EARTH SCIENCE
APPLIED SCIENCES

HEALTH & AIR QUALITY

Extreme humid heat impacts

Peter Kalmus

March 2023

Project Partners/Collaborators

Role	Name	Affiliation	Org. Type
Co-I: High-resolution T data	Glynn Hulley	JPL	NASA
Postdoc	Anamika Shreevastava		
Co-I: AC data and analysis	Kelly Sanders	USC	University
Student	McKenna Peplinski		
Co-I: Health data and analysis	Howard Chang	Emory	University
Student	Xiaping Zheng		
Co-I: Statistical methods	Emily Kang	U Cincinnati	University
Student	Ayesha Ekanayaka		
Collaborator: Physiological model	David Romps	UC Berkeley	University
Student	Yi-Chuan Lu		
Collaborator: Humid heat	Luke Parsons	Duke	University
Collaborator: Humid heat	Drew Shindell	Duke	University

Project Application Stakeholders

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Organization Name	Organization Type	Decision Making Activity
Red Cross Red Crescent	international / humanitarian	urban heat mitigation
LA County Chief Sustainability Office	county / government	urban heat mitigation

Engagement plan and recent updates

We meet every two weeks for group video meetings.
Our first stakeholder workshop is planned for April 11 2023.

Factors in heat stress: Temperature

The human body thermoregulates its core at 98.6 F / 37 C / 310 K.

When thermoregulation fails, this is called hyperthermia.

Blood flow transfers heat from the core to the skin.

The body can turn blood flow up, to a maximum level.

Factors in heat stress: Humidity

The body’s second trick for thermoregulation: sweat.

Water evaporation transfers a lot of heat.

Water evaporates more slowly in humid air.

At 100% relative humidity, no water evaporates. Sweat thermoregulation fails.

Factors in heat stress: Metabolic work rate

The body generates heat through metabolism.

When the body works harder, it generates more heat.

Thermoregulation must balance this heat by shedding heat to the environment.

Power output examples:

- Average human at rest: about 100 W of power
- Pro cyclist (sustained): about 500 W of power
- Pro cyclist (bursts): about 1000 W of power
- Average toaster: about 1000 W of power (mine is 846 W)

Factors in heat stress

- Temperature
- Humidity
- Metabolic work rate
- Health and medications (e.g. age, obesity, diabetes, anhidrosis, kidney disease)
- Wind speed
- Insolation
- Availability of drinking water
- Clothing
- Height and weight
- Air pollution levels

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Heat metrics

- “Regular” temperature (dry-bulb)
- Wet-bulb temperature
  - traditional fatal threshold: 35 C / 95 F

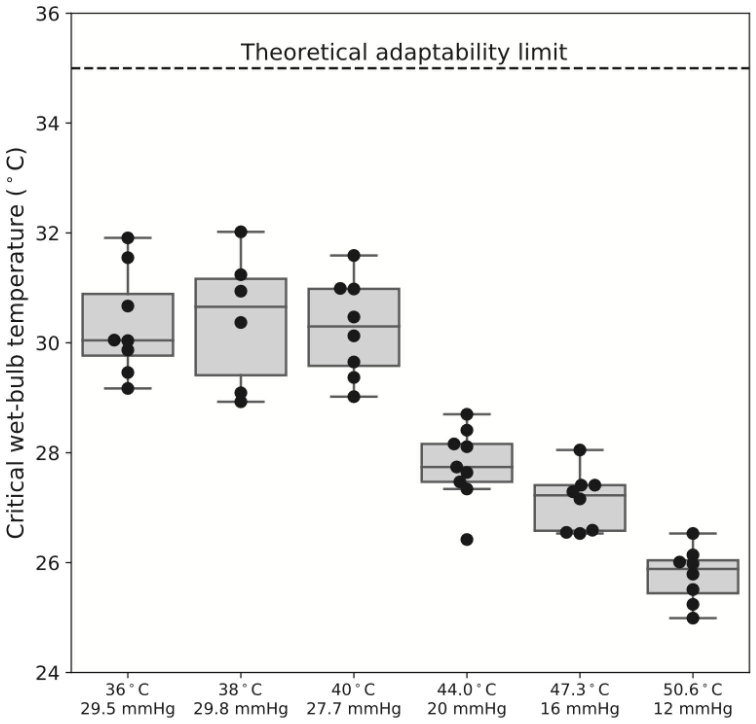
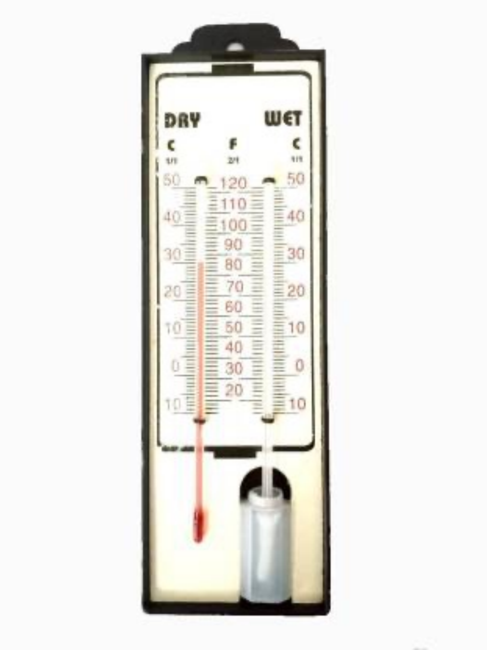


Figure 1. Critical wet-bulb temperature values for the study's six experimental protocols.

Vecellio et al. 2022



Temperature
Humidity
Metabolic work rate
Health
Wind speed
Insolation
Availability of drinking water
Clothing
Height and weight
Air pollution levels

Heat metrics

- Wet-bulb globe temperature
  - Includes T, q, insolation, wind speed
  - Commonly used in sports and labor contexts
- Heat Index
  - “temperature at 1.6 kPa that would be experience the same way by a human”
  - Developed by Steadman in 1979
  - Based on a physiological model
  - Assumes:
    - metabolic rate per skin area: 180 W m^{-2} (walking)
    - wind speed of 1.4 m s^{-1} (breeze, walking speed)
    - ideal health
    - average height and weight
    - minimal clothing, shade, unlimited water

Temperature
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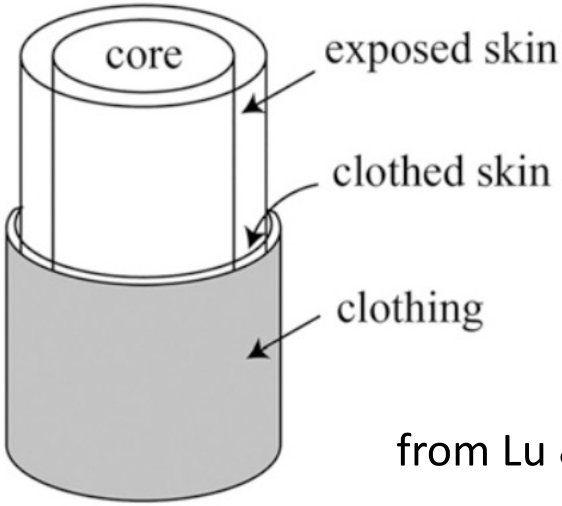

from Lu & Romps 2022

Heat metrics: problems

- Wet-bulb globe temperature
  - Difficult to calculate and use in projections
  - sWBGT formulations are inaccurate
    - e.g. Kong & Huber 2022
  - Not based on human physiology
    - choice-of-threshold problem
- Heat Index
  - Original formulation not valid at extremes
  - Polynomial extrapolation widely used (Rothfusz 1990)
    - Not based on science or physiology
    - Large errors (Lu & Romps 2022)
  - Poorly understood
  - One 2D “slice” through a >6D space

Temperature
Humidity
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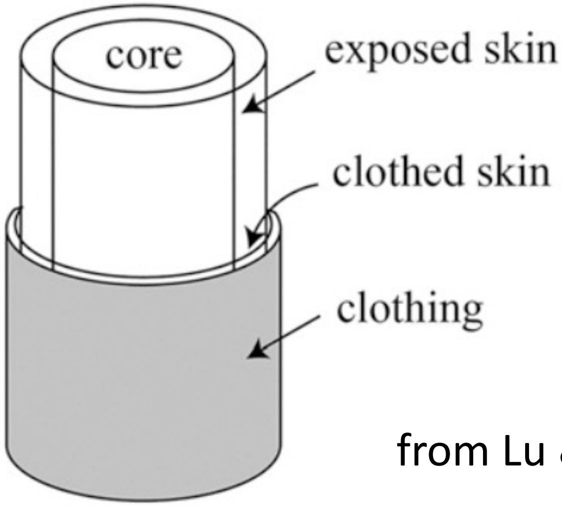

from Lu & Romps 2022

Heat metrics: physiological model

- Lu & Romps 2022: “Extending the Heat Index”
- They extend Steadman’s original model to hot and cold extremes
  - solve systems of equations of energy and water conservation at interfaces
  - assume ideal health, shade, unlimited water, minimal clothing, average height and weight
- The model can, e.g.:
  - take T, RH, metabolic rate, wind speed as inputs
  - provide human core temperature Tc
  - take T, Tc, metabolic rate wind speed as inputs
  - provide critical RH

Temperature
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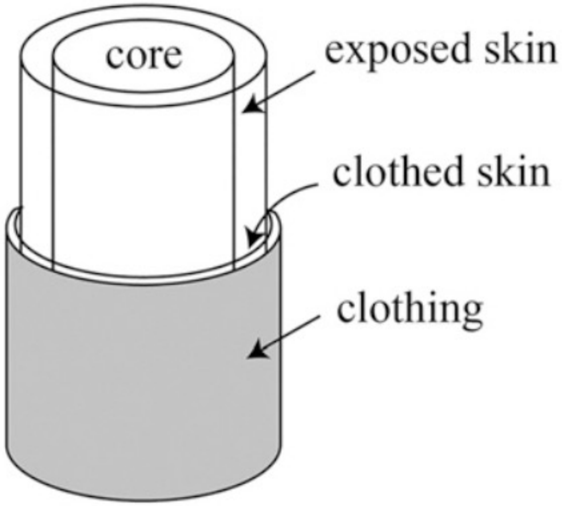

Humid heat thresholds

- Wet bulb temperature (TW)
  - 35°C / 95°F – "theoretical limit" of human thermoregulation
  - 30.55°C / 87.1°F – Vecellio et al. 2022, moderate activity, "uncompensable" heat stress
- Heat Index (used in Vargas Zeppetello et al. 2022)
  - 39.4°C / 103°F US NWS "danger" (heat exhaustion likely)
  - 51.1°C / 124°F US NWS "extreme danger" (heat stroke likely)
- We use physiological thresholds
  - hyperthermic (uncompensable) humid heat conditions
    - Tc forced above 98.6 F / 37 C / 310 K
  - fatal humid heat conditions
    - Tc forced above 107.6 F / 42 C / 315 K

