



Climate Change

COPERNICUS CLIMATE CHANGE SERVICE

Understanding Future Soil Erosion: A New Tool

C3S Demo Case "SOIL EROSION"

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Climate Europe Webstival
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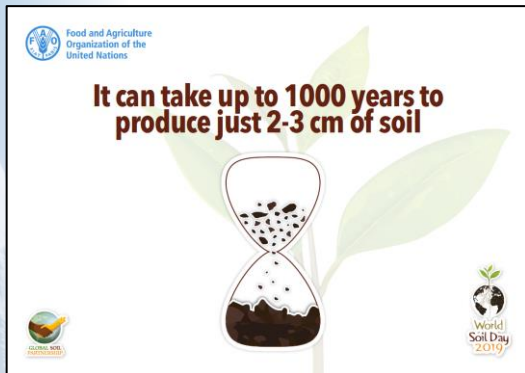
Soil Erosion: a cross-sectoral issue



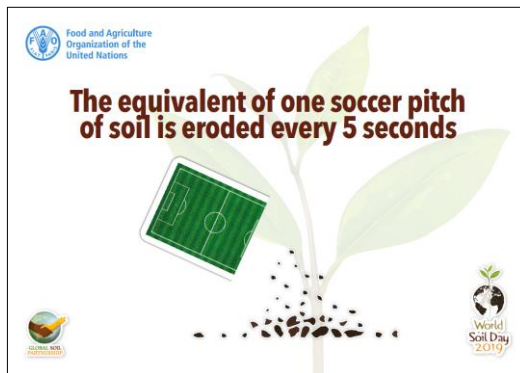


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Soil Erosion: 1st threat to Planet's soils

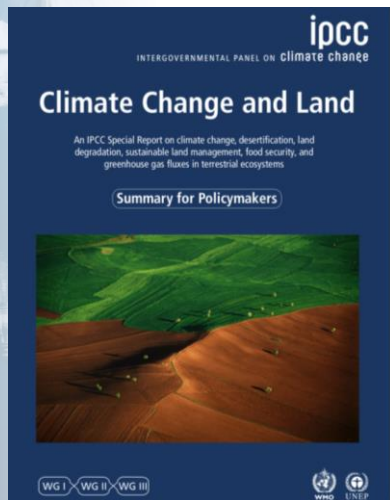


SOURCES: Status of the World's Soil Resources - Main Report (FAO, 2015)
Global Symposium on Soil Erosion (FAO, 2019)



75-80% eroded by water

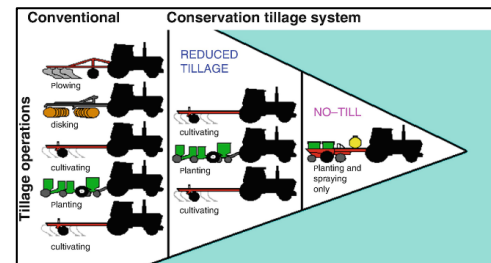
10% loss of total production potential by 2050



Soil erosion: from x10-20 (no tillage) to more than x100 (conventional tillage) higher than the soil formation rate.

Erosion control could benefit globally from 1.50 Mkm² (cultivated lands) to 11 Mkm² (desertified lands) globally.

Climate Services can support decisions for erosion reduction practices



European
Commission





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Climate Change & Land: SOIL EROSION

Habitat creation and maintenance	Pollination and dispersal of seeds and other propagules	Regulation of air quality	Regulation of climate	Regulation of ocean acidification	Regulation of freshwater quantity, flow and timing	Regulation of freshwater and coastal water quality	Formation, protection and decontamination of soils and sediments	Regulation of hazards and extreme events	Regulation of organisms detrimental to humankind	Energy	Food and feed	Materials and assistance	Medicinal, biochemical and genetic resources	Learning and inspiration	Physical and psychological experiences	Experiences	Supporting identities

Adapted from Table 6.70 SRCLL (IPCC, 2019)

Soil and Ecosystem Services



	Large positive impacts, strong evidence
	Medium positive impacts, some evidence
	Small positive impacts or low evidence
	Small negative impacts or low evidence
	Medium negative impacts, some evidence
	Large negative impacts, high evidence

1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY	6 CLEAN WATER AND SANITATION	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	14 LIFE BELOW WATER	15 LIFE ON LAND	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	17 PARTNERSHIPS FOR THE GOALS

