- FORESEE -

Future proofing strategies FOr RESilient transport networks against Extreme Events

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Assesment of existing climate databases

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1 INTRODUCTION

In recent years, the European transport infrastructures have been increasingly exposed to several extreme weather events (EWE). The starting point for evaluating the risk associated to that kind of events is to have access to the best source of information available in order to characterize EWE and to study its natural variability in time. Furthermore, some of these sources of information, such as satellite databases or numerical climate models, have a great potential since they allow us to cover non-instrumented areas as well as to make future predictions for different periods of interest.

In the present document, we carry out an extensive review of climatic databases, prioritizing European ones that could be used to analyze the effects of extreme weather events on transport infrastructures. The databases presented here provide high frequency information as well as an adequate spatial resolution. Three different types of databases will be included in the analysis:

- Instrumental: Pluviometric and meteorological station information, which constitutes the best representation of perceived weather. This will be the primary source of information for any analysis.
- Satellite: Satellite information presents biases that need to be accounted for, but it provides areal coverage that serves to properly include the spatial structure of the hydrometeorological variables.
- Numerical models: Numerical models do not normally capture the small-scale dynamics of climate, but they constitute an essential tool to study climate variability in decennial time scales.

Below we present a selection of the different databases that should be used to analyse the effect of climate and extreme weather events on transport infrastructures.

2 INSTRUMENTAL INFORMATION

Instrumental data is data obtained from a meteorological station. It is the most reliable weather information. However, it presents a number of limitations; it is subject to various types of uncertainties due to measurement errors, poor space-time coverage and insufficient time resolution; being this later issue crucial to capture extreme events.

To cover these limitations several products have been developed, in recent years that use geostatistical techniques and instrumental data to simulate continuous databases in space-time. These kinds of products are known as gridded datasets.

2.1 INSTRUMENTAL DATABASES

- **Global Instrumental datasets**: *Global Historical Climate Network Daily* (GHCN-daily) is a database that contains records from over 100,000 stations in 180 countries and territories. GHCN-Daily provides numerous daily variables, including maximum and minimum temperature, total daily precipitation, snowfall, and snow depth; however, about one-half of the stations only report precipitation. Both the record length and the frequency of record vary by station and cover intervals ranging from less than a year to more than 175 years (Menne, M.J., et al., 2012).

- **Regional (Europe) instrumental datasets**: National or local meteorological agencies have their own network of meteorological stations that are normally available at a daily resolution for free. These databases normally contain information about precipitation, temperature, air humidity, wind, etc. Local agencies often have information of historical meteorological records that might be very useful for risk assessment studies. There is currently no centralized repository of climate and weather information where the information from the national agencies is easily accessible.

- **ECAD**: The ECA (European Climate Assessment) dataset provides daily observation time series at meteorological stations in most of Europe and the Mediterranean. ECAD is available for free for non-commercial applications.

2.2 GRIDDED DATASETS

- **Global gridded datasets**: CPC Global Unified Gauge-Based Analysis of Daily Precipitation is a gauge-based analysis of precipitation at the daily temporal scale with global coverage. More than 30,000 stations are used to generate the gridded dataset. Comparisons with historical records, as well information from nearby stations, radar, satellite and numerical models are used for quality control. Precipitation fields are created interpolating the data, after the quality control procedure. The interpolations accounts for orographic effects. The daily analysis is constructed on a 0.125 degrees, both on latitude and longitude, grid over the land areas of the globe, and released on a 0.5 degrees grid over the same domain for the period from 1979 to the present (Xie, P., 2010).

- **Regional (Europe) gridded datasets:** List of daily gridded datasets**.** Gridded datasets were generated by interpolated techniques.
  - **Europe**: E-OBS (v10.0) (Haylock et al., 2008) and HMR (Dahlgren et al., 2014).
  - **European Alps**: EURO4M-APGD (v1.2) (Isotta et al., 2014).
  - **Germany**: REGNIE (DWD, 2009)
  - **Sweden**: PTHBV (Johansson, 2002)
  - **Norway**: KLIMAGRID (Mohr, 2009)
  - **Spain**: Spain02 (Herrera et al., 2012)
  - **Carpathians**: CARPATCLIM (Spinoni et al., 2015)
  - **United Kingdom**: UKCP09 (Perry and Hollis, 2005)
  - **France**: SAFRAN (Quintana-Seguí et al., 2008; Vidal et al., 2010).

