Automated weighting schemes for DAS data in geophysical inversion: a case study on event location (Supplementary Material)

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Abstract The supplementary materials are seven tables (description of the DAS deployments, data processing, and synthetic tests) and eighteen figures (additional synthetic and real data tests/applications) that complement the manuscript.

1 Supplementary Materials

DAS ID	Location	Length [km]	N° channels
AZ-V	Azuma-Volcano (Japan)	15	1404 (40.8, 10.2)
G-C	Gran-Canaria (Spain)	64	6400 (10, 10)

Table 1 Datasets collected in this study

* Note: Gauge length and channel spacing are shown in parentheses under the "Num. channels" field. More details on the Azuma-Volcano deployment can be found in (Nishimura et al., 2021) and (Ugalde et al., 2023).

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DAS ID	Distance [km]	Time	Magnitude	Info	BP filtering
G-C	24.5	2023-01-07-10:48:10	3.2	Earthquake event	3-10 Hz
AZ-V	0.6	2019-07-04-12:34:00	-0.1	Volcano-tectonic event	3-20 Hz

Table 2 Events used to test the algorithm

* Note: The event distance is computed from the closest DAS channel. More details on the Azuma-Volcano earthquake can be found in (Nishimura et al., 2021), while for Gran-Canaria in (Instituto Geográfico Nacional (IGN), 2022).

DAS ch. ID	Arrival time relative to the start of the file [s]	SNR [dB]
739	4.7850	10.4220
740	4.5224	9.0614
741	4.9048	8.8295
742	3.9272	8.7826
743	3.7576	9.5216
744	4.2681	8.5322
745	4.2889	11.4387
746	4.9188	11.1439
747	4.2616	12.7305

Table 3 Example of raw data and attributes for P-wave arrival times (Gran-Canaria). Raw P-wave arrival times are relative to the start of the file and automatically made relative to the minimum by the algorithm.

DAS ch. ID1	DAS ch. ID2	Differential times [s]	MCC	INTER-DIST [m]
0	0	0.0	1.00	0.00
0	1	-0.0049	0.6757	10.25
0	2	-0.0049	0.5449	20.50
0	3	-0.4349	0.4040	30.75
0	4	-0.4449	0.4371	41.01
0	5	-0.4449	0.4904	50.92
0	6	-0.4499	0.5955	61.25
0	7	-0.3449	0.6333	71.25
0	8	-0.3499	0.5996	81.10
0	9	-0.3449	0.5689	91.35

Table 4 Example of data and attributes for P-wave differential times (Azuma-Volcano)

* Note on DAS ch. IDs. DAS ch. ID1 refers to the channel that is iteratively cross-correlated with all the other channels (DAS ch. ID2).

Data type	DAS ID	H_1	$H_2[dB]$	H_3	$H_4[m]$	H_5
P-wave arrival time	AZ-V	0	20	1	nd	nd
P-wave arrival time	G-C	0	10	1	nd	nd
P-wave differential time	AZ-V	0	0.7	1	400	2
P-wave differential time	G-C	0	0.5	2	5000	2

Table 5 True values of hyperparameters for the synthetic tests

* Note for the hyperparameters. H_1: coherent weight that scales all the entries of the covariance matrix; H_2: threshold for SNR or MCC; H_3: weights for SNR or MCC; H_4: threshold for INTER-DIST; H_5: weight for INTER-DIST.

Array	ID	X [km]	Y [km]	Z [km]	Vp [km/s]	H_1	H_2	H_3
AZ-V	i	-10:10	-10:10	-0.8:-0.8	2.5:2.5	-1:5	0:0	0:0
AZ-V	ii	-10:10	-10:10	-0.8:-0.8	2.5:2.5	-1:5	-20:40	-1:5
G-C	i	-30:60	-30:60	-10:-10	5:5	-1:5	0:0	0:0
G-C	ii	-30:60	-30:60	-10:-10	5:5	-1:5	-20:40	-1:5

Table 6 Prior distributions of parameters for the real data test of the weighting scheme developed for P-wave arrival times on Azuma-Volcano and Gran-Canaria deployments.

* Note for the ID field. a) "i", All data (no weight); b) "ii", All data (auto weight).

ID-DAS	ID test	X [km]	Y [km]	Z [km]	Vp [km/s]	H_1	H_2	H_3	H_4	H_5
AZ-V	i	-10:10	-10:10	-0.8:-0.8	2.5:2.5	-1:5	0:0	0:0	0:0	0:0
AZ-V	ii	-10:10	-10:10	-0.8:-0.8	2.5:2.5	-1:5	-20:40	-1:5	0:0	0:0
AZ-V	iii	-10:10	-10:10	-0.8:-0.8	2.5:2.5	-1:5	0:0	0:0	0:1000	-1:5
G-C	i	-30:60	-30:60	-10:-10	5:5	-1:5	0:0	0:0	0:0	0:0
G-C	ii	-30:60	-30:60	-10:-10	5:5	-1:5	-20:40	-1:5	0:0	0:0
G-C	iii	-30:60	-30:60	-10:-10	5:5	-1:5	0:0	0:0	0:5000	-1:5

Table 7 Prior distributions of parameters for the real data test (mini-array) of the weighting scheme developed for P-wave differential times on Azuma-Volcano and Gran-Canaria deployments.

* Note for the ID test field. a) "i", No weight; b) "ii", Automatic weighting scheme (MCC), "iii" Automatic weighting scheme (INTER-DIST).

SUPPL1

P-wave arrival times

Azuma-Volcano

Vary H2(SNR) (vs manuscript)

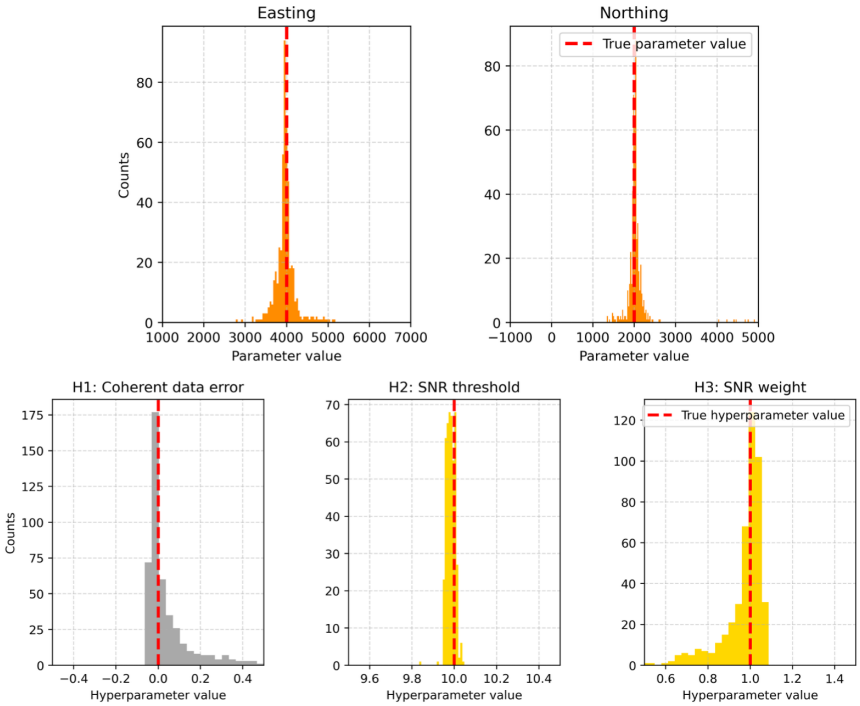

Figure 1 Supplementary synthetic test with the weighting scheme based on SNR (Azuma-Volcano). H_2 is different from the manuscript.