**SUSTAINABLE
DEVELOPMENT
GOALS**

Adapted from Table 6.73 SRCLL (IPCC, 2019)



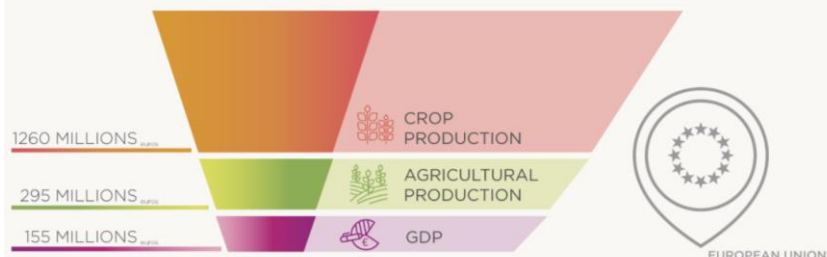


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C3S Demo Case "SOIL EROSION"

EU - COSTS OF SOIL LOSS DAMAGES DUE TO WATER

SOURCE: PANAGOS ET AL. (2018)



EU/ITALY ESTIMATED ANNUAL PRODUCTIVITY LOSS

DIRECT COST EVALUATION (YEAR 2010)



SOURCE: PANAGOS ET AL. (2018)



C3S APPLICATION DEMO CASE 429D SOIL EROSION



Quantifying the potential soil losses due to rainwater erosion over Italy, for current and future periods.

Supporting decision making processes for land management.

HANDLING SOIL EROSION THROUGH C3S TOOLS

SOIL EROSION, implemented by the CMCC Foundation, is a Copernicus Climate Change Service (C3S) Demo Case, for the assessment of soil loss by water erosion over Italy. The Application is based on the products and tools provided by the C3S and associated with Climate Data Store (CDS) infrastructure. The C3S is part of the Copernicus Earth Observation programme and is implemented by the ECMWF on behalf of the European Commission.

THE WEB APP

To estimate the rainfall-induced soil erosion, the Application adopts the Revised Universal Soil Loss Equation (RUSLE), an empirical model combining the Soil Susceptibility to erosion and the Rainfall Erosivity.

SOIL SUSCEPTIBILITY to erosion is assumed to be influenced by factors almost unchanging at the human time scale, like soil properties and topography, or changing however less rapidly than atmospheric conditions, as land cover and management.

RAINFALL EROSIVITY strongly depends on severity and frequency of extreme precipitation events. The assessment of this factor, to quantify current vs future potential loss, requires the last generation of rainfall data available on the Climate Data Store.

Past period

For historical period and most recent decades, rainfall time series are available from observational (E-OBS) and reanalysis (ERAS, ERA5-Land, UERRA) datasets, at (sub) daily time step and with horizontal resolution ranging from 31 km to 5.5 km.

Future

For the future, the simulations' ensemble within EURO-CORDEX (resolution ~12 km, daily time step) are used for robust evaluations, i.e. to consider the uncertainty due to alternative greenhouse gas concentration scenarios and model chain used.

THE END-USERS

The C3S SOIL EROSION Application is designed to meet the needs of different end-users, that will be able to gather and visualize information about soil loss due to water erosion for points/areas of interest accounting also for climate change projections. The Application will provide advanced visualization features, integrating Web GIS technology, showing climatological statistics or trends in the form of GIS layers, and giving information on the likelihood of assessments (e.g. classified soil loss - absolute values or anomalies) as results of the ensemble of climate projections.

The transparent formulation and the practicality of RUSLE will create a potential for tool visibility and transferability well beyond the test case of Italy.

PROJECT PARTNERS AND CONTACT INFORMATION

The Demo Case contract duration is from July 2019 to June 2020.

Lead: Fondazione Centro euro-Mediterraneo sui Cambiamenti Climatici (CMCC).

