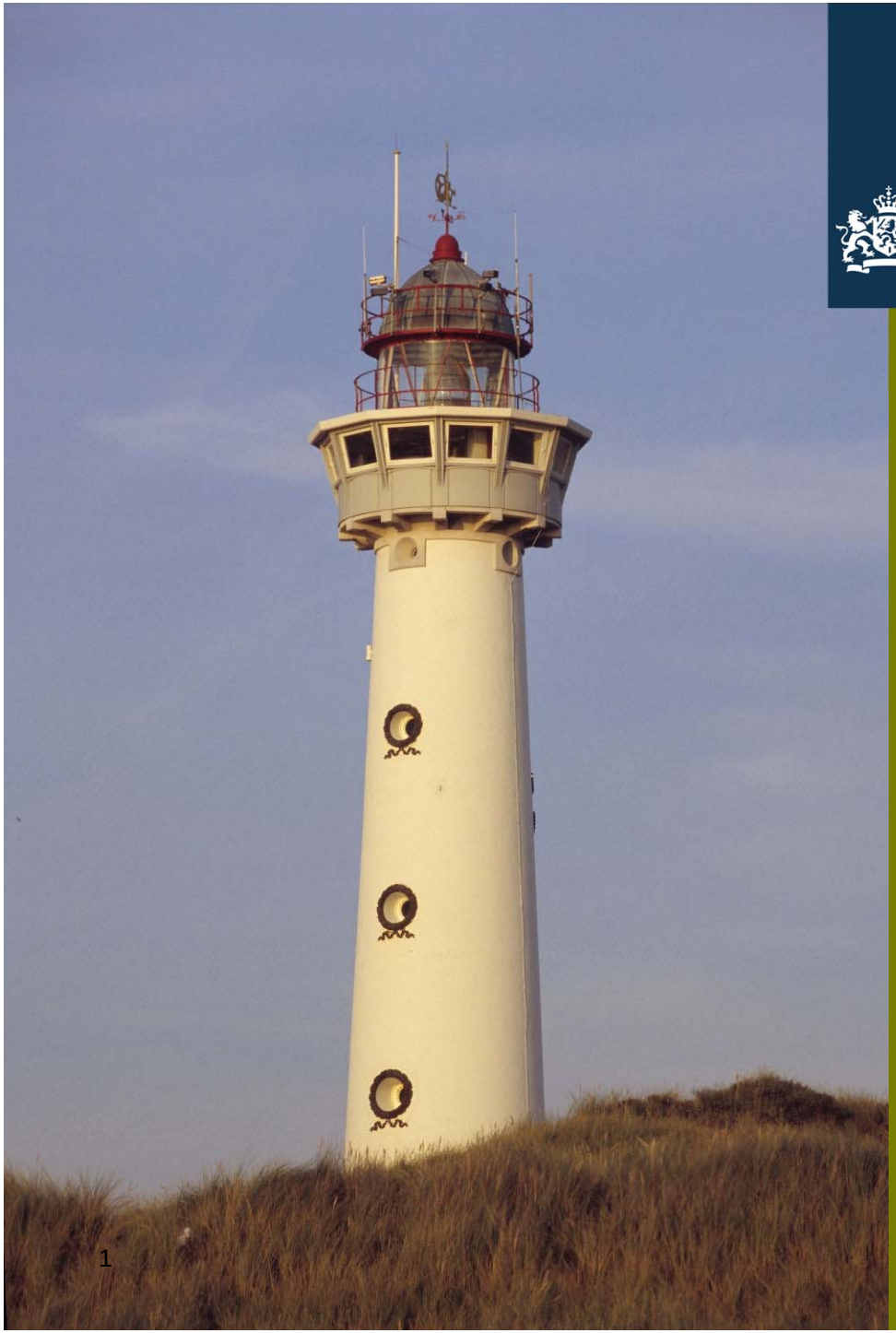

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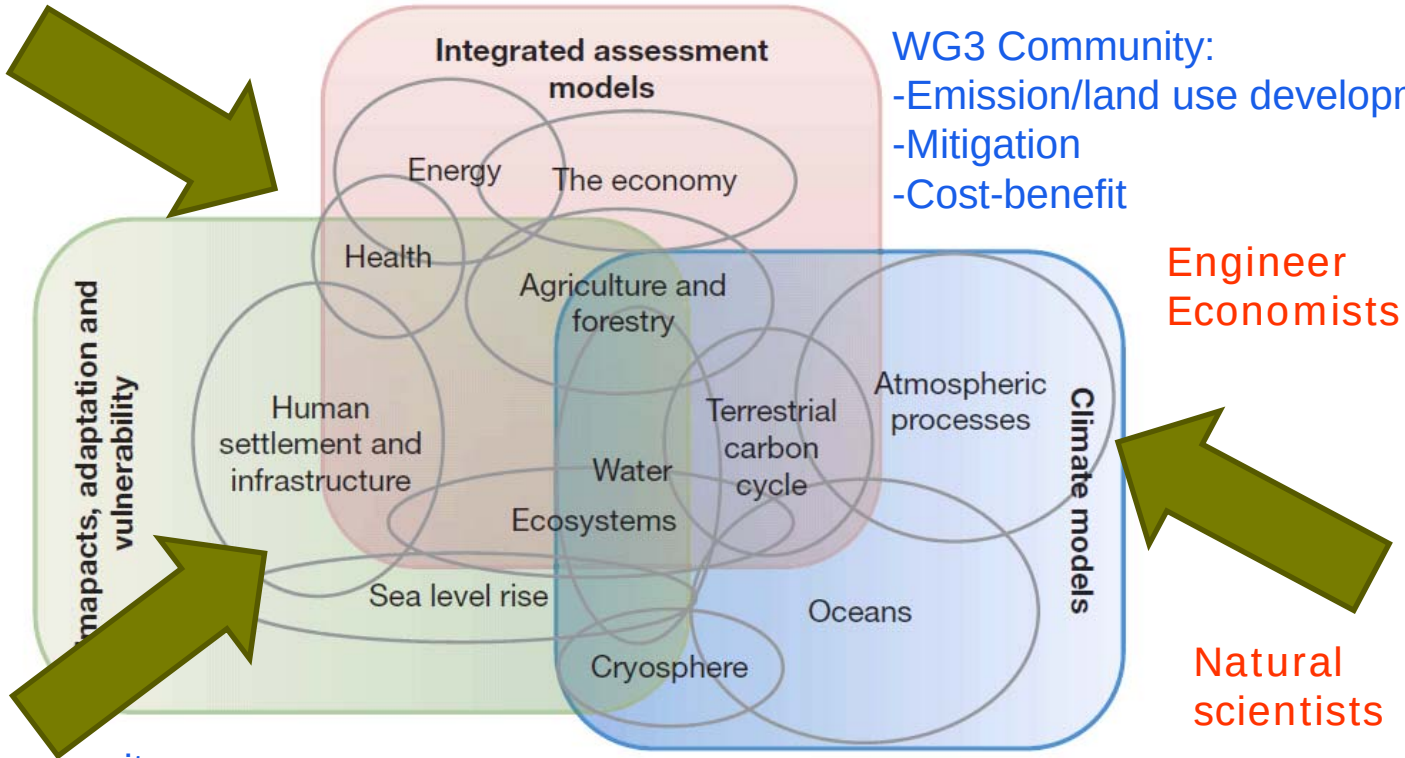
Going beyond the RCPs: scope for cooperation between ESM and IAM models

