Visualization of uncertainty in climate projections imposed by volcanic activity

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Background: Simulations by Uni Research Climate

- Ensemble simulations with NorESM carried out to estimate impact of potential volcanic futures on climate developments according to RCP4.5
- Ensemble dimension: Varying volcanic forcing
- Model and experiments described in

Ingo Bethke, Stephen Outten, Odd Helge Otterå, Ed Hawkins, Sebastian Wagner, Michael Sigl & Peter Thorne: Potential volcanic impacts on future climate variability, Nature Climate Change volume 7, pages 799–805 (2017), doi:10.1038/nclimate3394

Source of uncertainty

- Internal climate variability
- Model uncertainty:
  - representation of processes
  - climate sensitivity
- Scenario uncertainty (here: only RCP4.5 used)
- Unknown volcanic activity (space, time, magnitude)



Ensemble forcing – uncertainty in volcanic futures

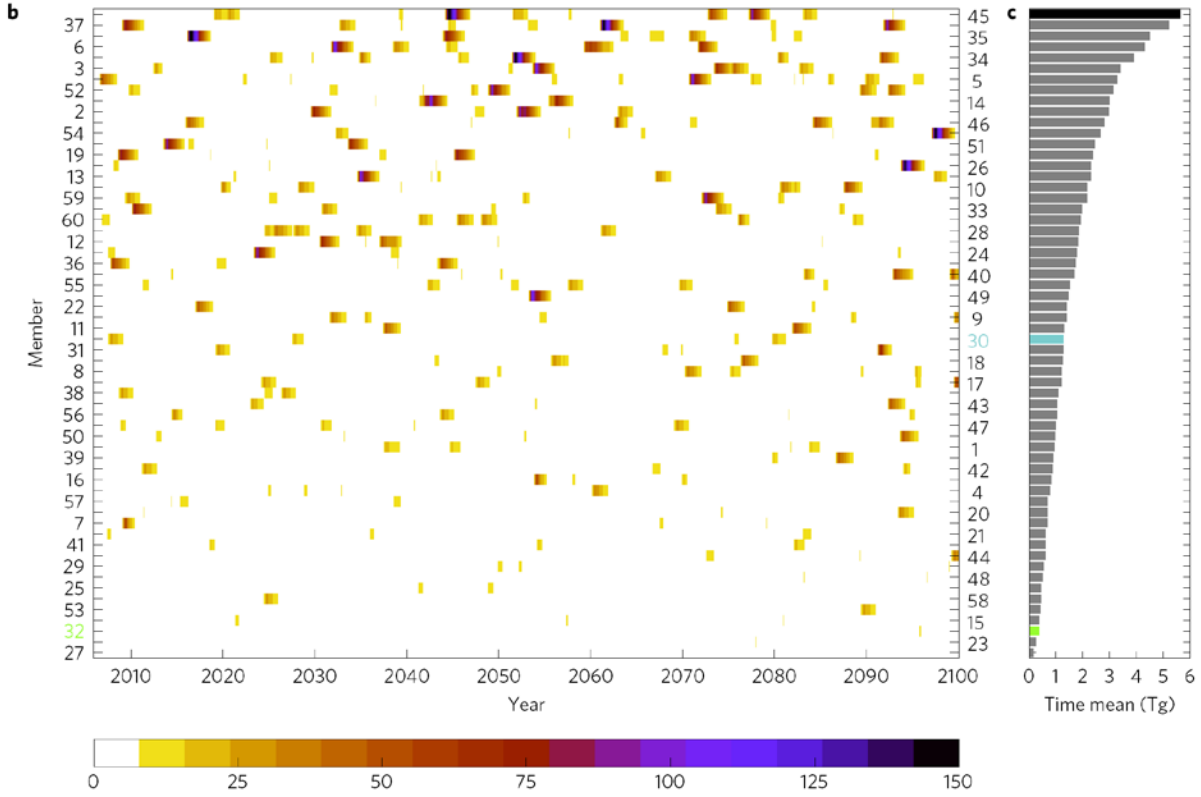

Figure 1 | Historical and plausible future volcanic forcing.
b,**c**, Stratospheric aerosol loading time series (**b**) and their century means for all simulation members (**c**). Members are ranked according to their time-mean loadings. Colour marked realizations correspond to the three realizations displayed in **a**.

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

Sources of uncertainty:

