



Application of NIR for evaluation of weathered samples from RR test

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Innovation in biomaterials for industry



IVALSA
TREES AND TIMBER INSTITUTE

Weathering

- Weathering is the general term used to define the **slow degradation** of materials exposed to the weather condition.
- The rate of weathering varies within **timber species, function of product, technical/design solution, finishing technology** applied but most of all on the **specific local conditions**.
- The process leads to a slow **breaking down of surface fibres, their removal**, and in consequence to a **roughening of the surface and reduction of the glossiness**.
- The formation of discontinuities on the wooden surface can cause penetration of the **wood-decaying biological agents** into the material structure and influencing mechanical performances of the load-bearing members.



Round Robin test set-up

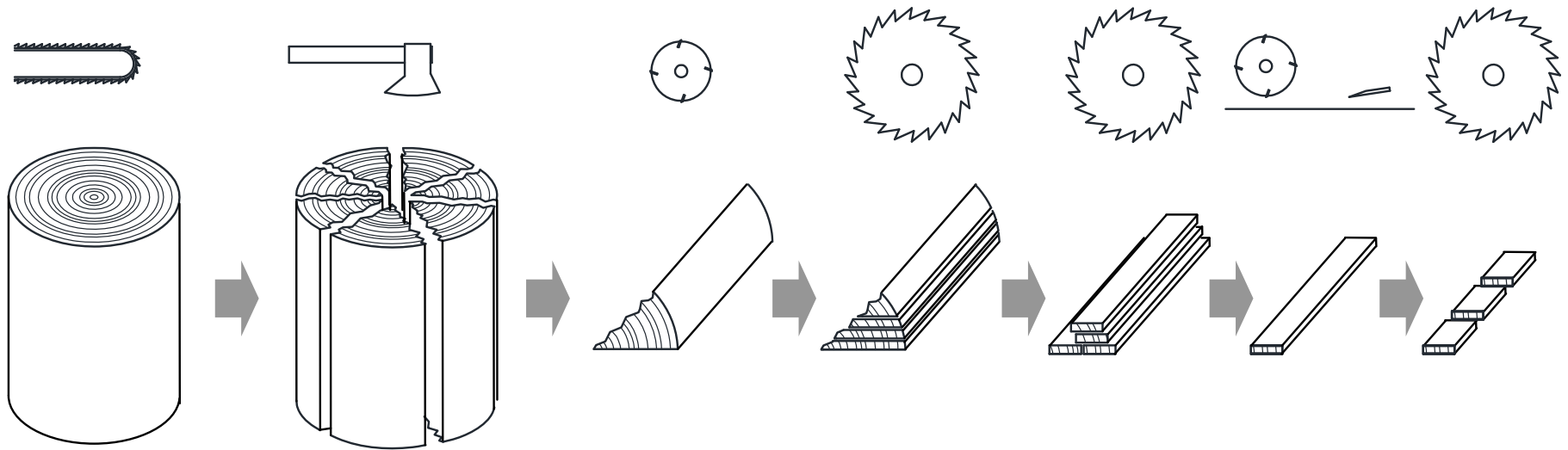
XX locations,
XX samples sets



samples weathered for one year, collected every month

Experimental samples

- one piece of Norway spruce (*Picea abies*)
- the efficient surface 30 x 30mm
- conditioned in 20°C, 60%RH



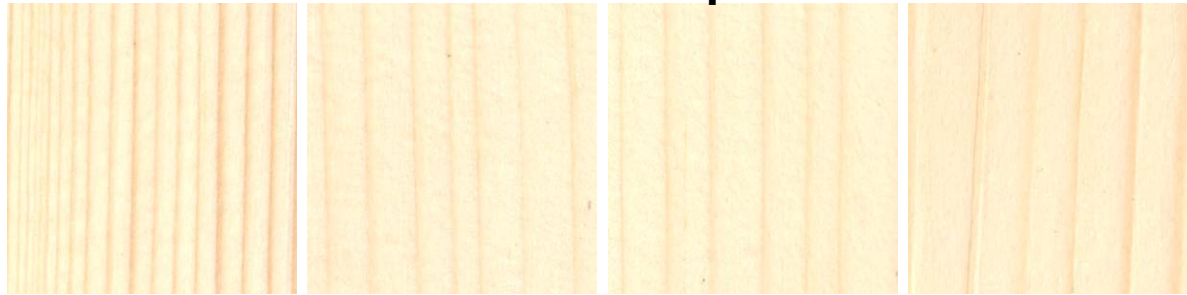
Degradation progress evaluation

- Undertaken tests
 - Colour changes (CIE Lab, hyperspectral imaging, hamatsu VIS-NIR, intergating sphere and UV-VIS-NIR)
 - Samples apperance and integrity (visual grading)
 - Chemical changes (MIR, NIR and Micro NIR)
 - Gloss
 - Roughness (Depth of filed, Laser line and laser displacement sensor)

- **Test to be focused on**
 - **Colour changes (CIE Lab)**
 - **Samples apperance and integrity (visual grading)**
 - **Spectroscopy (Micro NIR)**
 - **Gloss**
 - **Roughness (Depth of filed)**

Weathering effect on samples

Reference samples

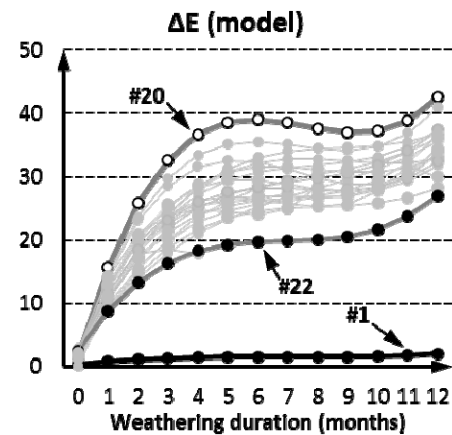
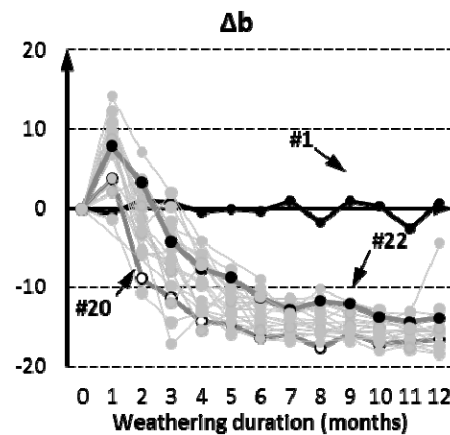
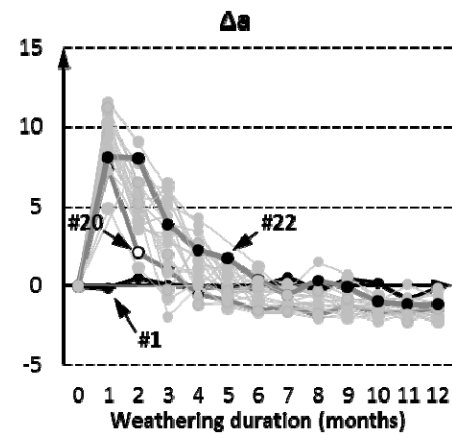
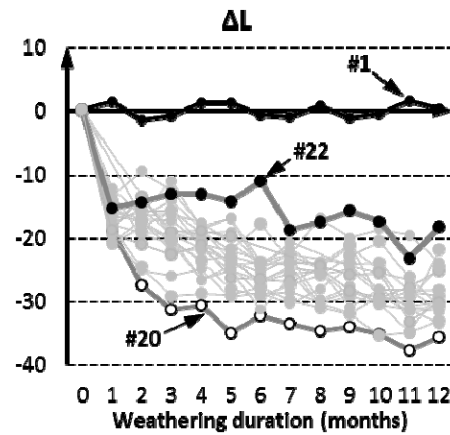


