International Institute for Applied Systems Analysis
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science for global insight

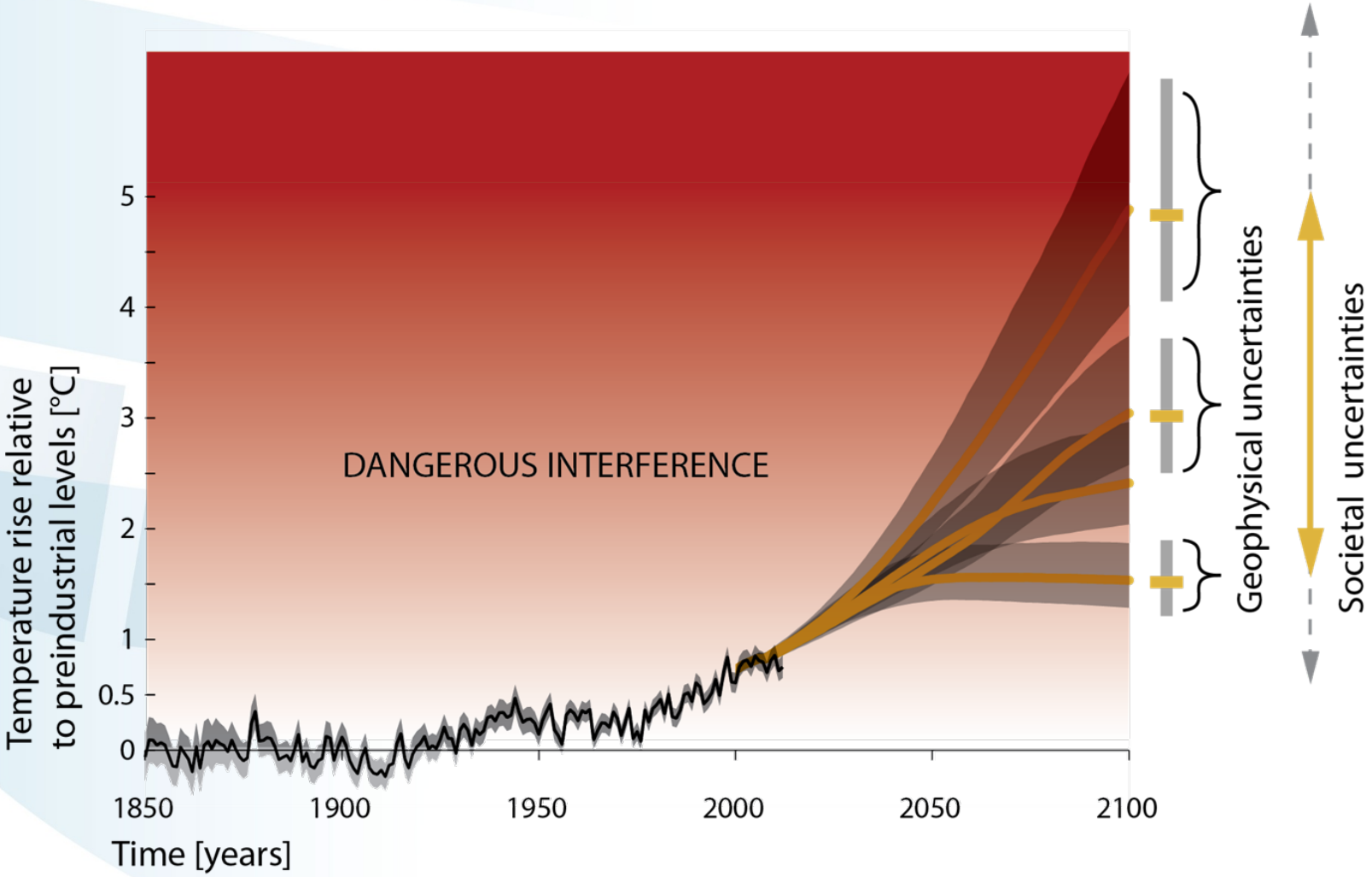
Keeping warming to below 1.5°C Possible? And if so, how?

Australian-German Climate & Energy College
EU Centre on Shared Complex Challenges
University of Melbourne, Australia
Joeri Rogelj – 26 April 2016

Outline

- Paris Agreement intro
- Emission implications
- What do 1.5°C scenarios look like?

Paris Agreement

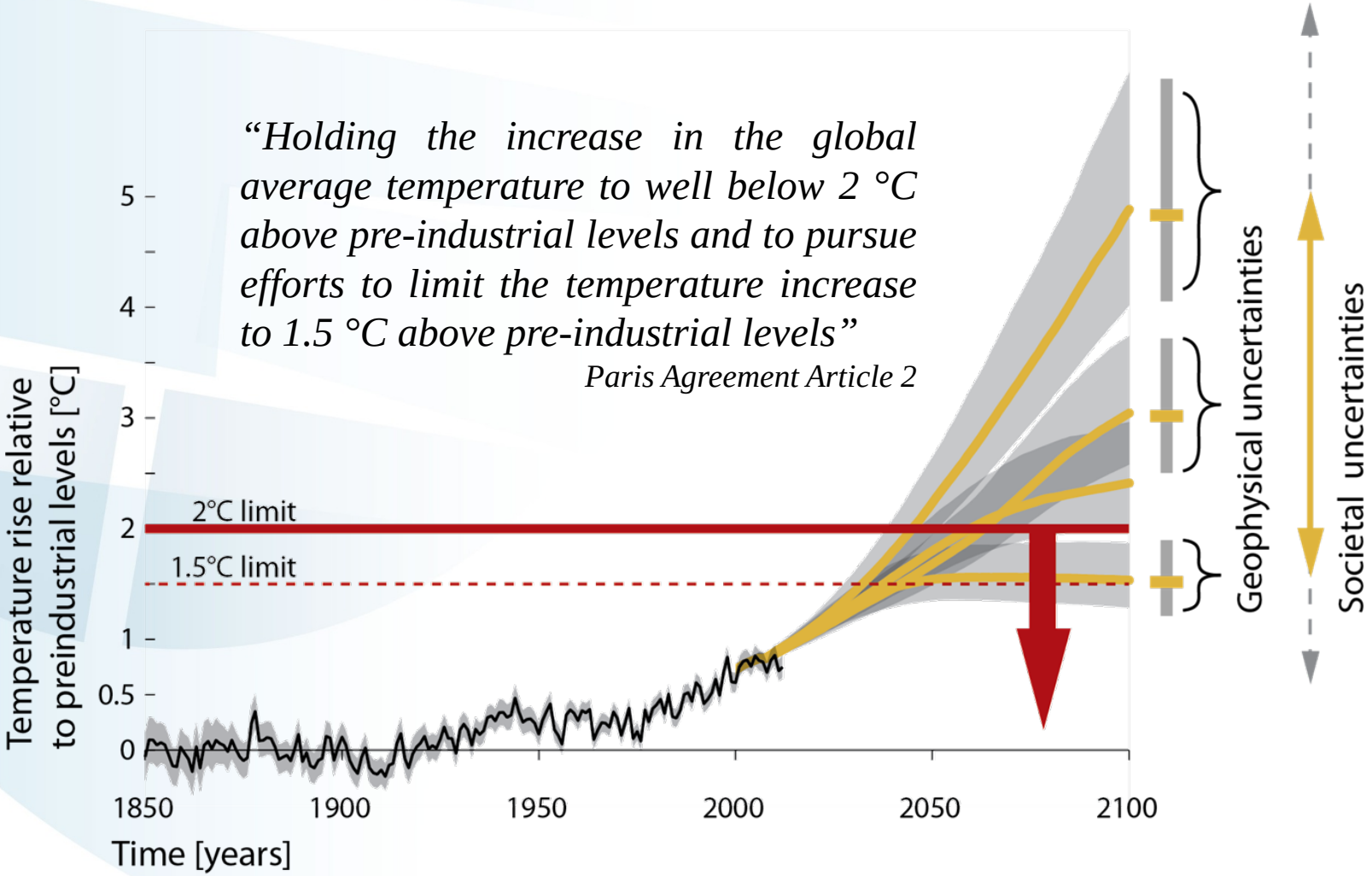


Own RCP projections; History: HadCRUT4

Paris Agreement

"Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels"

Paris Agreement Article 2



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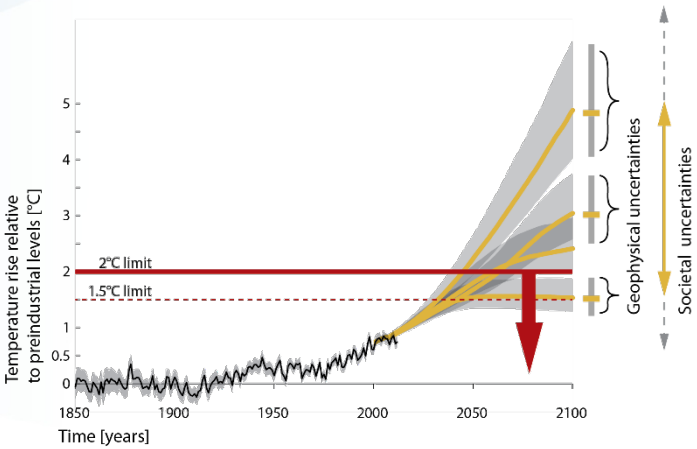
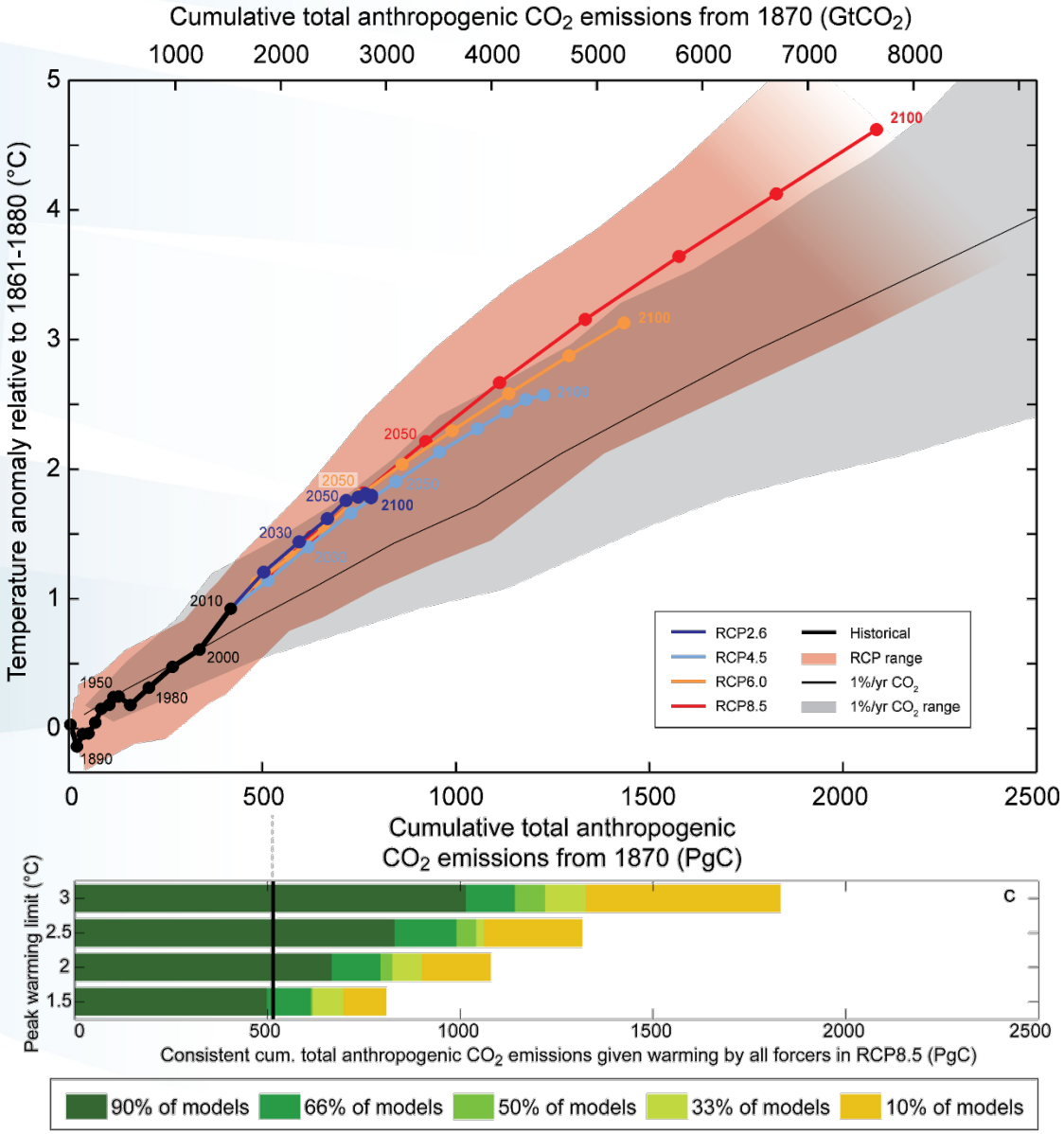
Paris Agreement Article 4



Own RCP projections; History: HadCRUT4

Emissions implications

carbon budgets



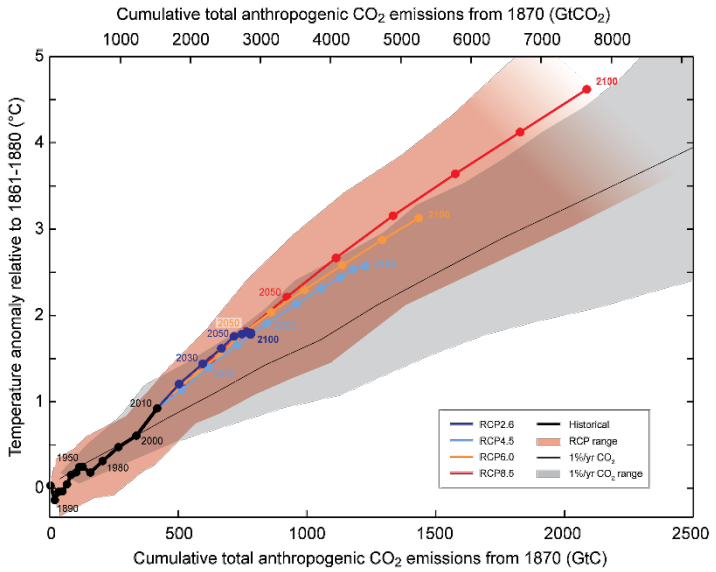
IPCC AR5 WGI TFE.8 Fig. 1

Emissions implications

How much remains for 1.5°C?

