Forecasting Solar Power Intermittency Using Ground-Based Cloud Imaging

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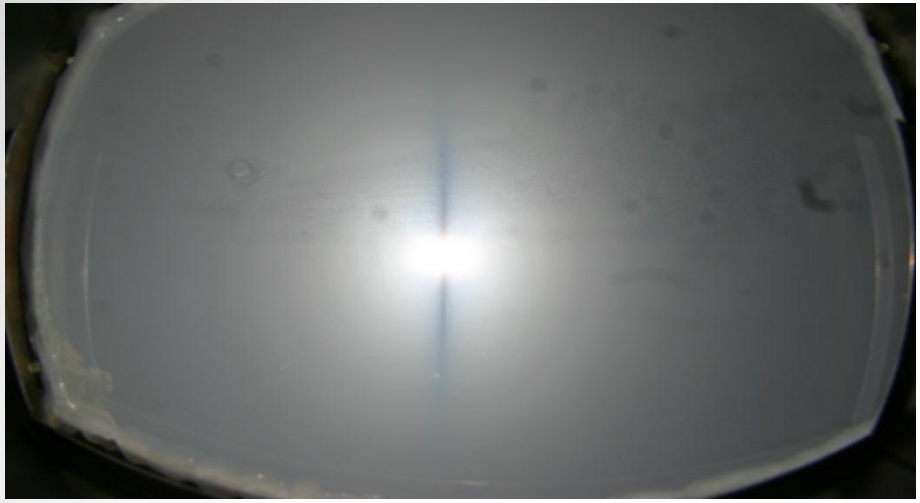
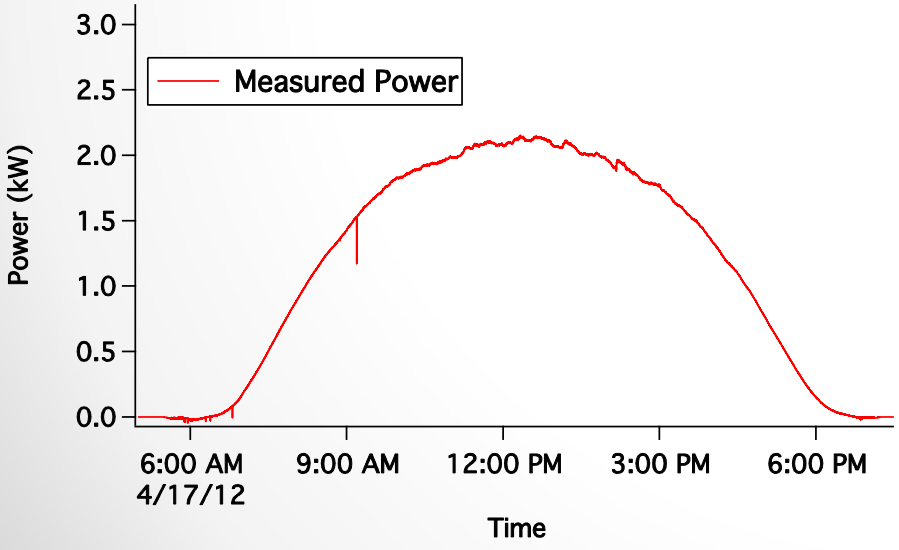
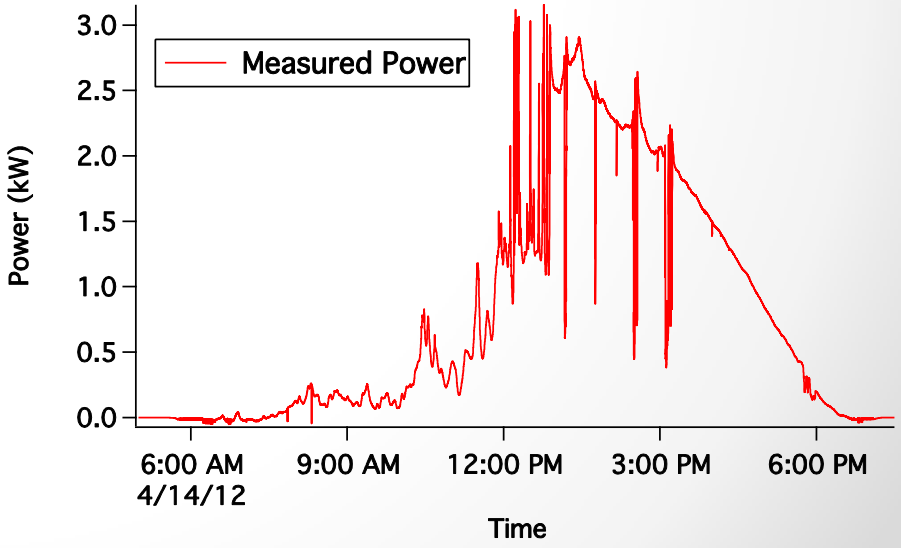
The Problem of Intermittency



