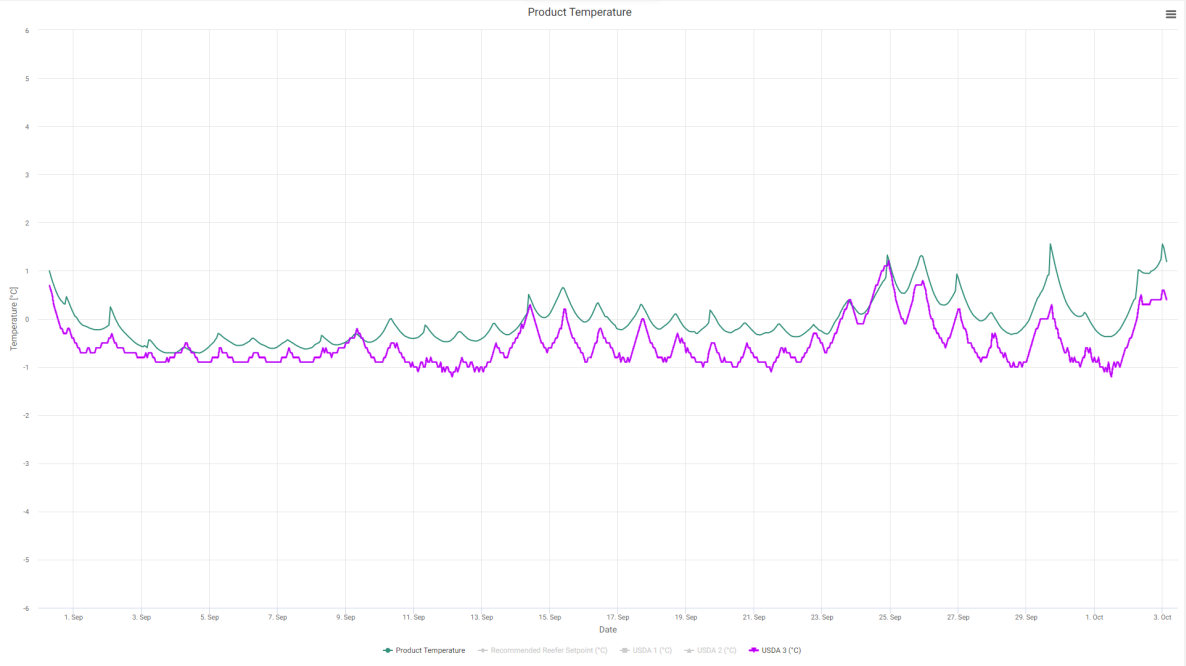
Predicting Product Temperatures

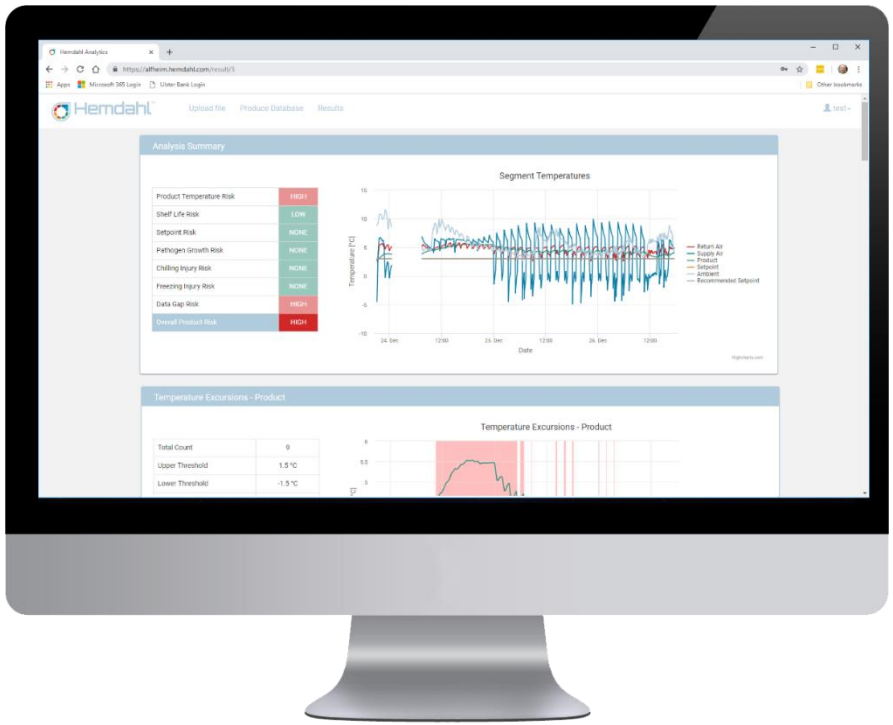
Ver 1.0



INTRODUCTION

Accurate product temperature readings for temperature-sensitive cargo are highly desirable, and allow a range of additional analyses including:

- Proof of compliance with international regulations, for example cold-treatment for tropical fruit
- Proof of adherence to customer temperature thresholds
- Accurate measurement of product temperature excursions
- Assessment of temperature-related injury
- Prediction of retail shelf-life

