WAGENINGEN UR
For quality of life

European vulnerability to global change

a spatially explicit and quantitative assessment

Marc Metzger

2nd AVEC summer school
Peyresq, 29 September 2005

WAGENINGEN UR

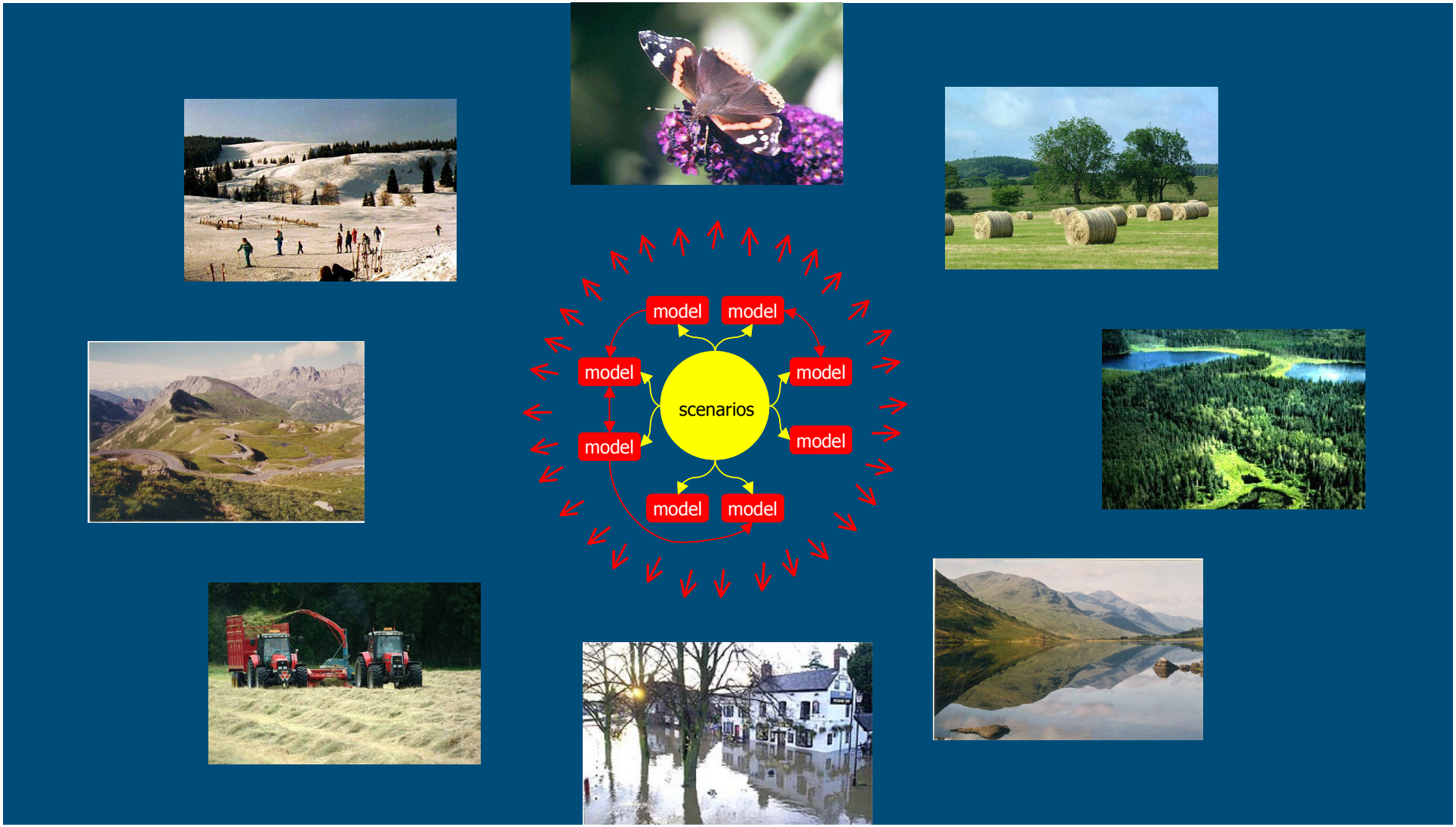
Presentation plan

- The ATEAM project
- Why vulnerability maps?
- Stratification
- The vulnerability framework
- Some maps and graphs
- Conclusions

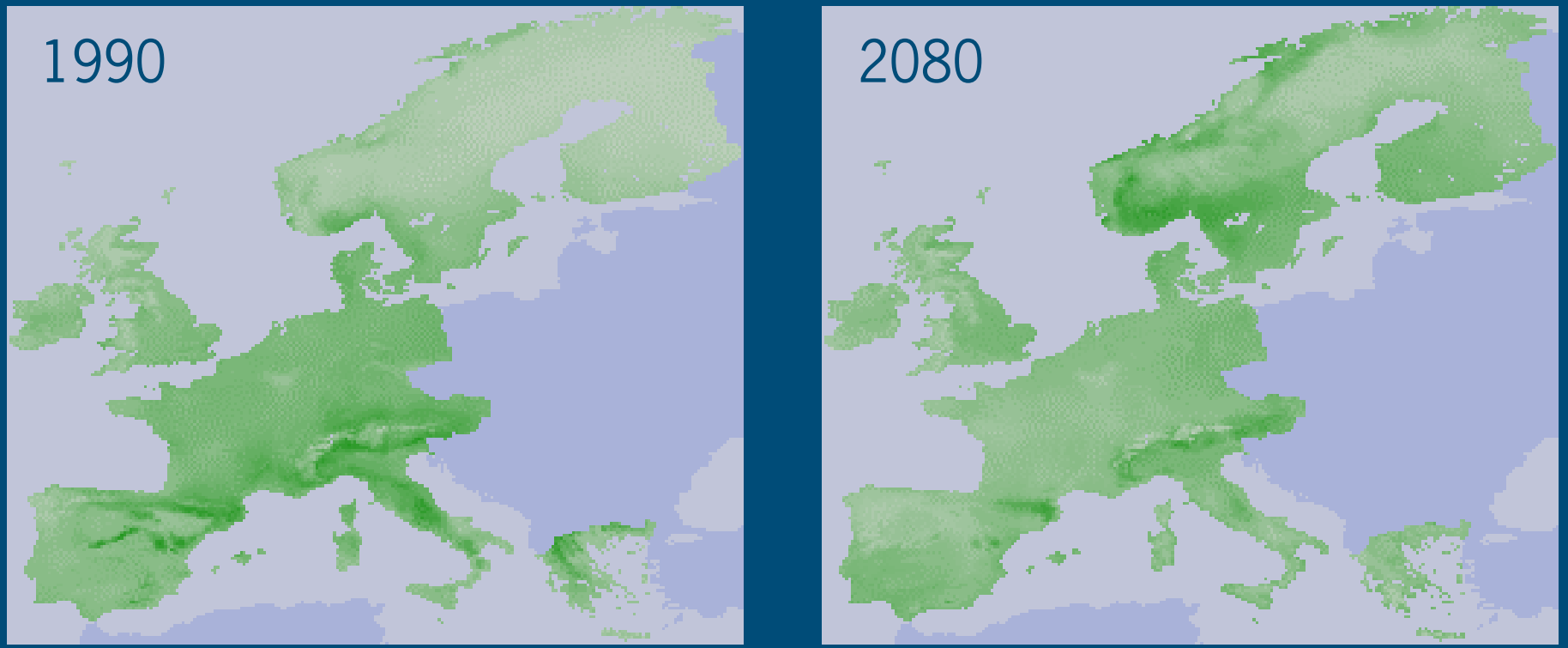
The ATEAM modelling framework

multiple GCMs, 4 scenarios
14 models
> 20 ecosystem services
1990, 2020, 2050, 2080
Europe wall to wall in 10' x 10'

Exposure, sensitivity and potential impacts



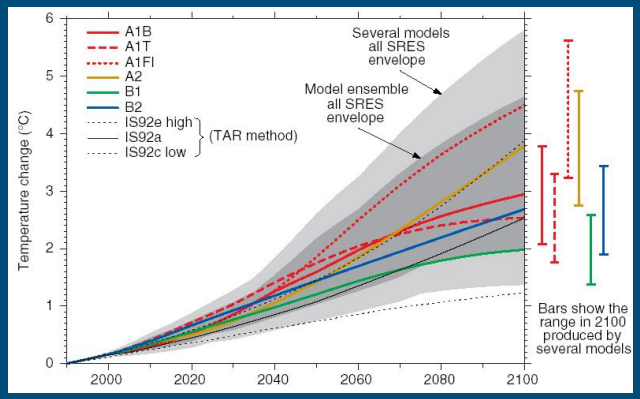
Example ecosystem service maps



WAGENINGEN UR
For quality of life

Vulnerability

'The degree to which an ecosystem service is sensitive to global environmental change and the degree to which the sector that relies on the service is unable to adapt to the changes.'



exposure

sensitivity

adaptive capacity

WAGENINGEN UR
For quality of life

Vulnerability

'The degree to which an ecosystem service is sensitive to global environmental change and the degree to which the sector that relies on the service is unable to adapt to the changes.'

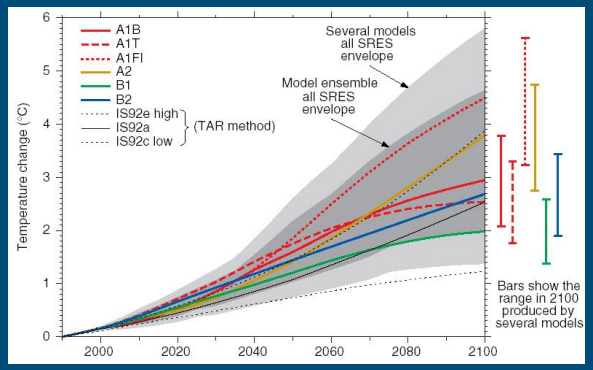
exposure

sensitivity

adaptive capacity

Vulnerability

‘The degree to which an ecosystem service is sensitive to global environmental change and the degree to which the sector that relies on the service is unable to adapt to the changes.’



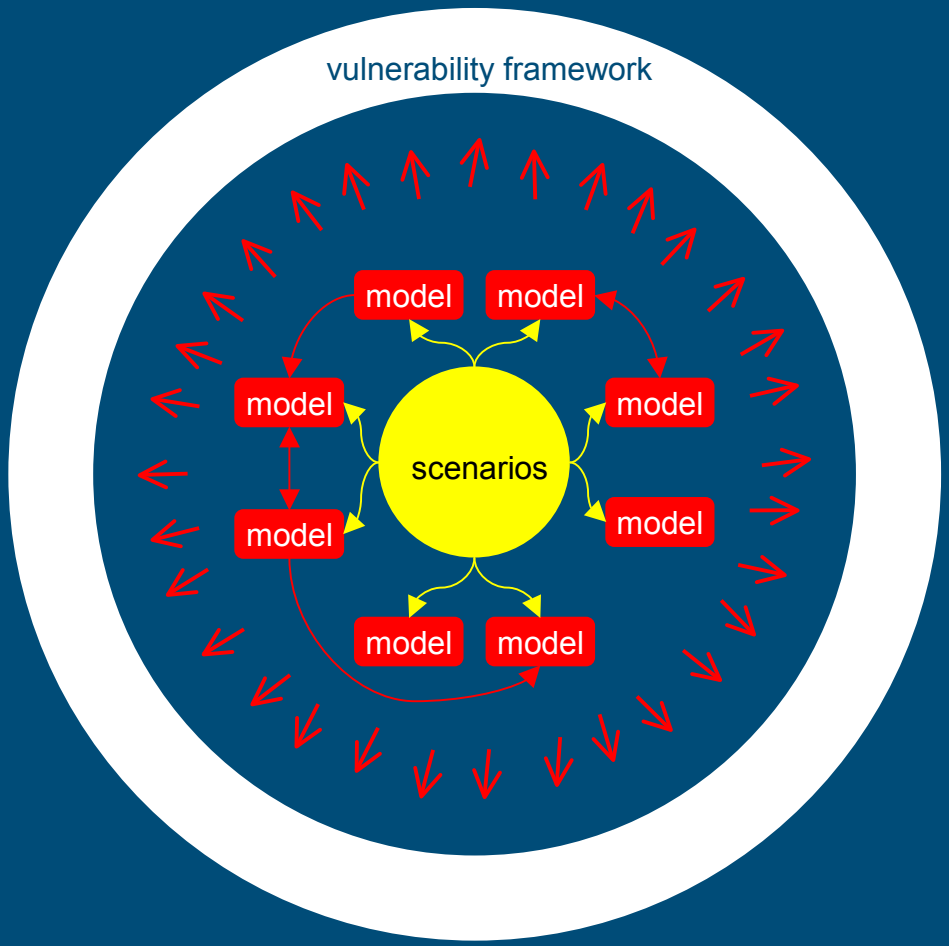
exposure

sensitivity

adaptive capacity

WAGENINGEN UR
For quality of life

Vulnerability in ATEAM



- Which regions are vulnerable?
- Which sectors are vulnerable?
- Which scenario is least harmful?
- How do two regions compare?
- …

ecosystem service

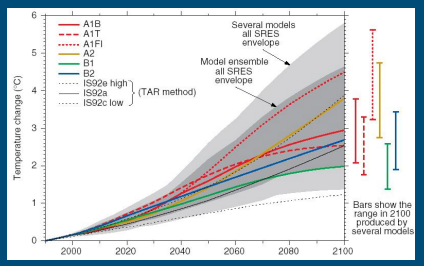
Towards quantifying vulnerability

1. $V(es, x, s, t) = f(E(es, x, s, t), S(es, x, s, t), AC(es, x, s, t))$

2. $PI(es, x, s, t) = f(E(es, x, s, t), S(es, x, s, t))$

3. $V(es, x, s, t) = f(PI(es, x, s, t), AC(es, x, s, t))$

V vulnerability
E exposure
S sensitivity
AC adaptive capacity
PI potential impact
es ecosystem service
x a grid cell
s a scenario
t a time slice



