CLIMATE CHANGE PROGRAMME

Whither climate scenarios for Europe?

Stefan Fronzek and Timothy Carter
Finnish Environment Institute (SYKE)

(Re)Thinking National Climate Scenarios Workshop

16–18 Dec 2013, Reading, UK

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Outline

- The need for climate observations
- Traceability, comparability and priority of climate scenarios
- Other sources of uncertainty: non-climate scenarios and impact ensemble modelling
- Some initiatives and portals providing climate scenarios and guidance with European focus
- Summary

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The need for climate observations

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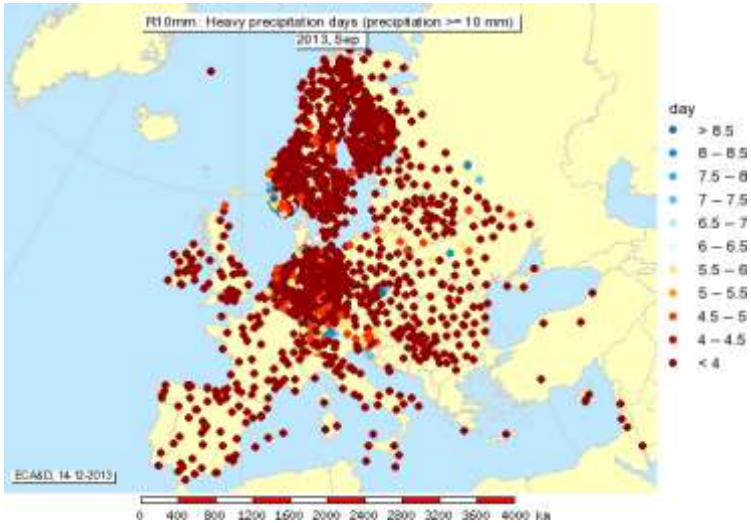
Availability and quality of station and gridded climate observations

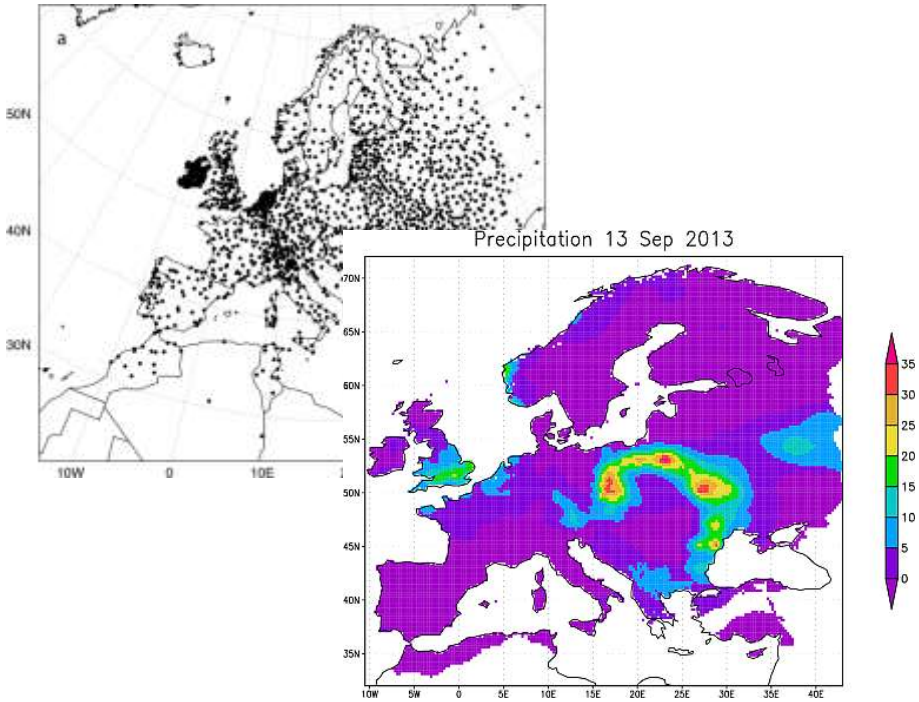
European Climate Assessment & Dataset



Source: www.ecad.eu (assessed 14 Dec 2013)

E-OBS daily gridded dataset

Source: Haylock et al. 2008



- Daily values starting 1950, 0.25 deg resolution
- >480 citations in GoogleScholar (>295 in WoS/ISI)

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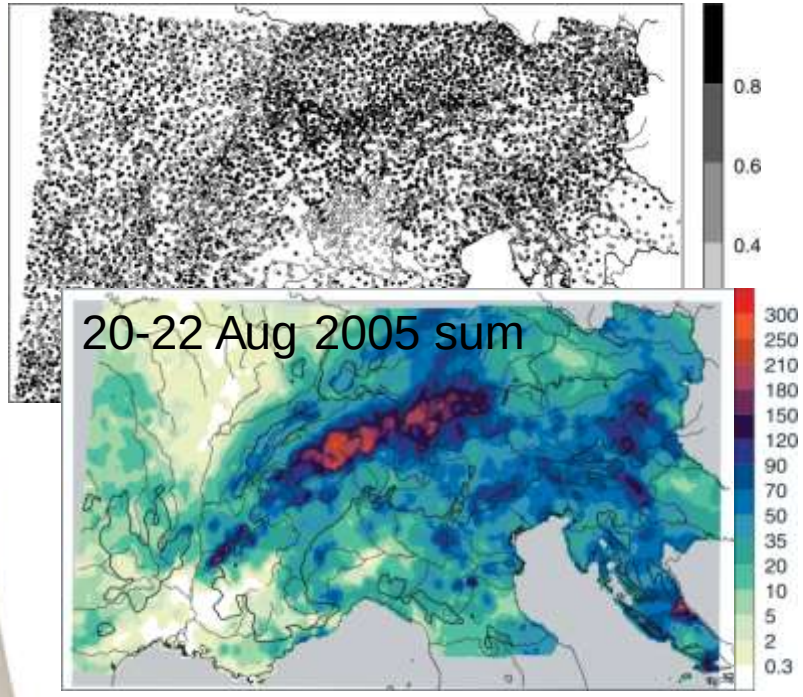
Availability and quality of station and gridded climate observations

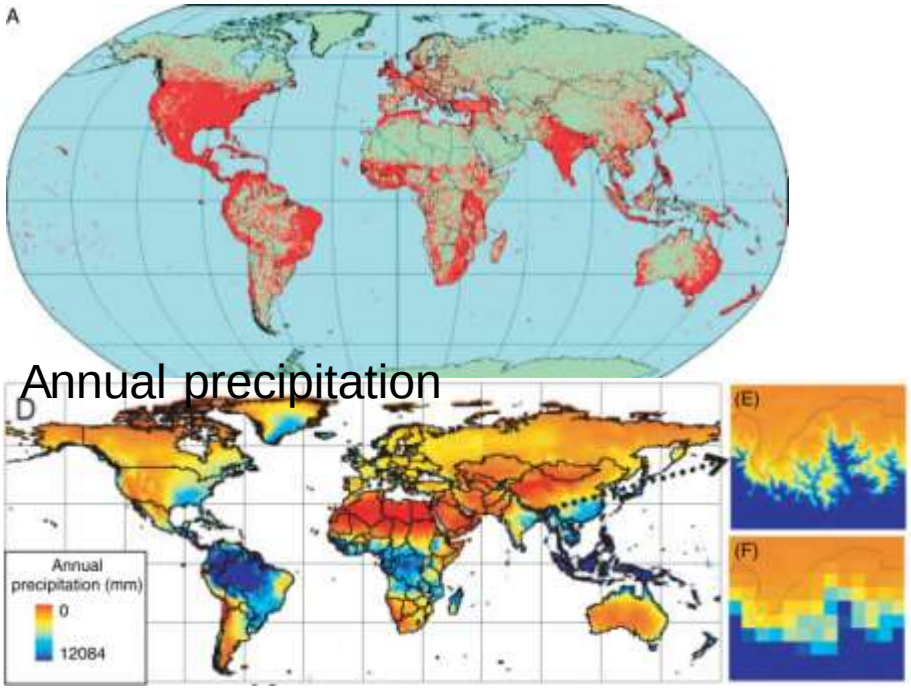
Daily precipitation in the Alps
Station network



Source: Isotta et al. 2013

- 5 km resolution, 1971-2008

WorldClim climatologies
Station network



Source: Hijmans et al. 2005

- Global climatologies, 30 arcsec resolution (~1 km)
- >3900 citations in GoogleScholar (>2600 in WoS/ISI)

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Traceability, comparability and priority of climate scenarios

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National climate projections in Europe

