What if?
From uncertain climate-economic scenarios to informed climate policy decisions

Giacomo Marangoni

Climate Action Lecture

TU Delft

November 9, 2023

CAN WE CONTROL CARBON DIOXIDE?

William D. Nordhaus

June 1975   WP-75-63

Can we control carbon dioxide?

- We can and we should.
- First suggestion of 2C as safe threshold for temperature stabilization.
- Optimal control starts only in 2020-centered period, which "implies that there is still a comfortable amount of time to continue research and to consider plans for implementation of carbon dioxide control if it is deemed necessary."

The precursor of Integrated Assessment Models
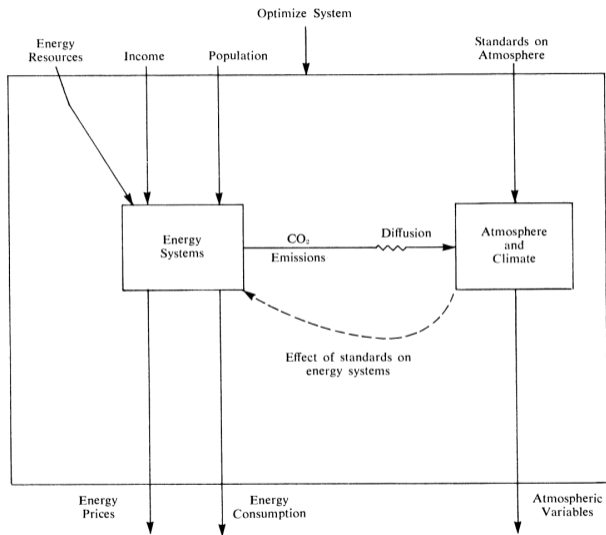
Nordhaus, 1977

41 years later

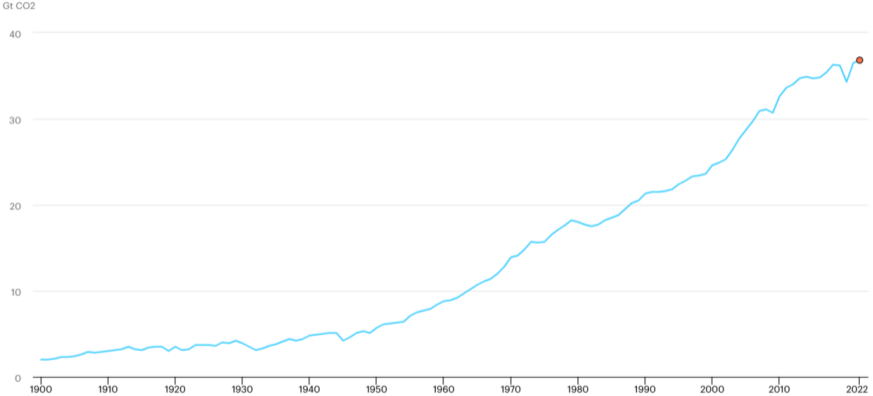Prize lecture: William D. Nordhaus, Prize in Economic Sciences 2018
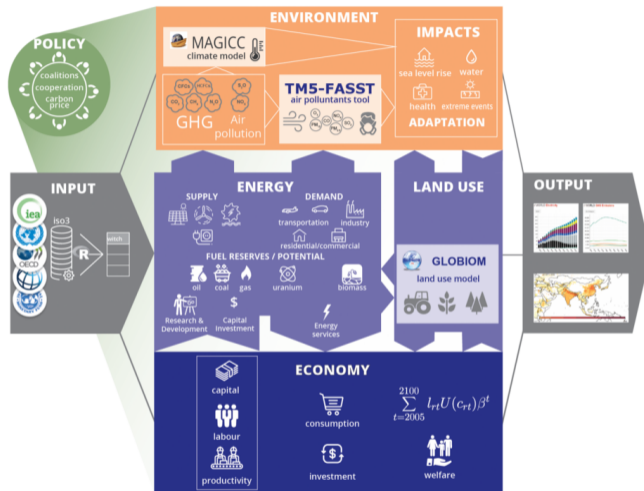
https://youtu.be/h1RkSuAs03Q

