# Climate Local Information in the Mediterranean region
# Responding to User Needs

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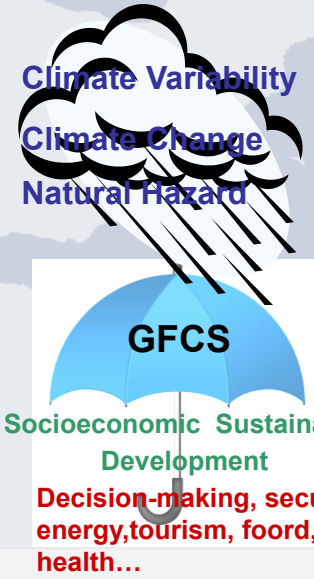
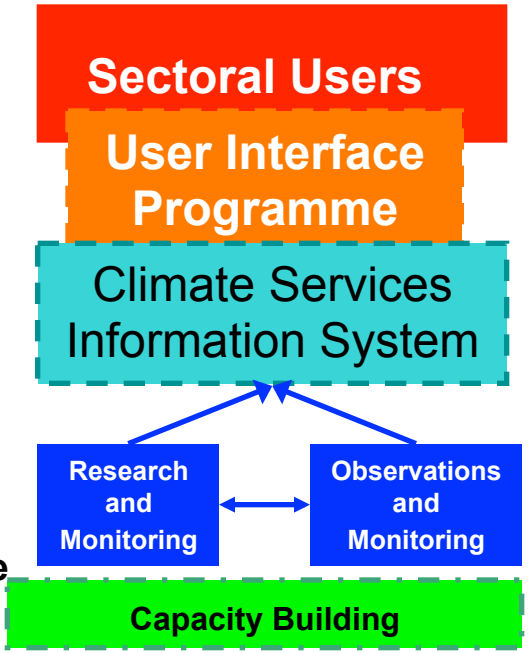
**Alessandro Dell'Aquila**

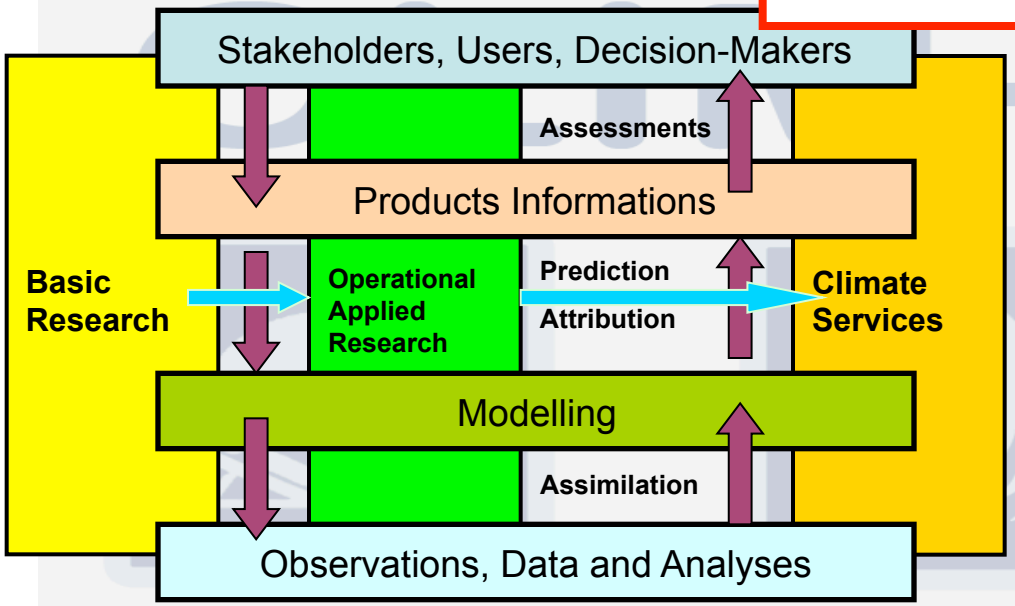
# CLIM-RUN

# A WMO initiative: A Global Framework for Climate Services

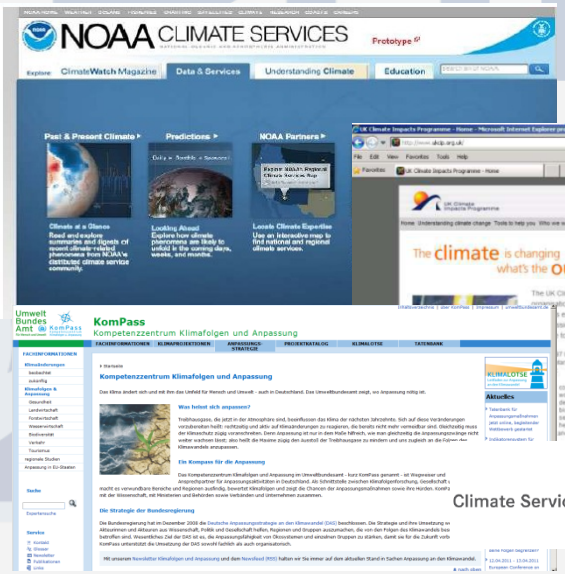



- **Expected essential components:**
  - Observations, Monitoring
  - Research, modelling, prediction
  - Climate Services Infromation System
  - User Interface
  - Capacity building
- **Framework to support climate affected socioenomic sector**




*from WMO….*

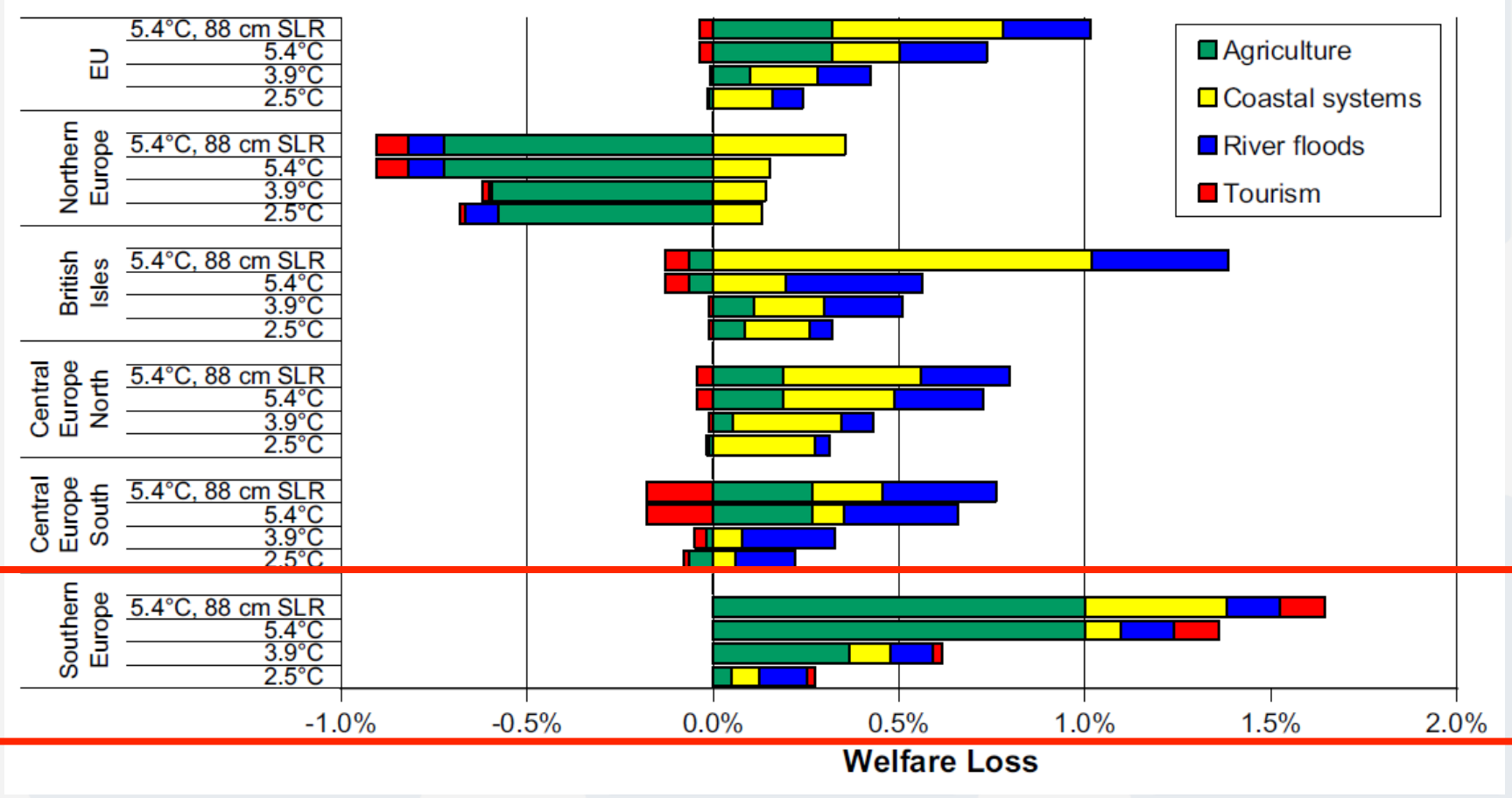



# ENV.2010.1.1.4.1. Underpinning work to enable provision of local scale climate information (annual to decadal timescales)

In the context of emerging measured impacts of climate change the **demand for climate services** is growing. However, the supply of relevant climate information and forecasts at the appropriate spatial and time scale **does not currently match with requirements needed** on the demand side, notably for the implementation of adaptation measures. **Bridging the gap between demand and supply** in this field requires better data, improved models based on innovative methodologies and techniques and further studies at regional and local level. Research in this area should use a **bottom-up approach** in order to (1) contribute to the **identification of the relevant climate services** (from observations and model projections) (2) advancing the **science underpinning the delivery of climate information** and (3) identifying, for selected region known for their **climate vulnerability**, the spatial and time scale for which climate information serving operational adaptation activities could be provided.

# Cross-Sectoral Impacts of Climate Change

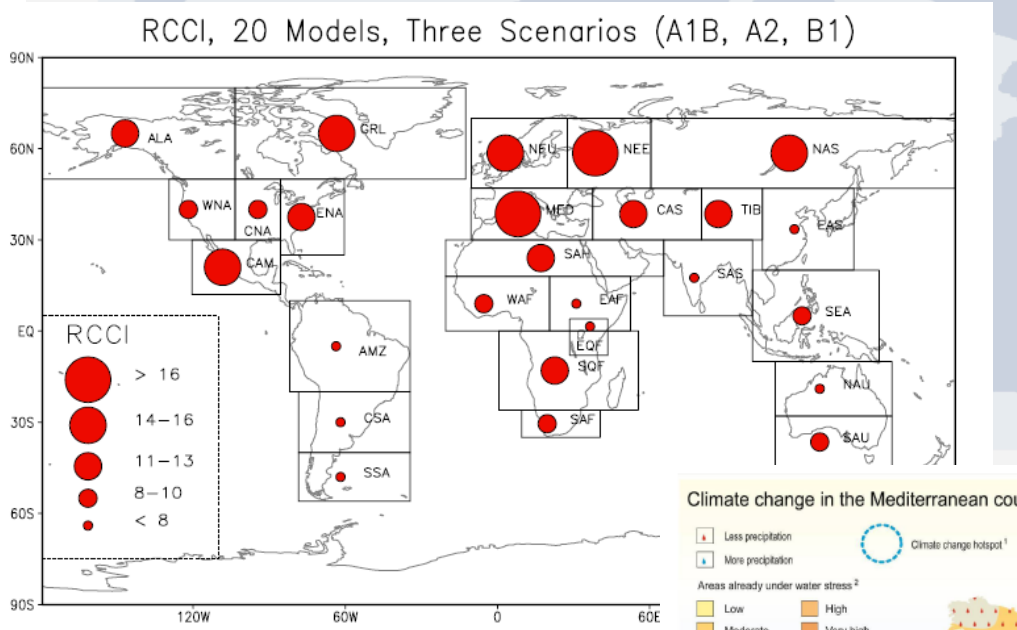
## EU Regional welfare (% change) for different 2080s T changes




**Source: Ciscar et al., 2011: Physical and economic consequences of climate change in Europe, *PNAS*.**

# Mediterranean Perspective

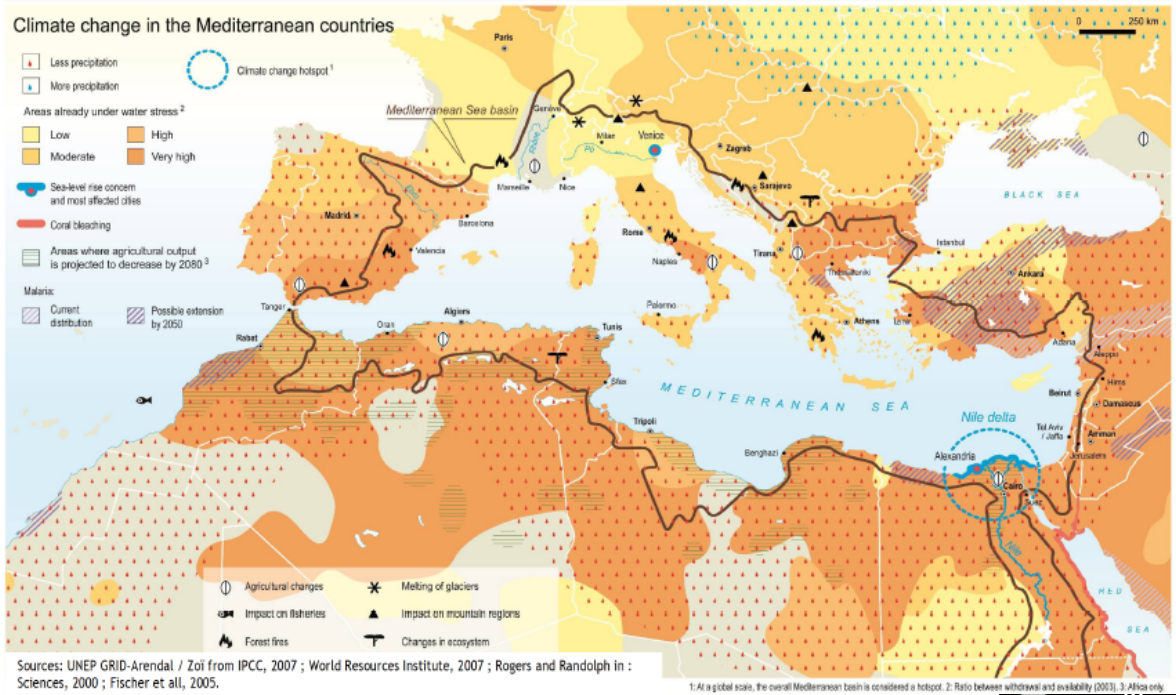
## HIGHLY VULNERABLE HOT- SPOT




Giorgi, GRL 2006

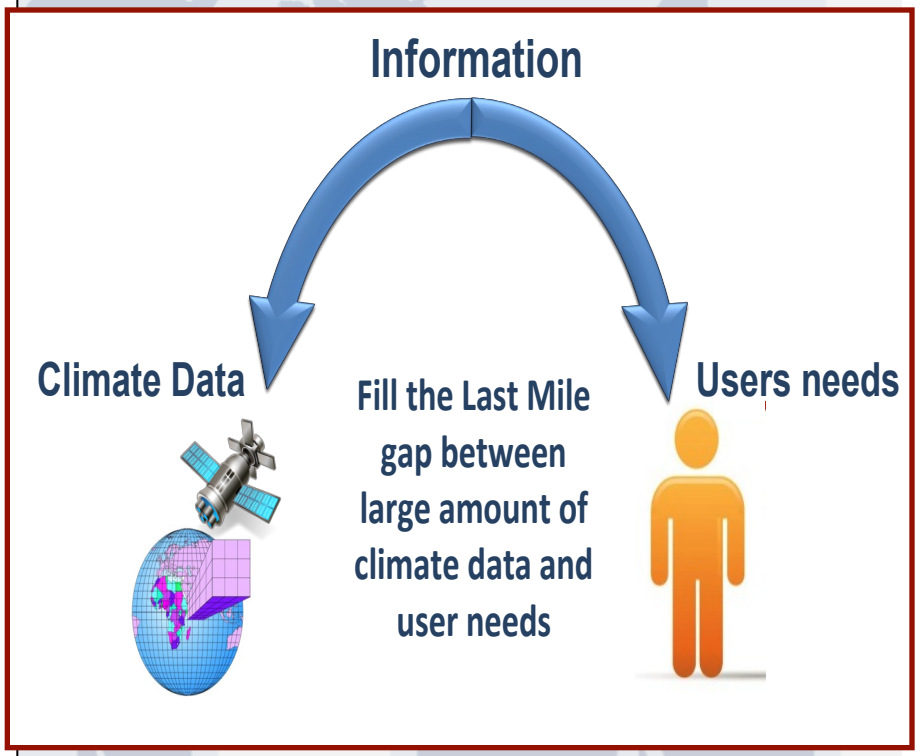
Synthesis of climate change effects and vulnerabilities in the Mediterranean

(*Plan Blue 2009*)



# CLIM-RUN Objectives

- Design and implementation of a **protocol** for optimizing the **two-way information transfer** (bottom-up /up-bottom) between climate experts and stakeholders
- Advancement of the **science underpinning** the production of detailed **climate information** at regional to local scales tailored for **stakeholder needs**
- Test of the protocol via its application to a number of real world **case studies** in the **Mediterranean area** (mainly on Energy & Tourism and Natural hazards)

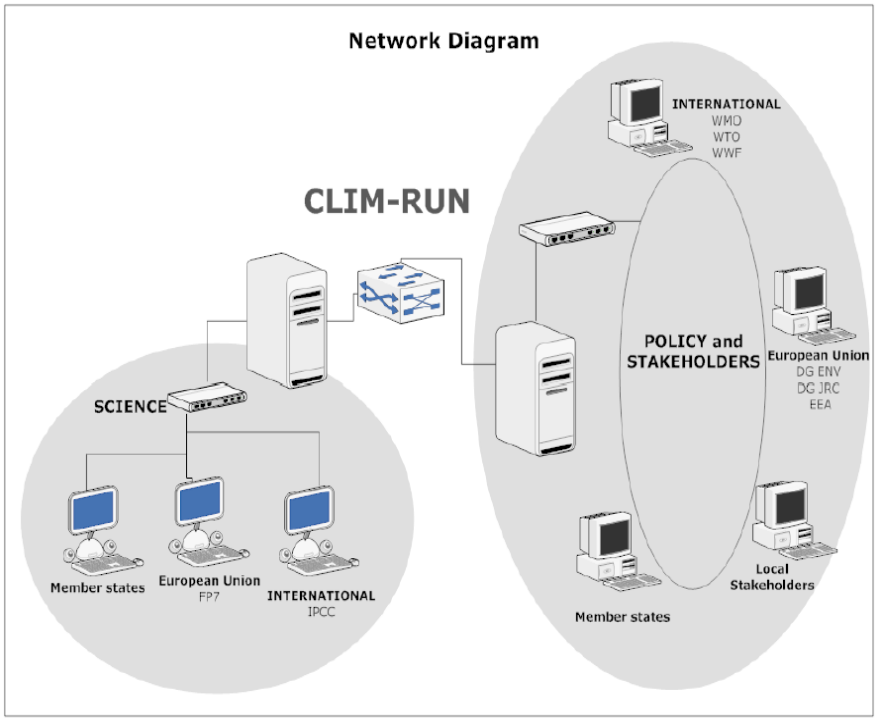


# CLIM-RUN Approach

- CLIM-RUN follows a **bottom-up approach** in which the early involvement of stakeholders is crucial to establish productive **two-way communication channels** to identify well-defined climate information needs and assess the envisioned protocol for selected inter-dependent sectors (in particular energy, tourism and natural hazards).

- CLIM-RUN will also work on **improved modelling** and **downscaling tools** to optimally respond to the specific needs of end users.

- CLIM-RUN is intended to provide the **seed for a Mediterranean basin-side climate service network** which will converge into a pan-European network.



