

Package ‘DyMEP’

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Type Package

Title Dynamic Multi Environment Phenology-Model

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Description Mechanistically models/predicts the phenology (macro-phases) of 10 crop plants (trained on a big dataset over 80 years derived from the German weather service (DWD) <<https://opendata.dwd.de/>>). Can be applied for remote sensing purposes, dynamically check the best subset of available covariates for the given dataset and crop.

License LGPL (>= 3)

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Imports stats, utils

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Contents

asymptotic_prediction	2
available_crops_and_phases	3
available_environmental_covariates	3
DyMEP	4
DyMEP_DRC_visualizer	5
DyMEP_prediction_visualizer	6
envpredutils.pheno_phase_prediction_glm_model	7
non_linear_prediction	8

pheno_phase_prediction	9
reg_linear_prediction	10
WangEngels_prediction	11
Index	12

asymptotic_prediction	<i>DRC function: asymptotic_prediction</i>
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Description

DRC function: asymptotic_prediction

Usage

asymptotic_prediction(x, params)

Arguments

- x input variable
- params list of input parameter; Asym a numeric parameter representing the horizontal asymptote on the right side (very large values of input). ; lrc a numeric parameter representing the natural logarithm of the rate constant; c0 a numeric parameter representing the x for which the response is zero.

Value

value with asymptotic response

Examples

```
asymptotic_prediction(5,list("Asym_value"=0.5,
                             "lrc_value"=0.2,
                             "c0_value"=4))
# visualization
asymptote <- lapply(seq(0, 10, 0.1),
                    asymptotic_prediction,
                    list("Asym_value"=0.5, "lrc_value"=0.2, "c0_value"=4))
plot(seq(0, 10, 0.1), asymptote)
```

```
available_crops_and_phases
    available_crops_and_phases
```

Description

check what crops and corresponding phenology phases are available at the moment. Chose a crop (crop_abbrev), phenological phase from the output of this function further usage

Usage

```
available_crops_and_phases()
```

Value

dataframe with available crops and phenology phases

Examples

```
available_crops_and_phases()
```

```
available_environmental_covariates
    available_environmental_covariates check what environmental co-
    variates are implemented, use or alter prediction these abbreviations
    and the corresponding unit
```

Description

available_environmental_covariates check what environmental covariates are implemented, use or alter prediction these abbreviations and the corresponding unit

Usage

```
available_environmental_covariates()
```

Value

dataframe with available environmental covariates

Examples

```
available_environmental_covariates()
```

Description

Empirically models/predicts the phenology (macro-phases) of 10 crop plants (trained on a big dataset over 80 years derived from the German weather service (DWD)). Can be applied for remote sensing purposes, environmental inputs can be chosen from a range of pre-trained response curves and applied to the trained crops and phenological phases. No retraining is done within the use of this package.

Examples

```
available <- available_crops_and_phases()
#what is the best environmental covariates for one or multiple phases?
# check what covairates are implemented in the model
available_covariates <- available_environmental_covariates()

best_DyMEP_model(env_covariates = c("tas", "tasmin", "VPD", "SPI",
  "global_radiation", "tasmax", "RH"),
  pheno_phases = c("sowing-emergence", "jointing-heading"),
  crop_abbrev = "WW")
# create a list of wanted phases and corresponding environmental covariates
phase_covariate_list <- list("sowing-emergence" = c("tasmin", "VPD", "SPI"),
  "emergence-jointing" = c("tas", "tasmin", "VPD", "SPI"),
  "jointing-heading" = c("global_radiation", "tas", "SPI"))

# alternatively you can create this input list directly like this with the
# best available model:
phase_covariate_list <- best_DyMEP_model(env_covariates =
  c("tas", "tasmin", "VPD", "SPI", "global_radiation", "tasmax", "RH"),
  pheno_phases = c("sowing-emergence", "emergence-jointing", "jointing-heading"),
  crop_abbrev = "WW",
  output_list_for_prediction = TRUE)

# create dummy environmental data
environmental_data <- data.frame("DATE" = seq.Date(
  from = as.Date("2021-01-01"), to = as.Date("2023-12-31"), by=1),
  "tas"=runif(1095,min=-10,max=40),
  "RH"=runif(1095,min=0,max=100),
  "tasmin"=runif(1095,min=-10,max=40),
  "tasmax"=runif(1095,min=-5,max=40),
  "VPD" = runif(1095,min=0,max=40),
  "SPI"= runif(1095,min=-1,max=4),
  "global_radiation"= runif(1095,min=0,max=3500))

pheno_phase_prediction(phase_covariate_list = phase_covariate_list,
  environmental_data = environmental_data,
```

```

phase_starting_date =as.Date("2021-01-01"),
crop_abbrev = "WW")

# you can also get a more detailed output, containing detailed predictions
# and the parameters of the used DRC curves:
detailed_output <- pheno_phase_prediction(
  phase_covariate_list = phase_covariate_list,
  environmental_data = environmental_data,
  phase_starting_date =as.Date("2021-01-01"),
  crop_abbrev = "WW",
  output_type = "detailed_information")

# this output can be visualised like:
# get overview plot of the prediction
DyMEP_prediction_visualizer(detailed_output)
# check the DRC curves of the used model
DyMEP_DRC_visualizer(detailed_output)

