

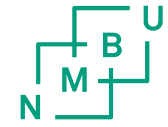


# Weather degradation of thin wood samples assessed with NIR spectral imaging

Ingunn Burud,

NORWEGIAN UNIVERSITY OF LIFE SCIENCES

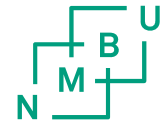
Knut Arne Smeland, Thomas Thiis, Anna Sandak, Jakub Sandak, Lone  
Ross Gobakken, Kristian Liland



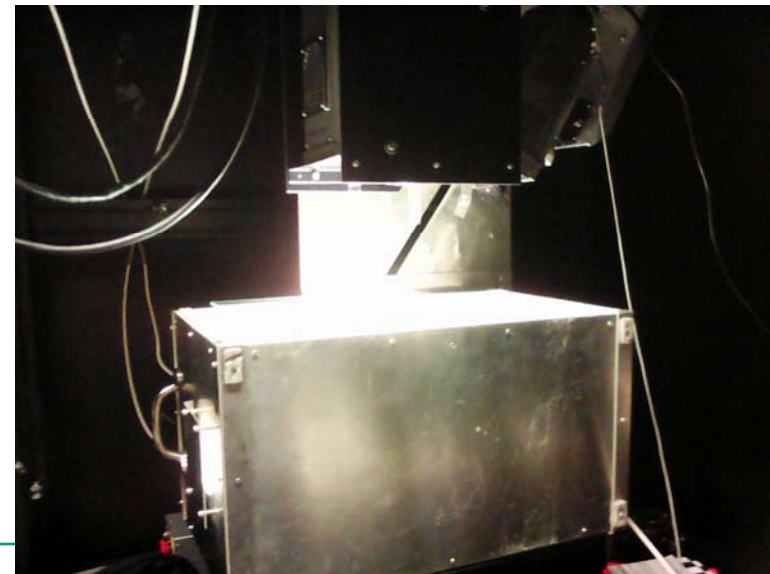
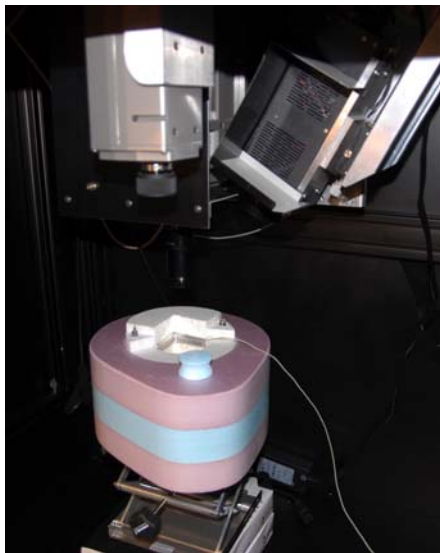
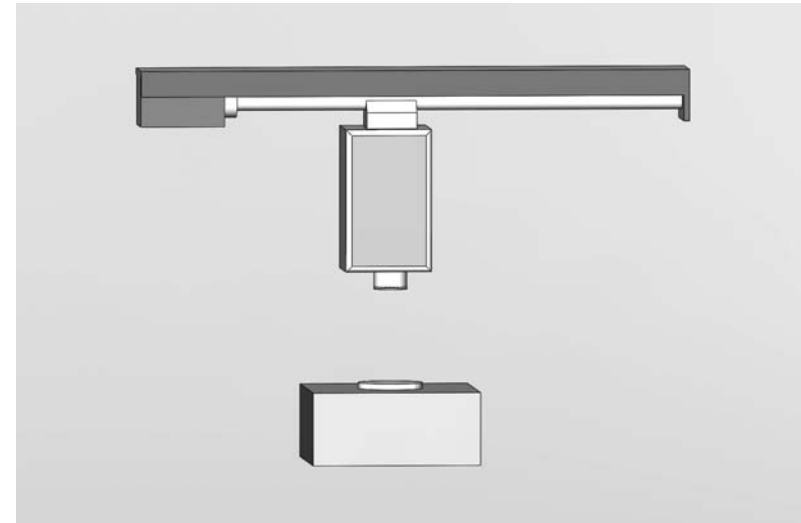
# Norwegian University of Life Sciences



