

Fireless ABL

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Program for today: 21 October 2025

13:30-13:50 Introduction to the practical: getting acquainted with the software model

13:20-14:15 The evolving Fireless ABL

What controls the ABL and LCL? (all together)

14:15-14:30 Discussing results (all together)

14:30-14:45 *Break*

14:45-16:00 Sensitivities of the Fireless ABL

Surface control: sensible versus latent heat flux

Initial morning control: weak versus strong thermal inversions

Free troposphere control: weak versus strong lid

16:30-17:15 Group presentation

Where is the ABL height?
What happens there with respect the plumes?
How is the potential temperature within the ABL?
And at the inversion?

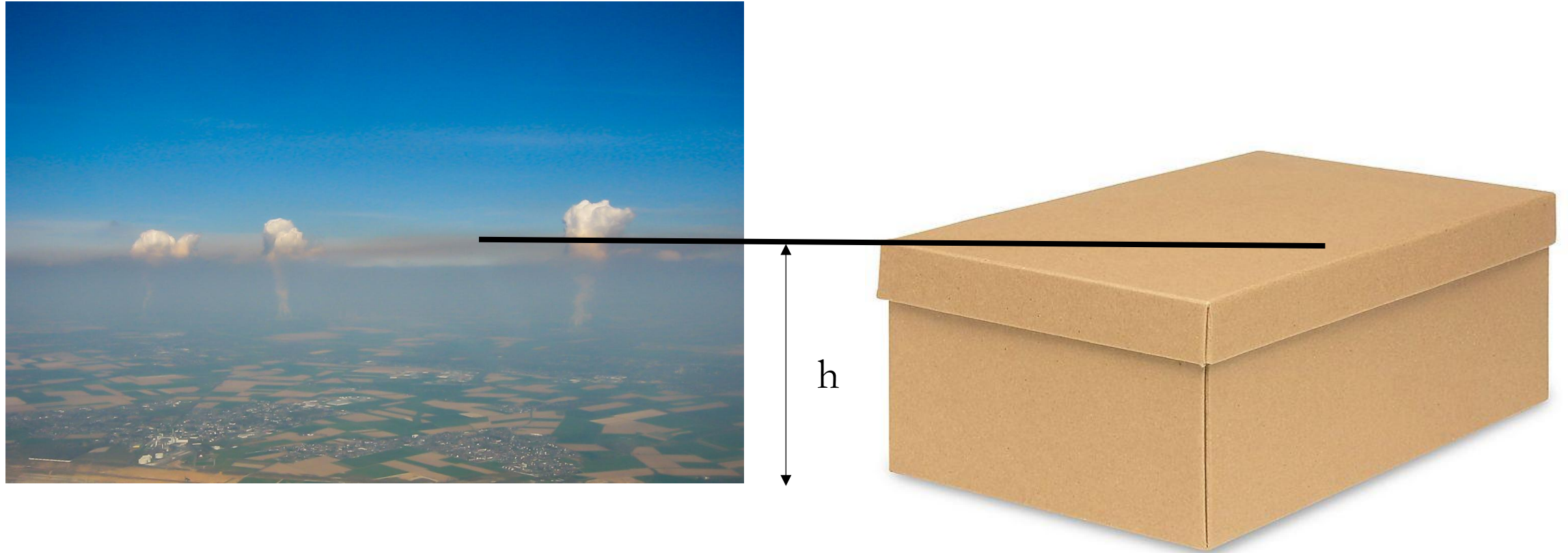


The **atmospheric boundary layer** is the layer connecting the surface (vegetation, soil) with the free atmosphere.

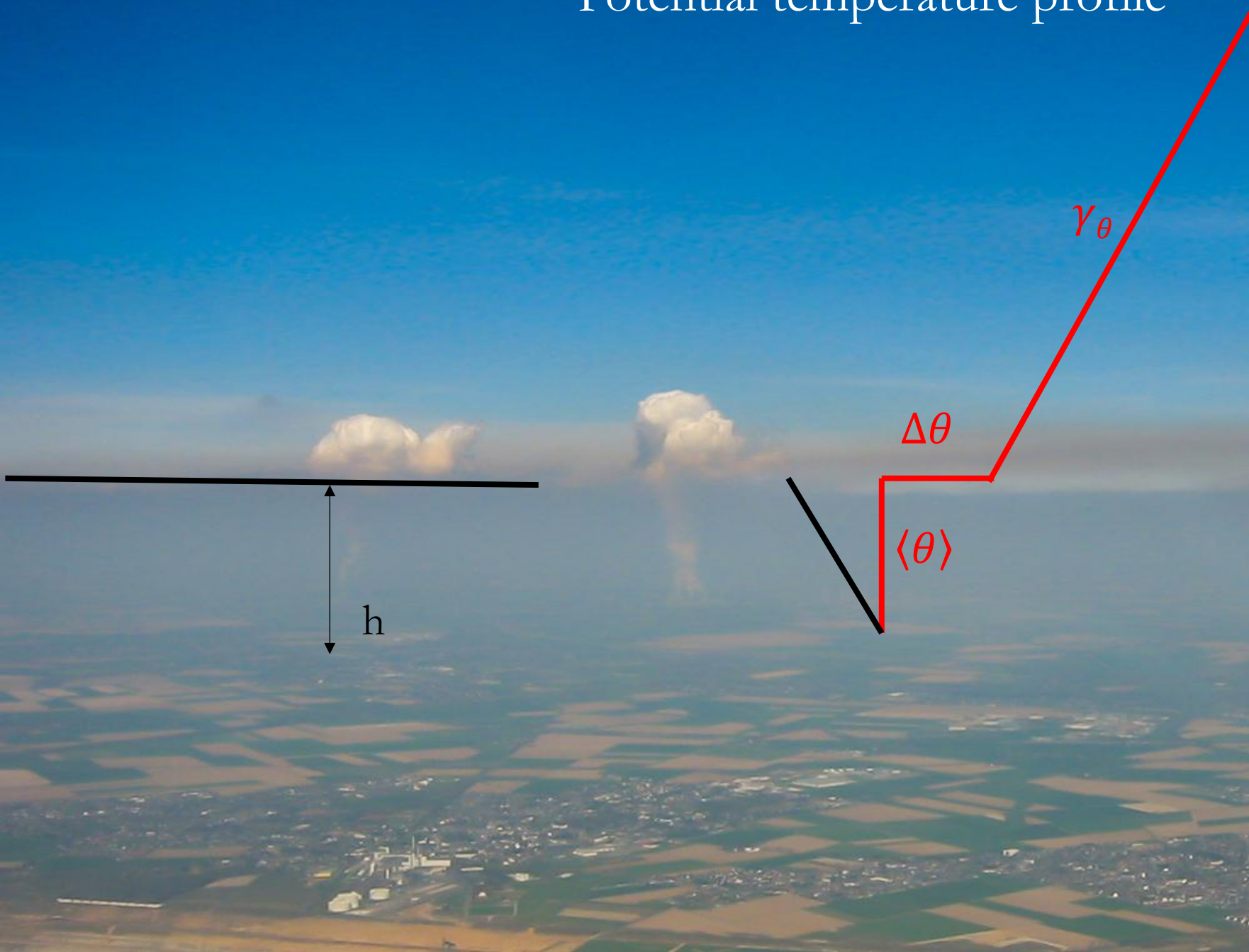
This connection is driven by
convective and mechanical turbulence

Wildfire and atmosphere coupling

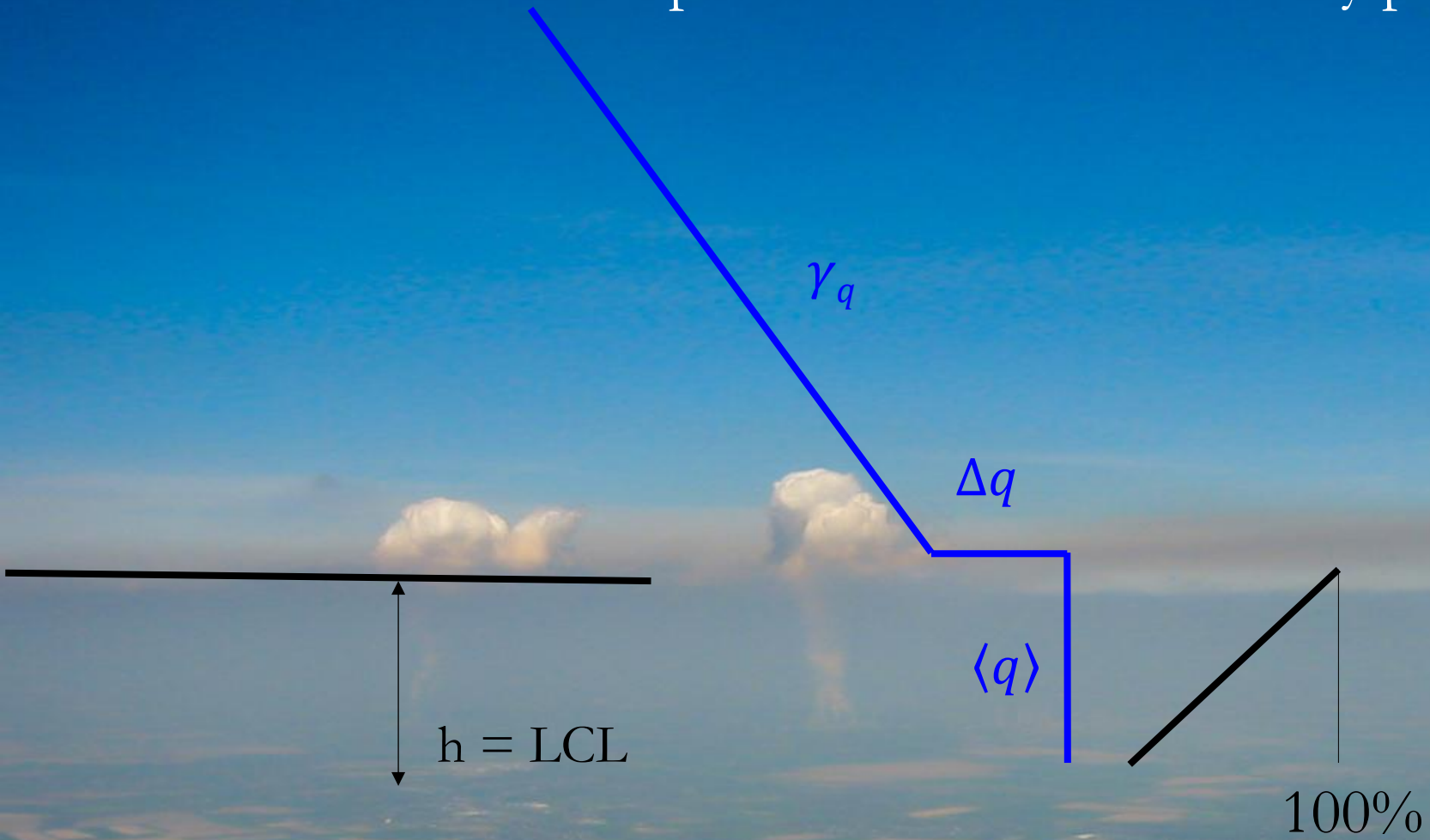
From reality to model
(Chiel)



