DOCKETED

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Cost Effectiveness and Examples of Climate Ready Building Standards, full document

Additional submitted attachment is included below.

TO: California Energy Commission

FROM: Thomas J. Phillips, Healthy Building Research, Davis, CA

DATE: March 9, 2021

SUBJECT: Cost Effectiveness and Examples of Climate Ready Building Standards, Docket No.19-BSTD-03, 2022 Title 24 Pre-Rulemaking

Thank you for your efforts to decarbonize new buildings and improve kitchen ventilation. However, in the face of major climate change underway, we clearly need immediate and aggressive actions to prepare buildings for more extreme heat and power outages.[1] California should be a leader in the field of climate ready buildings, and now it has climate change modeling with high spatial resolution to enable climate ready design.

Please consider these comments, in support of previous comments I submitted on February 11, 2021.

In short, climate ready design of buildings can be very cost effective, based on energy concerns alone, and it is already being done in many parts of the world.[2] Of course, the optimum approaches and benefits depend on the local climate, building type, life cycle length, discount rates, and valuation of carbon emissions and other co-benefits.

- **Cost effectiveness and business studies have been conducted** in Canada, the UK, and Australia (see attachments). Key progress in these areas are the British Columbia cost benefit report on multifamily buildings, the BC Energy Step Code, the UK draft Future Homes standard, and Canada's upcoming overheating assessment guide.

- **Overheating risk assessments and criteria are already being used in the US and other nations**, especially in green buildings, low carbon buildings, schools, care facilities, and hospitals, for example (see attached slides). Liability risk, energy cost, occupant satisfaction, and worker and student performance are they main drivers. Some researchers and designers are also developing methods to optimize for not only energy and cost but also for overheating risk, carbon reductions, and other objectives. Currently the UK and Canada are the leaders in the field of climate ready or future proof design. The UK has completed several demonstration projects.

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[1] Stagrum et al., 2020. Climate Change Adaptation Measures for Buildings—A Scoping Review. https://doi.org/10.3390/su12051721

[2] Nydahl et al. 2019. Including future climate induced cost when assessing building refurbishment performance. https://doi.org/10.1016/j.enbuild.2019.109428.

- **British Columbia energy standards include and overheating assessment, and Canada is developing an overheating assessment guide. The London building standards and the UK draft building standards include a requirement to assess overheating.** The EU has done some modeling work, developed EU policy on future proof building, and ramped up efforts on renovation and renovation business models, etc. Recently, research on this topic is growing rapidly in the U.S., Asia, Latin America, and the Middle East.

- **Future weather files from climate models are being used** to design climate ready buildings and infrastructure. Altostratus can produce localized weather files for California that factor in changes in urban heat island too. (CEC funded the methods development).[3]

- Recently, energy modeling experts are recommending the **development of not only future "average" weather files (TMY) but also extreme weather files (XMY), and in some cases, weather files for urban heat islands** (e.g., London & Manchester via the CIBSE method). Joe Huang, Dru Crawley, and others are working on the XMY file issue (see IBPSA 2019 Rome panel). In the meantime, many groups are using available Design Summer Years (DSY) to assess current extreme weather impacts. Bottom line: even fairly basic future weather files such as the morphed (shifted) weather files would be a big improvement over the status quo.

I hope these examples help California move quickly toward climate ready buildings, and thereby reduce impacts of building standards and practices on energy use, cost, carbon emissions, grid reliability, health, productivity, and liability. I look forward to helping CEC staff address our climate crisis.

Sincerely,

Thomas J. Phillips
Healthy Building Research, Davis, CA
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Attachments

[3] Taha H, 2020. Site-specific weather files and fine-scale probabilistic microclimate zones for current and future climates and land use. *IBPSA News*, 3, 2, pp. 29 - 41 (October 2020). More info: AltoStratus.

ATTACHMENTS

A) COST BENEFIT of "climate ready" building design (climate resilient, climate adapted, and future proof are other related terms used in this context):

RDH, 2019. Designing Climate Resilient Multifamily Buildings. Prepared for U. of British Columbia, et al.
Analyses of several types of MFam in BC under future climate conditions.
Includes recommendations for mitigating overheating, by building type.
Caveat: the ASHRAE 55 Thermal Comfort standard and its 80% acceptability limit for thermal comfort was used as benchmark, but this is not appropriate for residential settings, schools, care facilities, etc. and is not very health-protective.

