Overview of a new scenario framework for climate change research

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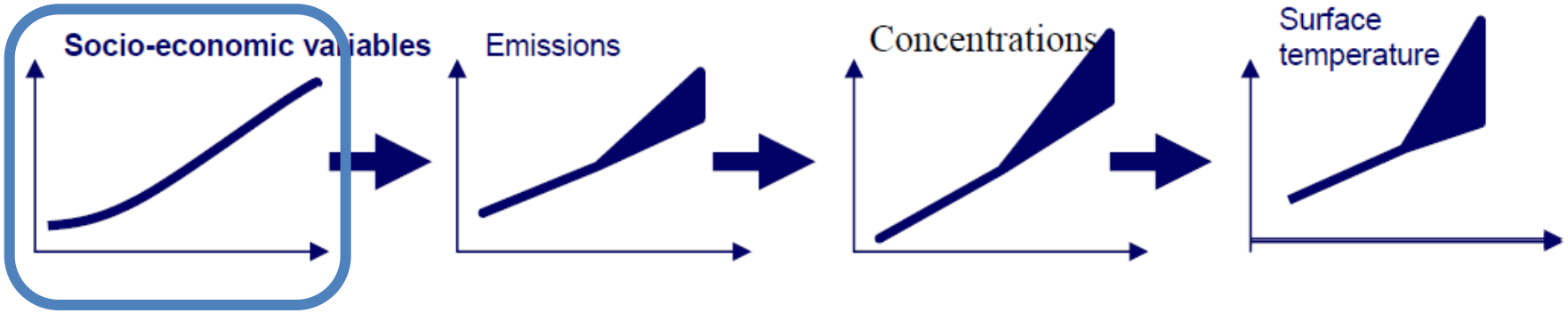
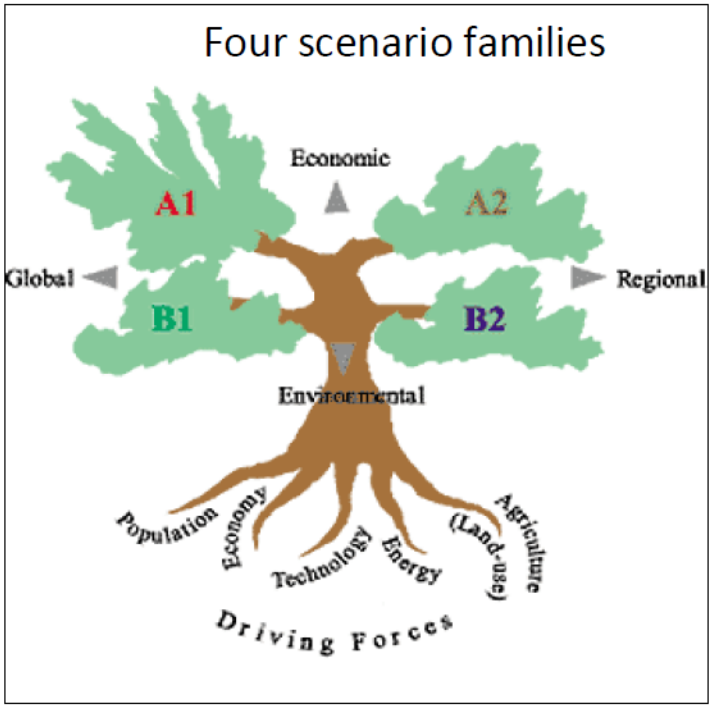
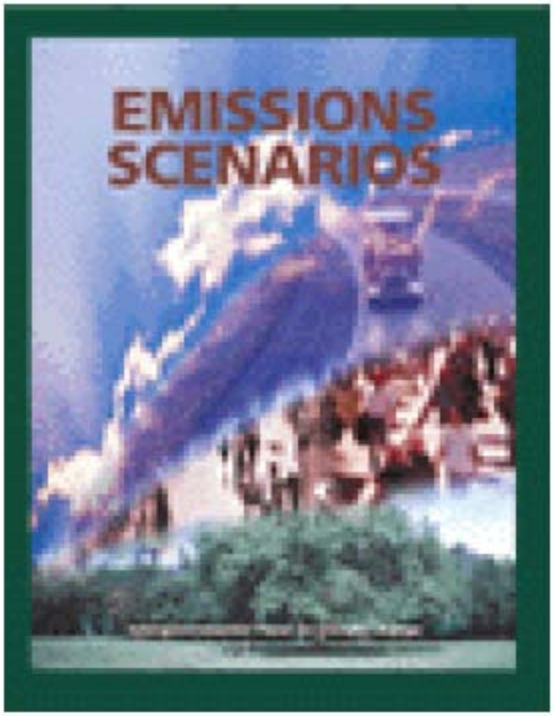
Traditional / linear / forward scenario process



