Climate Feedbacks in Buildings: Coupling Building Energy Modeling with Spatially Explicit Scenarios of Climate Change and Population Migration in the USA and China

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Outline

- **Background**
  - Most future scenarios of energy demand do not consider the influence of climate change on building energy requirement
    How would heating and cooling requirement change in response to global climate change?
  - There is substantial uncertainty surrounding several key factors that influences the impact of climate change on heating/cooling requirement
    How would our understanding about climate policy, climate science, and population migration affect heating and cooling requirement?
  - Actual energy consumption depends on a range of economic and other factors
    How would the resulting space conditioning requirement influence building energy consumption when considering building energy demand in an integrated assessment framework?
- **Talk Structure**
  - Population-Weighted HDD/CDDs
  - Building Energy Modeling
  - Future Research

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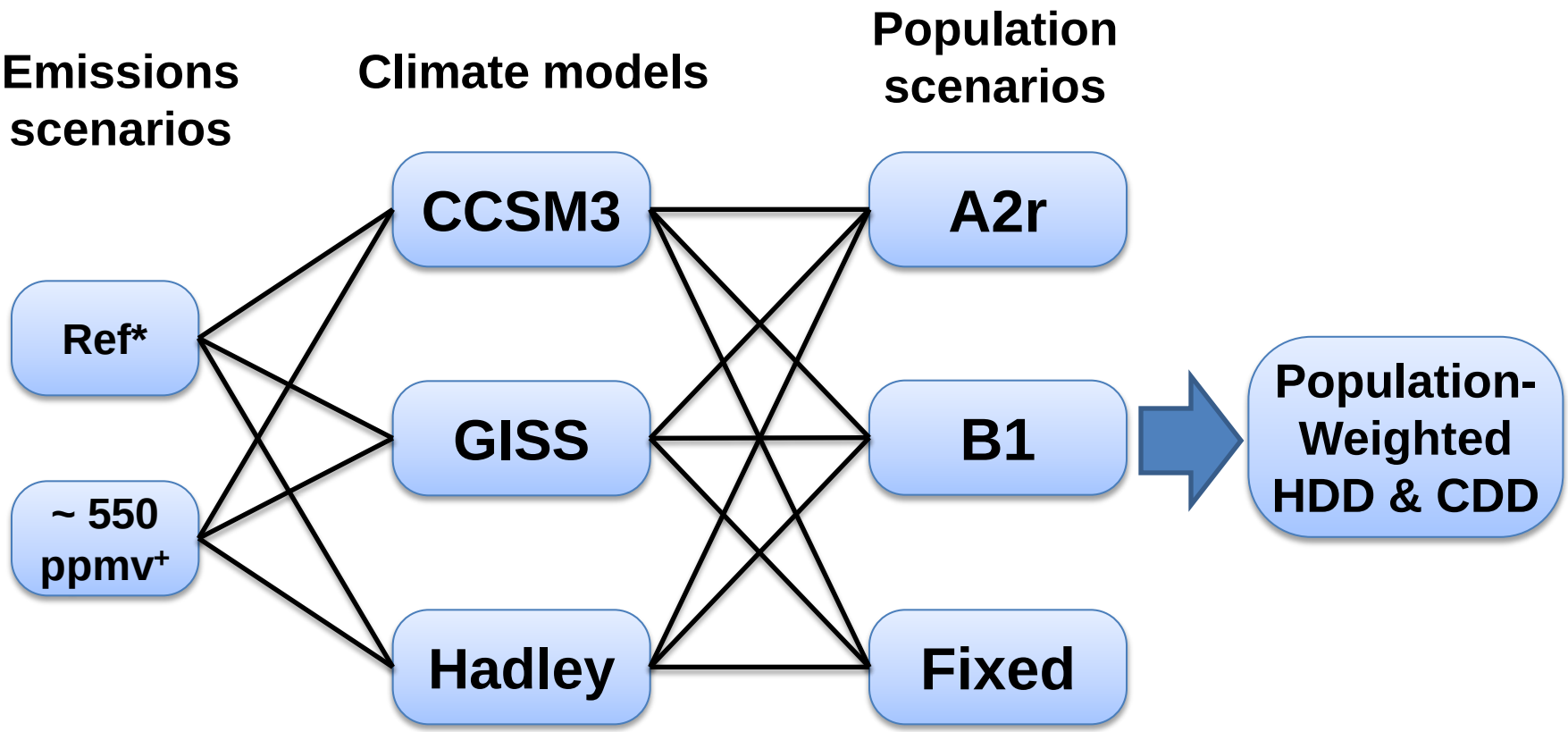
Population-Weighted HDD/CDDs