exposure

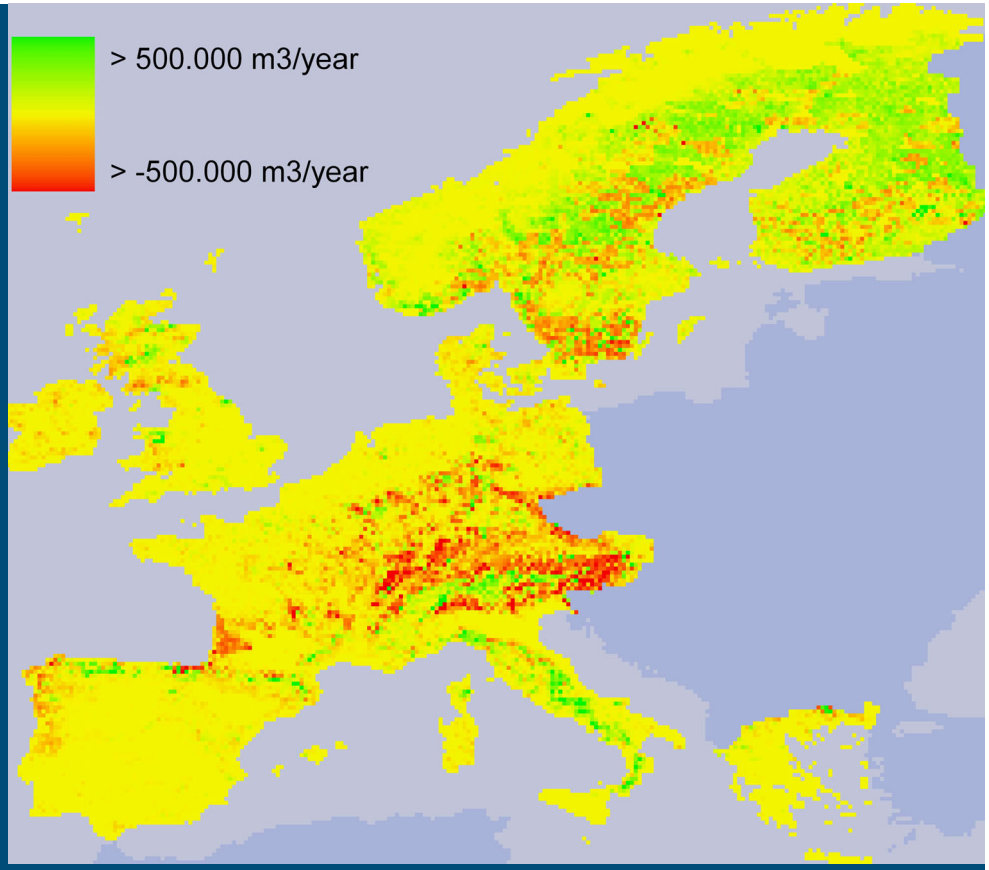
sensitivity

adaptive capacity

WAGENINGEN UR
For quality of life

PI = f(S,E)

Absolute change



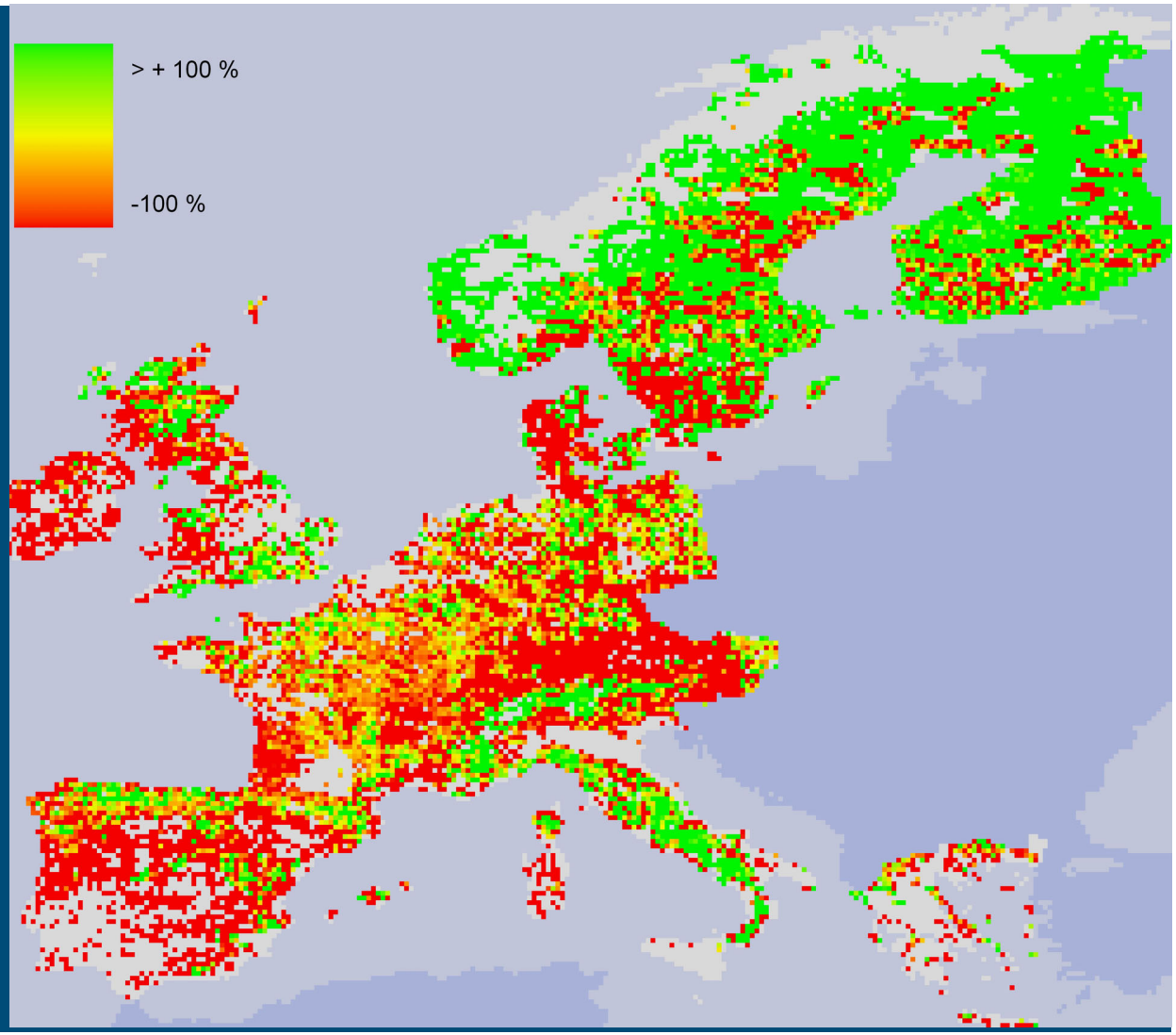
‘impacts that may occur in a grid cell given projected environmental change, without considering adaptation’ (based on IPCC TAR)

WAGENINGEN UR
For quality of life

Wood yield (m3 /year)

PI = f(S,E)

Relative change



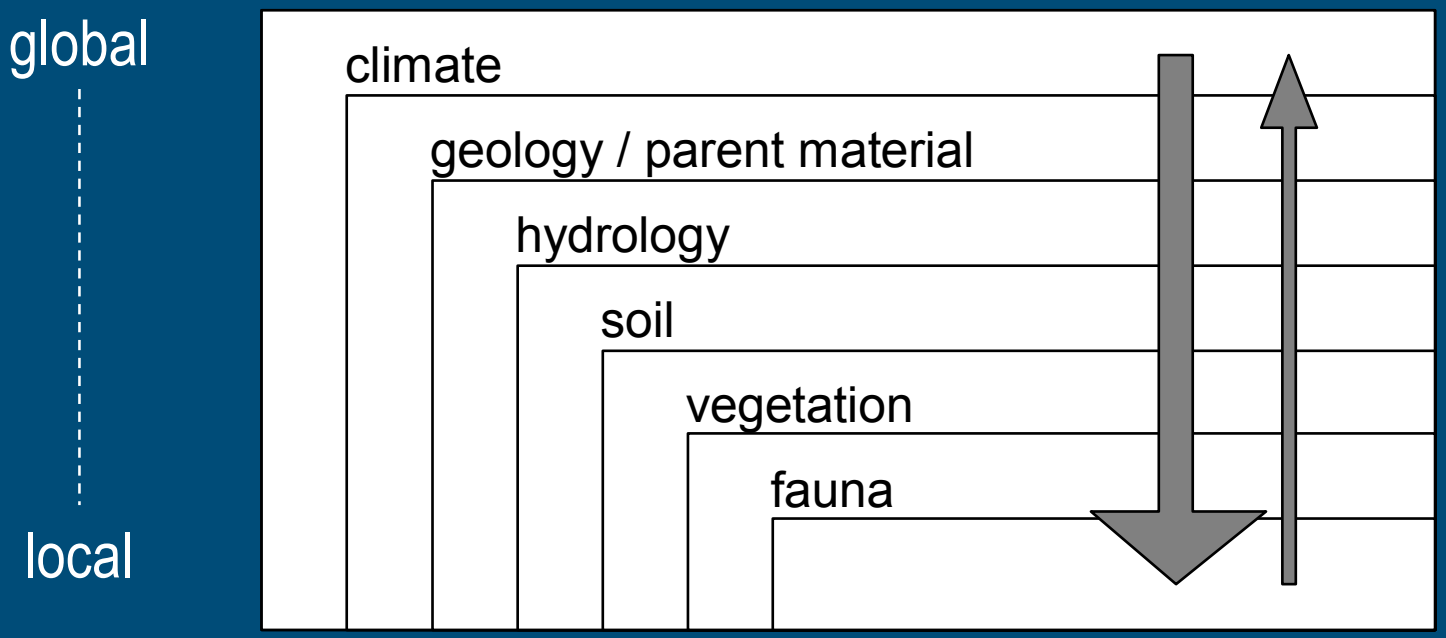
WAGENINGEN UR
For quality of life

Wood production (m3 /year)

Requirements

- Standardized scale, i.e. 0 – 1 range
- PI placed in their European environmental context
- Somehow the Adaptive Capacity needs to be quantified

Stratification of the European environment



(after Klijn, 1997)

reproducible and distinctive

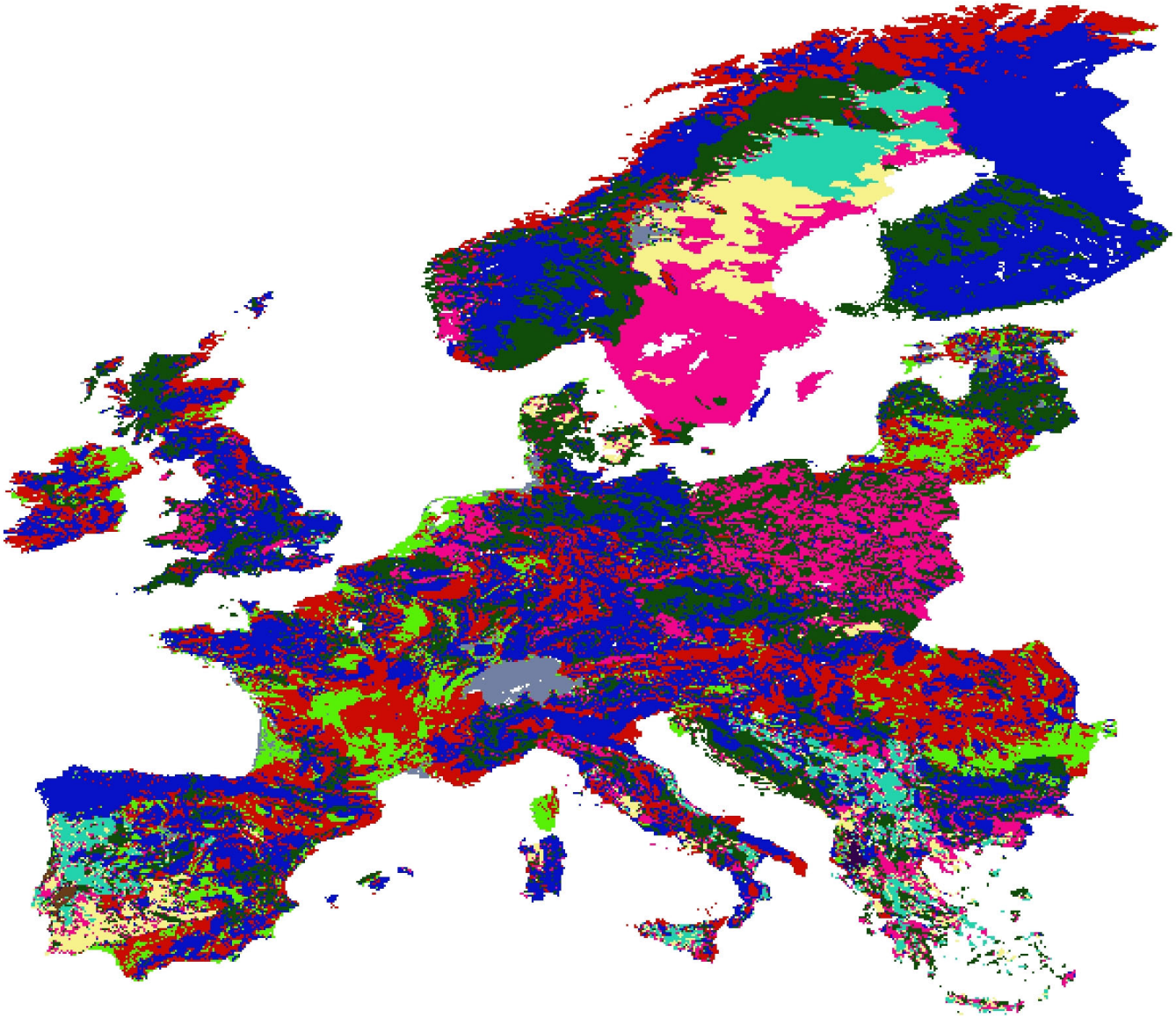
EEA biogeographical regions

WAGENINGEN UR
For quality of life

Potential Natural Vegetation (Bohn et al., 2000)

