How can cow-individual sensor data, national data, and drone images improve our understanding of resilience

ICAR April 2021

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What to expect today

1 Background information

2 Developing cow specific resilience proxies

3 Predicting lifetime resilience using sensor data and machine learning

4 Camera-mounted drones to obtain cow characteristics for resilience

5 Take-home messages

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BREEDFOOD

GENTORE

1 Background information

What is a resilient dairy cow?

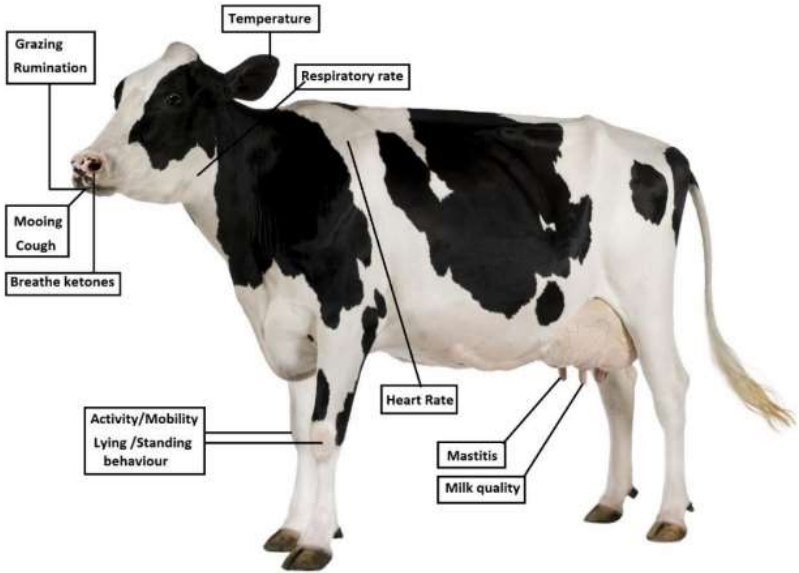
Colditz *et al.*, 2016

Advantages of improving resilience are clear but how?

- long-term, multifactorial, complex trait
- management affects disturbances and resistance
- lack of phenotypic info

1. Background information

Sensors offer high-frequent, longitudinal, and continuous time-series of data at cow individual level



Can we develop proxies using sensor data?
Can we predict resilience?
Can machine learning be of help?
Can drones aid in extracting information for resilience?

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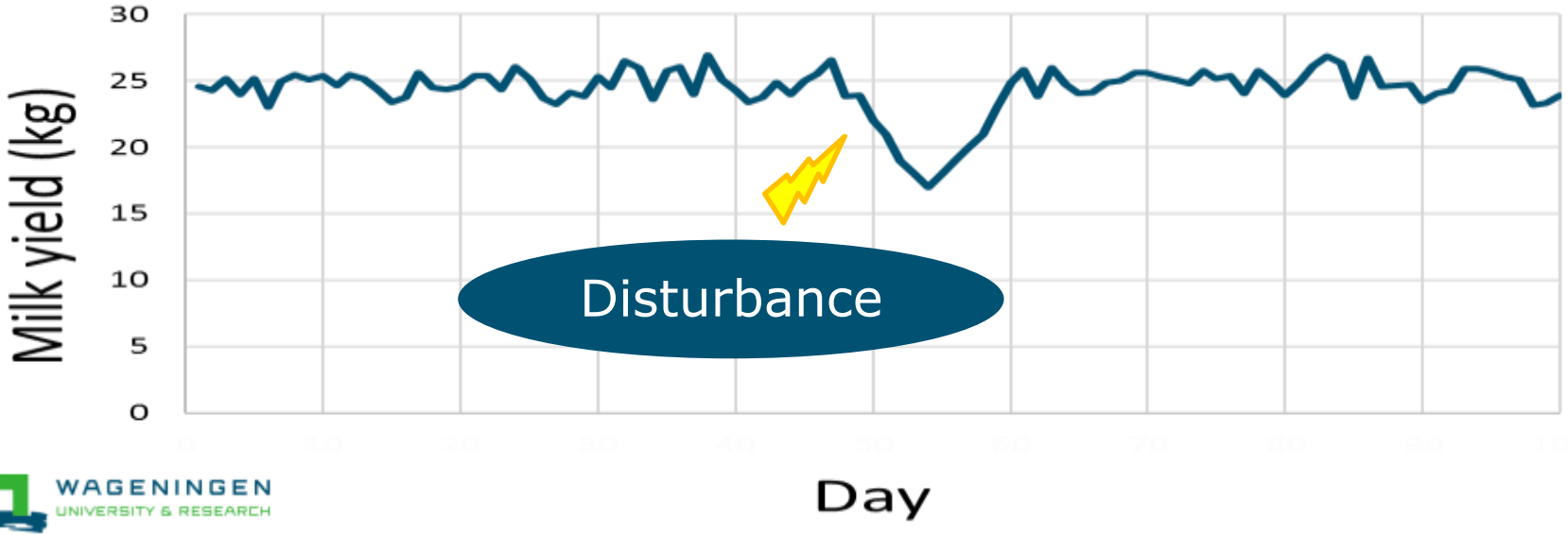
2 Developing cow specific resilience proxies