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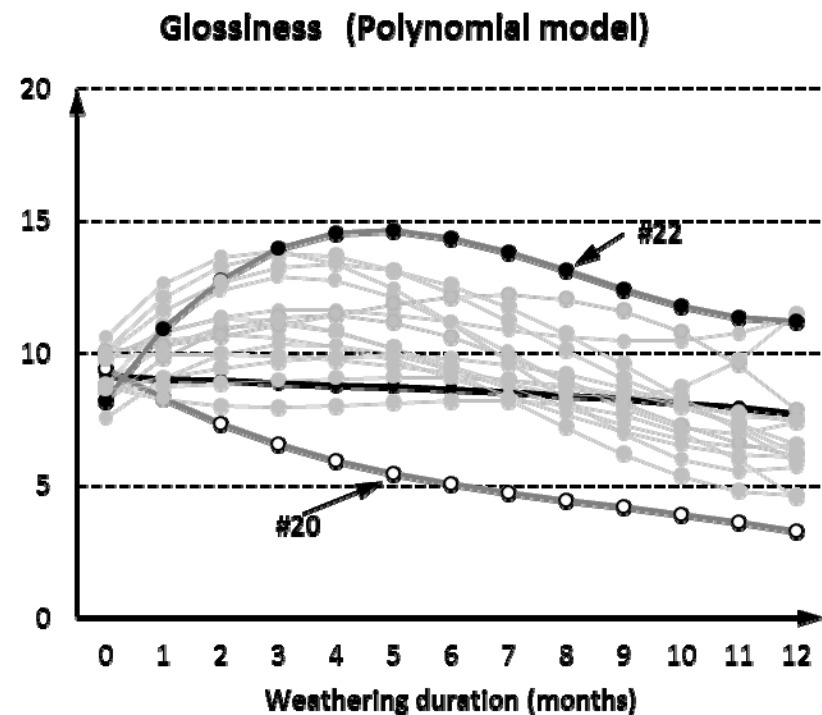
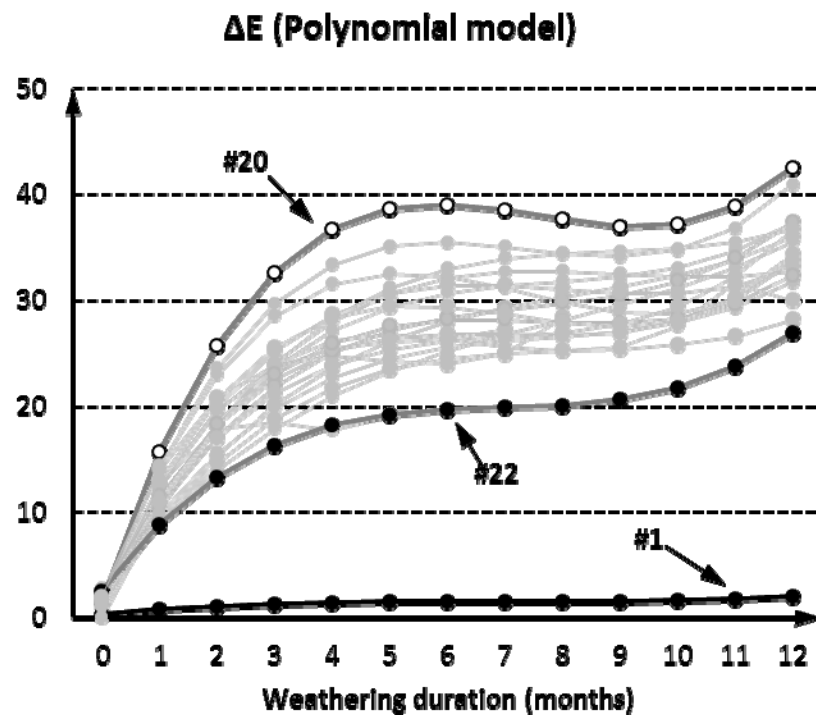