Potential temperature profile



Specific and relative humidity profiles



The height or level where the air parcels change from vapor to liquid is called the **Lifting Condensation Level (LCL)**

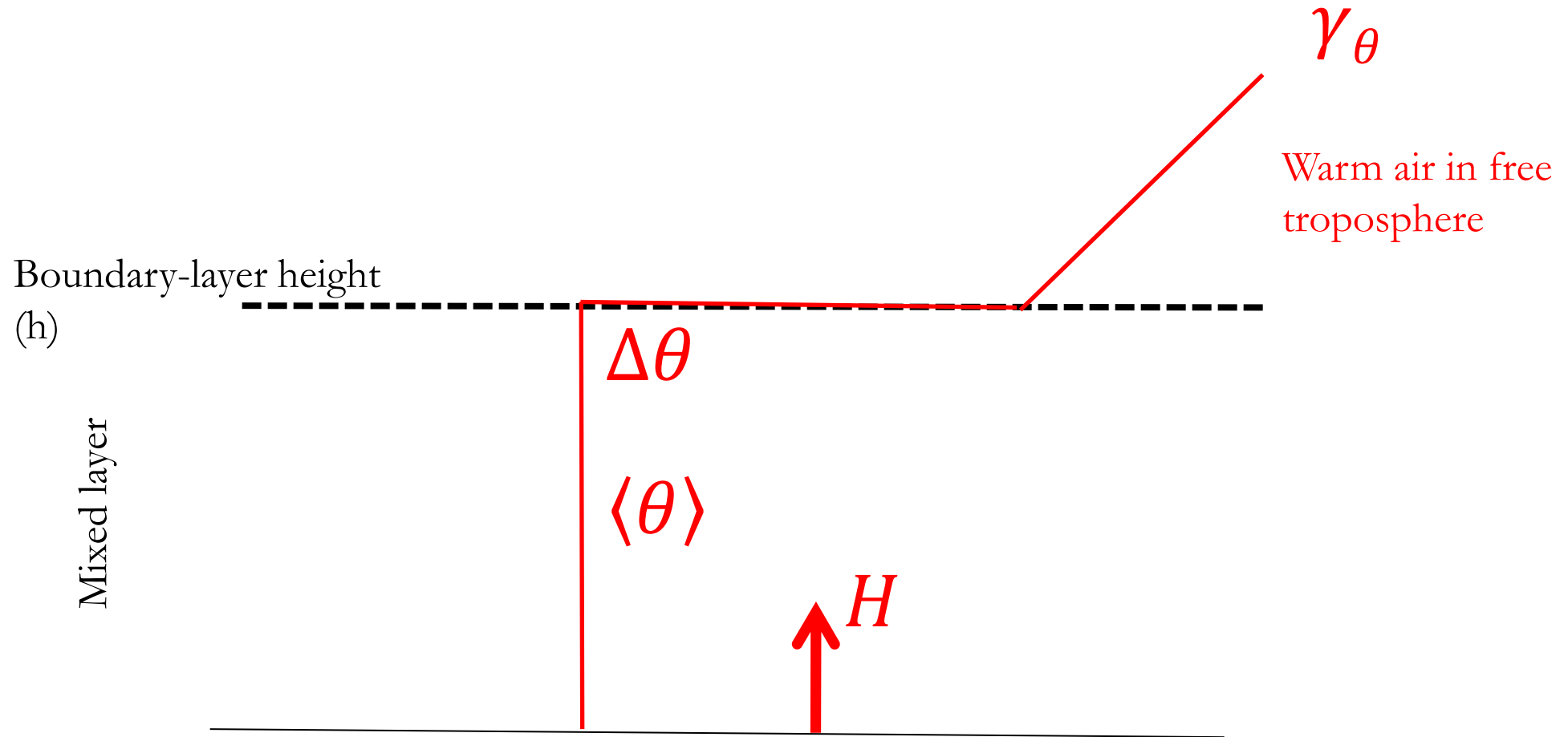
Free troposphere

Atmospheric
boundary layer
 h

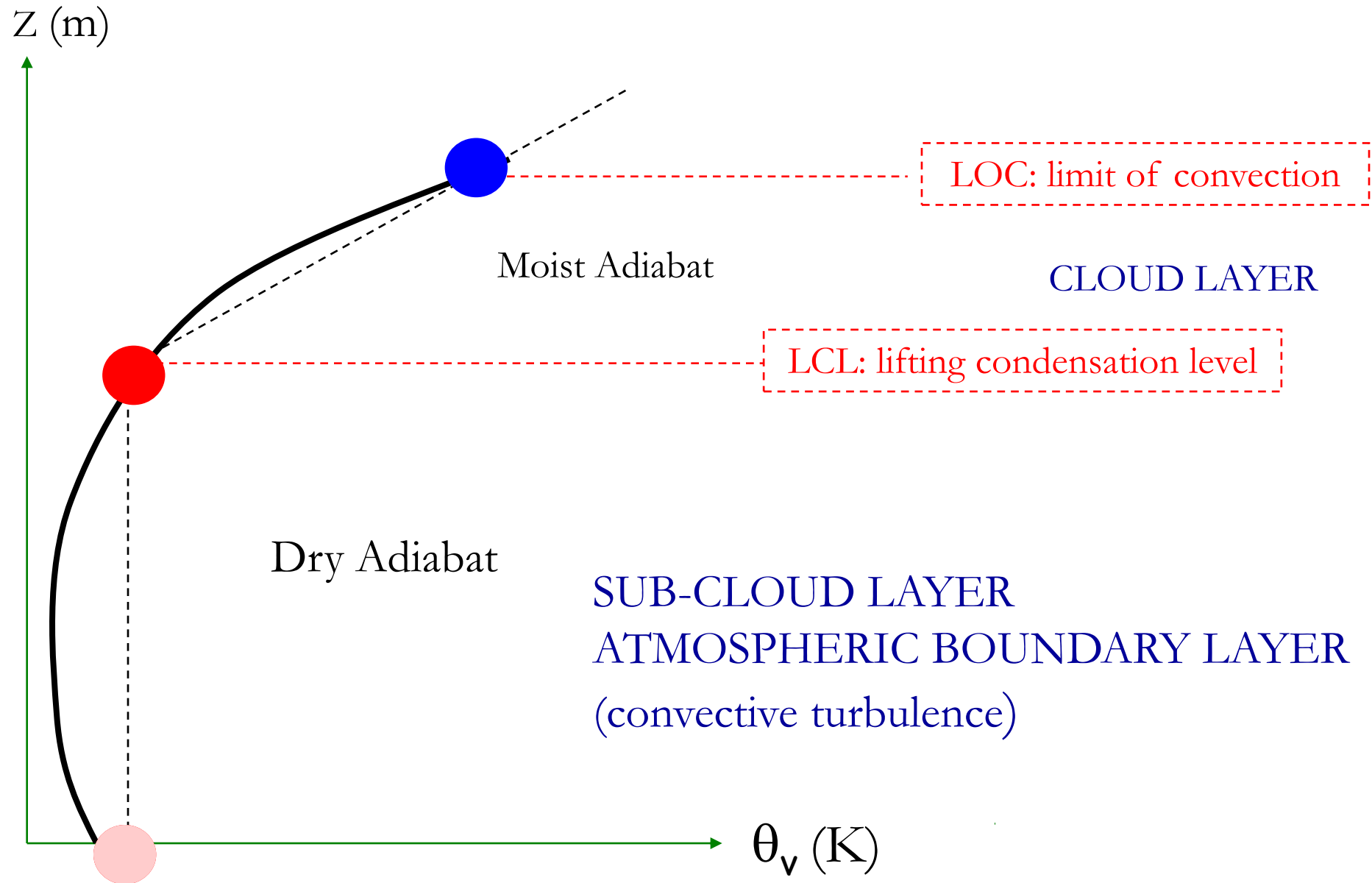
Surface



Potential temperature θ [K]



