RIVIERADE Kick-off meeting

Trieste 16-18 Feb 2026

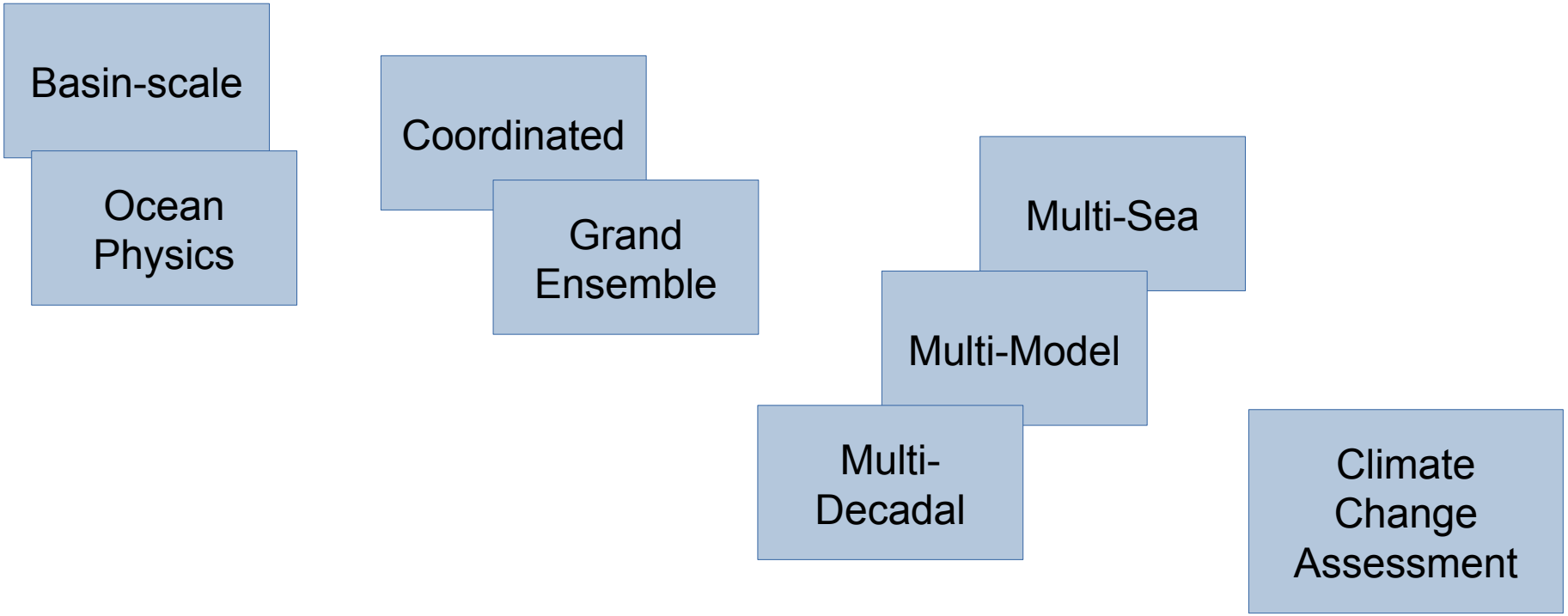
WP4 - Basin-scale Multi-Decadal Climate Projection Grand Ensemble for the European target seas physics

Work Package Leader: Samuel Somot, CNRS-CNRM

Work Package Co-leader: Marilaure Gregoire, ULIEGE

This project has received funding from Horizon Europe RIA under Grant Number 101181983

WP4 keywords



WP4 Objectives:

(1) **Design, produce, evaluate and analyse** a first-of-its-kind coordinated grand ensemble of high-resolution, multi-model, multi-sea and multi-decadal climate simulations (hindcast and projections) for the three target European seas.

(2) **Provide an assessment of the climate change impact** on the target seas physics at the basin spatial scale and at the multi-decadal temporal scale.

(3) **Establish the basis for** the development of the **climate services** at basin to coastal scales in WP2 and WP6.

(4) **Standardise and share** the **simulation outputs** as a **project legacy** for further use in climate services

Please list all partners who will contributing to this WP

WP contributors : 7 partners

- Black Sea :
  METU (Ali Osman Acar, Bettina Fach)
  ULIEGE (Marilaure Gregoire, Postdoc-to-be-hired)
  CMCC (Silvia Gualdi, Marco Chericoni)

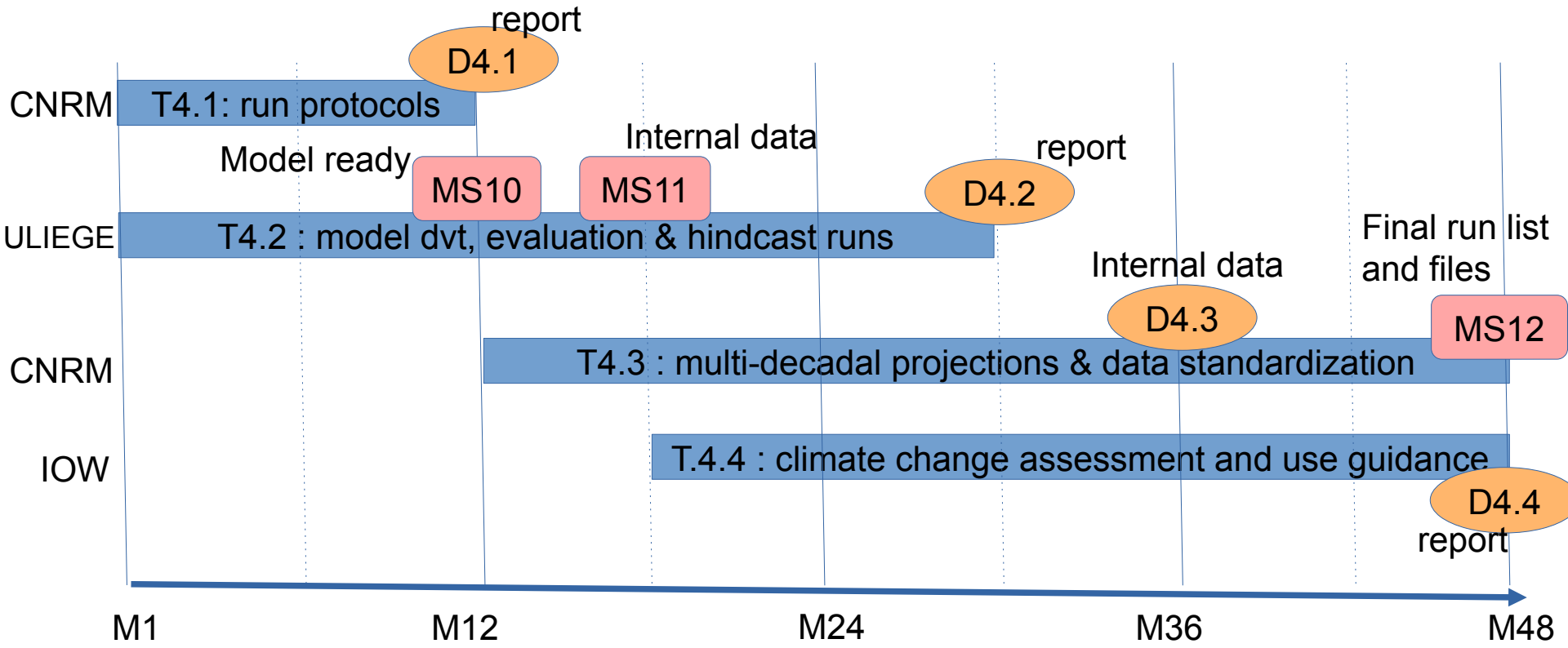
- Baltic Sea :
  IOW (Markus Meier, Sven Karsten, Leonie Barghorn)
  SMHI (Magnus Hieronymus, Nathan XXX, Per YYY, Germo ZZZ)