Clear Sky

Intermittency





Countering Intermittency

- Interconnecting geographically dispersed Photovoltaic systems
- Using dispatch-able spinning reserves like hydroelectric power to fill gaps
- Energy storage
- Smart Grid
- Forecasting intermittency due to clouds

The System

Camera Installed at TEP

LabVIEW Algorithm

Images at Regular Intervals

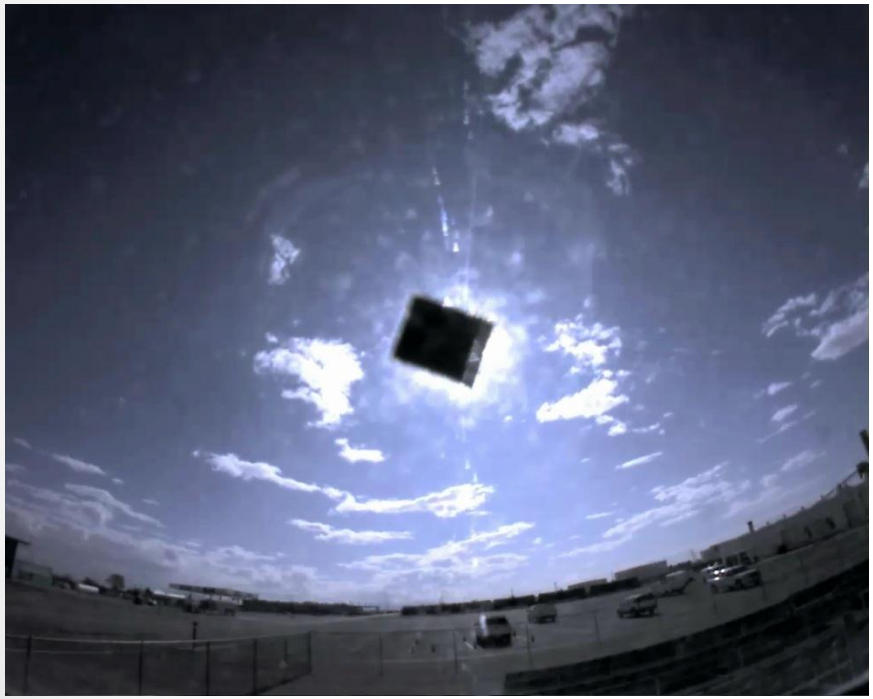
MATLAB Algorithm

Prediction

Smart Grid

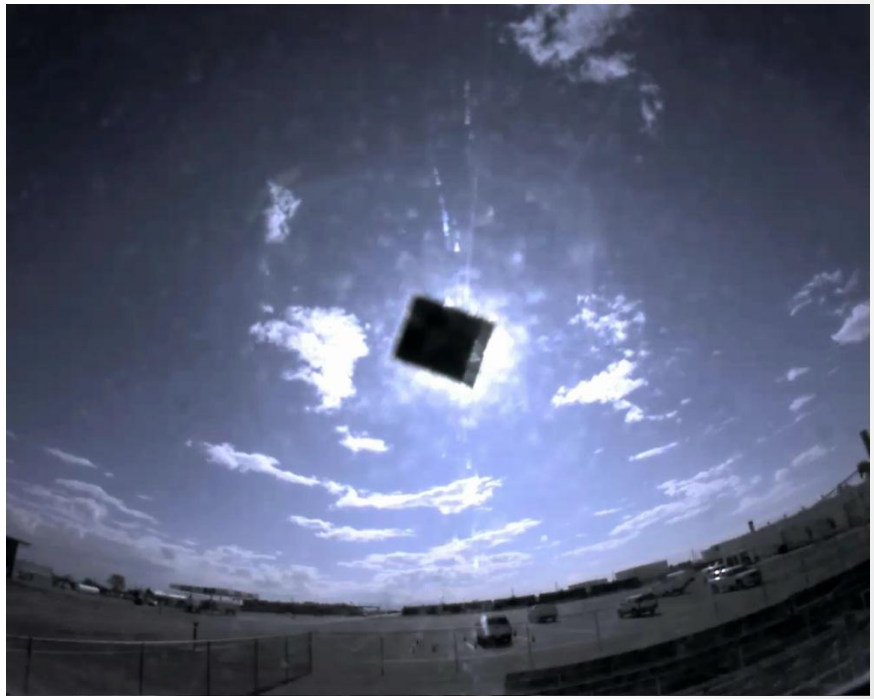
The MATLAB ALGORITHM

- We use a technique called “Block Based Motion Compensation”.