Detlef P. van Vuuren et al.

Climate change multi-faceted topic - traditionally studied from different disciplines



WG3 Community:
-Emission/land use development
-Mitigation
-Cost-benefit

Engineer
Economists

Natural
scientists

WG2 Community:
-Impacts
-Adaptation

Ecologist
Geographers

WG1 Community:
-Climate system

Always has been coooperation, but recent trend seems to be towards more integration

Reasons

- Discussion about costs and benefits of climate change
- Further development of ES Models: More-and-more into including humans (land use) and impacts.
- New scenarios as “common thread” to link different WGs IPCC
- …

Further integration IAM-ESMs

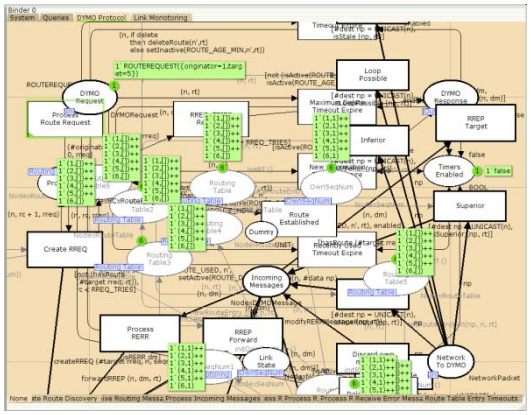
Focus here on the linkages of IAM and ES model

Default mode in discussions seem to be further model expansion → include IAM aspects into ES models

Is that a clever strategy?

Voldoire A, et al. (2007) Climate simulation of the twenty-first century with interactive land-use changes Clim. Dyn. 29 177–93

Bahn O, et al 2006 The coupling of optimal economic growth and climate dynamics Clim. Change 79 103–19



?

Van Vuuren et al., (2012). A comprehensive view on climate change:coupling of earth system and integrated assessment models. Environ. Res. Lett. 7 (2012) 024012

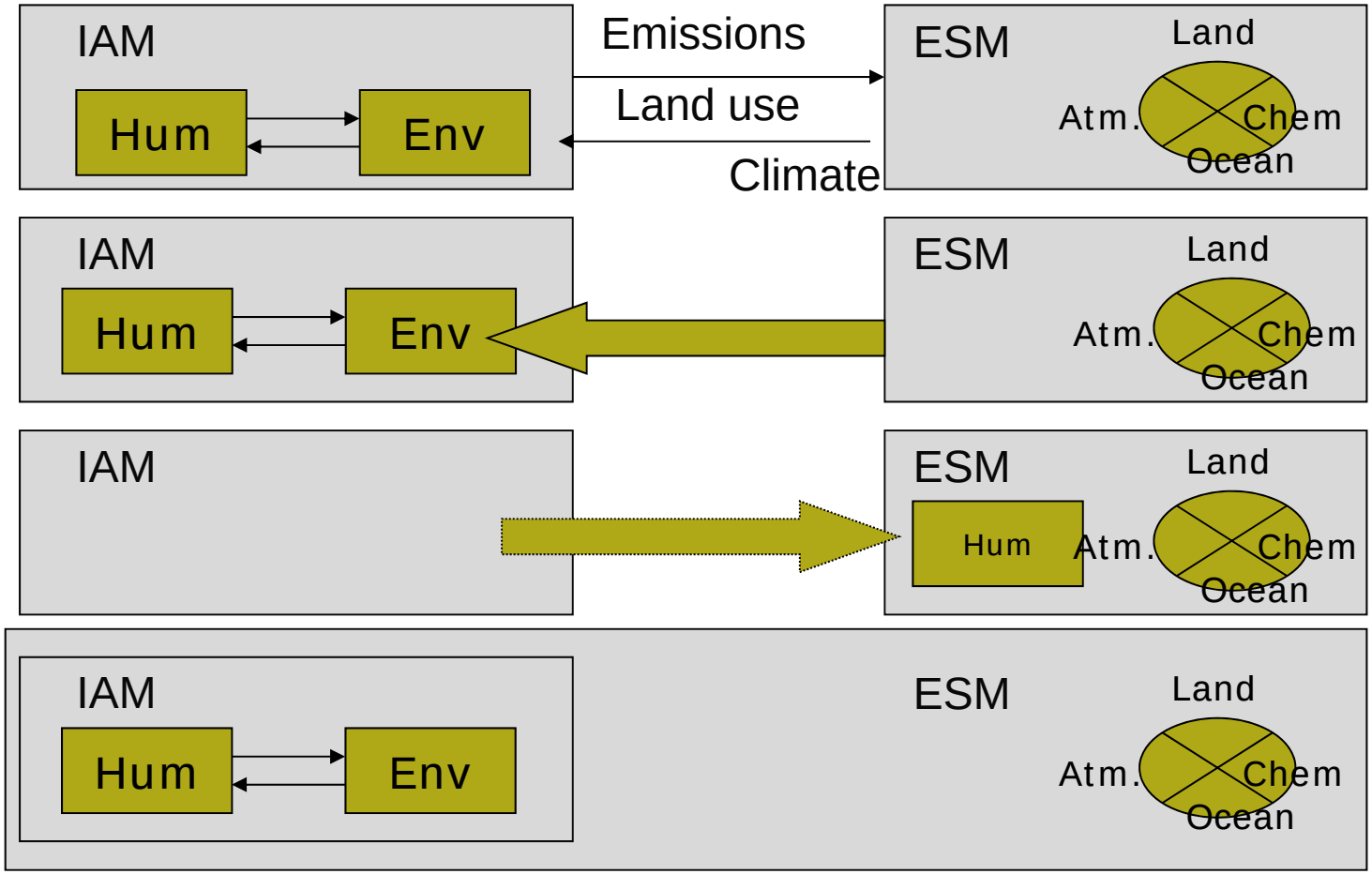
How to organize cooperation?

