

Interface Control Document

for

TITAN Storms (TSTORMS)

XML format

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TSTORMS XML Interface Control Document

1 Introduction

The Thunderstorm Identification, Tracking, Analysis and Nowcasting (TITAN) application identifies thunderstorms in 3-D radar data, tracks the storms from one radar volume time to the next, and then makes forecasts based on the extrapolation of storm motion.

Documentation on TITAN may be found at:

<http://www.rap.ucar.edu/projects/titan/home>

TITAN uses a rather complicated set of binary-format files for storing storm property and forecast data. These files are not generally suitable for export to users. Therefore a simple XML format has been developed to describe the TITAN forecasts and export them .

This document describes the TITAN storms (TSTORMS) XML format.

2 TSTORMS concepts

2.1 Storm tracking and forecasts

TITAN runs on volumetric 2-D or 3-D radar data. These volumes form a time sequence, normally at about 5-minute intervals.

TITAN identifies the storms in a radar volume, and then logically associates these storms with those which occurred in the previous volume. In this manner the storms are grouped into storm tracks, i.e. storms in a time sequence. TITAN computes the movement of the storms and the change in their size and severity. This allows TITAN to produce a forecast, based on the extrapolation of the recent behavior of the observed tracks. (Extrapolation-based forecasts are often referred to as ‘nowcasts’.)

2.2 Storm data

The main part of the XML file is the `storm-data` section.

`storm-data` contains the following:

- `observation-time`: the time of the radar data on which this file is based.
- `dbz-threshold`: the radar reflectivity threshold used to identify the storms.
- an array of `storm` objects.

The number of storm objects can be 0, if there are no storms present. There is no maximum number. The actual number depends on the weather at the observation time.

2.3 Storm instance attributes

For a given radar volume (i.e. at a particular time), TITAN will identify all of the storms.

TITAN will then attempt to associate each storm in the current volume with a storm in the previous volume. If this is successful, the storm will be tagged with the same **ID** as the storm in the previous volume. If not, the storm will be given a new, unique **ID**.

A storm which has been identified at a particular time are referred to as an **instance** of the storm.

An instance has a **relative-time** attribute, which can take the values **current**, **forecast** or **history**.

- for a given radar volume (i.e. at a particular time), TITAN will identify the storms. These are referred to as the **current** instances of the storms for that volume.
- based on the previous storm behavior, and the behavior of other storms which are close by, TITAN will make a forecast for the identified storms. These are referred to as the **forecast** instances of the storm.
- storms with the same ID from previous volumes are referred to as **history** instance of the storm.

2.4 Storm instance properties

Each storm instance has a number of main properties:

- **time**
- **location**
- **storm-parameters**

2.4.1 Storm time

This is always in UTC time coordinates.

2.4.2 Storm location

Since storms extend over some spatial area, the storm location is wrapped in an **area** object.

Within the **area** object are two possible descriptions of the storm in space:

- **ellipse**
- **polygon**

2.4.3 Storm parameters

The following storm parameters are supported:

- **age**: the storm age, in seconds, up to this time.
- **cell_top**: the storm radar top, in km.
This is the maximum height of the **dbz-threshold** reflectivity used to identify the storm. The actual storm top will be higher.
- **max_dbz**: the maximum radar reflectivity, in dBZ, in the storm.

2.5 Ellipse properties

Each ellipse has the following properties:

- **moving-point**: the moving centroid of the storm. A moving point has both location and motion. The location is specified by **latitude** and **longitude**. The motion is specified by **polar_motion**, which has the properties **speed** and **direction_to**.
- **major_axis**: the length of the major axis of the ellipse, in km.
- **minor_axis**: the length of the minor axis of the ellipse, in km.
- **orientation**: the orientation of the major axis, relative to True North, in degrees.

