P5.6   **AN XML FORMAT FOR NOWCAST DATA**

Elizabeth Ebert*, Sandy Dance, David Scurrah, Rod Potts, and Elena Dozortseva
Bureau of Meteorology, Melbourne, Australia

1. INTRODUCTION

The electronic exchange of weather data is becoming increasingly important for a variety of applications including public weather, emergency management, and commercial enterprises, to name a few. EXtensible Markup Language (XML) is an internationally recognized format for self-describing text files that are extremely flexible in nature and facilitate data exchange across different information systems including the internet. XML is being used by the National Weather Service and private companies to provide weather data via the World Wide Web.

A new XML format called Weather Markup Language (WxML) is being developed at the Australian Bureau of Meteorology to support the exchange of meteorological data from various sources including nowcasts and the Australian Digital Forecast Database. In addition, WxML will be the standard format for exchanging nowcast data in the WWRP Beijing 2008 Forecast Demonstration Project.

2. BACKGROUND

There were two motivations for the development of WxML.

First, a standard format for exchanging nowcast data was required to facilitate the display and verification of nowcasts in the WWRP Beijing 2008 Forecast Demonstration Project (B08FDP) (Yu 2005). In this project a number of nowcast systems will be installed at the Beijing Meteorological Bureau to provide state of the art nowcasts during the 2008 Olympic Games. It would have been possible to use the same format that was used in the WWRP Sydney 2000 FDP (Keenan et al. 2002), namely the Bureau of Meteorology's AIFS Exchange Format (AXF), but

an international standard such as XML was considered preferable. A search for existing XML formats for nowcasts turned up only one, the output from the Warning Decision Support System (WDSS) (Eilts, 1997). However, it was not considered sufficiently general in its existing form for use with a wide variety of nowcast systems. Therefore development of a more general XML format for nowcasts was required.

The second motivating factor was the need for the Bureau of Meteorology to provide weather data from the Australian Digital Forecast Database. This is modelled on the National Weather Service's National Digital Forecast Database (NDFD) (Glahn and Ruth 2003), and involves a close partnership with both NOAA's Global Systems Division and Meteorological Development Laboratory. The NDFD uses an XML format known as Digital Weather Markup Language (DWML) to enable its customers and partners to request NDFD data over the internet. The Bureau of Meteorology plans to provide a similar service using similar technology.

We found that DWML provided a suitable framework for representing weather and climate data, and that this framework could be extended to handle data from nowcasts. The extension of DWML into a Weather Markup Language (WxML)[1] was begun in February 2006, with the bulk of the effort directed toward the development of an appropriate schema for nowcasts.

3. XML BASICS

A good source of general information on XML can be found online at the W3 Schools (http://www.w3schools.com). Briefly, XML is a markup language similar to HTML. However, unlike HTML, which displays data and focuses on

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.*Corresponding author address:*   Elizabeth Ebert, Bureau of Meteorology Research Centre, GPO Box 1289, Melbourne, Australia 3000; e-mail: e.ebert@bom.gov.au

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[1] We are aware of the existence of another WxML called Weather Object Markup Language (see http://sdg.ocs.ou.edu/docs/wxml/) that supports mapping and graphing of weather data.

