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GROUNDWATER RECHARGE INDICATORS AT THE EUROPEAN SCALE

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HS2.5.1 – Large scale hydrology

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PRESENT and FUTURE potential GROUNDWATER RECHARGE at EUROPEAN scale

Overview

- 1- SPATIALIZED EFFECTIVE PRECIPITATION CALCULATION
- 2- EFFECTIVE PRECIPITATION INFILTRATION RATIO
- 3- PRESENT POTENTIAL GROUDWATER RECHARGE
- 4- FUTURE POTENTIAL GROUNDWATER RECHARGE



<http://www.indecis.eu/>

1 - SPATIALIZED EFFECTIVE PRECIPITATION COMPUTATION

Data collection and formatting

0.25° mesh over Europe for E-OBS dataset

EOBS gridded data (v21.0)

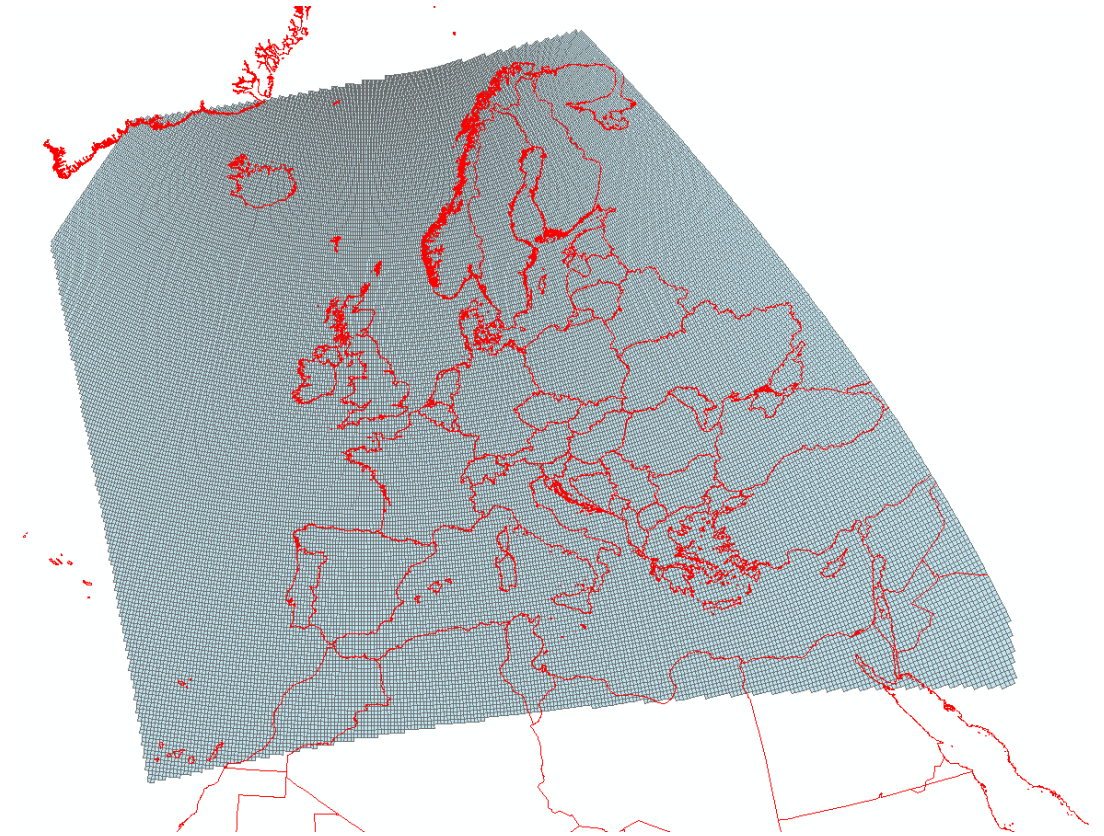
Spatial coverage

E-OBS is an ensemble meteorological dataset available on a regular grid covering a large area over Europe (25N-71.5N x 25W-45E).

Data

We used the v21.0 daily gridded observational dataset, with a 0.25° spatial resolution.

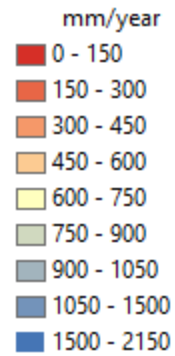
https://surfobs.climate.copernicus.eu/dataaccess/access_eobs.php



Ref: EU-FP6 UERRA and ECA&D projects (<https://www.ecad.eu>). "Cornes, R., G. van der Schrier, E.J.M. van den Besselaar, and P.D. Jones. 2018: An Ensemble Version of the E-OBS Temperature and Precipitation Datasets, J. Geophys. Res. Atmos., **123**. [doi:10.1029/2017JD028200](https://doi.org/10.1029/2017JD028200)

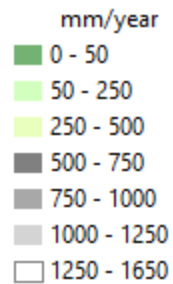
Data collection and formatting

Rainfall

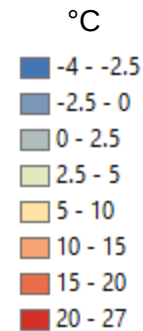


1981 – 2010
Inter-annual mean

Snowfall



Temperature



1 - SPATIALIZED EFFECTIVE PRECIPITATION COMPUTATION

Data collection and formatting

1981 – 2010
Inter-annual mean

Potential Evapotranspiration (PET)