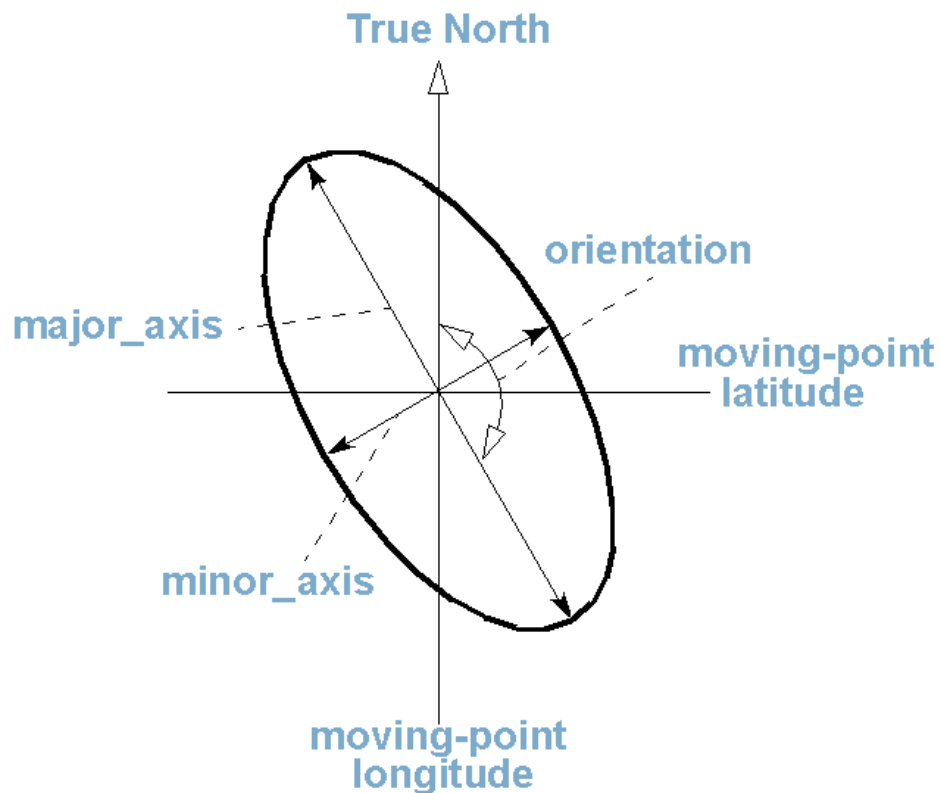


Figure 1 Ellipse properties

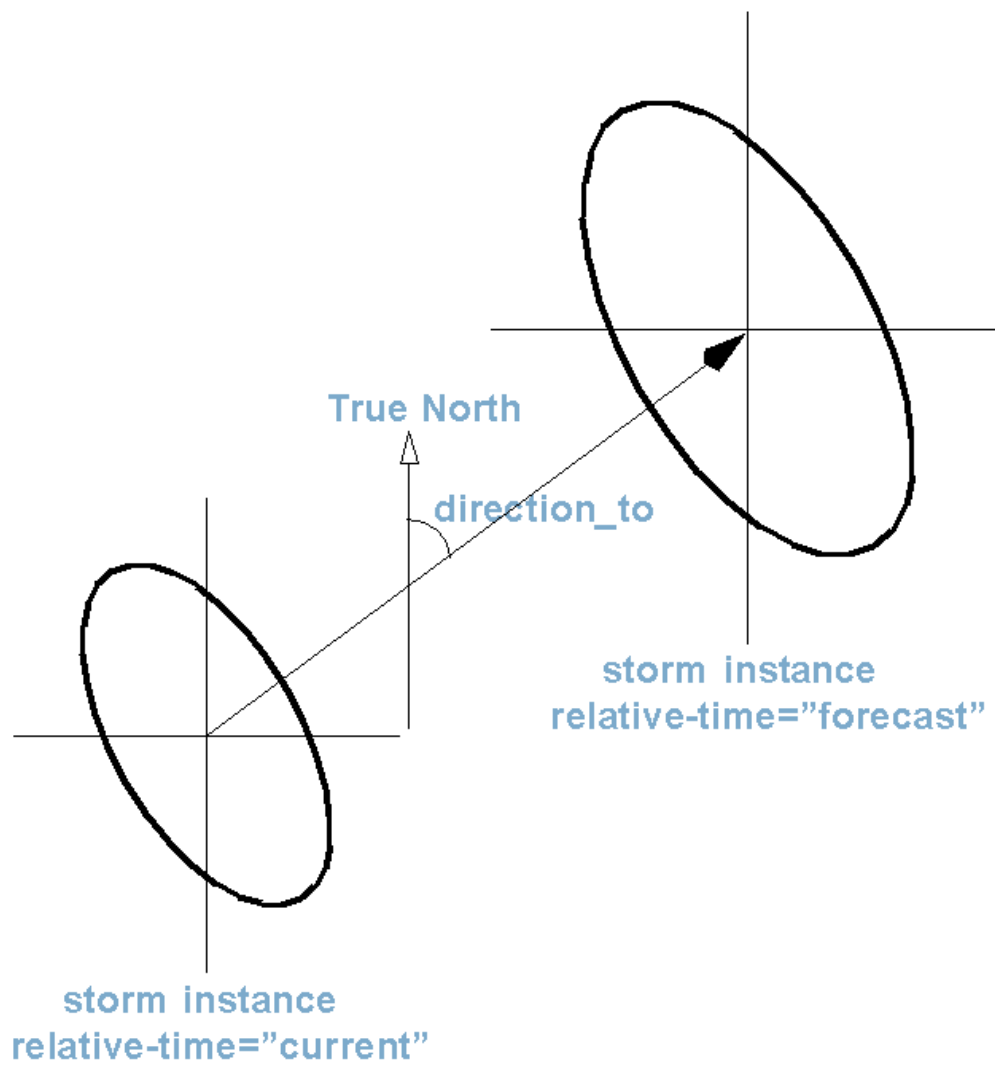


Figure 2 Storm current and forecast properties, using ellipses

2.6 Polygon properties

Each polygon has the following properties:

- **npoints**: attribute indicating the number of points
- **moving-point**: the moving centroid of the storm. A moving point has both location and motion. The location is specified by **latitude** and **longitude**. The motion is specified by **polar_motion**, which has the properties **speed** and **direction_to**.
- array of **point** objects

Each point object has two attributes, **latitude** and **longitude**.

