

A SEDRIS Representation of Atmospheric Data

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ABSTRACT: *It has been the objective of the DoD to analyze its fielded and prototype systems, train its warfighters, and simulate the potential future conflicts using Modeling and Simulation (M&S). A significant component in this M&S activity is the creation of environmental databases that represent the physical world. The Synthetic Environment Data Representation and Interchange Specification (SEDRIS) facilitates the transmission and reuse of environmental data among heterogeneous systems through a standard data representation model and interchange mechanism. It fully represents the environment by capturing all data elements and their relationships. It also provides a standard data interchange mechanism and format to support the distribution of environmental data and promotes the sharing of databases between systems.*

This paper describes the mapping that was performed for atmospheric gridded fields using the SEDRIS Data Representation Model (DRM), the Spatial Reference Model (SRM), and the Environmental Data Coding Specification (EDCS). An initial mapping for atmospheric observation data will also be presented. The DRM, SRM, and EDCS are currently going through a joint International Standards Organization (ISO) and International Electrotechnical Commission (IEC) standardization process. The DRM provides the organization structure for representing the atmospheric data. The SRM provides a consistent way of specifying the coordinate system used. The EDCS provides a rich set of labels for identifying environmental data in a simulation and for this effort the atmospheric structures and parameters

Programs have been developed to map a set of atmospheric gridded fields to SEDRIS and then to convert the data from GRIB to the SEDRIS Transmittal Format (STF). GRIB is a World Meteorological Organization (WMO) Gridded Binary standard format for gridded atmospheric data. The conversion program uses an API provided by the SEDRIS project. The Conversion program is used in the Defense Modeling and Simulation Office (DMSO) Integrated Natural Environment (INE) in the creation and delivery of integrated data sets. An INE project called EnviroFed uses an atmospheric data set that has been converted to the STF format using the conversion program. A early version of a program to convert atmospheric observation data from the WMO Binary Universal Form for the Representation of meteorological data (BUFR) standard format to STF will also be discussed.

1. Introduction

The U.S. Defense Modeling and Simulation Office (DMSO) has a program call the Integrated Natural Environment (INE). Under this program there are several projects that address data representation and delivery, data set discovery and creation, and integration and experimentation. The SEDRIS project was created to address the data representation and delivery issues.

1.1 Background

It has been the objective of the U.S. Department of Defense (DOD) for years to analyze its fielded and prototype systems' capabilities. To accomplish a portion of this objective, modeling and simulation (M&S) activities were developed. A significant component in this M&S activity was the creation of databases that represent the physical world. As various simulation systems were developed for different programs, databases were developed for each program. As the simulation efforts grew, so did the need and desire to network the simulations together. However, this was complicated by the fact that many of the environmental databases were proprietary in nature and no easy means of interchanging the data was available. Also, the existing interchange mechanisms were not able to support additional information and data types required to support newer simulations under development. Therefore, these systems were faced with the challenge of establishing consistent and correlated databases at the lowest possible cost, both in terms of time and money.

Without an effective way to interchange the full range of environmental data in the networked M&S community, it became apparent a new database interchange mechanism was required. Thus, the Synthetic Environment Data Representation and Interchange Specification (SEDRIS) program was initiated.

2. SEDRIS vision

Data interchange is not just for reuse in building M&S databases, but is key for achieving interoperability between distributed, heterogeneous training systems/networks. The successful interchange of environmental data requires both a loss-less and an unambiguous transfer of data from one system to another. Loss-less in the sense, that no data is lost during the conversion and interchange process. Unambiguous in the sense that the meaning of all data interchanged is fully understood.

The SEDRIS vision is to articulate and capture the complete set of data elements and associated relationships needed to fully represent environmental data. This includes a data representation model, a data coding standard, a spatial reference model, and an interchange mechanism. These will enable the open interchange of data by providing a common representation from which native (possibly proprietary) data can be converted to and from SEDRIS.

2.1 SEDRIS objectives

The U. S. Defense Modeling and Simulation Office (DMSO) stated in the DOD Modeling and Simulation Master Plan that providing timely and authoritative representations of the environment is a core requirement to achieve interoperability among aggregated heterogeneous simulation systems. SEDRIS will be key to satisfying this requirement.

The specific objectives of SEDRIS are:

- By using a data representation model, capture the complete set of environmental data elements and their relationships.
- Implement a standard API for accessing data elements.
- Minimize the cost to access and reuse data by lowering the software barrier to entry.
- Provide a standard interchange mechanism between database builders and consumers.
- Facilitate interoperability of networked heterogeneous simulations.
- Support reuse of environmental databases between disparate simulations.
- Use the same data model as an access mechanism to import and export source data into and out of various database generation systems.
- Promote consensus understanding of the diverse requirements and implementation choices used within the M&S community through education

2.2 Current Core SEDRIS Software

For this work, the SEDRIS 3.0.2 release was used. It can be found at the SEDRIS web site: www.sedris.org. SEDRIS 3.0.02 was released in January 2001.

