Automated Stratigraphic Mapping using Convolutional Neural Networks

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Mapping Layered Deposits on Mars

Layered deposits have been found all over Mars.

We don't know why/how!

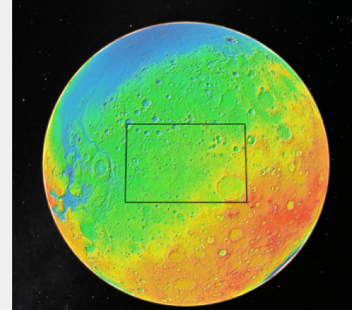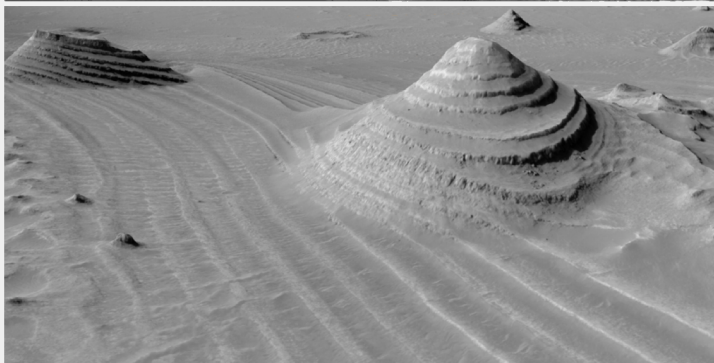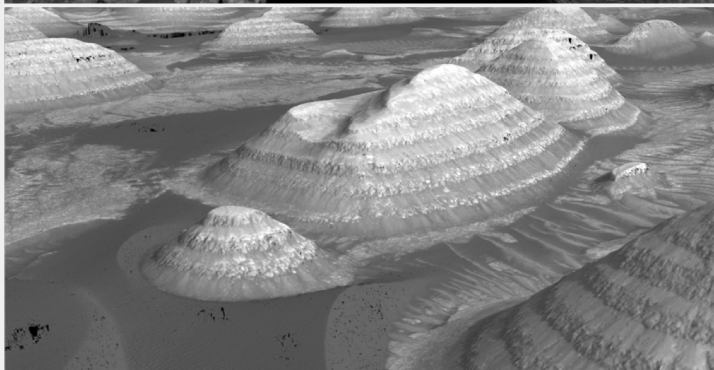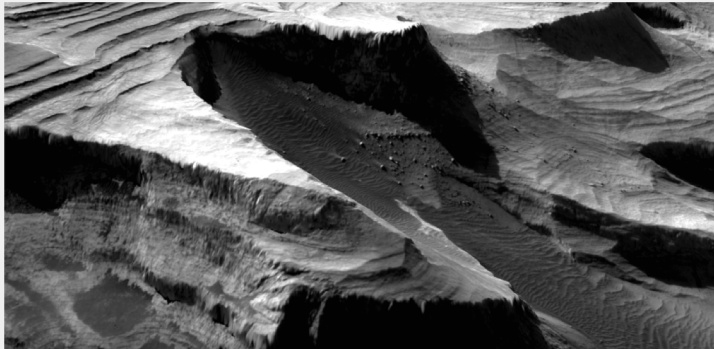We make high resolution DEMs (elevation models) with HiRISE images