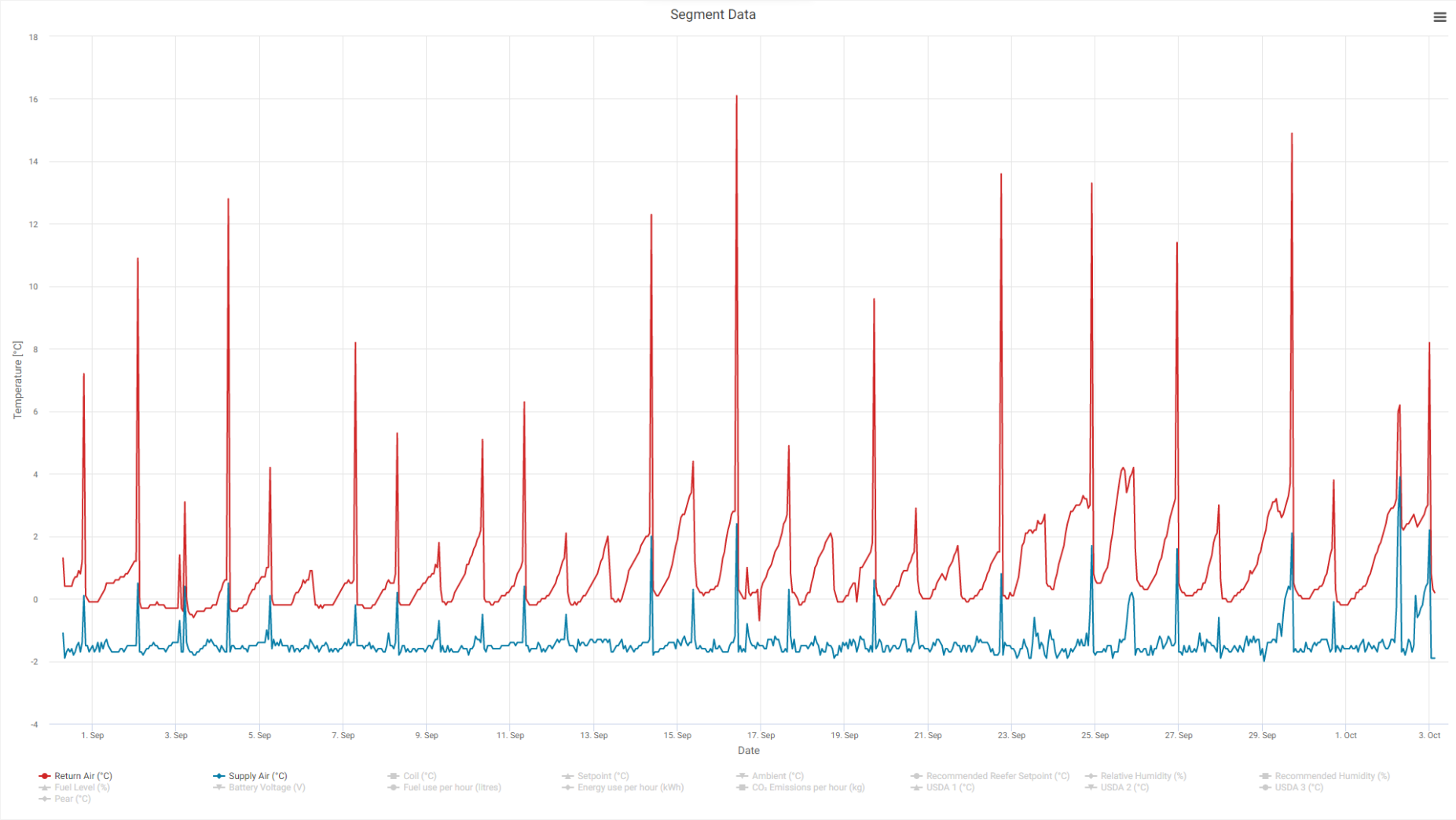


Today, the main choices are either to:

- Install and use product probes/individual loggers within the cargo
- Rely on inaccurate air temperature measurements as an estimate for product temperatures in transit.

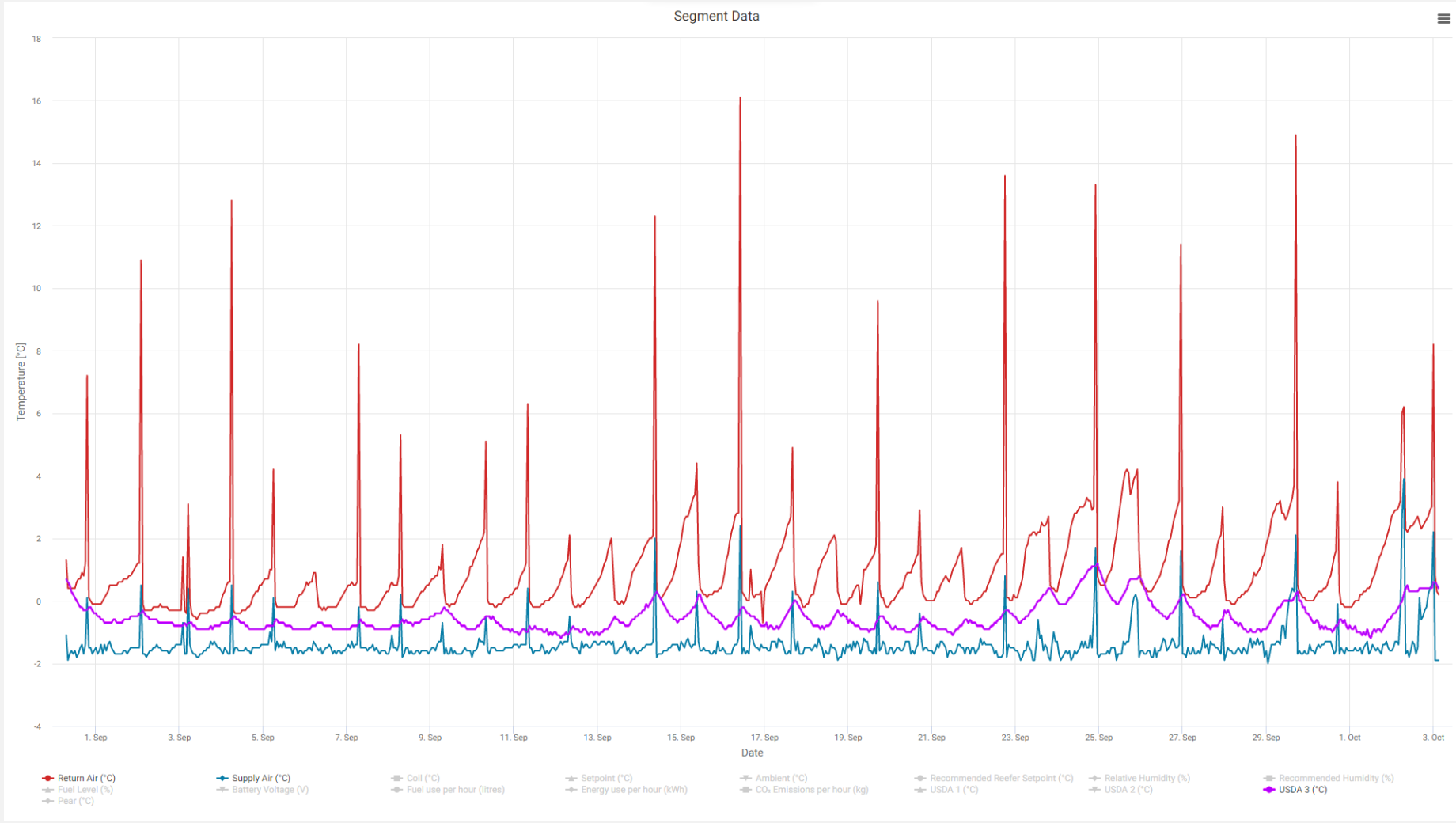
What if we could develop an accurate model for predicting product temperatures based on available data such as air temperatures, product type, loading patterns, packaging, etc.?
This would allow for accurate product temperature data without the need for any additional hardware such as product probes or dataloggers, saving costs on hardware, installation, and manual handling.

