CLIMRISK:

Integrated Assessment Model for Physical Risks

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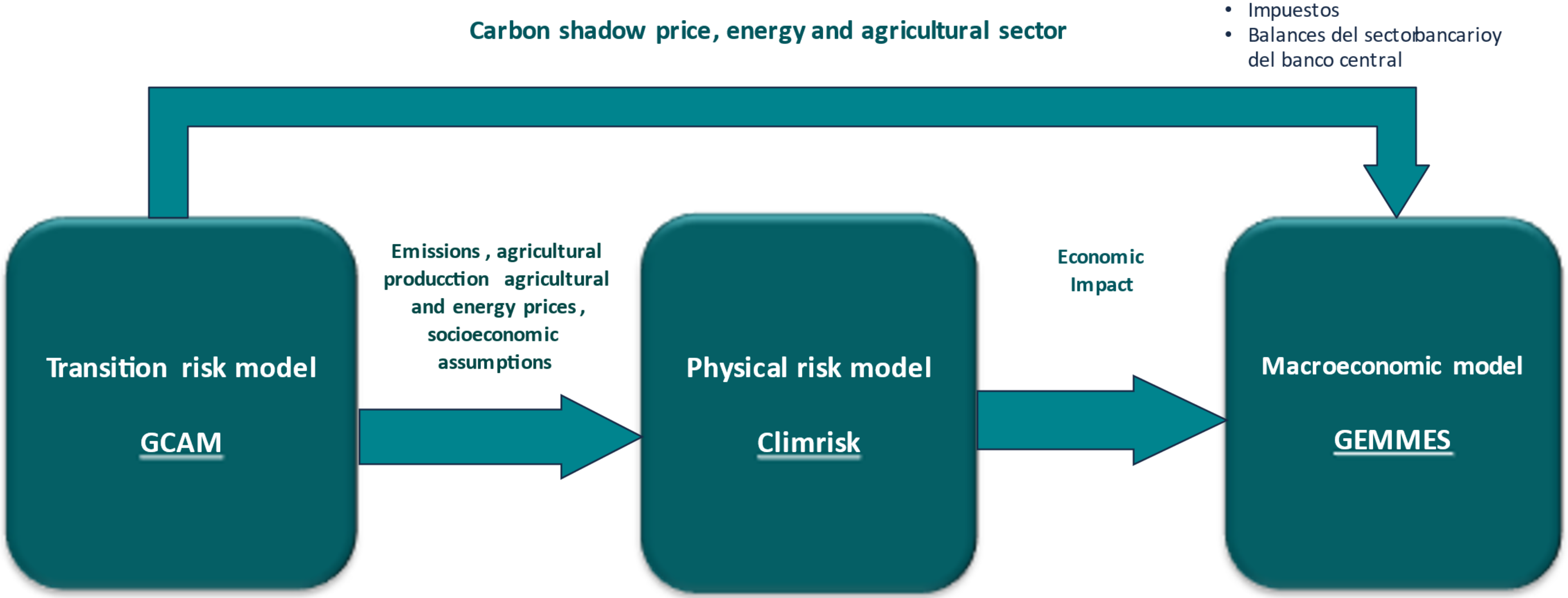
PINCC Programa de Investigación en Cambio Climático

IVM Institute for Environmental Studies

VU

Model suite

Calibration :
- Sistema de cuentas nacionales
- Balanza de pagos
- Remesas
- Impuestos
- Balances del sector bancario y del banco central



Output: Emisiones GEI por sector económico, precio sombra del carbono, producción y consumo de 9 energías, generación de electricidad por tecnología, costos y precios, servicios de transporte, energía utilizada por tecnología de transporte y combustible utilizado, uso de la tierra (ejem. biomasa, cereales, bosque), extracción y consumo de agua por sector y por cuenca hidrográfica, precios de agua and costos de agua por cuenca, entre otras.

Output: La vulnerabilidad, los impactos y los riesgos con una resolución espacial de unos 50km x 50km para todo el mundo. Combinando escenarios probabilísticos de cambio climático global con el calentamiento local en zonas urbanas producido por la **UHI** para generar estimaciones de los impactos económicos del cambio climático y medidas de riesgo dinámicas uni y multivariadas .

Output: Variables macroeconómicas, como reservas, tipos de cambio nominales/reales, cotizaciones sociales, prestaciones, deuda de los hogares, déficit y deuda pública, PIB, balanza de cuenta corriente, posición de reserva bruta/neta en divisas, inversión internacional, desempleo, entre otras.

CLIMRISK:

Integrated Assessment Model for Physical Risks

Comprehensive and flexible model

Transform data into actionable information to support decision-making

Equipped to emulate/incorporate process-based models and other climate-economy IAMs

Expands economic IAMs used for climate change assessments

Spatial resolution for better representation of exposure, sensitivity, hazard and risk

Improved, updated and extended damage functions

Local climate change and impacts (UHI in cities)

Uni- and multivariate dynamic risk measures to give a more complete picture of the problem

Uncertainty and risk perspective

Explore uncertainty in socioeconomic scenarios

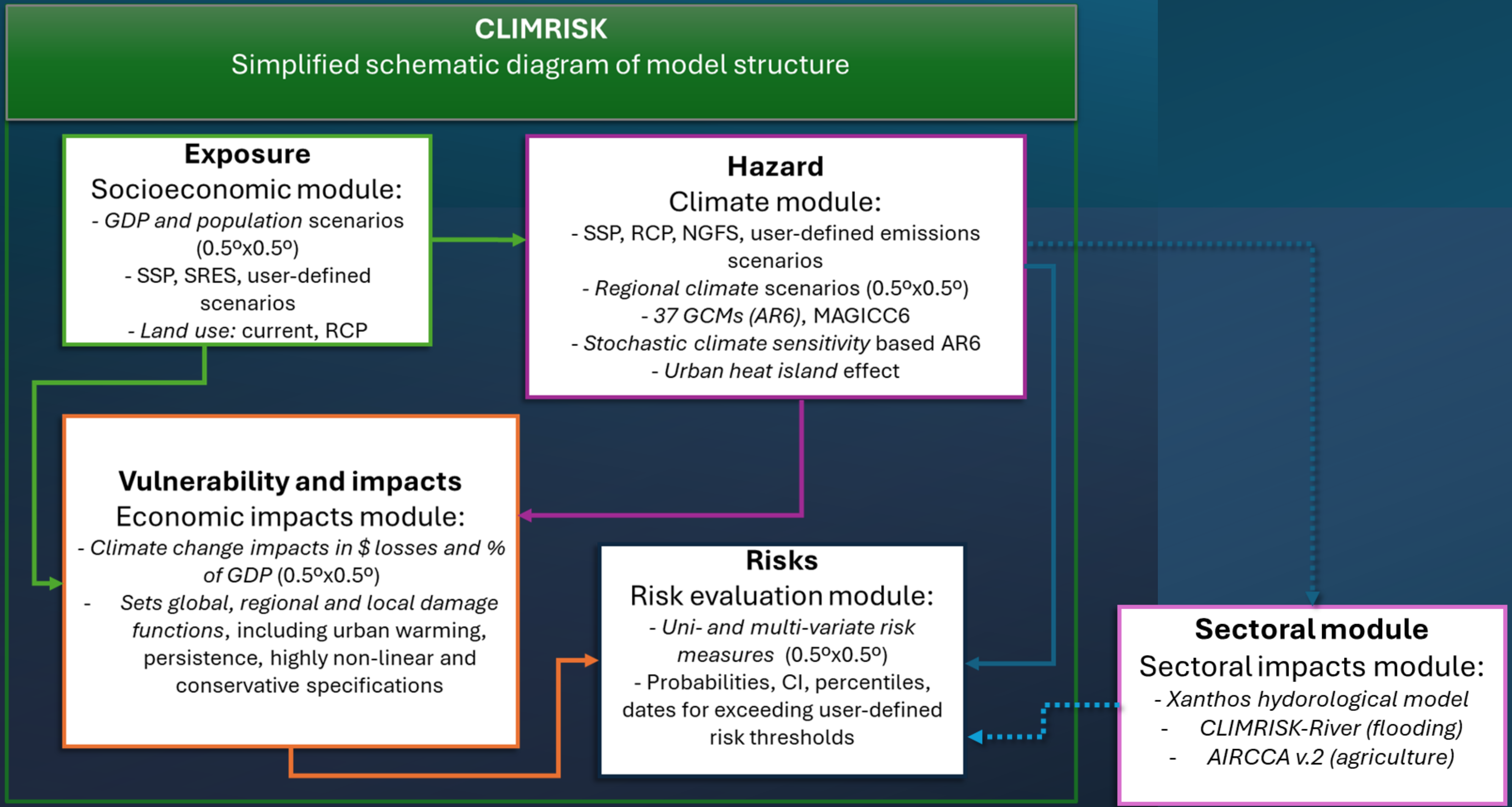
Probabilistic climate scenarios

Contrasting damage functions

Communicating risk

Tailor-made assessments

User defined risk measures, climate and impact metrics, and emissions scenarios


CLIMRISK
Simplified schematic diagram of model structure
Exposure
Socioeconomic module:
- GDP and population scenarios (0.5ºx0.5º)
- SSP, SRES, user-defined scenarios
- Land use: current, RCP
Hazard
Climate module:
- SSP, RCP, NGFS, user-defined emissions scenarios
- Regional climate scenarios (0.5ºx0.5º)
- 37 GCMs (AR6), MAGICC6
- Stochastic climate sensitivity based AR6
- Urban heat island effect
Vulnerability and impacts
Economic impacts module:
- Climate change impacts in $ losses and % of GDP (0.5ºx0.5º)
- Sets global, regional and local damage functions, including urban warming, persistence, highly non-linear and conservative specifications
Risks
Risk evaluation module:
- Uni- and multi-variate risk measures (0.5ºx0.5º)
- Probabilities, CI, percentiles, dates for exceeding user-defined risk thresholds
Sectoral module
Sectoral impacts module:
- Xanthos hydrological model
- CLIMRISK-River (flooding)
- AIRCCA v.2 (agriculture)

Spatially explicit.

- Quantifications of exposure, hazard, vulnerability and impacts, and user-defined risk indices in a global grid of 0.5ºx0.5º.

Comprehensive damage functions.

- Variety of damage functions that incorporate aspects such as local climate change in cities, the persistence of economic impacts, and catastrophic climate change. It has a unique upscaling/downscaling approach.

Urban heat island (UHI) effect.

- CLIMRISK is the only IAM that simulates the local warming produced by the UHI and that includes urban-specific damage functions.

Probabilistic global and regional climate projections.

- Emulates 37 Earth System Models included in CMIP6 for producing probabilistic regional changes in climate at annual and monthly frequencies.

Socioeconomic scenarios.

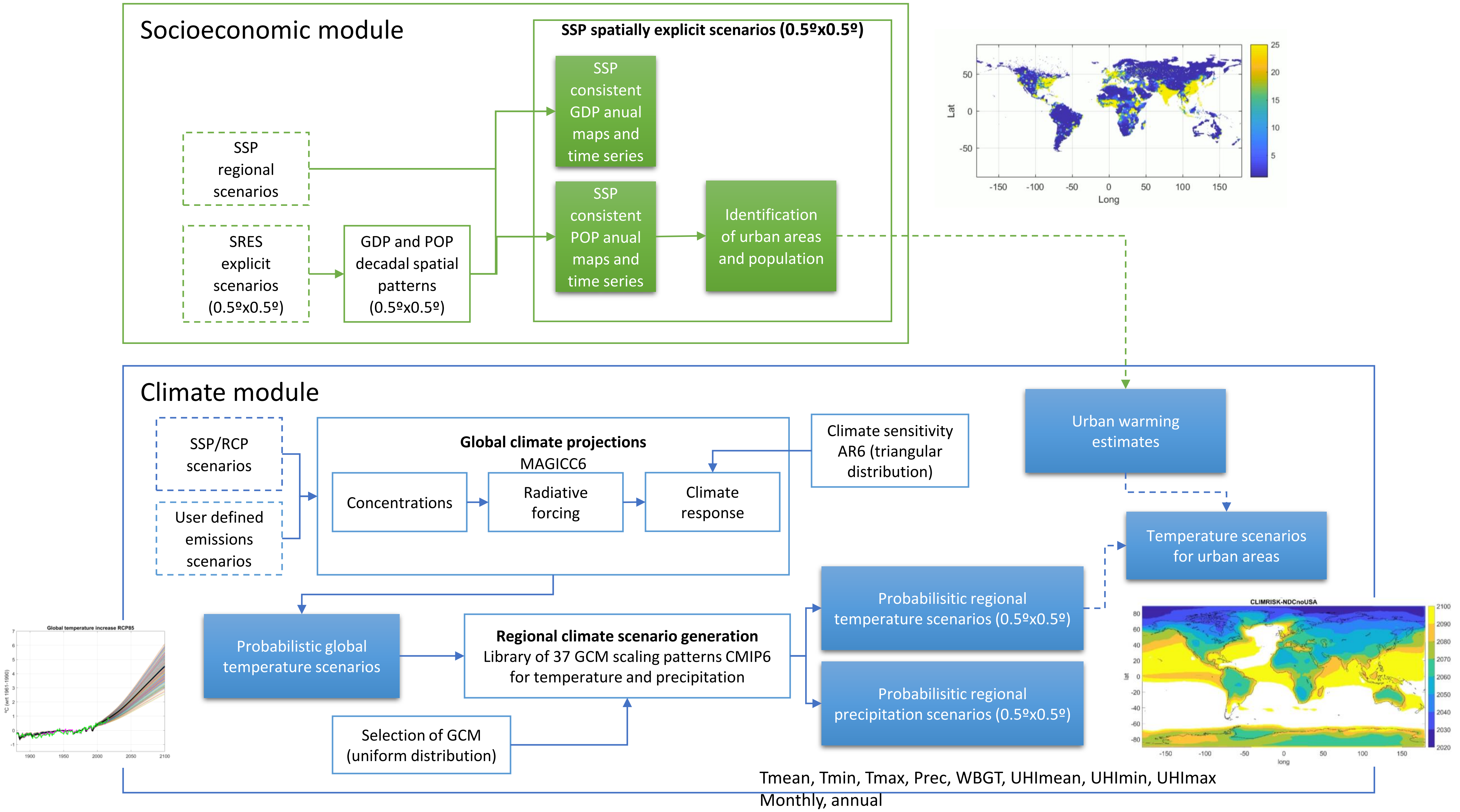
- Spatially explicit population and GDP scenarios for five Shared Socioeconomic Pathways (SSP) and three modeling centers.

Integration with process-based IAMs

- Integration with GCAM and is possible with other IAMs

Uni- and multivariate risk indices and identification of hotspots.

- User-specified risk indices based on probabilities and dates for exceedance of climatic and economic thresholds.