# Hyperspectral cameras at IMT (Department of Mathematical Sciences and Technology)

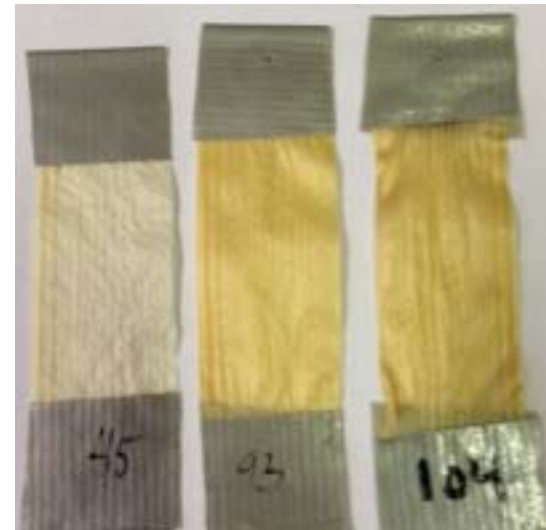
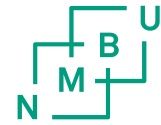


VIS/NIR 400-1000 nm (Specim)  
NIR 1000-2500 nm (Specim)  
NIR 900-1700 nm (NEO)  
VIS/NIR 400-1000 nm (Bayspec)





# Weathering of thin wood samples



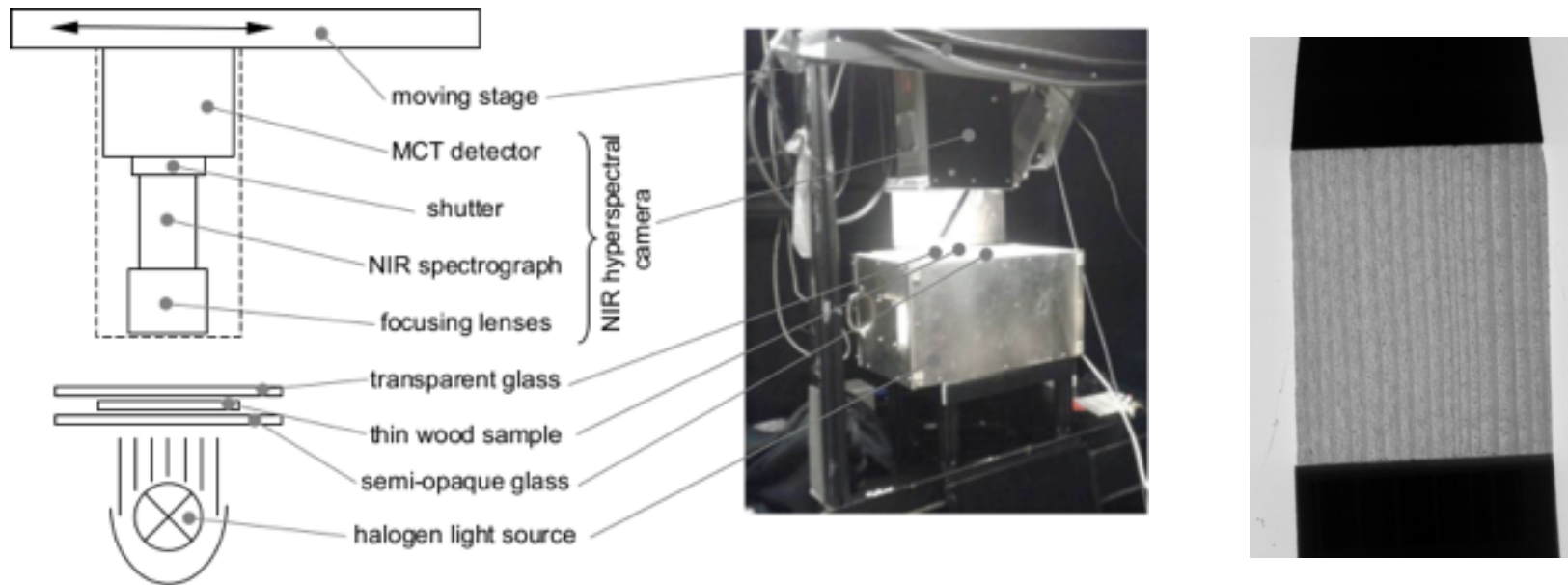
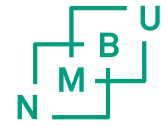
21 x 5 thin samples (100 microns)  
facing south