45 years later

Global CO2 emissions from energy combustion and industrial processes (IEA)

Integrated Assessment Models today

credits: icons from flaticon.com made by Freepik, EpicCoders, Chanut is Industries, Nikita Golubev, Eucalyp, Made by Made, Zlatko Najdenovski, OCHA, Madebyoliver, Vectors Market
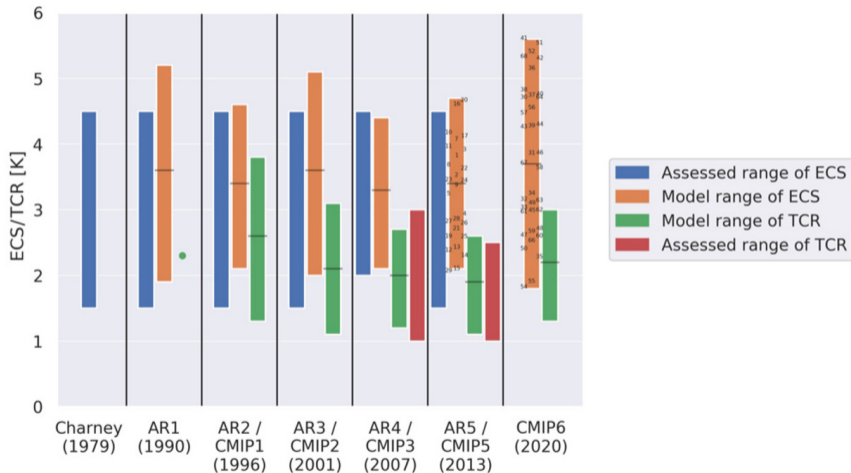
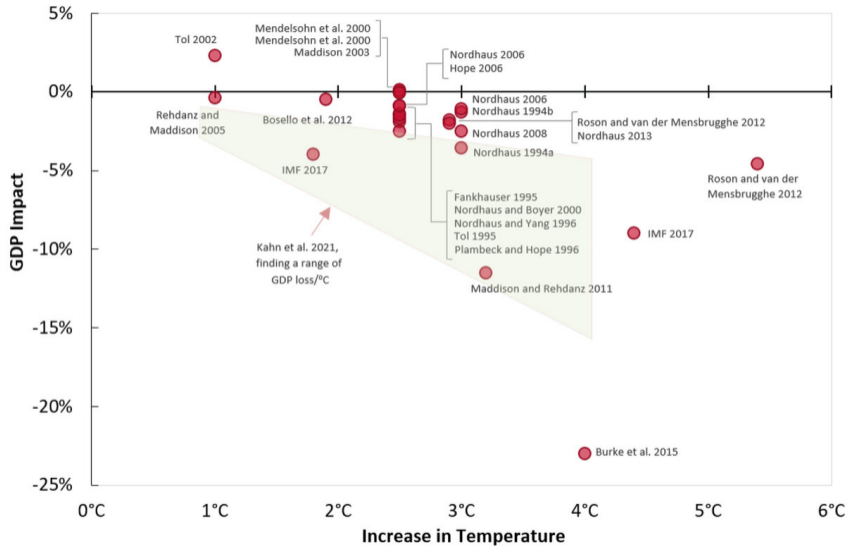# One big challenge: uncertainty

Harry Potter and the Prisoner of Azkaban (Warner Bros.)

