"oaf" Product Specification

Michael Barall 01/20/2022

This document describes the "`oaf`" product that is used to transmit Operational Aftershock Forecasts to PDL, which in turn forwards them to Comcat. It is assumed that the reader has a working knowledge of PDL and Comcat, which are documented at:

https://usgs.github.io/pdl/index.html
https://earthquake.usgs.gov/data/comcat/

Type

`oaf`	The product type for Operational Aftershock Forecasts.

Source

`US`	USGS Earthquake Science Center, Moffett Field, California.

Properties

`eventsource`	The event network for the mainshock.
`eventsourcecode`	The event network code for the mainshock.
`review-status`	The value is "`reviewed`" if the product was submitted manually by an analyst. This property is omitted if the product was submitted by the automatic system.

Contents

`forecast.json`	Machine-readable, JSON-formatted file that contains the forecast. The format of this file is documented below. Note: Prior to January 2022, this file did not exist. Instead, the JSON-formatted file was stored inline in the product, using a

	filename of "" (*i.e.*, the empty string). The correct way to access the forecast is to first check if `forecast.json` exists, and then, if it does not exist, look for the inline file.
`forecast_data.json`	Technical data and parameters used to compute the forecast. This file is primarily for assessing the performance of the OAF system, and its format is likely to change as the system evolves.

Format of `forecast.json`

The forecast is supplied as a JSON-formatted file. An example of a `forecast.json` file is appended at the end of this document. JSON is a simple file format for data interchange, which is documented here:

https://www.json.org/json-en.html

The `forecast.json` file contains a single JSON object, which contains several key/value pairs. Some of the values are themselves JSON objects or arrays, which means that key/value pairs can be nested several levels deep.

The top-level key/value pairs in `forecast.json` are described in the following table.

Table 1: Top-level key/value pairs.	
`creationTime`	The time at which the forecast was created. The value is an integer giving the number of milliseconds since midnight on January 1, 1970.
`expireTime`	The end time of the longest forecast contained in the file, which generally is one year in the future. The value is an integer giving the number of milliseconds since midnight on January 1, 1970.
`advisoryTimeFrame`	A text string which expresses the amount of time that the forecast advisory is in effect. It can be one of: "`1 Day`", "`1 Week`", "`1 Month`", or "`1 Year`". In practice, the "`1 Day`" value is never used.
`template`	A text string which is used to select one of several layouts for the earthquake event page. For most forecasts it is "`Mainshock`". Other possibilities are "`Earthquake of Interest`" which is sometimes used for one-time manual forecasts, and "`Swarm`".
`injectableText`	A text string that is included in the Commentary section of the earthquake event page. An analyst can use this to provide additional information about the aftershock sequence. It is an empty string, "", if no injectable text is supplied.
`observations`	An array that summarizes the aftershocks that have been observed so far. Each element of the array is an object that contains the key/value pairs described in Table 2. Some of the observations appear in the Commentary section of the event page.

`model`	An object that contains a description of the statistical model used to construct the forecast. Table 3 describes the key/value pairs that appear in this object. This information is used to construct the Model section of the event page.
`forecast`	A table that gives the forecasted number of earthquakes for various time periods and magnitudes. At present, the time periods are 1 day, 1 week, 1 month (defined to be 30 days), and 1 year (defined to be 365 days). The magnitudes are 3, 4, 5, 6, and 7; and larger than the mainshock. The value of `forecast` is an array. Each element of the array corresponds to one time period, and contains the forecasts for that time period, as described in Table 5. This information is used to construct the Forecast section of the event page, plus some of the information in the Commentary section.
`nextForecastTime`	The time at which the next forecast is scheduled to occur. The value is an integer giving the number of milliseconds since midnight on January 1, 1970. The value is `-1` if no additional forecasts are scheduled. Note: Prior to January 2022, this key/value pair was not included, and so `advisoryTimeFrame` was used calculate the next update time that was displayed on the event page.

Each element of the `observations` array contains information about the aftershocks that have occurred so far, as described in the following table.

Table 2: Key/value pairs that appear within the `observations` array.	
`magnitude`	An aftershock magnitude. Currently this will be 3, 4, 5, 6, or 7.
`count`	The number of aftershocks observed so far, whose magnitude is at least as large as the value of `magnitude`.

The `model` object contains information about the statistical model used to create the forecast, as described in the following table.

Table 3: Key/value pairs that appear within the `model` object.	
`name`	A text string that identifies the statistical model used.
`reference`	A placeholder for the URL of a page that describes the statistical model. Currently the value is "`#url`" which indicates that no URL is provided.
`parameters`	The parameter values used in the statistical model. This is an object that contains a set of key/value pairs as shown in Table 4.

The `parameters` object contains parameter values for the statistical model. The following table shows the parameters that may currently appear. This list changes over time, as the system evolves, and as more statistical models are introduced. Some parameters are optional, depending on the statistical model chosen and on other parameters.