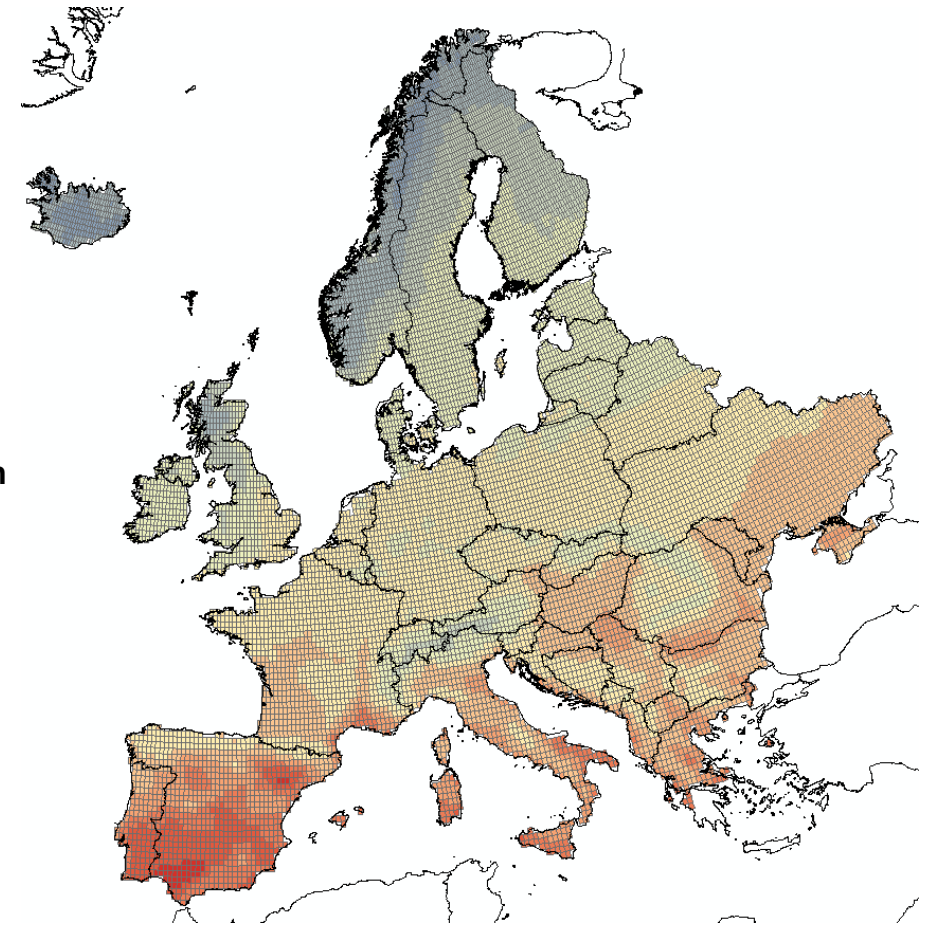
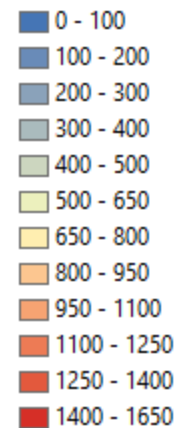
Daily ETo (reference evapotranspiration) is calculated with the FAO Penman-Monteith formula using atmospheric temperature, humidity, net radiation and wind speed data.

<http://www.fao.org/3/x0490e/x0490e06.htm>

ERA5 reanalysis dataset had to be used to complement the E-OBS observational dataset which does not provide all the necessary data.

