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

Toky Rakotoarivelo, Frédéric Miranville, Claude Gronfier, Bruno Malet-Damour

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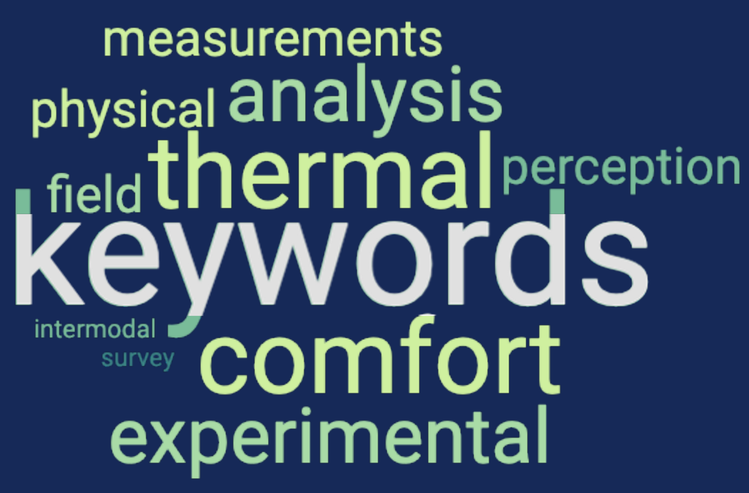
# Thermal comfort analysis: comparison between model and experimental data in tropical climate




## 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<br>Light ambiance: intermediate<br>"Active" porosity: 13% | Clear sky (morning); overcast sky (afternoon)<br>Light ambiance: bright (morning); intermediate (afternoon)<br>"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

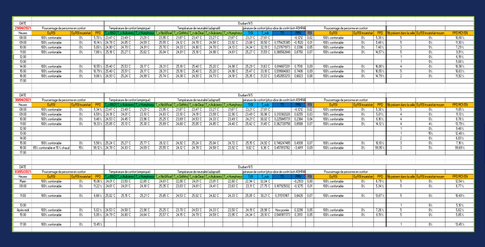
### Measurement

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

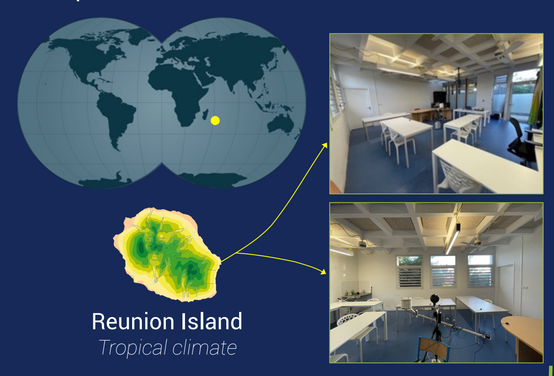
Implementation of the models in a spreadsheet

| 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

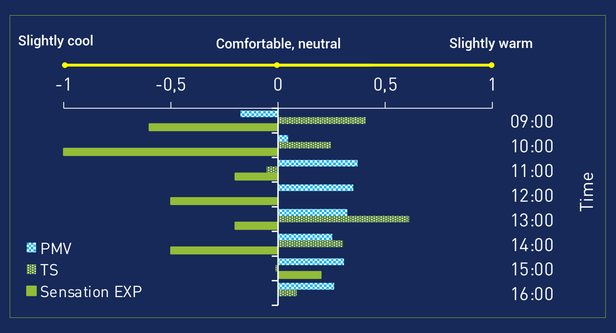



Comparative analysis between
**Modeling & Experiments results**

## Results

### Comfort indexes

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

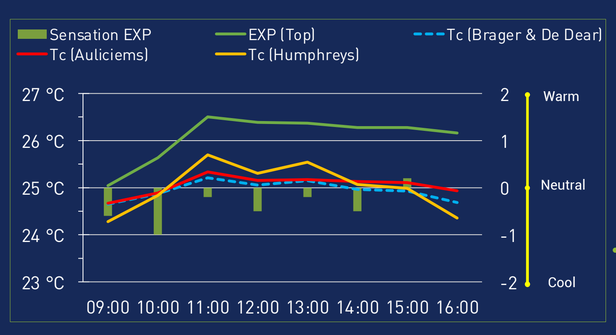



**Experiment analysis**
- Sensations between "slightly cold" and "slightly warm"

**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

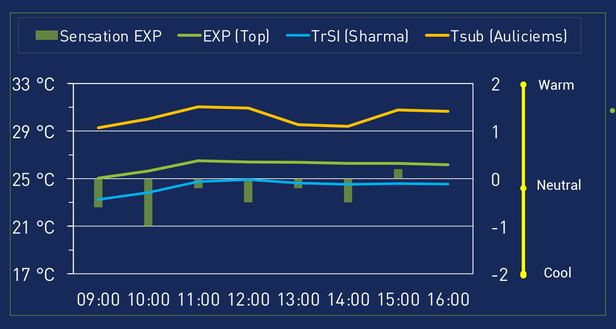



**Experiment analysis**
- Neutral situation = thermal comfort
- $T_{op_{neutral}}$ = 26.3 °C

**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) !


Toky Rakotoarivelo
Supervised by Dr B. Malet-Damour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