Using daily milk yield records

Sensitive to different kinds of disturbances & available on daily basis (AMS)



2 Developing cow specific resilience proxies

Collected daily milk yield data

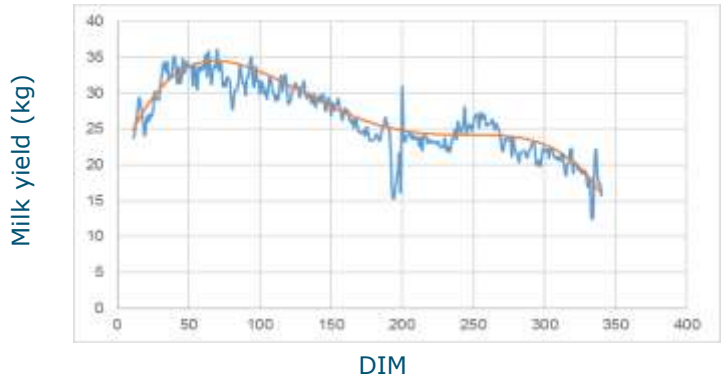
~200K primiparous Holstein cows (CRV)
up to 350DIM

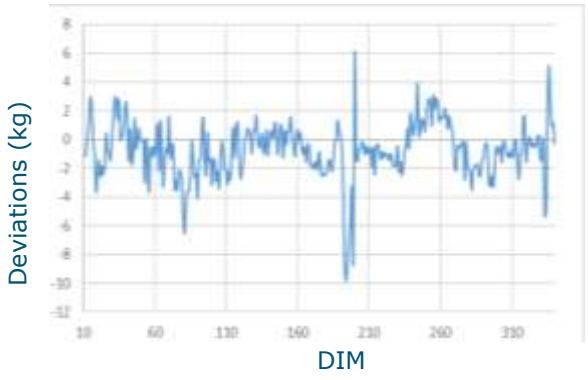
4th order polynomial 0.7 quantile regression curve