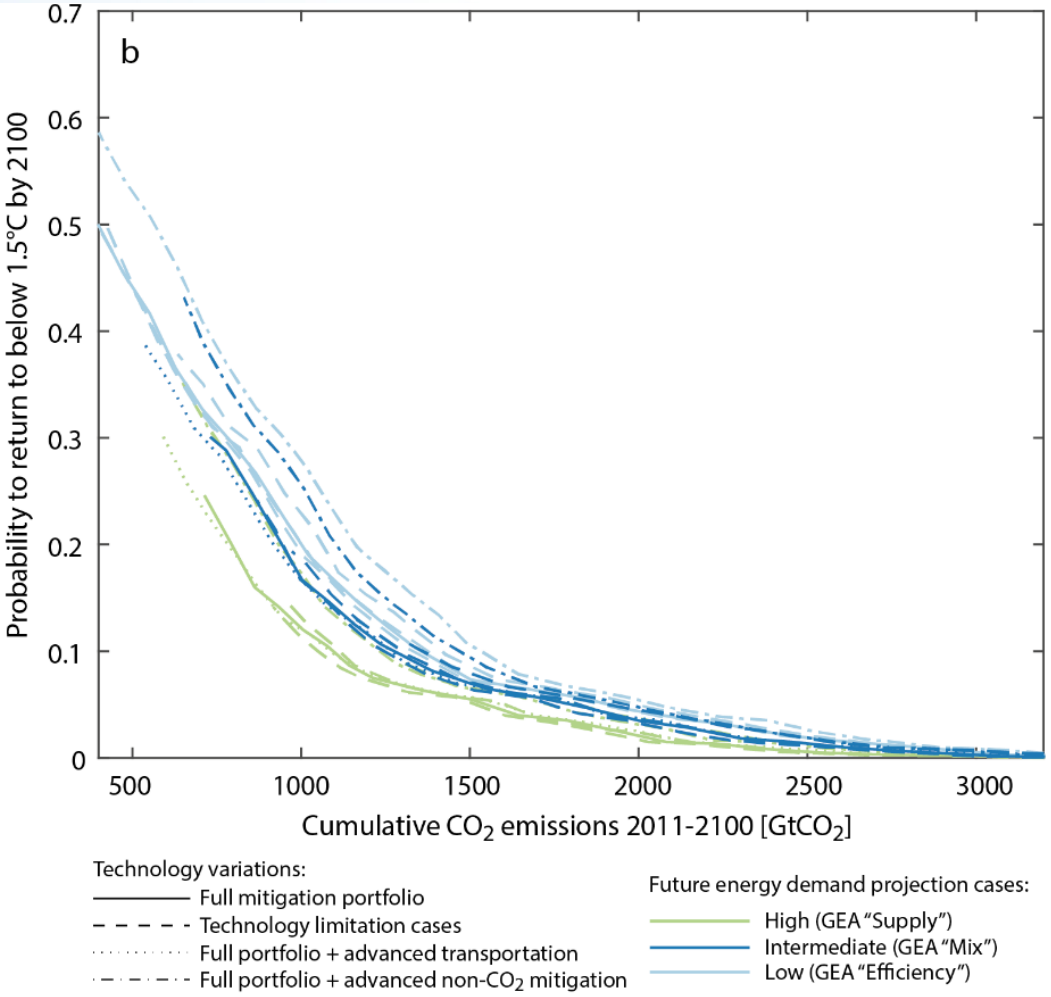
- IPCC AR5 SYR
  550 $GtCO_2$ after 2011
- CMIP5 (near-term adjusted)
  650 $GtCO_2$ since 2010-2020 average

- Current annual emissions ~37 $GtCO_2$



Emissions implications

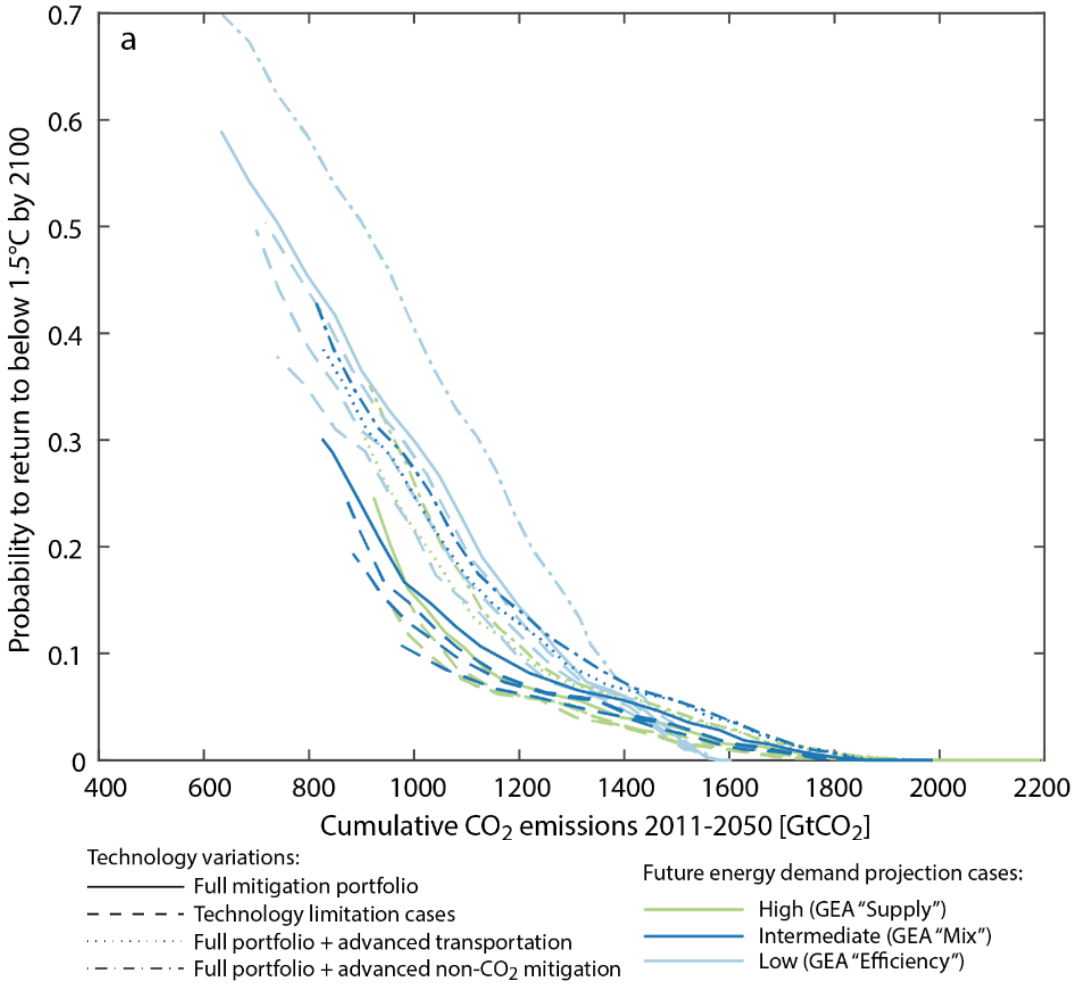
How much remains for 1.5°C?



Rogelj et al. 2015, ERL

Emissions implications

How much remains for 1.5°C?



Rogelj et al. 2015, ERL

Emissions implications

Internal consistency Paris Agreement

"Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels"

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Emissions implications

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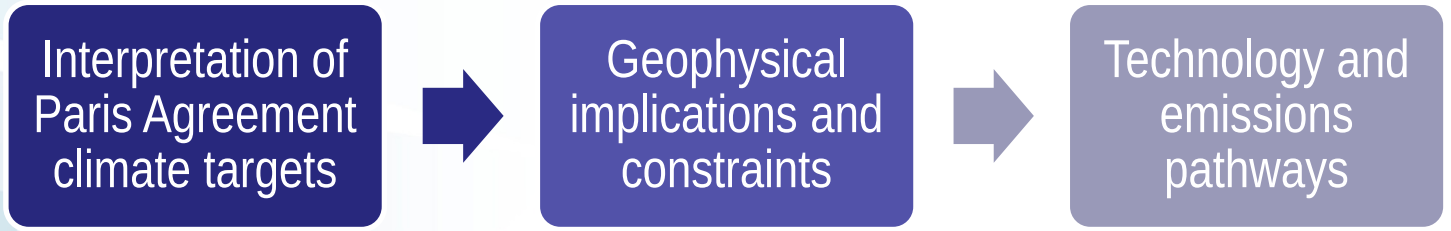
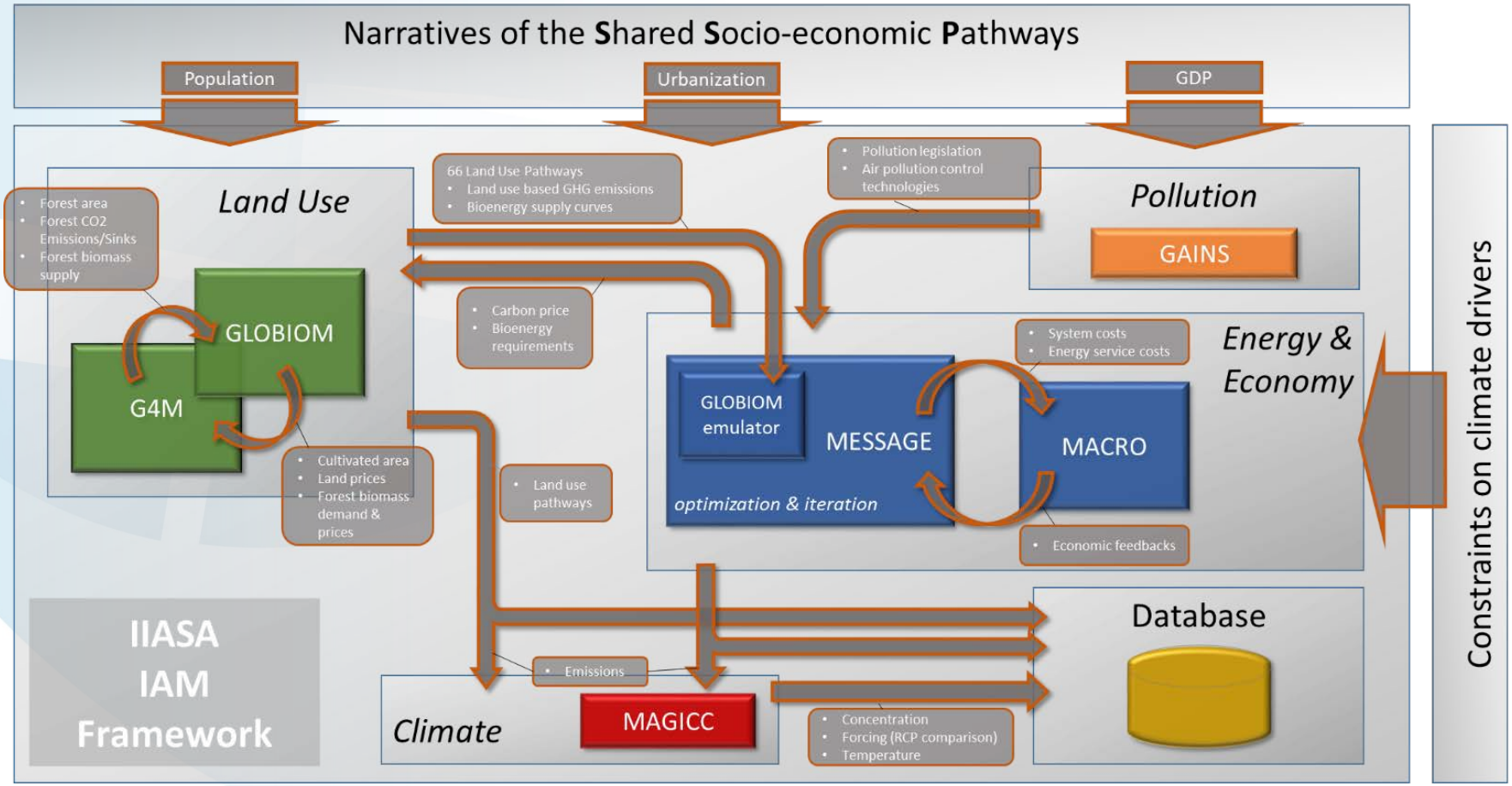


Example: IIASA IAM framework
(MESSAGE-GLOBIOM)

