Climate Emulators to Increase Access to Climate Information

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## Reliable and local climate information is not always easily accessible

- How much warmer will Boston be at the end of the 21st century with current policies? **5F? 10F? 20F?**
- What will be **the tide level** in the new Seaport district ($billions to build), which is at sea level currently?
- What will the **100-year return period storm** look like in the future in Boston?

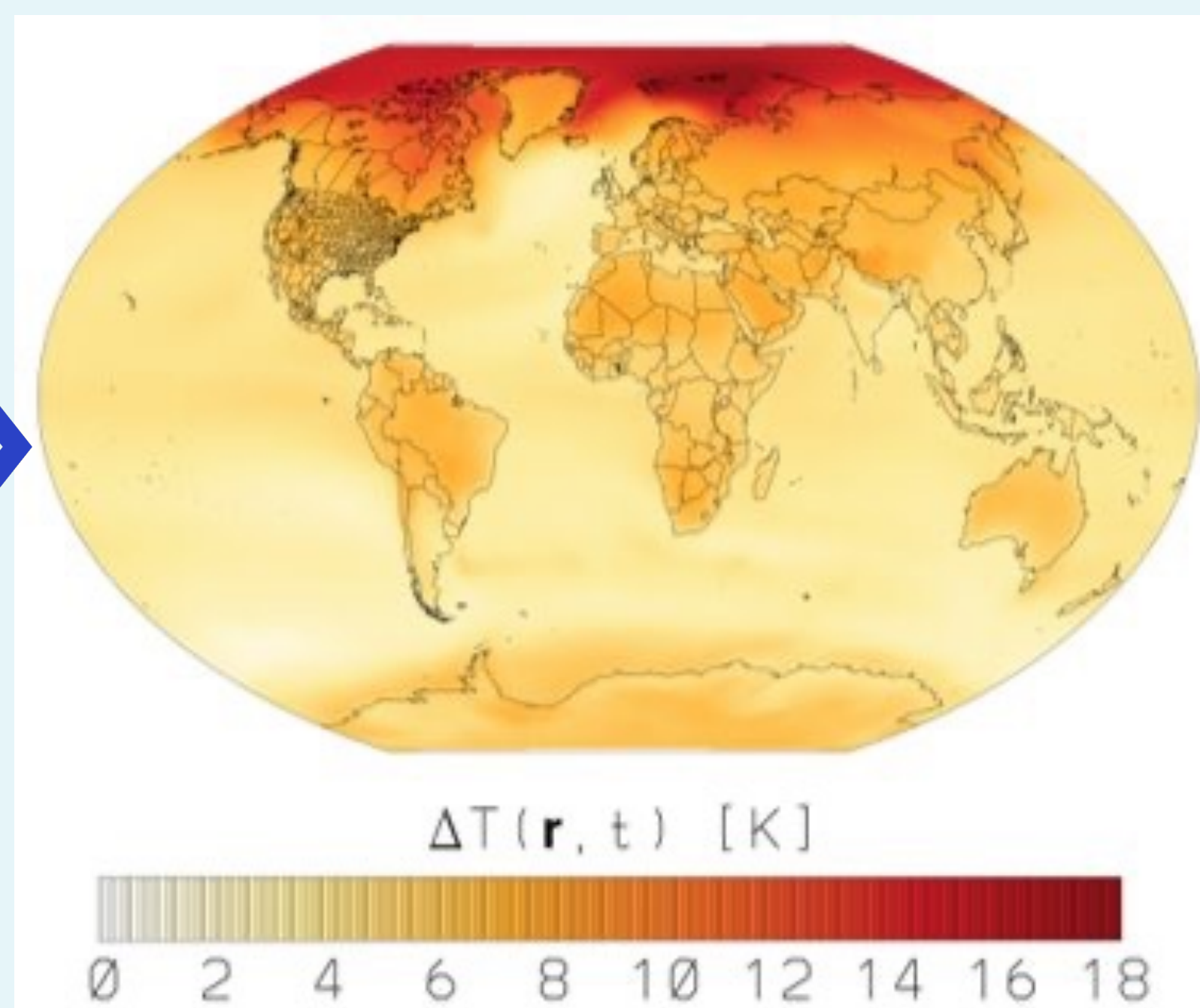Climate models are expensive...

