



ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA



## Scientific Literacy and transformative change for facing societal challenges

**Giulia Tasquier**

Dipartimento di Fisica e Astronomia "A. Righi", ALMA MATER STUDIORUM –  
Università di Bologna

- **Call:** H2020-SwafS-2018-2020 (Science with and for Society)
- **Type:** Coordination and Support Action (CSA)
- **Topic:** SwafS-01-2018-2019 (Open-schooling)
- **Length:** 36 months (September 2019 – August 2022)
- **Coordinator:** Erik Knain, Department of Teacher Education and School Research, University of Oslo
- **PARTNER:** 12 partners (7 countries)
- **SEAS website:**  
<https://www.seas.uio.no>



# SEAS overall aims

- 1) Promote *scientific literacy* and the skills necessary to ensure the development of a conscious citizenship capable of actively contributing to address the complex challenges of sustainability in real life
- 2) Identify fundamental principles and good practices needed to create and explore ways to expand science education beyond traditional school models, in particular to support *open-schooling networks*



**To achieve its aims, the project intends to** establish, coordinate, monitor and evaluate the collaboration of 6 open schooling networks in 6 different countries (Austria, Belgium, Estonia, Italy, Norway and Sweden).

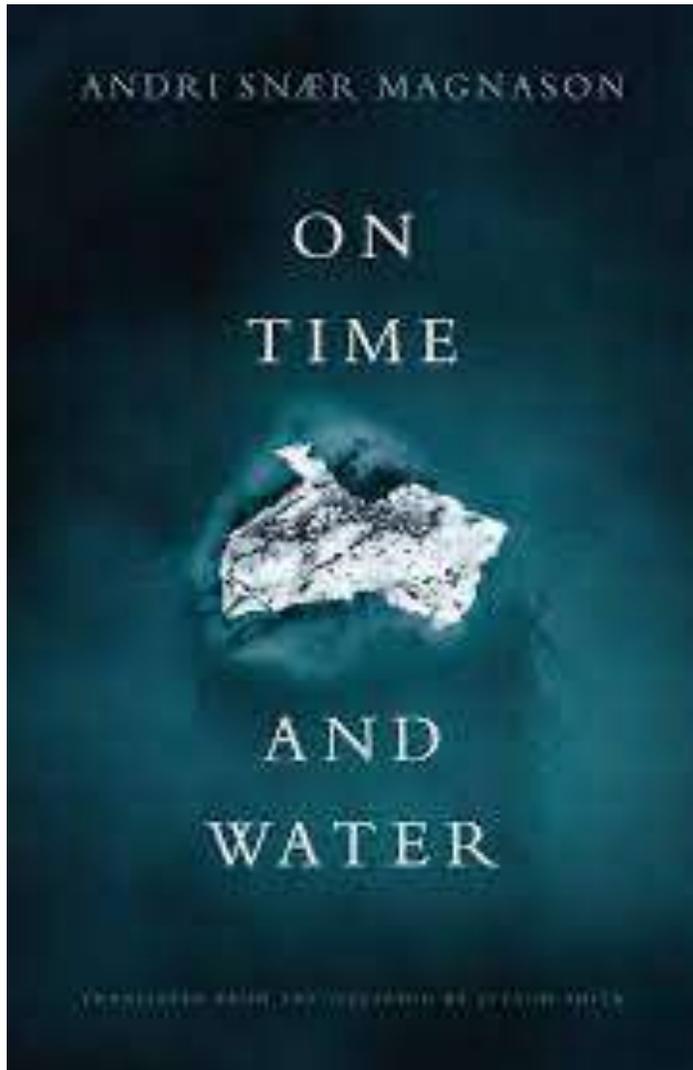
- The networks represent **multi-actor local communities**, linked to the territorial contexts of individual countries, based on collaborations between schools and other institutions / organizations, which aim to involve teachers, students and their families in contemporary challenges related to sustainability and complexity
- The networks aim to develop **open schooling models** that can support institutions, both school and extra-curricular, in promoting responsible citizenship skills



Da dove nasce il progetto SEAS e come si colloca?

**SEAS**





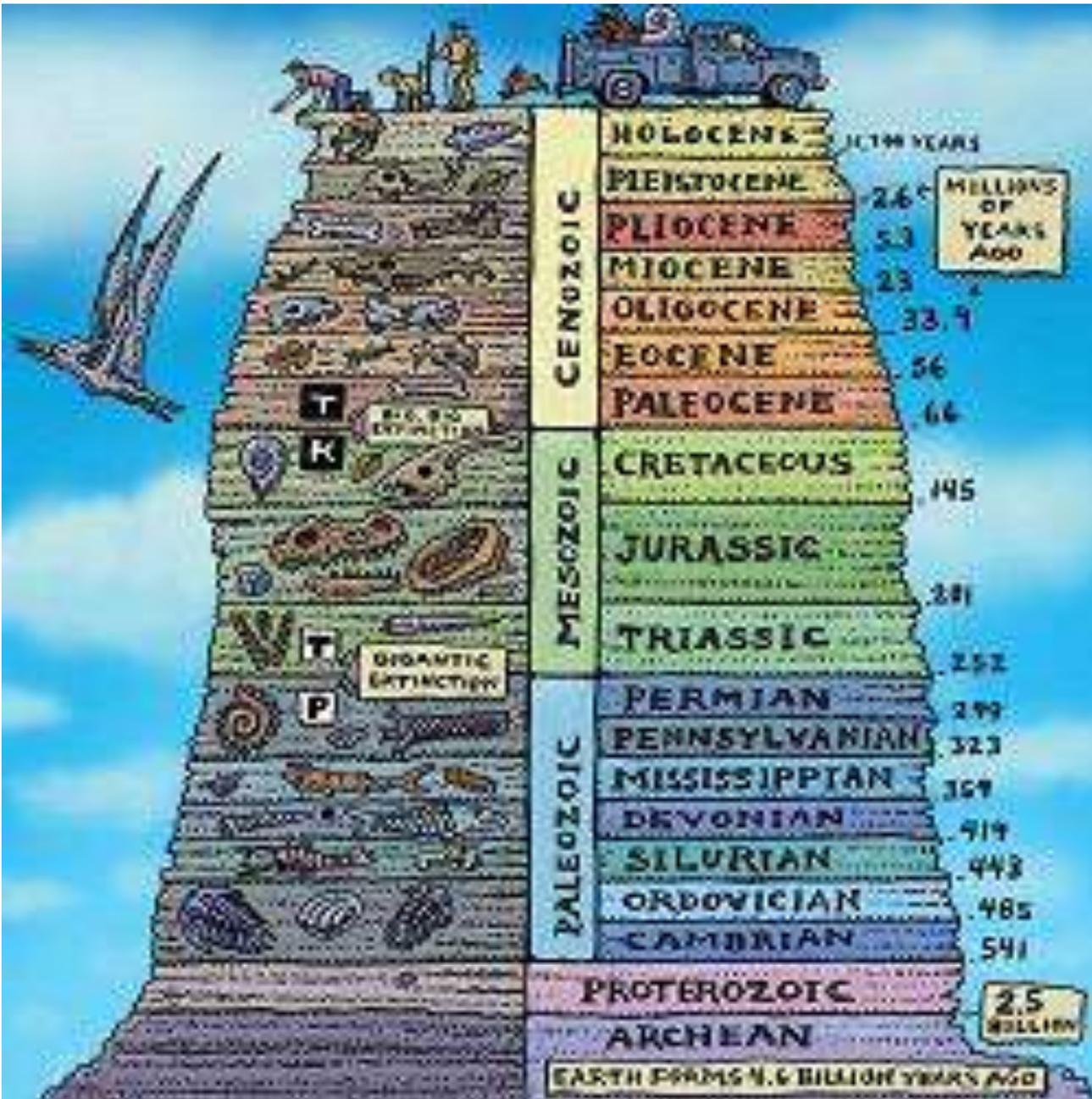
«The great forces of the Earth have abandoned geological times to change at the pace of man. Changes that previously occurred in thousands of years are now occurring in a hundred. It is a speed that has the flavour of myth: it involves every form of life on our planet and has repercussions on the very foundation of everything we think, choose, produce and believe. It affects all the people we know, all the people we love. We are facing with changes much greater than what our mind is used to, more challenging than any of our previous experiences, more complex than the language and metaphors we use to orient ourselves in reality.»

