



# Open Source for Climate

## Focus on WITNESS Integrated Assessment Model and health related aspects included

CAFÉ conference  
February 5-7<sup>th</sup> 2024

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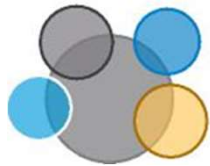


OS-C Transition risk tool development is proudly sponsored by

# Linux Foundation Open Source for Climate (OS-Climate or OS-C)



Applying the community-based open-source approach that has enabled breakthroughs in Life Sciences & Tech to solve data & analytics challenges required for investment to achieve Paris Climate Accord goals



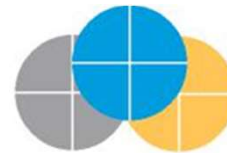
## OPEN SOURCE COMMUNITY

- Governance, licensing, and collaboration structures enabling stakeholders to share cost, intellectual property, and effort.
- Joint projects for new data, modelling, standards, and supporting technology



## COMMONS

- Curated library of public and private sources, for both transition and physical risk/opportunity
- More accurate corporate historical and forward-looking climate & ESG metrics as a public good



## GLOBAL DATA ANALYTIC TOOLS

- Integrate climate-related risk and opportunity into decisions by investors, financial institutions, regulators, etc.
- Top-down and bottom-up modelling
- Scenario analysis tools
- Alignment tools

Premium Members

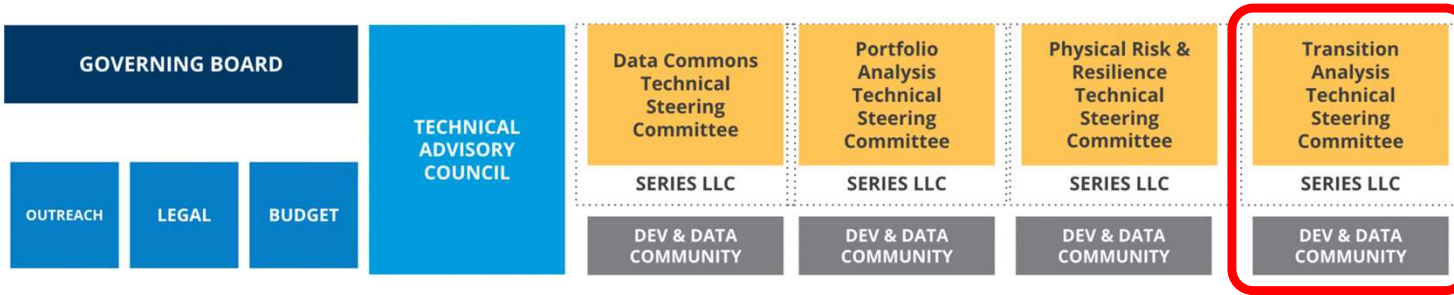
General Members

Associate Members

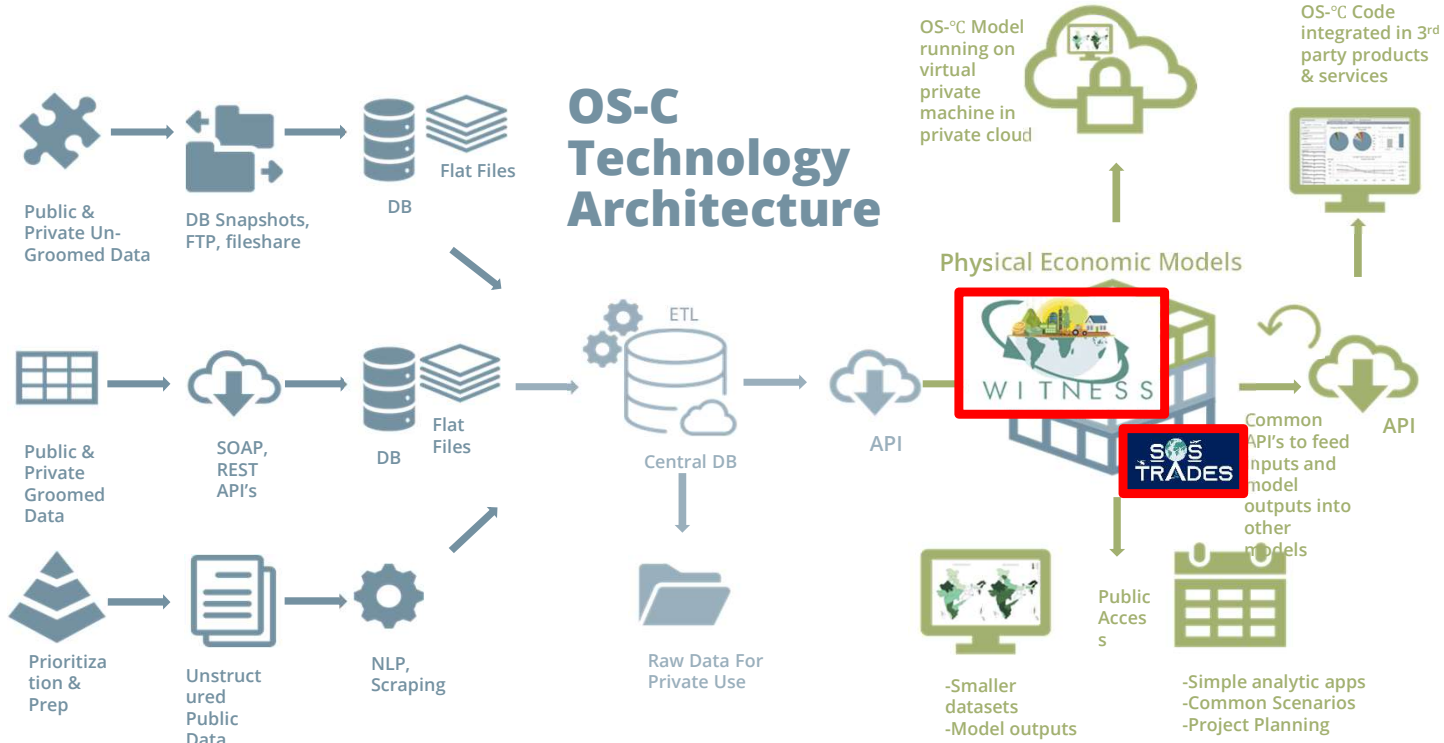
Data and Model Partners

Visit [www.os-climate.org](http://www.os-climate.org) for more information

# OS-Climate architecture overview



**Integrated Assessment Model Community**



# Transition challenge



## Inconsistent reports

on climate & energy transition risks / potential actions

## Inconsistent opinions

on why reports reach different conclusions

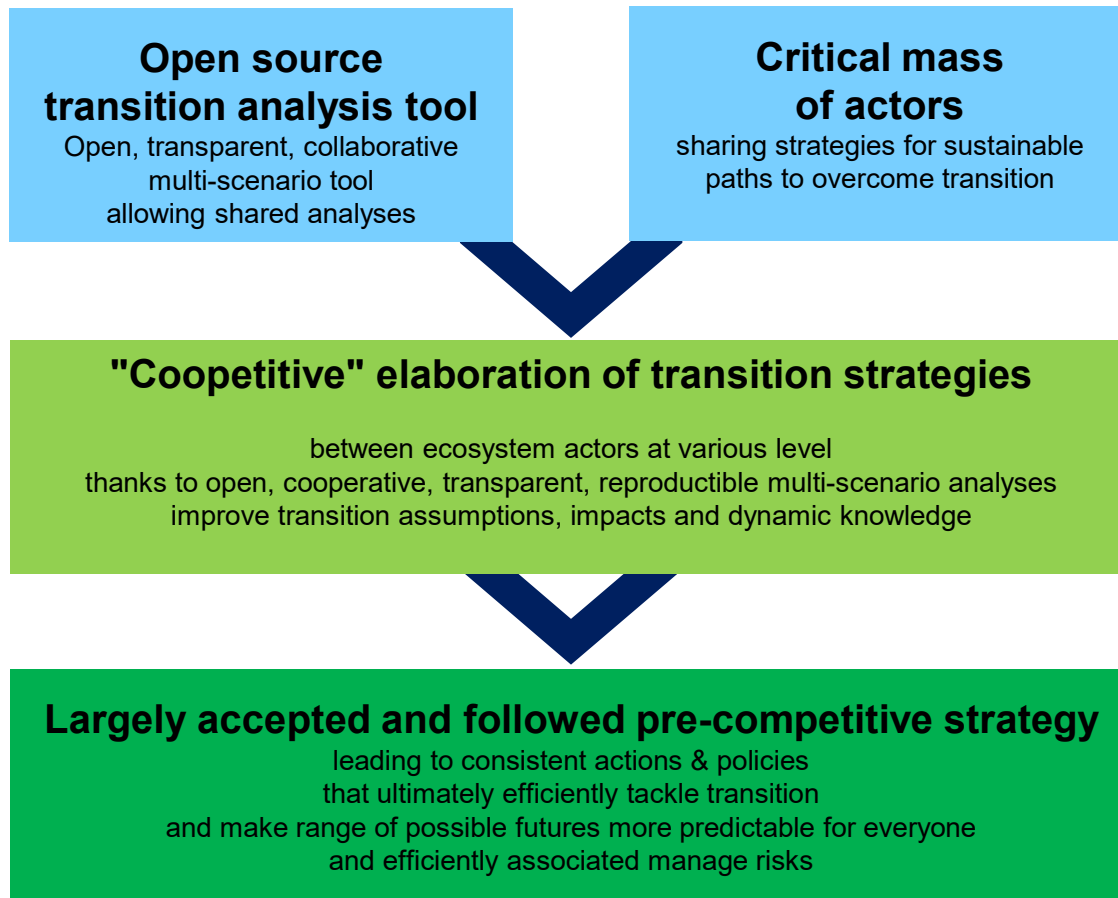
## No consensual strategy to overcome transition

due to inability to build a constructive analysis of differences as reports are in nature not reproducible, hard to audit, and might incur many conscious/unconscious biases/errors