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

RCP4.5 Temperature change - global mean

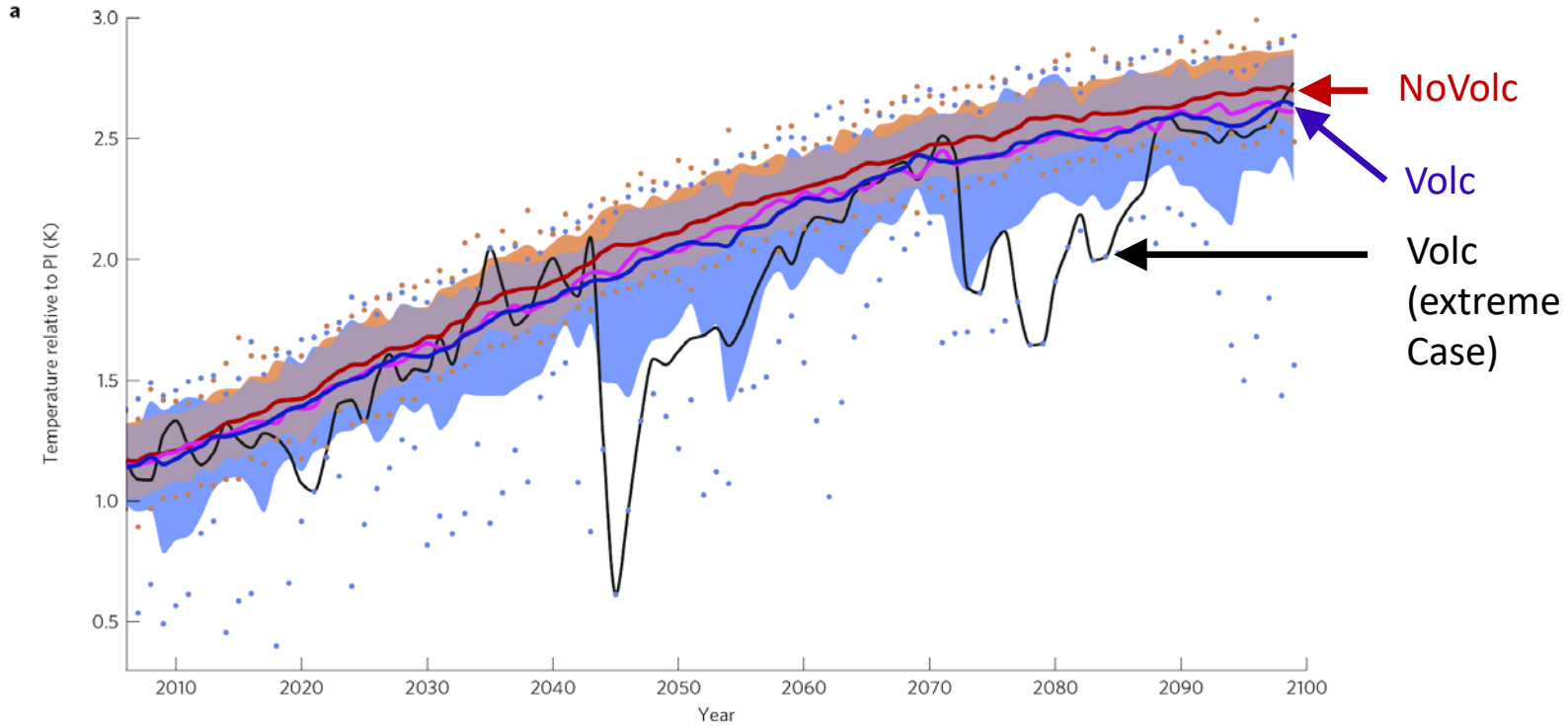
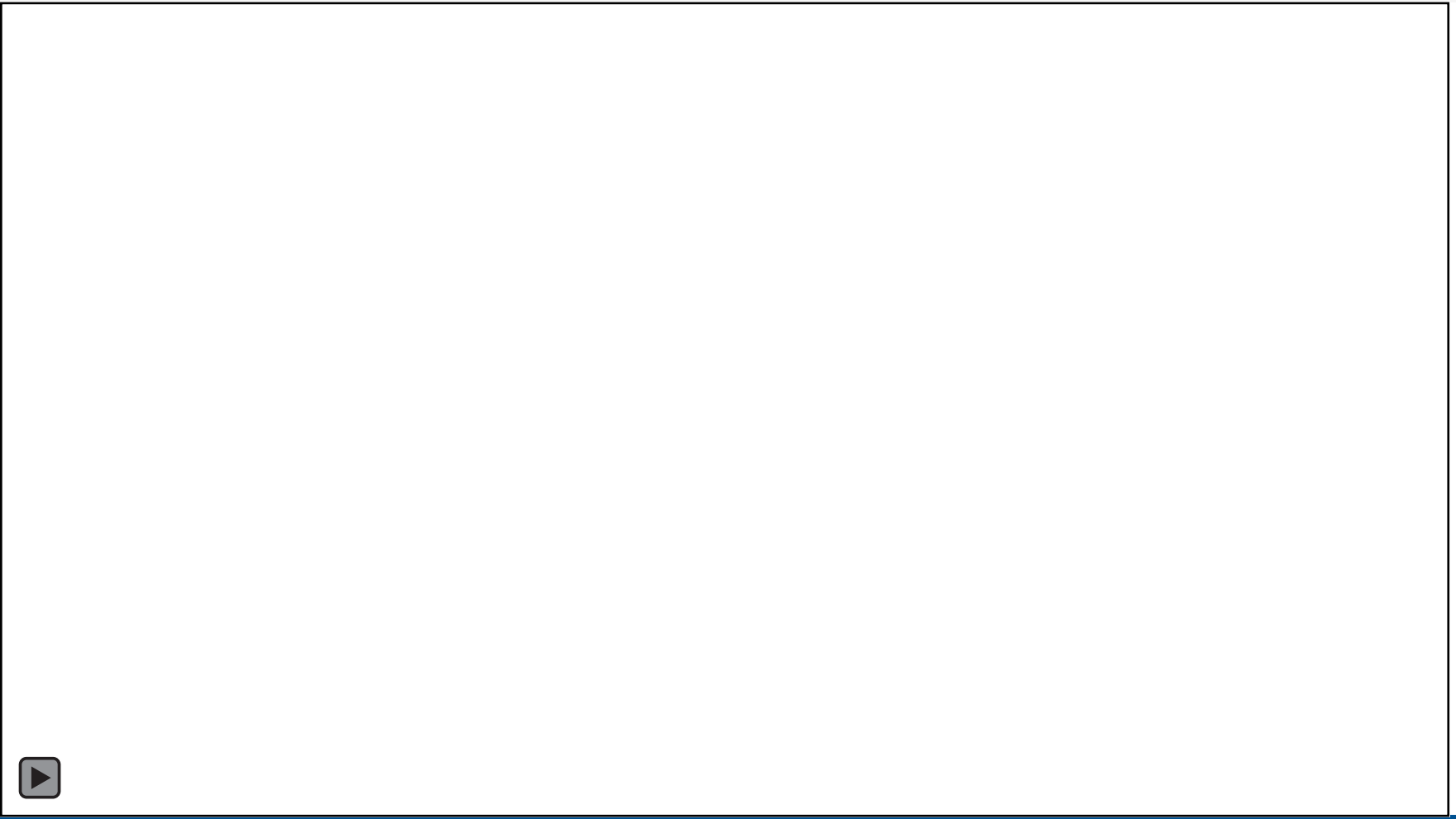


