Update on GENESIS

Studying coherent structures in the boundary layer

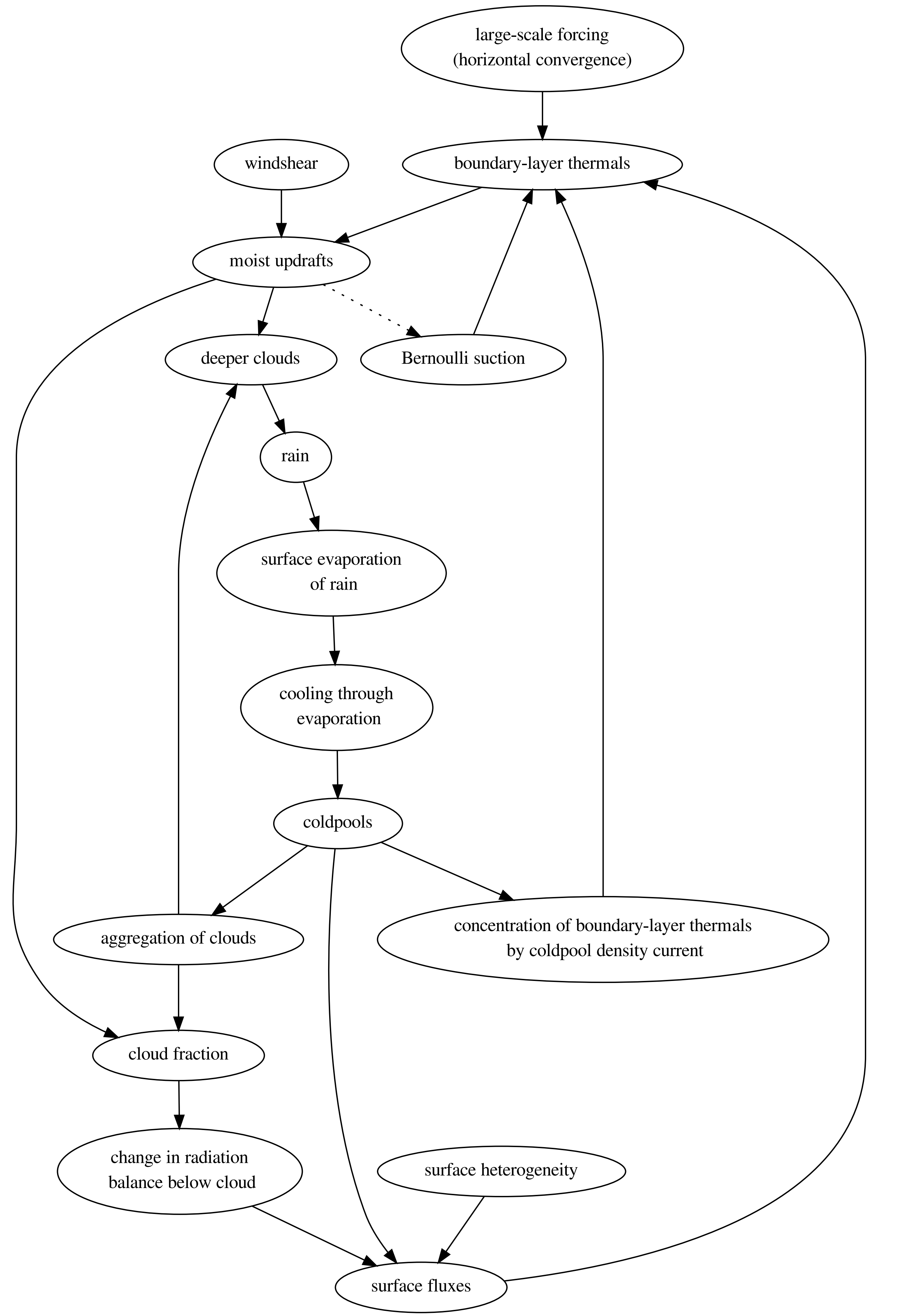
2nd May 2017

Overview

1. Sources of interaction in the boundary layer
2. Spatial size and magnitude of BL structures
3. Compatibility with Exeter multi-fluid framework