2.3 SEDRIS Data Representation Model

The 3.0.2 release of SEDRIS includes 364 SEDRIS classes. The OMT diagram covers twenty-four pages (and is available in either PostScript or PDF format). The Data Representation Model (DRM) is used to

describe and organized the data, including the relationships between data objects. Figure 1 is a compressed DRM showing the main classes that could be used in the representation of atmospheric data. A data dictionary, which defines and describes each of the classes, is also available in either plain text or in HTML. The easiest way to use the data model is to examine the OMT diagram with the HTML version of the data dictionary displayed in your browser. Within the HTML dictionary, all of the classes have the appropriate links to any and all related classes. For a single class, the dictionary describes the class, gives examples of how to use the class, has a list of Frequently Asked Questions (FAQs) with their answers for that class, and lists the ANSI C structures used by SEDRIS to represent the data for that class.

Certain parts of the data model are complicated enough to be worthy of their own separate, more detailed explanation. Technical guides are being written to cover the following topics within the SEDRIS data model: Topology, Control Links, Data Tables, Hierarchical Index Tables, Images and Color Models, Attribute Inheritance and Contexts.

2.4 Environmental Data Coding Specification

The Environmental Data Coding Specification (EDCS) [1] fulfills a very important need in SEDRIS — a mechanism to specify the environmental “things” that a particular data model construct is intended to represent. The EDCS defines a set of Classification/Feature Codes (ECC), Attributes Codes (EAC), and Unit Codes (EUC). The ECC answers the "what is it" question. Is it a road, grid of terrain elevations, or an atmospheric analysis grid? It is used by a user to find what they are looking for inside a SEDRIS transmittal. Want to find railroads? Then look for objects in SEDRIS that have the code for railroad attached. The same is true when looking for atmospheric object.

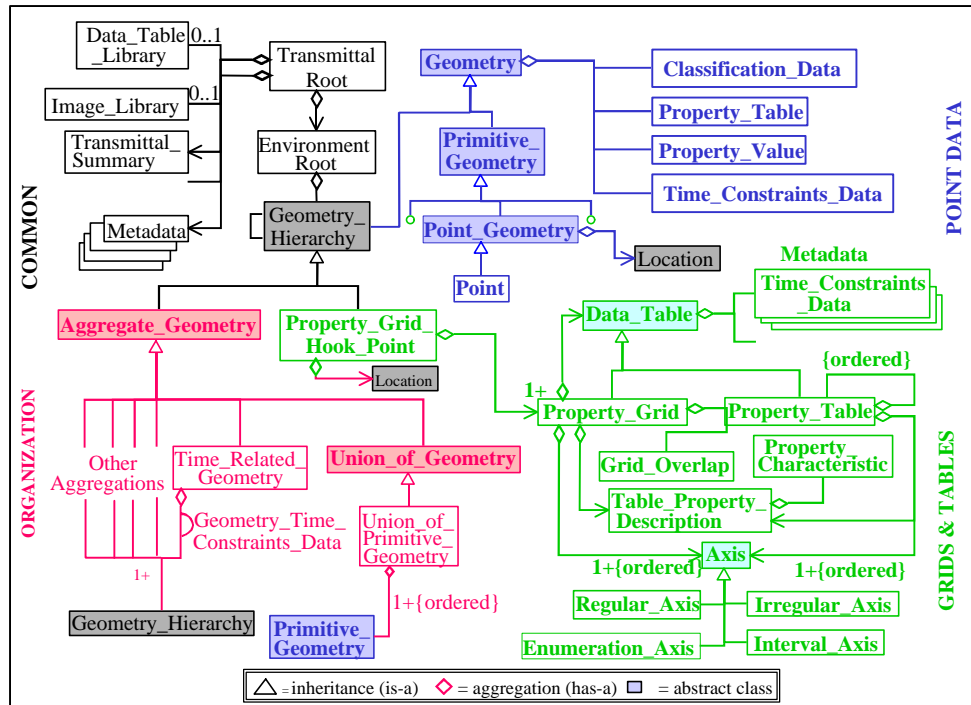


Figure 1: Compressed SEDRIS Data Representation Model (DRM) showing those classes most applicable for representing atmosphere data.

The EAC address the issue of "additional clarifying characteristics/information". It can be used further information about an object; i.e. is the road dirt, gravel, *etc.* It can also be used to identify parameters contained in a data object such as a grid. By using the EAC in conjunction with the ECC, we can say that an atmospheric grid contains air temperature, wind speed, *etc.*

The EUC are used to specify how an EAC is measured. Is the road width in feet or meters? Is the atmospheric temperature in degrees Celsius or degrees Kelvin?

By using the ECC, EAC, and EUC, an unambiguous description can be given of an object. In conjunction with the DRM, an unambiguous representation of a dataset can be created.

2.5 SEDRIS API

The SEDRIS API has been broken into distinct sections or ‘functional groups.’ ANSI C ‘header’ files define all SEDRIS APIs.

The Conversions API provides the ‘low-level’ functionality to convert coordinate values between coordinate systems, to convert color values between color models, and to convert measurements for certain units. The Conversions API is independent of all of the

other SEDRIS APIs. This is a very important part of the SEDRIS core activities and the reader is directed to the SEDRIS web site for detailed discussions and papers.