We measure <u>orientations</u> and <u>layer</u> thickness to examine spatial trends in the deposits. (Annex et al. 2018 in prep)
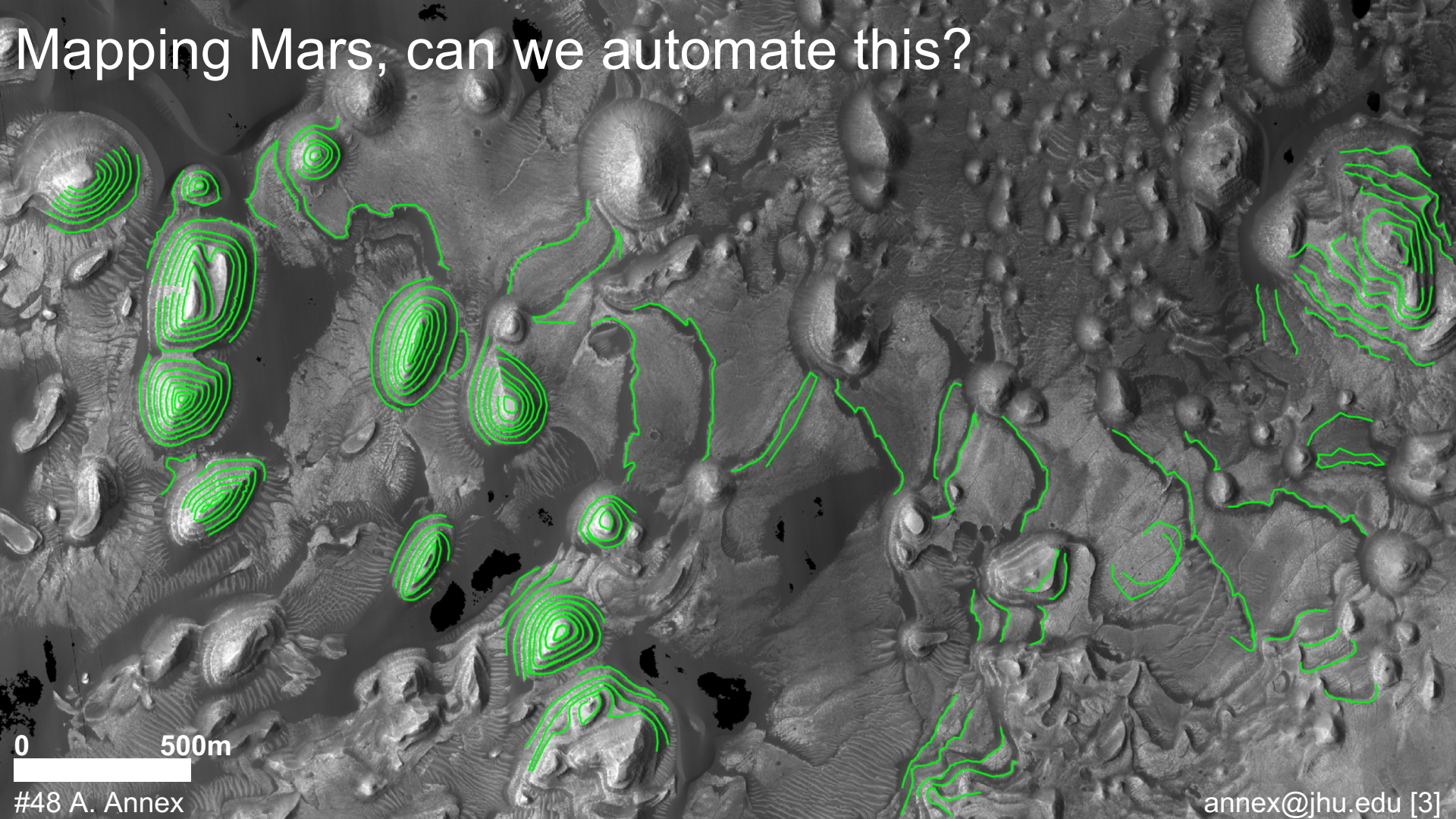
It is a lot of work!

#48 A. Annex
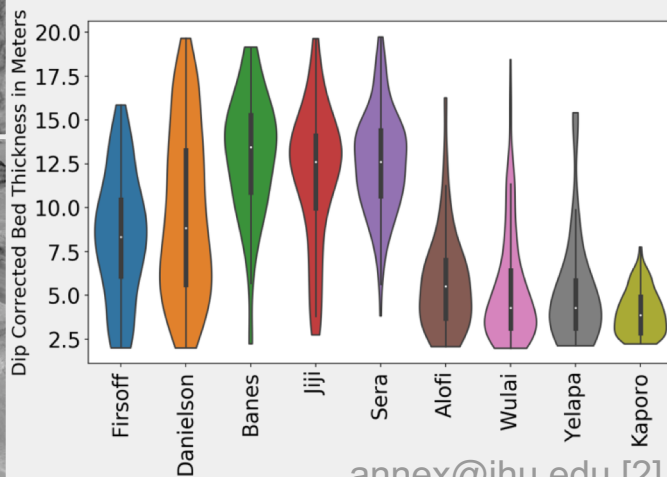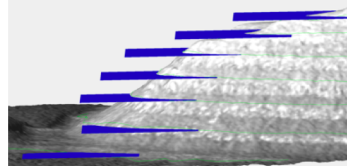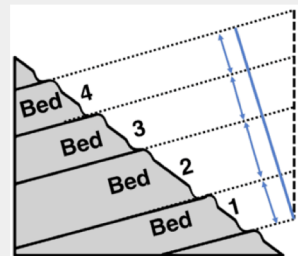
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Mapping Mars, can we automate this?