AIR TEMPERATURES



Here we see the a typical temperature chart from a marine container. The chart displays recorded air temperatures: supply air (blue) and return air (red). Neither of these air temperatures are a good estimate of the actual product temperature.

ACTUAL PRODUCT TEMPERATURE



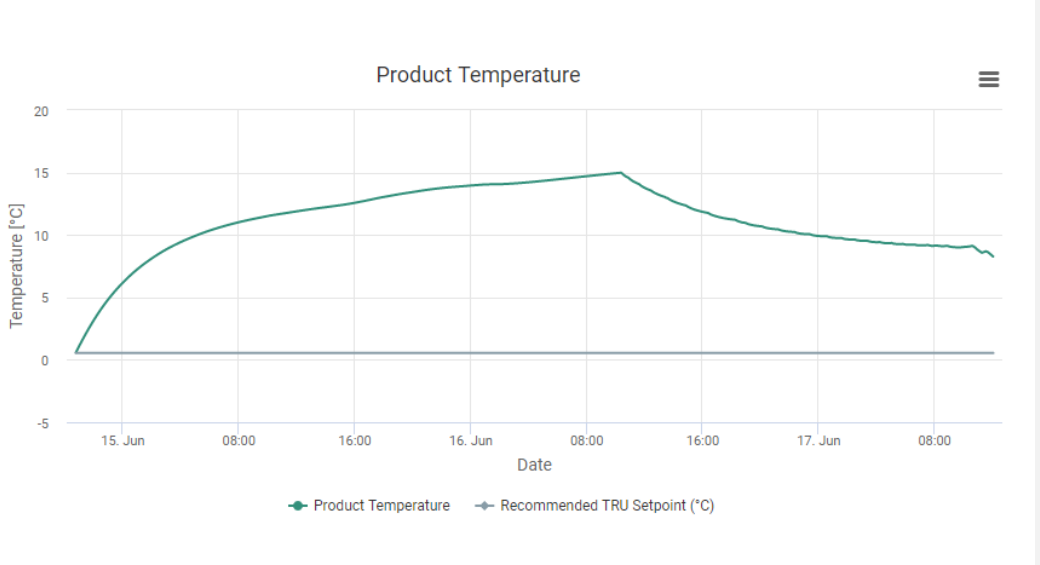
Here we see the same temperature chart, but with the addition of a product temperature sensor (purple). In this case a USDA temperature sensor. We can see that actual product temperature is not the same as either supply air temperature or return air temperature. Could it be possible to predict the product temperature using data such as air temperature readings from the container?

