Med-CORDEX phase 2:
Common protocol for the baseline runs

Version 0: S. Somot, 30 nov 2016, using the notes from Roma's discussion
Version 1: S. Somot, 7 dec 2016, cleaning + add the forms to be filled by each modelling groups
Version 2: S. Somot, 3 avril 2017, re-read and check
Version 3: Med-CORDEX steering committee meeting, 5th May 2017, decisions
Version 4: G. Jordà, S. Somot, 28 june 2017, decisions + links towards required datasets, first final version ready to be shared with modelling groups for discussion in Barcelona
Version 5: S. Somot, 19-26 july 2017, implementation of the decisions taken in Barcelona
Version 6: S. Somot, 8 March 2018, first final version
Version 7: S. Somot,6 April 2018, second final version
Version 8: S. Somot, 14 jan 2020, adaptation following the Med-CORDEX workshop (Toulouse, Nov 2019) + cleaning for publication on the www.medcordex.eu

***

***

A. Introduction

Since its launch, one of the main strength and originality of the Med-CORDEX initiative within CORDEX is the setting, coordination and use of coupled RCMs also called Regional Climate System Models (RCSM) including at least the representation of the atmosphere, land-surface and ocean components (see Ruti et al. 2016 for more details and illustrations of the first results or https://www.medcordex.eu/simulations-phase1.php). This led the Med-CORDEX community to propose RCSM simulations to become the baseline runs for the second phase of Med-CORDEX.

The goals of the current document are to:
- present the main challenges addressed by these baseline runs
- recall the process leading to the chosen common protocol
- describe the agreed common protocol for the simulations
- document the participating institutes and models
- describe the naming of the model output files and the lists of model output variables

Note that in addition to the baseline runs, the phase 2 of Med-CORDEX includes 3 Flagship Pilot Studies (FPS) officially approved by CORDEX in May 2016: the convection FPS using Convection-Permitting RCM proposed jointly with Euro-CORDEX, the air-sea coupling and ocean small scale FPS and the aerosol-climate FPS. Those FPS are described in other documents.

B. Main challenges addressed by the baseline runs

also see the last section of Ruti et al. (2016)
- Characterization of the past regional climate variability and trends
- Characterization (incl. uncertainty) of the future regional climate evolution
- Characterization of the past variability and future evolution of the relevant Mediterranean climate phenomena
- Contribution to the characterization of the Mediterranean climate change impacts

C. The steps of the definition of the Med-CORDEX phase 2

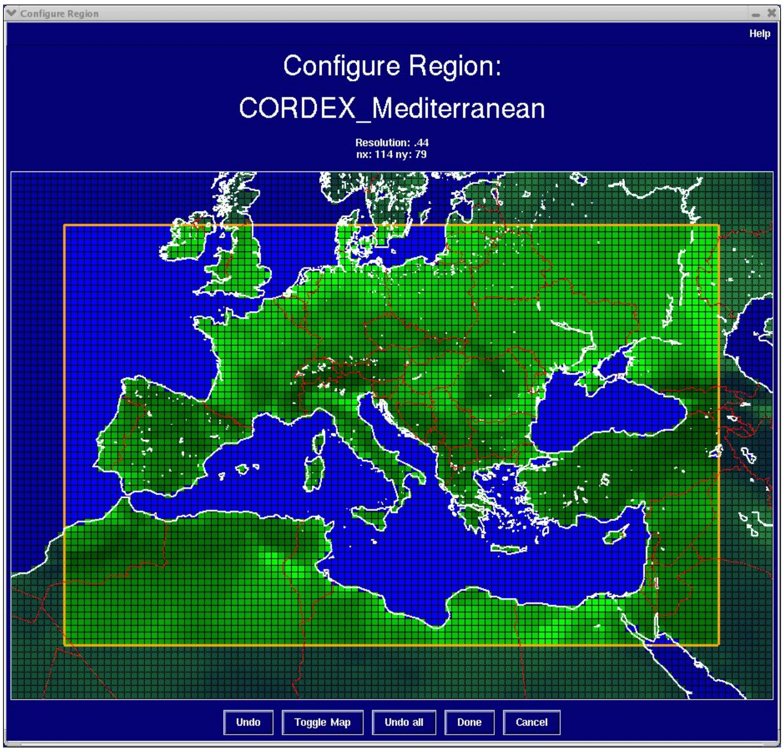
- First round tables dedicated to the preparation of the phase 2 of Med-CORDEX during the Med-CORDEX meeting in Palaiseau (France) in June 2014
- Regular Med-CORDEX steering committee dedicated meetings (B. Ahrens GUF, E. Coppola ICTP, G. Jordà IMEDEA, G. Sannino ENEA, S. Somot CNRM)
- Definition of the main principles and scientific axes of the Med-CORDEX phase 2 in the concluding section of Ruti et al. (2016, BAMS)
- Interactions with CORDEX SAT, Euro-CORDEX, HyMeX, Med-CLIVAR and MedECC during 2015

