LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL

Atlântico Pavilion

Monitoring a large timber structure and modelling its response to environmental conditions

H Cruz, P Palma, M J Henriques, P Bele Mateus

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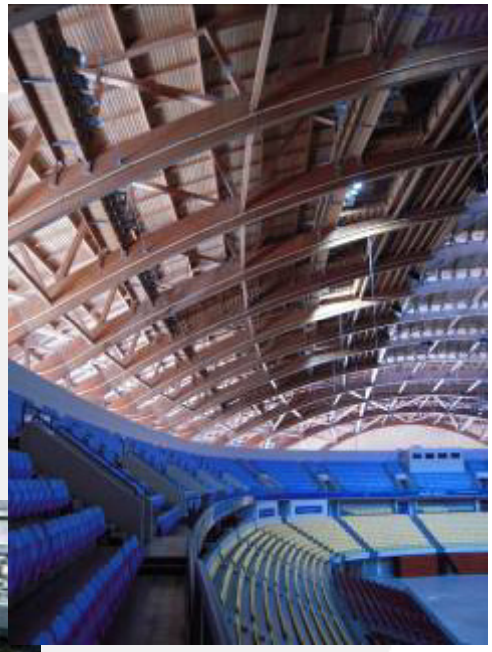
- **designed for the world fair Expo'98 in Lisbon**
- **is a multi-purpose hall that receives up to 16 500 people**
- **17 transversal glulam arches, max span= 114 m**



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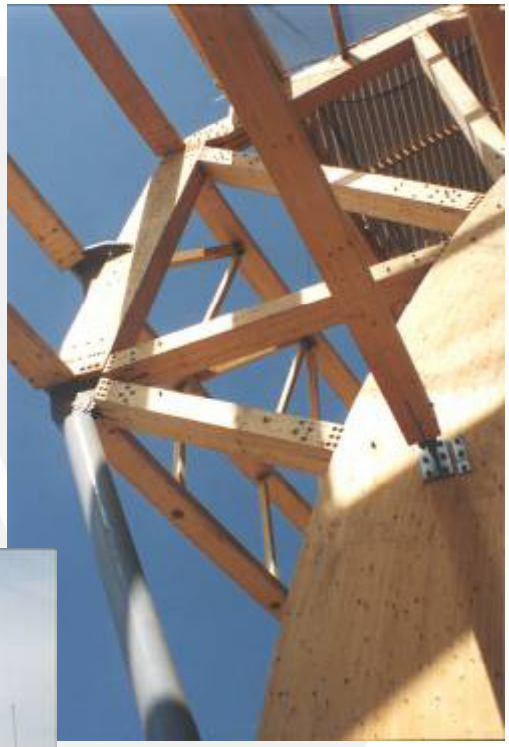
- **First large glulam structure built in Portugal**
- **One of first buildings designed according to Eurocode 5**
- **Need for reinforcing joints identified during production**



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Since 2000 LNEC has followed the glulam structure:

- periodic visual inspections
- measurements of wood moisture content
- continuous measurements of RH and T
- horizontal and vertical displacements (geodetic surveying methods)