## Inconsistent actions and policies

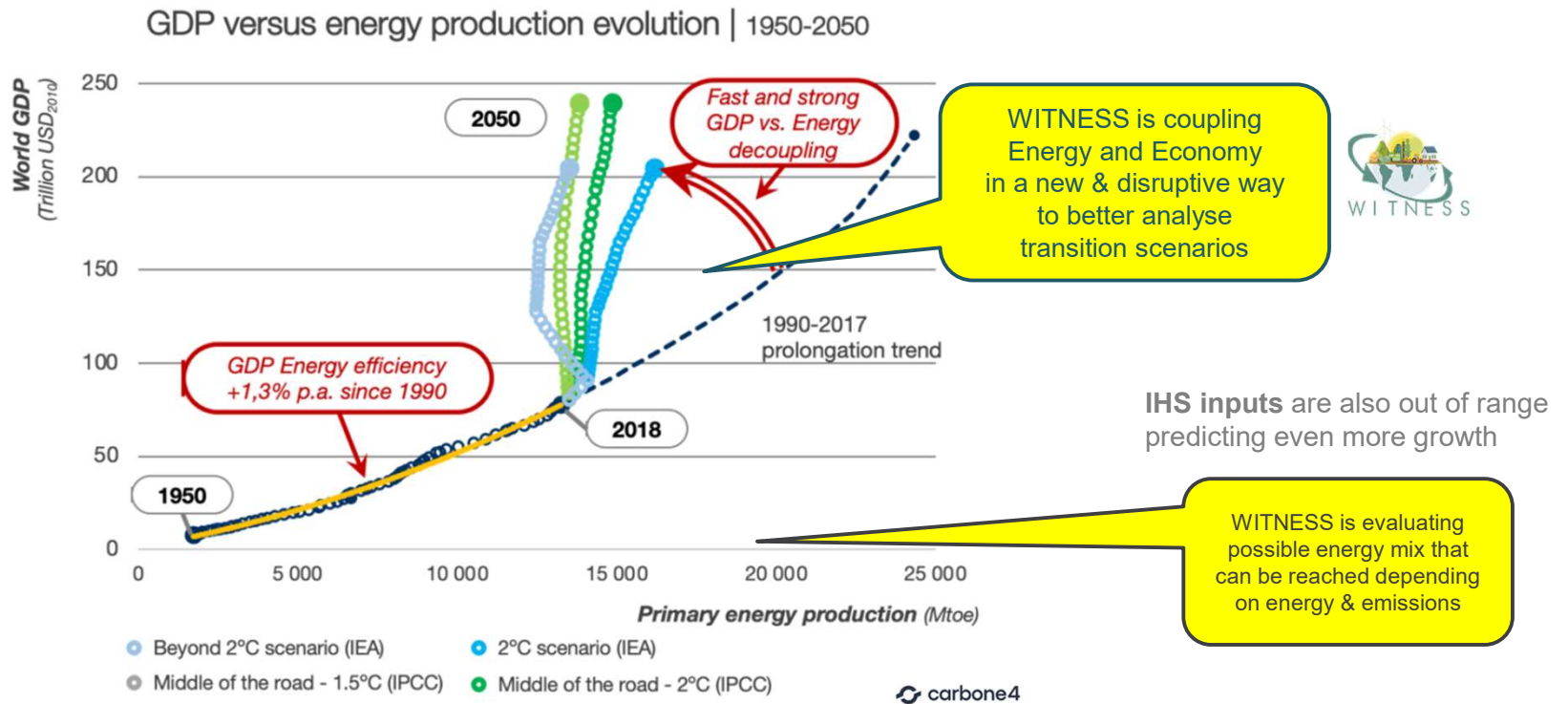
that ultimately fail to address transition efficiently and make future highly unpredictable for anyone

# OS-Climate Transition tool tentative answer





# Transition threat to economy growth



IHS, IEA and IPCC GDP assumptions are not reliable in the energy transition context  
 'Black box' reports discrepancies & doubtful assumptions do not favor actors alignment...

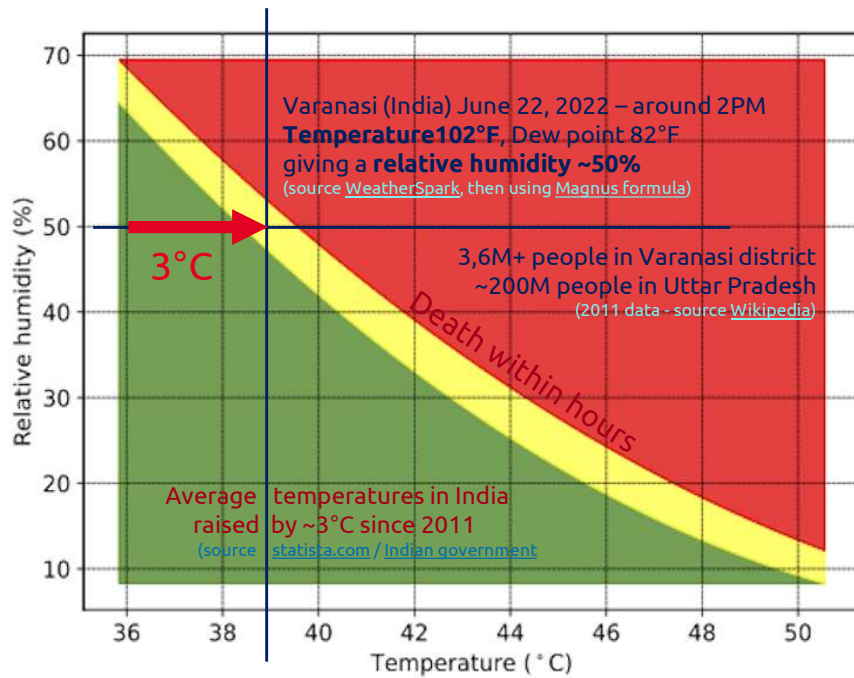


# Transition threat to human survivability in large areas

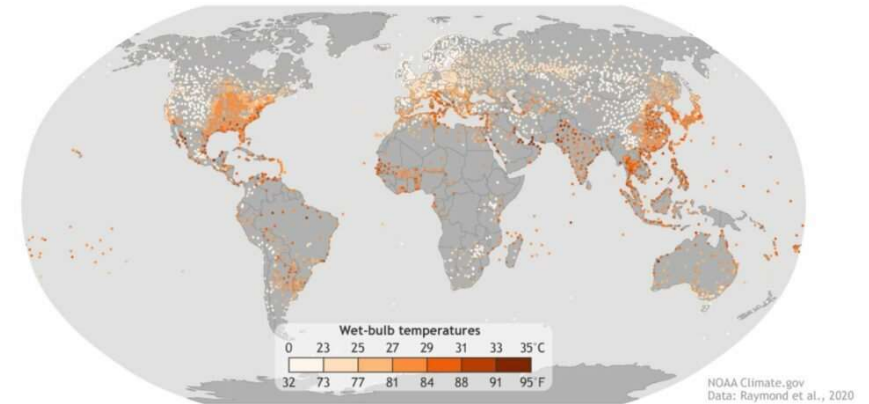


## Critical environmental limit for humans

(source [theconversation.com](https://theconversation.com) mentioning PSU H.E.A.T. project results)



This chart translates combinations of air temperature and relative humidity into critical environmental limits, above which core body temperature rises. The border between the yellow and red areas represents the average critical environmental limit for young men and women at minimal activity. (W. Larry Kenney, [CC BY-ND](https://creativecommons.org/licenses/by-nd/4.0/))



This map shows zones where extreme air temperature and extreme humidity occurred during a short period (0.1% of maximum hottest daily temperatures) from 1979 and 2017. Darkest colors show most critical combination of extreme air temperature and humidity

Map published by NOAA. Data : [Radley Horton & al](#)

