

Supplementary Material for “Change Detection from a Street Image Pair using CNN Features and Superpixel Segmentation”

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Additional Results

Figures 1 - 100 show the results of the scenes of Panoramic Change Detection Dataset. The rows show, from top to bottom, input image pair, ground-truth of change detection, final change detection results, superpixel segmentation results, feature distance between each grid using feature of pool-5 layer, feature distance projected to superpixel segmentation result of each input image, probabilities of the sky and the ground estimated using Geometric Context.

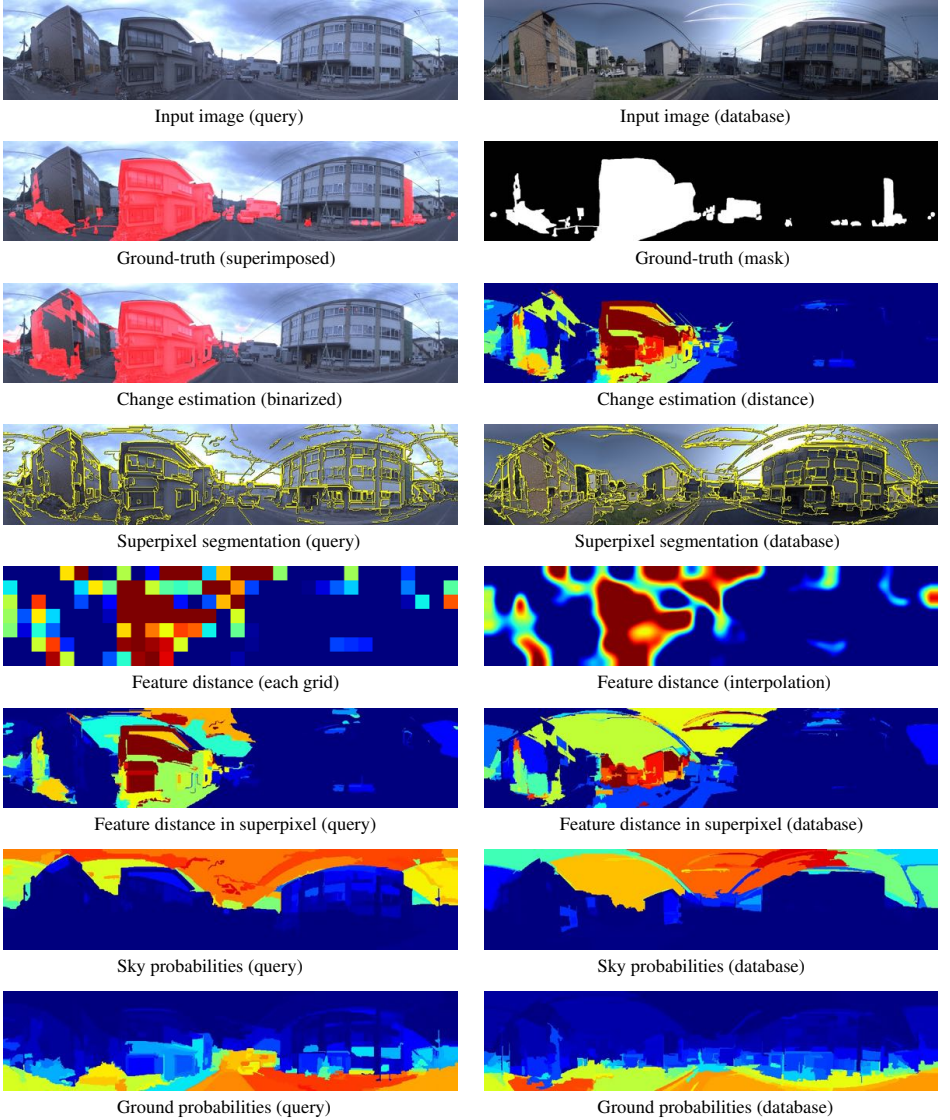


Figure 1: Results of change detection using pool-5 feature of CNN (Frame No. 1/100 in change detection dataset of tsunami)

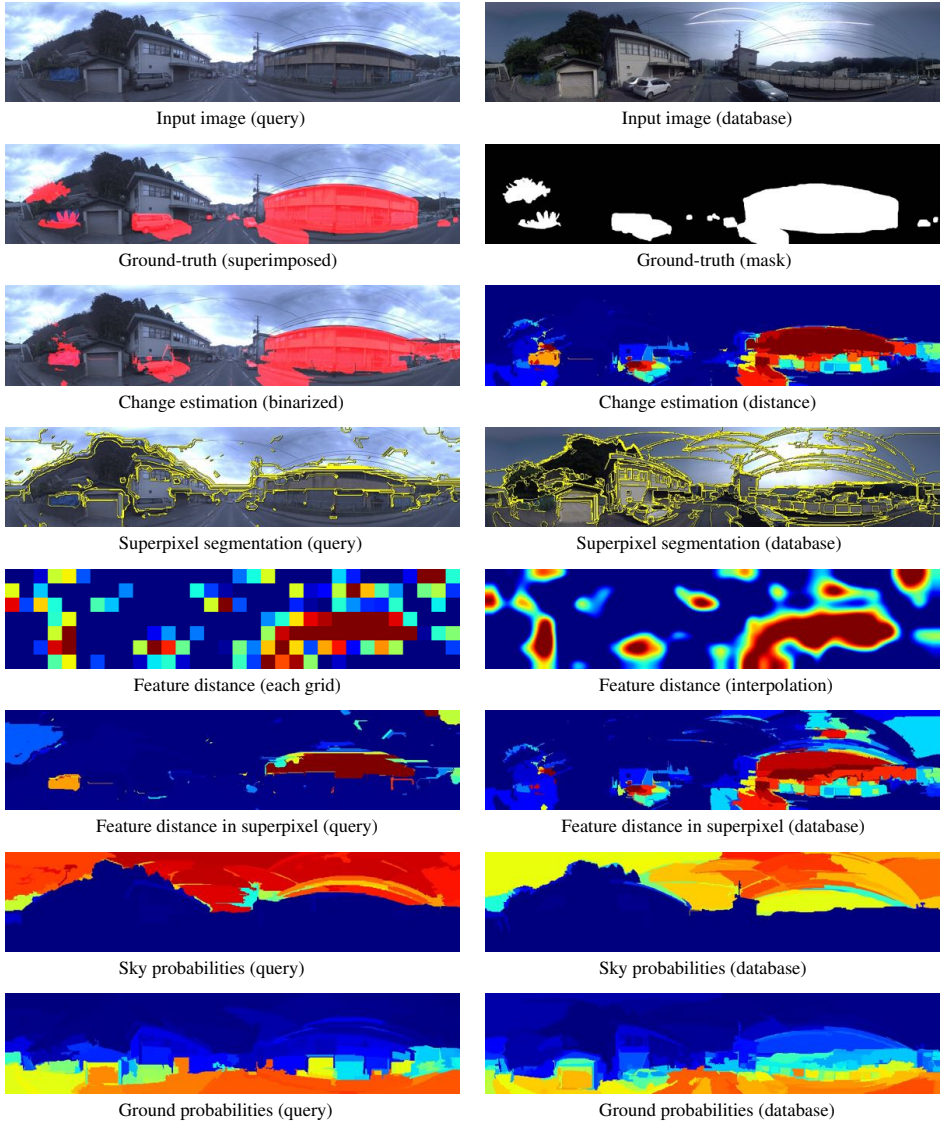


Figure 2: Results of change detection using pool-5 feature of CNN (Frame No. 2/100 in change detection dataset of tsunami)

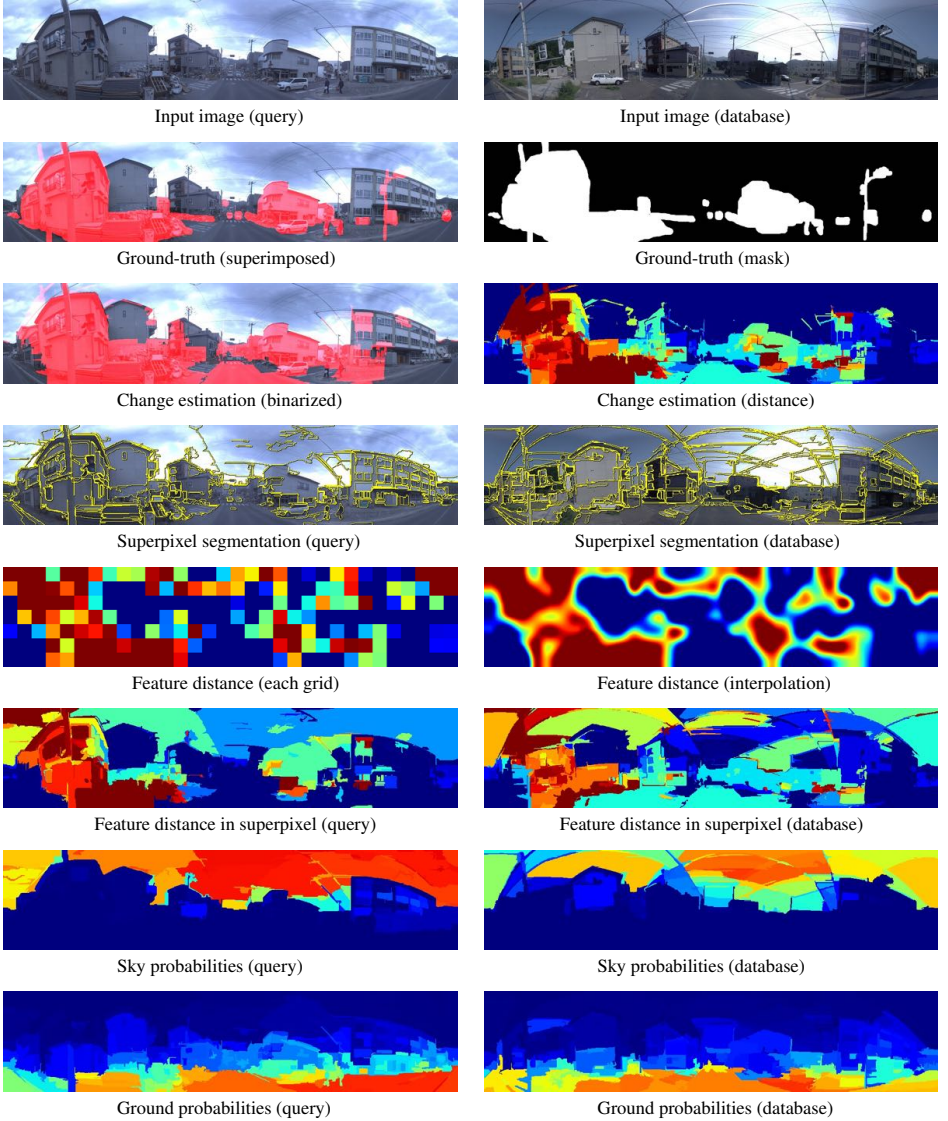


Figure 3: Results of change detection using pool-5 feature of CNN (Frame No. 3/100 in change detection dataset of tsunami)

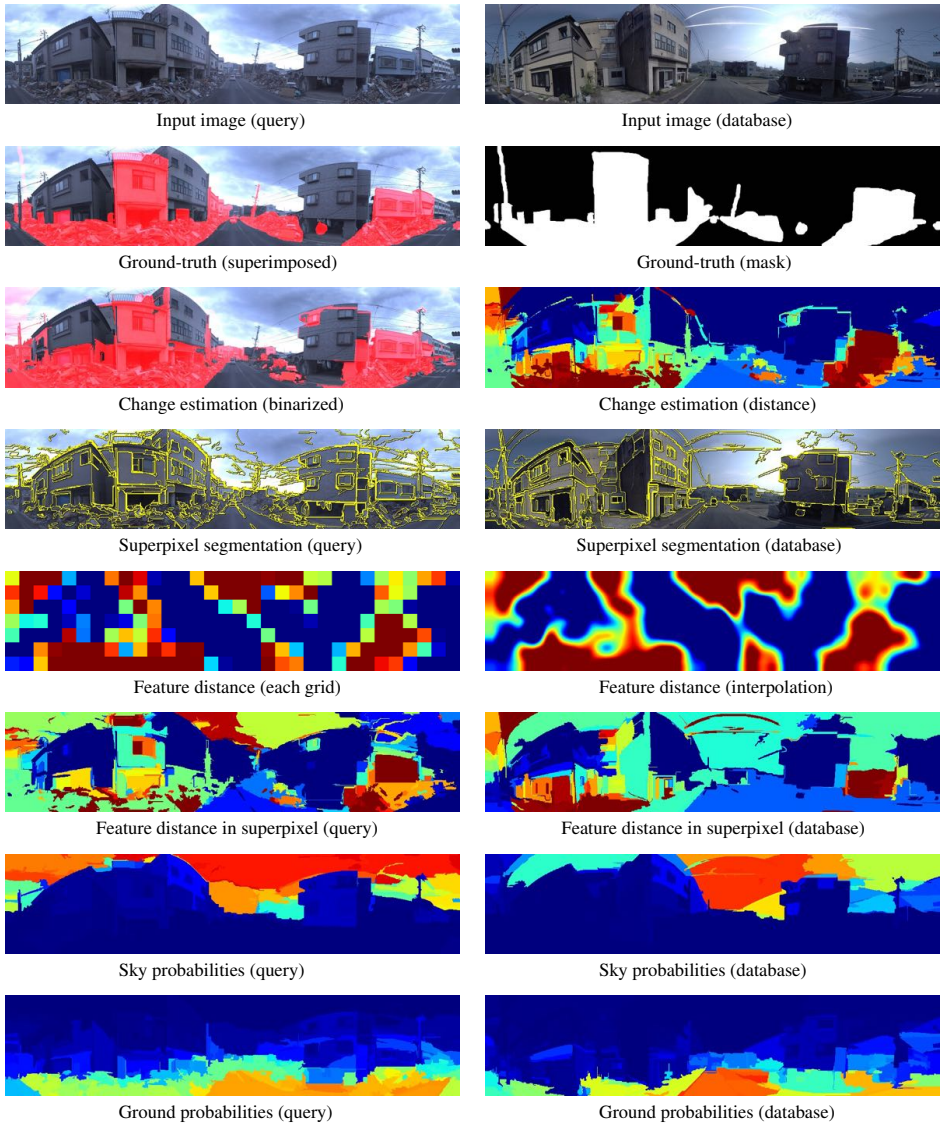


Figure 4: Results of change detection using pool-5 feature of CNN (Frame No. 4/100 in change detection dataset of tsunami)

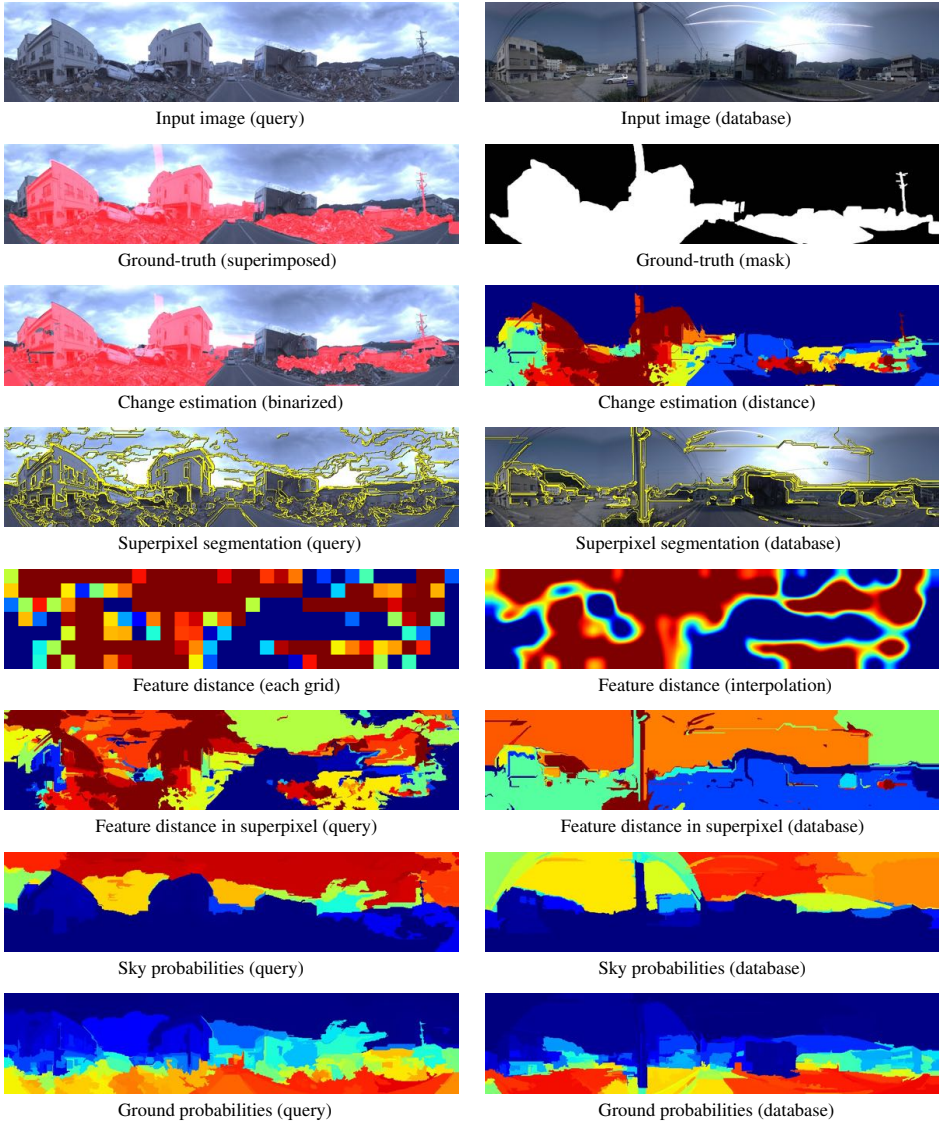


Figure 5: Results of change detection using pool-5 feature of CNN (Frame No. 5/100 in change detection dataset of tsunami)

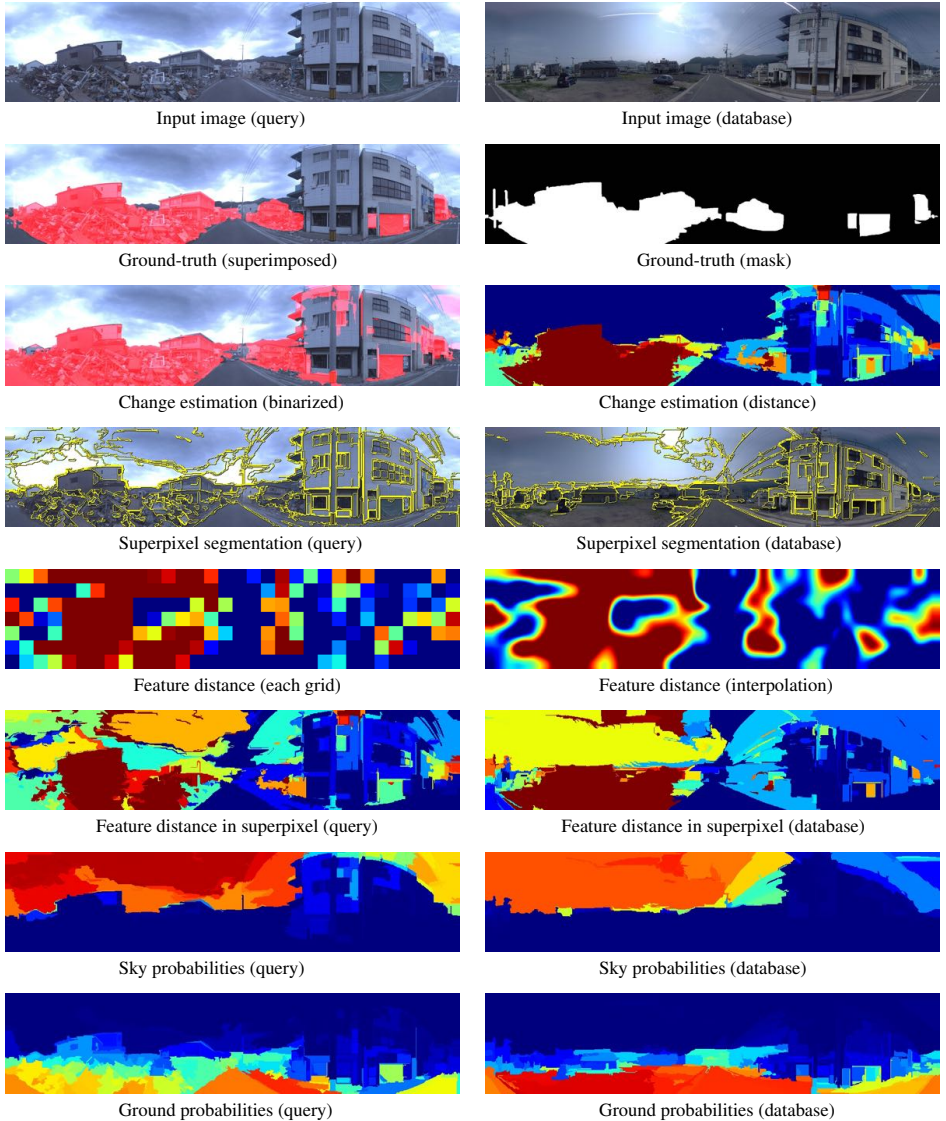


Figure 6: Results of change detection using pool-5 feature of CNN (Frame No. 6/100 in change detection dataset of tsunami)

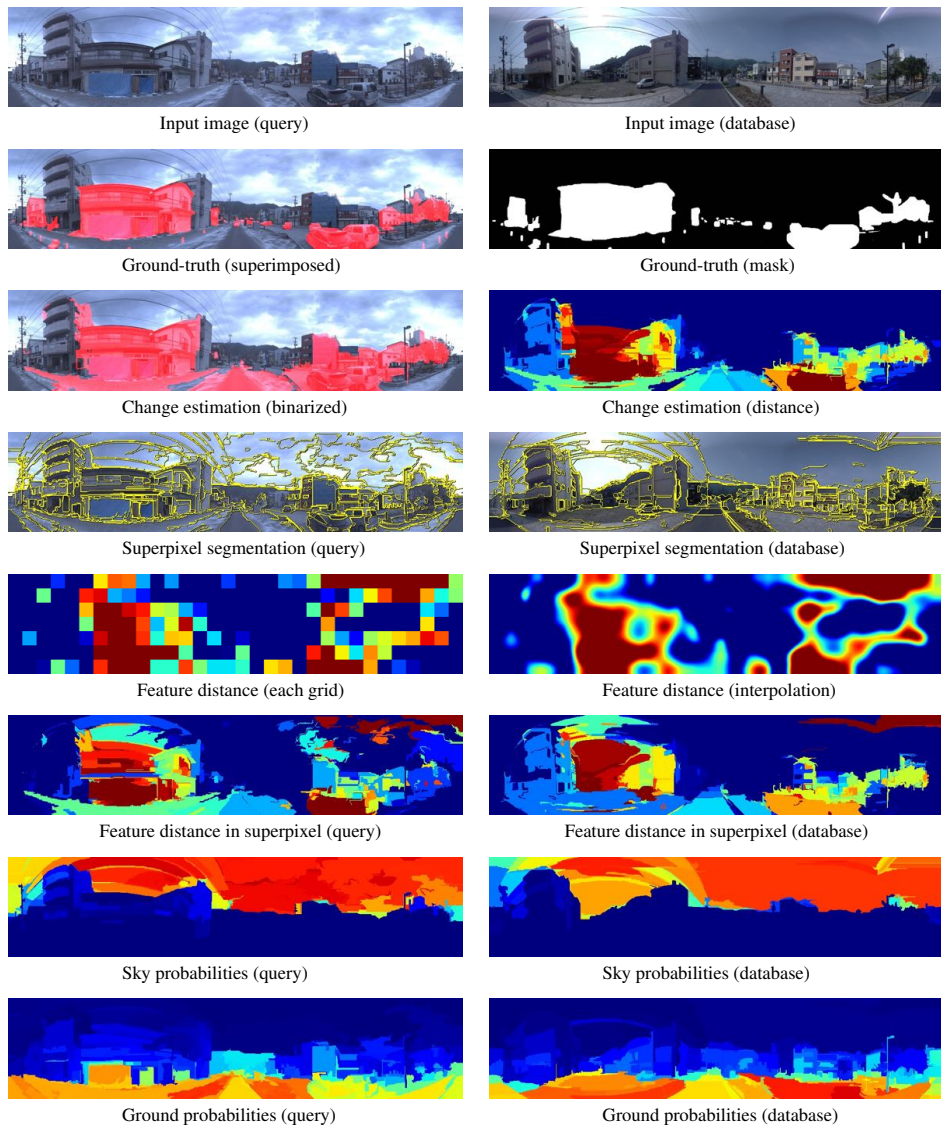


Figure 7: Results of change detection using pool-5 feature of CNN (Frame No. 7/100 in change detection dataset of tsunami)

