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Tracking Cloud Motion with Deformation in Satellite Imagery: Lagrangian Techniques for PV Forecasts

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With the expanded role of solar power in Germany, there is a need to better forecast weather-driven elements in order to maintain safe grid operation and drive energy markets. In the short term, identifying clouds and predicting their future trajectories from real-time satellite imagery is more accurate than relying on numerical weather predictions. Standard block-matching or image correlation techniques rely on matching non-deforming subwindows to resolve Eulerian velocity fields. These techniques are not however in principle well suited to the noisy and deforming images made by clouds. We instead employ the more computationally expensive image correlation velocimetry technique described by Tokumaru & Dimotakis (1995). Here, two consecutive images are matched while allowing for arbitrary orders of deformation within a Taylor series expansion of the Lagrangian displacement field. This technique can track deforming structures and we use it to build Lagrangian time histories of cloud movement and deformation, while extracting flow data on e.g. velocity, vorticity, and strain rate in the process. Benefiting from the longer autocorrelation times of Lagrangian quantities as compared to Eulerian ones, we then forecast the future trajectories and deformed states of clouds for short-term PV power forecasts.