# Balanced subsampling of future regional climate ensembles of opportunity

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GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD
CGL2016-79210-R
MULTI-SDM
CGL2015-66583-R
co-funded by FEDER/ERDF European Union funds

# Background

The **EURO-CORDEX** Regional Climate Model (RCM) simulation ensemble is an **ensemble of opportunity**, in the sense that its GCM-RCM combination matrix was filled with no strong constraint in the GCMs used as boundary conditions or in the number of contributing members per RCM.

Fernández et al. (2019) found in this ensemble a strong influence of the driving GCM on the regional climate change signal, along with favored GCMs.

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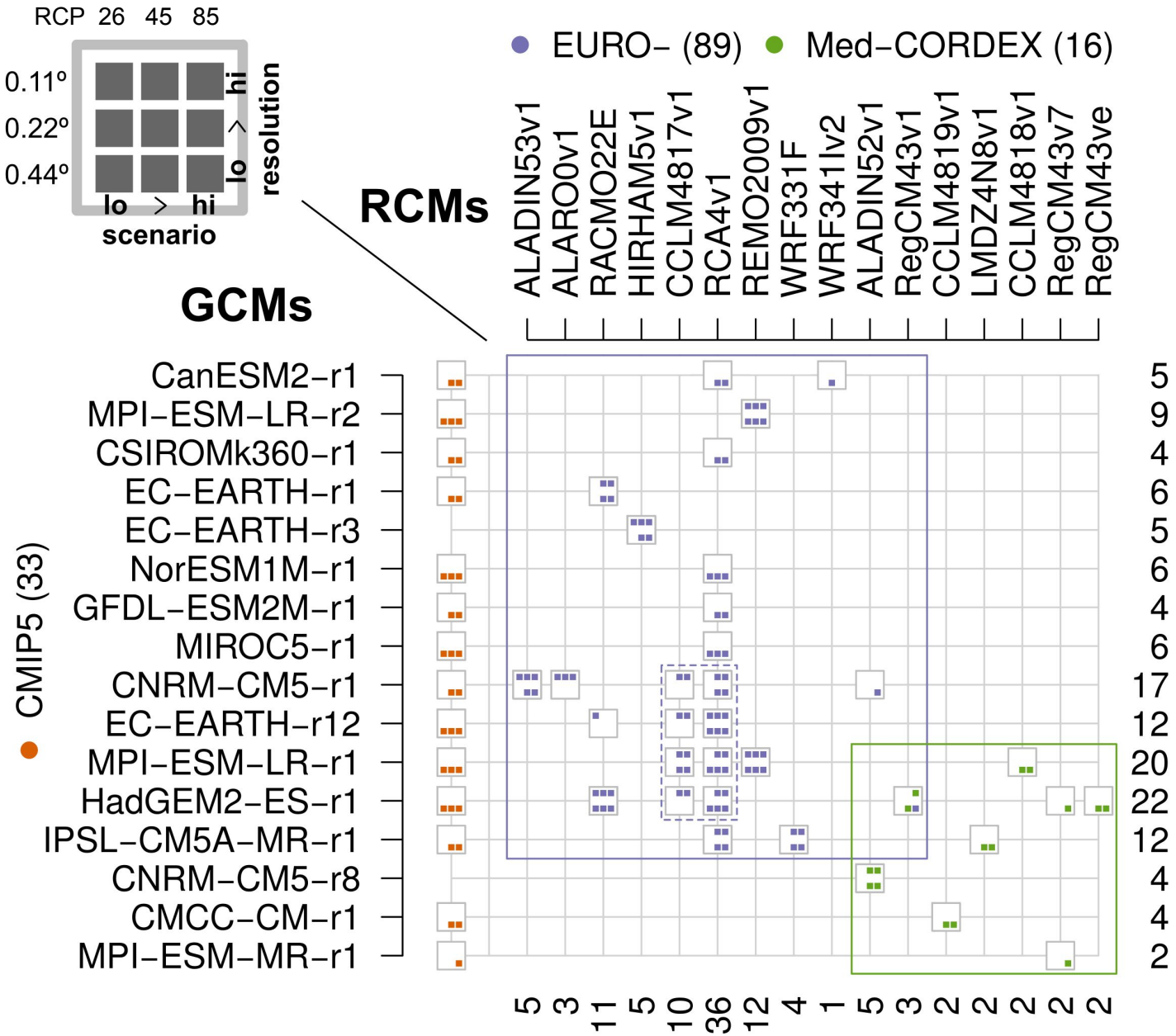
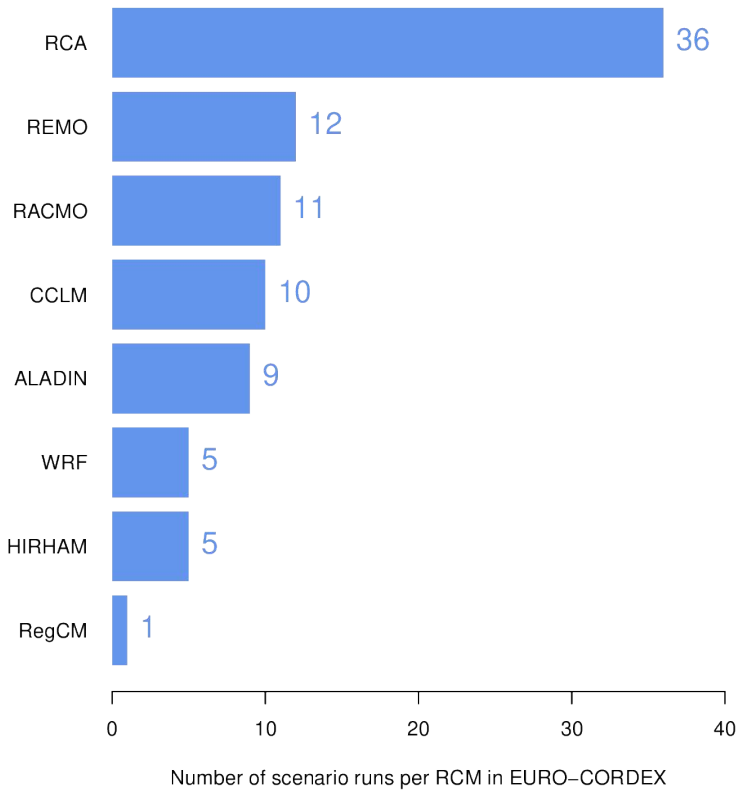
# EURO-CORDEX GCM-RCM matrix




Large number of available projections (89, as of April 2018) but strong imbalance among RCMs and among downscaled GCMs.

**Source:** adapted from Fernández et al. (2019) https://doi.org/10.1007/s00382-018-4181-8

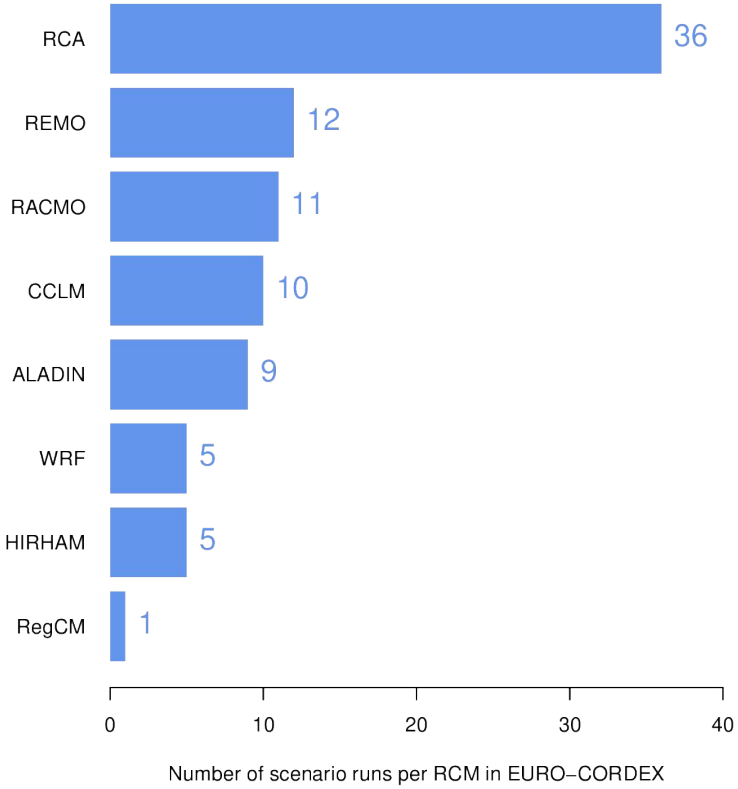
# Number of projections

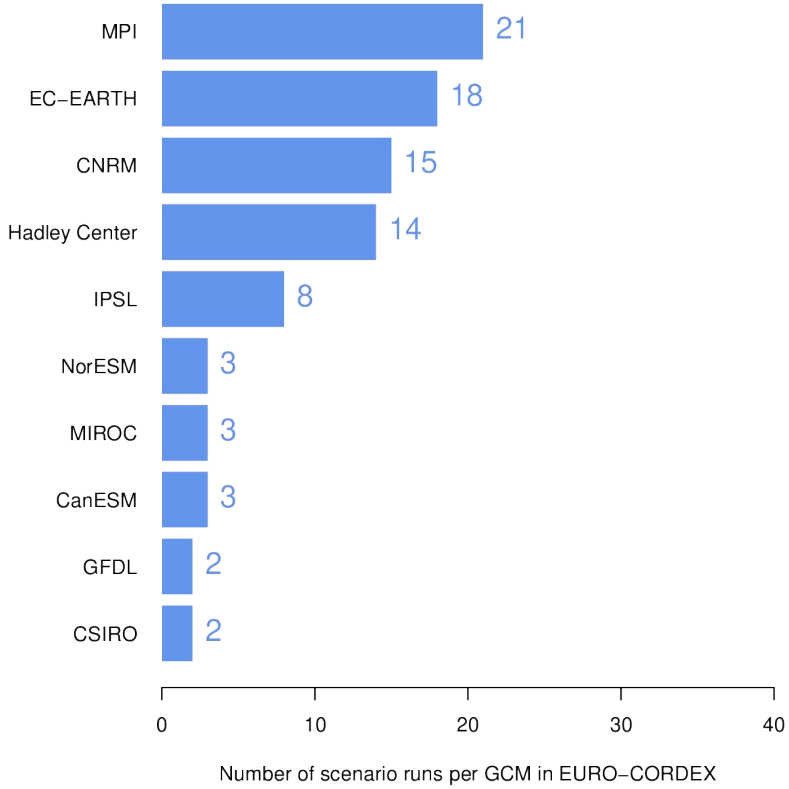



Strong imbalance in the number of contributed runs.

E.g. the RCA model from SMHI contributed 3 times as many simulations as the second (REMO).