1. Sources of interaction

More literature review needed



1. Sources of interaction

Boundary-layer coherent structures and phenomena

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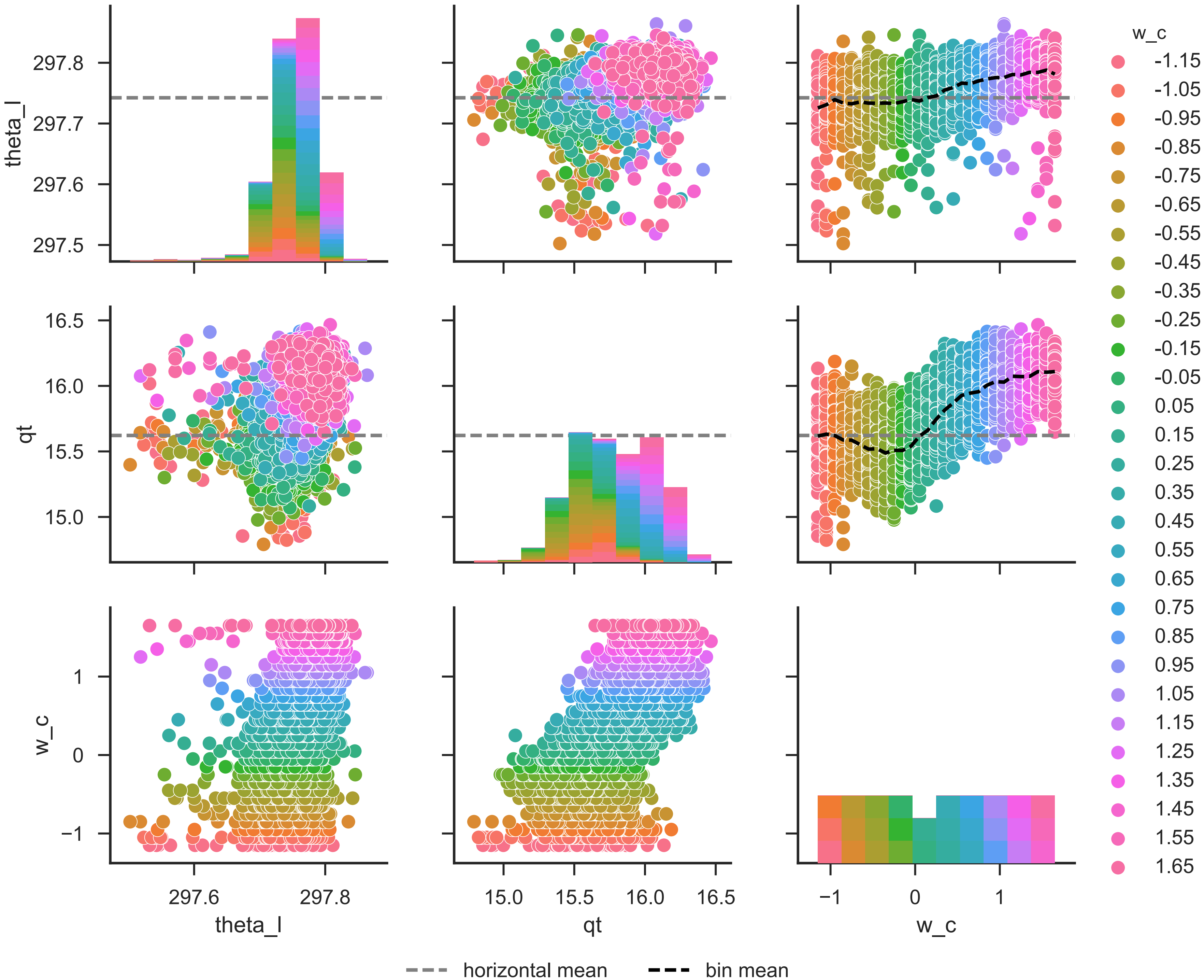
	A	B	C	D	E
1		Effect of external forcing on boundary-layer structures			
2		**Forcing (magnitude of)**			
3		**Horizontal convergence**		**Surface fluxes (surface heterogeneity)**	
4	**Effect on**	**Heat (temperature) convergence**	**Moisture convergence**	**Heat flux**	**Moisture flux**
5	**Horizontal lenght-scale of BL perturbations**	Maybe increase i is Gaussian but r must increase an perturbation shaj similar?			
6	**Variation in BL perturbation length-scales**	Larger range of length-scales exc larger perturbatio			
7	**Magnitude of BL perturbations**	increased?			
8	**Horizontal spatial distribution of BL perturbations**				
9	**Vertical spatial distribution of BL perturbations**	Largest at height convergence is tl			
10	**Perturbation in vertical velocity**	Increase as conv increases			

