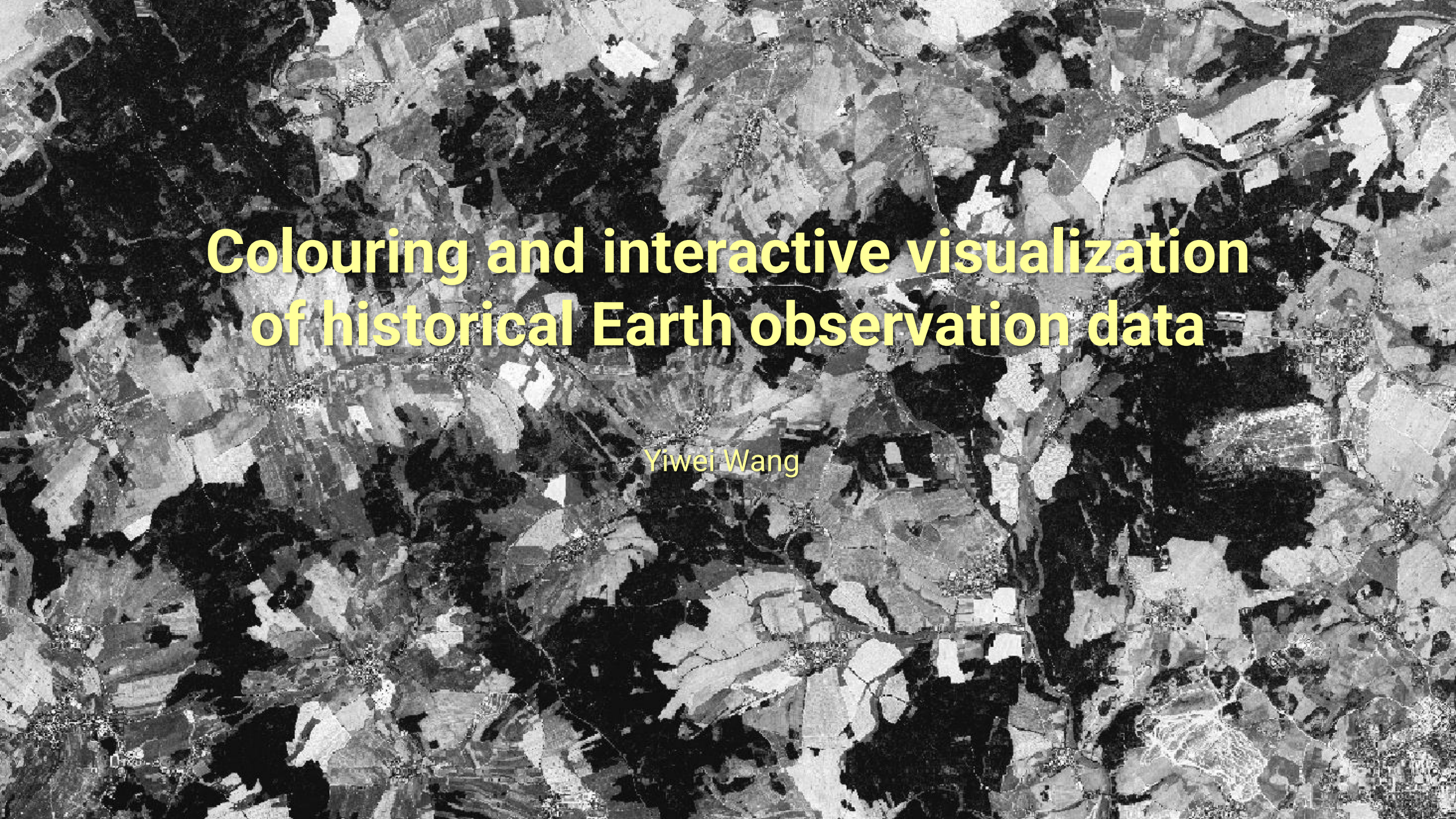


Colouring and interactive visualization of historical Earth observation data

Yiwei Wang

Outline

- Introduction
- Research Objectives and Questions
- Background
- Methodology
- Results and discussion
- Conclusions
- References

Introduction

- Early Earth observation data “Corona” images taken in the 1960s and 1970s
- High spatial resolution but only panchromatic (grey-scale) information
- Valuable information for historical land cover and land use change study
- Limited radiometric information due to its grey scale
- Enhance visual information through colourization

Research Objectives and Questions

To colourize the grey scale CORONA images taken from 1960s to 1970s in the region of Saxony and visualize the results

1. To propose a deep learning based method to colourize grey scale CORONA images and achieve a natural looking result
2. To propose quantitative and qualitative measurements to evaluate the quality of the colourized images
3. To design a web based interactive interface to display the obtained results and allow users to browse and possibly download the interested dataset

Research Objectives and Questions

RO1: To propose a deep learning based method to colourize grey scale CORONA images and achieve a natural looking result

a. What are existing deep learning based methods to colourize images and how to adapt them to apply to CORONA satellite images?

RO2: To propose quantitative and qualitative measurements to evaluate the quality of the colourized images

RO3: To design a web based interactive interface to display the obtained results and allow users to browse and possibly download the interested dataset

Research Objectives and Questions

RO1: To propose a deep learning based method to colourize grey scale CORONA images and achieve a natural looking result

RO2: To propose quantitative and qualitative measurements to evaluate the quality of the colourized images

b. What quantitative measurements can be used to evaluate the similarities between artificially colourized CORONA images and ground truth images?

c. How to design a user study to evaluate the plausibility of artificially colourized CORONA images?

d. How would humans perceive a colourized image that has a good performance in quantitative measurement as natural looking?

RO3: To design a web based interactive interface to display the obtained results and allow users to browse and possibly download the interested dataset

Research Objectives and Questions

RO1: To propose a deep learning based method to colourize grey scale CORONA images and achieve a natural looking result

RO2: To propose quantitative and qualitative measurements to evaluate the quality of the colourized images

RO3: To design a web based interactive interface to display the obtained results and allow users to browse and possibly download the interested dataset

e. How to build the interface of the webpage and display large satellite images?

f. What is a suitable workflow and implementation to provide custom extraction of displayed data?

Background

Image colourization | web mapping application

Scribble-based & Example-based

- Different levels of user intervention
- Extra specific data provided by the user
- Relatively simple

