Package: potentiomap (via r-universe)

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Title Build Potentiometric Surfaces and Flow Arrows

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Description Builds potentiometric surface products from groundwater monitoring data. The package prepares groundwater observations from direct water-level measurements or depth-to-water data paired with land-surface elevations, interpolates thin-plate spline surfaces by default, supports alternative and user-supplied interpolation methods, exports raster and contour products, and derives hydraulic-gradient flow arrows. Raster operations use methods from Hijmans (2025) <doi:10.32614/CRAN.package.terra>, thin-plate spline interpolation uses methods from Nychka et al. (2021) <doi:10.5065/D6W957CT>, and geostatistical interpolation uses methods from Pebesma (2004) <doi:10.1016/j.cageo.2004.03.012>.

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Contents

`ps_arrow_vertices` *Extract arrow base or tip points*

Description

Extract arrow base or tip points

Usage

```
ps_arrow_vertices(arrows, which = c("last", "first"), out_file = NULL)
```

Arguments

`arrows`	A line `SpatVector` or path to a line vector file.
`which`	`"first"` for arrow bases or `"last"` for arrow tips.
`out_file`	Optional output vector path.

Value

A point `SpatVector`.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                      "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
arrows <- ps_flow_arrows(s$IDW, res_factor = 4, scale = 60)
tips <- ps_arrow_vertices(arrows$arrows, which = "last")
tips
```

ps_contours *Create contours from a surface raster*

Description

Create contours from a surface raster

Usage

```
ps_contours(surface, interval = 1, levels = NULL)
```

Arguments

surface	A terra::SpatRaster potentiometric surface.
interval	Contour interval in map elevation units.
levels	Optional explicit contour levels. When supplied, interval is ignored.

Value

A line terra::SpatVector of contours.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                      "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
ctr <- ps_contours(s$IDW, interval = 1)
ctr
```

ps_export_surfaces *Export surfaces, contours, and quicklook PNGs*

Description

Export surfaces, contours, and quicklook PNGs

Usage

```
ps_export_surfaces(
  surfaces,
  out_dir,
  out_stub = "gw",
  contour_interval = 1,
  points = NULL,
  write_raster = TRUE,
```

```
  write_contours = TRUE,
  write_png = TRUE
)
```

Arguments

`surfaces`	A named list of `SpatRaster` objects, such as the result of `ps_interpolate()`.
`out_dir`	Output directory.
`out_stub`	File prefix.
`contour_interval`	Contour interval.
`points`	Optional observation points to draw on quicklook figures.
`write_raster`, `write_contours`, `write_png`	Choose which outputs to write.

Value

A data frame listing written files.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                      "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
out <- ps_export_surfaces(s, points = pts, out_dir = tempdir())
out
```

---

ps_flow_arrows *Generate hydraulic-gradient flow arrows*

Description

Derives slope, aspect, hydraulic gradient, and downgradient arrows from a potentiometric surface raster.

Usage

```
ps_flow_arrows(
  surface,
  res_factor = 7,
  scale = 50,
  min_gradient = 1e-05,
  log_gradient = FALSE,
  log_arrow = FALSE,
  out_dir = NULL,
  out_stub = "gw"
)
```

Arguments

surface	A groundwater elevation SpatRaster.
res_factor	Factor used to thin arrows by resampling to a coarser grid.
scale	Arrow length multiplier.
min_gradient	Gradients below this value are dropped.
log_gradient	Store log1p() transformed gradient in the output raster.
log_arrow	Use log1p() transformed gradient for arrow lengths.
out_dir	Optional output directory. When supplied, files are written.
out_stub	File prefix used when writing outputs.

Value

A list with raster, points, and arrows.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                      "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
arrows <- ps_flow_arrows(s$IDW, res_factor = 4, scale = 60)
arrows$arrows
```

---

ps_interpolate *Interpolate potentiometric surfaces*

Description

Creates one raster per requested interpolation method. The default method is thin-plate spline ("TPS"). Other built-in methods are inverse distance weighting ("IDW"), ordinary kriging ("OK"), and universal kriging with quadratic drift ("UK"). Advanced users can also pass named custom interpolation functions through custom_methods.

