Integrating IAV Concepts into IAMs

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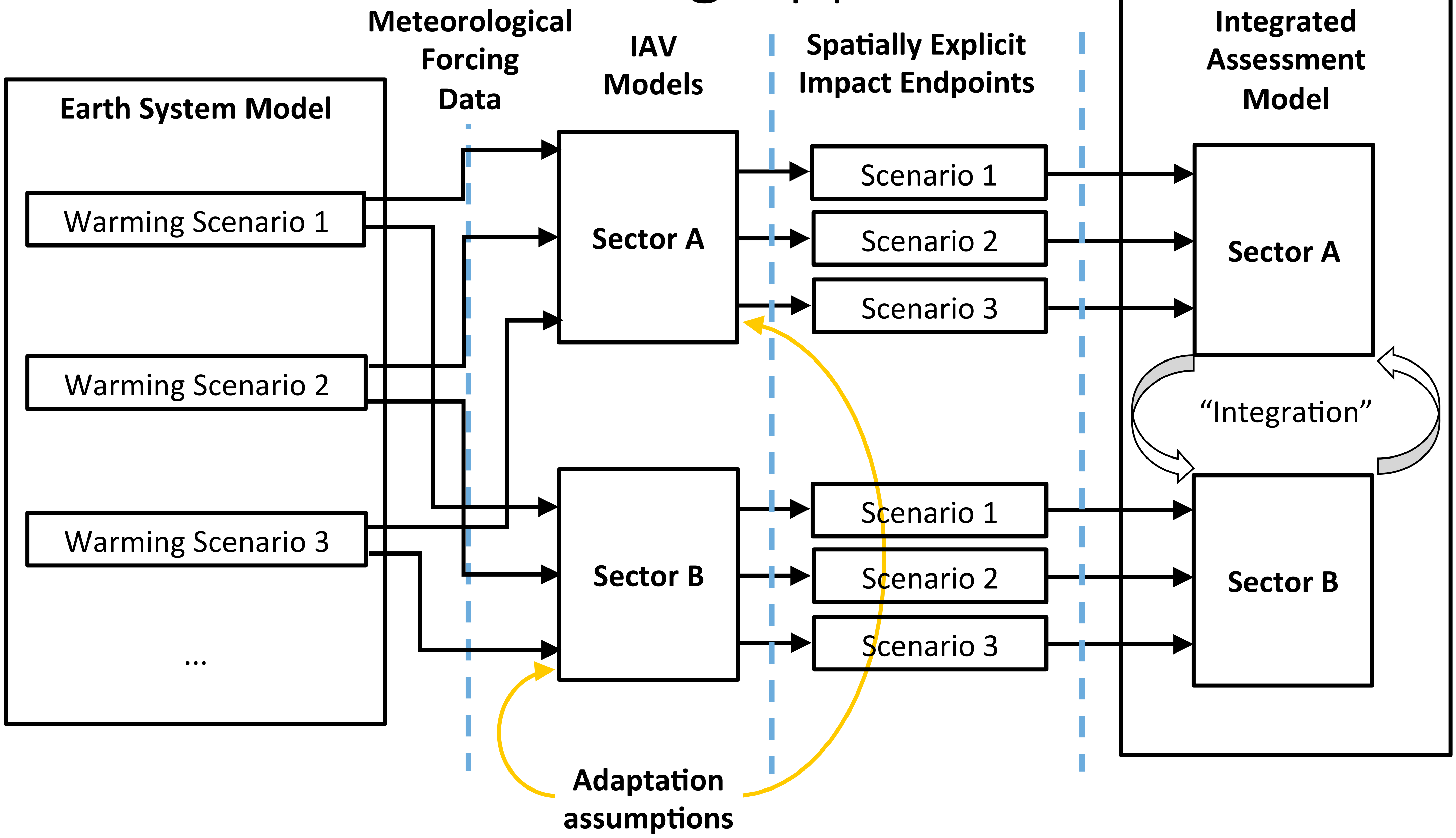
The "Process Modeling Approach"



Challenges

<u>Computational expense</u>

IAV models can be expensive to run

<u>Infexibility</u>

To accommodate meteorological projections by different ESMs, or use different scenarios, requires re-running models

<u>“Lock-in”</u>

All results downstream of IAV models are ESM x IAV model specific, raises the obtain more generic responses

