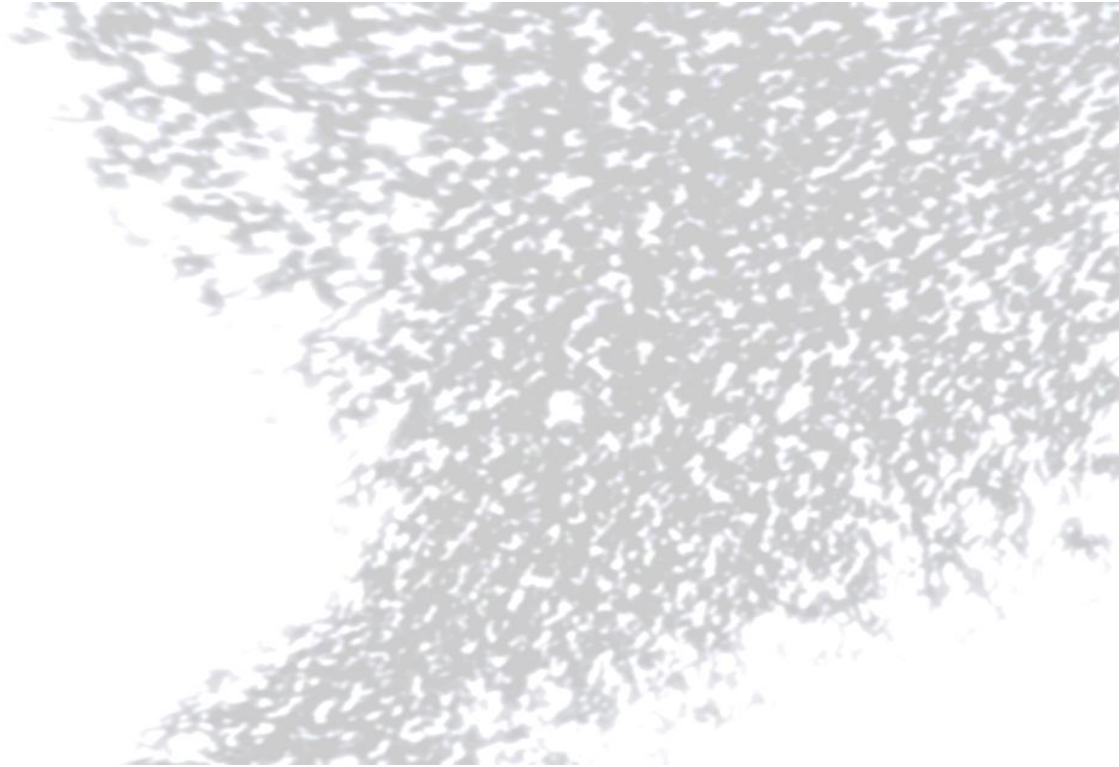


# Keeping warming below 2 or 3°C: an integrated view at costs and trade-offs

Joeri Rogelj  
Aspen Global Change Institute  
27 February 2014



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## Acknowledgments

Malte Meinshausen  
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David McCollum  
Reto Knutti  
Jan Sedláček

# Integrated assessments of climate change



# Geophysical uncertainties



- **Equilibrium climate sensitivity**
- **Transient climate response**
- **Carbon cycle response**
- **(non-CO<sub>2</sub>) forcing**
- **...**

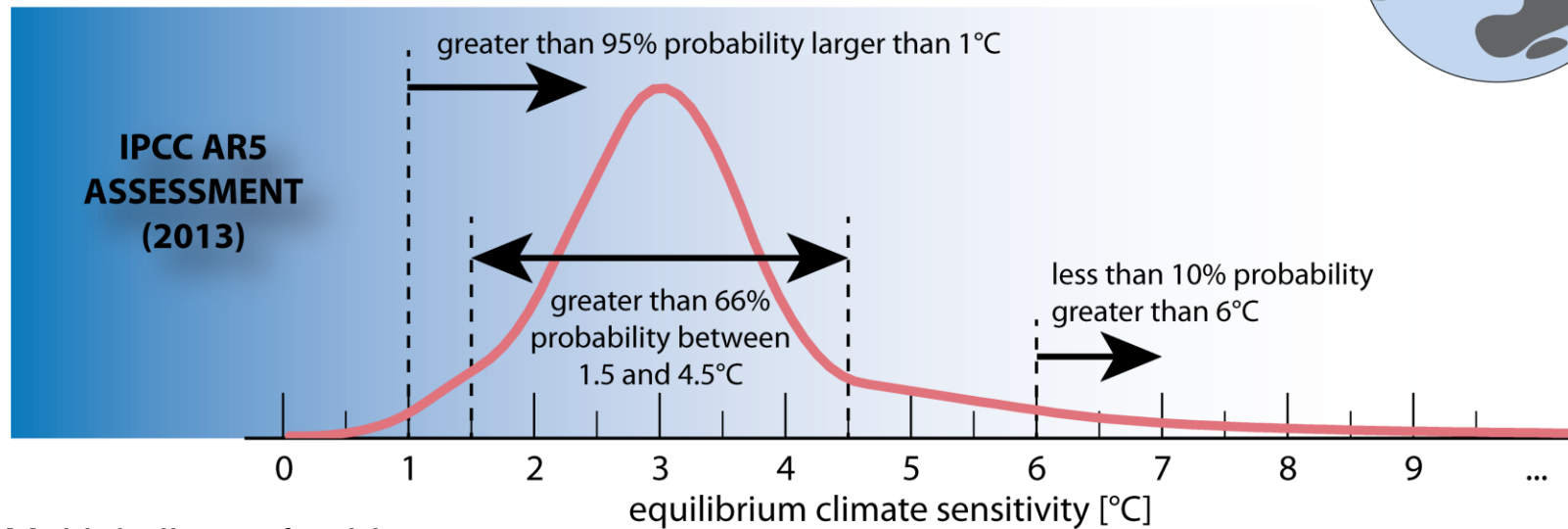
# Geophysical uncertainties



**What's up with  
climate sensitivity?**

# Geophysical uncertainties

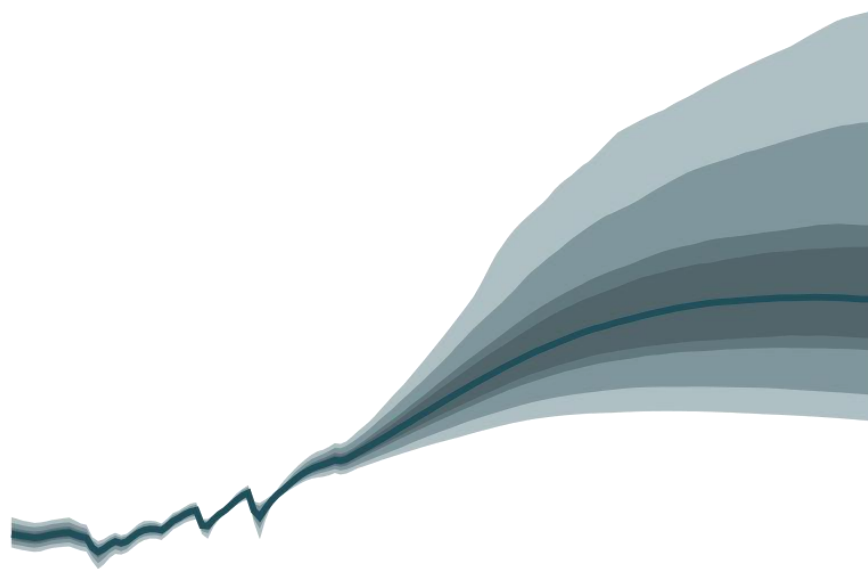
## What's up with climate sensitivity?



Multiple lines of evidence:

- Confirmation of range (Andrews *et al.*, 2012; E. J. Rohling *et al.*, 2012)
- Lower end: observed temperatures and ocean heat uptake (Schmittner *et al.*, 2011; Aldrin *et al.*, 2012; Lewis, 2013; Otto *et al.*, 2013)
- Higher end: observed climatology (Fasullo and Trenberth, 2012; Sherwood *et al.*, 2014)

# Tools: geophysical uncertainties

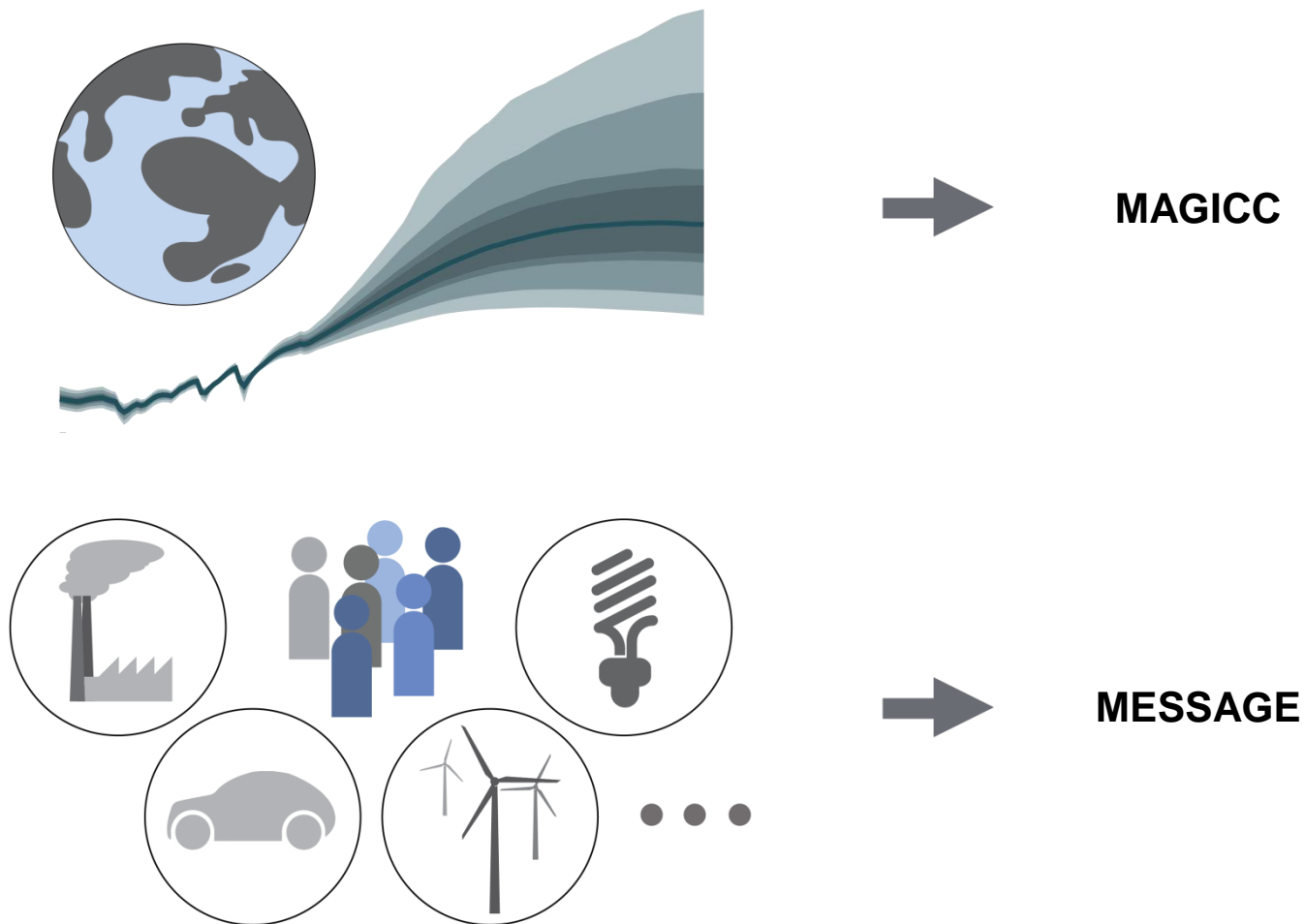


MAGICC

(Model for the Assessment of Greenhouse Gas Induced Climate Change)