Humid heat story lines

Use of the physiological model allows us to choose "story lines" for applications

- Story lines are set by assumptions in the analysis
- Here (initially) we choose a story line of "**healthy person indoors**"
  - ideal health
  - low metabolic work rates corresponding to resting and light indoor work
  - indoor wind speed (0.2 m s^{-1})
  - shade, minimal clothing, unlimited drinking water
- Other possible humid heat story lines:
  - **agricultural or construction labor**: high metabolic rates, sun, higher wind speed
  - **athletics**: very high metabolic rates, sun, higher wind speed, limited water
  - **emergency responders**: high metabolic rates, protective clothing
  - **elderly people indoors**: non-ideal health (lower blood flow, perspiration rates)
- Some story lines will require extending the physiological model

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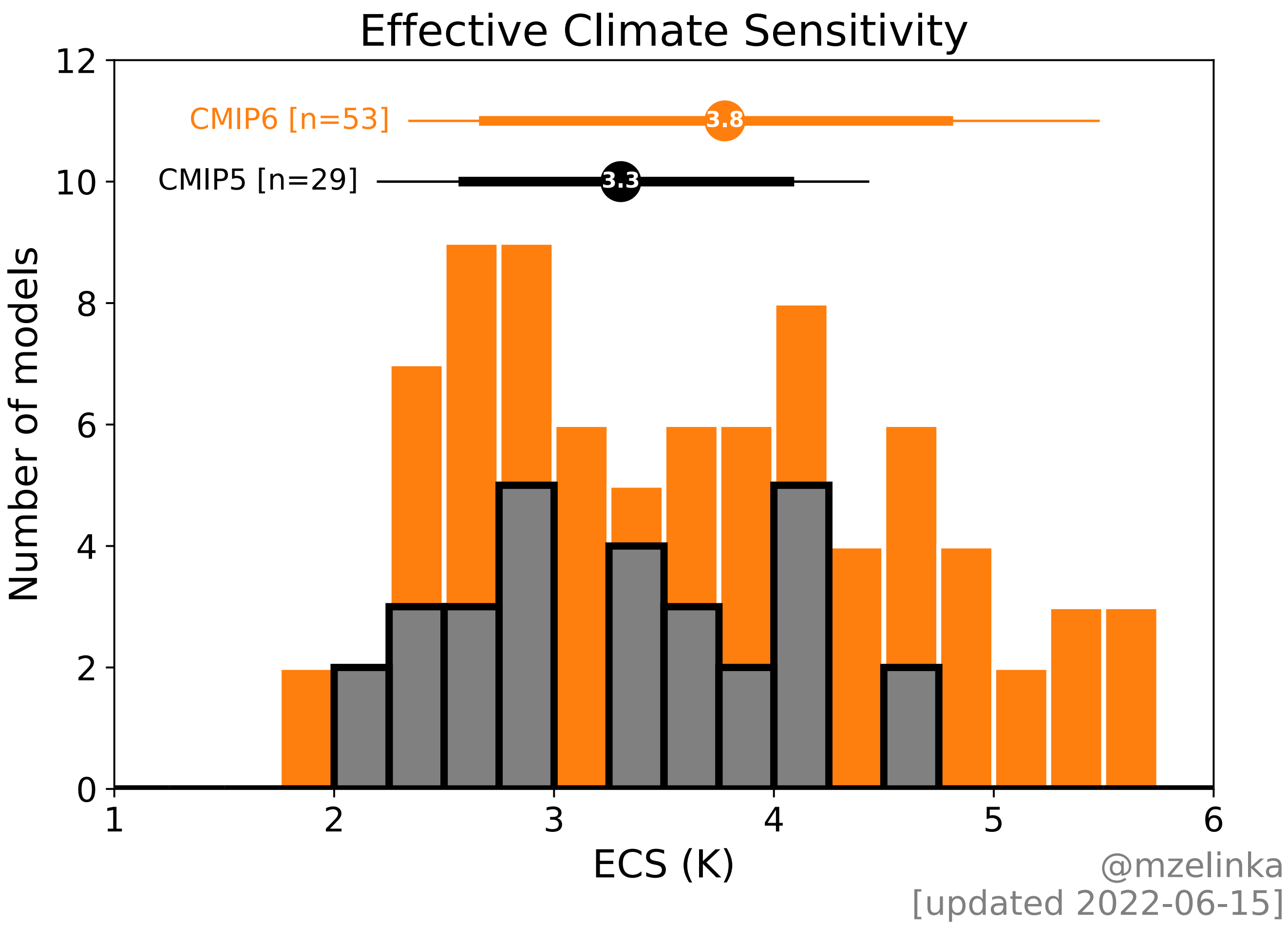
CMIP6 Earth system models and runs



Zelinka et al. 2020

- We require daily surface specific humidity, min and max surface air temperature, surface pressure.
- We have run on 4 models to 2100:
  - GFDL-ESM4 ECS: 2.7 K
  - CMCC-ESM2 ECS: 3.6 K
  - CNRM-ESM2-1 ECS: 4.8 K
  - CanESM5 ECS: 5.6 K
- We have run on 3 models to 2300:
  - MRI-ESM2-0 ECS: 3.1 K
  - ACCESS-CM2 ECS: 4.7 K
  - CanESM5 ECS: 5.6 K

CMIP6 Earth system models and runs

- Shared Socioeconomic Pathways (SSPs)
  - SSP 1-2.6: Aggressive mitigation; in 2100: 2°C CMIP6 / 1.7°C CMIP5
  - SSP 2-4.5: Current, non-binding agreements?; in 2100: 3°C CMIP6 / 2.6°C CMIP5
  - SSP 3-7.0: Failing to meet agreements; about 4°C in 2100
  - SSP 5-8.5: High emissions scenario, prioritizing growth over mitigation: 2100 about 5°C
- Only 5 CMIP6 models have run to 2300, and only on SSP 1-2.6 and SSP 5-8.5

Statistical Downscaling

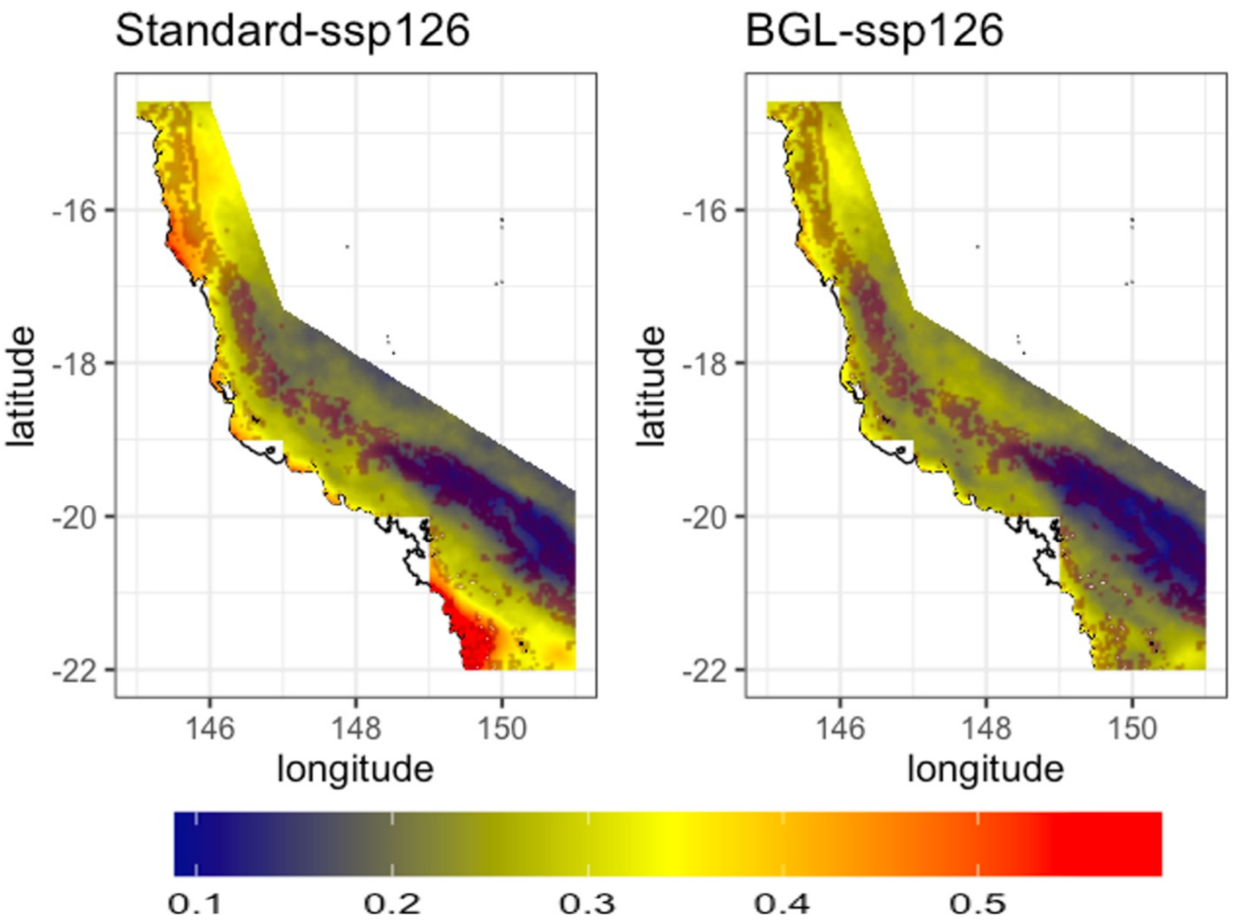
GCM outputs are at ~100 km scale

Capture fine-scale patterns from ERA5 0.1°

downscale t2m, RH separately

We apply Basis Graphical Lasso (BGL, see Ekanayaka et al., 2022) which models spatial dependence structure across the coarse and fine scales, reducing errors and producing uncertainty estimates

Developed for prior coral reef projection work (Kalmus et al. 2022, NASA ROSES Ecological Forecasting program)



Standard and BGL downscaling MSE (°C^2) estimated from validation against withheld 2018-2020 MUR data in the central GBR. Reefs are indicated by brown mask. Note improvement in near-coastal regions. Averaged over reefs, standard had MSE of 0.25°C^2 while BGL had MSE of 0.17°C^2, a reduction of 31%.