Start from IAMs' economic representation of sectors

In sector j in location l at future time period t', output (Q) generated from inputs of capital (K), labor (L), energy (E) and materials (M)

$$Q_{j,l,t'} = A_{j,l,t'}^{Q} \cdot F\left[A_{j,l,t'}^{K} \cdot K_{j,l,t'}, A_{j,l,t'}^{L} \cdot L_{j,l,t'}, A_{j,l,t'}^{E} \cdot E_{j,l,t'}, A_{j,l,t'}^{M} \cdot M_{j,l,t'}\right]$$

As are associated sector x input x location-specific productivity parameters. For example, A^{ω} may be set = 1 in some baseline future without climate change, but value will decline below 1 with adverse impact

Initial challenge is figuring out what inputs in a particular sector are affected in what ways by a particular category of impact

Key step is to abstract from the details of the IAV model to characterize the

Focus is on developing reduced form representation of shocks

Productivity of input ω is the impact endpoint of interest, and can be expressed as a function of meteorological forcing variables—e.g., temperature (T) and precipitation (P)

$$A_{j,t}^{\omega} = h_{j}^{\omega}\left[T_{t}, T_{t-1}, T_{t-2}, \ldots; P_{t}, P_{t-1}, P_{t-2}, \ldots; \ldots\right]$$

h is a response function representation of the IAV model, which is what we refer to as an emulator

How to obtain $h[\cdot]$? (1)

<u>Estimation phase</u>

This has been the purview of the empirical climate change economics literature that has rapidly been developing over the past decade

Main methodological contribution is cross-section/time-series statistical model. Given observations of impact endpoints Y at locations l over historical time periods t,

$$Y_{l,t} = \alpha_l + g(t) + \Phi[T_{l,t}; \boldsymbol{\beta}^T] + \Psi[P_{l,t}; \boldsymbol{\beta}^P] + \varepsilon_{l,t}$$

where Φ and Ψ are nonlinear functions of temperature and precipitation, parameterized by the vectors of estimated coefficients $\boldsymbol{\beta}^T$ and $\boldsymbol{\beta}^P$

How to obtain $h[\cdot]$? (2)

<u>Projection phase</u>

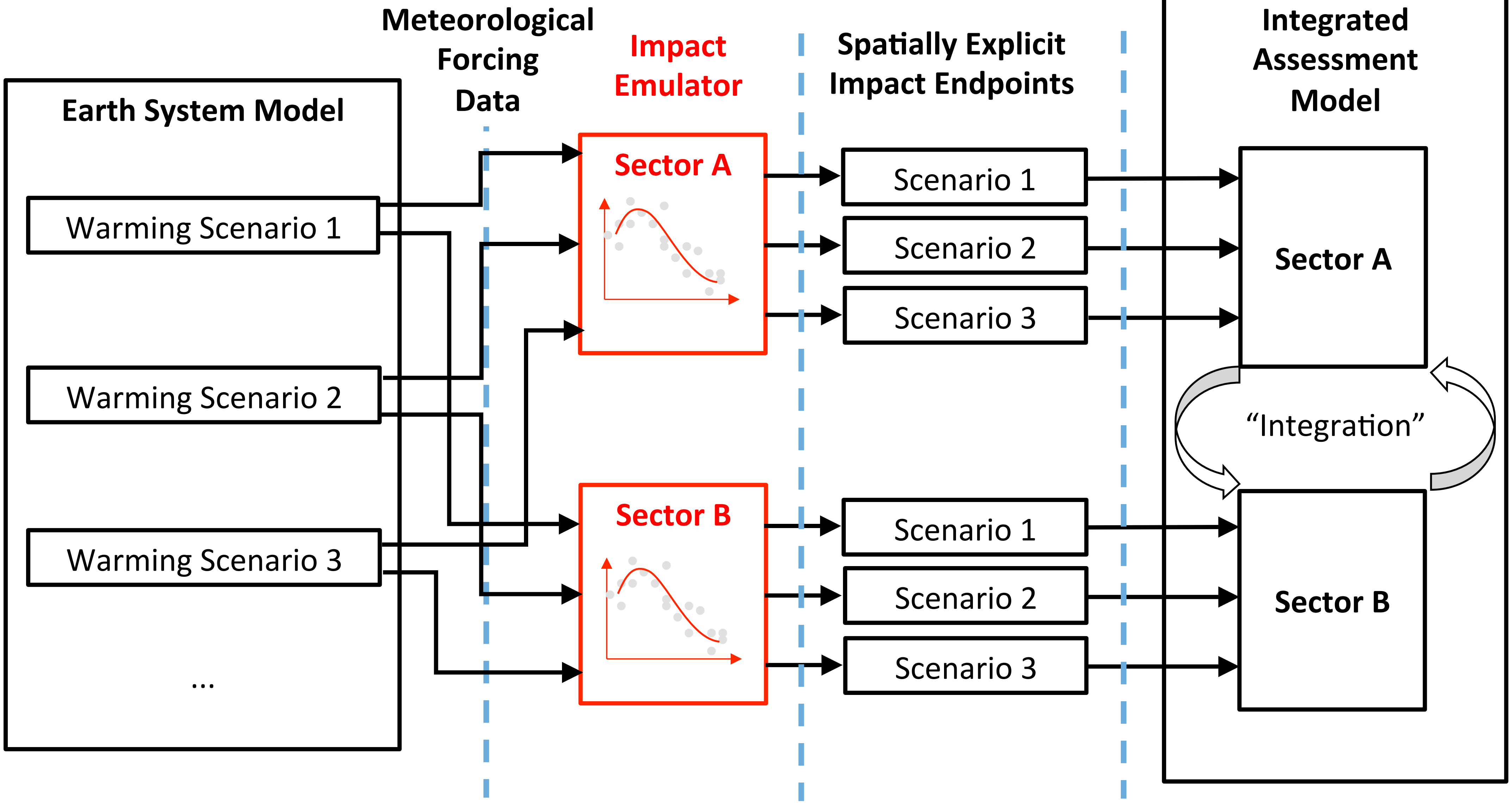
For any future period (with a changed climate), the change in the impact endpoint due to pure effect of a shift in the climate from present-day average is the difference in the fitted meteorological response component

