Fog Simulation on Real LiDAR Point Clouds for 3D Object Detection in Adverse Weather (Supplementary Materials)

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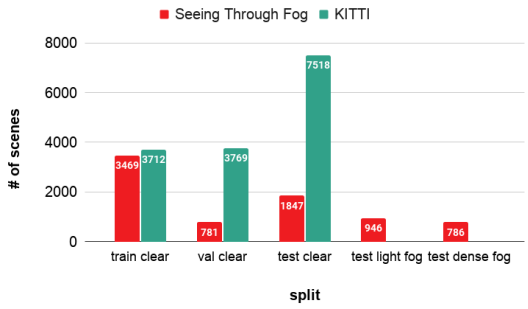

Figure 1: Size comparison of the STF [1] and the well known KITTI [2] dataset for 3D Object Detection.

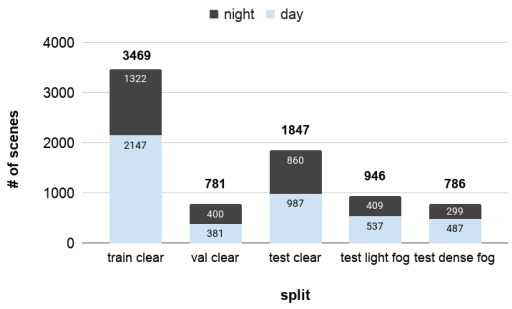

Figure 2: Number of day- and nighttime scenes per split in STF [1].

In this supplemental document we provide additional information about the Seeing Through Fog (STF) [1] dataset (Sec. 1). We show an extended comparison of our fog simulation and the simulation in [1] (Sec. 2). Finally, we also present additional 2D, 3D and Bird's Eye View (BEV) results of the 3D object detection methods presented in the paper (Sec. 3).

1. Additional Details on Seeing Through Fog

Fig. 1 shows a size comparison between the Seeing Through Fog (STF) [1] and the well known KITTI [2] dataset. While the training set of STF [1] is of almost similar size, the validation and test set is considerably smaller. However, STF [1] has the benefit of having separate test splits for different adverse weather conditions. E.g. it comes with 946 scenes recorded in light fog and 786 scenes recorded in dense fog.

Each scene further contains a label if it was collected at day- or at nighttime. This information is shown in Fig. 2. In Fig. 3 we show the number of annotated objects per class and split. While the number of cars and pedestrians is fairly balanced, we can see that cyclists are quite underrepresented in STF [1].

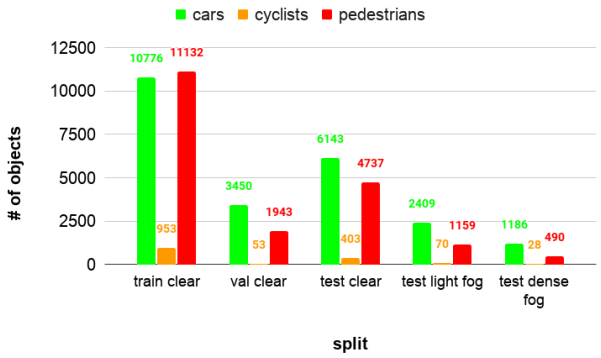

Figure 3: Number of objects per per class and split in STF [1].

As stated in the paper, we assume that this is why all reported methods struggle with the *Cyclist* class and underperform in comparison to the two other classes *Car* and *Pedestrian*.

2. Additional Fog Simulation Results

In Fig. 5 and 6 we visually compare our fog simulation to the fog simulation in Bijelic et al. [1]. While in the top row there is the clear weather point cloud, we continue down from top to bottom with the values 0.005, 0.01, 0.02, 0.03, 0.06, 0.12 and 0.3 which corresponds to a meteorological optical range (MOR) of approximately 600, 300, 150, 100, 50, 25 and 10m respectively. In Fig. 4 we display the image that the camera captured at the same time. In Fig. 6 we can see that both our simulation and the simulation in [1] modify the *intensity* of the point cloud in a similar way. In Fig. 5 however, we can clearly see that in contrast to our fog simulation, the fog simulation in [1] fails to replicate the returns caused by fog. In the fog simulation of [1], these returns only become apparent at a very low MOR (i.e. < 25m). Clearly, this does not correspond to what we see in real measurements.

