Project Report
ATC-355

CIWS Product Description
Revision 1.0

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November 10, 2009

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Lexington, Massachusetts

Prepared for the Federal Aviation Administration,
Washington, DC 20591

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the National Technical Information Service,
Springfield, VA 22161

ABSTRACT

Lincoln Laboratory has developed a set of information models for the encoding and distribution of data products from the National Corridor Integrated Weather System (CIWS) prototype, currently operating at Lincoln Laboratory in Lexington, Massachusetts.

CIWS data products can be categorized as gridded and non-gridded. Gridded products are typically expressed as rectangular arrays whose elements contain a data value coinciding with uniformly-spaced observations or computed results on a 2-D surface. Gridded data arrays map to earth's surface through a map projection, for example, Lambert Conformal or Lambert Azimuthal Equal-Area. Non-gridded data products express observations or computed results associated with singular or sparsely distributed sets of geo-spatial locations such as points, curves, or contours.

CIWS prototype data products were used to develop, refine, and evaluate reference information models for the CIWS gridded and non-gridded data. Data packaging methods were evaluated and selected on the basis of public-domain open-source availability and metadata support. Network Common Data Format (NetCDF), provided by Unidata, was selected as the information model for gridded CIWS products. For the non-gridded products, XML schemas have been developed along with sample XML instances to illustrate schema-compliant product encodings. These models follow and extend upon a number of Open Geospatial Consortium (OGC) and ISO standards including Geography Markup Language (GML), Observations and Measurements (OM), and Eurocontrol’s Weather Exchange Model (WXXM).

This document is intended to serve as a reference for the description of CIWS data product files.

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1. INTRODUCTION

This document contains a description of Corridor Integrated Weather System (CIWS) data products that are packaged and distributed for external users. CIWS data products are categorized as gridded and non-gridded. Gridded CIWS products are typically expressed as rectangular arrays whose elements contain a data value coinciding with uniformly-spaced observations or computed results on a 2-D surface. Gridded data arrays map to earth's surface through a map projection, for example, Lambert Conformal or Lambert Azimuthal Equal-Area. Non-gridded data usually express observations or computed results associated with singular geo-spatial locations.

CIWS prototype data products were used to develop, refine, and evaluate a reference information model for gridded and non-gridded data. Data packaging methods were evaluated and selected on the basis of public-domain open-source availability and metadata support. Network Common Data Format (NetCDF), provided by Unidata, was selected as the information model for gridded CIWS products. Geography Markup Language (GML), defined by the Open Geospatial Consortium (OGC) was selected for non-gridded products.

2. NATIONAL CIWS GRIDDED PRODUCT FILES

National CIWS gridded products consist of one or more rectangular arrays of data values or flags, uniformly-spaced in some map projection such as Lambert Azimuthal Equal Area (LAEA). The files are formatted using Unidata Network Common Data Format - Version 4 (NetCDF-4) which relies on NetCDF Application Programming Interface (API) software and Hierarchical Data Format - Version 5 (HDF5) file access software.

Product descriptions are summarized in the following sections. Appendix A includes more detailed product file summaries in "network Common Data Form Language" (CDL), generated by the *ncdump* utility.

Whenever possible, variables and attributes defined in CIWS product files abide by Climate and Forecast (CF) metadata conventions. The recommendations defined for the CF convention are available via Web site: **http://cf-pcmdi.llnl.gov/**.

2.1 GRID MAPPING PROJECTIONS

The National CIWS gridded product files are mapped using the Lambert Azimuthal Equal Area projection. This projection was selected for its convenience while forming the mosaic of individual radar observations. According to CF convention, an additional pair of grids is packed with each NetCDF file to declare the latitude and longitude of every grid element. However, in order to reduce the file sizes, the latitude/longitude grids are omitted from CIWS product files. Clients may instead compute grid bin locations using element indices and well-defined projection mapping routines available at a number of public-domain Web sites. Useful map projection attributes are included in the CIWS NetCDF. The grid mapping variable and its corresponding attributes, as they appear in most CIWS gridded product files, is as follows:

```
int grid_mapping0 ;
            grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
            grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
            grid_mapping0:latitude_of_projection_origin = 38. ;
            grid_mapping0:longitude_of_projection_origin = -98. ;
            grid_mapping0:false_easting = 0. ;
            grid_mapping0:false_northing = 0. ;
            grid_mapping0:earth_radius = 6370997. ;
```

The grid mapping variable may also contain attribute information describing the Earth radius associated with the map projection. The Earth radius information is typically required for software that maps projected grid elements (x, y offset) to locations (latitude, longitude). A sample software bin-to-location mapping is provided below, using the General Cartographic Transformation Package (GCTP). The GCTP software is available at URL: http://gcmd.nasa.gov/records/USGS-GCTP.html

The GCTP library, named “geolib.a”, contains functions that perform forward and inverse mapping projection conversions. Instructions for building the library accompany the software package.

The following sample program, written in C++, illustrates how the location of each bin in a nominal National CIWS grid may be computed:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <iostream>

extern “C”
{
#include “cproj.h”
}

using namespace std;

int main( int argc, char** argv )
{
  static double pi = 4.0 * atan( 1.0 );

  int numRows = 3520;
  int numCols = 5120;
  double eastSpacing_m = 1000.;
  double northSpacing_m = 1000.;
  double centerLat_deg = 38.0;
  double centerLon_deg = -98.0;
  double falseEasting_m = 0.0;
  double falseNorthing_m = 0.0;
  double earthRadiusSpereical_m = 6370997.;  /* see sphdz.c */

  double centerLat_rad = ( pi / 180. ) * centerLat_deg;
  double centerLon_rad = ( pi / 180. ) * centerLon_deg;

  lamazinvint( earthRadiusSpereical_m, centerLon_rad, centerLat_rad,
               falseEasting_m, falseNorthing_m );

  for( int row = -numRows/2 ; row < numRows/2 ; row++ )
  {
    double y_m = (double)row * northSpacing_m;

    for( int col = -numCols/2 ; col < numCols/2 ; col++ )
    {
      double x_m = (double)col * eastSpacing_m;
      double gc_lat_rad, gc_lon_rad;

      if( lamazinv( x_m, y_m, &gc_lon_rad, &gc_lat_rad ) != OK )
      {
        fprintf( stderr, “Error converting x_m=%f, y_m=%f\n”, x_m, y_m );
        exit( EXIT_FAILURE );
      }
      else
      {
        double gc_lat_deg = ( 180. / pi ) * gc_lat_rad;
        double gc_lon_deg = ( 180. / pi ) * gc_lon_rad;

        printf( “ %5d %5d : %7.1f %7.1f : %8.4f %8.4f\n”,
          row, col, x_m*.001, y_m*.001, gc_lat_deg, gc_lon_deg );
      }
```

```
    } // for(col)

  }  // for(row)

  exit( EXIT_SUCCESS );
}
```

The highlighted text in the above code refers to GCTP functions. In the above example, the arguments passed to the *lamazinvint* function would be extracted from a NetCDF file as the attributes of the grid mapping variable. For the Lambert Azimuthal Equal Area map projection, the National CIWS and GCTP both define earth radius as spherical (identical major and minor axis lengths) and equal to 6370997.0 meters.

Applications written in Java may use similar map projection manipulation software available from the PROJ.4 Cartographic Projections Library at URL: **http://trac.osgeo.org/proj/**.

2.2 QUANTIZED DATA VALUES

Some of the National CIWS products are expressed in "quantized" format, for the benefit of clients with reduced-bandwidth communication circuits to the Internet. A quantized product file contains a primary data variable whose elements are filtered to a pre-defined set of thresholds. The resultant NetCDF file therefore contains a data array with less variation among its elements, thereby improving its compression, and resulting in smaller product files.

An example of Vertically Integrated Liquid Water (VIL) quantization is illustrated in Table 1. The information in this table should not be hard-coded into client software for decoding purposes. Instead, the threshold values and associated intensity levels may be extracted from the VIL variable attributes (see Appendix A for NetCDF listings in CDL).

TABLE 1

VIL Quantization Table

Encoded VIL Codes	Decoded VIL Values (kg/m^2)	Corresponding Precip Intensity (NWS Levels)
0	0.0	0
13	0.0331	0a
63	0.1544	1a
113	0.2772	1b
216	0.5274	1c
317	0.7757	2
1449	3.5384	3
2902	7.0866	4
4981	12.1629	5
13240	32.3264	6
Notes: Level “0a” is depicted as Level 0 in Standard Mode and as Level 1a in Winter Mode. Levels 1a, 1b, and 1c are all depicted as Level 1 in Standard Mode.		

An example of Echo Top quantization is illustrated in Table 2. The information in this table should not be hard-coded into client software for decoding purposes. Instead, the threshold values and associated intensity levels may be extracted from the ECHO_TOP variable attributes (see Appendix A for NetCDF listings in CDL).

TABLE 2

Echo Top Quantization Table

Encoded Echo Top Codes	Decoded Echo Top Values (kfeet)
0	0.0
5	5
10	10
15	15
20	20
25	25
30	30
35	35
40	40
45	45
50	50+

2.3 DATA DIMENSIONS

Data variables in gridded NetCDF product files are declared as four-dimensional (4-D) arrays to allow for future expansion of product coverage and for commonality among all gridded product files. The 4-D arrays are packed according to NetCDF convention with the least-varying dimension first and most-varying dimensions last. For example, a VIL array is defined as follows:

