Let’s Construct Europe’s Future
With Innovative Buildings and Infrastructures
Construction and Societal Challenges

Radisson Blu Centrum Hotel - WARSAW
04 / 05 October 2011

FP7 CLIMATE FOR CULTURE - Damage risk assessment, economic impact and mitigation strategies for sustainable preservation of cultural heritage in the times of climate change

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Contract nr. 226973
FP7 Climate for Culture (CfC)

• Large scale integrated project
• overall budget 6,55 Mio €, EC contribution: 5 Mio €

• Duration:
• 5 years, November 2009 - October 2014

• 27 Partners from Europe and Egypt, co-ordinator Fraunhofer
• (Austria, Croatia, Czech Republic, France, Germany, Greece, Italy, Netherlands, Poland, Slovenia, Spain, Sweden, United Kingdom) 12+3

• Subcontractors
• (Romania, Israel, Morocco)
12+3 countries

27 partners + 3 subcontractors
Consortium as a whole – a multidisciplinary team

natural sciences, humanities, economics, cultural sciences, heritage owners, SMEs and industry, restoration/conservation practice, decision makers

Climate Change modelling
(MPG/MPI-Met, GCU)

Building simulation
(Fraunhofer-IBP, CVUT, TUE, GCU, Kybertec, GI ZRMK, KUG, Käferhaus, RSD)

Risk, damage and economic assessment
(CNR ISAC, JAS, LSE, FORTI, Fraunhofer-ISC, TUM, ULMGG, ACCIONA, IIGO, AWR)

Stakeholder Group
(INP, CULTNAT, NT, DOERNER, BSV, Haftcourt, AWR, IIGO)
CO$_2$ concentration in the atmosphere

Earth’s CO$_2$ Home Page  391.76 ppm atmospheric CO$_2$ for February 2011
Preliminary data released March 8, 2011 (Mauna Loa)

For 650,000 years, atmospheric CO$_2$ has never been above this line … until now

How do we care for the welfare of future generations?
Climate change, Global warming

• Climate change is a reality:
  • In the last 100 years global temperature raised for 0.75 °C.

• Prognosis:
  the raise between 1.1 °C to 6.4 °C by the end of 21st century, with current growth of CO2 emissions.

• Scientific estimation:
  • Temperature raise should be limited to max. 2 °C (comparing to pre-industrial period) or to max. 1.2 °C comparing the current situation; otherwise our society will face dangerous, perhaps even catastrophic consequences in global environment.
EU plan for a competitive low-carbon economy by 2050 to fight climate change

8 March 2011

• To keep global warming below 2°C, the world will need to halve its emissions of carbon dioxide and other greenhouse gases by 2050 (compared with 1990 levels).

• Europe has to invest **270 billion € per year** for changing industrial production, renovating buildings and creating CO₂-free mobility (Commissioner Hedegaard)
Climate change impact on cultural heritage

**Direct**
- building envelope - T, rH, wind-driven rain, wind speed, solar radiation, sea level rise and land slide, frost/thaw cycles ...
- building interior - changing indoor conditions ...

**Indirect**
- low carbon economy and energy problem, scarcity of resources, financial crisis, budget restrictions in the public sector
- destabilization of political systems and societies (climate refugees)
- demographic change / change of interest / no visitors
- destruction, abandoning of land - danger of landslides
CfC concept

• The CLIMATE FOR CULTURE project builds on the three most urgent questions for cultural heritage in the times of climate change:
  
  – 1. What will be the effects of climate change on cultural heritage in Europe?
  
  – 2. What mitigation strategies are necessary to prevent damage to movable and immovable cultural heritage?
  
  – 3. What will it cost us, if we do not react in time?
Project cornerstones

- High resolution climate modelling on a regional scale
- Development of hygrothermal whole building simulation software
- Case study database on climate induced damage in EU heritage sites and stakeholder contributions
- Economic impact report like the Stern Review
Climate modelling - A1B scenario

Assumptions

- rapid economic growth
- increasing global population until 2050, decline after 2050
- rapid introduction of new and more efficient technologies
- balanced energy sources
- High resolution simulation (10x10 km)

ENSEMBLES project (http://ensembles-eu.metoffice.com)
Climate classification maps
Baseline 1960-1989 vs Far Future 2070-2099

