O3.1-256

Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans
Jonathan MacCarthy
Brady Spears

Los Alamos National Laboratory

Los Alamos NATIONAL LABORATORY

Presentation Date: 08 September 2025

This work was completed for the U.S. Department of Energy, National Nuclear Security Administration, Office of Nonproliferation and Arms Control by Los Alamos National Laboratory under award number 89233218CNA000001.
The views expressed here do not necessarily reflect the views of the United States Government, the United States Department of Energy, the National Nuclear Security Administration, or the Los Alamos National Laboratory.
LA-UR-25-28248

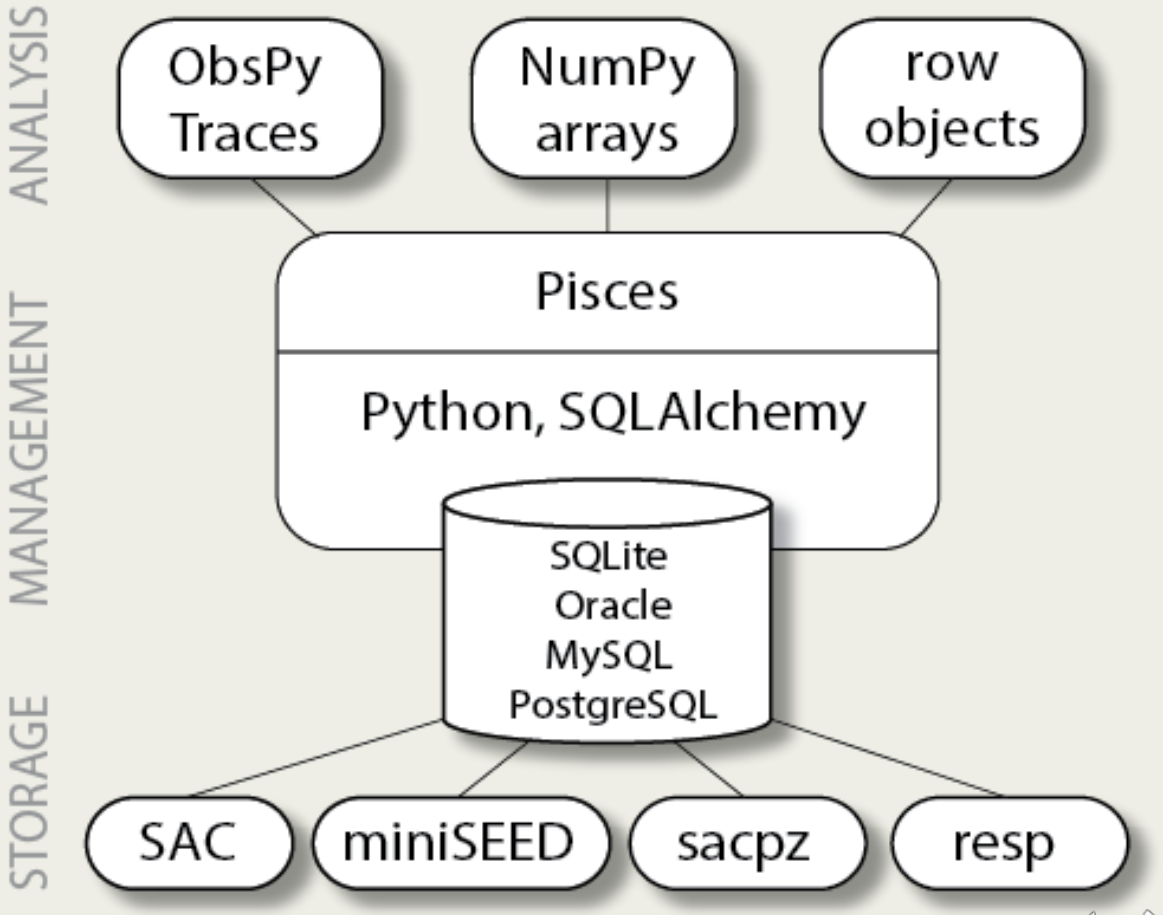
Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

What is Pisces?