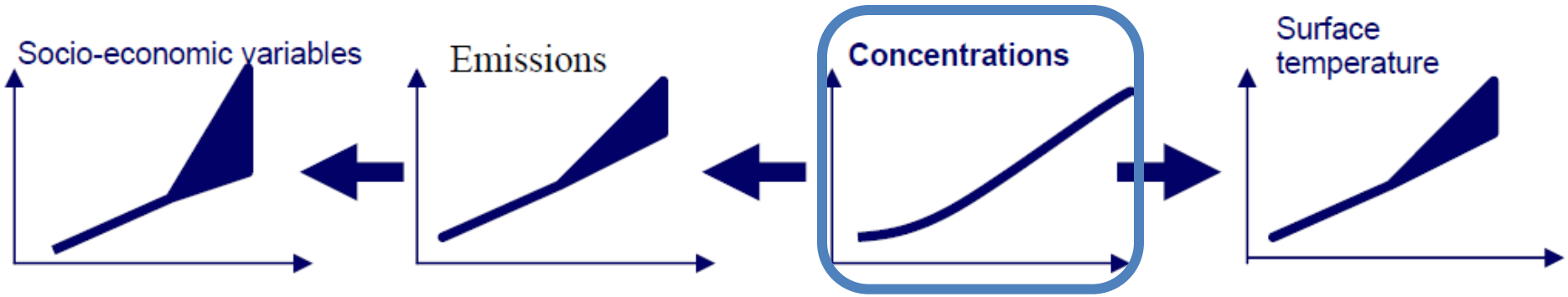


SRES Scenarios



Meehl et al. 2007, WCRP Report.

New parallel / reverse scenario process



Shared Socio-economic Pathways (in process)

RCPs (Complete)

CMIP5 (Complete)

- **Small number**
- **Shared across RCPs**

Meehl et al. 2007, WCRP Report.

Representative Concentration Pathways (RCPs)

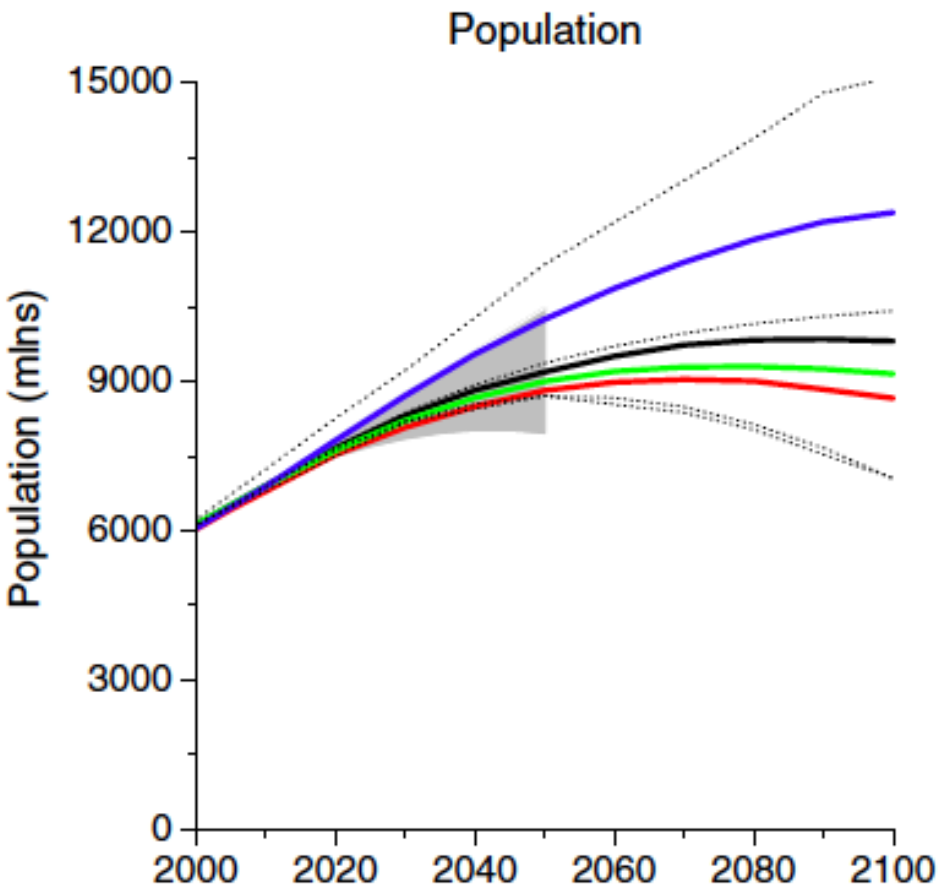
- IAM-Climate Modeling community product
- Designed to span the full scenario space
- Be based on already published literature
- Be far enough apart from each other to be distinguishable in the climate models

