# Towards a better representation of the real water cycle: introducing irrigation in the SASER modelling chain

Open Project Day

isardSAT, Barcelona | March 11th, 2022

# Towards a better representation of the real water cycle: introducing irrigation in the SASER modelling chain

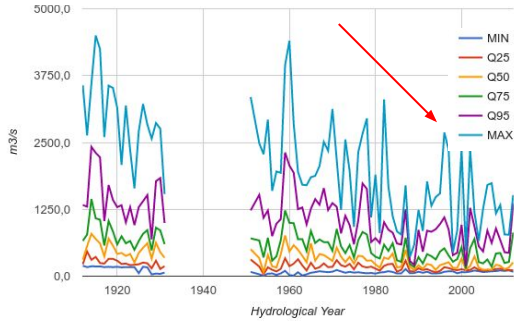**Anaïs Barella-Ortiz and Pere Quintana-Seguí**
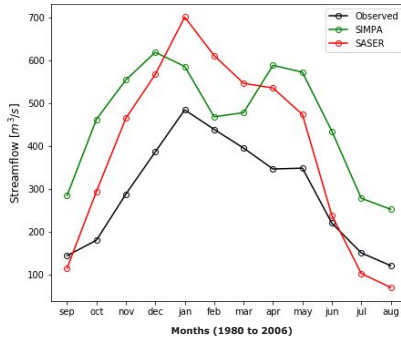
**Observatori de l'Ebre**

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# Anthropization of the Ebro basin

**Annual percentiles (daily data) of observed streamflow**



- Negative trends in most percentiles
- Less variability
- Extremes decrease

**Simulated vs. observed streamflow: mean annual cycle**



- Observed streamflow is lower than estimated streamflow in natural regime

*Figures referred to the Ebro at Tortosa.*

Water from mountains is stored in **dams** during Fall/Winter and transported to **irrigated** areas in Spring/Summer through the river and canals

- Benefits: ↓ drought effects, ↑ agricultural production
- Consequences: ↑ evaporation, ↓ streamflow, affect ecosystems

**Ebro basin hydraulic infrastructure**

# Irrigated agriculture: state of the art
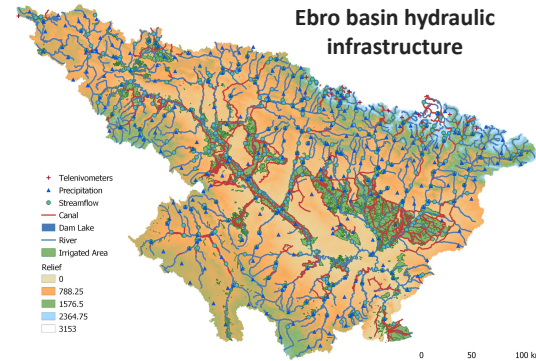
- Uses more than 70% of the water withdrawn worldwide from lakes, rivers, and aquifers.
- There are plans to increase the irrigated surface, which may be complex in a context of climate change.
- Irrigation can also be understood as a measure to adapt to climate change.
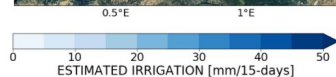- Scientific community works on a better representation of anthropic processes.

**Remote sensing**

Mapping, timing, and quantification products
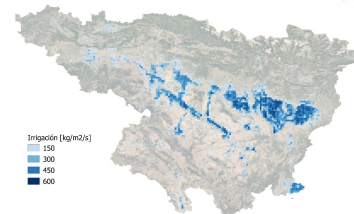
**Irrigated areas (Urgell)**
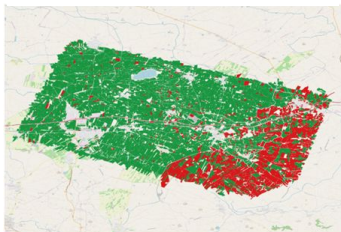
**Estimated irrigation (16/04/2011)**

