Enhancing the ability of the atmosphere to respond to subgrid land surface heterogeneity

AMWG 2023

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NCAR

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Image: wallpaperflare.com

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Land-atmosphere interactions

- Relatively small-scale land surface heterogeneity can impact the overlying atmosphere
  - Boundary layer cumulus (*Berg and Stull,* 2005)
  - Generation of mesoscale circulations *(Doran et al*., 1995; *Avissar and Schmidt*, 1998; *Bou-Zeid et al*. 2005)
  - LWP and TKE (*Simon et al.* 2021)

Figure courtesy of Nate Chaney

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  - LWP and TKE (*Simon et al.* 2021)

- Land-atmosphere coupling in most global climate models relies only on grid-cell mean values (i.e., fluxes)

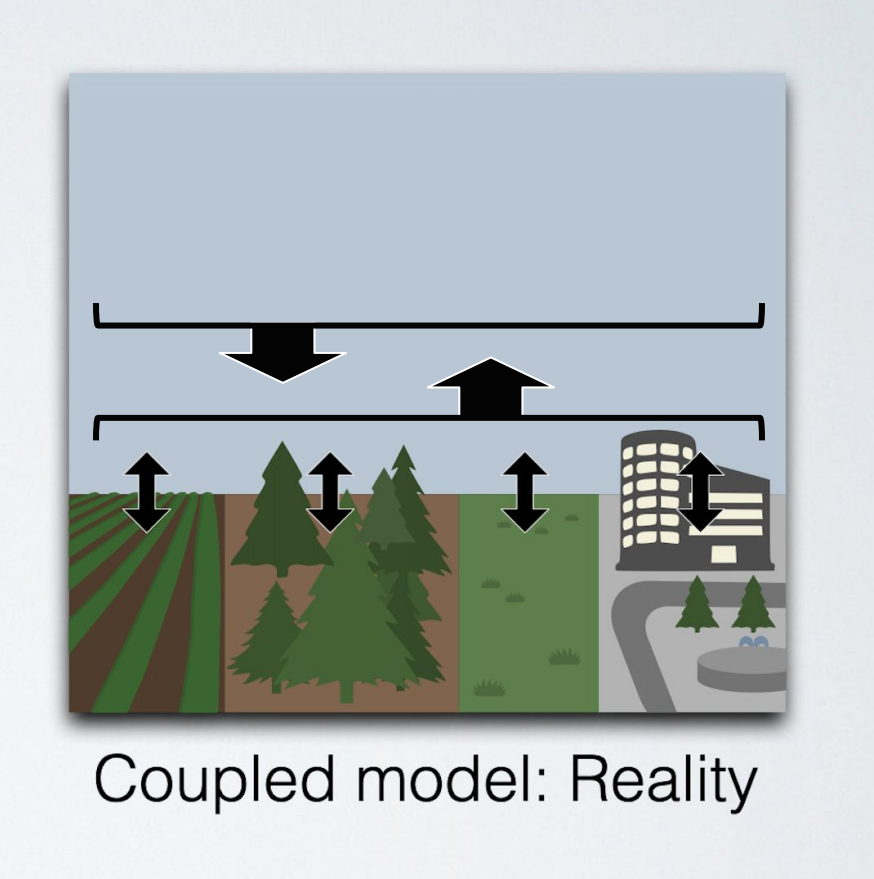
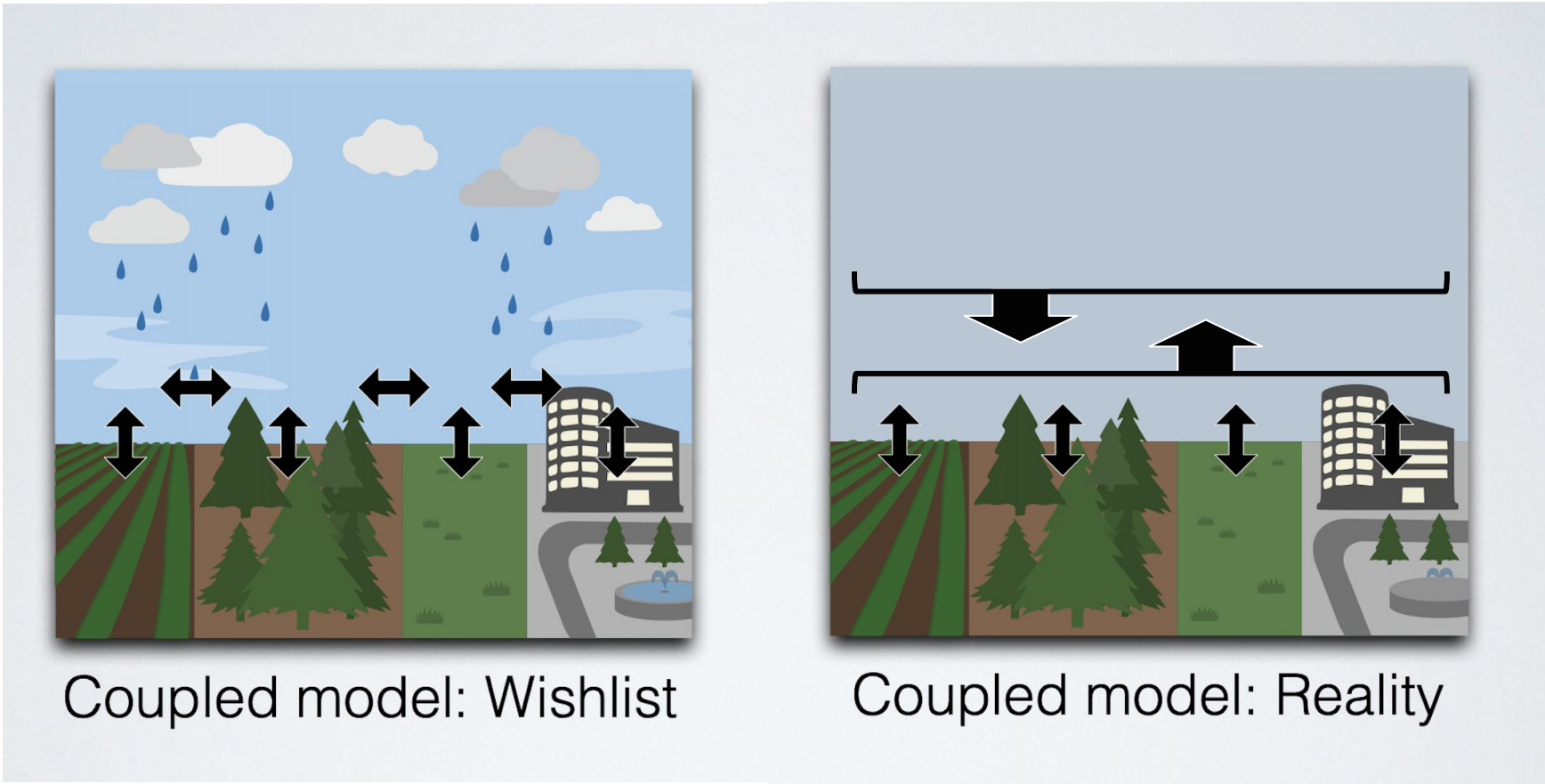


