Exceptional weather and sea level events in changing climate: experiences on providing user-relevant information to support nuclear power plant safety in Finland

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Background and motivation
- Energy technologies not resulting in direct greenhouse gas emissions include renewable energy sources and nuclear energy (NE).
- In Finland in 2016, ~1/3 of electricity was produced with NE, and its portion of total energy consumption was 17%.[1] (Fig. 1).
- An issue in using NE is its safety: the release of radioactive substances from a nuclear power plant (NPP) to the environment must be prevented with high reliability.

Extreme weather and sea level events affect the design principles of NPPs, may hamper normal NPP operation, or endanger a safe shutdown.

Probability estimates of exceptional weather and sea level conditions in the current and future climate are needed for:
- the determination of the design basis for new power plant units
- the Probabilistic Risk Assessment of new and existing NPPs
- periodic safety reviews of existing NPPs

Weather-related risks for nuclear power plants
- Ice, hail, ice, organic material in water
- Snow, frost, freezing rain
- Lightning
- Floods due to high seawater or heavy rain
- High atmospheric temperature, high air enthalpy
- High wind speed

Main challenges in providing user-relevant information to support nuclear safety in Finland
- Major nuclear accidents are typically low-probability–high-consequence events
- Probabilities of occurrence of extremely rare events, unseen in the past 100 years of observations and corresponding to return periods of thousands or even millions of years, are needed.
- The ongoing climate change alters the frequencies and severity of the events in the future.
- Weather forecasts and warnings issued to the public, or to authorities, are not designed with the needs of nuclear power production in mind.

Research to support nuclear safety in Finland
- FMI has examined extreme weather, climate and sea level events potentially posing risks to NPPs since 2007,[2] currently in the PREDICT project within the SAFIR2022 program.[3]
- Aim: to develop and maintain research expertise and methods needed for assessing probabilities of occurrence of safety-relevant single and compound extreme events.
- Research topics

Improving forecasts of extreme weather and sea level events
- Short-term forecasts of extreme weather and sea level events and conditions may allow NPP operators to take appropriate action, provided that they can be issued in time.
- A workshop between experts in nuclear power production and in weather prediction on 9 Oct 2019
  - to decide upon a set of relevant events to be predicted and
  - to deliver recommendations for weather services in support of safe and economic nuclear power production

References
[11] Leijala U. 2018: Climate studies of extreme precipitation and wind events over the Baltic Sea region. These studies are based on the CORDEX regional climate models and applied to the Baltic Sea region. The main results include: 1. The regional climate model MECOSEL-KARMA is used to simulate extreme precipitation events over the Baltic Sea region. 2. The model results are compared with observations from weather stations. 3. The model results are compared with observations from radar data. 4. The model results are compared with observations from satellite data. 5. The model results are compared with observations from historical data.

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