... Emulators are not!

Bringing Computation the Climate Challenge (BC3) project

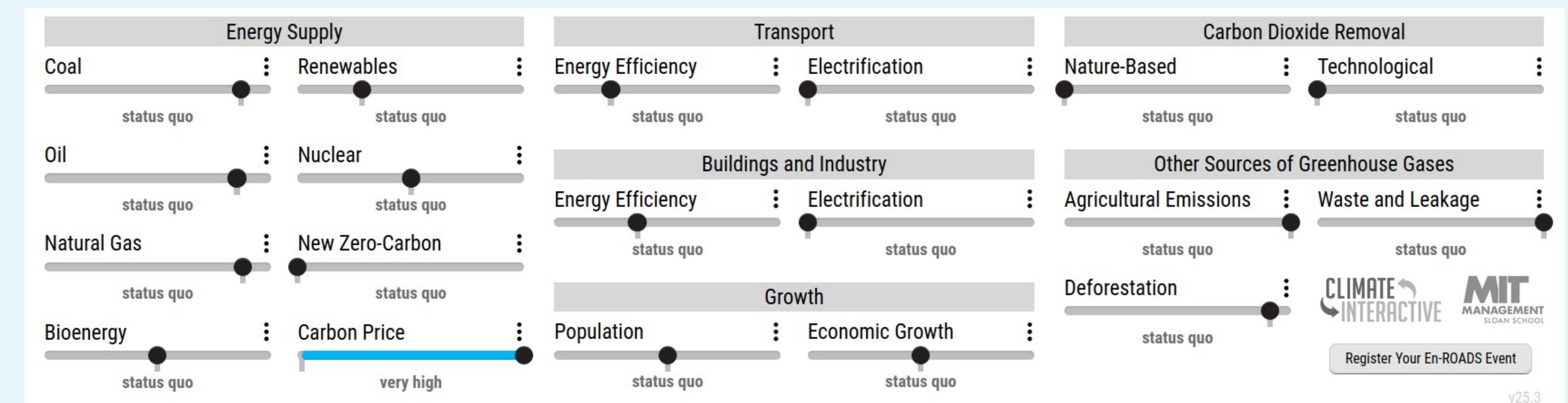