

Extreme Mediterranean cyclones and associated variables in an atmosphere-only vs an ocean-coupled regional model
WCD-2024-2829

This paper aims to quantify the impact of air-sea interactions during extreme cyclone events on the structure of the atmospheric and oceanic boundary layers. This is addressed by performing two 33-year simulations using coupled (CPL) and atmosphere only (STD) models. First the cyclone climatologies from the CPL and STD simulations are compared to an atmospheric reanalysis dataset (ERA5). Then the climatological SST fields during extreme cyclones from the CPL and STD are compared to satellite-based SST dataset (MED-REP-L4). Next, the CPL and STD atmospheric fields are compared and finally the evolution of the ocean structure in the CPL simulation is compared to an ocean reanalysis dataset (CMES). I found the paper a bit confusing to read and the grammar is incorrect in many places. The motivation for the analysis and importance of the study needs more emphasis before the paper can be considered to be suitable for publication.

General comment

1. There are fairly large differences between the CPL/STD cyclone climatologies and ERA5, shown in figs 2 & 3, which are dismissed as small in the paper. Do these differences result in differences in the cyclone-climatology atmospheric fields (precipitation, pbl height, 10m wind speed, evaporation and 2m specific humidity)? Figure 4 does not compare with ERA5 fields so it's not possible to determine the answer to this question.
2. There are large differences between CPL and satellite-based SST cyclone climatology fields (0.5K) shown in figs 5 and 6. Unsurprisingly, these differences go on to dominate the spatial maps shown in figures 7 and 8, as demonstrated by the high correlations in figure 9. I missed the importance of this result. The authors have demonstrated that differences in SSTs leads to large differences in the atmospheric fields, but what is the link to the extreme cyclones. Are the SST differences larger during cyclone events than non-cyclone events, and thus accurate prediction of extreme cyclones is important? If so, do the non-cyclone climatologies also need to be included to demonstrate this?
3. Figure 10 is the most interesting result because it removes the bias in SST and thus allows a comparison of the effect of coupling. What causes the difference between CMEMS and STD SST evolution (using daily ERA5 SST) prior to the cyclone event?

Specific comments

1. Line 12, 13: ENEA-REG, Med-CORDEX, ERA5, WRF, MITgcm acronyms need to be defined. Is it important for the general reader to know the names of these datasets and models? If not, please consider writing the abstract using more general language and leave the detailed acronyms to the main body of the paper.
2. Line 24: What do the authors mean by the 'effectiveness' of the coupled model?
3. Line 54: Which side of the Alps is the 'leeward side'? Surely, this depends on the wind direction?
4. Line 80: What do the authors mean by 'proper' air-sea coupling effects?
5. Line 107: Why is the role of SST and air-sea fluxes on extreme events expected to be stronger in the Autumn season?
6. Line 163: 500 cyclones represent almost 20% of the cyclone distribution. This does not seem particularly extreme.
7. Line 175: I found the terminology θ -gradient ambiguous. Why not use static stability or potential temperature lapse rate which are more standard terms for such a metric?
8. Line 216: Why is a radius of 1.5° around the cyclone centre chosen? This seems to suggest that the enhanced surface fluxes occur very close to the cyclone centre and are axisymmetric. Is this supported by any analysis?
9. Figure 2: This figure shows that there is some seasonal dependence on the performance of the CPL and STD model simulations when compared to ERA5 for predicting the number of cyclones. Is there also seasonal dependency in the other statistics (intensity, lifetime and speed)?

10. Figure 3: The maxima in frequency of cyclones in CPL model, over land, does not correspond to maxima in the STD simulation. Furthermore, the frequency over the ocean reduces in the CPL simulation. Therefore, I do not think the evidence supports the statement on line 230 that 'the spatial distribution of extreme cyclones is similarly reproduced by the models compared to ERA5' or on line 241 that 'differences between STD and CPL are limited and non-significant'. Perhaps difference plots would demonstrate the similarity or differences in the simulations more clearly?
11. Line 264: How do the cyclones 'turn into precipitation when they reach the coast'? Do you mean that at the coast, orographic ascent causes water vapour to be converted into water droplets, which then grow into precipitation droplets?
12. Line 267: Can the authors expand on their statement that the transition between sea and land fosters the convection processes? Are you referring to convergence at the coast?
13. Figure 4: How do these composites differ from the full winter climatology? Perhaps anomaly fields could be shown?
14. Fig 6: The order of the figures is different to that in figure 5 which confused me for a while.
15. Fig 7: The order of the figures is different to those in fig 4. Could they be reordered to be consistent?
16. Figure 8: Since these fields are similar to those shown in previous figures, I do not think they add much to the analysis.
17. Line 304: Reference is made to latent and sensible heat fluxes. Could these fields be shown instead of evaporation, wind speed, specific humidity and theta gradient? They are directly responsible for increasing the vertical exchange of heat and moisture between the Mediterranean sea and overlying atmosphere so would be more relevant.
18. Figure 10: It appears that the MLD deepens more in the CPL model than in the CMEMS, why is this?
19. Figure 10: It is interesting that the MLD is twice as deep in winter than in autumn. Is this why the change in SST is so much smaller in winter?
20. Line 417: Is there evidence to support the statement that extreme cyclone significantly influences the Mediterranean climate? By climate, do the authors mean the long-term average conditions?

Typographical errors

1. Line 20: 'Planet' should be 'planetary'.
2. Line 20: 'mixing of the turbulent processes' should be 'mixing by the turbulent processes'.
3. Line 98: 'insights on how' should be 'insights into how'.
4. Line 117: 'than STD' should be 'as STD'.
5. Line 174: 'planet boundary layer' should be 'planetary boundary layer'.
6. Line 179: What is the 'e' after STD? Is this a typographical error?
7. Line 226: 'upscaled at ERA5 resolution' should be 'upscaled to ERA5 resolution'.
8. Line 290: 'norther' should be 'northern'.
9. Line 350: 'THETA' is represented as θ elsewhere.
10. Line 53: 'Not statistically significant differences' should be 'statistically insignificant differences'.