Figure courtesy of Nate Chaney

CLASP CPT: Coupling of Land & Atmospheric Subgrid Parameterizations



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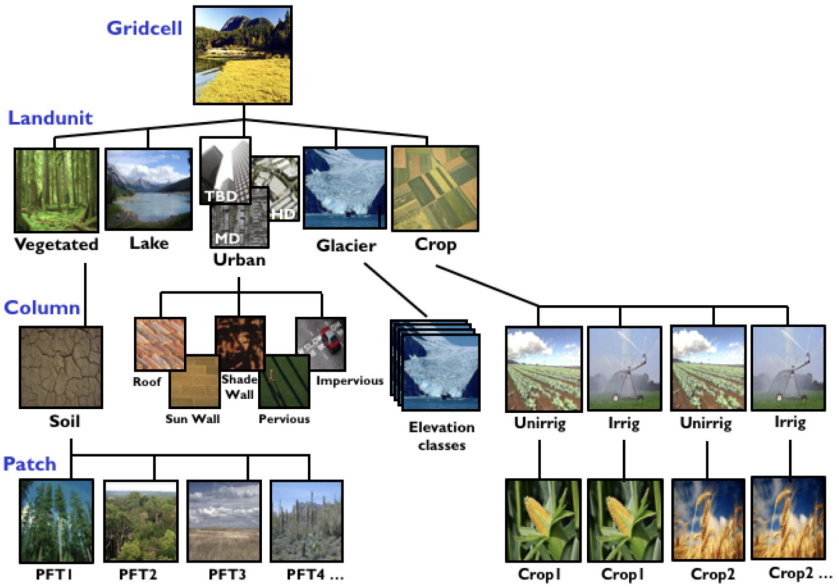
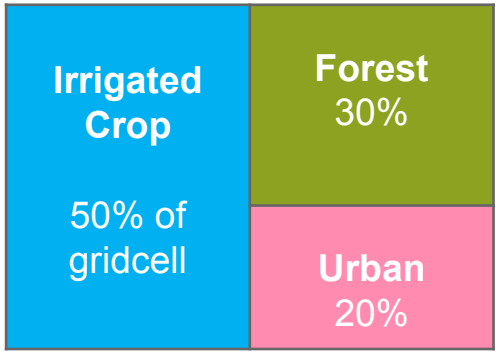
An opportunity to move beyond gridcell means: Both **CLM** and CAM represent subgrid heterogeneity