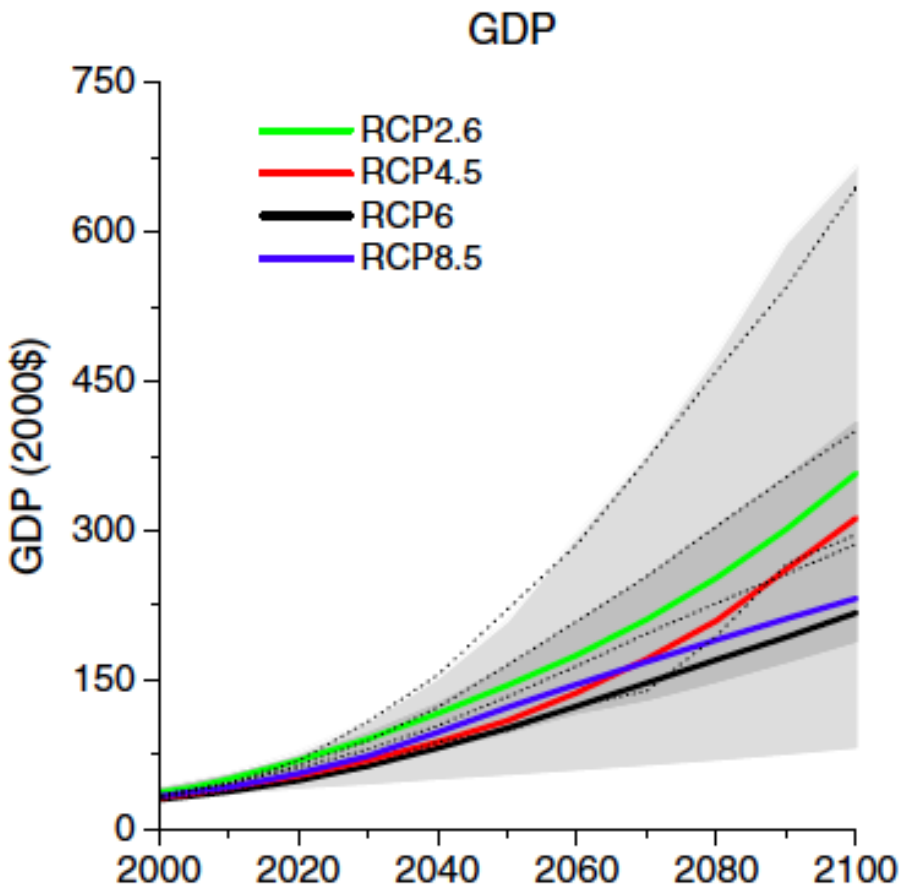
	Description	Publication – IA Model
RCP8.5	Rising radiative forcing pathway leading to 8.5 W/m^2 (~1370 ppm CO_2 eq) by 2100.	(Riahi et al., 2007) MESSAGE
RCP6.0	Stabilization without overshoot pathway to 6 W/m^2 (~850 ppm CO_2 eq) at stabilization after 2100	(Fujino et al., 2006; Hijioka et al., 2008) AIM
RCP4.5	Stabilization without overshoot pathway to 4.5 W/m^2 (~650 ppm CO_2 eq) at stabilization after 2100	(Clarke et al., 2007; Smith and Wigley, 2006; Wise et al., 2009) GCAM
RCP2.6	Peak in radiative forcing at ~ 3 W/m^2 (~490 ppm CO_2 eq) before 2100 and then decline (the selected pathway declines to 2.6 W/m^2 by 2100).	(Van Vuuren et al., 2007a; van Vuuren et al., 2006) IMAGE

What's different from the SRES?

- Based on insight that multiple reference socioeconomic pathways can lead to the same emissions pathway, RCPs include just forcing/concentration/emissions/land use information and NOT underlying storylines and quantitative drivers
  - SRES included storylines, drivers, and emissions/land use
- RCPs were developed by the IAM community NOT the IPCC
- RCPs include climate stabilization scenarios
- RCPs provide very long-term radiative forcing trajectories—to the year 2300
- RCPs provide (as ½° x ½° gridded data)
  - Land-use and land cover information
  - Short-lived species emissions

SSPs largely independent of some emissions drivers





van Vuuren et al. 2011

Process to develop SSPs

- **Series of meetings over past 2 years between IAM and IAV/VIA communities**
  - **NRC – IPCC in February 2010**
  - **IPCC workshop in November 2010**
  - **NCAR in November 2011**
  - **PBL – IPCC workshop in May 2012**
- ***A framework for a new generation of socioeconomic scenarios for climate change impact, adaptation, vulnerability, and mitigation research***
  - **CLAs: Nigel Arnell and Tom Kram. LAs: Tim Carter, Kristie Ebi, Jae Edmonds, Stephane Hallegatte, Elmar Kriegler, Ritu Mathur, Brian O'Neill, Keywan Riahi, Harald Winkler, Detlef van Vuuren, Timm Zwickell**
  - **Invitations to review sent to IPCC author lists; listservs for HDGEC and CLIMLIST; and to personal contacts**

