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Climatological Data Option in My Weather Impacts Decision Aid (MyWIDA) Overview

by Subing Zeng

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14. ABSTRACT My Weather Impacts Decision Aid (MyWIDA), a rules-based tactical decision aid, provides weather effects on weapon systems by coupling weather forecast data with system-specific environmental rules. It consists of 2 databases, a data service server, a collection of web service, and web applications that show weather impacts on selected assets on an overlay map. The Climatological Data Option in MyWIDA (ClimoMyWIDA) is intended to augment MyWIDA. It provides weather effects on various systems by using climatological data. However, it is designed as a self-contained application and can be integrated into other systems as well. This report describes the ClimoMyWIDA application in general, each component and its functionality, as well as the data sources.					
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1. Introduction

My Weather Impacts Decision Aid (MyWIDA),¹ a rules-based tactical decision aid, provides weather effects on weapon systems by coupling forecast data with system-specific environmental rules. It consists of 2 databases, a data service server, a collection of web services, and web applications that show weather impacts on selected assets on an overlay map.

Climate accounts for all past weather events. If we assume that climate is not changing rapidly, then high-quality, long-term climate data can tell us the qualitative range of weather events we might expect in the future.

For the purpose of advance and strategic planning, modeling and simulation, or when current forecasts are not available, use of climatological data becomes an option. Therefore, the application “Climatological Data Option in MyWIDA (ClimoMyWIDA)” is developed to augment the MyWIDA, by incorporating model-archived and historic weather data.

Additionally, ClimoMyWIDA follows MyWIDA’s software design and coding standards, and reuses existing MyWIDA codes as well.

2. Application Description

This section gives an overall description of the ClimoMyWIDA application. First, it shows the architectural design and how this application interacts with MyWIDA, then it describes the implementation and deployment details, and finally it illustrates how the application is operated.

The major prototype development is focused on server-side components, which consist of 2 underlying databases, a data service server, and a collection of web services.

2.1 Architectural Design

ClimoMyWIDA is designed to be a self-contained application and can be easily integrated into MyWIDA and other systems as well.

Figure 1 shows the component layout and process flow among the web service client, the weather data service center, the data service server, and the underlying database and web service.

