THE EURO-MEDITERRANEAN CENTRE FOR CLIMATE CHANGE (CMCC):
THE NEXT GENERATION OF CLIMATE MODELLING

Carlo Carraro
Director, Climate Impacts and Policy Division
IPCC Vice-Chair, Working Group III
Euro-Mediterranean Centre for Climate Change (CMCC)

- Italian research centre on climate science and policy.
- Financially supported by the Italian Ministry for the Environment and Territory, the Ministry for Education, University and Research and the Ministry for Economy.
- Aims to develop applications of models of climate dynamics and valuations of impacts of climate change and adaptation and mitigation policies.
Partnerships

- **6 Partners:**
  - Istituto Nazionale di Geofisica e Vulcanologia (INGV)
  - University of Salento
  - Fondazione Eni Enrico Mattei (FEEM)
  - Consorzio Venezia Ricerche (CVR)
  - Centro Italiano Ricerche Aerospaziali (CIRA)
  - University of Sannio

- **8 Associate Partners** at national and international level (University of Sassari, University of Viterbo, WHO, ICTP, CNR, IAMBE, SPACI, CRMPA)
Main Features

- 6 Locations: Lecce, Venice, Milan, Benevento, Sassari, Capua
- High computing capacity: two clusters with a computing power of 30 TFlops (1 - one vector system consisting of NEC nodes of SX-8R and SX-9 series, 2- one scalar system consisting of Power 6 IBM nodes)
- Italian Focal Point for the Intergovernmental Panel on Climate Change (IPCC)
6 Research Divisions

- **SCO - Scientific Computing and Operations**  
  *Scientific Co-ordinator:* Giovanni Aloisio, UNISA

- **ANS - Numerical Applications and Scenarios**  
  *Scientific Co-ordinator:* Simona Masina, INGV

- **CIP - Climate Impacts and Policies**  
  *Scientific Co-ordinator:* Carlo Carraro, FEEM

- **ISC - Impact on Soil and Coast**  
  *Scientific Co-ordinator:* Pasquale Schiano, CIRA

- **IAFENT - Impacts on Agriculture, Forest, and Natural Ecosystems**  
  *Scientific Co-ordinator:* Riccardo Valentini  
  UNITUSCIA, Donatella Spano, UNISS

- **FDD - Education, Documentation and Dissemination**  
  *Scientific Co-ordinator:* Francesco Paparella, UNISA
Scientific Computing and Operations

Numerical Applications & Scenarios

Impacts on Ground and Coasts

Impacts on Agriculture and Forests

Climate Impacts and Policies. An Economic Assessment

Climatic simulations (temperature, sea level rise, precipitations, etc)

Physical impacts of climate change

Emission Scenarios

Economic Impacts, Structural Changes, International Policy

Education, Dissemination and Documentation
Research Activities

- Development of numerical simulations of global and regional models of climate change
- Economic analysis of its impacts on terrestrial and marine ecosystems and on economic activities.
- Valuation of climate policies, jointly with their implications on energy investments, research and development and the diffusion of climate-friendly technologies.
- Valuation of the global impact of climate change integrating the land use changes, deforestation and afforestation
- Studies of future paths of economic development in different world regions
Main Research Projects

Currently, the CMCC research projects portfolio is composed by 28 (national e international) projects for a total amount of ca. 13 M Euro

- **IFCG** - International Forum on Climate Governance, *Italian Ministry of Environment*
- **RECIPE** - Report on Energy and Climate Policy in Europe, *WWF, Allianz RAS*
- **CIRCE** - Climate Change and Impact Research: the Mediterranean Environment, *EC FP6*
- **CLARIS (LPB)** - A Europe-South America Network For Climate Change Assessment and Impact Studies in La Plata Basin, *EC FP7*
- **MY OCEAN** - Development and Pre-operational validation of GMES Marine Core Services, *EC FP7*
- **BRIDGE** - Sustainable urban planning decision support accounting for urban metabolism, *EC FP7*
- **CANTICO** - Climate and local anthropogenic drivers and impacts for the Tunisian coastal area, *Italian Ministry for Environment Era-net Circle*
- **IS-ENES** - InfraStructure for the European Network for Earth System Modelling, *EC FP7*
- **COMBINE** - Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection, *EC FP7*
Cooperation Agreements