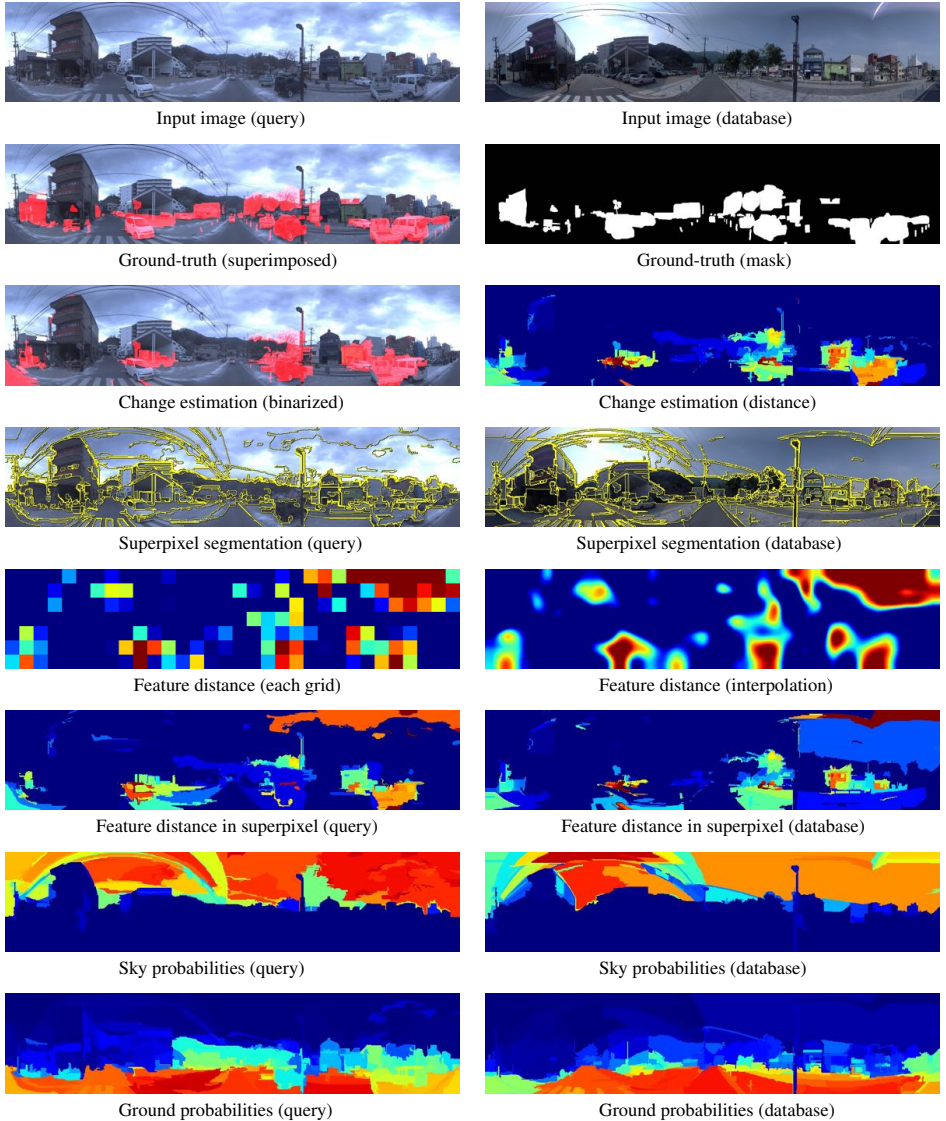


Figure 8: Results of change detection using pool-5 feature of CNN (Frame No. 8/100 in change detection dataset of tsunami)



Input image (query)



Input image (database)



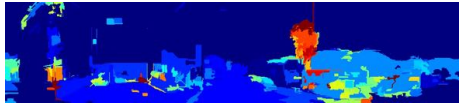
Ground-truth (superimposed)



Ground-truth (mask)



Change estimation (binarized)



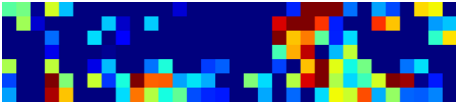
Change estimation (distance)



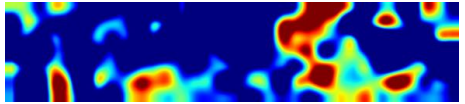
Superpixel segmentation (query)



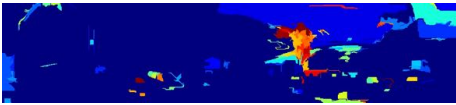
Superpixel segmentation (database)



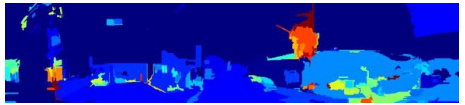
Feature distance (each grid)



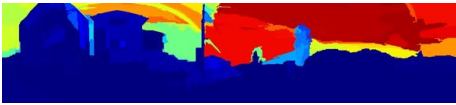
Feature distance (interpolation)



Feature distance in superpixel (query)



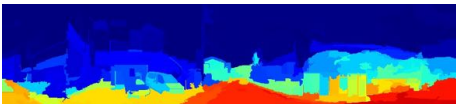
Feature distance in superpixel (database)



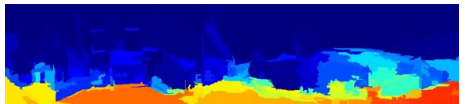
Sky probabilities (query)



Sky probabilities (database)



Ground probabilities (query)



Ground probabilities (database)

Figure 9: Results of change detection using pool-5 feature of CNN (Frame No. 9/100 in change detection dataset of tsunami)

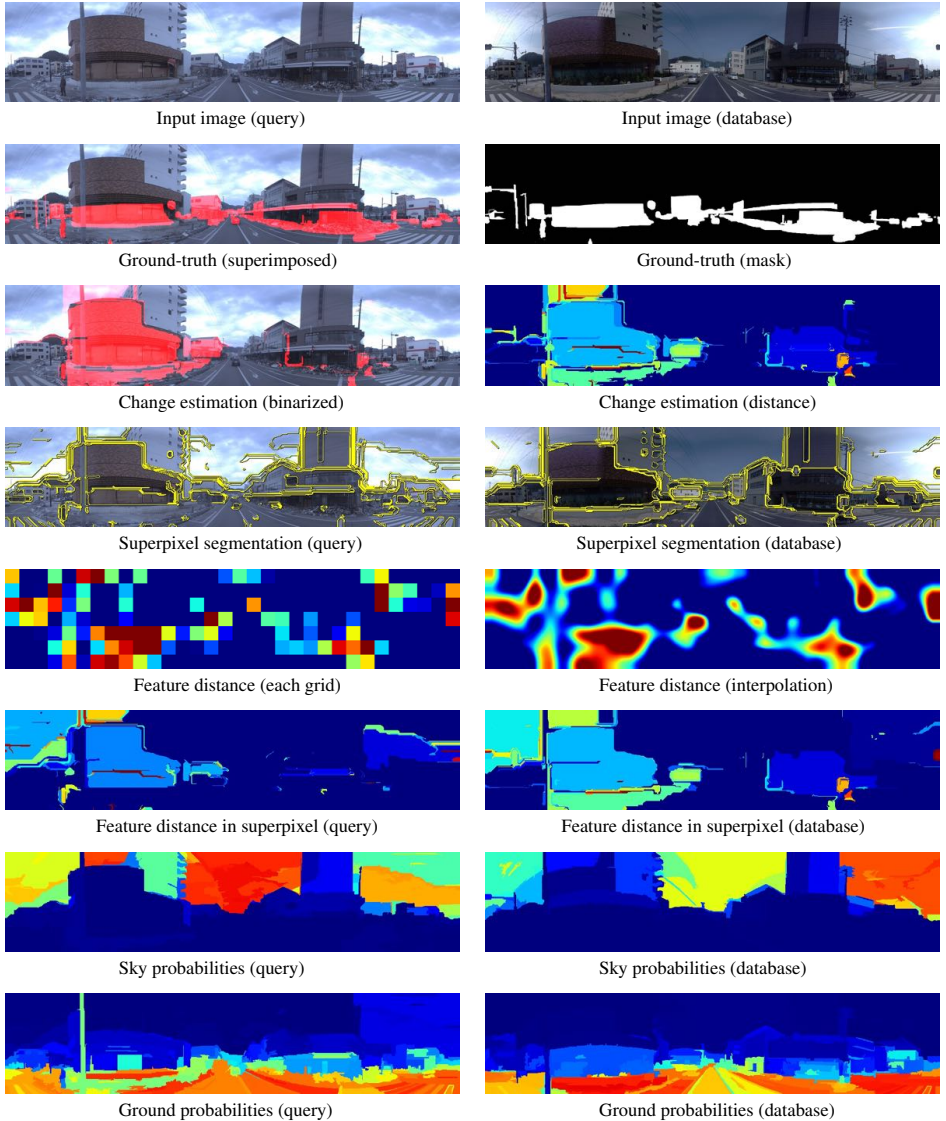


Figure 10: Results of change detection using pool-5 feature of CNN (Frame No. 10/100 in change detection dataset of tsunami)

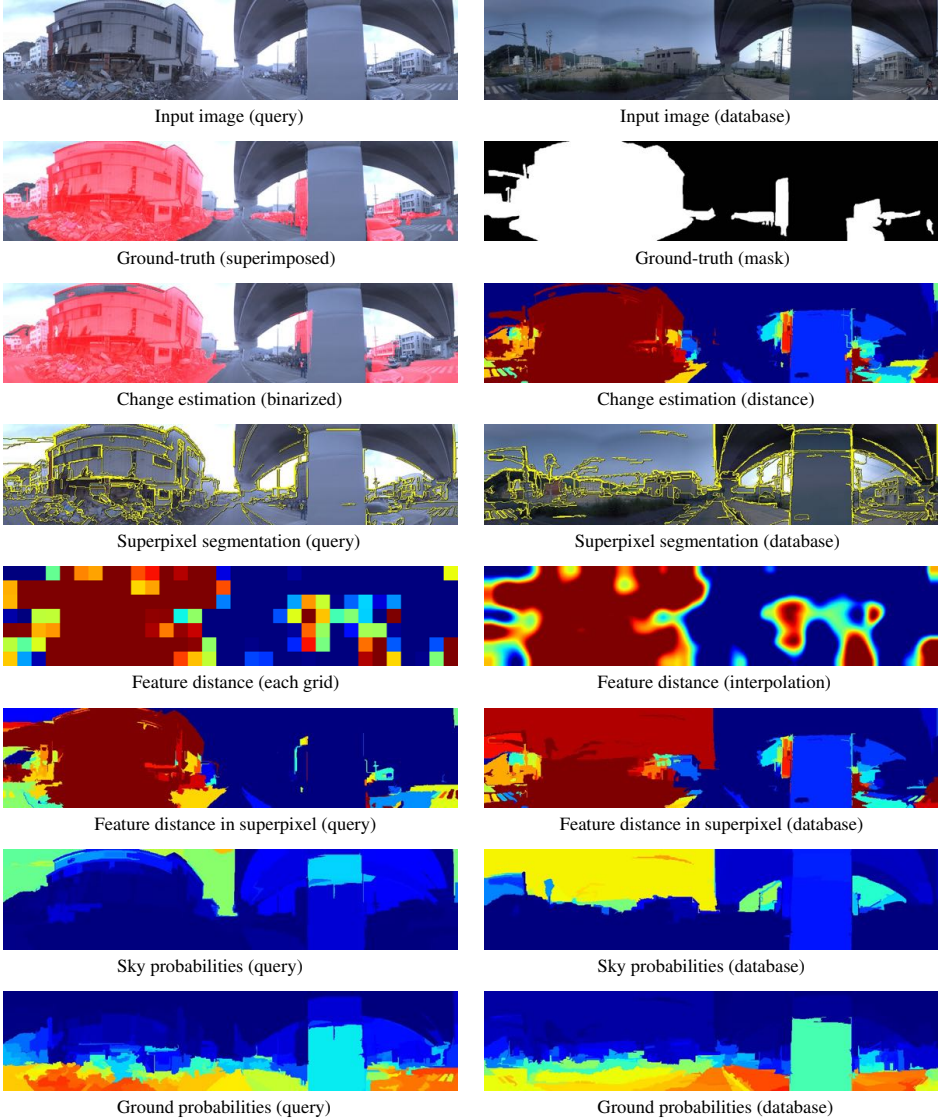


Figure 11: Results of change detection using pool-5 feature of CNN (Frame No. 11/100 in change detection dataset of tsunami)

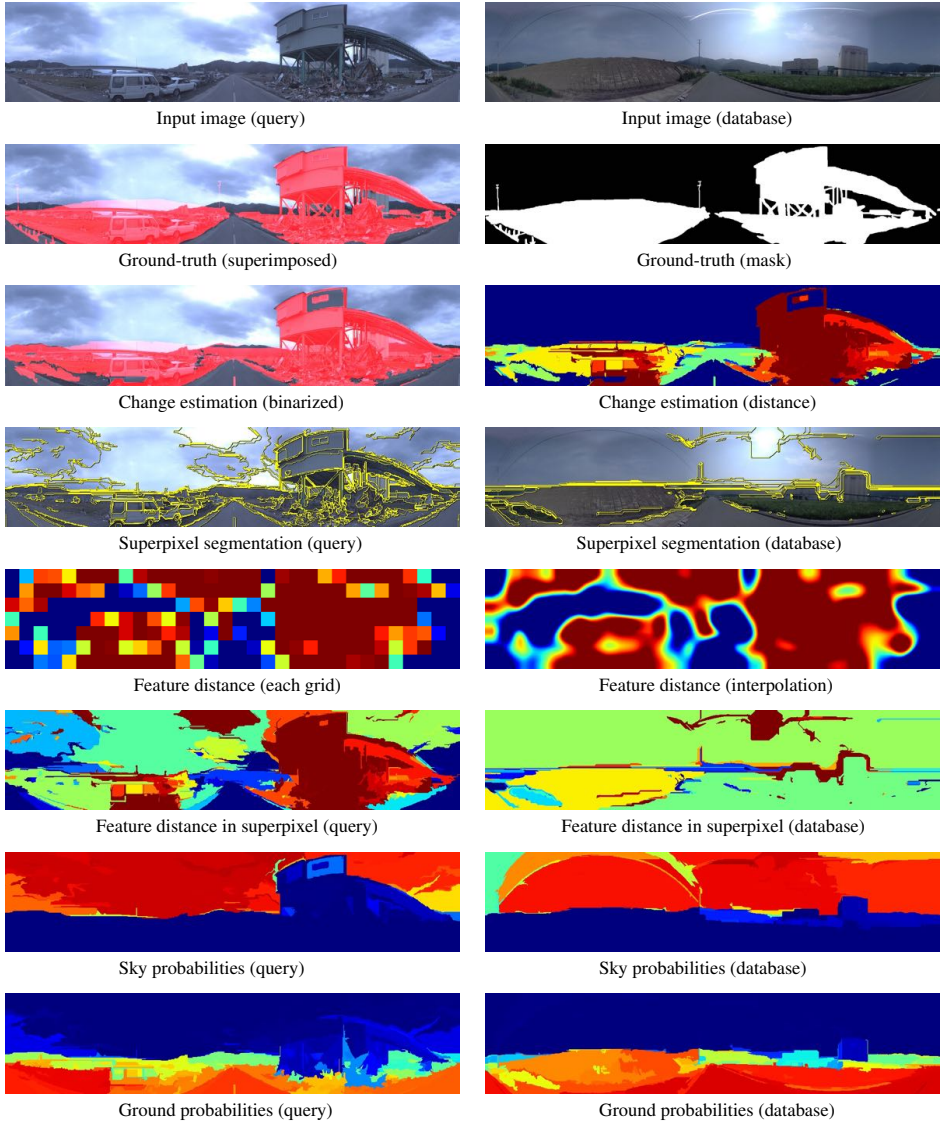


Figure 12: Results of change detection using pool-5 feature of CNN (Frame No. 12/100 in change detection dataset of tsunami)

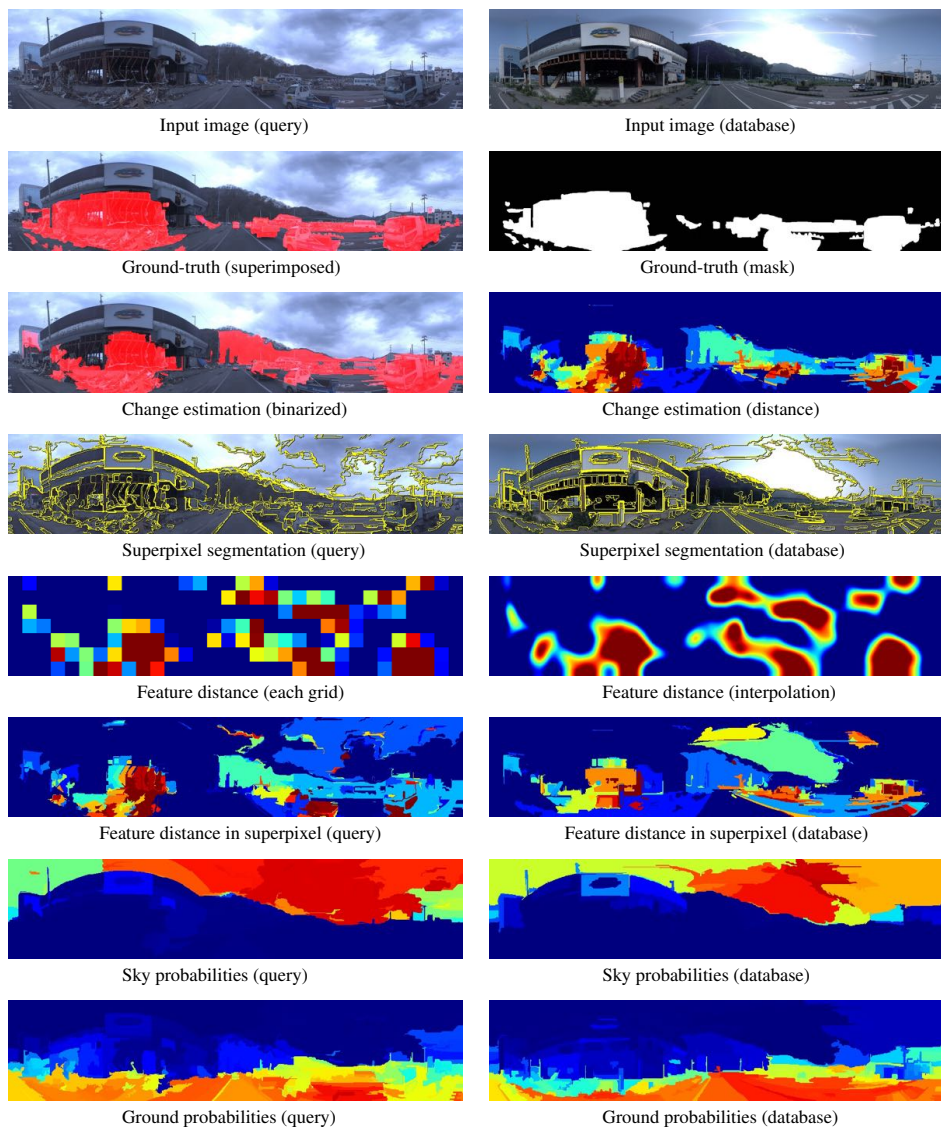


Figure 13: Results of change detection using pool-5 feature of CNN (Frame No. 13/100 in change detection dataset of tsunami)

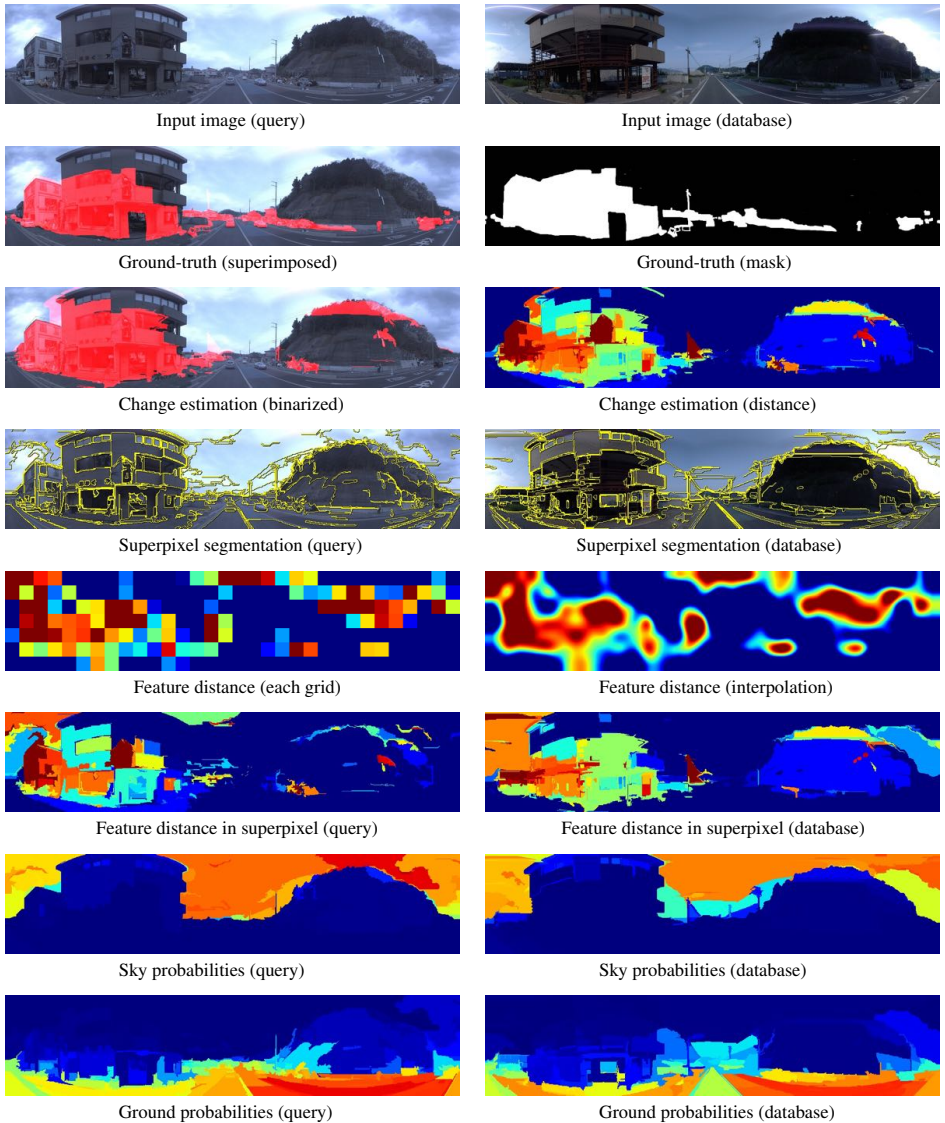


Figure 14: Results of change detection using pool-5 feature of CNN (Frame No. 14/100 in change detection dataset of tsunami)



Input image (query)



Input image (database)



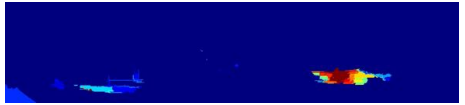
Ground-truth (superimposed)



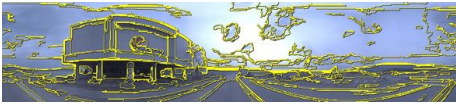
Ground-truth (mask)



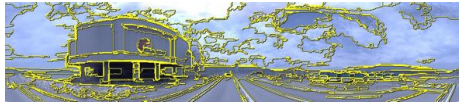
Change estimation (binarized)



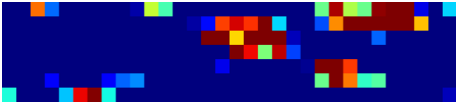
Change estimation (distance)



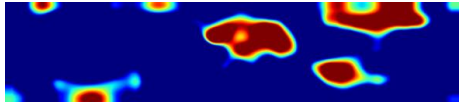
Superpixel segmentation (query)



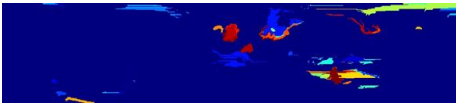
Superpixel segmentation (database)



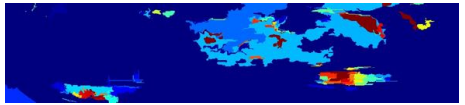
Feature distance (each grid)



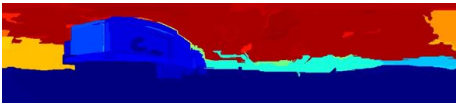
Feature distance (interpolation)



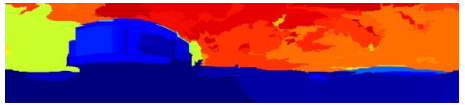
Feature distance in superpixel (query)



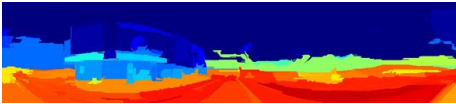
Feature distance in superpixel (database)



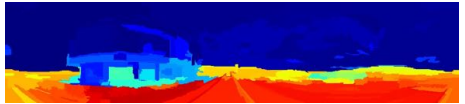
Sky probabilities (query)



Sky probabilities (database)



Ground probabilities (query)



Ground probabilities (database)

Figure 15: Results of change detection using pool-5 feature of CNN (Frame No. 15/100 in change detection dataset of tsunami)

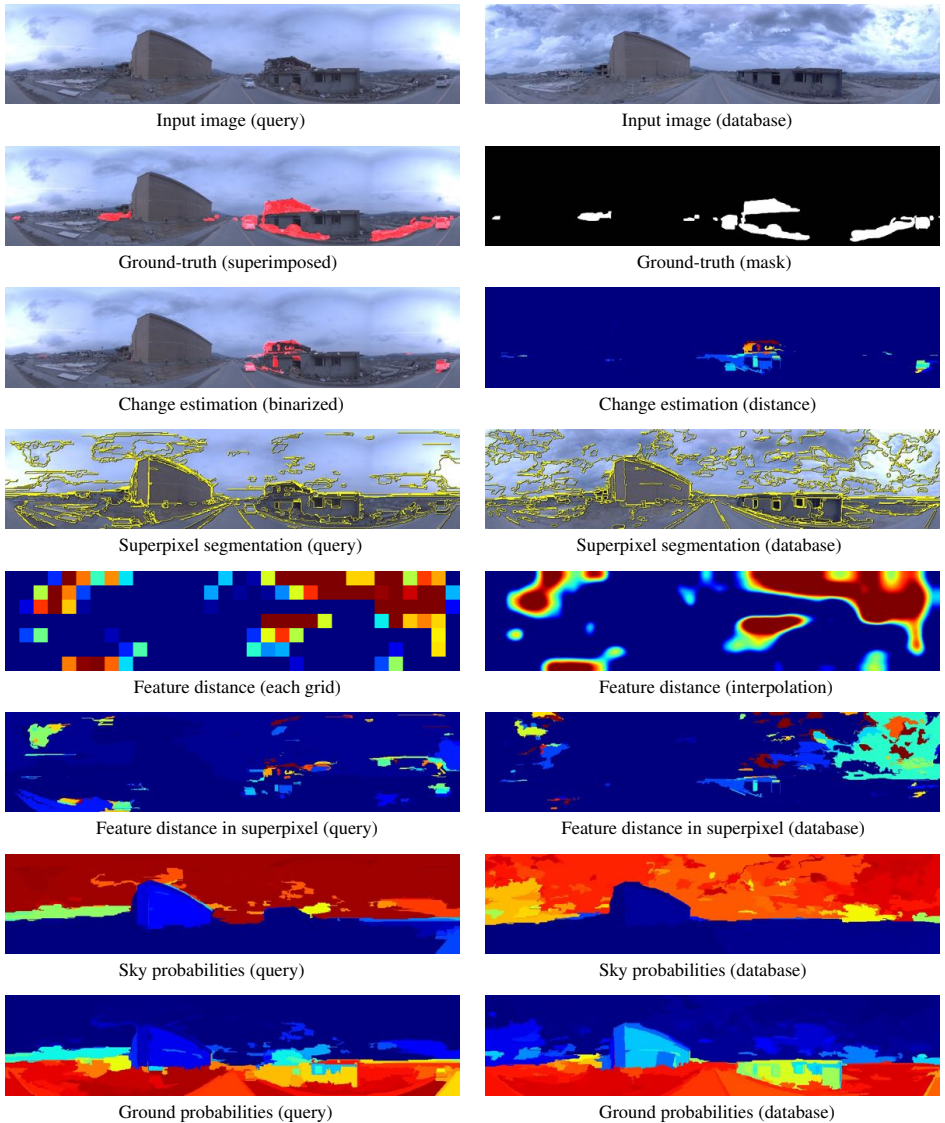


Figure 16: Results of change detection using pool-5 feature of CNN (Frame No. 16/100 in change detection dataset of tsunami)