3 SATELLITE OBSERVATIONS

Satellites provide precipitation estimates at a global scale. In some cases, the temporal resolution is even subdaily. Satellite observations are indirect measurements, as the observation does not correspond with precipitation but instead with other atmospheric characteristics such as cloud temperatures, and echoes from the precipitating particles and the hydrometeors. These observations are converted into precipitations amounts with the help of different models. Nonetheless, satellite information is very useful to complement, and even to fill in data gaps, on site measurements. Satellite can also complement radar measurements. As satellites make use of electromagnetic radiation emitted or reflected by the different phenomena, it can provide a more complete description of the precipitation process, as it captures its three-dimensional structure.

Biases in satellite observations of rainfall time series are influenced by errors in both rainfall frequency and rainfall intensity. Satellite precipitation will thus be corrected using meteorological stations in the magnitude of rainfall, but not in its temporal structure.

The most important satellite databases are presented in the following paragraphs:

- TRMM**:** The Tropical Rainfall Measurement Mission (TRMM), is a joint mission between the National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency (JAXA). It was launched in 1997. TRMM was designed to measure from heavy to moderate rain precipitation over subtropical and tropical latitudes. The measurements from TRMM served to advance the understanding of tropical precipitation, most notably over the ocean where no continuous historical record exists, by providing three-dimensional images of storm intensity and structure from space (Huffman, G.J., 2007).
  - Data Period**:** 1997–2015.
  - Coverage**:** 60°S to 60°N.
  - Resolution**:** 0.25°x0.25°.
  - Time steps**:** 3-hours.

- GPM: another joint NASA-JAXA mission, successor to TRMM, called the Global Precipitation Measurement (GPM) Core Observatory was launched on February 28, 2014 from the Tanegashima Space Center in Japan. It carries two instruments -the Dual-frequency Precipitation Radar (DPR) and GPM Microwave Imager (GMI)-. The serve to collect observations that allow scientists to analyze storms in more detail. The DPR provides a 3D profile of the storm -not unlike the information obtained from a CAT scanner- that shows the intensities of precipitation, solid and liquid. The GMI provides a 2D image to study in detail falling snow and rain -similar to the information obtained from X-rays-. The Core Observatory makes part of an international constellation of satellites that together provide global observations of precipitation from space—called the GPM mission.
  - Data Period**:** 2014–Present.
  - Coverage**:** 60°S to 60°N.
  - Resolution**:** 0.1°x0.1°.

- Time steps: 3-hourly.

- PERSIANN-Cloud Classification System (PERSIANN-CCS) is a real-time global high resolution (0.04° x 0.04° or 4km x 4km) satellite precipitation product developed by the Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California, Irvine (UCI). The PERSIANN-CCS system enables the categorization of cloud-patch features based on cloud height, areal extent, and variability of texture estimated from satellite imagery. At the heart of PERSIANN-CCS is the variable threshold cloud segmentation algorithm. In contrast with the traditional constant threshold approach, the variable threshold enables the identification and separation of individual patches of clouds. The individual patches can then be classified based on texture, geometric properties, dynamic evolution, and cloud top height. These classifications help in assigning rainfall values to pixels within each cloud based on a specific curve describing the relationship between rain-rate and brightness temperature. Precipitation intensity and distribution of classified cloud patch is initially trained using ground radar and TRMM observations. The PERSIANN-CCS enables recursive (in space and time) data assimilation and system training, allowing for flexibility in the adjustment of the cloud-rain distribution curves as new ground or space-based radar measurements become available (Nguyen, P., et al., 2018).
    - Data Period: January 2003–Present.
    - Coverage: 60°S to 60°N.
    - Resolutions: 0.04°x0.04°.
    - Time steps: 1-hourly.

4 NUMERICAL MODELS

Climate models simulate the interactions of the atmosphere, oceans, land configuration and ice. There are mainly three kinds of numerical models databases that are useful for risk assessment studies. The first kind are **short-term forecasting products.** Numerical weather prediction uses mathematical models of the atmosphere and oceans to predict the weather for the following days based on current weather conditions. A number of global and regional forecast models are run in different countries worldwide, using current weather observations relayed from radiosondes, weather satellites and other observing systems as inputs. Short-term numerical models are very useful to predict and prepare for extreme events in the short term (1 to 7 days).