- Degree-days are the metrics by which heating and cooling requirement are typically described
- Degree-days are essentially the summation of temperature differences from a human comfort level over time. They capture both extremity and duration of outdoor temperatures.
- Heating degree day (HDD) and cooling degree day (CDD) are measured in “degree-days” below (HDD) or above (CDD) the set point (typically18^{o}C).
- HDD and CDD need to be “population-weighted” (or otherwise-weighted) to reflect regional aggregated heating and cooling requirement with a changing population distribution

Scenarios design

Totally 18 scenarios
+
Fixed HDD/CDD scenario



* Reference represented by IPCC SRES A2 scenario

+ 550 ppmv scenario represented by IPCC SRES B1 scenario

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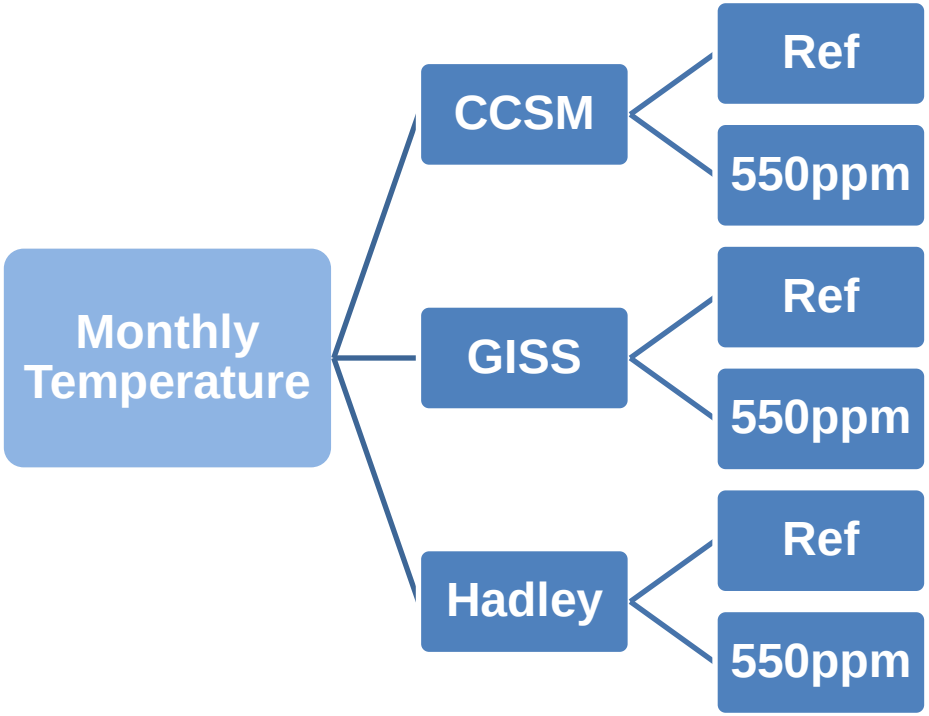
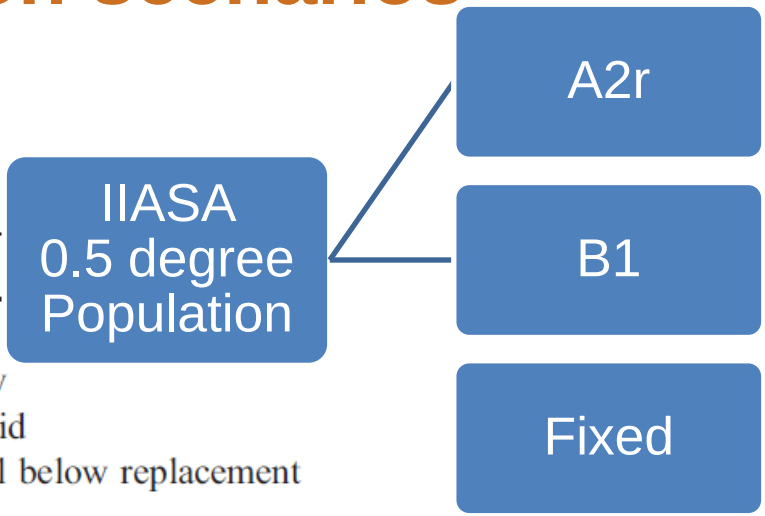
Three Climate Models
(0.5 degree and monthly temperature)

- **CCSM (#15)**
  - National Center for Atmospheric Research, USA (Collins et al., 2006)
- **GISS (#7)**
  - NASA/Goddard Institute for Space Studies, USA (Russell et al., 2000)
- **Hadley (#16)**
  - Hadley Centre for Climate Prediction and Research/Met Office, UK (Gordon et al., 2000)



Three population distribution scenarios (A2r, B1, Fixed)



	A2r	B1
Population		
Population size	High	Low
Demographic transition	Delayed and slow	Rapid
Long-term fertility levels	Near or below replacement	Well below replacement
Urbanization		
Urbanization rates	High	Low
Megacity growth	High	Low (constrained)
Urban–rural gradient	Medium–high	Converging to zero
Income		
Income growth	Medium–low	High
Income convergence	Very low (initially diverging)	Very rapid
Domestic/international price differences (for PPPs)	Initially persistent, slow convergence after 2040	Rapid convergence

Fixed scenario: we maintain the year 2000 population distribution.

