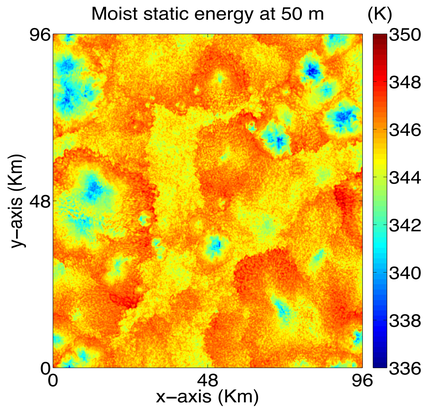
Mechanisms for convection triggering by cold pools

Giuseppe Torri, Zhiming Kuang and Yang Tian
Earth and Planetary Sciences, Harvard University

1. Introduction

- Cold pools are areas of evaporatively cooled downdraft air that spread on the surface like density currents.
- Crucial ingredients of deep convection.
- Known for long time that they can trigger new convective cells by gust front lifting at their leading edge – **mechanical forcing**.
- More recently, it has been argued that a positive anomaly of moist static energy around the cold pool edges may also favor convection – **thermodynamic forcing**.



2. Research questions

We aim to answering the following questions:

1. How can we **disentangle** the two forcings?
2. What is the **relative importance** of each forcing at different altitudes, from surface to level of free convection?
3. What is the effect of the thermodynamic forcing in the **inhibition layer** encountered by the particles during their ascent?

3. Methods

We proceed using a Lagrangian Particle Dispersion Model in a RCE oceanic case.

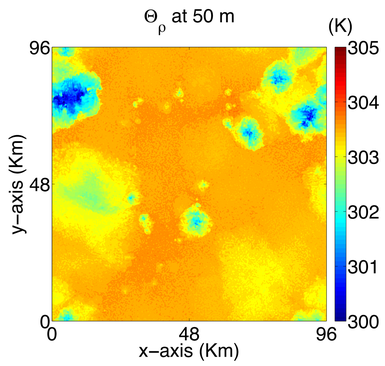
Forcings are distinguished according to:

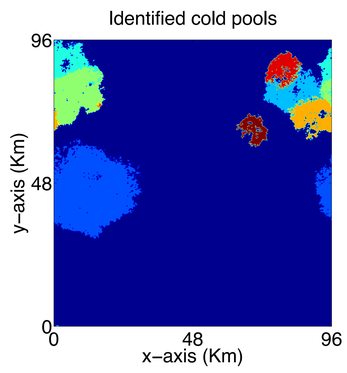
- **Particles' accelerations** from the surface until when they reach level of free convection.
- The **age of cold pool**s when particles are lifted.
- The amount of time spent by a particle within a cold pool – **residence time**.

4. Tracking cold pools

A novel algorithm is used to track each cold pool and measure its age:

- When its θ_ρ is 1.5 K below the horizontal average, a particle is considered in a cold pool and tracked until buoyancy is recovered.
- When tracking starts, particles are given a clock to measure time spent in cold pool.
- Connected regions of cells containing cold pool particles are recognized as cold pools.

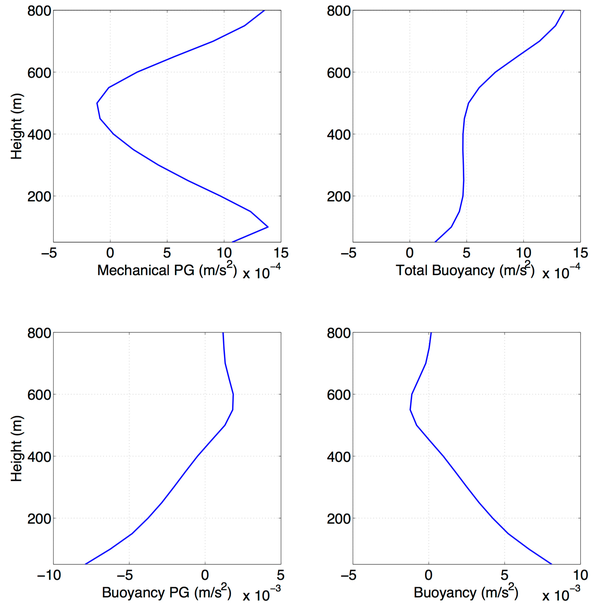




5. Results

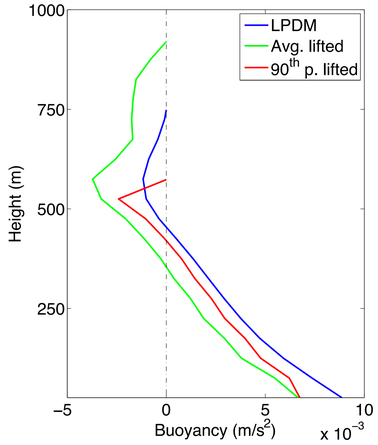
Averages of **particles' accelerations** show:

- Mechanical pressure gradients dominate near surface (gust front lifting)
- Large degree of cancellation between buoyancy and buoyancy pressure gradients
- Total buoyancy greater than mechanical pressure gradients after first 300 m.



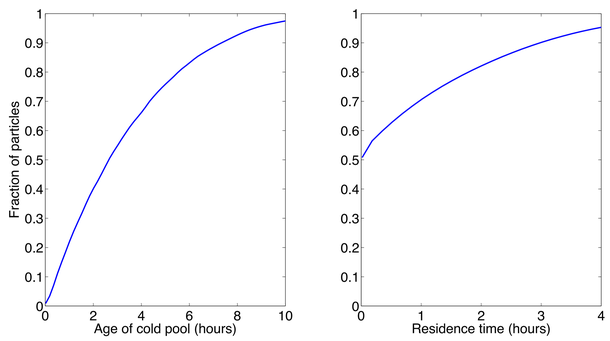
To analyze effect of thermodynamic forcing in the inhibition layer, we **compare** Lagrangian particles with **a distribution of idealized parcels**:

- Initial values of parcels are taken from distribution of MSE and q_t in the environment.
- Average buoyancy of lifted parcels shows convective inhibition 5 times bigger than Lagrangian particles.
- Only lifted parcels in high percentiles of the distribution have comparable convective inhibition to Lagrangian particles.



Cumulative distributions of **cold pool ages** and particles' **residence times** support idea that gust front lifting is dominant near the surface:

- Significant number of particles are lifted by younger cold pools, which have strong gust fronts.
- Most particles have very little or nil residence time



6. Conclusions

The following picture emerges:

- Neither of the forcing is absolutely dominant – particles reach level of free convection through a **cooperation** of the two mechanisms.
- Mechanical forcing important to **lift particles from the surface**.
- Particles start ascending in moist regions near cold pools but most of their buoyancy is **cancelled** by buoyancy pressure gradients.
- Thermodynamic forcing plays an important role in the inhibition layer by sensibly **reducing the convective inhibition**.

7. Bibliography

Tompkins, A. (2001), *J. Atmos. Sc.*, **58**, 1650-1672.

Böing S. J., et al. (2012), *J. Atmos. Sc.*, **69**, 2682-2698.

Schlemmer, L., C. Hohenegger (2014), *J. Atmos. Sc.*, **71**, 2842-2858.

Li, Z. et al. (2014), *J. Atmos. Sc.*, **71**, 2823-2841.

8. Further information

Torri et al. (2015), Mechanisms for convection triggering by cold pools, *Geophys. Res. Let.*, in press

Corresponding author:
Giuseppe Torri
torri@fas.harvard.edu