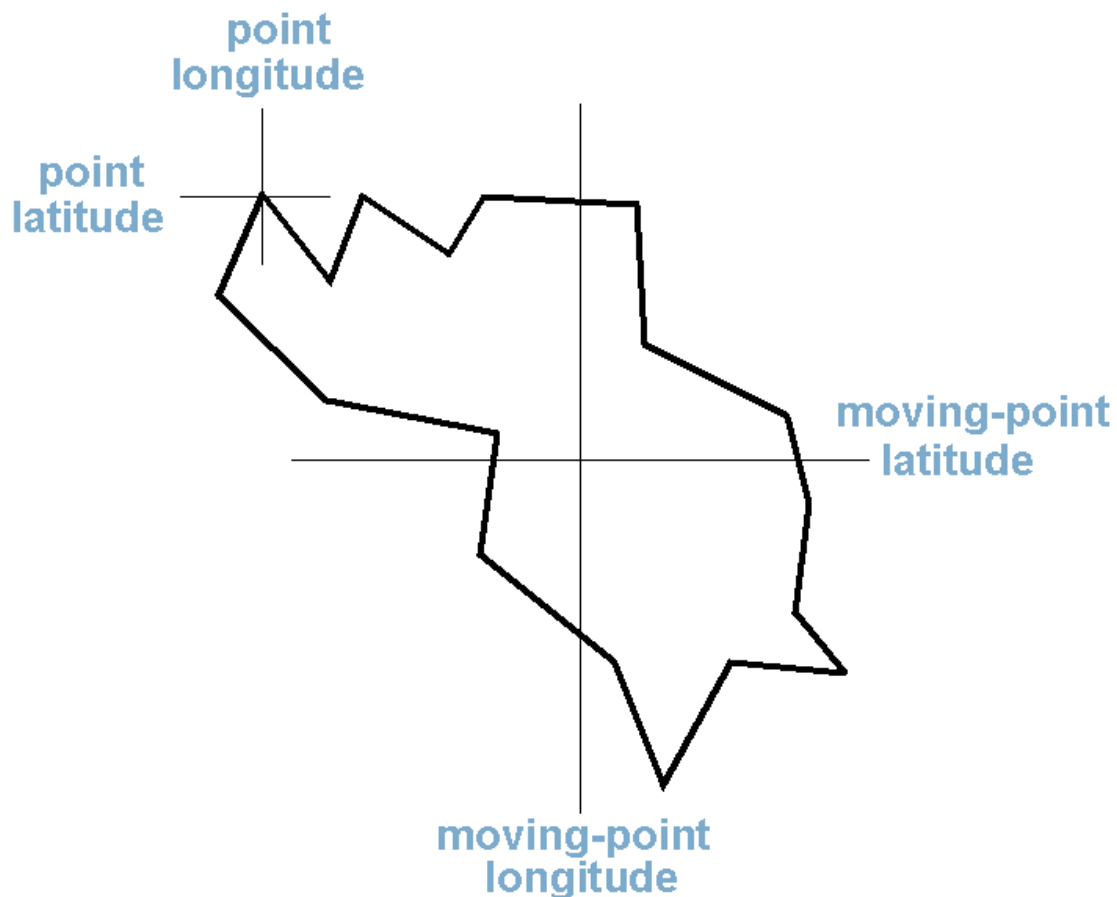


Figure 3 Storm polygon properties

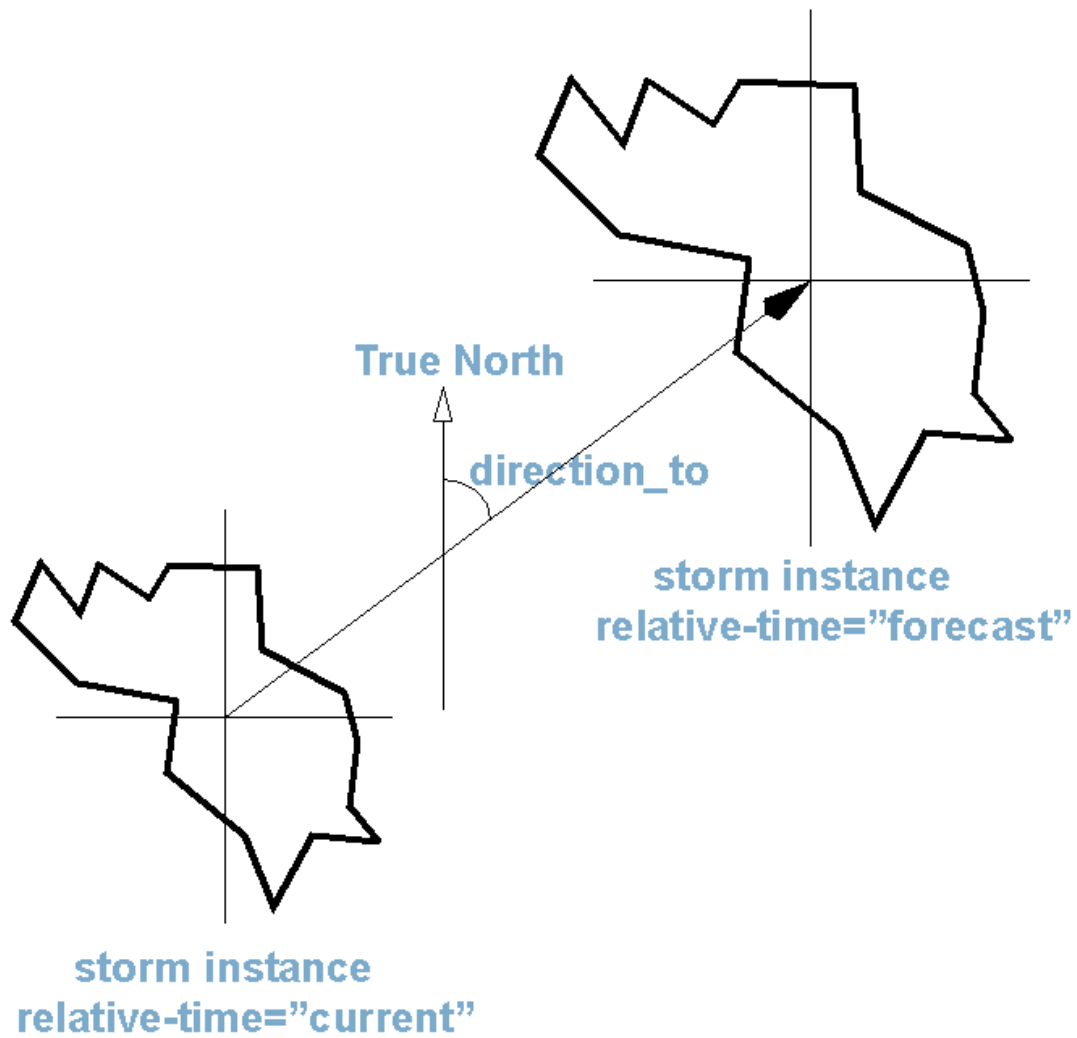


Figure 4 Storm current and forecast properties, using polygons

3 File naming convention

Each Tstorms XML file contains data anchored at a single time. In the XML file this is referred to as the **observation-time**.

The file name is based on that time:

`data_dir/yyyymmdd/yyyymmdd_hhmmss.tstorms.xml`

4 XML schema

4.1 Schema location

The TSTORMS XML meta-data conforms to an XML schema which is published on the web at:

<http://www.ral.ucar.edu/xml/schemas/tstorms.1.0.xsd>

4.2 Schema text

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:annotation>    <xs:documentation>    SCHEMA for TITAN STORMS XML format
RAL, NCAR    </xs:documentation>  </xs:annotation>
  <xs:element name="tstorms">
    <xs:complexType>    <xs:sequence>
      <xs:element ref="head"/>
      <xs:element ref="storm-data"/>
    </xs:sequence>
    <xs:attribute name="version" use="required" type="xs:decimal"/>
  </xs:complexType>
</xs:element>

<xs:element name="head">
  <xs:complexType>
    <xs:all>
      <xs:element ref="system"/>
      <xs:element ref="title"/>
      <xs:element ref="product-description"/>
      <xs:element ref="time-coordinate"/>
      <xs:element ref="write-time"/>
    </xs:all>
  </xs:complexType>
</xs:element>

<xs:element name="system" type="xs:NCName"/>
