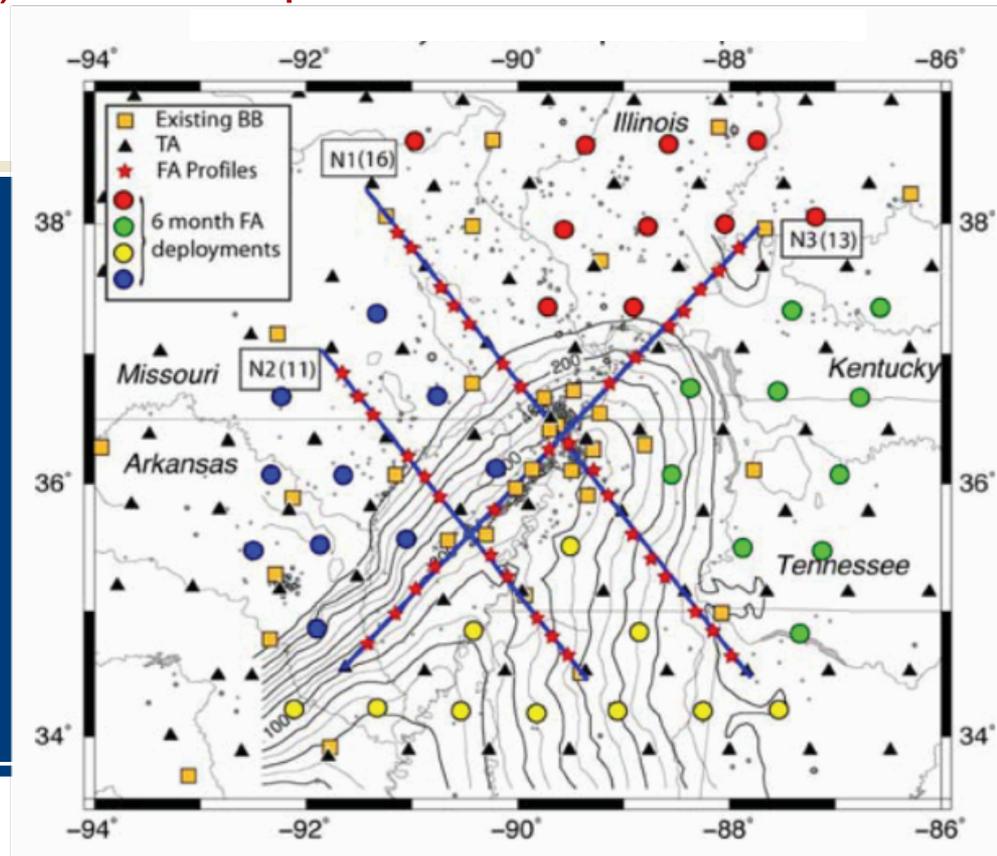


Relational Database Management Systems

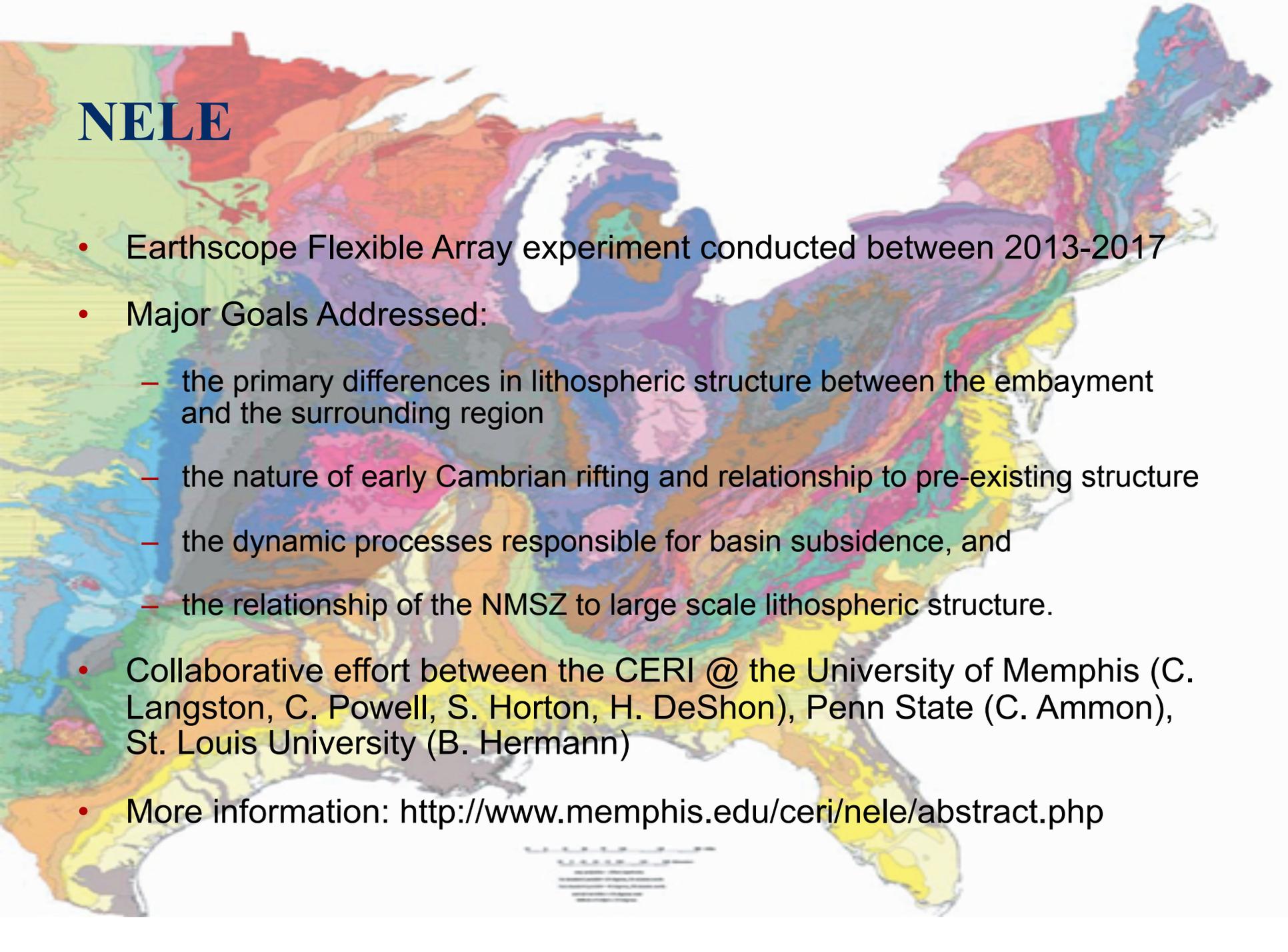
A practical introduction using Antelope, the Northern Lithosphere Embayment Experiment (NELE), & the Cooperative New Madrid Seismic Network (CNMSN)

Heather DeShon
Southern Methodist University

IRIS USArray Short-course 2016
Northwestern University
August 3, 2016



NELE



- Earthscope Flexible Array experiment conducted between 2013-2017
- Major Goals Addressed:
 - the primary differences in lithospheric structure between the embayment and the surrounding region
 - the nature of early Cambrian rifting and relationship to pre-existing structure
 - the dynamic processes responsible for basin subsidence, and
 - the relationship of the NMSZ to large scale lithospheric structure.
- Collaborative effort between the CERI @ the University of Memphis (C. Langston, C. Powell, S. Horton, H. DeShon), Penn State (C. Ammon), St. Louis University (B. Hermann)
- More information: <http://www.memphis.edu/cei/nele/abstract.php>

Why do seismologists need to know about relational databases (RDB)?