Presented earlier today ……

Country	Name of projection	Publ. date	Time horizon	Number of Em. sce	GCM	RCMs	Data download	Uncertainty representation in maps	graphs
AT	reclip:century	2011	2050	2	2	2	X	Ind.sim.	–
BE	Regional projections (Walloon region)	2011	2100	1	3	3	–		
	CCI-HYDR & INBO (Flamish region)	2009	2100	3	3	3	–	Ind.sim.	Ind.sim.
CH	CH2011	2011	2100	3	4	9	X	MMM	Ind.sim.; % (2.5,50,97.5)
CZ	Projekt VaV 2007-2011	2011	2100	1	1	1	–	Ind.sim.; MMM; sign-rob	Ind.sim.; % (25,50,75)
DE	Deutscher Klimaatlas	2011	2100	5	4	11	–	% (15, 50, 85)	Ind. simulations
	Regionaler Klimaatlas	?	2100	4	3	3	–	Ind.sim.; rge.; sign-rob	–
ES	Escenarios regional. de cambio climático	2009	2100	2	3	9	–	Ind.sim.; MMM	Ind.sim.; MMM; unc.rge (±1 st.dev.)
	PNACC 2012	2013	2100	3	3	3	X	–	% (0, 25, 50, 75, 100)
FI	ACCLIM	2009	2100	3	19	9	–	MMM	MMM; % (5, 95)
FR	Climat de la France …	2012	2100	3	3	2	X	Ind.sim.	% (2.5, 97.5)
HU	OMSZ 2008	2008	2100	1	2	2	–	Ind.sim.	–
IE	C4I	2008	2100	4	5	2	–	Ind.sim.; MMM	–
NL	KNMI'06, Klimaateffectatlas	2006, 2009	2050, 2100	n.a.	5	10	–	Best guess	Unc. Range
NO	Klima i Norge 2100	2009	2100	3	6	10	–	Ind.sim.; MMM; % (5, 50, 95)	Ind.sim.; MMM; % (10, 50, 90); unc.rge (±1 st.dev.)
PL	Projekcje klimatu	?	2100	1	4	7	–	MMM; % (0, 10, 50, 90, 100)	–
UK	UKCP09	2009	2100	3	1	1	X	MMM; % (10, 50, 90)	MMM; PDF/CDF; joint prob. plot

Ind.sim. – individual simulations; MMM – multi-model mean; % - percentiles; sign-rob – robustness of sign; unc.rge – uncertainty range

Source: adopted from Füssel (in press), in Capela et al. (eds.) Adapting to an Uncertain Climate – Lessons from Practice

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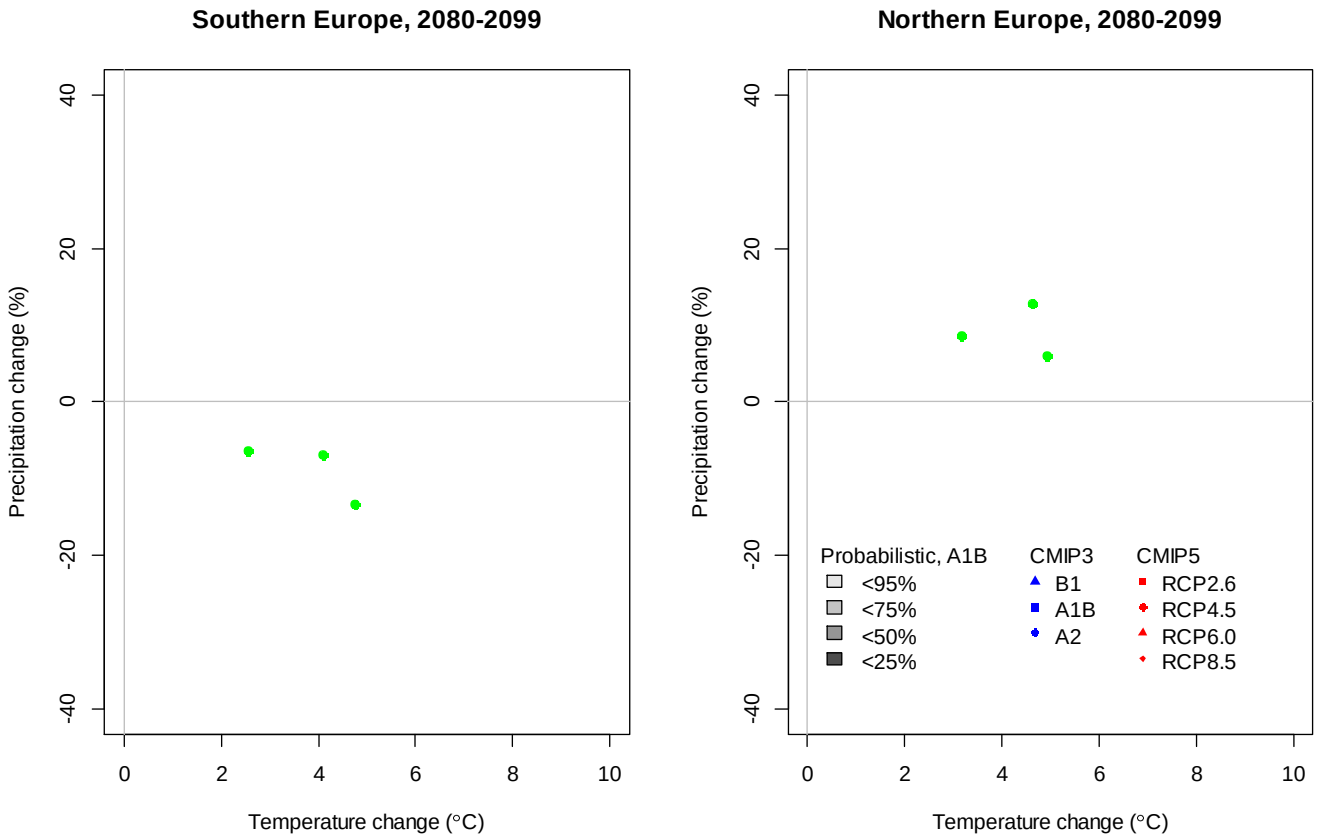
European-wide climate projections

Often developed on a project-by-project basis; some examples:

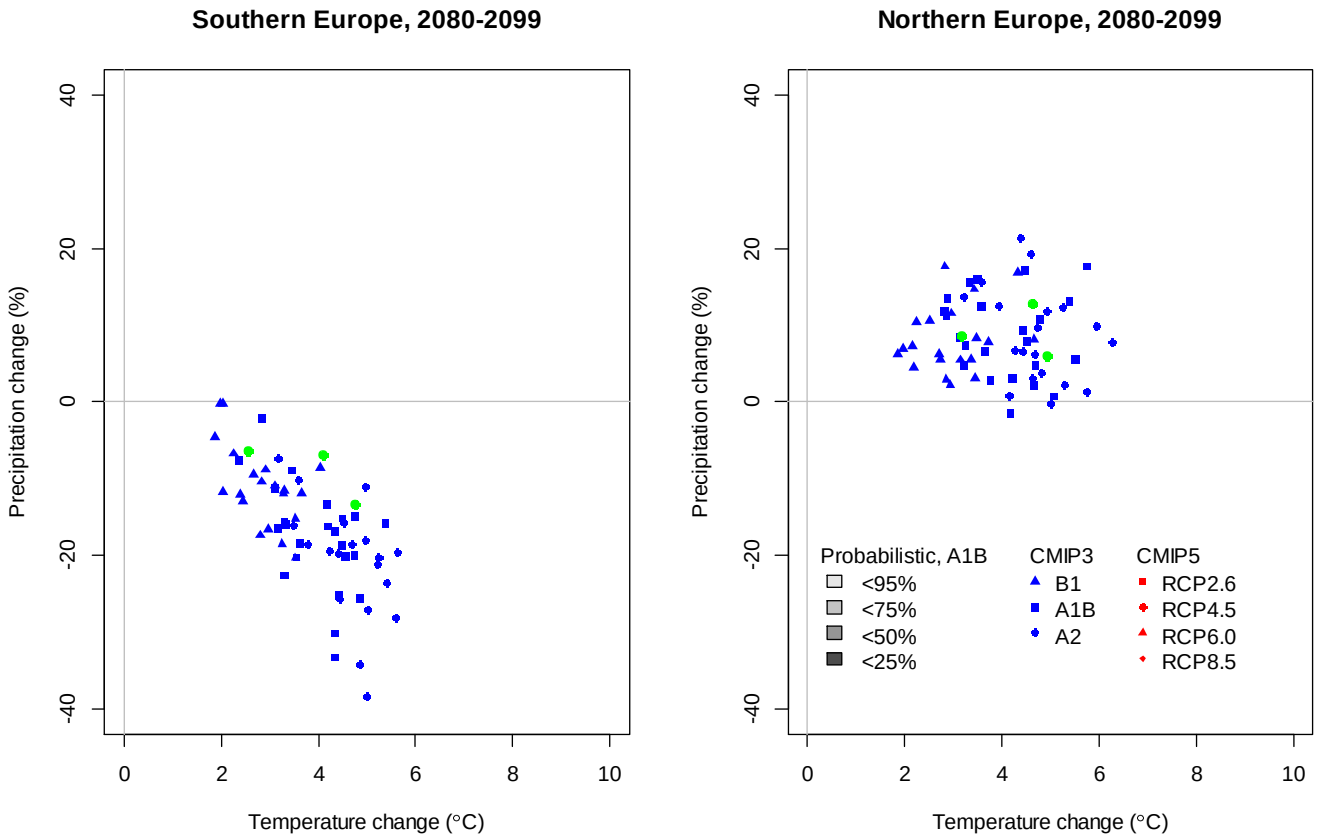
Name of projection	Ref	Time horizon and res.	Number of			Regionalizaton method	Data or tool download
			Em. sce	GCM	RCMs		
ATEAM project, TYN_SC_1.0	Mitchel et al. 2004	1901-2100, monthly	4	4	0	Delta change	www.cru.uea.ac.uk/cru/data
ALARM project, offshoot from TYN_SC_1.0	Fronzek et al. 2012	1901-2100, monthly	3 + THC shutdown	3	1	Delta change	www.alarmproject.net
ELPIS, LARS-WG	Semenov et al. 2010	-2100	3	15		Weather generator applied across 25km grid	www.rothamsted.ac.uk/mas-models/larswg.html
Statistical downscaling portal, Univ. of Cantabria	Gutierrez et al. 2012	Daily				Several statistical downscaling methods	
Statistical downscaling model (SDSM)	Wilby et al. 2002	Daily				Statistical downscaling	*www.**sdsm**.org.uk*
WorldClim scenarios		-2100, monthly climatologies	4	19		Delta change	www.worldclim.org/downscaling

