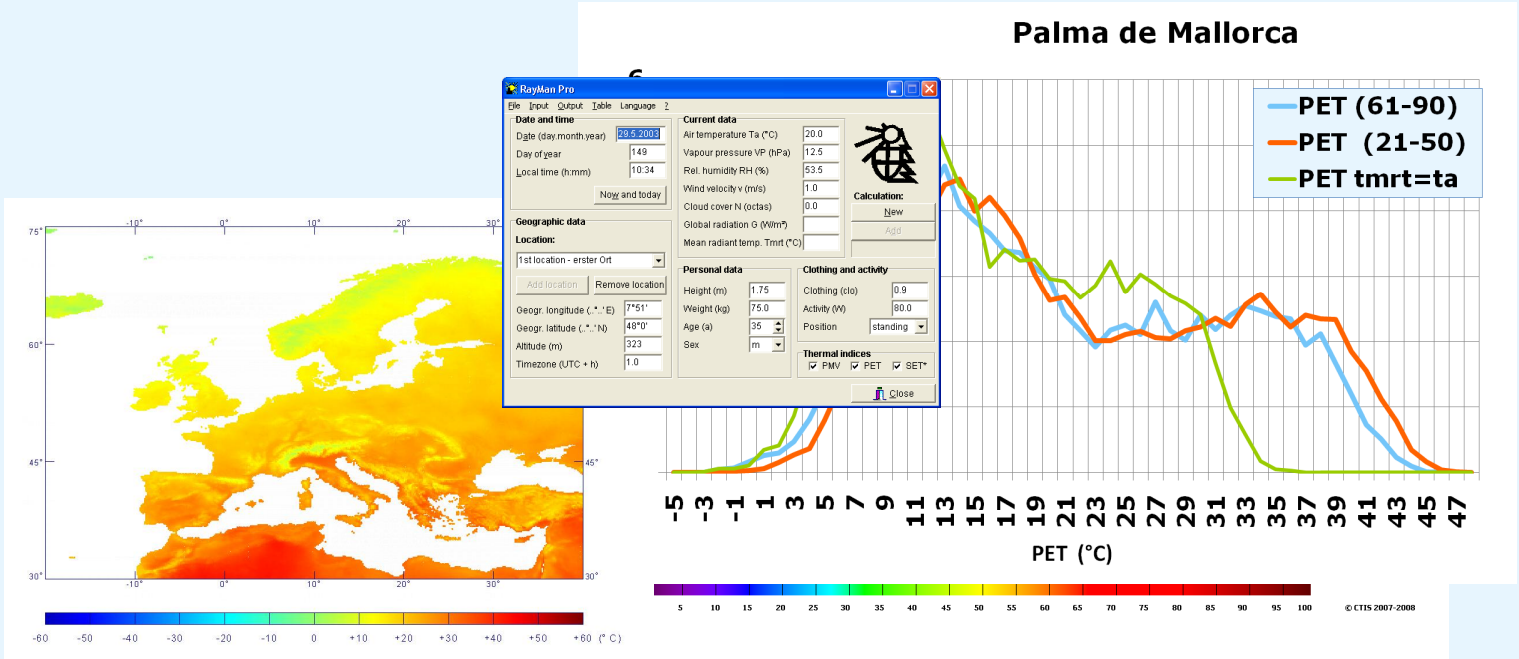
ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

Meteorological Institute
Faculty of Forest and Environmental Sciences

Canvi climàtic i turisme: l´adaptació al temps atmosfèric, el canvi climàtic I el clima extrem

Climate Change and Tourism: Adaptation to weather, climate and climate extremes



Prof. Dr. Andreas Matzarakis

Contents

- Introduction
- Methods for assessment of Climate for Tourism
- Examples
  - Trees and Climate Change
  - Climate scenarios – climate manipulation
  - Perfect day
- Conclusions

My nightmare ! ! – modification of microclimate

(Sheet: Baumüller, 2008)

Arten von Tourismus

Kinds of Tourism

Tourismus W dient primär der Erholung und Freizeitgestaltung. Wenn Reisende selbst planen sind es Individualreisen W - standardisierte Angebote von Reiseveranstaltern W dagegen Pauschalreisen W. Je nach Neigung, Interessen und Bedürfnissen gibt es eine Vielfalt von Reisearten:

Abenteuerreise W, Agrotourismus W, Aktivurlaub W, Autoreise, Badeferien W, Bahnreise W, Bildungstourismus W, Blaue Reise W, Busreise W, Butterfahrt W, Camping W, Caravaning W, Cluburlaub W, Drogentourismus W, Ethnotourismus W, Event-Tourismus W, Radreisen W, Fernreise W, Flusskreuzfahrt W, Flugreise W, Forschungsreise W, Frauenreise W, Golfreise W, Gruppenreise W, Heliskiing W, Incentive Reise W, Jugendreisen W, Kaffeefahrt W, Katastrophentourismus W, Kreativurlaub W, Kreuzfahrt W, Kulturtourismus W, Kur W, Kinderreisen W, Ökotourismus W, Outgoing-Tourismus W, Reiterferien W, Rucksacktourismus W (Backpacking W), Rundreise W, Safari W, Sanfter Tourismus W, Segeltörn W, Seniorenreise W, Sextourismus W, Singlereise W, Sportreise W, Schienenkreuzfahrt W, Sprachreisen W, Surfreise W, Survival Tour W, Sportreise W, Städtereise W, Studienreise W, Tauchreise W, Therapeutisches Reisen W, Trekking Tour W, Wanderreise W, Wellnessreise W, Weltraumtourismus W, Weltreise W, Wintersport W, Wohnmobilreisen W.

Sekundäre Arten des Tourismus sind:

- Geschäftsreisen W (Reisen aufgrund eines wirtschaftlichen Zweckes)
- Pilgerreise W (religiöse Motivation)
- Missionsreise W (Ausbreitung des Glaubens)
- Forschungsreise, Expedition W (Reisen aufgrund eines wissenschaftlichen Zieles)
- Entdeckungsreise W (historische Bedeutung, Entdeckungsreisen in unbekannte Teile der Welt z.B. durch Marco Polo W, Christoph Kolumbus W, Vasco da Gama W, Ferdinand Magellan W und James Cook W)

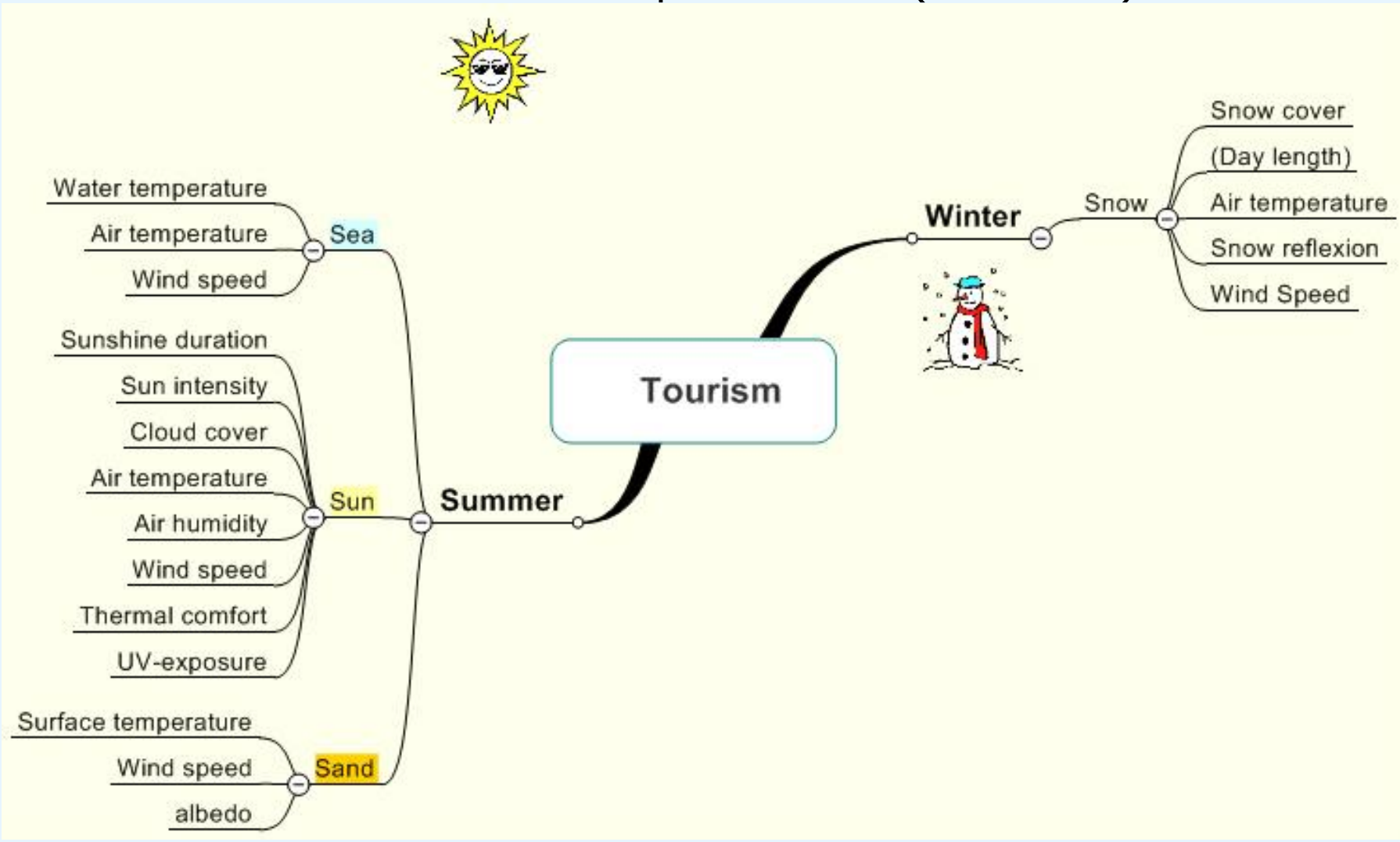
GlobalTravel Magazin
Let's travel around the world

Missing: Scientific tourism

Weather, Climate, Climate Extremes

- Weather - current situation (storm two days ago)
- Climate - means and sums
- Climate - max, min and higher statistical moments
- Climate - frequencies, possibilities
- Climate Change: trends and possibilities

Tourism und climate parameters (Selection)