ETo Penman-Monteith

mm/year



1 - SPATIALIZED EFFECTIVE PRECIPITATION COMPUTATION

Data collection and formatting

Land Use impact on evapotranspiration

$$PET = Kc. * ETo$$

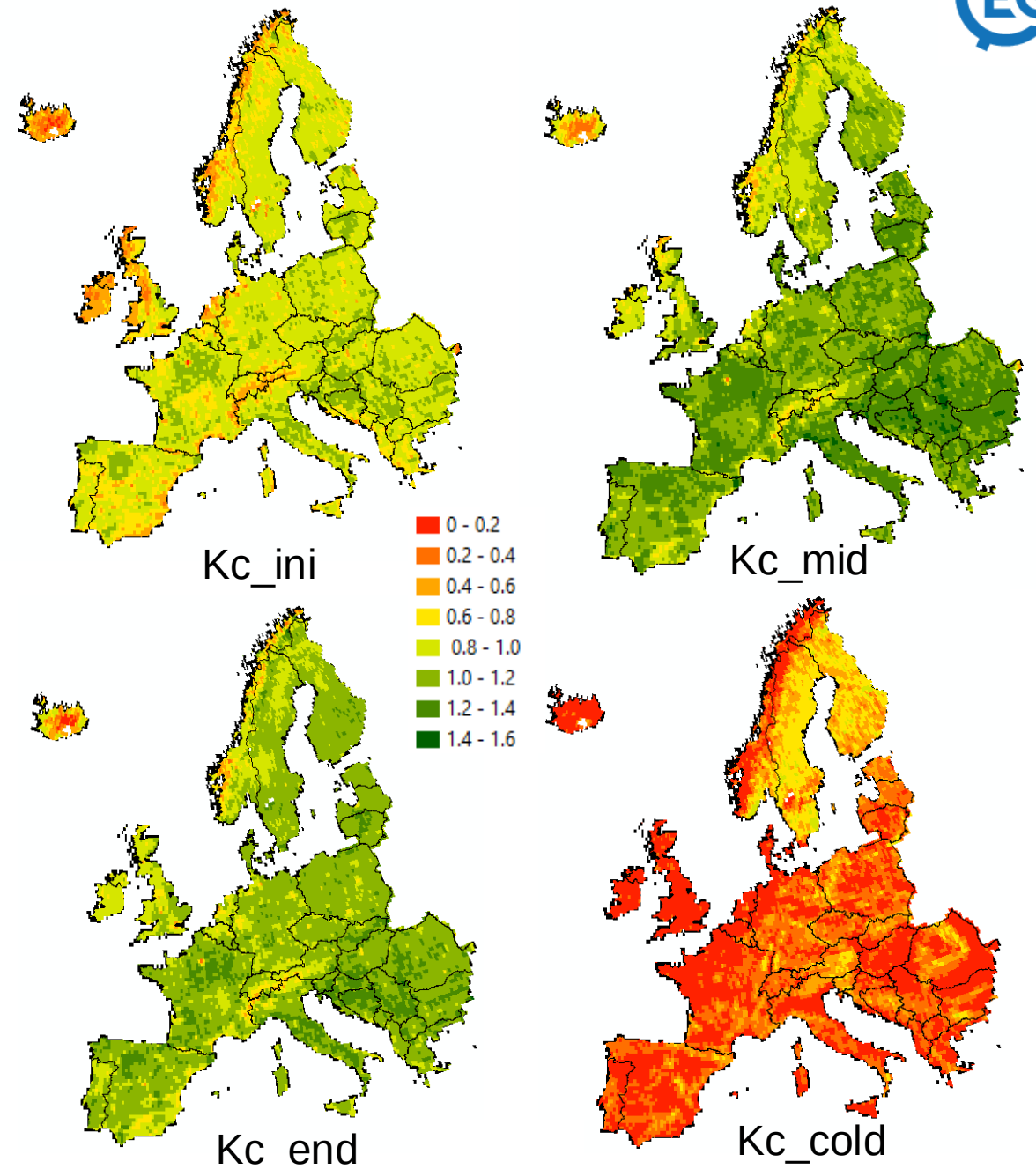
Seasonal crop coefficient maps

Corine Land Cover 2018 + FAO crop coefficient tables association

Projection on 0.25° mesh, mean value on each cell for each seasonal Kc

- Kc_ini for initial season (March, April and May)
- Kc_mid for mid-season (June, July and August)
- Kc_end for the end of crop season (September and October)
- Kc_cold when no vegetation growth (November, December, January and February)

Ref: Nistor et al. (2018) – Land Cover and Temperature Implications for the Seasonal Evapotranspiration in Europe. *Geographia Technica*, Vol 13, Issue no. 1/2018, pp. 85-108 - [DOI: 10.21163/GT_2018.131.09](https://doi.org/10.21163/GT_2018.131.09)



Data collection and formatting

Soil Water Storage capacity (SWS)

Available data

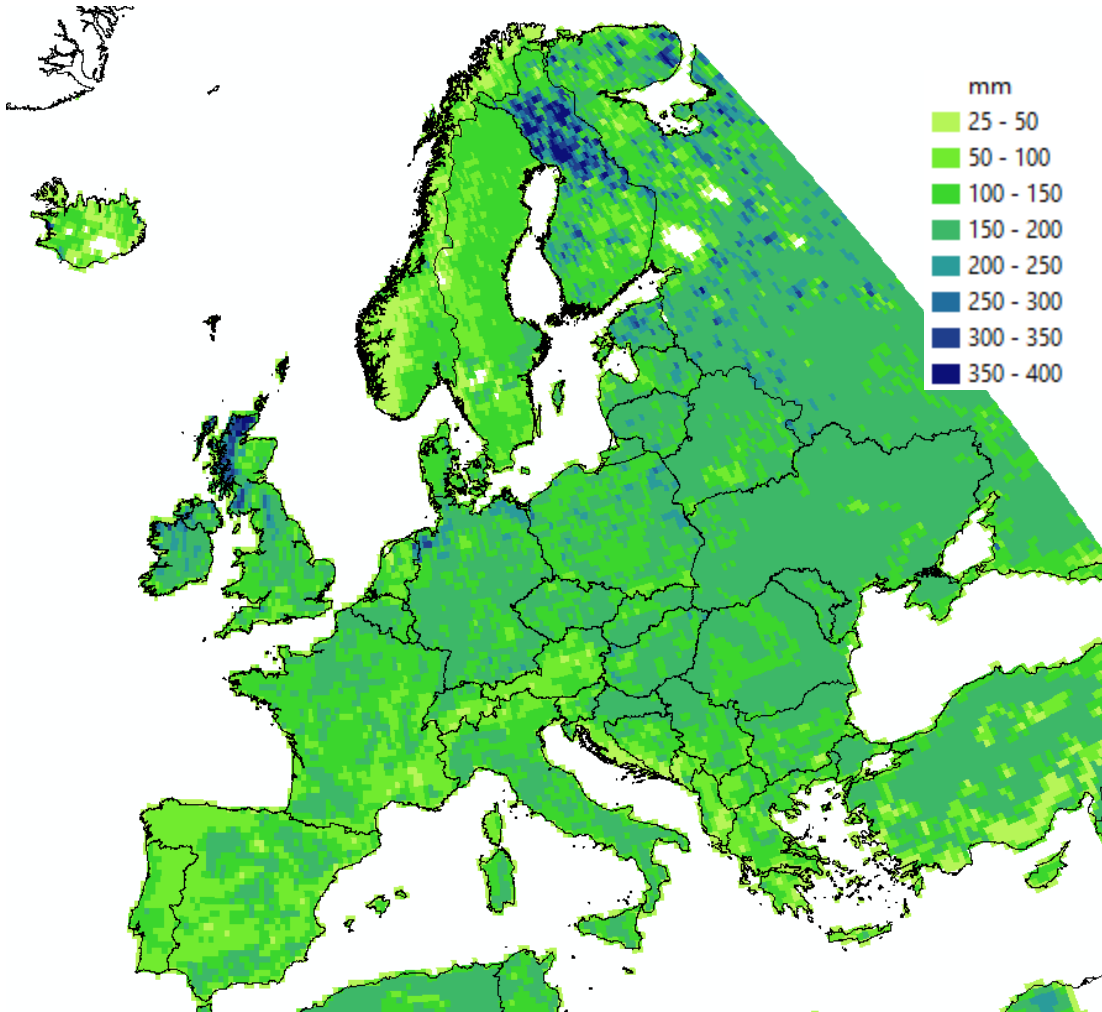
ESDAC (European Soil Data Centre).