Technology Strategy Board, 2014 (UK). The business case for adapting buildings to climate change: Niche or mainstream? Summary report: The business case for adapting buildings to climate change: Niche or mainstream? Aimed at building designers, construction professions, policy makers, regulators, etc., the report is based on various case studies and interviews with experts, and questionnaires. Slides at https://www.slideshare.net/SustEast/building-a-resilient-environment-morning-session.
Note: since then CIBSE building design standards for addressing overheating and urban heat island impacts have been more widely used, e.g. various projects, the London Plan and the draft UK standards (see below).

ASBEC & Climate Works Australia, 2018 (AU). Final Report. Built to Perform: An industry led pathway to a zero carbon ready building code.
https://www.monash.edu/__data/assets/pdf_file/0011/1602758/180703_asbec_cwa_built_to_perform_-_zero_carbon_ready_building_code_-_web.pdf. The report outlines a set of energy performance targets for different building types across different climates, based on societal cost-benefit analysis of energy efficiency and on-site renewable energy opportunities. The goal of the analysis is to assess the contribution that the Code could make towards achieving GHG emissions reductions in line with overarching zero carbon targets.

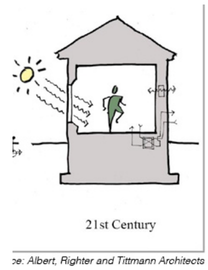
Benefits & Cost, p. 8 +, p. 19; health discussed re: underestimate of costs.
Cost estimate for passive measures by building types and climate zones: p. 20+
Note: Australia has some climate zones similar to those in CA, but their building stock is somewhat different than ours.
The CRC for Low Carbon Living has undertaken work to investigate inclusion of comfort metrics in the NatHERS framework through its 'Advanced Comfort Index for Residential Homes' project, assuming a 70 year lifetime for homes.

B) OVERHEATING STANDARDS AND GUIDELINES

International standards and guidelines for assessing overheating in building design (From Phillips and Higbee, July 2020 Zero Carbon Retreat).

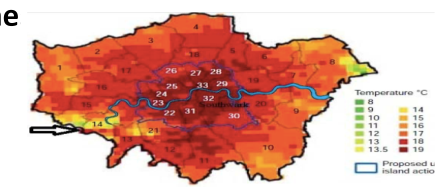
Overheating Guidelines: *International*

- **Passive House Program:** [1]
  ≤ 10% (h/y) > 25 C, and moisture limit



- **CIBSE TM 59 Overheating Design Guide (UK):** [2,3]
  - **Mechanical ventilation: Operative Temperature ≤ 26 C for < 3% of occupied hours**
  - **Natural Ventilation: temperature (summer occupied hours) and annual delta T limits for bedrooms**
  - **Weather files for 50 %ile future climate, high emissions. Mid & late century scenarios also recommended**

- **CIBSE TM 49 Urban Heat Island Design Guide (UK and London Plan):** [4]
  - **Overheating risk assessment for urban heat zone**
  - **Design Summer Year weather file**
  - **Hierarchy of efficiency measures, before mechanical cooling is allowed**



Average outdoor air temperature in London during August 2013

1. Passive House Institute, 2016. Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard.
2. CIBSE, 2017: TM 59, Design methodology for the assessment of overheating in homes.
3. Diamond, S., May 22, 2017. TM 59 webinar. Inking Associates.
4. CIBSE, 2014. TM49 Design Summer Years for London. See also: ARCC Network, 2017. Designing for Future Climate.

Overheating and adaptation standards and guidelines in Canada and the US (Updated from Phillips and Higbee, July 2020 Zero Carbon Retreat).

Overheating and Adaptation/Resilience Guidelines : *N. America*

- ✓ **Build It Green (2019): GreenPoint Rated 7.0 (CA Homes)** [1]
- ✓ **Collaborative for High Performance Schools Criteria**
  - **National Climate Adaptation and Resilience credits (2019).**
  - **California update (2021)** [2]
- ✓ **National Research Council Canada** [3]
  - **Overheating assessment guide (April 2021)**
  - **Risk assessment framework, and health based evaluation method.**

1. **Build It Green, 2017. Version 7.0 Update, Executive Summary.**
2. **CHPS 2019 update and webinar.**
3. **National Research Council Canada, 2019-2020.**: Preventing Overheating. Risk analysis framework. Health based evaluation method.