Close to meteorological station

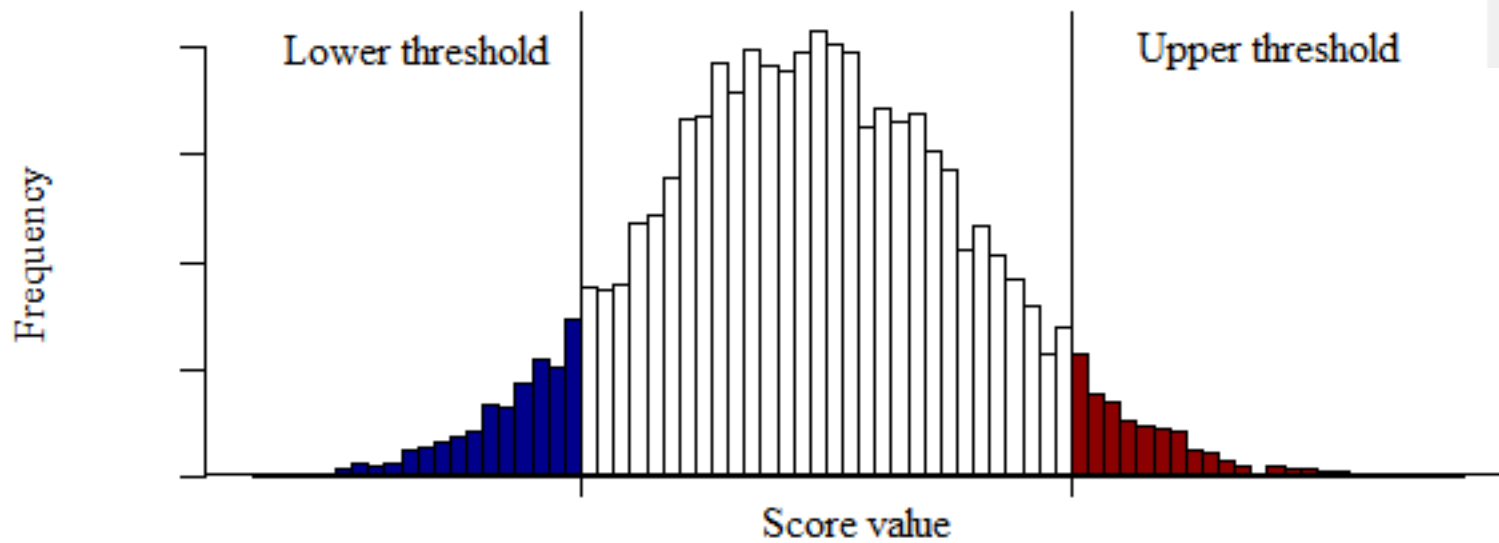
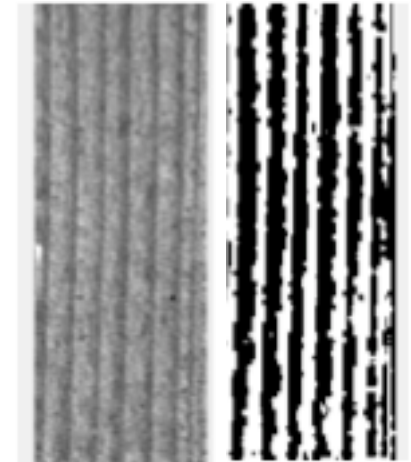
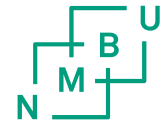
Exposure times from 1 to 21 days

UV chamber exposure (Atlas UVTest™)

