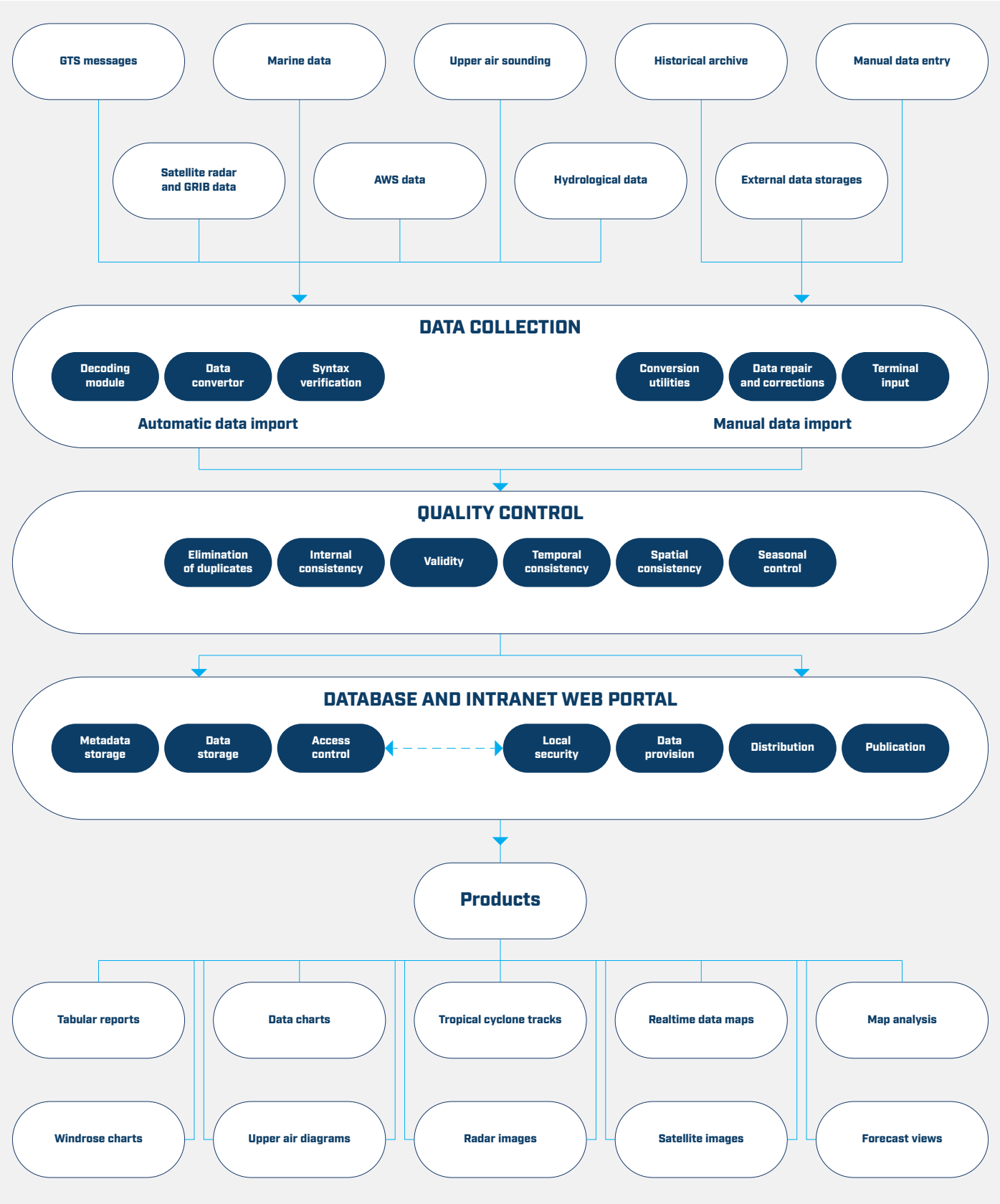
IMS4 CLDB and EnviDB

Climatological and Integrated Environmental Database

Climatological database is a critical component of any modern meteorological institute of today. The main utilization of such system is storage of all collected meteorological data in one unified structure to avoid data inconsistencies and discrepancies and to enable standard comfortable data access for all users and other software systems.



Scheme of functions

Universal and reliable climate database management system

Customized CLDB menu

Scalable solution

High availability option

Manual or automatic data sources

Highly configurable quality control

Metadata management

Export to standard formats

Mathematical / statistical packages

Advanced graphical presentation tool and map analysis

Within the Climatological Database (CLDB), the above mentioned unified structure is based on SQL Database Server and the standard data access is based on SQL language. The guarantee of data storage quality is the industry proven Oracle® Database Server, the world leader in database technologies. Great alternative is based on an open source solution offered by PostgreSQL.

CLDB is based on WMO[1] recommended practices for climatological data processing (WMO Guide No. 100). It follows the WMO suggestion of a RDBMS (Relational Database Management System) application with wide use in climatology (World Climate Program efforts concerning new Climate Data Management Systems - CDMSs).

Great advantage of CLDB is its modular architecture, which gives the end user the possibility of detailed customization. The end user can specify additional non-standard input and

[1] *World Meteorological Organization*

output modules. Modules can be easily implemented and added to any existing or future installation. One of the most interesting extensions offered is upgrade to environmental database (integration of AWS, radar, satellite, profiler, historical observations, marine data, radiation and air pollution monitoring and more).

To provide high availability of the database we use Oracle Real Application Cluster - the database solution provides fault tolerance and high performance for mission-critical applications.