Overheating building standards: BC and UK

Overheating Standards

- ✓ **British Columbia Energy Step Code, Supplement 3 on Overheating and Air Quality (2019)** [1]

- ✓ **Draft UK Future Homes Standard and Building Regulations. Overheating assessment, low carbon, and ventilation requirements (2021)** [2]

1. BC Housing, 2019. Overheating and AQ Design Guidelines Supplement. BC Energy Step Code Design Guide & Supplemental. Summary at Builder Insight 19: Modeling the Future Climate ... - BC Housing.
2. UK draft standards: https://www.gov.uk/government/consultations/the-future-buildings-standard. News: https://www.architecture.com/knowledge-and-resources/knowledge-landing-page/the-future-homes-standard-explained.

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EXAMPLES OF DESIGN STANDARDS TO ASSESS AND PREVENT OVERHEATING

1) BC Housing, 2019. Overheating and AQ Design Guidelines Supplement. BC Energy Step Code Design Guide & Supplemental.
Summary at **Builder Insight 19: Modeling the Future Climate ... - BC Housing.**

RCP 8.5 climate scenario is recommended. Morphed weather files have their limitations, but "...using the weather files described in this Builder Insight is a good first step toward improving building resilience…"
Note: Based on recent discussions at weekly Passive House Accelerator webinars, many designers have already run into overheating problems in new Canadian & US homes, mainly due to poorly controlled solar heat gain. Some are starting to use window films for lower SHGC windows, and better external shading. Almost all are using HSPHs so they can do some mechanical cooling too and still meet or approach Passive House energy, carbon, and thermal comfort standards. Some are doing overheating assessments, with future weather files.

2) Toronto Atmospheric Fund, TowerWise project: various case studies and IEQ & overheating studies of deep MFam retrofits, by Touche & Siegel at U. Toronto. Future overheating impacts were assessed. 10 buildings have been completed so far.

3) National Research Council Canada: Preventing Overheating (2019).
The project aims to produce decision support tools, including codes, guides and models for the design of new climate resilient buildings and infrastructure.
A risk analysis framework was published in 2019. They have recently published articles on reference weather files for Canada, and a health based evaluation method. They plan to publish national guidance for overheating risk assessment in April 2021 publication.

4) Draft 2021 UK Future Homes Standard and Building Regulations are in the consultation phase until mid April 2021. They include low carbon and ventilation measures. Also, in response to earlier comments from a public health commission, architects, etc., they have included an **overheating assessment method and requirement.**
News: https://www.architecture.com/knowledge-and-resources/knowledge-landing-page/the-future-homes-standard-explained
Draft standards: https://www.gov.uk/government/consultations/the-future-buildings-standard

The overheating part is based on the CIBSE TM 59 standard, which has been around for several years. An independent health commission recommended last year and previously that the UK standards address the overheating issue in current and future climates, and various demonstration projects have been done in the UK using future climate projections (see below).

5) Greater London Authority. London Plan. See attached slide on international design standards re: CIBSE methods for addressing overheating and urban heat island .

7) German thermal comfort design standard, DIN 4108-2: 2013.
The requirement for thermal comfort is that, for the indoor operative temperature, the annual sum of ' kelvin * hours' exceeding 26 °C (i.e., Berlin is in the area "B" of the standard) must be not higher than 500 Kh/a. This index is commonly known as ' weighted temperature hours'. About the limit of 26 °C, the entire Germany is divided in three climate summer zones, with limit operative temperatures from 25 °C to 27 °C. More information: Krone et al., 2015, summer overheating assessment case study.

8) German Climate Adaptation Rule: DIN SPEC 35220 Beiblatt 1:2018-08. Projections on climate change and ways for handling uncertainties; Supplement 1: Summer thermal insulation of buildings - An example of vulnerability analysis in the event of a temperature increase of 2 °C and possible measures to adapt to the consequences of this temperature increase.

9) Australia policy recommendations and research: they have conducted some modeling and demonstration projects, but are still mostly at the policy stage for climate ready building after major political setbacks for climate action. They are also focused on updating the weak building energy standards. See ASBEC & Climate Works Australia item above.

C) MORE INFORMATION

BC Overheating and AQ: webinars and reports, https://www.bchousing.org/research-centre/library/residential-design-construction (search on Overheating)

April 28, 2020 webinar, Building Overheating and Air Quality: Considerations in New Construction. Lisa Westeroff, Integral Group:
Slide 17 suggests that their current building design parameters will **be OBSOLETE BY 2035.**
Slide 20: **cost-benefit of climate adaptation.**

BC Mobilizing Building Adaptation and Resilience (MBAR) Program:
multi-year, multi-stakeholder knowledge and capacity building project led by BC Housing, with participation and contribution from over 30 organizations, including national, provincial, and local agencies; and industry partners.
Overheating mitigation measure effectiveness in current & future climates and ASHRAE 55 Thermal Comfort and ventilation specs are included (NOTE: natural ventilation tends to be problematic in much of CA due to urban and regional outdoor air pollution, wildfires, allergens, human behavior, and noise and security concerns in some cases).
Pilot studies, resources, training, and overheating webinars.
Sadia Afrin, BC Housing, saafrin@bchousing.org:.