(Andri Snær Magnason, *On Time and Water*

\* Freely translated \*)

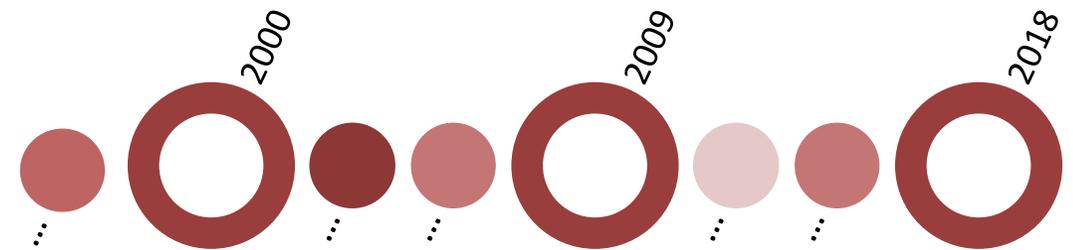


ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA



«Time is running out. Nature has left geological speed of change. Our reactions are still on a geological scale.»

(Andri Snaer Magnason, *On Time and Water*)



# Anthropocene

The biologist Eugene Storer and the chemist Paul Crutzen in 2000 coined and made popular the term **Anthropocene**, derived from the Greek words *anthropo*, for “man,” and *cene* for “new”. It represents an unofficial unit of geologic time, used to describe the most recent period in Earth’s history when human activity started to have a significant impact on the planet’s climate and ecosystems.



IMAGE

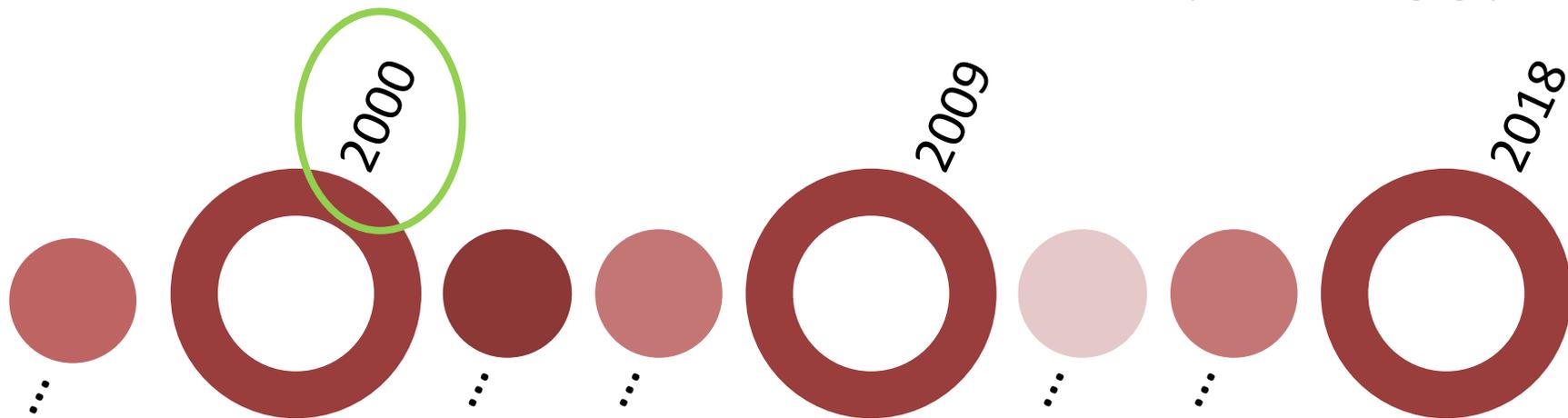
## mushroom cloud

Atomic bomb tests like this one at Bikini Atoll in 1946 not only reassured military personnel that the bomb worked, but also created a powerful new symbol of the destructive power of the human species: the mushroom cloud.