Increasing spatial resolution will facilitate applications

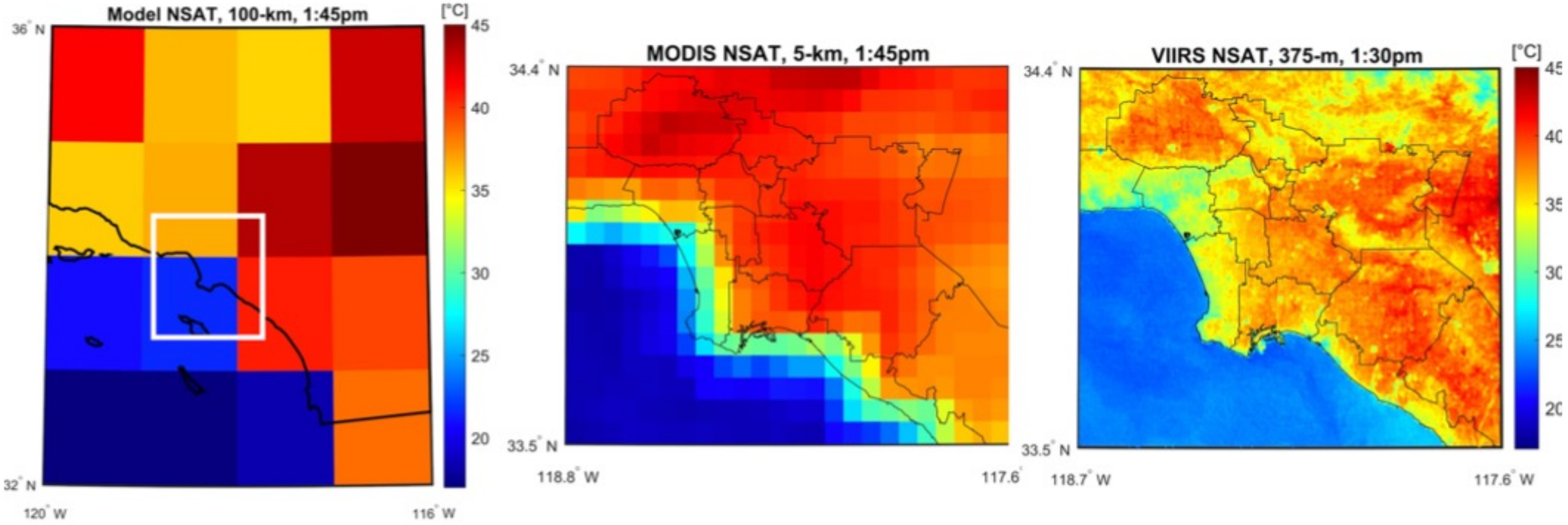
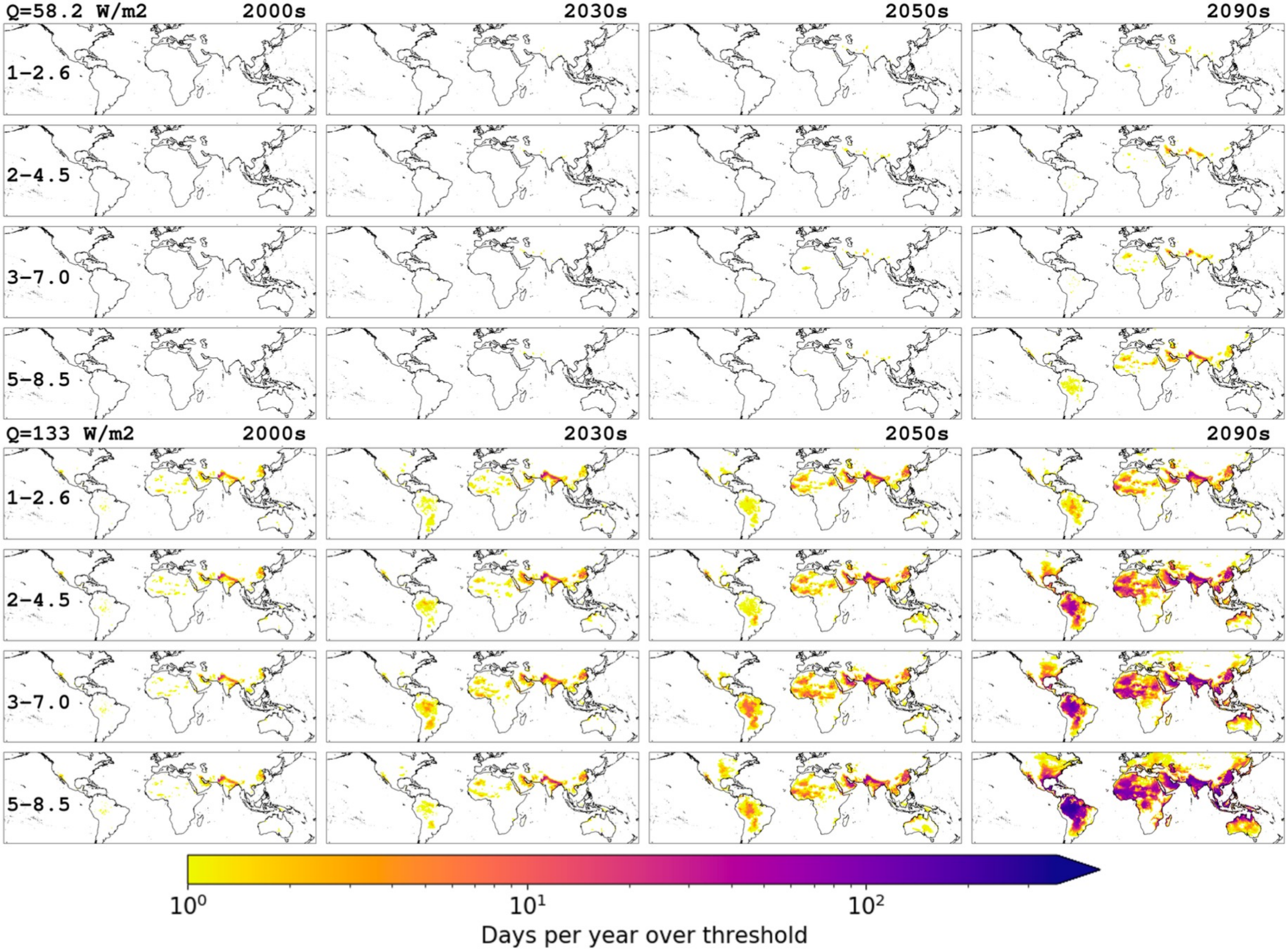


Figure 3-1. Sample NSAT estimates over Los Angeles during the heatwave of 14 August 2020; 400 km region on the left, smaller regions (boxed in white) on center and right. Aqua MODIS NSAT averaged to 100 km resolution (left); Aqua MODIS at native 5 km resolution (center); VIIRS on Suomi-NPP at 375 m resolution (right), demonstrating capability of resolving UHI variation. Note that prior projection studies are closest to the 100 km sample on the left.

Important caveats on results

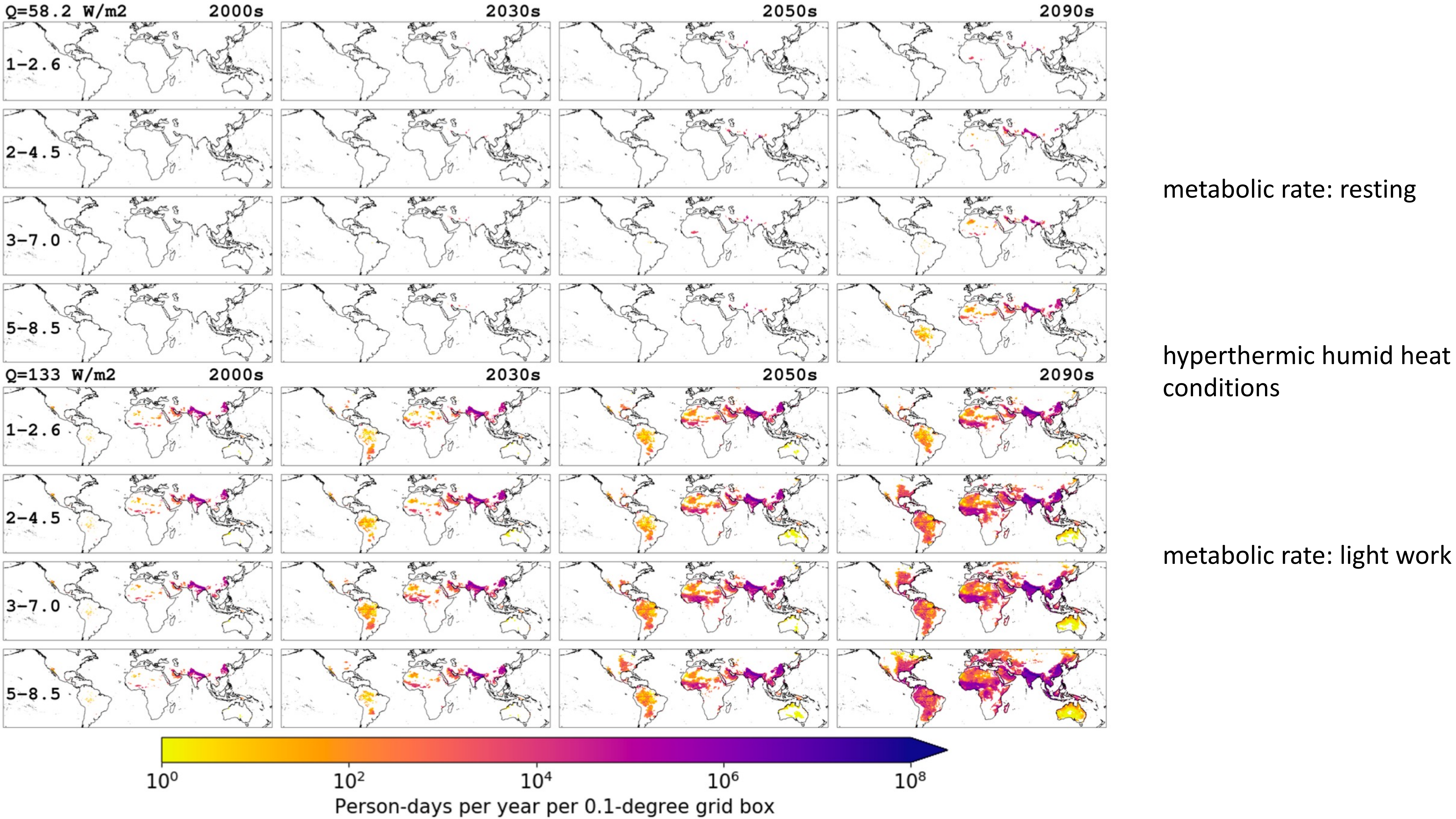
- Projections of conservative physiological upper limits
  - apply only to an ideally healthy but otherwise average human
  - highest possible blood flow and perspiration rate
  - do not depend on regional variations in acclimatization
- Projections of humid heat conditions that **if sustained** would:
  - lead to elevated core temperature (hyperthermia)
  - lead to elevated core temperature above 315 K (death)