Socioeconomic module
SSP spatially explicit scenarios (0.5ºx0.5º)
SSP regional scenarios
SRES explicit scenarios (0.5ºx0.5º)
GDP and POP decadal spatial patterns (0.5ºx0.5º)
SSP consistent GDP anual maps and time series
SSP consistent POP anual maps and time series
Identification of urban areas and population
Lat
Long
Climate module
SSP/RCP scenarios
User defined emissions scenarios
Global climate projections
MAGICC6
Concentrations
Radiative forcing
Climate response
Climate sensitivity AR6 (triangular distribution)
Urban warming estimates
Temperature scenarios for urban areas
Global temperature increase RCP85
Probabilistic global temperature scenarios
Regional climate scenario generation
Library of 37 GCM scaling patterns CMIP6 for temperature and precipitation
Selection of GCM (uniform distribution)
Probabilisitic regional temperature scenarios (0.5ºx0.5º)
Probabilisitic regional precipitation scenarios (0.5ºx0.5º)
CLIMRISK-NDCnoUSA
lat
long
Tmean, Tmin, Tmax, Prec, WBGT, UHImean, UHImin, UHImax
Monthly, annual

Reducción de escala de escenarios socioeconómicos

Para narrativas divergentes (diferentes SSPs)

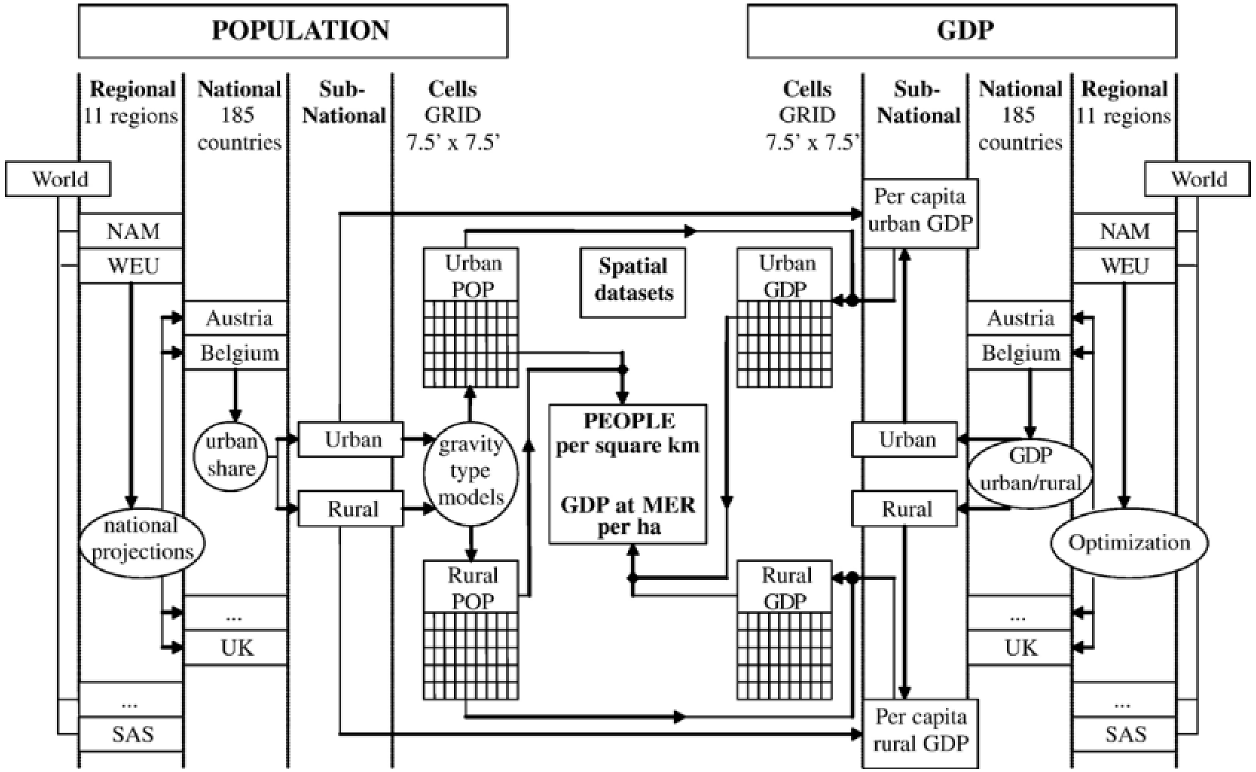


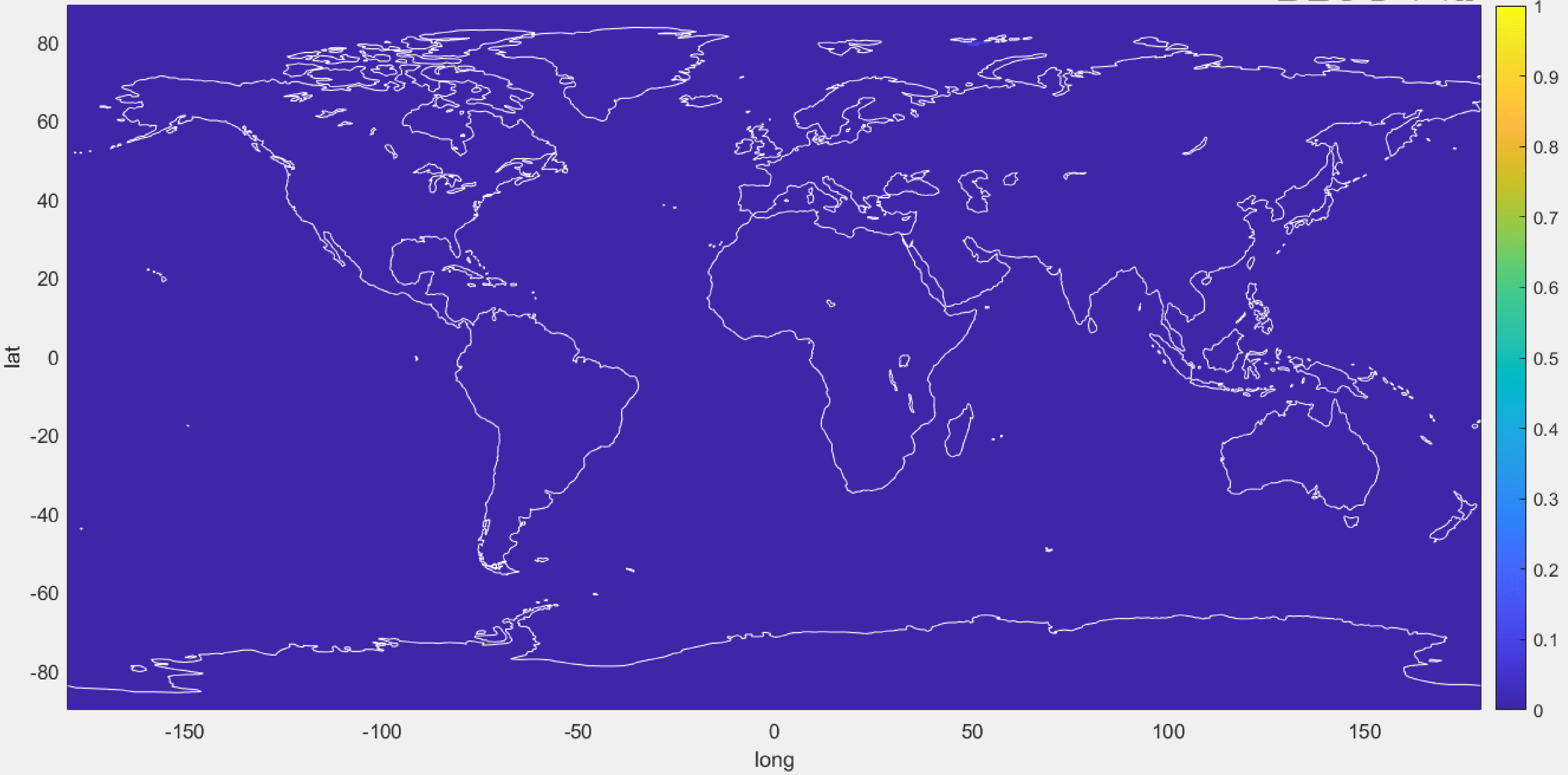
Fig. 1. Flow chart of the scenario-downscaling methodology aimed at developing consistent population and GDP scenario interpretations at the global, world regional, national, and subnational level.

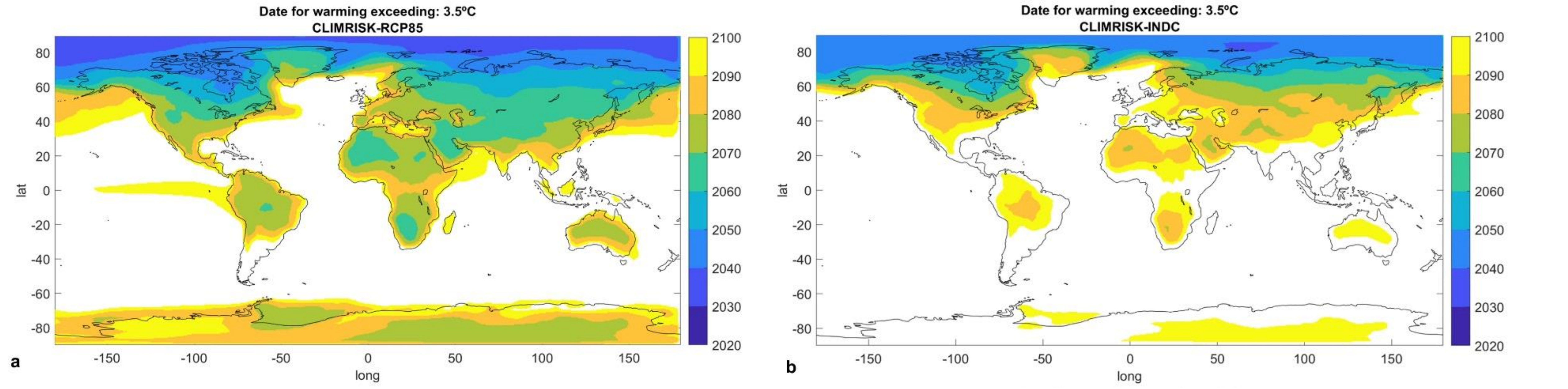
Para variaciones sobre la misma narrativa (mismo SSP)

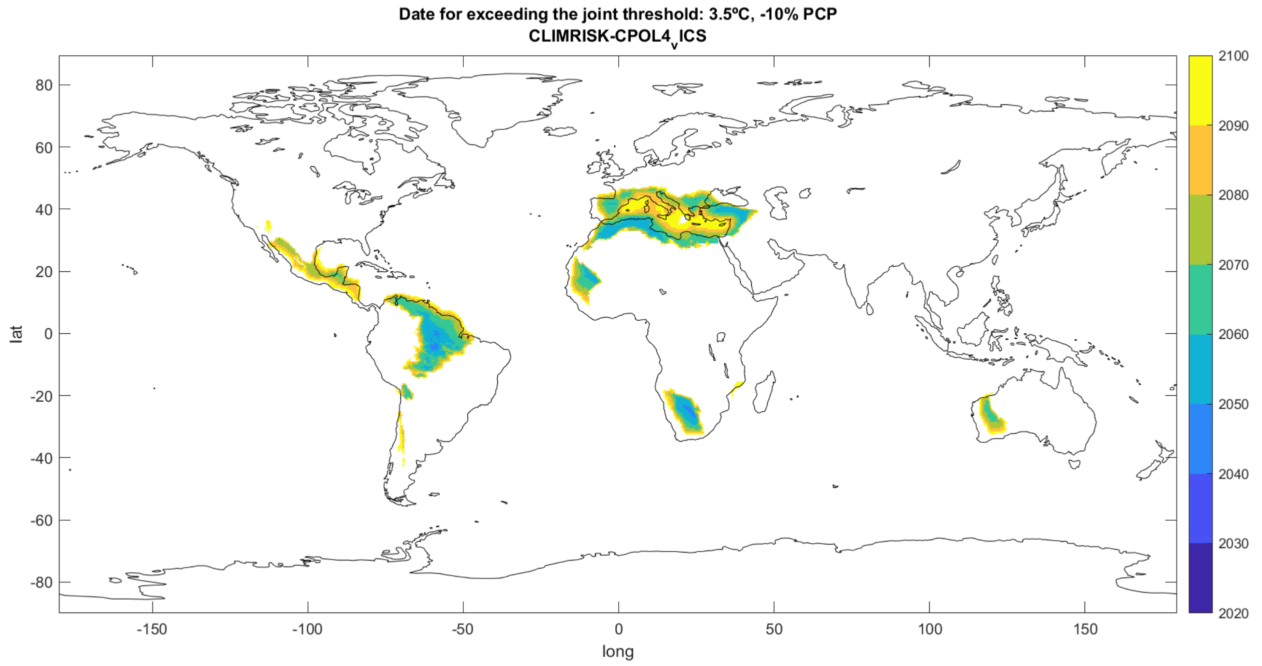
$$P^{R}_{i,j,t} = y^{SRES,R}_{i,j,t} / \left(\sum_{i,j} y^{SRES,R}_{i,j,t}\right)$$

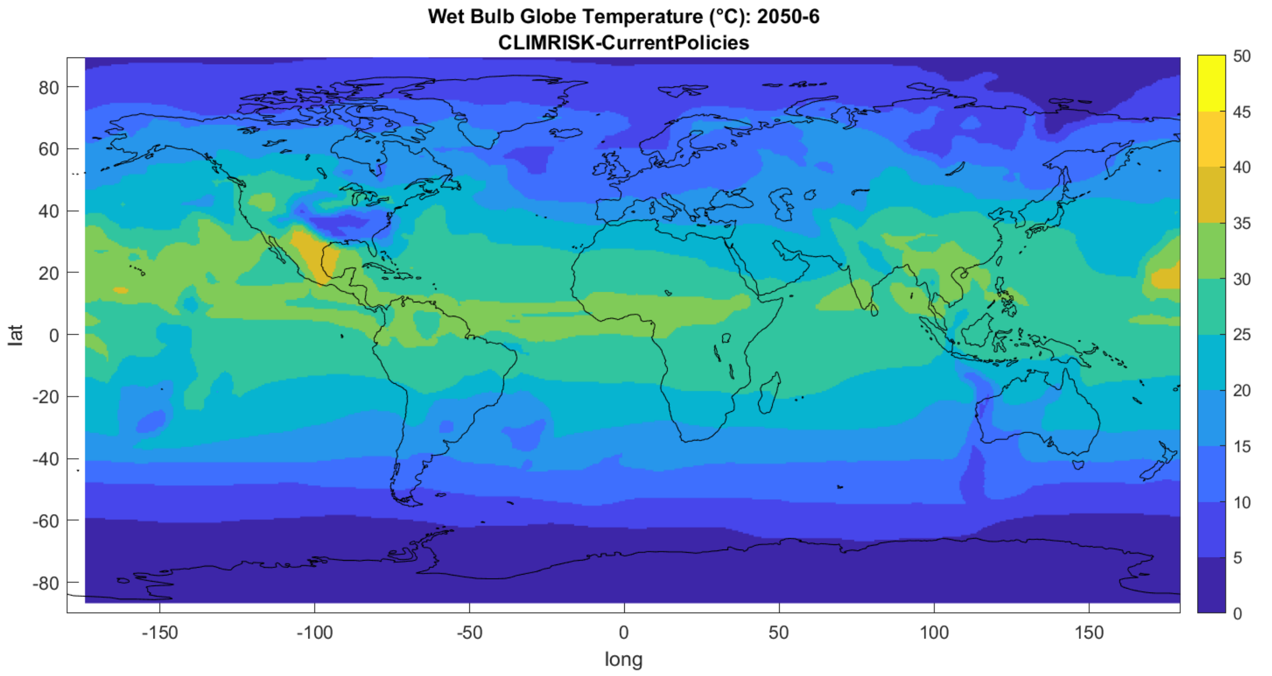
$$y^{SSP,R}_{i,j,t} = P^{R}_{i,j,t} * y^{SSP,R}_{t}$$

Probability of warming exceeding: 4ºC
CLIMRISK-RCP85
Year: 2010




Date for warming exceeding: 3.5ºC
CLIMRISK-RCP85
2100
2090
2080
2070
2060
2050
2040
2030
2020
lat
long
a
Date for warming exceeding: 3.5ºC
CLIMRISK-INDC
lat
long
b


Date for exceeding the joint threshold: 3.5ºC, -10% PCP
CLIMRISK-CPOL4$_v$ICS
2100
2090
2080
2070
2060
2050
2040
2030
2020
lat
long


Wet Bulb Globe Temperature (°C): 2050-6
CLIMRISK-CurrentPolicies
50
45
40
35
30
25
20
15
10
5
0
lat
long

Joint impacts of global and local climate change

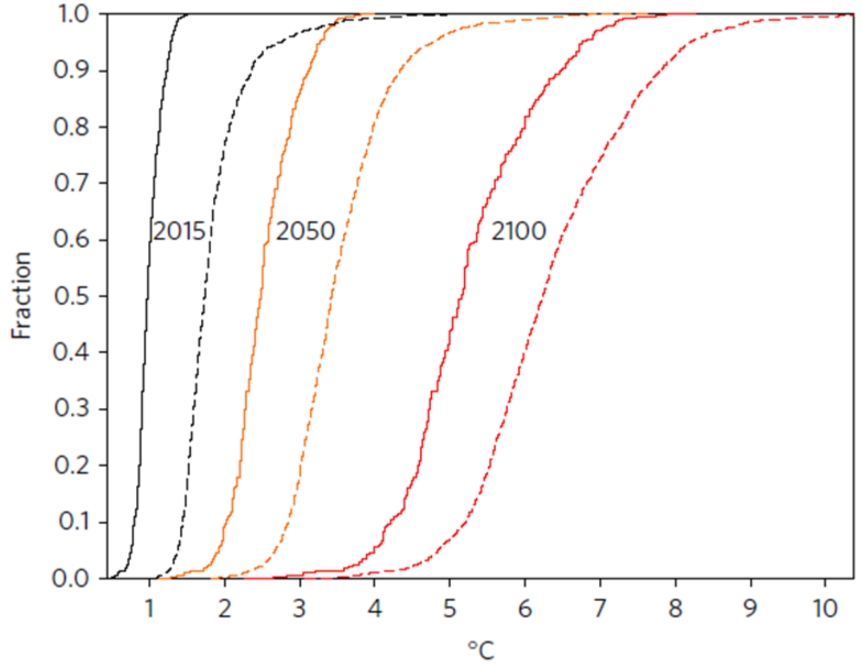


Figure 2 | Cumulative density functions of temperature changes of the 1,692 most populated cities in the world. The continuous lines show the estimated temperature increase for 2015 (black), 2050 (orange) and 2100 (red) under the RCP8.5 emissions scenario. Dashed lines include the estimated temperature increase from the UHI effect.