# Number of projections

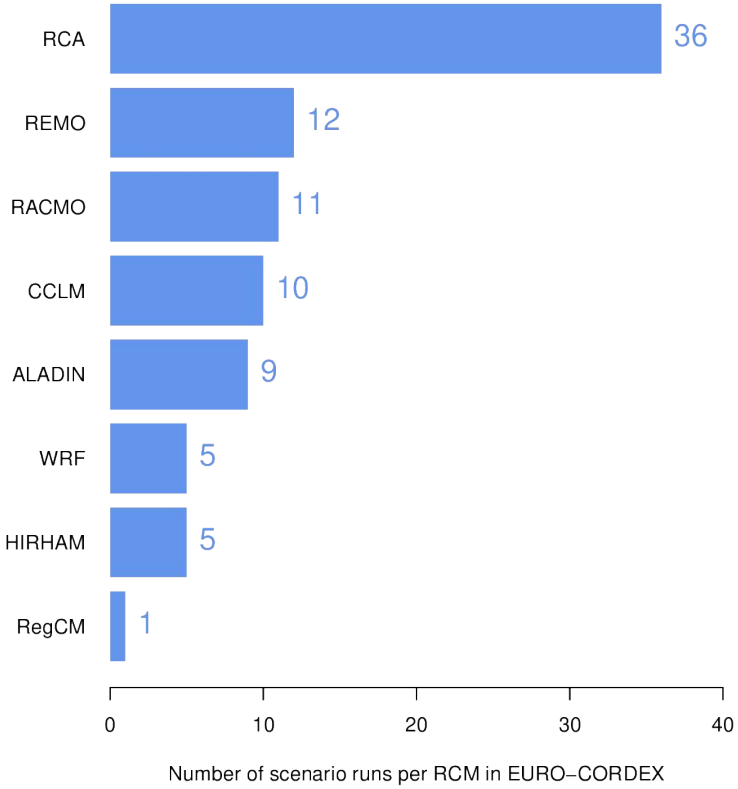


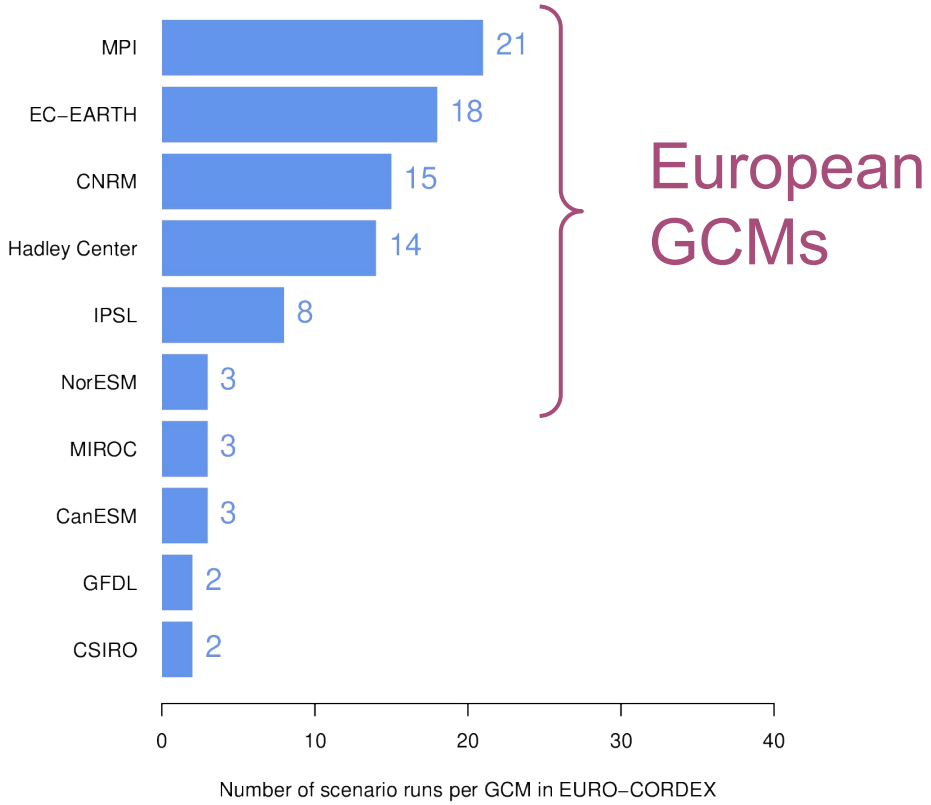




There are also “preferred” driving GCMs.

85% of the simulations nested into half (5) of the GCMs used.

# Number of projections

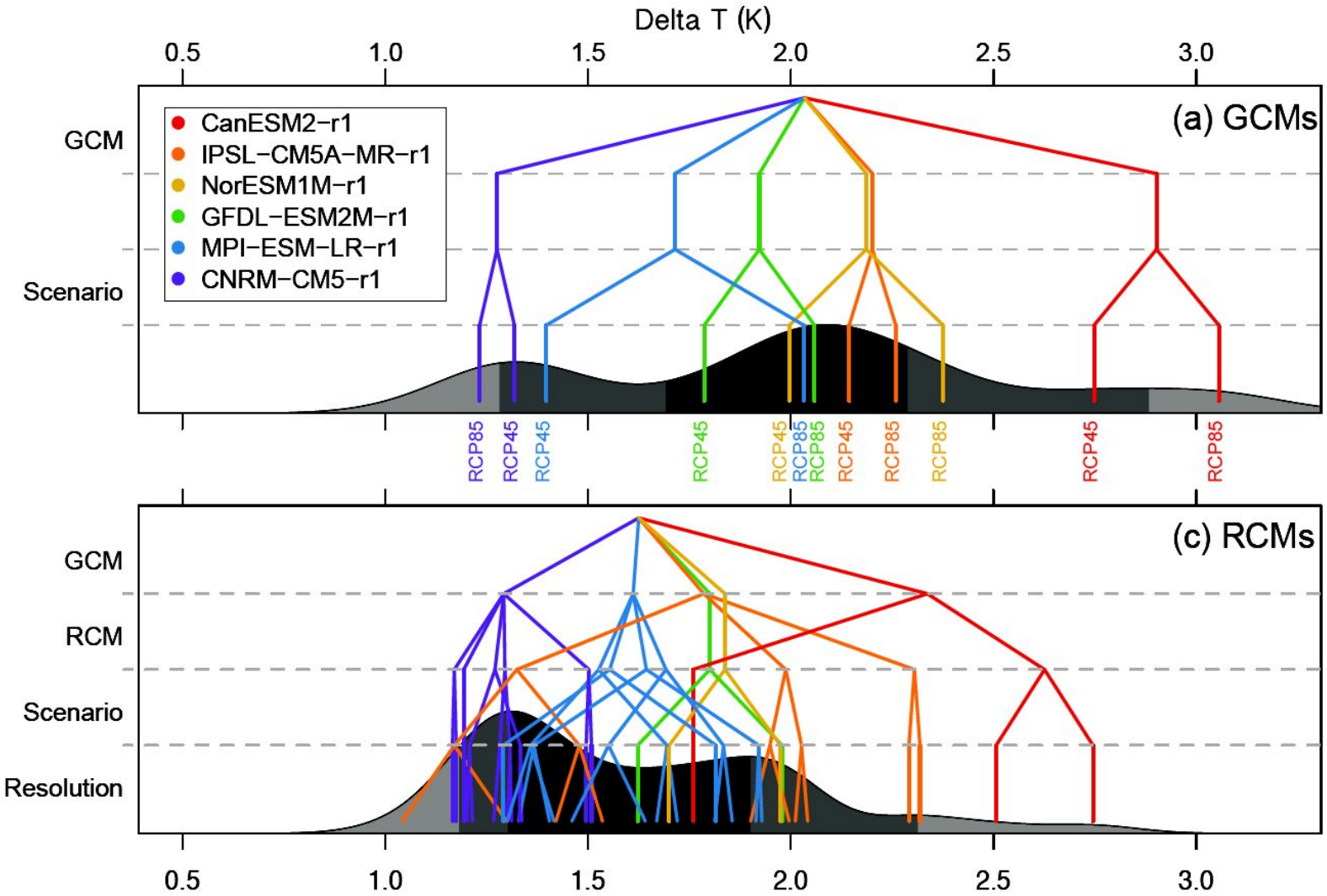



There are also “preferred” driving GCMs.

85% of the simulations nested into half (5) of the GCMs used.
89% of the simulations nested into European GCMs

# Effect of preferred GCMs




**Source:** adapted from Fernández et al. (2017) http://www.clivar.org/documents/exchanges-73

Some of the most downscaled GCMs show the smallest projected delta changes and these small deltas are inherited by the RCMs, potentially leading to an artificial shift in downscaled delta changes (Fernández et al., 2019).

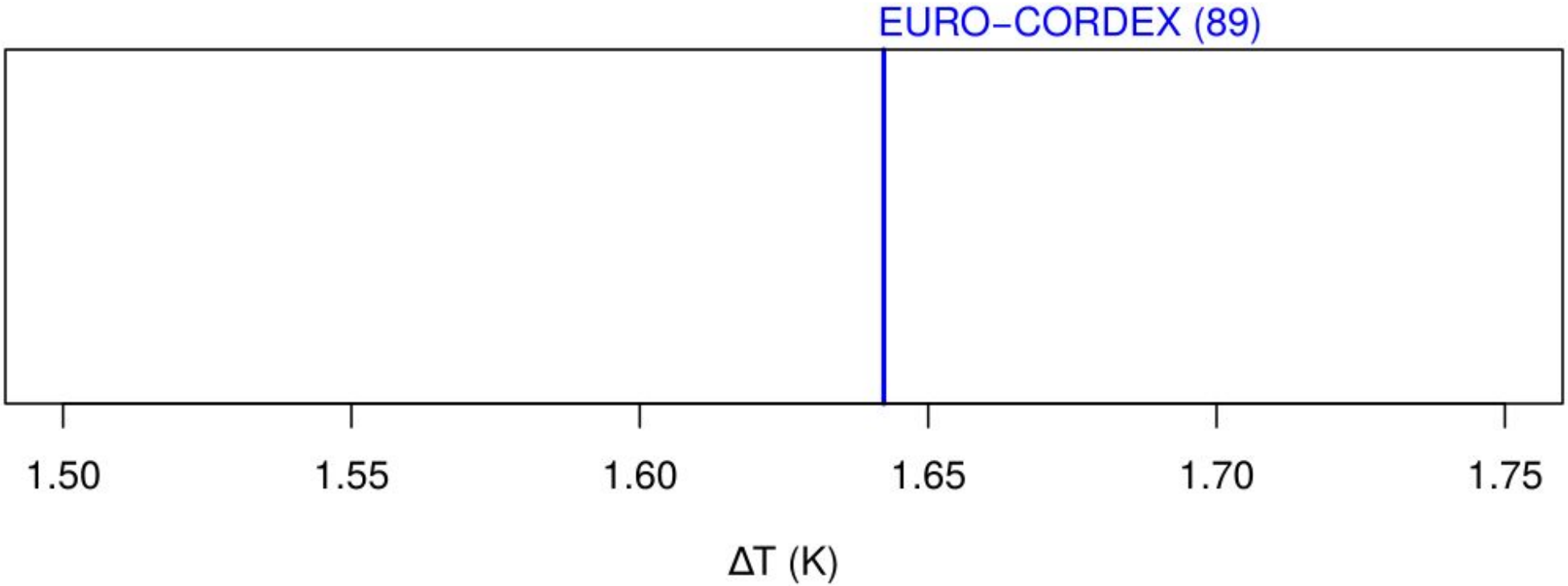
# Objective

- Quantitatively assess the impact of an unbalanced GCM-RCM matrix design on projected delta changes

How?

- Explore alternative matrix designs ("What-if" situations).
- Sub-sample unbalanced EURO-CORDEX ensemble of opportunity to obtain smaller but more balanced ensembles.
- Use the data set from Fernández et al. (2019):
  - Only continental Spain and Balearic Islands
  - Future period 2021-2050, reference 1971-2000
  - Contains frozen EURO-CORDEX ensemble as of April, 2018 (89 projections).
  - Publicly available at: http://meteo.unican.es/work/visualizeR/data/multimip_sclim_es.rda