- HyMeX/Med-CORDEX Mykonos workshop in Sept 2015 : participating modelling groups UCLM, CNRM, IPSL(WRF), ENSTA, ENEA, ICTP, MERCATOR, CMCC, GUF, IIBR, LA
- Interactions with the MISTRALS programs concerning the Med-CORDEX related topics for the assessment of the Mediterranean climate change impacts on hydrology (SICMED), land biodiversity (Biodivmex), ocean biogeochemistry and marine ecosystems (MERMEX, Biodivmex), aerosols, air-quality and chemistry (Charmex), Paleoclimatology (PaleoMex): workshop in Toulouse in January 2015 and Marseille in October 2015
- Interactions on common « scientific questions » with the Baltic Sea community (Roma meeting, Nov. 2015) and with the CORDEX domains interested in coupled RCMs (Stockholm RCSM side event, May 2016)
- Submission of the Med-CORDEX FPS to the CORDEX SAT in March 2016 and review process
- Official approval of the 3 FPS proposed by Med-CORDEX at the ICRC CORDEX meeting (Stockholm, May 2016)
- FPS Kickoff meetings for the convection FPS (October 2016, Trieste), for the aerosol-climate FPS (November 2016, Cyprus) and for the air-sea and ocean FPS (November 2016, Roma)
- First scientific sessions dedicated to Med-CORDEX phase 2 activities: HyMeX/Med-CORDEX meeting in Barcelona, July 2017

D. Common Protocol

1. Minimal Domain

same Med-CORDEX phase 1 (for a precise definition see domain #12 in https://www.medcordex.eu/cordex_domains_250610.pdf)
NB: Eastward extension (if possible in new settings) welcome to better cover the Black Sea and the whole Turkey country



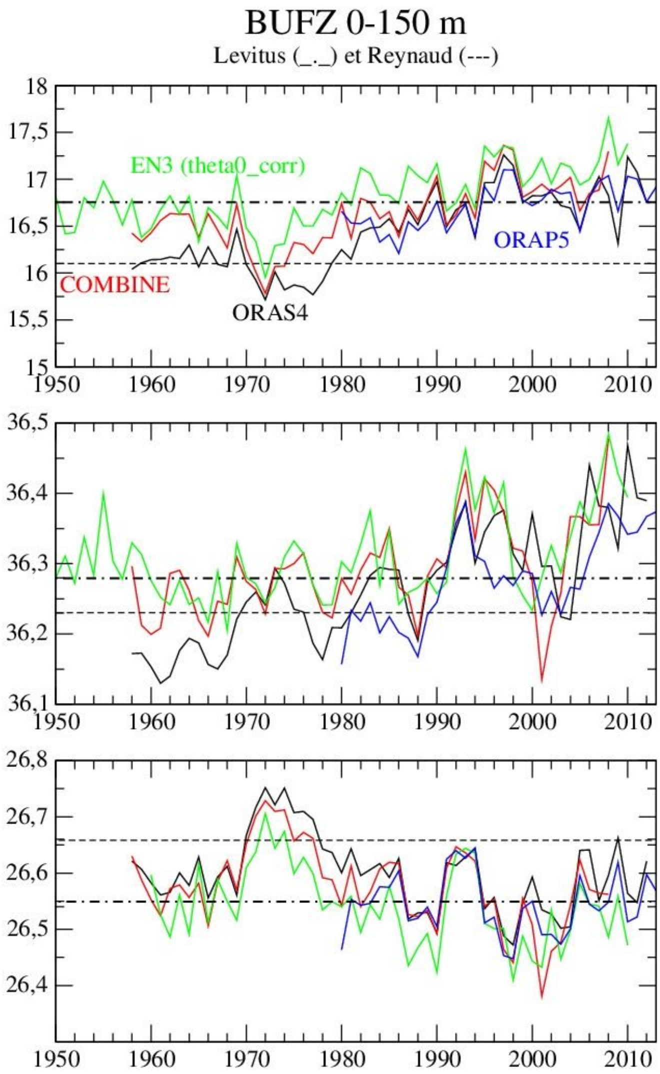
2. Minimal model configuration

2.1 fully-coupled RCSM with atm-land-river-ocean (ALRO)
NB1: Contrary to phase 1, river coupling (outside Nile) became mandatory in phase 2. It is particularly relevant for scenario simulations
NB2: Other components such as marine biogeochemistry, interactive aerosols, interactive vegetation or waves are welcome but not mandatory
2.2 Atmosphere/Land/River resolution: 0.11° or 12km recommended (lower-resol. accepted)
2.3 Ocean resolution: 1/12° or 10km recommended (lower-resol. accepted)
2.4 River: Land-to-ocean coupling may be done with simple approaches but using an up-to-date river routine scheme is recommended
2.5 Using a common ocean bathymetry is recommended. An ocean bathymetry file (already used by NEMOMED12 and MITgcm) can be provided in netcdf format for those who want to adopt a common bathymetry and model grid. Please contact Thomas Arsouze at ENSTA

(thomas.arsouze@ensta-paristech.fr) or see
https://cloud.ensta.fr/index.php/s/3OzDXPMPakYRM7Y
2.6 Coupling frequency: at least daily, hourly is advised for a good representation of the diurnal cycle