$$\Delta Y_l = Y_{l,t}' - Y_l = \Phi[T_{l,t}' ; \boldsymbol{\beta}^T] - \Phi[T_l ; \boldsymbol{\beta}^T] + \Psi[P_{l,t} ; \boldsymbol{\beta}^P] - \Psi[P_l ; \boldsymbol{\beta}^P]$$

NB. the validity of this approach depends on how well the function $g(\cdot)$ in the estimation phase captures the effects of historical adaptation

Imperfect controls lead to potential contamination of Φ and Ψ with the effects of adaptation, in which case shocks may understate pure climate impact response

The “Emulator Approach”



$h \sim$ agricultural supply

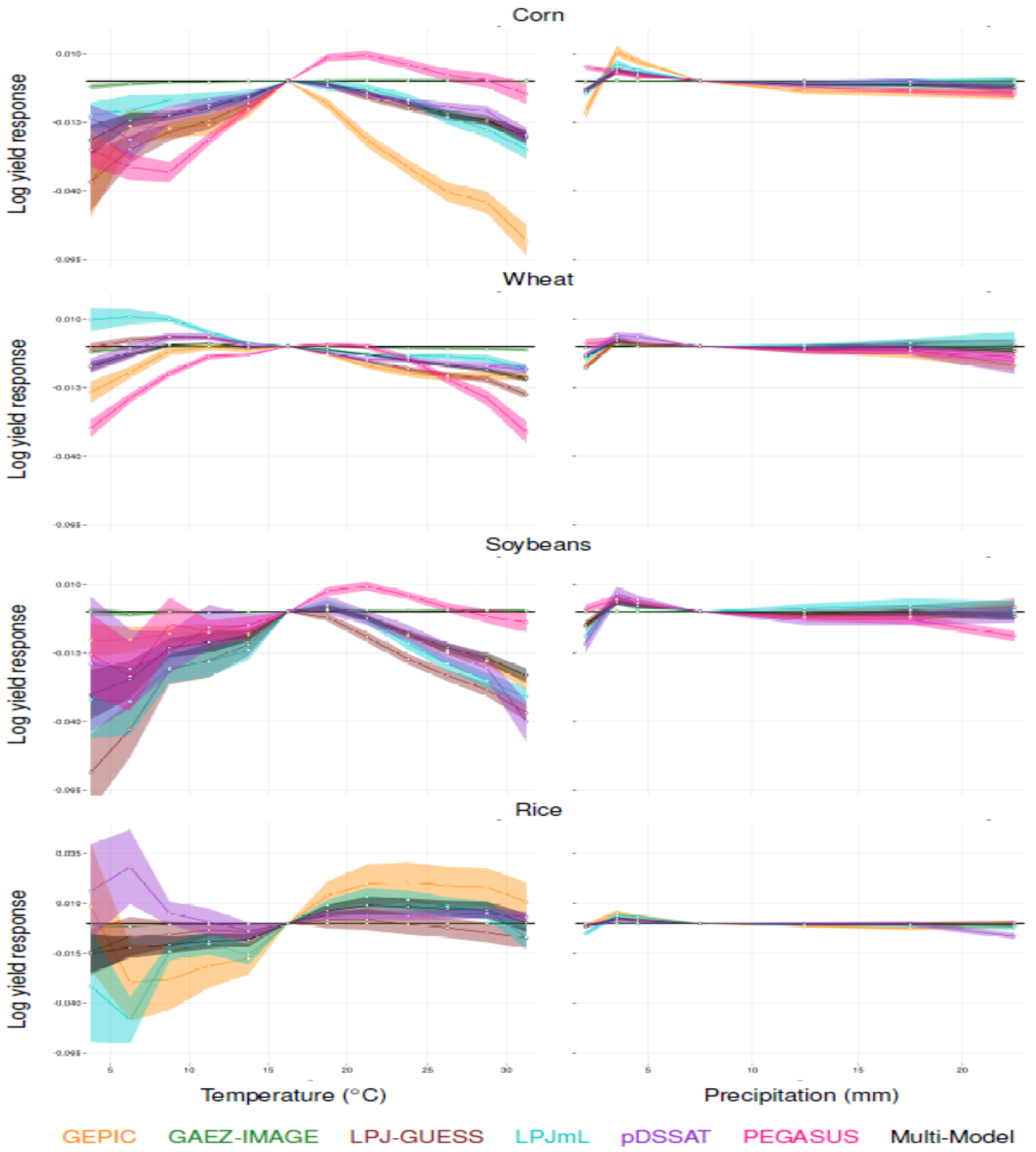
Y = yields, T and P taken from ISIMIP fast track archive, annually for 1972-2099