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Periodic visual inspections

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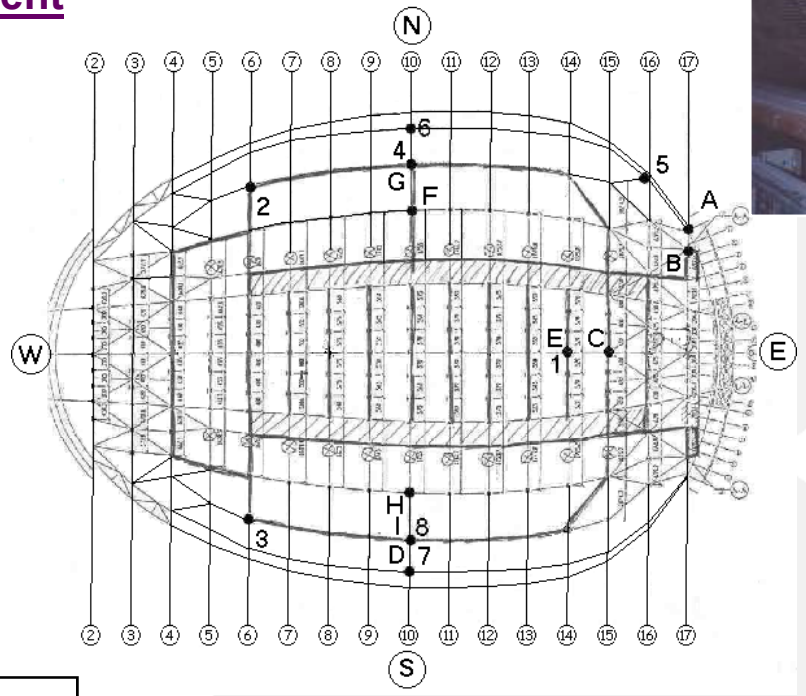
Measurements of wood moisture content

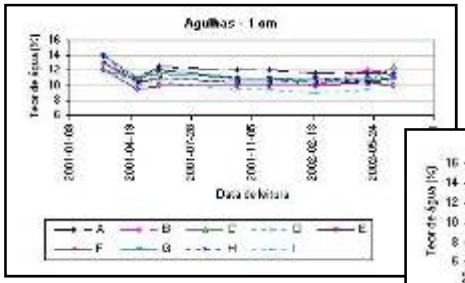
Each location (A to H)

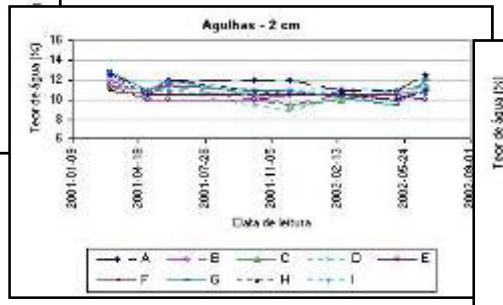
= 4 pairs of needles

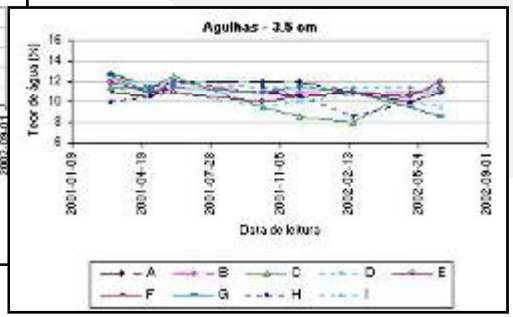
(1cm, 2,5cm, 3,5cm and 5cm deep)