0.5°E          1°E
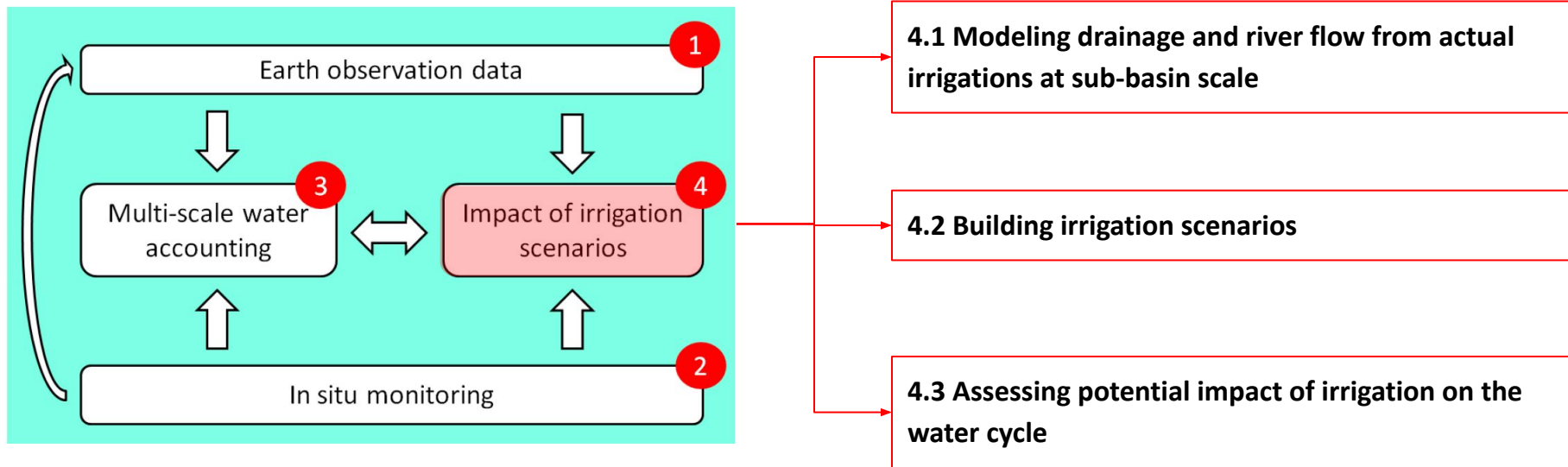
0   10   20   30   40   50
ESTIMATED IRRIGATION [mm/15-days]

**Models**

- Data assimilation
- Irrigation schemes implementation
- Analysis of irrigation scenarios

**Simulated irrigation (acc.)**

Irrigación [kg/m2/s]
150
300
450
600

*Figures from the IRRIGATION+ project.*

Graphical representation of the five WP and their interaction. WP5 encompasses all the WP.

**4.1 Modeling drainage and river flow from actual irrigations at sub-basin scale**

**4.2 Building irrigation scenarios**

**4.3 Assessing potential impact of irrigation on the water cycle**

# SASER hydrometeorological chain

The Ebro Observatory has developed the SASER hydrometeorological modelling chain
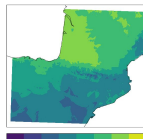
- Simulate the Iberian Peninsula
  - 1979 - current period
  - Climate change scenarios
- Simulate variables like:
  - Soil moisture
  - Snow
  - Evaporation and Transpiration
  - Streamflow

**SAFRAN** → **SURFEX** → **EAUDYSSÉE** → RAPID / RCB

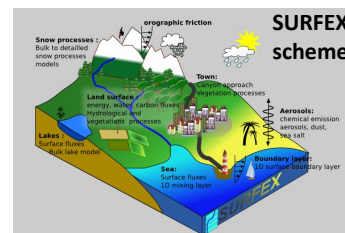| Region | Ebro basin |
|---|---|
| Spatial res. | 1 km |
| Period | 2008-2020 |
| Data | AEMET & SMC |
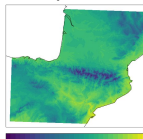
Temperature    Rel. humid.