Connection and data input

The CLDB can hold textual and numerical data, graphical information and animations. The database is capable of receiving, decoding and storing of the following data types from different data sources:

1. Data electronically imported from third party database system (e.g CLICOM)
2. Data manually entered or sent by SMS from manned stations with regular or irregular observing schedule.
3. Data from meteorological messages received via GTS[2] or other distribution system:
   - surface (SYNOP, METAR)
   - upper air (TEMP, PILOT)
   - marine data (BUOY)
   - binary messages (BUFR, GRIB , NetCDF, HRIT)
   - special (AIREP, AMDAR)
4. Data collected from automated weather stations (AWS); distributed in various formats, including:
   - Comma Separated Value (csv)
   - Other Delimiter Separated Values
   - Text Files (txt)
   - MS Excel 2000 - 2016 (xls)
   - Open Document Format
   - xml (schema/DTD/raw)
5. Remote sensing data: radar and satellite images:
   - Satellite IR, WV, VIS channels, colored RGB composites
   - Radar products: Intensity, Rainfall Rate, Velocity
   - Lightning positions
   - Wind profiles
6. Model predictions (NWP outputs)
7. Other numerical, textual, binary or graphical data according user requirements can be stored in CLDB after proper analysis

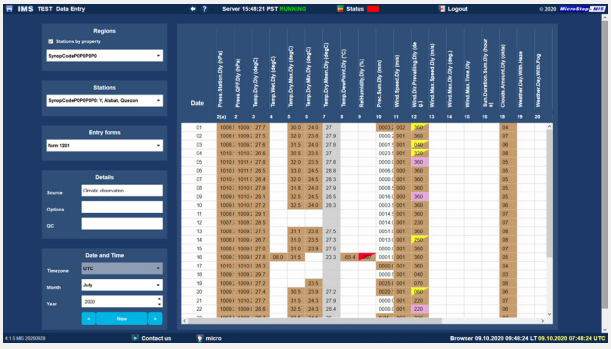
CLDB is capable to integrate and use also wis2box software for downloading and publishing data through the WMO Information System (WIS2 network).

[2] *Global Telecomunication System*

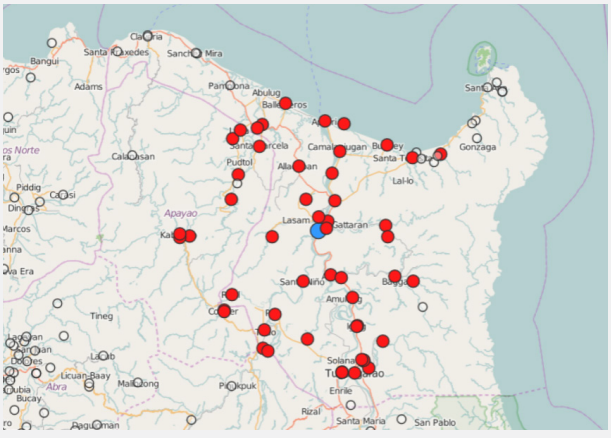
Data processing and quality control

Climatological data in the CLDB system are processed by different modules before presentation to the end user. The data are collected from different sources by the respective UDCS (Unified Data Collection System) module. The module decodes the received data and passes them to the database as raw and unchecked values. The decoding mechanism is customizable to client message types Periodical quality check monitors data validity (elements limits), internal consistency (elements relationships), temporal consistency (rate of change), standard deviation, spatial consistency and other more complex relationships between three elements. The quality checks are fully configurable by the database administrator in a very user friendly interface.

Manually entered data are checked simultaneously with the key entry process. A more advanced quality check is performed periodically at a later time in the database. During quality check processing, CLDB calculates derived values (e.g. sea level pressure, vapor pressure). The calculated elements and derivation formulas are customized according to customer's requirements.



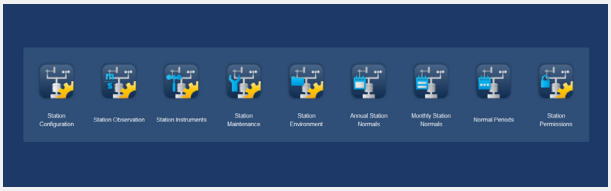
Original data - correct
Suspect, but not erroneous data
QC generated values
Manually entered or overwritten data - correct
Original data - not yet pass by QC
Erroneous data



Spatial QC configuration

Emphasis on metadata

Detailed description of observing stations and their history are inevitable part of climate data itself. CLDB extends CLICOM metadata into the WIGOS Metadata Representation (WMDR) compatible powerful textual and graphical metadata management tool. The metadata can be exported to WMO OSCAR database. In addition to the standard descriptive values, system administrator can define new metadata entries.



Metadata cover these areas:

- Station Instruments module contains searchable database entries for sensor parameters traceable to individual sensor piece with assigned serial number
- Textual and numerical information is accompanied by copies of datasheets, photos of sensor and environment and calibration certificates with possible e-mail alerts announcing recalibration need
- Station Observation describes observational program, setting and environment complete with panorama photos and maps
- Full history of instrumentation and applied corrections is tracked
- Station Maintenance module keeps records of regular and special maintenance
- Interfaces are fully web based which creates possibility to access the system from the field via mobile networks
- System can ingest all kinds of metadata: WMO required and recommended, nationally developed, special metadata of individual scientific projects and inter-comparisons, Leroy siting classification.

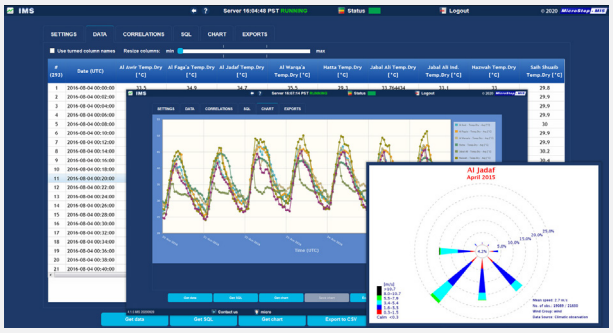
Reports and statistics

The data stored in the database can be viewed and exported in many ways.