Frame 1

t = -30 s



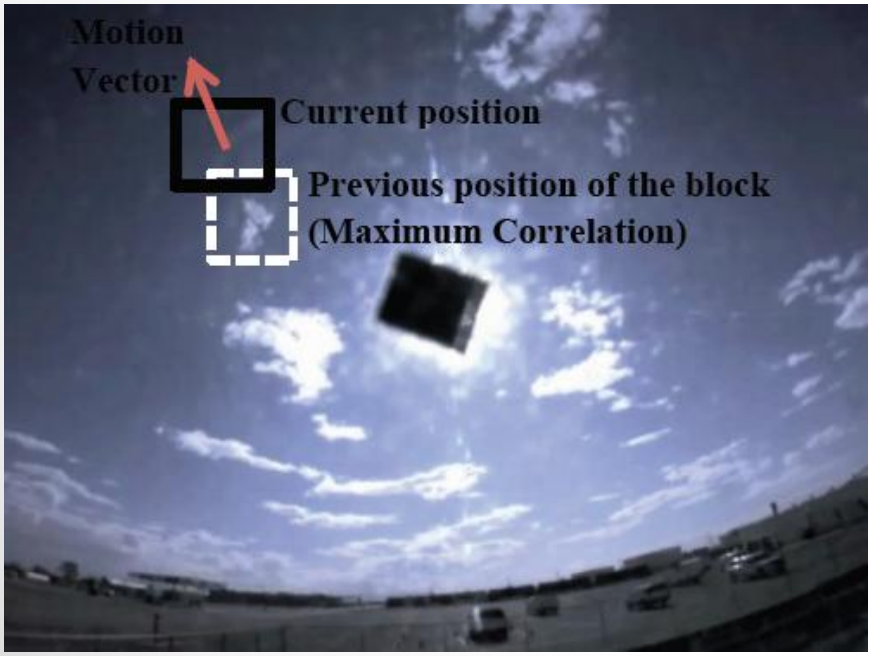
Frame 2

t = 0 s

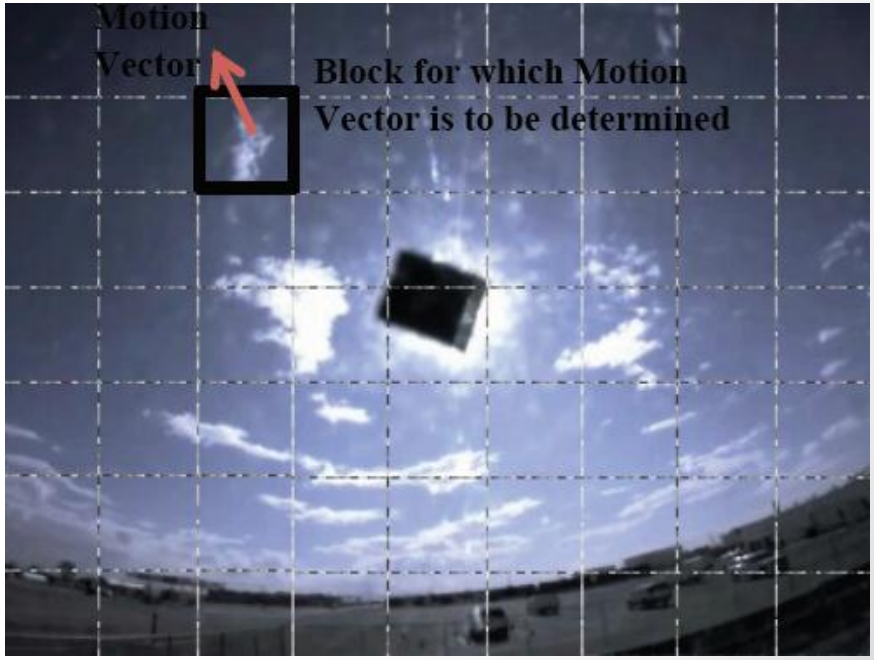
Block based Motion Compensation

Steps Involved:

- Divide the frame for which motion is to be estimated into square blocks.
- For Each block in Frame 2, find the position of best match in Frame 1.

