Climate Impacts of Near Term Forcers: Insights from Multi-Model CMIP6 Analysis

Alba Santos-Espeso[1], Pablo Ortega[1], Carlos Pérez García-Pando[1,2], Markus Donat[1,2], Margarida Samso[1], Saskia Loosveldt[1] and María Gonçalves-Ageitos[1,3]

[1]Barcelona Supercomputing Center, Barcelona, Spain.
[2]ICREA, Catalan Institution for Research and Advanced Studies, Barcelona, Spain.
[3]Projects and Construction Engineering Department, Universitat Politècnica de Catalunya, Terrassa, Spain.

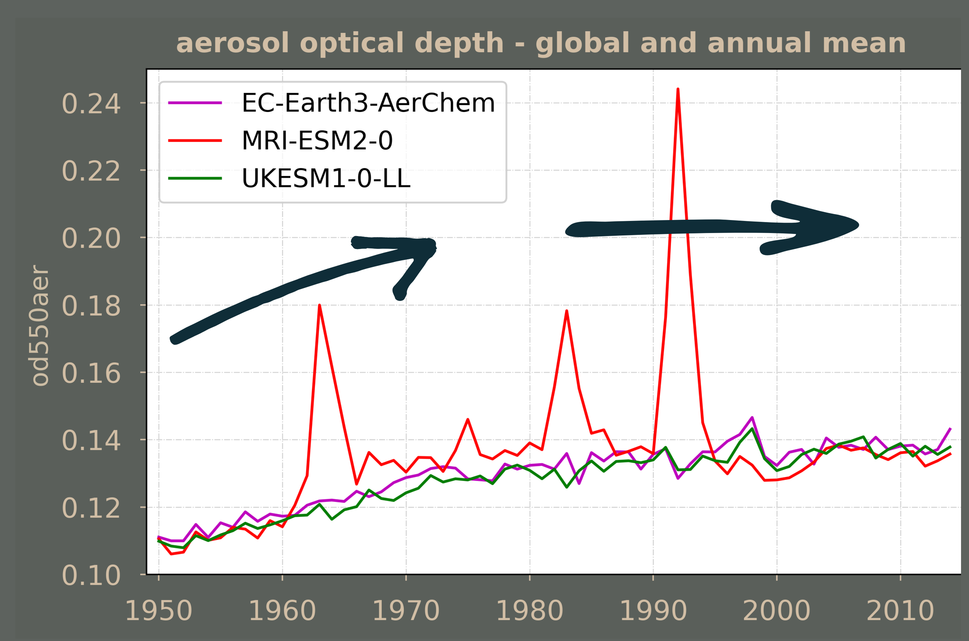
More info!

1. Near Term Climate Forcers

NTCFs are chemically and physically reactive compounds with atmospheric lifetimes shorter than a decade.

NTCFs' **brief atmospheric lifetime**, heterogeneous composition and distribution derives in global and regional climatic effects that are yet not fully understood.

In this work, we focus on **anthropogenic** non-methane NTCFs, namely: **aerosols, tropospheric ozone and their precursors.**



Global aerosol optical depth evolution in the historical CMIP6 experiment

2. Methodology

We isolate the NTCFs signal on climate in the **period 1950-2014** through a **multi-model analysis** of simulations from the AerChemMIP - CMIP6 initiative (Collins et al., 2017).

Experiment	Description
historical	historical forcings
hist-piNTCF	historical forcings but NTCF emissions fixed to 1850 values

Model requirements:

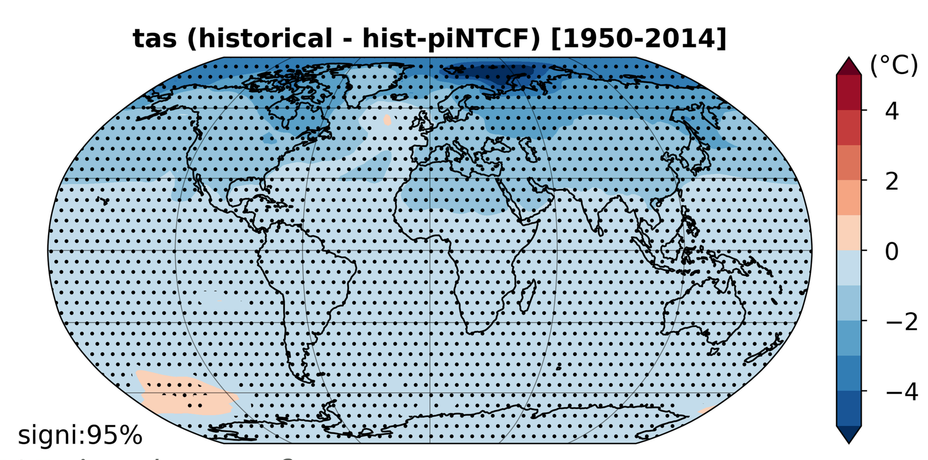
- interactive tropospheric aerosols and chemistry
- at least 3 members to filter model internal variability