fx Interactions between boundary-layer structures an observed physical phenomena

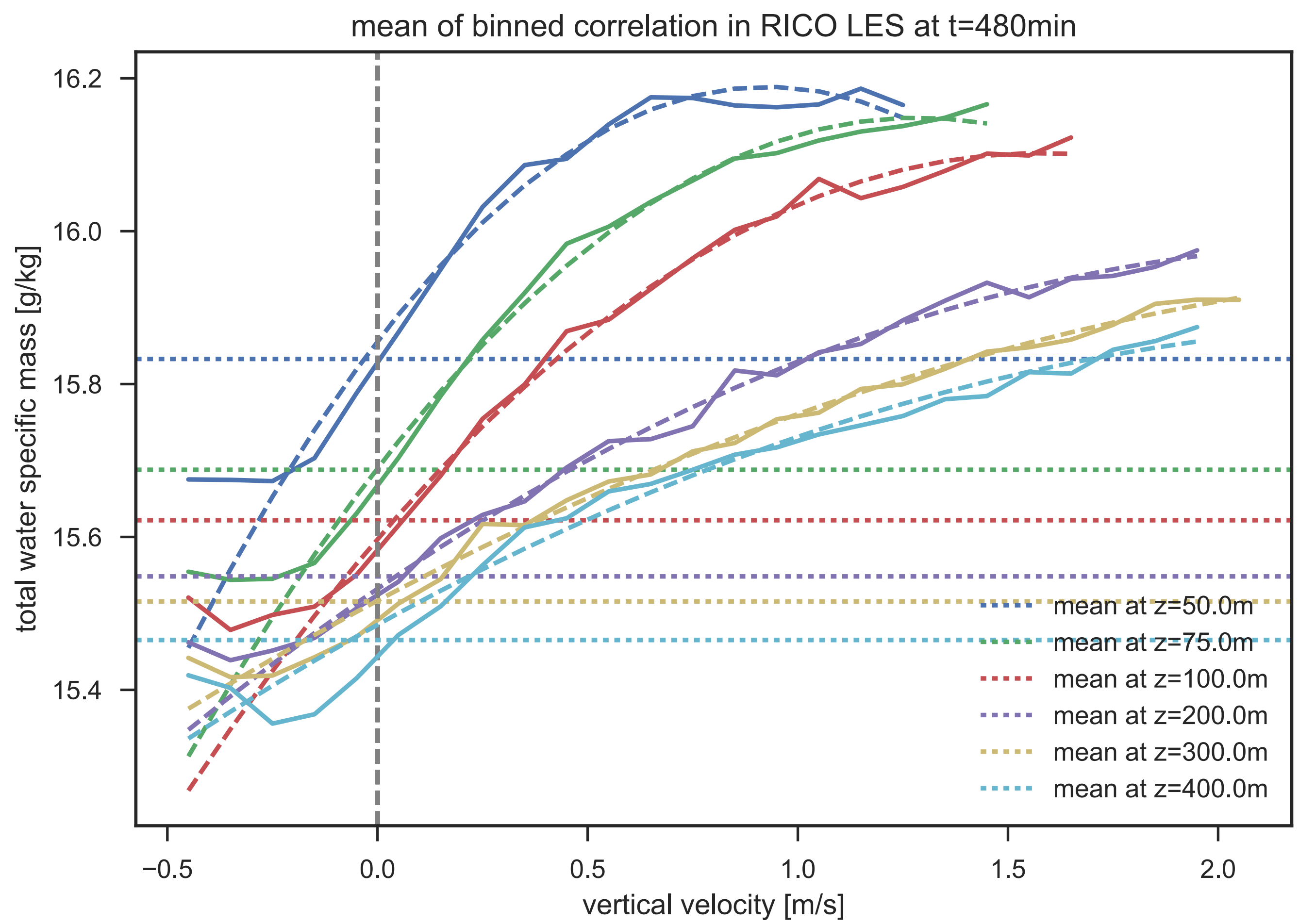
	A	B	C	D	E	
1		Interactions between boundary-layer structures an observed physical phenomena				
2		**Phenomena**				
3	**Effect on**	**Deep convection**	**Shallow convection**	**Coldpools**	**Fronts**	**Convecti**
4	**Horizontal lenght-scale of BL perturbations**	Similar to updrafts? I.e. kilometers?	Similar to updrafts/cloud base (equivalent) radius? Height of the boundary layer (A Blyth)? Length-scale of overturning?	Characteristic size altered with the appearance of coldpools?	On size of updrafts within front, front width or front length?	Reduce in rate (beca to convec friction wi
5	**Distribution of BL perturbation horizontal length-scales**	Are there more large eddies than for say shallow convection?	?	Restricted in size because of coldpools? Appearance of a second distribution due to thermals lifted from cold pool edge?	?	Reduced length-sca
6	**Horizontal (xy) aspect ratio to BL horizontal length-scale distribution?**	No preferential direction (assuming no wind)?	None?	Appearance of more horizontally elongated perturbations?	Appearance of more horizontally elongated perturbations?	None?
7	**Magnitude of BL perturbations**	Larger than shallow convection (because clouds are fed by larger eddies) or smaller (because deep convective clouds are self-perpetuating)?	Defined by surface fluxes?	Increased/decreased?	Larger because of downdrafts causing increased circulation in boundary layer?	Reduced time?
8	**Horizontal spatial distribution of BL perturbations**	Fewer isolated areas of convection compared to shallow. Is cloud fraction	Isotropic or clustered?	More closely spaced thermals (because of reduced horizontal area with	Concentrated along and near front?	Unchange

2. Magnitude of BL structures

Cross-correlations of θ_l, q_t and w binned by w (bin width $\Delta w = 0.1 m/s$, 200 samples per bin)
in z=100.0m cross-section from UCLALES RICO simulation at t=480min