- Pisces is a practical and extensible data management library for CSS3.0, KB Core, and Antelope databases that leverages existing widely used free and open-source technologies, such as SQL databases and Python
- Pisces interfaces with SQL databases through the open-source software SQL alchemy to construct and return queries specifically for CSS3-like schemas
- Pisces functionality includes the conversion of metadata from CSS3 tables to ObsPy objects such as Streams and Response objects with Catalog and Inventory objects in development



Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

PAZFIR Response Files

- File specification is defined in the appendix of the 2002 IDC Processing Manual
- Defined stages include Poles Zeros (PAZ), Finite Impulse Response (FIR), Infinite Impulse Response (IIR), and Frequency Amplitude Phase (FAP)
- Scaling information stored in the Instrument table of CSS3 Database
- Group delay stage present in files but not defined in specification

Header
PAZ Stage
FIR Stage

Truncated Example File

```
# Network: IU
# Station: ANMO
# Location: 10
# Channel: HHZ10
#
theoretical         1         instrument          paz        SEED_RESP
 1.161172e-19
7
-1.245140e-02  -1.219380e-02   0.000000e+00   0.000000e+00
…
-5.081780e+02   4.237750e+02   0.000000e+00   0.000000e+00
9
 0.000000e+00   0.000000e+00   0.000000e+00   0.000000e+00
…
 0.000000e+00   0.000000e+00   0.000000e+00   0.000000e+00
#
theoretical         2         instrument          fir        SEED_RESP
1.000000E+02
65
 1.315490e-11   0.000000e+00
 1.501070e-04   0.000000e+00
…
0
#EOF
```

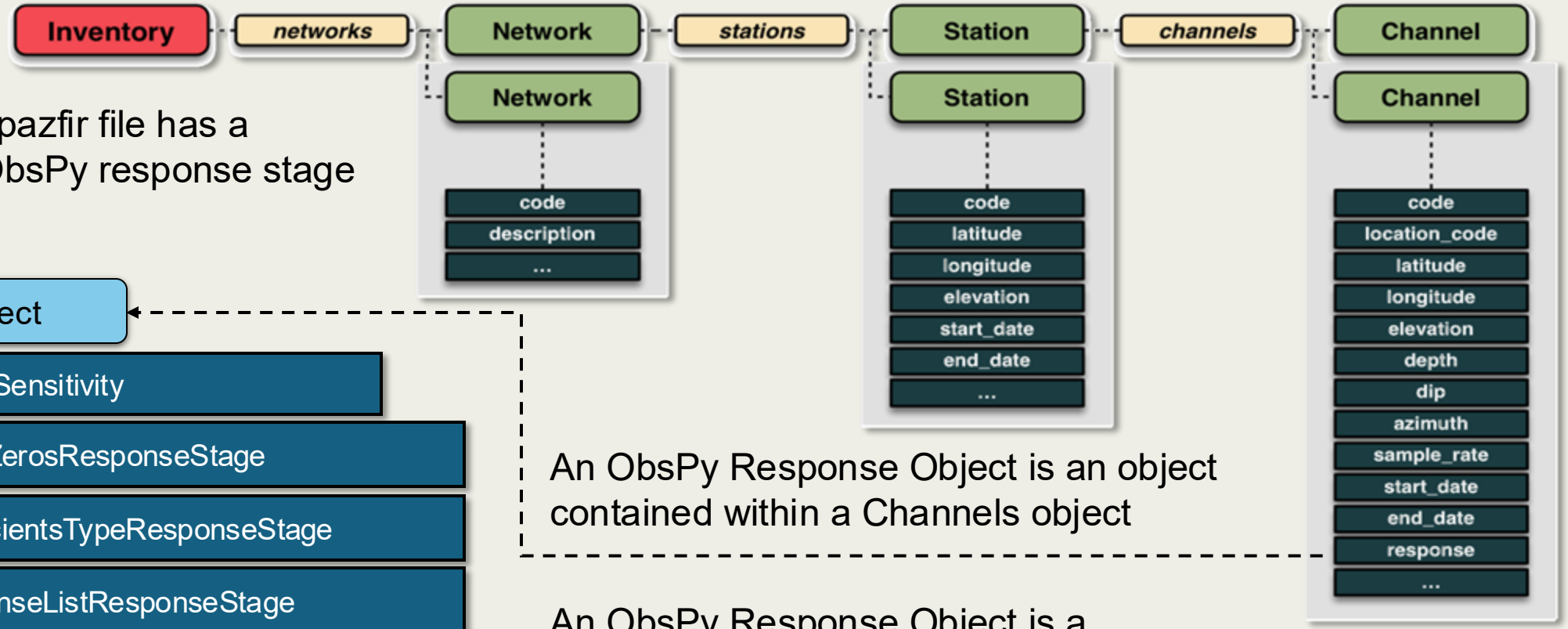
STA	CHAN	JDATE	INSNAME	SAMPRATE	NCALIB	NCALPER	RSPTYPE
ANMO	HHZ10	2019158	Streckeisen STS-5 360 second corner	100	0.06154011	1	pazfir