Deep learning-based

- Highly automated
- Massive data source
- Relatively complex

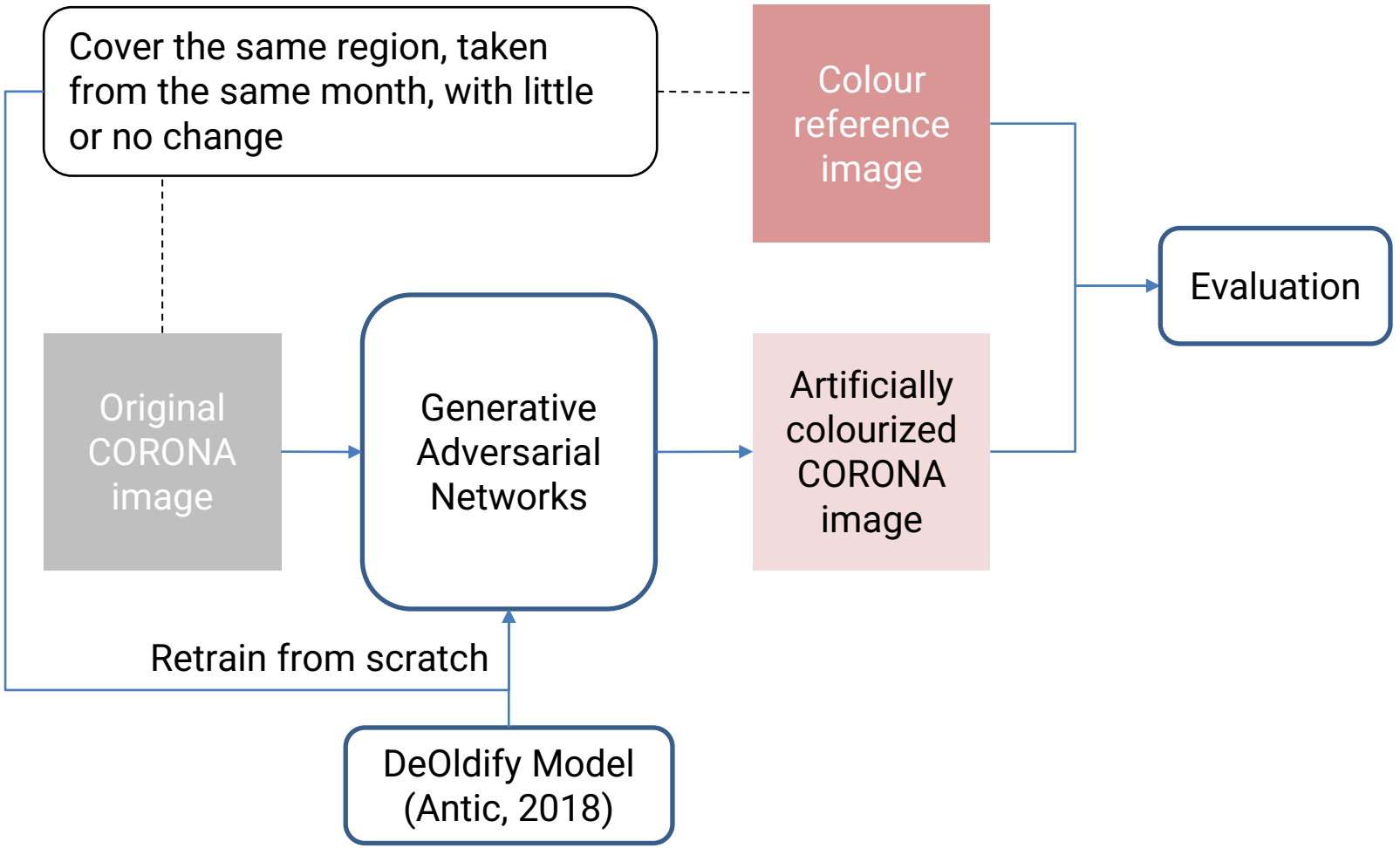
Background

Image colourization | **web mapping application**

- Static maps → Dynamic maps → Interactive maps
- OGC standards facilitate data publishing and visualization and geospatial processing services implementation
- Tiling and caching services accelerate data accessing on the client side and ease the load on server