Snow
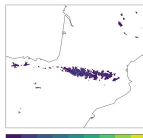
Precipitation
Wind speed
Cloudiness
Radiation

**SURFEX scheme**

- **Water and energy balance**
- **Irrigation scheme (Météo-France)\***
  - Vegetation & irrigation information is needed
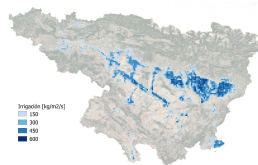
Streamflow ($m^3$/s)
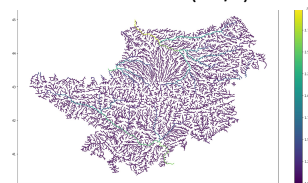
Management rules
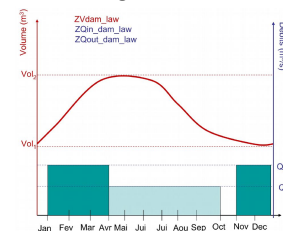
*\* No link between irrigation and dam management*

# SASER hydrometeorological chain

Forcing → LSM → Mod. platform & modules

SAFRAN → SURFEX → EAUDYSSÉE → RAPID / RCB

- A **Land Cover Map (LCM)** to identify the different land cover classes.
- An **Irrigated Areas Map (IAM)** to let the model know which crops have to be irrigated.
- An **Irrigation Methods Map (IMM)** to assign the correct method (flood, sprinkler or drip) to each crop.

We will see how these maps have been developed.
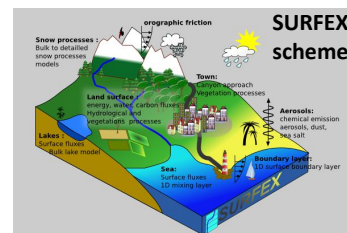
LCM   IAM   IMM

**SURFEX scheme**

- Water and energy balance
- **Irrigation scheme (Météo-France)***
  - Vegetation & irrigation information is needed

# Validation of SURFEX Land Cover Map
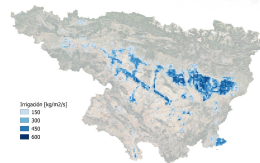
- ECOCLIMAP-SG database: i) ecosystem classification and ii) set of land surface parameters necessary in meteorological modelling.
- SIGPAC: Agricultural Plot Geographic Information System (Spanish Ministry of Agriculture, Fisheries, and Food)
- Since SURFEX uses the LCM provided by ECOCLIMAP-SG, we decided to validate the LCM using SIGPAC over an area of the Ebro basin.



ECOCLIMAP-SG    Ebro basin    Catalonia

SIGPAC

| | SIGPAC | | | | | | | | Validation results | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cereals | Summer cereals | Citrus | Forage crops | Pome fruits | Olive grove | Vineyard | Nuts | SIGPAC 1st corresp. | F1-score | SIGPAC 2nd corresp. | F1-score |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | | |
| Temp. broad. deciduos | | | | | ▮ | | ▮ | ▮ | 5,7 | 0.33 | - | - |
| Temp. broad. evergreen | | | ▮ | | | ▮ | | | 3,6 | 0.05 | - | - |
| Win. C3 crops | ▮ | | | ▮ | | | | | 1 | 0.67 | 1 | 0.63 |
| Sum. C3 crops | | | | ▮ | | | | | 4 | 0.13 | 4 | 0.12 |
| C4 crops | | ▮ | | | | | | | 2 | 0.06 | 2 | 0.06 |
| Shrubs | | | ▮ | | ▮ | ▮ | ▮ | ▮ | - | - | 3,5,6,7,8 | 0.06 |

(Row labels grouped under **ECOCLIMAP-SG**)

Develop a new LCM to simulate irrigation over the Ebro basin

# Creation of an improved Land Cover Map



**ECOCLIMAP-SG: SURFEX's Land Cover Map**
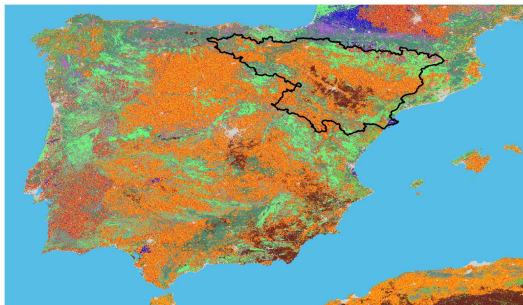


Legend:
- Sea and oceans
- Lakes
- Rivers
- Bare land
- Bare rock
- Permanent snow
- Boreal broadleaf deciduous
- Temperate broadleaf deciduous
- Tropical broadleaf deciduous
- Temperate broadleaf evergreen
- Tropical broadleaf evergreen
- Boreal broadleaf evergreen
- Temperate needleleaf evergreen
- Boreal needleleaf deciduous
- Shrubs
- Boreal grassland
- Temperate grassland
- Tropical grassland
- Winter C3 crops
- Summer C3 crops
- C4 crops
- Flooded trees
- Flooded grassland
- LCZ (10 classes)