- A sizable proportion of the population is experiencing much greater warming
- Economic impacts are at least 2.6 times those previously calculated (global climate change)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NATURE CLIMATE CHANGE | LETTER

A global economic assessment of city policies to reduce climate change impacts

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Affiliations | Contributions | Corresponding author

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1,692 large cities around the world

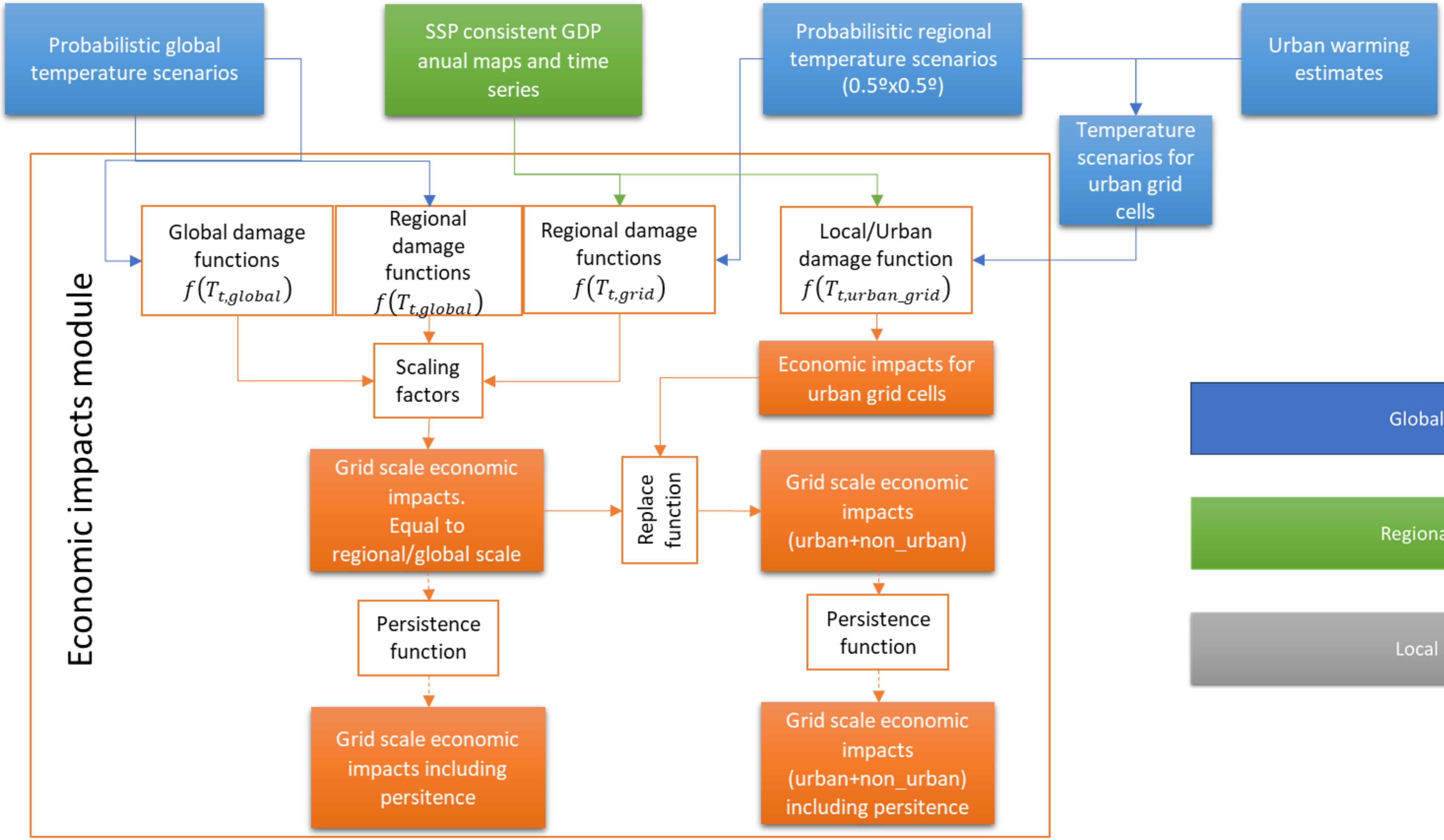
+50% world population lives in urban areas

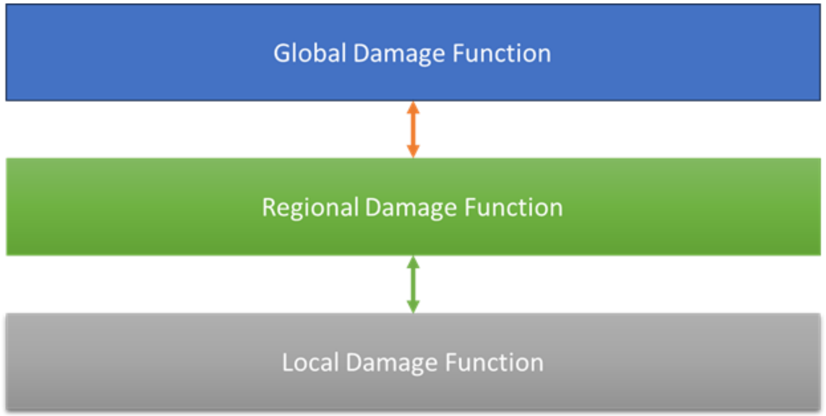
80% of global GDP is produced in cities

Convergence of socioenvironmental issues

Global, regional, local damage functions

A down/up-scaling approach





Global damage functions

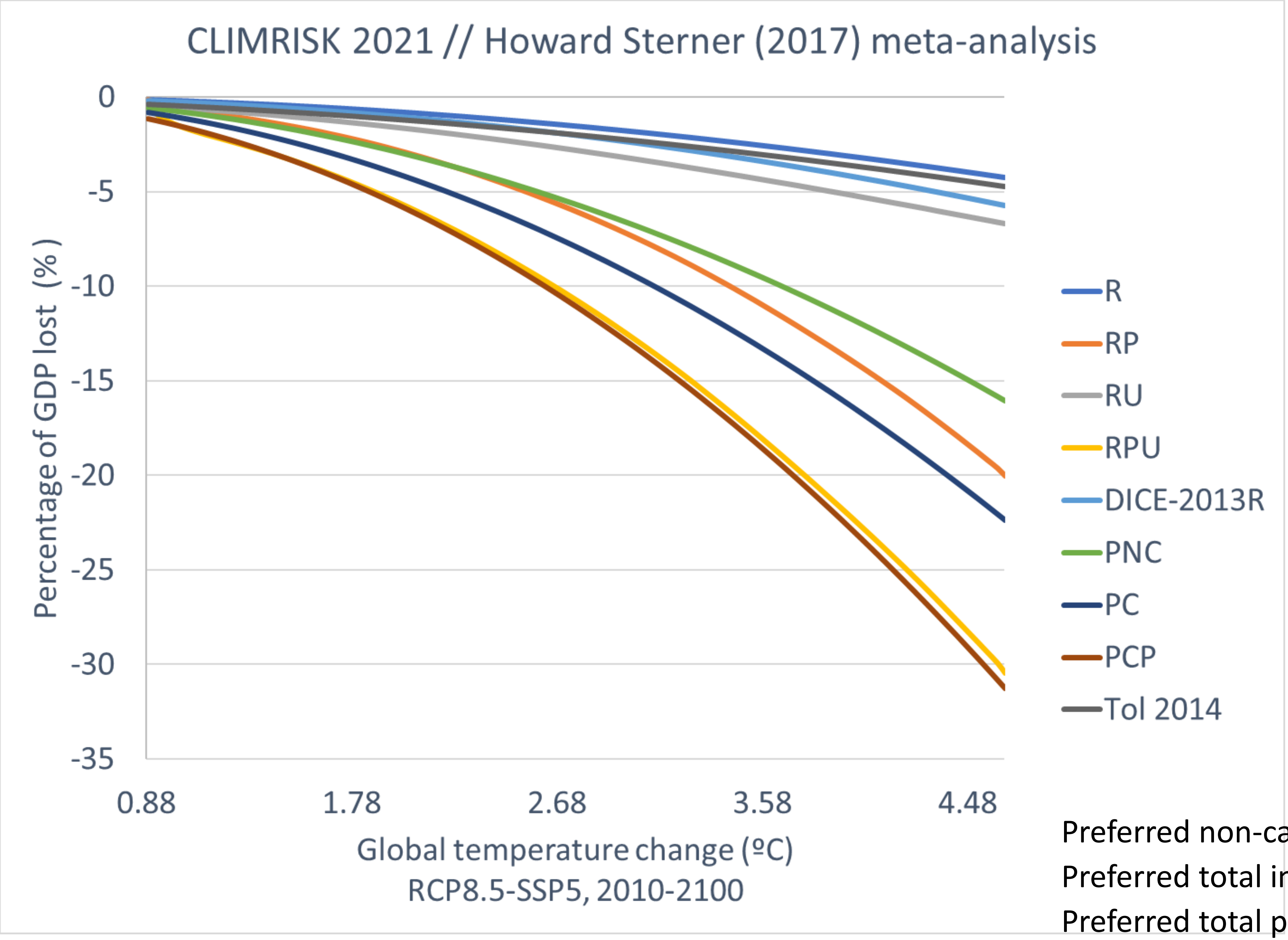
Kompas et al.* (K) Kalkuhl Wenz (KW panel, KWCS cross-sectional)* Howard and Sterner (PNC) Estrada et al. (P, persistence) DICE2016 (d) RICE2010* (R) ***<u>Catastrophic</u>*** Howard and Sterner (PC, PCP) Weitzman (w)	K, KW, KWCS, d,R KU, KWU, RU, RUd, Ruw RP, RPU Rd, RPd, RUd, RPUd Rw, RPw, RUw, RPUw

Regional damage functions

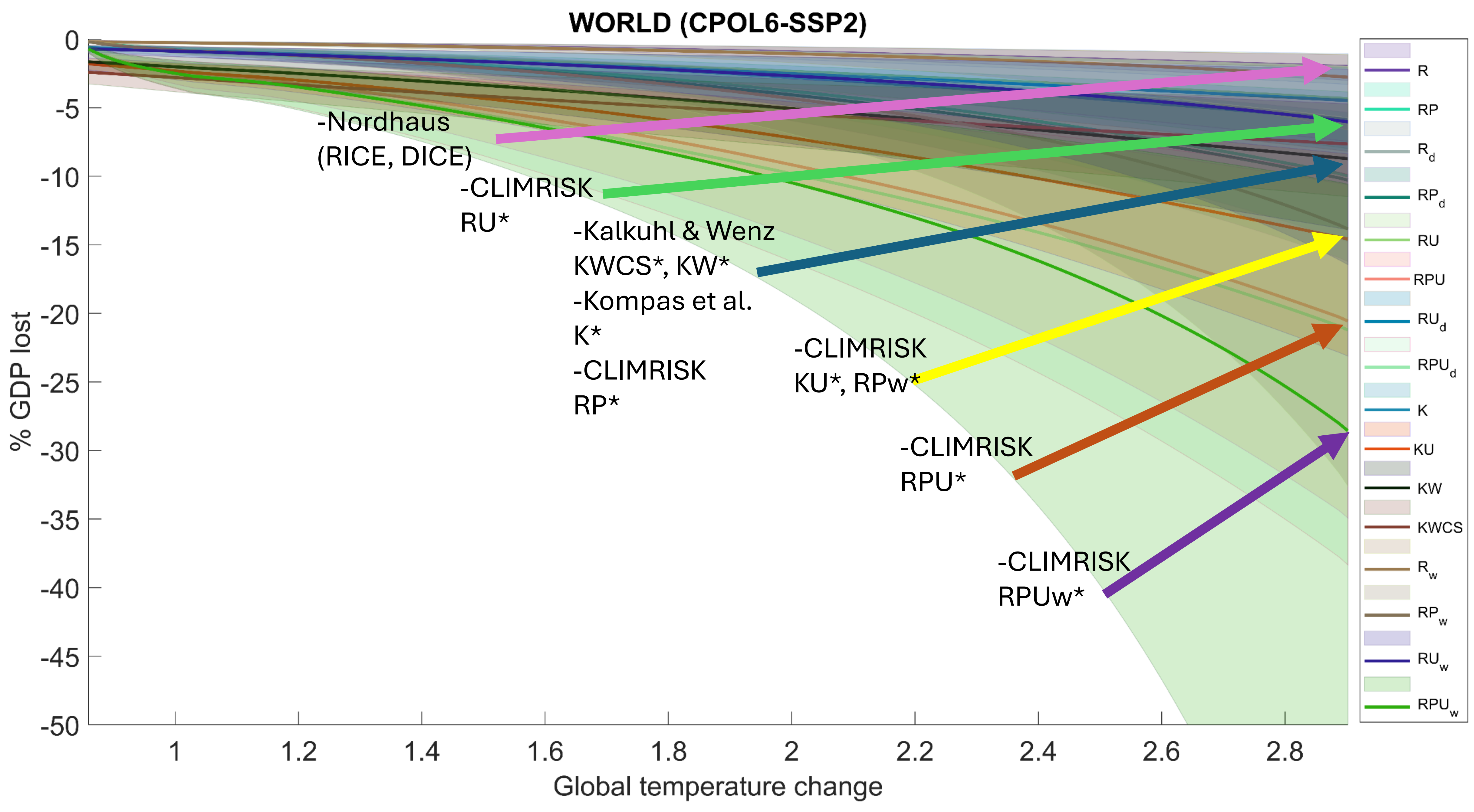
Kompas et al. (K; 173 countries) Kalkuhl Wenz (panel, cross-sectional) RICE2010 (R; 13 regions)	K, KU, KW, KWCS, KWU Rd, Rw, RP, RPU, RPd, Rud, RPUd RPw, RUw RPUw

Local damage functions

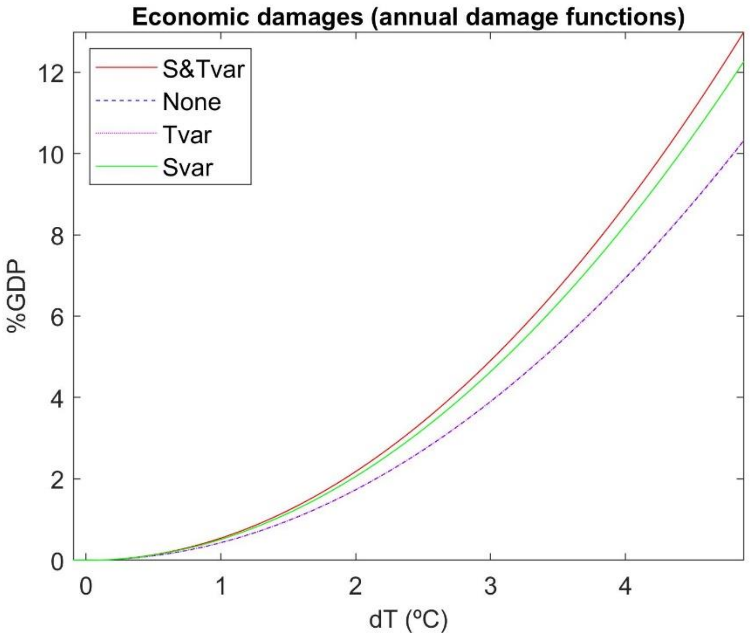
Kompas et al. (K; 60,000+ local DF) Kalkuhl Wenz (panel, cross-sectional) Estrada et al. (U; urban)	K, KU, KWU, RU,RPU RUd, RPUd, RUw, RPUw

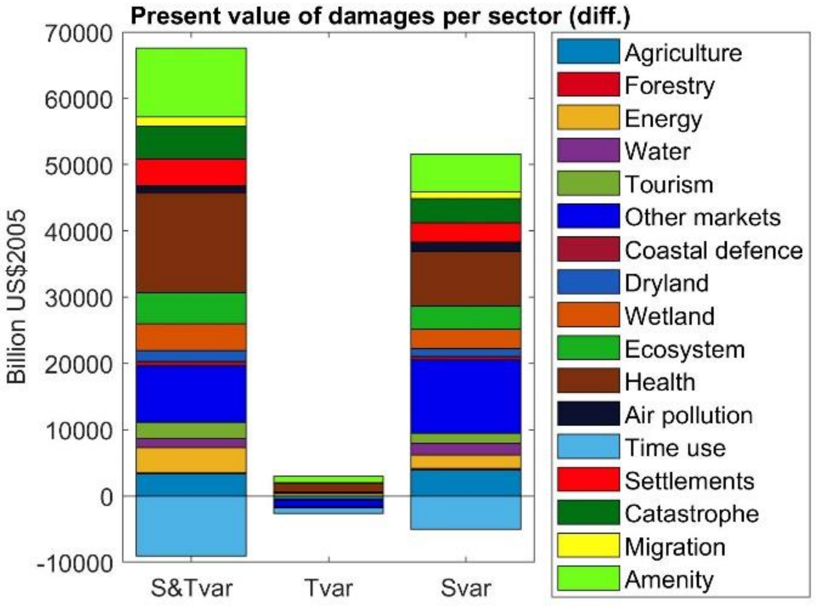


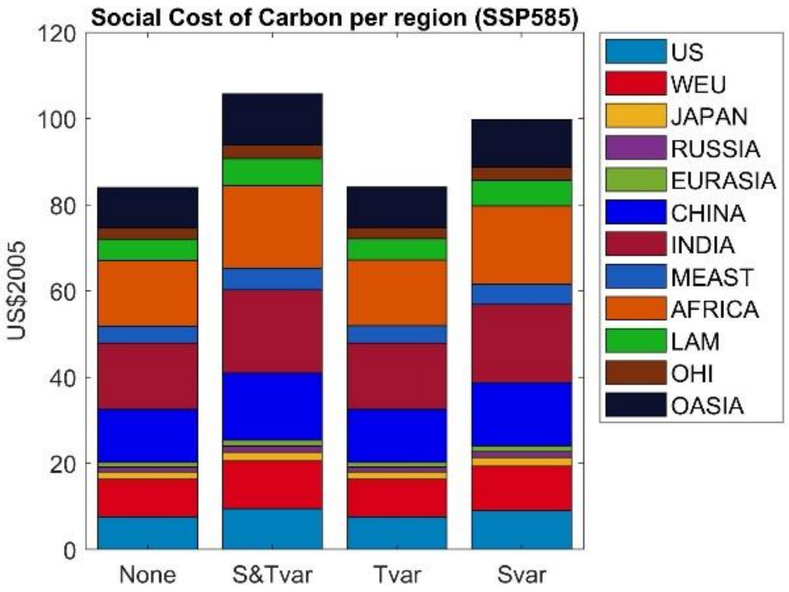
Preferred non-catastrophic (PNC)
Preferred total inc. catastrophic (PC)
Preferred total plus productivity (PCP)