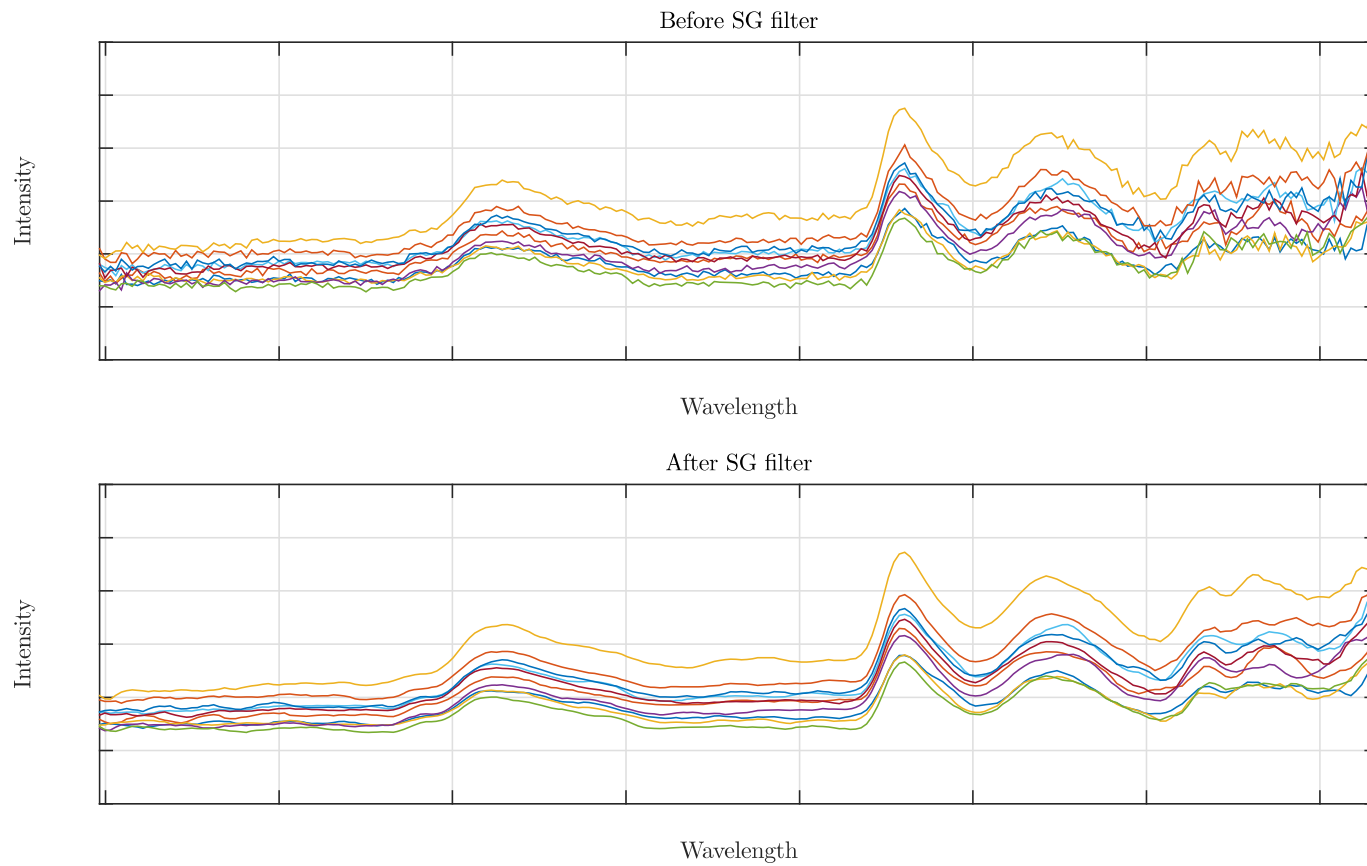
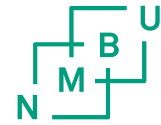
# Hyperspectral imaging in transmission mode



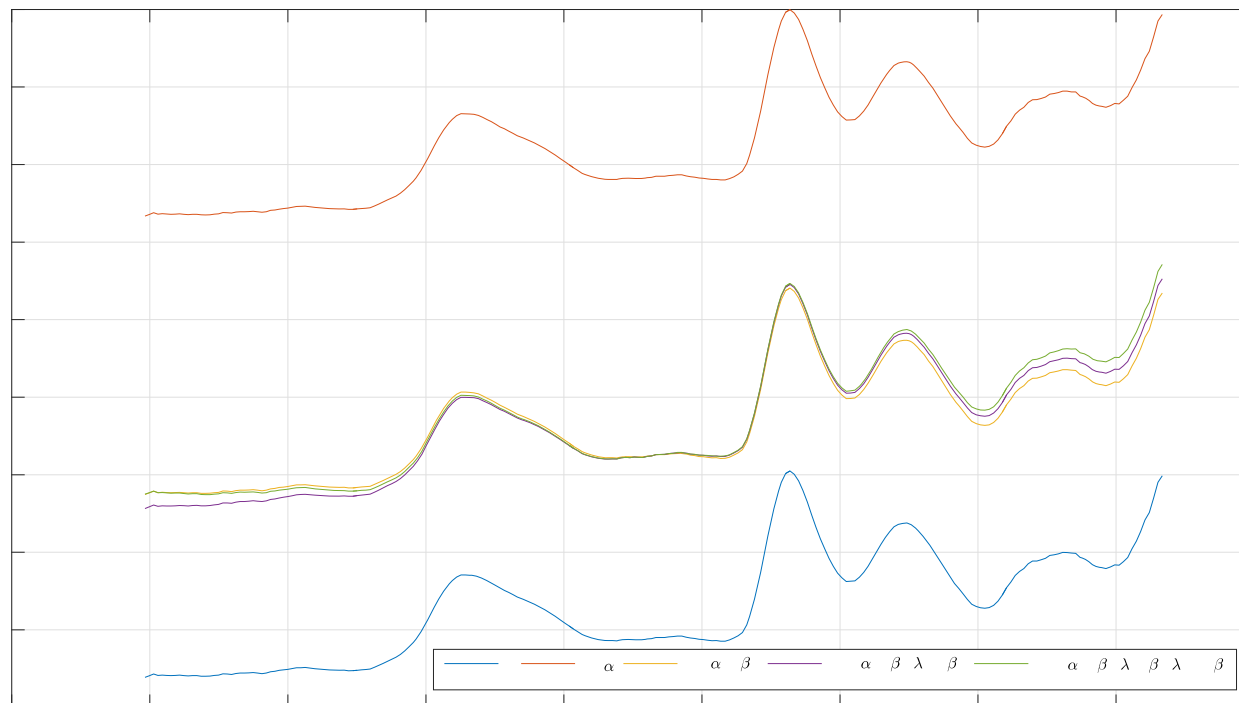
# Extracting mean spectra from earlywood and latewood