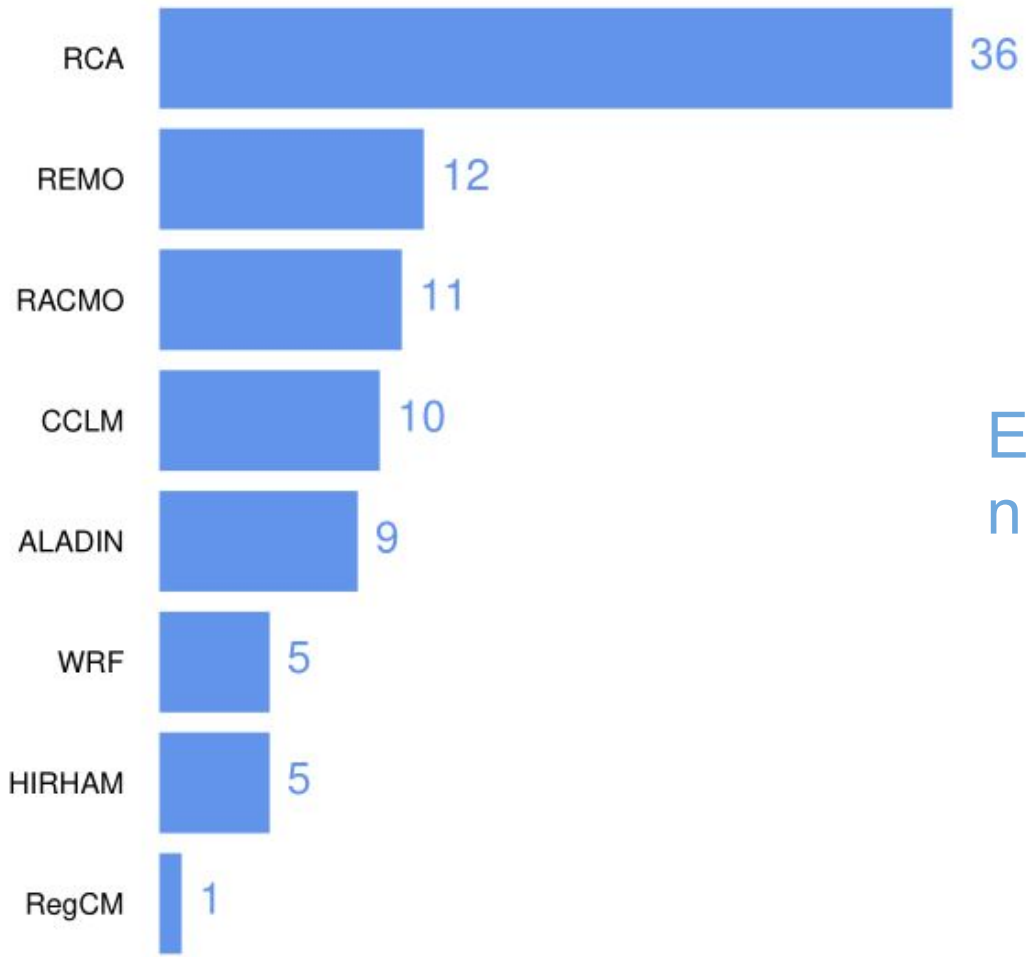
# Methodology




This (1.64 K) is the mean summer (JJA) surface temperature change over continental Spain and the Balearic Islands for the period 2021-2050 with respect to the reference 1971-2000.

It is the ensemble mean of 89 EURO-CORDEX RCM projections.

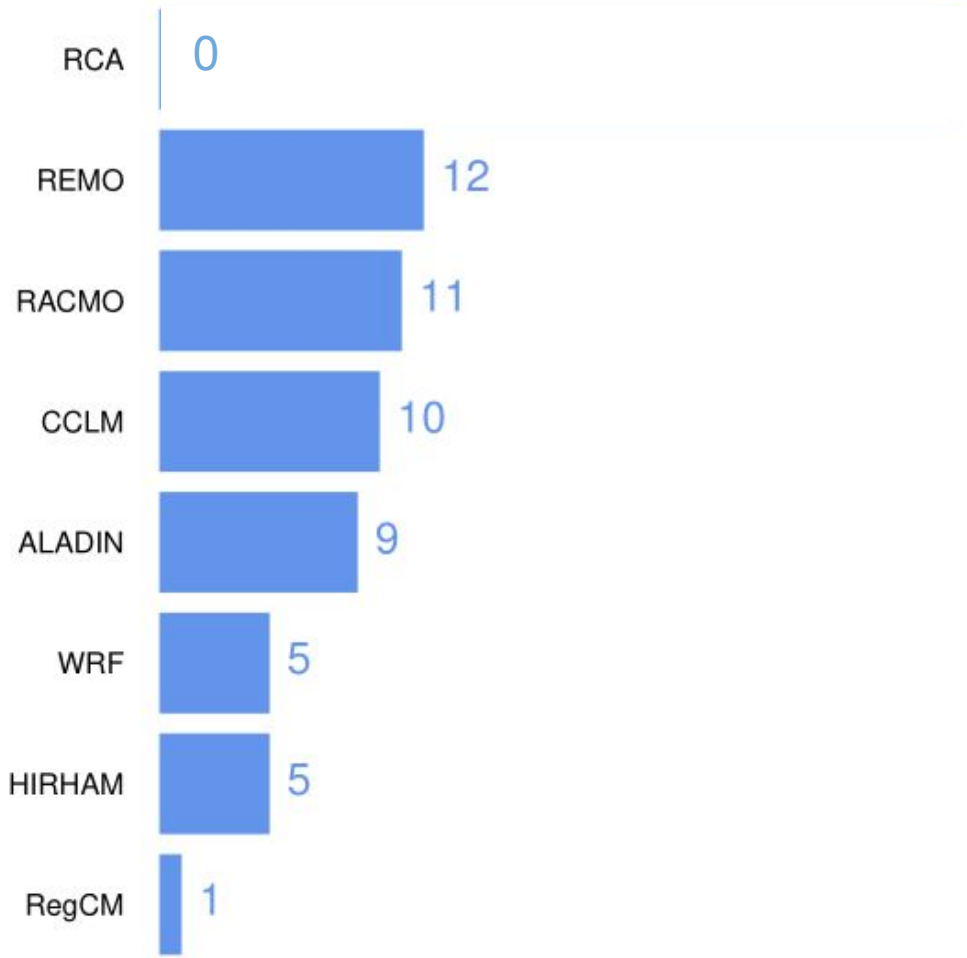
# What if …




Ens. members
n = 89

# What if …

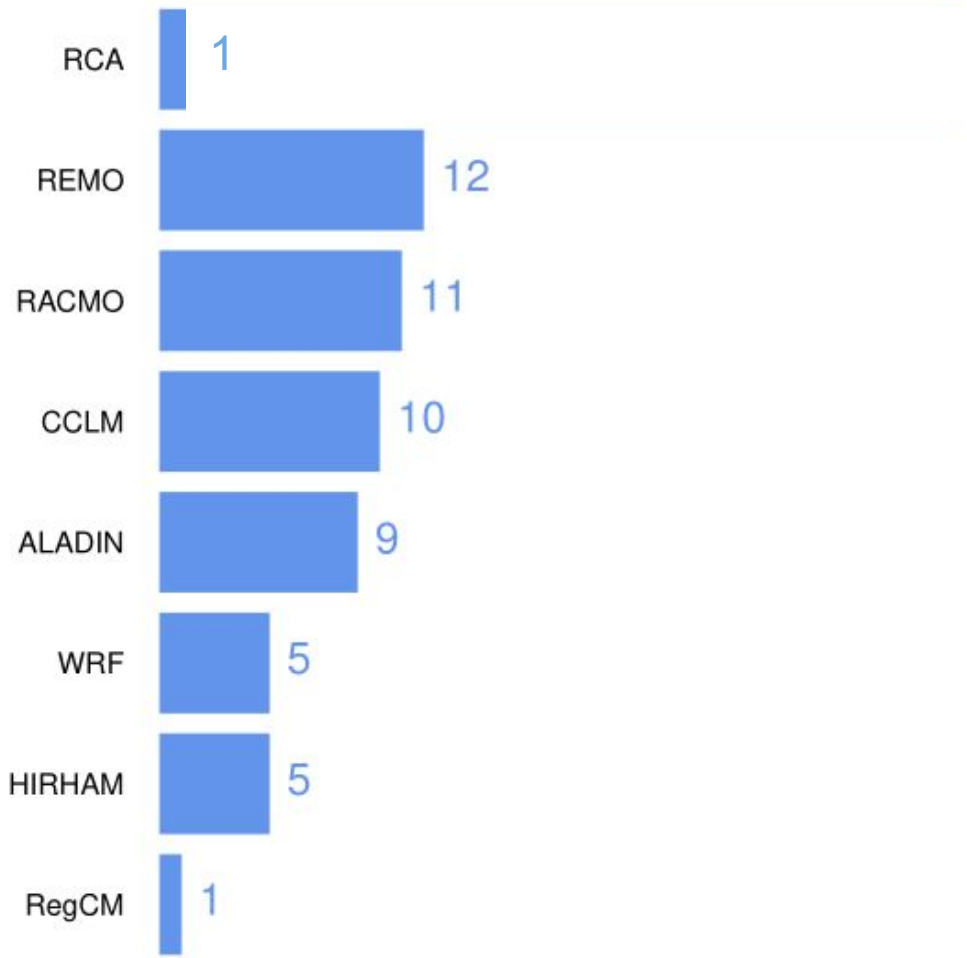
… the RCA model had not contributed to EURO-CORDEX?




Ens. members
n = 53

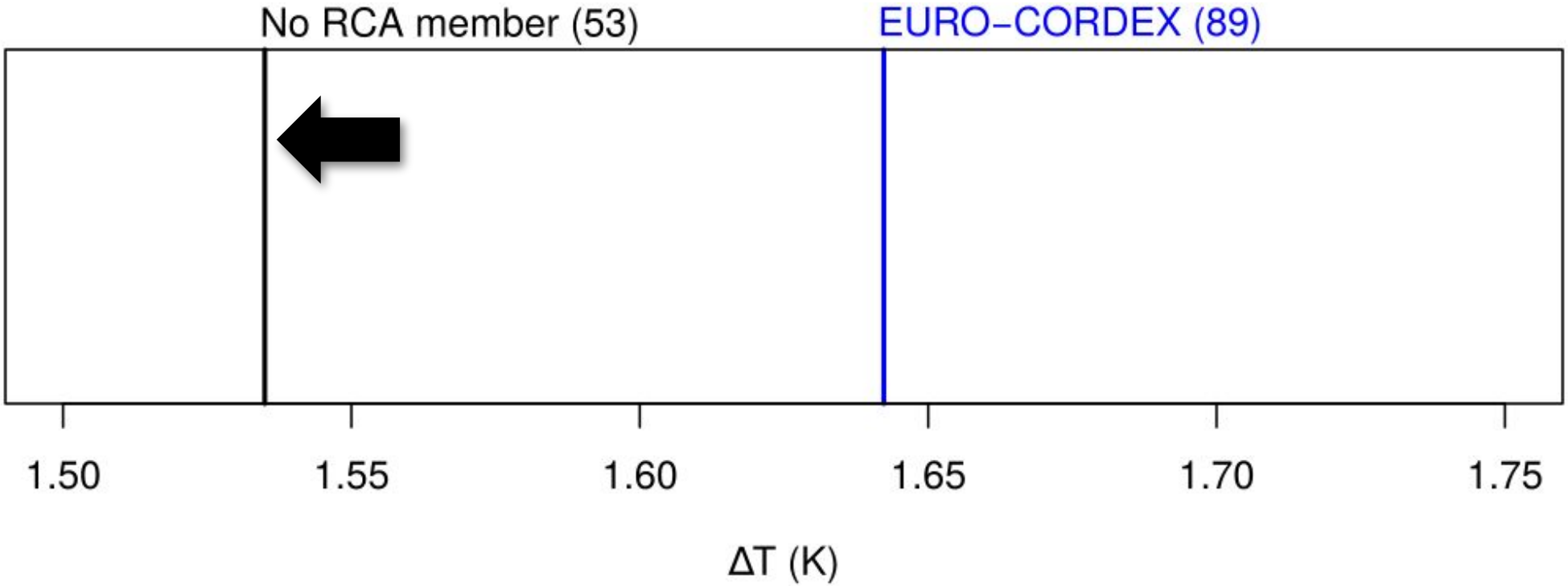
# What if …

… the RCA model had contributed a single simulation?