Control for CO2 fertilization effect by using constant-CO2 runs

Implemented as piecewise linear functions using counts of days in different T and P ranges over a fixed annual growing season

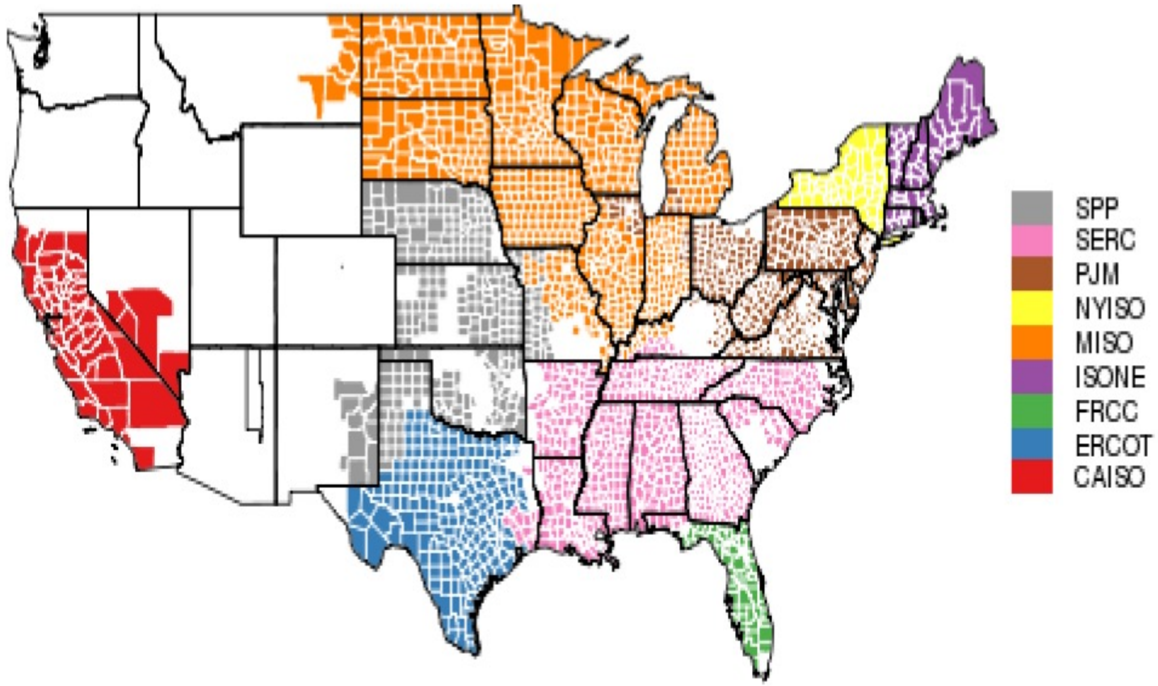
$$\log Y_{l,t} = \alpha_l + \tau_t$$
$$+ \Sigma_\kappa \beta_\kappa^T N_\kappa [T_{l,t}] + \Sigma_\lambda \beta_\lambda^P N_\lambda [P_{l,t}] + \varepsilon_{l,t}$$

