Report on the EMS24 conference, 1-6 Sep 2024, Barcelona

The role of weather and climate research in the achievement of a climate-neutral Europe

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Not only good science, but also nice people, eye-opening presentations and numerous links with societal issues were the basic ingredients of my experience at the EMS24 conference.

First of all, I had the chance to co-organize the “Mindful Climate Communication” workshop that took place on the 1st of September (https://www.ems2024.eu/programme/workshops/workshop_on_mindful_climate_communication.html). The workshop included a set of four invited presentations, a group activity and a final fish-bowl discussion. The talks touched different aspects of climate science communication that we, as physical scientists, hardly consider. They covered the cognitive biases related to the topic, the possibility of having good alliances with journalists and activists, and the importance of correctly framing the topic. One of the key messages that I took from the workshop is that we have to come together to make a good and effective communication of climate-related issues: it is a participatory and shared process that involves all elements of society. The support provided by EMS and the FuturMed COST action was crucial in making this interesting and stimulating workshop happen.

During the conference, I mostly followed sessions related to large-scale atmospheric dynamics, where I learned many things that are relevant for my ongoing postdoctoral project, entitled ELASTYC, Effects of zonaL Asymmetries in Surface Temperature changes on the planetarY Circulation. I also attended sessions on machine learning applications, air-sea interactions and boundary layer dynamics. I will briefly summarize here some of the things that I’ve learnt and that I consider particularly relevant for my work. This is not intended to be an exhaustive list or a judgment of the many numerous interesting talks and posters that I’ve attended and looked at.

Weather regimes are an important component of the large-scale atmospheric circulation. They are recurrent quasi-stationary structures of the atmospheric flow typically defined by some appropriate dimensionality reduction and clustering techniques. Messori et al. (https://doi.org/10.5194/ems2024-1006) have shown that weather regimes are characterized by a high level of persistence and a low dimensionality (from a dynamical system point of view). This is used as a proof to show that they are actual physical states of the flow and do not only have a statistical meaning. Moreover, a joint analysis of the American and Euro-Atlantic weather regimes highlights that there are physical links between the two sets of weather regimes that could serve as medium-range statistical predictability tools.

Weather regimes also influence extratropical cyclones, which are often associated with extreme events. Portal et al. (https://doi.org/10.5194/ems2024-812) have investigated the role of Mediterranean cyclones in triggering compound extreme events, where the simultaneous occurrence of extreme states (in terms of rainfall, wind, temperature, for example) is responsible for high societal impacts. The importance of cyclones for compound events is modulated by the type of event, the cyclone class and the season, with the presence of the warm conveyor belt being always a relevant feature. Compound events have also been linked to omega blocking by Mittermeier et al. (https://doi.org/10.5194/ems2024-964) that showed an interesting numerical technique to study such rare events. The technique is called ensemble boosting and consists of selecting a few analogs to the event of interest, to be perturbed and used as initial conditions for a large ensemble of simulations. Loizou and Raveh-Rubin (https://doi.org/10.5194/ems2024-102), then, have interestingly shown how atmospheric blocking and Mediterranean cyclones are connected. In particular, they have found that cyclones associated with blocking conditions are more intense and bring more precipitation, with an impact on the rainfall spatial distribution over the Mediterranean basin.

The ocean state may also play a role in atmospheric blocking events. For example, Greenland atmospheric blockings have been shown to depend on the Gulf Stream heat transport by Mathews et al. (https://doi.org/10.5194/ems2024-1053). The physical explanation for that starts from a negative potential vorticity (PV) anomaly that is generated in the marine atmospheric boundary layer when the surface latent heat flux is strong (linked to the Gulf Stream heat transport). Cyclones passing over the Gulf Stream, then, bring such negative PV at higher atmospheric levels via their warm conveyor belts. This excess negative PV is associated with an increase in Greenland blocking events. Another example of the complex interplay between ocean and atmosphere has been provided by Berthou et al. (https://doi.org/10.5194/ems2024-963), who discussed in detail the land and marine heatwave that struck Northwest Europe in June 2023. They found that a particularly strong atmospheric forcing produced a shallow marine heat wave that fed back on the weather dynamics, generating record-breaking land temperature in England. Global warming has also been shown to be partly responsible for such an extreme event.

To better understand climate change impacts on extratropical cyclone dynamics Sinclair et al. (https://doi.org/10.5194/ems2024-691) have introduced an interesting semi-idealized framework. It consists of a large ensemble of aquaplanet simulations where realistic cyclones are represented and the impact of a single changing parameter on the cyclone dynamics (e.g. surface mean temperature, lapse rate, relative humidity, etc.) can be directly evaluated. CMIP6 models are used to constrain the range of variability of the sensitivity parameters. Climate change is also impacting global precipitation. Benestad et al. (https://doi.org/10.5194/ems2024-135) have highlighted how daily precipitation intensity, wet day frequency and the fractional rain area are tightly related in the present climate. Based on this finding, they argue that the precipitation increase with increasing global mean temperature can be separated in a component due to Clausius Clapeyron, that affects precipitation intensity, and a component that can be ascribed to changing rainfall pattern (modified storm tracks and convective patterns) that, thus, mostly affects the fractional precipitation area.

Finally, one of the numerous interesting machine learning applications was presented by Seltz and Craig (https://doi.org/10.5194/ems2024-556), who tested how different AI-based weather prediction models reproduce the butterfly effect, finding that all of them fail to do so quite dramatically. This has important implications in the use of AI-based models to assess the spread of weather predictions, as their error growth representation is too weak.