A. Off-line

B. Improved IAM

C. Improved ESM

D. Full coupling



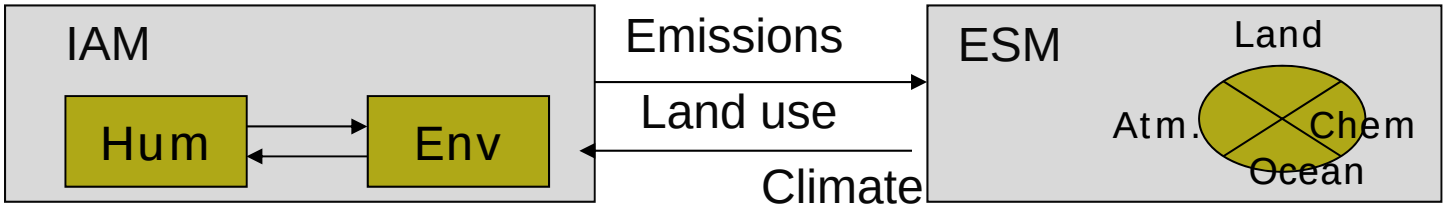
Cooperation type A.

- Comparable to current set-up CMIP5/RCPs

•work with existing terminology and tools
•transparent information exchange
•High flexibility : easy exchange of ESMs and IAMs
•separate research strategies

•Feedbacks are only captured via (one-single) iterations.
•potential inconsistencies

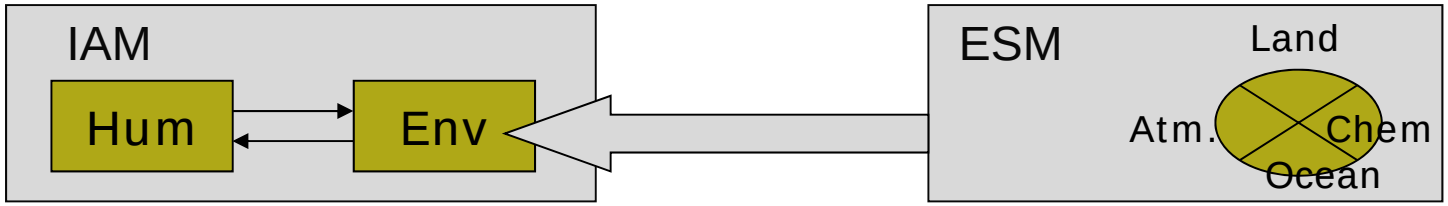
A. Off-line



Cooperation type B.

- Further improve climate models in ESM (MAGICC emulation of CMIP4 models; pattern scaling; refined pattern scaling (sulphur, albedo etc)
  - IAMs designed as integration platform
  - allows for good representation of uncertainty
  - Flexibility : different ESM might be represented
  - model complexity tailored to question
  - detail in treatment of socio-economic processes
- lack of detail in treatment of biophysical processes (often meta modeling)

B. Improved IAM



Cooperation type C.

- Further include human system elements in ESMs (e.g. urban environment, land-use rules to better describe land-cover, water consumption rules)

- higher resolution analyses than in IAMs
- detail in treatment of biophysical processes

- lack of detail in treatment of socio-economic processes
- limitation of model runs limits representation of uncertainty

C. Improved ESM

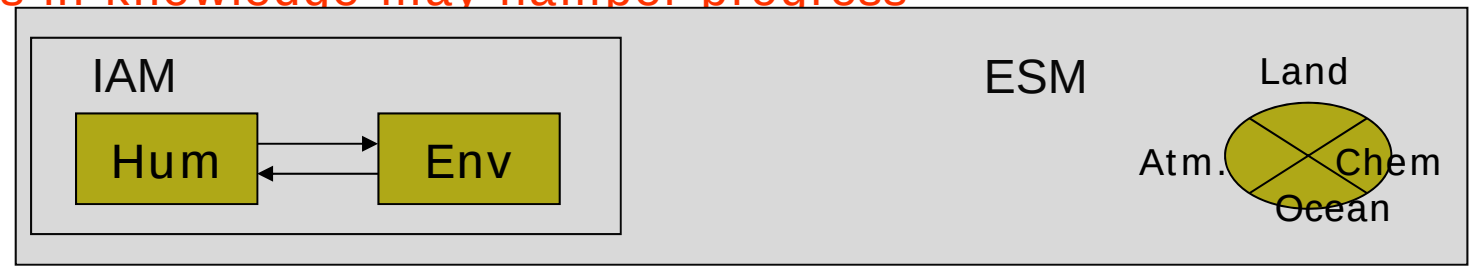
Cooperation type D.

- Include full IAMs in ESMs (e.g. IMAGE in CNRM-CM3, Voldoire et al, 2006; GCAM in CCSM, IMAGE-EC Earth, MERGE-Bern).