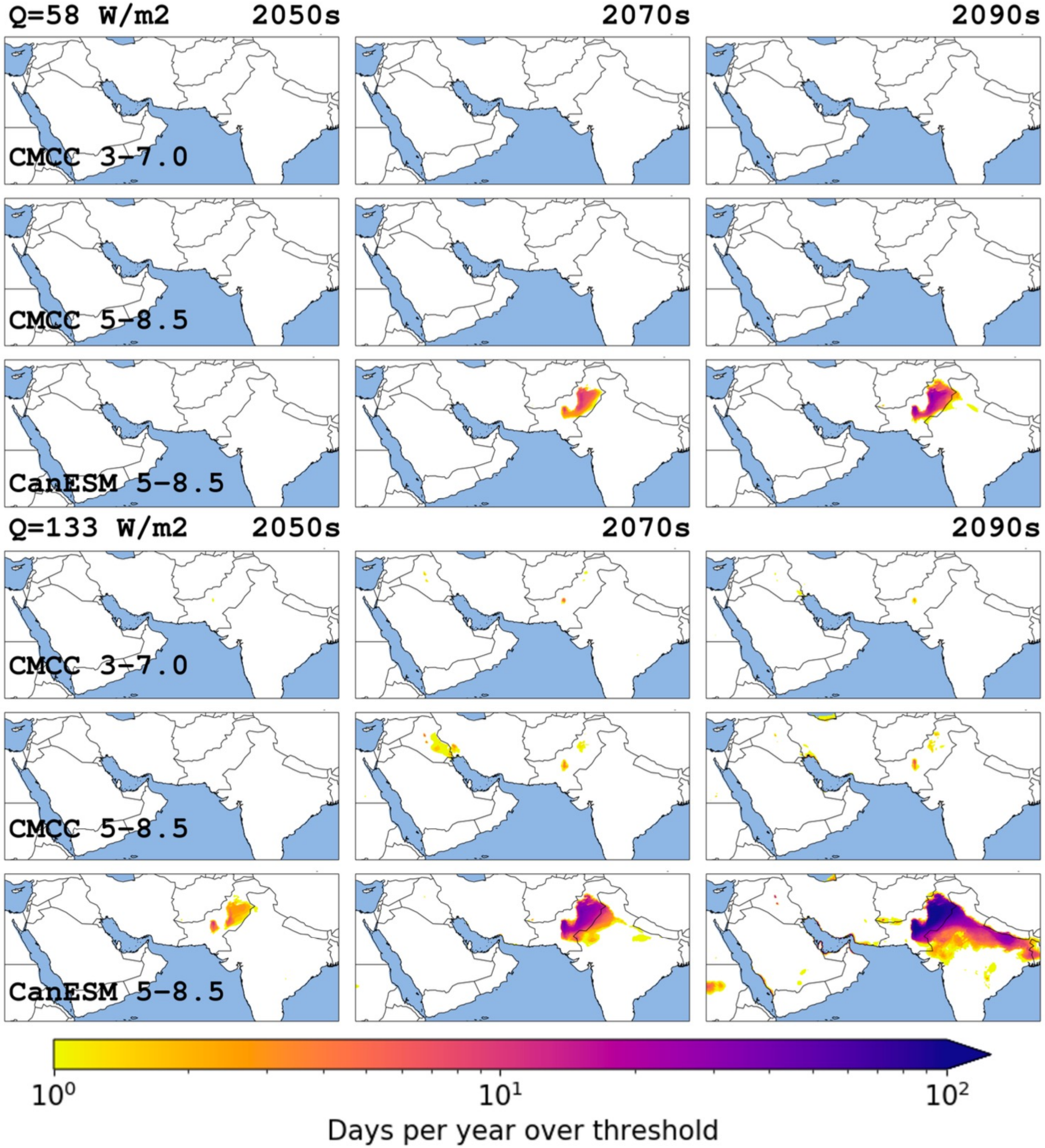


metabolic rate: resting

hyperthermic humid heat conditions

metabolic rate: light work

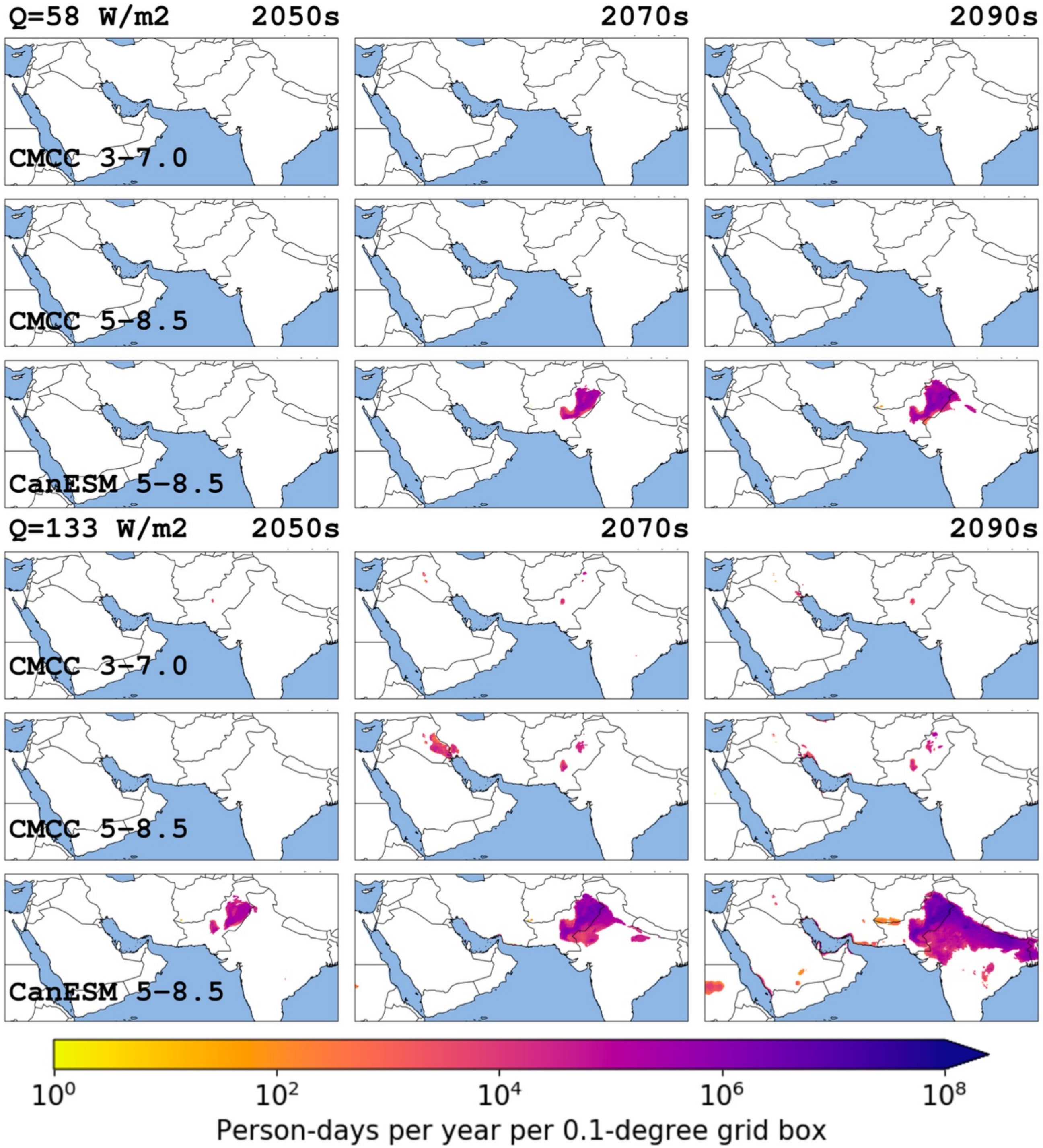

Q=58.2 W/m2
2000s
2030s
2050s
2090s
1-2.6
2-4.5
3-7.0
5-8.5
Q=133 W/m2
2000s
2030s
2050s
2090s
1-2.6
2-4.5
3-7.0
5-8.5
10^0
10^2
10^4
10^6
10^8
Person-days per year per 0.1-degree grid box
metabolic rate: resting
hyperthermic humid heat conditions
metabolic rate: light work