The DRM API provides information about the SEDRIS data model. It is independent of any transmittal. It is primarily useful for developing applications that benefit from knowing the structure of SEDRIS classes. This structural information includes the text names of the classes, how many fields the classes have, the text names of the fields, the C types of the fields, the text names of the enumerated values, etc.

The Level 0 Read API is used to find and extract information from one or more SEDRIS transmittals. More than one transmittal can be open at the same time. There can be many implementations of the Level 0 Read API. It can be implemented "on" a native database or file so that it appears to a user as a SEDRIS transmittal, or it can be implemented to support the SEDRIS Transmittal Format (STF). The SEDRIS project has provided one such implementation that allows a user to read SEDRIS transmittals from STF files. SEDRIS documentation at the web site fully explains the details on how to read SEDRIS data using the Level 0 Read API.

Two different approaches can be used to create a STF. The simplest, most direct method is to use the SEDRIS Write API. The other approach is to use the SEDRIS Traverse application. This latter approach can be used when the SEDRIS Level 0 Read API has been implemented on a native database or file format as mentioned above. Using the Write API to create the transmittal is the most efficient approach and will produce the more efficient transmittal. The STF is the standard file format for SEDRIS transmittals. STF is not a library or repository of databases, just as SEDRIS is not a library or repository of databases.

Various 'pass through' APIs also exist for the Level 0 Read API. The Debug API is an example. It acts as a thin layer between the user and whatever other API implementation is actually going to read the transmittal. The Debug API never reads a transmittal on its own. The Debug API does however keep track of objects to ensure that all objects for a transmittal are freed before the transmittal is closed, that only valid objects are used in data retrieval calls, etc. The Debug API is intended for use by SEDRIS consumers to help debug their applications.

2.6 SEDRIS Applications

There are several SEDRIS applications that have been

developed. These applications allow a SEDRIS user to review and view the data for "correctness." The *browser* allows one to examine a STF and view its structure and the object fields. The *syntax_checker* routine checks the organization of a STF for compliance with the DRM syntax, and the *rules_checker* check for compliance with the business rules associated with the DRM. It is left to the reader to visit the SEDRIS web site for a detailed discussion of these and other SEDRIS applications.

2.7 Standardization Efforts

SEDRIS is in the process of becoming an international standard through the International Organization for Standardization (ISO), which is a worldwide federation of over 130 countries. There are approximately 30,000 technical experts on loan from business, industry, government, academia, and other bodies that take part in the development of ISO standards.

The ISO standards Process is divided into different sub-process. One of the sub-process is "Principles." Principles are further divided into consensus, industry-wide, and voluntary. Essentially, this sub-process takes into account the views of all interested parties, to include customers worldwide, to establish a market driven standard. Another sub-process involves the ISO product. The product is based on a set of drafting rules that is written in specialized language with a consistent structure. The standard uses international English with one or more document Editors for each standard.

The actual process involves six different stages: proposal, preparatory, committee, enquiry, approval, and publication stage. Currently, the SEDRIS technology is divided into six different proposed standards that are in the preparatory stage. There are three encodings of SEDRIS and their associated language binding. The encodings are SEDRIS technologies, Environmental Data Coding Specification, and the Spatial Reference Model. The language bindings for these are in C.

At this time, the various pieces of SEDRIS are in the working draft stage and are expected to be completed within the next 2-years. The reader is referred to the SEDRIS web site for a complete description of the SEDRIS standardization process.

3. Atmospheric Environment in SEDRIS

The actual incorporation of atmospheric data into SEDRIS involves two key aspects: 1) Determining how

Table 1: Example EDCS Classification Labels and associated definitions relevant to atmospheric data sets.

EDCS Classification Label	Definition
EDCS_CC_ATMOSPHERE	Pertaining to characteristics or attributes of the planetary atmosphere (e.g., wind, clouds). May include an unspecified mixture of atmosphere characterizations which may be capable of elaboration or separation into individual object types based on status/type grouping information which was unable to be determined at the time of classification assignment.
EDCS_CC_ATMOSPHERIC FORECAST_SURFACE	Pertaining to forecasted characteristics or attributes of the atmosphere associated with a specific type of generally horizontal surface (e.g., ground level, mean sea level, constant altitude). May include an unspecified mixture of forecasted atmospheric surface characterizations which may be capable of elaboration or separation into individual object types based on status/type grouping information which was unable to be determined at the time of classification assignment.
EDCS_CC_ATMOSPHERIC FORECAST_VOLUME	Pertaining to forecasted characteristics or attributes of the atmosphere occurring within a three-dimensional region. May include an unspecified mixture of forecasted atmospheric volume characterizations which may be capable of elaboration or separation into individual object types based on status/type grouping information which was unable to be determined at the time of classification assignment.
EDCS_CC_ATMOSPHERIC ANALYSIS_VOLUME	Pertaining to characteristics or attributes of the atmosphere determined through a process of analysis, which occur within a three-dimensional region. May include an unspecified mixture of analysis-derived atmospheric volume characterizations which may be capable of elaboration or separation into individual object types based on status/type grouping information which was unable to be determined at the time of classification assignment.
EDCS_CC_ATMOSPHERIC OBSERVATION	Pertaining to observed characteristics or attributes of the atmosphere. May include an unspecified mixture of observed atmospheric characterizations which may be capable of elaboration or separation into individual object types based on status/type grouping information which was unable to be determined at the time of classification assignment.
EDCS_CC_PRECIPITATION REGION	A region where precipitation is occurring (e.g., rain, snow, hail), over land or water.

to represent the atmospheric data using the DRM, and 2) determining the correct EDCS codes to use to label and identify the data as represented using the DRM. This over all process is frequently referred to as the mapping process.

