



Preservation metrics applied to environmental management of collections

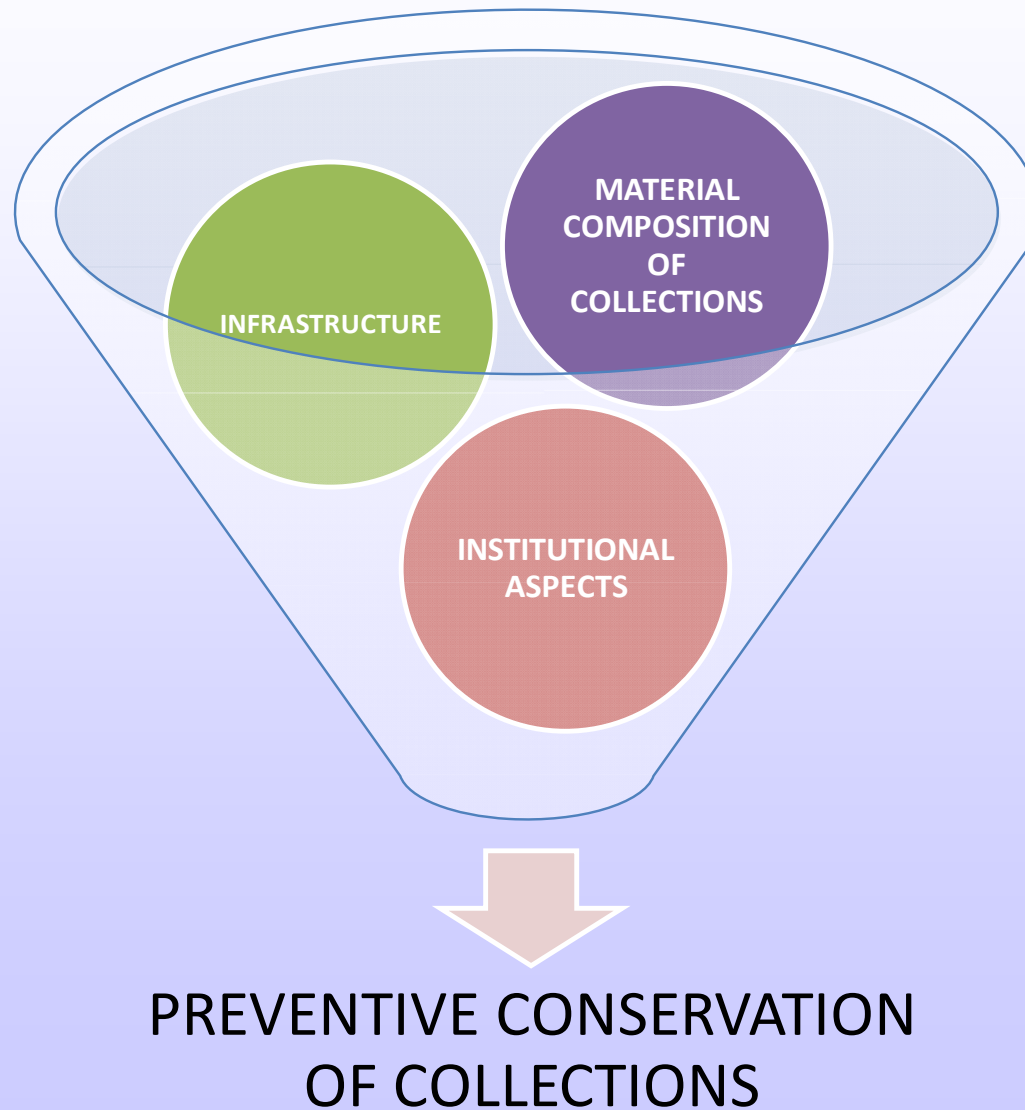
Gonçalves, W.B, Souza, L.A.C.

UFMG – Federal University of Minas Gerais – School of Fine Arts
Belo Horizonte – MG - Brazil

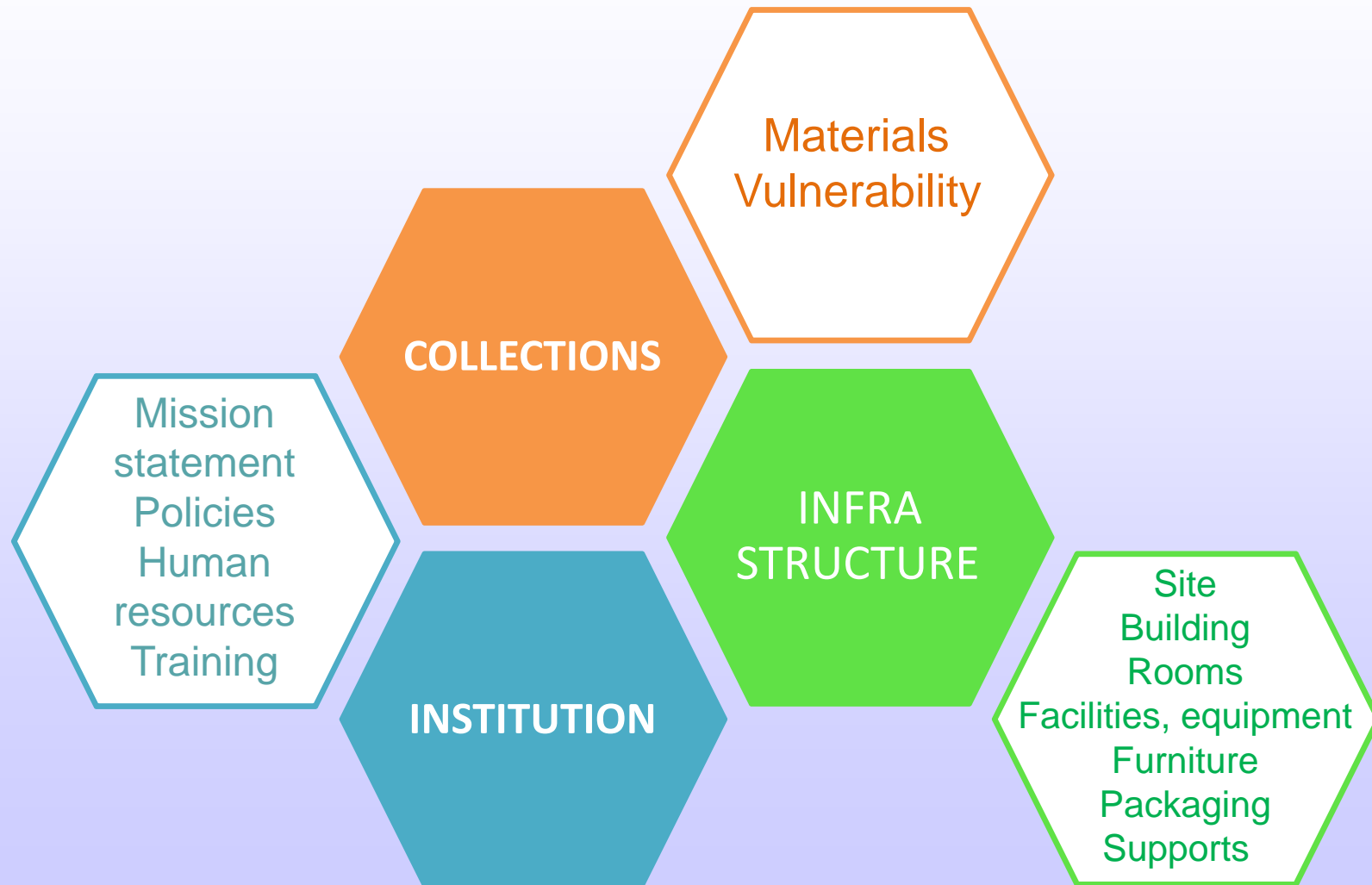
CECOR – Center for Conservation and Restoration of Cultural Properties

LACICOR – Conservation Science Laboratory

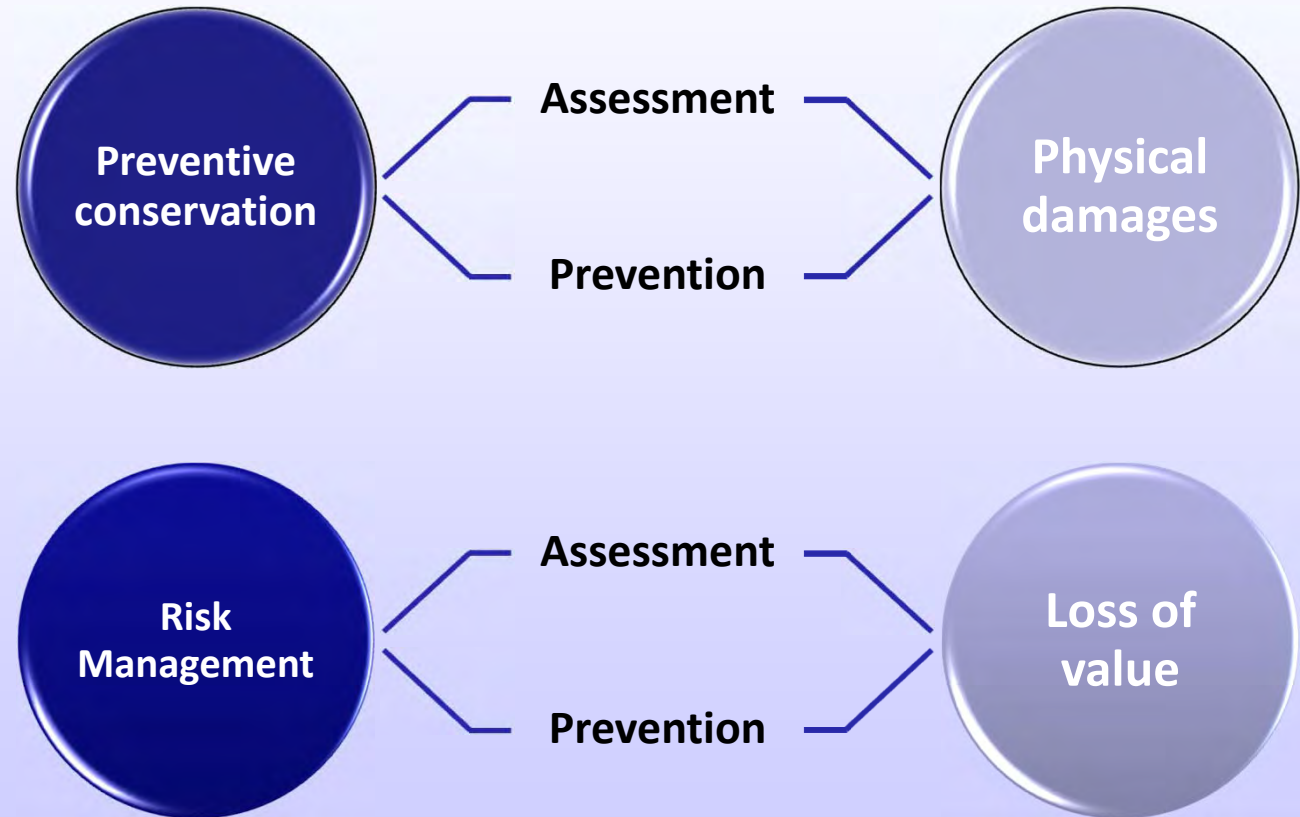
Environmental management of collections



Environmental management of collections



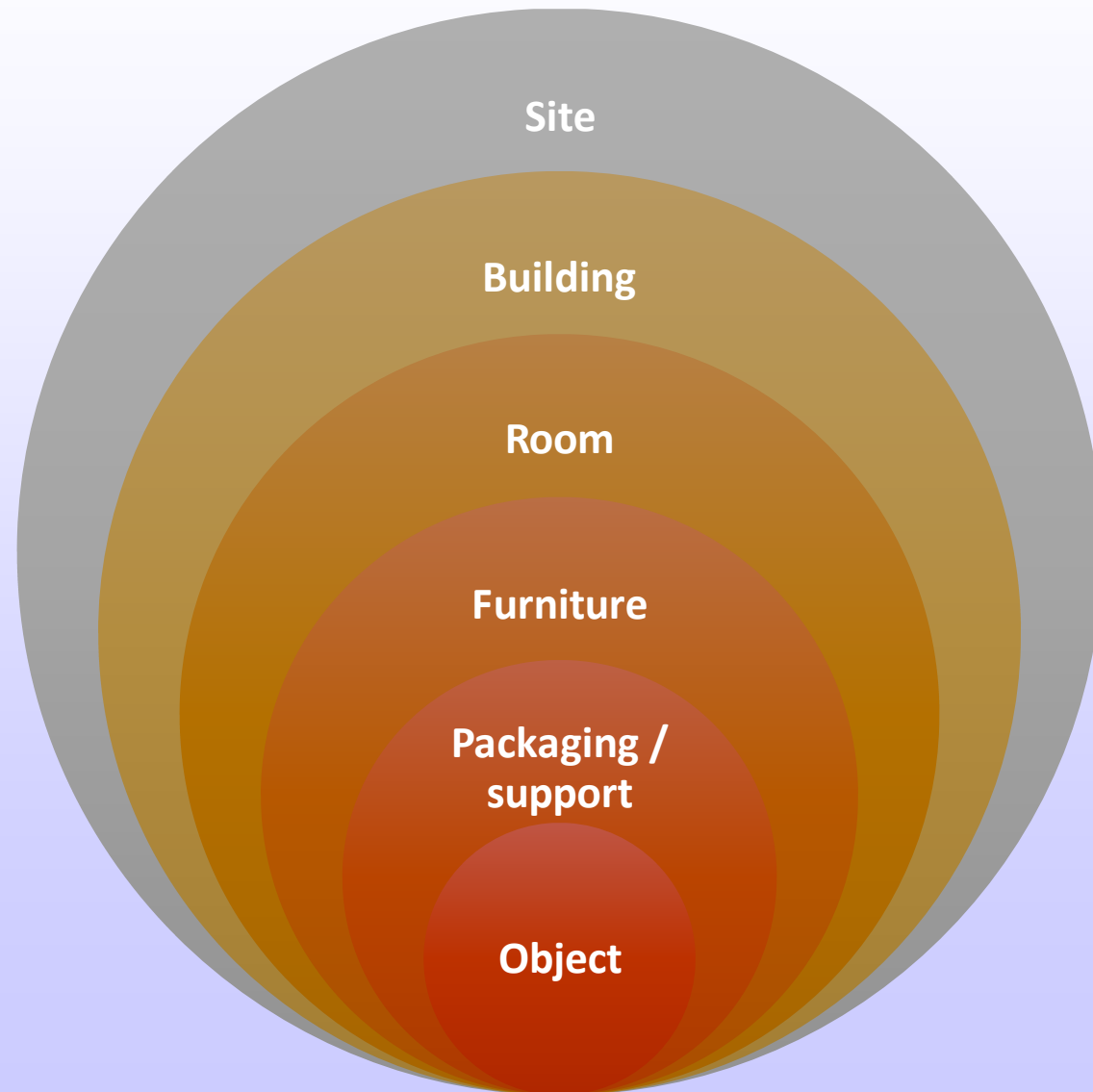
Environmental management: towards a realistic approach



Agents of deterioration

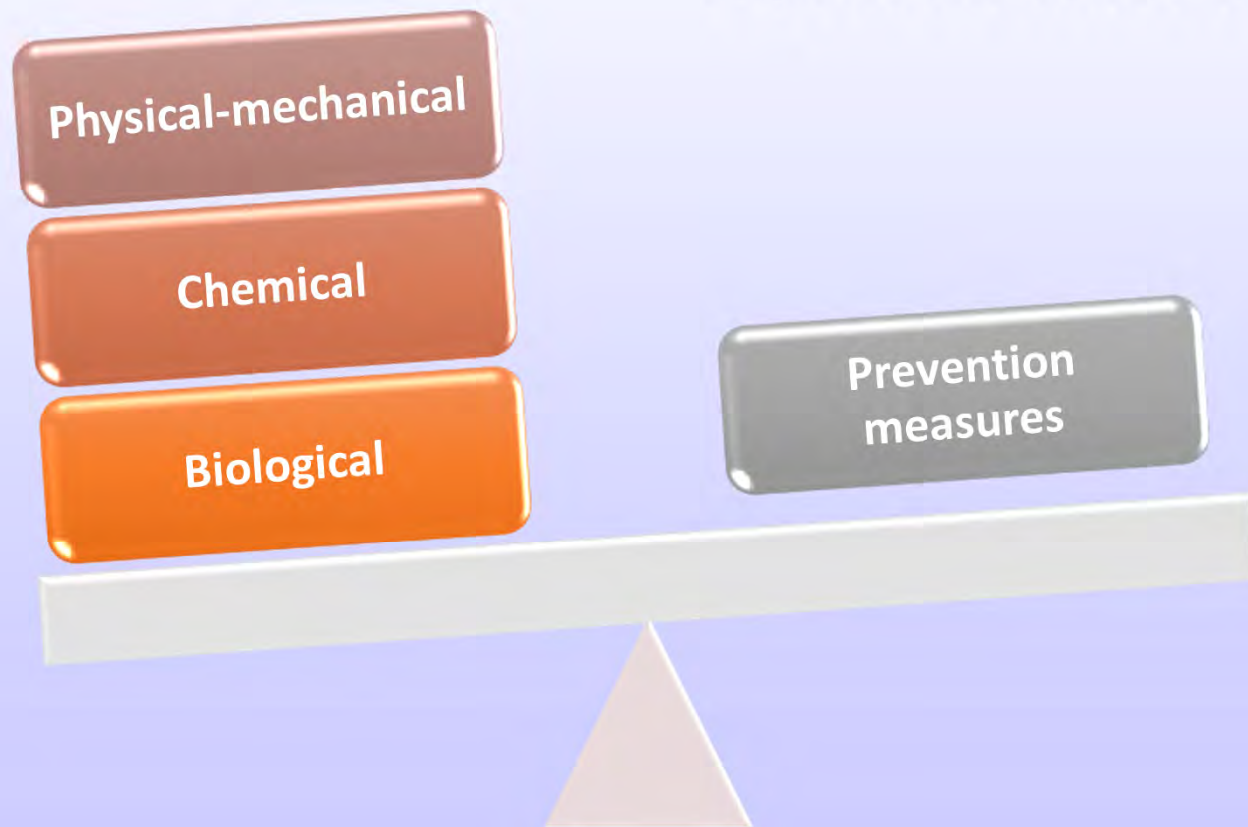


Strategic control levels



Deterioration assessment x evaluation

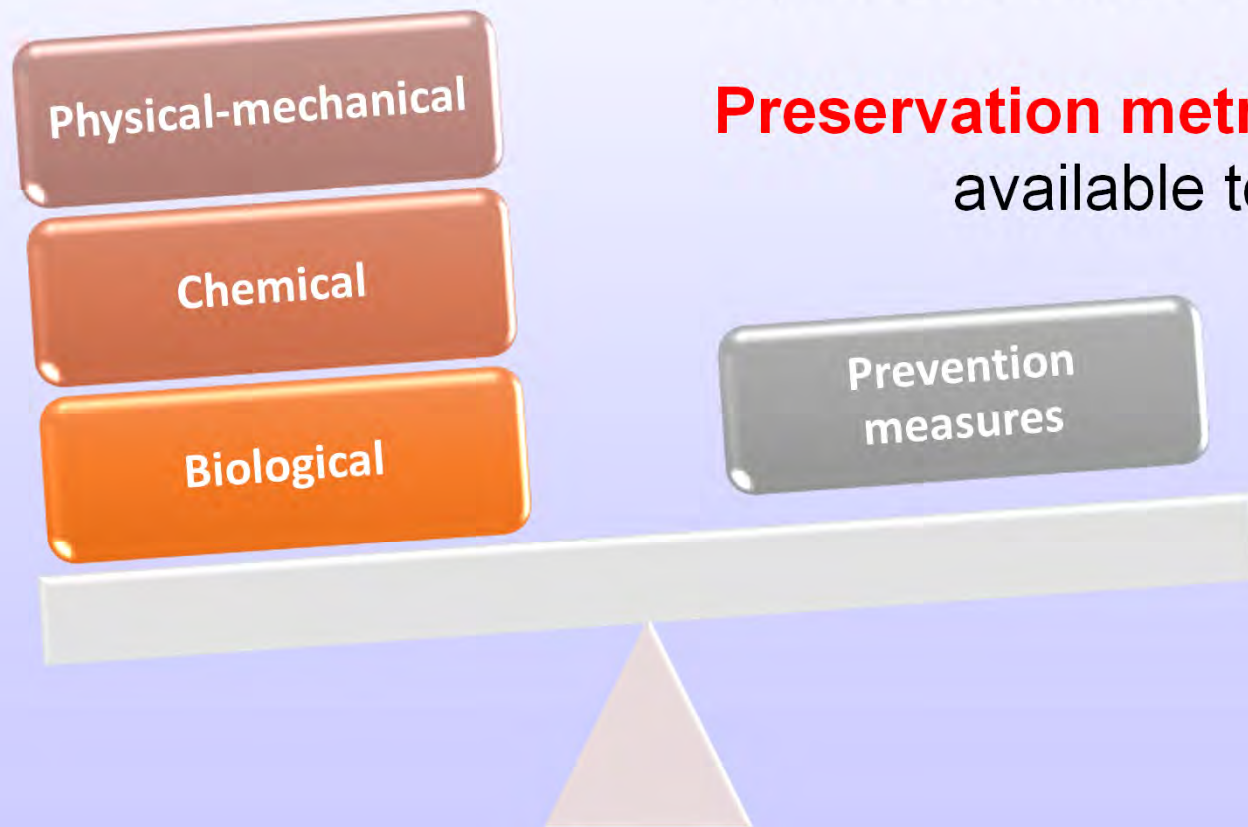
How to evaluate actual present or possible future deterioration?



