Visualizing projected Climate Changes - the CMIP5 Multi-Model Ensemble

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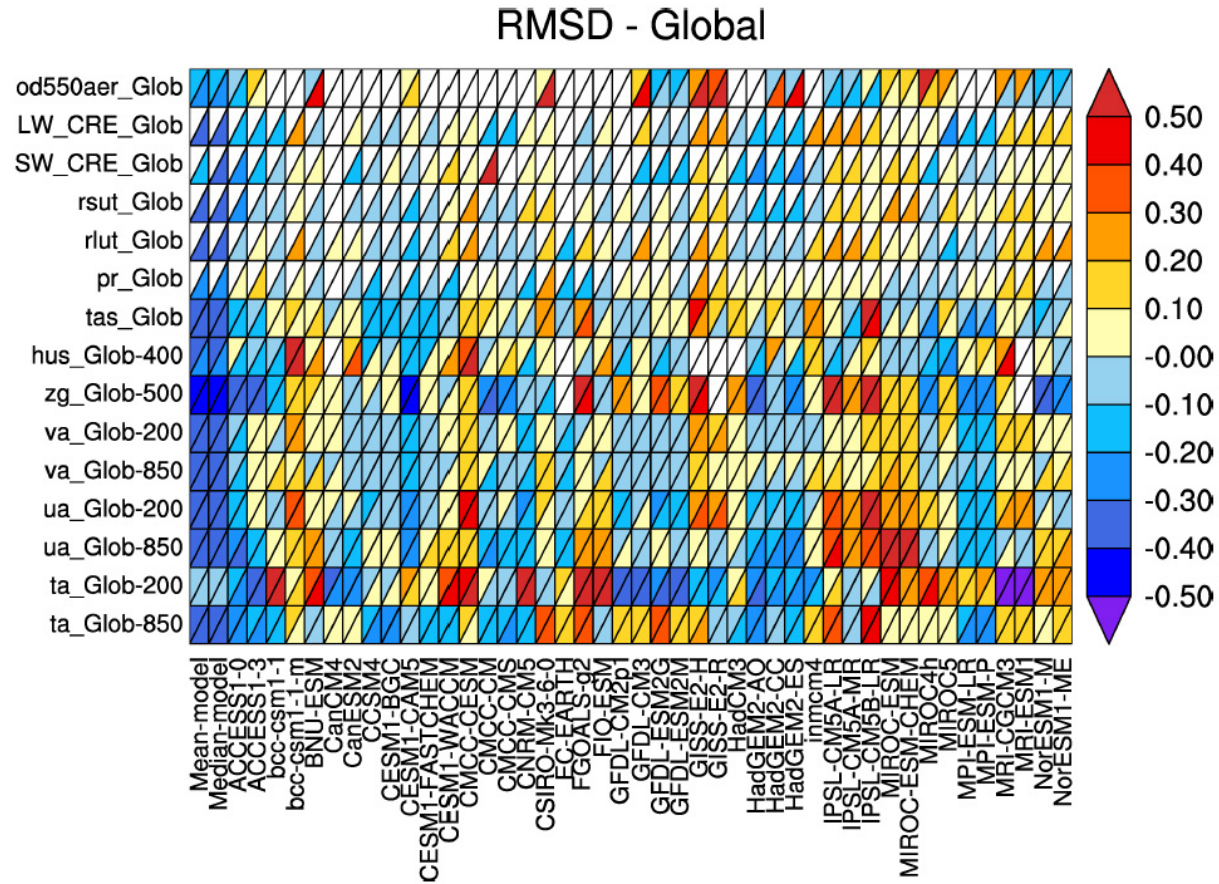
Background: CMIP5

- CMIP = The Coupled Model Intercomparison Project
- WCRP/WGCM established CMIP as a standard experimental protocol for studying the output of coupled atmosphere-ocean general circulation models (AOGCMs)
- CMIP5 = fifth phase of CMIP, simulations carried out w.r.t. IPCC AR5

The CMIP5 Multi Model Ensemble



~ 25 Modeling groups

~ 40 different models/configurations

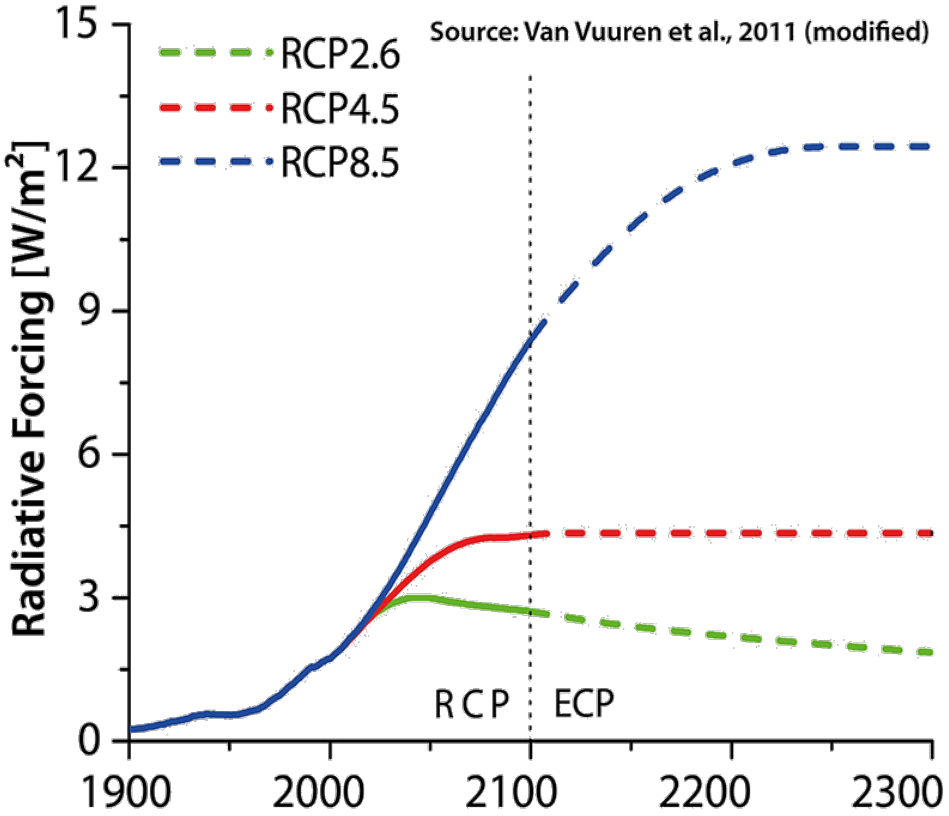
Sources of uncertainty:

- Internal climate variability
- Model uncertainty: different
  - representation of processes
  - climate sensitivity
- Scenario uncertainty

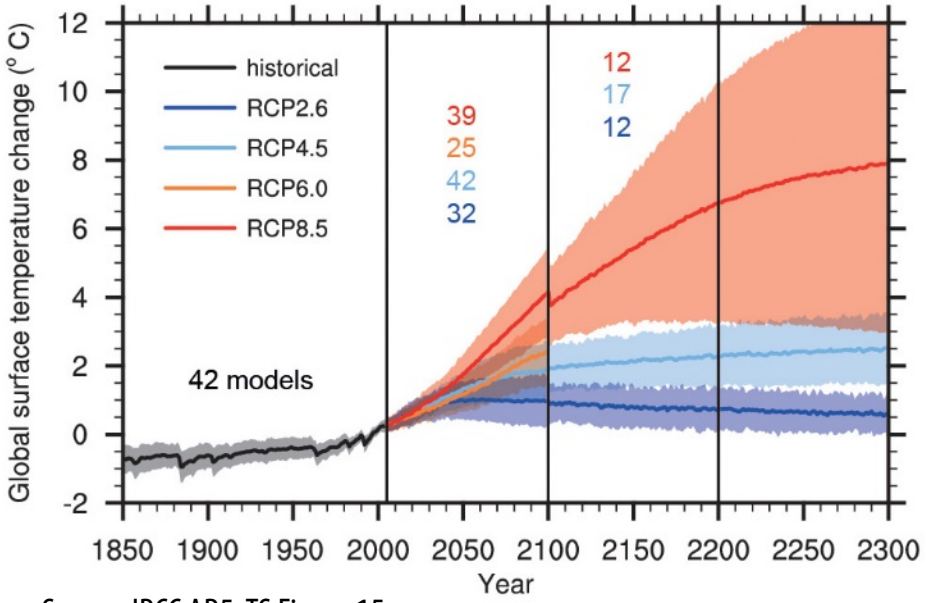
Source: Eyring et al. 2017, doi:10.5194/gmd-9-1747-2016

CMIP5 – The RCP Climate Change Scenarios

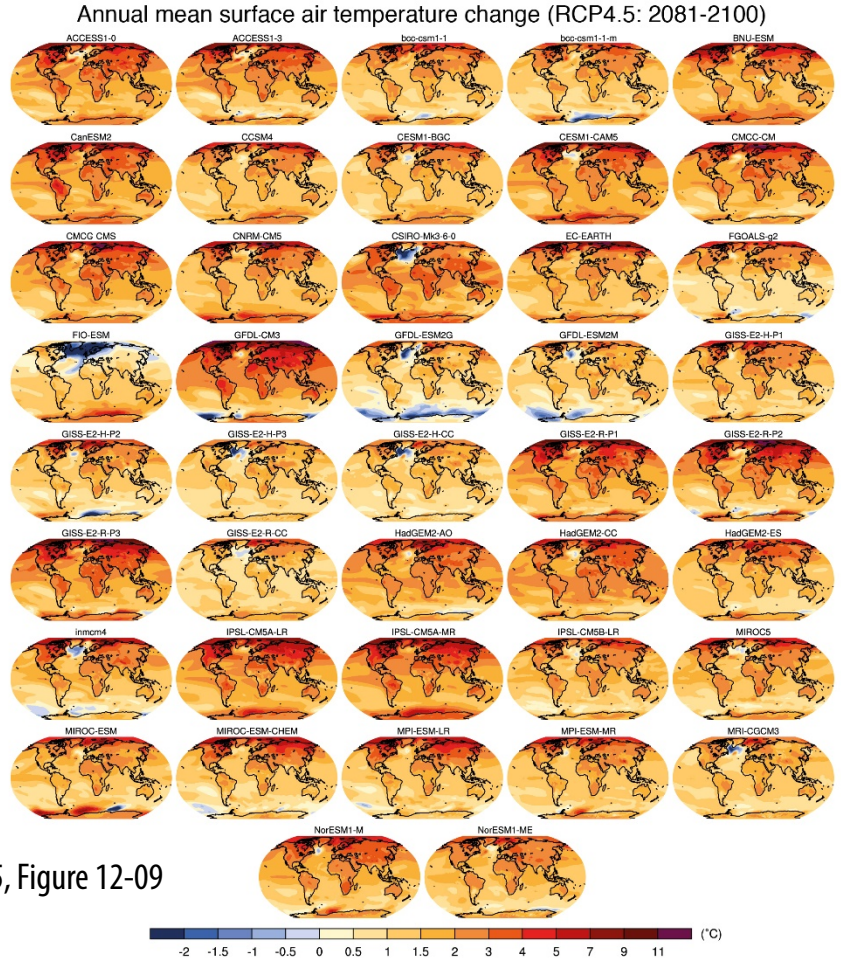
RCPs = Representative Concentration Pathways *(RCP6.0 omitted)*