Canadian Academy of Engineering, Oct. 16, 2020. **Roadmap to Resilient Ultra-Low Energy Built Environment with Deep Integration of Renewables in 2050**. Various papers on resilient design, e.g., M. Touchie on Toronto MFam, thermal stress tests, and BC energy step code. **Draft roadmap expected in mid 2021.**
Proceedings and short presentations: https://cae-acg.ca/publications-of-the-academy/.

UK Technology Strategy Board, 2014. Design for future climate: adapting buildings competition project factsheets, Building a resilient future, Phase 1 and 2. Several case studies of climate adaptation projects for various types of buildings.
Project report, overview and project listing by building type: ARCC Network. Example: Bicester EcoDevelopment (5K homes).

USGBC Resilient Design credits: they were merged last year with the RELi standard, which **weakened the overheating assessment method for passive survivability** (power outage). They now use a heat index metric, which is not an appropriate metric for indoor settings, and some of the target levels seem way too high.

BREAM Thermal Comfort credits include adaptation to future climate scenarios, using dynamic thermal simulations and **Test Reference Year (TRY) and Design Summer Year (DSY) future weather files.**

UK Schools: BB 101: Ventilation, thermal comfort and indoor air quality 2018. Education and Skills Funding Agency. Calculation tools and guidance on ventilation, thermal comfort, and IAQ in classroom. Department for Children, Schools and Families (DCSF, formerly DfES) which provides a simplified method of assessing the extent of classroom overheating. ClassCool may not be appropriate for other spaces, such as libraries and halls, and other means of assessing overheating will be required. **Sec. 4.1.5, Climate change adaptation, addresses the need for future proofing of the indoor environment of teaching spaces.**
CIBSE KS16 contains useful advice about managing overheating in existing buildings.

RECENT SCIENTIFIC LITERATURE

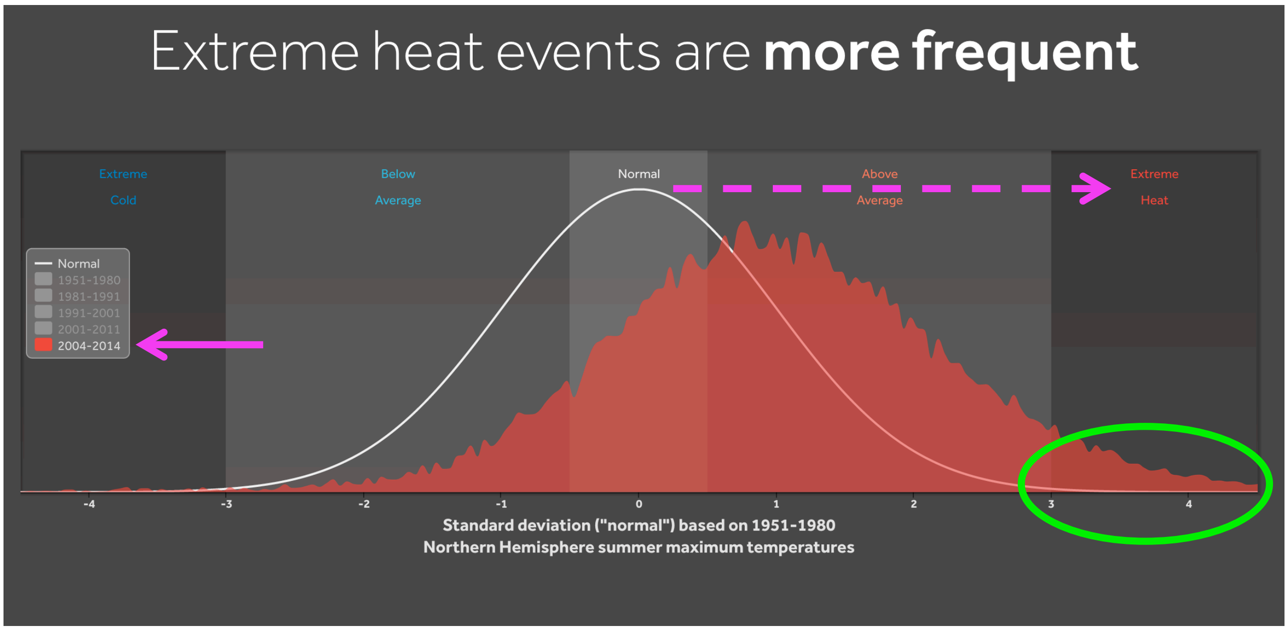
(Selected from brief search on cost effective of climate adapted design of buildings, overheating assessment etc.):