3. Additional Quantitative Results

Early in our experiments we found that the official KITTI [2] 3D average precision metric with an intersection over union (IoU) threshold of 0.7 for the *Car* and 0.5 for the *Cyclist* and *Pedestrian* category is too strict for an evaluation on STF [1] under adverse weather. The performance of all reported methods was very low (i.e. 24% and 16% average precision at best for the moderate car and moderate pedestrian class in the dense fog test split). We concluded that these IoU thresholds are too strict with respect to the localization of the objects of interest.

In adverse weather, where accurate predictions are even more challenging than in clear weather, we claim it is important to put more emphasis on the *detection* per se rather than the rigorous *localization* of objects. That is, it is better to accept a rough detection of an object than to discard it because localization is imprecise. This is why for our evaluations on the STF [1] dataset, we chose to relax the IoU threshold to 0.5 for the *Car* and 0.25 for the *Cyclist* and *Pedestrian* category, effectively taking away emphasis on the *localization* precision.

In Tab. 1 we report the Bird's Eye View (BEV) results on the dense fog test split of STF [1]. We can see that, as expected, the BEV performance for all methods and classes is slightly higher than the performance in 3D and except a few cases, training using our fog simulation again outperforms training with competing approaches. In Tab. 2 we report the BEV results of the *Car* class on the dense fog, light fog and clear test set.

In Tab. 3 - 8, we present the results using the official KITTI [2] IoU strictness with 0.7 for the *Car* and 0.5 for the *Cyclist* and *Pedestrian* category. For all tables we use the same snapshots as we used for the quantitative results in the main paper and all average precision (AP) and mean average precision (mAP) numbers reported here are again being calculated using 40 recall positions as suggested in Simunelli et al. [7].

Figure 4: Camera reference of point clouds visualized in Fig. 5 and 6. On the right hand side we have open space while on the left hand side we have vegetation.

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Method		Car AP@.5IoU			Cyclist AP@.25IoU			Pedestrian AP@.25IoU			mAP over classes		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	49.09	50.23	49.30	24.33	24.63	24.63	**44.45**	**42.60**	**40.83**	39.29	39.15	38.25
fog simulation in [1]	*	49.32	50.25	50.08	26.42	26.93	27.80	43.08	41.06	39.29	39.61	39.41	39.06
our fog simulation	*	**50.91**	**51.75**	**50.94**	**27.89**	**27.89**	**29.29**	42.86	41.32	40.02	**40.55**	**40.32**	**40.08**
PointRCNN [5] *y*	0	48.74	49.75	48.56	**22.99**	**22.99**	24.23	42.19	38.80	36.92	37.97	37.18	36.57
fog simulation in [1]	*	50.42	51.46	50.14	20.36	20.36	20.36	43.28	41.85	40.22	38.02	37.89	36.91
our fog simulation	*	**51.11**	**52.01**	**50.72**	22.88	22.88	**25.18**	**47.94**	**45.29**	**43.08**	**40.64**	**40.06**	**39.66**
SECOND [8] *y*	0	48.31	49.09	48.02	24.03	25.21	25.21	37.11	36.19	34.51	36.48	36.83	35.91
fog simulation in [1]	*	47.86	48.98	48.17	26.28	27.11	27.11	38.13	36.78	35.55	37.42	37.62	36.94
our fog simulation	*	**48.61**	**49.40**	**48.50**	**26.85**	**27.21**	**27.46**	**38.59**	**37.54**	**36.13**	**38.02**	**38.05**	**37.36**
Part-A² [6] *y*	0	40.61	41.51	41.23	24.51	25.59	25.59	**41.88**	**40.61**	**38.87**	35.67	35.90	35.23
fog simulation in [1]	*	**46.34**	46.79	**46.03**	21.12	21.73	21.73	39.00	37.82	35.79	35.49	35.45	34.52
our fog simulation	*	45.92	**46.84**	46.02	**25.13**	**25.72**	**26.22**	39.44	38.90	36.66	**36.83**	**37.15**	**36.30**
PointPillars [3] *y*	0	38.36	39.55	39.32	23.05	23.26	25.50	27.12	25.93	24.37	29.51	29.58	29.73
fog simulation in [1]	*	41.52	42.76	42.67	21.68	21.68	23.33	29.35	28.52	27.23	30.85	30.99	31.08
our fog simulation	*	**41.98**	**43.12**	**43.09**	**23.40**	**23.77**	**25.76**	**31.66**	**30.48**	**28.58**	**32.35**	**32.46**	**32.48**