0   500m

annex@jhu.edu [3]
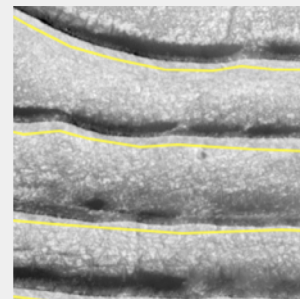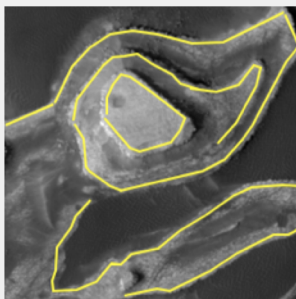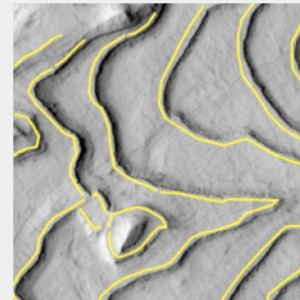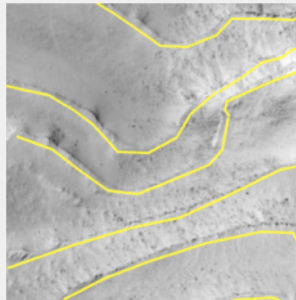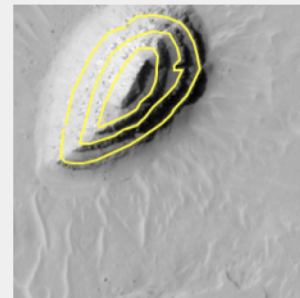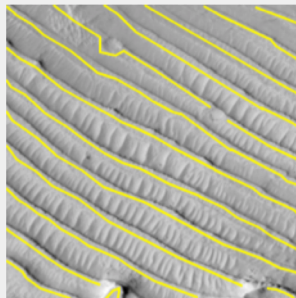
Training data & examples

Human labels (yellow lines),
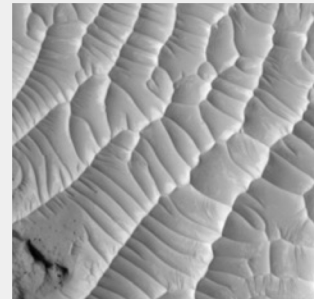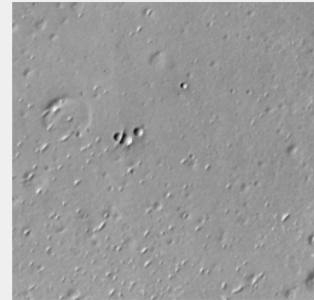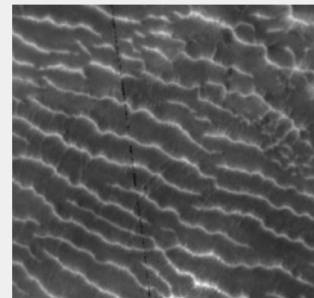1 meter per pixel images

1. Improved labels with VGG Image Annotator (VIA)
2. Training data covers diverse morphologies of layered deposits,
3. 797 images total
4. Overall, an imbalanced classification problem!