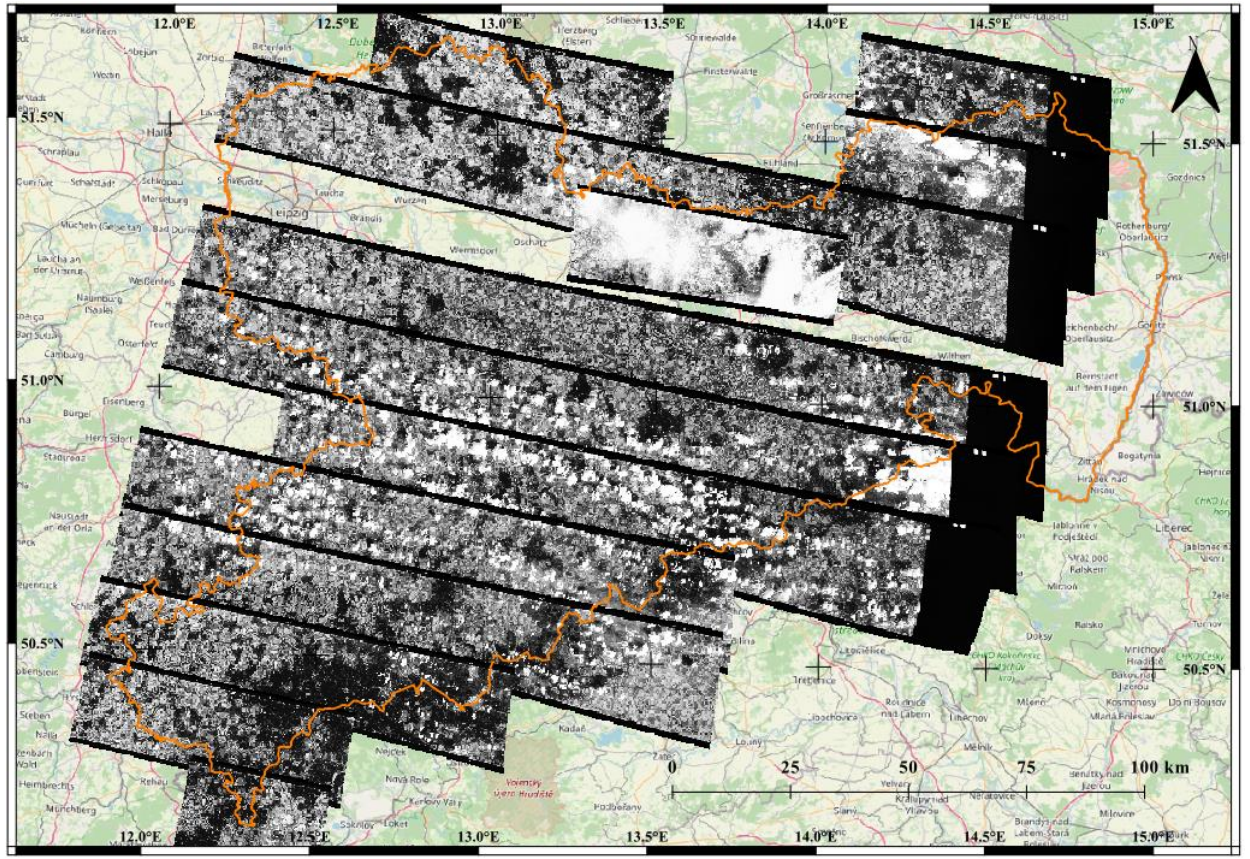
Methodology

Colourization: workflow



Methodology

Colourization: data overview

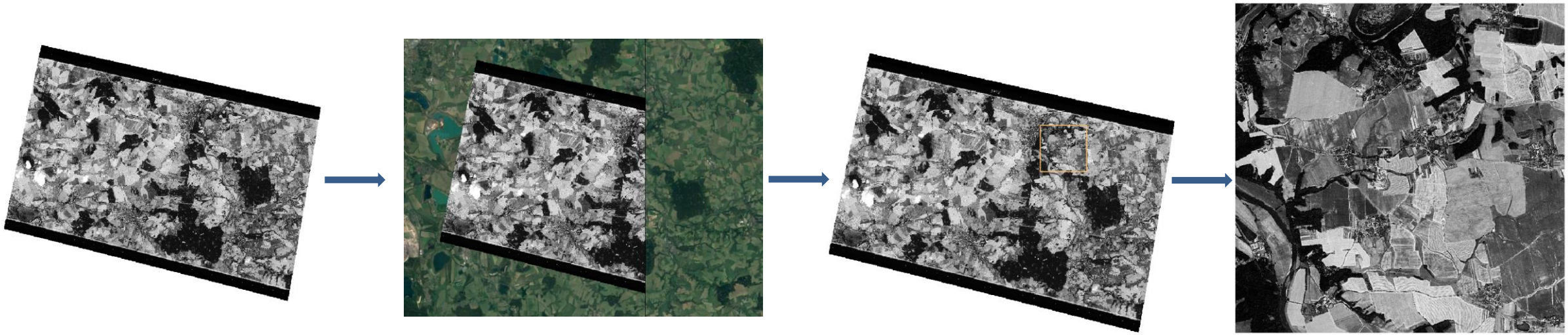


41 greyscale images derived from 12 film strips taken on 10.08.1975

Methodology

Colourization: data pre-processing

CORONA images → crop to study regions



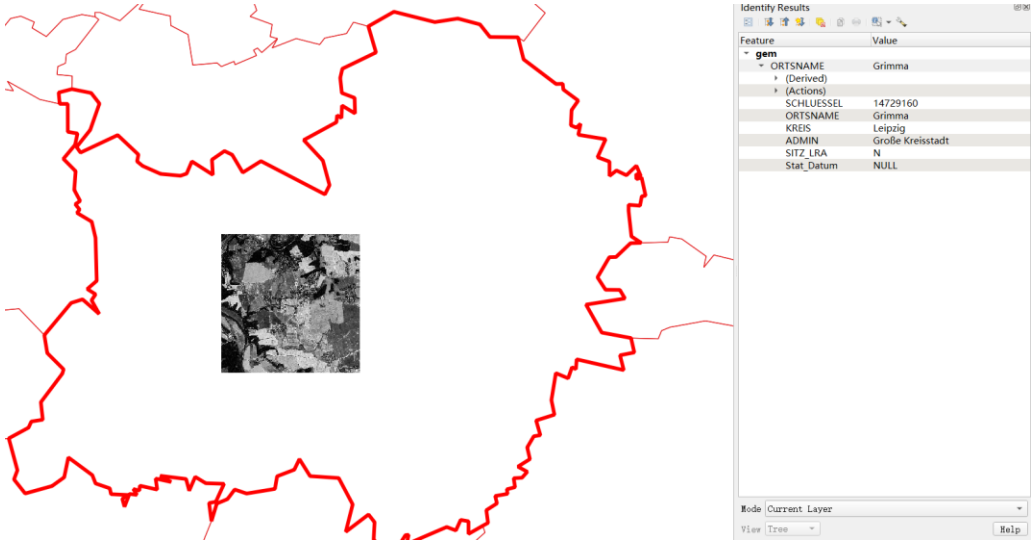
20 study regions, 2m resolution, each 2240 x 2240

Methodology

Colourization: data pre-processing

Digital Orthophoto (0.2m) from GeoSN Sachsen as colour reference images

Staatsbetrieb Geobasisinformation und Vermessung Sachsen GeoSN
Olbrichtplatz 3
01099 Dresden

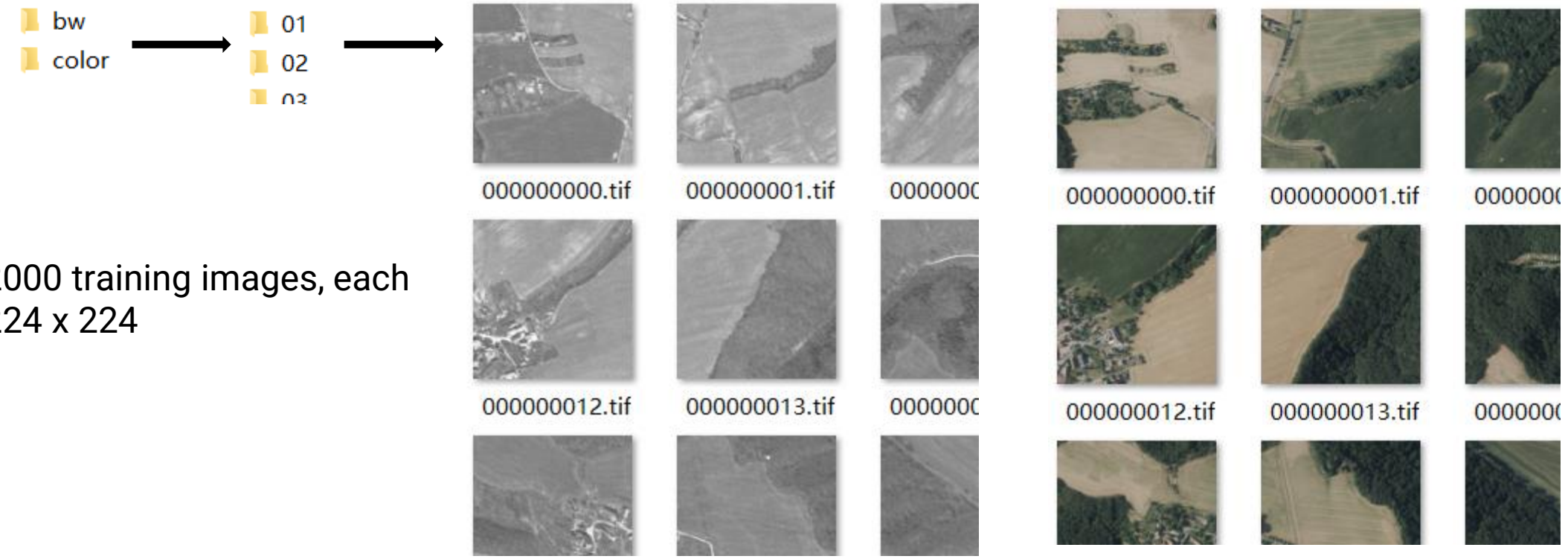


Download image patches → merge → crop to the same extent → resample

Methodology

Colourization: data pre-processing

ImageNet-like dataset



2000 training images, each 224 x 224

Methodology

Colourization: GAN and the DeOldify model – Training setting

GAN training steps:

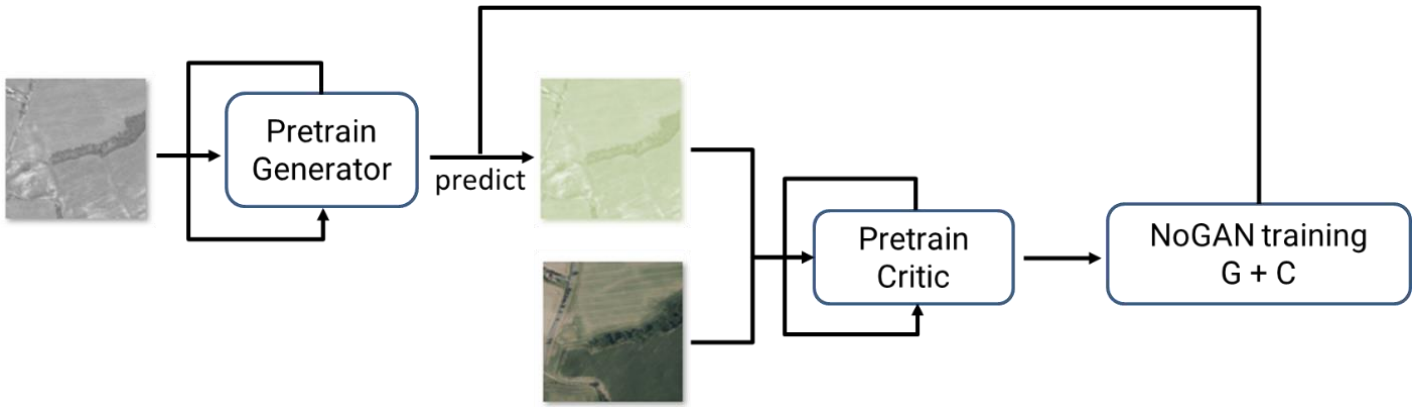
1. Freeze the generator and train the critic for one or more steps
2. Freeze the critic and train the generator for one step
3. Repeat steps 1 and 2 alternatively until the network converges

