A pan - European framework for strengthening Critical Infrastructure resilience to climate change EU-CIRCLE

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on behalf of the EU-CIRCLE consortium

EU-CIRCLE Data

- Call: H2020-drs-2014: “Disaster-resilience: Safeguarding And Securing Society, Including Adapting To Climate Change”

- **Topic: Disaster Resilience & Climate Change topic 1**:

Science and innovation for adaptation to climate change: from assessing costs, risks and opportunities to demonstration of options and practices

- Grant Agreement: 653824

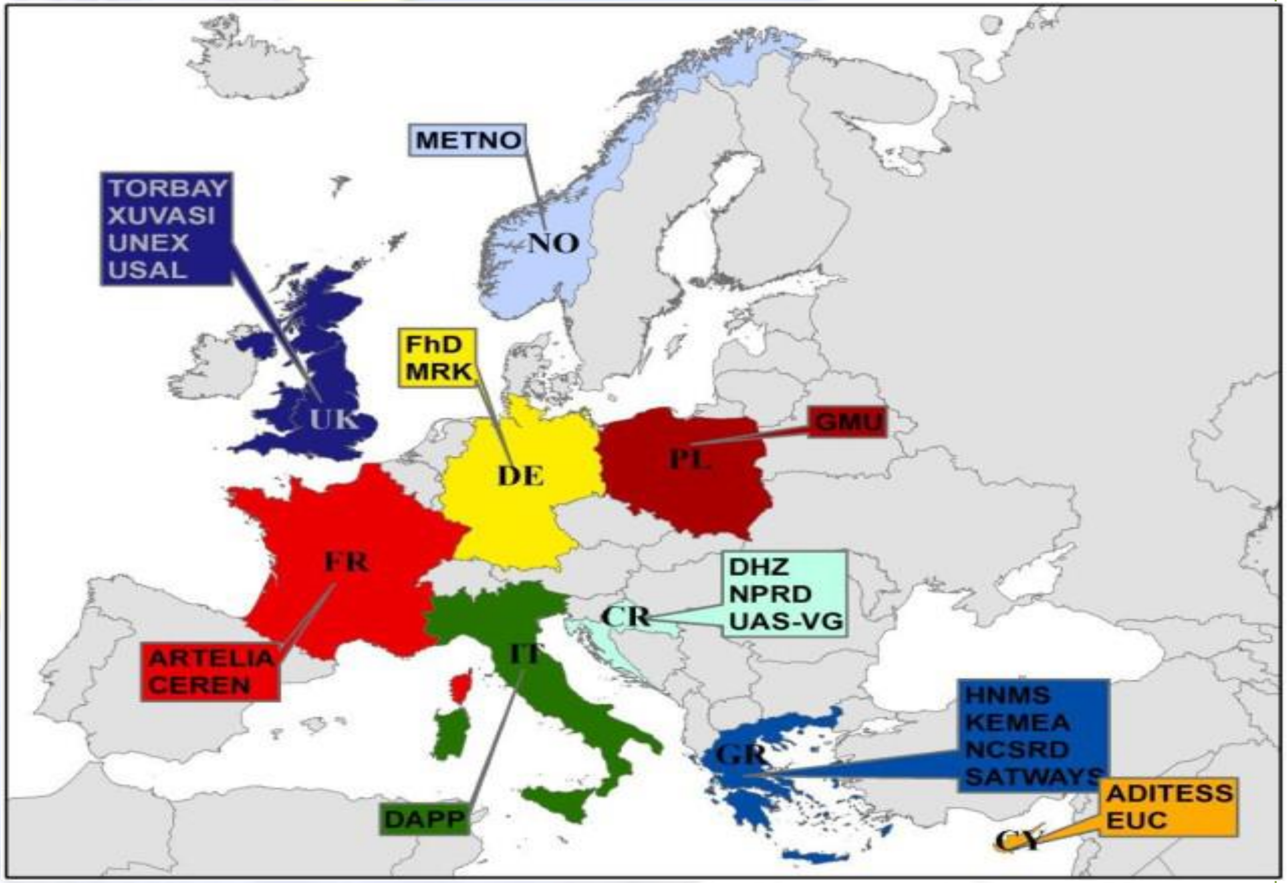
- Total Budget: 7,283,525.00 €

EU-CIRCLE Consortium

20 partners

9 EU countries

13 International members of Stakeholder's Advisory Group



EU-CIRCLE Main Scope

EU-CIRCLE's scope: to derive an innovative framework for supporting the ***interconnected European Infrastructure's resilience to climate pressures***.

Development of a validated Climate Infrastructure Resilience Platform **(CIRP)** that will:

✓assess potential impacts due to climate hazards,
✓provide monitoring through new resilience indicators and
✓ support cost-efficient adaptation measures.

Addressing community requirements, either in responding to **short-term hazards and extreme weather** events or in **deriving the most effective long term adaptation measures**.

Related Policies

- **The EU Strategy on Climate adaptation, as identified in *COM (2013) 216 - An EU Strategy on adaptation to climate change*,**

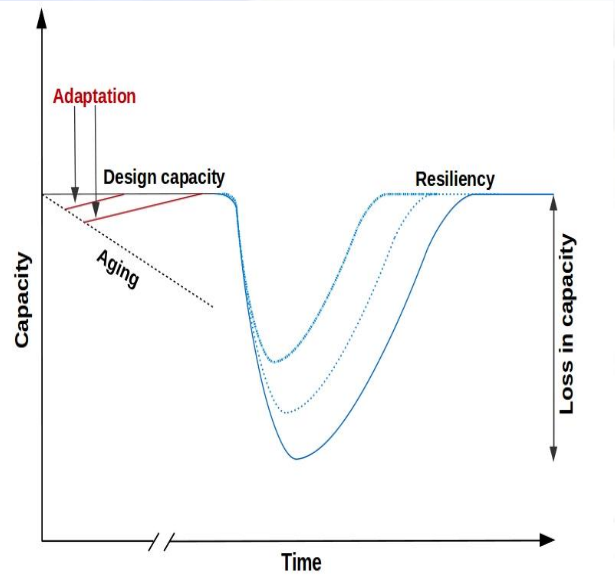
- **National Risk Assessment Plans**
  - COMMISSION STAFF WORKING PAPER on Risk Assessment and Mapping Guidelines for Disaster Management, SEC(2010) 1626, Brussels, 21.12.2010.
  - COMMISSION STAFF WORKING DOCUMENT, Overview of natural and man-made disaster risks in the EU, SWD(2014) 134, Brussels, 8.4.2014

- **European Programme for Critical Infrastructure Protection**:
  - DIRECTIVE 2008/114/EC, on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, 8.12.2008
  - COMMISSION STAFF WORKING DOCUMENT, on the review of the European Programme for Critical Infrastructure Protection (EPCIP), SWD(2012) 190, Brussels, 22.6.2012
  - COMMISSION STAFF WORKING DOCUMENT on a new approach to the European Programme for Critical Infrastructure Protection Making European Critical Infrastructures more secure, SWD(2013) 318, Brussels, 28.8.2013