Deterioration assessment x evaluation

How to evaluate actual present or possible future deterioration?

Preservation metrics are one available tool.



Preservation metrics

- What are they?
- Parameters / indicators that allow:
 - (1) Easily understandable, standardized, reproducible assessment and interpretation of large amounts of monitored data and conservation conditions of collections, as well as of risks to their preservation, related to environmental deterioration agents;
 - (2) To integrate complex dynamic deterioration mechanisms in simplified quantitative indicators – this imply various **uncertainties and limitations**;
 - (3) **To compare** two or more different situations, eg. same room or case and different year season or different rooms / cases, in terms of objects life expectancy affected by chemical, biological or physical-mechanical deterioration;

Preservation metrics

- **Performance indices** – percentage of time in which conditions fit *predetermined criteria* eg. Relative humidity and/or temperature ranges
- **Chemical deterioration metrics**
 - Isoperms (Sebera, Michalski, Strang & Grattan)
 - Preservation Index / Time weighted Preservation Index (IPI, Reilly, Padfield);
- **Physical-mechanical damage metrics**
 - EMC (equilibrium moisture content) fluctuations;
 - Dimensional Change;
 - RH fluctuations (Camuffo, Bratasz, Schellen, Martens)
- **Biological attack**
 - Mould Risk Factor (IPI, Reilly)
 - TOW – Time of wetness.
- **Contaminants, corrosion, light...**

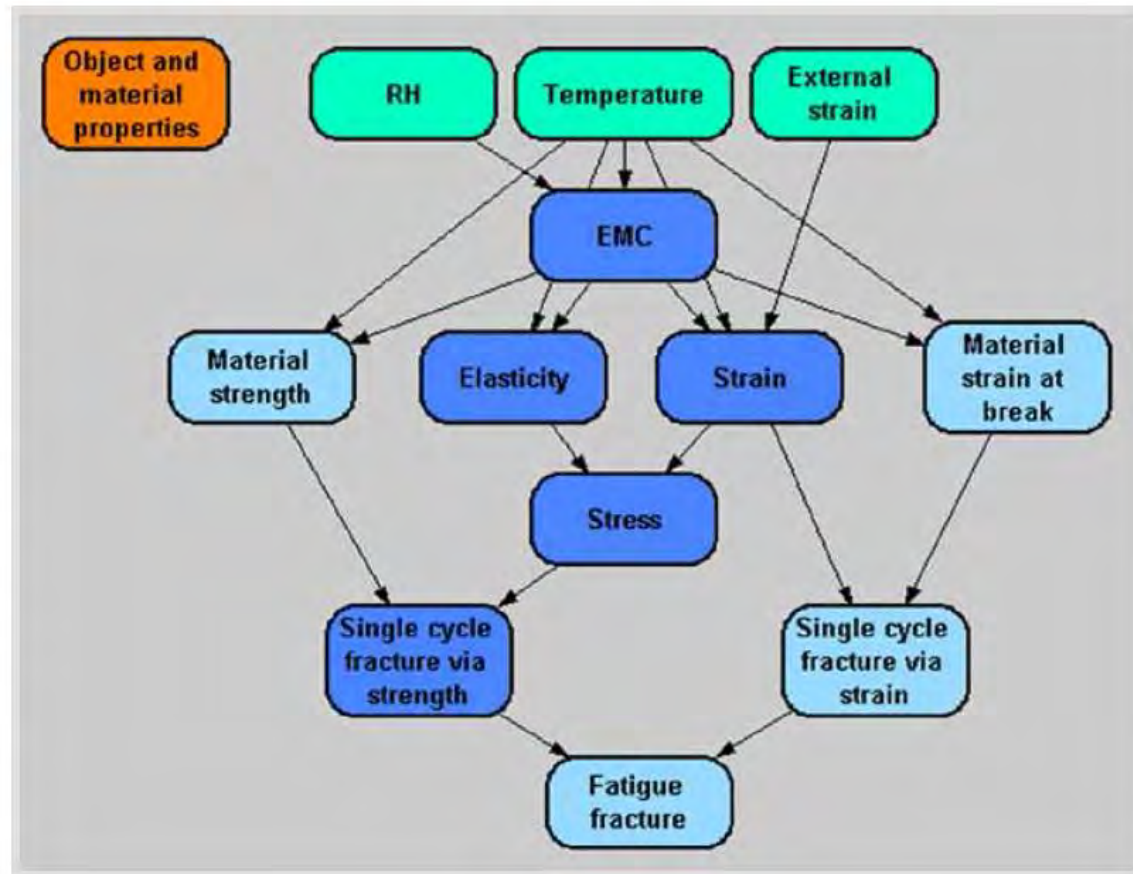
Scientific background

- **Physics**
- **Materials Engineering**
- **Solid mechanics**
- **Fatigue and fracture mechanics**
- **Fluid dynamics**
- **Life cycle analysis**
- **...**

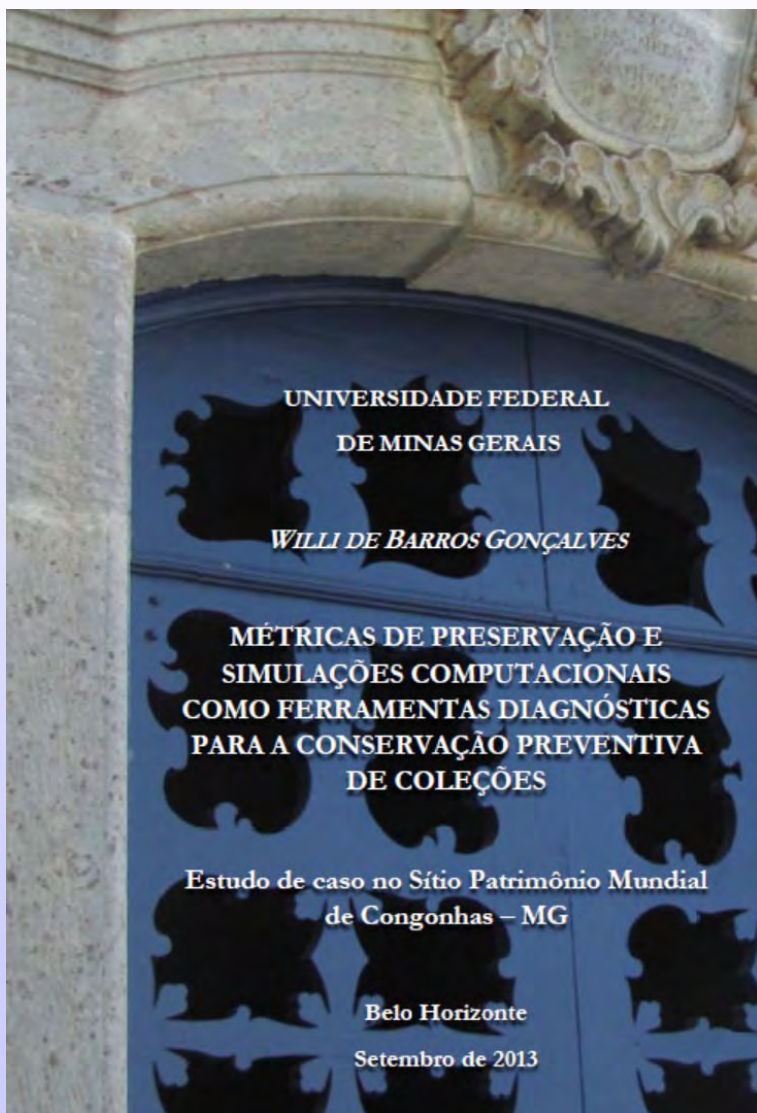
Scientific background

Michalski, S. (2013). **Stuffing everything we know about mechanical properties into one collection simulation.** *Climate for Collections-Standards and Uncertainties*. London: Archetype Publications, 349-62.

Figure 2. The top layer of the Analytica™ influence diagram. Orange – object and material data; Green – climate and strain inputs; Blue – calculating nodes (pale blue for those incomplete as of January 2013). Arrows from the object and material properties box are not shown for clarity, since they enter almost all the blue nodes



Scientific background



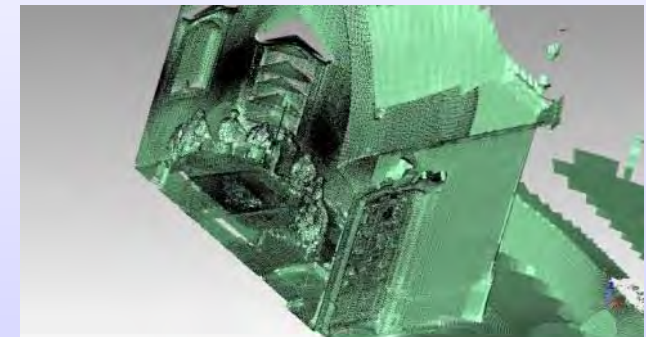
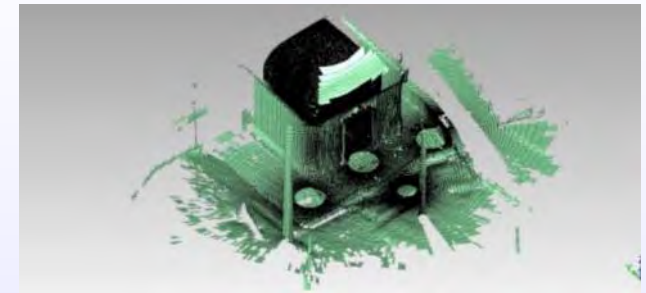
Preservation metrics and
computational simulations as
diagnostic tools for preventive
conservation of collections
Case study at world heritage site
of Congonhas-MG

PhD Thesis (Portuguese)
Available at

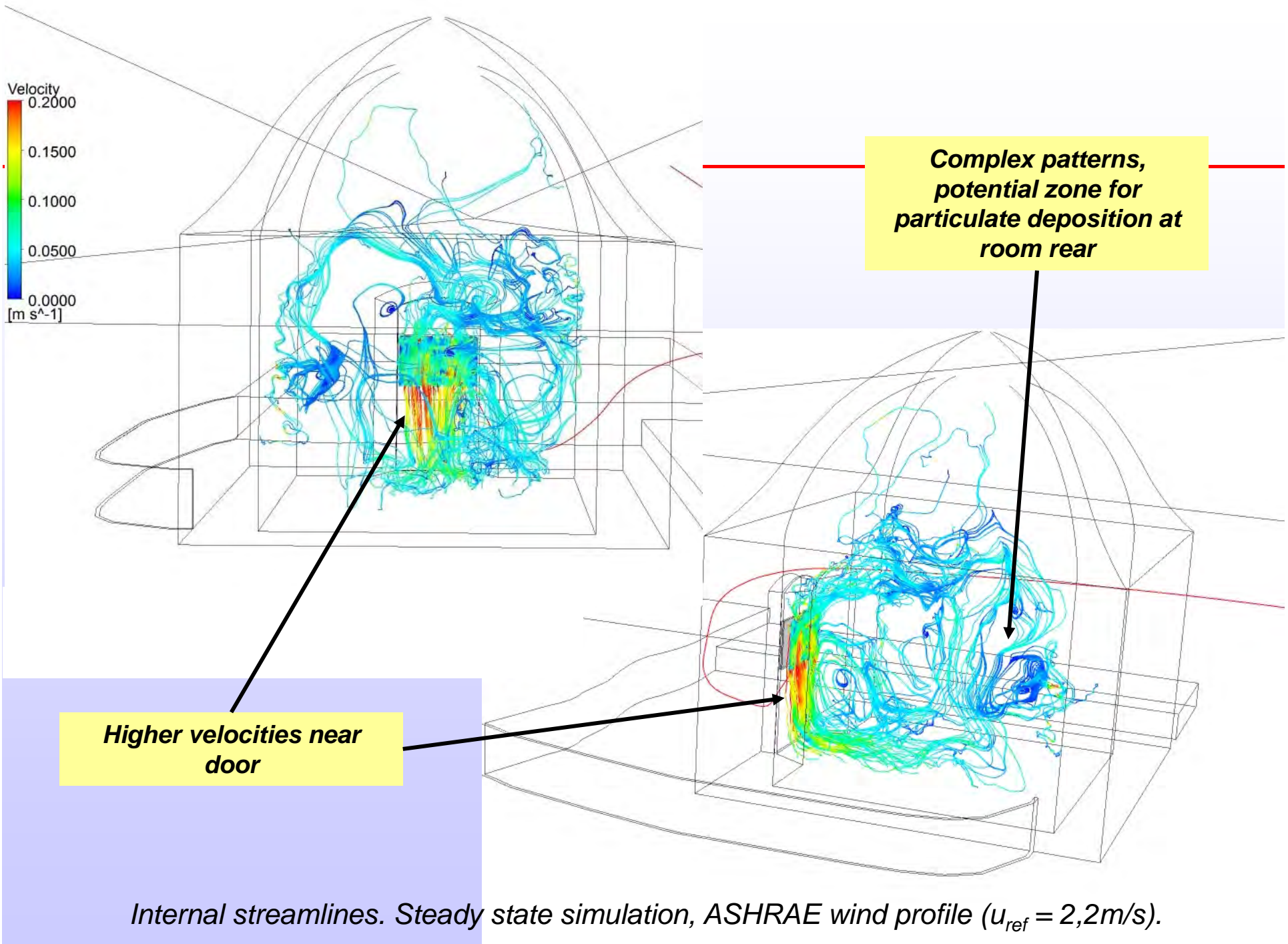
<http://www.bibliotecadigital.ufmg.br/dspace/handle/1843/JSSS-9GRH79>

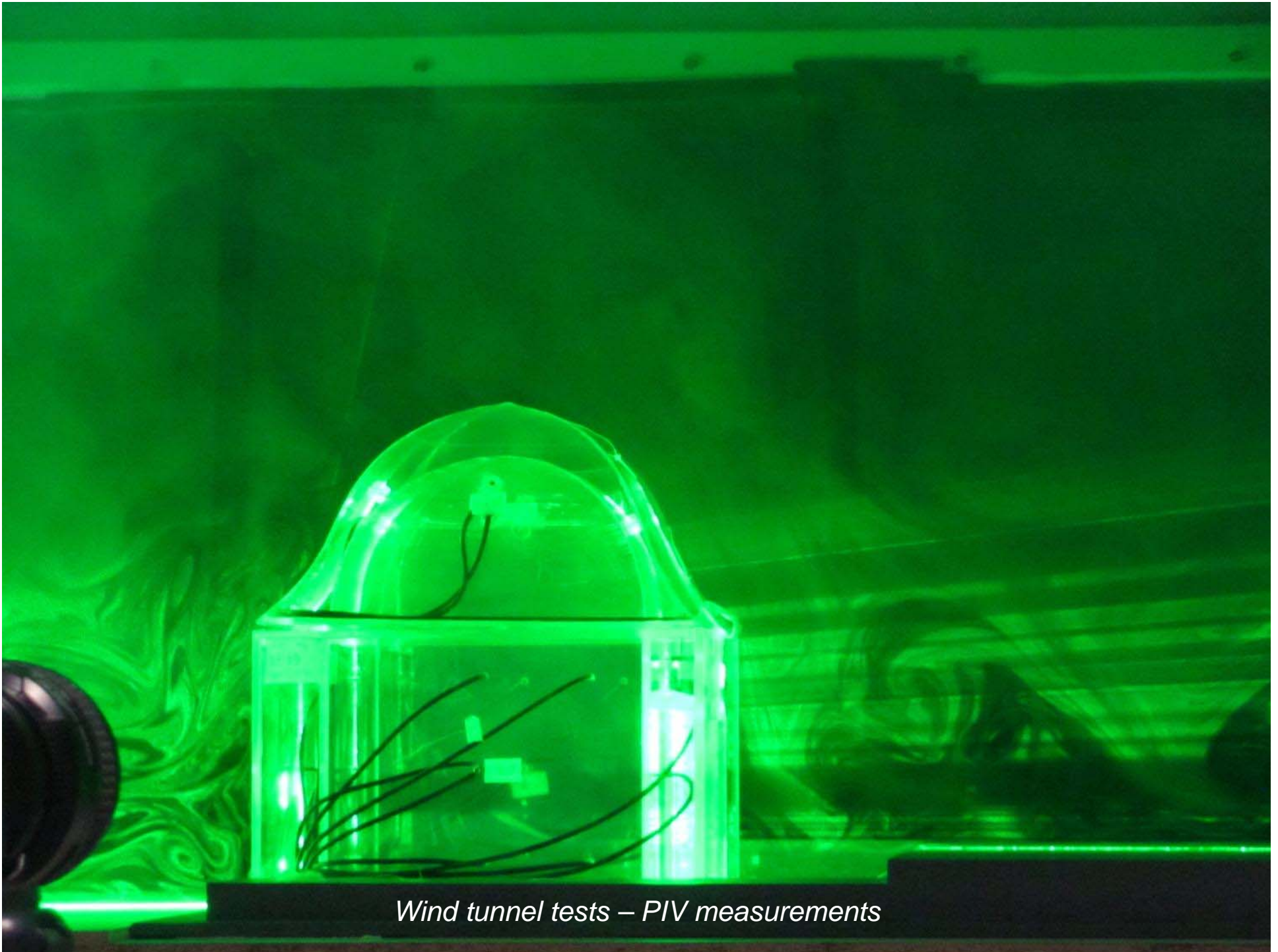
Scientific background

- Architectural survey – 3D scanning



3D scanning – collaboration with CPE/PEEX – generated surfaces from points cloud.