reflecting potential yield without disturbances

Calculated deviations from disturbance-free regression curve

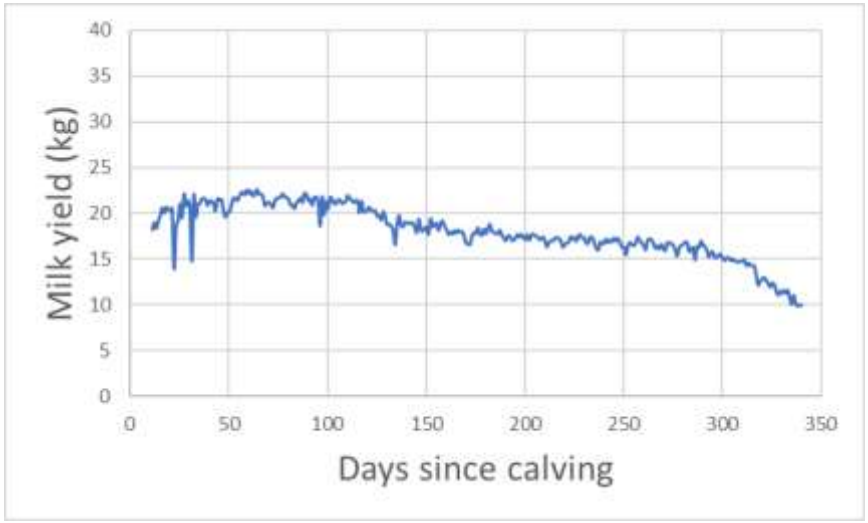
Calculated natural transformed logarithm of variance as proxy





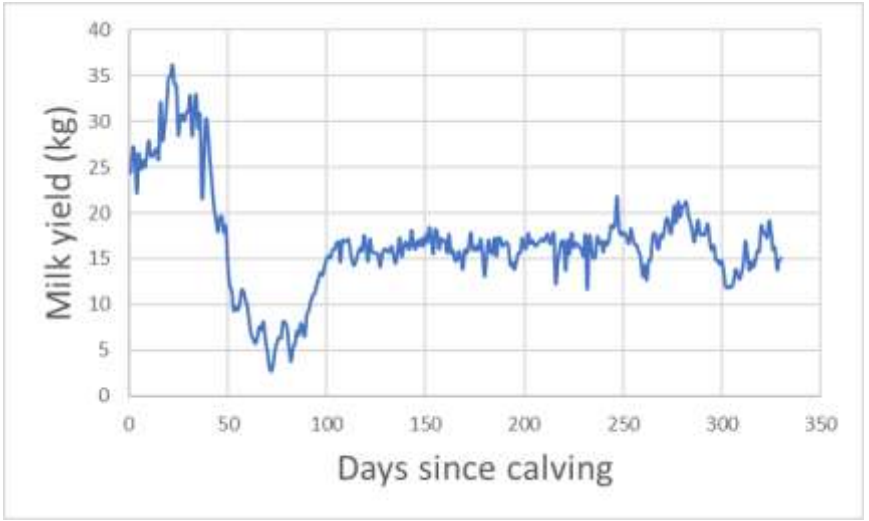
LnVar

2 Developing cow specific resilience proxies



Low variance

Resilient?



High variance

Not resilient?

2 Developing cow specific resilience proxies

LnVar demonstrated to have

a good heritability (0.21) & genetic correlation with mean milk yield (0.79)

good genetic correlation with other traits in the expected direction

	Udder health	Hoof Health	Ketosis resistance	Longevity	Fertility	BCS
Correlation	-0.32	-0.04	-0.33	-0.34	-0.17	-0.40

LnVAR seems to be a useful cow-individual proxy for resilience


J. Dairy Sci. 103:1667–1684
https://doi.org/10.3168/jds.2019-17290

Exploration of variance, autocorrelation, and skewness of deviations from lactation curves as resilience indicators for breeding

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[2]Cooperation CRV, Animal Evaluation Unit, PO Box 454, 6800 AL Arnhem, the Netherlands

2 Developing cow specific resilience proxies

What about resilience at herd level?

Herd management is expected to influence both cow resilience and number and severity of disturbances

are there differences in herd resilience between herds?

can these differences be explained by herd performance indicators and management?