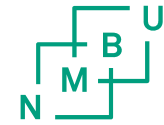
# Smoothing with a Savitsky Golay filter







$$z_{\text{observed}} = \alpha + \beta_1 m + \beta_2 \lambda + \beta_3 \lambda^2$$

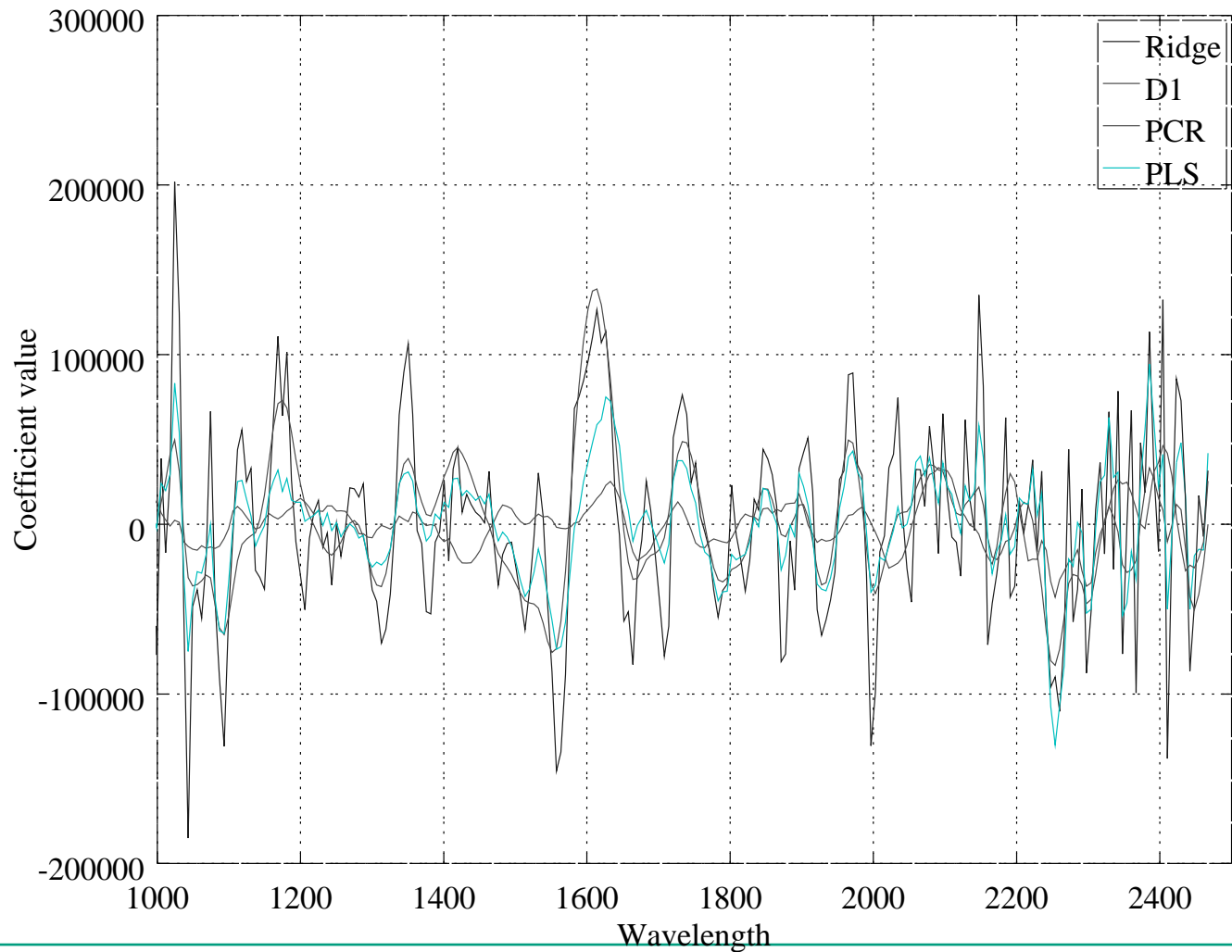
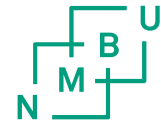


