Fraser King, PhD

DEEP LEARNING AND REMOTE SENSING DATA SCIENTIST

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Education _____

University of Waterloo

РнD

- Advisor: Dr. Christopher Fletcher
- Thesis: Developing a radar-based machine learning snowfall retrieval algorithm
- Finalist for the Waterloo 2023 Governor General's Gold Academic Medal (doctoral)

University of Waterloo

MASTER OF SCIENCE

- Advisor: Dr. Christopher Fletcher
- Thesis: Validating CloudSat-CPR retrievals for the estimation of snow accumulation in the Canadian Arctic

University of Waterloo

BACHELOR OF COMPUTER SCIENCE (HONOURS)

- Graduated with distinction on the Dean's honour list
- · Participated in the honours co-op program with outstanding performance reviews

Professional Experience

- 2023 Postdoctoral Research Fellow, University of Michigan
- 2022 Artificial Intelligence Research Intern, Aquanty Inc.
- 2019 Machine Learning Research Intern, Aquanty Inc.
- 2016-2017 Software Engineer, TD Bank

Publications_

- King, F., Pettersen, C., Dolan, B., Shales, J., Posselt, D., (2024). Primary Modes of Northern Hemisphere Snowfall Particle Size Distributions. *Journal of Atmospheric Science*, in review.
- King, F., Pettersen, C., Bliven, L., Cerrai, D., Chibisov, A., Cooper, S.J., L'Ecuyer, T., Kulie, M.S., Leskinen, M., Mateling, M., Mc-Murdie, L., Moisseev, D., Nesbitt, S.W., Petersen, W.A., Rodriguez, P., Schirtzinger, C., Stuefer, M., von Lerber, A., Wingo, M.T., Wolff, D.B., Wong, T., Wood, N., (2024). A Comprehensive Northern Hemisphere Particle Microphysics Dataset from the Precipitation Imaging Package. *Earth and Space Science*, in review.
- **King, F.**, Pettersen, C. & Fletcher, C. G., Geiss, A. (2024). Development of a deep full-scale connected U-Net for reflectivity inpainting in spaceborne radar clutter zones. *Artificial Intelligence for the Earth Systems*. https://doi.org/10.1175/AIES-D-23-0063.1.
- King, F., Kelly, R., & Fletcher, C. G. (2023). New opportunities for low-cost LiDAR-derived snow depth estimates from a consumer drone-mounted smartphone. *Cold Regions Science and Technology*, 207, 103757. https://doi.org/10.1016/ j.coldregions.2022.103757
- King, F., Duffy, G., Milani, L., Fletcher, C. G., Pettersen, C., & Ebell, K. (2022). DeepPrecip: A deep neural network for precipitation retrievals. *Atmospheric Measurement Techniques*, 15, 6035–6050. https://doi.org/10.5194/amt-15-6035-2022
- **King, F.**, Duffy, G., & Fletcher, C. G. (2022). A Centimeter Wavelength Snowfall Retrieval Algorithm Using Machine Learning. *Journal of Applied Meteorology and Climatology*, https://doi.org/10.1175/JAMC-D-22-0036.1
- King, F., Kelly, R., & Fletcher, C. G. (2022). Evaluation of LiDAR-Derived Snow Depth Estimates From the iPhone 12 Pro. *IEEE Geoscience and Remote Sensing Letters*, https://doi.org/10.1029/2021MS002836
- Fletcher, C. G., McNally, W., Virgin, G., & **King, F.** (2022). Toward efficient calibration of higher resolution Earth System Models. *Journal of Advances in Modeling Earth Systems*, 19, 1–5. https://doi.org/10.1109/LGRS.2022.3166665

Waterloo, Ontario, Canada 2019 - 2022

Waterloo, Ontario, Canada 2017 - 2019

n Arctic

Waterloo, Ontario, Canada 2012 - 2017

- King, F., & Fletcher, C. G. (2021). Using CloudSat-derived snow accumulation estimates to constrain gridded snow water equivalent products. *Earth and Space Science*, e2021EA001835. https://doi.org/10.1029/2021EA001835
- Duffy, G., **King, F.**, Bennartz, R., and Fletcher, C. G. (2021). Seasonal Estimates and Uncertainties of Snow Accumulation from CloudSat Precipitation Retrievals. *Atmosphere*, 12(3), 363. https://doi.org/10.3390/atmos12030363
- King, F., Erler, A. R., Frey, S. K., and Fletcher, C. G. (2020). Application of machine learning techniques for regional bias correction of snow water equivalent estimates in Ontario, Canada, *Hydrol. Earth Syst. Sci.*, 24, 4887–4902, https://doi.org/ 10.5194/hess-24-4887-2020
- King, F., & Fletcher, C. G. (2020). Using CloudSat-CPR Retrievals to Estimate Snow Accumulation in the Canadian Arctic. *Earth and Space Science*, 7(2), e2019EA000776. https://doi.org/10.1029/2019EA000776