← Instrument Sensitivity Information

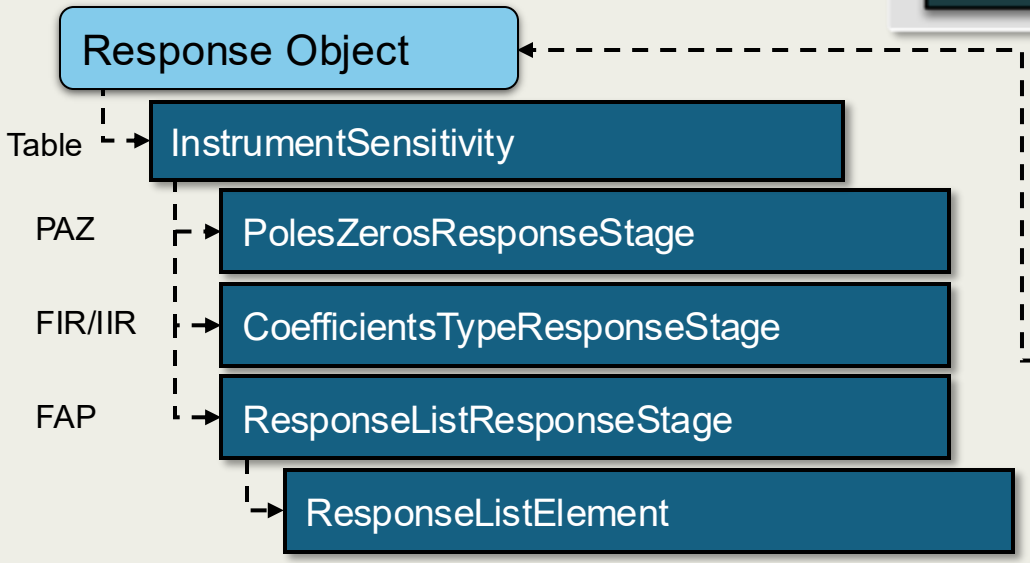
Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

ObsPy Response Objects



Each stage in a pazfir file has a corresponding ObsPy response stage object



An ObsPy Response Object is an object contained within a Channels object

An ObsPy Response Object is a combination of individual response stage objects

Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

Reading PAZFIR files as ObsPy Response Objects

Column	Description [Instrument]
inid	instrument identifier (unique)
insname	instrument name
instype	instrument type
band	frequency band
digital	recording system flag
samprate	sampling rate
ncalib	nominal calibration factor
ncalper	nominal calibration period
dir	directory
dfile	data file
rsptype	instrument response type
lddate	load date

```
respObj = pisces.io.response.read_pazfir('dfile',\
       input_samp_rate = samprate, calib = ncalib,\
       calper = ncalper, input_units = 'M')
                                                    *
```

```
Channel Response
   From M (Displacement in Meters) to
         COUNTS (Digital Counts)
   Overall Sensitivity: 1.62496e+10 defined at 1.000 Hz
   2 stages:
      Stage 1: PolesZerosResponseStage
               from M to COUNTS, gain: 1.62496e+10
      Stage 2: CoefficientsTypeResponseStage
               from COUNTS to COUNTS, gain: 1
```

```
theoretical   1   instrument    paz SEED_RESP
 1.161172e-19
7
-1.245140e-02  -1.219380e-02   0.000000e+00   ...
-1.245140e-02   1.219380e-02   0.000000e+00   ...
...
 0.000000e+00   0.000000e+00   0.000000e+00   ...
 0.000000e+00   0.000000e+00   0.000000e+00   ...
...
theoretical   2   instrument    fir SEED_RESP
1.000000E+02
65
 1.315490e-11   0.000000e+00
 1.501070e-04   0.000000e+00
 1.339680e-02   0.000000e+00
...
0
```

- Requires filepath, calib, calper, and sample rate from Instrument table
- File units are assumed to be in NM with option to produce output in NM or M
- Sensitivities from all stages are combined into the calib/ncalib value
- Since sensitivities cannot be broken out by stage, set stage 1 gain to the overall sensitivity value and all remaining gains are set to 1.