1. MicroStep-MIS selection tools

End user applications are provided by MicroStep- MIS for retrieving data from the database. Maximally flexible export from CLDB to user-defined tables is possible with user-friendly CLDB "Select" tool.

When selecting the data, user can set element(s), variable(s), region(s), station(s), observation terms or time periods as a retrieval criteria. User then selects the form of output - all raw data, aggregated data (minima, maxima, means, sums, counts, standard deviations), or a long year statistics over selected month. The resulting data is in the form of a graph or a table. The table could be saved as a spreadsheet or a text file (comma separated values, space separated values,…). The output files are directly usable by standard mathematical/ statistical software products or data mining tools.

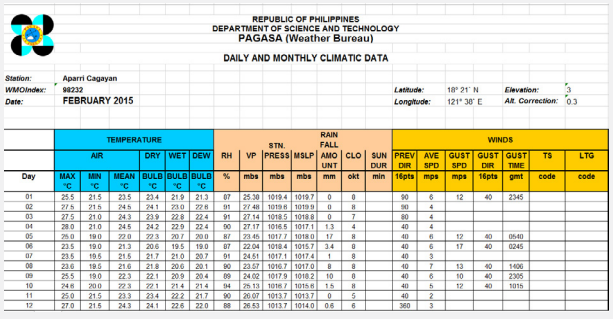


2. User's standard desktop tools

- End user can work with the database within standard desktop publishing, statistical and graphical tools which are capable of retrieving data using standard interfaces like ODBC or contain tools for direct connection to Oracle® Database.
- The user can also export files to Spread Sheets (e.g. with Microsoft® Excel) with simple few clicks.

3. Reports - predefined CLDB statistics

The CLDB Reports application provides an easy to use interface for generating tabular and graphical reports (daily, monthly, annual, over normal periods). Reports are generated directly in printable form (.pdf) or as Excel worksheets.



REPUBLIC OF PHILIPPINES
DEPARTMENT OF SCIENCE AND TECHNOLOGY
PAGASA (Weather Bureau)

DAILY AND MONTHLY CLIMATIC DATA

Station: Aparri Cagayan
WMOIndex: 98232
Date: FEBRUARY 2015
Latitude: 18° 21' N
Longitude: 121° 38' E
Elevation: 3
Alt. Correction: 0.3

	TEMPERATURE						RH	VP	STN. PRESS	MSLP	RAIN FALL AMOUNT	CLO	SUN DUR	WINDS						
	AIR			DRY BULB	WET BULB	DEW								PREV DIR	AVE SPD	GUST SPD	GUST DIR	GUST TIME	TS	LTG
Day	MAX °C	MIN °C	MEAN °C	°C	°C	°C	%	mbs	mbs	mbs	mm	okt	min	16pts	mps	mps	16pts	gmt	code	code
01	25.5	21.5	23.5	23.4	21.9	21.3	87	25.30	1019.4	1019.7	0	8		90	6	12	40	2345		
02	27.5	21.5	24.5	24.1	23.0	22.6	91	27.48	1019.6	1019.9	0	8		90	4					
03	27.5	21.0	24.3	23.9	22.8	22.4	91	27.14	1018.5	1018.8	0	7		80	4					
04	28.0	21.0	24.5	24.2	22.9	22.4	90	27.17	1016.5	1017.1	1.3	4		40	4					
05	25.0	19.0	22.0	22.3	20.7	20.0	87	23.45	1017.7	1018.0	17	8		40	6	12	40	0540		
06	23.5	19.0	21.3	20.6	19.5	19.0	87	22.04	1018.4	1015.7	3.4	8		40	6	17	40	0245		
07	23.5	19.5	21.5	21.7	21.0	20.7	91	24.51	1017.1	1017.4	1	8		40	3					
08	23.6	19.5	21.6	21.8	20.6	20.1	90	23.57	1016.7	1017.0	8	8		40	7	13	40	1406		
09	25.5	19.0	22.3	22.1	20.9	20.4	89	24.02	1017.9	1018.2	10	8		40	6	10	40	2305		
10	24.6	20.0	22.3	22.1	21.4	21.4	94	25.13	1016.7	1015.8	1.5	8		40	5	12	40	1015		
11	25.0	21.5	23.3	23.4	22.2	21.7	90	26.07	1013.7	1013.7	0	5		40	2					
12	27.0	21.5	24.3	24.1	22.6	22.0	88	26.53	1013.7	1014.0	0.6	6		360	3					

Example of a report generated by the Unified Meteorological Information System developed for the Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Republic of the Philippines.

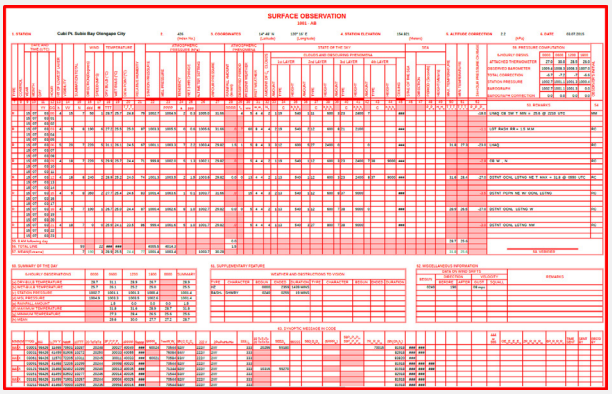
Tabular reports:

- climatic elements summaries (means, extremes, counts)
- long-term means and extremes

