

Rethinking the Economic Impact of Future Energy Demand Changes : Focus on Human Thermal Comfort

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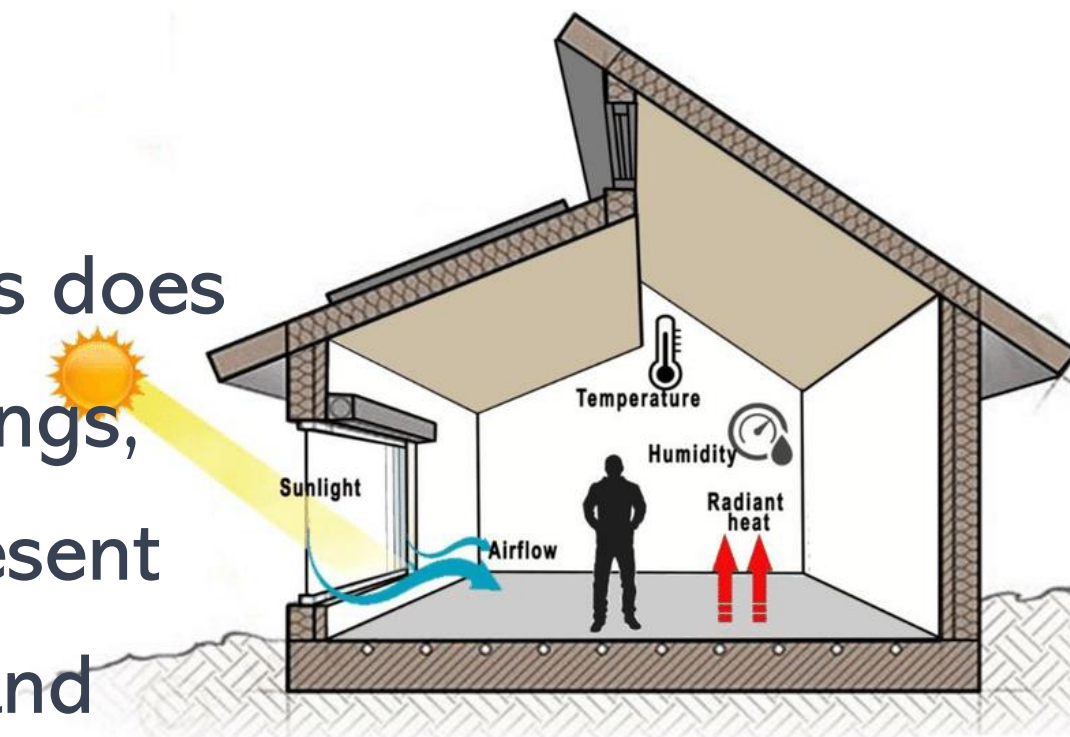
Previous Research :

Quantifying economic impacts due to energy demand changes in IAM(Integrated Assessment Models) with degree days, calculated by daily mean temperature and ASHRAE method

$$HDD_t = \sum_{d=1}^{D_t} (T_{ref} - T_a)_d^+, \quad CDD_t = \sum_{d=1}^{D_t} (T_a - T_{ref})_d^+$$

Limitation in previous work :

Using temperature alone for ASHRAE degree-days does not fully capture human thermal comfort in buildings, which means this method cannot accurately represent the economic impacts of changes in energy demand