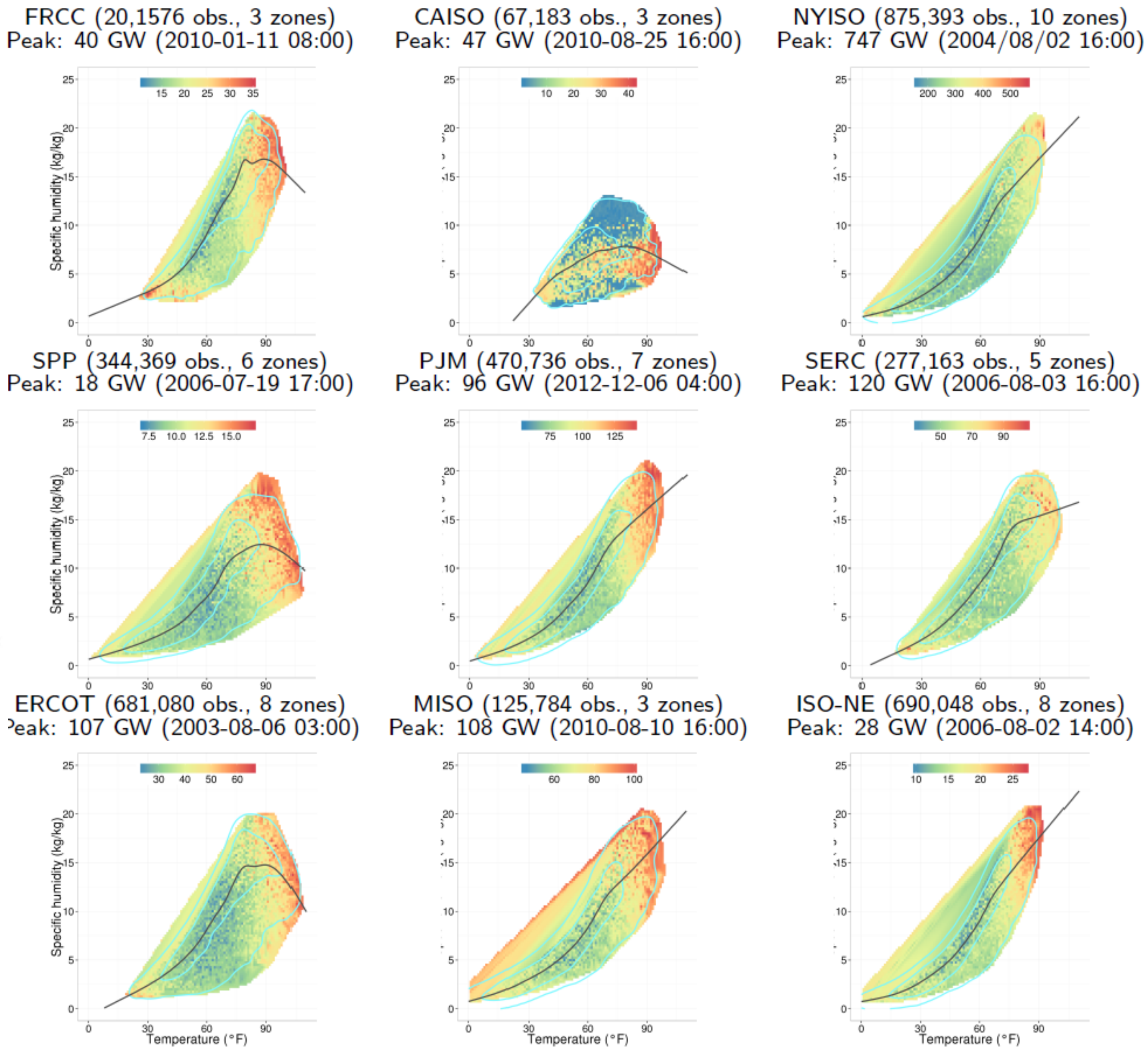
Question whether $\Delta \log Y_{l,t}$ should be implemented in IAMs as a neutral technology shock (A^Q) versus a shock to land productivity (A^{Land})