- Med Sea :
  CMCC (Silvia Gualdi, Marco Chericoni)
  ENEA (Alessandro Anav, Gianmaria Sannino)
  CNRM (Samuel Somot, Florence Sevault, Robin Waldman, Ivan Parras-Berrocal)

WP4 Methods

- Develop simulation protocols (T4.1, lead: CNRM)
- Develop evaluation protocol (T4.2, lead: ULIEGE)
- Develop and evaluate 7 modelling platforms (T4.2, ULIEGE)
(3 for Black Sea, 2 for Baltic Sea, 3 for Med Sea)
- Produce hindcast simulations (T4.2, ULIEGE)
- Produce historical and future projection simulations (T4.3,CNRM)
- Produce ESGF-ready standardized model outputs (T4.3, CNRM)
- Multi-model, multi-sea, climate change assessments for the regional seas, including uncertainty quantification and ensemble use guidance (T4.4, IOW)

WP4 timeline (incl. Deliverables and Milestones)



Deliverables and Milestones

Deliverables

D4.1 – Final protocol documents for the coordinated grand ensemble (CNRS-CNRM, Month 12)

D4.2 – Report on model development and model evaluation (ULIEGE, Month 30)

D4.3 – Delivery of the final simulation ensemble data to the project partners (CNRS-CNRM, Month 36) Delivery of the final simulation ensemble data to the project partners (Task 4.3). This deliverable is indicated as sensitive (SNS in Tab3.1c) because this will guarantee the data sharing among the partner to happen earlier than the official publication on the ESGF archive

D4.4 – Basin-scale climate change assessment based on the grand ensemble (IOW, 48)

Milestones

MS10 - Model configuration ready and start of the WP4 production (ULIEGE, Month 12) : List of the modelling platform configurations with a synthetic description of the validated developments openly published on Zenodo and linked to the project website

MS11 - Initial ensemble of hindcast simulations ready to be used for the other WPs (ULIEGE, Month 18) : Files in the CINECA internal storage

MS12 - Final list of simulations and CMOR-compliant and ESGF-ready files – T4.3 (CNRS-CNRM, Month 48) : List of simulations, available variables and CMORized status published openly on Zenodo and linked to the project website

WP4 Outcomes for project internal use and project legacy

- New standards (documents): simulation protocols, evaluation protocols, simulation quality assessment, regional ocean climate data standards, ensemble use guidance

- Simulations (data): hindcast and projections for ocean physics

- Climate change assessment (documents, figures, indicators)

WP4 Contributions to RIVIERADE SOs

SO1 : Improve ocean regional climate modelling capabilities

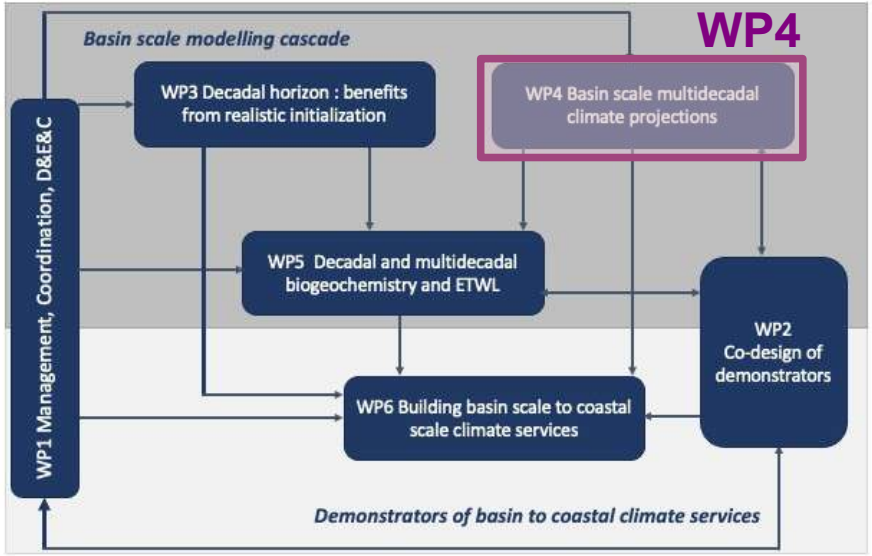
SO2 : Delivering coherent and first-of-its-kind coordinated simulation ensembles, ocean indicators