- ◆ Increasing complexity of seismology data acquisition requires efficient means to organize and access data
- ◆ Only want to type information once and keep it in a central location! A piece of information is only found in one place
- ◆ Standard RDB tools to create, edit, combine, and destroy tables already exist
- ◆ Entire discipline of study in computer science

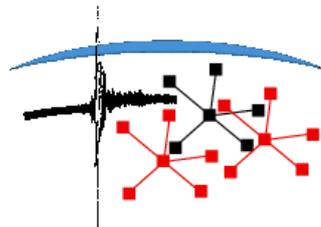
How do seismologists use RDBs?

- Processing, analysis and storage of data and associated metadata
- RDBs are at the heart of every seismic/infrasound network operation
- Most RDBs are embedded in combinations of commercial and open source software packages



AQMS
Earthworm

*ITSI



SeisComp3

MySQL, SQLite, postgresSQL

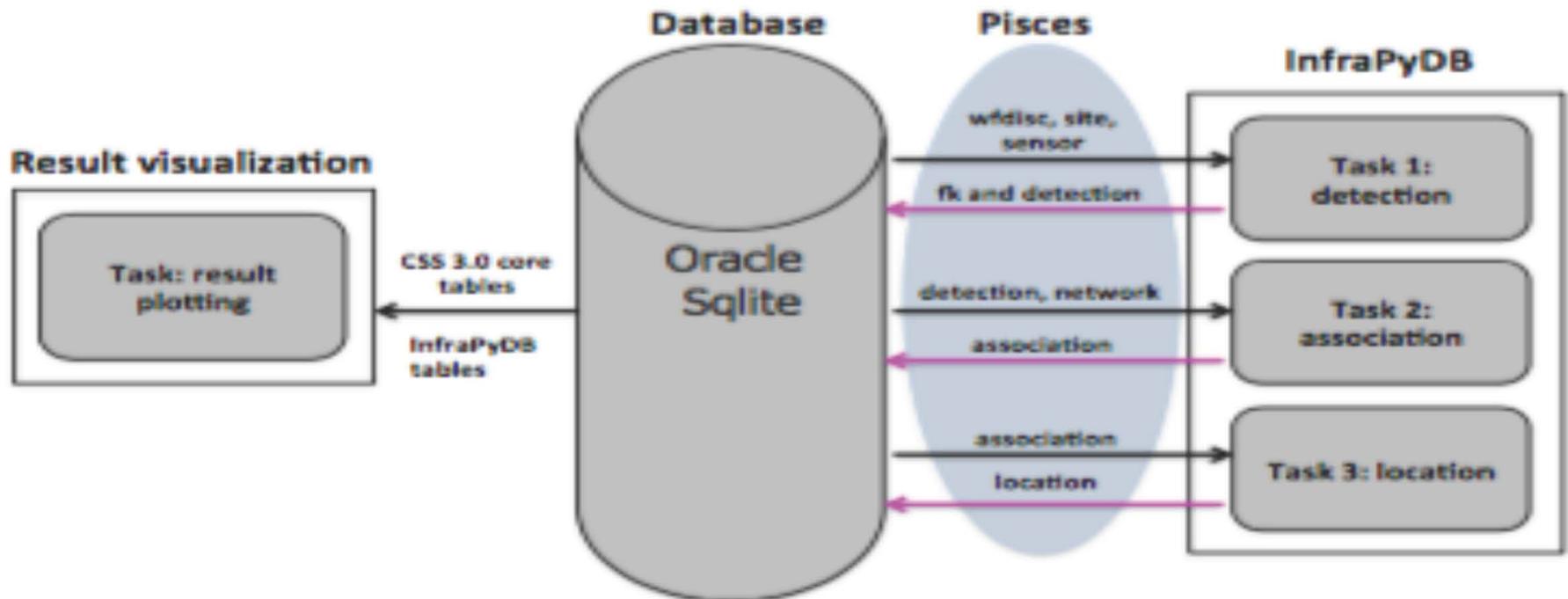
*gempa GmbH

Antelope
Datascope

*Boulder RealTime Technologies/
Kinematics



The Wrappers



Example from Blom et al. of a set of Python modules wrapped around an Oracle SQLite RDB to analyze infrasound data

What is Antelope?

- ◆ Software platform designed to acquire, distribute, archive, and process environmental data
- ◆ Provides a standard substrate (middleware) for interconnecting diverse data sources with diverse data processing
 - ◆ Commercial and public-domain components
 - ◆ Closed and open source components
 - ◆ Can handle ANY packetized data
 - ◆ Encapsulates diverse specific data formats and uses standard protocols for communication

more about Antelope

- ◆ Built upon the Datascope Relational Database
 - ◆ Handles real-time and offline batch mode data
 - ◆ Easy integration of user developed modules
 - ◆ Property of Boulder Real Time Technologies, Inc (BRTT)
-

What is Datascope?

- ◆ Relational database component → ASCII fixed format tables which are related or linked to each other so that every record (row) of the table is unique
- ◆ Originally developed at UC-Boulder and distributed through IRIS for use with PASSCAL deployments
- ◆ Academic usage was primarily offline batch mode processing for creating seed volumes, phase picking, locations, etc.
- ◆ Used to create DMC SEED volumes for archiving

- ◆ **Seismology-specific processing functions using derivatives of the CSS3.0 schema**
 - ◆ **Data and metadata archiving (waveforms, site and instr char, etc.)**
 - ◆ **Information archiving (picks, hypocenters, etc.)**
 - ◆ **Import/export (SEED, SAC, SEG-Y, etc.)**
 - ◆ **“routine” network processing (detection, association, location, etc.)**
 - ◆ **Ground motion estimation (similar to Shakemap)**
 - ◆ **Interactive analysis review**
 - ◆ **Archive management functions (backup, restore, copy, excerpt, etc.)**
 - ◆ **Interface with other research tools (SAC, MATLAB, etc.)**