CMIP5 - Projected Changes in the the 2m-Temperature



Source: IPCC AR5, TS Figure 15

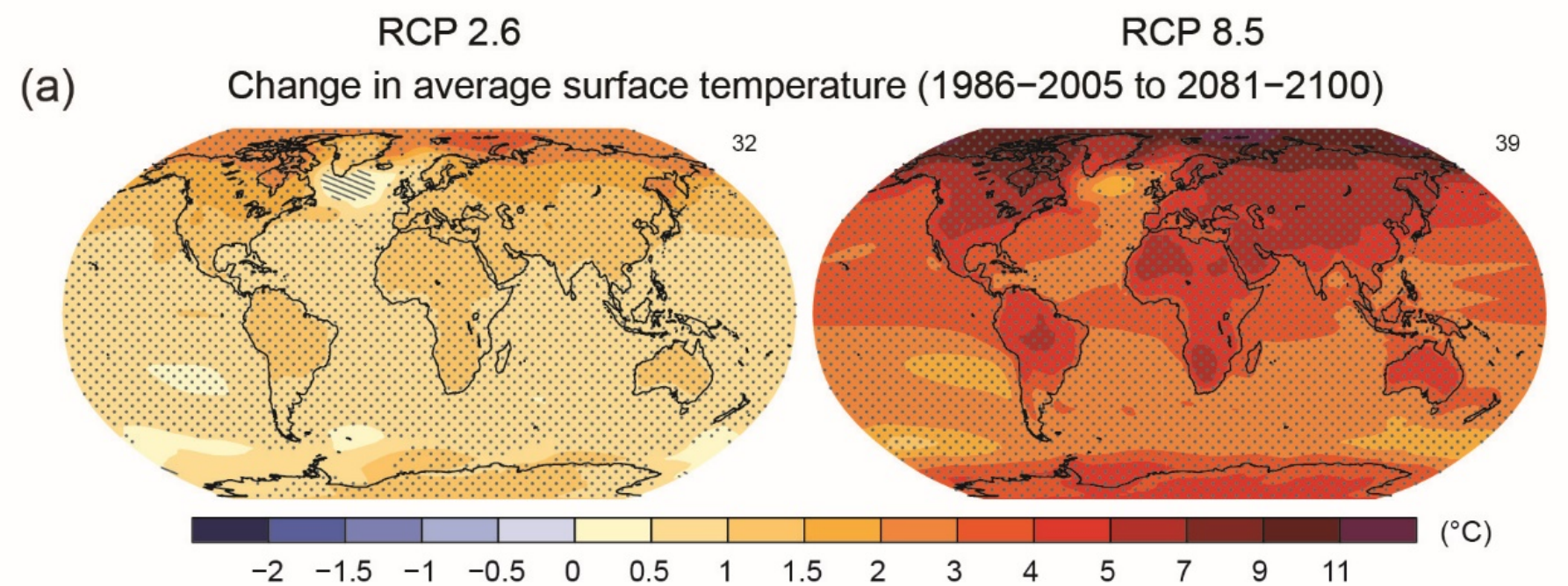


Source: IPCC AR5, Figure 12-09

Uncertainty versus Robustness

- Uncertainty
  - What we don‘t know
  - Communicate some result plus some uncertainty range (model spread)
- Robustness
  - What we know (= positive)
  - Determine which part of the data (i.e. projected signals) is statistically significant