PHOTOGRAPH BY UNITED STATES NAVY



<https://www.nationalgeographic.org/encyclopedia/anthropocene/>

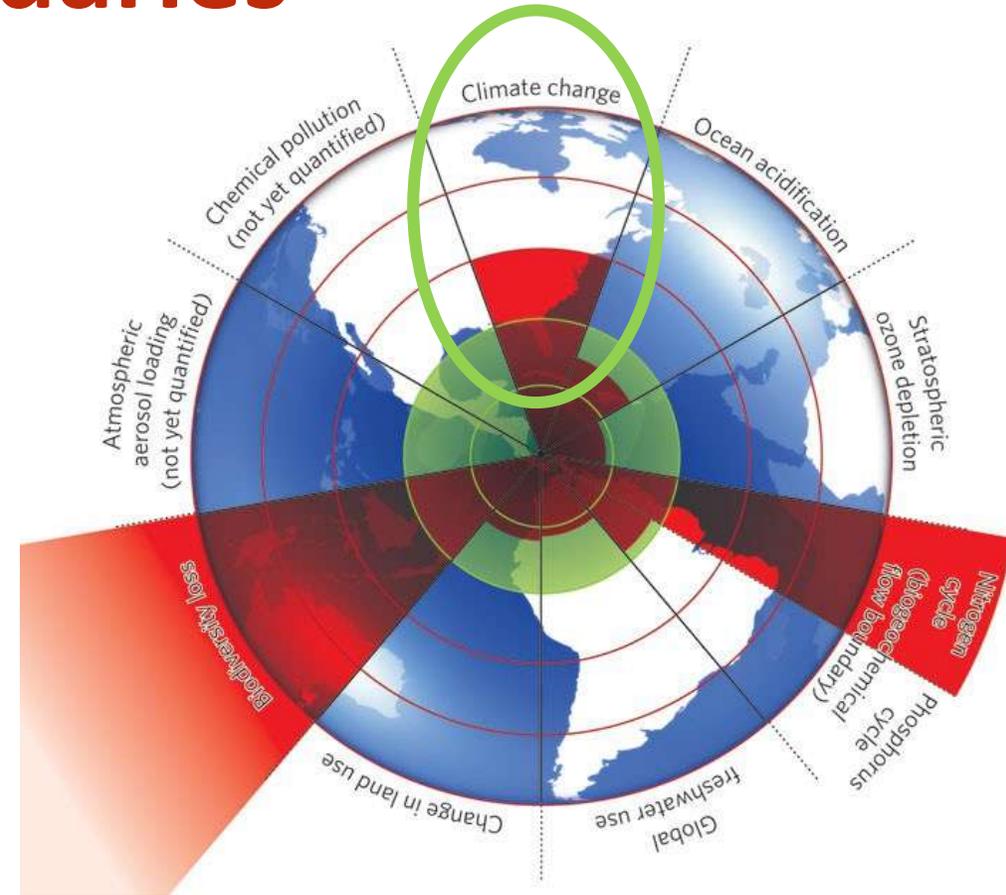


ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA

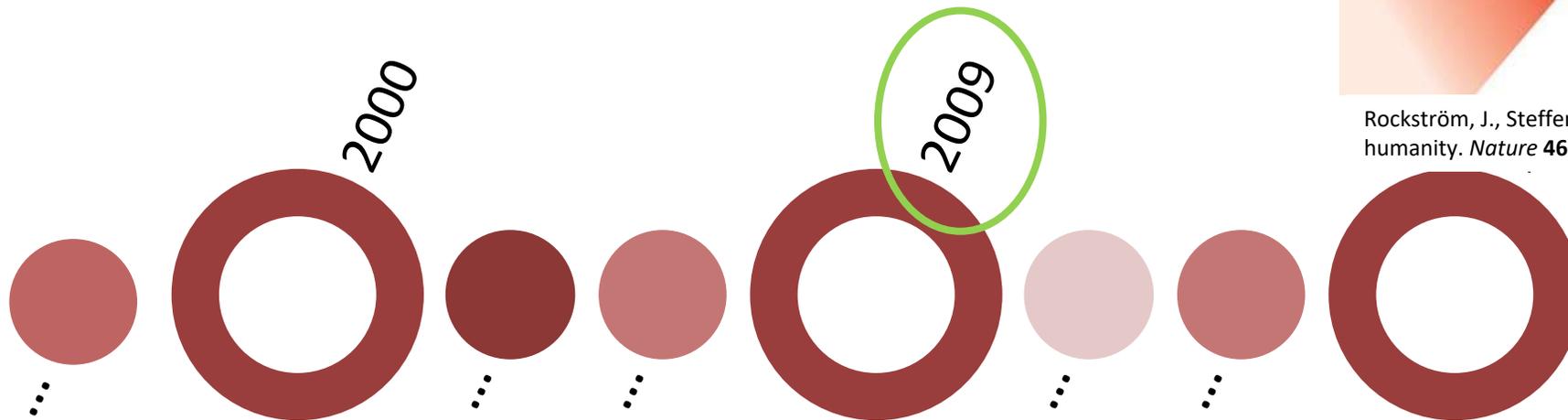
# Planetary boundaries



[https://www.ted.com/talks/johan\\_rockstrom\\_let\\_the\\_environment\\_guide\\_our\\_development?language=it](https://www.ted.com/talks/johan_rockstrom_let_the_environment_guide_our_development?language=it)

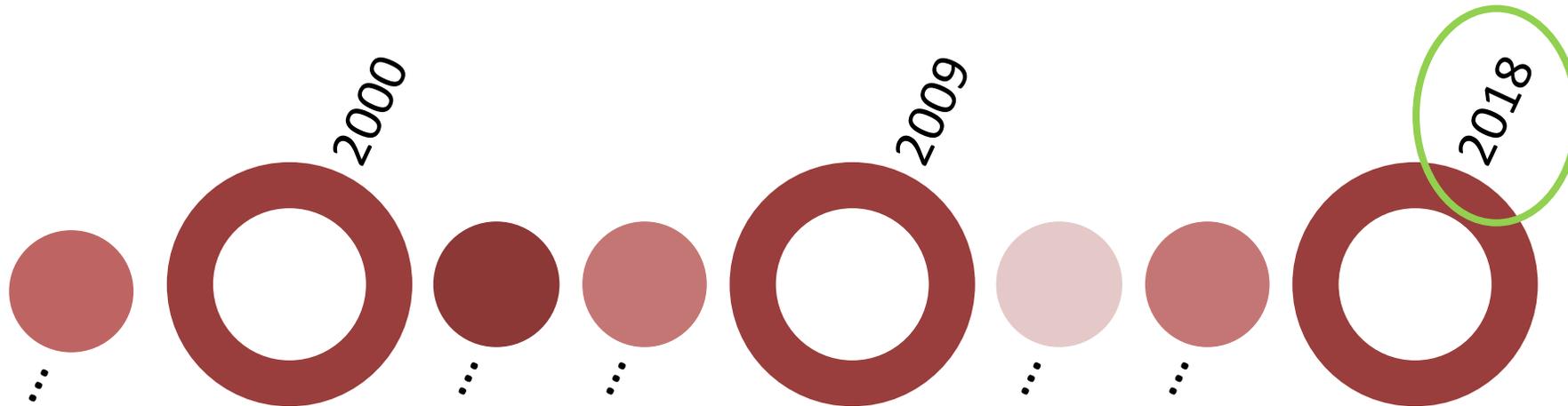
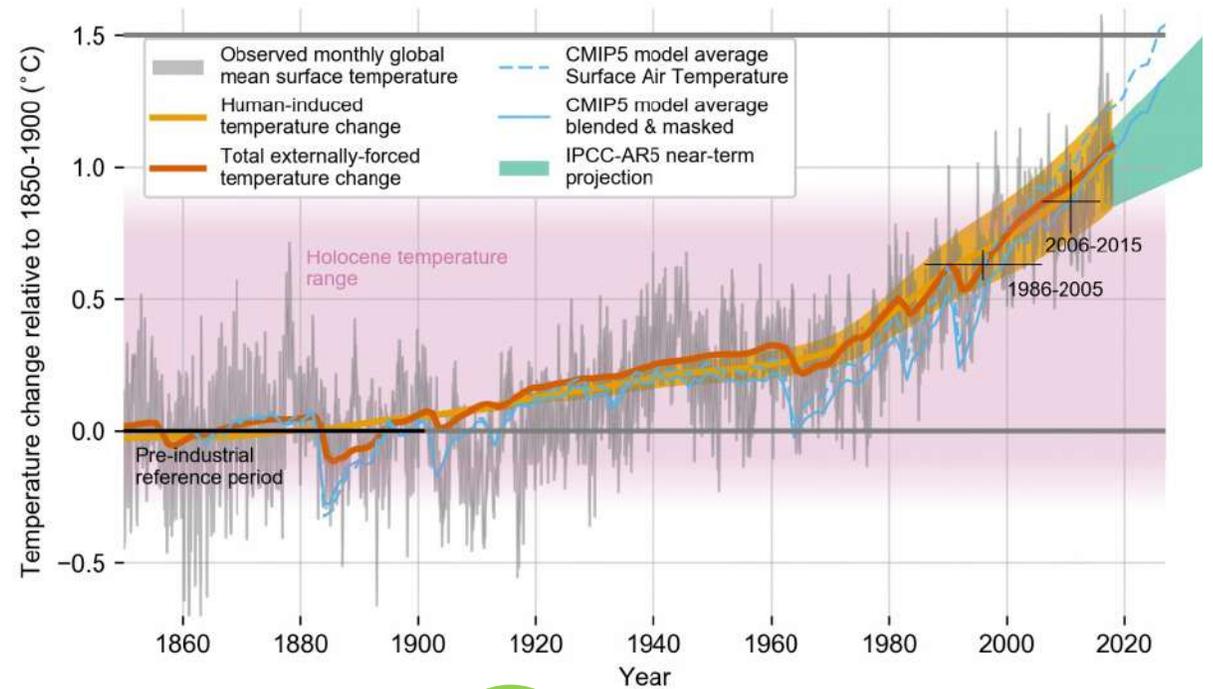