*API Subject to change

Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

Writing to PAZFIR files from StationXML

- Only required input is a stationxml file
- Outputs include fixed-width formatted flat files of the Instrument and Sensor tables as well as the PAZFIR files itself
- Since one stationxml can contain multiple response files, file naming is determined by the function and includes network, station, channel, location, year, and julian date of response
- Flat files ID numbers start at 0 and will have to changed by user when uploading to a database

*API Subject to change

Column	Description [Instrument]
inid	instrument identifier (unique)
insname	instrument name
instype	instrument type
band	frequency band
digital	recording system flag
samprate	sampling rate
ncalib	nominal calibration factor
ncalper	nominal calibration period
dir	directory
dfile	data file
rsptype	instrument response type
lddate	load date

Column	Description [Sensor]
sta	station code
chan	channel code
time	start time (epoch)
endtime	ending time (epoch)
inid	instrument identifier
chanid	channel identifier
jdate	julian date
calratio	calibration conversion ratio
calper	calibration period
tshift	processing time correction
instant	snapshot indicator
lddate	load date

```
theoretical   1   instrument    paz SEED_RESP
 1.161172e-19
7
-1.245140e-02  -1.219380e-02   0.000000e+00   ...
-1.245140e-02   1.219380e-02   0.000000e+00   ...
...
 0.000000e+00   0.000000e+00   0.000000e+00   ...
 0.000000e+00   0.000000e+00   0.000000e+00   ...
...
theoretical   2   instrument    fir SEED_RESP
1.000000E+02
65
 1.315490e-11   0.000000e+00
 1.501070e-04   0.000000e+00
 1.339680e-02   0.000000e+00
...
0
```

```
Sensor, Instrument = pisces.io.response.sxml2pazfir(\
        input_xml, out_freq = None, dir_path = None, \
        write_tables = True)
                                                    *
```

```
Inventory created at 2023-12-28T22:58:20.869100Z
        Created by: IRIS WEB SERVICE: fdsnws-station |
          version: 1.1.52
          http://service.iris.edu/fdsnws/station/1/que-
          ry?starttime=2020-05-...
        Sending institution: IRIS-DMC (IRIS-DMC)
        Contains:
                Networks (1):
                        IU
                Stations (1):
                        IU.ANMO (Albuquerque, New Mexico,
                Channels (1):
                        IU.ANMO.10.HHZ
```

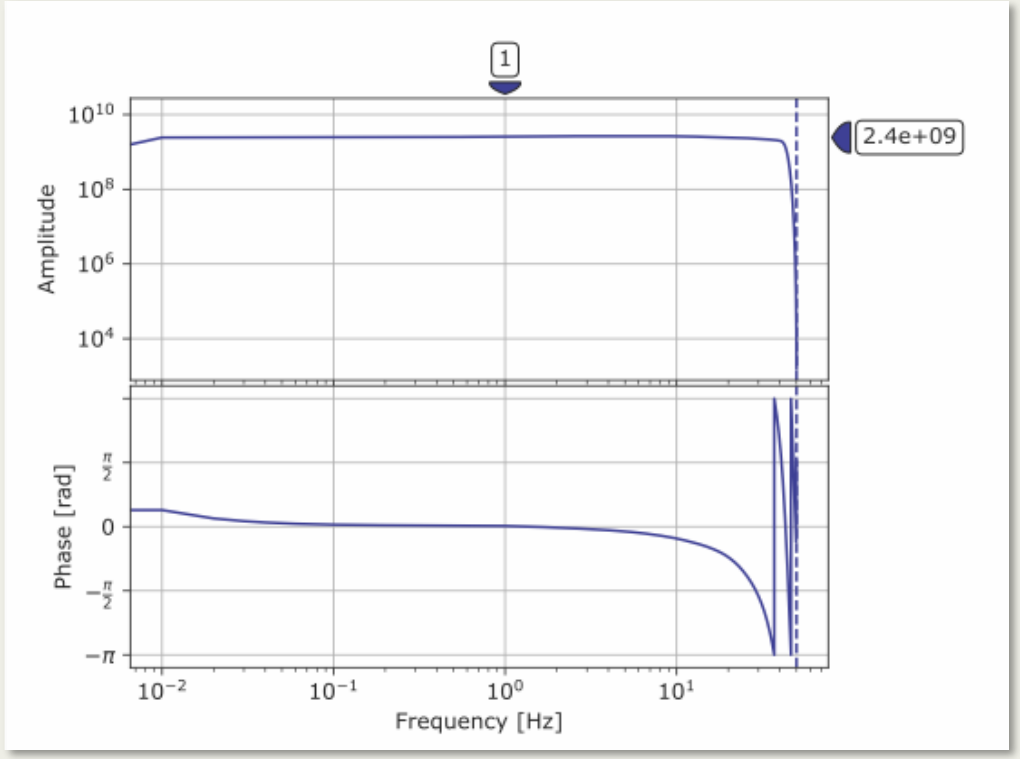
Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