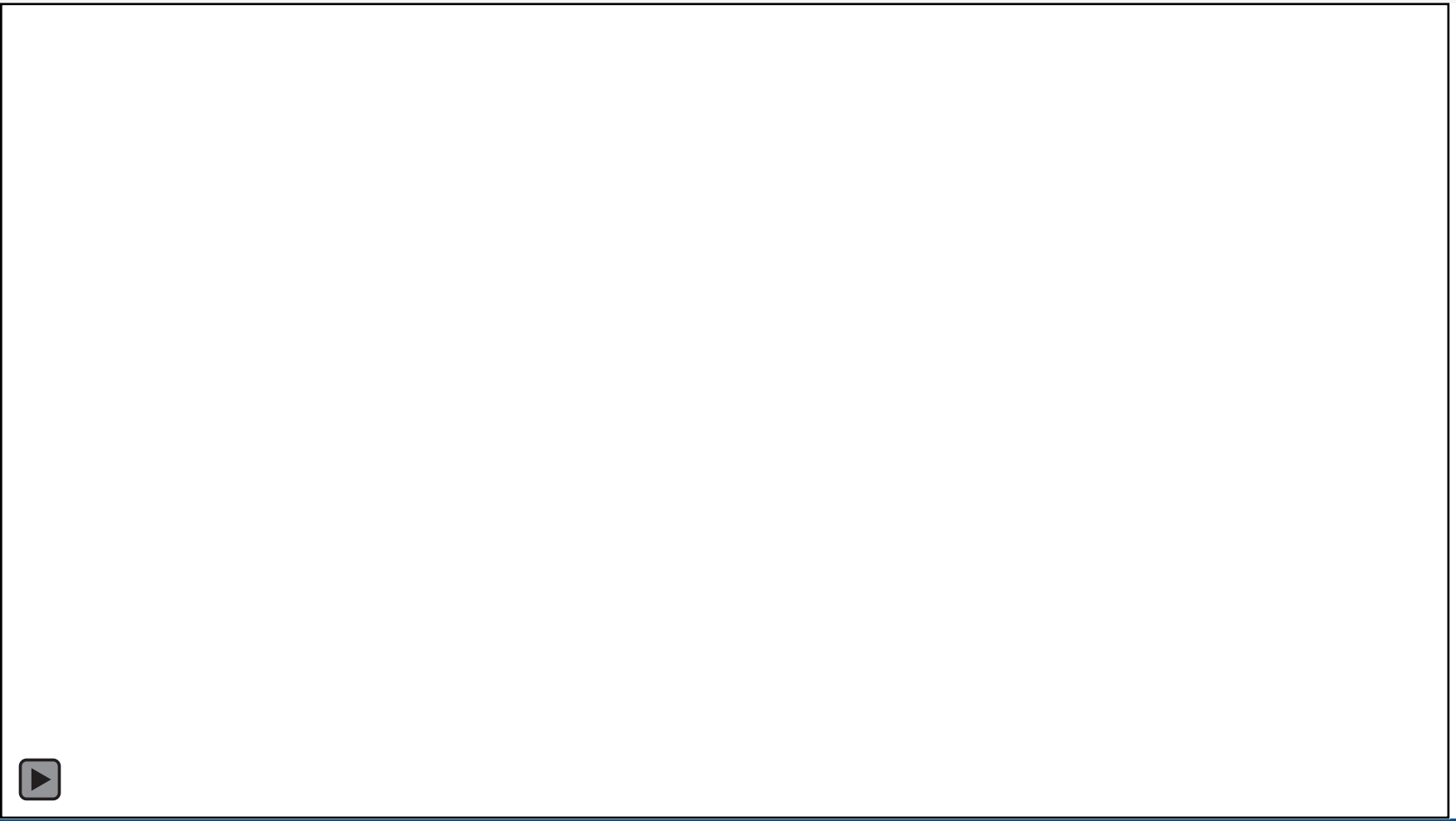
Overlayed Stippling and Hatching indicating Robustness



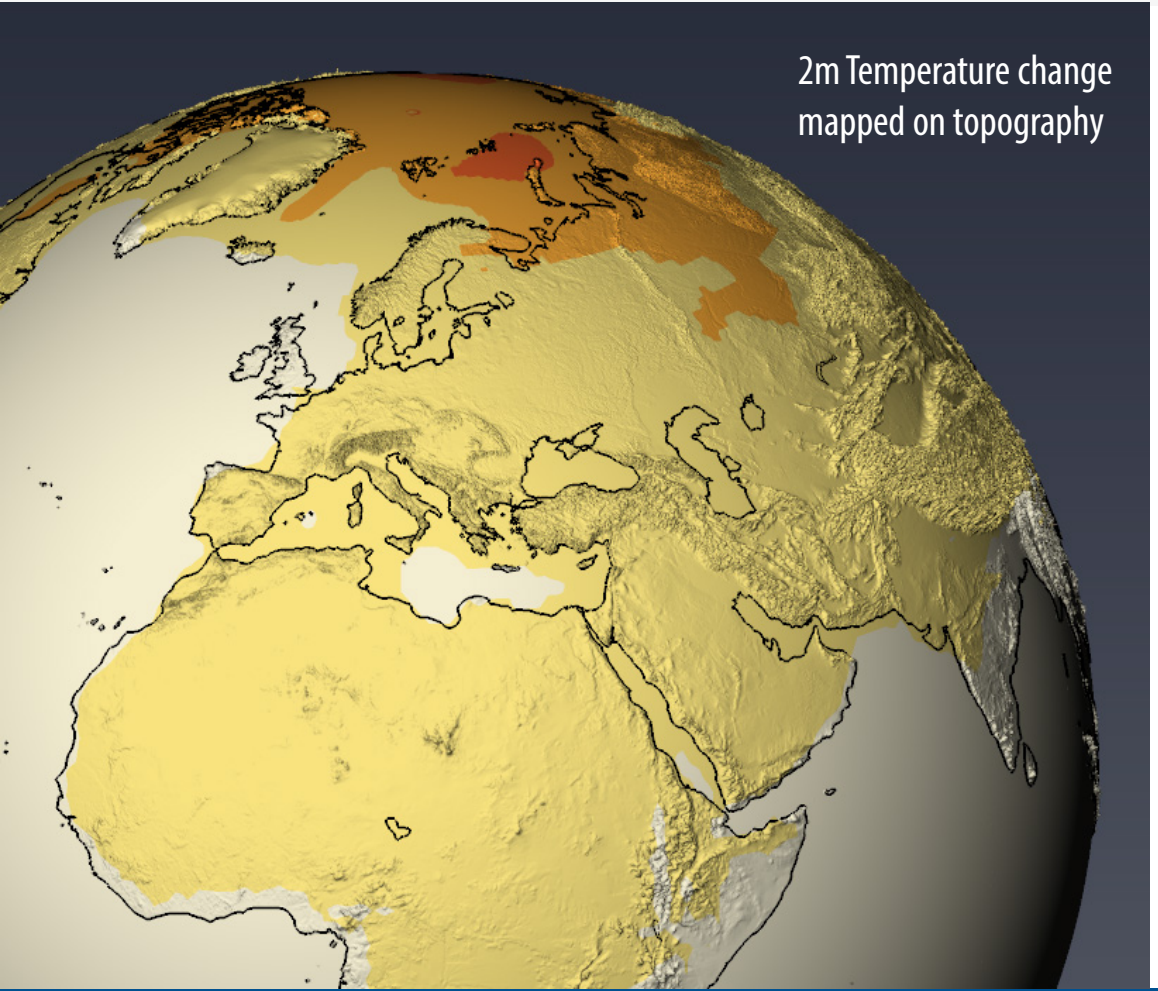
Stippling indicates multi-model mean is more than two standard deviations of natural internal variability in 20-yr means; hatching indicates multi-model mean is less than one standard deviation of natural internal variability in 20-yr means, and where at least 90% of models agree on the sign of change.