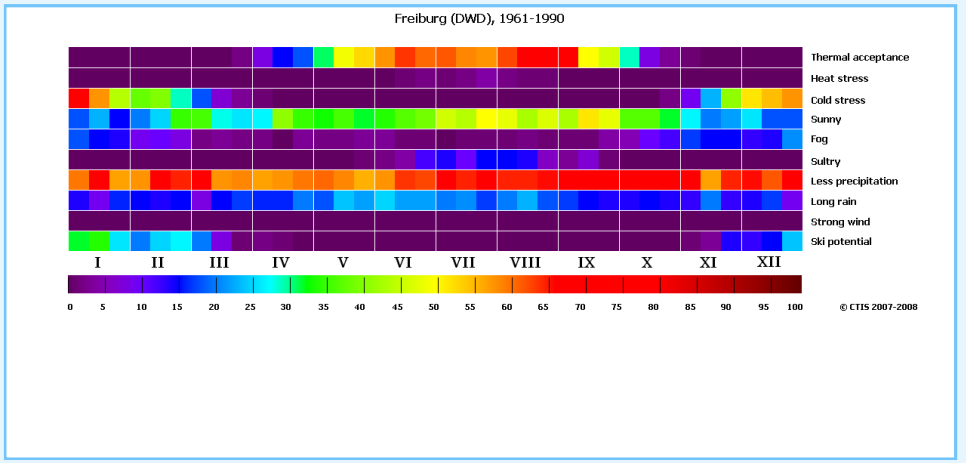


Quantification of Climate in Tourism

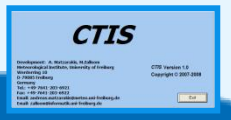
Facet of climate	Significance	Impact
Aesthetic		
Sunshine/cloudiness	Quality of experience	Enjoyment, attractiveness of site
Visibility	Quality of experience	Enjoyment, attractiveness of site
Day length	Convenience	Hours of daylight available
Physical		
Wind	Annoyance	Blown belongings, sand, dusté
Rain	Annoyance, charm	Wetting, reduced visibility, enjoyment
Snow	Winter sports/activities	Participation in sports/activities
Ice	Danger	Personal injury, damage to property
Severe weather	Annoyance, danger	All of above
Air quality	Annoyance, danger	Health, physical wellbeing, allergies
Ultraviolet radiation	Danger, attraction	Health, suntan, sunburn
Odours	Annoyance	Attractiveness of site
Noise	Annoyance	Attractiveness of site
Thermal		
Integrated effects of air temperature, wind, solar radiation, humidity, long wave radiation, metabolic rate, clothing.	Thermal comfort	Environmental stress
	Therapeutic, restorative	Physiological strain
		Hypothermia
		Hyperthermia
		Potential for recuperation

CTIS (Climate-Tourism-Information-Scheme)

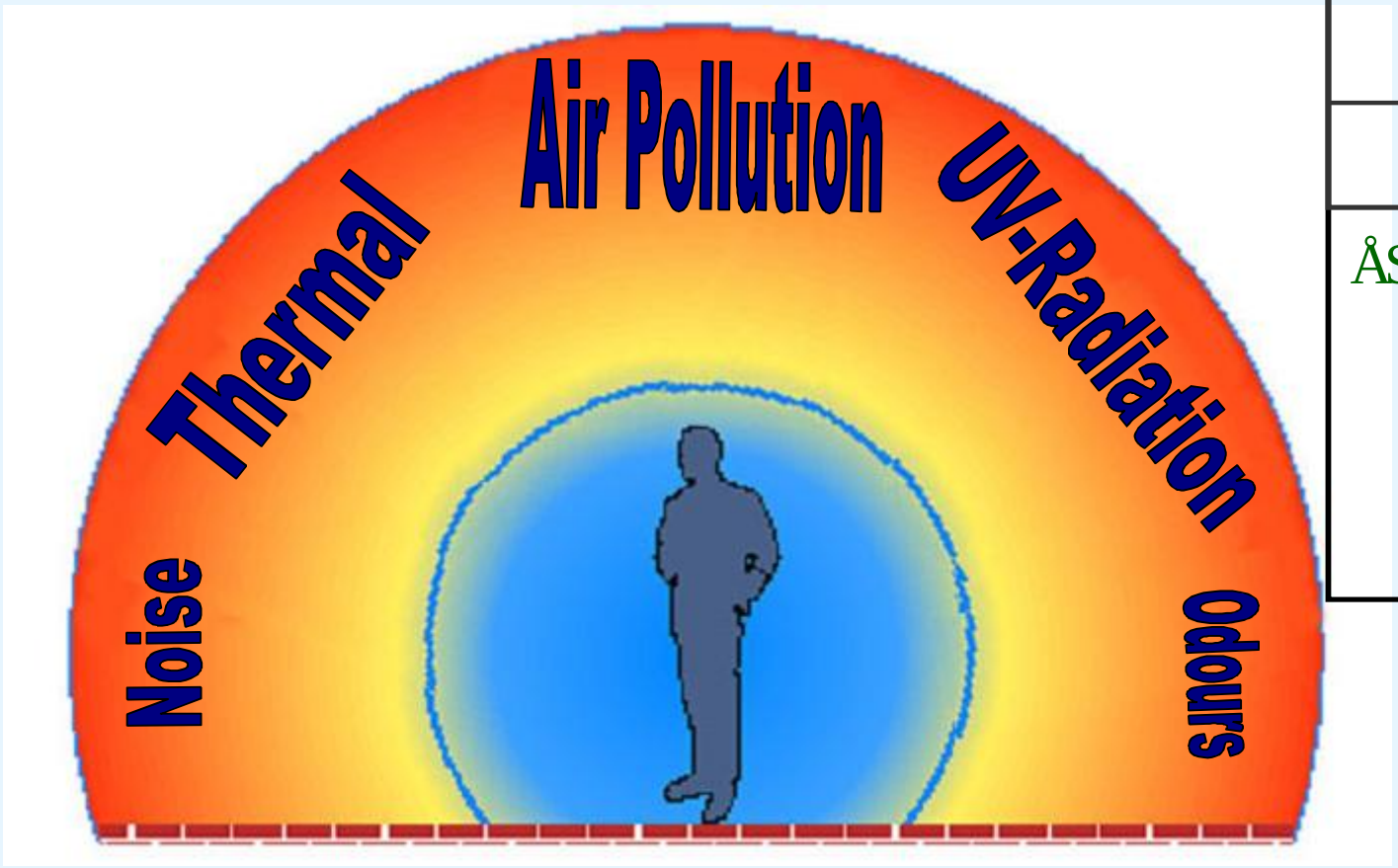
Threshold values for (Freiburg):



- Thermal acceptability (PET 18 °C and 29 °C)
- Heat stress (PET > 35 °C),
- Cold stress (PET < 0 °C),
- Sunny (< 5 octas),
- Fog (based on rel. humidity > 93 %),
- Sultriness (based on vapour pressure > 18 hPa),
- Dry day (precipitation < 1 mm),
- Wet day (precipitation > 5 mm),
- Windy (> 8 m/s),
- Ski potential (based on snow cover > 10 cm).



Atmospheric Environment



- Thermal
- Air Pollution
- UV-Radiation
- Air temperature
- Air humidity
- Wind speed
- Short and long wave radiation
- ....

... others

Human-Biometeorological Assessment of the Thermal Component of Different Climates

atmospheric environment
- air temperature
- vapour pressure
- wind speed
- short- and long-wave radiation from the whole surroundings (mean radiant temperature)

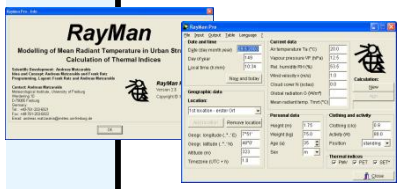
human beings
- grade of activity
- heat transfer resistance of the clothing

human heat balance
- comfort equation by FANGER
- model MEMI
- model IMEM
- ...

assessment standards

thermophysiological assessment indices
- Predicted Mean Vote PMV
- Physiologically Equivalent Temperature PET
- SET*, Univ. Thermal Climate Index, ...

neutral conditions at 20 °C



results (maps, temporal variability, ...)

Thermal indices (PMV, PET), Thermal perception, Physiological stresss

PET	Thermal Sensivity	Grade of Physiologic Stress
	very cold	extreme cold stress
4 °C	----------	----------
	cold	strong cold stress
8 °C	----------	----------
	cool	moderate cold stress
13 °C	----------	----------
	slightly cool	slight cold stress
18 °C	----------	----------
	comfortable	no thermal stress
23 °C	----------	----------
	slightly warm	slight heat stress
29 °C	----------	----------
	warm	moderate heat stress
35 °C	----------	----------
	hot	strong heat stress
41 °C	----------	----------
	very hot	extreme heat stress

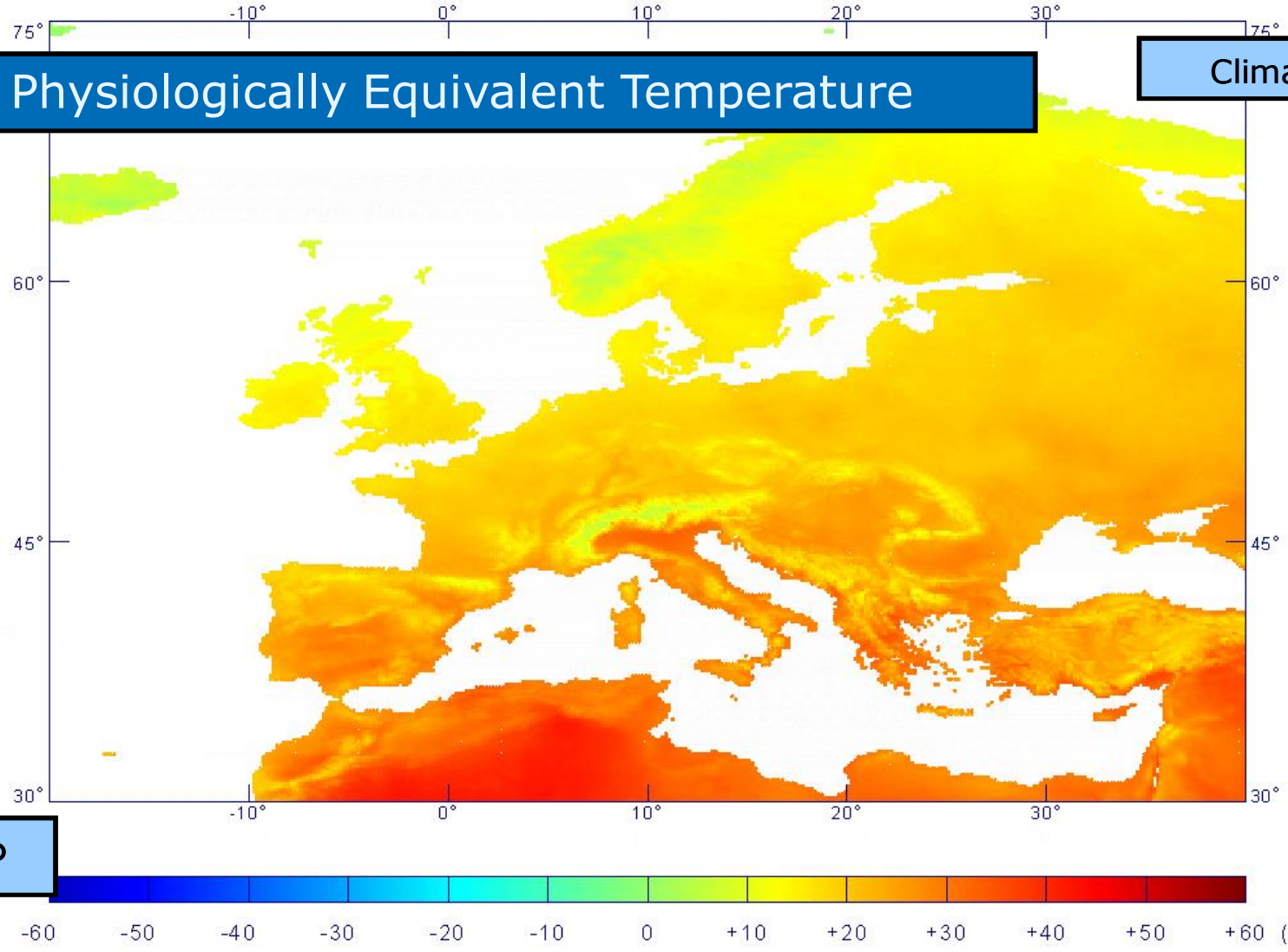
Threshold values of thermal indices PMV and PET for different grades of thermal sensitivity of human beings and physiological stress on human beings