Variance = **Herd-Year** + Animal + Year-Season + e

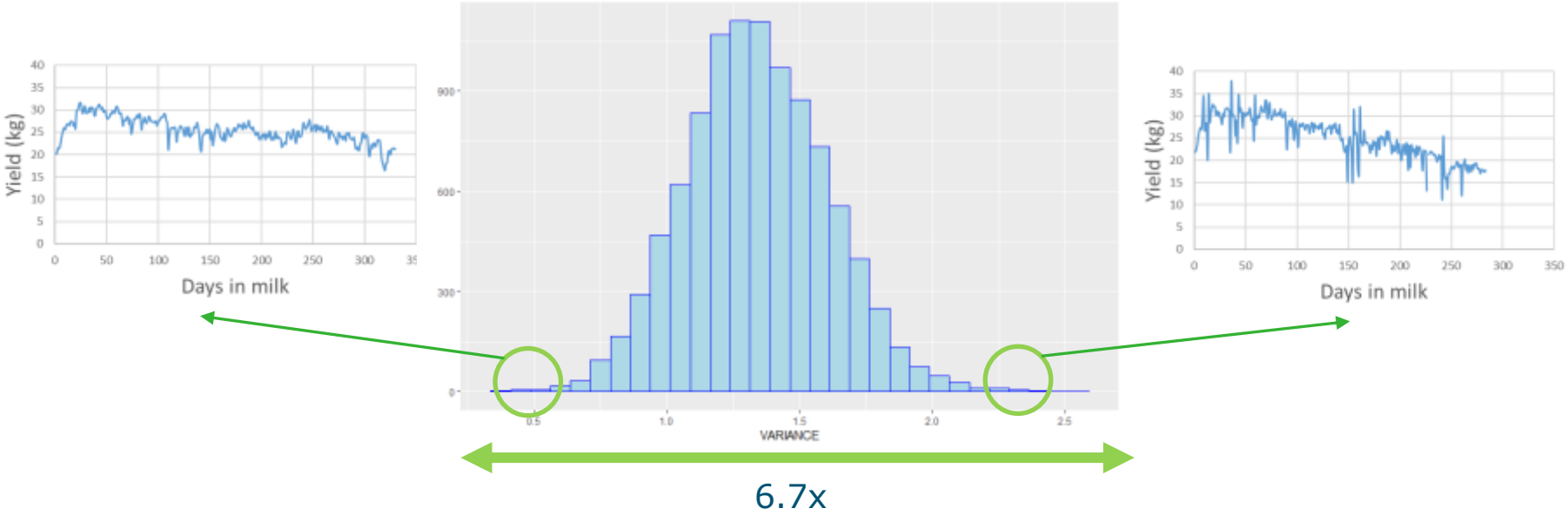
~227K primiparous Holstein cows

2,644 herds for years 2011-2017: 9,917 herd-year classes

Indicators of performance and management from national milk recording system

2 Developing cow specific resilience proxies

Variance = **Herd-Year** + Animal + Year-Season + e



2 Developing cow specific resilience proxies

Herd performance indicator	Correlation with variance
Somatic cell score	0.19
% cows with acidosis indication	0.31
% cows with ketosis indication	0.03
% survival to 2nd lactation	-0.13
Calving interval	0.14
Milk yield	0.10

Poor resilience = low health and fertility

Rumen acidosis indication important → feed management important?

Milk yield hardly affects variance

J. Dairy Sci. 104:616–627
https://doi.org/10.3168/jds.2020-18525

Between-herd variation in resilience and relations to herd performance

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3 Predicting lifetime resilience using sensor data and machine learning

There is more than just milk yield information available on-farm

Multiple lactations, good (re)productive performance, no/few health problems that are overcome easily, efficient and consistent in milk production
(Adriaens et al., 2020)

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3 Predicting lifetime resilience using sensor data and machine learning

Lifetime Resilience Scoring system

(Adriaens et al., 2020)

A summation of scores for
- number of lactations
- age at first calving/calving interval
- number of inseminations
- number of curative treatment days
- When culled in lactation

1,800 cows scored
Average 1,518 (31 – 6,031)

Divided into 3 evenly distributed classes (H,M,L)

Cows with data from 4 sensor in first parity
N = 370 (109H, 141M, 120L)