PRODUCT TEMPERATURE MODEL

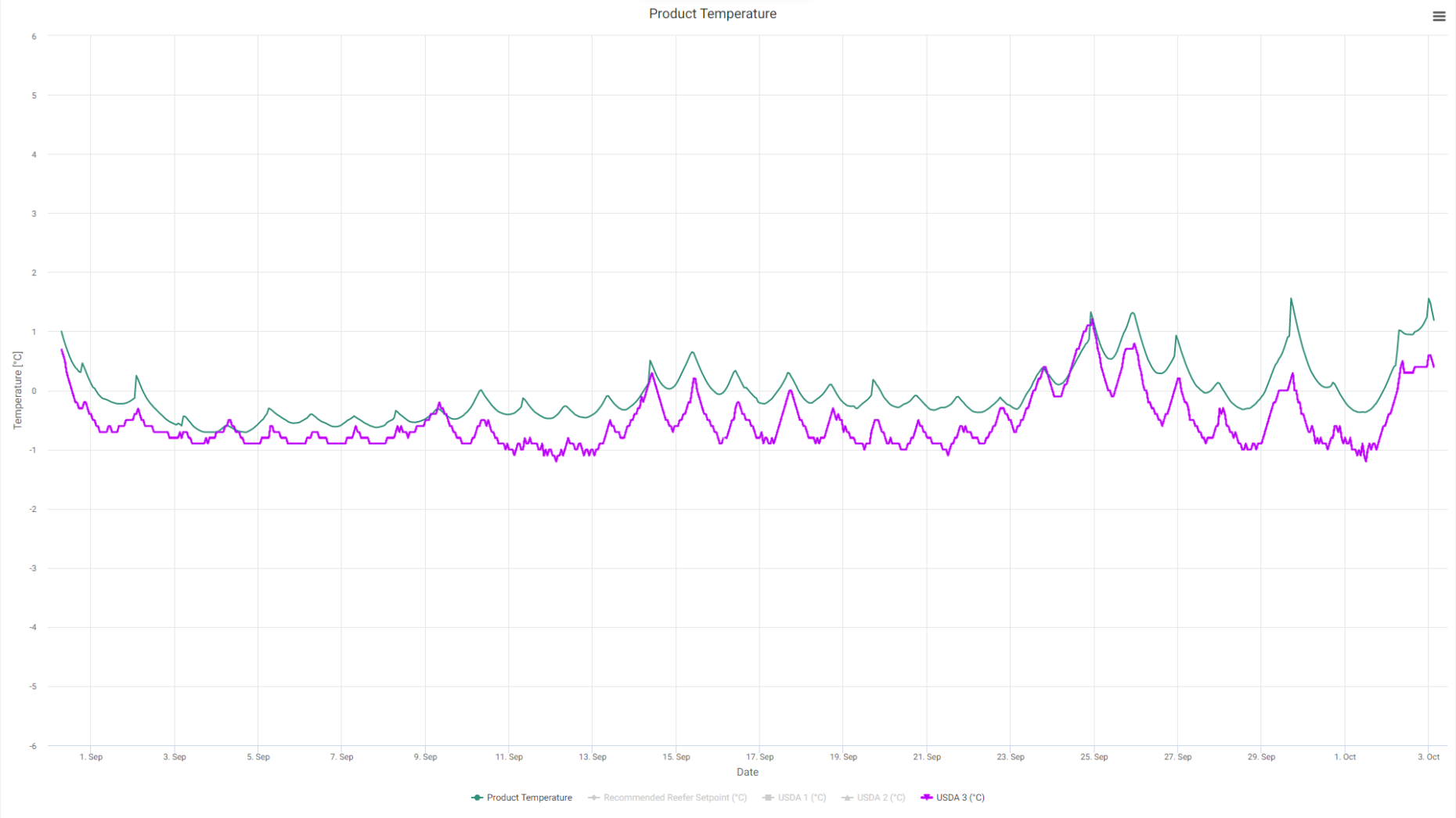
Hemdahl have developed a product temperature prediction model uses a proprietary third-generation algorithm to calculate product temperature from known parameters including supply air temperature, return air temperature, product type, product weight, ambient air, loading pattern, packaging type, etc.