<xs:element name="title" type="xs:string"/>
<xs:element name="product-description" type="xs:string"/>

<xs:element name="time-coordinate" type="xs:NCName"/>
<xs:element name="write-time" type="xs:dateTime"/>

<xs:element name="storm-data">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="observation-time"/>
      <xs:element ref="dbz-threshold"/>
      <xs:element maxOccurs="unbounded" ref="storm"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>

<xs:element name="observation-time" type="xs:dateTime"/>
<xs:element name="dbz-threshold" type="xs:decimal"/>

<xs:element name="storm">
```

```

    <xs:complexType>
      <xs:sequence>
        <xs:element maxOccurs="unbounded" ref="instance"/>
      </xs:sequence>
      <xs:attribute name="ID" use="required" type="xs:integer"/>
    </xs:complexType>
  </xs:element>

  <xs:element name="instance">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="time"/>
        <xs:element ref="location"/>
        <xs:element ref="storm-parameters"/>
      </xs:sequence>
      <xs:attribute name="relative-time" use="required" type="relative-
time_enum"/>
    </xs:complexType>
  </xs:element>

  <xs:element name="time" type="xs:dateTime"/>

  <xs:element name="relative-time" type="relative-time_enum"/>
  <xs:simpleType name = "relative-time_enum">
    <xs:annotation>
      <xs:documentation>
        relative-time indicates wether this is current data, forecast
        data or data from the past.
      </xs:documentation>
    </xs:annotation>
    <xs:restriction base = "xs:string">
      <xs:enumeration value = "history"/>
      <xs:enumeration value = "current"/>
      <xs:enumeration value = "forecast"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:element name="location">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="area"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>

  <xs:element name="area">
    <xs:complexType>
      <xs:all>
        <xs:element ref="ellipse"/>
        <xs:element ref="polygon"/>
      </xs:all>
    </xs:complexType>
  </xs:element>

  <xs:element name="ellipse">
    <xs:complexType>
      <xs:all>
        <xs:element ref="moving-point"/>
        <xs:element ref="major_axis"/>

```

```
<xs:element ref="minor_axis"/>
<xs:element ref="orientation"/>
</xs:all>
</xs:complexType>
</xs:element>

<xs:element name="major_axis">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:decimal">
        <xs:attribute name="units" use="required" type="xs:NCName"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

<xs:element name="minor_axis">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:decimal">
        <xs:attribute name="units" use="required" type="xs:NCName"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