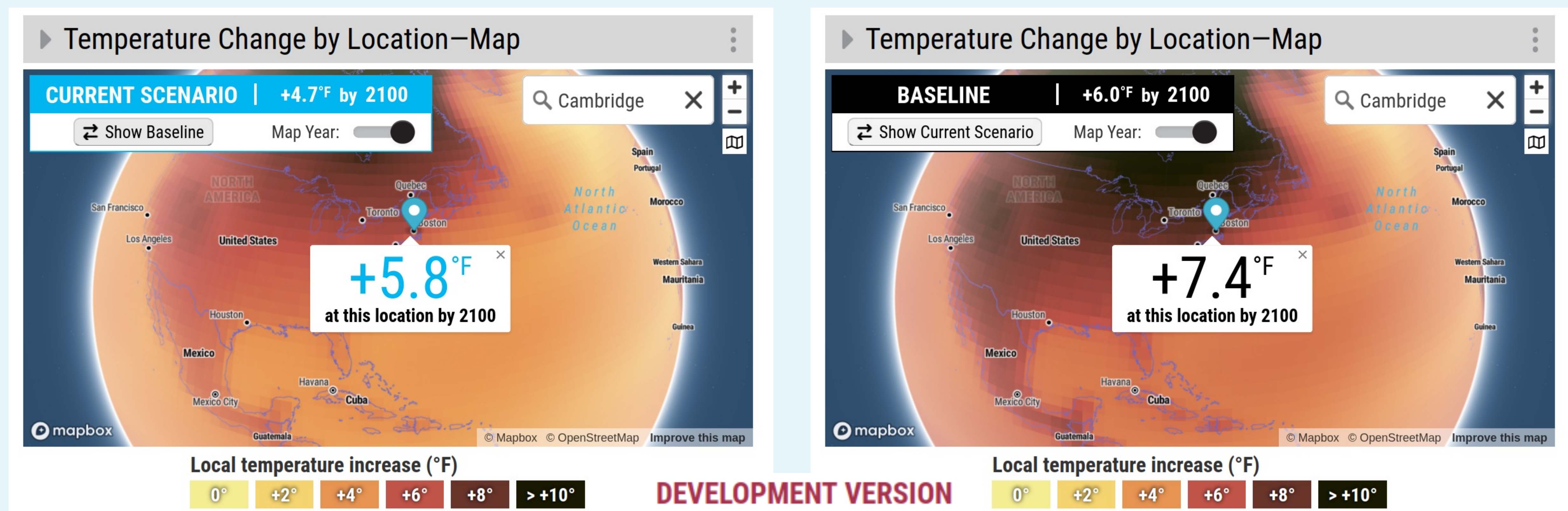Expensive projections from CMIP6 models
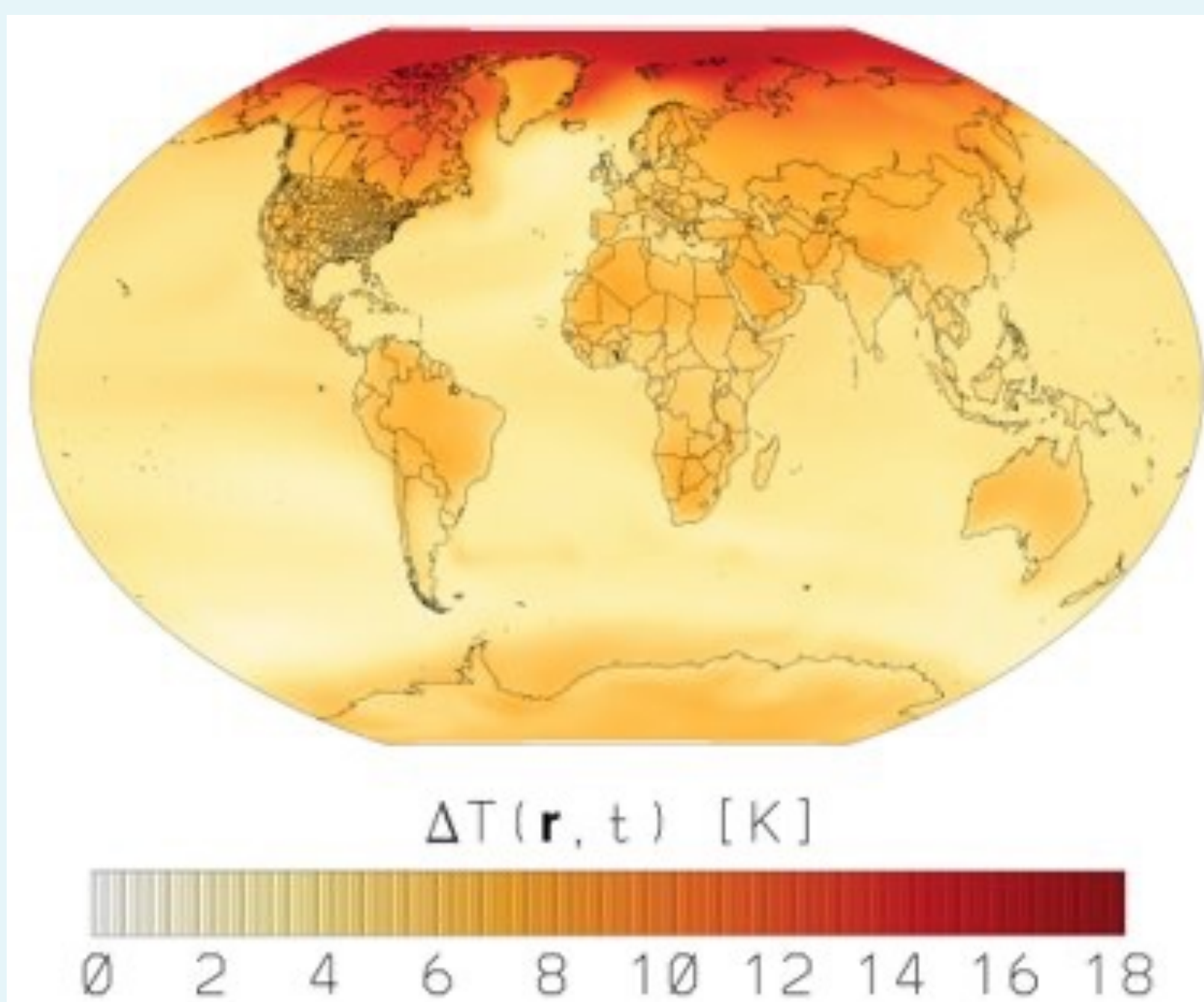
Fast projections from the BC3 team