SO5 : Delivering RIVIERADE digital catalogue as legacy

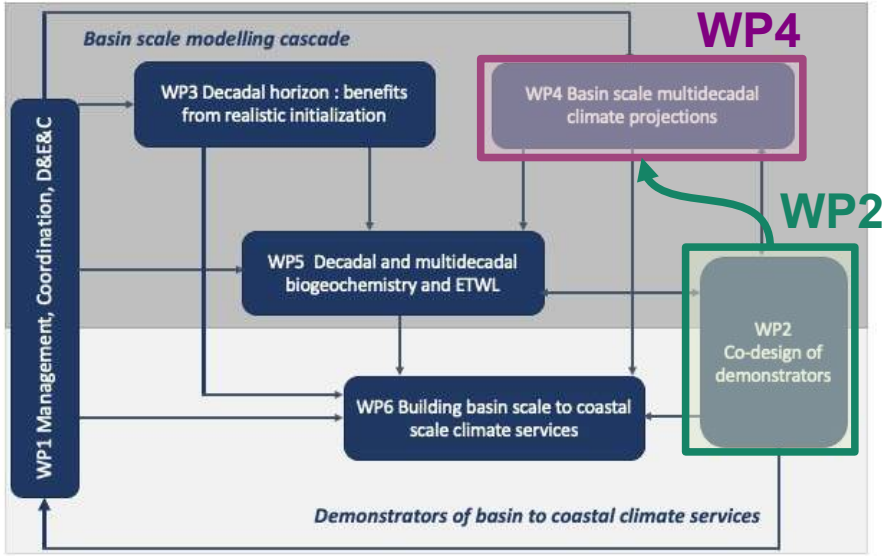
Table 1.1. RIVIERADE specific objectives.

SO#	Specific Objective [means of verification] and WPs
SO1	Improve ocean and regional climate modelling capabilities to produce climate change impact assessment in European seas (BAL, BLK, MED) and their coastal area by: i) sharing, integrating and merging existing capabilities to improve the representation of ocean and marine ecosystem processes and dynamic into climate models, and ii) developing a common framework and protocol for multi-model multi-sea evaluation to assess the representativeness of the model ensemble against available observations and to quantify its uncertainties [number of coupled atmosphere-ocean-biogeochemical modelling systems used in the ensemble; number of coupled model simulation runs; reports on protocols and on model evaluation; and open peer-review publications] (WP3, WP4, WP5)
SO2	Delivering a coherent ocean dataset of a first-of-its-kind coordinated ensemble of high-resolution, multi-model, multi-sea, decadal to multi-decadal climate simulations for quality assessed indicators on ocean status and health at basin scale for the three *target seas*, including uncertainty quantification [reports on protocols, on model development, production of ESGF-ready datasets (raw data)] (WP3, WP4, WP5)
SO3	Delivering coherent ocean data sets of dynamically downscaled very-high-resolution, multi-model, multi-sea, climate simulations for indicators on extreme sea level and coastal risk along all coasts and of relevant physical and biogeochemical indicators at selected *coastal regions* [Adriatic Sea, Swedish Coast, Marmara Sea, Southern Black Sea] at the decadal to multi-decadal temporal scale. [scientific publications; FAIR data and information (key variables and indicators), open documents (e.g. protocols, reports on Zenodo, peer-review publications) and codes (models, codes, tools on GitHub repository)] (WP6)
SO4	Delivery of regional ocean climate impact/risk services and of regional ocean climate services supporting blue economy (aquaculture, fishery, tourism) in 4 *local selected coastal sites* to be chosen and co-designed with end-users and stakeholders board. [use cases documentation, fact sheets] (WP1, WP2, WP5, WP6)
SO5	Delivery of a RIVIERADE catalogue produced in compliance with Open Science recommendation and FAIR principles, including key variables data sets, indicators, documents and codes, to support future studies and further climate services, and in order to favour the integration of project products and results into the digital perspective and the Digital Twin Ocean activities [digital catalogue] (WP2, WP3, WP4, WP5, WP6)