Table 4: Key/value pairs that appear within the `parameters` object.	
`a`	Reasenberg-Jones a-value, which is productivity.
`b`	Gutenberg-Richter b-value.
`magMain`	The mainshock magnitude.
`p`	Omori exponent p, used in Reasenberg-Jones models.
`c`	Omori c-value, used in Reasenberg-Jones models.
`aSigma`	Standard deviation of the Reasenberg-Jones a-value.
`pSigma`	Standard deviation of the Omori exponent p, used in Reasenberg-Jones models.
`Mc`	Catalog magnitude of completeness, for time-independent magnitude of completeness. Note that for large mainshocks, this may be larger than the configured value in order to limit the number of aftershocks processed.
`Mcat`	Normal catalog magnitude of completeness, for modeling time-dependent magnitude of completeness. Note that for large mainshocks, this may be larger than the configured value in order to limit the number of aftershocks processed.
`F`	F-parameter for modeling time-dependent magnitude of completeness.

G	G-parameter for modeling time-dependent magnitude of completeness.
H	H-parameter for modeling time-dependent magnitude of completeness.
regionType	The type of region used to collect aftershocks. It is either "circle" or "rectangle". So far all regions have been circular.
regionCenterLat	For a circular region, the latitude of the center of the circle, in degrees.
regionCenterLon	For a circular region, the longitude of the center of the circle, in degrees.
regionRadius	For a circular region, the radius of the circle, in kilometers.
regionSouthLat	For a rectangular region, the latitude of the south side of the rectangle, in degrees.
regionNorthLat	For a rectangular region, the latitude of the north side of the rectangle, in degrees.
regionWestLon	For a rectangular region, the longitude of the west side of the rectangle, in degrees.
regionEastLon	For a rectangular region, the longitude of the east side of the rectangle, in degrees. Note that if the rectangle crosses the date line, then regionEastLon will be less than regionWestLon.

Each element in the forecast array represents one time period: 1 day, 1 week, 1 month, or 1 year. The key/value pairs appearing in each array element are shown in the following table.

Table 5: Key/value pairs that appear within each element of the forecast array.	
timeStart	The start of the time period. The value is an integer giving the number of milliseconds since midnight on January 1, 1970. Note that all elements of the forecast array have the same start time.
timeEnd	The end of the time period. The value is an integer giving the number of milliseconds since midnight on January 1, 1970. At present, it will be either 1 day, 1 week, 1 month, or 1 year after the start time.

`label`	A text string that describes the time period. Currently it is either "`1 Day`", "`1 Week`", "`1 Month`", or "`1 Year`".
`bins`	An array. Each element of the array corresponds to one aftershock magnitude, and contains the forecast for aftershocks of that magnitude or larger, within the current time period, as described in Table 6.
`aboveMainshockMag`	An object, that contains the forecast for aftershocks larger than the mainshock magnitude, as described in Table 7.

Each element in the `bins` array represents one aftershock magnitude, currently 3, 4, 5, 6, or 7. It contains the forecast for aftershocks of that magnitude or larger, within the relevant time period. The key/value pairs appearing in each array element are shown in the following table.

Table 6: Key/value pairs that appear within each element of the `bins` array.	
`magnitude`	The magnitude. Currently it is 3, 4, 5, 6, or 7.
`p95minimum`	An integer, giving the lower limit of the 95% confidence interval.
`p95maximum`	An integer, giving the upper limit of the 95% confidence interval. It is forecasted that there is a 95% probability that the number of aftershocks, with the given magnitude or larger, within the relevant time period, lies between `p95minimum` and `p95maximum` inclusive.
`probability`	A floating-point number. It is the forecasted probability that at least one aftershock, with the given magnitude or larger, occurs within the relevant time period.
`median`	An integer. It is the forecasted median number of aftershocks, with the given magnitude or larger, within the relevant time period. Note: Prior to January 2022, the `median` key/value pair was not included.

The `aboveMainshockMag` object contains the forecast for aftershocks larger than the mainshock, within the relevant time period. The key/value pairs appearing in the object are shown in the following table.

Table 7: Key/value pairs that appear within the `aboveMainshockMag` object.	
`magnitude`	The magnitude of the mainshock
`probability`	A floating-point number. It is the forecasted probability that at least one aftershock, with magnitude larger than the mainshock, occurs within the relevant time period.