**SIGPAC plots (Eastern Aragón)**
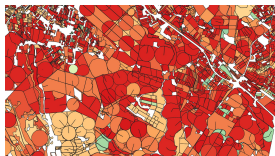


SIGPAC products have been classified into the different ECOCLIMAP-SG classes and replaced in the original ECOCLIMAP-SG LCM.

| ECOCLIMAP-SG classes | Temp. broad. deciduos | Trop. broad. deciduos | Temp. broad. evergreen | Trop. broad. evergreen | Winter C3 crops | Summer C3 crops | C4 crops |
|---|---|---|---|---|---|---|---|
| Nº prods. | 47 | 1 | 24 | 14 | 66 | 82 | 11 |

**Improved ECOCLIMAP-SG LCM**
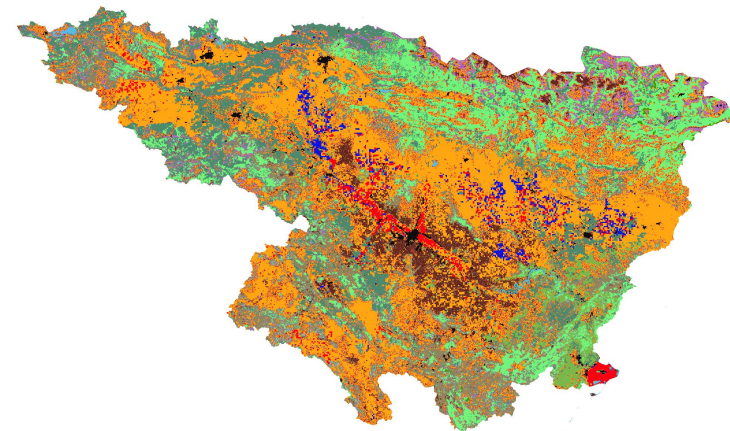


- Increase of Summer C3 and C4 crops
- Spatial distribution of herbaceous and tree crops is closer to reality

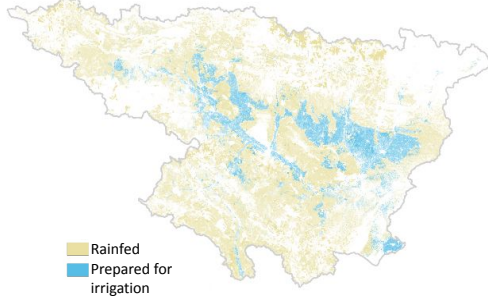Land cover classes are now better represented over the Ebro basin.