At the heart of the algorithm is a compartment-modelling system that predicts product temperature using a first-order thermal model.

Additional parameters such as product weight, loading patterns, packaging type allow us to model the behaviour of heat energy within the compartment even more accurately, allowing for a predicted product temperature to be calculated from existing known data.



ACTUAL TEMPERATURE VS PREDICTED TEMPERATURE



Here we see a comparison between the actual product temperature (purple) and the predicted product temperature (green) using the Hemdahl prediction algorithm. The predicted product temperature correlates well with the actual product temperatures recorded in the container by the USDA temperature probe.

STATISTICAL ANALYSIS

MEAN ABSOLUTE ERROR

The mean absolute error between the predicted product temperature and the actual product temperature (as per the USDA sensor readings) was 0.48 °C.

MEAN ERROR

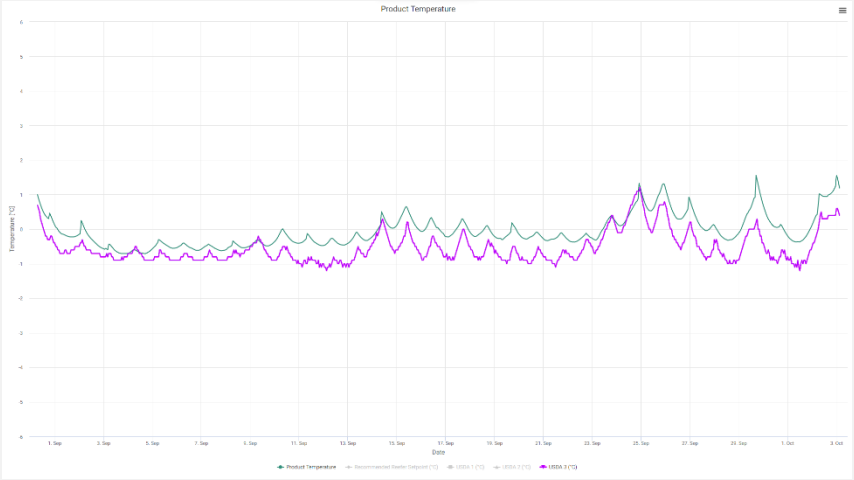
The mean error between the predicted product temperature and the actual product temperature as per the USDA sensor readings was 0.48 °C.

ERROR STANDARD DEVIATION

The error standard deviation between the predicted product temperature and the actual product temperature as per the USDA sensor readings was 0.25 °C.

CORRELATION

The correlation between the predicted product temperature and the actual product temperature was 0.84.



CONCLUSIONS

An algorithm to predict product temperatures using readily available data such as air temperatures, product type, cargo weight, and loading patterns has been developed.

The algorithm shows good correlation with actual product temperatures recorded using a USDA product probe.

The use of predicted product temperatures as a virtual probe could remove the need for physical product sensors and/or dataloggers in the compartment.

Accurate product temperature prediction allows for a range of additional analysis such as proof of compliance with USDA and EU regulations, assessment of temperature-related injury, and retail shelf life prediction.

Hemdahl have developed an algorithm to predict the extent of temperature-related injuries such as chilling injury, freezing injury, phase-change injury, etc. based on the storage conditions of temperature-sensitive cargo in the cold chain

Hemdahl have also developed an algorithm to predict remaining retail shelf life based on the storage conditions of temperature-sensitive cargo in the cold chain.

Hemdahl's predictive algorithms for product temperature, temperature-related injury, and retail shelf life can be used for all transport modes (marine, rail, road, and air) and are independent of the reefer make, datalogger type, telematics system, etc.

HEMDAHL

Hemdahl provides a SaaS platform that analyses logged data for perishable products to provide unique, actionable insights into product quality and safety. Our mission is to make the world's perishable products safer, cutting waste and reducing carbon footprints.

More information is available at www.hemdahl.com.