ClimoMyWIDA Component and Process Diagram

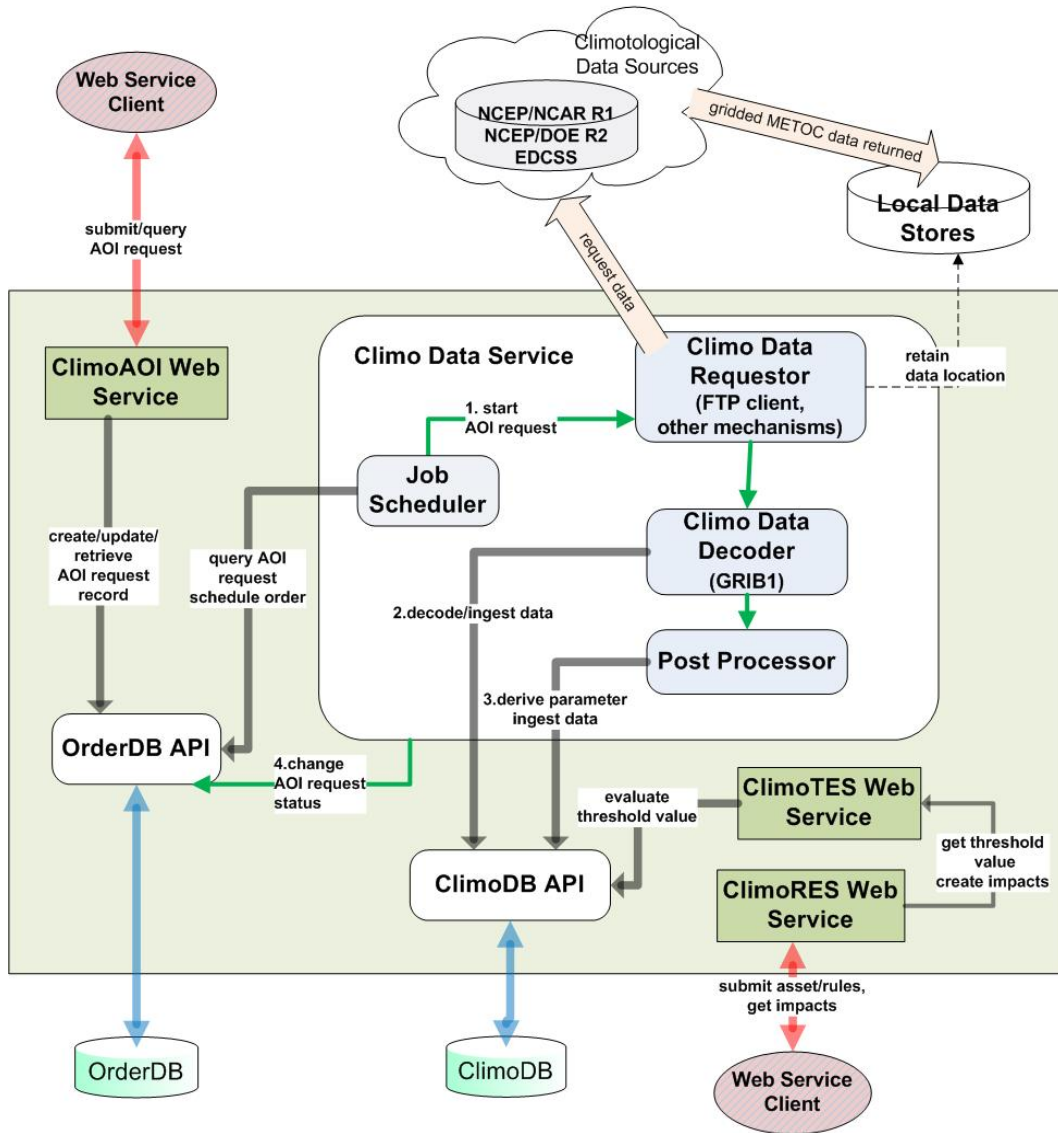


Fig. 1 ClimoMyWIDA component and process flow

The core software modules facilitate the following:

- 1) user data request order being placed into OrderDB database;
- 2) data transfer from various weather data centers to local data store;
- 3) data being decoded/stored into Gridded Meteorological DataBase (GMDB);
- 4) additional meteorological fields being post processed and stored into GMDB;
- 5) generation of asset impact grids; and

- 6) scheduling of data request and updating of order status.

Figure 2 shows the layout of MyWIDA and ClimoMyWIDA and the interaction between the 2 systems.