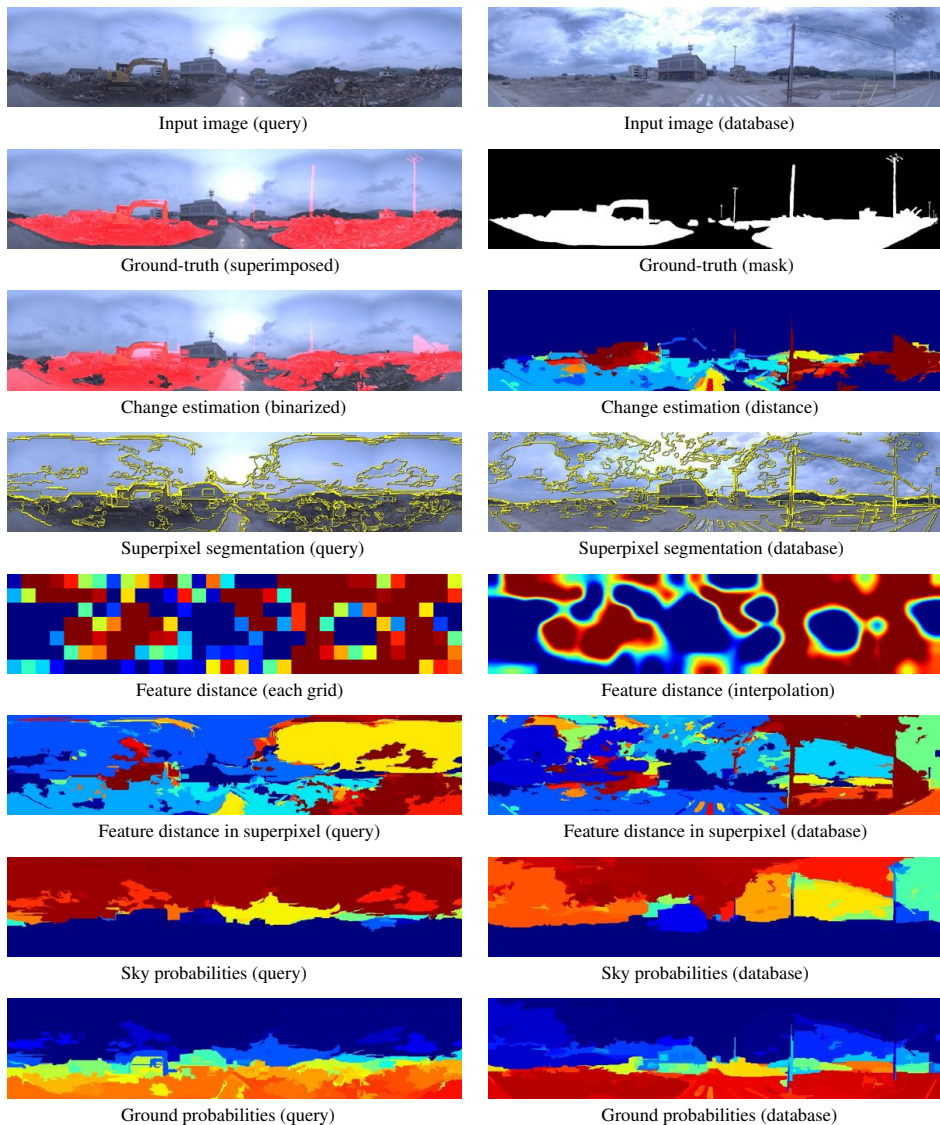


Figure 17: Results of change detection using pool-5 feature of CNN (Frame No. 17/100 in change detection dataset of tsunami)

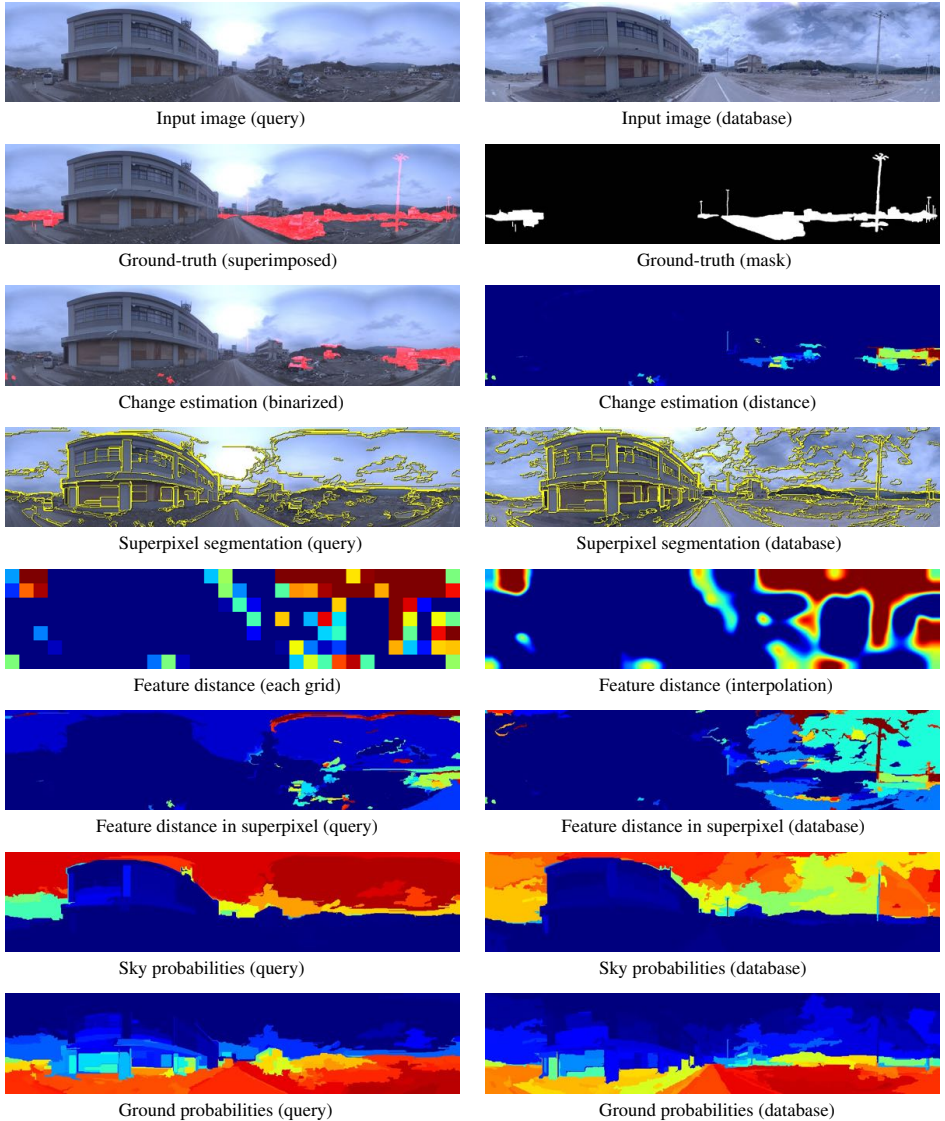


Figure 18: Results of change detection using pool-5 feature of CNN (Frame No. 18/100 in change detection dataset of tsunami)



Input image (query)



Input image (database)



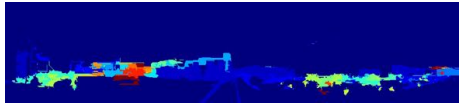
Ground-truth (superimposed)



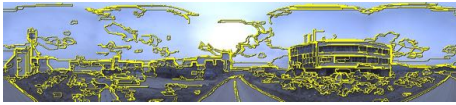
Ground-truth (mask)



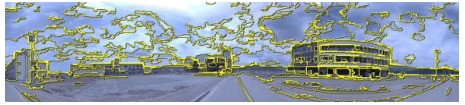
Change estimation (binarized)



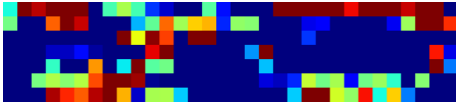
Change estimation (distance)



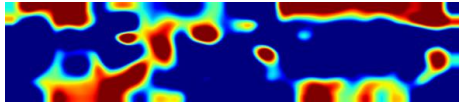
Superpixel segmentation (query)



Superpixel segmentation (database)



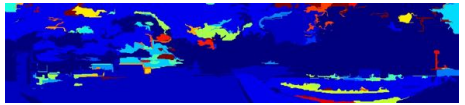
Feature distance (each grid)



Feature distance (interpolation)



Feature distance in superpixel (query)



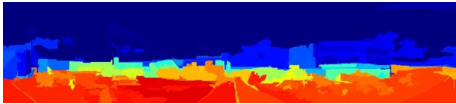
Feature distance in superpixel (database)



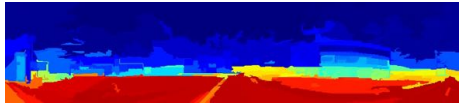
Sky probabilities (query)



Sky probabilities (database)



Ground probabilities (query)



Ground probabilities (database)

Figure 19: Results of change detection using pool-5 feature of CNN (Frame No. 19/100 in change detection dataset of tsunami)

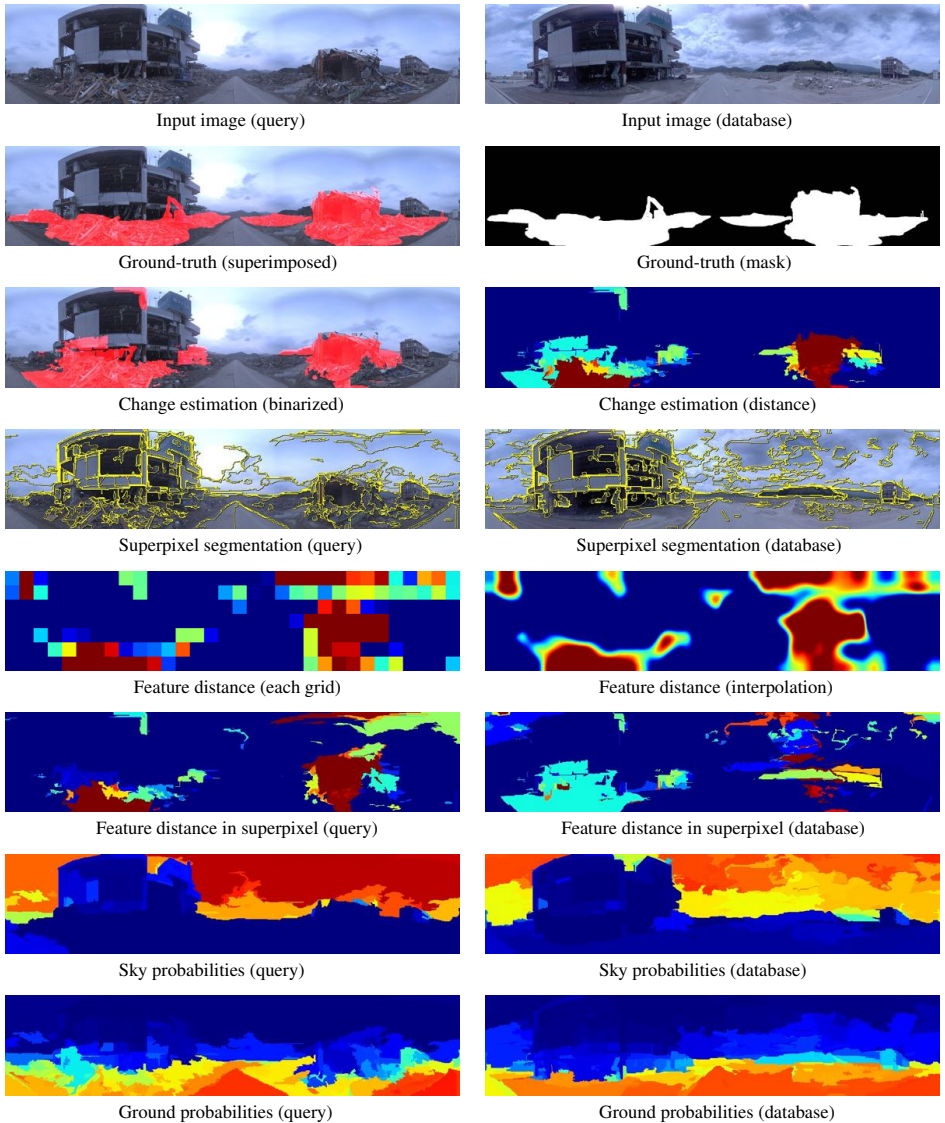


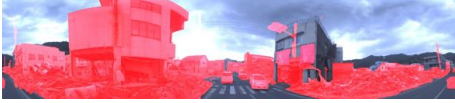
Figure 20: Results of change detection using pool-5 feature of CNN (Frame No. 20/100 in change detection dataset of tsunami)



Input image (query)



Input image (database)



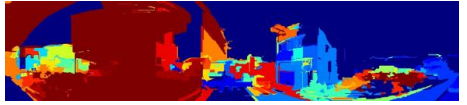
Ground-truth (superimposed)



Ground-truth (mask)



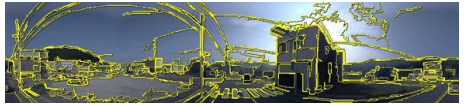
Change estimation (binarized)



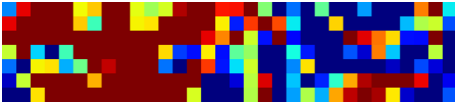
Change estimation (distance)



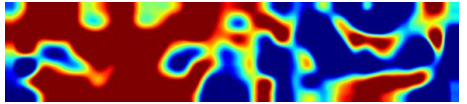
Superpixel segmentation (query)



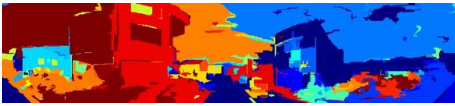
Superpixel segmentation (database)



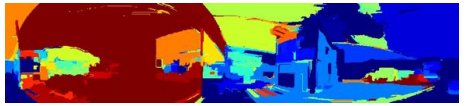
Feature distance (each grid)



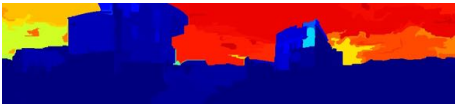
Feature distance (interpolation)



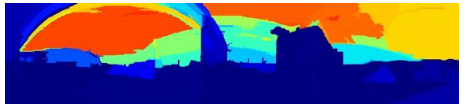
Feature distance in superpixel (query)



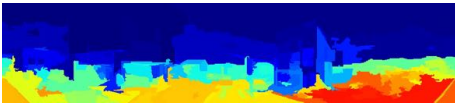
Feature distance in superpixel (database)



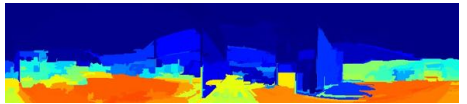
Sky probabilities (query)



Sky probabilities (database)



Ground probabilities (query)



Ground probabilities (database)

Figure 21: Results of change detection using pool-5 feature of CNN (Frame No. 21/100 in change detection dataset of tsunami)

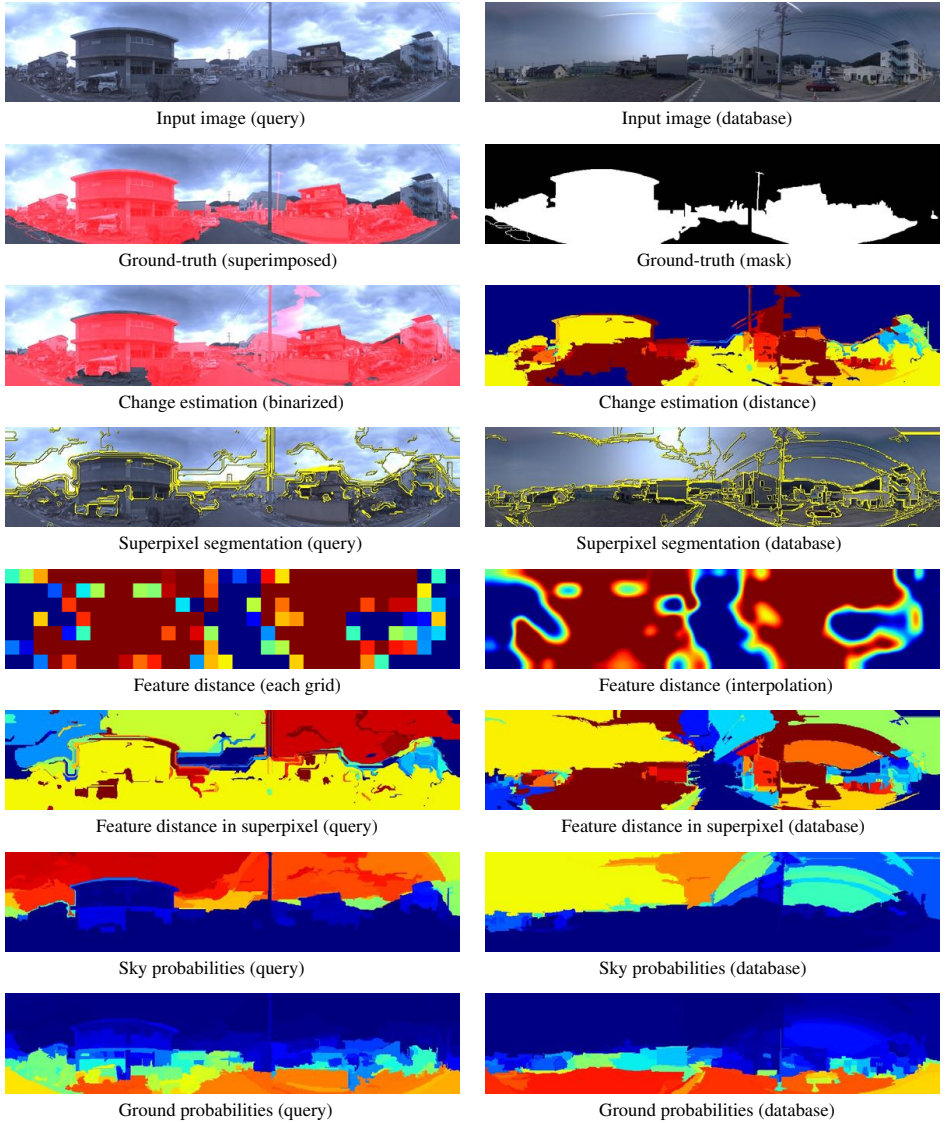


Figure 22: Results of change detection using pool-5 feature of CNN (Frame No. 22/100 in change detection dataset of tsunami)

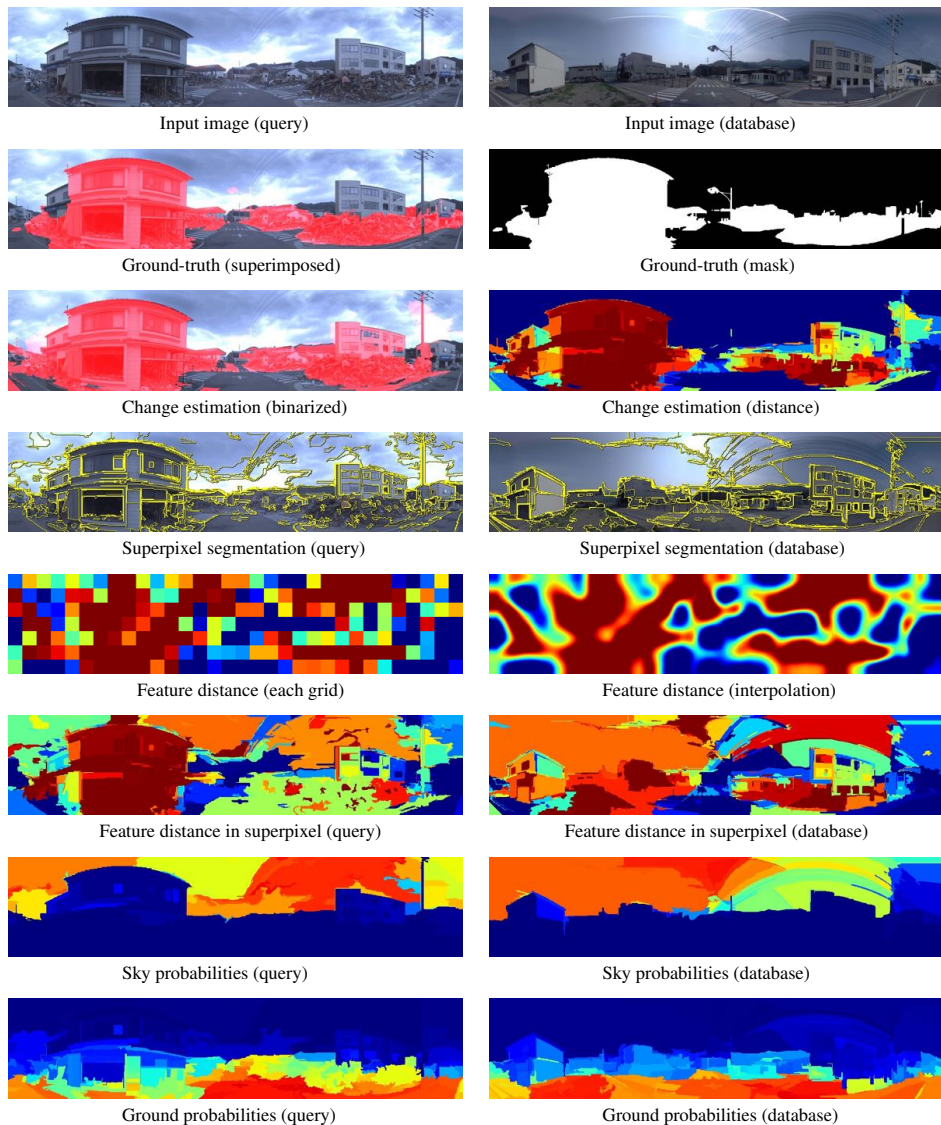


Figure 23: Results of change detection using pool-5 feature of CNN (Frame No. 23/100 in change detection dataset of tsunami)

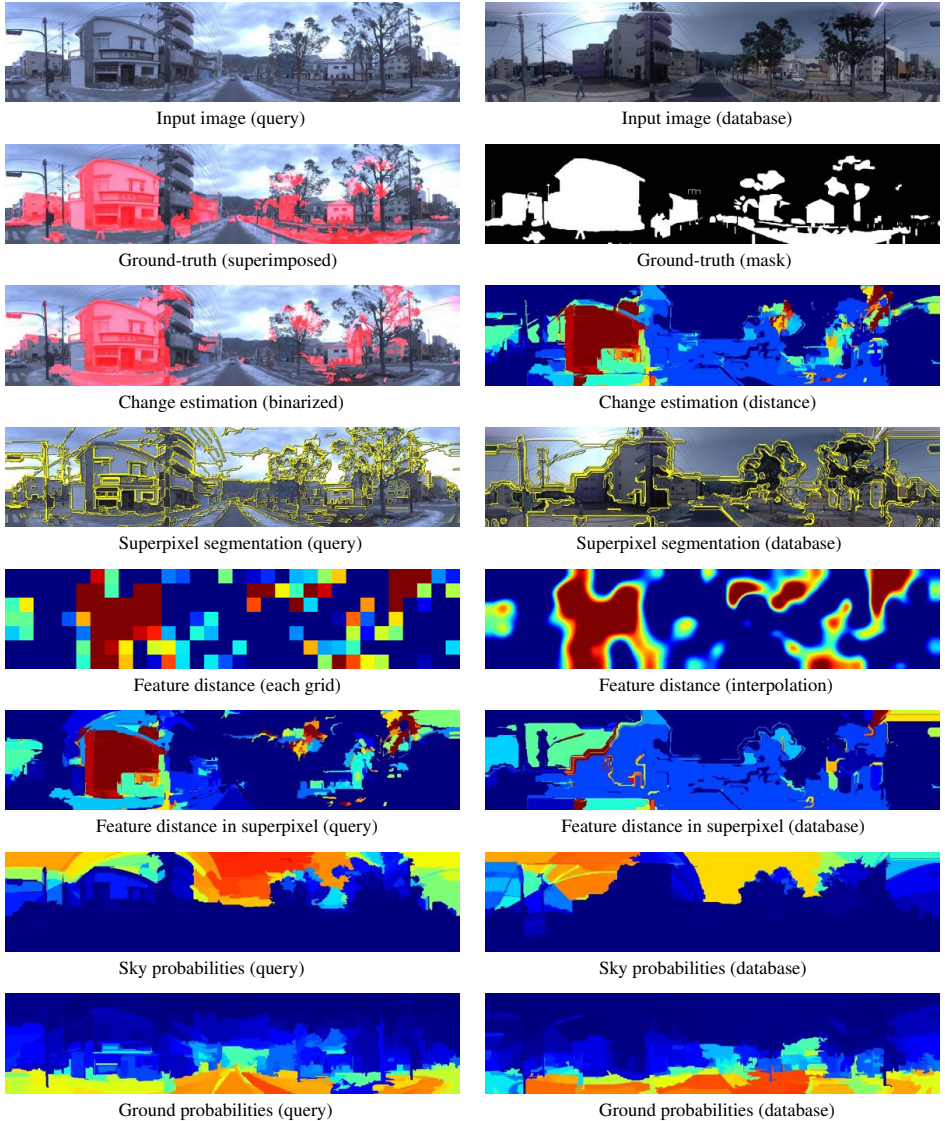


Figure 24: Results of change detection using pool-5 feature of CNN (Frame No. 24/100 in change detection dataset of tsunami)

