



# STSM: Surface characterisation of spruce to understand the effects of natural weathering

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## 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 change in colour.
- 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



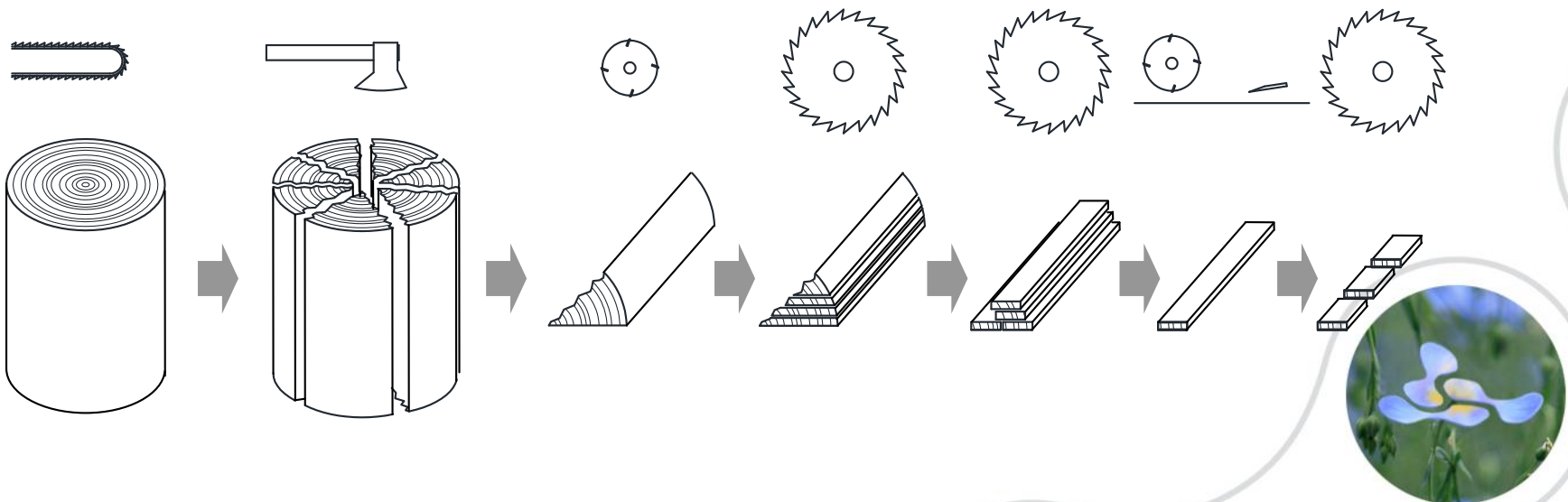
Samples weathered for one year, collected every month





## Experimental samples

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



## Weathering effect evaluation

- Undertaken tests
- Aesthetical changes
  - Colour
  - Imaging
  - Visual grading
  - Glossiness
- Chemical changes
  - FT-IR
  - FT-NIR
  - UV-VIS-NIR
  - Micro NIR
  - XRF
- Morphological changes
  - Laser displacement sensor
  - Laser line
  - Focus depth measurement