Source: IPCC AR5, SPM Figure 8

Animation: Overlayed Stippling indicating Robustness

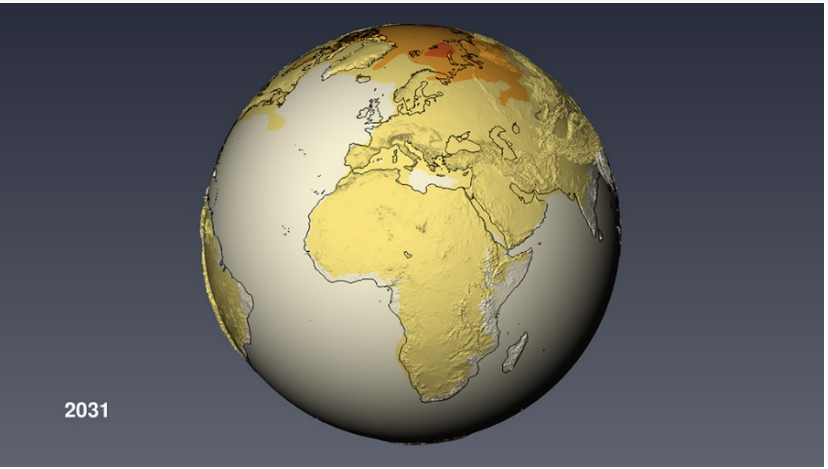


Our Approach I



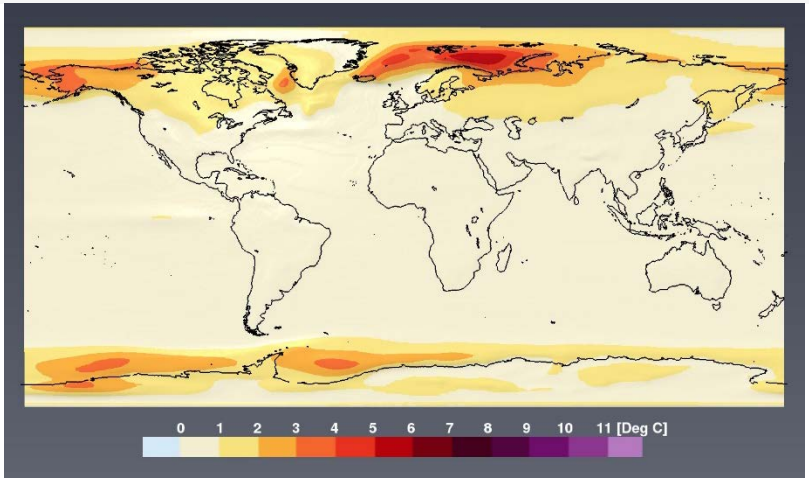
- Data Processing with ESMValTool (Eyring et al., 2016, doi:10.5194/gmd-9-1747-2016)
- Visualization performed with the commercial 3D-Tool „Avizo“ (Climatology Edition).
- Relief shading potentially reveals correlations of the data with topographic features.