Climate Change Adaptation Measures for Buildings—A Scoping Review. Stagrum et al. 2020, https://doi.org/10.3390/su12051721. "… **The predictions of climate scenarios suggest regulatory/policy measures on climate adaptation should be taken as quickly as possible to avoid greater costs in the future. However, further research into future scenarios is also essential."**

Nydahl et al. 2019, including future climate induced cost when assessing building refurbishment performance. https://doi.org/10.1016/j.enbuild.2019.109428. Life cycle approach to refurbishments was analyzed for case studies, including both embodied and operational energy and climate cost. **Traditionally non-profitable measures may become financially sound investments.**

Future cooling needs and peak grid demand will increase (heating needs will decrease)

The New ABNORMALS:
Dynamic Shift to Extreme Temperatures (and More Variance) is Occurring



Adapted from Wx Shift, Jan. 2020. Interactive chart at Extreme Heat.
https://wxshift.com/climate-change/climate-indicators/extreme-heat.

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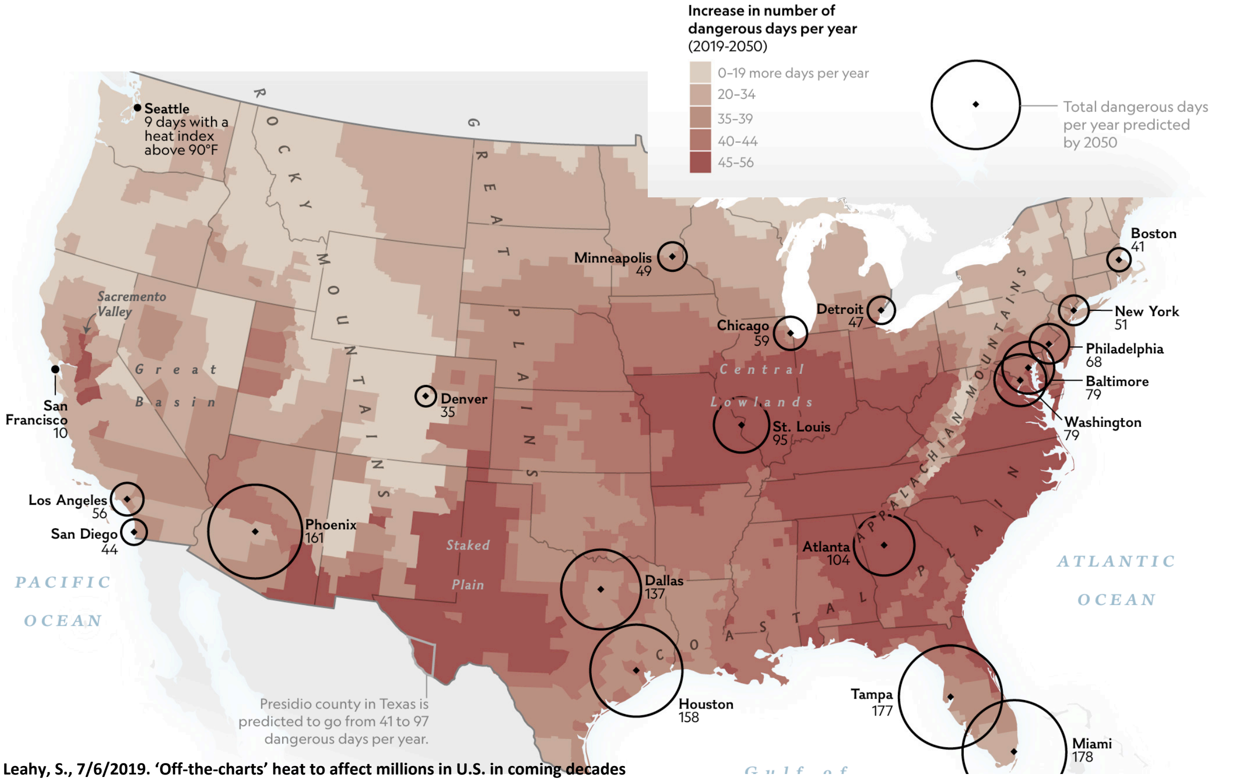
Future Heat Index in the US: extreme days will increase substantially by mid century. California's more populated areas will see 10-56 more dangerous days, especially in the South Coast and Central Valley. Some future values will be beyond the capability of the heat index method.

