Simulation and Parameter Estimation for Biomass Crops

Fernando E. Miguez
Energy Biosciences Institute
University of Illinois

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Abstract

Simulation and parameter estimation of photosynthesis and crop growth.

1 Introduction

This was started with the idea of being able to estimate parameters of models used to simulate different aspect of the growth of a generic crop. The model itself is largely based on WIMOVAC although it has been completely re-written. Thus, this package does not only simulate growth of crops but is also provides optimization routines for parameter estimation. In addition, it uses the lattice for building custom graphics.

A simple example follows

```
> data(weather05)
> res <- BioGro(weather05)
> res
```

```
   DayofYear          Hour            Leaf              Stem
 Min.   :123.0   Min.   : 0.00   Min.   :0.002548   Min.   : 0.009072
 1st Qu.:168.0   1st Qu.: 6.00   1st Qu.:2.105234   1st Qu.: 8.231500
 Median :212.0   Median :12.00   Median :3.279083   Median :22.241687
 Mean   :212.5   Mean   :11.50   Mean   :2.735301   Mean   :19.677484
 3rd Qu.:257.0   3rd Qu.:18.00   3rd Qu.:3.445012   3rd Qu.:30.757924
 Max.   :301.0   Max.   :23.00   Max.   :3.451869   Max.   :34.385957
      Root            Rhizome          Grain         LAI
 Min.   :0.00868   Min.   : 2.617   Min.   :0   Min.   :0.00119
 1st Qu.:2.91625   1st Qu.: 3.922   1st Qu.:0   1st Qu.:3.57798
```

```
 Median :3.09229   Median : 6.400   Median :0   Median :5.57409
 Mean   :2.77854   Mean   : 7.021   Mean   :0   Mean   :4.64953
 3rd Qu.:3.21666   3rd Qu.:10.208   3rd Qu.:0   3rd Qu.:5.85652
 Max.   :3.28450   Max.   :12.582   Max.   :0   Max.   :5.86818
    ThermalT
 Min.   :   0.2090
 1st Qu.: 865.7519
 Median :1961.2109
 Mean   :1940.2779
 3rd Qu.:3038.9036
 Max.   :3746.7109
```

First, an example data set was loaded using the `data` function. Then an object called `res` was created which stores the result of running the function `BioGro` with the weather data as input. The printing method displays only some of the relevant information of the simulation. The function `BioGro` has many options and the documentation is a good place to start to inquire further (try `?BioGro`).

The plotting method provides a convenient way of displaying the results.

```
> plot(res)
```

2 Parameter Estimation

Often the carbon allocation needs to be modeled from samples of biomass including stem, leaf, rhizome and root. To evaluate the ability of the model to recover the 'true' coefficients some data were simulated.

```
> data(weather05)
> pheno.ll <- phenoParms(kLeaf1 = 0.48, kStem1 = 0.47, kRoot1 = 0.05,
+     kRhizome1 = -1e-04, kLeaf2 = 0.14, kStem2 = 0.65, kRoot2 = 0.21,
+     kRhizome2 = -1e-04, kLeaf3 = 0.01, kStem3 = 0.56, kRoot3 = 0.13,
+     kRhizome3 = 0.3, kLeaf4 = 0.01, kStem4 = 0.56, kRoot4 = 0.13,
+     kRhizome4 = 0.3, kLeaf5 = 0.01, kStem5 = 0.56, kRoot5 = 0.13,
+     kRhizome5 = 0.3, kLeaf6 = 0.01, kStem6 = 0.56, kRoot6 = 0.13,
+     kRhizome6 = 0.3)
> system.time(ans <- BioGro(weather05, phenoControl = pheno.ll))
> dbp.ll <- phenoParms()
> tts6 <- c(1, 500, 1300, 2000, 2600, 3200, 3700)
> indx <- BioCro:::indfun(tts6, ans$ThermalT)
> ans.dat <- as.data.frame(unclass(ans)[1:11])
> sel.rows <- indx
> simDat <- ans.dat[sel.rows, c("ThermalT", "Stem", "Leaf", "Root",
+     "Rhizome", "Grain", "LAI")]
> ans0 <- BioGro(weather05)
> rss0 <- RssBioGro(simDat, ans0)
> idb <- valid_dbp(idbp(simDat))
> op1 <- OpBioGro(phen = 0, WetDat = weather05, data = simDat,
+     iCoef = idb, op.method = "optim")
```