Used modified U-net architecture (added batchnorm).
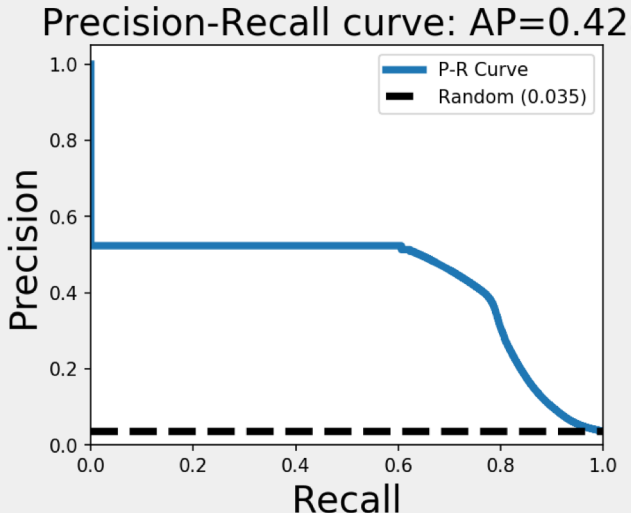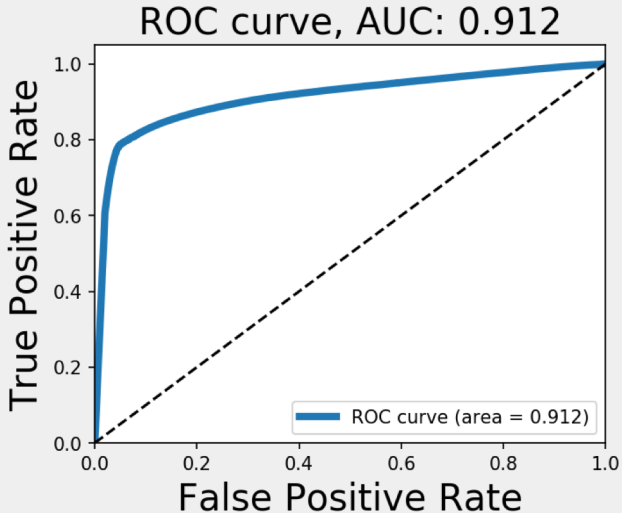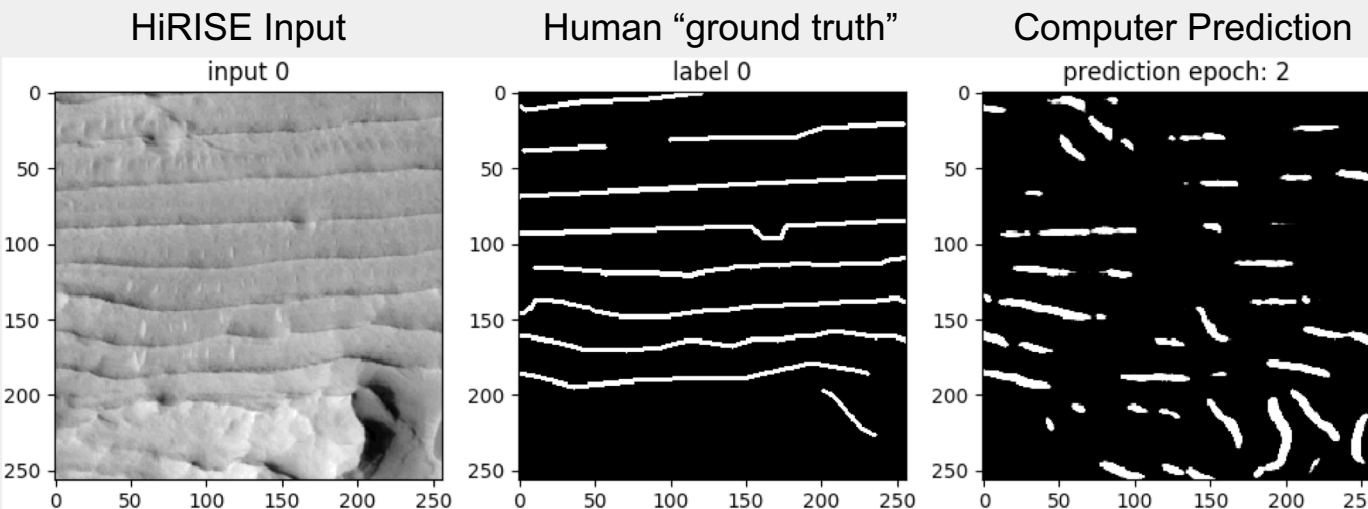keras data augmentation

