

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

LMWG 2023

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February 6, 2023

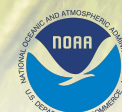
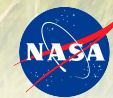


Image: wallpaperflare.com

# 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)

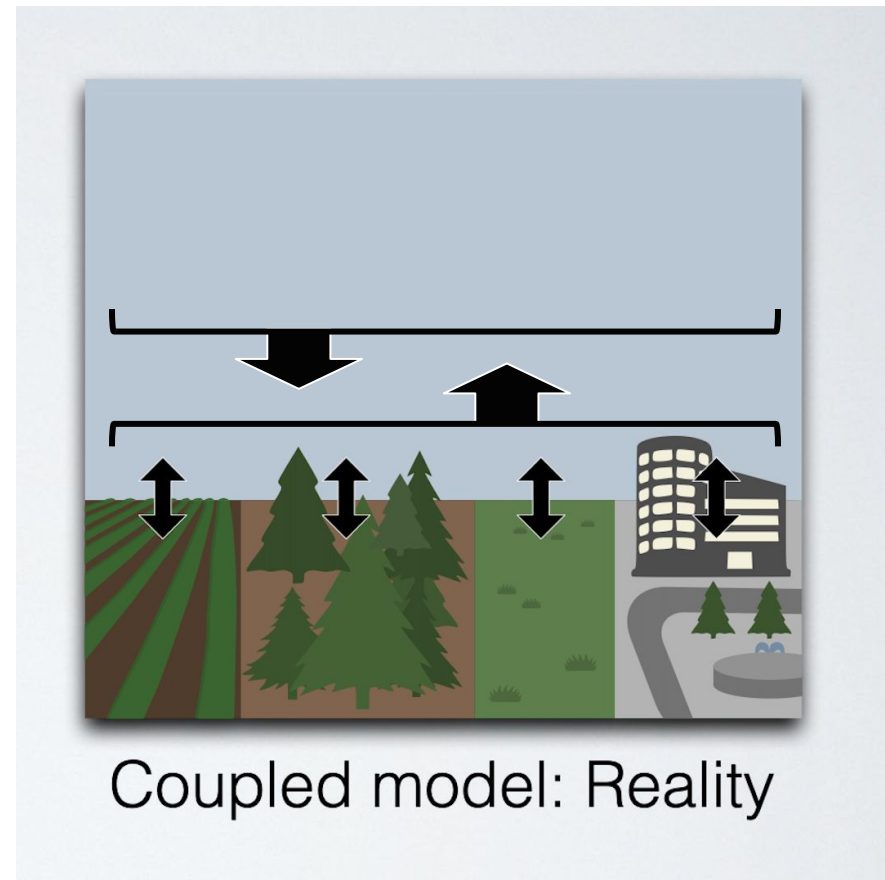
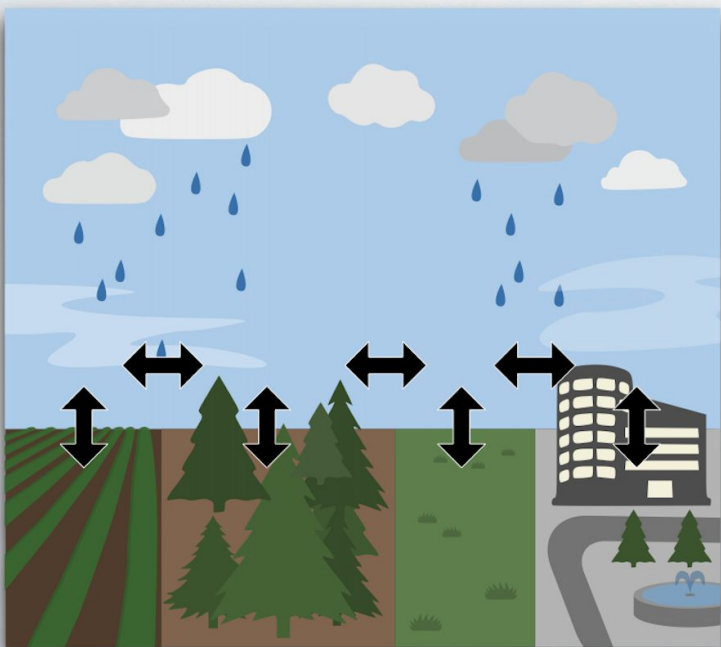
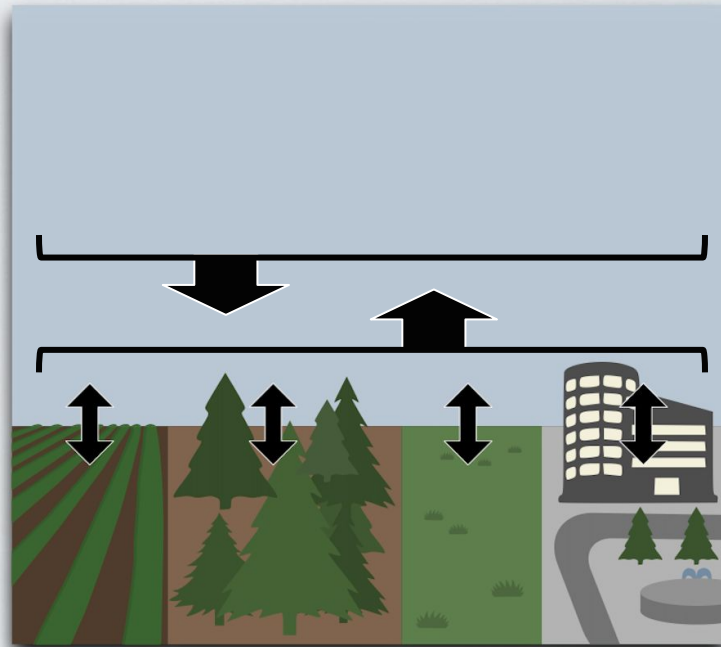