Rockström, J., Steffen, W., Noone, K. *et al.* A safe operating space for humanity. *Nature* 461, 472–475 (2009). <https://doi.org/10.1038/461472a>



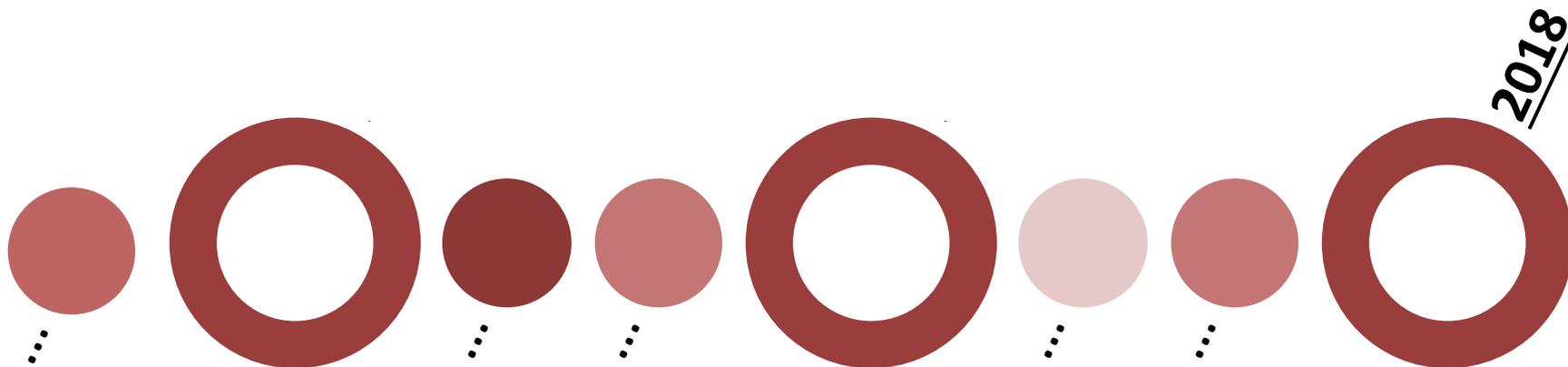
# IPCC Special report: Global Warming of 1.5°C

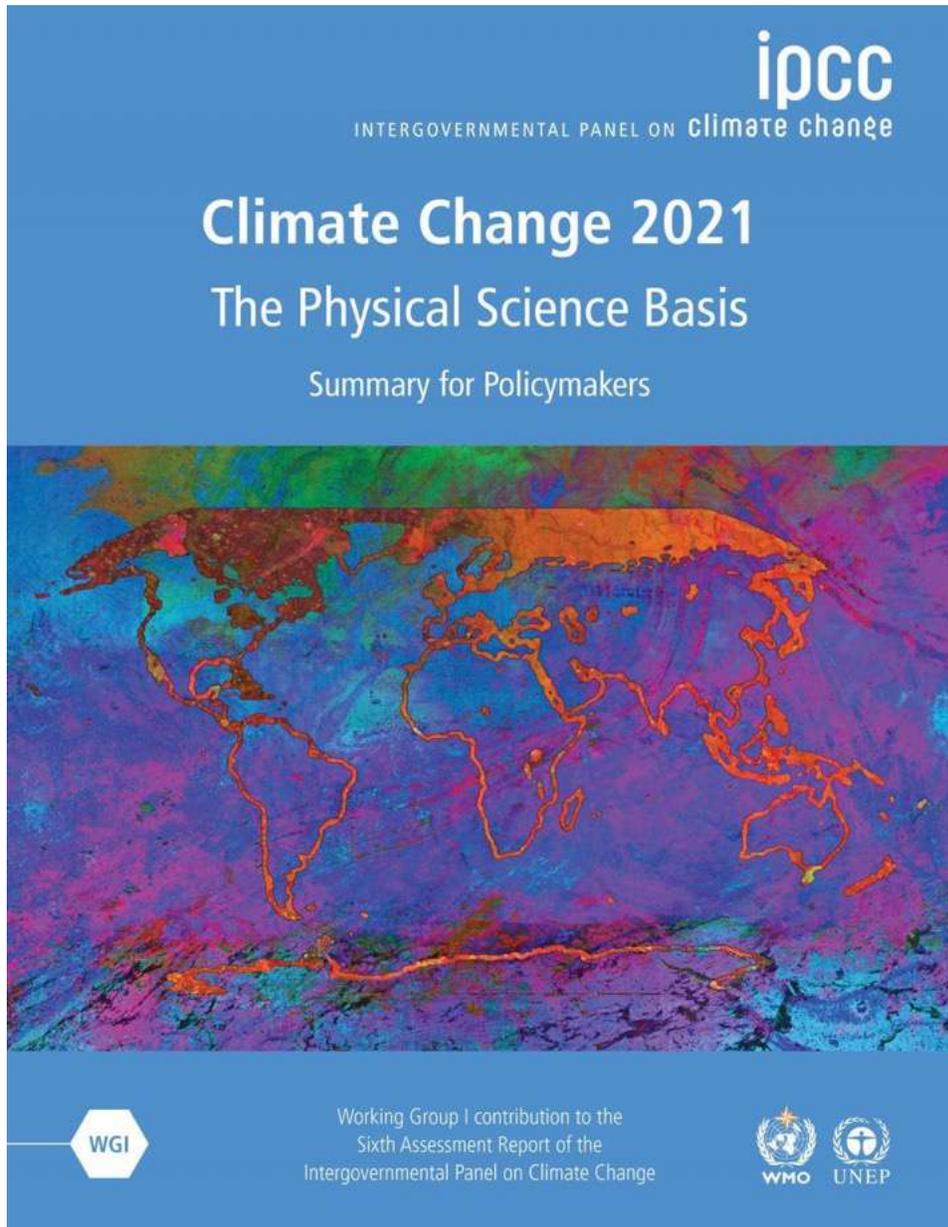
«Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (high confidence) (Figure SPM.1) {1.2}»