Scenario matrix architecture

SPAs

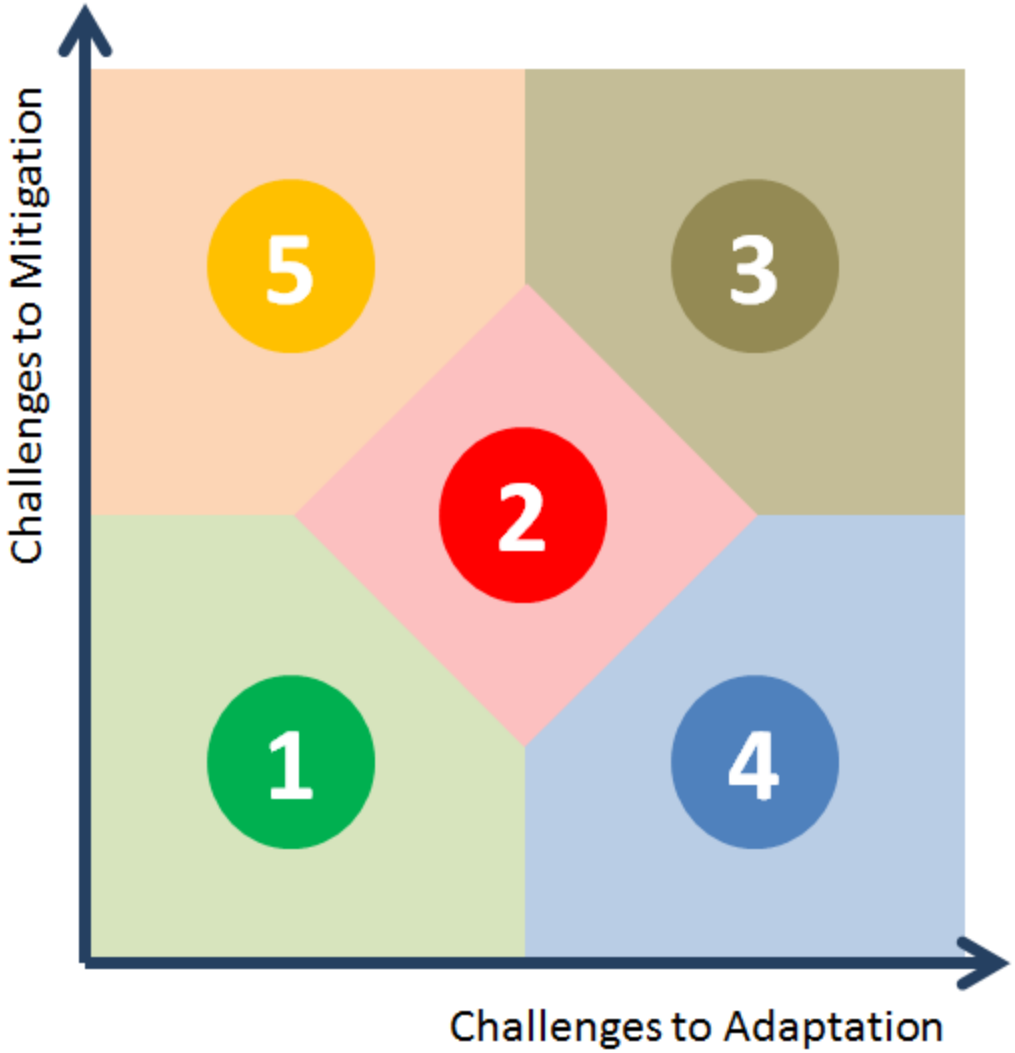
		SSP 1	SSP 2	SSP 3	SSP4	SSP5
	Reference	X	X	X	X	X
RCP Replication	8.5 Wm^{-2}			X		
	6.0 Wm^{-2}		X	X	X	X
	4.5 Wm^{-2}	X	X	X	X	X
	2.6 Wm^{-2}	X	X		X	

Van Vuuren et al. 2013

Questions new scenarios can address

- Given the world is on a particular development pathway, what are the potential impacts of climate change under different rates and magnitude of change?
  - For example, if the world is making progress towards sustainable development, then what might be the climate change attributable burden of malaria under different RCPs?
- Given the world is on a particular trajectory of climate change, what are the potential impacts under different development pathways?
  - For example, if the world is on track for 4.5 w/M^2 by 2100, then what might be the climate change attributable burden of malaria under different development pathways?

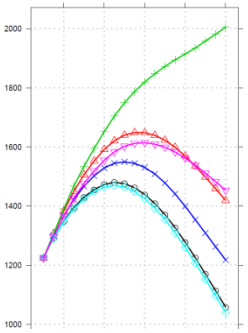
Shared socioeconomic pathways



O'Neill et al. 2013

SSP Elements

Narrative: The storyline is a verbal description of the state of the world. All non-quantitative aspects of the scenario are included in the storyline.



IAM Quantitative Elements define IAM reference "no-climate-policy" inputs, e.g. reference population by region by year, GDP, urbanization, technology availability

IAV Quantitative Elements define reference "no-climate-policy" inputs that are not IAM drivers, e.g. governance index or ecosystem productivity and sensitivity

Note: SSPs specify only pathways for quantitative input assumptions used by IAMs. They do NOT include IAM model outputs and do not include climate policy. Further, they are not influenced by climate change.

