# ERAHUMED DSS

Valerio Gherardi    Pablo Amador Crespo    Andreu Rico

# Table of contents

# Preface

The purpose of this book is to provide a comprehensive reference for the ERAHUMED Decision Support System. Here you can find the technical descriptions of the algorithms employed by the system, as well as the user manual for the accompanying software.

The Support System and, hence, this book are currently under development on Github. In particular, the `{erahumed}` R package is hosted here.

For general information on the ERAHUMED project, please refer to the official website. If you want to get in touch, you can contact any of us via e-mail:

- Andreu Rico (Coordinator)
- Pablo Amador (PhD Researcher)
- Valerio Gherardi (Software Developer)

# 1 Introduction

This is a book created from markdown and executable code.

See Martínez-Megías et al. (2024) for additional info.

# Part I

# Technical description

# 2 The ERAHUMED model: a bird's eye view

The ERAHUMED model for assessing the ecological status of the Albufera Natural Park consists of three key components:

- **Hydrology**: Water dynamics within the park
- **Exposure**: Estimating the exposure to toxic chemicals
- **Risk Assessment**: Evaluating the impact of exposure

From a spatial perspective, the natural park is divided into three types of water bodies: the Albufera lake, rice field clusters[1], and irrigation ditches, which hydrologically connect the lake to the fields. Each of the model's computational layers incorporates specific quantitative models to simulate the relevant processes across all water bodies. This is summarized in Figure 2.1, where arrows indicate downstream dependencies and define the logical computation order.

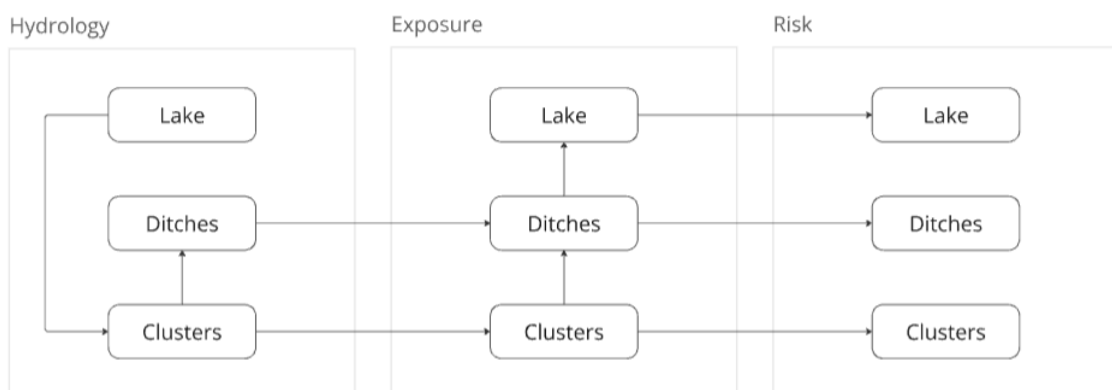


Figure 2.1: Scheme of ERAHUMED model components. Directional arrows indicate the downstream dependencies of the various simulation layers.

To clarify this structure, we can summarize the role of each simulation layer in Figure 2.1 as follows:

[1]The exact definition of "clusters" is discussed in Section 4.2. For the purposes of this high-level description, we can think of them simply as groups of rice fields.

1. The system's hydrology, including water volumes and flows for all hydrological elements, is derived from minimal input data: daily water levels and sea outlet outflows for the Albufera lake. This is achieved through a set of simplifying assumptions about the hydrology of rice fields and irrigation ditches. Details on this model are provided in Chapter 4.

2. Exposure to chemicals is calculated by first simulating their application to rice fields based on typical cultivation patterns. The dispersion of chemicals is then modeled using a simplified set of differential equations designed to capture the key physical processes driving their spread. These calculations are described in detail Chapter 5.

3. The impact of chemicals is evaluated across all water bodies using a simplified approach based on Species Sensitivity Distributions, utilizing publicly available toxicity data for their estimation. This is described in detail in Chapter 6.

# 3 Model inputs

This chapter will collect all model inputs (numeric parameters, as well as more complex information such as time-series or data-frames). The description should be generally succinct and parameters should be collected in a table - leveraging on `erahumed::erahumed_docs()` to retrieve parameters documentation).

The goal here is not to explain in detail what every parameter represents, which will be clarified when explaining the algorithms. Rather, the goal is to have a central reference for all users inputs.