WORLD (CPOL6-SSP2)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
% GDP lost
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
Global temperature change
-Nordhaus
(RICE, DICE)
-CLIMRISK
RU*
-Kalkuhl & Wenz
KWCS*, KW*
-Kompas et al.
K*
-CLIMRISK
RP*
-CLIMRISK
KU*, RPw*
-CLIMRISK
RPU*
-CLIMRISK
RPUw*
R
RP
R_d
RP_d
RU
RPU
RU_d
RPU_d
K
KU
KW
KWCS
R_w
RP_w
RU_w
RPU_w

Temporal variability and spatial variation

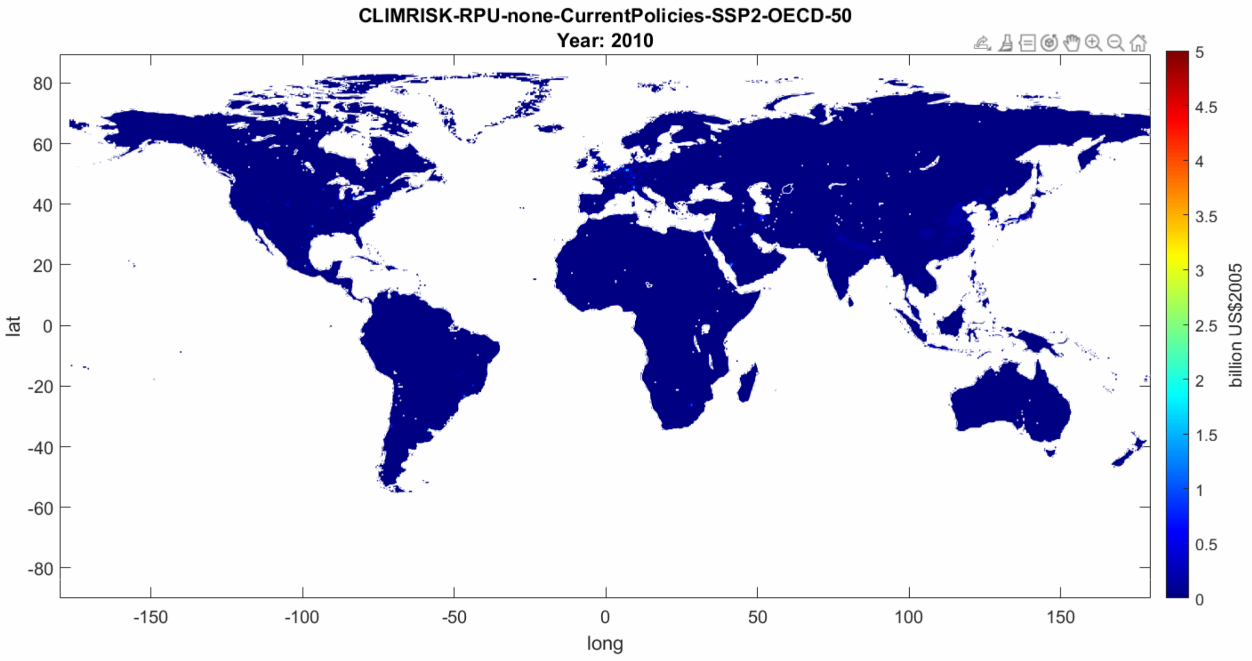




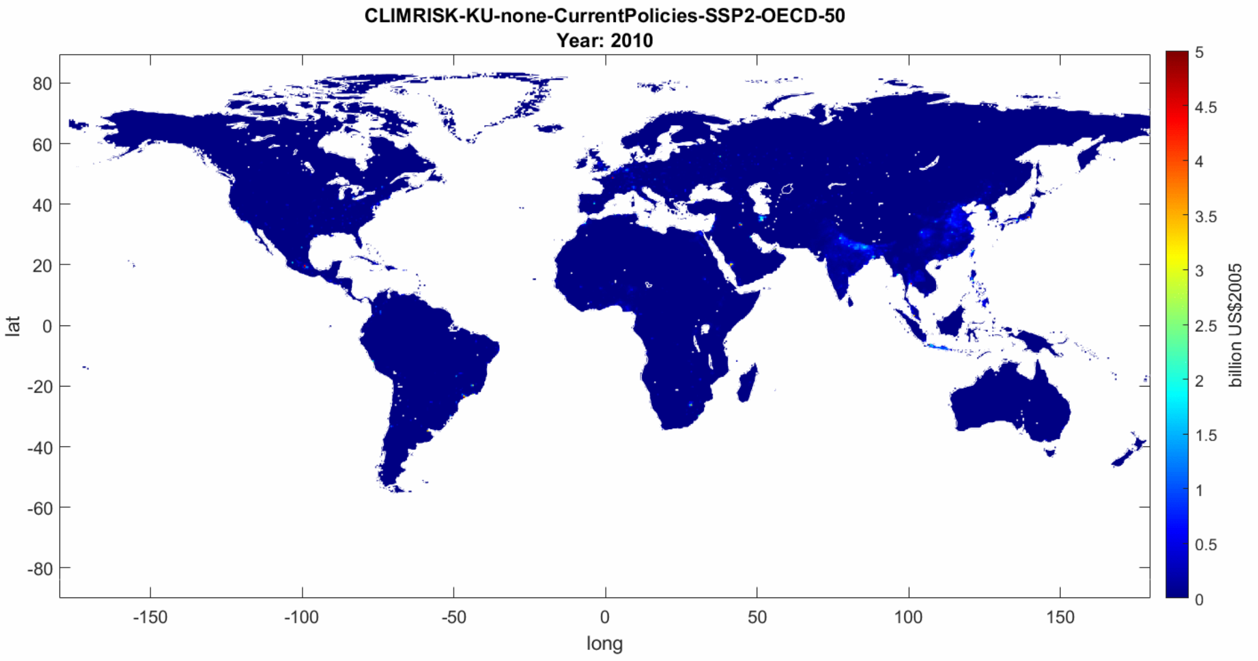


Under a high emissions scenario, losses are underestimated by 23-36%, representing US$1,900-US$3,000 billion by 2050 and US$24-US$38 trillion by the end of the century.
The present value of losses over this century exceeds previous estimates by US$57-US$89 trillion, representing 56-88% of 2020 global GDP.

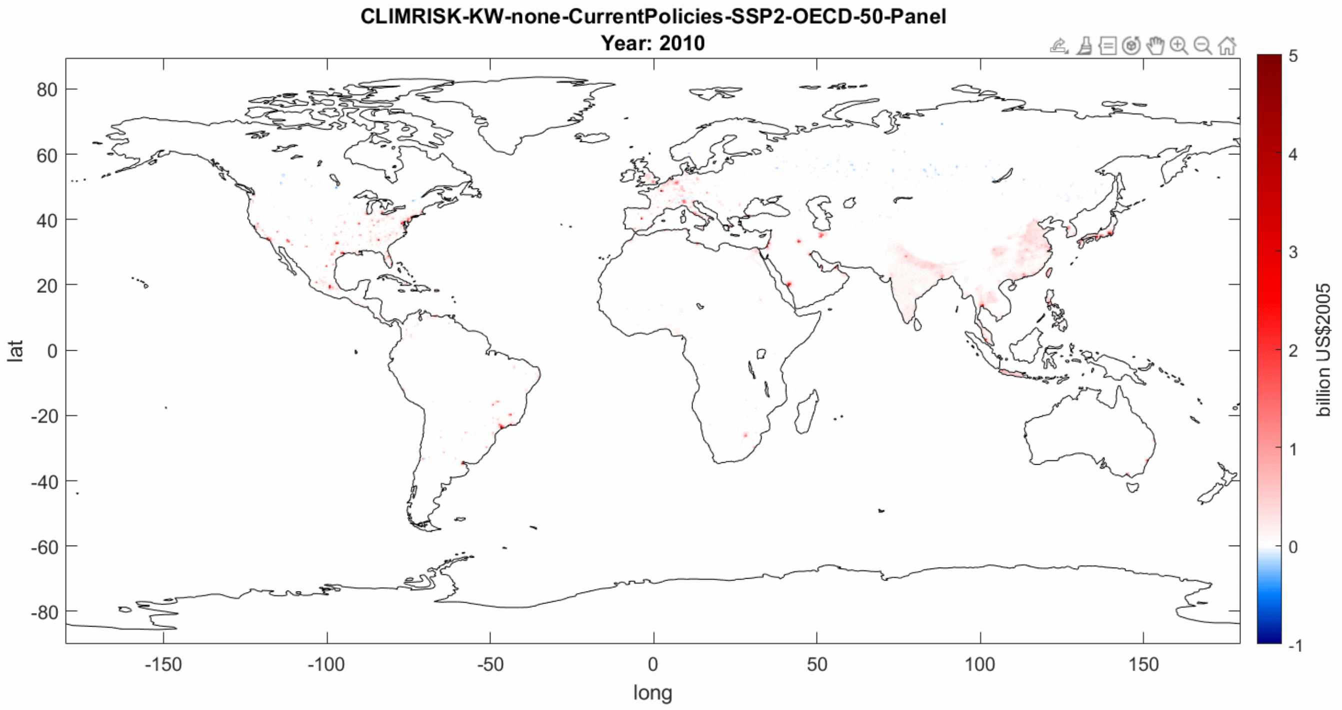
Estrada F., Tol R.S.J., Botzen W.J.W. 2024.Economic consequences of the spatial variation and temporal variability of climate change (submitted)



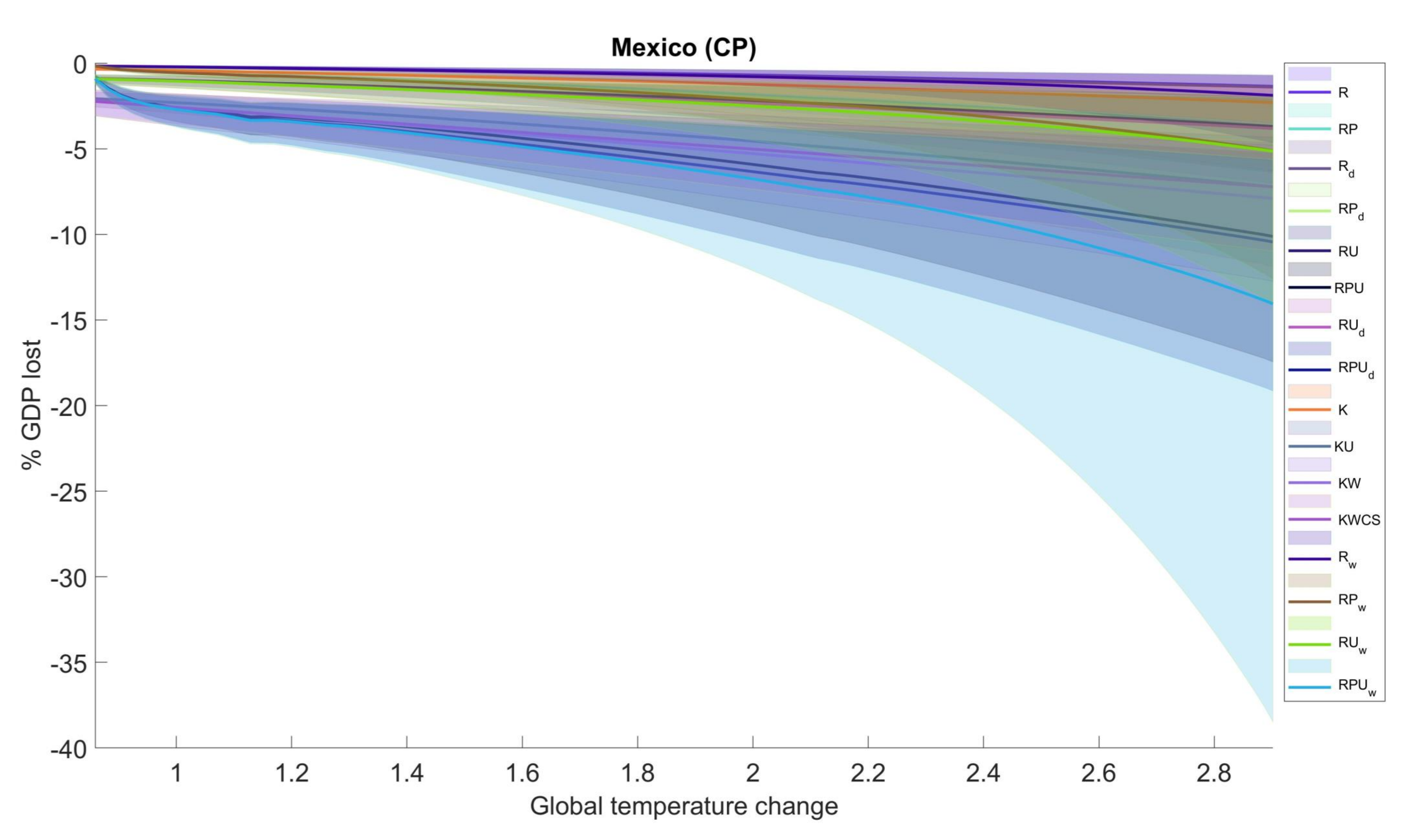
CLIMRISK-RPU-none-CurrentPolicies-SSP2-OECD-50
Year: 2010
lat
long
billion US$2005



CLIMRISK-KU-none-CurrentPolicies-SSP2-OECD-50
Year: 2010
lat
long
billion US$2005



CLIMRISK-KW-none-CurrentPolicies-SSP2-OECD-50-Panel
Year: 2010
lat
long
billion US$2005



Mexico (CP)
% GDP lost
Global temperature change
0
-5
-10
-15
-20
-25
-30
-35
-40
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
R
RP
R_d
RP_d
RU
RPU
RU_d
RPU_d
K
KU
KW
KWCS
R_w
RP_w
RU_w
RPU_w

Present value of economic losses as % current GDP

World, NGFS current policies

World region	Damage functions (RU) Config. B	Damage functions (RPU) Config. B
US	157.83% (103.29%, 256.84%)	377.2% (247.11%, 613%)
EU	203.38% (125.59%, 325.57%)	393.82% (243.38%, 629.81%)
Japan	149.91% (100.82%, 232.46%)	359.73% (242.21%, 557.07%)
Russia	211.94% (131.24%, 353.69%)	937.82% (582.41%, 1559.66%)
Eurasia	222.13% (140.24%, 376.97%)	685.71% (433.63%, 1161.28%)
China	260.58% (164.99%, 414.1%)	1166.27% (740.2%, 1848.02%)
India	819.07% (551.9%, 1244.86%)	3545.47% (2395.92%, 5369.73%)
MEAST	457.26% (308.38%, 734.73%)	1995.18% (1349.63%, 3193.6%)
Africa	1133.95% (739.09%, 1807.39%)	7785.96% (5110.57%, 12319.82%)
LAM	271.3% (182.96%, 431.04%)	728.57% (492.17%, 1155.1%)
OHI	201.22% (131.01%, 322.59%)	479.96% (312.83%, 768.45%)
OASIA	534.03% (362.86%, 819.51%)	2298.89% (1567.26%, 3514.27%)
MX	265.69% (187.62%, 417.37%)	713.02% (504.36%, 1117.62%)