Methodology

Colourization: GAN and the DeOldify model – Training setting

NoGAN training steps:

1. Pretrain the generator
2. Save the images generated by the pretrained generator
3. Pretrain the critic.
4. Train the generator and critic in a GAN training approach
5. Repeat steps 2 to 5



Methodology

Evaluation

Quantitative evaluation:

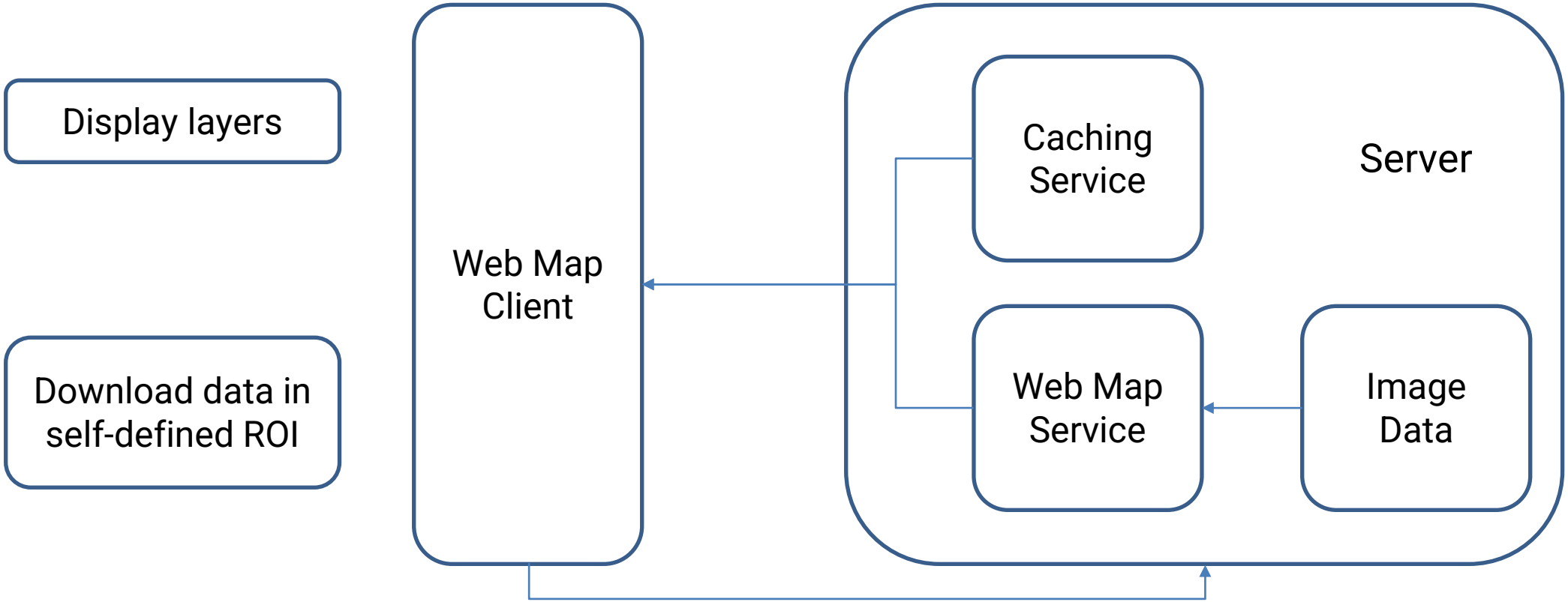
- Root mean square error (RMSE), simple and intuitive to compare the pixel-wise numeric similarities, commonly used in image problems (Guo et al., 2022; Larsson et al., 2016; Shi et al., 2016; Sugawara et al., 2018).
- Peak signal-to-noise ratio (PSNR), evaluates the reconstruction quality between two images (Cheng et al., 2015; Larsson et al., 2016; Poterek et al., 2020; Wu et al., 2021)

Qualitative evaluation:

- Main task is to produce plausible colour images rather than recreate the exact original colour images
- A user study to qualitatively evaluate the generated colour images (Cao et al., 2017; Chia et al., 2011; Gupta et al., 2012; Iizuka et al., 2016; Salimans et al., 2016; Zhang et al., 2016)
- The participants are shown a set of colour images composed of real colour images and their artificially colourized counterparts and asked “Does this image look natural?”

