MOSTAFA BOUSBAA
Ph.D. Candidate in Remote Sensing,
Hydrology, and Geoinformatics

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Research Interests

Methodological Expertise: Remote Sensing, Multi-sensor Image and Data Fusion, Spatio-temporal Modeling, Machine Learning, Deep Learning, Geospatial Artificial Intelligence (GeoAI).
Application Domains: Snow Hydrology, Snow–Groundwater Interactions, Hydrological Modeling and Forecasting, Climate Change Impact Assessment, Water Resources Management.

Education

- **Visiting Researcher**
  September 2024 - February 2025
  Institute of Methodologies for Environmental Analysis (CNR-IMAA), Italy
  Supervisor: Dr. Gemine Vivone
- **Ph.D. Researcher**
  December 2021 - Present
  Center for Remote Sensing Applications (CRSA), College of Agriculture and Environmental Sciences (CAES), Mohammed VI Polytechnic University, Ben Guerir, Morocco
  PhD Thesis Title: **"Spatio-temporal Fusion of Multi-sensor Satellite Data for Snow Hydrology Applications in the Moroccan Context"**
  Supervisors: Prof. Abdelghani Boudhar and Prof. Abdelghani Chehbouni
- **Master of Science and Technics in Environmental Geomatics**
  September 2019 - 2021
  Sultan Moulay Slimane University, Faculty of Science and Technology, Beni Mellal, Morocco
  Major of Class 2019-2021 Master's Degree.
- **Bachelor of Science and Technics in Geomatics and Territory Management**
  September 2018 - 2019
  Sultan Moulay Slimane University, Faculty of Science and Technology, Beni Mellal, Morocco
  Major of Class 2018-2019 Bachelor's Degree.
- **University Degree in Science and Technics in Mathematics, Computing, Physics, and Chemistry**
  September 2015 - 2018
  Sultan Moulay Slimane University, Faculty of Science and Technology, Beni Mellal, Morocco
- **High School Degree in Physics**
  September 2014 - 2015
  Annasr High School, Bradia Fquih Ben Salah, Morocco

Additional Education

- **Drone Technologies and Smart Irrigation Water Management in Agriculture**, April 21-23, 2025, Marrakech, Morocco.
- **Advanced Training Course on Land Remote Sensing: Snow and Glaciers**, European Space Agency (ESA) and University of Innsbruck, September 16-20, 2024, Innsbruck, Austria.
- **Deep Learning Approaches to Overcome Small Data Challenges in Remote Sensing for Agriculture**, April 2025, Leibniz Center for Agricultural Landscape Research, Müncheberg, Germany.
- **OpenGeoHub Summer School: "Processing and Visualizing Large Geospatial Data Using R, Python, and Julia"**, August 27 – September 2, 2023, Adam Mickiewicz University, Poznan, Poland.
- **Artificial Intelligence Summer School**, July 17-21, 2023, MoroccoAI in partnership with Al Akhawayn University, Ifrane, Morocco.

- **Climate Change AI Summer School 2023**, June 23 – July 27, 2023, Mila & Worldsphere & Cifar & Denvr (Remote).
- **AI4Science Workshop**, December 12-16, 2022, Google DeepMind & Fondation MAScIR, Rabat, Morocco.
- **Math for Machine Learning Summer School**, July 25-30, 2022, École Polytechnique Paris and EMINES-UM6P, Benguerir, Morocco.
- **TAI4ES 2022 Summer School: Trustworthy Artificial Intelligence for Environmental Science (TAI4ES)**, June 27-30, 2022, National Center for Atmospheric Research, USA.

Research Experience

Dec 2021 - Nov 2022 **Pre-Doctoral Fellow**
Mohammed VI Polytechnic University (UM6P), Benguerir, Morocco

Achievements

- Conducted research on spatio-temporal fusion of multi-sensor satellite data for snow hydrology applications in Morocco.
- Collected, processed, and analyzed large-scale datasets from remote sensing images and geospatial data for water resource management.
- Automated data processing workflows using programming languages such as MATLAB, Python, R, and Google Earth Engine.
- Designed and implemented data management systems, including geospatial databases, and developed tools for visualizing hydrological data and satellite-derived products.
- Developed innovative models for spatio-temporal fusion of multi-sensor satellite data, applied to snow hydrology in mountainous regions—marking the first application of its kind in both the literature and the region.
- Collaborated with interdisciplinary teams to integrate remote sensing data with hydrological models, focusing on geospatial data management, snow depth prediction using AI, and streamflow simulation, while analyzing the impacts of climate change on snow hydrology and water availability.