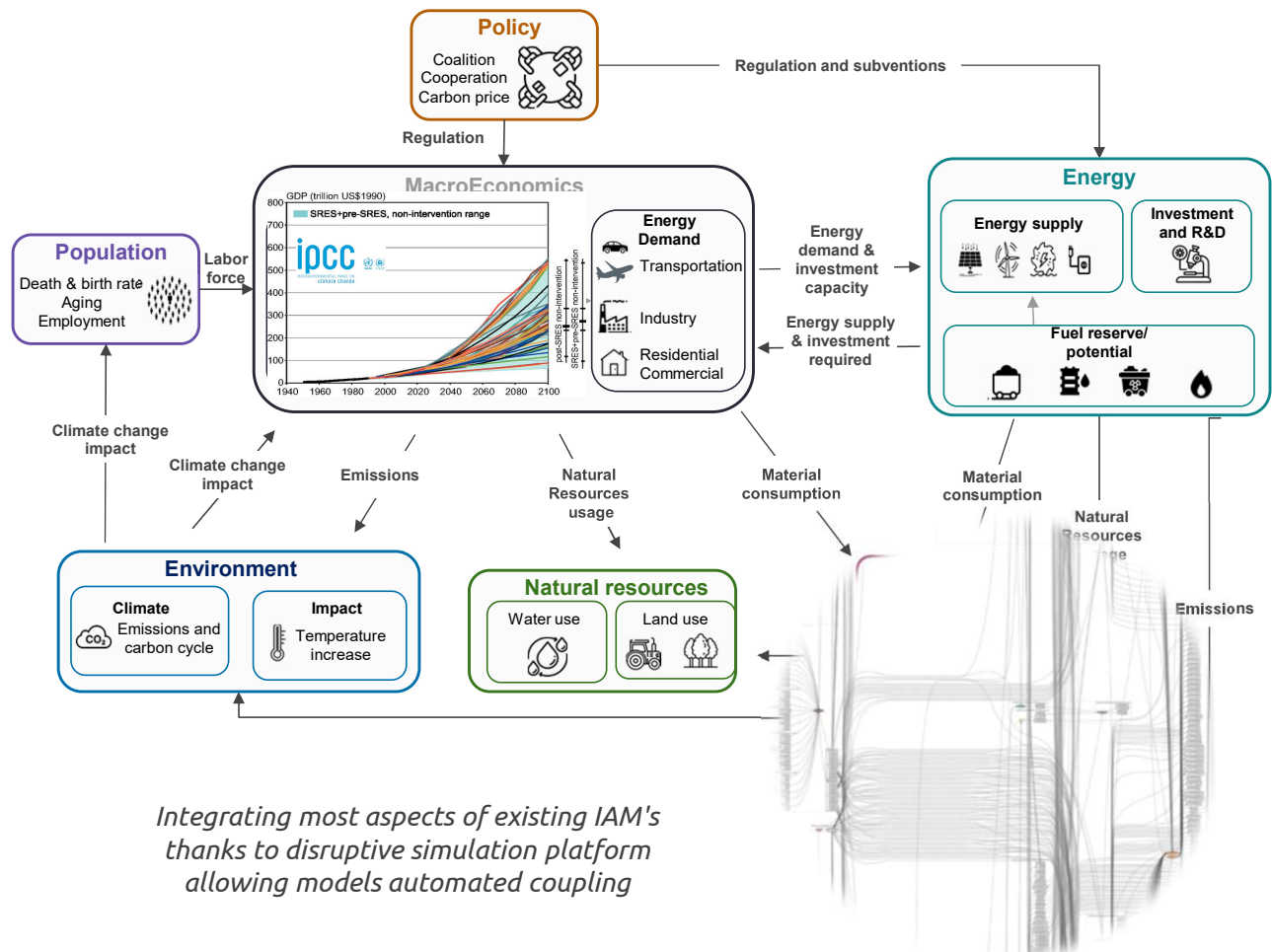
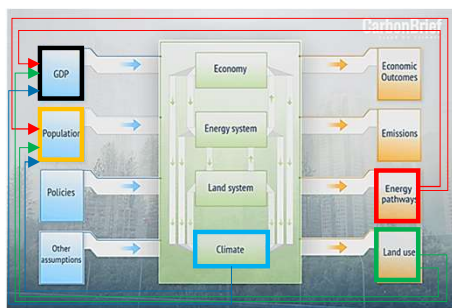
Do we wait for a massive 100M+ death event likely to come in the next years ?





# World environmental Impact and Economics Scenarios (WITNESS)

## How most IAMs work



Gross Domestic Product depends on capital, labour and net energy output

Need to have a population model to properly create world scenarios (as in World3 model)

Access to net energy production to properly feed production function

Earth is a finite system with many resources limits reflected in the framework

*Integrating most aspects of existing IAM's thanks to disruptive simulation platform allowing models automated coupling*

