Report

Project title: Simulation of the Mediterranean climate in the framework of HyMeX
Project: 896
Project leader: Bodo Ahrens
Report Authors: Naveed Akhtar, Bodo Ahrens

The main objective of this work is the implementation and evaluation of the ocean-atmosphere coupled regional climate model in the framework of HyMeX (Hydrological cycle in Mediterranean Experiment) for the better understanding of ocean-atmosphere interactions. HyMeX aims to improve the understanding of the Mediterranean water cycle, with emphasis on extreme events by monitoring and modeling the Mediterranean atmosphere-land-ocean system (www.hymex.org). The Mediterranean region is known as a Hot Spot in future climate change projections due to large decrease in mean precipitation and increase in precipitation variability during warm and dry seasons (Giorgi, 2006). Its climate is known for its large contrast in seasonal temperature variations, strong winds, heavy precipitation and cyclones. The semi-enclosed Mediterranean Sea has a strong impact on the local and even the remote climate system as a source of moisture and heat reservoir. Therefore, it is important to understand how large-scale climate variability and climate change influence the climate of the Mediterranean region as well as the influence of the Mediterranean Sea on the global climate.

To study the complex interactions between the atmosphere and ocean, simulations have been done using an atmosphere-only and coupled model. In this study, we employed the regional climate model COSMO-CLM v4.21 (CCLM), based on the non-hydrostatic equations (Rockel et al., 2008), in atmosphere-only and in coupled (atmosphere-ocean) with ocean component NEMO-MED12 configurations. The NEMO-MED12 is a regional configuration of the OGCM (Ocean General Circulation Model) NEMO (Madec and the NEMO Team, 2008) for the Mediterranean Sea. Coupling has been implemented using OASIS3-MCT (Valcke, 2013) with a coupling time step of 3 h. The ocean model was spun up for 25 years to get the near equilibrium state of the Mediterranean Sea. The CCLM uses the lateral boundary conditions from the reanalysis or GCM simulation data for both coupled and atmosphere-only simulation. In the coupled configuration Sea Surface Temperature (SST) as a lower boundary condition is also prescribed and derived from the driving model except over the Mediterranean Sea where it is calculated by the regional ocean model NEMO-MED12. The computational domain is chosen to meet the MED-CORDEX requirements (www.medcordex.eu).

In a first phase atmosphere-only and coupled simulations have been done from 1979 to 2011 using atmospheric grid resolution (~50 km). The results show that air-sea fluxes are better represented in the COSMO-CLM/NEMO-MED12 coupled model compared to the other models (Fig. 1). These simulations are also used for intercomparison with other regional climate models within the HyMeX community. The results of these simulations are also included in recent paper “MED-CORDEX initiative for Mediterranean Climate studies”.

In a second phase high resolution atmosphere-only and coupled simulations have been done from 2000 to 2003 using higher atmospheric grid resolution (~9 km) to study the impact of higher atmospheric grid resolution and ocean coupling on air-sea fluxes. The simulations of high atmospheric grid resolution (~9 km) are compared to the coarser atmospheric grid simulations (~50 km). The results show that the coupled model with higher atmospheric grid resolution improves the air-sea fluxes over the Mediterranean Sea (Fig. 2 and 3). To study the

impact of SST diurnal variations on air-sea fluxes simulations with atmospheric grid resolution ~50 km and ~9 km are performed with temporally smoothed (5-days averaged) SST from the coupled simulation. Based on these simulations several manuscripts emerged which are accepted or submitted in the peer reviewed journals (see Appendix).