# Regression algorithms

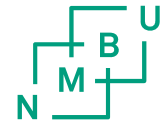
- Test of robustness (bias versus variance)
  - PCR
  - PLS
  - Ridge regression
  - Tikhonov 1D

# Coefficient vectors

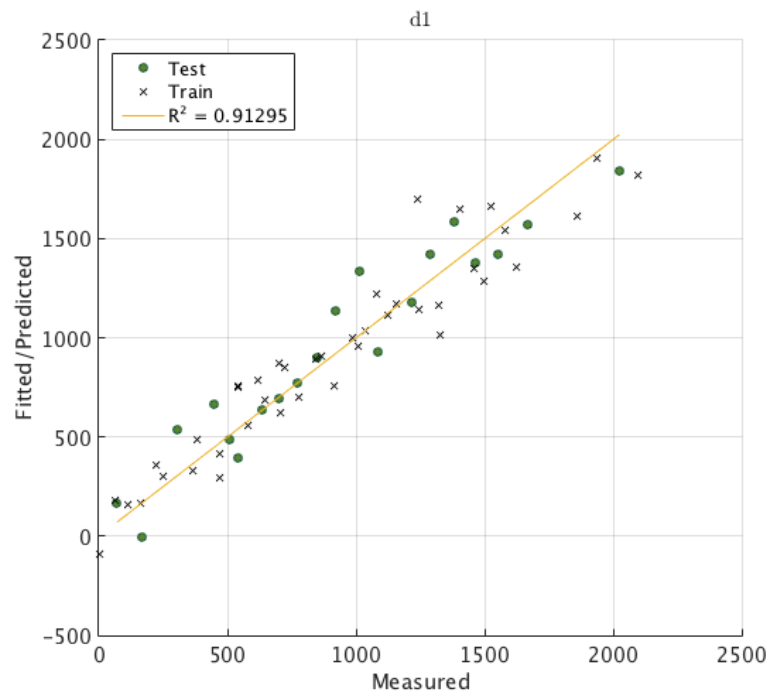
$$X\beta = y$$



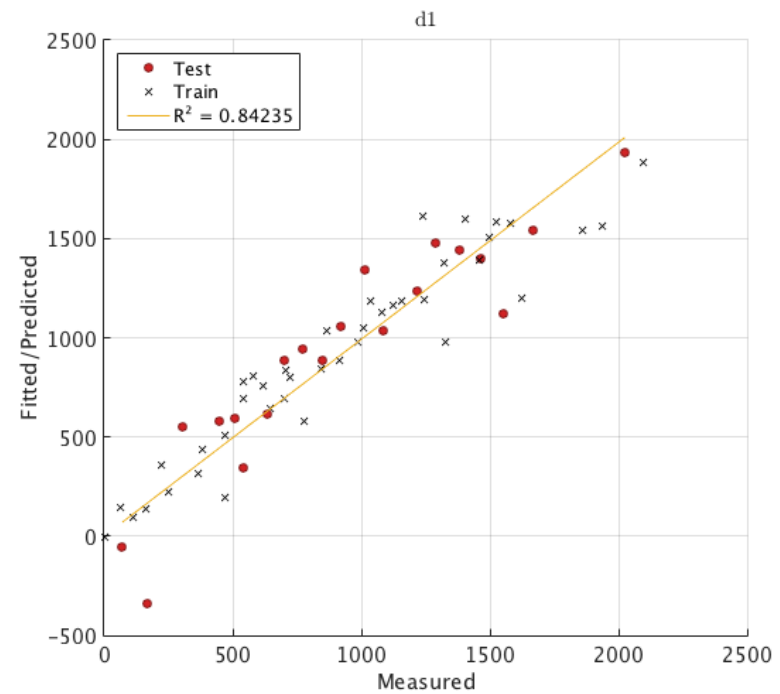
# UV radiation to model weathering effect with Tikhonov regression