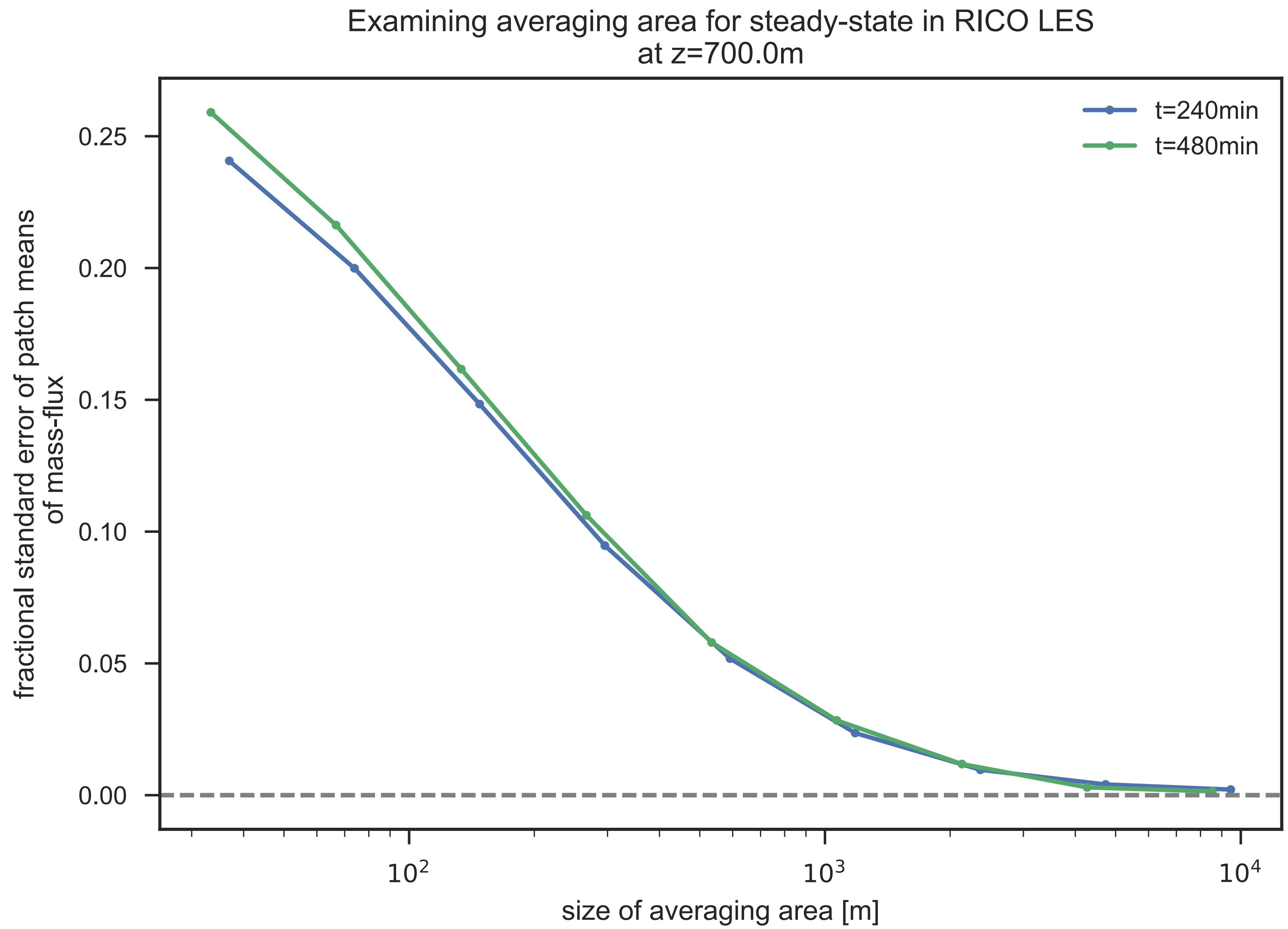


2. Magnitude of BL structures



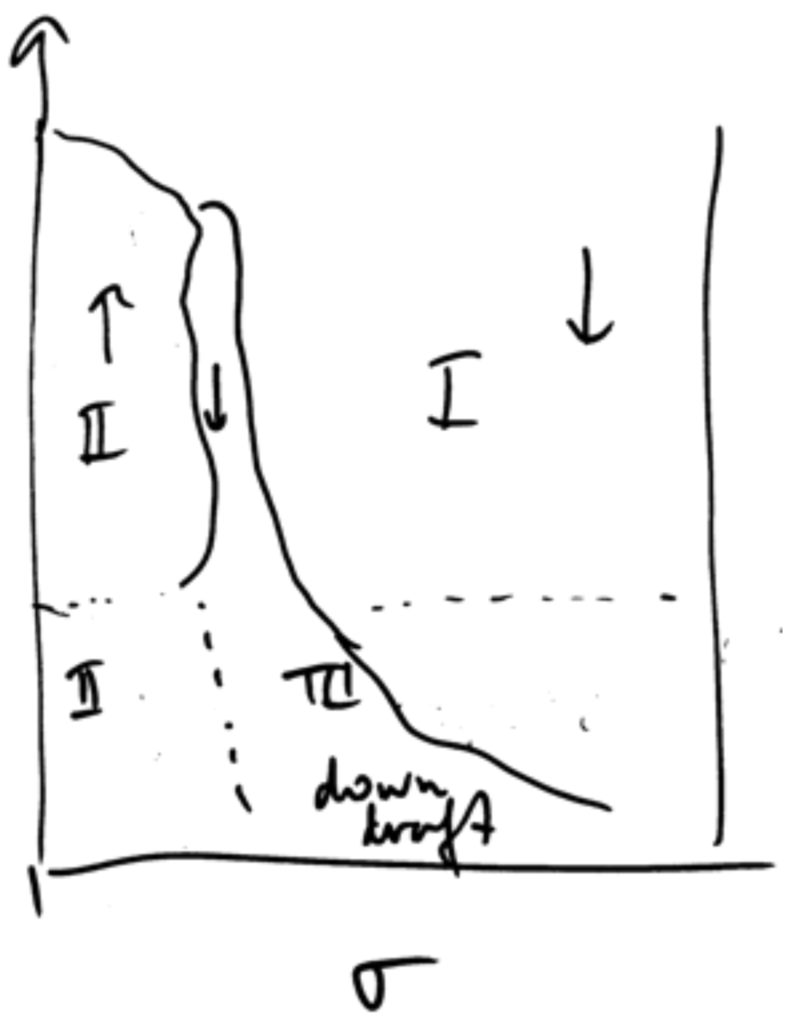
- Acceleration largest for most buoyant air, causes stretching of profile with height
- Good fit with parabolic profile => easy to parameterise