Climate for Culture
Baseline 1960 - 1989 (left)
Far Future 2070 - 2099 (right)
T and RH

by Melanie Eibl, 2011
Grouping monitoring case studies in 4 climatic zones

<table>
<thead>
<tr>
<th>Zone</th>
<th>Zone Leader</th>
<th>Partner</th>
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<tbody>
<tr>
<td>I North</td>
<td>Jan Holmberg</td>
<td>Haftcourt</td>
</tr>
<tr>
<td>II Central Europe</td>
<td>Ralf Kilian</td>
<td>FRAUNHOFER</td>
</tr>
<tr>
<td>III North Atlantic</td>
<td>Henk Schellen</td>
<td>TUE</td>
</tr>
<tr>
<td>IV Mediterranean</td>
<td>Dario Camuffo</td>
<td>CNR-ISAC</td>
</tr>
</tbody>
</table>

Source: Melanie Eibl, Doerner Institut
Distribution of Case Studies

Collection of data from Europe & Egypt

climate
microclimate
building
observed damages
Geographical distribution of indoor Relative Humidity in heated historical buildings

\[ T_{in} = 18^\circ C \]

January, outside

\[ T_{out}=1961-90 \]

RH=100\% (fog)

Indoor Relative Humidity (\%)

- Red: 0 to 30
- Orange: 30 to 40
- Green: 40 to 60
- Blue: 60 to 70
- Dark Blue: 70 to 100

Source: Dario Camuffo, Chiara Bertolin
Development of hygrothermal whole building simulation software

Hygrothermal building simulation
Hygrothermal building simulation and simulation of global climate change 2010 - 2100

The project aims at assessing the influence of climate change and microclimatic functioning of historic buildings with regard to the dangers for the interior equipment or works of art, as well as at new strategies for the improvement of the microclimatic control and the optimization of the buildings.
Comparison of measured and modelled data for a building - first results

Temperature [°C]

-10
-5
0
5
10
15
20
25

Years

1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2085-2100

Interior

- Measurement 1995-2010
- Climate Modelling 1995-2010
- Climate Modelling 2085-2100

Fraunhofer by Florian Antretter, 2011
Risk assessment of climate induced damages

measured data
Risk assessment of climate induced damages

measured data  simulation

[Graphs showing temperature and humidity data with shaded regions labeled Frost, Microbiology, and Dryness]
Simulated change of use – heating to 4°C

measured data  simulated change

- Frost
- Microbiology
- Dryness

Temperature [°C]  Relative Humidity [%]

EU 7th Framework Programme  Climate for Culture  Fraunhofer
Simulated change of use – 800 visitors per day

measured data

simulated change
Objectives

• **Climate evolution** (time slices 1960-1989, 2070-2100, 1x1 km) for damage assessment of movable and immovable cultural heritage objects in the near and far future

• In situ non-destructive monitoring of cultural objects with Laser Reflectography, 3D Microscopy, Glass sensor measurements and Free Water sensor measurements

• Analysis of the collections of movable cultural assets in historic buildings throughout Europe (SoA of preservation, interpretation of indoor climate conditions, a different preventive conservation strategies)

• **Simplified classification of historic buildings in Europe** in order to develop adequate risk scenarios

In-situ monitoring, Brezice castle, Slovenia, april 2011
Objectives

• Retrospective investigation of climate induced damage processes and state of preservation of works of art over the past centuries

• Development of a new damage risk assessment methodology for preventive conservation—(decision support systems to adapt to climate change impacts)

• Development of a software tool for hygothermical simulation at the whole building level (Wufi+)

• Adaptation of software tools for hygrothermal building simulation to the specific tasks of historic buildings (heating patterns, T, TH...)

• New and energy saving approaches to microclimate control for mitigation of climate change impacts (strategies: wall tempering, conservation heating...)
Objectives

• Development of easy to read outdoor and indoor climate risk maps for decision makers in the different climate zones throughout Europe

• Assessment on the economics of climate change impacts on cultural heritage for decision makers and interested public (akin to 2006 Stern Report)

• Improving the climate management of major European institutions taking part in the project

• Contribution to the next IPCC report

Analysis and decision support system
Climate for Culture

Damage risk assessment, macroeconomic impact and mitigation strategies for sustainable preservation of cultural heritage in the times of climate change

Grant agreement no. 226973 1
November 2009 - 31 October 2014

Climate change impact on movable and immovable cultural heritage

Analysis and decision support system

Mitigation, adaptation and preservation strategies

Hygrothermal building simulation

Case studies

Climate change scenarios

Damage assessment
http://www.climateforculture.eu/