# CLIM-RUN Members

ENEA(Italy) EEWRC(Cyprus) CNRM(France) ICTP(Italy)
IC3(Spain) NOA(Greece ) CMCC(Italy) TEC(France)
PlanBleu(France) PIK(Germany) UEA(UK) GREVACHOT(Tunisia)
JRC (Spain) DHMZ (Croatia) USMD(US) UC(Spain)







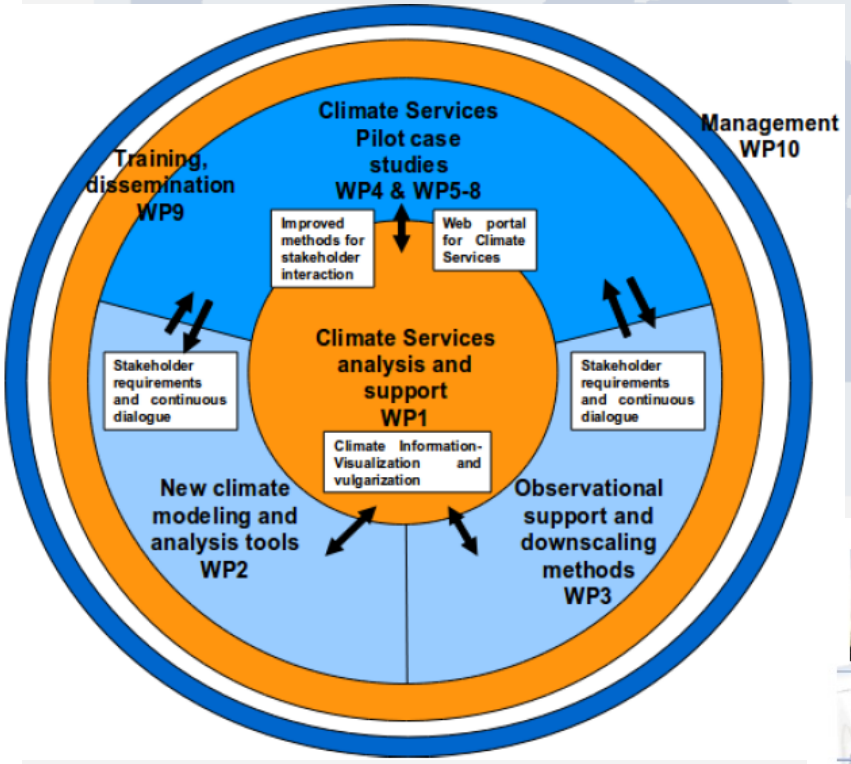


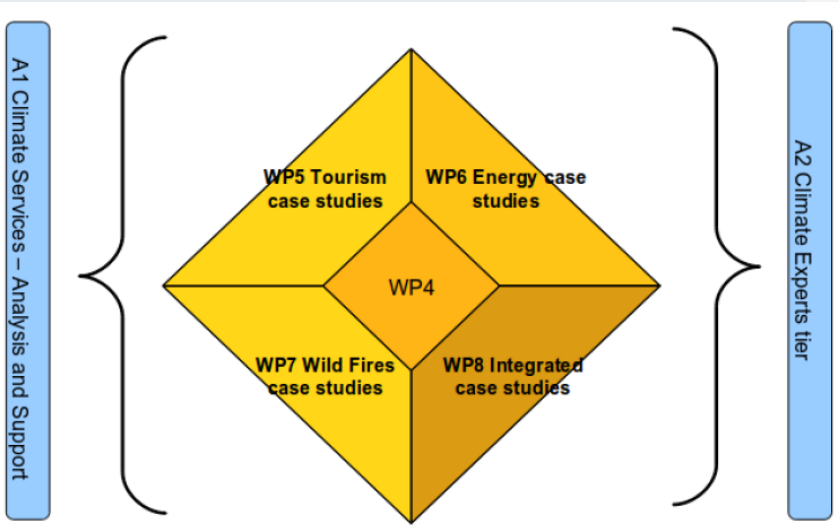

**Coordination & Management**: - *Italian National Agency for New Technologies, Energy and Sustainable Economic Development*.

*UTMEA-CLIM Energy & Environment Modeling Unit*

*Climate & Impact Modeling Laboratory*. Contact paolo.ruti@enea.it

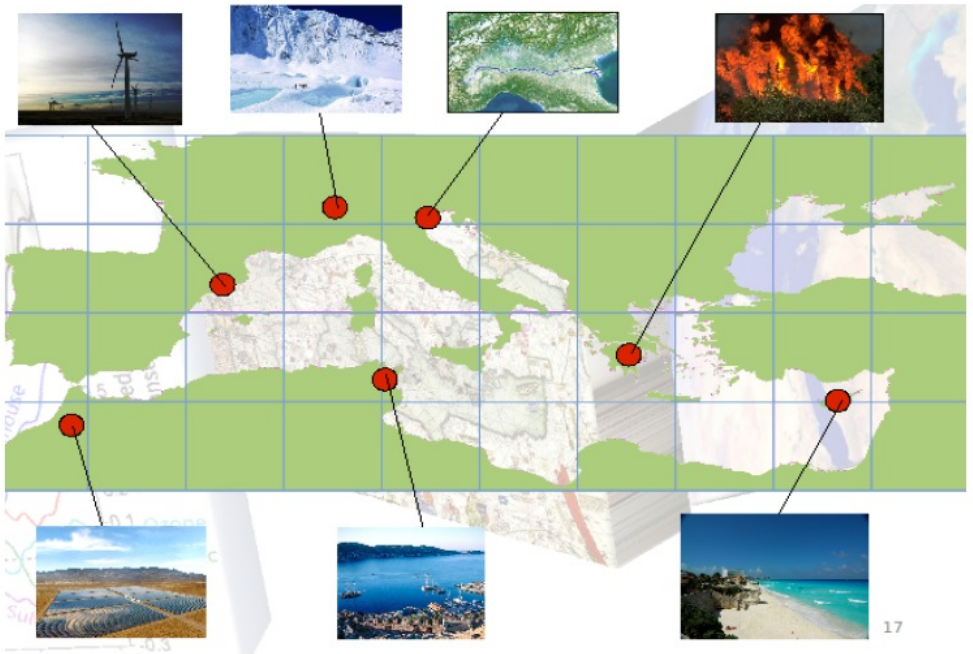
# Structure of CLIM-RUN




## CASE STUDIES

- **Tourism**: Tunisia, Savoie (France), Cyprus
- **Energy**: East and South Spain, Morocco, Cyprus
- **Coastal Zone Integrated Case Studies:** North Adriatic Sea
- **Wild Fires**: Greece



# Structure of CLIM-RUN

## The case studies

### Stage setting

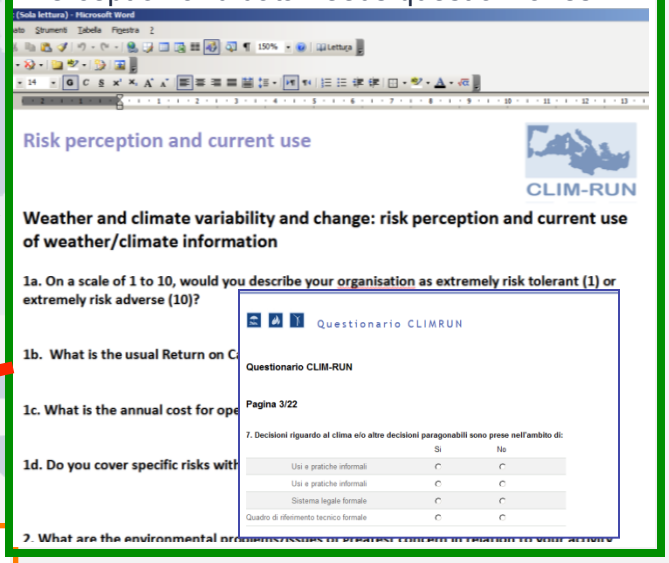
**The 'who' and the 'what'**

- Who are the climate services stakeholders?
  - Why is climate variability and change relevant to you?
  - How do climate issues fit within your decision making mechanisms and your perception of risk?
- What do you need/want from climate services?
  - Specific data
  - Analysis tools
  - Guidance and training
  - Other things…..


### First Workshops

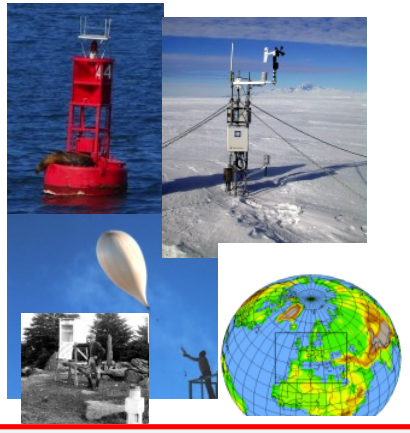

### Mapping the issues

Perception and data needs questionnaires

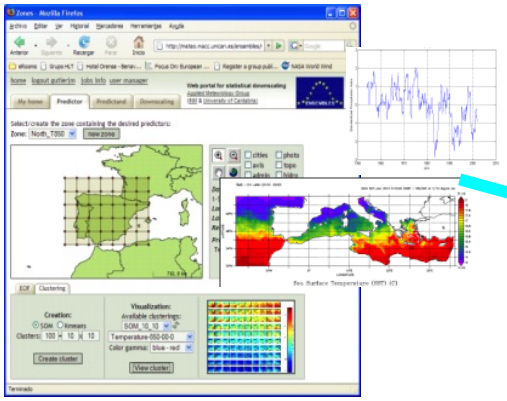



**Iterative consultation and collaboration**

### Interaction with climate community



### Tailored climate information



### Generalization: protocol for 2-way information transfer

# INTEGRATED: North Adriatic

# stakeholder involvement

- identification of stakeholders
- invitation: email and follow up calls
- climate products needs
  - workshop 1
  - questionnaire: climate products needs
- interaction with climate experts
  - discussion
- climate products validation
  - workshop 2
  - focus group

# stakeholder involvement

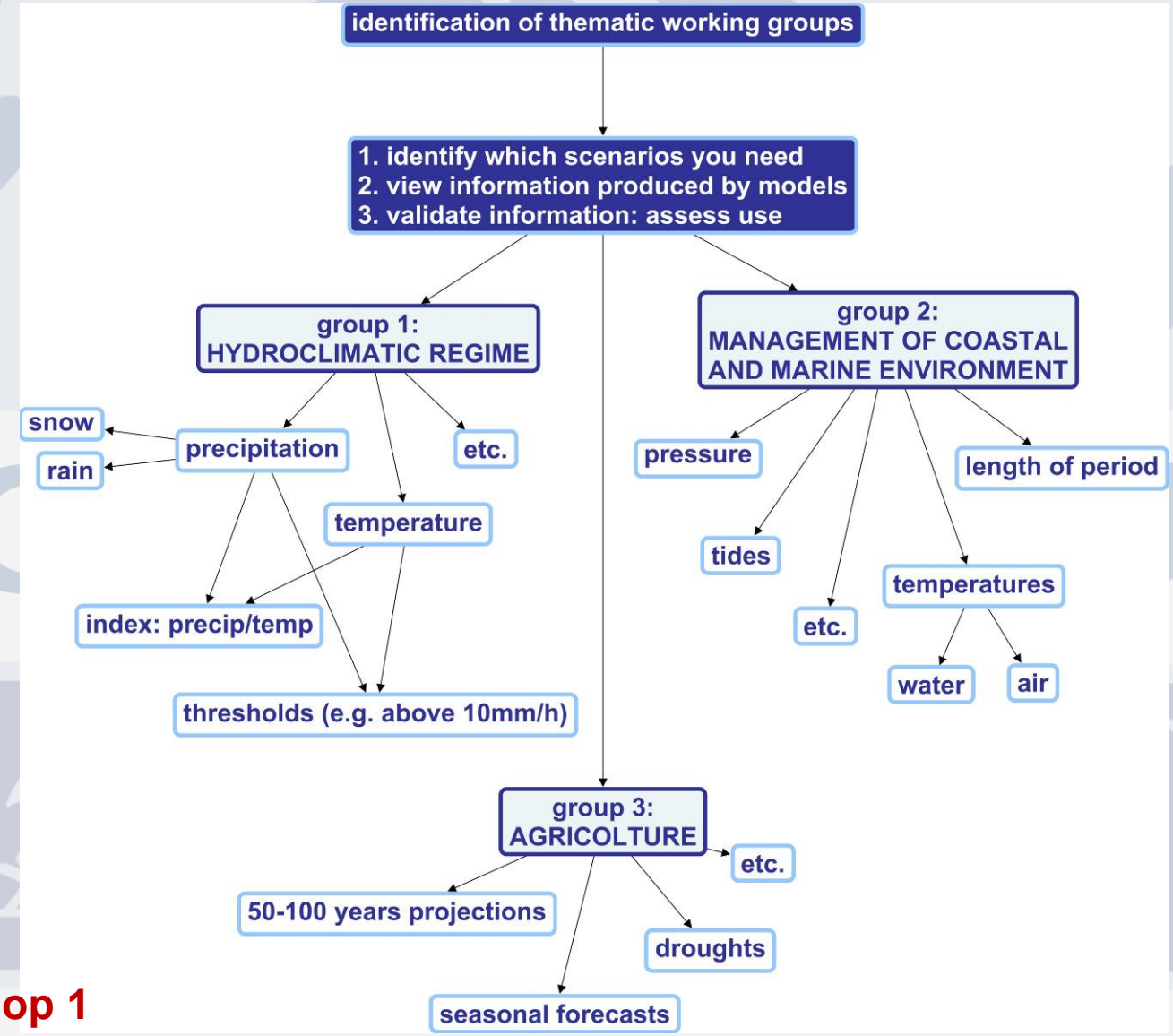
- criteria for stakeholder identification: institutions which have mandate for ICZM (Integrated Coastal Zone Management), according to EU Recommendation:
  - fisheries and aquaculture, transport, energy, resource management, species and habitat protection, cultural heritage, employment, regional development in both rural and urban areas, tourism and recreation, industry and mining, waste management, agriculture and education (Ch.3)
- comprehensive list of offices (63 total)
  - 4 national, 31 from Veneto, 28 from FVG: from macro to micro
  - scoring by expert team (1 to 5): importance, influence, effects, relevance, attitude
- 40 offices were selected, 26 agreed to participate
  - 20 participated to workshop 1
  - 13 answered the online questionnaire
  - 11 gave feedback
  - 11 participated to workshop 2 and 4 to focus group

Macro

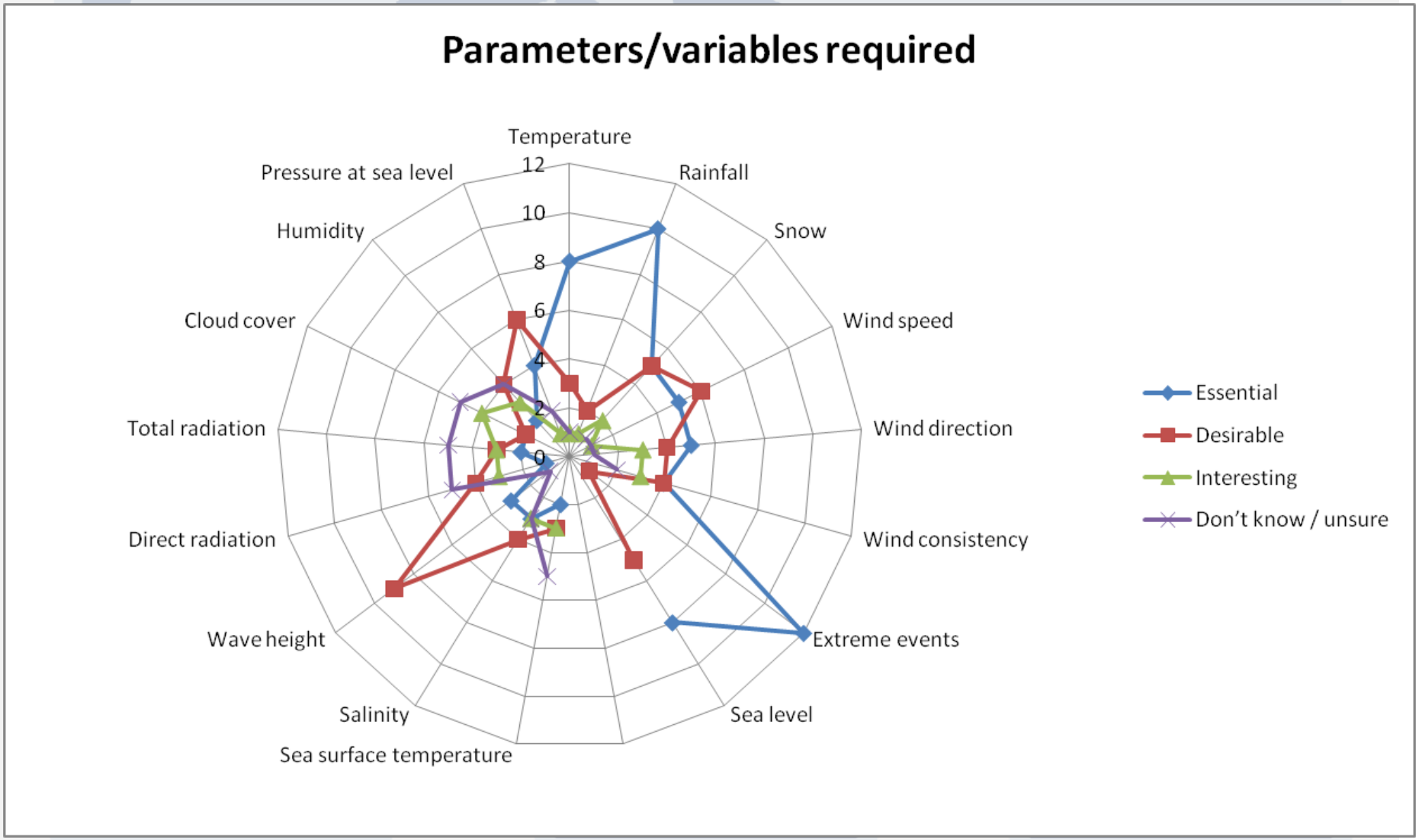
Micro

| Level | Veneto | Friuli Venezia Giulia |
|---|---|---|
| National | ▪ Civil Protection, regional office | ▪ Civil Protection, regional office |
| Inter-regional | ▪ Autorità di bacino delle Alpi Orientali<br>▪ Autorità di bacino dell'Alto Adriatico<br>▪ Autorità di bacino del Po | |
| Regional | ▪ ARPAV<br>▪ Segreteria regionale per l'ambiente<br>▪ Segreteria regionale per le infrastrutture e l'urbanistica<br>▪ Genio Civile (Regione Veneto)<br>▪ Segreteria regionale per la cultura e turismo<br>▪ Pesca ed acquacoltura<br>▪ Servizio idrico integrato: ATO<br>▪ Industria<br>▪ Energia | ▪ ARPA FVG<br>▪ Sviluppo sostenibile<br>▪ Urbanistica e pianificazione territoriale (incluso infrastrutture)<br>▪ Aree naturali e biodiversità<br>▪ Ente tutela pesca<br>▪ Servizio idrico integrato<br>▪ Industria<br>▪ Energia<br>▪ Turismo |
| Independent Authorities | ▪ Port Authoritiy of Venice<br>▪ ASPO Chioggia<br>▪ Magistrato delle acque di Venezia<br>▪ Consorzio di Bonifica Adige Po<br>▪ Consorzio di Bonifica Delta Po Adige<br>▪ Consorzio di Bonifica Adige Euganeo<br>▪ Consorzio di Bonifica Bacchiglione<br>▪ Consorzio di Bonifica Acque Risorgive<br>▪ Consorzio di bonifica Piave<br>▪ Consorzio di Bonifica Veneto Orientale | ▪ Port Authoritiy of Trieste<br>▪ ASPO Monfalcone<br>▪ Consorzio di Bonifica Bassa Friulana<br>▪ Consorzio di Bonifica Cellina Meduna<br>▪ Consorzio di Bonifica Ledra Tagliamento<br>▪ Consorzio di Bonifica Pianura Isontina |
| Parks and reserves | ▪ Parco Regionale Veneto del Delta del Po<br>▪ Riserva Naturale Bocche di Po<br>▪ Riserva Naturale Integrale Bosco Nordio | ▪ Area Marina Protetta di Miramare<br>▪ Riserva Naturale della Foce dell'Isonzo<br>▪ Riserva Naturale Foci dello Stella<br>▪ Riserva Naturale della Valle Canal Novo<br>▪ Riserva Naturale della Valle Cavanata<br>▪ Riserva Naturale delle Falesie di Duino<br>▪ Riserva Naturale regionale laghi di Doberdò e Pietrarossa<br>▪ Riserva Naturale della Val Rosandra<br>▪ Biotopo Magredi di San Canciano |
| Provinces | ▪ Venezia<br>▪ Rovigo | ▪ Trieste<br>▪ Gorizia<br>▪ Udine |
| Municipalities | ▪ San Michele al Tagliamento<br>▪ Caorle, Eraclea<br>▪ Jesolo<br>▪ Cavallino-Treporti<br>▪ Venezia<br>▪ Chioggia<br>▪ Rosolina<br>▪ Porto Viro<br>▪ Porto Tolle | ▪ Muggia<br>▪ Trieste<br>▪ Duino Aurisina<br>▪ Monfalcone<br>▪ Staranzano<br>▪ Grado<br>▪ Marano Lagunare<br>▪ Lignano Sabbiadoro |

