

Biosphere 2 Landscape Evolution Observatory (LEO) Sensor Data Model (SensorDB) Description

The LEO data acquisition allows real-time monitoring of all data streams and save them to a database for the further processing, visualization and publication. The LEO database (SensorDB) was derived and adopted the control vocabulary from the Observations Data Model (ODM) (Horsburgh et al., 2008). The data model used for LEO experiment was developed and implemented as relational database, see Figure 1. It focuses more on the extensive description of sensors (metadata) which allows reducing the description of each measured value to time, sensor and variable. This implementation of SensorDB effortless transformation of values to the ODM database after quality control was completed. Measured data from all sensors can be visualized, plotted and queried in real time (<http://b2.arizona.edu:8080/LEOdatasets/> or <http://desert.uits.arizona.edu:8080/LEOdatasets/>).

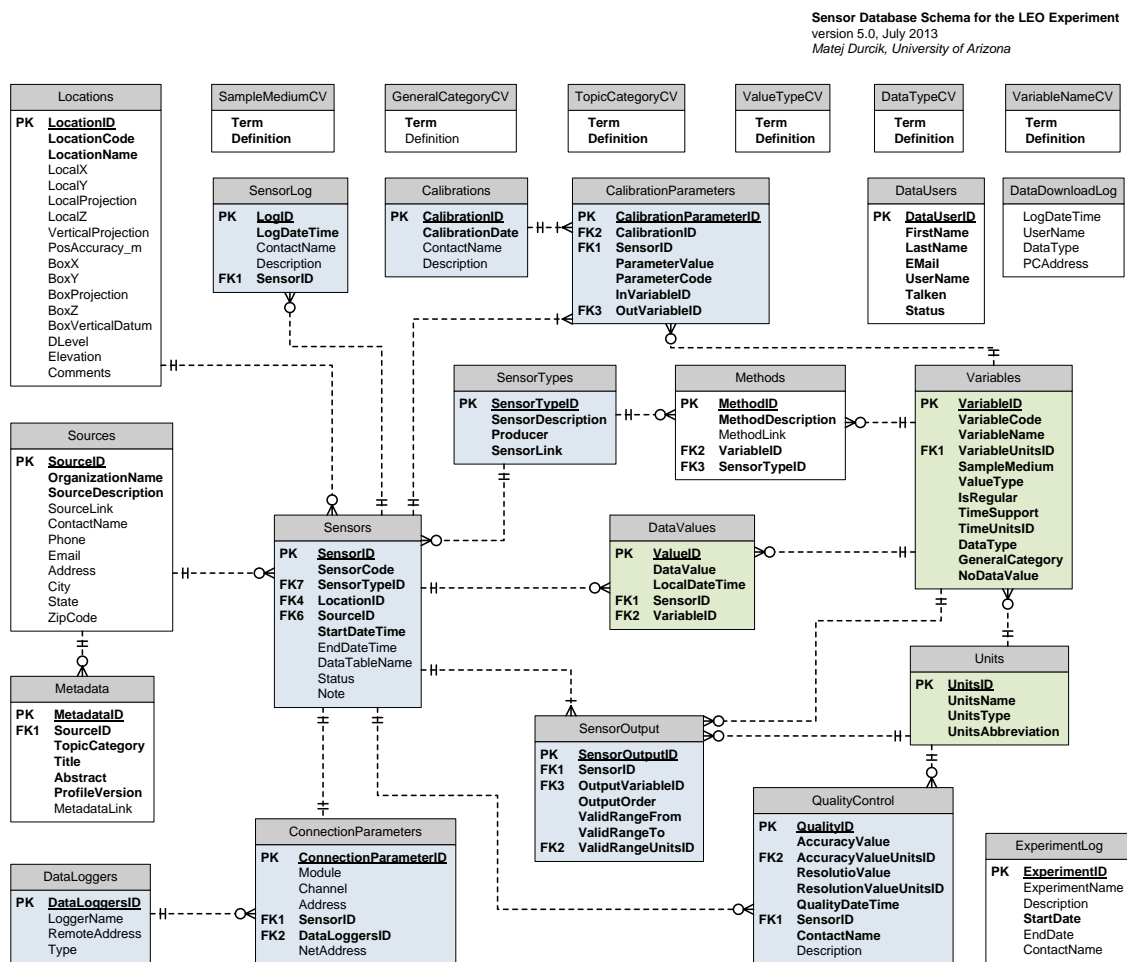


Figure 1 LEO SensorDB schema.