Scatter-plots of T- + P-changes as simple devices to compare climate scenarios



Annual changes in temperature and precipitation in Europe for the period 2080-2099 relative to 1961-1990 for 3 of the scenarios of the ALARM project, from the "Grand ensemble" probabilistic projection for the A1B scenario (Harris et al. 2010) and GCM simulations part of CMIP3 and CMIP5.

Scatter-plots of T- + P-changes as simple devices to compare climate scenarios



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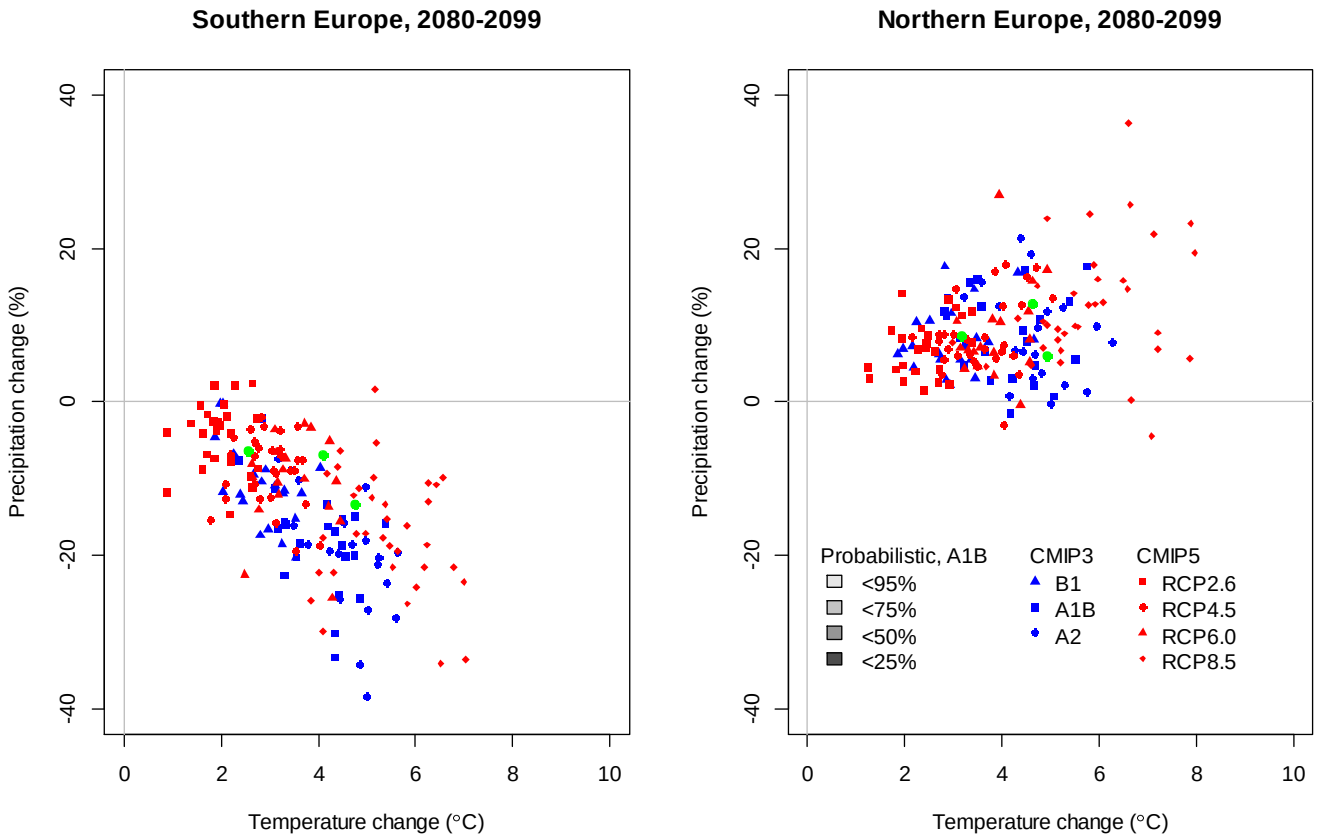

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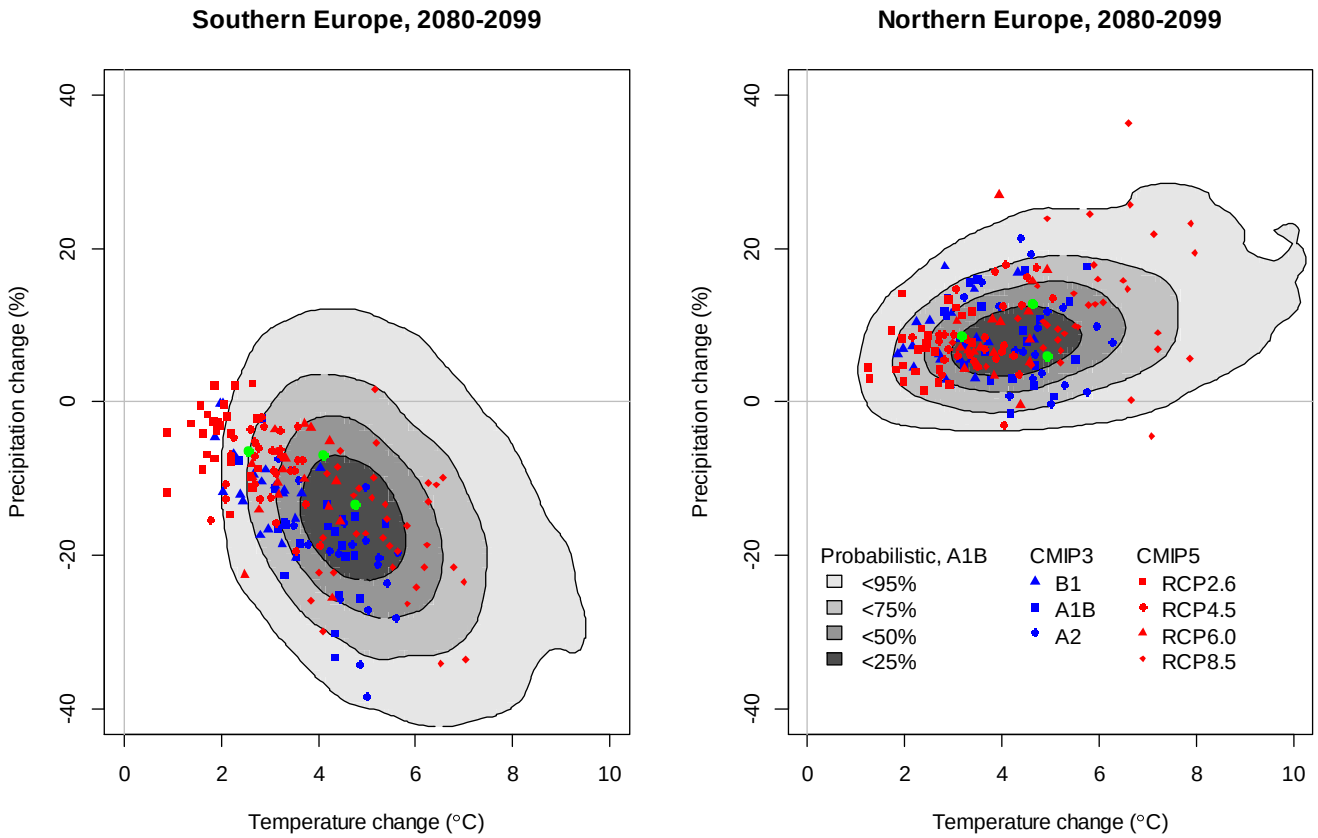
Scatter-plots of T- + P-changes as simple devices to compare climate scenarios