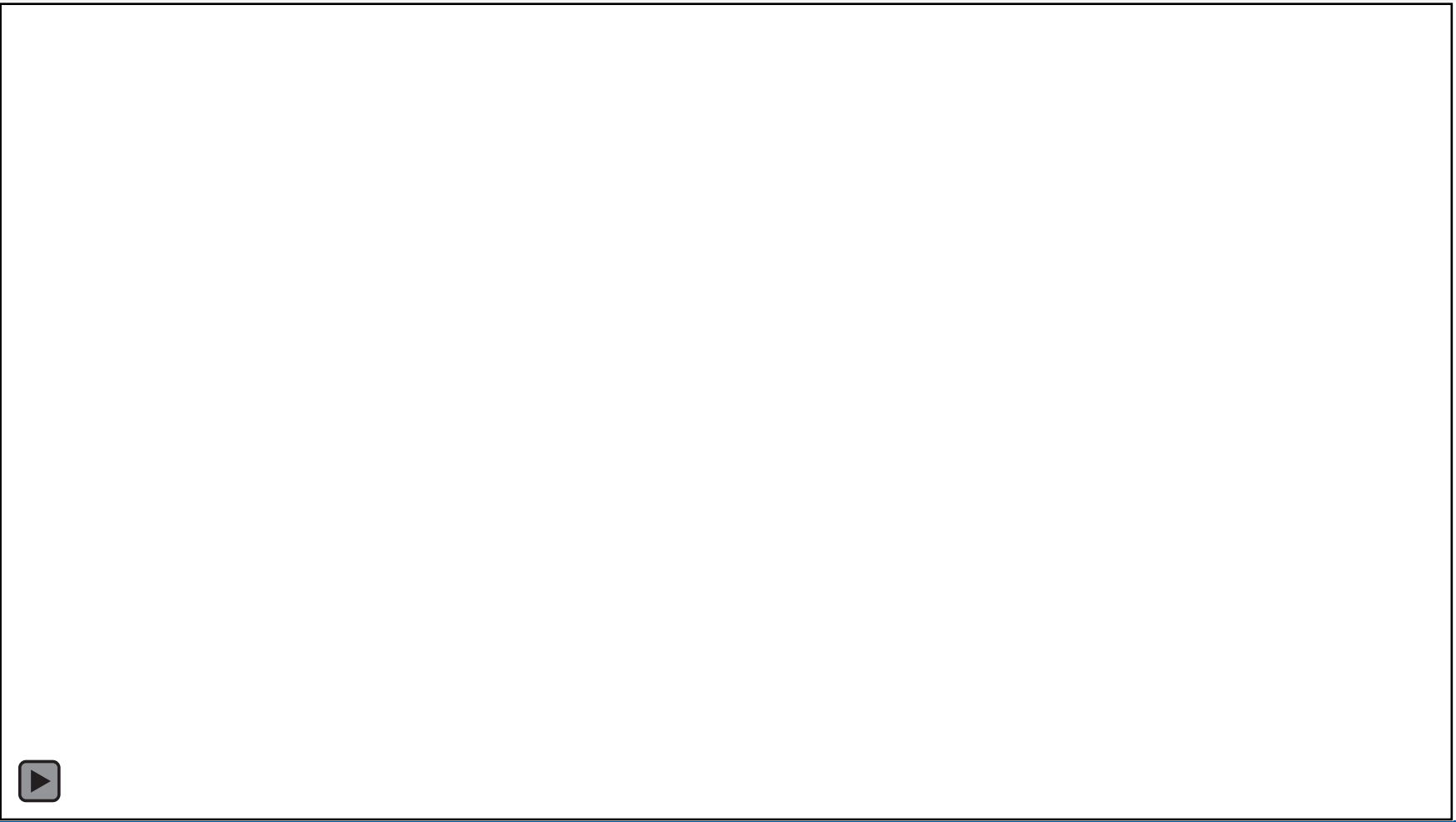
Figure 2 | Annual-mean GMST. a, Ensemble mean (solid) of VOLC (blue), VOLC-CONST (magenta) and NO-VOLC (red/orange) with 5–95% range (shading) and ensemble minima/maxima (dots) for VOLC and NO-VOLC; evolution of the most extreme member (black).

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

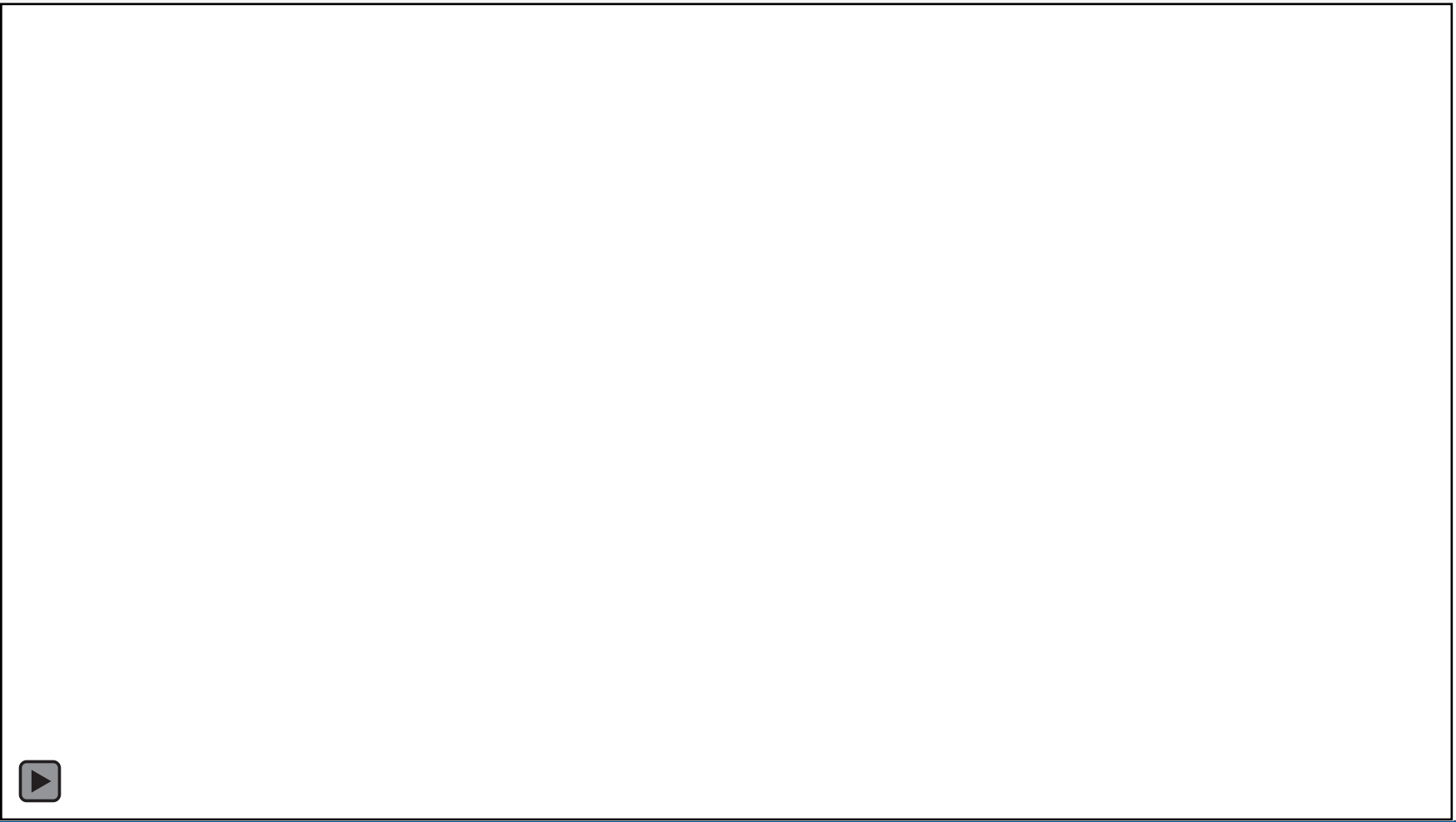
Impact on warming pattern – most extreme realizations



