

Package ‘BayesRE’

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Type Package

Title Bayesian Multiple Linear Regression Estimation for Crop Yield

Version 0.1.0

Description Implements Bayesian multiple linear regression models for estimating crop yield response to climatic variables. Posterior predictions and regional sensitivity coefficients are returned and can be visualised with built-in plotting utilities. Methods are based on Stan (Carpenter et al. (2017) [<doi:10.18637/jss.v076.i01>](https://doi.org/10.18637/jss.v076.i01)) and Bayesian workflow described in Gelman et al. (2013, ISBN:9781439840955).

Depends R (>= 4.0)

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bayesre_example	<i>Example Rice Yield Dataset</i>
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Description

Simulated rice yield dataset with temperature and precipitation.

Usage

bayesre_example

Format

A data frame with 130 rows and 5 variables:

- Location** Location ID
- Year** Year
- Yield** Crop yield (t/ha)
- Temp** Mean seasonal temperature (°C)
- Precip** Seasonal precipitation (mm)

compute_metrics	<i>Compute Model Metrics</i>
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Description

Computes root mean squared error (RMSE) and root mean absolute percentage error (RMAPE) from posterior mean predictions.

Usage

compute_metrics(predictions)

Arguments

predictions A data frame returned by `predict_bayesre`.

Value

A named list with two numeric elements:

RMSE Root mean squared error between observed and posterior mean predicted yield. Expressed in the same units as the yield variable.

RMAPE Root mean absolute percentage error, expressed as a percentage. Computed as $100 \times \sqrt{|e_i/y_i|}$, where e_i is the prediction error and y_i is the observed yield for observation i .

Examples

```
# Small deterministic toy predictions; runs in well under 5 seconds.
toy_predictions <- data.frame(
  Yield_obs = c(10, 12, 15),
  Yhat_mean = c(9.5, 12.5, 14),
  Yhat_lo = c(8, 11, 13),
  Yhat_hi = c(11, 14, 16)
)
metrics <- compute_metrics(toy_predictions)
stopifnot(is.list(metrics), all(c("RMSE", "RMAPE") %in% names(metrics)))

# A full Stan workflow is intentionally excluded from the automatic
# example run because model compilation/sampling can exceed 5 seconds.

data(bayesre_example)
fit <- fit_bayesre(bayesre_example, chains = 1, iter = 500, warmup = 200)
pred <- predict_bayesre(fit, bayesre_example)
compute_metrics(pred)
```

fit_bayesre

Fit Bayesian Regression Model

Description

Fits Bayesian linear regression using Stan.

Usage

```
fit_bayesre(data, chains = 1, iter = 500, warmup = 200)
```

Arguments

data	Data frame containing Yield, Temp, Precip
chains	Number of MCMC chains
iter	Total iterations
warmup	Warmup iterations

Value

A stanfit object containing the posterior samples. Use [predict_bayesre](#) to obtain predictions, [plot_diagnostics](#) for MCMC trace plots, and [plot_response_surface](#) for a yield response heatmap.

plot_diagnostics	<i>Plot Diagnostics</i>
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Description

Generates MCMC trace plots for the model parameters ...

Usage

plot_diagnostics(fit)

Arguments

fit	A stanfit object returned by fit_bayesre .
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Value

A ggplot object (the trace-plot grid) returned invisibly by bayesplot::mcmc_trace(). The plot is also printed to the active graphics device as a side effect.

plot_observed_vs_predicted	<i>Plot Observed vs Predicted Yield</i>
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Description

Generates an observed vs posterior mean predicted yield plot with 95

Usage

```
plot_observed_vs_predicted(
  predictions,
  save = FALSE,
  filename = NULL,
  width = 8,
  height = 6,
  dpi = 300
)
```

Arguments

predictions	A data frame returned by predict_bayesre , containing columns Yield_obs, Yhat_mean, Yhat_lo, and Yhat_hi.
save	Logical; if TRUE the plot is saved to filename as a PNG file. Default is FALSE.
filename	Character string giving the file name (including extension) for the saved plot. If NULL, a temporary file is used.
width	Plot width in inches. Default is 8.
height	Plot height in inches. Default is 6.
dpi	Resolution in dots per inch. Default is 300.