# climate products needs



# climate products needs




questionnaire

# climate products needs

## SUMMARY TABLE: hydro-climatic regime

| STAKEHOLDERS | | RESEARCHERS | | |
|---|---|---|---|---|
| **Workshop 13 Sept 2011** | **Additional comments** | **Variable** | **Spatial scale** | **Time scale** |
| extreme events forecasts | percentiles, return periods; duration; trend; add pressure | precipitations, winds | 15-50 km: models, local scale: downscaling | 1-3 hours, daily, seasonal, decadal, multidecadal |
| how trends will vary | fog; snow cover variation | temperature, precipitations | 15-50 km: models, local scale: downsc. | daily, seasonal, decadal, multidecadal |
| design and management of structural defence measures, and of pumps | description of weather events as modified by climate change to improve design | extreme events of precipitations | 15-50 km: models, local scale: downsc. | 1-3 hours, daily, seasonal, decadal, multidecadal |
| extreme events monitoring for intervention and early warning system | | precipitations, winds | 15-50 km: models, local scale: downsc. | 1-3 hours, daily, seasonal |
| improve knowledge of climate change scenarios, of models used, and of uncertainty | mean sea level | temperature, precipitations | global and regional model ensembles, possible downsc | decadal, multidecadal |
| data availability from ARPA Veneto and Friuli Venezia Giulia | identify uncertainty and confidentiality levels at regional scale | precipitations, winds, temperature | local data coming from stations | daily, seasonal, decadal, multidecadal |
| improve monitoring | | need feedback from stakeholders | | |

# climate products needs

## SUMMARY TABLE: coastal-marine environment

| STAKEHOLDERS | | RESEARCHERS | | |
|---|---|---|---|---|
| **Workshop 13 Sept 2011** | **Additional comments** | **Variable** | **Spatial scale** | **Time scale** |
| environmental sustainability: beach erosion, salt water intrusion, forest fires, drinking water availability | continuous monitoring of: hydrometric levels, piezometric levels, electrical conductivity | sea level, wind, precipitation, sea level pressure | 15-50 km: models, local scale: downscaling | daily, seasonal till multidecadal |
| improvement of forecasts | | | | |
| return periods | | | | |
| climatic information for urban planning | | | | |
| climatic information for coasts: sea level rise scenarios | | sea level, wind, precipitation, sea level pressure | global and regional model for the North Adriatic area | |
| fishery resources and variation in species present | seasonal cycles | precipitation, runoff, evaporation, currents | 15-50 km: models, local scale: downscaling | |

interaction

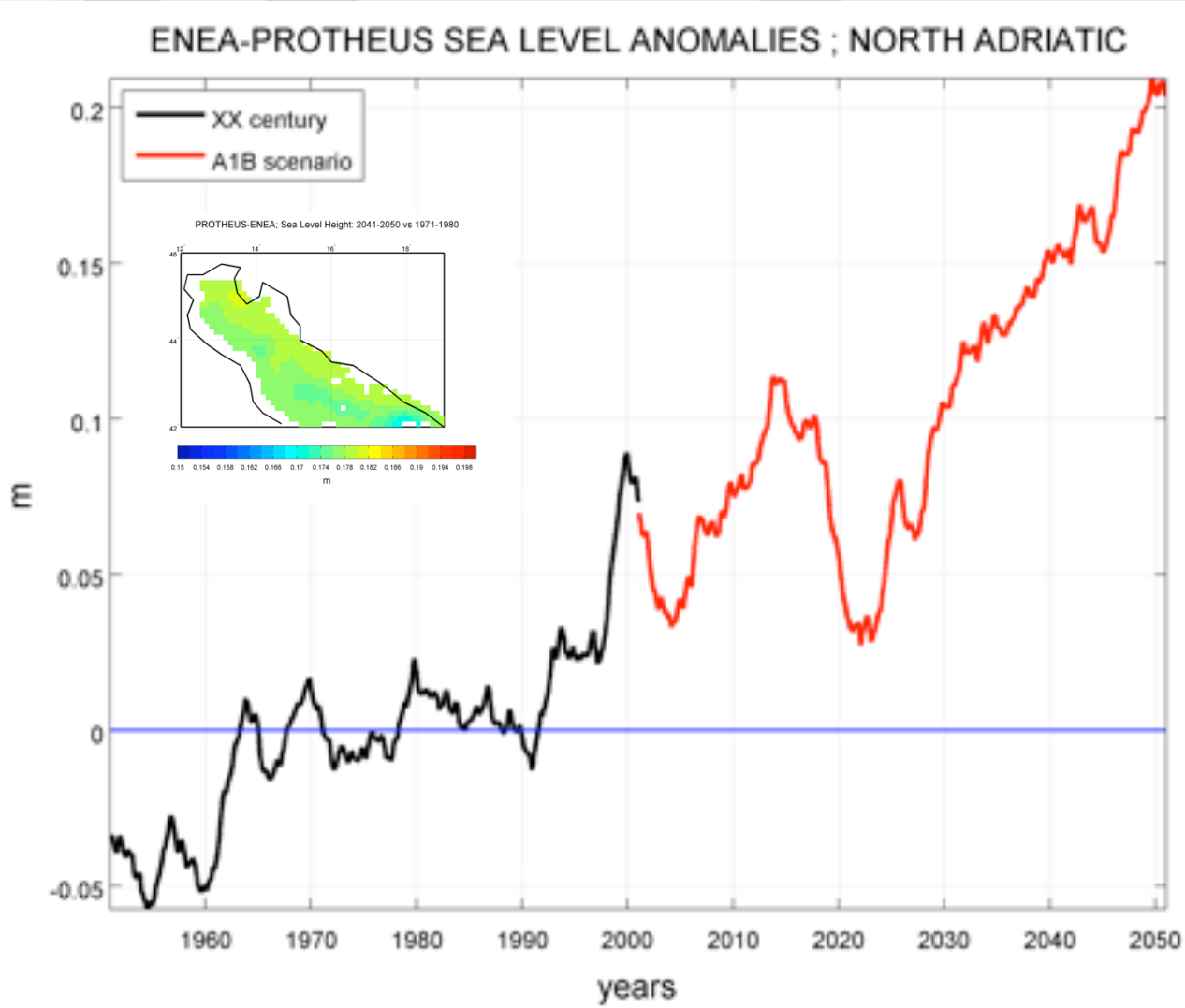
# climate products needs

## SUMMARY TABLE: agriculture

| STAKEHOLDERS | | RESEARCHERS | | |
|---|---|---|---|---|
| **Workshop 13 Sept 2011** | **Additional comments** | **Variable** | **Spatial scale** | **Time scale** |
| drought and irrigation | potential evapotranspiration; hydroclimatic balance; extreme temperatures; heat waves; general trend (up to 2100), decadal trends (2010-2010, etc.), multidecadal (2010-2030, etc.); pressure. | precipitation, temperature, drought indicators | 15-50 km from models, local scale from downscaling | daily, seasonal till multidecadal |

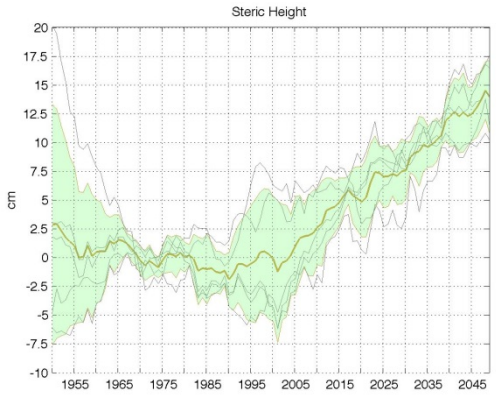
interaction

# climate products




uncertainty:

- ice melt
- models



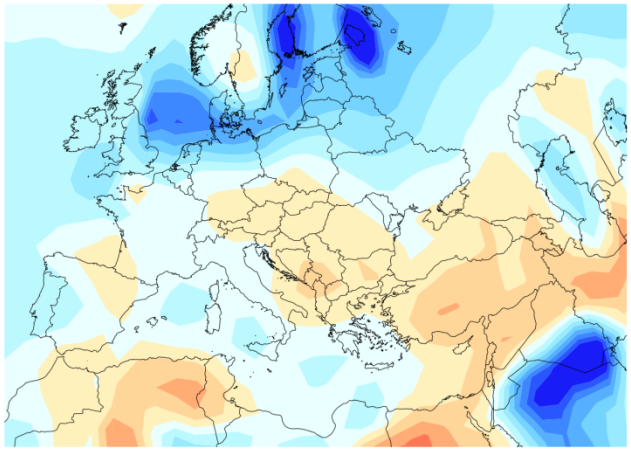

Gualdi et al., 2013

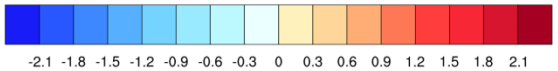
Trend (2000-2050): 2.8 mm/yr

slr

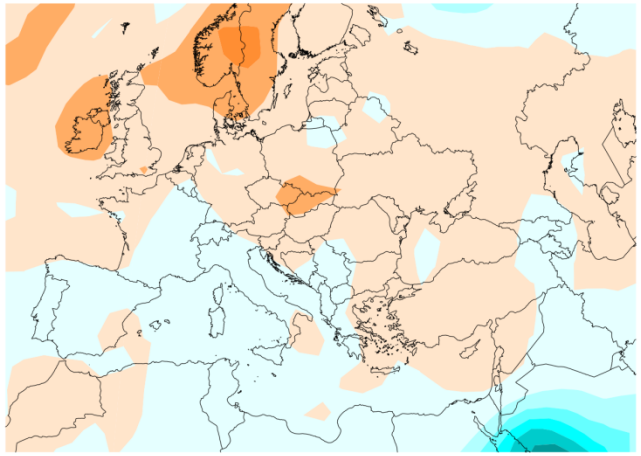
# climate products

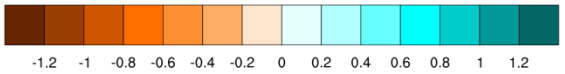
201304 jja Temperature anomalies (˚C)





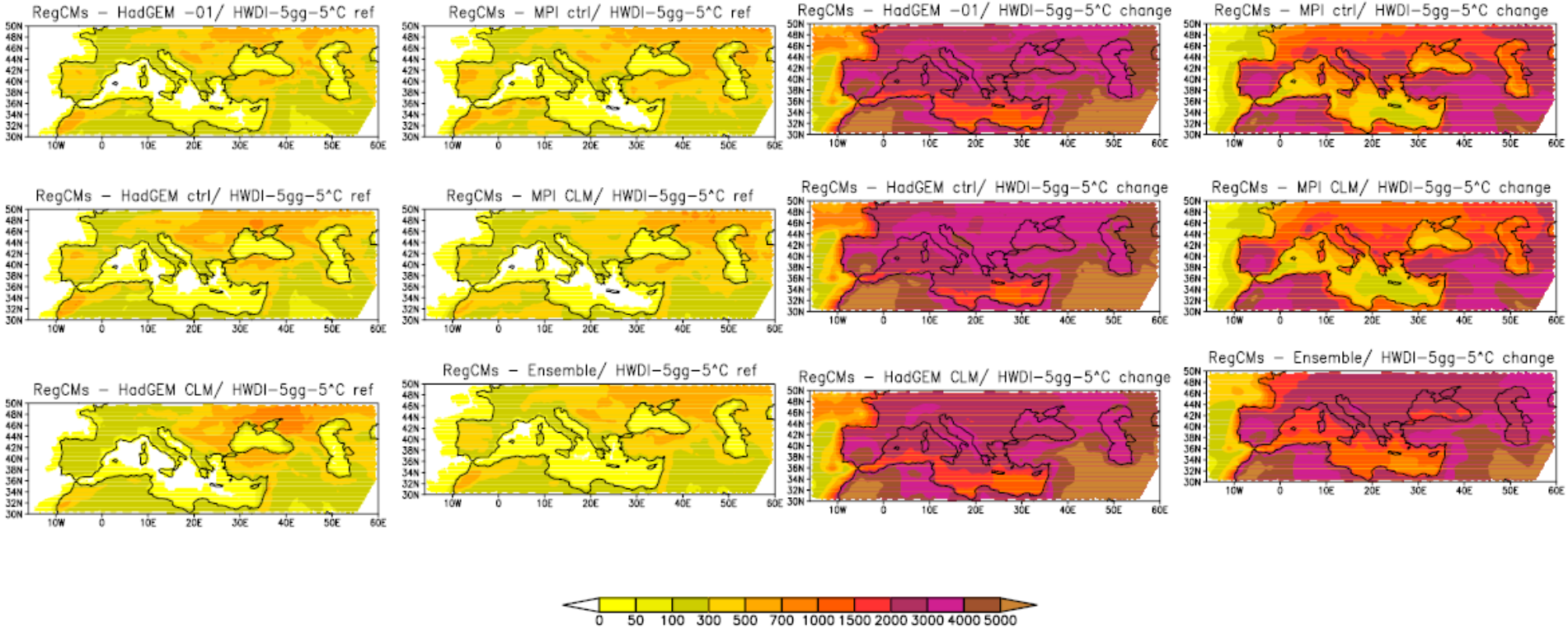

201304 jja Precipitation anomalies (mm/day)





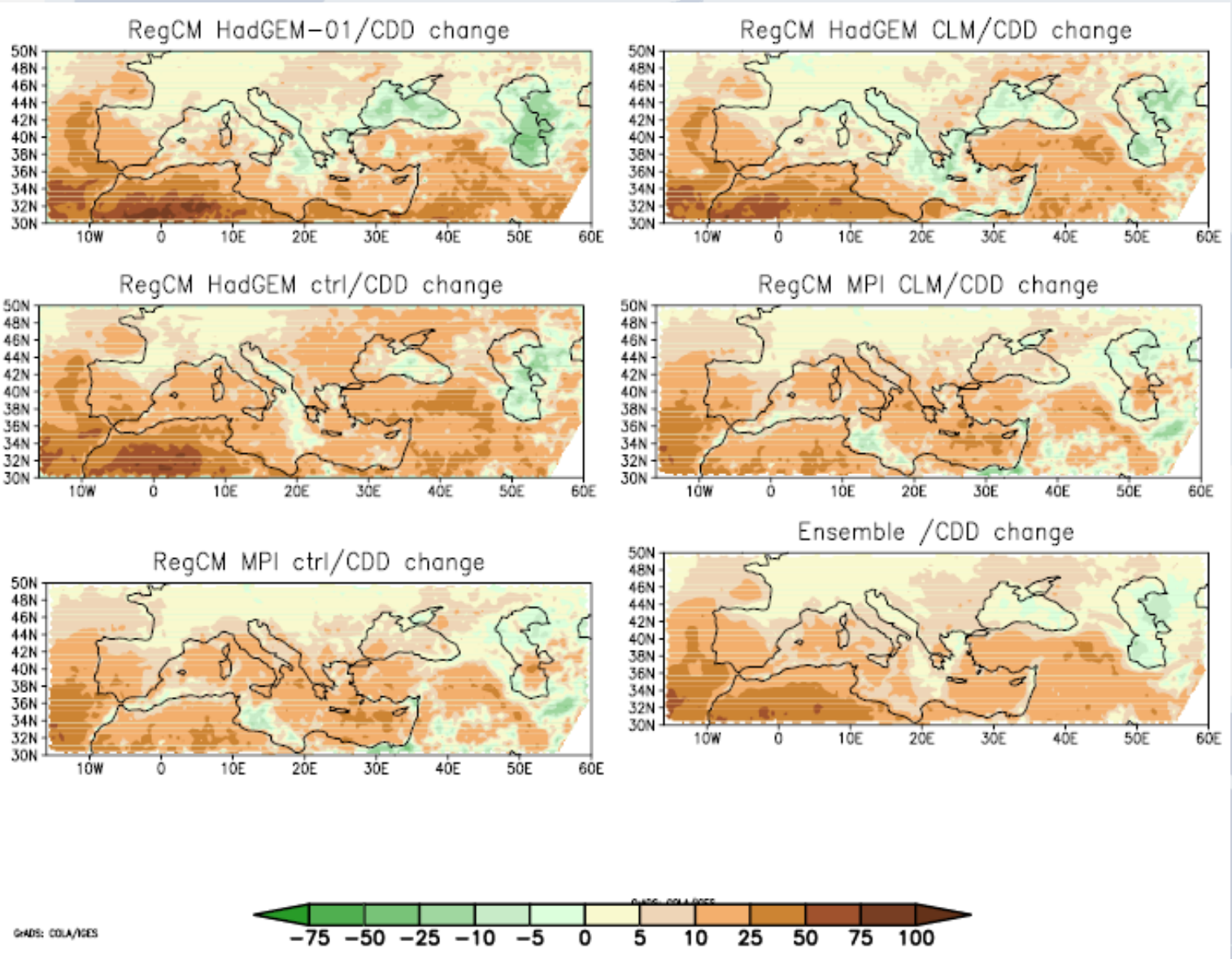

extreme events

# climate products



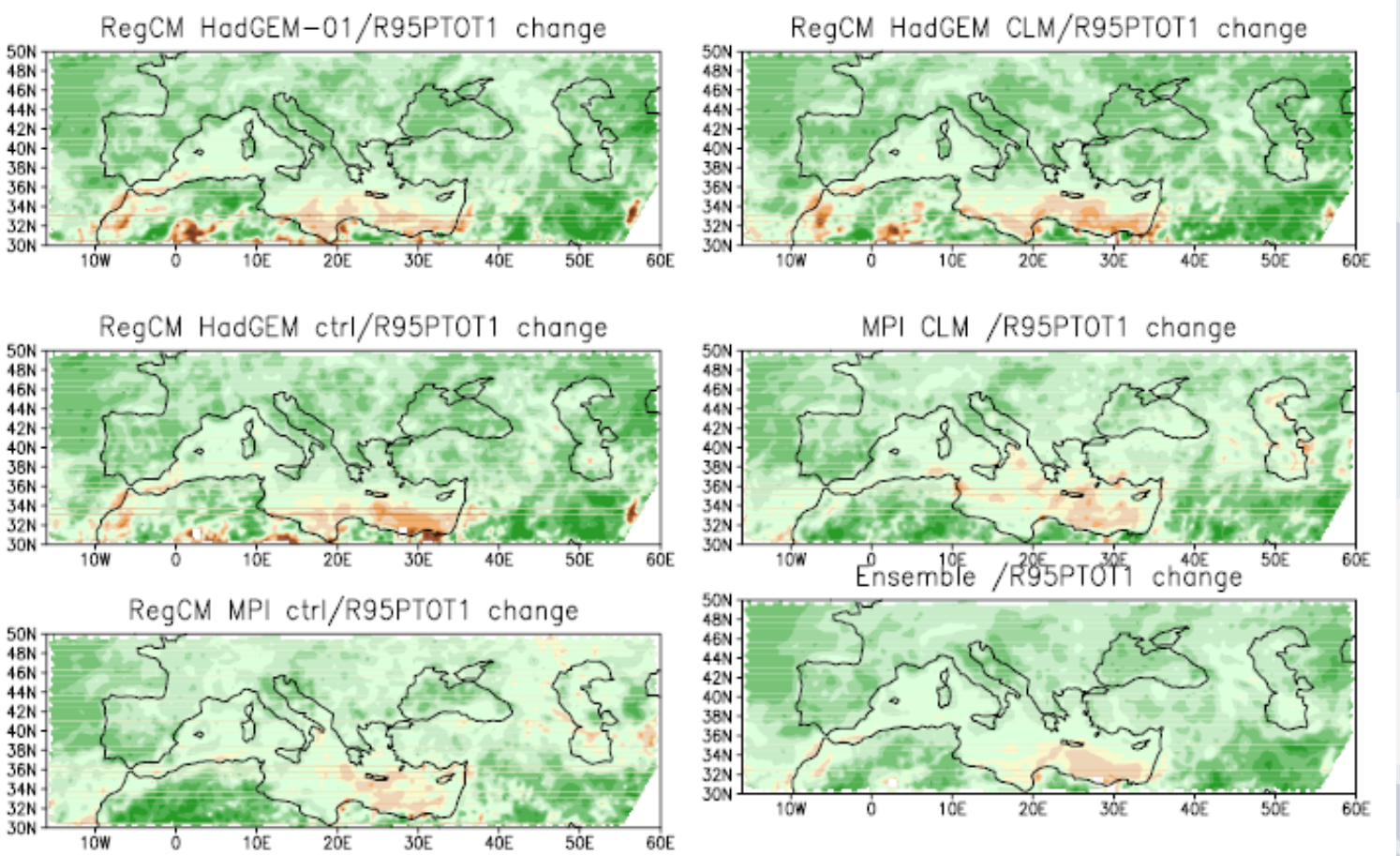

**downscaling: heat wave day index**

# climate products




downscaling: dry spell length index

# climate products




downscaling: heavy precipitation index

# climate products

*CLIM-RUN Product Information Sheet: September 2013*

## Local climate change projections and associated uncertainty: The North Adriatic case study

*Sandro Calmanti, Alessandro Dell'Aquila*
**ENEA, Rome, Italy**

**Keywords: Climate Change, uncertainty, risk management, investment**

### Target groups

- **Local/Regional Autorithies**
- **Private Stakeholders**
- **Regional met offices**

### Relevance to the case-study requirements

Climate variability and change in the Mediterranean basin and in the local sub-basins (i.e. North Adriatic) is a subject which, in recent years, has received an increasing amount of interest within the international climate science community. However, the numerical climate projections available for certain areas such as the North Adriatic basin do not completely agree in the foreseen changes. The idea of uncertainty associated to climate projections needs to be correctly communicated to end-users

### The approach

Regional Climate Models (RCMs) produce high-resolution (about 20 km) climate scenarios over selected areas by taking the input at the lateral boundaries from coarser resolution (more than 100 km) Global Climate Models (GCMs). RCMs enhance the quality of climate projections with respect to GCMs, especially in the presence of complex orography (Artale et al., 2010) and in the proximity of coastal areas (Feser et al., 2011). In CLIMRUN, we have evaluated climate change projections over the Euro-Mediterranean area using what is currently the largest and most consolidated ensemble of RCM simulations - produced during the EU-FP6 project ENSEMBLES (van der Linden and Mitchell, 2009).