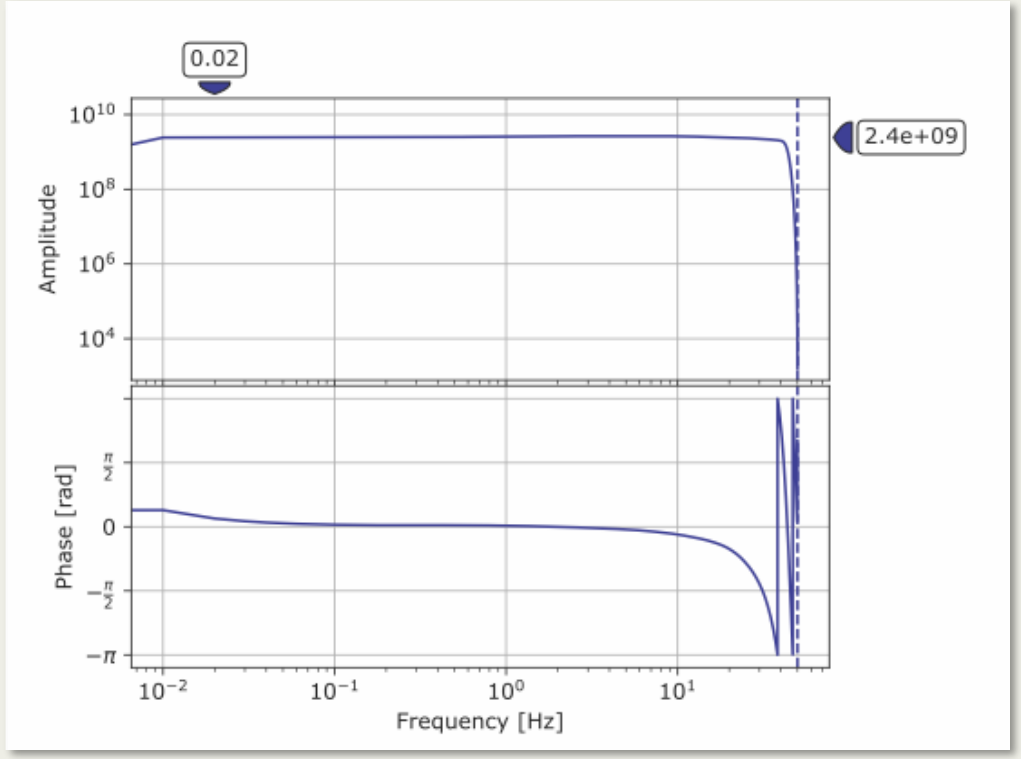
Comparison of Response Curves from StationXML and PAZFIR Files

PAZFIR Response from Database*



Response from database is in NM at 1 Hz, response object was constructed in M, but plot is displayed in M/S.

StationXML Response from IRIS



Response from IRIS is in M/S at 0.02 Hz and displayed as such.