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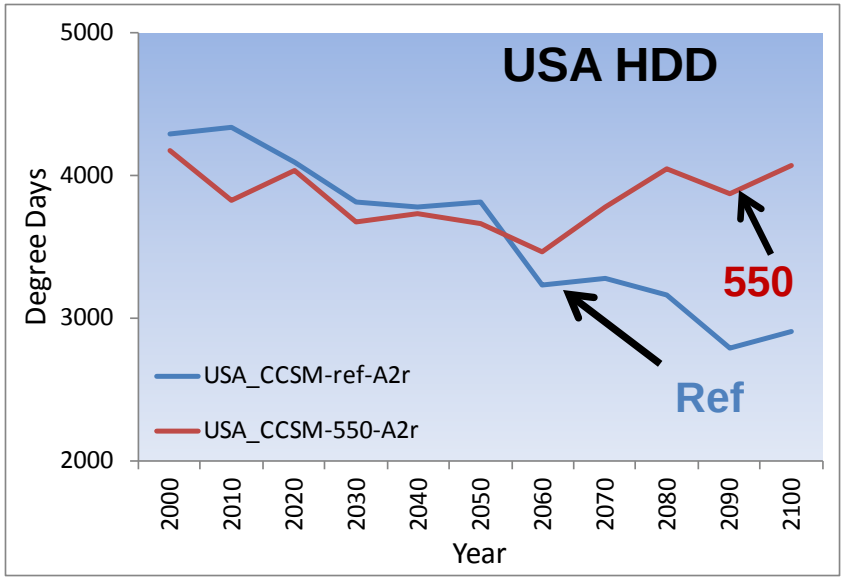
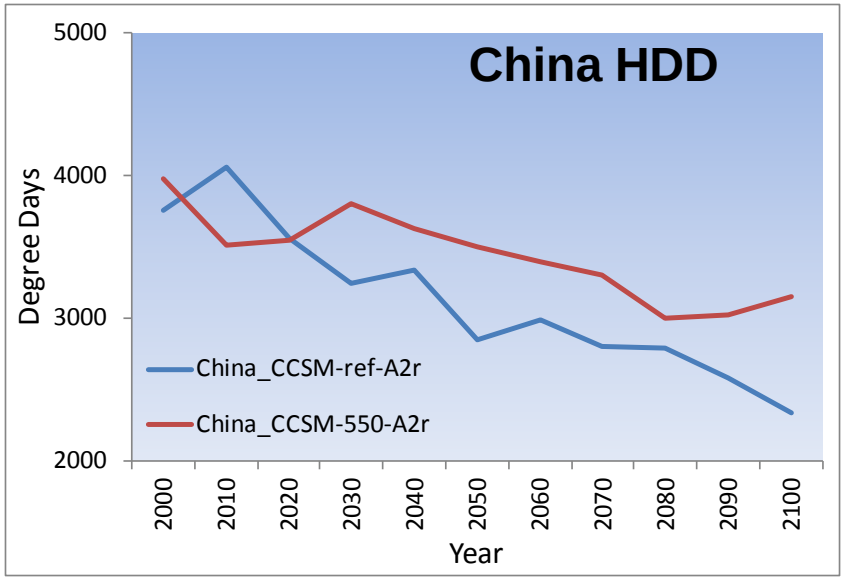
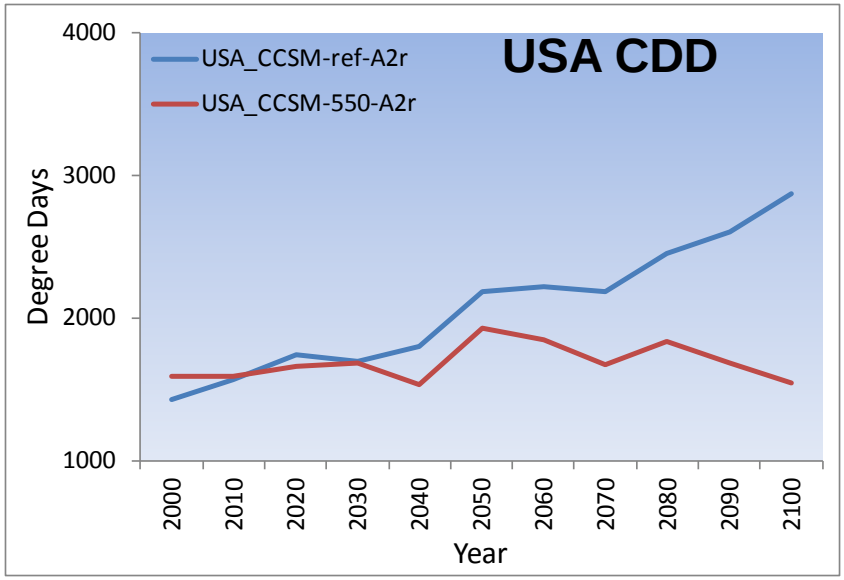
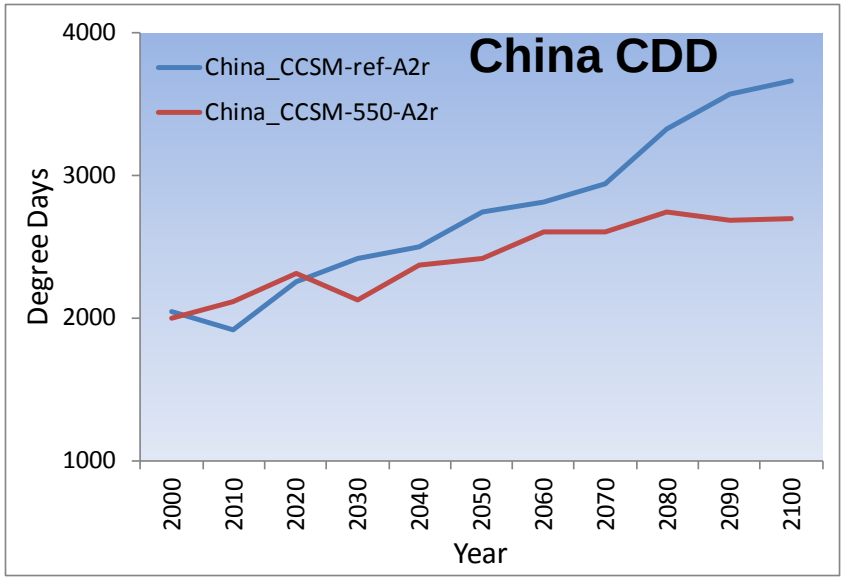
Source: A. Grübler et al. / Technological Forecasting & Social Change 74 (2007) 980–1029