how it looks, XML describes data and focuses on its content. The huge advantage of XML is that the author can design his/her own tags to describe the data and structure to define the document. For example, a simple XML file to describe weather observations might look something like Figure 1 below:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<weather>
    <time>2006-09-05T12:00:00<time>
    <site>
        <name>Melbourne</name>
        <temperature units="C">20</temperature>
    </site>
    <site>
        <name>Sydney</name>
        <temperature units="C">22</temperature>
    </site>
</weather>
```

Figure 1. Simple XML file.

XML data is written as text which makes it very easy to read, although somewhat verbose.

The most common way to define the structure of an XML document is via a schema. The schema essentially provides the "rules" for the elements (e.g. tags such as <temperature> in the example above), attributes (descriptors within tags, such as *units* in the example above), and data values that can be included in the XML file. The schema is itself an XML file.

In practice, the schema for a particular XML format is written by the "owner" of the format. The XML files can be written by anyone so long as the "rules" specified by the schema are followed. The schema is typically available online which means that anyone can download and extend or modify it to suit his/her own purposes.

4. WxML DESCRIPTION

The first part of the format describes metadata including the name of the product, the source data, the producing center, and so on. The remainder of the format describes the meteorological data itself.

As set out in DWML and repeated in WxML, most weather data are given for static locations such as sites or regions. Information is provided on the details of the locations, the times of observation or forecast validity, followed by the weather parameters themselves (e.g., temperature, wind, significant weather, etc.)

Many nowcasts are unlike other weather data in that the locations of thunderstorm cells and warning polygons are not fixed and the timing may also be irregular. WxML was designed to handle these irregularities. It can represent spatial data as geometric shapes, polygons, polylines, and point data. The meteorological data may include a large variety of characteristics such as location, speed and direction, maximum reflectivity, VIL, hail probability, weather type, and so on. The "extensible" nature of XML makes it extremely easy for users to add new characteristics that are relevant to their particular nowcast application.

Although possible in principle, WxML was not designed to hold gridded nowcasts. Since XML files contain text as opposed to binary data, they could become quite large for some gridded datasets. Other binary formats such as netCDF were considered more suitable for gridded data.

A sample WxML file is shown in Figure 2 for a cell tracking nowcast from the Thunderstorm Initiation, Tracking, Analysis, and Nowcasting (TITAN) system running in the Bureau of Meteorology (Potts 2005). Metadata is found at the top of the file within the element <head>. The data source in this case was Sydney radar.

The remainder of the file describes the nowcast data. The data are defined by "events", each of which has a unique ID. In this example events represent individual thunderstorms cells; for other applications events might correspond to threat areas or gust fronts. Each time instance of the event is given by a "case". In addition to the time stamp, the location of the case is described by its shape and movement. This is followed by the nowcast parameters that describe the meteorological state of the event at that time.

WxML nowcast files can hold multiple events and multiple cases within each event. For some applications it may be convenient to record the full event histories in a single file rather than a separate file for each time; other applications such as real time displays may find it easier to deal with only the most recent nowcast data.

5. CONCLUDING REMARKS

WxML will replace the Bureau of Meteorology's existing AXF format as the primary format for

nowcast data within the Bureau. As mentioned earlier, WxML will also be the standard format for B08FDP (non-gridded) nowcasts. Several nowcast systems including TITAN, WDSS, the CAnadian Radar Decision System (CARDS), the Bureau of Meteorology's Thunderstorm Interactive Forecast System (TIFS), and Hong Kong Observatory's Short-range Warnings of Intense Rainstorms in Localized Systems (SWIRLS), have been configured to write nowcast data in WxML format.

Further information on WxML, including documentation, schemas, and examples, can be found online at http://www.bom.gov.au/bmrc/wefor/projects/b08fdp/WxML/. We encourage nowcast providers and other weather providers to make use of, and extend, this format.

6. ACKNOWLEDGEMENTS

We gratefully acknowledge the developers of DWML who provided excellent documentation of their format, making it relatively easy to extend for use with nowcasts.

7. REFERENCES

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```xml
<?xml version="1.0" ?>
<wxml
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" version="1.0"
xsi:schemaLocation="http://www.bom.gov.au/bmrc/wefor/projects/b08fdp/WxML
http://www.bom.gov.au/bmrc/wefor/projects/b08fdp/WxML/wxml.1.01.xsd">
<head>
  <product concise-name="track" operational-mode="experimental">
    <system>TITAN</system>
    <title>TITAN Thunderstorm Track</title>
    <description>B08FDB TITAN</description>
    <category>analysis</category>
    <creation-date refresh-frequency="PT10M">2006-09-05T23:41:39</creation-date>
  </product>
  <data-source>
    <radar name="Sydney" type="radar" latitude="-34.2640" longitude="150.8740" />