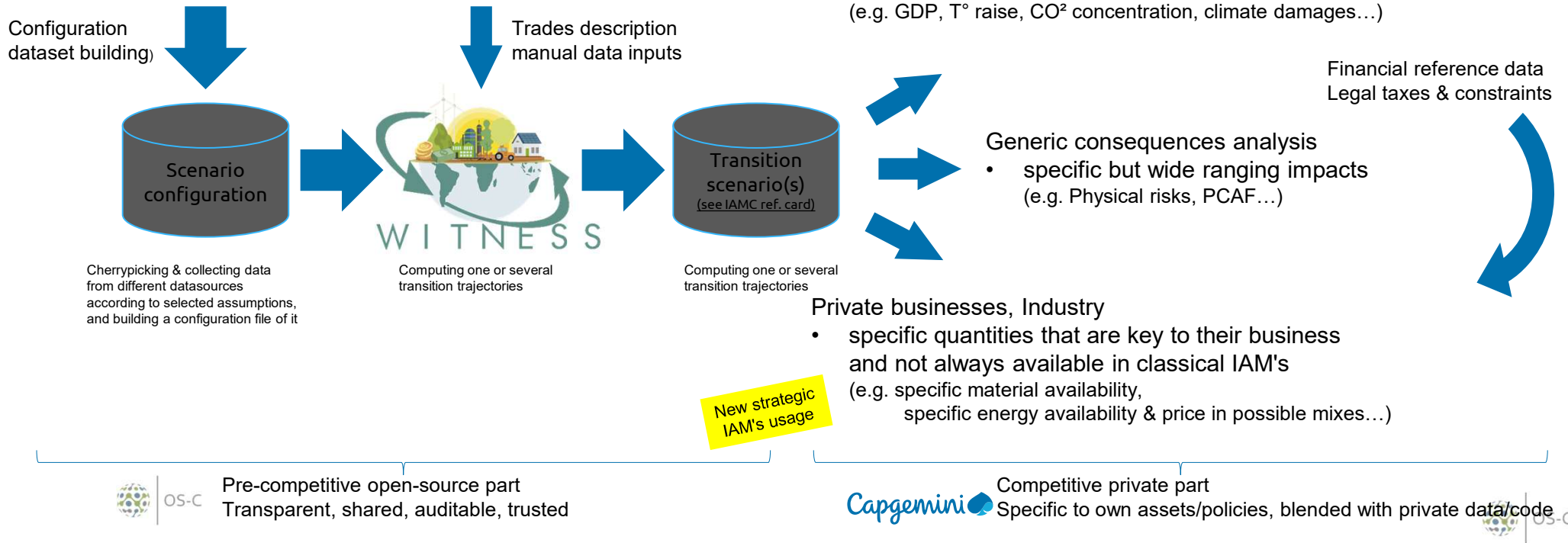


# Which IAM usage and for whom



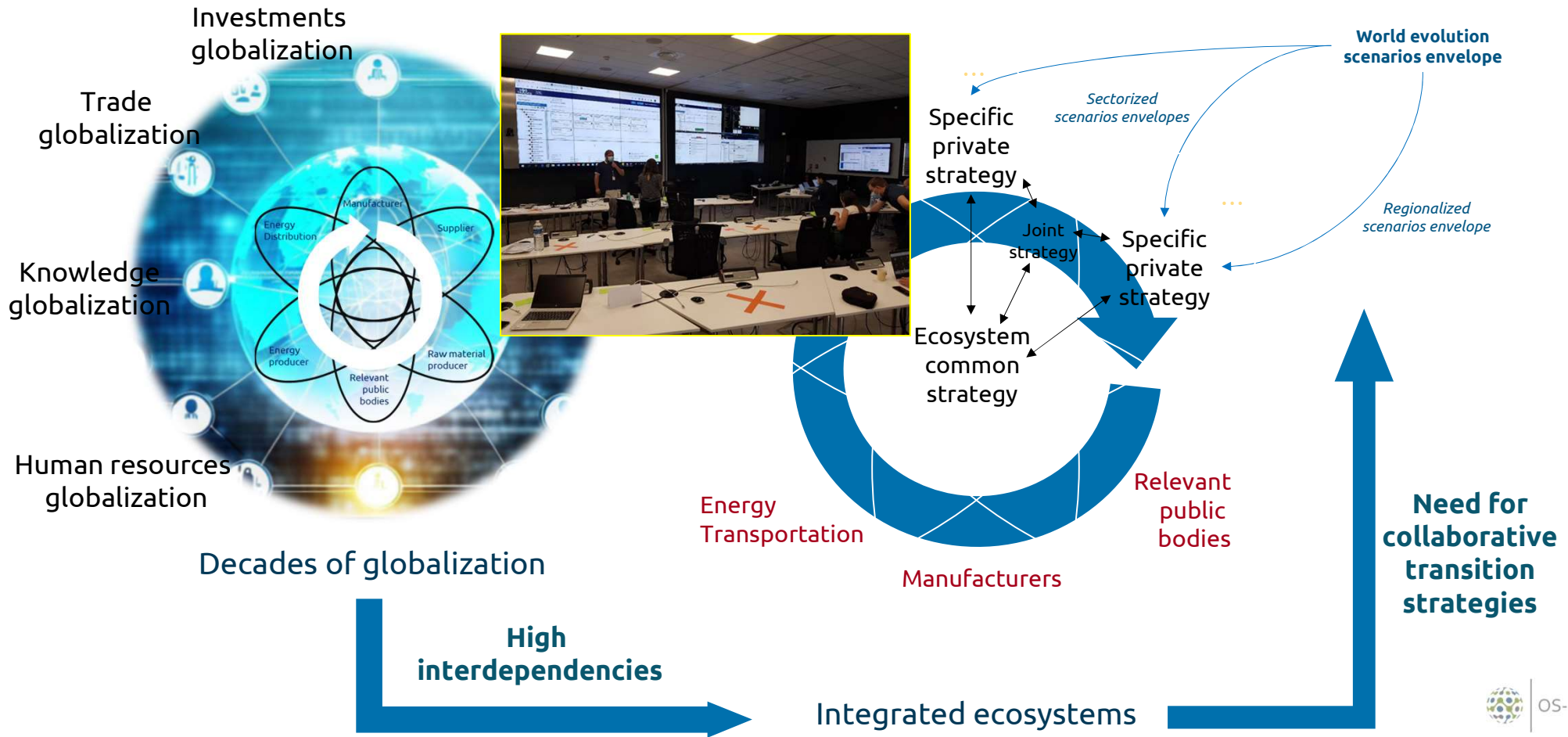
## Assumptions

- what modules or couplings are activated ?
- what are the initial conditions ?
- what are fixed evolutions vs what are optimized ones ?  
(e.g. fixed Carbon tax vs optimized energy technologies investment)



# Cooperative platform suited to transition "coopetition" needs

Providing additional confidence to boards, shareholders, authorities and citizens



# Demo



- EnergyMix
  - methane
    - FossilGas
    - UpgradingBiogas
  - hydrogen
    - gaseous\_hydrogen
      - WaterGasShift
      - Electrolysis
      - PlasmaCracking
    - liquid\_hydrogen
      - HydrogenLiquefaction
    - biogas
      - AnaerobicDigestion
    - syngas
      - BiomassGasification
        - SMR
        - CoalGasification
        - Pyrolysis
        - AutothermalReforming
        - CoElectrolysis
    - fuel
      - liquid\_fuel
        - hydrotreated\_oil\_fuel
        - biodiesel
      - solid\_fuel
        - CoalExtraction
        - Pelletizing
      - biomass\_dry
        - ManagedWood
        - UnmanagedWood
        - CropEnergy
      - electricity
        - WindOffshore
        - WindOnshore
        - SolarPv
        - SolarThermal
        - Hydropower
        - Nuclear
        - CombinedCycle
        - GasTurbine
        - BiogasFired
        - Geothermal
        - CoalGen
        - OilGen
        - BiomassFired

### Models

Public OSC 07.08.2023

Cache File Path: climateeconomics.sos\_wrapping.sos\_wrapping\_land\_use\_land\_use\_v2\_disc\_input\_cache\_file\_path

Ending year: climateeconomics.sos\_wrapping.sos\_wrapping\_land\_use\_land\_use\_v2\_disc\_input

Output parameters: 4

Name: Util

Agricultural surface for food: climateeconomics.sos\_wrapping.sos\_wrapping\_land\_use\_land\_use\_v2\_disc\_out

Land surface detail data: climateeconomics.sos\_wrapping.sos\_wrapping\_land\_use\_land\_use\_v2\_disc\_out

QR Code

Search variable

coarse\_mis\_policy\_30\_05

- optimization scenarios
  - scenario\_policy=0,0%
  - scenario\_policy=25,0%
  - WITNESS\_MDO
  - WITNESS\_Eval
  - DesignVariables
  - WITNESS
  - Land

Update charts

scenario\_policy=0,0%

scenario\_policy=25,0%

scenario\_policy=50,0%

scenario\_policy=75,0%

scenario\_policy=100,0%

scenario\_policy=125,0%

Temperature in 2100 vs Welfare

Welfare

Temperature increase since Ind

Message configuring ...

### Global land use (Gha) in 2020

### Surface taken to produce food over time

### Global CO2 breakdown sankey by years

### Energies CO2 intensity by years

### Breakdown of energy investments

### Temperature in 2100 vs Welfare

### copper\_resource consumption by technologies

### Technology production for carbon capture

- carbon\_capture
  - flue\_gas\_capture
    - CalciumLooping
    - ChilledAmmoniaProcess
    - CO2Membranes
    - MonoEthanolAmine
    - PiperazineProcess
    - PressureSwingAdsorption
  - direct\_air\_capture
    - AmineScrubbing
    - CalciumPotassiumScrubbing
- carbon\_storage
  - BiomassBuryingFossilization
  - EnhancedOilRecovery
  - GeologicMineralization
  - PureCarbonSolidStorage

# Population & health aspects poorly addressed in current IAM's



Thierry Chevalier Talk Preferences Watchlist Contributions Log out

Page Discussion Read Edit Edit source View history

## Model comparison

This page makes it possible to create a comparison between (a selection of) models and reference card group. You can create a model selection first. This selection will be passed to the 'group features' button, a new tab will be opened containing the 'run query form' with all features of the reference card

### Model selection

You can select models from a list of all IAMC models.

Select models

Current selection is: GCAM; IMAGE; MEDEAS; MESSAGE-GLOBIOM

### Feature selection

The buttons below will open a query page in a new tab containing a form to select features and run the query

[About model](#)
[Model scope and methods](#)
[Socio-economic drivers](#)
[Macro-economy](#)
[Energy](#)
[Land-use](#)
[Emission, climate and impacts](#)

[About model features](#)
[Scope and method features](#)
[Socio-economic drivers](#)
[Macro-economy features](#)
[Energy features](#)
[Land-use features](#)
[Emission, climate and impacts features](#)

Special page Search IAMC-Documentation

## Model Comparison Socio-economic drivers

Selected models: \* GCAM \* IMAGE \* MEDEAS \* MESSAGE-GLOBIOM \* REMIND-MAGPIE \* WITCH \* WITNESS

Select Socio-economic drivers from the list below:

[Select all][Select none]

Population
  Population age structure
  Education level
  Urbanization rate

GDP
  Income distribution
  Employment rate
  Labor productivity

Total factor productivity
  Autonomous energy
  Other socio economic driver efficiency improvements