metabolic rate: resting

fatal humid heat conditions

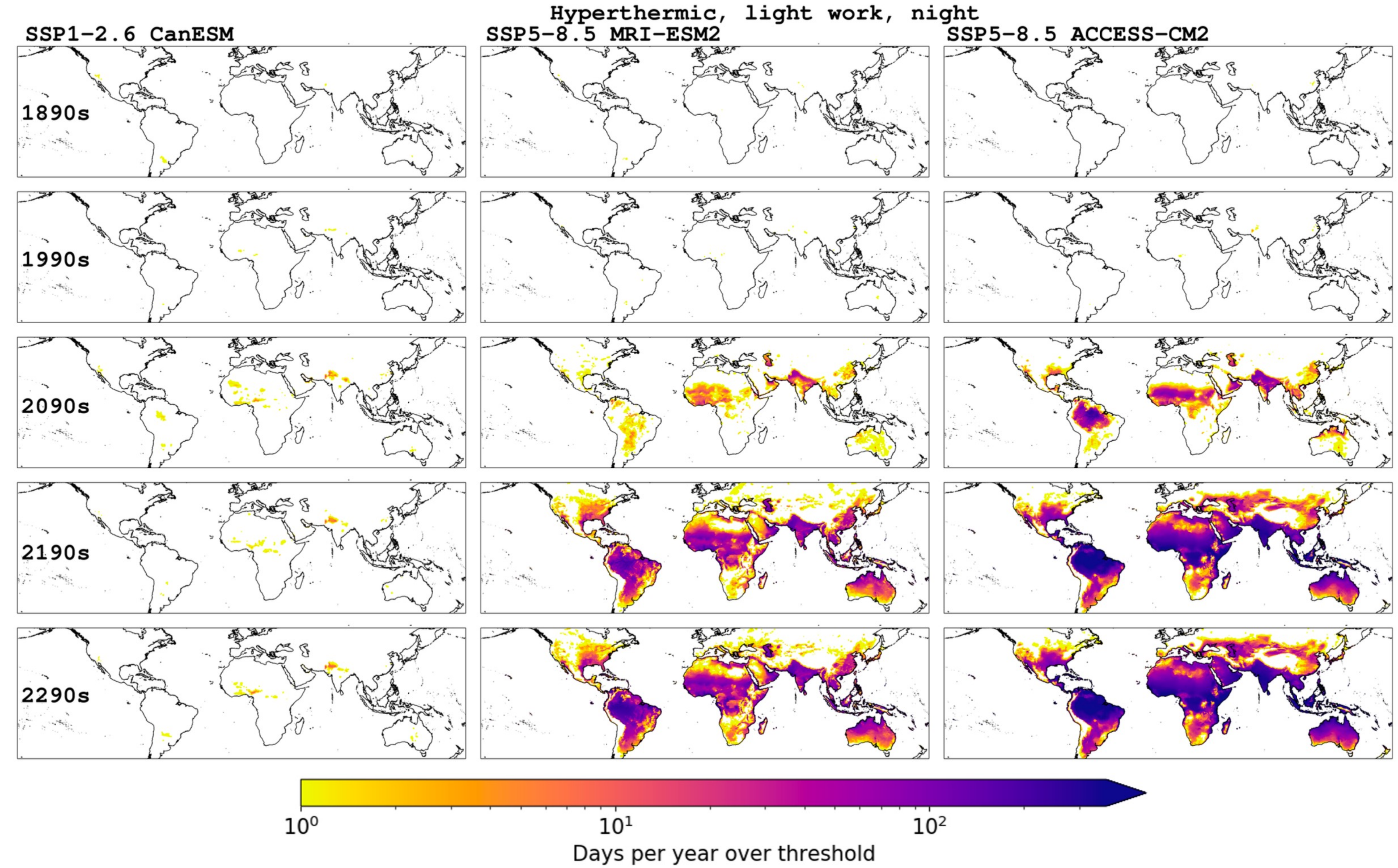
metabolic rate: light work



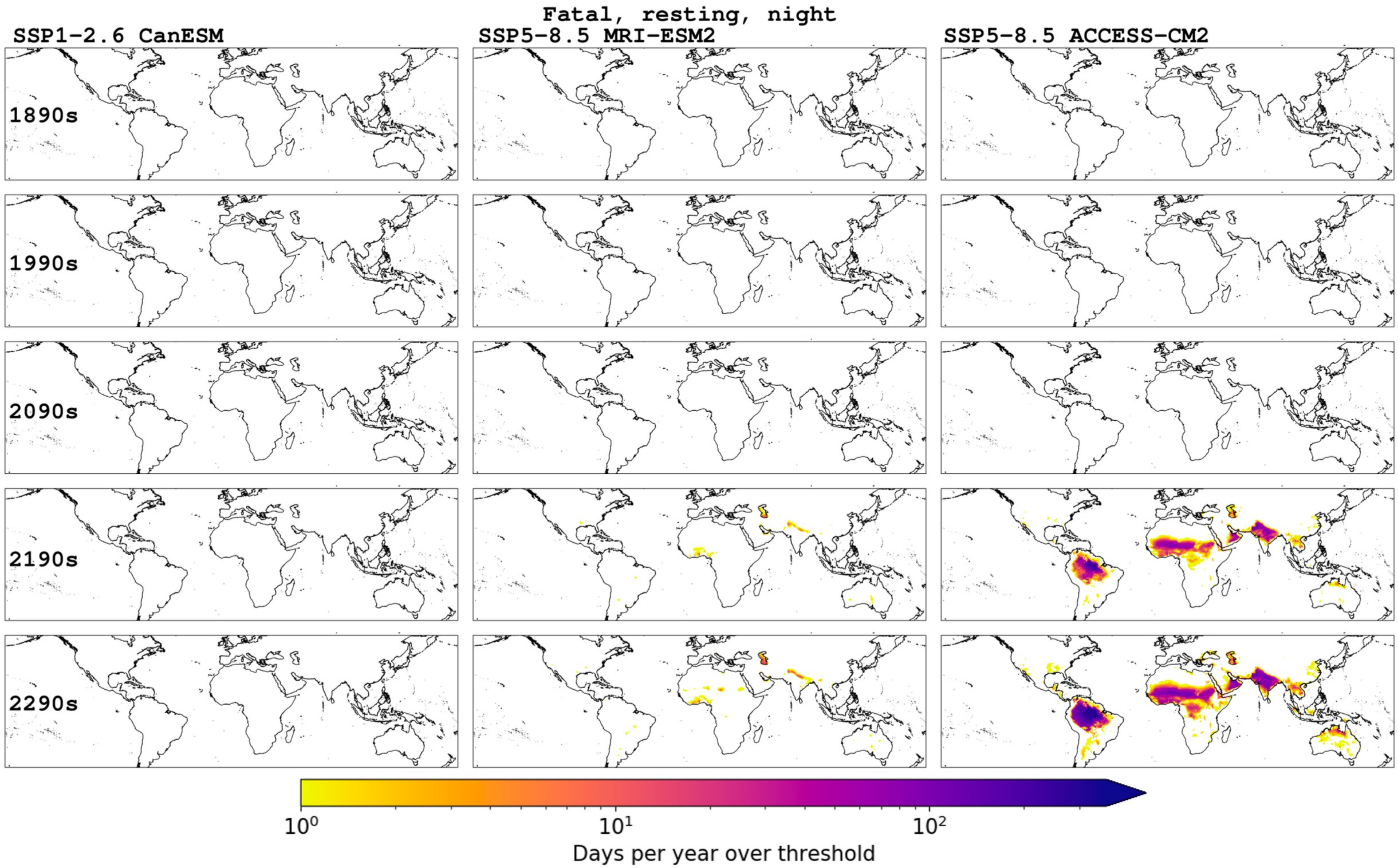
metabolic rate: resting

fatal humid heat conditions

metabolic rate: light work



Hyperthermic, light work, night
SSP1-2.6 CanESM
SSP5-8.5 MRI-ESM2
SSP5-8.5 ACCESS-CM2
1890s
1990s
2090s
2190s
2290s
10^0
10^1
10^2
Days per year over threshold


Fatal, resting, night
SSP1-2.6 CanESM
SSP5-8.5 MRI-ESM2
SSP5-8.5 ACCESS-CM2
1890s
1990s
2090s
2190s
2290s
10^0
10^1
10^2
Days per year over threshold

meant there was no refuge anywhere, the world both inside and outside well higher than human body temperature ought to be. They were being poached. Surreptitiously he uncapped his water jug and drank. Its water was now tepid, but not hot, and it was clean. His body craved it and he couldn't stop himself, he drank it all down.

People were dying faster than ever. There was no coolness to be had. All the children were dead, all the old people were dead. People murmured what should have been screams of grief; those who could still move shoved bodies out of the lake, or out toward the middle where they floated like logs, or sank.

Frank shut his eyes and tried not to listen to the voices around him. He was fully immersed in the shallows,

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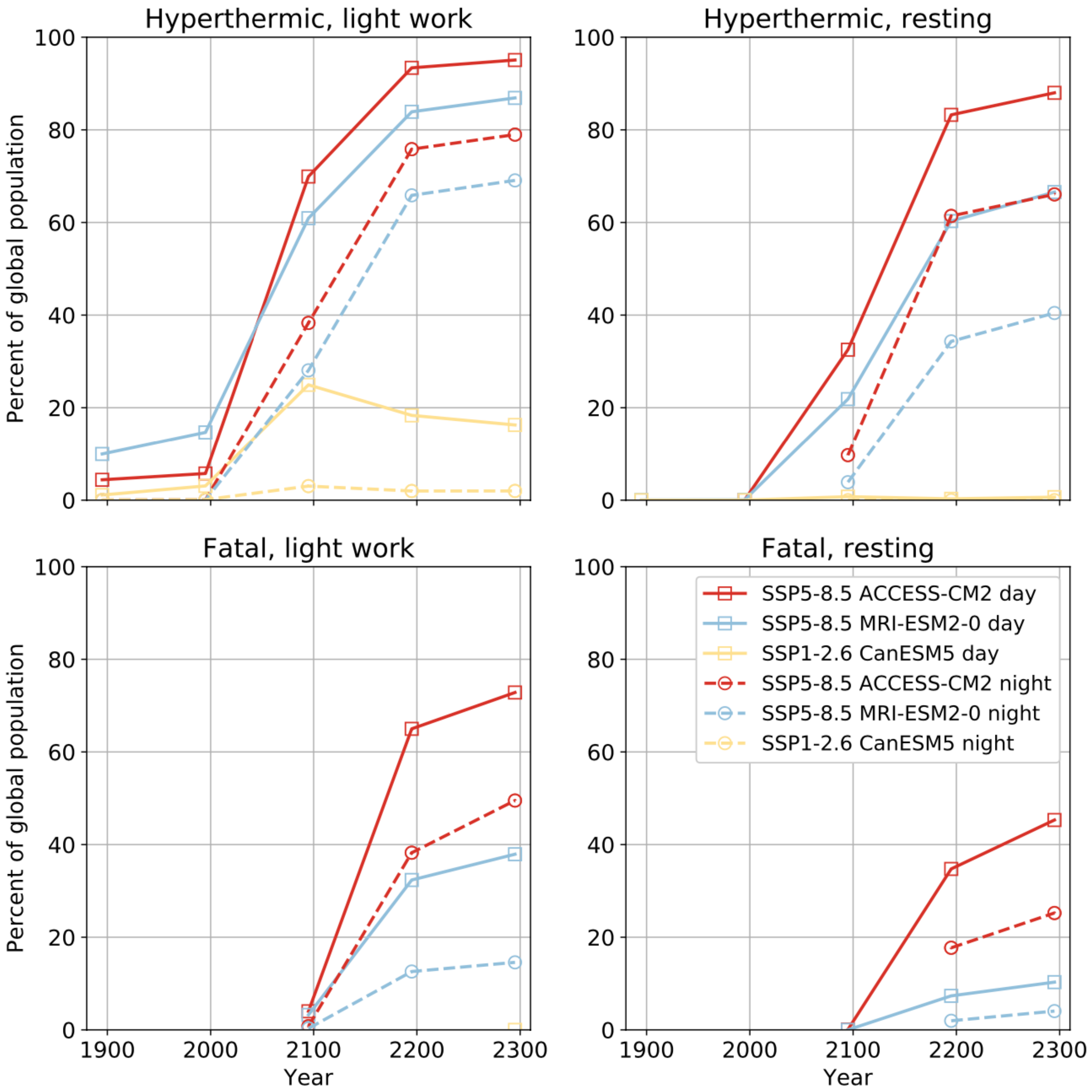