<xs:element name="orientation">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:double">
        <xs:attribute name="units" use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

<xs:element name="polygon">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="moving-point"/>
      <xs:element ref="point" maxOccurs="73"/>
    </xs:sequence>
    <xs:attribute ref="npoints"/>
  </xs:complexType>
</xs:element>
<xs:attribute name="npoints" type="xs:integer"/>

<xs:element name="point">
  <xs:complexType>
    <xs:attribute name="latitude" use="required" type="xs:decimal"/>
    <xs:attribute name="longitude" use="required" type="xs:decimal"/>
  </xs:complexType>
</xs:element>

<xs:element name="storm-parameters">
  <xs:complexType>
    <xs:all>
      <xs:element ref="ID_child" minOccurs="0"/>
      <xs:element ref="ID_parent" minOccurs="0"/>
    </xs:all>
  </xs:complexType>
</xs:element>
```

```
<xs:element ref="age"/>
<xs:element ref="cell_top"/>
<xs:element ref="max_dbz"/>
</xs:all>
</xs:complexType>
</xs:element>

<xs:element name="ID_child">
  <xs:complexType mixed="true">
    <xs:attribute name="units" use="required" type="xs:NCName"/>
  </xs:complexType>
</xs:element>

<xs:element name="ID_parent">
  <xs:complexType mixed="true">
    <xs:attribute name="units" use="required" type="xs:NCName"/>
  </xs:complexType>
</xs:element>

<xs:element name="age">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:integer">
        <xs:attribute name="units" use="required" type="xs:NCName"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

<xs:element name="cell_top">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:decimal">
        <xs:attribute name="units" use="required" type="xs:NCName"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

<xs:element name="max_dbz">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:decimal">
        <xs:attribute name="units" use="required" type="xs:NCName"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

<xs:element name="moving-point">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="latitude"/>
      <xs:element ref="longitude"/>
      <xs:element ref="polar_motion"/>
    </xs:sequence>
    <xs:attribute name="type" use="required" type="xs:NCName"/>
  </xs:complexType>
</xs:element>
```

```

<xs:element name="latitude" type="xs:decimal"/>
<xs:element name="longitude" type="xs:decimal"/>

<xs:element name="polar_motion">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="speed"/>
      <xs:element ref="direction_to"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>

<xs:element name="speed">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:decimal">
        <xs:attribute name="units" use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

<xs:element name="direction_to">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:decimal">
        <xs:attribute name="units" use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>

</xs:schema>

```

5 Example of TSTORMS XML file

The following example file contains 2 storms. For each storm there are 3 instances, one current instance and 2 forecast instances.

The polygons in these storms have been smoothed. Therefore the number of points is less than the maximum of 73.

```

<?xml version="1.0" ?>
<tstorms xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" version="1.0"
xsi:schemaLocation="http://www.ral.ucar.edu/xml/schemas/
http://www.ral.ucar.edu/xml/schemas/tstorms.1.0.xsd">
<head>
  <system>TITAN</system>
  <title>TITAN Thunderstorm Tracks</title>
  <product-description>TITAN on SAWS Radar mosaic</product-description>
  <time-coordinate>UTC</time-coordinate>
  <write-time>2008-01-26T02:23:37</write-time>

```

