

Growth Stage Models - Weather Application Example

Topic: Growth stage, GDD models

Data Access: API

Toolset: R

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Introduction

Plant development depends, in part, on temperature. Plants each require a specific amount of heat to develop from one point in their life cycle to another, such as from seeding to the four-leaf stage. Traditionally, a calendar is used to predict plant growth. However, it is possible for temperature to vary greatly from year to year, and even in locations where temperature is relatively stable, insight can still be gained by analyzing growth stages by looking at cumulative temperature rather than just time elapsed.

Growing degree days (GDD) is an agronomic value that assigns a heat value to each day in a particular region. Based on GDD, agronomic scientists have developed growth stage models to describe a plant's physiological response to temperature. Most GDD models are developed for crops in the developed world, where large commercial farms create an incentive to use models for insight over a large land area.

In the "Use Growth Stage Models to Visualize Corn Growth" case study, we used data from a trial study of the Situka variety of maize in Uganda to create a growth stage model that represents the development of the Ugandan maize crop. In this example, we will explore how to use similar process to scale growth stage models of any crop, to any location, globally.¹

In this below paragraphs, we will break down the process an analyst must follow in developing a GDD model, covering all the steps from querying agronomic data and crop models from the API, to scaling the models, adjusting parameters and visualizing the final results.

¹ A prerequisite to applying this method is that the user must know the numbers of days for a given crop to mature. In addition to temperature, a crop's growth stage is influenced by its soil and water conditions, and many other factors. Please note that the scaled crop growth stage model is intended to provide guidance on crop management. It is not meant to forecast the exact date of crop maturity.

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Determine Location and Time Frame

To begin, the analyst needs to determine the location and time frame of interest for their analysis. The aWhere API provides the necessary information for any location and time frame you would like to analyze. Ideally, your analysis should focus on an area where the crop of interest is commonly grown, and the typical timeline of growth for that crop in that region.

For example, according to this information sheet from the FAO², corn can be grown in most Ugandan soils, and the FAO recommends that farmers plant at the onset of seasonal rains, with the first rainy season occurring from Mid-February or March to June, and the second rainy season occurring from Mid-August to December. According to this sheet, select common maize varieties in Uganda take 100 to 125 days to mature.

Based on this information, the analyst can set the following parameters for their analysis as shown by the screenshot to the right.

The example application will scale the GDD model by using data from the selected range of years and using an average scaled model to apply that to the current year. We selected 2010-2015 in the year slider.

The screenshot displays a web interface for configuring an analysis. It features several input fields and a slider:

- Location and Time Selections**: A tabbed header.
- Crop and Model Selections**: A sub-header.
- Assign a Latitude**: A dropdown menu followed by a text input field containing the value **0.5032648**.
- Assign a Longitude**: A dropdown menu followed by a text input field containing the value **32.9550755**.
- Assign a Start Date**: A text input field containing the value **02-15**.
- Assign a Number of days for crop to mature**: A text input field containing the value **100**.
- Year**: A horizontal slider with a scale from 2,008 to 2,015. The selected range is from 2,010 to 2,015, indicated by blue markers and a blue bar above the slider.

² "Maize Production in Uganda," FAO, http://teca.fao.org/sites/default/files/resources/Maize%20Production%20in%20Uganda_SASAKAWA_%20GLOBAL%202000.pdf (Accessed June 6, 2016). <http://goo.gl/YhvWm9>

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Query agronomic data and models

Next, we selected our crop of interest from the drop down menu. We queried all of the models available from the aWhere agronomics API and selected the model needed to base our analysis.

Finally, click on the Go! button to view the results.

