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Determination of accelerometers' 3-C orientations at the first EGS Collab Testbed

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We determine the accelerometers' three-component (3-C) orientations at the first EGS Collab testbed using CASSM data and hodogram analysis.

- Use the principal component analysis (PCA) analysis of the CASSM data recorded in May 2018 to determine the x-components' positive direction orientation. Those directions are almost parallel to the borehole, which matches the record of instrumental set-up.
- 10 accelerometers have x-components' positive directions (green arrows in Figure 1) in pointing away from the drift, but those of accelerometers OT-16 and OB-13 point to the drift. This implies that the y and z components' cable for these two accelerometers were switched in the Geode recording system.
- Apply the hodogram analysis (Figure 2) to each accelerometer to determine the rotation of y and z components.

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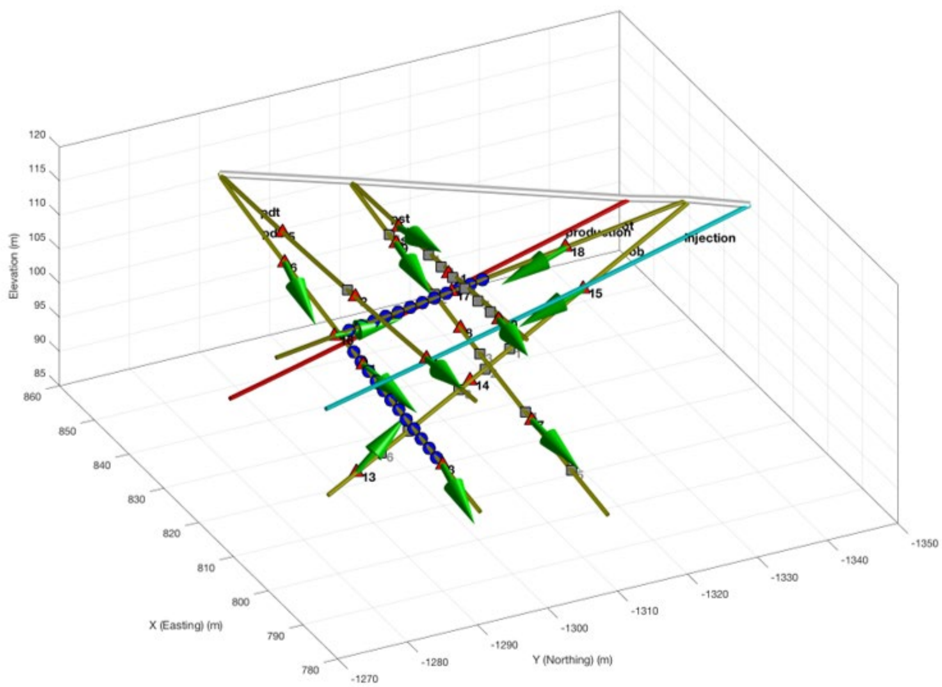

Figure 1. 3-D view of the well geometry, accelerometer positions (red triangles), and accelerometers' x-component positive directions (green arrows). The accelerometers' x-component positive directions obtained from the PCA analysis are almost parallel to the well direction. 10 of them points away from the drift, while OT-16 and OB-13 have x positive direction pointing to the drift.