WAGENINGEN UR
For quality of life

ESB Soils



WAGENINGEN UR
For quality of life

ESB Soils

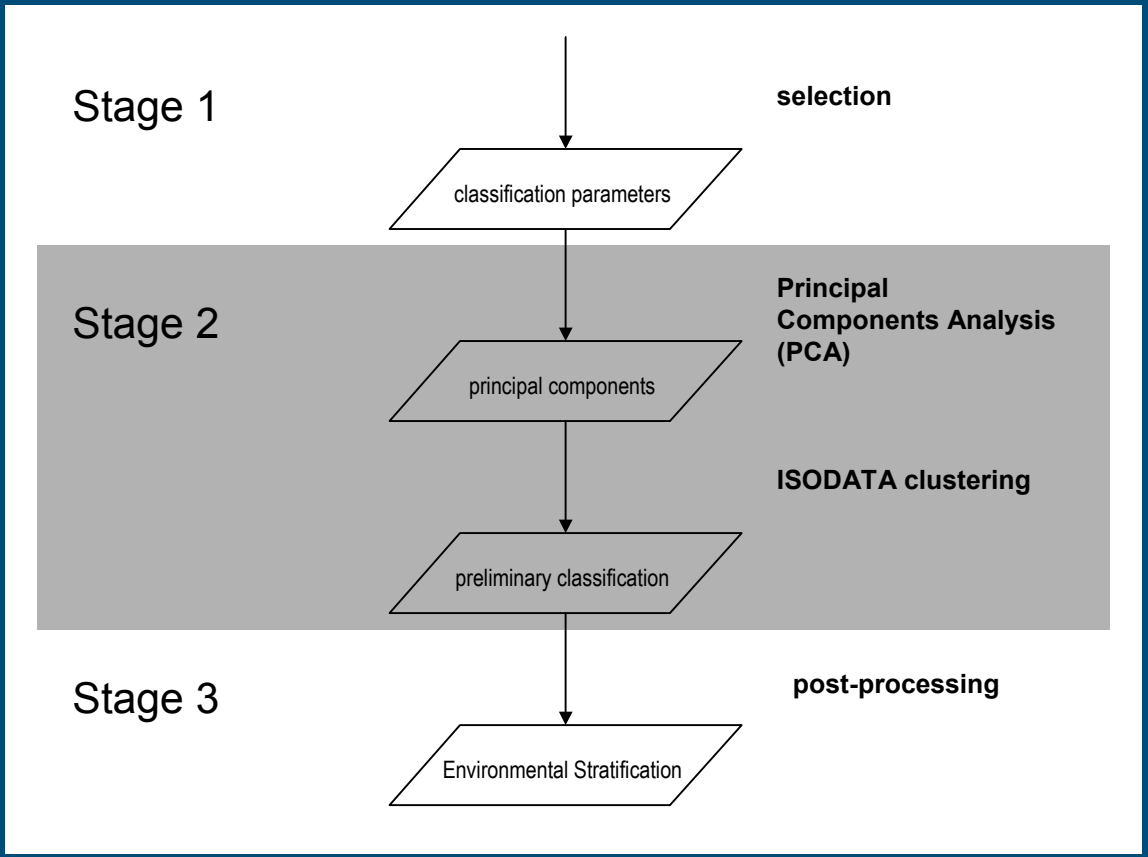
WAGENINGEN UR
For quality of life

There are existing stratifications

… these form a useful description, but

- Class divisions are not quantified
- Are not easily related to global change scenarios
- Distinguish too many or too few classes

Statistical stratification for Europe

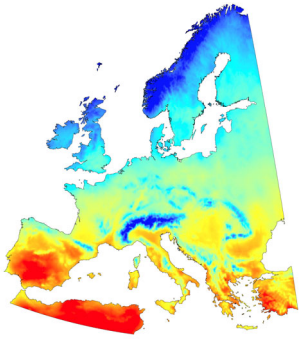


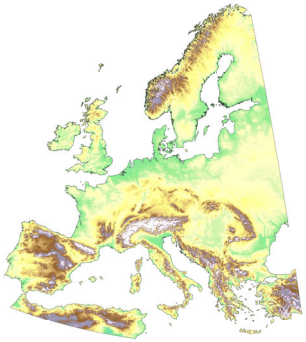
climate
- minimum temperature
- maximum temperature
- precipitation
- sunshine

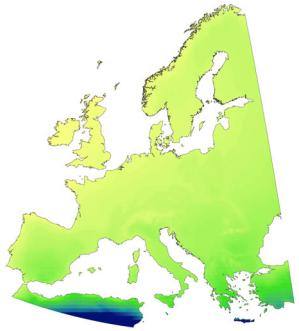
geomorphology
(substitutes)
- altitude
- slope

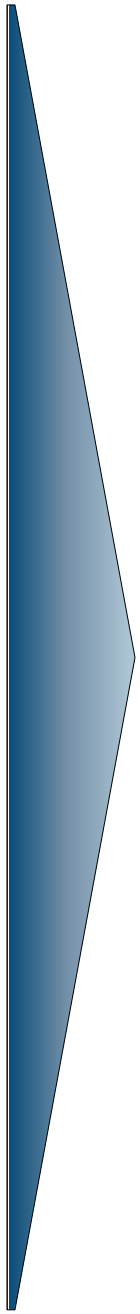
oceanicity
- annual temperature range divided by latitude

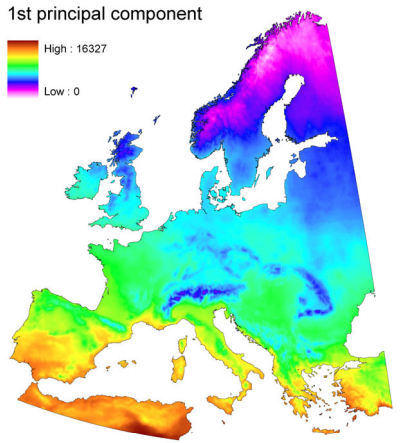
northing
- latitude

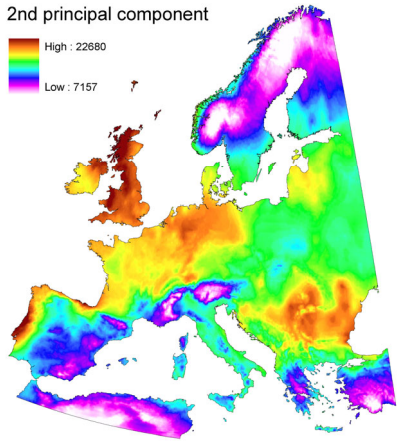


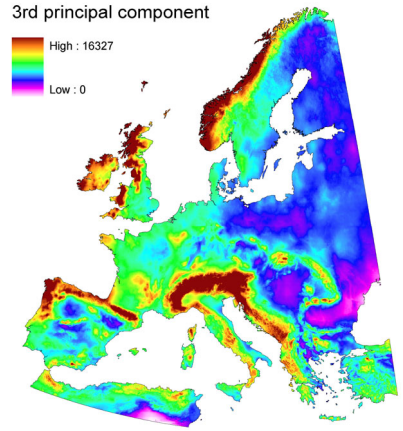








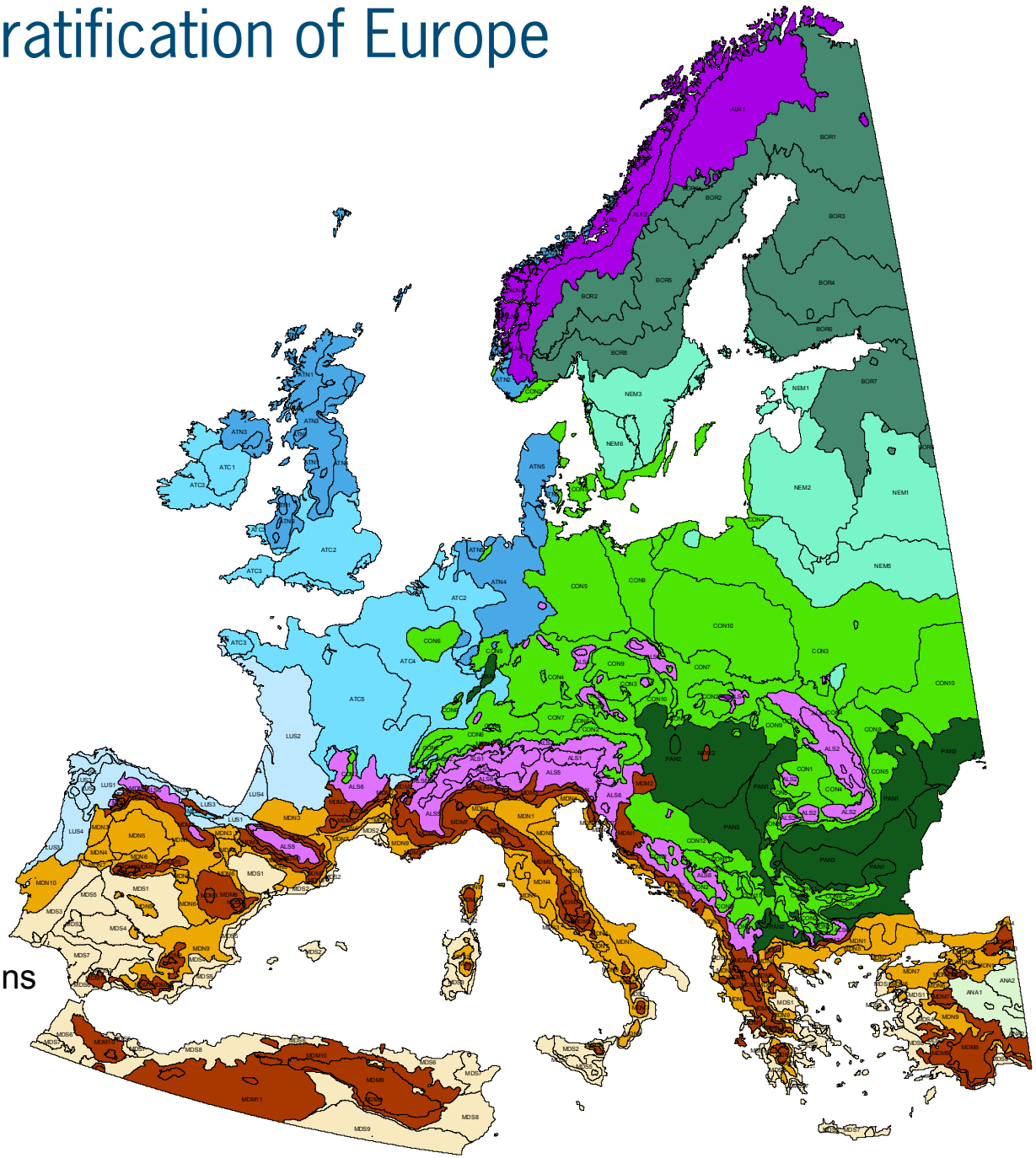




The Environmental Stratification of Europe

Environmental Zone

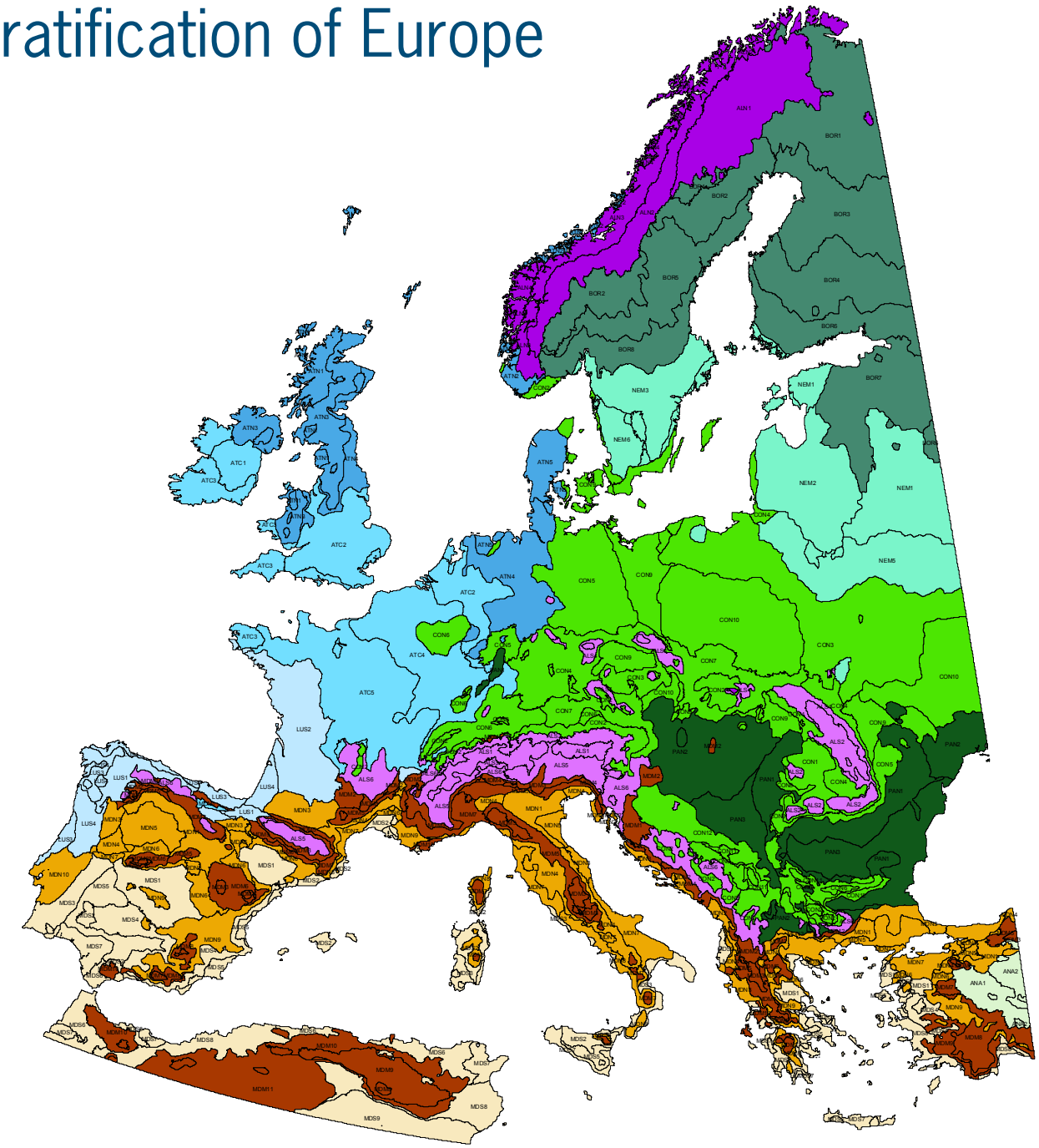
- ALN - Alpine North
- BOR - Boreal
- NEM - Nemoral
- ATN - Atlantic North
- ALS - Alpine South
- CON - Continental
- ATC - Atlantic Central
- PAN - Pannonian
- LUS - Lusitanian
- ANA - Anatolian
- MDM - Mediterranean Mountains
- MDN - Mediterranean North
- MDS - Mediterranean South