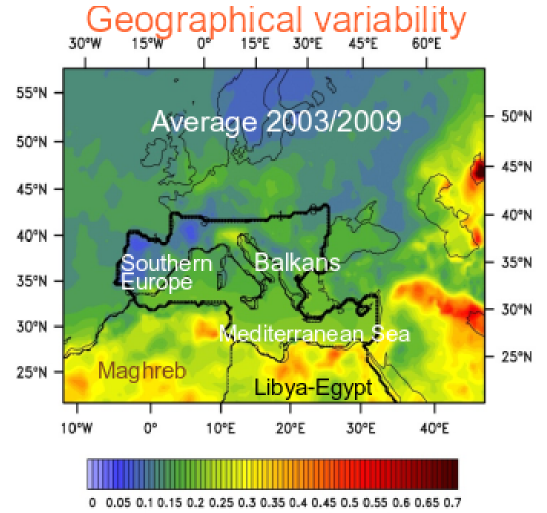
3. Evaluation runs (also called Hindcast) : EVAL

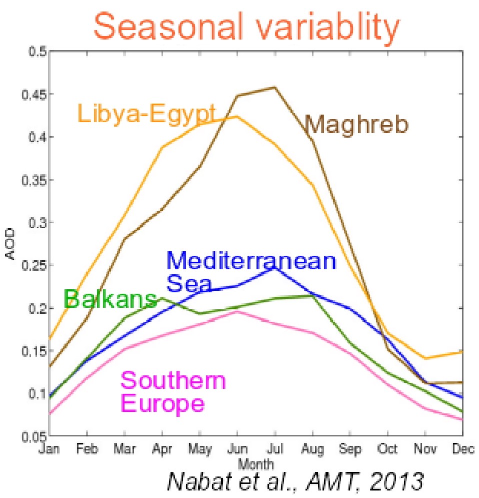
3.1 Period: minimum 1979-2015. Extension to the end of ERA-Int (2018) is recommended.
3.2 Atmosphere Lateral Boundary conditions: Use ERA-Interim reanalysis and see the relevant metadata table.
NB: try to use the 6-hourly high-resolution version
NB: Due to a time constraint, ERA-5 reanalysis (33km, same period as ERA-Int) is not an option for this initiative. Twin tests are however welcome.
NB: ERA-Int should be extended up to 2018 reaching 40 years
3.3 Ocean Lateral Boundary conditions in Near-Atlantic: use ORAS4 reanalysis from ECMWF (data available at ECMWF https://www.ecmwf.int/en/research/climate-reanalysis/ocean-reanalysis) and see the relevant metadata table.
NB: To our knowledge, ORAS5 / ORAP5 products are not yet available and qualified for Med Sea model forcing. So we decided to keep ORAS4
NB: ORAS4 Monthly-mean value for T3D, S3D and sea level in the near-Atlantic ocean can be provided including the Adloff et al. (2017) correction for the sea level seasonal cycle (contact point: Florence Sevault at CNRM, florence.sevault@meteo.fr). The figure shows the interannual variability of temperature, salinity and density in the near-Atlantic (Buffer zone of NEMOMED12 model) for the 0-150m layer (that is to say the layer approximately affecting the Mediterranean Sea), for various datasets used as OLBC (*Florence Sevault, CNRM, pers. comm.*)

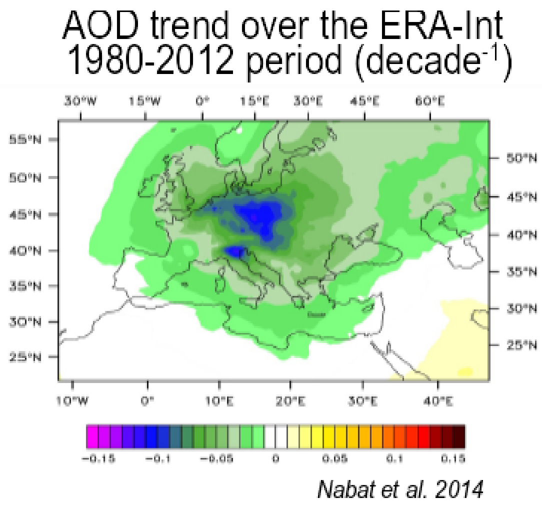


3.4 SST outside the coupling area: use ERA-Int SST for consistency
NB: tests with higher-resolution SST datasets outside the coupling zone (e.g. CMEMS products) are welcome
3.5 GHG: realistic evolution for past runs should be implemented following CMIP5 forcing recommendations.
NB: time series can be provided by CNRM if needed (contact samuel.somot@meteo.fr)
3.6 Aerosol representation: We strongly advise to use recent aerosol climatologies and to take care about its implementation and interaction with the radiation code.
Aerosol representation to be documented in each model, see the relevant metadata table.
NB: A realistic, recent and validated climatology (*Nabat et al. 2013)* already used to force Med-CORDEX simulations *(Nabat et al. 2014, 2015*) is advised by the FPS-aerosols (contact: fabien.solmon@aero.obs-mip.fr, marc.mallet@meteo.fr). It can be provided for those who want to adopt a common forcing (2D maps at 50km resolution with a seasonal cycle and trends over the ERA-Int period). Various aerosol classes as well as radiative

characteristics can be provided. The dataset is available in the Charmex database: (http://mistrals.sedoo.fr/?editDatsId=1006&datsId=1006&project_name=ChArMEx&q=nabat)
Or by asking pierre.nabat@meteo.fr
The figures show the spatial variability, seasonal variability and long-term trend of the proposed AOD climatology.