Location and Time Selections

Crop and Model Selections

Select a crop

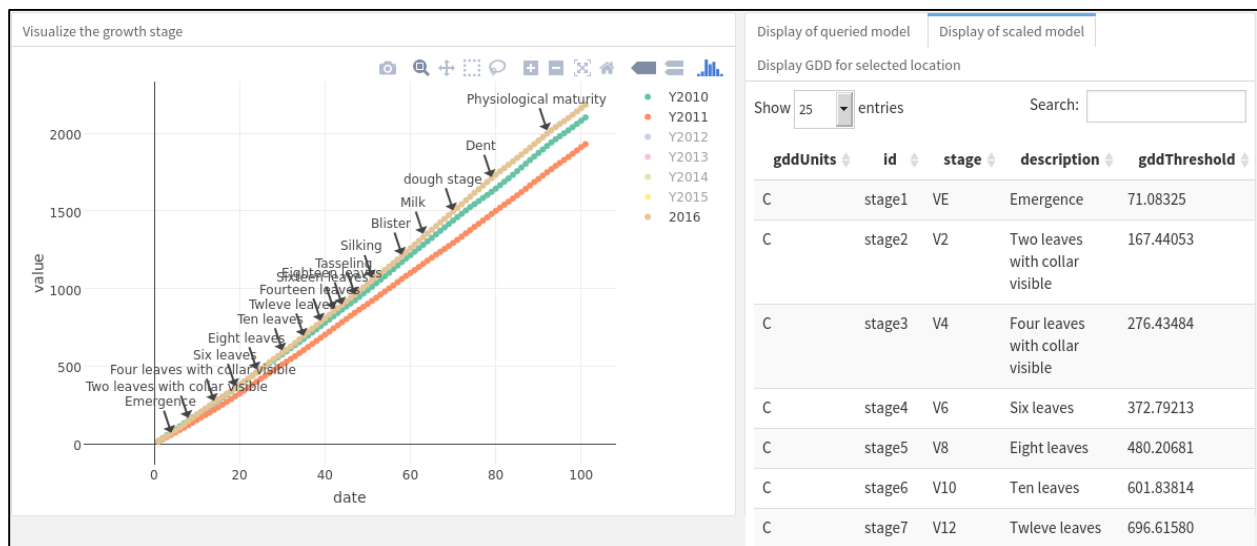
Corn

Select a model

Corn2300ISUAbendroth

Go!

Visualize Growth Stage



This graph shows all the growth stages of the crop from the first date of planting to the last stage of growth. Around day 51, the corn in this model reached the silking stage and around day 97, it reached physiological maturity. Of course, the information from this model needs further verification and adjustment based on real-world observations to be as accurate as possible.

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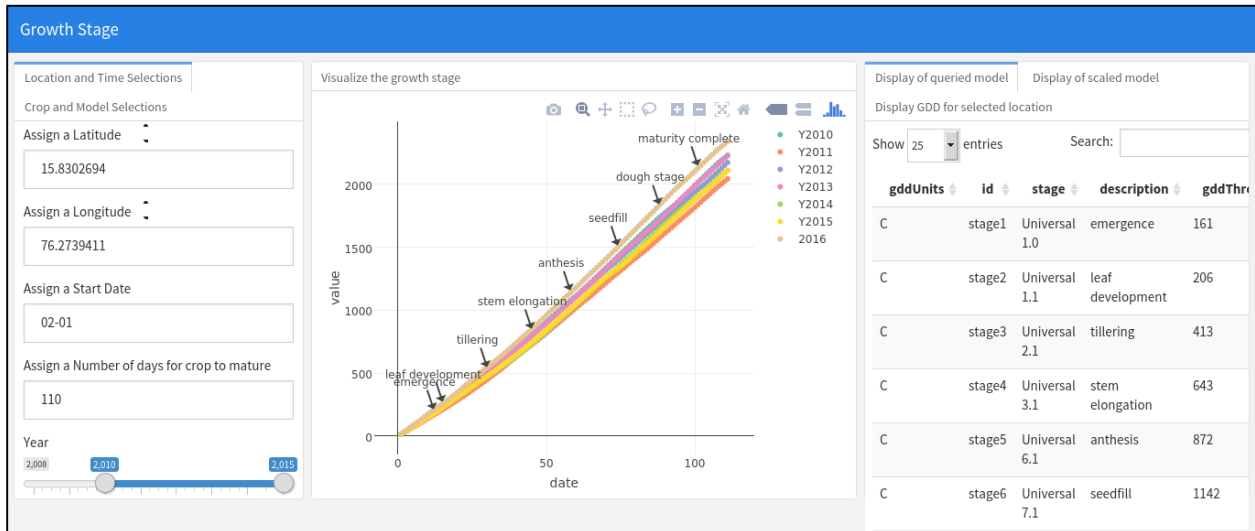
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Appendix

Another example



Complete code to replicate this analysis³

```

---
title: "Growth Stage"
output:
  flexdashboard::flex_dashboard:
    orientation: column
    vertical_layout: scroll
runtime: shiny
---
```{r setup, include=FALSE}
library(flexdashboard)
library(tidyr)
library(plotly)
library(shiny)

```

<sup>3</sup> Flex Dashboard: <http://rmarkdown.rstudio.com/flexdashboard/>

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```
source("../api_functions.R")
```

```
```
```

