## OVERVIEW OF RESEARCH OUTPUT FROM THE HEAT-SHIELD PROJECT

### Andreas D. Flouris

### FAME Lab, University of Thessaly, Greece





✓ Mission: to address the negative impacts of workplace heat stress on the health and productivity of workers in strategic European industries



Horizon 2020 European Union funding for Research & Innovation



Funded by the EU Horizon 2020 research and innovation programme (no.668786)

# - THE HEAT-SHIELD PROJECT

## ≺ 20 partners | 11 countries

- ≺ University of Copenhagen
- ≺ University of Ljubljana
- ≺ University of Thessaly
- ≺ University of Wolverhampton
- $\prec$  University of Florence
- $\prec$  Swiss Federal Laboratories for Materials Science and Technology
- ≺ Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek
- $\prec$  Lund University
- $\prec$  Federal Office of Meteorology and Climatology MeteoSwiss
- $\prec$  Loughborough University
- ≺ Institute Josef Stefan
- ≺ Tuscany Centre of Injuries & Occupational Diseases
- ≺ Age UK
- ≺ University of Porto
- $\prec$  Dutch National Health Service
- $\prec$  Center for Technology Research and Innovation Ltd.
- ≺ Karditsa Travel
- ≺ ACCIONA Co.
- $\prec$  University of Nicosia
- ≺ Odelo Slovenia d.o.o.



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# $\mathbf{A}^{\mathrm{fame}}$ ilo methodology to address occupational challenges

### $\prec$ Assess needs

- hazards assessment
- profile of the target population
- background on the social context
- ≺ Gain support
  - identify and involve key actors that provide ongoing advice, support, networking
- $\prec$  Establish education objectives and content
  - identify specific learning objectives to create an activist workforce that will advocate effectively for a healthier work environment

### $\prec$ Select education methods

- select methods based on objectives, content areas and the profile of the workforce
- $\prec$  Implementing an education program
  - carry out the plan
- $\prec$  Evaluate and follow up
  - allow lerners to judge the progress toward new knowledge, skills, attitudes or actions
  - allow educators to judge the effectiveness of the training and what has been accomplished



International Labour Organization

# $\prec$ FIELD STUDIES ACROSS EUROPE

✓ HEAT-SHIELD mission: to address the negative impacts of workplace heat stress on the health and productivity of workers in strategic European industries



# $\prec$ FIELD STUDIES ACROSS EUROPE – METHODOLOGY

### **Metabolic Rate**

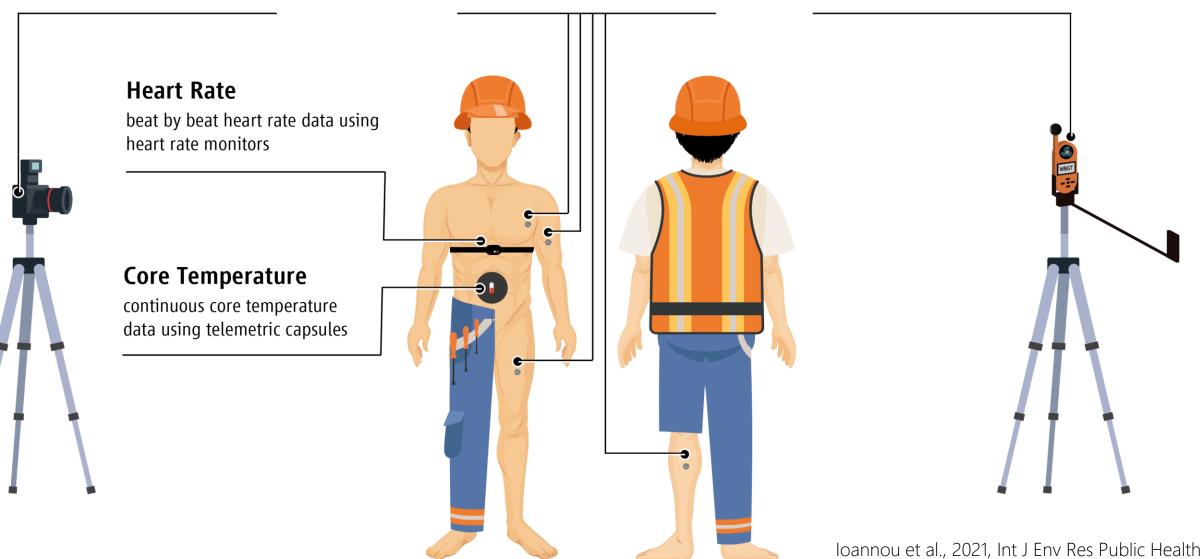
second by second time-motion analysis or real-time analysis

#### Mean Skin Temperature

continuous skin temperature from four sites using wireless thermistors

### **Occupational Heat Stress**

continuous environmental data using a portable weather station



## $-\langle I_{AB}^{EAB} | FIELD STUDIES ACROSS EUROPE - MITIGATION$

- $\prec$  Personalized warning system
- $\prec$  Adaptation strategies

work-rest ratios



### hydration



### mechanization



### clothing



### ≺ Vulnerable workers

# $\mathcal{A}^{\text{\tiny EABE}}$ all project outputs are shown in our webpage

## $\prec$ Outputs to date:

- guidance documents
- 52 scientific articles
- >40 conference presentations
- 6 videos
- 9 infographics