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<https://climate.copernicus.eu/soil-erosion>



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Susceptibility: soil properties & topography

RUSLE Revised Universal Soil Loss Equation

Wischmeier & Smith (1978) and Renard et al. (1997)

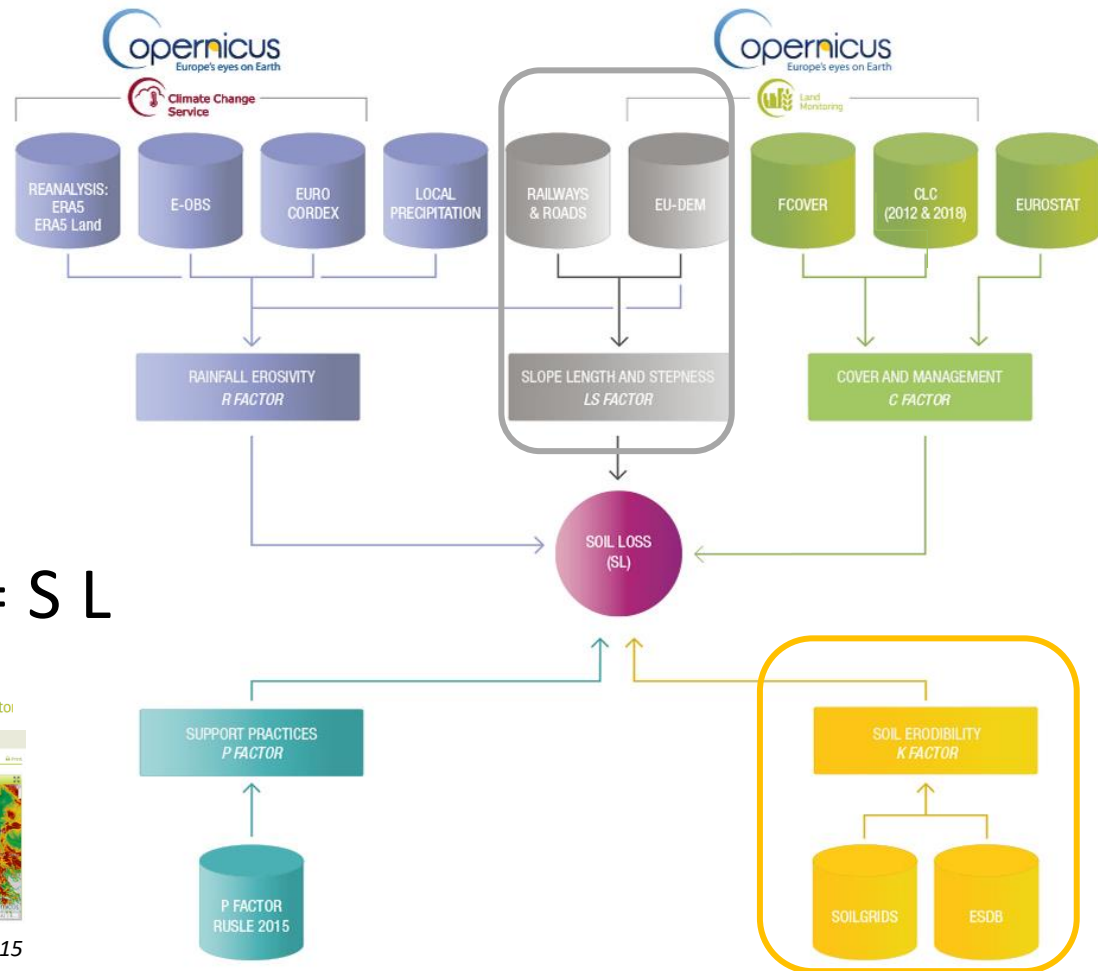
Unchanging

$$(K * L * S * C * P) * R = SL$$

Erodibility Topography



Panagos et al. (2015) – RUSLE 2015





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Susceptibility: land cover & soil management