```

DyMEP_DRC_visualizer *DyMEP_DRC_visualizer*

Description

Visualizes the Dose-Response Curves (DRC) for each phenological phase and environmental covariate.

Usage

```
DyMEP_DRC_visualizer(detailed_output)
```

Arguments

`detailed_output`

Output of the `pheno_phase_prediction` function with `output_type = "detailed_information"`.

Value

Returns plots showing the DRC curves for each phenological phase and environmental covariate. Each row represents a phenology phase.

Examples

```

phase_covariate_list <- best_DyMEP_model(env_covariates =
c("tas", "tasmin", "VPD", "SPI", "global_radiation", "tasmax", "RH"),
pheno_phases = c("sowing-emergence", "emergence-jointing", "jointing-heading"),
crop_abbrev = "WW",
output_list_for_prediction = TRUE)
# create dummy environmental data
environmental_data<- data.frame("DATE"=seq.Date(from = as.Date("2021-01-01"),

```

```

    to = as.Date("2023-12-31"),by=1),
      "tas"=runif(1095,min=-10,max=40),
      "RH"=runif(1095,min=0,max=100),
      "tasmin"=runif(1095,min=-10,max=40),
      "tasmax"=runif(1095,min=0,max=40),
      "VPD" = runif(1095,min=0,max=40),
      "SPI"= runif(1095,min=-1,max=4),
      "global_radiation"= runif(1095,min=0,max=3500))

DyMEP_DRC_visualizer(detailed_output = pheno_phase_prediction(
  phase_covariate_list = phase_covariate_list,
  environmental_data = environmental_data,
  phase_starting_date =as.Date("2021-01-01"),
  crop_abbrev = "WW",
  output_type = "detailed_information")
)

```

DyMEP_prediction_visualizer

DyMEP_prediction_visualizer

Description

Visualizes the predictions of the DyMEP model.

Usage

```
DyMEP_prediction_visualizer(detailed_output)
```

Arguments

detailed_output

Output of the pheno_phase_prediction function with output_type = "detailed_information".

Value

A plot with one panel per phenology phase, showing the environmental covariate responses, the GLM prediction, and the phase prediction (points).

Fields

timestamp Description of timestamp column.

Examples

```

phase_covariate_list <- best_DyMEP_model(env_covariates =
  c("tas", "tasmin", "VPD", "SPI", "global_radiation", "tasmax", "RH"),
  pheno_phases = c("sowing-emergence", "emergence-jointing",
    "jointing-heading"),

```

```

crop_abbrev = "WW",
output_list_for_prediction = TRUE)

# Create dummy environmental data
environmental_data <- data.frame("DATE" =
  seq.Date(from = as.Date("2021-01-01"),
    to = as.Date("2023-12-31"), by = 1),
  "tas" = runif(1095, min = -10, max = 40),
  "RH" = runif(1095, min = 0, max = 100),
  "tasmin" = runif(1095, min = -10, max = 40),
  "tasmax" = runif(1095, min = 0, max = 40),
  "VPD" = runif(1095, min = 0, max = 40),
  "SPI" = runif(1095, min = -1, max = 4),
  "global_radiation" = runif(1095, min = 0, max = 3500))

DyMEP_prediction_visualizer(detailed_output = pheno_phase_prediction(
  phase_covariate_list = phase_covariate_list,
  environmental_data = environmental_data,
  phase_starting_date = as.Date("2021-01-01"),
  crop_abbrev = "WW",
  output_type = "detailed_information"))