Thierry Chevalier Talk Preferences Watchlist Contributions Log out

Special page Search IAMC-Documentation

## Model Comparison Socio-economic drivers

### Socio-economic drivers

**Exogenous or non-existing...**

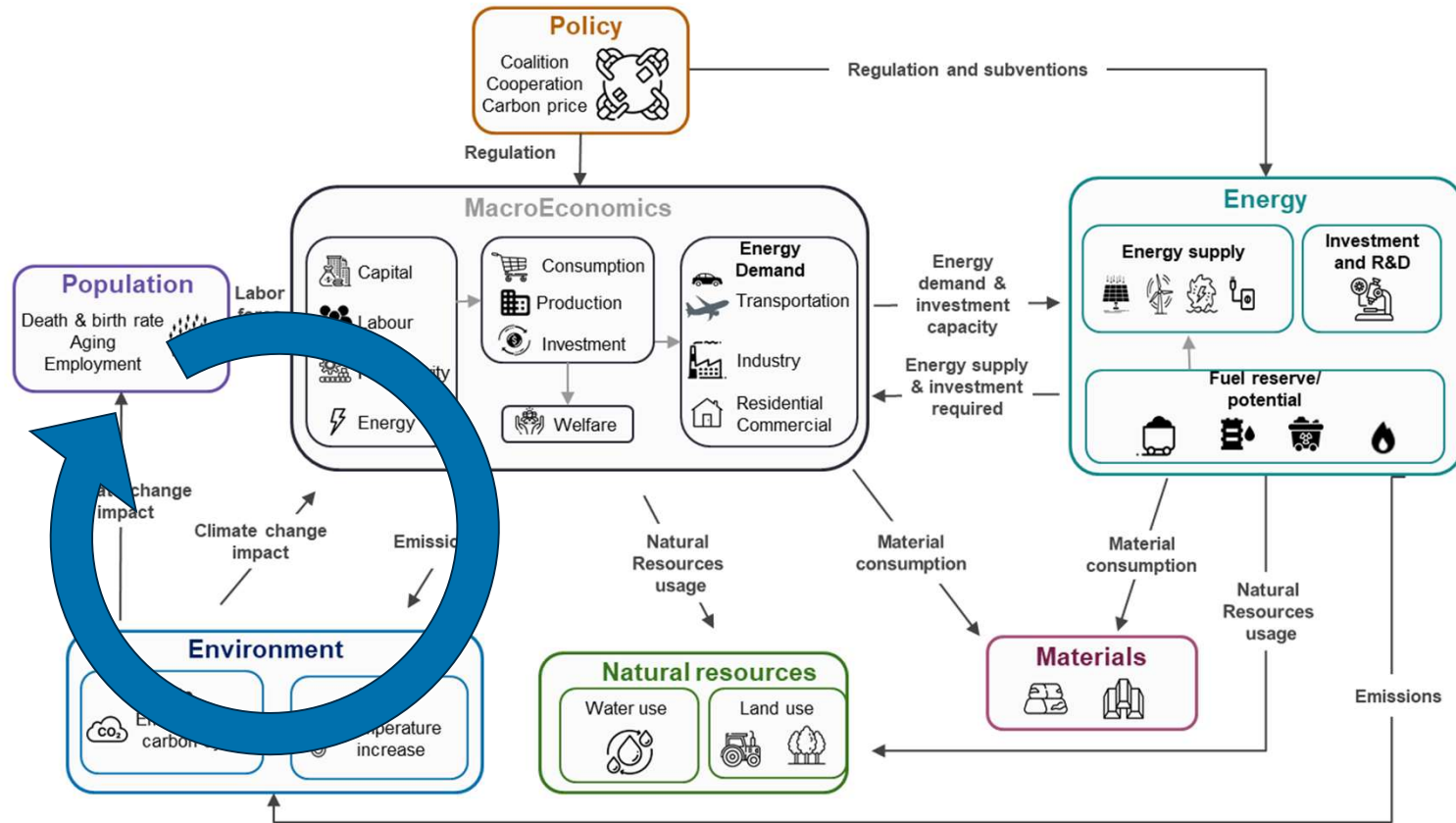
	GCAM	IMAGE	MEDEAS	MESSAGE-GLOBIOM	REMIND-MAGPIE	WITCH	WITNESS
Population	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input type="checkbox"/> Yes (exogenous) <input checked="" type="checkbox"/> Yes (endogenous)
Population age structure	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input checked="" type="checkbox"/> Yes (exogenous) <input type="checkbox"/> Yes (endogenous)	<input type="checkbox"/> Yes (exogenous) <input checked="" type="checkbox"/> Yes (endogenous)
Other socio economic driver				<input checked="" type="checkbox"/> Behavioural change			<input checked="" type="checkbox"/> Behavioural change

e.g. diet





# Looping effects through the rest of the IAM





# Population in WITNESS

## Based on existing literature(\*) with modifications

- One year time step and population divided into one year age group
- Evolution of the population depends on birth rate, and death rate per 5 years age group
- More detailed 1 year age classes and level of education are considered

## Birth rate

- Function of economics activity and a proxy for education  
in case of degrowth we will not retrieve past level of birth rate because of all the knowledge acquired (e.g. better access to contraception, higher level of education...)

## Death rate

- Classic death rate: function of **economics activity** and a proxy for **education**
- Improved death rate: classic death rate + sum of **climate and nutrition** effect
- Key endemic diseases considered

## Key model strengths

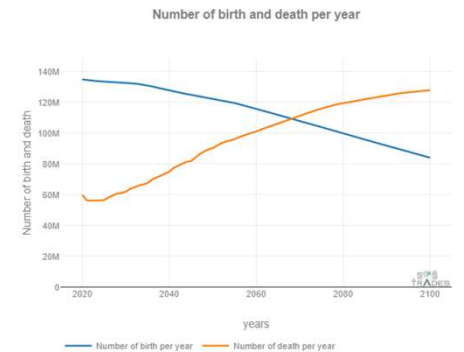
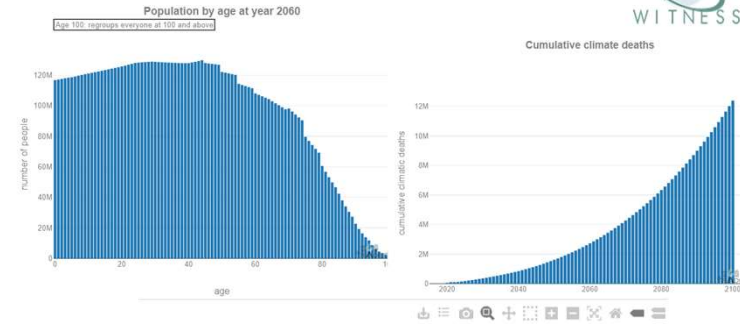
- Population dynamic fully considered
- Flexible model allowing fast modelling improvements

## Improvement required

- Better model of labour productivity
- Model additional effects on both birth rate & death rates
- Only at global level, need to work on population distribution

(\*) Mclsaac, F. (2020) "A Representation of the World Population Dynamics for Integrated Assessment Models. Environmental Modeling & Assessment", pp.611-632.  
WHO. (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. Geneva: World Health Organization

Model documentation in GitHub

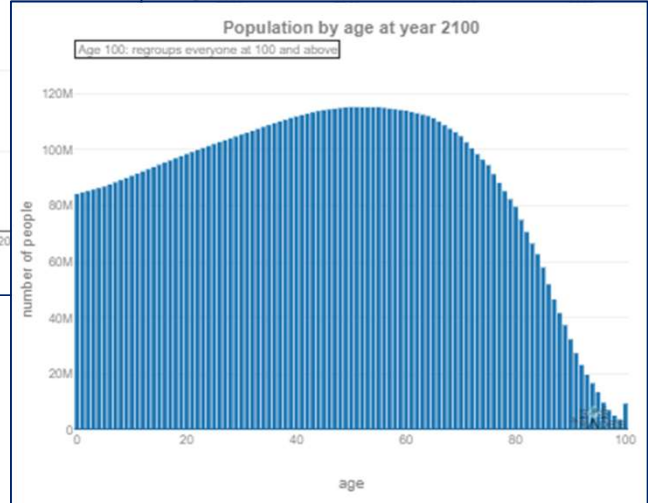
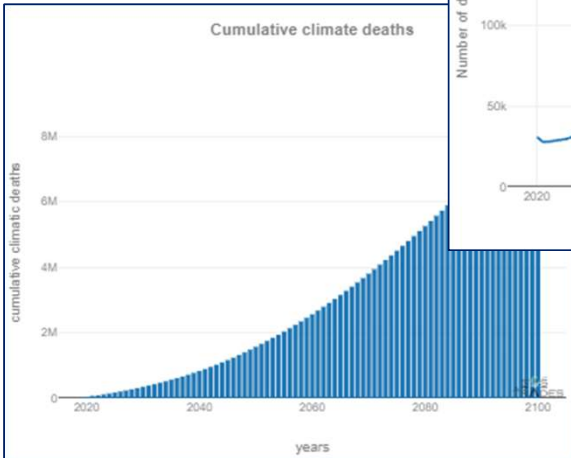
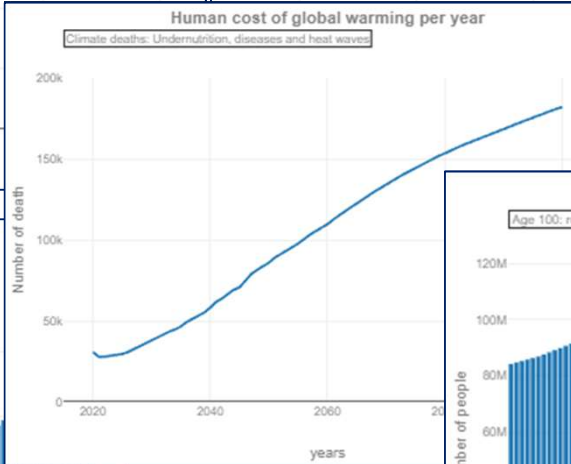
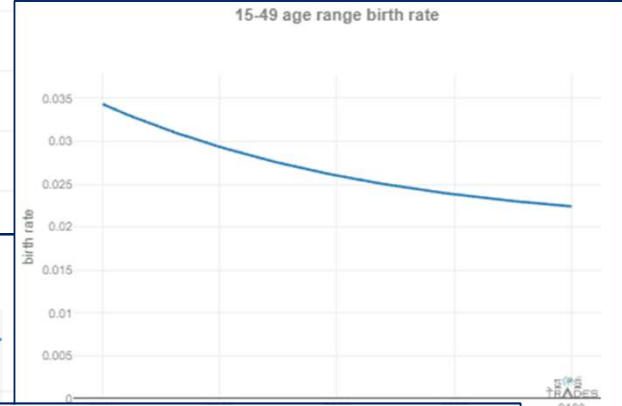
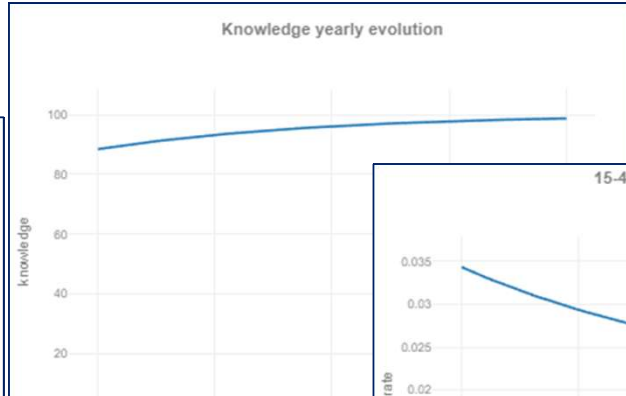
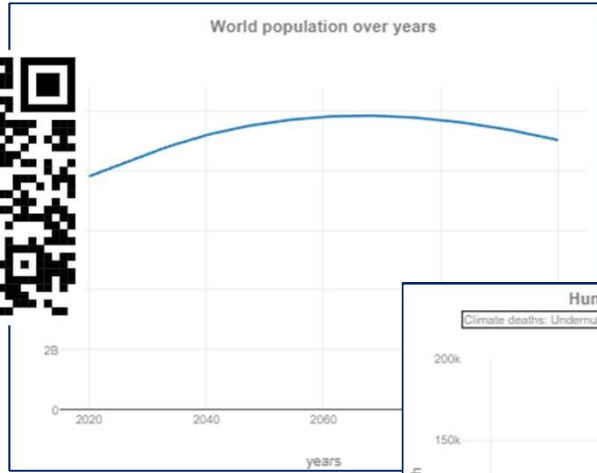