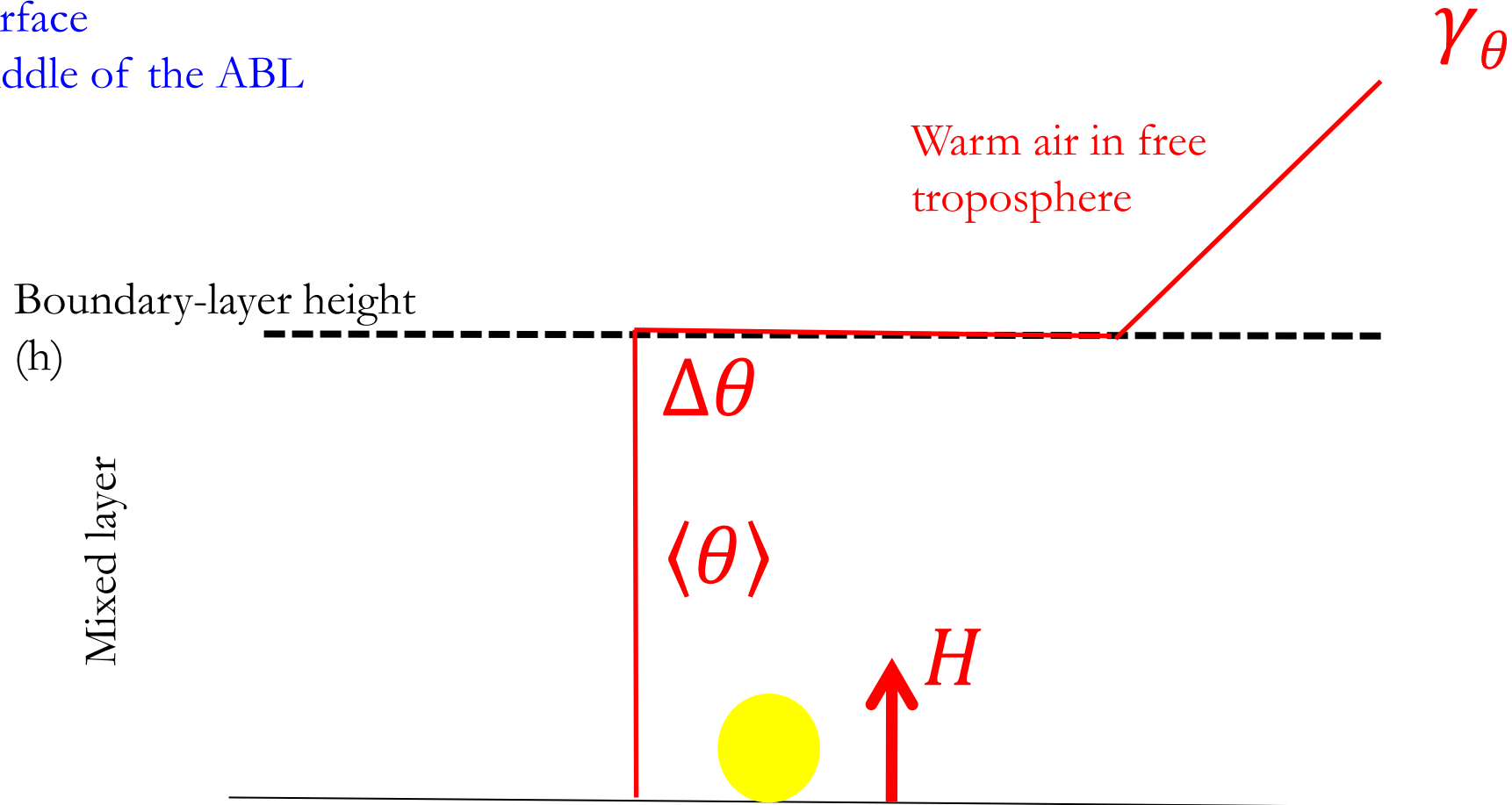
Environment versus fire plume



Quiz I

Where do the parcel emitted at the surface will end up?

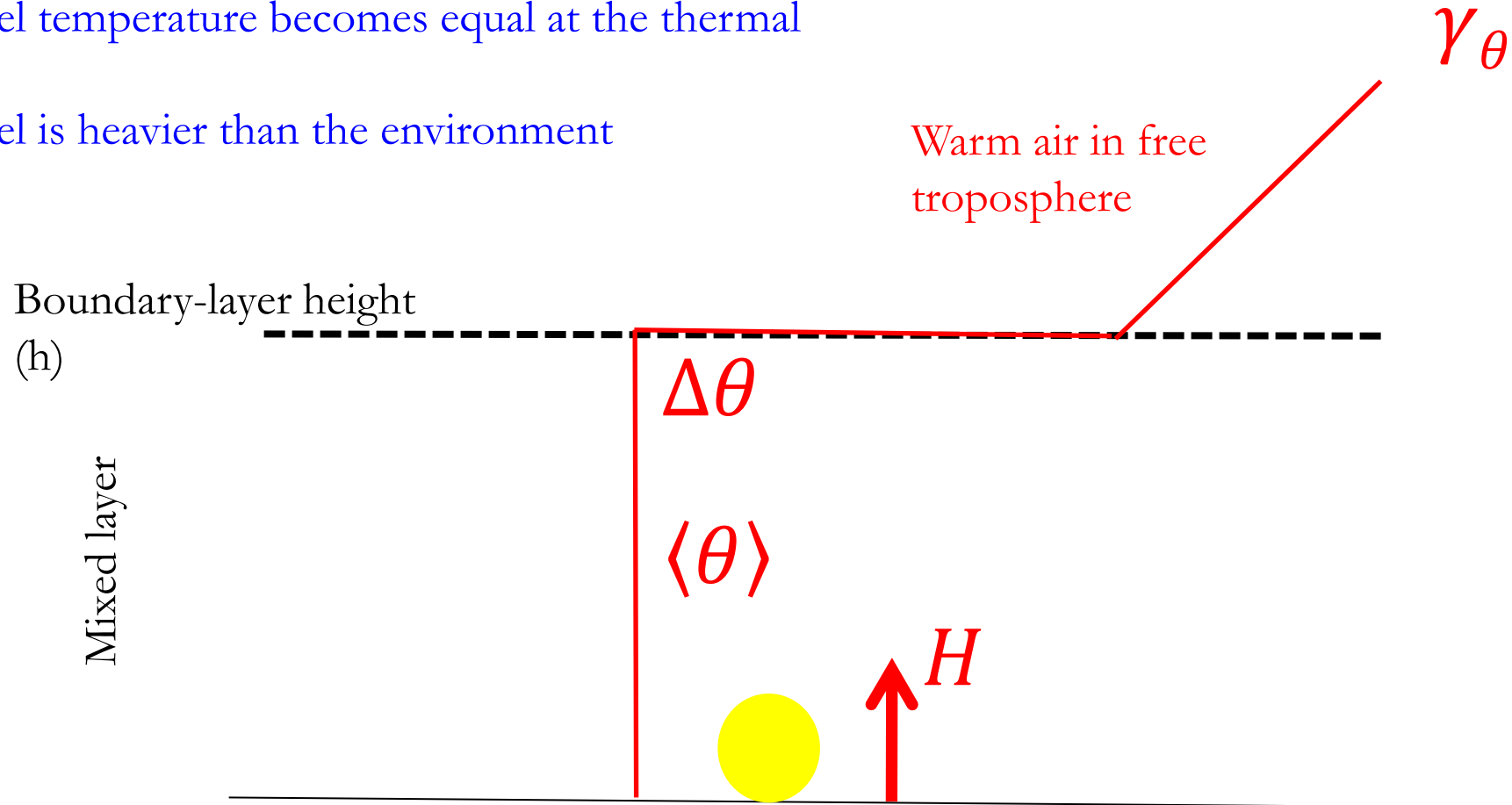
- 1) At the ABL height
- 2) At the surface
- 3) In the middle of the ABL



Quiz II

Why?