  - assessment of feedbacks
  - highest degree of consistency

  - technical difficulties
  - Compex cooperation
  - lack of representation of uncertainty
  - Inflexibility (one IAM, one ESM)
  - complexity/intransparency
  - limitations in knowledge may hamper progress

D. Full coupling



Consideration for best form of cooperation

- One-way linkage dominant (feedbacks are weak, very slow, or non-existent) → **category A**
- Interactions significant in both directions and simple formulation possible → **category B** (e.g. radiative forcing by long-lived greenhouse gases)
- Main focus natural system; simple human system representation possible → **category C** (e.g. land-use rules)
- Interactions (likely) significant and processes are complex (geographical, temporal) and/or cannot be adequately represented in simple models → **category D.**
- Non-linear threshold behavior --> **category D?**
- Uncertainty very large? → **category A or B**, at least to explore uncertainty range. Only if results indicate possible strong feedback → **C or D analysis.**

- In other words, it is only useful to consider complex coupling if potentially strong feedbacks are involved and the processes involved are rather well established.

Van Vuuren et al., (2012). A comprehensive view on climate change:coupling of earth system and integrated assessment models. Environ. Res. Lett. 7 (2012) 024012

Examples

- *Impact of climate change on energy use.* Relatively well-known, but mostly via aggregated processes (see Isaac et al, Aebisher et al, Hadley et al). Small impacts (thus category B?). Maybe impacts via air pollution could warrant more complex interactions (first exploration via A)?
- *Impact of climate change on transport and shipping routes.* More uncertain, but global impacts likely to be small (Eyring et al.). Coupling via A.
- *Interaction between air pollution and crop growth.* For instance, ozone/nitrogen on crop/vegetation growth. Still rather unknown → Type A.

al., (2012). A comprehensive view on climate change:coupling of earth system and integrated assessment models. Environ. Res. Lett. 7 (2012) 024012

Examples

- *Interaction between climate change and land use.*
  - The importance of representing dynamic vegetation in ES models is well known and it is equally known that human activities play an important role in land use/land cover trends.
  - Interactions might be at local scale (albedo, heat / water exchange processes).
  - Examples: Amazon forest deforestation; monsoon consequences in South Asia.
  - Use various methods: Method A for exploration; Method D for trying to find potential feedbacks.

Van Vuuren et al., (2012). A comprehensive view on climate change:coupling of earth system and integrated assessment models. Environ. Res. Lett. 7 (2012) 024012

Land use pattern mixed with climate pattern

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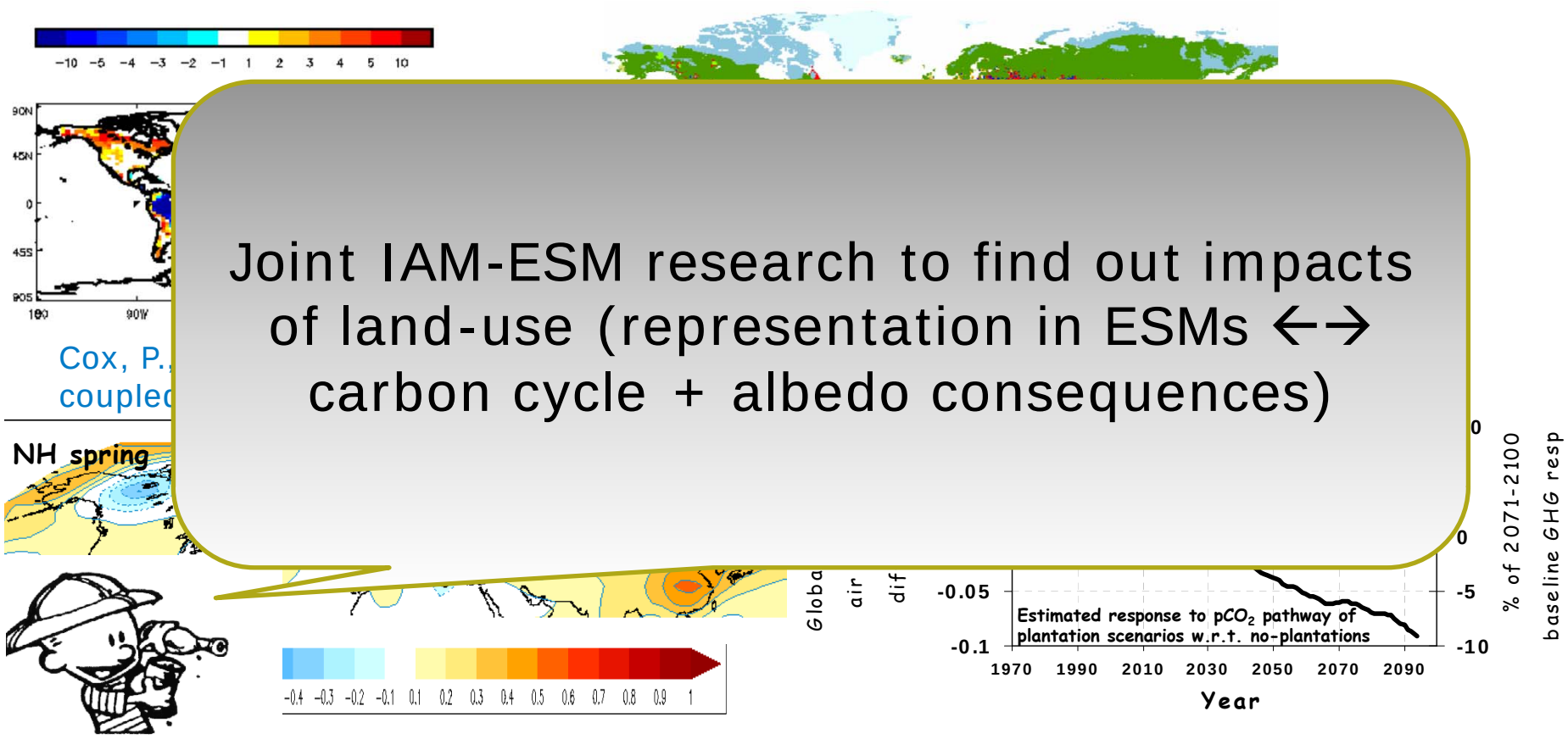
Land use consistent with temperature?