Figure courtesy of Nate Chaney

# CLASP CPT: Coupling of Land & Atmospheric Subgrid Parameterizations



Coupled model: Wishlist

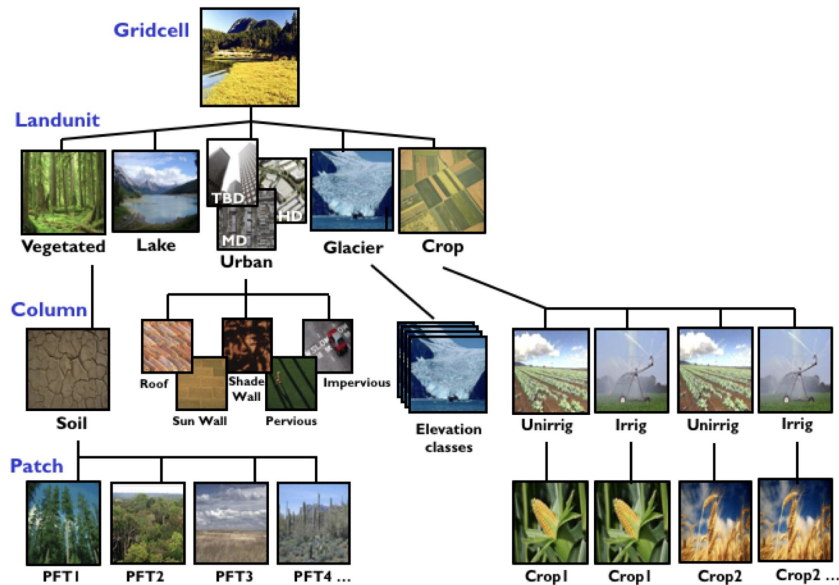


Coupled model: Reality

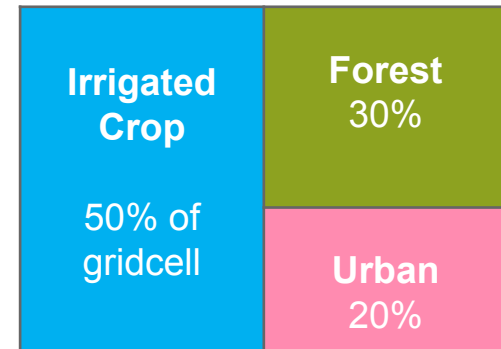
Figure courtesy of Nate Chaney

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