Ens. members
n = 54

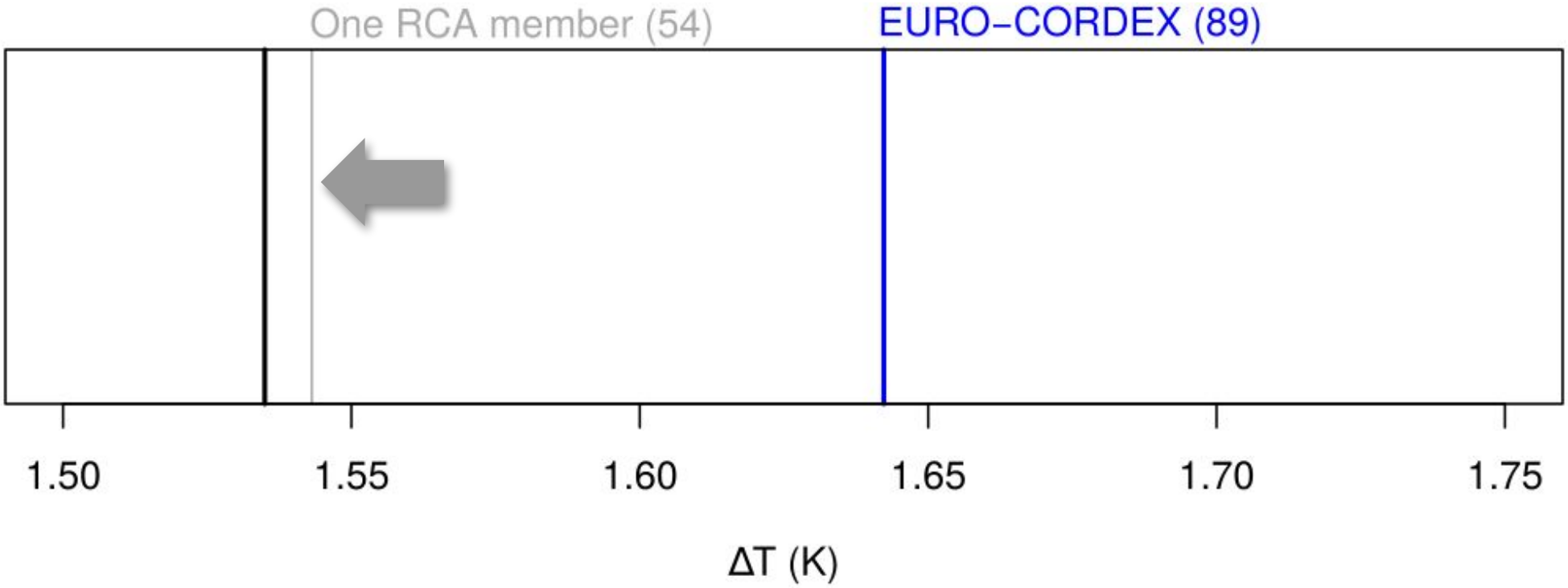
# Methodology




This is the ensemble mean with no RCA members in it.

There were 36 RCA members, so the resulting ensemble size is 53

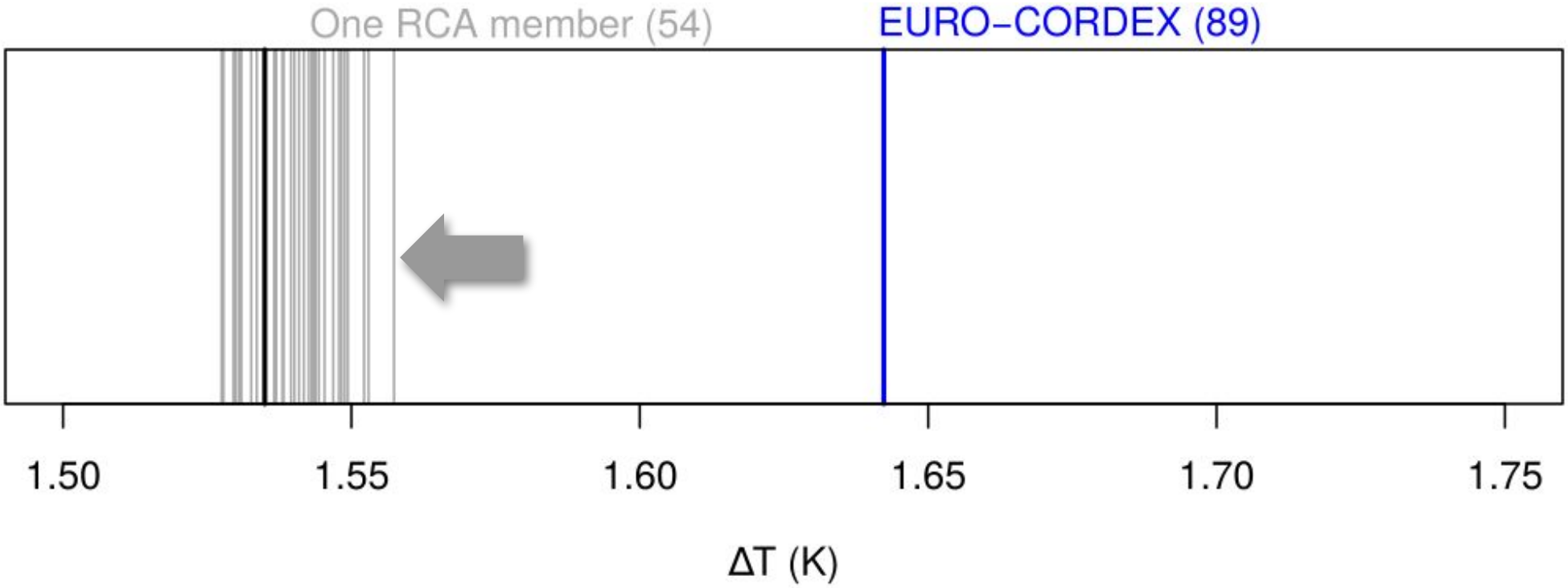
# Methodology




And this is the ensemble mean with a single RCA member in it. There are, then, 54 ensemble members now.

Wait … there are 36 ways to build an ensemble with a single RCA. One for each of the RCA members available

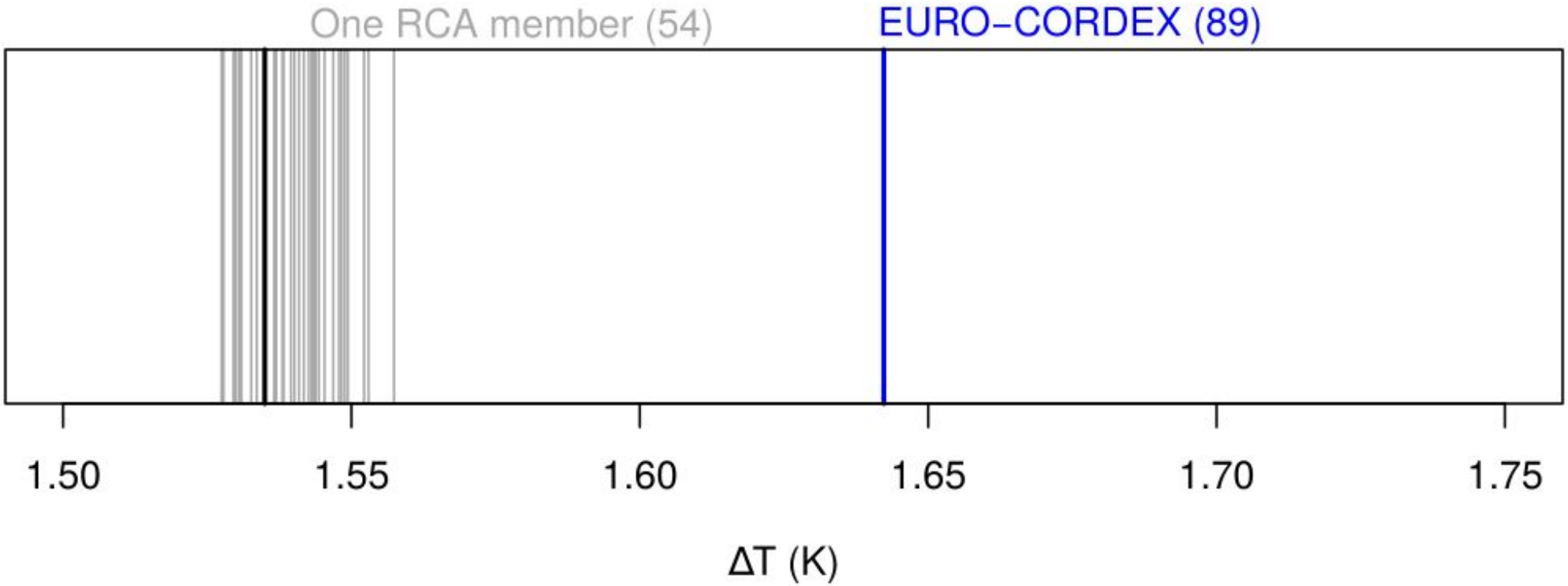
# Methodology




Here they are!

These are the ensemble means of all sub-ensembles that can be constructed with a single RCA simulation into them.

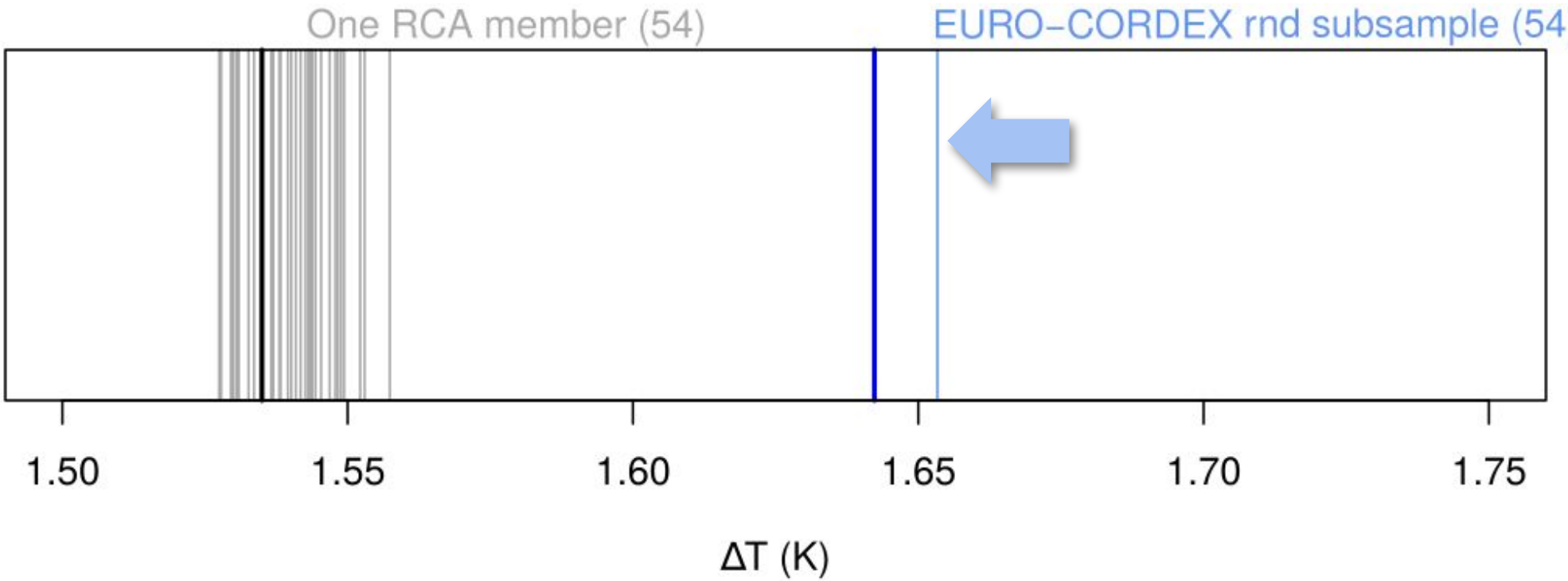
# Methodology




How likely is it that they lie that far from the full ensemble mean?

Let's build other ensembles of size 54. We can generate one by randomly subsampling the original EURO-CORDEX ensemble.