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Changes in colour



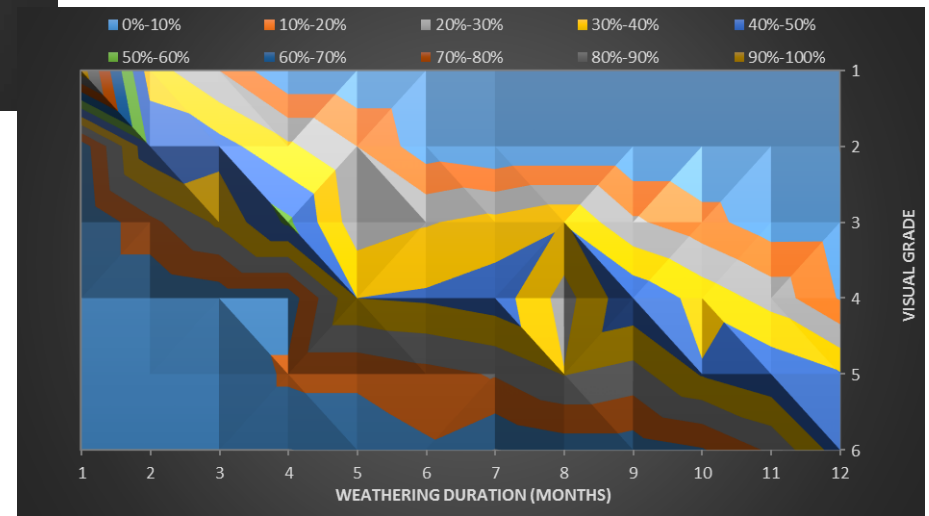
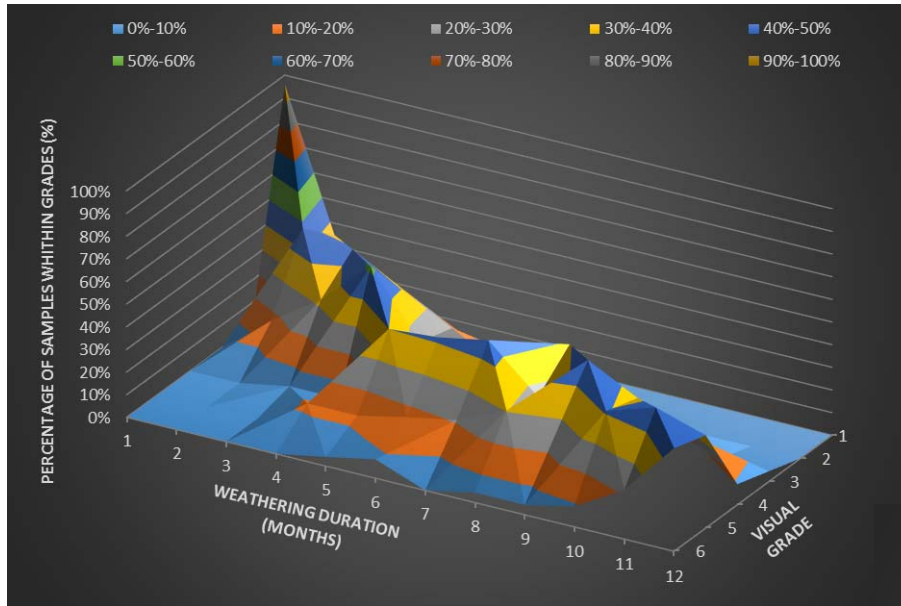
Changes in colour and glossiness



Visual grading

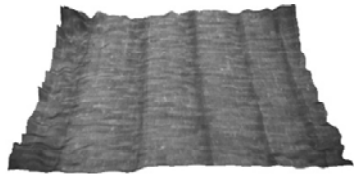
Grading	Degradation	Characteristics
0	No degradation	No colour changes
1	Small aesthetical changes	Yellow appearance
2	Mild aesthetical changes	Yellow grey appearance
3	Moderate aesthetical changes	Light grey colour
4	More intense changes	Grey colour with warm tonality, no visible cracks
5	Advanced changes	Dark grey colour with cold tonality, some raised fibres, surface erosion, no visible open cracks
6	Very advanced changes	Dark grey, uneven discolouration, surface erosion, presence of cracks, mould, algae