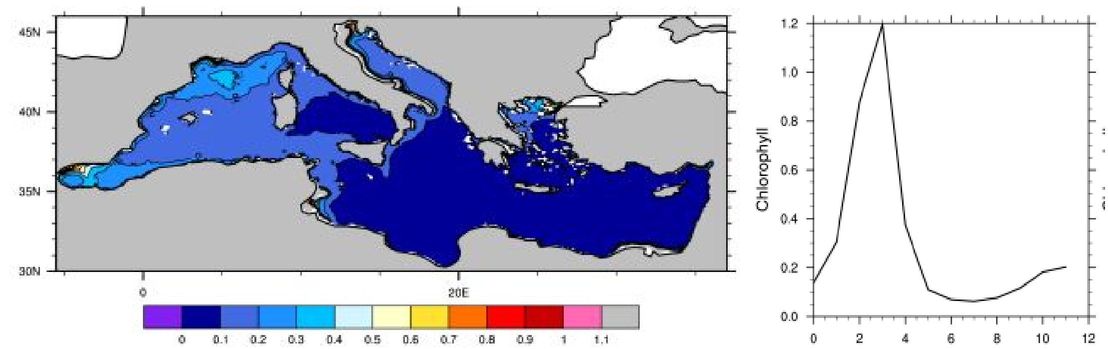


NB: interaction and prognostic aerosols are outside the perimeter of the baseline runs and will be assessed in the dedicated FPS
3.7 Sea albedo: recommendation is to use an ocean albedo depending on the zenital angle, that is to say depending on space and time (see Dubois et al. 2012, contact: rfarneti@ictp.it). If constant, the albedo should be around 0.07 for the Mediterranean Sea.
To be documented for each model, see the relevant metadata table.
3.8 Land-surface characteristics : to be checked and documented by each modelling group, see the relevant metadata table.
NB: use land-use/land-cover map changes if possible (even if this is more relevant in the dedicated Euro-CORDEX FPS LUCAS)
3.9 Nile river discharge: we propose to use a common seasonal cycle (12 values) with an annual value of 444 m^3/s that is equivalent at 14 km^3/y in agreement with Nixon (2003) and FAO information. (contact: Erika Coppola, coppolae@ictp.it). Note that a split in 2 river mouths has been proposed for NEMOMED12 users (contact: florence.sevault@meteo.fr)

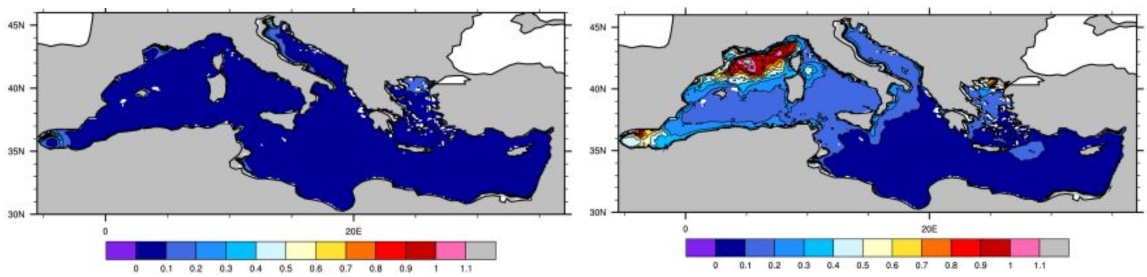
Also see the relevant metadata table.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANN
Values (m^3/s)	336	396	407	399	472	615	634	557	412	373	372	352	444

NB: the decision has been taken taking into account Dubois et al. (2012) for the state of the art during the CIRCE project, values used currently in Med-CORDEX models (NEMOMED8, NEMOMED12, MITgcm, GETM), advice from J. Polcher (LMD), Nixon (2003), Global River Data Center (GRDC, Germany) dataset available at the Nelson Institute website (https://nelson.wisc.edu/sage/data-and-models/riverdata/station_table.php?qual=256&filenum=1609) and FAO information (http://www.fao.org/nr/water/aquastat/countries_regions/egy/)
3.10 Suez canal: closed but sensitivity tests are welcome
3.11 Black Sea representation (simple param or more): at least conserve the Black Sea water budget : E-P-R (*Sevault et al. 2014*). Adding the effect of the local atmospheric pressure and wind can be tested.
Also see the relevant metadata table.
3.12 Surface chlorophyll climatology for the ocean: if you don't use on-line biogeochemistry model, we propose to use a common 12-map climatology for the surface Chlorophyll (L3 ESA-CCI, 2003-2011 average). Please contact Thomas Arsouze at ENSTA (thomas.arsouze@ensta-paristech.fr).