SUPPL2

P-wave arrival times

Azuma-Volcano

Vary H3(SNR) (vs manuscript)

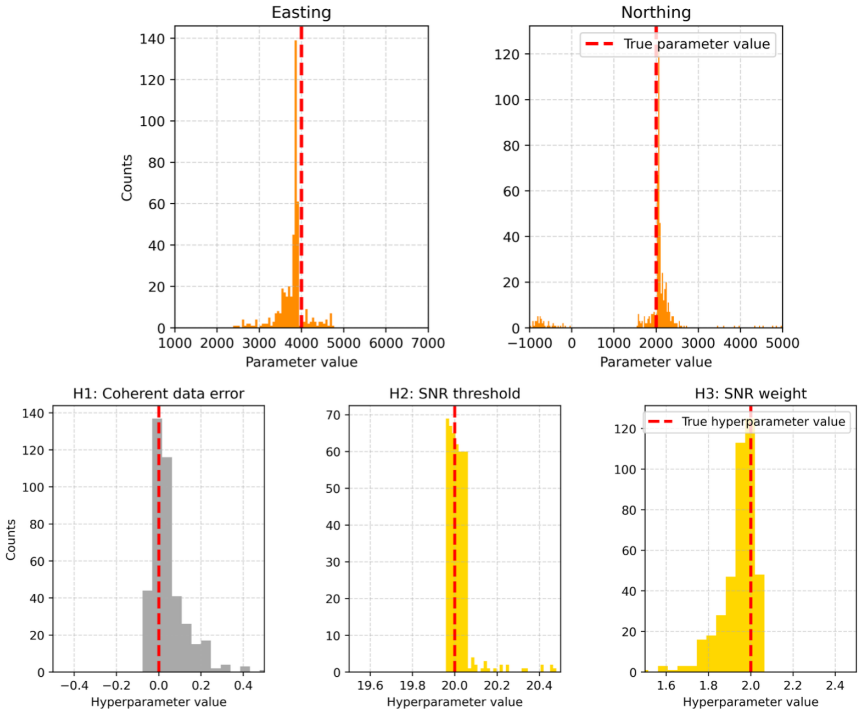

Figure 2 Supplementary synthetic test with the weighting scheme based on SNR (Azuma-Volcano). H_3 is different from the manuscript.

References

Instituto Geográfico Nacional (IGN). Spanish Seismic Catalogue. https://doi.org/10.7419/162.03.2022, 2022. doi: 10.7419/162.03.2022.

SUPPL3

P-wave arrival times

Azuma-Volcano

Vary X,Y (vs manuscript)

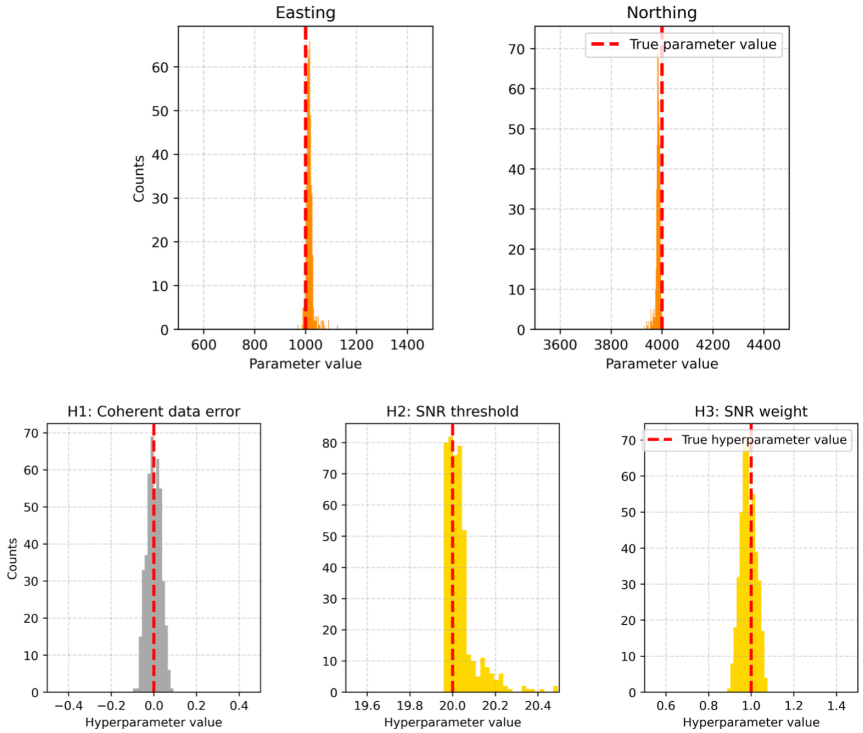

Figure 3 Supplementary synthetic test with the weighting scheme based on SNR (Azuma-Volcano). X and Y are different from the manuscript.

SUPPL4

P-wave arrival times

Azuma-Volcano

Vary X,Y, H2(SNR) and H3(SNR) (vs manuscript)

