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CO_2 Dynamics in the Pore Volume of Stored-Grain Bulk: Data Acquisition and Analysis via Machine Learning

Iris Ramaj, Steffen Schock, Joachim Müller

Introduction

- Real-time monitoring of in-store grain bulks is a powerful tool for the early detection of incipient grain deterioration.
- This study aimed to investigate the influence of spatial and temporal in-store grain conditions on the intergranular CO_2 dynamics.

Material and Methods

- A storage silo (2011 × 5040 mm) filled with 10 tons of wheat grains (Pionier A DSV AG, moisture of 0.16 kgkg^{-1} dry basis) was employed as an experimental basis (Fig. 1).
- A sensor system network comprised of 12 sensor nodes developed in-house was installed equidistantly within the grain bulk.
- The grain and air conditions in terms of temperature *T*, relative humidity *RH*, atmospheric pressure *P*, moisture content *MC*, carbon dioxide CO_2 concentration were monitored in real-time.
- Supervised machine learning using Gaussian Process Regression (GPR) was employed as an analytical approach.
- A dataset of 360 days of grain storage with internment cooling and a measuring resolution of 10 min was selected for the training and validation procedures.

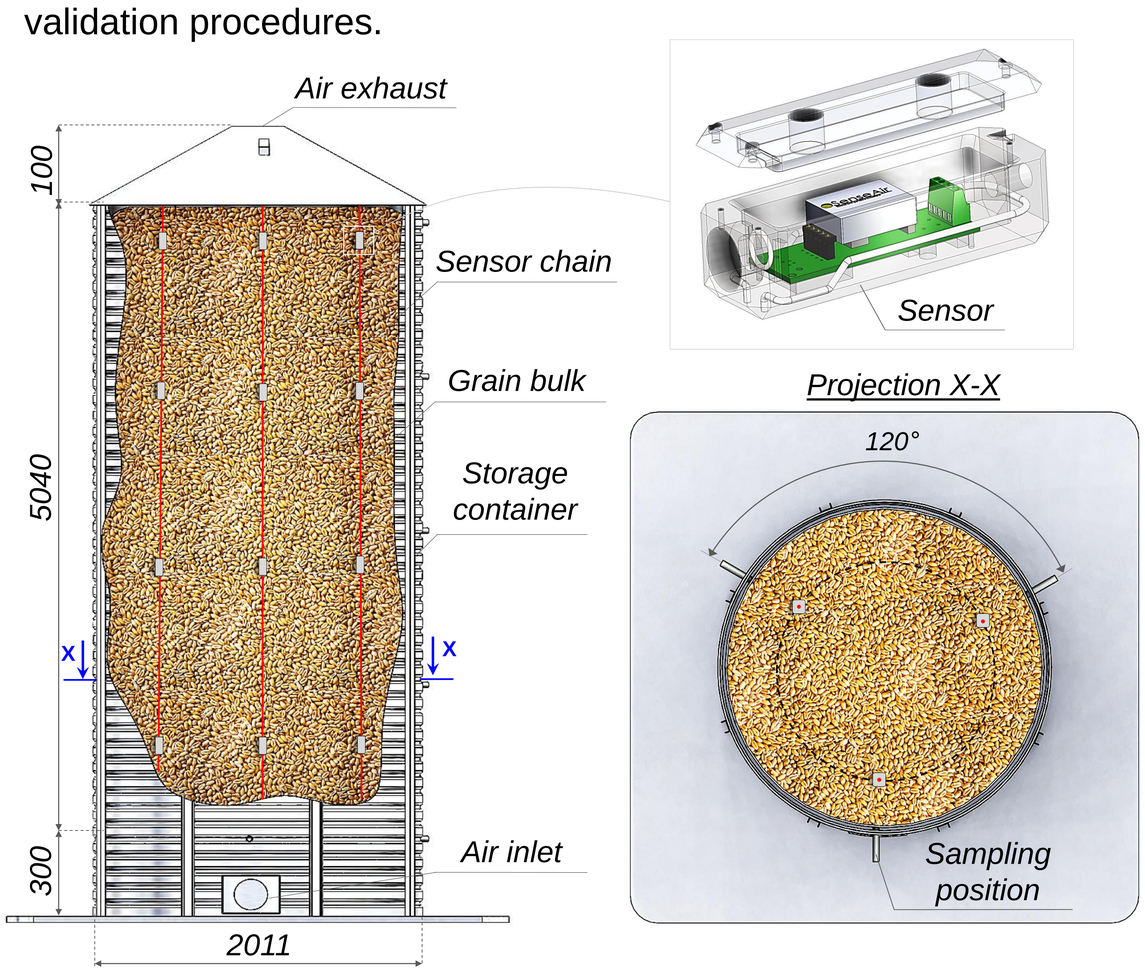

Fig. 1. Schematic design of the experimental set-up and sensor installation for the data acquisition (dimensions given in mm).

Results

- The intergranular CO_2 was highly influenced by the diurnal and seasonal variations of external environmental conditions of the storage facility (Fig. 2)