Dangerous Days Ahead: Heat Index by Mid-Century



Leahy, S., 7/6/2019. 'Off-the-charts' heat to affect millions in U.S. in coming decades
Within 60 years, hot days in the U.S. could be so intense that the current heat index can't measure them.
National Geo., https://www.nationalgeographic.com/environment/2019/07/extreme-heat-to-affect-millions-of-americans/.
Interactive mapping tool: https://ucsusa.maps.arcgis.com/apps/MapSeries/index.html?appid=e4e9082a1ec343c794d27f3e12dd006d.
Dahl et al. 2019. https://iopscience.iop.org/article/10.1088/2515-7620/ab27cf.

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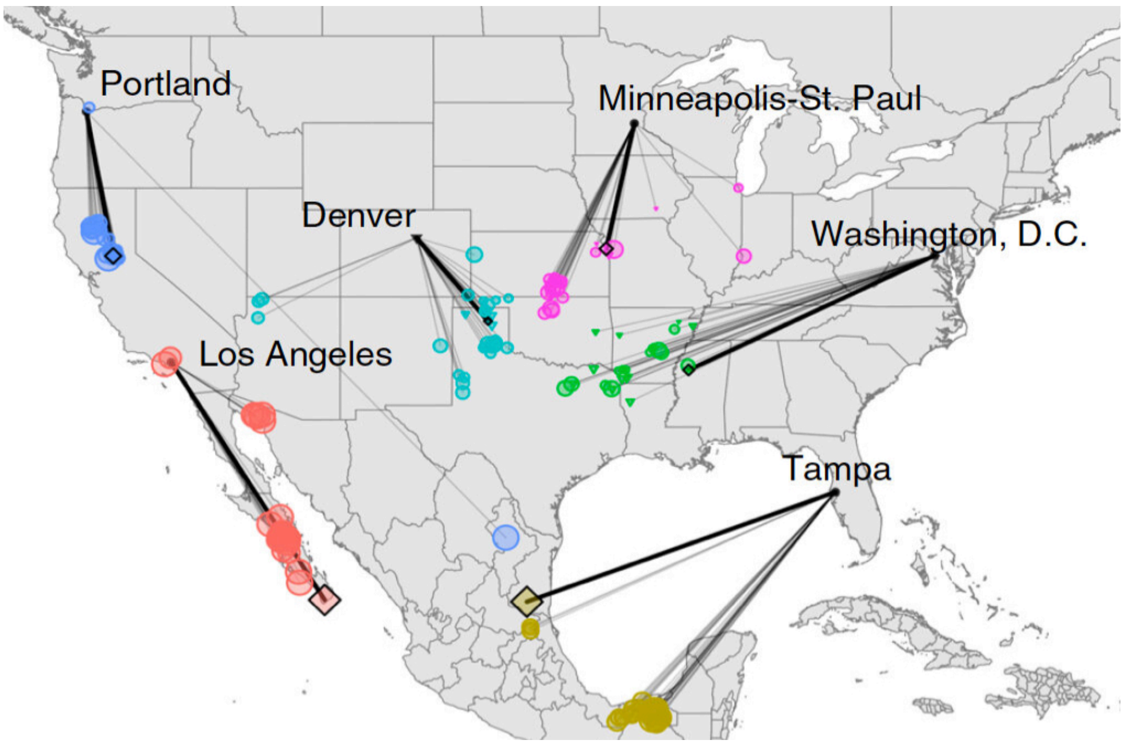
Future climate in US shifts southward (interactive tool: 12 climate parameters, 4 seasons)

U.S. Climate Shift Southward
(From 1960-90 to 2080s, RCP 8.5, 4 seasons)



Phys.org, 2/12/19. Climate of North American cities will shift hundreds of miles in one generation.
Based on projections for 12 climate parameters across 4 seasons. Interactive map at http://www.umces.edu/futureurbanclimates.
Fitzpatrick et al., 2019. https://doi.org/10.1038/s41467-019-08540-3

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