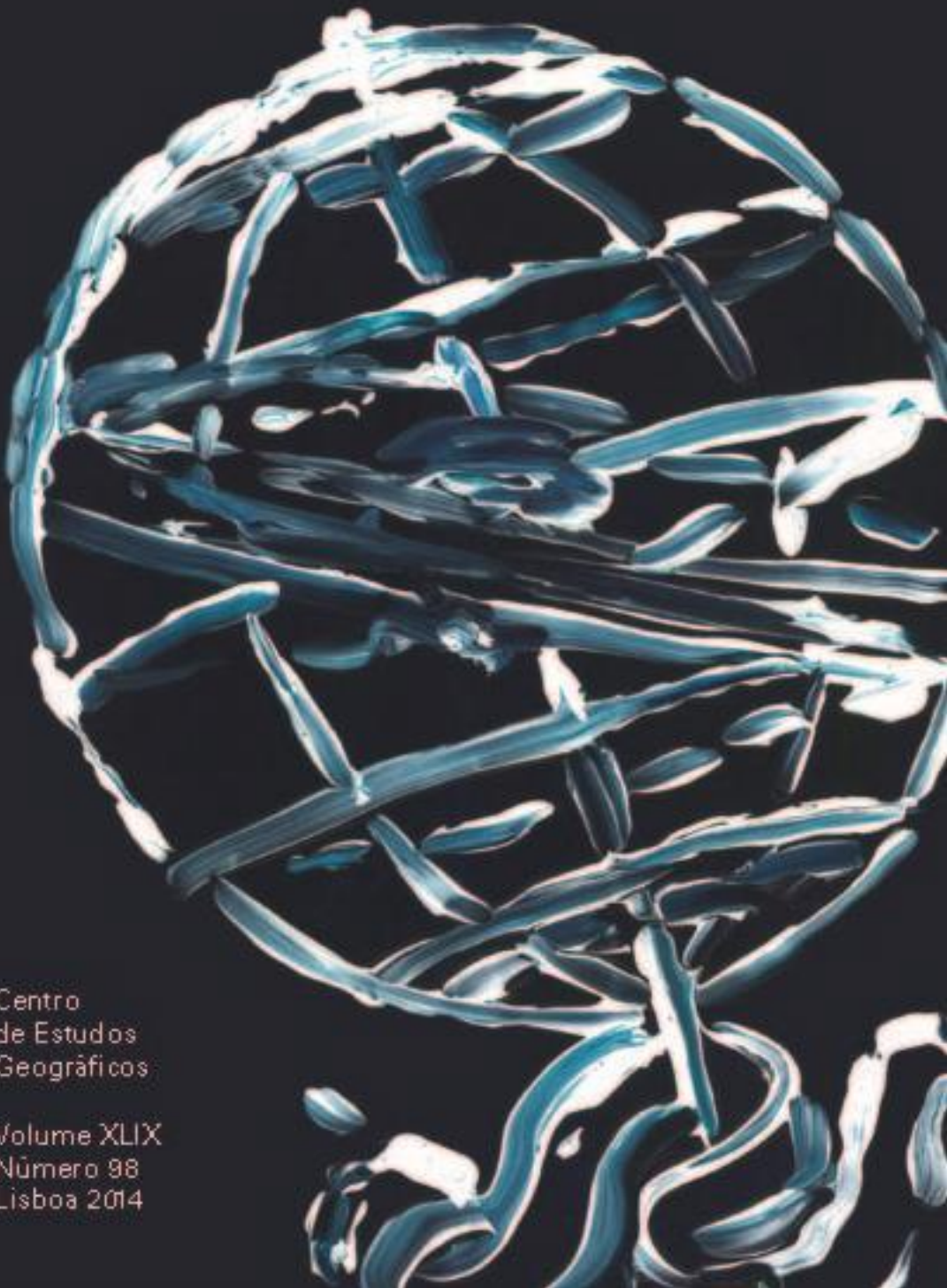
FINISTERRA

Revista Portuguesa de Geografia



Centro
de Estudos
Geográficos

Volume XLIX
Número 98
Lisboa 2014

Finisterra, XLIX, 98, 2014, pp. 3-14

ISSUE ON APPLIED HUMAN BIOCLIMATOLOGY IN MEMORY OF HENRIQUE ANDRADE

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1. ISSUE PRESENTATION

This issue of *Finisterra* is dedicated mostly to human bioclimatology and urban climatology, as these were the main research topics of our late colleague Henrique Andrade, to whom this issue is dedicated. Furthermore, these topics are of current interest and can be of use for applied purposes.