- percentage frequencies of occurrence of concurrent wind direction and speed
- frequencies of element occurrence below/above the specified thresholds
- return periods, cumulative frequencies
- characteristics of distribution (measures of central tendency mean, mode, median,
- fractiles (percentiles), vector mean; measures of dispersion, coefficient of variation, etc.)
- Upper Air summaries
- counts of missing data
- customized tables and many others

Graphical outputs:

- wind roses (user definable colors, scale, 4, 8, 12, 16 sectors)
- elements mean, max, min graphs
- rainfall bar
- customized graphs and many other graphs

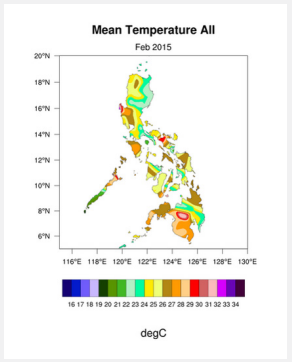


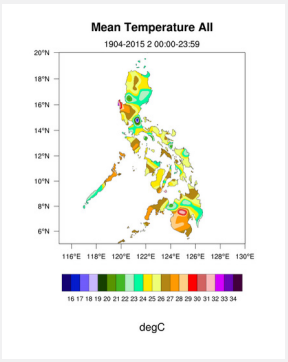
Example of a report generated by the Unified Meteorological Information System developed for the Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Republic of the Philippines.

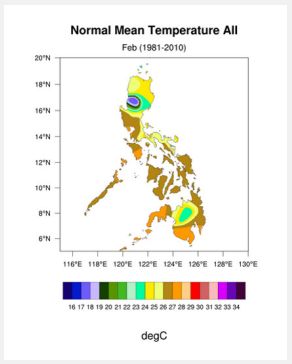
Map analysis

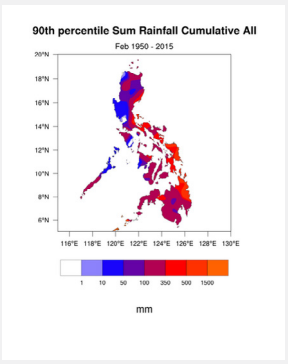
Map analysis is a flexible computer graphics system designed for professional usage, which employs statistical interpolation methods (Kriging, etc.) and provides spatial visualization of climatological information and helps users by creation of more comprehensive views of historical and currently received data:

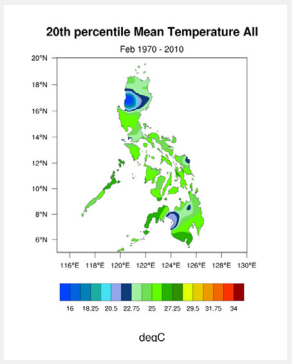
- map analysis of current data, historical data and normals
- comparison analysis of actual data and normal (selectable normal)
- comparison analysis of actual data and historical data (selectable any historical period)
- comparison analysis of selected historical data with selected normal
- selectable percentile values for all meteorological variables in any period
- Standard Precipitation Index, other indices