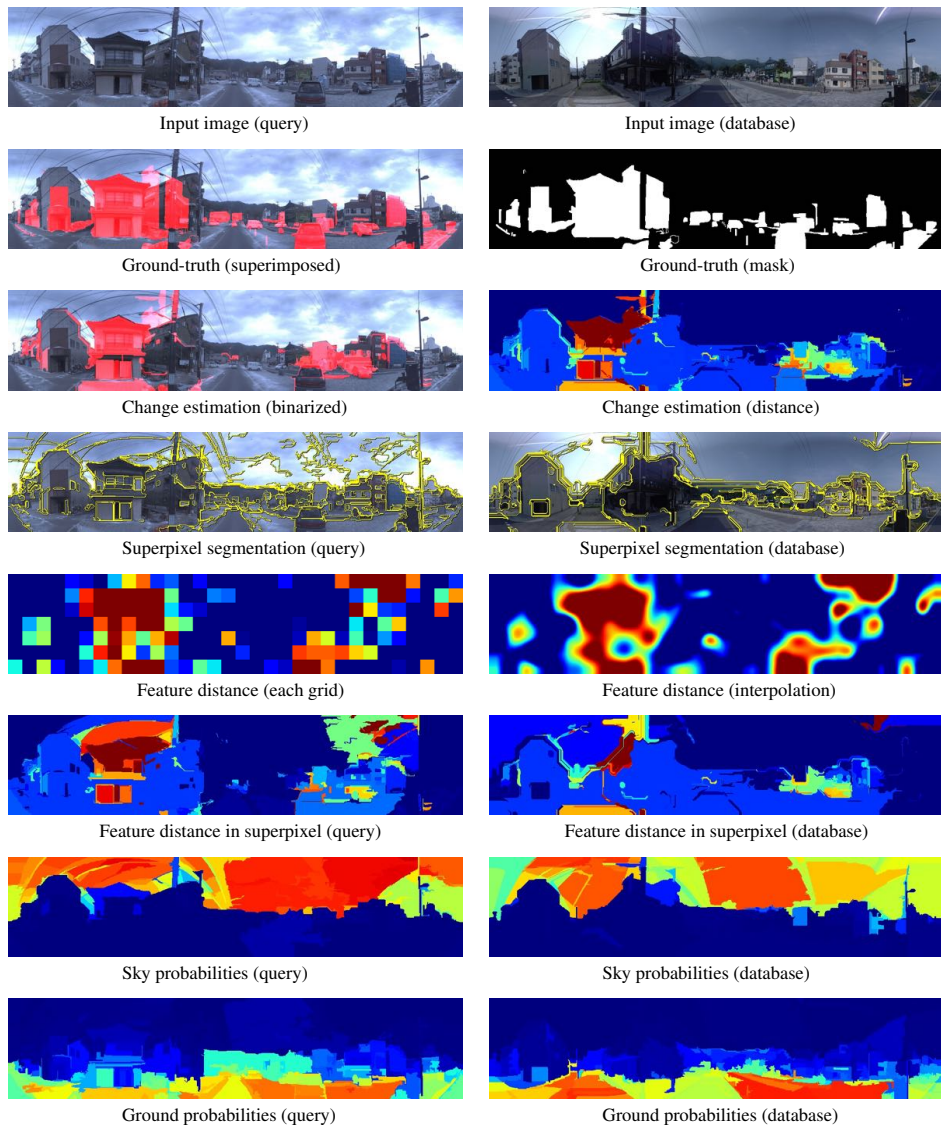


Figure 25: Results of change detection using pool-5 feature of CNN (Frame No. 25/100 in change detection dataset of tsunami)

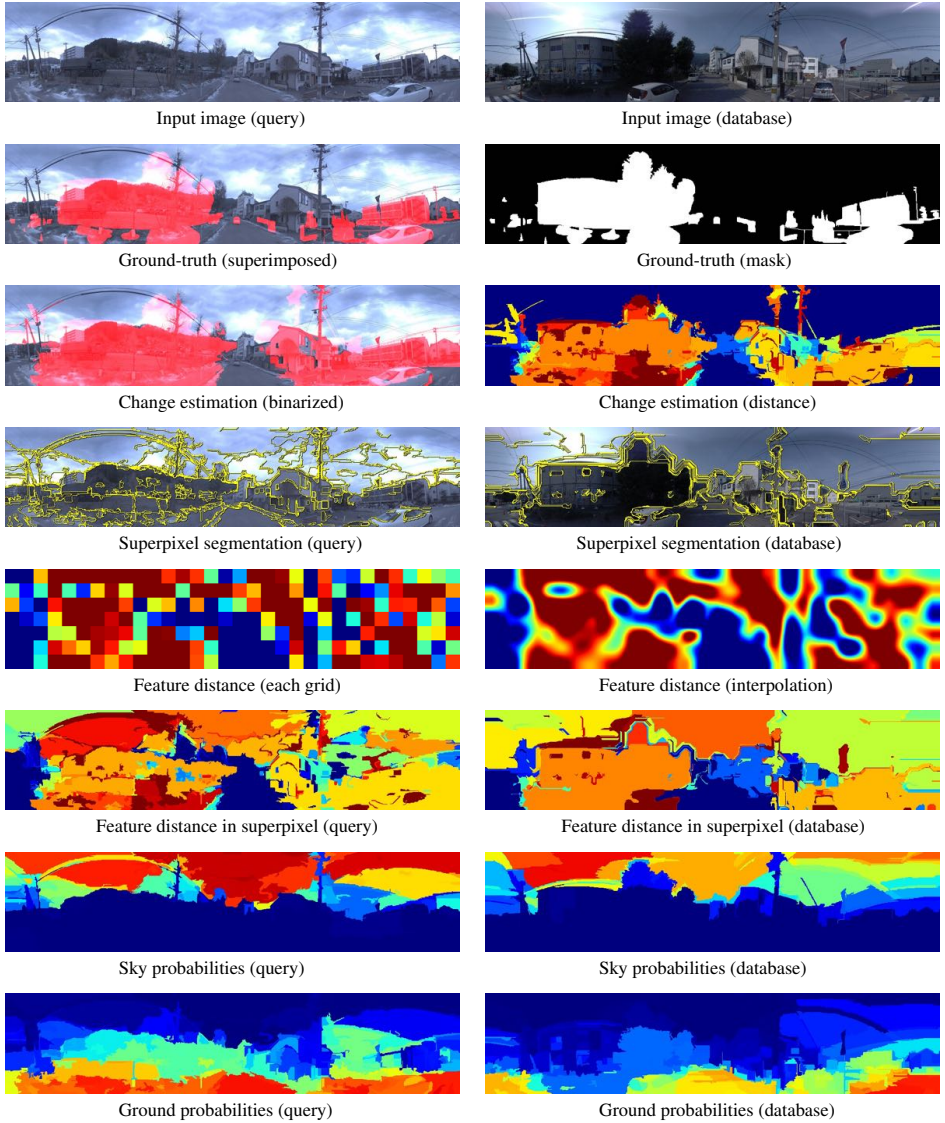


Figure 26: Results of change detection using pool-5 feature of CNN (Frame No. 26/100 in change detection dataset of tsunami)

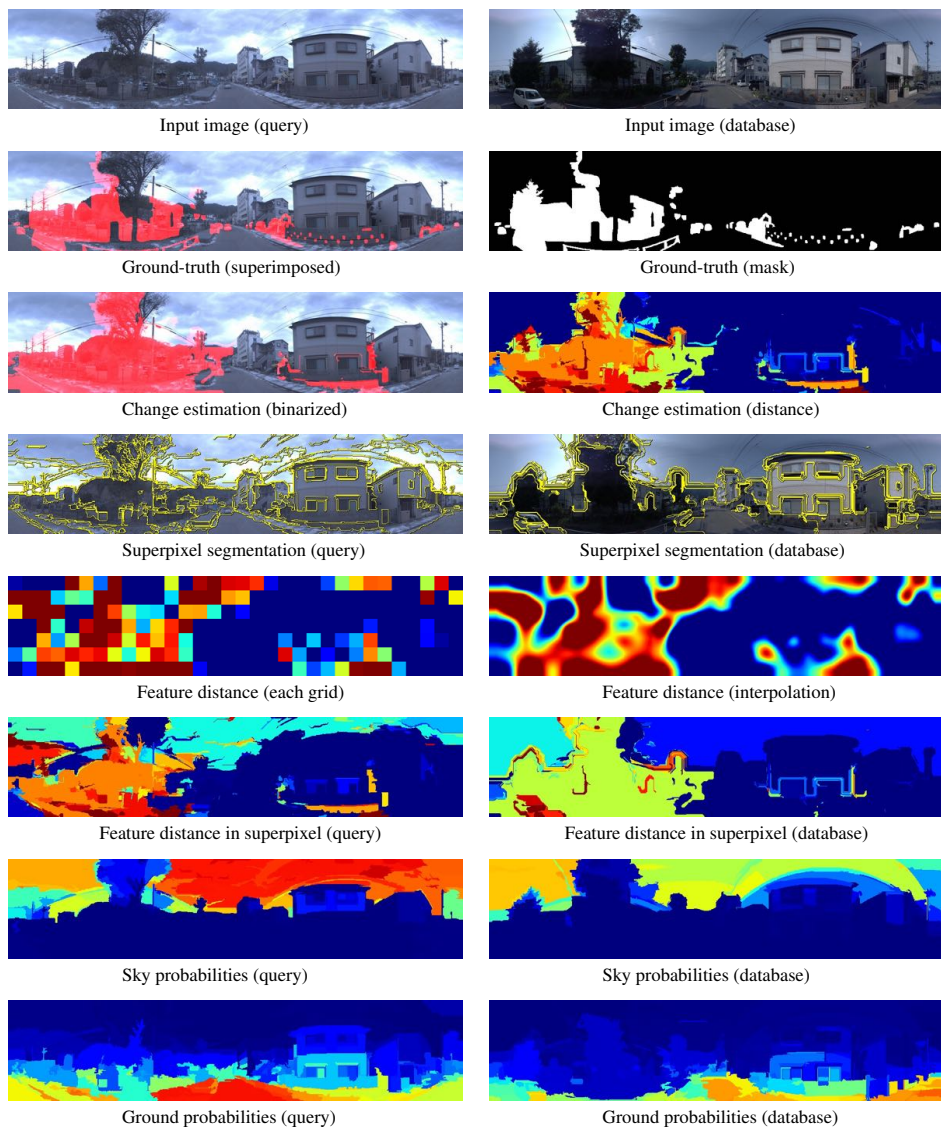


Figure 27: Results of change detection using pool-5 feature of CNN (Frame No. 27/100 in change detection dataset of tsunami)

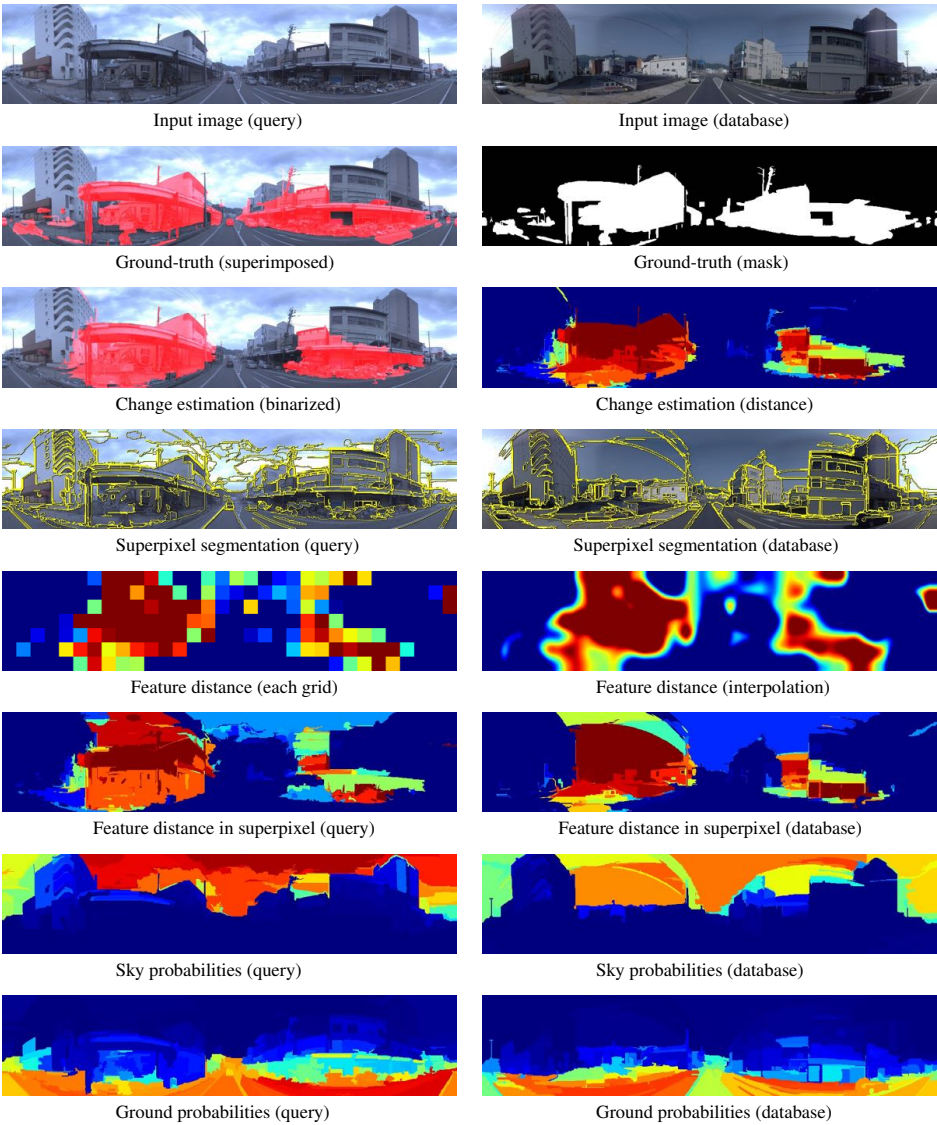


Figure 28: Results of change detection using pool-5 feature of CNN (Frame No. 28/100 in change detection dataset of tsunami)

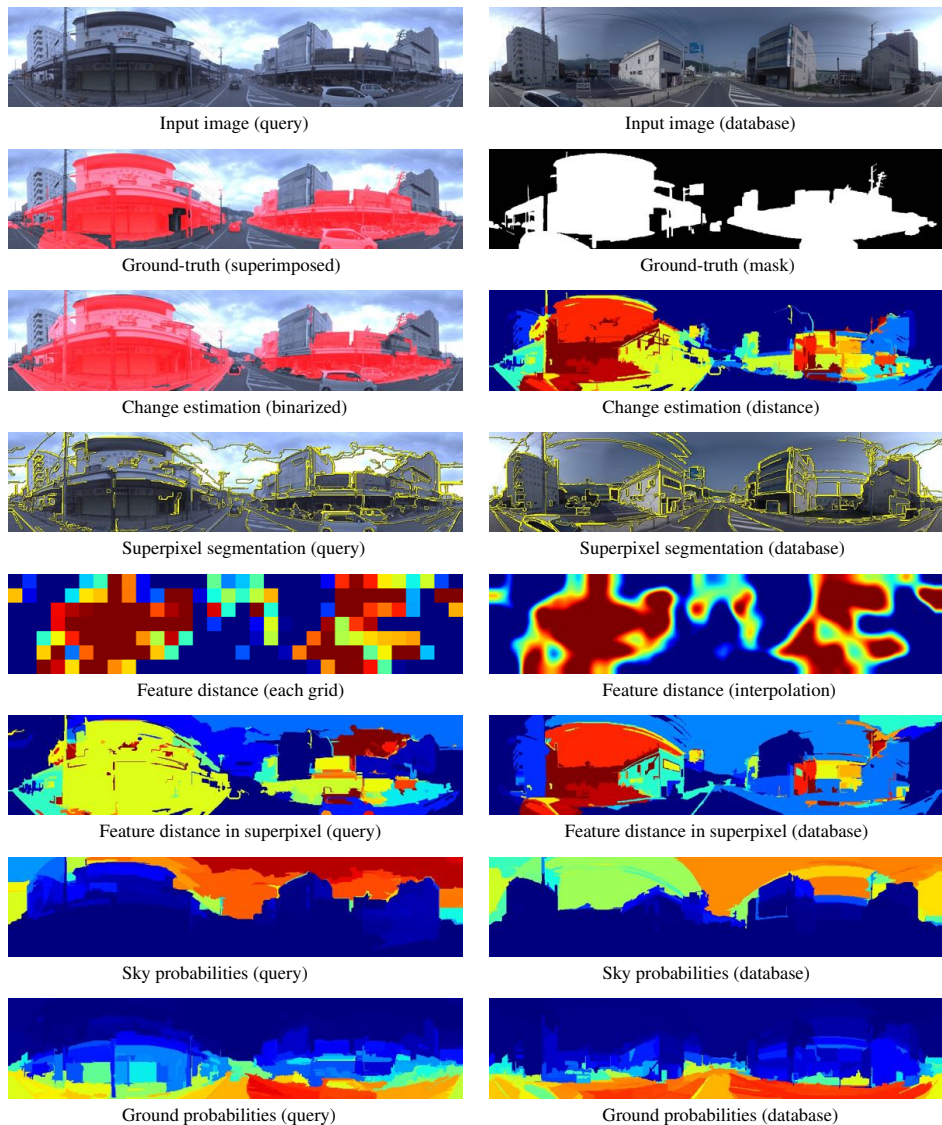


Figure 29: Results of change detection using pool-5 feature of CNN (Frame No. 29/100 in change detection dataset of tsunami)

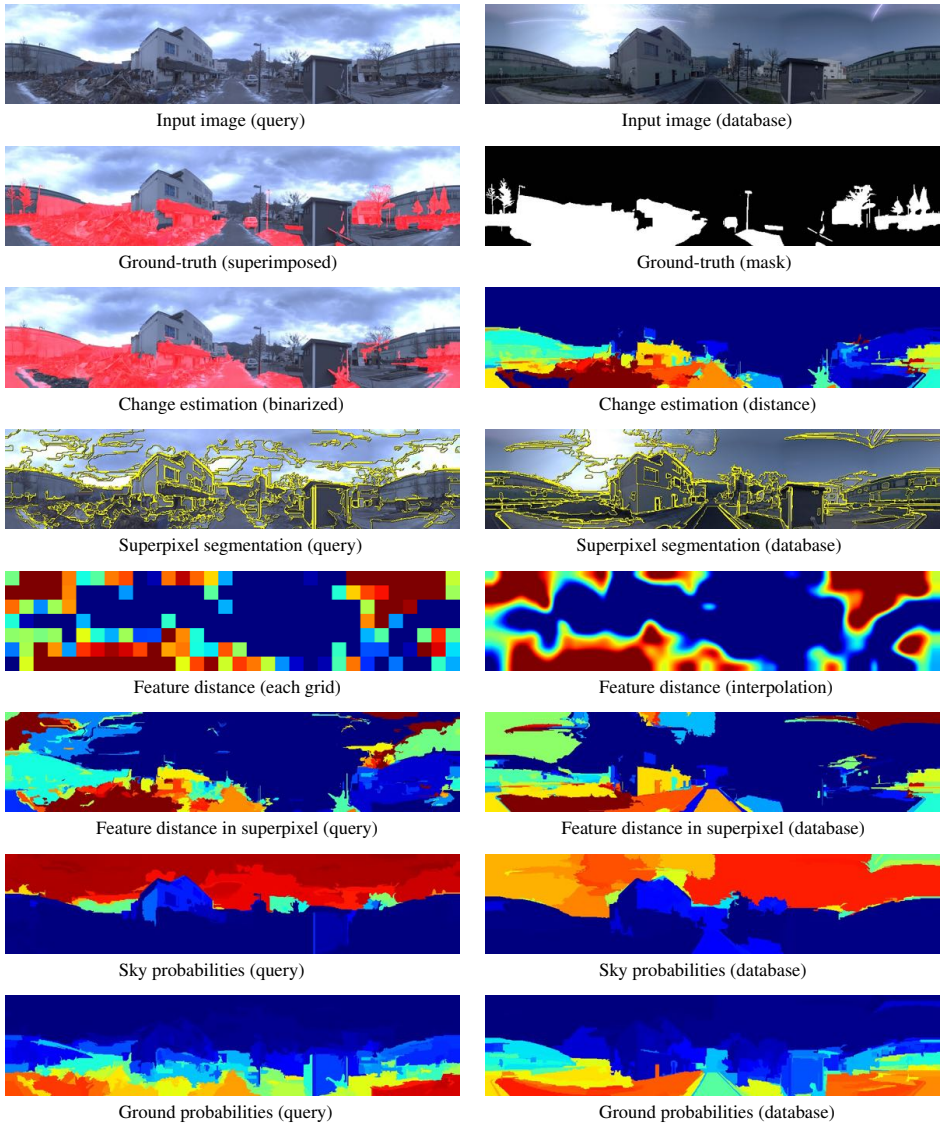


Figure 30: Results of change detection using pool-5 feature of CNN (Frame No. 30/100 in change detection dataset of tsunami)

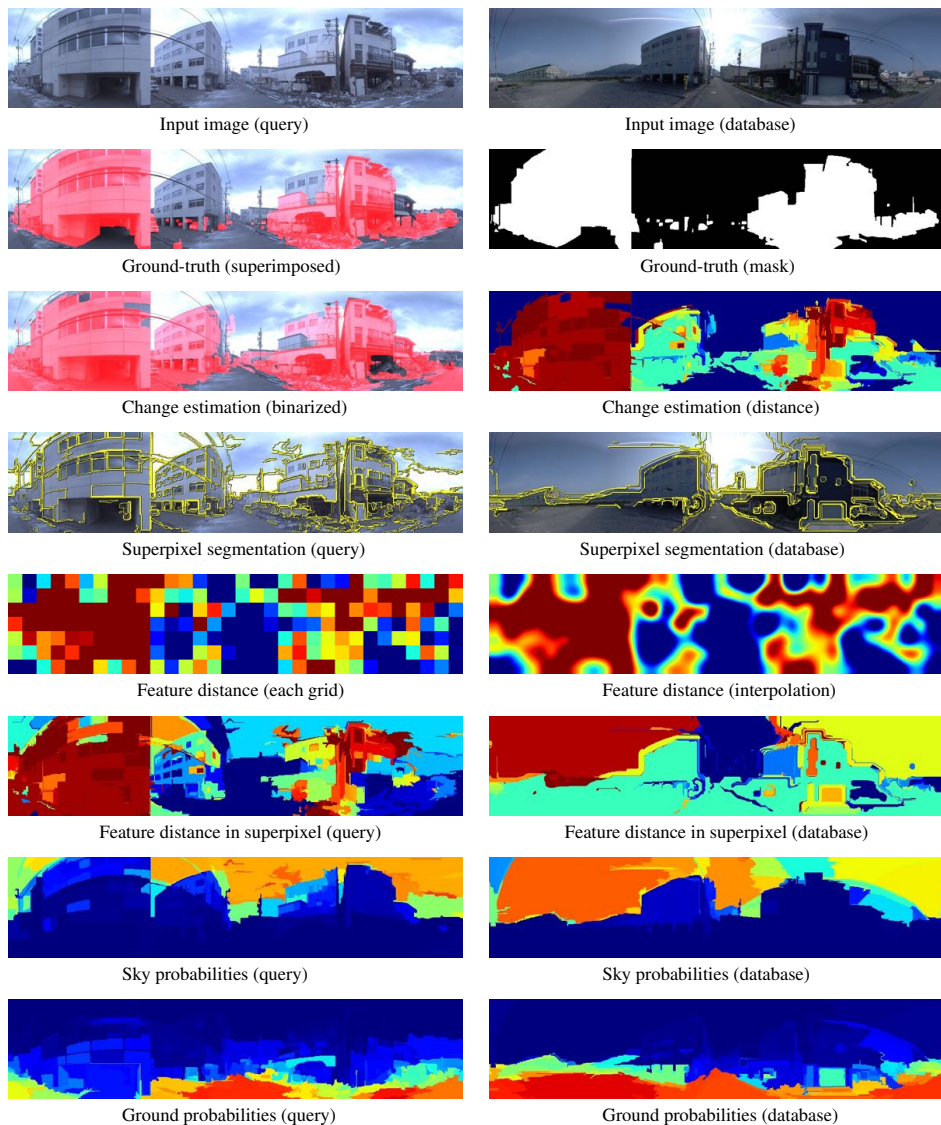


Figure 31: Results of change detection using pool-5 feature of CNN (Frame No. 31/100 in change detection dataset of tsunami)