  </data-source>
  <product-source>
    <more-information>
        http://www.bom.gov.au/bmrc/wefor/projects/b08fdp/info.html
    </more-information>
    <production-center>Bureau of Meteorology
      <sub-center>Research Centre</sub-center>
    </production-center>
    <disclaimer>http://www.bom.gov.au/other/disclaimer.shtml</disclaimer>
    <credit>http://www.bom.gov.au</credit>
    <credit-logo>http://www.bom.gov.au/images/bom_logo.gif</credit-logo>
  </product-source>
</head>
<nowcast-data>
  <time-layout time-coordinate="UTC">
    <start-valid-time>2005-11-22T00:50:00</start-valid-time>
    <end-valid-time>2005-11-22T01:10:00</end-valid-time>
  </time-layout>
  <event ID="1">
    <case>
      <time time-coordinate="UTC">2005-11-22T00:55:39</time>
      <location>
        <area>
          <ellipse>
            <moving-point type="centroid">
              <latitude>-33.9154</latitude>
              <longitude>149.9629</longitude>
              <polar-motion>
                <speed units="km h-1">18.654</speed>
                <direction_to units="degrees true">107.981</direction_to>
              </polar-motion>
            </moving-point>
            <major_axis units="km">5.40467</major_axis>
            <minor_axis units="km">3.61102</minor_axis>
            <orientation units="degrees true">51.3226</orientation>
          </ellipse>
```

```xml
      </area>
    </location>
    <nowcast-parameters>
      <ID_child units="none">3</ID_child>
      <reflectivity_threshold units="dbz">35</reflectivity_threshold>
      <volume_threshold units="km3">30</volume_threshold>
      <height_threshold units="km">3</height_threshold>
      <cell_volume units="km3">218.953</cell_volume>
      <cell_top units="km">6.625</cell_top>
      <projected_area units="km2">61.3125</projected_area>
      <mean_area units="km2">36.4922</mean_area>
      <max_dbz units="dbz">51</max_dbz>
      <height_max_dbz units="km">4</height_max_dbz>
      <VIL units="kg m-2">11.2023</VIL>
      <storm_intensity units="category">2</storm_intensity>
      <hail_probability units="percent">
        <value threshold_value="0" threshold_units="mm">30</value>
      </hail_probability>
      <hail_mass units="kg">0.313052</hail_mass>
      <hail_mass_aloft units="kg">0</hail_mass_aloft>
    </nowcast-parameters>
  </case>
  <case>
    <time time-coordinate="UTC">2005-11-22T01:05:41</time>
    <location>
      <area>
        <ellipse>
          <moving-point type="centroid">
            <latitude>-33.9124</latitude>
            <longitude>150.0103</longitude>
            <polar-motion>
              <speed units="km h-1">22.3681</speed>
              <direction_to units="degrees true">93.6247</direction_to>
            </polar-motion>
          </moving-point>
          <major_axis units="km">4.78264</major_axis>
          <minor_axis units="km">3.48168</minor_axis>
          <orientation units="degrees true">35.3648</orientation>
        </ellipse>
      </area>
    </location>
    <nowcast-parameters>
      <ID_child units="none">3</ID_child>
      <reflectivity_threshold units="dbz">35</reflectivity_threshold>
      <volume_threshold units="km3">30</volume_threshold>
      <height_threshold units="km">3</height_threshold>
      <cell_volume units="km3">162.844</cell_volume>
      <cell_top units="km">6.625</cell_top>
      <projected_area units="km2">52.3125</projected_area>
      <mean_area units="km2">27.1406</mean_area>
      <max_dbz units="dbz">49.5</max_dbz>
```

```xml
        <height_max_dbz units="km">1</height_max_dbz>
        <VIL units="kg m-2">7.5417</VIL>
        <storm_intensity units="category">2</storm_intensity>
        <hail_probability units="percent">
          <value threshold_value="0" threshold_units="mm">0</value>
        </hail_probability>
        <hail_mass units="kg">0.166683</hail_mass>
        <hail_mass_aloft units="kg">0</hail_mass_aloft>
      </nowcast-parameters>
    </case>
  </event>
  <event ID="2">
    <case>
      <time time-coordinate="UTC">2005-11-22T01:05:41</time>
      <location>
        <area>
          <ellipse>
            <moving-point type="centroid">
              <latitude>-33.9214</latitude>
              <longitude>150.0976</longitude>
              <polar-motion>
                <speed units="km h-1">0</speed>
                <direction_to units="degrees true">0</direction_to>
              </polar-motion>
            </moving-point>
            <major_axis units="km">3.9329</major_axis>
            <minor_axis units="km">2.59498</minor_axis>
            <orientation units="degrees true">29.9059</orientation>
          </ellipse>
        </area>
      </location>
      <nowcast-parameters>
        <ID_child units="none">3</ID_child>
        <ID_child units="none">4</ID_child>
        <reflectivity_threshold units="dbz">35</reflectivity_threshold>
        <volume_threshold units="km3">30</volume_threshold>
        <height_threshold units="km">3</height_threshold>
        <cell_volume units="km3">79.3125</cell_volume>
        <cell_top units="km">5.125</cell_top>
        <projected_area units="km2">32.0625</projected_area>
        <mean_area units="km2">17.625</mean_area>
        <max_dbz units="dbz">48</max_dbz>
        <height_max_dbz units="km">1</height_max_dbz>
        <VIL units="kg m-2">5.48846</VIL>
        <storm_intensity units="category">0</storm_intensity>
        <hail_probability units="percent">
          <value threshold_value="0" threshold_units="mm">0</value>
        </hail_probability>
        <hail_mass units="kg">0.107068</hail_mass>
        <hail_mass_aloft units="kg">0</hail_mass_aloft>
      </nowcast-parameters>
```

```
      </case>
    </event>
</nowcast-data>
</wxml>
```

Figure 2. Sample XML output for a TITAN nowcast.