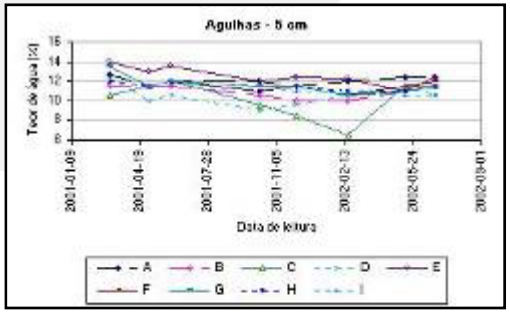
Readings every 2 months











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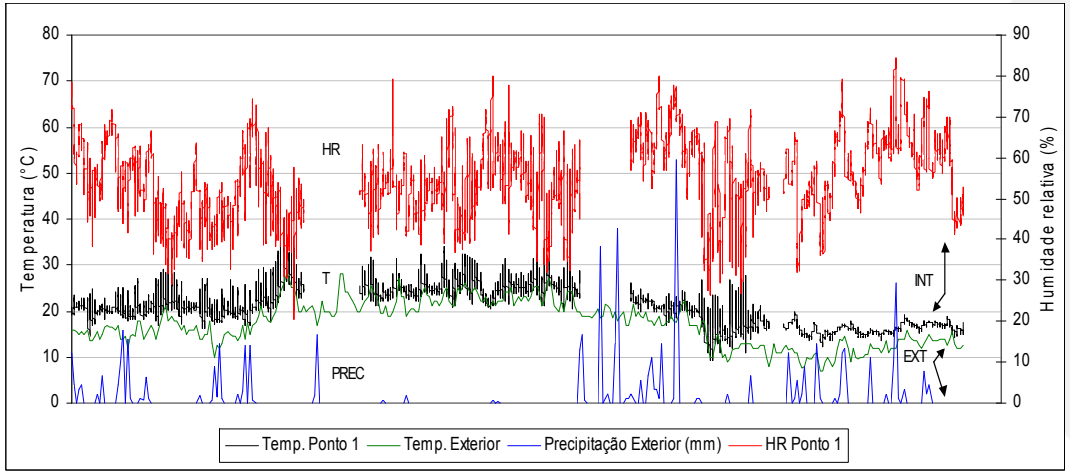
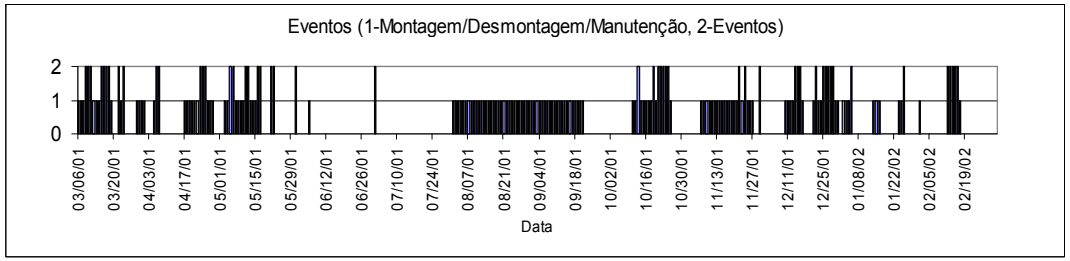
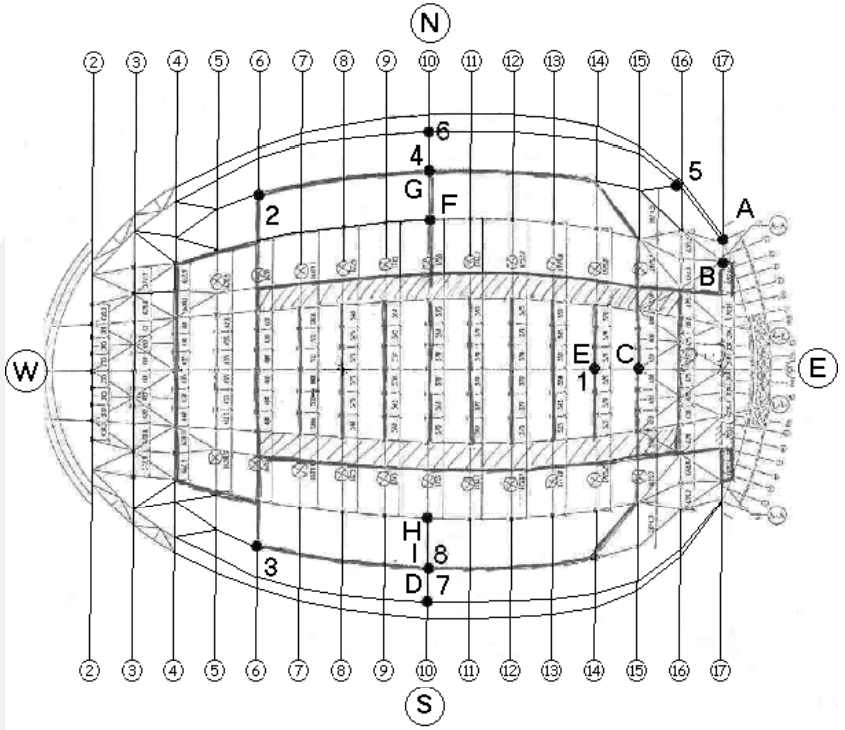
Continuous measurements of RH and T