Henrique passed away last year (January 9th 2013) and a short note on his life has already been published in this Journal (*Finisterra*, XLVIII, 95:9-13, available online). He taught at the Geography Department of the Faculty of Letters of Lisbon University, from 1991 until 2008, and later at the newly founded Institute of Geography and Spatial Planning (IGOT) at the same University. H. Andrade was member of the board of the Centre of Geographical Studies (CEG) and of the Executive Committee of *Finisterra* from 2003 to 2006. He was deeply involved in research within the CliMA research group, at the Centre of Geographical Studies of the University of Lisbon. He also collaborated with several foreign colleagues, with whom he had several ongoing research projects.

This presentation will include brief comments on the papers written by authors who worked with Henrique Andrade. The papers are organized into four groups: *Bioclimatology – From Temperate to Tropical Environments; Urban Climatology and Bioclimatology of Lisbon; Tourism Bioclimatology and Environmental Impacts,* demonstrating the diversity of H. Andrade's work. The research that he carried out in each topic will be briefly depicted and some of his bibliography is included in the reference section below. The current text does not intend to make an exhaustive account of Henrique Andrade's whole scientific career, but only to show the relationship between his research and the papers written by some of his colleagues and co-workers.

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In addition to the presentation of this issue a tribute to Henrique Andrade is paid by Viriato Soromenho-Marques, a Philosopher and University Professor, with whom he taught a course on *Environment in Europe* to students of European Studies, at the Faculty of Letters of the University of Lisbon. The text that Viriato wrote shortly after Henrique's death[1] depicted our colleague so accurately, that we asked him to adapt it for this homage.

1.1. Bioclimatology: From Temperate to Tropical Environments

The first main section contains three papers on bioclimatology in temperate, subtropical and tropical areas. Bioclimatology studies are situated in the intersection between atmosphere and life sciences (Andrade, 2000) and bioclimate is frequently accessed by means of indices that are continuously being improved and modified.

The first paper was written by Andreas Matzarakis and co-authors. A. Matzarakis is a Meteorology Professor at the University of Freiburg, in Germany, with whom the Centre of Geographical Studies has had scientific collaboration for several decades; further he was a member of the jury of Henrique's PhD in 2004. Matzarakis and co-authors compare the application to Freiburg of the Physiological Equivalent Temperature (PET) and of the Universal Thermal Comfort Index (UTCI). PET was first proposed by Höppe and Mayer in 1987 and UTCI by Jendrizky, in 2012. They were often applied by Matzarakis who developed the *Rayman* free software that performs a fast calculation of the two indices. The authors conclude that both PET and UTCI are appropriate for hot conditions, but that UTCI gives more details in cold situations.

Henrique Andrade began to use PET following a study visit to the University of Freiburg, where he was worked with Helmut Mayer and Andreas Matzarakis, in the frame of a project between the German Academic Exchange Service Office (DAAD) and the Portuguese Council of Rectors (CRUP). One of his papers was on the application of PET to summer conditions in Lisbon (Andrade, 1998), at a time when this index was hardly known and applied in Portugal. Thereafter he used PET in his PhD thesis (2003), and later in several other papers, such as Andrade and Alcoforado (2008) and Andrade *et al*. (2008). In the last ones (Oliveira *et al.*, 2007; Andrade *et al,*. 2011 and Oliveira *et al*., this issue), H. Andrade and co-authors decided to verify if the PET thresholds defined by A. Matzarakis were well adapted to the Portuguese population by conducting questionnaires simultaneously with itinerant meteorological measurements in Lisbon green areas. Another of his aims was to verify the importance of adaptation through the thermal perception of individuals living in particular climatic environments (Tzu-Pin *et al.,* this issue).