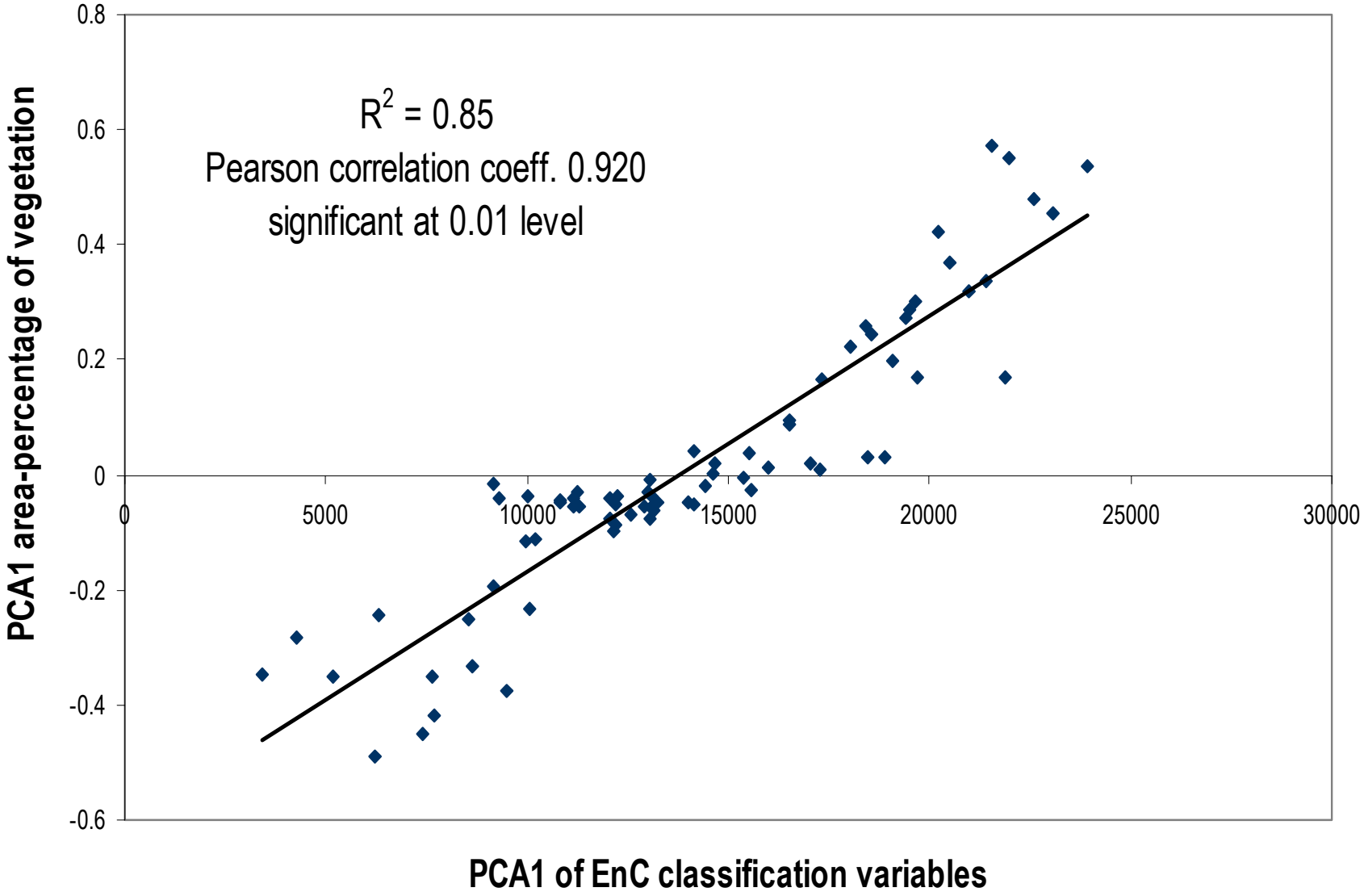
The Environmental Stratification of Europe

- statistically derived
- explicit classes
- 1km^2 resolution
- 84 classes
- 3 aggregation levels

- core classification
- easily adapted to user's need



Potential Natural Vegetation

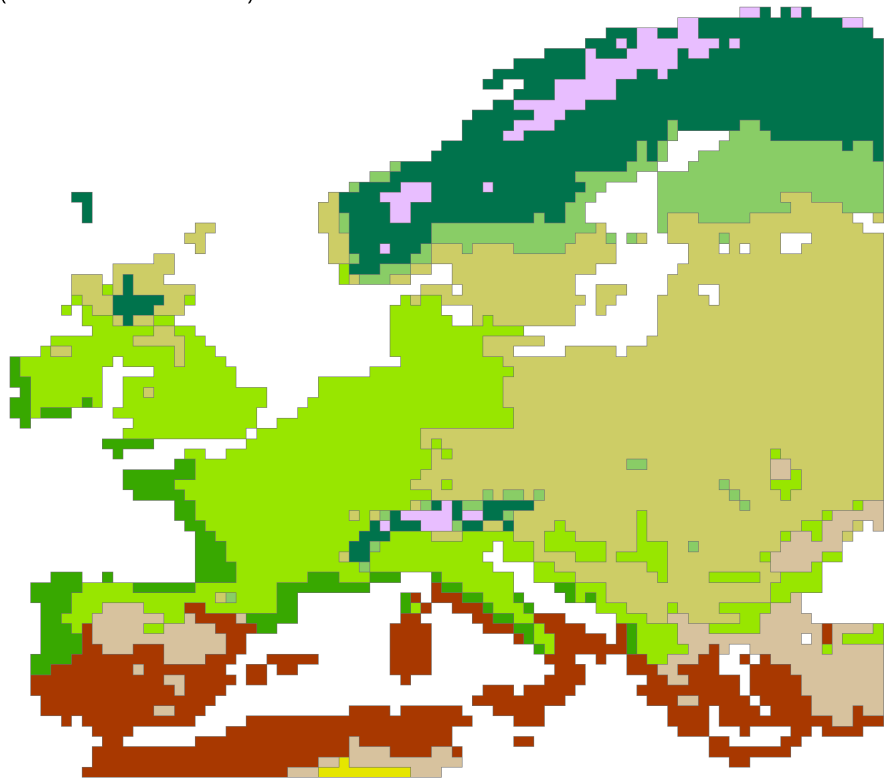


WAGENINGEN UR
For quality of life

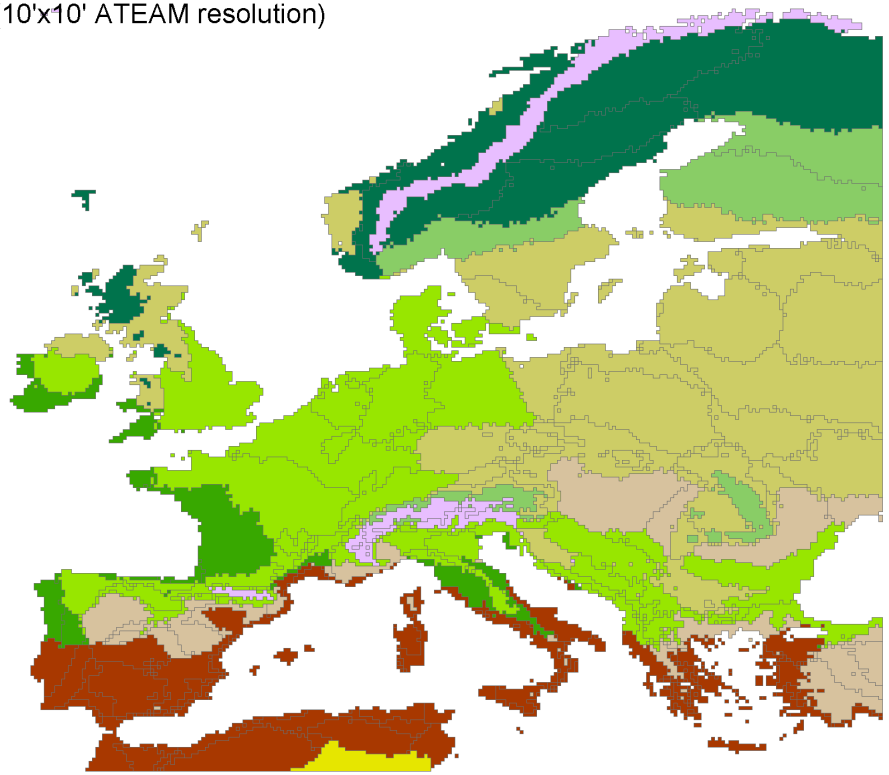
European Biomes

as defined by IMAGE

IMAGE 2.2, 1990
(0.5°x0.5° resolution)



Environmental Classification of Europe
84 classes aggregated
(10'x10' ATEAM resolution)



Kappa statistic for whole map: 0.719

Strength of agreement (Monserud & Leemans, 1992)

Kappa	strength of agreement
0-40 - 0.55	fair
0.55 - 0.70	good
0.70 - 0.85	very good
> 0.85	excellent

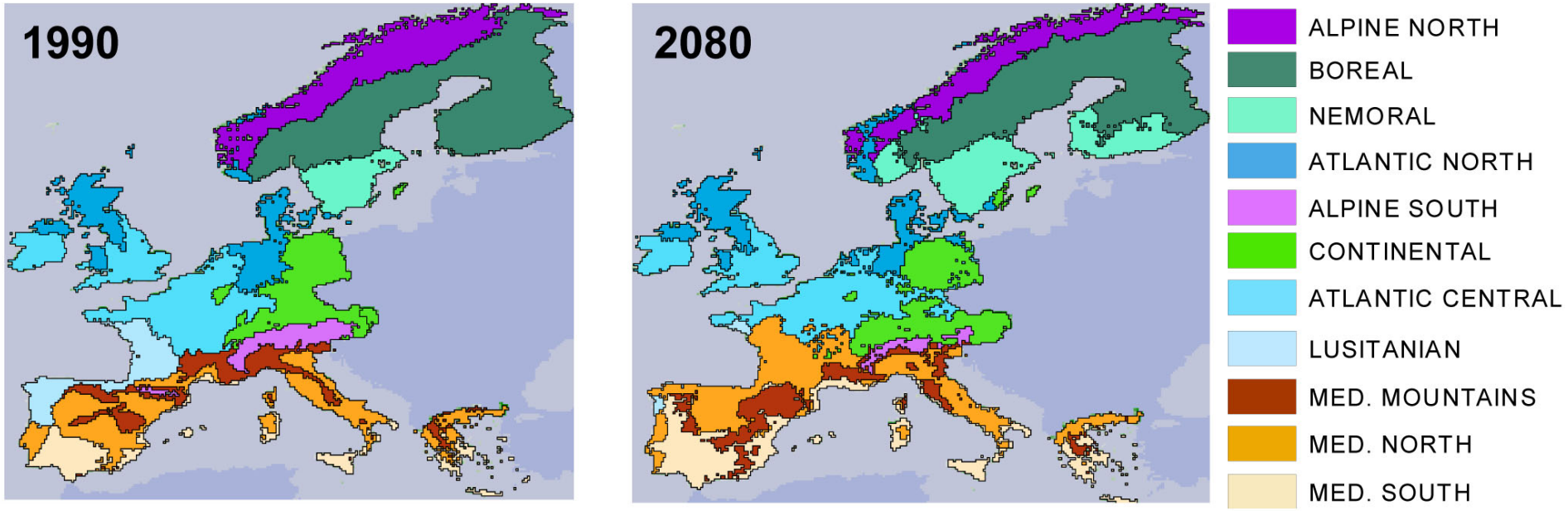
Legend with Kappa statistics per biome

0.406 alpine (tundra / wooded tundra)	0.770 temp. mixed forest	0.481 grassland / steppe
0.753 boreal forest	0.719 temp. decidious forest	0.587 hot desert
0.694 cool conifer	0.493 warm mixed forest	0.888 scrubland