Visual grading

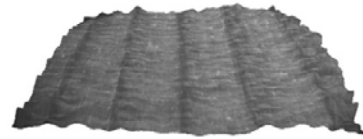


Surface erosion: Depth of field

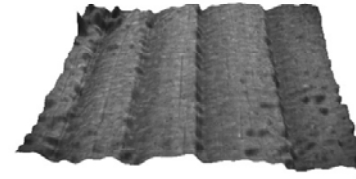
1st month



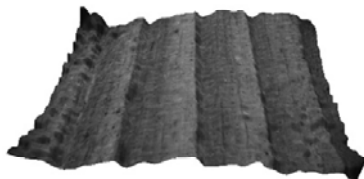
2nd month



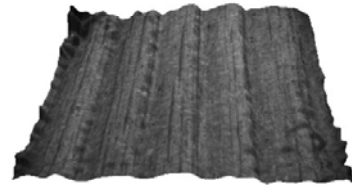
3rd month



4th month



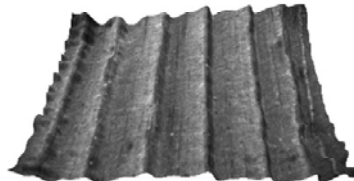
5th month



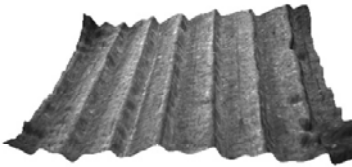
6th month



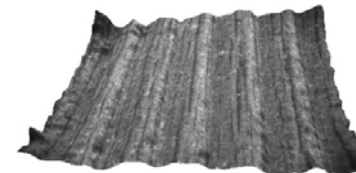
7th month



8th month



9th month



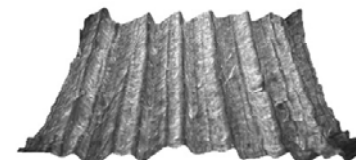
10th month



11th month

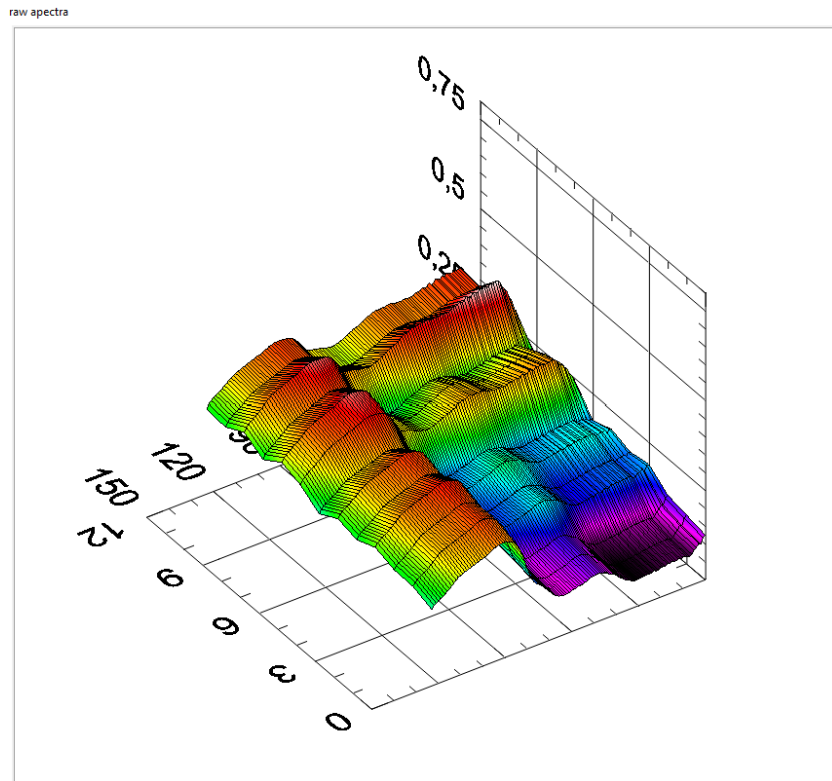


12th month

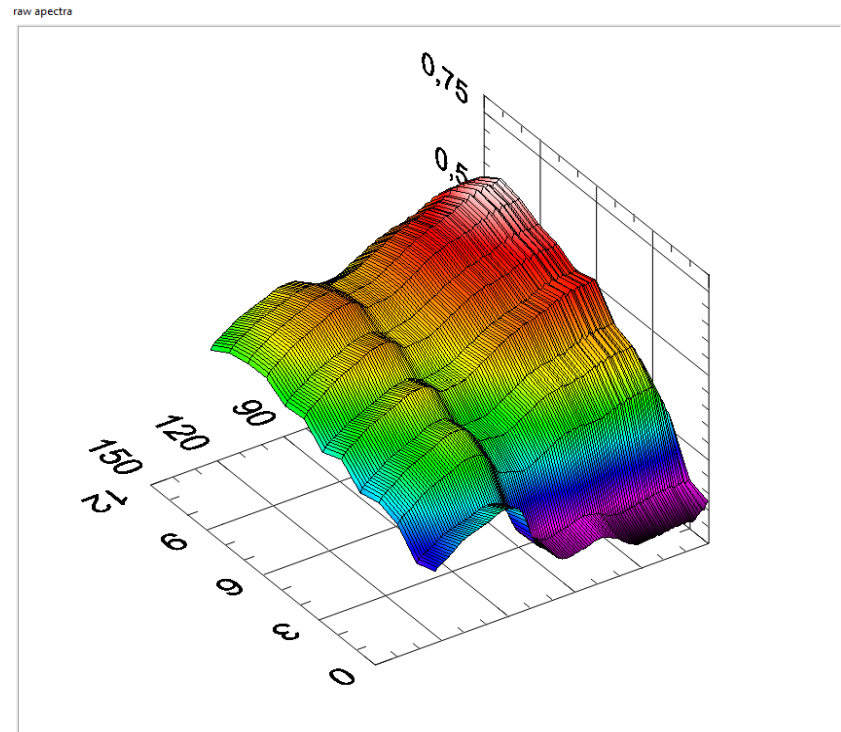


NIR correlation spectroscopy

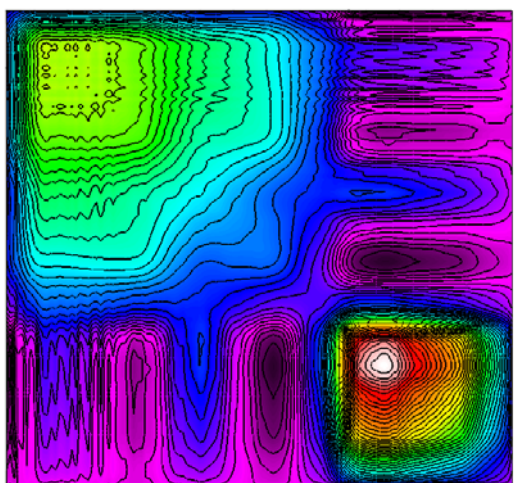
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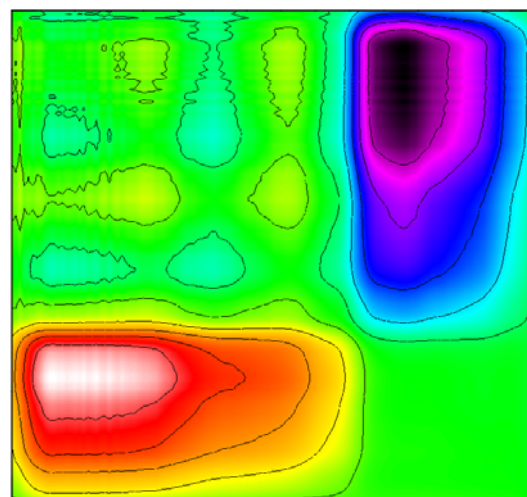


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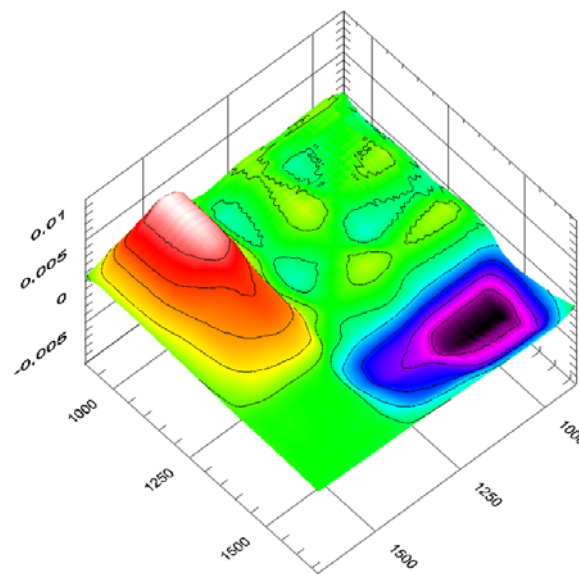
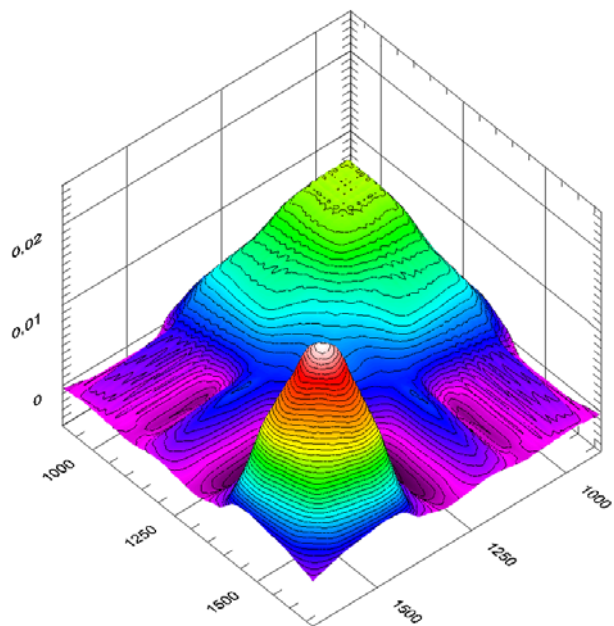
1000
1250
1500