(according to Matzarakis and Mayer, 1996)

July

Physiologically Equivalent Temperature

Climate model



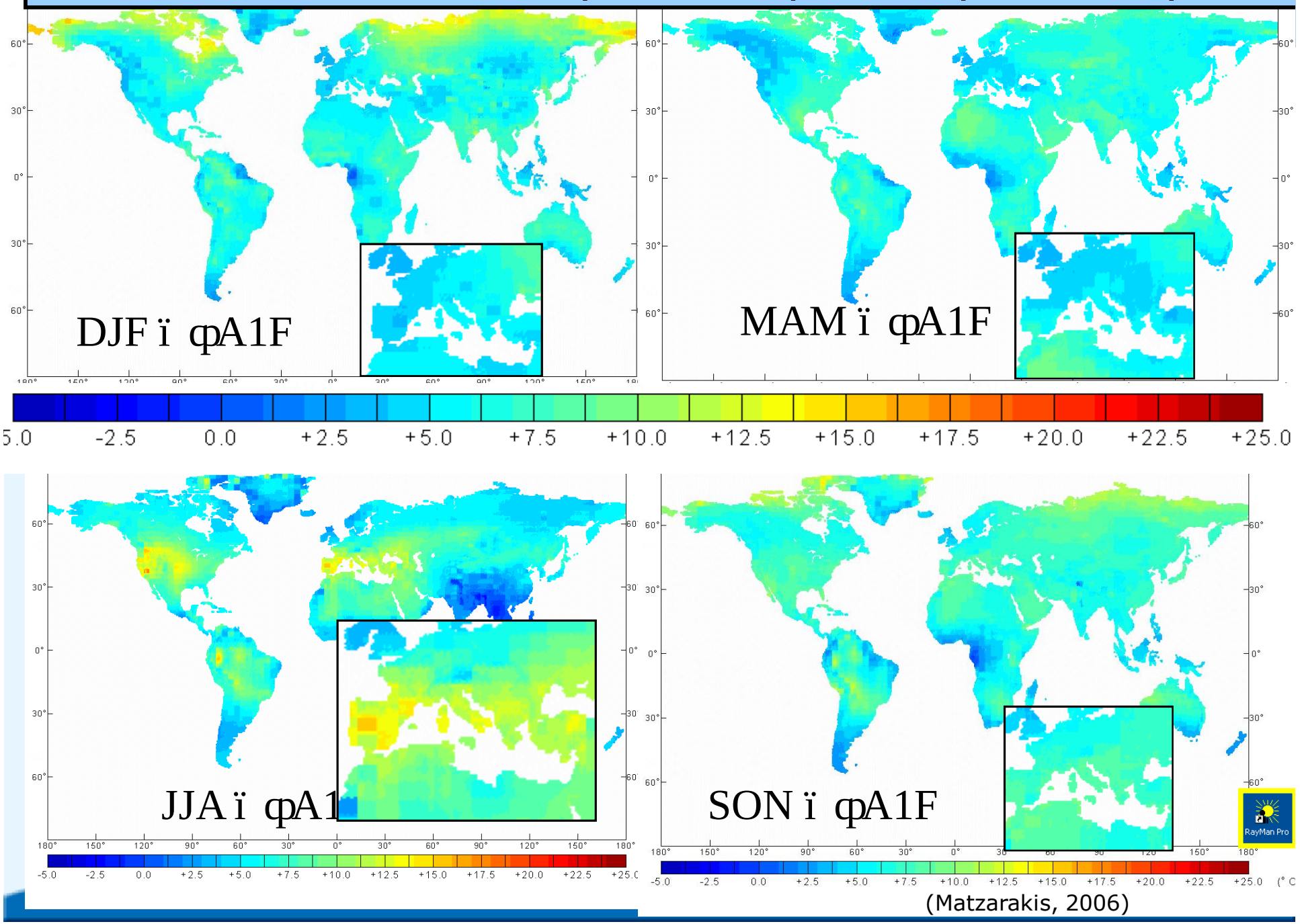
0.1 °

RayMan Pro

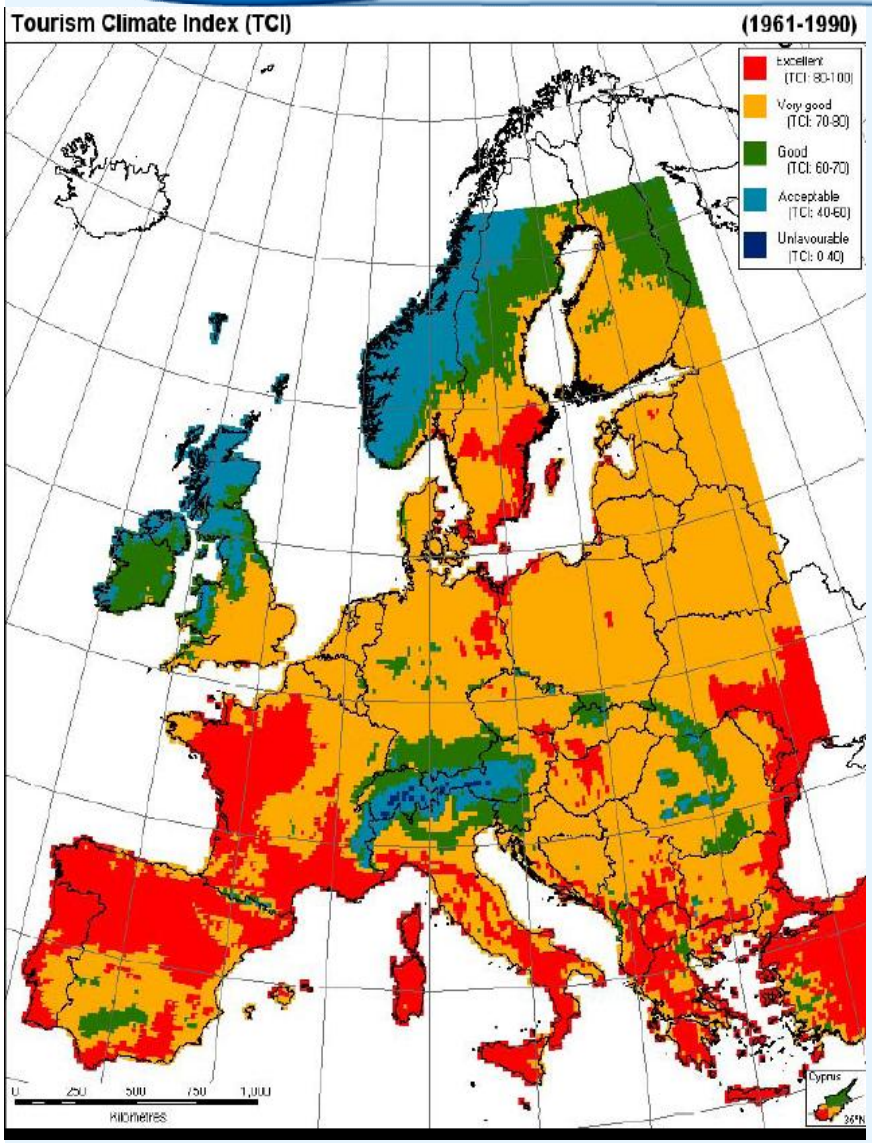
Results: thermal

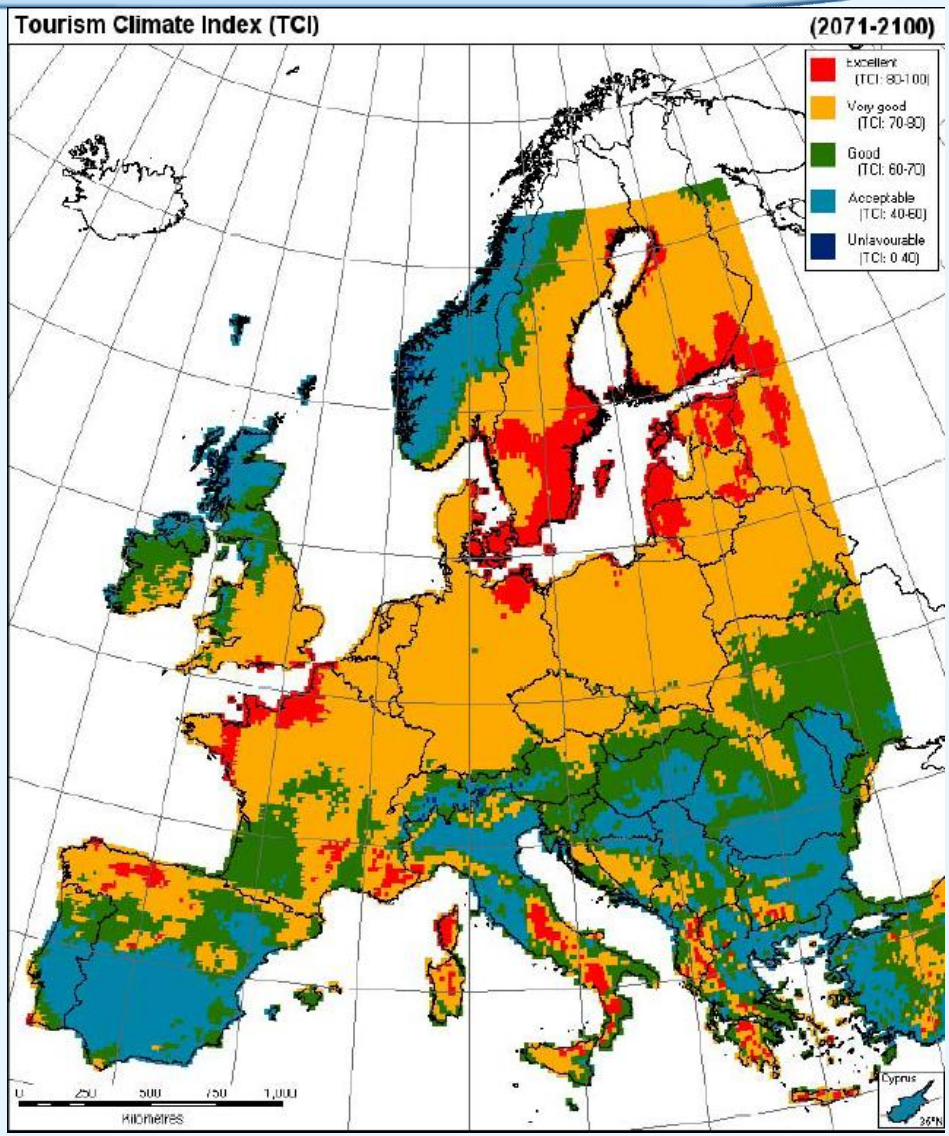
Matzarakis, Georgiadis, Rossi, 2007, Il Nuovo Cimento C