Value

A ggplot object.

Examples

```
# Small toy predictions; no Stan model is needed.
toy_predictions <- data.frame(
  Yield_obs = c(10, 12, 15, 17),
  Yhat_mean = c(10.2, 11.7, 14.6, 17.4),
  Yhat_lo = c(9, 10.5, 13.5, 16),
  Yhat_hi = c(11.5, 13, 15.8, 18.5)
)
p <- plot_observed_vs_predicted(toy_predictions)
stopifnot(inherits(p, "ggplot"))
plot_observed_vs_predicted(
  toy_predictions,
  save = TRUE,
  filename = tempfile(fileext = ".png")
)

# A full Stan workflow is intentionally excluded from the automatic
# example run because model compilation/sampling can exceed 5 seconds.

data(bayesre_example)
fit <- fit_bayesre(bayesre_example, chains = 1, iter = 500, warmup = 200)
pred <- predict_bayesre(fit, bayesre_example)
plot_observed_vs_predicted(pred)
```

plot_response_surface *Plot Yield Response Heatmap*

Description

Generates a posterior mean yield response surface over a grid of temperature and precipitation values, using the posterior means of the intercept and regression coefficients extracted from the fitted model.

Usage

```
plot_response_surface(
  fit,
  temp_range = c(20, 35),
  precip_range = c(50, 200),
  grid_size = 50
)
```

Arguments

fit	A stanfit object returned by fit_bayesre .
temp_range	A numeric vector of length 2 giving the minimum and maximum temperature (degrees Celsius) for the prediction grid. Default is c(20, 35).
precip_range	A numeric vector of length 2 giving the minimum and maximum precipitation (mm) for the prediction grid. Default is c(50, 200).
grid_size	A positive integer controlling the resolution of the prediction grid. A value of n produces an n x n grid of temperature-precipitation combinations. Default is 50.

Value

A ggplot object displaying a tile heatmap with:

- Temperature (degrees Celsius) on the x-axis.
- Precipitation (mm) on the y-axis.
- Posterior mean predicted yield mapped to the fill colour using the viridis colour scale.

The predicted yield at each grid point is computed as $\hat{\alpha} + \hat{\beta}_{\text{temp}} \times T + \hat{\beta}_{\text{precip}} \times P$, where $\hat{\alpha}$, $\hat{\beta}_{\text{temp}}$, and $\hat{\beta}_{\text{precip}}$ are the posterior means of the respective parameters.

`plot_response_surface_data`*Plot Response Surface with Observations*

Description

Overlays observed temperature-precipitation data points on the posterior mean yield response surface produced by `plot_response_surface`.

Usage

```
plot_response_surface_data(fit, data)
```

Arguments

<code>fit</code>	A stanfit object returned by <code>fit_bayesre</code> .
<code>data</code>	A data frame containing at least two columns: Temp (temperature in degrees Celsius) and Precip (precipitation in mm). These values are plotted as points on top of the heatmap.

Value

A ggplot object: the posterior mean yield heatmap from `plot_response_surface` with the observed temperature-precipitation points from data overlaid as filled black circles (size 1.5, alpha 0.7). The temperature and precipitation ranges of the heatmap default to `c(20, 35)` and `c(50, 200)` respectively; pass a customised base plot via `plot_response_surface` if different ranges are needed.

`predict_bayesre`*Posterior Predictions*

Description

Draws posterior predictions from a fitted stanfit object and summarises them per observation.

Usage

```
predict_bayesre(fit, data)
```

Arguments

<code>fit</code>	A stanfit object returned by <code>fit_bayesre</code> .
<code>data</code>	The data frame used to fit the model, containing a Yield column.

Value

A data frame with one row per observation and four columns:

Yield_obs Observed yield values from `data$Yield`.

Yhat_mean Posterior mean of the predicted yield.

Yhat_lo 2.5th percentile of the posterior predictive distribution (lower bound of the 95% credible interval).

Yhat_hi 97.5th percentile of the posterior predictive distribution (upper bound of the 95% credible interval).

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