```

envpredutils.pheno_phase_prediction_glm_model
apply the prediction with glm model

Description

apply the prediction with glm model

Usage

```

envpredutils.pheno_phase_prediction_glm_model(
  env_data_pheno_phase,
  pheno_phase,
  crop_abbrev,
  model,
  output_type = "dates"
)

```

Arguments

env_data_pheno_phase	environmental data required to predict the phase
pheno_phase	phenological phase
crop_abbrev	abbreviation of the crop
model	the selected model to predict the wanted phenological phase

output_type either "dates" or "detailed_information"; defines what output of the model they user wants to have as return, default is set to "dates". If a user wants to get the response parameters, curves, predictions and model thresholds, it should be chosen "detailed_information" output = "dates" will return a dataframe with the stages and according dates output = "detailed_information" will return a list with the dates, but also the corresponding dose response parameters and predictions

Value

final output, either detailed (if output_type = "detailed_information") as list, or data.frame with dates if output_type = "dates"

non_linear_prediction *DRC function: non_linear_prediction*

Description

broken stick model according to an env variable

Usage

```
non_linear_prediction(env_variate, params)
```

Arguments

env_variate value of a environmental covariate

params list of input parameter; base_value: minimal value; slope estimated value, slope of the linear phase

Value

value with non_linear response

Examples

```
non_linear_prediction(1,list("base_value"=5,"slope_value"=1))

# visualization
non_linear <- lapply(seq(0, 10, 0.1),
  non_linear_prediction,
  list("base_value"=5,"slope_value"=1))
plot(seq(0, 10, 0.1), non_linear)
```

pheno_phase_prediction

function to predict the a phenological phase in winter wheat

Description

predict one or all phenological phases

Usage

```
pheno_phase_prediction(
  phase_covariate_list,
  environmental_data,
  phase_starting_date,
  crop_abbrev,
  output_type = "dates",
  external_params_path = NULL
)
```

Arguments

phase_covariate_list	list like: list("sowing-emergence" = c("tas", "VPD", "SPI"), "emergence-jointing" = c("tas")) indicating per phenological phase the covariates to use. List of of phenological phases must be consecutive!
environmental_data	data.frame with the necessary environmental data, one column must be "DATE" (as.Date format), the others with the names of the environmental covariates (e.g. tas, tasmin etc.)
phase_starting_date	starting date of the first phase which will be predicted (object of class "Date" (use as.Date()))
crop_abbrev	abbreviation of the crop to be modeled (valid crop_abbrevs can be found with available_crops_and_phases())
output_type	either "dates" or "detailed_information"; defines what output of the model they user wants to have as return, default is set to "dates". If a user wants to get the response parameters, curves, predictions and model thresholds, it should be chosen "detailed_information" output = "dates" will return a dataframe with the stages and according dates output = "detailed_information" will return a list with the dates, but also the corresponding dose response parameters and predictions
external_params_path	path where additional crop parameters should be stored if not possible to download in to the regular R repository. The default is NULL, which will use the regular R repository as path

Value

returns the end-date of each phase

either return an object of class 'DyMEP', if detailed_information is selected as output_type, from a dataframe containing phenology data, or

Examples

```
pheno_phase_prediction(phase_covariate_list = list(
  "sowing-emergence" = c("tasmin", "VPD", "SPI", "tasmax", "tas", "RH",
    "global_radiation"),
  "emergence-jointing" = c("tasmin", "VPD", "SPI", "tasmax", "tas", "RH",
    "global_radiation"),
  "jointing-heading" = c("tasmin", "VPD", "SPI", "tasmax", "tas", "RH",
    "global_radiation")),
environmental_data <- data.frame("DATE" = seq.Date(
  from = as.Date("2021-01-01"), to = as.Date("2023-12-31"), by=1),
  "tas"=runif(1095,min=-10,max=40),
  "RH"=runif(1095,min=0,max=100),
  "tasmin"=runif(1095,min=-10,max=40),
  "tasmax"=runif(1095,min=-5,max=40),
  "VPD" = runif(1095,min=0,max=40),
  "SPI"= runif(1095,min=-1,max=4),
  "global_radiation"= runif(1095,min=0,max=3500)),
phase_starting_date =as.Date("2021-01-01"),
crop_abbrev = "WW")
```