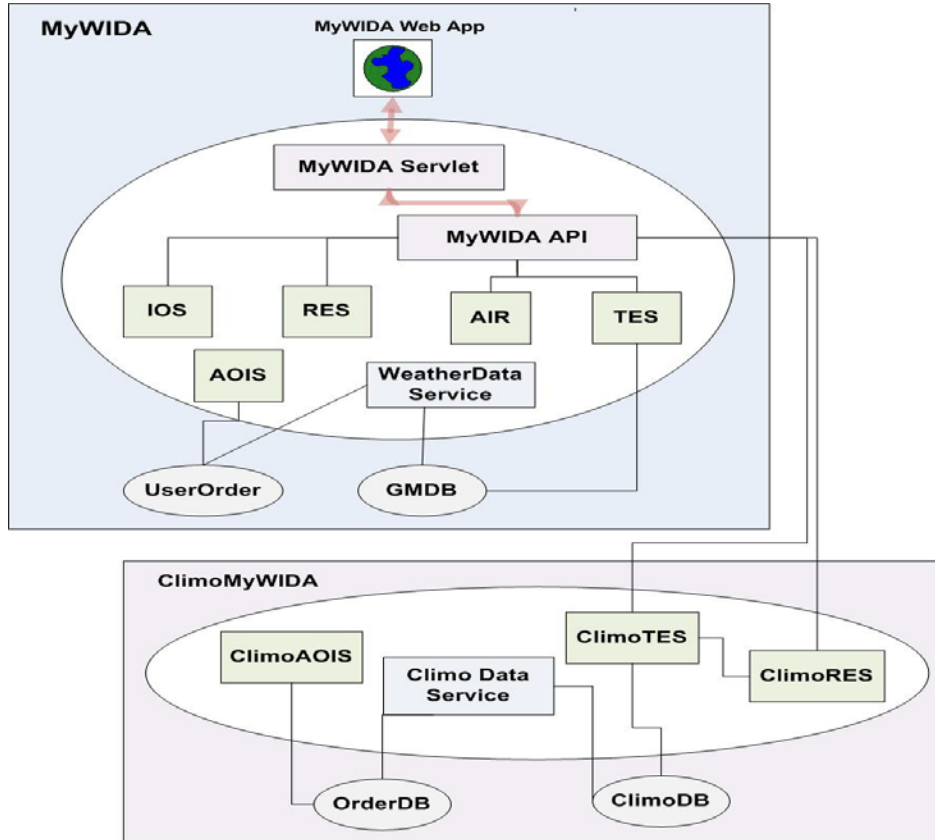


Fig. 2 ClimoMyWIDA interaction with MyWIDA

2.2 Implementation

The application is developed using the following software and technologies:

- The application is built on Java SE Development Kit 8.
- The external data repository (database) is implemented in Hyper Structured Query Language Database² for storing metadata and data.
- Job scheduler (a data service server) for data acquiring/processing is implemented using Quartz Scheduler framework.³
- The web services are defined by the Web Services Description Language (WSDL). Other systems interact with these web services in a manner prescribed by their description in eXtensible Markup Language (XML),

using the Simple Object Access Protocol (SOAP), conveyed with Hypertext Transfer Protocol (HTTP).

- The software component is built with script using Apache Ant.⁴

2.3 Deployment

The components are built, deployed, and tested on the UNIX and Windows operating systems. The server-side components, such as database and data service server, are deployed and operated on the host machines; web service is deployed on a Glassfish 4 application server.

2.4 Operation

The following executables/commands are used by the user to perform necessary tasks:

- Data Service Server
 - ClimoDataService.sh: start up data service server
 - StopClimoDataService.sh: stop data service server
- Data Acquiring/Transfer
 - getOneValidtime.sh: download data from National Centers for Environmental Prediction (NCEP) archived data for one valid time
 - getMoreValidTime.sh: download data from NCEP archived data for multiple valid times
- Data Processing
 - ClimoGribDecoder.sh: decode General Regularly distributed information in Binary Edition 1 (GRIB1) message and store data into GMDB
 - ClimoPostProcess.sh: derive additional parameters and store these parameters into GMDB
- Data and Database Management
 - CleanFile.sh: remove cached local files
 - ClimoDBManager.sh: check database entries
 - ClimoMetaData.sh: display metadata of model run in GMDB

- ClimoReadData.sh: display data for a model run in GMDB

A web service client is available for viewing data inventory/threshold value:

- This web application enables the user to view the data inventory in the database and display the thresholds values via a web browser.

3. Component and Functionality

This section describes the component and its functionality.

3.1 Database

Two underlying databases are provided for managing user information, data order requests, and processed meteorological gridded data.

3.1.1 OrderDB

This component (database and application programming interfaces [APIs]) provides the functionality for storing/accessing/manipulating user information and data requests. It is configurable by configuration files and implemented with Hibernate for accessing the database layer.

3.1.2 ClimoDB

This component (database and APIs) provides the functionality for storing/accessing/manipulating climatological gridded metadata and data.

3.2 Data Service

The Data Service module comprises Data Requestor, Data Decoder, Post Processor, and the Job Scheduler.

3.2.1 Data Requestor

The Data Requestor provides the functionality for acquiring user-defined data from the remote server of the data provider (machine-to-machine). The data are downloaded and stored locally for further processing.