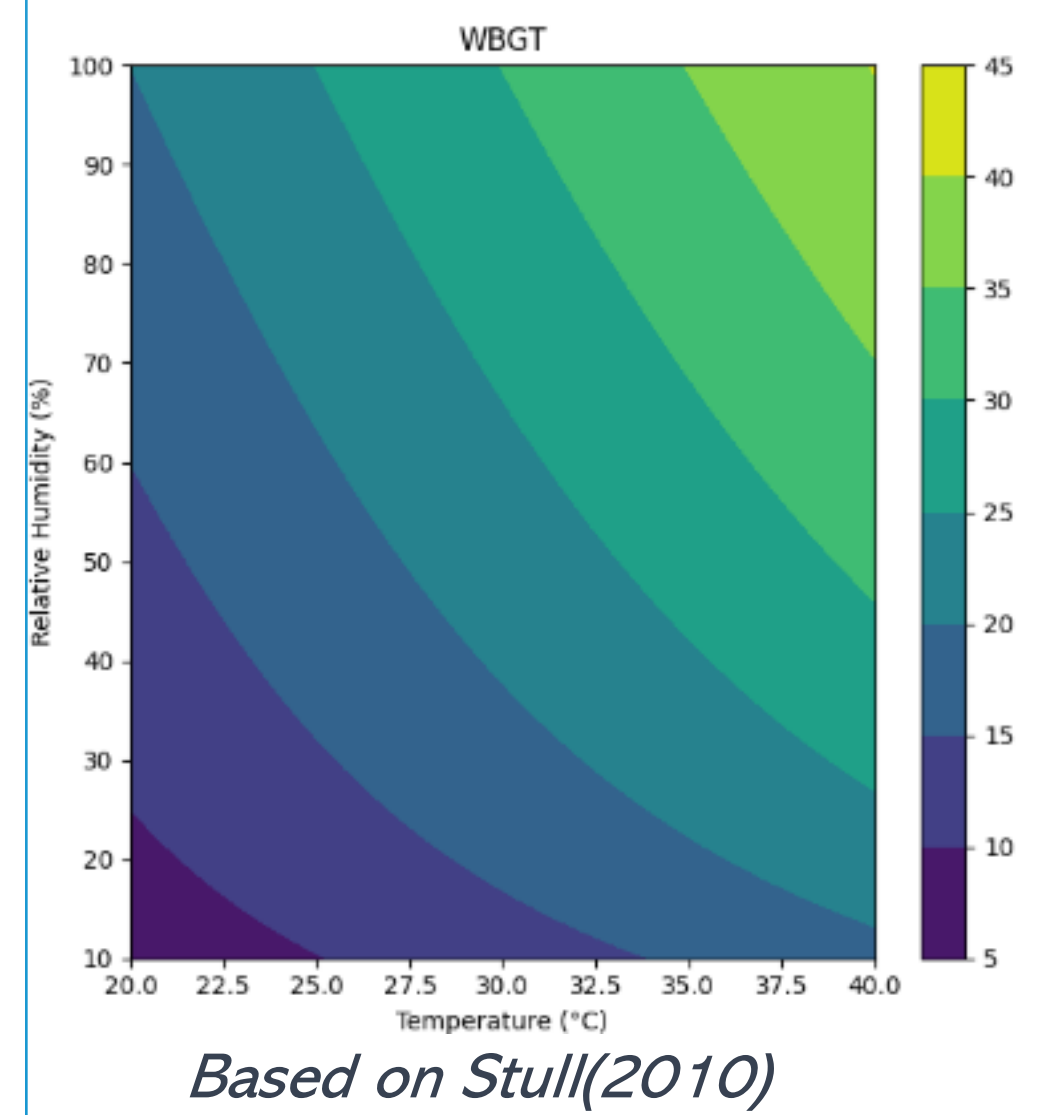


Research Framework

1. Update Degree Days Calculation

WBGT : temperature with humidity

UKMO : update daily temperature gap in DDs

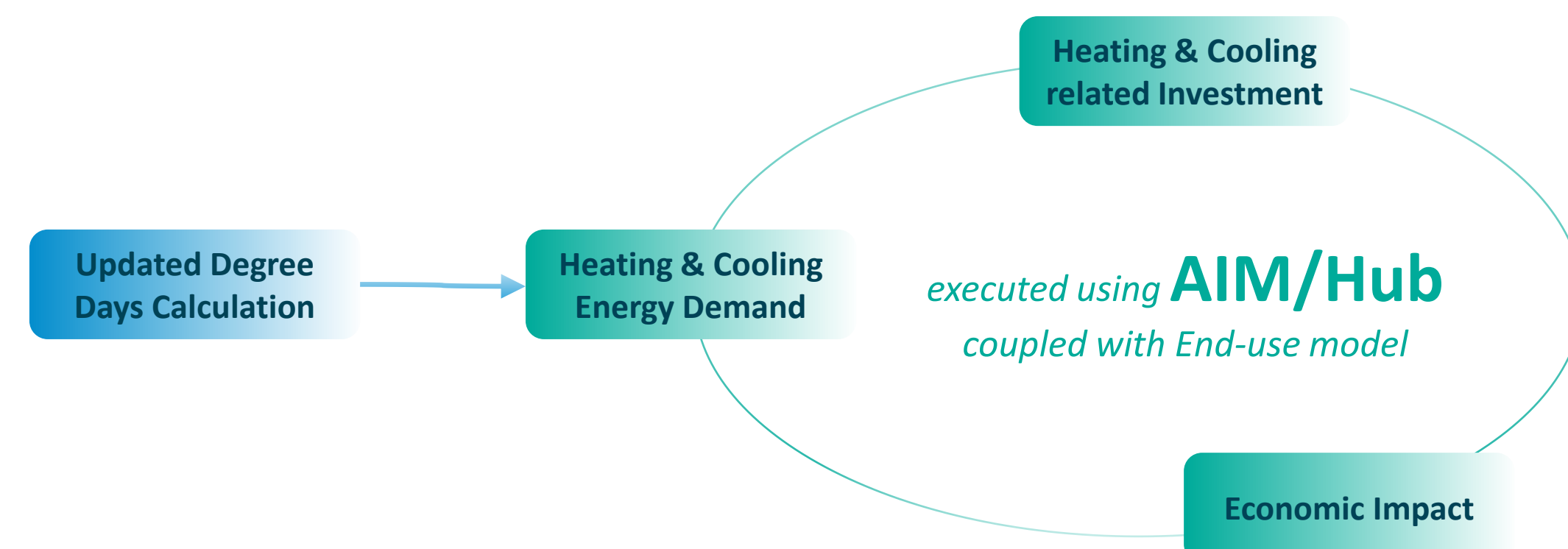


$$CDD = \begin{cases} \bar{T} - T_b & T_{min} \geq T_b \\ 0.5 \cdot \Delta T_{max} - 0.25 \cdot \Delta T_{min} & T_{max} > T_b \text{ and } \Delta T_{max} > \Delta T_{min} \\ 0.5 \cdot \Delta T_{max} & T_{min} < T_b \text{ and } \Delta T_{max} < \Delta T_{min} \\ 0 & T_{max} \leq T_b \end{cases}$$

$$HDD = \begin{cases} \bar{T} - T_b & T_{max} \leq T_b \\ 0.5 \cdot \Delta T_{max} - 0.25 \cdot \Delta T_{min} & T_{min} < T_b \text{ and } \Delta T_{max} < \Delta T_{min} \\ 0.5 \cdot \Delta T_{min} & T_{max} > T_b \text{ and } \Delta T_{max} > \Delta T_{min} \\ 0 & T_{min} \geq T_b \end{cases}$$