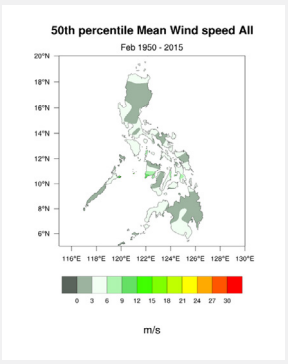


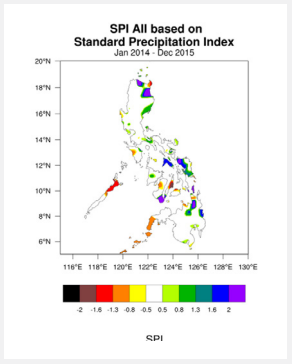


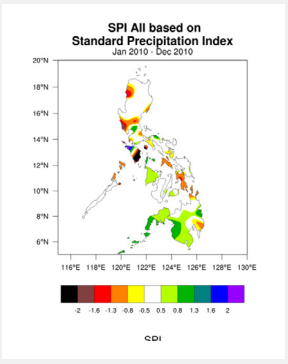


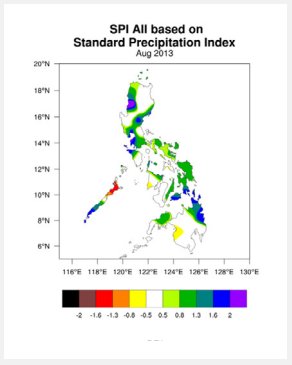






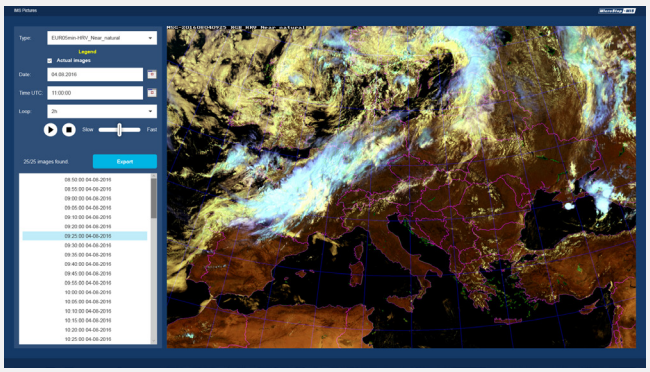


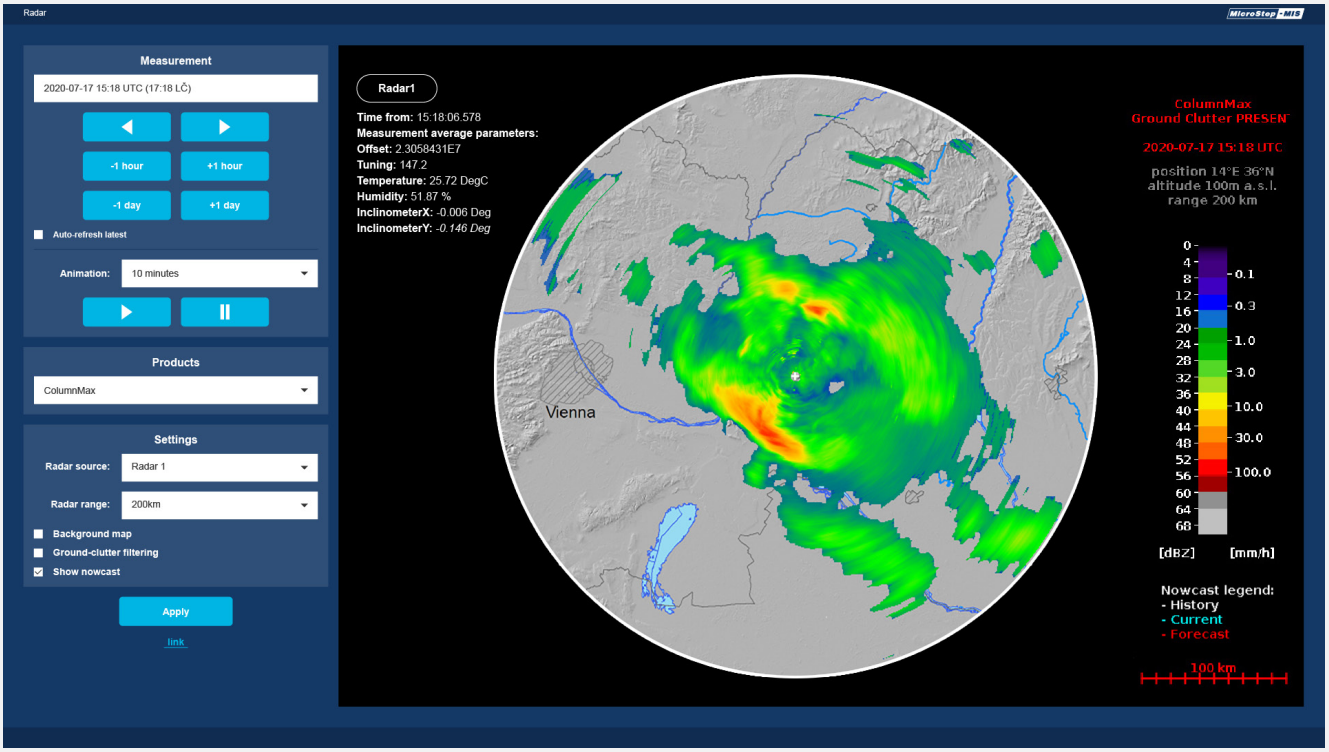


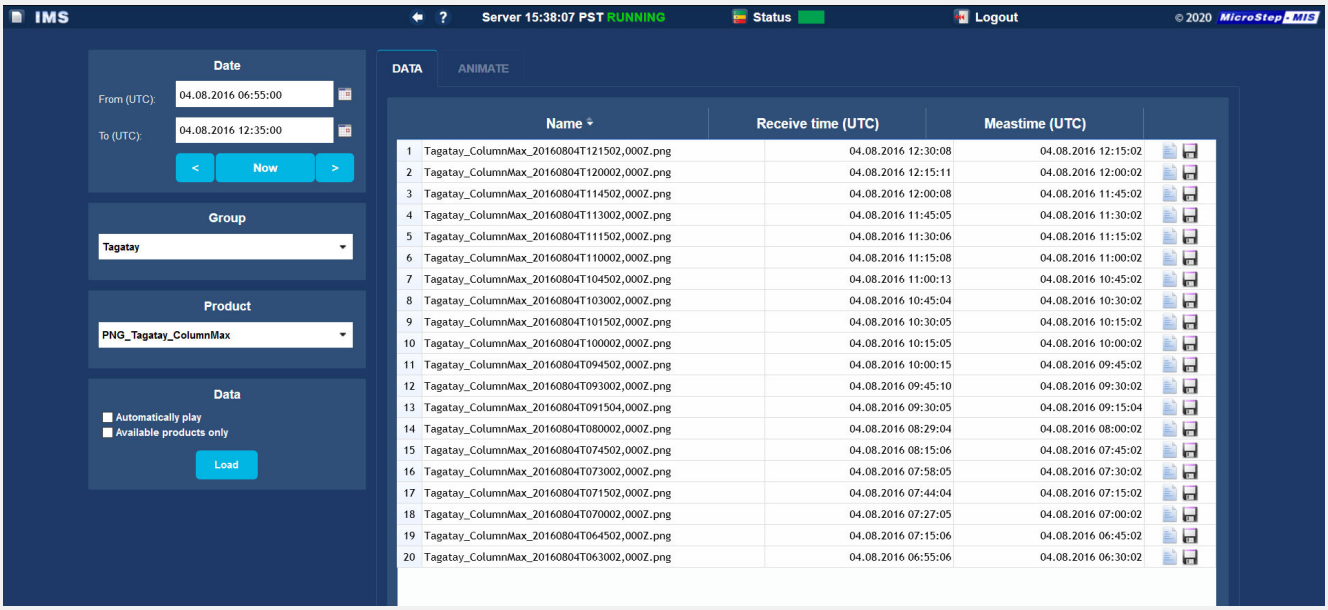


Radar and satellite data application

This application enables to display, manage, integrate into composites and archive radar data from various sites and manufacturers as well as satellite data.