IAV elements: key determinants of adaptation challenges

Determinant:	SSP variable:
Average wealth	GDP projection
Poverty	Income distribution
Quality of governance	Governance
People in coastal zones	Spatial population projection
Urbanization	Urbanization
Education	Education
Innovation	Innovation
Quality of healthcare	Health projections

Storyline
IAM elements
IAV elements

Schweitzer 2014

Adaptation challenges

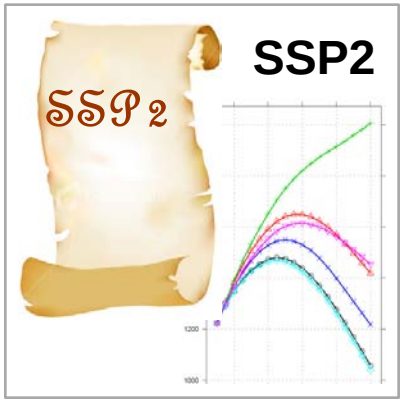
SSP5 Meet development goals, high economic growth, highly engineered infrastructure	SSP3 Delayed development; low human capital; high inequality; weak institutions; barriers to trade
SSP1 Meet development goals; reduced inequality; high education; improved health	SSP4 High inequality; large fraction of poor with low human capital; institutions ineffective for most

Mitigation challenges

SSP5 High demand; fossil-dominated supply	SSP3 Slow reduction in fossil dependency; slow tech change
SSP1 Reduced fossil dependency, low resource intensity; environmental awareness; effective institutions; high tech development	SSP4 Actual or potential low-C tech development driven by scarcity or policy concerns; few high income emitters; institutions effective for elite

Basic vs Extended SSPs

Basic

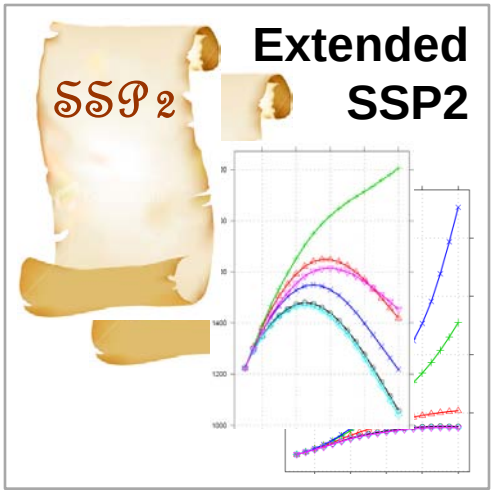


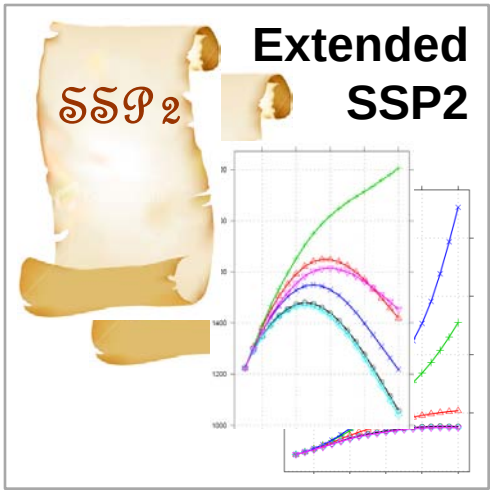
Information sufficient to locate SSP in Domain 2 of the challenges space

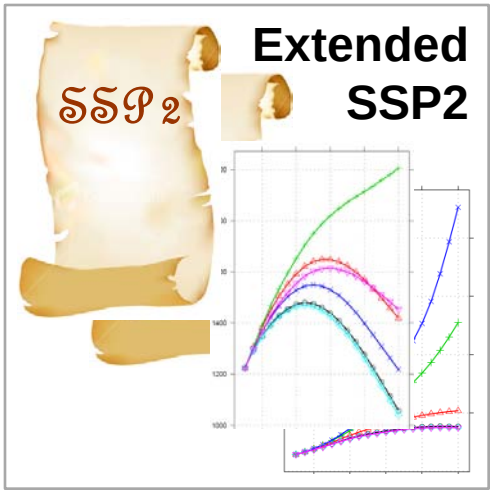
Regional Extension

Sectoral Extension

Global Extension







Shared Climate Policy Assumptions

- RCPs do not characterize the nature of climate policy interventions
- Climate policy assumptions may alter the challenges to adaptation and to mitigation
- Each RCP-replication would be undertaken with a particular set of policy assumptions
  - Consistent with the SSP with which it is associated
  - Each SSP could have a different set of assumptions about how emissions were mitigated