Joint IAM-ESM research to find out impacts of land-use (representation in ESMs ←→ carbon cycle + albedo consequences)



Schaeffer et al. (2006) CO2 and albedo climate impacts of extratropical carbon and biomass plantations Glob. Biogeochem. Cycles 20 GB2020

Other examples

- *Interaction between climate policy and air pollution policies*
- *Droughts, availability of water and impacts on societies*
- *Mitigation policy responses to realized/projected climate change*
- *Extreme and catastrophic events*
- *Avoiding particular (regional) climate change outcomes or impacts*
- *… (in paper we discuss in total 10 examples including literature)*

Van Vuuren et al., (2012). A comprehensive view on climate change:coupling of earth system and integrated assessment models. Environ. Res. Lett. 7 (2012) 024012

Conclusions

- More cooperation ES / IAM community useful and interesting (better understanding of joint development human / earth system)
- Cooperation can take many different forms – each with strenghts and weaknesses
- Some clear issues related to RCPs (land use, aerosols)
- Full integration might not always be the best approach (uncertainty; lack of strong feedbacks)
- Full integration in particular useful when local-scale processes become important (not represented by IAMs)

Beyond RCPs

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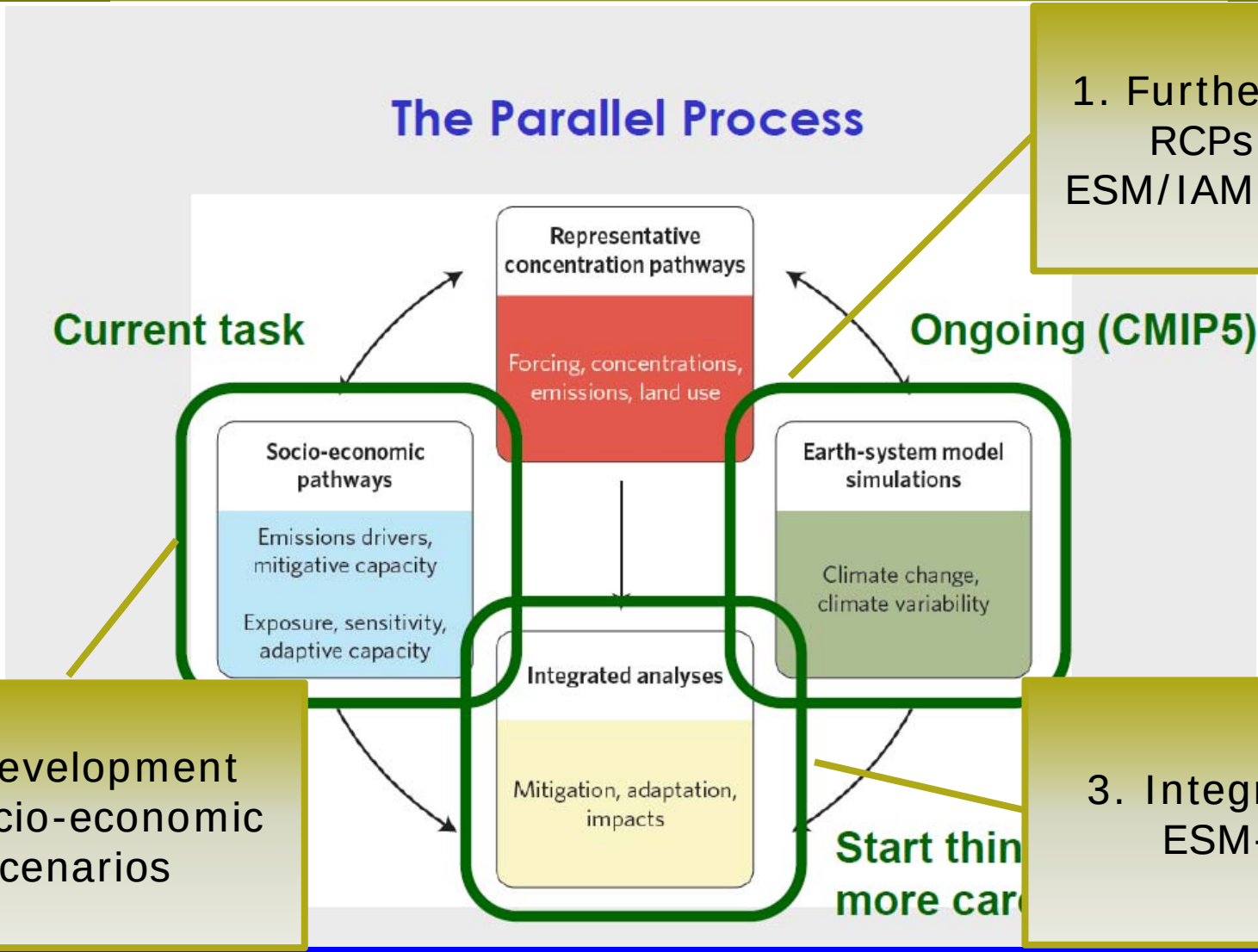

1. Further work on RCPs (joint ESM/IAM research)

2. Development Of socio-economic scenarios

3. Integration of ESM-IAM

Moss RH, et al (2010) The next generation of scenarios for climate change research and assessment. Nature 463:747-756.