```
short VIL( t0, z0, y0, x0 );
```

t0 is the time coordinate which will be constant for single-grid files and an array of times for forecast grid files. Thus, most current product files (non-forecast) are fundamentally 2-D arrays. **z0** is an altitude coordinate and remains constant (zero) for most National CIWS products (since altitude is not varied among CIWS products). **y0** is the grid row index and **x0** is the grid column index.

2.4 GRIDDED FILE TIME EXPRESSIONS

The National CIWS gridded files contain a number of expressions for time, most of which are assigned standard names that follow Climate and Forecast (CF) convention. However, two non-CF metadata variables qualify data collection times: **start_time** and **stop_time**. The start and stop time describe the collection time interval from which the data sample was gathered. Table 3 defines all of the time variables appearing in the gridded CIWS product files and identifies those that match CF convention. Figure 1 illustrates how these times relate to each other with respect to data collection, processing, and forecast.

TABLE 3

Gridded Product Time Expressions

Variable Name	CF Standard Name	Definition
time	time	Product validity time
start_time	--	The time data collection began
stop_time	--	The time data collection ended
forecast_reference_time	forecast_reference_time	The time of the analysis from which the forecast was made
forecast_period	forecast_period	The time interval between the forecast reference time and the validity time
Time entries highlighted (yellow) only appear in forecast product files.		

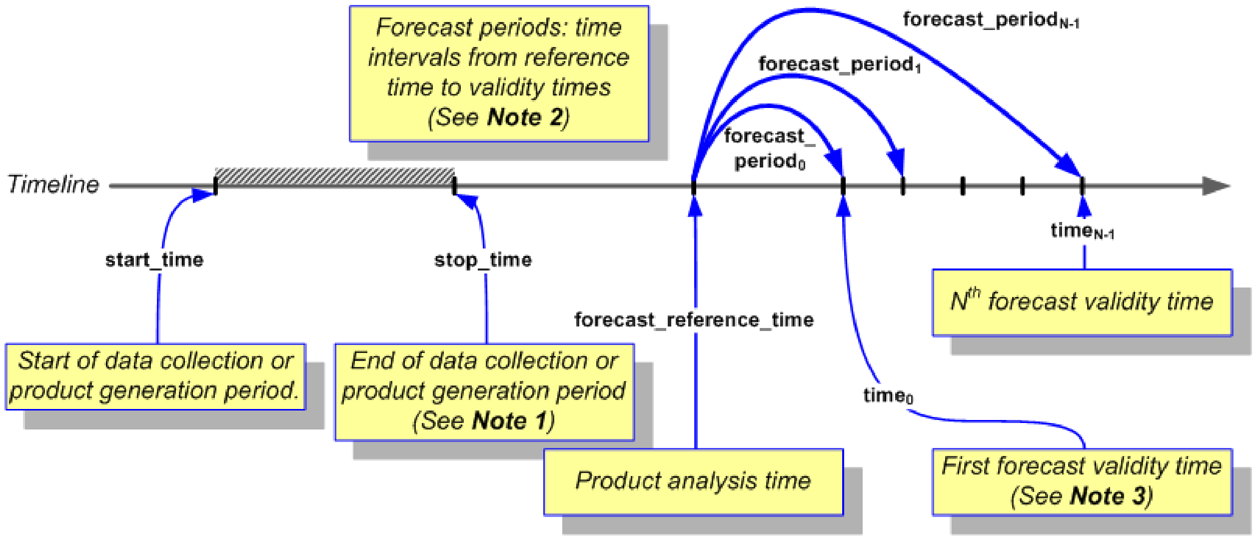

Figure 1. Gridded file time expression diagram

Notes:

[1] The **stop_time** may drift beyond the **forecast_reference_time** in systems that continue collecting data while processing existing data sets.

[2] The forecast periods may be computed using:

$$\textbf{forecast\_period}_i = \textbf{time}_i - \textbf{forecast\_reference\_time}$$

However, the **forecast_period** values are included in the NetCDF files as a convenience for file clients.

[3] For current (non-forecast) data sets, $\textbf{time}_0$ is identical to the **forecast_reference_time** and the **forecast_period** is zero.

3. NATIONAL CIWS GRIDDED PRODUCT DESCRIPTIONS

The gridded CIWS data products that have been encoded with NetCDF format are:

- Current Continental United States (CONUS) Precip (VIL) Dataset
- Current CONUS Quantized Precip (VIL) Dataset
- Forecast CONUS Precip (VIL) Dataset
- Forecast CONUS Quantized Precip (VIL) Dataset
- Current CONUS Echo Top Dataset
- Current CONUS Quantized Echo Top Dataset
- Forecast CONUS Echo Top Dataset
- Forecast CONUS Quantized Echo Top Dataset
- Current CONUS Satellite Dataset

The following subsections contain descriptions of National CIWS gridded product files. Examples of gridded product file summaries (CDL listings) appear in Appendix A.

3.1 CURRENT CONUS PRECIP (VIL) DATASET

The Current Precip (VIL) dataset is a NetCDF-4 file containing three CONUS-extent variables:

- VIL(1,1,3520,5120) Current VIL indicates the amount of atmospheric liquid as observed with radar and computed over an extent of a volume scan. VIL values are expressed with 16-bit digital codes whose scaled values span the full range of VIL: **0.0 to 80.0 kg/m^{2}**. VIL variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded VIL into floating point values according to NetCDF and CF convention.

- VIL_FLAGS(1,1,3520,5120) VIL status flags indicate data quality with CF-compliant bit-mapped status flags:
    - The **no coverage** status condition indicates that no radar coverage was available for the corresponding VIL data array element.
    - The **impaired** status condition indicates that the corresponding VIL data array element suffers some form of degradation, such as beam blockage.

- PRECIP_PHASE(1,1,3520,5120) Precipitation phase flags only assume three possible values to indicate the potential for precipitation phase or state:

    - The **liquid** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of liquid precipitation.
    - The **mixed** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of a mixture of liquid and frozen precipitation.

- The **frozen** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of frozen liquid, for example, snow.

3.2 CURRENT CONUS QUANTIZED PRECIP (VIL) DATASET

The Current Quantized Precip (VIL) dataset is a NetCDF-4 file containing three CONUS-extent variables. Quantized VIL values are filtered to a pre-defined set of thresholds for improved compressibility and smaller files.

- VIL(1,1,3520,5120) Current quantized VIL indicates the amount of atmospheric liquid as observed with radar and computed over an extent of a volume scan. Quantized VIL values are expressed with 16-bit digital codes whose scaled values span the full range of VIL: **0.0 to 80.0 kg/m^2**. VIL variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded VIL into floating point values according to NetCDF and CF convention.

- VIL_FLAGS(1,1,3520,5120) VIL status flags indicate data quality with CF-compliant bit-mapped status flags:

  - The **no coverage** status condition indicates that no radar coverage was available for the corresponding VIL data array element.
  - The **impaired** status condition indicates that the corresponding VIL data array element suffers some form of degradation, such as beam blockage.

- PRECIP_PHASE(1,1,3520,5120) Precipitation phase flags only assume three possible values to indicate the potential for precipitation phase or state:
  - The **liquid** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of liquid precipitation.
  - The **mixed** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of a mixture of liquid and frozen precipitation.
  - The **frozen** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of frozen liquid, for example, snow.

3.3 Forecast CONUS Precip (VIL) Dataset

The Forecast VIL dataset is a NetCDF-4 file containing two CONUS-extent variables:

- VIL(24,1,3520,5120) Forecast VIL represents a forecast of the amount of atmospheric liquid. Forecast VIL values are expressed with 16-bit digital codes whose scaled values span the full range of VIL: **0.0 to 80.0 kg/m^2**. VIL variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded VIL into floating point values according to NetCDF and CF convention. All 24 VIL forecasts are included in each NetCDF file by varying the time coordinate of the 4-D VIL variable from 5 minutes to 2 hours at 5-minute intervals.

- PRECIP_PHASE(24,1,3520,5120) Forecast precipitation phase flags only assume three possible values to indicate the forecast potential for precipitation phase or state. A precipitation phase grid is defined for each forecast so the PHASE_FLAGS array uses a time coordinate with 24 values.
    - The **liquid** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of liquid precipitation.
    - The **mixed** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of a mixture of liquid and frozen precipitation.
    - The **frozen** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of frozen liquid, for example, snow.

- VIL_FLAGS(1,1,3520,5120) VIL status flags indicate data quality with CF-compliant bit-mapped status flags:

    - The **no coverage** status condition indicates that no radar coverage was available for the corresponding VIL data array element.
    - The **impaired** status condition indicates that the corresponding VIL data array element suffers some form of degradation, such as beam blockage.

  This VIL_FLAGS array in the forecast file is identical to the VIL_FLAGS array in the current VIL file (See Section 3.1) and is duplicated here for user convenience. The same flag array may be applied to all forecast time horizons.

3.4 FORECAST CONUS QUANTIZED PRECIP (VIL) DATASET

The Forecast Quantized VIL dataset is a NetCDF-4 file containing two CONUS-extent variables. Quantized VIL values are filtered to a pre-defined set of thresholds for improved compressibility and smaller files.

- VIL(24,1,3520,5120) Forecast quantized VIL represents a forecast of the amount of atmospheric liquid. Forecast Quantized VIL values are expressed with 16-bit digital codes whose scaled values span the full range of VIL: **0.0 to 80.0 kg/m^2**. VIL variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded VIL into floating point values according to NetCDF and CF convention. All 24 VIL forecasts are included in each NetCDF file by varying the time coordinate of the 4-D VIL variable from 5 minutes to 2 hours at 5-minute intervals.

- PRECIP_PHASE(24,1,3520,5120) Forecast precipitation phase flags only assume three possible values to indicate the forecast potential for precipitation phase or state. A precipitation phase grid is defined for each forecast so the PHASE_FLAGS array uses a time coordinate with 24 values.
    - The **liquid** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of liquid precipitation.
    - The **mixed** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of a mixture of liquid and frozen precipitation.
    - The **frozen** phase flag indicates that precipitation in the corresponding VIL data array is likely to consist of frozen liquid, for example, snow.

- VIL_FLAGS(1,1,3520,5120) VIL status flags indicate data quality with CF-compliant bit-mapped status flags:

    - The **no coverage** status condition indicates that no radar coverage was available for the corresponding VIL data array element.
    - The **impaired** status condition indicates that the corresponding VIL data array element suffers some form of degradation, such as beam blockage.

  This VIL_FLAGS array in the forecast file is identical to the VIL_FLAGS array in the current Quantized VIL file (See Section 3.2) and is duplicated here for user convenience. The same flag array may be applied to all forecast time horizons.

3.5 CURRENT CONUS ECHO TOP DATASET

The Current Echo Top dataset is a NetCDF-4 file containing two CONUS-extent data variables:

- ECHO_TOP(1,1,3520,5120) Current Echo Top indicates the maximum altitude of observed radar returns computed over an extent of a volume scan. Echo Top values are expressed with 8-bit digital codes whose scaled values span the full range of Echo Tops: **0 to 70,000 feet** (1000-foot increments). Echo Top variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded Echo Tops into floating point values according to NetCDF and CF convention.

- ECHO_TOP_FLAGS(1,1,3520,5120) Echo Top status flags indicate data quality with CF-compliant bit-mapped status flags:
    - The **no coverage** status condition indicates that no radar coverage was available for the corresponding Echo Top data array element.
    - The **impaired** status condition indicates that the corresponding Echo Top data array element suffers some form of degradation, such as beam blockage.
    - The **topped** status condition indicates that significant radar returns were observed among the uppermost elevation scans and that a storm may extend above the reported echo top values.

3.6 CURRENT CONUS QUANTIZED ECHO TOP DATASET

The Current Quantized Echo Top dataset is a NetCDF-4 file containing two CONUS-extent variables. Quantized values are filtered to a pre-defined set of thresholds for improved compressibility and smaller files.

- ECHO_TOP(1,1,3520,5120) Current Echo Top indicates the maximum altitude of observed radar returns computed over an extent of a volume scan. Echo Top values are expressed with 8-bit digital codes whose scaled values span the full range of Echo Tops: **0 to 70,000 feet** (1000-foot increments). Echo Top variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded Echo Tops into floating point values according to NetCDF and CF convention.

- ECHO_TOP_FLAGS(1,1,3520,5120) Echo Top status flags indicate data quality with CF-compliant bit-mapped status flags:
  - The **no coverage** status condition indicates that no radar coverage was available for the corresponding Echo Top data array element.
  - The **impaired** status condition indicates that the corresponding Echo Top data array element suffers some form of degradation, such as beam blockage.
  - The **topped** status condition indicates that significant radar returns were observed among the uppermost elevation scans and that a storm may extend above the reported echo top values.

3.7 FORECAST CONUS ECHO TOP DATASET

The Forecast Echo Top dataset is a NetCDF-4 file containing one CONUS-extent data variable:

- ECHO_TOP(24,1,3520,5120) Forecast Echo Top indicates the maximum altitude of forecast precipitation. Echo Top values are expressed with 8-bit digital codes whose scaled values span the full range of Echo Tops: **0 to 70,000 feet** (1000-foot increments). Echo Top variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded Echo Tops into floating point values according to NetCDF and CF convention.

3.8 Forecast CONUS Quantized Echo Top Dataset

The Forecast Quantized Echo Top dataset is a NetCDF-4 file containing one CONUS-extent data variable:

- ECHO_TOP(24,1,3520,5120) Forecast Echo Top indicates the maximum altitude of forecast precipitation. Echo Top values are expressed with 8-bit digital codes whose scaled values span the full range of Echo Tops: **0 to 70,000 feet** (1000-foot increments). Echo Top variable attributes (*scale_factor* and *add_offset*) are included for the conversion of encoded Echo Tops into floating point values according to NetCDF and CF convention.

3.9 Current CONUS Satellite Dataset

The Current Satellite dataset is a NetCDF-4 file containing one CONUS-extent variable. Since this product consists of remapped satellite observations, data values are expressed using 8-bit codes whose scaled values represent an intensity level derived from both Geostationary Operational Environmental Satellite (GOES) satellites (East and West). The current satellite intensity values range from 0 to 33 and have no units. Although a unit-less data quantity does not comply with normal CF conventions, this non-standard satellite data expression will be used until an alternate expression is identified.

Note: The CIWS RemappedSatellite value range is scheduled to increase from 0-to-33 to 0-to-100 for improved satellite image quality. To accommodate either range, the RemappedSatellite “valid_range” attribute will express the value limits (minimum and maximum).

- RemappedSatellite(1,1,3520,5120) Current satellite observations from East and West GOES satellite stations. Satellite image values are expressed with 8-bit digital codes from 0 to 33.

4. NATIONAL CIWS NON-GRIDDED PRODUCT DESCRIPTIONS

Non-gridded CIWS data products contain data values organized as points, curves, contours, or text messages, along with associated attributes and properties. The geospatially sparse and irregular spacing of these data lend themselves to encoding using the human-readable, text-based Extensible Mark-up Language (XML) format.

XML application schemas have been developed to support the CIWS non-gridded product data models. These include and extend upon the foundational XML data types and content models provided by the XML Schema standard (ISO 19139) as well as additional data types developed in accordance with Open Geospatial Consortium (OGC) and ISO standards including Geography Markup Language (GML), and Observations & Measurements (OM). Weather and aviation weather domain data types collaboratively developed by US and European agencies including Eurocontrol's Weather Exchange Model (WXXM) and Climate Science Modeling Language (CSML) are also utilized.

The XML schema (.xsd) files utilize an XML grammar to specify what elements may be used in XML documents, the order of the elements, the number of occurrences of each element, and the content and data type of each element and attribute. Thus, the schemas serve as a type of format description for the XML data files. Every XML data file should not only be well-formed (syntactically correct XML), but must also be valid in that it obeys the element ordering, frequency, and types defined in the associated schema.

Namespace prefixes are used within XML element tags to avoided naming conflicts when utilizing data types from multiple packages. CIWS non-gridded product XML data are encoded utilizing data types from the namespaces listed in Table 4. Schema sub-directory locations with respect to the root schema directory are listed in the table.

To reduce storage and transmission sizes, the XML files produced by the Lincoln Laboratory XML translator for CIWS products (WxToGmlAdapter) are compressed using gzip and the XML text content is formatted without spaces or indentation (not pretty-printed). Although this makes the XML less human-readable, simple XSLT stylesheets can be applied to reformat the XML for readability if desired. In addition, many web browsers (e.g., Firefox, Internet Explorer) will automatically transform the XML file contents for display, inserting spaces and indentations that make the XML easy to view.

TABLE 4

XML Schema Used to Model CIWS Non-Gridded Products

Namespace Prefix	Namespace	Schema Directory	Schema Version	Description
Default (no prefix)	http://www.w3.org/2001/XMLSchema	N/A	1.0	XML standard schema
gml	http://www.opengis.net/gml/3.2	net/opengis/gml/3.2.1	3.2	OGC GML schema
om	http://www.opengis.net/om/1.0/gml32	net/opengis/om/1.0.0_gml32	1.0	OGC Observations & Measurements (O&M) schema
wx	http://www.eurocontrol.in/wx/1.1	int/eurocontrol/wx/1.1.0	1.1	General weather schema
avwx	http://www.eurocontrol.int/wxxs/1.1	int/eurocontrol/wxxs/1.1.0	1.1	Aviation weather schema implementation of Eurocontrol's WXXM
nawx	http://www.faa.gov/nawx/1.1	gov/faa/nawx/1.1.0	1.1	North American (e.g., FAA) aviation weather schema

The CIWS non-gridded product data models make strong use of the feature model of GML and the OGC schema for Observations and Measurements, which defines an observation as follows:

> *"An Observation is an action with a result which has a value describing some phenomenon. […] An observation feature binds a result to a feature of interest, upon which the observation was made. The observed property is a property of the feature of interest. An observation uses a procedure to determine the value of the result, which may involve a sensor or observer, analytical procedure, simulation, or other numerical process."*[1]

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[1] Cox, S., ed. (2006), "Observations and Measurements", OpenGIS Consortium document 05-087r4, Version 0.14.7, [Web URL: http://portal.opengeospatial.org/files/?artifact_id=17038 (March, 2009)]

Additionally, the CIWS data models take advantage of a developmental extension of O&M that adds a Forecast type as a semantically parallel companion of the Observation type (see wxForecast.xsd in the wx namespace). The following is a skeletal XML fragment that illustrates the typical pattern of elements used for encoding the CIWS products:

```
<!--Top level feature collection containing Observation and Forecast (if applicable) features -->
<wx:WxFeatureCollection>
  <wx:featureMember>

    <wx:Observation gml:id=“id2”>
      <!--Time period over which observation was made -->
      <om:samplingTime/>
      <!–Process used to obtain the result (e.g. instrument, sensor, algorithm) -->
      <om:procedure xlink:href=“urn:…”/>
      <!-- Phenomenon associated with observation result (e.g. Wind shear ontology reference) -->
      <om:observedProperty/>

      <!-- Describes the observation target (e.g., radar sampling area, algorithm grid)
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id=“id4”/>

      <!--
        Observation result contains value(s) generated by the procedure (consistent with
        observation property).  Feature collection is used to hold multiple result features.
      -->
      <om:result>
        <wx:WxFeatureCollection>
          <wx:featureMember>
            <wx:GustFront gml:id=“id5”/>
          <wx:featureMember>
            <wx:GustFront gml:id=“id6”/>

  <wx:featureMember>
    <!--
      Forecast type is WXXM extension that follows O&M model with additional forecast-related
      time properties.
    -->
    <wx:Forecast gml:id=“id6”>
      <!-- Forecast-related time stamps -->
      <wx:forecastTime/>
      <wx:forecastAnalysisTime/>
      <wx:issueTime/>
      <wx:procedure xlink:href=“urn:…”/>
      <wx:forecastProperty/>

      <!--
        Forecast may have same featureOfInterest as the Observation, so we can use a link
        reference to the Observation’s featureOfInterest object.
      -->
      <wx:featureOfInterest xlink:href=“#id4”/>

      <!-- Forecast result -->
      <wx:result>
        <wx:WxFeatureCollection>
          <wx:featureMember>
            <wx:GustFront>
              <wx:forecastTime/>
              <!-- Link to corresponding Observation feature (e.g., gust front detection)
              <wx:associatedFeature xlink:href=“#id5”/>
```

The non-gridded CIWS data products that have been encoded with XML format are:

- Growth & Decay Trends
- Storm Info : Echo Top Tags
- Storm Info : Leading Edges
- Storm Info : Motion Vectors
- Forecast Standard-Mode Precip (VIL) Contours
- Forecast Winter-Mode Precip (VIL) Contours
- Forecast Echo Tops Contours
- Echo Tops Forecast Accuracy Scores
- Standard-Mode Precip (VIL) Forecast Accuracy Scores
- Winter-Mode Precip (VIL) Forecast Accuracy Scores
- Lightning

The following subsections contain descriptions of National CIWS non-gridded product files. Examples of non-gridded product XML files appear in Appendix B. Note that these XML data models are based on the XML schema versions listed in Table 4.

4.1 GROWTH AND DECAY TRENDS

The Growth & Decay Trends product contains sets of contours that indicate regions where storm growth or decay has been detected. A single outline contour delineates a growth or decay region (but there may be many separate growth or decay regions).

The original CIWS Growth and Decay product contour values are expressed as integer-scaled “interest” probability values ranging from 0 to 254. Values greater than 128 are considered to be growth, and values less than 128 are considered to be decay. A value of 125 was the threshold that was applied to produce the decay contour, and a value of 130 was the growth contour level. For XML encoding, these interest values are converted to a signed probability ranging from -1.0 to 1.0 using the relation:

GD Probability = (InterestValue – 128) / (254 - 128)

Thus, growth contours are identified in the XML by positive contour values (+0.016), and decay contours are identified by negative contour values (-0.024).

The XML representation consists of an *Observation* feature whose *result* property is a collection of *Contour* features. The following is an example XML excerpt showing the encoding of a growth contour feature