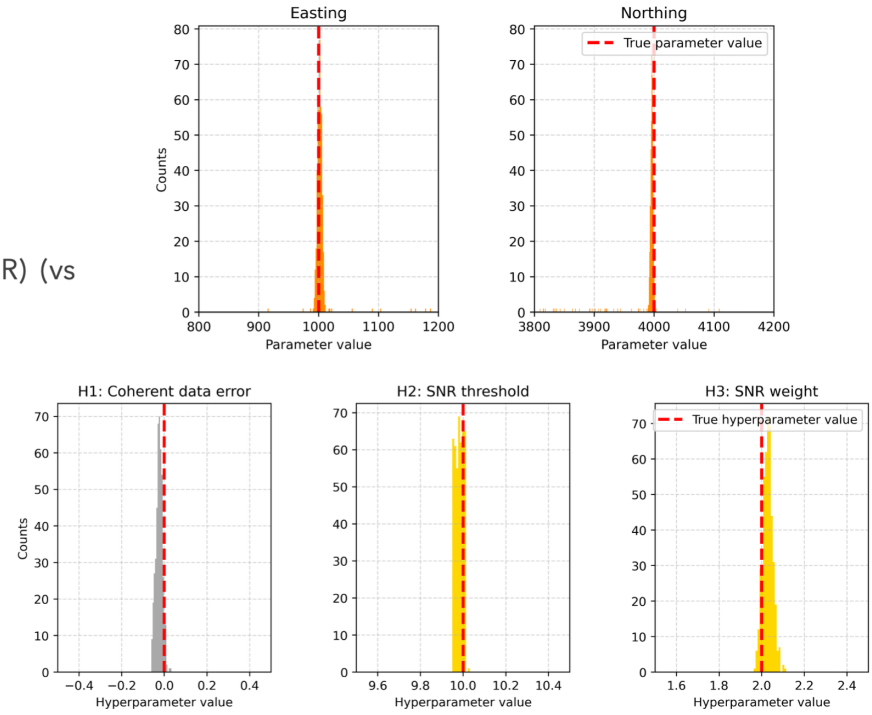

Figure 4 Supplementary synthetic test with weighting scheme based on SNR (Azuma-Volcano). H_2, H_3, X and Y are different from the manuscript.

SUPPL5

P-wave arrival times

Gran Canaria

Vary X,Y, H2(SNR) and H3(SNR) (vs manuscript)

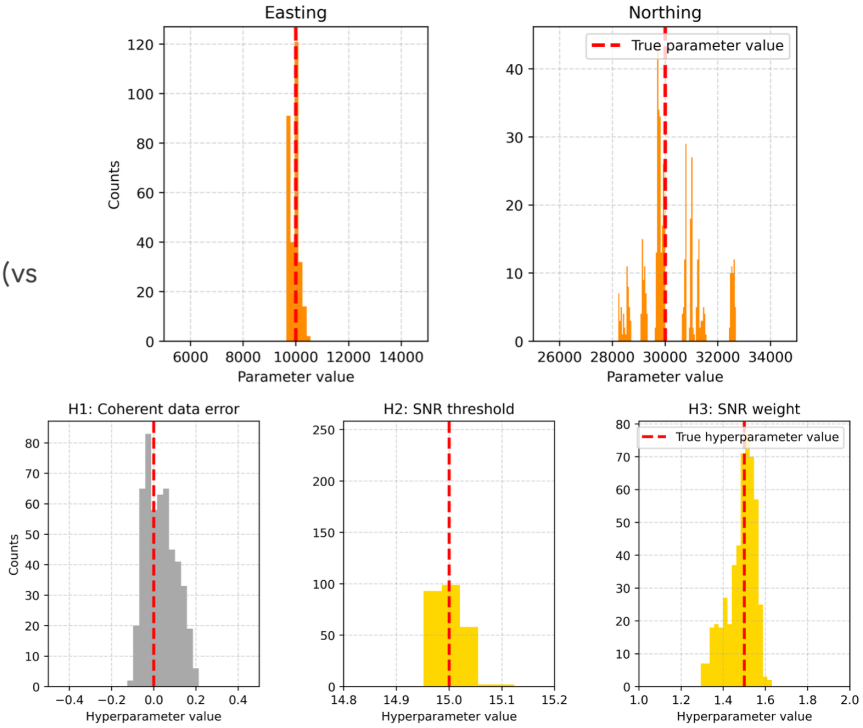

Figure 5 Supplementary synthetic test with the weighting scheme based on SNR (Gran-Canaria). H_2, H_3, X and Y are different from the manuscript.

SUPPL6

P-wave differential times

Azuma-Volcano

Vary H2(MCC) (vs manuscript)

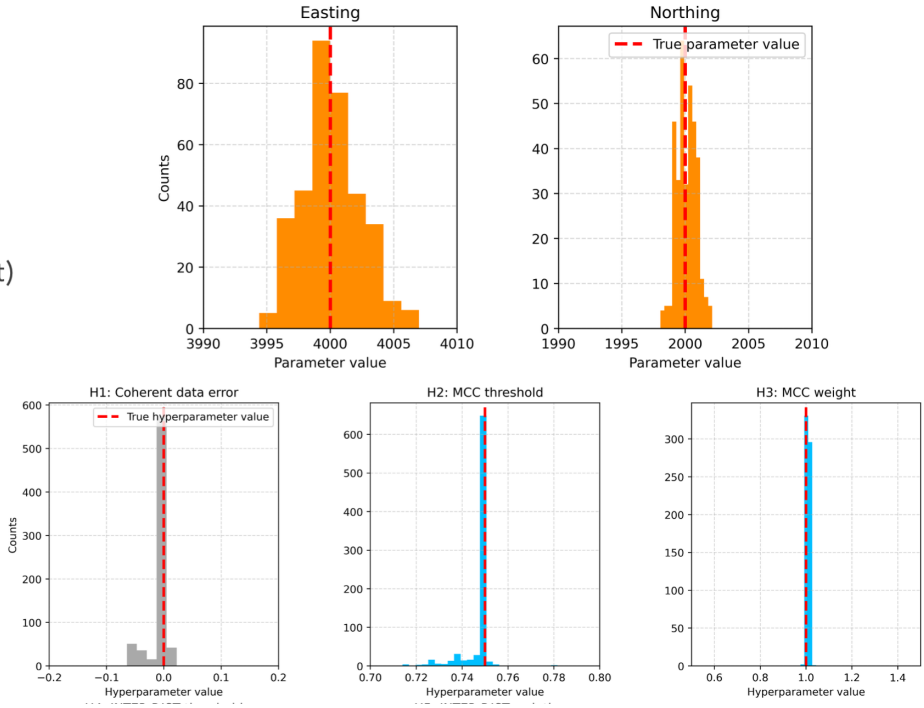

Figure 6 Supplementary synthetic test with the weighting scheme based on MCC (Azuma-Volcano). H_2 is different from the manuscript.