Adapted from *Lawrence et al., 2019*

- In practice: break down a gridcell based on area covered by each ”patch” (surface type)



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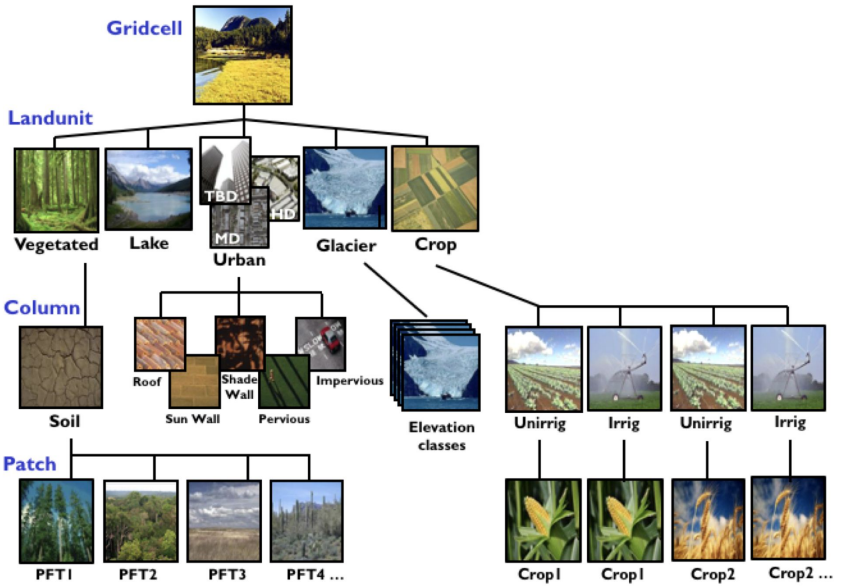

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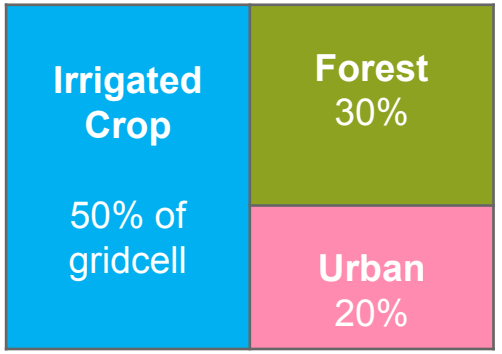
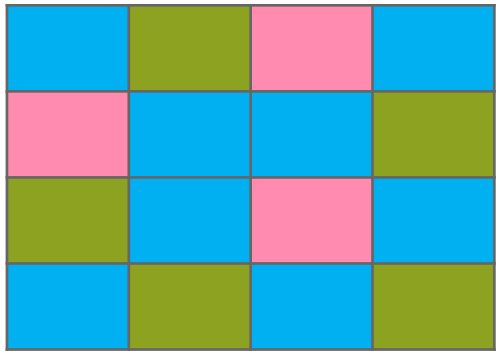
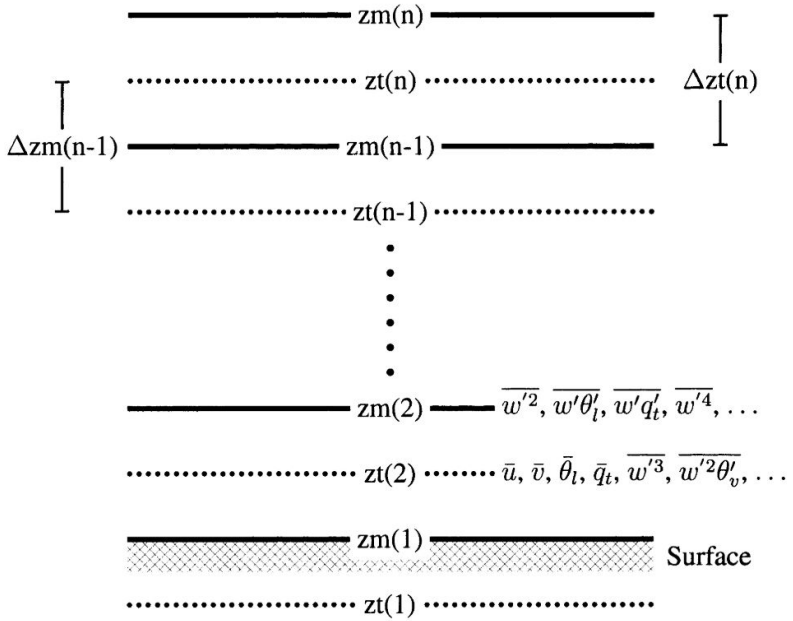