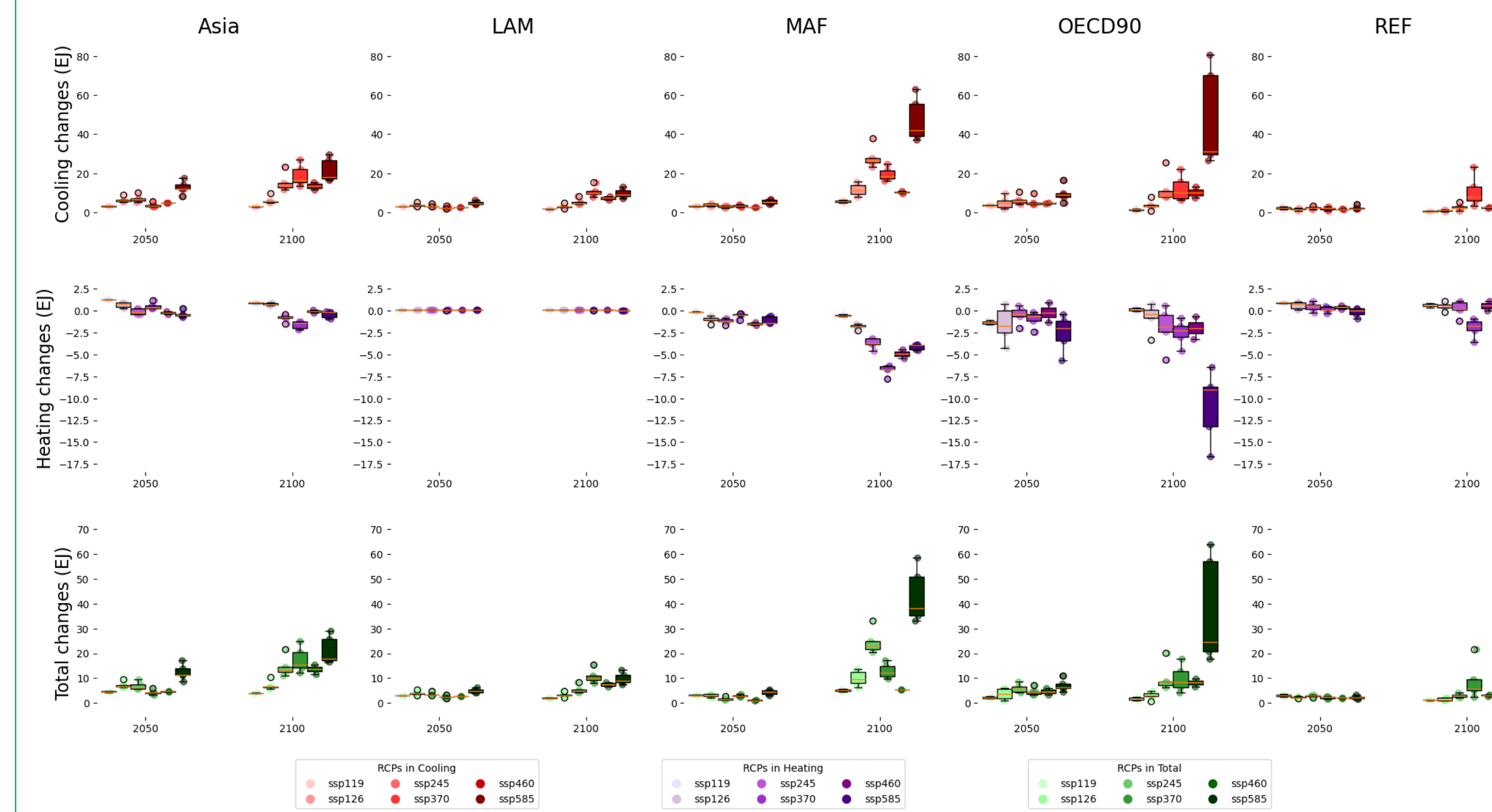
2. AIM/Hub

	Temperature Index (CDD only)	DD Calculation Technique	Detailed
Base	Temperature	ASHRAE	Dataset : CMIP6 • Model : GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0, UKESM1-0-LL • Variable : Daily mean temperature / Relative Humidity / maximum & minimum temperature • Scenario : SSP119, SSP126, SSP245, SSP370, SSP460, SSP585
WBGT X ASHRAE	WBGT	ASHRAE	
UKMO	Temperature	UKMO	
WBGT X UKMO	WBGT	UKMO	