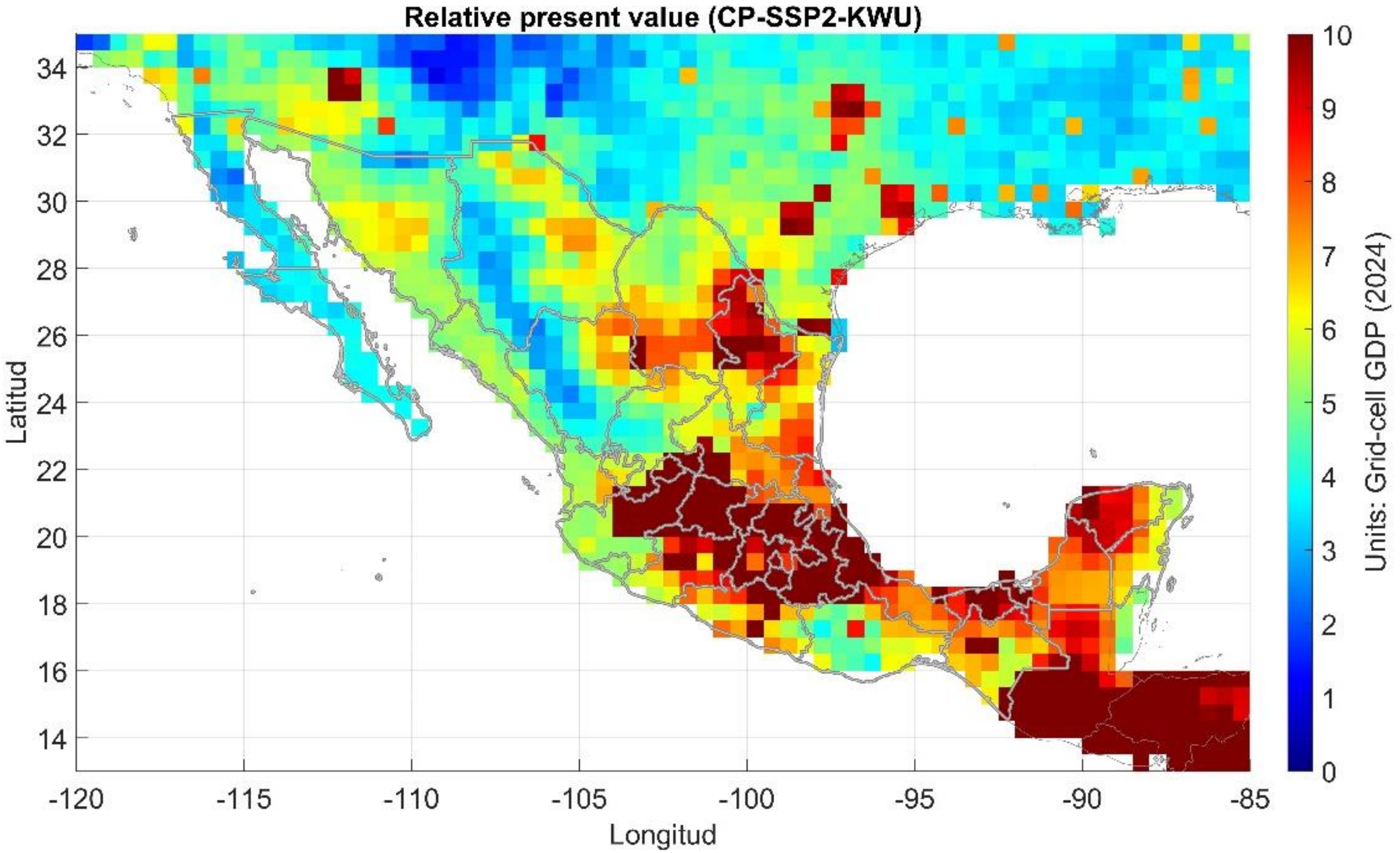
Discount rate=1.5%

Mexico, NGFS Current policies; Below 2ºC
Exploring different configurations of damage functions (units of MX GDP 20204)

Scenario	**K**	**KWU**
CP	1.19 [0.71, 1.7]	10.7 [7.52, 15.43]
B2	0.81 [0.48, 1.12]	8.91 [6.28, 12.41]
AL	0.38 [0.23, 0.58]	1.79 [1.24, 3.02]

Estrada F., et al. 2024. Assessing the physical risks of climate change for the financial sector: a case study from Mexico's Central Bank. Submitted

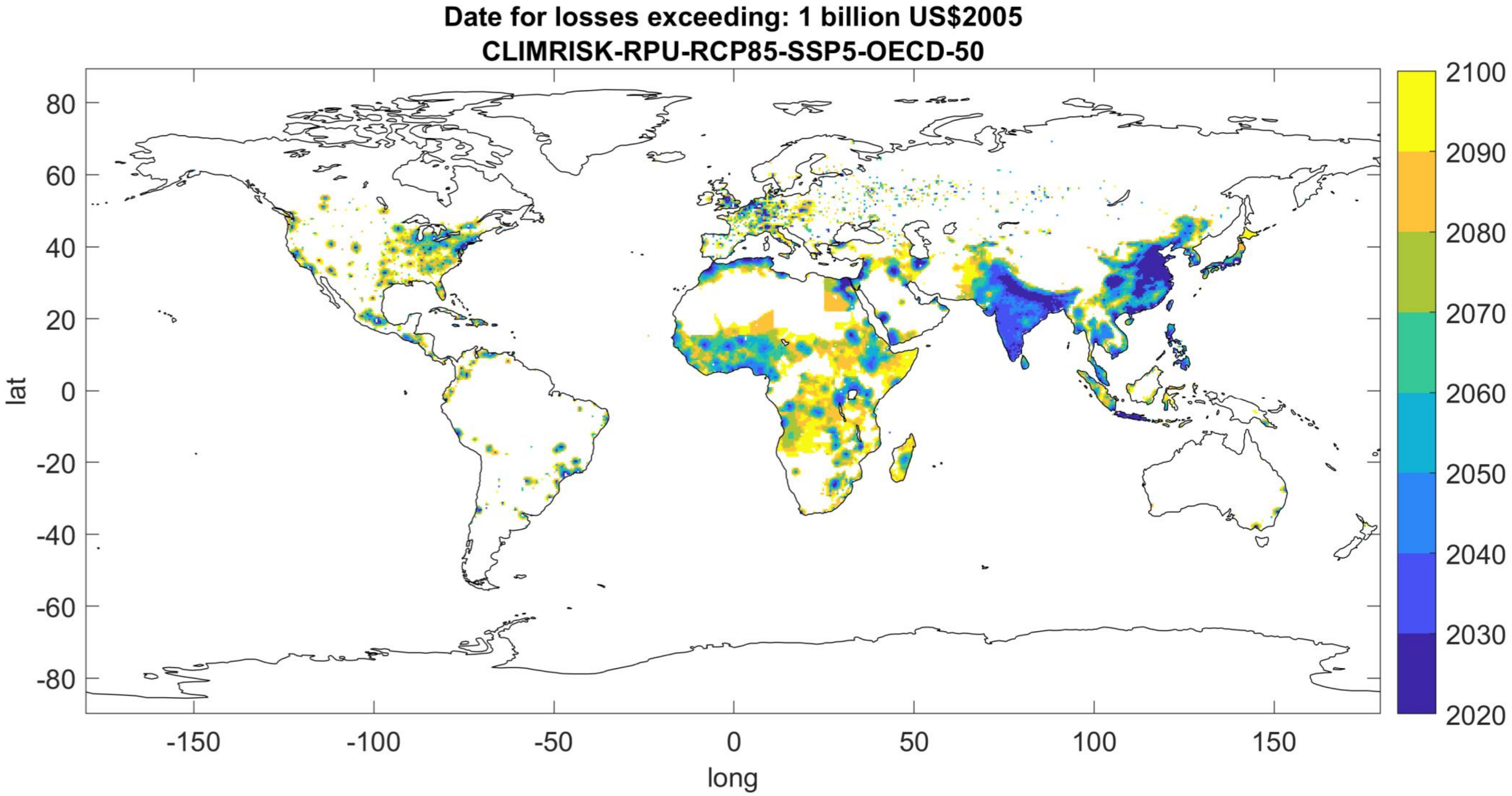
Relative present value of economic losses and social cost of carbon



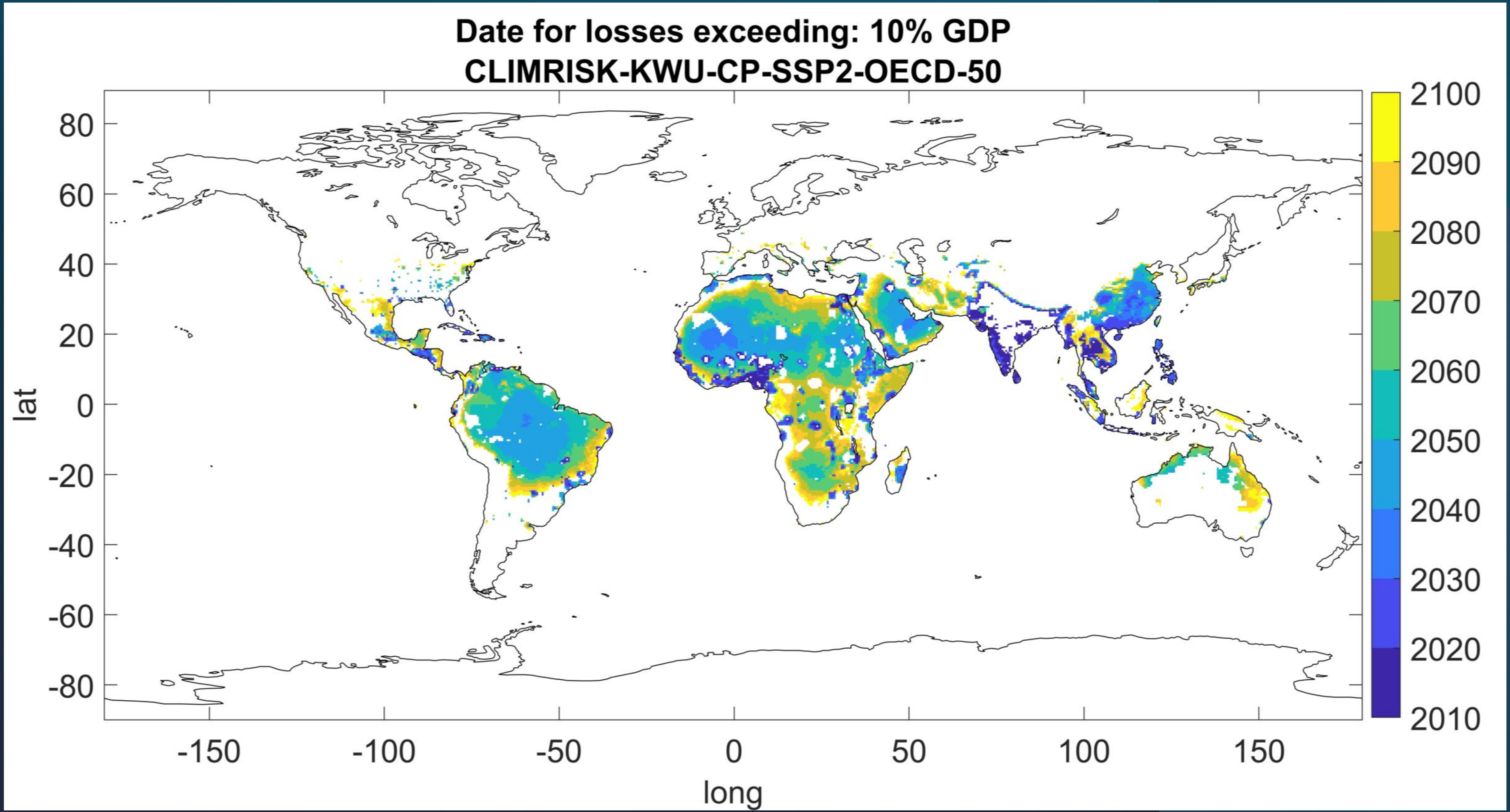
Social Cost of Carbon Current Policies
$US per tCO_2

	KU	*RU*	*RPU*
SCC	$229 [$166, $303]	$118 [$75, $169]	$488 [$316,$693]

Estrada F., et al. 2024. Assessing the physical risks of climate change for the financial sector: a case study from Mexico’s Central Bank. Submitted



Estrada F., Botzen W.J.W., 2021. Economic impacts and risks of climate change under failure and success of the Paris Agreement. Ann. N.Y. Acad. Sci. https://doi.org/10.1111/nyas.14652


Date for losses exceeding: 10% GDP
CLIMRISK-KWU-CP-SSP2-OECD-50
80
60
40
20
0
-20
-40
-60
-80
lat
-150
-100
-50
0
50
100
150
long
2100
2090
2080
2070
2060
2050
2040
2030
2020
2010

Costo social del CO_2

Damage function	Global SCC (US2005/tCO2)
RPU(d)	1188.63
RU(d)	290.15
RP(d)	579.84
R(d)	136.60
KU	482.93
K	185.93
	Catastrophic
RPU(w)	6221.57
RU(w)	1473.18
RP(w)	3069.87
R(w)	696.37
KU(w)	1796.07
K(w)	696.37

https://medioambiente.nexos.com.mx/el-costo-ambiental-de-dos-bocas/

Environ. Res. Lett. **16** (2021) 074039 https://doi.org/10.1088/1748-9326/ac0d7a

ENVIRONMENTAL RESEARCH
LETTERS

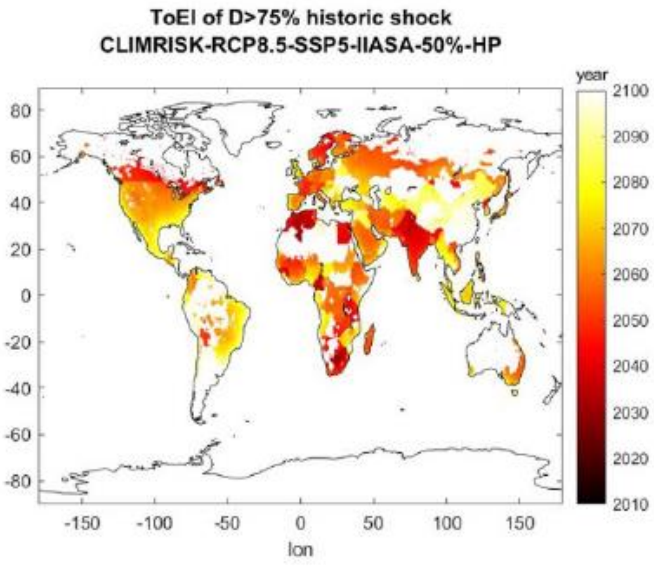
LETTER

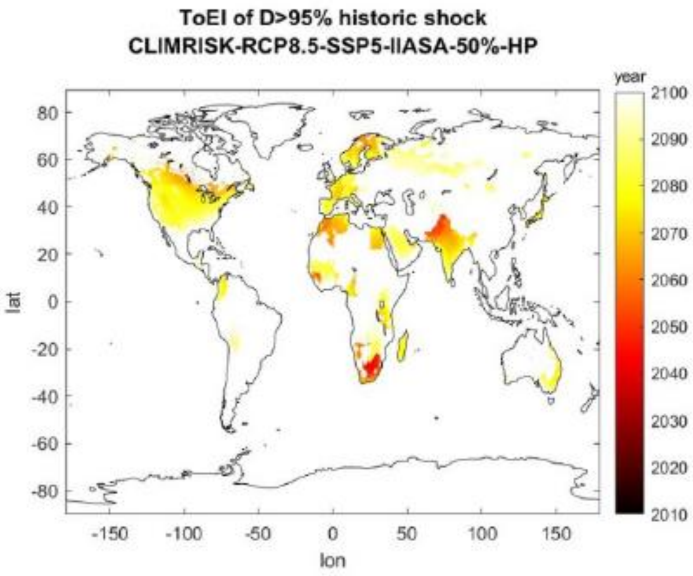
Time of emergence of economic impacts of climate change

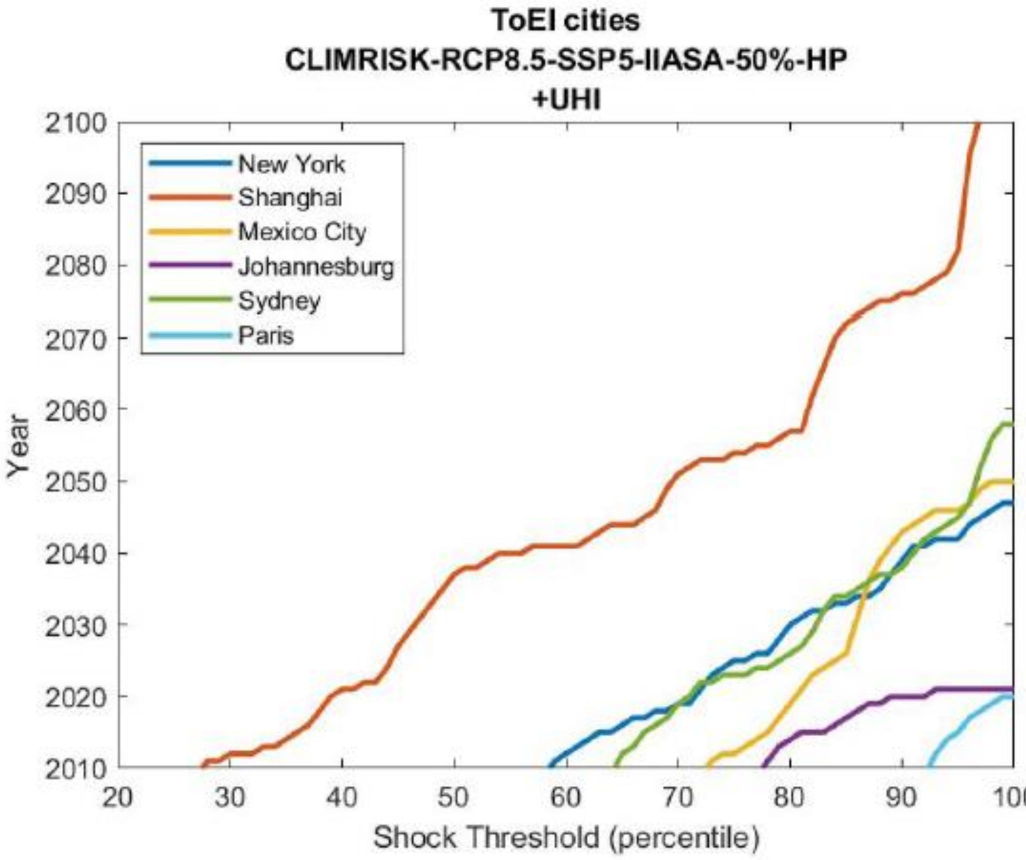
Predrag Ignjacevic[1,*], Francisco Estrada[1,2,3] and W J Wouter Botzen[1,4]

When would we start "feeling" the climate change impacts on the economy?