# Creation of an Irrigated Areas Map

**ECOCLIMAP-SG Irrigated Areas Original Map**
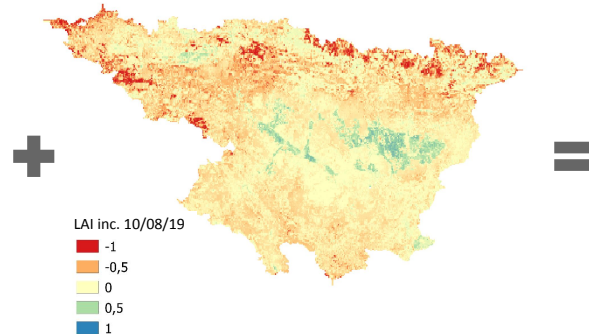


Non irrigated
Irrigated
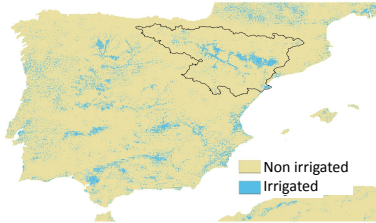
1. SIGPAC informs which plots are prepared for irrigation, but does not identify irrigated ones.
2. Météo-France provided 2 maps of LAI CGLS (Leaf Area Index Copernicus Global Land Service) increments at 1 km:
   - 20/08/2017 & 10/08/2019
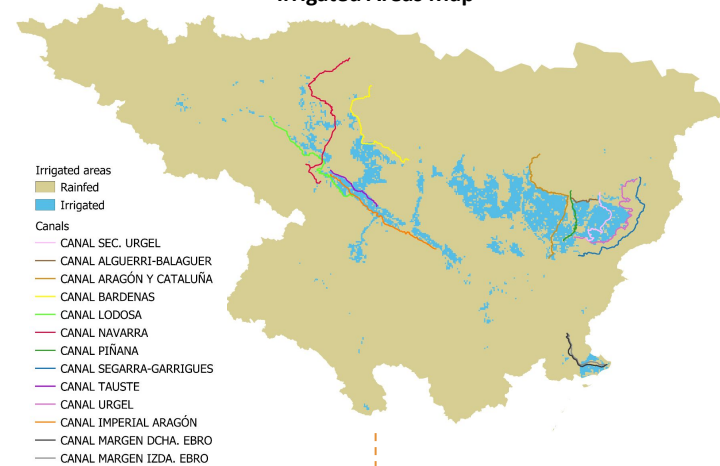   - Irrigated area threshold = 0.2

LCM   IAM   IMM

RAPID
RCB

**Irrigated Areas Map**



**1. SIGPAC plots prepared for irrigation**



Rainfed
Prepared for irrigation

**2. LAI Increments**



LAI inc. 10/08/19
- -1
- -0,5
- 0
- 0,5
- 1

Irrigated areas
- Rainfed
- Irrigated

Canals
- CANAL SEC. URGEL
- CANAL ALGUERRI-BALAGUER
- CANAL ARAGÓN Y CATALUÑA
- CANAL BARDENAS
- CANAL LODOSA
- CANAL NAVARRA
- CANAL PIÑANA
- CANAL SEGARRA-GARRIGUES
- CANAL TAUSTE
- CANAL URGEL
- CANAL IMPERIAL ARAGÓN
- CANAL MARGEN DCHA. EBRO
- CANAL MARGEN IZDA. EBRO
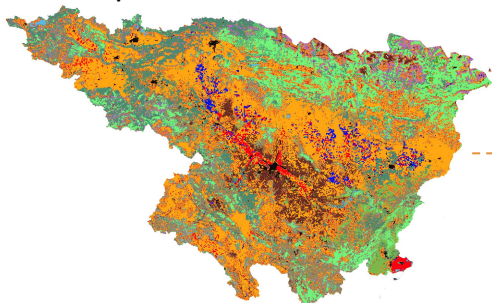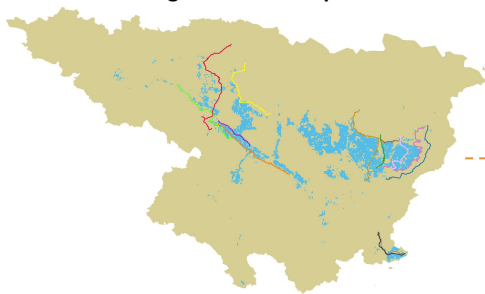
Irrigated areas receive water from the main canals that belong to the main irrigation systems identified in the Hydrological Plan from 2015 - 2021 (Spanish Ministry of Agriculture, Fisheries and Food).

# Creation of an Irrigation Methods Map
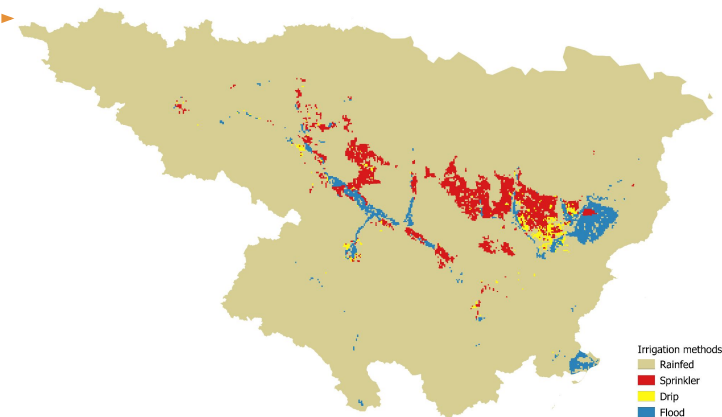
**Improved ECOCLIMAP-SG LCM**

**Irrigated Areas Map**

Both maps are combined to develop a map of irrigation methods per area.