<https://esdac.jrc.ec.europa.eu/content/european-soil-database-derived-data>

Pedo-Transfer Rules used to estimate Total Available Water Capacity (TAWC) – Ballabio et al. (2016)

Soil capacity estimation

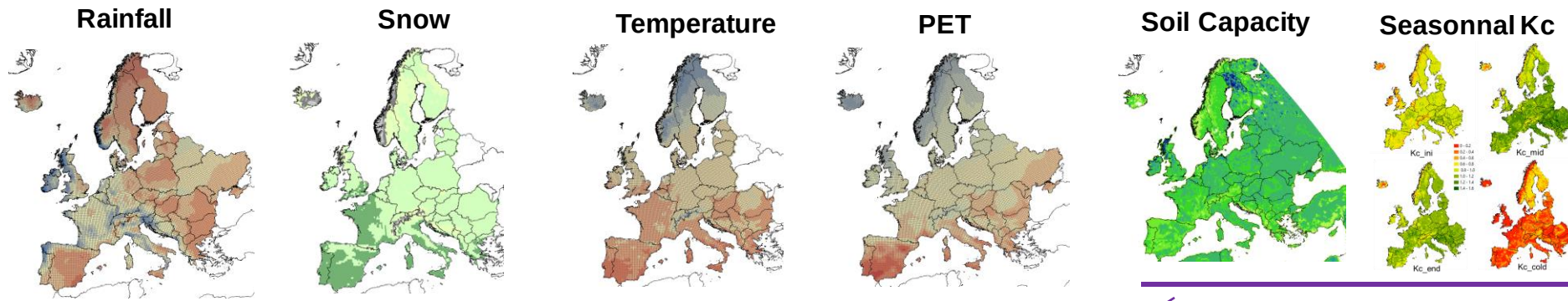
Sum of Topsoil+Subsoil TAWC projected on the EOBS mesh (0.25°)



European Soil Water Storage capacity map

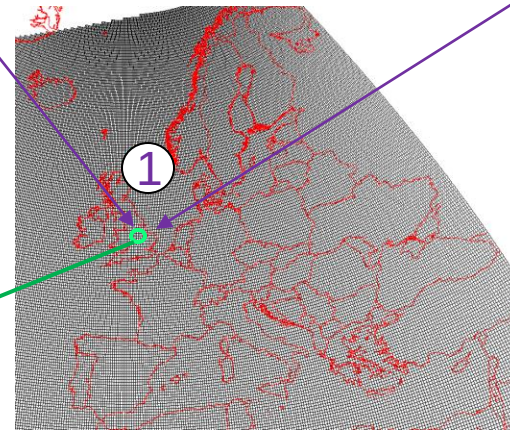
1 - SPATIALIZED EFFECTIVE PRECIPITATION CALCULATION

Methodology



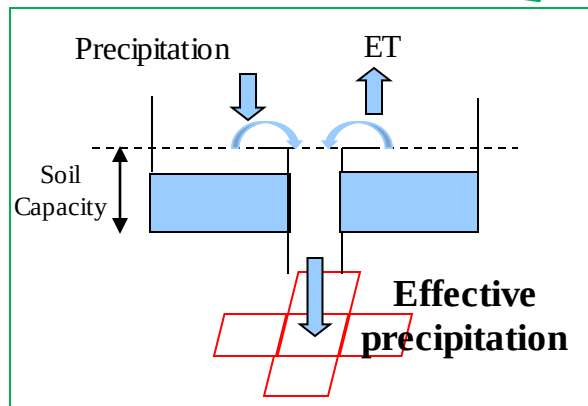
Illustrative maps: interannual means 1981 - 2010