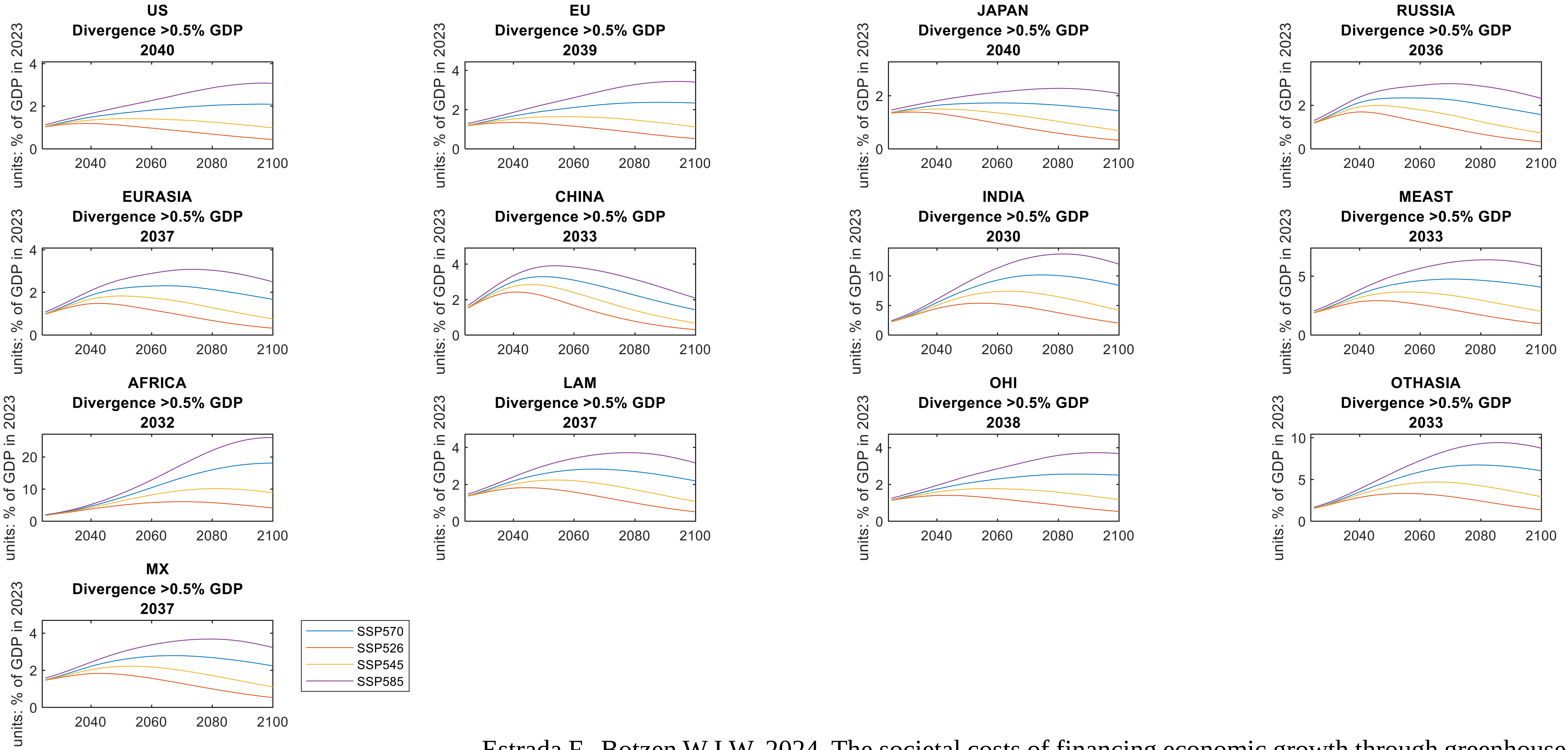
- ToEI: Identifies the initial moment when the climate change impact signal exceeds a previously defined threshold of past economic output shocks in a given geographic area.





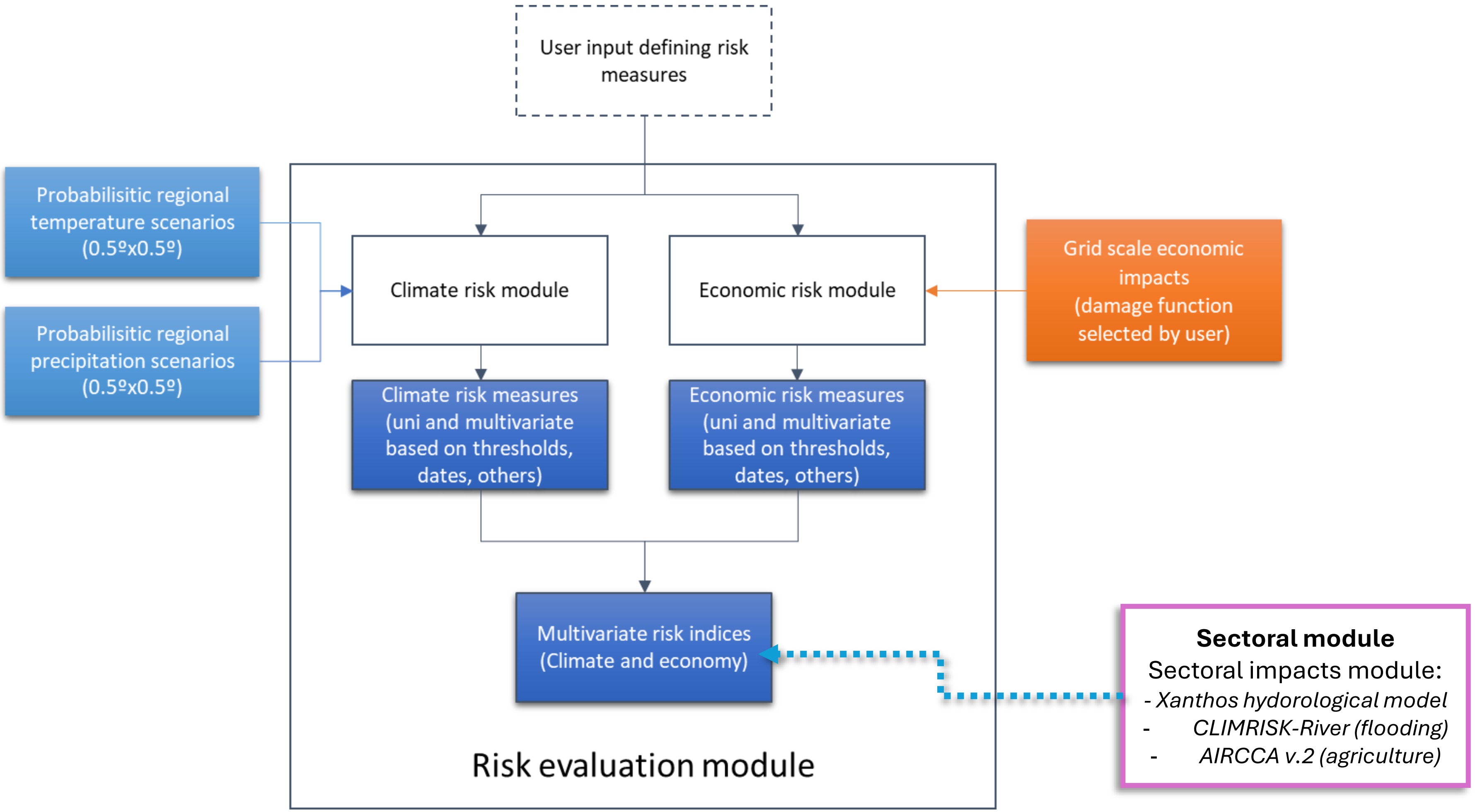


Cost of postponing mitigation for an additional year

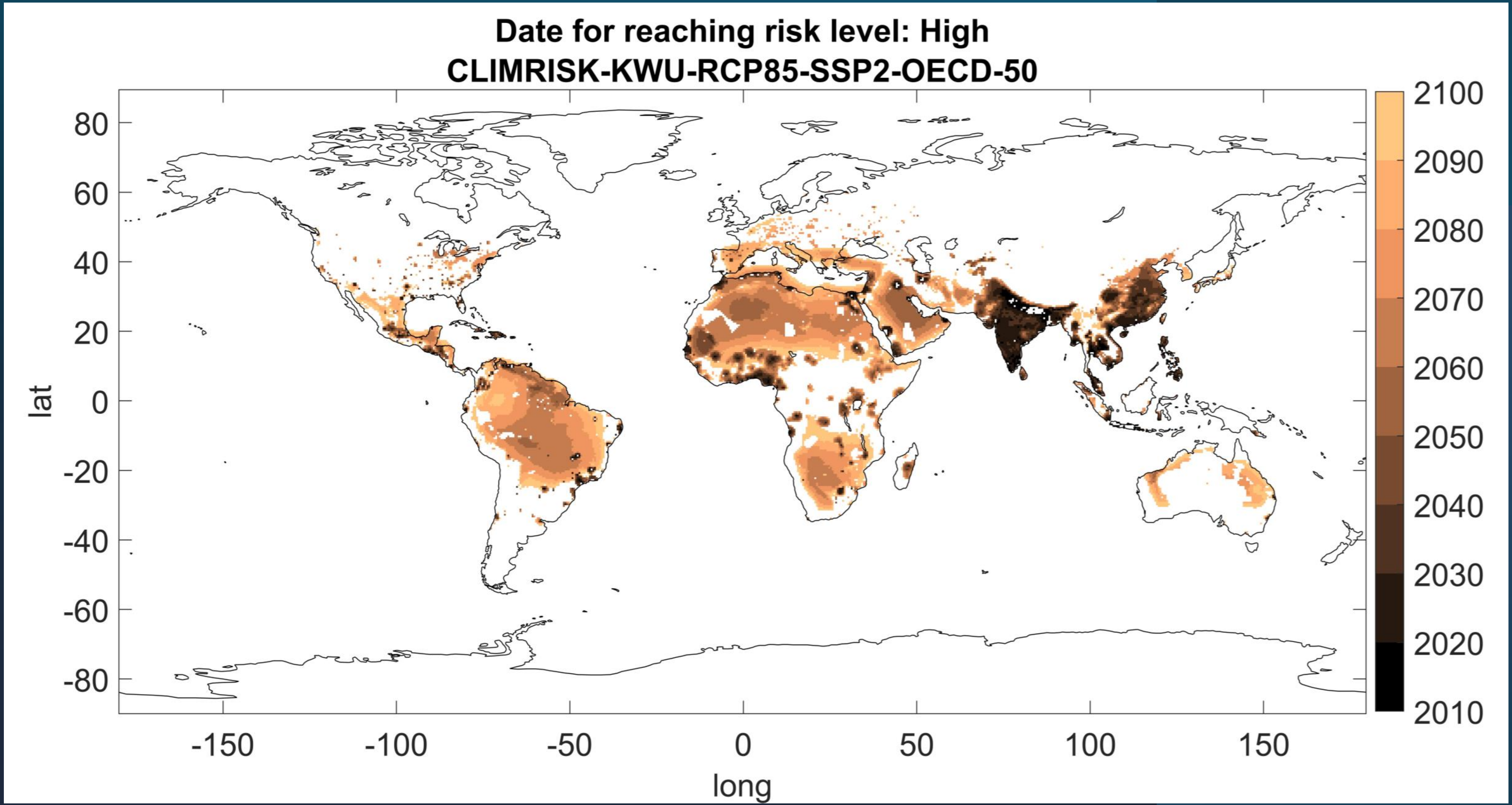


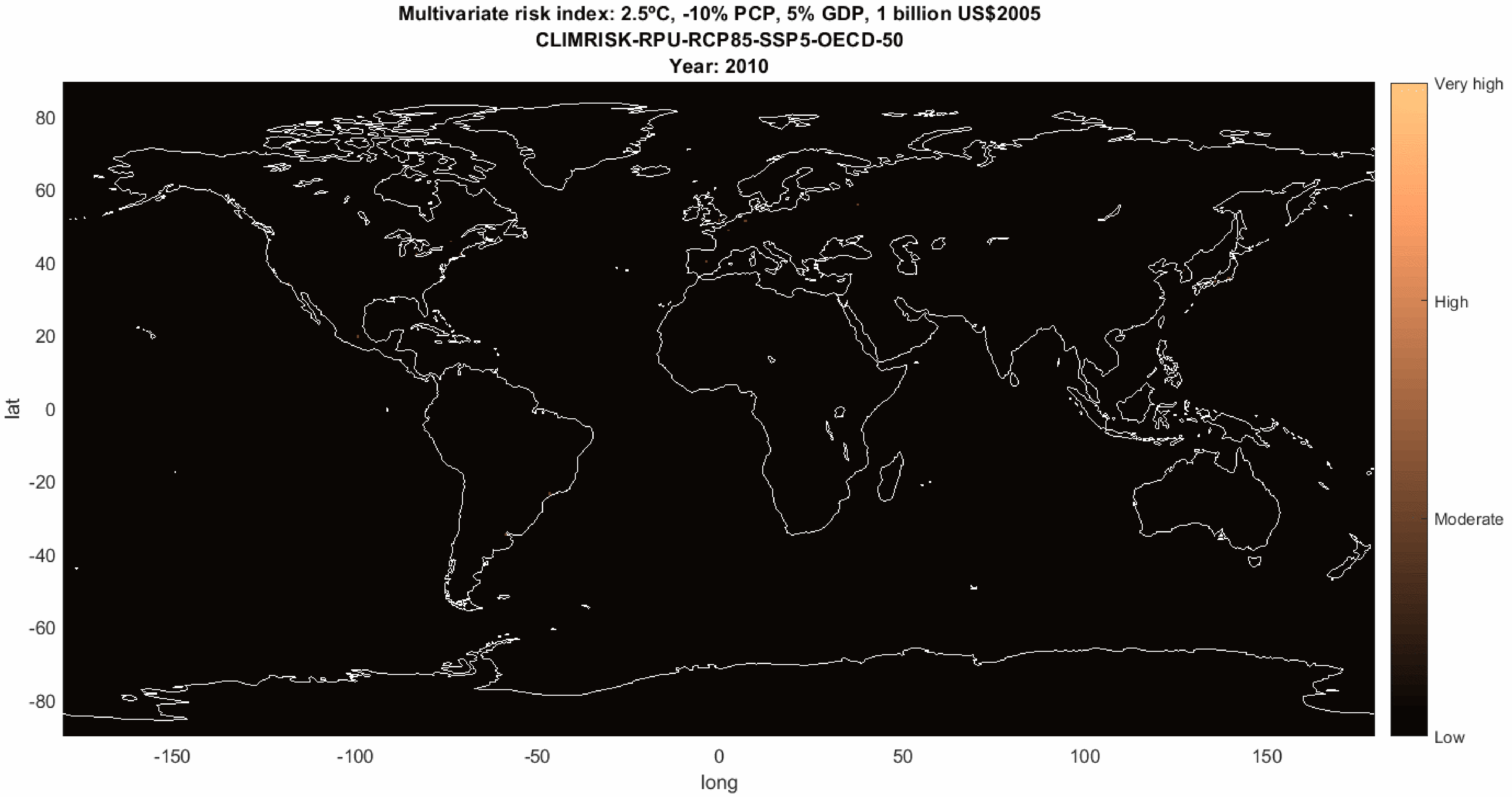
Estrada F., Botzen W.J.W. 2024. The societal costs of financing economic growth through greenhouse gas emissions. (submitted)