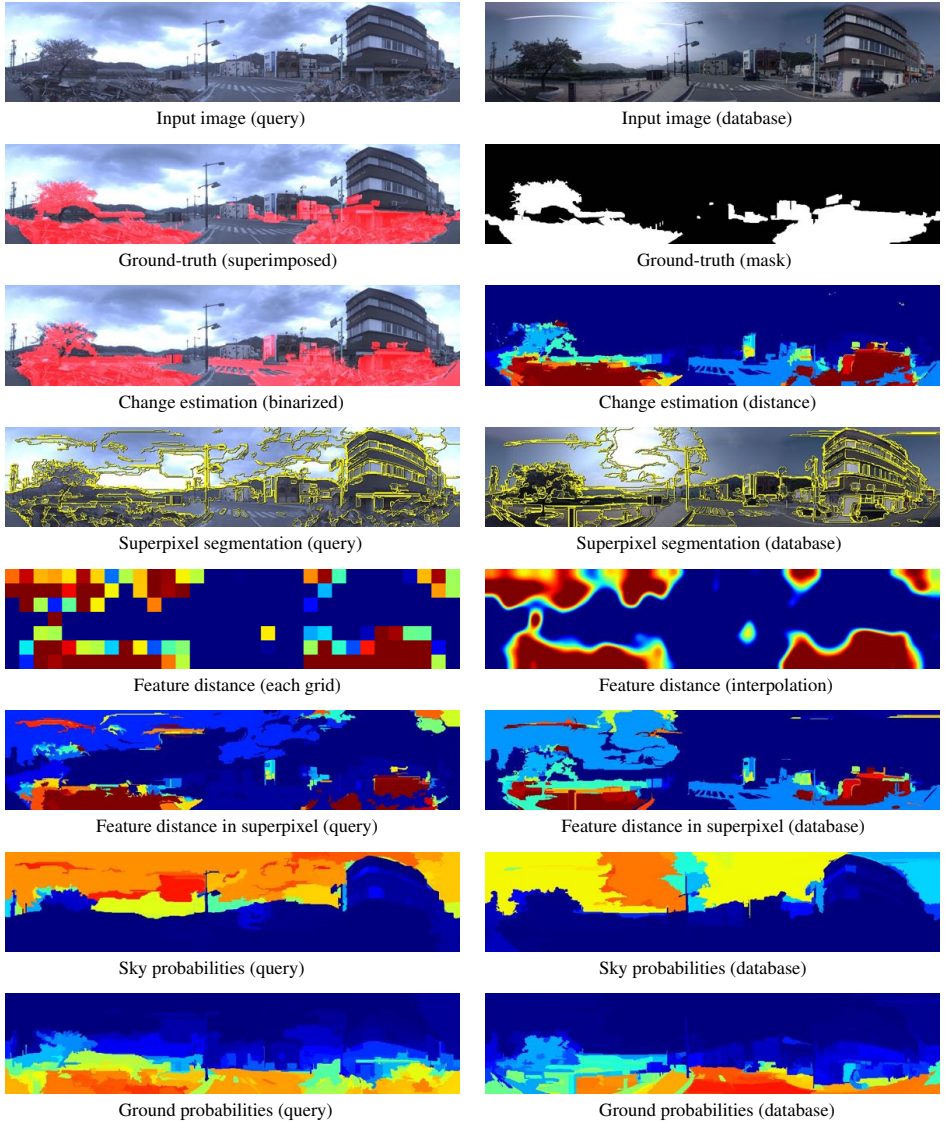


Figure 32: Results of change detection using pool-5 feature of CNN (Frame No. 32/100 in change detection dataset of tsunami)

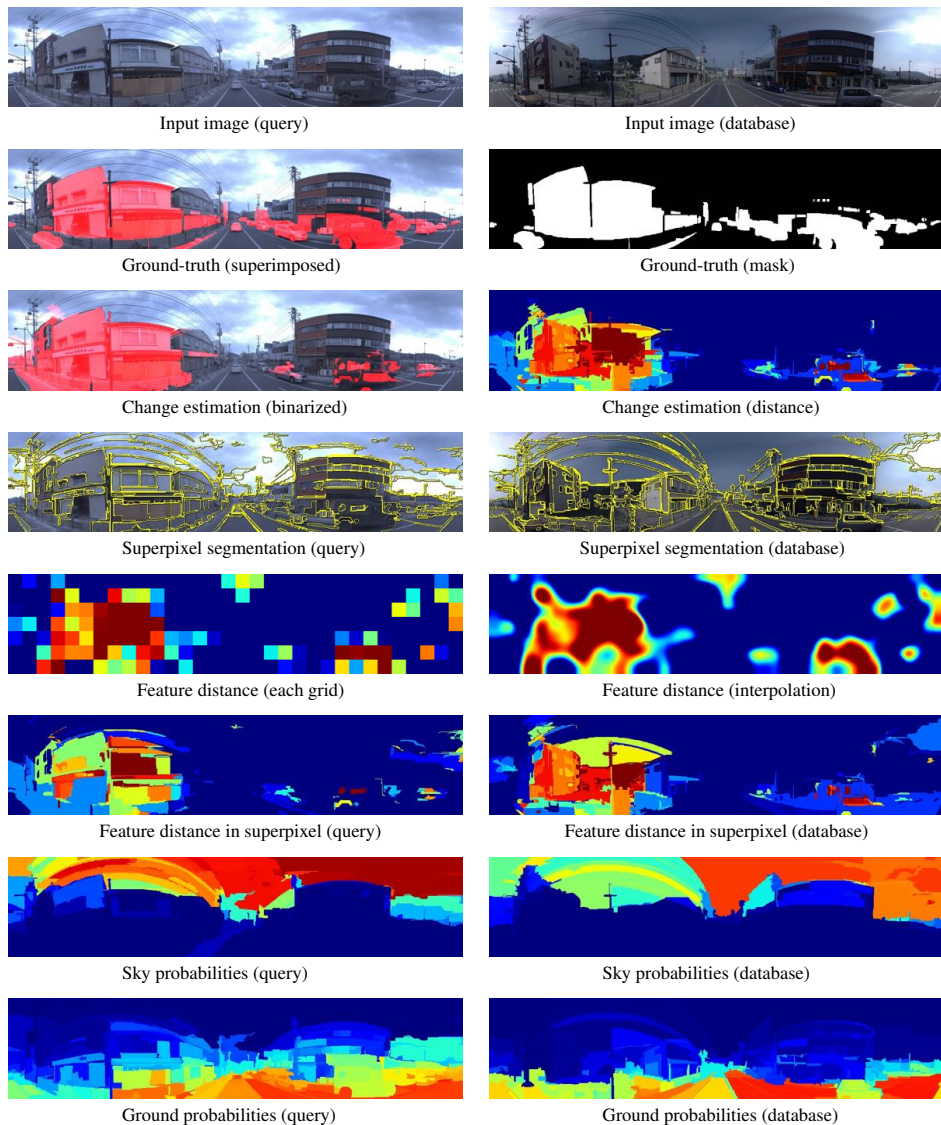


Figure 33: Results of change detection using pool-5 feature of CNN (Frame No. 33/100 in change detection dataset of tsunami)

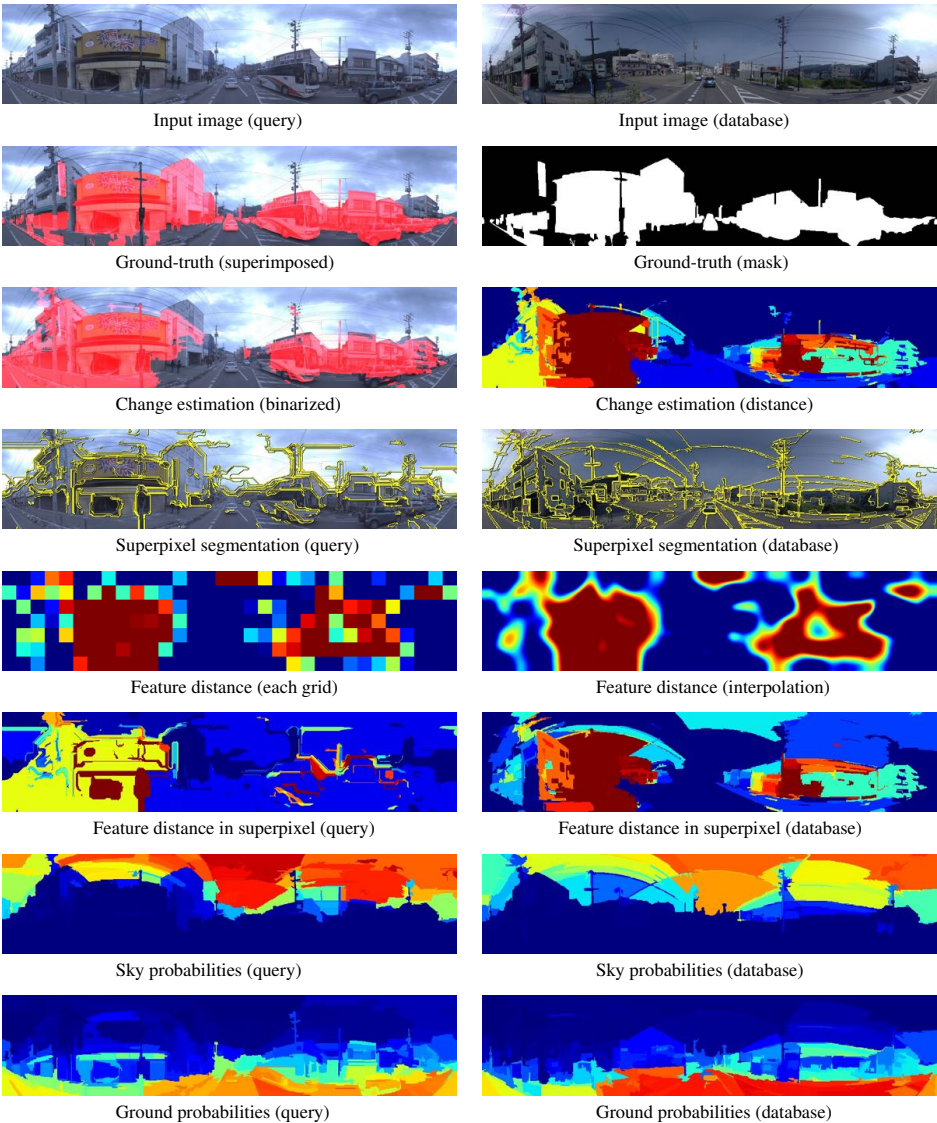


Figure 34: Results of change detection using pool-5 feature of CNN (Frame No. 34/100 in change detection dataset of tsunami)

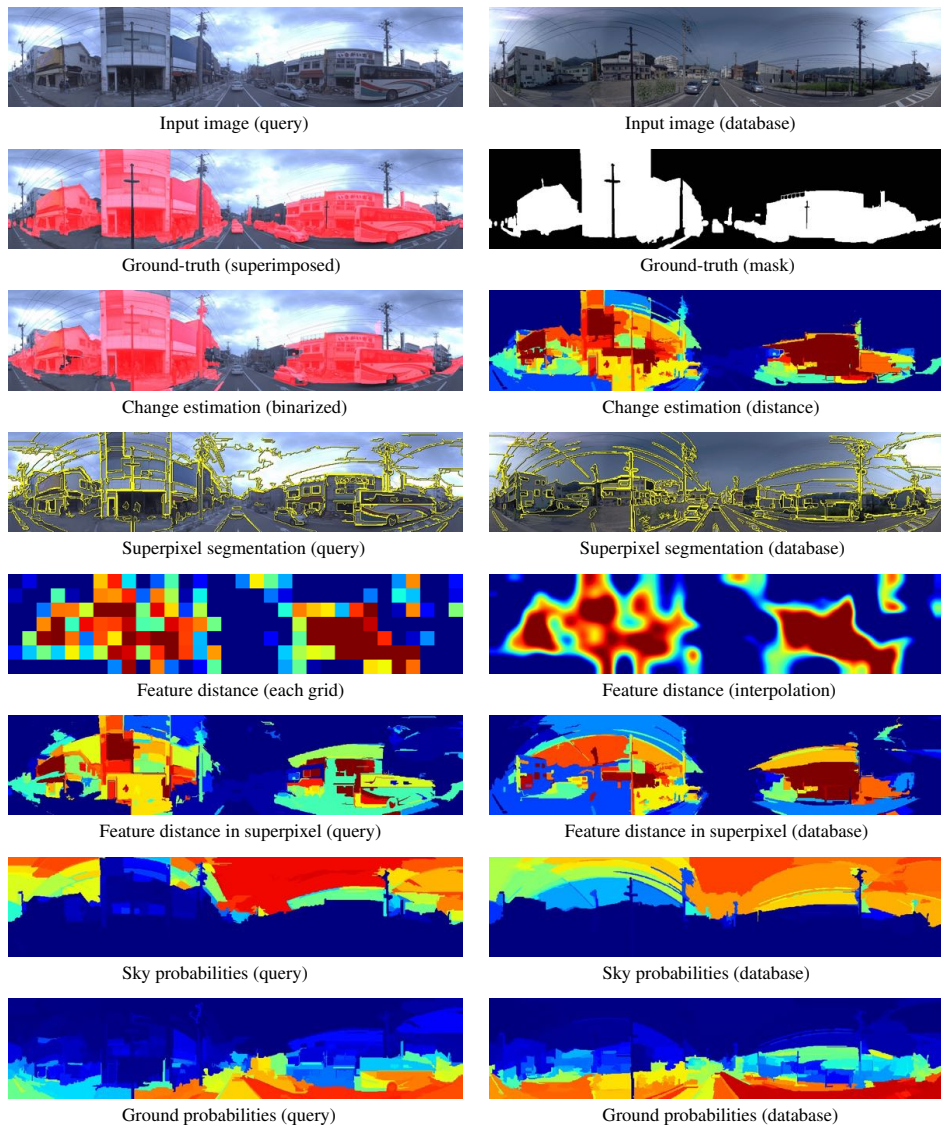


Figure 35: Results of change detection using pool-5 feature of CNN (Frame No. 35/100 in change detection dataset of tsunami)

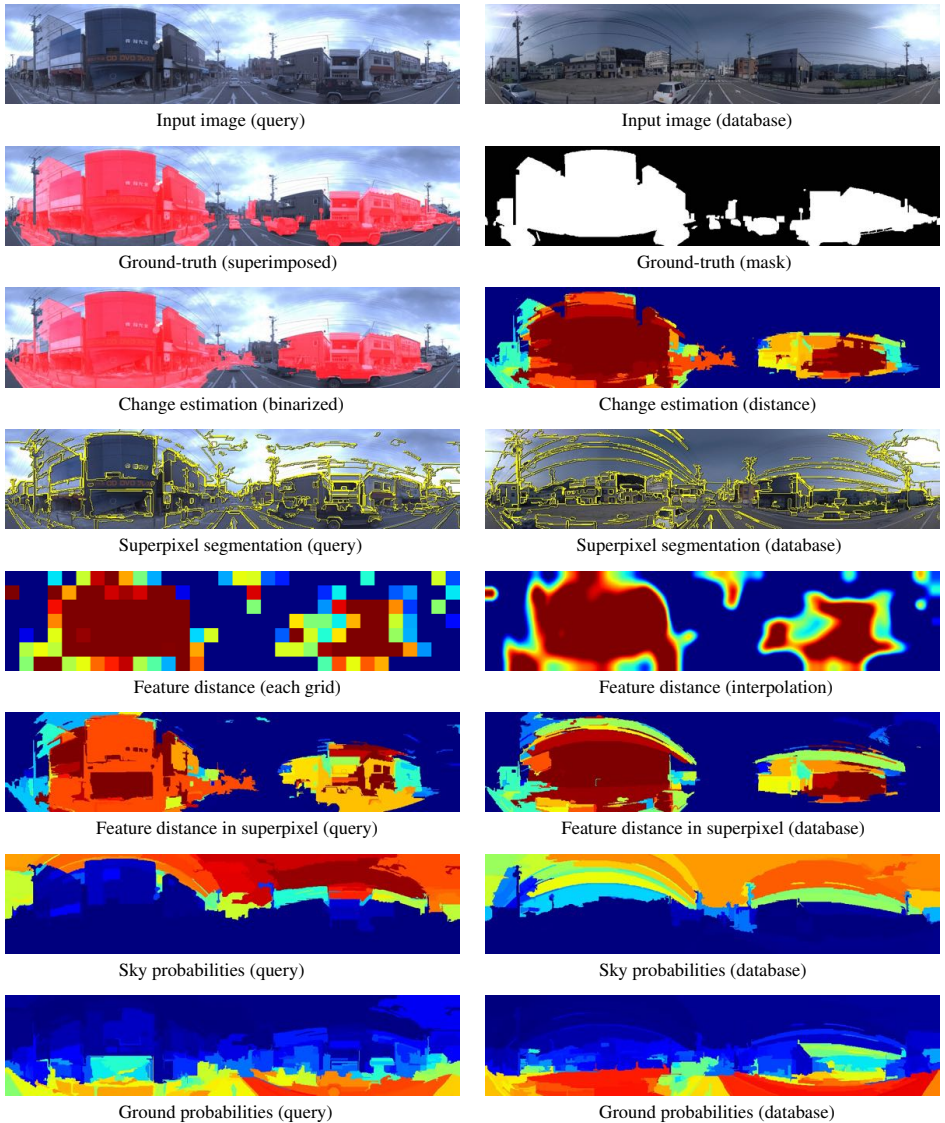


Figure 36: Results of change detection using pool-5 feature of CNN (Frame No. 36/100 in change detection dataset of tsunami)

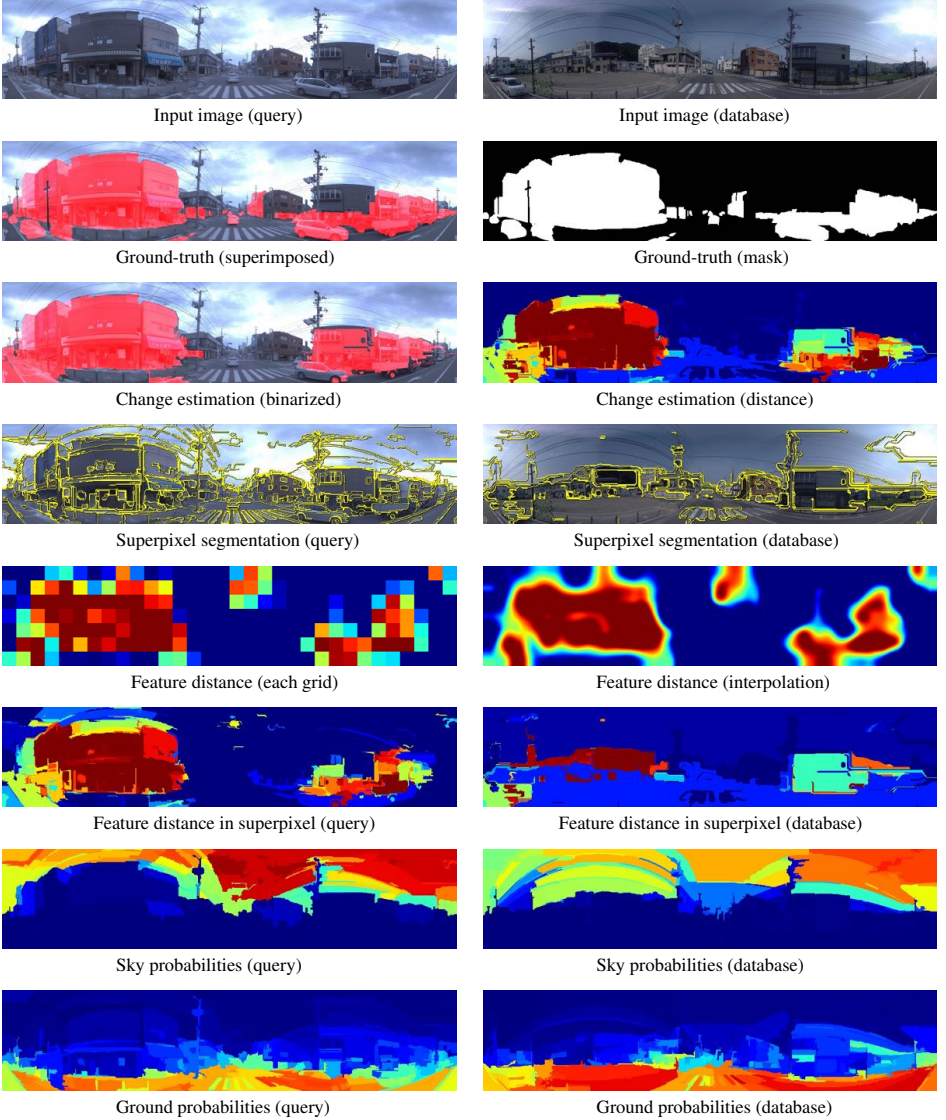


Figure 37: Results of change detection using pool-5 feature of CNN (Frame No. 37/100 in change detection dataset of tsunami)

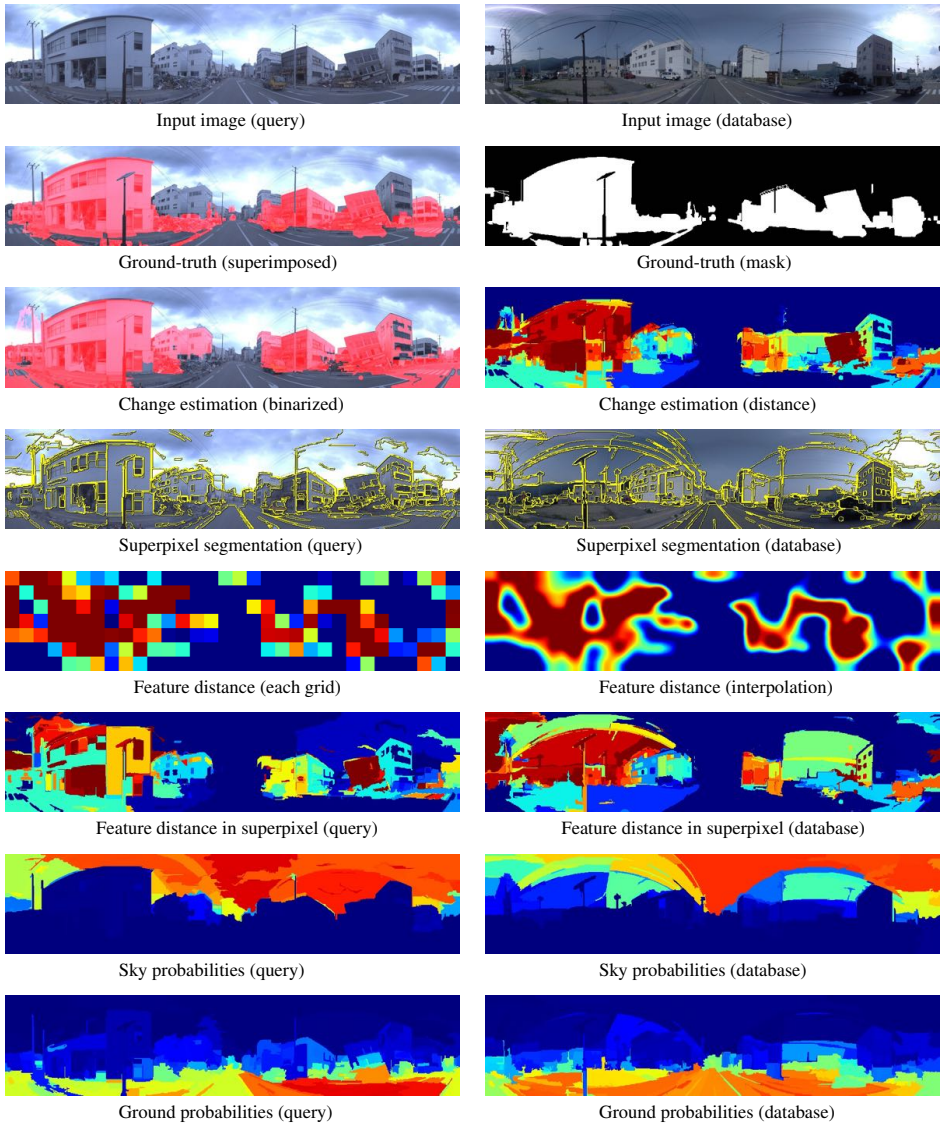


Figure 38: Results of change detection using pool-5 feature of CNN (Frame No. 38/100 in change detection dataset of tsunami)

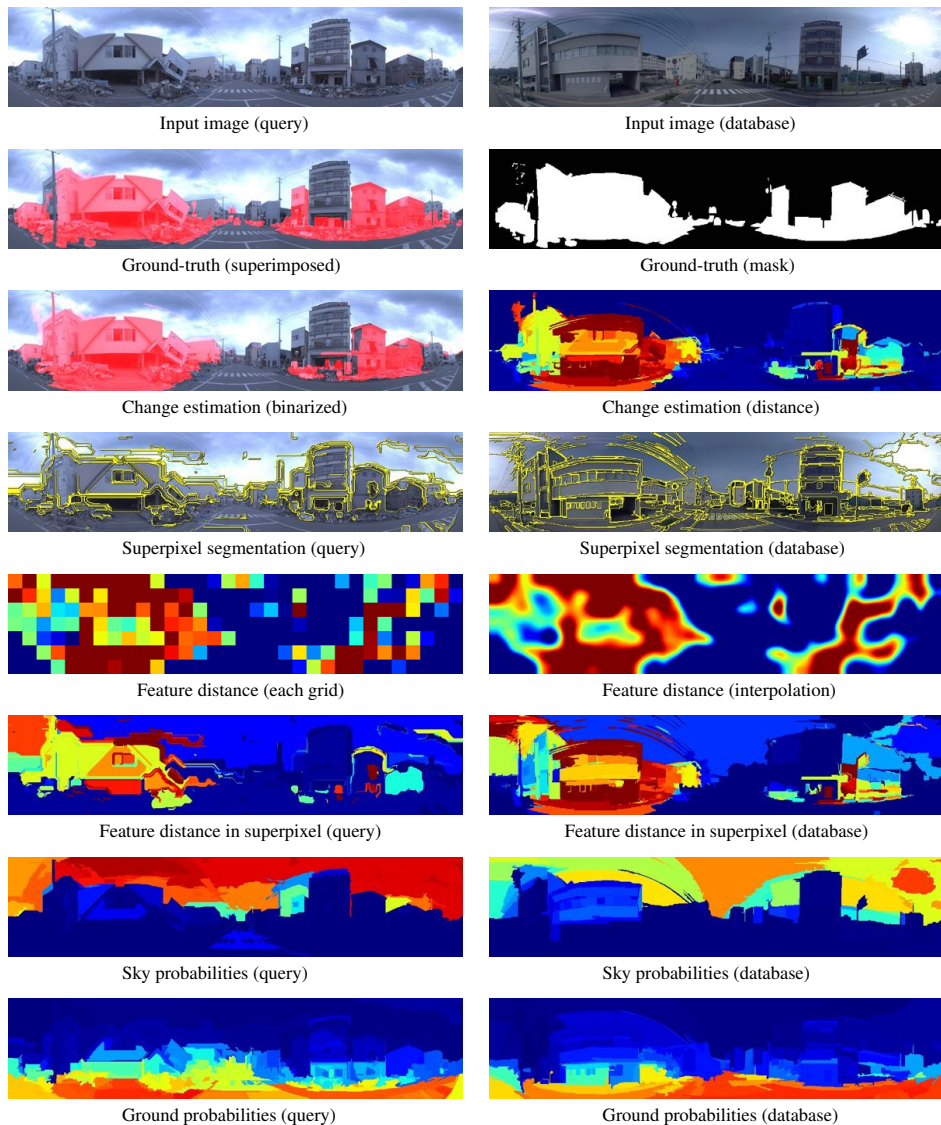


Figure 39: Results of change detection using pool-5 feature of CNN (Frame No. 39/100 in change detection dataset of tsunami)