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

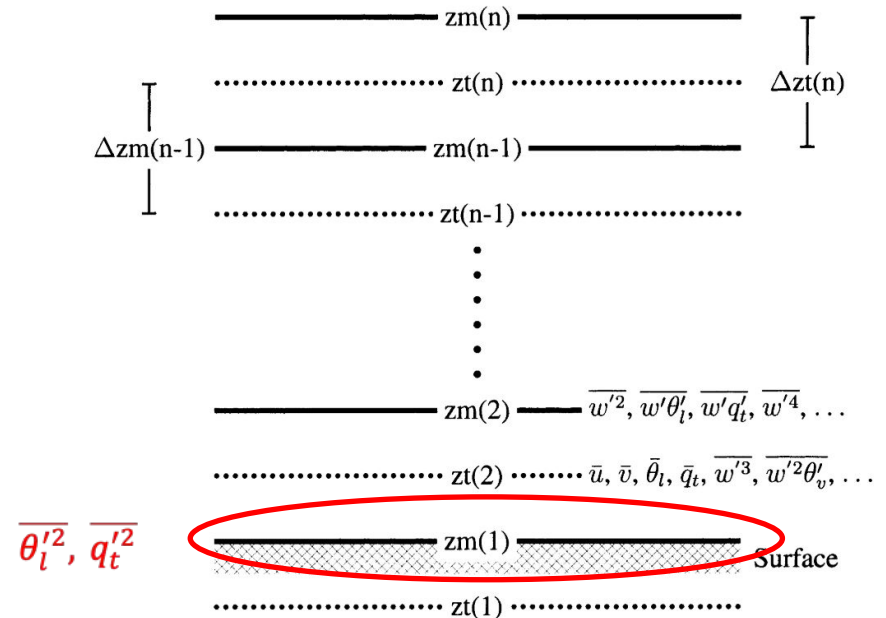


Adapted from *Lawrence et al., 2019*



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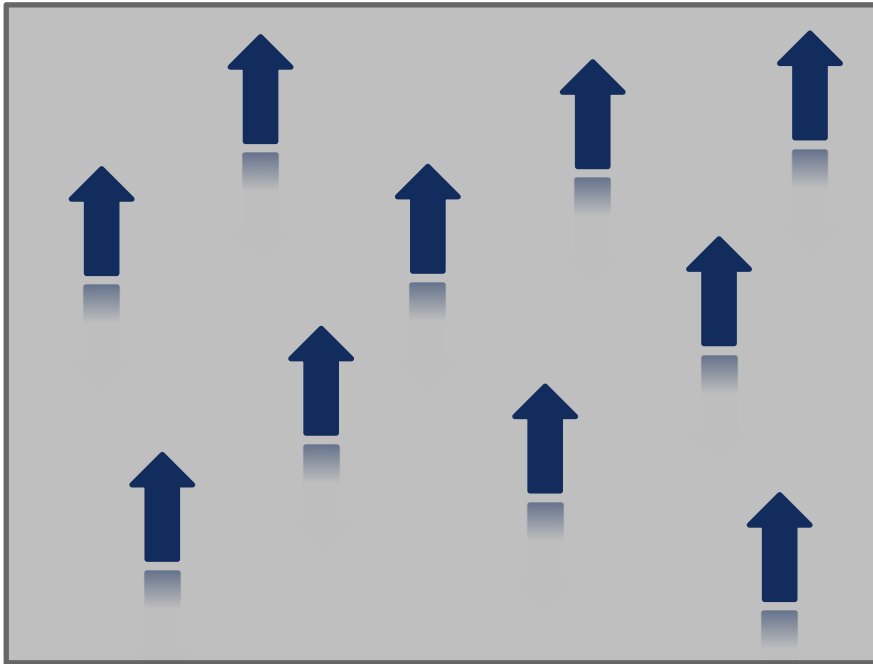
CLUBB predicts higher order moments of temperature  $\theta_l$ , moisture  $q_t$ , and velocity  $w$  via an assumed double gaussian