```
</head>
<storm-data>
  <observation-time>2008-01-04T00:00:00</observation-time>
  <dbz-threshold>35</dbz-threshold>
  <storm ID="2">
    <instance relative-time="current">
      <time>2008-01-04T00:00:00</time>
      <location>
        <area>
          <ellipse>
            <moving-point type="centroid">
              <latitude>-26.3117</latitude>
              <longitude> 29.7217</longitude>
              <polar_motion>
                <speed units="km h-1">27.133</speed>
                <direction_to units="degrees true">70.0176</direction_to>
              </polar_motion>
            </moving-point>
            <major_axis units="km">0.034208</major_axis>
            <minor_axis units="km">0.0258476</minor_axis>
            <orientation units="degrees true">158.234</orientation>
          </ellipse>
          <polygon npoints="15">
            <moving-point type="centroid">
              <latitude>-26.3117</latitude>
              <longitude> 29.7217</longitude>
              <polar_motion>
                <speed units="km h-1">27.133</speed>
                <direction_to units="degrees true">70.0176</direction_to>
              </polar_motion>
            </moving-point>
            <point latitude="-26.2750" longitude="29.7249" />
            <point latitude="-26.2916" longitude="29.7417" />
            <point latitude="-26.3085" longitude="29.7583" />
            <point latitude="-26.3149" longitude="29.7583" />
            <point latitude="-26.3250" longitude="29.7583" />
            <point latitude="-26.3403" longitude="29.7417" />
            <point latitude="-26.3416" longitude="29.7390" />
            <point latitude="-26.3417" longitude="29.7357" />
            <point latitude="-26.3418" longitude="29.7243" />
            <point latitude="-26.3418" longitude="29.7190" />
            <point latitude="-26.3417" longitude="29.6916" />
            <point latitude="-26.2816" longitude="29.6916" />
            <point latitude="-26.2759" longitude="29.6917" />
            <point latitude="-26.2749" longitude="29.6959" />
            <point latitude="-26.2750" longitude="29.7249" />
          </polygon>
        </area>
      </location>
      <storm-parameters>
        <age units="seconds">4200</age>
        <cell_top units="km">6.5</cell_top>
        <max_dbz units="dbz">44.5</max_dbz>
      </storm-parameters>
    </instance>
    <instance relative-time="forecast">
      <time>2008-01-04T00:30:00</time>
      <location>
        <area>
```

```

<ellipse>
  <moving-point type="centroid">
    <latitude>-26.2699</latitude>
    <longitude> 29.8495</longitude>
    <polar_motion>
      <speed units="km h-1">27.133</speed>
      <direction_to units="degrees true">70.0176</direction_to>
    </polar_motion>
  </moving-point>
  <major_axis units="km">0.034208</major_axis>
  <minor_axis units="km">0.0258476</minor_axis>
  <orientation units="degrees true">158.234</orientation>
</ellipse>
<polygon npoints="15">
  <moving-point type="centroid">
    <latitude>-26.2699</latitude>
    <longitude> 29.8495</longitude>
    <polar_motion>
      <speed units="km h-1">27.133</speed>
      <direction_to units="degrees true">70.0176</direction_to>
    </polar_motion>
  </moving-point>
  <point latitude="-26.2333" longitude="29.8527" />
  <point latitude="-26.2499" longitude="29.8696" />
  <point latitude="-26.2667" longitude="29.8862" />
  <point latitude="-26.2731" longitude="29.8862" />
  <point latitude="-26.2833" longitude="29.8862" />
  <point latitude="-26.2986" longitude="29.8696" />
  <point latitude="-26.2999" longitude="29.8668" />
  <point latitude="-26.2999" longitude="29.8635" />
  <point latitude="-26.3000" longitude="29.8522" />
  <point latitude="-26.3000" longitude="29.8469" />
  <point latitude="-26.2999" longitude="29.8195" />
  <point latitude="-26.2399" longitude="29.8195" />
  <point latitude="-26.2342" longitude="29.8195" />
  <point latitude="-26.2332" longitude="29.8238" />
  <point latitude="-26.2333" longitude="29.8527" />
</polygon>
</area>
</location>
<storm-parameters>
  <age units="seconds">4200</age>
  <cell_top units="km">6.5</cell_top>
  <max_dbz units="dbz">44.5</max_dbz>
</storm-parameters>
</instance>
<instance relative-time="forecast">
  <time>2008-01-04T01:00:00</time>
  <location>
    <area>
      <ellipse>
        <moving-point type="centroid">
          <latitude>-26.2281</latitude>
          <longitude> 29.9773</longitude>
          <polar_motion>
            <speed units="km h-1">27.133</speed>
            <direction_to units="degrees true">70.0176</direction_to>
          </polar_motion>
        </moving-point>

```