- US-ITALY - Co-operation on Science and Technology of Climate Change
- NCAR - National Center for Atmospheric Research acting on behalf of the University Corporation for Atmospheric Research, Boulder, Colorado, USA
- PEI - Princeton Environmental Institute, Princeton University, USA on Ordering Stabilisation Wedges
- CIR - Italy-Rumenia Cooperative Programme on Environment Research and Training
- CGMD - Climate and Global Modelling Division of the Indian Institute of Tropical Meteorology, Pashan, India on climate change and earth science
- ITALY-SIDS - Cooperation on climate change impacts and mitigation policies
- University of Adelaide, Australia
- Tel Aviv University, Israel
Training Activities

Doctorate School in Global Change Science and Policy (ChangeS), based at the University of Venice and in collaboration with CMCC, University of Salento and University of Sassari:

- Four Ph.D programs are currently active:
  - Ph.D in Science and Management of Climate Change – Impacts, Economic Assessment and Policy in Venice
  - Ph.D in Science and Management of Climate Change - Dynamic Climatology in Bologna
  - Ph.D in Environmental and Energy Systems in Lecce
  - Ph.D in Agriculture and Forestry Systems in Sassari
- Program of Winter and Summer schools
Publications

- **Research Papers**: Series of working papers in English collecting output of CMCC research in the field of Climate Change

- **Policy Notes**: Short papers that concisely address key scientific and policy issues on Climate Change and foster the dialogue between science and policy


- **Bi-monthly Report “International Climate Policy and Markets”**: News and comments on international climate negotiations, domestic climate policy measures around the world, and recent research on the cost of climate policy.
Forthcoming Events

- The Economics of Adaptation to Climate Change, Venice, 02-03 April 2009
- Coalitions for Climate Cooperation. A Game-Theoretic Analysis of Post 2012 Climate Policy, Venice, 15-16 June 2009
- 2009 International Energy Workshop (IEW), Venice, 17-19 June 2009
- Scoping Meeting 5th AR-IPCC, Venice, 13-19 July 2009
Climate Impacts and Policies. An Economic Assessment (CIP)

Three Research Units:

- Emission Scenarios and Mitigation Policies
- Economic Assessment of Climate Change Impacts and Adaptation Policies
- International Negotiations and Support to Domestic and EU Institutions
CIP Research Objectives

- Predictions and GHG emissions scenarios
- Assessment of the economic value of impacts of climate change
- Analysis of mitigation and adaptation policies
- Support to climate negotiators
Research Unit 1: Activities

- Economic valuation of climate change impacts (direct and indirect)
  Sectors: water, land productivity and agriculture, land ecosystems, coastal zones and marine ecosystems, human settlements, energy and industrial sectors, insurance and other financial services, health.

- Adaptation policies
  Economic valuation of costs and benefits of adaptation policies to climate change. Dynamic analysis of the adaptation capacity of socio-economic systems, at different geographical scales and for different sectors.
Research Unit 2: Activities

- **Integrated economic models of climate change**
  Development of long term models to define greenhouse gas emissions scenarios and to identify the optimal investments in the energy sector and in technologies to control GHG emissions.

- **Mitigation policies**
  Identification of optimal mitigation policies and their costs and benefits as a function of participants in international agreements, of energy technical change diffusion and of optimal investment strategies in various world regions.
Research Unit 3: Activities

- **Policy Support**
  Scientific and technical support in international negotiations on scientific issues of climate change, in multilateral sessions and in particular in the field of climate change science policies.

- **National IPCC Focal Point**
  Meeting point among IPCC, the scientific community and the public at national level to promote the dissemination of the IPCC activities.

- **Networking and outreach**
  National and international networking aimed to the outreach of the scientific and technical aspects of the climate change.
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www.cmcc.it
WITCH
World Induced Technical Change Hybrid model
http://www.feem-web.it/witch/

ICES
Intertemporal Computable Equilibrium System
http://www.feem-web.it/ices/
**ICES (Intertemporal Computable Equilibrium Systems)**

### 14 Regions:
- **USA:** United States
- **Med_Europe:** Mediterranean Europe
- **North_Europe:** Northern Europe
- **East_Europe:** Eastern Europe
- **FSU:** Former Soviet Union
- **KOSAU:** Korea, S. Africa, Australia
- **CAJANZ:** Canada, Japan, New Zealand
- **NAF:** North Africa
- **MDE:** Middle East
- **SSA:** Sub Saharan Africa
- **SASIA:** India and South Asia
- **CHINA:** China
- **EASIA:** East Asia
- **LACA:** Latin and Central America