Feb 2021 - Aug 2021 **Master's Degree Internship MorSnow Project**
Center for Remote Sensing Application (CRSA), Benguerir, Morocco

Achievements

- Data acquisition, preparation, and preprocessing (Satellite image, re-analysis data, and In-situ measurements).
- Visualization and automatic generation of graphs, interactive maps, and statistics from available data.
- Analysis of multi-source data via processing software (ENVI, ArcGIS, RStudio, Matlab, and Python) and online analysis platforms (GEE)
- Development of high spatial and temporal resolution snow cover products for use in hydrological modelling to improve water management.

March 2019 - July 2019 **Bachelor's Degree Internship**
Research laboratory of Remote Sensing and GIS, FST Beni Mellal, Morocco

Achievements

- Developed a mobile GIS for water and wastewater networks, specifically designed for field agents.
- Improved the management of intervention orders through mobile access.
- Visualized intervention orders and provided real-time updates for efficient management.
- Enabled access to network mapping, including pipes, manholes, structures, and more.
- Allowed users to enter and send reports directly from the field, enhancing reporting efficiency.
- Managed user accounts (field agents) for better coordination and streamlined operations.

Selected contributions in open-source code repositories

- **MorSnowAI v1.0** : An Open-Source Python Package for Empowering Artificial Intelligence in Snow Hydrology - A Comprehensive Toolbox. In progress.

- **SnowMapPy v1.0**: A Python Package for Automated Snow Cover Mapping and Monitoring in the Mediterranean Atlas Mountains. In progress.

Publications / Conferences

Publications

- **Bousbaa.M** et al. 2025: "Spatio-Temporal Fusion of MODIS and Sentinel-2 Imagery Using Deep Learning and Classical Methods for Daily High-Resolution NDSI Estimation in the Moroccan Atlas Mountains". IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (in progress).

- **Bousbaa.M** et al. 2025: "Remote Sensing-Based Groundwater Storage Forecasting Using Deep Learning and Machine Learning Techniques in the Major Moroccan River Basins". Journal of Hydrology (in progress).

- **Bousbaa.M** et al. 2025: "Assessing Groundwater Storage Response to Snow Cover Dynamics in Large Moroccan River Basins Over the Last Decades Using Remote Sensing Data". Groundwater for Sustainable Development (under review).

- **Bousbaa.M**, Boudhar.A, Kinnard.C, Elyoussfi.H, Karaoui.I, Eljabiri.Y, Bouamri.H, Chehbouni.A (2024): "An accurate snow cover product for the Moroccan Atlas Mountains: Optimization of the MODIS NDSI index threshold and development of snow fraction estimation models". International Journal of Applied Earth Observation and Geoinformation 129, 103851.`https://doi.org/10.1016/j.jag.2024.103851`

- **Bousbaa.M**, Htitiou.A, Boudhar.A, Eljabiri.Y, Elyoussfi.H, Bouamri.H, Ouatiki.H, Chehbouni.A, (2022). "High-Resolution Monitoring of the Snow Cover on the Moroccan Atlas through the Spatio-Temporal Fusion of Landsat and Sentinel-2 Images". Remote Sensing 14, 5814. `https://doi.org/10.3390/rs14225814`

- Y. El Jabiri, A. Boudhar, A. Htitiou, E.A. Sproles, **M. Bousbaa**, H. Bouamri, A. Chehbouni (2024). "A method for robust estimation of snow seasonality metrics from Landsat and Sentinel-2 time series data over Atlas Mountains scale using Google Earth Engine". Geocarto Int., 39 (2024), p. 2313001 `10.1080/10106049.2024.2313001`

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Nifa.K, Bargam.B and Chehbouni.A (2025):"Leveraging advanced deep learning and machine learning approaches for snow depth prediction using remote sensing and ground data", Journal. Hydrol. Reg. Stud., vol. 57, p. 102085, févr. 2025, `https://doi.org/10.1016/j.ejrh.2024.102085`

- **Bousbaa.M**, Boudhar.A, Kinnard.C, Elyoussfi.H, Nifa.K, Bargam.B And Chehbouni.A: "Seasonal Snow Cover Variability and Snow Trends Analysis in the Moroccan Atlas Mountains (2000-2023)", Euro-Mediterranean Journal for Environmental Integration (Conference paper : EMCIE 2024 Accepted).