synchronous 2D spectra

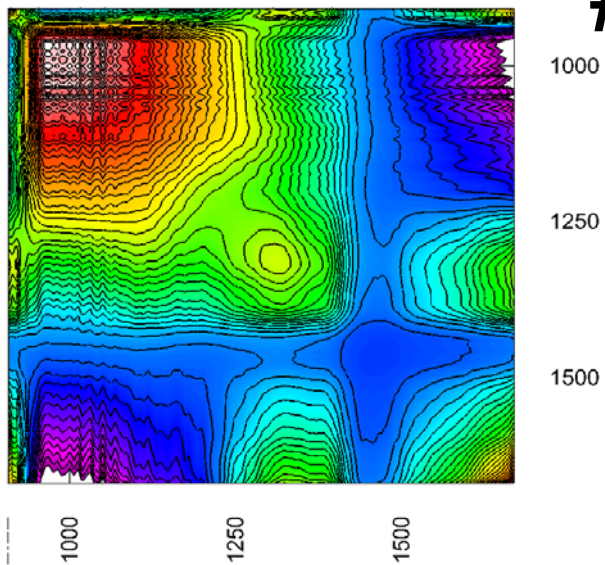


1000
1250
1500

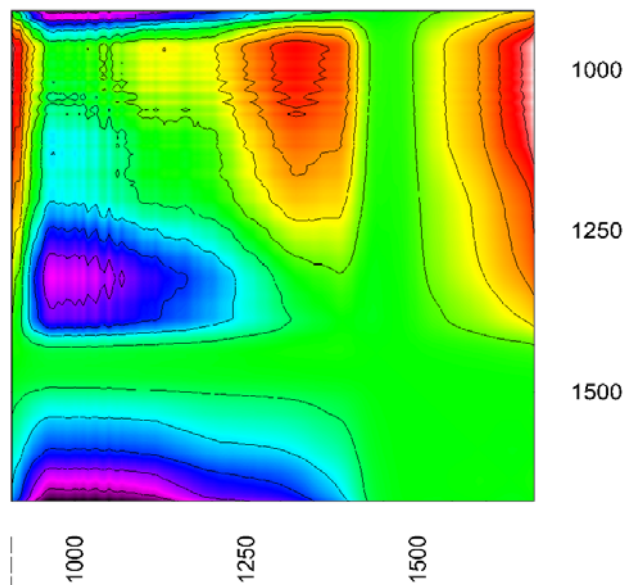
asynchronous 2D spectra



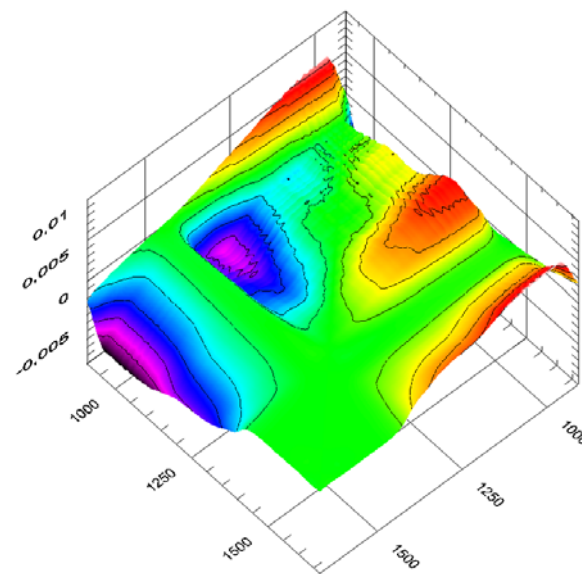
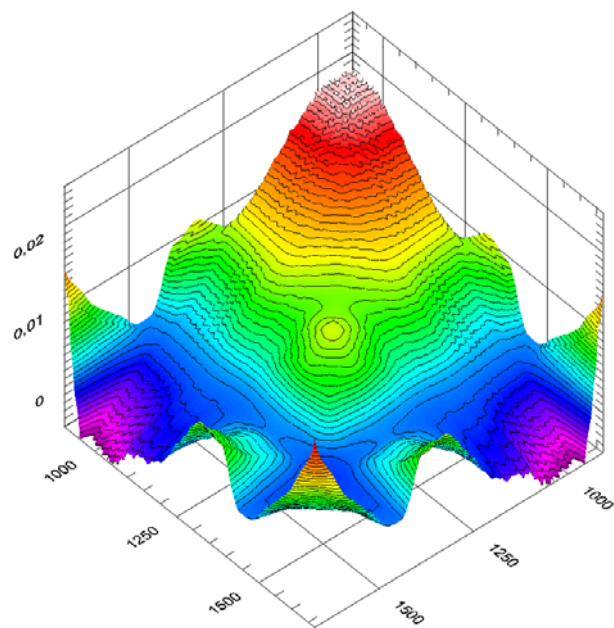
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synchronous 2D spectra