Uncertainty: Climate response

Equilibrium climate sensitivity (gregory method) and transient climate response

Meehl et al. 2020

Uncertainty: Economic climate impacts

Kahn et al. 2021

Uncertainty: Socio-economic drivers

Socio-Economic Challenges to Mitigation	Socio-Economic Challenges to Adaptation		
	Low	**Medium**	**High**
High	**SSP5: Fossil-fuelled development** • low population • very high economic growth per capita • high human development • high technological progress • ample fossil fuel resources • very resource intensive lifestyles • high energy and food demand per capita • economic convergence and global cooperation		**SSP3: Regional rivalry** • high population • low economic growth per capita • low human development • low technological progress • resource-intensive lifestyles • resource-constrained energy and food demand per capita • focus on regional food and energy security • regionalization and lack of global cooperation
Medium		**SSP2: Middle of the road** • medium population • medium and uneven economic growth • medium and uneven human development • medium and uneven technological progress • resource-intensive lifestyles • medium and uneven energy and food demand per capita • limited global cooperation and economic convergence	
Low	**SSP1: Sustainable development** • low population • high economic growth per capita • high human development • high technological progress • environmentally oriented technological and behavioural change • resource-efficient lifestyles • low energy and food demand per capita • economic convergence and global cooperation		**SSP4: Inequality** • Medium to high population • Unequal low to medium economic growth per capita • Unequal low to medium human development • unequal technological progress: high in globalized high-tech sectors, slow in domestic sectors • unequal lifestyles and energy /food consumption: resource intensity depending on income • Globally connected elite, disconnected domestic work forces

https://tntcat.iiasa.ac.at/SspDb/

Uncertainty: Technological

IPCC AR6 WG3 Summary for Policy Makers 2022
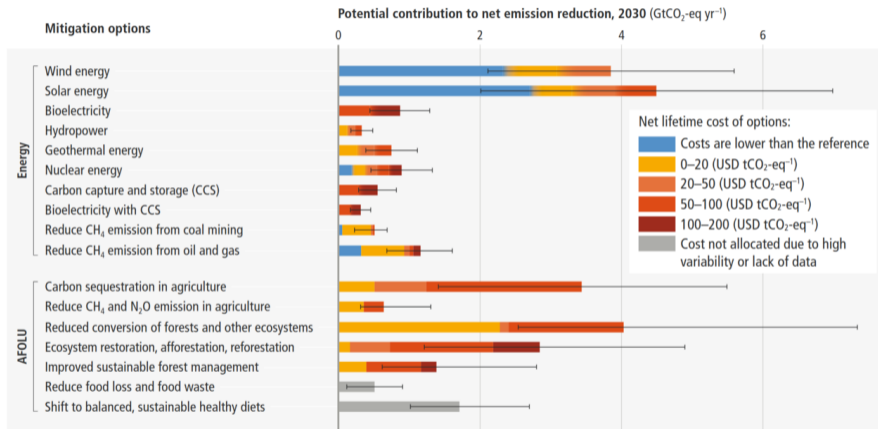
Other uncertainties

- Discount rates
- Elasticity of substitution between factors of production
- Adaptation costs
- Istitutional development
- Systemic links
- ...

What to do?
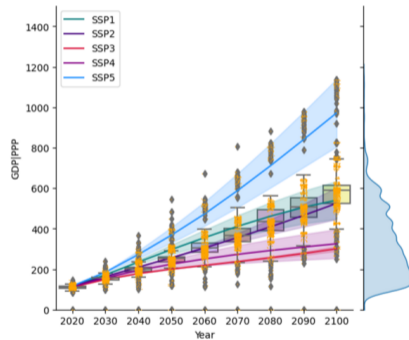
Ensembles of scenarios: Scenario explorer