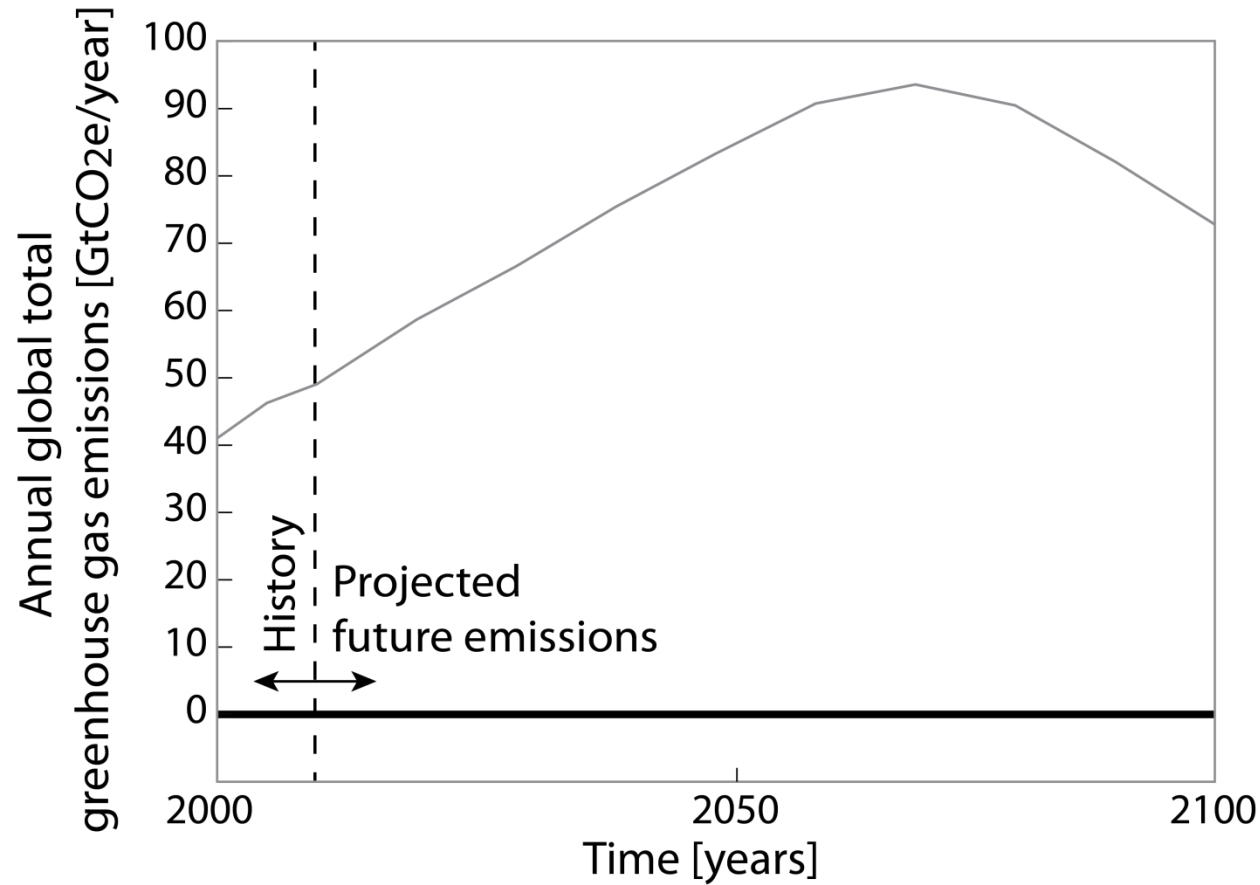
Meinshausen et al. (2011) and earlier papers

# Tools

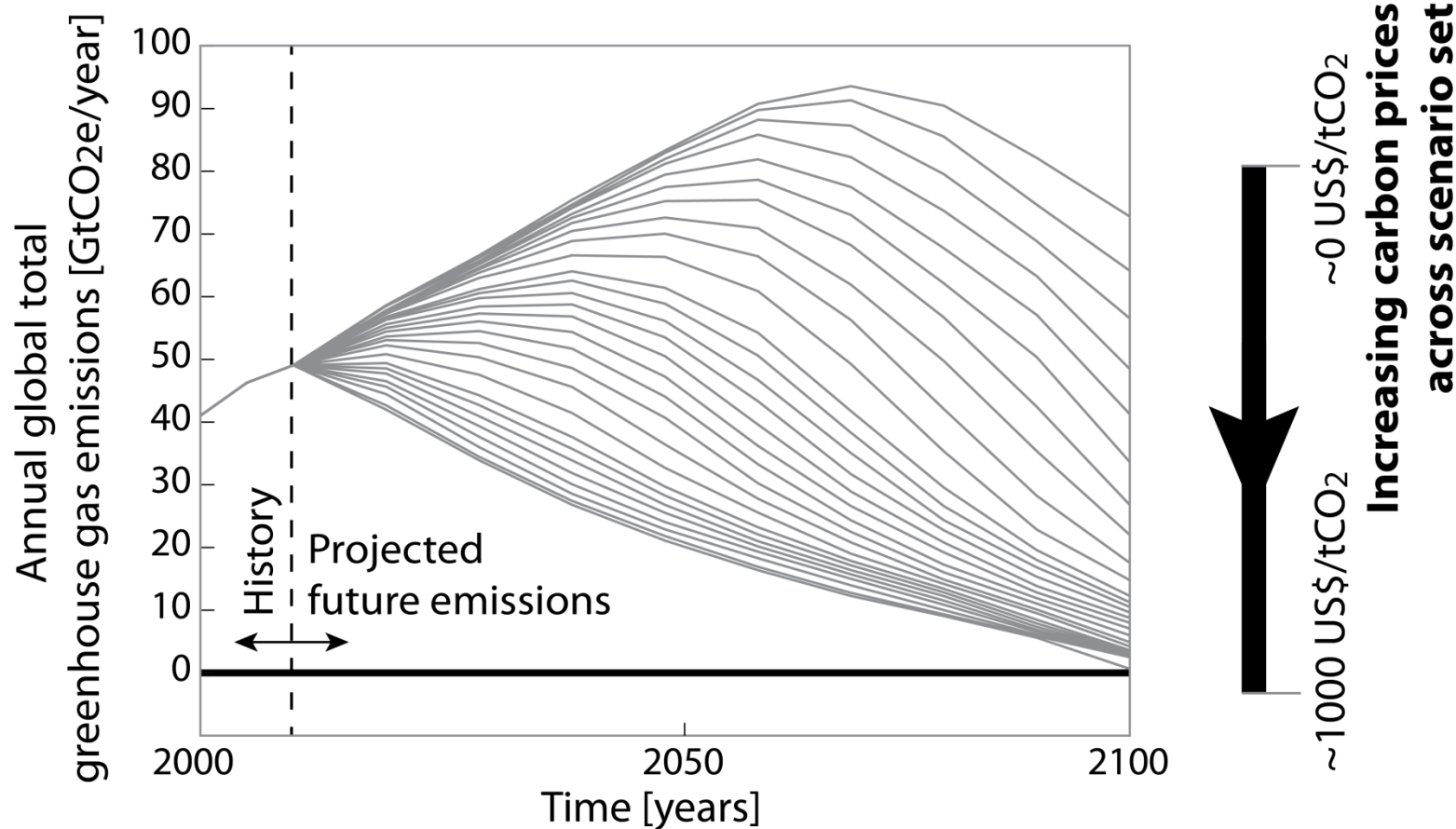




# Methodology

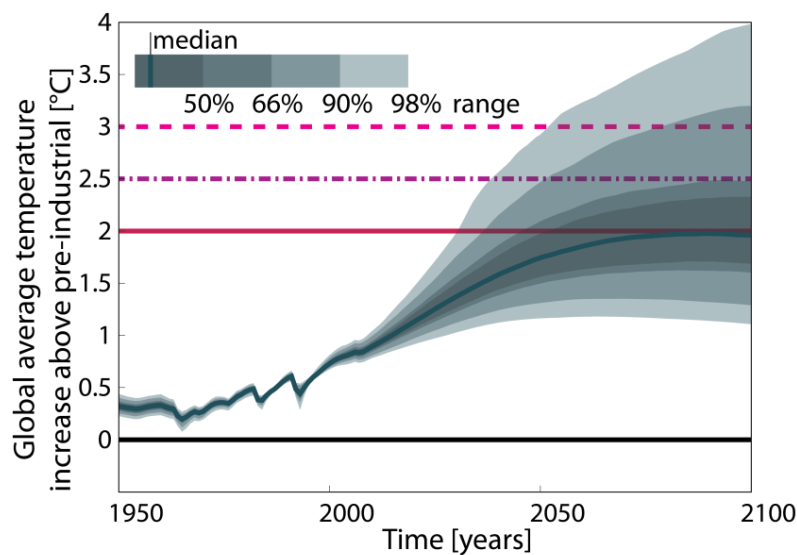
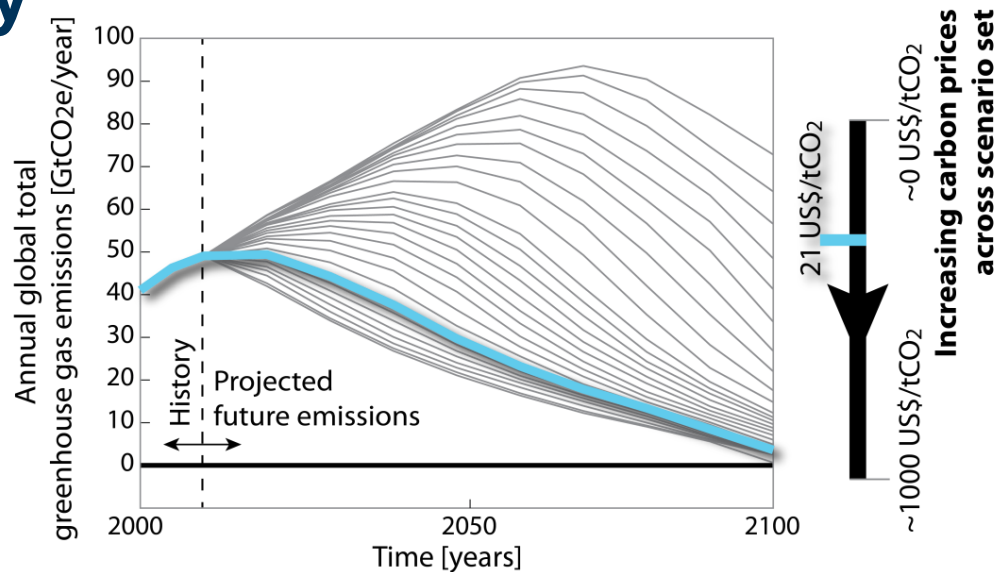


# Methodology



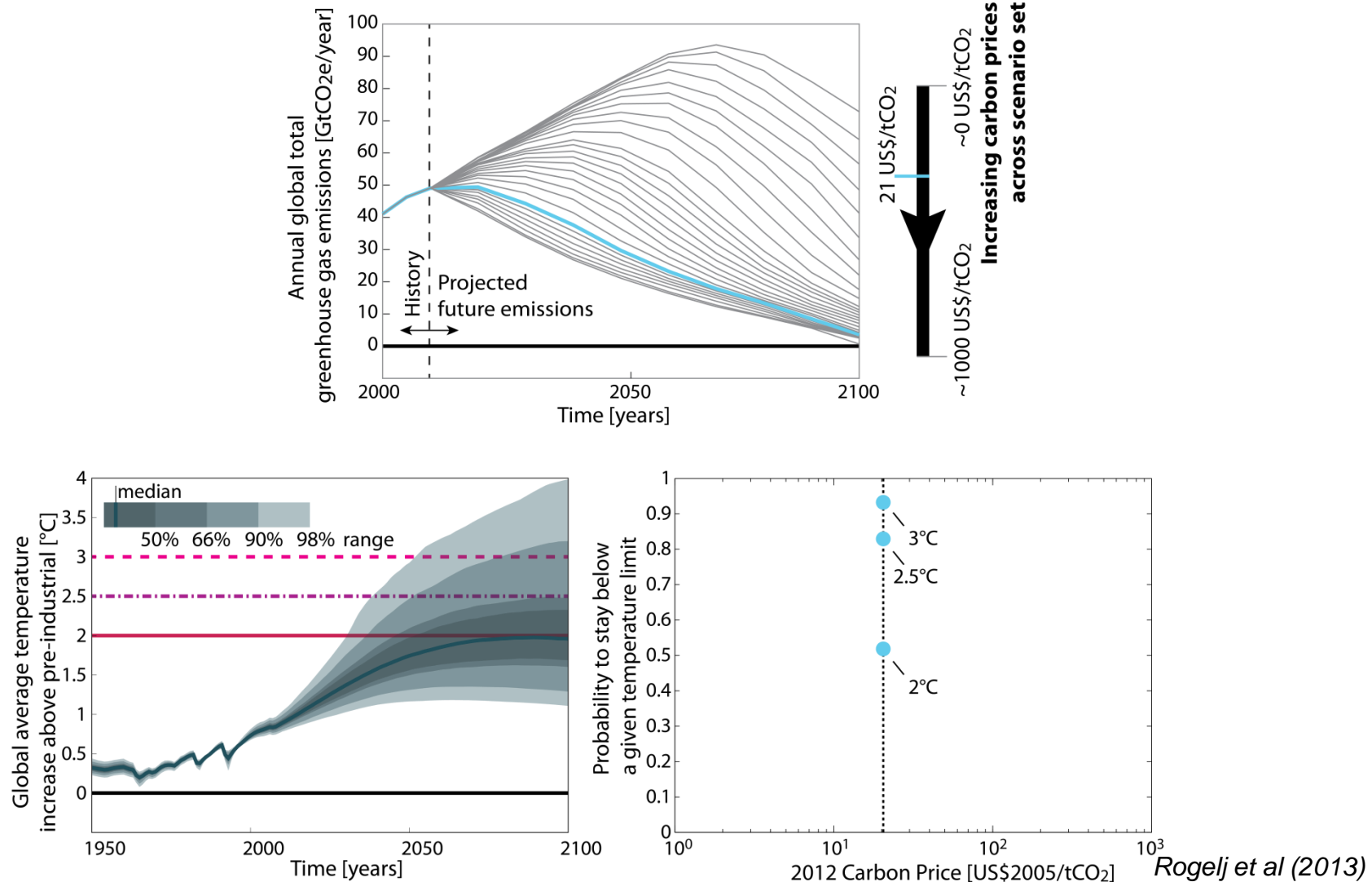
Rogelj et al. Nature (2013)