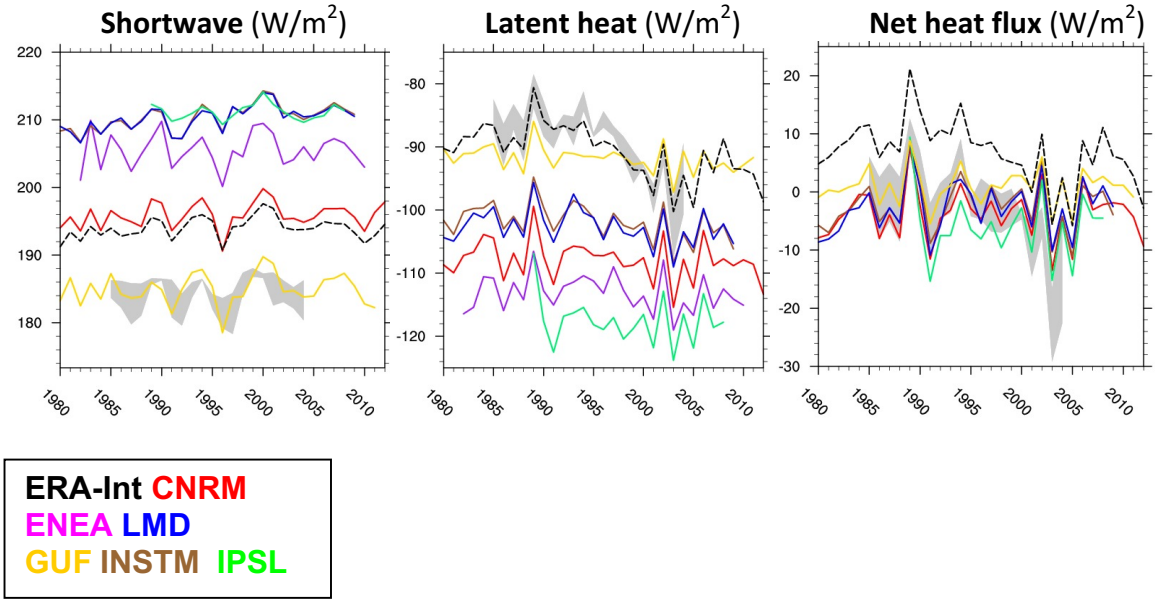
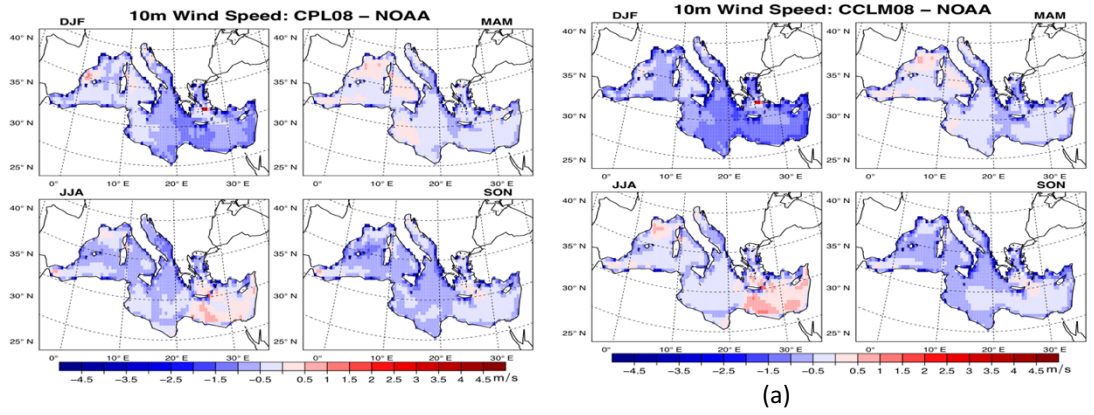


Fig.1. The air-sea fluxes evaluations Models: ERA-Int driven run, ENEA, CNRM, **GUF (Goethe Uni),** LMD, INSTM, IPSL, Obs (Flux, gray shading): NOCS, SRB-QC, SRB-GEWEX, ISCCP-FD, OAFLUX, GEBA, BRSN (Fig: S. Somot)



(b) (a)