SUPPL7

P-wave differential times

Azuma-Volcano

Vary H3(MCC) (vs manuscript)

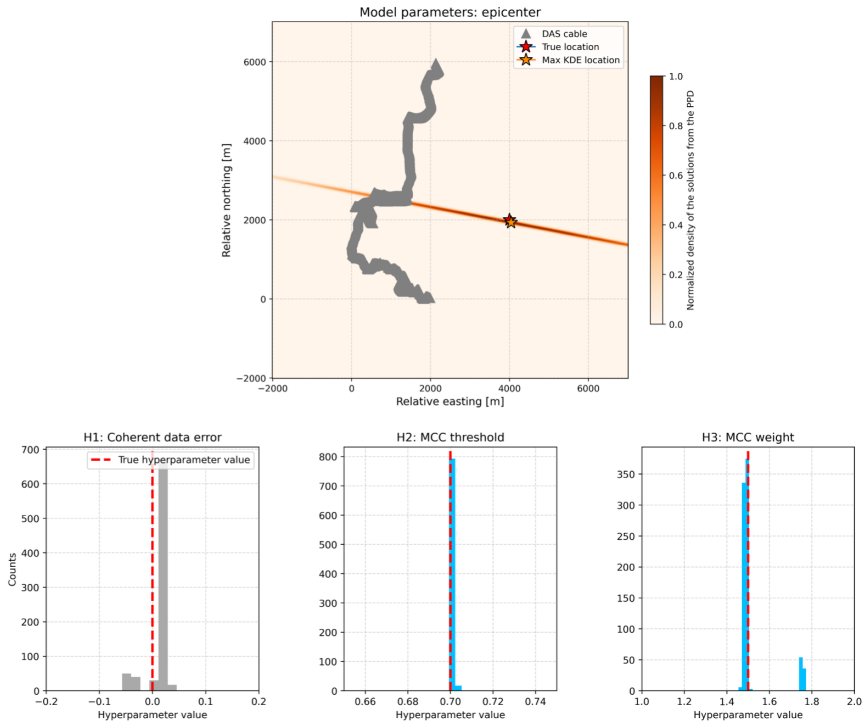

Figure 7 Supplementary synthetic test with the weighting scheme based on MCC (Azuma-Volcano). H_3 is different from the manuscript.

SUPPL8

P-wave differential times

Azuma-Volcano

Vary H4(INTER-DIST) (vs manuscript)

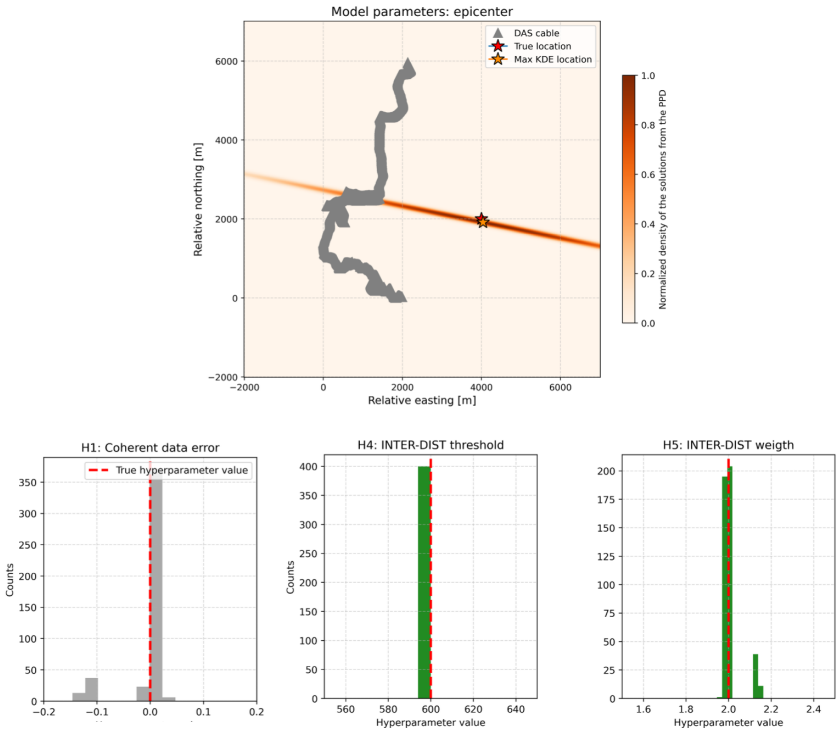

Figure 8 Supplementary synthetic test with the weighting scheme based on INTER-DIST (Azuma-Volcano). H_4 is different from the manuscript.

SUPPL9

P-wave differential times

Azuma-Volcano

Vary H5(INTER-DIST) (vs manuscript)

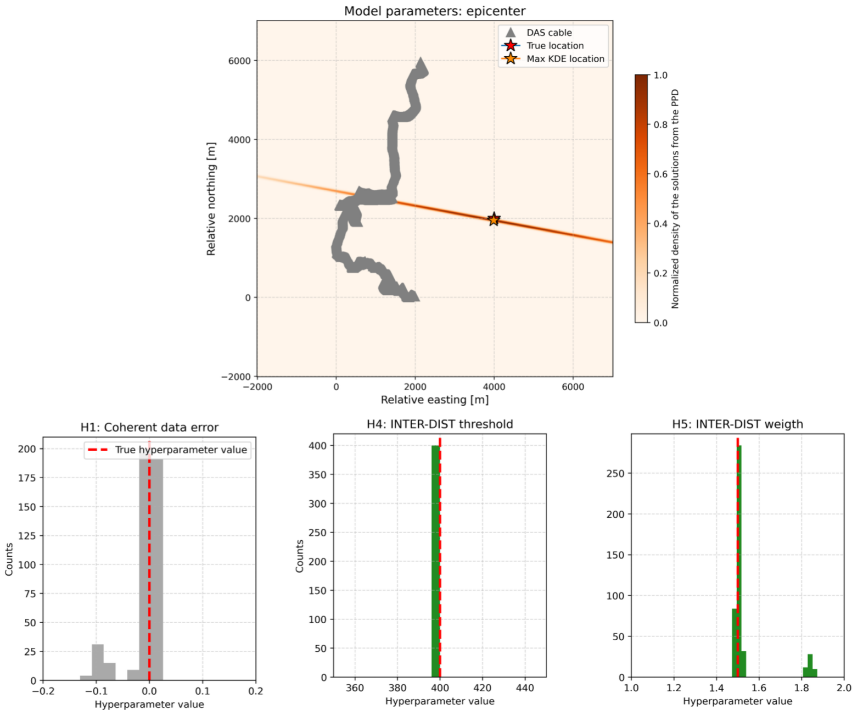

Figure 9 Supplementary synthetic test with the weighting scheme based on INTER-DIST (Azuma-Volcano). H_5 is different from the manuscript.