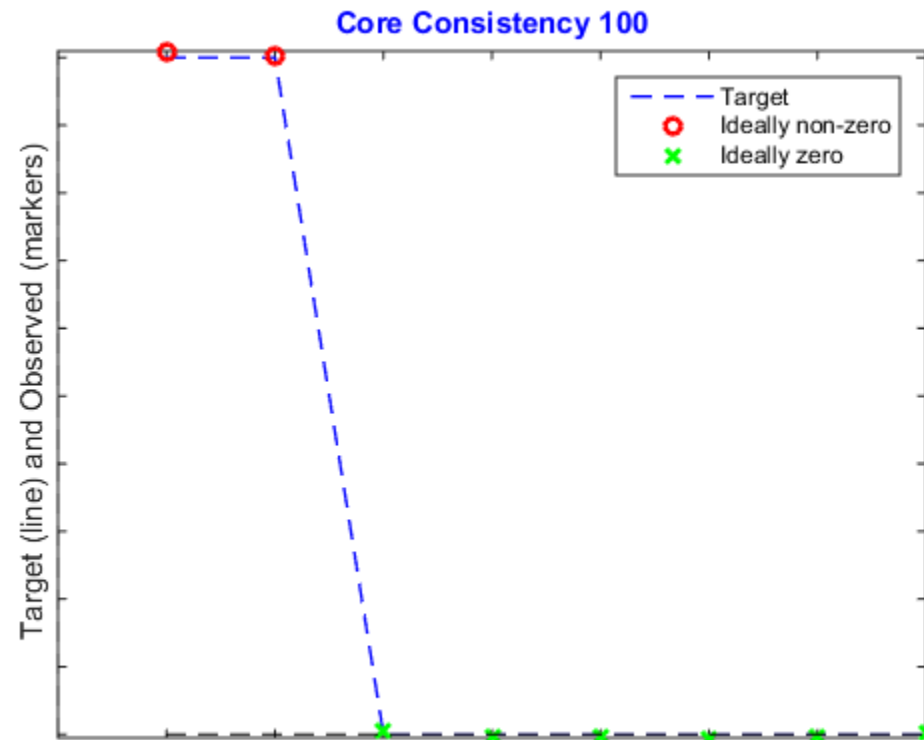


asynchronous 2D spectra



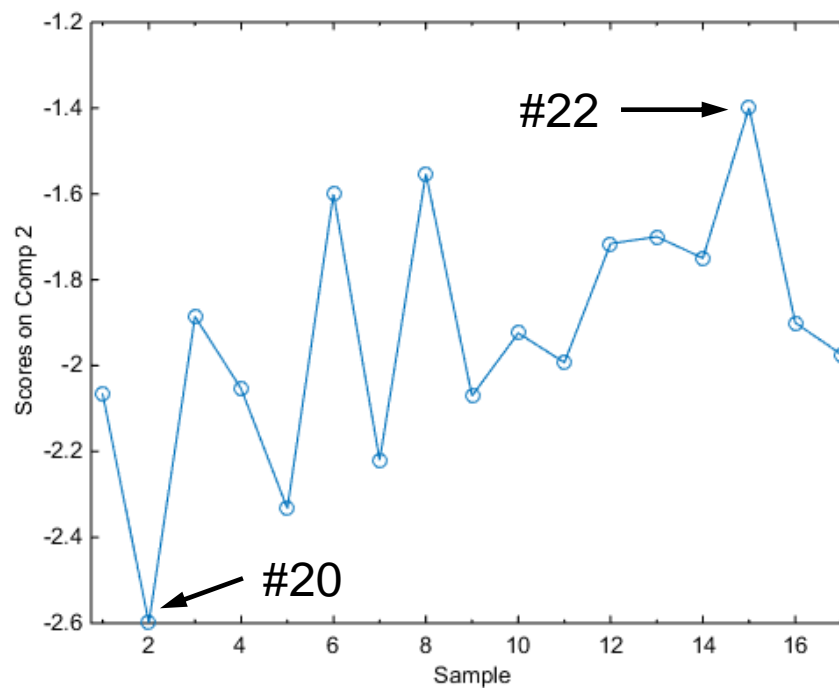
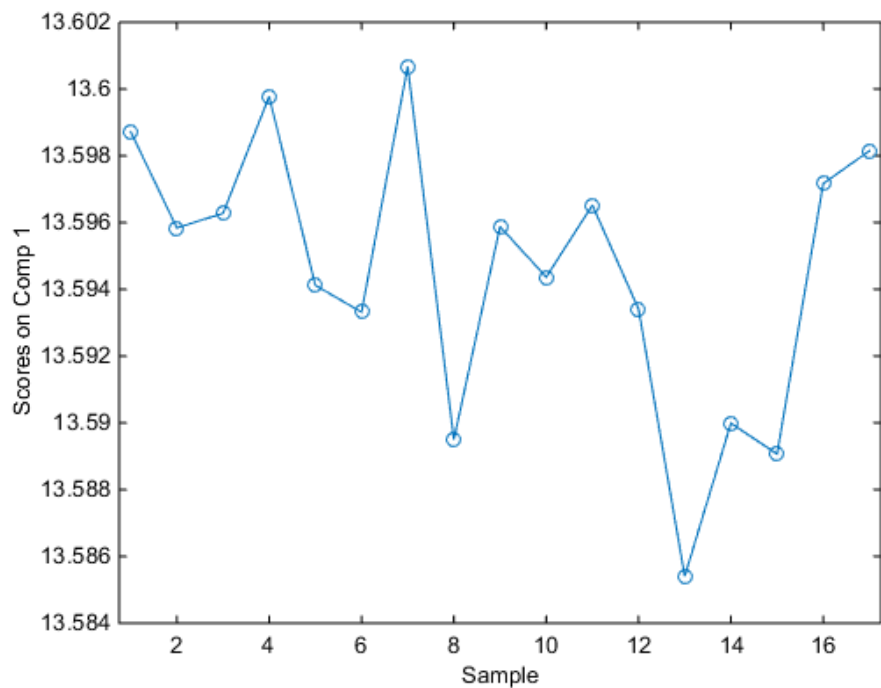
NIR parafac

- Consistency plot



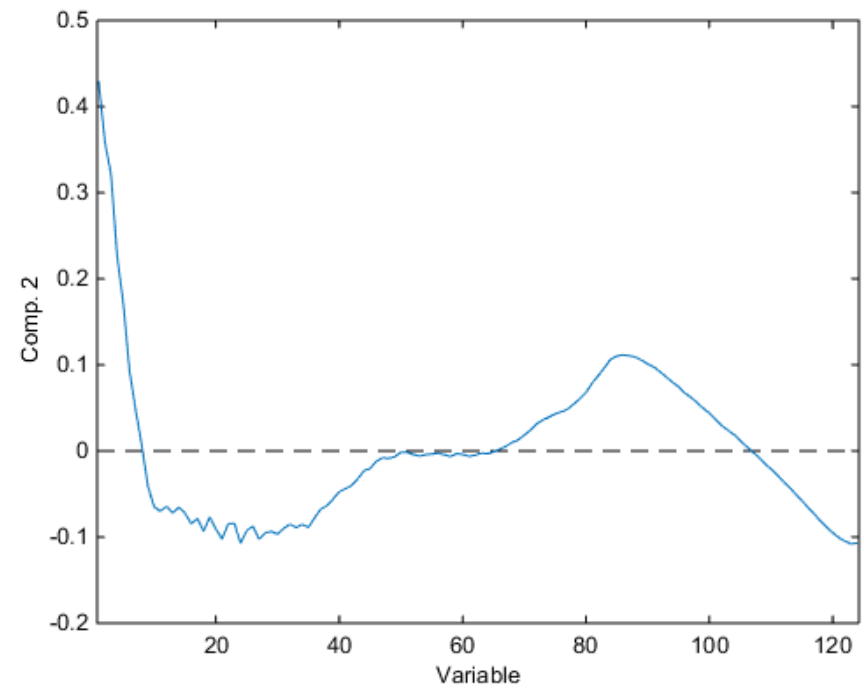
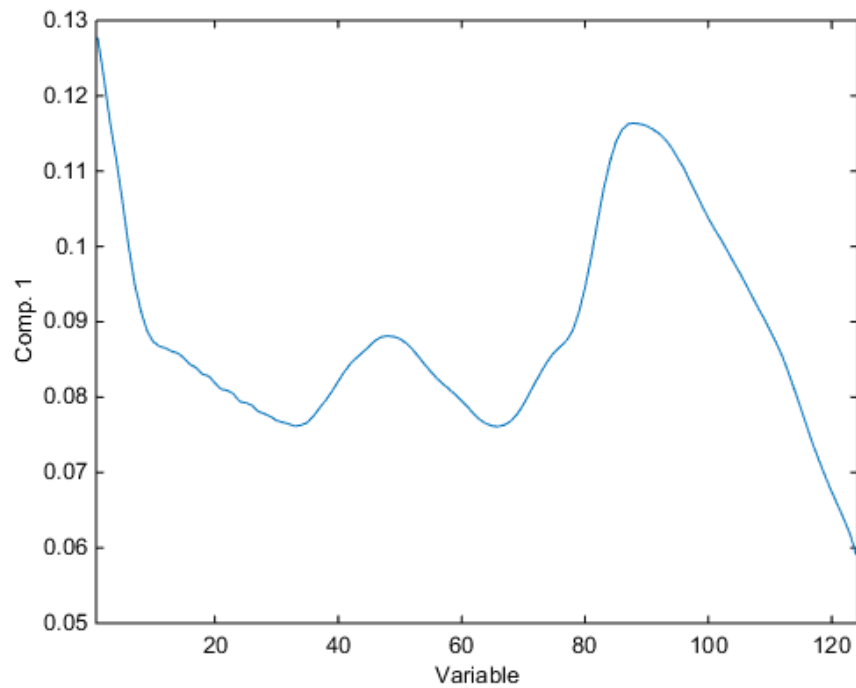
NIR parafac