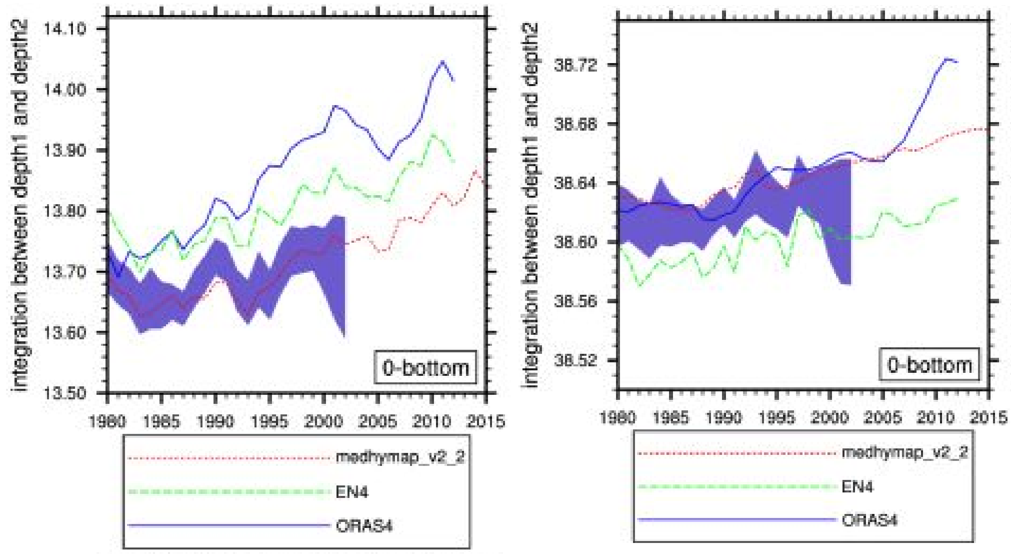


(left) Spatial map of the yearly average value of the surface cholorophyll (g/L) and (right) monthly-mean seasonal cycle at the LION buoy location (NW Mediterranean Sea). figure from Florence Sevault (pers. comm.)

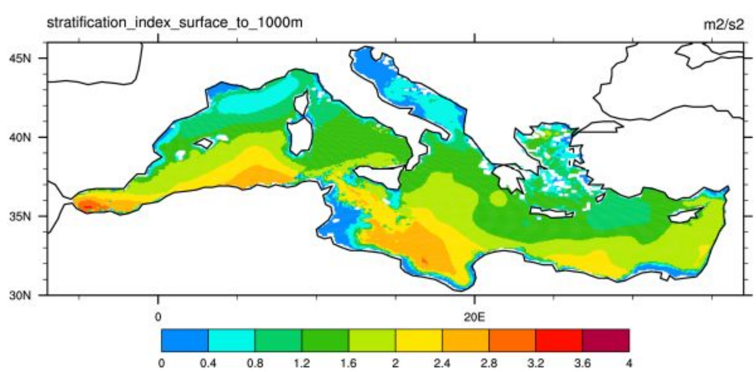


Spatial map of the surface chlorophyll (g/L) averaged for the (left) July-August months and (right) March-April months. figure from Florence Sevault (pers. comm.)

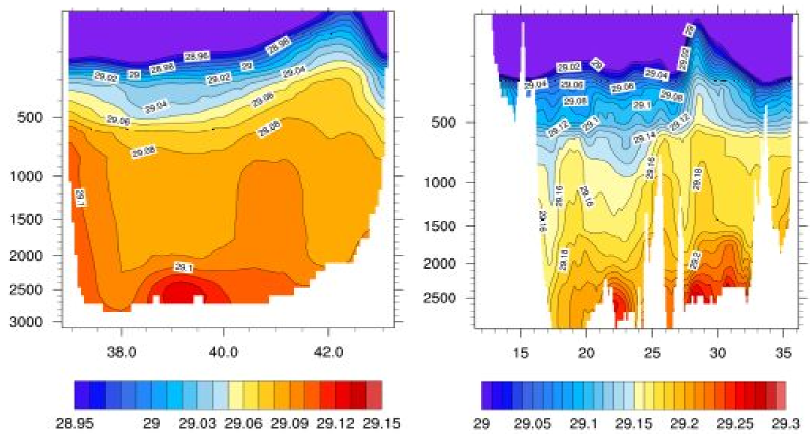
3.13 Coupling over the near-atlantic buffer.
No agreement has been reached. See the relevant metadata table for a documentation of the model setup.
3.14 Nudging in the atmosphere (grid-point nudging, spectral nudging or no specific nudging). See the relevant metadata table.
3.15 Ocean Initial Conditions:
The recently-developed and evaluated MedHYMAPv2.2 dataset for the 1970s is recommended. We recommend to start from a Summer month using the year 1975 from the 10-year filtered dataset version. It is provided by IMEDEA (contact: gabriel.jorda@ieo.es). Also see the relevant metadata table.