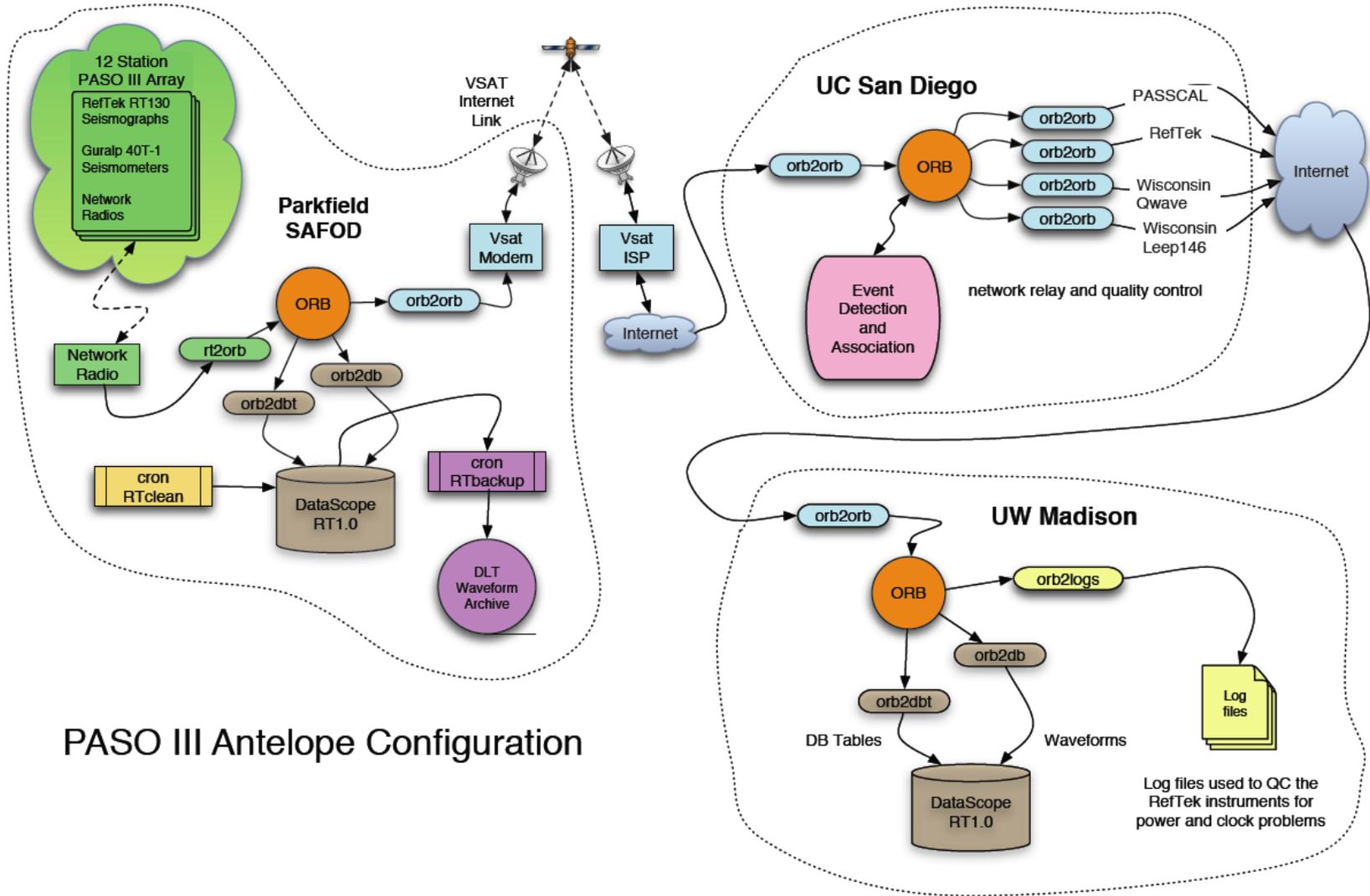
- ◆ Seismology-specific processing functions using derivatives of the CSS3.0 schema
 - Data and metadata archiving (waveforms, site and instr char, etc.)
 - Information archiving (picks, hypocenters, etc.)
 - Import/export (SEED, SAC, SEG-Y, etc.)
 - “routine” network processing (detection, association, location, etc.)
 - Ground motion estimation (similar to Shakemap)
 - Interactive analysis review
 - Archive management functions (backup, restore, copy, excerpt, etc.)
 - Interface with other research tools (SAC, MATLAB, etc.)

Why use BRTTs Antelope?

- ◆ It was originally designed to deal with seismic data
- ◆ Contains numerous tools for processing and analyzing seismic data of many formats
- ◆ Flexible enough so that users can create their own schema or integrate home-grown location algorithms, magnitude calculators, etc.
- ◆ It's FREE for research use at US educational institutions

Real-time or ORB system

- ◆ The real time system is built around a large, flexible, non-volatile ring buffer.
- ◆ Ring Buffer: a method of using memory within a computer program. “Ring” alludes to the rotation through the buffer of the positions where the next data will be read and written. When moving through the buffer, the writer moves forward one step each time it writes, and when it passes the end of the buffer it starts again at the beginning. The reader moves through the buffer in the same way.



Offline processing or the DB system

- ◆ Offline batch mode processing built upon algorithms originally developed with Datascope
- ◆ The common way in which data for temporary or non-telemetered PASSCAL arrays are processed and seed files for DMC archiving are created
- ◆ DB: acronym for database which marks algorithms that work with offline data (ie. dbassoc)

dbe - The database editor

- New version with Antelope 5.6

The screenshot shows the dbe: NewMadrid application window. The menu bar includes File, Edit, View, Options, Graphics, and Help. The toolbar contains various icons for file operations and a 'Tables' dropdown menu. The main window displays a table with 178 rows and 16 columns. The columns are: arrival, assoc, calibration, emodel, event, instrument, lastid, netmag, network, origerr, origin, predarr, schanloc, sensor, site, and sitechan. The table contains data for various stations, including their arrival dates, associated station IDs, calibration dates, model IDs, event IDs, instrument types, last IDs, netmagnitudes, network names, origin error rates, origin dates, prediction arrival dates, sensor locations, sensor IDs, and site channel IDs.

arrival	assoc	calibration	emodel	event	instrument	lastid	netmag	network	origerr	origin	predarr	schanloc	sensor	site	sitechan
0	A01	2013248	2015365	34.6231	-89.5059	0.1450	Waterford, MS, USA	ss		7/26/16 (208)	15:45:57.26690	UTC			
1	A01X	2013301	2015365	34.3935	-89.2951	0.1250	Oxford, MS, USA	ss		7/26/16 (208)	15:45:57.27256	UTC			
2	A02	2013248	2015365	34.7837	-89.6919	0.1300	Byhalia, MS, USA	ss		7/26/16 (208)	15:45:57.27863	UTC			
3	A03	2013273	2015365	34.9223	-89.8102	0.1240	Olive Branch, MS, USA	ss		7/26/16 (208)	15:45:57.28415	UTC			
4	A04	2013248	2014220	35.2793	-90.0560	0.1030	Memphis, TN, USA	ss		7/26/16 (208)	15:45:57.29907	UTC			
5	A05	2013254	2015365	35.4108	-90.2608	0.0650	West Memphis, AR, USA	ss		7/26/16 (208)	15:45:57.34315	UTC			
6	A05X	2013254	2015365	35.6892	-90.5899	0.0750	Truman, AR, USA	ss		7/26/16 (208)	15:45:57.34964	UTC			
7	A06	2013239	2015365	35.8667	-90.7218	0.1010	Jonesboro, AR, USA	ss		7/26/16 (208)	15:45:57.36335	UTC			
8	A07	2013239	2015365	36.0157	-90.8708	0.0780	Walnut Ridge, AR, USA	ss		7/26/16 (208)	15:45:57.36805	UTC			
9	A08	2013239	2015365	36.1822	-91.0474	0.0950	Walnut Ridge, AR, USA	ss		7/26/16 (208)	15:45:57.37420	UTC			
10	A08X	2013239	2015365	36.3447	-91.2089	0.1960	Ravenden, AR, USA	ss		7/26/16 (208)	15:45:57.37877	UTC			
11	A09	2013240	2015365	36.5038	-91.3684	0.2420	Farmington, MO, USA	ss		7/26/16 (208)	15:45:57.38439	UTC			
12	A10	2013240	2015365	36.6489	-91.4903	0.2850	Koshkonong, MO, USA	ss		7/26/16 (208)	15:45:57.38903	UTC			
13	A11	2013240	2015365	36.8414	-91.6844	0.3290	PeaceValley, MO, USA	ss		7/26/16 (208)	15:45:57.39355	UTC			
14	ARPT	1995320	2599365	35.7560	-89.6730	0.1220	Arp, TN	ss		7/26/16 (208)	15:45:57.39777	UTC			
15	ASAR	2001273	2015045	35.8430	-90.6710	0.3000	Arkansas State, Jonesboro, AR(CERI)	ss		7/26/16 (208)	15:45:57.43602	UTC			
16	B02	2013213	2015365	34.8275	-88.1847	0.1810	Inco, MS, USA	ss		7/26/16 (208)	15:45:57.44586	UTC			
17	B03	2013213	2015365	34.9779	-88.3077	0.2150	Iuka, MS, USA	ss		7/26/16 (208)	15:45:57.45084	UTC			
18	B03X	2013213	2015365	35.1256	-88.4374	0.1490	Selmar, TN, USA	ss		7/26/16 (208)	15:45:57.45565	UTC			
19	B04	2013213	2015365	35.2595	-88.6095	0.1740	Bethel Springs, TN, USA	ss		7/26/16 (208)	15:45:57.46047	UTC			
20	B05	2013213	2015365	35.4259	-88.7056	0.1360	Henderson, TN, USA	ss		7/26/16 (208)	15:45:57.46542	UTC			
21	B06	2013214	2015365	35.5649	-88.9444	0.1630	Denmark, TN, USA	ss		7/26/16 (208)	15:45:57.47015	UTC			
22	B06X	2013232	2015365	35.7279	-89.0319	0.1290	Gadsden, TN, USA	ss		7/26/16 (208)	15:45:57.47513	UTC			
23	B07	2013232	2015365	35.8823	-89.1647	0.1220	Friendship, TN, USA	ss		7/26/16 (208)	15:45:57.48003	UTC			
24	B08	2013232	2015365	36.0747	-89.2561	0.1080	Newbern, TN, USA	ss		7/26/16 (208)	15:45:57.48513	UTC			
25	B09	2013232	2015365	36.3072	-89.5168	0.0880	Tiptonville, TN, USA	ss		7/26/16 (208)	15:45:57.49044	UTC			
26	B10	2013233	2015365	36.7451	-89.9169	0.1030	Dexter, MO, USA	ss		7/26/16 (208)	15:45:57.49515	UTC			
27	B11	2013233	2015365	36.8924	-90.1532	0.1310	Puxico, MO, USA	ss		7/26/16 (208)	15:45:57.50110	UTC			
28	B11X	2013233	2015365	37.0833	-90.2878	0.1970	McGee, MO, USA	ss		7/26/16 (208)	15:45:57.52116	UTC			
29	B12	2013234	2015365	37.2205	-90.4388	0.1910	Silva, MO, USA	ss		7/26/16 (208)	15:45:57.52572	UTC			
30	B13	2013297	2015365	37.3781	-90.6038	0.1910	Annapolis, MO, USA	ss		7/26/16 (208)	15:45:57.53087	UTC			
31	B14	2013297	2015365	37.4864	-90.7262	0.3130	Arcadia, MO, USA	ss		7/26/16 (208)	15:45:57.53538	UTC			
32	B14X	2013297	2015365	37.6685	-90.8865	0.3420	Bellevue, MO, USA	ss		7/26/16 (208)	15:45:57.53989	UTC			
33	B15	2013298	2015365	37.7972	-91.0088	0.3400	Potosi, MO, USA	ss		7/26/16 (208)	15:45:57.54469	UTC			
34	B16	2013297	2015365	37.9144	-91.1576	0.2740	Steelville, MO, USA	ss		7/26/16 (208)	15:45:57.54916	UTC			