Equally possible:



An opportunity to move beyond gridcell means:
Both CLM and **CAM** represent subgrid heterogeneity

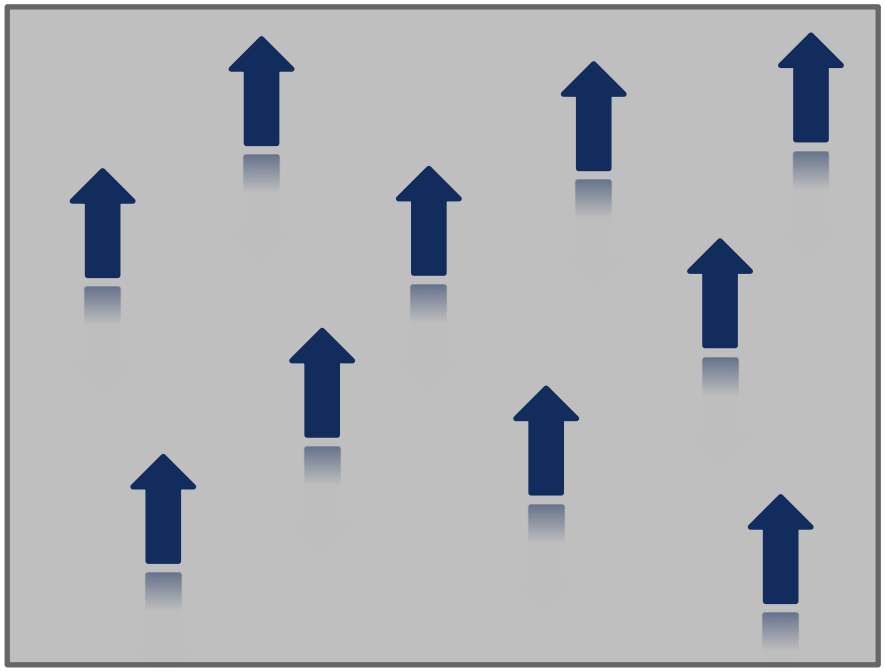
CLUBB predicts higher order moments of temperature θ_l, moisture q_t, and velocity w via an assumed double gaussian



Golaz et al., 2002

An opportunity to move beyond gridcell means: Both CLM and **CAM** represent subgrid heterogeneity

The addition of a multi-plume mass-flux scheme (CLUBB-MF) introduces updraft heterogeneity



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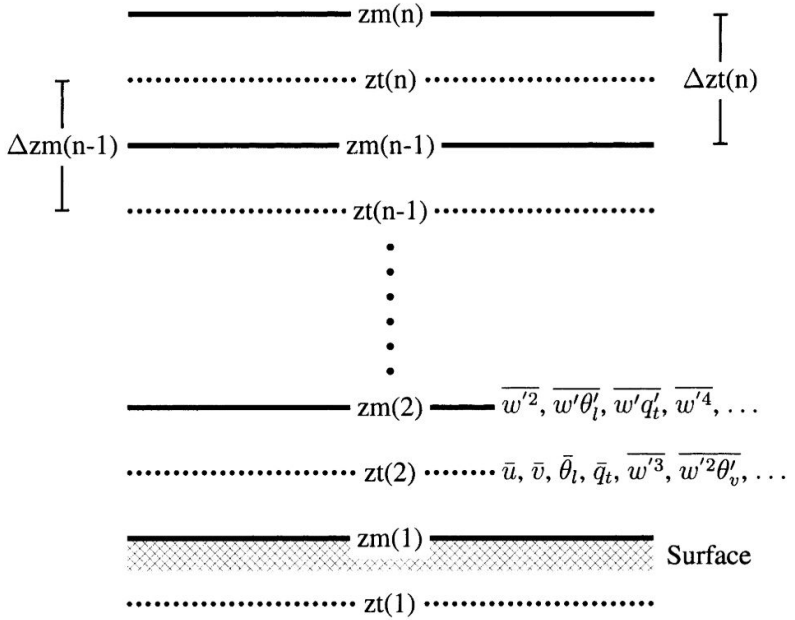