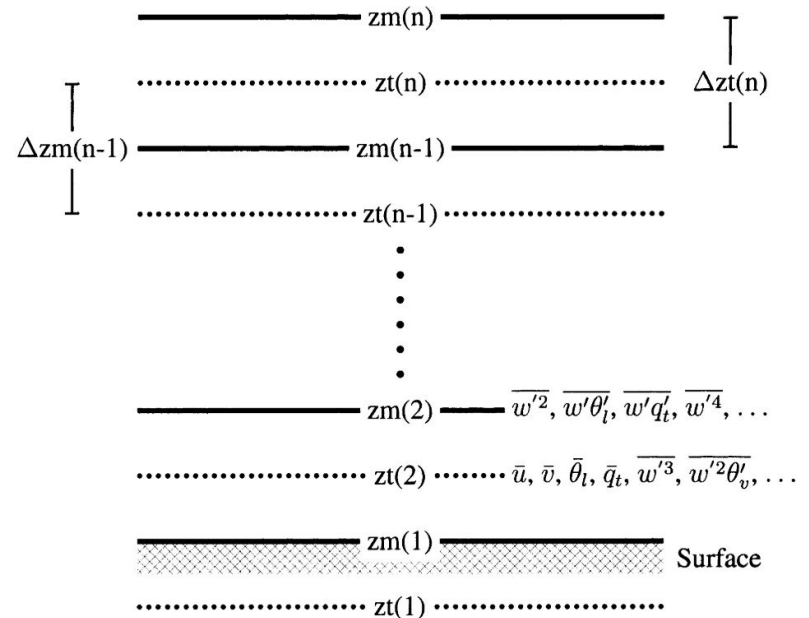
*Golaz et al., 2002*

# 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



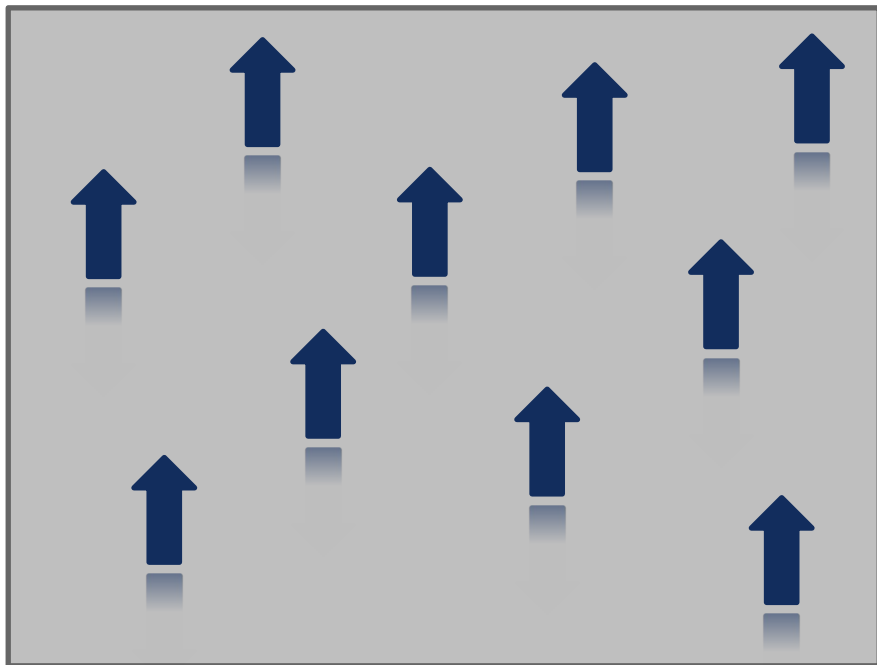
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# How can we link this sub-grid information together?

