

Score-based IND performance

Output from trend models

Output from pressure models

Scoring based on model outputs

press	press_type

Additional tibble provided by the user that lists the pressure type of each pressure needed for criterion C11 (link to management) and the visualisation [PRESS_TYPE].

crit	subcrit	score	weight	condition	condition_var

The package provides the full criteria template ("crit_scores_tmpl") described in the underlying framework (Otto et al., 2018, Ecol. Ind.), which is set as **default** in the scoring-related functions. It contains the scores and weights for each (sub-)criterion, the variables from the model output tibbles on which each(sub)criterion is based on as well as the condition to determine the actual score. The user can modify the weights, scores, conditions or remove specific (sub-)crits.

```
scores <- scoring(trend_tbl = m_trend, mod_tbl = m_all,
  press_type = PRESS_TYPE, crit_scores = crit_scores_tmpl)
```

Remove single criteria, e.g. trend criterion C8 (no trend model output needed anymore):

```
scoring(mod_tbl = m_press, press_type = PRESS_TYPE, crit_scores = crit_scores_tmpl[crit_scores_tmpl$crit_id > 1, ])
```

```
scores <- expect_resp(mod_tbl = m_all,
  scores_tbl = scores)
```

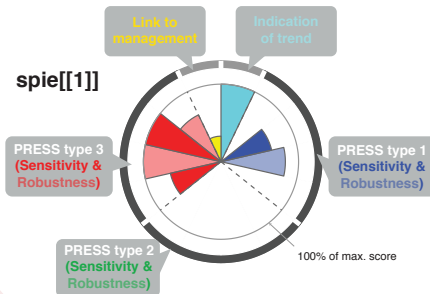
Runs a **SHINY APP** to modify the score for the sub-criterion 10.1 (IND response as expected) based on the response curves (default score 1 for neutral / no expectation).

```
sum_sc <- summary_sc(scores_tbl = scores)
```

Provides a user-friendly summary of the scoring output tibble.

Score visualization

```
spie <- plot_spiechart(sum_sc)
```



Cluster analysis

```
scores_dist <- dist_sc(scores)
```

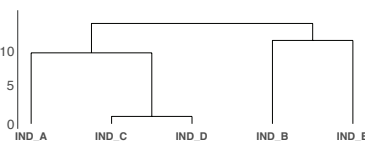
Calculates a (Euclidean) distance matrix based on all scores.

```
scores_clust <- clust_sc(
  scores_dist)
```

Returns a hclust object and prints the Gower distance and Cophonetic correlation coefficient.

```
plot_clust_sc(scores_clust)
```

ggplot2 that can be modified with additional themes.



Selection of best performing and complementary IND suite

State assessment based on IND suite

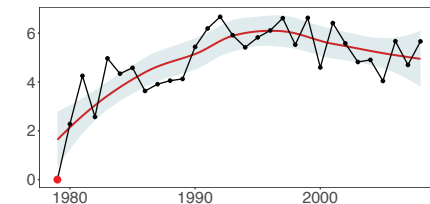
Two approaches based on trajectories in state space are implemented in the package to determine the current state of the system in comparison to an earlier reference period using the selected IND suite (state space = n-dimensional space of possible locations of IND variables).

Euclidean distance in state space

Calculation of the Euclidean distance in state space of any dimensionality between each single year and a defined reference year.

```
ed <- statespace_ed(x = IND_sub, time = YEAR, ref_time = YEAR[1])
```

```
plot_statespace_ed(ed)
```



Convex hull of state space

Given the identification of a reference domain in state space, more recent observations might lie within or outside this domain. The convex hull is a multivariate measure derived from computational geometry representing the smallest convex set containing all the reference points in Euclidean plane or space. For visualization, only 2 dimensions considered (dimension reduction through e.g. Principal Component Analysis suggested).

State space of 2 INDs

```
ch <- statespace_ch(x = IND$A, y = IND$B, period_ref = 1979:1983,
  period_current = 2004:2008)
```

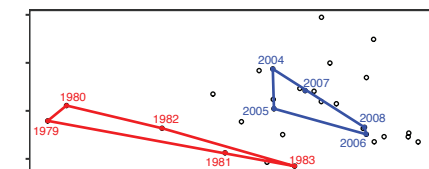
State space of first 2 principal components

```
pca <- vegan::rda(IND_sub, scale = TRUE)
```

```
pcas <- vegan::scores(pca_out, scaling = 0)
```

```
ch <- statespace_ch(x = pcas$scores[,1], y = pcas$scores[,2],
  period_ref = 1979:1983, period_current = 2004:2008)
```

```
plot_statespace_ch(ch)
```



Final output tibble from all modeling functions (m_all)

output of function:
model_trend()

```
$ ind_id      <int> ...
$ ind         <chr> ...
$ p_val       <dbl> ...
$ model       <list> ...
$ ind_train   <list> ...
$ time_train  <list> ...
$ pred        <list> ...
$ ci_up       <list> ...
$ ci_low      <list> ...
```

scoring crit. 8
(reflect change)

output of functions:
model_gam()
model_gamm()

```
$ id          <int> ...
$ ind         <chr> ...
$ press       <chr> ...
$ model_type  <chr> ...
$ corrstruc   <chr> ...
$ aic         <dbl> ...
$ edf         <dbl> ...
$ p_val       <dbl> ...
$ signif_code <chr> ...
$ r_sq        <dbl> ...
$ expl_dev    <dbl> ...
$ nrmse       <dbl> ...
$ ks_test     <dbl> ...
$ tac         <lgl> ...
$ pres_outlier <list> ...
$ excl_outlier <list> ...
$ model       <list> ...
```

for scoring subcrit. 10.2
(robustness: non-linearity of IND response)

for scoring crit. 9.1
(sensitivity: strength of IND response)

for scoring crit. 10.3
(robustness: predictability)

remaining columns
for diagnostics
and plots

added by function:
calc_deriv()

```
$ prop        <dbl> ...
$ zero_in_conf <list> ...
$ zic_start_end <list> ...
$ adj_n_boot   <dbl> ...
$ boot_error   <list> ...
$ press_seq    <list> ...
$ pred         <list> ...
$ pred_ci_up   <list> ...
$ pred_ci_low  <list> ...
$ deriv1       <list> ...
$ deriv1_ci_up <list> ...
$ deriv1_ci_low <list> ...
```

for scoring subcrit. 9.2
(sensitivity: proportion of pressure
range IND responses to)

added by function:
test_interaction()

```
$ interaction <lgl> ...
$ thresh_var  <list> ...
$ thresh_models <list> ...
$ tac_in_thresh <list> ...
```

for scoring crit. 10.4
(robustness: pressure interactions)