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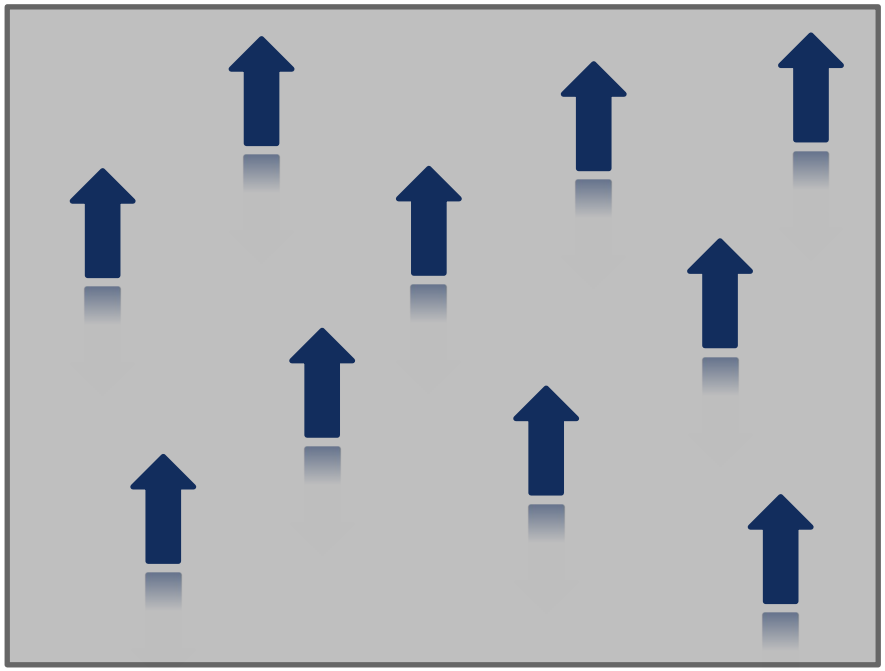
How can we link this sub-grid information together?

Surface below plumes has a single grid-mean latent/sensible heat flux



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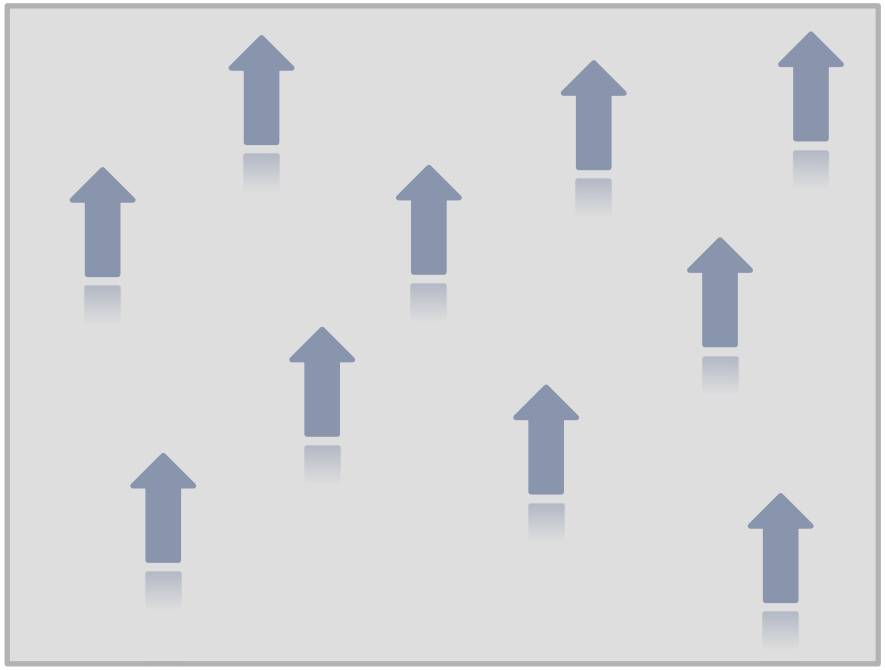
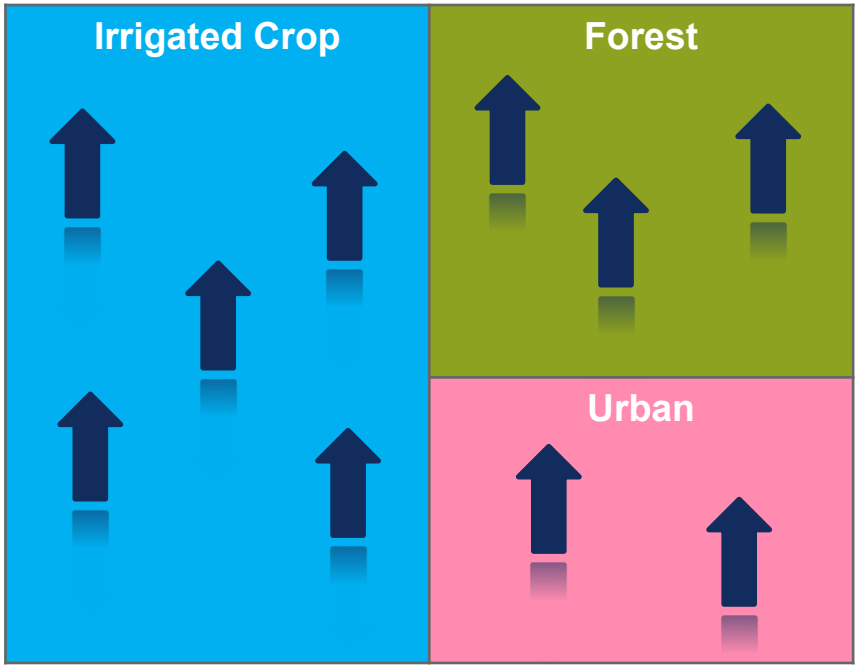