```
<wx:Contour gml:id="id5">
  <wx:observationTime>
    <gml:TimeInstant gml:id="id6">
      <gml:timePosition>20080709T040000Z</gml:timePosition>
    </gml:TimeInstant>
  </wx:observationTime>
  <wx:contourValue uom="1">0.016</wx:contourValue>
  <wx:geometry>
    <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id7">
      <gml:segments>
        <gml:LineStringSegment>
          <gml:posList srsDimension="2" count="69">
            22.7981 -98.3621 ... 22.7981 -98.3621
          </gml:posList>
        </gml:LineStringSegment>
      </gml:segments>
    </gml:Curve>
  </wx:geometry>
</wx:Contour>
```

The growth contour features are ordered first in the XML feature collection, followed by the decay contours. However, as noted above, the growth contours can be distinguished from the decay contours by the sign of their values without relying on any presumed ordering. See the full annotated example in Appendix B1.

XML Application Schema

Table 5 lists some of the important application-level schema used to model the encoding of the Growth and Decay Trends product.

Table 5

XML Schemas Used for the Growth and Decay Trends Product

Namespace	Schema Location	Schema File
wx	int/eurocontrol/wx/1.1.0	wxBase.xsd
wx	int/eurocontrol/wx/1.1.0	wxObservation.xsd
wx	int/eurocontrol/wx/1.1.0	wxContour.xsd

4.2 STORM INFO : ECHO TOP TAGS

The Storm Info : Echo Top Tags product consists of sets of echo top “tag” blocks encoding the latitude/longitude coordinate location of the echo top measurement along with an accompanying value indicating the storm echo top altitude in meters. A flag indicates whether or not the storm top was cleared by the top of the measurement scan.

The XML representation consists of an *Observation* feature whose *result* property is a collection of *EchoTopPoint* features. Each *EchoTopPoint* feature includes the *observationTime*, the *echoTop* value, a *topped* flag indicating whether the storm top was adequately measured, and the 2D location for the echo top tag encoded as a latitude/longitude *Point* object within a *geometry* property. The following is an example XML excerpt showing the encoding of an *EchoTopPoint* feature:

```
<nawx:EchoTopPoint gml:id="id5">
  <wx:observationTime>
    <gml:TimeInstant gml:id="id6">
      <gml:timePosition>20080709T040000Z</gml:timePosition>
    </gml:TimeInstant>
  </wx:observationTime>
  <nawx:echoTop uom="m">17678.4</nawx:echoTop>
  <nawx:topped>true</nawx:topped>
  <nawx:geometry>
    <gml:Point gml:id="id7" srsName="urn:ogc:def:crs:EPSG:4326">
      <gml:pos>35.8601 -96.2508</gml:pos>
    </gml:Point>
  </nawx:geometry>
</nawx:EchoTopPoint>
```

See the full annotated example in Appendix B2.

XML Application Schema

Table 6 lists some of the important application-level schema used to model the encoding of the Storm Info : Echo Top Tags product.

Table 6

XML Schemas Used for the Storm Info : Echo Top Tags Product

Namespace	Schema Location	Schema File
wx	int/eurocontrol/wx/1.1.0	wxBase.xsd
wx	int/eurocontrol/wx/1.1.0	wxObservation.xsd
nawx	gov/faa/nawx/1.1.0	wxEchoTopPoint.xsd

4.3 STORM INFO : LEADING EDGES

The Storm Info : Leading Edges product contains current and forecast leading edge contours of NWS Level 3 (41 dBZ) precipitation intensity.

The top-level feature collection in the XML contains two feature members: the *Observation* and the *Forecast*. The *result* section of the *Observation* contains a feature collection of the current *LeadingEdge* contours. The *result* section of the *Forecast* contains a feature collection of the 10- and 20-minute forecast *LeadingEdge* extrapolation contours. Each forecast *LeadingEdge* contour contains a *featureOfInterest* link to the associated current *LeadingEdge* contour in the *Observation* block (see the full XML example in Append B3). The following is an example XML excerpt showing the encoding of an *EchoTopPoint* feature within an *Observation result*:

```
<nawx:LeadingEdge gml:id="id8">
  <wx:observationTime>
    <gml:TimeInstant gml:id="id9">
      <gml:timePosition>20080709T040000Z</gml:timePosition>
    </gml:TimeInstant>
  </wx:observationTime>
  <wx:contourValue uom="dBZ">41.0</wx:contourValue>
  <wx:geometry>
    <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id10">
      <gml:segments>
        <gml:LineStringSegment>
          <gml:posList srsDimension="2" count="25">
            21.6194 -81.2048 ... 21.4 -81.2073
          </gml:posList>
        </gml:LineStringSegment>
      </gml:segments>
    </gml:Curve>
  </wx:geometry>
</nawx:LeadingEdge>
```

See the full annotated example in Appendix B3.

XML Application Schema

Table 7 lists some of the important application-level schema used to model the encoding of the Storm Info : Leading Edges product.

Table 7

XML Schemas Used for the Storm Info : Leading Edges Product

Namespace	Schema Location	Schema File
wx	int/eurocontrol/wx/1.1.0	wxBase.xsd
wx	int/eurocontrol/wx/1.1.0	wxObservation.xsd
wx	int/eurocontrol/wx/1.1.0	wxForecast.xsd
wx	int/eurocontrol/wx/1.1.0	wxContour.xsd
nawx	gov/faa/nawx/1.1.0	wxLeadingEdge.xsd
gml	net/opengis/gml/3.2.1	geometryPrimitives.xsd

4.4 STORM INFO : MOTION VECTORS

The Storm Info : Motion Vectors product consists of vectors indicating the speed and direction of motion for individual storm cells having a precipitation intensity of NWS Level 3 or greater. Each motion vector is encoded in the XML as a *MotionVector* feature element within the *Observation result* feature collection, and consists of an observation time, position (latitude, longitude), speed in knots, and direction in degrees.

The following is an example XML excerpt showing the encoding of an *MotionVector* feature:

```
<wx:MotionVector gml:id="id5" srsName="urn:ogc:def:crs:EPSG:4326">
  <wx:observationTime>
    <gml:TimeInstant gml:id="id6">
      <gml:timePosition>20080709T040000Z</gml:timePosition>
    </gml:TimeInstant>
  </wx:observationTime>
  <gml:pos>40.3277 -83.7614</gml:pos>
  <wx:speed uom="kt">14.74</wx:speed>
  <wx:direction uom="deg">61.12</wx:direction>
</wx:MotionVector>
```

See the full annotated example in Appendix B4.

XML Application Schema

Table 8 lists some of the important application-level schema used to model the encoding of the Storm Info : Motion Vectors product.

Table 8

XML Schemas Used for the Storm Info : Motion Vectors Product

Namespace	Schema Location	Schema File
wx	int/eurocontrol/wx/1.1.0	wxBase.xsd
wx	int/eurocontrol/wx/1.1.0	wxObservation.xsd
wx	int/eurocontrol/wx/1.1.0	wxMotionVector.xsd

4.5 FORECAST CONTOURS

The Forecast Contours product contains contour outlines of current forecasts of Level 3+ (Standard-Mode Precip) or Level 1c+ (Winter-Mode Precip) or 30+ kft (Echo Tops).

In the XML, these are encoded as a *Forecast* feature member whose *result* block contains a feature collection of zero or more *Contour* features valid for each forecast time instant.

Note that The forecastTime property of the top-level Forecast feature is encoded as a TimePeriod whose beginPosition and endPosition values indicate the time period spanned by the series of forecasts that are issued. It flexibly reflects the time range of forecast contours that were produced by the product generator and contained in the Forecast result feature collection that follows.

The CIWS Forecast Verification Contours are generated by simply retrieving the previously generated forecast contours whose Contour forecastTimes (in the Forecast result feature collection) correspond to the current time. There is no difference in their format.

Each *Contour* includes: forecast valid time (forecastTime), contour value (expressed in VIL units of kg/m^2 for the two types of precip contours and meters for echo tops), and a *Curve* with a list of latitude and longitude coordinates delineating the contour outline. Separate XML files are generated for the three types of forecast contours.

Prior to XML translation, the precip forecast contour values are represented in units of “8-bit Digital VIL” which has values in the range of 0 to 255. During XML translation, the digital VIL values are converted to standardized VIL units of kg/m^2 by using the following relationships:

```
0 </= VIL < 0.189:      8BitDigitalVIL = 90.6591*VIL+2
VIL >/= 0.189:          8BitDigitalVIL = (82.9028 + 38.8763 * ln(VIL)) + 1
```

The echo top forecast contour values are converted from kft to meters during XML translation.

The following is an example XML excerpt showing the encoding of an *Contour* feature for a Standard-Mode Precip Forecast Contour:

```
<wx:Contour gml:id="id5">
  <!-- Valid time of forecast -->
  <wx:forecastTime>
    <gml:TimeInstant gml:id="id6">
      <gml:timePosition>2008-07-09T04:30:00Z</gml:timePosition>
    </gml:TimeInstant>
  </wx:forecastTime>
  <wx:contourValue uom="kg_m-2">3.54</wx:contourValue>
  <wx:geometry>
    <gml:Curve gml:id="id7" srsName="urn:ogc:def:crs:EPSG:4326">
      <gml:segments>
        <gml:LineStringSegment>
          <gml:posList>
            21.3645 -81.3251 ...  21.3645 -81.3251
          </gml:posList>
        </gml:LineStringSegment>
      </gml:segments>
    </gml:Curve>
  </wx:geometry>
</wx:Contour>
```

See Appendix B5 for a complete sample XML encoding of the CIWS Standard-Mode Precip Forecast Contours product. Encodings for Winter-Mode Precip and Echo Tops Forecast contours follow the same format.

XML Application Schema

Table 9 lists some of the important application-level schema used to model the encoding of the Forecast Contours product.

Table 9

XML Schemas Used for the Forecast Contours Product

Namespace	Schema Location	Schema File
wx	int/eurocontrol/wx/1.1.0	wxBase.xsd
wx	int/eurocontrol/wx/1.1.0	wxForecast.xsd
wx	int/eurocontrol/wx/1.1.0	wxContour.xsd
gml	net/opengis/gml/3.2.1	geometryPrimitives.xsd

4.6 FORECAST ACCURACY SCORES

The Forecast Accuracy Scores product contains accuracy scores for the Echo Tops, Standard-Mode Precip (VIL), and Winter-Mode Precip (VIL) forecast products. The Forecast Accuracy is a measure of how well the 30-, 60- or 120-minute forecasts performed in the past. It is not a measure of the current forecast accuracy.

The XML *result* section of the *Observation* contains a feature collection of forecast accuracy *ScoredRegion* elements. A *ScoredRegion* contains information about the region that was scored, the contour level that was scored, and a *regionScores* block containing a repeating series of *periodScore* properties corresponding to each of the three forecast periods. For example:

```
<nawx:ScoredRegion>

  <!-- Info about the region that was scored -->
  <nawx:region>

    <wx:AreaOfInterest gml:id="id6">
      <gml:description>ABQ</gml:description>
      <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:Airports"/>
      <gml:name>ABQ</gml:name>
    </wx:AreaOfInterest>

  </nawx:region>

  <!-- Contour level that was scored (30 kft in this example)-->
  <nawx:scoredContourLevel>Height30</nawx:scoredContourLevel>

  <!-- Scores for each forecast interval -->
  <nawx:regionScores>
    <nawx:PeriodScore>
      <nawx:period uom="minutes">30</nawx:period>
      <nawx:score uom="percent">70</nawx:score>
    </nawx:PeriodScore>

    <nawx:PeriodScore>
      <nawx:period uom="minutes">60</nawx:period>
      <nawx:score uom="percent">55</nawx:score>
    </nawx:PeriodScore>

    <nawx:PeriodScore>
      <nawx:period uom="minutes">120</nawx:period>
      <nawx:score uom="percent">60</nawx:score>
    </nawx:PeriodScore>

  </nawx:regionScores>

</nawx:ScoredRegion>
```

A complete sample XML encoding of the Forecast Accuracy Scores product is provided in Appendix B6. The encoding is similar for the two seasonal variants of the Precip Forecast Accuracy Scores products.

XML Application Schema

Table 10 lists some of the important application-level schema used to model the encoding of the Forecast Accuracy Scores product.

Table 10

XML Schemas Used for the Forecast Accuracy Scores Product

Namespace	Schema Location	Schema File
wx	int/eurocontrol/wx/1.1.0	wxBase.xsd
wx	int/eurocontrol/wx/1.1.0	wxObservation.xsd
nawx	gov/faa/nawx/1.1.0	wxForecastAccuracy.xsd

4.7 LIGHTNING

The Lightning product contains cloud-to-ground lightning flash detections from the National Lightning Detection Network (NLDN). For CIWS, there are two types of lightning products available: raw and aggregated. The aggregated product contains lightning flashes that have been aggregated over the preceding six-minutes, and are output every minute. The raw lightning product is unaggregated and is updated every 15 seconds. A new XML file is produced with each product update.

The same XML model format is used to encode both the raw and aggregate variants of the lightning product. The XML *result* section of the *Observation* contains a feature collection of *LightningFlash* features. Each *LightningFlash* element contains the observation time, strength (in kiloAmperes), number of strokes, and the latitude/longitude point location. Here is an example encoding of a *LightningFlash* feature:

```
<nawx:LightningFlash gml:id="id5">
  <wx:observationTime>
    <gml:TimeInstant gml:id="id6">
      <gml:timePosition>20080709T035425Z</gml:timePosition>
    </gml:TimeInstant>
  </wx:observationTime>
  <nawx:strength uom="kA">-30.00</nawx:strength>
  <nawx:numStrokes>3</nawx:numStrokes>
  <nawx:geometry>
    <gml:Point gml:id="id7" srsName="urn:ogc:def:crs:EPSG:4326">
    <gml:pos>
      38.6116 -81.6016</gml:pos>
    </gml:Point>
  </nawx:geometry>
</nawx:LightningFlash>
```

For aggregate lightning data, the *Observation samplingTime* indicates the period spanned by the earliest and most recent lightning observation within the aggregate. For example:

```
<wx:Observation gml:id="id1">
  <om:samplingTime>
    <gml:TimePeriod gml:id="id2">
      <gml:beginPosition>2009-12-04T19:19:16Z</gml:beginPosition>
      <gml:endPosition>2009-12-04T19:24:46Z</gml:endPosition>
    </gml:TimePeriod>
  </om:samplingTime>
```

For the raw lightning data, the *Observation samplingTime* will have the same start and end time position. A complete sample XML encoding of the Lightning product is provided in Appendix B7.

XML Application Schema

Table 11 lists some of the important application-level schema used to model the encoding of the Lightning product.

Table 11

XML Schemas Used for the Lightning Product

Namespace	Schema Location	Schema File
wx	int/eurocontrol/wx/1.1.0	wxBase.xsd
wx	int/eurocontrol/wx/1.1.0	wxObservation.xsd
nawx	gov/faa/nawx/1.1.0	wxLightning.xsd

5. SUMMARY AND FUTURE WORK

The file formats described in this document for the National CIWS data products were intended to meet current metadata standards and conventions. In particular, the CIWS product metadata were crafted to meet internationalized conventions for weather data and to enable data discovery capabilities of Service-Oriented Architecture, such as Web services. However, the best practices for metadata expression continue to evolve among an expanding set of users with diverse applications. Future changes to metadata conventions or file formats that relate to CIWS data expression may warrant modifications to the CIWS product descriptions. In that case, this document may require additions to remain up-to-date with the latest metadata standards.

APPENDIX A: GRIDDED PRODUCT DATASET FILE SUMMARIES

The following summaries were produced with the *ncdump* utility, which comes with the NetCDF software library. It reads a NetCDF file and writes the CDL text equivalent. In the examples to follow, the lengthy y0 and x0 coordinate variable listings were abbreviated for the sake of brevity; a "…" indicates where data were removed. The filenames appearing in the CDL reflect the output of one particular NetCDF adapter and are not specific to the CIWS information model. NetCDF filenames may vary among different product adapter implementations. The NetCDF files were produced in compliance with the CF convention, version 1.3 (7 November, 2008).

A1 CURRENT CONUS PRECIP (VIL) DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.VIL.Netcdf4.1km.20090327T143500Z {
dimensions:
        time = 1 ;
        z0 = 1 ;
        y0 = 3520 ;
        x0 = 5120 ;
        xml_metadata_len = 43781 ;
      variables:
        double time(time) ;
          time:standard_name = "time" ;
          time:long_name = "Product validity time" ;
          time:units = "seconds since 1970-01-01T00:00:00Z" ;
          time:calendar = "gregorian" ;
          time:string = "2009-03-27T14:35:00Z" ;
        double z0(z0) ;
          z0:standard_name = "altitude" ;
          z0:long_name = "Product altitude" ;
          z0:units = "meters" ;
          z0:axis = "Z" ;
          z0:positive = "up" ;
        double y0(y0) ;
          y0:standard_name = "projection_y_coordinate" ;
          y0:long_name = "Distance from projection reference point latitude" ;
          y0:units = "meters" ;
        double x0(x0) ;
          x0:standard_name = "projection_x_coordinate" ;
          x0:long_name = "Distance from projection reference point longitude" ;
          x0:units = "meters" ;
        double start_time ;
          start_time:long_name = "Data observation start time" ;
          start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
          start_time:calendar = "gregorian" ;
          start_time:string = "2009-03-27T14:25:00Z" ;
          start_time:comment = "Data observation start time is the time data collection began" ;
        double stop_time ;
          stop_time:long_name = "Data observation stop time" ;
          stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
          stop_time:calendar = "gregorian" ;
          stop_time:string = "2009-03-27T14:35:00Z" ;
```

```
    stop_time:comment = "Data observation stop time is the time data collection ended" ;
  int grid_mapping0 ;
    grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
    grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
    grid_mapping0:latitude_of_projection_origin = 38. ;
    grid_mapping0:longitude_of_projection_origin = -98. ;
    grid_mapping0:false_easting = 0. ;
    grid_mapping0:false_northing = 0. ;
    grid_mapping0:earth_radius = 6370997. ;
  char xml_metadata(xml_metadata_len) ;
    xml_metadata:long_name = "Product meta data" ;
    xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
  short VIL(time, z0, y0, x0) ;
    VIL:standard_name = "atmosphere_cloud_liquid_water_content" ;
    VIL:long_name = "Vertically integrated liquid water (VIL)" ;
    VIL:class_name = "VIL" ;
    VIL:product_name = "VIL" ;
    VIL:ancillary_variables = "VIL_FLAGS PRECIP_PHASE" ;
    VIL:units = "kg m-2" ;
    VIL:grid_mapping = "grid_mapping0" ;
    VIL:scale_factor = 0.00244148075807978 ;
    VIL:add_offset = 0. ;
    VIL:_FillValue = -1s ;
    VIL:valid_range = 0s, 32767s ;
  byte VIL_FLAGS(time, z0, y0, x0) ;
    VIL_FLAGS:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    VIL_FLAGS:long_name = "VIL data quality flags" ;
    VIL_FLAGS:class_name = "VIL_FLAGS" ;
    VIL_FLAGS:product_name = "VIL_FLAGS" ;
    VIL_FLAGS:grid_mapping = "grid_mapping0" ;
    VIL_FLAGS:_FillValue = 0b ;
    VIL_FLAGS:valid_range = 1b, 3b ;
    VIL_FLAGS:flag_masks = 3b, 3b ;
    VIL_FLAGS:flag_values = 1b, 2b ;
    VIL_FLAGS:flag_meanings = "no_coverage impaired" ;
  byte PRECIP_PHASE(time, z0, y0, x0) ;
    PRECIP_PHASE:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    PRECIP_PHASE:long_name = "Precipitation phase flags" ;
    PRECIP_PHASE:class_name = "PHASE_FCST" ;
    PRECIP_PHASE:product_name = "PHASE000" ;
    PRECIP_PHASE:grid_mapping = "grid_mapping0" ;
    PRECIP_PHASE:_FillValue = 0b ;
    PRECIP_PHASE:valid_range = 1b, 3b ;
    PRECIP_PHASE:flag_values = 1b, 2b, 3b ;
    PRECIP_PHASE:flag_meanings = "liquid mixed frozen" ;

// global attributes:
    :Conventions = "CF-1.3" ;
    :history = "File created 2009-03-27T14:35:10Z on machine compute-7-4.local by ProductAdapterVIL 1.0.0" ;
    :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
    :references = "http://www.wx.ll.mit.edu" ;
    :source = "National CIWS Data Stream: MosTileAsm:Mosaic:CiwsRelay" ;
```

```
        :title = "National CIWS VIL Mosaic Product - 1 km @ 2.5 minutes" ;
        :comment = "Mosaic of VIL derived from NEXRAD, TDWR and Canadian radar systems." ;
        :FileType = "NetCDF" ;
        :FileFormat = "Netcdf4" ;
    data:

    time = 1238164500 ;
    z0 = 0 ;
    y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
        -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
    ...
        1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
        1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

     x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
        -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
    ...
        2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
        2558500, 2559500 ;
}
```

A2 CURRENT CONUS QUANTIZED PRECIP (VIL) DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.QuantizedVIL.Netcdf4.1km.20090327T143500Z {
dimensions:
  time = 1 ;
  z0 = 1 ;
  y0 = 3520 ;
  x0 = 5120 ;
  xml_metadata_len = 43781 ;
variables:
  double time(time) ;
    time:standard_name = "time" ;
    time:long_name = "Product validity time" ;
    time:units = "seconds since 1970-01-01T00:00:00Z" ;
    time:calendar = "gregorian" ;
    time:string = "2009-03-27T14:35:00Z" ;
  double z0(z0) ;
    z0:standard_name = "altitude" ;
    z0:long_name = "Product altitude" ;
    z0:units = "meters" ;
    z0:axis = "Z" ;
    z0:positive = "up" ;
  double y0(y0) ;
    y0:standard_name = "projection_y_coordinate" ;
    y0:long_name = "Distance from projection reference point latitude" ;
    y0:units = "meters" ;
  double x0(x0) ;
    x0:standard_name = "projection_x_coordinate" ;
    x0:long_name = "Distance from projection reference point longitude" ;
    x0:units = "meters" ;
  double start_time ;
    start_time:long_name = "Data observation start time" ;
    start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    start_time:calendar = "gregorian" ;
    start_time:string = "2009-03-27T14:25:00Z" ;
    start_time:comment = "Data observation start time is the time data collection began" ;
  double stop_time ;
    stop_time:long_name = "Data observation stop time" ;
    stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    stop_time:calendar = "gregorian" ;
    stop_time:string = "2009-03-27T14:35:00Z" ;
    stop_time:comment = "Data observation stop time is the time data collection ended" ;
  int grid_mapping0 ;
    grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
    grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
    grid_mapping0:latitude_of_projection_origin = 38. ;
    grid_mapping0:longitude_of_projection_origin = -98. ;
    grid_mapping0:false_easting = 0. ;
    grid_mapping0:false_northing = 0. ;
    grid_mapping0:earth_radius = 6370997. ;
  char xml_metadata(xml_metadata_len) ;
    xml_metadata:long_name = "Product meta data" ;
    xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
  short VIL(time, z0, y0, x0) ;
    VIL:standard_name = "atmosphere_cloud_liquid_water_content" ;
    VIL:long_name = "Vertically integrated liquid water (VIL)" ;
    VIL:class_name = "VIL" ;
    VIL:product_name = "VIL" ;
    VIL:ancillary_variables = "VIL_FLAGS PRECIP_PHASE" ;
    VIL:units = "kg m-2" ;
```

```
    VIL:grid_mapping = "grid_mapping0" ;
    VIL:scale_factor = 0.00244148075807978 ;
    VIL:add_offset = 0. ;
    VIL:_FillValue = -1s ;
    VIL:valid_range = 0s, 32767s ;
    VIL:flag_values = 0s, 13s, 63s, 113s, 216s, 317s, 1449s, 2902s, 4981s, 13240s ;
    VIL:flag_meanings = "0 0a 1a 1b 1c 2 3 4 5 6" ;
  byte VIL_FLAGS(time, z0, y0, x0) ;
    VIL_FLAGS:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    VIL_FLAGS:long_name = "VIL data quality flags" ;
    VIL_FLAGS:class_name = "VIL_FLAGS" ;
    VIL_FLAGS:product_name = "VIL_FLAGS" ;
    VIL_FLAGS:grid_mapping = "grid_mapping0" ;
    VIL_FLAGS:_FillValue = 0b ;
    VIL_FLAGS:valid_range = 1b, 3b ;
    VIL_FLAGS:flag_masks = 3b, 3b ;
    VIL_FLAGS:flag_values = 1b, 2b ;
    VIL_FLAGS:flag_meanings = "no_coverage impaired" ;
  byte PRECIP_PHASE(time, z0, y0, x0) ;
    PRECIP_PHASE:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    PRECIP_PHASE:long_name = "Precipitation phase flags" ;
    PRECIP_PHASE:class_name = "PHASE_FCST" ;
    PRECIP_PHASE:product_name = "PHASE000" ;
    PRECIP_PHASE:grid_mapping = "grid_mapping0" ;
    PRECIP_PHASE:_FillValue = 0b ;
    PRECIP_PHASE:valid_range = 1b, 3b ;
    PRECIP_PHASE:flag_values = 1b, 2b, 3b ;
    PRECIP_PHASE:flag_meanings = "liquid snow mixed" ;

// global attributes:
    :Conventions = "CF-1.3" ;
    :history = "File created 2009-03-27T14:35:13Z on machine compute-7-4.local by
ProductAdapterQuantizedVIL 1.0.0" ;
    :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
    :references = "http://www.wx.ll.mit.edu" ;
    :source = "National CIWS Data Stream: MosTileAsm:Mosaic:CiwsRelay" ;
    :title = "National CIWS Quantized VIL Mosaic Product - 1 km @ 2.5 minutes" ;
    :comment = "Mosaic of VIL derived from NEXRAD, TDWR and Canadian radar systems." ;
    :FileType = "NetCDF" ;
    :FileFormat = "Netcdf4" ;
data:

 time = 1238164500 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

A3 FORECAST CONUS PRECIP (VIL) DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.VILForecast.Netcdf4.1km.20090327T143000Z {
dimensions:
  times = 24 ;
  time = 1 ;
  z0 = 1 ;
  y0 = 3520 ;
  x0 = 5120 ;
  xml_metadata_len = 43760 ;
variables:
  double times(times) ;
    times:standard_name = "time" ;
    times:long_name = "Product validity times" ;
    times:units = "seconds since 1970-01-01T00:00:00Z" ;
    times:calendar = "gregorian" ;
    times:string = "2009-03-27T14:35:00Z/2009-03-27T16:30:00Z" ;
  double time(time) ;
    time:long_name = "Product flags validity times" ;
    time:units = "seconds since 1970-01-01T00:00:00Z" ;
    time:calendar = "gregorian" ;
    time:string = "2009-03-27T14:30:00Z" ;
  double z0(z0) ;
    z0:standard_name = "altitude" ;
    z0:long_name = "Product altitude" ;
    z0:units = "meters" ;
    z0:axis = "Z" ;
    z0:positive = "up" ;
  double y0(y0) ;
    y0:standard_name = "projection_y_coordinate" ;
    y0:long_name = "Distance from projection reference point latitude" ;
    y0:units = "meters" ;
  double x0(x0) ;
    x0:standard_name = "projection_x_coordinate" ;
    x0:long_name = "Distance from projection reference point longitude" ;
    x0:units = "meters" ;
  double start_time ;
    start_time:long_name = "Data observation start time" ;
    start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    start_time:calendar = "gregorian" ;
    start_time:string = "2009-03-27T14:20:00Z" ;
    start_time:comment = "Data observation start time is the time data collection began" ;
  double stop_time ;
    stop_time:long_name = "Data observation stop time" ;
    stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    stop_time:calendar = "gregorian" ;
    stop_time:string = "2009-03-27T14:30:00Z" ;
    stop_time:comment = "Data observation stop time is the time data collection ended" ;
  double forecast_reference_time ;
    forecast_reference_time:standard_name = "forecast_reference_time" ;
    forecast_reference_time:long_name = "Forecast reference time" ;
    forecast_reference_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    forecast_reference_time:calendar = "gregorian" ;
    forecast_reference_time:string = "2009-03-27T14:30:00Z" ;
    forecast_reference_time:comment = "Forecast reference time is the time of the analysis from
which the forecast was made" ;
  int forecast_period(times) ;
    forecast_period:standard_name = "forecast_period" ;
    forecast_period:long_name = "Time interval between the forecast reference time and the
validity time" ;
```

```
    forecast_period:units = "seconds" ;
  int grid_mapping0 ;
    grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
    grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
    grid_mapping0:latitude_of_projection_origin = 38. ;
    grid_mapping0:longitude_of_projection_origin = -98. ;
    grid_mapping0:false_easting = 0. ;
    grid_mapping0:false_northing = 0. ;
    grid_mapping0:earth_radius = 6370997. ;
  char xml_metadata(xml_metadata_len) ;
    xml_metadata:long_name = "Product meta data" ;
    xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
  short VIL(times, z0, y0, x0) ;
    VIL:standard_name = "atmosphere_cloud_liquid_water_content" ;
    VIL:long_name = "Vertically integrated liquid water (VIL)" ;
    VIL:class_name = "FCST" ;
    VIL:product_name = "FCST" ;
    VIL:ancillary_variables = "PRECIP_PHASE" ;
    VIL:units = "kg m-2" ;
    VIL:grid_mapping = "grid_mapping0" ;
    VIL:scale_factor = 0.00244148075807978 ;
    VIL:add_offset = 0. ;
    VIL:_FillValue = -1s ;
    VIL:valid_range = 0s, 32767s ;
  byte PRECIP_PHASE(times, z0, y0, x0) ;
    PRECIP_PHASE:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    PRECIP_PHASE:long_name = "Precipitation phase flags" ;
    PRECIP_PHASE:class_name = "PHASE_FCST" ;
    PRECIP_PHASE:product_name = "PHASE_FCST" ;
    PRECIP_PHASE:grid_mapping = "grid_mapping0" ;
    PRECIP_PHASE:_FillValue = 0b ;
    PRECIP_PHASE:valid_range = 1b, 3b ;
    PRECIP_PHASE:flag_values = 1b, 2b, 3b ;
    PRECIP_PHASE:flag_meanings = "liquid mixed frozen" ;
  byte VIL_FLAGS(time, z0, y0, x0) ;
    VIL_FLAGS:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    VIL_FLAGS:long_name = "VIL data quality flags" ;
    VIL_FLAGS:class_name = "VIL_FLAGS" ;
    VIL_FLAGS:product_name = "VIL_FLAGS" ;
    VIL_FLAGS:grid_mapping = "grid_mapping0" ;
    VIL_FLAGS:_FillValue = 0b ;
    VIL_FLAGS:valid_range = 1b, 3b ;
    VIL_FLAGS:flag_masks = 3b, 3b ;
    VIL_FLAGS:flag_values = 1b, 2b ;
    VIL_FLAGS:flag_meanings = "no_coverage impaired" ;