LEO Sensors Data Model Tables

This section describes tables included in the SensorDB database schema and relations between the tables.

The value of attributes in tables can be mandatory (M) and cannot be NULL or optional (O) which can be NULL.

DataTypeCV (adopted from ODM)

The DataTypeCV table contains the controlled vocabulary for data types. Only values from the Term field in this table can be used to populate the DataType field in the Variables table.

Field Name	Data Type	Description	Examples	Constraint
Term	Text	Controlled vocabulary for DataType	“Continuous”	M Unique
Definition	Text	Definition of DataType controlled vocabulary. The definition is optional if the term is self explanatory.	“A quantity specified at a particular instant in time measured with sufficient frequency (small spacing) to be interpreted as a continuous record of the phenomenon.”	O

SampleMediumCV (adopted from ODM)

The SampleMediumCV table contains the controlled vocabulary for sample media.

Field Name	Data Type	Description	Examples	Constraint
Term	Text	Controlled vocabulary for sample media.	“Surface Water”	M Unique
Definition	Text	Definition of sample media controlled vocabulary. The definition is optional if the term is self explanatory.	“Sample taken from surface water such as a stream, river, lake, pond, reservoir, ocean, etc.”	O

ValueTypeCV (adopted from ODM)

The ValueTypeCV table contains the controlled vocabulary for the ValueType field in the Variables and SeriesCatalog tables.

Field Name	Data Type	Description	Examples	Constraint
Term	Text	Controlled vocabulary for ValueType.	“Field Observation”	M Unique
Definition	Text	Definition of the ValueType controlled vocabulary. The definition is optional if the term is self explanatory.	“Observation of a variable using a field instrument”	O

VariableNameCV (adopted from ODM)

The VariableName CV table contains the controlled vocabulary for the VariableName field in the Variables and SeriesCatalog tables.

Field Name	Data Type	Description	Examples	Constraint
Term	Text	Controlled vocabulary for Variable names.	"Temperature", "Discharge", "Precipitation"	M Unique
Definition	Text	Definition of the VariableName controlled vocabulary. The definition is optional if the term is self explanatory.		O

TopicCategoryCV (adopted from ODM)

The TopicCategoryCV table contains the controlled vocabulary for the ISOMetaData topic categories.

Field Name	Data Type	Description	Examples	Constraint
Term	Text	Controlled vocabulary for TopicCategory.	"InlandWaters"	M Unique
Definition	Text	Definition of TopicCategory controlled vocabulary. The definition is optional if the term is self explanatory.	"Data associated with inland waters"	O

GeneralCategoryCV (adopted from ODM)

The GeneralCategoryCV table contains the controlled vocabulary for the general categories associated with Variables. The GeneralCategory field in the Variables table can only be populated with values from the Term field of this controlled vocabulary.

Field Name	Data Type	Description	Examples	Constraint
Term	Text	Controlled vocabulary for GeneralCategory	"Hydrology"	M Unique
Definition	Text	Definition of GeneralCategory controlled vocabulary. The definition is optional if the term is self explanatory.	"Data associated with hydrologic variables or processes."	O

Controlled vocabulary tables are pre-populated and updated with the CUAHSI HIS's master controlled vocabulary downloaded from (<http://his.cuahsi.org/mastercvreg.html>).

Units

The Units table gives the Units and UnitsType associated with variables, time support, and offsets. This is a controlled vocabulary table and can be pre-populated and updated with the CUAHSI HIS's master controlled vocabulary downloaded from (<http://his.cuahsi.org/mastercvreg.html>)..

Field Name	Data Type	Description	Example	Constraint
UnitsID	Integer	Primary key. Unique integer identifier that identifies each unit.	6	M Unique
UnitsName	Text	Full text name of the units.	"Milligrams Per Liter"	M
UnitsType	Text	Text value that specifies the dimensions of the units.	"Length" "Time" "Mass"	M
UnitsAbbreviation	Text	Text abbreviation for the units.	"mg/L"	M

Variables (adopted from ODM)

The Variables table lists the full descriptive information about what variables have been measured.