- traditional: flood
- modern-herbaceous: sprinkler
- modern-trees: drip

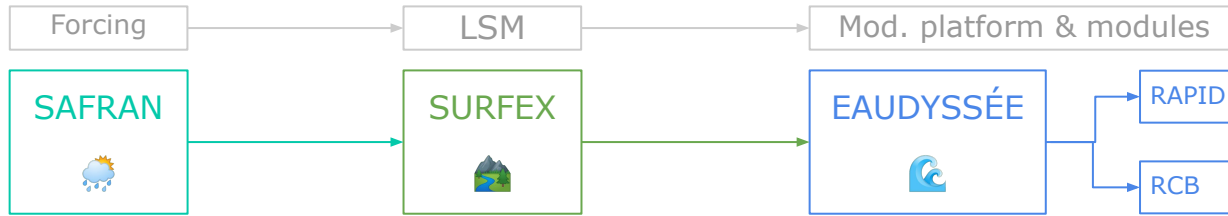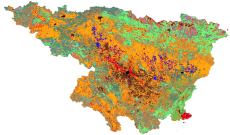**Flood**  **Sprinkler**  **Drip**

**Irrigation Methods per Area Map**

Irrigation methods
- Rainfed
- Sprinkler
- Drip
- Flood

- Potential collaboration with Giovanni Paolini (isardSAT).
- The Catalan government published an irrigation type map for Catalonia, but it is not accurate.
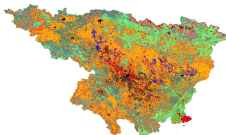
# SURFEX irrigation scheme

Forcing → LSM → Mod. platform & modules

SAFRAN → SURFEX → EAUDYSSÉE → RAPID / RCB

LCM

IAM

IMM

# SURFEX irrigation scheme



| Information to configure the scheme | Default value |
|---|---|
| Sowing and harvesting dates | sow = 15/03<br>harvest = 31/08 |
| Threshold to trigger irrigation (water stress) | [0.7, 0.55, 0.4, 0.25] |
| Duration of an irrigation event | 8 hours |
| Amount of water used in an irrigation event | 30 mm |
| Minimum time spent between two irrigation events | sprinkler & flood = 1 week<br>drip = 0 |
| Nº of days since the end of irrigation and the beginning of harvest time | 14 days |

LCM

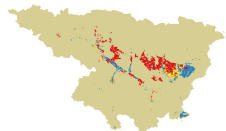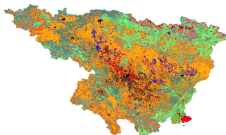IAM