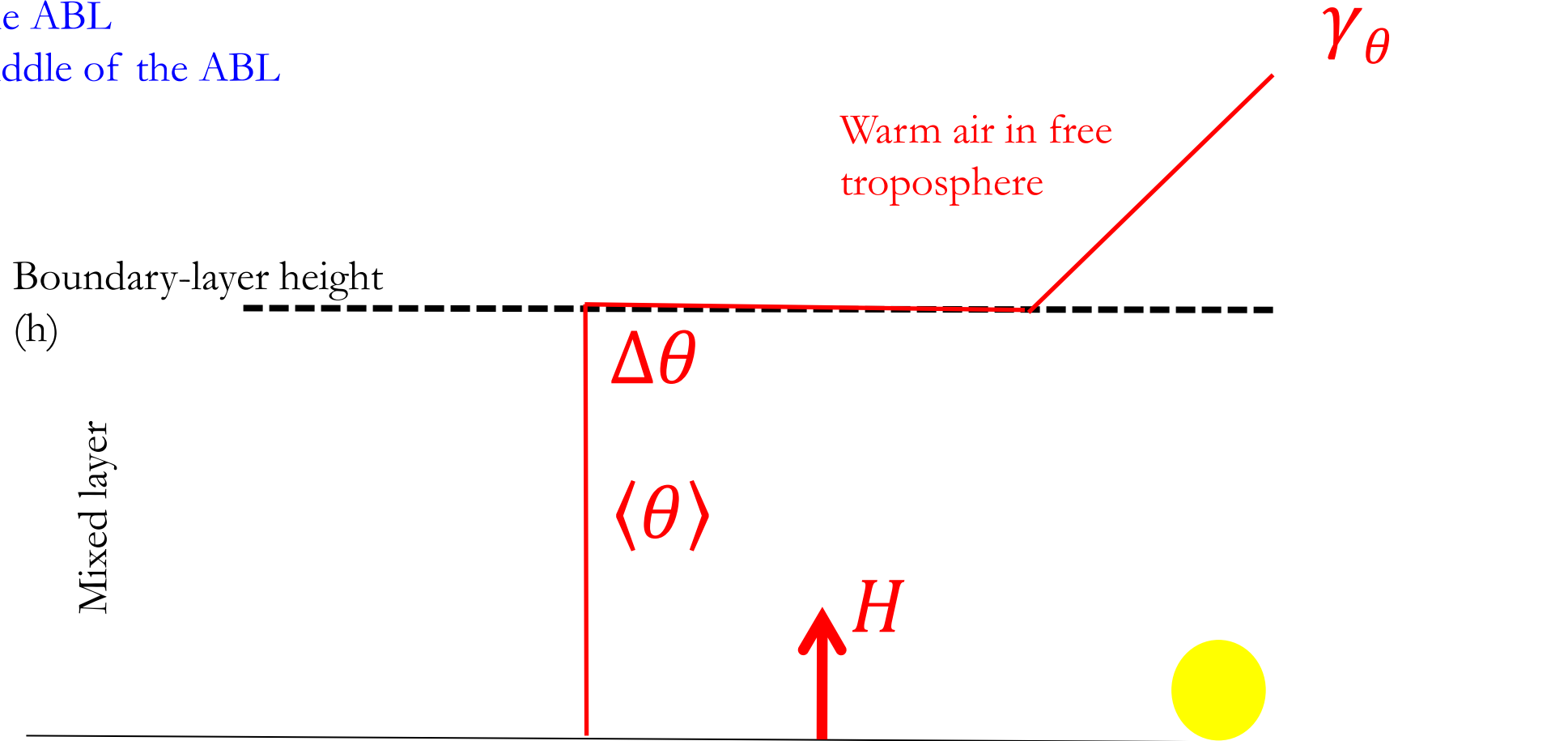
- 1) The parcel is colder than the environment
- 2) The parcel temperature becomes equal at the thermal inversion
- 3) The parcel is heavier than the environment



Quiz III

Where do the parcel emitted at the surface will end up?

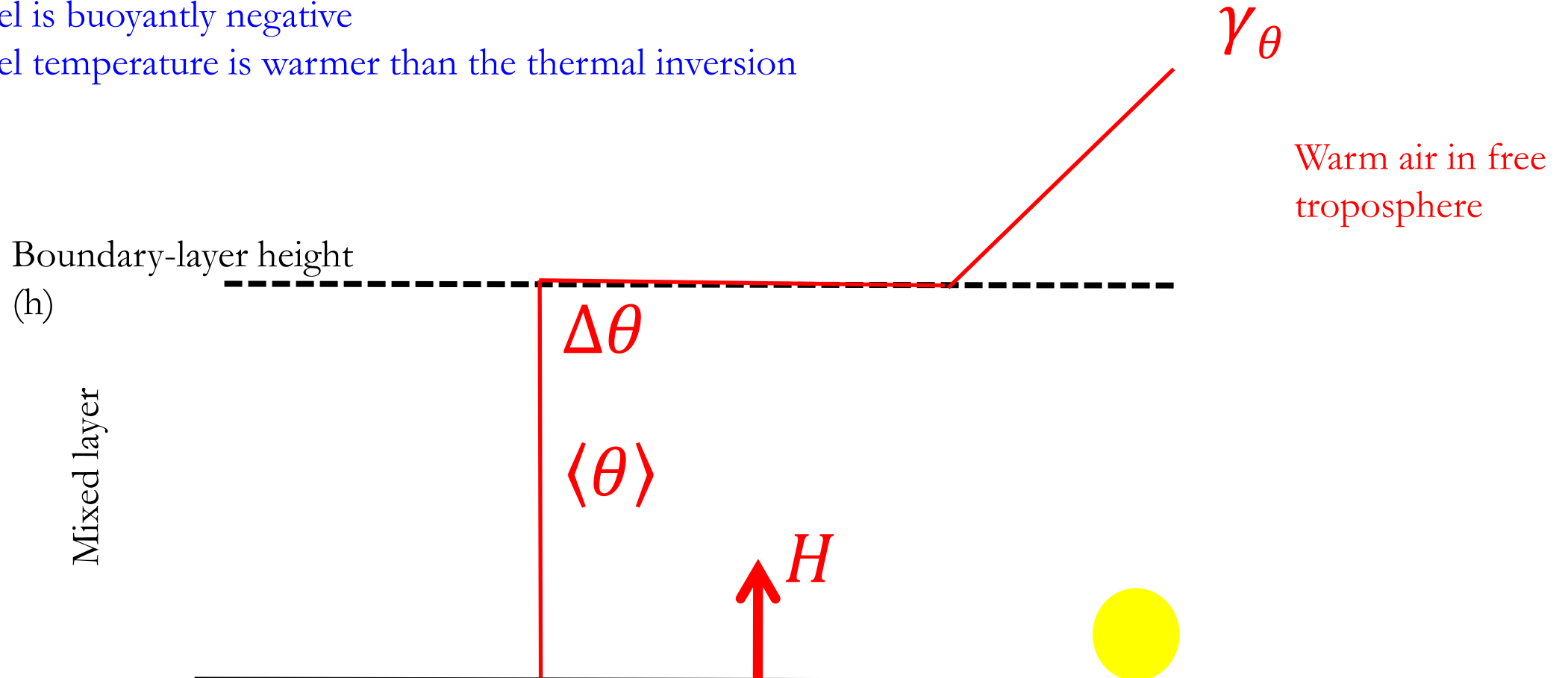
- 1) At the ABL height
- 2) Above the ABL
- 3) In the middle of the ABL



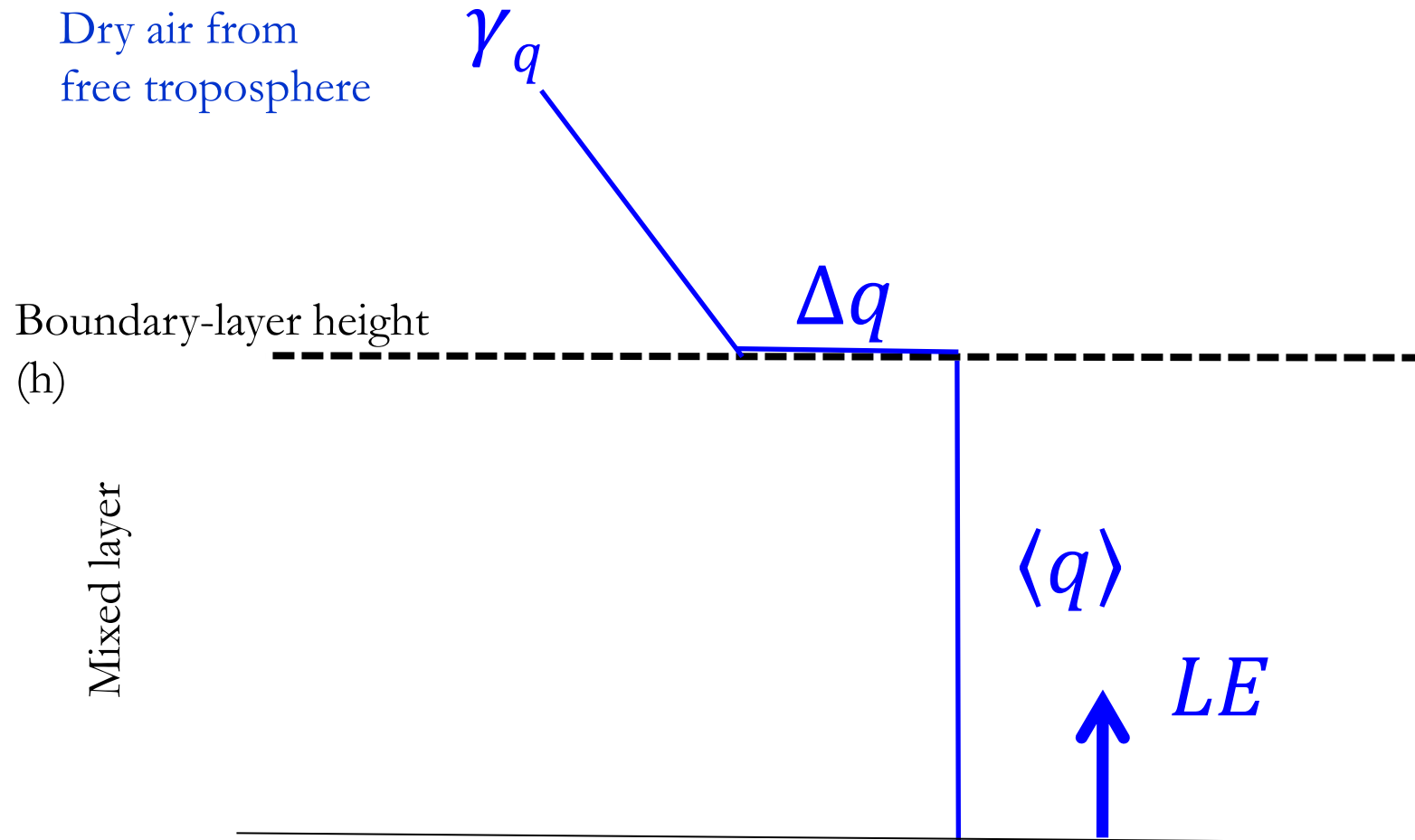
Quiz IV

Why?