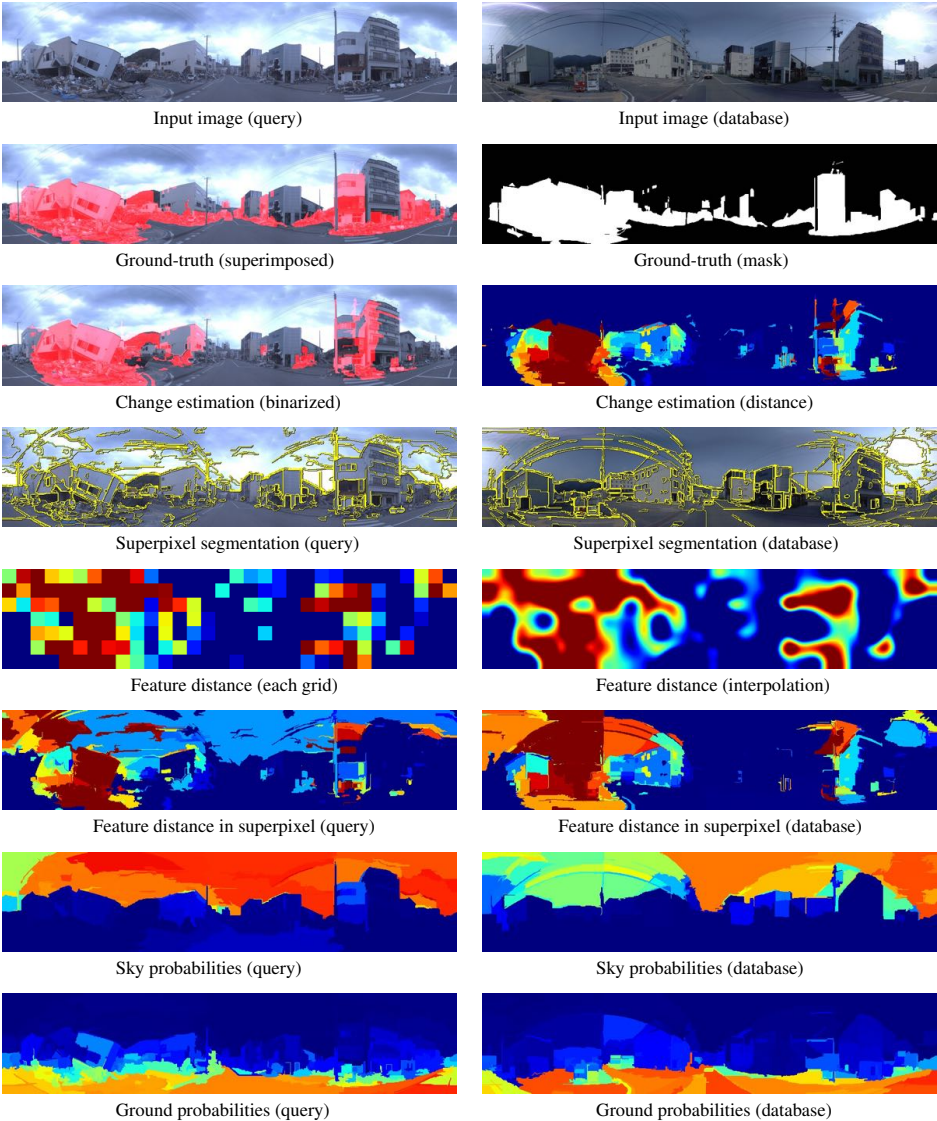


Figure 40: Results of change detection using pool-5 feature of CNN (Frame No. 40/100 in change detection dataset of tsunami)

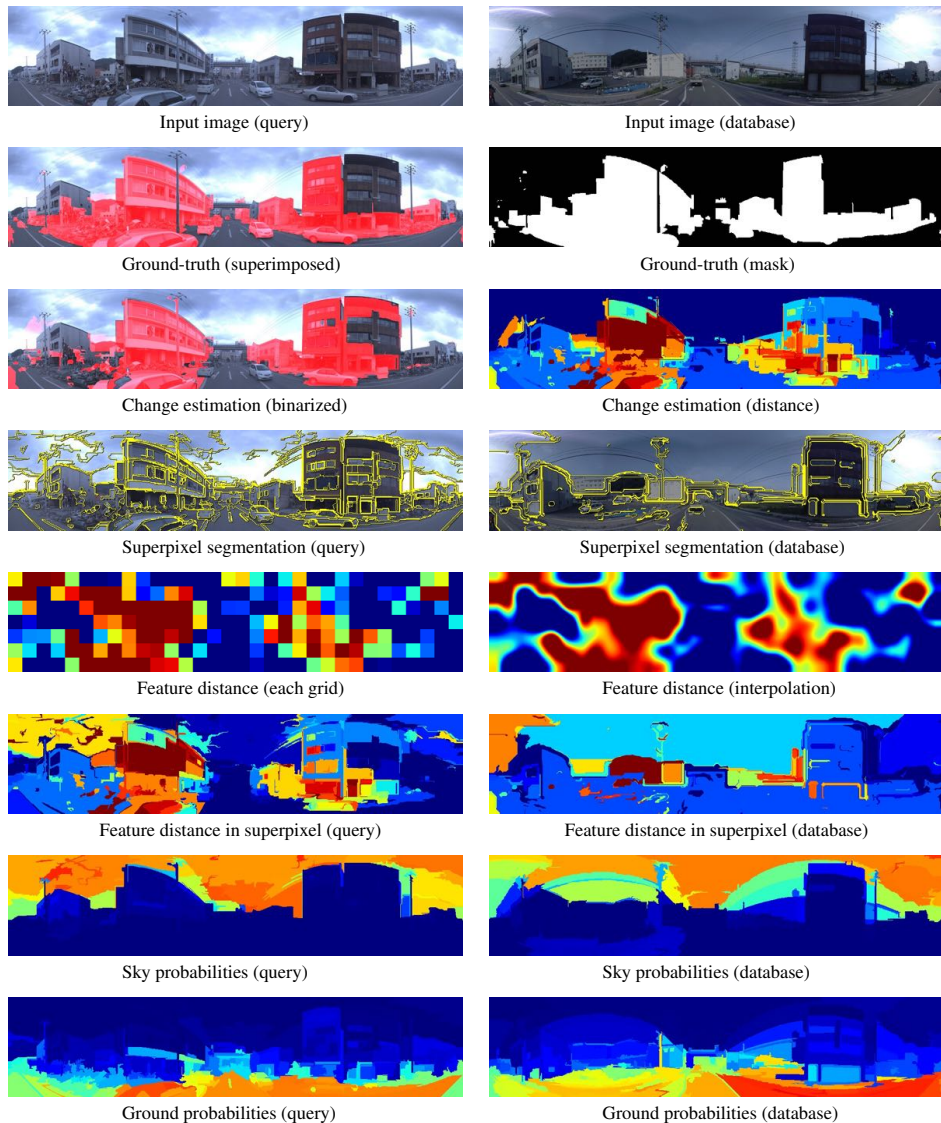


Figure 41: Results of change detection using pool-5 feature of CNN (Frame No. 41/100 in change detection dataset of tsunami)

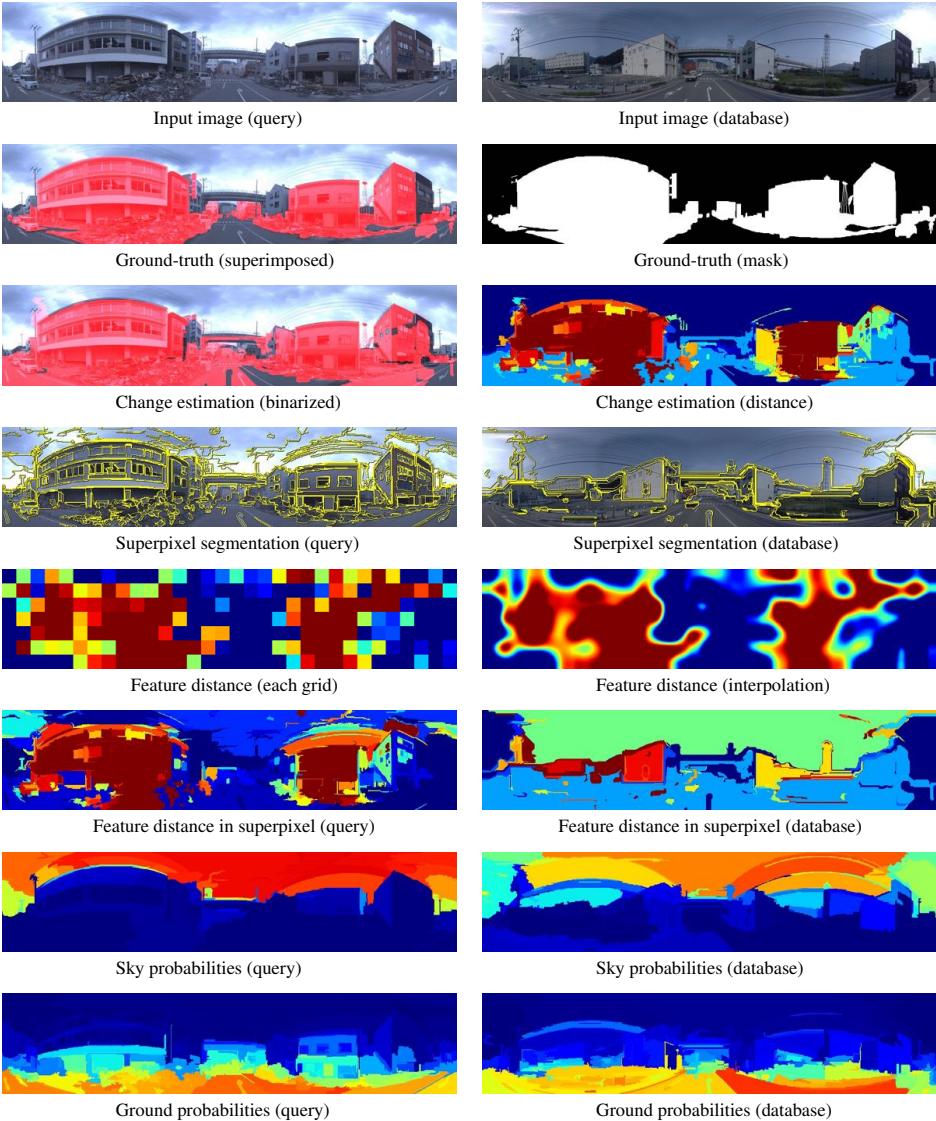


Figure 42: Results of change detection using pool-5 feature of CNN (Frame No. 42/100 in change detection dataset of tsunami)

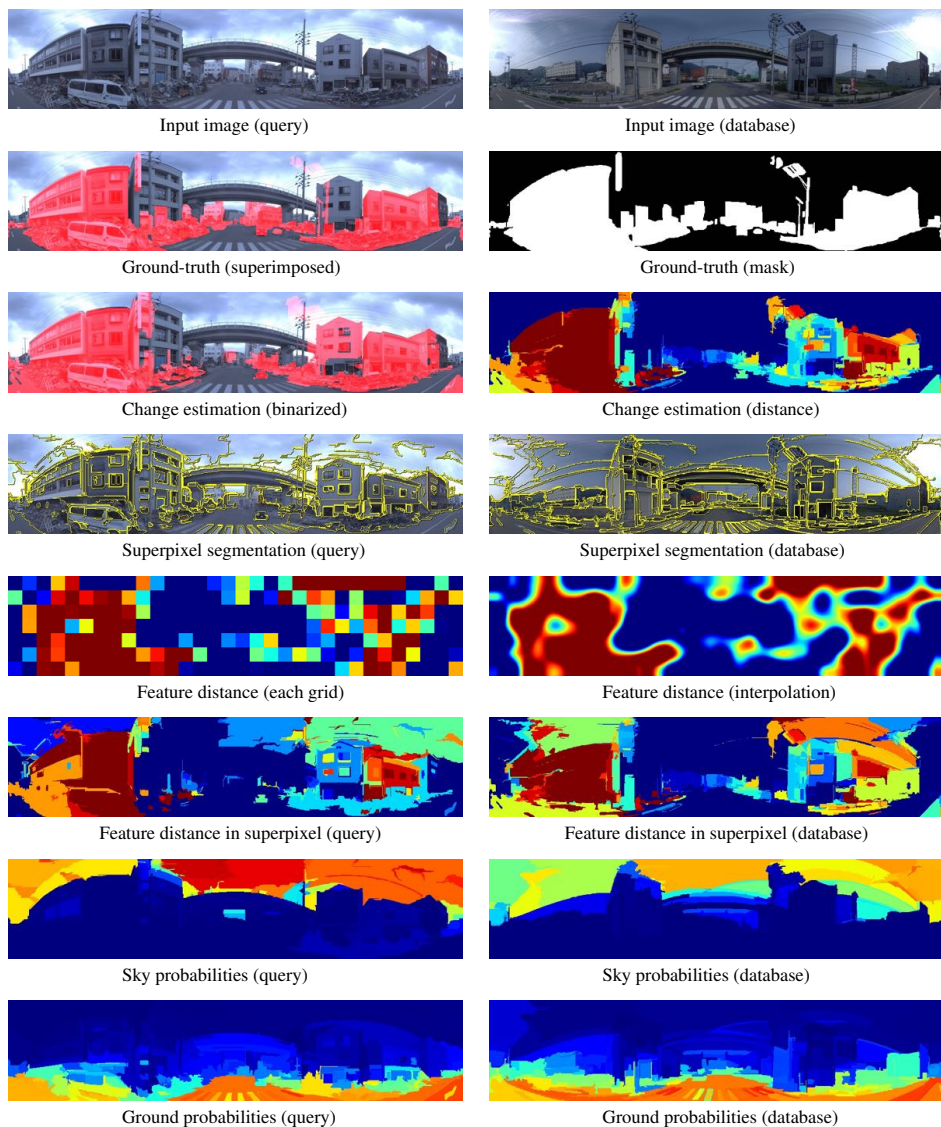


Figure 43: Results of change detection using pool-5 feature of CNN (Frame No. 43/100 in change detection dataset of tsunami)

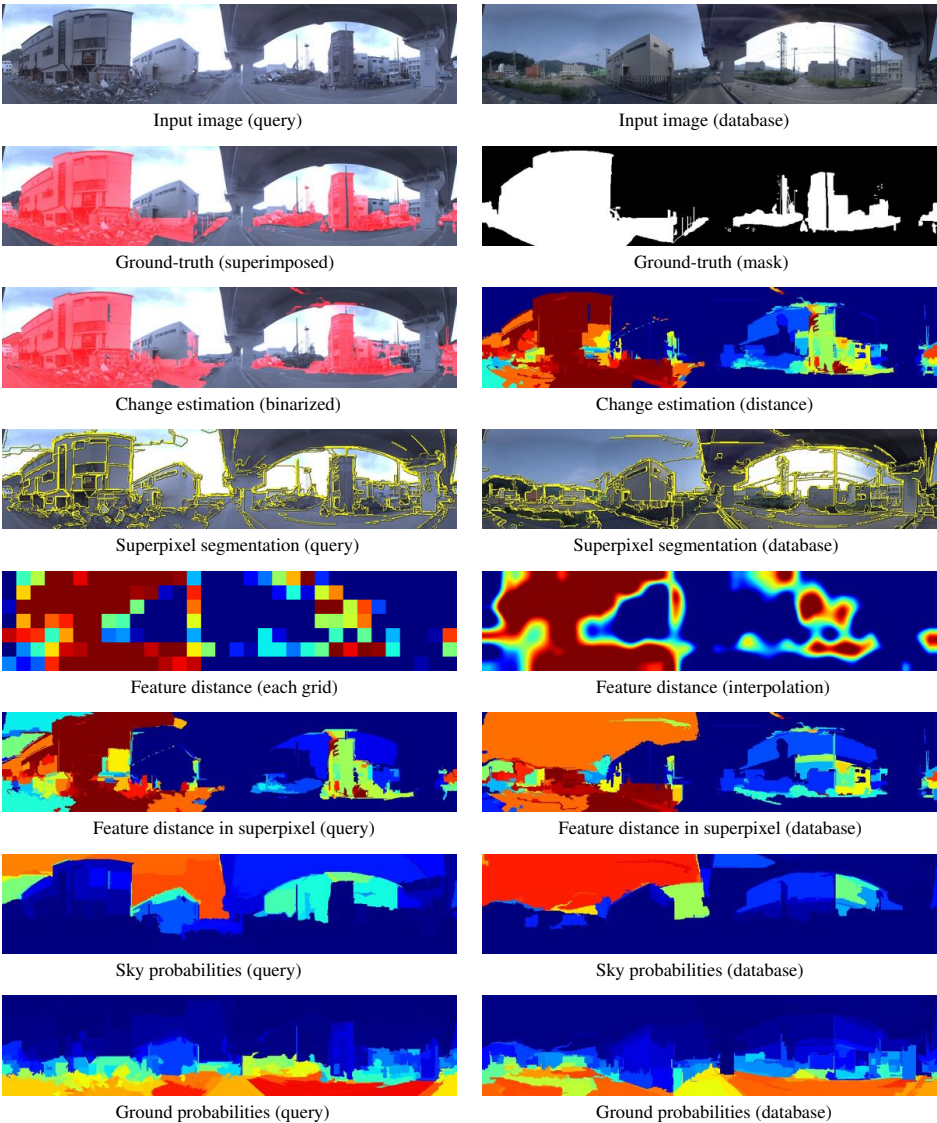


Figure 44: Results of change detection using pool-5 feature of CNN (Frame No. 44/100 in change detection dataset of tsunami)

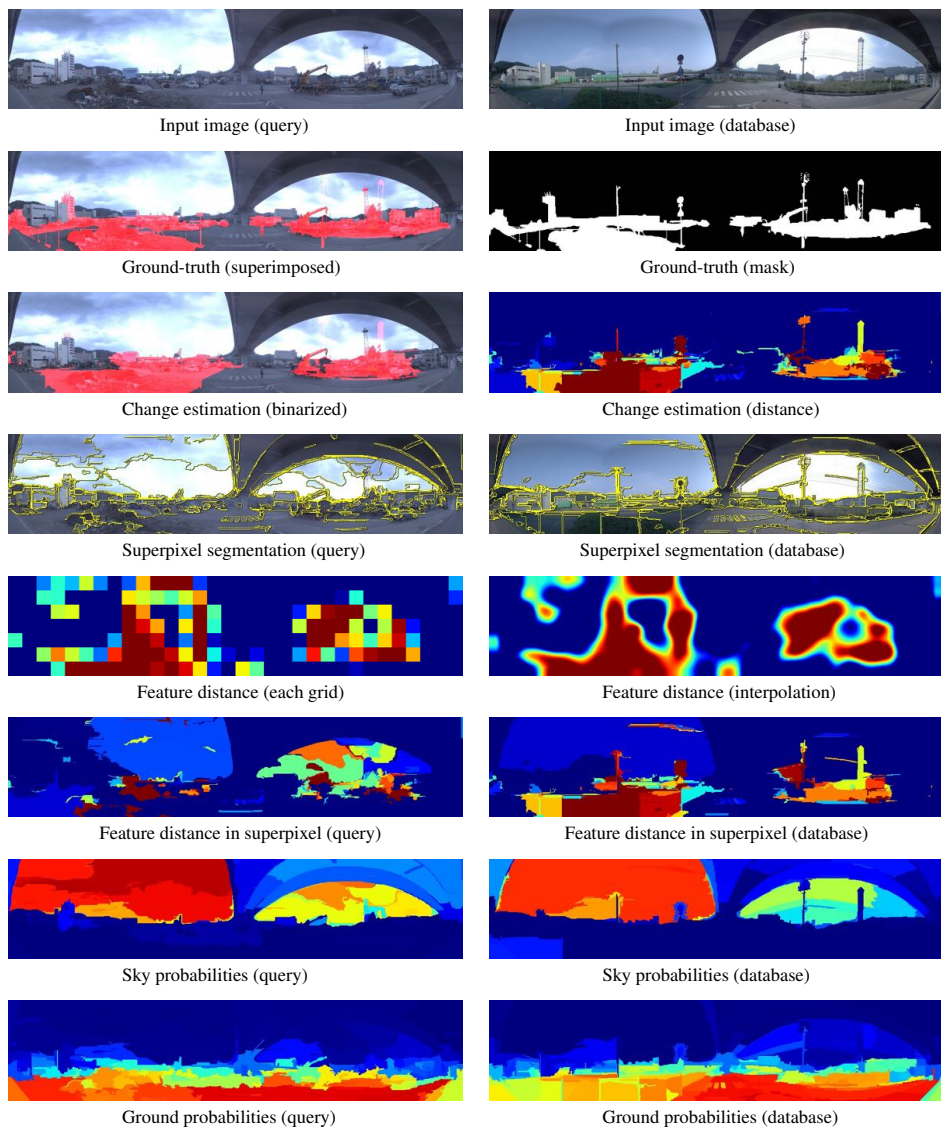


Figure 45: Results of change detection using pool-5 feature of CNN (Frame No. 45/100 in change detection dataset of tsunami)

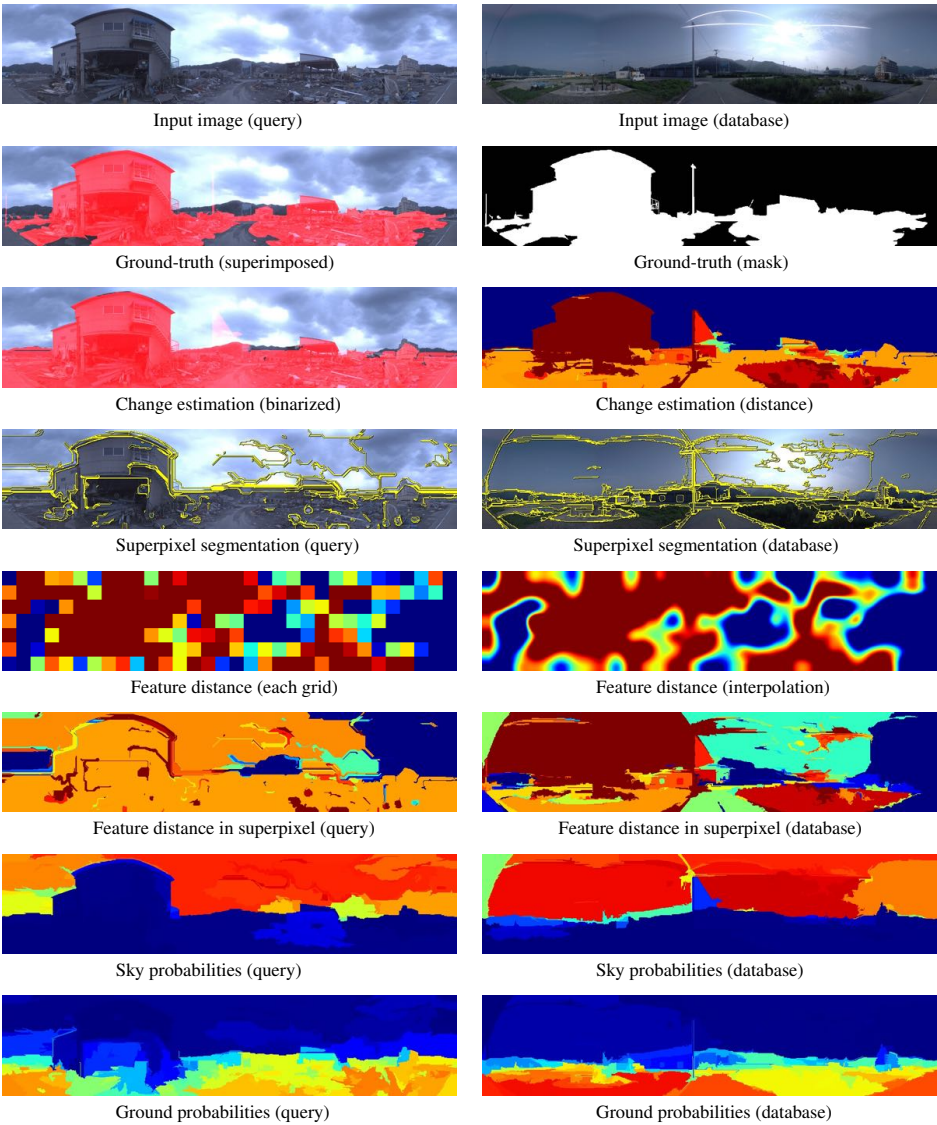


Figure 46: Results of change detection using pool-5 feature of CNN (Frame No. 46/100 in change detection dataset of tsunami)