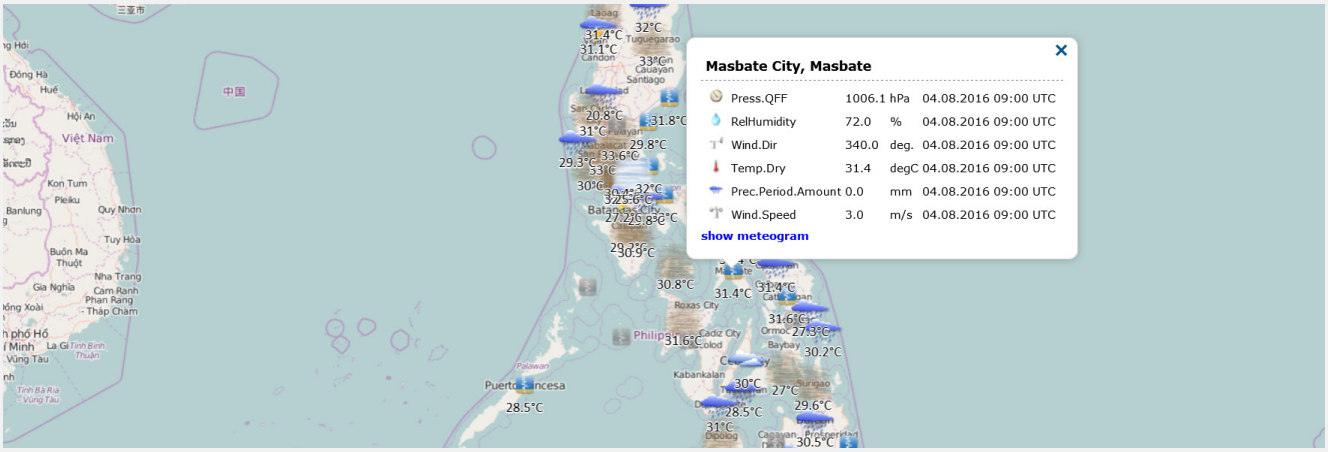


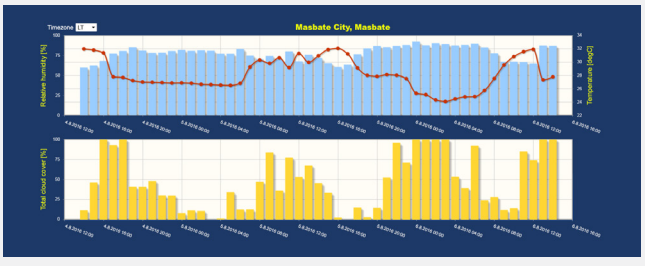


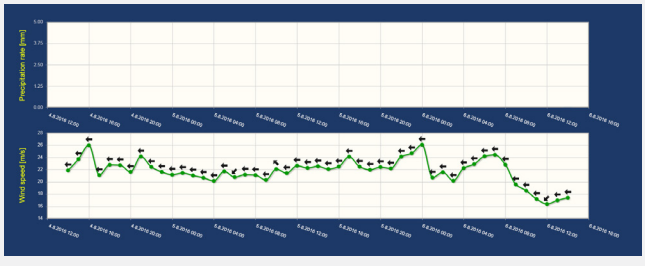


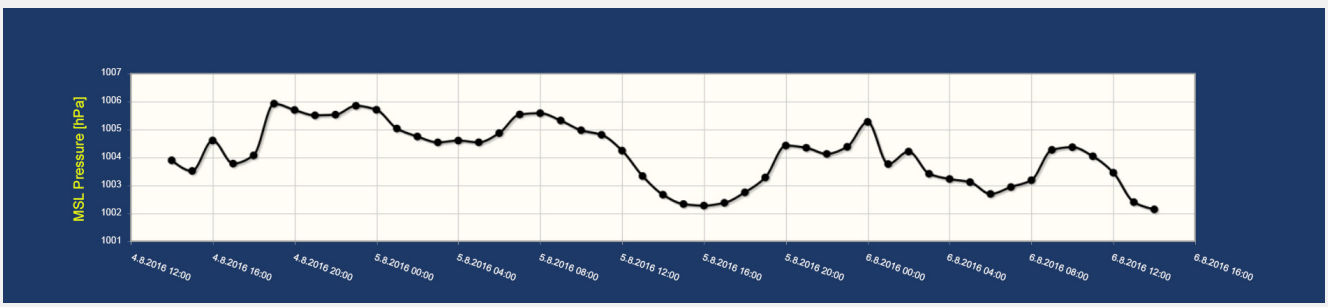
Numerical Weather Prediction products application

The application serves for displaying, managing and archiving of Numerical Weather Prediction products.