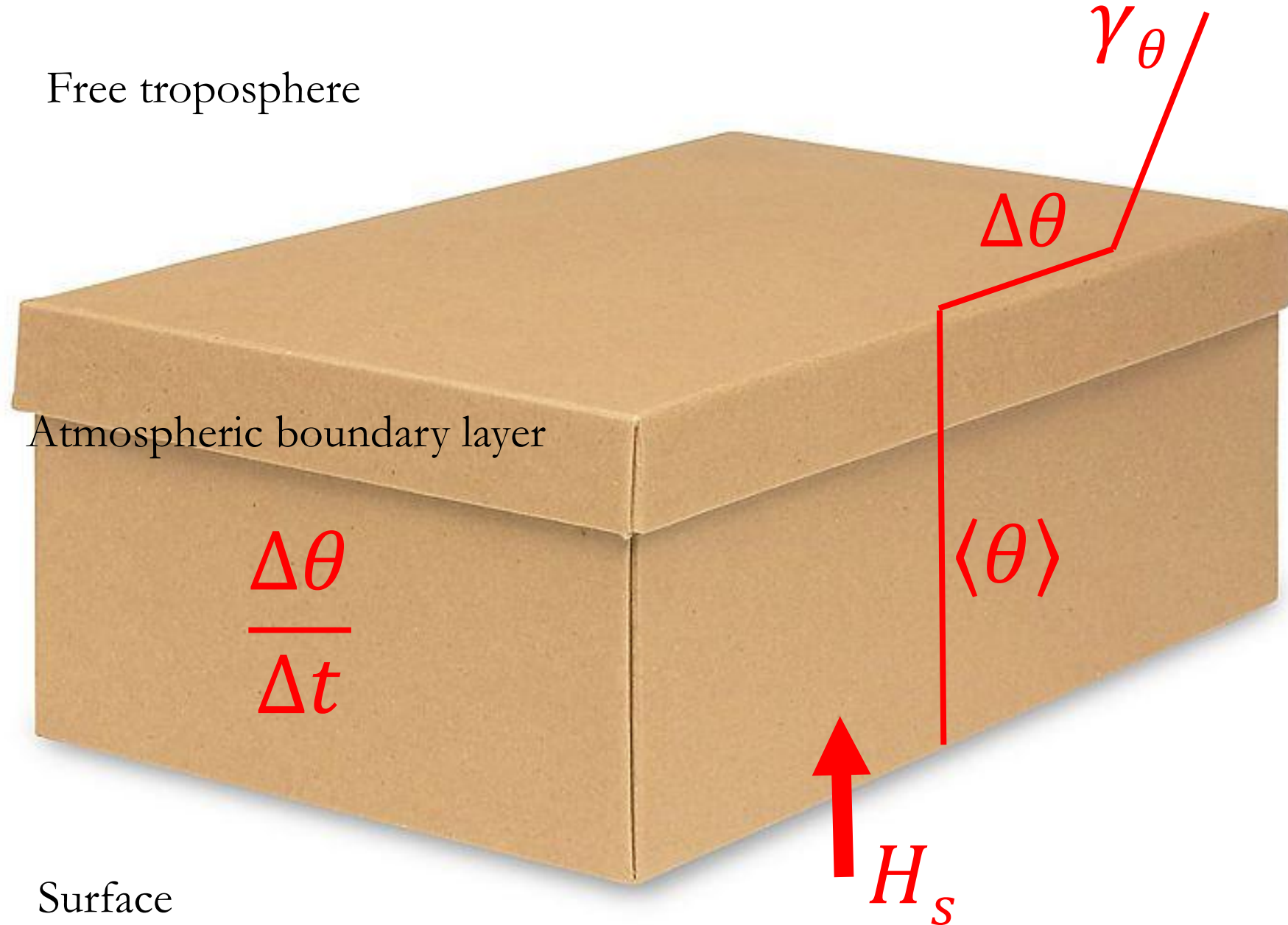
- 1) The parcel is colder than the environment
- 2) The parcel is buoyantly negative
- 3) The parcel temperature is warmer than the thermal inversion



Specific humidity q [$\text{kg}_w \text{ kg}_a^{-1}$]



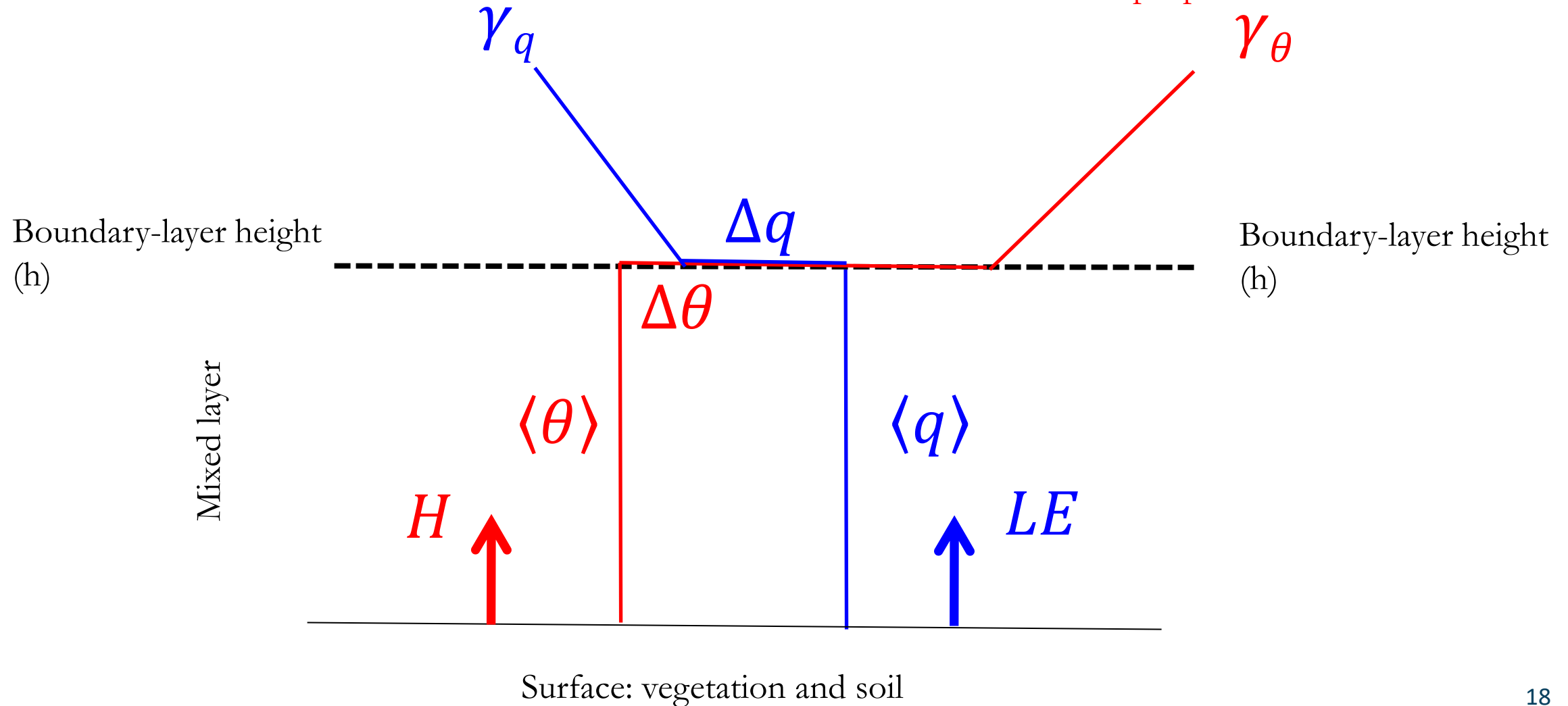
Representing in a mixed layer model: CLASS