The table shows (in blue) the GCMs-RCMs combinations that have been extracted from the ENSEMBLES archive http://ensembles-eu.metoffice.com to develop the CLIMRUN products.

| Regional Model \ Global Model | HadCM3Q16 | ARPEGE | BCM | ECHAM5-MPIOM r3 | MIROC3.2 hires | HadCM3Q0 |
|---|---|---|---|---|---|---|
| C4IRCA3 | ■ | | | | | |
| CNRM-RM4.5 | | ■ | | | | |
| DMI-HIRAM5 | | ■ | ■ | ■ | | |
| ETHZ-CLM | | | | | | ■ |
| ICTP-RegCM3 | | | | ■ | | |
| KNMI-RACMO2 | | | | ■ | ■ | |
| METNO-HIRAM | | | ■ | | | ■ |
| METO-HC HadRM3Q0 | | | | | | ■ |
| MPI-M-REMO | | | | ■ | | |
| SMHIRCA | | | ■ | ■ | | |
| UCLM-PROMES | | | | | | ■ |

*References:*
*Artale et al., 2010. An atmosphere-ocean regional climate model for the Mediterranean area: assessment of a present climate simulation Clim. Dyn. doi:10.1007/s00382-009-0691-8*
*Feser et al., 2011. Regional climate models add value to global model data". Bull. Of the American Meteorological Society 92. 1181-1192.*
*van der Linden P., and J.F.B. Mitchell , 2009. ENSEMBLES: Climate Change and its Impacts: Summary of research and results from the ENSEMBLES project. Met Office Hadley Centre, FitzRoy Road, Exeter EX1 3PB, UK. 160pp*

*CLIM-RUN Product Information Sheet: Sepetmber 2013*

## Local climate change projections and associated uncertainty: The North Adriatic case study

### The products

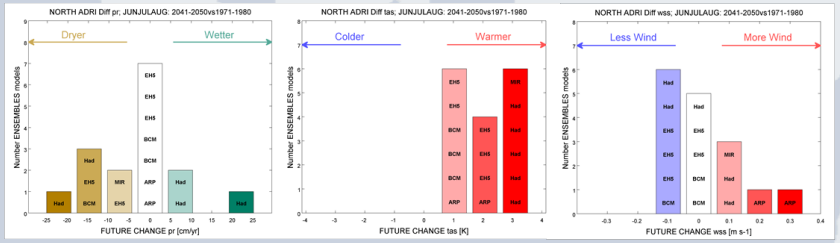



Fig1: Histogram of ENSEMBLES Regional Climate Models (RCMs) for foreseen changes (2041-2050 against 1971-1980) in **summer mean precipitation (pr)**, **surface temperature (tas)**, and **wind speed (wss)** over North Adriatic. Each bar indicates the number of Regional Climate Models (RCMs) producing a change of a given amplitude. The labels inside the bars represent the global climate models (GCMs) adopted as global drivers for the corresponding regional downscaling.

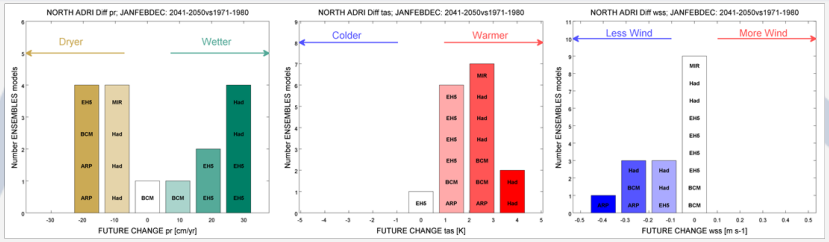



Fig2: Histogram of ENSEMBLES Regional Climate Models (RCMs) for foreseen changes (2041-2050 against 1971-1980) in **winter mean precipitation (pr)**, **surface temperature (tas)**, and **wind speed (wss)** over North Adriatic. Each bar indicates the number of Regional Climate Models (RCMs) producing a change of a given amplitude. The labels inside the bars represent the global climate models (GCMs) adopted as global drivers for the corresponding regional downscaling.

### Making the product usable

The CLIMRUN team is seeking collaborations with the end users involved in the case study over North Adriatic to make this climate product usable. Areas for potential cooperation include:

- Derivation tailored indices based on end users needs
- Statistics of extremes
- Critical thresholds

***Contact: sandro.calmanti@enea.it, alessandro.dellaquila@enea.it** **Further information: www.climrun.eu**

**information sheets: climate change projections**

# climate products validation

IMPROVEMENTS

- data to support land-use planning
- data with greater resolution and longer time series
- data on climate impacts and risks
- precipitation patterns to improve irrigation

COLLABORATION

- regional agencies can do downscaling
- acquire information → disseminate to public
- knowledge for land-use planning, DRR and EWS
- repository of daily data since 1960

# risk assessment

- PRODUCT 1: sea level rise inundation risk maps
- PRODUCT 2: pluvial flood inundation risk maps in urban areas
- PRODUCT 3: water stress index and maps for agricultural typologies

**presentation by Antonio Marcomini**

# conclusions

- need for a “strong” document on climate change scenarios so that climate information will be considered in planning
- communication of uncertainty in model outcomes, which is generally an excuse for inaction
- need for a network to enable data exchange

# Beyond the state of the art

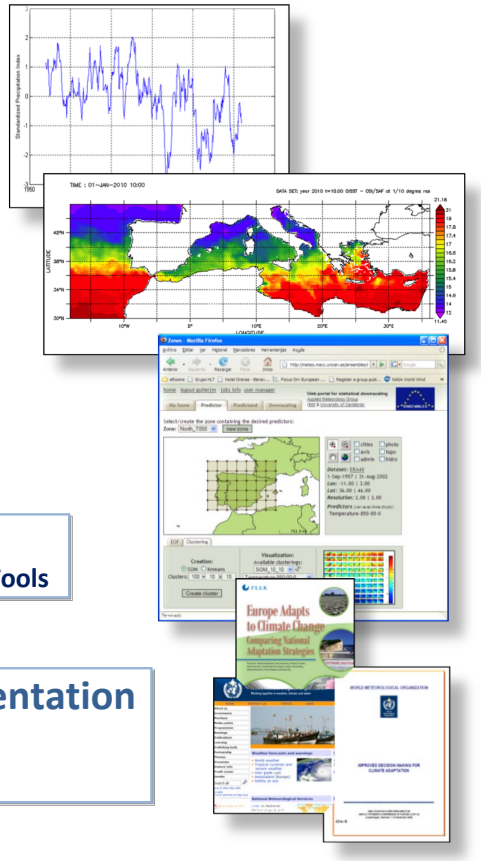
Products


**Raw climate data**
observations, model output, …

**Elaborated data**
Indices, maps

**Elaborated products**
Diagrams, interactive maps, Tools

**Research & Documentation**
Adaptation measures, recommendations

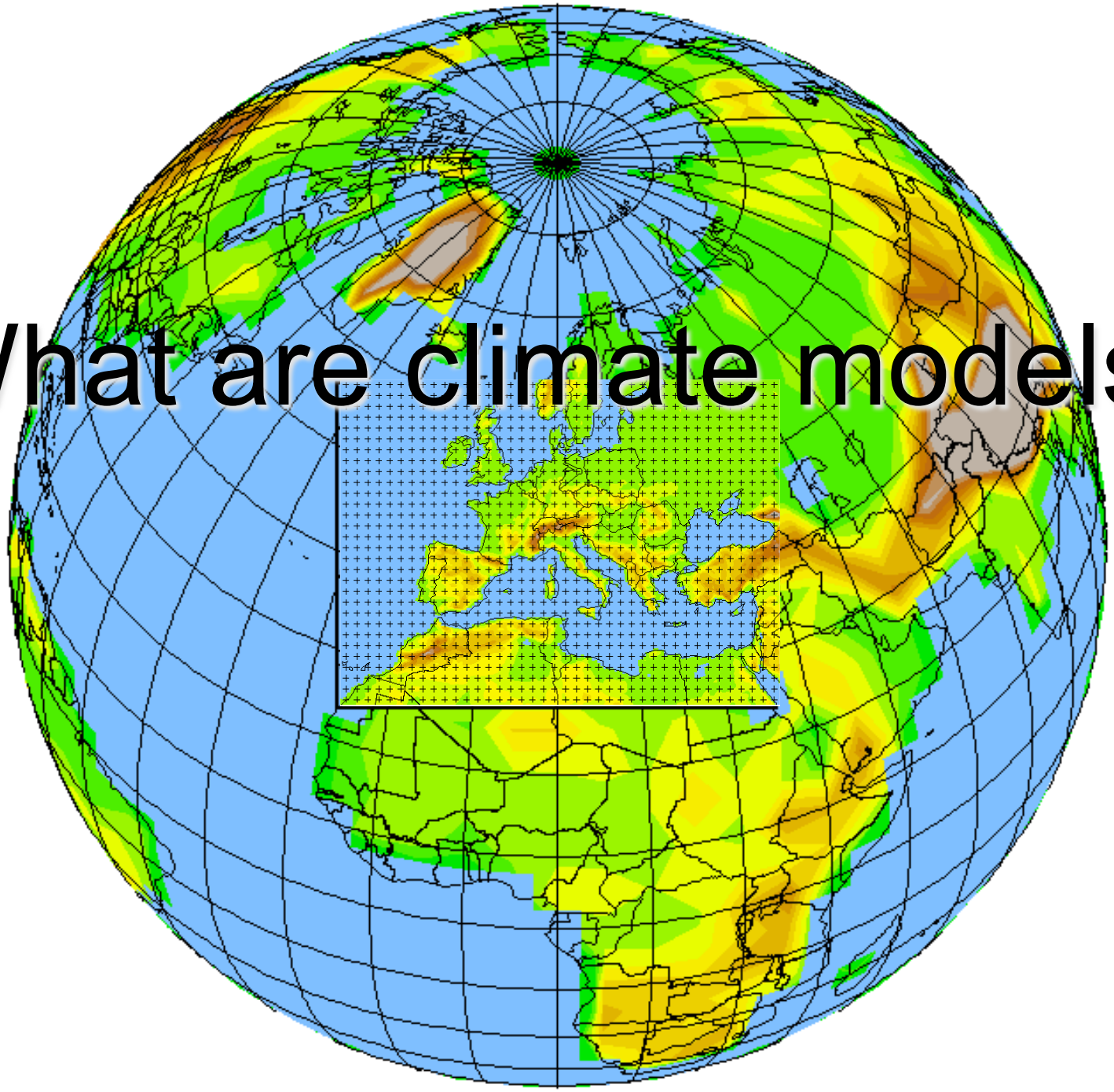



**CLIM-RUN** will bring progress beyond the state of the art in two main respects:

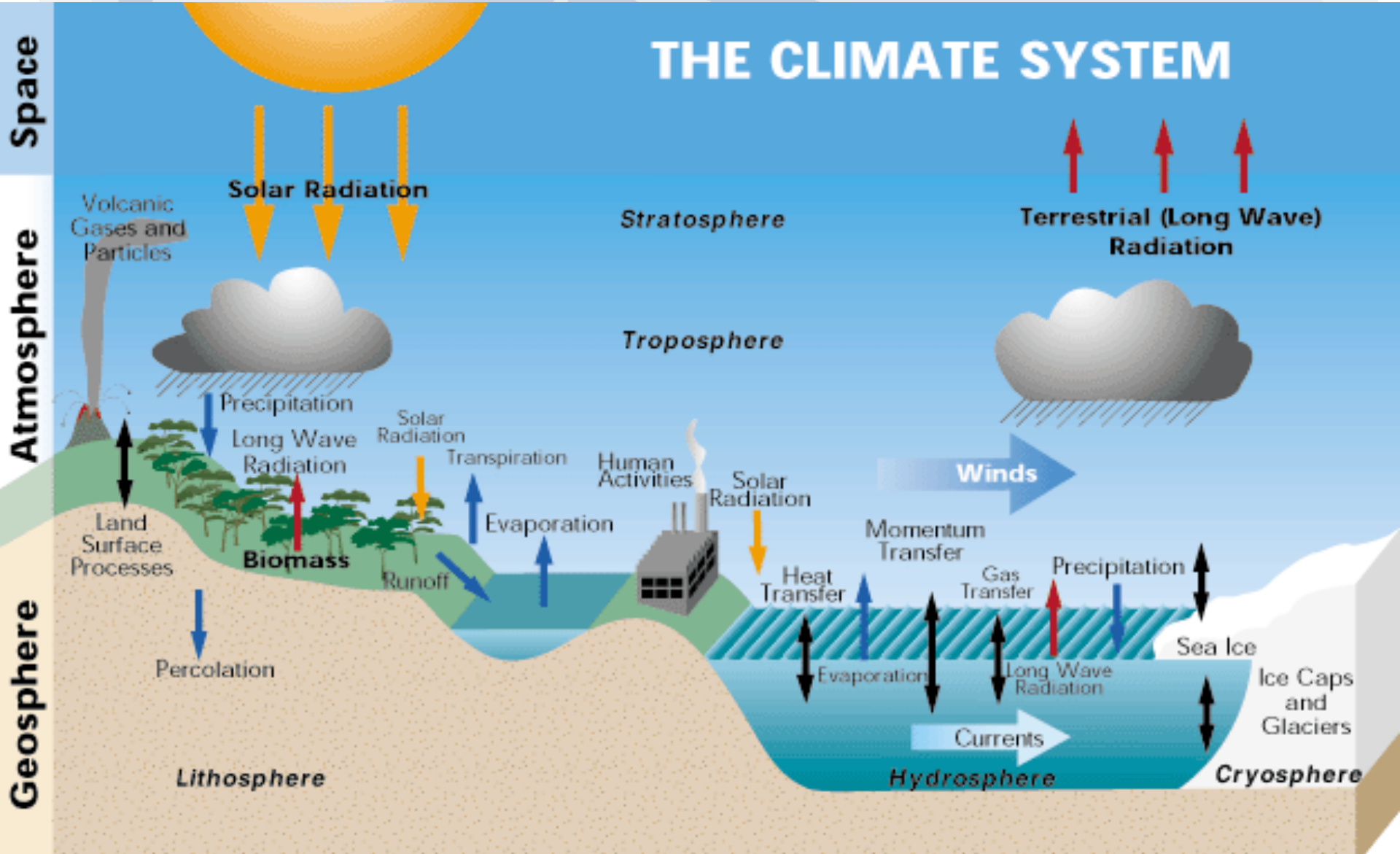
Underpinning science to produce **local scale climate information** at decadal and longer time scales, and characterization of related uncertainties

**Bottom-up climate service protocol** and strengthening of the **interactions between climate experts and stakeholders**

# What are climate models?



The climate system is a highly non-linear coupled system whose components interact on a wide range of spatial and temporal scales

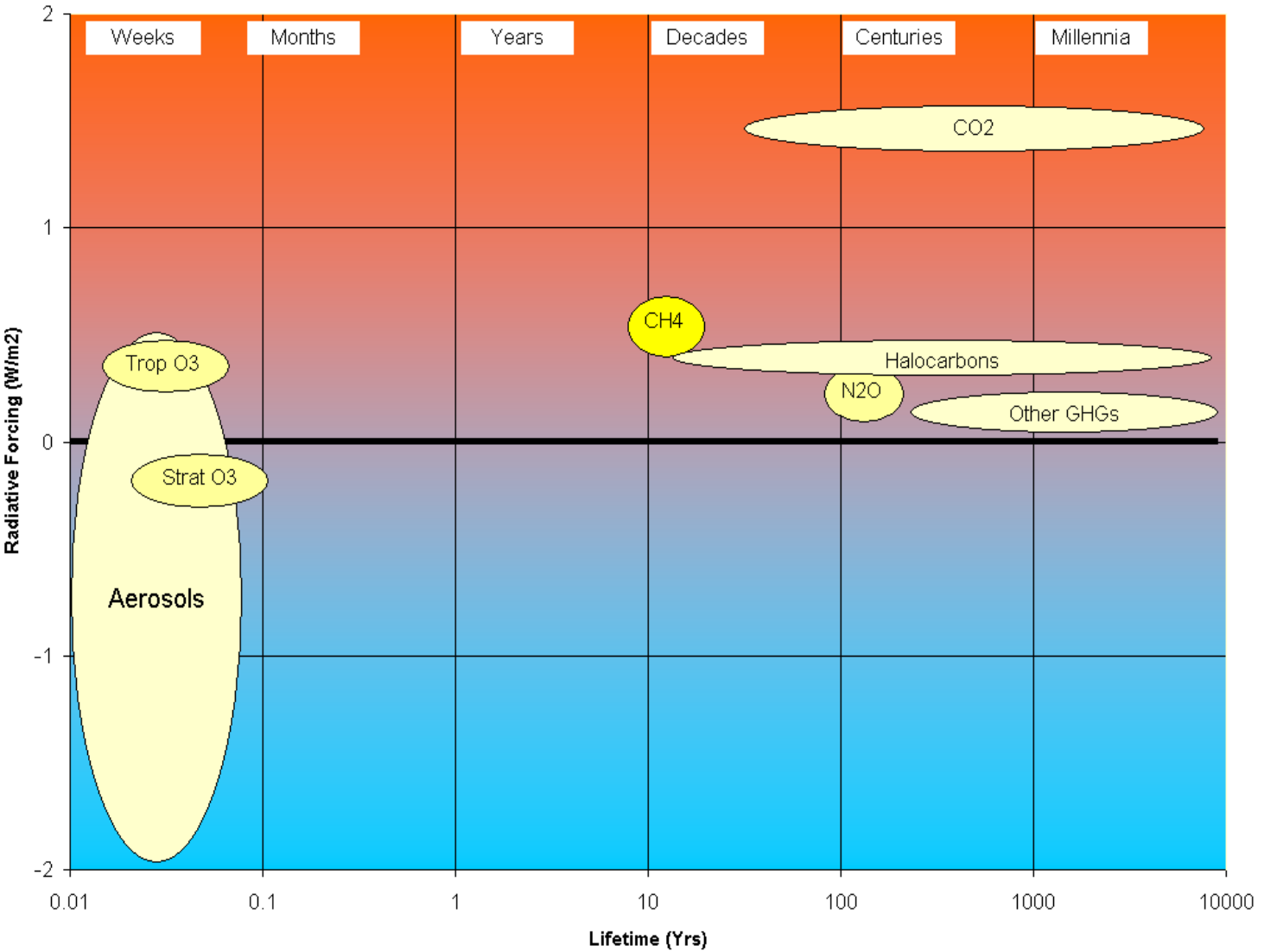


# Temporal scales of forcings

Many key warming agents live for decades or more

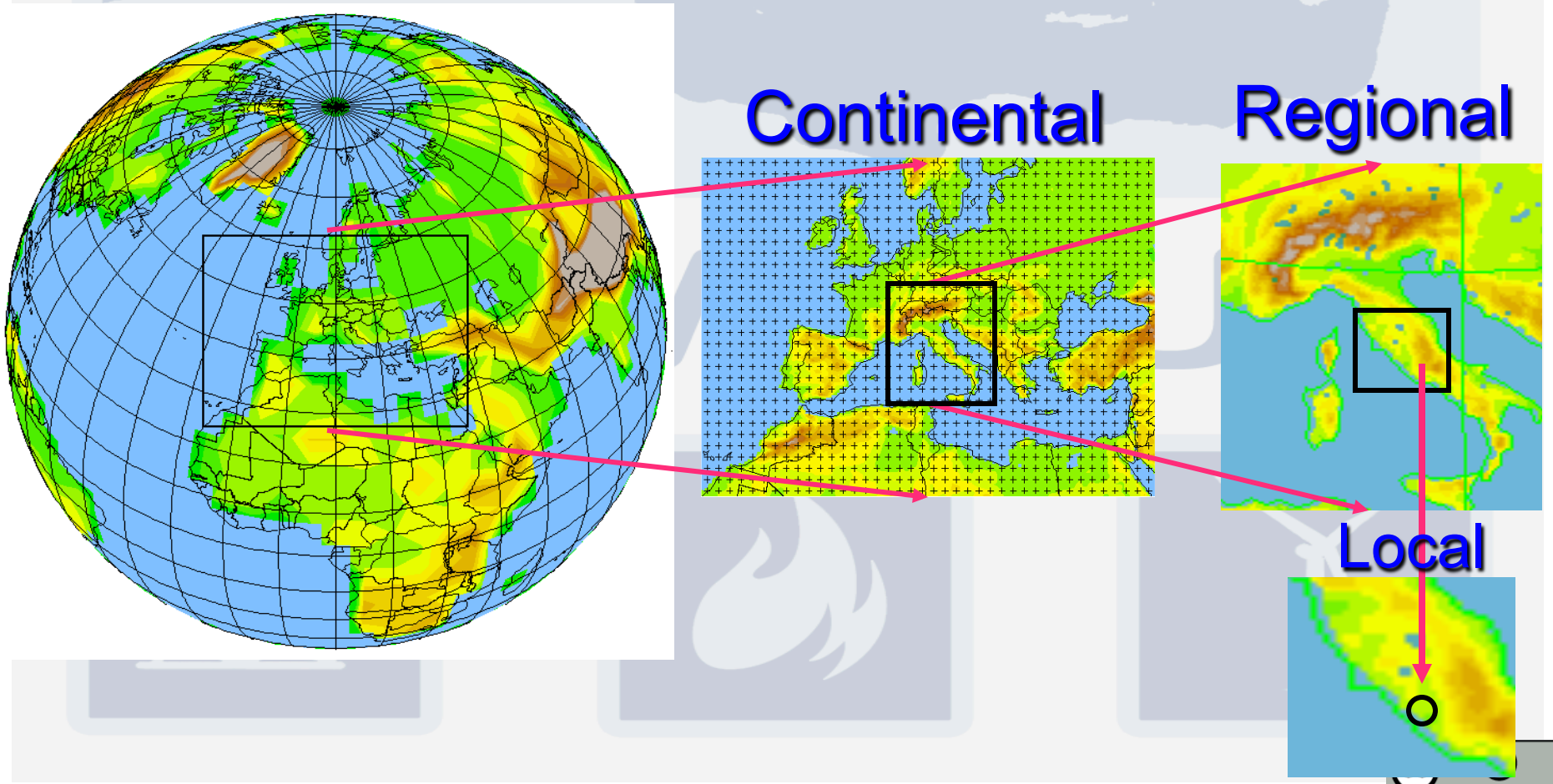
All known cooling agents are relatively short-lived