# Weathering effect on samples



Reference samples



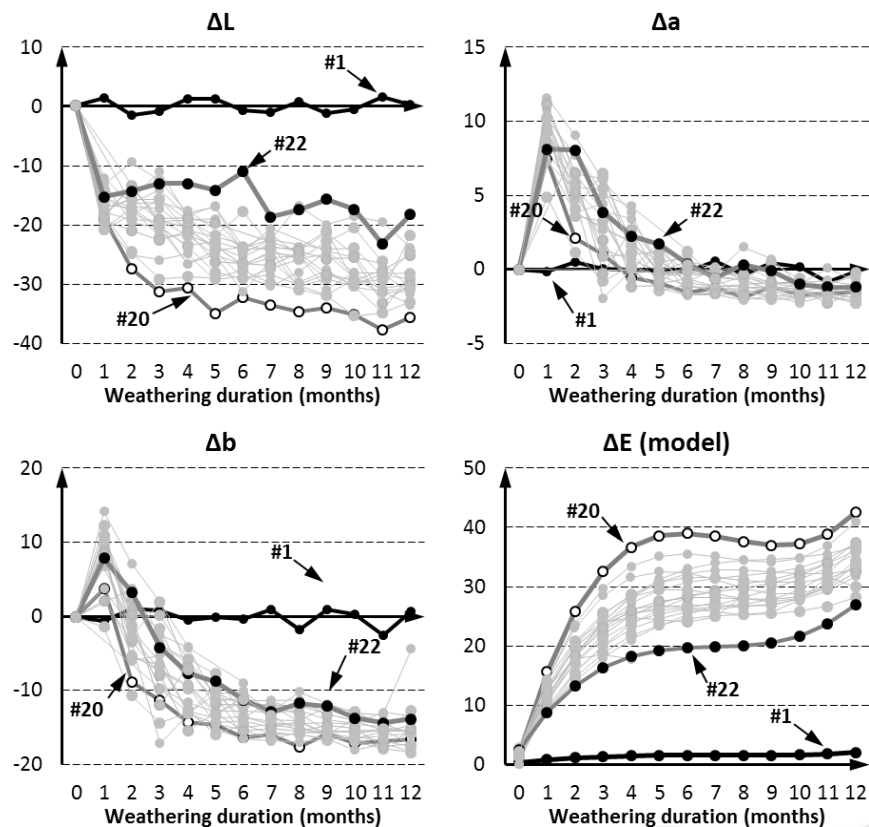
#22



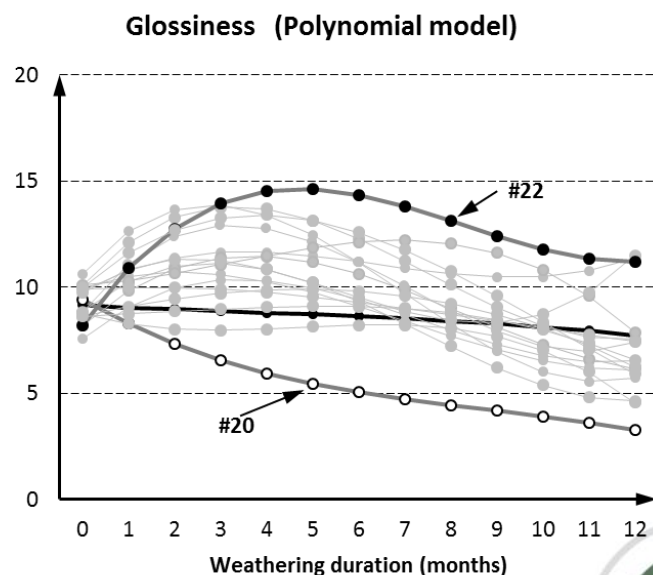
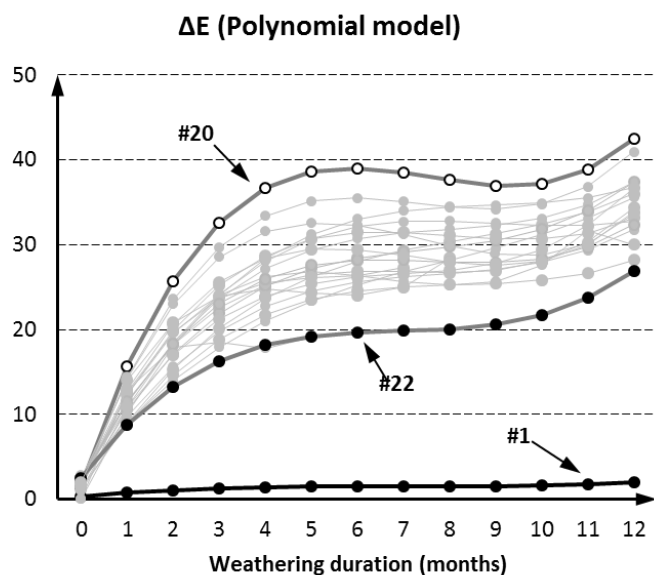
#20