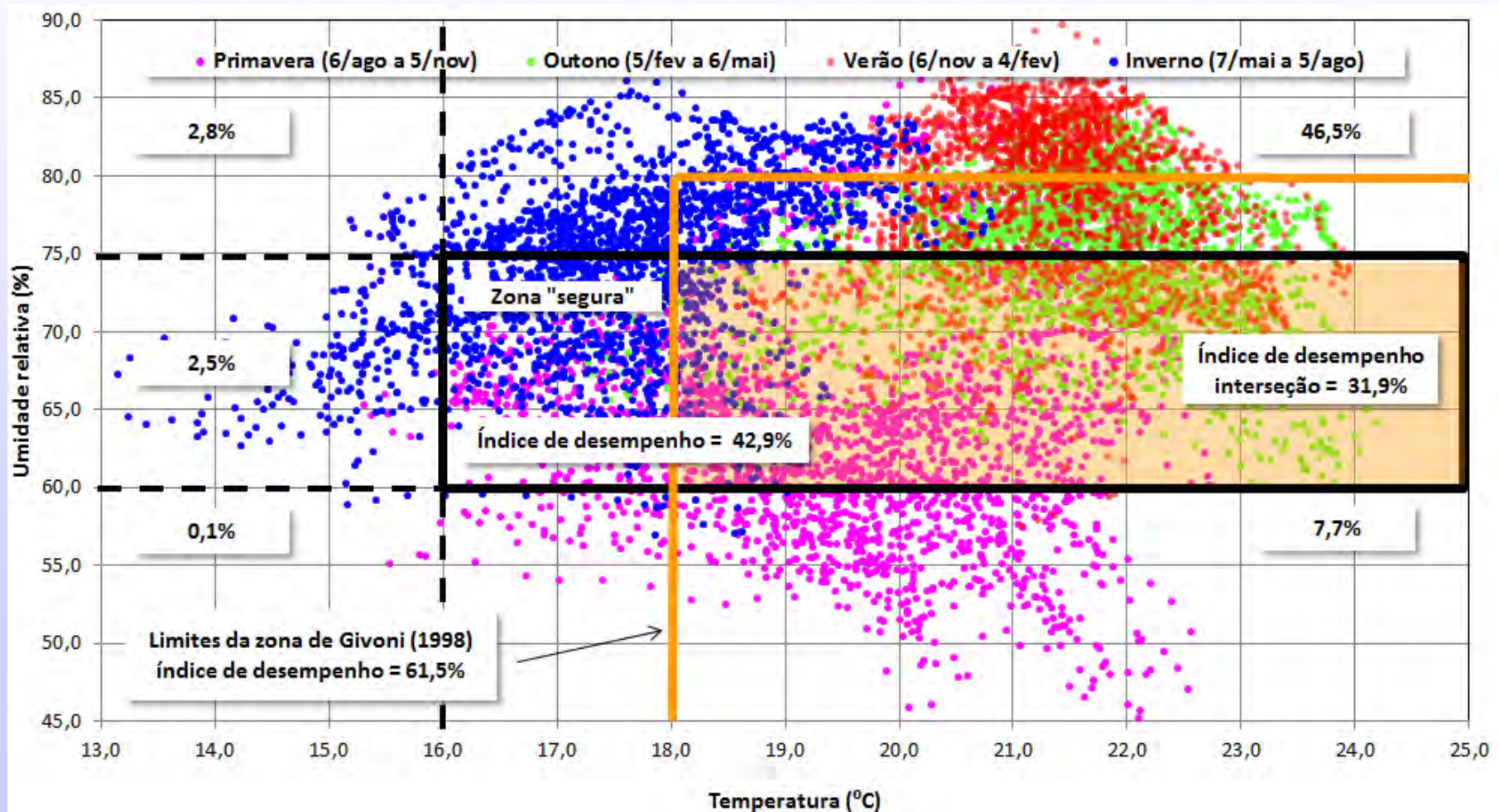




Wind tunnel tests – PIV measurements

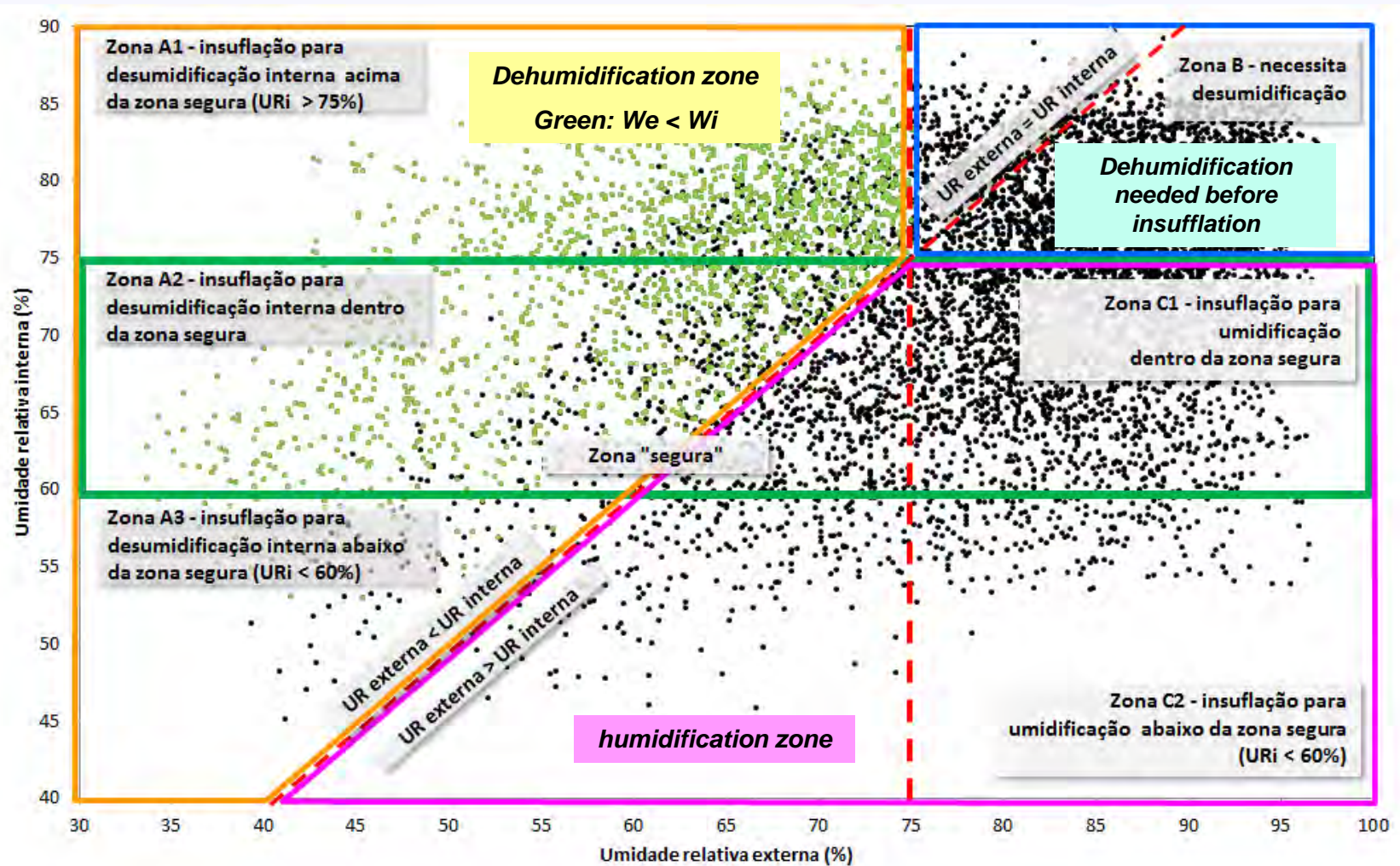
Preservation metrics – performance indices

Gonçalves, W.B. (2016). Interfaces e conflitos entre o conforto ambiental humano e a conservação preventiva do acervo em edifícios que abrigam coleções. *Museologia e patrimônio*. Vol. 9, n.2, p.10-27



Preservation metrics – performance indices

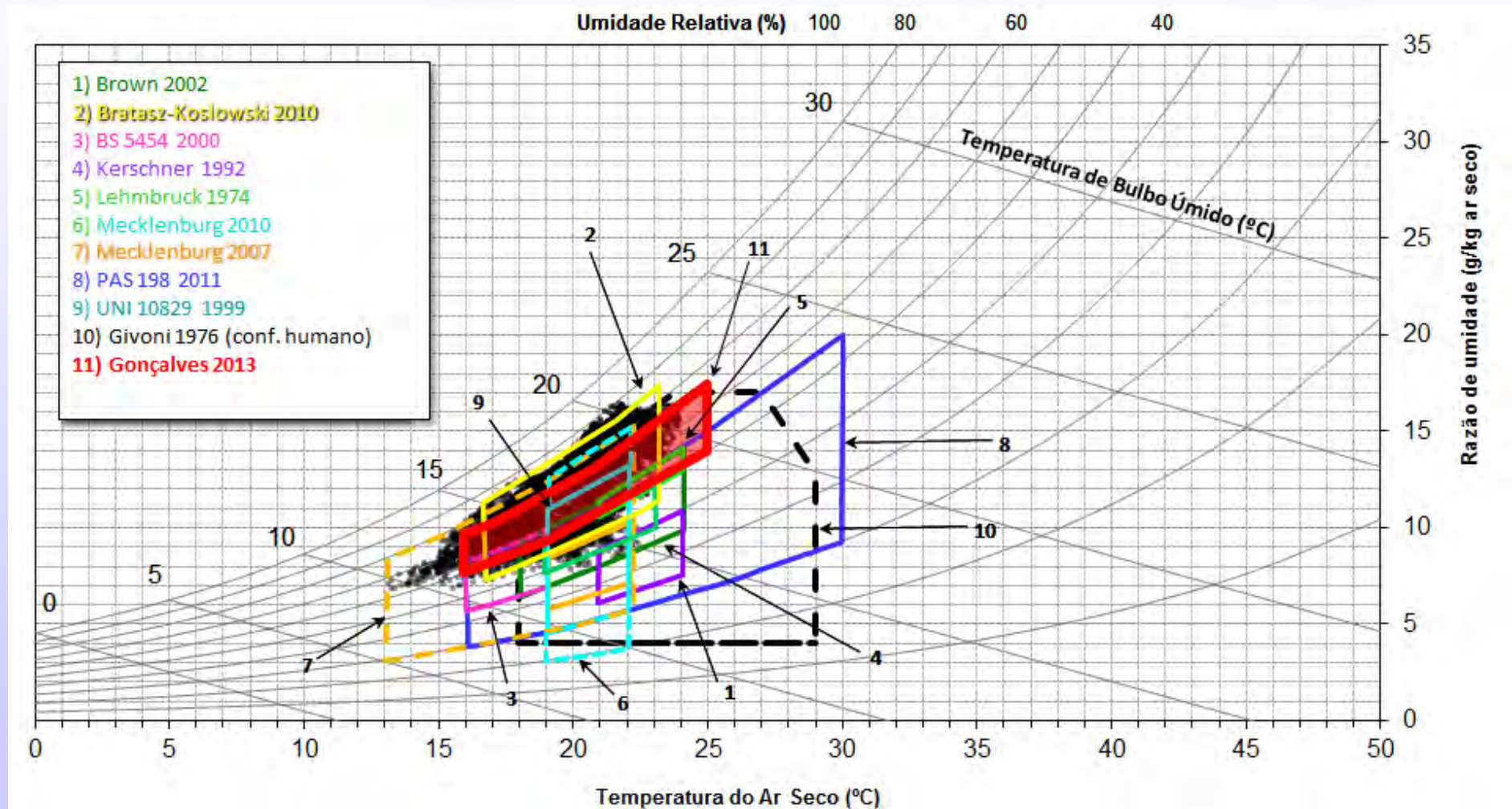
Gonçalves, W.B., Souza, L.A.C.(2013). Potencial de uso de ventilação natural ou forçada na conservação preventiva de bens culturais móveis estudo de caso. ENCAC 2013 proceedings, p. 925-934.



Performance indices: “safe” ranges / zones

- “Safe ranges” for various materials are abundantly found in technical literature;
- Usually they are obtained empirically and therefore, not universally valid;
- Indicated safe zones for generic materials like “wood”, “paper”, “stone” can be very variable;
- Methods for range / zone determination are often based on statistical analysis of monitored environmental data or laboratory experiments;
- Need for national Technical Standards;

Performance índices: “safe” ranges

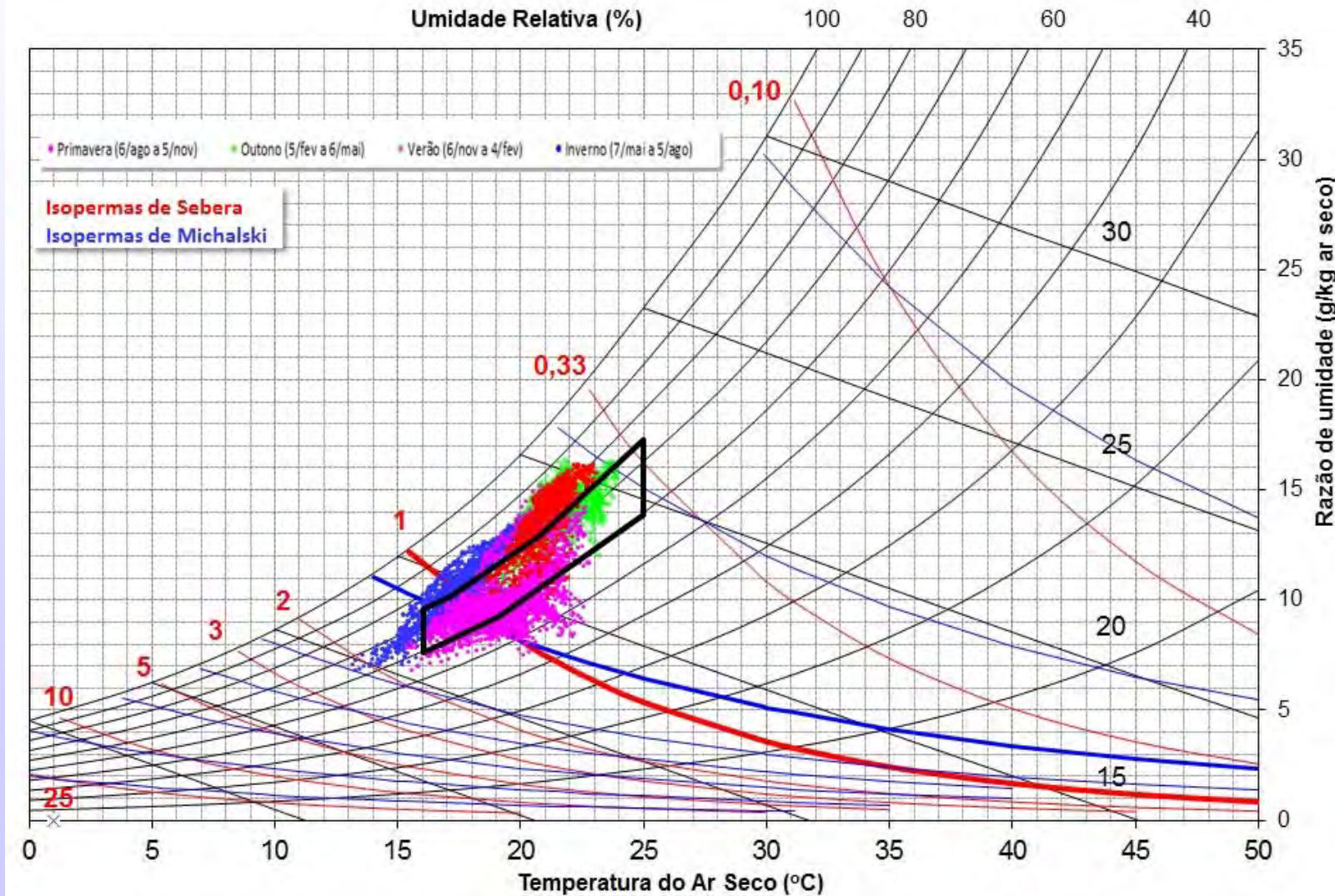


Comparing “safe” zones for collections with wooden objects. Gonçalves, (2013).

Preservation metrics - isoperms

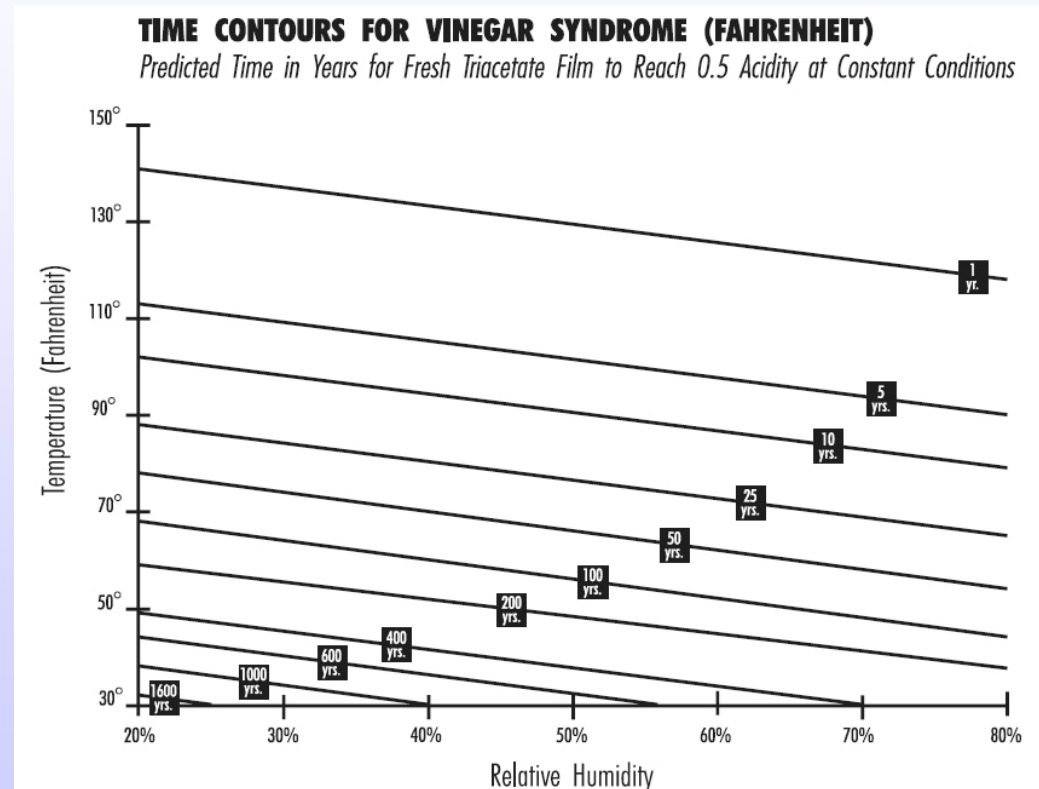
- Sebera (1988, 1994) – Brazil: CPBA Technical Leaflet #18
- Chemical deterioration of “most of papers” – activation energy for hydrolysis of cellulose
- Reference conditions: 20°C / 50% RH (isoperm 1)
- $\uparrow T, \uparrow RH \rightarrow \downarrow \text{permanence}, \uparrow \text{deterioration rate}$
- $\downarrow T, \downarrow UR \rightarrow \uparrow \text{permanence}, \downarrow \text{deterioration rate}$
- Rising in deterioration rate due to relative humidity rising can be compensated by lowering temperature and vice-versa.
- Use for comparisons: space x time;
- Michalski: *lifetime multipliers* (2002) – activation energy reviews;
- Strang and Grattan (2009) – sorption models reviews;
- Strlic (2013) – acidity reviews;

Preservation metrics - isoperms

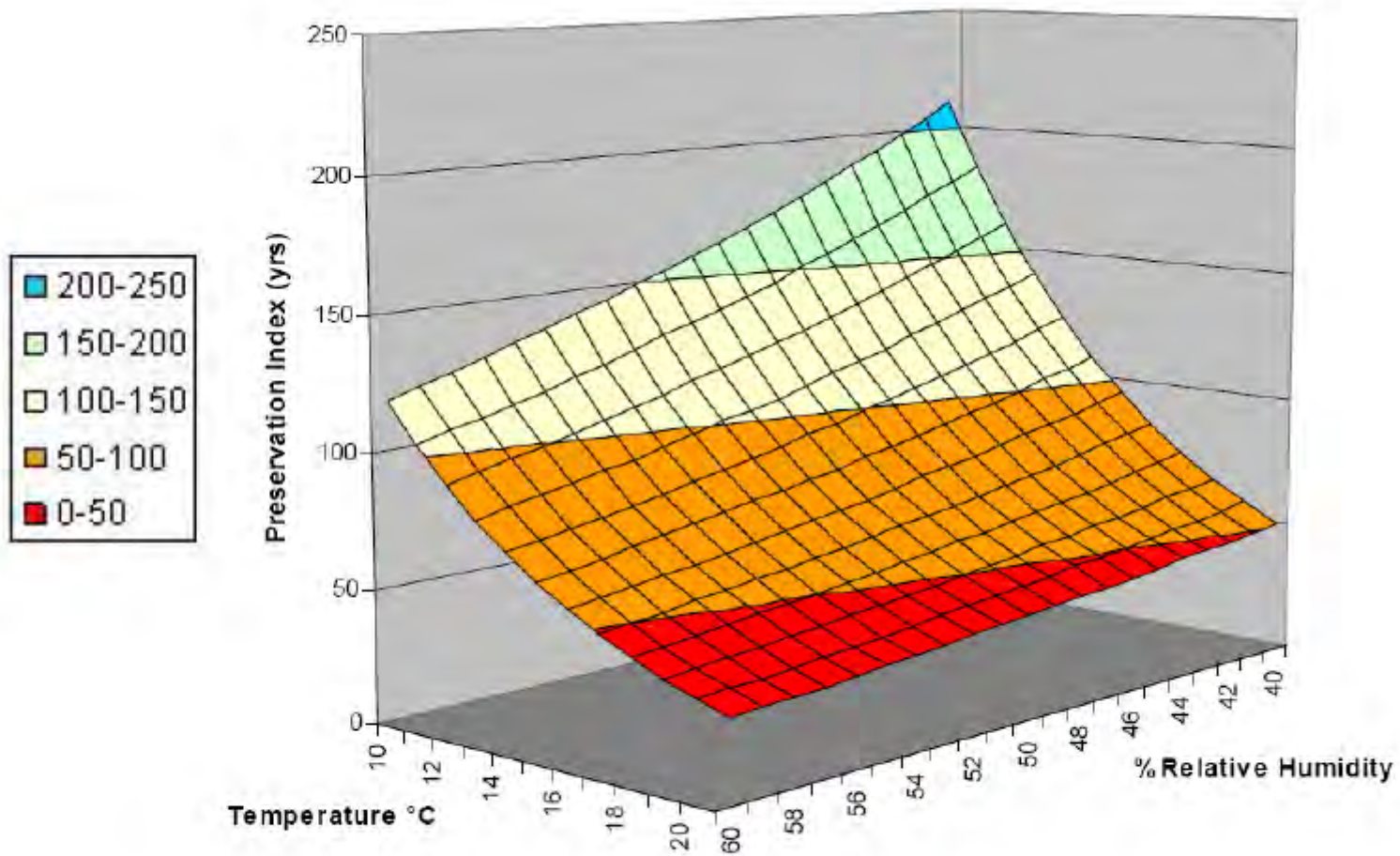


Preservation metrics – Preservation Index

- James Reilly (1993)
- Image Permanence Institute / Rochester Technical Institute
- A similar approach to isoperms;
- Activation energy for hydrolysis of cellulose acetate films
- Brazil: CPBA Technical Leaflet #19
- Life expectancy in years – **strictly for comparative purposes**
- Mathematical model not published - “Black box” software
- Revised by Padfield (2004) based on empirical data;
- Instantaneous x time-weighted;
- Used in Lacicor reports;