# Methodology

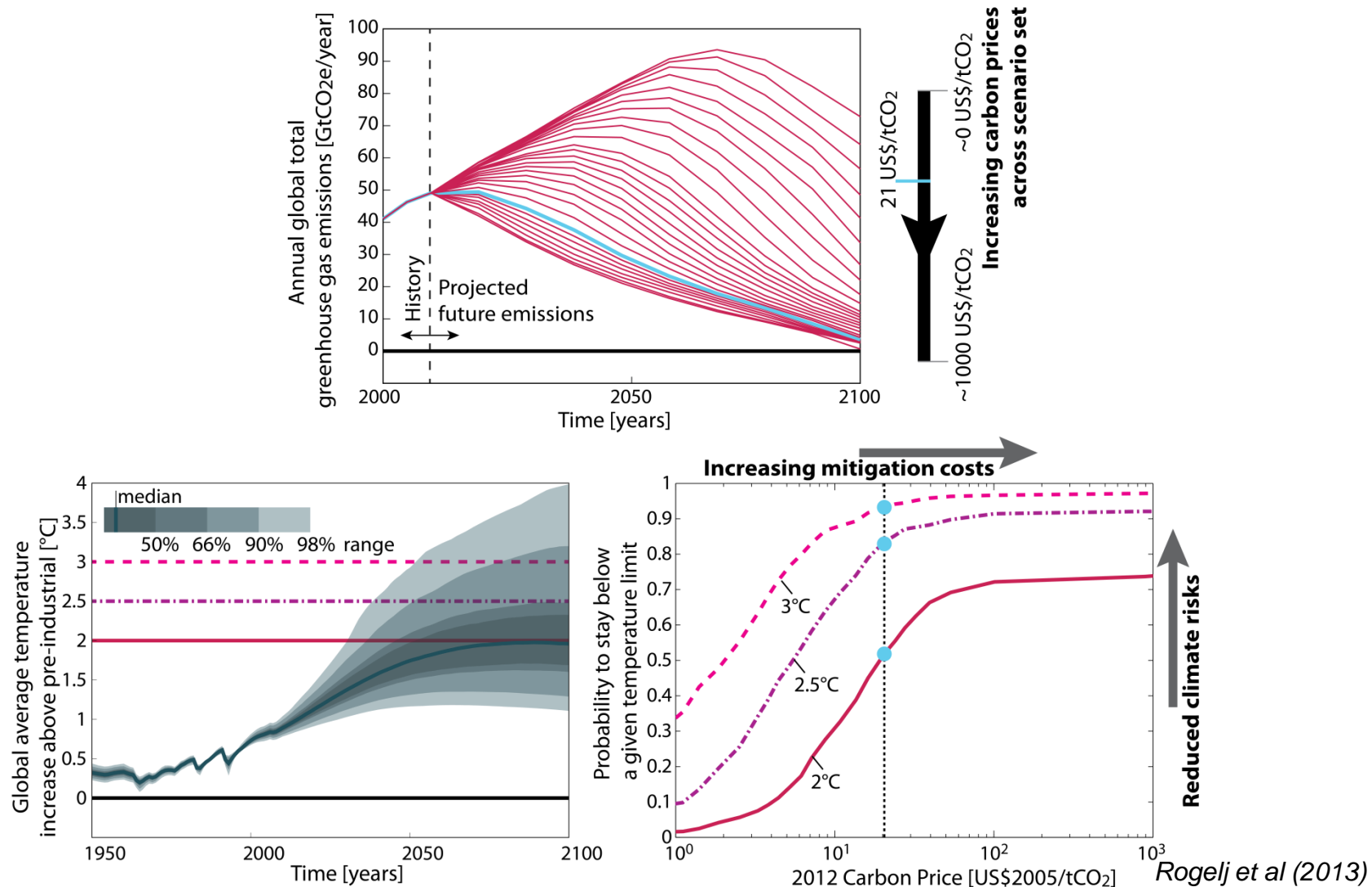


*Rogelj et al. Nature (2013)*

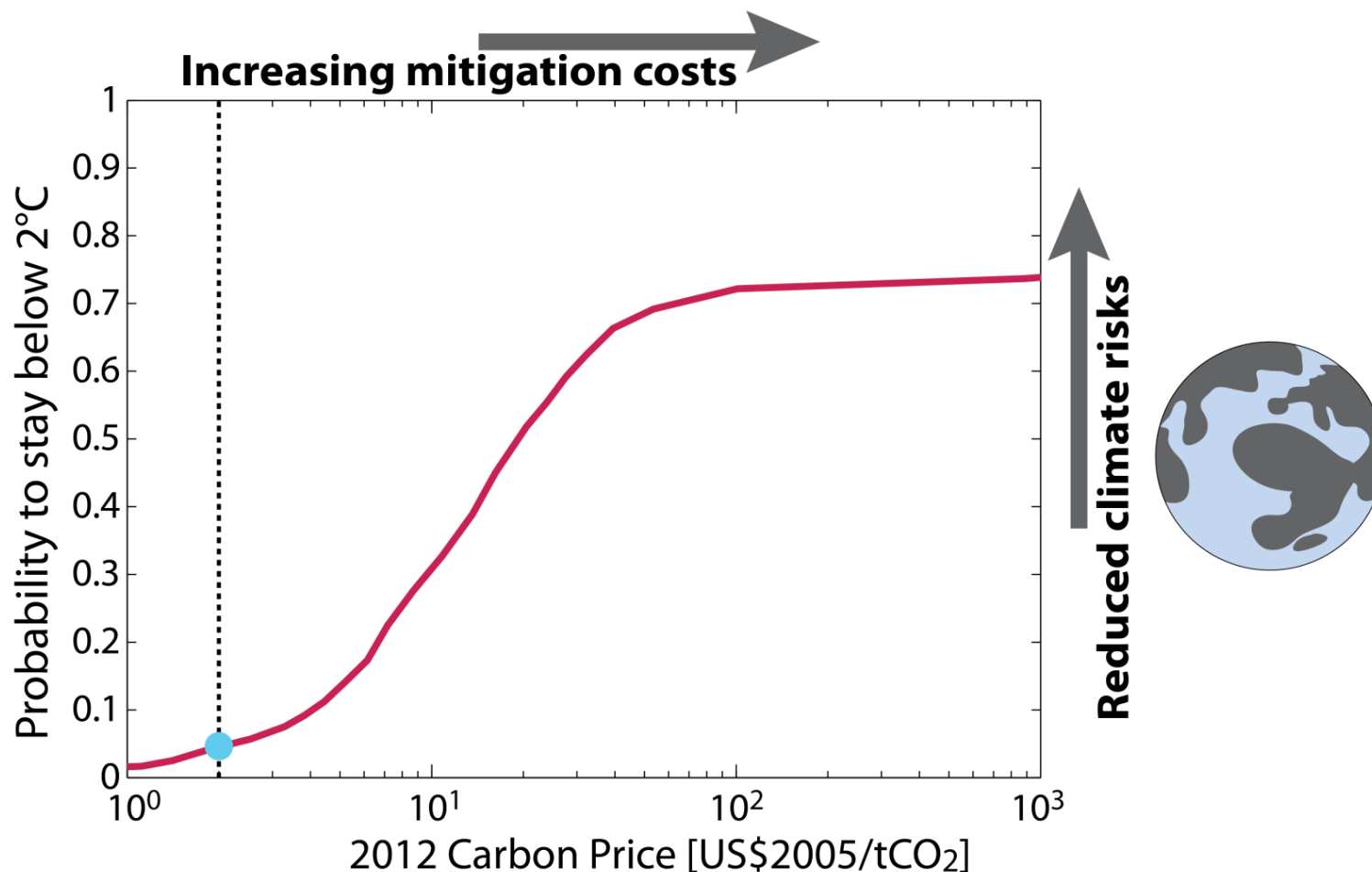
# Methodology



# Methodology – cost-risk distributions



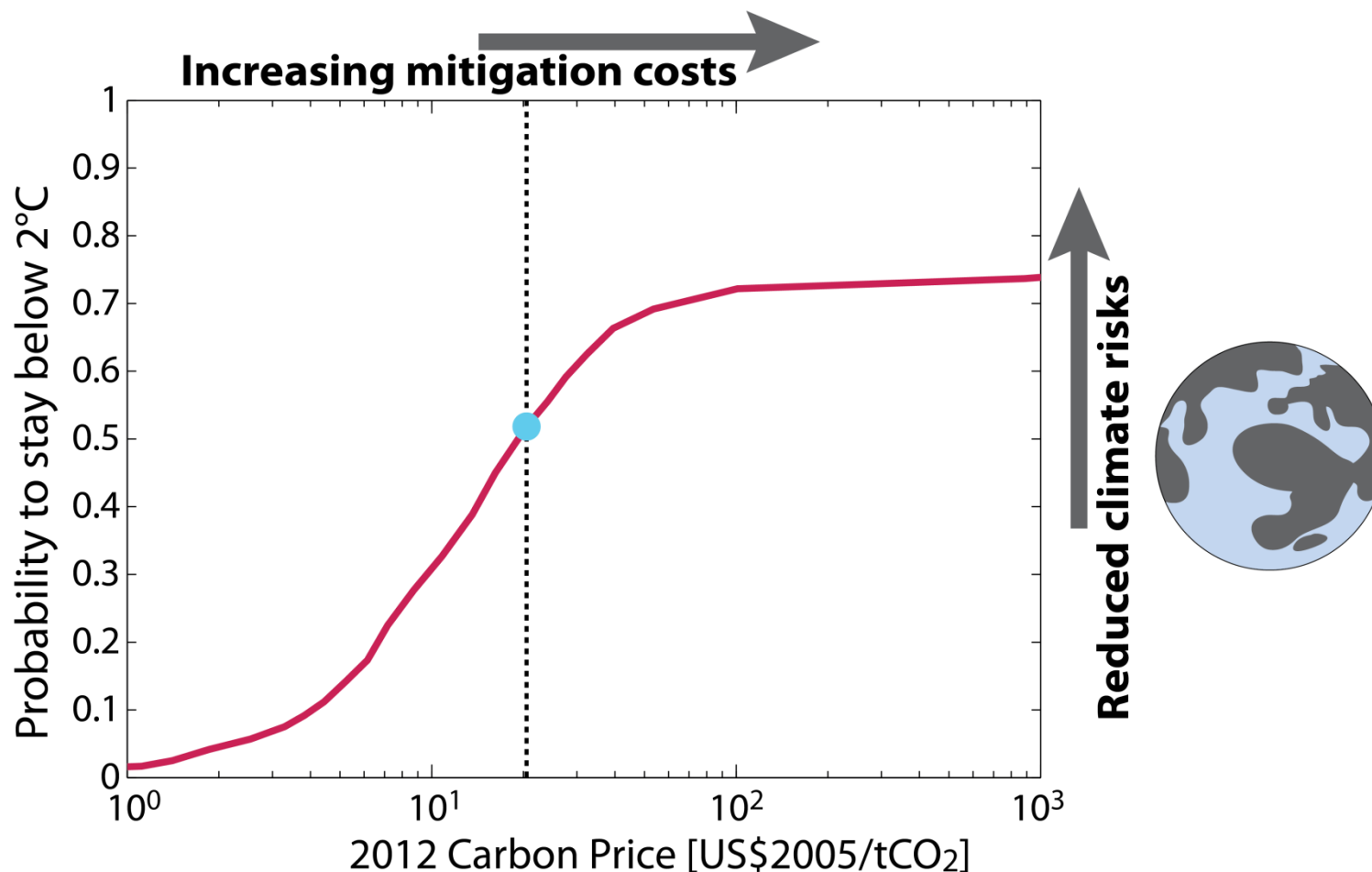
# Results: cost-risk distributions



Rogelj et al. Nature (2013)

