# Thermal Identification

The centroid method does not make use of all the sensor data available when it attempts to identify when the glider encounters a thermal. The autopilot provides data such as current position, velocity, airspeed, and acceleration. We compared two approaches that could better use the limited information available.

The centroid method merely provides an estimate of where the thermal center may be. One improvement upon this method would be to predict what the entire thermal looks like. We investigated two possible approaches: Bayesian parameter estimation, which predicts a probability distribution over possible values each parameter of a model could take on, and Gaussian process regression, which predicts a Gaussian probability distribution over values each point in a 𝑛-dimensional space could take on. Because of its speed and superior prediction in tests, Gaussian process regression was pursued further, being implemented in simulation.

BAYESIAN PARAMETER ESTIMATION. If we start off with a simple symmetric Gaussian-shaped model of the vertical velocity in a thermal, shown in Figure 2, there are three parameters: the location of the thermal center, the maximum upward velocity (occurring at that center point), and how quickly the velocity falls off moving away from the center. A sliding window of past measurements from the autopilot is run through parameter estimation resulting in estimates of what the most likely values are for each of these thermal parameters.

GAUSSIAN PROCESS REGRESSION. An alternate approach does not assume a model for the thermal, but tries to predict a function’s output over a region given the measurements at select points. This approach returns a Gaussian probability distribution over possible function values at each point, i.e. providing both a most likely value and also an uncertainty for that value.

RESULTS. As the glider flies a flight path gaining altitude, it collects and runs the last 45 seconds of data through Gaussian process regression predicting the vertical velocity in a 20-meter radius around the glider. Because it predicts a probability distribution, which provides a measure of uncertainty, this can be used in determining whether it is beneficial to latch onto a thermal. The glider will start circling the point of the highest predicted vertical velocity if with 85 percent confidence this velocity is above a certain threshold. Figure 3 shows a test in simulation where the glider successfully found a thermal and has orbited it twice.