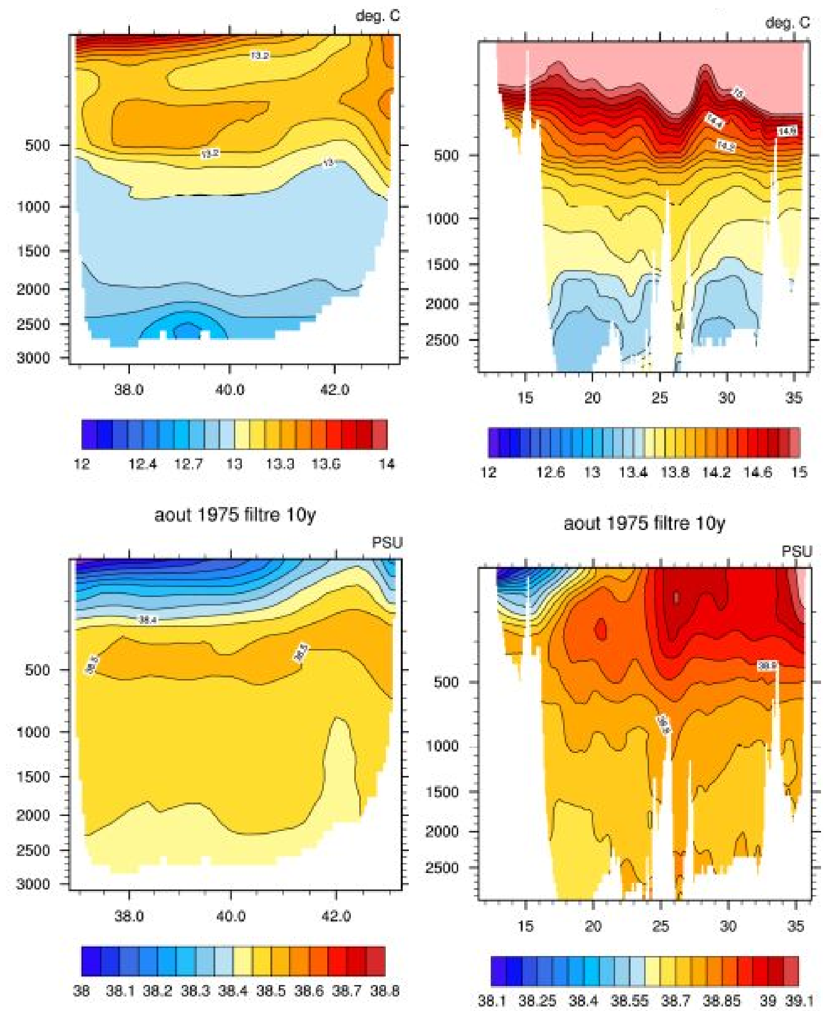


Interannual time series of the Mediterranean Sea (left) heat content (expressed in °C) and (right) salt content (in psu) for the advised IMEDEA-MedHYMAPv2.2 dataset (red) compared to EN4 (green), ORAS4 (blue) and Med-Atlas/Rixen dataset (purple). figure from Florence Sevault (pers. comm.)



Average Stratification Index over the 0-1000m depth and the 1980-2012 period (in m2/s2) for the advised IMEDEA-MedHYMAPv2.2 dataset. figure from Florence Sevault (pers. comm.)





Vertical section for (left) the Western Mediterranean Sea (South-North section at 5°E) and (right) the Eastern Mediterranean Sea (West-East section at 34°N) for the month of August 1975 of the 10-year filtered version of the advised IMEDEA-MedHYMAPv2.2 dataset for the potential density (top), the potential temperature (middle) and salinity (bottom). figure from Florence Sevault (pers. comm.)

3.16 Atmospheric initial conditions: do not matter (probably 1st of January 1979 in ERA-Int)
3.17 Spin-up strategy: based on the community experience, we prefer to recommend stability criteria for the model run after the spin-up period than to set a common spin-up length or strategy. For the ocean, we advise to keep the model trends below an acceptable level based on observed trends including error bars (minimum acceptable thresholds to be provided by IMEDEA over a given period and for different variables and layers, contact: gabriel.jorda@ieo.es . NOT YET AVAILABLE).
Spin-up strategy is documented in the relevant metadata table.