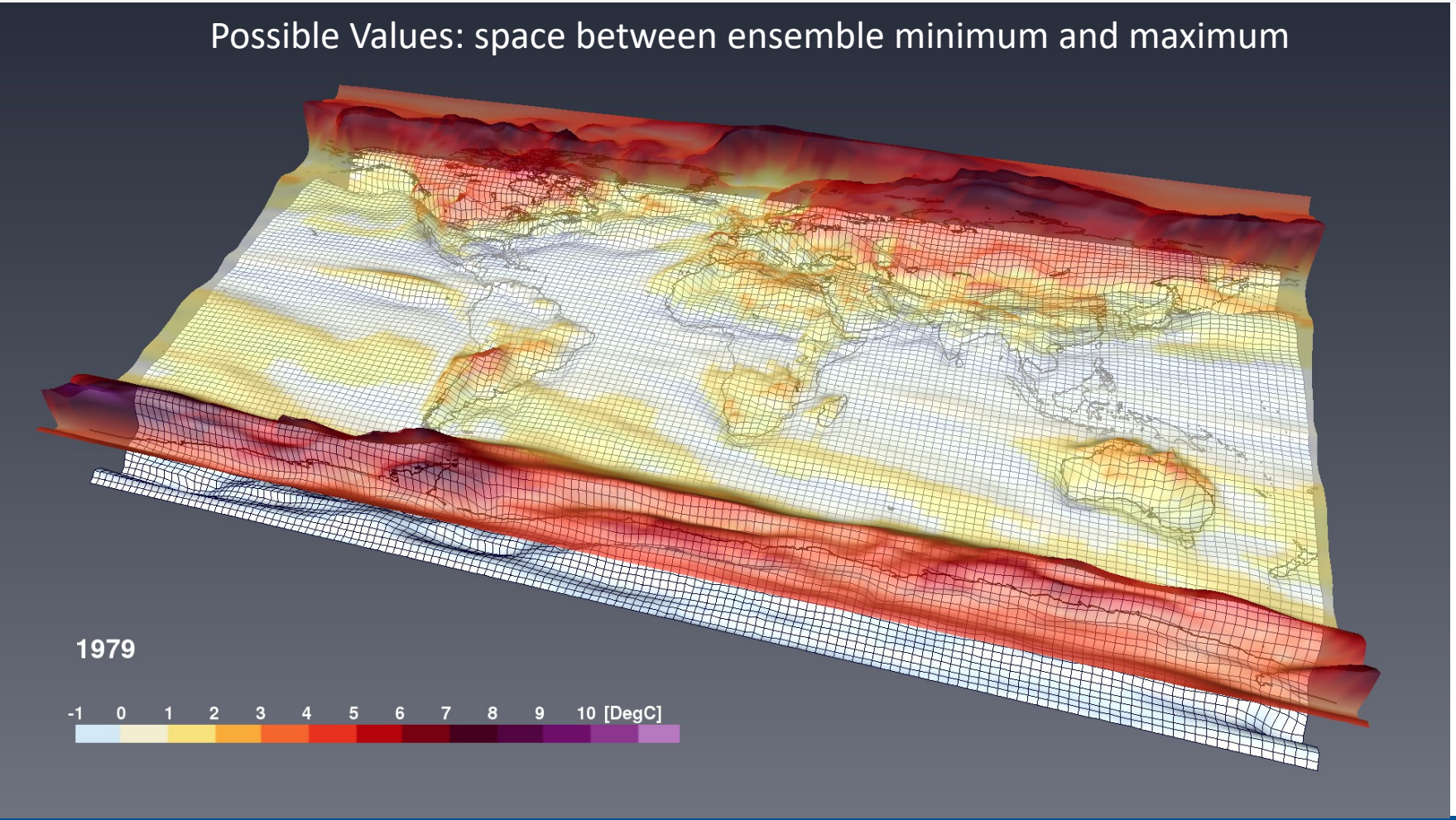
Relative impact of volcanism on **ensemble mean**



