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Case Study: Developing a Grain Trading Strategy with the Point-in-time Forecast API

Introduction

To support the CropProphet mission of enabling profitable grain trading, Prescient Weather (the creators of CropProphet) is releasing a point-in-time forecast application programming interface (API). The API provides access to historical crop production weighted observed and forecast weather indices designed to aid discretionary and systematic grain trading.

The dataset and the API allow users to quantify the impact of weather forecasts, weather forecast changes, and weather observations on price changes in weather forecast-sensitive markets such as the corn and soybean futures markets.

This case study provides an example analysis of weather's impact on grain prices using data available in the API. After following the case study, the API user will be able to analyze the relationship between US corn weather conditions and corn futures price movements, as shown in Figure 1. This figure shows that a US corn production-weighted temperature and precipitation index can be used to predict extreme corn futures price movements under certain conditions.

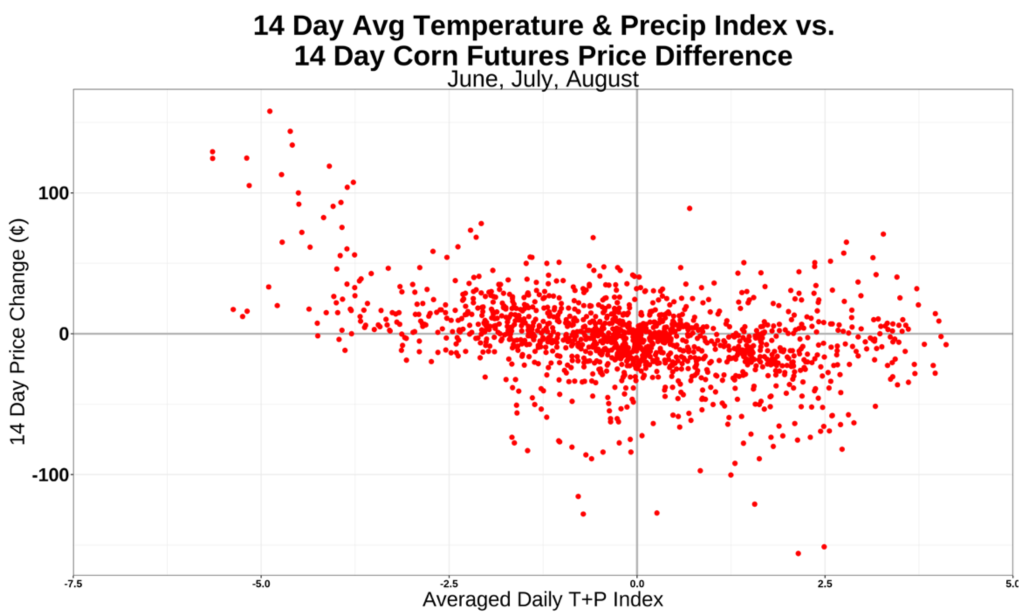

Figure 1. Comparison of a 14-day averaged US corn production-weighted daily maximum temperature and precipitation as a percent of normal derived weather index to 14-day changes in a continuous corn futures price.

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PiT Forecast API

The API provides access to the weather forecasts released to grain markets from May of 2017 to the present day. It also includes real-time updated weather forecasts. Forecast models available include the 00Z and 12Z forecasts from:

- ECMWF Ensemble Prediction System
- NOAA's Global Ensemble Prediction System (GEFS)
- NOAA's global forecast system (GFS) operational

The total archive has a data volume of hundreds of terabytes and can't be made available directly via the API. We have transformed the data into energy and agriculture-weighted indices designed to ease data delivery while enabling customers to find alpha-generating relationships with the indices created.

US Corn Production-Weighted Data

The API includes point-in-time forecast histories and observed weather condition data for several US and European crops. Each index comprises crop production-weighted maximum and minimum temperature and precipitation weather observations and forecasts for the crops shown in Table 1.

US			
Corn	Soybeans	Spring Wheat	Winter Wheat
Oats	Cotton	Barley	Rice
Europe			
Winter Wheat	Corn	Winter Barley	Spring Barley
Winter Rapeseed	Sunflower	Oats	Rye

Table 1. The US and European production-weighted crops available in the API.