178 Rows Table 'site' updated: 7/26/16 (208) 15:45:59.00000 UTC

- Slides are going to show the old version, db_e_dep

The screenshot shows the dbe: NewMadrid application window. The menu bar includes File, Options, and Help. The toolbar contains various icons for file operations and a 'Quit' button. The main window displays a table with 178 rows and 16 columns. The columns are: arrival, assoc, calibration, detection, emodel, event, instrument, lastid, netmag, network, origerr, origin, predarr, schanloc, sensor, site, sitechan, snetsta, stamag, and wfdisc. The table contains data for various stations, including their arrival dates, associated station IDs, calibration dates, model IDs, event IDs, instrument types, last IDs, netmagnitudes, network names, origin error rates, origin dates, prediction arrival dates, sensor locations, sensor IDs, site channel IDs, snetsta, stamag, and wfdisc.

arrival	assoc	calibration	detection	emodel	event	instrument	lastid	netmag	network	origerr	origin	predarr	schanloc	sensor	site	sitechan	snetsta	stamag	wfdisc
0	A01	2013248	2015365	34.6231	-89.5059	0.1450	Waterford, MS, USA	ss			7/26/16 (208)	15:45:57.26690	UTC						
1	A01X	2013301	2015365	34.3935	-89.2951	0.1250	Oxford, MS, USA	ss			7/26/16 (208)	15:45:57.27256	UTC						
2	A02	2013248	2015365	34.7837	-89.6919	0.1300	Byhalia, MS, USA	ss			7/26/16 (208)	15:45:57.27863	UTC						
3	A03	2013273	2015365	34.9223	-89.8102	0.1240	Olive Branch, MS, USA	ss			7/26/16 (208)	15:45:57.28415	UTC						
4	A04	2013248	2014220	35.2793	-90.0560	0.1030	Memphis, TN, USA	ss			7/26/16 (208)	15:45:57.29907	UTC						
5	A05	2013254	2015365	35.4108	-90.2608	0.0650	West Memphis, AR, USA	ss			7/26/16 (208)	15:45:57.34315	UTC						
6	A05X	2013254	2015365	35.6892	-90.5899	0.0750	Truman, AR, USA	ss			7/26/16 (208)	15:45:57.34964	UTC						
7	A06	2013239	2015365	35.8667	-90.7218	0.1010	Jonesboro, AR, USA	ss			7/26/16 (208)	15:45:57.36335	UTC						
8	A07	2013239	2015365	36.0157	-90.8708	0.0780	Walnut Ridge, AR, USA	ss			7/26/16 (208)	15:45:57.36805	UTC						
9	A08	2013239	2015365	36.1822	-91.0474	0.0950	Walnut Ridge, AR, USA	ss			7/26/16 (208)	15:45:57.37420	UTC						
10	A08X	2013239	2015365	36.3447	-91.2089	0.1960	Ravenden, AR, USA	ss			7/26/16 (208)	15:45:57.37877	UTC						
11	A09	2013240	2015365	36.5038	-91.3684	0.2420	Farmington, MO, USA	ss			7/26/16 (208)	15:45:57.38439	UTC						
12	A10	2013240	2015365	36.6489	-91.4903	0.2850	Koshkonong, MO, USA	ss			7/26/16 (208)	15:45:57.38903	UTC						
13	A11	2013240	2015365	36.8414	-91.6844	0.3290	PeaceValley, MO, USA	ss			7/26/16 (208)	15:45:57.39355	UTC						
14	ARPT	1995320	2599365	35.7560	-89.6730	0.1220	Arp, TN	ss			7/26/16 (208)	15:45:57.39777	UTC						
15	ASAR	2001273	2015045	35.8430	-90.6710	0.3000	Arkansas State, Jonesboro, AR(CERI)	ss			7/26/16 (208)	15:45:57.43602	UTC						
16	B02	2013213	2015365	34.8275	-88.1847	0.1810	Inco, MS, USA	ss			7/26/16 (208)	15:45:57.44586	UTC						
17	B03	2013213	2015365	34.9779	-88.3077	0.2150	Iuka, MS, USA	ss			7/26/16 (208)	15:45:57.45084	UTC						
18	B03X	2013213	2015365	35.1256	-88.4374	0.1490	Selmar, TN, USA	ss			7/26/16 (208)	15:45:57.45565	UTC						
19	B04	2013213	2015365	35.2595	-88.6095	0.1740	Bethel Springs, TN, USA	ss			7/26/16 (208)	15:45:57.46047	UTC						
20	B05	2013213	2015365	35.4259	-88.7056	0.1360	Henderson, TN, USA	ss			7/26/16 (208)	15:45:57.46542	UTC						
21	B06	2013214	2015365	35.5649	-88.9444	0.1630	Denmark, TN, USA	ss			7/26/16 (208)	15:45:57.47015	UTC						
22	B06X	2013232	2015365	35.7279	-89.0319	0.1290	Gadsden, TN, USA	ss			7/26/16 (208)	15:45:57.47513	UTC						
23	B07	2013232	2015365	35.8823	-89.1647	0.1220	Friendship, TN, USA	ss			7/26/16 (208)	15:45:57.48003	UTC						
24	B08	2013232	2015365	36.0747	-89.2561	0.1080	Newbern, TN, USA	ss			7/26/16 (208)	15:45:57.48513	UTC						
25	B09	2013232	2015365	36.3072	-89.5168	0.0880	Tiptonville, TN, USA	ss			7/26/16 (208)	15:45:57.49044	UTC						
26	B10	2013233	2015365	36.7451	-89.9169	0.1030	Dexter, MO, USA	ss			7/26/16 (208)	15:45:57.49515	UTC						
27	B11	2013233	2015365	36.8924	-90.1532	0.1310	Puxico, MO, USA	ss			7/26/16 (208)	15:45:57.50110	UTC						
28	B11X	2013233	2015365	37.0833	-90.2878	0.1970	McGee, MO, USA	ss			7/26/16 (208)	15:45:57.52116	UTC						
29	B12	2013234	2015365	37.2205	-90.4388	0.1910	Silva, MO, USA	ss			7/26/16 (208)	15:45:57.52572	UTC						
30	B13	2013297	2015365	37.3781	-90.6038	0.1910	Annapolis, MO, USA	ss			7/26/16 (208)	15:45:57.53087	UTC						
31	B14	2013297	2015365	37.4864	-90.7262	0.3130	Arcadia, MO, USA	ss			7/26/16 (208)	15:45:57.53538	UTC						
32	B14X	2013297	2015365	37.6685	-90.8865	0.3420	Bellevue, MO, USA	ss			7/26/16 (208)	15:45:57.53989	UTC						
33	B15	2013298	2015365	37.7972	-91.0088	0.3400	Potosi, MO, USA	ss			7/26/16 (208)	15:45:57.54469	UTC						
34	B16	2013297	2015365	37.9144	-91.1576	0.2740	Steelville, MO, USA	ss			7/26/16 (208)	15:45:57.54916	UTC						