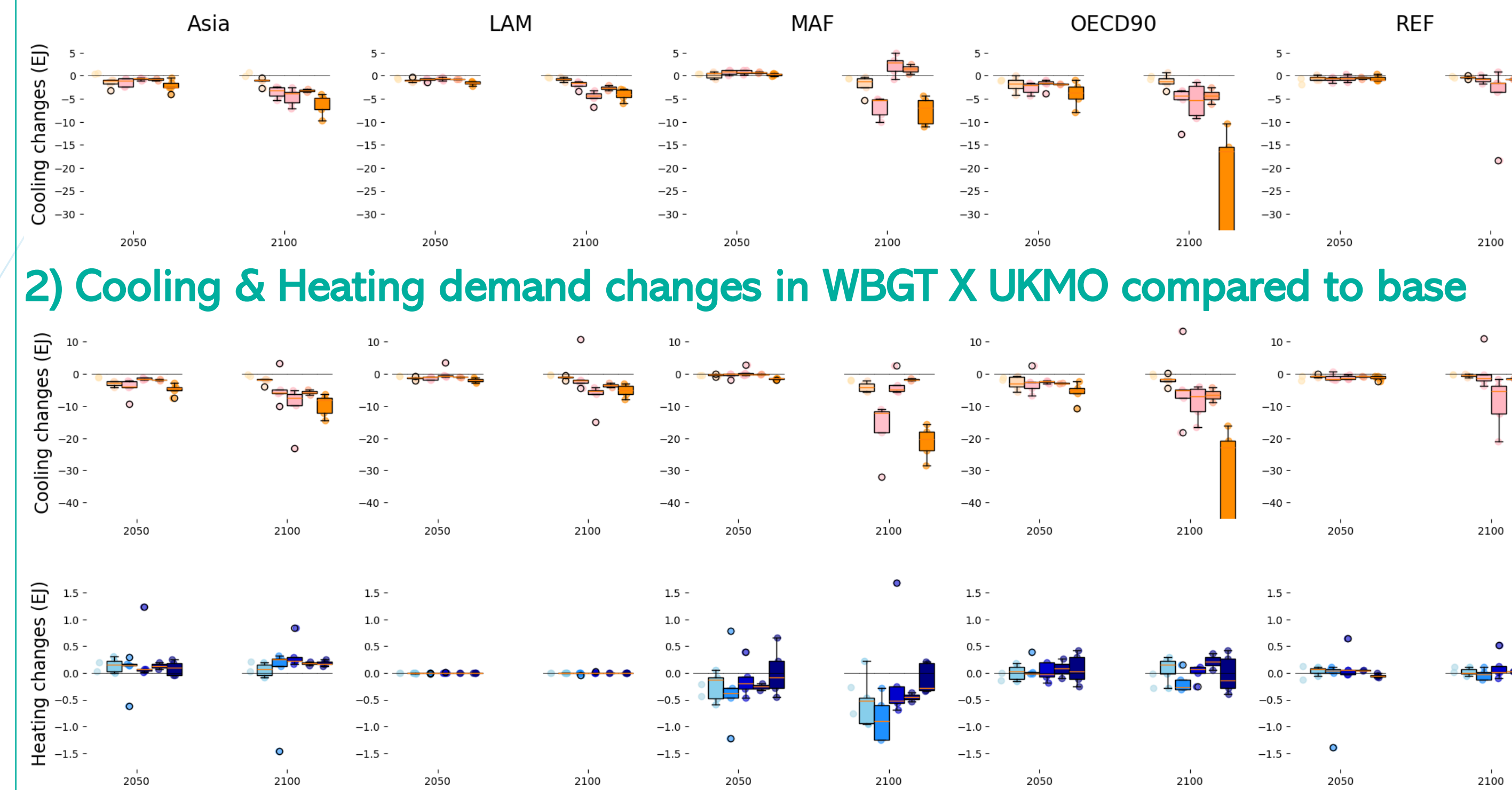


Results (1) : Energy Demand Changes in Cooling & Heating