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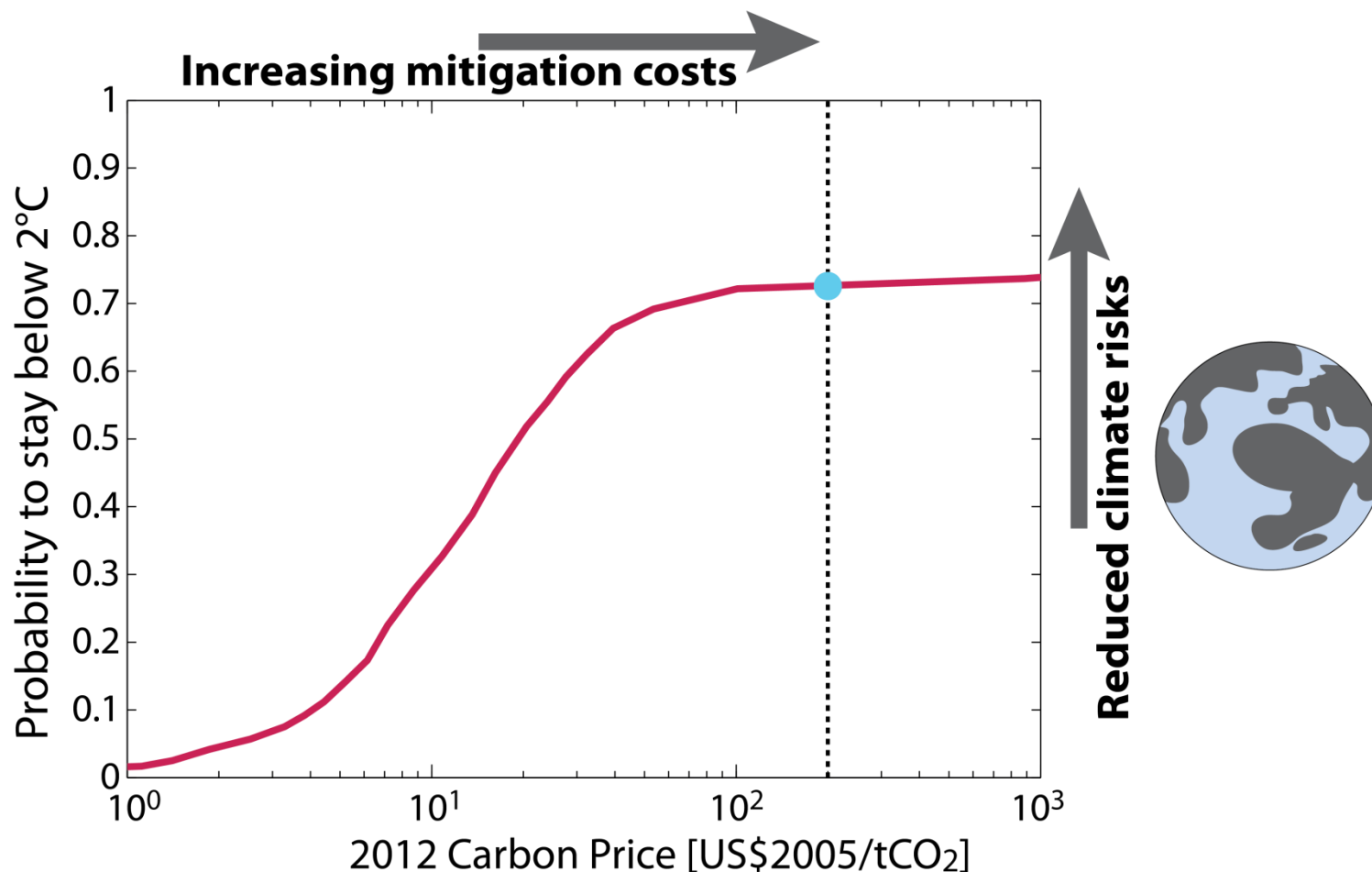
# Results: cost-risk distributions



Rogelj et al. Nature (2013)

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# Results: cost-risk distributions

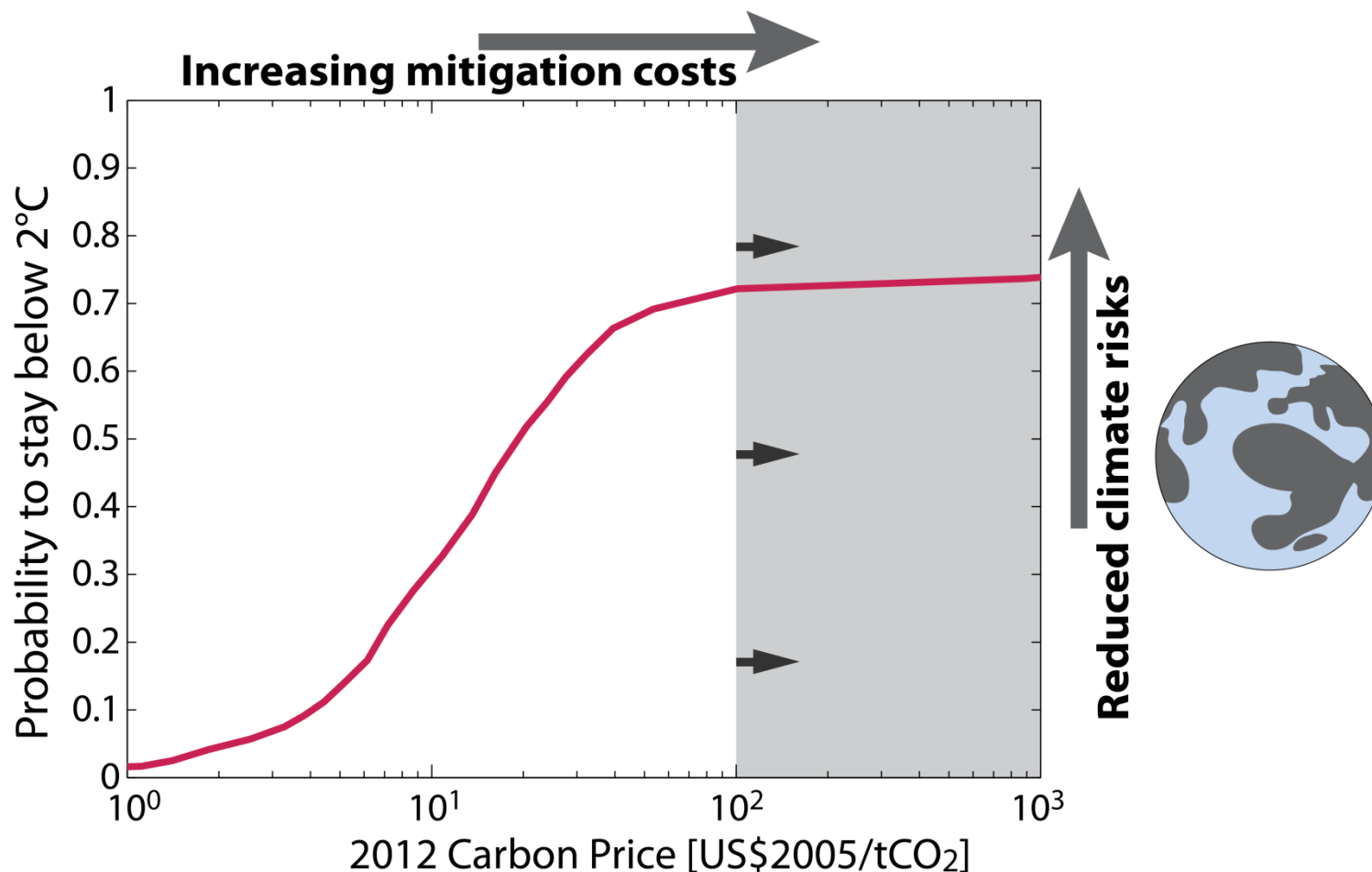


Rogelj et al. Nature (2013)

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# Results: cost-risk distributions

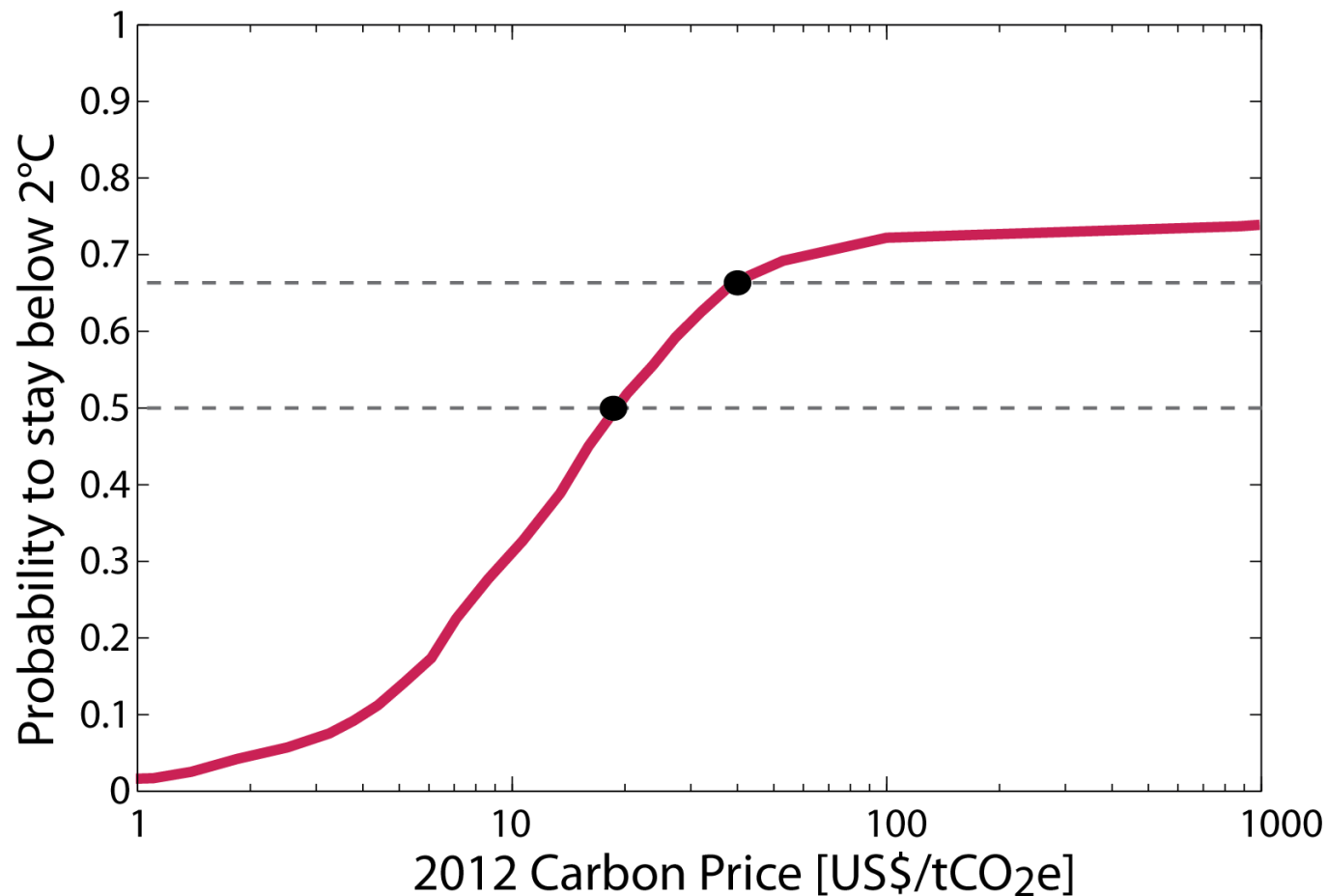


Rogelj et al. Nature (2013)

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# Results: cost-risk distributions

2°C

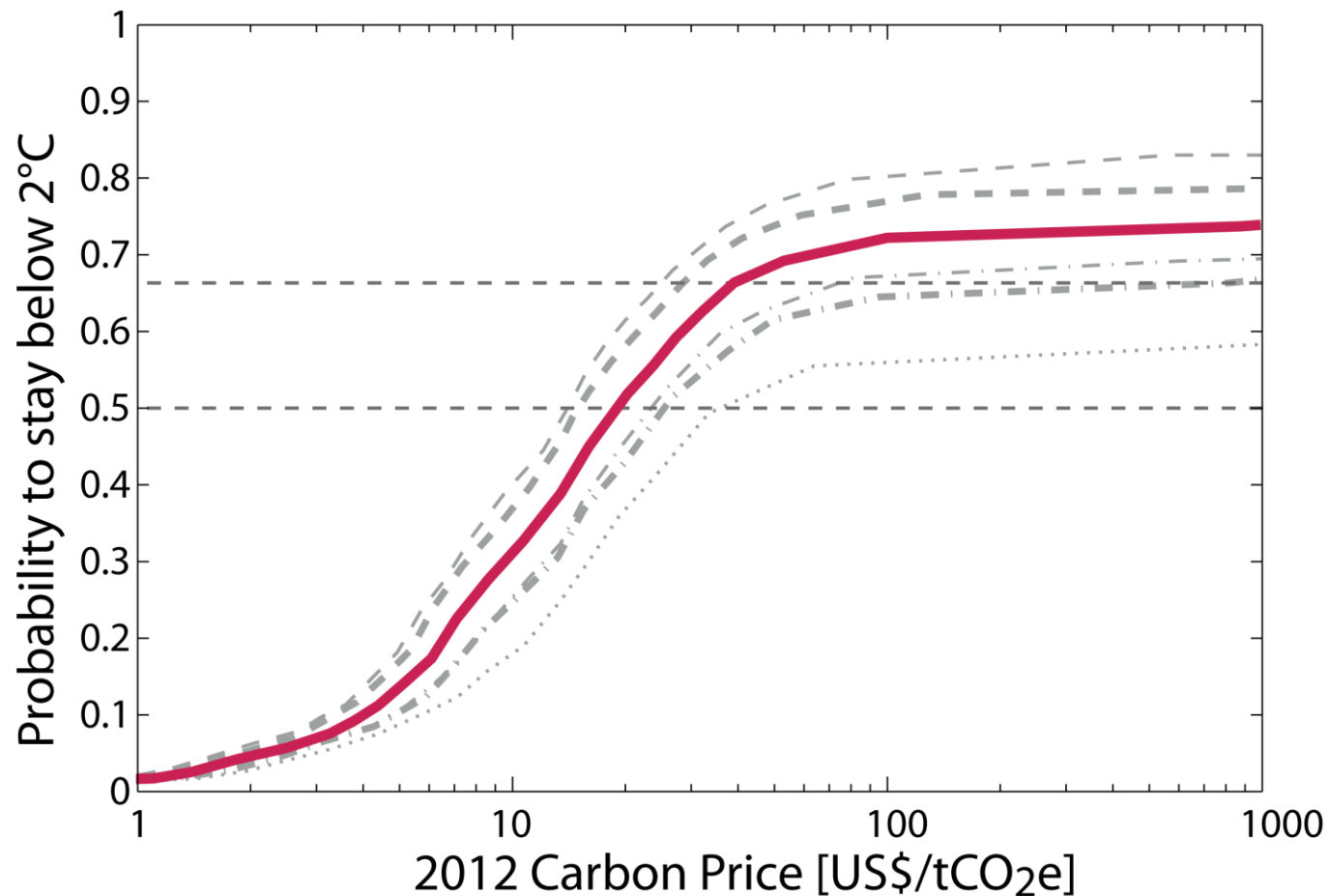
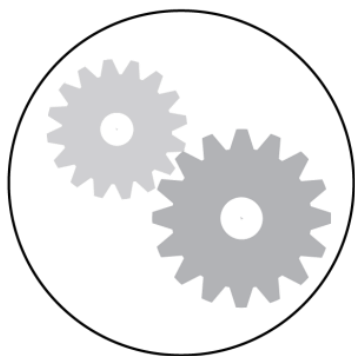