“We can’t solve a crisis without treating it as a crisis. We need to keep the fossil fuels in the ground, and we need to focus on equity. And if solutions within the system are so impossible to find, maybe we should change the system itself. ... We have come here to let you know that **change is coming, whether you like it or not.**”

(Grete Thunberg at COP24, Katowice, December 2018)





# IPCC 2021: warning!

In presenting the publication of the first part of the IPCC Assessment Report (AR6), dedicated to the physical understanding of the climate system and climate change (WGI), the UN Secretary stressed that this report should constitute **“a red code for humanity”** (McGrath, 2021).

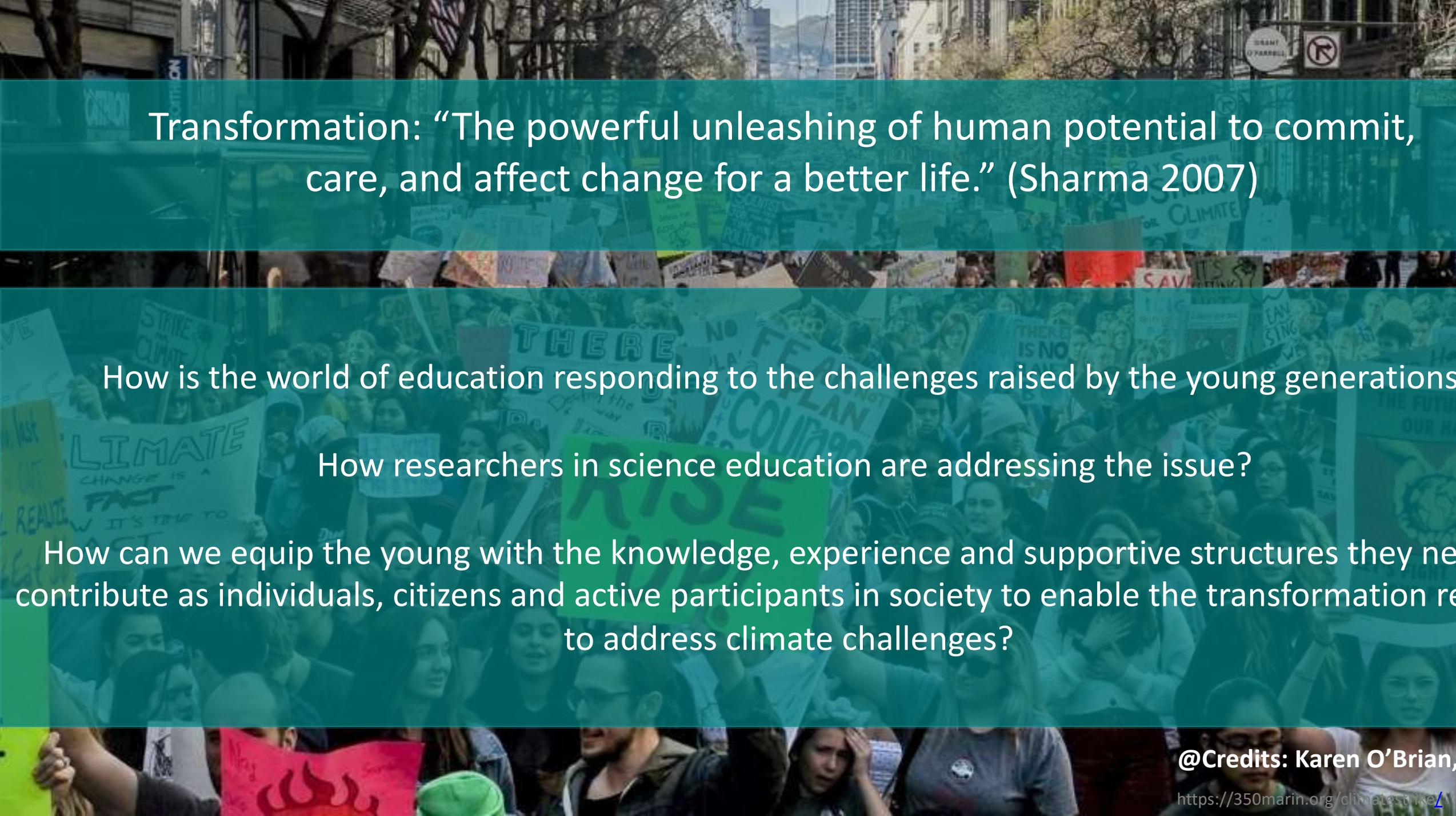


## *... How humans are reacting to all of this?*

- As a reaction to the the exponential speed of change, everyday citizens have a hard time catching up the sense of change and, feeling scared, **they don't want to know about science behind it.**
- Especially **the young generations fear for the future** and for the perception **that who is in power today gets stuck and is doing too little to deal with the global fast changes of society and climate change.**

(Eurobarometer, 2015; 2019)





Transformation: “The powerful unleashing of human potential to commit, care, and affect change for a better life.” (Sharma 2007)

How is the world of education responding to the challenges raised by the young generations?

How researchers in science education are addressing the issue?

How can we equip the young with the knowledge, experience and supportive structures they need to contribute as individuals, citizens and active participants in society to enable the transformation required to address climate challenges?

@Credits: Karen O’Brian,

<https://350marin.org/climatestrike/>



# Science Education for Action and Engagement towards Sustainability (SEAS)

We develop tools and methods that facilitate collaboration between schools and local communities facing sustainability challenges.

# SEAS



<https://www.seas.uio.no>



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824522



# Leverage Points for Systems Change



How do we transform at the scope, scale, speed and depth that is called for by global change research?