-> implications for short and long-term effects and options



# From global to regional climate

## The spatial scales of climate processes

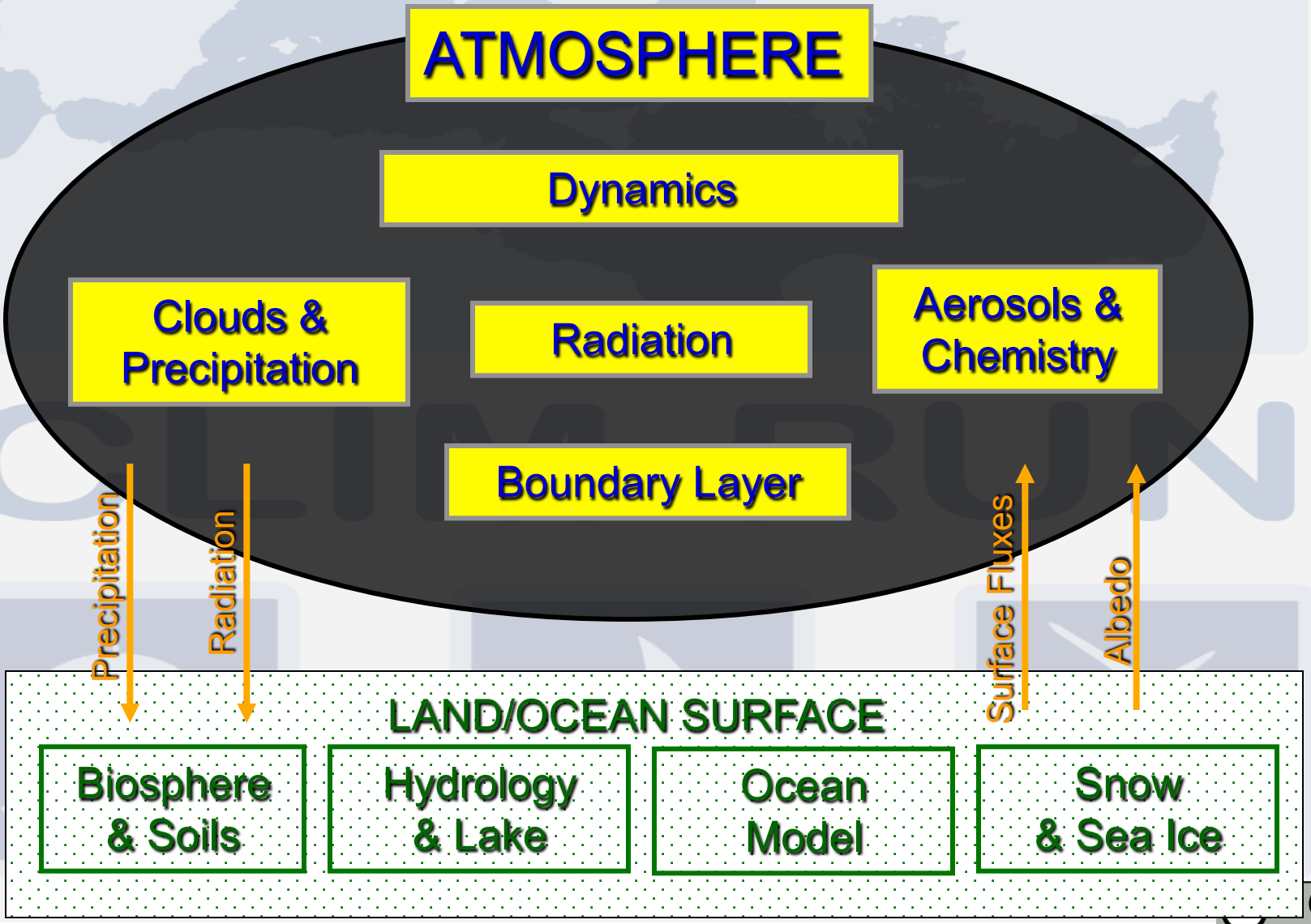


# Hierarchy of tools to simulate the global climate

- Simple climate models
  - 1D or 2D models including different components of the climate system and a few parameters tuned to reproduce the global behavior of full GCMs
- Earth system models of intermediate complexity (EMICs)
  - Three dimensional coupled models with low resolution and highly simplifed representation of physical processes
- Climate system models (or Earth system models)
  - Three dimensional coupled models with higher resolution, comprehensive and sophisticated representation of physical processes

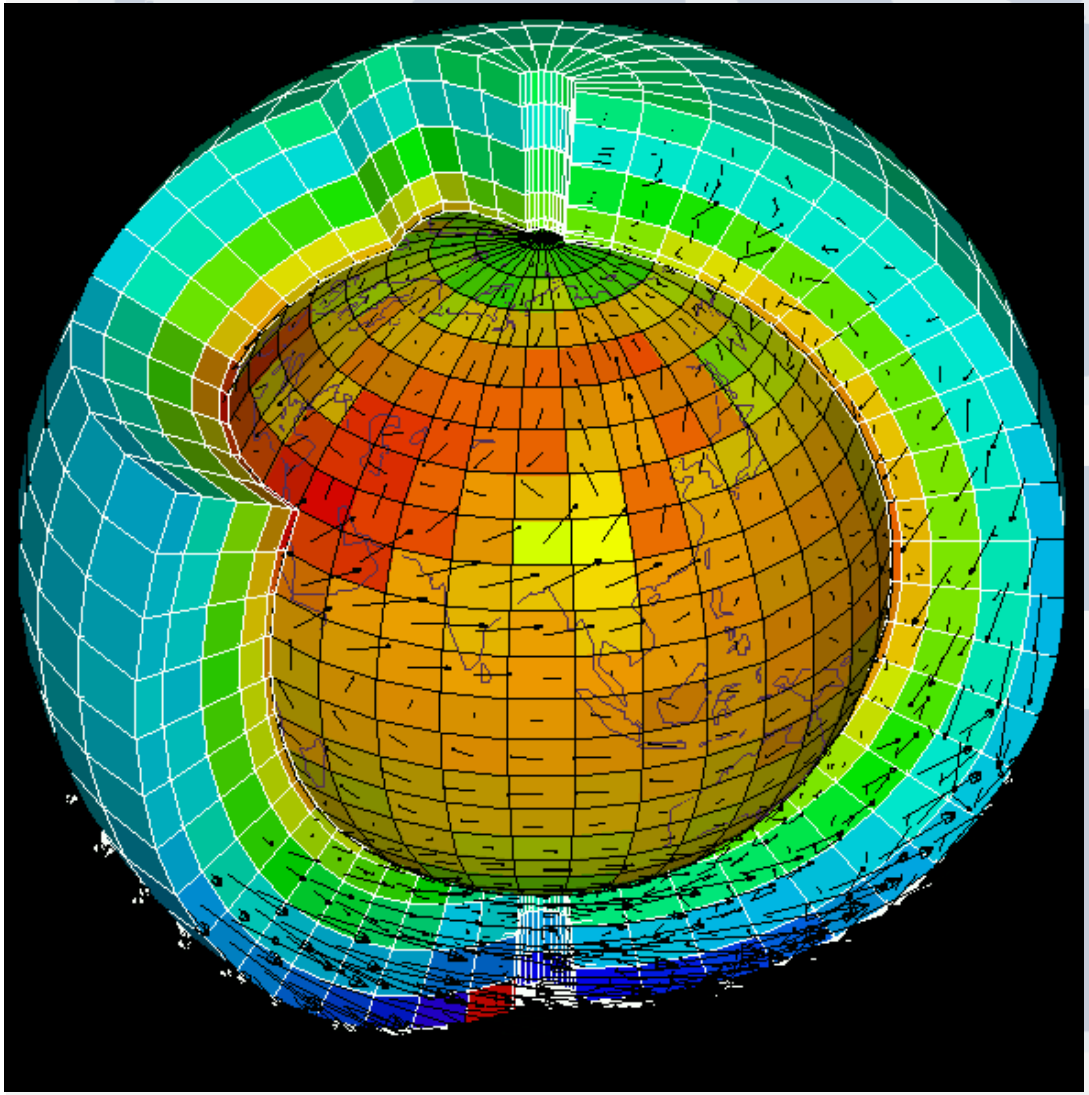
Climate system models are numerical representations of the fundamental equations that describe the behavior of the climate system and the interactions across its components (atmosphere, ocean, cryosphere, biosphere, chemosphere)

# An "atmosphericentric" view of a climate model



# The “dynamical core” of a climate model

## Horizontal discretization



Integration methods

Finite differences

Spectral

Semi-Lagrangian

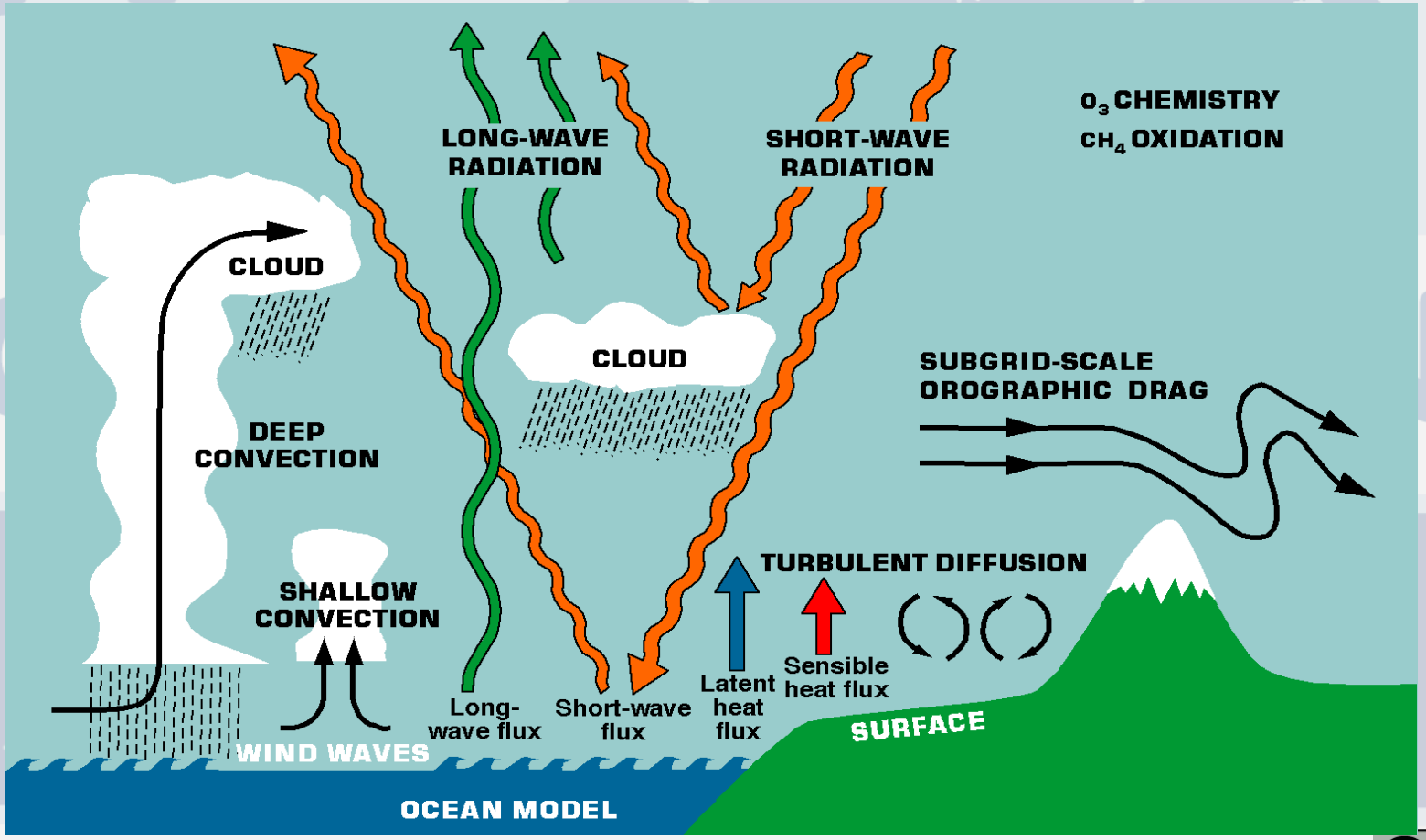
Finite elements

Horizontal resolution

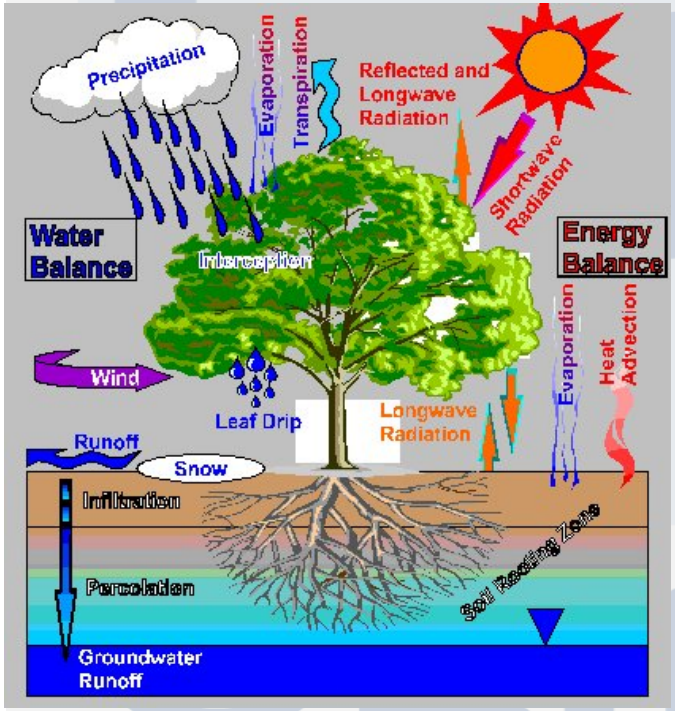
50-300 km

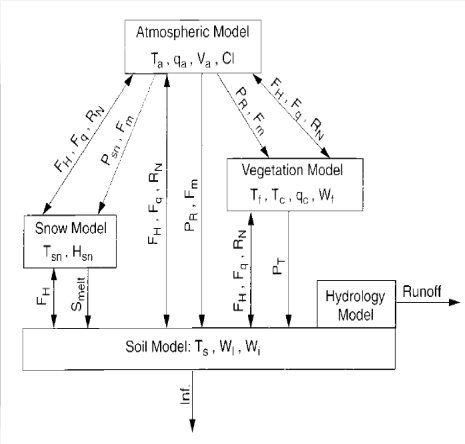
# Physical parameterizations in a climate model

Processes that are not explicitly represented by the basic dynamical and thermodynamic variables in the basic equations on the grid of the model need to be included by *parameterizations*.