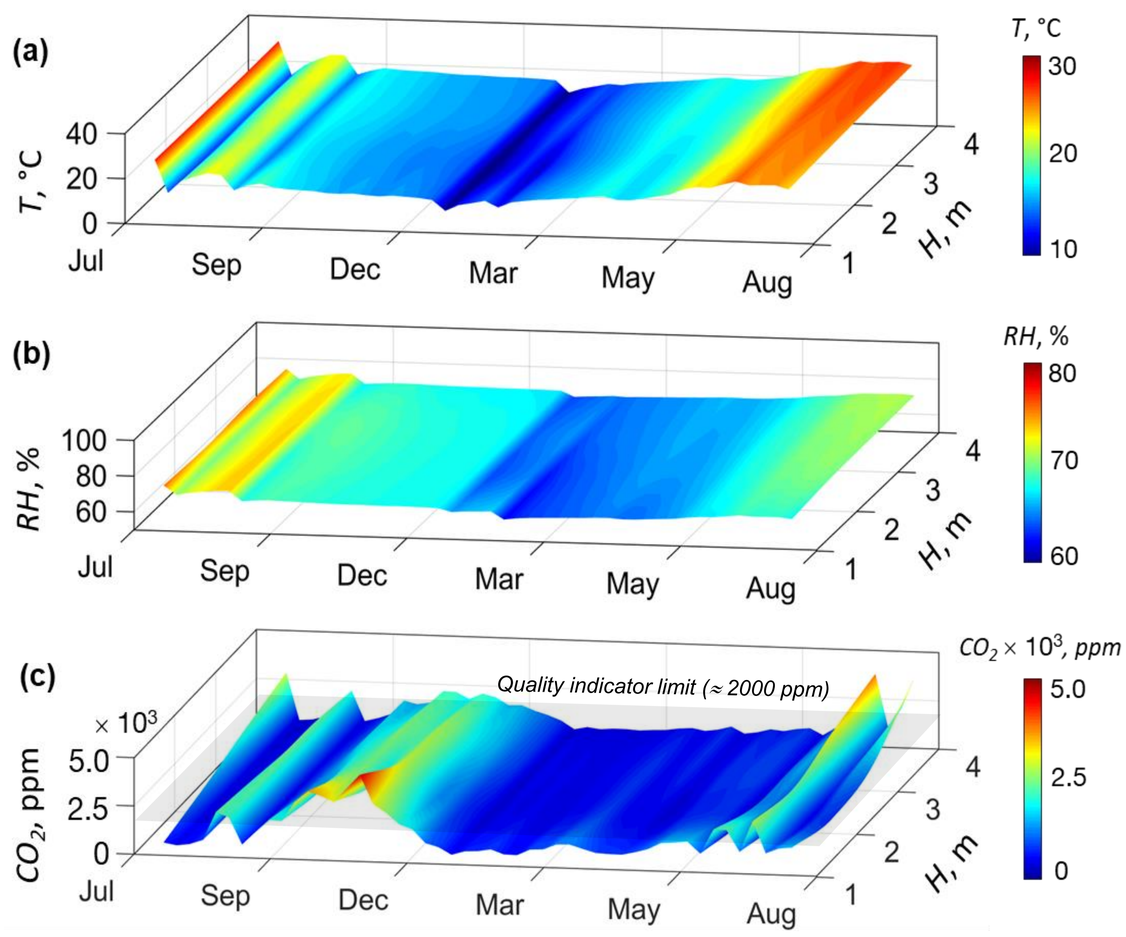

Fig. 2. Surface plot of (a) temperature *T*, (b) relative humidity *RH*, and (c) CO_2 concentrations dependent on the storage time and bulk height.

- CO_2 increased with the increase of temperature, relative humidity, moisture content of grain bulk and decrease of atmospheric pressure and bulk height.
- The model was able to predict at a high accuracy (R^2=0.99 and RMSE=20.65) the dynamic behavior of experimental data (Fig. 3).

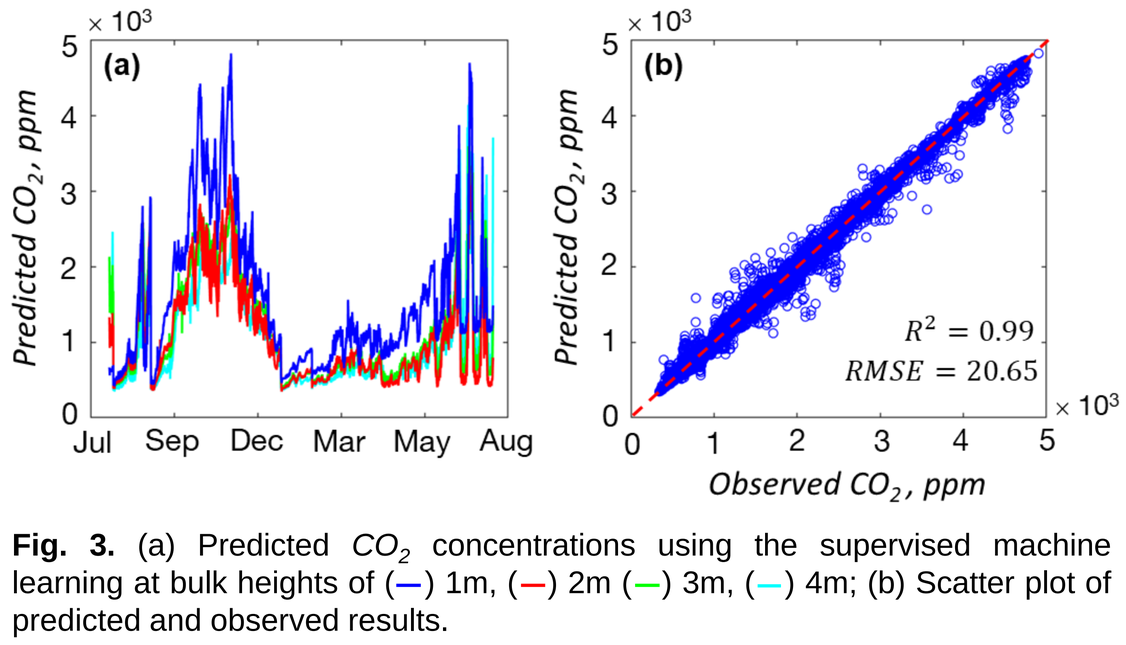

Fig. 3. (a) Predicted CO_2 concentrations using the supervised machine learning at bulk heights of (—) 1m, (—) 2m (—) 3m, (—) 4m; (b) Scatter plot of predicted and observed results.

Conclusions

- This work demonstrated a great potential of the applied machine-learning algorithm to predict the dynamics behavior of intergranular CO_2 concentrations depending on the in-store grain conditions.
- The anticipated approach should be accommodated as a tool for depicting the incipient grain deterioration.

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Contact:
Mail: ramaj@uni-hohenheim.de
Phone: +49 (0) 711 45923119
Fax: +49 (0) 711 45923298