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Climate Change Explained | Maps, graphs and data | Community Response Wizard

Observed and projected climate | Impacts of climate change | Instructions

Climate and impacts

Water resources

- Snow duration (days)
- Maximum snow amount (kg/m²)
- Soil moisture deficit (mm)
- Annual evapotranspiration (mm)
- Maximum runoff (mm)
- Total runoff (mm)
- Timing of maximum runoff (percent of years)

Potential energy demand

- Cooling demand (°Cd or degree-days)
- Heating demand (°Cd or degree-days)

Natural ecosystems

- Rate of litter decomposition (relative units)

Time period

- Baseline
- 2010 - 2039
- 2040 - 2069
- 2070 - 2099

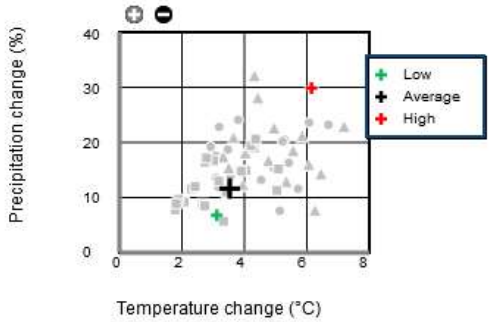
Map option

- value
- change

Climate scenario

no view

Change in annual temperature and precipitation for Finland



Soil moisture deficit (mm)

Select county: Suomi

relative to baseline

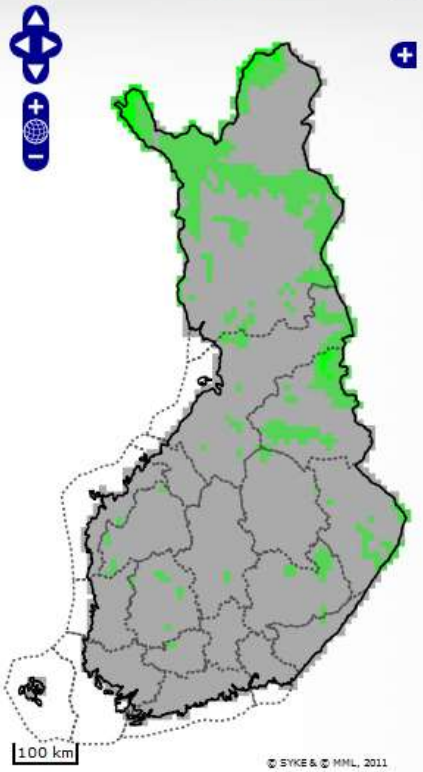
Time period: 2070 - 2099

Emission scenario: B2

Climate model: multi model mean

Unit: %

- 0
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 -



Explanation

Map

Maps show estimates of the impacts of climate change in different parts of Finland, either on a regular network of grid boxes (10km squares), or by region.

Types of impacts

Different types of impacts can be selected. In this prototype version, maps can be produced showing impacts of climate change on hydrology (water-related factors), energy demand for heating and cooling of buildings and the natural decomposition rate of dead plant

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Climate and CO_2 scenarios recommended for ATEAM

Priority order: high, medium, low

All scenarios were available for Europe, 2001-2100

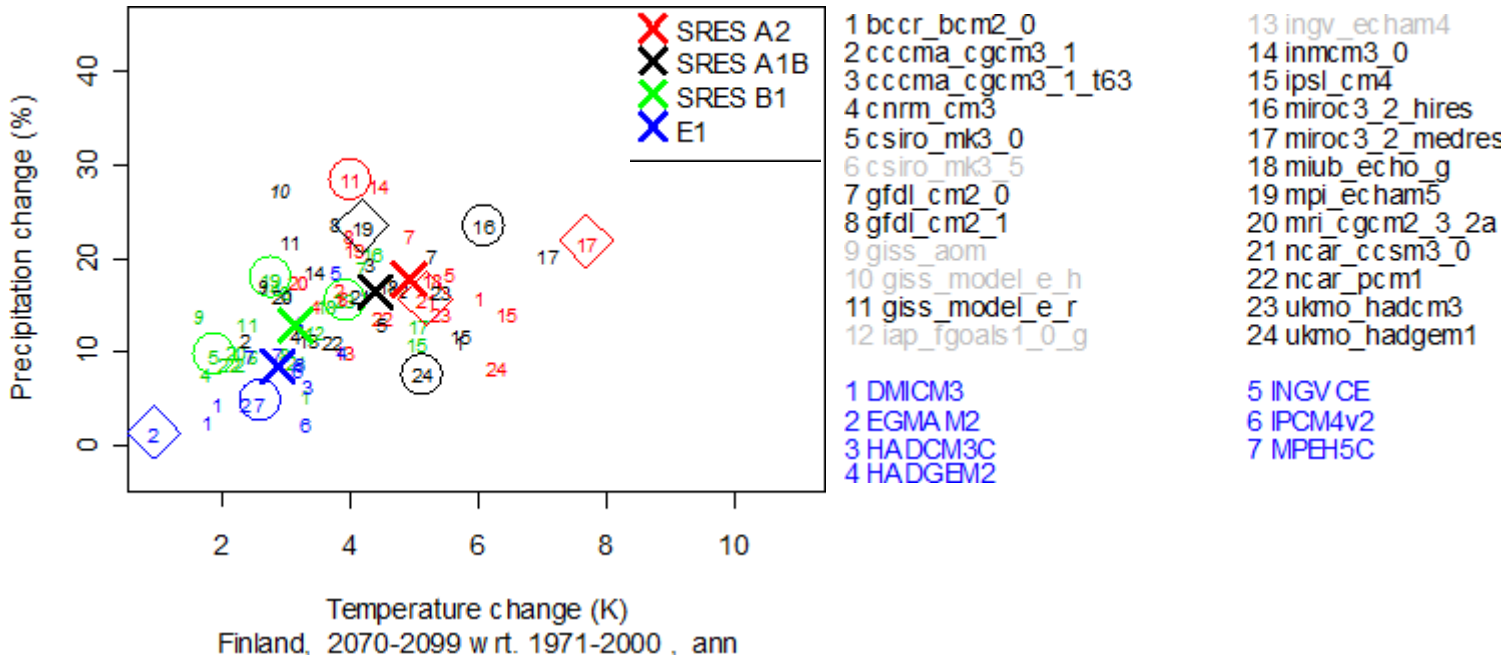
Climate model uncertainty →

Emissions uncertainty ↑ ↓

Scenario	CO_2 concentration in 2100 (ppm)	NCAR-PCM	CGCM2	HadCM3	CSIRO2
A1FI	958	Low	Low	High	Low
A2	871	High	High	High	High
B2	607	Low	Low	High	Low
B1	516	Medium	Low	High	Low

Schröter et al. 2006

Core and extended set of climate scenarios from a national project on biodiversity and agriculature (A-LA-CARTE)



◊ core set (plus A1B ensemble average)

O extended set (including all ensemble averages

X ensemble average for

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Other sources of uncertainty: non-climate scenarios and impact ensemble modelling

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National non-climate scenarios

Country	Date	Name	Comment
FI	2005	FINADAPT scenarios for the 21st century	Downscaled scenarios of population, sector-specific GDP, household consumption, nitrogen deposition and land use consistent with 3 out of 4 SRES scenario families
	2007	Assessing the adaptive capacity of the Finnish environment and society under a changing climate: FINADAPT	
NL	2006	Welfare, Prosperity and Quality of the Living Environment (WLO)	The 4 WLO scenarios comprise 26 variables related to demography, economy, housing, industrial areas, mobility, energy, agriculture and environment. They were re-evaluated in 2010 and they build the basis of the IC11 scenarios.
	2010	Bestendigheid van de WLO-scenario's	
	2011	Socio-economic Scenarios in Climate Assessments (IC11)	
UK	2001	Socio-economic scenarios for climate change impact assessment (SES)	The 4 SES scenarios aligned with the 4 SRES scenario families provide quantitative projections until 2050 for 12 variables related to economic development, population and land use. Further qualitative scenarios are given for those thematic areas as well as for values and policy, agriculture, water, biodiversity, coastal zone management and built environment. The SES scenarios were critically reviewed in 2009.
BE	2009	Environment Outlook 2030 – Flanders	A single scenario for demography, economic development, employment and energy prices
DE	2012	Trends der Siedlungs-flächenentwicklung - Status quo und Projektion 2030	Regionalized scenarios for changes in land use