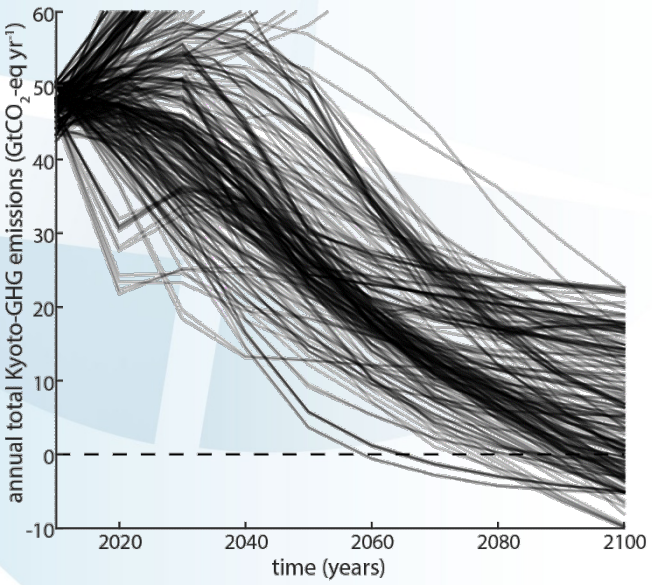


Fricko et al (in review) GEC

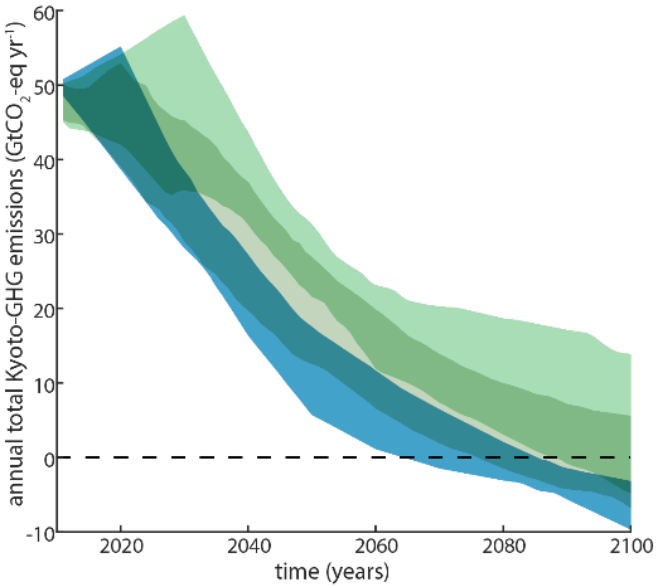
Emissions implications

Internal consistency Paris Agreement

IPCC AR5
Scenario Database



ex-post temperature
characterization



medium chance (50-66%) of limiting warming <2°C in 2100

likely chance (>66%) of limiting warming <2°C in 2100

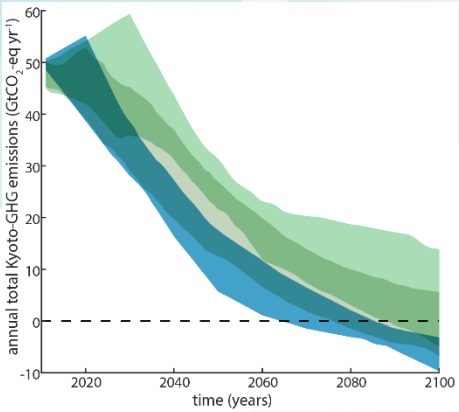
>50% chance of returning warming to below 1.5°C in 2100

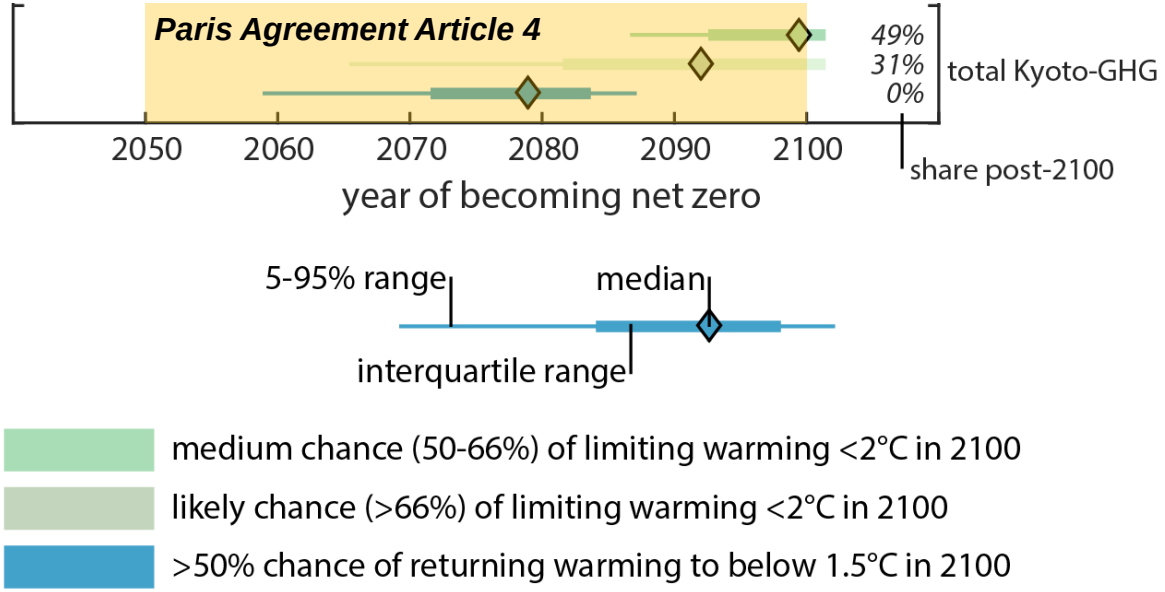
IPCC AR5 Scenario Database; Rogelj et al (2015) ERL

Emissions implications

Internal consistency Paris Agreement

Consistency between
Article 2 & Article 4



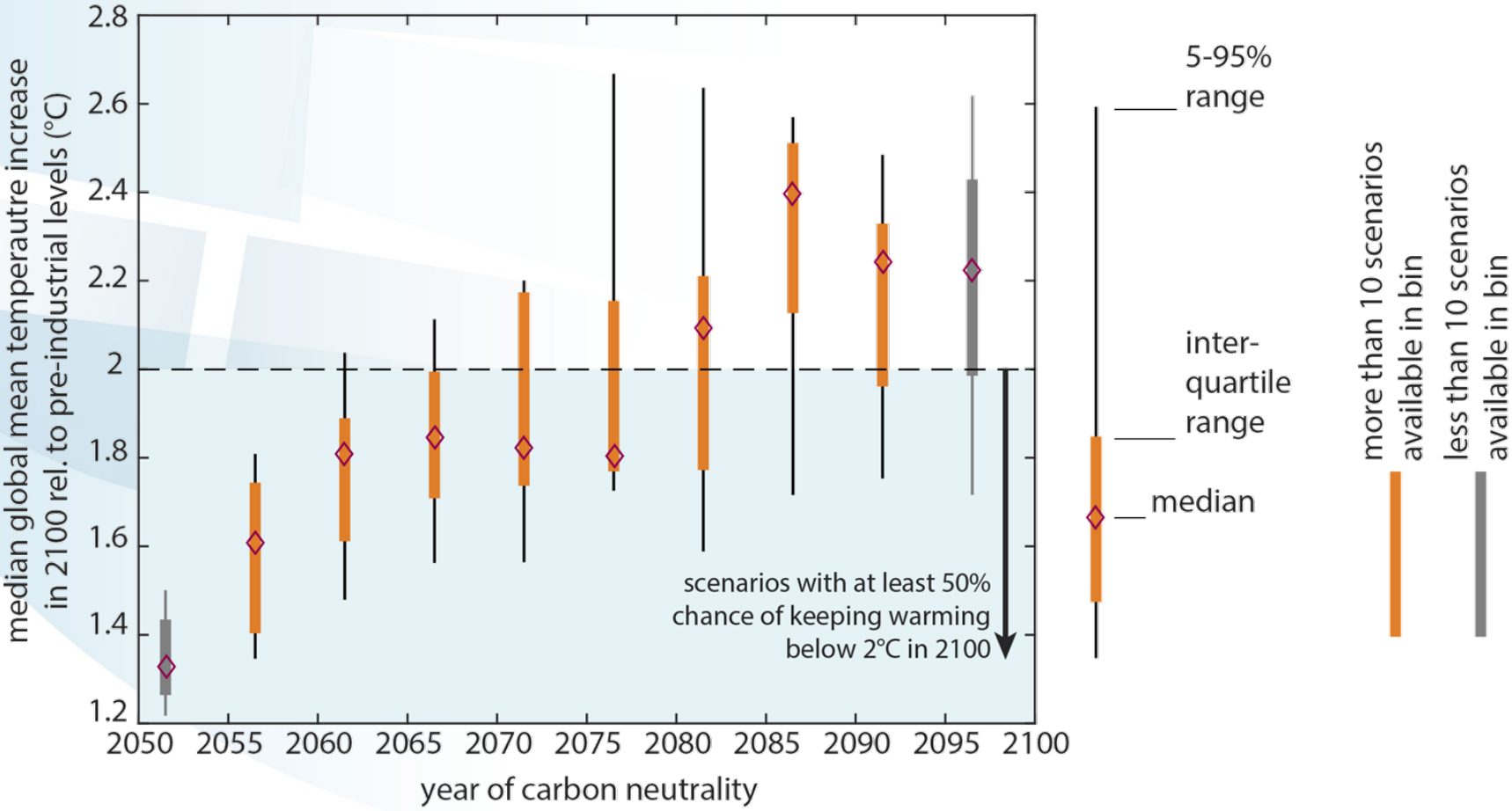


IPCC AR5 Scenario Database; Rogelj et al (2015) ERL

Emissions implications

Internal consistency Paris Agreement

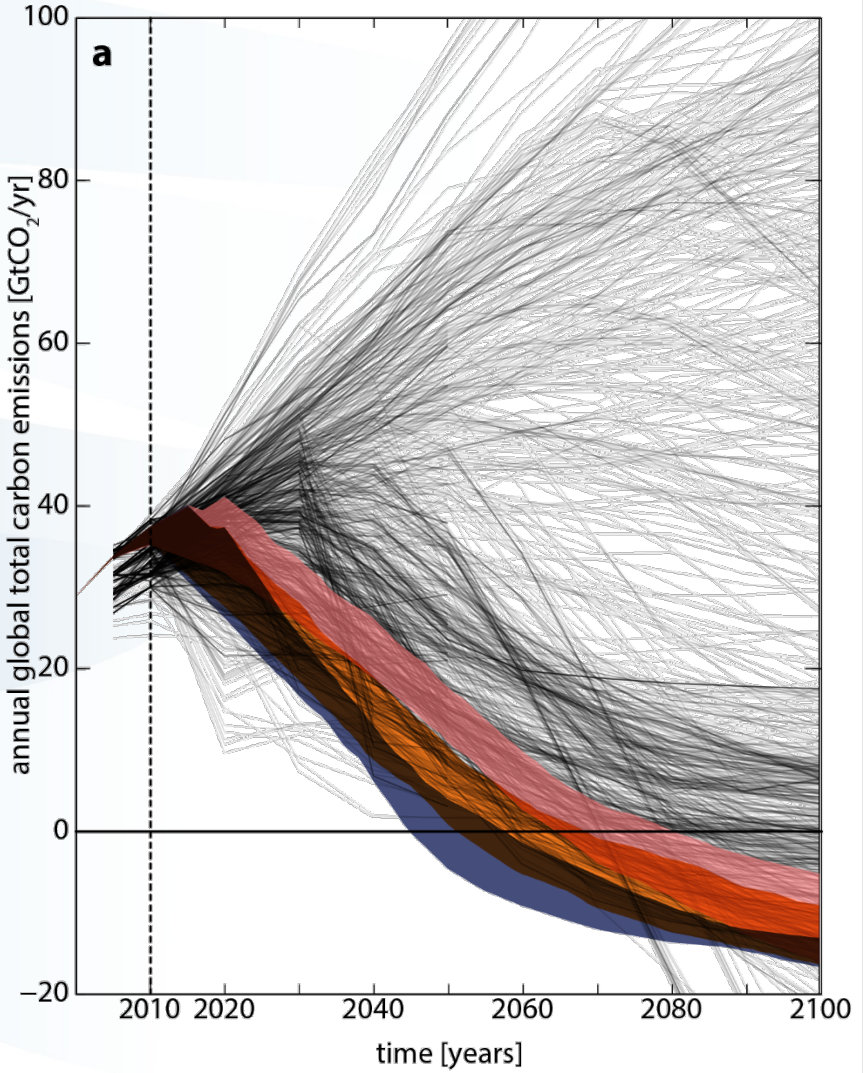
Global zero target: a sufficient condition?



IPCC AR5 Scenario Database; Rogelj et al (2015) ERL

What do 1.5°C scenarios look like?

(How do they differ from 2°C?)



Rogelj et al (2015) NCC

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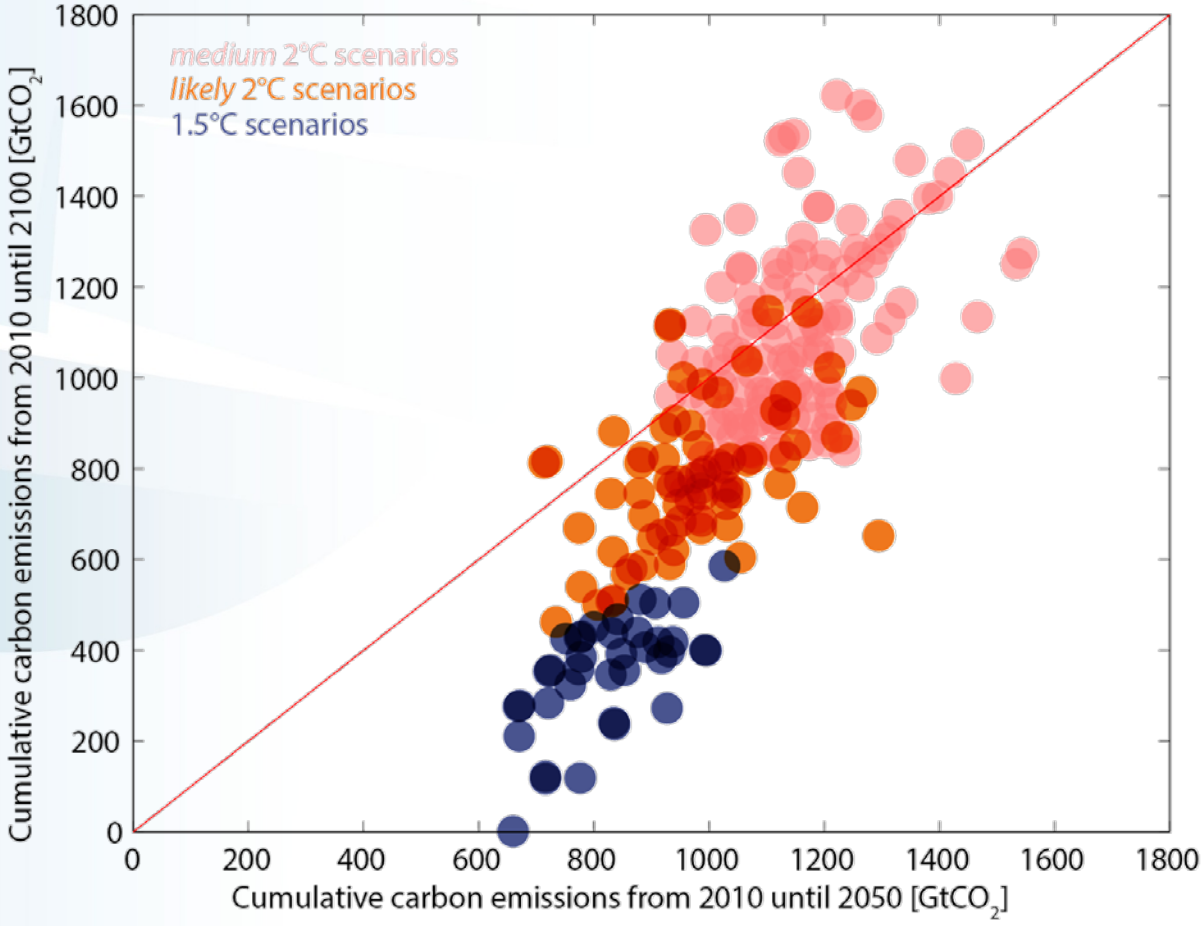