A second type are **reanalysis databases.** Reanalyses are created via an unchanging ("frozen") data assimilation scheme and model(s) which ingest all available observations every 6-12 hours over the period being analyzed. This unchanging framework provides a dynamically consistent estimate of the climate state at each time step. The one component of this framework, which does vary, are the sources of the raw input data. This is unavoidable due to the ever-changing observational network, which includes, but is not limited to, radiosonde, satellite, buoy, aircraft and ship reports. Currently, about 8 million observations are ingested at each time step. Over the duration of each reanalysis product, the changing observation mix can produce artificial variability and spurious trends. Still, the various reanalysis products have proven to be quite useful when used with appropriate care.

Finally, we can find **seasonal prediction**. Seasonal forecasts do not aim to predict the timing of a particular weather event with any accuracy; however, the likelihood of receiving above-, near- or below-normal precipitation/temperature during the next season, or similar-in-length period, can be predicted in some cases and for some regions, particularly in the tropics, where teleconnections and synoptic patterns explain a big part of the natural variability.

The numerical models used to make the three types of products (short-term forecasting products, reanalysis databases and Seasonal prediction) are often the same. Their differences reside mainly in the parameterization of each model as well as in the forcing used.

4.1 SHORT-TERM PRODUCTS

- Global Forecast System (GFS): The Global Forecast System (GFS) is a weather forecast model produced by the National Center for Environmental Prediction (NCEP). Dozens of atmospheric and land-soil variables are available through this dataset, from temperatures, winds, and precipitation to soil moisture and atmospheric ozone concentration. The entire globe is covered by GFS at a base horizontal resolution of 18 miles (28 kilometers) between grid points, which is used by the operational forecasters who predict weather up to 16 days in the future. Horizontal resolution drops to 44 miles (70 kilometers) between grid points for forecasts between one week and two weeks.
    - ❑ Data Period: January 2007–Present.
    - ❑ Coverage: 90°S to 90°N.
    - ❑ Resolutions: 28x28 km.
    - ❑ Time steps: 3-hourly.

- ECMWF: The European Centre for Medium-Range Weather Forecasts (ECMWF) creates forecasts for the upcoming 15 days and is a global leader in forecast skill. However, it offers only a small number of parameters for free. The 00Z and 12Z runs are coming in twice daily between 6 and 7 UTC and 18 and 19 UTC.
    - ❑ Data Period: January 2003–Present.
    - ❑ Coverage: Europe.
    - ❑ Resolutions: 0.1°x0.1°.
    - ❑ Time steps: 3-hourly.

- UKMO: Model output from the United Kingdom Met Office (UKMO). Maps are updated twice daily around 6:45 and 18:45 UTC. Only basic pressure maps are available and forecast data ranges from day 3 to 6.

4.2 REANALYSIS DATABASES

- NCEP/NCAR: The NCEP/NCAR Reanalysis 1 project is using a state-of-the-art analysis/forecast system to perform data assimilation using past data from 1948 to the present. A large subset of this data is available from PSD in its original 4 times daily format and as daily averages. However, the data from 1948-1957 is a little different, in the regular (non-Gaussian) gridded data (Kalnay, E. et al., 1996).
  - ❑ Data Period: January 1948–Present.
  - ❑ Coverage: 90°S to 90°N.
  - ❑ Resolutions: 2.5°x2.5°.
  - ❑ Time steps: 6-hourly.

- The NCEP Climate Forecast System Reanalysis (CFSR): CFSR was created running a global, high resolution model that represented the coupled dynamics of the atmosphere, ocean, land surface, sea, ice system. CFSR includes the atmosphere-ocean couplings, a coupled sea-ice model, and assimilation of satellite radiances over the period 1979-2009. High horizontal and vertical resolution of the atmospheric model, improved assimilation schemes over the last 15 years and dynamics prescriptions of atmospheric CO2 are some additional improvements implemented lately. Some of these improvements makes CFSR more suitable for its applications to climate change studies (Saha, S. et al., 2010).
  - ❑ Data Period: January 1979–Present.
  - ❑ Coverage: 90°S to 90°N.
  - ❑ Resolutions: 38x38 km.
  - ❑ Time steps: 1-hourly.