# Surface process schemes




Surface schemes are needed to:

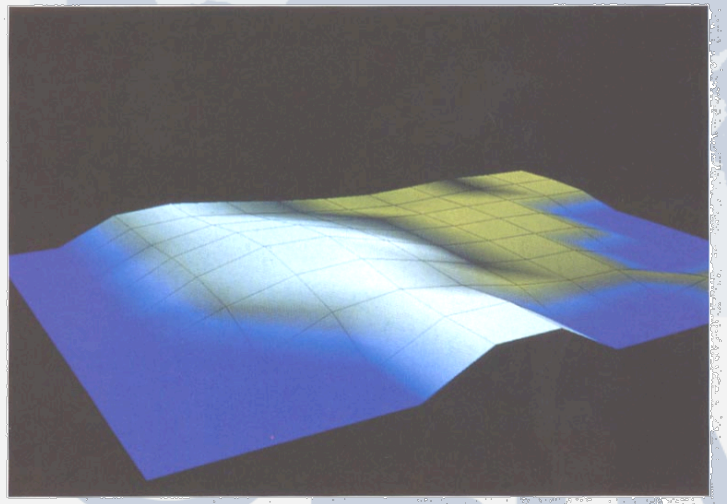
1. Calculate the exchanges of heat, moisture and momentum between the surface and atmosphere
2. Calculate surface temperature, and other variables
3. Describe the land surface hydrologic cycle (soil water content, snow, runoff)

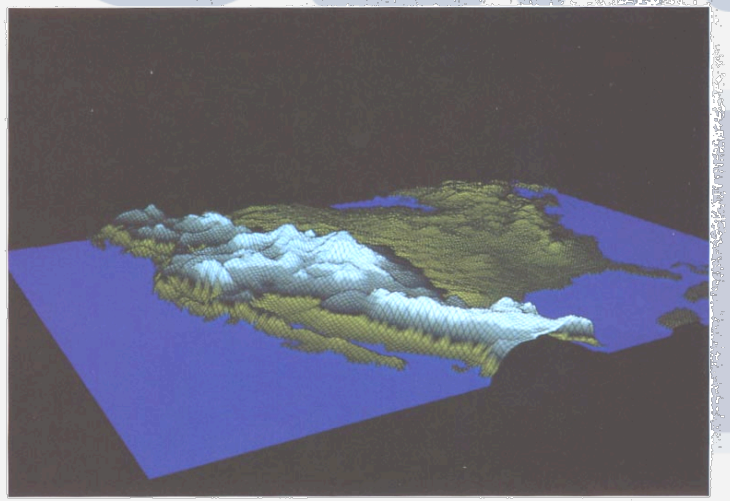
- Over the oceans, the schemes are quite simple
- Over land, the schemes are composed of a combination of modules interacting with each other: soil, vegetation, snow, runoff
- Land surface schemes can be very sophisticated

# Running a climate model

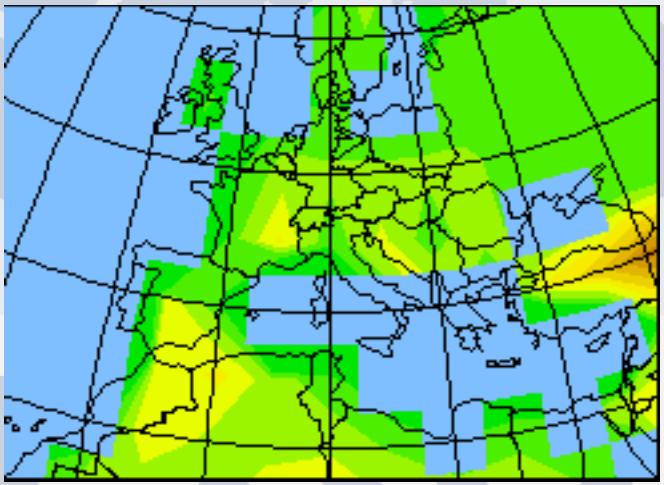
## Boundary conditions

Topography

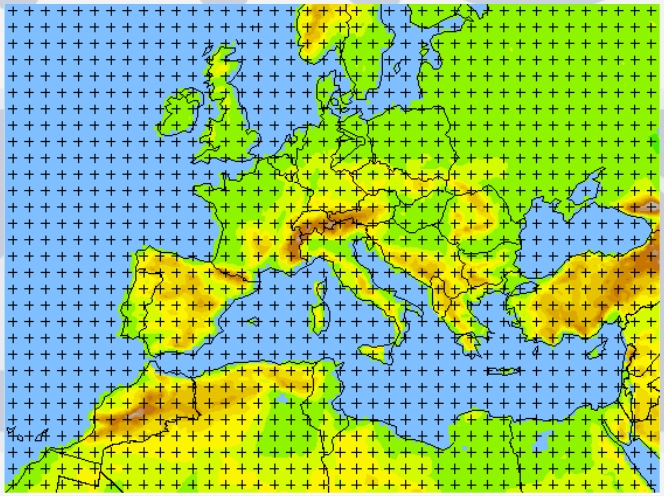




Land-sea mask



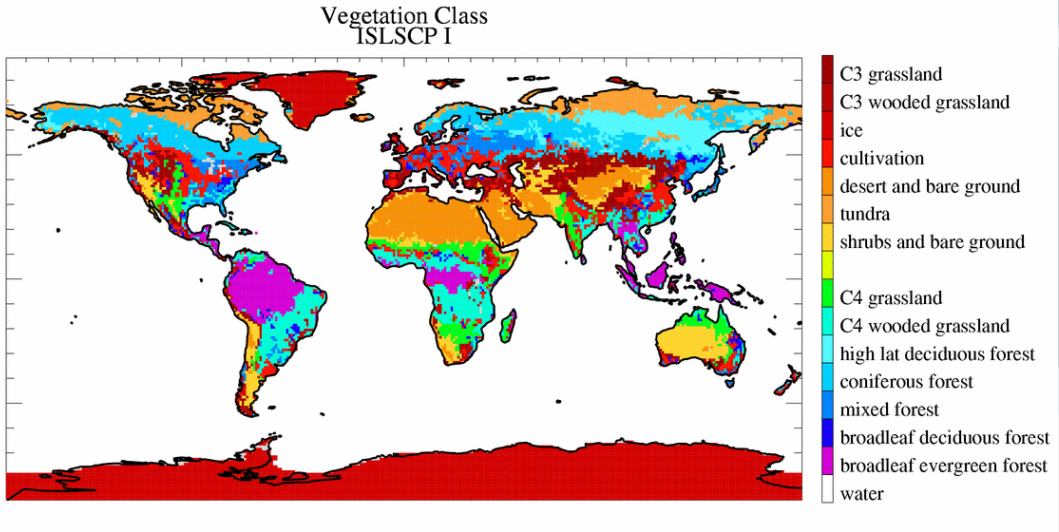
300 km resolution



50 km resolution

# Running a climate model

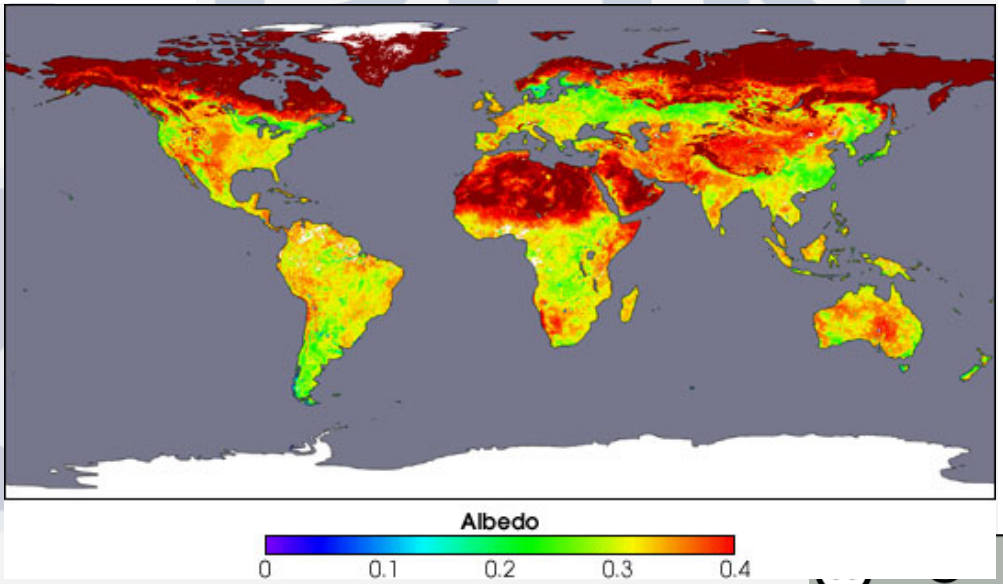
## Boundary conditions



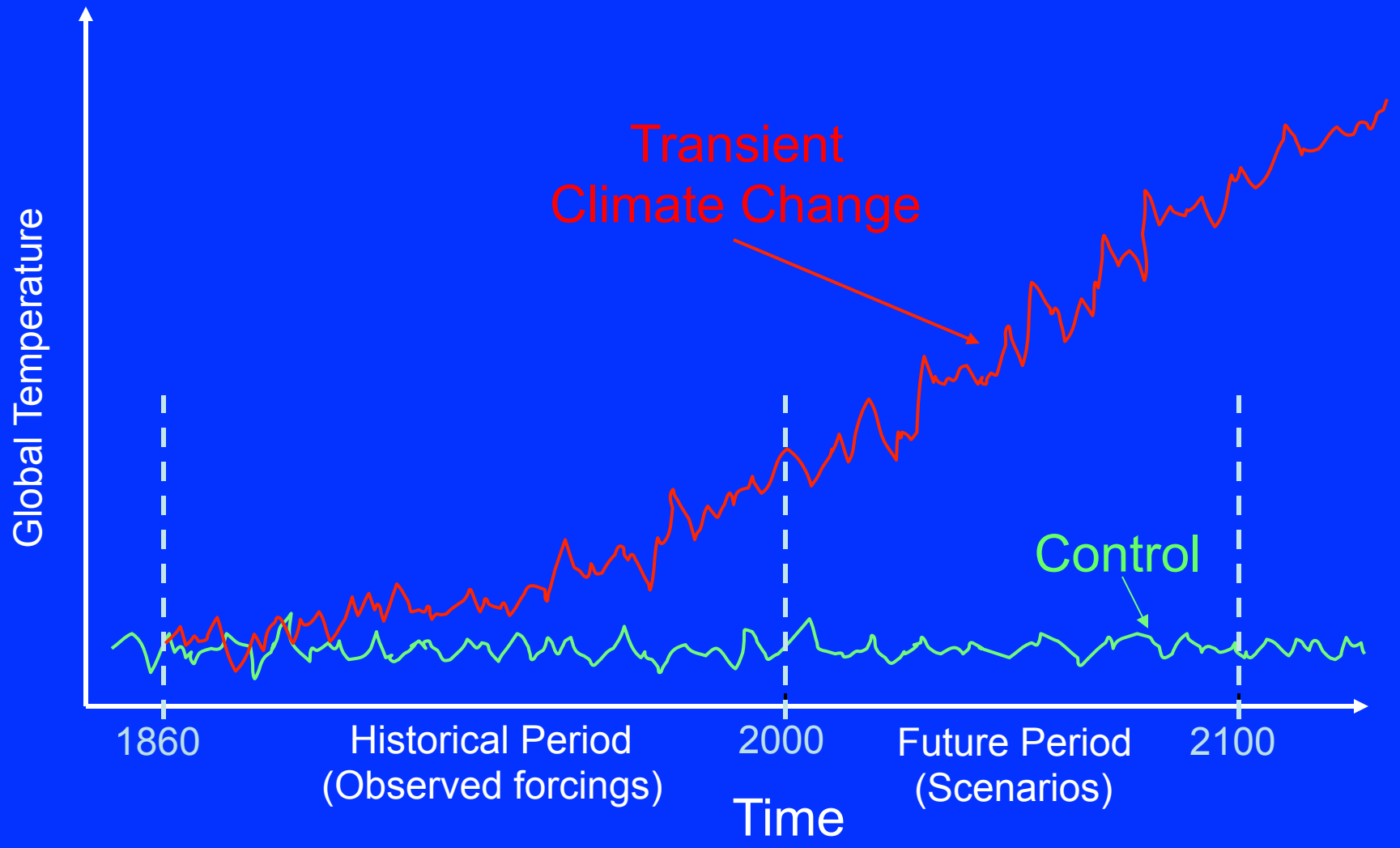

Vegetation variables

Vegetation type

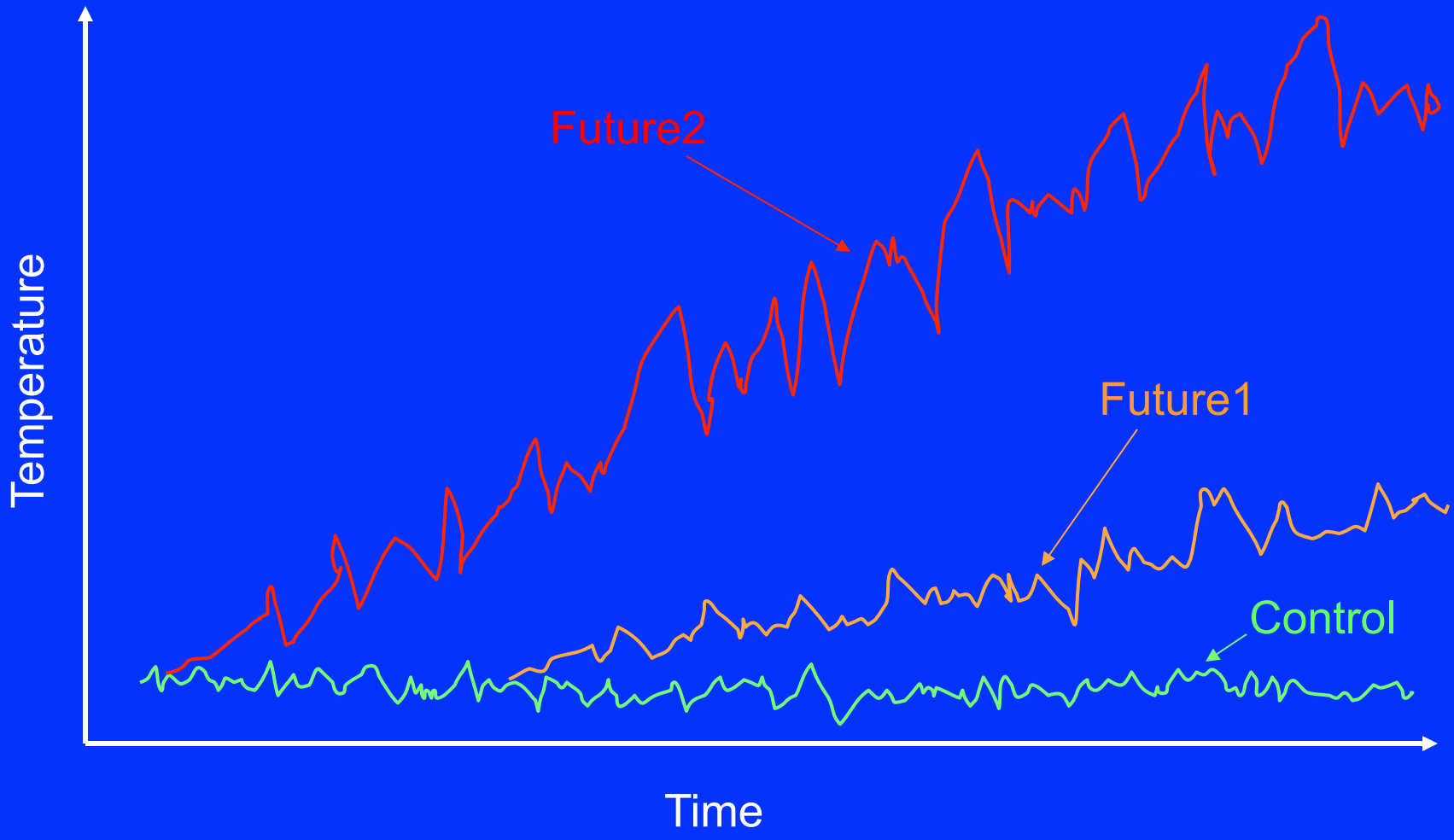
Surface albedo



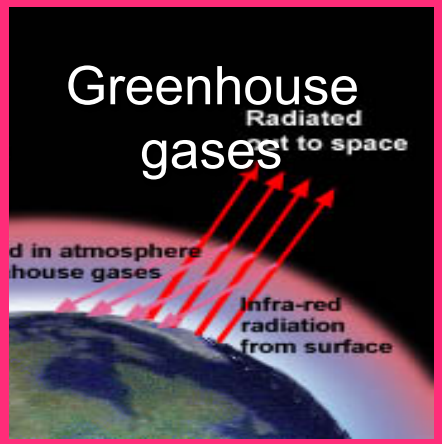
# Transient Climate Change Simulation

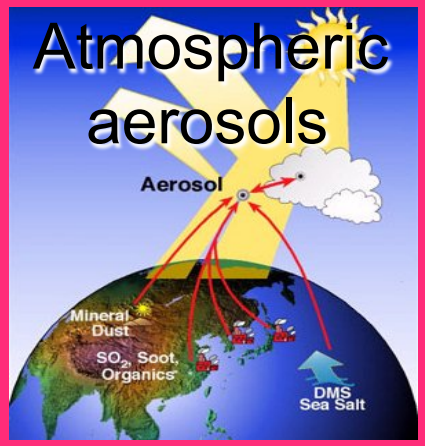


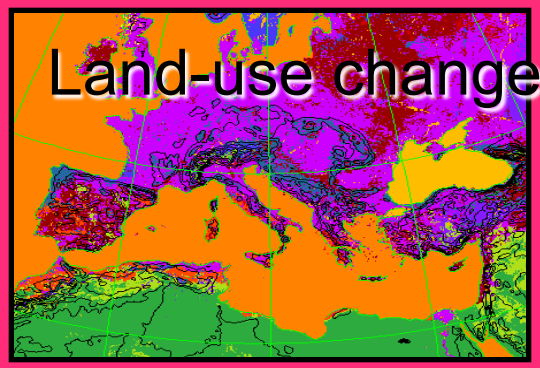
# Running a climate model
## Initial conditions