Representative concentration pathways

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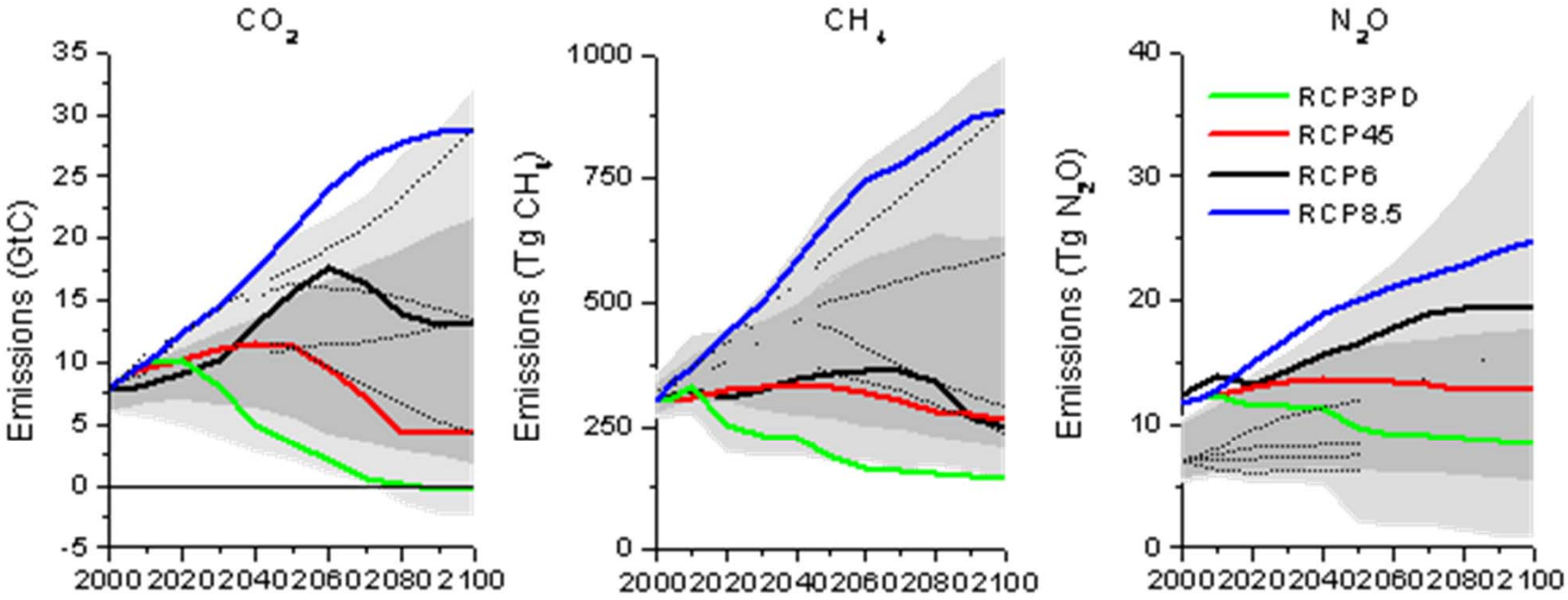
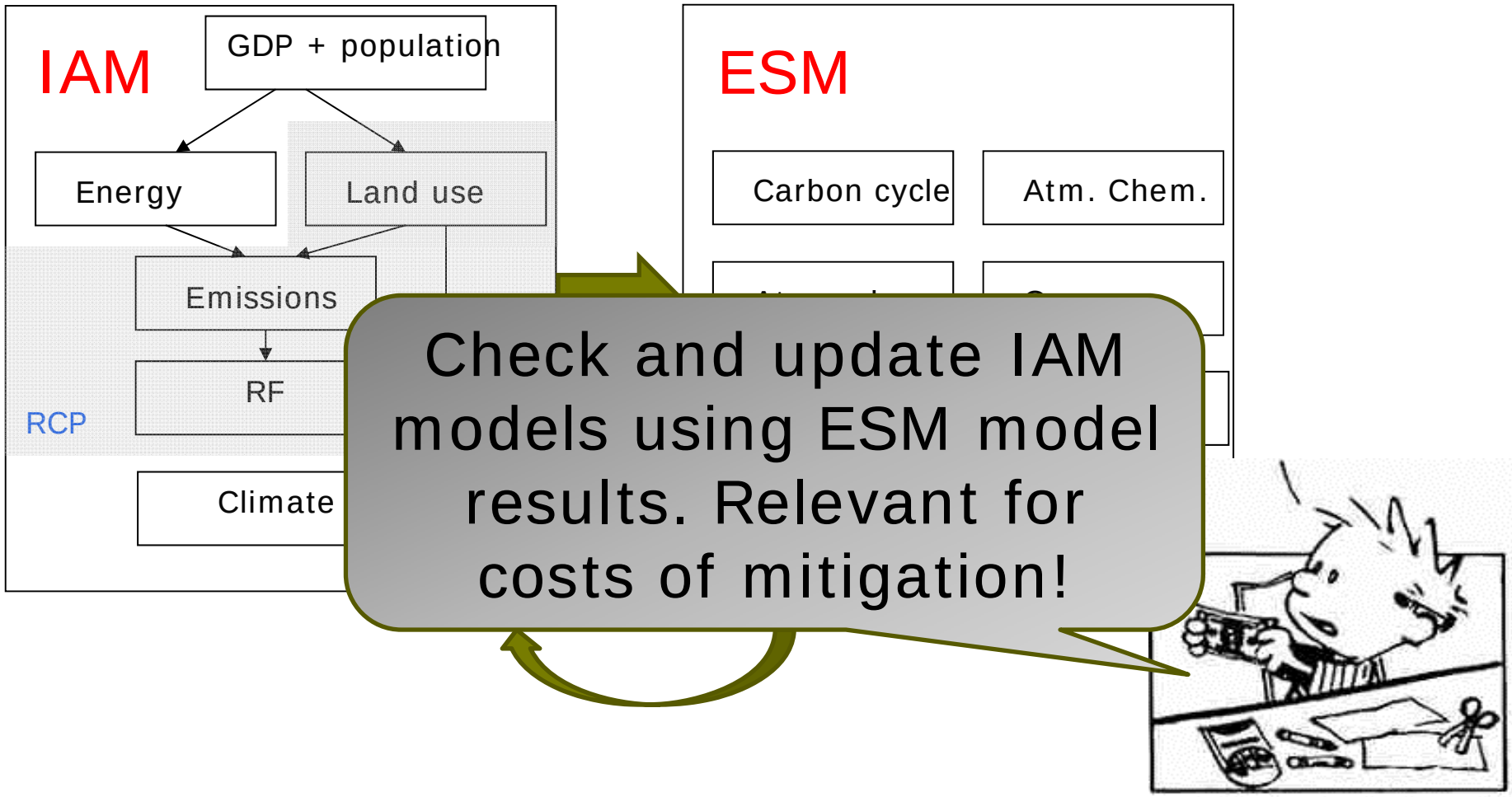


- Set of scenarios that is consistent with scenario range in literature (emissions and land use)
- Range is broader than AR4: Climate policy accounted for

Van Vuuren, D.P. et al 2011. Representative Concentration Pathways: An overview. Climatic Change.

What do the RCPs provide?