Usage

```
ps_interpolate(
  points,
  value = "Z",
  methods = "TPS",
  grid_res = NULL,
  template = NULL,
  mask = NULL,
  padding = NULL,
  idw_power = 2,
  idw_nmax = 15,
```

```
  tps_lambda = NULL,
  kr_auto_cutoff = TRUE,
  kr_cutoff = NA_real_,
  kr_width = NA_real_,
  custom_methods = NULL,
  x = "x",
  y = "y",
  name_col = NULL,
  crs = NULL
)
```

Arguments

points	A point SpatVector, sf object, or coordinate table with a data column to interpolate.
value	Data column name when points is not already standardized. Defaults to "Z".
methods	Character vector of interpolation methods. Built-in values are "TPS", "IDW", "OK", and "UK". Names supplied in custom_methods can also be used.
grid_res	Output raster cell size in map units.
template	Optional template SpatRaster; overrides grid_res, padding, and mask extent construction.
mask	Optional AOI polygon used to crop and mask output rasters.
padding	Padding added around the convex hull extent when building a template from points.
idw_power, idw_nmax	IDW power and maximum neighbors.
tps_lambda	Thin-plate spline smoothing parameter. NULL lets fields::Tps() choose by GCV.
kr_auto_cutoff	Use automatic variogram cutoff and lag width.
kr_cutoff, kr_width	Manual variogram cutoff and lag width.
custom_methods	Optional named list of custom interpolation functions. Each function is called as fun(points, template, grid) and must return either a SpatRaster matching template or a numeric vector with one value per template cell.
x, y, name_col, crs	Used when points is a coordinate table.

Value

A named list of SpatRaster surfaces.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                      "well_id", "EPSG:26916")
surfaces <- ps_interpolate(pts, grid_res = 100)
names(surfaces)
```

ps_make_points *Make groundwater observation points*

Description

Convert a coordinate table, `sf` point object, or `terra` vector to a `SpatVector` with standard `Z` and `Name` fields.

Usage

```
ps_make_points(data, x = "x", y = "y", value, name_col = NULL, crs = NULL)
```

Arguments

`data`	A data frame, `sf` object, or `terra::SpatVector`.
`x, y`	Coordinate column names for tabular data.
`value`	Groundwater elevation column name.
`name_col`	Optional well or station name column.
`crs`	Coordinate reference system for tabular data, such as `"EPSG:26916"`.

Value

A point `terra::SpatVector` with standardized attributes.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(
  synthetic_wells,
  x = "x", y = "y",
  value = "gw_elevation",
  name_col = "well_id",
  crs = "EPSG:26916"
)
pts
```

ps_potentiometric_points *Build potentiometric points from depth-to-water measurements*

Description

Calculates groundwater elevation as surface elevation minus depth to water. Surface elevation can come from a DEM raster, a column in the depth table, or separate surface-elevation points. Separate surface points are matched by name when possible; otherwise their elevations are interpolated to the depth points with inverse distance weighting.

Usage

```
ps_potentiometric_points(
  data,
  x = "x",
  y = "y",
  depth_col,
  surface = NULL,
  surface_col = NULL,
  name_col = NULL,
  surface_name_col = name_col,
  crs = NULL,
  idw_power = 2
)
```

Arguments

data	Depth-to-water observations as a data frame, sf, or terra::SpatVector.
x, y	Coordinate column names for tabular depth data.
depth_col	Depth-to-water column name. Positive values are assumed to be depth below land surface.
surface	A DEM SpatRaster, separate surface-elevation observations, or NULL when surface_col is used.
surface_col	Surface-elevation column in data, or in surface when surface is a point/table object.
name_col	Optional name column in data.
surface_name_col	Optional name column in separate surface observations.
crs	CRS for tabular depth data.
idw_power	Power used when interpolating separate surface points.

Value

A point terra::SpatVector with surface_elevation, depth_to_water, and Z groundwater elevation fields.