## ✓ www.heat-shield.eu



Public Guidance

News

Scientific

About HEAT-SHIELD

Contact

## $\mathbf{A}^{\mathrm{EAB}^{\mathrm{E}}}$ HEALTH IMPACT OF OCCUPATIONAL HEAT

 $\prec$  During or at the end of a single work shift under heat stress

- 35% of workers experience symptoms of occupational heat strain

		Articles
Workers' health and productiv strain: a systematic review and		۴. 🗶
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workers' ability to live healthy and productive lives. We es health and productivity outcomes.	nvironmental heat stress on the body directly threatens limited the effects of occupational heat strain on workers' atic review and meta-analysis, we searched PubMed and	I scor Powelischt 2018; In 621 31 FAME Jako stay, Jopan neut of East setSchnig, University of Theory, Tribals, Gener
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Funding EU Horizon 2020 research and innovation progra	inune.	
Copyright @ 2018 The Author(s). Published by Ebevier L1 license.	d. This is an Open Access article under the CC BY-NC-ND	
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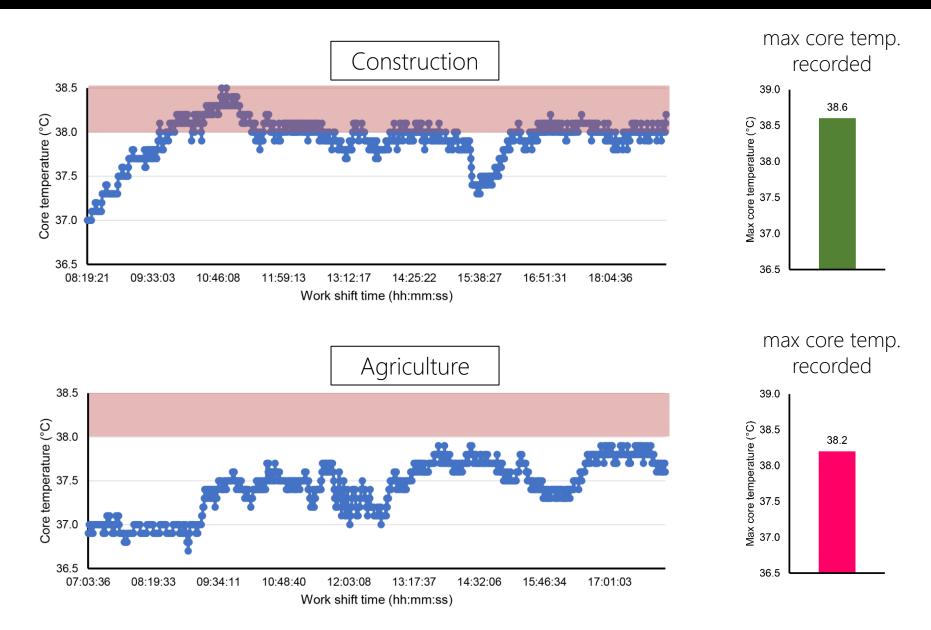
## $\mathbf{A}^{\mathrm{fame}}$ health impact of occupational heat

- $\prec$  Those who frequently work in the heat experience
  - 4-fold increase in the likelihood of having heat strain
  - -0.7°C higher body temperature
  - -14.5% increase in urine specific gravity
  - -15% risk for kidney disease / acute kidney injury

		Articles	
Workers' health and productiv strain: a systematic review and	· ·	<b>†</b>	
Andreas D Hocais, Patros C Dinas, Leanidas G Ieannoc, Lois Alyba, Seorg	e Havenich, Glen P. Konny, Tavi Ajelfstram	oa	
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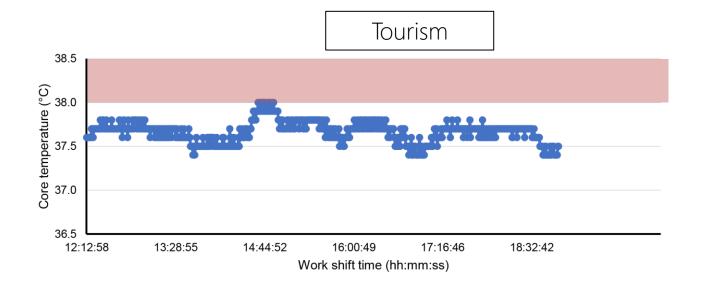
witelannet.com/planetary-health Vol 2 Basember 2028

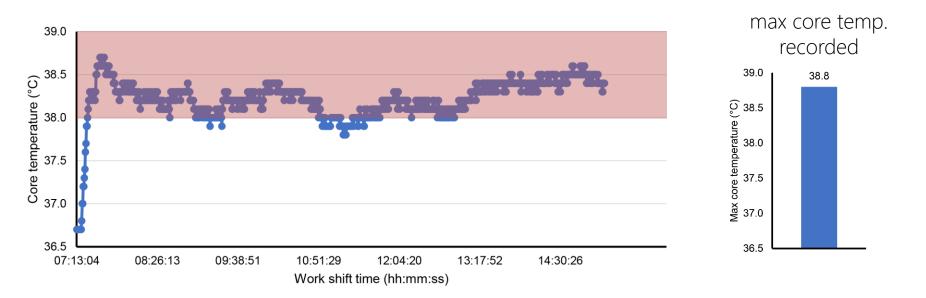
## - Heat in the workplace



Flouris et al., Unpublished Data

## - HEAT IN THE WORKPLACE





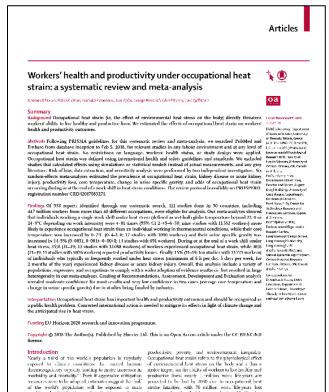
Flouris et al., Unpublished Data

## $\left< {}^{\text{FAMME}} \right.$ PRODUCTIVITY IMPACT OF OCCUPATIONAL HEAT

 $\prec$  During or at the end of a single work shift under heat stress

- 30% of workers report productivity losses

✓ In most cases, the adopted units of labor reflected the total volume of output over an hour or a day recorded from <u>tens</u> or even <u>thousands</u> of workers grouped together



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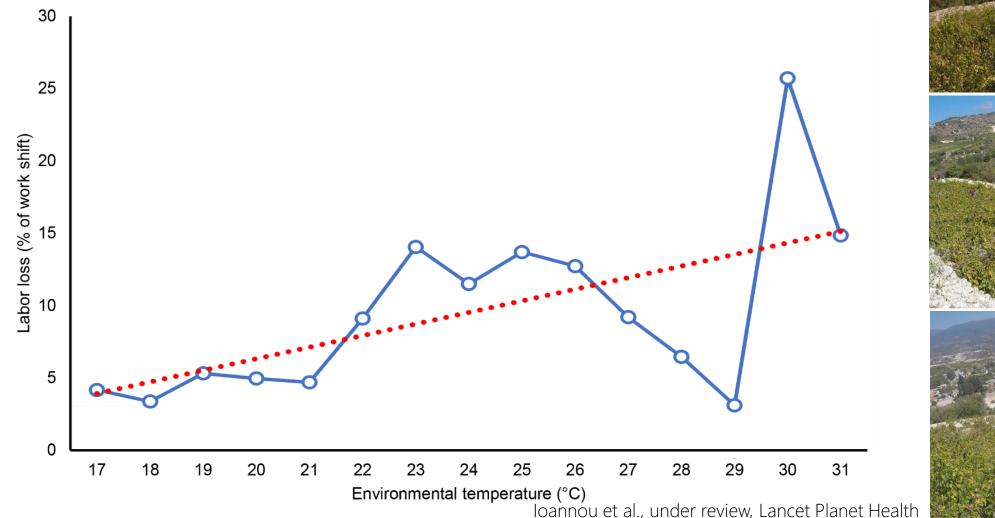
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# $-\langle L^{\text{EABME}}$ do you think the heat affects your productivity?