**Table 6** Proportion of the additional deaths provided by WHO [61] assigned to each age-group

	Undernutrition	Malaria	Dengue	Diarrheal diseases	Heat waves
0-4	1	1/14	1/14	1/3	0
5-9	0	1/14	1/14	1/3	0
10-14	0	1/14	1/14	1/3	0
15-19	0	1/14	1/14	0	0
∴ ∴ ∴	∴ ∴ ∴	∴ ∴ ∴	∴ ∴ ∴	∴ ∴ ∴	∴ ∴ ∴
60-64	0	1/14	1/14	0	0
>65	0	1/14	1/14	0	1

# Demo focused on health

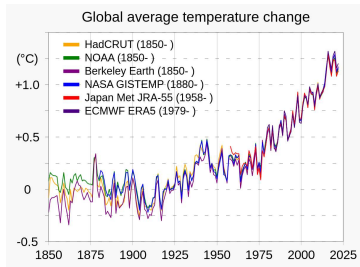
- witness\_coarse\_mda\_ums\_sprint14
  - mda\_scenarios
    - Full fossil, no damage no tax
      - Macroeconomics
      - GHGCycle
      - Damage
      - Temperature\_change
      - Utility
      - Policy
      - Land\_Use
      - AgricultureMix
      - Population
      - GHGEmissions
      - EnergyMix
      - CCUS
      - Resources
      - InvestmentDistribution
    - IEA energy mix, no damage with tax
    - Fossil + 2020 invest renewable & CCS, with damage no tax
    - Fossil + renewable (step) & 2020 CCS invest, with damage no tax
    - NZE inspired, with damage no tax
    - NZE, with damage with tax
      - Macroeconomics
      - GHGCycle
      - Damage
      - Temperature\_change
      - Utility
      - Policy
      - Land\_Use
      - AgricultureMix
        - Crop
        - Forest
      - Population
      - GHGEmissions
        - Industry
        - Agriculture
        - Energy
      - EnergyMix
      - CCUS
        - carbon\_capture
        - carbon\_storage
      - Resources
        - coal\_resource
        - oil\_resource
        - natural\_gas\_resource
        - uranium\_resource
        - copper\_resource



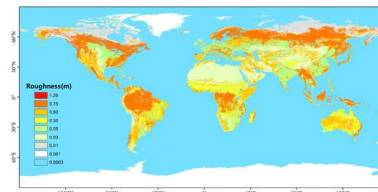
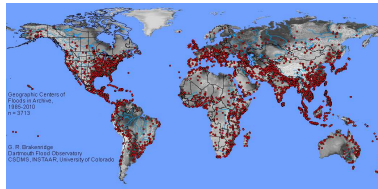
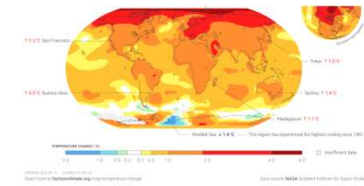
# Possible developments: Advanced damage functions



Proposal of a damage function based on geo-spatial data (1/3)



Build correlations between local information and global temperature change



## Resulting models

- Local temperature change (Global T)
- Flooding occurrences (Global T)
- Extreme weather occurrences (Global T)

...

Extracted from CMIP5 or future CMIP6

# Possible developments: Advanced damage functions

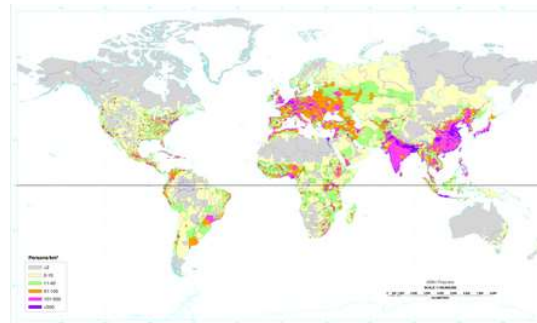
Proposal of a damage function based on geo-spatial data (2/3)

## Resulting models

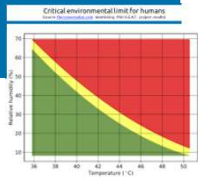
- Local temperature change (Global T)
- Flooding occurrences (Global T)
- Extreme weather occurrences (Global T)
- ...



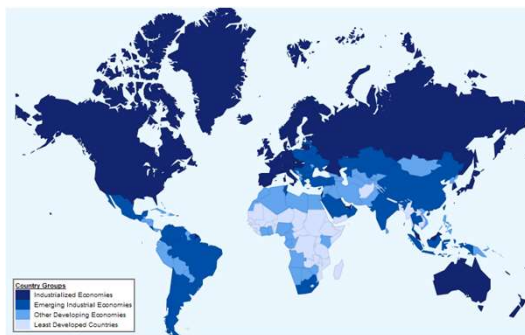
Use models with population distribution data



Climate induced death model



Use models with capital/Industrialization distribution data

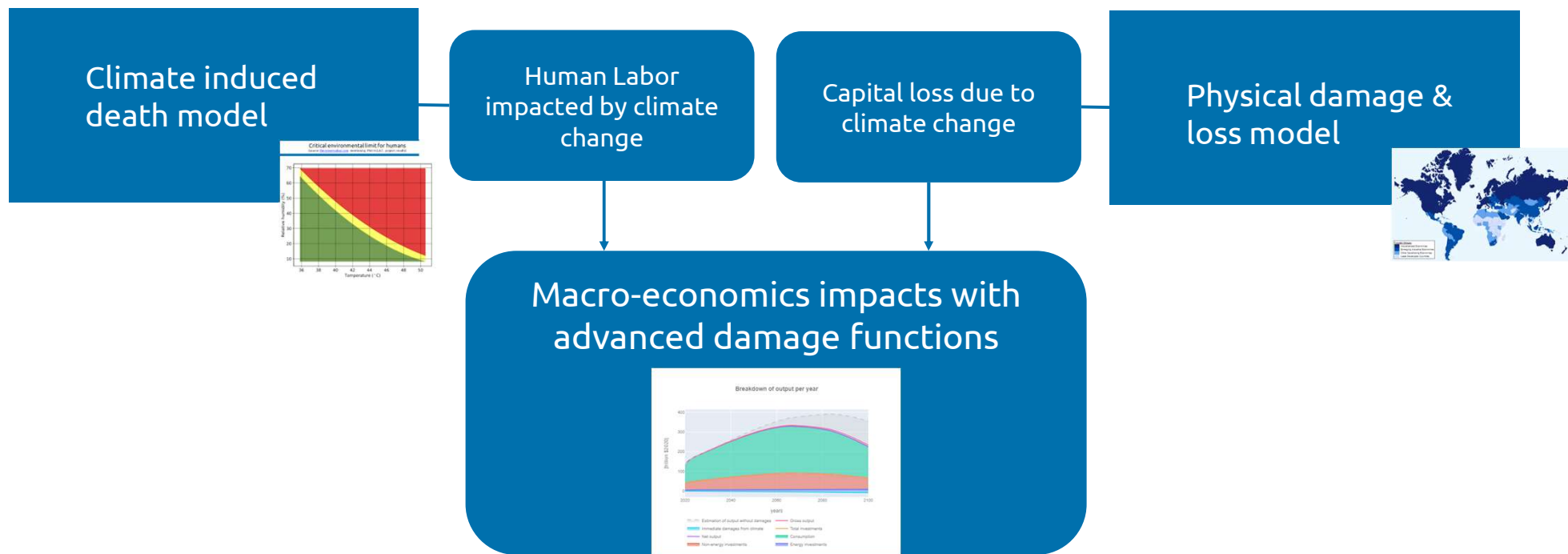


Physical damage & loss model

# Possible developments: Advanced damage functions



Proposal of a damage function based on geo-spatial data (3/3)