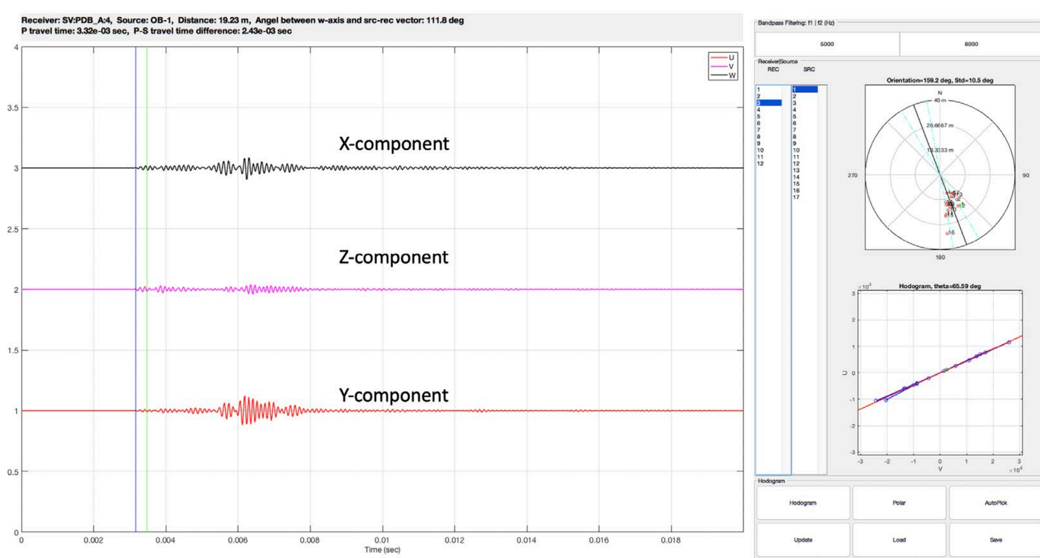

Figure 2. Illustration of the hodogram analysis. For each accelerometer, we bandpass filter the data and select a window around the first arrival to check its hodogram. The frequency band for all accelerometers are 5~8kHz, except for the accelerometer PDB-6 (frequency band is 3~5kHz).

Base vectors of x,y,z components are defined in the ENU (East-North-Up) system
base_x = [x1,x2,x3]
base_y = [y1,y2,y3]
base_z = [z1,z2,z3]

To rotate the waveforms from the local system to the ENU system, we can use:
[dat_E, dat_N, dat_U] = [dat_x, dat_y, dat_z]*[base_x; base_y; base_z]; for each accelerometer.

For example: for the 1st accelerometer PDT-1
We can rotate it as:

```
[dat_E, dat_N, dat_U] = [dat_x, dat_y, dat_z]*[-0.987188, -0.132298, -0.089199
                                                0.125816, -0.301610, -0.945094
                                                0.098131, -0.944208,  0.314391];
```

The values of x1,x2,x3,y1,y2,y3,z1,z2,z3 for 12 accelerometers are given in the following:

```
name,x1,x2,x3,y1,y2,y3,z1,z2,z3
PDT-1,-0.987188,-0.132298,-0.089199,0.125816,-0.30161,-0.945094,0.098131,-0.944208,0.314391
PDB-3,-0.893842,-0.012001,-0.448221,0.227677,-0.873329,-0.430651,-0.386276,-0.486983,0.78335
PDB-4,-0.898223,-0.171004,-0.40491,0.438255,-0.27805,-0.854764,0.033583,-0.945223,0.324694
PDB-6,-0.892329,-0.168106,-0.418914,0.429743,-0.032471,-0.902367,0.138091,-0.985234,0.101217
PSB-7,-0.906486,-0.165397,-0.388494,0.373648,0.114288,-0.920503,0.196649,-0.979583,-0.0418
PSB-9,-0.898046,-0.157808,-0.410621,0.212384,-0.972981,-0.09056,-0.385235,-0.168537,0.907298
PST-10,-0.993688,-0.096499,-0.057199,0.091889,-0.407721,-0.908471,0.064345,-0.907993,0.414014
PST-12,-0.993341,-0.089704,-0.072303,-0.09956,0.352471,0.930512,-0.057986,0.931514,-0.359055
OB-13,-0.042499,0.883082,-0.46729,0.291912,-0.436329,-0.85112,-0.9555,-0.17258,-0.239239
OB-15,-0.060299,0.882785,-0.465892,-0.883599,-0.264331,-0.3865,-0.464346,0.388356,0.795966
OT-16,0.0231,0.98808,-0.152197,-0.700674,0.124592,0.702519,0.713107,0.090413,0.6952
OT-18,-0.052797,0.992146,-0.113394,-0.831318,-0.106583,-0.545482,-0.553283,0.065467,0.830417
```