True Positives

True Negatives

U-net metrics

# Params	10,700,546
MCC (-1,1)	0.54
Macro F1	0.76
Macro Precision	0.71
Macro Recall	0.85

Normalized Confusion Matrix

T=382564 F=10627484	False (P)	True (P)
False (A)	0.964	0.035
True (A)	0.261	0.738

HiRISE Input

input 0

Human "ground truth"

label 0

Computer Prediction

prediction epoch: 2

ROC curve, AUC: 0.912

Precision-Recall curve: AP=0.428

Human vs CNN results in Danielson Crater

N →

Human labels

5 Km

22 Km

Model Prediction

Banes

Sera

Nan pixels

Wulai

0 100 m

0 100 m

0 100 m

Danielson

Jiji

Kaporo

0 100 m

0 100 m

0 100 m
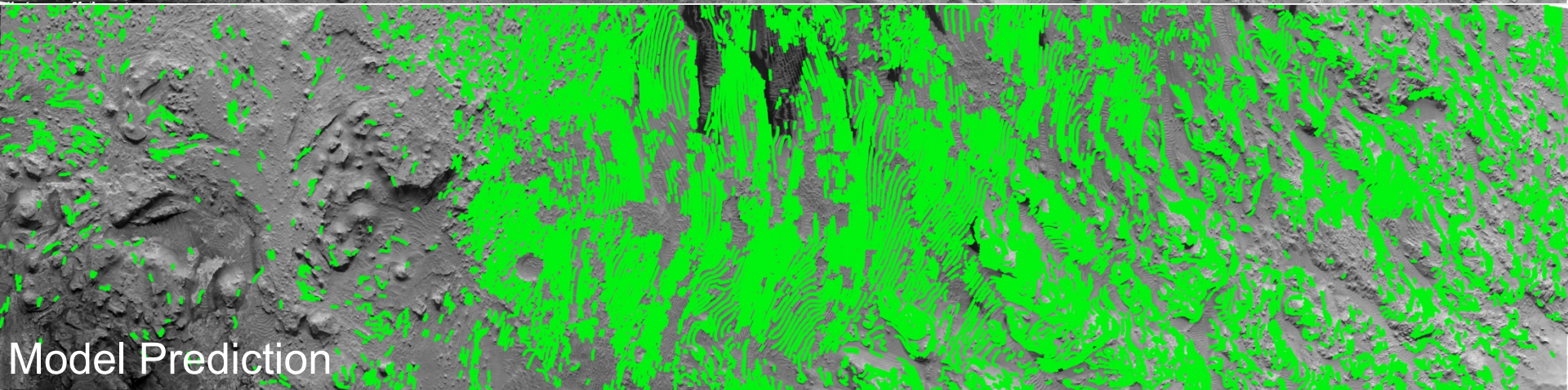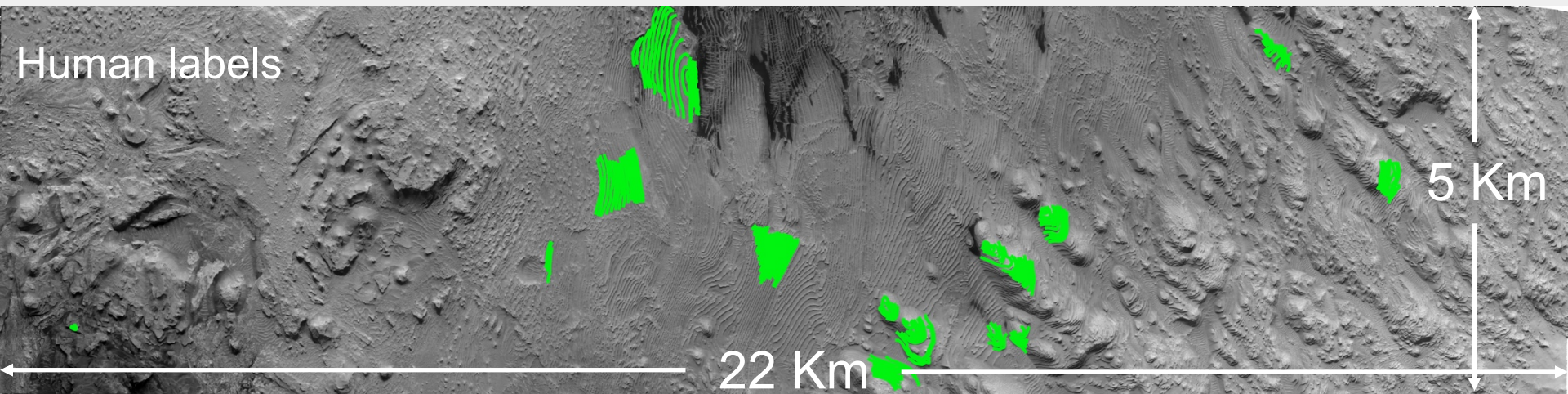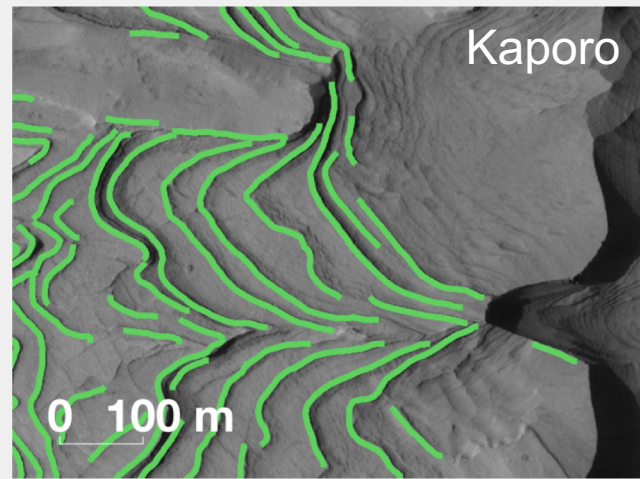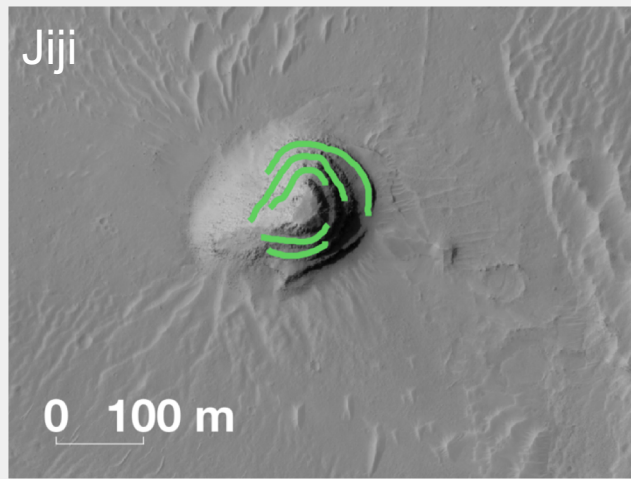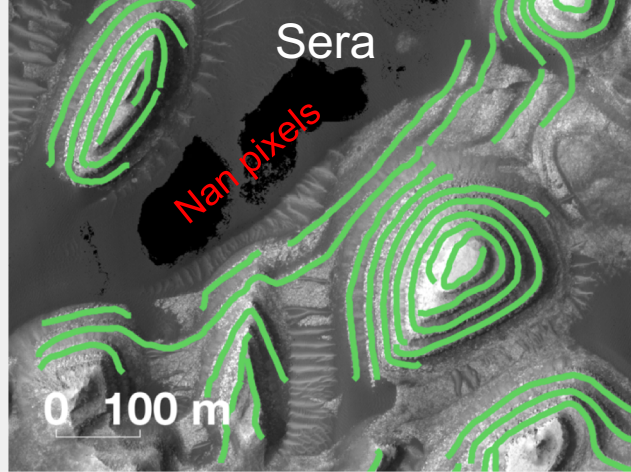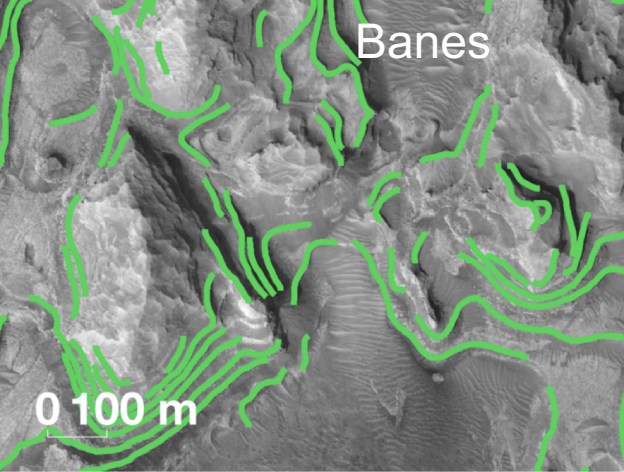
Results from CNN mapping