SUPPL10

P-wave differential times

Azuma-Volcano

Vary X, Y and H3(MCC) (vs manuscript)

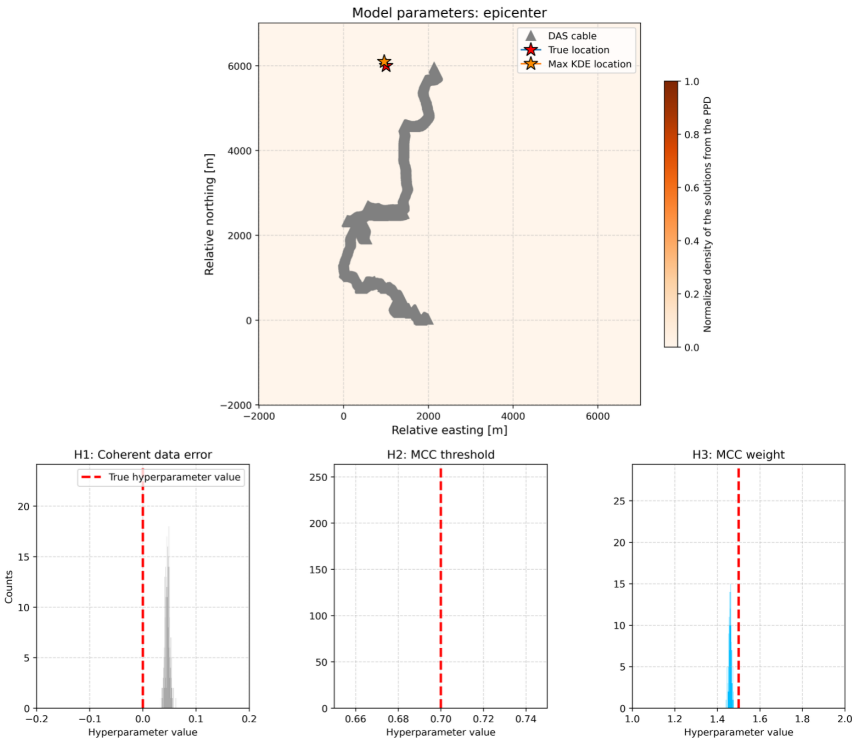

Figure 10 Supplementary synthetic test with the weighting scheme based on MCC (Azuma-Volcano). H_3, X and Y are different from the manuscript. Initial signs of trade-off between H_1 and H_3 are observed.

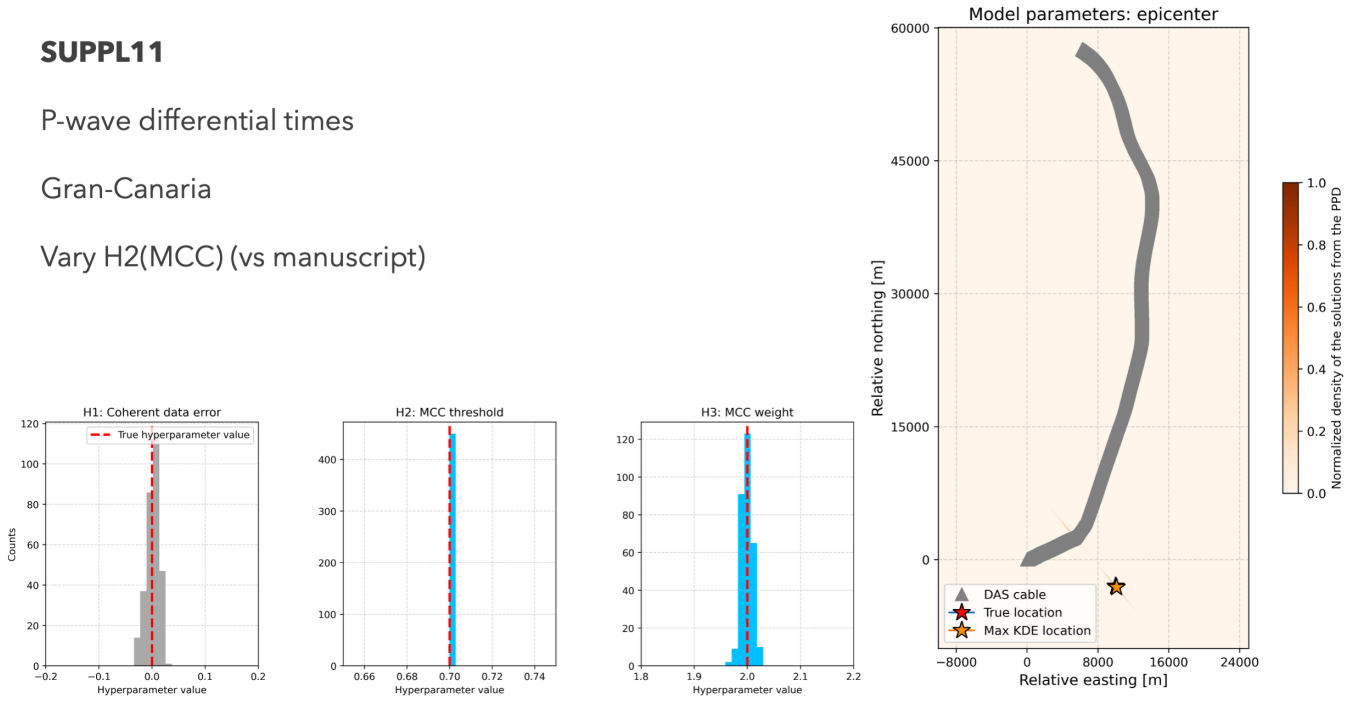

Figure 11 Supplementary synthetic test with the weighting scheme based on MCC (Gran-Canaria). H_2 is different from the manuscript.