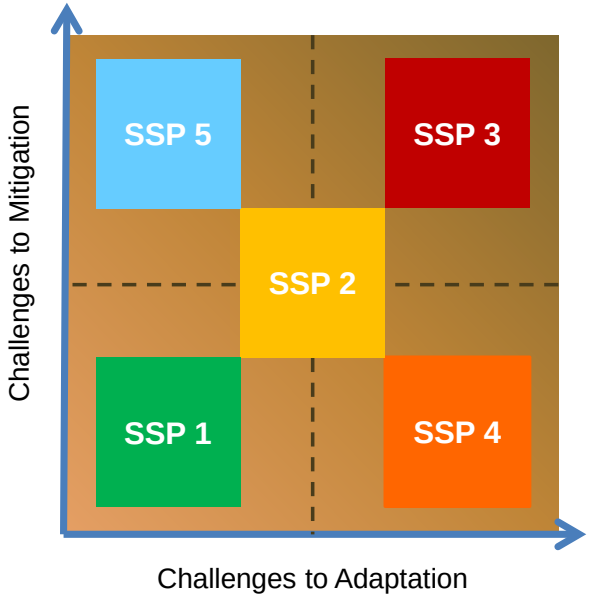
SPA Storyline: Like SSPs, SPAs have a narrative component

Quantitative Assumptions: SPAs have a quantitative set of assumptions, e.g. level of radiative forcing, rising or falling, timing of participation, policy instrument choice.

Kriegler et al. 2013

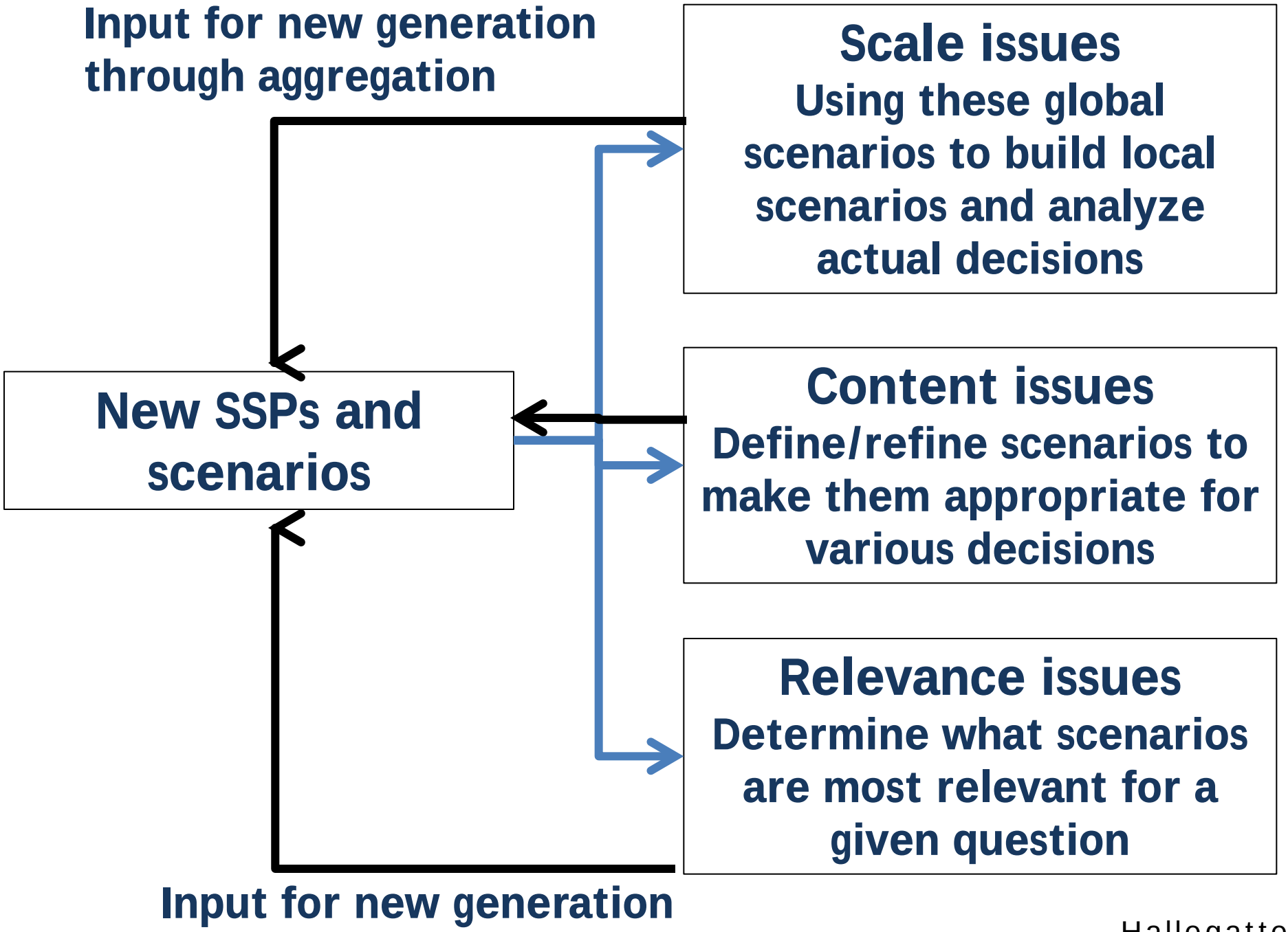
Uses for SSPs

- Binning function: ANYTHING that has high challenges to mitigation and adaptation is an SSP3
  - How to define the boundaries between SSPs?
- Points of external reference for IAV and IAM research: there would only be 5
  - But, for local and regional IAV research there is no right or wrong way to reference back
  - Quantitative information for some global-scale variables will be available