Schedule & Milestones: proposed schedule

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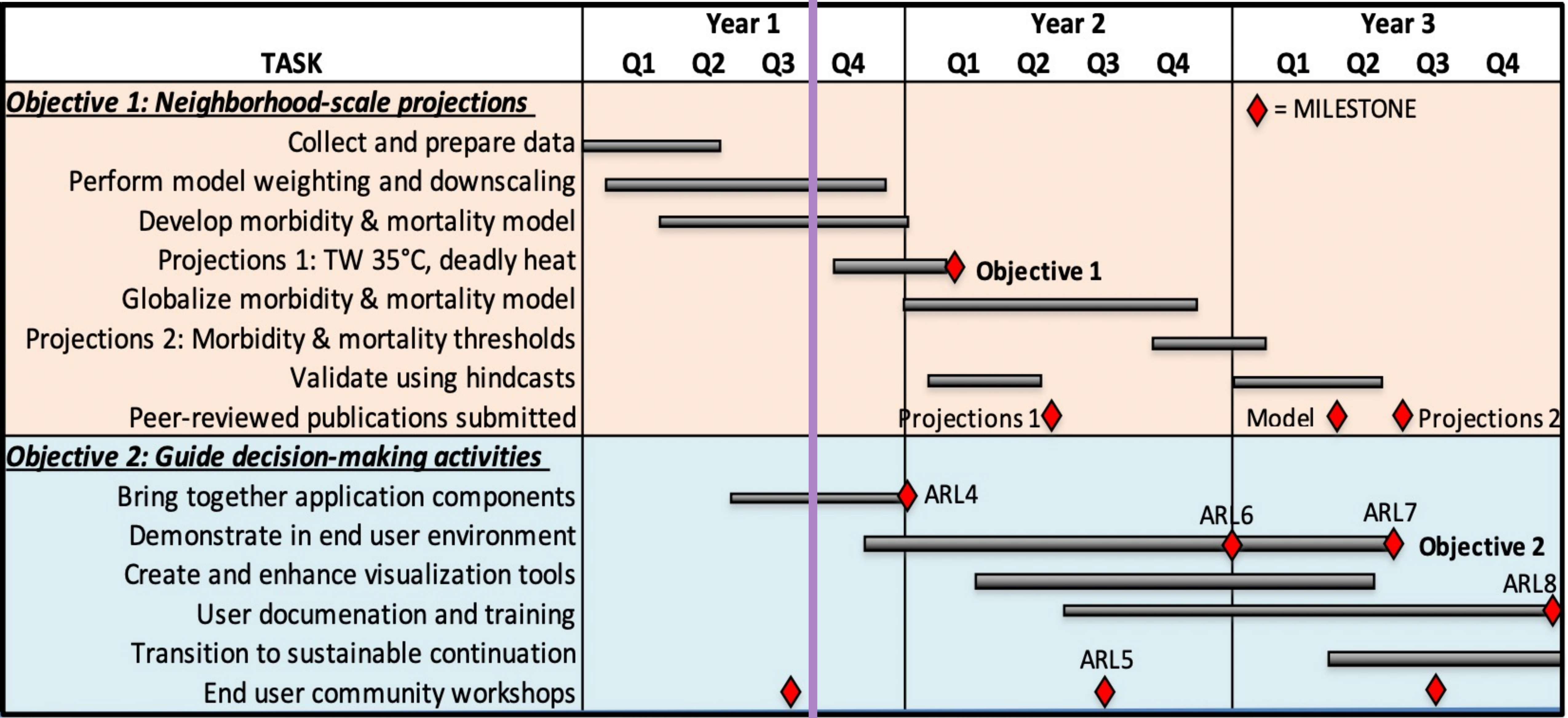

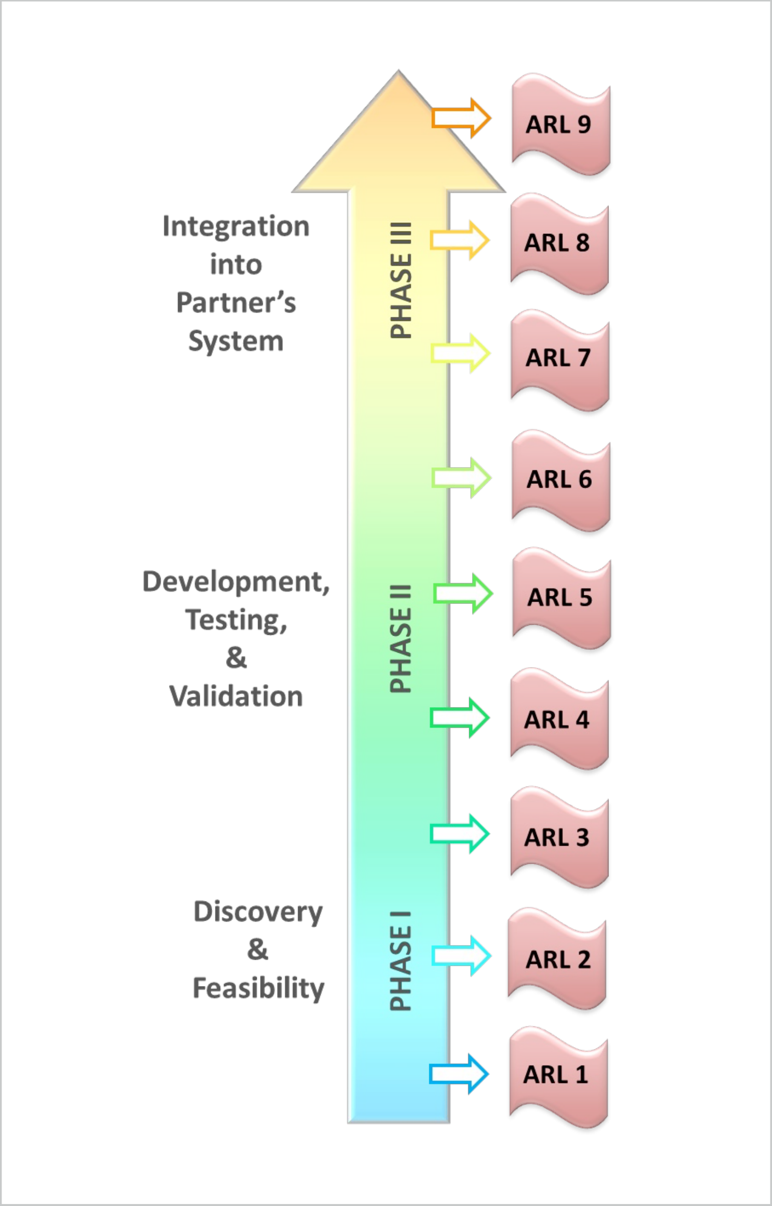

ARL Performance

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- Start-of-Project ARL = 3 *(July 2022)*
  - All project components needed for obtaining Objective 1 have been created and validated independently, and decision-making activity has been characterized.
- Goal ARL = 7
- Current ARL = 3 *(March 2023)*
  - We now have results at 0.1-degree (~10 km) spatial resolution. We may obtain ARL 4 (applications prototype) next quarter, as planned, as we obtain 375 m projections and also better understand the implications of these results for end users' applications in the first workshop.

Challenges and Risks

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Rank	Type*	Risk	Mitigation Action	Date first noted/Date resolved (if applicable)
1	T	High computational cost for 375m-resolution analyses	Limit analysis to major cities only if necessary	Noted in proposal / resolved
2	ES	Limited engagement by end users to date	We are planning our first workshop for spring. We are about to submit first paper which we will use to engage.	December 2022 / unresolved
3	ES	Kristen Pawling no longer works at Los Angeles County.	Ali Frazzini is now our sole LA County stakeholder representative.	March 2023 / resolved
4		Reviewer delaying publication (original deadline: Feb. 27)		March 2023
5				
…				

* Please designate risk type as: Technical (T), Budget (B), End-User/Stakeholder (ES), or Project Management (PM)

Next steps

- Visualization
  - We have created a great visualization and explorationtool that can zoom in to any region
  - **We don’t know how to make it public through the NASA red tape!** (help)
- Extend physiological model and explore additional critical humid heat story lines
  - Add insolation, and do outside labor and sports story lines
  - Add non-ideal health capability, and move away from ideal health upper limits
  - Consider cumulative heat health impacts (over multiple hours and days)
- Increase spatial resolution
  - We are currently collecting data and beginning to implement 375 m 2m T from VIRS
- Applications
  - First workshop planned for April 11 (only 2 hours, virtual)
  - Objectives: build long-term relationships, solicit feedback
  - Red Cross Red Crescent stakeholders are co-leading
  - We expect 15-20 stakeholder attendees expected from around the world

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Conclusions

- Our results are conservative physiological upper limits
  - do NOT depend on regional acclimatization
  - adverse health impacts will occur much sooner than our upper limit projections
- Results are model- and pathway-dependent
- Extreme humid heat exposure (person-days per year) could increase by an order of magnitude over the next 70 years
- Impacts on cities and regions will be highly non-uniform
  - Densely populated cities and regions in the Global South will experience highest impact
- Under SSP1-2.6, extreme impacts would be nearly completely avoided

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Thank you!

@ClimateHuman
@ClimateHuman
@ClimateHuman@climatejustice.social

Accomplishments since Last Update

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- We have written and submitted two peer-reviewed papers (as previously mentioned).
- We are in the process of collecting and preparing data for the high-resolution analyses (375 m).
    - Data has been transferred to the Pleiades supercomputer by Tinh La, a new collaborator who works with Glynn Hulley
- Peter is still in discussion with the PI of the CHIRTS daily dataset, which has the potential to produce results at an intermediate 5 km resolution
    - This pathway for our work has a barrier in that CHIRTS daily currently only goes up to 2016. Also, it currently only covers 60° S-70° N and I would prefer to switch to a global analysis at the 10 km and 5 km resolutions if possible.
- New collaborations:
    - Angel Hsu at UNC, an expert in climate justice and socioeconomic data. Peter will attend a workshop she is leading on March 10.
    - Tinh La, a computational expert who is a contractor at JPL.
    - Collaborations at Duke are now very firm (Drew Shindell, Luke Parsons, Erik Patton). I have been appointed Adjunct Professor at Duke.
    - Collaborations at Berkeley are now very firm (David Romps, Yi-Chuan Lu).
- Peter has submitted an abstract to the AGU Chapman on on Climate and Health for Africa, June 12-15 in Washington DC.

Accomplishments since Last Update

University of Cincinnati

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Summary of work completed in the reporting period:

- Work with Ayesha and others on the team to improve and validate the downscaling algorithms for temperature and ERA: (i) A new trend function is used for both variables with improved downscaling accuracy; (ii) ERA is analyzed with logit transformation to ensure that the downscaled projection (and resulting interval) is between 0 and 100; (iii) We made comparison with the standard downscaling method demonstrating improved accuracy.
- Ayesha finished a brief guideline so that other team members can try running the downscale code. Peter has successfully tried running it, and refactoring / performance analysis is commencing
- Model weighting code for MCMC derivation is complete

Plan for the next reporting period:

- Implement C++ part in MCMC for model weighting and testing with synthetic data (speed up)
- Completing the model weighting paper
- New idea to improve the downscaling algorithm: Boosting Downscaling, to introduce data-driven basis function for small regions; testing its performance

Accomplishments since Last Update
Emory University

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- Accomplishments since last update (last three months)
  - Conducted state-wide analyses of short-term associations between temperature and emergency department visits for heat-sensitive outcomes
  - Compared effect estimates derived using wet-bulb and ambient temperature metrics.