https://data.ece.iiasa.ac.at/ar6/

Dimensionality reduction
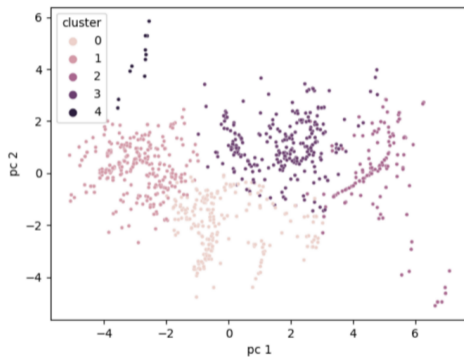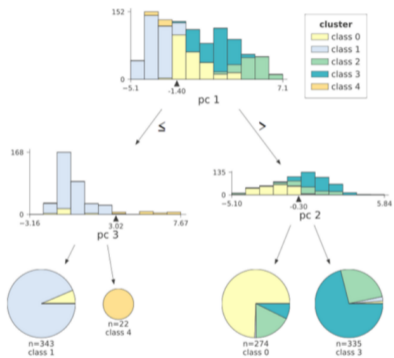
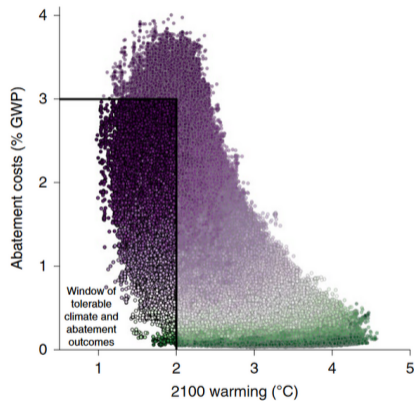# Under/over representation
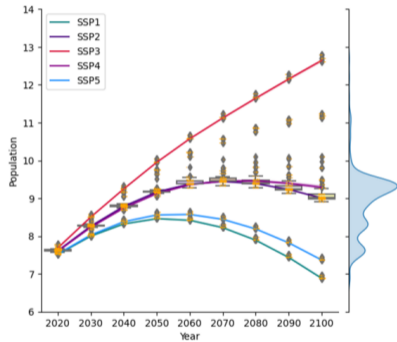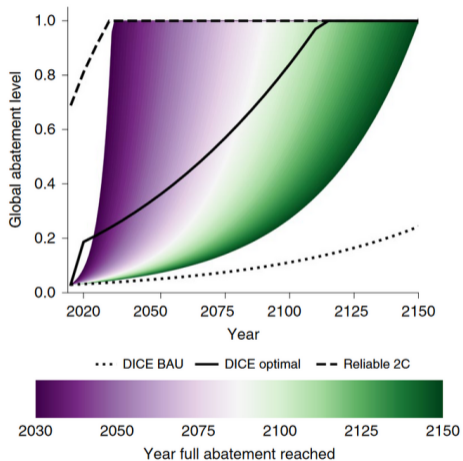

Giarola, Marangoni et al. - WIP
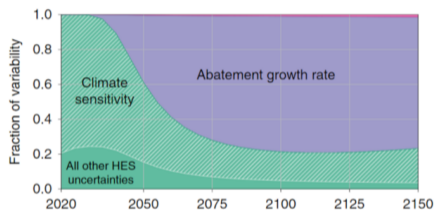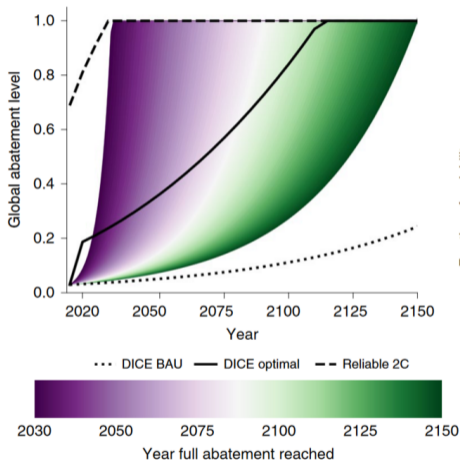
What drives emissions the most?

% Change in Cumulative CO2 Fossil Fuels Emissions 2010-2050 wrt SSP2 under BAU

SSP2 → SSP1

Legend:
- GEM-E3
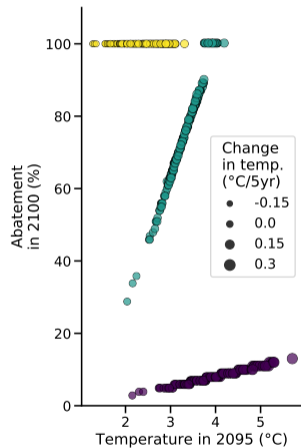- IMACLIM
- IMAGE 3.0
- MESSAGE-GLOBIOM_1.0
- TIAM-UCL
- WITCH-GLOBIOM

X-axis: TOTAL, POP, GDPPC, END, FF, LC

Marangoni et al. 2017

What drives emissions the most?