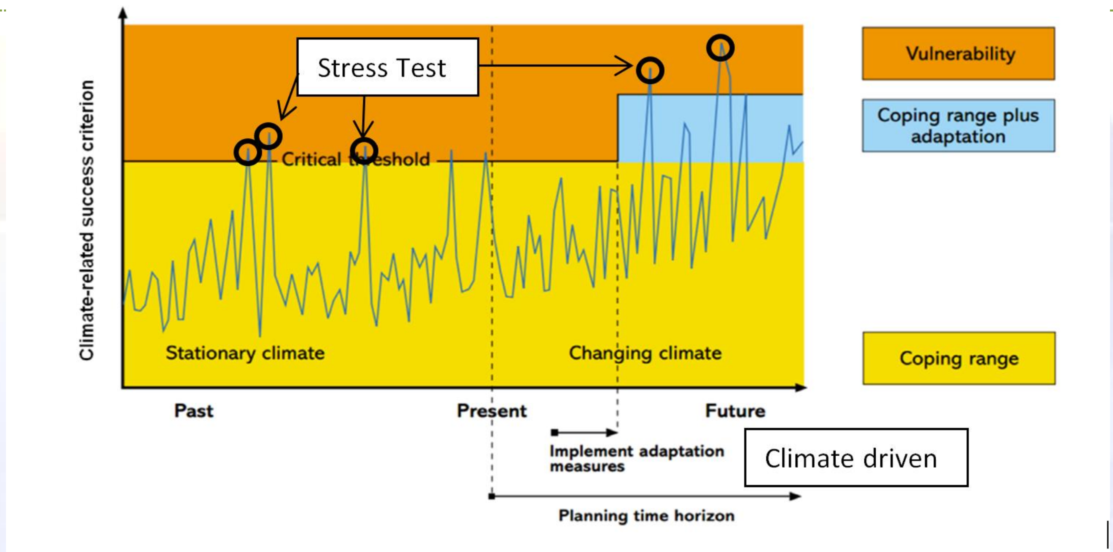
The Time Scales Involved

CI are large scale projects, that will service the community for very long time frames.

- Climate change is expected to impact the security / safety critical levels of the infrastructure
- Expose new vulnerabilities due to ageing, changes in the climate patterns, land use…
- Impact the type and characteristics of the interconnections between infrastructures



The link: climate related critical thresholds



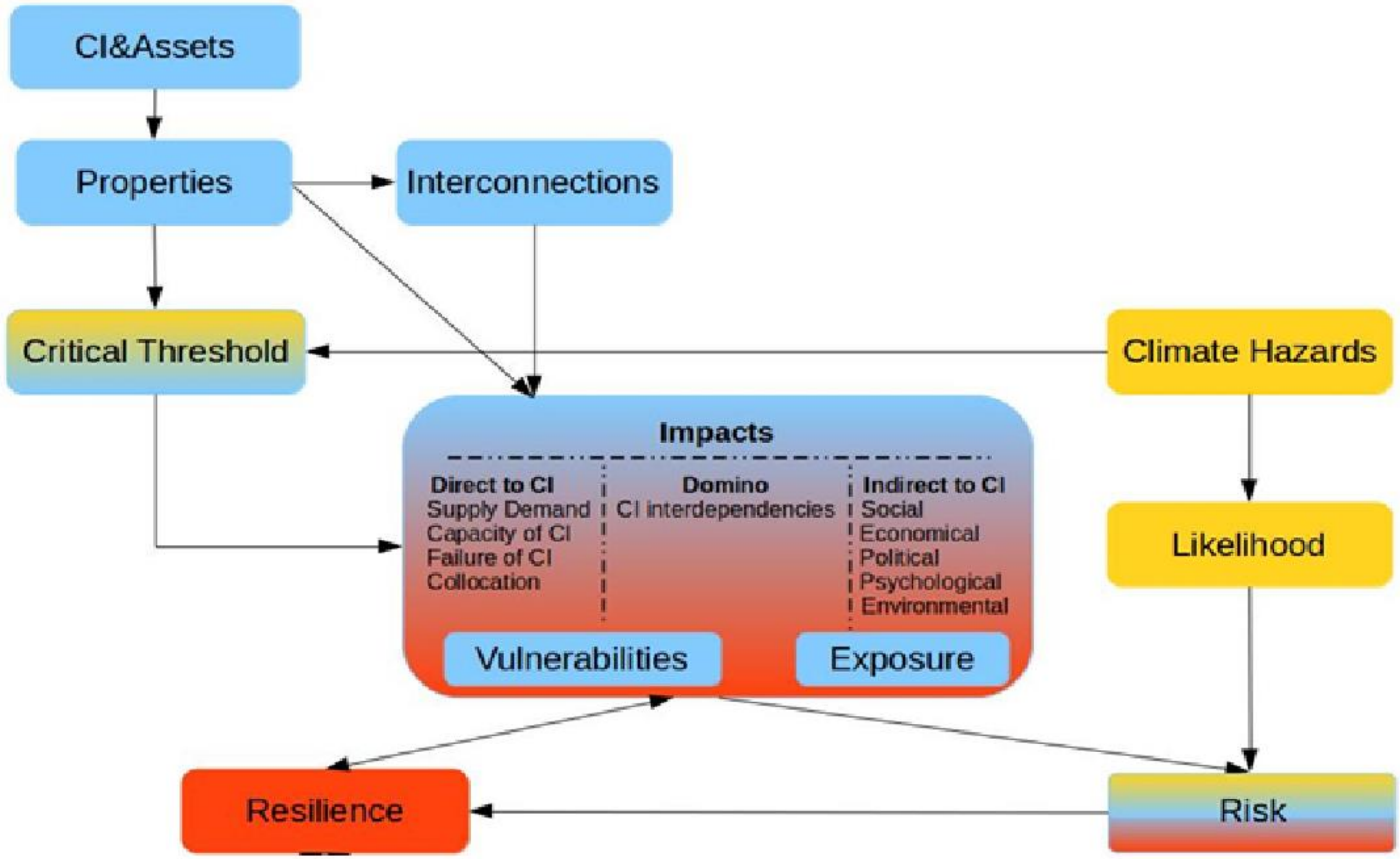
- Two pathways
  - "Stress – test" as the driver. Use CIRP to determine the impacts to the CI Networks (based on critical thresholds) , and link them to climate data – return periods
  - "using climate" as the driver. From climate data obtain the thresholds for a specific analysis / assessment and then feed them to CIRP and obtain output.