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Nifa.K, Bargam.B, B.Sebbar and Chehbouni.A :"Hybrid CNN-BiLSTM Approach for Local-Scale Snow Depth Forecasting in the Mountainous Regions of Morocco", Euro-Mediterranean Journal for Environmental Integration (Conference paper : EMCIE 2024 Accepted).

- Sebbar.B, Merlin.O, Khabba.S, Simonneaux.V, Chouaib ElHachimi.C, Elyoussfi.H, **Bousbaa.M**, and Chehbouni.A: "Assessing Groundwater Sensitivity: Impact of Topography on Evapotranspiration Uncertainty and Water Balance Closure at Basin Scale", Euro-Mediterranean Journal for Environmental Integration (Conference paper : EMCIE 2024 Accepted).

Conferences

- **Bousbaa.M**, Boudhar.A, Kinnard.C, Vivone.G, Elyoussfi.H, Sproles.E.A, Bargam.B, Nifa.K and Chehbouni.A: "Remote Sensing of Mountain Snow from Space: Developing Accurate Snow Products for Efficient Water Resource Management in Morocco's Atlas Mountains", EGU General Assembly 2025, Vienna, Austria, 27 Apr–2 May 2025, EGU25-13326, `https://doi.org/10.5194/egusphere-egu25-13326`, 2025.

- **Bousbaa.M**, Boudhar.A, Kinnard.C, Elyoussfi.H, Elbouanani.N, Htitiou.A, Bargam.B, Nifa.K and Chehbouni.A: "Towards a Deep Learning-based Spatio-temporal Fusion Approach for Accurately Improving Snow Cover Mapping: A Case Study in the Moroccan Atlas Mountains with Performance Evaluation", EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-13030, `https://doi.org/10.5194/egusphere-egu24-13030`, 2024.

- **Bousbaa.M**, Boudhar.A, Kinnard.C, Elyoussfi.H, Nifa.K, Bargam.B And Chehbouni.A: "Seasonal Snow Cover Variability and Snow Trends Analysis in the Moroccan Atlas Mountains (2000-2023)", 6Th Euro-Mediterranean Conference for Environmental Integration, May 2024, Marrakech, Morocco.

- **Bousbaa.M**, Boudhar.A, Htitiou.A, Eljabiri.Y, Elyoussfi.H, Bouamri.H, Ouatiki.H and Chehbouni.A: "Spatio-Temporal Fusion Approach of Landsat and Sentinel-2 Images for Snow Cover Mapping in the Moroccan Atlas". GESOC 2022, Symposium on Water Management in Semi-arid areas, Tools, Global changes, November 2022, Marrakech, Morocco.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Bechri.H, Eric A Sproles, Fatima Benzhair, Abdelghani Boudhar: "**SnowMapPy v1.0**: A Python Package for Automated Snow Cover Mapping and Monitoring in Mountain Regions", EGU General Assembly 2025, Vienna, Austria, 27 Apr–2 May 2025, EGU25-20632, `https://doi.org/10.5194/egusphere-egu25-20632`, 2025.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Azamz.R, Acharki.S and Chehbouni.A: "Deep Learning-Based Approach for Predicting Snow Water Equivalent in the Atlas Mountains Morocco", 6Th IAHR Africa Congress 2024, December 2024, Marrakech-Benguerir, Morocco.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Azamz.R, Acharki.S and Chehbouni.A: "Large-Scale Snow Depth Estimation in the Moroccan Mountains Using Satellite Remote Sensing and Statistical Models for Water Resource Management", Mediterranean Geosciences Union (MedGU) 4Th Annuel Meeting (Track 6. Geo-Informatics and Remote Sensing), November 2024, Barcelona, Spain.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Kinnard.C, Nifa.K, Bargam.B and Chehbouni.A: "Hybrid CNN-BiLSTM Approach for Local-Scale Snow Depth Forecasting in the Mountainous Regions of Morocco", 6Th Euro-Mediterranean Conference for Environmental Integration, May 2024, Marrakech, Morocco.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M** and Chehbouni.A : "Snow Depth Prediction in the Moroccan Mountains Using Analytical Modeling and Remote Sensing", 13th ESA Advanced Training Course on Land Remote Sensing: Snow and Glaciers, September 2024, University of Innsbruck, Austria.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Nifa.K, Bargam.B, Karaoui.I, Bouihrouchane.A, Benmira.T and Chehbouni.A: "**MorSnowAI v1.0** : An Open-Source Python Package for Empowering Artificial Intelligence in Snow Hydrology - A Comprehensive Toolbox", EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-13159, `https://doi.org/10.5194/egusphere-egu24-13159`, 2024.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, **Bousbaa.M**, Nifa.K and Chehbouni.A: "Towards a Deep-Learning Approach for Snow Depth Prediction Over Mountainous Area in Morocco", 44th Canadian Symposium on Remote Sensing, June 2023, Canada.