Awards, Fellowships, & Grants ____

| 2023 | Governor General's Gold Academic Medal (Finalist), University of Waterloo | - |
|------|--|--------------|
| 2023 | Postdoctoral Fellowship, Natural Sciences and Engineering Research Council (NSERC) | \$ 90,000 |
| 2022 | Early Career Scientist Award (2nd), International Precipitation Working Group | \$ <i>50</i> |
| 2021 | Campbell Scientific Canada Award, Eastern Snow Conference | \$ 500 |
| 2020 | Doctoral Scholarship, Natural Sciences and Engineering Research Council (NSERC) | \$ 63,000 |
| 2019 | Exceptional Doctoral Student Scholarship, University of Waterloo | \$ 10,000 |
| 2019 | ESRI Canada GIS Centres of Excellence National Hackathon (1st), ESRI Canada | \$ 500 |
| 2019 | Jack Rosen Memorial Award for Environmental Innovation (1st), University of Waterloo | \$ 2,000 |
| 2019 | GRADflix Research Communication Video Winner (1st), University of Waterloo | \$ 1,000 |
| 2019 | ESM-SnowMIP EGU Travel Grant, Snow Models Intercomparison Project | \$ 1,000 |
| 2012 | Governor General's Bronze Academic Medal, Central Huron Secondary School | - |

Presentations.

INVITED TALKS

- Spring 2024. Interpretable Artificial Intelligence: How do we know what our models are doing? Invited Speaker, University of Illinois Urbana-Champaign. In person.
- Spring 2024. *Documenting and Maintaining Large Geospatial Datasets*. Invited Panelist, University of Michigan Research Data Stewardship Initiative. Online.
- Spring 2024. *Towards Interpretable Artificial Intelligence in the Atmospheric Sciences*. Invited Speaker, NASA Jet Propulsion Laboratory. In person.
- Winter 2024. Let it Snow! Let it Snow! Let it Snow! Climate Series Talks. Invited Speaker, Maitland Valley Conservation Authority. Online.
- Winter 2024. A Comprehensive Northern Hemisphere Particle Microphysics Dataset from the Precipitation Imaging Package. Invited Speaker, PSD Working Group. Online.
- Fall 2023. Development of a deep full-scale connected U-Net for reflectivity inpainting in spaceborne radar clutter zones. Invited Speaker, AGU 2023. In person.
- Fall 2022. Do neural networks dream of falling snow? Invited Speaker, Intact Financial Corporation. Online.
- Summer 2022. *DeepPrecip: A deep neural network for precipitation retrievals*. Invited Speaker, PMM Land Surface Working Group. Online.
- Fall 2021. Enhancing the accuracy of current snow water equivalent products using remote sensing and machine learning. Guest Lecture, Machine Learning Research Group, University of Guelph. Online.
- Winter 2019. Bias correcting snow water equivalent data using machine learning. Guest Lecture, Aquanty Inc. In person.

CONTRIBUTED PRESENTATIONS

King, F., Pettersen, C., & Fletcher, C. G., & Posselt, D. (2024). Towards Interpretable Artificial Intelligence in the Atmospheric Sciences. Invited oral presentation: International Precipitation Working Group (IPWG) Snowfall Focus Group. Online.