Context

Operational objectives

- How will a {transportation network, …} will respond to extreme events,
- What is the risk of an extreme climate event to the rail sector or network / region
  - How resilient is the rail networks to a specific climate hazard,
  - Can we prevent future similar events?
- Which is the optimal adaptation measure for CI, and is this also beneficial for other CH
- How to reduce the domino effects to transportation from electricity network
- Cost benefit analysis (comparison) of different adaptation alternatives
- What is the economic / societal impacts of resilience

Our approach



Climate change - increase in climate hazards

- Risk for CI
  - Threat-weather and climate hazards
    - Heat and cold waves
    - River and coastal flooding
    - Wildfires
    - Windstorms
    - Droughts
  - Potential loss

- A prominent spatial gradient toward south-western regions
- Key hotspots along coastlines and in floodplains
- Hazards are results of weather and climate extemes
- Current extremes from observations
- Future extremes and change from NWF and CM

(Forzieri et. al. 2016)

Type of existing data

Climate change

Observed climate data

- Some important differences – station data
- Importance of the gridded data (Haylock et al., 2008)
- Some important differences – gridded data
- Essential climate variables

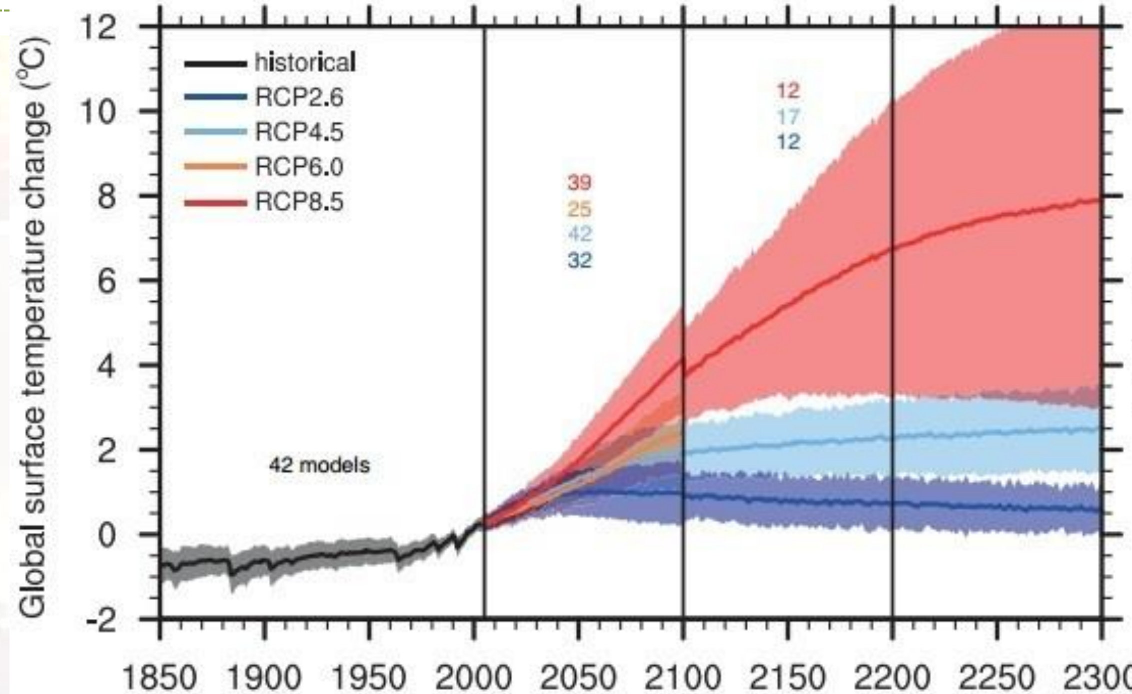
Weather prediction models and data

- Numerical Weather Prediction (NWP) in Europe
- ALADIN in Croatia

Climate models and projections

- Climate models and data - glossary
- RCP differences
- Spatial resolution of climate models
- Uncertainties in regional climate modelling
- EURO-CORDEX climate projections
- Other relevant projects/initiatives
- Changes in frequency of extreme climatic events

Climate Change



Scenario	Warming in 2081–2100 (°C)
RCP2.6	1.6 ± 0.4
RCP4.5	2.4 ± 0.5
RCP6.0	2.8 ± 0.5
RCP8.5	4.3 ± 0.7

- IPCC: impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways.