- Effect of provenance



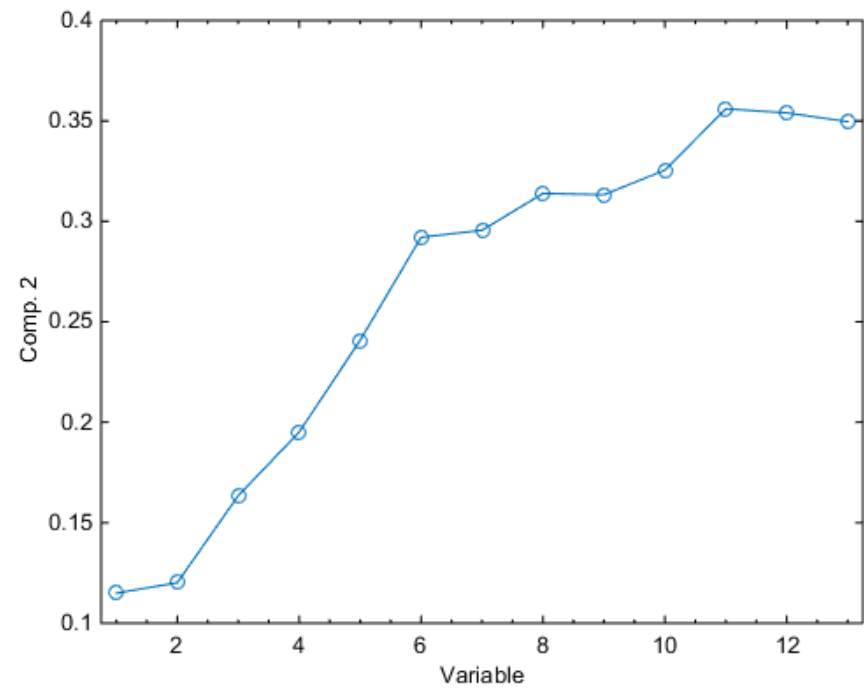
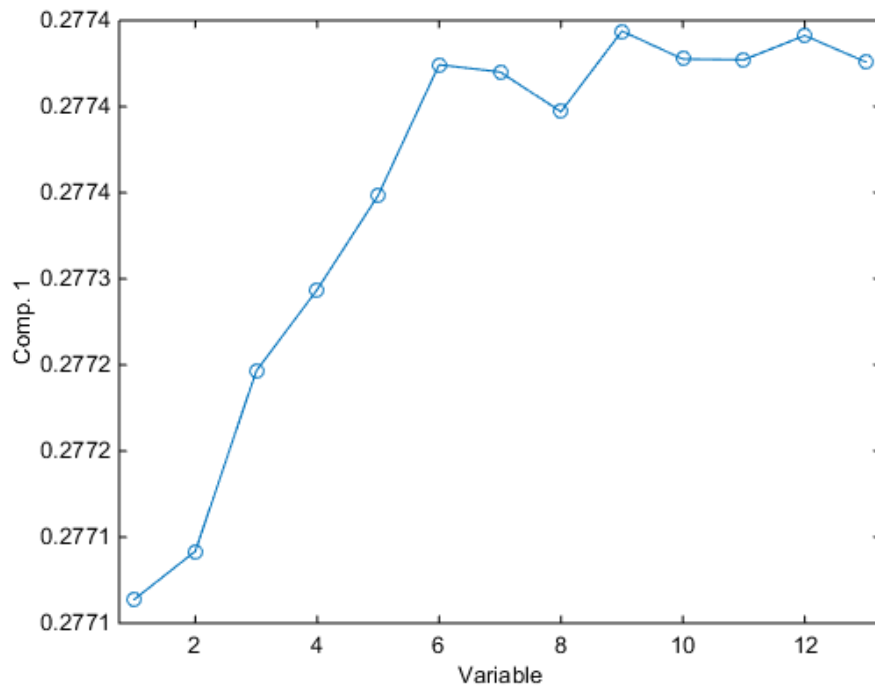
NIR parafac