# Human factors

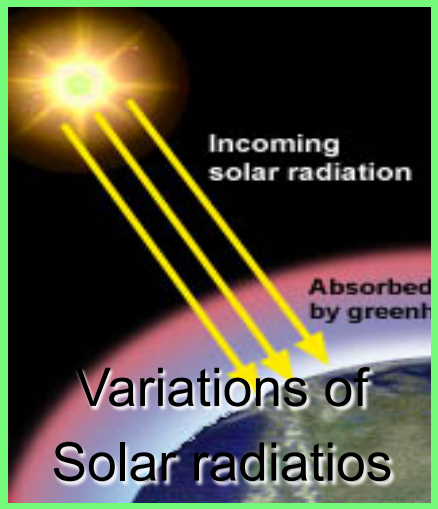


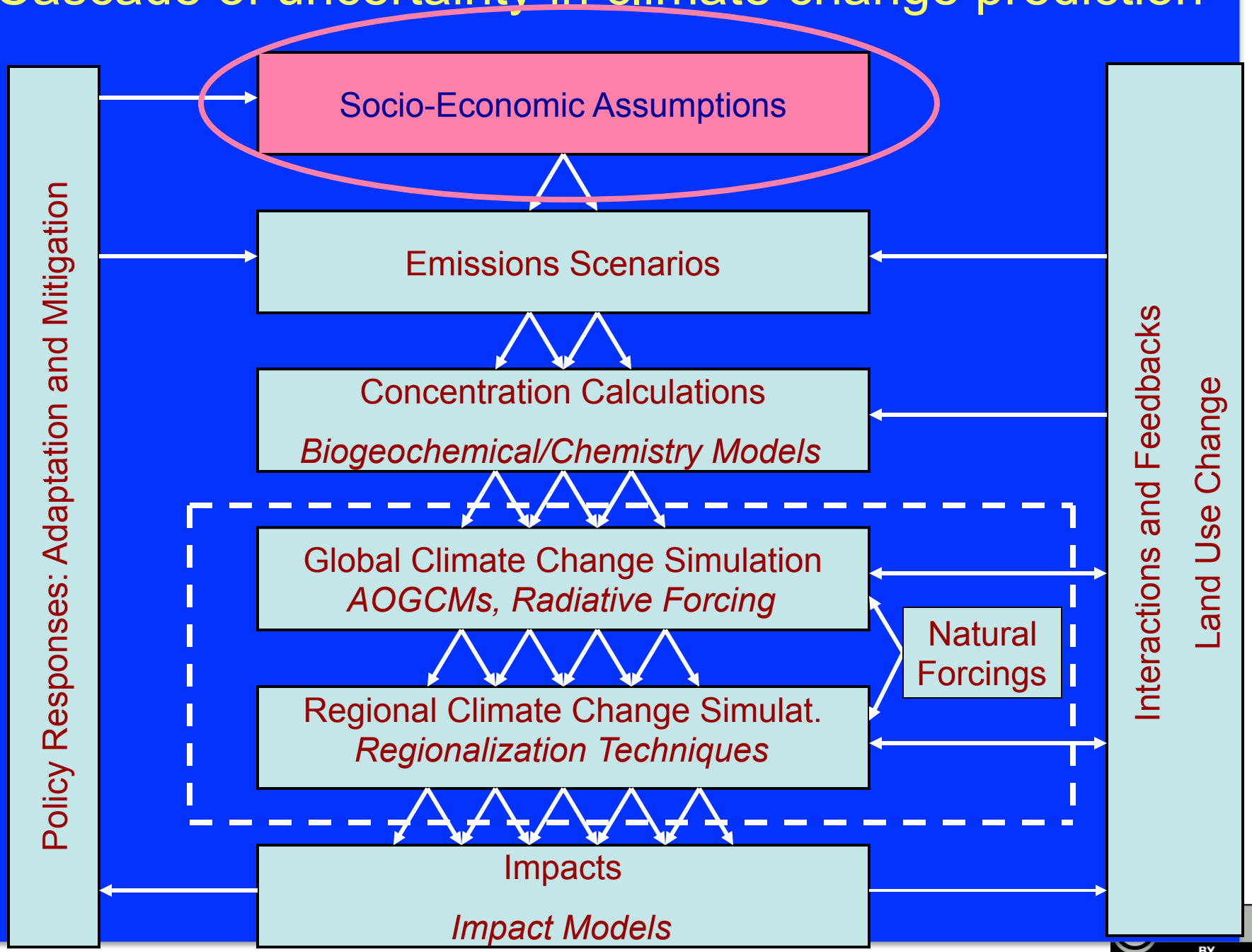




## Running a climate model: External forcing factors

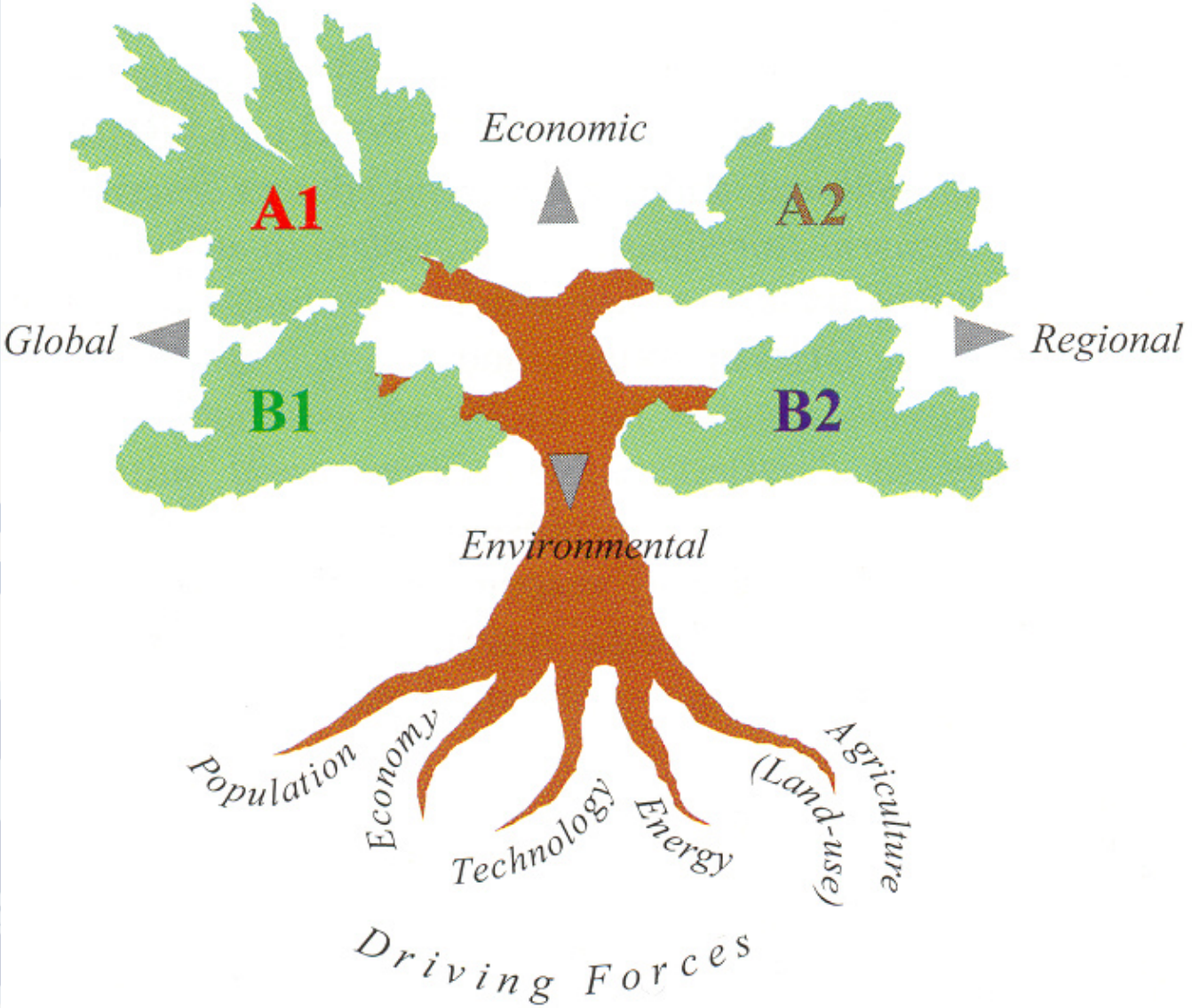
# Natural factors



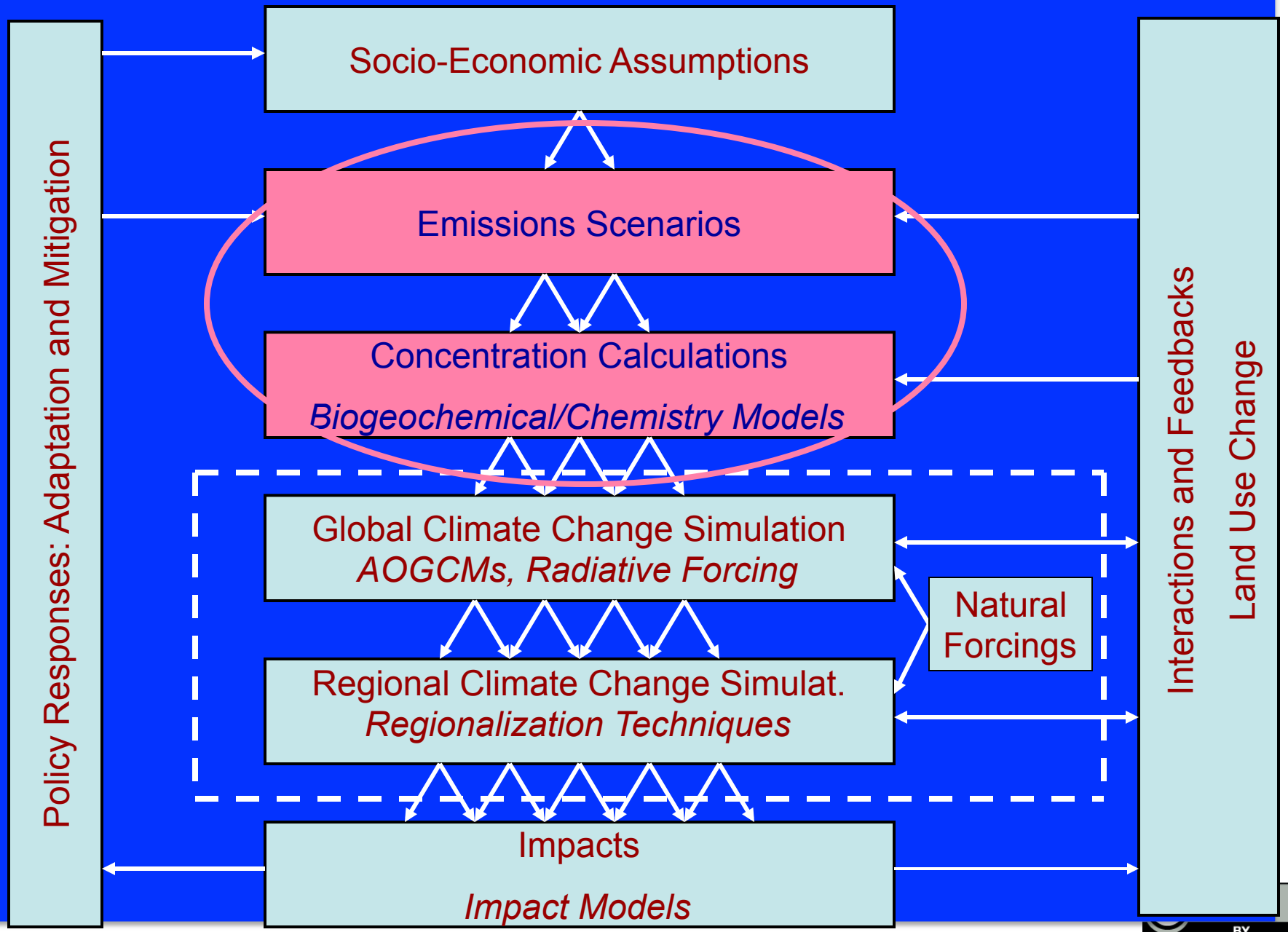

# Cascade of uncertainty in climate change prediction



# SRES Emission Scenarios

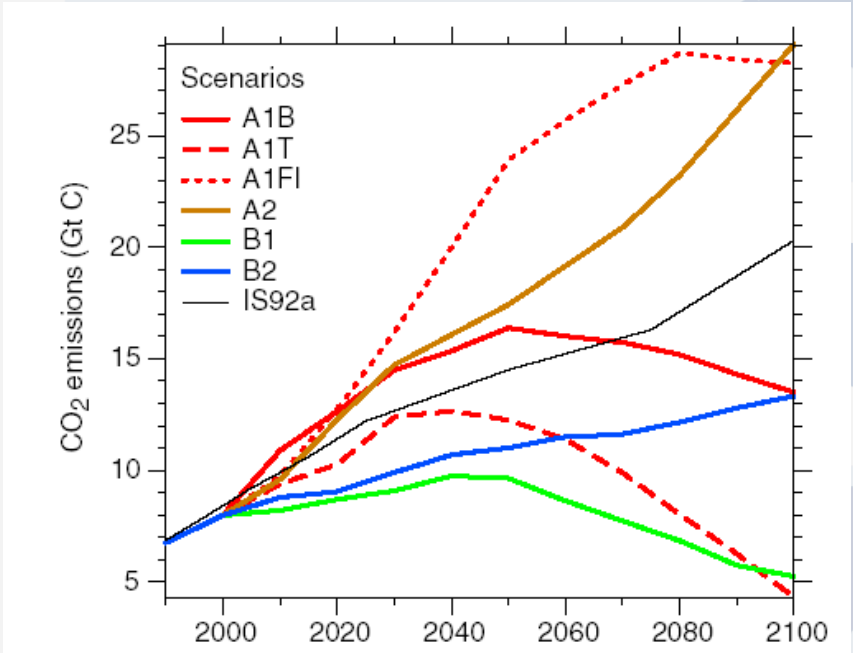


# Cascade of uncertainty in climate change prediction

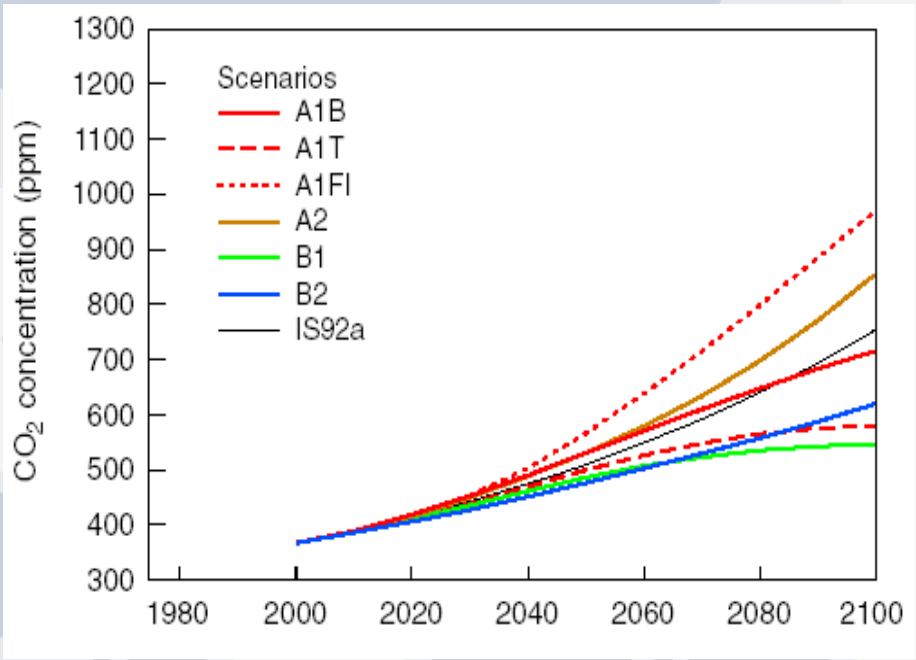


# IPCC Emission and Concentration Scenarios

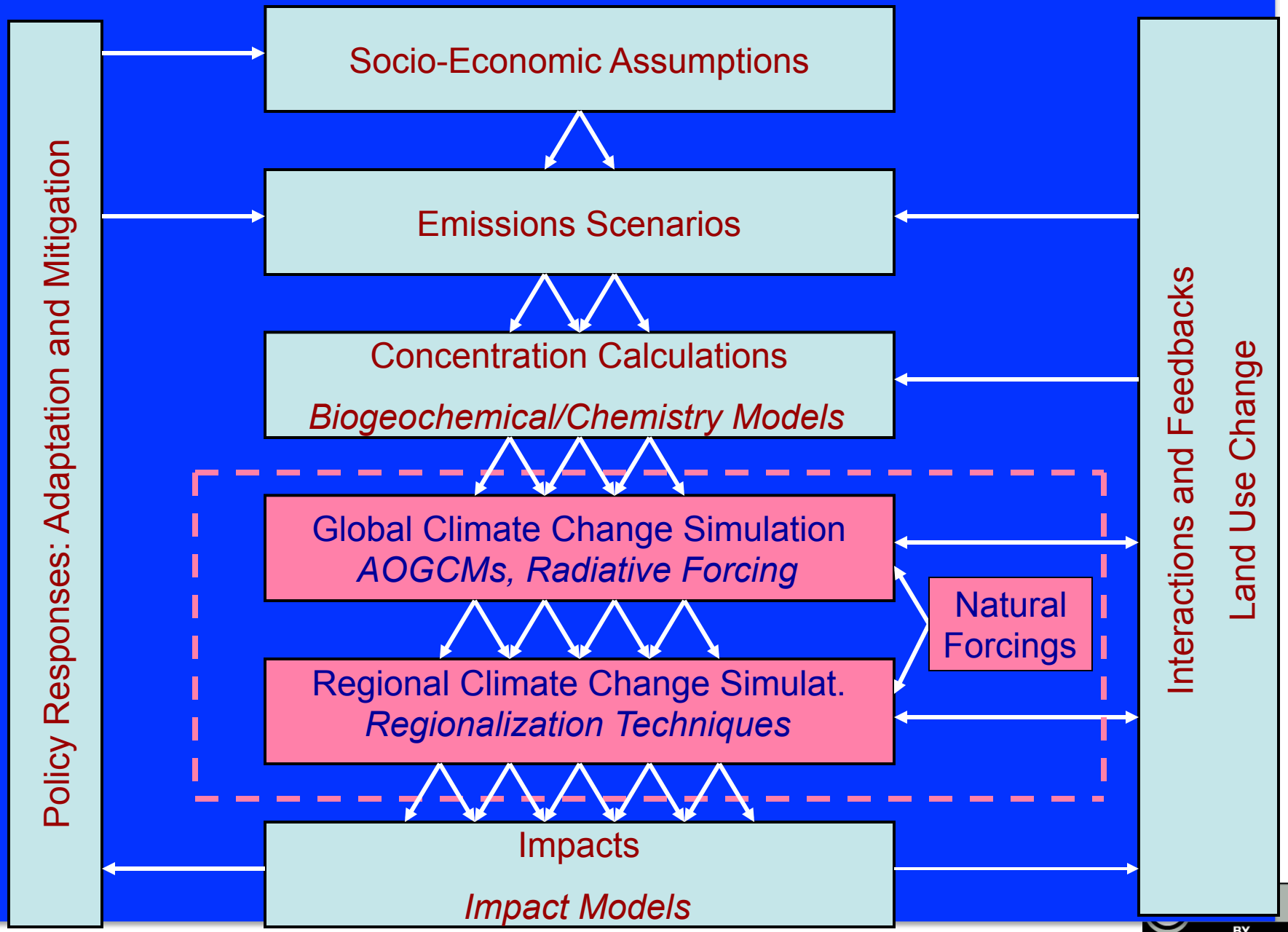
## CO2 Emissions



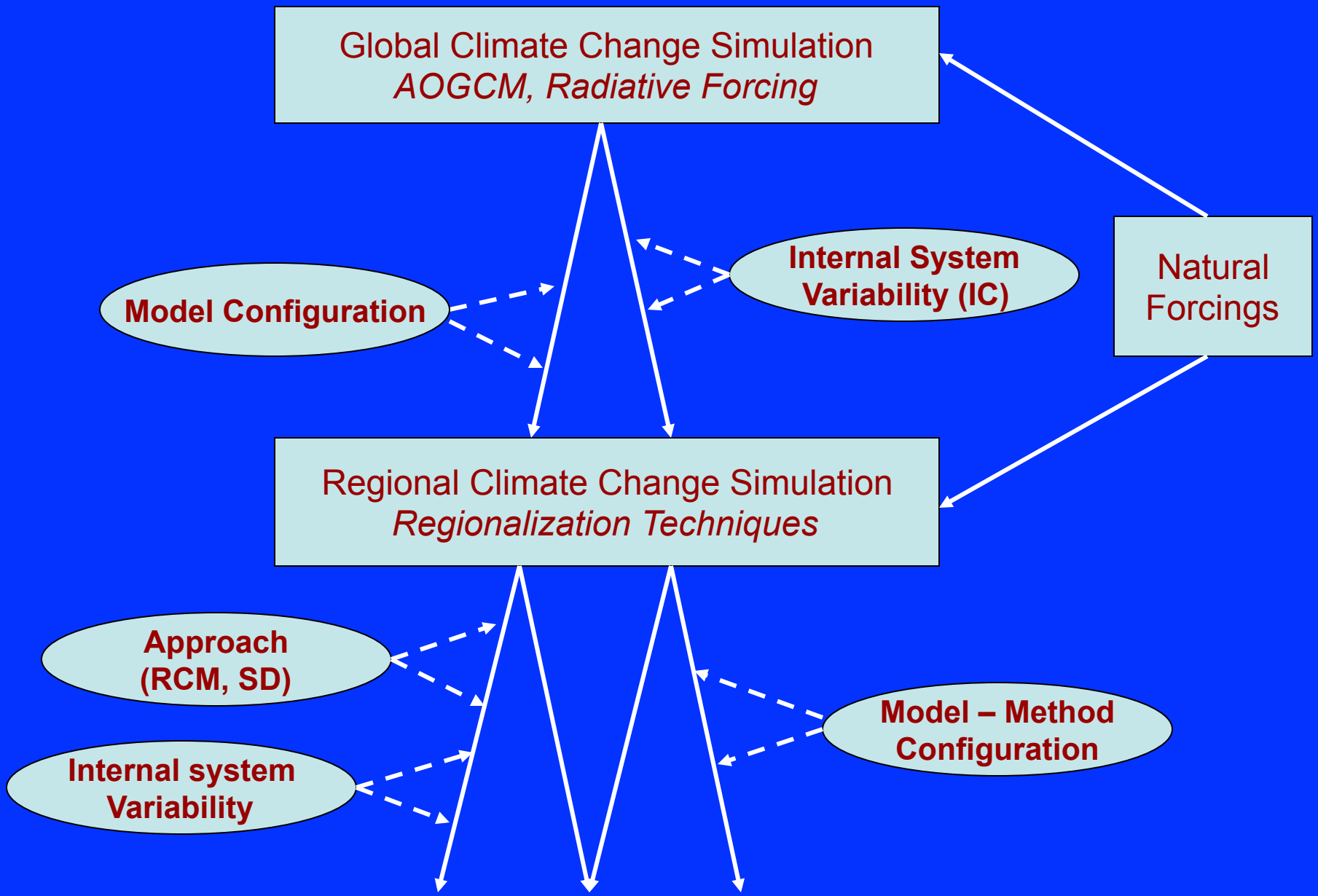

## CO2 Concentrations



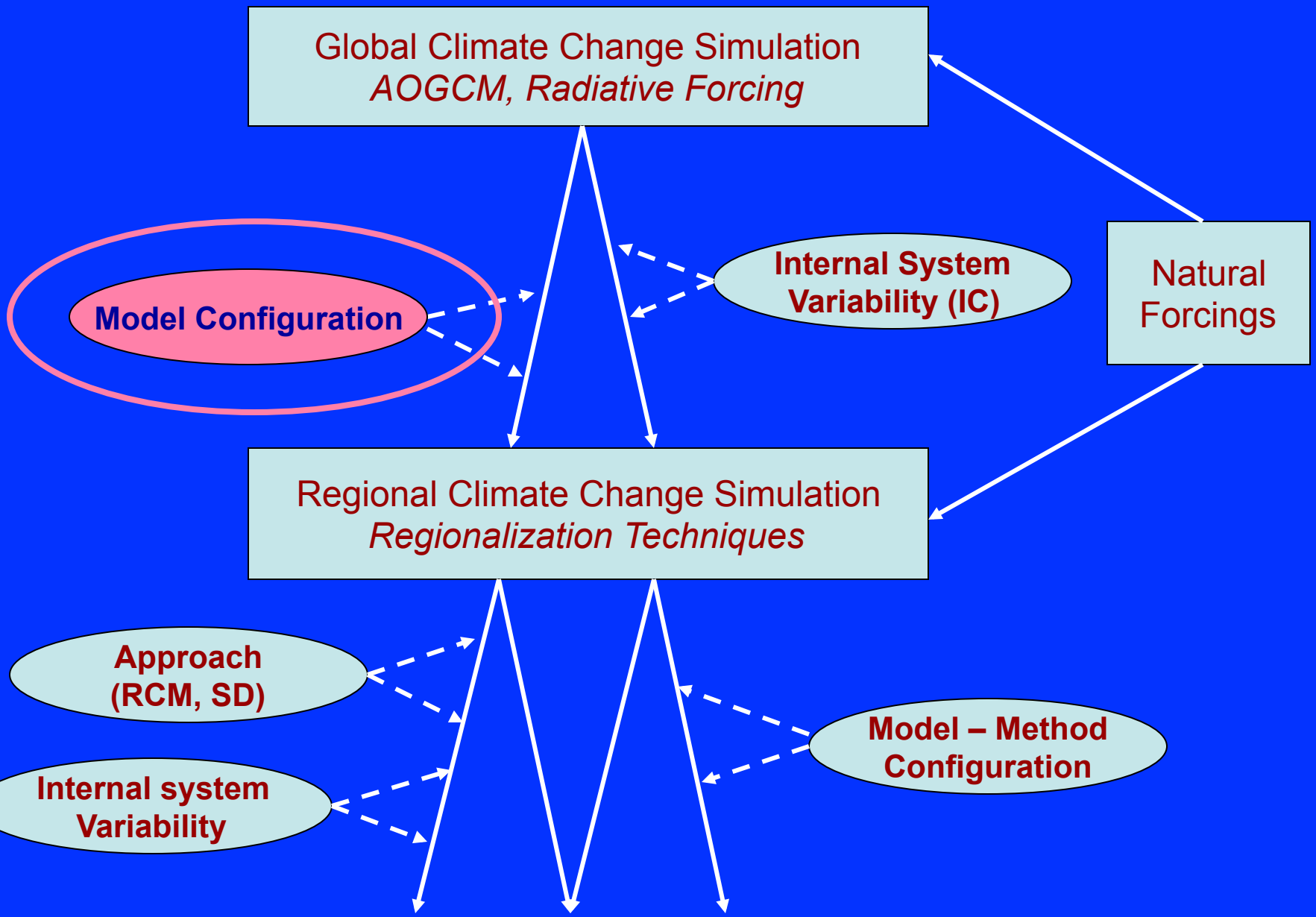
# Cascade of uncertainty in climate change prediction