Changes in frequency of extreme climatic events

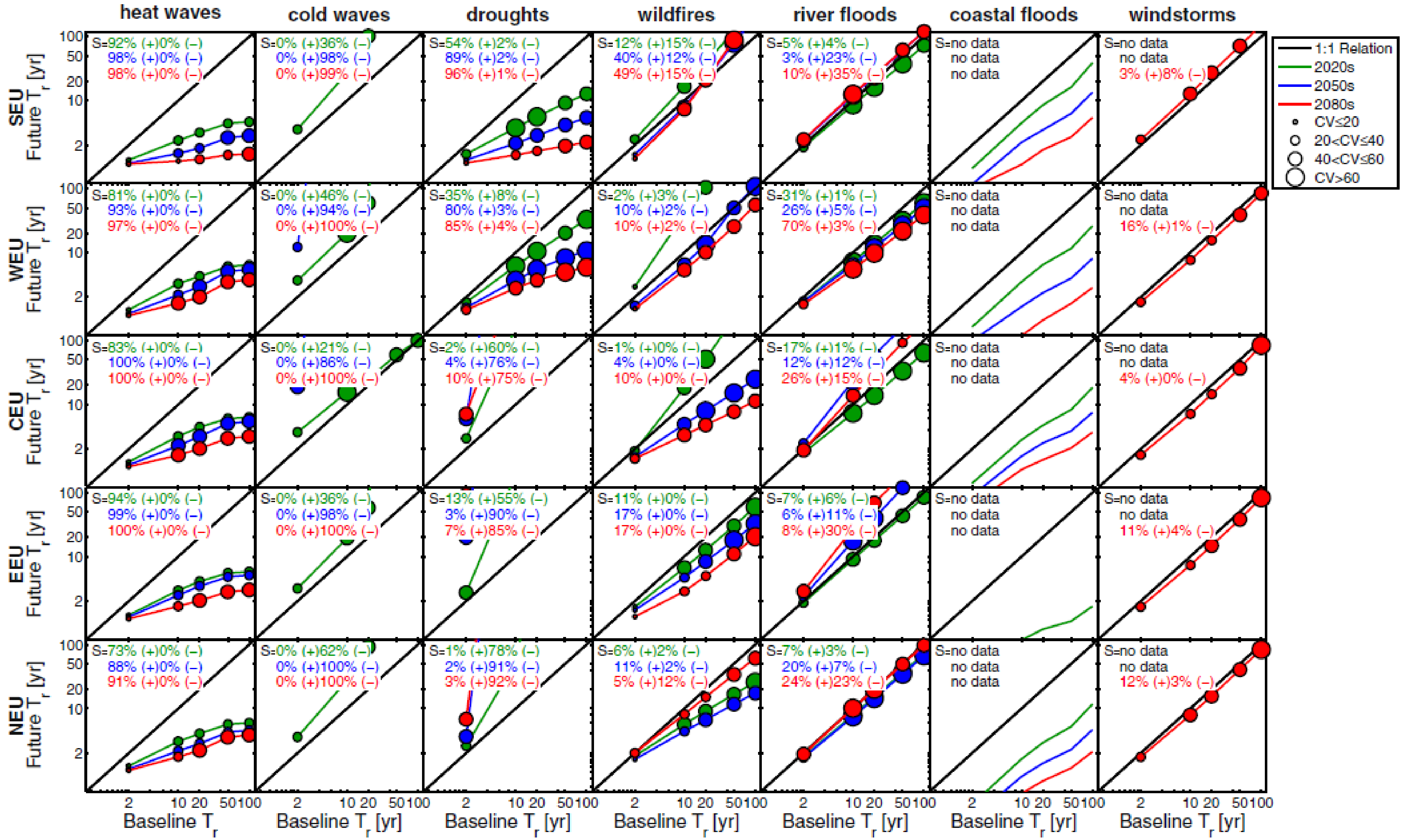


Fig. 1 Changes in frequency of extreme climatic events. Baseline (x-axis) versus future (y-axis) hazard return periods for 2020s (*green*), 2050s (*blue*) and 2080s (*red*) for specific hazards. Return period values shown are the zonal median for different European regions of the grid-cell ensemble median return period of the experiments driven by the different climate realizations, including all significant pixels within the hazard modelling domain (Fig. S2). Circle sizes represent the coefficient of variance (CV) amongst climate models and S values explicit the percentage of cells within a region with significant decrease/increase (−/+). Note that future scenarios with outstanding decrease/increase in frequency are out of plot

Severe weather conditions related to the impacts: Transport - ROAD

HAZARD	IMPACTS	HAZARD	IMPACTS
# of days with Tmax(heat stress): Tmax≥ 25 ^{o}C, Tmax≥ 32 ^{o}C, Tmax≥ 43 ^{o}C	*Reduced safety for vehicles driving, Railroad track deformities, instability of road substructure, melting asphalt and rutting, roadside fires, road asphalt cracking, problems on steel bridges, buckling risk, reduced safety for vehicles driving, fatigue among drivers, augmentation of Urban Heat Island Effect*	**Snowfall Rs ≥ 1 cm/d, Rs ≥ 10 cm/d, Blizzard: Rs ≥ 10 cm/d, Tmean≤ 0 ^{o}C, WG ≥ 17 m/s**	*reduced visibility, ice on the roads increased propability of incidents, reduced safety for vehicles driving, Damage to roadway integity due to thawing of permafrost, soil instability, ground movement and slope instability*
Cold waves: Tmean≤ 0 ^{o}C, Tmean≤ -7 ^{o}C, Tmean≤ -20 ^{o}C	*fatigue among drivers, Damage to roadway integity due to thawing of permafrosts*	**Sea level rise, sea storm**	*floods, coastal infrastructure at risk of inundation, erosion of coastal structures, buckling risk, reduced safety for vehicles driving*
Extreme precipitation - floods: # of days R≥30- 50mm/day, 100mm/day Total daily precipitation	*evacuation flooded roads/tunnels, bridges exposed to 20%-40% increase in 100-yr river discharge, reduced safety for vehicles driving*	**extreme winds, wind gusts(6h): WG ≥ 17 m/s , WG ≥ 25 m/s**	*trees and branches overturned trucks etc increased noise reduced road speed*
Humidity, dew-point, fog	*Reduced safety for vehicles driving, reduced visibility FMI Road Weather Model*	**Landslides (R≥ 150-200 mm/24h)**	*landslides, lushflow avalanches, landslides and associated risks, reduced safety for vehicles driving*

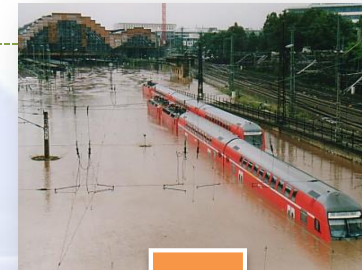
Severe weather conditions related to the impacts: Transport - RAILWAY

HAZARD	IMPACTS	HAZARD	IMPACTS
# of days with Tmax(heat stress): Tmax≥ 25 ^{0}C, Tmax≥ 32 ^{0}C, Tmax≥ 43 ^{0}C	*Rail buckling risk Disturbance to transport electronic infrastructures, signaling, shortened life expectancy of rail, increase wildfires can damage infrastructure*	**Snowfall Rs ≥ 1 cm/d, Rs ≥ 10 cm/d, Blizzard: Rs ≥ 10 cm/d, Tmean≤ 0 ^{0}C, WG ≥ 17 m/s**	*increased propability of incidents, soil instability, ground movement and slope instability, Ice on trains and catenary*
Cold waves: Tmean≤ 0 ^{0}C, Tmean≤ -7 ^{0}C, Tmean≤ -20 ^{0}C		**Sea level rise, sea storm**	*bridge washouts, underpass and basement flooding, disturbance to transport electronic infrastructures, signaling, erosion of coastal structures*
Extreme precipitation - floods: # of days R≥30- 50mm/day, 100mm/day Total daily precipitation	*flooding of underground transist systems, ushflow avalanches, trees and branches, landslides and associated risks,destabilization of embankment*	**extreme winds, wind gusts(6h): WG ≥ 17 m/s , WG ≥ 25 m/s**	*Disturbance to transport electronic infrastructures, signaling, trees and branches*
Humidity, dew-point, fog	*reduced visibility*	**Landslides (R≥ 150-200 mm/24h)**	*ushflow avalanches, landslides and associated risks*

Risk management - concept

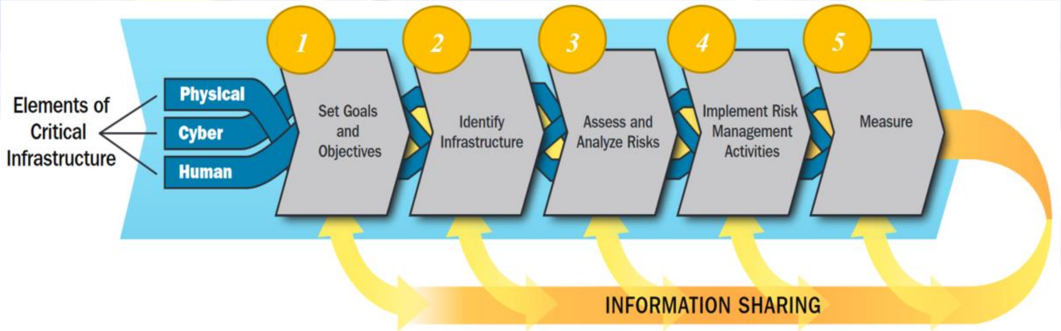
- Risk management is an approach to structure the practical work in order to prepare for future threat situations on the base of experienced hazards.