Seasonal PET ---- A1B (2070-2100) – Base (1960-1990)



(Matzarakis, 2006)

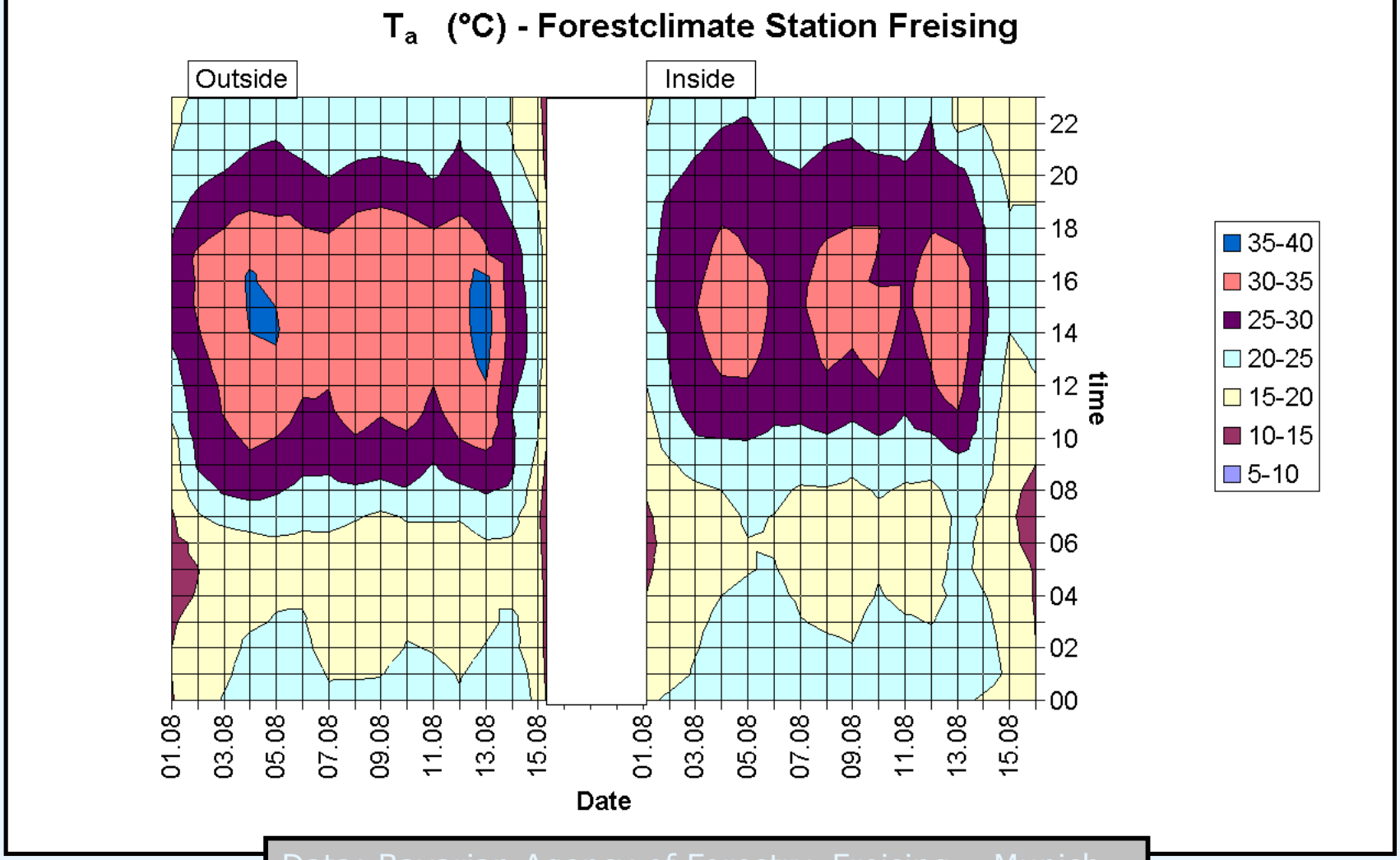

Tourism Climate Index (TCI)
(1961-1990)
Excellent (TCI: 80-100)
Very good (TCI: 70-80)
Good (TCI: 60-70)
Acceptable (TCI: 40-60)
Unfavourable (TCI: 0 40)
Cyprus
Kilometres


Tourism Climate Index (TCI)
(2071-2100)
Excellent (TCI: 80-100)
Very good (TCI: 70-80)
Good (TCI: 60-70)
Acceptable (TCI: 40-60)
Unfavourable (TCI: 0 40)
Cyprus
Kilometres

Weather and heat waves

(Foto: Matzarakis, Norhern Germany, 2. June 2008,

Forests and Air Temperature

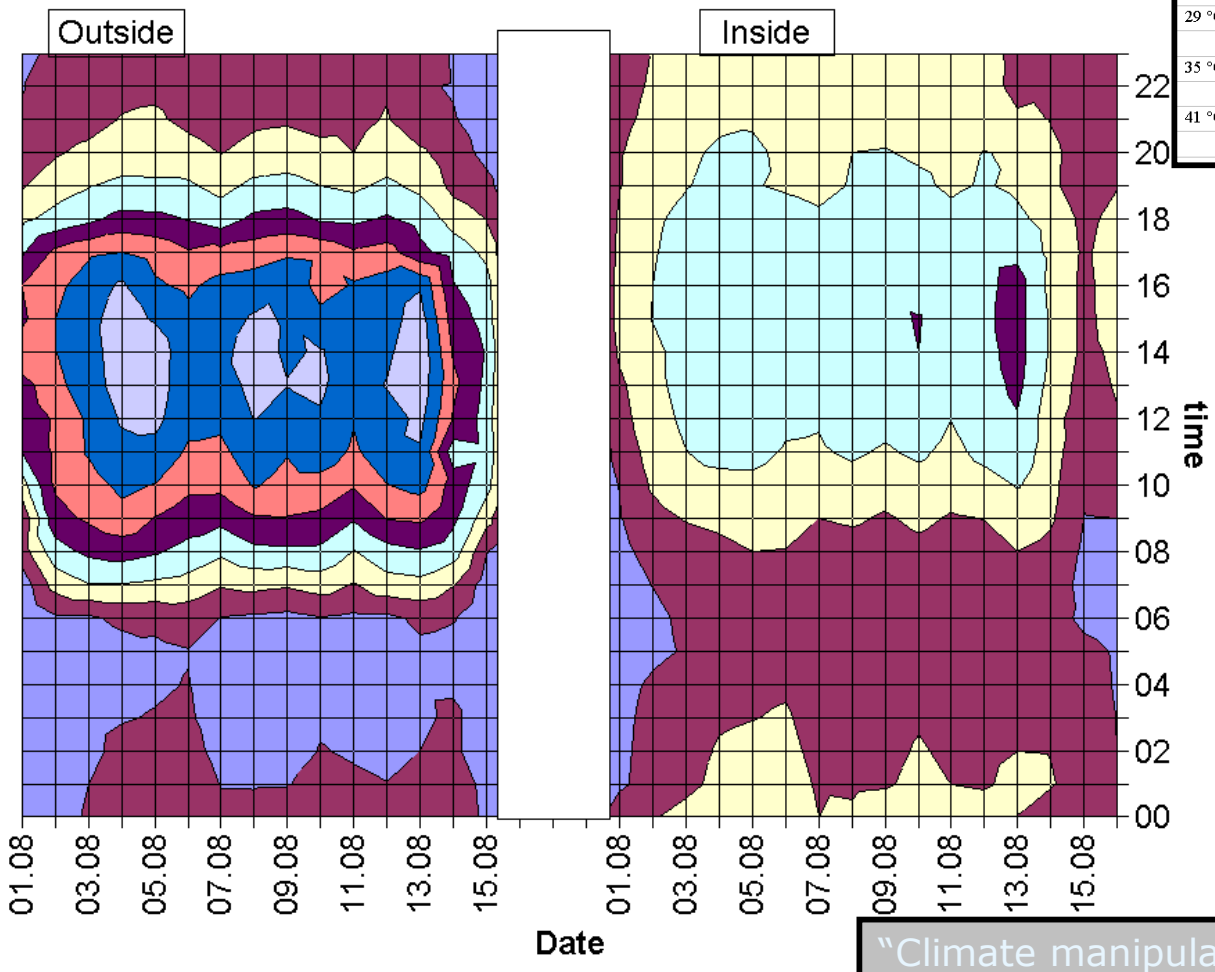


Data: Bavarian Agency of Forestry. Freising – Munich

Question: Forests and Bioclimate during heat waves

Forests and Bioclimate

PET (°C) - Forestclimate Station Freising



PET	Thermal Sensivity	Grade of Physiologic Stress
	very cold	extreme cold stress
4 °C		
	cold	strong cold stress
8 °C		
	cool	moderate cold stress
13 °C		
	slightly cool	slight cold stress
18 °C		
	comfortable	no thermal stress
23 °C		
	slightly warm	slight heat stress
29 °C		
	warm	moderate heat stress
35 °C		
	hot	strong heat stress
41 °C		
	very hot	extreme heat stress