- Challenges and risks
  - None noted.

- Goals for next three months
  - Refine epidemiologic analyses to the Los Angeles metropolitan area.
  - Examine effect modification of temperature and emergency department visit associations by air conditioning penetrance.
  - Evaluate the sensitivity of effect modification by other areal level variables.

Accomplishments since Last Update

USC

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Accomplished since last update:

- Completed the analysis for the heat metric and AC penetration rates study and drafted a manuscript. We hypothesize that dry-bulb temperature correlates with AC best because the sensible load of an AC unit dominates over the latent load, meaning the energy signal for dehumidifying the air is difficult to observe in most climates. It is possible that the study may have different results in a hot humid region.
- We also used the reanalysis ERA5 data as inputs to the linear regression model, and computed AC penetration rates in the study region using both dry bulb and wet bulb temperature. We are currently in the process of comparing those results against those found using weather station data.

Goals over the next three months:

- We expect to gain access to smart meter data from PG&E for 70,000 homes in 13 different cities.

Planned deliverables:

- A dataset including census tract or zip code level (depending on needs of public health team) AC
- Penetration rate estimates for major metro areas in SCE and PG&E territories.

Challenges and Risks:

- We expect the PG&E data to come in this quarter, but given this data request has taken more than a year there is a risk of further delay.

Current ARL-Supporting Evidence

ARL 3

- **Components of your application have been tested & validated independently.**
- Key components of our application, namely statistical downscaling, ecological projection, and a tool for public display of data to end users and the public, have been tested and validated in a prior ROSES A.8 project, "Identifying coral refugia from observationally weighted climate model ensembles." We are using the same statistical downscaling methodology for this project, namely spatial dependence modeling using basis graphical lasso (BGL, Kalmus et al. 2022, https://doi.org/10.1029/2021EF002608). The ecological projection analysis methodology using thresholds was also developed and validated in this same paper (https://doi.org/10.1029/2021EF002608).
- In addition, this quarter we have applied similar methods to produce daily projections of extreme humid heat at 0.1-degree (~10 km) spatial resolution, employing a physiological model of humid heat impacts on the humid body, developed by Lu and Romps (https://doi.org/10.1175/JAMC-D-22-0021.1), and validated by them (work in review).
- These are the four key components of our capacity to project extreme humid heat and present those projections to end users and the public (downscaling, impact modeling, projection, visualization).

Current ARL-Supporting Evidence

ARL 3

- **Detailed characterization of user decision-making process has been completed (e.g., pre-application baseline performance, mechanisms, and limitations).**

The detailed characterization of the user decision-making process is ongoing, but progress has been made.

Pre-application baseline performance metrics:

- Number of cities in Los Angeles County with climate action plans informed by humid heat projections at the neighborhood scale. Baseline: 0.
- Number of resource decisions in Los Angeles County government informed by humid heat projections at the neighborhood scale. Baseline: 0.
- Number of municipalities where the Red Cross red Crescent (RCRC) is implementing programs that involve heatwave risk reduction, preparedness, or response efforts informed by the research outcomes. Baseline: 0.
- A summary of decision-maker success metrics to inform research development, outlined within the first six-months of the project. Baseline: 0.
- An action plan that translates the outcome of the research into priority implementation interventions to reduce heat risks around the world; which also outlines a roadmap to implement priorities beyond the 3-year period of performance. Baseline: 0

Current ARL-Supporting Evidence

ARL 3

- **Detailed characterization of user decision-making process has been completed (e.g., pre-application baseline performance, mechanisms, and limitations).**

Limitations: It will take the duration of the project to address the following challenges, which will limit the decision-making process in the meantime:

- Limited resolution: We first produced projections at ~10 km spatial resolution. Later, we plan to move to higher resolutions. Higher spatial resolution will better facilitate focused decisions on urban heat mitigation.
- Idealized health impact model: We first produced projections with thresholds applicable to ideally healthy humans, a "conservative case" that will underestimate humid heat impacts on real populations. Later, we plan to factor in nonidealities. Doing this will require heat health records and human thermoregulatory SMEs.
- Heatwave projections: We first produced single-day projections of extreme humid heat. Later, we plan to produce projections of multi-day/night heatwaves.

Current ARL-Supporting Evidence

ARL 3

- **A convincing case for the viability of your application concept has been made.**
- We have the tools to make high-resolution extreme humid heat projections, and these projections are the key input to mitigation actions of urban hot spots.
- This quarter, we have created projections at ~10 km, demonstrating the concept at a preliminary resolution. The final projections are planned to be at 375 m.
- Here is one quote from our end user, the Red Cross Red Crescent: “Red Cross Red Crescent has committed to ensuring that 250 million people are better protected from heat (the most ignored and rapidly rising climate risk) by 2025, in at least 150 cities and towns, one of four global goals for climate action over the next five years. Neighborhood-scale humid heat projections will be crucial to guiding heat mitigation efforts, especially in low-income countries where heat-health research has been woefully underfunded. In addition, lack of clear results that heat is deadly now, and will be worse in the future, is a key barrier to catalyzing heat action, which is routinely experienced by colleagues in our network.”

Achieving ARL-4

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ARL4 Definitions: Basic components of Earth science products and the decision making activity (decision support system, tool, etc.) are integrated together into a prototype “application system” to establish that they will work together. At this level, the technical, organizational, and human process issues related to the decision support activities are also worked out. Project team must verify that components will work together to achieve this ARL.

Milestones:

- Components of eventual application system brought together and technical integration issues worked out
- Organizational challenges and human process issues identified and managed

This quarter, I will work with the applications stakeholders to leverage the new 10-km resolution results, and possibly initial 375 m results if available in time, to achieve ARL4.

The key is communication with stakeholders. I am working with the LA County and Red Cross stakeholders to create a plan for prototyping the first applications system.

Schedule & Milestones

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- In Q3, we technically accomplished Objective 1: "**produce high-quality, validated projections of extreme humid heat at unprecedented spatial resolution.**"
  - We are continuing to push to higher spatial resolutions up to 375 m, as proposed.
- We have written and submitted two peer-reviewed papers for the initial (10 km) analysis
  - "Global projections of uncompensable and fatal humid heat," submitted to PLOS Climate (open access)
  - "Fatal humid heat conditions to 2300," submitted to Environmental Research Letters (open access)
- We are revisiting the idea for model weighting for daily heat projection
  - Model weighting was not included in the first two submitted papers, and it will be possible to achieve all project objectives without it.
  - Model weighting is one way to achieve model-independence. We will continue to weigh its pros and cons.
  - Model weighting is appropriate for monthly projections of sea-surface temperature for coral reefs. My concern is that it would "tamp down" extremes for daily heat projection.

Schedule & Milestones

EARTH SCIENCE
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- We may be somewhat behind schedule in developing the initial morbidity and mortality model, which was scheduled to be complete after Q4.
    - We are now approaching this task on two fronts: via medical data and statistical modeling, as proposed (and led by Emory), but also via the Berkeley thermal physical model, by leveraging it via calibration with medical data and theory.
- Planning for first workshop and first applications is ongoing, planned for first half of April
    - Our applications partner Roop Singh at Red Cross Red Crescent is spearheading
    - We are planning a two-hour virtual workshop for the first workshop, to make stakeholder attendance as easy as possible. Goals of the workshop:
        - Get to know stakeholders
        - Communicate project goals, plans, and status
        - Solicit stakeholder input for applications, new research directions, and tweaks
        - Plant the seed for continuing engagement and attendance at future, more in-depth workshops
    - We have a preliminary list of international stakeholder invitees and have set an internal deadline of March 10 for sending invitations

Highlight Image

Figure 2 from our paper, submitted to PLOS Climate.