- What are the objectives? Identify and evaluate risks („risk assessment“); and to prioritise concrete strategies, and to monitor their effectiveness.



Risk management - procedure

- Typical 5-step procedure comprises the following stages (sometimes also 6-steps):
  (1) Establishment of operational objectives/imperatives
  (2) Identify assets, systems, networks, and functions
  (3) Assess and evaluate risks
  (4) Select and implement protective programs
  (5) Measure effectiveness (monitoring of implemented measures)
- Feedback loops/ iterations always possible



Resilience : Capacities

the ability of the CI system to anticipate and reduce the impact

- Anticipative
- Absorptive
- Coping
- Adaptive

Resilience : Capacities

the ability of CI system to buffer, bear and endure the impacts

Anticipative

Absorptive

Coping

Adaptive

Resilience : Capacities

ability of CI system to face and manage adverse conditions using available skills and resources,

Anticipative

Absorptive

Coping

Adaptive

Resilience : Capacities

ability of CI system to face and manage adverse conditions using available skills and resources,

Anticipative

Absorptive

Coping

Adaptive

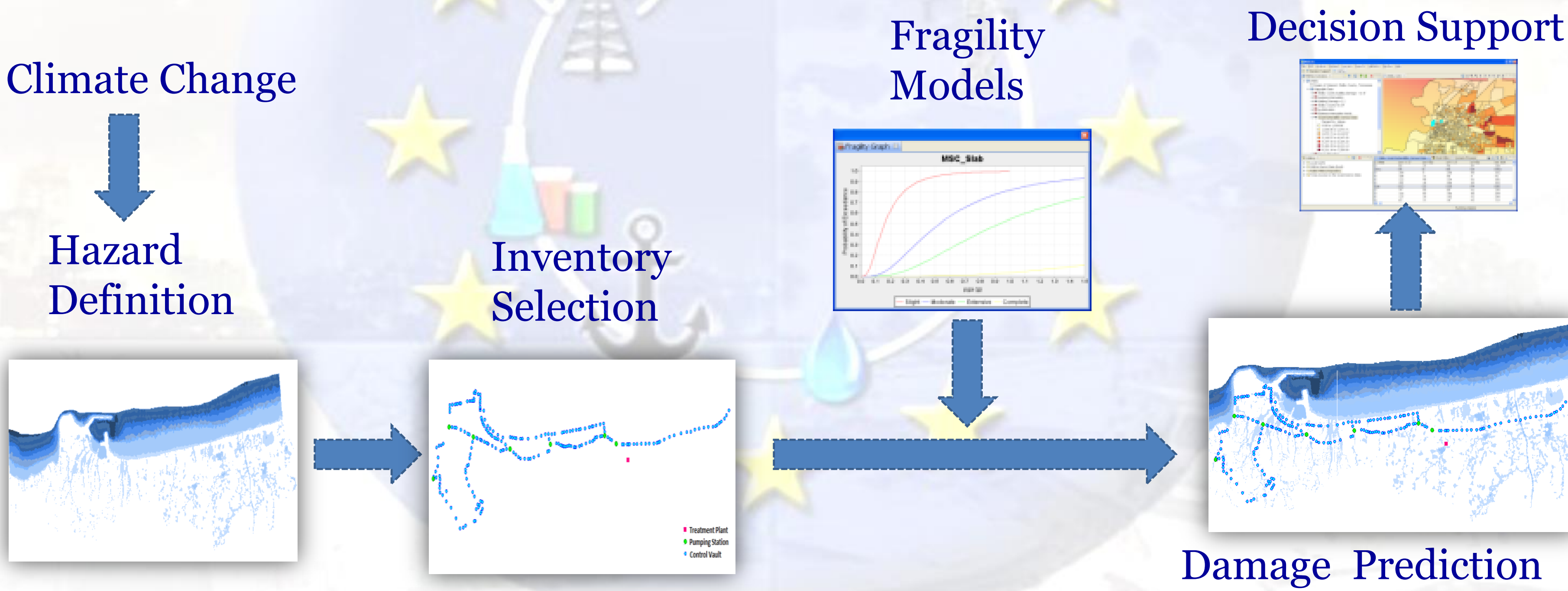
The CIRP Objectives (1)

- EU-Circle will design and develop an innovative prototype solution for **detailed modeling of large scale interconnected CI** supported by modules **to assess cost – efficient adaptation of solutions in different types of scenarios**.

- EU-CIRCLE will provide the **generic plug-and-play environment** for **different and diverse types of simulation models** and climate information to be introduced and ***will apply partners' capabilities (models, climate data, risk – resilience assessment, adaptation scenarios) in the suggested test cases***.

CIRP – Input & Outputs

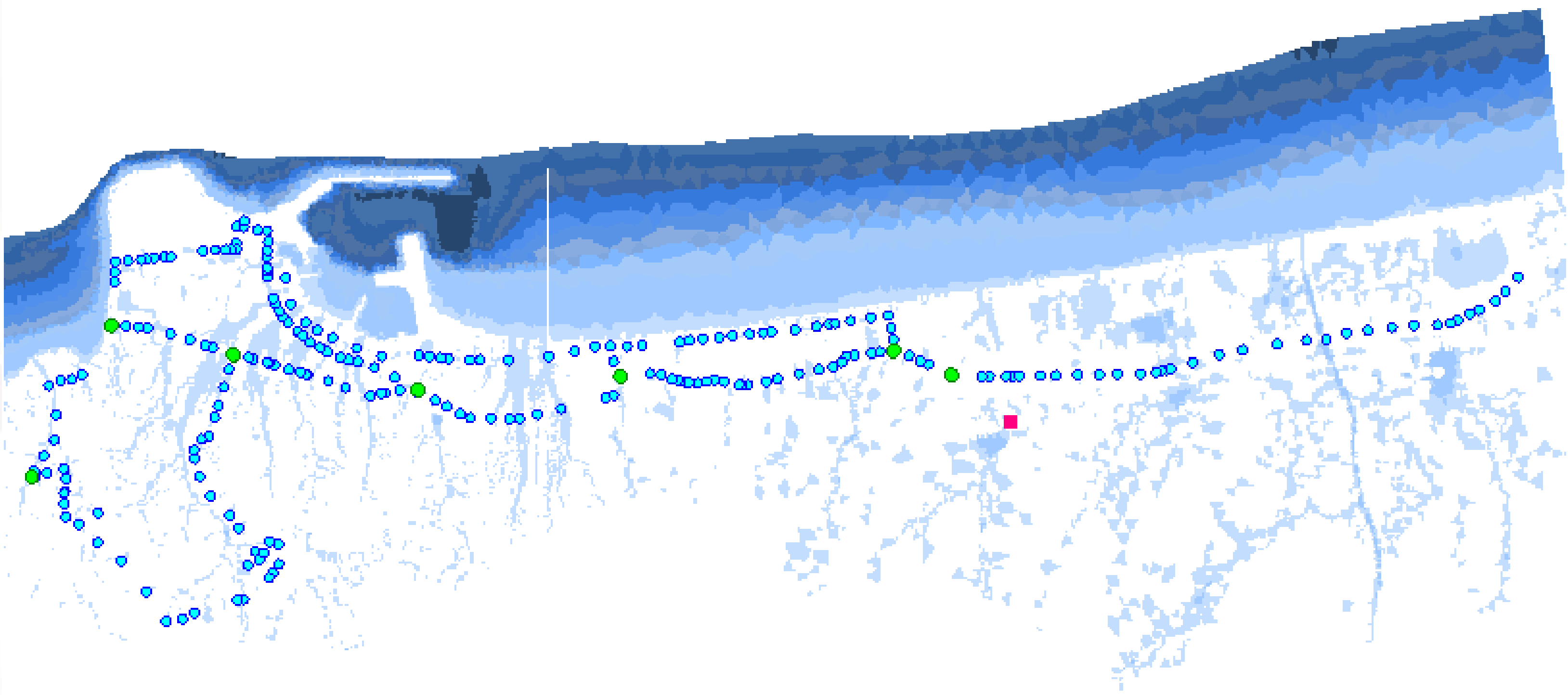
- **Inputs** - Hazards, Inventory, Fragility Models
- **Output** - Damage Prediction, Reporting, Decision Support