RUSLE Revised Universal Soil Loss Equation

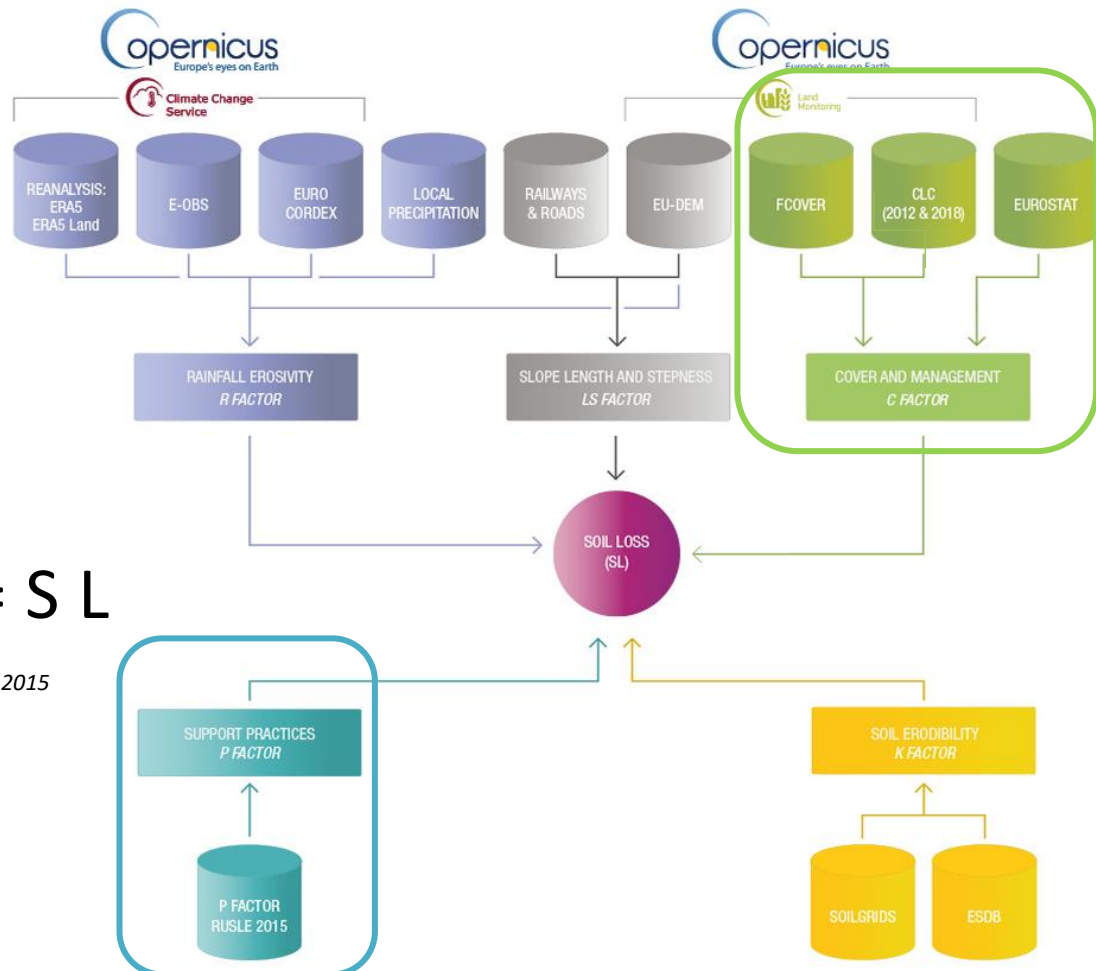
Wischmeier & Smith (1978) and Renard et al. (1997)

Changing «slowly»