3.1 EDCS Atmospheric Entries

The initial set of atmospheric parameters included in early versions of the SEDRIS Data Coding Standard (SDCS), now EDCS, were determined by subject matter experts. More recently, additional parameters were added after analyzing the requirements as stated by the DMSO Air and Space Natural Environment (ASNE) Modeling and Simulation Executive Agent (MSEA) and ensuring the EDCS was updated for any additional parameters that were required. The primary document used to map atmospheric requirements to SEDRIS is the ASNE Modeling and Simulation Baseline Requirements Assessment (ASNEM&SBRA). This report describes the ASNE requirements of a selected subset of major simulation programs that are

now in development (e.g. JWARS, JSIMS JMASS, and STOW). Procedures are in place for additional classification and attribute codes to be submitted for consideration to be added to the EDCS.

The EDCS ECC contains codes for classifying atmospheric data according to its type. Table 1 shows some of the atmospheric related classification codes, ECC codes. The EAC contains codes for identifying the atmospheric parameters. Table 2 shows some of the atmospheric related attribute codes, EAC codes.

3.2 Mapping Process

As previously stated the DRM is used to organize the data and the EDCS is used to label the components of the organization. Using the DRM, the data producer can indicate how the data is organized. Is it organized by time, by area, by domain, by some hierarchy of these, etc?

The mapping process involves several steps.

Table 2: Example EDCS Attribute codes for atmospheric parameters.

EDCS Attribute Label	Definition
EDCS_AC_AIR_STABILITY_PASQUIL_INDEX	A classification of atmospheric stability based on the standard deviation of horizontal wind direction fluctuations and temperature change with height.
EDCS_AC_AIR_TEMPERATURE_MINIMUM	The minimum air temperature that occurred during the measurement period.
EDCS_AC_RELATIVE_HUMIDITY	The ratio of vapor pressure to saturation vapor pressure. Vapor pressure is the pressure exerted by the molecules of water vapor. Saturation vapor pressure is the pressure exerted by molecules of water vapor in air that has attained saturation.
EDCS_AC_PRECIPITATION_ACCUMULATED	The depth of the precipitation (water equivalent) that accumulated during a measurement time interval.

- The user must first become familiar with the DRM
- The user must understand how their data is or should be organized.
 - What is basic data structure: points, grids, tables, etc?
 - Can this basic structure be further organized: grid of profiles, by time, by location?
- Identify corresponding DRM classes and relationships
- Repeat until all data relationships are captured
- May have to try several approaches to determine "best" approach.
- Fill in class fields
 - Determine appropriate ECCs.
 - Determine appropriate EACs

This procedure was applied in arriving at the mapping for atmospheric gridded data described in the Section 4.

4. Atmospheric Forecast/GRIB Mapping

Gridded atmospheric data is usually the result of an objective analysis, an atmospheric model run, or a

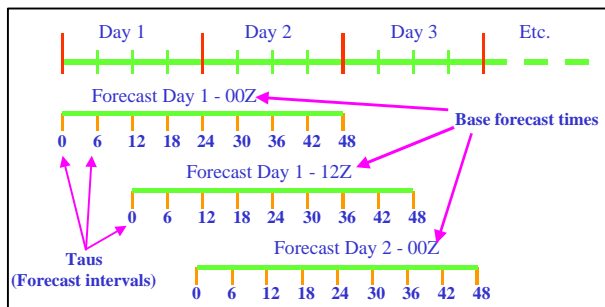


Figure 2: Relationship between base forecast time and associated taus for data set composed of multiple model runs.

combination of these. Numerical atmospheric models are used to produce forecast data and simulated atmospheric environments. Atmospheric model output typically consists of fields at mean sea level, the earth's surface and at various levels in the atmosphere. The fields are also output for the base time (analysis time) and at forecast times usually expressed as a delta (tau) from the base time. A large data set may be composed of several sets of forecast periods. Figure 2, illustrates the relationship between the various forecast periods.

These fields are usually distributed as grids using the World Meteorological Organization (WMO) Gridded Binary (GRIB) format in the form of GRIB messages. These messages may each be a separate file or be concatenated together into one or several files. There is no implied organization to the GRIB messages except what might be provided by the data provider in a file naming convention and how the messages are concatenated or otherwise organized using some directory structure.