# Changes in colour

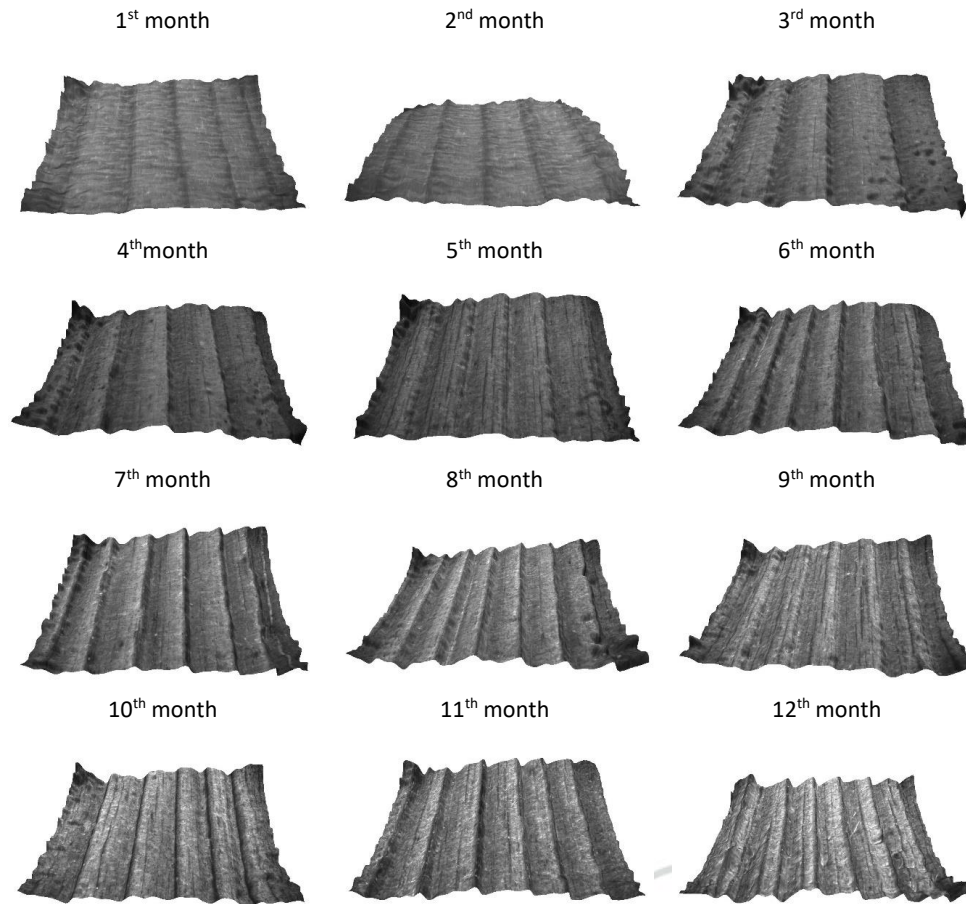


# Changes in colour and glossiness



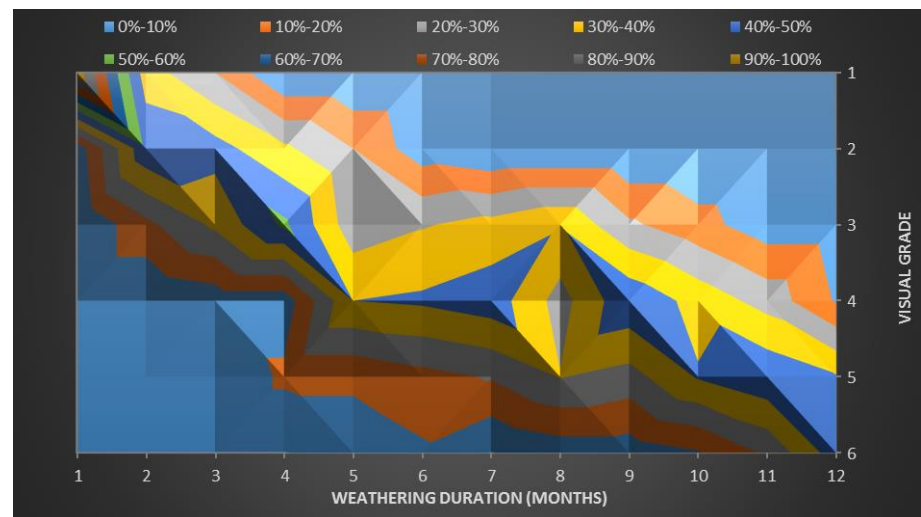
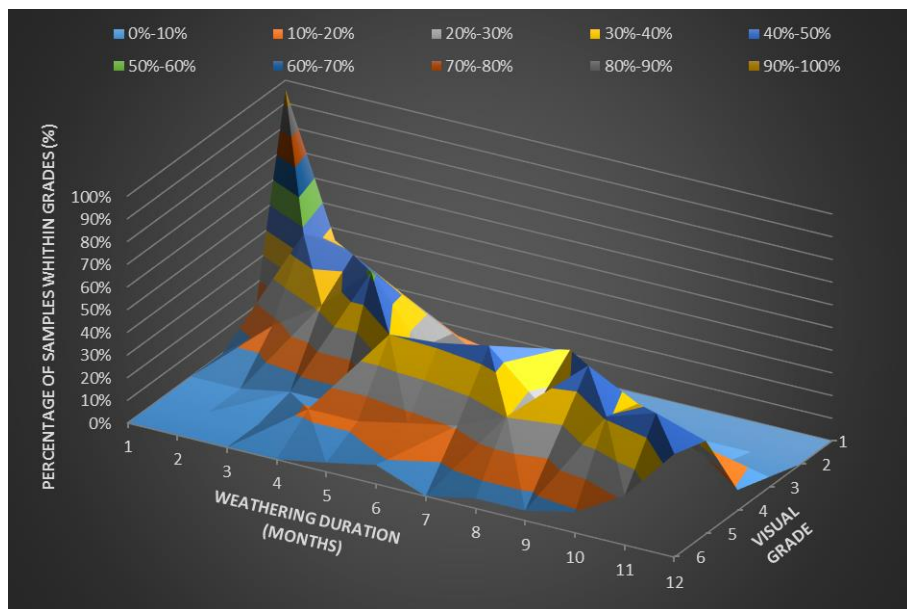