$$(K * L S * \boxed{C} * \boxed{P}) * R = S L$$

Cover Support Practices

Panagos et al. (2015) – RUSLE 2015





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Rainfall Erosivity

RUSLE Revised Universal Soil Loss Equation

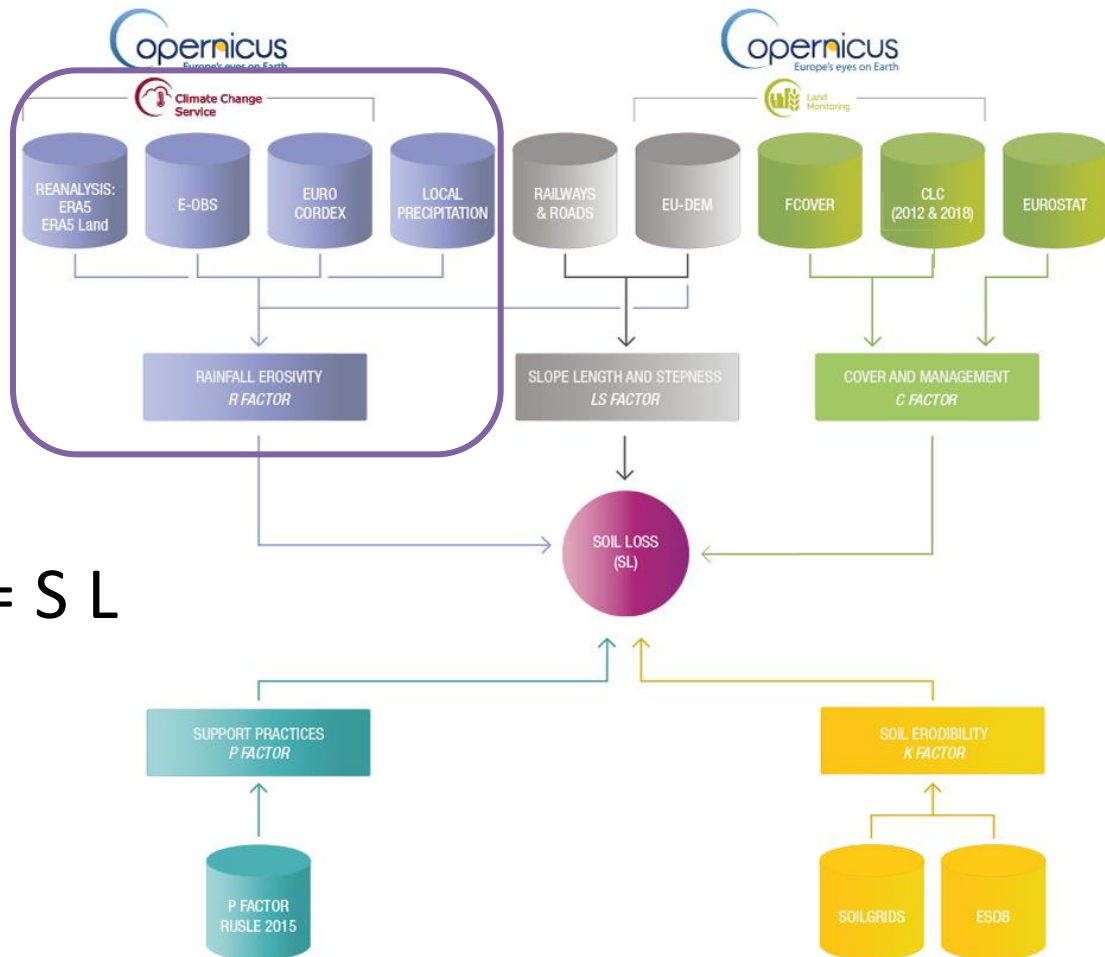
Wischmeier & Smith (1978) and Renard et al. (1997)

Unchanging Changing «slowly»

$$(K * L S * C * P) * \boxed{R} = S L$$

Soil Susceptibility factors

Rainfall
erosivity





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Empirical approaches for R factor

$$R = \frac{1}{N} \sum_{i=1}^N \sum_{k=1}^{S_i} (E \cdot I_{30})_k$$

(MJ mm)/(ha h yr)

Number of storm events in the year «i»

Number of storm events in the year «i»

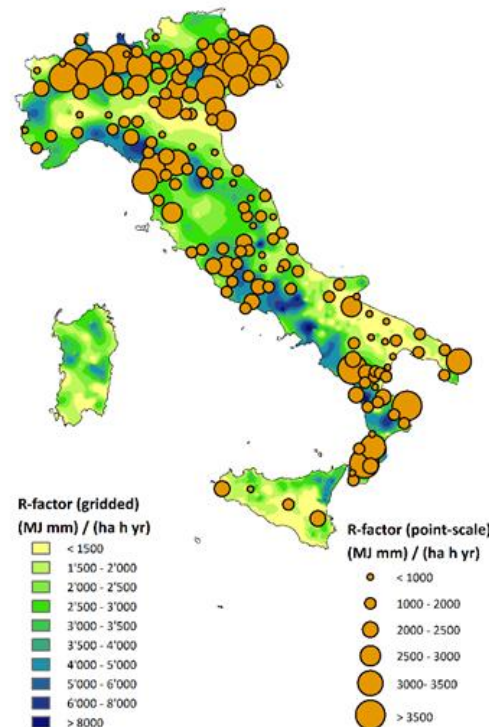
Erosive storm event «k»

Maximum 30min intensity

Erosive energy

Rainfall erosivity of storm event «k»

sub-hourly data vs. empirical models



Thanks to JRC-REDES team!



