Flux analysis

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**Meteorological data:** (UFORA) You only need the data corresponding to your study site.

* Time of the measurement (YEAR, MONTH, and DAY)
* Daily average temperature T (°C)
* Daily average night temperature, T\_NIGHT (°C)
* Daily average day temperature, T\_DAY (°C)
* Incoming shortwave radiation, SWDOWN (W/m²)
* Incoming longwave radiation, LWDOWN (W/m²)
* Vapor pressure deficit, VPD (hPa)
* Rainfall, RAIN (mm)
* Windspeed, WIND (m/s)
* Net radiation, RN (W/m²)
* Soil temperature, TSOIL (°C)
* Soil heat flux, GF (W/m²)
* Latent heat flux QLE (W/m²)
* Sensible heat flux QH (W/m²)
* Net Ecosystem Exchange, NEE (gC/m²/d)
* Gross primary production, GPP (gC/m²/d)
* Ecosystem respiration, Reco (gC/m²/d)

**Additional helpful Metadata:**

* World map of Köppen-Geiger climate classification (PDF)
* Site information: Find from [fluxnet sites list](https://fluxnet.org/sites/site-list-and-pages) or just google the name of your site

### Step 1: Explore your dataset

Data cleanup, units conversion; typical ranges, annual sums and averages

* Check and filter missing (NA) or impossible (e.g. very larges, -9999) values
* Convert variables into easy interpretable units (land fluxes into kgC /m²/year or tC /ha/year)
* Calculate the minimal and maximal value for each variable, as a quick check
* Calculate annual sum of precipitation, and the annual mean for each other variable.

# Loading data  
Fluxname <- "ZM-Mon\_daily"  
data.file <- file.path("./",paste0(Fluxname,".csv"))  
data <- read.csv(data.file,header = TRUE,sep = ";")

### Step 2: Mean annual cycles

Seasonal cycle, patterns, extreme events

* **Plot 1**: Produce mean seasonal cycle graphs (= you compile your data to obtain one average year) for each meteorological variable (in a single plot)
* Check the correspondence of these plots: do patterns concur or differ? Why? Try to explain the causal relationship.
* **Plot 2**: Compare your average year with every single year of data. Are there any extreme events in your data? Document it.
* **Plot 3**: Using bar plots, plot the average precipitation yearly cycle

### Step 3: Surface energy balance

Radiation balance, energy closure, Bowen ratio

* **Plot 4**: Plot mean annual cycles for Rn, Qh, Qle, GF (W/m²), in one graph and interpret the annual cycles.
* **Plot 5**: Scatterplot of energy balance (Qh+Qle vs. Rn-GF) (W/m²), select only 1 year of your dataset for this plot, fit a linear regression line (include equation + R²). Compare with 1:1 line.
* Analyze the closure of the energy balance. How much is the energy gap? What causes this? Did you expect such magnitude? Refer to literature in your answer.
* Calculate the Bowen ratio (= Qh/Qle).

### Step 4: Carbon fluxes

Carbon balance, carbon closure

* **Plot 6**: mean annual cycles for GPP, Reco and NEE, all in one plot
* Interpret the annual cycles. Is the site more a carbon source (NEE > 0) or a carbon sink (NEE < 0)?

### Step 5: Interpretation

Climate type, links between variables, relation with ecosystem

* **Plot 7**: Are there links between different meteorological variables?
* **Plot 8**: Are some of the land fluxes (GPP, Reco, NEE) correlated with one or several meteorological variables?
* Compare climate type with that on other locations (e.g. other groups, textbook examples, papers, …)
* Comment on extreme events, inter-annual variability, anomalies, …
* What is the relation between the climate and the site characteristics? What is the role of vegetation in this climate system?
* Any surprising details?

### Useful R cheatsheets

1. Summary of Rstudio functions: <https://raw.githubusercontent.com/rstudio/cheatsheets/master/rstudio-ide.pdf>
2. R basic commands: <https://raw.githubusercontent.com/rstudio/cheatsheets/master/base-r.pdf>
3. Data visualization: <https://raw.githubusercontent.com/rstudio/cheatsheets/master/data-visualization-2.1.pdf>
4. Work with dates: <https://raw.githubusercontent.com/rstudio/cheatsheets/main/lubridate.pdf>
5. More R cheatsheets: <https://rstudio.com/resources/cheatsheets/>