- ~40k strata mapped
- 16k layer thicknesses
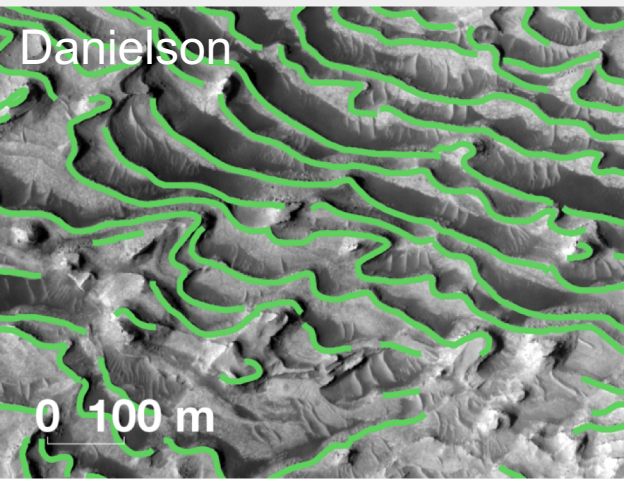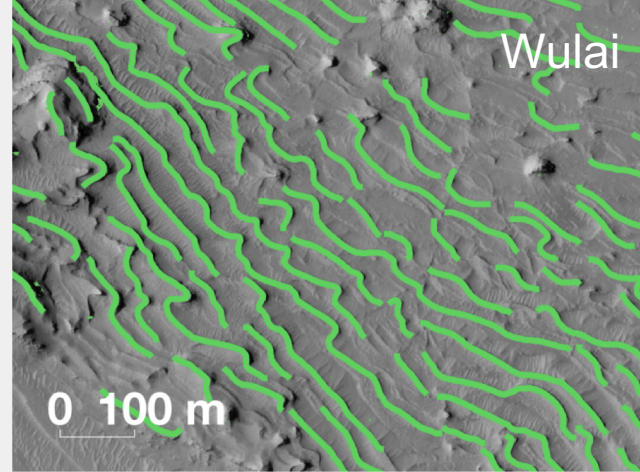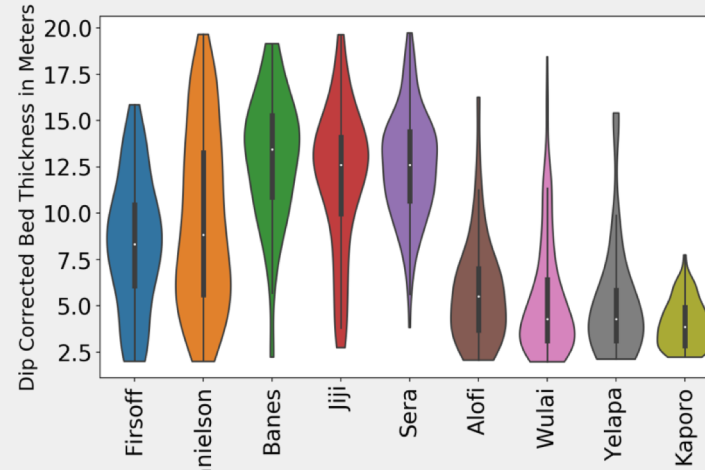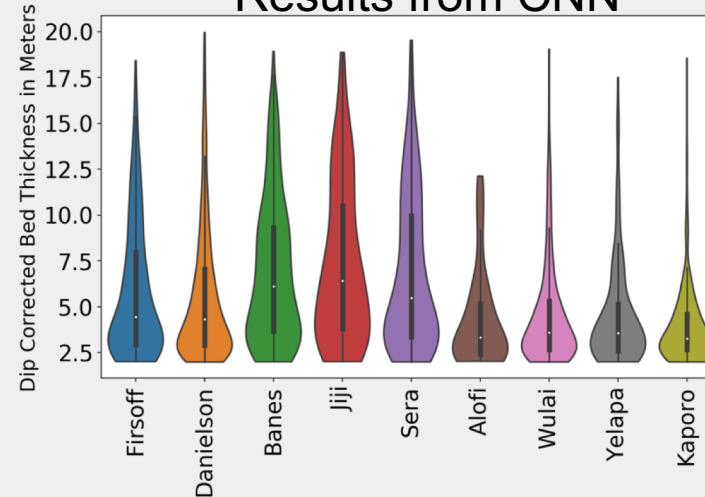- 5k after naive filtering
- Human time: several days, months in human "wall time"
- Computer time: a few hours to train, minutes to run predicts & fits
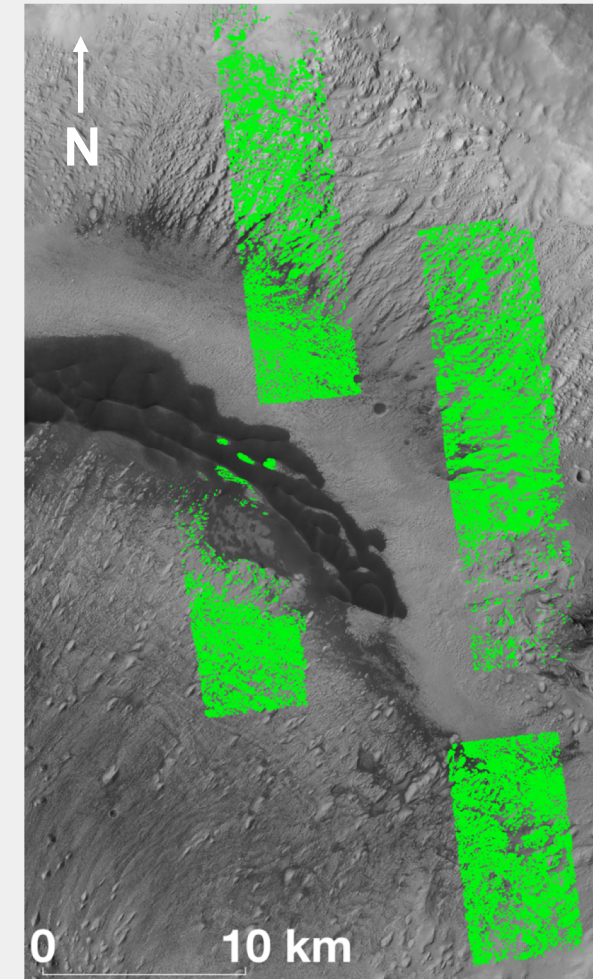- Need to work on better post processing and filtering…

Manual Results

Results from CNN

CNN predictions in Green

Conclusions

1. Planetary Sciences can benefit from dl/ml to automate tasks that are not science! Save grad students from scientific busy work.
2. U-net produced good results, with multiple morphologies of layered units present in training data.
3. Newer architectures to test: 100 layer Tiramisu, GANs.
4. Need to try older methods: HOG+SVM.
5. Need to use CV to compare these models.
6. Mutual benefits between EO and Planetary fields.

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