Quit

Relational databases – Some definitions

- ◆ Table: fix format ASCII text files made up of records (rows) and fields (columns)

TABLE NAME wfdisc

0	sta	chan	time	endtime	dir	dfile
	BANE	BHE	4/01/2001 (091) 0:00:00.024	4/01/2001 (091) 0:46:38.324	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 0:46:38.334	4/01/2001 (091) 2:41:15.959	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 2:41:15.971	4/01/2001 (091) 4:41:19.696	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 4:41:19.706	4/01/2001 (091) 6:41:10.831	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 6:41:10.842	4/01/2001 (091) 8:41:51.517	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 8:41:51.528	4/01/2001 (091) 10:41:16.853	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 10:41:16.863	4/01/2001 (091) 12:41:26.538	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 12:41:26.549	4/01/2001 (091) 14:41:02.824	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 14:41:02.835	4/01/2001 (091) 17:20:06.335	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 17:20:06.347	4/01/2001 (091) 18:41:24.497	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 18:41:24.502	4/01/2001 (091) 20:41:24.327	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 20:41:24.338	4/01/2001 (091) 22:41:33.613	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 22:41:33.623	4/01/2001 (091) 23:59:59.998	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHN	4/01/2001 (091) 0:00:00.024	4/01/2001 (091) 0:46:36.524	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 0:46:36.534	4/01/2001 (091) 2:41:27.009	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 2:41:27.021	4/01/2001 (091) 4:41:14.446	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 4:41:14.456	4/01/2001 (091) 6:41:11.081	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 6:41:11.092	4/01/2001 (091) 8:41:58.117	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 8:41:58.128	4/01/2001 (091) 10:41:02.053	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 10:41:02.063	4/01/2001 (091) 12:41:35.838	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 12:41:35.849	4/01/2001 (091) 14:41:05.524	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 14:41:05.535	4/01/2001 (091) 17:20:09.835	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 17:20:09.847	4/01/2001 (091) 18:41:29.747	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 18:41:29.752	4/01/2001 (091) 20:41:15.977	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01

◆ Field: has the same attributes (size, type, format) in every table in which it appears

◆ Record: unique combination of information

AprilNicoya wfdisc

File Edit View Options Graphics Process Help

0	sta	chan	time	endtime	dir	dfile
	BANE	BHE	4/01/2001 (091) 0:00:00.024	4/01/2001 (091) 0:46:38.324	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 0:46:38.334	4/01/2001 (091) 2:41:15.959	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	E.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 2:41:15.971	4/01/2001 (091) 4:41:19.696	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	E.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 4:41:19.706	4/01/2001 (091) 6:41:10.831	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	E.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 6:41:10.842	4/01/2001 (091) 8:41:51.517	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 8:41:51.528	4/01/2001 (091) 10:41:16.853	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 10:41:16.863	4/01/2001 (091) 12:41:26.538	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 12:41:26.549	4/01/2001 (091) 14:41:02.824	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 14:41:02.835	4/01/2001 (091) 17:20:06.335	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 17:20:06.347	4/01/2001 (091) 18:41:24.497	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 18:41:24.502	4/01/2001 (091) 20:41:24.327	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 20:41:24.338	4/01/2001 (091) 22:41:33.613	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHE	4/01/2001 (091) 22:41:33.623	4/01/2001 (091) 23:59:59.998	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHE.2001.091.01
	BANE	BHN	4/01/2001 (091) 0:00:00.024	4/01/2001 (091) 0:46:36.524	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 0:46:36.534	4/01/2001 (091) 2:41:27.009	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 2:41:27.021	4/01/2001 (091) 4:41:14.446	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 4:41:14.456	4/01/2001 (091) 6:41:11.081	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 6:41:11.092	4/01/2001 (091) 8:41:58.117	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 8:41:58.128	4/01/2001 (091) 10:41:02.053	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 10:41:02.063	4/01/2001 (091) 12:41:35.838	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 12:41:35.849	4/01/2001 (091) 14:41:05.524	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 14:41:05.535	4/01/2001 (091) 17:20:09.835	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 17:20:09.847	4/01/2001 (091) 18:41:29.747	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01
	BANE	BHN	4/01/2001 (091) 18:41:29.752	4/01/2001 (091) 20:41:15.977	/mnt/s24/hdeshon/CostaRica/Nicoya_data/2001.091	BANE.XY.BHN.2001.091.01

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Dismiss

Schema

- ◆ The attributes and relations that define the relational database
- ◆ Defined by single text file that contains
 - schema description
 - attribute statements for every field
 - relation statements for every table which describe how the tables are linked/related

Example Schema

Schema: **css3.0**
 Path: **.ldb{AprilNicoya}:/dbmaster{AprilNicoya}**
Center for Seismic Studies Schema Version 3.0

Modifications from original CSS documentation:
 1) Null values corrected for certain attributes.
 2) offdate added to primary keys for tables in which it occurs.
 3) endtime added to primary keys for tables in which it occurs.
 4) time made first primary key in origin for sorting.
 5) arid and orid added to foreign keys in assoc.
 6) made range values expression for automated testing
 7) added wfedit relation 12/3/93
 8) changed the primary key in sitechan to chanid, and added chanid as a foreign key in sensor to force joins of sitechan to go through sensor table.
 9) changed primary keys in moment and centryd table to orid.
 10) added calibration and stage tables 1/31/94
 11) changed primary keys in stamag to arid, magtype, sta, orid
 12) changed primary key in site to sta (no ondate, offdate)
 13) changed null values for origerr's covariant matrix
 14) changed definition of ndef for origins included from other catalogs
 15) added beam, fkgrid and stgrid tables to accomodate array processing 12/15/94
 16) added wftar table to accomodate tar tape waveform archiving 1/9/95

SCHEMA DESCRIPTION

achanaux	affiliation	anetsta	arrival	assoc	beam	calibration	centryd	dmcseed	dmcwf
emodel	event	fkgrid	fplane	gregion	instrument	lastid	moment	netmag	network
origerr	origin	predarr	predmech	remark	schanloc	seedformat	seedindex	sensor	site
sitechan	snetsta	specdisc	sregion	stage	stamag	stassoc	stgrid	wfdisc	wfedit
wfmeas	wfrms	wftag	wftape	wftar					

Search for...