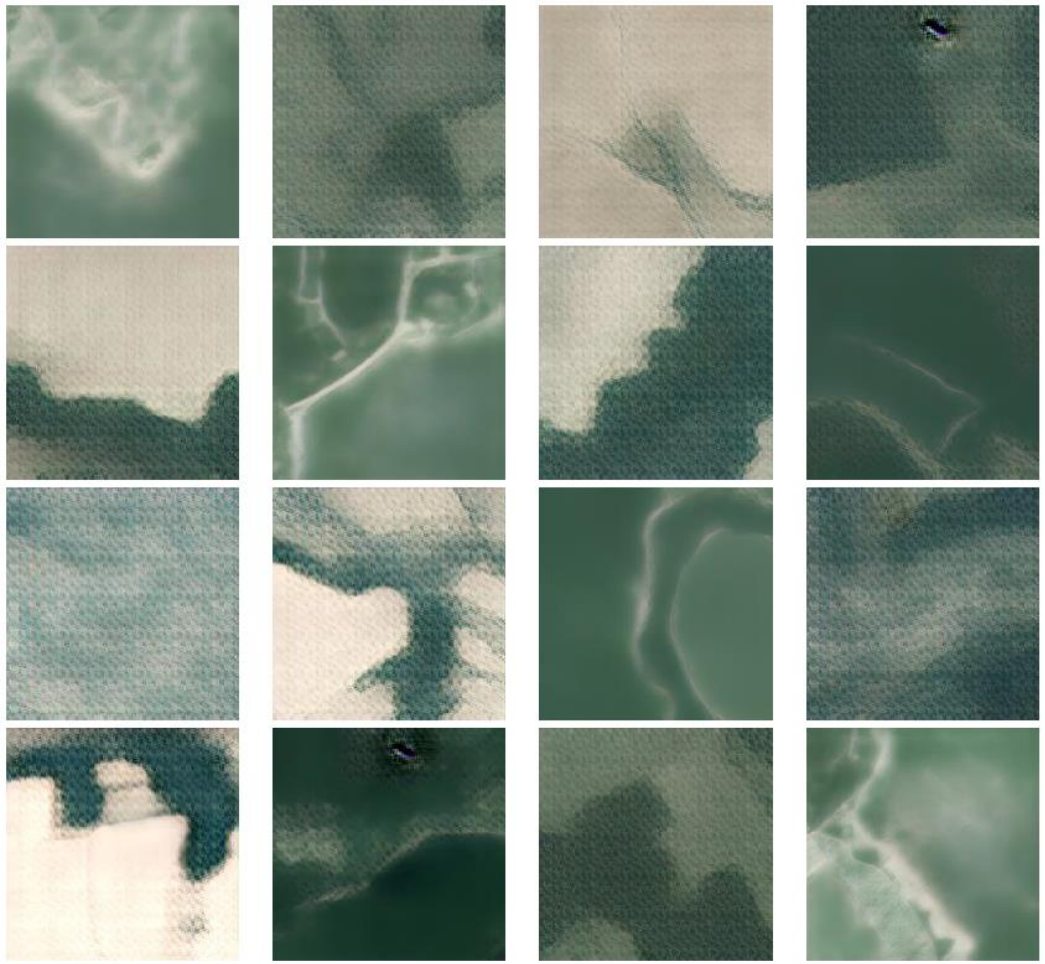
Methodology

Visualization: workflow



Results and discussion

Colourization: generator pretraining

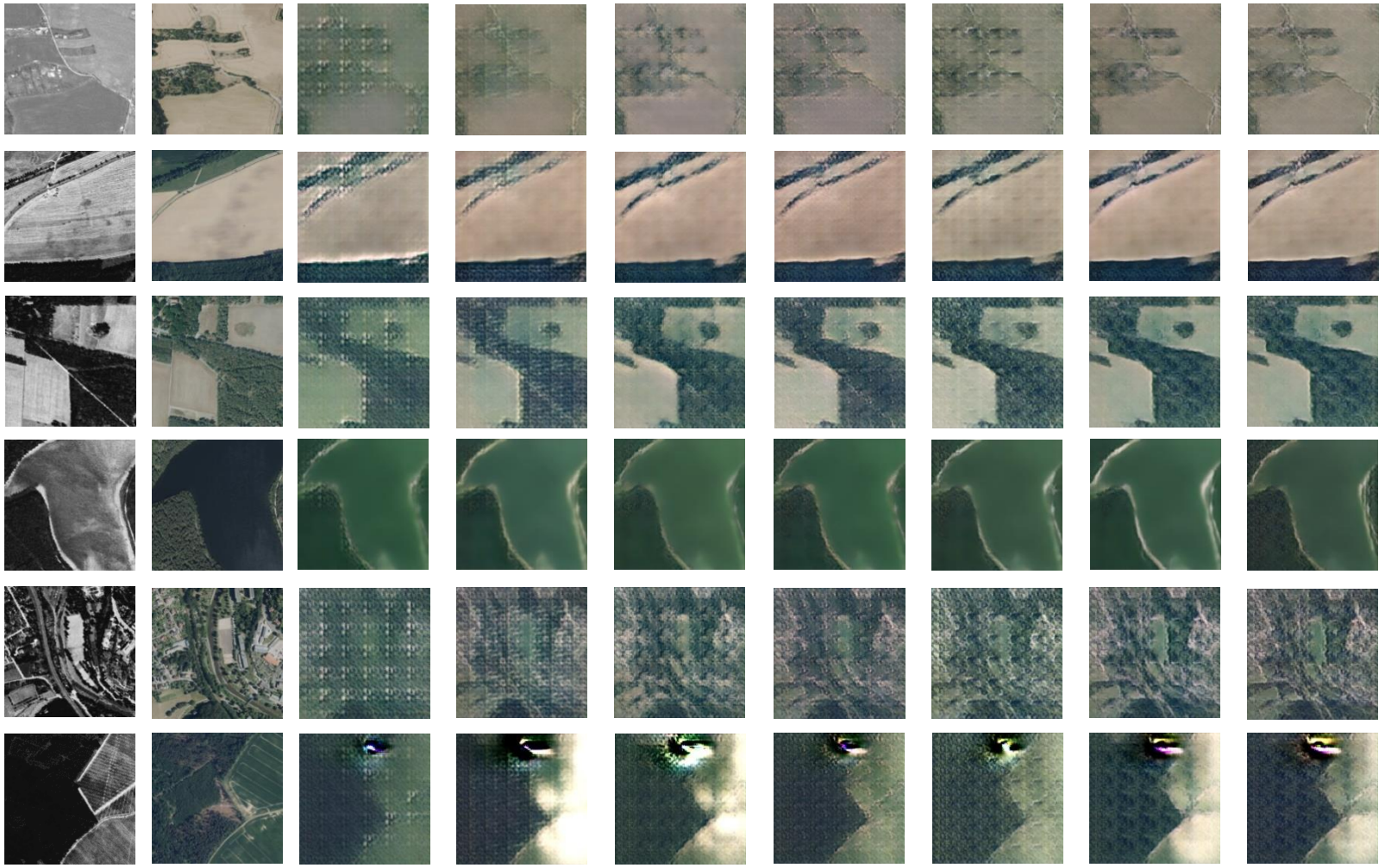


- Stable mode → artistic mode
- In total 450 epochs of training, 7 hours

- Boundaries roughly identified
- Noticeable artefacts and errors
- Details not fully reconstructed except in homogeneous areas

Results and discussion

Colourization: critic pretraining – GAN training

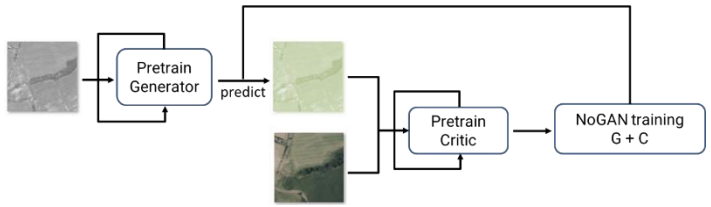


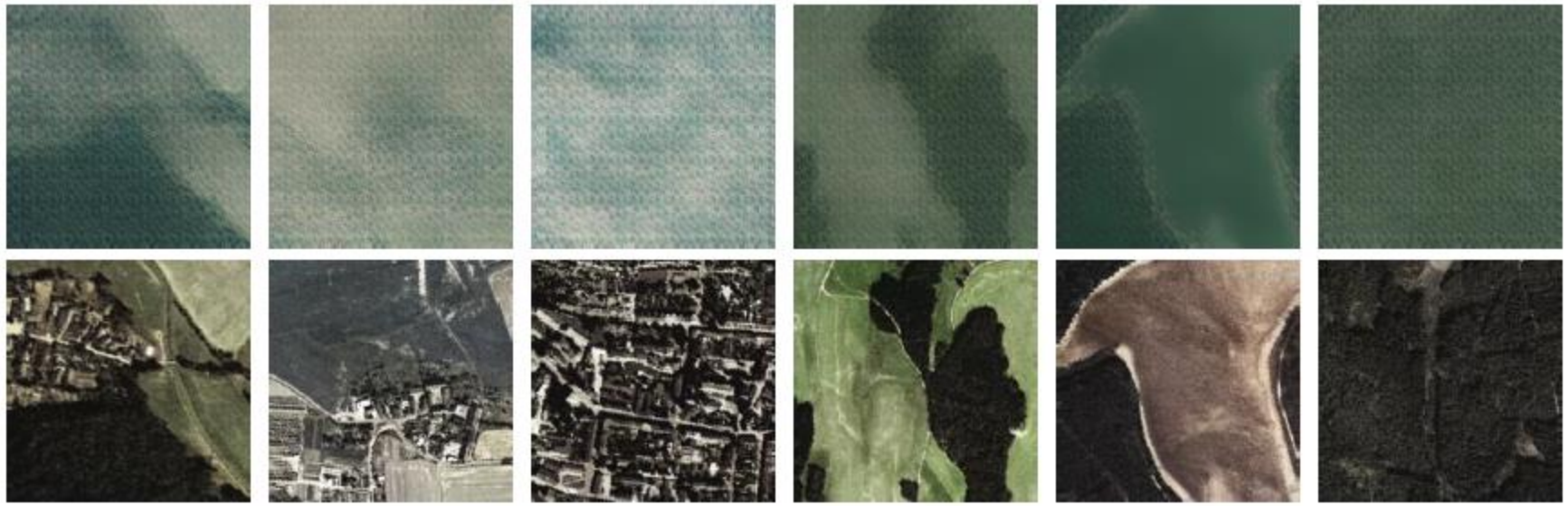
- Artefacts decrease or vanish in bare ground, agricultural land and water body, large homogeneous areas with few changes in texture or patterns
- Artefacts in forest and urban land continue to exist as the training goes on, with slight improvements
- Inconsistence in training data