Our Approach II – Derive Robustness Mask



2m Temperature change

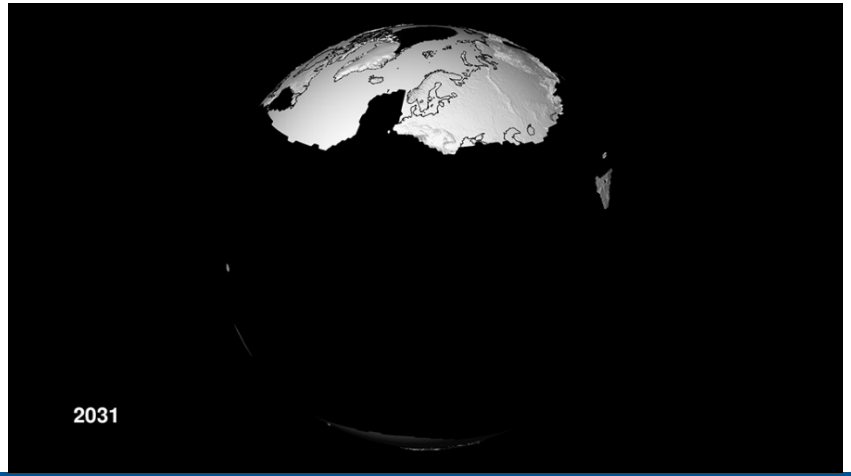
> (2



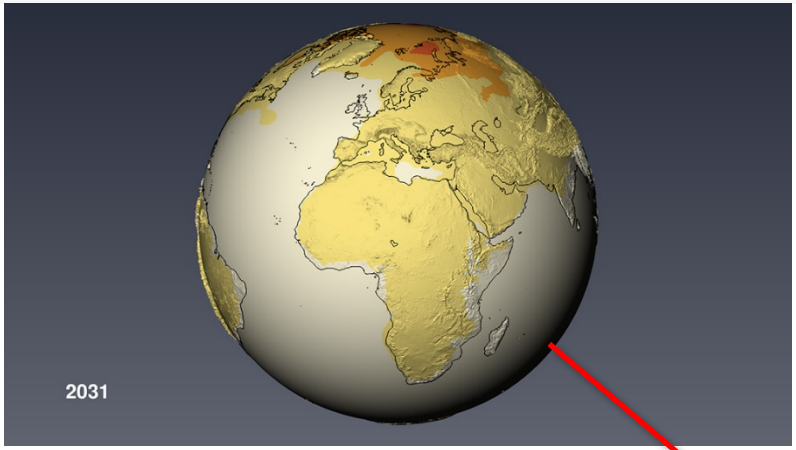
Standard deviation σ
500 years PiControl

)?

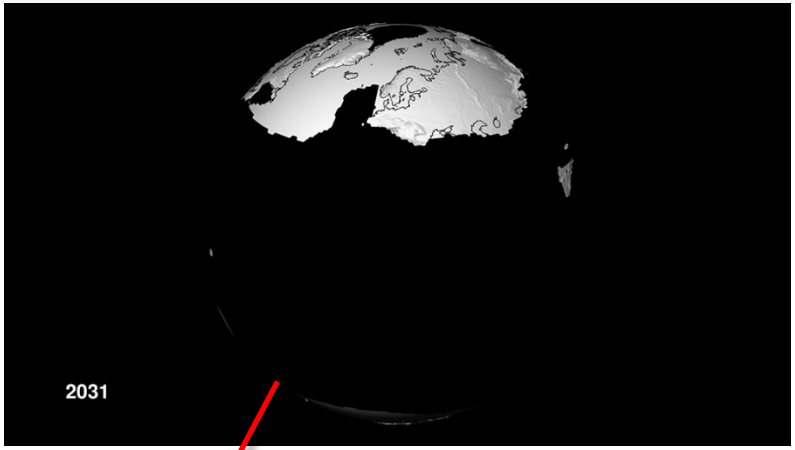
Robustness mask (2 σ)
(black = robust)