WP4 in the project workflow

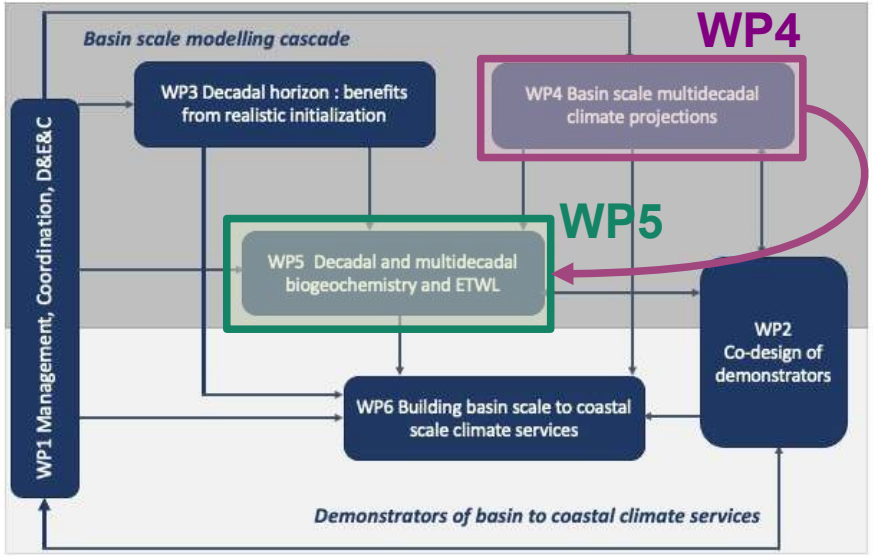


WP4 in the project workflow



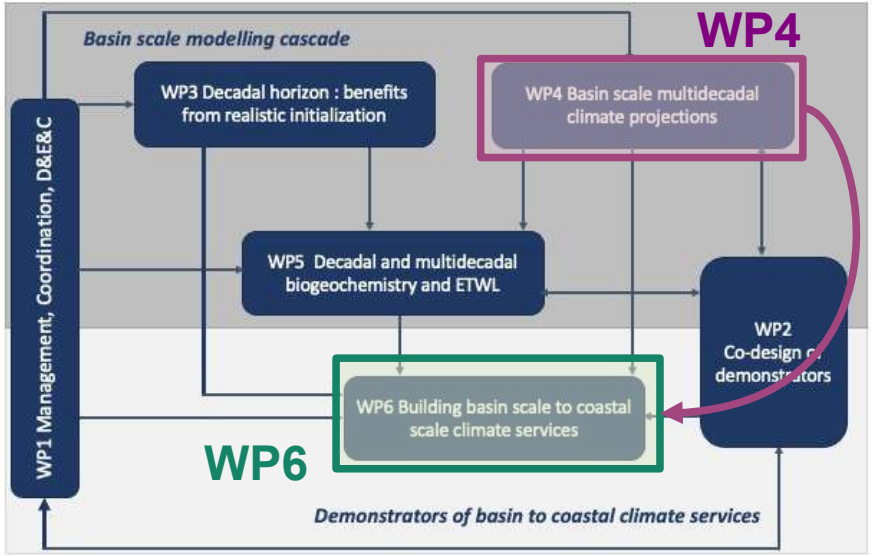
WP2 → WP4: USAB needs (Users and Stakeholders Advisory Board)

WP4 in the project workflow



WP4 → WP5:
Protocol coordination
Ensemble use guidance
Hindcast/Projection data to drive BGC models
Hindcast/Projection data to drive ETWL models

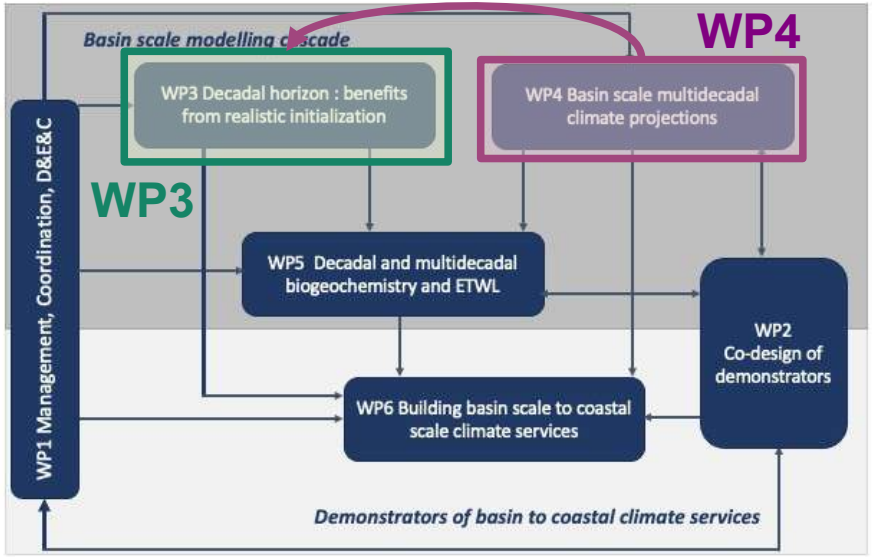
WP4 in the project workflow



WP4 → WP6:
Simulation quality assessment
Ensemble use guidance
Hindcast/Projection Data to compute basin-scale indicators and to set climate services

Hindcast/Projection Data to drive very high resolution models ?

WP4 in the project workflow



WP4 & WP3
Coordination on protocols
Decadal/Multi-Decadal Consistent Climate change assessment

WP4-related KPIs

- KPI1 : Number of improved modelling platform configurations for multi-decadal projections of the basin-scale European seas (cible : 7)

- KPI2 : Total number of multi-decadal scenario simulations for the basin-scale target sea (cible : >25) → min : 3 scenario runs / model

- KPI4 : Number of multi-partner publications assessing the impact of climate change on the physics, biogeochemistry, ETWL and/or coastal risks (>10)

- KPI5 : Number of CMOR-standardised basin-scale model output datasets ready for publication on the ESGF at the end of the project (>30) → 1 HIND, 1 HIST et 2 SSP / model

Risks

- WP4 is central in the modelling chain. Any delay in the WP4 production will delay the whole project
- No quick consensus on the simulation protocols
- Models not ready to start the runs at Month 12
- Running time too long or computer time not available
- Hindcast runs not ready at Month 18
- Scenario runs not ready at Month 36
- Difficulties to make the datasets ESGF-compliant
- Difficulties in accessing the CINECA storage space
- USAB needs arriving too late or impossible to take into account

Work plan for the first year

THIS WEEK:
- T4.1 : start the simulation protocol discussion (CNRM lead)
- T4.2 : start the model developements (ULIEGE lead)
- T4.2 : start the evaluation protocol discussion (ULIEGE lead)

YEAR 1:
- T4.2 : start the hindcast runs (ULIEGE lead)
- T4.3 : start to collect the hist-ssp forcings (CNRM lead)
- Collect the USAB needs and other WP needs

Questions?

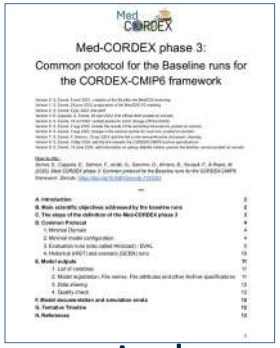
Discussion

T4.1 : Simulation protocol (D4.1@M12)

- experiment design
- list of planned simulations (KPI2: min. 3 scenario runs / model)
- model documentation
- list of output variables (or Data Request)
- archive specifications (file naming, metadata)

Something missing ?
Recall : we will have coupled and ocean stand-alone config
Coordination with the sister projects
Coordination with international initiatives (Med-CORDEX, Baltic Earth, jWG ROCP, ...)

T4.1 : Experiment design


Med-CORDEX phase 3:
Common protocol for the Baseline runs for the CORDEX-CMIP6 framework

- 1 for the 3 seas ?
- 1 for coupled and 1 for ocean-stand alone ?
- Minimum requirements for the model configurations (domains, min. Horiz-vertical resolution, min. components, river forcings, min. coupling/forcing freq., min. period, ...)
- External forcings (air-sea fluxes, ocean LBCs, river, GHG, aerosols, land-use, Chl-a, ...)
- Sea specific aspects (e.g. Nile, Suez canal, Marmara Sea, Danish Straits, sea ice, ...)
- Initial conditions
- Spin-up procedure
- Driving Atmosphere/Ocean Reanalysis/GCM selection
- ...