NCEPDataRequestor, a subcomponent of the Data Requestor, is used for requesting data from the National Oceanic and Atmospheric Administration (NOAA) Operational Model Archive and Distribution System (NOMADS)⁵ via File Transfer Protocol (FTP).

3.2.2 Data Decoder

The Data Decoder provides the functionality for decoding/ingesting meteorological-gridded data files from various data centers into GMDB. The GRIB1 DataDecoder, a subcomponent, is used to decode the GRIB1 message.

3.2.3 Post Processor

The Post Processor provides the functionality for applying some algorithms on some meteorological variables to derive one or more variables.

This module is not meant to operate alone. It relies on the successful completion of data ingest process managed by the Data Decoder. Based on the data ingested in the ClimoDB database and the parameter/layer required by the application, the Post Processor derives additional parameters and stores the results into GMDB.

3.2.4 Job Scheduler

The Job Scheduler acts as a data server and provides the following functionality:

- Monitors and updates the status of incoming/existing data orders
- Schedules the process of data requests based on the order specifics
- Downloads, ingests, and postprocesses returned data files from the remote server into GMDB
- Performs database management tasks at specific times or regular intervals of time
- Keeps track of data records and prevents database overflow

3.3 Web Service

3.3.1 ClimoAOI

This web service (Area of Interest [AOI] Service) is responsible for validating/accepting user order requests. Data orders placed into the OrderDB database include information such as user ID, order ID, originating data center, data model, content of the data request (spatial/temporal extent, parameter, and layer), and order status.

3.3.2 ClimoTES

This web service (Threshold Evaluation Service [TES]) analyzes climatological data to determine where the weather thresholds are exceeded. The web service client supplies threshold values for evaluation against the gridded data, including

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the surface level, over an area of interest (AOI). The primary information returned is a grid representing where the thresholds are exceeded.

3.3.3 ClimoRES

This web service (Rule Evaluation Service [RES]) provides asset impact grids by evaluating a set of rules for a specified data set.

Given a list of assets and their associated rules, the ClimoRES first disassembles the rules into a collection of independent clauses, which are sent to the ClimoTES for threshold evaluation. The ClimoTES clause evaluations are then combined by ClimoRES into asset impacts.

4. Data Source

Although a wide range of data sources are available from multiple data centers, the data option of ClimoMyWIDA depends on the data source's data inventories, formats, and access methods. Only a couple of data sources are included in the prototype development.

4.1 Data Format

The application currently only operates on meteorological-gridded reanalysis type of data in GRIB1 format.

4.2 Data Center and Model and Access

4.2.1 NOMADS

- **Sources of Global Reanalysis Data**
 1. NCEP/ National Center for Atmospheric Research (NCAR) Reanalysis I (1948–present)
 - Model runs, 4 times/day
 - Global grids
 - Pressure level
 - 2.5 ° by 2.5 °
 2. NCEP/Department of Energy (DOE) Reanalysis II (1979–present)
 - Model runs, 4 times/day

- Global grids
- Pressure level
- 2.5 ° by 2.5 °

- **Data Access**

The NCEP/NCAR Reanalysis I⁶ and NCEP/DOE Reanalysis II⁷ data sets in GRIB1 format are available online.^{8,9} It allows users to subset GRIB1 files and download the data to a local machine via FTP/HTTP.

4.2.2 Environmental Data Cube Support System (EDCSS)

The EDCSS¹⁰ is a Department of Defense–sponsored program to provide a consistent suite of environmental products for the modeling and simulation community.

- Environmental Data Archive Resources

This is the data source from National Climatic Data Center (NCDC), but with customized options such as additional parameters, specific scenario condition, specific data range, and additional products (25+ years).

- Model runs, 4 times/day
- Global grids
- Pressure level
- 2.5 ° by 2.5 °

- Higher Fidelity Data with Weather Research and Forecasting (WRF) Model Run

The WRF modeling capability is leveraged to reproduce historical scenarios with conditions relevant to exercise objectives. From the WRF model run it reproduces the scenario at a much higher resolution:

- Model runs, hourly
- Global grids
- Pressure level
- 15 km by 15 km

- Data Access

The user needs to register with the EDCSS web site to access/request data.