Relative impact of volcanism on **ensemble minimum**



Uncertainty range for temperature anomaly



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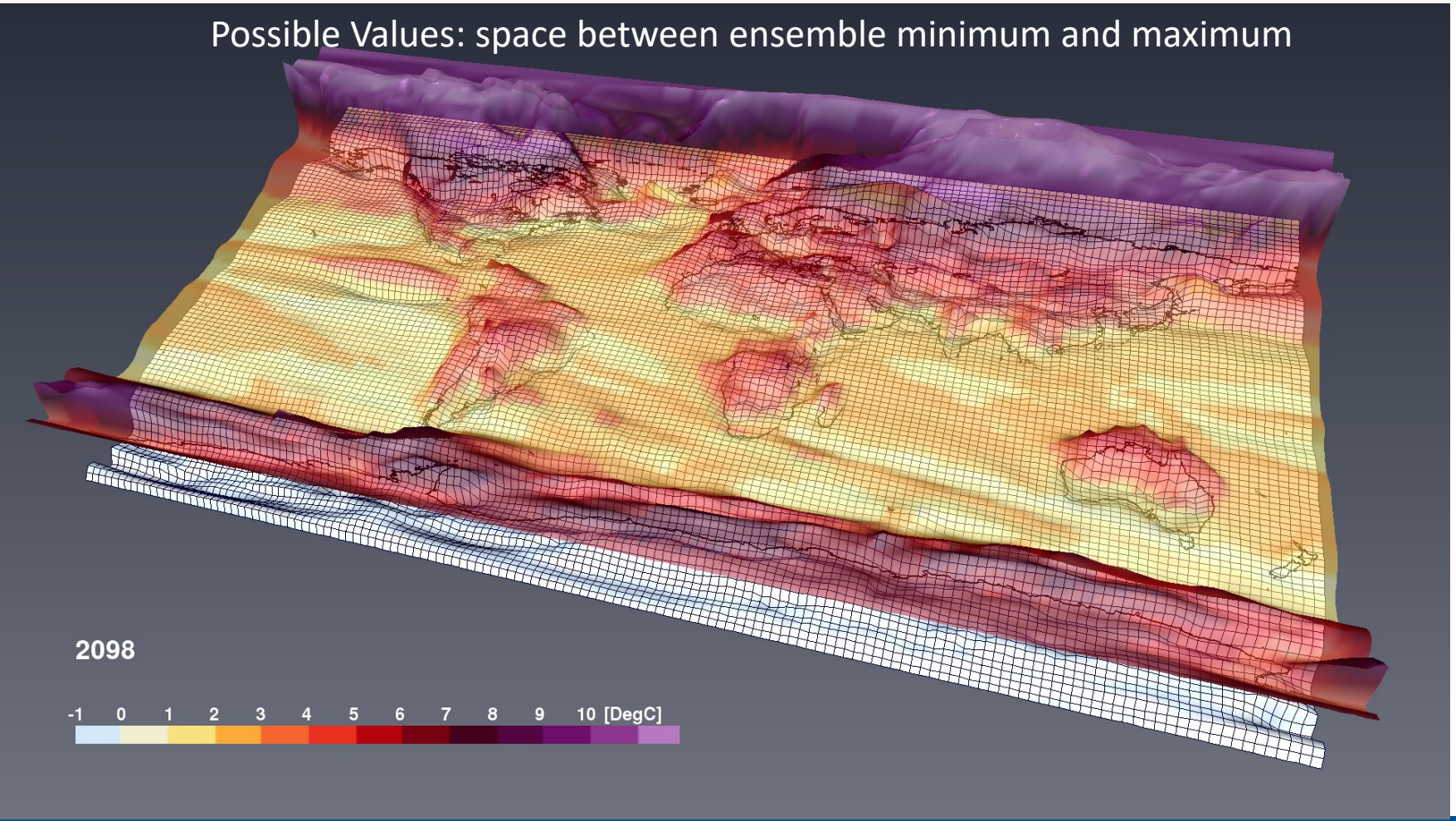
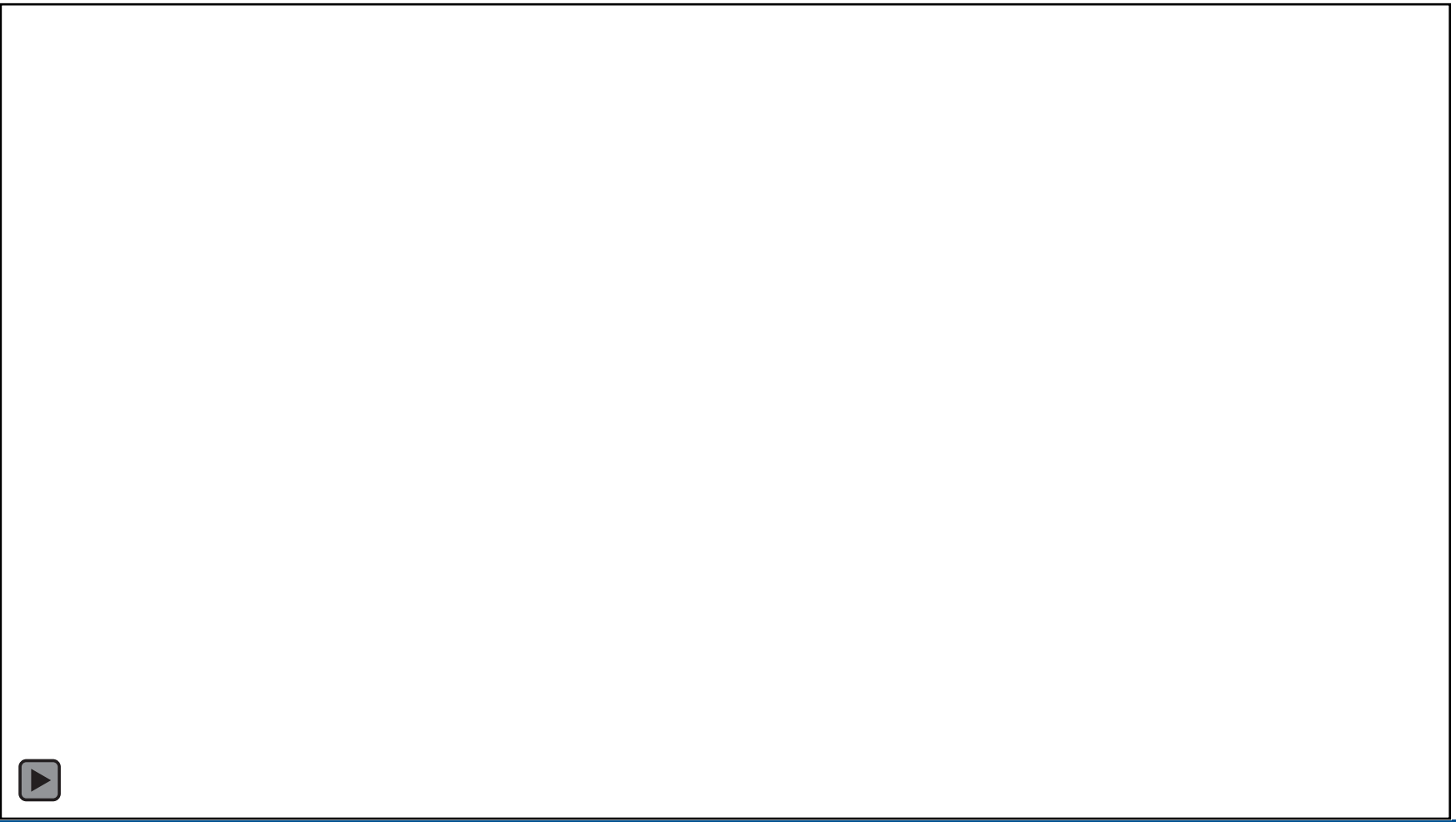
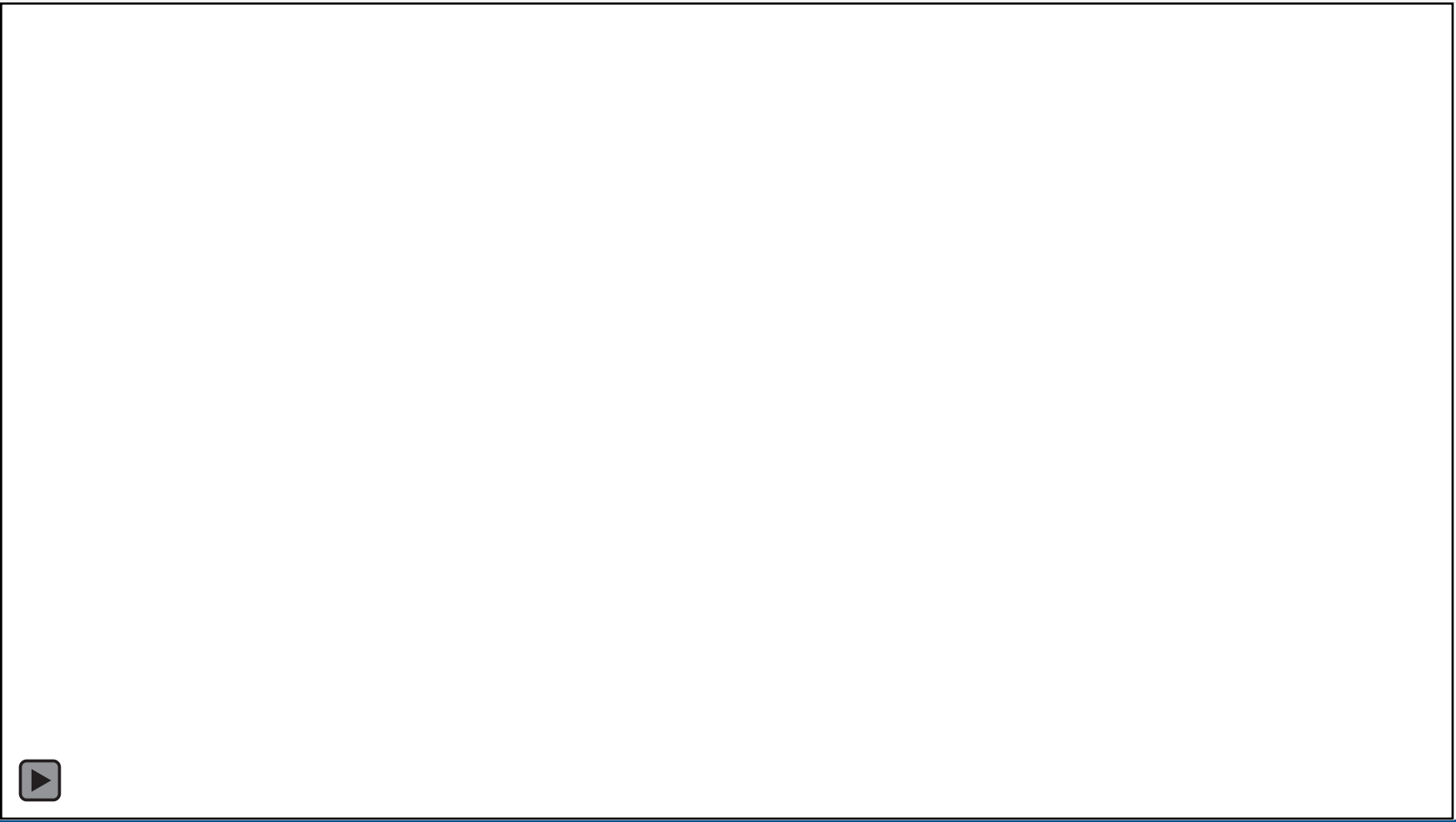