Our Approach III – Compositing

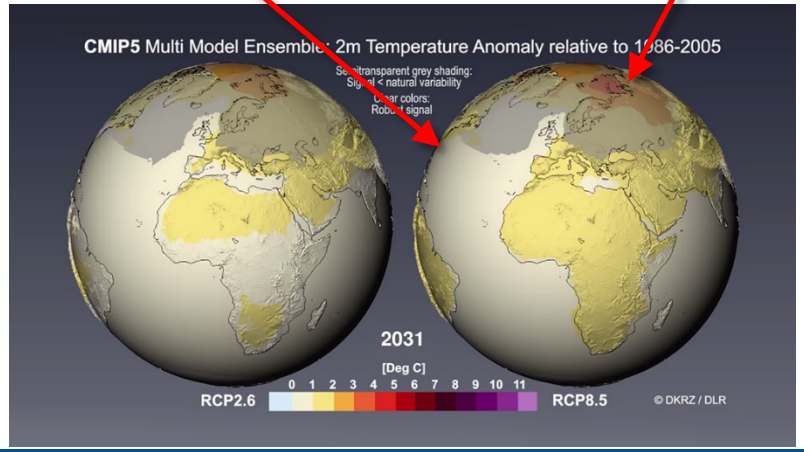


2m Temperature change

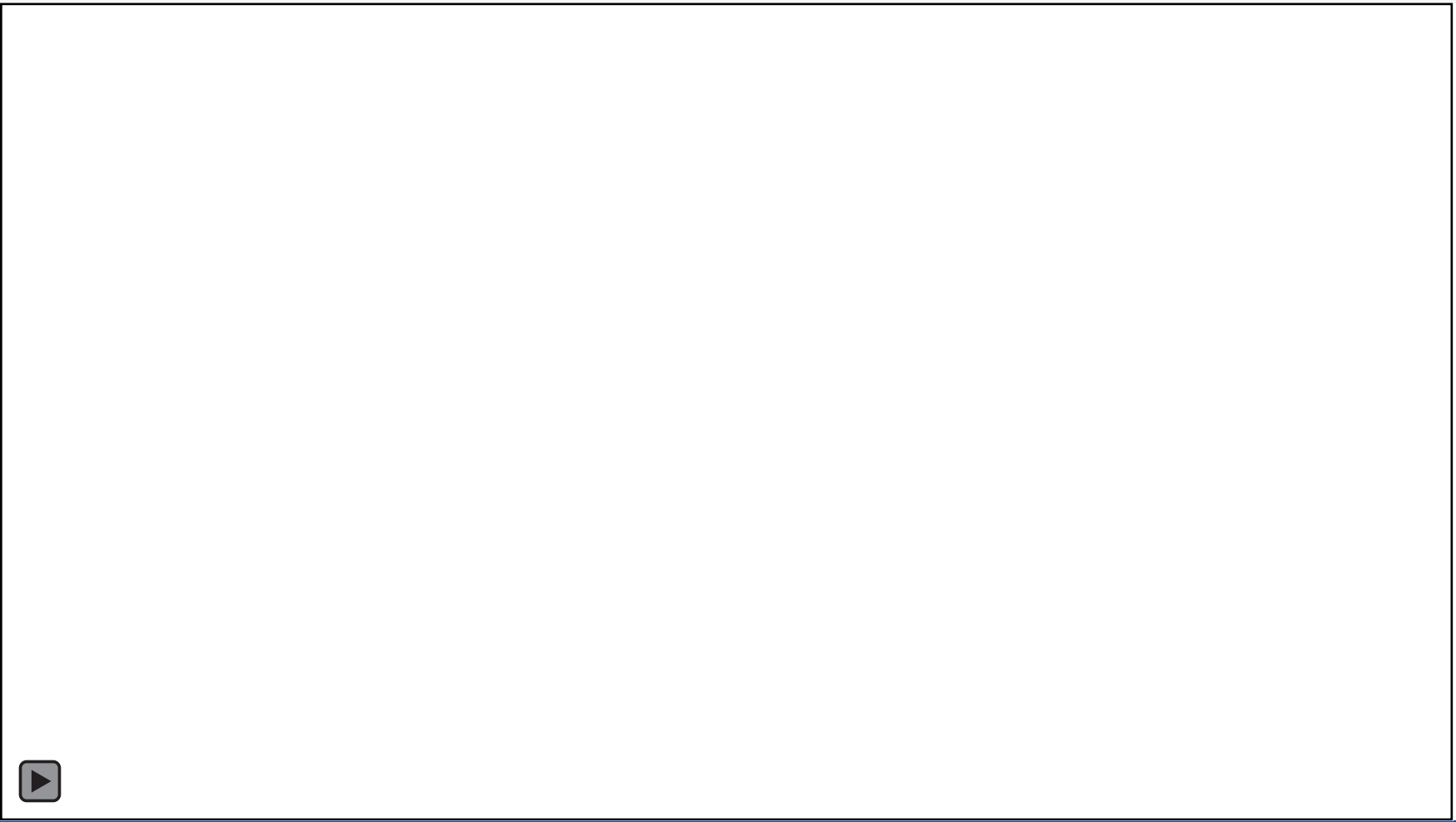


Robustness mask (2 σ)

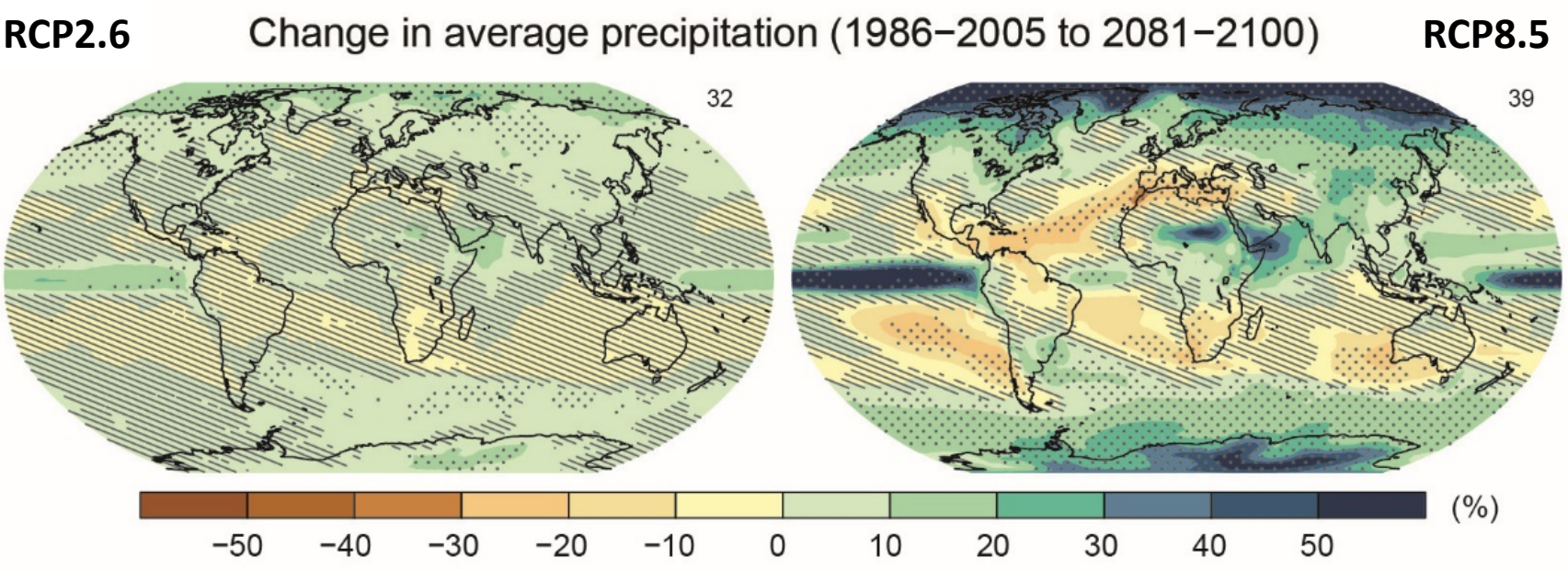
Composite:
2m Temperature change
and robustness