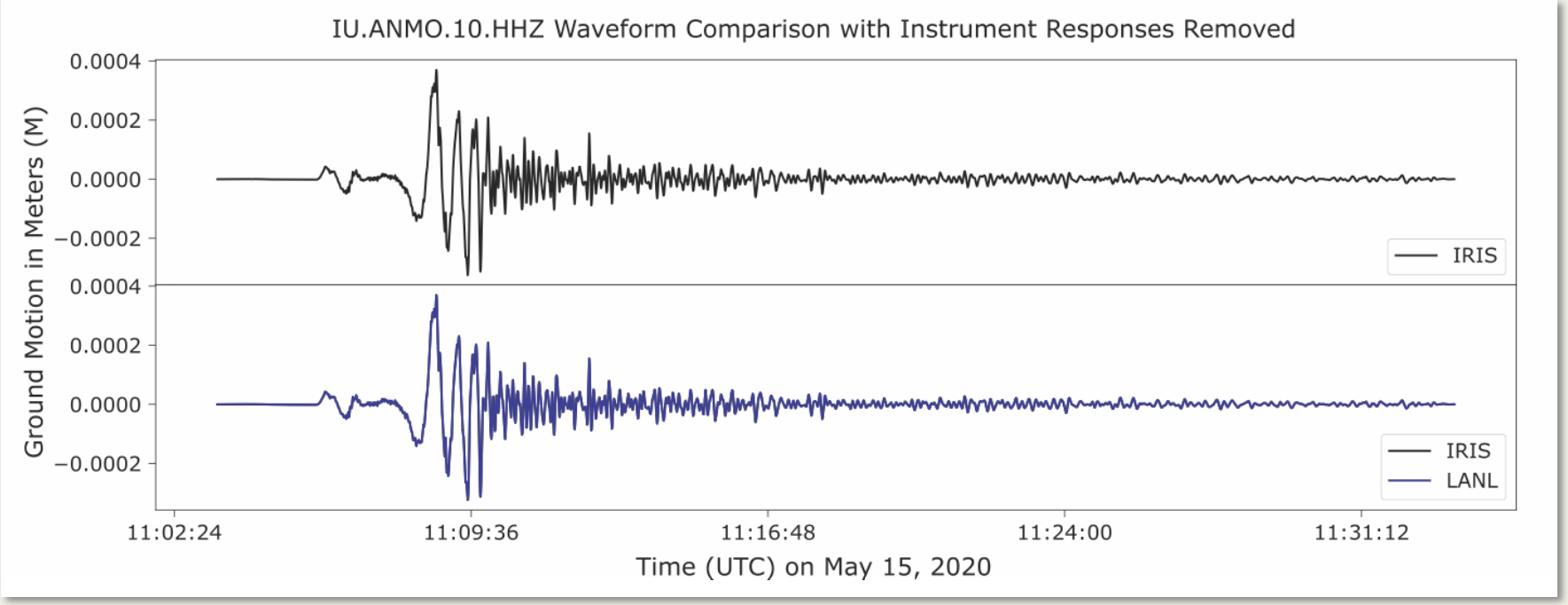
*Phase correction had to be manually applied.

Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

PAZFIR Response Removal



- Event shown is M_w6.5 earthquake from Nevada on May 15, 2020 recorded at ANMO
- The converted PAZFIR response and the IRIS StationXML response are deconvolved using `obspy.core.trace.Trace.remove_response(output = 'DISP')`
- Resulting waveforms are effectively identical

SnT 2025 CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE

Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

ObsPy Inventory Objects from CSS3 Like Database Tables: In Development

- Requires Site, Sitechan, Sensor, Instrument tables and Network and Affiliation if network code(s) is provided
- If network code(s) is not provided, all stations will be given a network of '__'.
- Not all FDSN metadata is defined in CSS3 spec, e.g. location codes
- Pisces will convert what is in a database as it is in a database

```
Inventory created at 2024-11-12T23:39:48.136092Z
        Created by: ObsPy 1.4.0
                    https://www.obspy.org
        Sending institution: ObsPy 1.4.0
        Contains:
                Networks (1):
                        __
                Stations (1):
                        __.ANMO (Albuquerque, New Mexico, USA)
                Channels (3):
                        __.ANMO..HH110, __.ANMO..HH210,
                        __.ANMO..HHZ10

Station ANMO (Albuquerque, New Mexico, USA)
        Station Code: ANMO
        Channel Count: None/None (Selected/Total)
        None -
        Access: None
        Latitude: 34.9459, Longitude: -106.4572,
        Elevation: 1820.0 m
        Available Channels:
            ..HH[000]   100.0 Hz  2019-06-07 to 2286-11-20
        Depth: 146.0 m

Channel 'HHZ10', Location ''
        Time range: 2019-06-07T20:00:00.000000Z -
                    2286-11-20T17:46:39.999001Z
        Latitude: 34.9459, Longitude: -106.4572,
        Elevation: 1820.0 m, Local Depth: 146.0 m
        Sampling Rate: 100.00 Hz
        Response information available
```