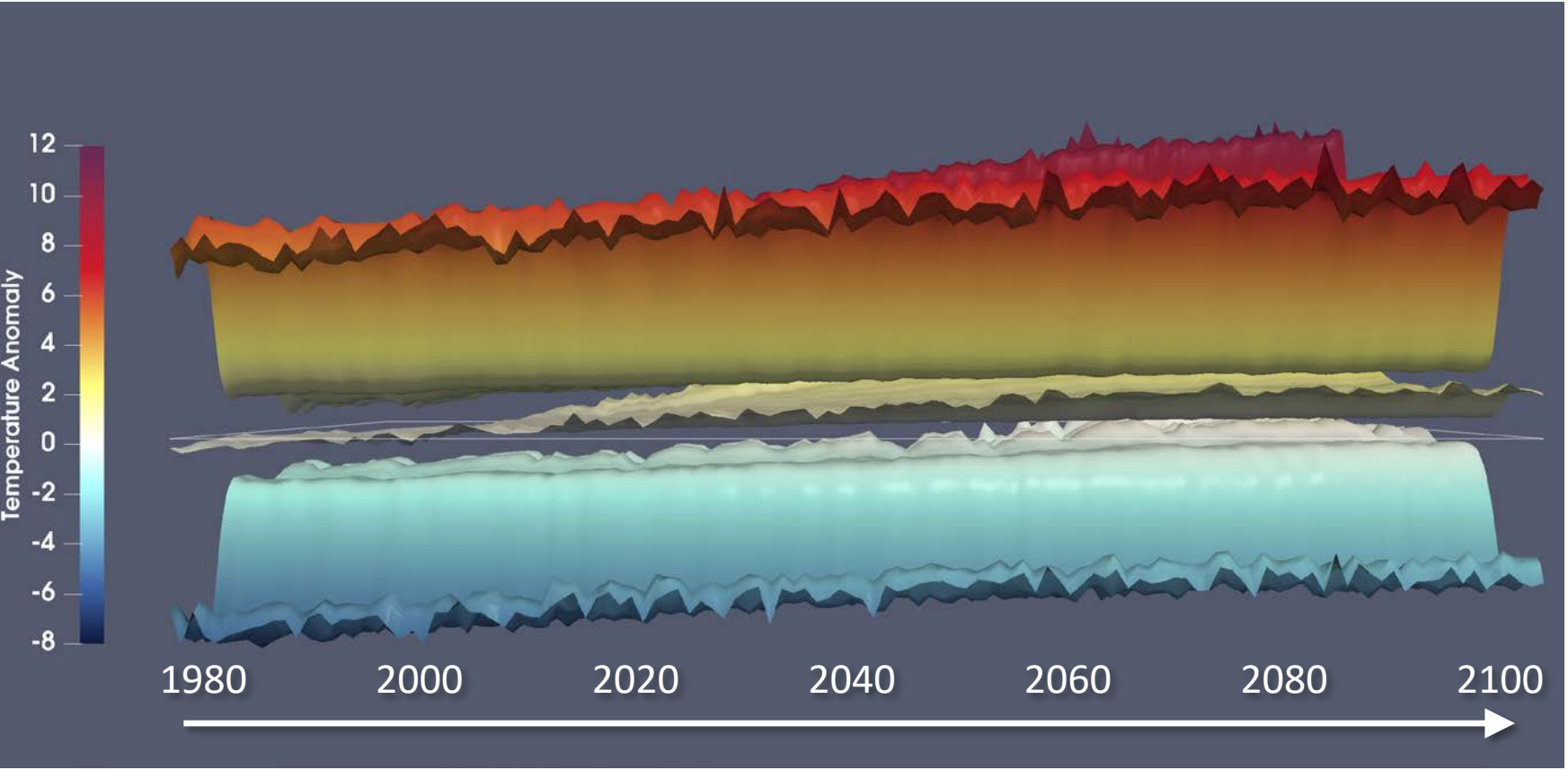
Development of ensemble mean, minimum and maximum