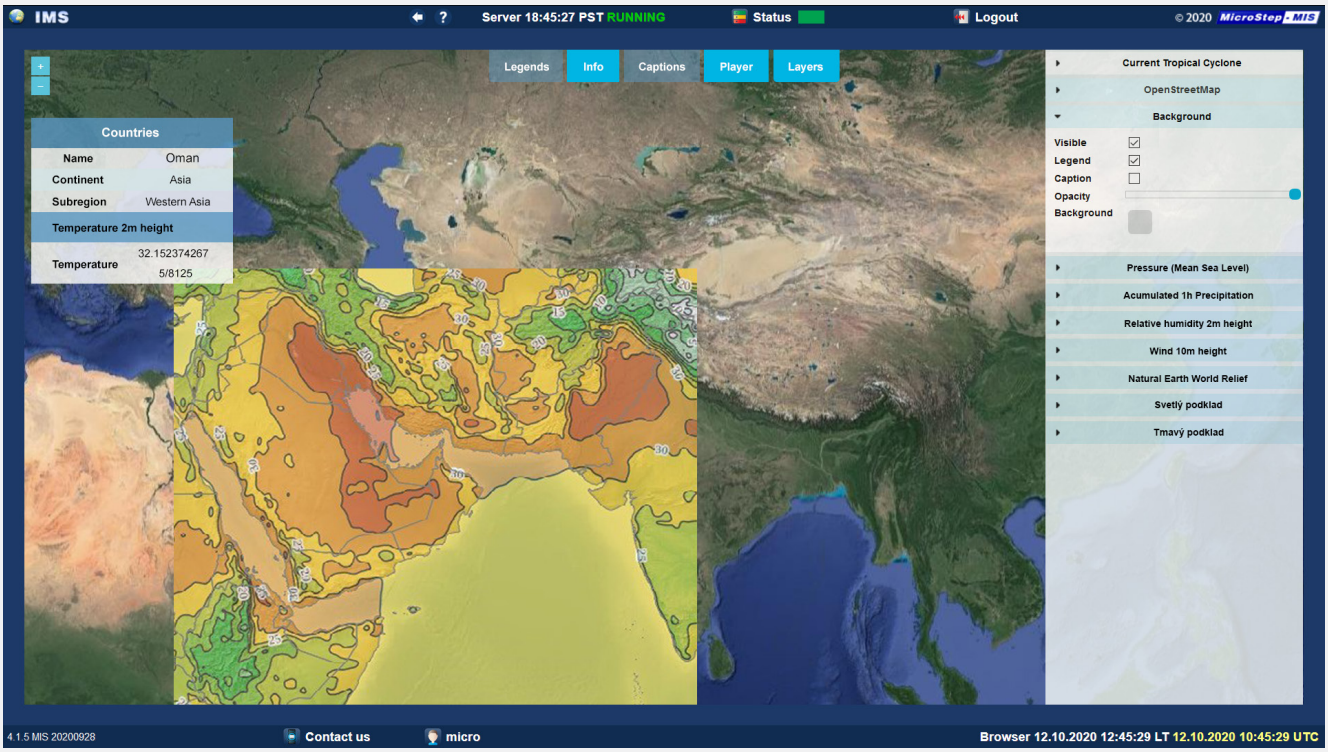




IMS4 Maps - Map server

Map server enables publication of the spatial data using open standards and the implementation of the Web Map Service. The maps could be created in variety of formats.

- Connection to the traditional GIS architecture such as ESRI ArcGIS
- Topographic/geographic data
- Station data layer
- Meteo data layer – spatial climatic analyzes
- "Movie" mode



Multi-platform product

The server and client can run on:

- Microsoft Windows ®
- Linux ®

Industry proven technologies:

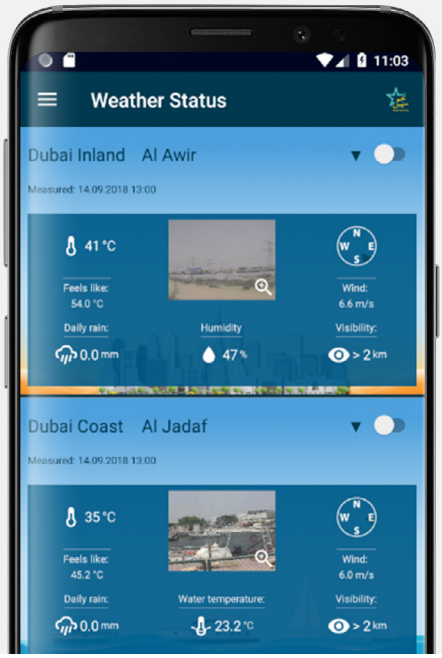
- PostgreSQL, ORACLE
- Java
- XML
- HTML5, Java Script, CSS

Presentation tier:

- Web interface: jQuery, Mozilla, Chrome, Internet Explorer
- Mobile applications: Android, iOS

App screens

- Java Web Services



Operational Database for Public Web Page

A special version of CLDB has been optimized to serve as the robust back-end infrastructure for public web weather portals and/or weather mobile apps. This version is designed to efficiently handle the demands of millions of potential users, ensuring reliable performance, rapid data retrieval, and seamless integration with various front-end interfaces. It supports real-time data updates and scalable operations to meet the growing needs of a global audience.

Notifications

The EnviDB built-in Notification Manager generates E-mail and/or SMS user notifications of various operational situations:

- Status of communication infrastructure (availability / unavailability of connection to the stations / 3rd party systems)
- Status of data (absence of the data due to QC, achieving or crossing of the thresholds of operational significance)

The Notification Manager allows customization of:

- Alert templates
- Information to be included in the warnings
- Type and levels of warnings
- Type of hazards / phenomena
- Communication channel to be used for the notification dissemination

Product Automation

The optional Product Scheduler module provides interface for the configuration and automation of the data product generation. The product configuration includes metadata (name, description, physical unit), timing information for scheduler as well as specification of missing data inputs handling (percentage thresholds for enabling the product generation).

The products include but are not limited to:

- virtual station dataset populated from various sources (interpolation of station data, NWP analysis, radar)
- data tables in various formats (.csv, .txt, Microsoft Excel) from station data (real / virtual stations / NWP / radar data)
- data charts in various formats (Microsoft Excel, .jpg, .png) from station data (real / virtual stations / NWP / radar data)
- Excel reports: predefined / customer defined templates, flagging of the data exceeding of the thresholds of operational significance, etc.
- comparisons of the data from various sources (stations, NWP, radars)
- wind roses
- products of map analysis / Kriging
- WMO codes
- WMO/OASIS Common Alerting Protocols alerts from various sources using the user-defined criteria (station data, NWP / satellite / radar data).
- Raster products re-gridding / re-projecting
- Format conversions
- Timeseries generation:
  - Meteograms from NWP models
  - Raster data integration over preselected areas

The system provides the extension points / interfaces to the scripts written in other languages (statistical programming language R, etc.).

