

Glaciology and Machine Learning Summer School - Intro Slides

GlaMacLeS

June 15, 2024



Introductions

- Name
- Research focus
- What you like to do when you're not working!
- (and whatever else you think is pertinent)

Why are we here?

- To gain knowledge needed to *understand* applied ML literature.
- To gain knowledge needed to *apply* ML to novel cryosphere research.
- To build a *community* of practitioners.

A little history



An operational definition of Machine Learning

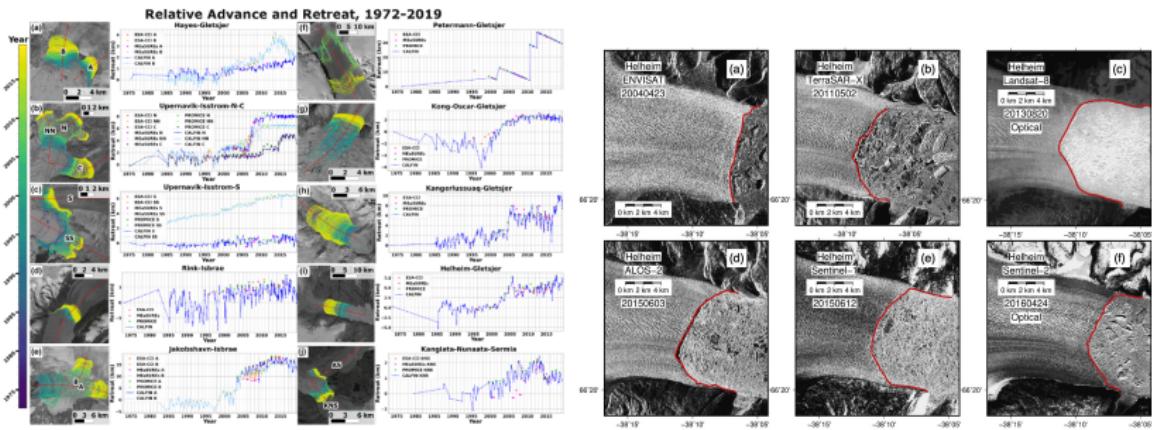
Wikipedia: 'Machine learning (ML) is a field of study in artificial intelligence concerned with the development and study of statistical algorithms that can learn from data and generalize to unseen data, and thus perform tasks without explicit instructions.'

Goodfellow et al.: 'The difficulties faced by systems relying on hard-coded knowledge suggest that AI systems need the ability to acquire their own knowledge, by extracting patterns from raw data. This capability is known as machine learning.'

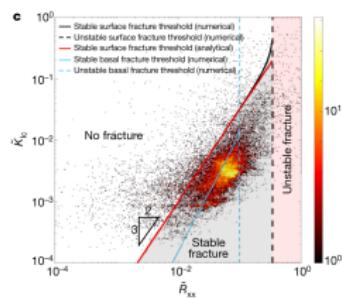
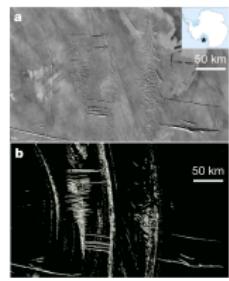
Yan Lecun: 'Deep learning is constructing networks of parameterized functional modules and training them from examples using gradient-based optimization. That's it.'

Me: Employing highly flexible functions to approximate the complex and unknown mappings between arbitrary data sets. The difference with statistics - ML emphasizes learning functions, while statistics emphasizes learning (distributions over) parameters.

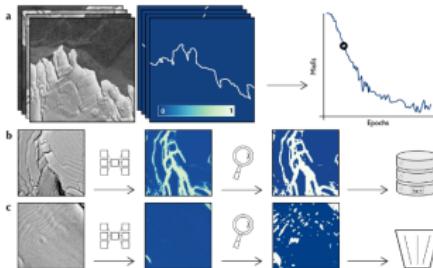
Uses in glaciology - Calving fronts



Uses in glaciology - Crevasse detection

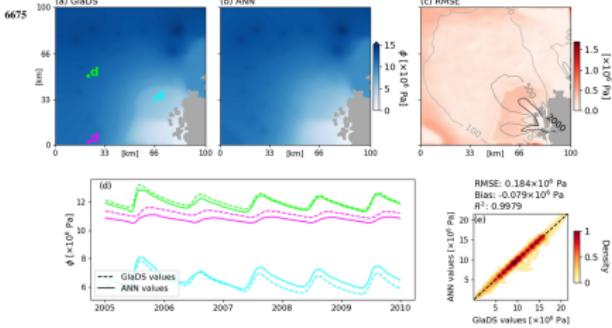
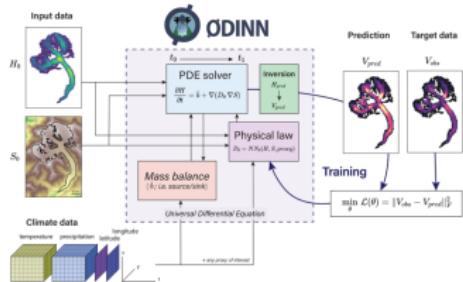