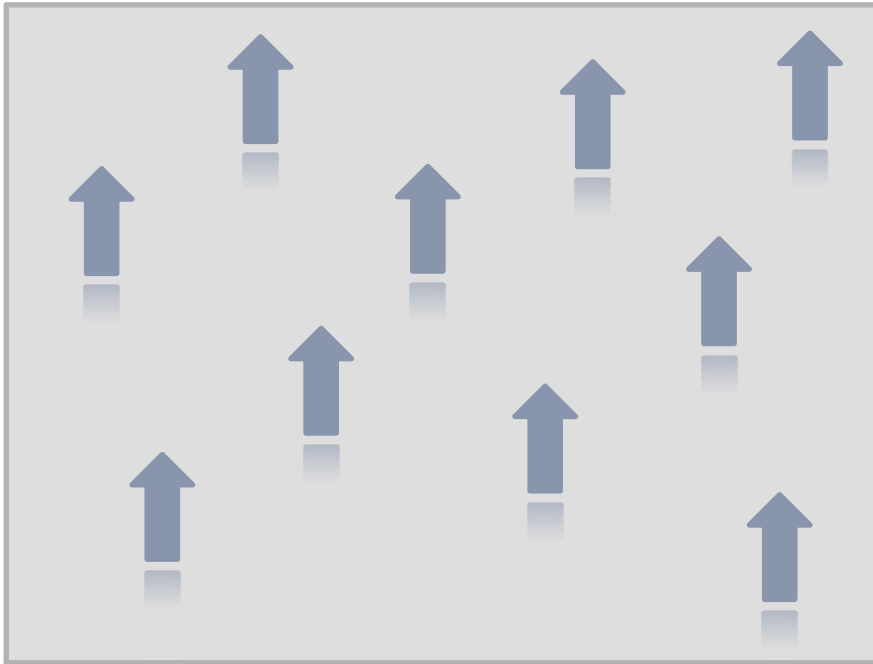
Surface below plumes has a single grid-mean latent/sensible heat flux



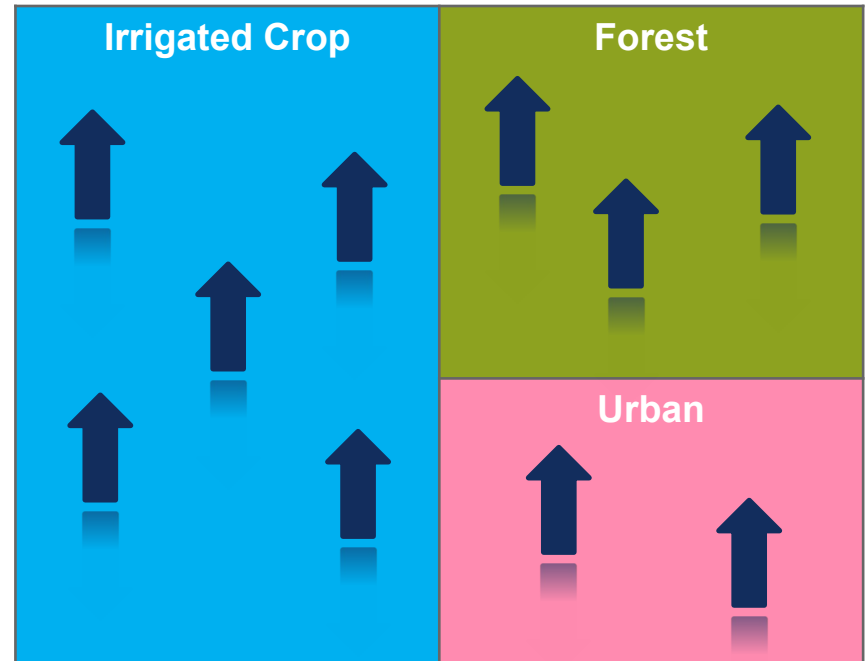


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Surface below plumes has a single grid-mean latent/sensible heat flux



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 (which already exist in CLM)

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## Initial tests: **Single-column (SCAM) ensemble**