Field Name	Data Type	Description	Example	Constraint	Default Value
VariableID	Integer	Primary key. Unique integer identifier for each variable.	6	M Unique	
VariableCode	Text	Code used by the organization that collects the data to identify the variable.	"AirTemp" Temperature measured in Air	M	
VariableName	Text	Full text name of the variable that was measured, observed, modeled, etc. This should be from the VariableNameCV controlled vocabulary table.	"Discharge"	M	
VariableUnitsID	Integer	Foreign key. Integer identifier that references the record in the Units table giving the units of the data values associated with the variable.	4	M	
SampleMedium	Text	The medium in which the sample or observation was taken or made. This should be from the SampleMediumCV controlled vocabulary table.	"Surface Water" "Sediment"	M	"Unknown"
ValueType	Text	Text value indicating what type of data value is being recorded. This should be from the ValueTypeCV controlled vocabulary table.	"Field Observation" "Laboratory Observation"	M	"Unknown"

IsRegular	Boolean	Value that indicates whether the data values are from a regularly sampled time series.	“True” “False”	M	False
TimeSupport	Real	Numerical value that indicates the time support (or temporal footprint) of the data values. 0 is used to indicate data values that are instantaneous. Other values indicate the time over which the data values are implicitly or explicitly averaged or aggregated.	0, 24	M	0 = Assumes instantaneous samples where no other information is available
TimeUnitsID	Integer	Foreign key. Integer identifier that references the record in the Units table giving the Units of the time support. If TimeSupport is 0, indicating an instantaneous observation, a unit needs to still be given for completeness, although it is somewhat arbitrary.	4	M	103 = hours
DataType	Text	Text value that identifies the data values as one of several types from the DataTypeCV controlled vocabulary table.	“Continuous” “Sporadic” “Cumulative” “Incremental” “Average” “Minimum” “Maximum” ...	M	“Unknown”
GeneralCategory	Text	General category of the data values from the GeneralCategoryCV controlled vocabulary table.	“Climate” “Water Quality”	M	“Unknown”
NoDataValue	Real	Numeric value used to encode no data values for this variable.	-9999	M	-9999

Sources (adopted from ODM)

The Sources table lists the original sources of the data, providing information sufficient to retrieve and reconstruct the data value from the original data files if necessary.

Field Name	Data Type	Description	Example	Constraint	Default Value
SourceID	Integer	Primary key. Unique integer identifier that identifies each data source.	5	M Unique	
OrganizationName	Text	Name of the organization that collected the data.	“Biosphere 2, University of Arizona”	M	
SourceDescription	Text	Full text description of the source of the data.	“LEO Experiment”	M	

SourceLink	Hyperlink	Link that can be pointed at the original data file and/or associated metadata stored in the digital library or URL of data source.		O	NULL
ContactName	Text	Name of the contact person for the data source.	"Joe Doe"	M	"Unknown"
Phone	Text	Phone number for the contact person.	"520-626-0000"	M	"Unknown"
Email	Text	Email address for the contact person.	"JoeDoe@email.az.edu"	M	"Unknown"
Address	Text	Street address for the contact person.	"845 N Park St."	M	"Unknown"
City	Text	City in which the contact person is located.	"Tucson"	M	"Unknown"
State	Text	State in which the contact person is located. Use two letter abbreviations for US. For other countries give the full country name.	"AZ"	M	"Unknown"
ZipCode	Text	US Zip Code or country postal code.	"85721"	M	"Unknown"

Metadata (*adopted from ODM*)

The Metadata table contains dataset and project level metadata required for compliance with standards such as the draft ISO 19115 or ISO 8601. The mandatory fields in this table must be populated to provide a complete set of ISO compliant metadata in the database.