Crop-production weighting converts each US county's and European NUTS 3 region weather data into a single index representing the weather conditions the crop experienced in aggregate. The weights used to calculate the US corn-production weighted statistics are the percentage of each subregion's contribution to national/regional corn production.

The US corn production weights are shown below in Figure 2.

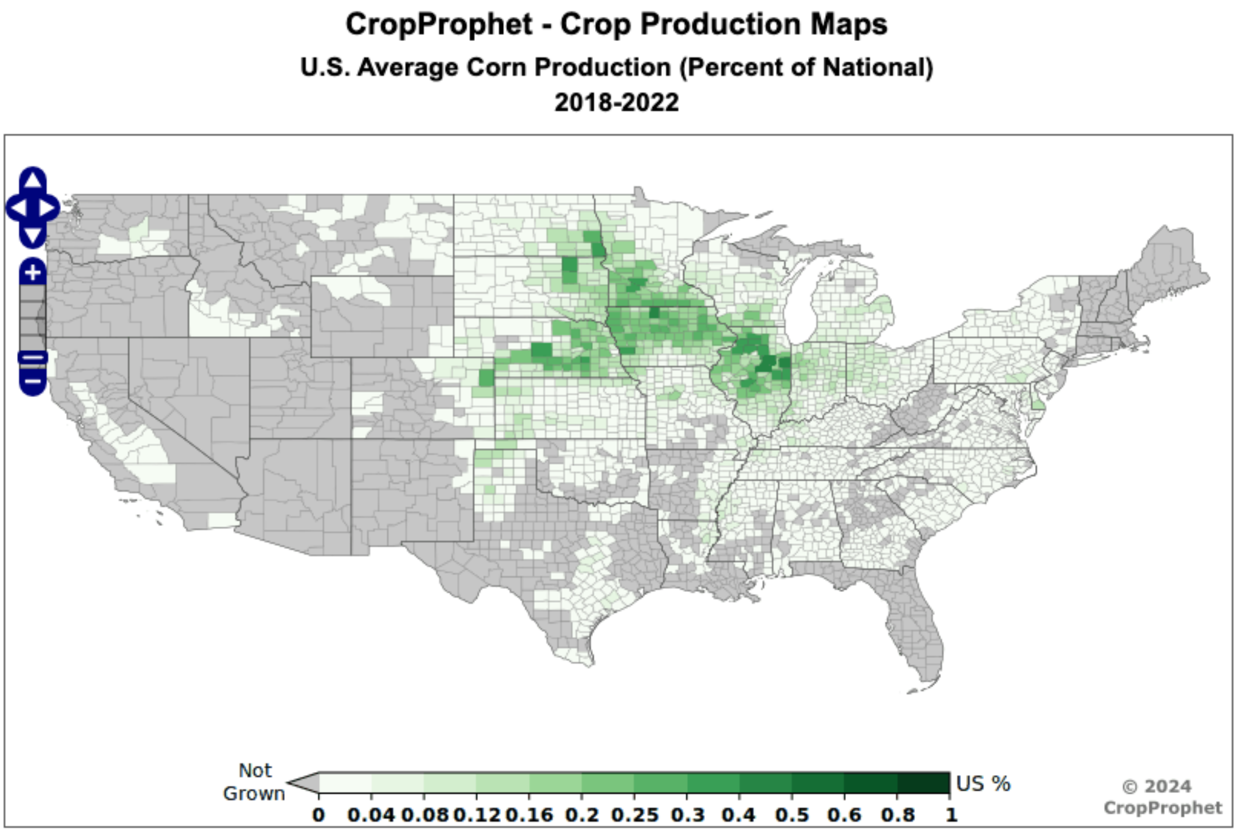

Figure 2. US corn production as a percentage of national corn production. Counties in the deeper green regions produce more corn than those in lighter green regions. The percentage of national corn production for each county is the weighs used to calculate a US corn production-weighted weather statistic.

The January 1, 2020, to March 6, 2024, US corn production weighted daily maximum temperatures are shown in Figure 3.