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

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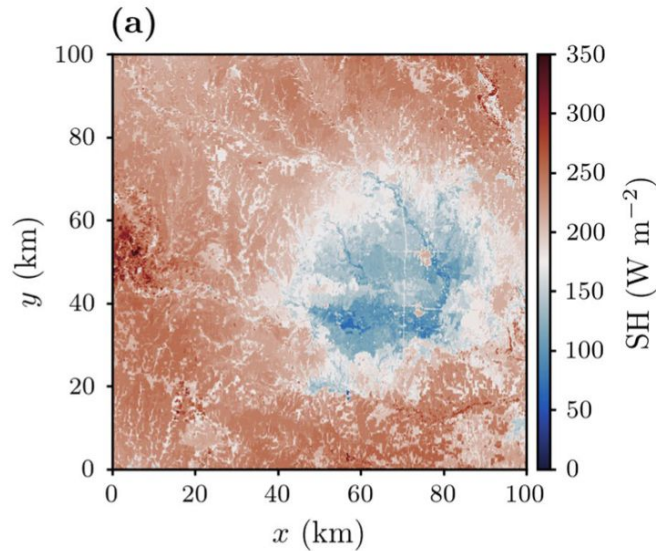
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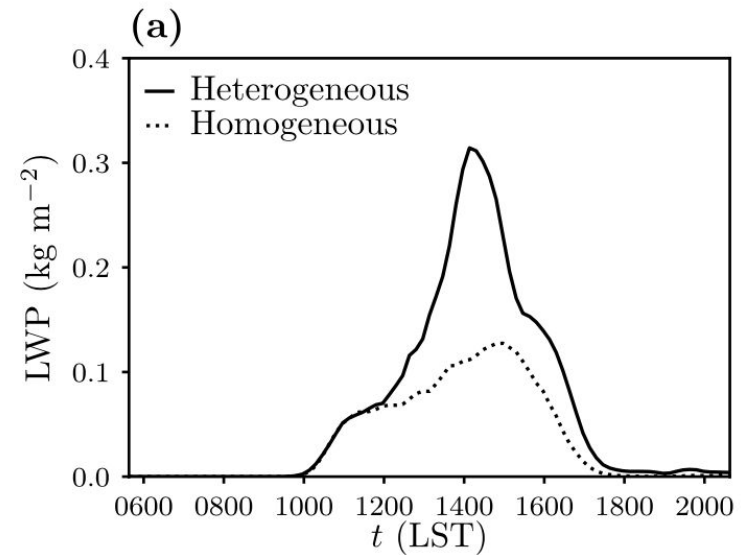
**Preliminary results ahead!**



# Surface heterogeneity may lead to increases in cloud liquid water path

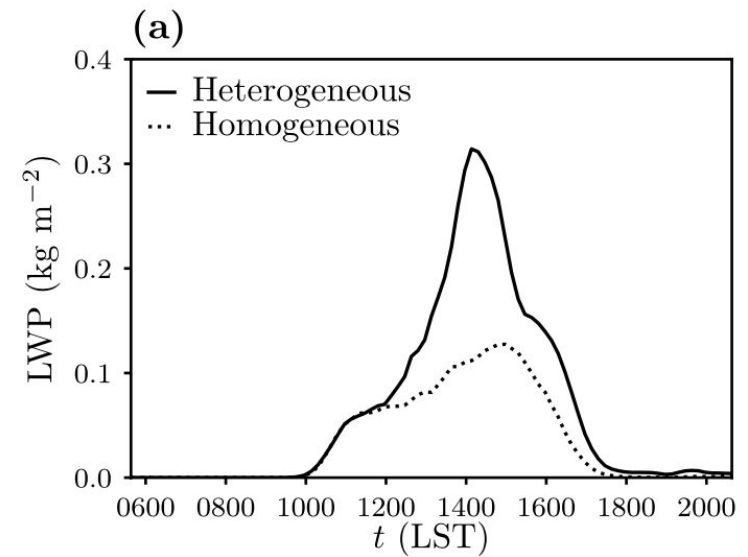
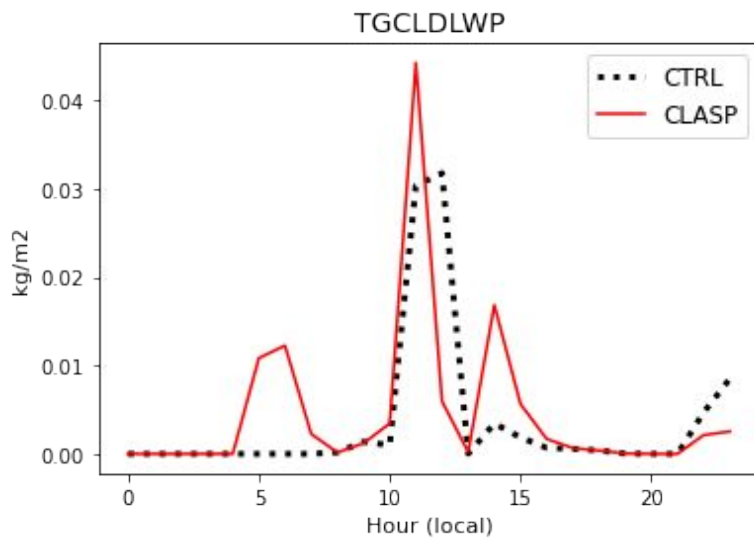