@Credits: Karen O'Brian, 2019

Finding a new perspective (from today's world) from which to look at the knowledge built in school

Open schooling



Transformative Change

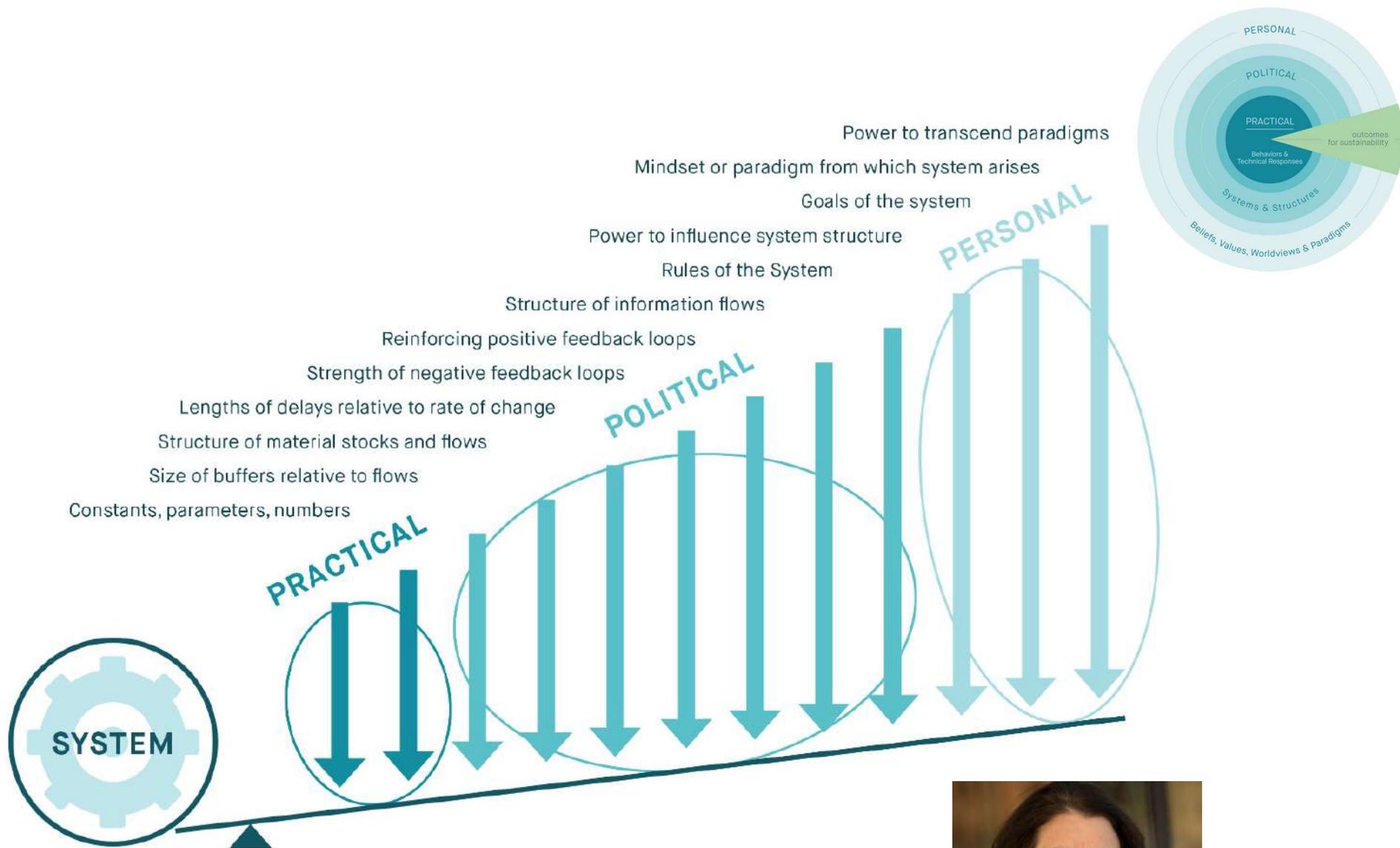
Scientific Literacy



- Change in the **practical sphere** (e.g. behaviours, practices and technical responses)
- Change in the **political sphere** (e.g. dynamics and institutional structures)
- Change in the **personal sphere** (e.g. values, beliefs, aims, world views)

- Connecting scientific knowledge to beliefs, values and interests ((Knain & Ødegaard, 2018)
- Use scientific knowledge as a means to activate socially sustainable behaviours and to actively participate in decision-making processes (Damsa & Jornet, 2016)

# Leverage Points for Systems Change



@Credits: Karen O'Brian, 2019



Based on: Meadows, D. H. 1999. "Leverage Points: Places to Intervene in a System." The Sustainability Institute.

Recognize the acting role of the individual and its importance in producing collective phenomena and **changing** the system.



Recognize that the system has properties that influence agents, **influencing** their individual behaviours.



UNIVERSITÀ DEGLI STUDI DI PALERMO

Corso di Dottorato di Ricerca in *Fisica applicata*  
 Indirizzo in *Scienze e Discipline delle Matematiche, della Fisica e della Chimica*  
 Dipartimento di Fisica e Chimica  
 SIC - PUGA

**LEADING SECONDARY SCHOOL STUDENTS TO FACE THE  
 DISCIPLINARY, EPISTEMOLOGICAL AND SOCIETAL  
 CHALLENGES OF CLIMATE CHANGE:  
 DESIGN AND ANALYSIS OF MULTI-DIMENSIONAL  
 TEACHING/LEARNING EXPERIENCES**

DOTTORANDO  
 GIULIA TASQUER

COORDINATORE  
 PROF. BERNARDO SPAGNOLO

REFERENTE DI DOTTORATO  
 PROF. AURELIO AGLIOLO GALLITTO

TUTORE  
 PROF. ROSAMARIA SPERANDEO MINEO

CO TUTORE  
 PROF. OLIVIA LEVINI

CICLO XXV - 2015

It's your time to imagine the future

SEE

The project is co-funded by the Erasmus Programme of the European Union (Grant Agreement No. 101015923-1)

**Science Education for  
 Action and engagement  
 towards Sustainability  
 (SEAS)**

Climate Change module



# Climate change module

**cCHALLENGE**  
(dall'individuale al collettivo)

(O'Brien & Sygna, 2013; <https://www.cchallenge.no>)