## Earlywood

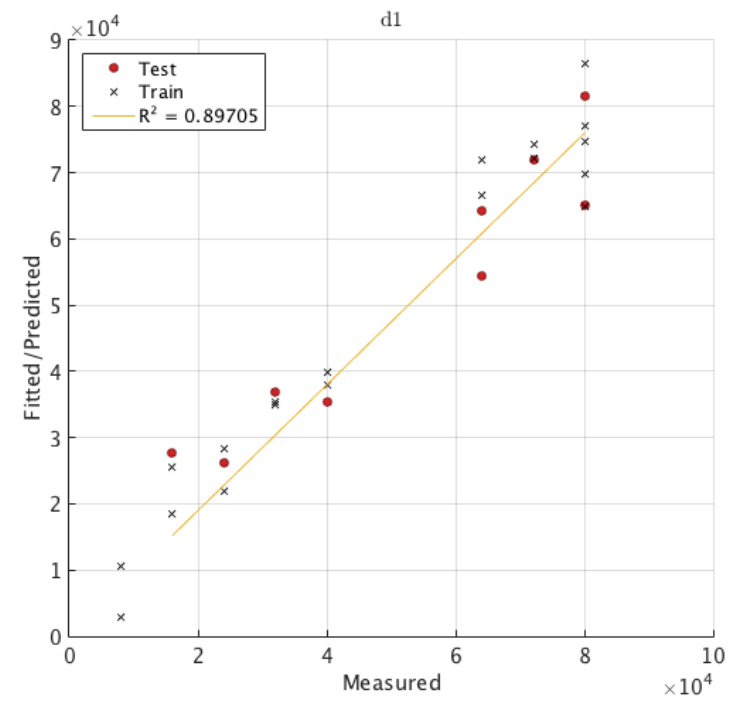
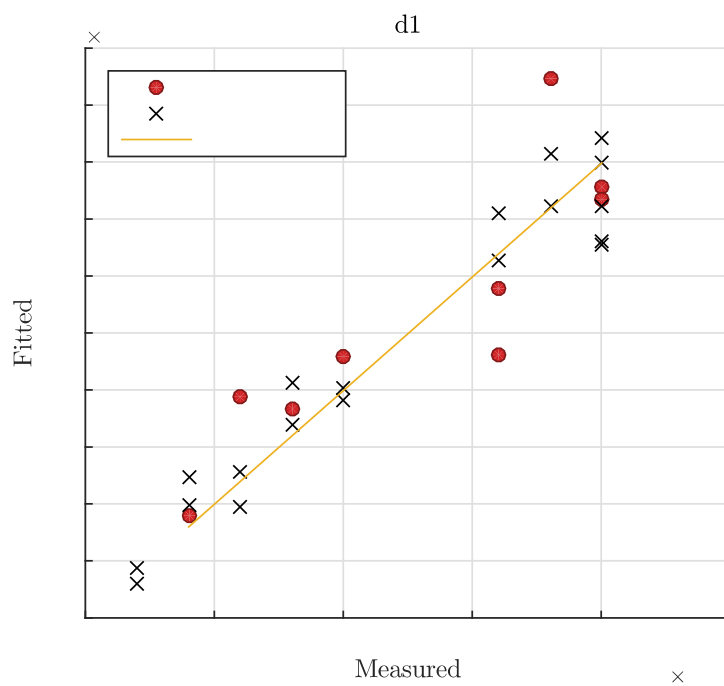