$\Delta T(\mathbf{r}, t)$ [K]

0 2 4 6 8 10 12 14 16 18
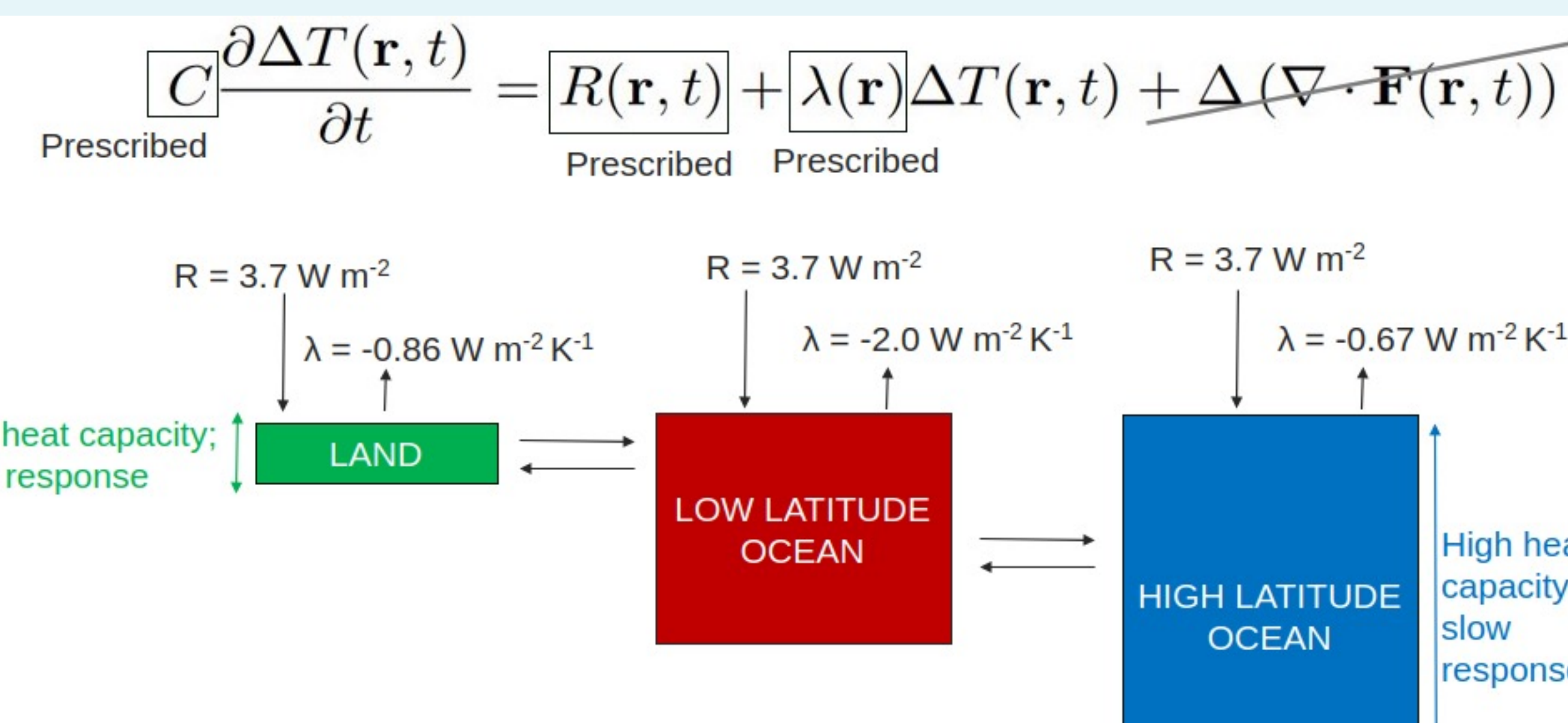
$\Delta T(\mathbf{r}, t)$ [K]