We are looking for financing of this initiative

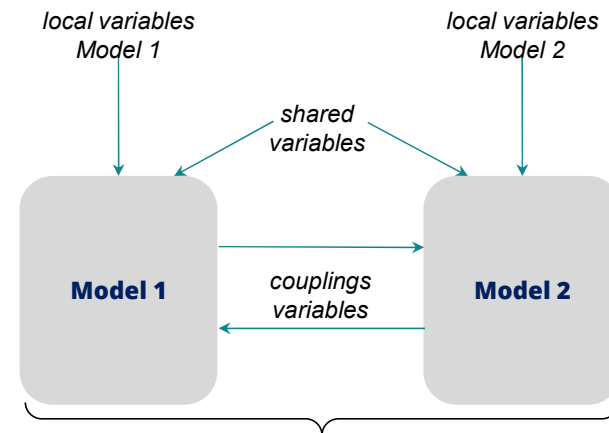
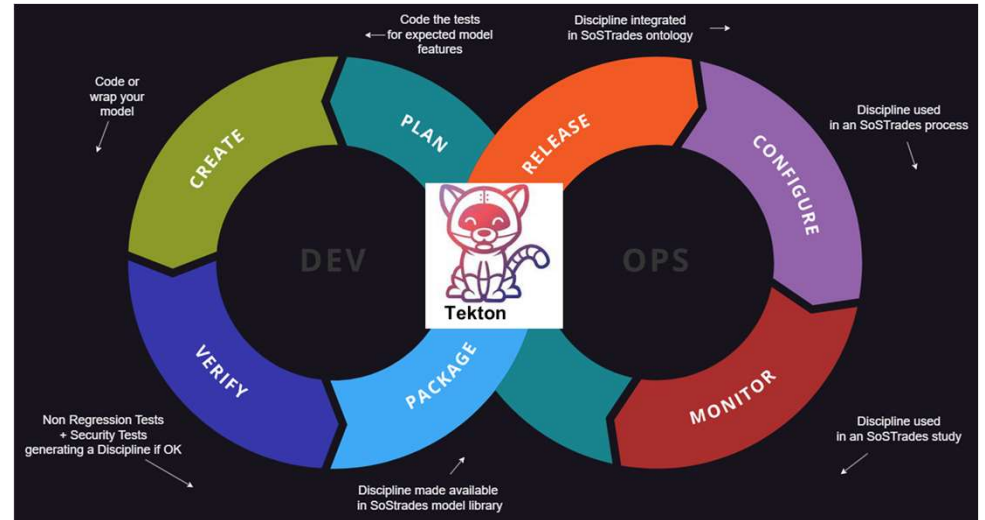




# SoSTrades Model DevSecOps

1. Develop your core model (Python)
2. Wrap your model
  - check parameters ontology for your interfaces
  - write the wrapper code (Python)
    - grab inputs by name in proper namespace\*\*
    - run your core model
    - transfer outputs by name in proper namespace\*\*
  - add post-processing graphs (Plotly)
  - write the doc (markdown language)
3. Add your new wrapper in proper simulation namespace
4. Check in your developments and write validation tests
5. Wait next DevSecOps batch (triggered after a push on integration pipeline)
6. Use your new features (or fix regression or security issues ☺)

\*\* according to the discipline I/O names, couplings variables are **automatically** identified, and multi-disciplinary analyses automatically built



**Multi-Disciplinary Analysis (MDA)**

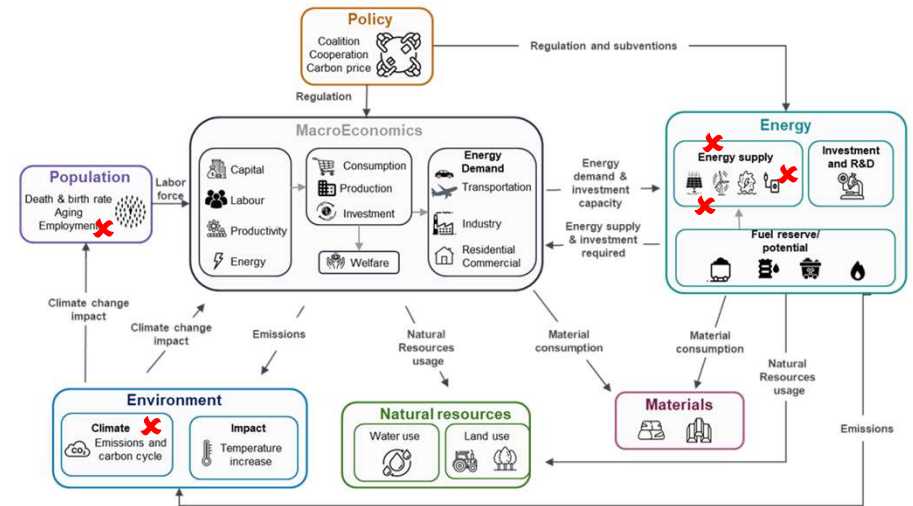
# Easy to complete or evolve with new effects, parameters...



## Let's say you want to add impact of ODS<sup>(\*)</sup> on health

<sup>(\*)</sup> ODS : ozone-depleting substances

1. Complete ontology with main elements/variables to be exchanged (ODS emissions, ozone layer thickness...)
2. Add ODS emissions from any relevant sources as needed (energy, macro-economics...)
3. Add environment system impact from all ODS emissions (ozone layer reduction, CFC contribution to green house effect...)
4. Add death rate impact in population model due to Ozone layer thickness reduction



## Automated

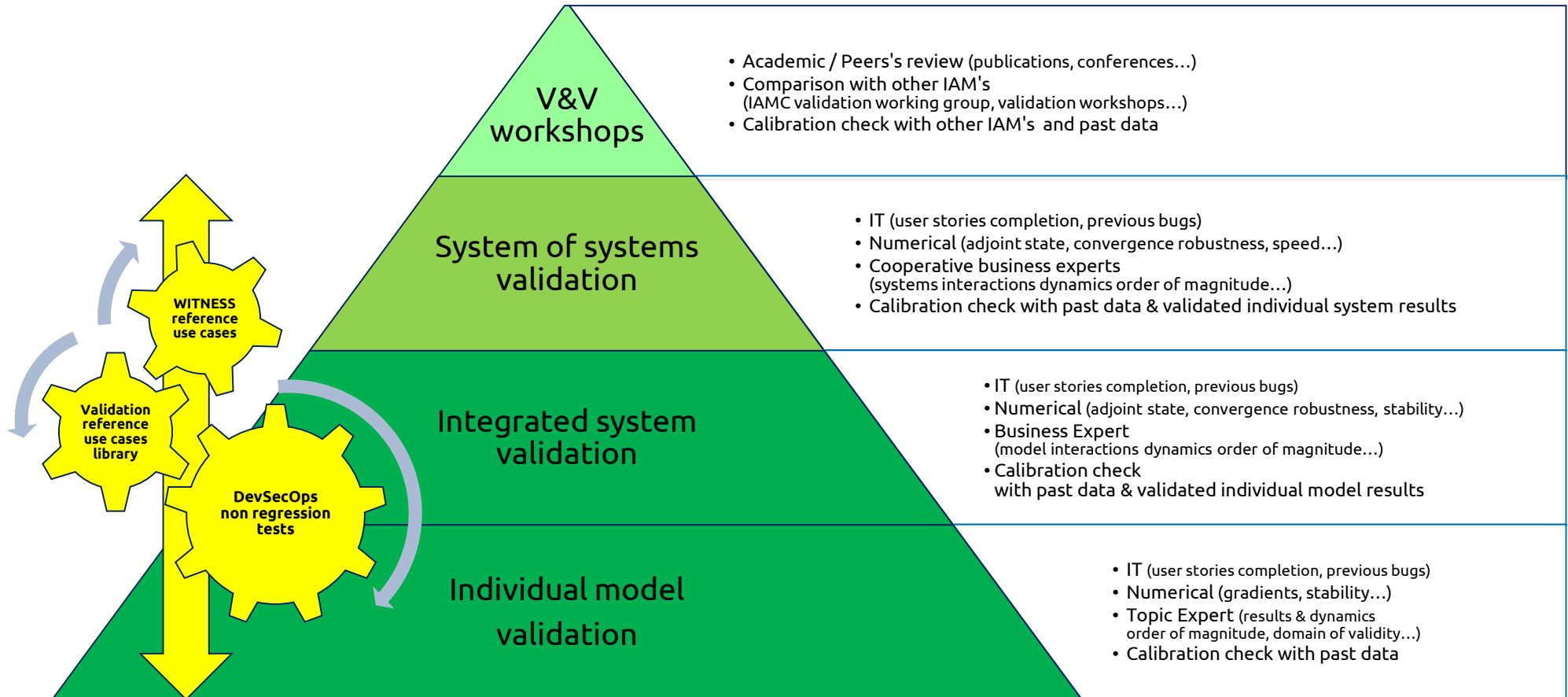
- Collection of all ODS emissions
- Cumulating greenhouse effect of ODS on top of other factors
- Population evolution due to population damage generated by thinner ozone layer
- Impact on labor for macro-economics