% Change in Cumulative CO2 Fossil Fuels Emissions 2010-2050 wrt SSP2 under BAU
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Legend:
- GEM-E3
- IMACLIM
- IMAGE 3.0
- MESSAGE-GLOBIOM_1.0
- TIAM-UCL
- WITCH-GLOBIOM

Labels: Individual Effect, Total Effect, Interaction Effect

X-axis: TOTAL, POP, GDPPC, END, FF, LC

Marangoni et al. 2017

Does climate action matter?

Lamontagne, Marangoni et al. 2019

Does climate action matter?

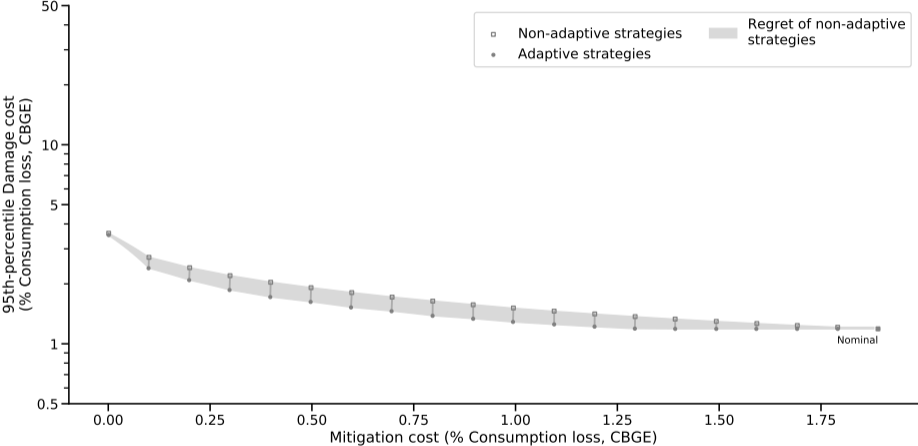

Lamontagne, Marangoni et al. 2019
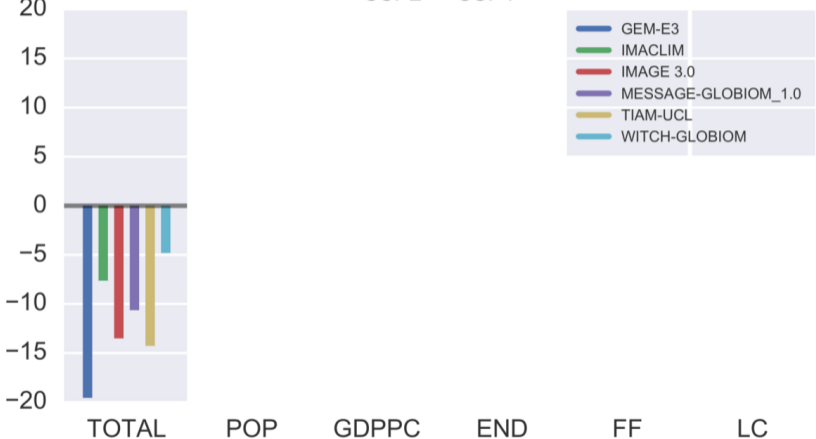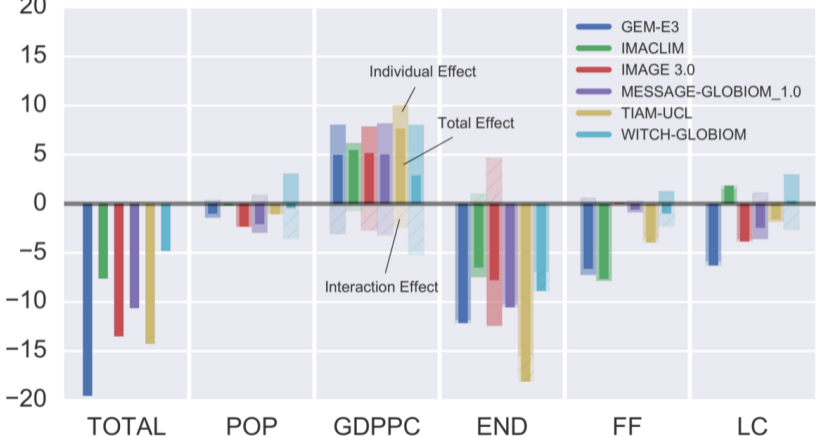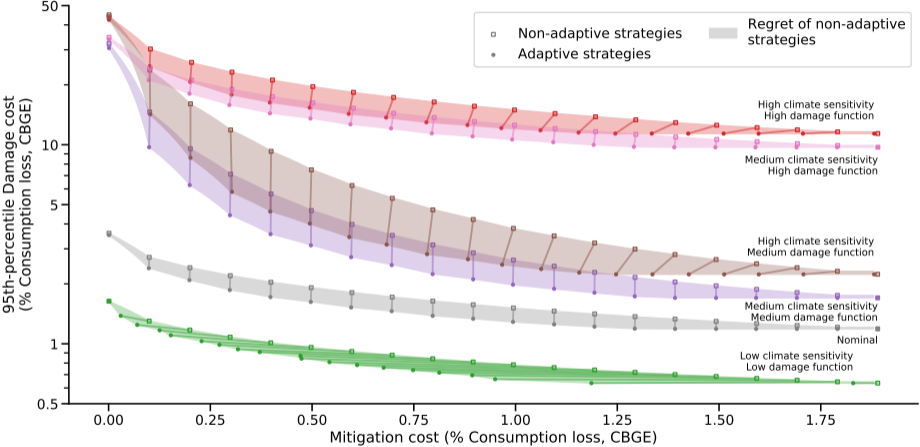
Decision space
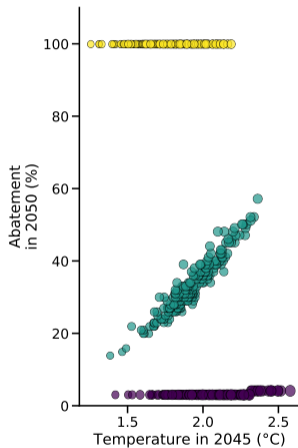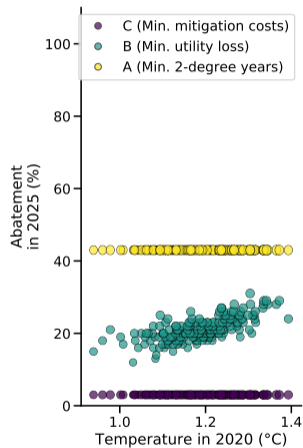
Marangoni et al. 2021

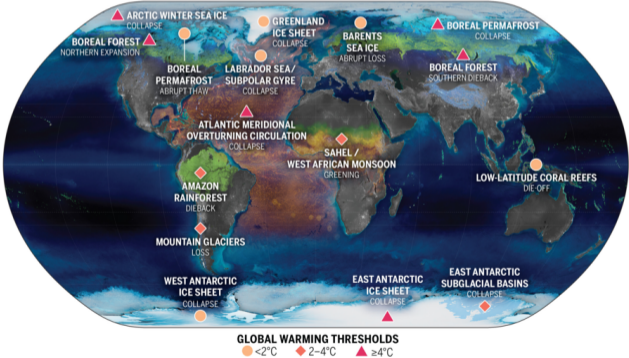# Adaptive strategies hedge extreme climate futures