# Surface erosion: Depth of field

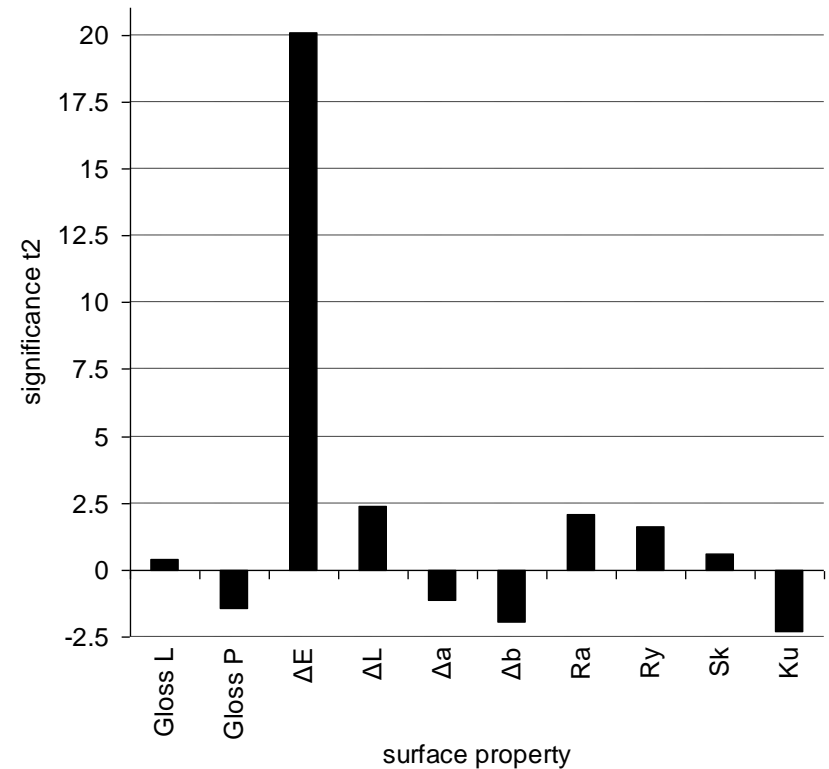
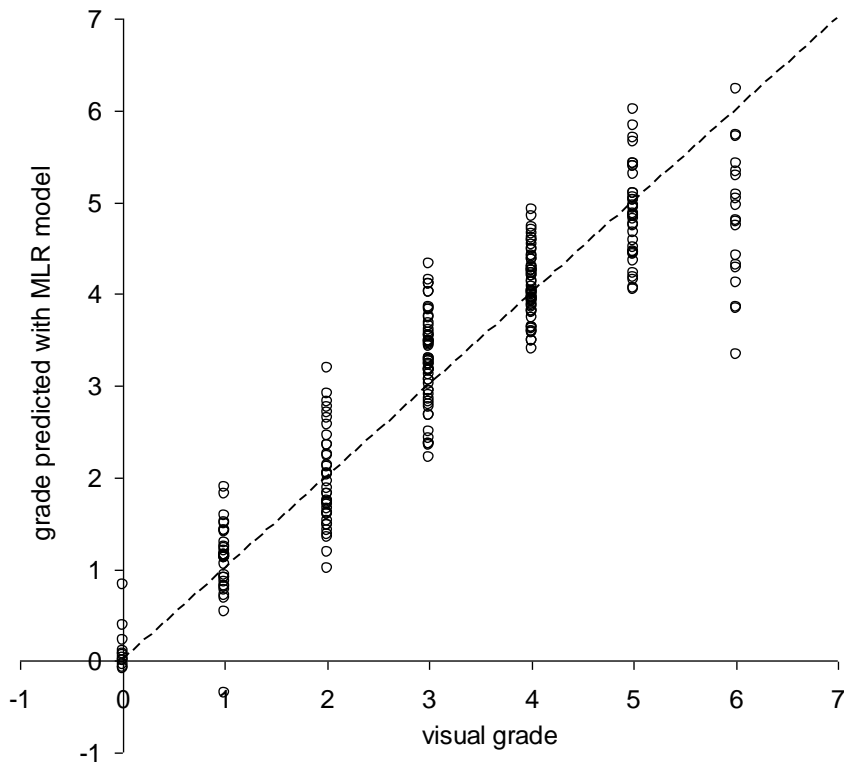