3 Predicting lifetime resilience using sensor data and machine learning

Activity, Rumination, Weight and Milk yield to predict LRS

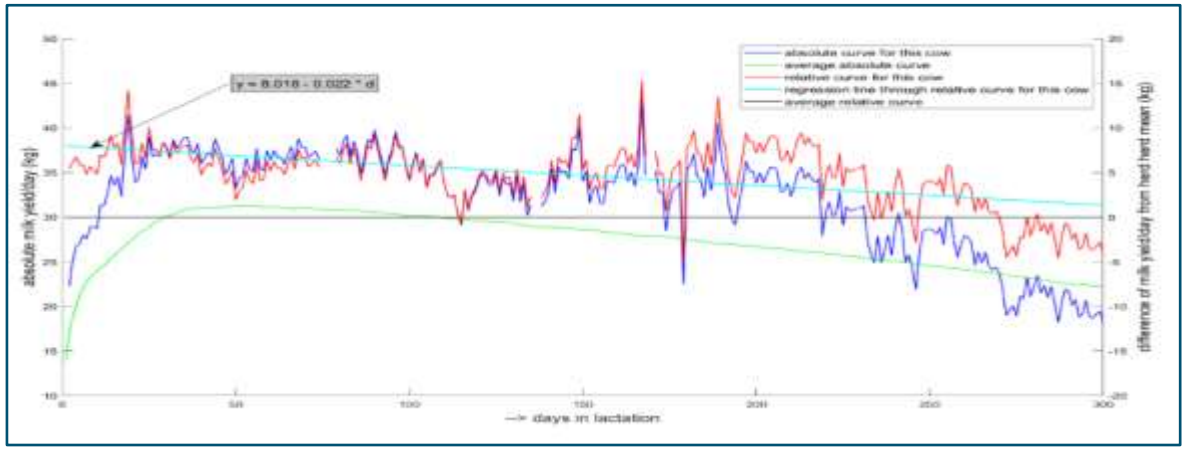
sensor data aggregated to daily values

for each cow, for each sensor, 14 sensor features

mean, minimum, maximum, 25th 50th and 75th percentile, std, skewness, kurtosis, autocorrelation (lag1)

slope, intercept, residual standard deviation

correlation relative curve values - fitted curve values



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3 Predicting lifetime resilience using sensor data and machine learning

Activity, Rumination, Weight and Milk yield to predict LRS

sensor data aggregated to daily values

for each lactation, for each sensor, 14 sensor features per sensor (56 total)

absolute daily values and their lactation averages (1,204 features)

Ordinal logistic regression
56 features
Stepwise selection ($p \leq 0.2$)
6 features selected

3 Random forests
6 significant sensor features
56 sensor features

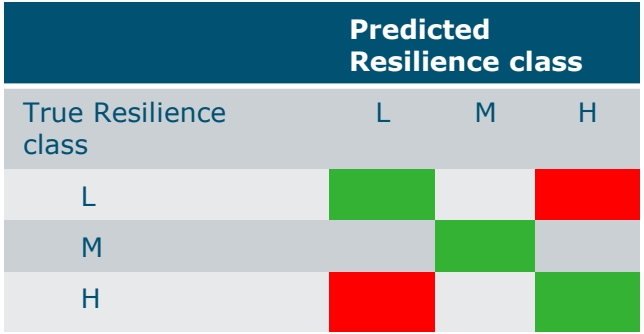
1,204 daily values as features

all models: 10-fold cross validation

3 Predicting lifetime resilience using sensor data and machine learning

Performance Accuracy (ACC)
Critical misclassified (CritMis)

Submitted to peer-reviewed journal



Model	ACC (%)	CritMis (%)
Ordinal Logistic Regression	45.1 ± 8.1	10.8
Random Forest 6F	45.7 ± 8.4	16.0
Random Forest 56F	51.2 ± 10.9	8.7
Random Forest 1204F	50.5 ± 6.3	8.4

4 Camera-mounted drones to obtain cow characteristics for resilience

New and innovative technology

Requires new methodology to retrieve relevant information

First steps focussed on **detection**, **identification, characterization**

Matrice 210

Mavic Pro

Phantom 3 & 4

EBEE X RTK

RGB & Video

Multispectral

Thermal

Laser scanning (LiDAR)