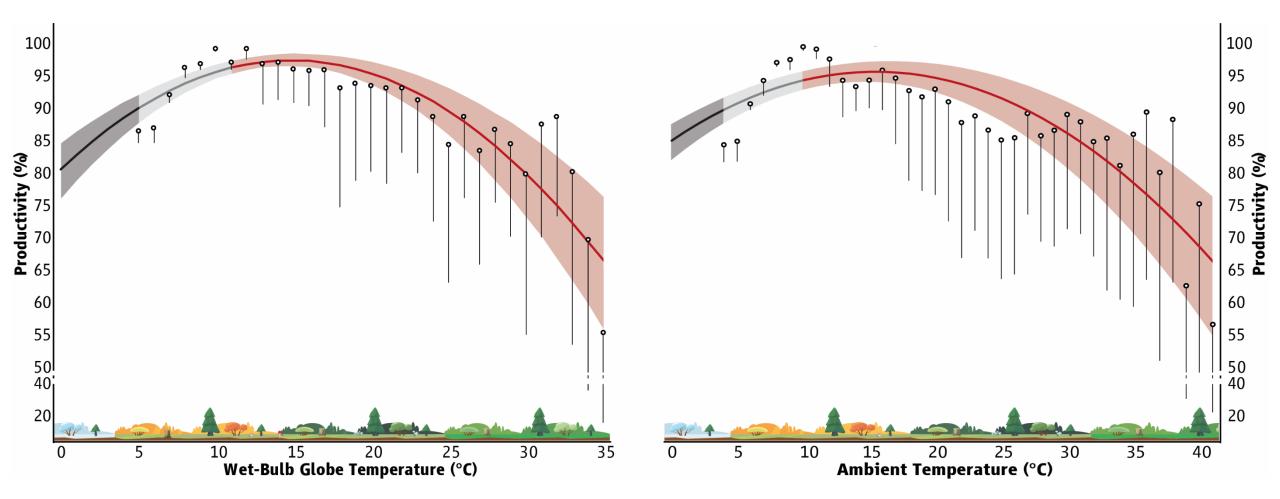
 $-\langle IBME DO YOU THINK THE HEAT AFFECTS YOUR PRODUCTIVITY?$ 

✓ Loss of 1% of labor time for every 1°C increase in environmental temperature, for this worker



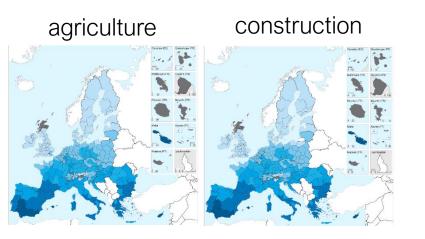


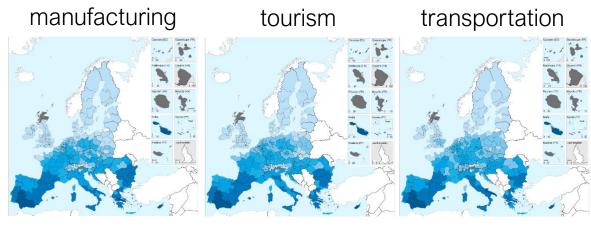
# $\mathcal{A}^{\mathrm{EAME}}$ IMPACT OF HEAT STRESS ON LABOUR PRODUCTIVITY