Preservation metrics – Preservation Index

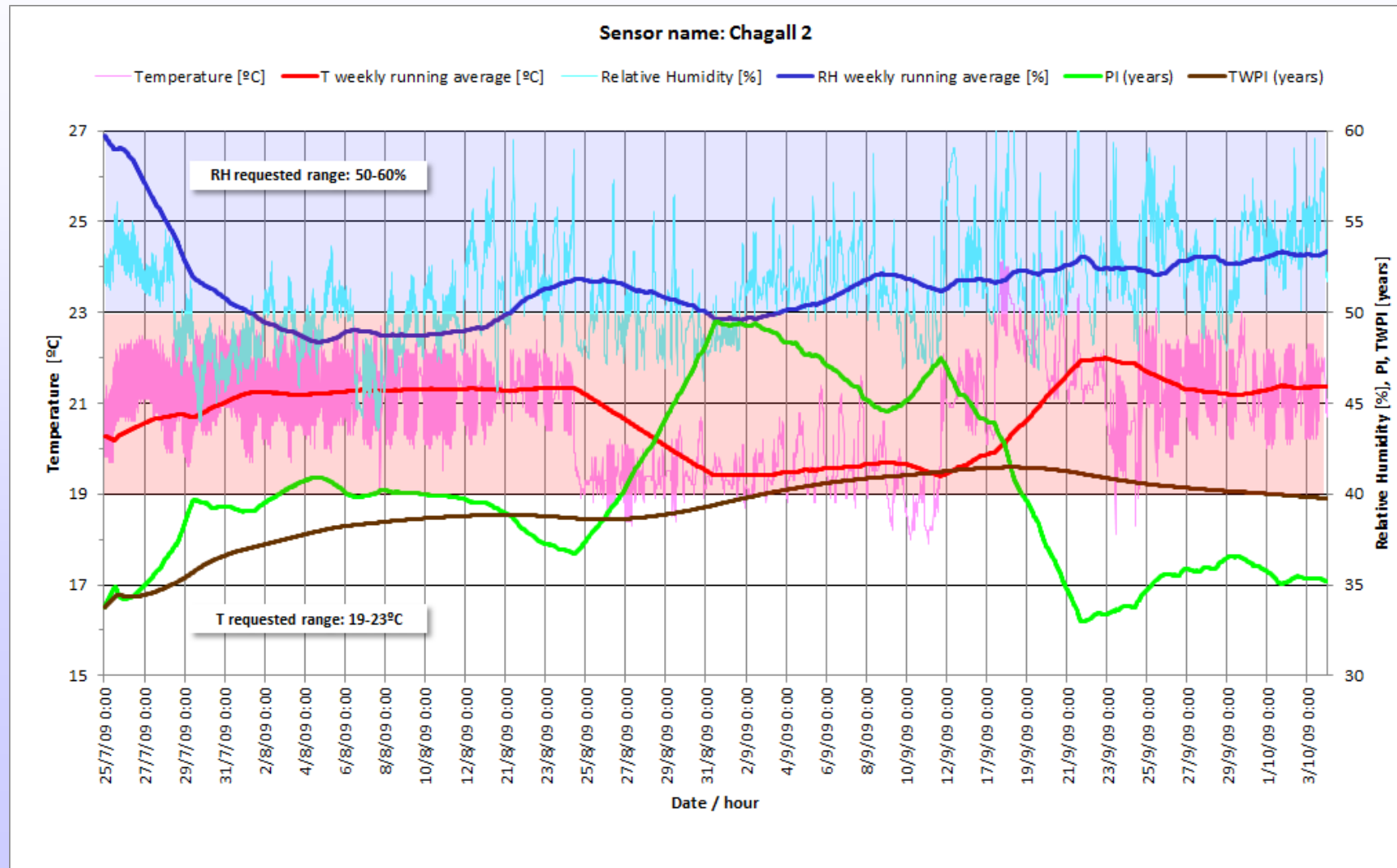


The effect of temperature and RH on the Preservation Index


Chagall (2009)



Chagall (2009)



Software packages delivering PI/TWPI



featuring PRESERVATION METRICS

EXISTING USERS +

USERNAME

PASSWORD (forgot)

Home
About
Tour
Pricing & Sign Up
Fundamentals
Resources
Support
PE/MZ
Contact

Take a tour of eClimateNotebook

Graphs
eCNB presents clear and accurate graphs of temperature, humidity, dew point and IPI's Preservation Metrics®

Analysis
eCNB provides unique and powerful data analysis features based on decades of preservation research

Information
Professional levels include a database to help you document, organize, and search information associated with each monitored location

Storage Planning
eCNB includes sophisticated management tools to help you provide the best collection stewardship possible

Note Manager
Improve communication about and documentation of activities that affect the storage environment

Data Manager
Easily upload, name, organize, and export data from a wide range of data sources

Reports
Automated reports designed to save time and improve communication

Analysis

Analyze the preservation quality of your storage environment and the risk of environmentally-induced decay

IPI Preservation Metrics®
These metrics provide automated analysis of environmentally-induced material decay and can help you accurately and objectively determine the preservation quality of each monitored location, compare one location to another, and document change over time

Use the metrics to help you identify:

- The rate of chemical decay in organic materials - Time-Weighted Preservation Index (TWPI)
- The risk of mold growth - Mold Risk Factor (MRF)
- The risk of mechanical damage due to extremes of dampness, dryness or fluctuations between the two - Equilibration Moisture Content (EMC Max and Min) and % of Dimensional Change (%DC)
- The risk of metal corrosion - Maximum Equilibration Moisture Content (EMC Max)

Risks & Metrics
An automatic overview of the risk of natural aging, mold growth, metal corrosion and mechanical damage for every monitored location

Statistics
Review numerical values, including the minimum, maximum, mean, and median values for each type of data. If you use temperature and RH limits eCNB will calculate the percentage of time spent above, below, and within the target range for each dataset.

Compare (Professional Level)
A detailed sortable table comparing risk ratings, metrics and statistics for data locations that you select. The bottom of the table provides an average of everything.

Pottery Storage

Risk Summary	
Natural Aging	OK
Mold Risk	GOOD
Metal Corrosion	OK
Mechanical Damage	RISK

Preservation Metrics	
TWPI	70
MRF	0
%EMC Max	7.2
	4.5
	0.78



Data Overview	
Start	2008-03-04
End	2008-06-10
T°F Mean	70.7
%RH Mean	28
DP°F Mean	35.6

Temperature		Relative Humidity	
T°F Mean	70.7	%RH Mean	28
T°F Median	70.5	%RH Median	29
T°F Min	69.3	%RH Min	17
T°F Max	76.1	%RH Max	47
T°F Stdev	0.6	%RH Stdev	8

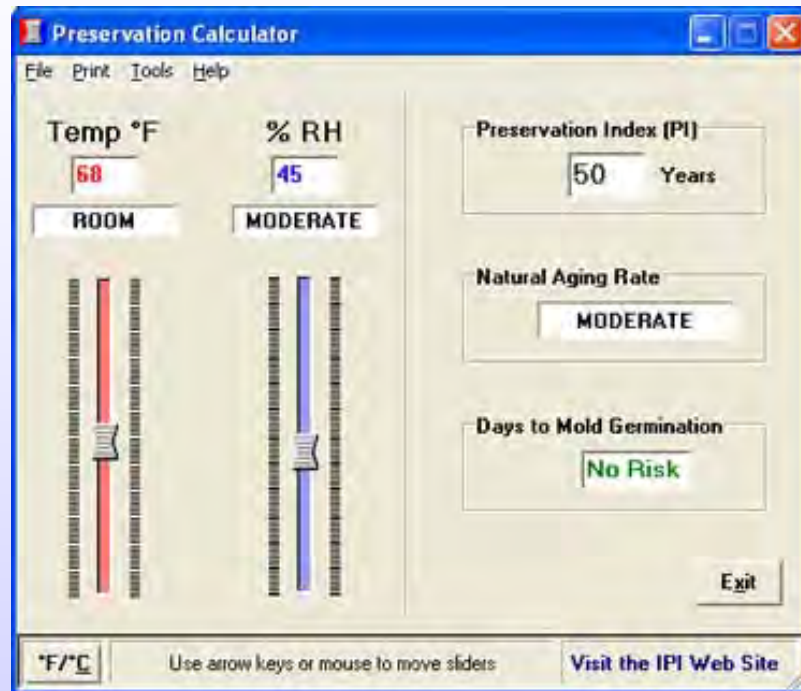
Location Dataset	Date Range	Natural Aging	Mechanical Damage	Metal Corrosion	Mold Risk	T°F	%RH	DP°F	TWPI	%DC Max	%DC Min	%EMC Max	MRF
Alabaster AL	2002-11-12 to 2012-03-30	RISK	RISK	RISK	RISK	62.9	72.7	52.6	22	2.22	11.4	19.3	27.54
History of Medicine	2005-03-04 to 2008-06-10	OK	RISK	OK	GOOD	70.7	28	35.6	70	0.78	4.5	7.2	0
Law	2008-03-10 to 2008-10-01	RISK	RISK	RISK	GOOD	71.3	46	47.9	30	2.04	4.8	13	0.03
Music Room	2002-11-12 to 2010-01-21	OK	RISK	OK	GOOD	72.5	35	42.6	65	1.58	4.3	10	0
Music Storage	2008-03-27 to 2008-12-30	RISK	RISK	RISK	RISK	68.5	56	51.4	35	1.81	8.3	14.8	1.41
Pottery Storage	2009-10-22 to 2012-02-23	RISK	OK	RISK	GOOD	70.5	50	50.5	33	1.35	6.9	11.8	0.15
Average (6 locations)						69.4	47.9	46.8	40.7	1.6	6.7	12.5	4.85

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eClimateNotebook® is a web-product created by the Image Permanence Institute, a non-profit preservation research lab devoted to the development and deployment of sustainable practices for the preservation of images and cultural property since 1985. The Image Permanence Institute is a department of the College of Imaging Arts and Sciences at Rochester Institute of Technology (RIT) in Rochester, NY, USA.

Software packages delivering PI/TWPI



Dew Point Calculator IMAGE · PERMANENCE · INSTITUTE

Home How to Use About

Welcome to the Dew Point Calculator

1. Use the sliders for Temperature, Relative Humidity (RH) and Dew Point to define an environment.

2. Observe the relationship of the three environmental variables. For example, as Temperature goes up, the RH goes down.

3. Notice the preservation consequences of different combinations of Temperature and RH in the Preservation Evaluation section.

Track Energy Savings!
With the PEM2 - IPI's newest electronic temperature and RH logger.
only \$349 (software included) Buy Now!

Click to solve for:
 Temperature % RH Dew Point

20 50 9

Temperature Scale: °F °C

Preservation Evaluation

Type of Decay	Environment Rating	Preservation Metric
Natural Aging	RISK	PI 44
Mechanical Damage	OK	% EMC 9.3
Mold Risk	GOOD	Days to Mold No Risk
Metal Corrosion	OK	% EMC 9.3

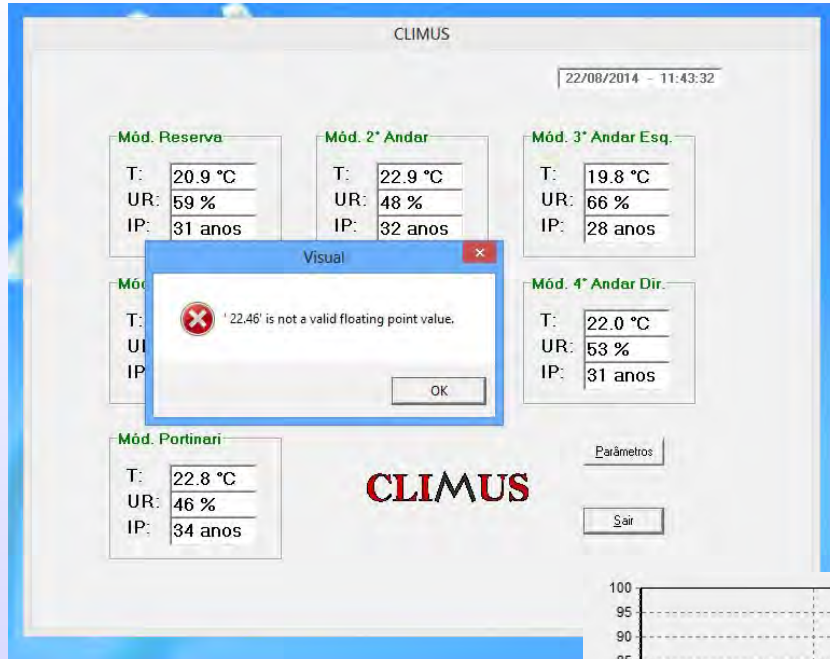
Record and Compare Values

T	RH	DP	PI	Days to Mold	EMC

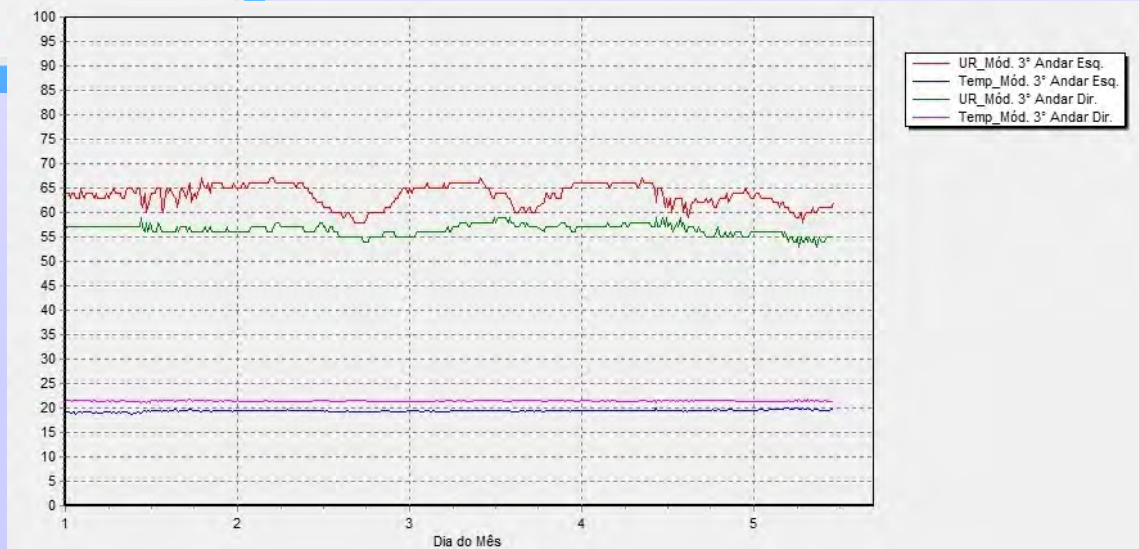
Save Clear Export

Image Permanence Institute
Rochester Institute of Technology | 70 Lomb Memorial Dr. Rochester, NY 14623-5604

Software packages delivering PI/TWPI



- CLIMUS
- Saulo Guths – UFSC
- WISE-MUSE
- Laura Peralta – Universidade da Madeira – Portugal
- Customization of common data acquisition packages



Software packages delivering PI/TWPI

MONITORAMENTO SALA

TERMOHIGRÔMETRO
TEMPERATURA
UMIDADE
(SALA MONITORADA)

MONITORAMENTO EXTERNO

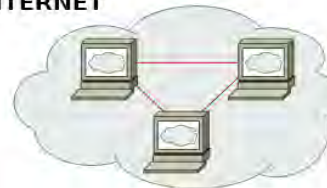
ESTAÇÃO METEOROLÓGICA:
TEMPERATURA, UMIDADE,
VENTO, RAIOS, CHUVA
NEBULOSIDADE
(AMBIENTE EXTERNO)

PREVISÃO DO TEMPO

PREVISÃO METEOROLÓGICA:
TEMPERATURA, UMIDADE
VENTO, RAIOS, CHUVA
NEBULOSIDADE
(AMBIENTE EXTERNO)



INTERNET



AÇÕES

AÇÕES:
ABRIR JANELAS,
FECHAR PORTAS,
ACIONAR
DESUMIDIFICADOR

DIAGNÓSTICO

DIAGNÓSTICO:
FUNGO,
CRAQUELE,
PERMANÊNCIA DO
PAPEL,
TRANSPORTE

ALERTAS

ALERTAS VIA
EMAIL/PAINEL:
CHUVA,
RAIOS, VENDEVAL
ELEVAÇÃO DE
TEMPERATURA
OU UMIDADE

ACESSIBILIDADE:



- CONCLIMA
- Antonio Oliveira - MNBA

Software packages delivering PI/TWPI

Índice de Permanência - Ip Transporte Fungo Craquelê ANA-Desumidificação VOLTAGE

Análise de temperatura e umidade

Ambiente	BIBLIOTECA
Temperatura do ar	25.00oC
Temperatura do orvalho	16.16oC
Amplitude condensação	8.84oC
Umidade absoluta	13.35g/m3
Umidade relativa	58.00%
Índice de permanência IP:	0.4755
Permanência em anos:	21.40
Sem condições de condensação	

Análise : TRANSPORTE

Ambiente [Fonte]	RESERVA
Temperatura do ar [Fonte]	24.00oC
Temperatura do orvalho [Fonte]	14.12oC
Umidade absoluta [Fonte]	11.75g/m3
Umidade relativa [Fonte]	54.00%
Ambiente [Destino]	GALERIA
Temperatura do ar [Destino]	27.00oC
Temperatura do orvalho [Destino]	19.86oC
Umidade absoluta [Destino]	18.38g/m3
Umidade relativa [Destino]	65.00%
Sem probabilidade de condensação no ambiente fonte	
Sem probabilidade de condensação no ambiente destino	
Sem condições de condensação no transporte	

Análise de fungo

Ambiente	RESERVA
Temperatura do ar	23.00oC
Umidade relativa	68.00%
Umidade de ativação:	70.5%
Sem probabilidade de fungo no ambiente	

- CONCLIMA
- Antonio Oliveira - MNBA

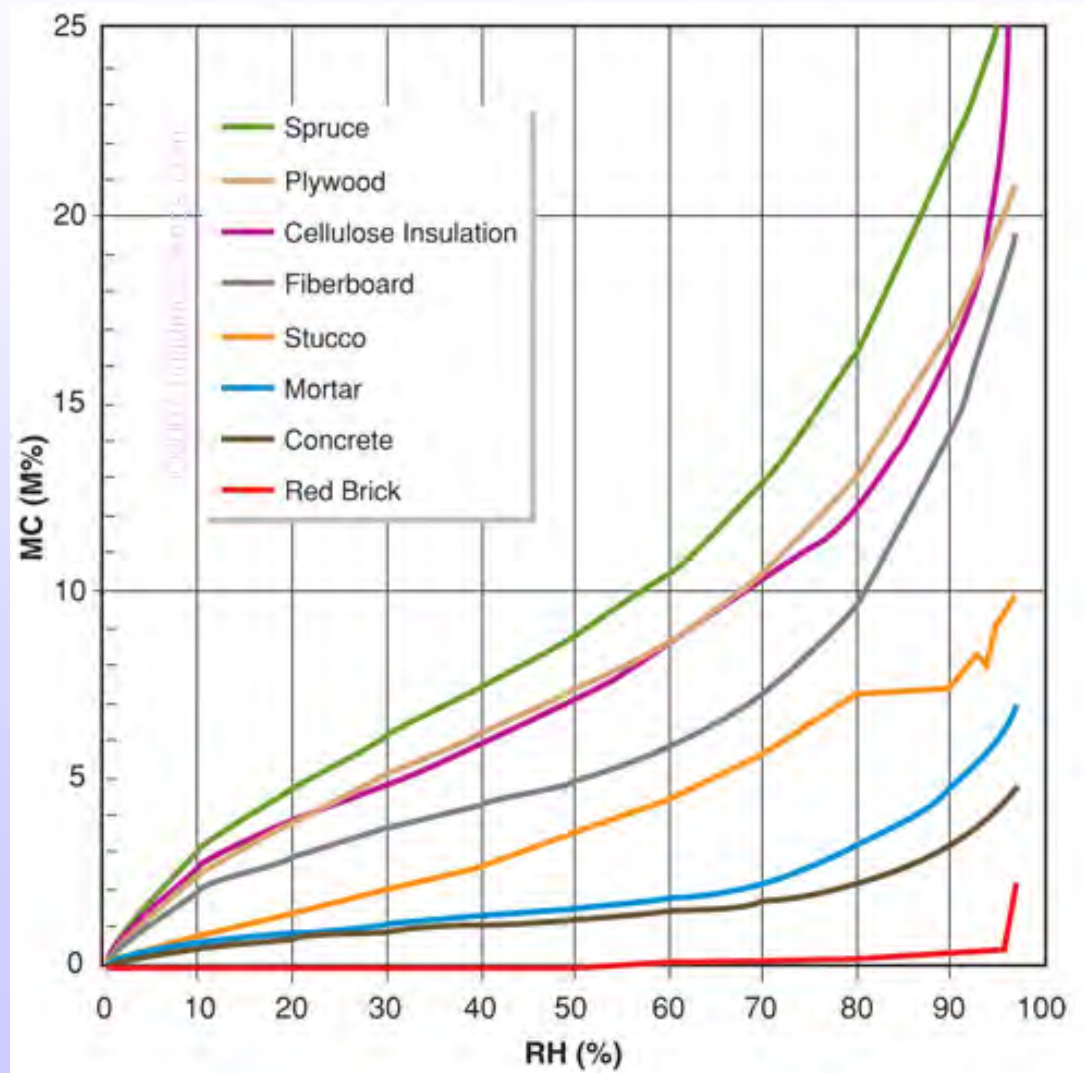
Análise Craquelê

Ambiente	RESERVA
Amplitude Térmica	5.00oC
Amplitude de Umidade absoluta	10.33g/m3
Amplitude de Umidade relativa	27.00%
Grande Probabilidade de craquelê!	