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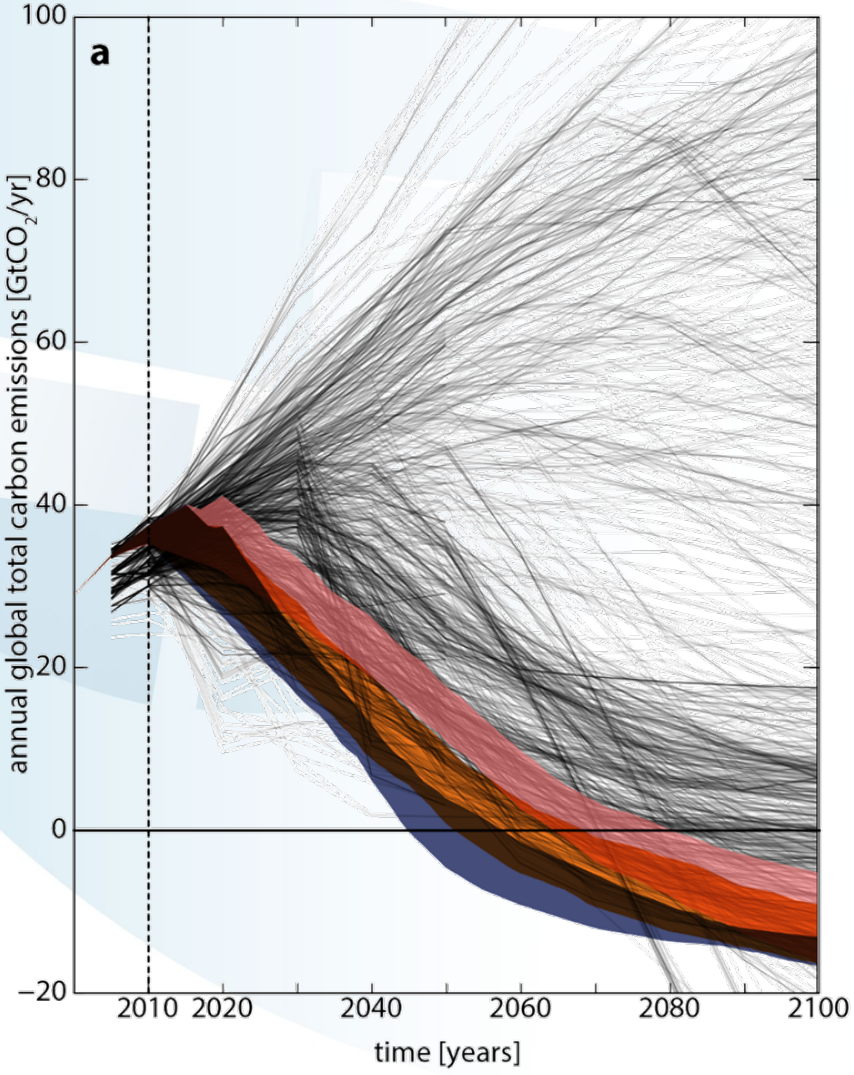

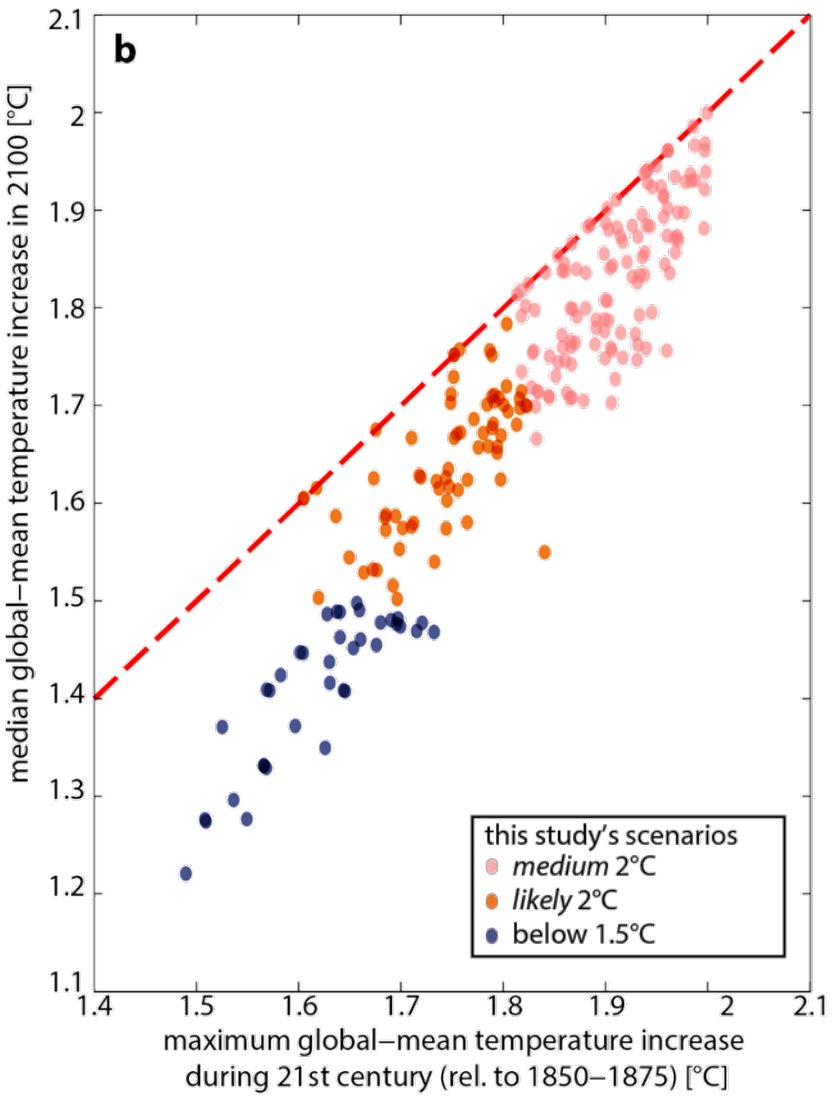

Rogelj et al (2015) NCC

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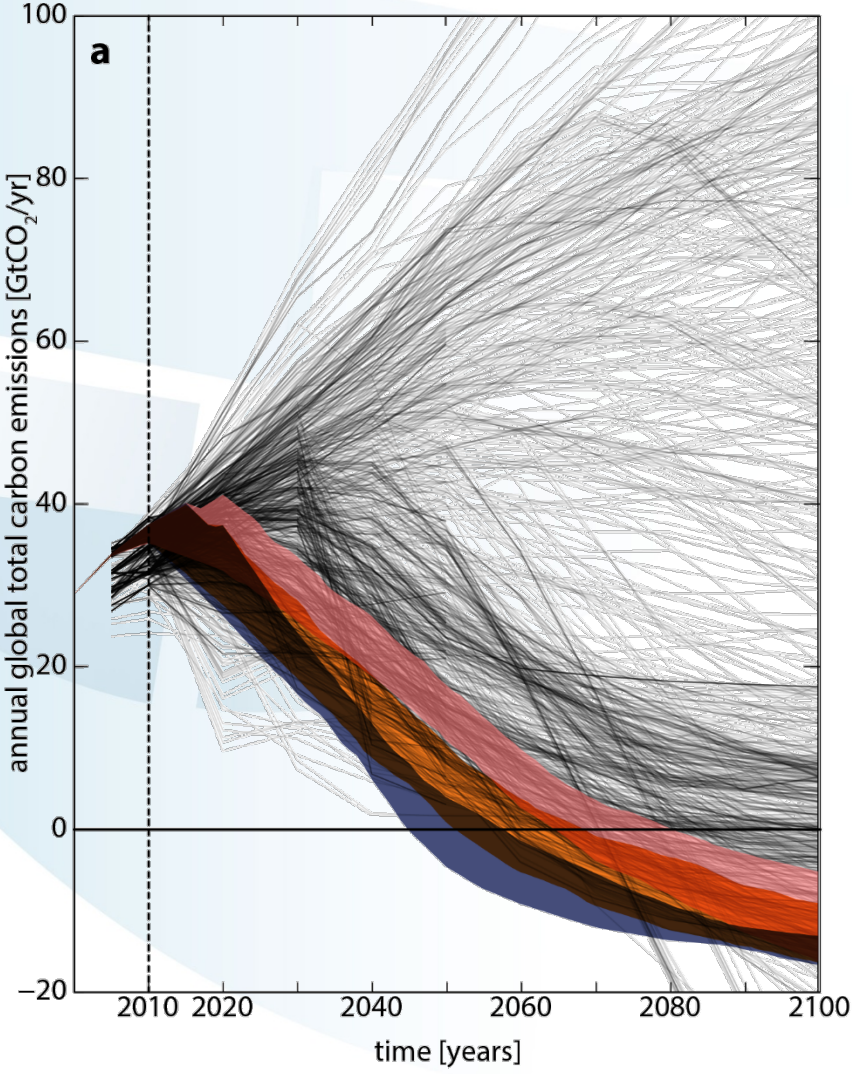
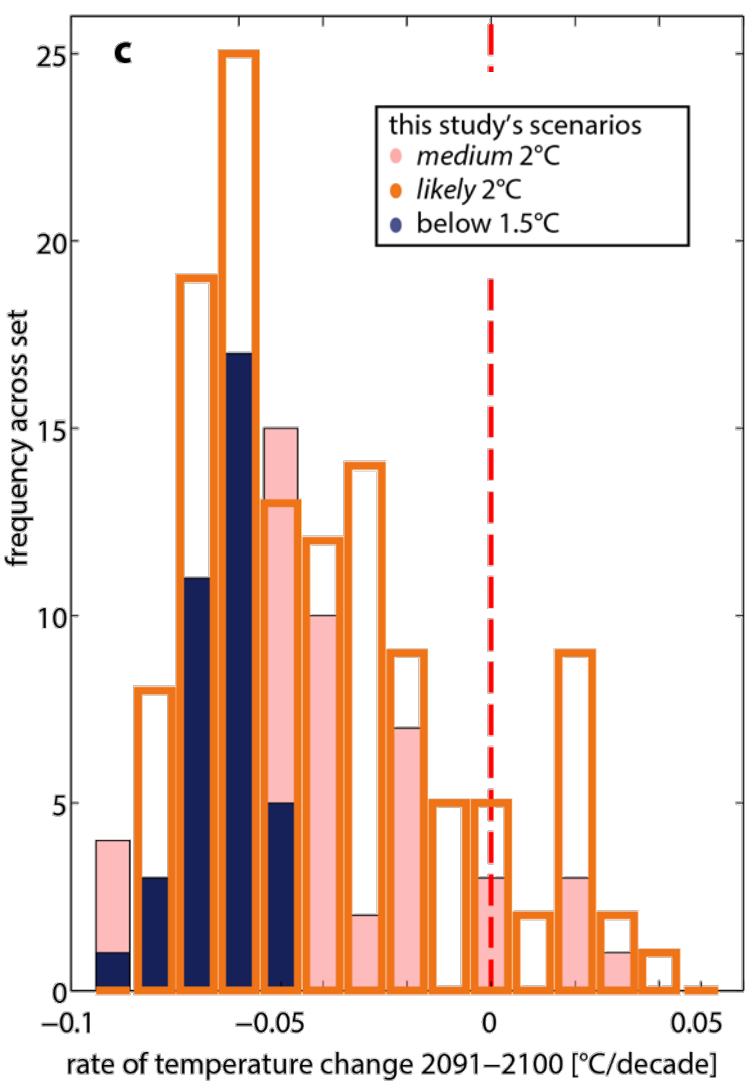




Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

Energy system characteristics

$$E = P * GC * EI * CI$$

with

E: $emissions$

P: $population$

GC: $GDP\ per\ capita$

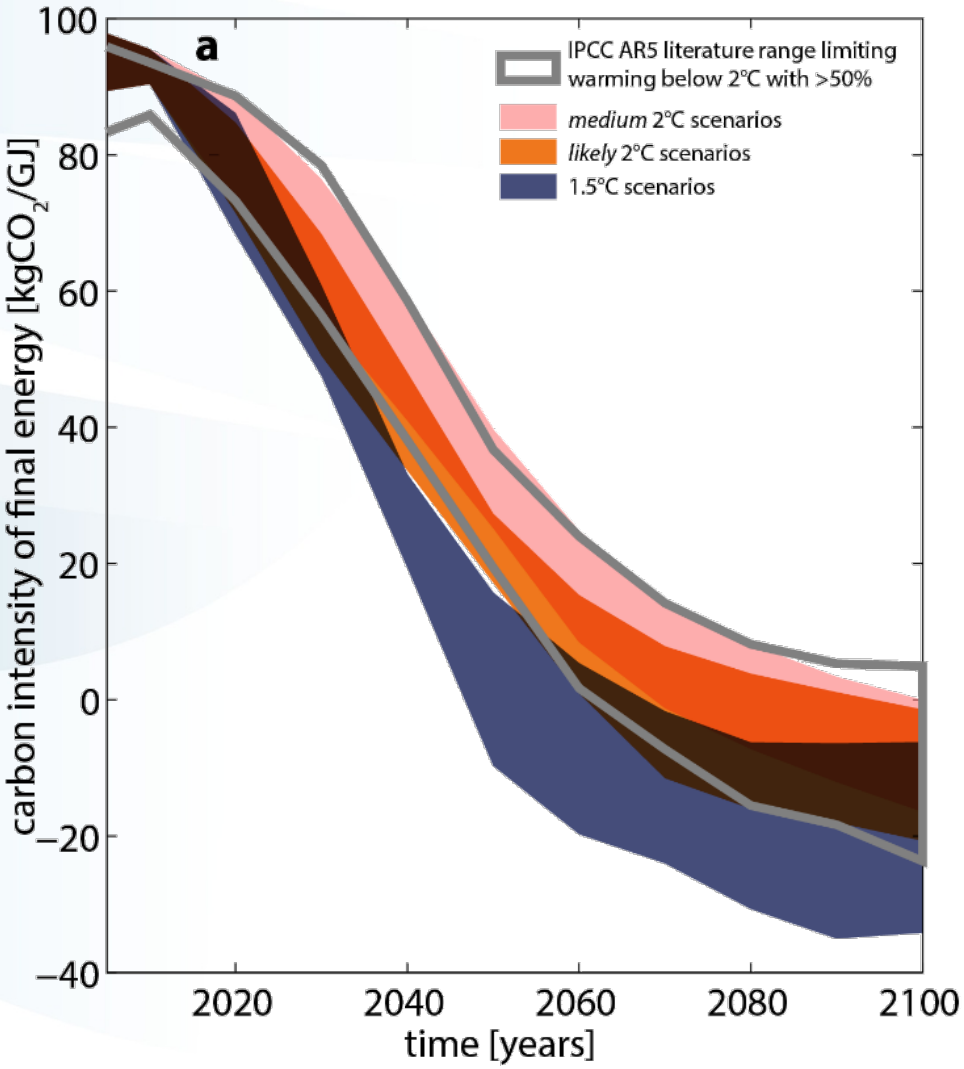
EI: $energy\ intensity$ $\left[\frac{EJ}{GDP}\right]$

CI: $carbon\ intensity$ $\left[\frac{CO_2}{EJ}\right]$

Kaya Y. (1990)

What do 1.5°C scenarios look like?