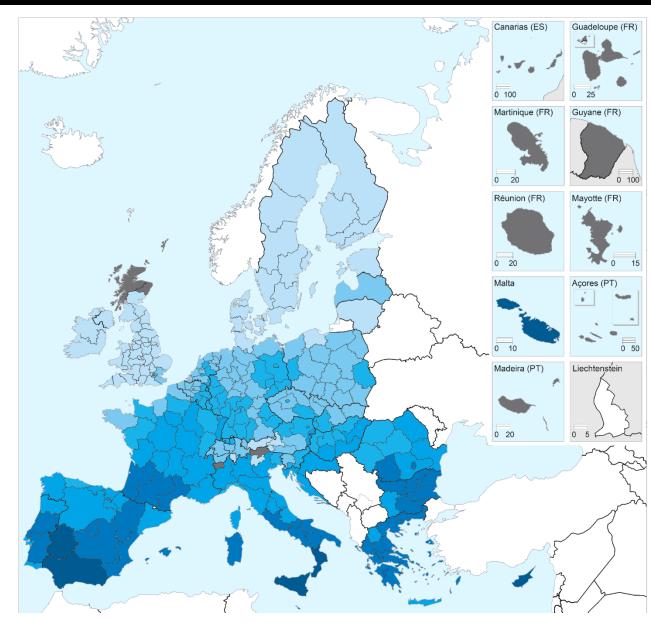


## **VULNERABILITY MAPS FOR EUROPE AT NUTS2**

✓ Percentage of gross value added lost across Europe

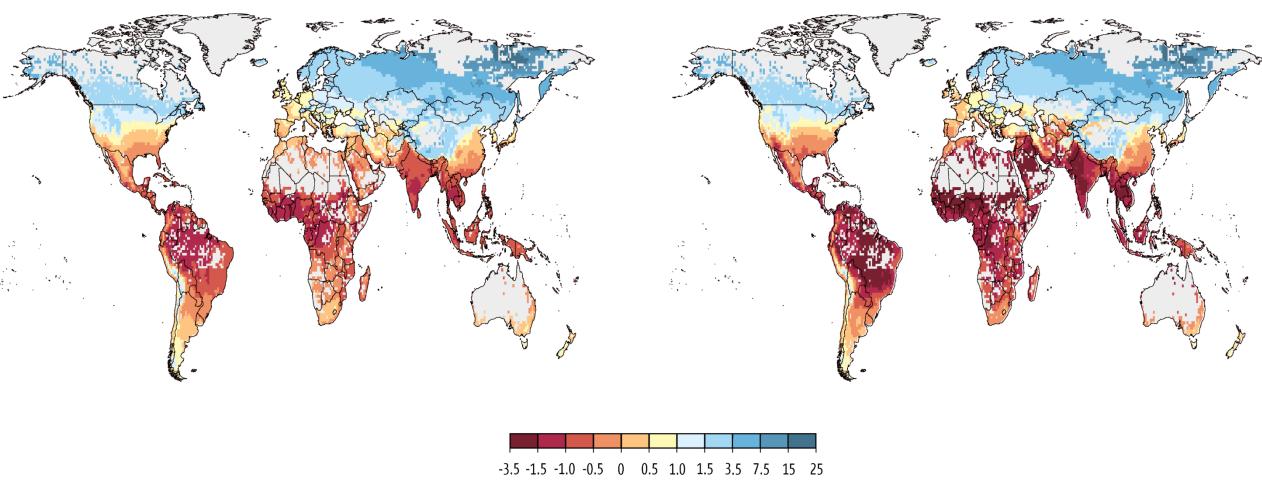






Flouris et al., Under Preparation

## IMPACTS IN AGRICULTURE LABOUR PRODUCTIVITY

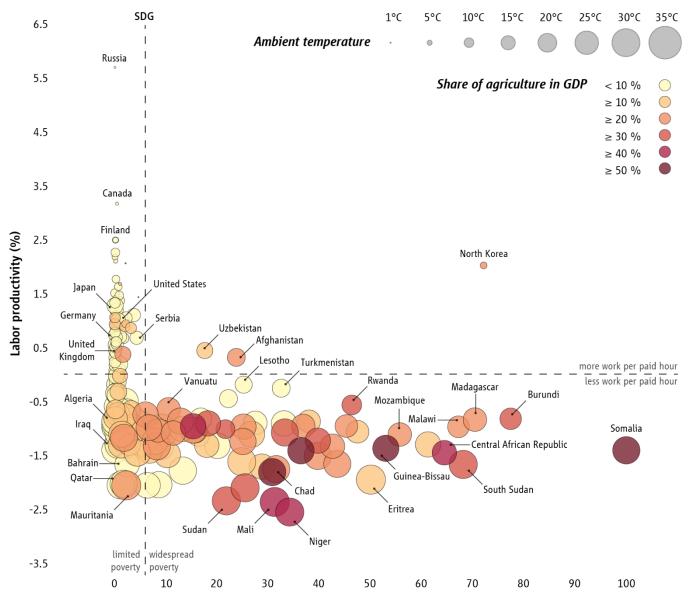


Ambient Temperature

Net agricultural labor productivity change (%) between 2000 and 2040

Wet-Bulb Globe Temperature

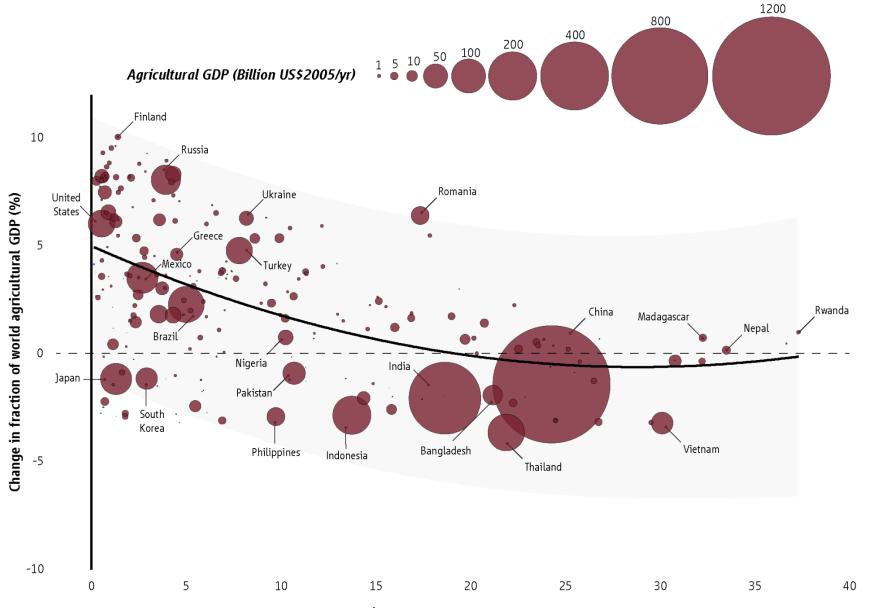
## IMPACTS IN AGRICULTURE – FUELING INEQUALITIES



Proportion of people living below the international poverty line (less than US \$1.9 a day)

Ioannou et al., under review, Lancet Planet Health

## $\langle \mathsf{IMPACTS} | \mathsf{N} \mathsf{AGRICULTURE} - \mathsf{FUELING} | \mathsf{NEQUALITIES} \rangle$



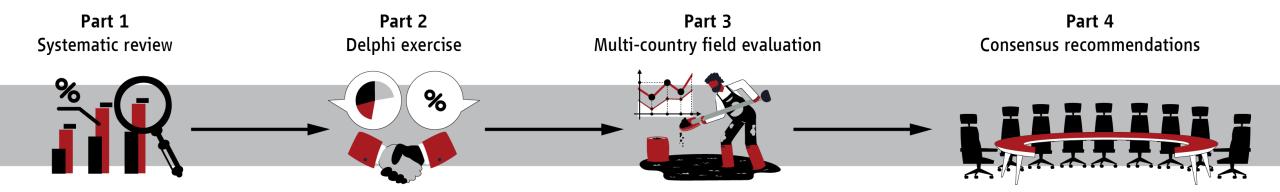
Country's share of agriculture in GDP in 2000 (%)

Ioannou et al., under review, Lancet Planet Health

How well do thermal indicators quantify the magnitude of occupational heat strain?