The next paper looks into dry tropical environment. António Lopes, Ezequiel Correia (two colleagues of Andrade, since 1986), the Rector of the University of Cape Verde, J. N. Nascimento and P. Canário, one of his PhD students, write about the urban bioclimate of the city of Praia, in Cape Verde archipelago. In the 2009,

H. Andrade coordinated a research project proposal to study the urban bioclimate of another tropical city, Maputo (Mozambique), which unfortunately is still waiting to be evaluated. With the same aim of studying tropical environments, António Lopes (current leader of *Zephyrus C*EG research Group, that has merged the former *CliMA* and AntECC groups) is launching a project with the University of Cape Verde, together with Ezequiel Correia, who wrote his master thesis in 1994 on Santiago island. In this paper, Lopes and co-authors study thermal comfort of Praia (Santiago island). The recent intense urban growth has modified bioclimatic conditions either in "planned" or "spontaneous" city-districts of Praia. According to PET thresholds, there is a period of extreme heat stress (PET from 29 to 40ºC) from August to October (the hotter and more humid season), while during the other months only moderate or no heat stress occurs. Part of this study was carried out at a microscale and the very detailed PET maps produced can be easily applied to practical purposes (e.g. urban planning). It is clear from the maps, that sun exposed and sheltered streets have still higher PET values and need interventions to ameliorate the thermal comfort of Praia inhabitants.

Tzu-Pin Lin and H. Andrade met frequently at conferences and had begun a joint research about the comparison of thermal bioclimate in Portugal and Taiwan. They used field surveys of meteorological parameters (in order to compute PET), together with questionnaires about "thermal sensation" to inhabitants of the cities of Lisbon and Taichung. Tzu-Pin Lin and co-authors concluded that people in Lisbon are less satisfied with high PET values than those of Taichung (more accustomed to heat stress), but tolerate better high wind speeds, which are frequent in Lisbon. The authors show the influence of adaptation to particular weather conditions on thermal perception and further recommend that the design of outdoors urban areas should take into account the preferences of local people and not only index values.

1.2. Urban Climatology and Bioclimatology of Lisbon

The following group of papers refers to Lisbon. Using his deep knowledge of every Lisbon's city-district and his fondness for nature, Henrique Andrade devoted great attention to Lisbon's urban environment, particularly to the urban atmosphere as it affects directly the comfort, health and the quality of life of urban dwellers. After his master thesis about air pollution in Lisbon (Andrade, 1994 and 1996), H. Andrade studied the thermal aspects of the urban environment, either of the city as whole, or at the microclimatic scale (favouring the study of green areas).

Due to the lack of urban meteorological information in Lisbon, Henrique Andrade conceived and built in 2001 the embryo of the present CEG "mesoscale network", equipped with modern shelters since 2004. He was in charge of this network until his death. The network is still working, thanks to the efforts of António Lopes (*Zephyrus* leader, as mentioned before) and to several generations of students who help collecting data and checking the devices. In the first paper of this group (Alcoforado *et al*.), a statistical study of Lisbon's Urban Heat Island (UHI) was

carried out based on Andrade's methodology (Andrade, 2003; Andrade, 2005) but using up-dated data. The authors concluded that the UHI is more intense in the summer (maximum UHI intensities up to 6.3ºC) than in winter (up to 3.8ºC) and higher at night than during the day. The relationship with the wind is interesting as some areas remain hotter due to the shelter effects (mostly from the prevailing North winds), whereas others are cooler due to the influence of the estuary and ocean breezes. The topics of UHI and PET, particularly if mapped at a detailed scale, can be of use for applied purposes, such as urban planning. H. Andrade worked actively in divulging the findings of academic work to stakeholders, either in the CliMA studies on climate guidelines for planning (e.g. Alcoforado *et al.,* 2009a; Alcoforado *et al.,* 2012), as well as producing booklets with basic urban climate information and lists of best practices to achieve high climate quality cities (Alcoforado *et al*., 2009b).