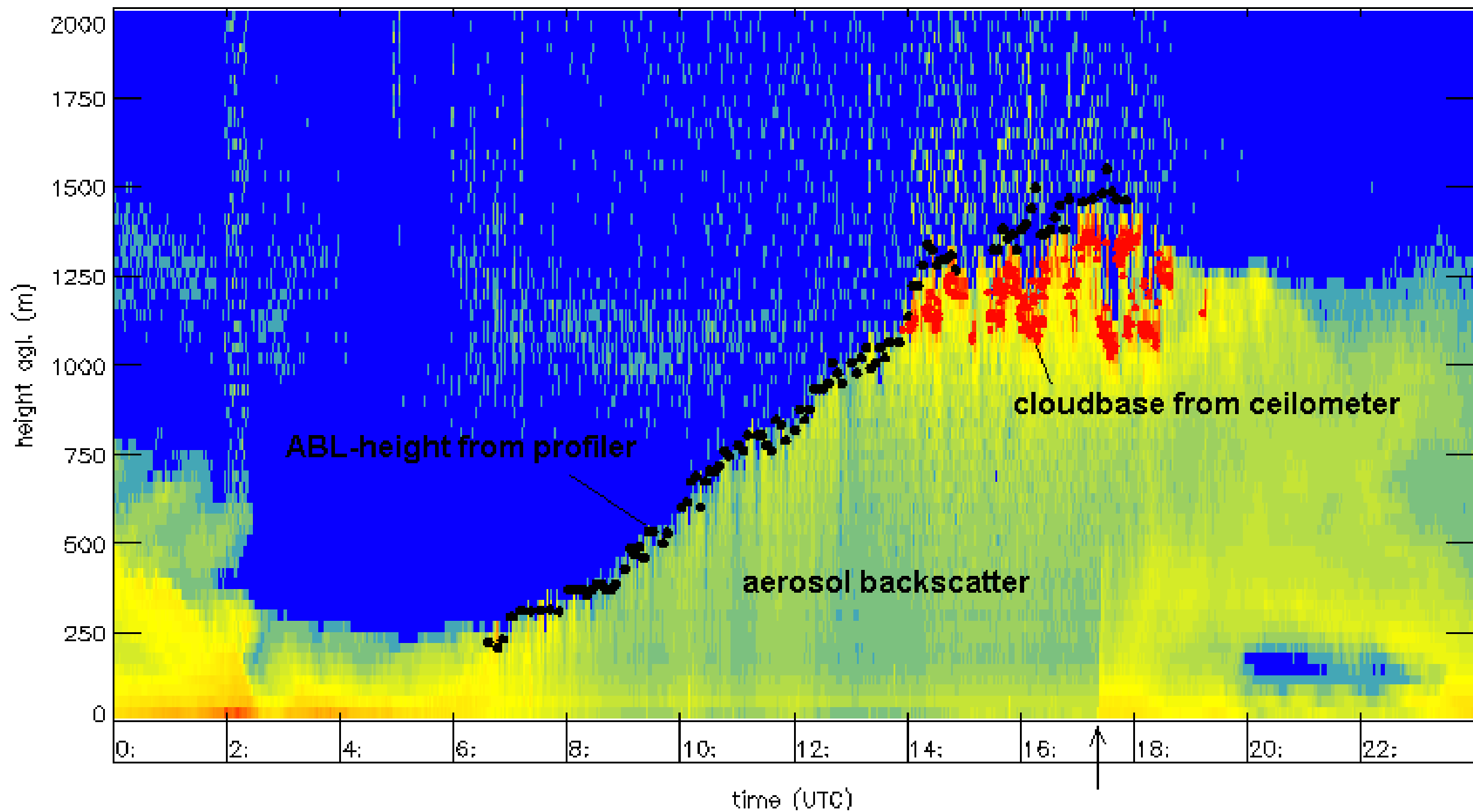
Connecting vertical profiles of θ and q

Dry Air in the
Free troposphere

Warm air in free
troposphere



But the atmospheric boundary layer evolves with time

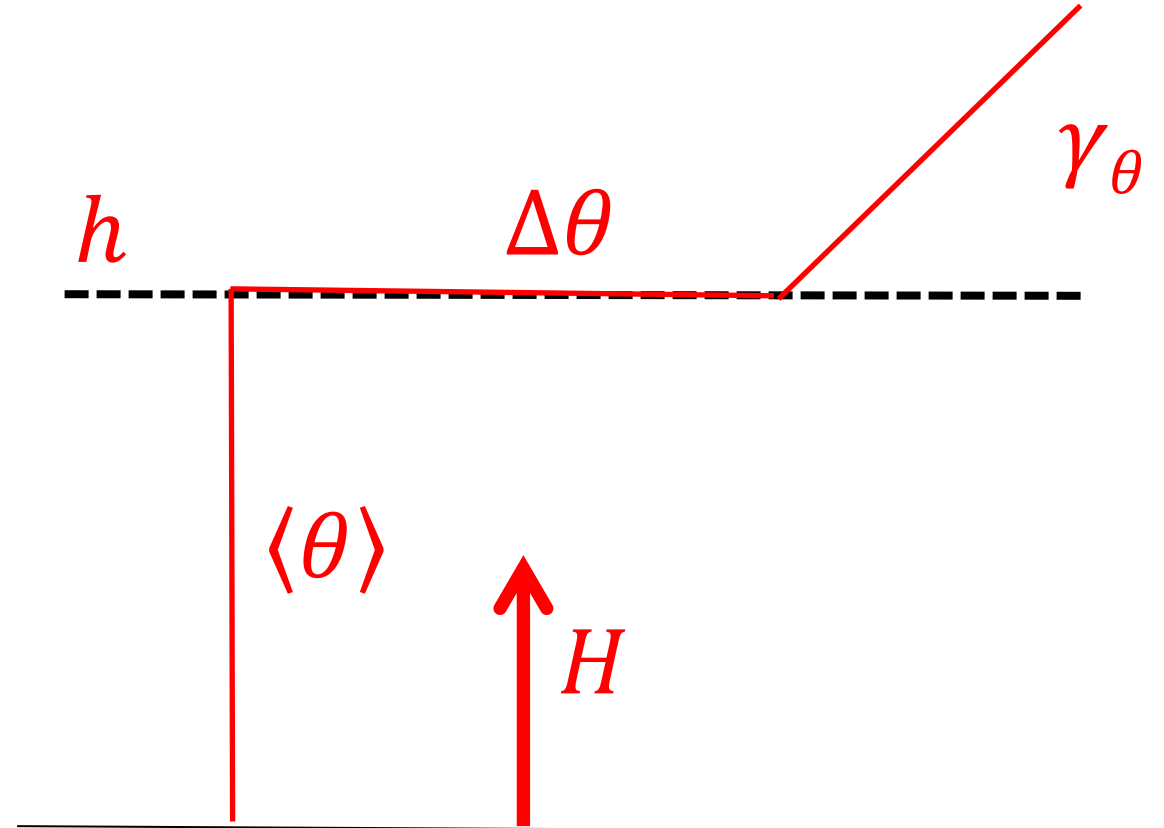
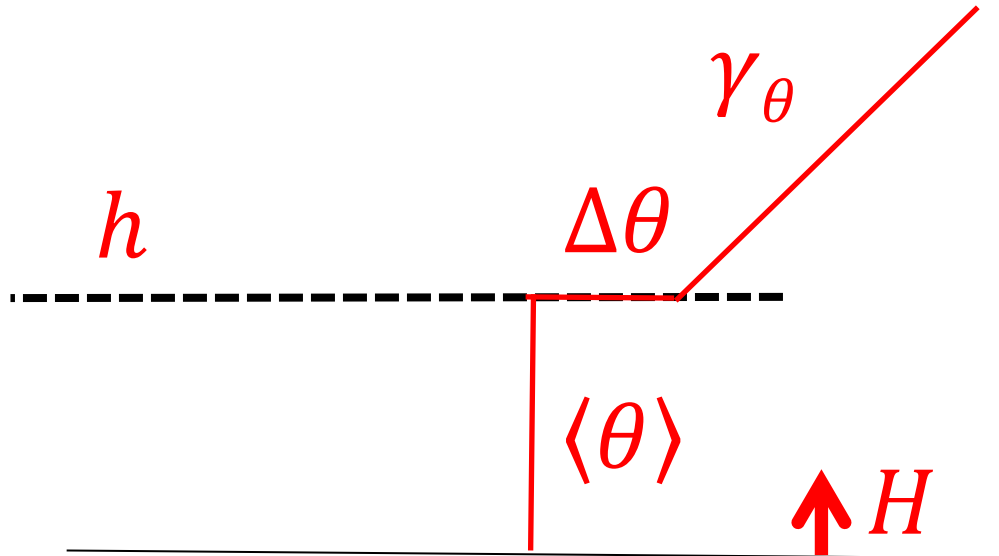