Each location (1 to 8)

= continuous measurement T







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Continuous measurements of RH and T

- Similar conditions inside and outside the buildings (T inside > T outside)
- RH inside varies with outside environment
  - foggy mornings explain high RH in summer
  - Events explain some peaks of inside conditions
- Despite the claimed continuous conditioning, inside conditions far from constant
- Inside environment follows the same variation pattern in all locations
- Higher daily variations at sunlight exposed members but similar mean values

Since 2000 LNEC has followed the glulam structure:

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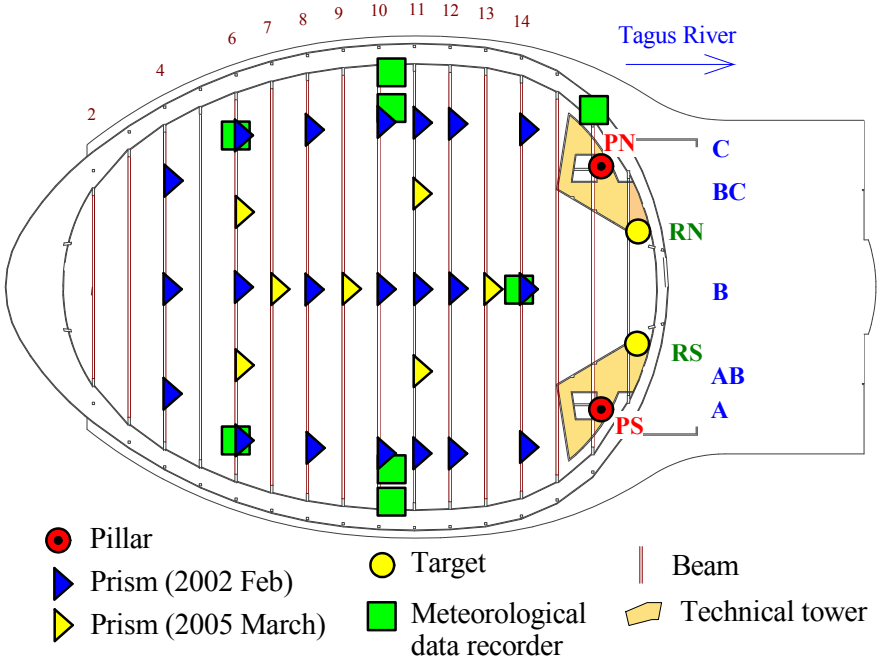
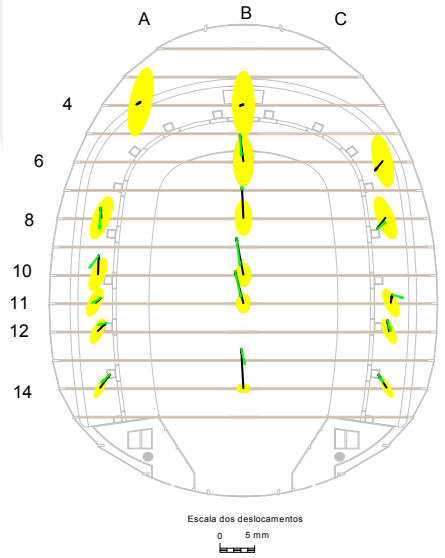
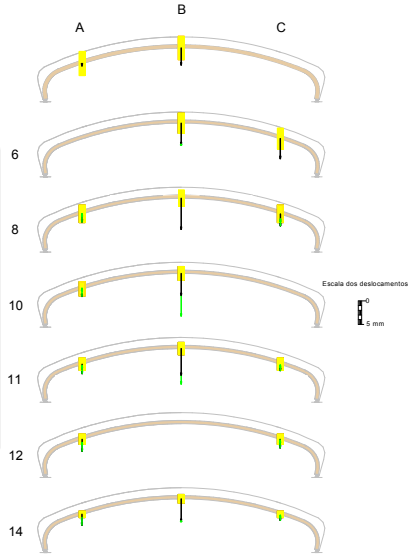
Horizontal and vertical displacements (geodetic surveying methods)