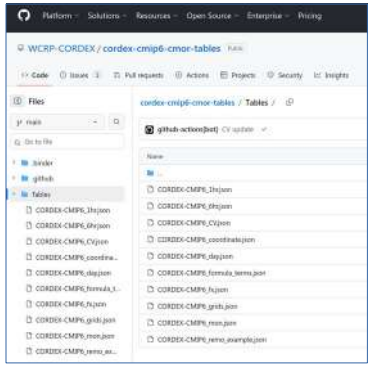
- Proposed Methods: respect the DoW, extend the CORDEX protocol, decide by consensus, use wording such as “mandatory”, “recommended”, “optional”
- Link with sister projects and international initiatives (Med-CORDEX, Baltic Earth, jWG ROCP)

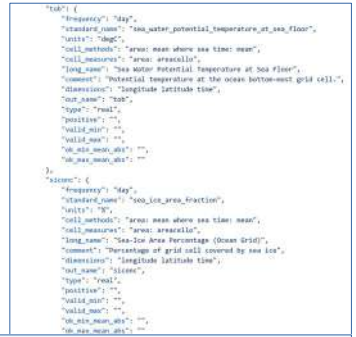
T4.1 : List of model outputs (Data Request)

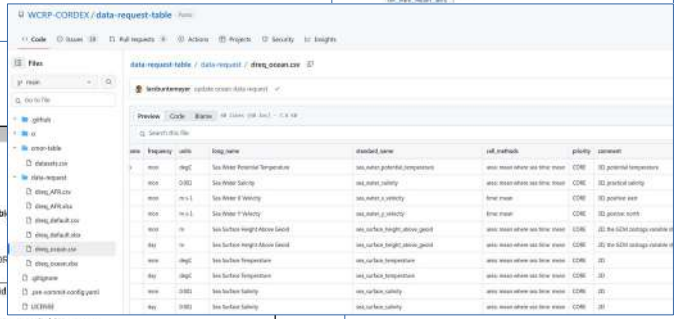
- 1 list for ocean physics
- 1 list for sea ice (Baltic, Black Sea ?)
- 1 list for atmosphere ?

(- WP5: 1 list for ocean BGC, and 1 for wave)

- Proposed Method: starting from CORDEX-Ocean list and adapt it to our needs using the CORE, TIER1, TIER2 priority approach
- Integrate the needs from USAB and other WPs
- Link with sister projects and international initiatives







CORDEX-CMIP6 Data Request: CORE Oceanic variables

ag - agregation for the highest-frequency output: i: instantaneous; a: averaged over output interval (in model); c: cumulative over sampling period

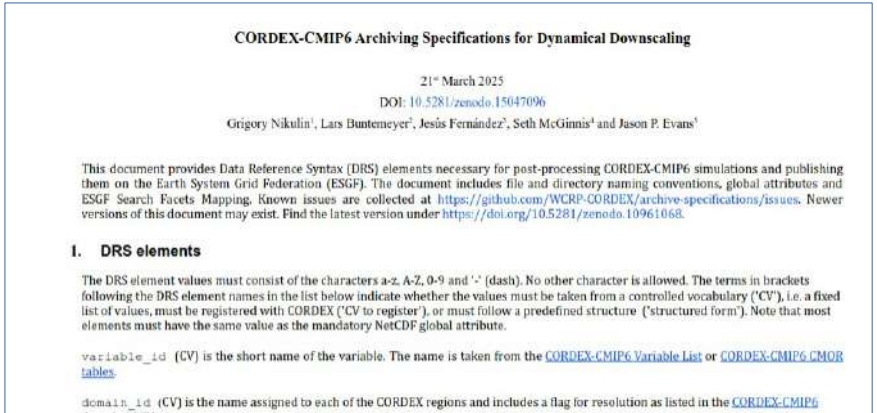
Version: 2024-06-25

output variable name	units	ag	long_name	standard_name	Output Frequency: mon	day	1hr	Priority	
thetao	degC	a	Sea Water Potential Temperature	sea_water_potential_temperature	x			CORE	3D, potential temperature
so	0.001	a	Sea Water Salinity	sea_water_salinity	x			CORE	3D, practical salinity
uo	m/s	a	Sea Water X Velocity	sea_water_x_velocity	x			CORE	3D, positive: east
vo	m/s	a	Sea Water Y Velocity	sea_water_y_velocity	x			CORE	3D, positive: north
zos	m	a	Sea Surface Height Above Geoid	sea_surface_height_above_geoid	x	x		CORE	2D, the GCM zostoga variable
tos	degC	a	Sea Surface Temperature	sea_surface_temperature	x	x		CORE	2D
sos	0.001	a	Sea Surface Salinity	sea_surface_salinity	x	x		CORE	2D
mlotst	m	a	Ocean Mixed Layer Thickness Defined by Sigma T	ocean_mixed_layer_thickness_defined_by_sigma_t	x	x		CORE	2D, positive: down, Med-COR
areacello	m²		Grid-Cell Area for Ocean Variables	cell_area		fx		CORE	Horizontal area of ocean grid
deptho	m		Sea Floor Depth Below Geoid	sea_floor_depth_below_geoid		fx		CORE	
sftof	%		Sea Area Percentage	sea_area_fraction		fx		CORE	Percentage of horizontal area occupied by ocean
thkcello	m		Ocean Model Cell Thickness	cell_thickness		fx		CORE	
volcello	m3		Ocean Grid-Cell Volume	ocean_volume		fx		CORE	

T4.1 : Archive specifications

- Includes file naming and metadata definition
- Required for file standardization allowing ESGF publication
- Ease the multi-model evaluation step
- Proposed method: try to adapt the CORDEX-CMIP6 archive specifications to ocean/sea-ice

```
tos_MED-12_CNRM-ESM2-1_ssp585_r1i1p1f2_CNRM_CNRM-RCSM6B_v1-r1_day_20260101-20301231.nc
```



CORDEX-CMIP6 Archiving Specifications for Dynamical Downscaling

21st March 2025

DOI: 10.5281/zenodo.15047096

Grigory Nikulin[1], Lars Buntemeyer[2], Jesús Fernández[3], Seth McGinnis[4] and Jason P. Evans[5]

This document provides Data Reference Syntax (DRS) elements necessary for post-processing CORDEX-CMIP6 simulations and publishing them on the Earth System Grid Federation (ESGF). The document includes file and directory naming conventions, global attributes and ESGF Search Facets Mapping. Known issues are collected at https://github.com/WCRP-CORDEX/archive-specifications/issues. Newer versions of this document may exist. Find the latest version under https://doi.org/10.5281/zenodo.10961068.