Results and discussion

Colourization: retraining the DeOldify model

- Pretrained generator can not fully reconstruct image details
- Replace with the pretrained generator from the original DeOldify model
- More image details but desaturated colours
- Retrain the DeOldify model with only critic pretraining – GAN training

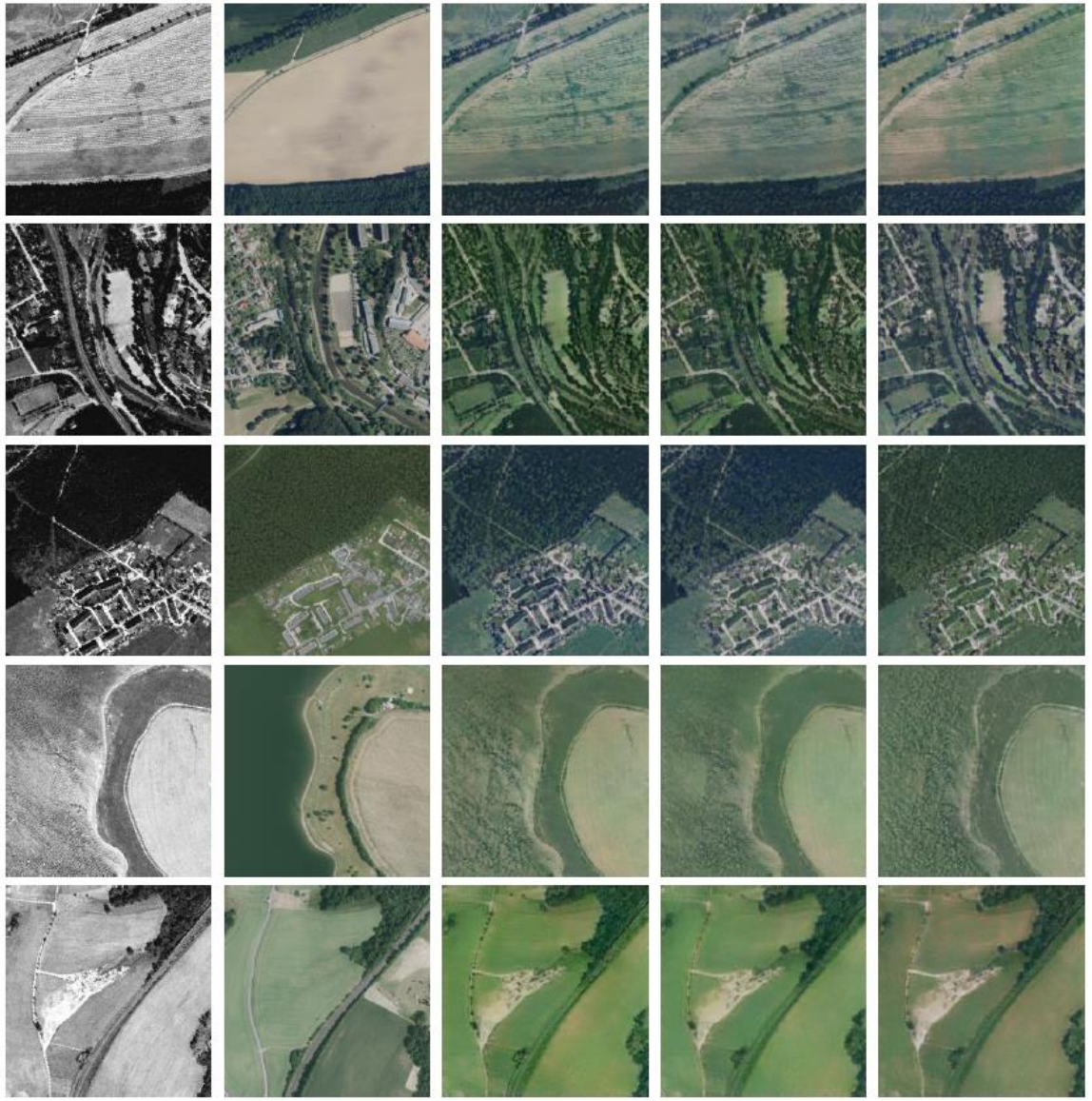




Results and discussion

Colourization: retraining the DeOldify model

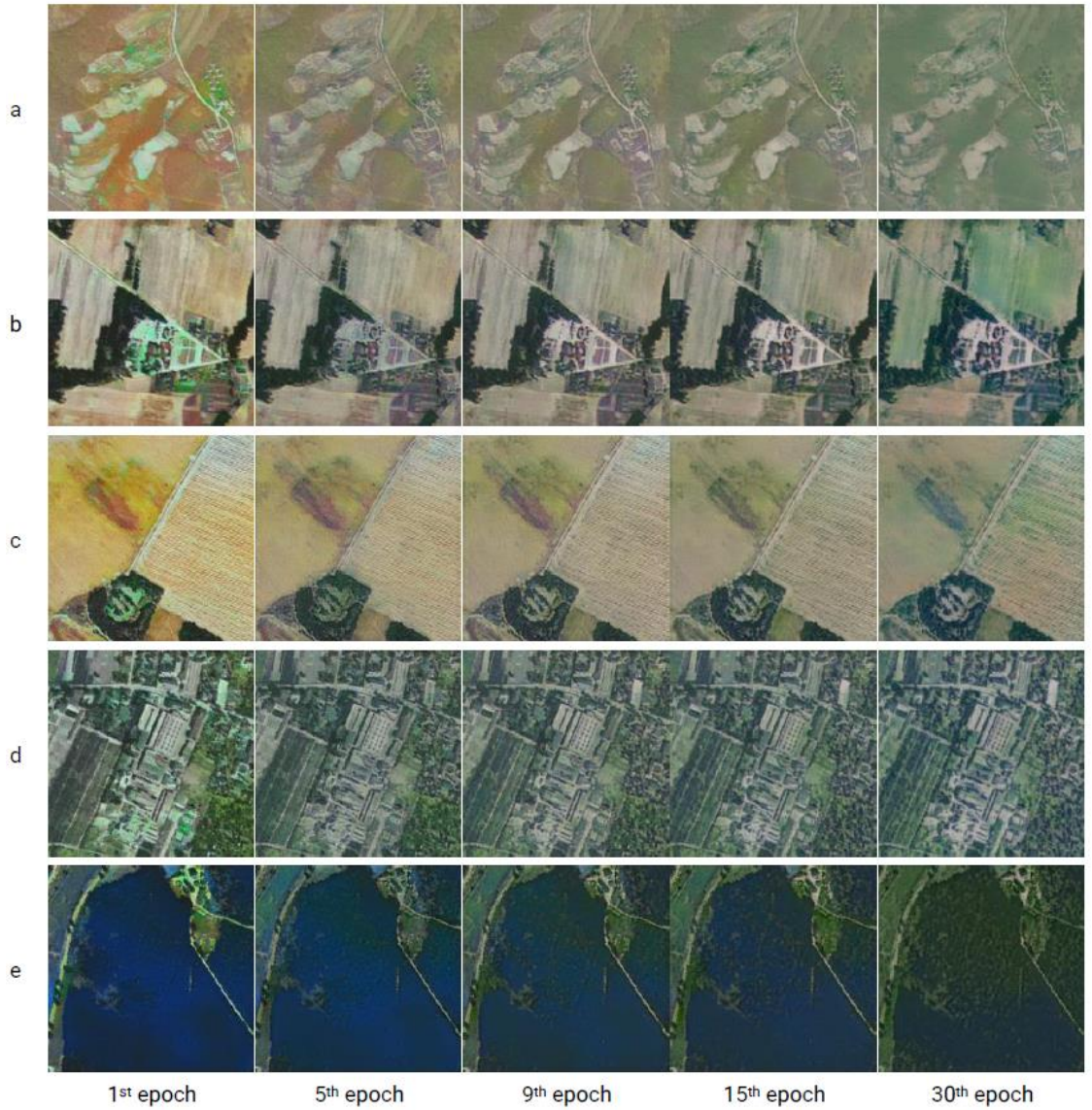
- Three rounds of critic pretraining – GAN training
- High level of details, no artefacts or errors
- In general a green tone
- the bias of large areas of greenness contributed mostly by forest and agricultural land might have resulted in this colourization trend