- ERA-Interim: ERA-Interim is a global atmospheric reanalysis from 1979 and will continue to be extended forward in time until 31 August 2019. The data assimilation system used to produce ERA-Interim is based on a 2006 release of the IFS (Cy31r2). The system includes a 4-dimensional variational analysis (4D-Var) with a 12-hour analysis window. The spatial resolution of the dataset is 80 km (T255 spectral), using 60 vertical levels from the surface up to 0.1 hPa (Dee, D., 2011).
  - ❑ Data Period: 1979–Present.
  - ❑ Coverage: 90°S to 90°N.
  - ❑ Resolutions: 80x80 km.
  - ❑ Time steps: 12-hourly.

- ERA5 reanalysis: ERA5 is a global weather reanalysis. Production is complete for the period from 1979 to the present, and by the first quarter of 2020 ERA5 will provide a detailed record of the global atmosphere, land surface and ocean waves from 1950 onwards. This new reanalysis replaces the highly successful ERA-Interim reanalysis that was started in 2006 and spans the period from 1979 to the present. ERA5 is based on 4D-Var data assimilation using Cycle 41r2 of the Integrated Forecasting System (IFS), which was operational at ECMWF in 2016. ERA5 thus benefits from a decade of developments in model physics, core dynamics and data assimilation relative to ERA-Interim. In addition to a significantly enhanced horizontal resolution (31 km grid spacing compared to 79 km for ERA-Interim), ERA5 has a number of innovative features. These include hourly output throughout and an uncertainty estimate. The uncertainty information is obtained from a 10-member ensemble of data assimilations with 3-hourly output at half the horizontal resolution (63 km grid spacing). Compared to ERA-Interim, ERA5 also provides an enhanced number of output parameters, including for example a 100 m wind product. The move from ERA-Interim to ERA5 represents a step change in overall quality and level of detail (Hersbach et al. 2018).

- ❑ Data Period: 1979–Present.
- ❑ Coverage: 90°S to 90°N.
- ❑ Resolutions: 31x31 km.
- ❑ Time steps: 3-hourly.

- ERA5-Land is a reanalysis dataset that provides a coherent view of the time evolution of several variables over land. It covers several decades at an improved resolution compared to ERA5. It has been generated rerunning the land component of the ECMWF ERA5 climate reanalysis. ERA5-Land provides historical information of the land variables making use of the other components -mainly the atmospheric one- simulated in ERA5. Observations are not directly included in ERA5-Land, but they have an influence as they were included in ERA5. Pressure, ait temperature and humidity are corrected in ERA5-Land, accounting for orographic effects, in order to accommodate the higher resolution of the ERA5-Land grid. The resolution of this dataset -spatial and temporal- makes it a very useful resource for flood and drought forecasting, which in turn enable decision makers, practitioners, entrepreneurs and the general public to access very accurate information on land variables (C3S, 2019).
    - ❑ Data Period: 2001–Present.
    - ❑ Coverage: 90°S to 90°N.
    - ❑ Resolutions: 0.04°x0.04°.
    - ❑ Time steps: hourly.

- This UERRA dataset contains analyses of surface and near-surface essential climate variables from the UERRA-HARMONIE and the MESCAN-SURFEX systems. Forecasts up to 30 hours, initialised from the analyses at 00 and 12 UTC, are available. UERRA-HARMONIE is a 3-dimensional variational data assimilation system, while MESCAN-SURFEX is a complementary surface analysis system. Using the Optimal Interpolation method, MESCAN provides the best estimate of daily accumulated precipitation and six-hourly air temperature and relative humidity at 2 meters above the model topography. The land surface platform SURFEX is forced with downscaled forecast fields from UERRA-HARMONIE as well as MESCAN analyses. It is run offline, i.e. without feedback to the atmospheric analysis performed in MESCAN or the UERRA-HARMONIE data assimilation cycles. Using SURFEX offline allows to take full benefit of precipitation analysis and to use the more advanced physics options to better represent surface variables such as surface temperature and surface fluxes, and soil processes related to water and heat transfer in the soil and snow. In general, the assimilation systems are able to estimate biases between observations and to sift good-quality data from poor data. The laws of physics allow for estimates at locations where data coverage is low. The provision of estimates at each grid point in Europe for each regular output time, over a long period, always using the same format, makes reanalysis a very convenient and popular dataset to work with.

