Thermal comfort analysis: comparison between model and experimental data in tropical climate

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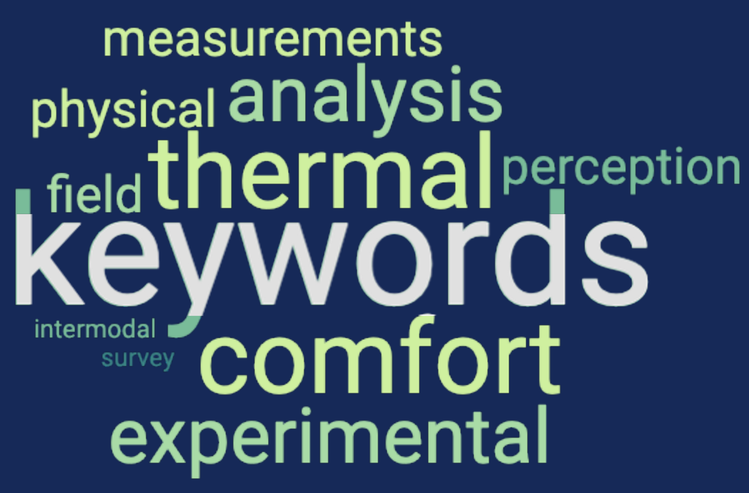


Introduction

Thermal Comfort means two things:
1. No physiological thermo-regulation
2. Hedonic feeling through thermal perception

How do we predict thermal comfort?

By choosing the right model

By experimental validation

For the right people and the right environment

Aim: to show that there is a need to promote the studies of thermal comfort for the Reunion context

Experimental & Numerical set-up

Subjects	Age	Activity	BMI	Clothing
Students	20 to 30 years old	Desk work	16.3 to 32.7	Everyday wear

The highest response rate to the comfort questionnaires was obtained on two particular days:

April 26, 2021	April 29, 2021
Overcast Light ambiance: intermediate "Active" porosity: 13%	Clear sky (morning); overcast sky (afternoon) Light ambiance: bright (morning); intermediate (afternoon) "Active" porosity: 13%

Questionnaire

The questionnaire was answered through online forms according to a normalized scale (ASHRAE)

Scale	Thermal sensation	Visual sensation
+3	Hot	Glare
+2	Warm	Bright
+1	Slightly warm	slightly bright
0	Comfortable, neutral	Comfortable, neutral
-1	Slightly cool	Slightly dark
-2	Cool	Dark
-3	Cold	Very dark

Each Hour

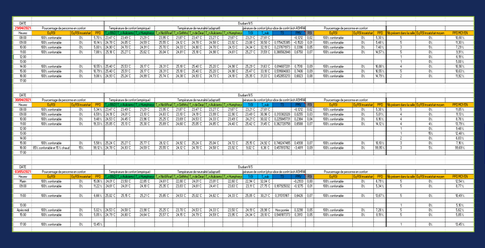
Measurement

The apparatus gathered all physical parameters proper to the room and physiological parameters for each participant through sensors

Parameters
Ta_{ind} , RH_{ind}
T_{sk} , T_{scl}
T_g
v_a
T_a , RH

Every Minute

Spreadsheet



The spreadsheet was used to calculate models results with the variables measured in situ. Three types of data were obtained:

Temperature	Thermal Perception Index	Portion of Population
in [°C]	**According to ASHRAE scale**	in [%]

Conclusion & Perspectives

Modeling
Marked discrepancy : unsuitable approaches for the survey conditions

Experiment
Identify the least intrusive perception assessment techniques possible

Consistent results
Highlighting the inadequacy of temperate climate studies in the tropical climate context

Perspectives in modeling
Create a generic model
Build a numeric model generator

Perspective for experiment
Develop a field survey combining physics-physiology-psychology