✓ Process to evaluate the efficacy of thermal indicators for assessing occupational heat stress and protecting workers



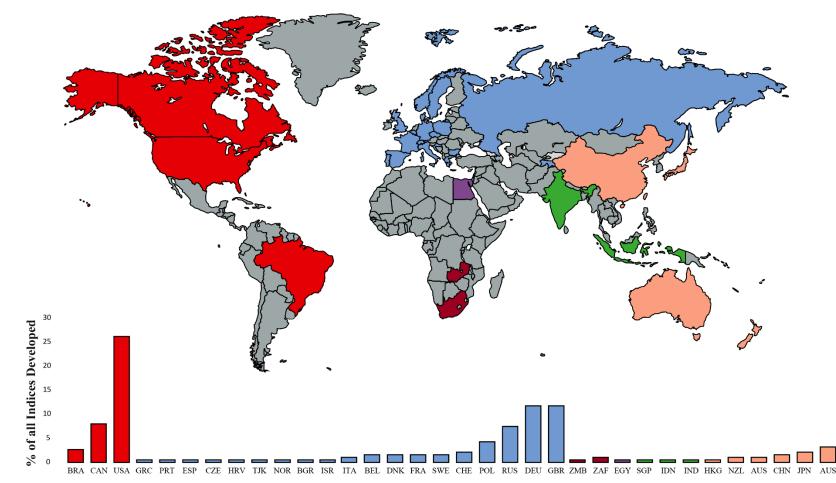
## $\prec^{\text{\tiny FAME}}$ thermal indicators to assess occup. Heat stress

≺ 232 publications (1905 – 2018)

## $\prec$ 339 thermal indicators

**– 187** calculated using meteorological data

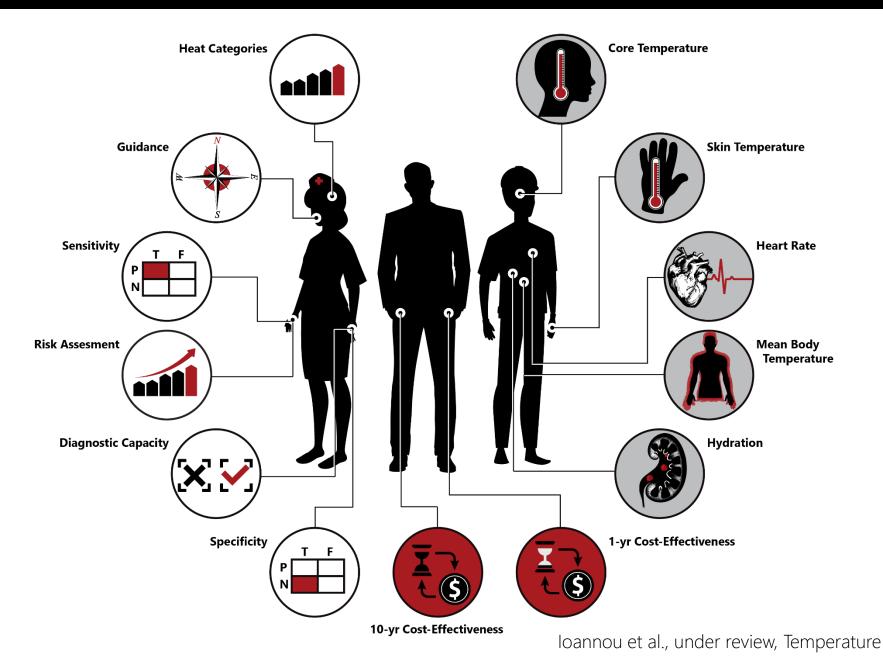
✓ 61 suitable for use in occupational settings



loannou et al., under review, Temperature

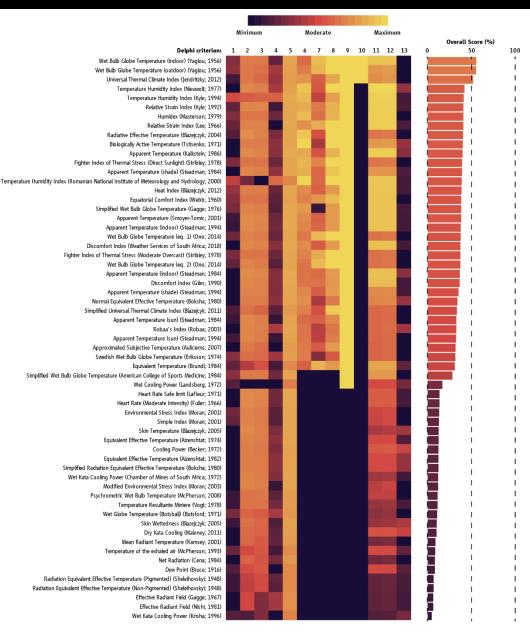
## $\mathbf{A}^{\text{EXP}}$ Thermal indicators to assess occup. Heat stress

✓ Criteria to consider when adopting a thermal indicator



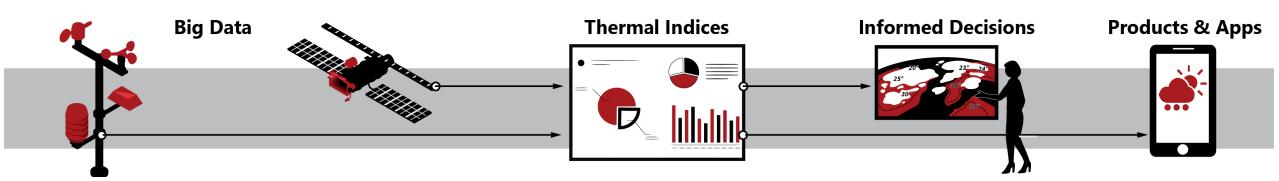
## THERMAL INDICATORS TO ASSESS OCCUP. HEAT STRESS

- ✓ Field experiments evaluating the efficacy of 61 meteorology-based indicators for occupational settings to quantify the physiological strain experienced by those who work in the heat
  - 9 countries (Australia, Cyprus, Canada, Denmark, Greece, Qatar, Slovenia, Spain, and USA)
  - 372 experienced and acclimatized workers
  - 1 to 5 work shifts per worker
    - ≺ core body temperature ≺ mean skin temperature
    - ≺ heart rate
    - $\prec$  urine specific gravity