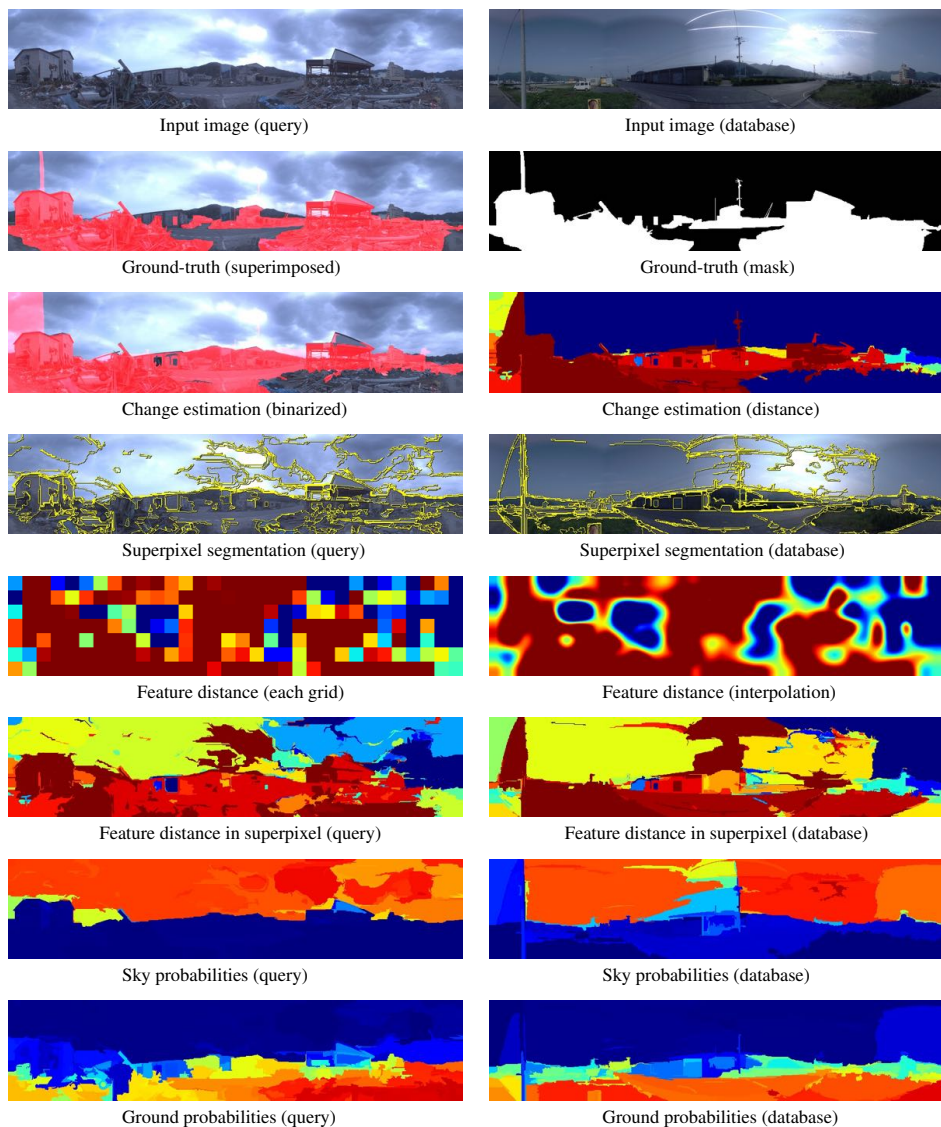


Figure 47: Results of change detection using pool-5 feature of CNN (Frame No. 47/100 in change detection dataset of tsunami)

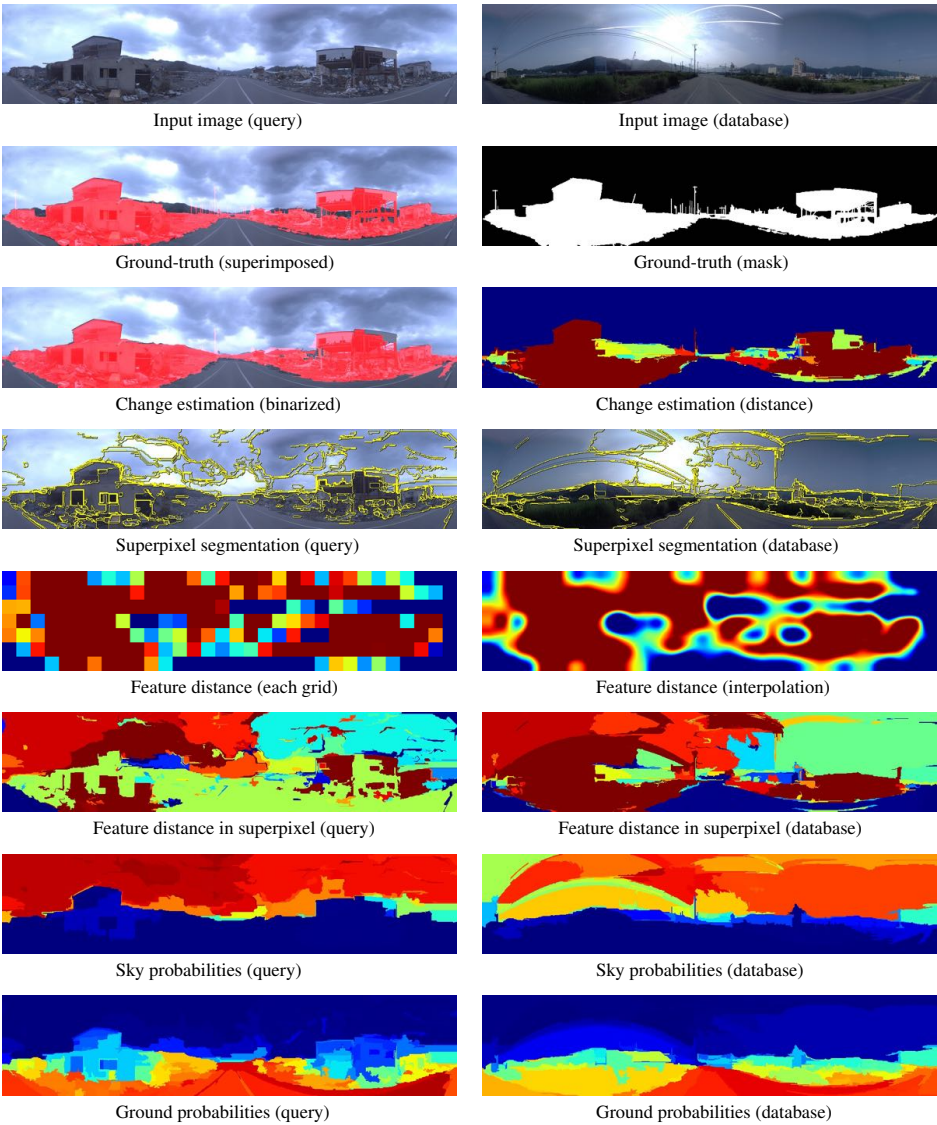


Figure 48: Results of change detection using pool-5 feature of CNN (Frame No. 48/100 in change detection dataset of tsunami)

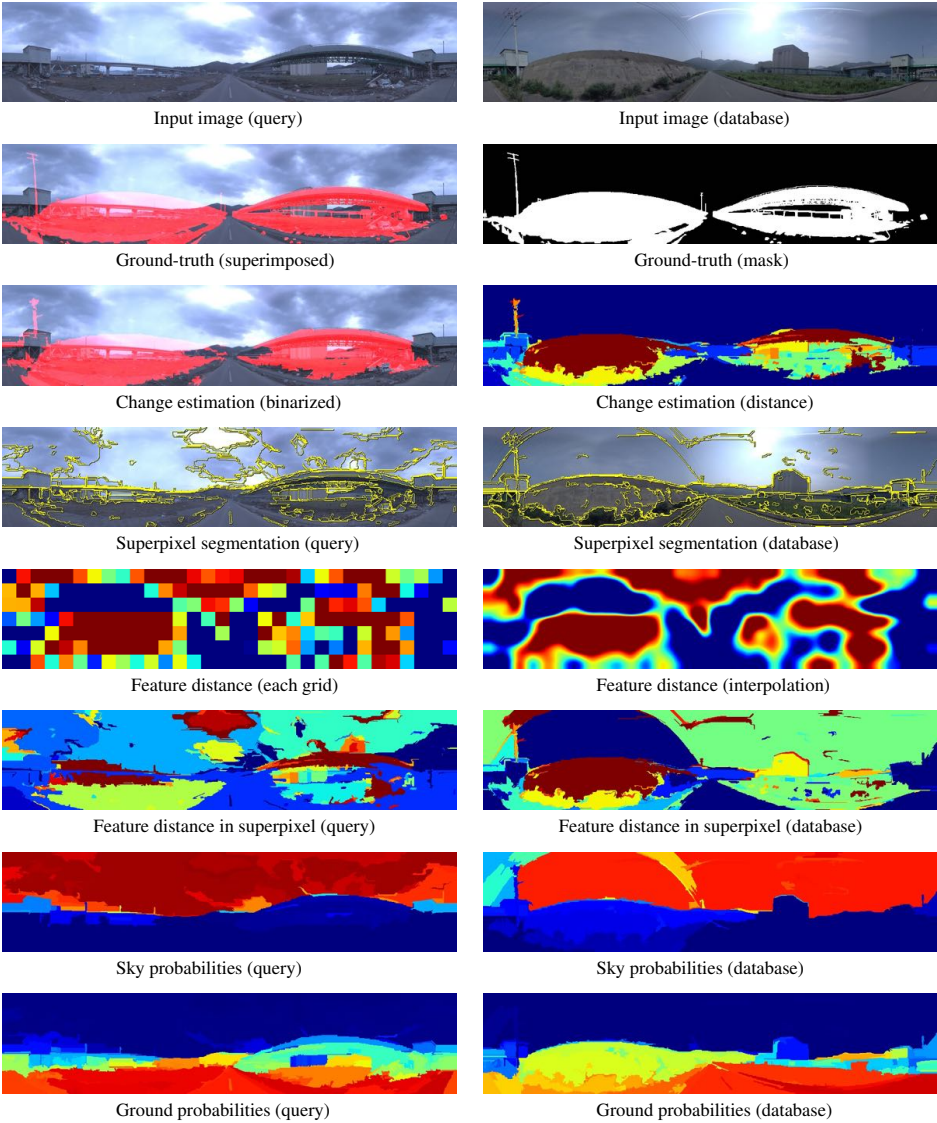


Figure 49: Results of change detection using pool-5 feature of CNN (Frame No. 49/100 in change detection dataset of tsunami)

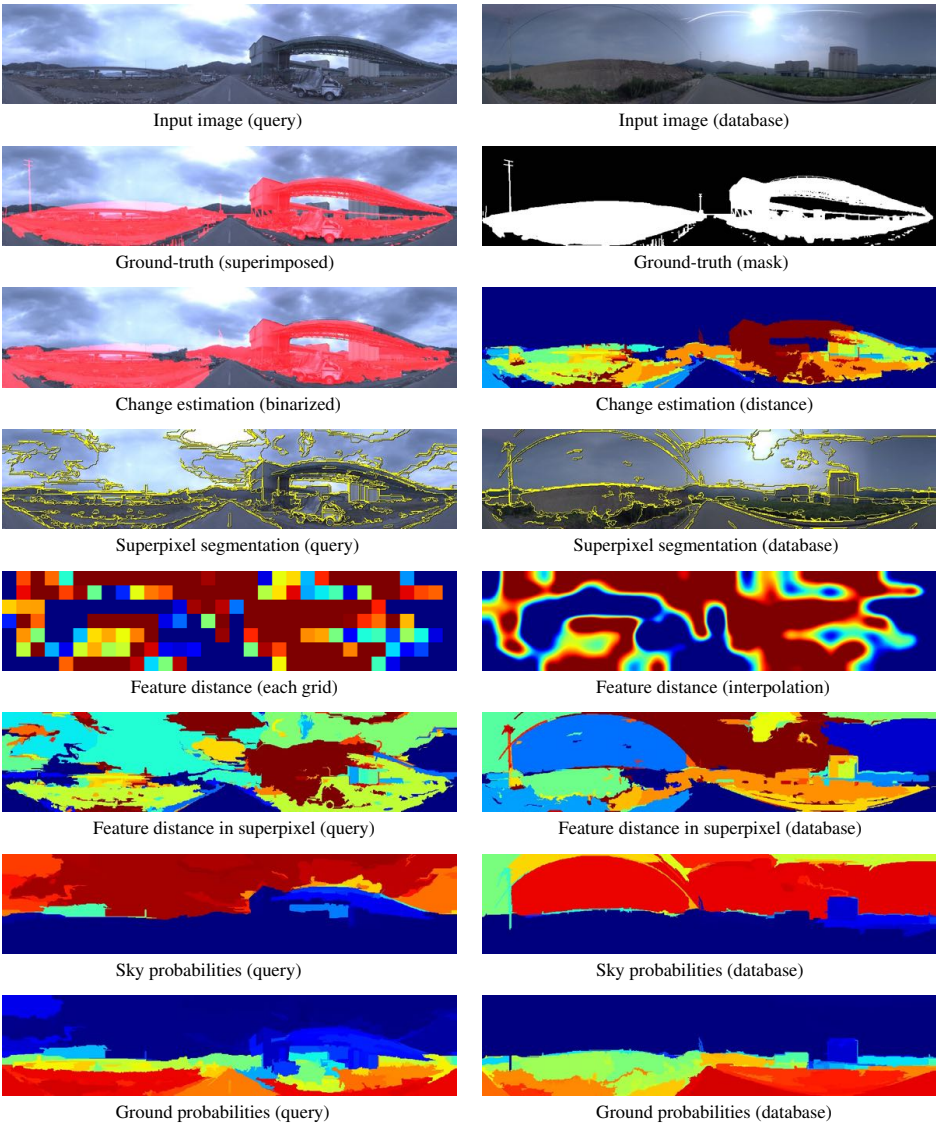


Figure 50: Results of change detection using pool-5 feature of CNN (Frame No. 50/100 in change detection dataset of tsunami)

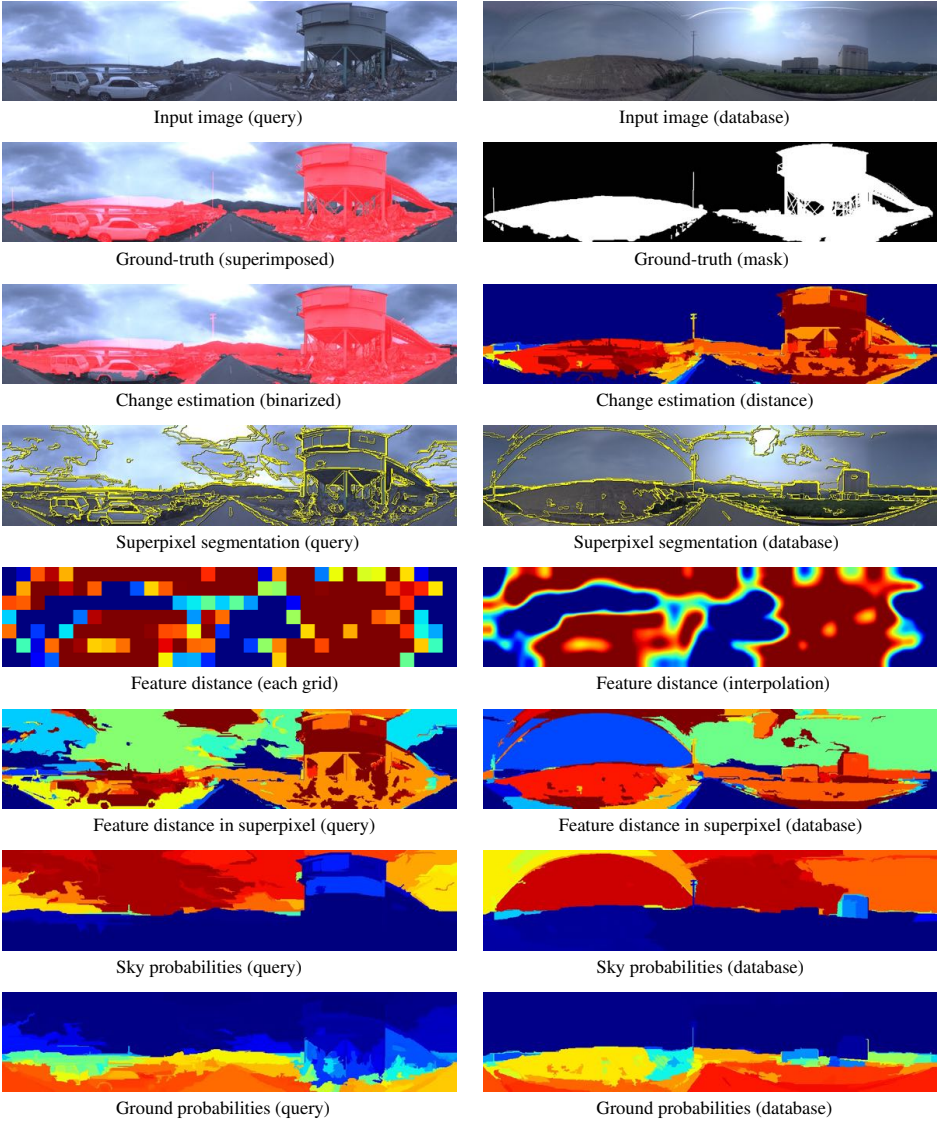


Figure 51: Results of change detection using pool-5 feature of CNN (Frame No. 51/100 in change detection dataset of tsunami)

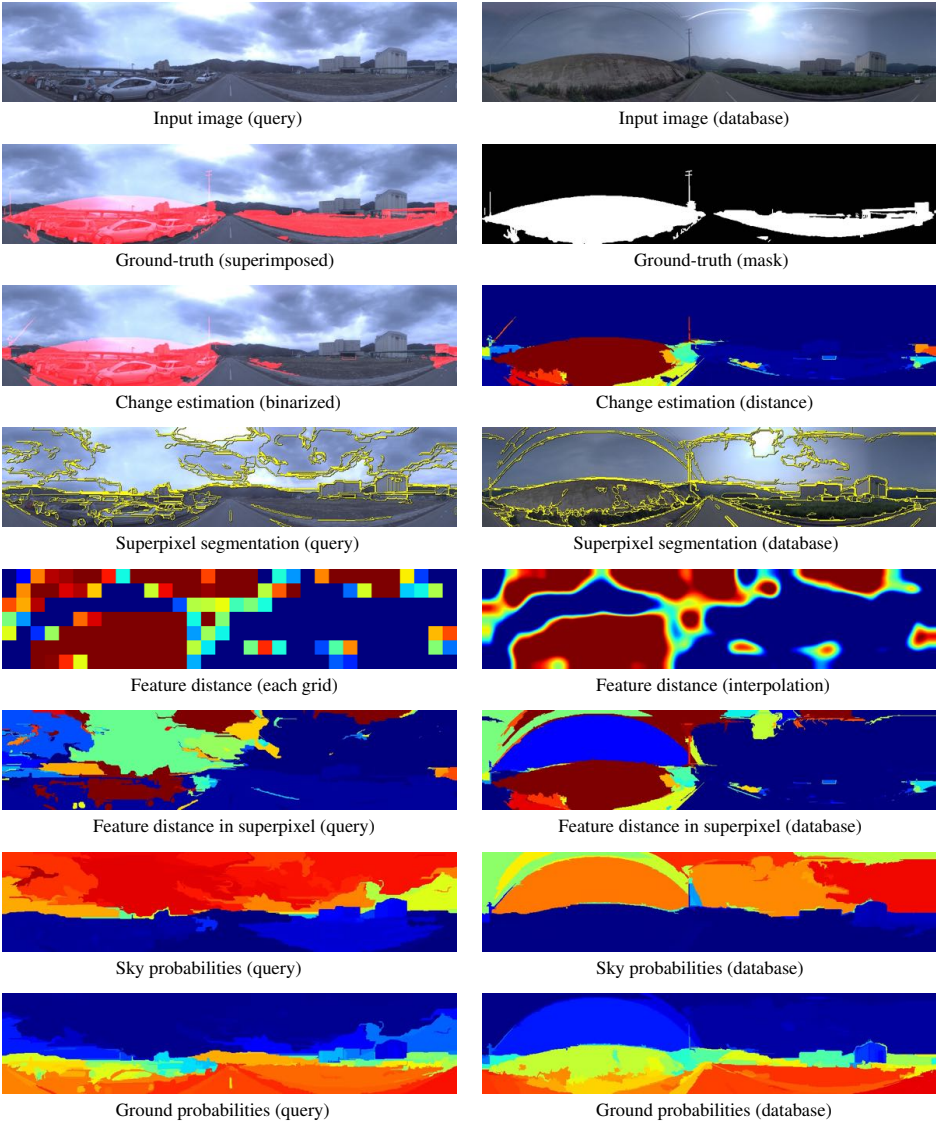


Figure 52: Results of change detection using pool-5 feature of CNN (Frame No. 52/100 in change detection dataset of tsunami)

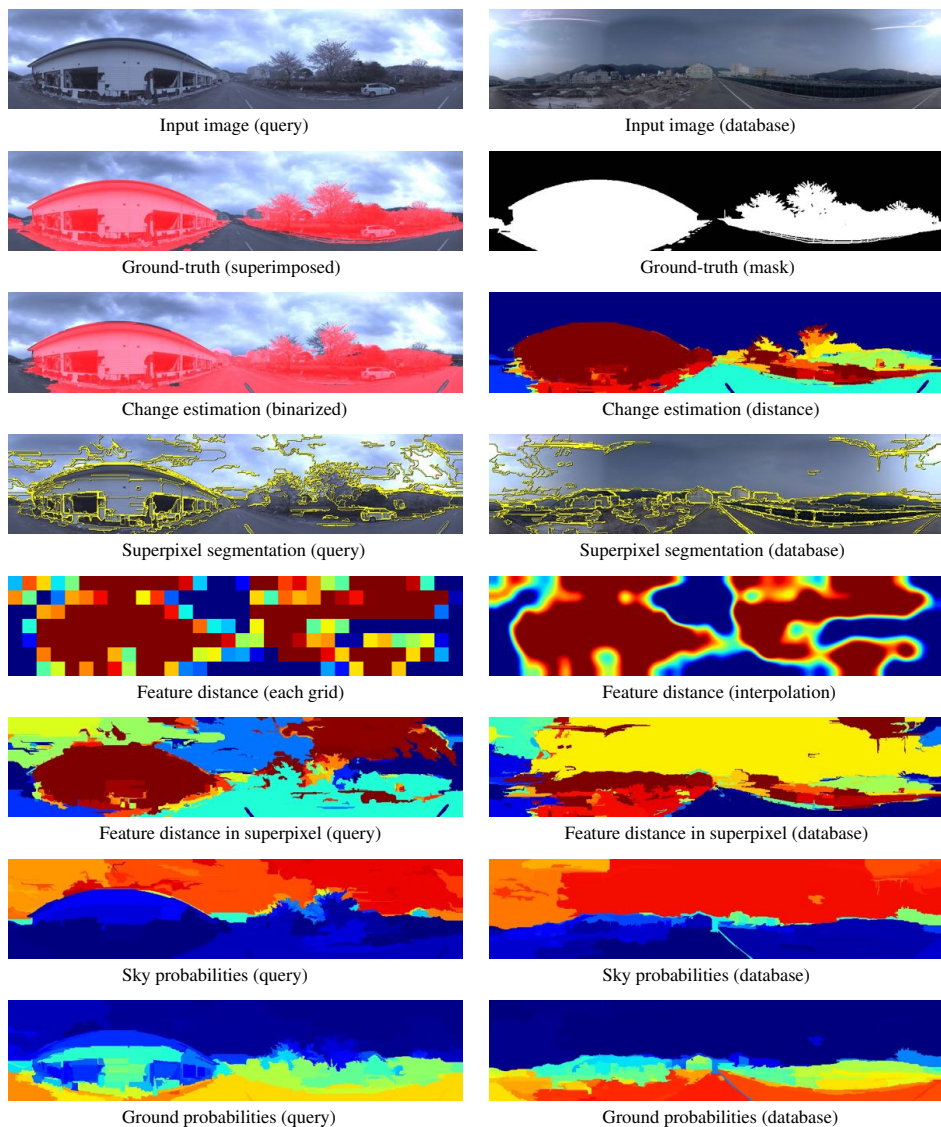


Figure 53: Results of change detection using pool-5 feature of CNN (Frame No. 53/100 in change detection dataset of tsunami)

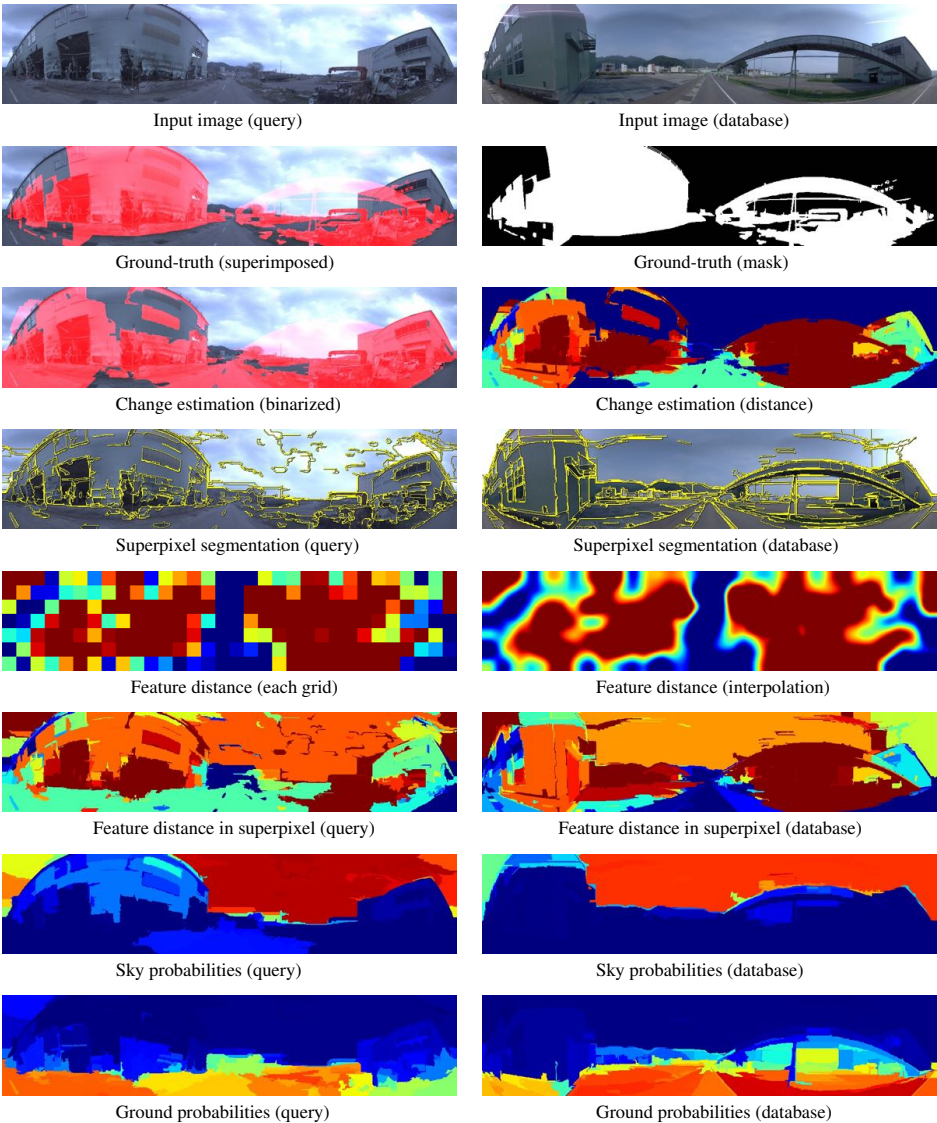


Figure 54: Results of change detection using pool-5 feature of CNN (Frame No. 54/100 in change detection dataset of tsunami)

