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ADVANCED CYBER TECHNOLOGIES

Weather Forecast Models

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1 INTRODUCTION

Extreme weather conditions can cause substantial disruptions in daily life, incur significant monetary costs and even cause deaths. The impacts of adverse weather events on society have been recently investigated in many studies, e.g. EU-funded projects EWENT (ewent.vtt.fi), MOWE-IT (mowe-it.eu), RAIN (rain-project.eu) and INTACT (intact-project.eu). Both in the EWENT and MOWE-IT projects the focus was on the impacts of adverse weather on the European transportation system, whereas in RAIN and INTACT the perspective was a bit wider covering different types of Critical Infrastructure (CI). The managers of different CI must be prepared for adverse weather events, and this calls for warning services. National weather services typically issue warnings against adverse weather events based on specific criteria, or event (impact) thresholds that are relevant for a given region. The warnings typically cover a 24- or 48-hour time period, but many weather services also produce so-called early warnings in the 2-5 day range (early warnings). Warnings at the European level are provided by the Meteoalarm (meteoalarm.eu) service under the EUMETNET (European Meteorological Services Network) umbrella, where most European national weather services have generated the original, local input to the Meteoalarm framework. They use warnings that are based on nationally defined fixed thresholds.

Heavy precipitation events often trigger severe floods that can cause large damage. Both short-duration but heavy downpours or long-lasting but moderate rainfalls can have negative impacts. Such phenomena were studied in detail in the RAIN project. The stakeholder and weather service interviews showed that a universal impact-threshold value is not easy to define for heavy precipitation. The thresholds being highlighted varied between 20 mm/hour to 30 mm/hour for short-term heavy precipitation events, and from 50 mm/day up to 100 mm/day for longer-lasting rain events (Nissen and Ulbrich, 2016; Groenemeijer et al., 2016). The potential users of I-Reactor system are typically disaster management authorities.

Instead of using fixed precipitation threshold values, another approach is to use local return values, i.e. the amount of precipitation per time unit, exceeded on average every N years (N being for example 10, 100 etc). In the RAIN project, 10-year return values (levels) for the detection of harmful precipitation events were used and this measure was also one of the extreme weather indicators (EWIs) used in the INTACT-project. These kind of measures are suitable for research purposes, whereas the use of a fixed threshold is more convenient for operational forecasting and warning procedures. In the INTACT-project, the EWIs were defined based on five case studies in different locations in Europe, as well as on input from stakeholders. The different EWIs enabled the charting of adverse weather impacts on CI in the present climate and also in the future climate. This kind of approach is suitable for climate change oriented studies.

Concerning warning services in the short or medium time-range, the threshold can be constant in a large area (e.g. for wind gust 17 m/s), or the threshold can be calculated (e.g. for every gridpoint) based on local climatology and the related probability distribution, according to percentiles (e.g. 2.5 / 97.5) used in many National Weather Services. Here in the I-REACT project we have done it both ways.

It is extremely important for society, the economy on which it depends, and the environment to produce accurate predictions of upcoming severe weather events. Due to the fact that weather forecasts are inherently uncertain, it is better to provide a distribution or range of possible future states of the atmosphere instead of one single 'best guess'. This type of approach is especially useful when forecasting the rare adverse weather events that often are also *extreme*.

1.1 PURPOSE OF THE DOCUMENT

The goal of this report is to provide a detailed description of the weather models and processes applied to develop the weather forecast products for the I-REACT project in the context of task 4.1 in work package 4. In this task, the Finnish Meteorological Institute (FMI) developed weather forecasts for time scales that range from hours up to two weeks. The project partner Meteosim focused on developing seasonal forecasts with time scales ranging from 6 to 9 months. The focus in this particular forecast production was to concentrate on the prediction of rare and high-impact weather events that could potentially produce significant damages.

1.2 STRUCTURE OF THE DOCUMENT

This report is organised in the following manner:

- **Chapter 1** includes this introduction and a description of the document;
- **Chapter 2** introduces the schematic data flow from input to output of the implemented weather forecast models;
- **Chapter 3** provides information about the applied numerical weather prediction and ensemble forecasting along with the specific description of the weather models used;
- **Chapter 4** describes the calibration methods used to improve the raw ensemble forecasts. In this chapter the verification results of the raw and calibrated ensemble forecasts are shown;
- **Chapter 5** introduces the weather forecast products providing lead times up to 15 days in advance specifically produced for the I-REACT project;
- **Chapter 6** describes the seasonal time-scale forecasts from input model to output products and;
- **Chapter 7** concludes the information provided in this report.

1.3 ACRONYMS LIST

CBRT	Cube root
CNTL	Control forecast
ECMWF	European centre for medium-range weather forecasts
ECMWF-ENS	ECMWF Ensemble Prediction System
FMI	Finnish Meteorological Institute
FWI	Fire weather index
GLAMEPS	Grand Limited Area Ensemble Prediction System
GRIB	Gridded Binary

HIRLAM	High resolution limited area model
HRES	High resolution model
IDI	I-REACT Data Interface
IRI	International Research Institute
JSON	JavaScript Object Notation
NetCDF	Network Common Data Format
NGR	Non-Gaussian Regression
NMME	North American Multi Model Ensemble
NWP	Numerical Weather Prediction
PR	Private
PU	Public
RMSE	Root Mean Square Error
TIFF	Tagged Image File Format
UTC	Coordinated Universal Time

1.4 REFERENCE AND APPLICABLE DOCUMENTS

ID	Title	Revision	Date
[RD01]	D2.1 Report on Multi Hazard Requirements analysis	-	17/10/2016
[RD02]	D2.6 Report on Design of Data Interfaces	-	31/10/2016
[RD03]	D2.7 Report on Technical Requirements and Overall System Architecture	-	30/11/2016