Sofia Baltazar developed a methodology to construct detailed PET maps of an urban area during the course of her thesis supervised by Henrique Andrade and António Lopes; the city of Lisbon was her case-study. The maps are very interesting because they show that for selected "weather-types", there is a great spatial and temporal difference in PET values and correspondent stress class. For example, in "cold winter nights", the entire city is under *extreme cold stress*, although the denser areas are not so cold. Conversely in "hot summer days", there is a greater spatial variation of heat stress classes: the city centre and the eastern city-districts are under *extreme heat stres*s, while in SW Lisbon, subject to ocean breezes, only *slight heat stress* occurs. Besides their importance in planning issues, these maps are also being used by biologists in an attempt to shed light on the relationship between the distribution of epiphyte species (lichens and bryophytes) and Lisbon urban climate. Lichens and bryophytes provide an integrated response to the climatic changes occurring in urban areas and may be used as instruments to evaluate the UHI.

During her stay in Lisbon, in 2011, Agota Szucs discussed with H. Andrade the best way to compute the Mean Radiant Temperature (MRT, a parameter needed to calculate PET) and they started a research on that topic. In their paper, A. Szucs and co-authors present the main results obtained using various softwares, such as *RayMan, SOLWEIG and ENVI-met t*o compute MRT, as opposed to using measured values. The research was carried out in green areas of Lisbon and the main conclusions are that *Rayman* and *SOLWEIG* are preferable in case of direct solar exposure, whereas in shaded areas ENVI-met provided the best results

Victor Barradas, Professor at the University of Mexico City, spent one year in Lisbon at the CliMA research group and began a joint research with H. Andrade, whose results he planned to present in his paper "The daytime energy budget of small parks in Mexico City and Lisbon, Portugal, as derived by tree sap-flow measurements and transpiration modelling". Unfortunately, V. Barradas was unable to participate in this homage volume, but the paper has been accepted for presentation at the 9th International Conference in Urban Climate (ICUC9), that will be held in Toulouse, in July 2015. Some months before his death H. Andrade attended the

ICUC8 in Dublin; a note on his life and career was published in the "Urban Climate News", the quarterly newsletter of the International Association of Urban Climate.

One of the preferred subjects of H. Andrade was the study of green areas. Together with R. Vieira he wrote about climate of the Gulbenkian Park in Lisbon (Andrade and Vieira, 2007) and he coordinated a task on urban green areas within the Urbklim Project (2008-2011). Sandra Oliveira was a grant-holder in this project who worked in close and productive collaboration with the senior CliMA researchers. For this issue, Sandra Oliveira and T. Vaz have worked out additional data collected during the project and have written about the perception of thermal comfort and user's preferences of two small green areas of Lisbon. The authors verified that differences between even a small green area and the surrounding streets vary between 2 and 7ºC and are greater in summer than in winter. These differences are higher between 10am and 4pm. This cooling effect of green areas may have an important role in mitigating climate change impacts. The paper also highlights the importance of personal characteristics of people on their "perception vote", expressed during face-to-face questionnaires.

1.3. Tourism Bioclimatology

The third group includes two papers on climate and tourism issues. Since 2004, Henrique Andrade showed interest in this topic (Alcoforado *et al*., 2004), became a member of the *Commission on Climate, Tourism and Recreation of the International Society of Biometeorology* and published two book chapters in 2007 and 2008. In 2009, he became national leader of an international Urbanet Project − "Urban Tourism and Climatic Change", participated in a paper (Brito-Henriques *et al*., 2010) and made several presentations on the topic. The grant holder of this project, Raquel Machete, became enthusiastic about these issues, and is now writing a PhD thesis on Climate Change and Tourism.

Raquel Machete and co-authors present some results of the Urbanet project, e.g. a paper on tourism and climate change in Lisbon, using a weather-type methodology to assess current and future weather adequacy for tourism in Lisbon. PET was included (as a thermal parameter) in the daily weather type definition and the thermal preference of tourists was used to define class thresholds. For the studied period (2000-2010), even when the weather was categorized extremely hot or uncomfortable for tourism, room occupancy rates did not decrease, which shows the importance of other variables (as room prices or thermal expectations).When making projections for 2020 and 2050 under the A1B scenario, the greatest differences concern the minimum temperature not included in this weather type definition (next step in Raquel´s PhD). Considering the maximum temperature, only a few days are expected to be unacceptably hot in 2050 (and none in 2020).