// global attributes:
    :Conventions = "CF-1.3" ;
    :history = "File created 2009-03-27T14:32:41Z on machine compute-7-5.local by
ProductAdapterVILForecast 1.0.0" ;
    :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
    :references = "http://www.wx.ll.mit.edu" ;
    :source = "National CIWS Data Stream:
StormForecast:CombineFinalForecast:ForecastImages:CiwsRelay" ;
    :title = "National CIWS VIL Mosaic Product - 1 km @ 2.5 minutes" ;
    :comment = "Mosaic of VIL derived from NEXRAD, TDWR and Canadian radar systems." ;
    :FileType = "NetCDF" ;
    :FileFormat = "Netcdf4" ;
data:

 times = 1238164500, 1238164800, 1238165100, 1238165400, 1238165700,
```

```
    1238166000, 1238166300, 1238166600, 1238166900, 1238167200, 1238167500,
    1238167800, 1238168100, 1238168400, 1238168700, 1238169000, 1238169300,
    1238169600, 1238169900, 1238170200, 1238170500, 1238170800, 1238171100,
    1238171400 ;

 time = 1238164200 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

A4 FORECAST CONUS QUANTIZED PREIP (VIL) DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.QuantizedVILForecast.Netcdf4.1km.20090327T143000Z {
dimensions:
  times = 24 ;
  time = 1 ;
  z0 = 1 ;
  y0 = 3520 ;
  x0 = 5120 ;
  xml_metadata_len = 43760 ;
variables:
  double times(times) ;
    times:standard_name = "time" ;
    times:long_name = "Product validity times" ;
    times:units = "seconds since 1970-01-01T00:00:00Z" ;
    times:calendar = "gregorian" ;
    times:string = "2009-03-27T14:35:00Z/2009-03-27T16:30:00Z" ;
double time(time) ;
    time:long_name = "Product flags validity times" ;
    time:units = "seconds since 1970-01-01T00:00:00Z" ;
    time:calendar = "gregorian" ;
    time:string = "2009-03-27T14:30:00Z" ;
  double z0(z0) ;
    z0:standard_name = "altitude" ;
    z0:long_name = "Product altitude" ;
    z0:units = "meters" ;
    z0:axis = "Z" ;
    z0:positive = "up" ;
  double y0(y0) ;
    y0:standard_name = "projection_y_coordinate" ;
    y0:long_name = "Distance from projection reference point latitude" ;
    y0:units = "meters" ;
  double x0(x0) ;
    x0:standard_name = "projection_x_coordinate" ;
    x0:long_name = "Distance from projection reference point longitude" ;
    x0:units = "meters" ;
  double start_time ;
    start_time:long_name = "Data observation start time" ;
    start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    start_time:calendar = "gregorian" ;
    start_time:string = "2009-03-27T14:20:00Z" ;
    start_time:comment = "Data observation start time is the time data collection began" ;
  double stop_time ;
    stop_time:long_name = "Data observation stop time" ;
    stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    stop_time:calendar = "gregorian" ;
    stop_time:string = "2009-03-27T14:30:00Z" ;
    stop_time:comment = "Data observation stop time is the time data collection ended" ;
  double forecast_reference_time ;
    forecast_reference_time:standard_name = "forecast_reference_time" ;
    forecast_reference_time:long_name = "Forecast reference time" ;
    forecast_reference_time:units = "seconds since 1970-01-01T00:00:00Z" ;
    forecast_reference_time:calendar = "gregorian" ;
    forecast_reference_time:string = "2009-03-27T14:30:00Z" ;
    forecast_reference_time:comment = "Forecast reference time is the time of the analysis from
which the forecast was made" ;
  int forecast_period(times) ;
    forecast_period:standard_name = "forecast_period" ;
    forecast_period:long_name = "Time interval between the forecast reference time and the
validity time" ;
```

```
    forecast_period:units = "seconds" ;
  int grid_mapping0 ;
    grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
    grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
    grid_mapping0:latitude_of_projection_origin = 38. ;
    grid_mapping0:longitude_of_projection_origin = -98. ;
    grid_mapping0:false_easting = 0. ;
    grid_mapping0:false_northing = 0. ;
    grid_mapping0:earth_radius = 6370997. ;
  char xml_metadata(xml_metadata_len) ;
    xml_metadata:long_name = "Product meta data" ;
    xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
  short VIL(times, z0, y0, x0) ;
    VIL:standard_name = "atmosphere_cloud_liquid_water_content" ;
    VIL:long_name = "Vertically integrated liquid water (VIL)" ;
    VIL:class_name = "FCST" ;
    VIL:product_name = "FCST" ;
    VIL:ancillary_variables = "PRECIP_PHASE" ;
    VIL:units = "kg m-2" ;
    VIL:grid_mapping = "grid_mapping0" ;
    VIL:scale_factor = 0.00244148075807978 ;
    VIL:add_offset = 0. ;
    VIL:_FillValue = -1s ;
    VIL:valid_range = 0s, 32767s ;
    VIL:flag_values = 0s, 13s, 63s, 113s, 216s, 317s, 1449s, 2902s, 4981s, 13240s ;
    VIL:flag_meanings = "0 0a 1a 1b 1c 2 3 4 5 6" ;
  byte PRECIP_PHASE(times, z0, y0, x0) ;
    PRECIP_PHASE:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    PRECIP_PHASE:long_name = "Precipitation phase flags" ;
    PRECIP_PHASE:class_name = "PHASE_FCST" ;
    PRECIP_PHASE:product_name = "PHASE_FCST" ;
    PRECIP_PHASE:grid_mapping = "grid_mapping0" ;
    PRECIP_PHASE:_FillValue = 0b ;
    PRECIP_PHASE:valid_range = 1b, 3b ;
    PRECIP_PHASE:flag_values = 1b, 2b, 3b ;
    PRECIP_PHASE:flag_meanings = "liquid snow mixed" ;
  byte VIL_FLAGS(time, z0, y0, x0) ;
    VIL_FLAGS:standard_name = "atmosphere_cloud_liquid_water_content status_flag" ;
    VIL_FLAGS:long_name = "VIL data quality flags" ;
    VIL_FLAGS:class_name = "VIL_FLAGS" ;
    VIL_FLAGS:product_name = "VIL_FLAGS" ;
    VIL_FLAGS:grid_mapping = "grid_mapping0" ;
    VIL_FLAGS:_FillValue = 0b ;
    VIL_FLAGS:valid_range = 1b, 3b ;
    VIL_FLAGS:flag_masks = 3b, 3b ;
    VIL_FLAGS:flag_values = 1b, 2b ;
    VIL_FLAGS:flag_meanings = "no_coverage impaired" ;

// global attributes:
     :Conventions = "CF-1.3" ;
     :history = "File created 2009-03-27T14:33:11Z on machine compute-7-5.local by
ProductAdapterQuantizedVILForecast 1.0.0" ;
     :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
     :references = "http://www.wx.ll.mit.edu" ;
     :source = "National CIWS Data Stream:
StormForecast:CombineFinalForecast:ForecastImages:CiwsRelay" ;
     :title = "National CIWS Quantized VIL Mosaic Product - 1 km @ 2.5 minutes" ;
     :comment = "Mosaic of VIL derived from NEXRAD, TDWR and Canadian radar systems." ;
     :FileType = "NetCDF" ;
     :FileFormat = "Netcdf4" ;
data:
```

```
 times = 1238164500, 1238164800, 1238165100, 1238165400, 1238165700,
    1238166000, 1238166300, 1238166600, 1238166900, 1238167200, 1238167500,
    1238167800, 1238168100, 1238168400, 1238168700, 1238169000, 1238169300,
    1238169600, 1238169900, 1238170200, 1238170500, 1238170800, 1238171100,
    1238171400 ;

 time = 1238164200 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

A5 CURRENT CONUS ECHO TOP DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.EchoTop.Netcdf4.1km.20090323T151500Z {
dimensions:
        time = 1 ;
        z0 = 1 ;
        y0 = 3520 ;
        x0 = 5120 ;
        xml_metadata_len = 42380 ;
variables:
        double time(time) ;
                time:standard_name = "time" ;
                time:long_name = "Product validity time" ;
                time:units = "seconds since 1970-01-01T00:00:00Z" ;
                time:calendar = "gregorian" ;
                time:string = "2009-03-23T15:15:00Z" ;
        double z0(z0) ;
                z0:standard_name = "altitude" ;
                z0:long_name = "Product altitude" ;
                z0:units = "meters" ;
                z0:positive = "up" ;
        double y0(y0) ;
                y0:standard_name = "projection_y_coordinate" ;
                y0:long_name = "Distance from projection reference point latitude" ;
                y0:units = "meters" ;
        double x0(x0) ;
                x0:standard_name = "projection_x_coordinate" ;
                x0:long_name = "Distance from projection reference point longitude" ;
                x0:units = "meters" ;
        double start_time ;
                start_time:long_name = "Data observation start time" ;
                start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                start_time:calendar = "gregorian" ;
                start_time:string = "2009-03-23T15:05:00Z" ;
                start_time:comment = "Data observation start time is the time data collection
began" ;
        double stop_time ;
                stop_time:long_name = "Data observation stop time" ;
                stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                stop_time:calendar = "gregorian" ;
                stop_time:string = "2009-03-23T15:15:00Z" ;
                stop_time:comment = "Data observation stop time is the time data collection
ended" ;
        int grid_mapping0 ;
                grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
                grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
                grid_mapping0:latitude_of_projection_origin = 38. ;
                grid_mapping0:longitude_of_projection_origin = -98. ;
                grid_mapping0:false_easting = 0. ;
                grid_mapping0:false_northing = 0. ;
                grid_mapping0:earth_radius = 6370997. ;
        char xml_metadata(xml_metadata_len) ;
                xml_metadata:long_name = "Product meta data" ;
                xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
        byte ECHO_TOP(time, z0, y0, x0) ;
                ECHO_TOP:standard_name = "convective_cloud_top_altitude" ;
                ECHO_TOP:long_name = "Echo Top (Echo Top)" ;
                ECHO_TOP:class_name = "ECHO_TOP" ;
                ECHO_TOP:product_name = "ECHO_TOP" ;
```

```
                ECHO_TOP:ancillary_variables = "ECHO_TOP_FLAGS" ;
                ECHO_TOP:units = "international_feet" ;
                ECHO_TOP:grid_mapping = "grid_mapping0" ;
                ECHO_TOP:scale_factor = 1000. ;
                ECHO_TOP:add_offset = 0. ;
                ECHO_TOP:_FillValue = -1b ;
                ECHO_TOP:valid_range = 0b, 70b ;
        byte ECHO_TOP_FLAGS(time, z0, y0, x0) ;
                ECHO_TOP_FLAGS:standard_name = "convective_cloud_top_altitude status_flag" ;
                ECHO_TOP_FLAGS:long_name = "Echo Top data quality flags" ;
                ECHO_TOP_FLAGS:class_name = "ECHO_TOP_FLAGS" ;
                ECHO_TOP_FLAGS:product_name = "ECHO_TOP_FLAGS" ;
                ECHO_TOP_FLAGS:grid_mapping = "grid_mapping0" ;
                ECHO_TOP_FLAGS:_FillValue = 0b ;
                ECHO_TOP_FLAGS:valid_range = 1b, 7b ;
                ECHO_TOP_FLAGS:flag_masks = 3b, 3b, 4b ;
                ECHO_TOP_FLAGS:flag_values = 1b, 2b, 4b ;
                ECHO_TOP_FLAGS:flag_meanings = "no_coverage impaired topped" ;

// global attributes:
                :Conventions = "CF-1.3" ;
                :history = "File created 2009-03-23T15:15:14Z on machine compute-7-4.local by
ProductAdapterEchoTop $Revision: 1.2.2.2 $" ;
                :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
                :references = "http://www.wx.ll.mit.edu" ;
                :source = "National CIWS Data Stream: MosTileAsm:Mosaic:CiwsRelay" ;
                :title = "National CIWS Echo Top Mosaic Product - 1 km @ 2.5 minutes" ;
                :comment = "Mosaic of Echo Top derived from NEXRAD, TDWR and Canadian radar
systems." ;
                :FileType = "NetCDF" ;
                :FileFormat = "Netcdf4" ;
data:

 time = 1237821300 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

A6 CURRENT CONUS QUANTIZED ECHO TOP DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.QuantizedEchoTop.Netcdf4.1km.20090323T151500Z {
dimensions:
        time = 1 ;
        z0 = 1 ;
        y0 = 3520 ;
        x0 = 5120 ;
        xml_metadata_len = 42380 ;
variables:
        double time(time) ;
                time:standard_name = "time" ;
                time:long_name = "Product validity time" ;
                time:units = "seconds since 1970-01-01T00:00:00Z" ;
                time:calendar = "gregorian" ;
                time:string = "2009-03-23T15:15:00Z" ;
        double z0(z0) ;
                z0:standard_name = "altitude" ;
                z0:long_name = "Product altitude" ;
                z0:units = "meters" ;
                z0:positive = "up" ;
        double y0(y0) ;
                y0:standard_name = "projection_y_coordinate" ;
                y0:long_name = "Distance from projection reference point latitude" ;
                y0:units = "meters" ;
        double x0(x0) ;
                x0:standard_name = "projection_x_coordinate" ;
                x0:long_name = "Distance from projection reference point longitude" ;
                x0:units = "meters" ;
        double start_time ;
                start_time:long_name = "Data observation start time" ;
                start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                start_time:calendar = "gregorian" ;
                start_time:string = "2009-03-23T15:05:00Z" ;
                start_time:comment = "Data observation start time is the time data collection
began" ;
        double stop_time ;
                stop_time:long_name = "Data observation stop time" ;
                stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                stop_time:calendar = "gregorian" ;
                stop_time:string = "2009-03-23T15:15:00Z" ;
                stop_time:comment = "Data observation stop time is the time data collection
ended" ;
        int grid_mapping0 ;
                grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
                grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
                grid_mapping0:latitude_of_projection_origin = 38. ;
                grid_mapping0:longitude_of_projection_origin = -98. ;
                grid_mapping0:false_easting = 0. ;
                grid_mapping0:false_northing = 0. ;
                grid_mapping0:earth_radius = 6370997. ;
        char xml_metadata(xml_metadata_len) ;
                xml_metadata:long_name = "Product meta data" ;
                xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
        byte ECHO_TOP(time, z0, y0, x0) ;
                ECHO_TOP:standard_name = "convective_cloud_top_altitude" ;
                ECHO_TOP:long_name = "Echo Top (Echo Top)" ;
                ECHO_TOP:class_name = "ECHO_TOP" ;
                ECHO_TOP:product_name = "ECHO_TOP" ;
                ECHO_TOP:ancillary_variables = "ECHO_TOP_FLAGS" ;
```

```
                ECHO_TOP:units = "international_feet" ;
                ECHO_TOP:grid_mapping = "grid_mapping0" ;
                ECHO_TOP:scale_factor = 1000. ;
                ECHO_TOP:add_offset = 0. ;
                ECHO_TOP:_FillValue = -1b ;
                ECHO_TOP:valid_range = 0b, 70b ;
                ECHO_TOP:flag_values = 0b, 5b, 10b, 15b, 20b, 25b, 30b, 35b, 40b, 45b, 50b ;
                ECHO_TOP:flag_meanings = "0 5 10 15 20 25 30 35 40 45 50+" ;
        byte ECHO_TOP_FLAGS(time, z0, y0, x0) ;
                ECHO_TOP_FLAGS:standard_name = "convective_cloud_top_altitude status_flag" ;
                ECHO_TOP_FLAGS:long_name = "Echo Top data quality flags" ;
                ECHO_TOP_FLAGS:class_name = "ECHO_TOP_FLAGS" ;
                ECHO_TOP_FLAGS:product_name = "ECHO_TOP_FLAGS" ;
                ECHO_TOP_FLAGS:grid_mapping = "grid_mapping0" ;
                ECHO_TOP_FLAGS:_FillValue = 0b ;
                ECHO_TOP_FLAGS:valid_range = 1b, 7b ;
                ECHO_TOP_FLAGS:flag_masks = 3b, 3b, 4b ;
                ECHO_TOP_FLAGS:flag_values = 1b, 2b, 4b ;
                ECHO_TOP_FLAGS:flag_meanings = "no_coverage impaired topped" ;

// global attributes:
                :Conventions = "CF-1.3" ;
                :history = "File created 2009-03-23T15:15:16Z on machine compute-7-4.local by
ProductAdapterQuantizedEchoTop $Revision: 1.3.2.3 $" ;
                :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
                :references = "http://www.wx.ll.mit.edu" ;
                :source = "National CIWS Data Stream: MosTileAsm:Mosaic:CiwsRelay" ;
                :title = "National CIWS Echo Top Mosaic Product - 1 km @ 2.5 minutes" ;
                :comment = "Mosaic of Echo Top derived from NEXRAD, TDWR and Canadian radar
systems." ;
                :FileType = "NetCDF" ;
                :FileFormat = "Netcdf4" ;
data:

 time = 1237821300 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

A7 FORECAST CONUS ECHO TOP DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.EchoTopsForecast.Netcdf4.1km.20090323T151000Z {
dimensions:
        times = 24 ;
        z0 = 1 ;
        y0 = 3520 ;
        x0 = 5120 ;
        xml_metadata_len = 42811 ;
variables:
        double times(times) ;
                times:standard_name = "time" ;
                times:long_name = "Product validity times" ;
                times:units = "seconds since 1970-01-01T00:00:00Z" ;
                times:calendar = "gregorian" ;
                times:string = "2009-03-23T15:15:00Z/2009-03-23T17:10:00Z" ;
        double z0(z0) ;
                z0:standard_name = "altitude" ;
                z0:long_name = "Product altitude" ;
                z0:units = "meters" ;
                z0:positive = "up" ;
        double y0(y0) ;
                y0:standard_name = "projection_y_coordinate" ;
                y0:long_name = "Distance from projection reference point latitude" ;
                y0:units = "meters" ;
        double x0(x0) ;
                x0:standard_name = "projection_x_coordinate" ;
                x0:long_name = "Distance from projection reference point longitude" ;
                x0:units = "meters" ;
        double start_time ;
                start_time:long_name = "Data observation start time" ;
                start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                start_time:calendar = "gregorian" ;
                start_time:string = "2009-03-23T15:00:00Z" ;
                start_time:comment = "Data observation start time is the time data collection
began" ;
        double stop_time ;
                stop_time:long_name = "Data observation stop time" ;
                stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                stop_time:calendar = "gregorian" ;
                stop_time:string = "2009-03-23T15:10:00Z" ;
                stop_time:comment = "Data observation stop time is the time data collection
ended" ;
        double forecast_reference_time ;
                forecast_reference_time:standard_name = "forecast_reference_time" ;
                forecast_reference_time:long_name = "Forecast reference time" ;
                forecast_reference_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                forecast_reference_time:calendar = "gregorian" ;
                forecast_reference_time:string = "2009-03-23T15:10:00Z" ;
                forecast_reference_time:comment = "Forecast reference time is the time of the
analysis from which the forecast was made" ;
        int forecast_period(times) ;
                forecast_period:standard_name = "forecast_period" ;
                forecast_period:long_name = "Time interval between the forecast reference time
and the validity time" ;
                forecast_period:units = "seconds" ;
        int grid_mapping0 ;
                grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
                grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
                grid_mapping0:latitude_of_projection_origin = 38. ;
```