4. Historical (HIST) and scenario (SCEN) runs

(for more information, see the same metadata tables as for the hindcast runs)

4.1 Principle: keep as much as possible consistency with the driving GCMs (ALBC, OLBC, SBC, land-use-land-cover, aero, GHG).
4.2 Use CMIP5 GCMs at least in the first years of the phase 2 before CMIP6 models become available
4.3 Analyse the GCM atmospheric behaviour (biases, weather regimes, climate change responses) over the Mediterranean area. This has been largely tackled in previous studies (McSweeney et al. 2015, Cattiaux et al. 2013, Brands et al. 2013, Van den Hurk et al. 2014, Jury et al. 2015, Zappa and Shepherd 2017) allowing in particular to select the best GCMs over the area and to know the regional future climate sensitivity of the GCMs (see McSweeney et al. 2015). When choosing a driving GCM, please try to avoid GCMs with too bad behaviours over the Mediterranean area and to maximize the spread in future climate change response.
4.4 Analyse the Atlantic Ocean behaviour near Gibraltar (biases, climate change responses) to document the chosen GCMs. Study on going at IMEDEA (contact: gabriel.jorda@ieo.es).
REPORT/RESULTS TO BE SHARED
4.5 if your Ocean-GCM has very large biases during the HIST period, think to use anomaly approach for OLBC
4.6 Scenario choice: RCP8.5 first, RCP2.6 in option
4.7 minimum period: 1971-2100 (1950-2100 recommended)
4.8 We advise to run a twin control run (without GHG and aerosol future evolution) if possible to check model stability
4.9 Nile: Keep it constant in time as in EVAL but sensitivity tests to the main protocol are welcome
4.10 Surface ocean chlorophyll: Keep it constant except for the models including the on-line biogeochemistry coupling
4.11 Black Sea representation: same as in EVAL
4.12 Ocean Initial Conditions: same as in EVAL but less relevant
4.13 Atmosphere initial conditions: same as in EVAL but do not matter
4.14 Spin-up strategy: same criteria as in EVAL, to be document

E. Model outputs

1. List of variables

- Updated CORDEX list for the atmosphere and land-surface (please use the last version, see https://www.medcordex.eu/references.php)
Variable list (version 3.1, 14 February 2014)
http://is-enes-data.github.io/CORDEX_variables_requirement_table.pdf
If you want to propose modifications of the variable list for any of the forthcoming multi-model study. Please contact miguel.gartner@uclm.es

- Updated Med-CORDEX list for the ocean including a coordination with Baltic Earth. See the list on www.medcordex.eu/references.php (contact: samuel.somot@meteo.fr)

- Med-CORDEX list for the river. See the list on www.medcordex.eu/references.php (contact: coppolae@ictp.it)

2. File format, file naming and archive specifications

- CF-CMOR netcdf format respecting CMIP and CORDEX standards for file naming and variable naming. More specifically:

- Atmosphere and land-surface. Use the latest CORDEX data specifications (version 3.1, 3 March 2014):
http://is-enes-data.github.io/cordex_archive_specifications.pdf

- Ocean. Modifications of the CORDEX archive specification document for ocean variables including a coordination with Baltic Earth (not yet endorsed by CORDEX SAT and ESGF), see www.medcordex.eu/references.php (contact: samuel.somot@meteo.fr)

- River. Modifications of the CORDEX archive specification document for river variables (not yet endorsed by CORDEX SAT and ESGF), see www.medcordex.eu/references.php (contact:coppolae@ictp.it)

3. Data sharing

- We propose a 2-stage framework. First stage for data sharing with the other Med-CORDEX participants for multi-model science studies. Second stage for data sharing with external CORDEX data users.
- Stage 1: The data can be shared using the common working space provided by ENEA for Med-CORDEX phase 2 (contact: gianmaria.sannino@enea.it) or through classical ftp in every data producer center.
- Stage 2: CF-CMOR-ESGF standards + publication on ESGF nodes. ENEA proposes to manage a central portal as in phase 1 but not anymore to host the data. Every producing center has to find its own way to share its dataset. For the groups who do not have in-house ESGF capacity, DKRZ proposes to host some of the Med-CORDEX phase 2 simulations. (contact: bodo.ahrens@iau.uni-frankfurt.de)

4. Quality check

Please use the Quality Check from DKRZ before publication. It is ready for atmosphere and land variables. To be adapted for ocean, river or aerosol variables.

F. Timeline

- March 2018: first final version of the protocol. DONE
- March 2018: first final version of the output list and file naming. DONE
- April 2018: finalize the data sharing strategy. DONE

- Early 2018: evaluation runs started. DONE FOR SOME GROUPS
- 2018-2019: first studies and publications with the new evaluation runs. DONE FOR SOME GROUPS
- 2018-2019: historical and scenario runs started. DONE FOR SOME GROUPS
- 2019-2020: contributions to IPCC reports and MedECC report. ON-GOING

- Opportunities to meet and discuss the baseline runs
  - FPS air-sea meeting in Majorca in March 2018
  - HyMeX meeting in May 2018
  - Med-CLIVAR meeting in Sept 2018
  - Med-CORDEX workshop and FPS-airsea meeting, Toulouse, November 2019
  - Next Med-CORDEX / Baltic Earth joint meeting and FPS-airsea meeting, Spring 2021 (place to be confirmed)

G. References

Adloff F., Jordà G., Somot S., Sevault F., Arsouze T., Meyssignac B., Li L., Planton S. (2017) Improving sea level simulation in Mediterranean regional climate models. *Climate Dynamics, Med-CORDEX special issue (accepted)*

Brands, S., Herrera, S., Fernández, J., & Gutiérrez, J. M. (2013). How well do CMIP5 Earth System Models simulate present climate conditions in Europe and Africa?. *Climate dynamics*, *41*(3-4), 803-817.