I. DRS elements

The DRS element values must consist of the characters a-z, A-Z, 0-9 and '-' (dash). No other character is allowed. The terms in brackets following the DRS element names in the list below indicate whether the values must be taken from a controlled vocabulary ('CV'), i.e. a fixed list of values, must be registered with CORDEX ('CV to register'), or must follow a predefined structure ('structured form'). Note that most elements must have the same value as the mandatory NetCDF global attribute.

`variable_id` (CV) is the short name of the variable. The name is taken from the CORDEX-CMIP6 Variable List or CORDEX-CMIP6 CMOR tables.

`domain_id` (CV) is the name assigned to each of the CORDEX regions and includes a flag for resolution as listed in the CORDEX-CMIP6

T4.2 : modelling platform developement (MS10@M12)

- Weakly coordinated
- Updated list of model configurations

MODELLING PLATEFORMS

PARTNER	MODEL NAME	ATMOSPHERE	LAND SURFACE	LAND HYDRO and RIVER	OCEAN PHYSICS	OCEAN BIOGEOCHEMISTRY	TARGETED SEA	COUPLED	CONFIRMED
IOW	IOW-ESM	CCLM@12km		statistical routing	MOM5@5.4km	ERGOM@5.4km	BALTIC	YES	YES
IOW	in dvt	ICON-A@12km							YES
SMHI		HCLIM43-ALADIN@12km	SURFEX@12 km	EHYPE4 per catchment basin	NEMO-Nordic@3.7k m	SCOBI@3.7km	BALTIC	NO	YES
ULiege		MAR@10km		CTRIP@10km	NEMO4.2@2.5km	BAMHBI@2.5km	BLACK	PERHAPS	YES
METU		HCLIM43-ALADIN@12km	SURFEX@12 km	Wflow-SBM@2km	NEMO@3km	TURSEM@3km	BLACK	NO	YES
CMCC		WRF461@12km	CLM5@12km	Hydros@12km	NEMOMFS@6km	NO	BLACK	YES	YES
CMCC		WRF461@12km	CLM5@12km	Hydros@12km	NEMOMFS@6km	NO	MED	YES	YES
CNRM, LEGOS, OGS	CNRM-RCSM6B-SN	ALADIN@12km	SURFEX@12 km	CTRIP@10km	NEMOMED@6km	EC03M-S@6km and BFM@6km	MED	YES	YES
ENEA	ENEA-REG3	WRF@12km		CaMa-flood@3km	MITgcm@9km	DARWIN@9km	MED	YES	YES
ENEA	in dvt	WRF@CPM-scale		CaMa-flood@	MITgcm@		MED	YES	YES

T4.2 : modelling platform developement (MS10@M12)

- Weakly coordinated
- Updated list of model developments

BOX4 - List of the planned model developments in RIVIERADE for each modelling platform.
IOW (BAL): replace the existing land surface scheme with an improved hydrological and terrestrial biogeochemical model. SMHI (BAL): improved open boundary forcing, higher temporal resolution, using machine learning regression technique (see Hieronymus et al., 2019). ULiege (BLK): development of a regional atmospheric model calibrated for BLK; 2-way coupling of the regional atmospheric model with the ocean physical-biogeochemical model; improved boundary conditions for rivers; improved initialization for DCPP. METU (BLK): online physical-biogeochemical coupling; higher spatial resolution and improved river and Bosporus boundary conditions; improving representation of the mid to higher trophic level. CMCC (MED, BLK): add a land-surface scheme improving the representation of hydrology, vegetation and of terrestrial biogeochemical fluxes; add a river routing scheme improving the representation of river discharge. CNRS-CNRM/CNRS-LEGOS (MED): add tides and tidal induced mixing; use open boundary conditions in the near-Atlantic; increase the river model resolution to 12 km and add more river mouths for MED and BLK; update NEMO version to 4.2 as in CMEMS; change vertical mixing scheme including a new deep convection scheme; improve the pelagic benthic coupling. OGS (MED): off-line biogeochemical-physics coupling with CNRS-CNRM system. ENEA (MED): higher resolution version at convection permitting scale (3-4 km) for the atmosphere and 1/16° for the ocean; DARWIN biogeochemistry model for the MED; higher-resolution river model. IHE Delft (All): coupling of PCR and ShorelineS model for rapid, high resolution coastal erosion and shoreline change projections.

MODEL DEVELOPMENTS

PARTNER	MODEL NAME	DVT1	DVT2	DVT3	DVT4	DVT5	DVT6	TARGET SEA	CONFIRMED
IOW	IOW-ESM	Improved hydrological and terrestrial biogeochemical model	replace CCLM by ICON-A	use of ML-base routing scheme				BALTIC	NO
SMHI		Improve OBC forcing, higher temporal resolution, using machine learning regression technique						BALTIC	NO
ULiege		Atmospheric model calibrated for BLACK	OA coupling	improved river boundary conditions				BLACK	NO
METU		on-line physical-biogeochemical coupling	higher spatial resolution	improved river	Improved Bosphorus boundary conditions			BLACK	NO
CMCC		land-surface model improving the representation of hydrology, vegetation and terrestrial biogeochemical fluxes	add a river routing scheme to improve river discharge representation					BLACK and MED	NO
CNRM	CNRM-RCSM6	add tides and tidal induced mising	use open boundary conditions for the near-Atlantic	increase river resolution to 12km	add more river mouths for MED and BLK	update to NEMO4.2	change vertical mixing scheme incl. new deep convection scheme	MED	NO
ENEA	ENEA-REG3	higher resolution at convection-permitting scale (3-4 km) for the atm	higher resolution at 1/16° for the ocean	add DARWIN for biogeochemistry	higher-resolution river model			MED	NO

T4.2 : simulation evaluation (MS11@M18)

- (multi-sea and) multi-model coordinated evaluation
- Hindcast runs and Historical runs
- A lot of sea-specific literature but no clear existing protocol
- What can bring CMEMS experience in model evaluation ?
- Historical runs can not be evaluated as hindcast or reanalysis
- CINECA internal storage access needed for MS11
- CINECA facility : usable for a centralized evaluation ?
- What are the objective(s) of this evaluation phase within the whole project story ? Building confidence, Documenting the simulations for the users, Selecting of the simulations for the services, ...
- What do we want to evalute ?