<b>Grading</b>	<b>Degradation</b>	<b>Characteristics</b>
0	No degradation	No colour changes
1	Small aesthetical changes	Yellow appearance
2	Mild aesthetical changes	Yellow grey appearance
3	Moderate aesthetical changes	Light grey colour
4	More intense changes	Grey colour with warm tonality, no visible 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



# MLR prediction model of morphological characteristics

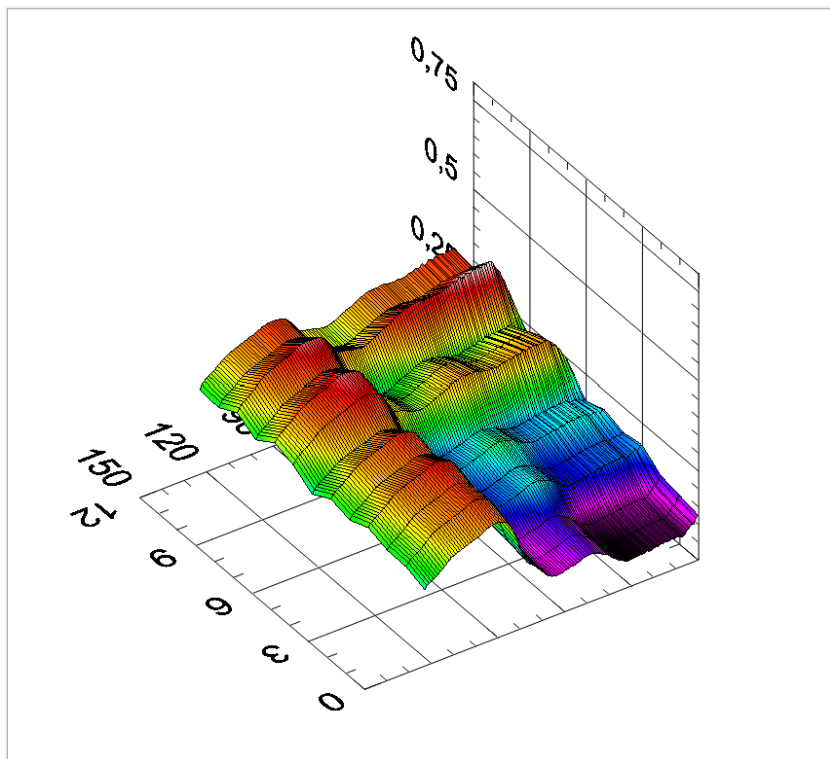




# NIR correlation spectroscopy

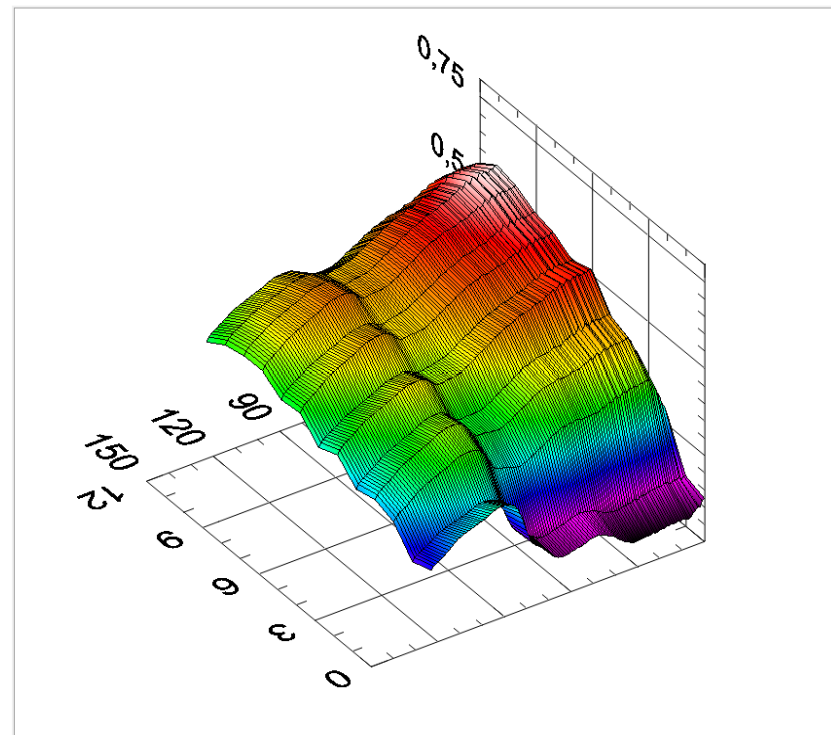
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raw spectra

