When Estimating Microphysical Process Rate, **Constrained Power Law > Perfect Direct Fit**, but **Single-Liquid Category Really Helps**

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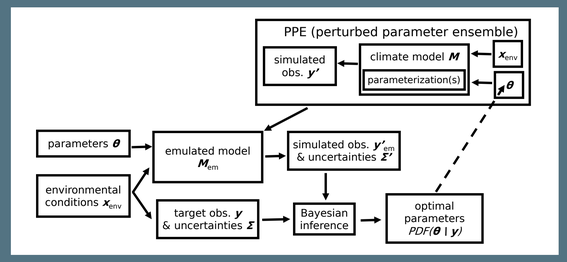
What's a bulk scheme?

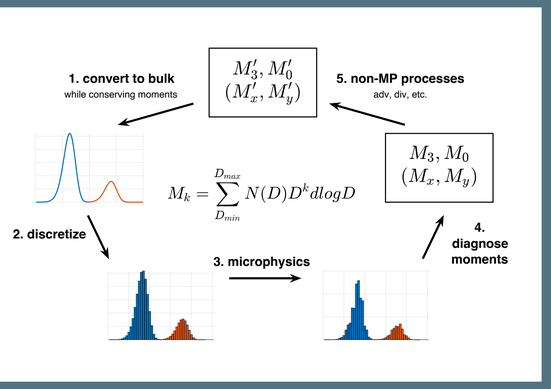
- Predicts bulk quantities of water (mass, number) in a grid box
- Fast enough to be used for forecast
- Often comes with assumptions
  - DSD shapes, categorization of liquid, etc.

MP Schemes Used

- BOSS
  - Online training using perturbed parameter ensemble, but power laws based (2-cat)



- AMP
  - Directly runs TAU for MP process rates but direct fit
  - 2-cat: separate cloud and rain category as usual
  - 1-cat: combined cloud and rain category and predicts 4 moments of total water



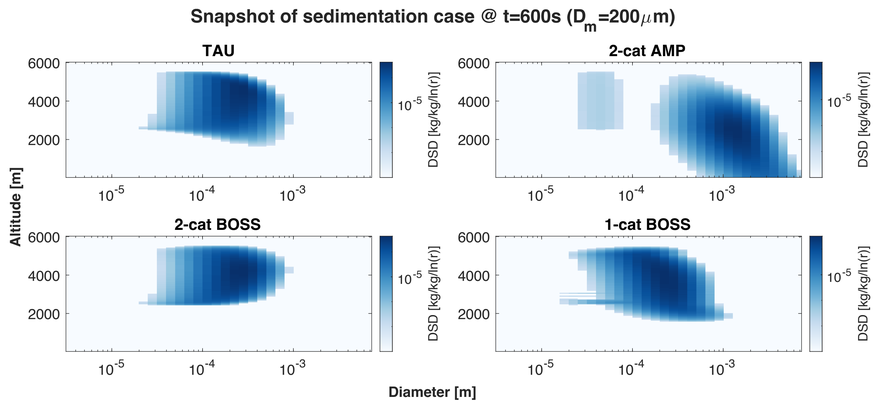
- TAU (reference)
  - Predicts mass and number of water droplets in each size bin

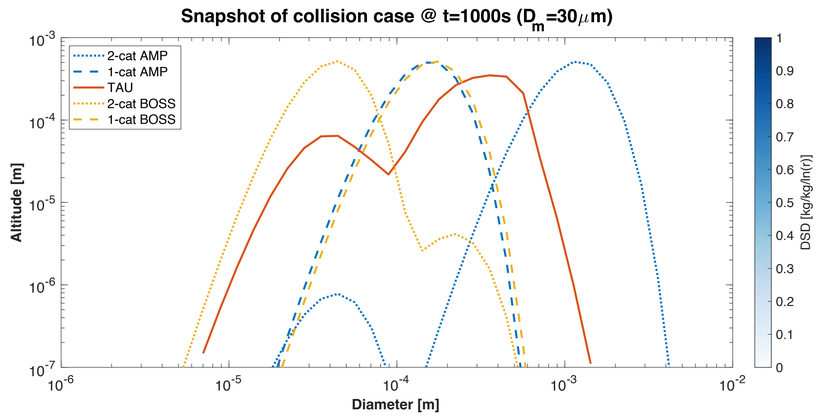
Motivation

- Long-term: integrate observation (remote and in-situ) into BOSS
- Short-term: simplify a complicated scheme (TAU) into BOSS without losing important information

What did we do?

- Compare individual processes runs between 2-cat BOSS, 2-cat AMP, 1-cat AMP, and TAU.
  - Sedimentation and collision-coalescence
- Use AMP's moment inversion routine to diagnose DSD from BOSS





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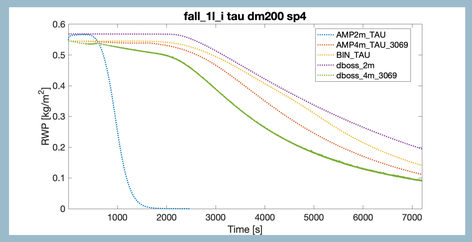
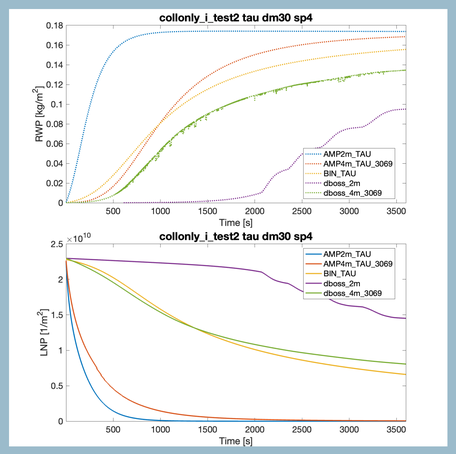
What did we find?

- Sedimentation
  - AMP's direct fit doesn't help size sorting
  - BOSS has less size sorting problem even in 2-cat
  - 1-cat is the ultimate solution, especially for a multi-layer case



- Collision-coalescence
  - Both 2-cat AMP and BOSS struggle to match TAU
  - Both 1-cat AMP and BOSS have great performance
  - 1-cat BOSS gets almost



Takeaway

- Power law-based (BOSS) can sometimes emulate a perfect direct fit (AMP), see Fig 2.
- Instead of a direct fit of the process rate (fall speed, collisional rate etc.), learning from quantities such as LWP and rain rate helps mitigate problems typical in 2-category 2-moment bulk schemes
- **Great news for the long-term goal** to incorporate observation, as process rates are not observable
- Single category bulk scheme is still better at tackling more complicated situations
- AMP can be helpful at diagnosing problems in nonparametric bulk schemes such as BOSS