Wischmeier & Smith (1978) and Renard et al. (1997)



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Climate Data Store (input data)

The screenshot shows the CDS homepage with a navigation bar (Home, Search, Datasets, Applications, Toolbox, FAQ, Live) and a 'Login/register' button. The main content area welcomes users and provides a search bar. Below the search bar are three featured links: 'Climate Data Store Toolbox', 'Climate Data Store API', and 'Access the CDS Forum'. The background of the website features a stylized image of a globe.



E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations

E-OBS is a daily gridded land-only observational dataset over Europe. The blended time series from the station network of the European Climate Assessment & Dataset (ECA&D) project form the basis for t...



ERA5-Land monthly averaged data from 1981 to present

ERA5-Land is a reanalysis dataset providing a consistent view of the evolution of land variables over several decades at an enhanced resolution compared to ERA5. ERA5-Land has been produced by replay...



ERA5 monthly averaged data on single levels from 1979 to present

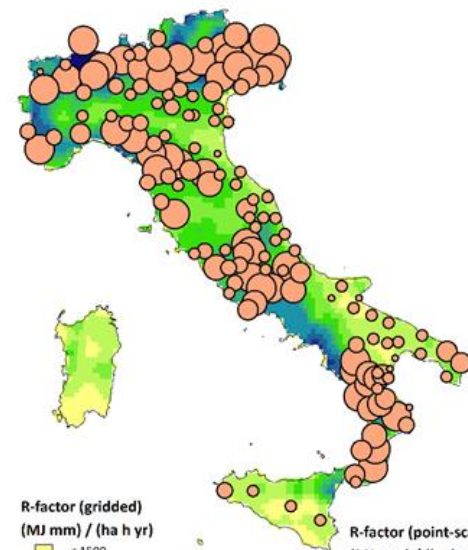
ERA5 is the fifth generation ECMWF reanalysis for the global climate and weather for the past 4 to 7 decades. Currently data is available from 1979. When complete, ERA5 will contain a detailed record ...



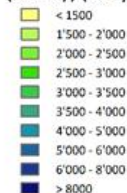
CORDEX regional climate model data on single levels for Europe

This catalogue entry provides daily and monthly Regional Climate Model (RCM) data on single levels from a number of experiments, models, members and time periods computed over Europe and in the framew...

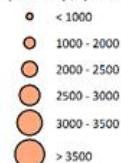
ERA5Land annual rainfall vs. annual observations



R-factor (gridded)
(MJ mm) / (ha h yr)



R-factor (point-scale)
(MJ mm) / (ha h yr)





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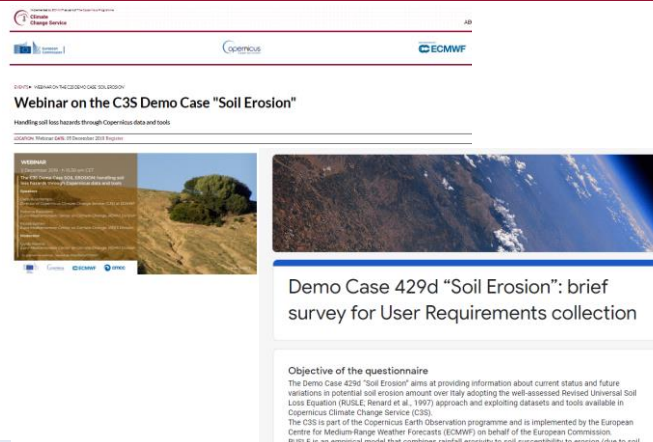
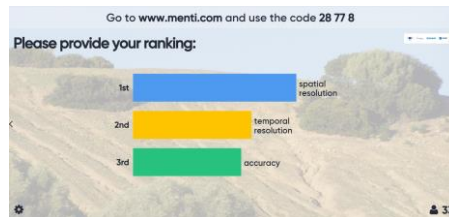
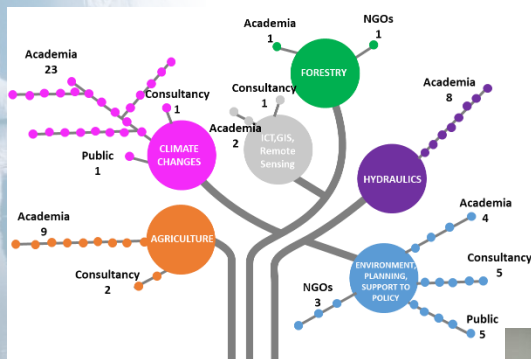
User Requirements