4 Camera-mounted drones to obtain cow characteristics for resilience

	Carus			Juchowo Farm
	2018	2019	2020	2019
Number of cows	4	6	16	100

AGISOFT Metashape

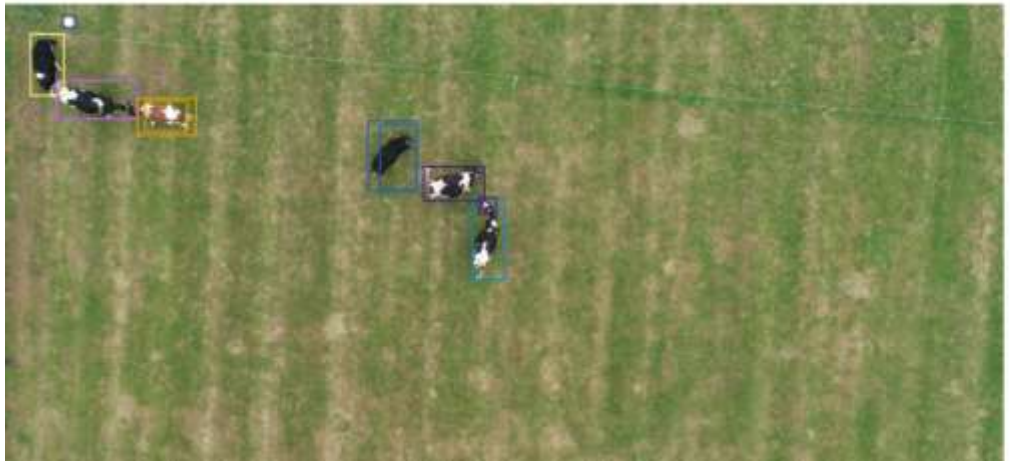
Volume in Agisoft Metashape and CloudCompare

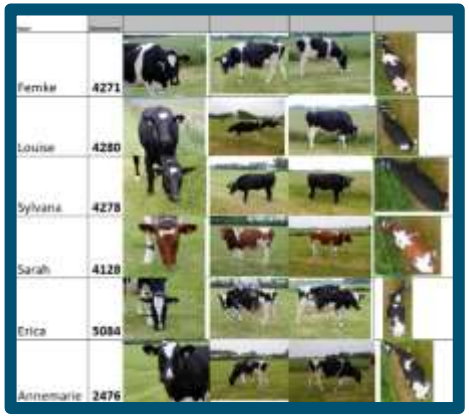
4 Camera-mounted drones to obtain cow characteristics for resilience

	Carus, Netherlands			Juchowo Farm, Poland
	2018	2019	2020	2019
Number of cows	4	6	16	100
Detection accuracy (%)				
Nanonets	95.0	96.2		97.3 shadow/ 99.9 no shadow
Video	80.0			

4 Camera-mounted drones to obtain cow characteristics for resilience

	Carus			Juchowo Farm
	2018	2019	2020	2019
Number of cows	4	6	16	100
Identification accuracy (%)	87.6	91.3		





4 Camera-mounted drones to obtain cow characteristics for resilience

	Carus			Juchowo Farm
	2018	2019	2020	2019
Number of cows	4	6	16	100
Characterization				
Standing/lying/grazing (%)	88.7			
Height		±6cm		
Weight			±31kg	

Challenging to distinct grazing from standing, not grazing from lying

4 Camera-mounted drones to obtain cow characteristics for resilience

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5 Take-home messages

The natural logarithm of the variance of deviations in daily milk yield is a good sensor-based proxy for resilience for individual cows

There were differences in herd resilience; feed management may have an important role

Random Forests require less pre-processing of sensor data to achieve similar classification performance as logistic regression

Camera-mounted drones are promising technologies for collecting resilience indicators in outdoor systems

Thank you

Co-authors & all their colleagues

involved in this work

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