"Climate manipulation":

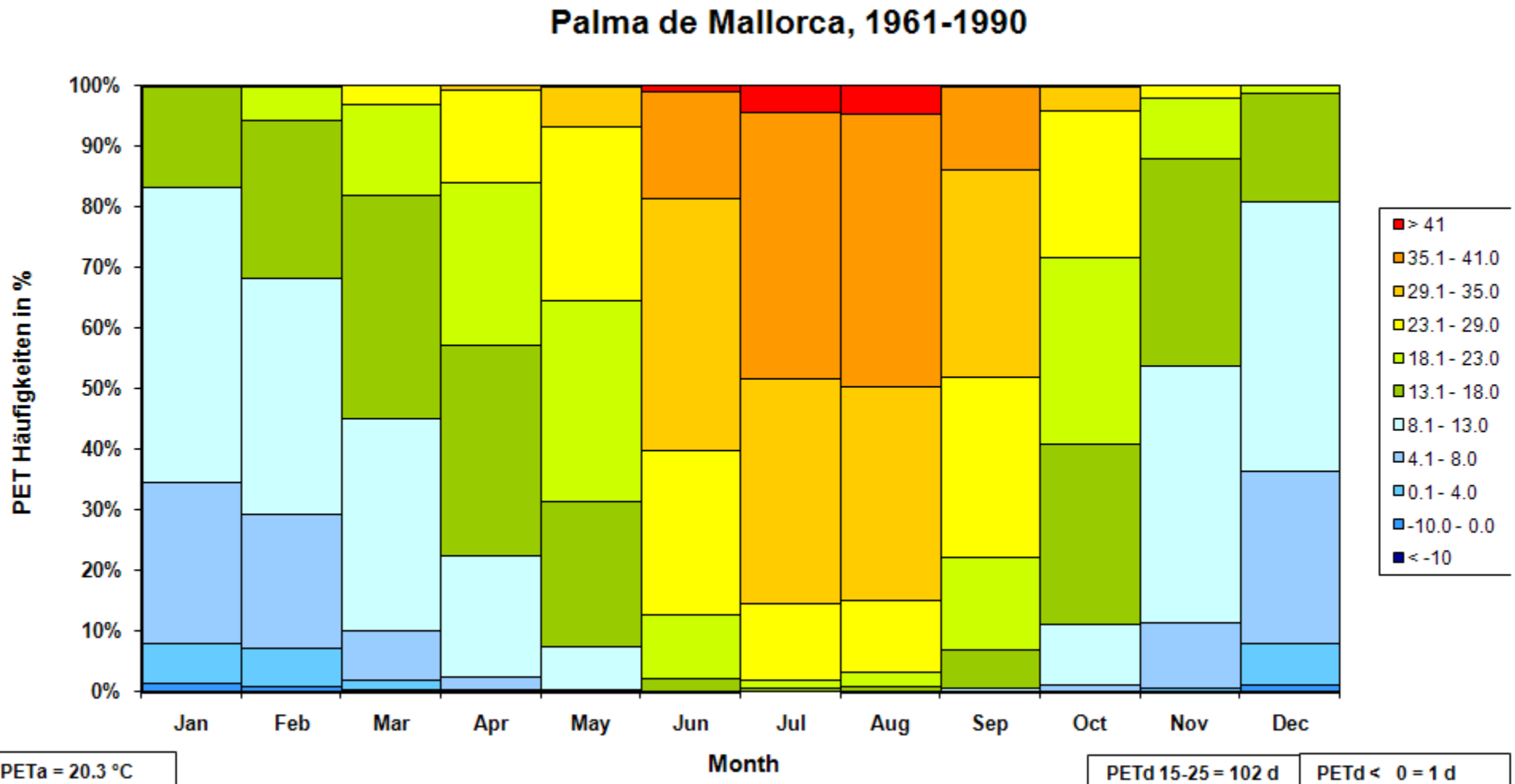
Create a better microclimate

Climate: Quantification for Tourism

– CC new destinations
- North Europe
- New Med.
- Shifting of tourism flows

- CC = 3 °C

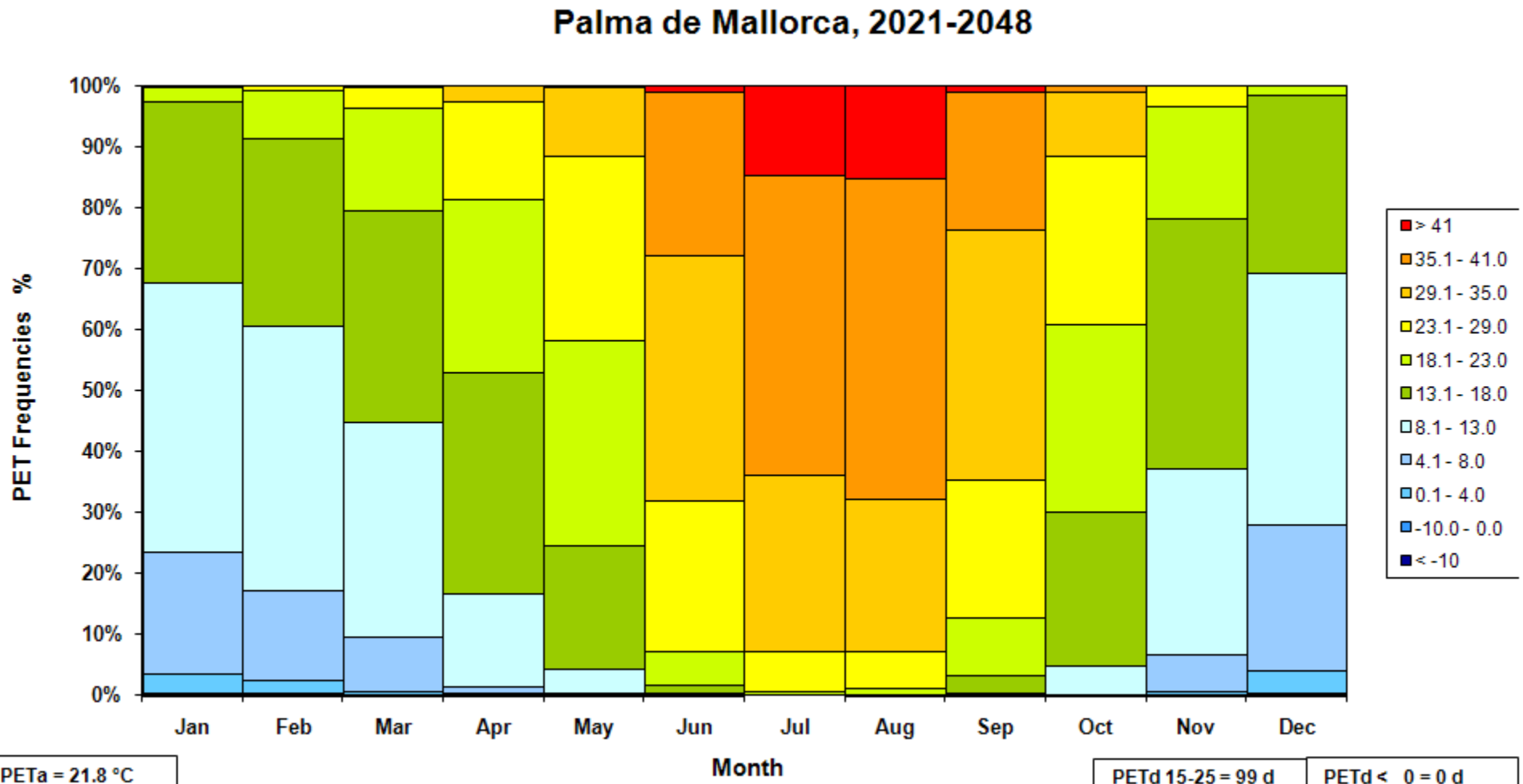
CLM, A1B – Climate Scenario



PETa = 20.3 °C	
PETmax = 44.3 °C	
PETmin = -2.9 °C	

PETd 15-25 = 102 d	PETd < 0 = 1 d
PETd 18-23 = 47 d	PETd > 30 = 83 d
PETd 18-29 = 96 d	PETd > 35 = 40 d

CLM, A1B – Climate Scenario



PETa = 21.8 °C	
PETmax = 46.1 °C	
PETmin = -1.3 °C	

PETd 15-25 = 99 d	PETd < 0 = 0 d
PETd 18-23 = 45 d	PETd > 30 = 93 d
PETd 18-29 = 87 d	PETd > 35 = 52 d

CLM, A1B – Climate Scenario

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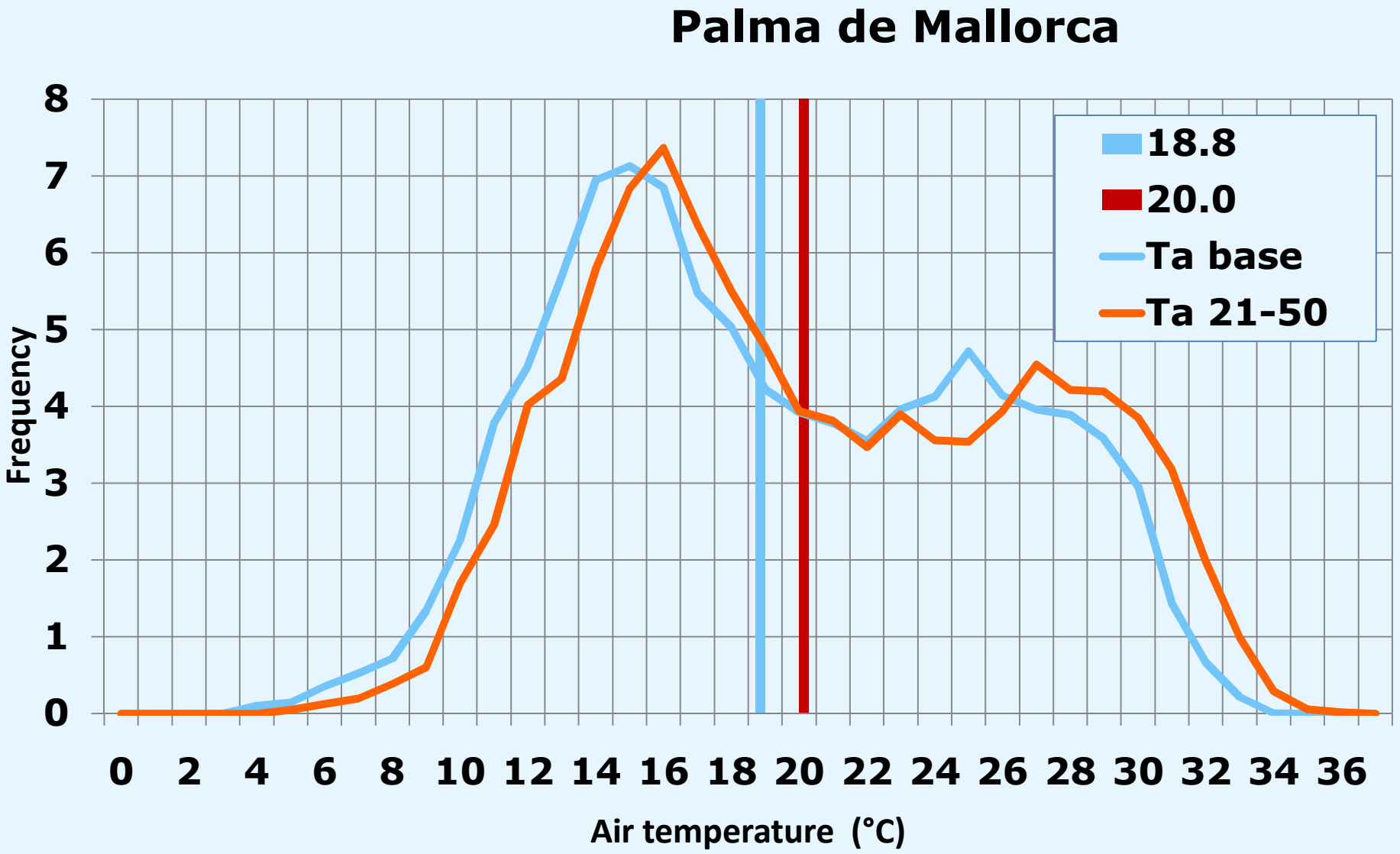