## Just add your model

Taking into account interactions and loop-back is automated



# Verification and Validation in WITNESS as of Jan'24



# Follow-up or work with the project

## For users

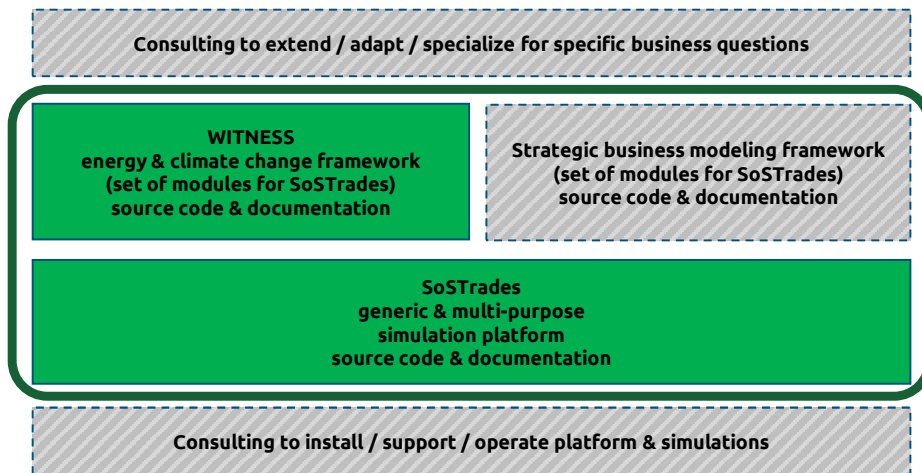
- Follow-up OS-Climate progress as a whole
  - ➔ "All hands meeting"  
1h every second Tuesday of the month, 10:00 AM ET
- Follow-up Transition tool more specifically
  - ➔ "Transition tool weekly"  
1/2h every Wednesday, 10:00 AM ET
- Specific interaction with Transition tool team
  - ➔ "Come as you are"  
2h every Thursday, 08:00 AM ET  
register at <https://www.witness4climate.org/events/>
- User's training
  - ➔ Training development in progress with Linux Foundation  
First MOOC's should be available in Q2'24

## For developers

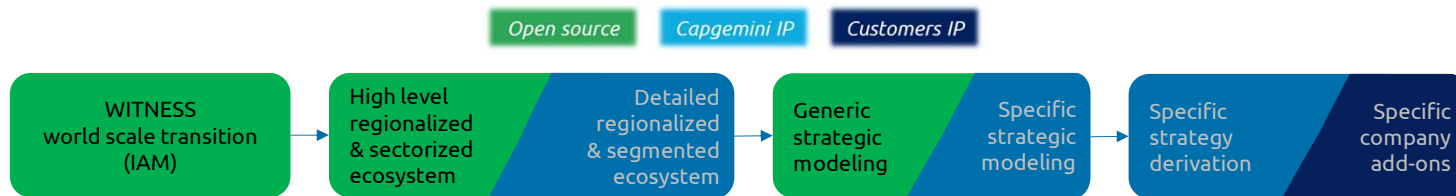
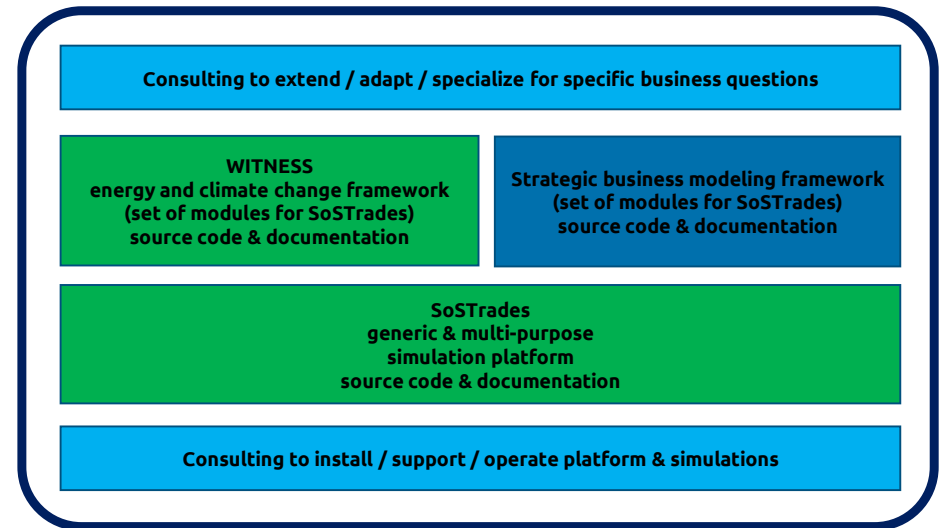
- Start your own developments
  - ➔ Setup development environment on your laptop  
(native or Docker containerized image available)
- Get specific support
  - ➔ "Code as you are"  
2h every Wednesday, 08:00 AM ET  
register at <https://www.witness4climate.org/events/>
- Contribute source code or documentation
  - ➔ Contact project to get a GIT branch  
where to contribute your developments  
<https://github.com/os-climate>
- Test integration of your code
  - ➔ Automated through DevSecOps loops  
when your code is properly contributed on project GitHub
- Developer's training
  - ➔ Training development in progress with Linux Foundation  
First MOOC's should be available in Q2'24

# Barebone open source offer can be completed by commercial support if needed

OS-Climate «Transition tool» source & documentation scope

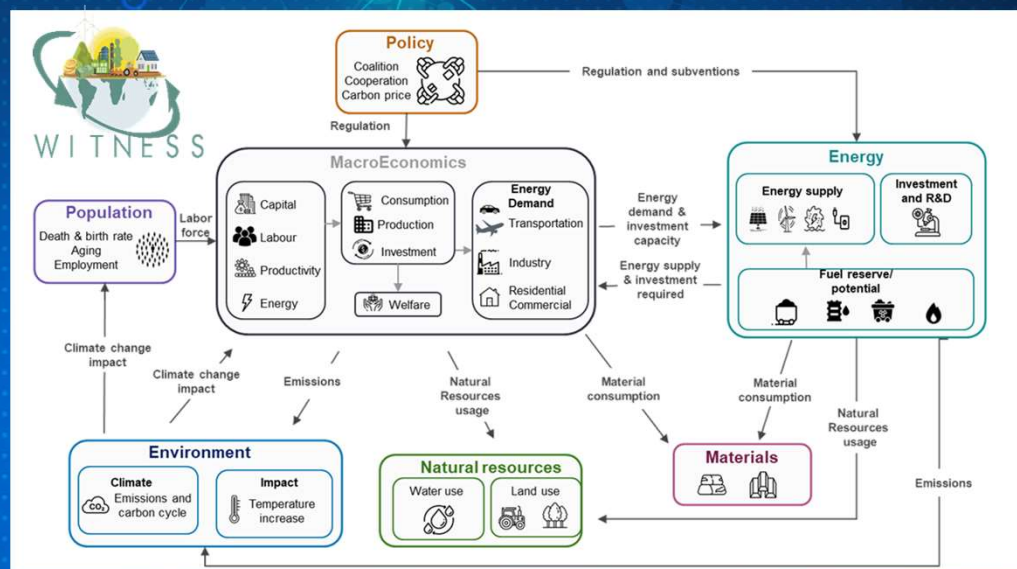


Capgemini « Business for Planet modeling » commercial offer scope





# Thank You!



Interested in Learning More:



<https://witness4climate.org>

WITNESS presentation  
and links to OS-C



<https://github.com/os-climate>

Source code repositories  
(include all models documentation)



<https://stable.osc-tsa.com/>

Stable public platform  
(basic github account needed)

# Links to different resources



<https://witness4climate.org>

WITNESS presentation  
and links to OS-C



<https://os-climate.org/>

Open Source for Climate



<https://github.com/os-climate>

Source code repositories  
on GitHub  
(include all models documentation)

Public  
platforms



Stable

<https://stable.osc-tsa.com/>



Validation

<https://validation.osc-tsa.com/>



Integration

<https://integration.osc-tsa.com/>