Cattiaux, J., Douville, H., & Peings, Y. (2013). European temperatures in CMIP5: origins of present-day biases and future uncertainties. *Climate dynamics*, *41*(11-12), 2889-2907.

Dubois C., S. Somot, S. Calmanti, A. Carillo, M. Déqué, A. Dell'Aquilla, A. Elizalde-Arellano, S. Gualdi, D. Jacob, B. Lheveder, L.Li, P. Oddo, G. Sannino, E. Scoccimarro, F. Sevault (2012) Future projections of the surface heat and water budgets of the Mediterranean sea in an ensemble of coupled atmosphere-ocean regional climate models, *Clim. Dyn.* 39 (7-8):1859-1884. DOI 10.1007/s00382-011-1261-4.

Jury, M. W., Prein, A. F., Truhetz, H., & Gobiet, A. (2015). Evaluation of CMIP5 models in the context of dynamical downscaling over Europe. *Journal of Climate*, *28*(14), 5575-5582.

McSweeney, C. F., Jones, R. G., Lee, R. W., & Rowell, D. P. (2015). Selecting CMIP5 GCMs for downscaling over multiple regions. *Climate Dynamics*, *44*(11-12), 3237-3260.

Nabat P., S. Somot, M. Mallet, I. Chiapello, J.-J. Morcrette, F. Solmon, S. Szopa, F. Dulac, W. Collins, S. Ghan, L.W. Horowitz, J.F. Lamarque, Y.H. Lee, V. Naik, T. Nagashima, D. Shindell, R. Skeie (2013) A 4-D climatology (1979-2009) of the monthly tropospheric aerosol optical depth distribution over the Mediterranean region from a comparative evaluation and blending of remote sensing and model products. *Atmos. Meas. Tech.,* 6, 1287-1314, doi:10.5194/amt-6-1287-2013

Nabat P., Somot S., Mallet M., Sanchez-Lorenzo A., Wild M. (2014) Contribution of anthropogenic sulfate aerosols to the changing Euro-Mediterranean climate since 1980. Geophys. Res. Lett., Volume 41, Issue 15, pages 5605–5611, doi:10.1002/2014GL060798

Nabat P., Somot S., Mallet M., Sevault F., Chiacchio M., Wild M. (2015a) Direct and semi-direct aerosol radiative effect on the Mediterranean climate variability using a coupled Regional Climate System Model. *Clim. Dyn. 44, 1127-1155, DOI:10.1007/s00382-014-2205-6, http://rd.springer.com/article/10.1007%2Fs00382-014-2205-6*

Nixon, S.W., 2003. Replacing the Nile: Are Anthropogenic Nutrients Providing the Fertility Once Brought to the Mediterranean by a Great River? Ambio 32, 30–39.

Ruti PM, Somot S, Giorgi F, Dubois C, Flaounas E, Obermann A, Dell'Aquila A, Pisacane G, Harzallah A, Lombardi E, Ahrens B, Akhtar N, Alias A, Arsouze T, Aznar R, Bastin S, Bartholy J, Béranger K, Beuvier J, Bouffies-Cloché S, Brauch J, Cabos W, Calmanti S, Calvet J-C, Carillo A, Conte D, Coppola E, Djurdjevic V, Drobinski P, Elizalde-Arellano A, Gaertner M, Galàn P, Gallardo C, Gualdi S, Goncalves M, Jorba O, Jordà G, L'Heveder B, Lebeaupin-Brossier C, Li L, Liguori G, Lionello P, Maciàs D, Nabat P, Onol B, Raikovic B, Ramage K, Sevault F, Sannino G, Struglia MV, Sanna A, Torma C, Vervatis V (2015) MED-CORDEX initiative for Mediterranean Climate studies. *BAMS.*
doi: http://dx.doi.org/10.1175/BAMS-D-14-00176.1
http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-14-00176.1

Sevault F., Somot S., Beuvier J. (2009) A regional version of the NEMO ocean engine on the Mediterranean Sea: NEMOMED8 user's guide. *Note de centre n°107.* Groupe de Météorologie de Grande Echelle et Climat. CNRM. mai 2009

Sevault F., Somot S., Alias A., Dubois C., Lebeaupin-Brossier C., Nabat P., Adloff F., Déqué M. and Decharme B. (2014) A fully coupled Mediterranean regional climate system model: design and evaluation of the ocean component for the 1980-2012 period. *Tellus A, 66, 23967, http://dx.doi.org/10.3402/tellusa.v66.23967*

van den Hurk, B., van Oldenborgh, G. J., Lenderink, G., Hazeleger, W., Haarsma, R., & de Vries, H. (2014). Drivers of mean climate change around the Netherlands derived from CMIP5. *Climate dynamics*, *42*(5-6), 1683-1697.

Zappa, G., & Shepherd, T. G. (2017). Storylines of atmospheric circulation change for European regional climate impact assessment. *Journal of Climate*, *30*(16), 6561-6577.