```
                grid_mapping0:longitude_of_projection_origin = -98. ;
                grid_mapping0:false_easting = 0. ;
                grid_mapping0:false_northing = 0. ;
                grid_mapping0:earth_radius = 6370997. ;
        char xml_metadata(xml_metadata_len) ;
                xml_metadata:long_name = "Product meta data" ;
                xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
        byte ECHO_TOP(times, z0, y0, x0) ;
                ECHO_TOP:standard_name = "convective_cloud_top_altitude" ;
                ECHO_TOP:long_name = "Echo Top (Echo Top)" ;
                ECHO_TOP:class_name = "ECHO_TOP" ;
                ECHO_TOP:product_name = "ECHO_TOP" ;
                ECHO_TOP:units = "international_feet" ;
                ECHO_TOP:grid_mapping = "grid_mapping0" ;
                ECHO_TOP:scale_factor = 1000. ;
                ECHO_TOP:add_offset = 0. ;
                ECHO_TOP:_FillValue = -1b ;
                ECHO_TOP:valid_range = 0b, 70b ;

// global attributes:
                :Conventions = "CF-1.3" ;
                :history = "File created 2009-03-23T15:13:09Z on machine compute-7-6.local by
ProductAdapterEchoTopsForecast $Revision: 1.2.2.2 $" ;
                :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
                :references = "http://www.wx.ll.mit.edu" ;
                :source = "National CIWS Data Stream: EchoTopsForecastProc:Images:CiwsRelay" ;
                :title = "National CIWS Echo Tops Mosaic Product - 1 km @ 2.5 minutes" ;
                :comment = "Mosaic of Echo Tops derived from NEXRAD, TDWR and Canadian radar
systems." ;
                :FileType = "NetCDF" ;
                :FileFormat = "Netcdf4" ;
data:

 times = 1237821300, 1237821600, 1237821900, 1237822200, 1237822500,
    1237822800, 1237823100, 1237823400, 1237823700, 1237824000, 1237824300,
    1237824600, 1237824900, 1237825200, 1237825500, 1237825800, 1237826100,
    1237826400, 1237826700, 1237827000, 1237827300, 1237827600, 1237827900,
    1237828200 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

A8 FORECAST CONUS QUANTIZED ECHO TOP DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.QuantizedEchoTopsForecast.Netcdf4.1km.20090323T151000Z {
dimensions:
        times = 24 ;
        z0 = 1 ;
        y0 = 3520 ;
        x0 = 5120 ;
        xml_metadata_len = 42811 ;
variables:
        double times(times) ;
                times:standard_name = "time" ;
                times:long_name = "Product validity times" ;
                times:units = "seconds since 1970-01-01T00:00:00Z" ;
                times:calendar = "gregorian" ;
                times:string = "2009-03-23T15:15:00Z/2009-03-23T17:10:00Z" ;
        double z0(z0) ;
                z0:standard_name = "altitude" ;
                z0:long_name = "Product altitude" ;
                z0:units = "meters" ;
                z0:positive = "up" ;
        double y0(y0) ;
                y0:standard_name = "projection_y_coordinate" ;
                y0:long_name = "Distance from projection reference point latitude" ;
                y0:units = "meters" ;
        double x0(x0) ;
                x0:standard_name = "projection_x_coordinate" ;
                x0:long_name = "Distance from projection reference point longitude" ;
                x0:units = "meters" ;
        double start_time ;
                start_time:long_name = "Data observation start time" ;
                start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                start_time:calendar = "gregorian" ;
                start_time:string = "2009-03-23T15:00:00Z" ;
                start_time:comment = "Data observation start time is the time data collection
began" ;
        double stop_time ;
                stop_time:long_name = "Data observation stop time" ;
                stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                stop_time:calendar = "gregorian" ;
                stop_time:string = "2009-03-23T15:10:00Z" ;
                stop_time:comment = "Data observation stop time is the time data collection
ended" ;
        double forecast_reference_time ;
                forecast_reference_time:standard_name = "forecast_reference_time" ;
                forecast_reference_time:long_name = "Forecast reference time" ;
                forecast_reference_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                forecast_reference_time:calendar = "gregorian" ;
                forecast_reference_time:string = "2009-03-23T15:10:00Z" ;
                forecast_reference_time:comment = "Forecast reference time is the time of the
analysis from which the forecast was made" ;
        int forecast_period(times) ;
                forecast_period:standard_name = "forecast_period" ;
                forecast_period:long_name = "Time interval between the forecast reference time
and the validity time" ;
                forecast_period:units = "seconds" ;
        int grid_mapping0 ;
                grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
                grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
                grid_mapping0:latitude_of_projection_origin = 38. ;
```

```
                grid_mapping0:longitude_of_projection_origin = -98. ;
                grid_mapping0:false_easting = 0. ;
                grid_mapping0:false_northing = 0. ;
                grid_mapping0:earth_radius = 6370997. ;
        char xml_metadata(xml_metadata_len) ;
                xml_metadata:long_name = "Product meta data" ;
                xml_metadata:comment = "Itemizes constituent mosaic tiles and radar sources" ;
        byte ECHO_TOP(times, z0, y0, x0) ;
                ECHO_TOP:standard_name = "convective_cloud_top_altitude" ;
                ECHO_TOP:long_name = "Echo Top (Echo Top)" ;
                ECHO_TOP:class_name = "ECHO_TOP" ;
                ECHO_TOP:product_name = "ECHO_TOP" ;
                ECHO_TOP:units = "international_feet" ;
                ECHO_TOP:grid_mapping = "grid_mapping0" ;
                ECHO_TOP:scale_factor = 1000. ;
                ECHO_TOP:add_offset = 0. ;
                ECHO_TOP:_FillValue = -1b ;
                ECHO_TOP:valid_range = 0b, 70b ;
                ECHO_TOP:flag_values = 0b, 5b, 10b, 15b, 20b, 25b, 30b, 35b, 40b, 45b, 50b ;
                ECHO_TOP:flag_meanings = "0 5 10 15 20 25 30 35 40 45 50+" ;

// global attributes:
                :Conventions = "CF-1.3" ;
                :history = "File created 2009-03-23T15:13:19Z on machine compute-7-6.local by
ProductAdapterQuantizedEchoTopsForecast $Revision: 1.2.2.2 $" ;
                :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
                :references = "http://www.wx.ll.mit.edu" ;
                :source = "National CIWS Data Stream: EchoTopsForecastProc:Images:CiwsRelay" ;
                :title = "National CIWS Quantized Echo Tops Mosaic Product - 1 km @ 2.5 minutes"
;
                :comment = "Mosaic of Echo Tops derived from NEXRAD, TDWR and Canadian radar
systems." ;
                :FileType = "NetCDF" ;
                :FileFormat = "Netcdf4" ;
data:

 times = 1237821300, 1237821600, 1237821900, 1237822200, 1237822500,
    1237822800, 1237823100, 1237823400, 1237823700, 1237824000, 1237824300,
    1237824600, 1237824900, 1237825200, 1237825500, 1237825800, 1237826100,
    1237826400, 1237826700, 1237827000, 1237827300, 1237827600, 1237827900,
    1237828200 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

A9 CURRENT CONUS SATELLITE DATASET CDL

```
netcdf edu.mit.ll.wx.ciws.Satellite.Netcdf4.1km.20090323T150836Z {
dimensions:
        time = 1 ;
        z0 = 1 ;
        y0 = 3520 ;
        x0 = 5120 ;
variables:
        double time(time) ;
                time:standard_name = "time" ;
                time:long_name = "Product validity time" ;
                time:units = "seconds since 1970-01-01T00:00:00Z" ;
                time:calendar = "gregorian" ;
                time:string = "2009-03-23T15:08:36Z" ;
        double z0(z0) ;
                z0:standard_name = "altitude" ;
                z0:long_name = "Product altitude" ;
                z0:units = "meters" ;
                z0:axis = "Z" ;
                z0:positive = "up" ;
        double y0(y0) ;
                y0:standard_name = "projection_y_coordinate" ;
                y0:long_name = "Distance from projection reference point latitude" ;
                y0:units = "meters" ;
        double x0(x0) ;
                x0:standard_name = "projection_x_coordinate" ;
                x0:long_name = "Distance from projection reference point longitude" ;
                x0:units = "meters" ;
        double start_time ;
                start_time:long_name = "Data observation start time" ;
                start_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                start_time:calendar = "gregorian" ;
                start_time:string = "2009-03-23T15:01:29Z" ;
                start_time:comment = "Data observation start time is the time data collection
began" ;
        double stop_time ;
                stop_time:long_name = "Data observation stop time" ;
                stop_time:units = "seconds since 1970-01-01T00:00:00Z" ;
                stop_time:calendar = "gregorian" ;
                stop_time:string = "2009-03-23T15:08:36Z" ;
                stop_time:comment = "Data observation stop time is the time data collection
ended" ;
        int grid_mapping0 ;
                grid_mapping0:grid_mapping_name = "lambert_azimuthal_equal_area" ;
                grid_mapping0:long_name = "Lambert Azimuthal Equal Area Projection" ;
                grid_mapping0:latitude_of_projection_origin = 38. ;
                grid_mapping0:longitude_of_projection_origin = -98. ;
                grid_mapping0:false_easting = 0. ;
                grid_mapping0:false_northing = 0. ;
                grid_mapping0:earth_radius = 6370997. ;
        byte RemappedSatellite(time, z0, y0, x0) ;
                RemappedSatellite:long_name = "Remapped satellite derived from visible, infrared
or both" ;
                RemappedSatellite:class_name = "RemappedSatellite" ;
                RemappedSatellite:product_name = "RemappedSatellite" ;
                RemappedSatellite:grid_mapping = "grid_mapping0" ;
                RemappedSatellite:_FillValue = -1b ;
                RemappedSatellite:valid_range = 0b, 33b ;
```

```
// global attributes:
                :Conventions = "CF-1.3" ;
                :history = "File created 2009-03-23T15:14:45Z on machine compute-7-4.local by
ProductAdapterSatellite $Revision: 1.2.2.1 $" ;
                :institution = "Data produced by the MIT Lincoln Lab Weather Sensing Group" ;
                :references = "http://www.wx.ll.mit.edu" ;
                :source = "National CIWS Data Stream:
SatelliteRemapper:SatelliteImages:CiwsRelay" ;
                :title = "National CIWS Satellite Mosaic Product - 1 km @ 15 minutes" ;
                :comment = "Mosaic of satellite derived from East and West GOES." ;
                :FileType = "NetCDF" ;
                :FileFormat = "Netcdf4" ;
data:

 time = 1237820916 ;

 z0 = 0 ;

 y0 = -1759500, -1758500, -1757500, -1756500, -1755500, -1754500, -1753500,
    -1752500, -1751500, -1750500, -1749500, -1748500, -1747500, -1746500,
...
    1745500, 1746500, 1747500, 1748500, 1749500, 1750500, 1751500, 1752500,
    1753500, 1754500, 1755500, 1756500, 1757500, 1758500, 1759500 ;

 x0 = -2559500, -2558500, -2557500, -2556500, -2555500, -2554500, -2553500,
    -2552500, -2551500, -2550500, -2549500, -2548500, -2547500, -2546500,
...
    2550500, 2551500, 2552500, 2553500, 2554500, 2555500, 2556500, 2557500,
    2558500, 2559500 ;
}
```

APPENDIX B: EXAMPLE NON-GRIDDED PRODUCT GML FILES

The following are annotated GML examples for the non-gridded CIWS data products. The GML examples were produced in compliance with the XML schema versions listed in Table 4.

B1 EXAMPLE GROWTH & DECAY TRENDS GML

```
<?xml version="1.0" encoding="UTF-8"?>
<wx:WxFeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation="http://www.eurocontrol.int/wx/1.1 ../wx.xsd"
 xmlns:wx="http://www.eurocontrol.int/wx/1.1"
 xmlns:xlin="http://www.w3.org/1999/xlink"
 xmlns:om="http://www.opengis.net/om/1.0/gml32"
 xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:nawx="http://www.faa.gov/nawx/1.1"
 gml:id="id0">

  <wx:featureMember>
    <!--
    Observation containing collection of storm growth and decay contours
    -->
    <wx:Observation gml:id="id1">
      <!--
      Sampling time in this example is a time period spanning the radar scan(s)
      used to observe the storms
      -->
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>20080709T035000Z</gml:beginPosition>
          <gml:endPosition>20080709T040000Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>

      <!--
      Unique identifier for Growth and Decay algorithm used to identify contour
      regions of storm growth and decay.
      -->
      <om:procedure xlin:href="urn:fdc:faa.gov:System:CIWS:Algorithm:GrowthDecay"/>

      <!-- Observed property is link to storm cell class in weather ontology -->
      <om:observedProperty xlin:href="http://sweet.jpl.nasa.gov/2.0/atmoFront.owl#Cell"/>

      <!--
        Feature of interest in this case is the CIWS national processing grid region
      -->
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>CIWS national radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:CIWS:National"/>
          <gml:name>CIWS-National</gml:name>
          <wx:extentOf>
            <gml:Envelope>
              <gml:lowerCorner>19.3098 -122.358</gml:lowerCorner>
              <gml:upperCorner>48.9457 -61.7424</gml:upperCorner>
```

```xml
      </gml:Envelope>
    </wx:extentOf>
  </wx:AreaOfInterest>
</om:featureOfInterest>

<!--
Observation result is a feature collection of Contour objects.
Growth regions will have positive probability contour values.
Decay regions will have negative probability contour values.
-->
<om:result>
  <!-- Feature collection of Contours -->
  <wx:WxFeatureCollection gml:id="id4">
    <!-- Growth contours (positive contourValues) -->
    <wx:featureMember>
      <wx:Contour gml:id="id5">
        <wx:observationTime>
          <gml:TimeInstant gml:id="id6">
            <gml:timePosition>20080709T040000Z</gml:timePosition>
          </gml:TimeInstant>
        </wx:observationTime>
        <wx:contourValue uom="1">0.016</wx:contourValue>
        <wx:geometry>
          <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id7">
            <gml:segments>
              <gml:LineStringSegment>
                <gml:posList srsDimension="2" count="69">
                  22.7981 -98.3621 ... 22.7981 -98.3621
                </gml:posList>
              </gml:LineStringSegment>
            </gml:segments>
          </gml:Curve>
        </wx:geometry>
      </wx:Contour>
    </wx:featureMember>
    <wx:featureMember>
      <wx:Contour gml:id="id8">
        <wx:observationTime>
          <gml:TimeInstant gml:id="id9">
            <gml:timePosition>20080709T040000Z</gml:timePosition>
          </gml:TimeInstant>
        </wx:observationTime>
        <wx:contourValue uom="1">0.016</wx:contourValue>
        <wx:geometry>
          <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id10">
            <gml:segments>
              <gml:LineStringSegment>
                <gml:posList srsDimension="2" count="35">
                  23.1515 -97.2881 ... 23.1515 -97.2881
                </gml:posList>
              </gml:LineStringSegment>
            </gml:segments>
          </gml:Curve>
        </wx:geometry>
      </wx:Contour>
    </wx:featureMember>

    <!-- Decay contours (negative contourValues) -->
    <wx:featureMember>
      <wx:Contour gml:id="id884">
        <wx:observationTime>
```

```xml
            <gml:TimeInstant gml:id="id885">
              <gml:timePosition>20080709T040000Z</gml:timePosition>
            </gml:TimeInstant>
          </wx:observationTime>
          <wx:contourValue uom="1">-0.024</wx:contourValue>
          <wx:geometry>
            <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id886">
              <gml:segments>
                <gml:LineStringSegment>
                  <gml:posList srsDimension="2" count="30">
                    25.2176 -80.9128 ... 25.2176 -80.9128
                  </gml:posList>
                </gml:LineStringSegment>
              </gml:segments>
            </gml:Curve>
          </wx:geometry>
        </wx:Contour>
      </wx:featureMember>
      <wx:featureMember>
        <wx:Contour gml:id="id887">
          <wx:observationTime>
            <gml:TimeInstant gml:id="id888">
              <gml:timePosition>20080709T040000Z</gml:timePosition>
            </gml:TimeInstant>
          </wx:observationTime>
          <wx:contourValue uom="1">-0.024</wx:contourValue>
          <wx:geometry>
            <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id889">
              <gml:segments>
                <gml:LineStringSegment>
                  <gml:posList srsDimension="2" count="53">
                    25.0624 -80.1727 ... 25.0624 -80.1727</gml:posList>
                </gml:LineStringSegment>
              </gml:segments>
            </gml:Curve>
          </wx:geometry>
        </wx:Contour>
      </wx:featureMember>
    </wx:WxFeatureCollection>
  </om:result>
 </wx:Observation>
</wx:featureMember>
</wx:WxFeatureCollection>
```