5. Conclusion

The ClimoMyWIDA application provides weather effects on weapon systems by using climatological-archived data. It is intended to augment the MyWIDA. However, it is designed as a self-contained system and can be integrated into other systems as well.

The prototype development is focused on server-side components, which consists of 2 databases (OrderDB and ClimoDB), a data service module, and 3 web services (ClimoAOIS/ClimoTES/ClimoRES). It can handle GRIB1 format and implement limited data sources (NCEP and EDCSS).

6. Future Plan

6.1 Additional Data Option

Data in other formats such as GRIB edition 2 (GRIB2) and Network Common Data Form (NetCDF), a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data, will be included with a plugin data decoder within the Data Decoder framework.

Additional data centers/sources can be considered.

6.2 Impact Overlay Web Service

The web service that provides a Keyhole Markup Language document containing color-coded asset weather impacts at one or more layers will be implemented.

6.3 Graphical User Interface

A web application similar to the reference implementation of MyWIDA, which shows weather impacts on selected assets on an overlay map based on climatological data, will be implemented.

7. References

1. Brandt J, Dawson L, Johnson J, Kirby S, Marlin D, Sauter D, Shirkey R, Swanson J, Szymber R, Zeng S. Second generation weather impacts decision aid applications and web services overview. White Sands Missile Range (NM): Army Research Laboratory (US); 2013 Jul. Report No.: ARL-TR-6525.
2. HyperSQL: HSQLDB-100% Java Database. [accessed 2017 Jul 05]. <http://hsqldb.org/>.
3. Quartz job scheduler. [accessed date 2017 Jul 05]. <http://quartz-scheduler.org/>.
4. The Apache Ant Project: Apache Ant. [accessed 2017 July 5]. <http://ant.apache.org>.
5. NOAA Operational Model Archive and Distribution System (NOMADS) User Manual. City (ST): Publisher [accessed 2017 July 5]. <http://nomads.ncdc.noaa.gov/guide>.
6. National Weather Service Climate Prediction Center: NCEP/NCAR Reanalysis Project (CDAS). City (ST): Publisher [accessed 2017 July 5]. <http://www.cpc.ncep.noaa.gov/products/wesley/reanalysis.html>.
7. National Weather Service Climate Prediction Center: NCEP/DOE Reanalysis II. City (ST): Publisher [accessed 2017 July 5]. <http://www.cpc.ncep.noaa.gov/products/wesley/reanalysis2/index.html>.
8. Document for Getting & Using Reanalyses. City (ST): Publisher [accessed 2017 July 5]. <https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/reanalysis-1-reanalysis-2>.
9. National Weather Service Climate Prediction Center: Fast downloading of GRIB files Partial http transfers. City (ST): Publisher [accessed 2017 July 5]. http://www.cpc.ncep.noaa.gov/products/wesley/fast_downloading_grib.html.
10. Environmental Data Cube Support System (EDCSS). City (ST): Publisher [accessed 2017 July 5]. <http://www.edcss.net/edc/>.

List of Symbols, Abbreviations, and Acronyms

AOI	area of interest
API	application programming interface
ClimoMyWIDA	Climatological Data Option in MyWIDA
DOE	Department of Energy
EDCSS	Environmental Data Cube Support System
FTP	File Transfer Protocol
GMDB	Gridded Meteorological Database
GRIB1	General Regularly distributed Information in Binary, Edition 1
GRIB2	General Regularly distributed Information in Binary, Edition 2
HTTP	Hypertext Transfer Protocol
ID	identification
MyWIDA	My Weather Impacts Decision Aid
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NOMADS	NOAA Operational Model Archive and Distribution System
RES	Rule Evaluation Service
SOAP	Simple Object Access Protocol
TES	Threshold Evaluation Service
WSDL	Web Services Description Language
XML	eXtensible Markup Language
WRF	Weather Research and Forecasting

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