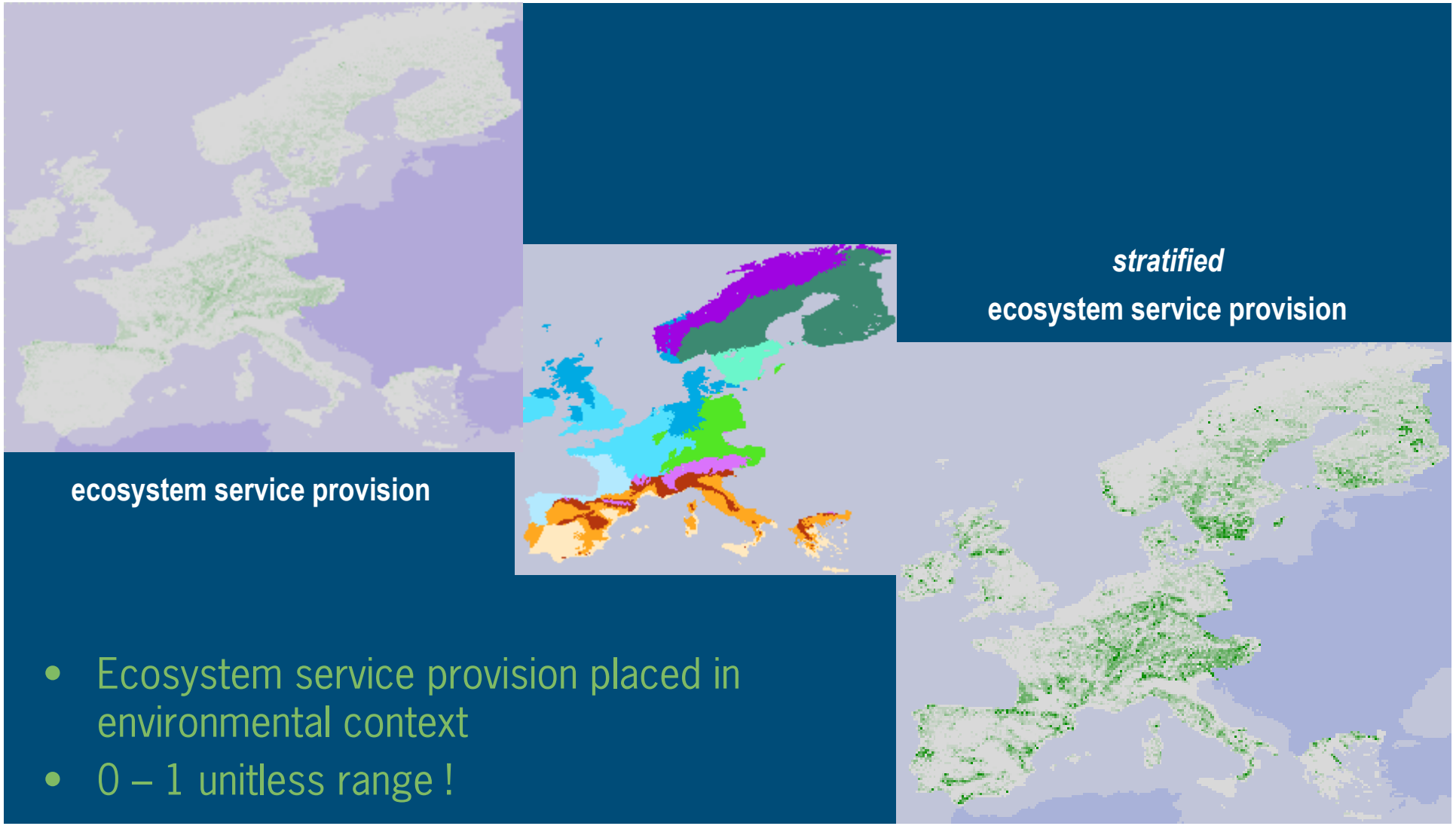
WAGENINGEN UR
For quality of life

Shifting environments

GCM HadCM3
Scenario A1 – global economic



Stratifying ATEAM maps



- Ecosystem service provision placed in environmental context
- 0 – 1 unitless range !

WAGENINGEN UR
For quality of life

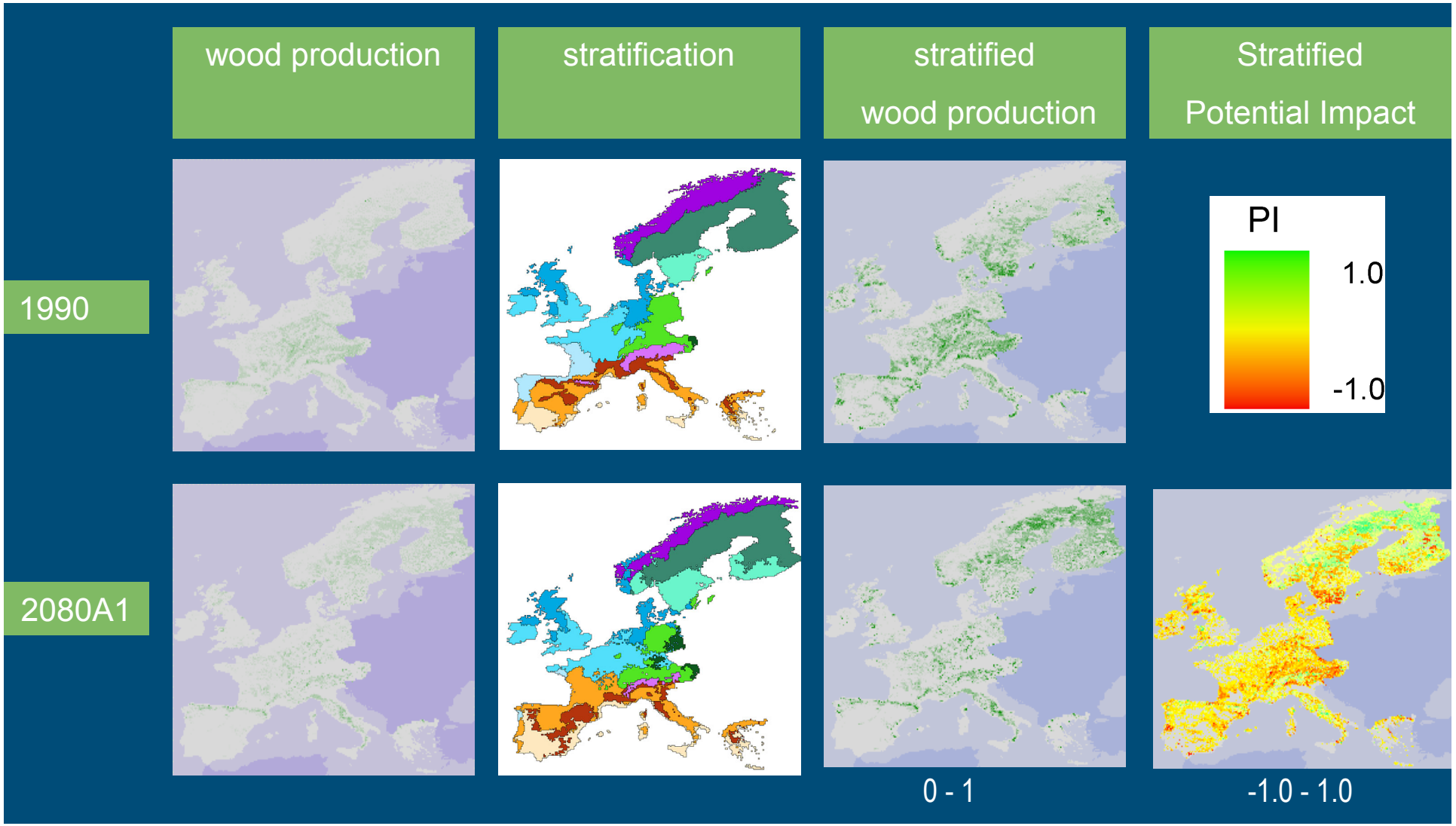
Wood production

Potential Impact

‘impacts that may occur in a grid cell given projected environmental change, without considering adaptation’ (based on IPCC TAR)

	environment 1				environment 2			
	grid cell A		grid cell B		grid cell C		grid cell D	
	present	future	present	future	present	future	present	future
Value in grid cell	3	2.4	1	0.8	8	6.4	5	4
Absolute change	**0.6**		**0.2**		**1.6**		**1**	
Relative change	**-20%**		**-20%**		**-20%**		**-20%**	
Highest ecosystem service value (ESref)	3	2.7	3	2.7	8	8.8	8	8.8
Stratified ES supply	1	0.9	0.3	0.3	1	0.7	0.6	0.5
Stratified Potential Impact	**-0.1**		**0**		**-0.3**		**-0.1**	