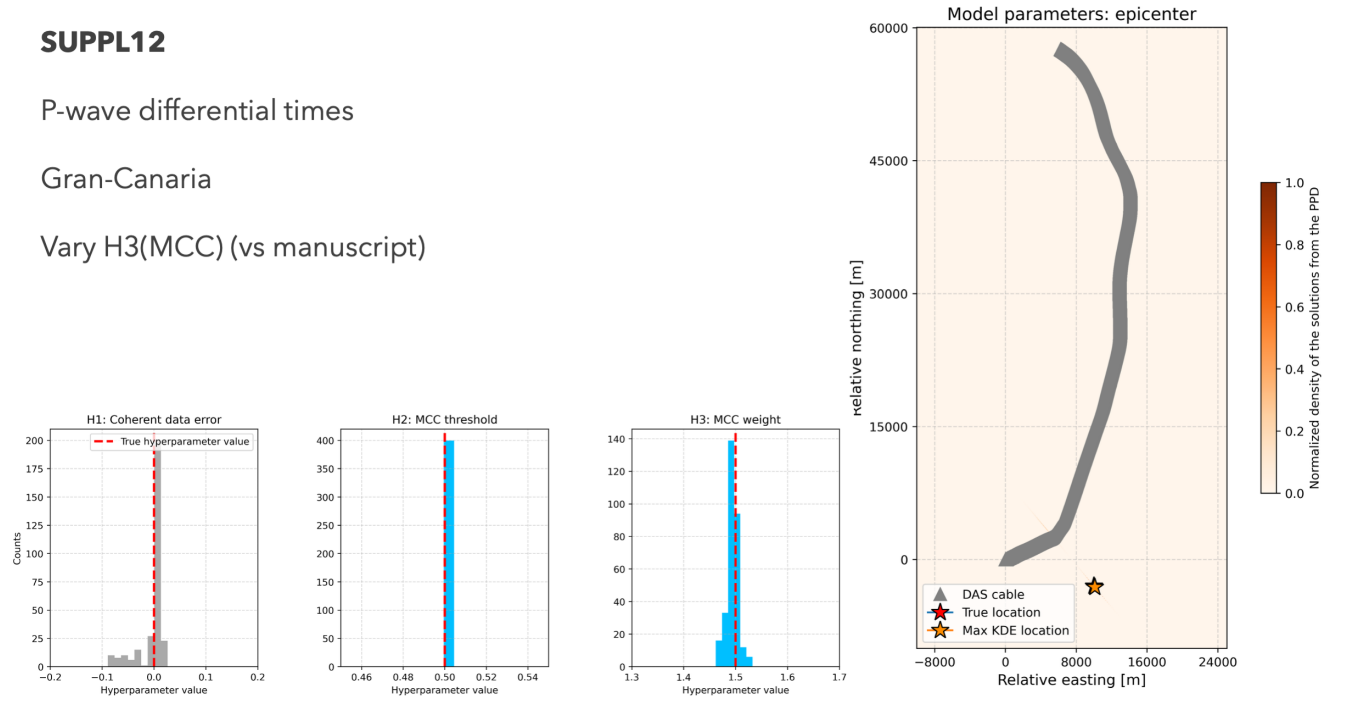

Figure 12 Supplementary synthetic test with the weighting scheme based on MCC (Gran-Canaria). H_3 is different from the manuscript.

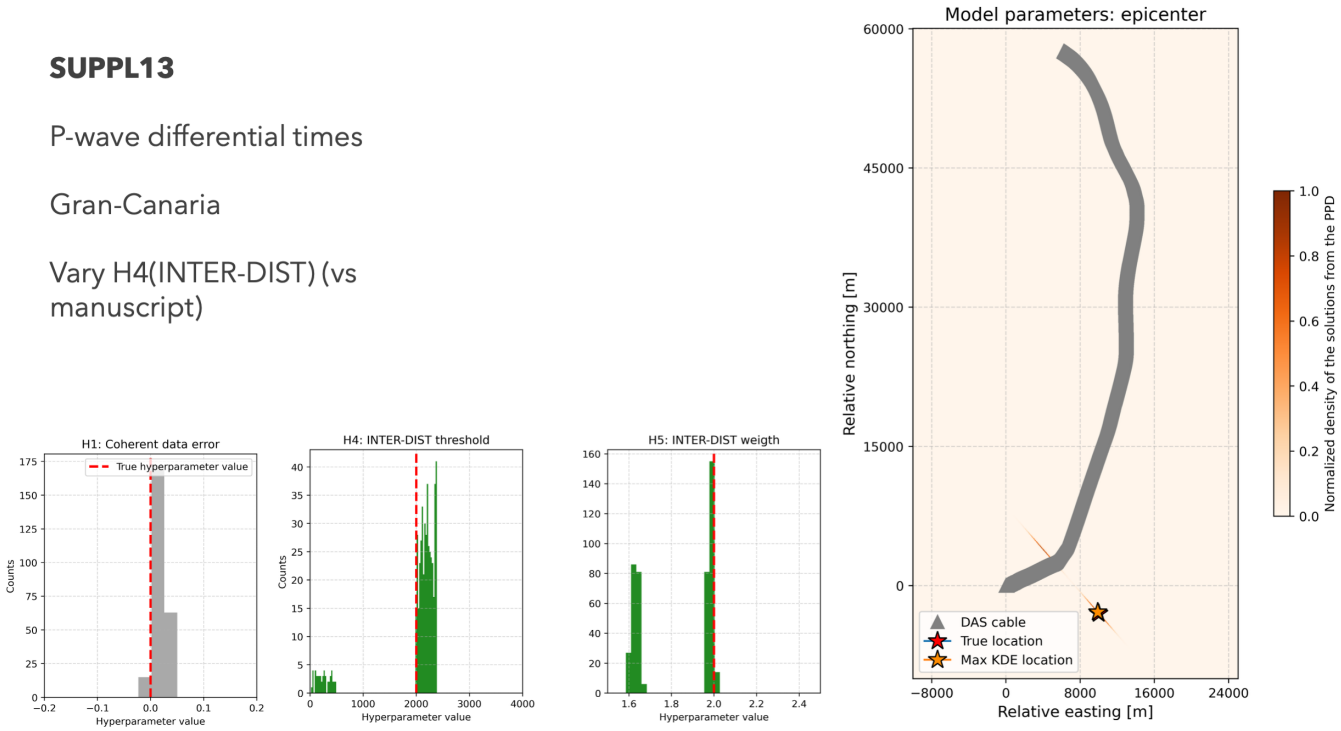

Figure 13 Supplementary synthetic test with the weighting scheme based on INTER-DIST (Gran-Canaria). H_4 is different from the manuscript.