*Simon et al. (2019) Figure 4: Surface flux heterogeneity on September 24, 2017*



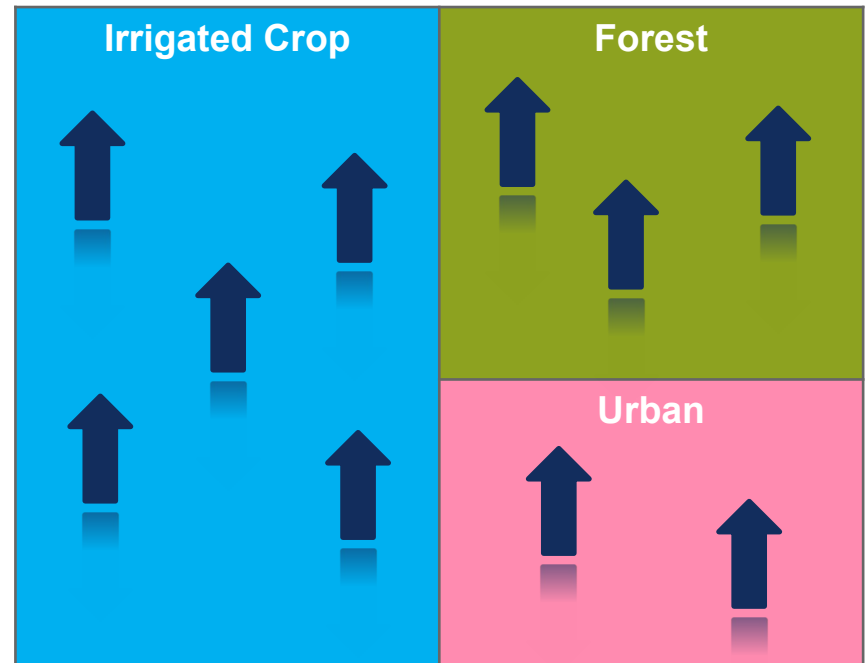
*Simon et al. (2019) Figure 5: domain-mean liquid water path on September 24, 2017*