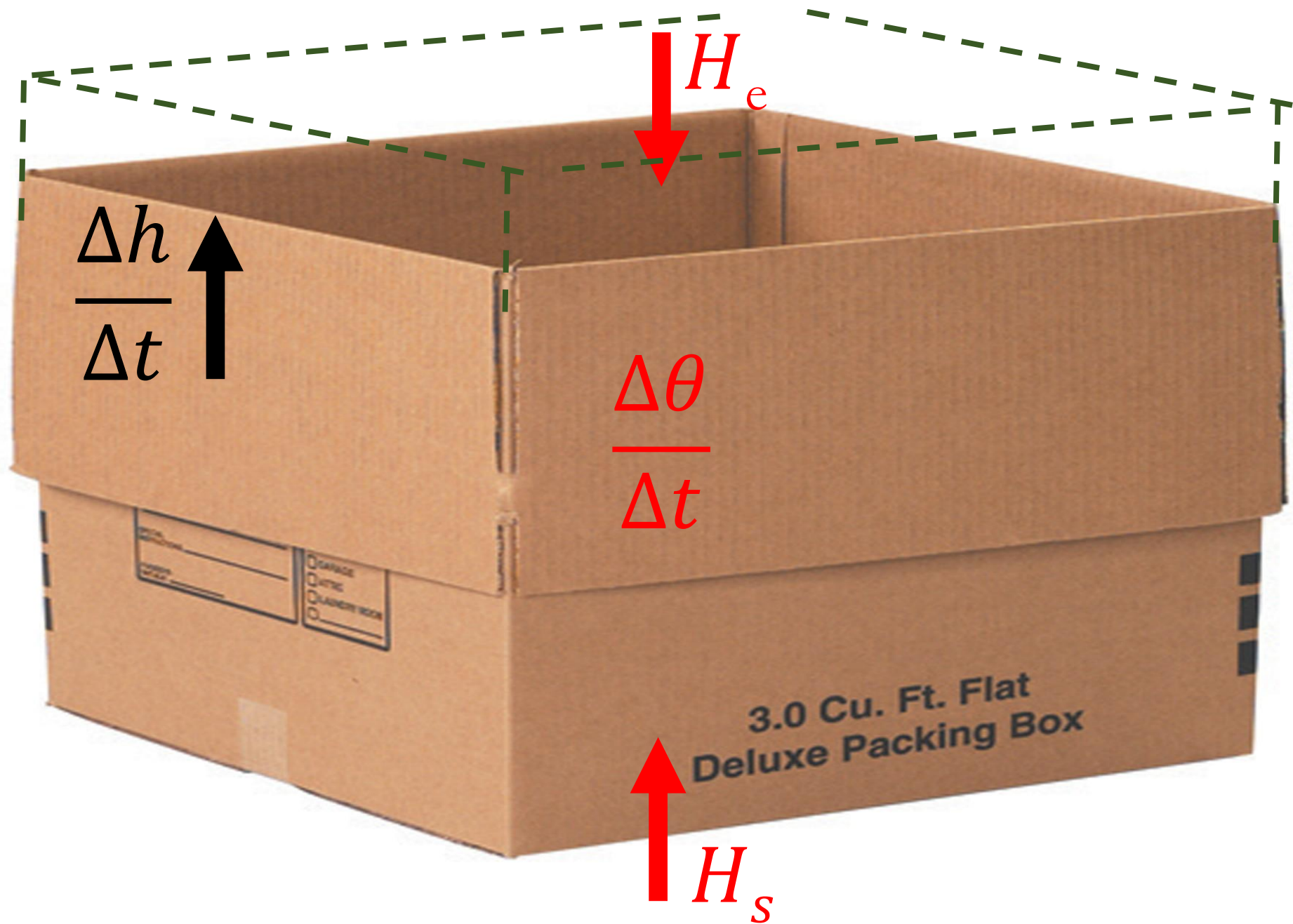
Evolution of the atmospheric boundary layer

