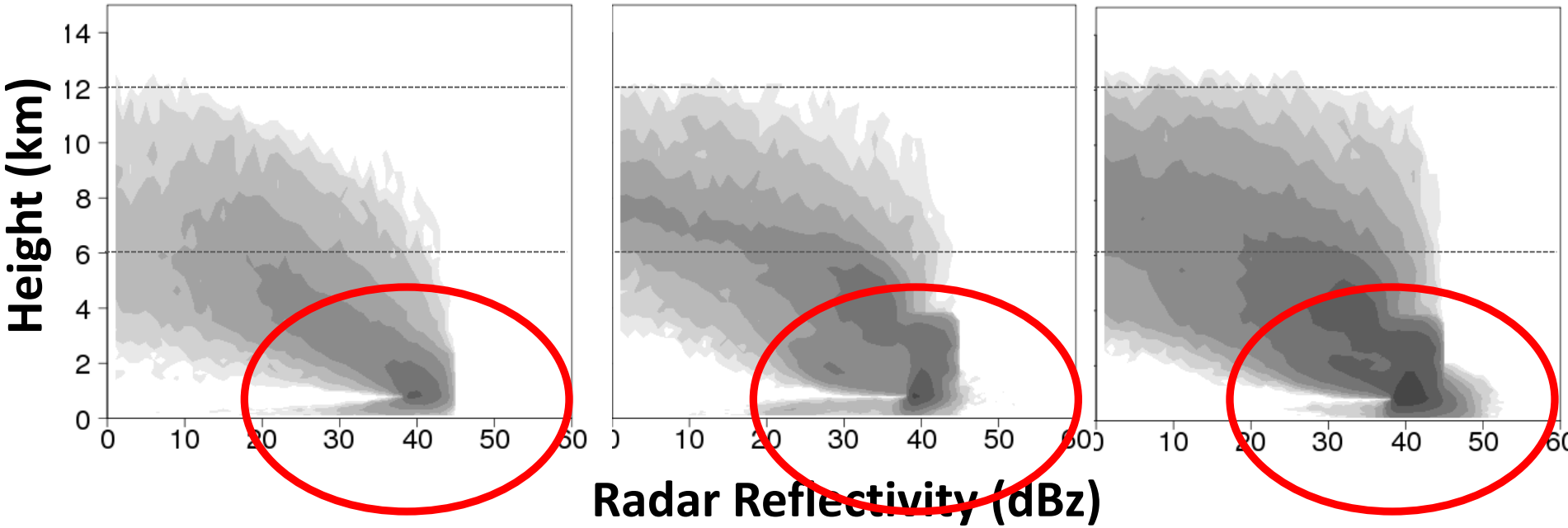

→ **Weak breakup results in too large reflectivities near the surface**

All cases, Surface rain > 10 mm/h, filtered for hail occurrence

Conclusions

- **Composite of convective 20 cases from 10-yr climate run**

  Representative slight dry bias

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  More breakup -> smaller drops -> more intense evaporation/ slower sedimentation -> lower peak rain rates

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- ***Next***
  - **Use other breakup parameterizations (all involve thresholds)**
  - **Evaluation with disdrometer and polarimetric radar data from the U.S. DOE ASR program/COPS**
  - **Impact microphysics complexity on hail occurrence**

Impact Microphysics Complexity on Hail Occurrence: POH

$$POH = 0.319 + 0.133(H_{45dBz} - H_{0°})$$