Marangoni et al. 2021

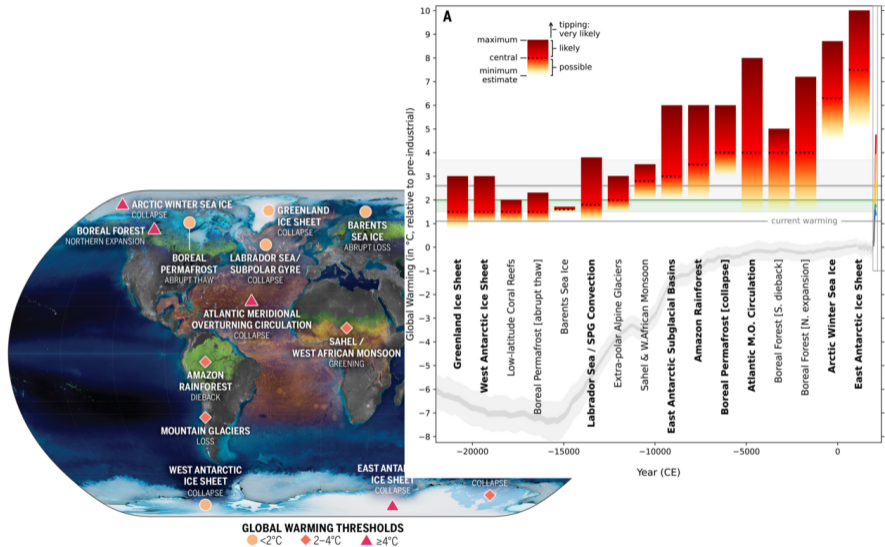# Adaptive strategies hedge extreme climate futures
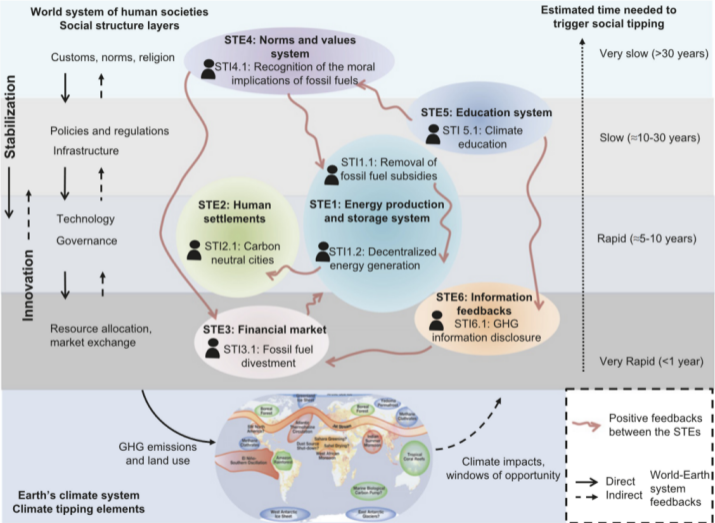