Análise de desumidificação

Ambiente	GALERIA
Volume m3	200
Água total em suspensão	2992 ml
Água a ser desumidificada	1264 ml

Preservation metrics – EMC, Dimensional Change



Preservation metrics – EMC, Dimensional Change

Wood and wooden structures 81

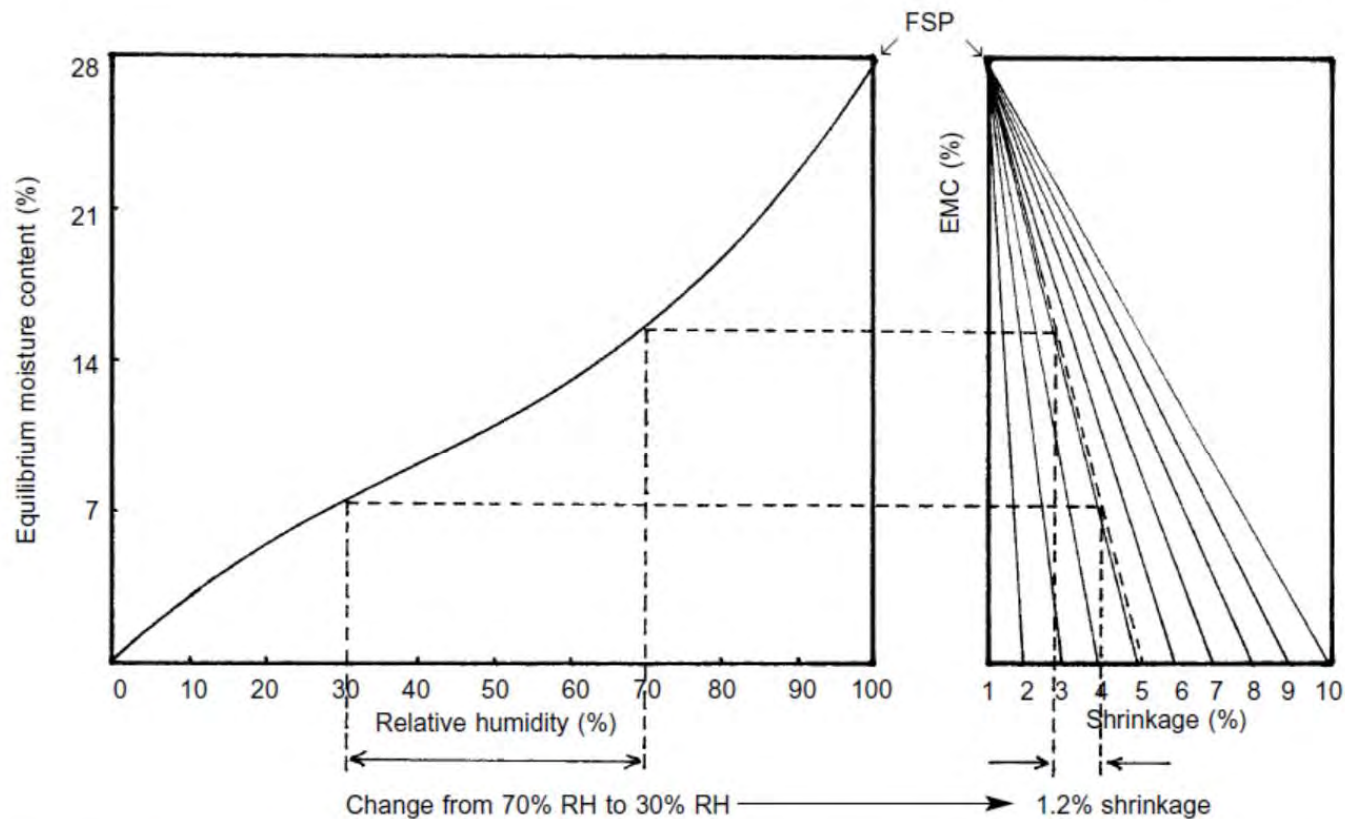
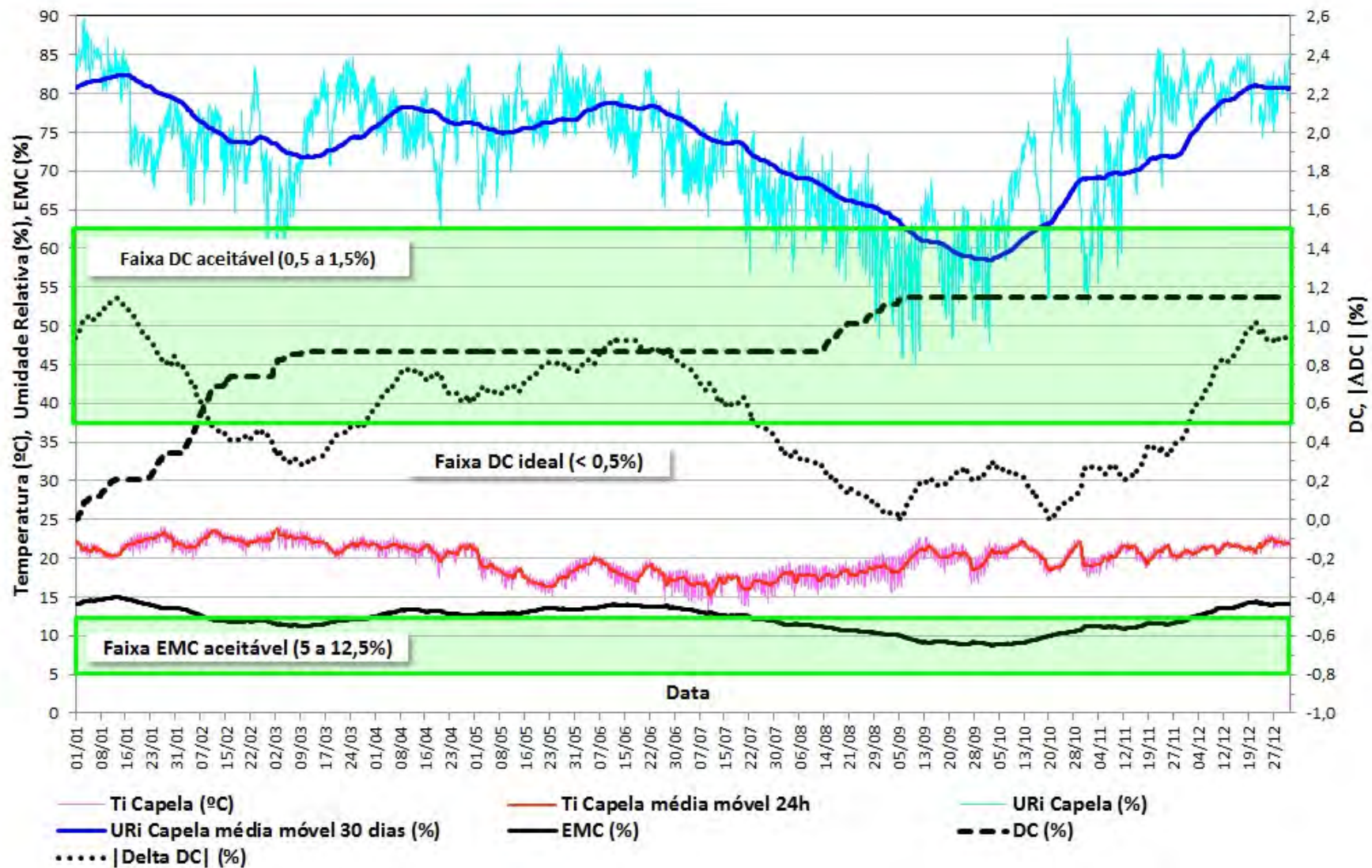


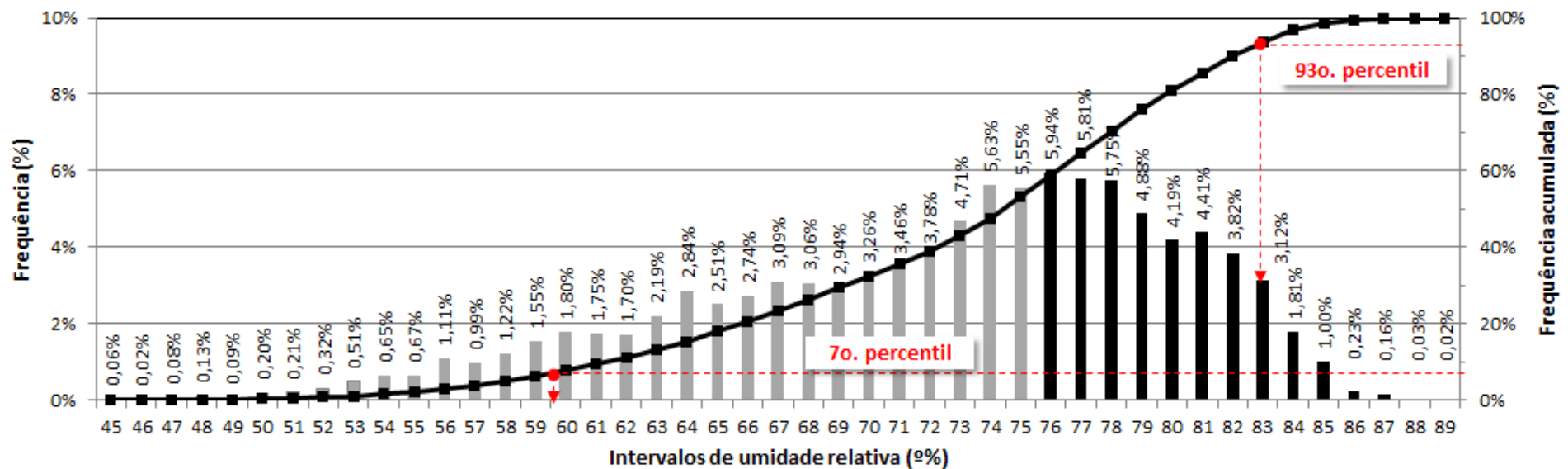
Figure 2.18 The relationship between relative humidity, equilibrium moisture content and shrinkage. Choose shrinkage according to species and growth ring orientation, for example, 5.1% for a tangentially sawn mahogany board (shown as a dotted line on the graph on the right). In this case a change from 70% RH to 30% RH will cause 1.2% shrinkage. In a board one metre wide, this produces 12 mm of shrinkage

Preservation metrics – EMC, Dimensional Change



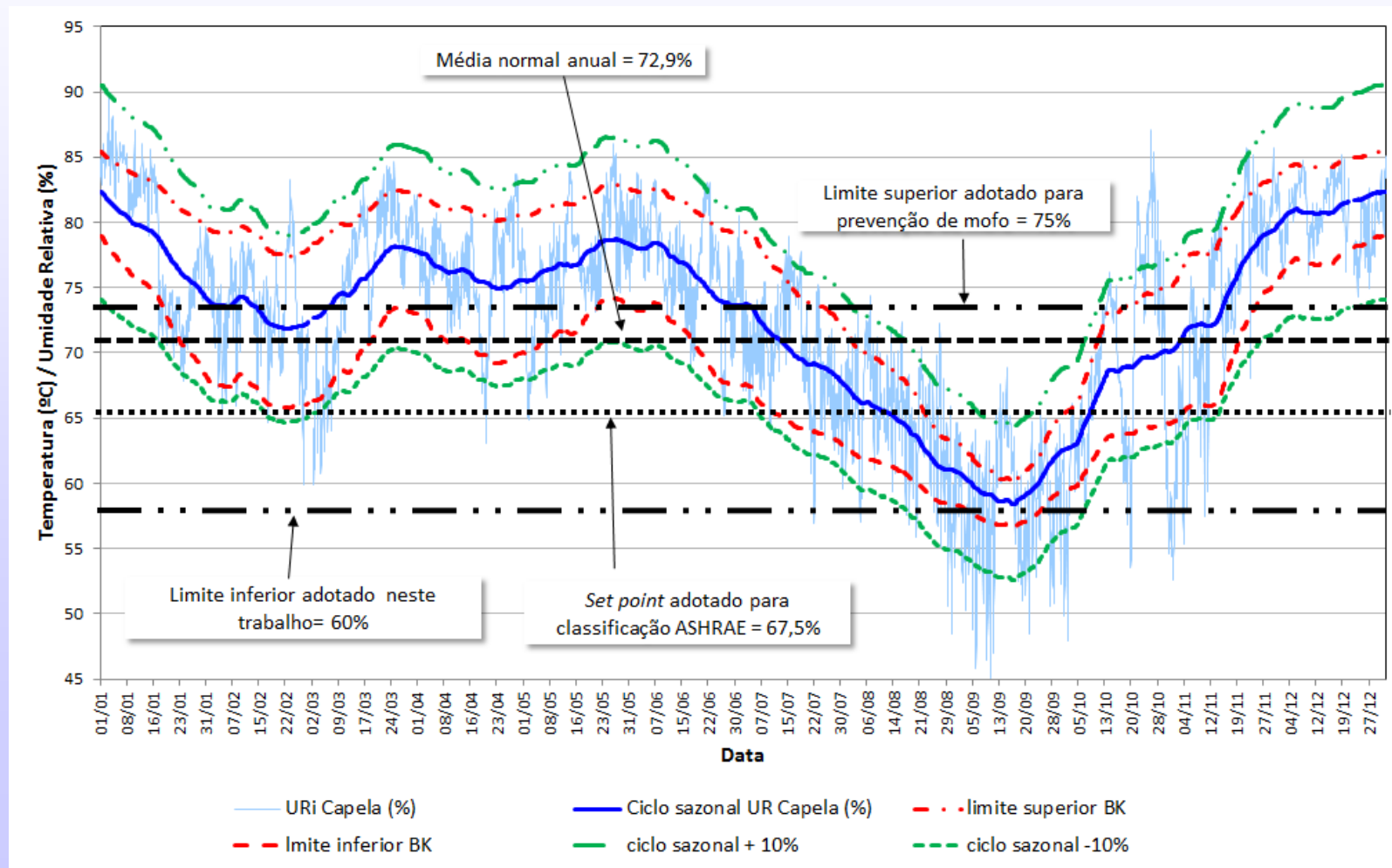
Preservation metrics – “safe” range for RH fluctuations

- Michalski’s “proofed” fluctuation concept
- Statistical analysis for determination of “extremes”
- EN 15757 – 7th to 93th percentiles in frequency distribution



Preservation metrics – RH fluctuations

- Example of safe limits for RH fluctuations, by Bratasz-Kozlowski method



ASHRAE classification of fluctuations In controlled spaces

What Best Describes Your Collection?¹

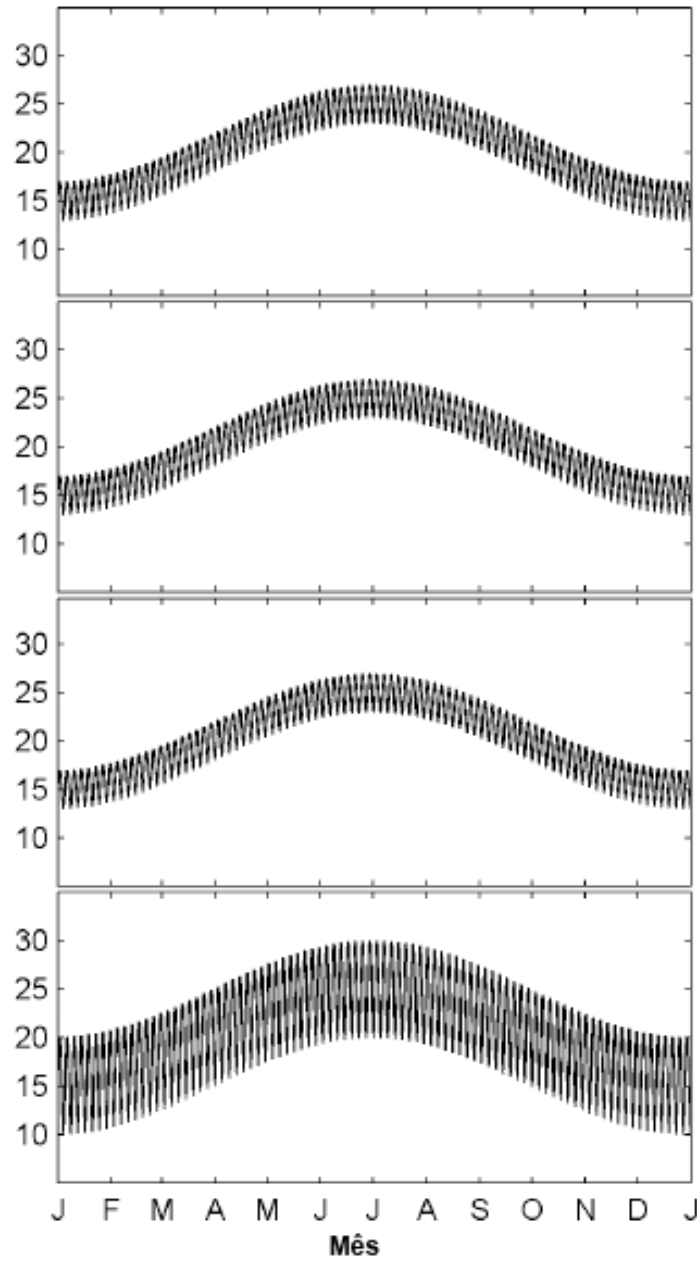
Collection Type: General museums, art galleries, libraries, and archives (all reading and retrieval rooms, rooms for storage of chemically stable collections, especially if mechanically medium to high vulnerability)

Set point: 50% RH with the temperature between 15 and 25°C

Maximum fluctuations and gradients in controlled spaces		Class of control
Short-term* fluctuations and space gradients	Seasonal adjustments in system set point	
±5% RH ±2°C	RH no change. Up 5°C and down 5°C.	AA Precision control, minimal seasonal changes to temperature only.
±5% RH ±2°C	Up 10% RH and down 10% RH. Up 5°C and down 10°C.	A Good control, some gradients or seasonal changes.
±10% RH ±2°C	RH no change. Up 5°C and down 10°C.	A Good control, seasonal change to temperature only.
±10% RH ±5°C	Up 10% RH and down 10% RH. Up 10°C (but not above 30°C) and down as low as necessary to maintain RH control.	B Control, some gradients plus winter temperature setback.
Within range 25–75% RH year-round. Rarely over 30°C, usually below 25°C.		C Prevent all high risk extremes.
Reliably below 75% RH.		D Prevent damp.

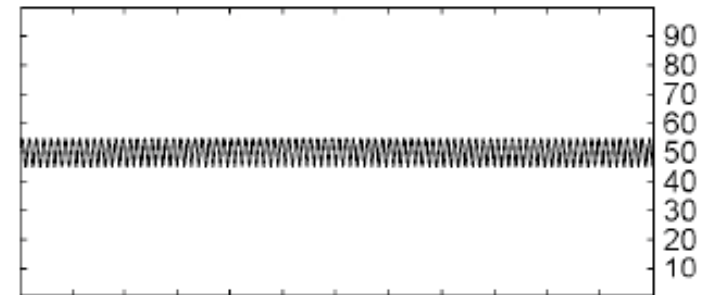
*Short-term fluctuations are any fluctuations less than the seasonal adjustment; however, some fluctuations are too short to affect some less-sensitive artifacts and those that are enclosed.

Temperatura [°C]

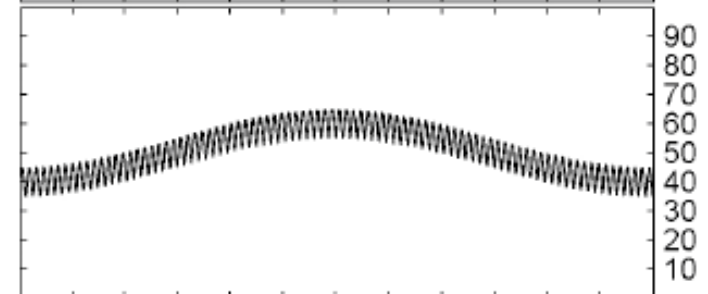


Umidade Relativa [%]

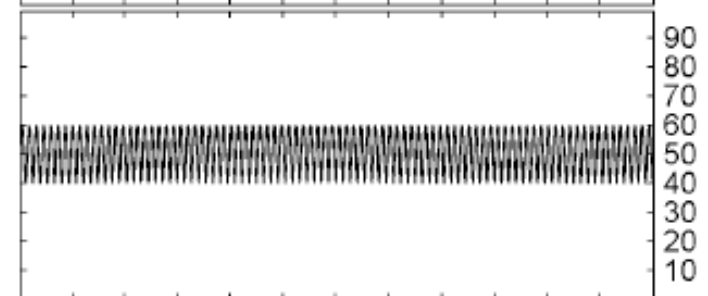
AA



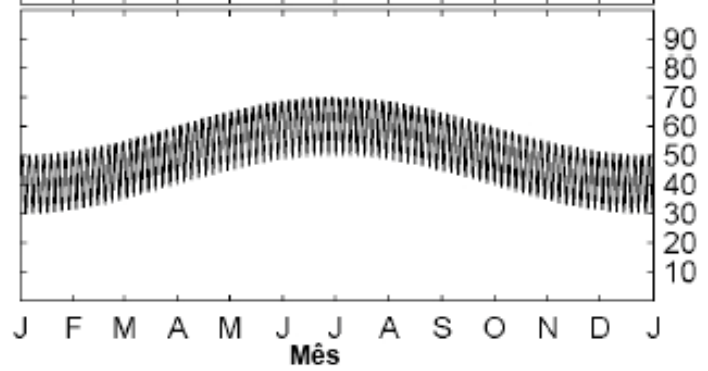
A1



A2



B



Preservation metrics – RH fluctuations

Ar condicionado com defeito ameaça obras na Galeria Borghese, em Roma

14 de maio de 2014

Problemas no sistema de ar condicionado na Galeria Borghese, em Roma, com valores inestimáveis de obras de arte, já ocorre redução de custos na manutenção dos equipamentos consertados.

Entre os quadros que foram danificados por conta do problema estão, "O Santo Entenamorado" (1514), "Santa Ana" (1605), de Ticiano (1475), de Antonello di Rubens.

A galeria é uma das mais importantes do país, que recebe cerca de 1 milhão de visitantes por ano. Mas para tentar amenizar o problema, a direção decidiu manter as portas abertas. Mas para a conservação e restauração, o problema pode gerar danos químicos e biológicos.

A diretora da galeria, Anna Coliva disse já que a substituição do equipamento há alguns anos, mas até agora nada foi resolvido. "O sistema de ar condicionado, construído em 1997, está completamente degradado e danificado devido aos anos de crônica falta de manutenção", afirma Coliva.