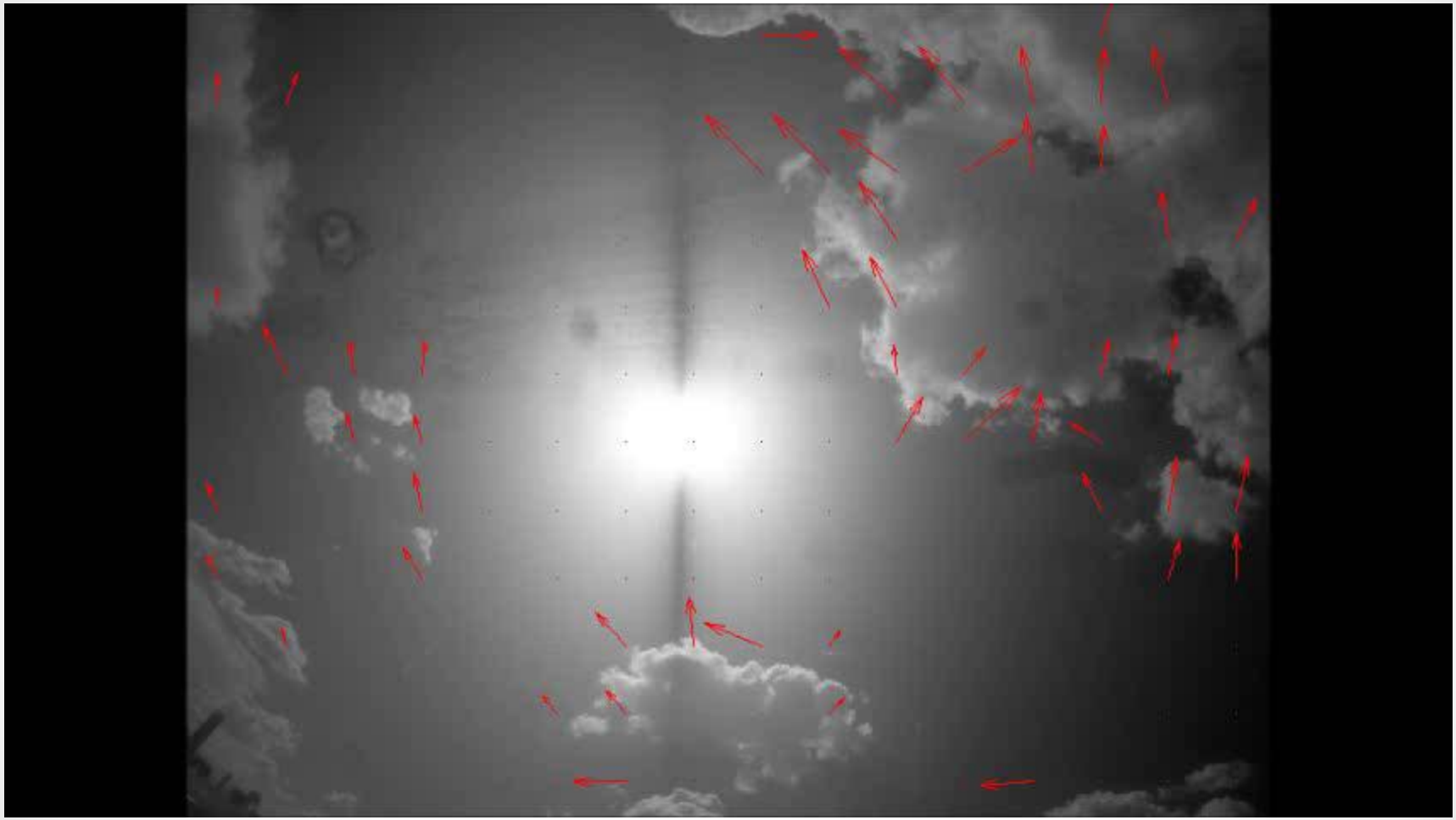


Frame 1

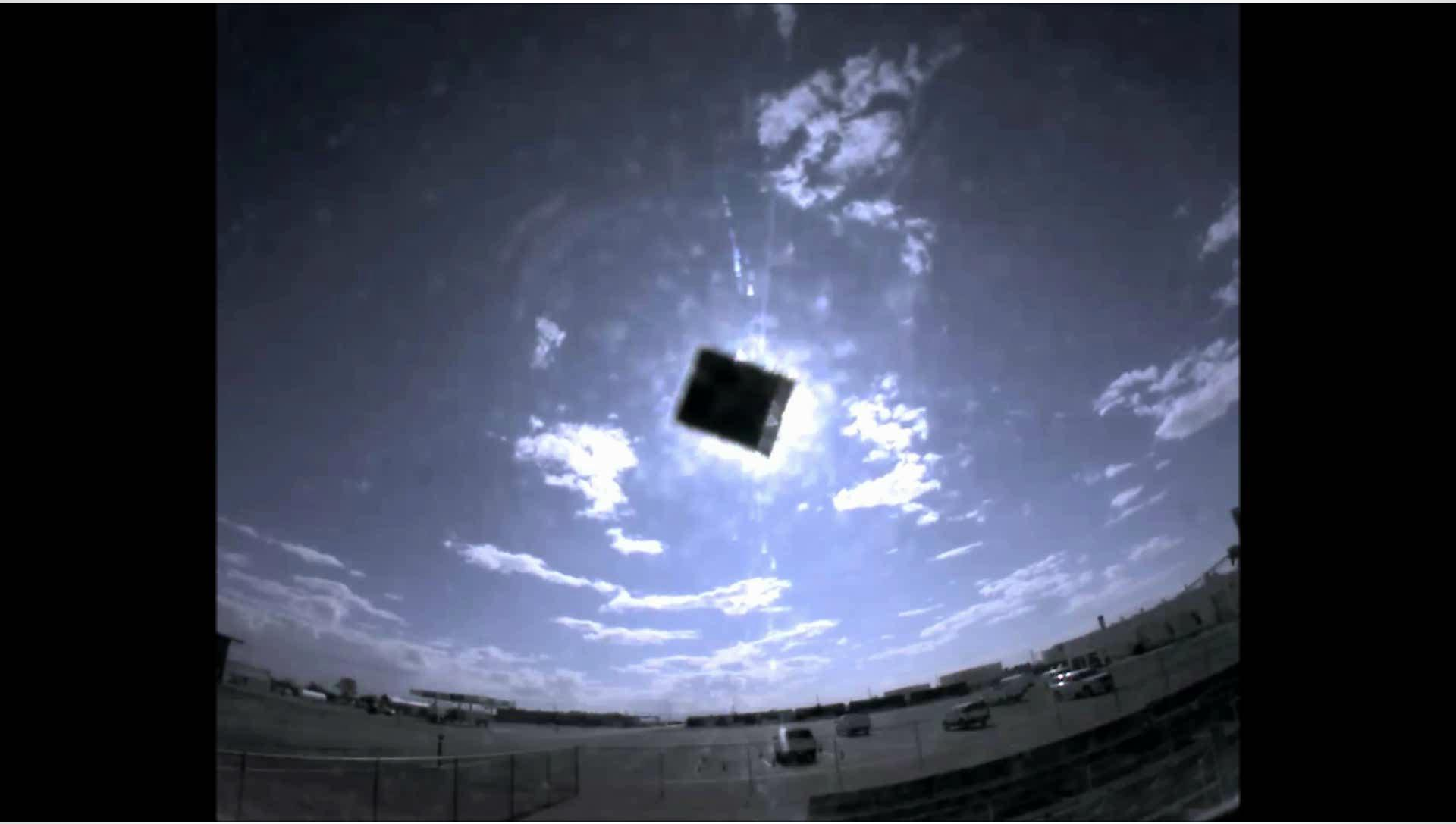


Frame 2

Motion Vectors

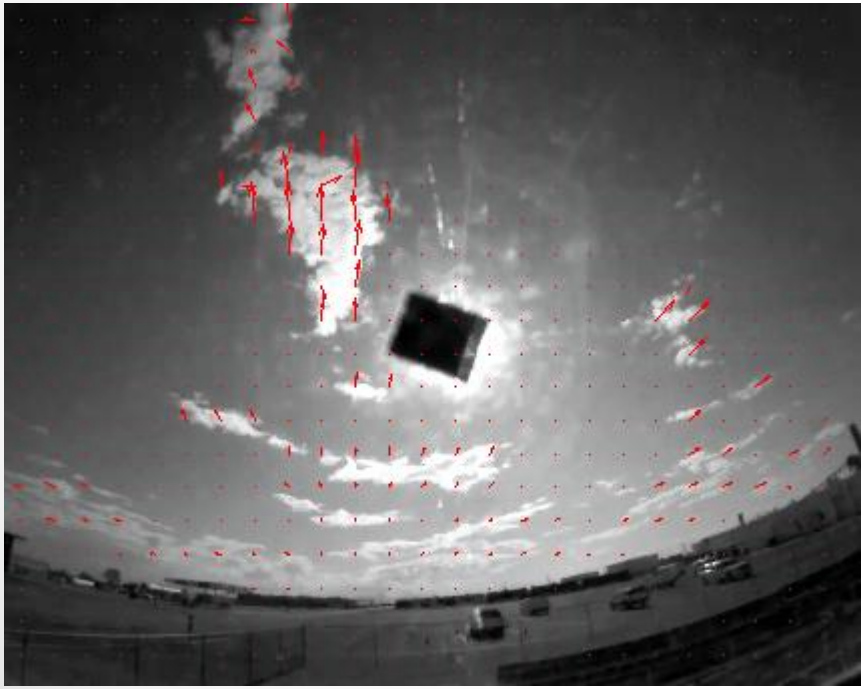