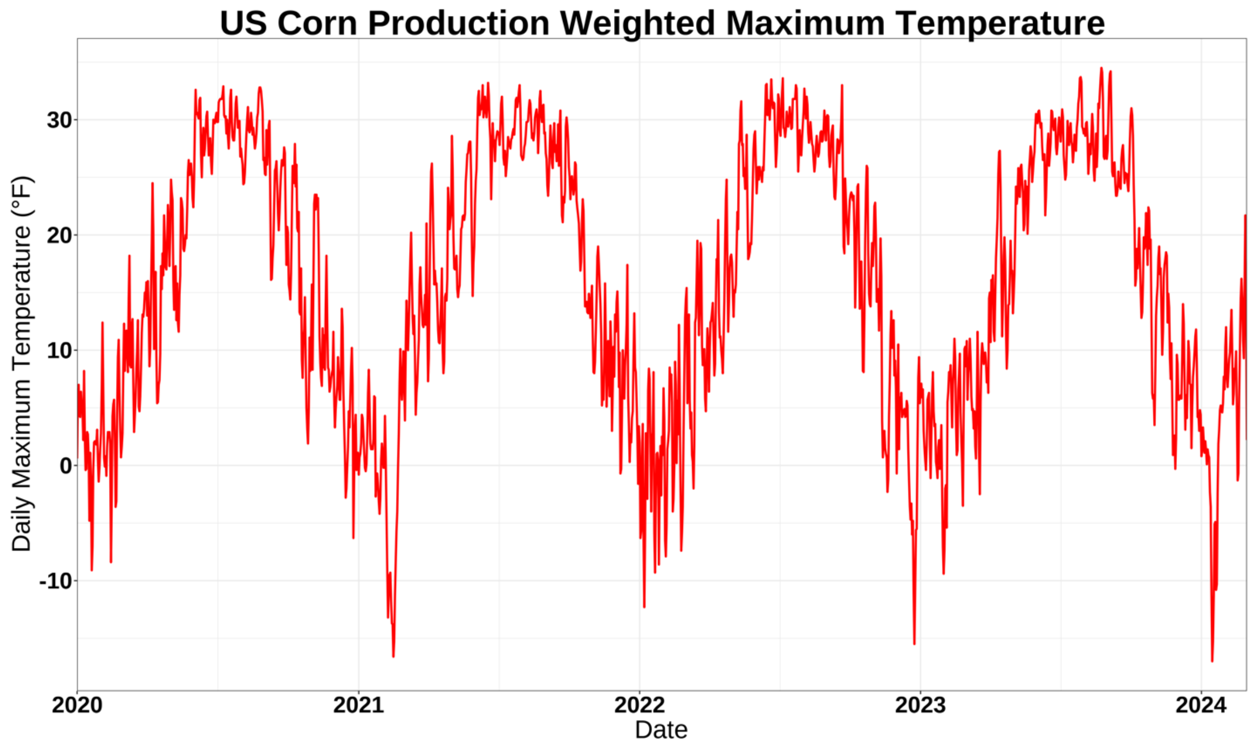

Figure 3. US corn production daily maximum temperatures from January 1, 2020 to March 6th, 2024.

Figure 2 clearly demonstrates the annual cycle of maximum temperatures. Further analysis of the daily maximum temperatures, along with US corn production weighted daily precipitation, is combined with corn futures price data to reveal a potential trading strategy.

Weather Impact on Corn Futures Prices

The following steps are taken to examine the relationship between observed weather conditions and corn futures prices.

1) Prepare the weather observation data:
    a. Obtain daily maximum temperature and percent of normal precipitation observations for June, July, and August from 1981 to 2023 from the API.
    b. Remove the annual cycle from each variable. This is achieved by calculating averages over Julian days using each year's data.
    c. Smooth the estimated annual cycle using a centered 30-day running average on the estimated annual cycle.
    d. Calculate each variable's deviation from the smoothed estimated annual cycle.
    e. Calculate the daily evolving average deviations from normal for maximum temperature and percent of normal precipitation for each period from seven to 21 days.