Table 1: Bird's Eye View (**BEV**) average precision (AP) results on the STF [1] dense fog test split. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]

Method		dense fog			light fog			clear			mAP over conditions		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	49.09	50.23	49.30	72.51	73.18	72.48	82.30	79.89	74.99	67.97	67.77	65.59
fog simulation in [1]	*	49.32	50.25	50.08	73.55	74.37	73.49	**82.42**	**80.37**	**76.34**	68.43	68.33	66.63
our fog simulation	*	**50.91**	**51.75**	**50.94**	**75.12**	**75.51**	**73.68**	82.34	80.05	75.32	**69.46**	**69.10**	**66.64**
PointRCNN [5] *y*	0	48.74	49.75	48.56	74.28	74.53	**72.64**	82.76	**79.47**	**73.90**	68.59	67.92	65.03
fog simulation in [1]	*	50.42	51.46	50.14	**75.08**	**74.62**	72.33	82.96	79.26	72.40	**69.48**	68.45	64.96
our fog simulation	*	**51.11**	**52.01**	**50.72**	73.97	74.23	72.00	**83.02**	**79.47**	73.83	69.36	**68.57**	**65.52**
SECOND [8] *y*	0	48.31	49.09	48.02	**74.54**	**74.15**	**72.99**	82.34	79.78	74.99	**68.40**	67.67	65.33
fog simulation in [1]	*	47.86	48.98	48.17	72.83	73.24	72.34	82.38	80.05	**75.60**	67.69	67.43	65.37
our fog simulation	*	**48.61**	**49.40**	**48.50**	73.26	73.64	72.94	**82.63**	**80.08**	**75.60**	68.17	**67.71**	**65.68**
Part-A² [6] *y*	0	40.61	41.51	41.23	68.67	69.22	68.35	79.68	76.96	**72.47**	62.99	62.56	60.68
fog simulation in [1]	*	**46.34**	46.79	**46.03**	69.58	69.92	68.27	**80.21**	**77.14**	72.38	65.38	64.62	**62.23**
our fog simulation	*	45.92	**46.84**	46.02	**70.86**	**70.91**	**68.81**	79.78	76.79	71.78	**65.52**	**64.85**	62.20
PointPillars [3] *y*	0	38.36	39.55	39.32	**71.78**	72.43	71.04	80.63	77.97	73.89	63.59	63.32	61.42
fog simulation in [1]	*	41.52	42.76	42.67	71.66	72.23	70.70	80.21	77.43	73.38	64.46	64.14	62.25
our fog simulation	*	**41.98**	**43.12**	**43.09**	71.50	**72.50**	**71.56**	**80.94**	**78.49**	**73.98**	**64.80**	**64.70**	**62.88**

Table 2: Car **BEV** AP@.5IoU results on all relevant STF [1] test splits. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]