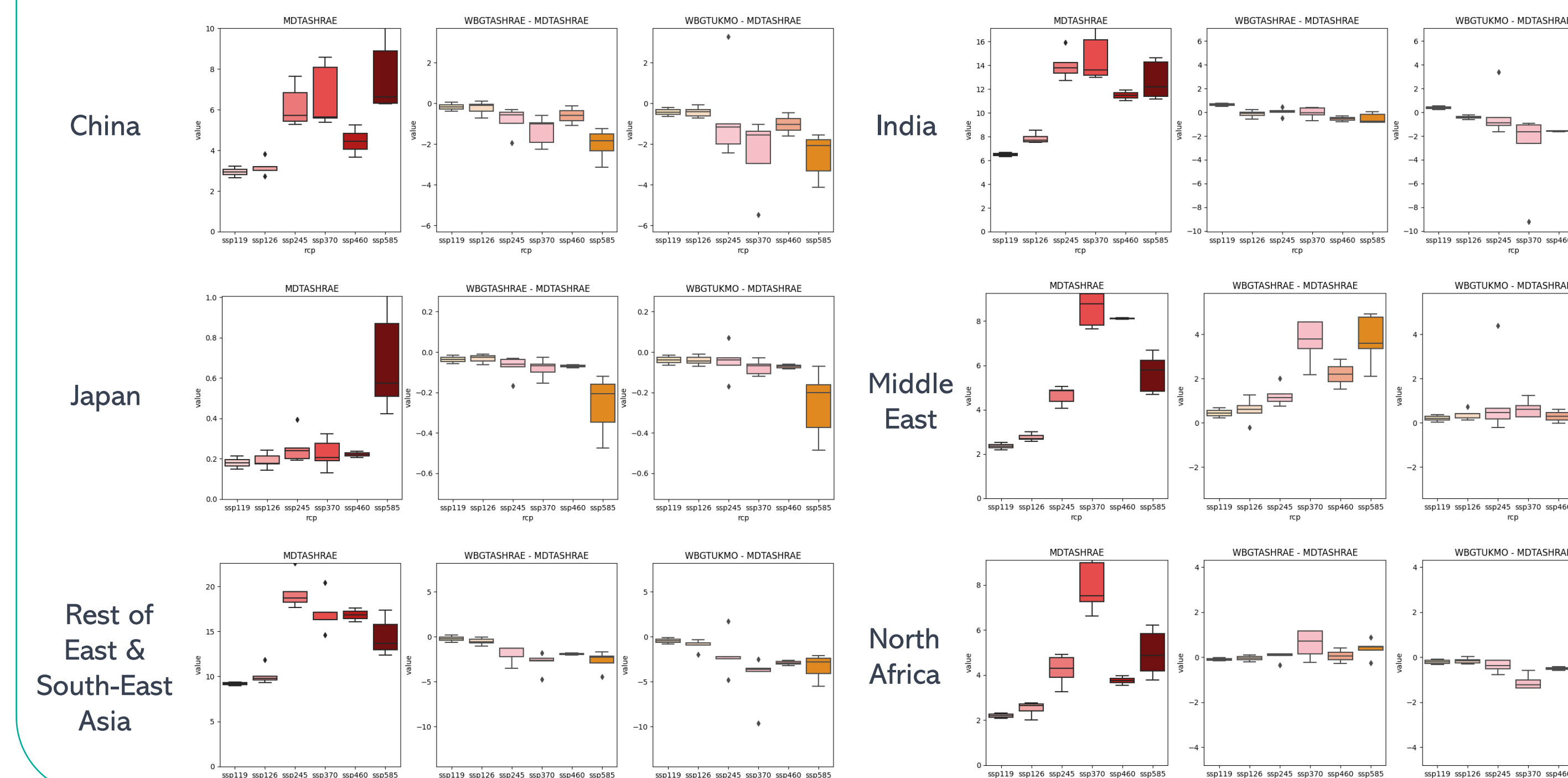
Previous approach (temperature alone with ASHRAE)