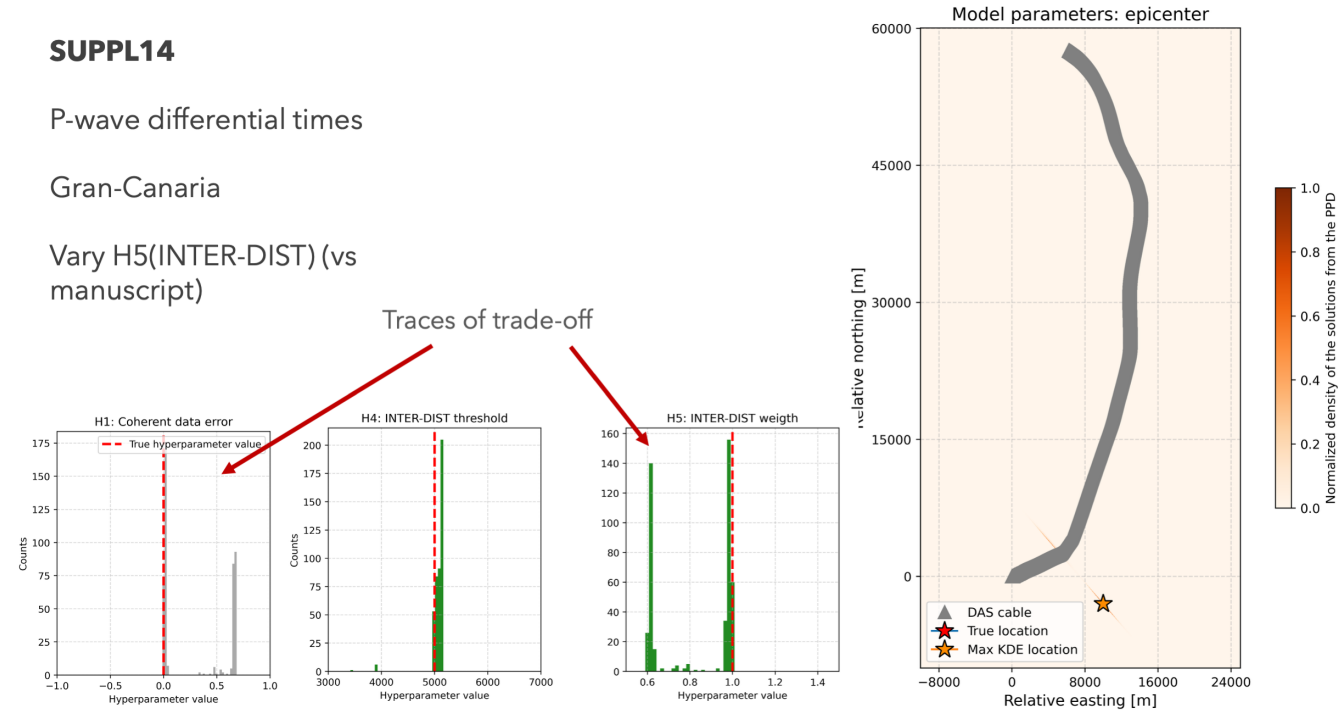

Figure 14 Supplementary synthetic test with the weighting scheme based on INTER-DIST (Gran-Canaria). H_5 is different from the manuscript. Signs of a trade-off between H_1 and H_5 are observed.

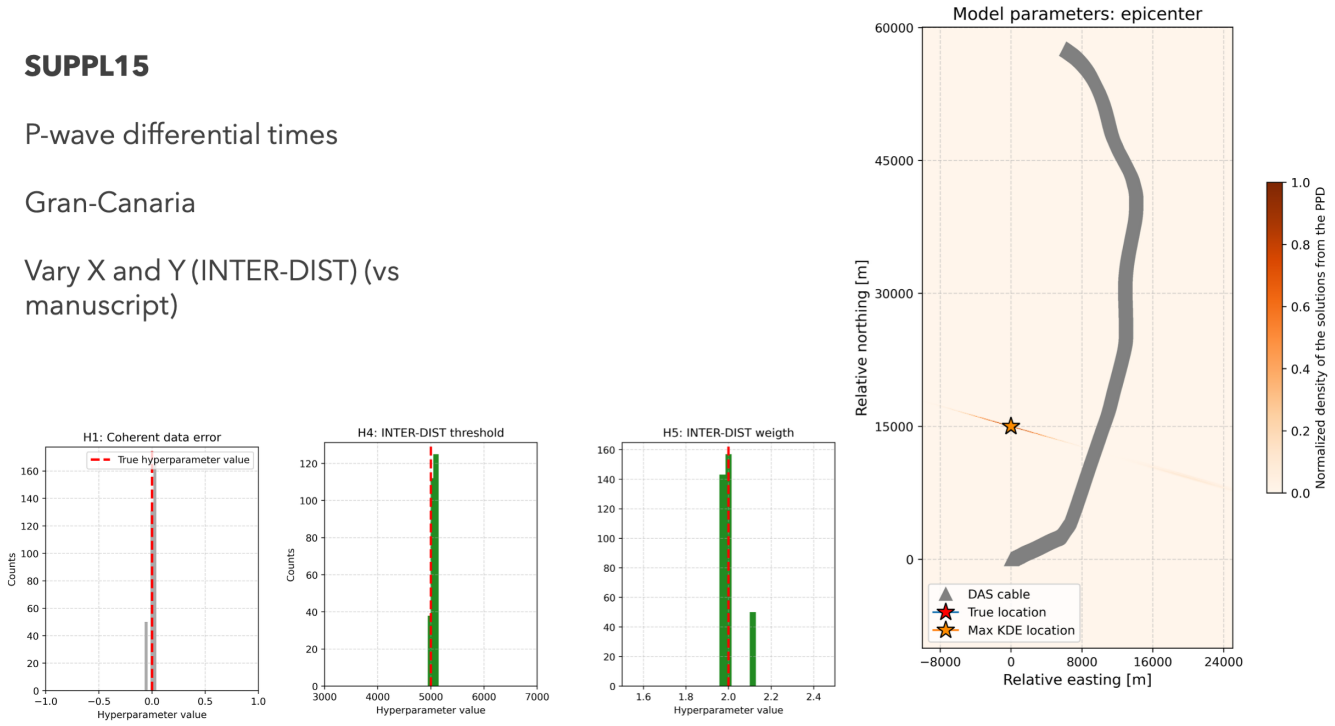

Figure 15 Supplementary synthetic test with the weighting scheme based on INTER-DIST (Gran-Canaria). X and Y are different from the manuscript.

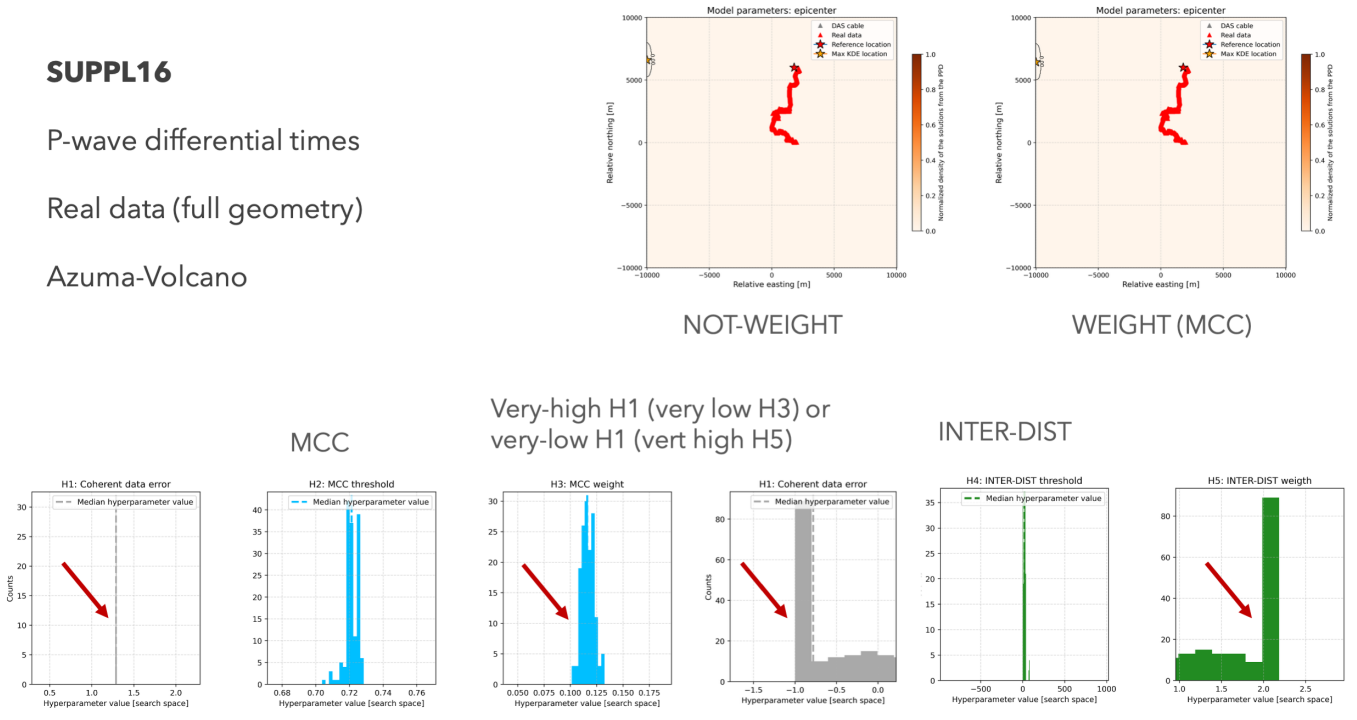

Figure 16 Real data application with channels along the entire length of the cable (Azuma-Volcano). Trade-offs between H_1 and the other weights (H_3 and H_5) are observed.