Surface below plumes reflects actual sub-grid surface fluxes/temperature



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Initiate plumes over actual sub-grid surface patches

- Pass patch-level data through the coupler to CAM
- Initiate MF plumes according to area of each patch
- Replaces grid-mean LHFLX, SHFLX, and surface temperature with patch-level values

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Initial tests: Single-column (SCAM) ensemble

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- 74 warm-season, shallow convection days driven by LASSO VARANAL forcing
- 2-day hindcasts, using the second day for analysis

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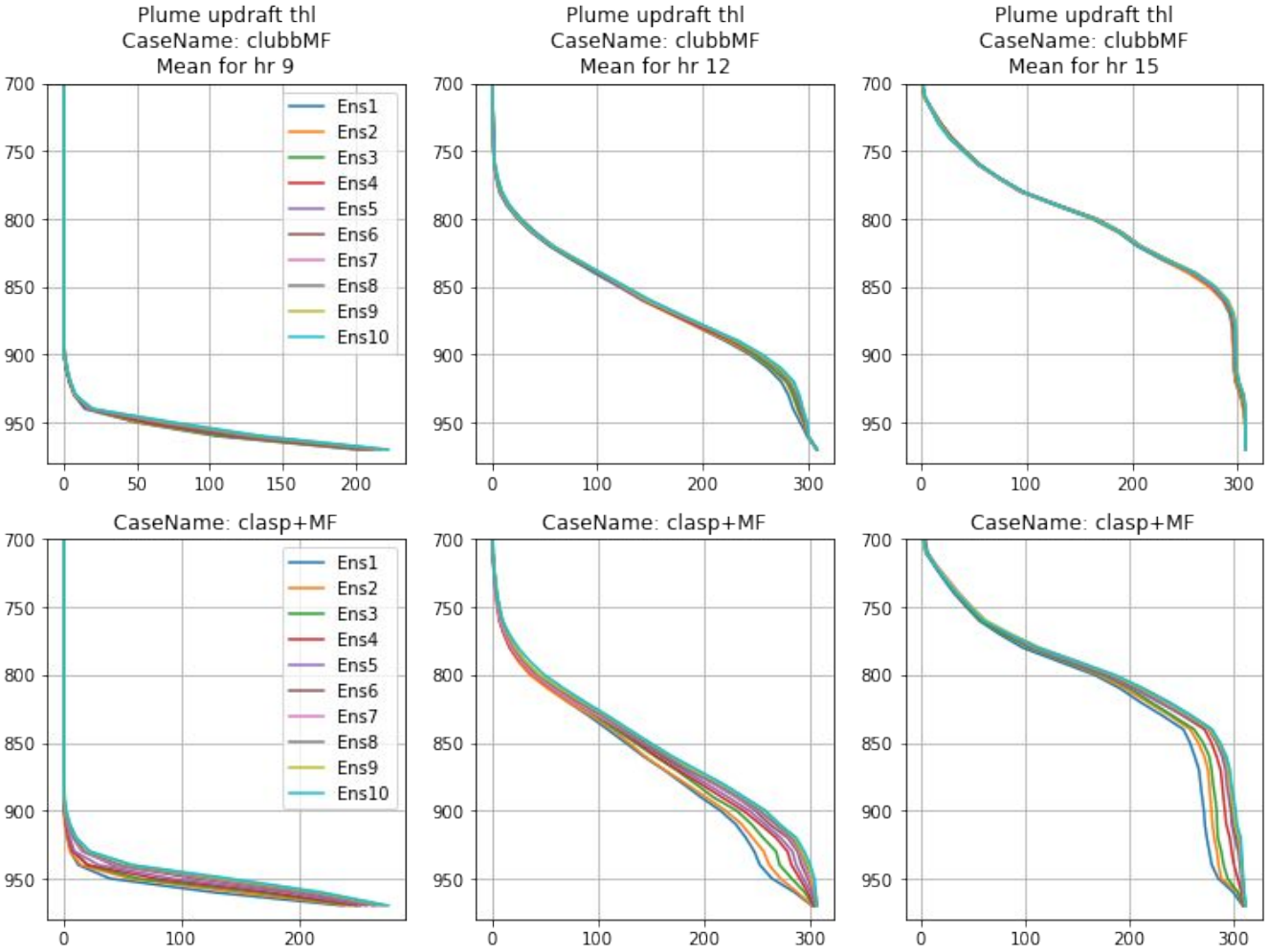
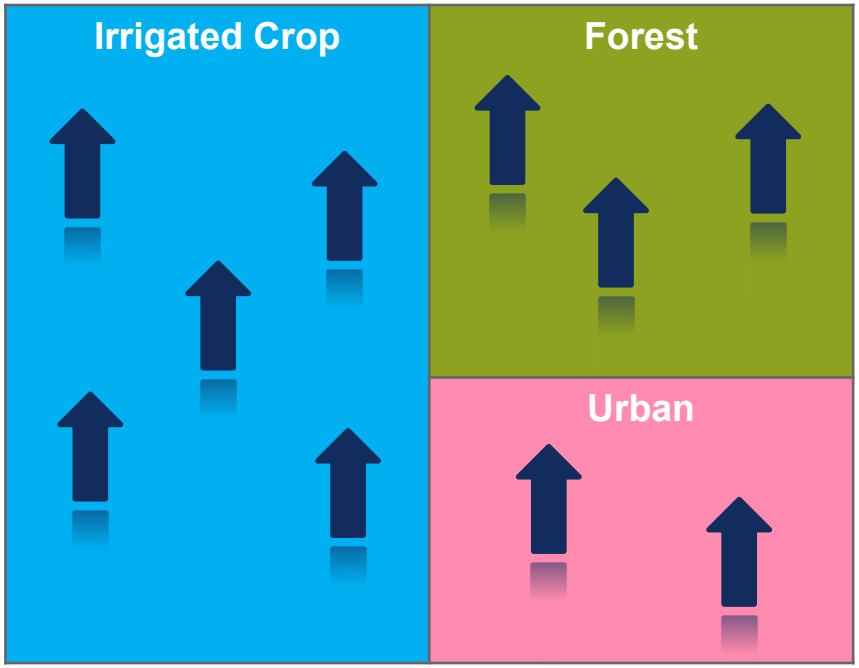
Preliminary results ahead!

Surface heterogeneity increases the vertical variances in CLUBB-MF plumes



MF plume ensembles of updraft temperature when using a homogeneous surface (top) vs. a heterogeneous one (bottom). Averages taken over all 74 days and over selected hours.

But there's a lot of opportunities for further development



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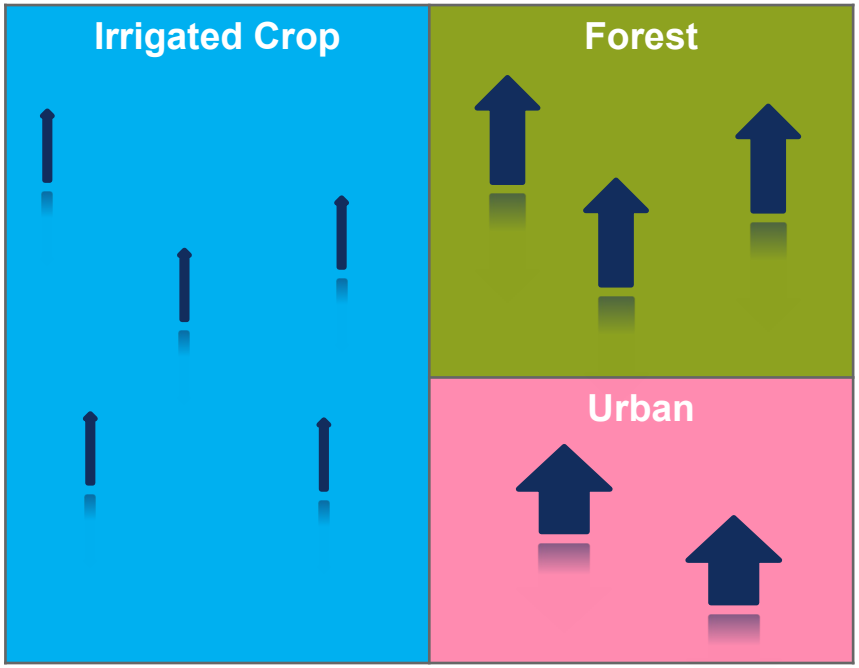
  - Khaled Ghanam has demonstrated the impact of such an approach