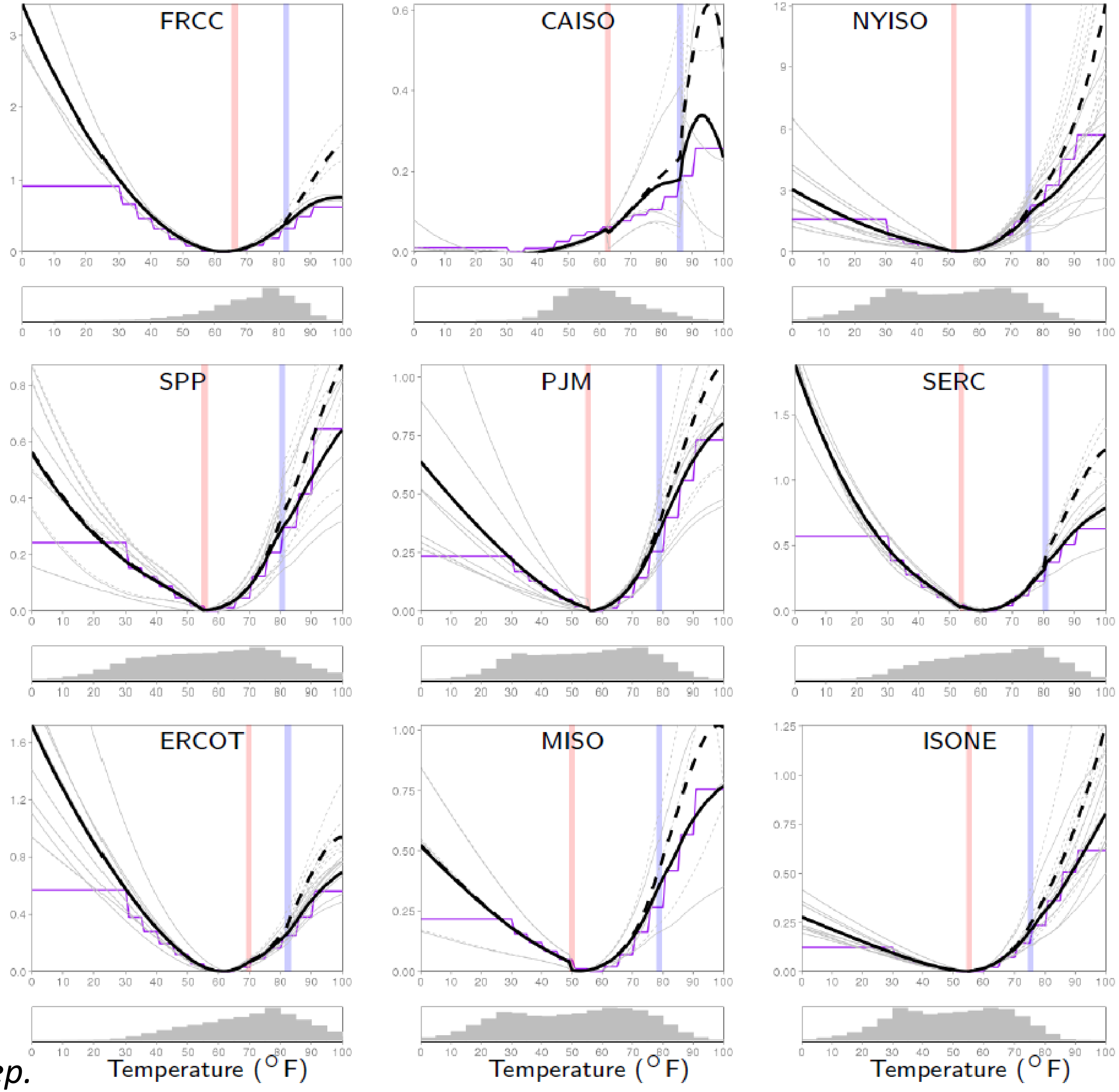
Mistry, De Cian and Sue Wing, *in prep.*

$h \sim$ electricity demand





Coffey and Sue Wing, *in prep.*



Coffey and Sue Wing, *in prep.*