Impact of Wind Shear on the Top of Stratocumulus Cloud

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Introduction

Analyzing data from Physics of Stratocumulus Top (POST) campaign [1] two different types of simulations were revealed:

- "classical", under strong temperature inversion, dry air above the cloud top and thin wind shear layer in the cloud top region;
- "non-classical" weak temperature inversions, humid air observed deep below.

In "non-classical" cases conditions prohibit Cloud Top Entrainment Instability.

One of "non-classical" cases TO13 was used to set up a series of LES simulations [profile (26b2s2blq) with LLNL model. In the first simulation we modeled cloud without both cloud cover and long time cooling. In the second simulation the wind shear was switched on while radiative cooling was off. In the third simulation the wind shear was off while radiative cooling enabled. In the fourth simulation the wind shear was on and radiative cooling was on. In the fifth simulation the wind shear was on and the second radiative cooling disabled. In the sixth simulation the wind shear was off and the second radiative cooling enabled. The light shearing span between the mean value and the minimum value at any given altitude. The light shearing span between the mean value and the minimum value at any given altitude. Black line marks the model domain averaged profile and dashed red line marks the initial profiles.

Comparison of liquid water mixing ratio profiles

**Comparison of liquid water mixing ratio profiles**

The left panel shows averaged profiles of potential temperature and wind components (middle panel) and water vapour mixing ratio (right panel) over the simulated domain. Red lines mark initial conditions and black lines mark domain averaged profile. Figures show fluctuations in the profiles effect from the horizontal variability. Virtual aircraft method produces comparable statistics as the statistics made for the whole domain except for the span between the maximum and the minimum value at any given altitude. Wind shear dilutes the cloud (lower values of liquid water path and cloud top altitudes than in no shear cases; see upper panels of figures 3 and 4).

Upper panels of both figures show data from simulations without wind shear and red lines mark data from simulations with the shear. Dashed lines are for simulations without radiative cooling, solid lines mark data from simulations with radiative cooling enabled. Shadowing of lower panels has the same meaning as in figure 6.

Radiative cooling enables growing of the cloud top and counteracts dilution due to wind shear (see upper panels of figures 3 and 4).

Virtual aircraft

Virtual aircraft is a method to sample computational domain. The main goal of this method is to collect data in the virtual reality of the model in the same way as the research aircraft performs measurements in a real cloud, along prescribed trajectories and in the course of cloud evolution. A series of trajectories are defined, and the virtual aircraft passes through those trajectories from TO13 flight.

Comparisons of liquid water mixing ratio profiles for four simulations. The left panel shows averaged profiles of liquid water mixing ratio for four simulations. The right panel shows liquid water path.

Virtual aircraft method produces comparable statistics as the statistics made for the whole domain except for the span between the maximum and the minimum value at any given altitude.

Conclusions

- Wind shear dilutes the cloud liquid water path and cloud top altitudes than in no shear cases; see upper panels of figures 3 and 4.
- In wind shear cases maximum value of liquid water mixing ratio is smaller and is located on lower altitude than in simulations without shear (see left panel of figures 3 and 4).
- Radiative cooling enables growing of the cloud top and counteracts dilution due to wind shear (see upper panels of figures 3 and 4).
- Virtual aircraft method produces comparable statistics as the statistics made for the whole domain except for the span between the maximum and the minimum value at any given altitude (see figure 5).

References


Acknowledgements

We thank Herman Gerber for organizing POST campaign. This research was supported by Polish National Science Centre with the grant UMO-2012/07/N/ST10/03473.