Main identified Users:

- Farmers and agri-food chain's players
- Actors of ecosystem/forest management
- Trainers/researchers incl. at the policy interface

Involved and feedback collected through:

- Side-exchanges during common project meetings/events
- Web surveys and 1-to-1 questionnaire/interview



Main outcomes:

- Periods of investigation:
 - historical (1981-2010)
 - near future (2021-2050)
 - far future (2051-2080)
- Multiple RCPs (2.6, 4.5, 8.5)
- Additional proxy indicators



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EURO-CORDEX datasets

Climate simulation chain			RCP 2.6		RCP 4.5		RCP 8.5	
GCM	RCM	1981-2010	2021-2050	2051-2080	2021-2050	2051-2080	2021-2050	2051-2080
CNRM-CERFACS-CNRM-CM5	CLMcom-CCLM4-8-17	✓			✓	✓	✓	✓
	KNMI-RACMO22E	✓	✓	✓	✓	✓	✓	✓
	SMHI-RCA4	✓			✓	✓	✓	✓
ICHEC-EC-EARTH	KNMI-RACMO22E	✓			✓	✓	✓	✓
IPSL-IPSL-CM5A-MR	SMHI-RCA4	✓			✓	✓	✓	✓
MOHC-HadGEM2-ES_r1i1p1_	CLMcom-CCLM4-8-17_v1	✓			✓	✓	✓	✓
	KNMI-RACMO22E	✓	✓	✓	✓	✓	✓	✓
	SMHI-RCA4	✓	✓	✓	✓	✓	✓	✓
MPI-M-MPI-ESM-LR	CLMcom-CCLM4-8-17_v1	✓			✓	✓	✓	✓
	MPI-CSC-REMO2009_v1	✓	✓	✓	✓	✓	✓	✓
	SMHI-RCA4	✓	✓	✓	✓	✓	✓	✓
NCC-NorESM1-M	DMI-HIRHAM5_v3	✓			✓	✓	✓	✓

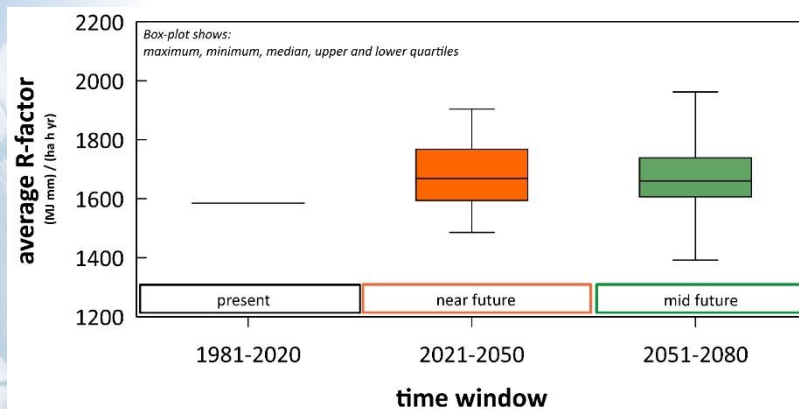
Bias-correction needed!



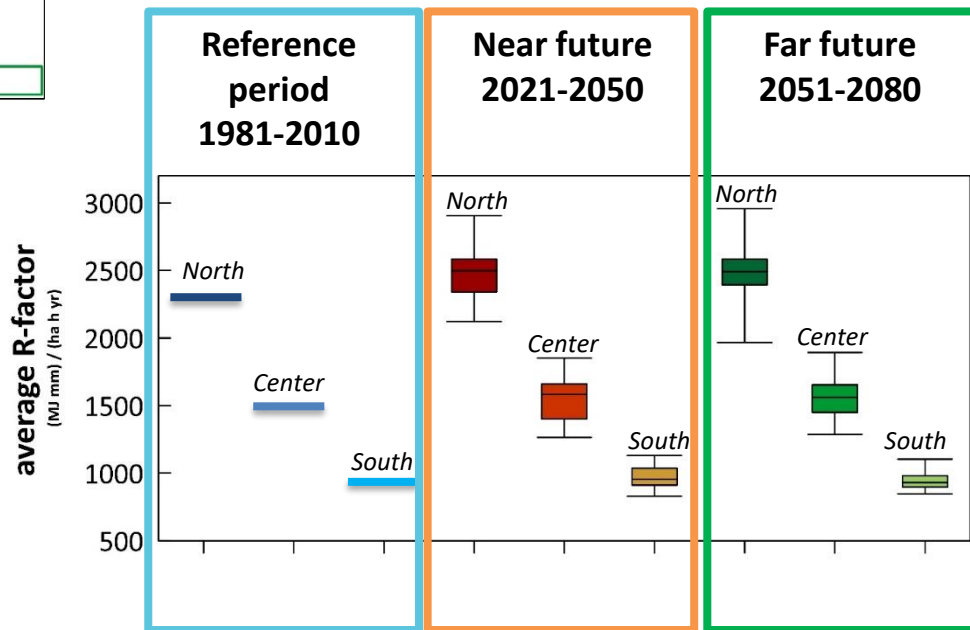
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R factor maps