Method		Car AP@**.7IoU**			Cyclist AP@**.5IoU**			Pedestrian AP@**.5IoU**			mAP over classes		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	21.70	22.07	21.10	20.44	20.44	20.44	16.44	15.13	14.05	19.53	19.21	18.53
fog simulation in [1]	*	21.27	21.85	20.69	23.32	23.32	23.32	**17.46**	**16.45**	**15.17**	20.68	**20.54**	19.72
our fog simulation	*	**21.98**	**22.28**	**21.20**	**24.69**	**24.69**	**24.69**	15.60	14.41	13.49	**20.76**	20.46	**19.79**
PointRCNN [5] *y*	0	21.93	22.84	21.72	**19.47**	**19.47**	**19.47**	13.75	13.00	11.86	**18.38**	**18.44**	**17.68**
fog simulation in [1]	*	22.11	22.67	21.34	18.04	18.04	18.04	10.84	10.33	9.85	17.00	17.01	16.41
our fog simulation	*	**23.63**	**24.29**	**23.17**	15.27	15.27	15.27	**14.89**	**13.67**	**13.05**	17.93	17.74	17.16
SECOND [8] *y*	0	18.52	18.94	18.18	18.72	18.72	18.72	13.03	12.50	10.87	16.76	16.72	15.92
fog simulation in [1]	*	**20.57**	**21.02**	**19.77**	21.05	21.05	21.05	12.89	12.47	12.06	18.17	18.18	**17.63**
our fog simulation	*	18.61	19.13	18.27	**22.46**	**22.46**	**22.46**	**14.18**	**13.33**	**12.17**	**18.41**	**18.30**	**17.63**
Part-A² [6] *y*	0	18.37	18.63	17.89	13.63	13.63	13.63	**14.77**	**13.83**	**12.63**	15.59	15.36	14.72
fog simulation in [1]	*	19.40	19.52	18.97	14.78	14.78	14.78	12.19	11.29	10.05	15.46	15.20	14.60
our fog simulation	*	**21.15**	**21.46**	**20.74**	**15.99**	**15.99**	**15.99**	11.75	10.94	10.38	**16.29**	**16.13**	**15.70**
PointPillars [3] *y*	0	13.17	13.34	12.41	13.50	13.50	13.50	10.23	9.64	**8.81**	12.30	12.16	11.57
fog simulation in [1]	*	**15.69**	**16.23**	**15.59**	9.99	9.99	9.99	9.96	8.82	7.81	11.88	11.68	11.13
our fog simulation	*	14.95	15.30	14.49	**17.26**	**17.26**	**17.26**	**10.61**	**9.81**	8.60	**14.28**	**14.12**	**13.45**

Table 3: 3D average precision (AP) results on the STF [1] dense fog test split. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]

Method		dense fog			light fog			clear			mAP over conditions		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	21.70	22.07	21.10	36.94	37.69	36.22	45.91	43.02	39.07	34.85	34.26	32.13
fog simulation in [1]	*	21.27	21.85	20.69	**39.39**	**40.32**	**38.18**	**46.79**	**44.91**	**40.12**	**35.82**	**35.69**	**33.00**
our fog simulation	*	**21.98**	**22.28**	**21.20**	37.13	37.62	36.20	44.59	42.87	38.87	34.57	34.26	32.09
PointRCNN [5] *y*	0	21.93	22.84	21.72	36.73	37.74	35.18	**46.23**	**43.85**	**38.86**	34.96	**34.81**	31.92
fog simulation in [1]	*	22.11	22.67	21.34	**38.24**	**39.25**	**36.22**	44.04	41.59	36.49	34.80	34.50	31.35
our fog simulation	*	**23.63**	**24.29**	**23.17**	36.74	37.99	35.44	44.94	41.81	37.40	**35.10**	34.70	**32.01**
SECOND [8] *y*	0	18.52	18.94	18.18	**37.21**	37.27	35.29	42.21	40.09	36.00	32.65	32.10	29.82
fog simulation in [1]	*	**20.57**	**21.02**	**19.77**	36.34	**37.29**	**35.38**	41.46	39.76	35.85	**32.79**	**32.69**	**30.33**
our fog simulation	*	18.61	19.13	18.27	35.83	35.72	34.13	**42.59**	**40.43**	**36.71**	32.34	31.76	29.70
Part-A² [6] *y*	0	18.37	18.63	17.89	33.06	34.31	32.75	43.37	40.89	**37.03**	31.60	31.28	29.22
fog simulation in [1]	*	19.40	19.52	18.97	34.13	34.53	33.36	42.26	40.31	36.49	31.93	31.45	29.61
our fog simulation	*	**21.15**	**21.46**	**20.74**	**37.25**	**38.03**	**35.24**	**43.83**	**41.35**	37.01	**34.07**	**33.61**	**31.00**
PointPillars [3] *y*	0	13.17	13.34	12.41	33.25	33.59	32.25	**42.35**	**39.07**	**35.15**	29.59	28.67	26.60
fog simulation in [1]	*	**15.69**	**16.23**	**15.59**	**33.84**	**34.62**	**33.50**	40.67	37.87	34.30	**30.07**	**29.58**	**27.80**
our fog simulation	*	14.95	15.30	14.49	33.14	33.81	32.47	39.96	37.13	33.56	29.35	28.75	26.84