Museu abre as janelas e põe obras de Rubens, Ticiano e Caravaggio em risco

CLÁUDIA LIMA CARVALHO 12
Galeria Borghese, em Roma, com umidade e à poluição



Paolina Borghese, escultura de

1 / 2

Sem ar condicionado, Biblioteca Nacional funciona com horário reduzido

21 de janeiro de 2013

Gosto 9 Tweet 1

Com ar-condicionado quebrado após apagão, Masp fecha as portas

Museu não funcionou nesta sexta (13), mas abrirá no sábado (14). Entidade diz que cobrará prejuízo de responsável por blecaute.

Do G1, em São Paulo

Tamanho da letra

A- A+

clique para ampliar



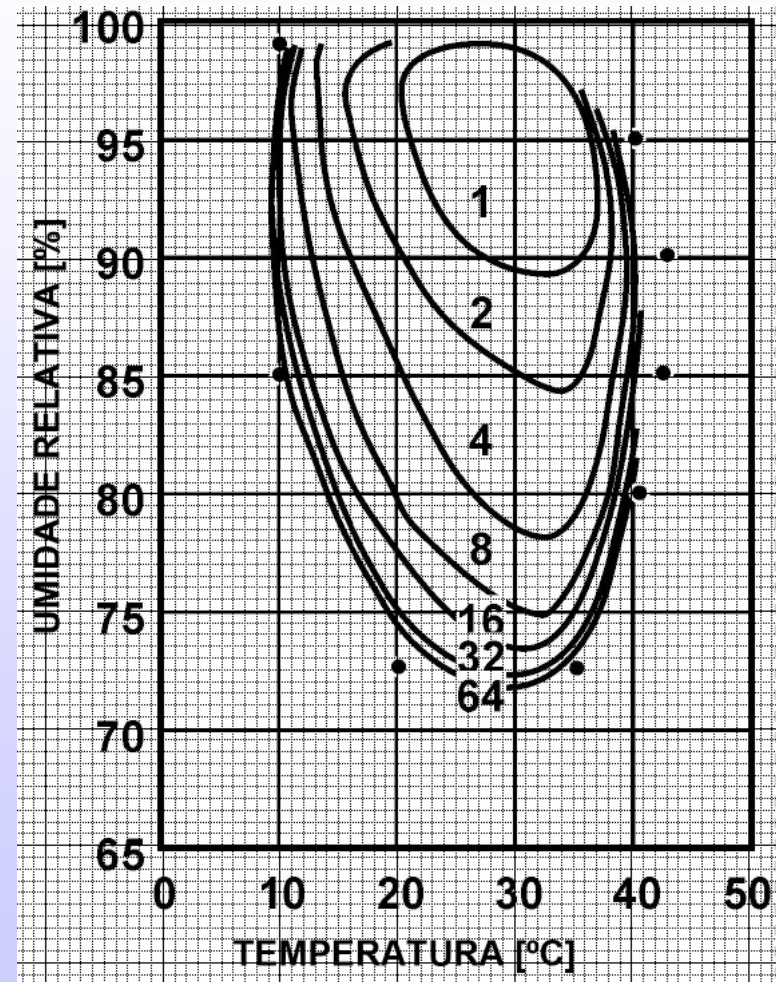
Imagem aérea do museu (Foto: Divulgação)

O Museu de Arte de São Paulo (Masp) está fechado para visitação nesta sexta-feira (13) devido a um problema no sistema de ar-condicionado, que, segundo o museu, foi danificado durante o apagão que atingiu vários estados brasileiros na noite de terça-feira (10). O Masp deve reabrir somente no sábado (14), a partir das 11h.

Segundo a assessoria de imprensa do museu, o local funcionou na quarta-feira (11) e na quinta-feira (12), sem cobrar entrada, por causa do defeito do ar-condicionado. Na quinta, o museu fechou mais cedo, às 16h, devido ao problema de manutenção do sistema de climatização.

Preservation metrics – biological attack

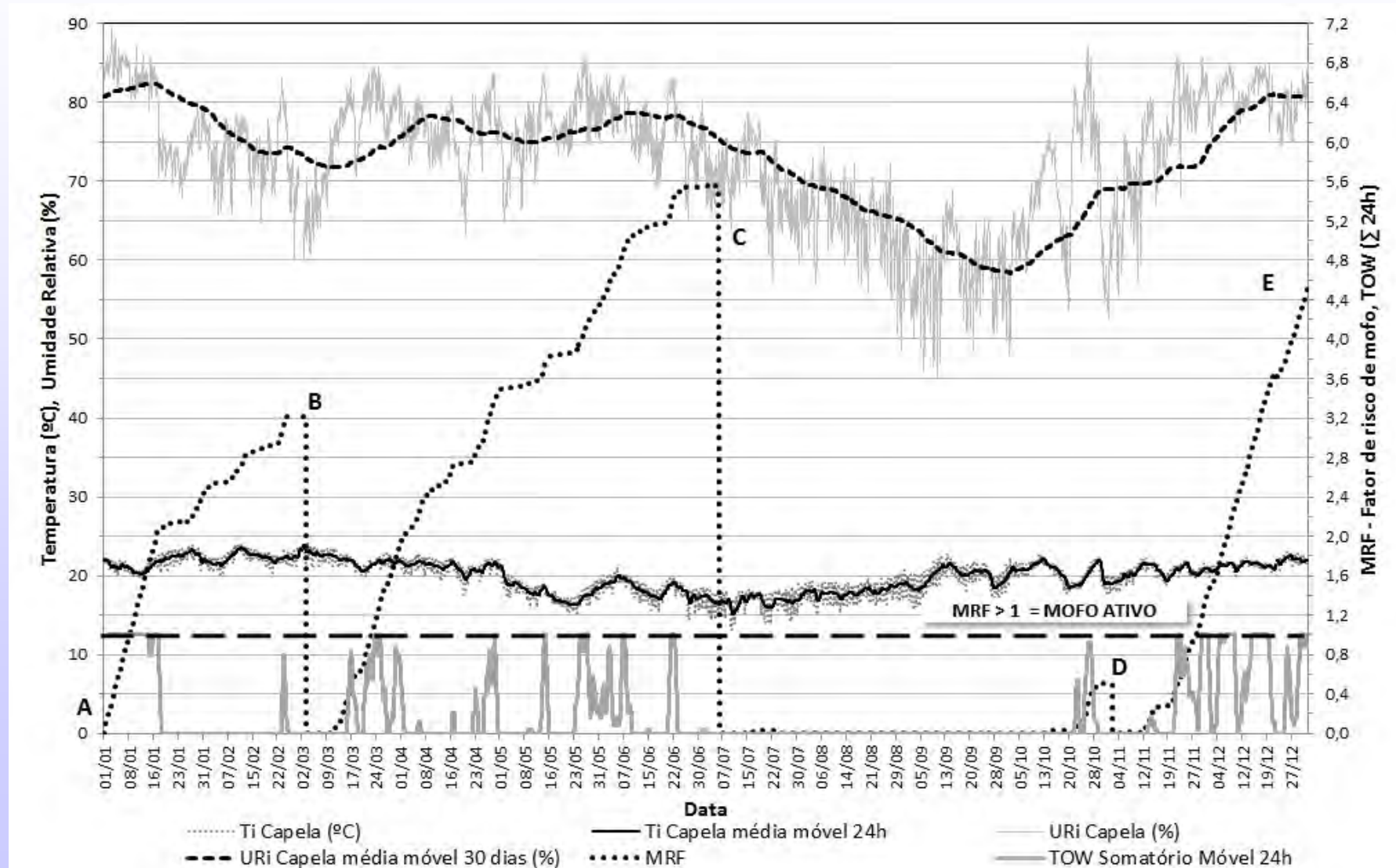
- Empirical models: isopleths
- Mould Risk Factor = time fraction for germination
- TOW = time of witness = time fraction with $RH > 80\%$ within last 24h



Preservation metrics – biological attack

Modelo / autor	Umidade relativa crítica (%)	Observações
Johansson, S. (2010)	80 a 95	Variável em função da temperatura
Johansson, P. (2012)	75 a 95	Variável em função da temperatura
IPI / Reilly / Nishimura	65 a 95	
ASHRAE / Michalski	70 a 90% (isopletas) 75% nas classes de controle C e D (vide Quadro 2)	70% corresponde a um tempo de germinação de 100 dias, 90% a 3 dias. Para um tempo de germinação longo (1000 dias) é considerada uma UR crítica de 60%.
TOW / Adan	80	
VTT / Viitanen	80 a ~95	Variável em função da temperatura
Ayerst / Moon e Augenbroe	70	Variável em função da temperatura
ESP-r / Clarke	~75 a 85	Variável em função da temperatura
Sedlbauer / Krus	~70 a 90	Variável em função da temperatura e do substrato

Preservation metrics – biological attack



Environmental management: temporary exhibitions

- (1) "The magical world of Marc Chagall: the dream and the life" (2009);
- (2) Rodin: from the workshop towards the museum" (2009 - remake of an exhibition shown in Musée Rodin, in Paris in late 2007 and early 2008);
- (3) "Tarsila and Brazil by modernists" (2010);
- (4) "To see and to be seen – human figure from Renaissance to Contemporary" (2010);
- (5) "Caravaggio and his followers" (2012);
- (6) "De Chirico: the feeling of Architecture" (2012).
- (7) "Baroque silver and gold at Fiat House of Culture" (2014).
- (8) "Masters of Renaissance: Italian masterpieces" (2013);

Environmental management: temporary exhibitions

- **Methodology:**
- Monitoring of external and internal T/RH, 15/15 min.;
- Real-time online data access (2012);
- Weekly reports: Occurrences, descriptive statistics, preservation metrics (PI and TWPI calculated using algorithms by PADFIELD), data analysis and recommendations;
- Intermediation / orientation for organizing board, engineers responsible for HVAC operation and the conservation team.

Environmental management: temporary exhibitions

1 LOCALIZAÇÃO DOS SENSORES

Na exposição "Caravaggio" foram instalados quatro registradores da marca T&D modelo RTR-53 (em amarelo na figura 1), que transmitem via rádio para uma central receptora da mesma marca, modelo RTR-57U. Um deles foi colocado no interior da vitrine da "Medusa", em 21/6. Como backup de segurança instalamos junto aos sensores da sala mais três registradores da marca Onset, modelo Hobo U10-003 (em verde na figura 1). A figura 1 abaixo mostra a localização dos sensores na sala. Foi ainda instalado um sensor externo, da marca T&D modelo RTR-53.

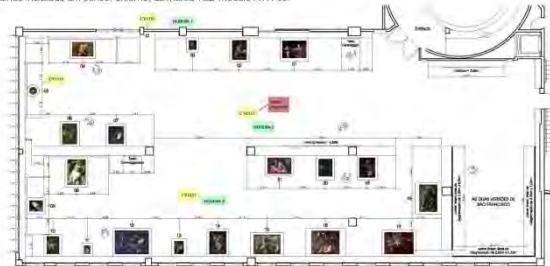


Figura 1 – Localização dos sensores na exposição "Caravaggio e seus seguidores"

2 OCORRÊNCIAS

No dia 16/7 ocorreu desligamento do sistema de monitoramento, sem perda de dados, demandando, entretanto, o deslocamento até a Casa Fiat para verificação e religação do computador.

Reforçamos o pedido anteriormente enviado para que a Engescom envie relatório formal sobre as intervenções realizadas no sistema em 19/6 e 30/6.

Tabela 1: Estatísticas descritivas das medições no período analisado

temperatura						umidade relativa					
temp. média normal (°C)	variação (desvio padrão) (°C)	temp. média dos máximos (°C)	temp. média dos mínimos (°C)	temp. máxima absoluta (°C)	temp. mínima absoluta (°C)	U.R. média normal (%)	variação (desvio padrão) (%)	U.R. média dos máximos (%)	U.R. média dos mínimos (%)	U.R. máxima absoluta (%)	U.R. mínima absoluta (%)
18,6	1,9	22,2	15,9	24,0	14,1	54,5	3,9	78,5	46,8	94,0	36,0
20,1	0,7	23,8	19,2	22,2	18,8	51,1	0,7	52,3	50,0	54,0	49,0
19,9	0,7	21,4	19,6	21,9	18,3	51,9	2,5	56,2	45,8	57,0	44,0
20,5	1,0	22,8	19,1	23,5	18,8	49,8	8,1	55,0	44,0	50,0	42,0
20,3	0,9	21,7	18,0	22,3	16,4	51,7	2,5	55,8	46,7	57,0	44,0
20,2	0,9	21,8	18,8	22,6	18,5	51,4	2,7	56,7	45,5	56,7	43,3

T média Sala CARAVAGGIO = 20,2 ± 0,9°C

UR média Sala CARAVAGGIO = 51,1 ± 2,7%

enta as estatísticas descritivas das variáveis medidas, calculadas para o período de 11 a 16 de julho de

"Caravaggio", a média semanal normal da temperatura, foi de 20,2 ± 0,9°C, atendendo à meta 0°C. A temperatura, na maior parte do tempo permaneceu dentro da faixa requisitada (19-21°C), de comprovar pelo gráfico 2 abaixo. Continuamos a observar o mesmo padrão das semanas elevações no período diurno, durante a visitação, com máximas absolutas cerca de até 1°C acima da.

de umidade relativa foi de 51,1 ± 2,7%, atendendo à meta requisitada (52,5%). Entretanto, serva no gráfico 2 abaixo, durante o período analisado, a tendência de queda da umidade relativa em que a temperatura se eleva, ocorreu de forma mais pronunciada e prolongada. A umidade de 30% do período analisado abaixo da faixa requisitada. A média das mínimas no período foi de

ss média de temperatura foi 20,1 ± 0,7°C, atendendo à meta requisitada e as flutuações nessa nharam as flutuações no interior da sala, conforme se pode observar nos gráficos 2 e 3 abaixo. A fe relativa 51,3 ± 0,7%, atendendo à meta requisitada (52,5%). Dentro da vitrine observou-se uma ral nas médias de umidade relativa, com flutuações desprezíveis e permanecendo dentro da faixa 5%) durante quase todo o período analisado.

Gráfico 2 – Médias normal de temperatura e umidade relativa na exposição "Caravaggio e seus seguidores"

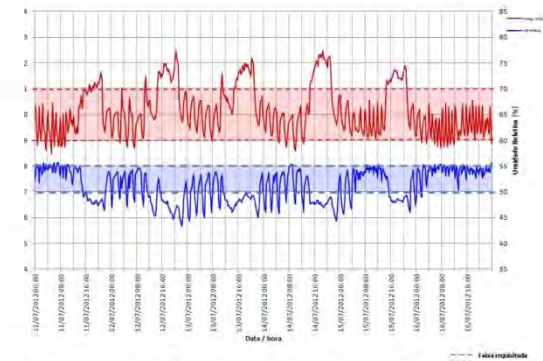


Gráfico 2 mostra a média dos valores simultaneamente medidos pelos três registradores na sala Caravaggio.

orme vimos apontando nos relatórios anteriores, continuamos observando um padrão de elevações da eratura durante o período diurno e de visitação, atingindo temperaturas máximas absolutas diárias de cerca de acima da faixa requisitada, regime que pode ser considerado satisfatório em relação às exigências dos restadores. A média das temperaturas máximas foi 21,9°C e a das máximas absolutas foi 22,6°C. A maior ma absoluta foi 23,5°C, observada no sensor CV1532. A média semanal normal da temperatura foi de 20,2 ± C, atendendo a meta de 20°C.

horários em que a temperatura se eleva observou-se uma piora com relação à ocorrência das mínimas diárias midade relativa, comparando-se com o período anterior. Nesta semana as quedas foram mais prolongadas, e a lade ficou cerca de 30% do tempo abaixo da faixa requisitada. A média das mínimas foi 45,5% e a das mínimas ludes 43,3%. A menor mínima absoluta foi 42%, observada no sensor CV1532. A média semanal normal de lade relativa foi 51,1 ± 2,7%, próxima da meta (52,5%).

condição pode estar sendo determinada por um número maior de visitantes, em função da aproximação do da exposição, bem como por uma maior frequência de abertura da porta.

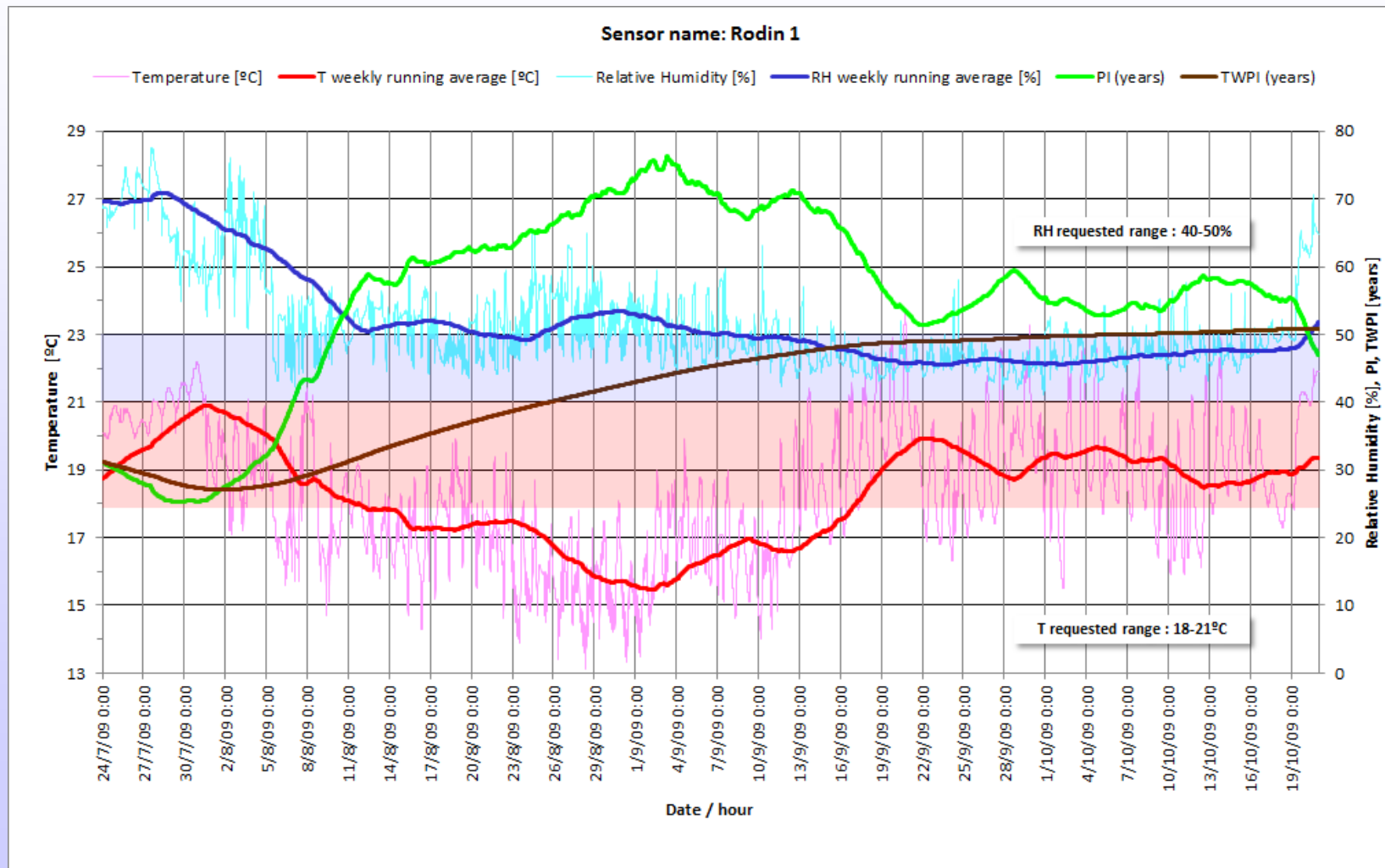
HVAC system target required ranges

Exhibition	Temp. range (°C)	RH range (%)
Chagall (2009)	19-23	50-60
Rodin (2009)	18-21	40-50
Tarsila (2011)	20-22	50-60
To see and to be seen (2011)	20-22	50-60
Caravaggio (2012)	19-21	50-55
De Chirico (2012)	20-22	50
Masters of Renaissance (2013)	19-21	50-60
Baroque silver and gold (2014)	20-24	50-56

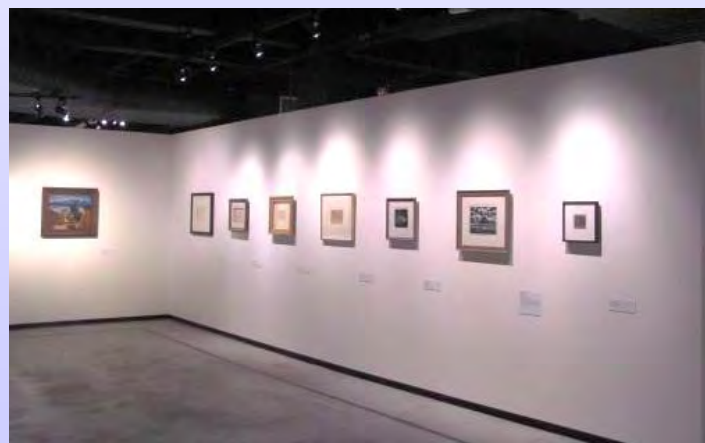
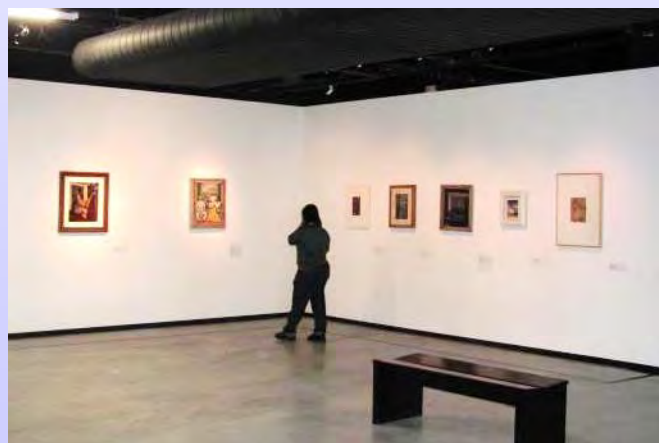
Rodin (2009)