R factor over Italy



R factor over Italian geographical regions

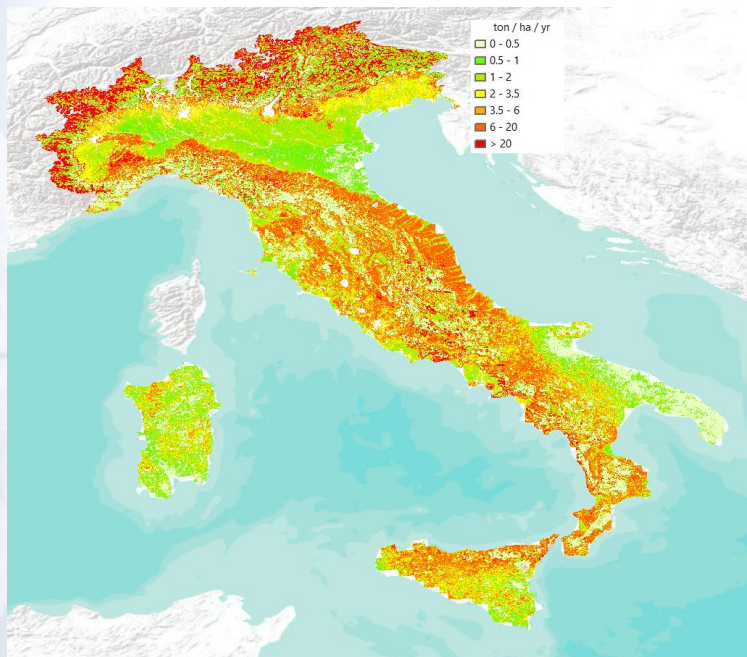




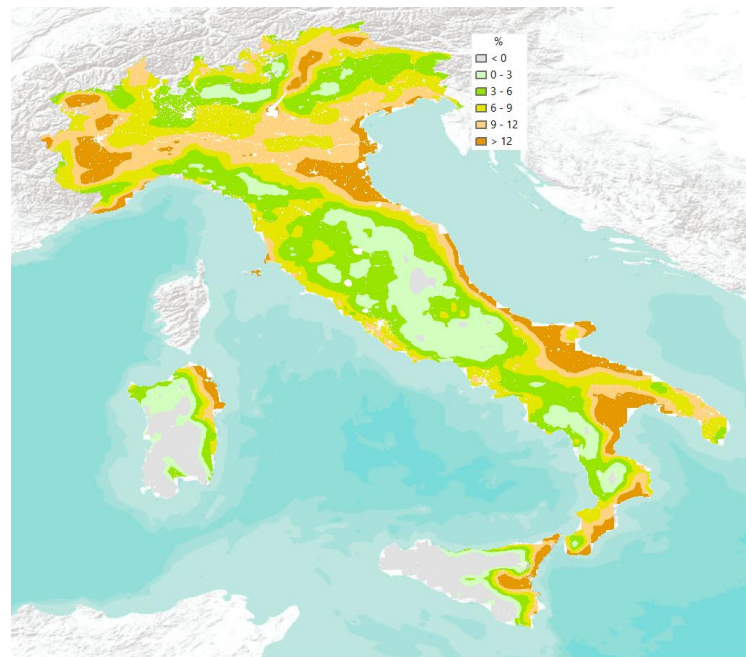
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Soil Loss maps

Soil Loss 1981-2010



**Soil Loss Anomaly 2021-2050 wrt 1981-2010
all RCPs**



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Thanks

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