Energy system characteristics



Rogelj et al (2015) NCC

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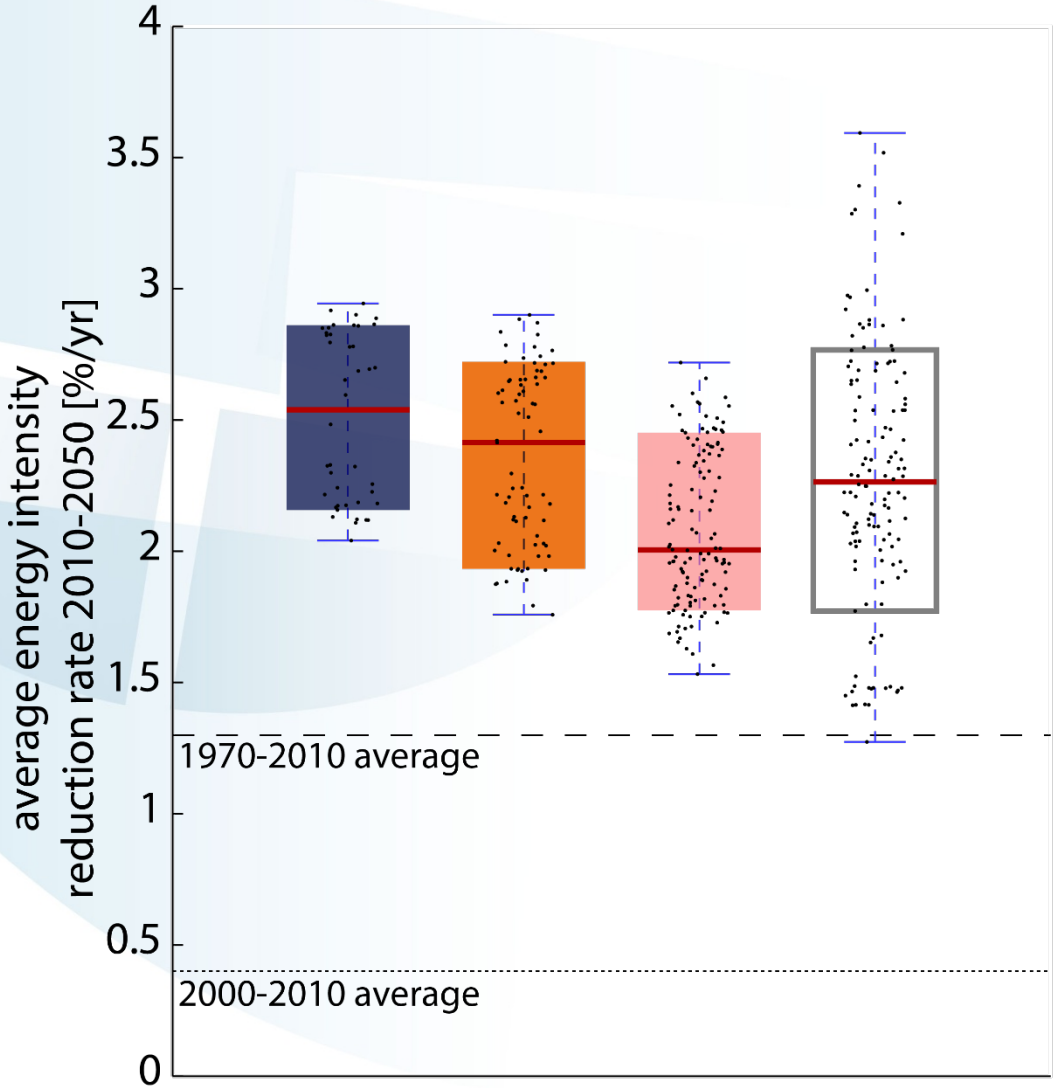


literature range limiting warming below 2°C with >50%

medium 2°C scenarios

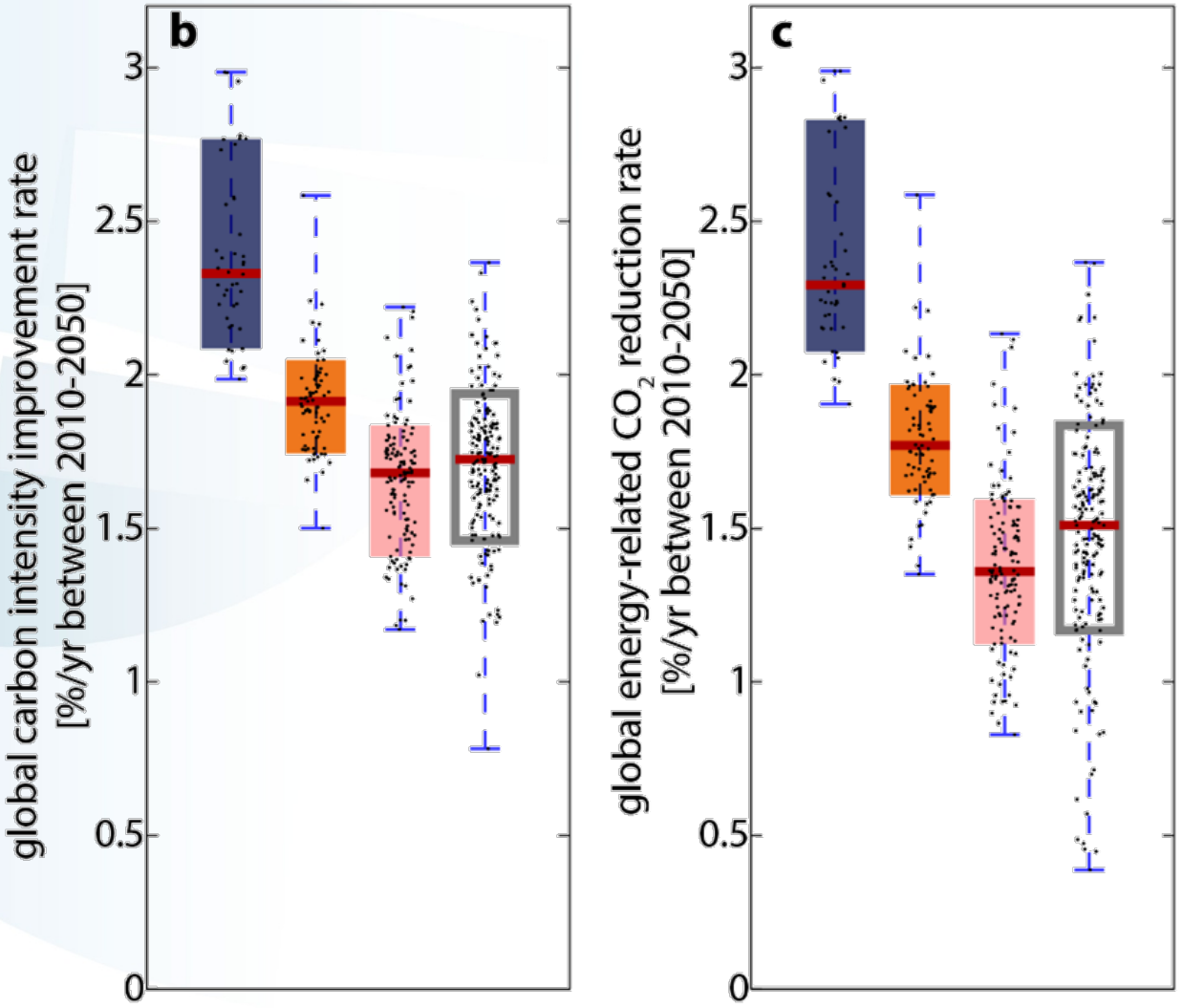
likely 2°C scenarios

1.5°C scenarios

Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

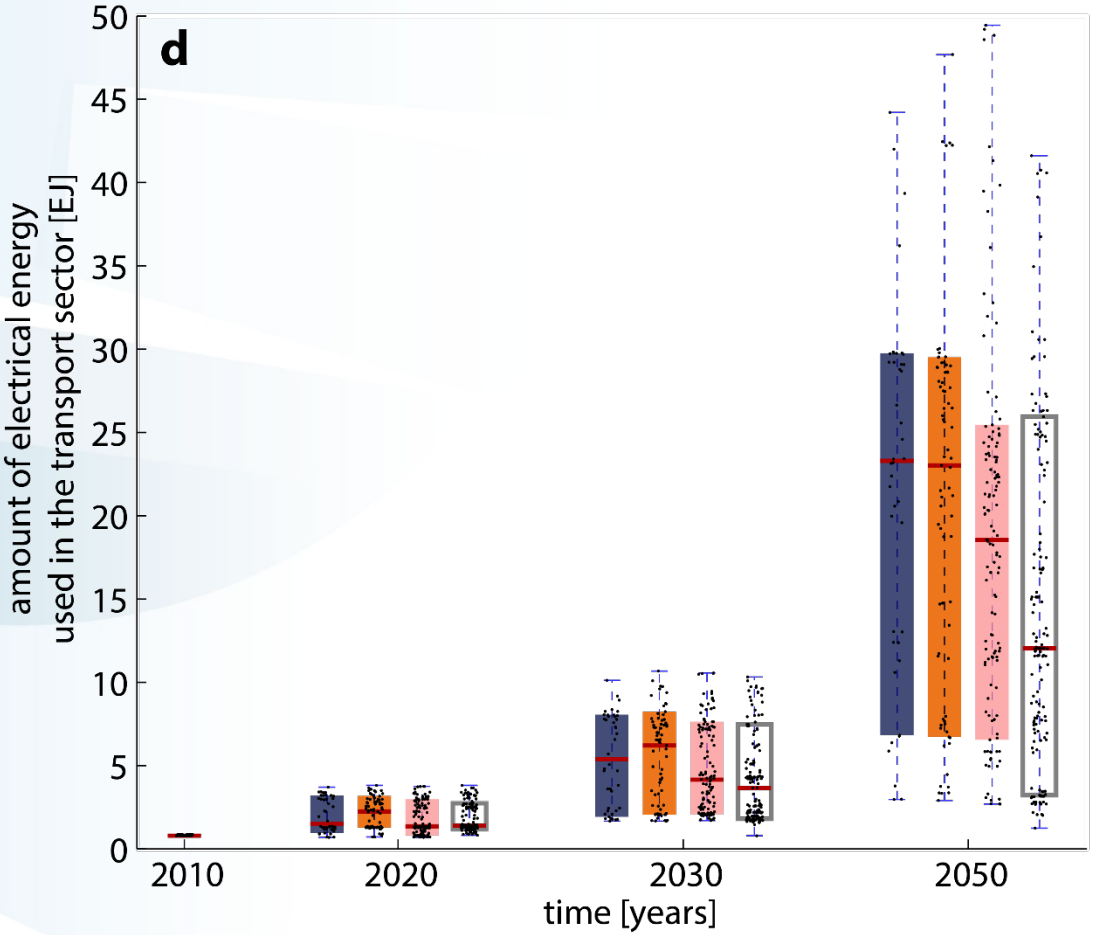
Energy system characteristics



Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

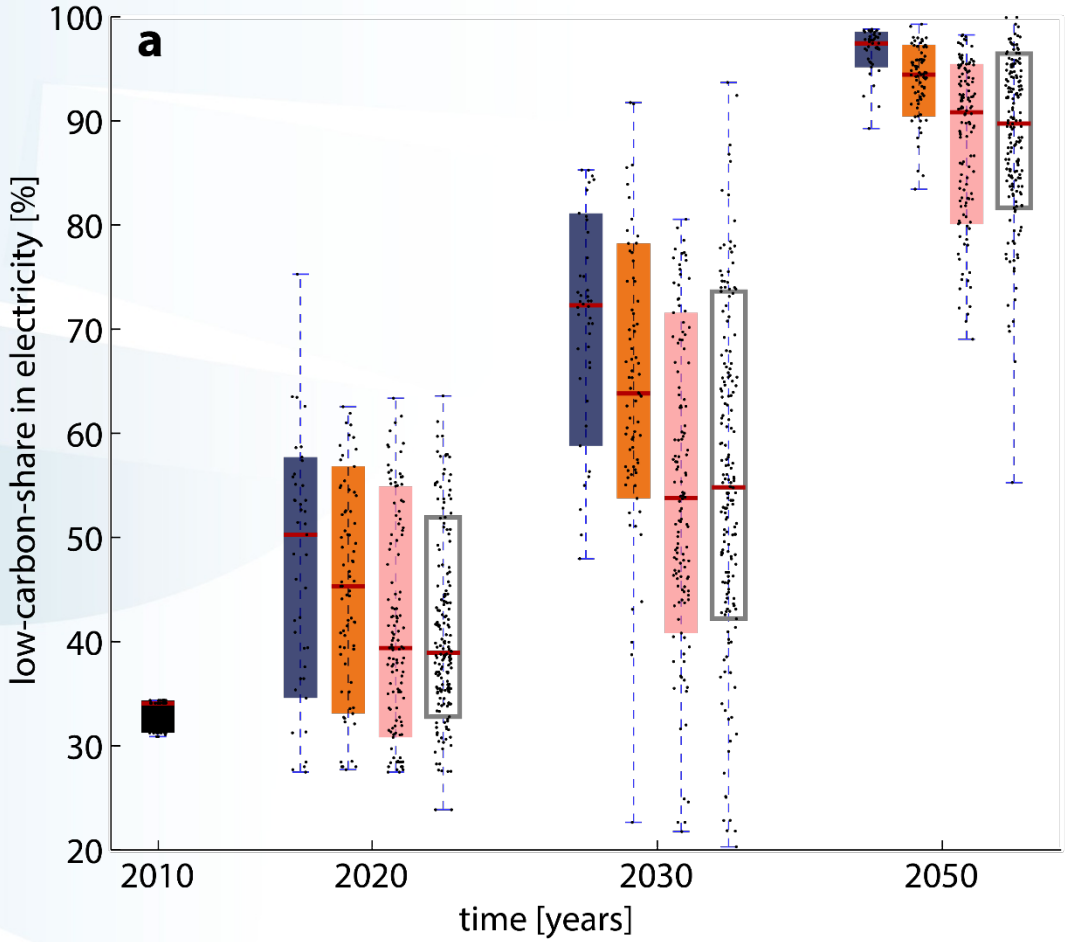
Energy supply characteristics – no differences



Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

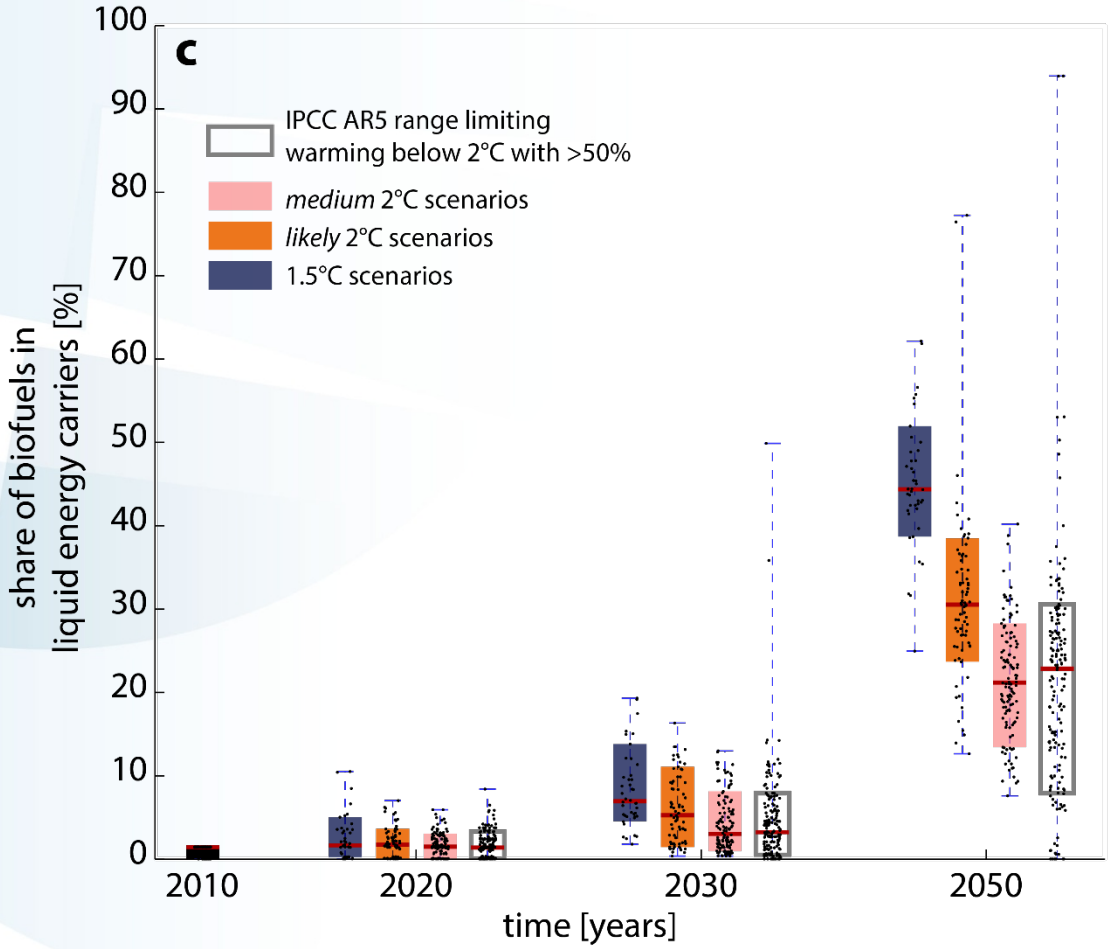
Energy supply characteristics – near-term differences



Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

Energy supply characteristics – medium-term differences



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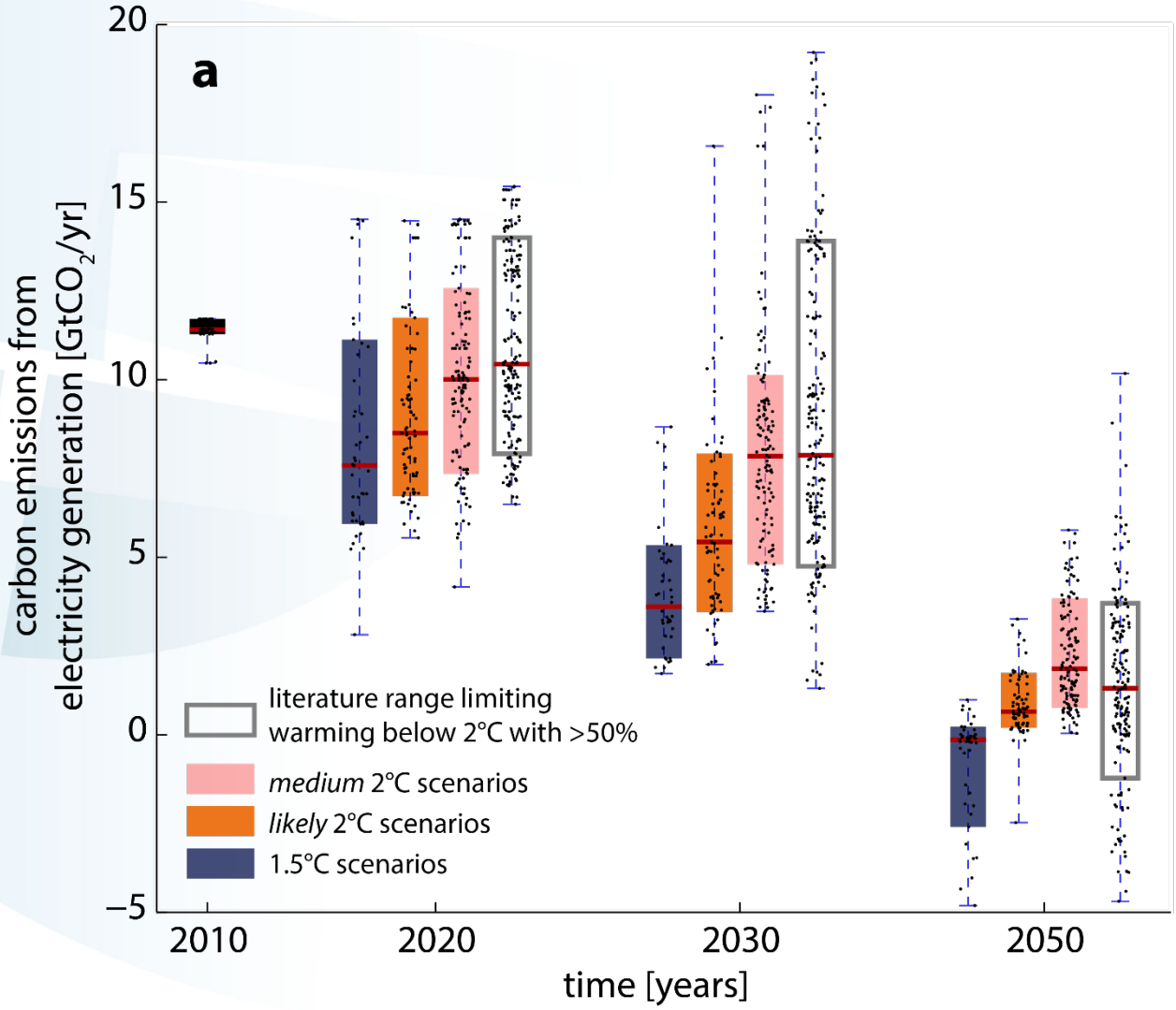
What do 1.5°C scenarios look like?

Sectorial emissions



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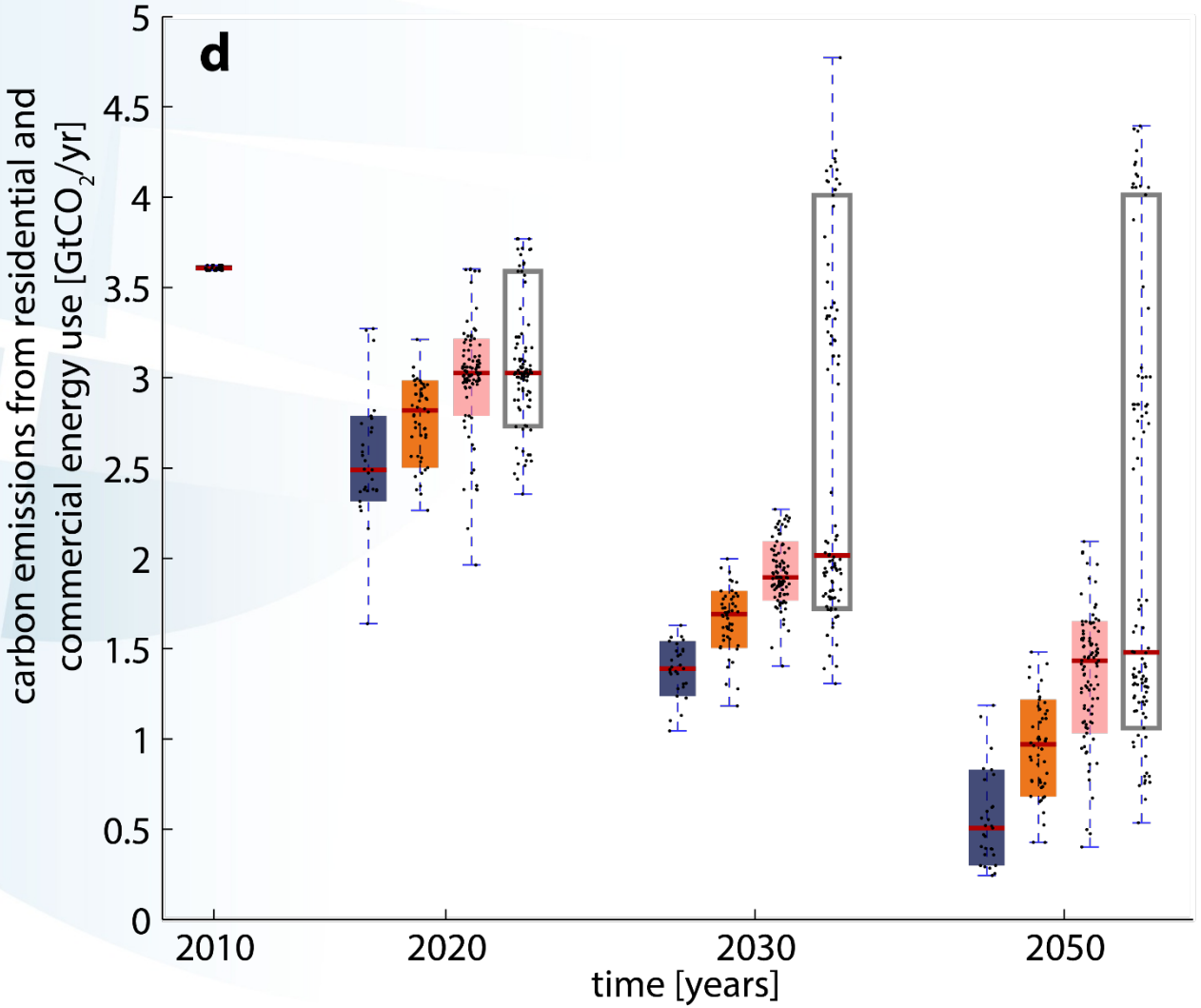
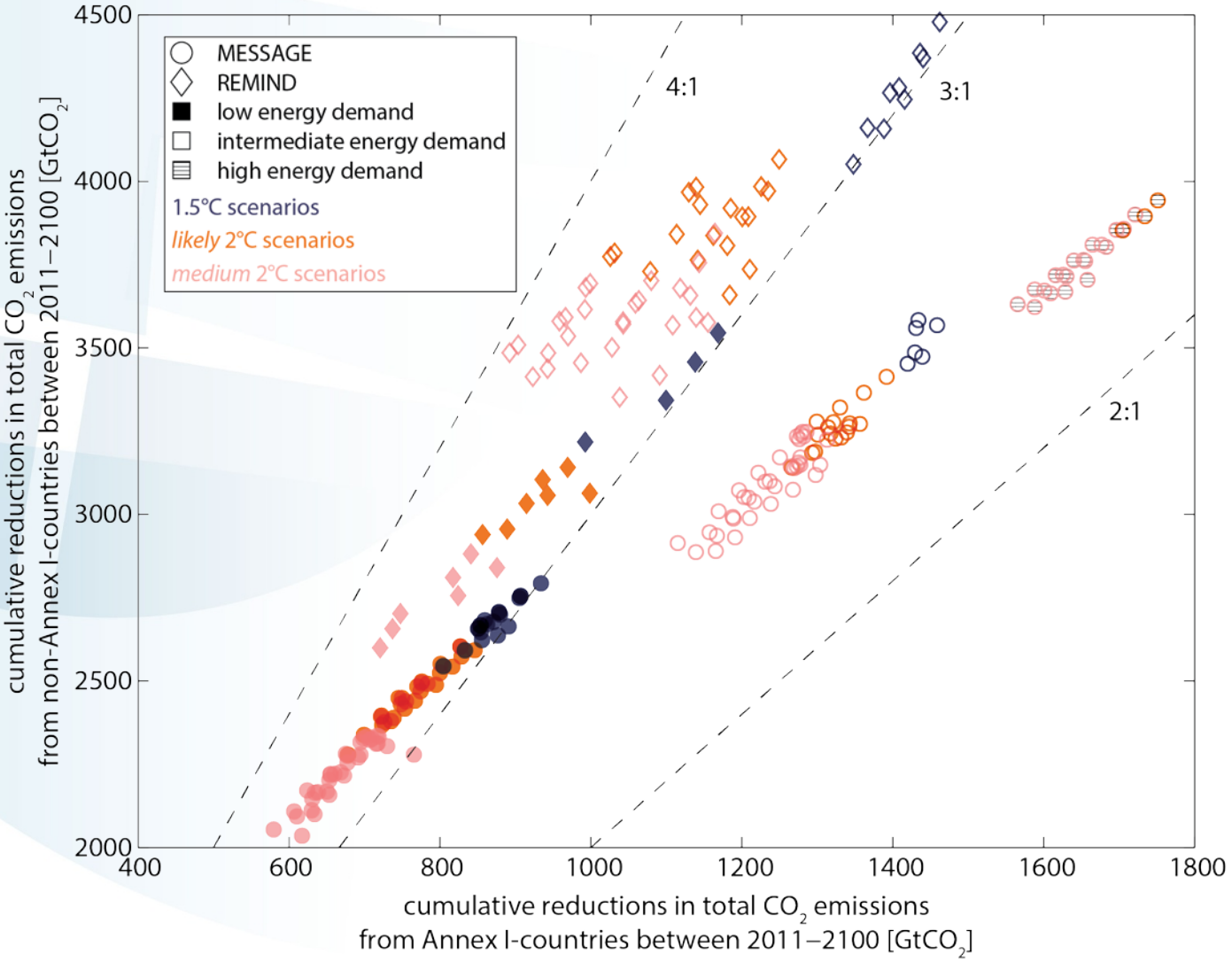


Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

Regional contributions



Rogelj et al (2015) NCC

Key mitigation options - BECCS

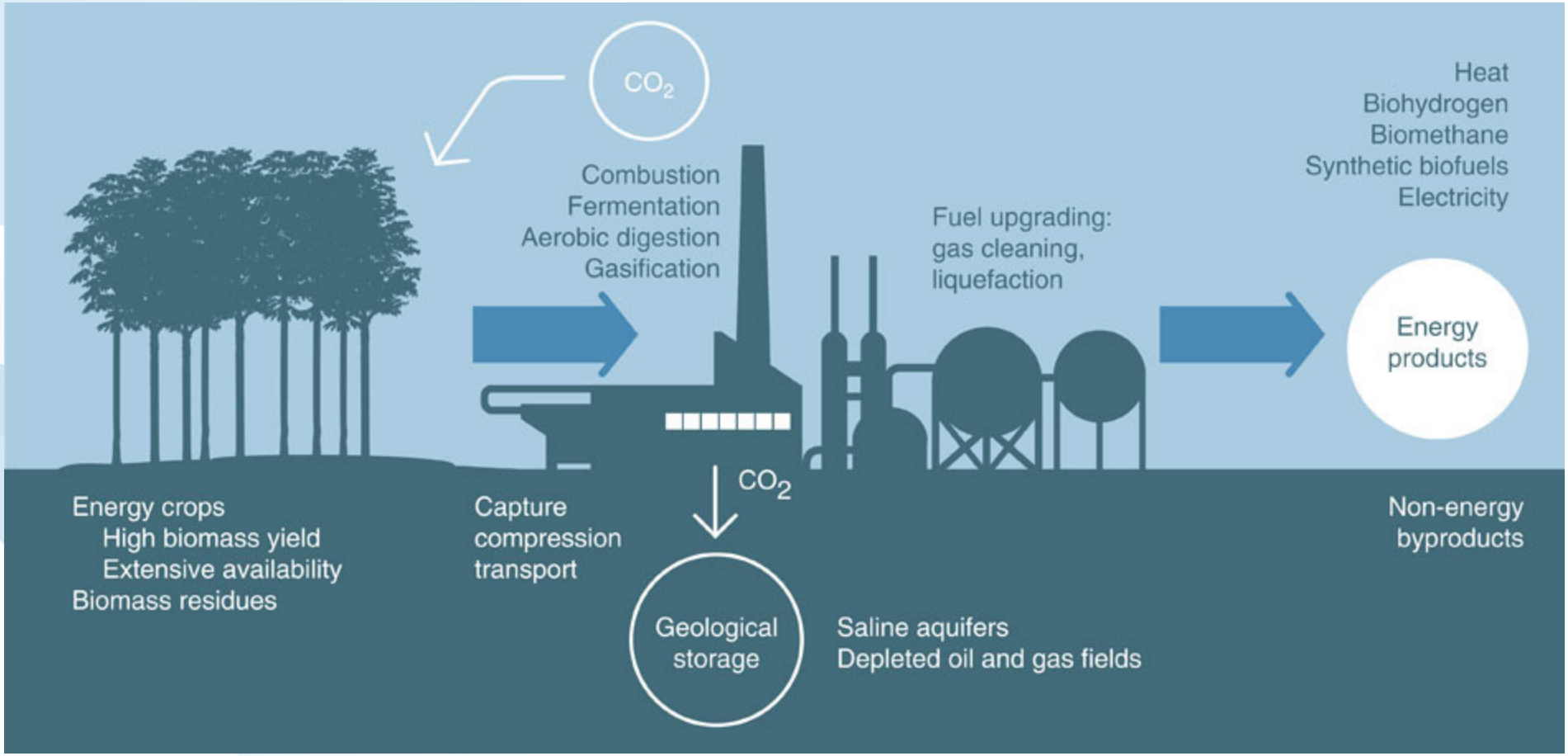
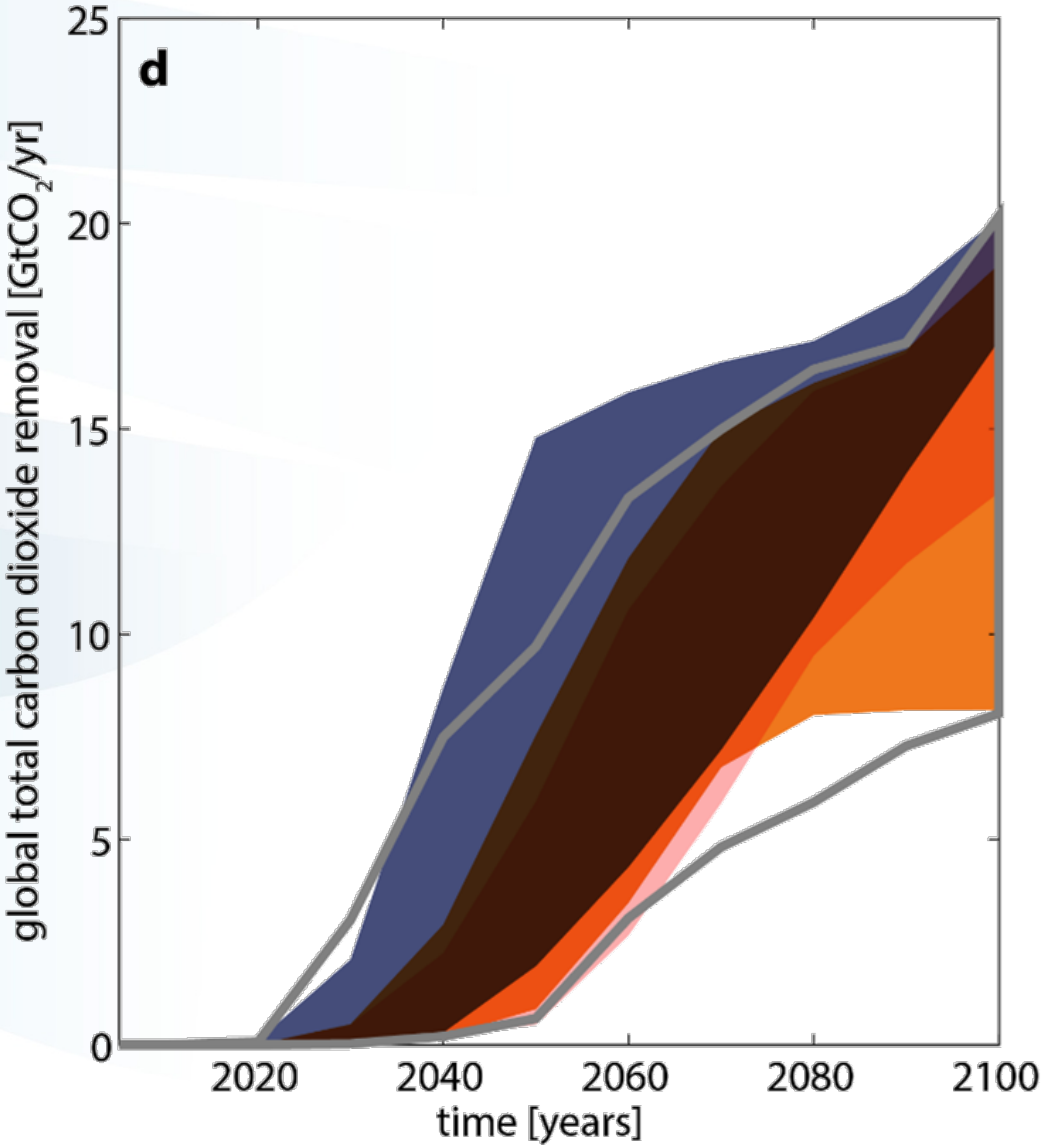


Diagram courtesy of Nature, downloaded from: http://news.berkeley.edu/

What do 1.5°C scenarios look like?

Negative emissions



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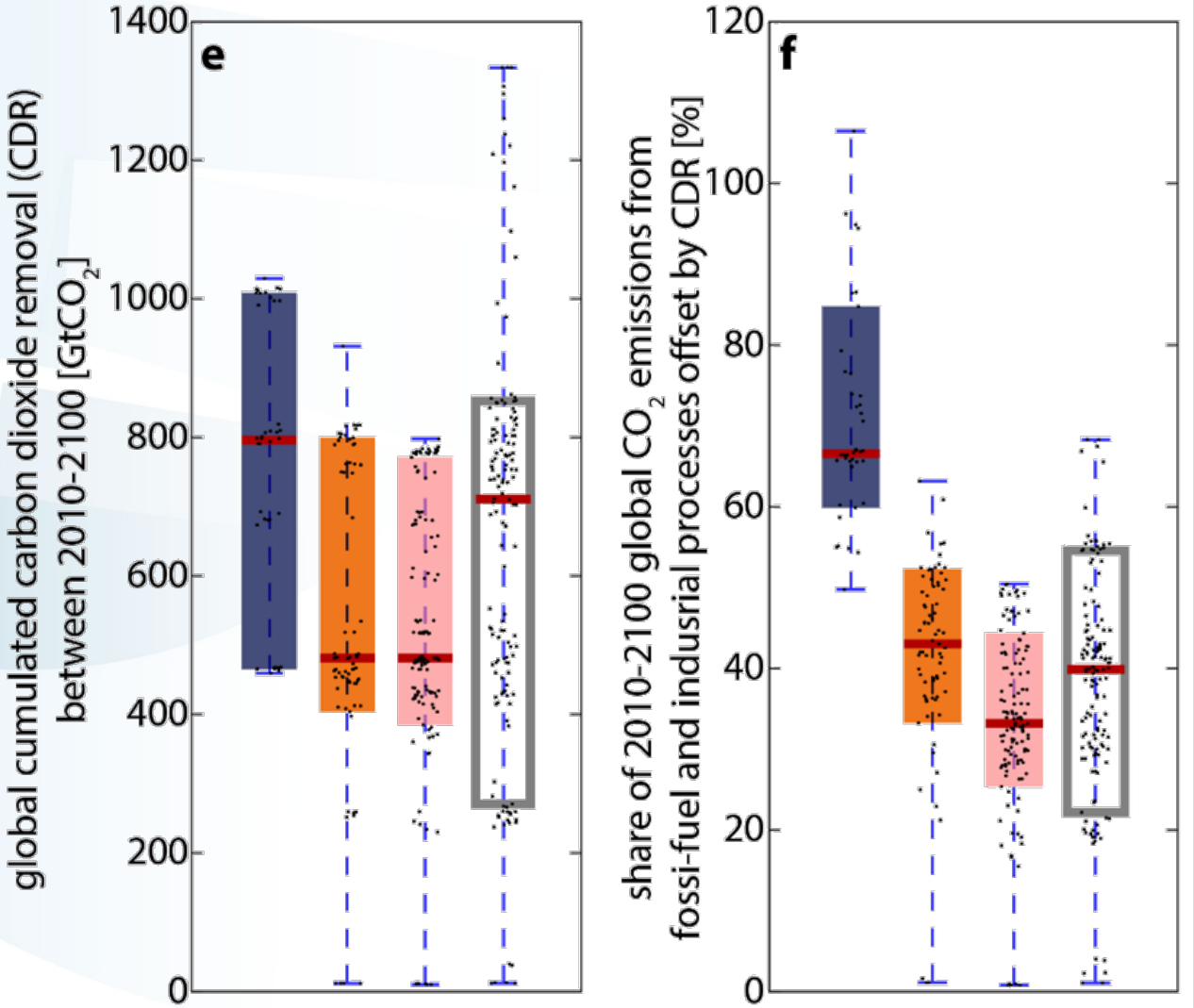
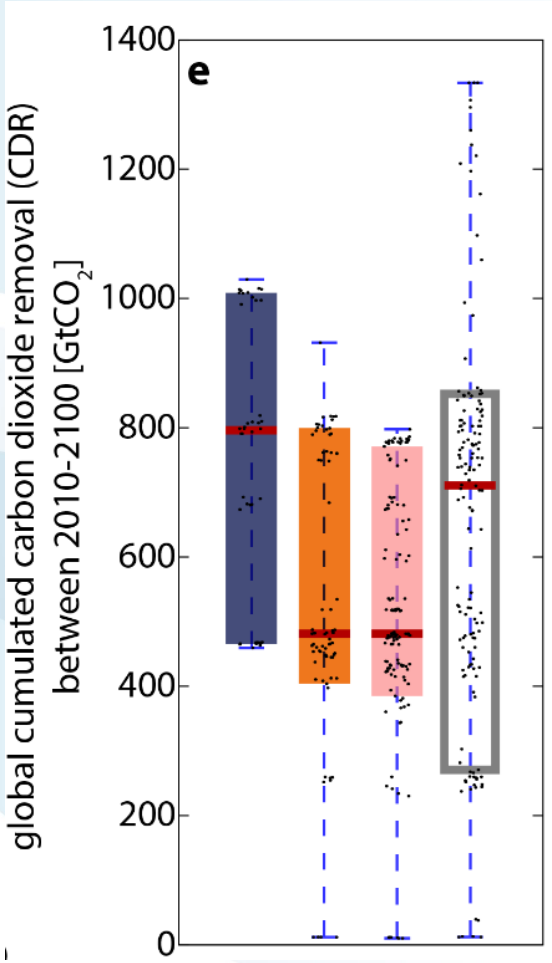


Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

Negative emissions – a requirement?