- ❑ Data Period: 1961–Present.
- ❑ Coverage: The domain spans from northern Africa beyond the northern tip of Scandinavia. In the west it ranges far into the Atlantic Ocean and in the east, it reaches to the Ural
- ❑ Resolutions: 0.1°x0.1°.
- ❑ Time steps: 6-hourly.

4.3 SEASONAL PREDICTION PRODUCTS

- The ECMWF system 4 (S4) consists of the atmosphere Integrated Forecast System (IFS, version Cy36r4) at TL255 resolution (80 km grid point resolution) coupled with the ORCA1 configuration of the Nucleus for European Modelling of the Ocean (NEMO). The IFS has 91 levels and includes the whole stratosphere. Ocean initial conditions come from an assimilation system based on an advanced multivariate variational analysis with bias adjustments. Atmosphere and land surface initial conditions come from a mixture of ERA Interim and ECMWF operations, and an offline run of the HTESSEL surface model (Kim et al. 2012, Molteni et al. 2011).
  - ❑ Data Period: 1981–2010.
  - ❑ Coverage: global.
  - ❑ Resolutions: 0.75ºx0.75.
  - ❑ Time steps: 6-hourly.

- The Météo-France system 5 (MF5) consists of the ARPEGE-Climat version 4 (Action de Recherche Petite Echelle Grande Echelle) for the atmospheric component coupled with ORCA, developed by LOCEAN, for the ocean model. The ocean initial conditions are prepared by MERCATOR. The atmospheric model has a horizontal resolution of 0.75º (TL255 truncation) and 91 leves.
  - ❑ Data Period: from latter 1990's.
  - ❑ Coverage: global.
  - ❑ Resolutions: 0.75º x 0.75º
  - ❑ Time steps: 6-hourly.

- The UK Met Office system 9 (GLOSEA5) has NEMO as ocean model with a spatial resolution of 0.25º x 0.25º with 75 levels, and the atmosphere model is GEM3 GA3.0. The operational setup N216L85 corresponds to approximately 50 km horizontal resolution and 85 levels.
  - ❑ Data Period: 1996-2010 / 1992-2013 depending on the dataset.
  - ❑ Coverage: global.
  - ❑ Resolutions: 0.25º x 0.25º.

    - ❑ Timesteps:6-hourly.

- The National Center for Environmental Prediction system version 2 (CFSv2) has an atmospheric component with a spatial resolution of 100 km and 64 vertical levels (Kim et al. 2012). The ocean component is the Geophysical Fluid Dynamics Laboratory Modular Ocean Model (MOM4) version 4 with horizontal resolution of 0.5º, refined at 0.25º between 10ºN and 10ºS, and 40 vertical levels.
    - ❑ Data Period: 1981–2010.
    - ❑ Coverage:.global
    - ❑ Resolutions: 1ºx1º.
    - ❑ Time steps: 6-hourly.

- The Japanese Meteorological Agency seasonal forecast system (JMA System 2) comes from JMA/MRI-CPS2. Atmospheric resolution is TL159 (approx. 110km grid spacing), with 60 levels and a model top at0.1 hPa. Atmosphere and land initial conditions come from JRA-55and ocean initial conditions come from MOVE/MRI.COM-G2.
    - ❑ Data Period: 1979–2014.
    - ❑ Coverage: global.
    - ❑ Resolutions: 110x110 km.
    - ❑ Time steps: 3-hourly and 6-hourly.

- The Canadian Seasonal to Interannual Prediction System (CanSIPS) from the Canadian Meteorological Centre (Montreal, CMC) has CanAM4 as atmospheric model with a resolution of T63/L35 (≈2.8° spectral grid), and CanOM4 as ocean model with a resolution of 1.41°×0.94°×L40.
    - ❑ Data Period: 2012–present.
    - ❑ Coverage: global
    - ❑ Resolutions: 2.5º x 2.5º.
    - ❑ Time steps: monthly mean.

