Setup of a data based simulation model for the assessment of resilience and risk factors in coastal regions

Aufsetzen eines datenbasierten Simulationsmodells zur Bewertung von Resilienz und Risikofaktoren in Küstengebieten

Bachelorthesis or higher

Prerequisites:
120 CPs, all basic modules passed, and 13 weeks of internship.

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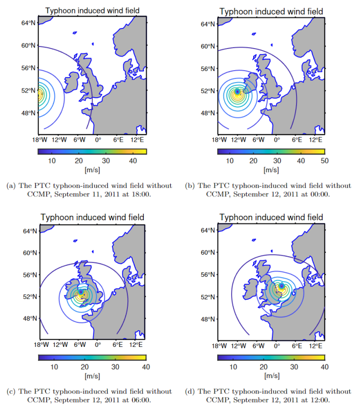

Fig. 1: Möglicher tropischer Zyklon in Europa

Despite the ongoing increase in computational performance in our current technology, the simulation and assessment of natural hazards such as earthquakes, floods, tsunamis, typhoons, and droughts continue to present challenging problems. Often, defining clear model boundaries is not straightforward, as these events can be the result of complex interactions between global variables and parameters. Furthermore, with globalization and industrialization driven by expanding markets, not only are the physical connections complex, but so are the human-made systems, including economic relations, infrastructural dependencies, and cultural arrangements.
In Zhang et al., 2020, a novel systematic framework was presented to establish connections between wind disasters and the resulting economic effects caused by disrupted port operations [1]. A data-driven hybrid wind simulation model was used to estimate wind speeds based on simulated typhoon trajectories. This physical model was combined with an economic model to estimate the total financial loss of four Chinese harbors. A critical wind speed threshold was defined to indicate when ports should immediately cease operations.
In this project, the hybrid wind field model will be revisited and validated using the data and descriptions provided in [1]. Additionally, considerations will be made for adapting this model for use in other regions, such as Europe. The validation will involve new data and different background wind information. Furthermore, a discussion of alternative models, beyond those presented in [3] and [4], will be explored. The economic loss of the four Chinese harbors will be revisited, and the possibility of collecting similar data for European ports (e.g., Rotterdam, Antwerp, and Hamburg) will be explored [2]. This exploration may provide insights into enabling the use of the systematic framework for other regions. Finally, the possibility of incorporating another load model will be discussed. For instance, in the Hamburg harbor, port operations typically do not cease based on specific wind speeds but rather on expected water levels. This raises questions about how to incorporate specific water levels as critical thresholds in the model to estimate the number of days of port disruptions caused by water-level-induced disasters, in addition to wind-induced ones. For this thesis, the following prerequisites are mandatory:

- Proficiency in programming (average to good programming skills).
- Some experience with simulation models and solvers (e.g., FEM, CFD, FDM).
- Knowledge of hydrodynamical systems or coastal engineering subjects is a big plus.
- Interest in risk assessment (e.g., having completed a module on risk & reliability analysis).

Literature (Selection)

[1] *Zhang*, Y., *Wei*, k., *Shen*, Z., *Bai*, X., *Lu*, X., *Soares*, C.G.,2020: Economic impact of typhoon-induced wind disaster on port operations: A case study on ports in China. Int. Jour. of Disaster and Risk Reduction(50) 101719.
[2] *Sun*, Y., *Bittner*, M., *Zhang*, Y., *Beer*, M., 2022: Simulation and risk evaluation of possible superstorms hitting Europe's north sea coast, Proceedings of the 8th International Symposium On Reliability Engineering and Management (ISRERM 2022), Hannover, Germany.
[3] *Ueno*, T., 1981. Numerical computations of the storm surges in tosa bay, J. Oceanogr. Soc. Jpn. 37(2) 61-73.
[4] *Wang*, X., 1991. Research and applications of a forecasting model of typhoon surges in China seas, Adv. Water Sci. 2(1) 1-10 (in Chinese).
[5] *Zhang*, Y., *Beer*, M., *Quek*, S.-T., 2015. Long-term performance assesment and design of offshore structures. Computers and Structures 154 101-115.
[6] *Wentz*, F.J., J. *Scott*, R. *Hoffman*, M. *Leidner*, R. *Atlas*, J. *Ardizzone*, 2015: Remote Sensing Systems Cross-Calibrated Multi-Platform (CCMP) 6-hourly ocean vector wind analysis product on 0.25 deg grid, Version 2.0. Remote Sensing Systems, Santa Rosa, CA. Available online at www.remss.com/measurements/ccmp. [Accessed 01.09.2020]
[7] *Luettich*, R., *Westerink*, J., *Scheffner* , N., 1992: ADCIRC: An Advanced Three-Dimensional Circulation Model for Shelves, Coasts, and Estuaries. Report 1. Theory and Methodology of ADCIRC-2DDI and ADCIRC-3DL.

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