Table 4: Car 3D AP@**.7IoU** results on all relevant STF [1] test splits. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]

Method		Car AP@**.7IoU**			Cyclist AP@**.5IoU**			Pedestrian AP@**.5IoU**			mAP over classes		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	34.40	35.69	34.66	22.97	22.97	22.97	20.70	19.83	18.59	26.02	26.16	25.41
fog simulation in [1]	*	36.13	36.87	36.23	23.32	23.32	23.32	**21.73**	**20.52**	**19.53**	**27.06**	**26.90**	**26.36**
our fog simulation	*	**37.01**	**37.59**	**36.41**	**24.69**	**24.69**	**24.69**	19.00	18.12	17.23	26.90	26.80	26.11
PointRCNN [5] *y*	0	33.91	35.18	33.86	**19.47**	**19.47**	**19.47**	17.00	16.16	15.07	23.46	23.60	22.80
fog simulation in [1]	*	35.53	36.66	35.07	19.27	19.27	19.27	16.83	16.07	14.95	**23.88**	**24.00**	**23.10**
our fog simulation	*	**36.64**	**37.85**	**36.27**	15.27	15.27	15.27	**17.68**	**16.81**	**16.13**	23.20	23.31	22.56
SECOND [8] *y*	0	33.63	34.66	**33.69**	18.83	18.83	18.83	16.42	16.13	14.42	22.96	23.21	22.31
fog simulation in [1]	*	32.15	33.39	32.12	**25.30**	**25.30**	**25.30**	**18.22**	**17.63**	**16.49**	**25.22**	**25.44**	**24.64**
our fog simulation	*	**33.75**	**34.81**	33.63	22.46	22.46	22.46	17.88	17.11	16.00	24.69	24.79	24.03
Part-A² [6] *y*	0	27.61	28.65	28.11	**17.30**	**17.30**	**17.30**	**17.43**	**17.06**	**15.71**	20.78	21.00	20.37
fog simulation in [1]	*	31.65	32.38	31.19	14.78	14.78	14.78	16.28	16.03	14.67	20.90	21.06	20.21
our fog simulation	*	**31.89**	**32.57**	**31.36**	16.14	16.14	16.14	16.09	15.49	14.47	**21.37**	**21.40**	**20.65**
PointPillars [3] *y*	0	25.86	26.81	26.31	15.55	15.55	15.55	14.37	13.36	12.31	18.59	18.57	18.06
fog simulation in [1]	*	**29.08**	30.24	**29.82**	15.82	15.82	15.82	14.02	13.08	12.10	19.64	19.71	19.24
our fog simulation	*	28.94	**30.52**	29.60	**17.84**	**17.84**	**17.84**	**15.67**	**14.52**	**13.22**	**20.82**	**20.96**	**20.22**

Table 5: **BEV** average precision (AP) results on the STF [1] dense fog test split. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]