1) Cooling demand changes in WBGT X ASHRAE compared to base



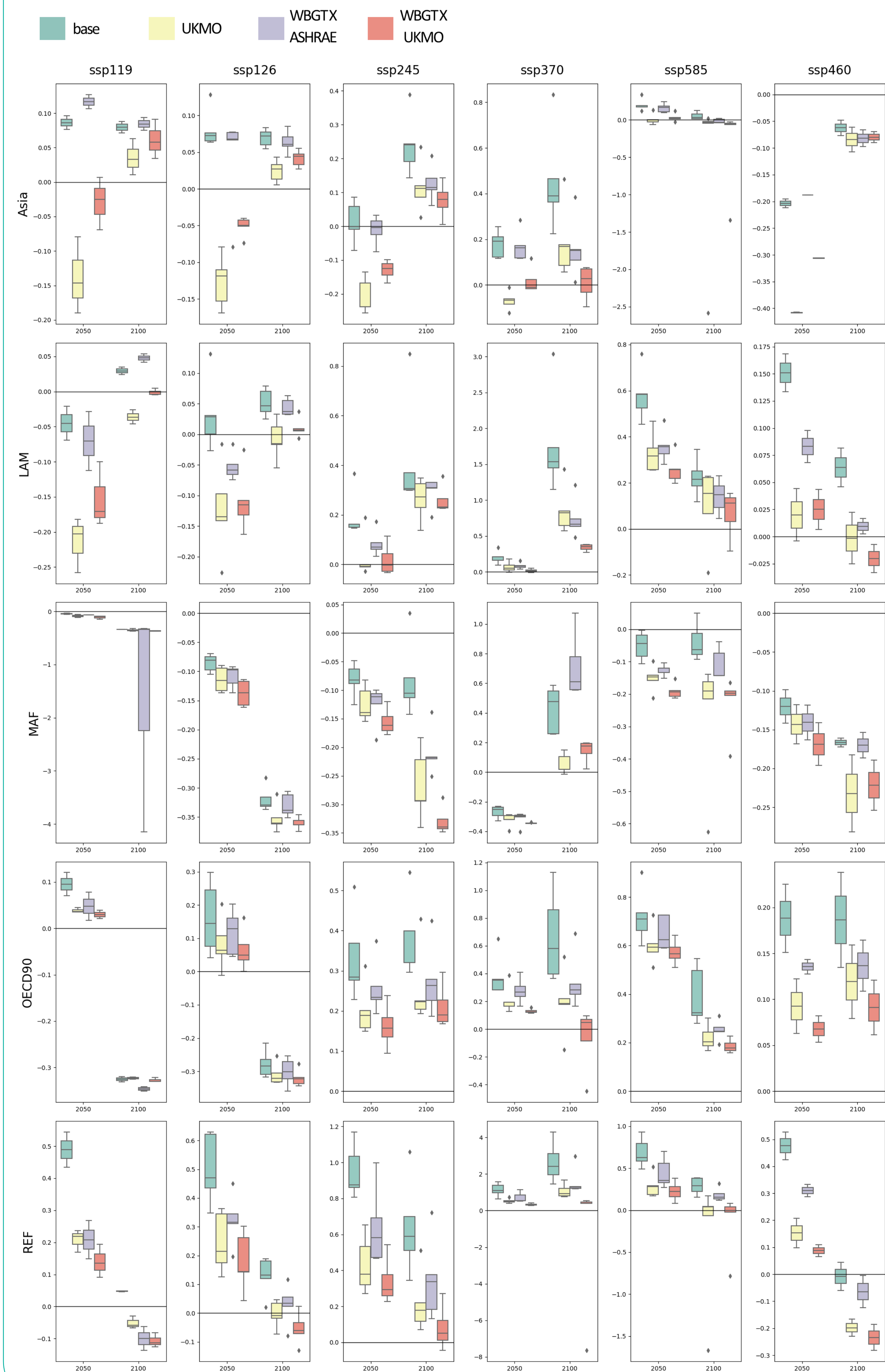
2) Cooling & Heating demand changes in WBGT X UKMO compared to base



Results (2) : GDP changed due to energy demand changes

GDP changes : compared to no climate change in each region and scenario

(negative value means GDP loss due to energy demand changes)



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