Source: adopted from Füssel (in press), in Capela et al. (eds.) Adapting to an Uncertain Climate – Lessons from Practice

Europe-wide socio-economic scenarios developed to be consistent with climate scenarios

ATEAM land-use scenarios

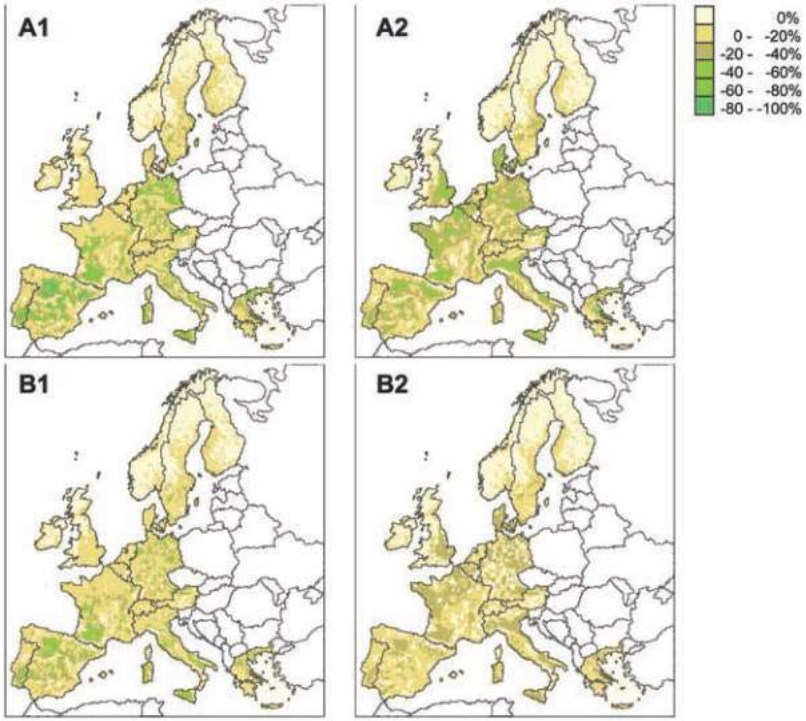


Fig. 1. Change in cropland area (for food production) by 2080 compared with the baseline (percentage of EU15+ area) for the four storylines [A1FI (A1), A2, B1, and B2] with climate calculated by HadCM3.

Source: Schröter et al. 2005

ALARM socio-economic scenarios

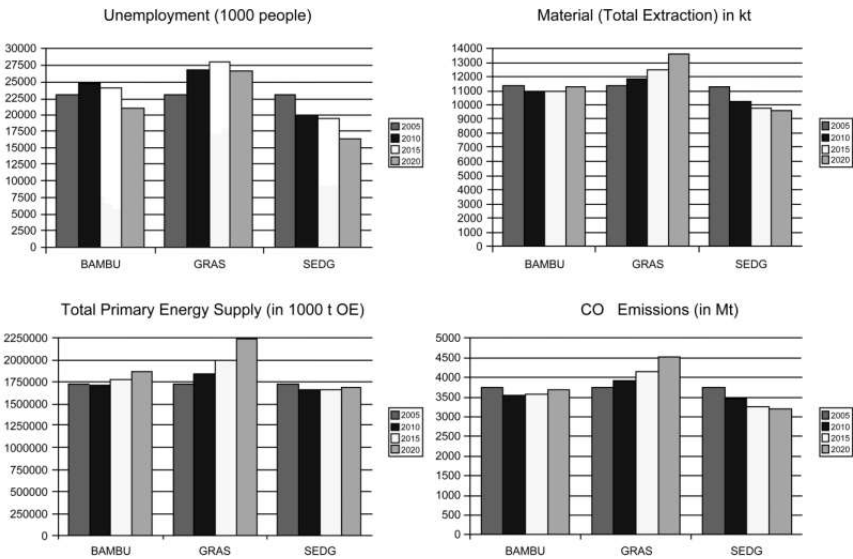
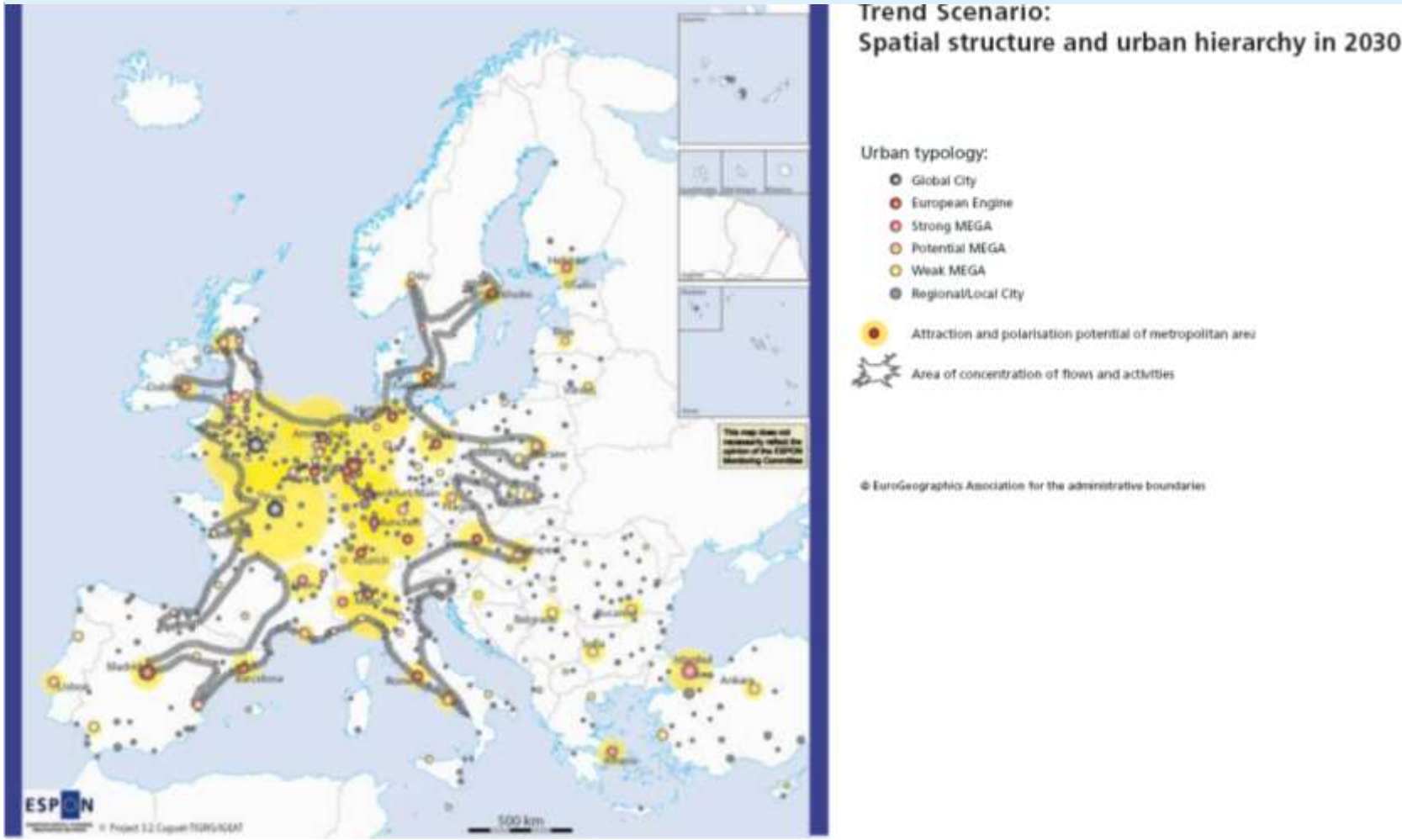


Figure 3 Comparison of the scenario results for selected variables (for the EU25: Austria, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom). OE, oil equivalents.