RCPs only cover limit air pollution range

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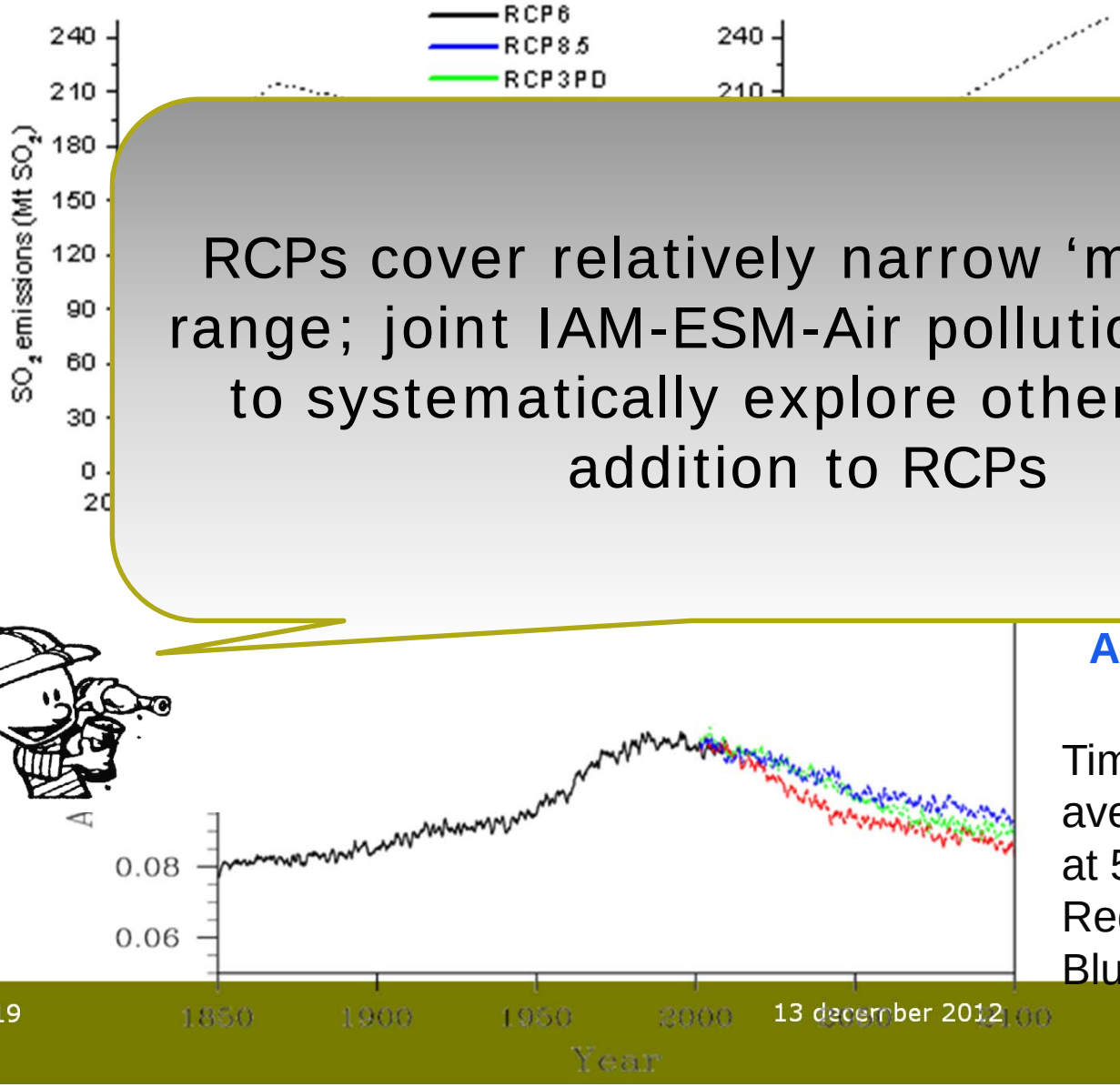

RCPs cover relatively narrow 'most likely' range; joint IAM-ESM-Air pollution research to systematically explore other areas in addition to RCPs

Aerosol forcing (NCAR)

Time evolution of globally-averaged aerosol optical depth at 550 nm annual 1850-2100. Red: RCP2.6. Green: RCP4.5. Blue: RCP8.5.

Scenarios for impact analysis

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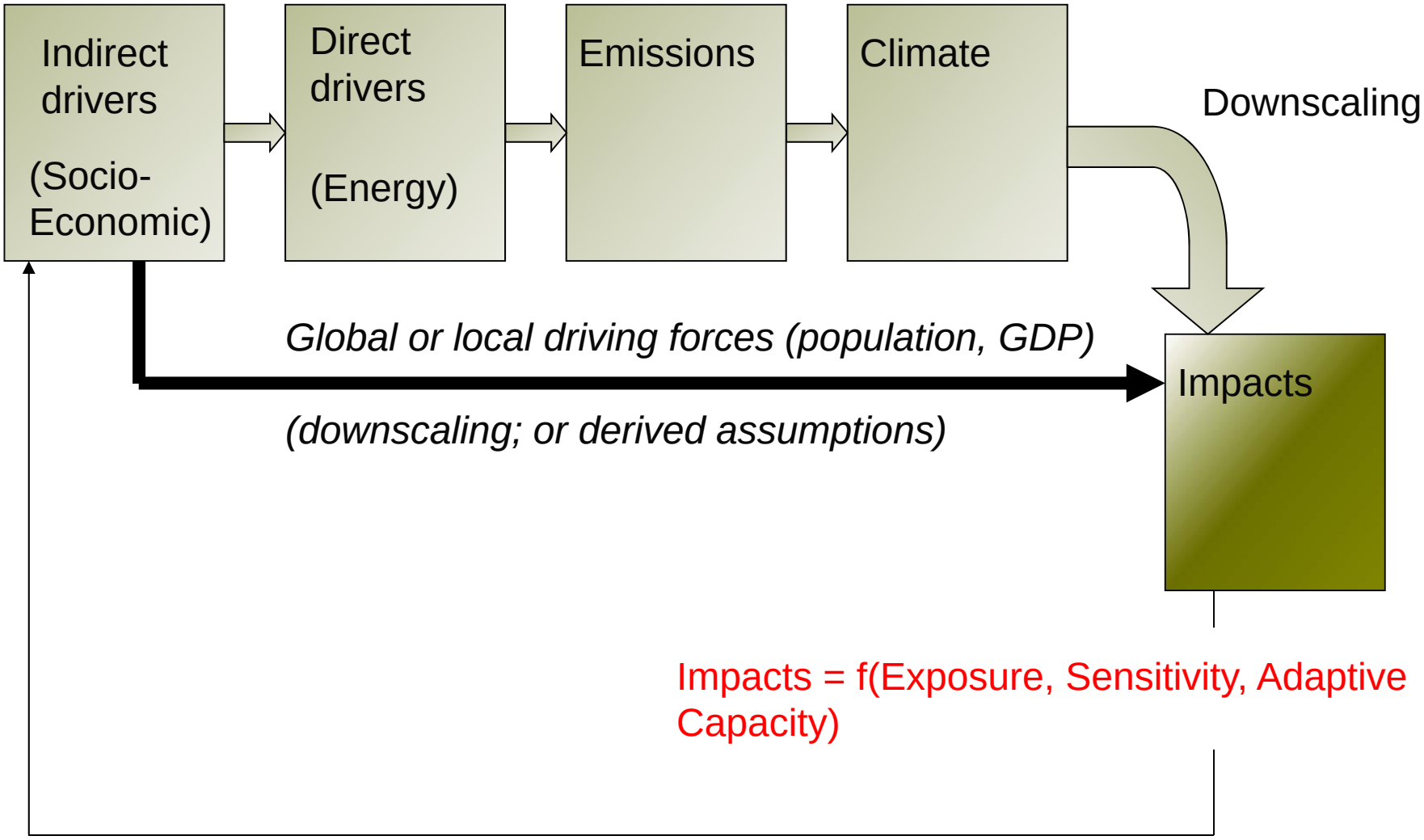