T. Surawy-Stepney et al.: Mapping Antarctic crevasses at high resolution

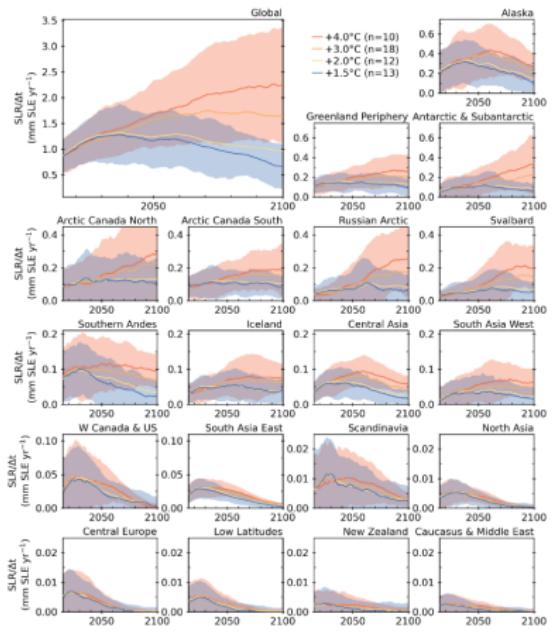
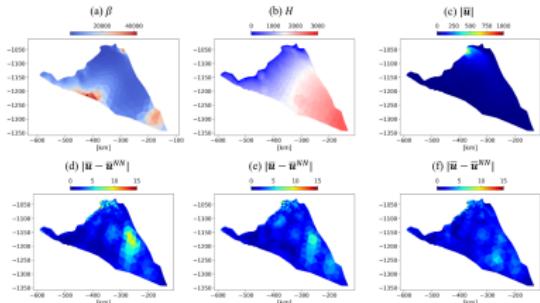


Uses in glaciology - Replacement of processes

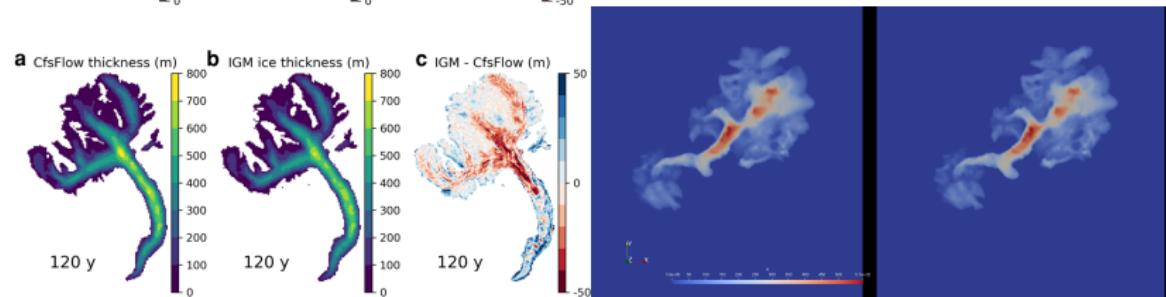
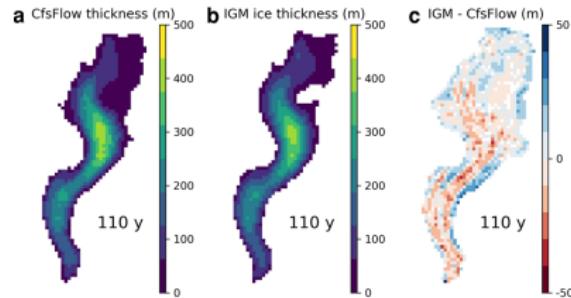
J. Bolíbar, F. Sapienza, et al.: UDEs for glacier ice flow modelling



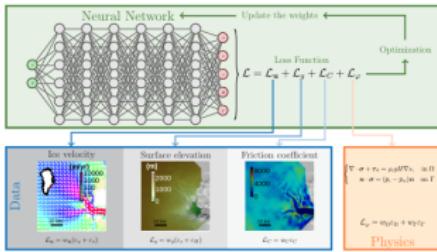
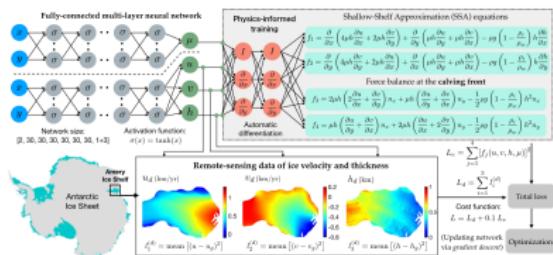
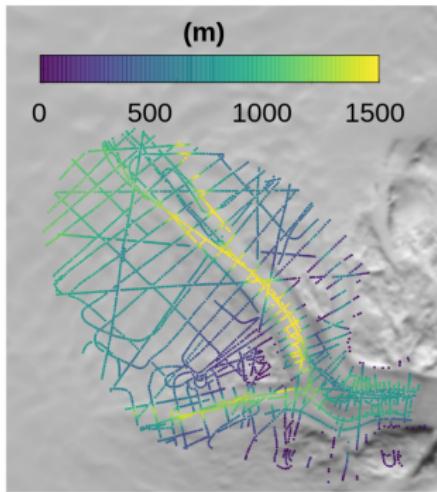
Uses in glaciology - Parameter to observable map



Uses in glaciology - Solution operator



Uses in glaciology - PDE solving



Curriculum

Monday

- Glacier Dynamics and Critical Uncertainties
- ML Models
- Measuring misfit
- Automatic differentiation
- Adjoint
- Pytorch

Tuesday

- The Bayesian approach
- Numerical methods for Bayesian inference
- Convolutional neural networks

Wednesday

- Emulation
- Gaussian process regression
- Operator networks

Thursday

- Local emulators
- Physics-informed neural networks
- Time-series architectures

Friday



Paul Reiffer

Saturday/Sunday - Projects

- ① CNN detection of melt ponds and rifts
- ② CNN detection of moulin
- ③ Emulation with operator networks
- ④ Fourier neural operators
- ⑤ Ice shelf inversion with PINNs
- ⑥ Learning time-dependent sliding laws

Other considerations

- Be awesome to and learn from one another.
- Don't hesitate to talk to me, any instructor, or TNC staff if you're not feeling good about something.
- Enjoy the location!