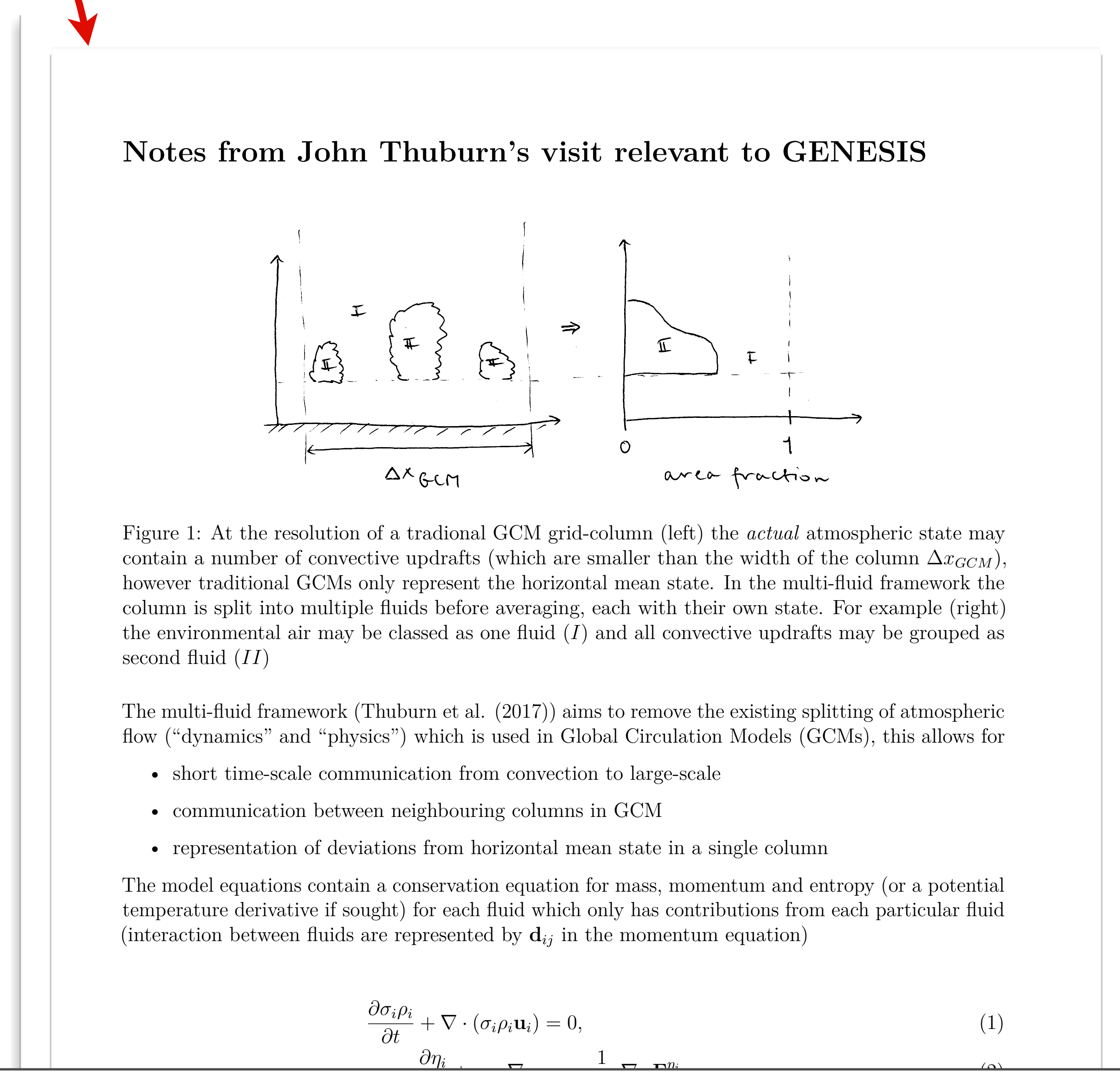
2. Spatial size of BL structures



- Averaging over ~2km gives ~2% error in representing mass-flux

3. GENESIS and Exeter *multi-fluid* framework





Notes from John Thuburn's visit relevant to GENESIS

Figure 1: At the resolution of a tradional GCM grid-column (left) the *actual* atmospheric state may contain a number of convective updrafts (which are smaller than the width of the column Δx_{GCM}), however traditional GCMs only represent the horizontal mean state. In the multi-fluid framework the column is split into multiple fluids before averaging, each with their own state. For example (right) the environmental air may be classed as one fluid (I) and all convective updrafts may be grouped as second fluid (II)

The multi-fluid framework (Thuburn et al. (2017)) aims to remove the existing splitting of atmospheric flow ("dynamics" and "physics") which is used in Global Circulation Models (GCMs), this allows for

- short time-scale communication from convection to large-scale
- communication between neighbouring columns in GCM
- representation of deviations from horizontal mean state in a single column

The model equations contain a conservation equation for mass, momentum and entropy (or a potential temperature derivative if sought) for each fluid which only has contributions from each particular fluid (interaction between fluids are represented by $\mathbf{d}_{ij}$ in the momentum equation)

$$\frac{\partial \sigma_i \rho_i}{\partial t} + \nabla \cdot (\sigma_i \rho_i \mathbf{u}_i) = 0, \qquad (1)$$

Next steps

- Bob Plant visiting Tuesday May 23rd (extensions to *bulk plume* model)
- Continuing literature review on influences on BL structures
- “Thermal vs plume vs bubble vs ...“ next week
- Build up catalog of previous LES to identify