H. Andrade had several scientific contacts with Krysztof Blazejczyk, one of the leading authors in Biometeorology and Bioclimatology. In their paper, K. Blazejczyk and co-author suggest a new index to verify the "Adaptation Strain" of tourists tra-

velling from Northern and Central Europe to the Mediterranean. They conclude that summer is the season with the greatest spatially differentiated adaptation strain, but in winter the need for adaptation is greater than in summer for tourists arriving to Barcelona, Rome and Athens.

1.4. Environmental impacts

The last group includes two papers on environmental impacts of extreme climatic and meteorological conditions, one about climate and health issues and the other on hydro-climatic hazards.

The topic "climate and health" was the latest one in H. Andrade's research, that he undertook after his participation in a small essay in 2007 (Alcoforado and Andrade, 2007). He started a study on the possible influence of weather and atmospheric electric discharges (AED) on asthma crisis in children, together with the physicians of a pediatric hospital in Lisbon (*Dona Estefânia* Hospital). The study was included in the Raiden Project coordinated by Marcelo Fragoso, a colleague of H. Andrade since 1986. He had also started another study with the University of Coimbra in collaboration with Helena Nogueira about the relationship between cold and mortality in Portugal. The first paper of this group is related to the preliminary findings of the research in collaboration with *Dona Estefânia* Hospital. The authors are Paulo Canário, Marcelo Fragoso, Carla Mora and Helena Nogueira. They have investigated the relationships between weather parameters and AED, and the variability of asthma crisis in children attending emergency services *at Dona Estefânia* Hospital*,* using a sample of Autumn days with thunderstorms during the period 2003-2009. They concluded that a decrease in minimum temperature caused in fact an increase of asthma crisis, while no relationship has been found so far between AED and asthma exacerbation. As these results are not in full agreement with others described in the literature, the authors intend to continue their study based on longer samples.

The last paper deals with an extreme meteorological event. H. Andrade was particularly interested in thermal extremes, either due to heat or cold; he supervised the master thesis of Jorge Marques (from the IPMA, Portuguese Institute of the Ocean and the Atmosphere) on this subject, showing that the widespread idea that in a Mediterranean country there would be no relationship between mortality and cold weather is not correct. João Vasconcelos, a former grant holder at the CliMA Group, also worked out the relationships of morbility and cold weather in Portugal in his PhD at the New University of Lisbon. But although in Portugal winter mortality is currently higher than in summer, extremely hot weather determines a rise in deaths especially among the more vulnerable people. Paulo Canário was supervised by Henrique Andrade during his PhD thesis (still ongoing) about heat stress and mortality in Lisbon Metropolitan Area, introducing a spatial context in his research down to the civil parish level and permitting to establish which ones are more vulnerable to heat-related mortality hazard.

The paper by Ângela Santos (CEG Riskam Research group), Susana Mendes (University of Bergen) and João Corte-Real (Universities of Évora and Lusófona) is about the consequences of another type of extreme event, the storm Hercules that hit Portugal in January 2014 and its main impacts. It was a deep depression in the lower atmosphere, centered at circa 40º North and associated with an occluded frontal system, triggering strong sea waves. The study was carried out through the analysis of documentary and media sources, as well through comparison of existing field evidence before the storm and with fieldwork carried out after the storm. Although the wave train was restricted to a narrow coastal area, the authors verified that it caused significant damage in beaches, front streets, ports and marinas, showing the weaknesses of coastal planning management.

As expressed elsewhere, Henrique Andrade's absence has been difficult to deal with. We will always remember him as the low-profile but discerning friend, and as the cultivated, hardworking and persevering colleague, who had a critical attitude towards us, but more so towards himself. I supervised his Master and PhD thesis and I can testify his enormous scientific and human value. Several research lines were opened by him, several papers were left unfinished. Some of these gaps are filled in this issue of Finisterra.

In short, in his dynamic academic career, H. Andrade launched many ideas and started new research topics within our research group. We are grateful to him and the *Zephyrus* researchers will pursue and develop his legacy in his memory.