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f. Create a crop weather index for each averaging period according to

$$index = -1 * T_{max} + log\ (P_{norm})$$

where T_{max} is the period averaged maximum temperature deviation from normal and P_{norm} is the period average precipitation as a percentage of normal deviation from normal.

2) Prepare the corn futures price data:

a. Obtain historical corn futures prices. We used continuous corn futures contract data provided by https://www.investing.com/commodities/us-corn-historical-data.

b. Calculate the change in corn futures price using the "market close to close" difference over each period from seven to 21-days. A comparison of the change in the continuous corn yield futures price for seven, 14, and 21 days is shown in Figure 4.

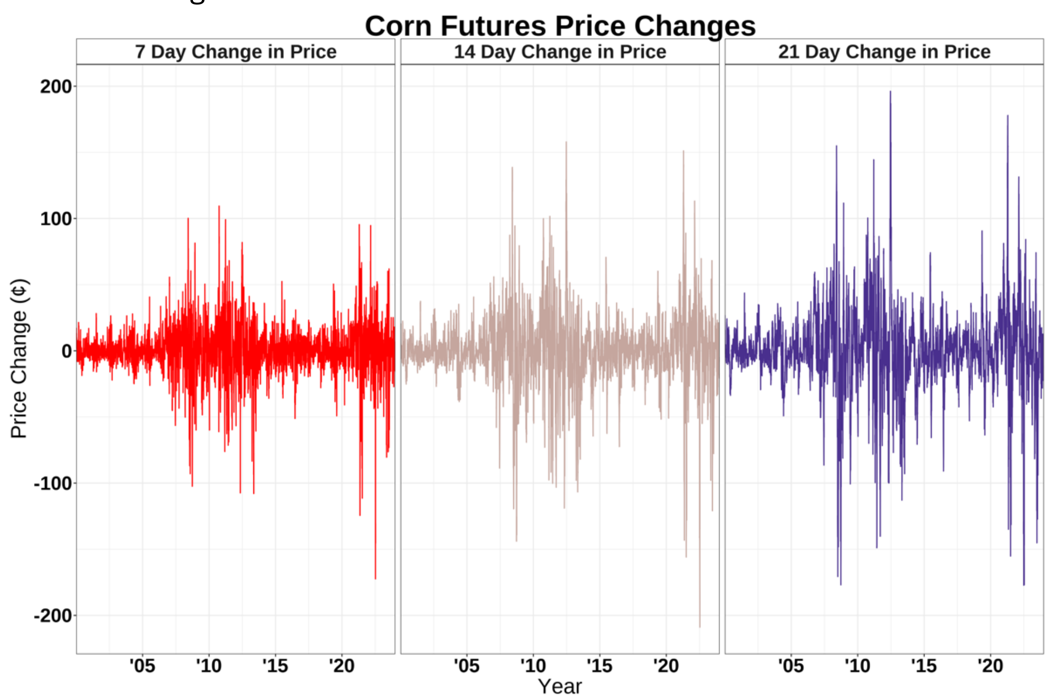

Figure 4. Example seven, 14, and 21-day changes in the continuous corn futures price contract.

3. Combine the prepared period averaged observed weather indices with the period change in the continuous corn prices. Using the R dplyr library function inner_join eliminates the weekend and holiday days for which there is no change in the futures contract prices.

4. Graph the data comparing the average deviation from the normal weather index with the change in corn futures prices. The result of the above steps is shown in Figure 4 below.