*Rogelj et al. Nature (2013)*

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# Technological uncertainties

2°C

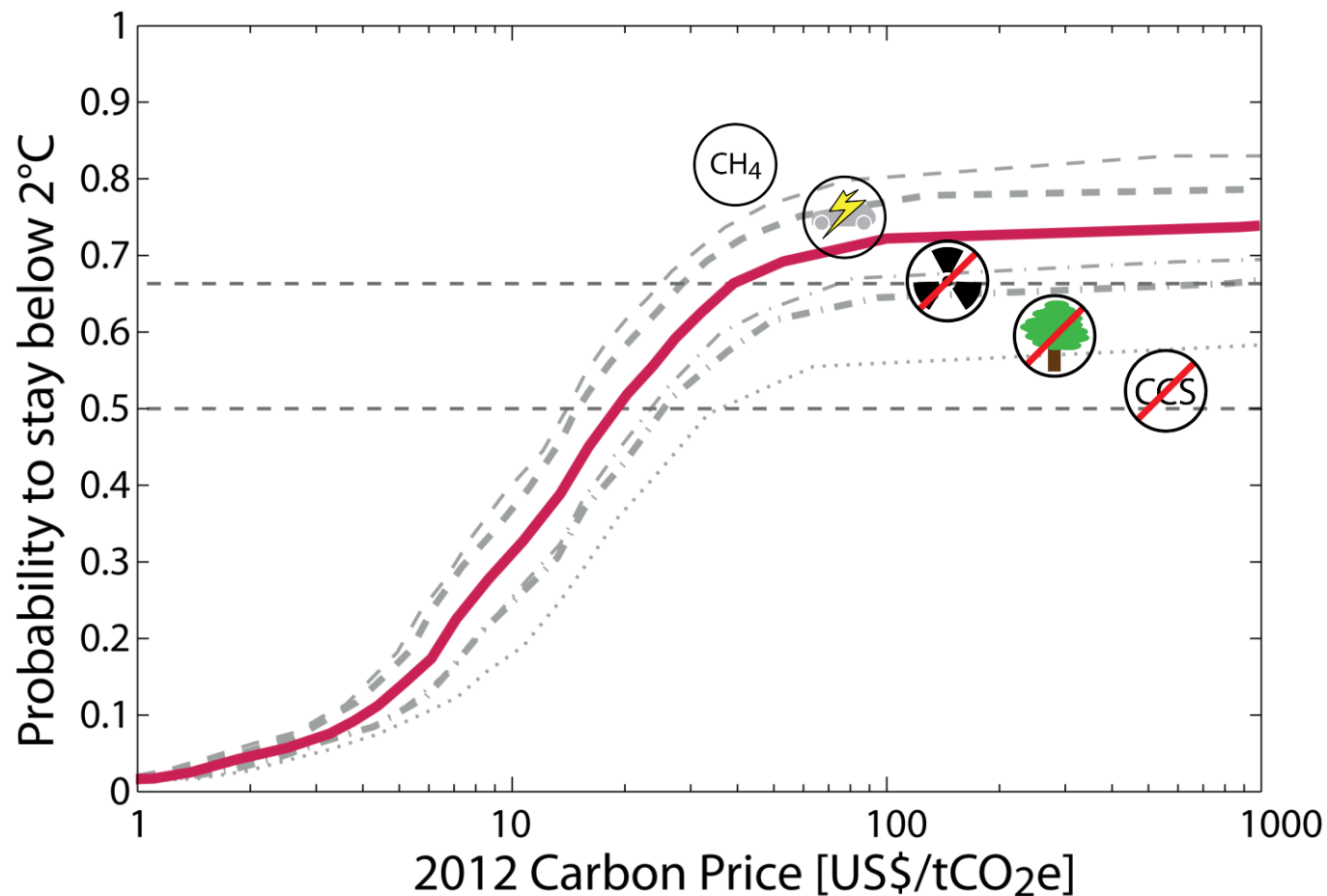
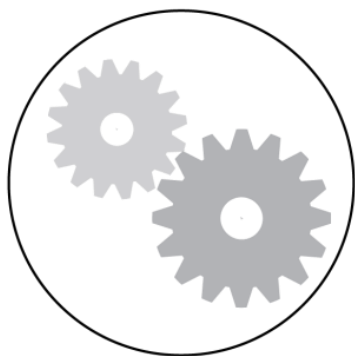


*Rogelj et al. Nature (2013)*

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# Technological uncertainties

2°C

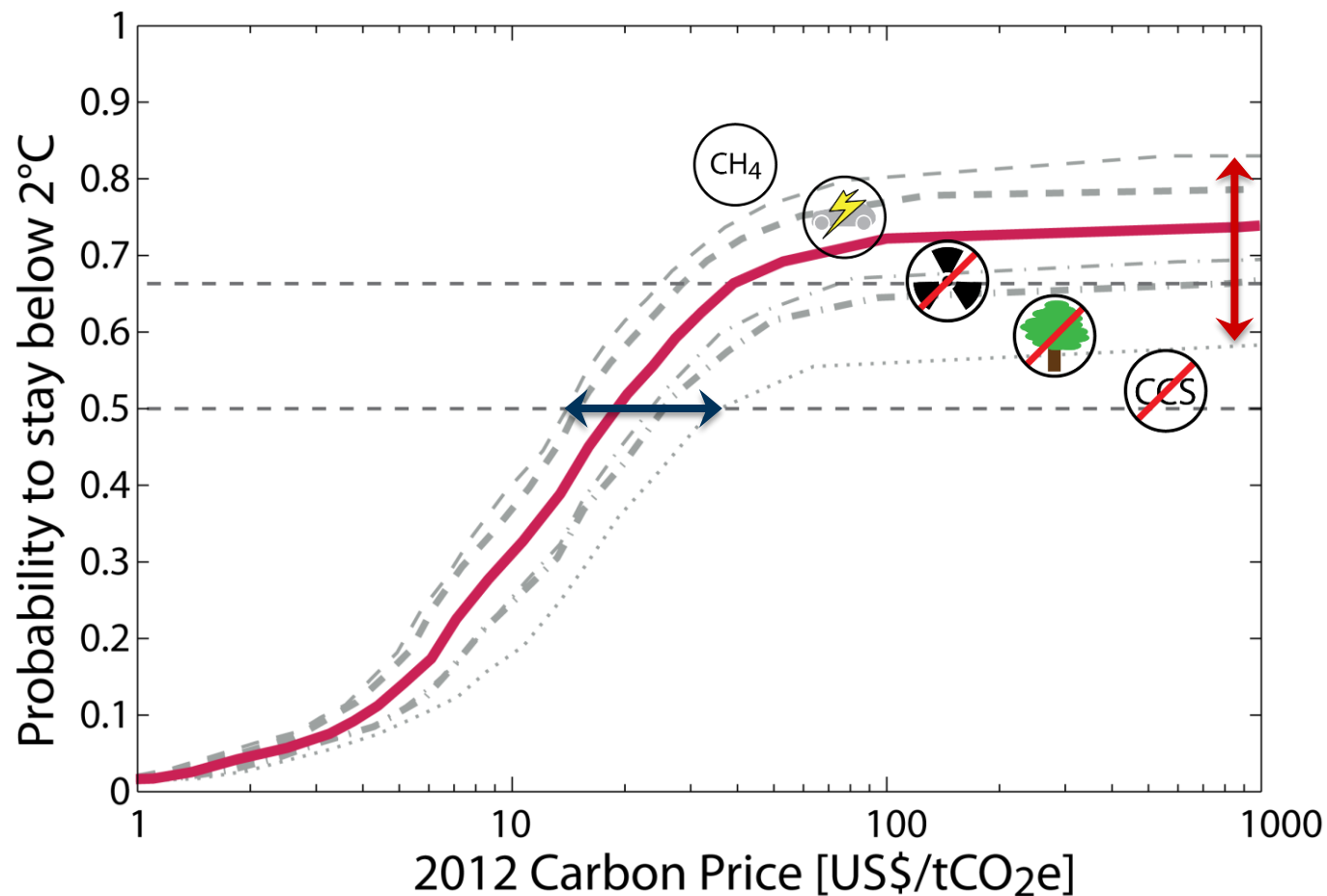
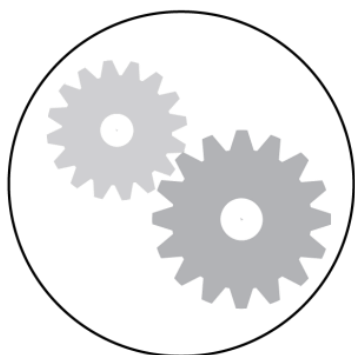


Rogelj et al. Nature (2013)

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# Technological uncertainties

2°C

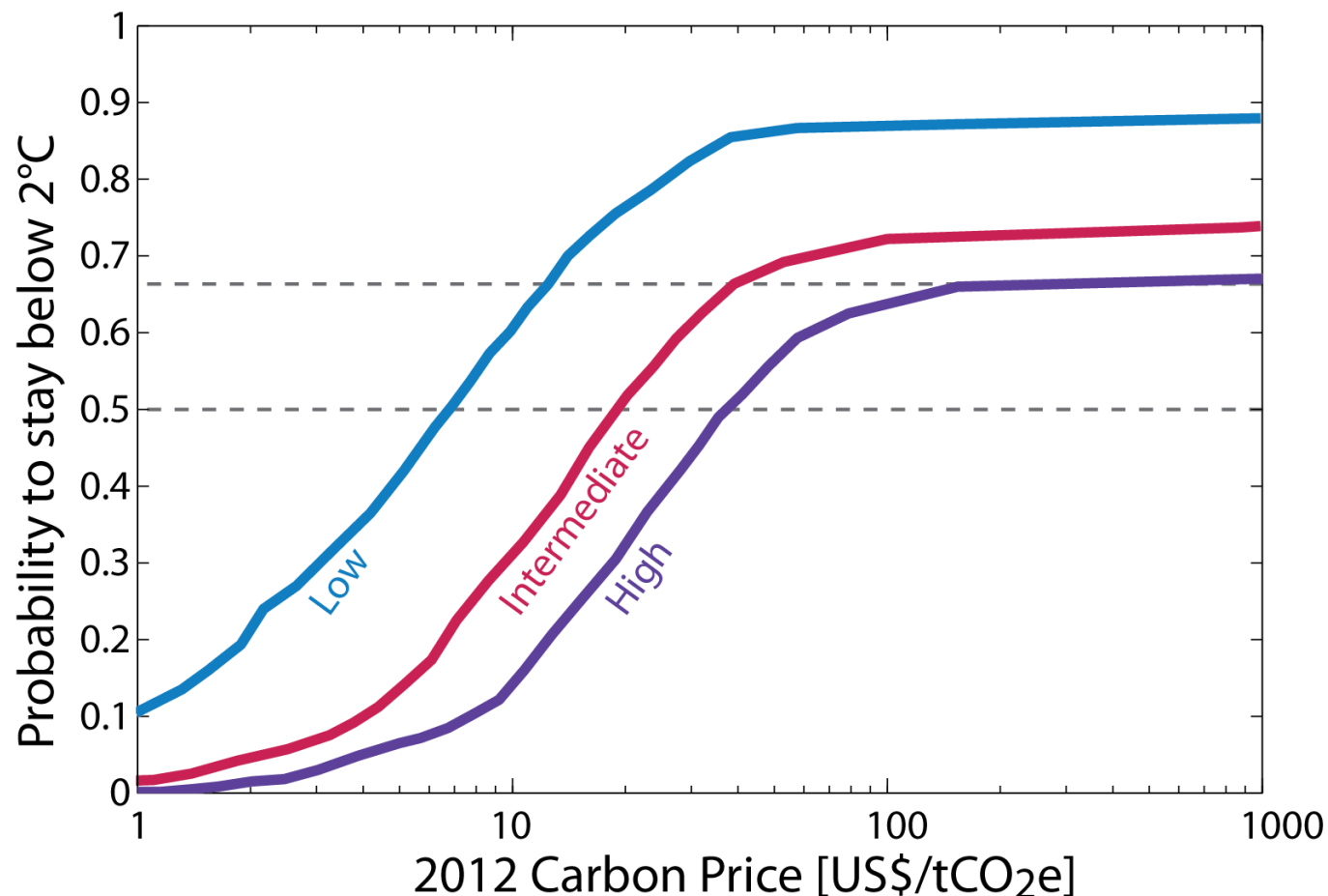


Rogelj et al. Nature (2013)