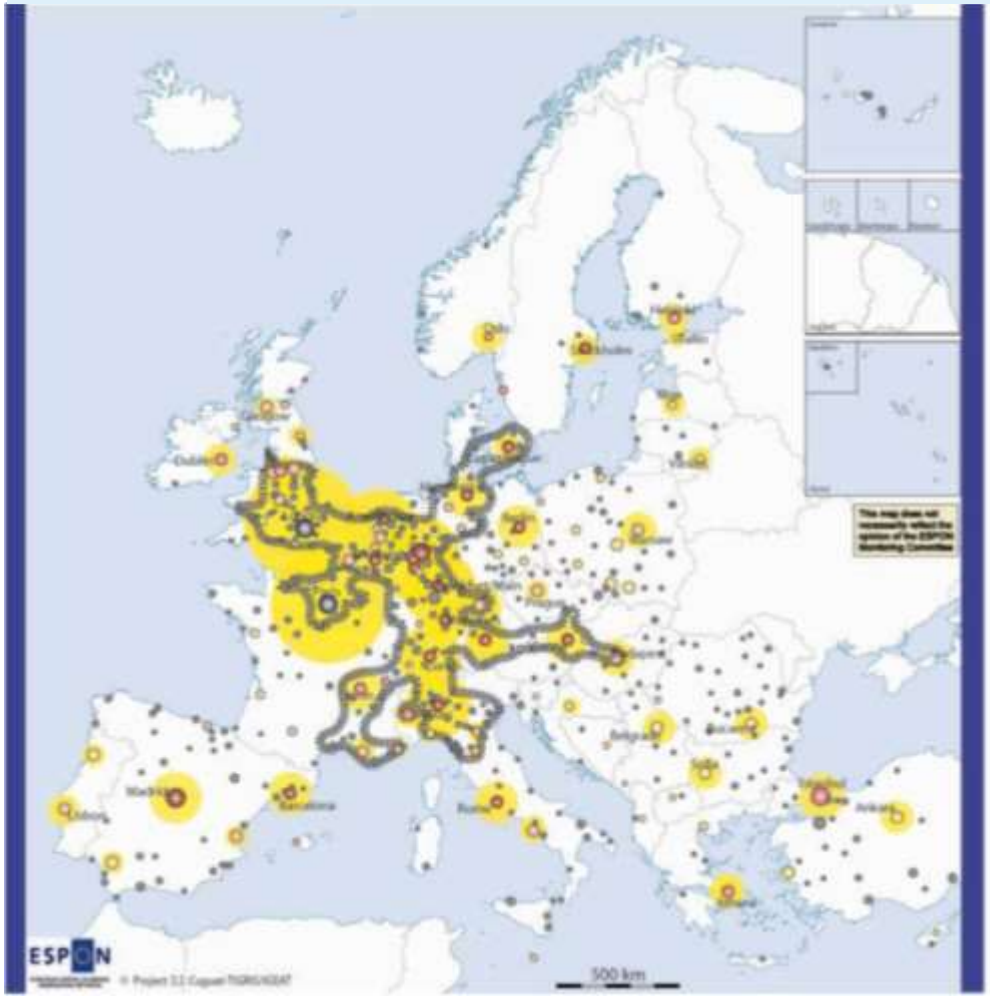
Source: Stocker et al. 2012

ESPON Territorial Futures: Trend Scenario



ESPON, 2007

ESPON Territorial Futures: Competitiveness-oriented Scenario



Competitiveness-oriented Scenario: Spatial structure and urban hierarchy in 2030

Urban typology:

- Global City
- European Engine
- Strong MEGA
- Potential MEGA
- Weak MEGA
- Regional/Local City

Attraction and polarisation potential of metropolitan area

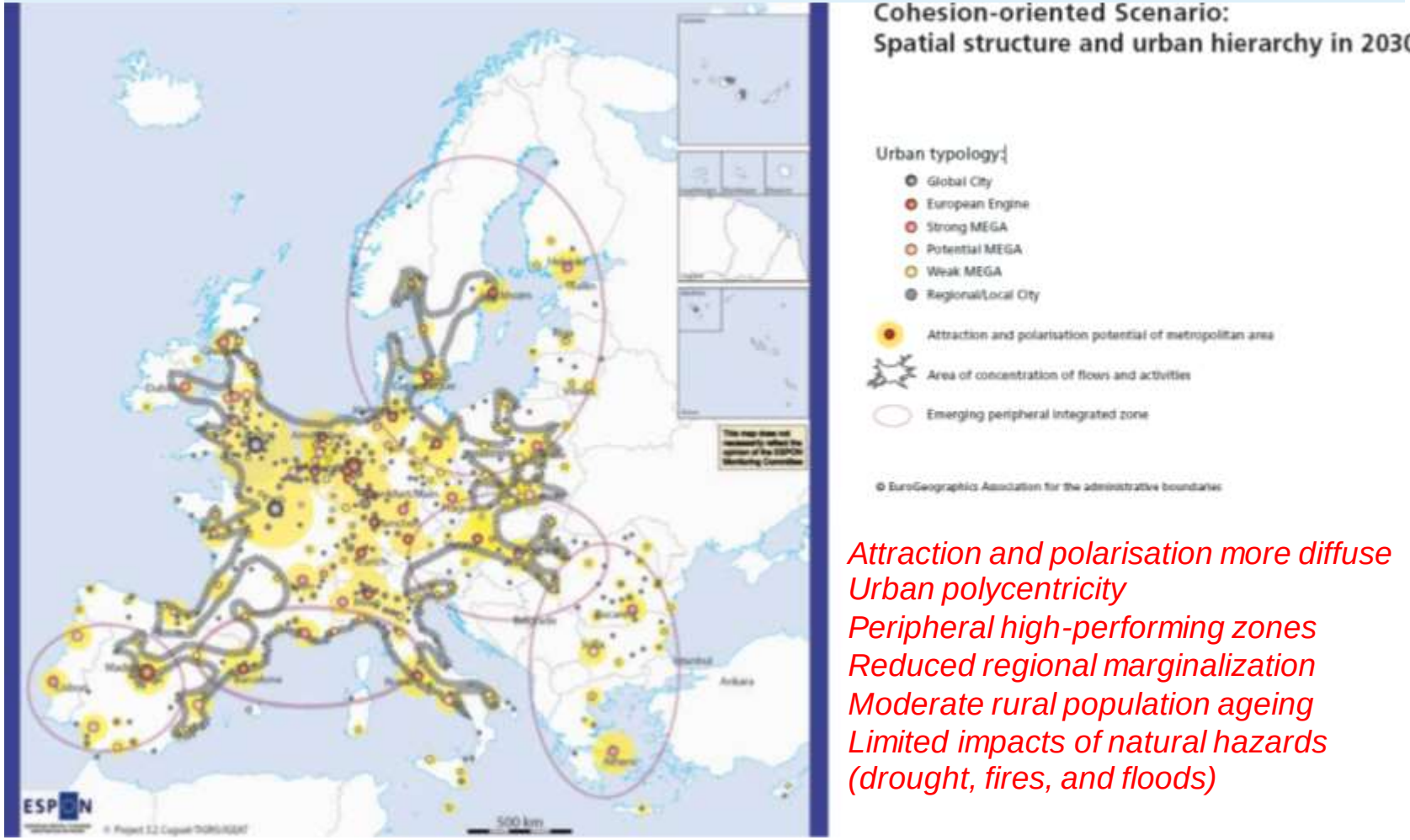
Area of concentration of flows and activities

© EuroGeographics Association for the administrative boundaries

Attraction and polarisation in Pentagon
Rural marginalisation.
Industrial decline
External immigration flows
Severe rural population ageing
Intensified impacts of natural hazards (drought, fires, and floods)

ESPON, 2007

ESPON Territorial Futures: Cohesion-oriented Scenario



Attraction and polarisation more diffuse
Urban polycentricity
Peripheral high-performing zones
Reduced regional marginalization
Moderate rural population ageing
Limited impacts of natural hazards (drought, fires, and floods)

ESPON, 2007

Matching RCPs and SSPs to SRES

Table 4 Scenario matrix architecture showing suggested SRES mappings onto SSPs (in blue, based on Fig. 1) and onto RCPs (red). The cells in the matrix have entries (black font) where the same SRES scenario approximates a combination of an RCP and an SSP. Here, not only the reference SRES scenarios are mentioned, but also possible positioning of mitigated SRES scenarios. Square brackets indicate mappings that are less robust. The E1 scenario is a mitigation scenario derived from the A1B storyline and leads to a forcing close to RCP2.6

Challenges to adaptation:		Low		Medium	High	
		SSP1	SSP5	SSP2	SSP3	SSP4
Reference	SRES	B1 / A1T	A1FI	B2	A2	[A2]
8.5 Wm^{-2}	A2 / A1FI		A1FI		A2	[A2]
6.0 Wm^{-2}	B2 / A1B			B2		
4.5 Wm^{-2}	B1	B1	←	Mitigated SRES		→
2.6 Wm^{-2}	[E1]	←	Mitigated SRES		→	

Source: van Vuuren & Carter (in press)