reg_linear_prediction *DRC function: reg_linear_prediction*

Description

linear model according to an env variable

Usage

```
reg_linear_prediction(env_variate, params)
```

Arguments

env_variate	value of a environmental covariate
params	list of input parameter; intercept estimated value, slope of the linear phase

Value

value with reg_linear response

Examples

```
reg_linear_prediction(1,list("intercept_value"=1, "slope_value"=5))
# visualization
reg_linear <- lapply(seq(0, 10, 0.1),
  reg_linear_prediction,
  list("intercept_value"=-1,"slope_value"=1))
plot(seq(0, 10, 0.1), reg_linear)
```

WangEngels_prediction *DRC function: WangEngels_prediction*

Description

DRC function: WangEngels_prediction

Usage

```
WangEngels_prediction(x, params)
```

Arguments

x	effective env_variable value
params	list of input parameter; xmin_value represents the minimal env_variable value above which growth response will happen ; xopt_value: optimal growth point, env_variable values here have the highest response; xmax_value represents the maximal env_variable value above which no growth response will happen according to the wang engel model.

Value

value with WangEngels response

Examples

```
WangEngels_prediction(10, params = list("xmin_value"=1,
                                         "xopt_value"=25,
                                         "xmax_value"=35,
                                         "r_value"=0.5))

# visualization
WangEngels <- lapply(seq(0, 40, 0.1),
  WangEngels_prediction,
  list("xmin_value"=1,
       "xopt_value"=25,
       "xmax_value"=35,
       "r_value"=0.5))
plot(seq(0, 40, 0.1), WangEngels)
```

Index

- * **DRC**
 - asymptotic_prediction, [2](#)
 - non_linear_prediction, [8](#)
 - reg_linear_prediction, [10](#)
 - WangEngels_prediction, [11](#)
 - * **and**
 - available_crops_and_phases, [3](#)
 - * **are**
 - available_crops_and_phases, [3](#)
 - available_environmental_covariates, [3](#)
 - * **available**
 - available_crops_and_phases, [3](#)
 - * **check**
 - available_crops_and_phases, [3](#)
 - available_environmental_covariates, [3](#)
 - * **corresponding**
 - available_crops_and_phases, [3](#)
 - * **covariates**
 - available_environmental_covariates, [3](#)
 - * **crops**
 - available_crops_and_phases, [3](#)
 - * **environmental**
 - available_environmental_covariates, [3](#)
 - * **glm**
 - envpredutils.pheno_phase_prediction_glm_model, [7](#)
 - * **implemented**
 - available_environmental_covariates, [3](#)
 - * **phases**
 - available_crops_and_phases, [3](#)
 - * **phase**
 - envpredutils.pheno_phase_prediction_glm_model, [7](#)
 - pheno_phase_prediction, [9](#)
 - * **phenology**
 - available_crops_and_phases, [3](#)
 - pheno_phase_prediction, [9](#)
 - * **prediction**
 - envpredutils.pheno_phase_prediction_glm_model, [7](#)
 - pheno_phase_prediction, [9](#)
 - * **visualization**
 - DyMEP_DRC_visualizer, [5](#)
 - DyMEP_prediction_visualizer, [6](#)
 - * **what**
 - available_crops_and_phases, [3](#)
 - available_environmental_covariates, [3](#)
- asymptotic_prediction, [2](#)
available_crops_and_phases, [3](#)
available_environmental_covariates, [3](#)

DyMEP, [4](#)
DyMEP_DRC_visualizer, [5](#)
DyMEP_prediction_visualizer, [6](#)

envpredutils.pheno_phase_prediction_glm_model, [7](#)

non_linear_prediction, [8](#)

pheno_phase_prediction, [9](#)
reg_linear_prediction, [10](#)
WangEngels_prediction, [11](#)