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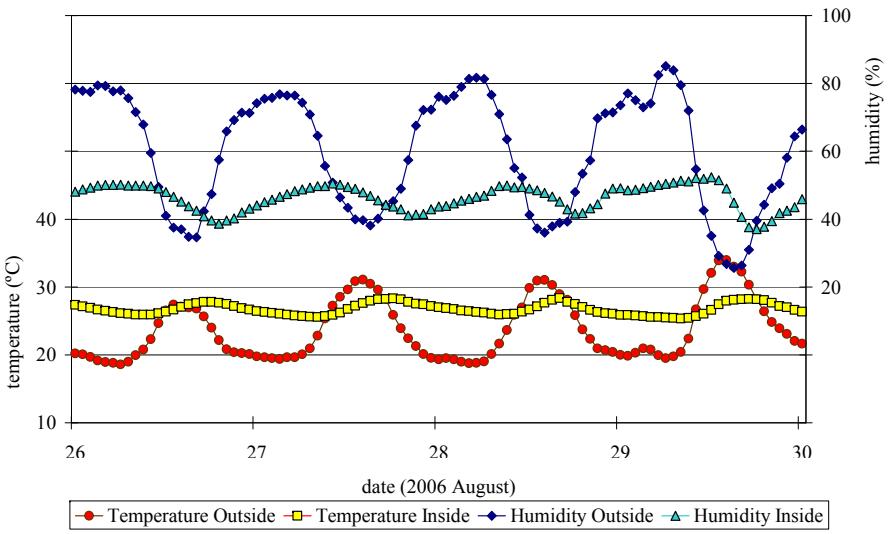
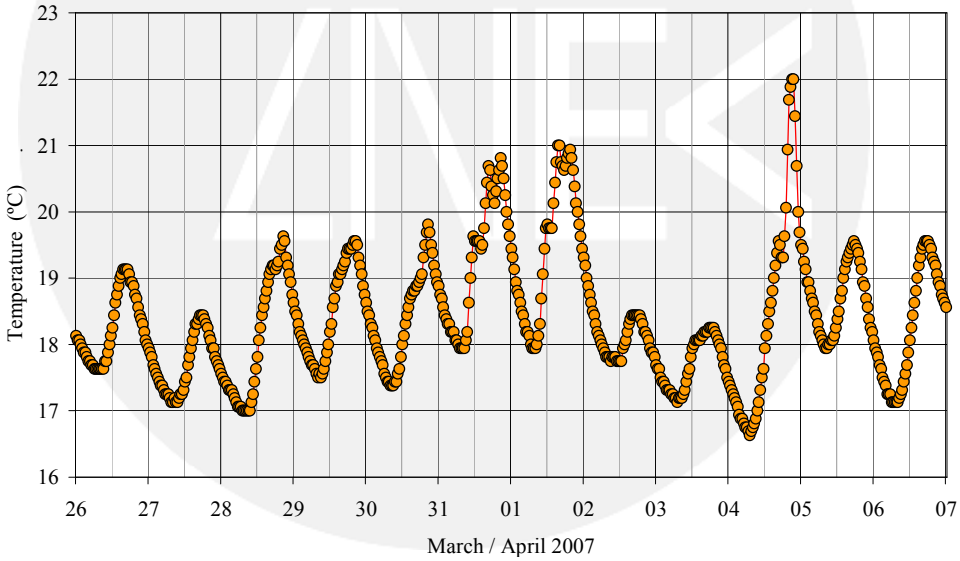
Historical vertical displacements of one arch was modelled as a function of:

> **Temperature (T); Relative humidity (RH); Age of the structure, in days (A)**

The model is calibrated using data from previous measurement campaigns



Temperature and humidity inside and outside the Pavilion (no events)