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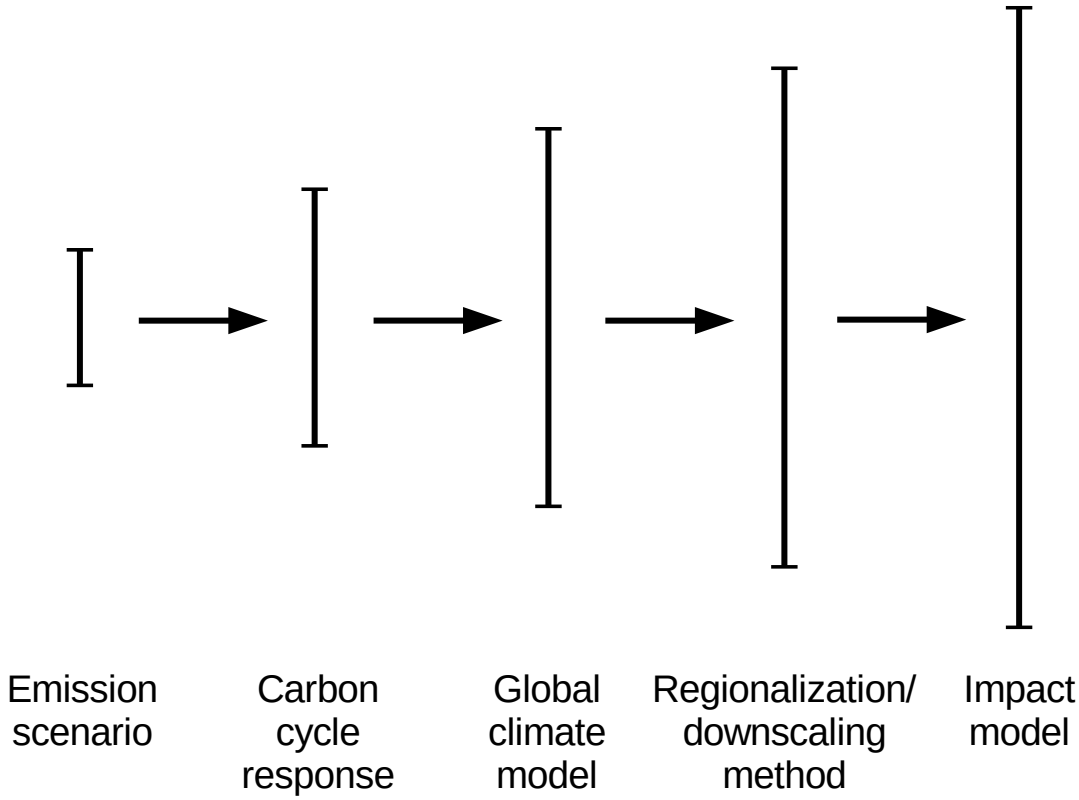
How to treat the *cascade of uncertainties* in climate change impact assessments?

Uncertainties can be quantified by using alternative scenarios and ensemble modelling.



Source: Fronzek 2013, adopted from Schneider 1983; Jones 2000

Impact model uncertainties matter

Example from Wilby et al. (2009): Effect of warming on net farm revenue for Sri Lanka

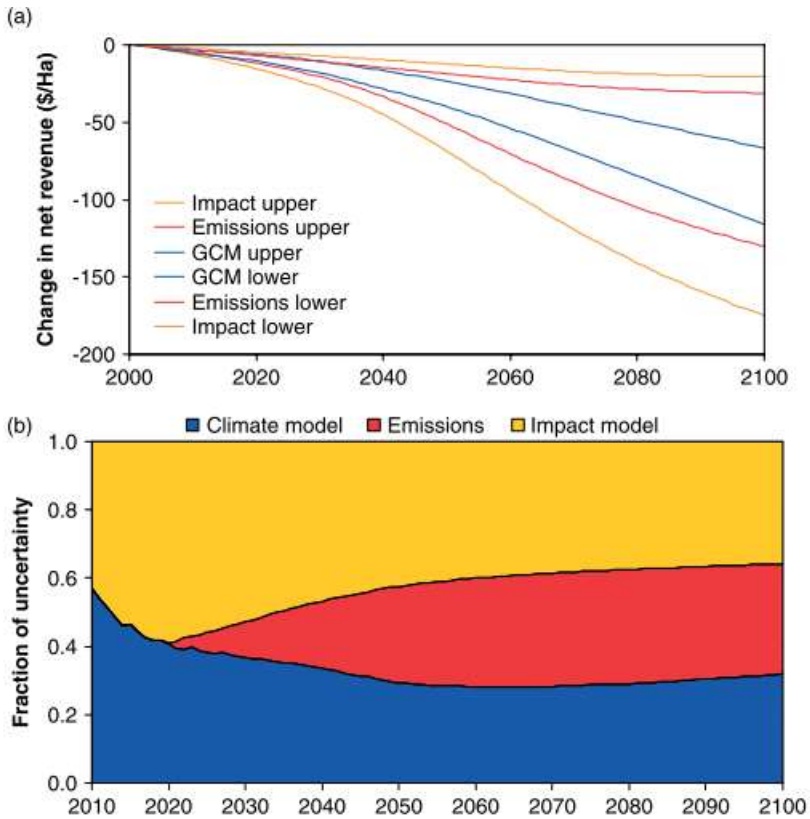


Figure 10. (a) Changing net revenue ($/Ha) reflecting uncertainty in GCM projections of temperature (blue envelope) combined with emissions (red envelope) and impact model parameter uncertainty (gold envelope). (b) The contribution of climate model, emissions and impact model uncertainty as a time-varying fraction of the total uncertainty in net farm revenues for Sri Lanka under projected increases in annual mean temperature. This figure is available in colour online at www.interscience.wiley.com/ijoc

Impact model intercomparisons

- **Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP)**
- **Agricultural Model Intercomparison and Improvement Project (AgMIP)**

AgMIP The Agricultural Model Intercomparison and Improvement Project

ISI-MIP

Impact response surfaces – climate projections are used only after the impact analysis

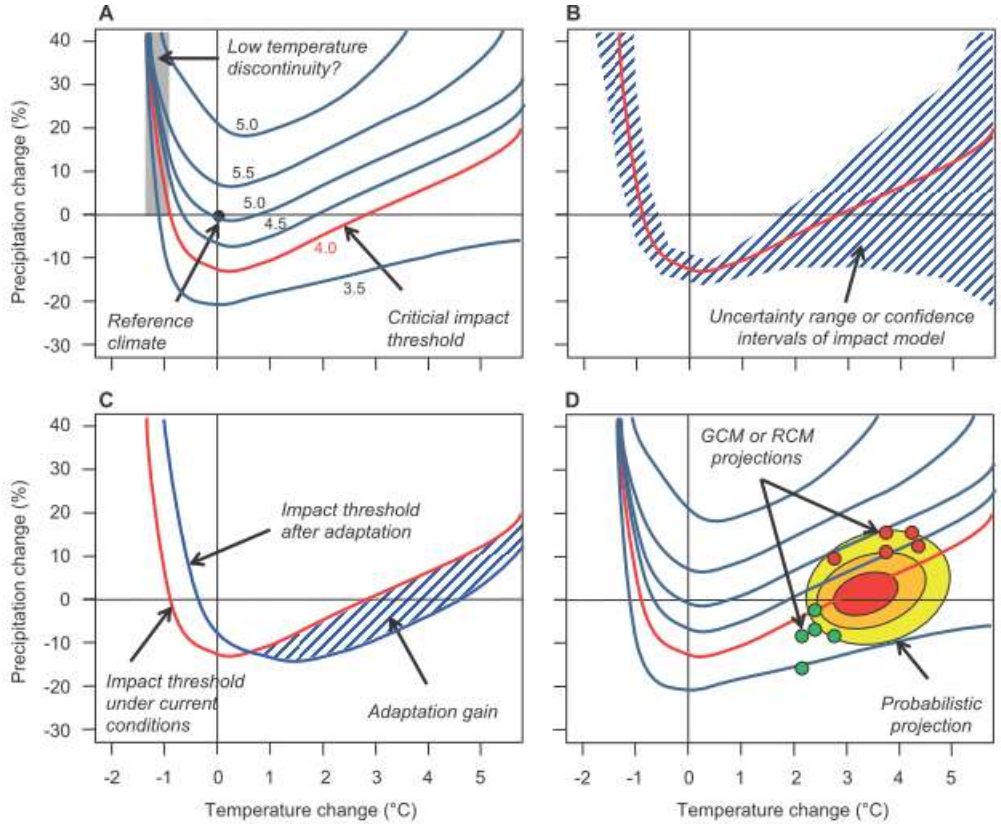


Fig. 11: Schematic impact response surfaces (IRSs) of a hypothetical impact model illustrating key features and some of potential uses. IRSs depict impact behaviour across a wide range of climate changes relative to a reference climate, so that: critical impact thresholds can be plotted and possible impact discontinuities identified (A); impact model uncertainties can be displayed (B); changes in impact behaviour following adaptation can be plotted to evaluate advantages gained by adaptation (C); and different climate change projections can be overlaid to allow a rapid assessment of impacts or of impact risks where probabilistic projections are applied (D). The IRSs shown could be for average crop yields (in t/ha) and a possible adaptation option (C) could be the switch to a different crop variety. The colour shading of the probabilistic projection in D illustrates the probability distribution with red indicating higher probability than yellow.