0 2 4 6 8 10 12 14 16 18

End-of-century (2085-2100) projections under a high emission scenario

The BC3 team is developing fast approximations of climate models

► Temperature Change by Location—Map

CURRENT SCENARIO | **+4.7°F by 2100**

Cambridge

Show Baseline   Map Year:

+5.8°F

at this location by 2100

Local temperature increase (°F)

0° +2° +4° +6° +8° > +10°

DEVELOPMENT VERSION

► Temperature Change by Location—Map

BASELINE | **+6.0°F by 2100**

Cambridge

Show Current Scenario   Map Year:

+7.4°F

at this location by 2100

Local temperature increase (°F)

0° +2° +4° +6° +8° > +10°

Energy Supply		Transport		Carbon Dioxide Removal	
Coal	Renewables	Energy Efficiency	Electrification	Nature-Based	Technological
status quo	status quo	status quo	status quo	status quo	status quo
Oil	Nuclear	Buildings and Industry		Other Sources of Greenhouse Gases	
status quo	status quo	Energy Efficiency	Electrification	Agricultural Emissions	Waste and Leakage
Natural Gas	New Zero-Carbon	status quo	status quo	status quo	status quo
status quo	status quo	Growth		Deforestation	
Bioenergy	Carbon Price	Population	Economic Growth	status quo	
status quo	very high	status quo	status quo		

CLIMATE INTERACTIVE   MIT MANAGEMENT SLOAN SCHOOL

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v25.3

I use idealized models and theory to answer the 'why' questions underlying emulators, for instance:

- Why is the North Pole warming 3x more than average?
- Why is land warming more than the ocean?

$$C\frac{\partial \Delta T(\mathbf{r}, t)}{\partial t} = R(\mathbf{r}, t) + \lambda(\mathbf{r})\Delta T(\mathbf{r}, t) + \Delta(\nabla \cdot \mathbf{F}(\mathbf{r}, t))$$

Prescribed   Prescribed Prescribed

R = 3.7 W m⁻²

$R = 3.7\ \mathrm{W\,m^{-2}}$ $R = 3.7\ \mathrm{W\,m^{-2}}$ $R = 3.7\ \mathrm{W\,m^{-2}}$

$\lambda = -0.86\ \mathrm{W\,m^{-2}\,K^{-1}}$ $\lambda = -2.0\ \mathrm{W\,m^{-2}\,K^{-1}}$ $\lambda = -0.67\ \mathrm{W\,m^{-2}\,K^{-1}}$

Low heat capacity; Fast response   LAND

LOW LATITUDE OCEAN

HIGH LATITUDE OCEAN

High heat capacity; slow response

For more info:

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BRINGING COMPUTATION TO THE CLIMATE CHALLENGE

Democratizing Access to Climate Data