Time-series (daily data) for each cell of the 0.25° mesh



Soil water balance

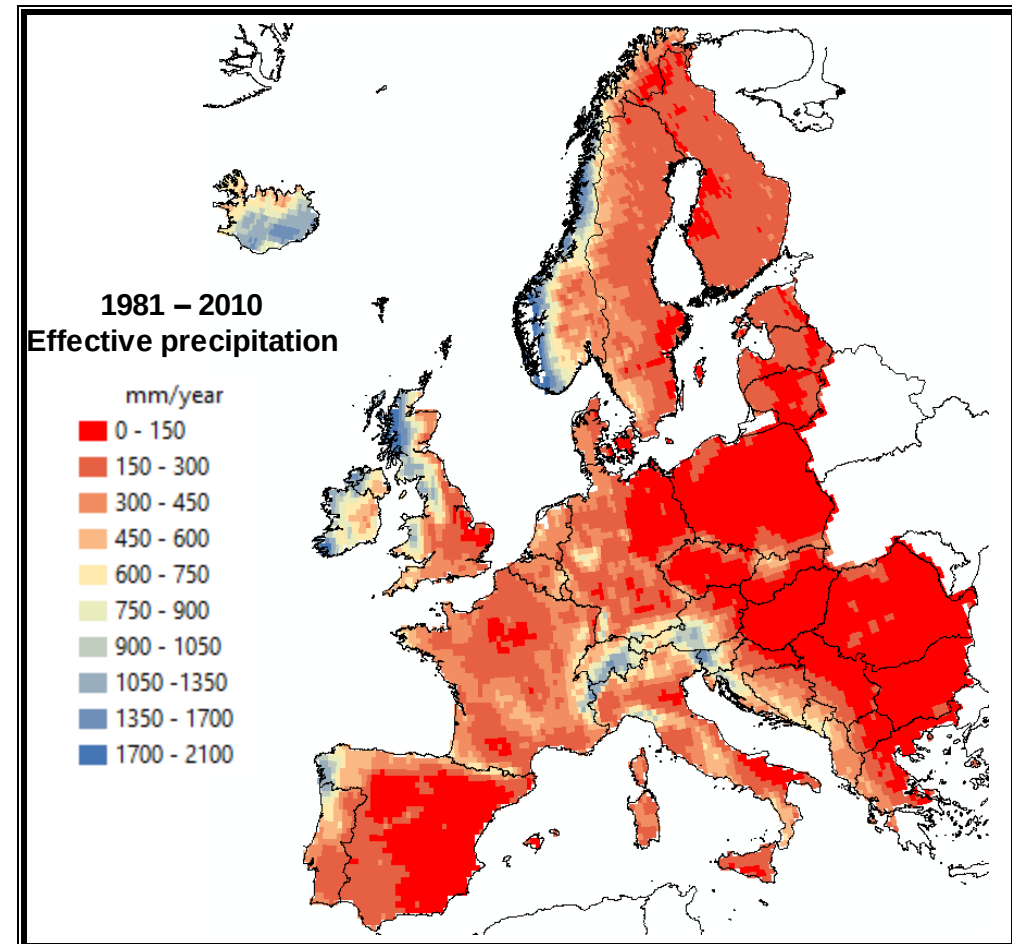
- ② daily time step, 3 methods (Thornthwaite, Dingman and Edijatno&Michel)



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③

Interannual mean for each cell, then 3 method members averaging



2 - EFFECTIVE PRECIPITATION INFILTRATION RATIO (EPIR)

Infiltration indexes

IDPR - Network Development and Persistence Index

- Cartographic index which gives qualitative information about spatial distribution of infiltration and runoff
- Available all over Europe with a 50 m resolution

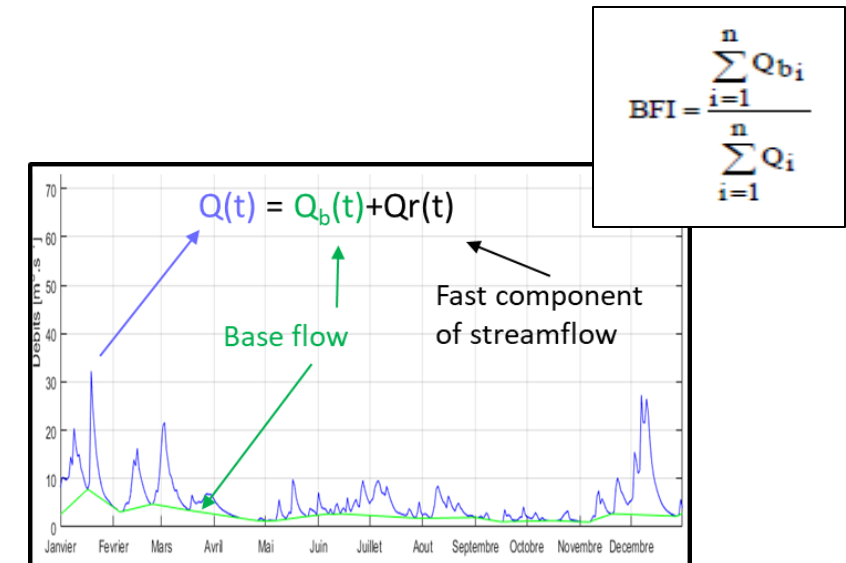
BFI – Base Flow Index

- Annual BFI is a good proxy of EPIR (assuming there is no storage, no inter-catchment fluxes, no anthropogenic impact on streamflow).
- Many filter procedures available, we used the Wallingford method.
- BFI can only be calculated for gauged watersheds

Ref:

Mardhel V., Pinson S. and Allier D. (2021) Description of an indirect method (IDPR) to determine spatial distribution of infiltration and runoff and its hydrogeological applications to the French territory. Journal of Hydrology, Vol. 592. doi.org/10.1016/j.jhydrol.2020.125609

Gustard A., A. Bullock and J. M. Dixon (1992), Low flow estimation in the United Kingdom, Report n°108, Institute of Hydrology, ISBN 0948540451