BCC-ESM1
MRI-ESM2-0
UKESM1-0-LL
EC-Earth3-AerChem

3. Main Effects on Climate

3.1. Arctic Cooling

Overall cooling in response to aerosols as the only NTCFs with negative radiative effects



NTCF signal on surface temperature

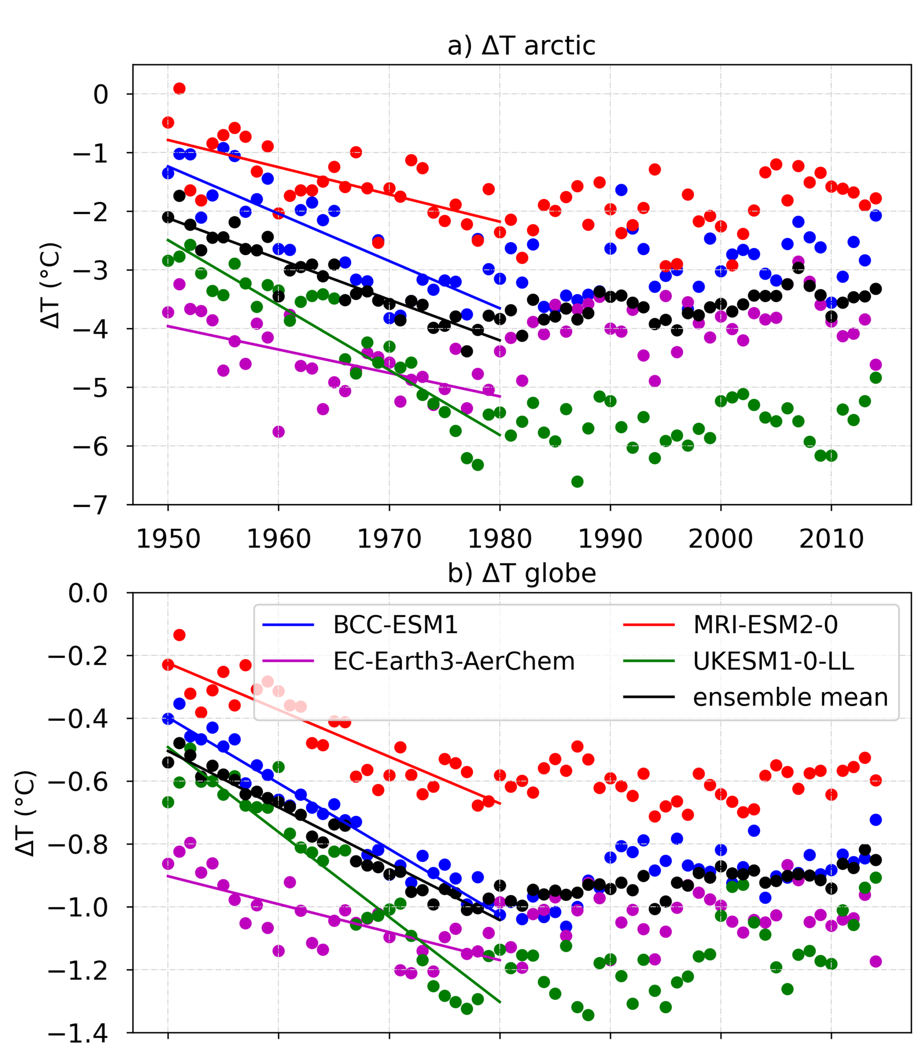
- The cooling is **maximum on the Arctic surface** and extends to the higher troposphere in the Tropics resembling the pattern reported by England et al. (2020) as a **response to Arctic sea ice loss**
- The cooling **peaks in boreal autumn**