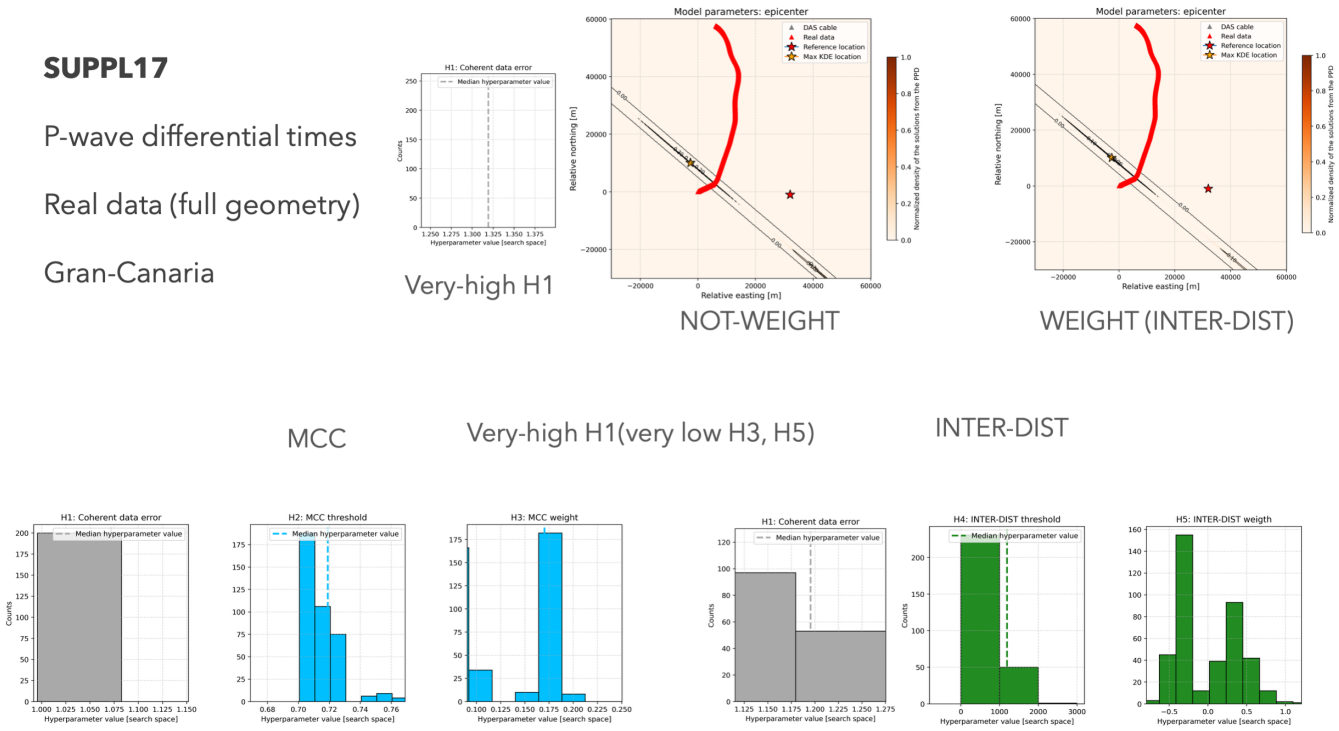

Figure 17 Real data application with channels along the entire length of the cable (Gran-Canaria). Trade-offs between H_1 and the other weights H_3 and H_5 are observed.

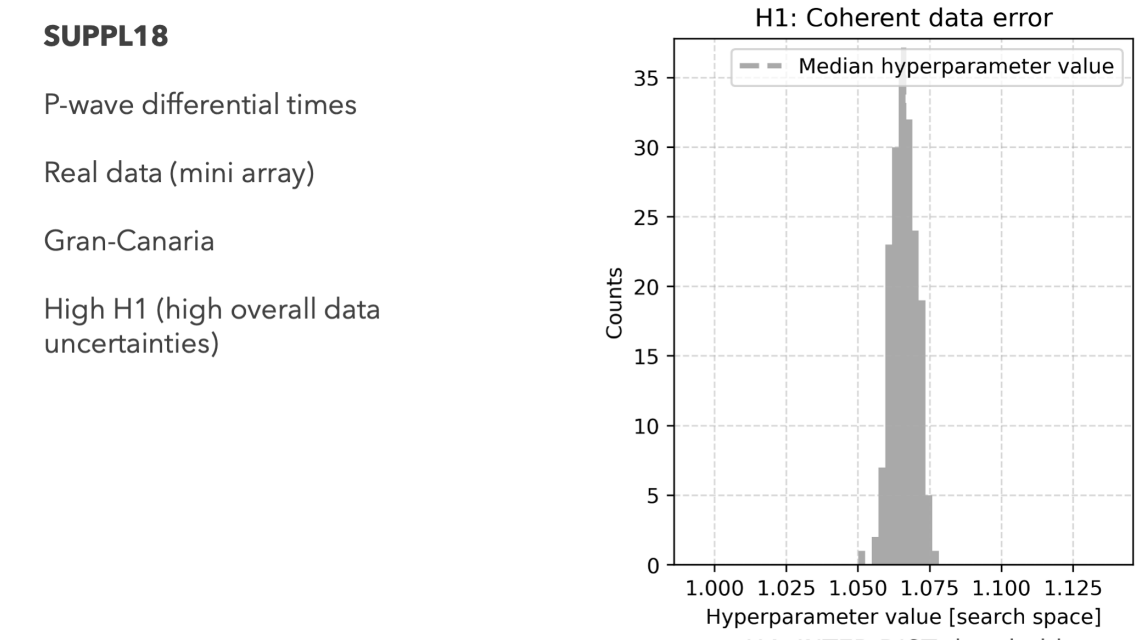

Figure 18 H_1 PPDs for real data application with mini-arrays having the original channel density(Gran-Canaria). H_1 is high compared to H_3 and H_5 shown in the text, suggesting an overall high uncertainty of the original data.

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