Examples

```
data("synthetic_wells")
data("synthetic_dem")
gw <- ps_potentiometric_points(
  synthetic_wells,
  x = "x", y = "y",
  depth_col = "depth_to_water",
  surface = synthetic_dem,
  name_col = "well_id",
  crs = "EPSG:26916"
)
head(terra::values(gw))
```

`ps_quicklook` *Draw a quicklook surface plot*

Description

Draw a quicklook surface plot

Usage

```
ps_quicklook(
  surface,
  contours = NULL,
  points = NULL,
  file = NULL,
  title = "Potentiometric surface",
  label_points = TRUE,
  width = 1600,
  height = 1200,
  res = 180
)
```

Arguments

`surface`	A `SpatRaster`.
`contours`	Optional contour `SpatVector`.
`points`	Optional observation point `SpatVector`.
`file`	Optional PNG output path. When `NULL`, plots to the active device.
`title`	Plot title.
`label_points`	Label points with `Name` and `Z`.
`width`, `height`, `res`	PNG dimensions and resolution.

Value

Invisibly returns `file`.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                      "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
ps_quicklook(s$IDW, points = pts, title = "Synthetic IDW")
```

ps_sample_aoi *Make the sample area-of-interest polygon*

Description

Make the sample area-of-interest polygon

Usage

```
ps_sample_aoi()
```

Value

A `terra::SpatVector` polygon in EPSG:26916.

Examples

```
aoi <- ps_sample_aoi()
aoi
```

ps_smooth_surface *Smooth a potentiometric surface raster*

Description

Applies a focal moving-window smoother to a potentiometric surface raster. This can be useful when an interpolated surface is technically valid but too locally rough for contour development or hydraulic-gradient visualization.

Usage

```
ps_smooth_surface(
  surface,
  window_size = 3,
  method = c("mean", "median"),
  weights = NULL,
  iterations = 1,
  na.rm = TRUE,
  preserve_na = TRUE,
  filename = "",
  overwrite = FALSE
)
```

Arguments

surface	A terra::SpatRaster potentiometric surface.
window_size	Odd integer window size used when weights is NULL.
method	Smoothing statistic. Supported values are "mean" and "median".
weights	Optional odd-dimension numeric matrix of focal weights. NA values in the matrix are ignored by terra::focal().
iterations	Number of smoothing passes.
na.rm	Ignore missing values inside the focal window.
preserve_na	Preserve the original NA footprint after smoothing.
filename	Optional output raster filename.
overwrite	Overwrite filename when it exists.

Value

A smoothed terra::SpatRaster.

Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                      "well_id", "EPSG:26916")
s <- ps_interpolate(pts, grid_res = 100)
smoothed <- ps_smooth_surface(s$TPS, window_size = 5)
smoothed
```

---

synthetic_dem *Synthetic DEM raster*

Description

A small artificial DEM matching synthetic_wells, stored as a packed terra raster. Use terra::rast(synthetic_dem) to unpack it.

Usage

```
synthetic_dem
```

Format

A terra::PackedSpatRaster with one layer named surface_elevation.

Examples

```
data("synthetic_dem")
dem <- terra::rast(synthetic_dem)
dem
```

synthetic_surface_points *Synthetic surface elevation measurement points*

Description

Artificial land-surface elevation points for demonstrating workflows that do not start with a DEM raster.

Usage

```
synthetic_surface_points
```

Format

A data frame with coordinate, surface-elevation, and name columns.

Examples

```
data("synthetic_surface_points")
head(synthetic_surface_points)
```

synthetic_wells *Synthetic groundwater monitoring wells*

Description

A real-looking artificial monitoring dataset with coordinates, land-surface elevation, depth to water, and calculated groundwater elevation.

Usage

```
synthetic_wells
```

Format

A data frame with 32 rows and 6 columns:

well_id Synthetic well identifier.

x Easting in EPSG:26916 map units.

y Northing in EPSG:26916 map units.

surface_elevation Land-surface elevation.

depth_to_water Depth to groundwater below land surface.

gw_elevation Groundwater elevation.

Examples

```
data("synthetic_wells")
head(synthetic_wells)
```

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