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# Societal choices (energy demand)

2°C

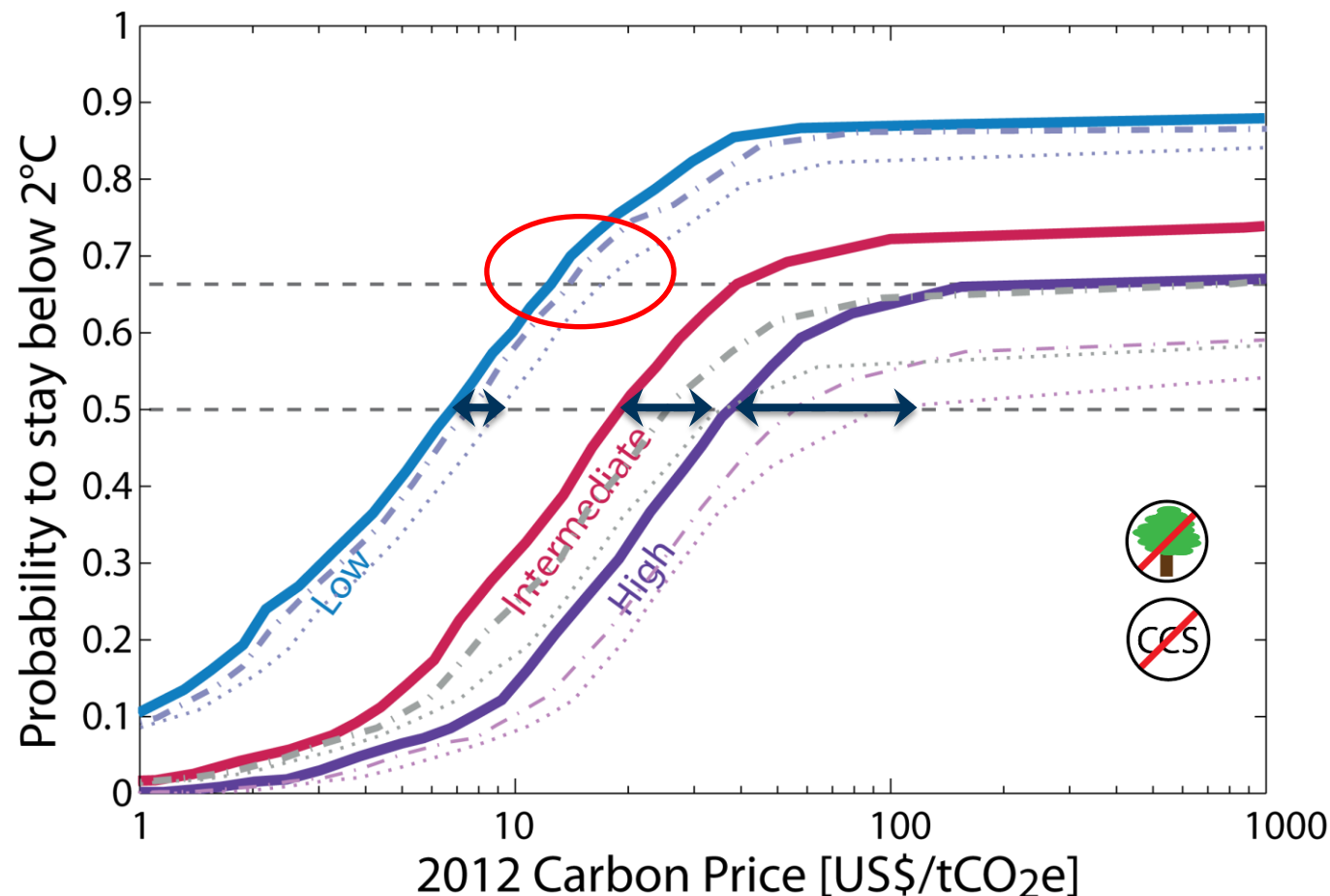


*Rogelj et al. Nature (2013)*

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# Societal choices (energy demand)

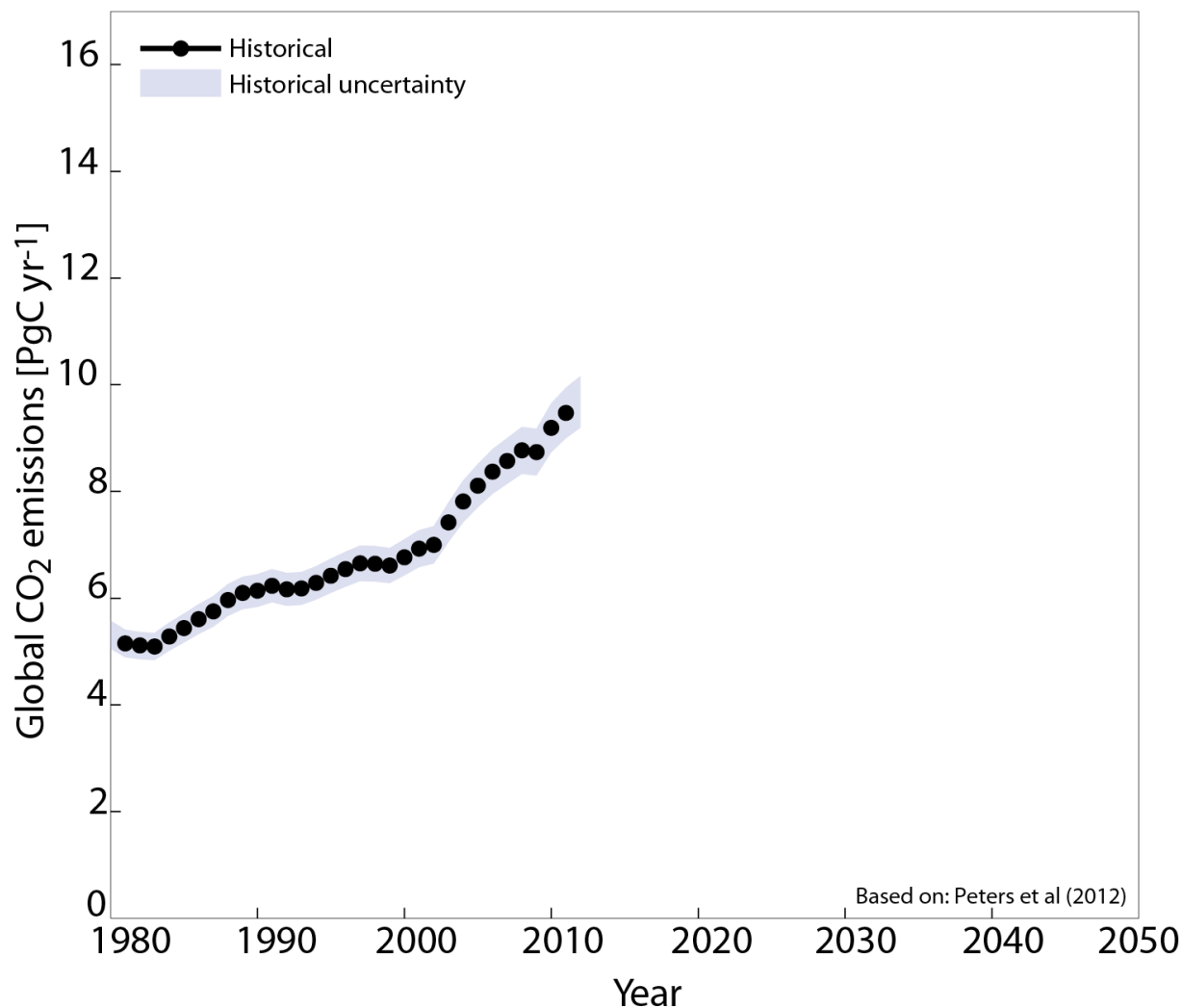
2°C



Rogelj et al. Nature (2013)

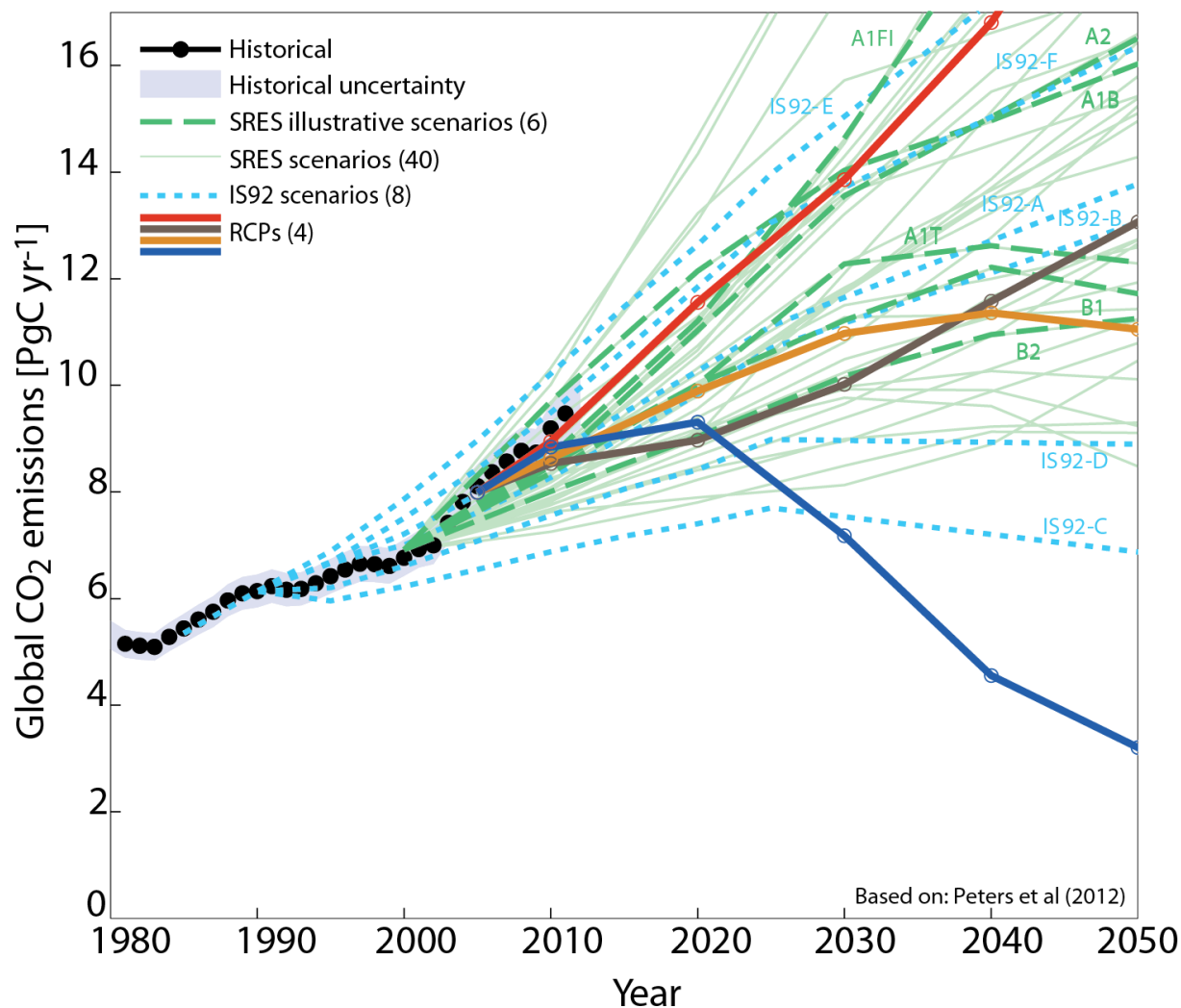
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# What has been achieved?