4.1 Detail Mapping

This section presents the details about various aspects of a mappings of atmospheric parameters into SEDRIS. Figure 3 is a high level mapping for an atmospheric forecast data set as described above. The mapping includes the required classes Transmittal_Root, Transmittal_Summary, Environmental_Root, Spatial_Domain, and metadata classes. Immediately below these classes are nested Time_Related_Geometry classes, which serve to organize the data by base forecast time and forecast tau. Below the Time_Related_Geometry class corresponding to the forecast taus, are the Property_Grid_Hook_Point classes, which serve to locate the grids with respect to the earth's surface. Multiple Property_Grid classes can be associated with each Property_Grid_Hook_Point and define characteristics of each grid. Each Property_Grid class can have multiple Table_Property_Description

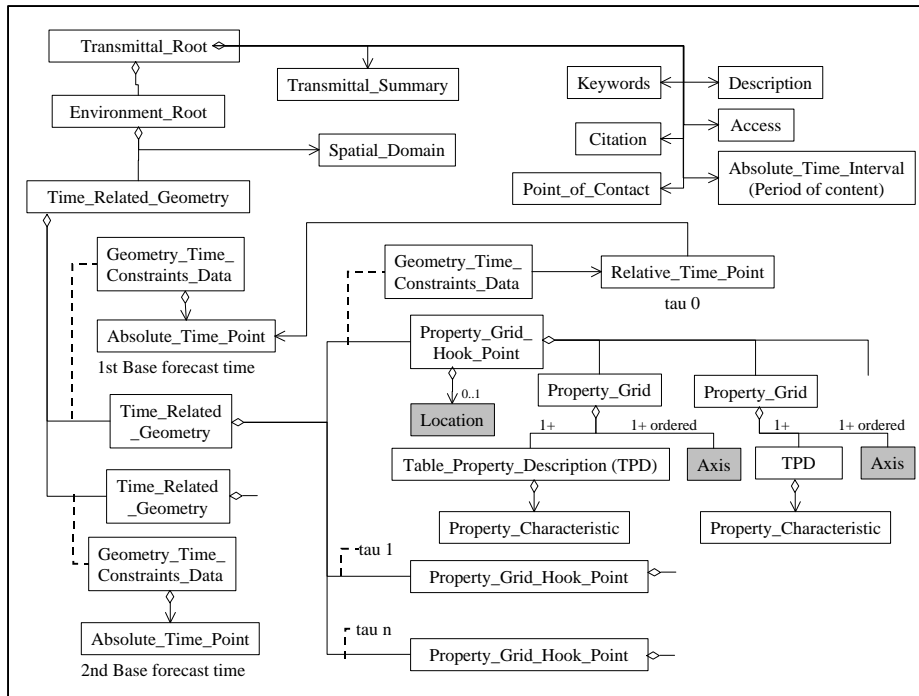


Figure 3: High Level mapping of a gridded atmospheric forecast data set.

classes, which describe what is contained in each cell of the grid.

The Transmittal_Root contains SEDRIS version information and the name of the dataset. The Transmittal_Summary class contains a summary of what is contained in the transmittal, classes, overall coordinate system, and hierarchies (Table 3). A consumer can use this information to decide if the transmittal contains what they need and if they can process the transmittal. Also associated with the Transmittal_Summary are classes that are used to summarize the EDCS codes, DRM classes, and environmental domains included in the transmittal, Figure 4. The use of these classes is optional and is dependent on the data producer.

Transmittal Summary
features present = SE NOT PRESENT
geometry present = SE PRESENT IN ENVIRONMENT ROOT
geometry topology present = SE NOT PRESENT
data tables present = SE PRESENT IN ENVIRONMENT ROOT
priority values present = SE NOT PRESENT
mobility values present = SE NOT PRESENT
thermal values present = SE NOT PRESENT
terrain lods present = SE NOT PRESENT
two D features flag SE NOT PRESENT
models present = SE FALSE
images present = SE FALSE
sounds present = SE FALSE
symbols present = SE FALSE
colors present = SE FALSE
color model = RGB
SDCS usage list is comprehensive = SE FALSE

the link class Geometry_Time_Constraints_Data (GTCD).

The first hierarchy, the first TRG below the Environmental_Root, corresponds to the base forecast time. The GTCD link class for each child, points to an Absolute_Time_Point class whose fields specify the corresponding date and time. Each of these children contains a second hierarchy level, another TRG, which corresponds to the forecast deltas (taus). In this case the GTCD link class points to a Relative Time Point class which specifies the delta from the base forecast time as indicated by their association with the corresponding Absolute_Time_Point. Note that the

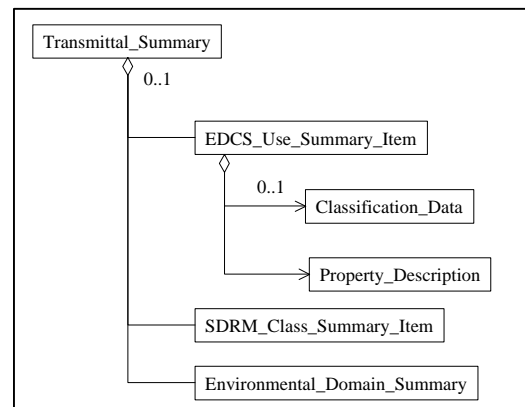


Figure 4: Classes used with the Transmittal Summary to summarize the contents of the transmittal.