Risk module



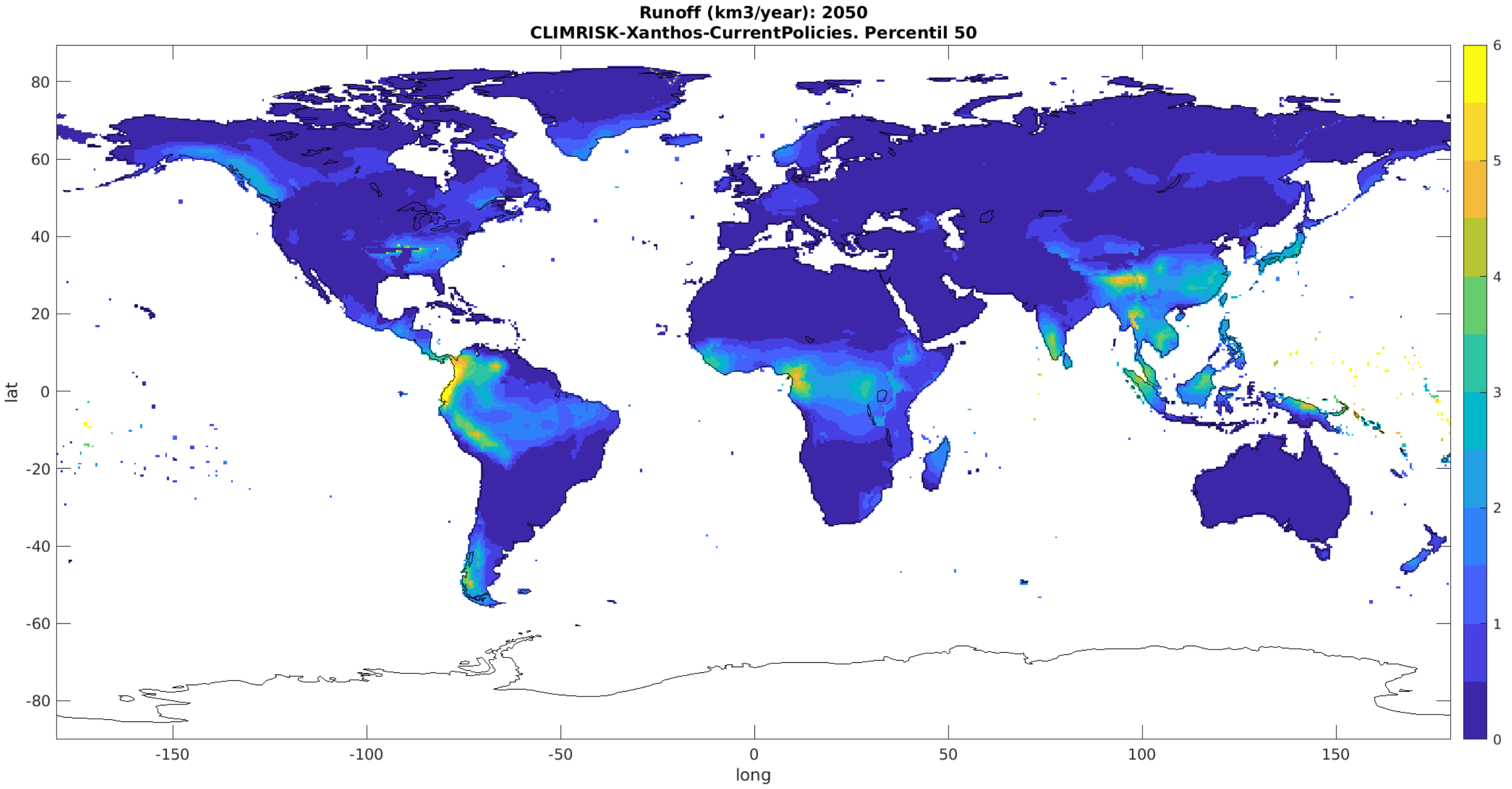
User input defining risk measures
Probabilisitic regional temperature scenarios (0.5ºx0.5º)
Probabilisitic regional precipitation scenarios (0.5ºx0.5º)
Climate risk module
Economic risk module
Grid scale economic impacts (damage function selected by user)
Climate risk measures (uni and multivariate based on thresholds, dates, others)
Economic risk measures (uni and multivariate based on thresholds, dates, others)
Multivariate risk indices (Climate and economy)
Risk evaluation module
Sectoral module
Sectoral impacts module:
- Xanthos hydrological model
- CLIMRISK-River (flooding)
- AIRCCA v.2 (agriculture)


Date for reaching risk level: High
CLIMRISK-KWU-RCP85-SSP2-OECD-50
lat
long
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
2100
2090
2080
2070
2060
2050
2040
2030
2020
2010



Multivariate risk index: 2.5ºC, -10% PCP, 5% GDP, 1 billion US$2005
CLIMRISK-RPU-RCP85-SSP5-OECD-50
Year: 2010
lat
long
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Very high
High
Moderate
Low

Integration of GCAM-CLIMRISK-Xanthos hydrological model (Pacific Northwest National Laboratory)

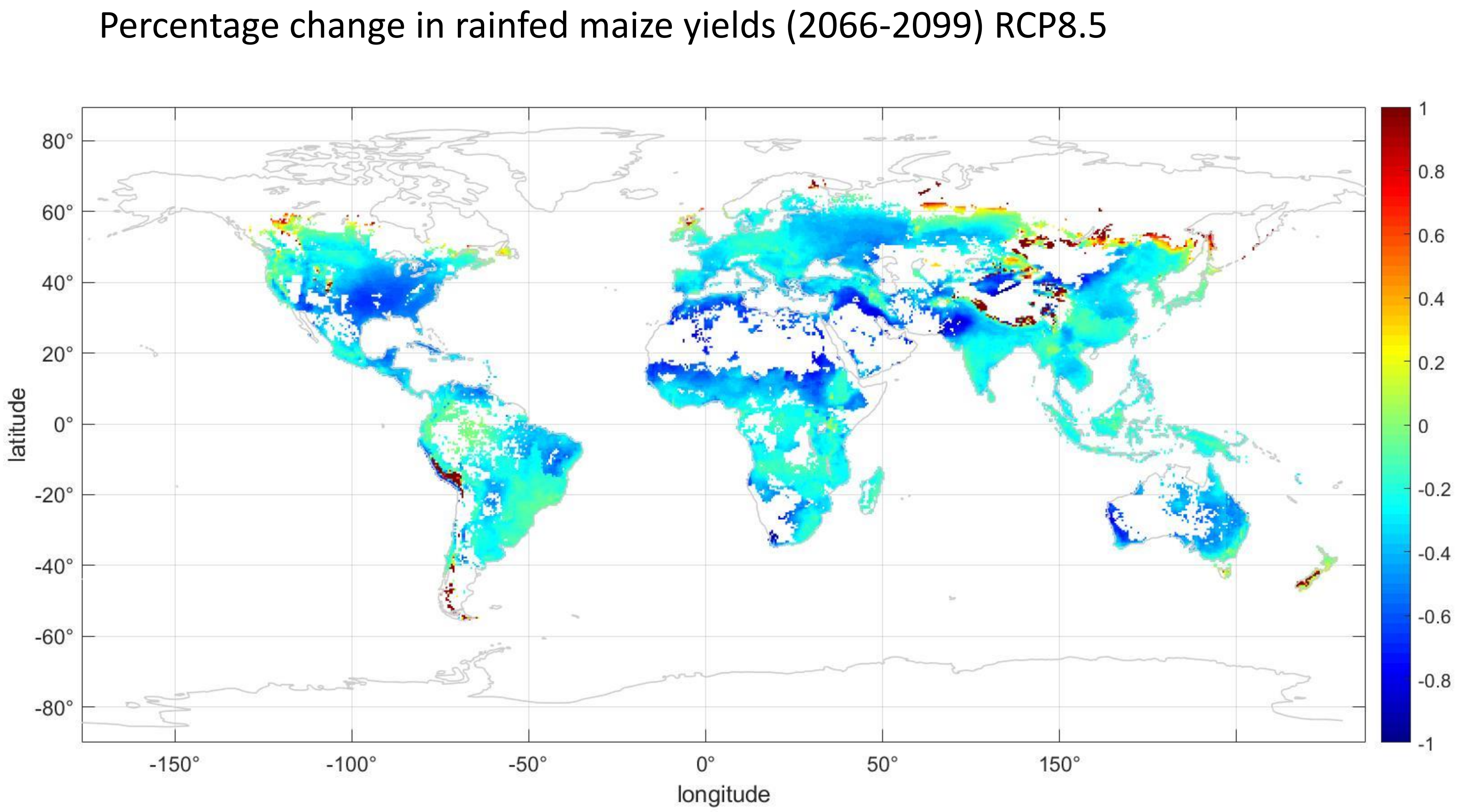


Complements water demand information for:

- assessing water stress and water availability for transition
- improving estimates of impacts on agriculture/power generation/industrial activities due to water scarcity/excess

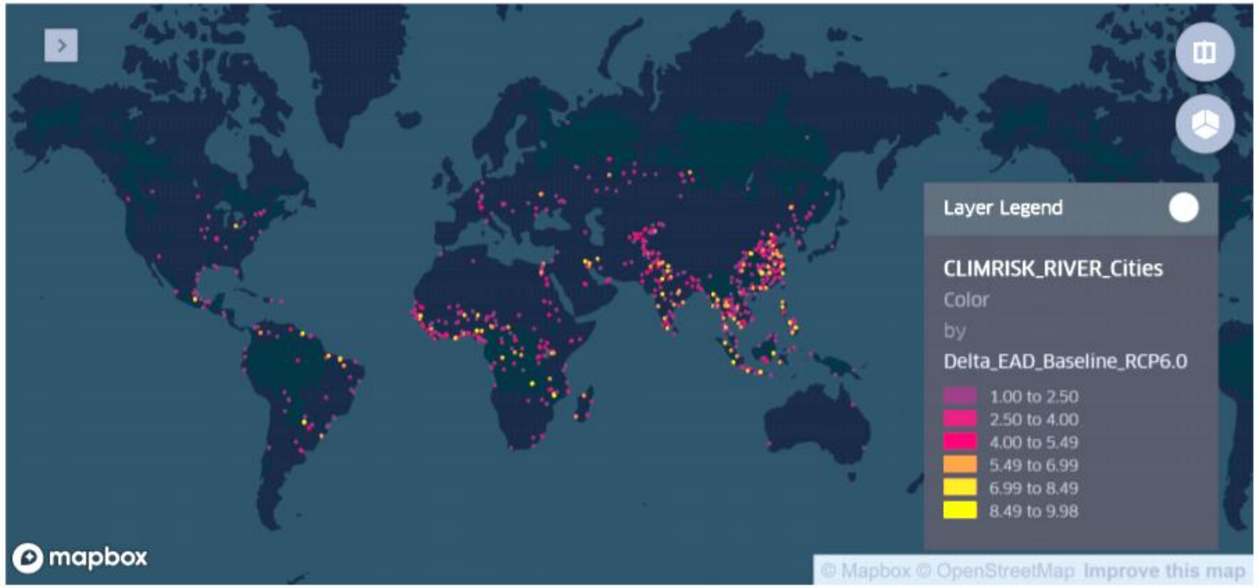
Historical and future estimates of regional and global water availability, water stress, potential evapotranspiration, runoff generation, and stream routing.

Agricultural crop model emulators



Estrada F., Botzen W.J.W., Calderón-Bustamante O., 2020. The Assessment of Impacts and Risks of Climate Change on Agriculture (AIRCCA) model: A tool for a rapid global risk assessment for crop yields at a spatially explicit scale. *Spatial Economic Analysis*.

9 crops, irrigated/rainfed, CO_2 fertilization



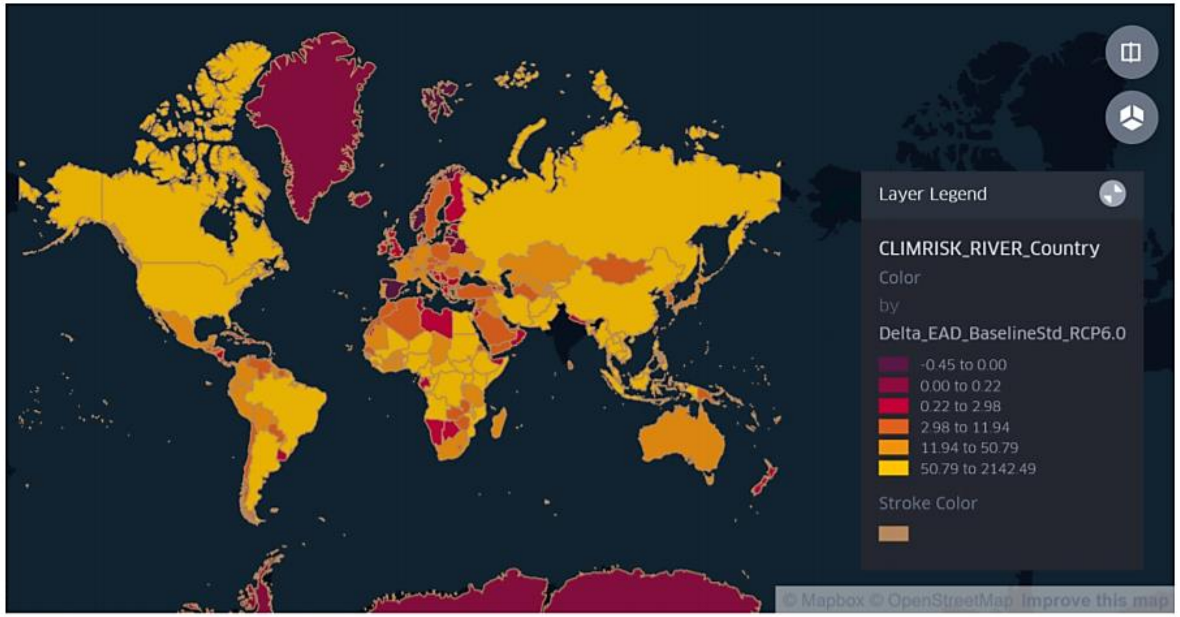
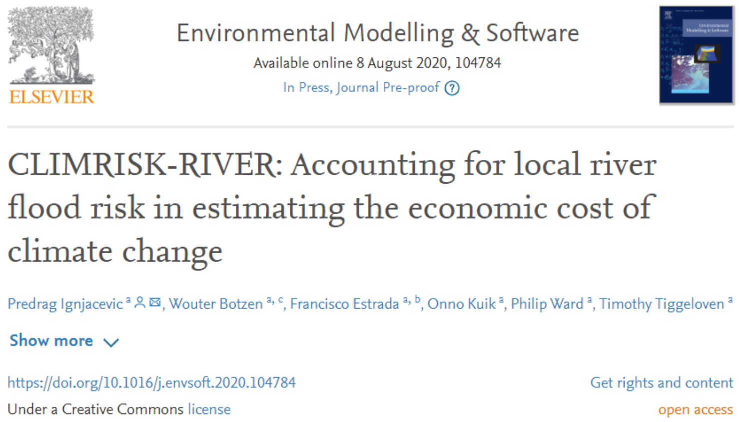


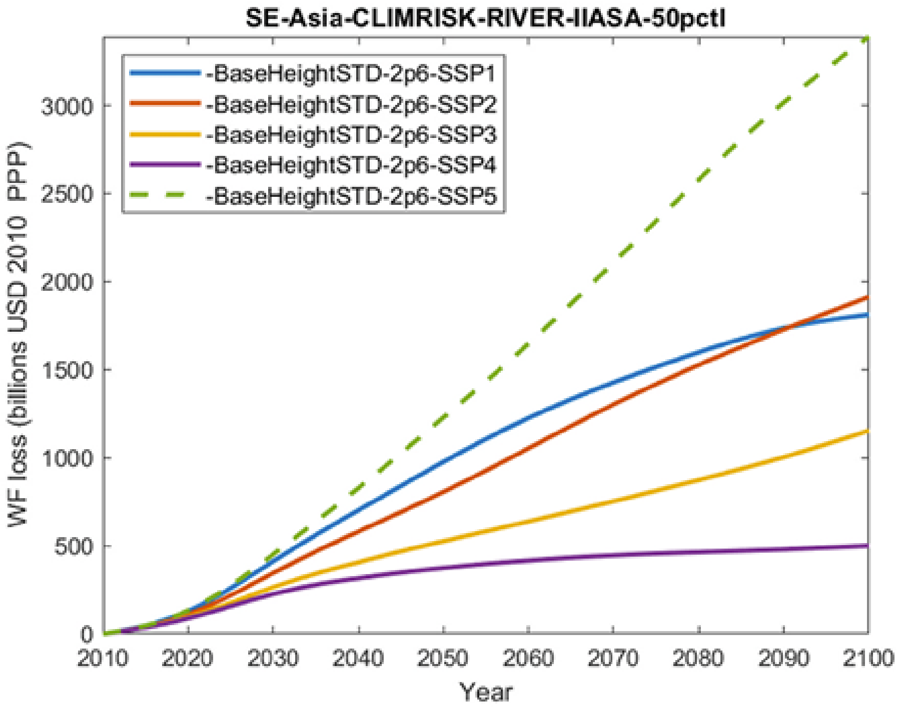
Figure 3.6: Discounted total ΔEAD in the world. The fill color represents the severity of damage under the *BaselineStd* flood protection assumption and RCP 6.0 climate scenario.