Impact of climate policy (Ref & 550 ppm) on HDD/CDDs based on CCSM & A2r pop

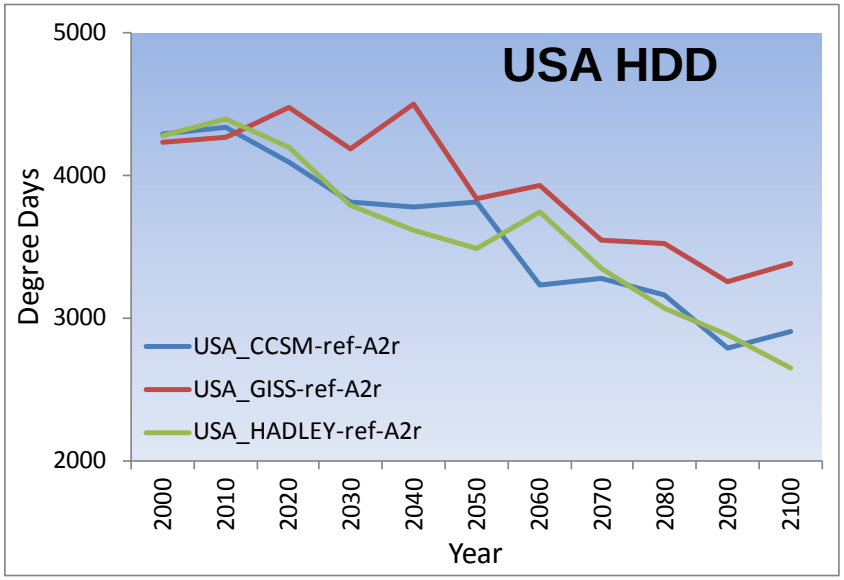


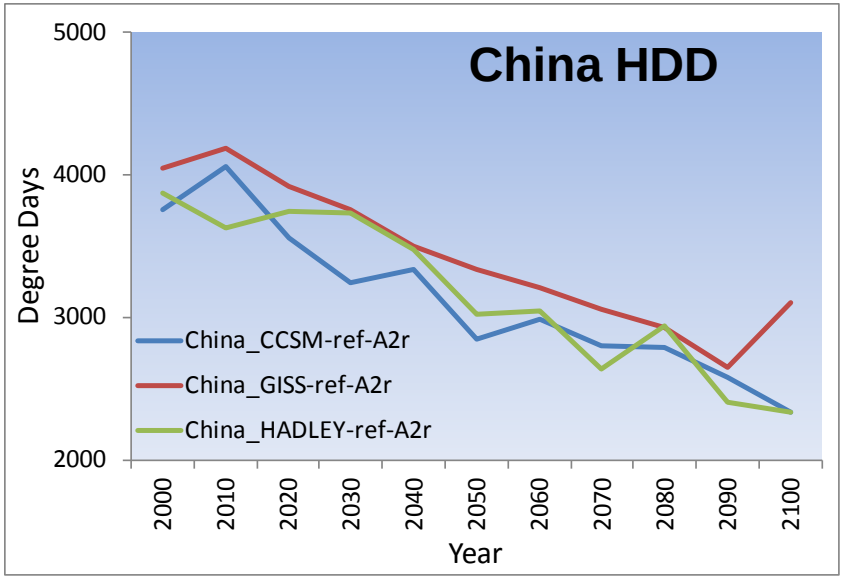