Absolute_Time_Point can be shared between the Relative_Time_Points under the same hierarchy. This conserves space. Each of these children contains the third hierarchy level corresponding to the PGHP. Note that while the PGHP for each tau are probably identical in contents, the objects cannot be shared because of how inheritance in an object based system works. If two times shared the same PGHP object, there would be no way to tell which time the Property_Grids under a PGHP were associated with. However, the Location object, which locates the PGHP, can be shared.

Table 4 shows the contents of a typical Property_Grid class. The Property_Grid field data_table_type uses a SEDRIS Classification Code to indicate the type of Property_Grid. The spatial_axes_count field gives the number of spatial axes. Notice that an atmospheric volume only has two spatial axes. This is because the vertical coordinates are not in units of height above the vertical datum. The normal atmospheric vertical units of pressure or sigma are not considered spatial units because they are not referenced to a fixed datum. Therefore, the vertical axis is not a spatial axis. The location_index identifies the grid point that corresponds to the PGHP location. The srf_parms structure is used to define the coordinate system used for the grid. The is_2d field is used to indicate if the the coordinate system is 2D or 3D. A 3D coordinate system implies that a third spatial axis is used, which is not the case in this example. The spatial_reference_frame indicates that the coordinate system is a 2d Geodetic_Coordinate_System. The data_present field is a flag used to indicate if data are actually present. In some applications where the terrain is represented using Triangulated Irregular Networks (TIN), it is desired to be able to describe the grid from which the TIN was derived. In this case no data is actually contained in the property grid.

Table 5 shows the axis classes associated with the property grid that defines the latitude axis. Note that the axes are ordered and that the spatial axes always come first. The two Regular_Axis classes define the two spatial axes. The class fields define the axes. Note that these two classes can be shared by the property grids. The vertical axis of the atmospheric volume is defined using the Irregular_Axis class as illustrated in Table 6. The actual values of the axis tick marks are supplied in an array.

Table 7 shows example Table_Property_Description classes. A Table_Property_Description class is required for each parameter contained in the Property_Grid. The Table_Property_Description fields define the parameter, its units, and its value type. Each Table_Property_Description can have several

Property_Characteristics classes associated with it. The Property_Characteristics class is used to provide additional information about the parameter. This class can be used to specify upper and lower bounds, significance digits, tolerance, missing data flags, and several other characteristics. The SEDRIS Write API will use the upper and lower bounds and the tolerance

Table 4: Contents of Property_Grid class.

Property_Grid
<pre> data_table_type = EDCS_CC_ATMOSPHERIC_ANALYSIS_VOLUME spatial_axes_count = 2 location_index = (0,0,0) srf_parms.is_2d = SE_TRUE srf_parms.u.parms_2d.spatial_reference_frame = SRM_GD_2D_SRF srf_parms.u.parms_2d.u.gd_parameters.horizontal_datum = SE_SPHERICAL_COA_HDATUM data_present = SE_TRUE </pre>

Regular_Axis
<pre> axis_type = "EDCS_AC_SPATIAL_GEODETTIC_LATITUDE" axis_unit = "SE_UNITS_DEGREE_ARC" axis_value_count = 231 interpolation_type = SE_INTERP_NOT_SUPPLIED" first_value = 0 spacing = .20 values_are_ints = SE_FALSE type_of_spacing = SE_LINEAR_SPACING axis_alignment = SE_ALIGN_LOWER </pre>

when they are present to compress the data when it is written to the SEDRIS transmittal in the next release.

Irregular_Axis
<pre> axis_type = EDCS_AC_PRESSURE_ATMOSPHERE axis_unit = "SE_UNITS_TECTOPASCAL" axis_value_count = 4 interpolation_type = SE_INTERP_NOT_SUPPLIED" AXIS_VALUE_ARRAY = (1000, 900, 700, 500) axis_alignment = SE_ALIGN_LOWER </pre>

So far there has been no mention of the actual data only the description of how the data is organized. To this point there has been no discussion of where the data is put. This is because the data is not explicitly contained in the DRM. However, it is implicitly contained. Early on it was decided not to include the Data_Table and

Table_Property_Description
<pre> attribute_code = EDCS_AC_WIND_SPEED_U_COMPONENT value_unit = SE_UNITS_METERS_PER_SECOND value_type = SE_PDV_FLOAT_32 </pre>

Table 7: Example Table_Property_Description

~~This table specifies parameters included in a vic~~

Property_Grid data in the DRM because the amount of data can be large. Instead, hidden pointers are maintained that point to the data. In a STF, the data is actually contained in files external to the DRM portion of the STF. When creating a STF, after the classes as described are created and added to a transmittal, the user makes additional function calls to add the actual data to the transmittal. When reading a STF, the opposite is done. Once a user has found the Property_Grid that they want, the user makes explicit calls to load the Property_Grid data.