Influence of events

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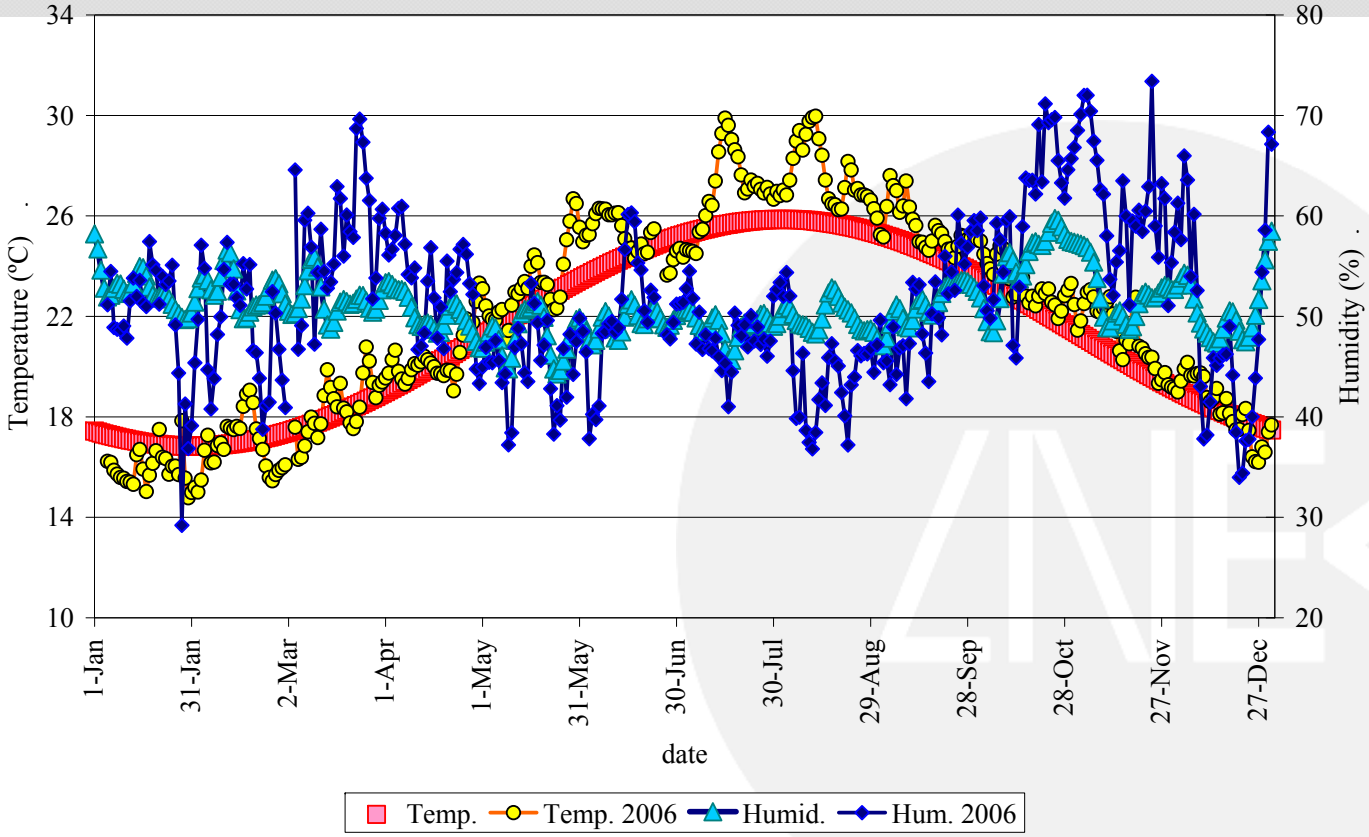