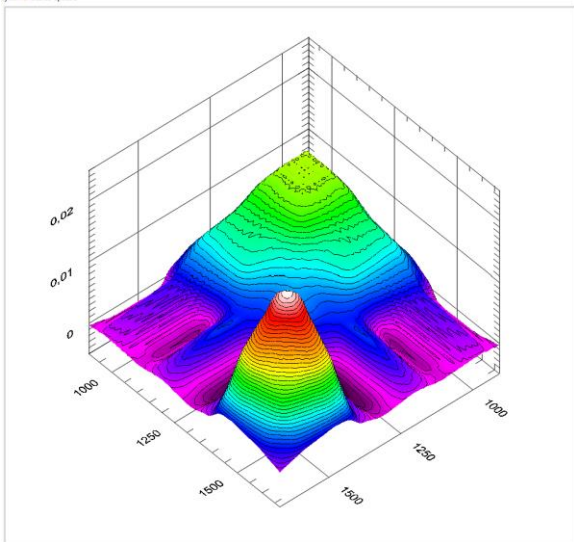


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raw spectra

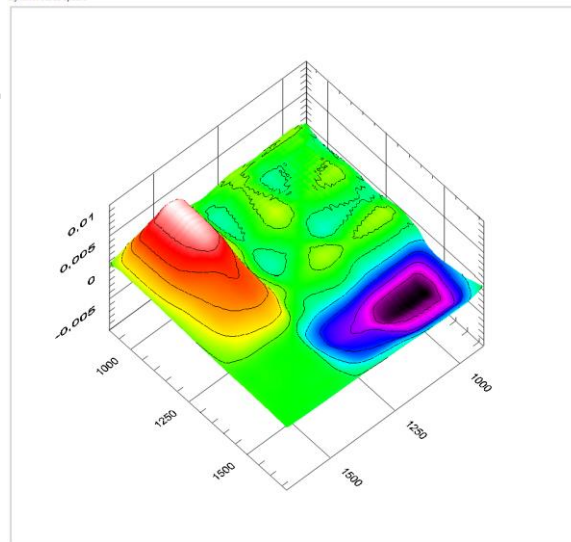


synchronous 2D spectra

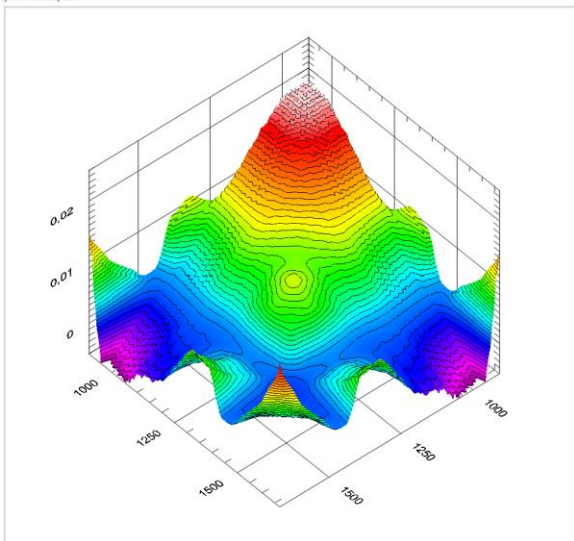


#22

asynchronous 2D spectra

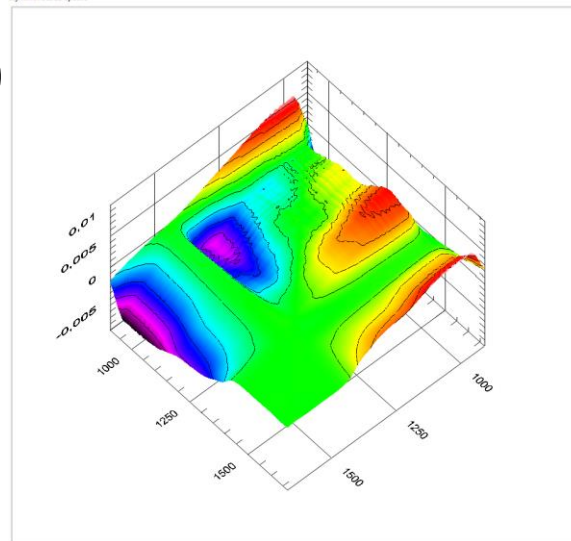


synchronous 2D spectra



#20

asynchronous 2D spectra

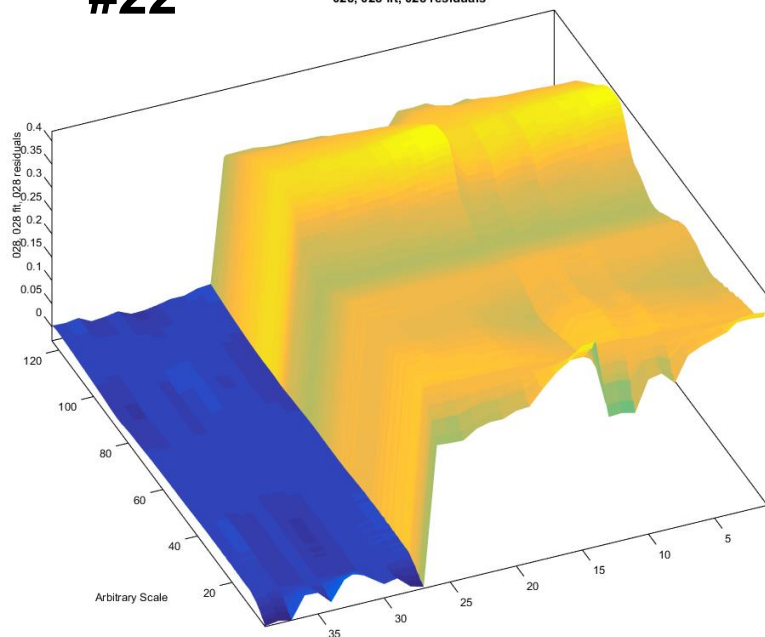


# NIR parafac

- Reconstructed spectra with parafac

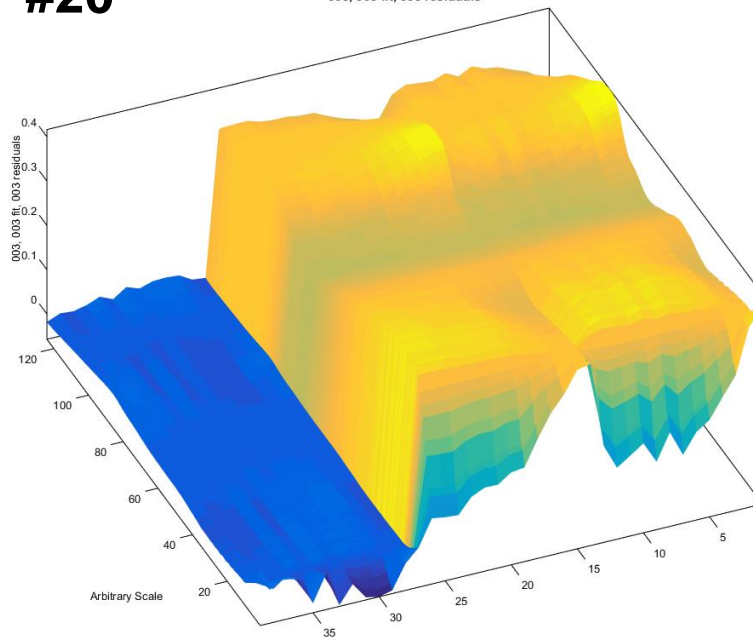
**#22**

028, 028 fit, 028 residuals



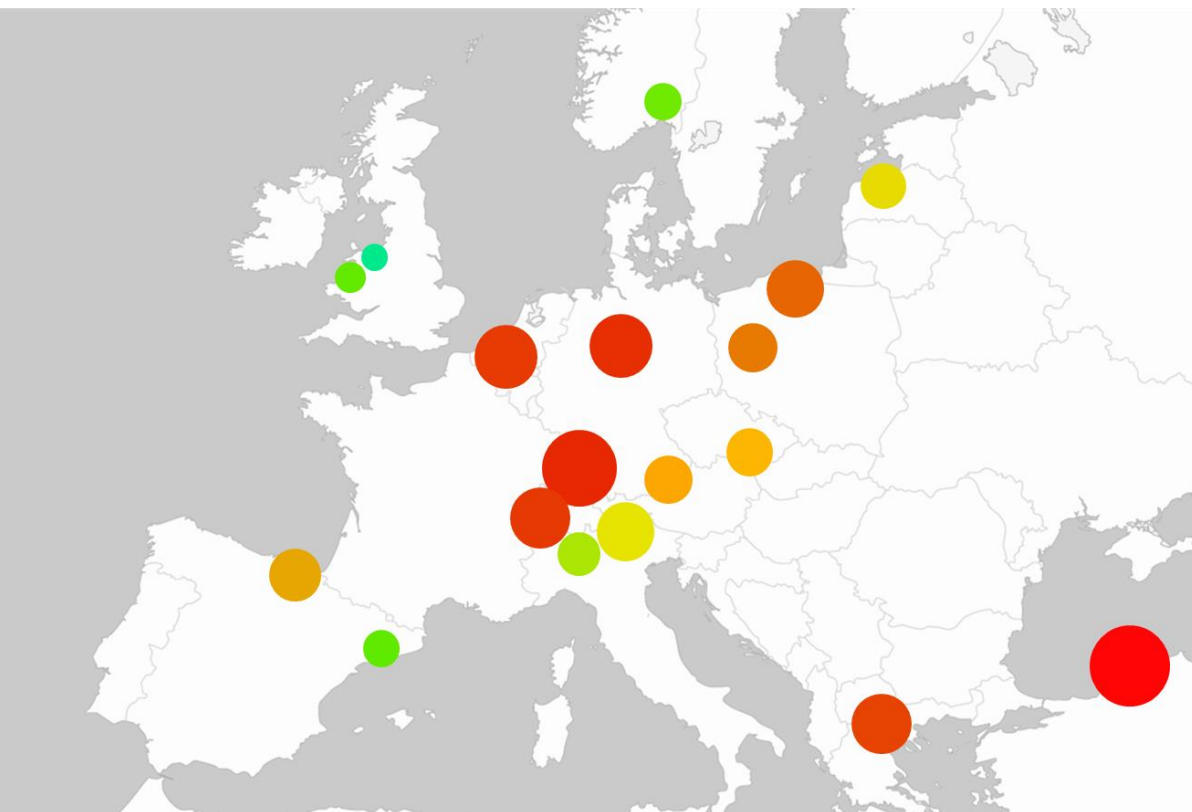
**#20**

003, 003 fit, 003 residuals



# Conclusions

Country	City	$\Delta E$ colour change
UK	Henfaes	27
UK	Bangor	28
Spain	Barcelona	30
Norway	As	30
Italy	San Michele	31
Italy	Sporminore	32
Latvia	Riga	32
Hungary	Sopron	33
Austria	Kuchl	33
Poland	Poznan	34
Spain	San Sebastian	34
Poland	Nowe	36
Greece	Thessaloniki	37
Switzerland	Biel	37
Belgium	Brussels	37
Germany	Göttingen	37
Switzerland	Duebendorf	41
Turkey	Bartın	42





## Conclusions

- The weathering effect is strongly influenced by the exposure location
- The highest colour changes ( $\Delta E$ ) occurred in Turkey and the lowest in UK
- The weathering kinetics showed similar trend in various magnitude among the different locations concerning the colour effect



## Conclusions

- Different chemical changes occur at the end of the weathering exposure. This might be a result of diverse intensity of the degradation process, like hydrolysis and photo degradation, related to the specific weather conditions of the sample exposure
- It is possible to accurately model the NIR spectral changes along the exposure duration and location
- Visual grading and MLR model showed that human perception on weathered wood is predominantly affected by colour



## Acknowledgments

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INNOVATION IN BIO-MATERIALS FOR INDUSTRY

Thank you for your attention!