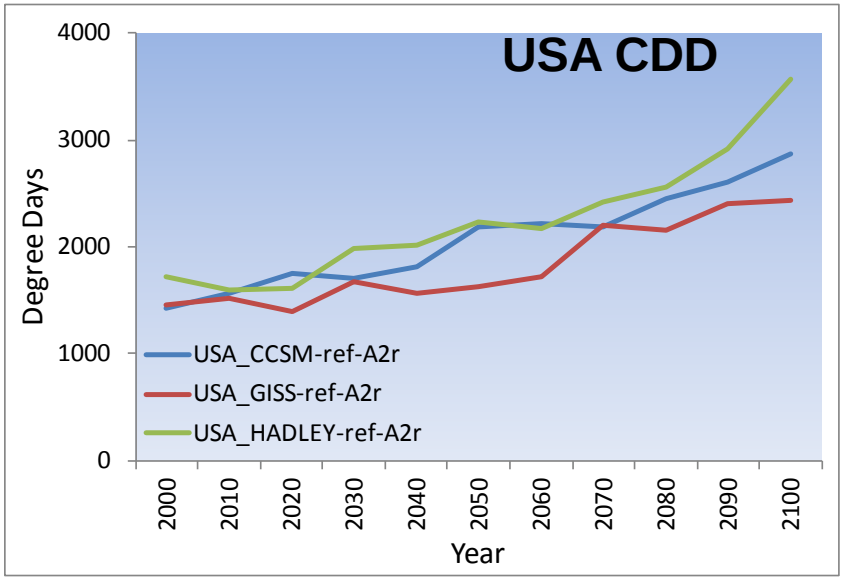


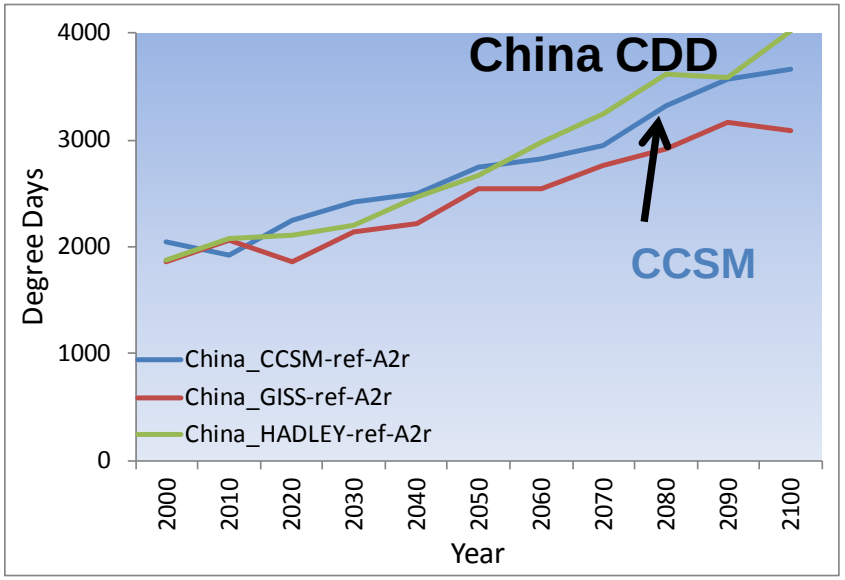


Impact of climate models (CCSM, GISS, & Hadley) on HDD/CDDs based on ref and A2r pop