Both of these behaviours point to the effect of **Arctic Amplification (AA)**. Following Wu et al. (2024), we computed the **Arctic Amplification Factor (AAF)** of the NTCF signal:

$$AAF = \frac{m(\Delta T_{arctic})}{m(\Delta T_{globe})}$$

And found two distinct behaviours in relationship to the potential driving effect of aerosols:

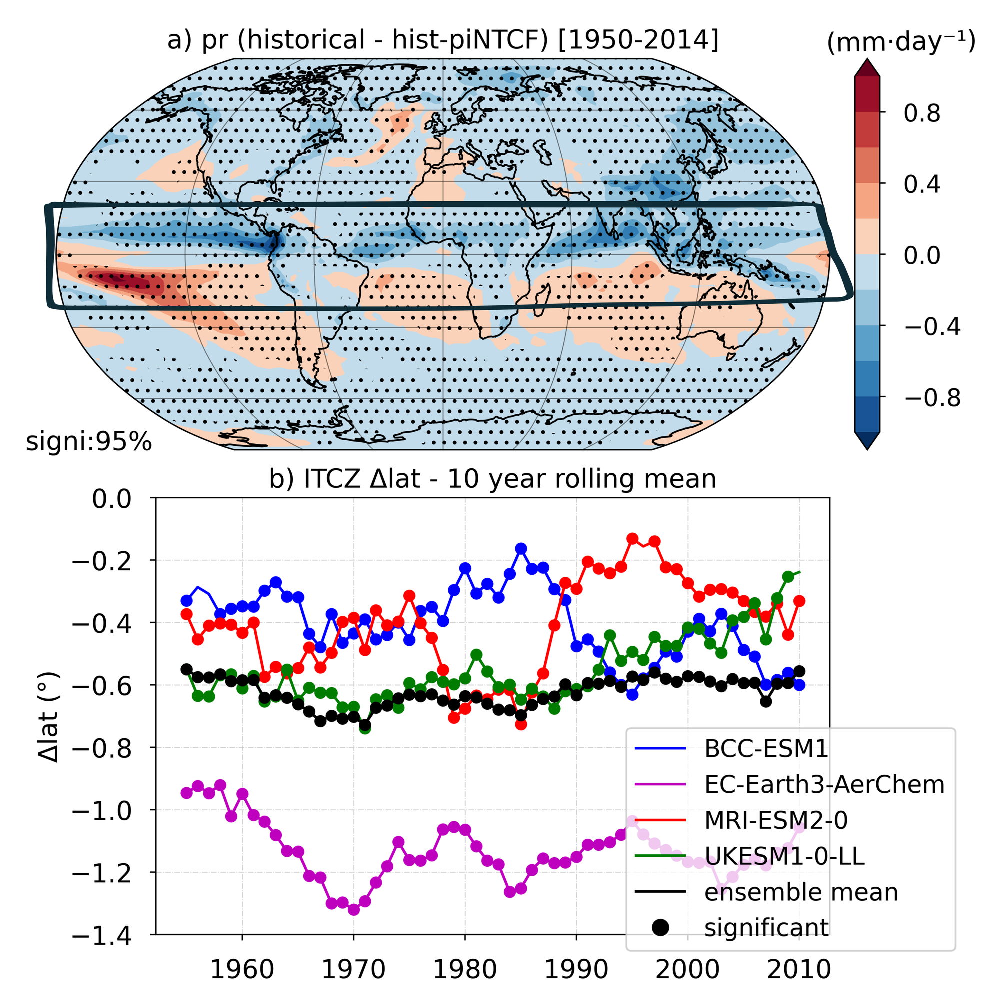
- **pre 80s:** strong NTCFs AAF of **3.87**
- **post 80s:** NTCFs lose relevance