Measured and modeled RH and T

– models of RH and T not accounting for daily variations

- average conditions of previous 5 days used to model displacements

Atlântico Pavilion – prediction of displacements

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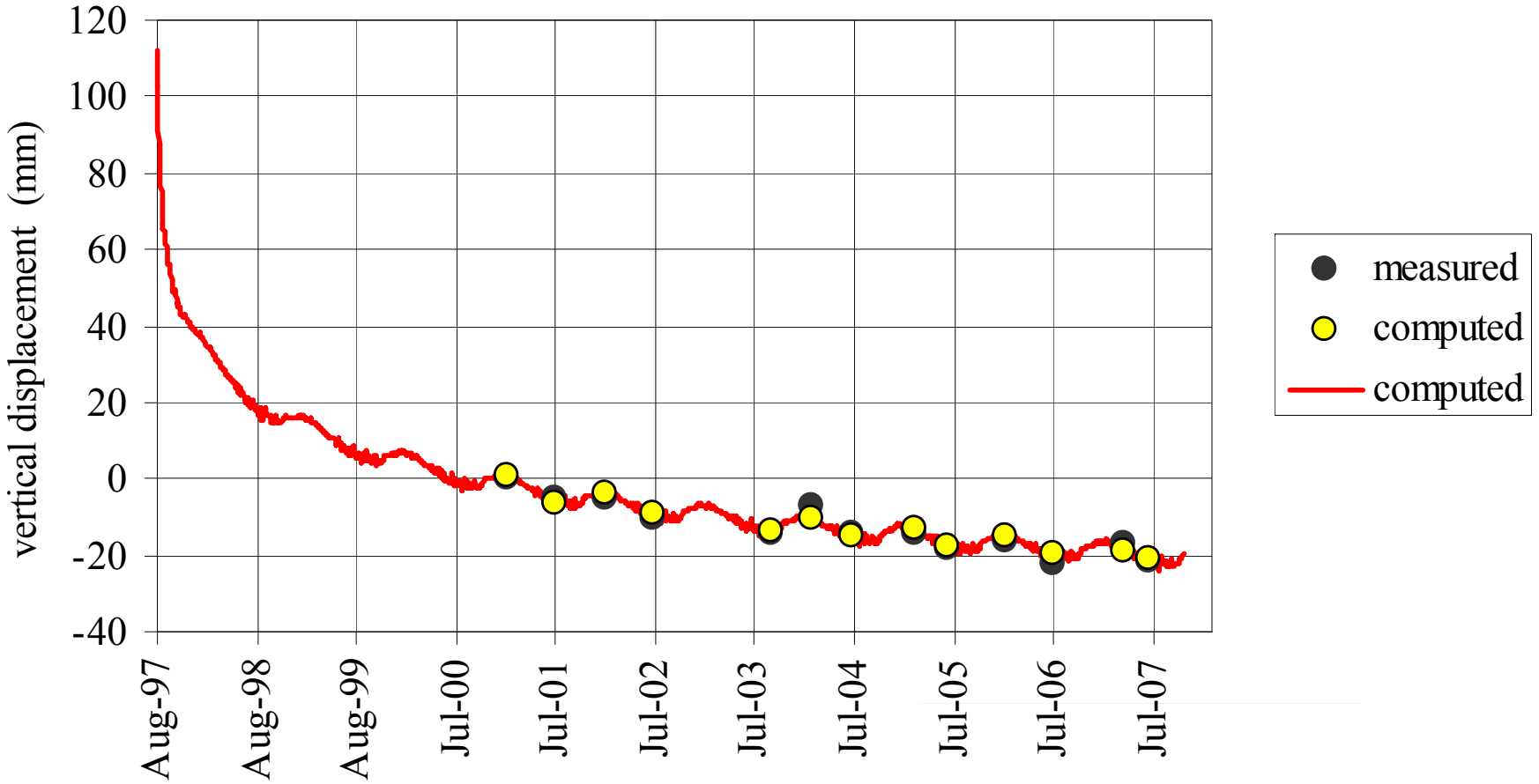

Results

Measured displacements closely follow a pattern that can be described as a function of environmental conditions (temperature and relative humidity) and age of the structure

(wind and suspended loads explain differences between model and reality)

thus suggesting the strong influence of these variables and the absence of materials degradation or structural instability phenomena so far.

$$D = a\,T + aH + a\ln(1/A) + a$$

$$D = a\,H + a\ln(1/A) + a$$

$$D = a\,T + a\ln(1/A) + a$$

$$D = aM(T,H) + a\ln(1/A) + a$$