IMS CLDB Web Screen for Intranet and Internet

The products (reports, forecasts, forecasting products) are disseminated to the pre-defined users (including general population) via:

- File based distribution (local, FTP, sFTP, scp)
- E-mail
- Web page publication

Documentation

CLDB comes with extensive user's and administrator's documentation. User's guide contains examples and how to instructions. Administrator's guide is especially focused on installation, database model, quality control settings and electronic data import. Additional guidance is covered by YouTube videos.

Application programming interface for the 3rd party applications

- REST API
- Web service SOAP API
- TLS/SSL, HMAC authentication (optional)
- Client side: Python, Java

Modules and Licensing

Module / functionality	UDCS/CLDB Lite	UDCS/CLDB	EnviDB.Cloud	Order Code
Web interface (English)	✓	✓	✓	
Web interface (other languages)	extra option	extra option	✓	MIS:IMS.LANG
Data collection from MicroStep-MIS stations (station number may be limited in UDCS/CLDB LITE if licensing per station is selected)	✓	✓	✓	
Data collection from 3rd party stations	extra option	extra option	extra option	various
Migration of the legacy/historical data	×	extra option	×	
Import of FM-12 SYNOP codes	×	✓	×	
Import of FM-15 METAR codes	×	✓	×	
Binary data collection (radar, satellite, NWP) using standard protocols (WMO, file based)	×	✓	✓	
Camera images support	extra option	✓	✓	MIS:UDCS.Lite.Camera
Station and variable metadata	✓	✓	✓	
Advanced metadata module	×	extra option	×	MIS:CLDB.Meta
AWS Network Status map	×	✓	✓	
Database statistics	✓	✓	✓	
Select application	✓	✓	✓	
Manual data entry application (standard forms)	✓	✓	✓	
Manual data entry application (customized forms)	×	extra option	×	
Reports application (basic reports, no customization)	✓	✓	✓	
Customized reports	×	extra option	×	
Quality control - ruled based QC	✓	✓	✓	
Quality control - spatial QC	×	extra option	×	MIS:CLDB.QC.Spatial
Quality control - NWP QC module	×	extra option	×	MIS:CLDB.QC.NWP
Basic text current data screen	✓	✓	✓	
Graphical current data screen	×	✓	×	MIS:UDCS.Lite.Current
Complex WIS compatible metadata management	×	extra option	×	MIS:CLDB.WIS
Wind roses	×	✓	×	
Database of normals and extremes	×	✓	×	
Map analysis basic	×	extra option	×	MIS:IMS.Maps.Basic
Map analysis advanced (difference from normals, from long-term averages, SPI index)	×	extra option	×	MIS:IMS.Maps. Advanced
FM-12 SYNOP (TAC)	×	extra option	×	

Module / functionality	UDCS/CLDB Lite	UDCS/CLDB	EnviDB.Cloud	Order Code
FM-13 SHIP (TAC)	×	extra option	×	MIS:IMS.SHIP
FM-15 METAR	×	extra option	×	
FM-71 CLIMAT (TAC)	×	✓	×	
TDCF (FM-94 BUFR, FM-95 CREX) code creation support	×	extra option	×	MIS:CLDB.TDCF
National code forms	×	extra option	×	
Homogenization toolset	×	extra option	×	MIS:CLDB.Homog
ETCCDI Climate Indices	×	extra option	×	MIS:CLDB.ETCCDI
High availability configuration	×	extra option	✓	MIS:UDCS.D and MIS:UCLDB.D
Upper air data import (TEMP), processing, aerological diagram	×	extra option	×	MIS:IMS.TEMP
Hydrological database module	×	extra option	extra option	MIS:IMS.Hydro
Radiation data database module	×	extra option	extra option	MIS:IMS.Rad
Tropical cyclone data module	×	extra option	×	MIS:IMS.Cyclone
Satellite weather data	×	extra option	×	MIS:IMS.Sat
Radar studio	×	extra option	×	MIS:IMS.RADAR
Lightning studio	×	extra option	×	MIS:IMS.LTNG
AMDAR module	×	extra option	×	MIS:IMS.AMDAR
Multimedia data database module	×	extra option	×	MIS:IMS.Media
ModelSuite database - forecast data integration	×	extra option	✓	MIS:IMS.MSDB
Warning suite - base, CAP	×	extra option	×	MIS:IMS.Wrng.Base
Warning suite - meteorology module	×	extra option	×	MIS:IMS.Wrng.MET
Warning suite - hydrology module	×	extra option	×	MIS:IMS.Wrng.Hydro
Warning suite - lightning warning module	×	extra option	×	MIS:IMS.Wrng.Ltng
Map Server (zoomable layered maps)	×	extra option	✓	MIS:IMS.Maps+modules
PDF documentation	✓	✓	✓	
Printed documentation	×	extra option	×	
UDCS/CLDB API (REST, Web Service SOAP)	×	extra option	extra option	MIS:CLDB API
OpenCDMS API	×	extra option		MIS:OPENCDMS

Compliance with standards

- WMO No. 8 Guide to Meteorological Instruments and Methods of Observation
- WMO No. 100 Guide to Climatological Practices
- WMO No. 306 Manual on Codes
- WMO No. 386 Manual on GTS, incl. Attachment II
- WMO No. 485 Manual on Global Data Processing System
- WMO No. 1131 Climate Data Management System Specifications
- WMO/TD No. 1185 Guidelines on Climate Observation Networks and Systems
- WMO/TD No. 1186 Guidance on Metadata and Homogenization
- WMO No. 1192 WIGOS Metadata Standard
- WMO No. 1203 Guidelines on the Calculation of Climate Normals
- CIMO/OPAG-SURFACE/ET ST&MT-1/Doc.4.3. Maintenance of Accurate Metadata for all Automatic Weather Station Installations

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