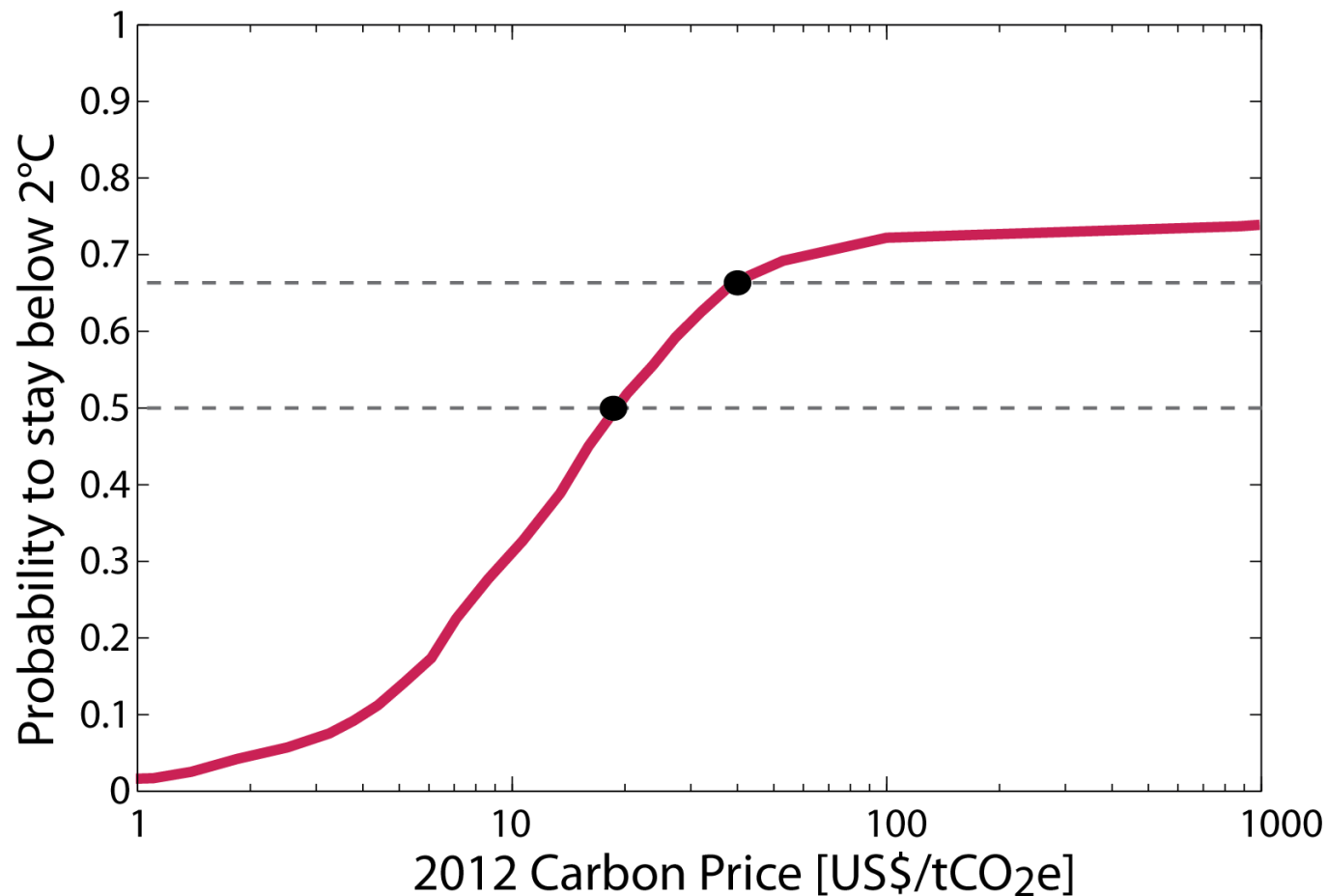


# What has been achieved?



# Political choices

2°C

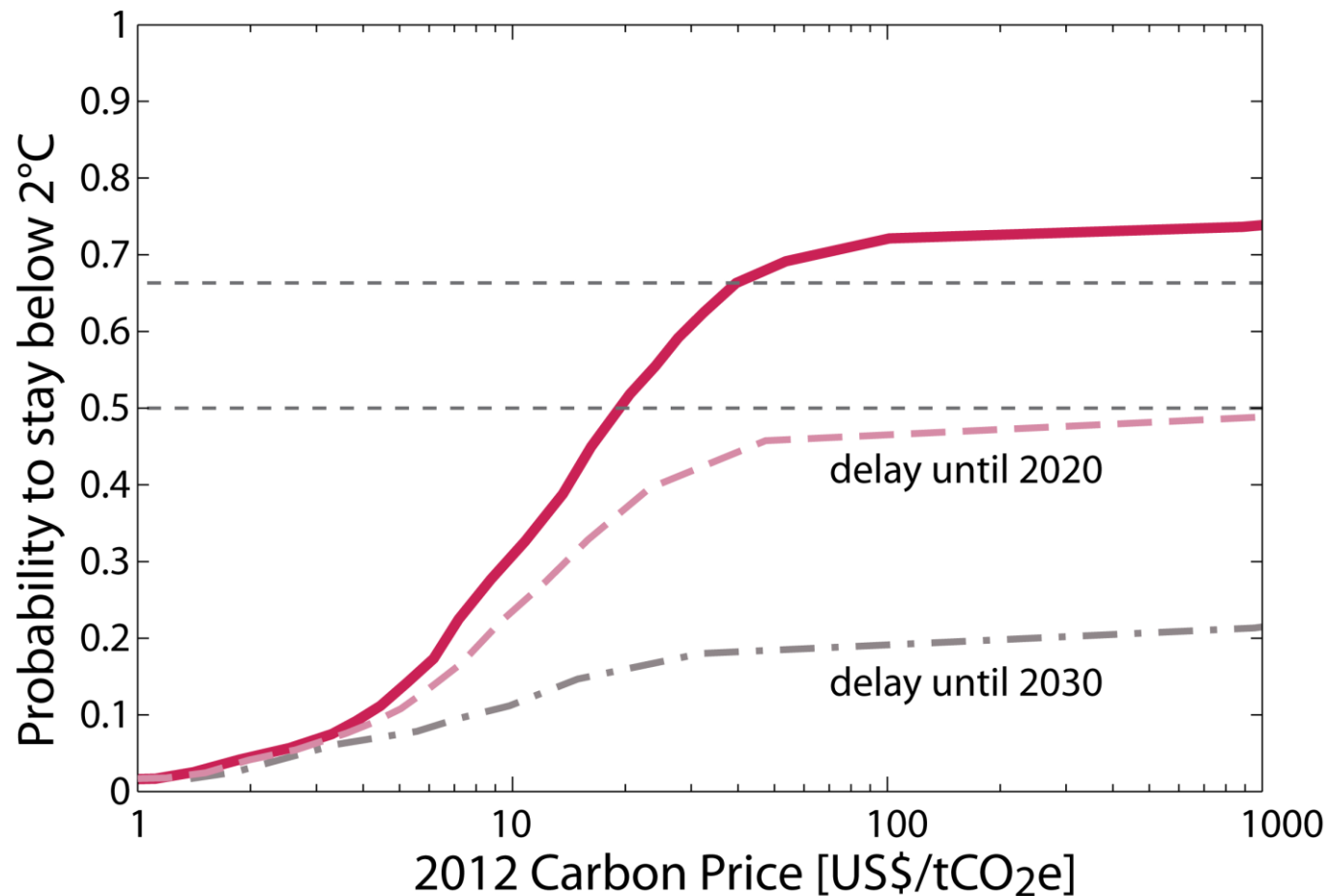


*Rogelj et al. Nature (2013)*

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# Political choices

2°C

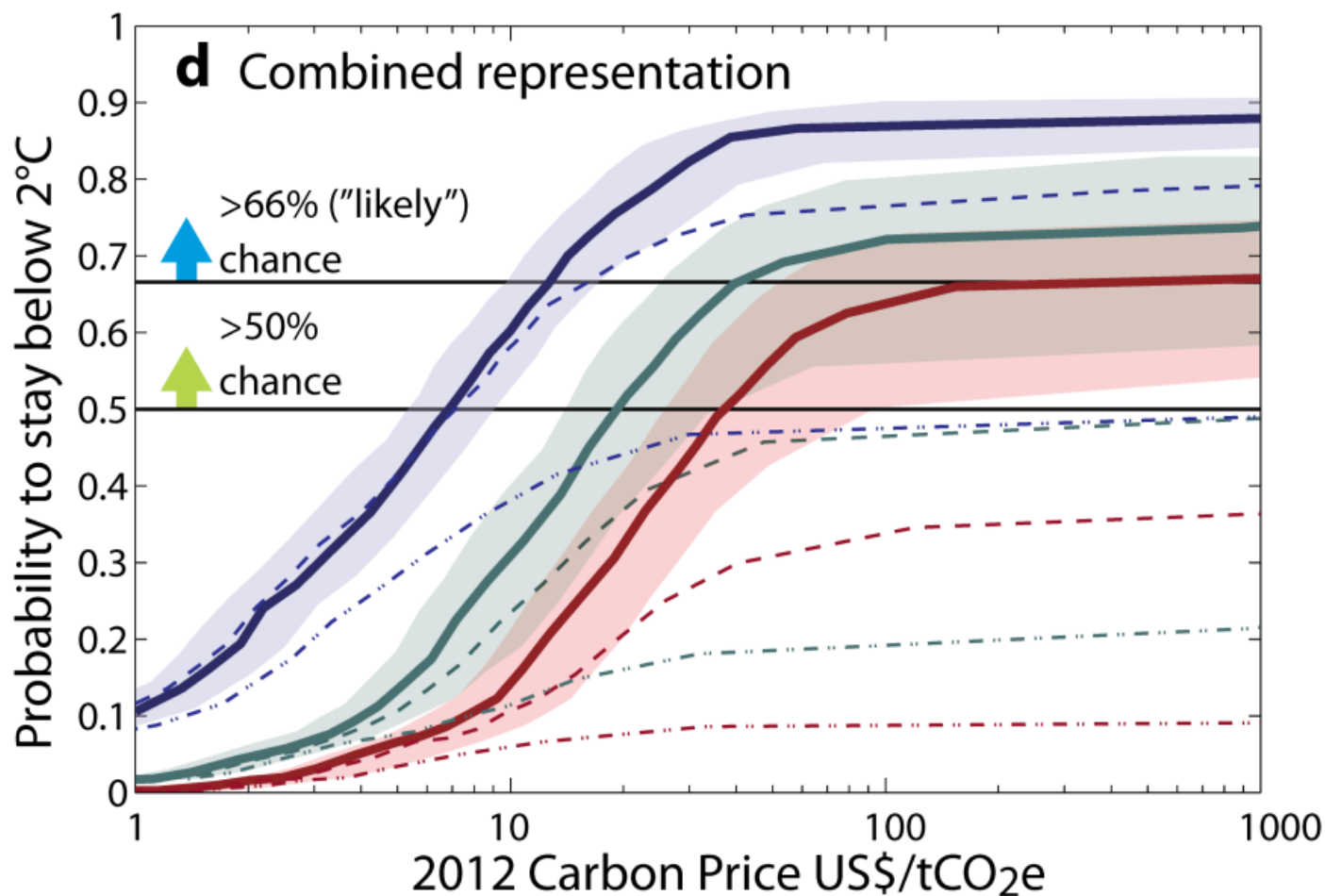


*Rogelj et al. Nature (2013)*

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# Political choices

2°C

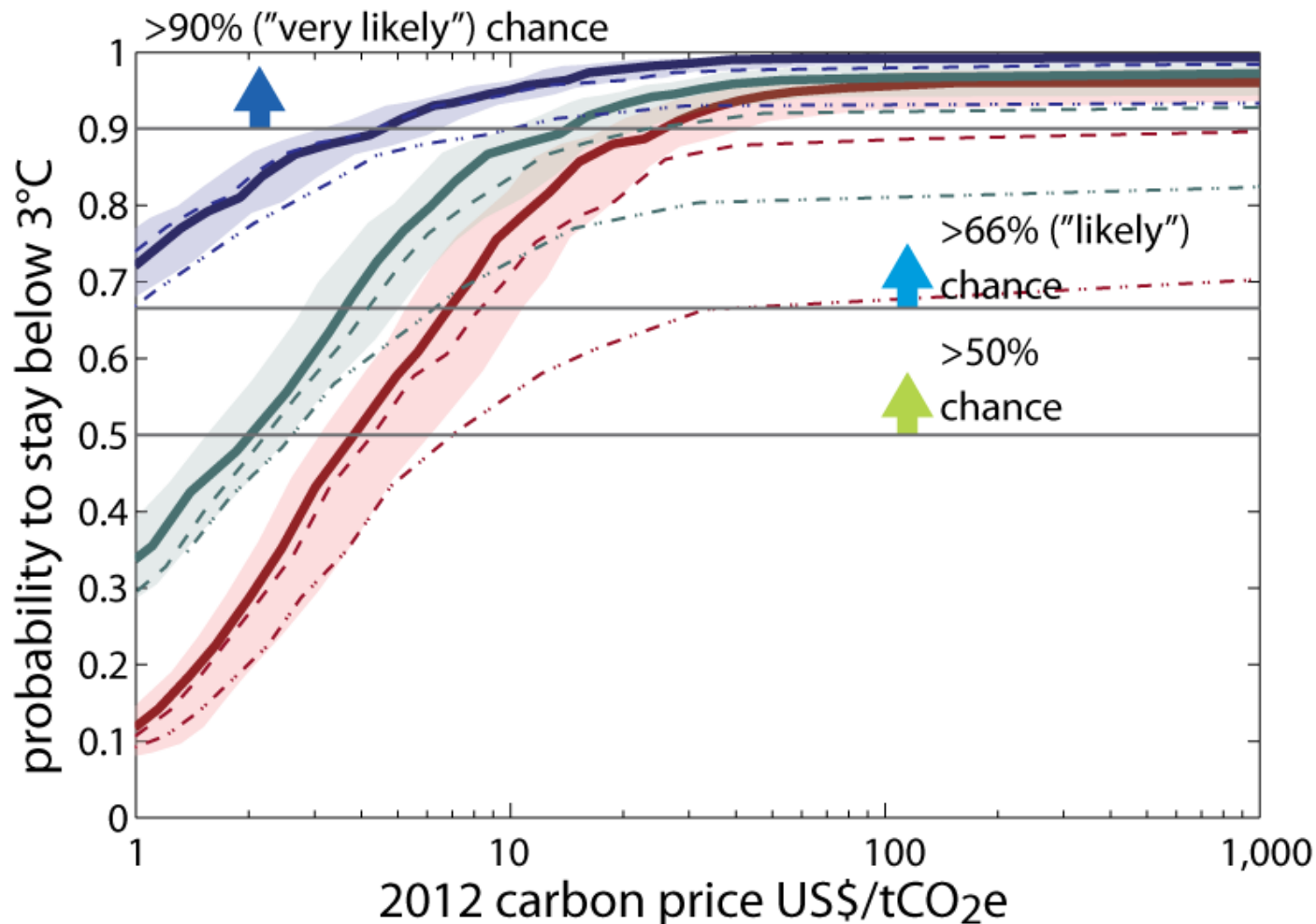


Rogelj et al. Nature (2013)

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# What if we move targets?