Development of ensemble minimum and maximum



3D Hovmoeller Diagram: temporal evolution of zonal means



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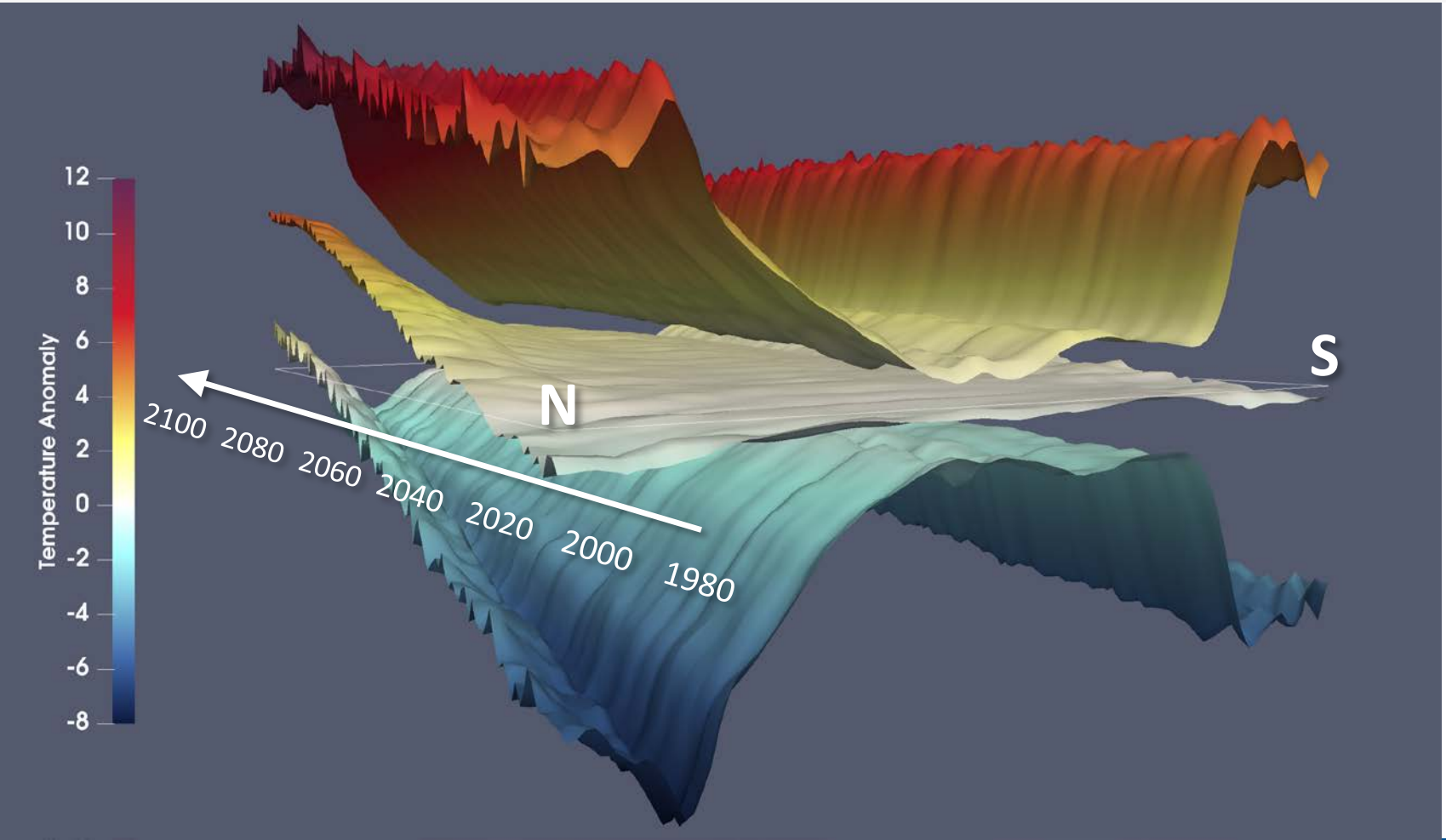
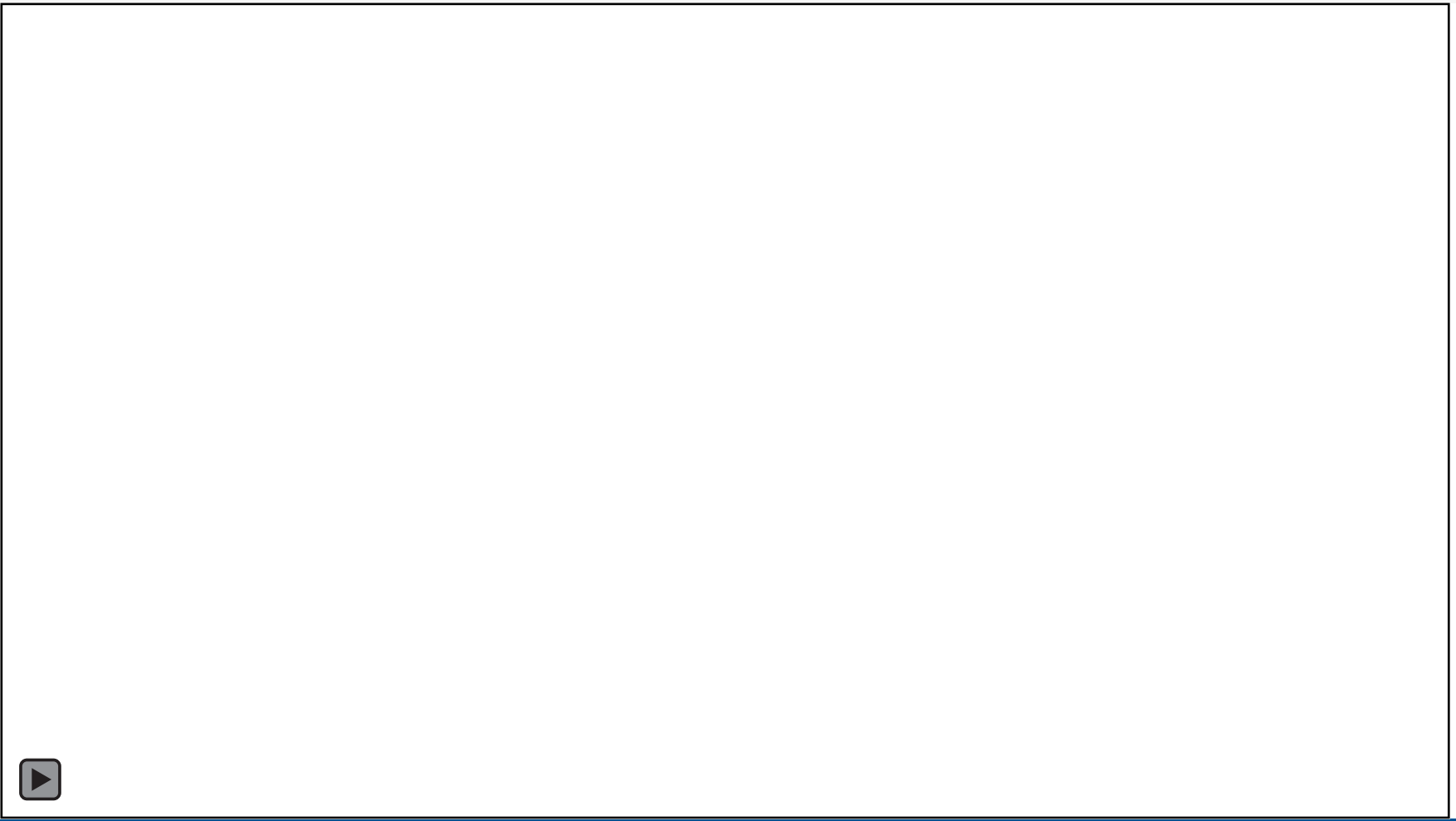


Animated 3D Hovmoeller Diagram



Summary

Using NorESM RCP4.5 ensemble simulations from Bethke et al. 2017, we

- visualized spatio-temporal RCP4.5 temperature changes for the most extreme volcanic futures in comparison,
- visualized the isolated spatio-temporal impact of volcanism on the 2m temperature by subtracting the temperature change data of the no-volcanism case to that of the volcanism case,
- visualized the spatio-temporal uncertainty space imposed by possible future volcanic activity at the presence of global warming according to RCP4.5.
- By developing a joint static 3D hovmoeller representation of ensemble minimum, maximum and mean, zonal mean changes in ensemble statistics could be evaluated.