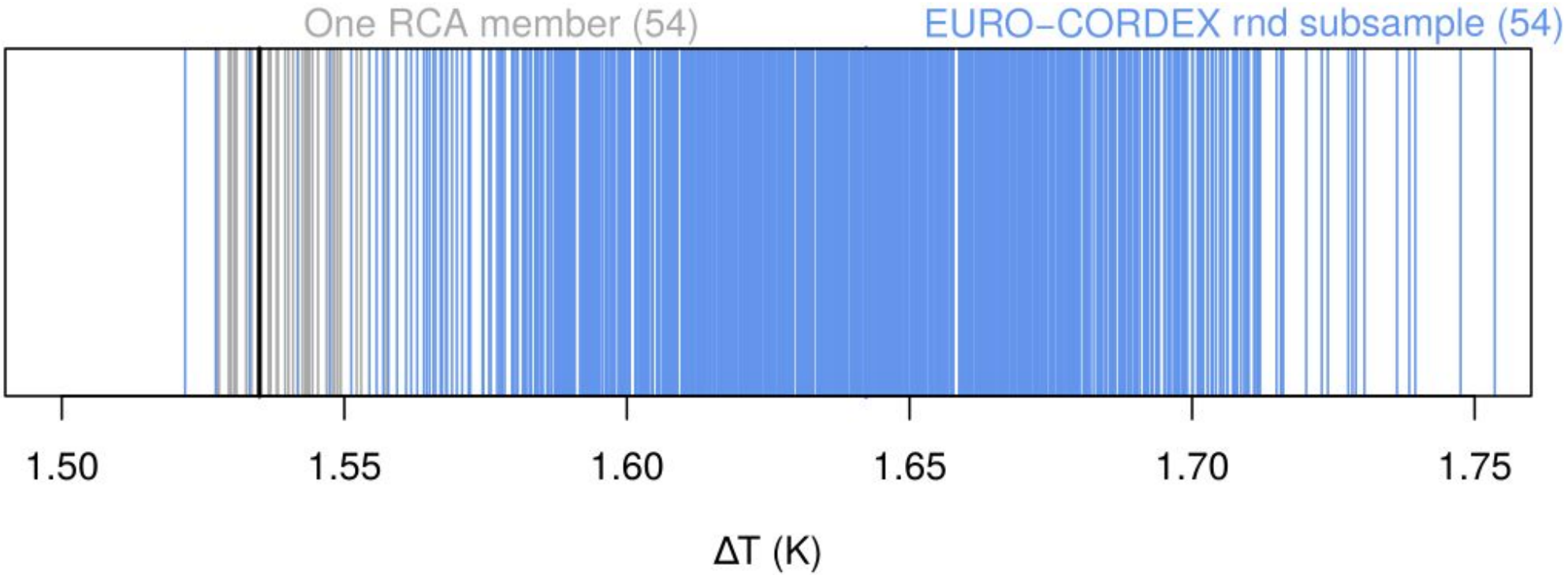
# Methodology




Here it is.

It doesn't fall as far from the grand-mean as "one-RCA" ensembles. It could have been just luck. But, we can build as many 54-member random subsamples as we like. Let's just take 1000 …

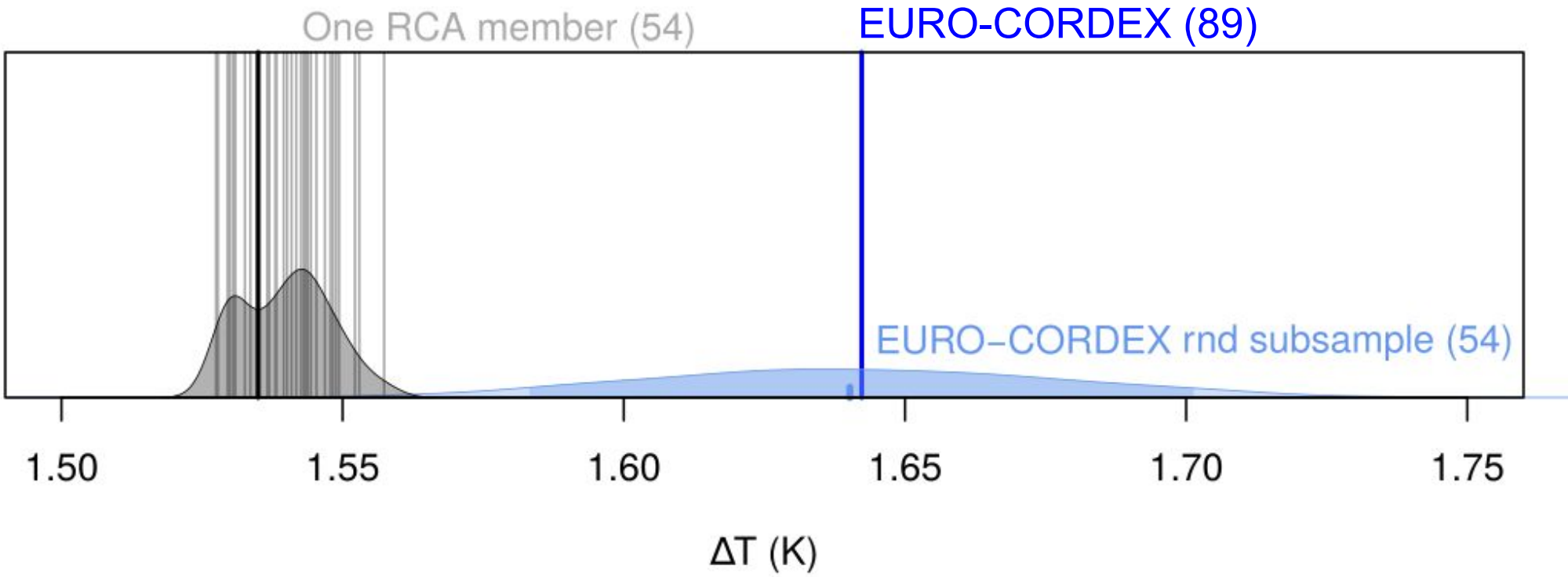
# Methodology




This barcode plot is becoming messy.

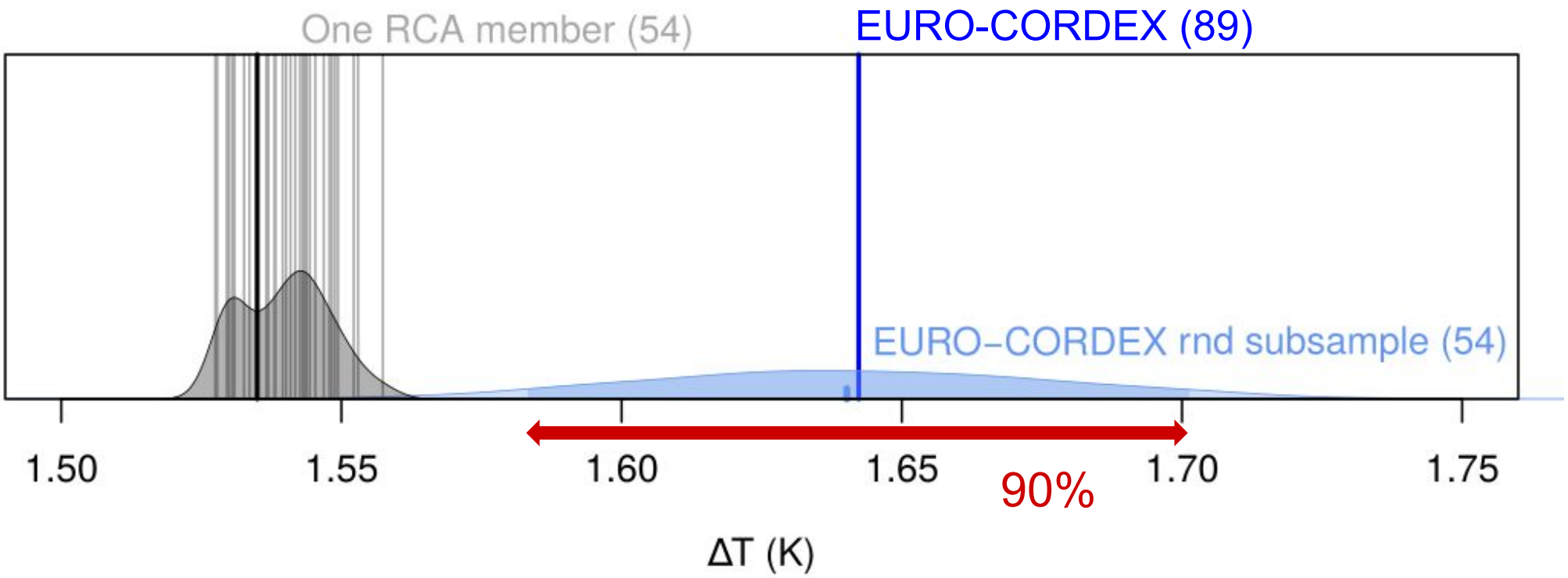
Let's see these as probability density estimates ...

# Methodology




Now we have a better idea of how unlikely are the no-RCA or one-RCA ensemble means.

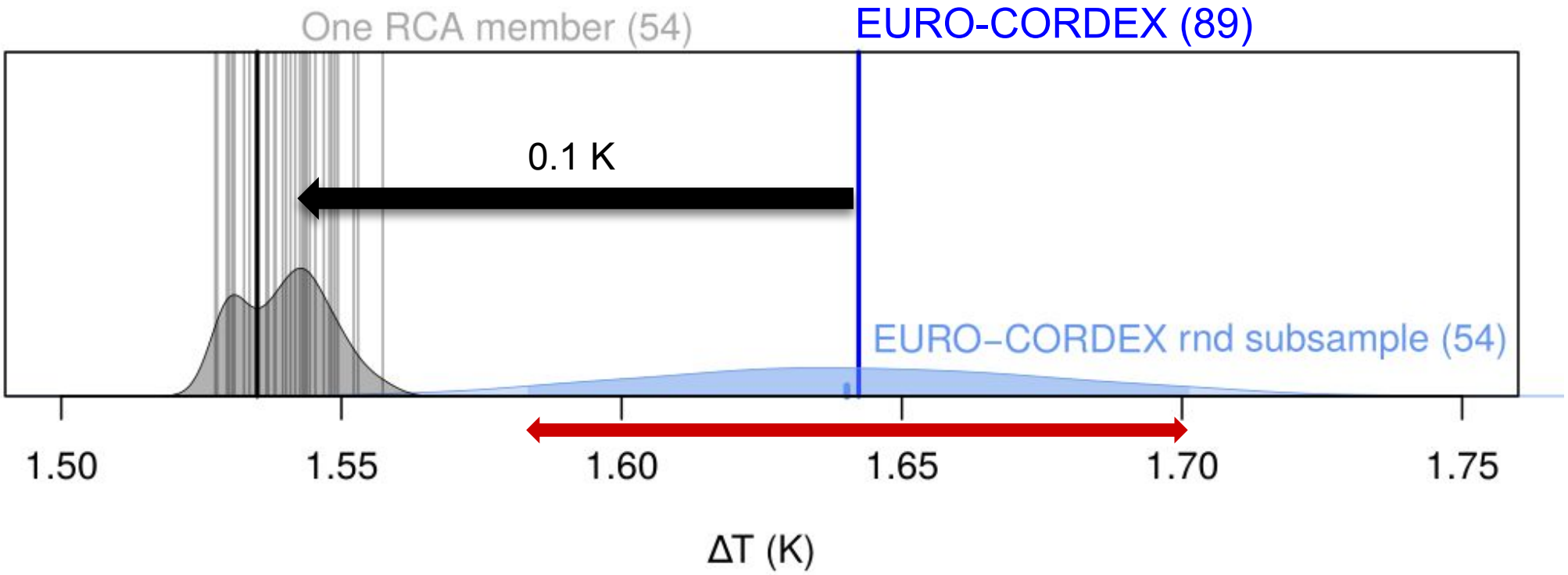
# Methodology




This dark shaded region is a centered 90% probability interval for the ensemble mean of a 54-member ensemble.

Summer temperature delta projections as small as those of non-RCA or one-RCA ensembles occur by chance in less than 1% of the sub-samples.

# Methodology




Despite the statistical significance, the practical significance of the shift in the delta change is negligible (-0.1 K).

What about other models?