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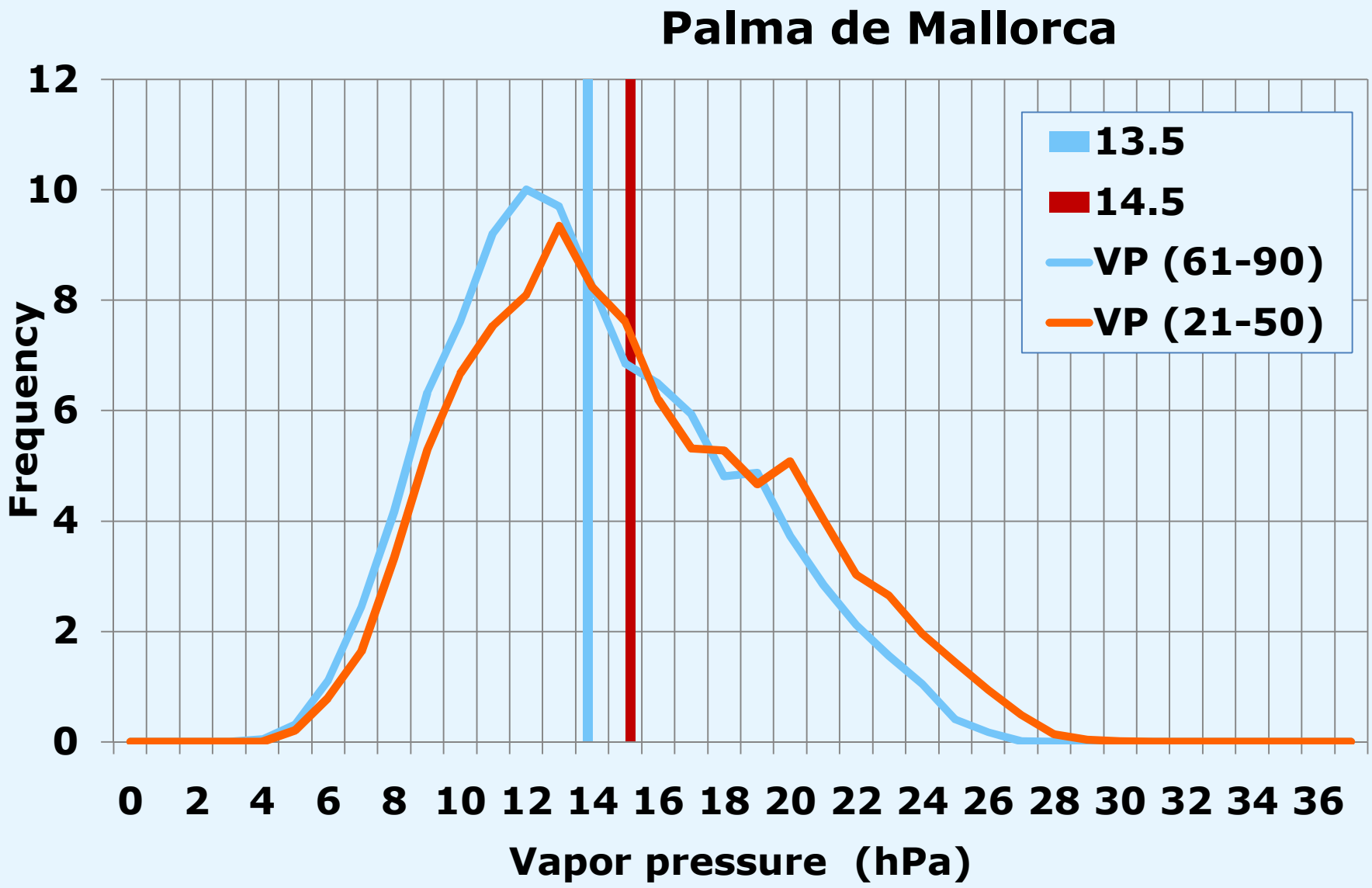

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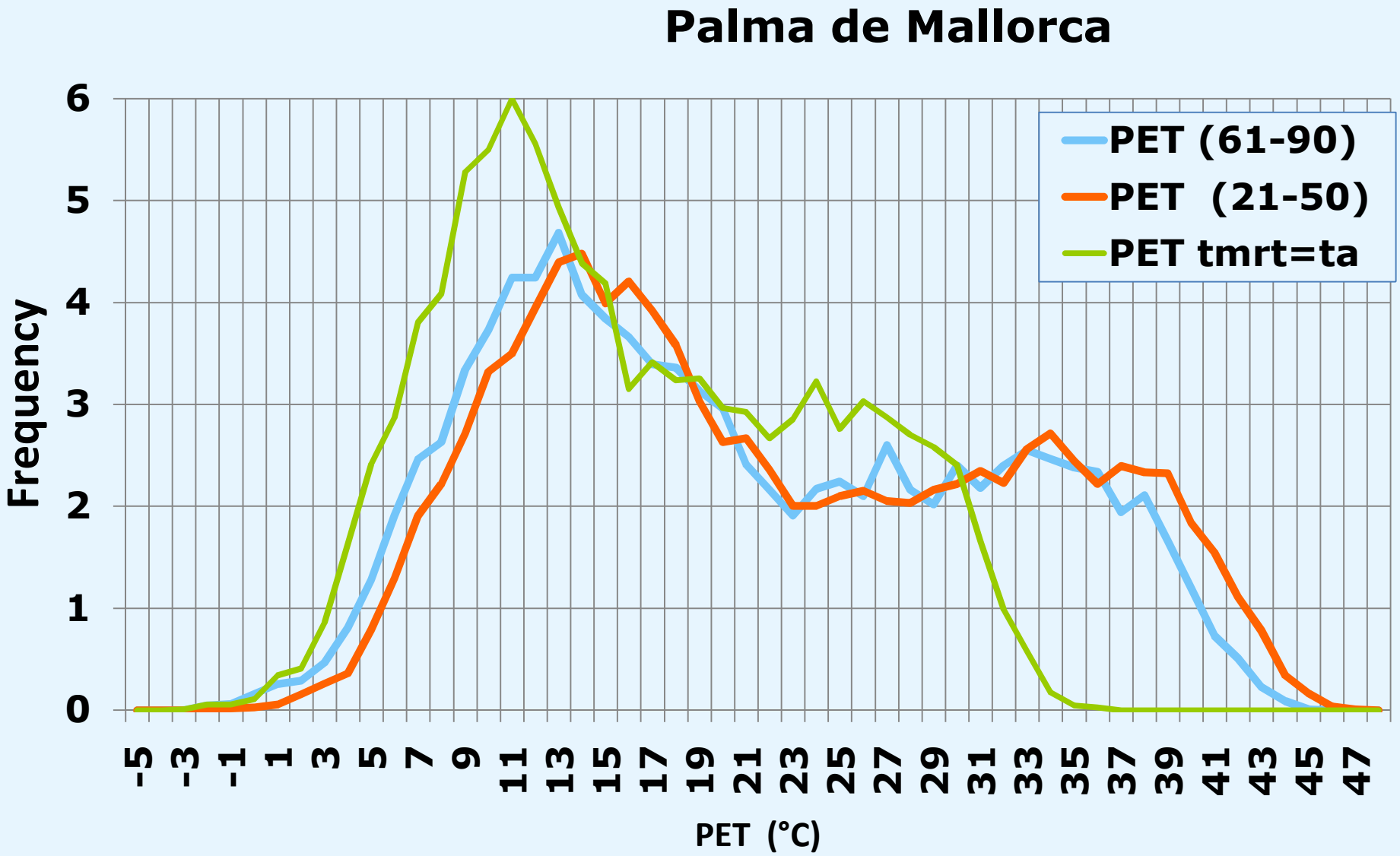