Field Name	Data Type	Description	Example	Constraint	Default Value
MetadataID	Integer	Primary key. Unique integer ID for each metadata record.	4	M Unique	
SourceID	Integer	Foreign key. Integer identifier referencing the record in the Sources table for this metadata.	3	M	
TopicCategory	Text	Topic category keyword that gives the broad ISO19115 metadata topic category for data from this source. The controlled vocabulary of topic category keywords is given in the TopicCategoryCV table.	"inlandWaters"	M	"Unknown"
Title	Text	Title of data from a specific data source.		M	"Unknown"
Abstract	Text	Abstract of data from a specific data source.		M	"Unknown"
ProfileVersion	Text	Name of metadata profile used by the data source	"ISO8601"	M	"Unknown"
MetadataLink	Hyperlink	Link to additional metadata reference material.		O	NULL

Locations

The Locations table provides information giving the spatial location at which data values have been collected.

Field Name	Data Type	Description	Example	Constraint	Default Value
LocationID	Integer	Primary key. Unique identifier for each location.	37	M Unique	
LocationCode	Text	Code used by organization that collects the data to identify the location. The location coding for LEO slopes is as follows: LEO-E_Y_X_D where LEO-E represents east slope (C - central or W – west slope); Y is up-slope coordinate; X is cross-slope coordinate; and D is depth level.	“LEO-E_4_2_1”	M Unique	
SiteName	Text	Full name of the sampling site.	“Hill slope east”	M	
LocalX	Real	Cross-slope distance in m	-2	M	
LocalY	Real	Up-slope distance in m	14	M	
LocalProjection	Text	Description of the local coordinate system	“Local coordinates to zero level – lower center of the slope”	M	0 = Unknown
LocalZ	Real	Elevation of sampling location in m	2.2	O	NULL
VerticalDatum	Text	Vertical datum of the elevation.	“Local distance in m to zero level defined as concrete floor.”	O	NULL
PosAccuracy_m	Real	Value giving the accuracy with which the positional information is specified in meters.	0.1	O	NULL
BoxX	Real	Box X coordinate in m.	-4	O	NULL
BoxY	Real	Box Y coordinate in m.	22	O	NULL
BoxProjection	Text	Metal rectangular box coordinate system.	“Box coordinates to zero level – lower center of the slope”	O	NULL
BoxZ	Real	Box Z coordinate in m.	0.35	O	NULL

BoxVerticalDatum	Text	Box vertical datum.	“Depth from the soil surface in m.”	O	NULL
DLevel	Integer	Depth level numbered from the surface	3	O	NULL
Comments	Text	Comments related to the site,		O	NULL

SensorTypes

The SensorTypes table provides information about sensor type, model and producer

Field Name	Data Type	Description	Example	Constraint	Default Value
SensorTypeID	Integer	Primary key. Unique identifier for each sensor type.	37	M Unique	
SensorType	Text	Sensor type/model code	“MPS-2”	M Unique	
SensorDescription	Text	Brief sensor description	“Dielectric Water Potential Sensor”	M	
Producer	Text	Producing company name	“Decagon”	M	
SensorLink	Text	URL to detail sensor description	“http://www.decagon.com”	O	NULL

Methods

The Methods table provides information how variables are measured or computed for each sensor type

Field Name	Data Type	Description	Example	Constraint	Default Value
MethodID	Integer	Primary key. Unique identifier for each method.	2	M Unique	
MethodDescription	Text	Description of measurement or computation method.	“Hukseflux surface heat flux plates HFPOSC (raw output)”	M	
MethodLink	Text	Link to additional reference material on the method.	“http://www.hukseflux.com/product/hfp01sc”	O	NULL
VariableID	Integer	Integer identifier for Variable that references the Variables table.	1	M	
SensorTypeID	Integer	Integer identifier for Sensor Type that references the SensorTypes table.	6	M	

Sensors

The Sensors table provides information about sensor status, location, source and the time period when it was operational.