Extra slides

T4.2 : modelling platforms

Table 1.2. *RIVIERADE modelling platforms (components, spatial resolution) for the multi-decadal simulations at basin-scale (ocean physics, PHY, biogeochemistry, BGC, ETWL, coastal flooding, CF, coastal erosion, CE).* [1]*: model configuration involved in CORDEX before the start of the project,* [2]*: model configuration involved in CMEMS before the start of the project. IOW, CMCC, SMHI, ULiege modelling platforms used for downscaling decadal predictions will match or be largely based on these configurations.*

Partner	**Atmosphere and land surfaces**	**Land hydrology and rivers**	**Ocean PHY**	**Ocean BGC**	**ETWL, CF, CE**	**Target sea**
IOW[1] **(a)**	CCLM 12 km	ML routing 12 km	MOM5 5.4 km	ERGOM 5.4 km	-	BAL
SMHI[1,2] **(b)**	HCLIM43-ALADIN 12 km	EHYPE4 per catchment	NEMO-Nordic 3.7 km	SCOBI 3.7 km	-	BAL
ULiege[2] **(c)**	MAR 10 km	CTRIP 10 km	NEMO4.2 2.5 km	BAMHBI 2.5 km	-	BLK
METU[2] **(d)**	HCLIM43-ALADIN 12 km	Wflow-SBM 2 km	NEMO 3 km	TURSEM 3 km	-	BLK
CMCC[1,2] **(e)**	WRF-ARW 12 km	Hydros 11 km	NEMOMFS 6 km	BFM 6 km	-	BLK MED
CNRS-CNRM[1] CNRS-LEGOS[1] **(f)** OGS[2] **(g)**	ALADIN 12 km	CTRIP 10 km	NEMOMED 6 km	ECO3M-S 6 km BFM 6 km	-	MED
ENEA[1] **(h)**	WRF 12 km	CaMa-flood 3 min	MITgcm 9 km	DARWIN 9 km	-	MED
IHE Delft **(i)**	-	-	-	-	SFINCS 12 km*^	All

T4.1 : list of planned simulations

- Use the CORDEX github to centralize the list of runs ?
- Fit in the new jWG on ROCP

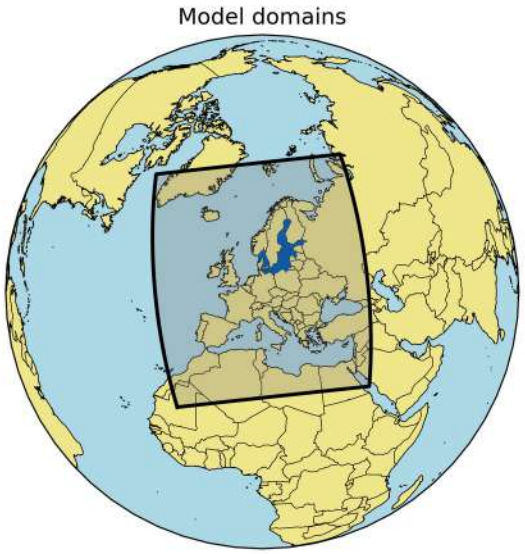
MED-12

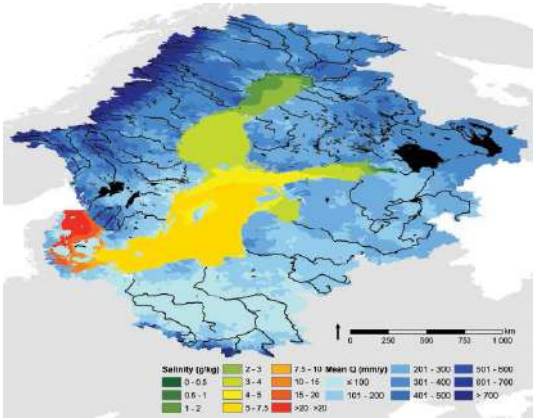
Colour legend for status: (planned running completed published) // source_type: (*unregistered* ARCM AORCM ESD)

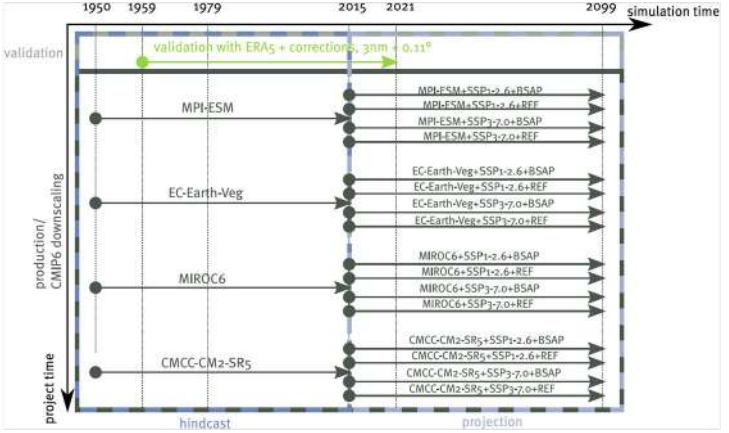
	Institution(s)	CLMcom-GUF	CNRM		UBEL	ENEA		CLMcom-IMS	CMCC	NKUA	ICTP	IPSL
	RCM	CCLM5-0-9-NEMOMED12-3-6	CNRM-RCSM6	CNRM-RCSM6B	EBUPOM2e	ENEA-REG2	ENEA-REG3	ICON-OASIS-NEMO	MedESM	MedX-CM	RegCM-ES1-1	RegIPSLv2
driving_model	ensemble											
ERA5		evaluation		evaluation	evaluation	evaluation	evaluation	evaluation	evaluation	evaluation	evaluation	evaluation
CNRM-ESM2-1	r1i1p1f2		hist ssp585	hist ssp126 ssp370								
EC-Earth3	r1i1p1f1						hist ssp370					
EC-Earth3-Veg	r12i1p1f1	hist ssp585										
	r1i1p1f1										hist ssp370	
MPI-ESM1-2-HR	r1i1p1f1					hist ssp126 ssp245 ssp585	hist ssp370	hist ssp370			hist ssp370	
NorESM2-MM	r1i1p1f1			hist ssp126 ssp370							hist ssp370	
TBD	TBD								hist	hist		