Methods

Modeling
Indoor thermal comfort models

Identification of models in the literature

Implementation of the models in a spreadsheet

Classes	Output type	Designation
Analytical models	Index	PMV
	Rate	PPD
	Index	TS
	Rate	RSI
	Temperature	T_{sub}
Empirical models	Temperature (comfort temperature)	$Tc_{Brager\ \&\ De\ Dear}$
		TrSI
		$T_{c_{Auliciems}}$
		$T_{c_{Humphreys}}$
Adaptative models	Temperature (neutrality temperature)	$T_{n_{Humphreys}}$
		$T_{n_{Auliciems}}$
		$T_{n_{Brager\ \&\ de\ Dear}}$
		$T_{n_{Griffiths}}$
		$T_{n_{Nicol\ \&\ Roaf}}$

Experiment on thermal perception
Measurement & field survey

Realization of online questionnaires on thermal perception (ASHRAE scale)

Physical measurements of the thermal environment and skin temperatures of the occupants

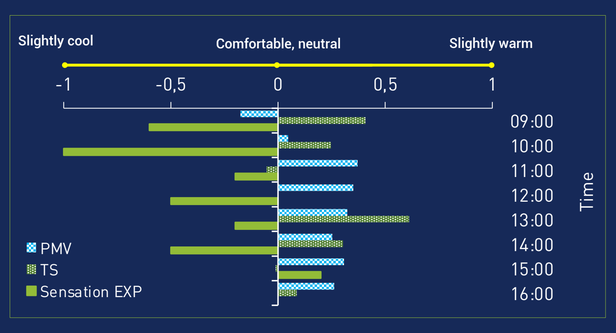
Reunion Island
Tropical climate

Comparative analysis between
Modeling & Experiments results

Results

Comfort indexes

Hourly evolution of the average comfort index (over the group)

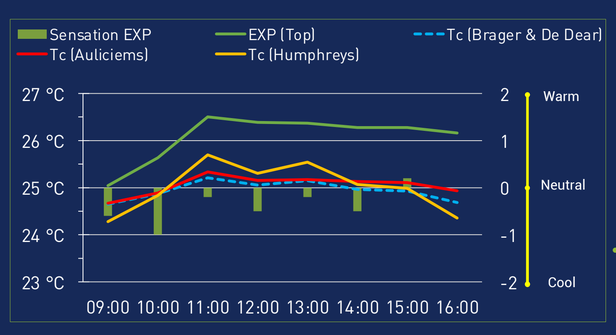


Experiment analysis
- Sensations between "slightly cold" and "slightly warm"

Indexes analysis
- PMV (Fanger) : inappropriate (temperate climate; AC building)
- Ts (Rholes and Nevins) : inappropriate (temperate climate; climatic chamber)

Comfort temperatures

Comparative analysis of average results of $T_{c_{average}}$ with $T_{op_{average}}$ and occupant perception

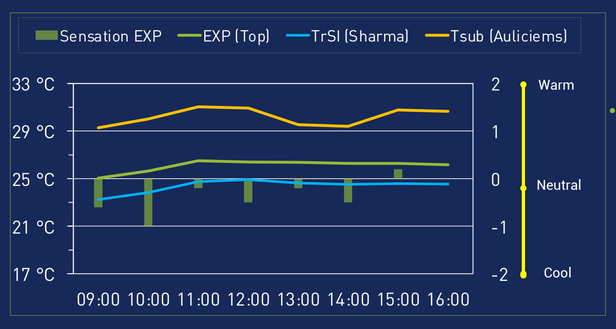


Experiment analysis
- Neutral situation = thermal comfort
- $T_{op_{neutral}}$ = 26.3 °C

Comfort temperatures analysis
- Brager and De Dear + Auliciems : inappropriate
- Humphreys : most efficient, but insufficient
- Possible origins of bias : physical (relative humidity or airspeed) or physiological (clothing, metabolic level, acclimatization) parameters : not considered

Neutrality temperatures

Evolution of $TrSI$, T_{sub} and $T_{op_{average}}$ and occupant perception



Comfort temperatures analysis
- Auliciems : overestimation (≃ 4°C, different trend) probably due to relative humidity (76% in the room // 50%)
- Sharma : same trend with a difference of 1.5 °C due to the climatic conditions under which this approach was developed (hot and humid climate of India)

… more results are available in the article (ID: 209) !

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Scan Me