# $\prec$ Thermal Indicators to assess occup. Heat stress

- ✓ Simply measuring one or more meteorological parameters (air temperature, humidity, wind, solar radiation) <u>does not</u> adequately reflect the physiological heat strain experienced by working individuals
- ✓ The indoor and outdoor Wet-Bulb Globe Temperature (WBGT) as well as the Universal Thermal Climate Index (UTCI) emerge as the <u>most efficacious</u> meteobased indicators for quantifying the physiological strain experienced by workers in different occupational settings



loannou et al., under review, Temperature

IMPROVING OCCUPATIONAL HEAT STRESS ASSESSMENT

✓ Wet-Bulb Globe Temperature (WBGT) ---> largest evidence base for use in occupational settings

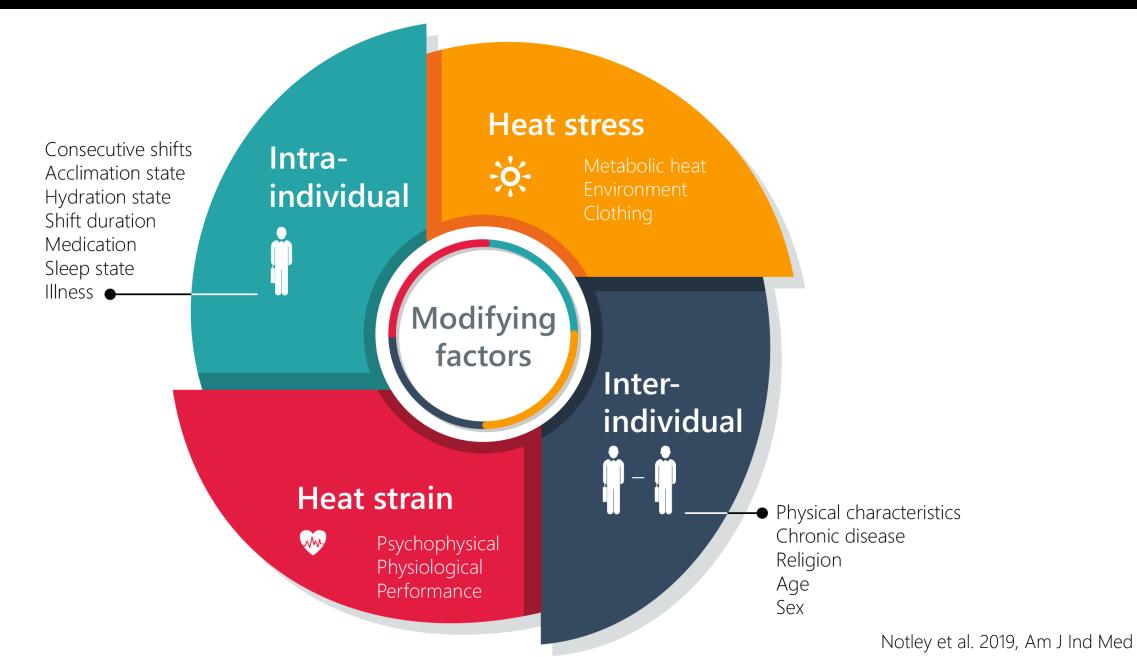
✓ Popularize adoption of WBGT for work settings



From the webpage of the Greek National Weather Service

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## $\mathbf{A}^{\text{fame}}$ factors determining response to heat



# $-\langle ABBE \rangle$ Addressing heat effects on occupational health,

### $\prec$ Assess needs

- hazards assessment
- profile of the target population
- background on the social context

## $\prec$ Gain support

- identify and involve key actors that provide ongoing advice, support, networking
- ≺ Establish education objectives and content
  - identify specific learning objectives to create an activist workforce that will advocate effectively for a healthier work environment

### $\prec$ Select education methods

- select methods based on objectives, content areas and the profile of the workforce

### $\prec$ Implementing an education program

- carry out the plan

### $\prec\,$ Evaluate and follow up

- allow lerners to judge the progress toward new knowledge, skills, attitudes or actions
- allow educators to judge the effectiveness of the training and what has been accomplished



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 $\mathcal{A}^{\text{\tiny FAME}}$  COLLABORATION WITH KEY ACTORS

- $\prec$  Workshops with industry and worker stakeholders
  - Florence, Italy
  - Athens, Greece
  - Tønder, Denmark
  - Nicosia, Cyprus
  - Ljubljana, Slovenia
  - Loughborough, UK
  - Madrid, Spain
- ≺ Supporting European Trade Union Confederation
- ≺ Supporting Global Heat Health Information Network
- ≺ Meetings/Workshops with policy makers
  - WHO, Geneva
  - Honk Kong, China
  - Wellington, New Zealand
  - Doha, Qatar
  - Athens, Greece



## $\left< {\rm Example} \right.$ Contribution to who, unfccc, and ghhin

#### Workshop #TEPA2020

Education and training to enhance climate adaptation action across sectors

28 July 2020 | 12:00 - 13:30 CEST

Register now at bit.ly/TEMA\_EducationWS





Dialogue: Heat in the workplace





#### Heat and health in the WHO European Region:

updated evidence for effective prevention

# $-\langle \mathcal{A}^{\text{EAME}} \rangle$ ADDRESSING HEAT EFFECTS ON OCCUPATIONAL HEALTH

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# $- \left< \frac{1}{2} \right>$ TECHNICAL REPORTS ON OCCUPATIONAL HEAT STRESS



Flouris et al., 2021

Flouris et al., 2019

## $-\langle A^{\text{EABHE}} WHO - WMO REPORT ON OCCUPATIONAL HEAT STRESS$

 $\prec$  Technical report on occupational heat stress to be jointly published in 2021 by:





# $-\langle \mathcal{A}^{\text{EAME}} \rangle$ ADDRESSING HEAT EFFECTS ON OCCUPATIONAL HEALTH

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International Labour Organization

## **INFORMATION FOR WORKERS & EMPLOYERS**

#### Agriculture 70% **WORKING IN THE HEAT? OF EUROPEANS WORKING IN Dehydration is a serious threat to your health HIGH HEAT ARE DEHYDRATED** Hydration is about maintaining your body's water and electrolytes stores by ingesting fluid and salt to match the amounts you lose through sweating 30 °C + THIRST **DOES IT PROTECT ?** Thirst may not be sufficient to secure that you stay hydrated in hot conditions WATER **AND SALT F 19** Read these steps to secure adequate daily water and salt intake HABITS **DAY-TO-DAY** It is not only about hydrating at work. Hydrating at home is equally important