## Latewood

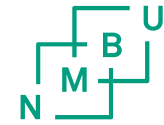


70 % of data in training set, 30 % in validation set

# Samples from UV chamber



# Thermogravimetry

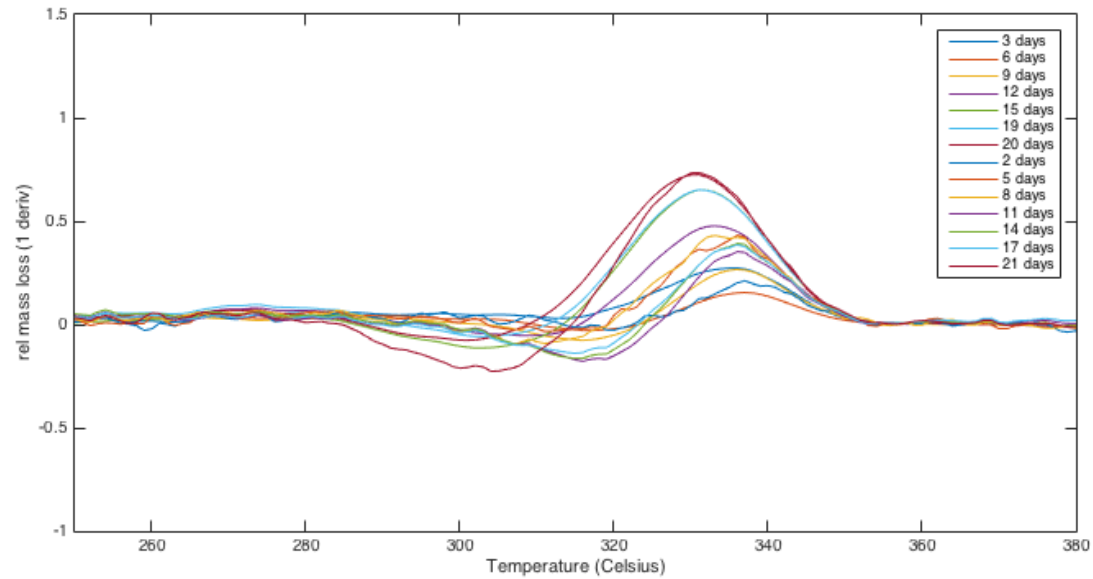
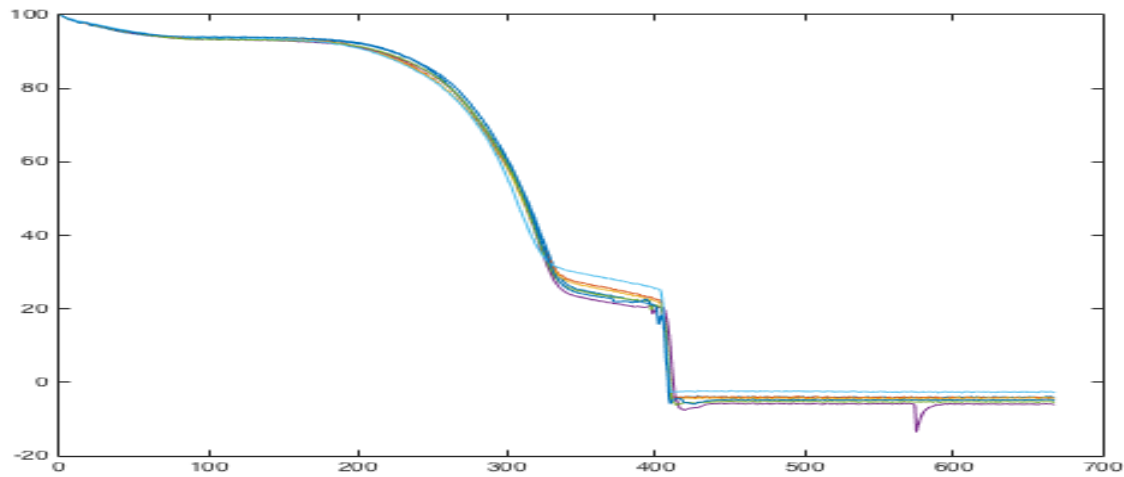
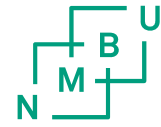


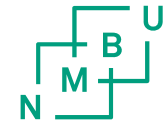
- STA – lignin estimate
- % lignin relative to weight of sample increases with weathering
- Weight of sample decreases with weathering
- Need to know exact weight of sample



Simultaneous Thermal Analyzer coupled with a Fourier Transform InfraRed spectrometer

# TGA curves





# Challenges – future work

- Measure the density of the weathered samples
- Relates NIR spectra to lignin degradation
- Include other meteorological parameters in addition to UV radiation (moisture, temperature)
- Determine a weather dose for the wood weathering