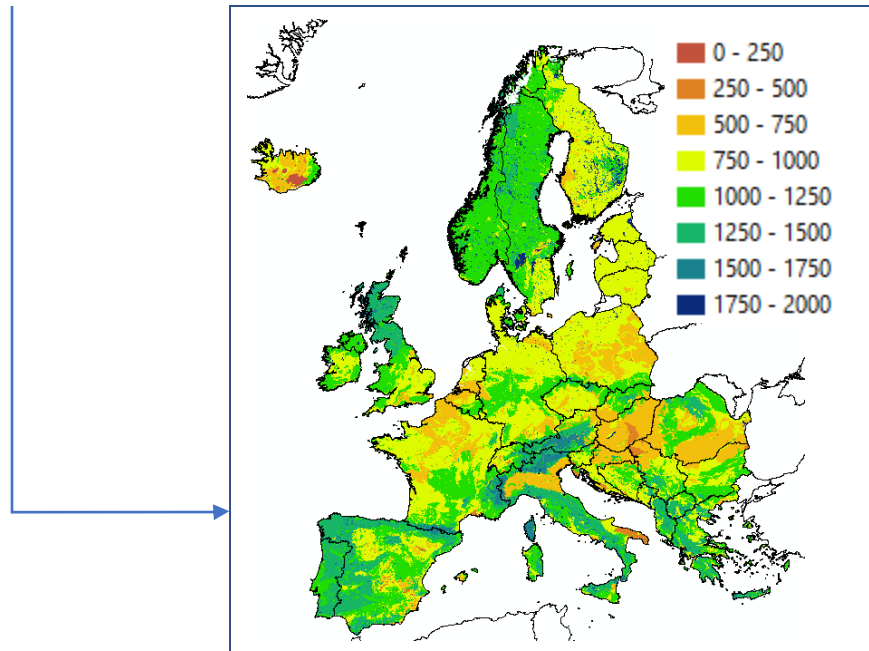


2 - EFFECTIVE PRECIPITATION INFILTRATION RATIO (EPIR)

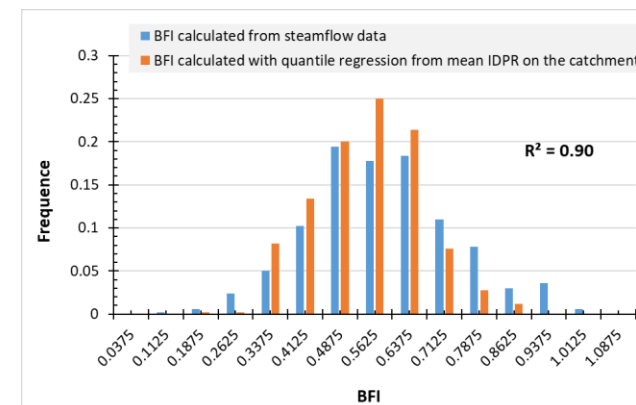
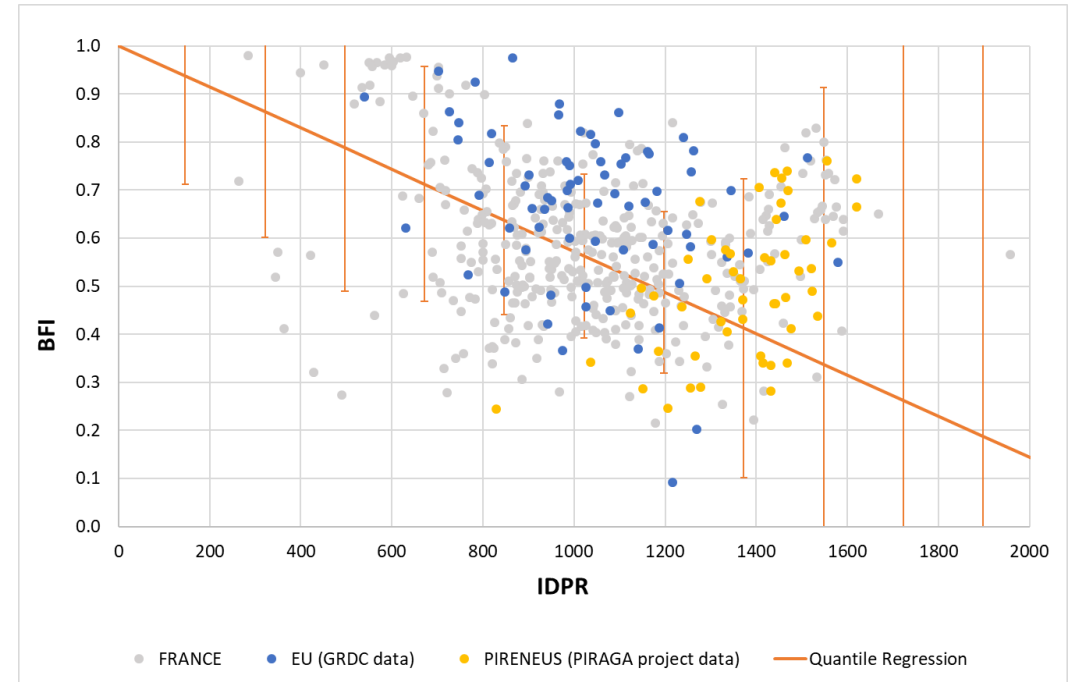
EPIR European map

