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How well do stereo cameras observe shallow cumulus spatial organization? An evaluation combining atmospheric path-tracing and high-resolution Large-Eddy Simulations (LES)

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Spatial organization is essential for convection parameterization in numerical weather and climate models. However, spatial organization is challenging to observe. Most ground-based measurements consist of one-dimensional profile data, often sampled by lidars or radars. A recently explored new method of obtaining multi-dimensional information is to utilize hemispheric images from networks with multiple cameras, which observe shallow cumuli in unprecedented spatial detail.

In this study, we apply an open-source Monte Carlo path-tracing algorithm to high-resolution LES cloud fields. This setup emulates a network of multiple stereo cameras, currently installed around the Jülich Observatory for Cloud Evolution (JOYCE) within the ongoing SOCLES project. Those camera snapshots were emulated based on three-dimensional LES cloud fields. Reconstructions of the cloud fields from the emulated camera snapshots were compared against the original LES-simulation, allowing precise error estimation. Our goal is to determine how many grid boxes of an arbitrary cloud field can be reliably detected by a stereo camera setup and use this information to optimize the camera network configuration.

The path tracing projections operate well in this workflow, as depicted in the figure. 81% of the reconstructable grid boxes of an LES cloud field are reconstructed by the stereo camera algorithm.

Caption:
Visualization of the reconstruction from the emulated stereo cameras (yellow grid boxes) compared to the original LES simulated grid boxes that are visible from both camera perspectives. The horizontal resolution of the grid boxes is 50 meter. The gray boxes at the bottom denote the camera position. Note that for visualization purposes those cameras are amplified.

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