Stratified Potential Impact

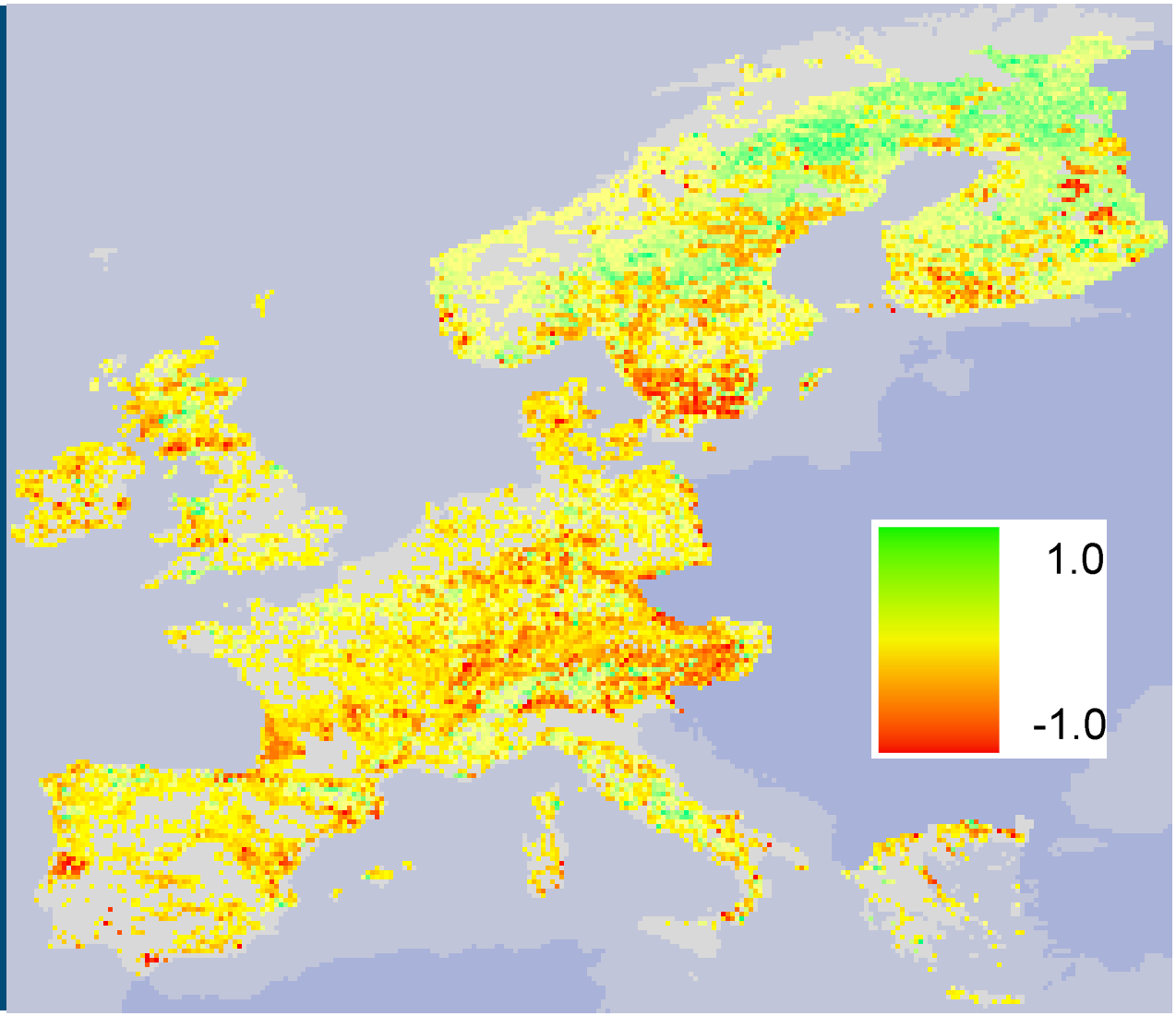


WAGENINGEN UR
For quality of life

Change in stratified Potential Impact

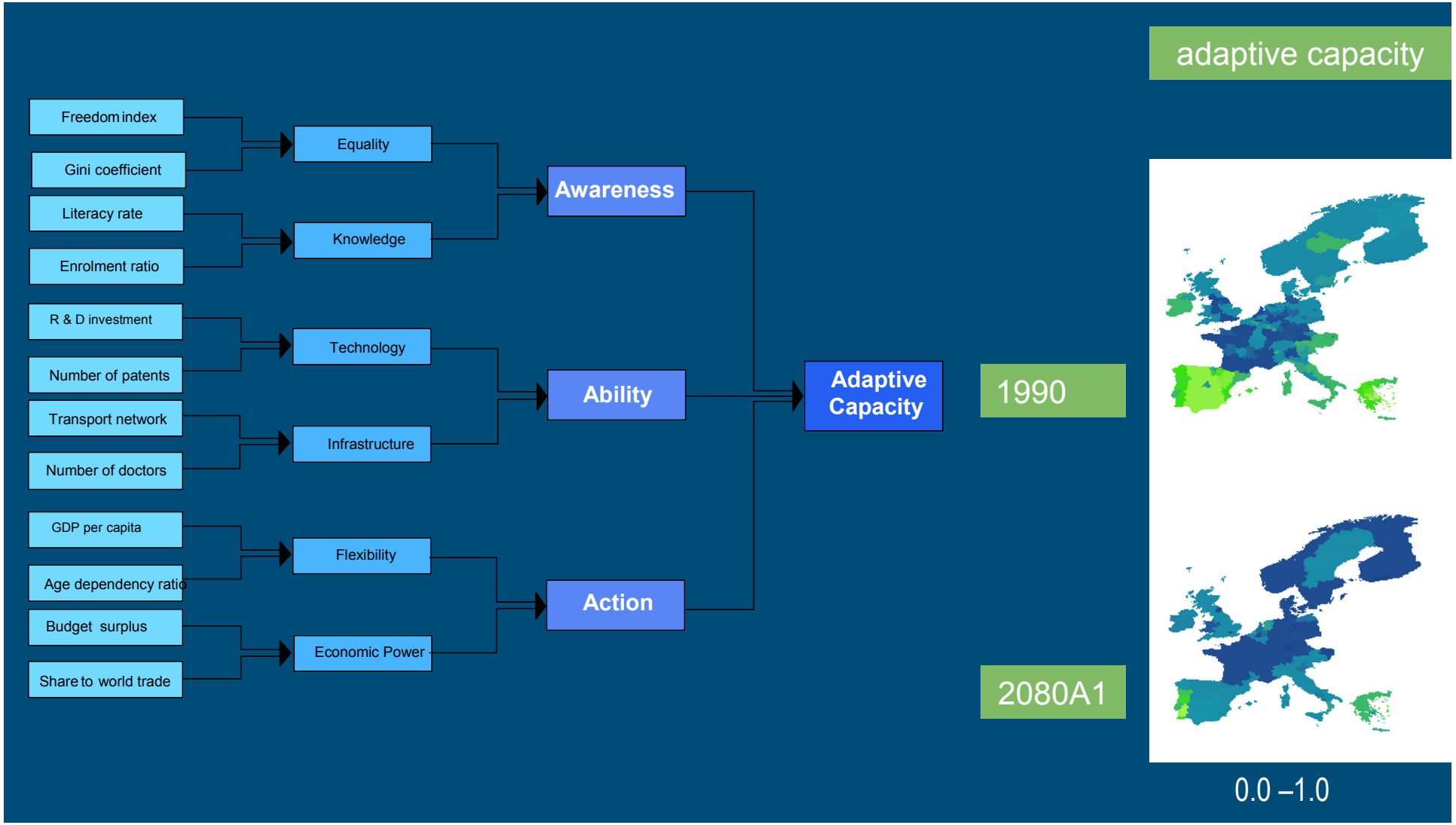
Stratified change

Places changes in environmental context



WAGENINGEN UR
For quality of life

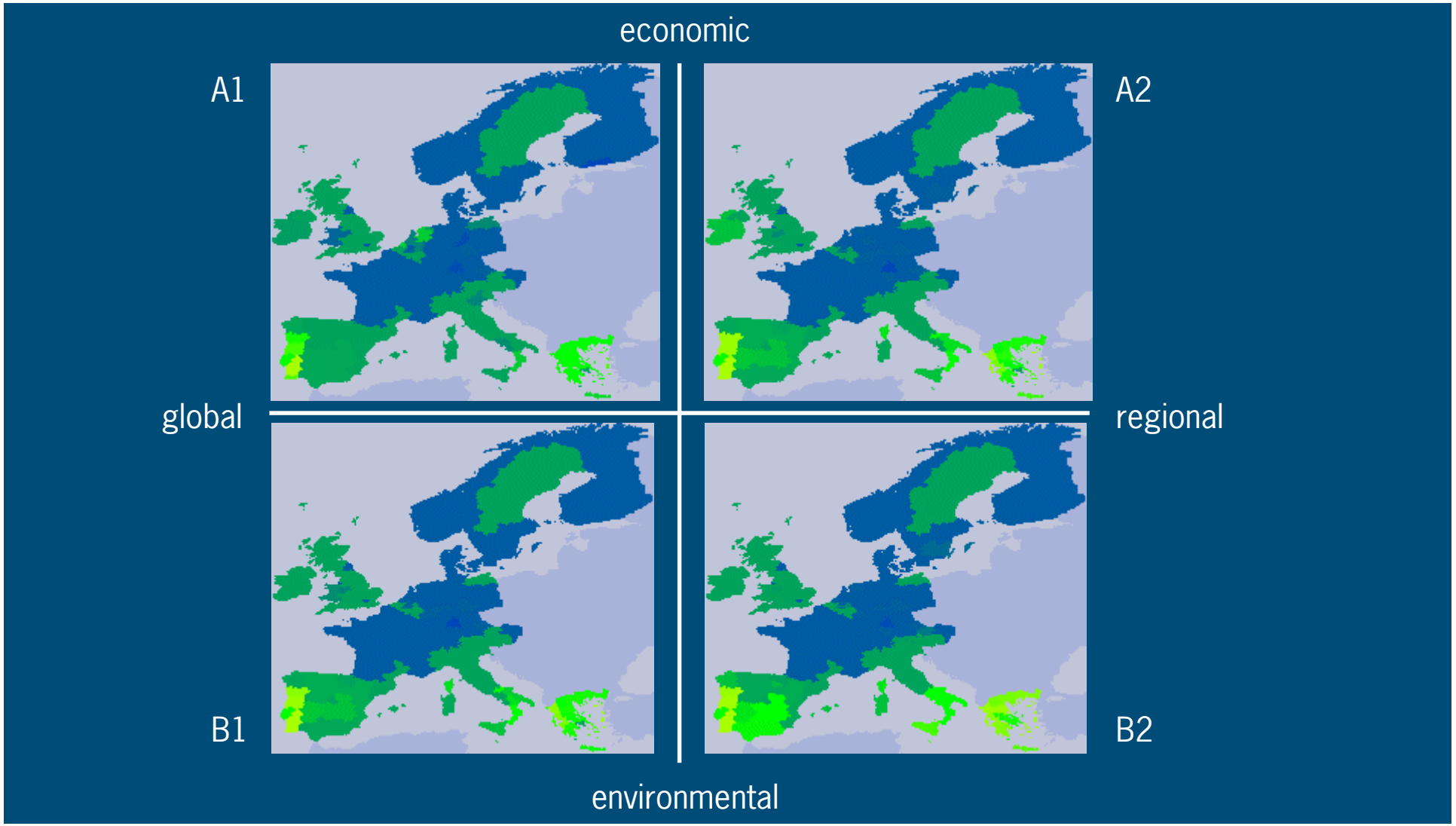
Adaptive Capacity



WAGENINGEN UR
For quality of life

(Klein et al., in prep.)