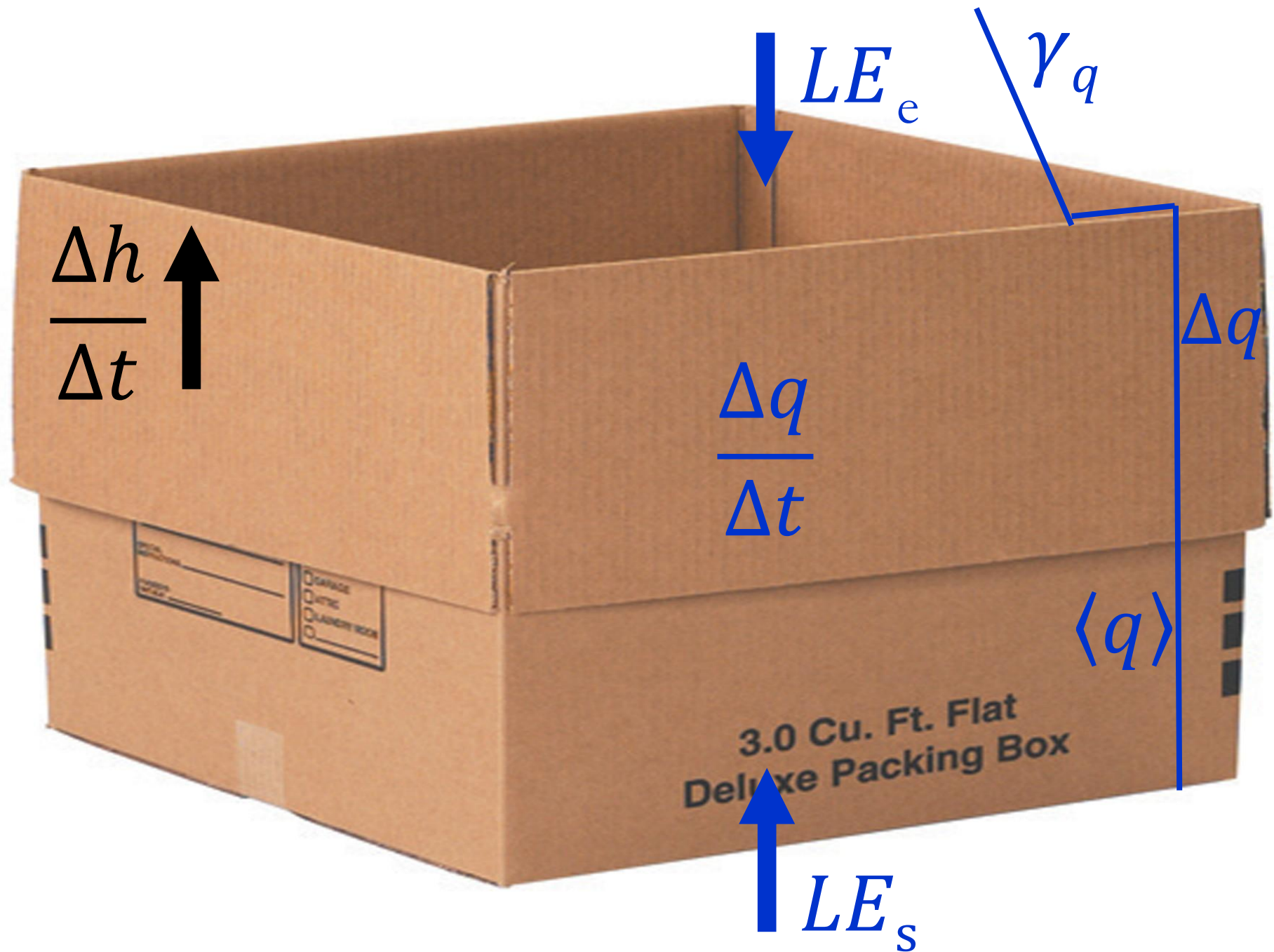
Sunrise

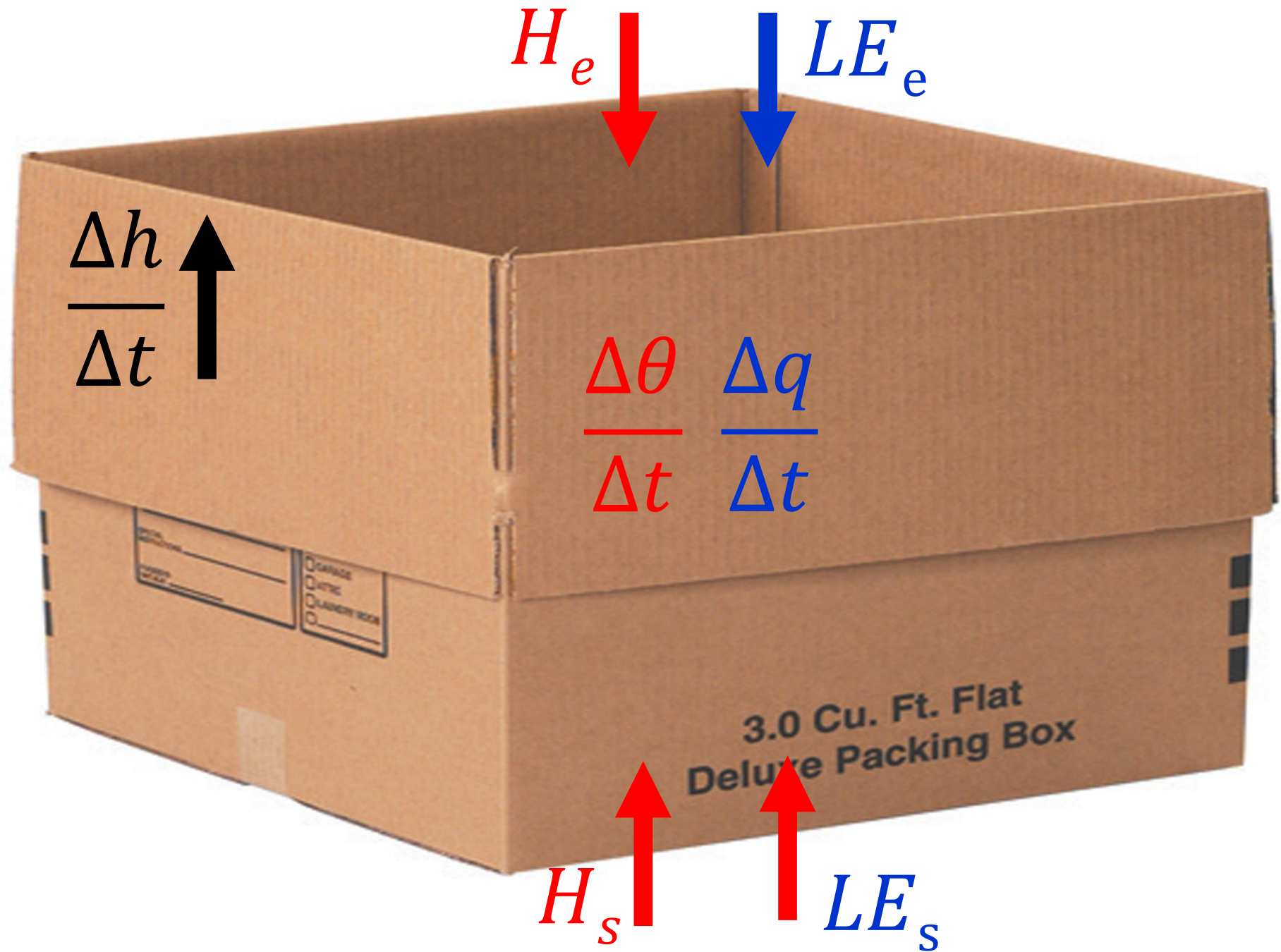


Afternoon



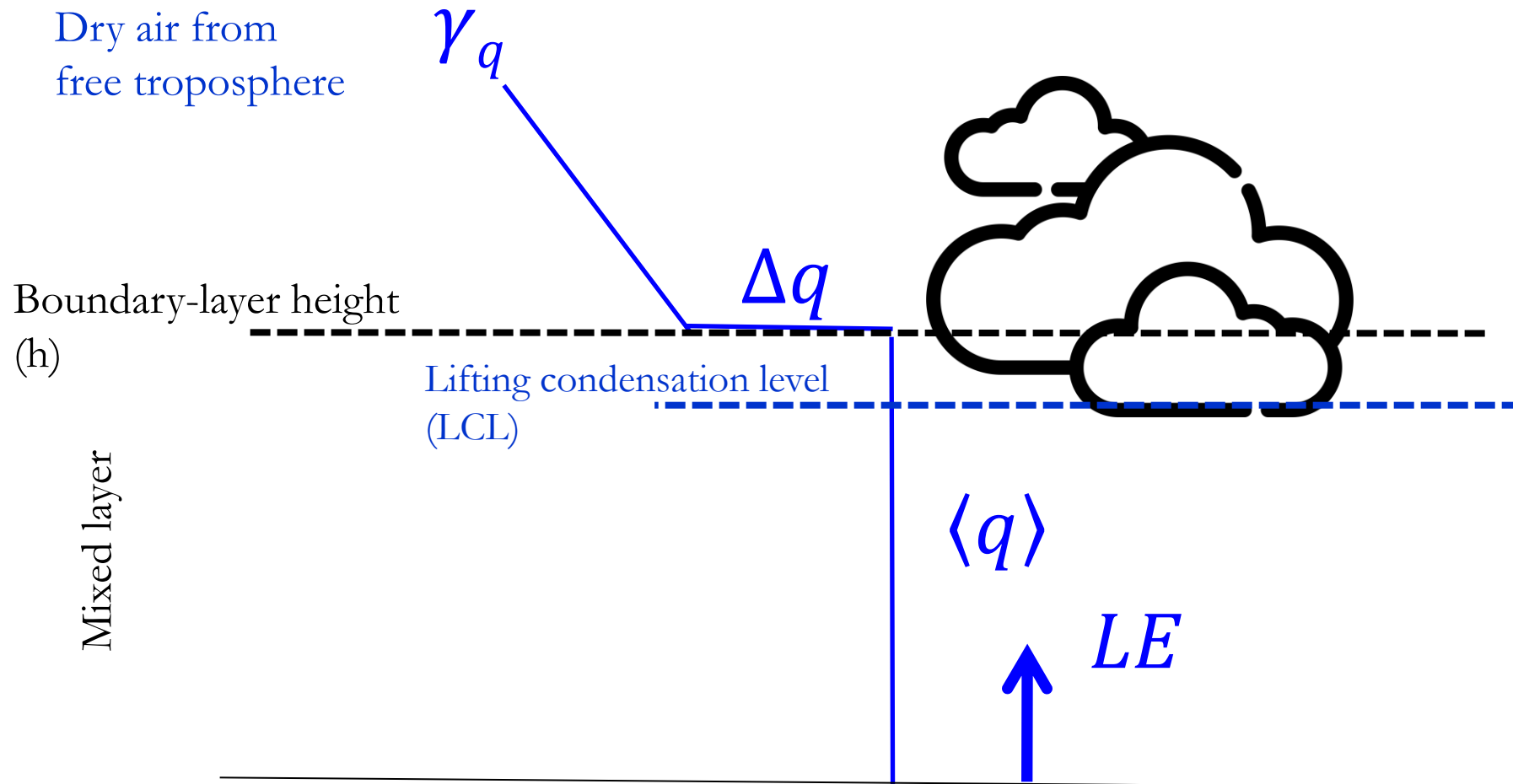






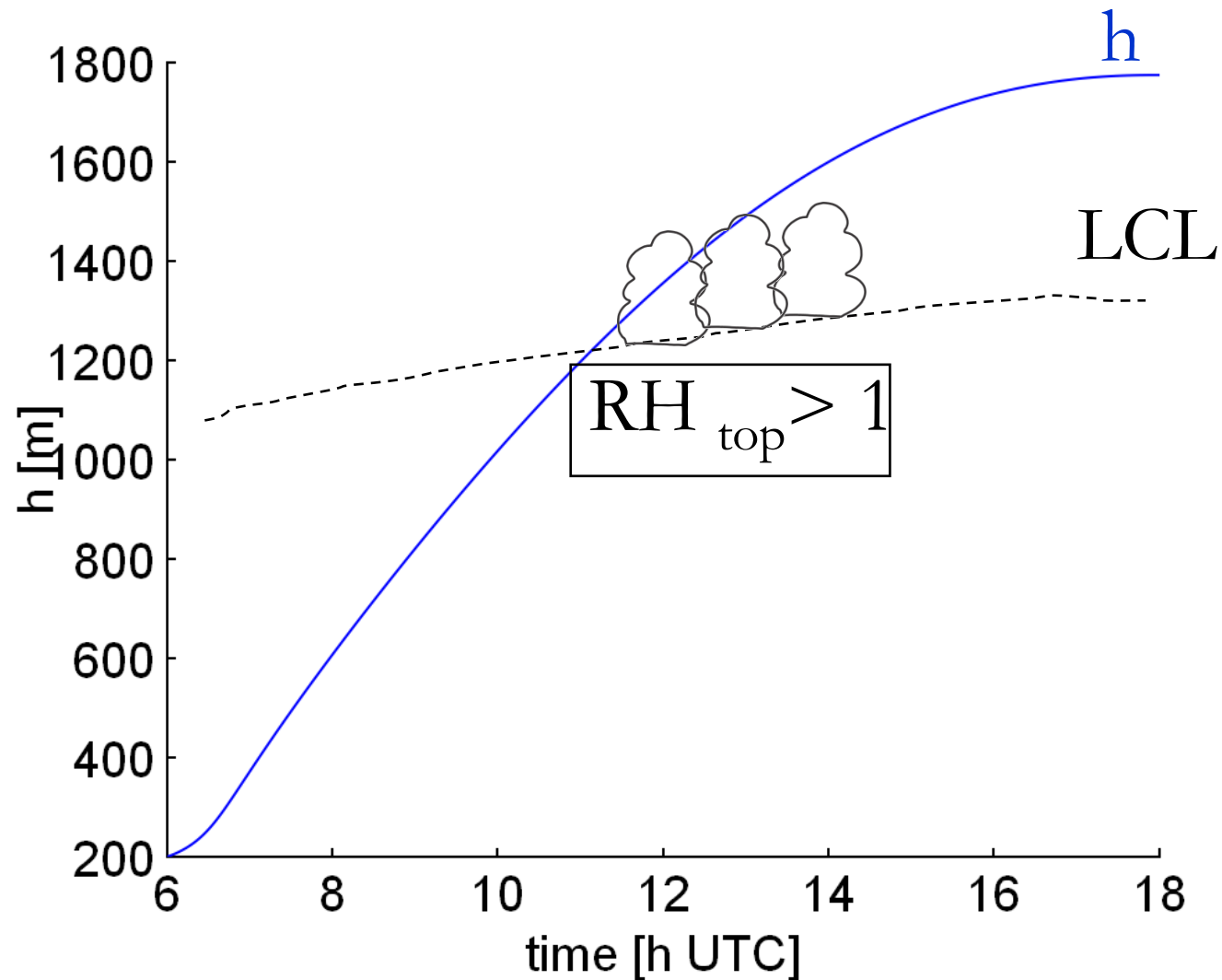
The practical:
The interplay between h and LCL

Cloud forms if $LCL < h$ [m]



To cloud or not to cloud?

- Criterium: clouds are form when $h > \text{LCL}$ or $\text{RH}_{\text{top}} > 1$



Working Groups

Surface control: sensible versus latent heat flux

Initial morning control: weak versus strong thermal inversions

Free troposphere control: weak versus strong lid

Plan of attack to analyze the results

We model with CLASS and we analyze systematically the results

- Radiation
- Energy balance
- Atmospheric boundary layer (h)
- Cloud formation (Rh_{top}) (LCL)

Cause and effect relationships

What makes grow the ABL?

What makes descend LCL?

Surface groups

$$SH? \rightarrow \theta? \rightarrow h? \rightarrow LCL?$$

Initial thermal groups

$$\Delta\theta_0 \rightarrow h? \rightarrow LCL?$$

Free troposphere groups

$$\gamma_\theta \rightarrow h? \rightarrow LCL?$$

When do clouds form?

To form clouds we need two conditions:

- Enough moisture in the atmospheric boundary layer (ABL) (driven by the evapotranspiration flux)
=> This will lower the lifting condensation level.
- Enough turbulence and boundary layer growth (driven by sensible heat flux)
=> This will allow the parcels to reach the colder height at which condensation takes place