3°C



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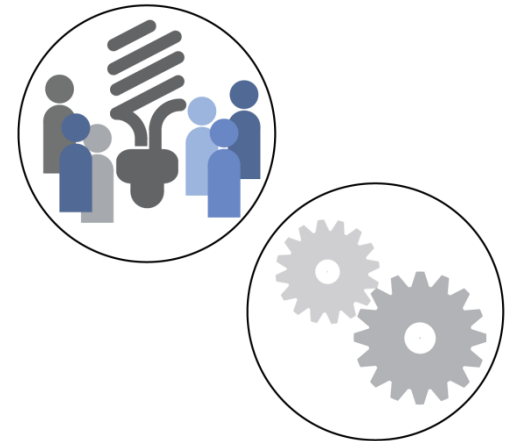
# Which uncertainties matter (most)?

2-3°C

# Which uncertainties matter (most)?

## 2-3°C

- 1.
- 2.
3. Societal (energy demand)
4. Technological



# Which uncertainties matter (most)?

## 2-3°C

- 1.
2. Geophysical
3. Societal (energy demand)
4. Technological





# Which uncertainties matter (most)?

## 2-3°C

1. Political (delayed action)
2. Geophysical
3. Societal (energy demand)
4. Technological



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**Thank you**

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## MESSAGE

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## MAGICC

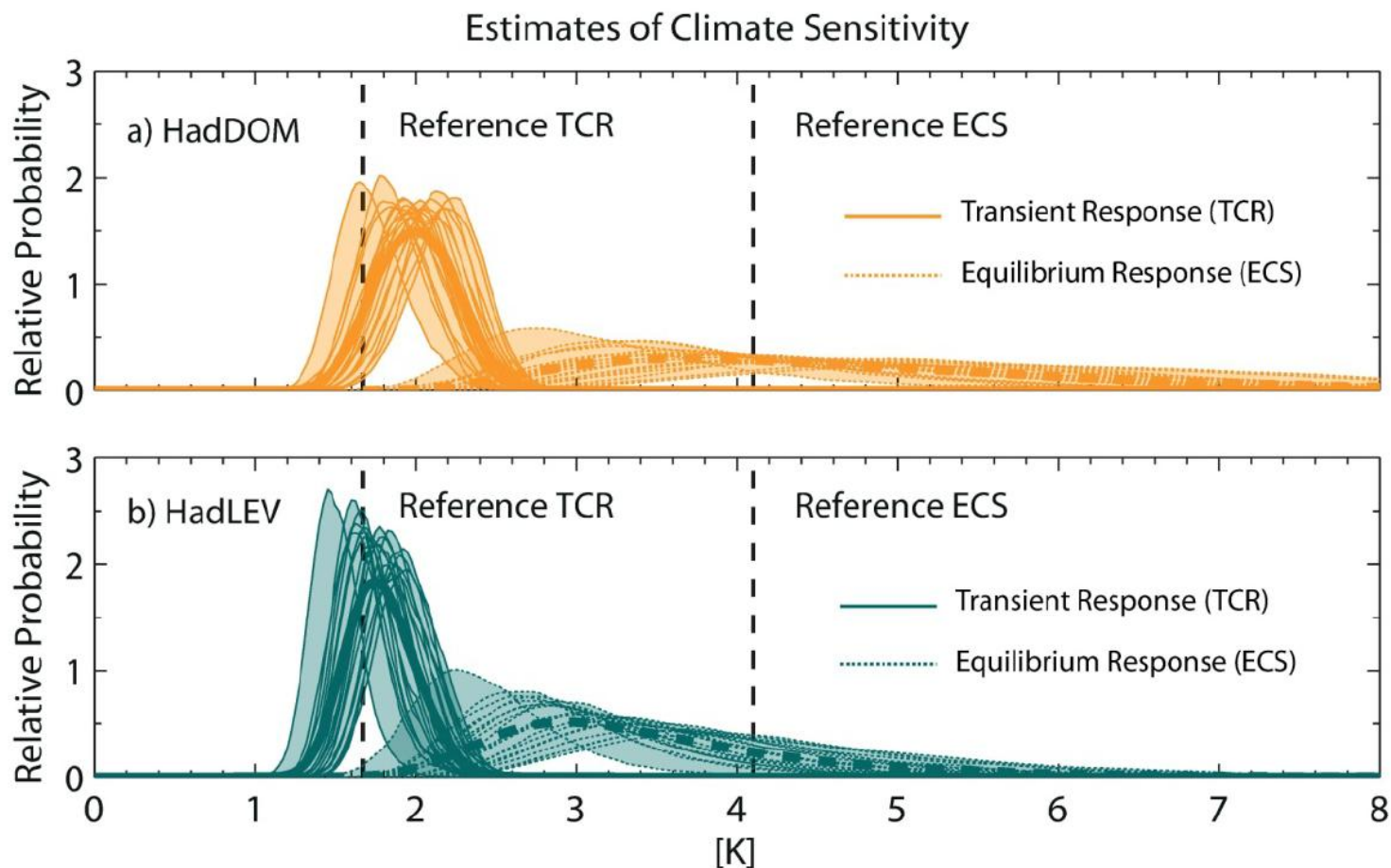
Meinshausen, M., et al. (2011). Atmos. Chem. Phys. 11(4): 1417-1456.

Meinshausen, M., et al. (2011). Atmos. Chem. Phys. 11(4): 1457-1471.

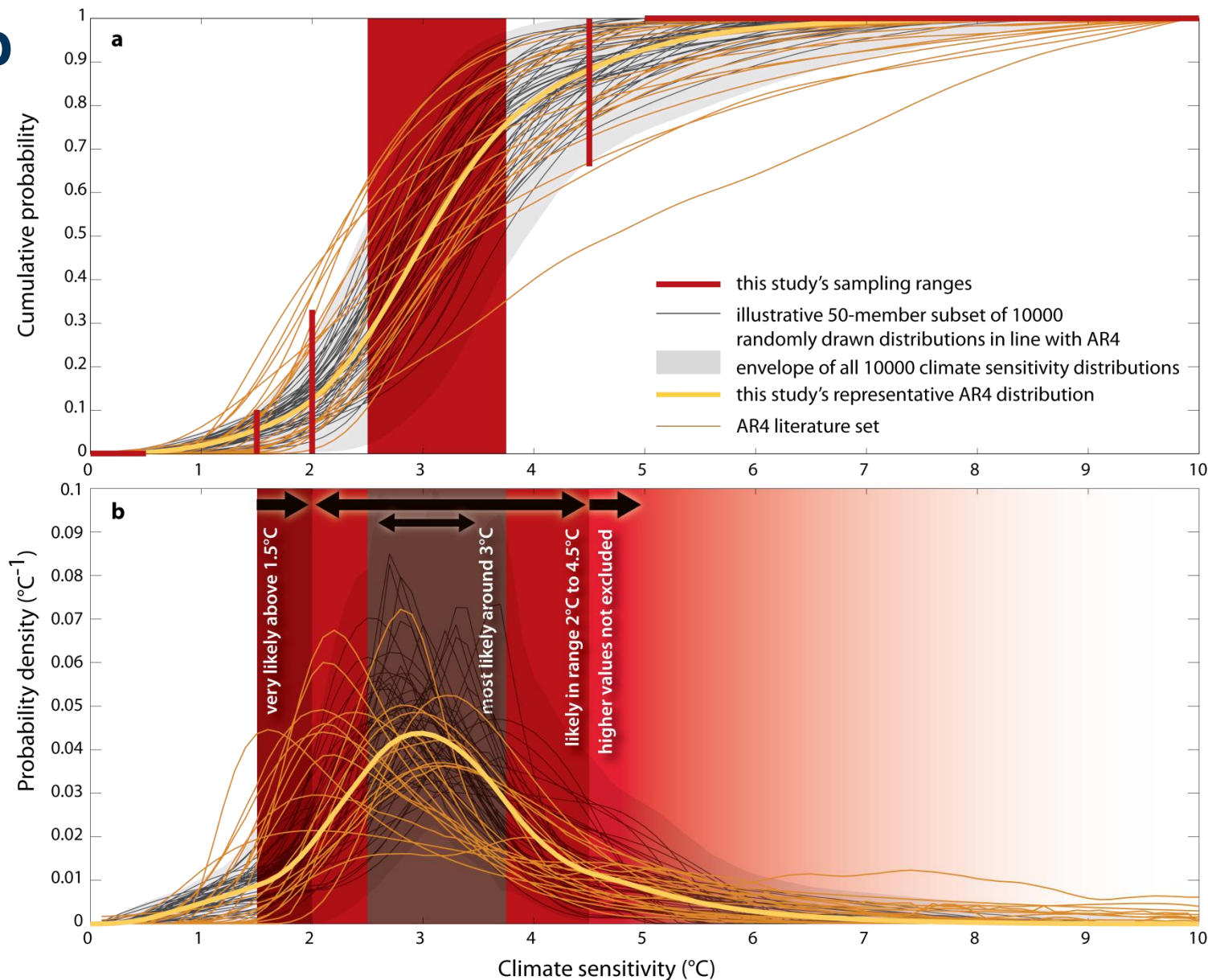
Rogelj, J., et al. (2012). Nature Clim. Change 2(4): 248-253.



# Backup: Geophysical uncertainties



# Back-up

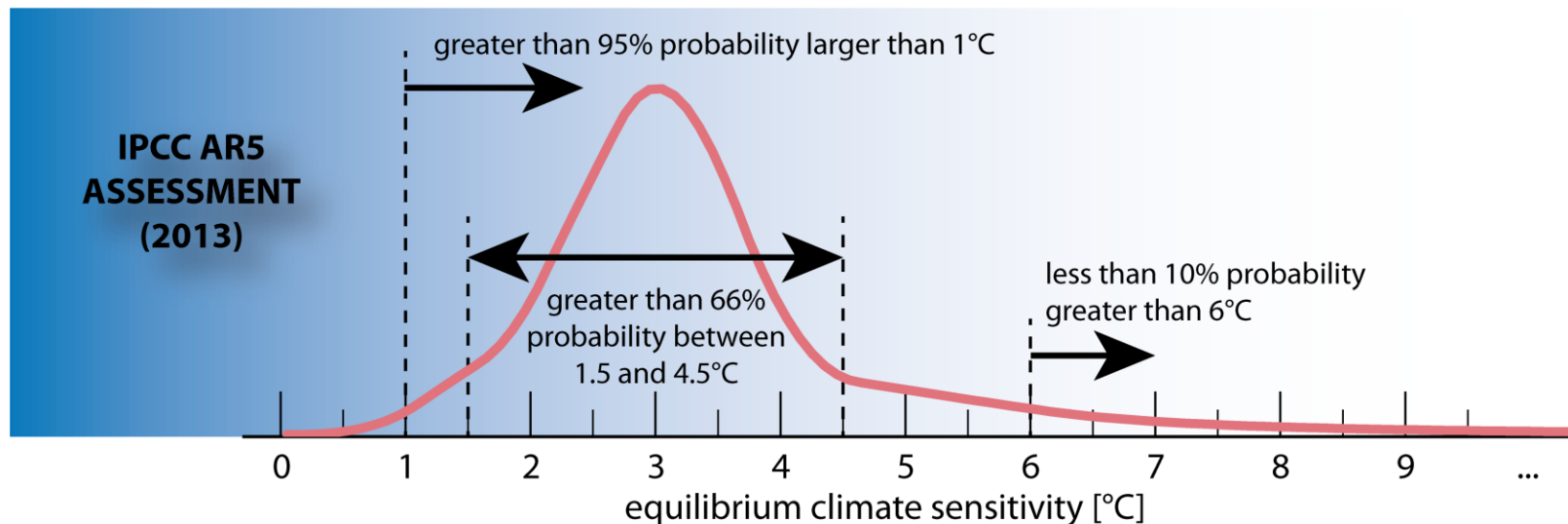


Rogelj et al. Nature Climate Change (2012)

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## Backup: Geophysical uncertainties

- Perturbed parameter ensemble (82-dimensional param. space)
- Constrained by (1) OHU, (2) hemispheric SST, and (3) RF estimates
- Resulting 600-member ensemble
- Posterior climate sensitivity distribution reflecting the IPCC assessment



MAGICC setup: Rogelj et al (2012), Meinshausen et al (2009)

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