LIST of TABLES

Schema css3.0

Description ("Center for Seismic Studies Schema Version 3.0 ")

Detail {

Modifications from original CSS documentation:

- 0) units of calib vary according to the instrument, with wfdisc,segtype and instrument,rsptype indicating both sensor type and units
- 1) Null values corrected for certain attributes.
- 2) offdate added to primary keys for tables in which it occurs.
- 3) endtime added to primary keys for tables in which it occurs.
- 4) time made first primary key in origin for sorting.
- 5) arid and orid added to foreign keys in assoc.
- 6) made range values expression for automated testing
- 7) added wfedit relation 12/3/93
- 8) changed the primary key in sitechan to chanid, and added chanid as a foreign key in sensor to force joins of sitechan to go through sensor table.
- 9) changed primary keys in moment and centryd table to orid.
- 10) added calibration and stage tables 1/31/94
- 11) changed primary keys in stamag to arid, magtype, sta, orid
- 12) changed primary key in site to sta (no ondate, offdate)
- 13) changed null values for origerr's covariant matrix
- 14) changed definition of ndef for origins included from other catalogs
- 15) added beam, fkgrid and stgrid tables to accomodate array processing 12/15/94
- 16) added wftar table to accomodate tar tape waveform archiving 1/9/95
- 17) changed all NONULL null values to reasonable values
- 18) added wfrms table
- 19) added wfmeas table for holding generic waveform measurements
- 20) segment origin and stassoc etype field into two fields, etype and review, so that analyst review status can be kept in origin table
- 21) add snetsta, anetsta, schanloc and achanaux tables to translate between foreign volumes of SEED or autoDRM into local databases.
- 22) add specdisc table and associated attributes to support spectral estimation processing
- 23) add rsprm to specdisc table
- 24) added tables dmcseed and dmcwf to database to support all the DMC requirements for building DMC seed volumes. Changed default value of fileno to -1.
- 25) changed format of chksum from Integer %15d to Real %12.0f to make sure table is written properly. Previous format would wrap to negative numbers in some cases which would corrupt the database.
- 26) added fields calib, calper, samprate, timever to table dmcwf and field totbytes to table dmcseed.
- 27) changed primary keys of stamag from arid magtype sta and orid to magid magtype sta and orid.
- 28) changed fields dmcseedfile to dfile and jdate to yearday in tables dmcwf and dmcseed.
- 29) added focal mechanism calculation related tables and emodel table
- 30) extensive changes to wfrms table to make compatible with orbwfrms
- 40) made instrument table alternate key all fields except inid and lddate
- 41) introduced new calibration table, with new fields samprate, segtype, dlsta, dchan, and lead.

}

Time date lddate

Attribute Statement

- ◆ Type
- ◆ Null value
- ◆ Range
- ◆ Format
- ◆ Units

The screenshot shows a window titled 'wfdisc.sta' with a tab labeled 'ATTRIBUTE'. The attribute name 'station' is highlighted in a red box. Below it, a description is provided: 'This is the common code-name of a seismic observatory. Generally only three or four characters are used.' A white box with red text 'DESCRIPTION & DETAIL' is overlaid on the description. Below the description, the following details are listed: Field type: STRING, # characters: 6, First character: 0, printf format: %-6s, Null value: -. Below these details, the text 'Used in tables:' is followed by a table of table names. At the bottom, there is a 'Dismiss' button.

station
This is the common code-name of a seismic observatory. Generally only three or four characters are used.

Field type: **STRING**
characters: **6**
First character: **0**
printf format: **%-6s**
Null value: **-**

DESCRIPTION & DETAIL

Used in tables:

achanaux	affiliation	anetsta	arrival	assoc	calibration	dmcwf	fkgrid	schanloc	seedformat
seedindex	sensor	site	sitechan	snetsta	specdisc	stage	stamag	stassoc	stgrid
wfdisc	wfedit	wfmeas	wfrms	wftape	wftar				

Dismiss

```
    }
    :
Attribute sta
    String (6)
    Format ( "%-6s" )
    Null ( "-" )
    Description ( "station" )
    Detail {
        This is the common code-name of a seismic observatory.
        Generally only three or four characters are used.
    }
    :
```

sta ATTRIBUTE

```
Attribute stageid
    Integer (8)
    Format ( "%8d" )
    Null ( "-1" )
    Range ( " 0 < stageid " )
    Description ( "stage number in the calibration response" )
    Detail {
        The ordered stage number of this discrete stage in the
        calibration response. Each individual stage corresponds
        to a sensor, analog filter, A/D converter, or FIR filter.
        The numbering scheme for a seismic system will generally
        assign stageid=1 for the sensor, stageid=2 for the
        anti-alias filter, stageid=3 for the analog-to-digital
        converter, stageid=4 for the first FIR filter, ...
    }
    ;
```

```
Attribute staname
    String (50)
    Format ( "%-50s" )
    Null ( "-" )
    Description ( "station description" )
    Detail {
        This is the full name of the station whose code-name is in
        sta. As an example, one record in the site relation
        connects sta = ANMO to staname = ALBUQUERQUE, NEW MEXICO
        (SRO).
    }
    ;
```

```
Attribute stassid
    Integer (8)
    Format ( "%8d" )
    Null ( "-1" )
    Range ( "stassid > 0" )
    Description ( "stassoc id" )
    Detail {
        The wavetrain from a single event may be made up of a
        number of arrivals. A unique stassid joins those arrivals
        believed to have come from a common event as measured at a
        single station. Stassid is also the key to the stassoc
        relation, which contains additional signal measurements
        not contained within the arrival relation, such as station
```

Relation Statement

RELATION / TABLE NAME

wfdisc

Waveform file header and descriptive information

This relation provides a pointer (or index) to waveforms stored on disk. The waveforms themselves are stored in ordinary disk files called wfdisc or .w files, containing only a sequence of sample values (usually in binary representation).

TEXT
DESCRIPTION

Primary key: sta chan time::endtime
Alternate key: wfid
Defines id: wfid
Foreign keys: commid chanid
Record Size (bytes): 284
Records: 23248
Size (bytes): 6602432
Permissions: may be modified
File: /db/AprilNicoya.wfdisc

sta	chan	time	wfid	chanid	jdate	endtime	nsamp
samprate	calib	calper	instype	segtype	datatype	clip	dir
dfile	foff	commid	lddate				

LIST of FIELDS

DISMISS

PRIMARY KEY: attributes which uniquely identify the records for each table

Primary key: sta chan time::endtime

Alternate key: wfid

Defines id: wfid

Foreign keys: commid chanid

FOREIGN KEY: attributes of the table that are primary keys of other tables in the schema

ALTERNATE KEY: Attributes which could uniquely identify a record but were not chosen as a primary key

sta	chan	time	wfid	chanid	jdate	endtime	nsamp
samprate	calib	calper	instype	segtype	datatype	clip	dir
dfile	foff	commid	lddate				