Column	Description [Network]
net	network code (unique)
netname	network name
nettype	
... [3]	

Column	Description [Affiliation]
net	network code
sta	station code
time	starttime (epoch)
endtime	endtime (epoch)
lddate	load date

Column	Description [Site]
sta	station code (unique)
ondate	on date (YYYYDDD)
offdate	off date (YYYYDDD)
lat	latitude
lon	longitude
elev	elevation
staname	station name
statype	station type
refsta	reference stat
dnorth	north offset (a
deast	east offset (a
lddate	load date

Column	Description [Sitechan]
sta	station code
chan	channel code
ondate	on date (YYYYDDD)
chanid	channel identifier (unique)
offdate	off date (YYYYDDD)
ctype	channel type
edepth	emplacement depth
hang	horizontal orientation
vang	vertical orientation
descrip	channel description
lddate	load date

read_pazfir() ← Instrument table on inid ← Sensor table on chanid

Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

ObsPy Catalog Objects from CSS3 Like Database Tables: In Development

Column	Description [Event]
evid	event identifier (unique)
evname	event name
prefor	preferred origin
auth	author, data source
... [2]	administrative fields [2]

Column	Description [Origin]
lat	latitude
lon	longitude
depth	source depth
time	source time (epoch)
evid	event identifier
orid	origin identifier (unique)
jdate	source day (YYYYDDD)
arrivals [3]	fields for arrival/phase info
regions [2]	fields for region info
etype	event type
depths [2]	fields for depth info
mb [2]	body wave mag fields
ms [2]	surface wave mag fields
ml [2]	local mag fields
algorithm	location algorithm
... [3]	administrative fields

Column	Description [Netmag]
magid	mag identifier (unique)
net	network code
evid	eventidentifier
orid	originidentifier
magtype	magnitude type
nsta	# stations used
magnitude	magnitude
uncertainty	magnidue uncertainty
... [3]	

Column	Description [Arrival]
sta	station code
time	arrival time (epoch)
arid	arrival identifier (unique)
chan	channel code
iphase	reported phase
deltim	time uncertainty
azimuth	observed azimuth
delaz	azimuth uncertainty
slow	observed slowness
delslo	slowness uncertainty
amp	insturment corrected amp
per	period
fm	first motion
snr	signal-to-noise ratio
qual	signal onset quality
... [11]	fields not included

Column	Description [Assoc]
orid	origin identifier
arid	arrival identifier (unique)
sta	station code
phase	phase type
delta	source-receiver distance
timesres	time residual
azres	azimuth residual
slores	slowness residual
... [11]	fields not included

```
Event:  2019-07-04T17:33:49.000000Z | +35.705, -117.504 | 6.4  Mw | manual
  resource_id: ResourceIdentifier(id= "smi:SCEDC/eventid=38443183")
  event_type: 'earthquake'
  creation_info: CreationInfo(...)
  preferred_origin_id: ResourceIdentifier(id="smi:SCEDC/originid=106065092")
  ---------
  picks: 259 Elements
  origins: 2 Elements
  magnitudes: 1 Elements
  amplitudes: 0 Elements

Origin
  resource_id: ResourceIdentifier(id="smi:SCEDC/originid=106065092")
  time: UTCDateTime(2019, 7, 4, 17, 33, 49)
  longitude: -117.5038333
  latitude: 35.7053333
  depth: 10500.0
  ---------
  arrivals: 105 Elements
```

- Requires Event, Origin, Assoc, Arrival, and Netmag tables for complete Catalog Object
- Catalog objects have slightly different terminology from CSS3 Schemas
- Specifically, in a Catalog object a Pick is equivalent to a CSS3 Arrival and Catalog Arrival is equivalent to a CSS3 Assoc
- CSS3 also has a different set of event types and associated codes so a translation layer is added to ensure consistency with FDSN standard outputs

SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Pisces updates for integrating CSS3.0-like database tables and files into ObsPy workflows

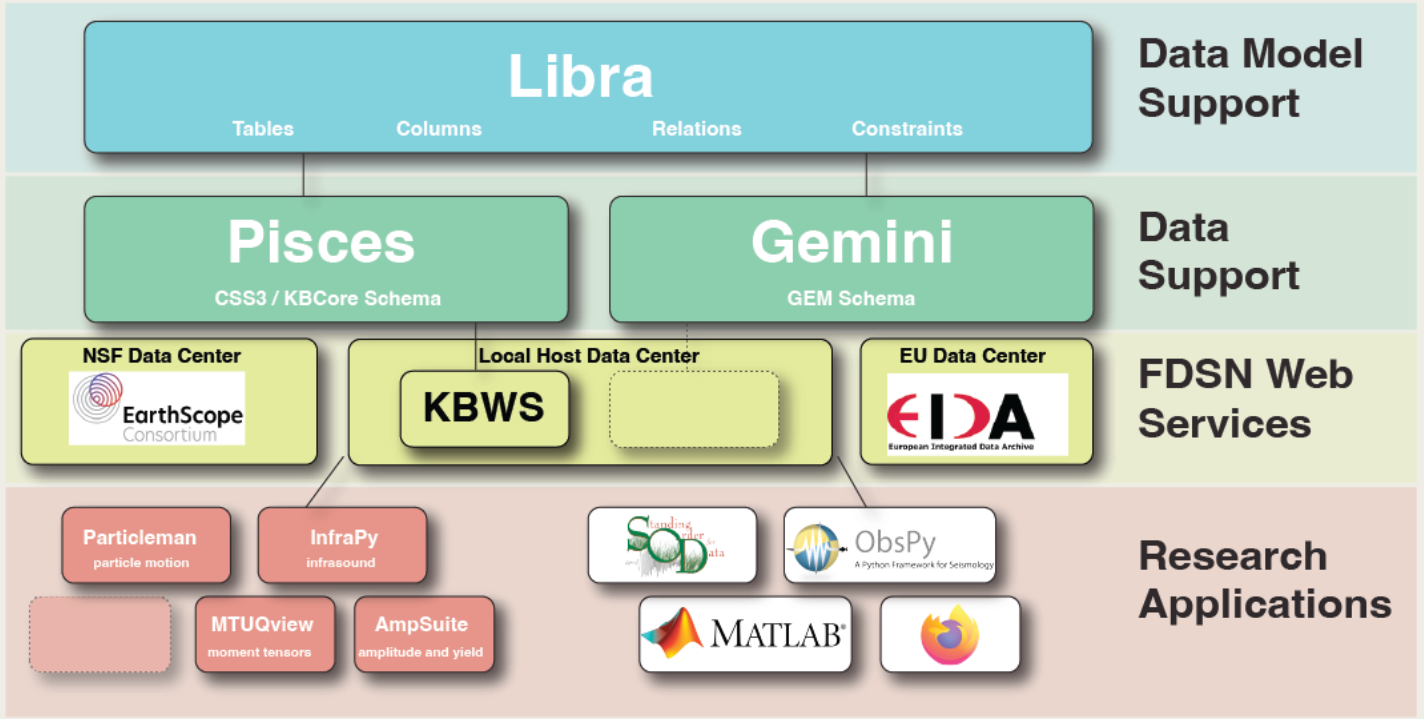
Christine Gammans, Jonathan MacCarthy, Brady Spears

O3.1-256

Summary

- Pisces is actively being updated and maintained
- Recent additions include read and write capabilities for instrument response files stored in CSS3 databases
- Inventory and Catalog support are in development
- Longer terms plans not shown here include:
  - Improve backend-agnostic datatyping using Libra, another LANL data management package open sourced in 2024
  - Adding web service interfacing for schemas supported by Pisces

Python Geophysical Suite (PyGS)



Pisces

PyGS

PyGS is developed and maintained by researchers at Los Alamos National Laboratory. PyGS contains a number of python-based data management, analysis, and modeling packages.

Los Alamos NATIONAL LABORATORY