### 17 Sectors:
- **Rice**
- **Wheat**
- **Other Cereal Crops**
- **Vegetable Fruits**
- **Animals**
- **Forestry**
- **Fishing**
- **Coal**
- **Oil**
- **Gas**
- **Oil Products**
- **Electricity**
- **Water**
- **Energy Intensive industries**
- **Other industries**
- **Market Services**
- **Non-Market Services**

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**Recursive- dynamic CGE running 2001-2050**
The typical structure of an Impact Assessment exercise

- **Climatic drivers**
  - Δ Temp.
  - Δ Preci.
  - Δ SLR
  - ...........

- **Environmental impacts**
  - Δ flood. land
  - Δ desert. land
  - Δ crop yield
  - Δ mort./morb.
  - ..................

- **Social Economic impacts**
  - Δ Agr. Prod.
  - Δ Health care expenditure
  - Δ Labour prod.
  - ..................

- **Economic Assessment**
  - Δ Tourism Flows
  - Δ Energy demand

- **Economic Equilibrium Impacts**
  - Terms of trade effects, capital flows, sectoral adjustments
In words…

The climatic information can be seldomly used directly for an economic assessments

Most likely, it has to be “mediated” by environmental impacts that must be suitably translated into changes of meaningful economic variables

i.e. “items” to which, directly and/or indirectly, an economic “value” can be associated.

The effect of these “items” is then evaluated at the equilibrium after all economic adjustments (autonomous adaptation) take place.
Temperature and precipitation changes over Europe and North Africa

Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Bottom row: same as top, but for fractional change in precipitation. Source IPCC AR4 (2007)
Temperature and precipitation changes over Asia and the Middle East

Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Bottom row: same as top, but for fractional change in precipitation. Source IPCC AR4 (2007)
Current Water Stress in MDE-NAF countries

Source IPCC AR4
% changes of crop yields for the main Mediterranean EU and North African regions by 2050

<table>
<thead>
<tr>
<th>Region</th>
<th>Legumes Without CO₂</th>
<th>Legumes With CO₂</th>
<th>Tubers Without CO₂</th>
<th>Tubers With CO₂</th>
<th>Cereals Without CO₂</th>
<th>Cereals With CO₂</th>
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<tbody>
<tr>
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<td>-8.11</td>
<td>-7.19</td>
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<td>-11.29</td>
<td>-3.42</td>
<td>-3.77</td>
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</tr>
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</table>

Note: N-W = Portugal, Spain, France and Italy; N-E = Serbia, Greece and Turkey; S-E = Jordan, Egypt and Libya; S-W = Tunisia, Algeria and Morocco. (Source: Bindi and Moriondo, (2005))
Data sources for additional impact assessments

- **Health**: Bosello et al. (2006).

- **Sea Level Rise**: Bosello et al. (2006), Bigano et al. (2008).

- **Tourism**: HTM model (Hamilton et al. (2005), Bigano et al. (2005), Bigano et al. (2008)).

- **Energy Demand**: Bigano et al (2006), De Cian et al. (2007).