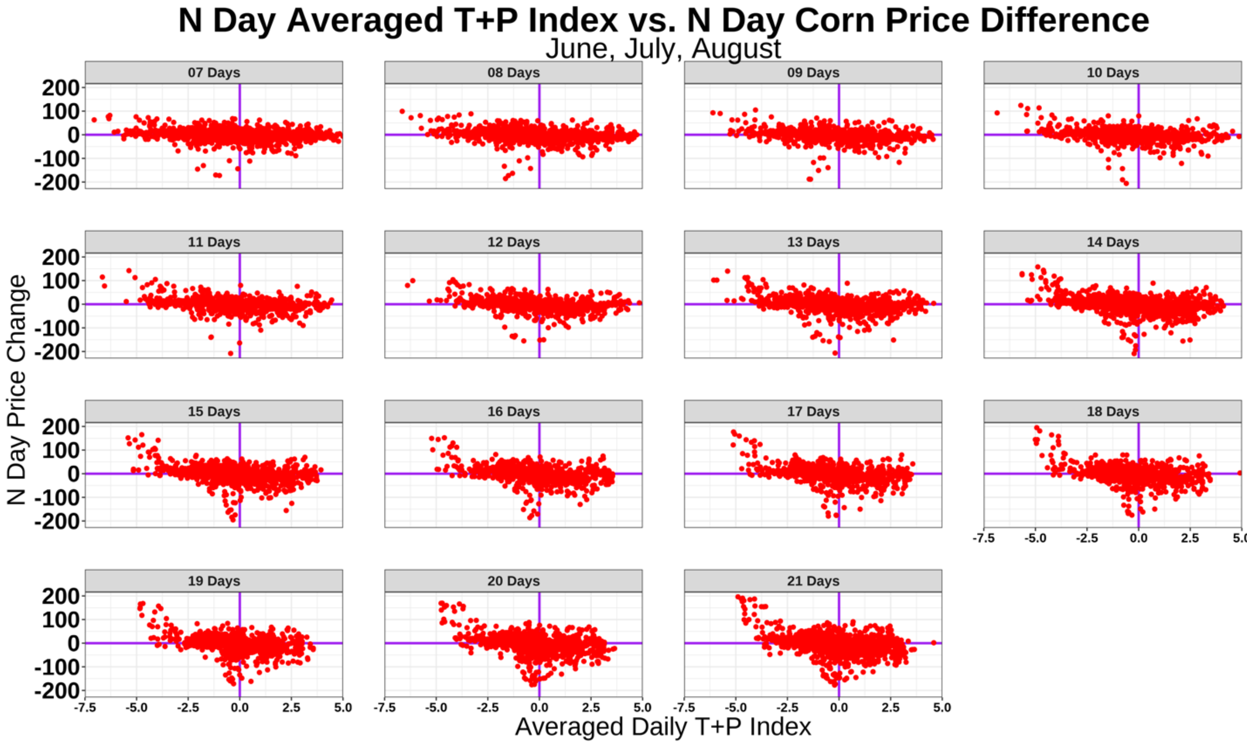

Figure 5. Comparison of a US corn production-weighted daily maximum temperature and precipitation as a percent of normal derived weather index to changes in a continuous corn futures price.

Figure 5 shows that over increasingly long averaging periods from seven to 21 days, dry and hot weather conditions during June, July, and August increasingly impact the corn futures price. The weather index was constructed so hot and dry conditions are increasingly negative values.

Discerning the weather/corn futures price relationship at 7-day averages is challenging. However, by 21-day averaging periods, the corn price changes are approximately exponential relative to the weather index. In other words, the corn market responds with price increases when the 21-day weather conditions are hotter and drier than normal. This is because hot and dry conditions are detrimental to yields and supply. The market is expecting less supply and prices to rise.

A Daily Corn Futures Trading Strategy

These results point to several possible weather-based corn futures trading strategies using the Point-in-Time Forecast API. They are:

1) Update the temperature and precipitation index daily during the corn growing season to monitor for the emergence of hot and dry conditions. Further analysis can determine the weather index's “momentum” to create triggers to determine under what index values a trade should be placed.

2) Combine the observed weather conditions with ensemble average forecast conditions provided by the API. For example, a user could combine seven days of weather index observations with 7-day of weather index forecasts. Knowing the 14-day weather index to corn price futures changes, shown below in Figure 1, enables a systematic trader to test for optimal index values to trigger a trade.

3) Combine the observed weather conditions with the full ensemble weather index forecast spread (provided by the API) to create a probabilistic view of likely future weather index outcomes. A systematic trader can optimize a trade based on finding the best probability of weather index forecasts that generate the highest return.

Next Steps

For trial access to the CropProphet Point-in-Time Forecast API, contact
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