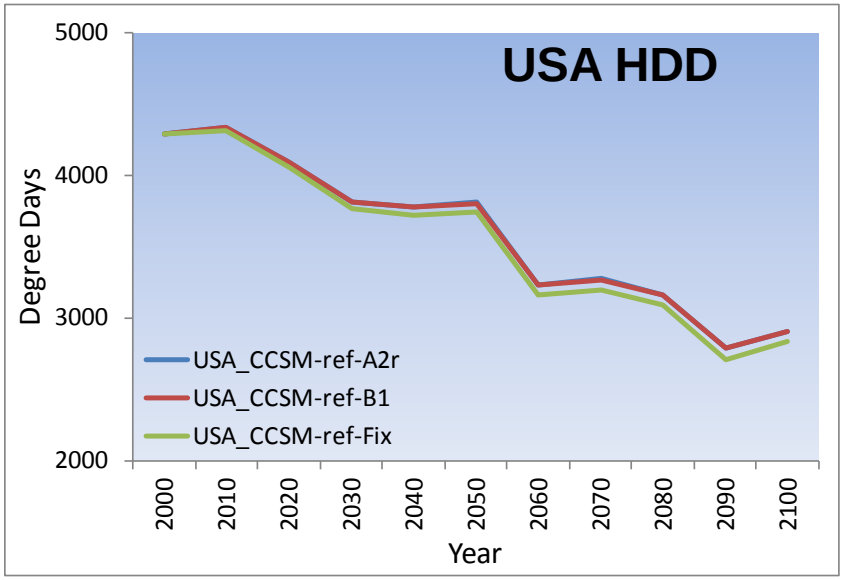


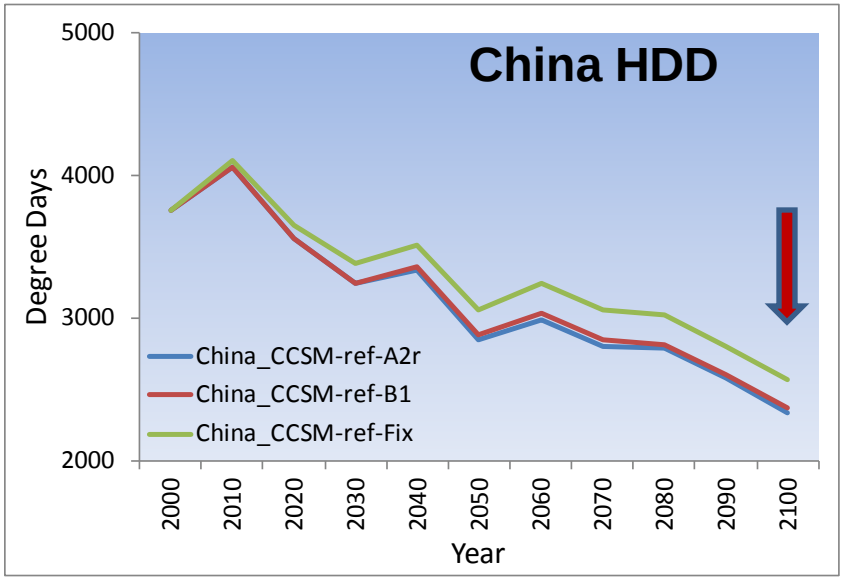


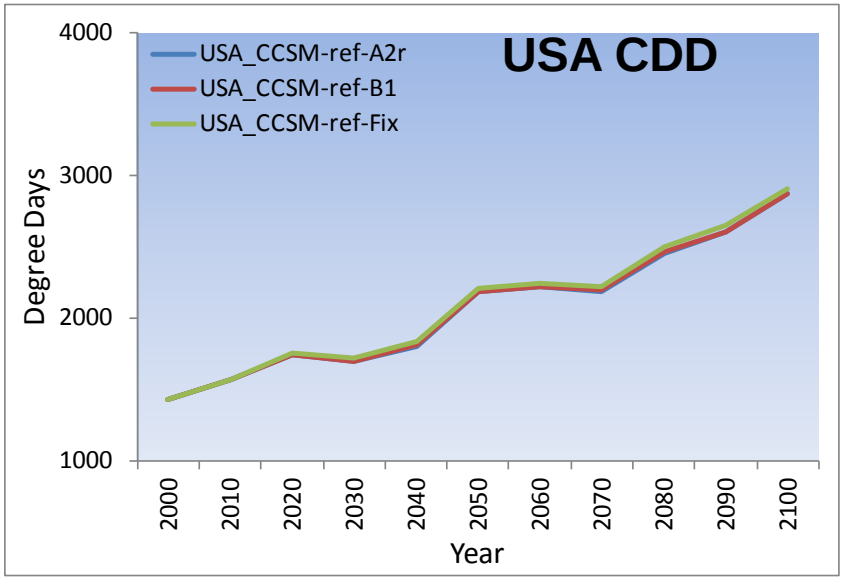


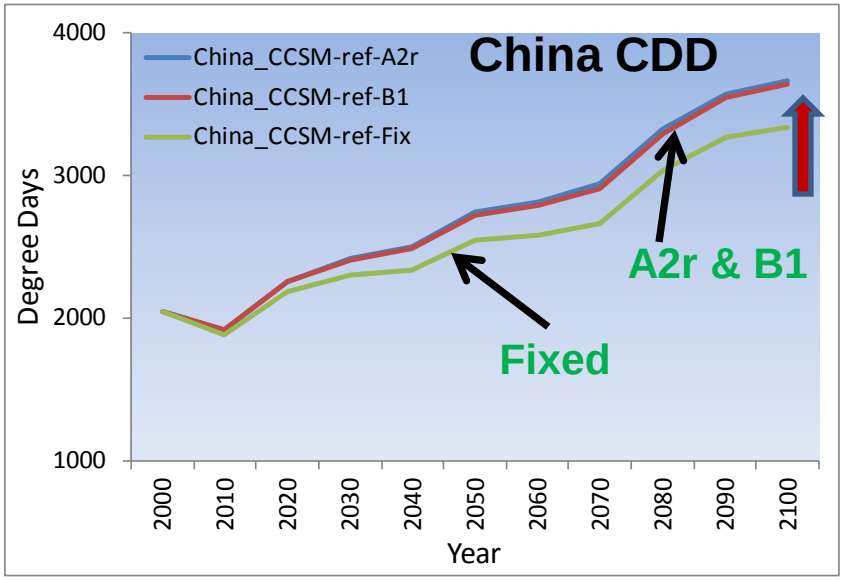
Impact of population scenarios (A2r, B1, & Fixed) on HDD/CDDs based on CCSM and ref