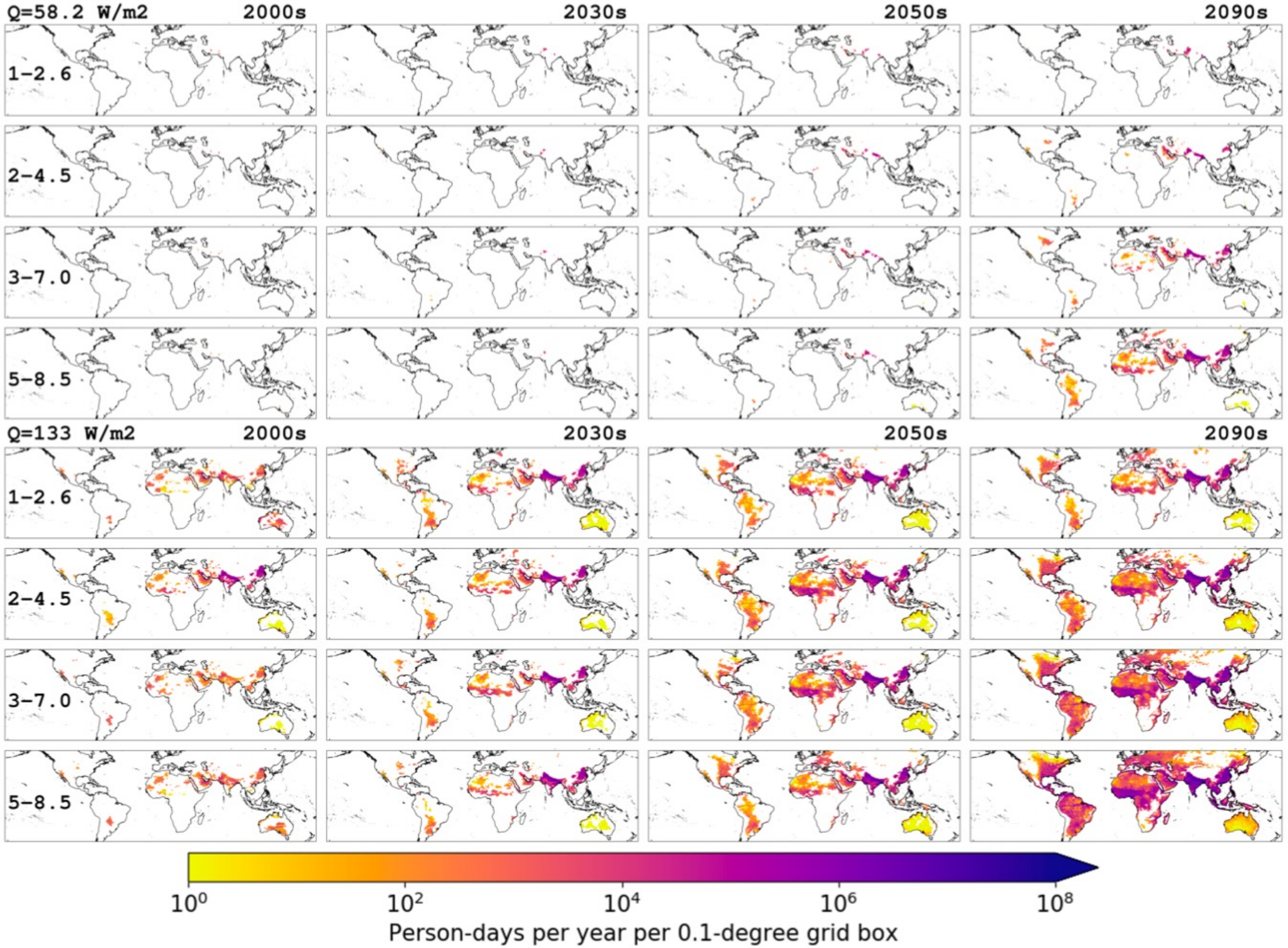
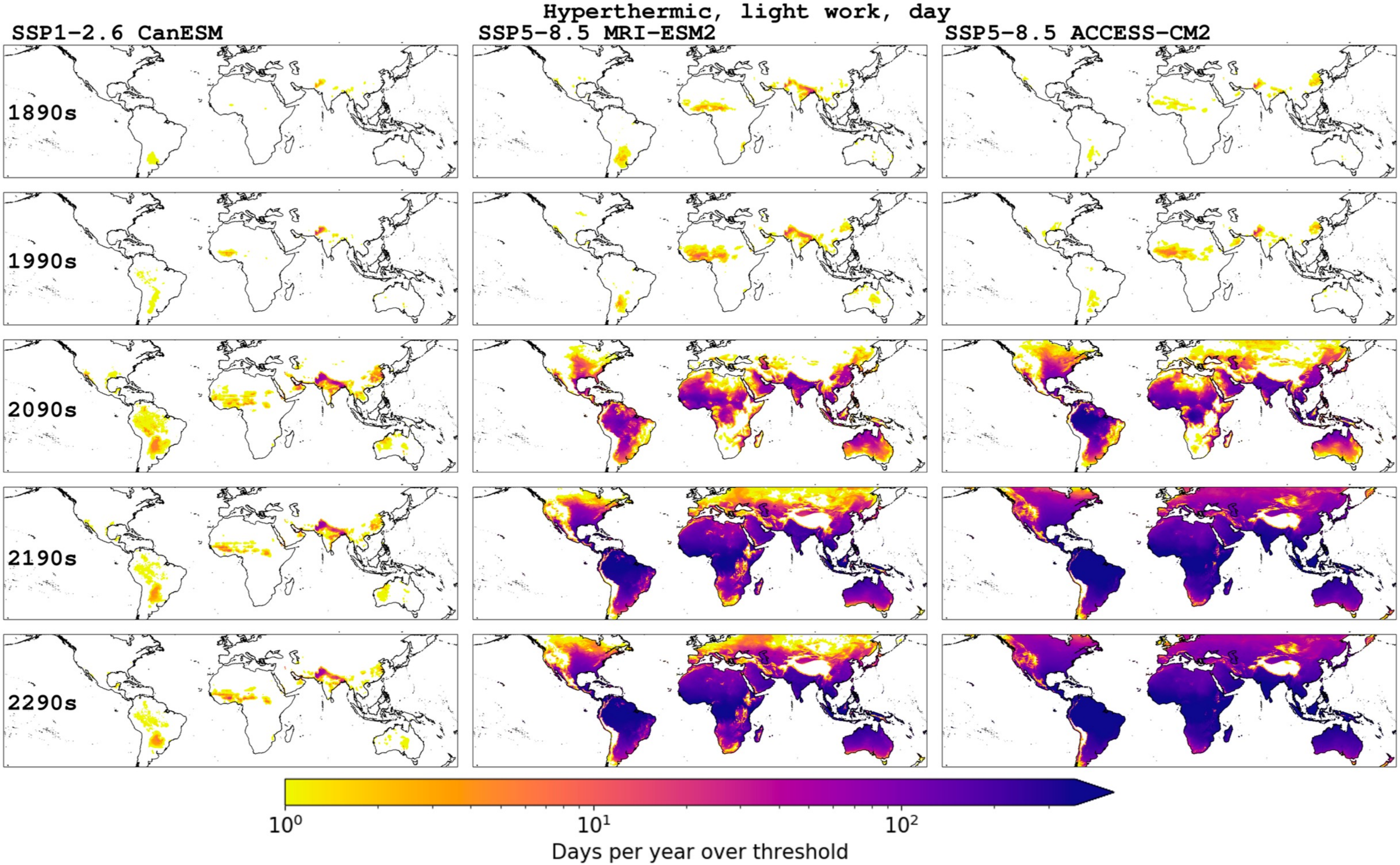
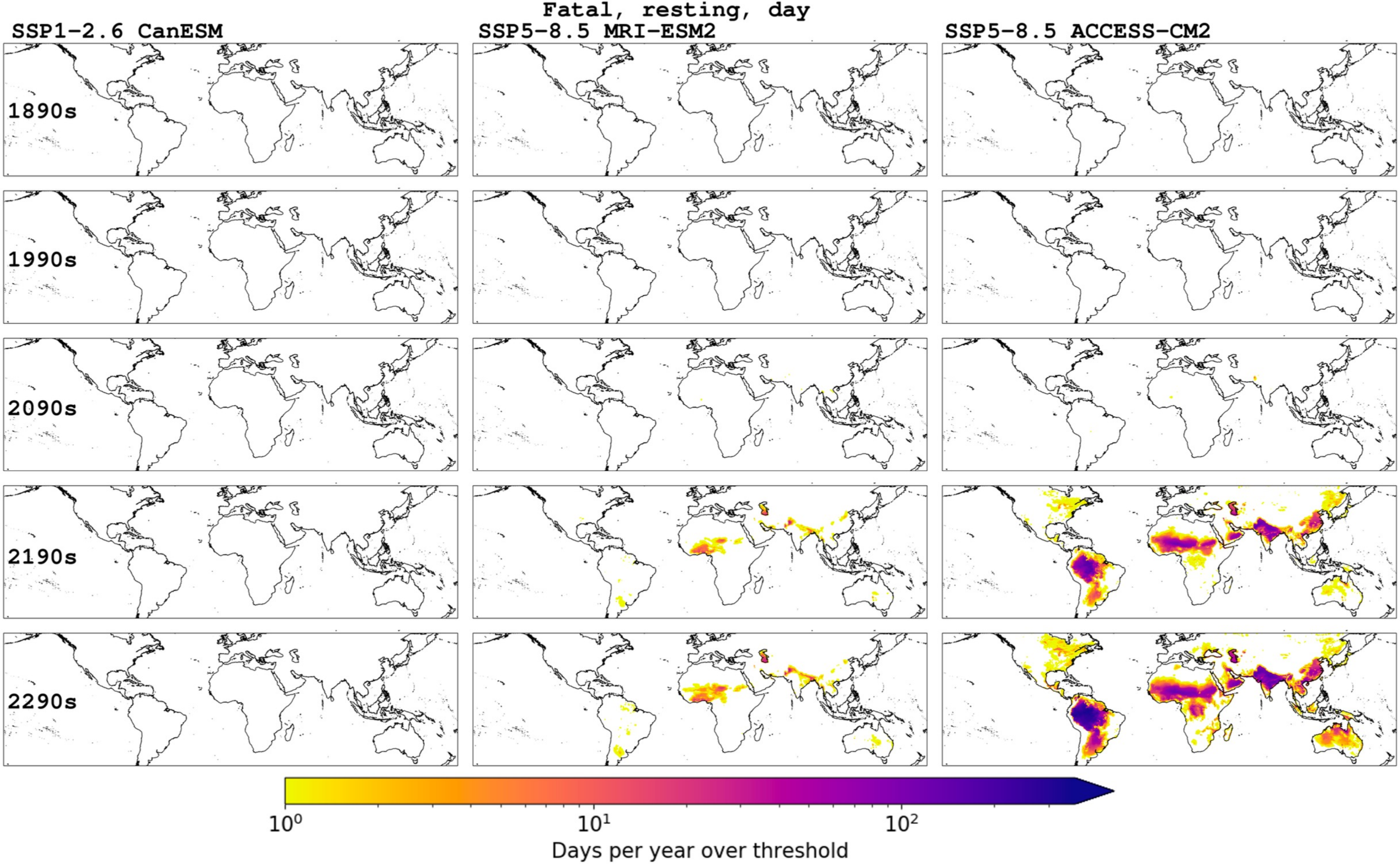


Fig 2. Person-days per year per 0.1° x 0.1° grid box with UHHC at a *resting* metabolic rate of Q=58.2 $\mathrm{W m^{-2}}$ (top four rows) and at a *low* metabolic rate of Q=133 $\mathrm{W m^{-2}}$ (bottom four rows). Columns show mean results for specific decades, from left: 2000s (from historic runs), 2030s, 2050s, 2090s. Rows show models and SSP runs, from top: CMCC-ESM2 SSP1-2.6, CMCC-ESM2 SSP2-4.5, CMCC-ESM2 SSP3-7.0, CMCC-ESM2 SSP5-8.5.



Hyperthermic, light work, day
SSP1-2.6 CanESM
SSP5-8.5 MRI-ESM2
SSP5-8.5 ACCESS-CM2
1890s
1990s
2090s
2190s
2290s
10^0
10^1
10^2
Days per year over threshold



Fatal, resting, day
SSP1-2.6 CanESM
SSP5-8.5 MRI-ESM2
SSP5-8.5 ACCESS-CM2
1890s
1990s
2090s
2190s
2290s
10^0
10^1
10^2
Days per year over threshold

Earth Observations, Models, and/or Technologies

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For phase 1: ~10 km projections

Satellite Sensor/Model/Tech.	Product Used	Temporal Coverage and Latency required	Comments
CMIP6 ESMs	tasmax: daily maximum 2m air temperature. tasmin: daily minimum 2m air temperature. huss: 2m specific humidity (daily average). ps: surface pressure.	Daily temporal coverage for tasmax, tasamin, huss; monthly for ps. No latency requirement.	~1° resolution, regridded to 1° resolution.
ERA5-Land reanalysis	2m air temperature, 2m dewpoint temperature	Daily temporal coverage. No latency requirement.	0.1° resolution.