EPIR evaluation

- Database: 500 gauged watersheds distributed over France and Europe, and representing various geological and climatic contexts
 - mean annual BFI calculated on the 1981-2010 period from daily streamflow data
 - spatial average of IDPR over the watershed area



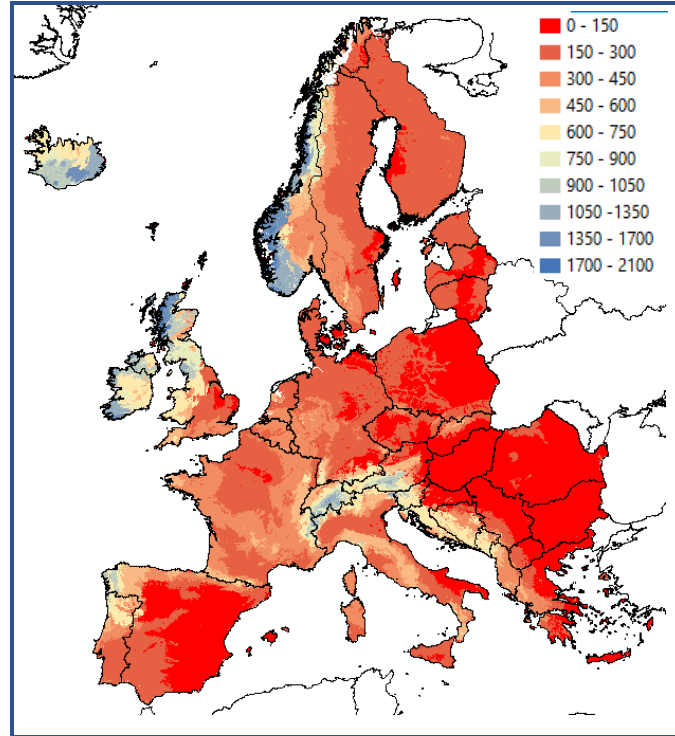
- Quantile regression applied between the two set of data => formula to calculate EPIR at the hydrogeological unit scale from IDPR map.



3 - PRESENT POTENTIAL GROUDWATER RECHARGE

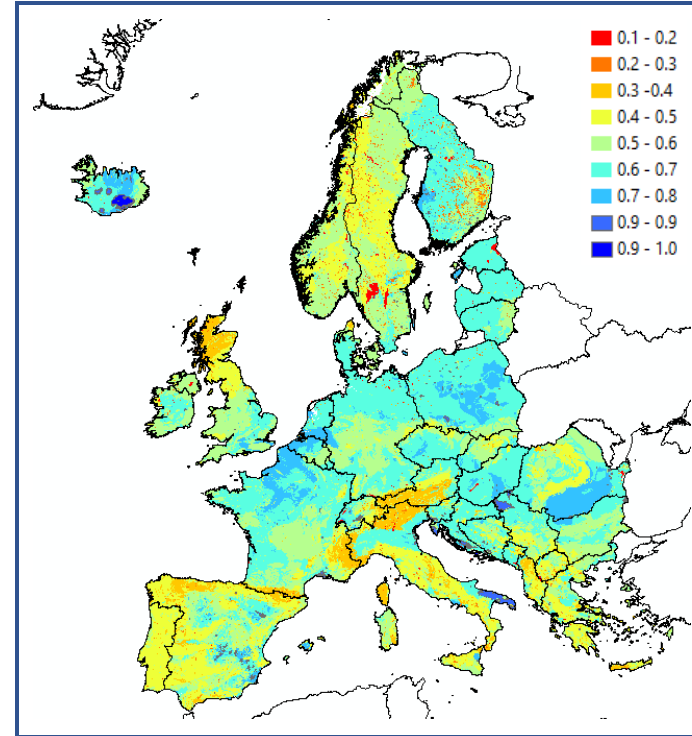
European map of present potential recharge

Methodology applied at the scale of hydrogeological units



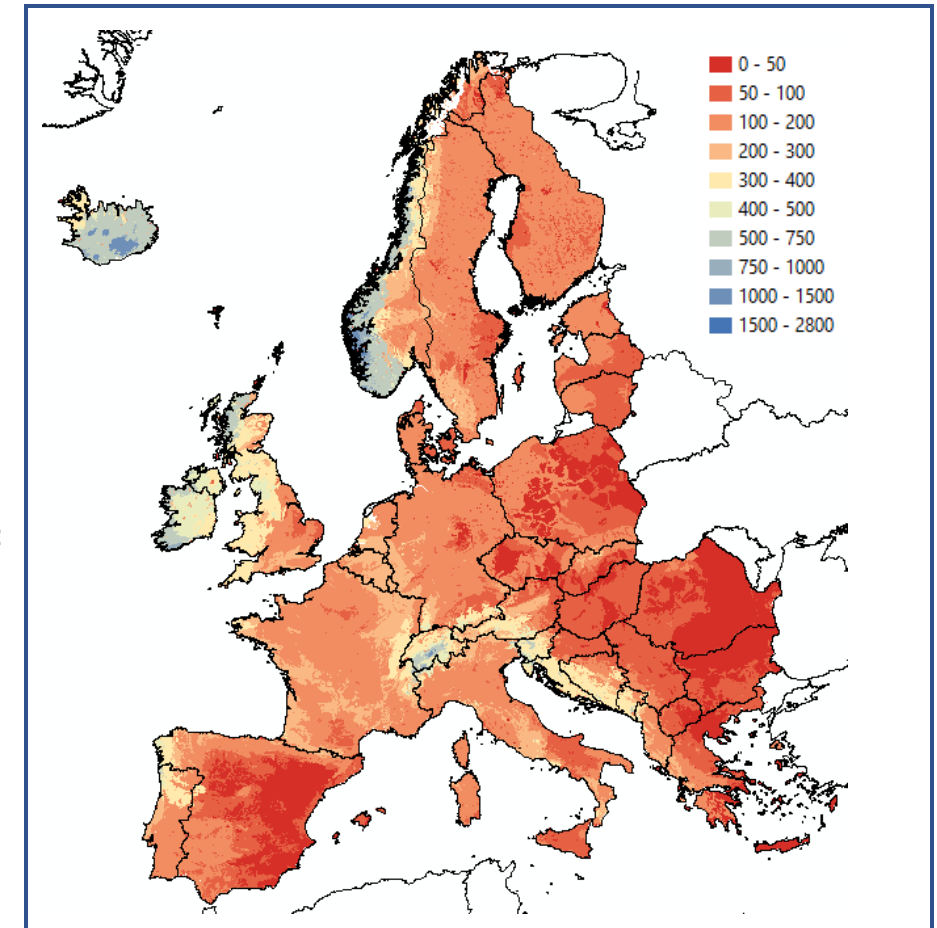
Effective precipitation (mm/y)
1981-2010