The table could contain links to the sections describing the specific algorithms for which the parameters being described play a role.

| name | type | description |
|---|---|---|
| outflows_df | data.frame | Time-series dataset that provides the observational hydrological |
| weather_df | data.frame | A dataset that provides the relevant metereological time series, |
| variety_prop | numeric(3) | Vector of '3' positive values. Controls the proportions of field su |
| seed | numeric(1) | Seed for random number generation used by the simulation algo |
| storage_curve_slope_m2 | numeric(1) | Slope of the (linear) storage curve of the Albufera Lake, in squa |
| storage_curve_intercept_m3 | numeric(1) | Intercept of the (linear) storage curve of the Albufera Lake, in c |
| petp_surface_m2 | numeric(1) | The value (in squared meters) of the surface that converts preci |
| management_df | data.frame | Dataset that provides the yearly schedule for irrigation and drai |
| ideal_flow_rate_cm | numeric(1) | Ideal inflow/outflow of a cluster, for days in which the cluster is |
| height_thresh_cm | numeric(1) | A positive number. Height threshold for water levels, below whi |
| ditch_level_m | numeric(1) | Constant water depth in ditches. |
| ca_schedules_df | data.frame | A dataset that provides the list of scheduled chemical applicatio |
| drift | numeric(1) | A number between '0' and '1'. Percentage of chemical applicatio |
| covmax | numeric(1) | A number between '0' and '1'. Interception potential of foliage a |
| jgrow | numeric(1) | A positive integer. Length (in days) of crop maturation cycle. |
| SNK | numeric(1) | A number between '0' and '1'. (TODO). |
| dact_m | numeric(1) | A positive number. Active sediment layer depth, expressed in m |
| css_ppm | numeric(1) | A positive number. Suspended sediment concentration, expresse |
| foc | numeric(1) | A number between '0' and '1'. Fraction of organic content. |
| bd_g_cm3 | numeric(1) | A positive number. Bulk density of the sediment, expressed in g |
| qseep_m_day | numeric(1) | A positive number. Seepage rate, expressed in meters per day. |
| wilting | numeric(1) | A number between '0' and '1'. Wilting point. |
| fc | numeric(1) | A number between '0' and '1'. Field capacity. |

# 4 Hydrological model of the Albufera Natural Park

## 4.1 Overview

## 4.2 Scheme of the hydrological model

The content of this sections should be roughly the same as the corresponding package vignette.

## 4.3 Water balance calculations

### 4.3.1 Albufera Lake

### 4.3.2 Rice field clusters

### 4.3.3 Irrigation ditches

# 5 Exposure

## 5.1 Overview

## 5.2 Pesticide applications

This should describe how chemical applications are simulated.

## 5.3 Pesticide dispersion

### 5.3.1 Diagram of physical processes

Roughly the content of this vignette.

### 5.3.2 Evolution Equations

### 5.3.3 Semi-numerical approach

# 6 Risk assessment

## 6.1 Overview

## 6.2 Calculation of risk using SSDs

# Part II

# User Manual

# 7 The ERAHUMED DSS User Interface

This chapter should explain how to run ERAHUMED simulations using the Shiny app. It may contain screenshots taken from the app to exemplify the various points.

### 7.0.1 How to run the DSS?

Describe various options available (which at the moment of writing may as well be “download the package” only - and perhaps a basic deployment on shinyapps.io).

### 7.0.2 The “Output” tab

### 7.0.3 The “Input” tab

# 8 The {erahumed} R package

This should not be an exhaustive description of the R package, but rather mention its existence and giving basic instructions for its installation and refer to the package vignette's and documentation for more details.

# References

Martínez-Megías, Claudia, Alba Arenas-Sánchez, Diana Manjarrés-López, Sandra Pérez, Yolanda Soriano, Yolanda Picó, and Andreu Rico. 2024. "Pharmaceutical and Pesticide Mixtures in a Mediterranean Coastal Wetland: Comparison of Sampling Methods, Ecological Risks, and Removal by a Constructed Wetland." *Environmental Science and Pollution Research* 31 (10): 14593–609.

# A Input Data

## A.1 Hydrological data

## A.2 Meteorological data

## A.3 Albufera Rice Paddies Management

## A.4 Storage curve and P-ETP function

## A.5 Definition of rice clusters