Motion of clouds far away is under estimated

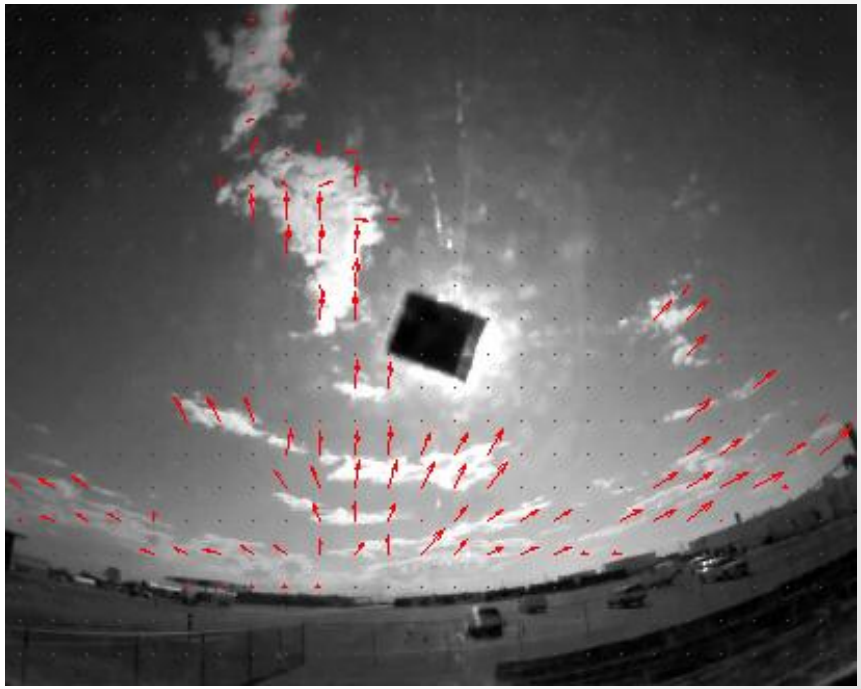


Geometric Correction

- Apply a Geometric transformation to convert pixel coordinates to real world coordinates.
- Convert the cloud velocity in pixels/second to meters/second.