- Elyoussfi.H, Boudhar.A, Belaqziz.S, Baba.MW, **Bousbaa.M**, Nifa.K and Chehbouni.A: "LSTM-based Deep Learning Approach for Prediction Snow Depth in Morocco : Case Study Tichki – Draa Valley". GESOC 2022, Symposium on Water Management in Semi-arid areas, Tools, Global changes, November 2022, Marrakech, Morocco.

- Bargam.B, Boudhar.A, Kinnard.C, Nifa.K, **Bousbaa.M**, Elyoussfi.H and Chehbouni.A: "Evaluation of input variables determination on the SVM and the ANN model performance using PCA, KPCA, and sequential forward selection techniques SFS for weekly streamflow prediction", 6Th Euro-Mediterranean Conference for Environmental Integration, May 2024, Marrakech, Morocco.

- Sebbar.B, Merlin.O, Khabba.S, Simonneaux.V, ElHachimi.C, Elyoussfi.H, **Bousbaa.M**, and Chehbouni.A: "Assessing Groundwater Sensitivity: Impact of Topography on Evapotranspiration Uncertainty and Water Balance Closure at Basin Scale", 6Th Euro-Mediterranean Conference for Environmental Integration, May 2024, Marrakech, Morocco.

- Bargam.B, Boudhar.A, Kinnard.C, Nifa.K, **Bousbaa.M**, Elyoussfi.H and Chehbouni.A: "Enhancing SVM's robustness of weekly streamflow prediction based on three 1 feature selection algorithms", EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024.

- Nifa.K, Boudhar.A, Elyoussfi.H, Eljabiri.Y, **Bousbaa.M**, Bargam.B, and Chehbouni.A: "Exploring Neural Network Performance in Hydrological Modeling in a Mountainous Region of Morocco: A Case Study on LSTM and GRU Architectures for Runoff Prediction", EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-11621, `https://doi.org/10.5194/egusphere-egu24-11621`, 2024.

- El jabiri.Y, Boudhar.A, Htitiou.A, Sproles.E.A, Bousbaa.M, Bouamri.H and Chehbouni.A: "Towards operational mapping and estimation of snow cover phenology parameters in the Atlas Mountains, Morocco, using multi-sensor satellite data and Google Earth Engine.". GESOC 2022, EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024.