Dismiss

```
98%Relation wfdisc
Fields ( sta chan time wfid chanid jdate endtime nsamp samprate calib calper instype segtype datatype clip dir dfile foff commid lddate )
Primary ( sta chan time::endtime )
Alternate ( wfid )
Foreign ( commid chanid )
Defines wfid
Description ( "Waveform file header and descriptive information" )
Detail {
    This relation provides a pointer (or index) to waveforms
    stored on disk. The waveforms themselves are stored in
    ordinary disk files called wfdisc or .w files, containing
    only a sequence of sample values (usually in binary
    representation).
}
;
```

wfdisc RELATION

```
Relation wfdedit
Fields ( sta chan edid time endtime probtype edittype auth commid lddate )
Primary ( sta chan time::endtime )
Alternate ( edid )
Foreign ( commid )
Defines edid
Description ( "Describes a waveform edit" )
Detail {
    Specifies a time slice for which a specified waveform has
    a problem, identified by the probtype field.
}
;
```

```
Relation wfmeas
Fields ( sta chan meastype filter time endtime tmeas twin val1 val2 units1 units2 arid auth lddate )
Primary ( sta chan meastype filter time endtime )
Foreign ( arid )
Description ( "waveform measurements" )
Detail {
    This relation provides a general way to store measurements made
    on segments of waveform data. The time::endtime fields give
    the time window of the data for which the measurement is unique.
    tmeas and twin specify the beginning of the measurement time
    for discrete measurements, and the time-span for extended measurements.
    The contents of val1 and val2, described by units1 and units2, depend
    on the type of measurement made.
}
;
```

**Tables are linked together by
the primary, alternate, and
foreign keys**

How links via keys work

Site

sta	ondate	offdate	lat	lon	elev	staname
BANE	1999340	2001365	9.9292	-84.9564	0.0490	Bajo de Negros
BONG	1999341	2001365	9.7535	-85.2078	0.0260	Rio Bongo
CORO	1999340	2001365	9.9729	-85.1711	0.0500	Corozal
COYO	1999340	2001365	10.3614	-85.6493	0.0670	Coyolito
GRAN	1999340	2001365	10.3404	-85.8458	0.0280	Playa Grande
GUAI	1999339	2001365	10.2702	-85.5105	0.0490	Guaitil
GUIO	1999342	2001365	9.9228	-85.6584	0.0280	Playa Guiones
HATA	1999341	2001365	10.4343	-85.2848	0.0440	Hacienda Tamarindo
HOJA	2000020	2001365	10.0498	-85.4230	0.3560	Hojancha
INDI	1999351	2001365	9.8647	-85.5022	0.0800	Punto Indio
JUDI	2000134	2001365	10.1659	-85.5387	0.7070	Juan Diaz
MARB	1999341	2001365	10.0630	-85.7544	0.0480	Marbella
PAPA	2000257	2001365	10.5902	-85.6760	0.0380	Golfo Papagayo (Near Playa de Coco)
PARG	1999340	2001365	10.1983	-85.8230	0.0200	Punto Pargo
PNCB	1999339	2001365	9.5895	-85.0917	0.0180	Parque Nacional Cabo Blanco
PNUE	1999341	2001365	9.8411	-85.3352	0.0210	Pueblo Nuevo
SAJE	2000091	2001365	10.6086	-85.4500	0.0200	San Jeronimo
SARO	2000029	2001365	10.8390	-85.6094	0.0300	Santa Rosa
TFER	1999340	2001365	10.2082	-85.2706	0.0690	Tempisque Ferry
VAIN	1999339	2001365	9.7768	-85.0102	0.0600	Vainilla

◆ Site Table Primary Keys

◆ Sta

◆ Ondate::Enddate

◆ SiteChan Table Primary Key

◆ Chanid

◆ Alternate Key

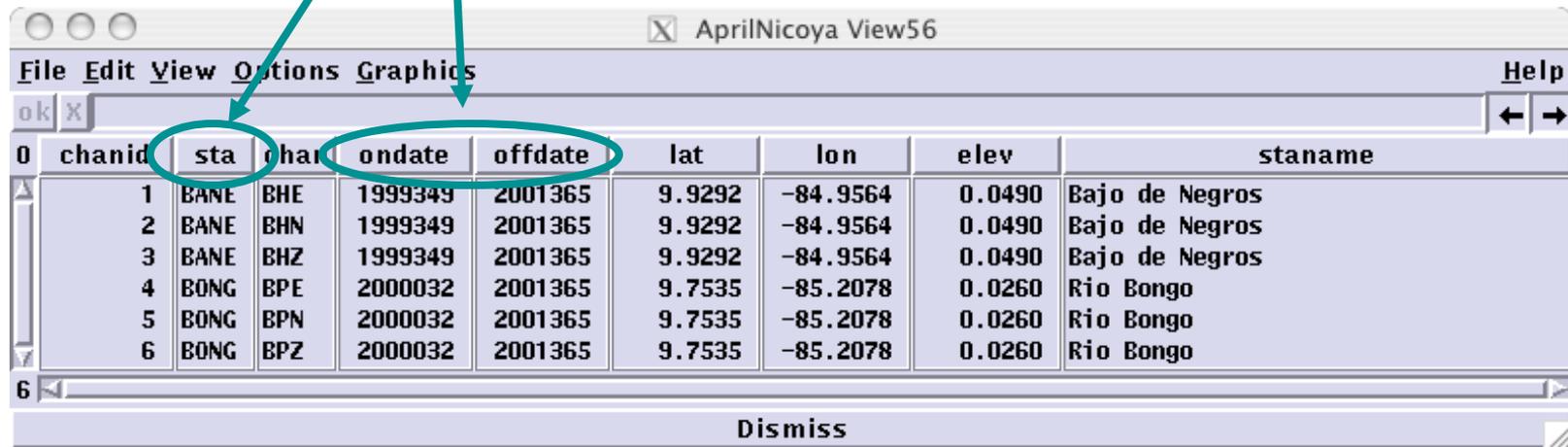
◆ Sta, Chan

◆ Ondate::Enddate

SiteChan Subset

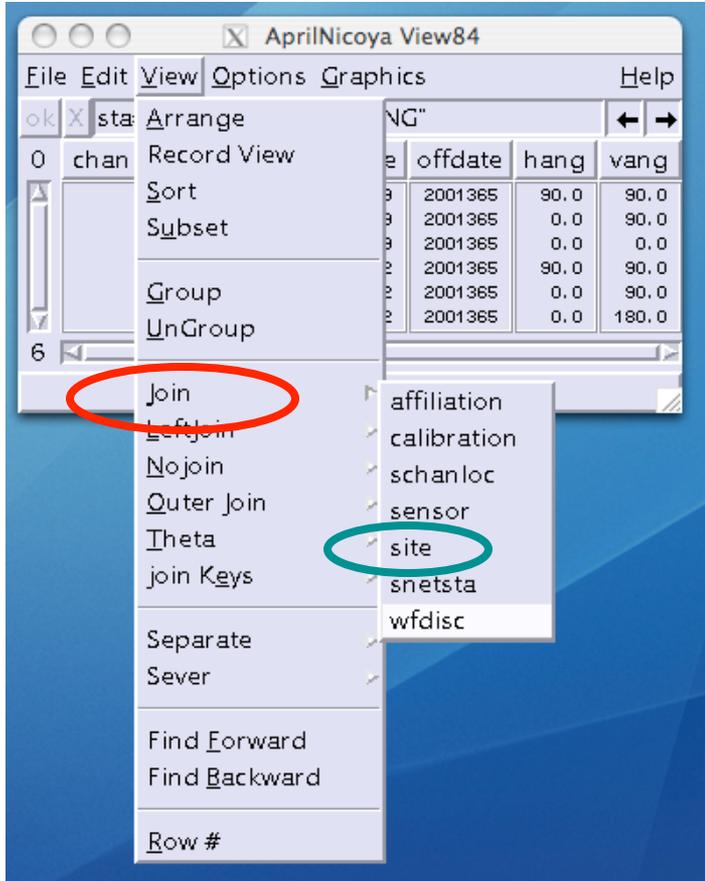
Result of joining the sitechan and site tables