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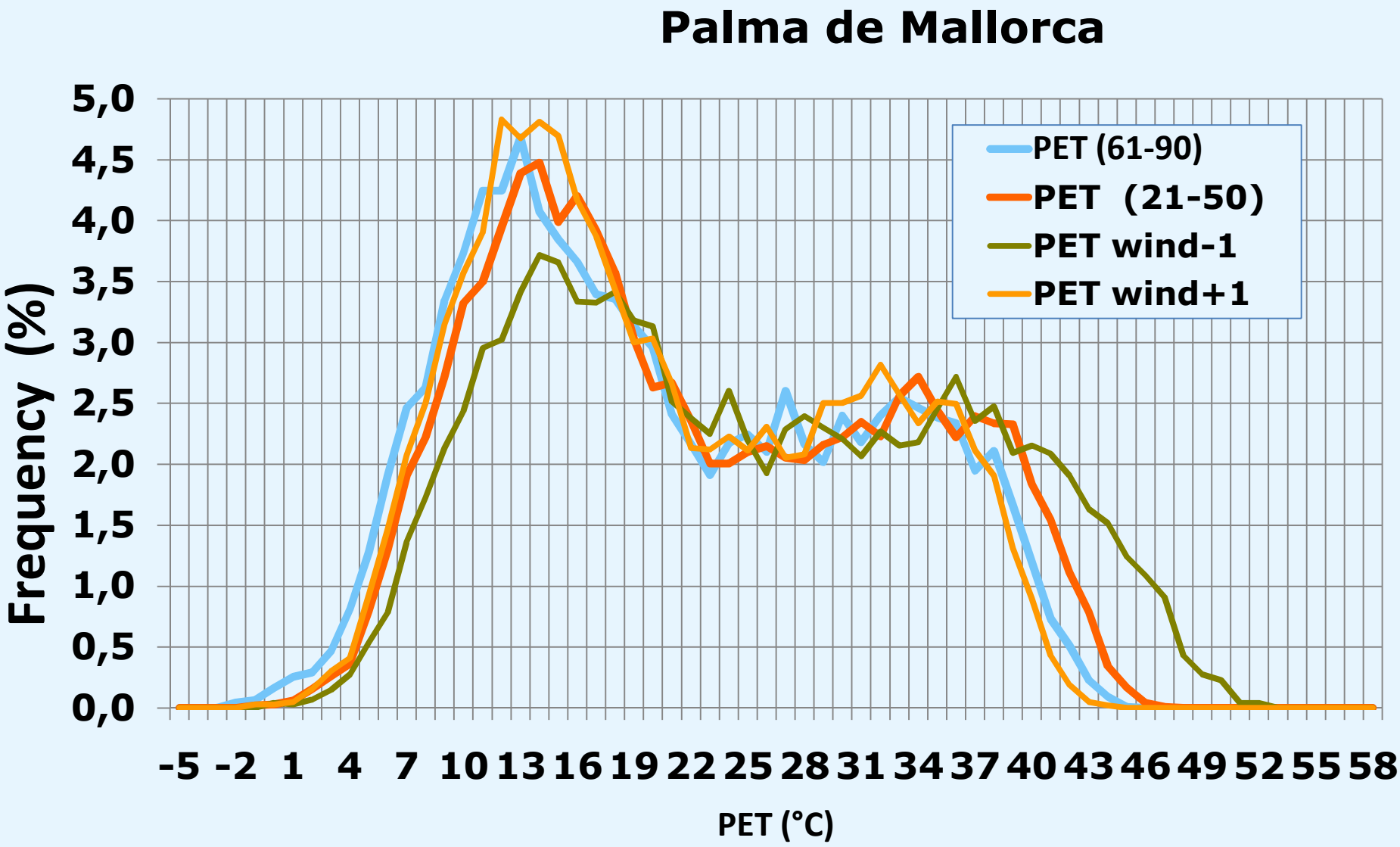
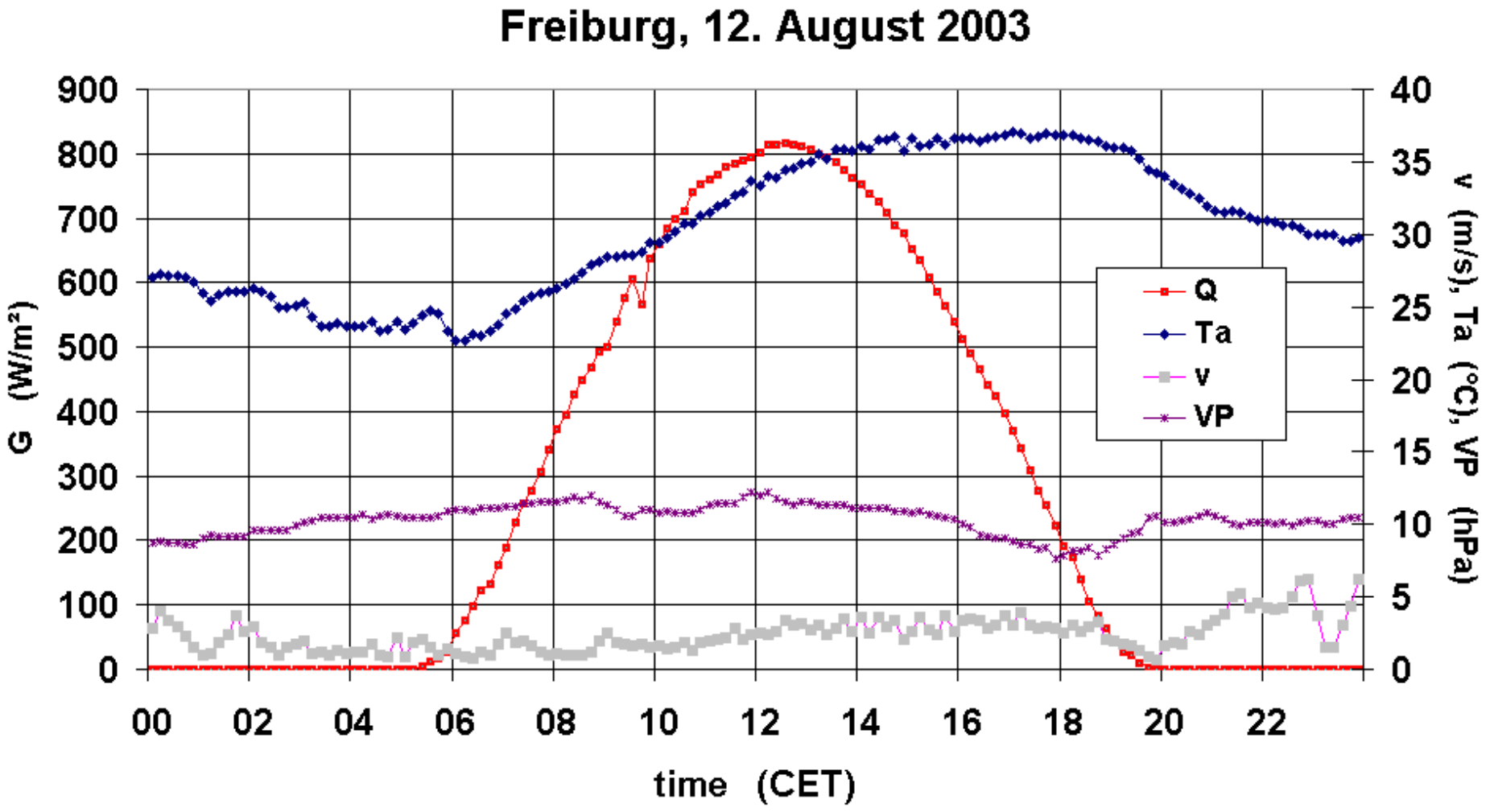


Climate extremes

Perfect day


Freiburg, 12. August 2003
G (W/m²)
v (m/s), Ta (°C), VP (hPa)
time (CET)
Q
Ta
v
VP
900
800
700
600
500
400
300
200
100
0
40
35
30
25
20
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12
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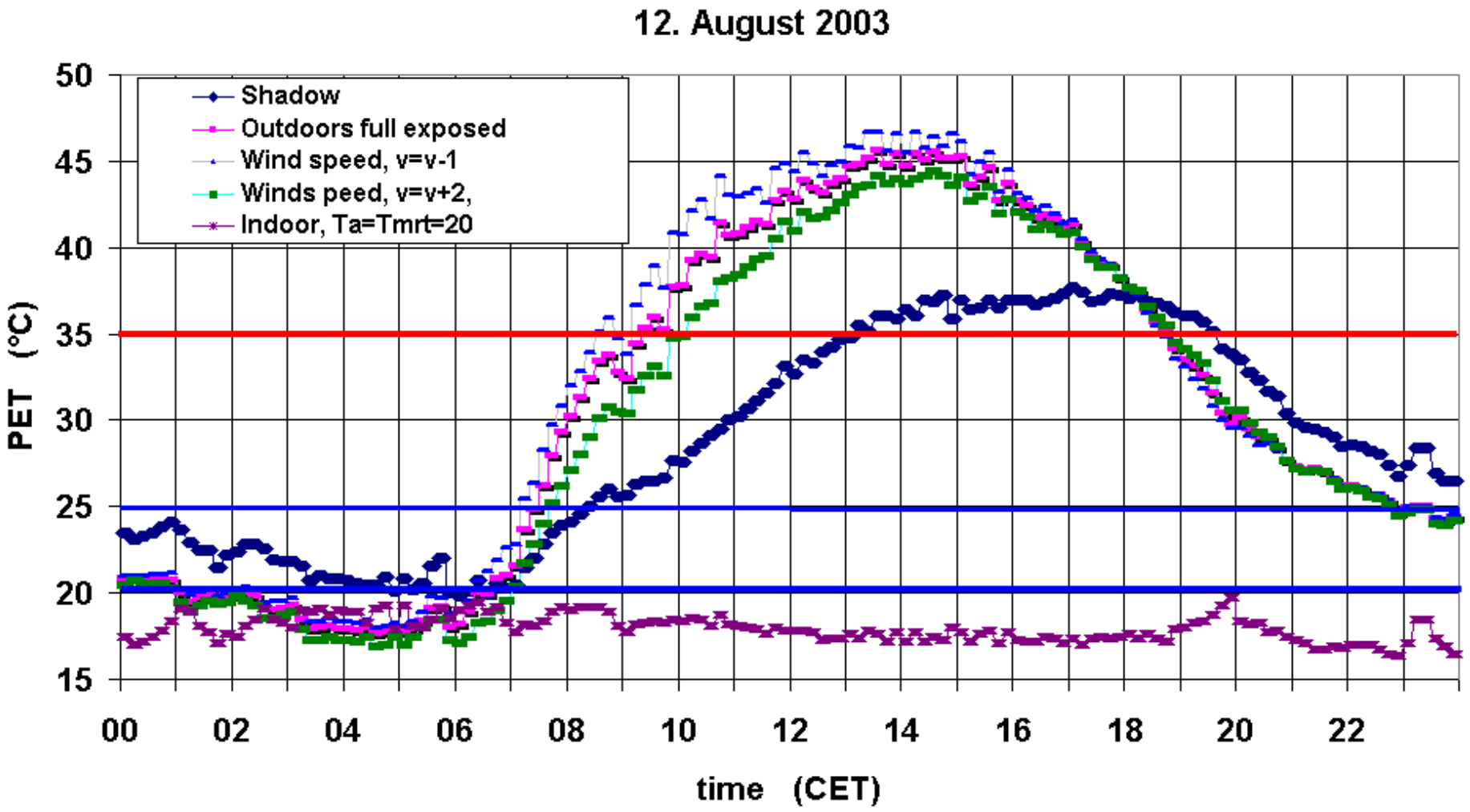
16
18
20
22

Perfect day and bioclimate



Aspects of bioclimate and others direct and indirect effects

- Radiation modification
- Wind modification
- Infrastructure protection
- Reduction energy costs
- Protection humans (UV)
- Modified micro climate (indoor and outdoor)
- Education (long time)
- Language between (long time)
- Information
- Natural ventilation
- Climate adapted architecture
- Climate adapted behavior
- Cool Biz
- ….