Next steps

- Enhancing the SSPs for IAV research
  - Applications across scale (Kasper Kok, Ben Preston)
  - Additional indicators (Marc Levy, Bas van Ruijven)
    - Income distribution / poverty
    - Spatial population projections
    - Governance
    - Human health
- IAM model drivers, implementations, narratives
  - Special issue GEC
- Evaluate SSPs for usefulness
- Application of the scenario framework
  - SSP + RCP = scenarios

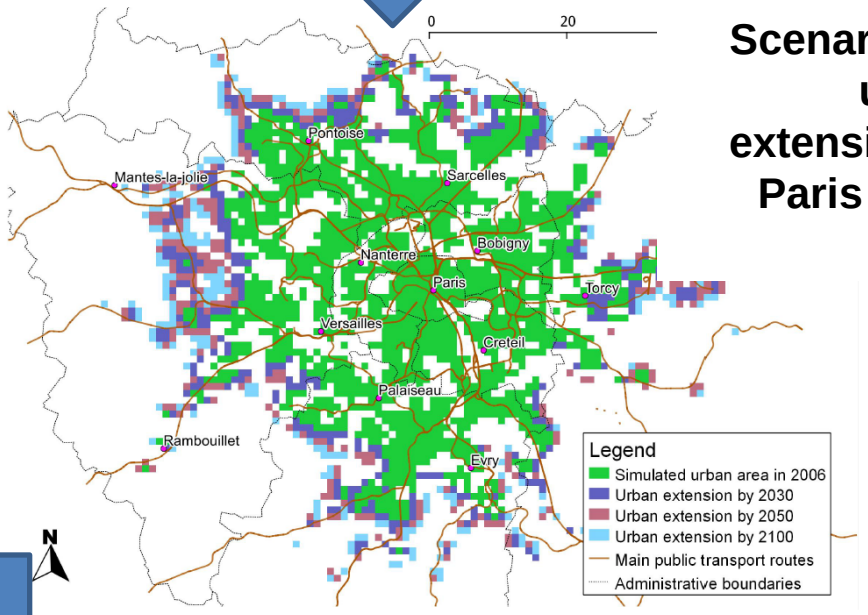

Input for new generation through aggregation
Scale issues
Using these global scenarios to build local scenarios and analyze actual decisions
New SSPs and scenarios
Content issues
Define/refine scenarios to make them appropriate for various decisions
Relevance issues
Determine what scenarios are most relevant for a given question
Input for new generation

Hallegatte

Global vs. local scenarios

Step 1: Defining global scenarios

Step 2: Downscaling from global scenario to local scenario



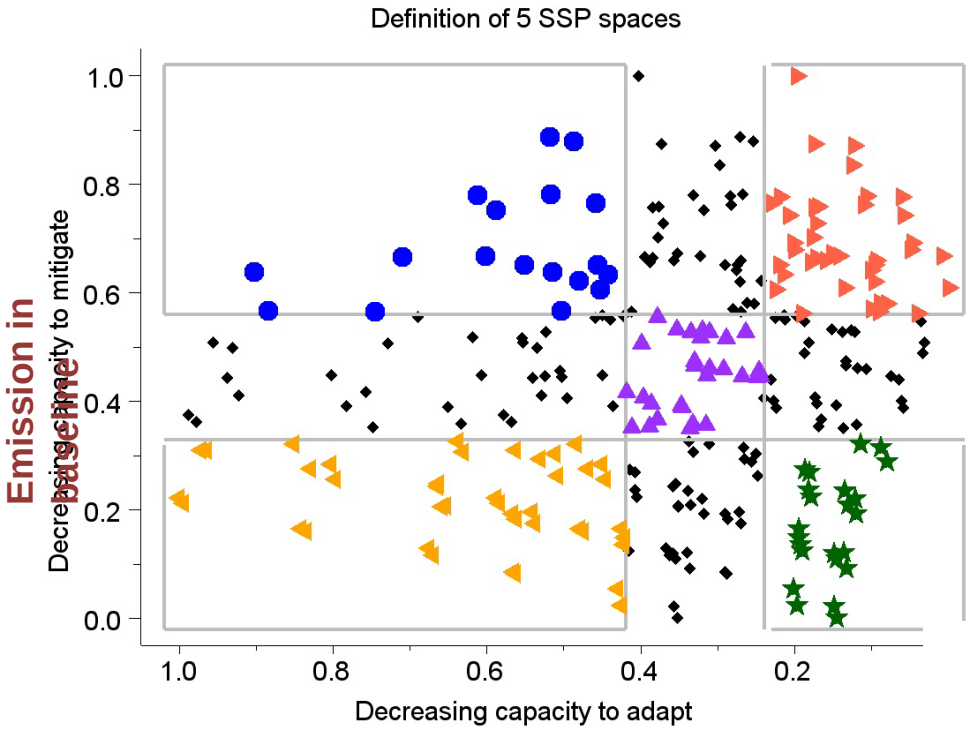
Scenario for urban extension in Paris up to 2100

Step 3 Aggregation of many local scenarios into new global scenarios?