- **Agriculture**: Tol (2002), Olesen and Bindi (2002).
<table>
<thead>
<tr>
<th>Climate-Change Impacts (% ch. wrt baseline ref. year 2050)</th>
<th>HEALTH</th>
<th>LAND PRODUCTIVITY</th>
</tr>
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<tbody>
<tr>
<td><strong>Labour Product.</strong></td>
<td>Public Exp.</td>
<td>Private Exp.</td>
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<td>**1.2°C</td>
<td>3.2°C</td>
<td>1.2°C</td>
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<tr>
<td>USA</td>
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<td>Med_Europe</td>
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<td>0.01</td>
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<tr>
<td>East_Europe</td>
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<td>0.23</td>
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<td>FSU</td>
<td>0.11</td>
<td>0.28</td>
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<tr>
<td>KOSAU</td>
<td>-0.43</td>
<td>-1.14</td>
</tr>
<tr>
<td>CAJANZ</td>
<td>0.09</td>
<td>0.22</td>
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<tr>
<td><strong>NATURAL GAS</strong></td>
<td><strong>OIL PRODUCTS</strong></td>
<td><strong>ELECTRICITY</strong></td>
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<tr>
<td><strong>USA</strong></td>
<td>**-0.026</td>
<td>-0.055</td>
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<tr>
<td><strong>Med_Europe</strong></td>
<td>**-0.007</td>
<td>-0.015</td>
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<tr>
<td><strong>North_Europe</strong></td>
<td>**-0.020</td>
<td>-0.041</td>
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<tr>
<td><strong>East_Europe</strong></td>
<td>**-0.022</td>
<td>-0.046</td>
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<tr>
<td><strong>FSU</strong></td>
<td>**-0.007</td>
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<td><strong>KOSAU</strong></td>
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<td>-0.011</td>
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<tr>
<td><strong>CAJANZ</strong></td>
<td>**-0.004</td>
<td>-0.009</td>
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<tr>
<td><strong>SEA LEV. RISE</strong></td>
<td><strong>TOURISM</strong></td>
<td><strong>HOUSEHOLDS' ENERGY DEMAND</strong></td>
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<tr>
<td><strong>Land Losses</strong></td>
<td><strong>Market Serv. Demand</strong></td>
<td><strong>Income Flows</strong></td>
</tr>
<tr>
<td>**1.2°C</td>
<td>3.2°C</td>
<td>1.2°C</td>
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<tr>
<td>USA</td>
<td>-0.026</td>
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<tr>
<td><strong>NAF</strong></td>
<td>**-0.017</td>
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<td>LACA</td>
<td>-0.025</td>
<td>-0.052</td>
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</table>
Climate Change: the global picture (1)
Climate Change: the global picture (2)

Climate Change Impacts: Summary

- Temperature increase
- % of GDP
- Agriculture, Energy Demand, Health, Sea Level Rise, Tourism, All Impacts

Temperature increase:
- 1.2 °C
- 3.1 °C

Locations:
- USA
- Med_Europe
- North_Europe
- East_Europe
- FSU
- KOSAU
- CAJANZ
- NAF
- SSA
- SASIA
- CHINA
- EASIA
- LACA
- World
Climate Change Impacts: a snapshot on MDE-NAF

**CC (3.1 °C) vs baseline: Real GDP % change**

North Africa

Middle East
Climate Change Impacts: a snapshot on MDE

CC (3.1 °C) vs baseline: Real GDP % change

- Agriculture
- Energy Demand
- Health
- SLR
- Tourism
- All impacts
Climate Change Impacts: a snapshot on NAF

CC (3.1 °C) vs baseline: Real GDP % change

-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5

Agriculture
Energy Demand
Health
SLR
Tourism
All impacts

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Climate-change costs over GDP (direct costs) vs GDP costs of climate change. Ex.1: Agriculture (1.2°C - 3.1°C, ref. Year 2050)

+ 1.2 °C wrt 2001

+ 3.1 °C wrt 2001
Climate-change costs over GDP (direct costs) vs GDP costs of climate change. Ex.2: Health (1.2°C - 3.1°C, ref. Year 2050)

+ 1.2 °C wrt 2001

+ 3.1 °C wrt 2001
Climate-change costs over GDP (direct costs) vs GDP costs of climate change. Ex.3: Sea-Level rise (2.1°C - 3.1°C, ref. Year 2050)

+ 1.2 °C wrt 2001

+ 3.1 °C wrt 2001
Climate-change costs over GDP (direct costs) vs GDP costs of climate change. Ex.4: All impacts (2.1°C - 3.1°C, ref. Year 2050)

+ 1.2 °C wrt 2001

+ 3.1 °C wrt 2001
<table>
<thead>
<tr>
<th></th>
<th>NAF</th>
<th>MDE</th>
<th>KOSAU</th>
<th>CAJANZ</th>
<th>NAF</th>
<th>MDE</th>
<th>SSA</th>
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<th>CHINA</th>
<th>EASIA</th>
<th>LACA</th>
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Conclusions

Developing countries are more severely damaged than developed countries

More concerning for developing countries is CC negative impact on agriculture → increase in food prices

MDE+NAF - in addition to agricultural (major determinant of NAF performance) and tourism sector (major determinant of MDE performance) losses - particularly suffer of the terms of trade worsening due to reduced energy demand worldwide. Sectorally energy producing sectors (except coal) are more damaged (production decreases)

Key role of autonomous adaptation and distributional effects
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