(a) Arctic and (b) global temperature response to NTCF

3.2. Tropical Precipitation

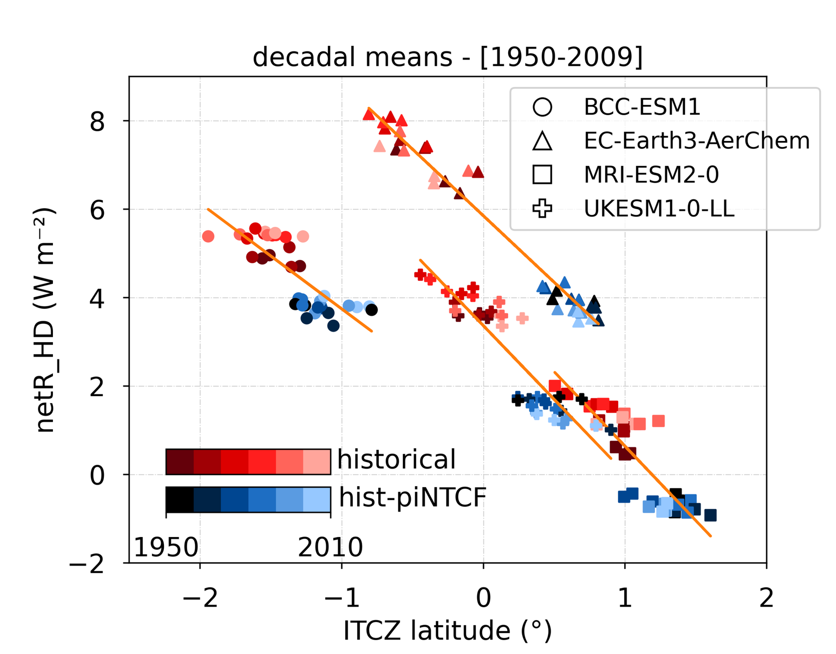
Decrease in tropical precipitation north of the equator and increase south of it. We determine an unanimous **southward shift of the ITCZ of 0.6°.**



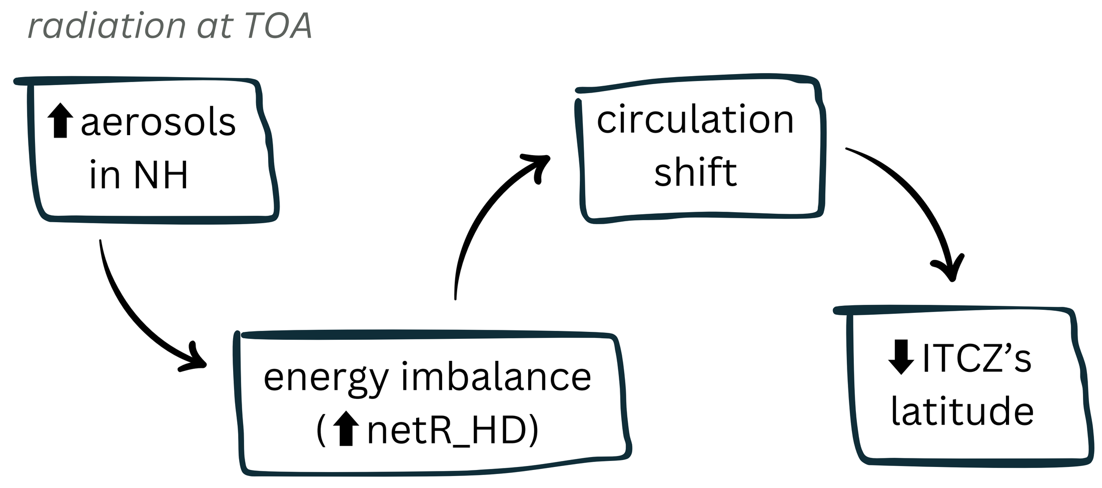
NTCF signal on (a) precipitation and (b) ITCZ latitude

By defining a **Net Radiation Hemispheric Difference index (netR_HD)** we are able to relate the ITCZ response to changes in global radiation:

$$netR_{HD} = \overline{netR_{SH}} - \overline{netR_{NH}}$$

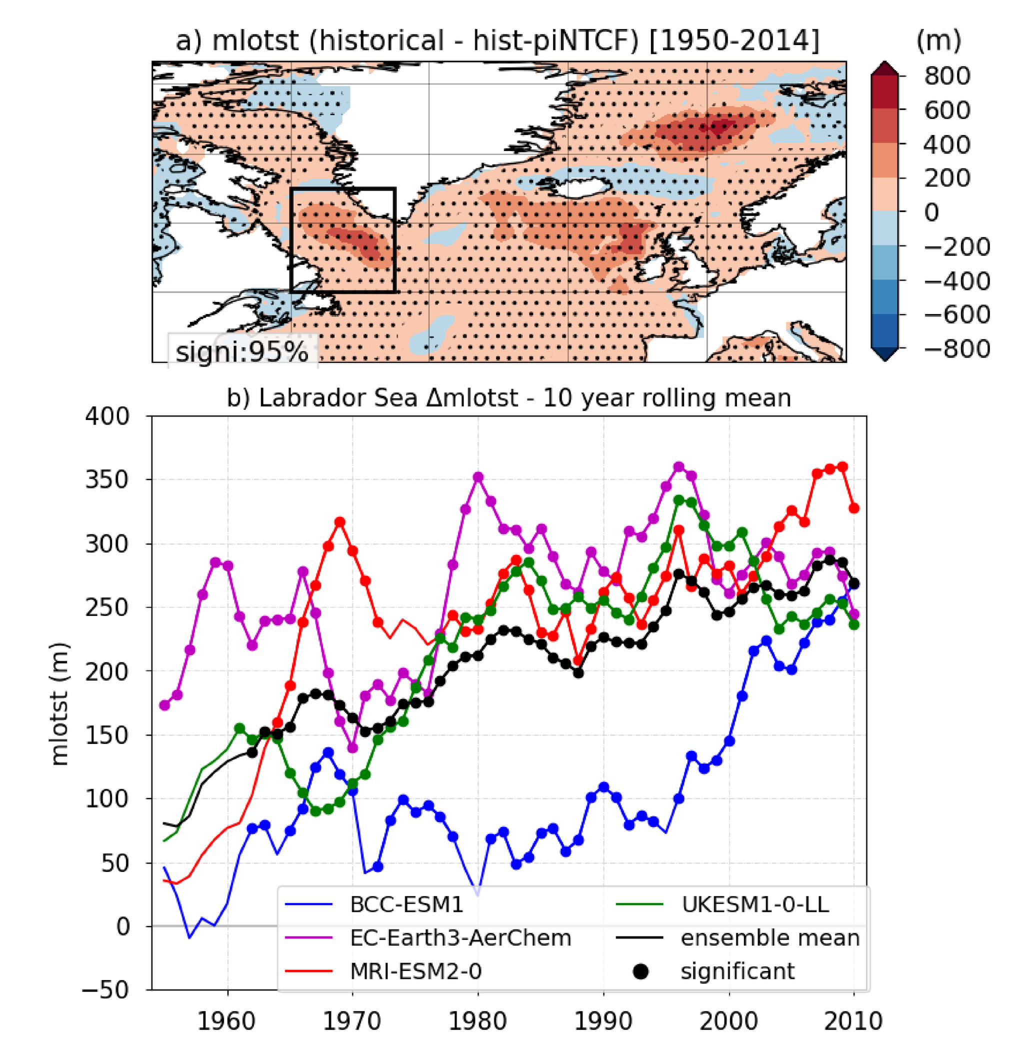


Relation between ITCZ latitude and interhemispheric radiation at TOA



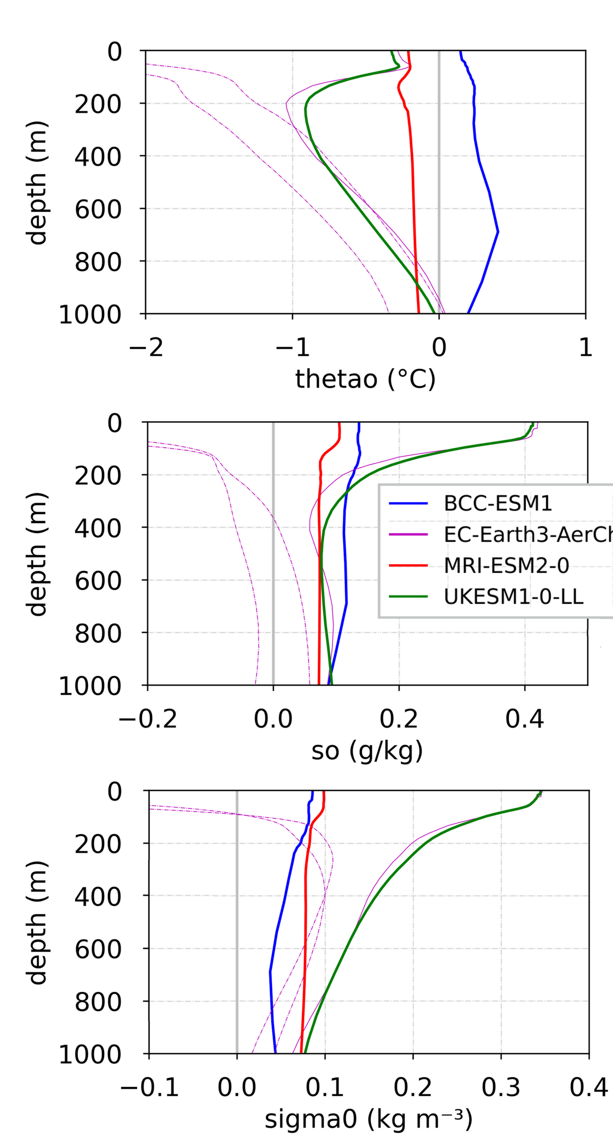
3.3. Labrador Sea Convection

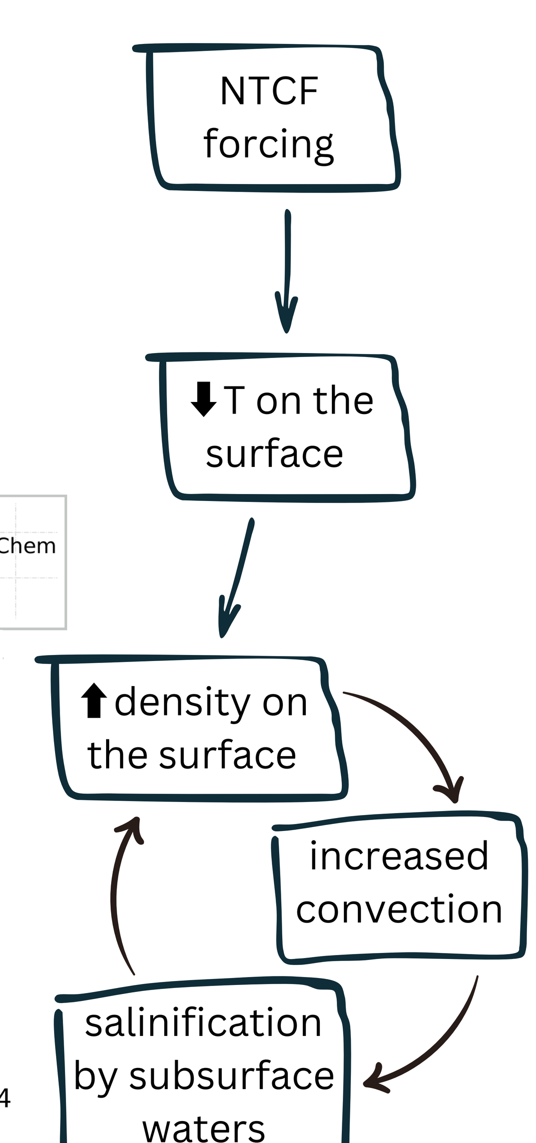
Increased mixed layer depth in the South Polar North Atlantic. **Convection increases by 38% in the Labrador Sea.**



NTCF signal on mixed layer depth in the (a) North Atlantic and (b) Labrador Sea

NTCF negative forcing triggers a **positive feedback** on Labrador Sea convection





NTCF signal on Labrador Sea FMA temperature, salinity and density profiles

4. Take Aways

From 1950 to 2014, **aerosols drive the NTCFs signal**:

- a general cooling with **stronger AA until 1980**
- a **southward displacement of the ITCZ of 0.6°**
- an **increase of Labrador Sea convection by 38%**

CONTACT: **alba.santos@bsc.es**

5. Future Work

Considering the increased convection in the South Polar North Atlantic, we will focus next on the **impacts of future NTCFs emissions on the AMOC.**

We will use a similar **multi-model framework** comparing future projections within the AerChemMIP initiative that isolate these species.

References

- Collins, W. J. et al. (2017) *Geosci. Model Dev.*, 10.
- England, M.R. et al. (2020) *Nat. Geosci.* 13.
- Wu, YT. et al. (2024) *npj Clim Atmos Sci* 7.

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