Hallegatte

Content example: SSP variables for health issues

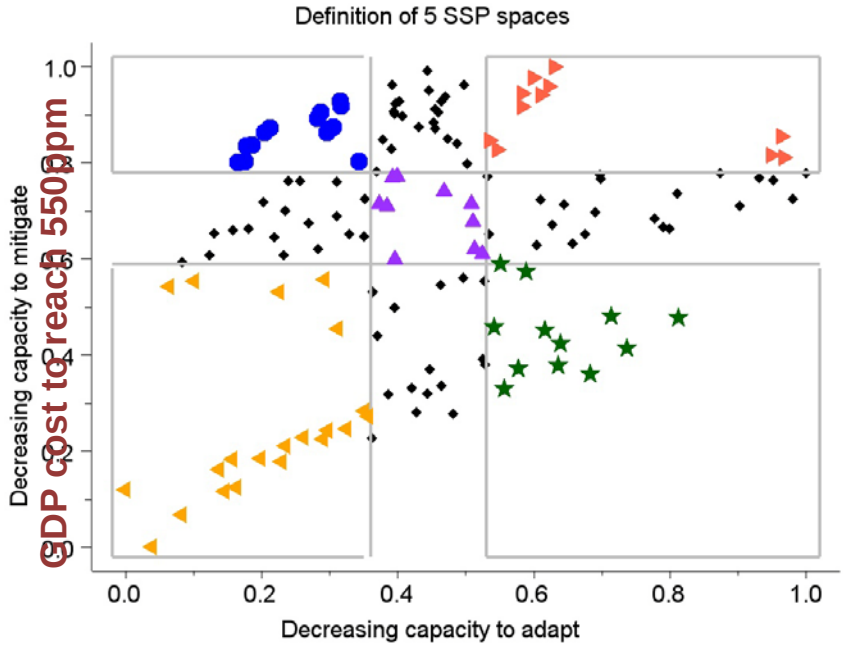
- In the previous generations of scenarios, many variables were missing for health issues:
  - Concentrations of air pollutant, inequality within countries, governance, health insurance, ...
- In the new generation, “extended” SSPs to include more variables. Work is needed to:
  - Identify what is required
  - Create the corresponding quantitative or qualitative information



GDP per capital of the 20% poorest in a selection of developing countries

Depending on how we define indicators of capacity to adapt and capacity to mitigation, the distribution of scenarios is different

Ideally, we will have different SSPs for each research question or policy analysis – toward a large dataset of scenarios?



Share of agriculture in GDP

Hallegatte

Relevant scenarios

- The 5 SSPs were chosen to inform most decisions on mitigation and adaptation, but certain decisions will require different scenarios
  - For water-borne illness, having scenarios that differ by oil prices may be useless
  - For local air pollution in cities, it is critical to have varying assumptions on oil prices
- Long-term objective: a large dataset of scenarios and a process to select a set of few scenarios for each decision or research question
- Question: for various health issues, what differences across scenarios do we need to perform an unbiased sensitivity analysis?
  - Differences in demographics (aging)
  - Differences in economic conditions (income, job)
  - Differences in access to services (drinking water)
  - Should they be correlated?

Special Issue *Climatic Change*

- A new scenario framework for climate change research: background, process, and future direction (Ebi et al.)
- A new scenario framework for climate change research: scenario matrix architecture (van Vuuren et al.)
- A new scenario framework for climate change research: the concept of Shared Socio-economic Pathways (O'Neill et al.)
- A new scenario framework for climate change research: the concept of Shared Policy Assumptions (Kriegler et al.)
- 10 other papers on various aspects of the framework

ICONICS

International Committee On New Integrated Climate change assessment Scenarios

http://www2.cgd. ucar.edu/research/iconics

Chairs: Kristie Ebi, Tom Kram

- **Narratives**
  - **Brian O'Neill, Elmar Kriegler**
- **IAM quantitative drivers and IAM scenarios**
  - **Detlef van Vuuren, Keywan Riahi**
- **IAV quantitative elements and evaluation metrics**
  - **Marc Levi, Bas van Ruijven**
- **Nested scenarios across geography and time**
  - **Kasper Kok, Ben Preston**
- **IAV-IAM handshake**
  - **Jae Edmonds**
- **Roadmap for future IAV-IAM collaboration on scenarios**
  - **Stephane Hallegatte**