China: population move to warmer areas



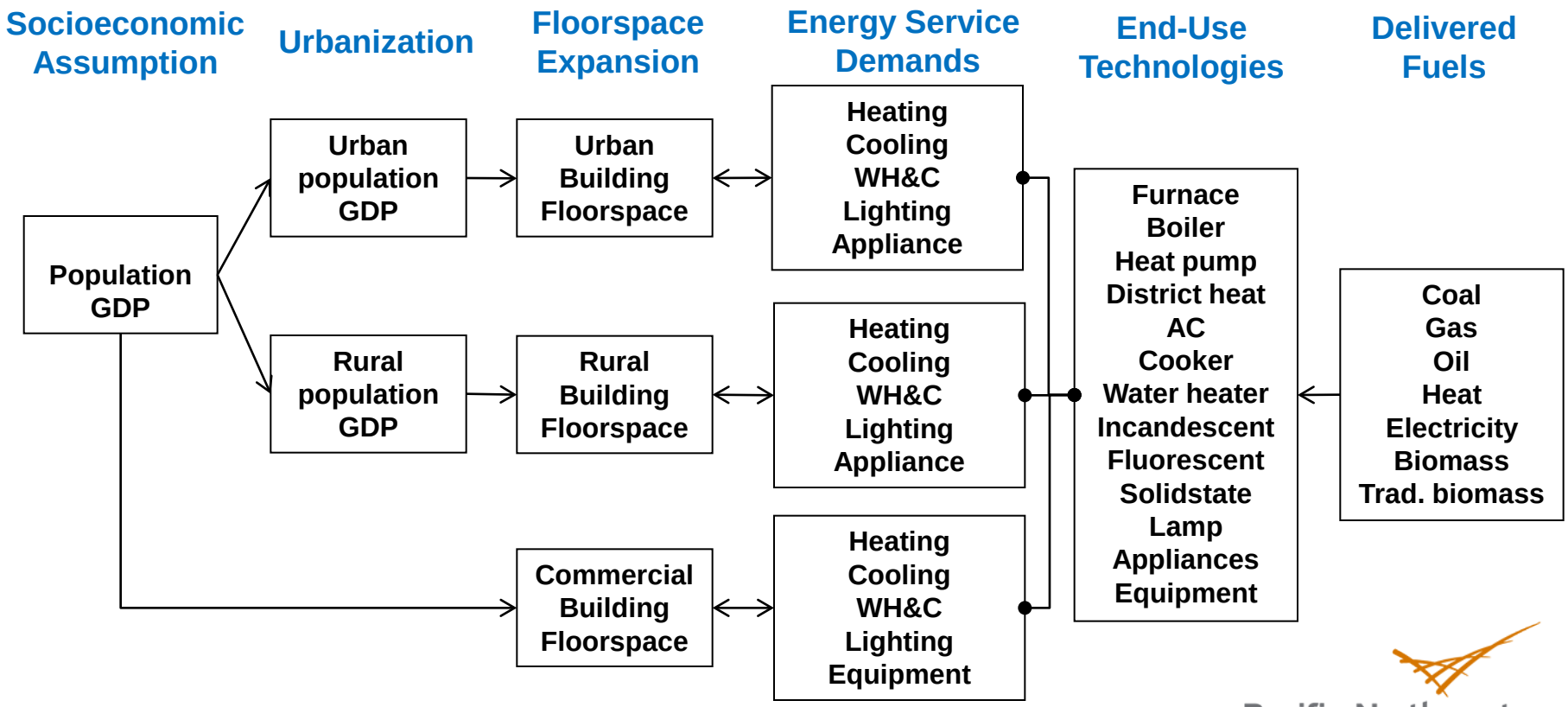






Building Energy Modeling

A detailed, service-based building energy model, nested in the long-term global integrated assessment framework, Global Change Assessment Model (GCAM)



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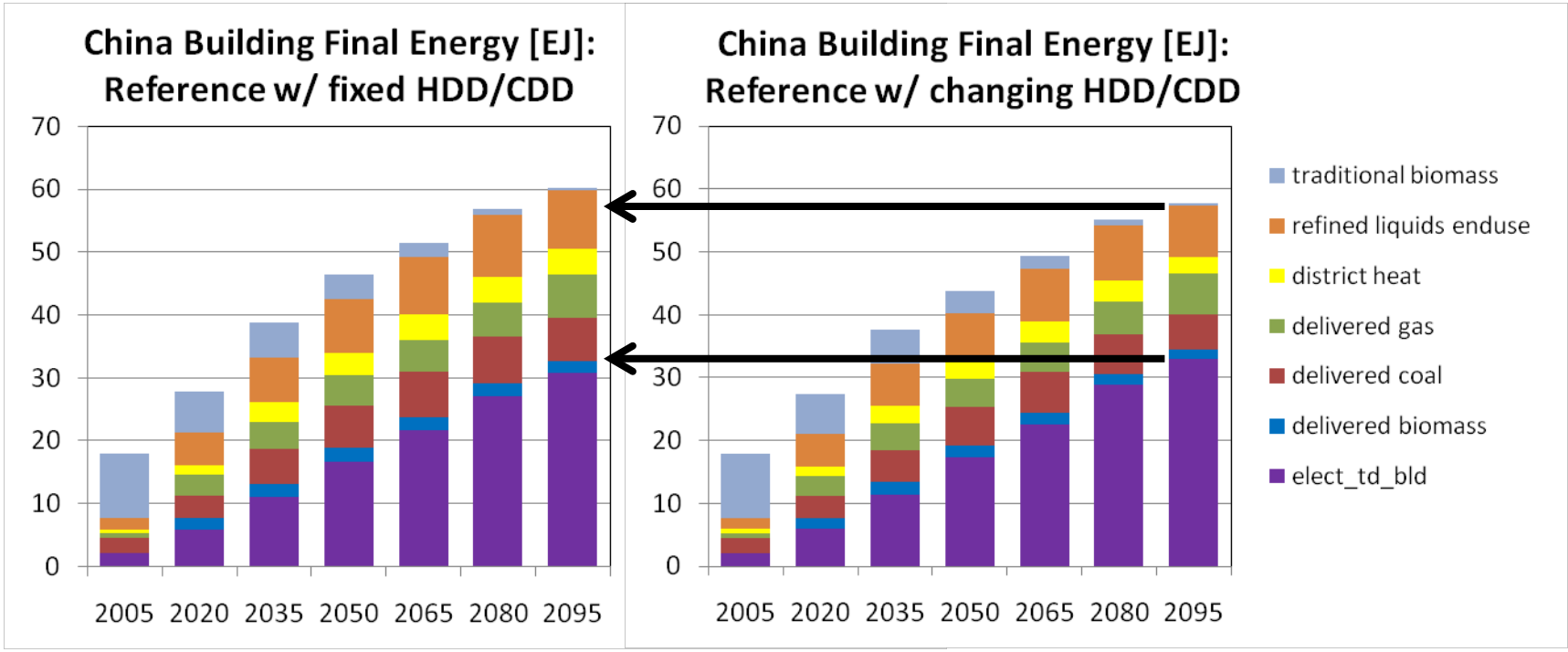
China Building Energy Use by Fuel

Fixed HDD/CDD **CCSM A2 scenario**



- Lower total building energy consumption
- Change of fuel share: increase of electricity use

*Note: This is energy consumption. The power could be a different story because of extreme temperature or variability induced by climate change

Future Research of Building Energy Modeling

- Development of a population migration model linked to income distribution and climate condition
- Climate feedback and downscaling within the framework of a integrated assessment model, GCAM
- Regional (with distinct climate and population patterns) building energy modeling

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