**BALANCE** Find your balance. Hydration needs vary from person to person



**SWEAT LOSS** Your water needs may be high if you are a "heavy-sweater"



**ELECTROLYTES** If your blood pressure is normal, extra salt to your meals may help



**STAY PROTECTED** Get support personalized to your needs at www.heat-shield.eu

Funded by EU Horizon 2020 grant agreement No 668786

THE ME

Construction

Manufacturing

**A 6** 

Tourism

Transportation



## $\mathbf{A}^{\text{EMM}}$ INFORMATION FOR WORKERS, EMPLOYERS & OHS EXPERTS

## HEAT AFFECTS YOUR HEALTH AND PRODUCTIVITY

HOT FACTs upon which you can ACT to minimize the detrimental effects on your organization's performance

ACCIDENTS - WORKERS' HEALTH - ORGANIZATION PERFORMANCE



Substantial productivity losses surpassing 15% on hot days

s Heat increases work injuries, leads to accumulated fatigue & acute sickness





Frequent work in the heat causes chronic health hazards (e.g., doubled risk of kidney disease)

Request the development of a heat mitigation plan for your organization



Create a buddy system and take breaks (e.g., 2-5 min per hour) that protect health and maintain productivity



Ensure your work uniform is safe, comfortable, and made from breathable fabrics that reflect radiation



Plan outdoor and ohysically demanding work in the cooler parts of the day



#### Employers



#### OHS experts

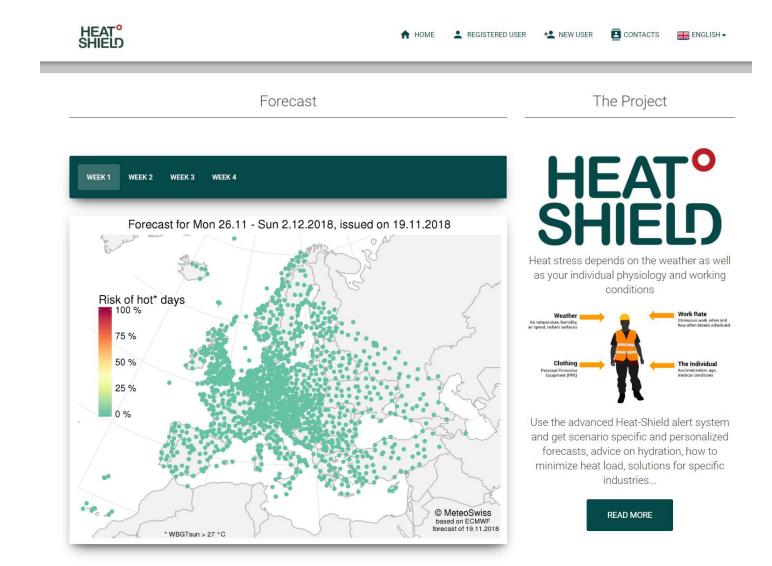


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PERSONALIZED WARNING SYSTEM

- ✓ Online platform providing forecasts and guidance
   up to 30 days in advance
- ✓ Designed for workers and employers



Personalized heat alerts and rest /hydration advice



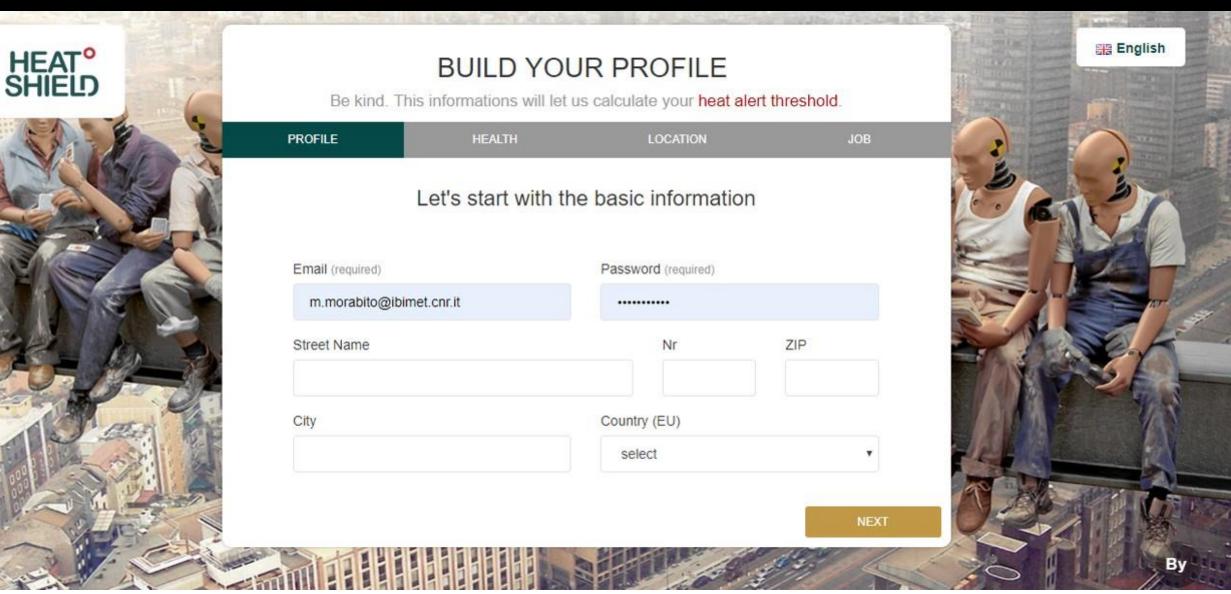




#### Already registered? Insert email and password



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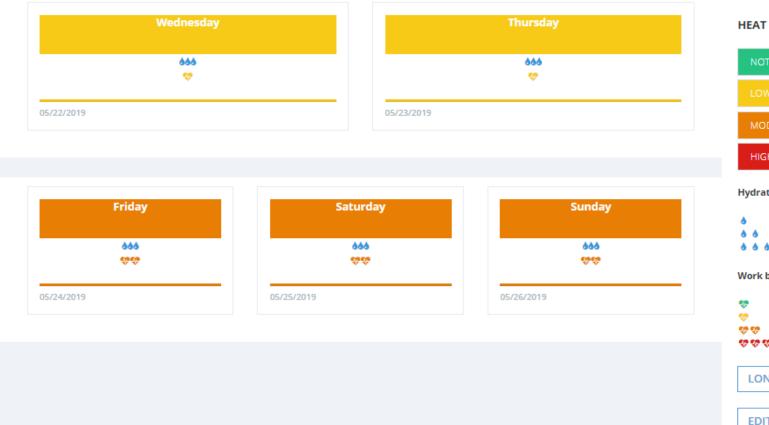