B2 EXAMPLE STORM INFO : ECHO TOP TAGS GML


```xml
<?xml version="1.0" encoding="UTF-8"?>
<wx:WxFeatureCollection
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:wx="http://www.eurocontrol.int/wx/1.1"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:om="http://www.opengis.net/om/1.0/gml32"
  xmlns:xlin="http://www.w3.org/1999/xlink"
  xmlns:nawx="http://www.faa.gov/nawx/1.1"
  xsi:schemaLocation="http://www.eurocontrol.int/wx/1.1 ../wx.xsd"
  gml:id="id0">

  <wx:featureMember>
    <!--
    Observation contains a collection of EchoTopPoint objects
    -->
    <wx:Observation gml:id="id1">
      <!--
      Sampling time in this example is a time period spanning the radar
      scan(s) used to observe the storms
      -->
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>20080709T035000Z</gml:beginPosition>
          <gml:endPosition>20080709T040000Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>
      <!--
      Unique identifier for algorithm used to identify storm echo tops
      -->
      <om:procedure xlin:href="urn:fdc:faa.gov:System:CIWS:Algorithm:StormInfoGen"/>

      <!-- Observed property is link to storm echo top class in weather ontology -->
      <om:observedProperty xlin:href="http://www.ll.mit.edu/2009/storm.owl#StormEchoTop"/>

      <!--
        Feature of interest in this case is the CIWS national processing grid region
      -->
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>CIWS national radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:CIWS:National"/>
          <gml:name>CIWS-National</gml:name>
          <wx:extentOf>
            <gml:Envelope>
              <gml:lowerCorner>19.3098 -122.358</gml:lowerCorner>
              <gml:upperCorner>48.9457 -61.7424</gml:upperCorner>
            </gml:Envelope>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </om:featureOfInterest>

      <!--
      Observation result is a feature collection of one or more
      EchoTopPoint objects.
      -->
      <om:result>
        <wx:WxFeatureCollection gml:id="id4">
          <wx:featureMember>
```

```
          &lt;nawx:EchoTopPoint gml:id="id5"&gt;
            &lt;wx:observationTime&gt;
              &lt;gml:TimeInstant gml:id="id6"&gt;
                &lt;gml:timePosition&gt;20080709T040000Z&lt;/gml:timePosition&gt;
              &lt;/gml:TimeInstant&gt;
            &lt;/wx:observationTime&gt;
            &lt;nawx:echoTop uom="m"&gt;17678.4&lt;/nawx:echoTop&gt;
            &lt;nawx:topped&gt;true&lt;/nawx:topped&gt;
            &lt;nawx:geometry&gt;
              &lt;gml:Point gml:id="id7" srsName="urn:ogc:def:crs:EPSG:4326"&gt;
                &lt;gml:pos&gt;35.8601 -96.2508&lt;/gml:pos&gt;
              &lt;/gml:Point&gt;
            &lt;/nawx:geometry&gt;
          &lt;/nawx:EchoTopPoint&gt;
        &lt;/wx:featureMember&gt;
        &lt;wx:featureMember&gt;
          &lt;nawx:EchoTopPoint gml:id="id8"&gt;
            &lt;wx:observationTime&gt;
              &lt;gml:TimeInstant gml:id="id9"&gt;
                &lt;gml:timePosition&gt;20080709T040000Z&lt;/gml:timePosition&gt;
              &lt;/gml:TimeInstant&gt;
            &lt;/wx:observationTime&gt;
            &lt;nawx:echoTop uom="m"&gt;15240.0&lt;/nawx:echoTop&gt;
            &lt;nawx:topped&gt;true&lt;/nawx:topped&gt;
            &lt;nawx:geometry&gt;
              &lt;gml:Point gml:id="id10" srsName="urn:ogc:def:crs:EPSG:4326"&gt;
                &lt;gml:pos&gt;34.9074 -79.9736&lt;/gml:pos&gt;
              &lt;/gml:Point&gt;
            &lt;/nawx:geometry&gt;
          &lt;/nawx:EchoTopPoint&gt;
        &lt;/wx:featureMember&gt;
      &lt;/wx:WxFeatureCollection&gt;
    &lt;/om:result&gt;
  &lt;/wx:Observation&gt;
 &lt;/wx:featureMember&gt;
&lt;/wx:WxFeatureCollection&gt;
```

B3 EXAMPLE STORM INFO : LEADING EDGES GML


```xml
<?xml version="1.0" encoding="UTF-8"?>
<wx:WxFeatureCollection
  gml:id="id0"
  xmlns:wx="http://www.eurocontrol.int/wx/1.1"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:om="http://www.opengis.net/om/1.0/gml32"
  xmlns:xlin="http://www.w3.org/1999/xlink"
  xmlns:nawx="http://www.faa.gov/nawx/1.1">
  <!--
  There are two featureMembers in this top-level feature collection: the
  Observation and the Forecast.  The Observation contains data for the current
  leading edge storm contours, while the Forecast contains data for the
  extraploated (forecast) leading edge contours.
  -->
  <wx:featureMember>
    <!--
    Observation
    -->
    <wx:Observation gml:id="id1">
      <!--
      Sampling time in this example is a time period spanning the radar scan(s)
      used to observe the storms
      -->
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>20080709T035000Z</gml:beginPosition>
          <gml:endPosition>20080709T040000Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>

      <!--
      Unique identifier for storm motion algorithm (notional example)
      -->
      <om:procedure xlin:href="urn:fdc:faa.gov:System:CIWS:Algorithm:StormInfoGen"/>

      <!-- Observed property is link to StormLeadingEdge class in weather ontology -->
      <om:observedProperty xlin:href="http://www.ll.mit.edu/2009/storm.owl#StormLeadingEdge"/>

      <!--
        Feature of interest in this case is the CIWS national processing grid region
      -->
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>CIWS national radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:CIWS:National"/>
          <gml:name>CIWS-National</gml:name>
          <wx:extentOf>
            <gml:Envelope>
              <gml:lowerCorner>19.3098 -122.358</gml:lowerCorner>
              <gml:upperCorner>48.9457 -61.7424</gml:upperCorner>
            </gml:Envelope>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </om:featureOfInterest>

      <!--
      Observation result is a feature collection of LeadingEdge contour
      objects. Each LeadingEdge has observationTime, contourValue, and geometry
```

```
    properties.
    -->
    <om:result>
      <wx:WxFeatureCollection gml:id="id4">
        <wx:featureMember>
          <nawx:LeadingEdge gml:id="id8">
            <wx:observationTime>
              <gml:TimeInstant gml:id="id9">
                <gml:timePosition>20080709T040000Z</gml:timePosition>
              </gml:TimeInstant>
            </wx:observationTime>
            <wx:contourValue uom="dBZ">41.0</wx:contourValue>
            <wx:geometry>
              <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id10">
                <gml:segments>
                  <gml:LineStringSegment>
                    <gml:posList srsDimension="2" count="25">
                      21.6194 -81.2048 ... 21.4 -81.2073
                    </gml:posList>
                  </gml:LineStringSegment>
                </gml:segments>
              </gml:Curve>
            </wx:geometry>
          </nawx:LeadingEdge>
        </wx:featureMember>
        <wx:featureMember>
          <nawx:LeadingEdge gml:id="id17">
            <wx:observationTime>
              <gml:TimeInstant gml:id="id18">
                <gml:timePosition>20080709T040000Z</gml:timePosition>
              </gml:TimeInstant>
            </wx:observationTime>
            <wx:contourValue uom="dBZ">41.0</wx:contourValue>
            <wx:geometry>
              <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id19">
                <gml:segments>
                  <gml:LineStringSegment>
                    <gml:posList srsDimension="2" count="12">
                      23.0977 -97.0796 ... 23.0902 -97.1876
                    </gml:posList>
                  </gml:LineStringSegment>
                </gml:segments>
              </gml:Curve>
            </wx:geometry>
          </nawx:LeadingEdge>
        </wx:featureMember>
      </wx:WxFeatureCollection>
    </om:result>
  </wx:Observation>
</wx:featureMember>

<!-- Forecast -->
<wx:featureMember>
  <wx:Forecast gml:id="id5">
    <wx:forecastTime>
      <!--
      This is the time period spanning the range of forecast times
      contained in the Forecast result.
      -->
      <gml:TimePeriod gml:id="id6">
        <gml:beginPosition>20080709T041000Z</gml:beginPosition>
```

```
    <gml:endPosition>20080709T042000Z</gml:endPosition>
  </gml:TimePeriod>
</wx:forecastTime>

<!-- The analysis time for the forecast (aka, "forecast reference time") -->
<wx:forecastAnalysisTime>20080709T040000Z</wx:forecastAnalysisTime>

<!-- Issue time of the forecast -->
<wx:issueTime>20080709T040000Z</wx:issueTime>

<!-- Next (expected) issue time for forecast of same time -->
<wx:nextIssueTime>20080709T040230Z</wx:nextIssueTime>

<!--
Unique identifier for storm motion algorithm (notional example)
-->
<wx:procedure xlin:href="urn:fdc:faa.gov:System:CIWS:Algorithm:StormInfoGen"/>

<!-- Observed property is link to StormLeadingEdge class in weather ontology -->
<wx:forecastProperty xlin:href="http://www.ll.mit.edu/2009/storm.owl#StormLeadingEdge"/>

<!-- Link to Observation's featureOfInterest -->
<wx:featureOfInterest xlin:href="#id3"/>

<!--
Forecast result is a feature collection of forecast LeadingEdge contour
objects.
-->
<wx:result>
  <wx:WxFeatureCollection gml:id="id7">
    <wx:featureMember>
      <nawx:LeadingEdge gml:id="id11">
        <!-- The target forecast time (10-minute forecast in this case) -->
        <wx:forecastTime>
          <gml:TimeInstant gml:id="id12">
            <gml:timePosition>20080709T041000Z</gml:timePosition>
          </gml:TimeInstant>
        </wx:forecastTime>
        <wx:contourValue uom="dBZ">41.0</wx:contourValue>
        <wx:geometry>
          <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id13">
            <gml:segments>
              <gml:LineStringSegment>
                <gml:posList srsDimension="2" count="25">
                  21.6137 -81.2589 ... 21.3942 -81.2614
                </gml:posList>
              </gml:LineStringSegment>
            </gml:segments>
          </gml:Curve>
        </wx:geometry>
      </nawx:LeadingEdge>
    </wx:featureMember>
    <wx:featureMember>
      <nawx:LeadingEdge gml:id="id14">
        <wx:forecastTime>
          <gml:TimeInstant gml:id="id15">
            <gml:timePosition>20080709T042000Z</gml:timePosition>
          </gml:TimeInstant>
        </wx:forecastTime>
        <wx:contourValue uom="dBZ">41.0</wx:contourValue>
        <wx:geometry>
```

```
                <gml:Curve srsName="urn:ogc:def:crs:EPSG:4326" gml:id="id16">
                  <gml:segments>
                    <gml:LineStringSegment>
                      <gml:posList srsDimension="2" count="25">
                        21.6079 -81.313 ... 21.3884 -81.3154</gml:posList>
                    </gml:LineStringSegment>
                  </gml:segments>
                </gml:Curve>
              </wx:geometry>
            </nawx:LeadingEdge>
          </wx:featureMember>
        </wx:WxFeatureCollection>
      </wx:result>
    </wx:Forecast>
  </wx:featureMember>
</wx:WxFeatureCollection>
```

B4 EXAMPLE STORM MOTION INFO : MOTION VECTORS GML


```xml
<?xml version="1.0" encoding="UTF-8"?>
<wx:WxFeatureCollection
  gml:id="id0"
  xmlns:wx="http://www.eurocontrol.int/wx/1.1"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:om="http://www.opengis.net/om/1.0/gml32"
  xmlns:xlin="http://www.w3.org/1999/xlink">

  <wx:featureMember>
    <!--
    Observation
    -->
    <wx:Observation gml:id="id1">
      <!--
      Sampling time in this example is a time period spanning the radar scan(s)
      used to observe the storms
      -->
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>20080709T035000Z</gml:beginPosition>
          <gml:endPosition>20080709T040000Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>

      <!--
      Unique identifier for storm motion algorithm (notional example)
      -->
      <om:procedure xlin:href="urn:fdc:faa.gov:System:CIWS:Algorithm:StormInfoGen"/>

      <!-- Observed property is link to StormMotion class in weather ontology -->
      <om:observedProperty xlin:href="http://www.ll.mit.edu/2009/storm.owl#StormMotion"/>

      <!--
        Feature of interest in this case is the CIWS national processing grid region
      -->
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>CIWS national radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:CIWS:National"/>
          <gml:name>CIWS-National</gml:name>
          <wx:extentOf>
            <gml:Envelope>
              <gml:lowerCorner>19.3098 -122.358</gml:lowerCorner>
              <gml:upperCorner>48.9457 -61.7424</gml:upperCorner>
            </gml:Envelope>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </om:featureOfInterest>

      <!--
      Observation result is a feature collection of MotionVector
      objects. Each MotionVector has observationTime, location, speed, and
      direction properties.
      -->
      <om:result>
        <wx:WxFeatureCollection gml:id="id4">
          <wx:featureMember>
```

```
            <wx:MotionVector gml:id="id5" srsName="urn:ogc:def:crs:EPSG:4326">
              <wx:observationTime>
                <gml:TimeInstant gml:id="id6">
                  <gml:timePosition>20080709T040000Z</gml:timePosition>
                </gml:TimeInstant>
              </wx:observationTime>
              <gml:pos>40.3277 -83.7614</gml:pos>
              <wx:speed uom="kt">14.74</wx:speed>
              <wx:direction uom="deg">61.12</wx:direction>
            </wx:MotionVector>
          </wx:featureMember>
          <wx:featureMember>
            <wx:MotionVector gml:id="id7" srsName="urn:ogc:def:crs:EPSG:4326">
              <wx:observationTime>
                <gml:TimeInstant gml:id="id8">
                  <gml:timePosition>20080709T040000Z</gml:timePosition>
                </gml:TimeInstant>
              </wx:observationTime>
              <gml:pos>35.0664 -79.9819</gml:pos>
              <wx:speed uom="kt">3.29</wx:speed>
              <wx:direction uom="deg">93.13</wx:direction>
            </wx:MotionVector>
          </wx:featureMember>
        </wx:WxFeatureCollection>
      </om:result>
    </wx:Observation>
  </wx:featureMember>
</wx:WxFeatureCollection>
```