Results and discussion

Colourization: retraining the DeOldify model

- Unnatural colours at the beginning of the training
- Turning into green tone gradually
- The model after the 40th epoch in the second round is chosen as the final generator



Results and discussion

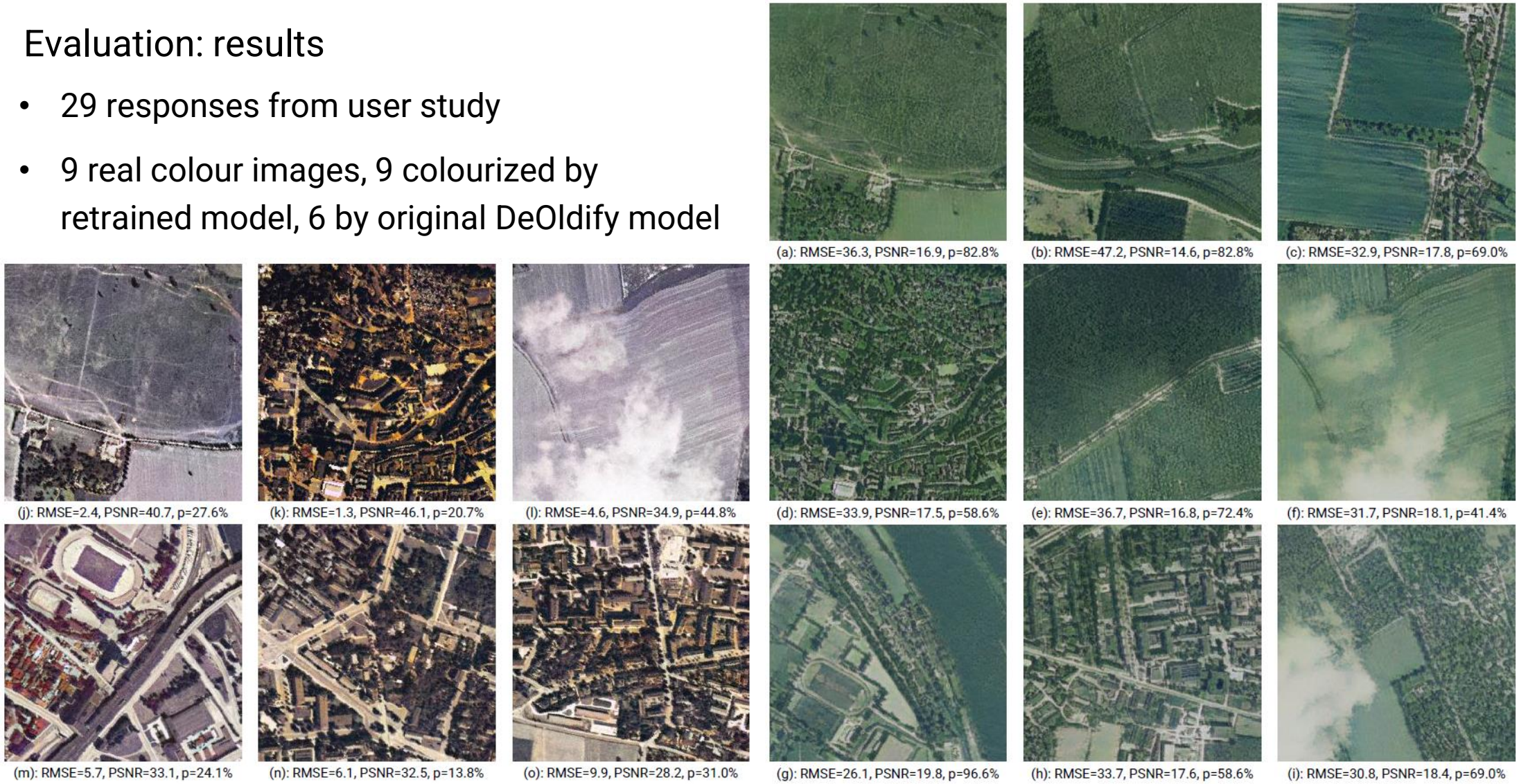
Evaluation: test images

- 6 test images of size 560x560
- Include various land cover types
- Colourized and then cut into smaller patches of size 280x280