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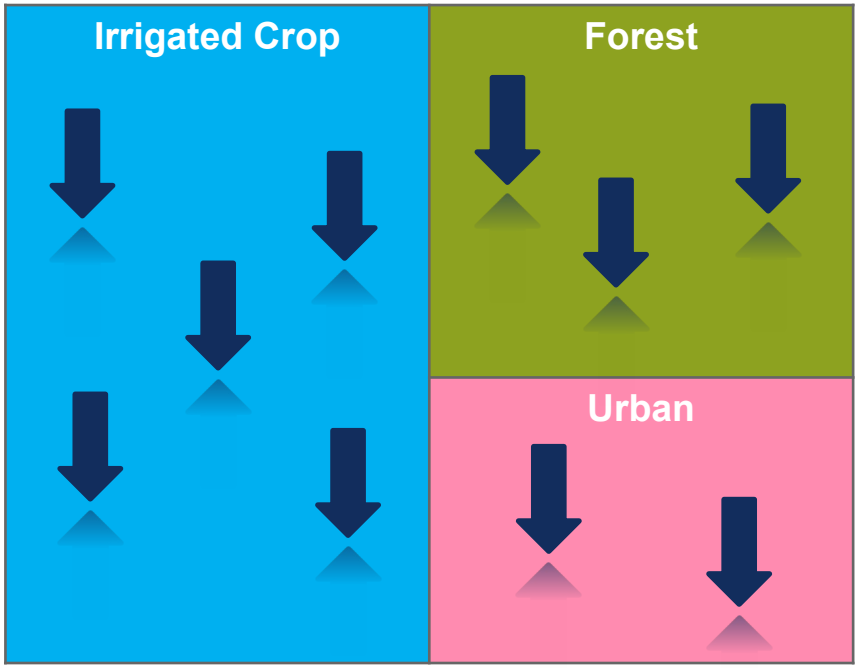

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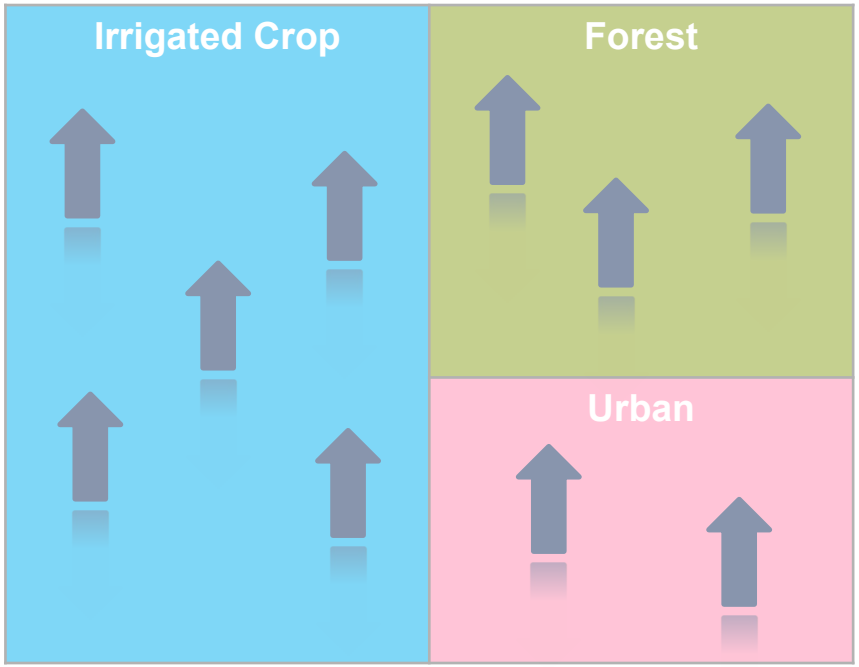

More development needed, but there's promise for moving beyond 'homogeneous' boundary conditions

Thank you!

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