Clear Colors for Robustness, Grey Shading for Uncertainty

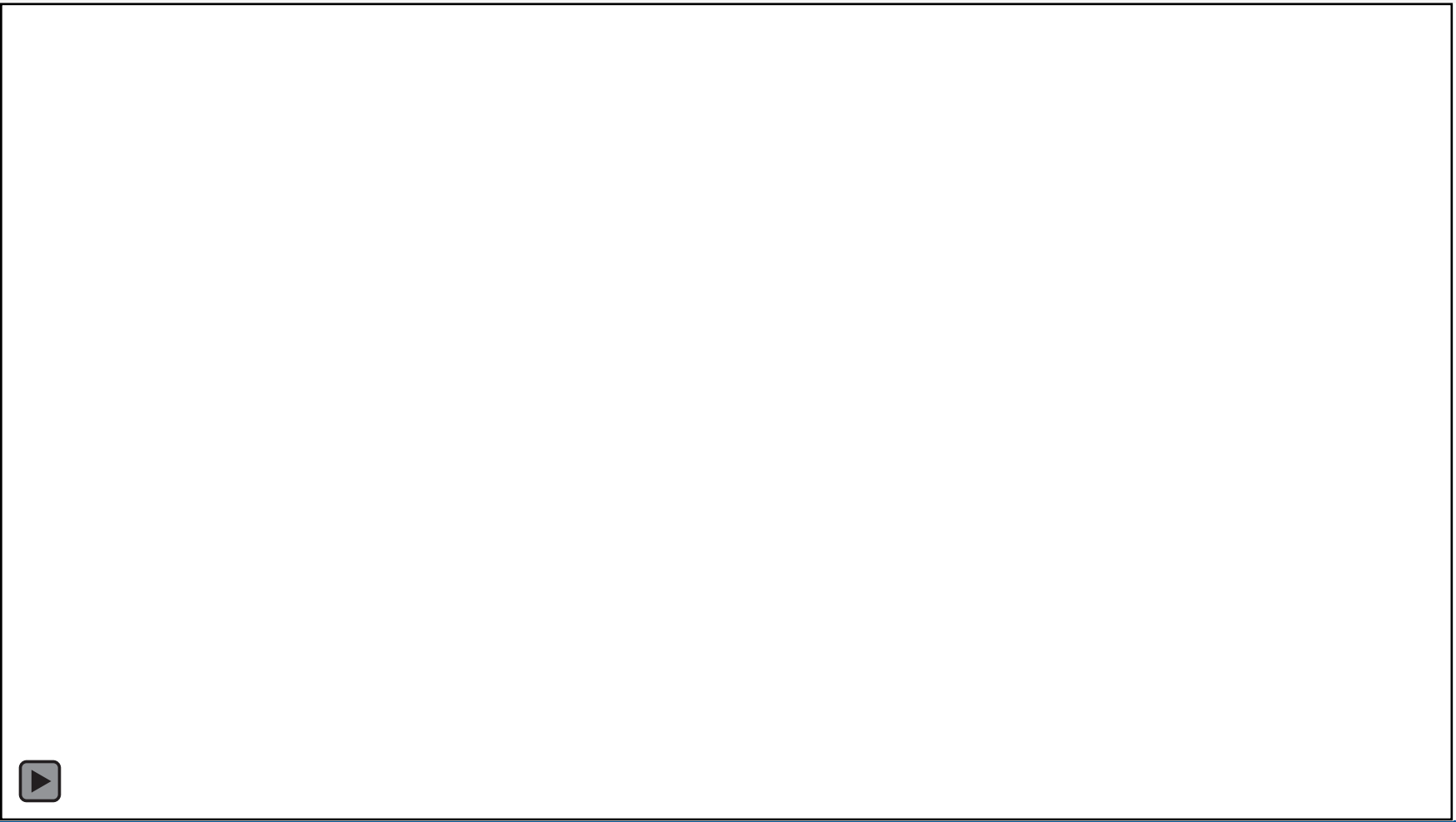


Overlayed Stippling and Hatching to indicate Robustness



Source: IPCC AR5, SPM Figure 8

Clear Colors for Robustness, Grey Shading for Uncertainty



Summary

- In literature, robustness of multi-model ensemble data is visualized using stippling/hatching overlays for presenting uncertainty measures to experts and non-experts.
- -> Stippling/hatching is not well suited for animations.
- - > Overlaying additional information on the robust part of the visualization might distract the perception of this (probably) more important part.
- We propose annotating the uncertain range instead of the robust range for communicating multi-model results to the public.
- -> Overlay of robustness-information by semi-transparent grey-shading is better suited for animations of uncertainty measures.
- The visualizations shown will be used within a video produced by WMO for communication to the public.