# WEATHER DATA INTEGRATION AND ASSIMILATION SYSTEM

Gihan Chanuka Karunarathne

178004U

Degree of Master of Science

Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

January 2021

# WEATHER DATA INTEGRATION AND ASSIMILATION SYSTEM

Herath Mudiyanselage Gihan Chanuka Karunarathne

178004U

Thesis submitted in partial fulfillment of the requirements for the degree Master of Science in Computer Science and Engineering

Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

January 2021

# Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: *UOM Verified Signature* Date: 02/01/2021

The above candidate has carried out research for the Masters thesis under our supervision.

Name of the supervisor: Dr. HMN Dilum Bandara

Signature of the supervisor: *UOM Verified Signature* Date: 03/01/2021

# Abstract

Numerical Weather Models (NWMs) utilize data collected via diverse sources such as automated weather stations, radars, air balloons, and satellite images. Before using such multimodal data in a NWM, it is necessary to transcode data into a format ingested by the NWM. Moreover, the data integration system's response time needs to be relatively low to forecast and monitor time-sensitive weather events like hurricanes, storms, and flash floods that require rapid and frequent execution of NWMs. The resulting weather data also need to be accessed by many researchers and third-party applications such as logistic and agricultural insurance firms. Existing weather data integration systems are based on monolithic or client-server architectures; hence, unable to benefit from novel computational models such as cloud computing and containerized applications. Moreover, most of these softwares are proprietary or closed-source, making it difficult to customize them for an island like Sri Lanka with different weather seasons. Therefore, in this research, we propose Weather Data Integration and Assimilation System (WDIAS) that utilizes microservices to achieve scalability, high availability, and low-cost operation based on cloud computing. The use of stateless microservices also enables WDIAS to add new features on the fly with rollover capabilities. Moreover, WDIAS provides a modular framework to integrate data from different sources, export into different formats, and add new functionality by adding extension modules. We demonstrate the utility of WDIAS using a cloud-based experimental setup and weather-related synthetic workloads.

**Keywords:** Cloud computing, data assimilation, data integration, microservice, weather

# Dedication

I dedicate this thesis work to teachers, lectures, my family and specially colleagues at Center for Urban Water, Sri Lanka (CUrW-SL). A special feeling of gratitude to my loving parents, Nandawathi Dissanayake and H.M.K. Karunarathne whose put countless sweats to support me throughout my entire life. My wife Jayani Kumarasinghe and my son Sasmitha Karunarathne who missed a lots of wonderful moments to give me freedom to work on this research.

Nevertheless I could not forget all of my friends at CUrW-SL who have supported and be with me during this period of time. Also, special thanks to Dr. Dilum Bandara and Prof. Srikantha Herath for giving me this wonderful opportunity to explore this new domain.

# Acknowledgements

I would like to thank the members of my evaluation committee who were more than generous with their expertise and their precious time. Special thanks to Dr Dilum Bandara, my research supervisor for helping me with his precious time, reading, encouragement and been patient with pushing me to the next level. Also, I am, thankful to Dr. Dilika Peris, and Dr. Indika Perera for serve as my evaluation panel without any hesitation and Dr. Srikantha Herath for giving more knowledge on weather domain and support as my external supervisor.

I would like to thank the Department of Computer Science and Engineering at the University of Moratuwa for allowing me to conduct my research and provide all the assistance requested. Special thanks go to the academic and non-academic staff of the department for their continued support. I also thank the Center for Urban Water, Sri Lanka (CUrW-SL) for providing the domain expertise, access to resources, and financial support during the research.

Finally, I would like to thank the lectures, the evaluation panel and the colleagues who helped me with this project. Their enthusiasm and willingness to provide feedback support me to go far beyond my limits and complete my research with an enjoyable experience.

# Contents

# List of Figures

# List of Tables

# List of Abbreviations

| | |
|---|---|
| Amazon EKS | Amazon Elastic Kubernetes Service |
| API | Application Programming Interface |
| CSV | Comma-separated Values |
| CUrW-SL | Center for Urban Water, Sri Lanka |
| Delft-FEWS | Deltares FEWS |
| DIAS | Data Integration and Analysis System |
| ESB | Enterprise Service Bus |
| GRIB | General Regularly-distributed Information in Binary form |
| JSON | JavaScript Object Notation |
| K8s | Kubernetes |
| LEAD | Linked Environments for Atmospheric Discovery |
| MADIS | Meteorological Assimilation Data Ingest System |
| Microservice | Microservice Architecture |
| MSM | Meta Scientific Modeling |
| netCDF | Network Common Data Form |
| NWM | Numerical Weather Model |
| RDBMS | Relational Database Management System |
| REST | Representational State Transfer |
| RPS | Requests Per Second |
| SOA | Service Oriented Architecture |
| WDIAS | Weather Data Integration and Assimilation System |
| WRF | Weather Research and Forecast |