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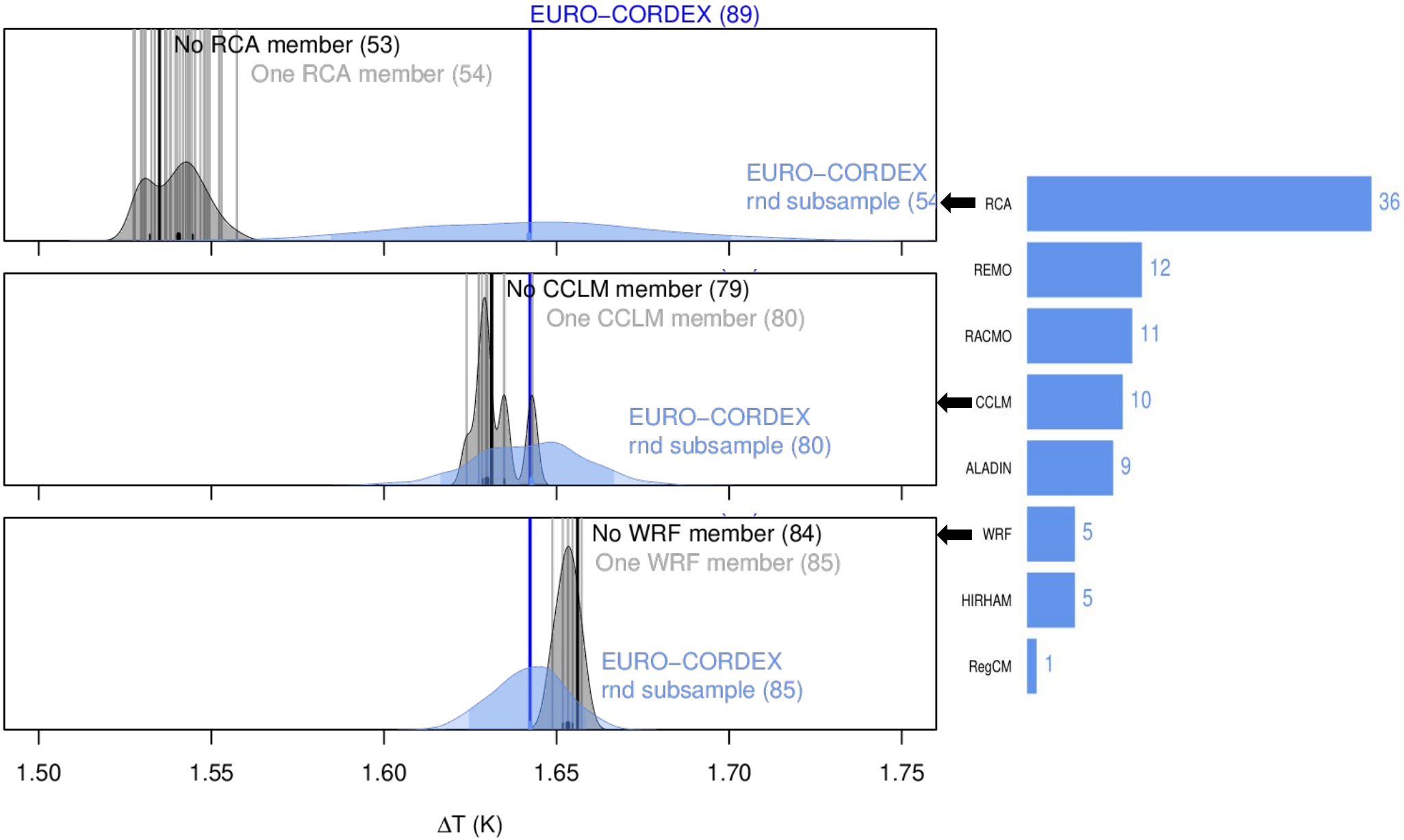
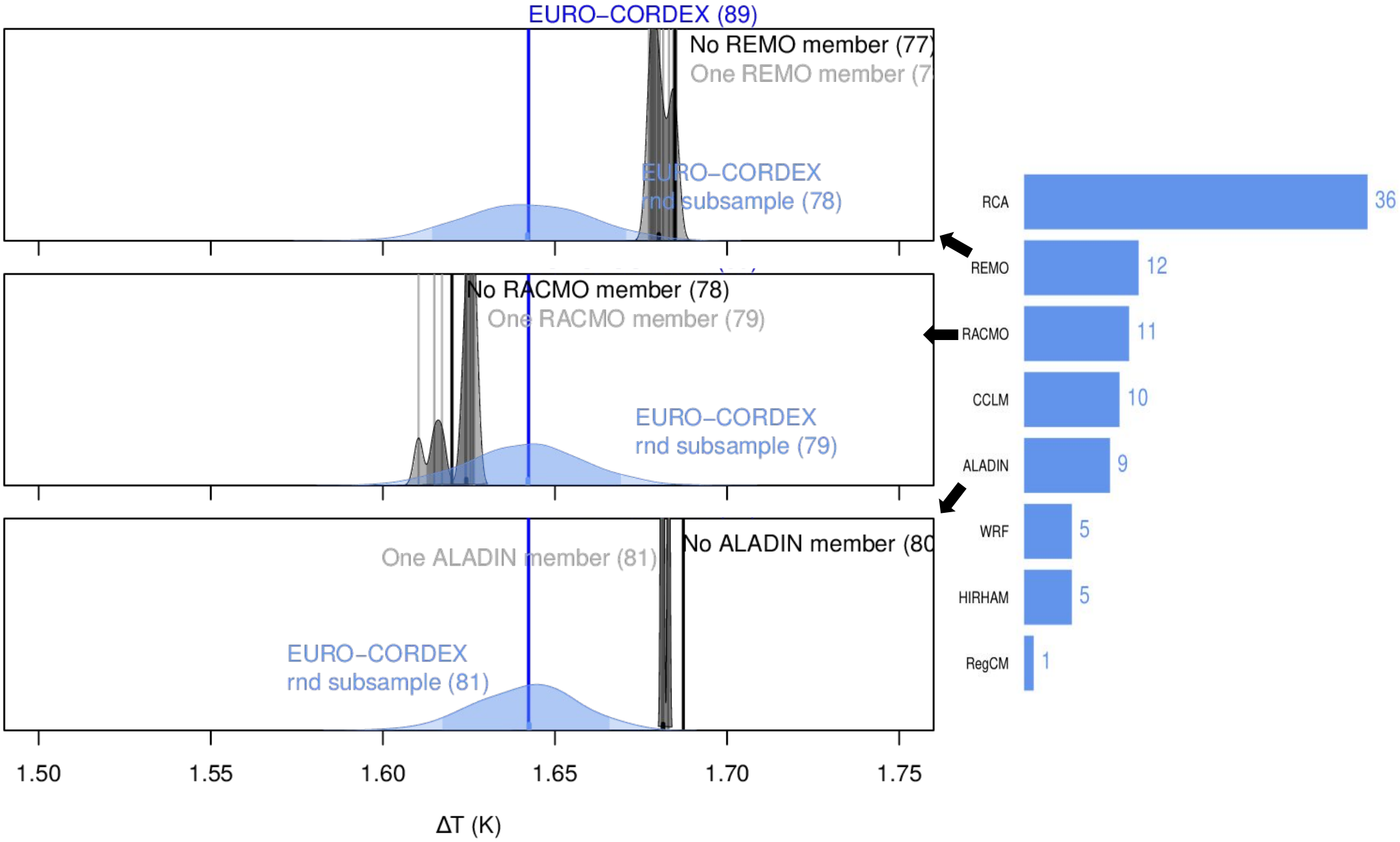
# What about other models?



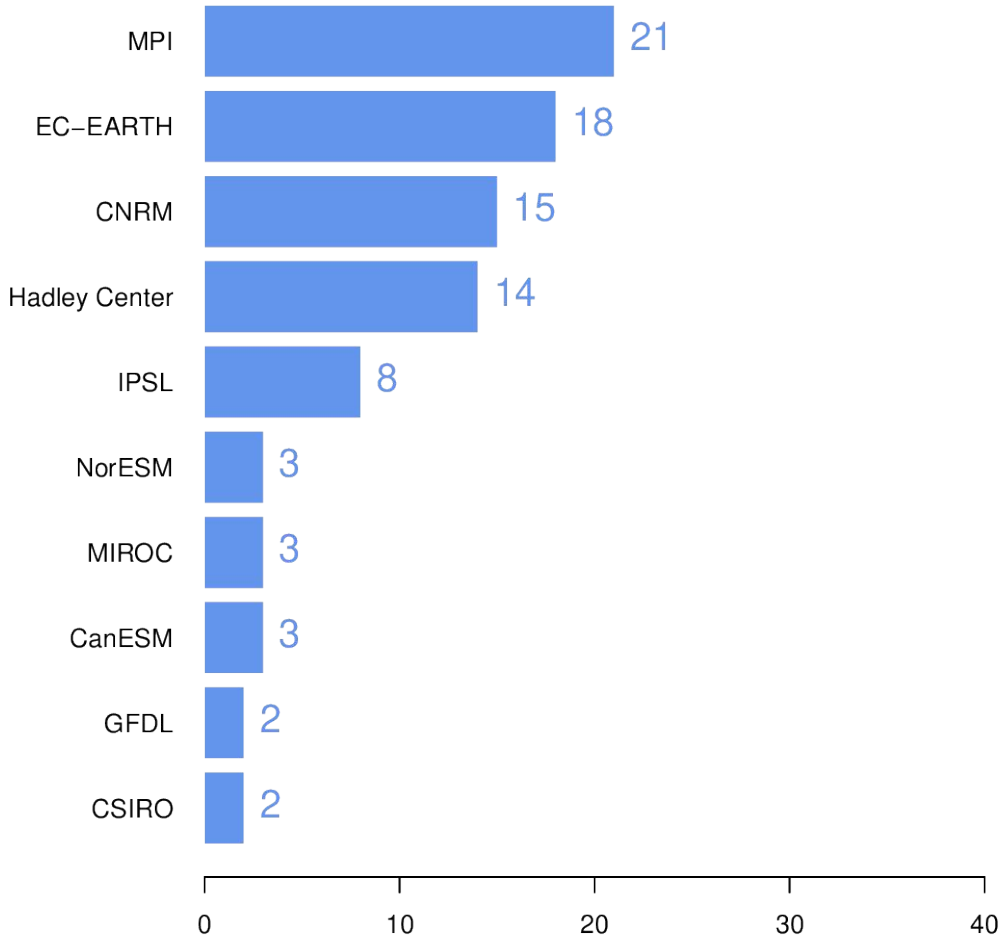
# What about other models?