Marangoni et al. 2021

Tipping points
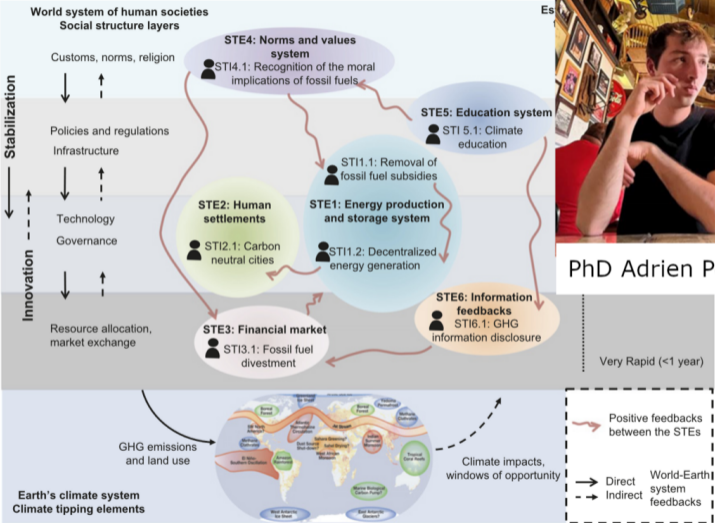

McKay et al. 2022

Tipping points
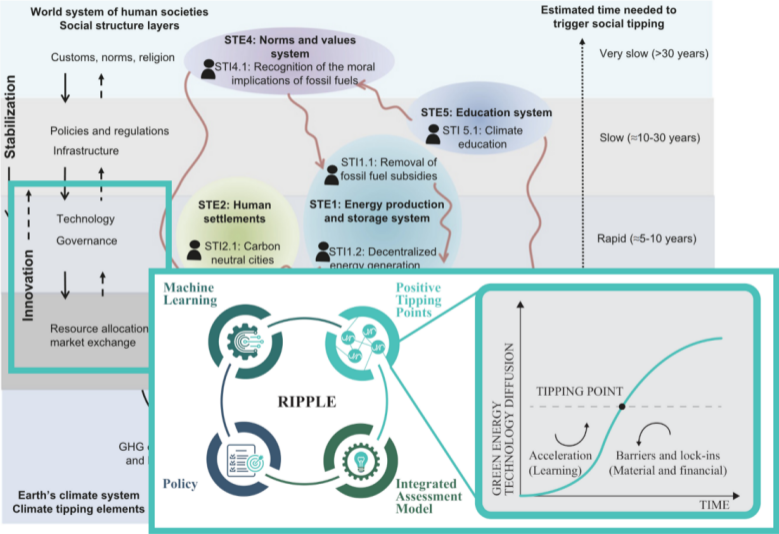

McKay et al. 2022

Socio-technical tipping points

Otto et al. 2020

Socio-technical tipping points
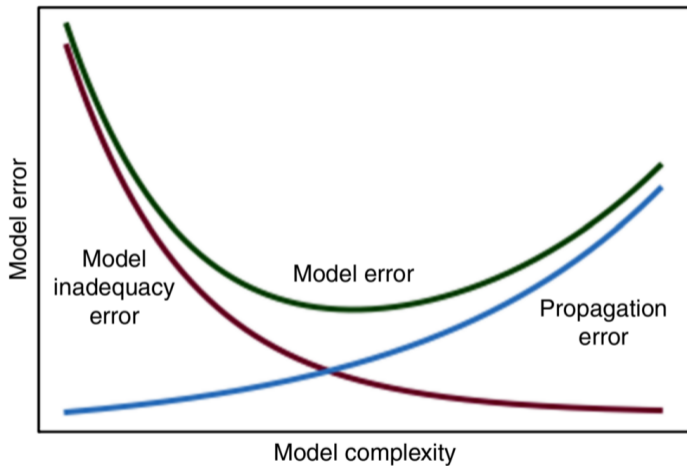

PhD Adrien Poujon

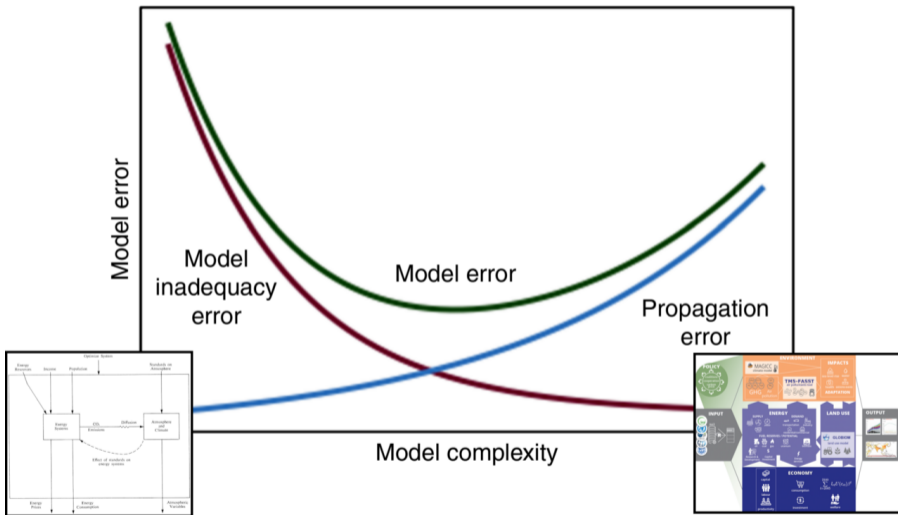# Socio-technical tipping points

One last thought: complexity

Saltelli 2019

One last thought: complexity

Thank you!

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