Results and discussion

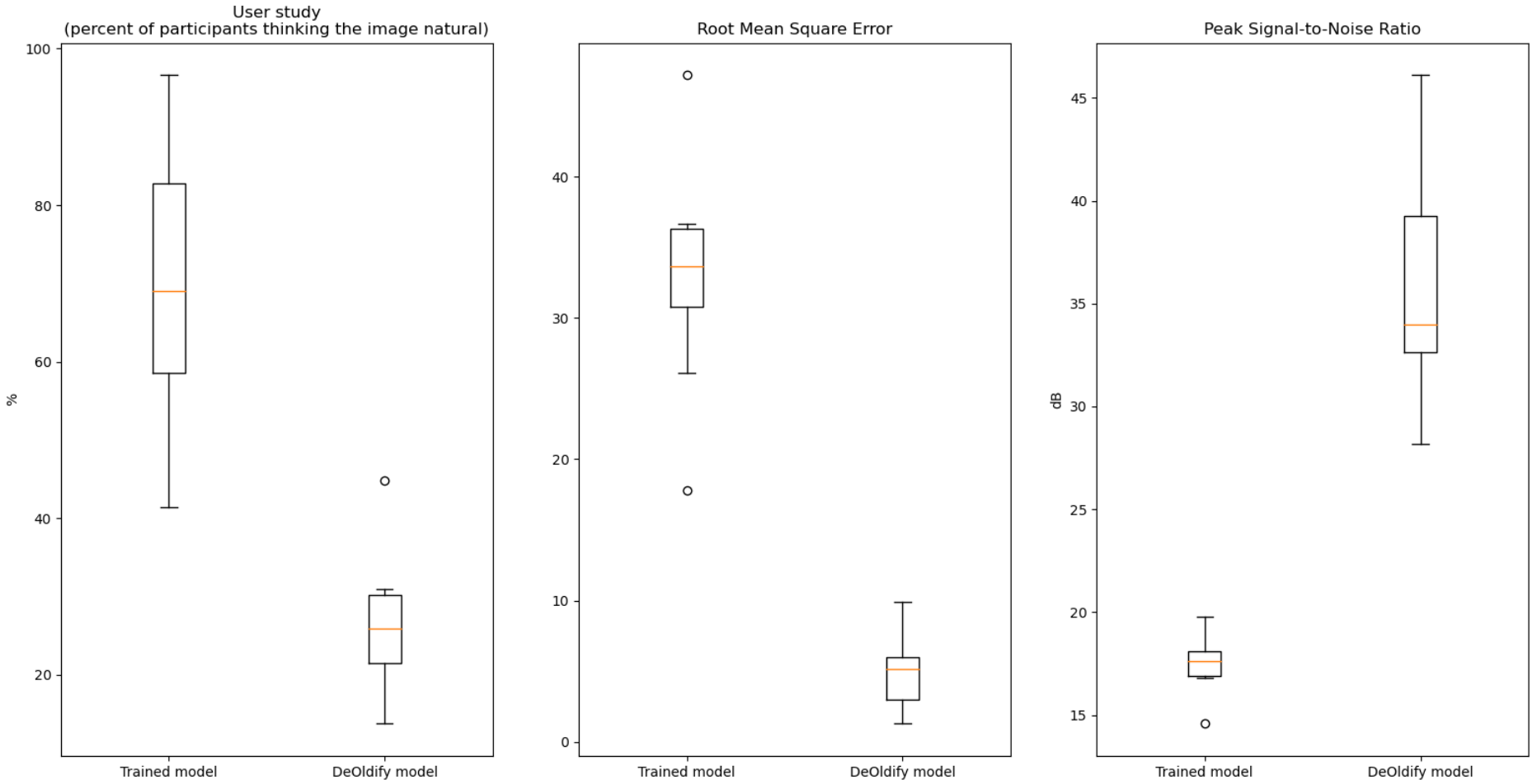
Evaluation: results

- 29 responses from user study
- 9 real colour images, 9 colourized by retrained model, 6 by original DeOldify model



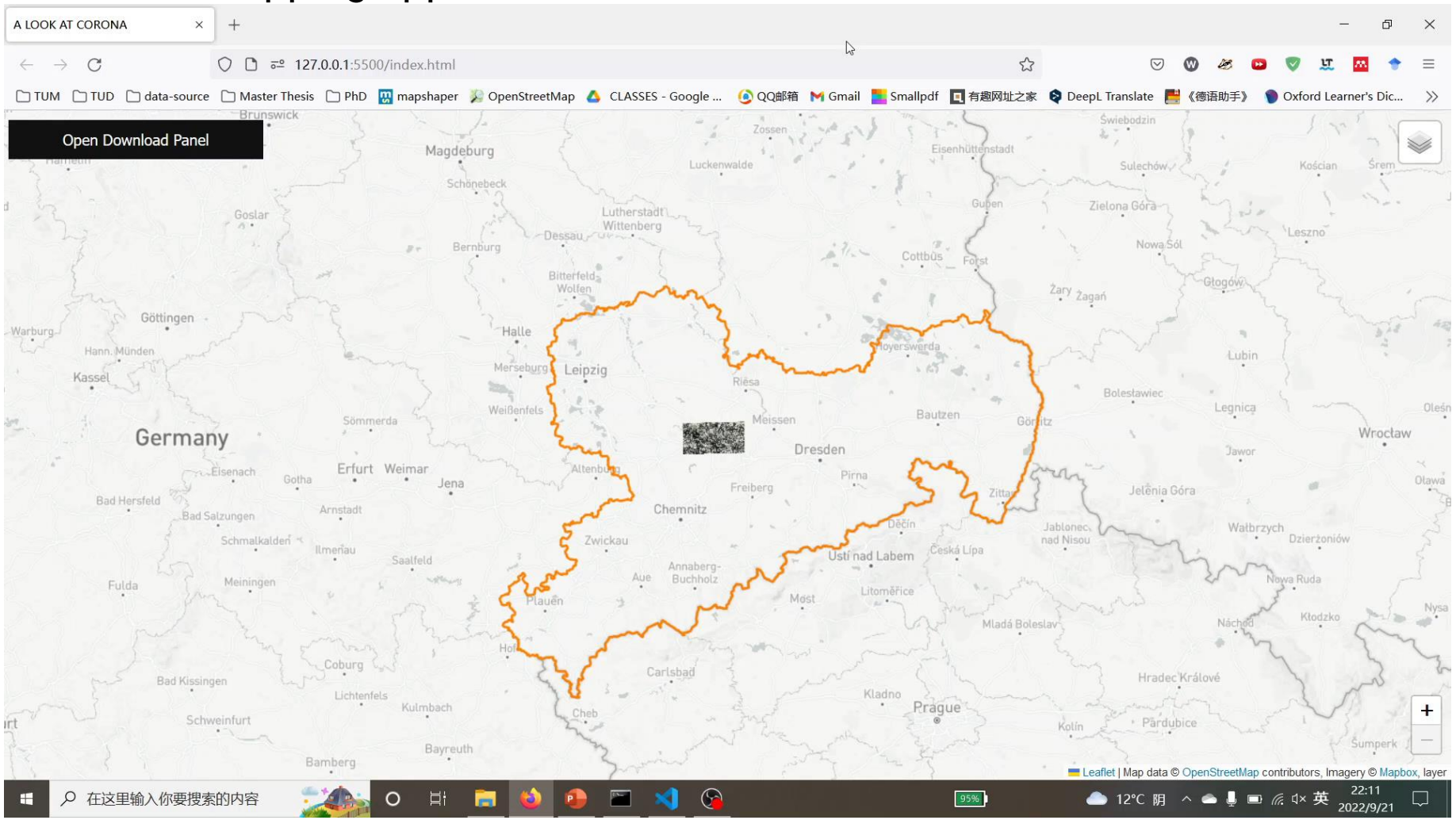
Results and discussion

Evaluation: results comparison



Results and discussion

Visualization: web mapping application



Conclusions

a) What are existing deep learning-based methods to colourize images and how to adapt them to apply to CORONA satellite images?

Colourization – Retraining the DeOldify model

b) Which quantitative measurements can be used to evaluate the similarities between artificially colourized CORONA images and ground truth images?

c) How to design a user study to evaluate the plausibility of artificially colourized CORONA images?

d) How would humans perceive a colourized image that has a good performance in quantitative measurement as natural looking?

Evaluation – RMSE and PSNR for quantity, a user study for quality

e) How to build the interface of the webpage and display large satellite images?

f) What are suitable workflow and implementations to provide custom extraction of displayed data?

Visualization – A web mapping application which enables users to browse images and download data

Conclusions

- Improve the data quality of the original CORONA images
- Select more training data with urban areas
- Improve the download function in the web mapping application
- Add a swap tool in the web map interface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Thank you!
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Vienna University of Technology

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