**Act for Future cCHALLENGE**  
Italy, 2020  
27 January – 25 February  
(<https://actforfuture.cchallenge.no>)

**Simulazione negoziati climatici**  
(dal collettivo all'individuale)

Sterman et al., 2015; <https://www.climateinteractive.org>

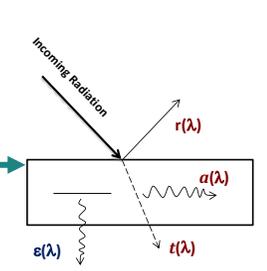
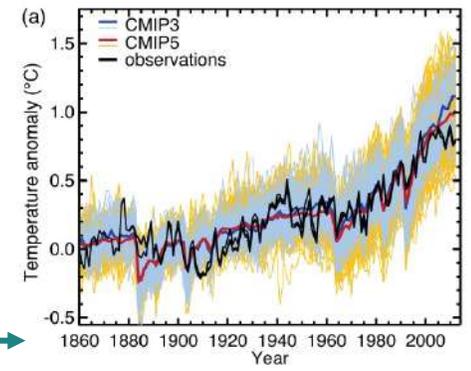


**NEW**



**NEW**

	Introduction to cCHALLENGE
1	Introduction to Climate Change: the scientific research and the new terms of the scientific controversy → [Climate Science, Math & Physics]
2	Experiments on examples of interaction between radiation and matter → [Experimental Physics]
3	Experiments on the construction of a Greenhouse model → [Experimental Physics]
4	Introduction to complex systems, modelling and simulation → [Science of complex system, Math & Physics]
5	Analysis of a scientific text, conversion into causal map and identification of feedback loops → [Linguistic, logic & Physics]
	Political and Economical scenarios: Role-play with a climate simulator → [Political, Economical and Sociological Science & Physics]



**Il modello predatore-preda**

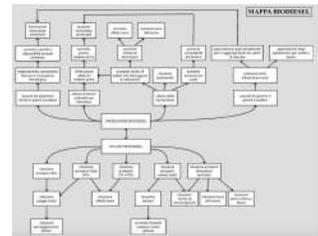
numero prede, coefficiente di nascita delle prede, coefficiente di predazione

$$\frac{dx}{dt} = (A - B)y)x$$

variazione del numero di prede, numero predatori

numero predatori, coefficiente di incontro tra prede e predatori, coefficiente di morte naturale dei predatori

$$\frac{dy}{dt} = (C)x - (D)y$$



# cCHALLENGE



## Act for Future cCHALLENGE

Italy, 2020  
27 January – 25 February  
(<https://actforfuture.cchallenge.no>)

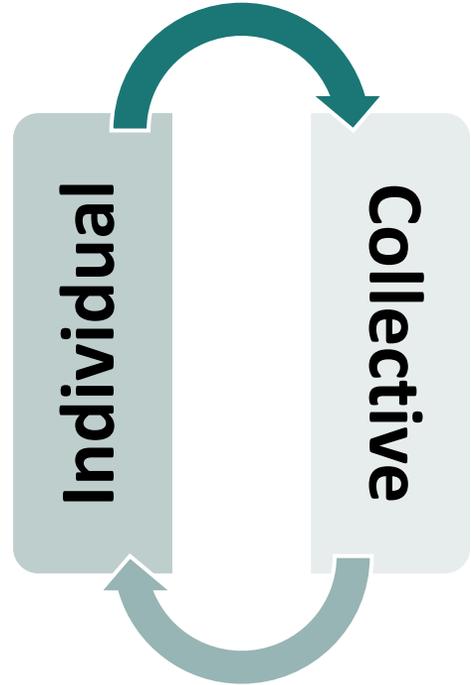
<https://www.cchallenge.no>

<https://www.changegame.org>

## Change Game



Recognize the acting role of the individual and its importance in producing collective phenomena and **changing** the system.



Recognize that the system has properties that influence agents, **influencing** their individual behaviours.

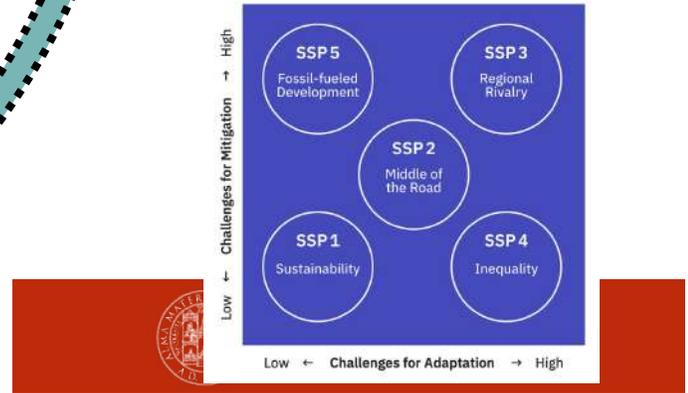


## Climate simulator

<https://www.climateinteractive.org>

<https://climatescenarios.org/primer/socioeconomic-development/>

## Climate scenarios



# System thinking

(Ben-Zvi Assaraf, 2005; Jacobson & Wilensky, 2006)



## Causal Knowledge

(Tasquier & Pongiglione, 2017)



## Scenario Narratives

(O'Neil et al., 2017)



# Examples



# Change Game



Use of dynamical tools (e.g. ChangeGame, Climate scenarios) to further explore the role of individual vs collective dynamics to establish reinforcing mechanisms that can drive a system transition towards the climate neutrality goal



# Tasks were created for putting in action individual strategies that build very different scenarios ...

PLS\_LUNA Codice: BYCLNFH2  
PLS\_SATURNO Codice: R4R4MEM3

COSTRUISCI CONDOMINI con aria condizionata

COSTRUISCI EDIFICI INDUSTRIALI

COSTRUISCI AGRICOLTURA INTENSIVA

COSTRUISCI CENTRALI A COMBUSTIBILI FOSSILI E TECNOLOGIE CHE RIMUOVONO CO2

USA ATTACCHI DI CORRUZIONE PER GUADAGNARE RISORSE

COSTRUISCI CASE SOSTENIBILI con parete verdi

COSTRUISCI FABBRICHE E AGRICOLTURA SOSTENIBILI

COSTRUISCI CENTRALI A FONTI RINNOVABILI

INVESTI IN SOLUZIONI BASATE SULLA NATURA

INVESTI IN PROGRAMMI EDUCATIVI e COLLABORA con le ALTRE CITTÀ NEL TUO PIANETA

PLS\_MARTE Codice: 8CF SR3ZG  
PLS\_GIOVE Codice: EZ5Y574F



- AL 59° TURNO DI GIOCO LA CITTÀ VIENE COLPITA DALLA SICCIITÀ E LA TEMPERATURA AUMENTA DA 0.1 GRADI A 0.2.
- AL 90° TURNO DI GIOCO LA CITTÀ VIENE COLPITA DA UNA INONDAZIONE E LA TEMPERATURA AUMENTA DA 0.2 GRADI A 0.3.
- AL 99° TURNO DI GIOCO LA CITTÀ VIENE COLPITA DALLA SICCIITÀ E LA TEMPERATURA AUMENTA DA 0.3 GRADI A 0.4.



#### FEEDBACK:

Se cresce la temperatura avvengono le catastrofi, se avvengono le catastrofi cresce la temperatura e così via.