Feedback 🛗 Profile G Forecast

#### Forecast Dashboard U.C.

#### Short term heat stress risk



#### HEAT STRESS RISK LEVELS

NOT SIGNIFICANT	+
LOW	+
MODERATE	+
HIGH	+

#### Hydratation

drink about half a liter of water per hour

- drink about a liter per hour
- lacktrian liter of water per hour

#### Work breaks

no further breaks are neeeded

small breaks

😻 😻 🛛 increase the number of breaks with cooling

😻 😻 💱 frequent breaks in shadow or cooled area

LONG TERM RISK

EDIT PROFILE



🛓 Posta in arrivo - Cartelle locali	🖸 Heatshield Heat Warnin	ng - F 🗙						<b>i</b>			
🐺 Scarica messaggi 🔽 🧨 Scrivi 🖍	🗸 🖵 Chat 🔏 Rubrica	🛇 Etichetta 🗸	🗑 Filtro veloce	Q Cerca < Ctr	+ K>					≡	
Da HeatShield < heatshield.unifi@	)gmail.com> 🚖				<b>5</b> Rispondi	→ Inoltra	Archivia	lndesiderata	Elimina	Altro 🗸	
Oggetto Heatshield Heat Warning									06/07/2	2018, 05:00	
A Marco Morabito 🚖											

According to your profile's features, the heat stress threshold is expected to exceed in the next five days, in the area you selected

Please check the suggestions indicated in your profile

Heat Shield Staff



## PERSONALIZED WARNING SYSTEM





☆ Forecast 🗰 Profile 🗹 Feedback

#### Forecast • Dashboard U.C.

#### Long term heat stress risk

Mon	Tue	Wed	Thu	Fri	Sat	Sun
mon	100	FIG.				
05/27/2019	05/28/2019	05/29/2019	05/30/2019	05/31/2019	06/01/2019	06/02/2019
Mon	Tue	Wed	Thu	Fri	Sat	Sun
06/03/2019	06/04/2019	06/05/2019	06/06/2019	06/07/2019	06/08/2019	06/09/2019
Mon	Tue	Wed	Thu	Fri	Sat	Sun
06/10/2019	06/11/2019	06/12/2019	06/13/2019	06/14/2019	06/15/2019	06/16/2019
Mon	Tue	Wed	Thu	Fri	Sat	Sun
06/17/2019	06/18/2019	06/19/2019	06/20/2019	06/21/2019	06/22/2019	06/23/2019
Mon	Tue	Wed	Thu	Fri	Sat	Sun
06/24/2019	06/25/2019	06/26/2019	06/27/2019	06/28/2019	06/29/2019	06/30/2019
Mon	Tue					

#### HEAT STRESS RISK LEVELS

NOT SIGNIFICANT	+
LOW	+
MODERATE	+
HIGH	+

# $-\langle \mathcal{A}^{\text{EAME}} \rangle$ ADDRESSING HEAT EFFECTS ON OCCUPATIONAL HEALTH

### $\prec$ Assess needs

- hazards assessment
- profile of the target population
- background on the social context
- ≺ Gain support
  - identify and involve key actors that provide ongoing advice, support, networking
- ≺ Establish education objectives and content
  - identify specific learning objectives to create an activist workforce that will advocate effectively for a healthier work environment

### $\prec$ Select education methods

- select methods based on objectives, content areas and the profile of the workforce

### $\prec$ Implementing an education program

- carry out the plan

44/45

## $\prec$ Evaluate and follow up

- allow lerners to judge the progress toward new knowledge, skills, attitudes or actions
- allow educators to judge the effectiveness of the training and what has been accomplished



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## OVERVIEW OF RESEARCH OUTPUT FROM THE HEAT-SHIELD PROJECT

### Andreas D. Flouris

### FAME Lab, University of Thessaly, Greece



Leonidas G. Ioannou,<sup>1,2,3</sup> Lydia Tsoutsoubi,<sup>1,3</sup> Paraskevi Gkiata,<sup>1</sup> Konstantinos Mantzios,<sup>1</sup> Maria Vliora,<sup>1</sup> Konstantinos Dallas,<sup>1</sup> Eleni Nintou,<sup>1</sup> Konstantina Poulianiti,<sup>1</sup> Giorgos Gkikas,<sup>1</sup> Gerasimos Agaliotis,<sup>1</sup> George Samoutis,<sup>4</sup> Lucka Kajfez Bogataj,<sup>5</sup> Marco Morabito,<sup>6,7</sup> Glen P. Kenny,<sup>8</sup> Igor Mekjavic,<sup>9</sup> George Havenith,<sup>10</sup> Chuansi Gao,<sup>11</sup> Tord Kjellstrom,<sup>3</sup> Lars Nybo<sup>2</sup>

<sup>1</sup>FAME Laboratory, School of Exercise Science, University of Thessaly, Greece <sup>2</sup>Department of Nutrition, Exercise and Sports, August Krogh Building, University of Copenhagen, Denmark

<sup>3</sup>Centre for Technology Research and Innovation (CETRI), Limassol, Cyprus

<sup>4</sup>Medical School, University of Nicosia, Nicosia, Cyprus

<sup>5</sup>Biotehnical Faculty, University of Ljubljana, Slovenia

<sup>6</sup>Institute of Biometeorology, National Research Council, 50145 Florence, Italy

<sup>7</sup>Centre of Bioclimatology, University of Florence, 50121 Florence, Italy

<sup>8</sup>Human and Environmental Physiology Research Unit, School of Human Kinetics, University of Ottawa, Ottawa, ON, Canada
 <sup>9</sup>Environmental Ergonomics Research Centre, Loughborough Design School, Loughborough University, Loughborough, United Kingdom
 <sup>10</sup>Jozef Stefan Institute, Ljubljana, Slovenia

<sup>10</sup>Thermal Environment Laboratory, Department of Design Sciences, Faculty of Engineering, Lund University, Lund, Sweden