5. GRIB to SEDRIS STF Conversion

Atmospheric forecast model output is usually distributed using the World Meteorological Organization (WMO) Gridded Binary (GRIB) format. A process was developed to convert GRIB files to a SEDRIS Transmittal Format (STF) using the above mapping. The process uses two programs, one to perform the mapping and the other to create the STF. The first program, GRIB2SED, analyzes the GRIB files and creates the mapping to SEDRIS. It creates a mapping file that describes how the GRIB data is to be mapped using the SEDRIS DRM. After the mapping file has been created, the second program, GRIB2STF, reads the GRIB files and creates the STF.

This mapping file approach was taken because, while the general form of the mapping is the same from data set to data set, the actual mapping depends on the number of base forecast time, number of taus, the parameters, and the surface types. Also, by decoupling the mapping from the actual creation of the STF, future support for other formats is easier to provide.

5.1 Testing

Conversions have been done for the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) and Wave Model (WAM) data sets. Execution time for a file of 510 GRIB messages took approximately 114 seconds. The resulting STF is often approximately the same size or smaller than the total of the original GRIB files.

Two approaches to testing were taken to make sure no information was being lost during the conversion process.

The first approach was qualitative and involved the comparison of plots of the data before and after conversion. The basic tool used for plotting the atmospheric data was VIS5D. VIS5d is a freeware tool developed by the University of Wisconsin and is a software package that displays standard meteorological

parameters. VIS5D requires a specific format for its input file. A program already existed to convert GRIB files to the VIS5D format. A program was developed to convert data retrieved from the STF to the VIS5D format. After VIS5D input files were created from both the GRIB files and the STF, VIS5D was used to view the data and comparisons were made. There were no noticeable differences.

The second approach was rigorous. In this approach actual data values were compared. As the data was read from the GRIB files, it was printed in a specific format to a dump file. Another program was developed that read the STF and dumped the retrieved data in exactly the same format as when it was read from the GRIB files. These two files were then compared and any differences noted. The only differences found were those expected in least significant digits of floating point numbers. This difference was expected because the tolerance specified in the Property_Characteristic class for each parameter, was used in the compression to truncate the number of digits retained during the compression process.

5.2 Usage

To use the conversion programs, a user must provide three files: 1) a file that contains the GRIB table that contains the GRIB parameter information for their data set, 2) a file that maps the GRIB parameter and level IDs to EDCS Attribute Codes), and 3) a metadata record either in the form of a Federal Geographic Data Committee's Content Standard for Digital Geospatial Metadata Version 2 1998 metadata record or a file that uses the same tags to identify the metadata sections. The metadata record is required to provide additional information required in a STF that is not available in the GRIB records. A fourth file that contains horizontal and vertical datum for supported data sources should be checked and updated if needed. While these files may be specific for each data set and resource, existing files can often be used with few if any changes for most GRIB data sets. Any changes required will reflect local additions and/or modification to the GRIB standard tables.

Currently the software is being used at the Master Environmental Library Naval Research Laboratory Resource Site. When a user places an order for data with a native format of GRIB, they can specify if they want the data to be delivered in GRIB or SEDRIS.STF. If they select SEDRIS, the conversion is done on the fly. The Environmental Scenario Generator component of the INE is also using the code to make datasets available in SEDRIS STF.

6. Observational Data Mapping

As of the writing of this paper, no observational datasets have yet been converted to the SEDRIS STF format. However a preliminary mapping does exist and is briefly presented here. There are two observational data format types that are of primary interest: the USAF DATSAVE3 and the WMO Binary Universal Format for meteorological data (BUFR). The basic mapping for both of these should be the same and have the same structure.

There are many types of atmospheric observational data. To limit the scope of the initial mapping, only surface observation data sets and atmospheric profiles are being considered initially.

6.1 Surface Observations

Surface observations are basically observations at a point for a given time. They are reported as being taken at a specific time, even though the actual observation time may vary slightly about this "reporting time". Figure 5 is a high level mapping for surface observations.

The higher levels of the mapping are the same as for gridded data down through the first Time_Related_Geometry (TRG). The TRG is used to organized the observations by their reporting times. The Union_of_Primitive_Geometry class is used to group the observation locations (points) under each TRG. Each observation location is represented by the primitive geometry Point class. The Point class itself do not contain any fields, but serves to associate other classes together. Each Point class has a Location_3D class associated with it and one or more Property_Value classes. The Location_3D class provides the location of the observations. The associated Property_Value classes define the parameters measured and their values. Optionally, a Time_Constraints_Data class can be associated with a point to give the actual observation time as opposed to the reporting time.

6.2 Profiles

The same basic mapping can

be used for most atmospheric profiles. Often, in addition to the profile information, there is surface information included with the report.

The mapping for profiles is just an extension of the mapping for surface observations. Figure 6 shows the additional classes required to represent profile type data. Instead of repeating the entire mapping, only a classes required to represent a profile are shown. Also note that the classification code associated with the Time_Related_Geometry shown in Figure 5 would need to reflect that the data is profile data.