Example of `forecast.json`


```
{
  "creationTime": 1642446558242,
  "expireTime": 1673985600000,
  "advisoryTimeFrame": "1 Month",
  "template": "Mainshock",
  "injectableText": "",
  "observations": [
    {
      "magnitude": 3.0,
      "count": 496
    },
    {
      "magnitude": 4.0,
      "count": 93
    },
    {
      "magnitude": 5.0,
      "count": 16
    },
    {
      "magnitude": 6.0,
      "count": 2
    },
    {
      "magnitude": 7.0,
      "count": 0
    }
  ],
  "model": {
    "name": "Reasenberg-Jones (1989, 1994) aftershock model (Sequence
Specific)",
    "reference": "#url",
    "parameters": {
      "a": -3.33,
      "b": 1.0,
      "magMain": 8.2,
      "p": 1.01,
      "c": 0.018,
      "aSigma": 0.058,
      "pSigma": 0.0468,
      "regionType": "circle",
      "regionCenterLat": 55.2119,
```

```
    "regionCenterLon": -157.236,
    "regionRadius": 274.16
  }
},
"forecast": [
  {
    "timeStart": 1642449600000,
    "timeEnd": 1642536000000,
    "label": "1 Day",
    "bins": [
      {
        "magnitude": 3.0,
        "p95minimum": 0,
        "p95maximum": 2,
        "probability": 0.3435,
        "median": 0
      },
      {
        "magnitude": 4.0,
        "p95minimum": 0,
        "p95maximum": 1,
        "probability": 0.04142,
        "median": 0
      },
      {
        "magnitude": 5.0,
        "p95minimum": 0,
        "p95maximum": 0,
        "probability": 0.004223,
        "median": 0
      },
      {
        "magnitude": 6.0,
        "p95minimum": 0,
        "p95maximum": 0,
        "probability": 4.232E-4,
        "median": 0
      },
      {
        "magnitude": 7.0,
        "p95minimum": 0,
        "p95maximum": 0,
        "probability": 4.233E-5,
        "median": 0
      }
    ],
```

```
  "aboveMainshockMag": {
    "magnitude": 8.2,
    "probability": 2.671E-6
  }
},
{
  "timeStart": 1642449600000,
  "timeEnd": 1643054400000,
  "label": "1 Week",
  "bins": [
    {
      "magnitude": 3.0,
      "p95minimum": 0,
      "p95maximum": 7,
      "probability": 0.9394,
      "median": 3
    },
    {
      "magnitude": 4.0,
      "p95minimum": 0,
      "p95maximum": 2,
      "probability": 0.2518,
      "median": 0
    },
    {
      "magnitude": 5.0,
      "p95minimum": 0,
      "p95maximum": 1,
      "probability": 0.0287,
      "median": 0
    },
    {
      "magnitude": 6.0,
      "p95minimum": 0,
      "p95maximum": 0,
      "probability": 0.002909,
      "median": 0
    },
    {
      "magnitude": 7.0,
      "p95minimum": 0,
      "p95maximum": 0,
      "probability": 2.913E-4,
      "median": 0
    }
  ],
```

```
  "aboveMainshockMag": {
    "magnitude": 8.2,
    "probability": 1.838E-5
  }
},
{
  "timeStart": 1642449600000,
  "timeEnd": 1645041600000,
  "label": "1 Month",
  "bins": [
    {
      "magnitude": 3.0,
      "p95minimum": 5,
      "p95maximum": 20,
      "probability": 1.0,
      "median": 11
    },
    {
      "magnitude": 4.0,
      "p95minimum": 0,
      "p95maximum": 4,
      "probability": 0.6852,
      "median": 1
    },
    {
      "magnitude": 5.0,
      "p95minimum": 0,
      "p95maximum": 1,
      "probability": 0.1107,
      "median": 0
    },
    {
      "magnitude": 6.0,
      "p95minimum": 0,
      "p95maximum": 0,
      "probability": 0.01168,
      "median": 0
    },
    {
      "magnitude": 7.0,
      "p95minimum": 0,
      "p95maximum": 0,
      "probability": 0.001174,
      "median": 0
    }
  ],
```

```
  "aboveMainshockMag": {
    "magnitude": 8.2,
    "probability": 7.411E-5
  }
},
{
  "timeStart": 1642449600000,
  "timeEnd": 1673985600000,
  "label": "1 Year",
  "bins": [
    {
      "magnitude": 3.0,
      "p95minimum": 52,
      "p95maximum": 123,
      "probability": 1.0,
      "median": 82
    },
    {
      "magnitude": 4.0,
      "p95minimum": 3,
      "p95maximum": 16,
      "probability": 0.9994,
      "median": 8
    },
    {
      "magnitude": 5.0,
      "p95minimum": 0,
      "p95maximum": 3,
      "probability": 0.5611,
      "median": 1
    },
    {
      "magnitude": 6.0,
      "p95minimum": 0,
      "p95maximum": 1,
      "probability": 0.08004,
      "median": 0
    },
    {
      "magnitude": 7.0,
      "p95minimum": 0,
      "p95maximum": 0,
      "probability": 0.008319,
      "median": 0
    }
  ],
```

```
      "aboveMainshockMag": {
        "magnitude": 8.2,
        "probability": 5.27E-4
      }
    }
  ],
  "nextForecastTime": 1645041600000
}
```