Matrix approach

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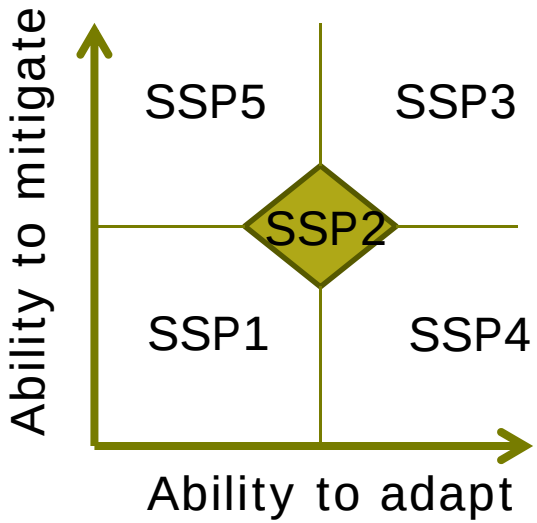
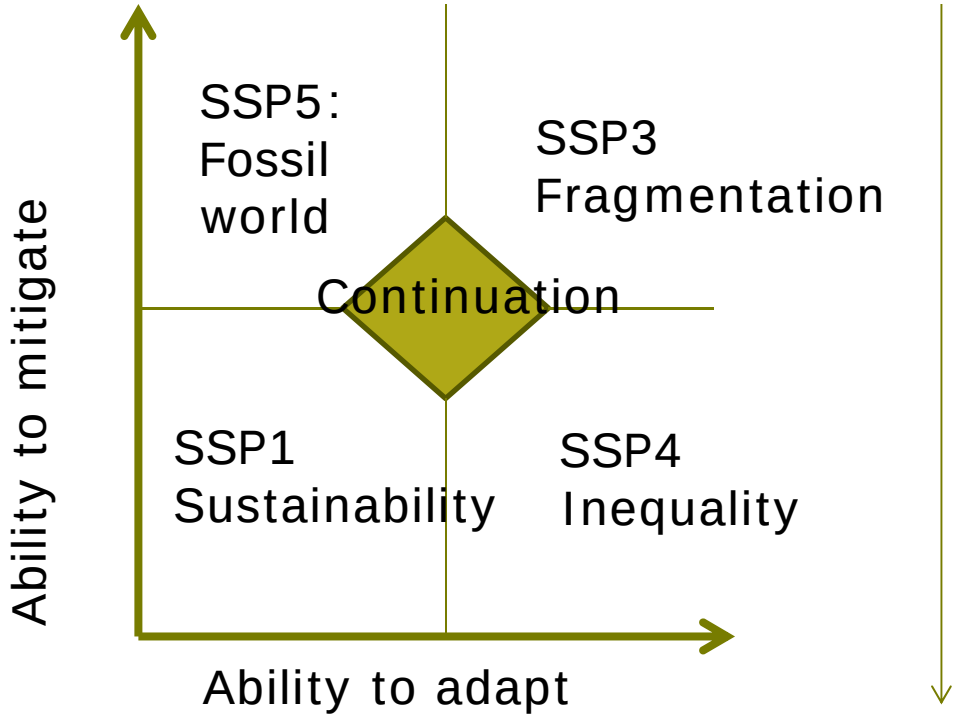
Shared socio-economic reference pathway

Forcing level (W/m²)	SSP1	SSP2	SSP3	SSP4	SSP5
8.5					
6.0					
4.5					
3.7					
2.6					



Van Vuuren, D.P. et al 2012. . A proposal for a new scenario framework to support research and assessment in different climate research communities . Global Environmental Change

SSP process



First round population / GDP
Numbers published → review

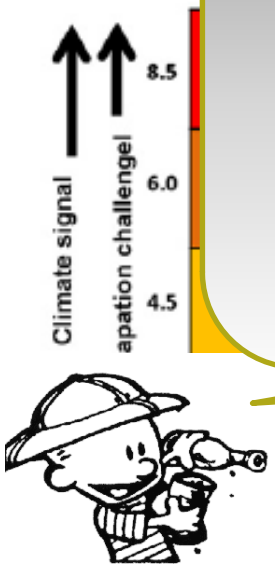
October/November: New GDP/
Population numbers published

Storylines published

Jan-March: Integrated
Assessment output published

O'Neill et al 2011. Report on the meeting on new Socio-economic scenarios. Workshop at NCAR. Boulder. Coldorado.

Application of these scheme to identify costs and benefits of laissez-faire, mitigation and adaptation strategies



Van Vuuren, D.P. et al 2012. . A proposal for a new scenario framework to support research and assessment in different climate research communities . Global Environmental Change