Source: Fronzek 2013, http://hdl.handle.net/10138/40184

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Some initiatives and portals providing climate scenarios and guidance with European focus

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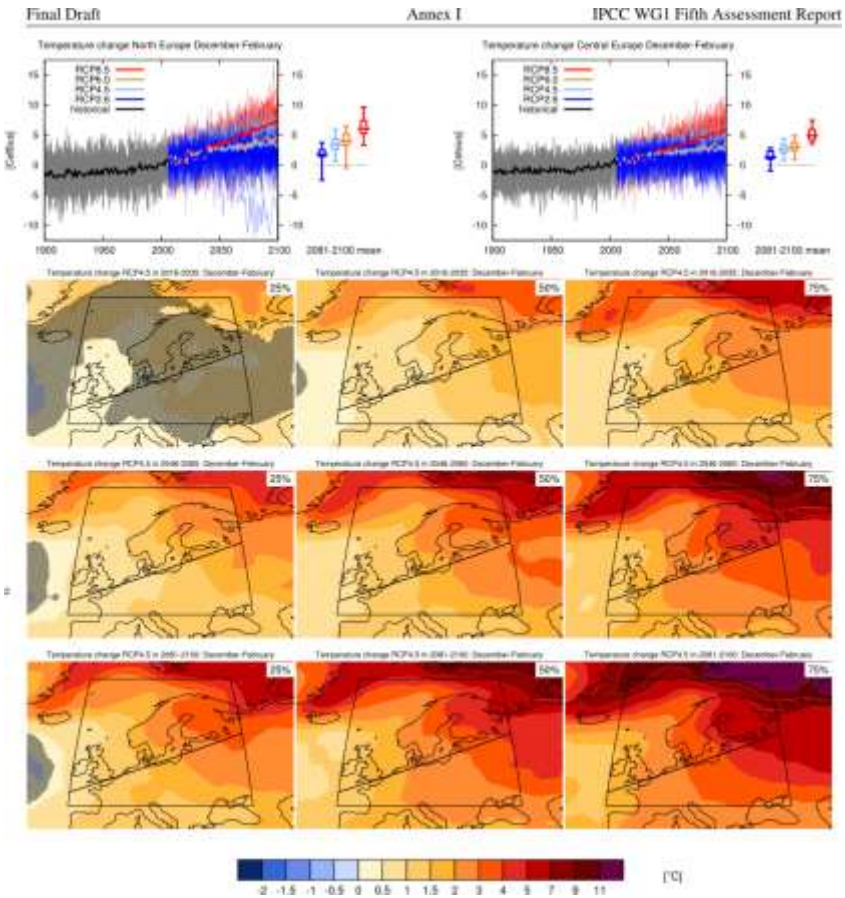
IPCC information on regional projections and guidance



Source: IPCC, 2013: Annex I: Atlas of Global and Regional Climate Projections [van Oldenborgh et al. (eds.)]. In: Climate Change 2013: The Physical Science Basis, in press

Climate-ADAPT

Observations and scenarios - climate-adapt

climate-adapt.eea.europa.eu/web/guest/observations-and-scenarios

CLIMATE-ADAPT
European Climate Adaptation Platform

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Observations and scenarios

General | Atmosphere | Cryosphere | Water systems | Oceans | Terrestrial biosphere | Urban areas and health

For the assessment of climate change and its impacts, both observations of past and present conditions, and scenarios for future developments are required. This section provides access to information on observations and scenarios for the atmosphere, the cryosphere, water systems, oceans, the terrestrial biosphere and urban areas and health.

Read more

Selected indicators

- Urban adaptation to climate change in Europe – indicators and maps
- Global and European temperature
- Mean precipitation
- Storms
- Glaciers
- Sea-level rise
- Snow cover

View all

Publications & reports

- Intergovernmental Panel on Climate Change - Emissions Scenarios - Summary for Policymakers
- IPCC WG2, 2007, chapter 12: Europe
- IPCC, WGI report, 2007: The Physical Science Basis
- Impacts of Europe

Information portals

- GMES - MyOcean Ocean Monitoring and Forecasting
- EDO - European Drought Observatory
- E3 Geoportal
- Snow, Water, Ice, Permafrost in the Arctic (SWIPA)
- UK Ocean Acidification Research Project
- European Floods Portal
- European Climate Assessment & Dataset project (ECA&D)
- Regional Climate Model (RCM) data portal of the FP7 ENSEMBLES project

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Interactive maps

- Annual Temperature Change 2071-2100
- Climate change signal (2070-2099 compared to 1961-1990) of mean temperature and precipitation for Europe according to SRES A1B scenario, (ENSEMBLES).
- Climate variables - projected changes (ESPON Climate Change project)

Climate Information Portal for Copernicus (CLIPC) – slide provided by Martin Juckes

British Atmospheric Data Centre
NATIONAL CENTRE FOR ATMOSPHERIC SCIENCE
NATURAL ENVIRONMENT RESEARCH COUNCIL

Copernicus
The European Earth Observation Programme

SEVENTH FRAMEWORK PROGRAMME

Climate Information Portal for Copernicus

CLIPC will use ESGF and the KNMI visualisation package to create a portal which brings together climate ~~data~~ estimates from models and observations (in-situ and EO) along with a knowledge base and a toolkit to streamline the generation of impact indicators.

The European Earth Observation Programme

FP7 Projects starting soon – to deploy pre-operational services

- Data Services
- Global reanalysis
- Regional reanalysis
- Essential climate variables
- Attribution

RAL Space
Harwell International Space Innovation Centre

Climate4impact.eu

European effort to provide an interface to Earth System Model data for climate impacts studies, hosted at KNMI.

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Statistical downscaling portal, Univ. of Cantabria

https://www.meteo.unican.es/downscaling/ensembles

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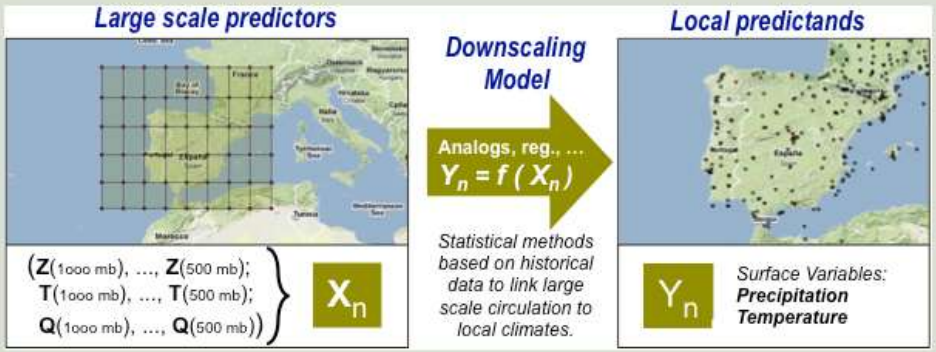
Downscaling Portal
Santander MetGroup

ENSEMBLES Downscaling Portal (version 2)

One of the goals of the ENSEMBLES project is maximizing the exploitation of the results by linking the outputs of the ensemble prediction system (multi-model climate change global simulations) to a range of applications, including agriculture, health, food security, energy, water resources, and insurance, which use high resolution climate inputs to feed their models. The **downscaling portal** allows end-users to calibrate/downscale the coarse model outputs in the region of interest using historical observed records. The portal includes public observation datasets (e.g. GSOD) and allows uploading new historical data (including private datasets, not available for other users).

This Statistical Downscaling portal provides **user-friendly web access** to different statistical downscaling techniques and works transparently with the observations, reanalysis and global climate simulations (see the common list of variables available for all models in the portal), obtaining the resulting **outputs in simple formats (e.g., text files).**



Three steps are neccessary to obtain high resolution forecasts in a region of interest:

1. Selecting the predictors,
2. Selecting the local stations and variable (predictand),
3. Running the desired downscaling jobs (local scenarios).

Downscaling Portal user guide:

Gutiérrez, J.M., San-Martín, D., Cofiño, A.S., Herrera, S., Manzanas, R., and Frías, M.D. (2012) User Guide of the ENSEMBLES Downscaling Portal. Version 3. Technical Note 2/2012. Santander Meteorology Group. Santander

Summary

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- Climate observations are an important ingredient for climate scenarios. Observational products, station and gridded data, are improving in quality, availability and access to them, especially in Europe.
- Climate scenarios should be traceable, comparable and priorities should ideally be set to different scenario selections. Examples of European-scale scenarios exist, but there are no “official” European climate scenarios.
- Other sources of uncertainty apart from climate are important for impacts. Socio-economic scenarios, consistent with climate scenarios, are often needed. Impact modellers have also started using ensemble approaches.
- Climate services are evolving both at national and European scales.

Summary

- Do policy-makers need scenarios (climate or non-climate) in the first place?
- What needs does the present provision of scenarios meet? At national scale, is the information provided consistent with what neighbouring regions are receiving? What advice do users receive?
- Do these incompatibilities matter? Does this imply a need for European scenarios?
- If these are provided, who should do this? Global Framework for Climate Services (GFCS) Should there be "European Centre for Climate Services (ECCS)"?