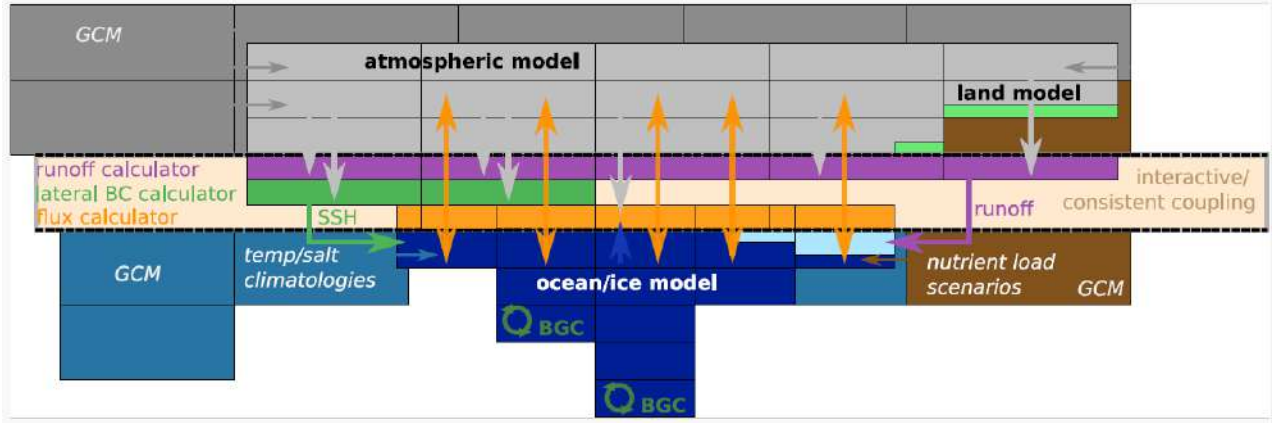
T4.2 : modelling platform, BAL: SMHI

T4.2 : modelling platform, BAL: IOW









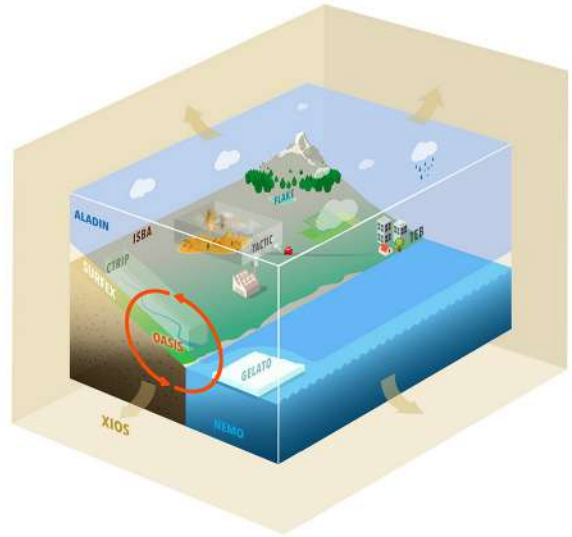
T4.2 : modelling platform, BLK: ULiege

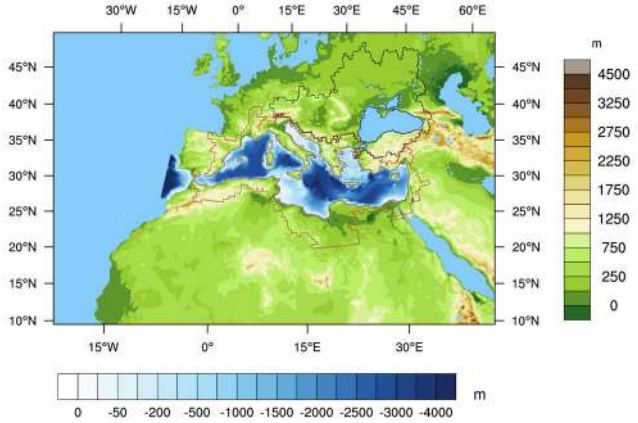
T4.2 : modelling platform, BLK: METU

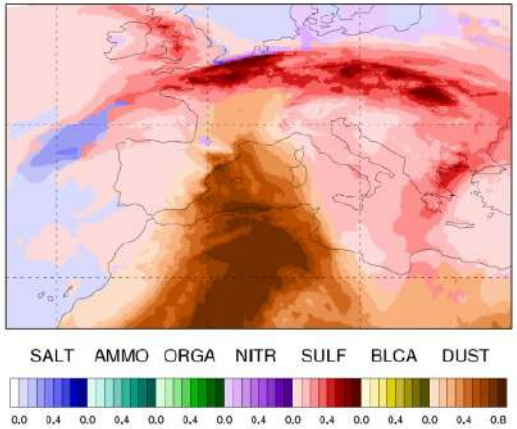
T4.2 : modelling platform, MED: CMCC

T4.2 : modelling platform, MED: ENEA

T4.2 : modelling platform, MED: CNRM-RCSM







CNRM-RCSM

Ocean Atmosphere Aerosols Land Hydrology River Wave

One of the coupled RCMs contributing to the Med-CORDEX initiative (Phase 1, 2, 3)

RIVIERADE

Partners