- Effect of spectra



NIR parafac

- Effect of time

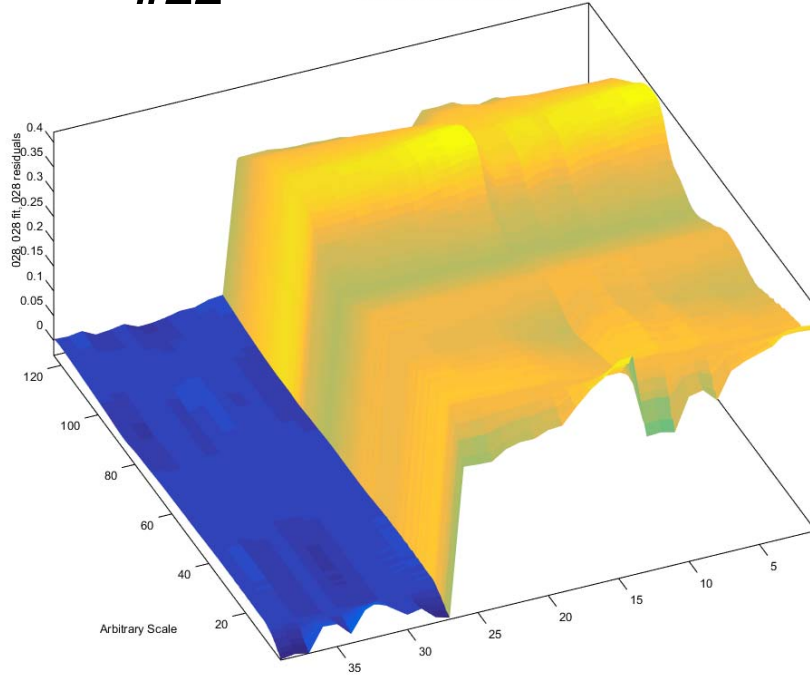


NIR parafac

- Reconstructed spectra with parafac

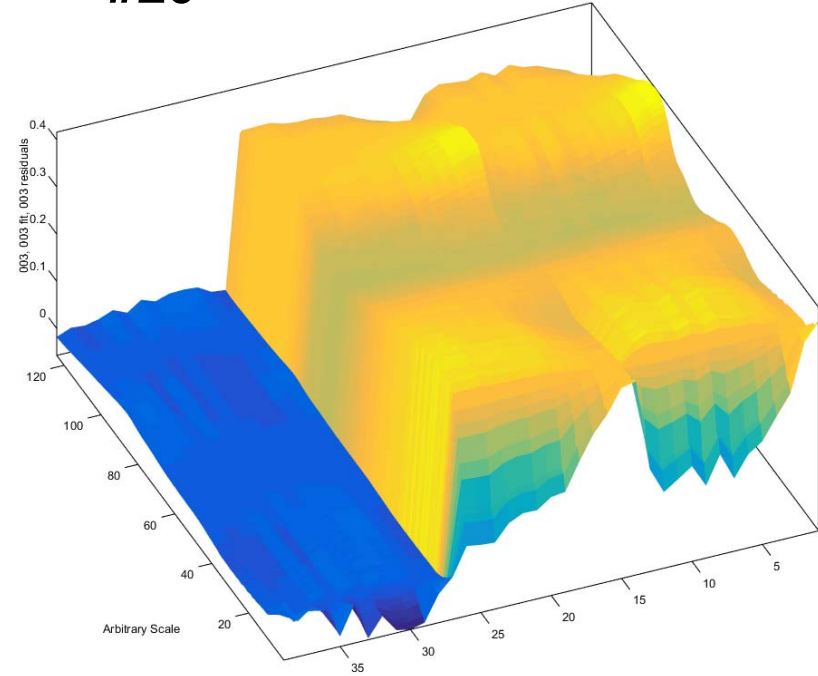
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028, 028 fit, 028 residuals

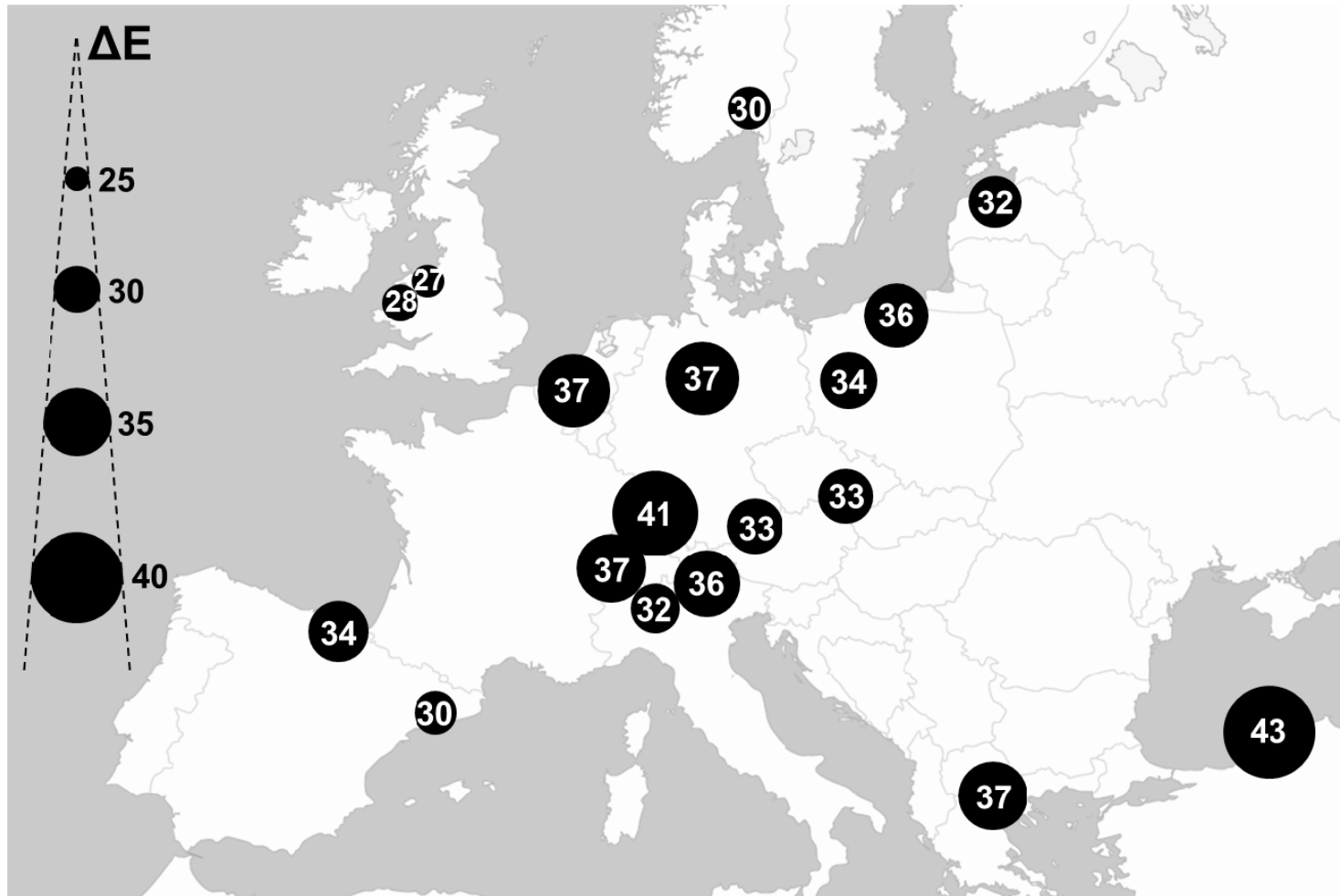


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003, 003 fit, 003 residuals



Conclusions



Conclusions

- Understanding the mechanisms of weathering and the role of the altering factors is fundamental to assess the actual conditions of timber structures.
- It is essential to predict the future performance, and, possibly, to ensure a long-term preservation and maintenance.

Acknowledgments

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Thank you!



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