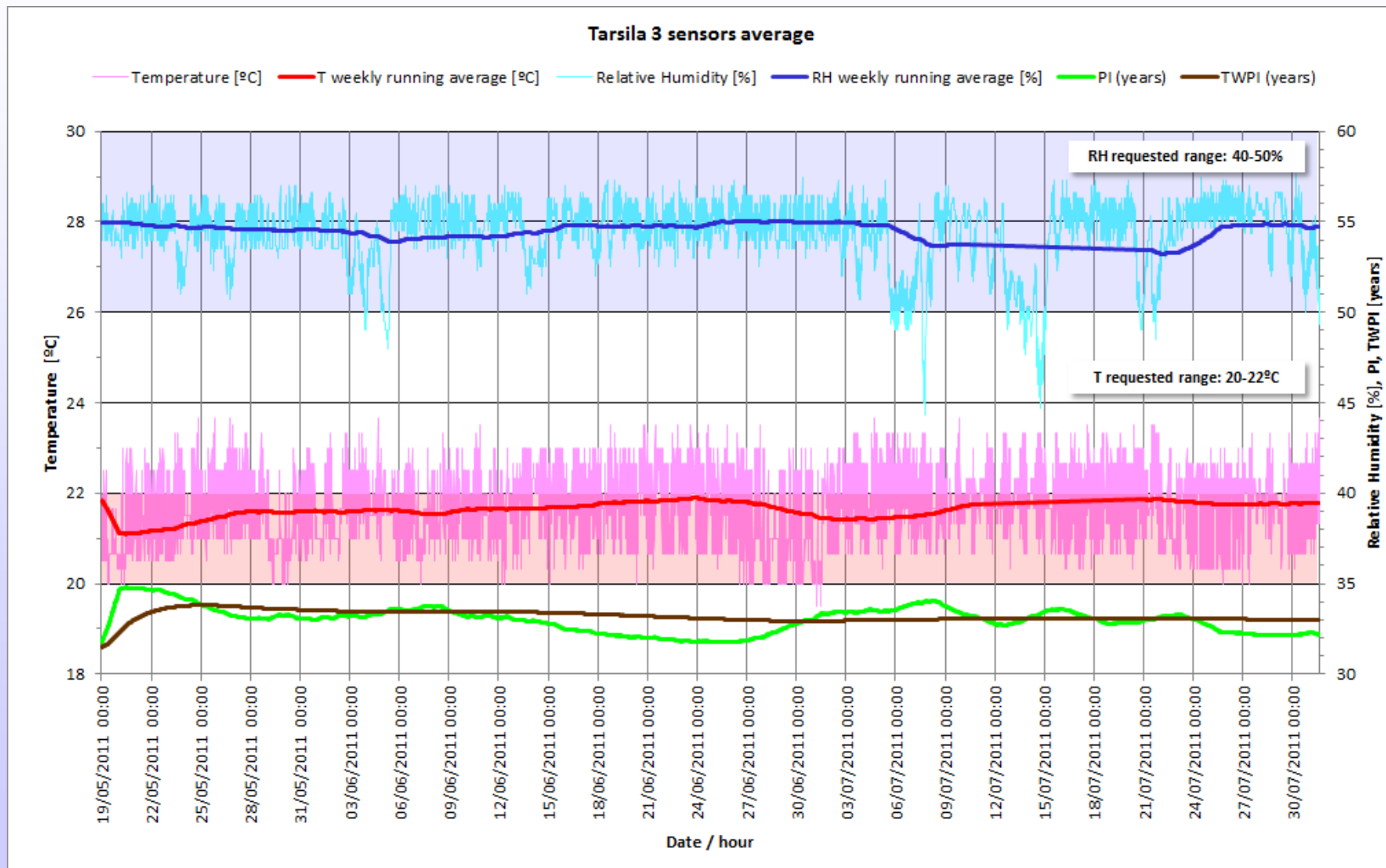
Rodin (2009)



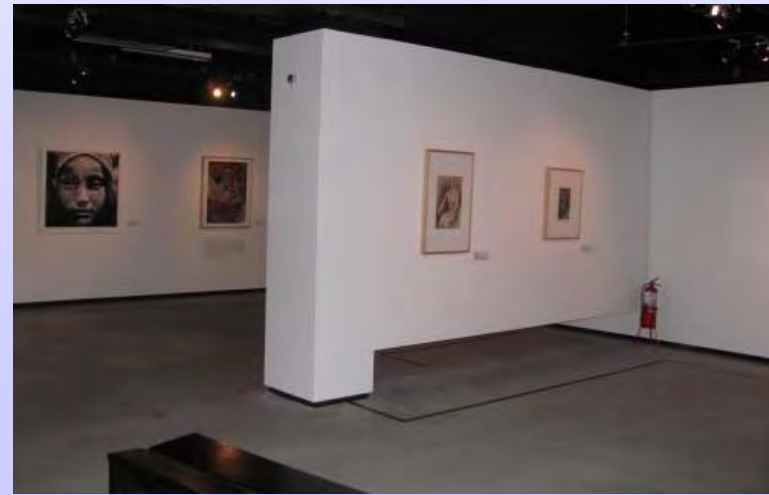
Tarsila (2011)



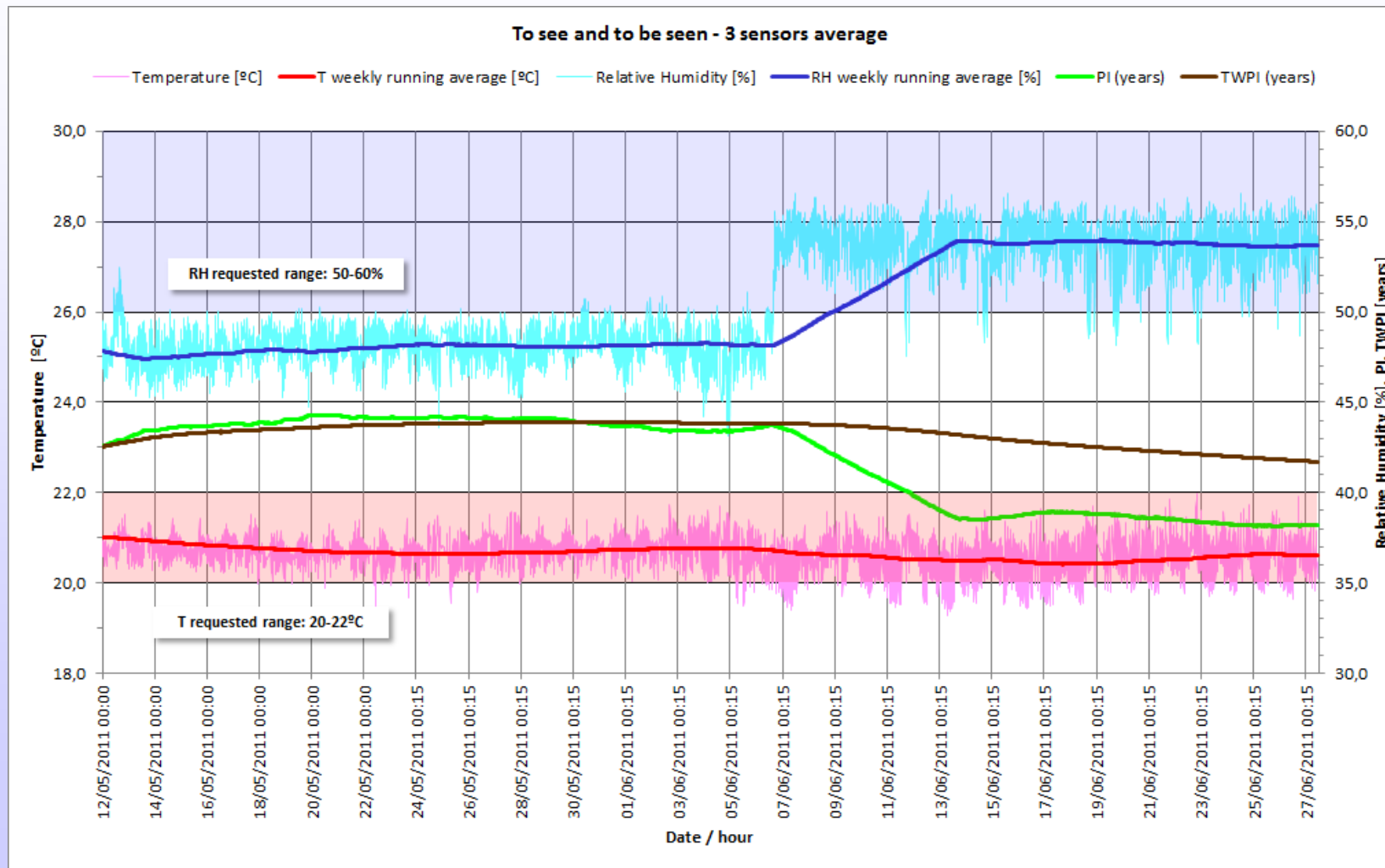
Tarsila (2011)



To see and to be seen (2011)



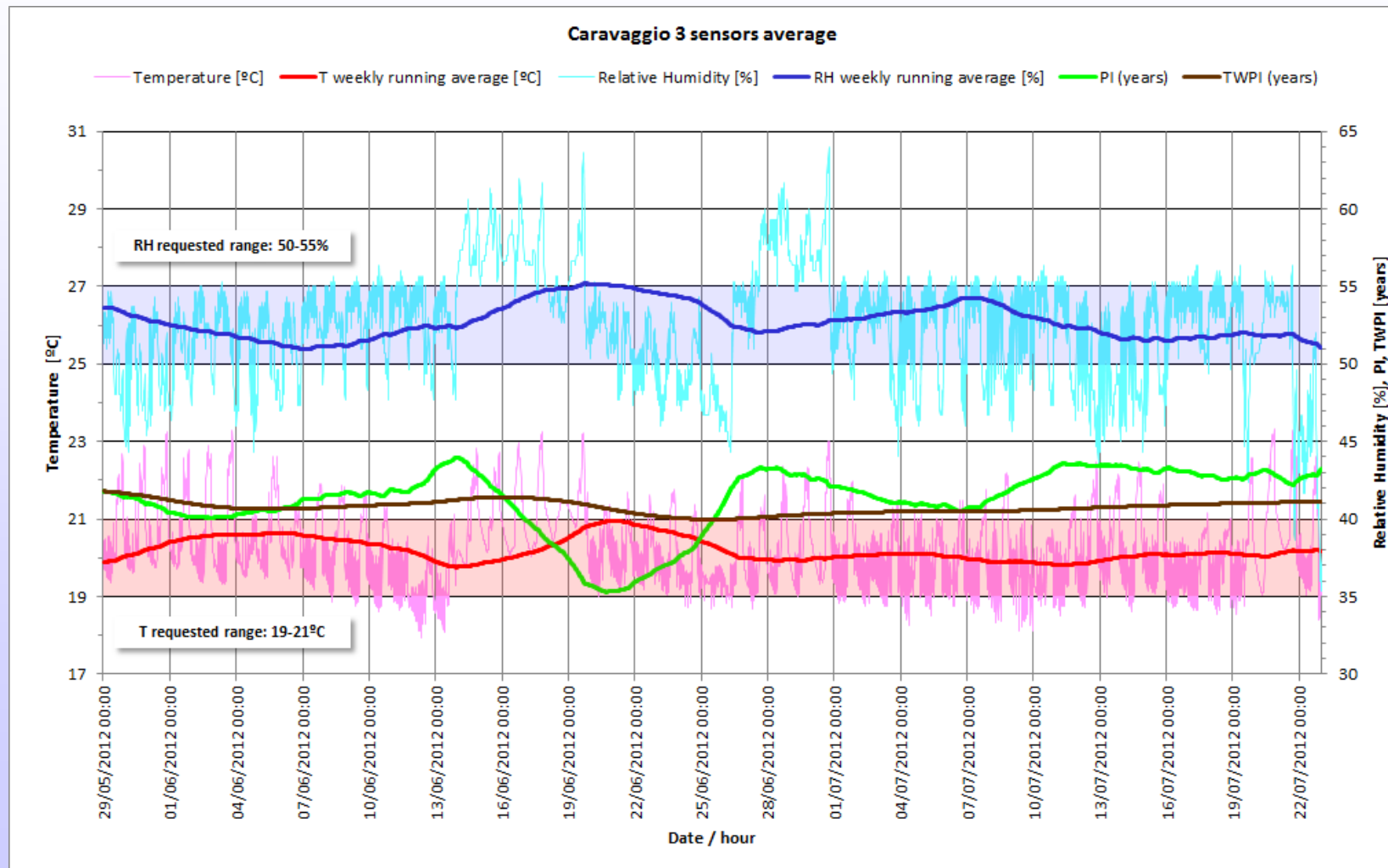
To see and to be seen (2011)



Caravaggio (2012)

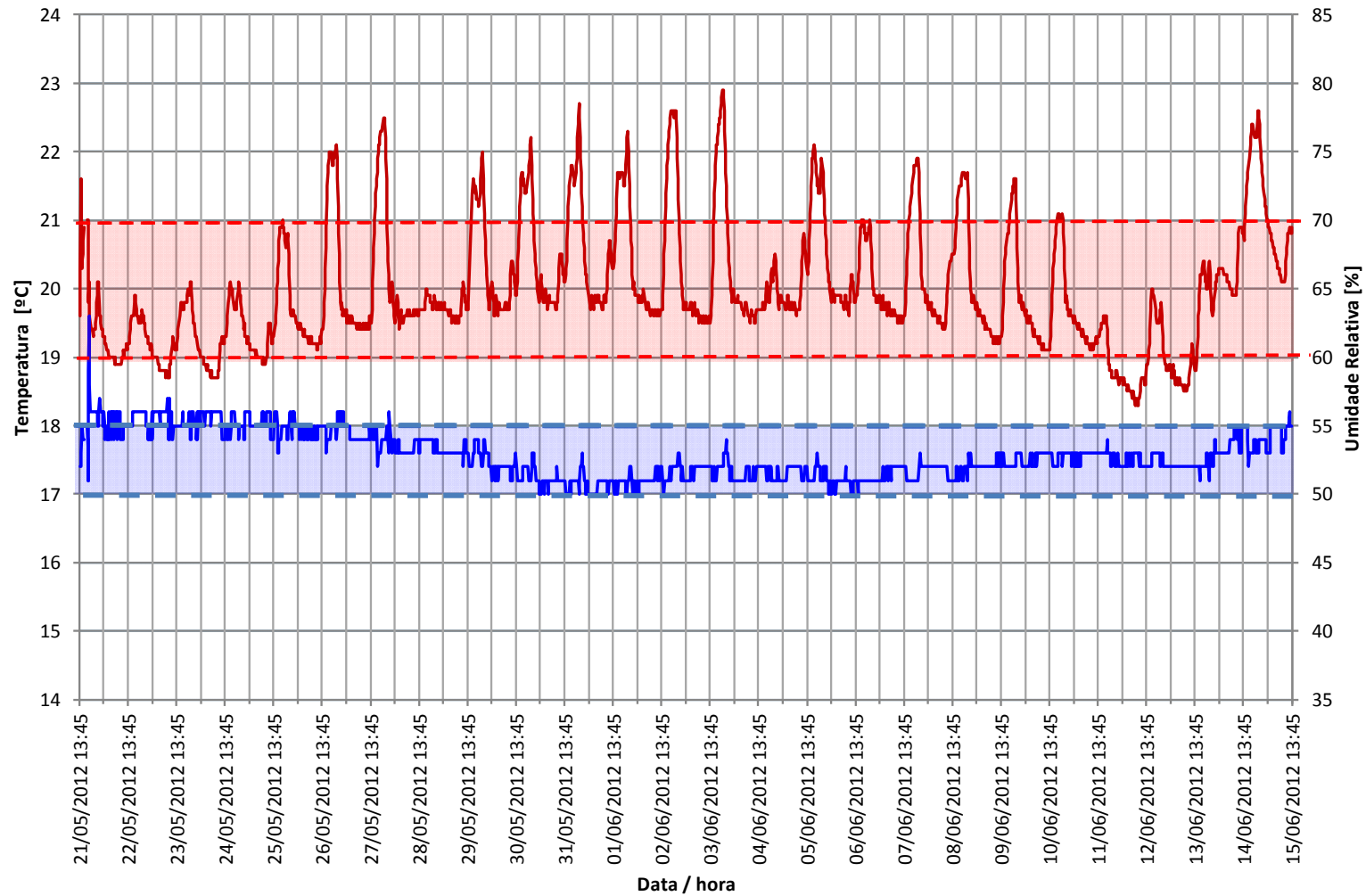


Caravaggio (2012)

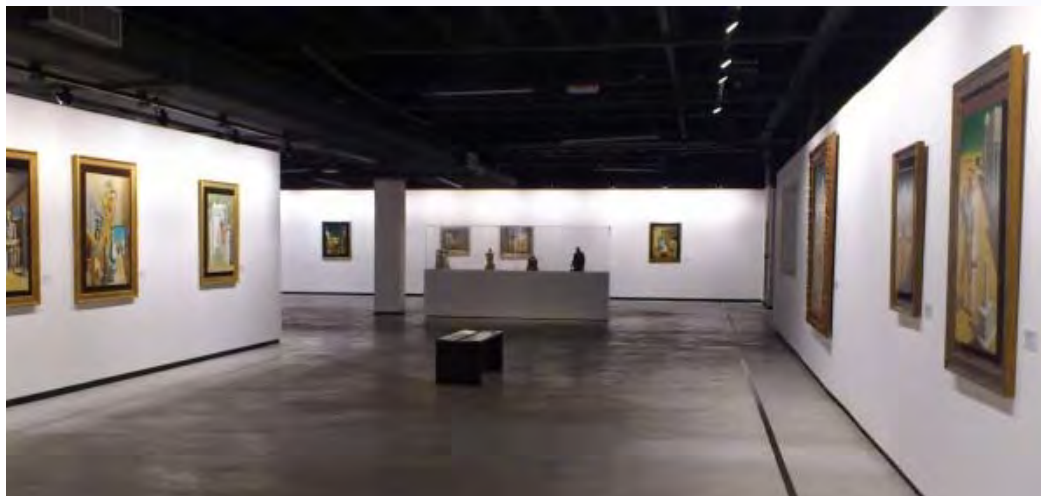


Caravaggio (2012)

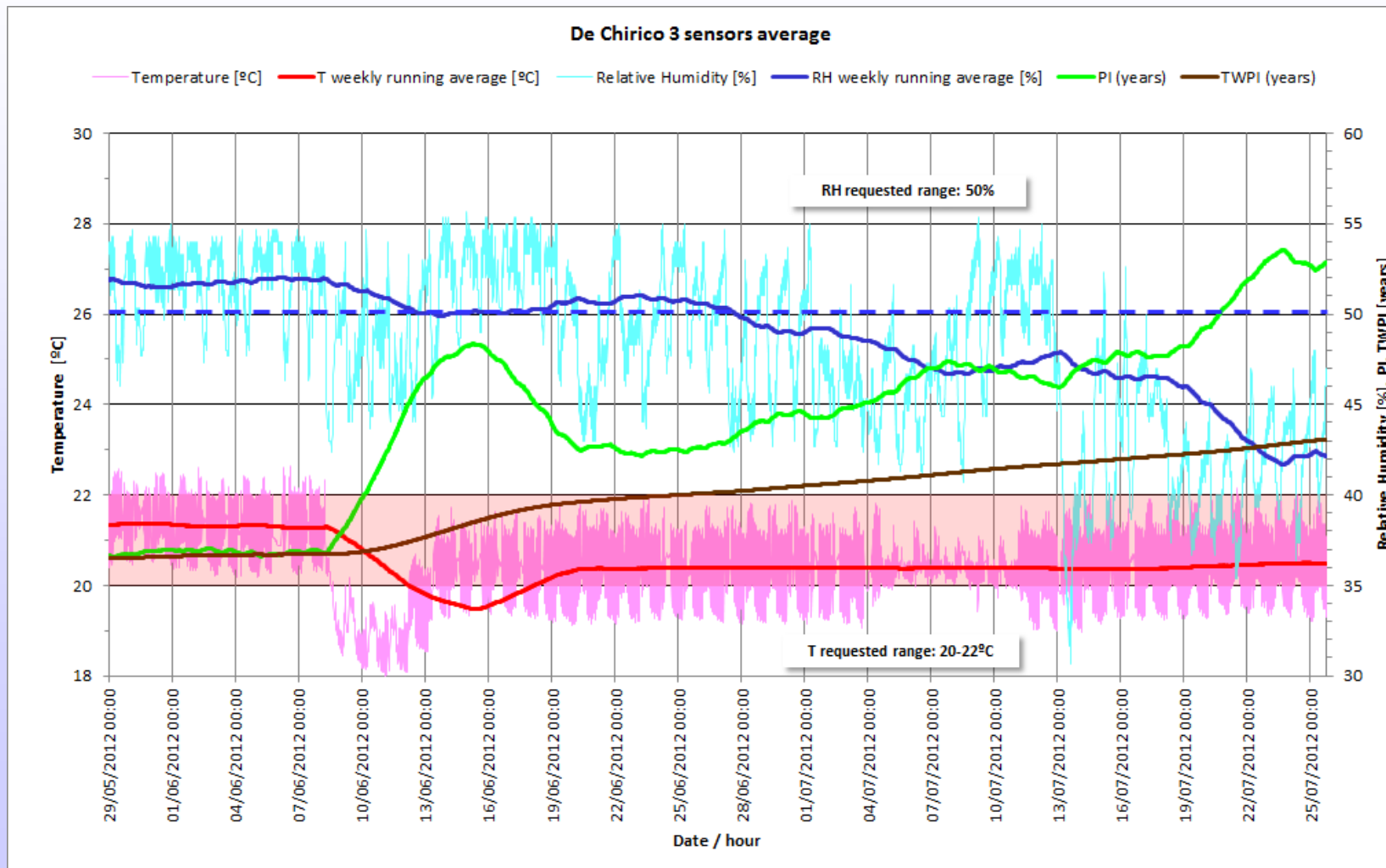
MEDUSA - 21/05 a 15/06/2012



De Chirico (2012)