```
<major_axis units="km">0.034208</major_axis>
<minor_axis units="km">0.0258476</minor_axis>
<orientation units="degrees true">158.234</orientation>
</ellipse>
<polygon npoints="15">
  <moving-point type="centroid">
    <latitude>-26.2281</latitude>
    <longitude> 29.9773</longitude>
    <polar_motion>
      <speed units="km h-1">27.133</speed>
      <direction_to units="degrees true">70.0176</direction_to>
    </polar_motion>
  </moving-point>
  <point latitude="-26.1914" longitude="29.9805" />
  <point latitude="-26.2080" longitude="29.9974" />
  <point latitude="-26.2249" longitude="30.0139" />
  <point latitude="-26.2313" longitude="30.0139" />
  <point latitude="-26.2414" longitude="30.0139" />
  <point latitude="-26.2567" longitude="29.9973" />
  <point latitude="-26.2580" longitude="29.9946" />
  <point latitude="-26.2581" longitude="29.9913" />
  <point latitude="-26.2581" longitude="29.9799" />
  <point latitude="-26.2581" longitude="29.9747" />
  <point latitude="-26.2581" longitude="29.9473" />
  <point latitude="-26.1980" longitude="29.9473" />
  <point latitude="-26.1923" longitude="29.9473" />
  <point latitude="-26.1913" longitude="29.9516" />
  <point latitude="-26.1914" longitude="29.9805" />
</polygon>
</area>
</location>
<storm-parameters>
  <age units="seconds">4200</age>
  <cell_top units="km">6.5</cell_top>
  <max_dbz units="dbz">44.5</max_dbz>
</storm-parameters>
</instance>
</storm>
<storm ID="39">
  <instance relative-time="current">
    <time>2008-01-04T00:00:00</time>
    <location>
      <area>
        <ellipse>
          <moving-point type="centroid">
            <latitude>-28.0958</latitude>
            <longitude> 27.6771</longitude>
            <polar_motion>
              <speed units="km h-1">30.2115</speed>
              <direction_to units="degrees true">121.323</direction_to>
            </polar_motion>
          </moving-point>
          <major_axis units="km">0.0667027</major_axis>
          <minor_axis units="km">0.0530229</minor_axis>
          <orientation units="degrees true">166.551</orientation>
        </ellipse>
        <polygon npoints="17">
          <moving-point type="centroid">
            <latitude>-28.0958</latitude>
```

```

    <longitude> 27.6771</longitude>
    <polar_motion>
      <speed units="km h-1">30.2115</speed>
      <direction_to units="degrees true">121.323</direction_to>
    </polar_motion>
  </moving-point>
  <point latitude="-28.0251" longitude="27.6771" />
  <point latitude="-28.0249" longitude="27.6896" />
  <point latitude="-28.0417" longitude="27.7225" />
  <point latitude="-28.0479" longitude="27.7250" />
  <point latitude="-28.0958" longitude="27.7415" />
  <point latitude="-28.1015" longitude="27.7416" />
  <point latitude="-28.1193" longitude="27.7417" />
  <point latitude="-28.1250" longitude="27.7397" />
  <point latitude="-28.1584" longitude="27.7063" />
  <point latitude="-28.1748" longitude="27.6702" />
  <point latitude="-28.1749" longitude="27.6631" />
  <point latitude="-28.1571" longitude="27.6417" />
  <point latitude="-28.1396" longitude="27.6249" />
  <point latitude="-28.0562" longitude="27.6084" />
  <point latitude="-28.0477" longitude="27.6083" />
  <point latitude="-28.0417" longitude="27.6125" />
  <point latitude="-28.0251" longitude="27.6771" />
</polygon>
</area>
</location>
<storm-parameters>
  <age units="seconds">5100</age>
  <cell_top units="km">10.5</cell_top>
  <max_dbz units="dbz">48.5</max_dbz>
</storm-parameters>
</instance>
<instance relative-time="forecast">
  <time>2008-01-04T00:30:00</time>
  <location>
    <area>
      <ellipse>
        <moving-point type="centroid">
          <latitude>-28.1664</latitude>
          <longitude> 27.8087</longitude>
          <polar_motion>
            <speed units="km h-1">30.2115</speed>
            <direction_to units="degrees true">121.323</direction_to>
          </polar_motion>
        </moving-point>
        <major_axis units="km">0.0667027</major_axis>
        <minor_axis units="km">0.0530229</minor_axis>
        <orientation units="degrees true">166.551</orientation>
      </ellipse>
      <polygon npoints="17">
        <moving-point type="centroid">
          <latitude>-28.1664</latitude>
          <longitude> 27.8087</longitude>
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