5 CLIMATE INFORMATION FOR APPLIED STUDIES

All the databases presented in this document may be used for risk analysis under current or future conditions. A detailed consideration of the needs of the specific application need to be developed to decide which one of the databases best suits the specific needs. In this section, a small suggestion on default databases for specific uses is given to simplify the application of this state of the art review to applied problems.

5.1 CLIMATOLOGY GENERATION

Climatology generation implies characterizing a variable or several variables (rainfall, temperature, etc.) in a given area to, for example, feed a hydrologic model. Local studies are very sensitive to small-scale variations; in these cases, it would be convenient to work with instrumental databases. However, when they do not fit a specific need in terms of spatio-temporal resolution, we can use alternative sources of information, such as satellite data or reanalysis databases, to cover those limitations; the latter being the most readily available option. Unlike local studies, regional studies focus on reproducing the average regimes, and then, gridded datasets could be used as input for the study.

5.2 EVALUATION OF CLIMATE CHANGE EFFECTS

Climate change projections come from numerical models that resolve the interactions between the ocean, the atmosphere and the land in regular cells of equal size. Gridded datasets or reanalysis databases are usually used as reference data to deal with the problem of non-invariance of scale. Furthermore, we should not believe all the results given by future models' projections; we must select only a specific number of models, or weight them, depending on how well models reproduce our variable of interest. Additionally, we should also evaluate the agreement between the models before giving a result with some rigor. In the case of Europe in particular, the models with the best spatio-temporal resolution would be those that come from the EURO-CORDEX regional grid (Jacob et al., 2014).

5.3 SHORT-TERM FORECASTING SYSTEMS

Short-term forecasting systems must be used with caution since they do not offer satisfactory results in many cases. However, this kind of products normally store the predictions done in the past. Therefore, before using a specific short-term forecasting model, we must estimate the uncertainty of the results, or their predictive skill, using historical information (instrumental databases, re-analysis databases, gridded data, etc.). Furthermore, this type of model does not have enough space-time resolution to capture small-scale processes, and that is why it is essential to have experience in the area to assess the predictive capacity of these models. As an example, to predict precipitation in a specific area of northern Spain such as the Cantabrian coast, with a very complex orography, we will have to resort to very high resolution models calibrated for that particular area, as it is the case of the HARMONIE-AROME model, that is operationally run and integrates a 2.5 km horizontal resolution from the Spanish Meteorological Agency AEMET.

5.4 SEASONAL FORECASTING SYSTEMS

As with short-term forecasting systems, seasonal forecasting must be evaluated using reference information (instrumental databases, re-analysis databases, gridded data, etc.). This type of information does not serve to predict a variable for a given day, but rather serves to detect possible weather anomalies in the coming months. An interesting approach, before using this type of model, would be to directly evaluate the percentage of variance explained between the seasonal prediction model and our variable of interest (agricultural production, electrical production, etc.). CFSv2 and ECMWFsystem 4(S4) are generally the models selected to perform seasonal forecasting studies in EUROPE, however it is important to note that precipitation scores tend to show big differences between domains. Best results generally correspond to the Eastern domain. Autumn shows remarkable good scores for all models over the East-Mediterranean domain.

6 CASE STUDIES

In this section, we will mention the main databases that may be used in each one of the case studies that will be developed in the project. It is important to realize that, all case studies pursue a very similar aim -to evaluate the current and future risk over an infrastructure- and thus, except for the location specific databases, most of them should resort to the same databases.

Case Study #1. Carsoli-Torano (Italy): A24 Highway: Estrada dei Parchi highway network is affected by frequent earthquakes and traffic congestions. The pilot will be a section of the A24 Highway (from km 52 to km 73). The case study will focus on the road linear network and critical assets, giving special attention to tunnels and bridges.

The main hazards that affect this case study are earthquakes, extreme weather (mainly in the form of snow) and the cascade effects with heavy traffic. Local records for precipitation and temperature should be used, if they are available. ECAD and E-OBS databases may be used to complement this information. ERA5 information could be used to gap infilling and to extend time series as required. Climate change effects should be incorporated using the EURO-CORDEX model projections.