CIRP –Example Analysis-Flood Structural Damage

Create and Load Input Datasets

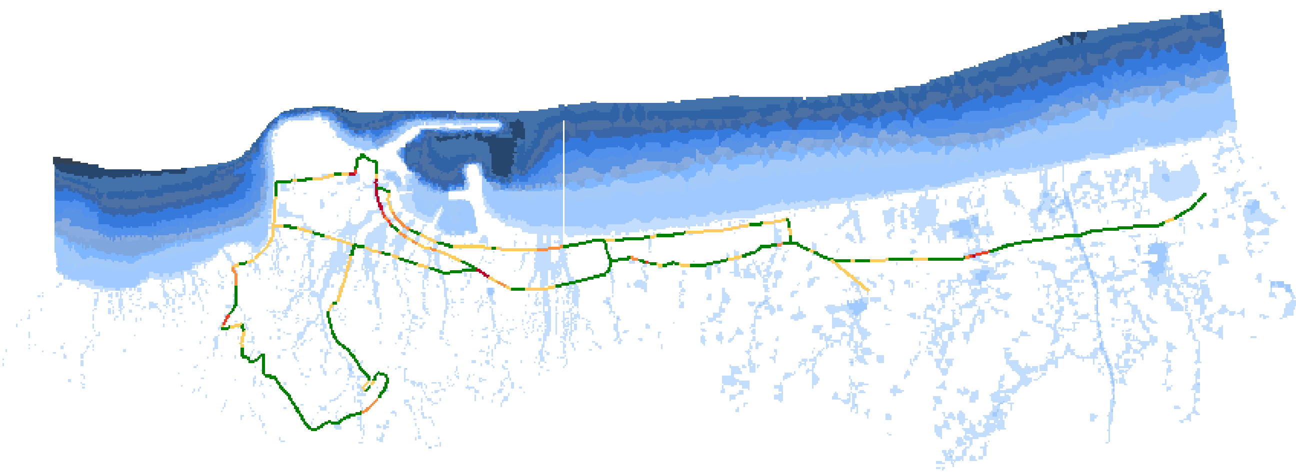
- **Input Visualization**



CIRP –Example Analysis-Flood Network Damage

Network Damage Analysis

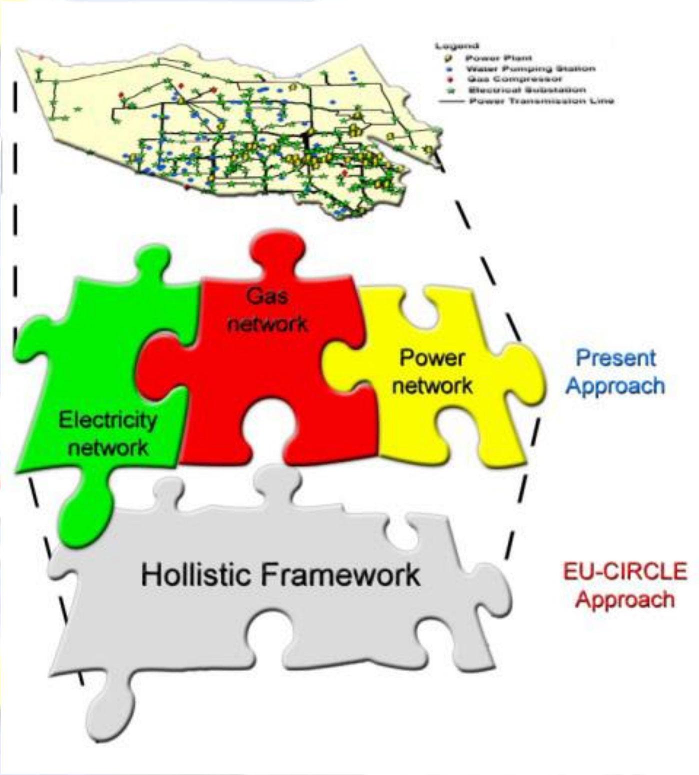
- **Results Visualization**



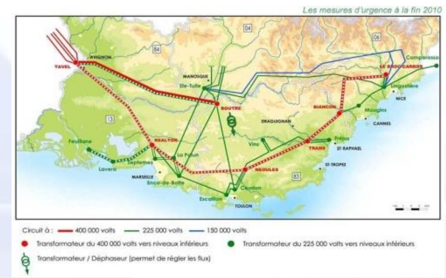
EU-CIRCLE Impact

✓Support the establishment of climate resilient infrastructure by ensuring that an asset is located, designed, built and operated with both the current and future climate in mind and incorporates resilience to the impacts of climate change over the lifetime of that asset.

✓ Provide a coherent baseline for moving from sector-based climate resilience infrastructure frameworks, into holistic resilience plans for entire regions, introducing the interdependencies of heterogeneous infrastructures in the implementation process.



