Flying a Quadcopter in Ground Effect

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Question
When a quadcopter is flying close to the ground how does the air flow change and what is the effect on flight performance? Is there a method to measure and model this interaction?

What is a Quadcopter
A quadcopter is an aerial vehicle which uses 4 propellers to force air downwards and keep it in the air. Unlike a conventional helicopter, which uses a tilting rotor to manoeuvre, the propellers on a quadcopter have a fixed tilt. Instead a quadcopter is able to manoeuvre by changing the speed of opposite pairs of propellers. By increasing the speed on one side and decreasing it on the other side the quadcopter tilts and moves.

What is Ground Effect
Hover thrust is the amount of thrust required to keep the quadcopter flying at a constant altitude. When a quadcopter is close to the ground the hover thrust decreases. Much like the quadcopter is sitting on a cushion of air. Similarly when close to the ceiling a decrease in hover thrust acts to suck the quadcopter towards the ceiling.

What was Found
Affordable barometric pressure sensors can be found in many modern phones used to measure air pressure and estimate altitude. Using a single barometric pressure sensor placed on the ground and moving two quadcopter propellers over it a pressure profile was generated.

Why is it Useful
Much work has already been done into the modelling and agile flight of quadcopters in free air. By understanding the ground effect in more detail it may be possible to identify and capitalise on properties which it offers. For instance taking advantage of the decreased hover thrust to increase battery life and flight duration.

Where to Next
An array of pressure sensors will be constructed allowing for multiple pressure readings to be captured simultaneously. Once a pressure map for the quadcopter has been characterised it is hoped that the data could be used in the future to create a pressure based location system.