Field Name	Data Type	Description	Example	Constraint	Default Value
SensorID	Integer	Primary key. Unique identifier for each sensor.	931	M Unique	
SensorCode	Text	Uniquely define each sensor and the sensor code contains following info: LEO-E_Y_X_D_ST where LEO-E represents east slope (C - central or W – west slope); Y is up-slope coordinate; X is cross-slope coordinate; D is depth level; and ST is sensor type.	LEO-E_0_0_0_EX81	M Unique	
SensorTypeID	Integer	Integer identifier for Sensor Type that references the SensorTypes table.	4	M	
LocationID	Integer	Integer identifier for Location that references the Locations table.	545	M	
SourceID	Integer	Integer identifier for Source (sensor owner) that references the Sources table.	1	M	
StartDateTime	Date	Date and time when sensor was installed.	“12-JAN-12”	M	
EndDateTime	Date	Date and time when sensor was removed/disconnected.	“12-JAN-15”	O	NULL
DataTableName	Text	Name of the table where data are stored for this sensor.	“Datavalues”	M	
Status	Text	Status for each sensor	“A” - Active “I” - Discontinued	M	
Note	Text	Notes about sensor status or maintenance, etc.	“Sensor was replaced with the same model SensorID=1333”	O	NULL

Data Values

The DataValues table stores all values measured/computed by sensors

Field Name	Data Type	Description	Example	Constraint	Default Value
ValueID	Integer	Primary key. Unique identifier for each data value.	7	M Unique	454
DataValue	Double	Numeric value of the observation or computation.	-0.145	M	-9999
LocalDateTime	Date	Local date and time at which the data value was observed.	4/22/2011 1:15	M	
SensorID	Integer	Unique integer identifier for each sensor. Foreign key.	922	M	
OutputVariableID	Integer	Unique integer identifier that references the variable that was measured. Foreign key.	47	M	

SensorLog

The SensorLog table describe any action associated with sensor, such as maintenance, calibration, testing, etc.

Field Name	Data Type	Description	Example	Constraint	Default Value
SensorLogID	Integer	Primary key. Unique identifier for each sensor log.	7	M Unique	
LogDateTime	Date	Date and time when sensor was manipulated.	“14-APR-14”	M	
ContactName	Text	Person name who performed the action	“John Worker”	M	
Description	Text	Detailed description of action performed on sensor	“Sensor calibration”	M	
SensorID	Integer	Integer identifier for Sensor that references the Sensors table.	456	M	

DataLoggers

The DataLoggers table provides information about data loggers

Field Name	Data Type	Description	Example	Constraint	Default Value
DataLoggersID	Integer	Primary key. Unique identifier for each data logger.	2	M Unique	
LoggerName	Text	Logger name or code	“cRIO-LEO-East-P03”	M	
RemoteAddress	Text	IP address of each logger	“192.168.1.153”	O	“0.0.0.0”
Type	Text	Datalogger type	“cRIO NI-9074”	O	

ConnectionParameters

The ConnectionParameters table provides information how sensors are connected to data loggers or network

Field Name	Data Type	Description	Example	Constraint	Default Value
ConnestionParameterID	Integer	Primary key. Unique identifier for each Connection Parameter.	7	M Unique	
Module	Text	I/O module slot label or code	“5”	O	
Channel	Text	I/O module channel label	“3”	O	
Address	Text	I/O module address label	“F”		
SensorID	Integer	Integer identifier for Sensor that references the Sensors table.	232	M	
DataLoggersID	Integer	Integer identifier for Data Logger that references the Dataloggers table.	4	M	
NetAddress	Text	IP address for sensor	“192.168.1.3”	O	

Calibrations

The Calibrations table describes calibration procedure and when it was performed

Field Name	Data Type	Description	Example	Constraint	Default Value
CalibrationID	Integer	Primary key. Unique identifier for each calibration.	11	M Unique	
CalibrationDate	Date	Date when calibration was performed.	“12-JAN-14”	M	
ContactName	Text	Person name who performed calibration	“John Worker”	M	
Description	Text	Description for the calibration procedure.	“Factory calibration parameters for VW-PZO”	O	

References

Horsburgh, J. S., D. G. Tarboton, D. R. Maidment and I. Zaslavsky, (2008), A Relational Model for Environmental and Water Resources Data, *Water Resources Research*, 44: W05406, doi:10.1029/2007WR006392.

David G. Tarboton, Jeffery S. Horsburgh, David R. Maidment (2007) CUAHSI Community Observations Data Model (ODM) Version 1.0 Design Specifications.
(<http://his.cuahsi.org/documents/ODM1.pdf>).