Any surface information associated with the profile would be represented using the same classes as for surface observations. The new class that allows the profile information to be represented is the Property_Table class. Associated with the Property_Table class is an Irregular_Axis class which

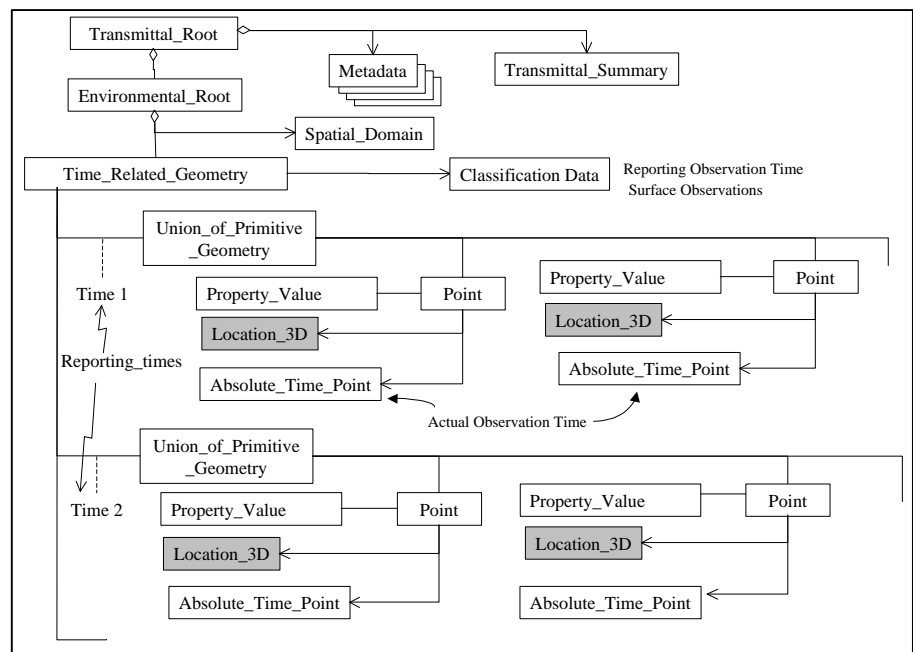


Figure 5: Proposed representation for atmospheric surface observations.

profile information to be represented is the Property_Table class. Associated with the Property_Table class is an Irregular_Axis class which specifies the levels at which the profile information is reported. As with Property_Grids, the Table_Property_Description classes specify what parameters are included.

7. Conclusion

In this paper, we presented the work to represent atmospheric data using the SEDRIS DRM, EDCS, and SRM and to convert atmospheric data from the GRIB format to the SEDRIS Transmittal Format (STF) using the SEDRIS API. These mappings provide the users a structured analysis of how the atmospheric data can be represented using SEDRIS and hence converted into an STF. It also provides the user a way or the knowledge of how to extract the data from STF. A converter was developed for atmospheric data in GRIB format and has been tested on several data sets. The converter is in use at a MEL resource site.

8. Author Biographies

Dr. Louis Hembree is a Research Meteorologist at the Naval research Laboratory Marine Meteorology Division, Monterey, CA. He has represented the Air and Space Natural Environment in the SEDRIS development as a subject matter expert for the atmosphere. He is also Technical Lead and Resource Site Lead for the Master Environmental Library.

Dr. Rob Cox is a Chief Scientist with SAIC. Dr. Cox serves as project director and principal investigator for SEDRIS. He leads the SAIC ASSET Group's Synthetic Natural Environment research efforts. Prior to joining SAIC, Dr. Cox was in the U.S. Air Force. He has served in a diverse set of positions in Korea, Nebraska, and Washington DC.

Valerie Pastor is a Research Programmer at SAIC, Monterey, CA. She has over 19 years of programming experience. She is the principle developer of the GRIB to SEDRIS conversion routine.

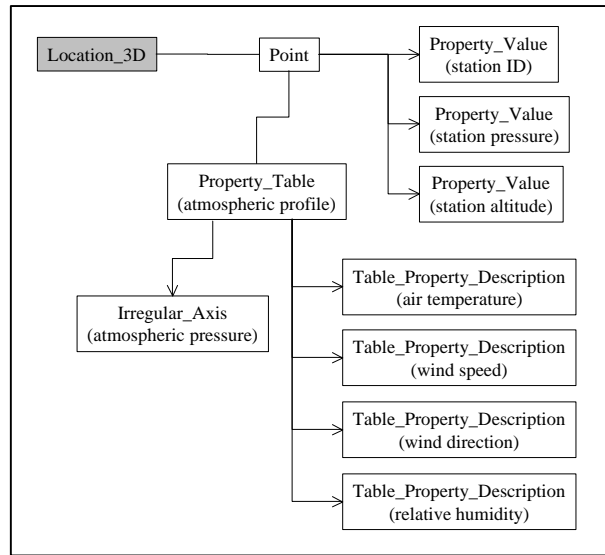


Figure 6: Classes required to represent profile data. Note that the representation above the Point object, is the same as in Figure 5, except the classification information would indicate profile