Services

- **Leading Training Courses** :
  - Conducted a training session on **"Machine Learning Algorithms for Satellite Image Classification using R Programming"**, November 18, 2024, Faculty of Science and Technology, Beni Mellal, Morocco.
  - Conducted a training session on **"Supervised and unsupervised classification of satellite images using GEE and QGIS open-source software"**, May 24, 2024, Faculty of Science and Technology, Beni Mellal, Morocco.
  - Conducted a training session on **"Introduction to Google Earth Engine for Remote Sensing Analysis"**, March 27, 2024, Mohammed VI Polytechnic University (UM6P), Ben Guerir, Morocco.
  - Conducted a training session on **"Introduction to Google Earth Engine"**, March 10, 2023, Mohammed VI Polytechnic University (UM6P), Ben Guerir, Morocco.
  - Conducted a training session on **"Geospatial Databases"**, April 22, 2022, Mohammed VI Polytechnic University (UM6P), Ben Guerir, Morocco.
- **Invited Talks** :
  - Talk on **"Advanced Satellite Data Fusion"**, January 16, 2025, for Master's students of Environmental Geomatics at the FST, Beni Mellal, Morocco.
  - Talk on **"Exploring the Power of Remote Sensing and GIS for Geospatial Insights"**, May 23, 2024, DigitalHub Network Webinars.
  - Talk on **"Remote Sensing Observations for Improving Knowledge on Water Resources Availability and Management"**, January 16, 2024, Mohammed VI Polytechnic University (UM6P), Ben Guerir, Morocco.
  - Talk on **"Fundamental Principles of Multi-Source Data Fusion"**, June 10, 2022, Center for Remote Sensing Applications (CRSA), Ben Guerir, Morocco.
  - Talk on **"Fundamentals of Remote Sensing and Geographic Information Systems (GIS)"**, April 27, 2022, Science for All Association, Agadir, Morocco.
- **Supervision and co-supervision** :
  - **Khadija Bouzzite** (M.Sc. student at FSSM), Research project on Deep Learning for Remote Sensing Data Fusion, Aug–Sep 2022 (2 months, PFA internship).
  - **Fatima Zahra Oumellaik** (M.Sc. student at FTP), Research project on Geospatial BIG DATA for Hydrological Decision Support, Aug–Sep 2022 (2 months, PFA internship).
  - **Zineb Aiach** (M.Sc. student at FTSB), Research project on Snowmelt Runoff Simulation using SRM model, Case study: Oum Er Rbia, Feb–Aug 2023 (6 months, PFE internship).
  - **Ayoub Oihi** (M.Sc. student at FTSB), Research project on Groundwater Prediction using Machine Learning Tools, Case study: Oum Er Rbia, Feb–Aug 2023 (6 months, PFE internship).
  - **Nadir Elbouanani** (M.Sc. student at FTP), Research project on Deep Learning for Water Resources Applications, Feb–Aug 2024 (6 months, PFE internship).
  - **Sabir Oussaoui** (M.Sc. student at FSTBM), Research project on Geospatial Data Management, Aug–Sep 2024 (6 months, PFE internship).
  - **Abdelaziz Babioui** (M.Sc. student at EHTP), Research project on Development of a Geoportail, Aug–Sep 2024 (6 months, PFE internship).
  - **Hatim Bechri** (M.Sc. student at FTSB), Research project on Modeling Climate Impacts on Groundwater Ressources using Remote Sensing and AT techniques, Feb–Jul 2025 (6 months, PFE internship).
  - **Rahma Azamz** (M.Sc. student at Universiapolis Agadir), Research project on GeoAI for Groundwater Level Forecasting in the Oum Er-Rbia Basin Using Remote Sensing and Climate Parameters, Feb–Jul 2025 (6 months, PFE internship).
- **Scientific Events: Doctoral Days UM6P** :
  - **Bousbaa, M.**, Boudhar, A., Htitiou, A., Elyoussfi, H., Ouatiki, H., Chehbouni, A. (2022). "Multi-sensor Image Fusion to Map Snow Cover in the Moroccan Atlas Mountains". Poster, Doctoral Day 2022, Mohammed VI Polytechnic University, June 24, 2022, Benguerir, Morocco.
  - **Bousbaa, M.**, Boudhar, A., Kinnard, C., Elyoussfi, H., Karaoui, I., Eljabiri, Y., Bouamri, H., Chehbouni, A. (2023). "NDSI Threshold Optimization of the Terra MODIS Snow Cover Product for Snow Cover Estimation over the Moroccan Atlas Mountains". Poster, Doctoral Day 2023, Mohammed VI Polytechnic University, September 25, 2023, Benguerir, Morocco.

  - Elyoussfi, H., Abdelghani, B., Belaqziz, S., **Bousbaa, M.**, Nifa, K., Kaissi, O., and Chehbouni, A. "MorSnowEO: A Geospatial Approach to Big Data for Water Resource Management". Poster, Doctoral Day 2023, Mohammed VI Polytechnic University, September 25, 2023, Benguerir, Morocco.

- **Peer Reviews** :
  - 4 reviews for IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.
  - 3 reviews for Journal of Mountain Science.
  - 2 reviews for IEEE Transactions on Geoscience and Remote Sensing.

- **Conference, Workshop, and Hackathon Organization**
  - Organizing Committee of the MorSnow-1 seminar on the theme **"Water Resources in Moroccan Mountains: Observations and Modeling"** held on June 9, 2022, at UM6P - Mohammed VI Polytechnic University

Languages and Skills

- **Languages:** English, French, and Arabic.
- **Personal Attributes:** Organized, reliable, fast-learner, highly motivated, creative, results-oriented.
- **Programming Languages:** Python, R, Matlab.
- **Cloud & Remote Computing:** Experienced with **Google Earth Engine**, **Google Colab**, and familiar with cloud-based processing for large-scale Earth observation data.
- **Development Environments (IDEs):** ArcGIS, QGIS, Panoply, Anaconda (Jupyter Notebook), ENVI, Notepad++.
- **Earth Observation Data Management:** Familiar with the structuring, access, and analysis of large Earth observation datasets; practical experience with multi-sensor image processing and open geospatial standards.
- **Database Management Systems (SGBD):** PostgreSQL, PostGIS.