# Preferred GCMs effect

## What if …

Driving GCMs

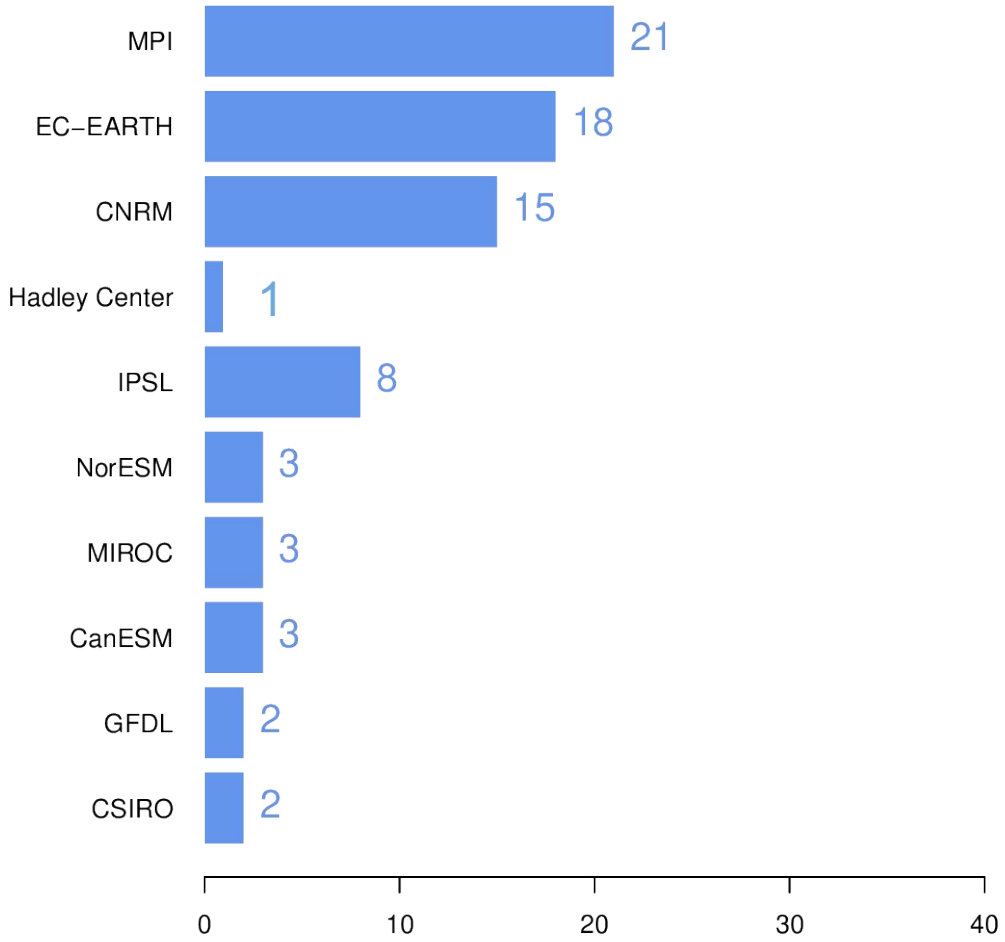


# Preferred GCMs effect

## What if …

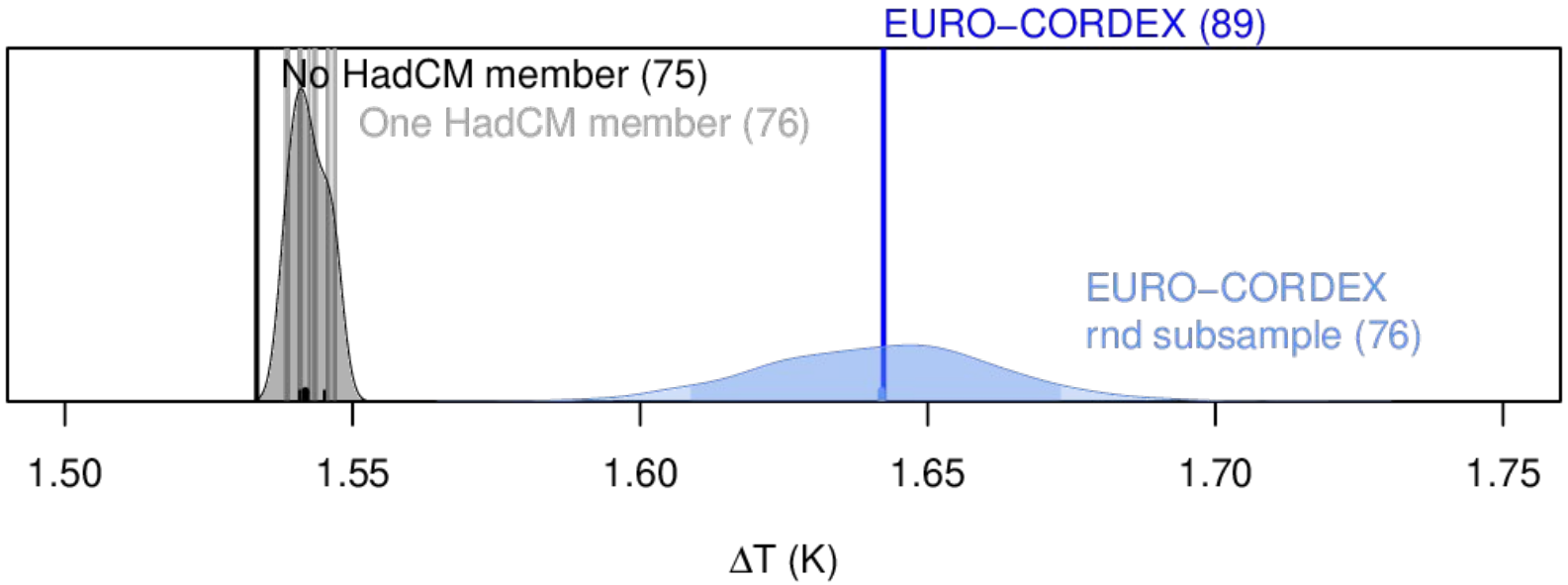
… the Hadley Centre models had driven a single RCM?