B5 EXAMPLE FORECAST STANDARD-MODE PRECIP (VIL) CONTOURS GML


```xml
<?xml version="1.0" encoding="UTF-8"?>

<wx:WxFeatureCollection gml:id="id0"
  xmlns:wx="http://www.eurocontrol.int/wx/1.1"
  xmlns:om="http://www.opengis.net/om/1.0/gml32"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

  <wx:featureMember>

    <wx:Forecast gml:id="id1">
      <!--
        Forecast target time. For a time series forecast (+30 min, +60 min, +120 min) the
        forecast time is a period spanning the series (same strategy as O+M sampling time).
      -->
      <wx:forecastTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>2008-07-09T04:30:00Z</gml:beginPosition>
          <gml:endPosition>2008-07-09T06:00:00Z</gml:endPosition>
        </gml:TimePeriod>
      </wx:forecastTime>

      <!--
         Analysis time for the forecast. Also commonly referred to as forecast
         reference time
      -->
      <wx:forecastAnalysisTime>2008-07-09T04:00:00Z</wx:forecastAnalysisTime>
      <!--
        Issue time and next expected issue time for forecast. In cases where the
        forecast is machine-generated, the issueTime is typically the same as the
        analysis time
      -->
      <wx:issueTime>2008-07-09T04:00:00Z</wx:issueTime>
      <wx:nextIssueTime>2008-07-09T04:05:00Z</wx:nextIssueTime>

      <wx:procedure xlin:href="urn:fdc:faa.gov:System:CIWS:Algorithm:VilForecastContours"/>
      <wx:forecastProperty xlin:href="http://sweet.jpl.nasa.gov/2.0/atmoFront.owl#Cell"/>

      <!--
        Feature of interest in this case is the CIWS national processing grid region
      -->
      <wx:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>CIWS national radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:CIWS:National"/>
          <gml:name>CIWS-National</gml:name>
          <wx:extentOf>
            <gml:Envelope>
              <gml:lowerCorner>19.3098 -122.358</gml:lowerCorner>
              <gml:upperCorner>48.9457 -61.7424</gml:upperCorner>
            </gml:Envelope>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </wx:featureOfInterest>

      <!-- The storm cell parameter being measured -->
```

```
<wx:parameter xlin:href="http://faa.gov/ontology/weather.owl#VIL"/>

<!-- Forecast result is a feature collection of wx:Contour features -->
<wx:result>
  <!--
  For CIWS, the expected sequence of forecast contour features within the
  following feature collection is as follows:
    30-min fcast Contours
    60-min fcast Contours
    120-min fcast Contours

  For Standard (non-winter) mode products, the fcst contours correspond to
  NWS Level 3

  For Winter mode products, the fcst contours correspond to
  NWS Level 1c
  -->
  <wx:WxFeatureCollection gml:id="id4">

    <!-- 30-minute forecasts -->
    <wx:featureMember>
      <wx:Contour gml:id="id5">
        <!-- Valid time of forecast -->
        <wx:forecastTime>
          <gml:TimeInstant gml:id="id6">
            <gml:timePosition>2008-07-09T04:30:00Z</gml:timePosition>
          </gml:TimeInstant>
        </wx:forecastTime>
        <wx:contourValue uom="kg_m-2">3.54</wx:contourValue>
        <wx:geometry>
          <gml:Curve gml:id="id7" srsName="urn:ogc:def:crs:EPSG:4326">
            <gml:segments>
              <gml:LineStringSegment>
                <gml:posList>
                  21.3645 -81.3251 ...  21.3645 -81.3251
                </gml:posList>
              </gml:LineStringSegment>
            </gml:segments>
          </gml:Curve>
        </wx:geometry>
      </wx:Contour>
    </wx:featureMember>

    <!-- 60-minute forecasts -->
    <wx:featureMember>
      <wx:Contour gml:id="id875">
        <wx:forecastTime>
          <gml:TimeInstant gml:id="id876">
            <gml:timePosition>2008-07-09T05:00:00Z</gml:timePosition>
          </gml:TimeInstant>
        </wx:forecastTime>
        <wx:contourValue uom="kg_m-2">3.54</wx:contourValue>
        <wx:geometry>
          <gml:Curve gml:id="id877" srsName="urn:ogc:def:crs:EPSG:4326">
            <gml:segments>
              <gml:LineStringSegment>
                <gml:posList>
                  21.3684 -81.5287 ... 21.3684 -81.5287
                </gml:posList>
              </gml:LineStringSegment>
            </gml:segments>
```

```
            </gml:Curve>
          </wx:geometry>
        </wx:Contour>
      </wx:featureMember>

      <!-- 120-minute forecasts -->
      <wx:featureMember>
        <wx:Contour gml:id="id1676">
          <wx:forecastTime>
            <gml:TimeInstant gml:id="id1677">
              <gml:timePosition>2008-07-09T06:00:00Z</gml:timePosition>
            </gml:TimeInstant>
          </wx:forecastTime>
          <wx:contourValue uom="kg_m-2">3.54</wx:contourValue>
          <wx:geometry>
            <gml:Curve gml:id="id1678" srsName="urn:ogc:def:crs:EPSG:4326">
              <gml:segments>
                <gml:LineStringSegment>
                  <gml:posList>
                    21.3354 -81.8537 ... 21.3354 -81.8537
                  </gml:posList>
                </gml:LineStringSegment>
              </gml:segments>
            </gml:Curve>
          </wx:geometry>
        </wx:Contour>
      </wx:featureMember>
    </wx:WxFeatureCollection>
  </wx:result>
 </wx:Forecast>
</wx:featureMember>
</wx:WxFeatureCollection>
```

B6 EXAMPLE ECHO TOPS FORECAST ACCURACY SCORES GML


```
<?xml version="1.0" encoding="UTF-8"?>
<wx:WxFeatureCollection xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xsi:schemaLocation="http://www.eurocontrol.int/wx/1.1 ../wx.xsd"
 xmlns:wx="http://www.eurocontrol.int/wx/1.1"
 xmlns:xlink="http://www.w3.org/1999/xlink"
 xmlns:om="http://www.opengis.net/om/1.0/gml32"
 xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:nawx="http://www.faa.gov/nawx/1.1"
 gml:id="id0">

  <!--
    Observation containing collection of forecast accuracy ScoredRegions
  -->
  <wx:featureMember>

    <wx:Observation gml:id="id1">

      <!--
      Sampling time in this example is a time period spanning the radar volume scan used to
      observe (and analyze) storms for motion.
      -->
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>20080709T040000Z</gml:beginPosition>
          <gml:endPosition>20080709T040000Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>

      <!--
      Unique identifier for ForecastAccuracy algorithm used to compute the scores
      -->
      <om:procedure

xlink:href="urn:fdc:faa.gov:System:CIWS:Algorithm:EchoTops:ForecastVerification:Standard_FcstAccu
racy"/>

      <!-- Observed property is link to storm cell class in weather ontology -->
      <om:observedProperty xlink:href="http://www.ll.mit.edu/2009/storm.owl#StormEchoTop"/>

      <!--
        Feature of interest in this case is the CIWS national processing grid region
      -->
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>CIWS national radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:CIWS:National"/>
          <gml:name>CIWS-National</gml:name>
          <wx:extentOf>
            <gml:Envelope>
              <gml:lowerCorner>19.3098 -122.358</gml:lowerCorner>
              <gml:upperCorner>48.9457 -61.7424</gml:upperCorner>
            </gml:Envelope>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </om:featureOfInterest>

      <!--
```

```
Observation result is a feature collection of ScoredRegion objects.
-->
<om:result>
  <!-- Feature collection of ScoredRegions -->
  <wx:WxFeatureCollection gml:id="id4">

    <wx:featureMember>
      <nawx:ScoredRegion gml:id="id5">
        <!-- Info about the region that was scored -->
        <nawx:region>
          <wx:AreaOfInterest gml:id="id6">
            <gml:description>ABQ</gml:description>
            <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:Airports"/>
            <gml:name>ABQ</gml:name>
          </wx:AreaOfInterest>
        </nawx:region>
        <!-- Contour level that was scored (30 kft in this example)-->
        <nawx:scoredContourLevel>Height30</nawx:scoredContourLevel>
        <!-- Scores for each forecast interval -->
        <nawx:regionScores>
          <nawx:PeriodScore>
            <nawx:period uom="minutes">30</nawx:period>
            <nawx:score uom="percent">70</nawx:score>
          </nawx:PeriodScore>
          <nawx:PeriodScore>
            <nawx:period uom="minutes">60</nawx:period>
            <nawx:score uom="percent">55</nawx:score>
          </nawx:PeriodScore>
          <nawx:PeriodScore>
            <nawx:period uom="minutes">120</nawx:period>
            <nawx:score uom="percent">60</nawx:score>
          </nawx:PeriodScore>
        </nawx:regionScores>
      </nawx:ScoredRegion>
    </wx:featureMember>

    <wx:featureMember>
      <nawx:ScoredRegion gml:id="id10">
        <!-- Info about the region that was scored -->
        <nawx:region>
          <wx:AreaOfInterest gml:id="id11">
            <gml:description>ATL</gml:description>
            <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:Airports:"/>
            <gml:name>ATL</gml:name>
          </wx:AreaOfInterest>
        </nawx:region>
        <!-- Contour level that was scored -->
        <nawx:scoredContourLevel>Height30</nawx:scoredContourLevel>
        <!-- Scores for each forecast interval -->
        <nawx:regionScores>
          <nawx:PeriodScore>
            <nawx:period uom="minutes">30</nawx:period>
            <nawx:score uom="percent">90</nawx:score>
          </nawx:PeriodScore>
          <nawx:PeriodScore>
            <nawx:period uom="minutes">60</nawx:period>
            <nawx:score uom="percent">85</nawx:score>
          </nawx:PeriodScore>
          <nawx:PeriodScore>
            <nawx:period uom="minutes">120</nawx:period>
            <nawx:score uom="percent">80</nawx:score>
```

```
                </nawx:PeriodScore>
              </nawx:regionScores>
            </nawx:ScoredRegion>
          </wx:featureMember>

        </wx:WxFeatureCollection>
      </om:result>
    </wx:Observation>
  </wx:featureMember>
</wx:WxFeatureCollection>
```

B7 EXAMPLE LIGHTNING FLASH GML

```xml
<?xml version="1.0" encoding="UTF-8"?>
<wx:WxFeatureCollection
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:wx="http://www.eurocontrol.int/wx/1.1"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:om="http://www.opengis.net/om/1.0/gml32"
  xmlns:xlin="http://www.w3.org/1999/xlink"
  xmlns:nawx="http://www.faa.gov/nawx/1.1"
  xsi:schemaLocation="http://www.eurocontrol.int/wx/1.1 ../wx.xsd"
  gml:id="id0">

  <wx:featureMember>
    <!--
    Observation contains a collection of LightningFlashes
    -->
    <wx:Observation gml:id="id1">
      <!--
      Sampling time in this example is the time period over which lightning
      flashes were aggregated
      -->
      <om:samplingTime>
        <gml:TimePeriod gml:id="id2">
          <gml:beginPosition>20080709T035425Z</gml:beginPosition>
          <gml:endPosition>20080709T035954Z</gml:endPosition>
        </gml:TimePeriod>
      </om:samplingTime>
      <!--
      Unique identifier for process used to collect lightning information
      -->
      <om:procedure xlin:href="urn:fdc:faa.gov:System:CIWS:Algorithm:LghtAggregator:National"/>

      <!-- Observed property is link to lightning flash class in weather ontology -->
      <om:observedProperty xlin:href="http://www.ll.mit.edu/2009/storm.owl#LightningFlash"/>

      <!--
        Feature of interest in this case is the CIWS national processing grid region
      -->
      <om:featureOfInterest>
        <wx:AreaOfInterest gml:id="id3">
          <gml:description>CIWS national radar coverage area</gml:description>
          <gml:identifier codeSpace="urn:fdc:faa.gov:AreaOfInterest:System:CIWS:National"/>
          <gml:name>CIWS-National</gml:name>
          <wx:extentOf>
            <gml:Envelope>
              <gml:lowerCorner>19.3098 -122.358</gml:lowerCorner>
              <gml:upperCorner>48.9457 -61.7424</gml:upperCorner>
            </gml:Envelope>
          </wx:extentOf>
        </wx:AreaOfInterest>
      </om:featureOfInterest>

      <!--
      Observation result is a feature collection of one or more
      LightningFlash objects.
      -->
      <om:result>
        <wx:WxFeatureCollection gml:id="id4">
```

```
          <wx:featureMember>
            <nawx:LightningFlash gml:id="id5">
              <wx:observationTime>
                <gml:TimeInstant gml:id="id6">
                  <gml:timePosition>20080709T035425Z</gml:timePosition>
                </gml:TimeInstant>
              </wx:observationTime>
              <nawx:strength uom="kA">-30.00</nawx:strength>
              <nawx:numStrokes>3</nawx:numStrokes>
              <nawx:geometry>
                <gml:Point gml:id="id7" srsName="urn:ogc:def:crs:EPSG:4326">
                  <gml:pos>
                    38.6116 -81.6016
                  </gml:pos>
                </gml:Point>
              </nawx:geometry>
            </nawx:LightningFlash>
          </wx:featureMember>

          <wx:featureMember>
            <nawx:LightningFlash gml:id="id8">
              <wx:observationTime>
                <gml:TimeInstant gml:id="id9">
                  <gml:timePosition>20080709T035425Z</gml:timePosition>
                </gml:TimeInstant>
              </wx:observationTime>
              <nawx:strength uom="kA">-8.00</nawx:strength>
              <nawx:numStrokes>1</nawx:numStrokes>
              <nawx:geometry>
                <gml:Point gml:id="id10" srsName="urn:ogc:def:crs:EPSG:4326">
                  <gml:pos>
                    35.5534 -96.7741
                  </gml:pos>
                </gml:Point>
              </nawx:geometry>
            </nawx:LightningFlash>
          </wx:featureMember>
        </wx:WxFeatureCollection>
      </om:result>
    </wx:Observation>
  </wx:featureMember>
</wx:WxFeatureCollection>
```

GLOSSARY

API	Application Programming Interface
CDL	Network Common Data Form Language
CF	Climate and Forecast
CIWS	Corridor Integrated Weather System
CONUS	Continental United States
CSML	Climate Science Modeling Language
FAA	Federal Aviation Administration
GCTP	General Cartographic Transformation Package
GML	Geography Markup Language
GOES	Geostationary Operational Environmental Satellite
HDF5	Hierarchical Data Format – Version 5
ISO	International Organization for Standardization
LAEA	Lambert Azimuthal Equal Area
MIT	Massachusetts Institute of Technology
MIT LL	MIT Lincoln Laboratory
NetCDF	Network Common Data Format
NLDN	National Lightning Detection Network
NWS	National Weather Service
OGC	Open Geospatial Consortium
OM	Observations and Measurements
Unidata	University Data Interactive Computing and Communications Systems
URL	Uniform Resource Locator
VIL	Vertically Integrated Liquid Water
WXXM	Weather Exchange Model
WXXS	Weather Exchange Schema
XML	Extensible Markup Language
XSLT	Extensible Stylesheet Language Transformations

WEB REFERENCES

The following Web site addresses provide useful information and/or software related to National CIWS product files.

Unidata NetCDF Software
`http://www.unidata.ucar.edu/software/netcdf/`

HDF5 Software
`http://www.hdfgroup.org/HDF5/index.html`

Climate and Forecast Meta Data Conventions
`http://cf-pcmdi.llnl.gov`

General Cartographic Transformation Package (GCTP)
`http://gcmd.nasa.gov/records/USGS-GCTP.html`

PROJ.4 Cartographic Projections Library
`http://trac.osgeo.org/proj/`