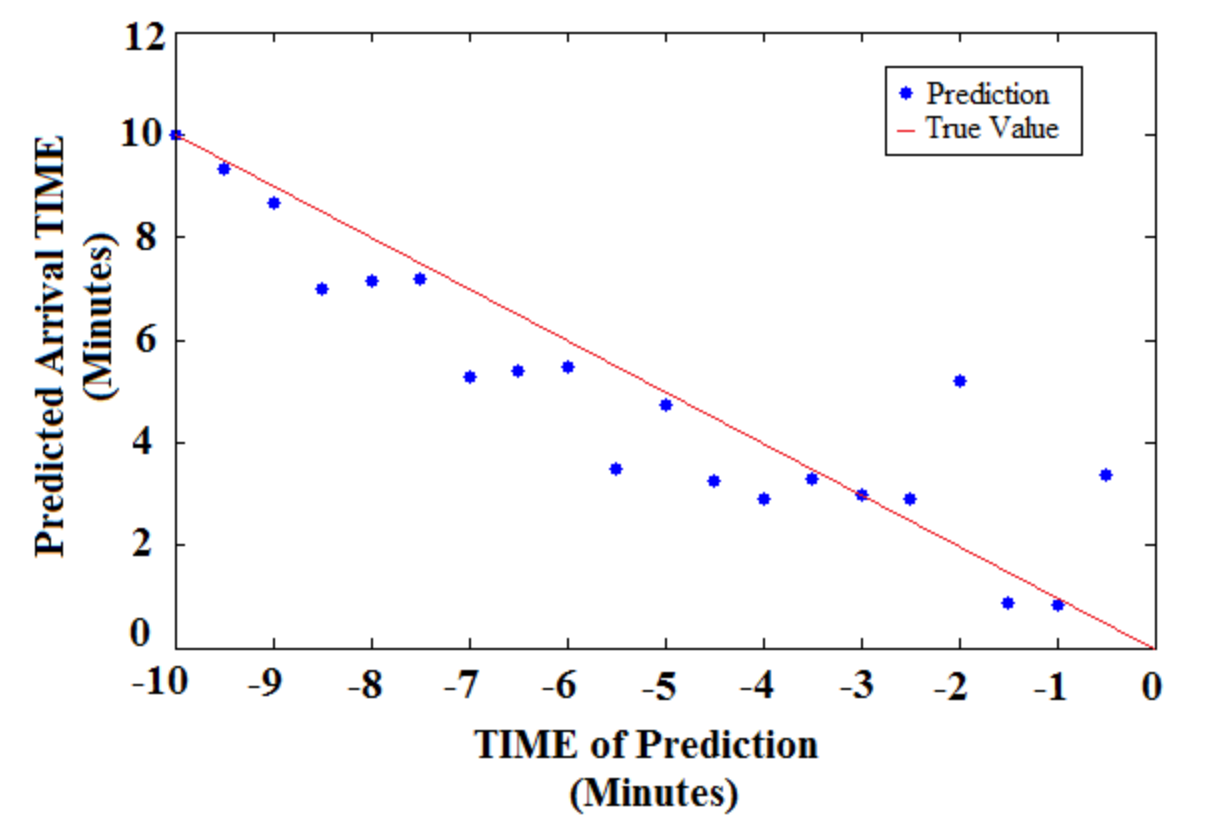
Without Geometric Correction



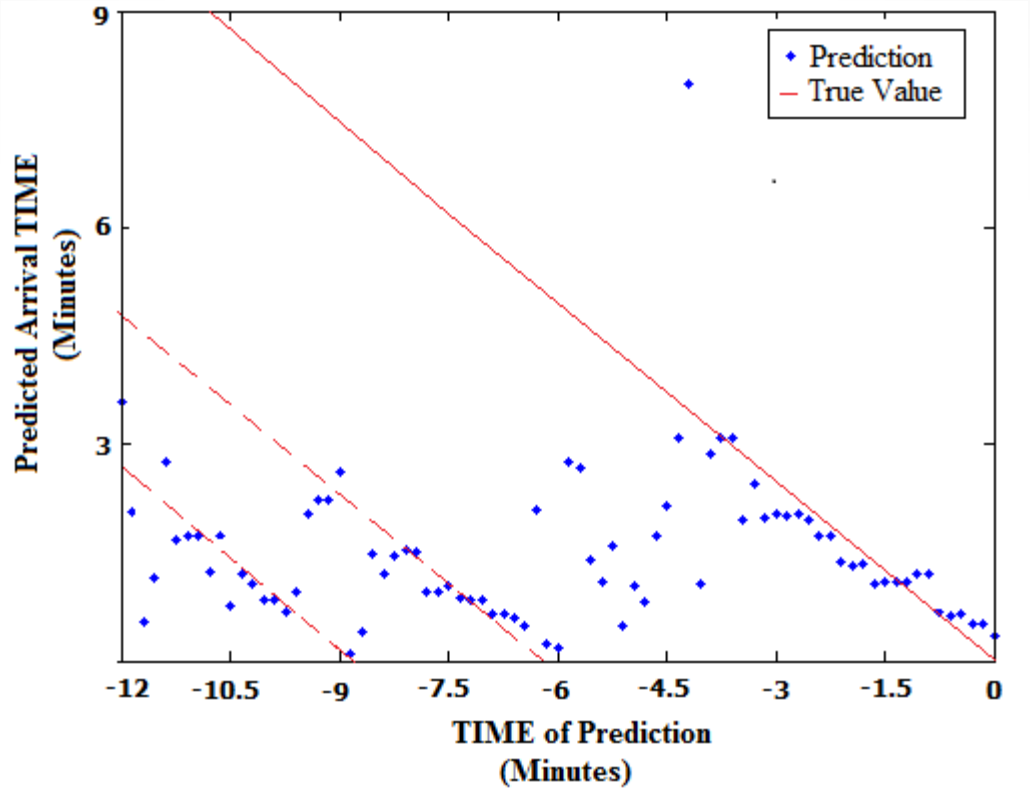
With Geometric Correction

Results

10 – Minute Ahead Prediction



Results



Multiple clouds are tracked. However, in this case two of the clouds disappear before reaching the sun.

Future Work

- Make PV Power Predictions
- Track cloud regions instead of individual blocks
- Attach a confidence window to the prediction

Thank you