- **King, F.**, Pettersen, C., & Fletcher, C. G., & Geiss, A. (2023). Development of a full-scale connected U-Net for reflectivity inpainting in spaceborne radar blind zones. Invited oral presentation: American Geophysical Union 2023. In Person.
- **King, F.**, Pettersen, C., & Fletcher, C. G., & Geiss, A. (2023). Development of a full-scale connected U-Net for reflectivity inpainting in spaceborne radar blind zones. Invited oral presentation: American Geophysical Union 2023. In Person.
- **King, F.**, Pettersen, C., & Fletcher, C. G., & Geiss, A. (2023). Development of a full-scale connected U-Net for reflectivity inpainting in spaceborne radar blind zones. Oral presentation: American Meteorological Society's 40th Conference on Radar Meteorology. In Person.
- King, F., Pettersen, C., & Fletcher, C. G., & Geiss, A. (2023). Development of a deep full-scale connected U-Net for reflectivity inpainting in spaceborne radar clutter zones. Oral presentation: Eastern Snow Conference 2023. In Person.
- **King, F.**, Pettersen, C., Fletcher, C. G., & Geiss, A. (2023). Development of a deep full-scale connected U-Net for reflectivity inpainting in spaceborne radar clutter zones. Oral presentation: Vanderbilt University Machine Learning and Snowfall Workshop. In Person.
- King, F., Duffy, G., Milani, L., Fletcher, C. G., Pettersen, C., & Ebell, K. (2022). DeepPrecip: A deep neural network for precipitation retrievals. Oral presentation: University of Waterloo Graduate Student Conference. In Person.
- King, F., Duffy, G., Milani, L., Fletcher, C. G., Pettersen, C., & Ebell, K. (2022). DeepPrecip: A deep neural network for precipitation retrievals. Oral presentation: AGU Collective Madison Meeting (SatMET). Online.
- King, F., Duffy, G., Milani, L., Fletcher, C. G., Pettersen, C., & Ebell, K. (2022). DeepPrecip: A deep neural network for precipitation retrievals. Oral presentation: AGU Frontiers in Hydrology Meeting. Online.
- King, F., Duffy, G., Milani, L., Fletcher, C. G., Pettersen, C., & Ebell, K. (2022). DeepPrecip: A deep neural network for precipitation retrievals. Oral presentation: International Precipitation Working Group. In person.
- King, F., Duffy, G., Milani, L., Fletcher, C. G., Pettersen, C., & Ebell, K. (2022). DeepPrecip: A deep neural network for precipitation retrievals. Oral presentation: Eastern Snow Conference. Online.
- King, F., Kelly, R., & Fletcher, C. G. (2022). What if you put a phone on a drone? Oral presentation: Canadian Meteorological and Oceanographic Society. Online.
- **King, F**, Duffy, G., Fletcher, C. G. (2021). A Centimeter Wavelength Snowfall Retrieval Algorithm Using Machine Learning. Poster: International Summer Snowfall Workshop. Online.
- **King, F**, Fletcher, C. G. (2021). Using CloudSat-CPR derived snow accumulation estimates to constrain gridded snow water equivalent products. Oral presentation: Canadian Meteorological and Oceanographic Society. Online.
- **King, F**, Kelly, R., Fletcher, C. G. (2021). Evaluation of LiDAR snow depth estimates from portable consumer devices and their application for citizen science. Oral presentation: Eastern Snow Conference. Online.
- **King, F**, Fletcher, C. G. (2021). Using CloudSat-CPR derived snow accumulation estimates to constrain gridded snow water equivalent products. Oral presentation: IEEE Geoscience and Remote Sensing Society (IGARSS). Online.
- **King, F**, Fletcher, C. G. (2020). Bias-correction of gridded SWE products using CloudSat-CPR snowfall estimates. Oral presentation: Canadian Meteorological and Oceanographic Society. Online.
- King, F, Erler, A., Frey, S., Fletcher, C. G. (2020). Application of Machine Learning Techniques for Regional Bias Correction of SWE Estimates in Ontario, Canada. Oral presentation: Climate Informatics (CI). Online.
- **King, F**, Fletcher, C. G. (2020). Evaluation of Gridded Snow Products Using CloudSat Snowfall Estimates. Poster: Canadian Space Agency (CSA) Workshop. CSA, Montreal, Canada. In person.
- **King, F**, Fletcher, C. G. (2019). Evaluation of Gridded Snow Products Using CloudSat Snowfall Estimates. Oral presentation: European Geosciences Union (EGU). Vienna, Austria. In person.
- **King, F**, Fletcher, C. G. (2019). Using CloudSat-CPR Retrievals to Estimate Snow Accumulation in the Canadian Arctic. Oral presentation: Canadian Meteorological and Oceanographic Society. Halifax, Nova Scotia. In person.