IMM

# SURFEX irrigation scheme



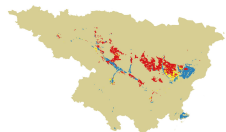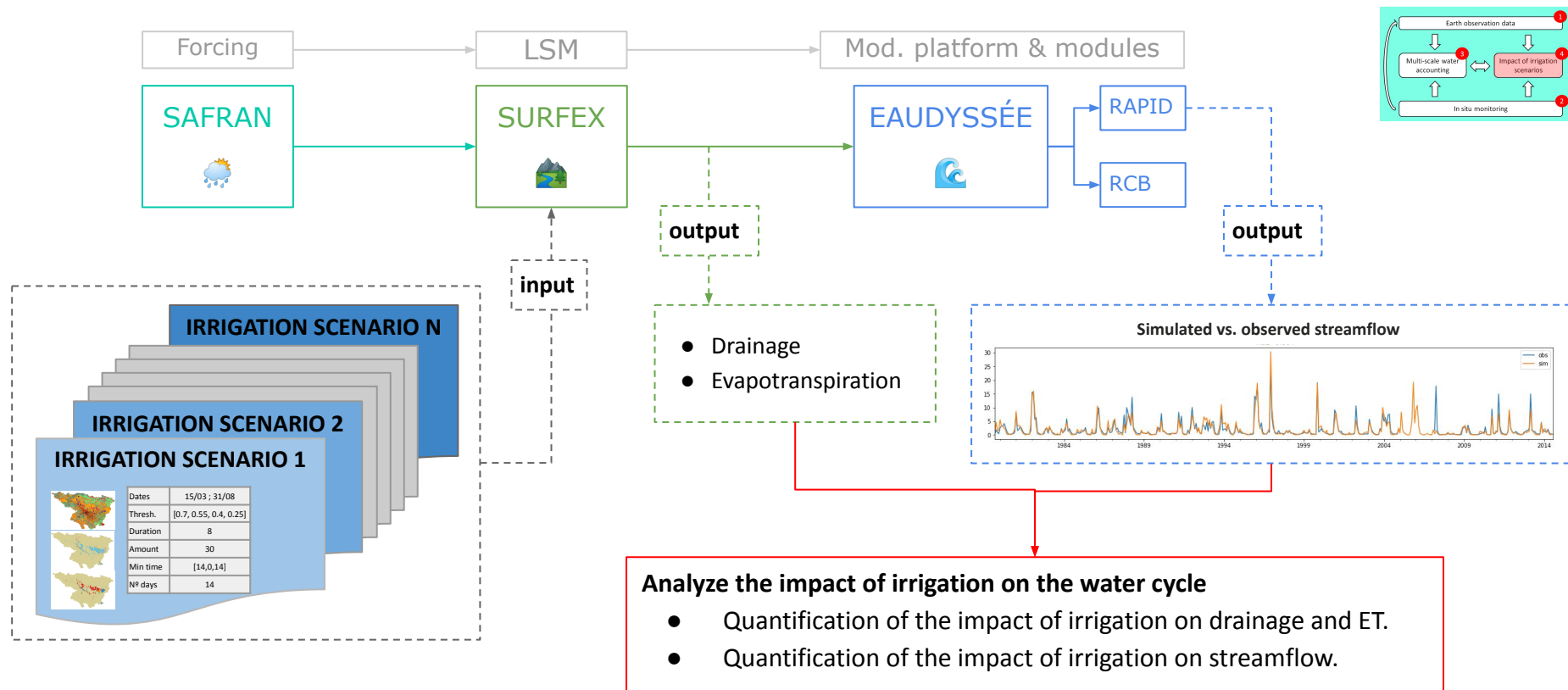| Information to configure the scheme | Default value |
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| Minimum time spent between two irrigation events | sprinkler & flood = 1 week<br>drip = 0 |
| Nº of days since the end of irrigation and the beginning of harvest time | 14 days |

**SURFEX irrigates if:**

- Irrigation method defined
- Water stress < irrigation threshold
- Within the irrigation period
- Enough time has passed since the last irrigation event

# IDEWA WP4 analyses

Forcing → LSM → Mod. platform & modules

**SAFRAN** → **SURFEX** → **EAUDYSSÉE** → RAPID / RCB

input

output:
- Drainage
- Evapotranspiration

output

Simulated vs. observed streamflow

**IRRIGATION SCENARIO N**
**IRRIGATION SCENARIO 2**
**IRRIGATION SCENARIO 1**

| Dates | 15/03 ; 31/08 |
| Thresh. | [0.7, 0.55, 0.4, 0.25] |
| Duration | 8 |
| Amount | 30 |
| Min time | [14,0,14] |
| Nº days | 14 |

**Analyze the impact of irrigation on the water cycle**
- Quantification of the impact of irrigation on drainage and ET.
- Quantification of the impact of irrigation on streamflow.

# Conclusions and next steps

- The SASER modelling chain is prepared to simulate irrigation.

- We have developed a dataset to simulate irrigation by means of a LSM over the Ebro basin (data paper in preparation):

  ○ Land Cover Map

  ○ Irrigated Areas Map

  ○ Irrigation Methods Map

  ○ Meteorological forcing (1 km)

- We will define irrigation scenarios and run the SASER modelling chain with them.

- We will analyze the impact of default and alternative irrigation scenarios on streamflow, evapotranspiration, and drainage.

**Thank you!**
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