X



Effective Precipitation Infiltration Ratio

=



Potential Recharge (mm/y)
1981-2010

4 - FUTURE POTENTIAL GROUNDWATER RECHARGE

Methodology

Ensemble simulations

Data

Euro-Cordex database (<https://euro-cordex.net>)

Two scenarios: RCP8.5 and RCP4.5

16 climatic projection datasets combining different GCM and 5 RCM (RCA4, RACMO22E, CLMcom-CCLM4-8-17, CLMcom-CCLM5-0-6, REMO2009)

Future effective precipitation calculation

Climatic data projected on the 0.25° mesh, and debiased compared to E-OBS data on the historical period

PET calculated with Penman-Montheith formula

Daily effective precipitation calculated over 1979 - 2100

Effective precipitation anomalies

Differences between future inter-annual mean and inter-annual mean for the reference period 1981-2010

Assuming EPIR will not vary with time, recharge anomalies are equal to effective precipitation anomalies.

4 - FUTURE POTENTIAL GROUDWATER RECHARGE

Methodology

First results

Data

RCP8.5

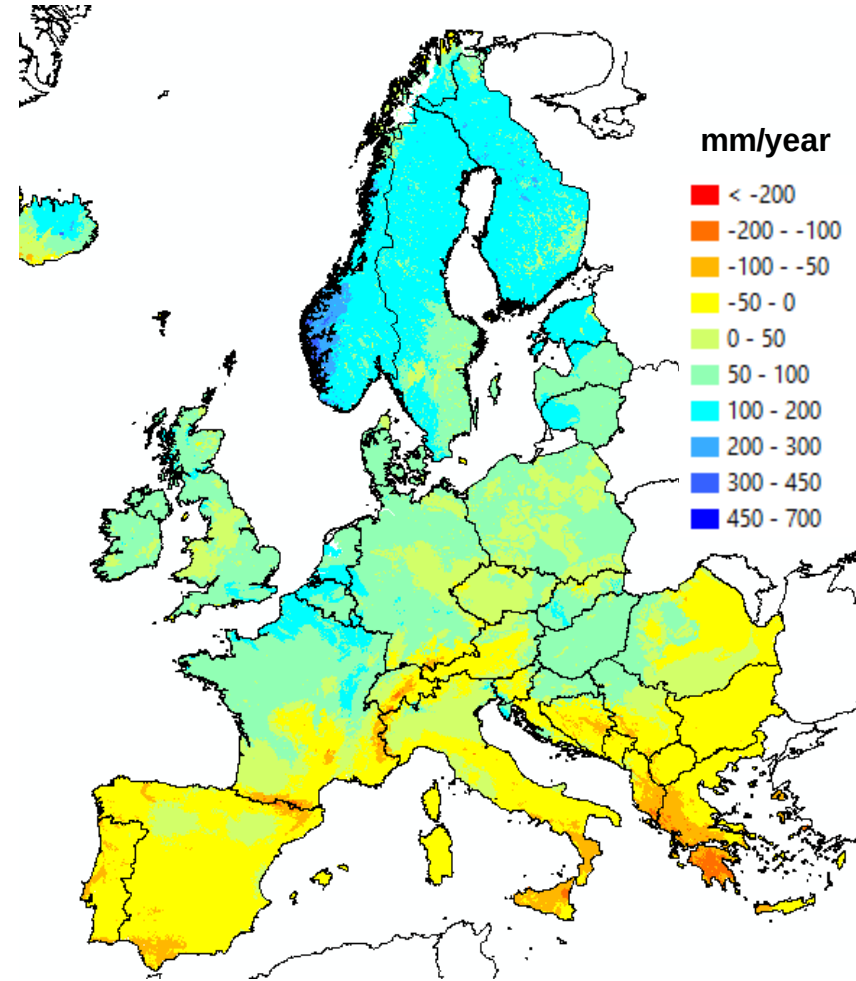
GCM: IPSL_CMA5_MR_H



RCM: SMHI-RCA4



Ensemble simulation, statistical results,
incertitude evaluation : work in progress !



Long term (2080-2099) groundwater recharge minus
reference recharge (1980-2009)