Case Study #2. Naples-Bari (Italy): A16 Highway: The A16 runs from Naples to Bari along the TEN-T core network Corridor n.5 Scandinavian – Mediterranean. In the area to be investigated (km 80 to km 110) are present around 20 bridges (for a total length of around 3 km) (for a total length of around 3 km). These bridges, generally with a simply supported structural scheme with beams and cross beams in prestressed post-tensioned concrete, are representative of a wide population of structures across Italy in similar conditions of environmental attack and hydrogeological risk. The highly clayey nature of these soils strongly influences the stability of the slopes.

Local records for precipitation and temperature should be used, if they are available. ECAD and E-OBS databases may be used to complement this information. ERA5 information could be used to gap infilling and to extend time series as required. Climate change effects should be incorporated using the EURO-CORDEX model projections.

Case Study #3. A67 Highway; Montabliz viaduct (Spain): The A67 highway connects the Cantabric coast with the Spanish inland provinces through the Cantabrian mountain range. This means that the A67 is a critic infrastructure for the Cantabria region due to it is the only high capacity infrastructure that connects the region with the main economic hubs and cities, including the Spanish capital, Madrid. Montabliz is the tallest viaduct of Spain and the 6th in Europe with 198m height. It is located in the A67 highway which connects Cantabria with the centre of Spain.

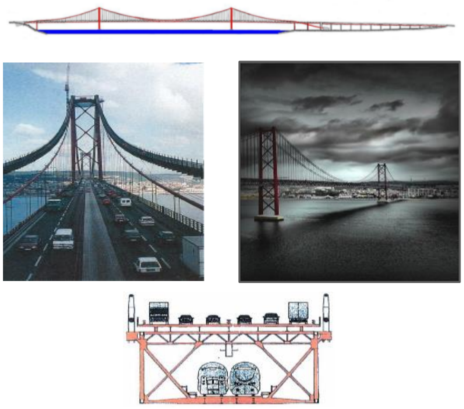
Local records for precipitation and temperature should be used, if they are available. ECAD and E-OBS databases may be used to complement this information. The Spain02 gridded database can also be used as an equivalent of observational records. ERA5 information could be used to gap infilling and to extend time series as required. Climate change effects should be incorporated using the EURO-CORDEX model projections.

Case Study #4. Railway track 6185, Oebisfelde – Berlin Spandau: The Case Study will study the influence of floodings to railway track. Therefore, the IVE chose track nr. 6185 between Oebisfelde and Berlin-Spandau, a high-speed line to connect Hannover and Berlin, owned by *DB Netz AG*. The railway track has many bridges crossing the river Elbe and several smaller rivers. The most interesting part, regarding will be the crossing of the river Elbe, which was already damaged by floodings in the year 2013.

Local records for precipitation and temperature should be used, if they are available. ECAD and E-OBS databases may be used to complement this information. The REGNIE gridded database can also be used as an equivalent of observational records. ERA5 information could be used to gap infilling and to extend time series as required. Climate change effects should be incorporated using the EURO-CORDEX model projections.

Case Study #1. M30 Ring road, Madrid (Spain): The M-30 ring-road is the most important and the busiest road infrastructure in Spain, with an ADT of over 200.000 vehicles, running through a complex urban environment, and includes circa 48 km of tunnels and a total of 220 lane km.

Local records for precipitation and temperature should be used, if they are available. ECAD and E-OBS databases may be used to complement this information. The Spain02 gridded database can also be used as an equivalent of observational records. ERA5 information could be used to gap infilling and to extend time series as required. Climate change effects should be incorporated using the EURO-CORDEX model projections.



Case Study #2. 25th April suspended bridge, Lisbon (Portugal): This case study will contribute to a major initiative of IP which will develop a "tool" based on knowledge of this bridge real behavior, and real response, in face of real actual actions and estimated future ones, allowing a safer and more economic maintenance and/or retrofitting, when needed. No weather-related risks are considered.

7 CONCLUSIONS

The present document will be sent to WP6 coordinator to include this database review document into the working documents for the project. This way, all partners will work with a common reference for climatic information. Each Case Study leader should incorporate the information presented here in their analysis, and select, when possible, the information from these climate databases for their analysis.

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