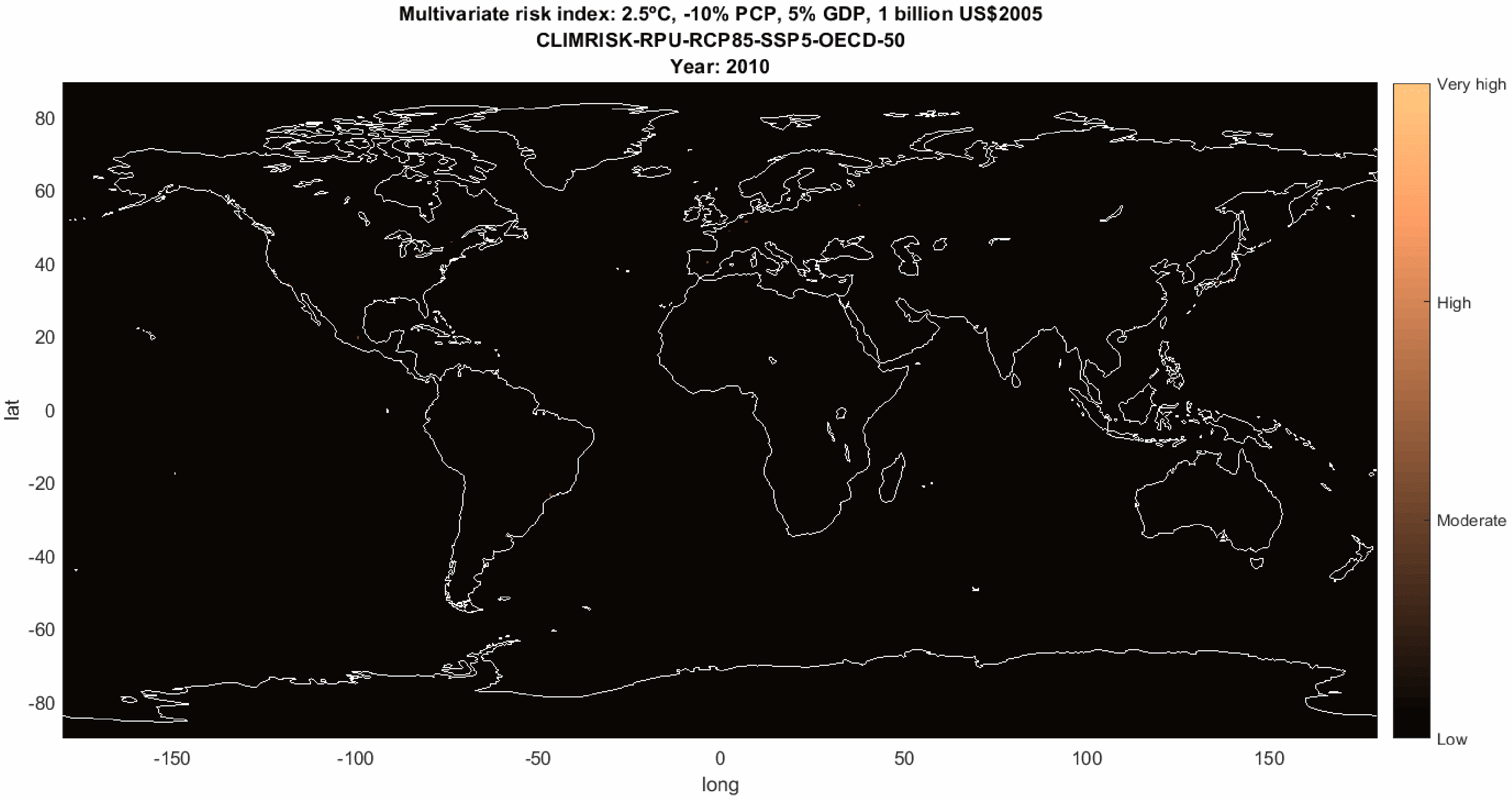

ELSEVIER
Environmental Modelling & Software
Available online 8 August 2020, 104784
In Press, Journal Pre-proof

CLIMRISK-RIVER: Accounting for local river flood risk in estimating the economic cost of climate change

Predrag Ignjacevic [a], Wouter Botzen [a, c], Francisco Estrada [a, b], Onno Kuik [a], Philip Ward [a], Timothy Tiggeloven [a]
Show more

https://doi.org/10.1016/j.envsoft.2020.104784





Estrada F., Botzen W.J.W., 2021. Economic impacts and risks of climate change under failure and success of the Paris Agreement. Ann. N.Y. Acad. Sci. https://doi.org/10.1111/nyas.14652

CLIMRISK:

Integrated Assessment Model for Physical Risks

Thank you for your attention

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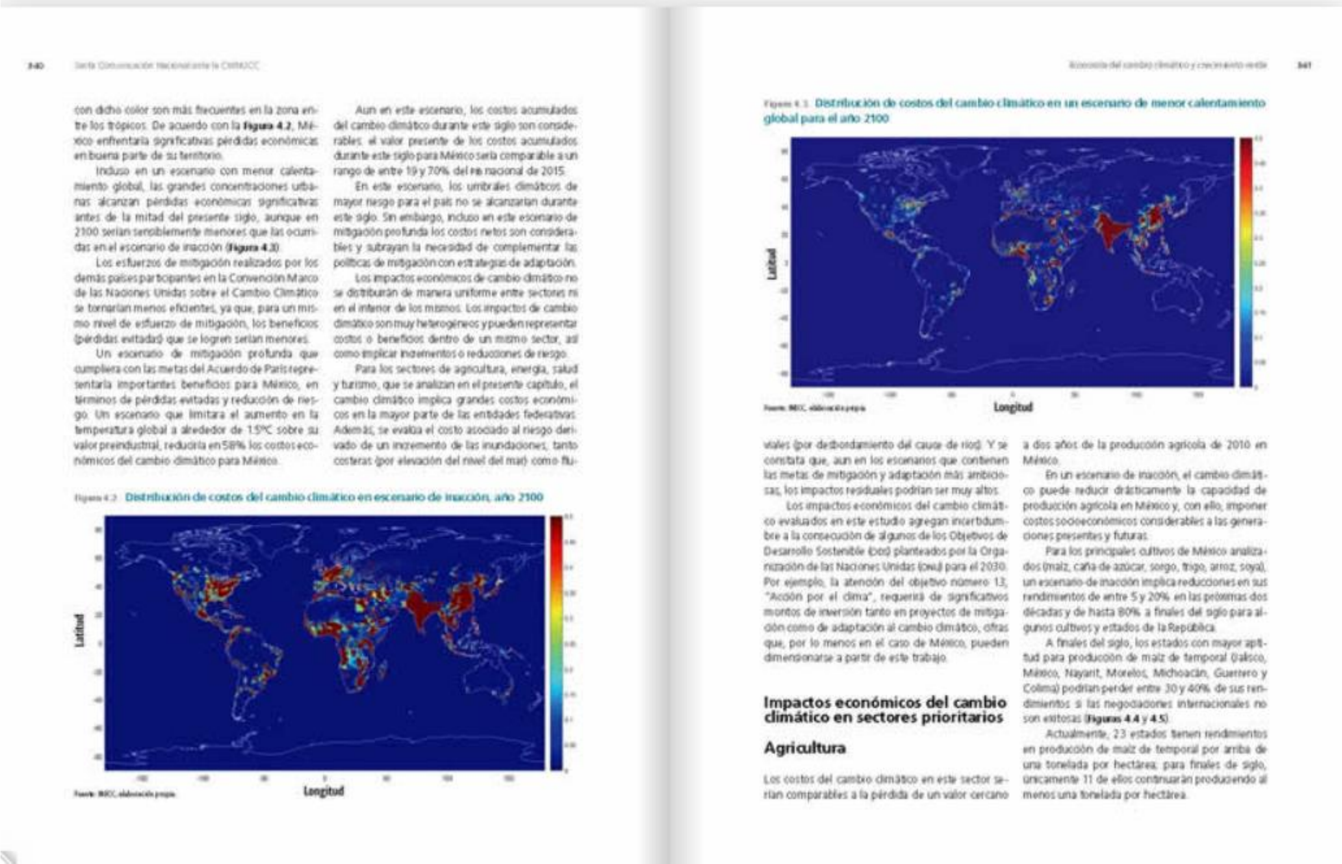
Experiencia internacional en el uso del modelo ClimRisk

INECC
INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO



COACCH
CO-DESIGNING THE ASSESSMENT OF CLIMATE CHANGE COSTS

IVM Institute for Environmental Studies

VU

Wouter J.W. Botzen
Francisco Estrada Porrua
Predrag Ignjacevic
Onno Kuik
Max Tesselaar

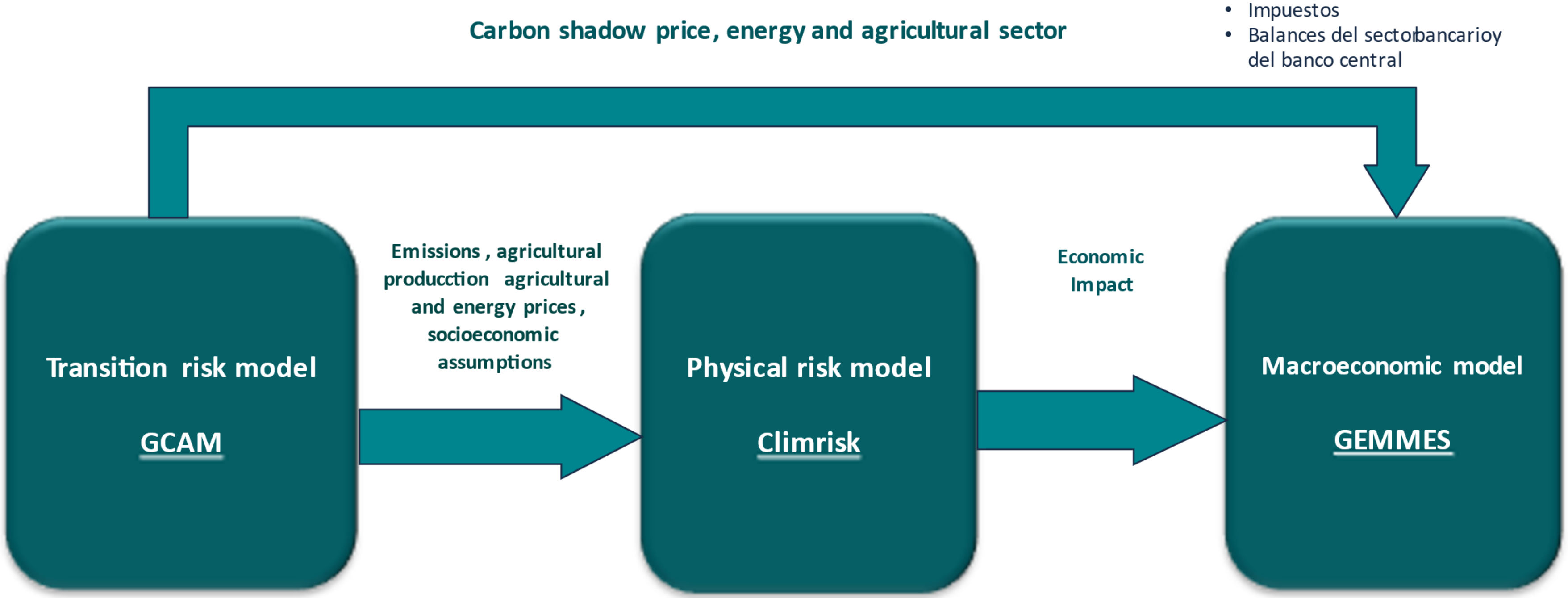
- Fondazione Centro Euro-Mediterraneo Sui Cambiamenti Climatici (FONDAZIONE CMCC), Italy (project coordinator)
- Paul Watkiss Associates Ltd (PWA), United Kingdom
- Internationales Institut Fuer Angewandte Systemanalyse (IIASA), Austria
- Universitaet Graz (UNI GRAZ), Austria
- Stichting Vu (STICHTING VU), Netherlands
- Ecologic Institut gemeinnützige GmbH (ECOLOGIC), Germany
- Univerzita Karlova (CUNI), Czech Republic
- PBL Netherlands Environmental Assessment Agency (PBL), Netherlands
- Basque Centre for Climate Change - Klima Aldaketa Ikergai (BC3), Spain
- Climate Analytics gemeinnützige GmbH (CA), Germany
- Stichting Deltares (DELTARES), Netherlands
- Global Climate Forum EV (GCF), Germany
- Potsdam Institut fuer Klimafolgenforschung (PIK), Germany

European Union’s Horizon 2020 research and innovation programme
14 European organizations

Model suite

Calibration :

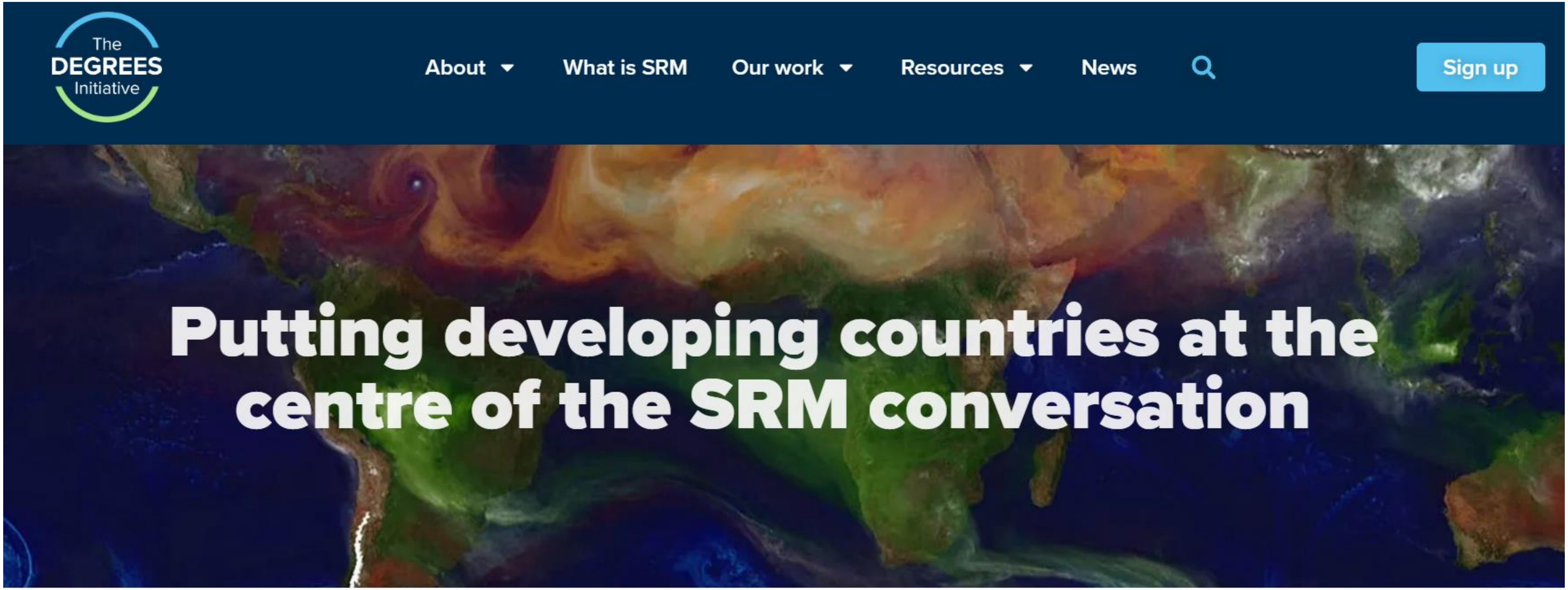
- Sistema decuentasnacionales
- Balanza de pagos
- Remesas
- Impuestos
- Balances del sectorbancarioy del banco central



Output: Emisiones GEI por sector económico, precio sombra del carbono, producción y consumo de 9 energías, generación de electricidad por tecnología, costos y precios, servicios de transporte, energía utilizada por tecnología de transporte y combustible utilizado, uso de la tierra (ejem. biomasa, cereales, bosque), extracción y consumo de agua por sector y por cuenca hidrográfica, precios de agua and costos de agua por cuenca, entre otras.

Output: La vulnerabilidad, los impactos y los riesgos con una resolución espacial de unos 50km x 50km para todo el mundo. Combinando escenarios probabilísticos de cambio climático global con el calentamiento local en zonas urbanas producido por la **UHI** para generar estimaciones de los impactos económicos del cambio climático y medidas de riesgo dinámicas uni y multivariadas .

Output: Variables macroeconómicas, como reservas, tipos de cambio nominales/reales, cotizaciones sociales, prestaciones, deuda de los hogares, déficit y deuda pública, PIB, balanza de cuenta corriente, posición de reserva bruta/neta en divisas, inversión internacional, desempleo, entre otras.



Socio-Political Fund Research Planning Workshop 2024

Assessing the economic risks and benefits for Latin America of an implementation of SRM options as a response to international climate policy failure

Publications related to CLIMRISK

- Estrada F., et al. 2024. Assessing the physical risks of climate change for the financial sector: a case study from Mexico's Central Bank. Submitted Ecological Economics.
- Estrada F., Lupi V., Botzen W.J.W, Tol R.S.J., 2024. Urban and non-urban contributions to the global and regional social cost of carbon. Working paper.
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- Estrada F., Botzen W.J.W., Tol R.S.J., 2023. Economic consequences of the spatial variation and temporal variability of climate change. *Nature Communications* (in review) .
- Estrada, F., Mendoza-Ponce, A., Murray, G., Calderón-Bustamante, O., Botzen, W., De León Escobedo, T., Velasco, J. A. 2023. Model emulators for the assessment of regional impacts and risks of climate change: A case study of rainfed maize production in Mexico. *Front. Environ. Sci.* 11, https://doi.org/10.3389/fenvs.2023.1027545
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- Estrada F., Botzen W.J.W., Tol R.S.J., 2017. A global economic assessment of city policies to reduce climate change impacts. *Nature Climate Change* 7, 403–406. doi:10.1038/nclimate3301.
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- Estrada, F., Tol, R.S.J., & Gay-García, C., 2015. The persistence of shocks in GDP and the estimation of the potential economic costs of climate change. *Environmental Modelling and Software*, 69:155-165.
- Estrada F. & Tol R.S.J., 2015. Towards Impact Functions for Stochastic Climate Change. *Climate Change Economics* 06, 1550015 DOI: 10.1142/S2010007815500153