Adaptive Capacity 2080



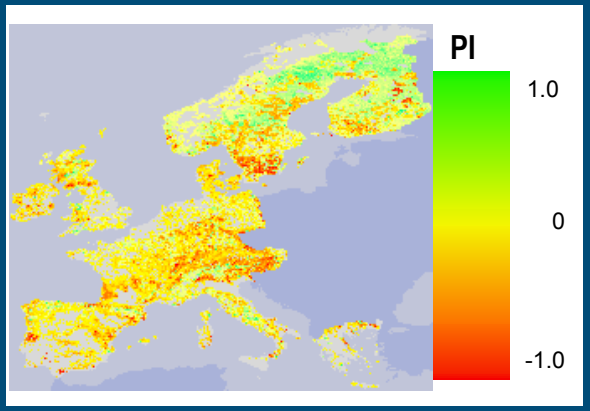
WAGENINGEN UR
For quality of life

Vulnerability

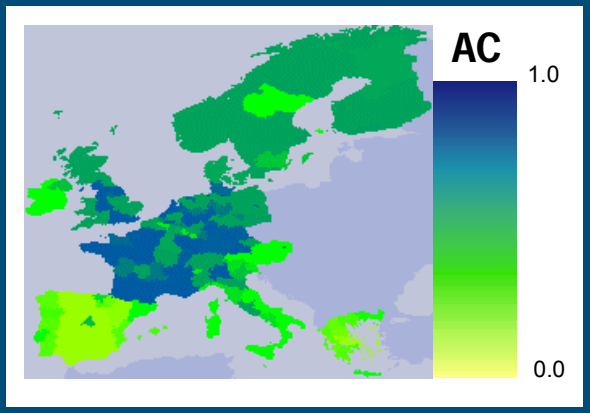
2080A1

wood production

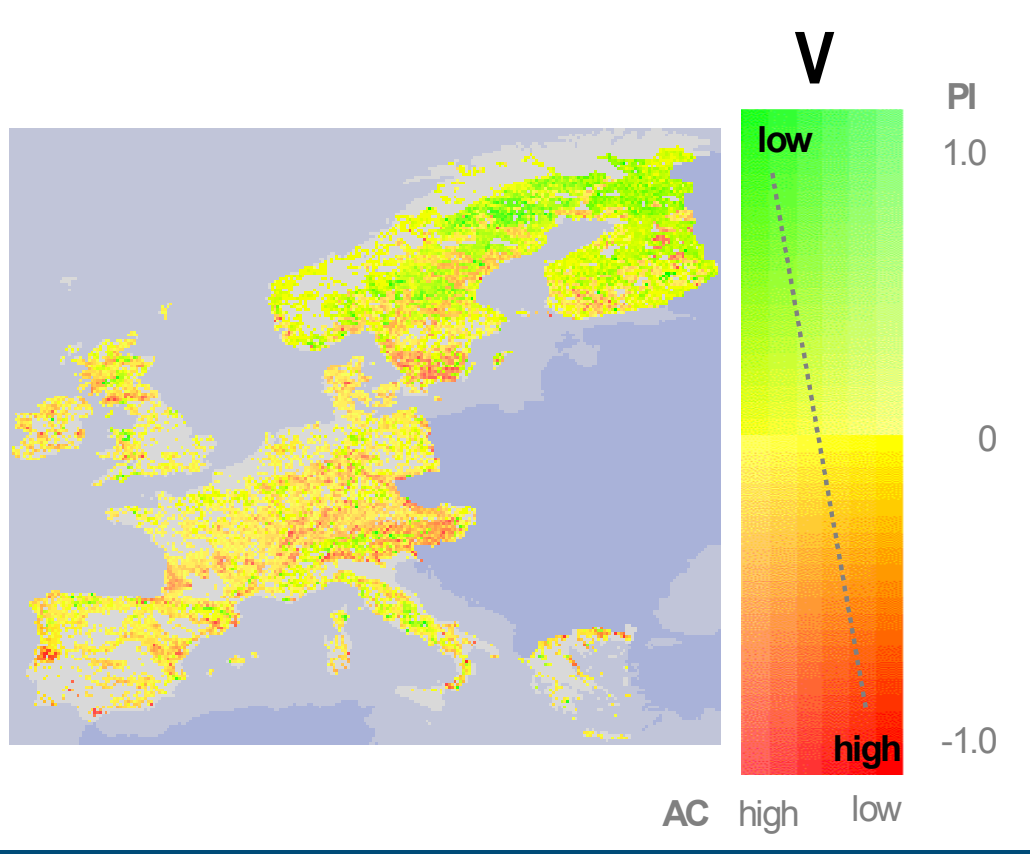
potential impact



adaptive capacity

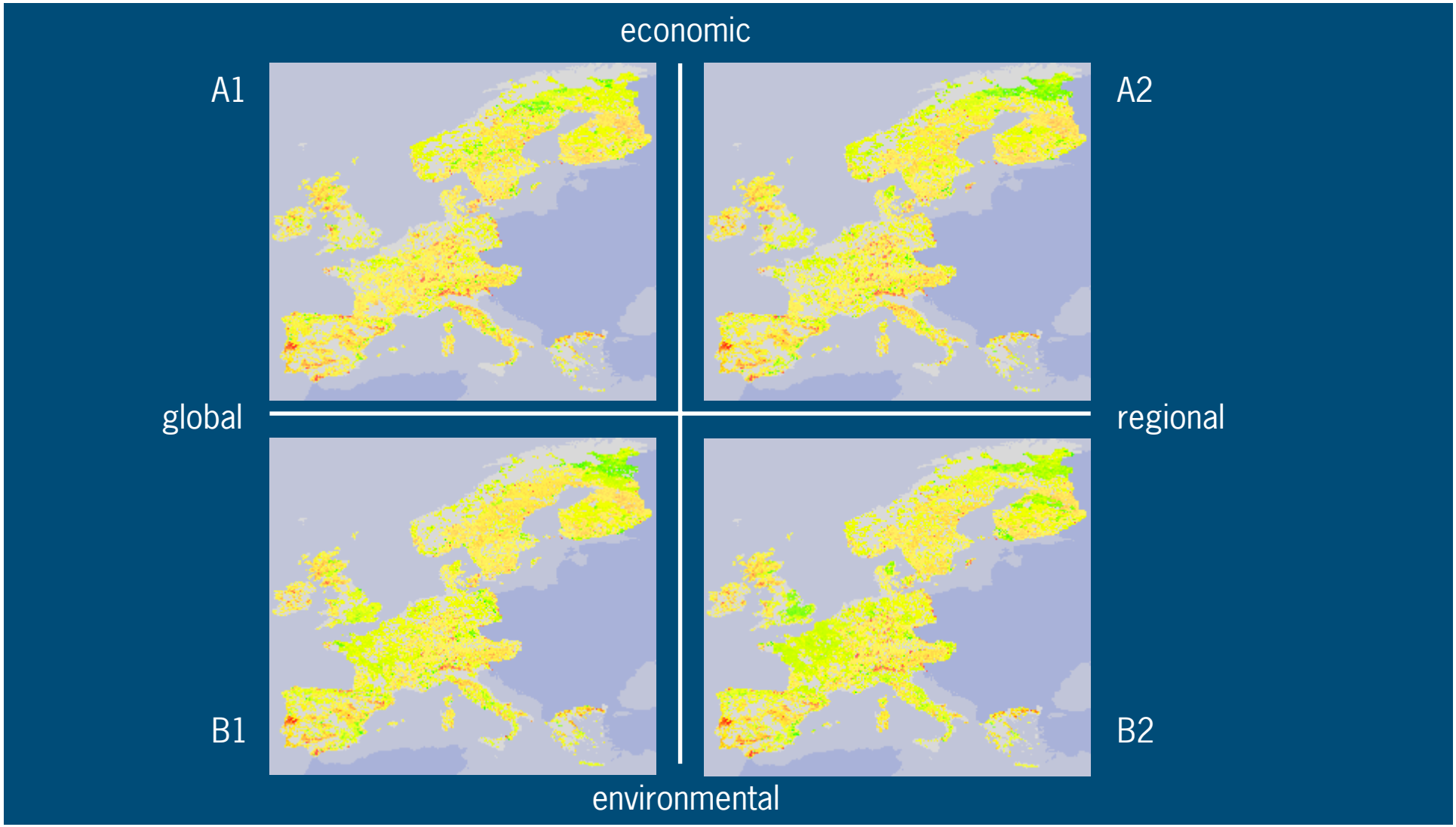


vulnerability

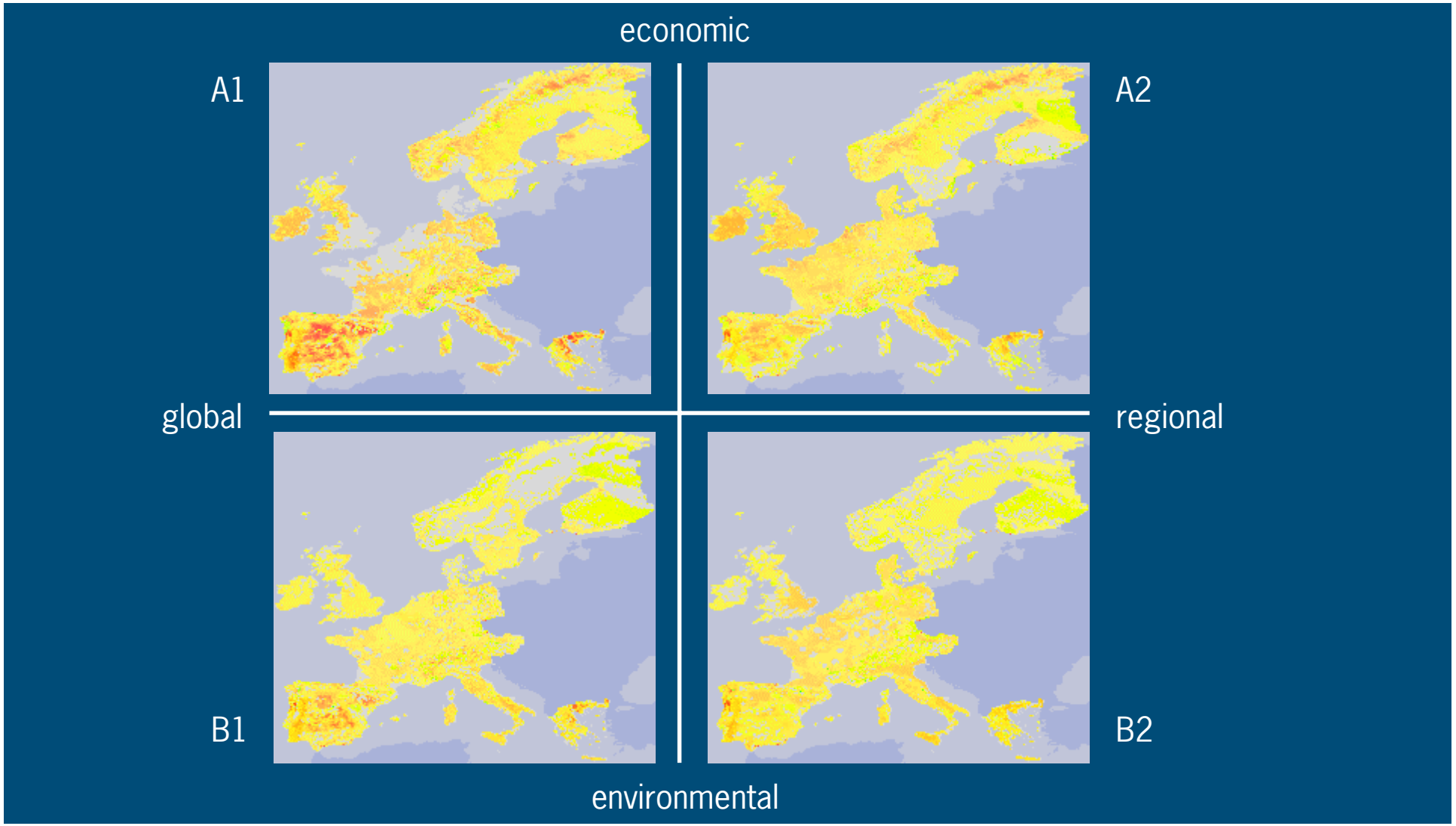


WAGENINGEN UR
For quality of life

Wood production 2080

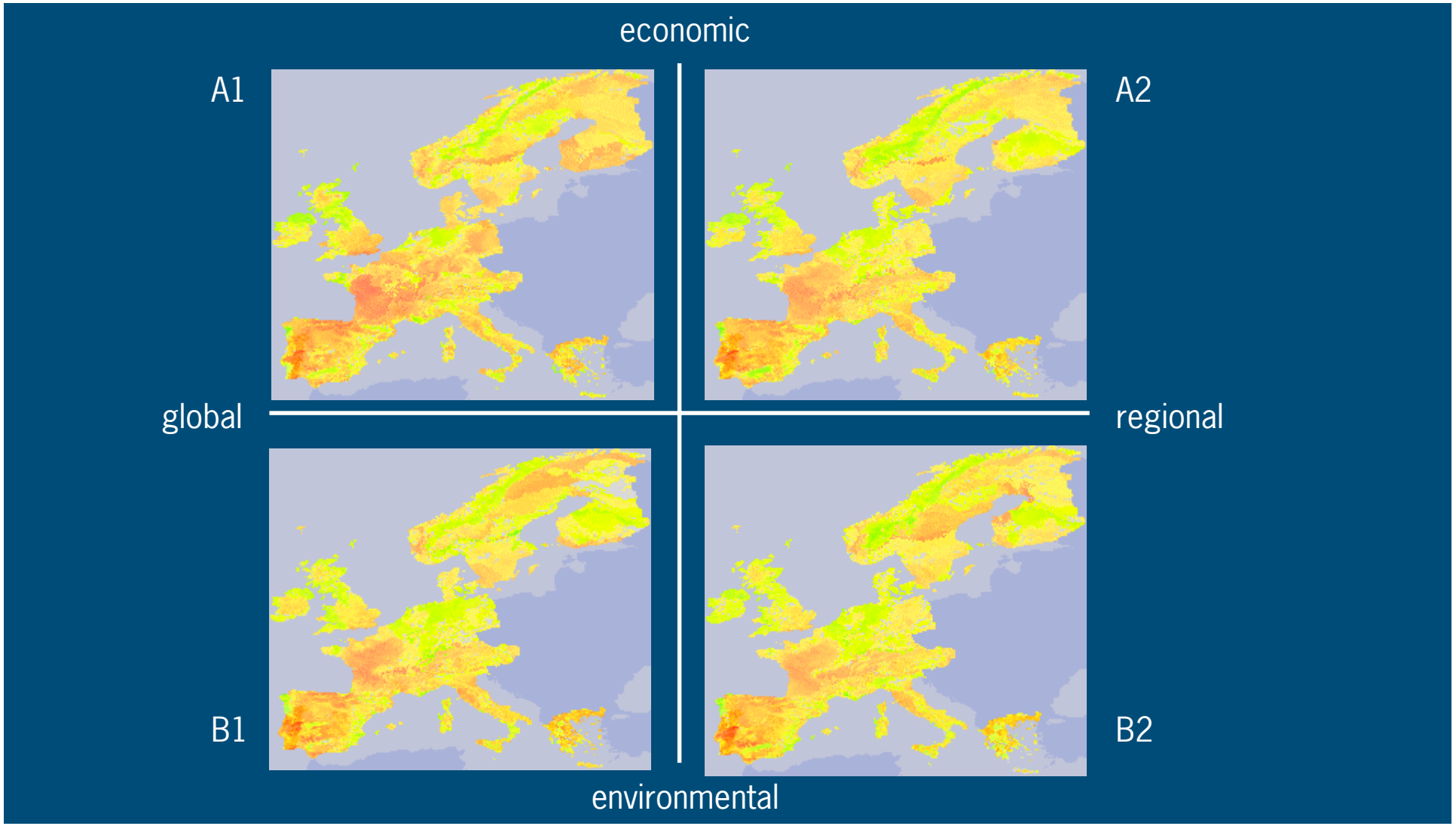


Farmer livelihood 2080



WAGENINGEN UR
For quality of life

Biodiversity trees 2080



WAGENINGEN UR
For quality of life

But how analyze these maps??

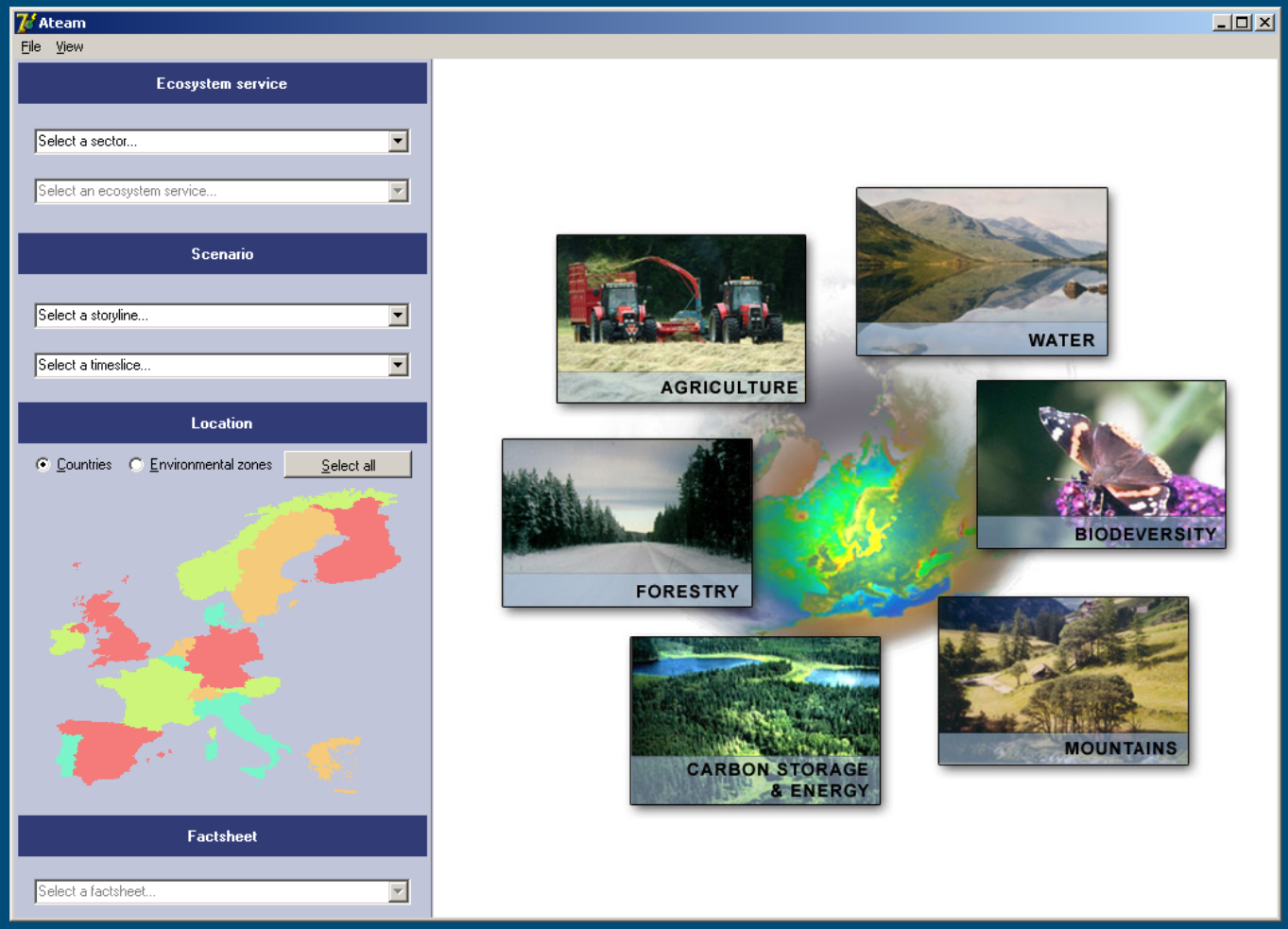
- 30.000 pixels
- 7 scenarios x 3 time slices + baseline
- 20 ecosystem services
- Service provision, PI, PIstr, AC, V