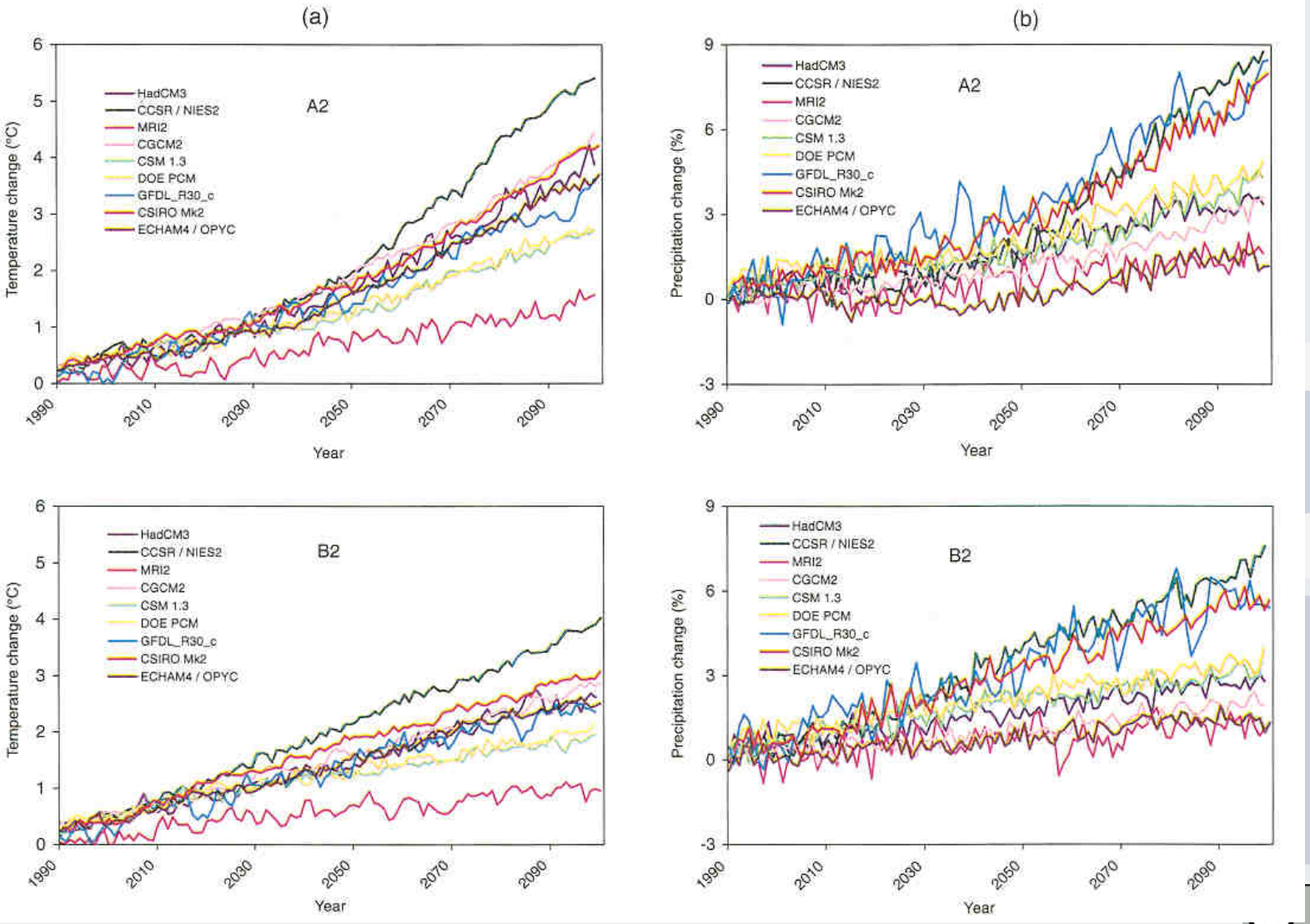
# Climate Simulation Segment of the Uncertainty Cascade



# Climate Simulation Segment of the Uncertainty Cascade

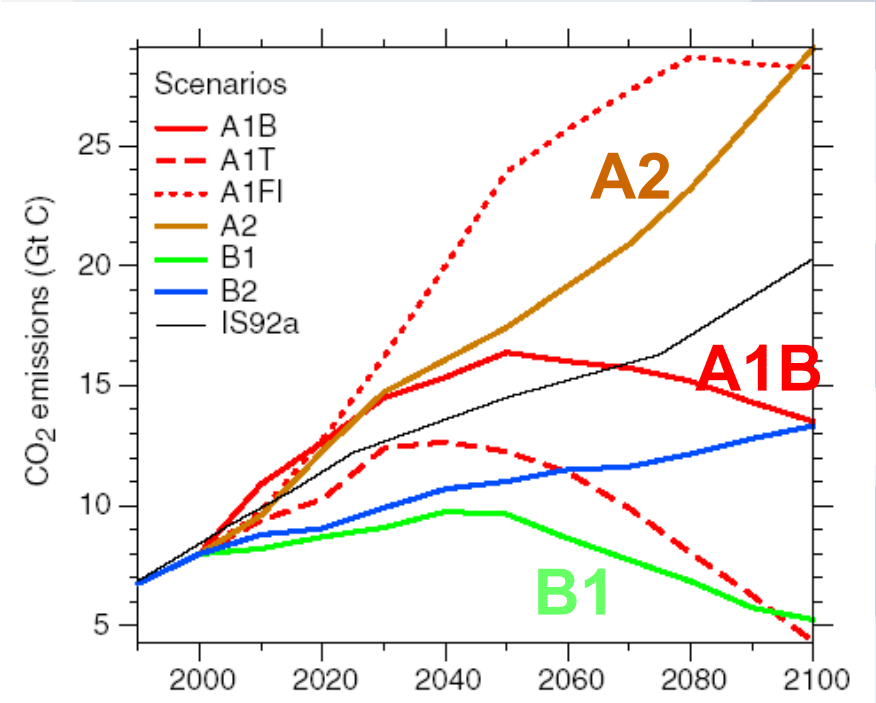


# Model configuration uncertainty
# Global scale

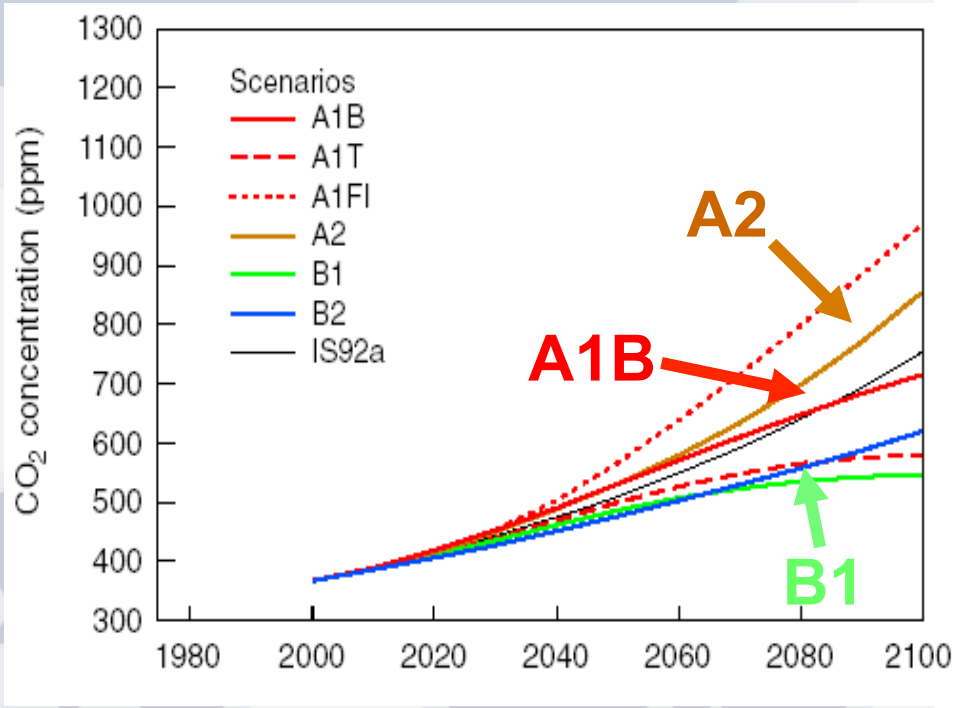


# Greenhouse gas emission and concentration scenarios (IPCC-2000)

## CO2 emissions




## CO2 Concentrations



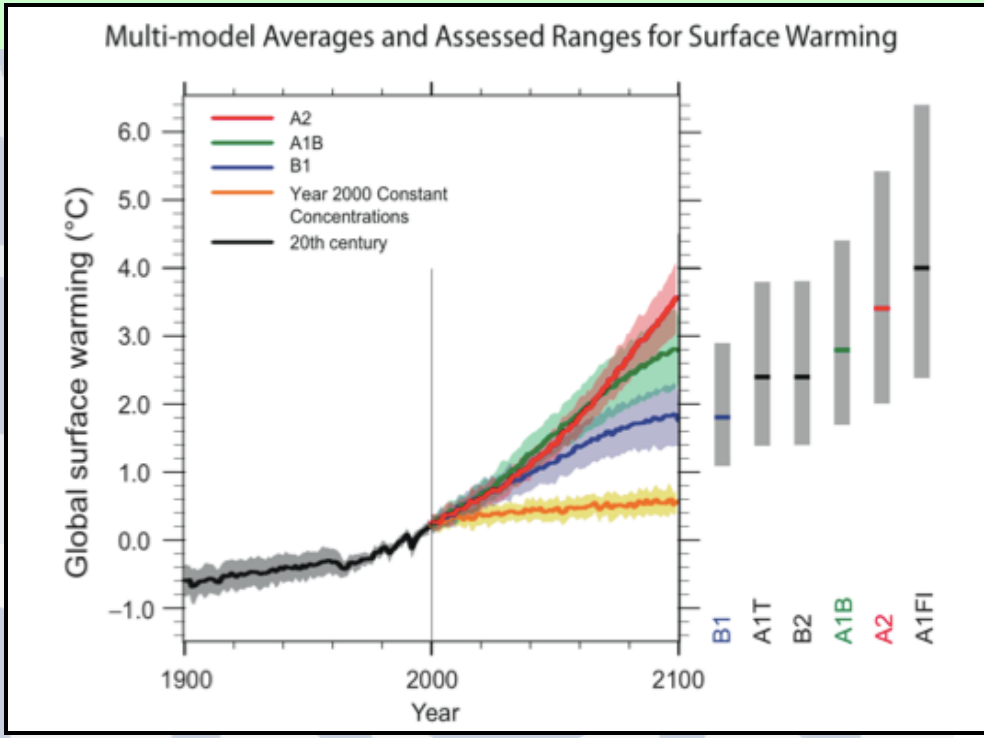
# Irreducible Uncertainty of Climate Change

**A1: Rapid economic growth, population 9B in 2050 then decline, quick spread of efficient technologies, convergent world**

**A1F: fossil fuels**
**A1B: mix of fuels**
**A1T: non-fossil fuels**

**A2: more divided/diverse world, continual population increases, regional economic development, slower and fragmented technological and economic gains**

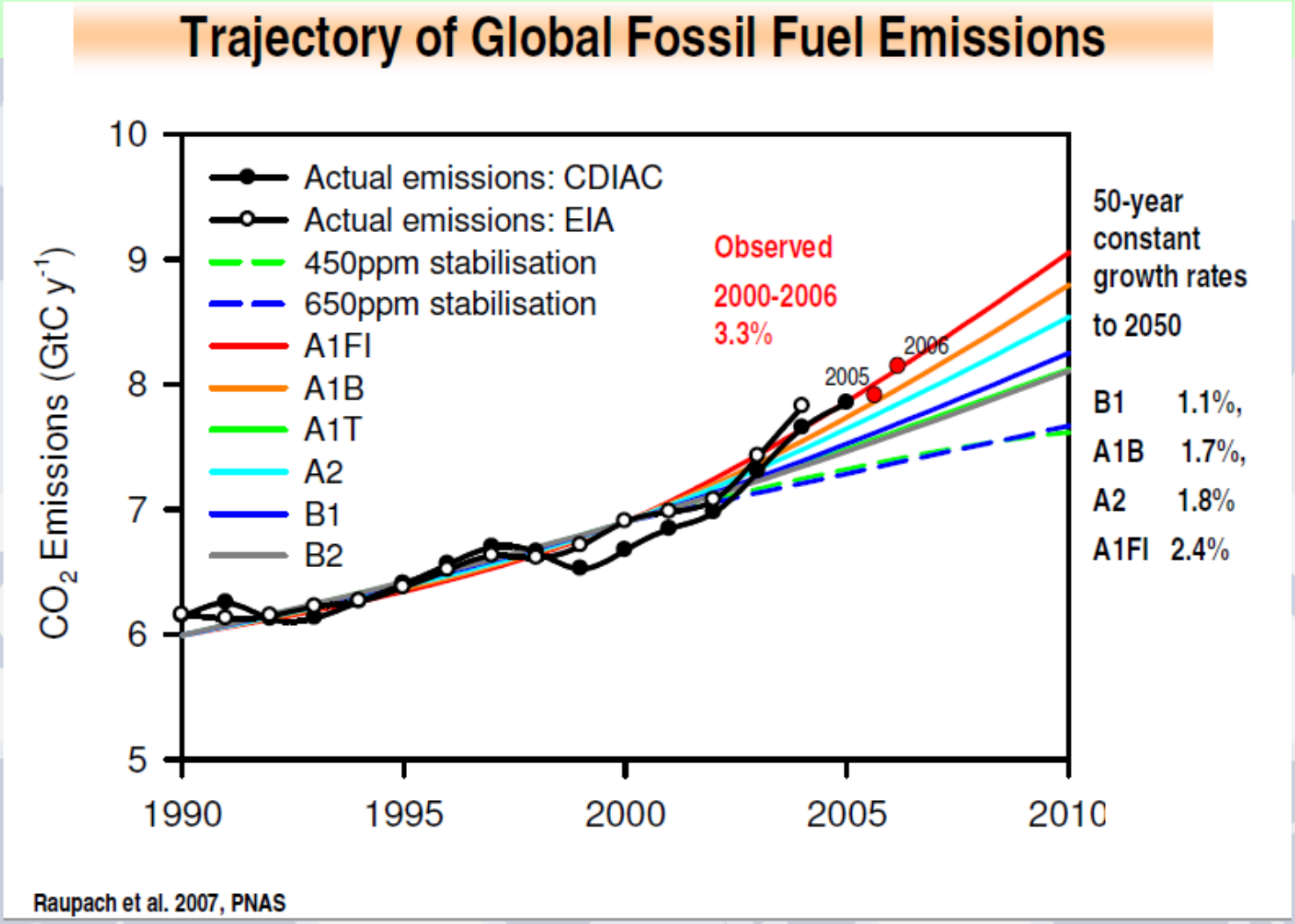
**B1: Same as A1, but change toward service and information economies, reductions in material intensity**




IPCC Fourth Assessment Report May 2007

**B2: More divided world but ecologically friendly, slower population growth than A2, intermediate economic development, less rapid technological change, more fragmented change at more local level**

# Moving Beyond IPCC 4 Scenarios




Liverman et al., 2009: planning should consider 4 deg C rise by 2060

# Moving Beyond IPCC 4 Scenarios

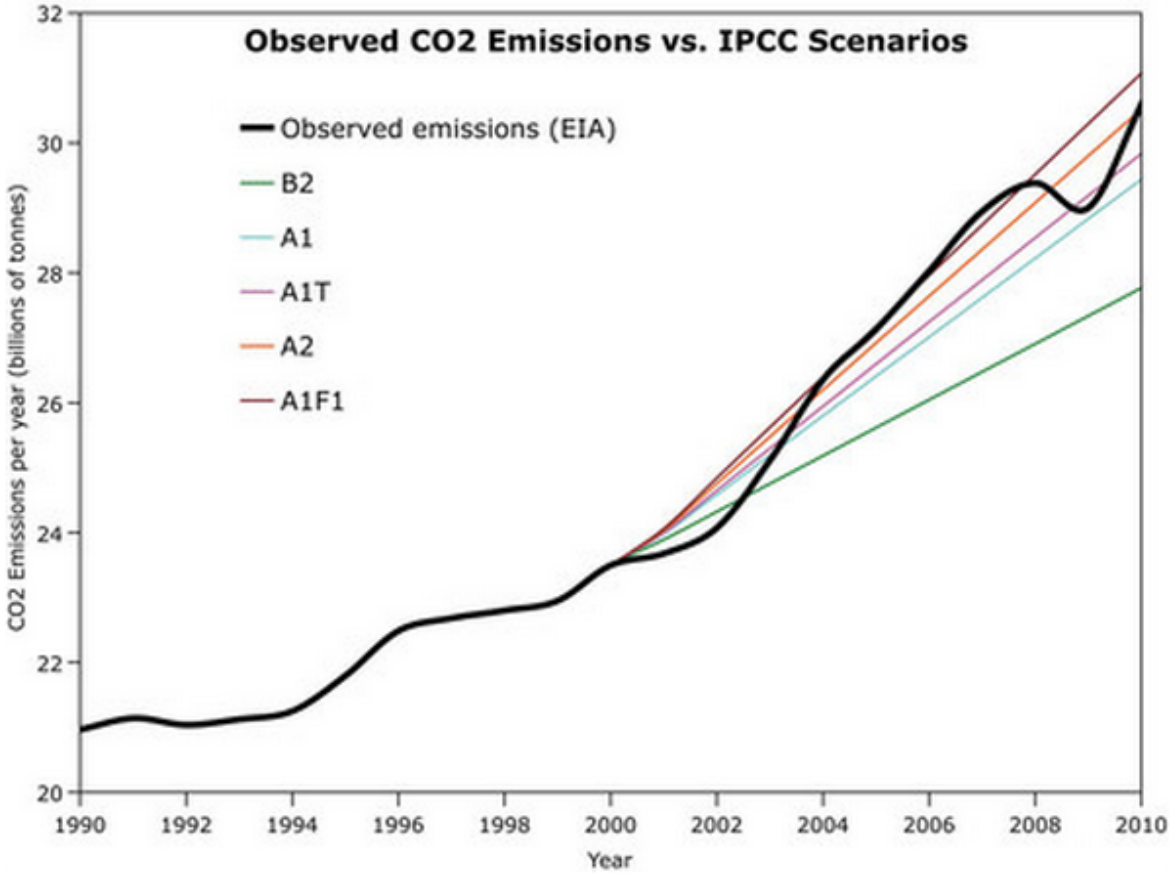
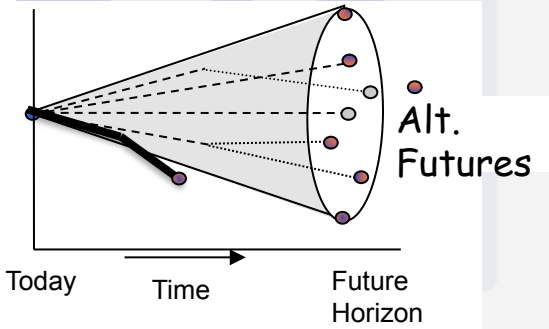



Figure 1: US Energy Information Administration (EIA) global human $CO_2$ annual emissions from fossil fuels estimates vs. IPCC SRES scenario projections. The IPCC Scenarios are based on observed $CO_2$ emissions until 2000, at which point the projections take effect.




Abraham, 2012, http://theconversation.edu.au

Liverman et al., 2009: planning should consider 4 deg C rise by 2060