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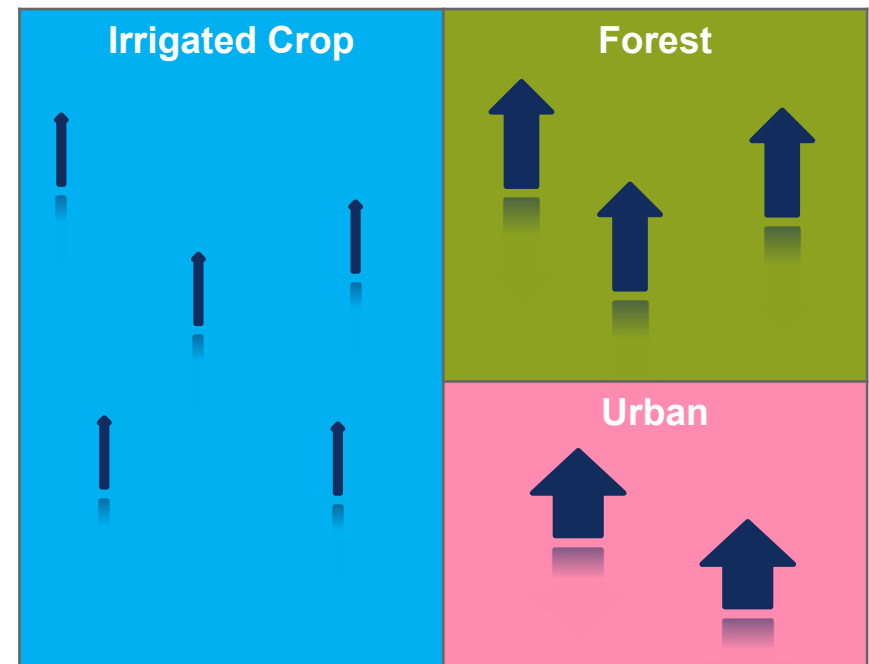
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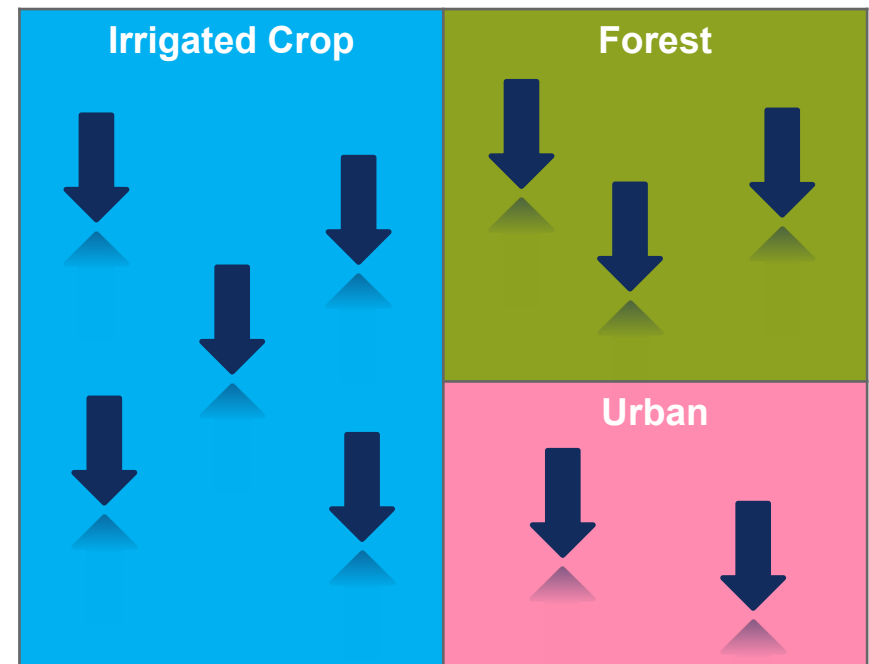
- Updraft area and vertical velocity could also be varied depending on surface type
  - Khaled Ghanam has demonstrated the impact of such an approach





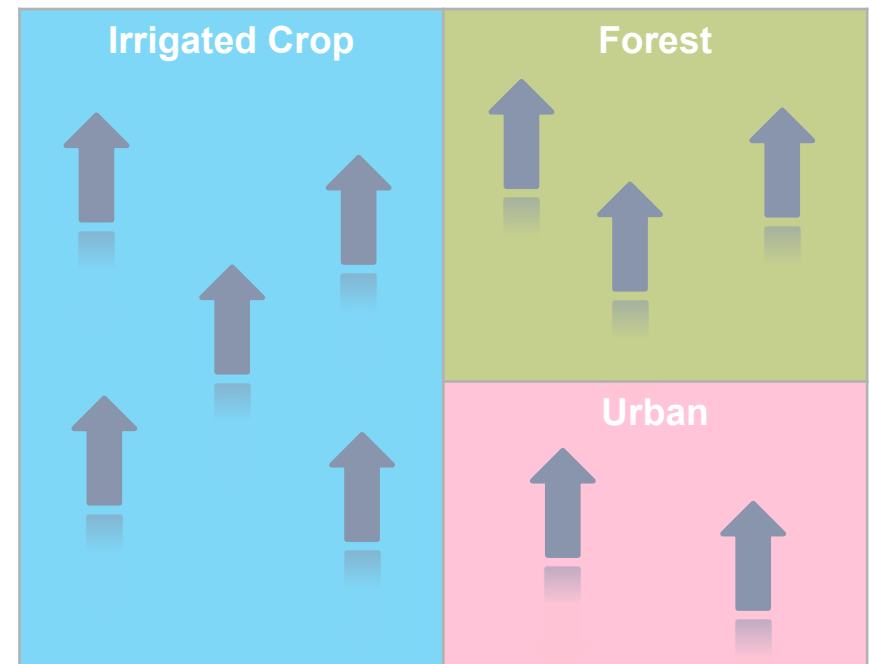
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  - Information on precipitation/cloud cover
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**More development needed, but there's promise for moving beyond 'homogeneous' boundary conditions**