Fig. 2. Seasonal mean difference of 10-m wind speed (ms^{-1}) between (a) CPL08 (coupled with 0.08° atmospheric grid resolution) and NOAA and (b) CCLM08 (atmosphere-only with 0.08° atmospheric grid resolution) and NOAA from 2001 to 2003

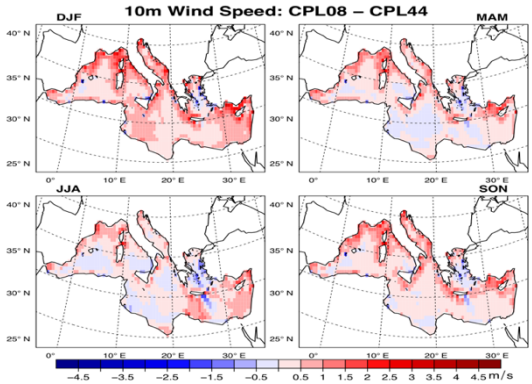


Fig. 3. Seasonal mean difference of 10-m wind speed (ms^{-1}) between CPL08 (coupled with 0.08° atmospheric grid resolution) and NOAA and CPL44 (coupled with 0.44° atmospheric grid resolution) from 2001 to 2003

Appendix

List of accepted/submitted papers

1. **Akhtar, N.,** J. Brauch, A. Dobler, K. Berenger, **B. Ahrens.**: Medicanes in an ocean-atmosphere coupled regional climate model. Nat. Hazards Earth Syst. Sci., 14, 2189-2201. doi:10.5194/nhess-14-2189-2014, 2014.
2. MED-CORDEX initiative for Mediterranean Climate studies: 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-Moy D, Nabat P, Onol B, Rajkovic 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: 10.1175/BAMS-D-14-00176.1
3. Mediterranean cyclone climatology: Assessment of an ensemble of coupled and uncoupled atmosphere-ocean regional climate models applying six cyclone tracking methods: Flaounas E., Gaertner M., Kelemen F., Lionello P., Sanchez E., Wernli H., **Akhtar N**., Calmanti S., Conte D., Podrascanin Z., Reale M., Romera R. and Somot S. *(submitted to clim. dyn.)*
4. A study of the heat budget of the Mediterranean Sea from MedCORDEX forced and coupled simulations: Harzallah A., Jordà G., Dubois C., Sannino G., Carillo A., Li L., Arsouze T., Cavicchia L., Beuvier J. and **Akhtar N**. *(submitted to clim. dyn.)*
5. Temperature-precipitation extremes relationship in the Mediterranean: past climate assessment and projection in anthropogenic scenarios: Drobinski P., Da Silva N., Panthou G., Bastin S., Muller C., **Ahrens B.,** Borga M., Conte D.,Fosser G., Giorgi F., Güttler I., Kotroni V., Li L., Morin E., Onol B., Quintana-Segui P., Romera R. and Zsolt T. C. *(in revision to clim. dyn.)*
6. Assessment of multiple daily precipitation statistics in ERA- Interim driven Med-CORDEX and EURO-CORDEX experiments against high resolution observations: Fantini, A., F. Raffaele, C. Torma, S. Bacer, E. Coppola, F. Giorgi**, B. Ahrens**, C. Dubois, E. Sanchez (2015). *(submitted to clim. dyn.)*

References:

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Madec, G., and the NEMO Team: NEMO Ocean Engine, Note Pôle Modél. 27, Inst. Pierre-Simon Laplace, Paris, 2008.

Rockel, B., Will, A., and Hense, A.: A spectral nudging technique for dynamical down-scaling purposes, The regional climate model COSMO-CLM (CCLM), Meteorol. Z., 17, 347–348, 2008.

Valcke, S. The OASIS3 coupler: a European climate modelling community software, Geosci. Model Dev., 6, 373–388, doi:10.5194/gmd-6-373-2013, 2013.