EU-CIRCLE Validation



Case Study 1: Extreme Dryness and forest fires on electricity and transport networks
Lead Partner: ENTENTE POUR LA FORÊT MÉDITERRANÉENNE

Case Study 2: Storm and Sea Surge at a Baltic Sea Port , Gdynia Poland
Lead Partner: AKADEMIA MORSKA W GDYNI

Case Study 3: Coastal Flooding (surface water, highway, sewer and watercourse flooding) across Torbay, UK
Lead Partner: UNEXE and Torbay Council

Case Study 4: International Event
Lead Partner: USAL and NCSRD

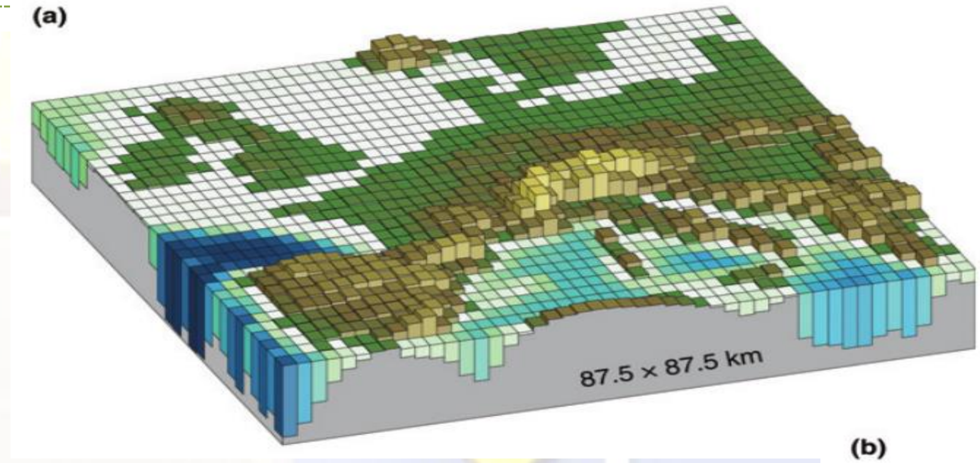
Case Study 5: Rapid Winter Flooding (melting ice, narrow mountain streams, flooding) around Dresden, Germany
Lead Partner: Fraunhofer IVI

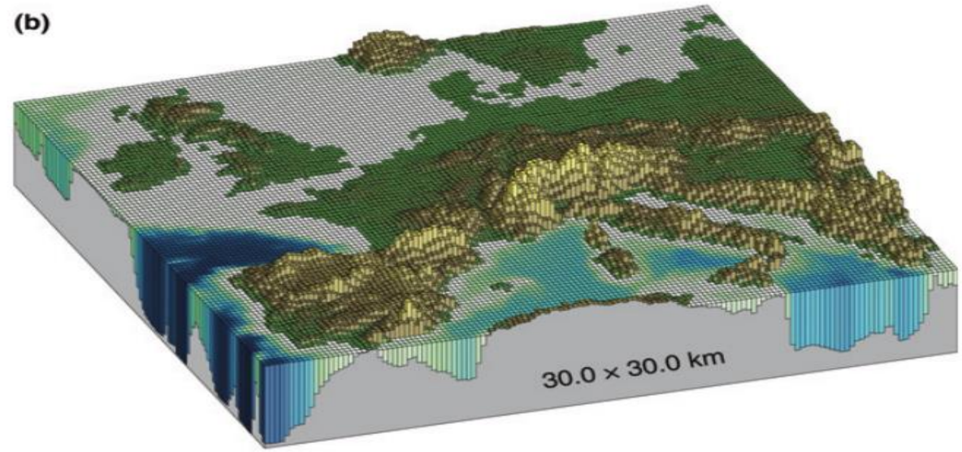
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653824

Thank You For Your Attention

http://www.eu-circle.eu

Spatial resolution of climate modes

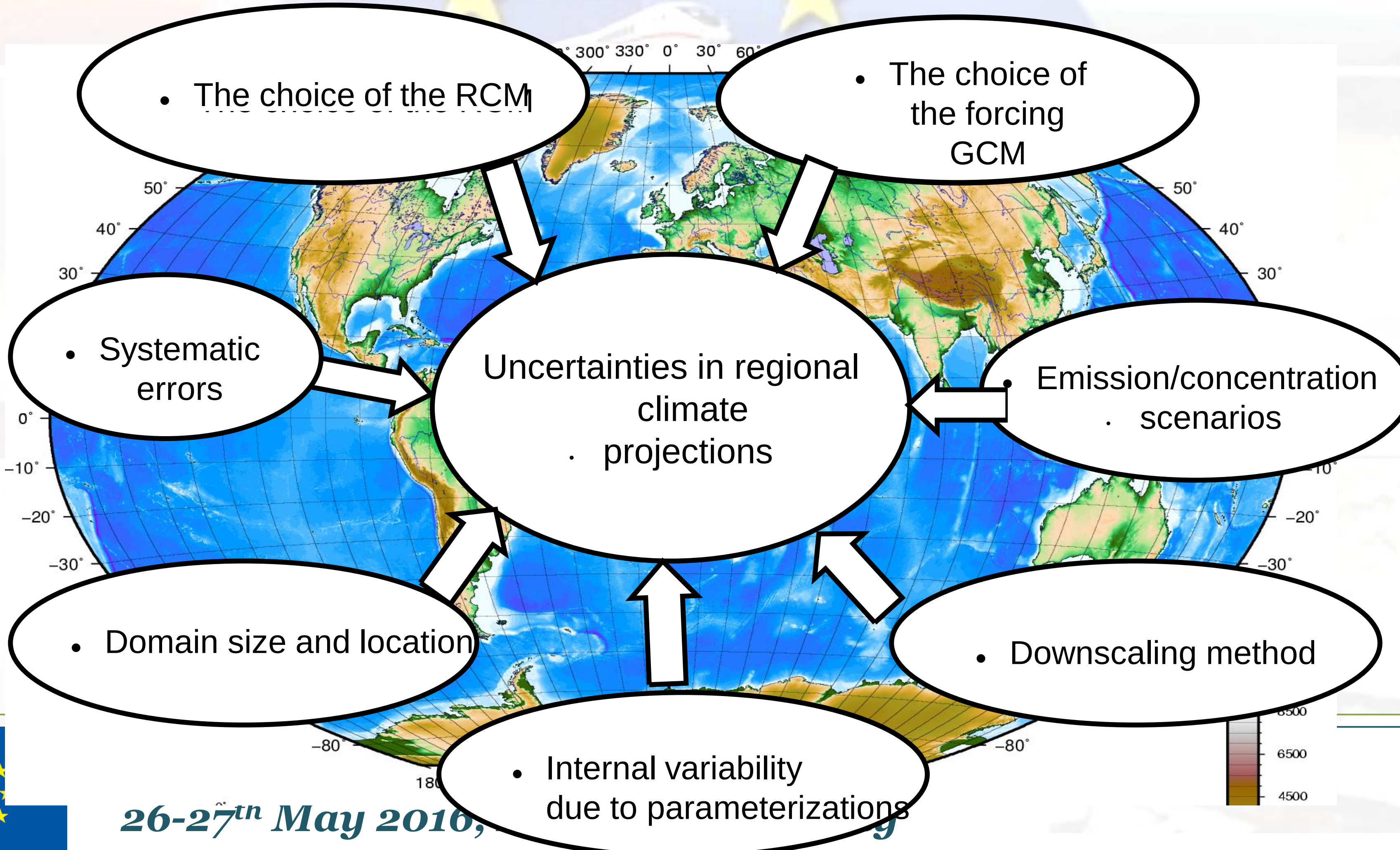




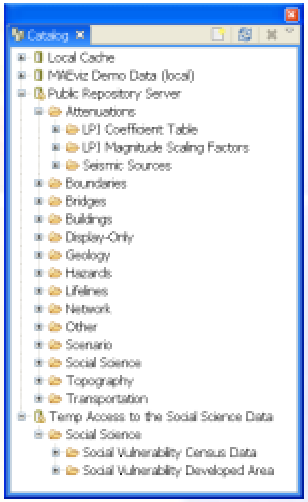
Rummukainen (2015; Figure 2)
(a) illustration of the European topography at the resolution 87.5 km
(b) same as (a) but for 30.0 km.