```
Column {.tabset data-width=300}
```

```
-----
```

```
### Location and Time Selections
```

```
```{r}
```

```
numericInput("latitude", label = "Assign a Latitude", value = 15.8302694)
```

```
numericInput("longitude", label = "Assign a Longitude", value = 76.2739411)
```

```
textInput("day_start", label = "Assign a Start Date", value = "02-01")
```

```
numericInput("num_days", label = "Assign a Number of days for crop to mature", value = 70)
```

```
sliderInput("years", label = "Year", min = 2008, max = 2015, value = c(2010, 2015), dragRange = TRUE)
```

```
```
```

```
### Crop and Model Selections
```

```
```{r}
```

```
selectInput("crop", label = "Select a crop", choices = c("Barley", "Canola", "Cotton", "Corn", "Oat", "Sugarbeet", "Sunflower", "Wheat"), selected = "Corn")
```

```
renderUI({
```

```
 tagList(
```

```
 selectInput("models", label = "Select a model", models(input$crop)$id),
```

```
 actionButton("go", "Go!")
```

```
)
```

```
})
```

```
```
```

```
```{r}
```

```
get model
```

```
model <- eventReactive(input$go, {
```

```
 if (!is.null(input$models)) model_detail(model_id = input$models)
```

```
})
```

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```
data <- eventReactive(input$go, {
 day_start <- input$day_start
 num_days <- input$num_days
 years <- input$years

 day_end <- as.Date(paste0(years[1]:years[2], "-", day_start)) + as.numeric(num_days)
 days <- cbind(day_start = paste0(years[1]:years[2], "-", day_start), day_end =
as.character(day_end))

 data <- do.call(cbind, lapply(1:nrow(days), function(i) {
 agronomic_values(latitude = 15.8302694, longitude = 76.2739411,
 day_start = days[i, 1], day_end = days[i, 2],
 gdd_method="standard", gdd_max_boundary=35)$accumulatedGdd
 })))

 colnames(data) <- paste0("Y", years[1]:years[2])

 data <- data.frame(date = seq(1, num_days+1), data, stringsAsFactors = FALSE)
 data
})

scale model
scaled_model <- eventReactive(input$go, {
 years <- input$years
 if (!is.null(input$models)) {
 scaled_models <- do.call(cbind, lapply(1:length(years[1]:years[2]), function (n) {
 multiplier <- data()[nrow(data()), n+1] /
model()$gddThreshold[[grep(model()$id[nrow(model())], model()$id)]]
 model()$gddThreshold*multiplier
 })))
 scaled_models
 }
})
```

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```
scaled_model <- cbind(subset(model(), select = -gddThreshold), gddThreshold =
rowMeans(scaled_models))

scaled_model
}
})

Current growth stage
gdd_current <- eventReactive(input$go, {
 day_start <- paste0(2016, "-", input$day_start)
 num_days <- input$num_days
 day_end <- as.Date(day_start) + num_days

 agronomic_values(latitude = 15.8302694, longitude = 76.2739411,
 day_start = day_start, day_end = as.character(day_end),
 gdd_method="standard", gdd_max_boundary=35)[, c("date", "accumulatedGdd")]
})

stages
stage <- eventReactive(input$go, {
 sapply(1:nrow(scaled_model()), function(i) {
 sum(gdd_current()$accumulatedGdd <= scaled_model()$gddThreshold[i])
 })
})

df <- eventReactive(input$go, {
 num_days <- input$num_days

 rbind(gather(data(), key = year, value = value, -date), data.frame(date = seq_len(length.out
= num_days+1), year = rep(2016), value = gdd_current()$accumulatedGdd, stringsAsFactors =
FALSE))
})

annotation <- eventReactive(input$go, {
 lapply(1:nrow(scaled_model()), function(i) {
 list(x = stage()[i],
```

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```
 y = scaled_model()$gddThreshold[i],
 text = scaled_model()$description[i],
 showarrow = TRUE)
 })
})
...

Column

Visualize the growth stage
```{r}
renderPlotly({
  plot_ly(df(), x = date, y = value, color = year, mode = "markers") %>%
    layout(annotations = annotation())
})
...

Column {.tabset data-width=400}
-----

### Display of queried model
```{r}
renderDataTable({
 model()
})
...

Display of scaled model
```{r}
renderDataTable({
  scaled_model()
})
...

### Display GDD for selected location
```

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```
````{r}
```

```
renderDataTable({
```

```
 gdd_current()
```

```
})
```

```
````
```

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