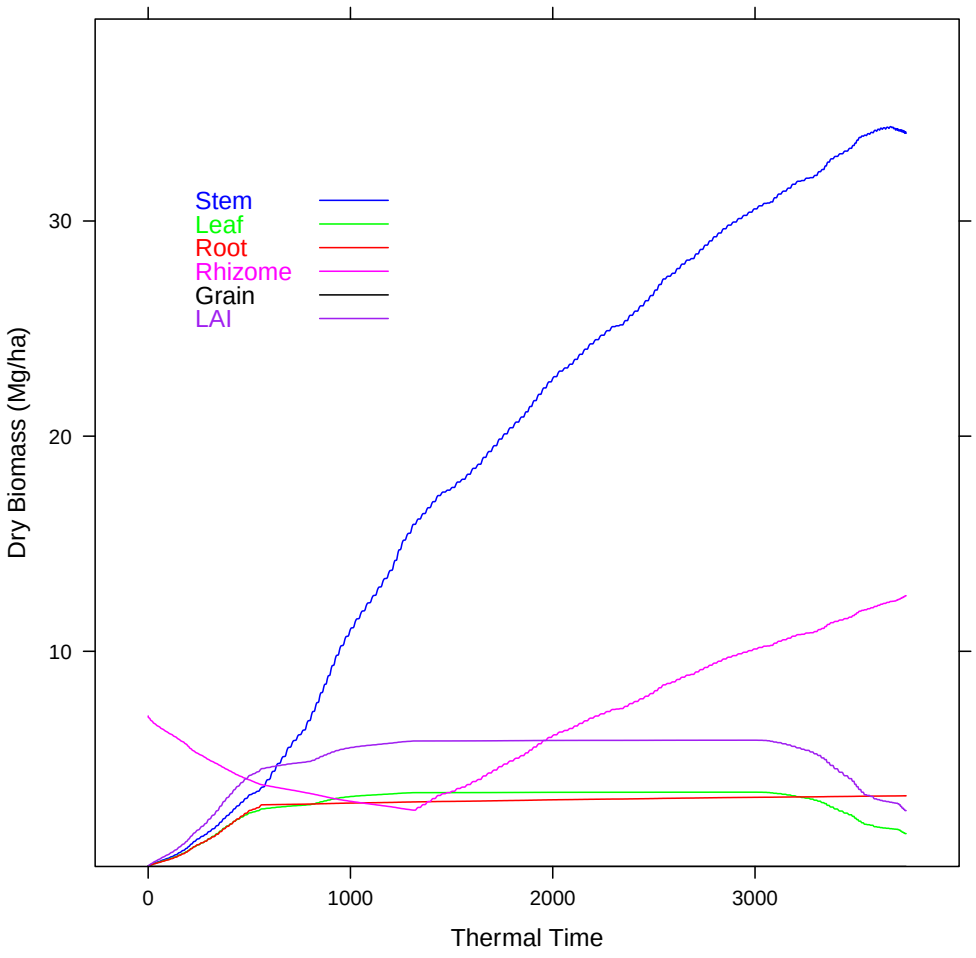

Figure 1: Dry biomass accumulation and Leaf Area Index for a generic biomass crop against thermal time.

```
> dbp.ll[7:31] <- op1$coefs
> ans1 <- BioGro(weather05, phenoControl = dbp.ll)
> (rss1 <- RssBioGro(simDat, ans1))
> (dist1 <- dist(rbind(op1$coefs, as.vector(unlist(pheno.ll)[7:31]))))
> (nconv1 <- length(op1$opar$convergence[op1$opar$convergence ==
+     0]))
```