Uncertainties in regional climate modelling

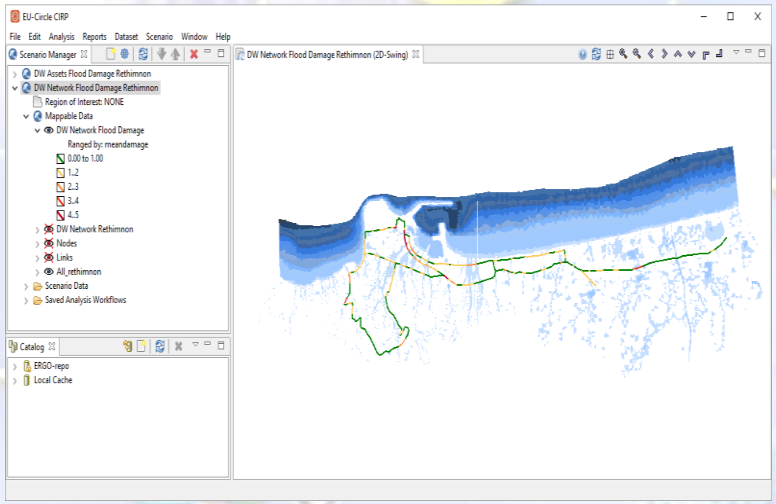
Range of possibilities, make the adaptation harder



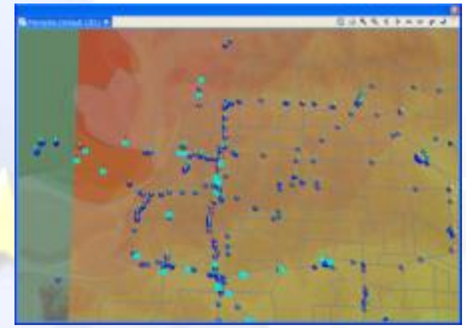
The CIRP User Interface



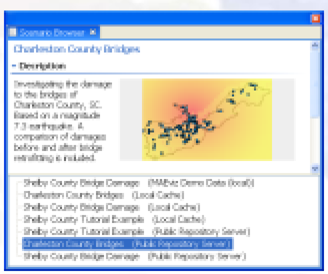
Data Catalog



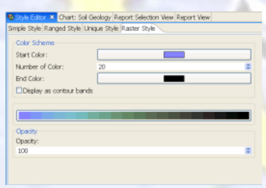
Main Window



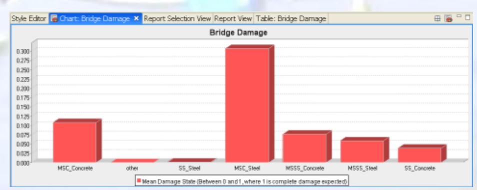
2D & 3D Views



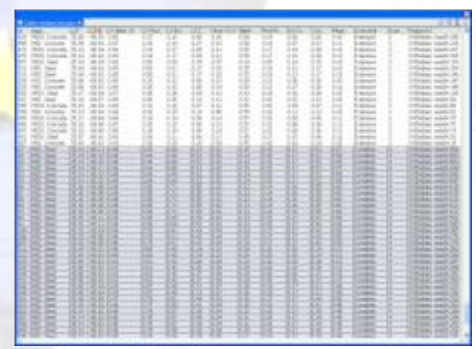
Scenario Browser



Style Editor



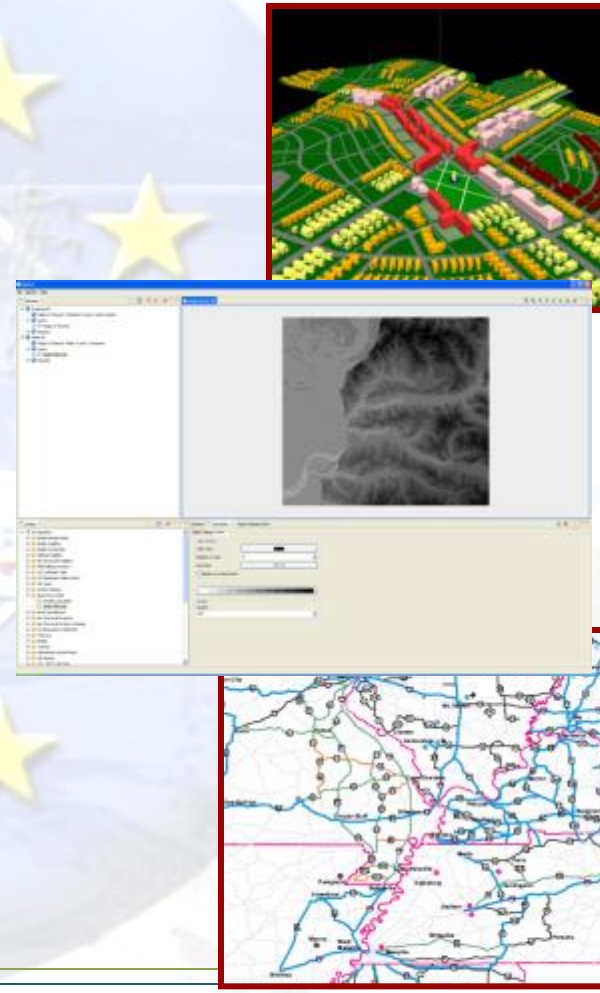
Result Charting



Synchronized Data Views

CIRP Input: Inventory, Terrain, Networks

- **Source -** Public data, Tax assessor data or inferences from aerial photography
- **Inventory -** CI buildings, bridges, pipelines, dams, hospitals, power/water plants, etc
- **Terrain –** satellite digital terrain maps for any region anywhere
- **Network information -** transportation, gas, water, electricity, telecommunications, etc.



CIRP Input: Fragilities

- **Engineering Models Fragility**
  - Dependent on the inventory content
  - evaluate probability of reaching limit states of damage
- **Social-Economic Models Fragility**
  - Uses relationships between physical and socio-economic losses to establish impact society
- **Source of fragilities**
  - scientific data, research papers, derived from observations, experiments or simulations