MODELLING PARAMETERS AND IMPACTS OF FOUR EXTRATROPICAL CYCLONES UNDER FUTURE CLIMATE SCENARIOS

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INTRODUCTION

Coastal zone is among the most vulnerable areas of the Earth to global warming, firstly, due to anticipated mean sea level rise, and secondly, regarding changes in storm activity. In Europe, much of the high-impact weather events are associated with extratropical cyclones (ETC). It is highly possible that tropical cyclones will get stronger under future climate conditions, however projections for ETC-s are still far more mixed. The study at hand is an improved extension to that of Mäll et al. (2017) where the authors aimed to study how an individual extreme storm (2005 Gudrun) would change under future climate conditions. The main aim is to learn whether the similar results are found for four different (tracks, thermal conditions) ETC-s under improved methodology and homogenous initial and boundary conditions in order to decrease uncertainty and draw stronger climatological generalizations. The study area is the Baltic Sea region and more specifically Estonia.

METHODOLOGY

The framework of the methodology in its core is somewhat similar to that of Mäll et al. (2017), consisting of an atmospheric model WRF-ARW and ocean model FVCOM(-SWAVE). It uses top-down approach, where the atmospheric model is run first and the output is subsequently used as an input to drive the ocean model (hindcast and future simulations).

The major components of this method lie in the atmospheric datasets. Firstly the models are driven by historical NCEP CFSR reanalysis datasets. The results of these simulations are compared against observational data to verify the degree of accuracy of the models (hindcast). Secondly, three parameters (atmospheric air temperature, sea surface temperature and relative humidity) from the general circulation models (GCM) are extracted for years 2050 and 2100 (RCP4.5 & RCP8.5) and interpolated into the meteorological fields of historical datasets, thus creating the necessary boundary conditions for the future simulations. Lastly, these future simulations will be analyzed against the base case simulations to draw the final conclusions.

Additionally, a sensitivity analysis of WRF model set-up is conducted to find the best forcing data, domain configuration and physics schemes for the study area. The biggest change however will be in the usage of CGM-s. According to Zappa et al. (2013) the higher resolution (about T106 or N96) CMIP5 models would be recommended to better capture the behavior of North Atlantic storm track during the boreal winter months. Considering that, 19 CMIP5 GCM-s were selected for this study which meet the suggested requirements.

RESULTS AND DISCUSSION

From the past decade, four notable yet different, storm cases (Fig. 1) have been chosen to further study the effects of potential climate change scenarios to the development of ETC-s in the mid-latitudes, with focus

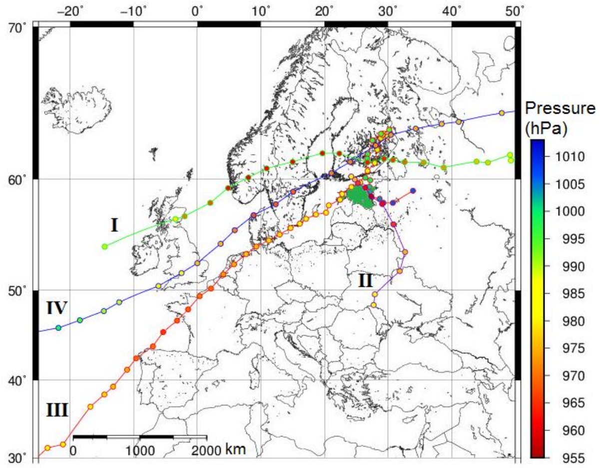

Figure 1 - Four storm tracks following the MSLP; I - 2005 Jan Gudrun, II - 2008 Nov storm., III - 2010 Feb/Mar Xynthia, IV - 2013 Oct St. Jude

being on the Baltic Sea region. Two storm events are directly related to storm surges (Gudrun & St. Jude). Figure 2 shows the 2005 Gudrun storm surge hindcast results with the NCEP FNL dataset, where the first peak difference was 4% (275 cm vs 264 cm). The other two storms are not surge related, but rather serve a prupose to determine whether different parameters (wind, pressure & precipitation) would be enhanced under future condtions.

Gahtering a large pool of data on development of different storms has the potential to give a more confident results on how these storms might change or not change in the future and how would that translate to coastal communities which are most susceptible to these events.

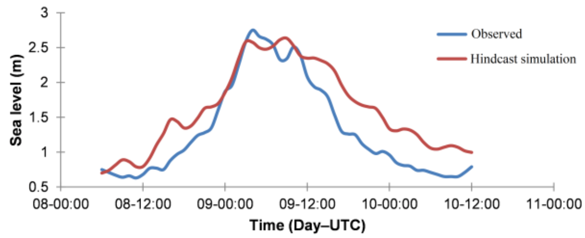

Figure 2 - 2005 Gudrun FVCOM surge simulation results at Pärnu tide gauge with NCEP FNL dataset

REFERENCES

Mäll, Suursaar, Nakamura, Shibayama (2017): Modelling a storm surge under future climate scenarios: case study of extratropical cyclone Gudrun, Natural Hazards, SPRINGER, (-), pp. 1-26.
Zappa, Shaffrey, Hodges, Sansom, Stephenson (2013): A multi-model assessment of future projections of north atlantic and european extratropical cyclones in the CMIP5 climate models, Journal of Climate, AMERICAN METEOROLOGICAL SOCIETY, (26), pp. 5846-5862.