Global tourism emissions for 2005: only CO2

Sub-Sectors	CO_2 (Mt)	
Air Transport *	**522**	40%
Car Transport	**418**	32%
Other Transport	**39**	3%
Accommodation	**274**	21%
Activity	**52**	4%
Total World	**1,307**	
Global (IPCC, 2007)	**26,400**	
Tourism contribution	**4.95 %**	

Transportation of Tourists = 75% of Sector Emissions

*- does not include non-CO2 emissions and impact on climate

UNWTO, 2007/8

First Step to CO_2 ï neutral City

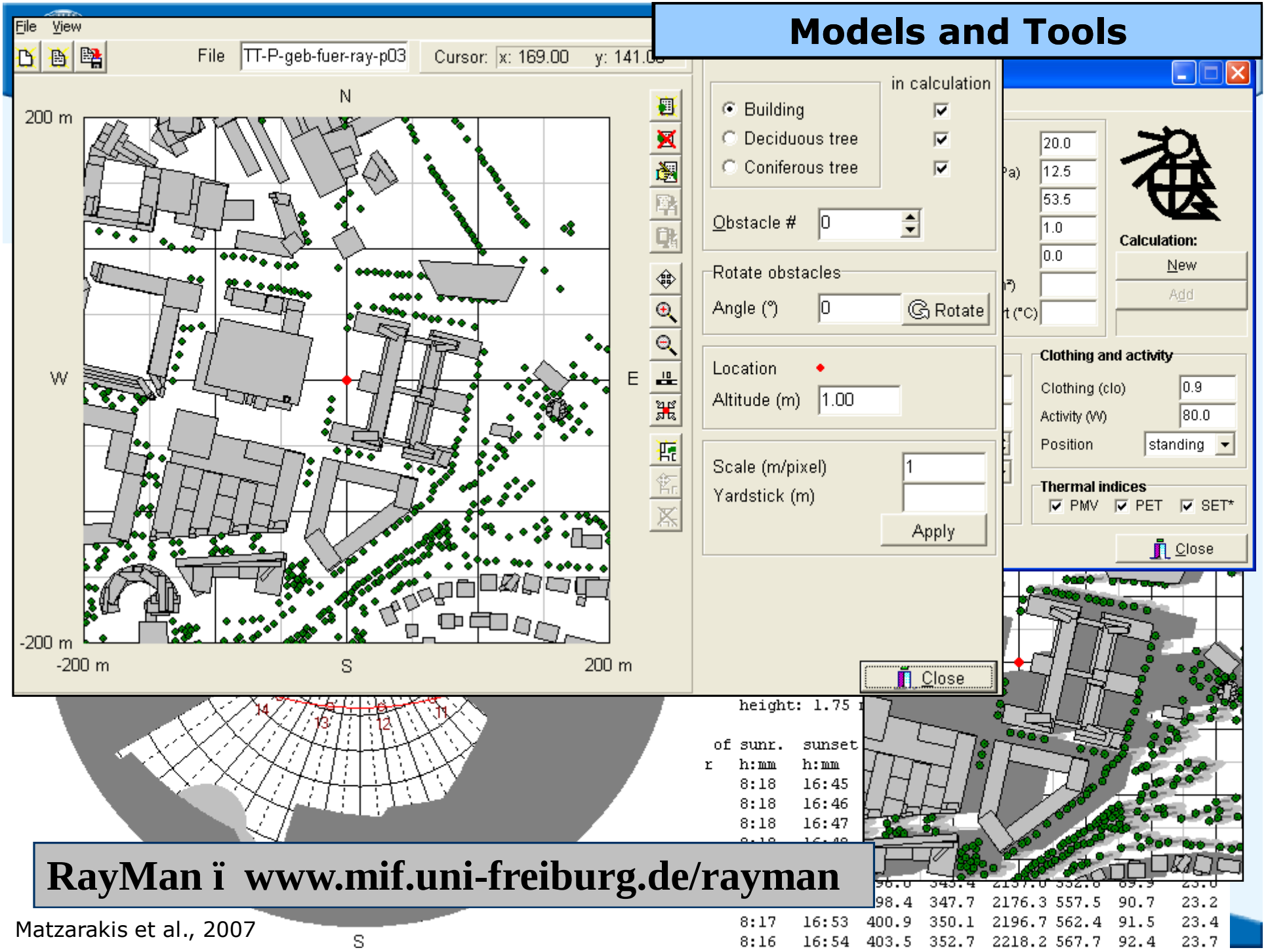
ĂWorld Future Energy Summitñ (Jan. 2008, Abu Dhabi): Norman Foster presents first CO_2 und waste free city (Masdar, Abu Dhabi; 6 km^2); Costs of ÆEco-CityñProjecj: 22 Mrd. $

Zero energy house
Burj Al Taqwa, Bahrein

Conclusions

- Effects and changes (CC) occur in local level
- Many information/tools from applied climatology for planners/Authorities/NGOs
- *Climate is on facet – air pollution, noise, UV - synergies*
- *Future conditions !*
- *Quality of Life (Remember 2003 and 2007)*
- Cooperation science and authorities
- **Connection: Indoor and Outdoor**
- **Finally: Flexibility - because of variability ï not only from climate**

Models and Tools



RayMan ï www.mif.uni-freiburg.de/rayman

Matzarakis et al., 2007

Bas Amelung - Krysztof Blazejczyk - Andreas Matzarakis

Climate Change and Tourism

Assessment and Copying Strategies

Maastricht – Warsaw – Freiburg, 2007

ISBN: 978-00-023716-4

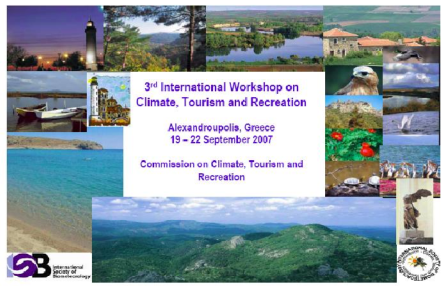
logical Institute
nmental Sciences

Price: 0 ú

Price: 0 ú

Developments in Tourism Climatology

A. Matzarakis, C. R. de Freitas and D. Scott (Eds.)



Commission on Climate, Tourism and Recreation
International Society of Biometeorology

Freiburg, December 2007

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www.urbanclimate.net/climtour

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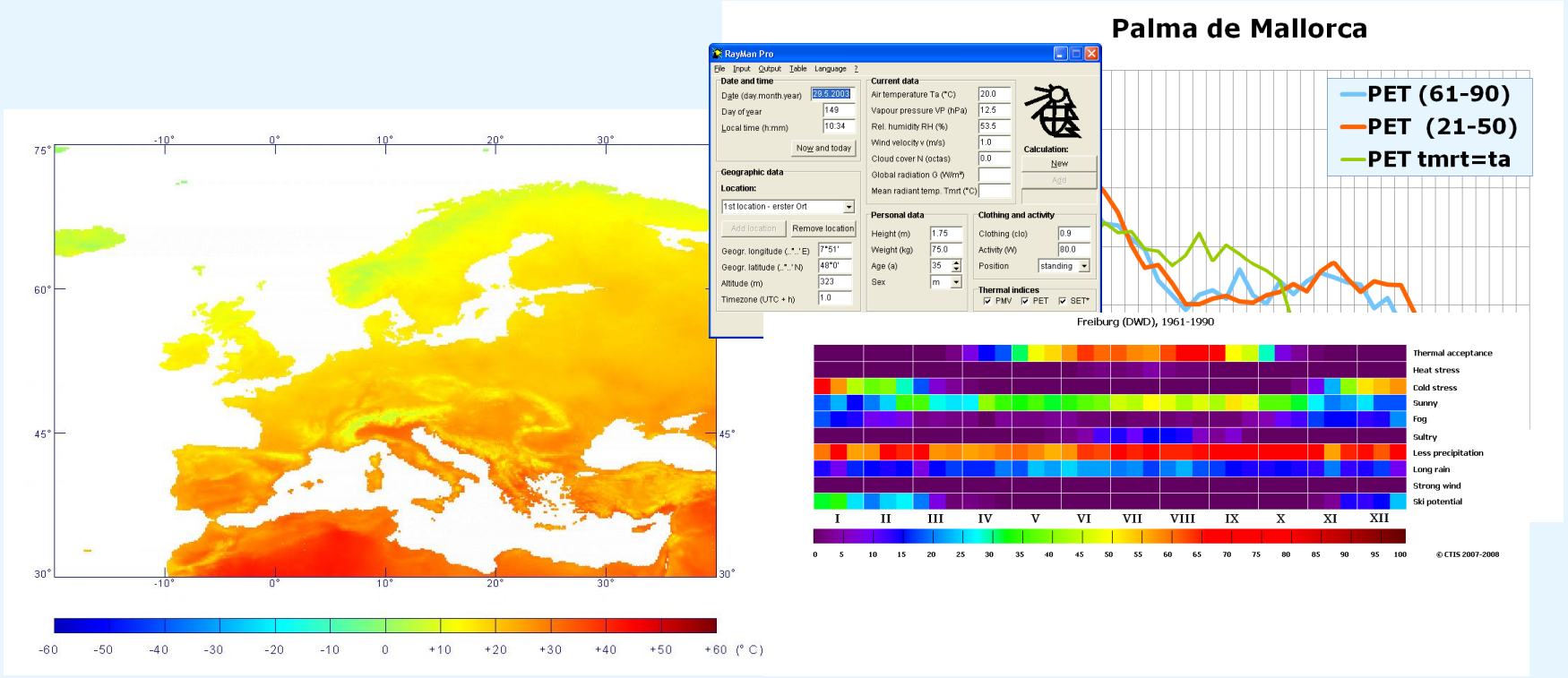

Prof. Dr. Andreas Matzarakis

Thermal indices (PMV, PET), Thermal perception, Physiological stresss

PMV	PET	Thermal Sensitivity	Grade of Physiological Stress
		very cold	extreme cold stress
-3,5	4 °C	----------	----------
		cold	strong cold stress
-2,5	8 °C	----------	----------
		cool	moderate cold stress
-1,5	13 °C	----------	----------
		slightly cool	slight cold stress
-0,5	18 °C	----------	----------
		neutral (comfortable)	*no thermal stress*
0,5	23 °C	----------	----------
		slightly warm	slight heat stress
1,5	29 °C	----------	----------
		warm	moderate heat stress
2,5	35 °C	----------	----------
		hot	strong heat stress
3,5	41 °C	----------	----------
		very hot	extreme heat stress

Threshold values of thermal indices PMV and PET for different grades of thermal sensitivity of human beings and physiological stress on human beings

(according to Matzarakis and Mayer, 1996)