2. MAIN PUBLICATIONS AND CONFERENCE PROCEEDINGS OF HENRIQUE ANDRADE

2.1. International journals

Burkart K, Canário P, Breitner S, Schneider A, Scherber K, Andrade H, Alcoforado MJ, Endlicher W (2013) Interactive short-term effects of equivalent temperature and air pollution on human mortality in Berlin and Lisbon. *Environmental Pollution*, 183: 54-63. DOI:10.1016/j.envpol.2013.06.002.

Andrade H, Alcoforado MJ, Oliveira S (2011) Perception of temperature and wind by users of public outdoor spaces: relationships with weather parameters and personal characteristics. *International Journal of Biometeorology*, 55(5): 665-680. DOI: 10.1007/s00484-010-0379-0

Oliveira S, Andrade H, Vaz T (2011) The cooling effect of green spaces as a contribution to the mitigation of urban heat: A case study in Lisbon. *Building and Environment*, 46(11): 2186-2194. DOI:10.1016/j.buildenv.2011.04.034

Machete R, Ferreira C, Brito-Henriques E, Andrade H, Couto J (2010) Anticipating the impacts of climate change on tourism in Lisbon Metropolitan Area - Assessing tourist perceptions. *Berichte des Meteorologischen Instituts der Albert-Ludwigs-Universität Freiburg, 20*: 346-351.

Canário P, Andrade H (2010) Mortality spatial variations in a small scale during heat waves in Lisbon - who is at risk? *Berichte des Meteorologischen Instituts der Albert-Ludwigs-Universität Freiburg, 20*: 225-228.

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Andrade H, Alcoforado MJ (2008) Microclimatic variation of thermal comfort in a district of Lisbon (Telheiras) at night. *Theoretical and Applied Climatology*, 92(3-4): 225-237. DOI: 10.1007/s00704-007-0321-5

Oliveira S, Andrade H (2007) Assessment of the climatic comfort in an outdoor public space of Lisbon. *International Journal of Biometeorology*, 52(1): 69-84. DOI 10.1007/s00484-007-0100-0

Alcoforado MJ, Andrade H (2006) Nocturnal urban heat island in Lisbon (Portugal): main features and modelling attempts. *Theoretical and Applied Climatology*, 84(1-3): 151-159. DOI: 10.1007/s00704-005-0152-1

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Alcoforado MJ, Lopes A, Andrade H (1999) Cartes thermiques et cartes du "risque" d'occurrence de basses températures en milieu urbain à Lisbonne. *Publications de l'Association Internationale de Climatologie*, 12: 433-441.

2.2. National journals

Oliveira S, Vaz T, Andrade H (2014) Perception of termal comfort by users of urban green areas in Lisbon. *Finisterra - Revista Portuguesa de Geografia*, XLIX(98): 113-131.

Scuzs A, Gál T, Andrade H (2014) Comparison of measured and simulated Mean Radiant Temperature. Case study in Lisbon (Portugal). *Finisterra - Revista Portuguesa de Geografia*, XLIX(98): 95-111.

Lin T-P, Andrade H, Oliveira S, Hwang R-L, Matzarakis A (2014) Outdoor thermal perception in different climatic regions. Initial results from Taichung (Taiwan) and Lisbon (Portugal). *Finisterra - Revista Portuguesa de Geografia*, XLIX(98): 49-58.

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Andrade H, Vieira R (2007) A climatic study of an urban green space: the Gulbenkian Park in Lisbon (Portugal). *Finisterra - Revista Portuguesa de Geografia*, XLII(84): 27-46.

Andrade H (2005) O clima urbano – natureza, escalas de análise e aplicabilidade. *Finisterra - Revista Portuguesa de Geografia*, XL(80): 67-91.

Andrade H (2000) Bioclimatologia humana: novas perspectivas. *Finisterra - Revista Portuguesa de Geografia*, XXXV(69): 157-159

Andrade H (1998) O desconforto térmico estival em Lisboa. Uma abordagem bioclimática. *Finisterra - Revista Portuguesa de Geografia*, XXXIII(66): 41-58.