Method		dense fog			light fog			clear			mAP over conditions		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	34.40	35.69	34.66	56.78	57.21	55.61	65.22	61.98	57.38	52.14	51.62	49.22
fog simulation in [1]	*	36.13	36.87	36.23	**57.44**	**57.94**	**56.87**	**66.09**	**63.74**	**59.11**	**53.22**	**52.85**	**50.74**
our fog simulation	*	**37.01**	**37.59**	**36.41**	57.37	57.41	55.78	64.83	62.72	58.11	53.07	52.57	50.10
PointRCNN [5] *y*	0	33.91	35.18	33.86	**59.52**	59.28	**57.07**	66.13	62.73	**56.54**	53.19	52.40	49.16
fog simulation in [1]	*	35.53	36.66	35.07	59.33	**59.44**	55.98	65.68	62.09	56.04	**53.51**	**52.73**	49.03
our fog simulation	*	**36.64**	**37.85**	**36.27**	57.01	56.91	55.02	**66.33**	**62.74**	56.40	53.33	52.50	**49.23**
SECOND [8] *y*	0	33.63	34.66	**33.69**	56.82	57.32	56.02	65.40	62.03	57.14	51.95	51.34	48.95
fog simulation in [1]	*	32.15	33.39	32.12	57.03	57.51	56.09	64.75	62.54	57.08	51.31	51.15	48.43
our fog simulation	*	**33.75**	**34.81**	33.63	**58.15**	**58.57**	**57.10**	**65.64**	**62.23**	**57.52**	**52.51**	**51.87**	**49.42**
Part-A² [6] *y*	0	27.61	28.65	28.11	52.83	52.86	51.19	62.11	59.78	**54.48**	47.52	47.10	44.59
fog simulation in [1]	*	31.65	32.38	31.19	53.08	53.32	51.79	61.79	59.33	54.22	48.84	48.34	45.73
our fog simulation	*	**31.89**	**32.57**	**31.36**	**55.76**	**55.87**	**53.79**	**62.43**	**59.97**	54.22	**50.03**	**49.47**	**46.46**
PointPillars [3] *y*	0	25.86	26.81	26.31	56.25	56.14	54.50	**64.52**	**61.31**	**56.74**	48.88	48.09	45.85
fog simulation in [1]	*	**29.08**	30.24	**29.82**	56.04	56.71	55.07	62.98	60.19	55.51	49.36	49.04	46.80
our fog simulation	*	28.94	**30.52**	29.60	**56.81**	**57.19**	**55.65**	63.83	60.75	56.14	**49.86**	**49.49**	**47.13**

Table 6: Car **BEV** AP@**.7IoU** results on all relevant STF [1] test splits. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]

Method		Car AP@**.7IoU**			Cyclist AP@**.5IoU**			Pedestrian AP@**.5IoU**			mAP over classes		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	42.95	43.16	41.66	24.33	24.63	24.63	**49.97**	**47.66**	**45.56**	39.08	38.49	37.28
fog simulation in [1]	*	41.29	41.88	40.94	26.70	26.70	27.57	48.89	46.52	44.83	38.96	38.36	37.78
our fog simulation	*	**43.57**	**44.07**	**43.00**	**28.47**	**28.47**	**29.90**	47.78	45.86	44.56	**39.94**	**39.47**	**39.15**
PointRCNN [5] *y*	0	40.85	41.45	40.36	22.99	22.99	24.23	45.99	42.61	39.94	36.61	35.68	34.84
fog simulation in [1]	*	43.17	44.07	42.43	22.49	22.75	22.75	49.18	47.62	46.28	38.28	38.15	37.15
our fog simulation	*	**45.45**	**45.24**	**43.80**	**23.25**	**23.43**	**25.77**	**51.57**	**49.61**	**47.84**	**40.09**	**39.43**	**39.14**
SECOND [8] *y*	0	**41.72**	**41.87**	**40.54**	24.54	25.76	25.76	40.20	39.06	38.25	35.49	35.56	34.85
fog simulation in [1]	*	39.18	40.25	39.05	27.85	**28.74**	**28.74**	41.75	40.67	39.18	36.26	36.56	35.66
our fog simulation	*	40.34	41.00	40.27	**28.05**	28.44	28.70	**42.10**	**41.10**	**39.79**	**36.83**	**36.84**	**36.26**
Part-A² [6] *y*	0	35.76	36.10	35.18	**25.25**	**25.25**	**25.25**	**48.04**	**46.02**	**43.42**	**36.35**	35.79	34.62
fog simulation in [1]	*	**40.42**	**40.86**	39.26	22.90	23.56	23.56	42.61	40.87	39.00	35.31	35.10	33.94
our fog simulation	*	40.38	40.83	**39.61**	23.30	23.85	24.32	43.45	42.85	40.60	35.71	**35.84**	**34.84**
PointPillars [3] *y*	0	31.85	32.54	32.27	**24.11**	**24.33**	**26.61**	28.42	26.94	25.75	28.13	27.94	28.21
fog simulation in [1]	*	**35.51**	**36.51**	**35.84**	23.08	23.08	24.78	29.28	28.68	27.67	29.29	29.42	29.43
our fog simulation	*	33.84	34.72	34.36	23.61	23.61	25.59	**33.45**	**32.45**	**30.44**	**30.30**	**30.26**	**30.13**