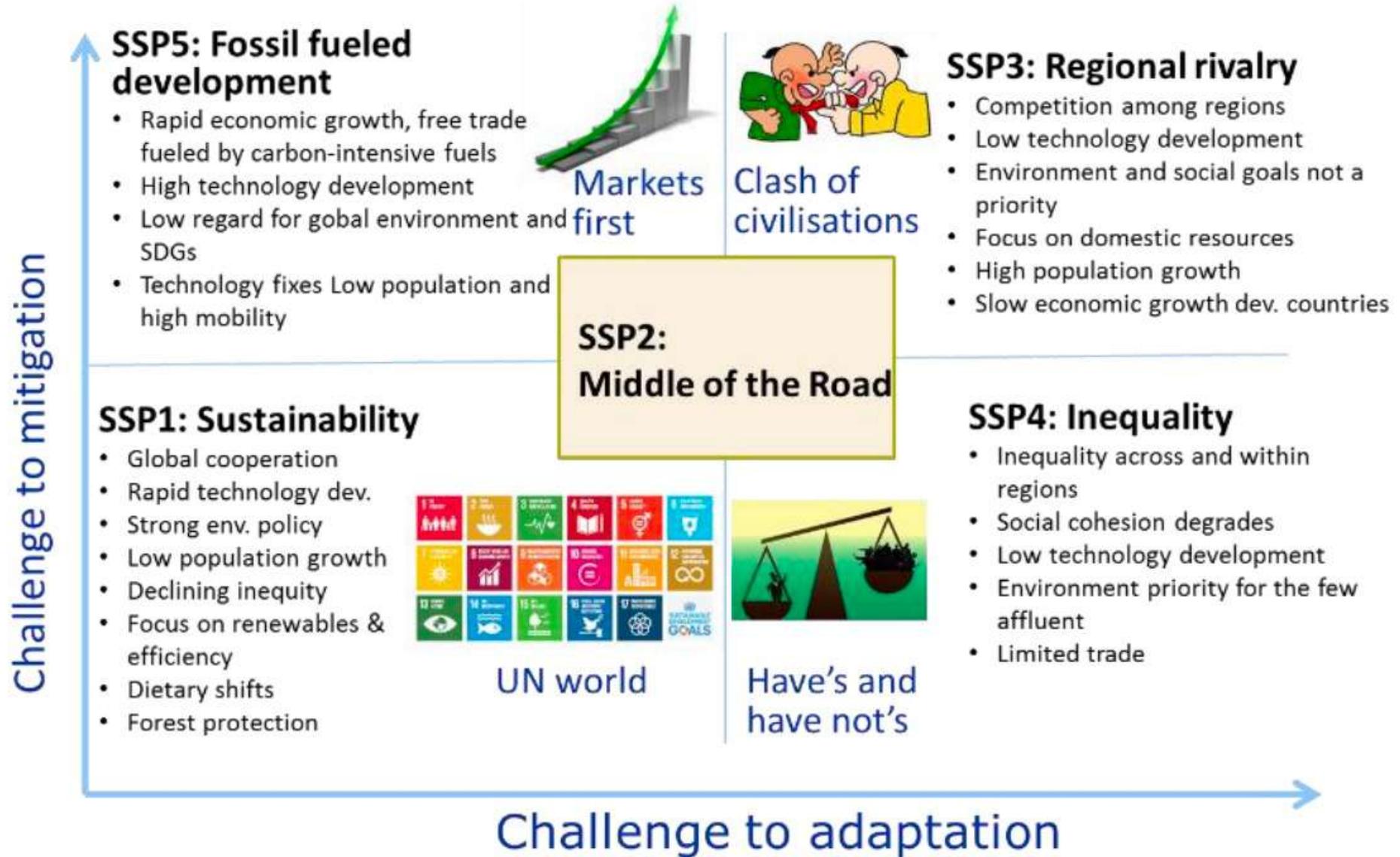
#### NON-LINEARITA':

L'aumento della temperatura, essendo non lineare fa sì che notiamo catastrofi sempre più ravvicinate nello svilupparsi dei turni di gioco.



# “Shared Socioeconomic Pathways” (SSPs) ...

## Climate scenarios



Over the past few years, an international team of climate scientists, economists and energy systems modellers have built a range of new “pathways” that examine how global society, demographics and economics might change over the next century. They are collectively known as the “**Shared Socioeconomic Pathways**” (**SSPs**).

The **SSPs** are **based on five narratives** describing broad socioeconomic trends that could shape future society. These are intended to span the range of plausible futures.

**SSP1** - a world of sustainability-focused growth and equality

**SSP2** - a “middle of the road” world where trends broadly follow their historical patterns

**SSP3** - a fragmented world of “resurgent nationalism”

**SSP4** - a world of ever-increasing inequality

**SSP5** - a world of rapid and unconstrained growth in economic output and energy use



**SSP1 Sustainability – Taking the Green Road (Low challenges to mitigation and adaptation)**

The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.

**SSP2 Middle of the Road (Medium challenges to mitigation and adaptation)**

The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.

**SSP3 Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation)**

A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

**SSP4 Inequality – A Road Divided (Low challenges to mitigation, high challenges to adaptation)**

Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle and high income areas.

**SSP5 Fossil-fueled Development – Taking the Highway (High challenges to mitigation, low challenges to adaptation)**

This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

**SSP1 and SSP5** envision relatively optimistic trends for human development, with **“substantial investments in education and health, rapid economic growth, and well-functioning institutions”**. They differ in that SSP5 assumes this will be driven by an energy-intensive, fossil fuel-based economy, while in SSP1 there is an increasing shift toward sustainable practices.

**SSP3 and SSP4** are more pessimistic in their future economic and social development, with **little investment in education or health in poorer countries coupled with a fast-growing population and increasing inequalities**.

**SSP2** represents a **“middle of the road”** scenario historical patterns of development are continued throughout the 21st century.

O'Neill, B. C., Kriegler, E., Ebi, K. L., et al. (2017). The roads ahead: narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change*, 42, 169-180.



# *How did the module impact?*

## *Research Results*

### *WORK IN PROGRESS ...*

- A preliminary analysis highlighted that tools trigger a dynamic to connect scientific knowledge and attitude to change behaviour (agency), they particularly seemed to:
  - i. making the science classroom a context **open to transformative change for society**;
  - ii. **including *values*** into scientific reasoning (*value-based science*)
  - iii. giving sense to science knowledge by **situating it in students' personal narratives** without losing the authenticity and authority of scientific teaching;





ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA

**Giulia Tasquier**

Department of Physics and Astronomy  
ALMA MATER STUDIORUM – University of Bologna

giulia.tasquier2@unibo.it

**Thank you!!**

[www.unibo.it](http://www.unibo.it)