Driving GCMs

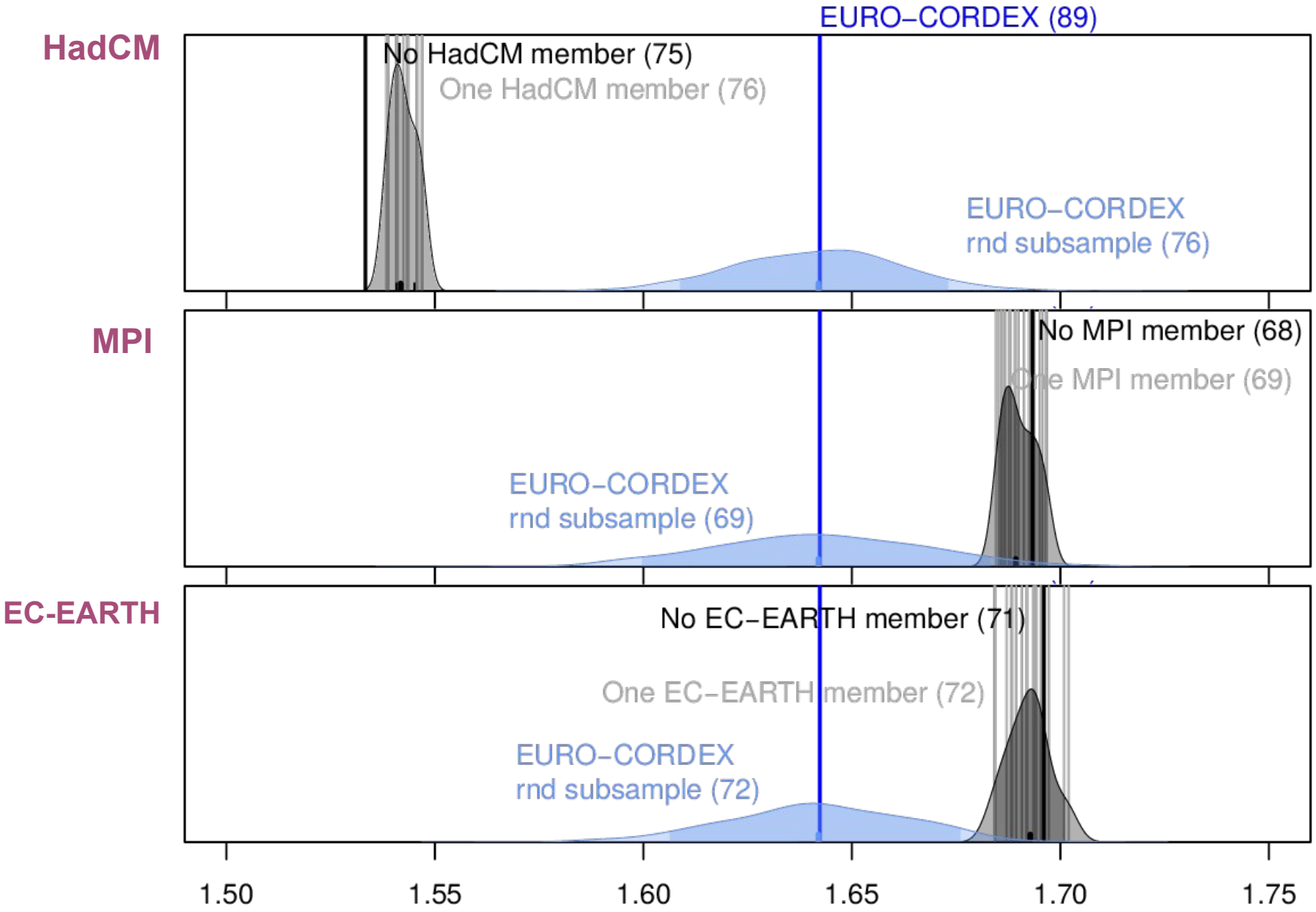


# Preferred GCMs effect

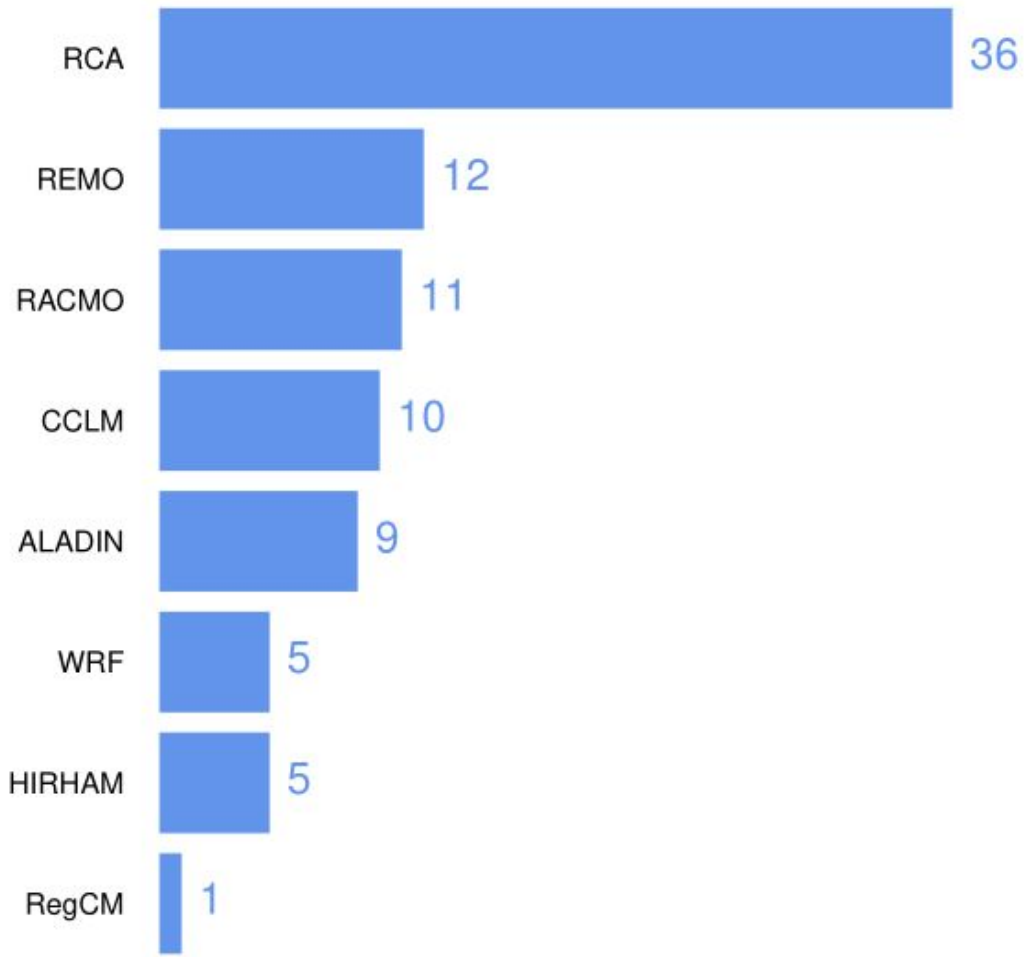
**HadCM**



# Preferred GCMs effect



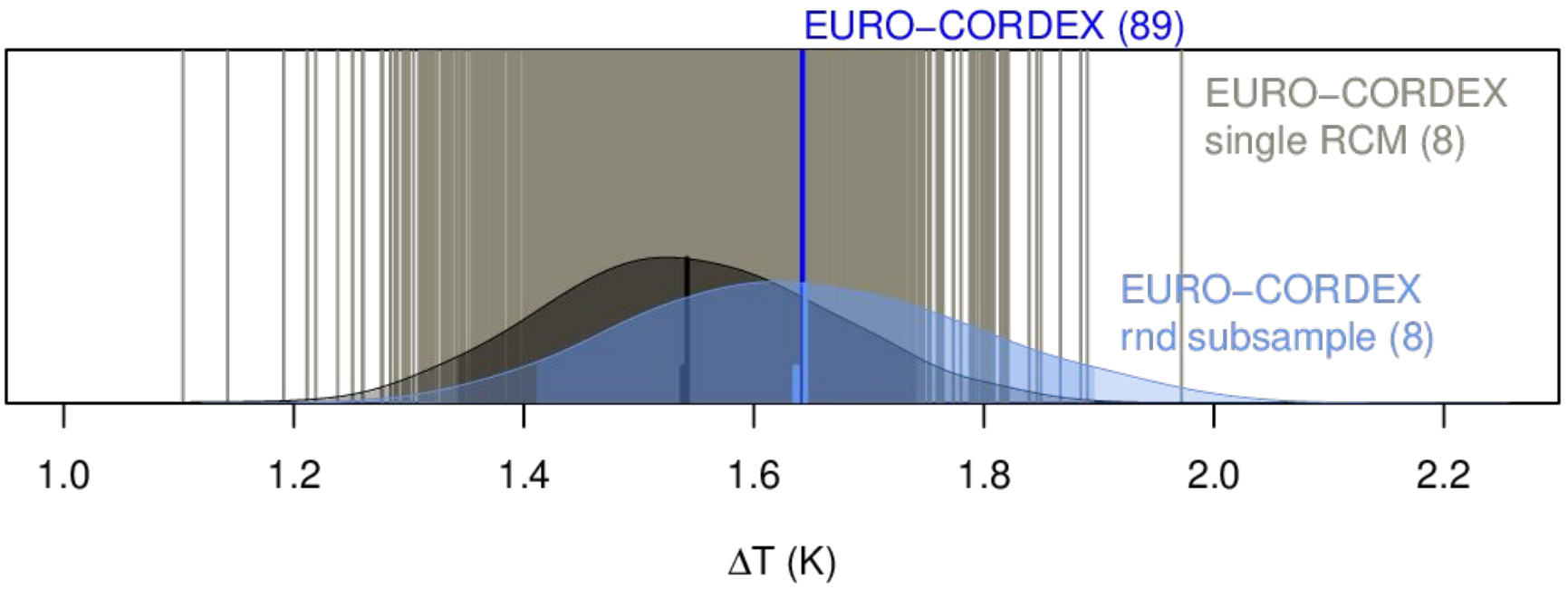
# What if we had …



# What if we had …

… a smaller but more balanced ensemble? One RCM, one vote

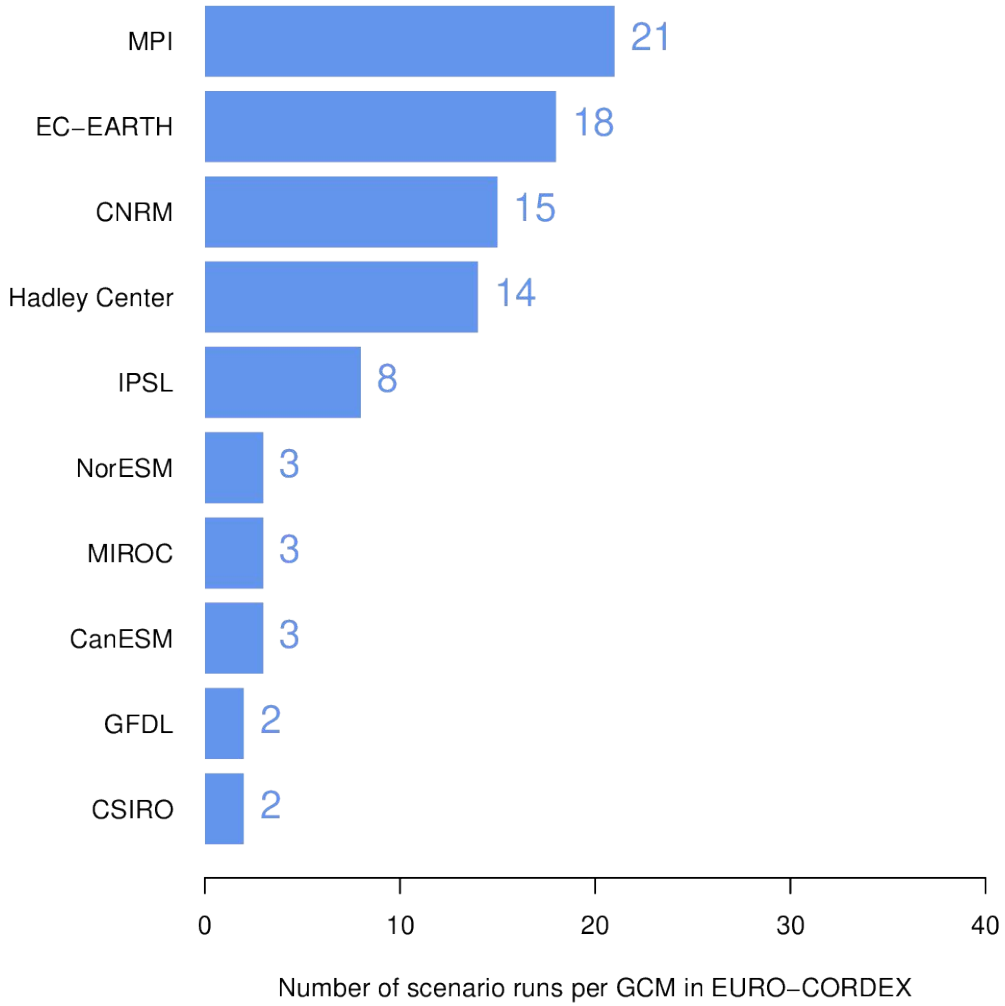
# Balanced ensemble




The signal (-0.1 K) is much smaller than sampling uncertainty.

# What if we had …

## Driving GCMs



# What if we had …

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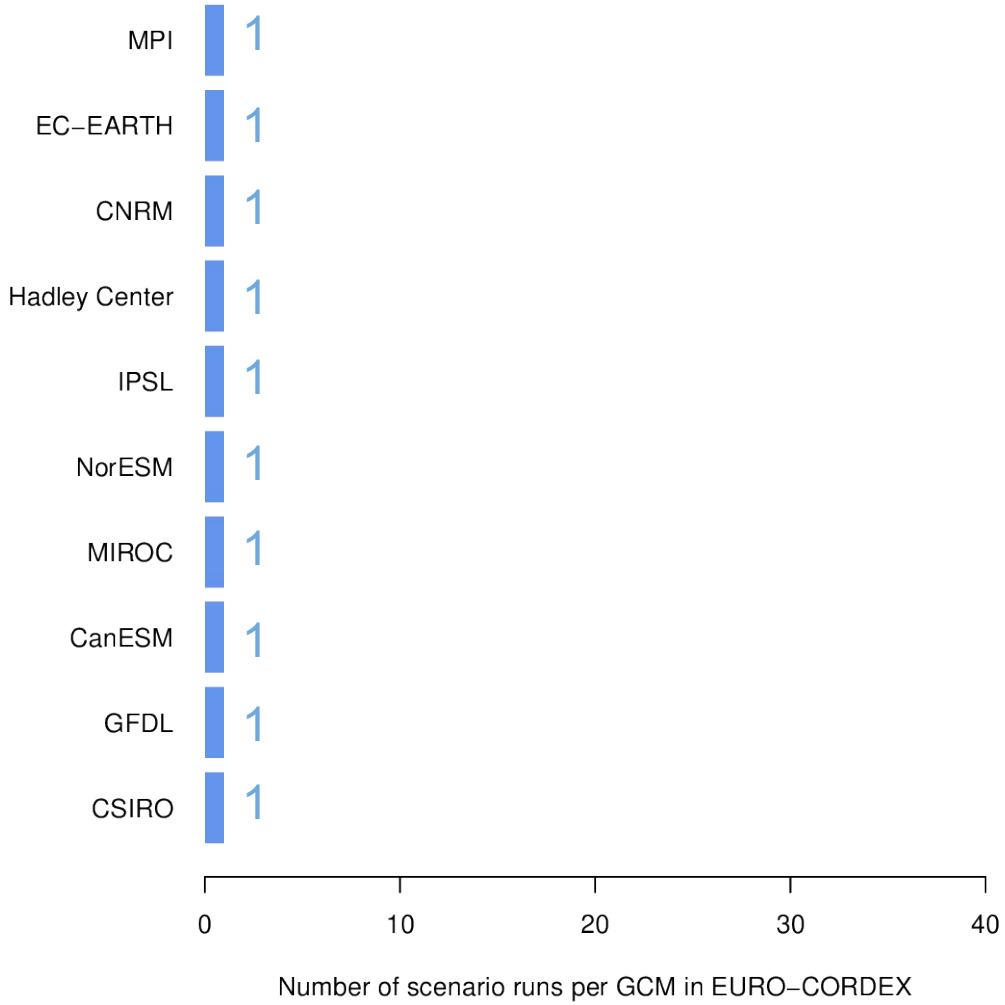
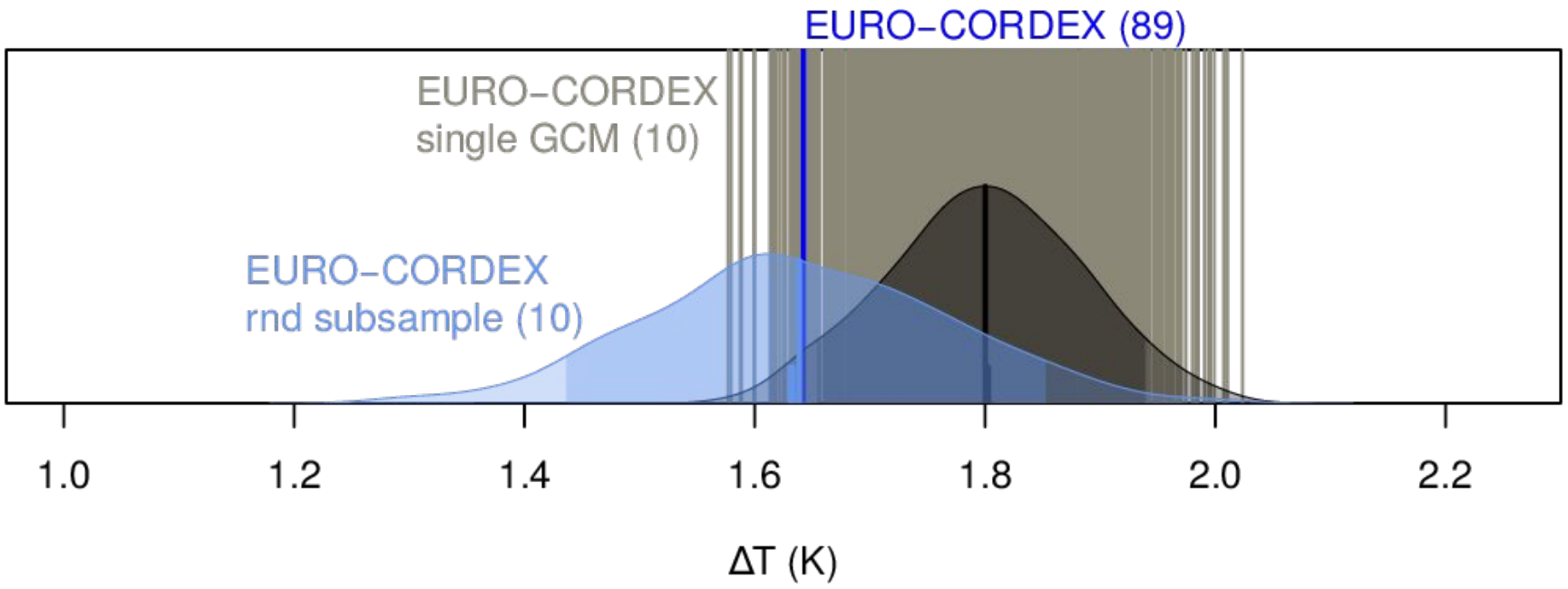
Driving GCMs



# Balanced ensemble




The signal (+0.2 K) is larger, but still small compared to sampling uncertainty.

# Conclusions

- We found:
  - Statistically significant changes of the climate change signal when some over-represented RCMs/GCMs are down-weighted.
  - Non-significant changes when considering small ensembles with a one-model-one-vote approach.
- Small practical significance of the changes seems to imply that the no-weight, use-them-all approach is appropriate.
- This a purely statistical approach, see Fernandez et al. (2019) for potential pitfalls of the use-them-all approach from a process / physical plausibility viewpoint.
- Work in progress:
  - Other variables, other regions.
  - Regional changes are likely stronger than the country averages shown.