BECCS deployment is:

- Most probably necessary for 1.5°C
- But scale could be much less than what cost-optimizing models suggest
- Artefact of intertemporal optimisation
- Also an issue for 2°C,
  and bioenergy even for 3°C

BECCS requirement dependent on choices regarding timing of action, and post-peak decline rates.

Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

Like-with-like comparison

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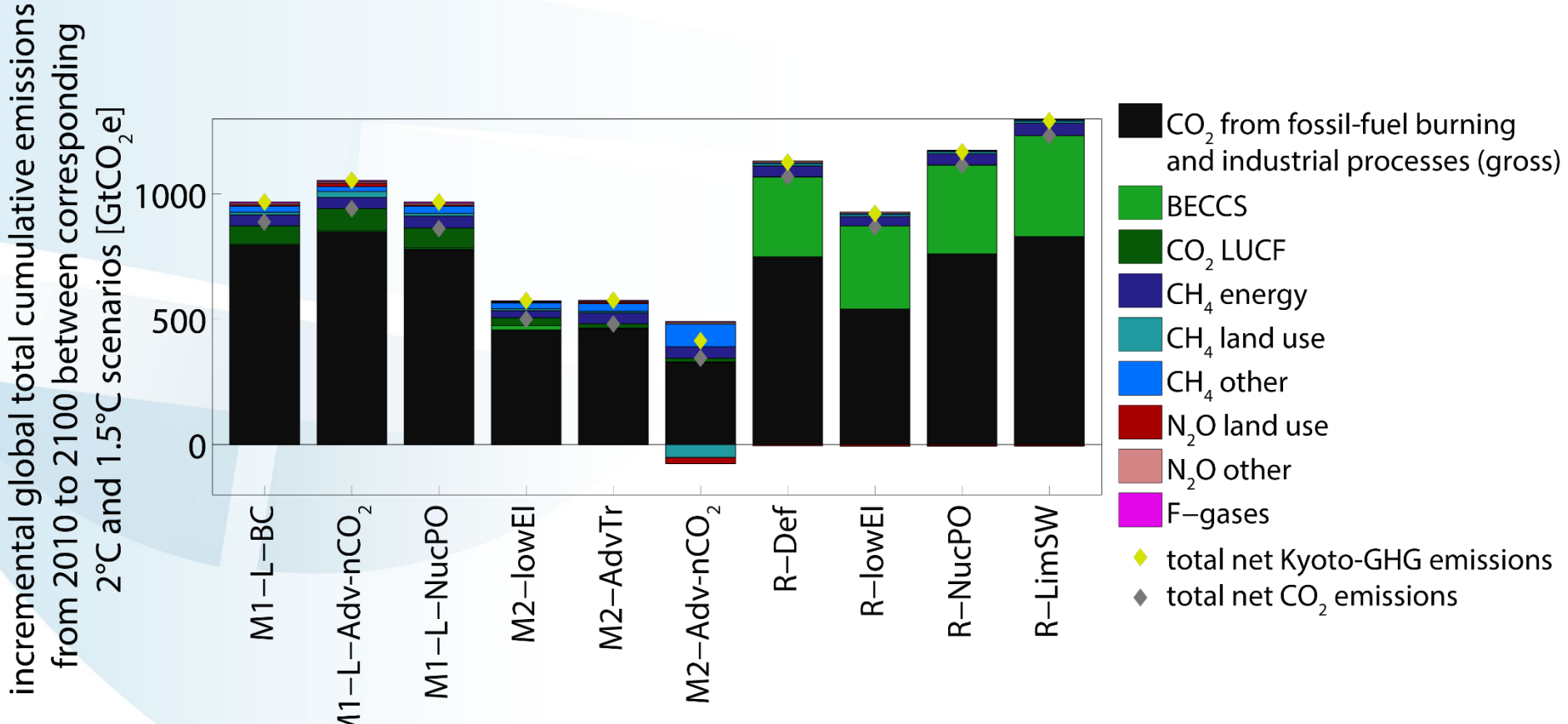
Like-with-like comparison



Rogelj et al (2015) NCC

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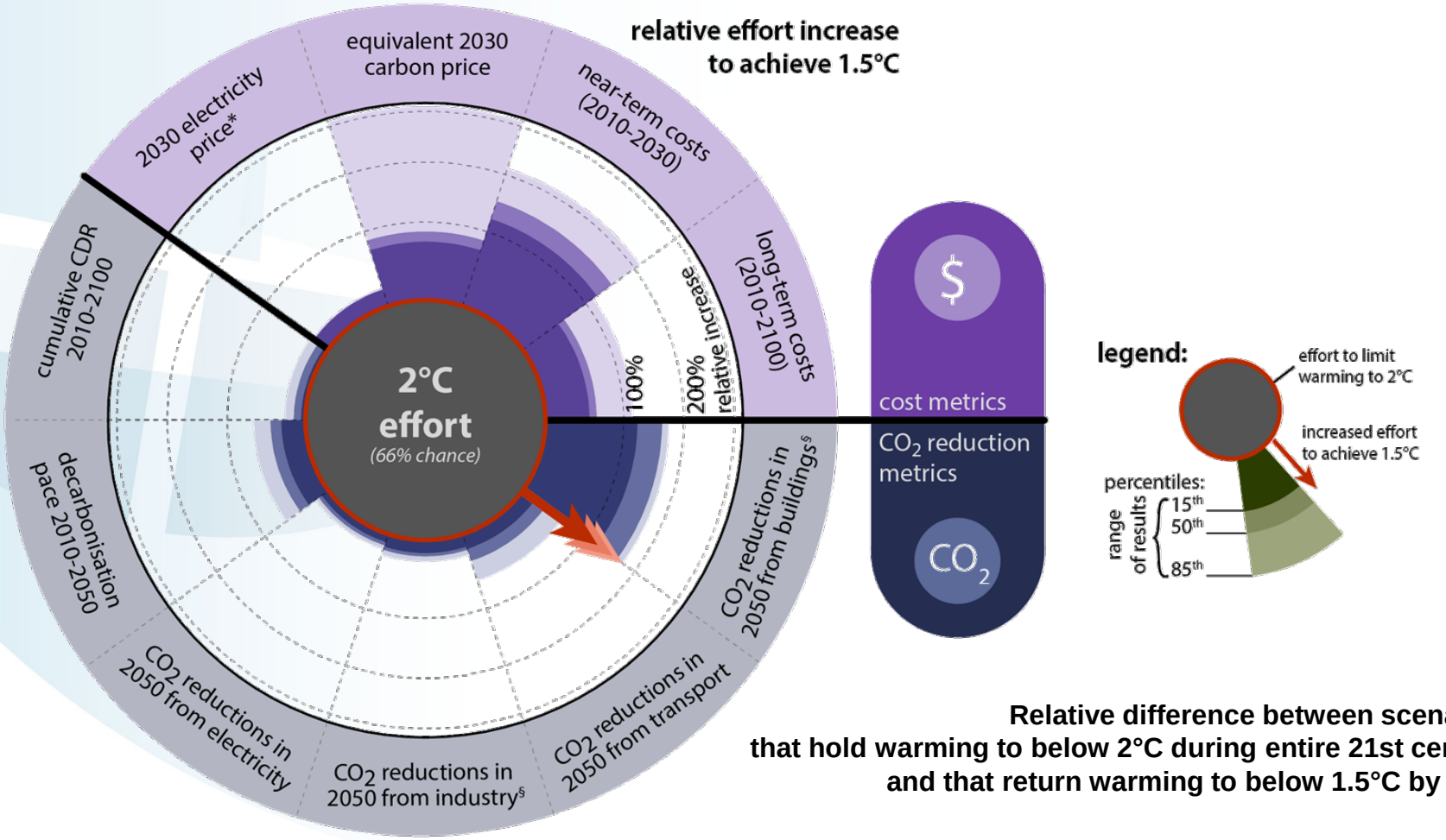
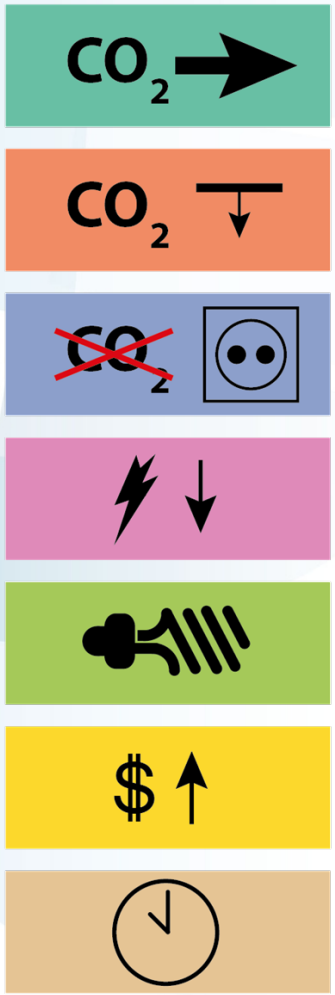


Relative difference between scenarios that hold warming to below 2°C during entire 21st century and that return warming to below 1.5°C by 2100

Rogelj et al (2015) NCC

What do 1.5°C scenarios look like?

Key differences with 2°C scenarios



additional GHG reductions, mainly from CO2

CO2 reductions beyond net zero

rapid near-term decarbonisation of energy supply

greater demand side mitigation efforts

energy efficiency improvements are crucial

higher mitigation costs

comprehensive reductions in the coming decade

Rogelj et al (2015) NCC

Conclusions

Photo: AFP

Thank you

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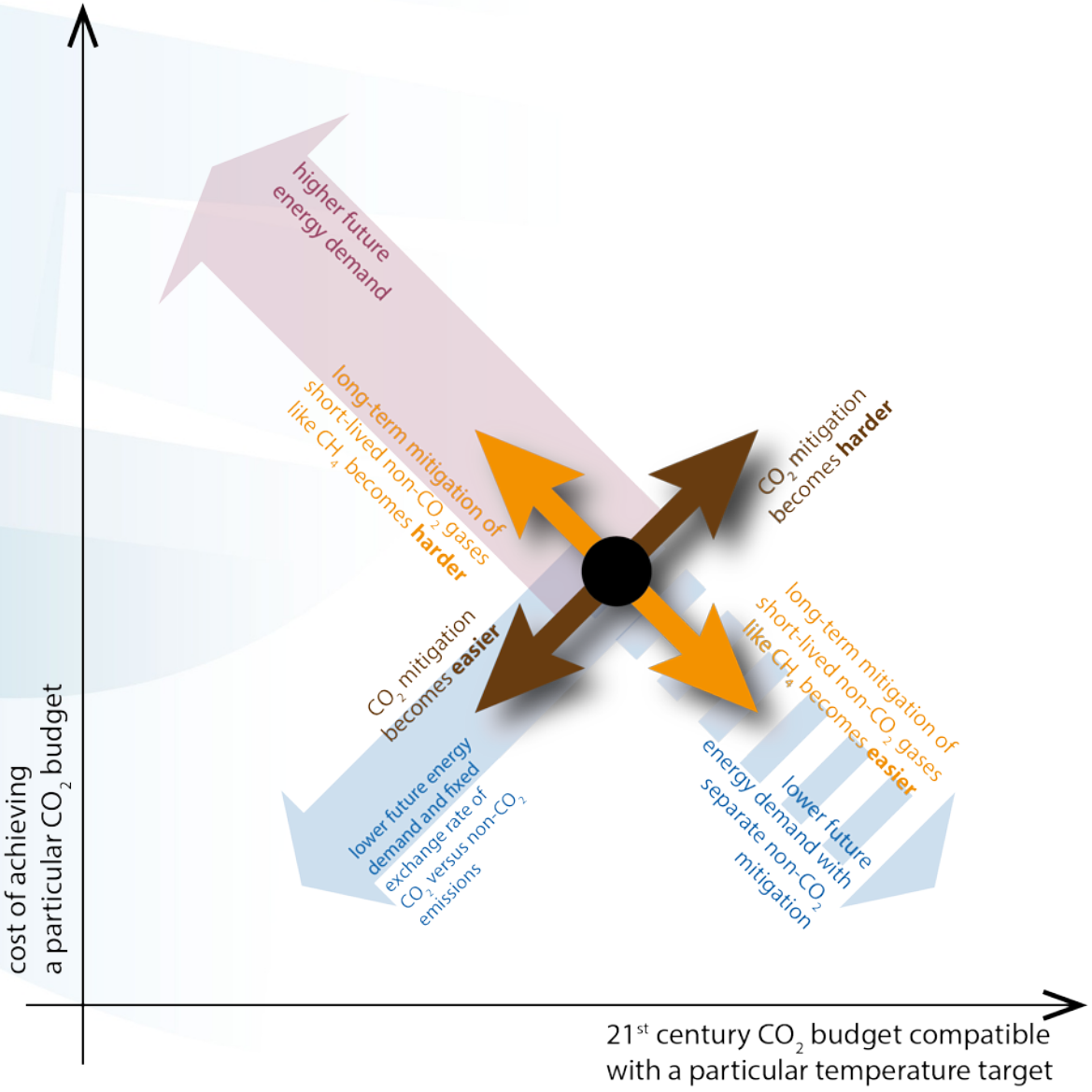
Emissions implications

Understanding carbon budget influences



Rogelj et al. 2015, ERL