Andrade H (1996) A qualidade do ar em Lisboa, valores médios e situações extremas. *Finisterra - Revista Portuguesa de Geografia*, XXXI(61): 43-66.

2.3. Books and book chapters

Alcoforado MJ, Lopes A, Andrade H (2015) Urban Climatic Map Studies in Portugal: Lisbon. In Ng E, Ren C (eds) *The urban climatic map for sustainable urban living*. Chapter 16. Routledge (in press).

Alcoforado MJ, Andrade H, Lopes A (2012) Urban Climate Maps in Lisbon, Portugal. *In* Ren Chao et al, (ed.) *Urban climatic map – an information tool for sustainable urban planning* (Chinese Version), The China Architecture & Building Press:95-110

Brito-Henriques E, Ferreira C, Andrade H, Machete R, Couto J (2011) Antecipando os impactos das alterações climáticas no turismo: percepção dos agentes económicos e medidas de mitigação e adaptação. *In* Santos N. e Cunha L (Eds.) *Trunfos de uma Geografia Activa: Desenvolvimento Local, Ambiente, Ordenamento e Tecnologia*, Imprensa da Universidade de Coimbra, Coimbra:165-175.

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Alcoforado MJ, Andrade H (2008) Global warming and urban heat island. *In* Marzluff JM, Shulenberger E, Endlicher W, Alberti M, Bradley G, Ryan C, Simon U, ZumBrunnen C (eds) *Urban Ecology*. Springer: 249-262.

Alcoforado MJ, Andrade H, Fragoso M, Lopes A, Lombardo M, Matzarakis A, Oliveira S (2008) *Estudos sobre Cidades e Alterações Climáticas*. Área de Investigação em Geo-Ecologia, 8, CEG, Lisboa.

Andrade H, Alcoforado MJ, Oliveira S (2008) Methodologies to assess the effects of climate on tourism: weather type and individual perception. *In* Matzarakis A, DeFreitas C R, Scott D (eds) *Advances in Tourism Climatology*, Commission on Climate, Tourism and Recreation International Society of Biometeorology, Freiburg: 74-79.

Alcoforado MJ, Andrade H (2007) Clima e saúde na cidade. Implicações para o Ordenamento. *In* Santana P *et al.* (ed) *A cidade e a saúde*. Coimbra, Almedina: 99-118.

Alcoforado MJ, Andrade H, Lopes A, Oliveira S (2007) A ilha de calor de Lisboa. Aquisição de dados e primeiros resultados estatísticos para aplicação ao ordenamento urbano. *In* Esteves A. *et al. (eds) Geophilia - O Sentir e os Sentidos da Geografia. Homenagem a Jorge Gaspar*. Centro de Estudos Geográficos, Lisboa: 593-612.

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2.4. Other publications

Mora C, Gutierres F, Andrade H, Alcoforado MJ (2009) *Algumas condicionantes ambientais na escala local em Fridão*. Parecer Climático inserido no EIA do Aproveitamento Hidroeléctrico do Fridão desenvolvido pelo núcleo CliMA para as empresas AGRI-PRO Ambiente Consultores SA e EDP - Energias de Portugal, Lisboa.

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Alcoforado MJ, Andrade H, Lopes A, Vasconcelos J, Vieira R (2004) *Princípios climáticos para o Planeamento urbano. Aplicação a Lisboa*. Relatório final do projecto CLIMLIS, CEG, Área de Investigação de Geo-Ecologia.

2.5. Proceedings and extended abstracts

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Carraça MGD, Fragoso M, Alcoforado MJ, Lopes A, Mora C, Correia S, Andrade H (2012) Effects of surface features on thunderstorm activity – a preliminary study for Lisbon region. *Proceedings of the 8th International Conference on Urban Climates (ICUC8)*, Dublin, Ireland, 6th-10th August (http://www.icuc8.org/abstracts/*programme)*.

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Andrade H, Alcoforado MJ, Canário P (2011) Modelação estatística da influência dos edifícios no campo térmico de Lisboa *VIII Congresso da Geografia Portuguesa*. Lisboa, Portugal, 26-29 October, APG, 4p, CD-Rom.

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