Research Projects _

SNOWFALL MICROPHYSICAL DIMENSIONALITY REDUCTION 2024 - Present

I was responsible for curating a high quality precipitation dataset containing over 1 million minutes of particle microphysical observations. This included measurements of particle size distribution, fall speed, effective density and snowfall/rainfall rates, which were standardized and packaged into an accessible online dataset. This data was then analysed using a combination of both linear and nonlinear dimensionality reduction techniques including PCA, Isomap, t-SNE and UMAP, to identify the primary modes of precipitation variability across the Northern Hemisphere. This NASA-funded work resulted in three research papers and multiple invited talks/conference presentations.

RADAR BLINDZONE INPAINTING USING ARTIFICIAL INTELLIGENCE 2023 - 2024

I am the primary investigator on a research project which uses deep learning to predict near surface reflectivity profiles in spaceborne radar. As the project lead, I am responsible for sourcing and processing the training data, designing and tuning the convolutional neural network, assigning tasks to other co-authors, and presenting the results at conferences and workshops. My 2-year Postdoctoral Fellowship proposal on this topic was approved and funded by NSERC, beginning in 2023.

DEEP LEARNING SNOWFALL RETRIEVAL (DEEPPRECIP) 2021 - 2022

I was the primary investigator on a deep learning snowfall retrieval project where my responsibilities included algorithm design, model implementation, and performance evaluation. As the leader of a team of 5 other researchers, I was also responsible for delegating project tasks and adhering to tight deadlines. I facilitated an ongoing collaborative effort with various international partners and data providers, and our work resulted in multiple conference presentations and a journal article publication.

Teaching Experience _____

| 2024 | Master's of Science Defense Committee Member, External Examiner | University of Waterloo |
|------------------|--|---------------------------|
| 2022 | Machine learning applications for land cover classification using Sentinel-2, Instructor | Aggregate Intellect |
| 2017-2019 | ENVS 278, Teaching Assistant | University of Waterloo |
| Mentorin | g | |
| 2023- Present | Research Mentor, Department of Climate and Space Sciences and Engineering | University of Michigan |
| 2017-2019 | Statistics Tutor, Undergraduate Students in Math, Computer Science and Geography | University of Waterloo |
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Technical Skills

- Languages: Python, C/C++, Objective-C, R, Rust, Go, Swift, Javascript, Bash
- Software: Tensorflow, scikit-learn, SciPy, Keras, PyTorch, Zarr, Xarray, Pandas, Git, SQL, HDF, netCDF, Slurm, CUDA
- Hardware: Azure, Graphcore, Google Compute, Great Lakes, Mist GPU Cluster, Google Colab, Paperspace

Outreach & Professional Development_

Service and Outreach

| 2023 | AGU Early Career Seminar, Seminar organizer, host | AGU |
|------|---|---------------|
| 2023 | AMS Radars, Machine Learning Session Abstract Reviewer | AMS |
| 2023 | Google Quantum AI, Design Consultant | Google |
| 2023 | International Precipitation Conference 14, Session Moderator | University of |
| | | Oklahoma |
| | | American |
| 2022 | AGU Precipitation Technical Committee, Executive Member (ongoing) | Geophysical |
| | | Union |
| 2022 | Eastern Snow Conference, Executive Council Member (ongoing) | ESC |
| 2022 | Canadian Meteorological and Oceanographic Society (CMOS) Bulletin, Author | CMOS |
| 2022 | NSERC Science Exposed, Lead Designer | NSERC |
| 2021 | Environment Building Mural Project (Canada Map), Creator, Designer and Project Lead | University of |
| | | Waterloo |
| 2021 | Environment Graduate Student Recruitment, PhD Student Panelist | University of |
| | | Waterloo |
| 2018 | Let's Talk Science, Student Volunteer | University of |
| | | Waterloo |

Development

GraphCore AI Training: Completed an online training course to use deep learning libraries like Tensorflow and Keras with big data on the Graphcore Intelligence Processing Unit pods.

- **Compute Canada High Performance Computing Course:** A two day in-person course provided in-depth detail into using the Niagara super-computing cluster (ie. submitting and parallelizing compute tasks).
- **3 Minute Thesis Competition:** As a participant in this competition, I learned valuable techniques for communicating my research in a clear and concise manner to a wide audience.