Table 7: **2D** average precision (AP) results on the STF [1] dense fog test split. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]

Method		dense fog			light fog			clear			mAP over conditions		
		easy	mod.	hard	easy	mod.	hard	easy	mod.	hard	easy	mod.	hard
PV-RCNN [4] *y*	0	42.95	43.16	41.66	68.59	67.48	64.08	**77.72**	**73.56**	**67.78**	63.09	61.40	57.84
fog simulation in [1]	*	41.29	41.88	40.94	68.05	66.71	64.27	77.02	73.11	67.69	62.12	60.57	57.63
our fog simulation	*	**43.57**	**44.07**	**43.00**	**69.29**	**67.74**	**64.31**	76.97	72.91	67.49	**63.28**	**61.57**	**58.27**
PointRCNN [5] *y*	0	40.85	41.45	40.36	**68.59**	66.96	**63.08**	74.79	70.72	**64.88**	61.41	59.71	56.11
fog simulation in [1]	*	43.17	44.07	42.43	68.15	**66.99**	62.80	75.44	**71.27**	64.23	62.25	60.78	56.49
our fog simulation	*	**45.45**	**45.24**	**43.80**	67.81	66.36	62.26	**75.48**	71.12	64.12	**62.91**	**60.91**	**56.73**
SECOND [8] *y*	0	**41.72**	**41.87**	**40.54**	**67.12**	**65.80**	**62.89**	73.77	69.68	64.18	**60.87**	**59.12**	55.87
fog simulation in [1]	*	39.18	40.25	39.05	65.87	65.33	62.41	74.44	**71.59**	**66.21**	59.83	59.06	**55.89**
our fog simulation	*	40.34	41.00	40.27	65.21	64.43	61.56	**74.66**	70.61	65.49	60.07	58.68	55.78
Part-A² [6] *y*	0	35.76	36.10	35.18	63.66	62.72	59.68	73.91	69.67	63.85	57.78	56.16	52.90
fog simulation in [1]	*	**40.42**	**40.86**	39.26	64.32	63.14	**60.12**	73.73	69.85	**63.97**	59.49	57.95	**54.45**
our fog simulation	*	40.38	40.83	**39.61**	**64.57**	**63.32**	59.91	**74.20**	**69.87**	63.66	**59.72**	**58.01**	54.39
PointPillars [3] *y*	0	31.85	32.54	32.27	**65.79**	**65.10**	**62.09**	72.49	**68.87**	62.60	56.71	55.50	52.32
fog simulation in [1]	*	**35.51**	**36.51**	**35.84**	64.60	63.47	60.32	**72.54**	68.56	**62.98**	**57.55**	**56.18**	**53.05**
our fog simulation	*	33.84	34.72	34.36	62.49	62.05	59.32	71.87	67.84	61.80	56.07	54.87	51.83

Table 8: Car **2D** AP@**.7IoU** results on all relevant STF [1] test splits. *y clear weather baseline*
** fog simulation gets applied to every training example with uniformly sampled from* [0, 0.005, 0.01, 0.02, 0.03, 0.06]