Common primary keys used for the join



0	chanid	sta	char	ondate	offdate	lat	lon	elev	staname
1	BANE	BHE		1999349	2001365	9.9292	-84.9564	0.0490	Bajo de Negros
2	BANE	BHN		1999349	2001365	9.9292	-84.9564	0.0490	Bajo de Negros
3	BANE	BHZ		1999349	2001365	9.9292	-84.9564	0.0490	Bajo de Negros
4	BONG	BPE		2000032	2001365	9.7535	-85.2078	0.0260	Rio Bongo
5	BONG	BPN		2000032	2001365	9.7535	-85.2078	0.0260	Rio Bongo
6	BONG	BPZ		2000032	2001365	9.7535	-85.2078	0.0260	Rio Bongo

Join using the GUI dbe



or

Join via command line

```
/Users/hdeshon/Projects/AntelopeTutorial/CostaRicaDBs/Tutorial/Step1
[hdmacpro:CostaRicaDBs/Tutorial/Step1] hdeshon% dbsubset AprilNicoya.sitechan "sta=='BANE' || sta=='BONG'" \
? dbjoin - site \
? dbselect - chanid sta chan ondate offdate lat lon elev staname
  1 BANE  BHE      1999349  2001365    9.9292  -84.9564    0.0490 Bajo de Negros
  2 BANE  BHN      1999349  2001365    9.9292  -84.9564    0.0490 Bajo de Negros
  3 BANE  BHZ      1999349  2001365    9.9292  -84.9564    0.0490 Bajo de Negros
  4 BONG  BPE      2000032  2001365    9.7535  -85.2078    0.0260 Rio Bongo
  5 BONG  BPN      2000032  2001365    9.7535  -85.2078    0.0260 Rio Bongo
  6 BONG  BPZ      2000032  2001365    9.7535  -85.2078    0.0260 Rio Bongo
[hdmacpro:CostaRicaDBs/Tutorial/Step1] hdeshon% 
```

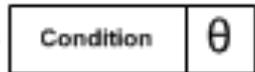
Relational Algebra

- ◆ **Union:** If A and B are sets, then the union of A and B is the set R that contains all elements of A and all elements of B , but no other elements.
- ◆ **Difference:** If A and B are sets, then the difference of B and A , is the set R which contains all of elements in B , but not in A .
- ◆ **Rename:** change the name of a field

Relational Algebra

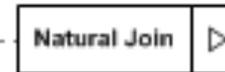
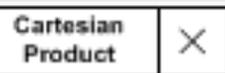
- ◆ **Selection:** selecting records by applying a test using binary operators ($<, \leq, =, \geq, >$) based on the table fields
- ◆ **Projection:** if a_1, \dots, a_n is a set of field names, the result of projection is defined as the set R that is obtained when all records in R are restricted to the set $\{a_1, \dots, a_n\}$
- ◆ **Cartesian Product:** If A and B are sets, the Cartesian product is the set R containing all possible ordered pairs whose first component is a member of A and whose second component is a member of B

Relational Algebra Operators and Symbols

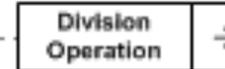
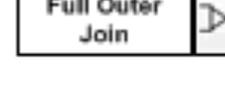
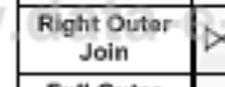
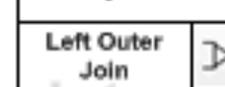


Basic Condition	
Grater Than	>
Less Than	<
Equal	=
Grate Than and Equal	≥
Less Than and Equal	≤
Not Equal	≠

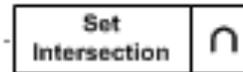
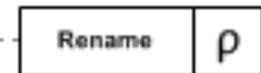
Composite Condition	
AND	∧
OR	∨
NOT	¬



Symbols



- ↓ Sort
- ⊂ Subset
- { } Group



Codd's Primitive Algebra Operation	
Selection	$\sigma_{\theta}(R)$
Projection	$\pi_{A_1, \dots, A_k}(R)$
Cartesian Product	$R_1 \times R_2$
Set Union	$R_1 \cup R_2$
Set Difference	$R_1 - R_2$
Rename	$\rho_{a \rightarrow b}(R)$

Codd's Updated Algebra Operation	
Natural Join	$R_1 \bowtie R_2$
Theta Join	$R_1 \bowtie_{\theta} R_2$
Left Outer Join	$R_1 \bowtie_L R_2$
Right Outer Join	$R_1 \bowtie_R R_2$
Full Outer Join	$R_1 \bowtie_F R_2$
Division Operation	$R_1 \div R_2$
Set Intersection	$R_1 \cap R_2$

Relational operations

- ◆ Subset

```
$dbsubset dbsite 'lat > 45'
```

- ◆ Sort

```
$dbsort dbsite sta
```

- ◆ Join

```
$dbjoin db.arrival site
```

◆ Select/Arrange

```
%dbselect - sta lat lon elev staname
```

```
% dbsubset AprilNicoya.site 'lat < 11 && elev > .5' |\  
dbselect - sta lat lon elev staname
```

```
dbsort - sta |\  
dbselect - sta lat lon elev staname
```

```
dbjoin - arrival |\  
dbselect - sta lat lon arid arrival.time chan
```

```
JUDI  10.1659 -85.5387  30026  986357438.70800 BHZ  
JUDI  10.1659 -85.5387  31083  988433330.21200 BHZ  
JUDI  10.1659 -85.5387  31093  988479025.88600 BHZ  
JUDI  10.1659 -85.5387  31099  988518786.98200 BHZ  
JUDI  10.1659 -85.5387  31108  988529215.11200 BHZ  
JUDI  10.1659 -85.5387  31114  988558341.28100 BHZ  
JUDI  10.1659 -85.5387  31120  988565702.96100 BHZ  
JUDI  10.1659 -85.5387  31128  988606800.21600 BHZ
```

What is a join?

- ◆ For example, given an arrival pick, you need to know the location of the recording station
- ◆ ie, given station name and arrival time, lookup the location of the station in the site table.
- ◆ Consider new virtual table which combines arrival and site table; each record has 1 arrival plus matching record from site table

demo2 arrival

File Edit View Options Graphics Help

ok X

10	sta	time	chan	iphase	auth
	AML	2/20/1995 (051) 8:08:16.35994	BHN	S	dbp:gwagner:953
	CHM	2/20/1995 (051) 8:08:16.64488	BHZ	P	dbp:gwagner:953
	USP	2/20/1995 (051) 8:08:17.59614	BHZ	P	dbp:gwagner:953

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Dismiss

demo2 site

File Edit View Options Graphics Help

ok X

4	sta	lat	lon	elev	staname
	AML	42.1311	73.6941	3.4000	
	ANT0	39.8689	32.7936	0.8830	Ankara, Turkey
	ARU	56.4302	58.5625	0.2500	Arti, Russia

48

Dismiss

demo2 View73

File Edit View Options Graphics Help

ok X

10	sta	time	iphase	auth	lat	lon	elev
	AML	2/20/1995 (051) 8:08:16.35994	S	dbp:gwagner:953	42.1311	73.6941	3.4000
	CHM	2/20/1995 (051) 8:08:16.64488	P	dbp:gwagner:953	42.9986	74.7513	0.6550
	USP	2/20/1995 (051) 8:08:17.59614	P	dbp:gwagner:953	43.2669	74.4997	0.7400
	TKM2	2/20/1995 (051) 8:08:22.74517	P	dbp:gwagner:953	42.9208	75.5966	2.0200
	ULHL	2/20/1995 (051) 8:08:24.85287	P	dbp:gwagner:953	42.2456	76.2417	2.0400

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Dismiss

Relational Operators

< : test for less than

<= : test for less than or equal to

> : test for greater than

>= : test for greater than or equal to

== : test for equal to

~= : test for not equal

Logical Operators

`&&` : logical AND ; tests that both expressions are true

`||` : logical OR ; tests that one or both of the expressions are true

`!` : logical NOT; tests that expression is true