→ About 2500 maps

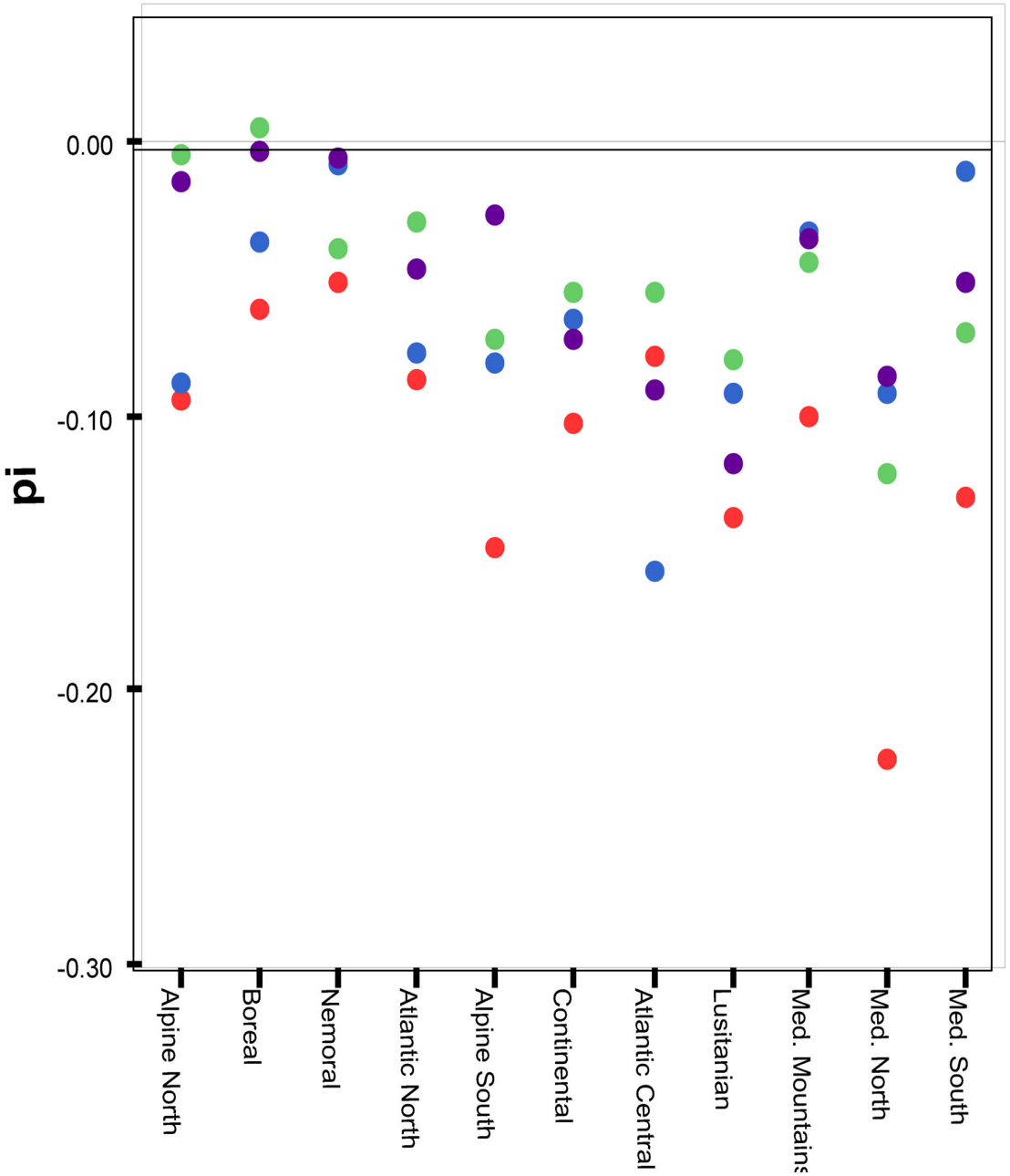
- Climate, land use, socio economics

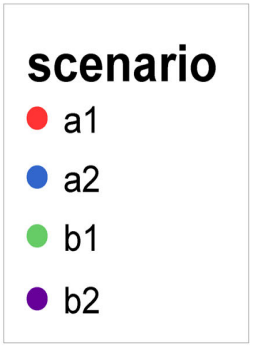
→ Another 700 maps

Further analysis possible in ATEAM tool



Some results





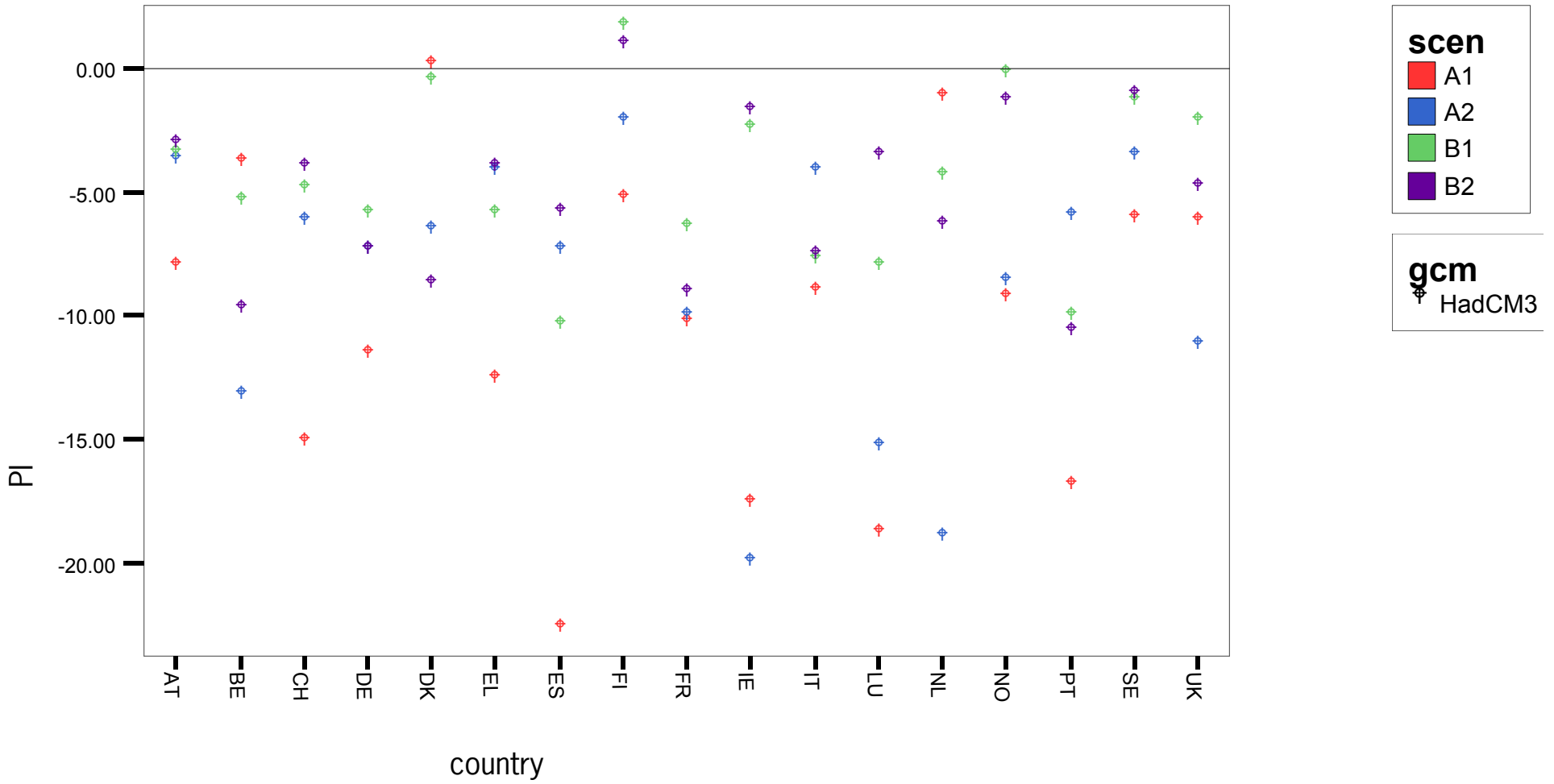
farmer livelihood

2080A1

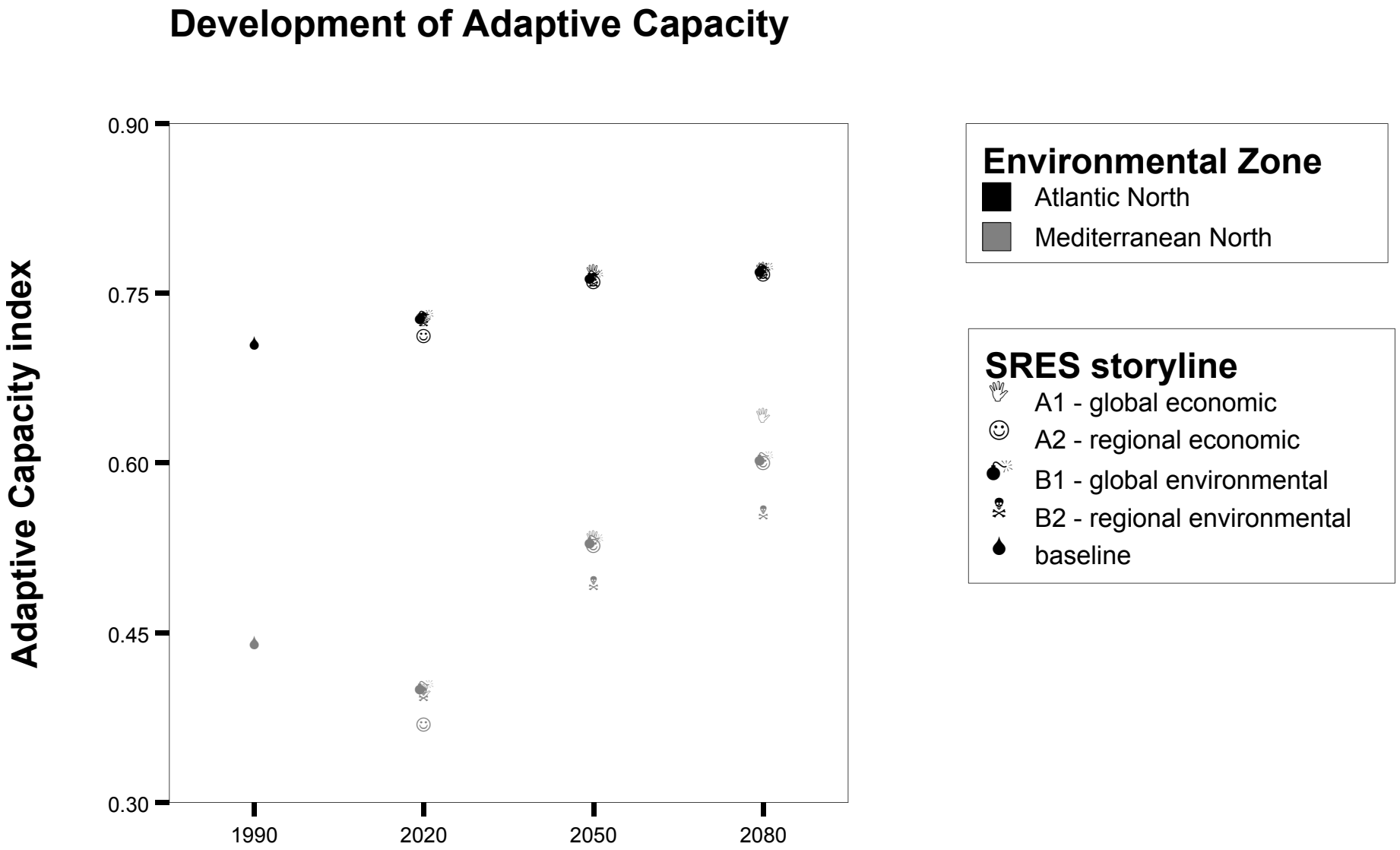
Some results

2080A1

farmer livelihood

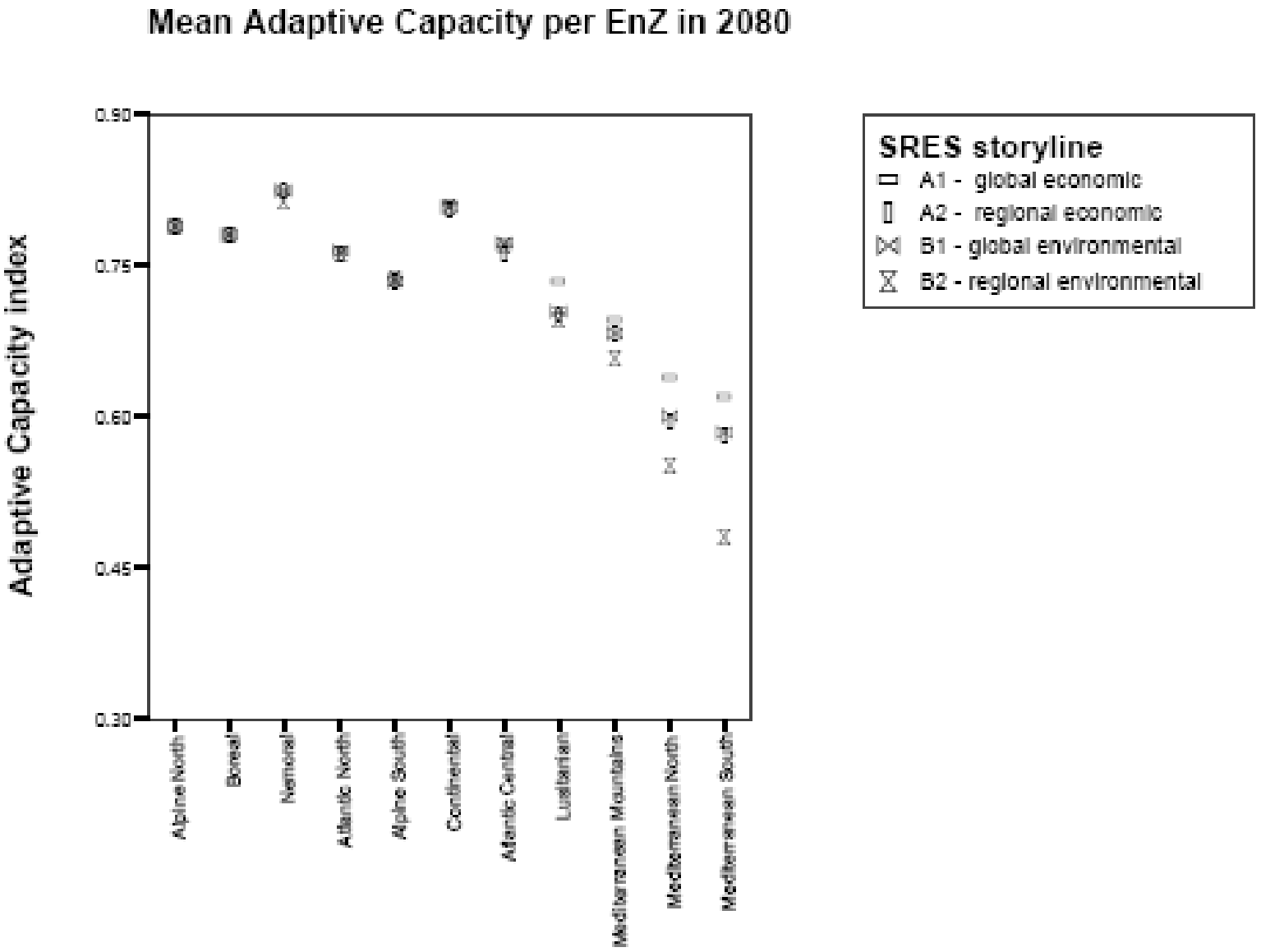


Some results…



WAGENINGEN UR
For quality of life

Some results…



WAGENINGEN UR
For quality of life

Some conclusions

- There is large heterogeneitiy in vulnerability
  - between regions
  - between ecosystem services
  - between scenarios
- The Mediterranean region is most vulnerable
- NW European countries are least vulnerable
- Agriculture and nature conservation sectors most vulnerable
- Dicotomy between AC and PI in scenarios

Discussion of approach

- Increased uncertainty
- Limited knowledge adaptive capacity
- Difficult to relate to regional situation
- Confrims existing knowledge, detailed analysis possible
- Stimulates discussion…