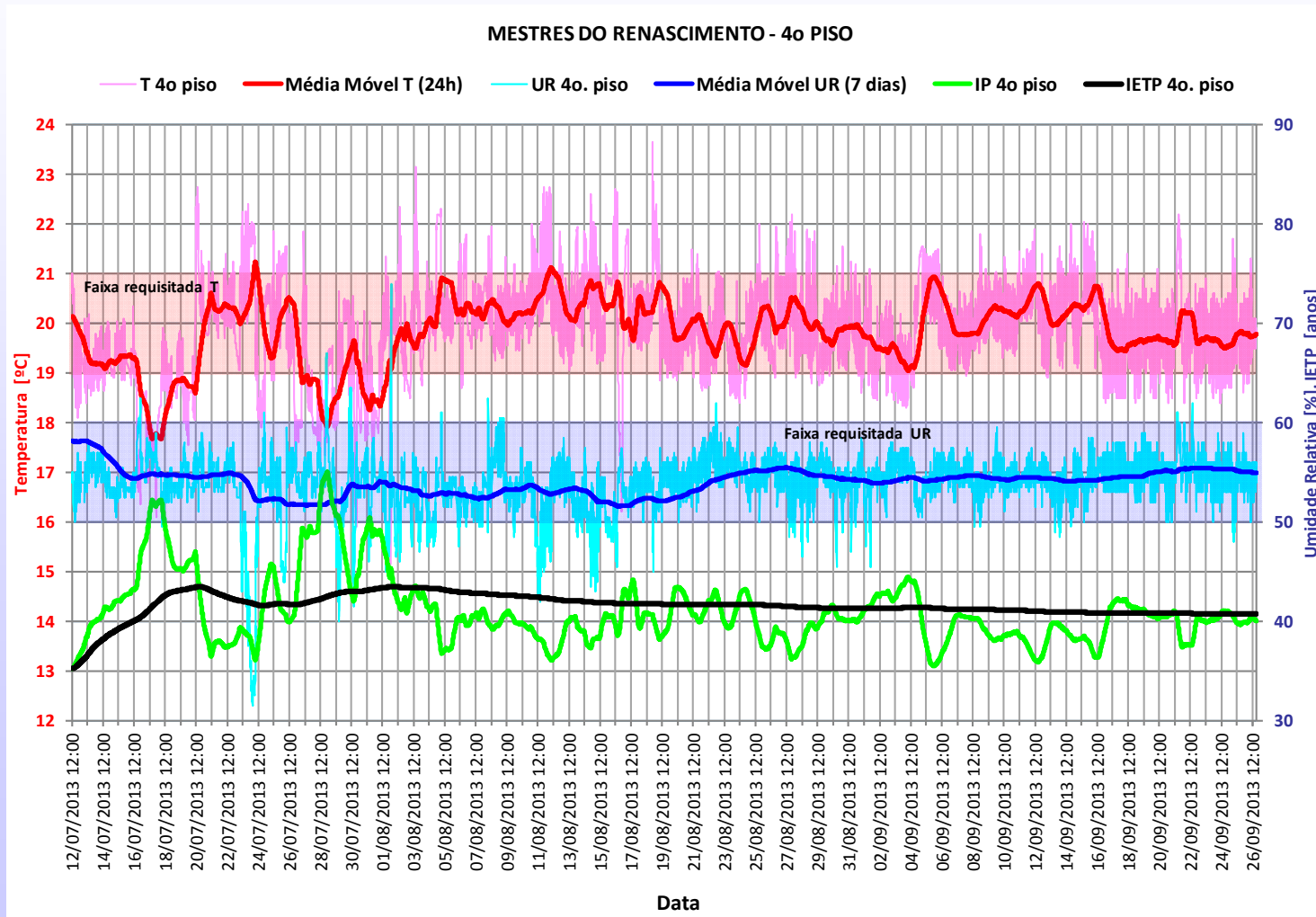
De Chirico (2012)



Masters of Renaissance (2013)



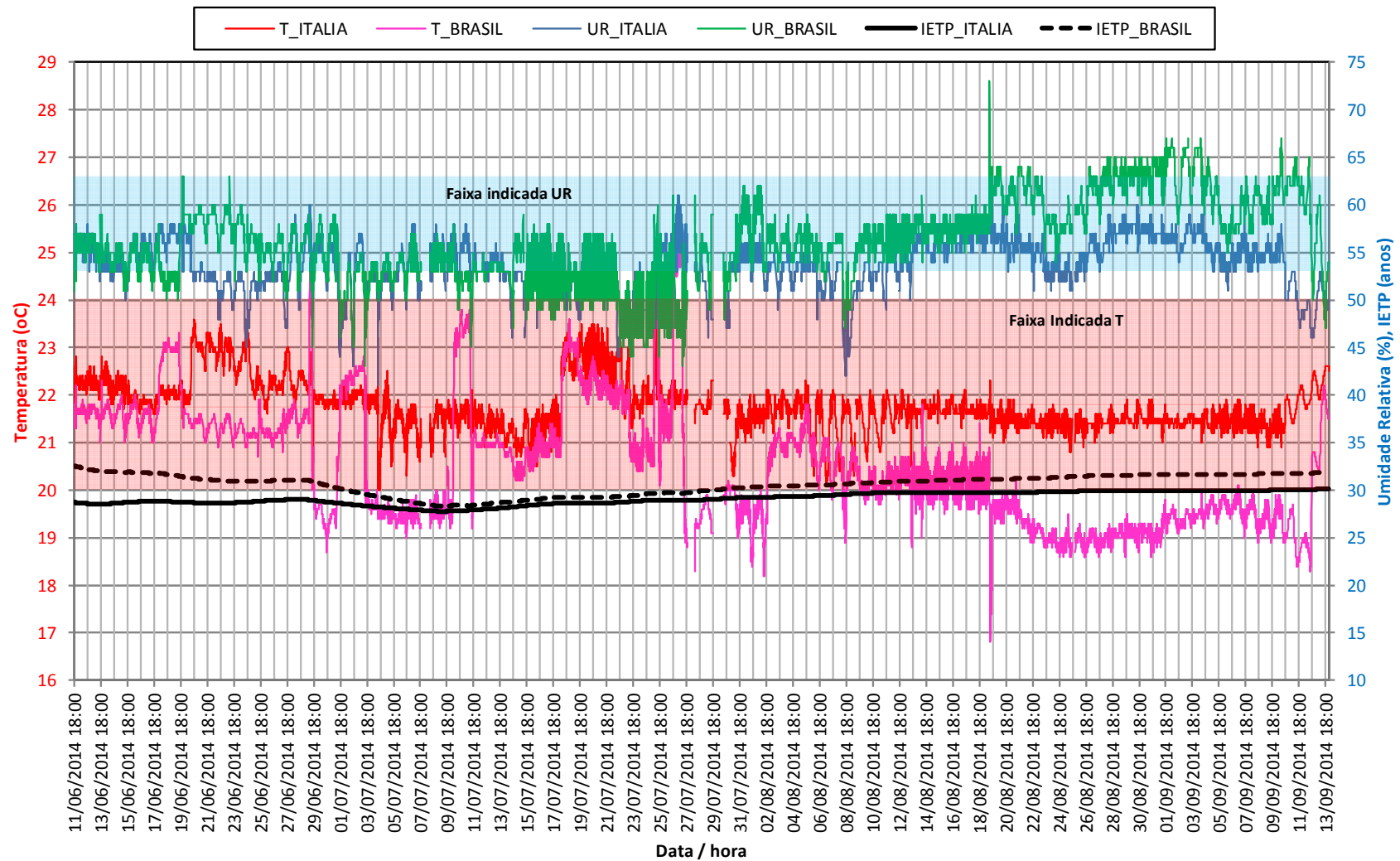
Masters of Renaissance (2013)



Baroque silver and gold (2014)



Baroque silver and gold (2014)



Se prepara Brasil (2016)

From April – September 2016

Two trucks

30.000 km

45 cities

1000 visitors/day

25 visitors/turn



Se prepara Brasil (2016)

From April – September 2016

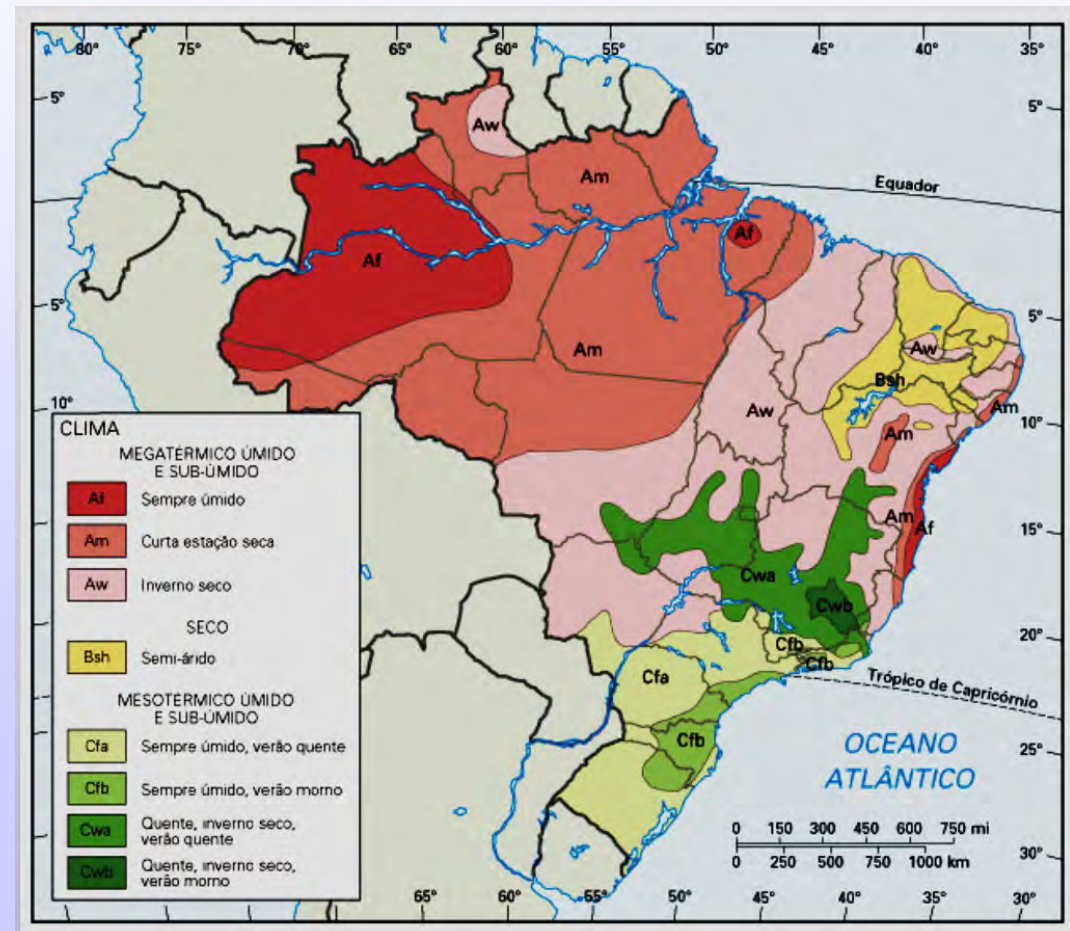
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25 visitors/turn



Se prepara Brasil (2016)



Metals

Textiles

Plastics

Composite materials

(acrylic showcases)

Originals

Replicas

Se prepara Brasil (2016)

Case materials and design

Pre-conditioned Silica Gel

Holistic approach:

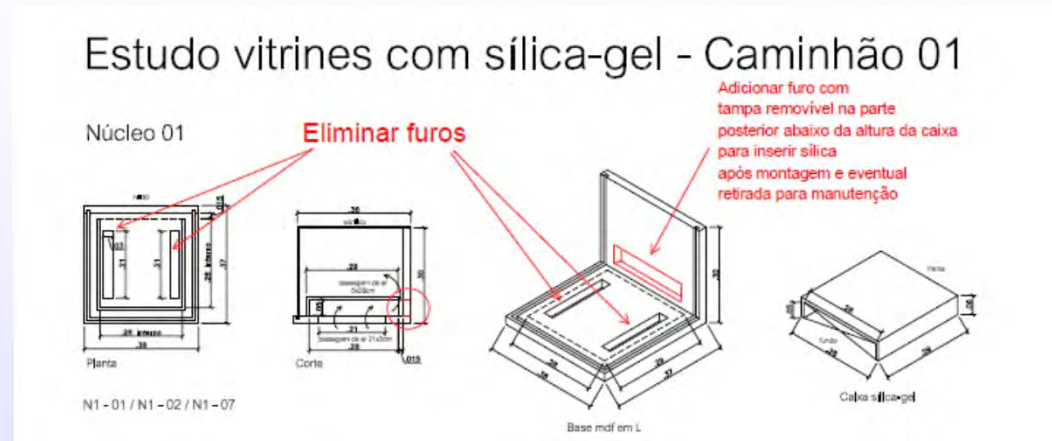
team work;

emergency response training;

itinerary and site pre-evaluation;

cleaning protocols;

shared responsibilities



Final Remarks

- HVAC systems are not always a solution for indoor climate problems;
- Passive methods can be useful to create stable microclimates (bags, boxes, cases..)
- This can be achieved even during transport with effective wrapping;
- It's essential to have good knowledge about material composition and physical behavior of the collection – Hire a conservator-restorer!
- In order to get a better HVAC system project an integrated participation involving a multidisciplinary team is needed, since the beginning;
- Think global climate, act with local microclimates!
- Sources of additional information:



CLIMATE FOR COLLECTIONS STANDARDS AND UNCERTAINTIES


Edited by Jonathan Ashley-Smith, Andreas Burmeister and Melanie Ehl



PROCEEDINGS OF THE SMITHSONIAN INSTITUTION

SUMMIT ON THE MUSEUM PRESERVATION ENVIRONMENT

EDITED BY SARAH STAUDERMAN AND WILLIAM G. TOMPKINS

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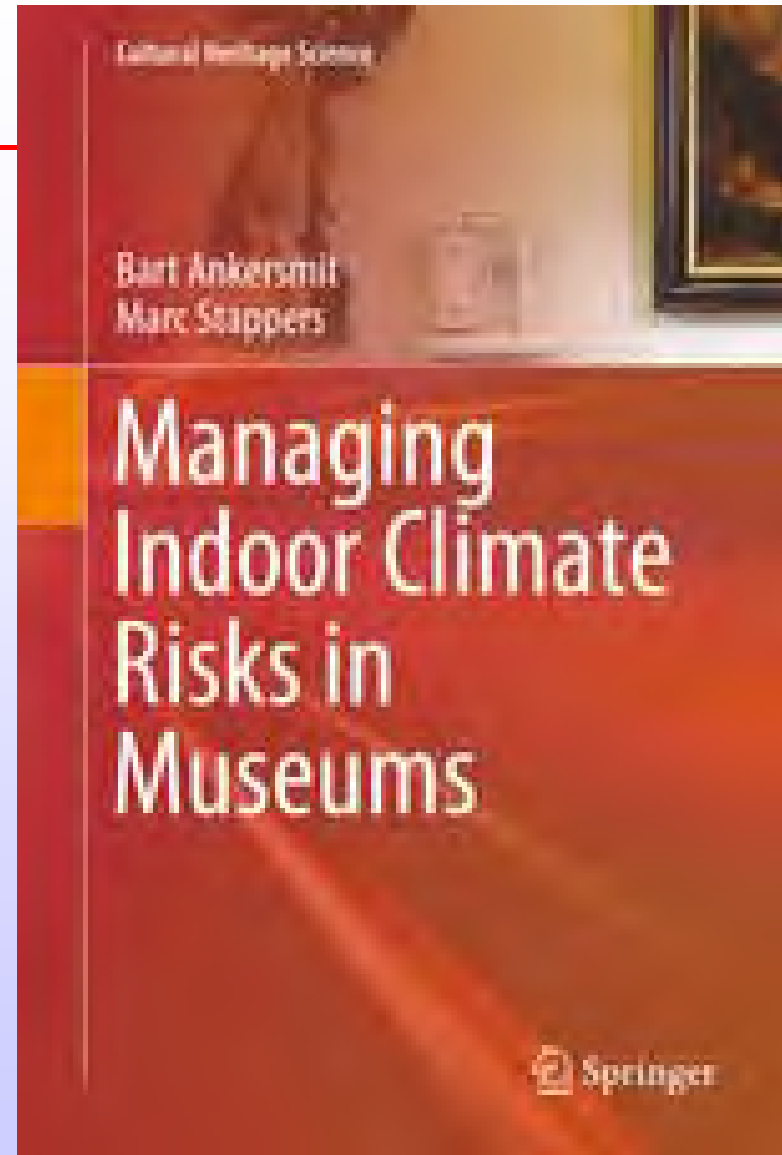
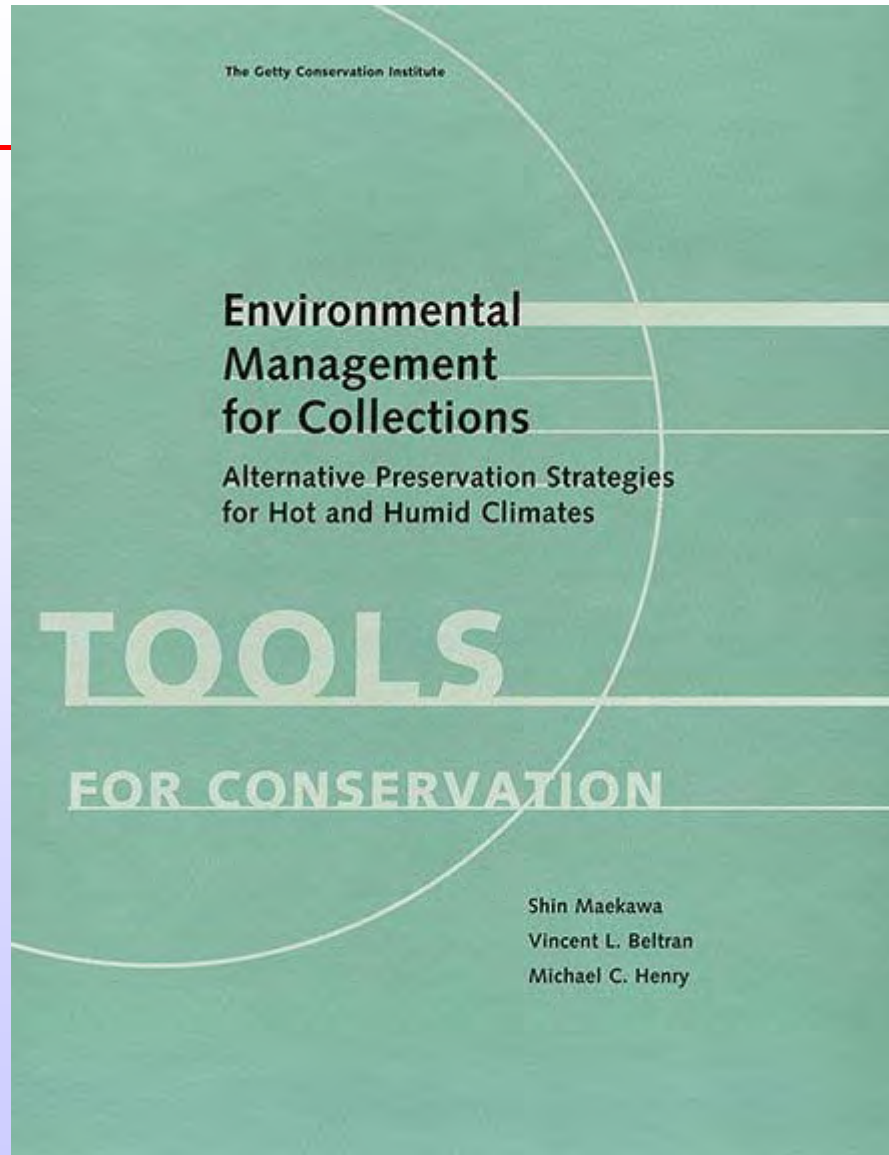
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FAPEMIG

Thank you for your attention.

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