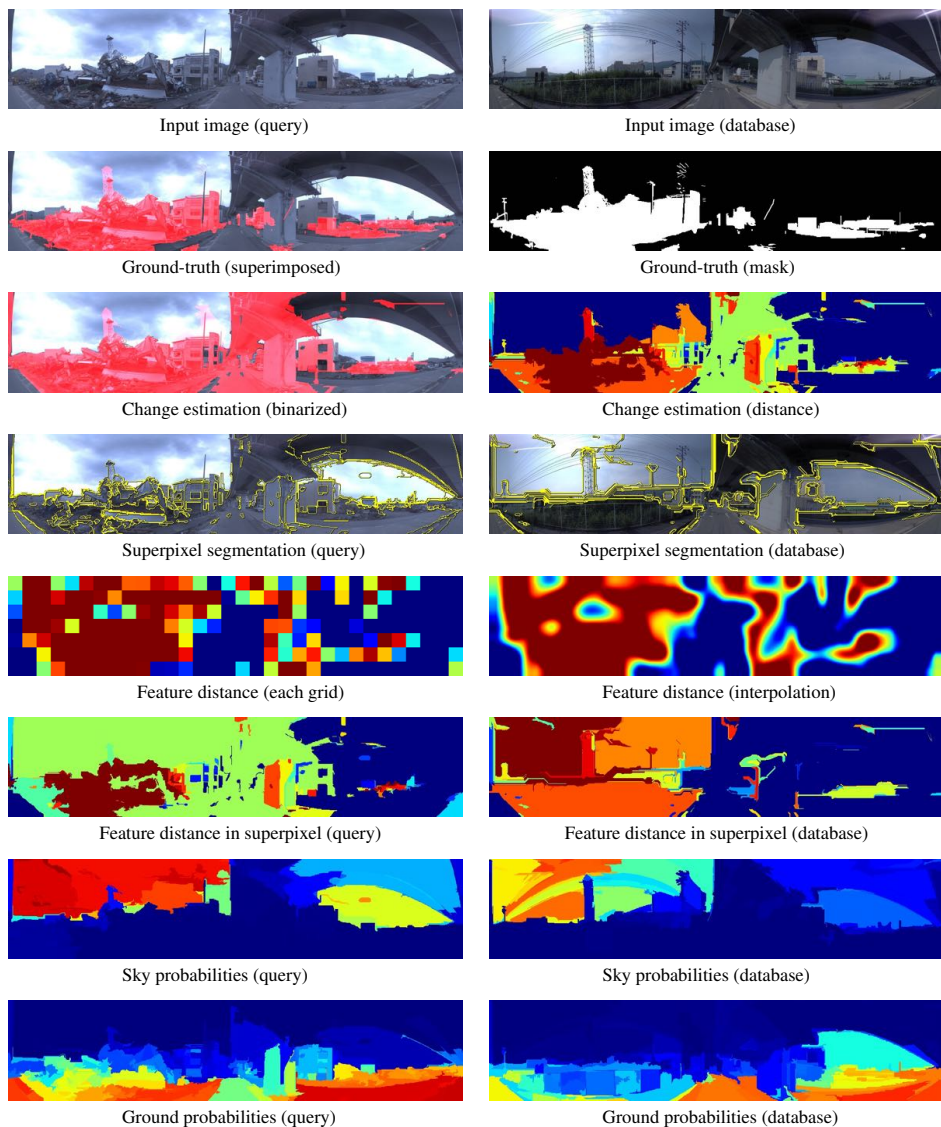


Figure 55: Results of change detection using pool-5 feature of CNN (Frame No. 55/100 in change detection dataset of tsunami)

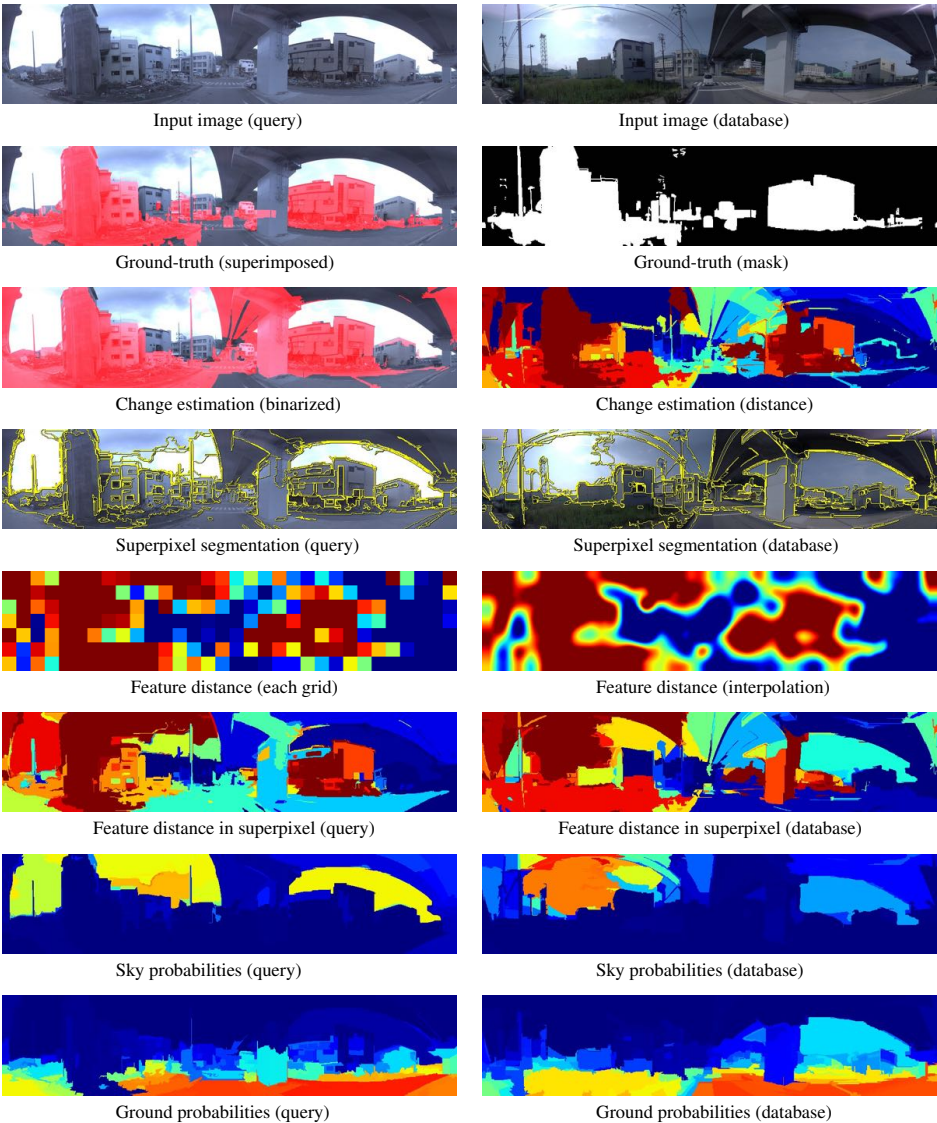


Figure 56: Results of change detection using pool-5 feature of CNN (Frame No. 56/100 in change detection dataset of tsunami)

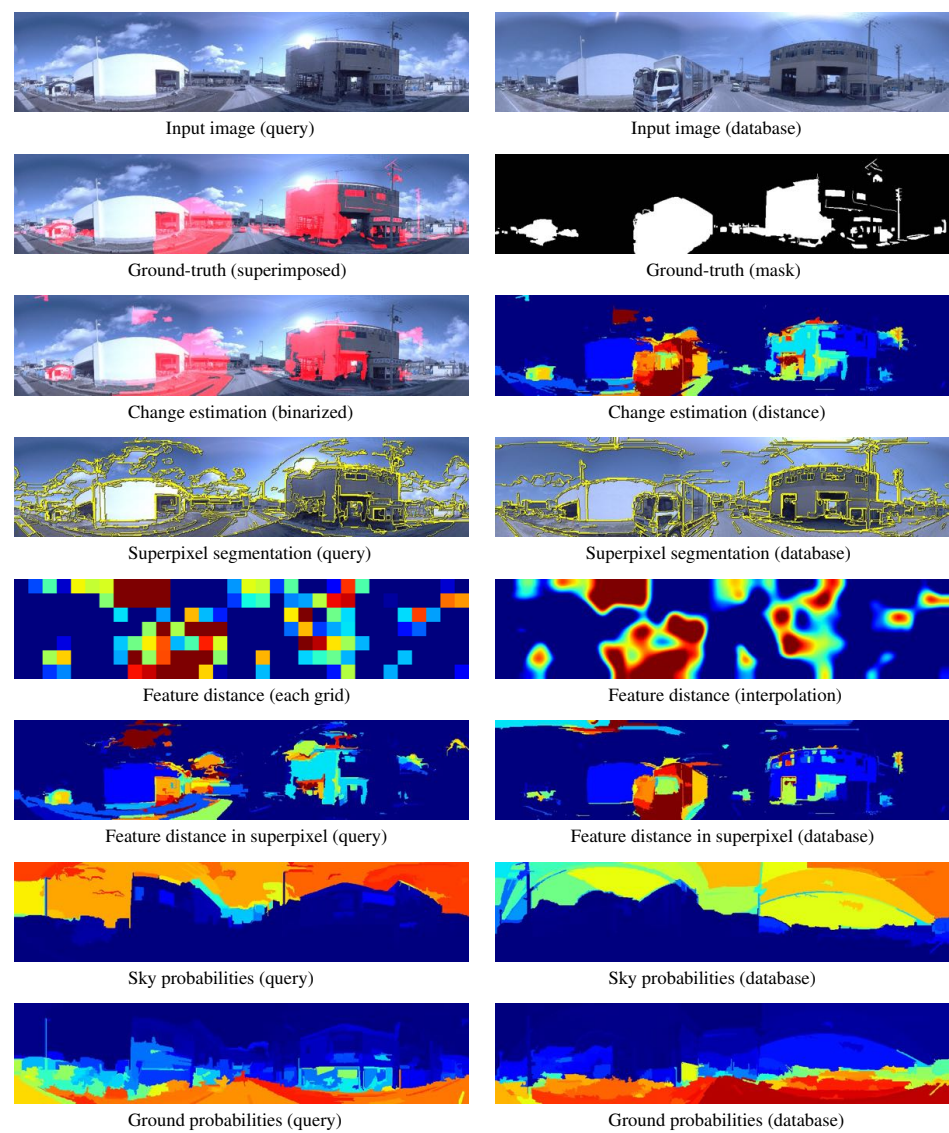


Figure 57: Results of change detection using pool-5 feature of CNN (Frame No. 57/100 in change detection dataset of tsunami)

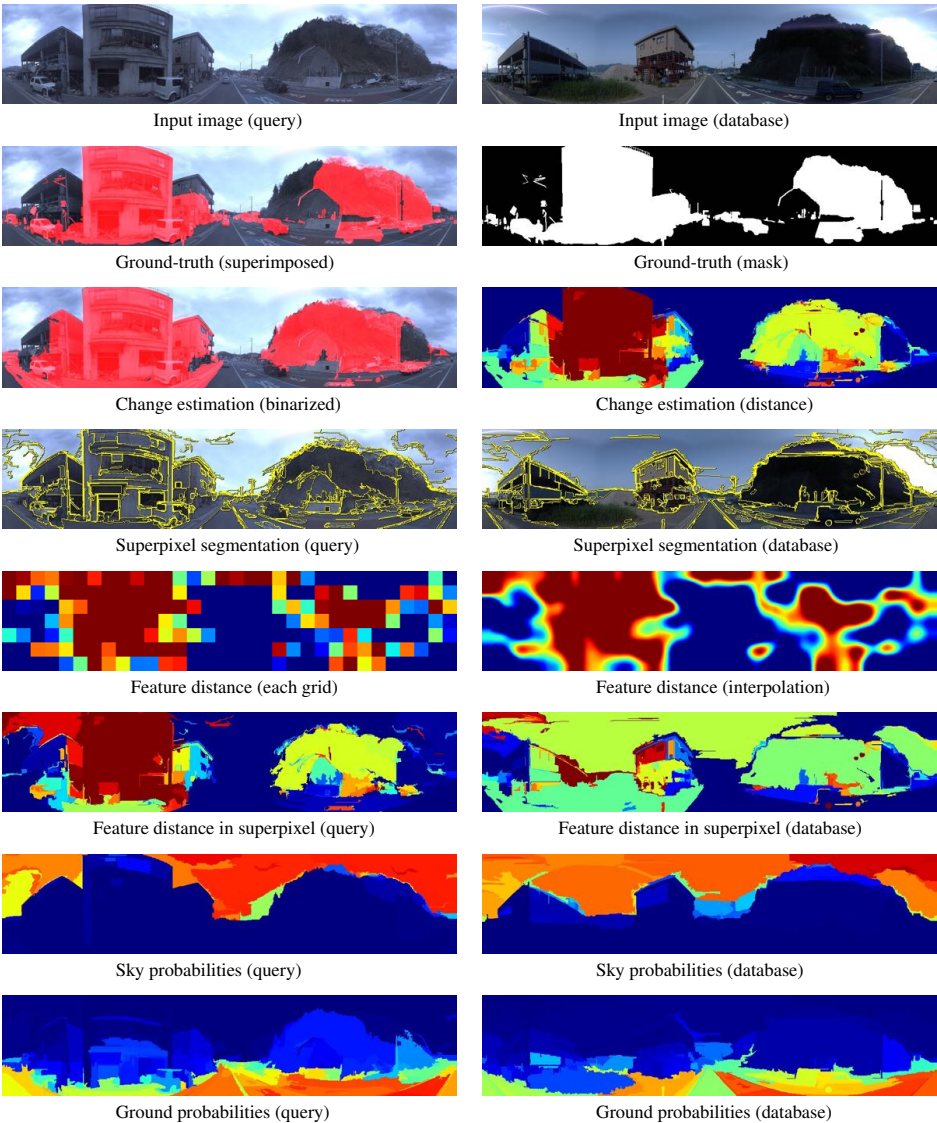


Figure 58: Results of change detection using pool-5 feature of CNN (Frame No. 58/100 in change detection dataset of tsunami)

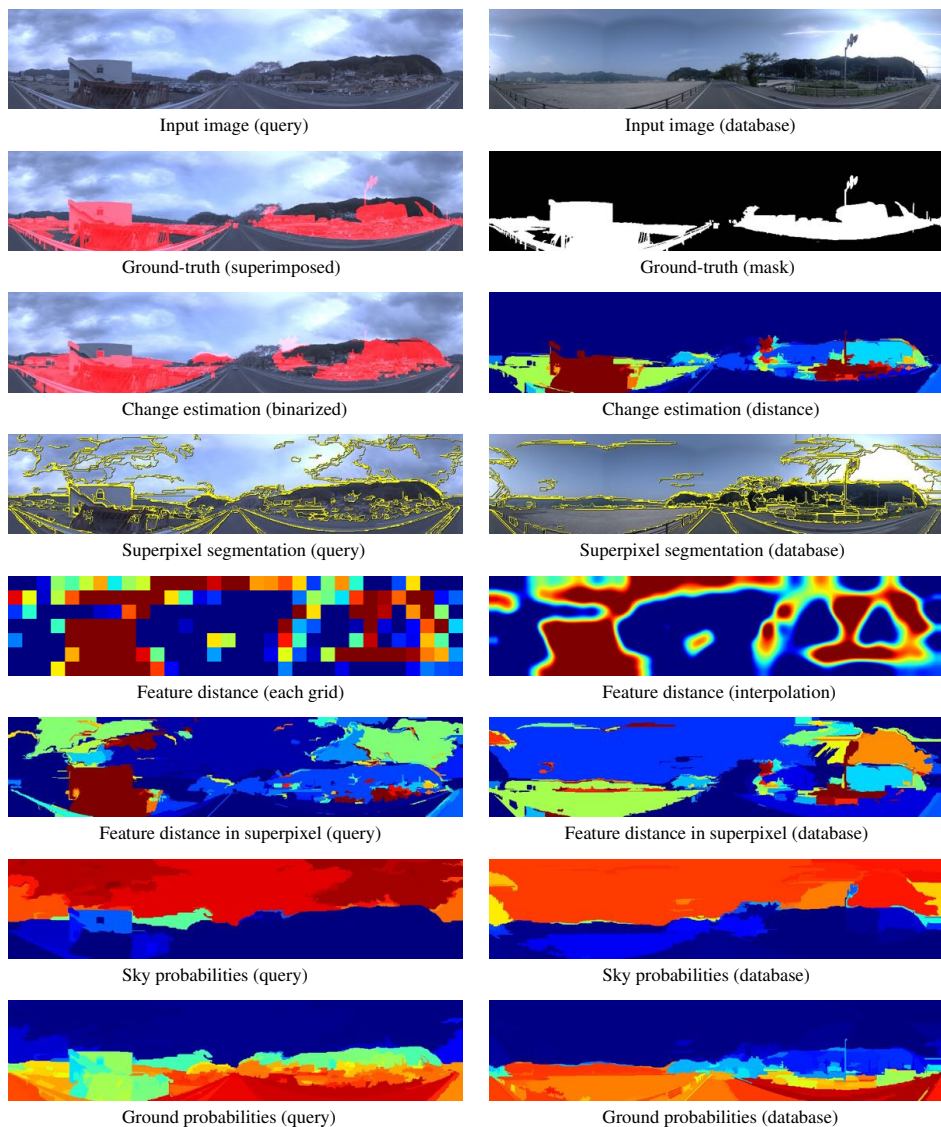


Figure 59: Results of change detection using pool-5 feature of CNN (Frame No. 59/100 in change detection dataset of tsunami)

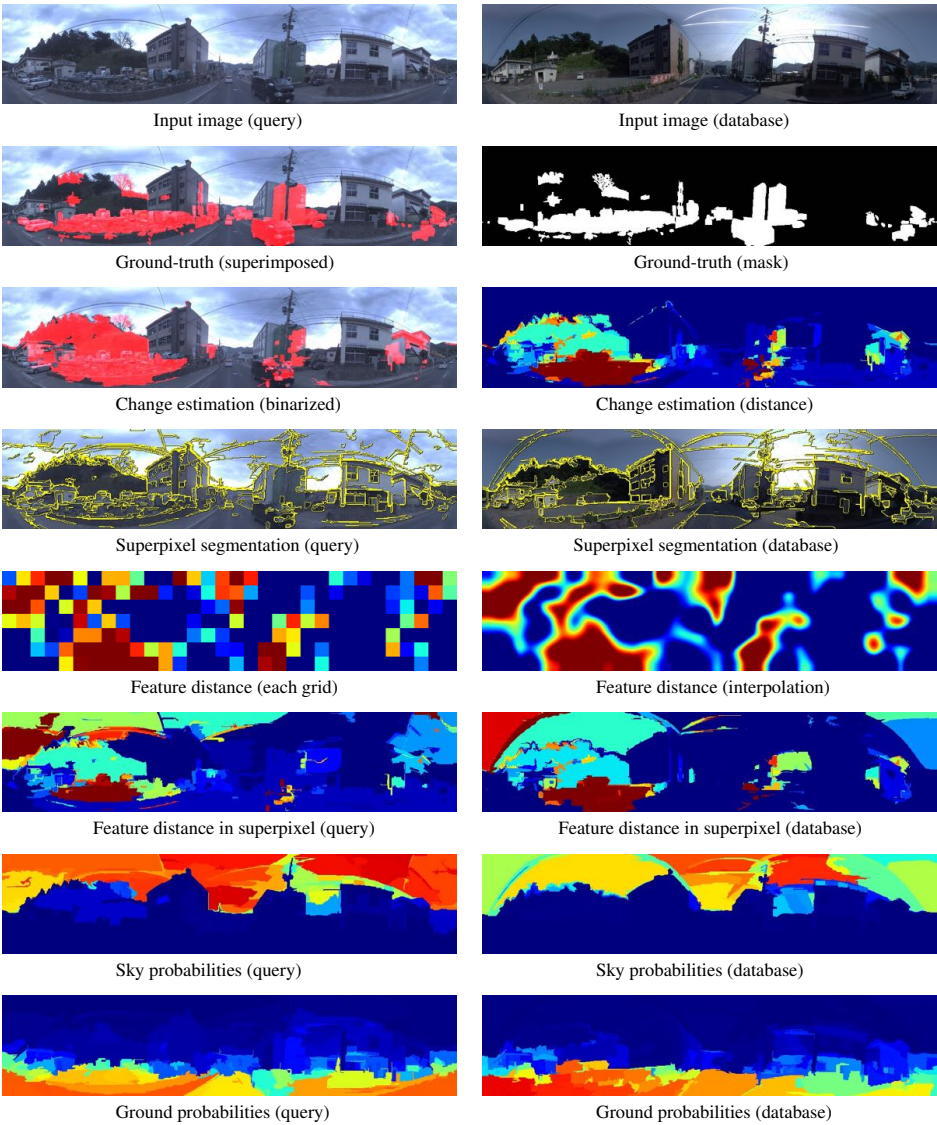


Figure 60: Results of change detection using pool-5 feature of CNN (Frame No. 60/100 in change detection dataset of tsunami)

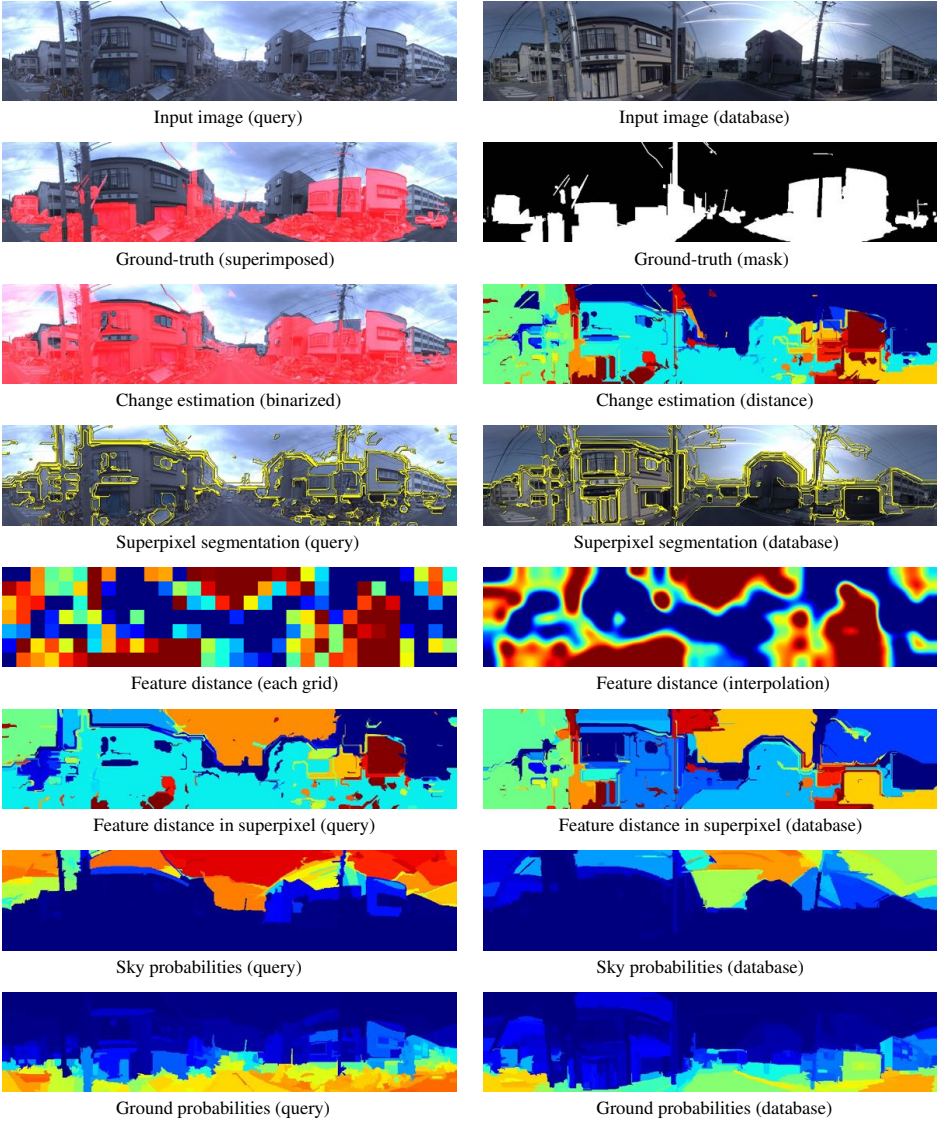


Figure 61: Results of change detection using pool-5 feature of CNN (Frame No. 61/100 in change detection dataset of tsunami)

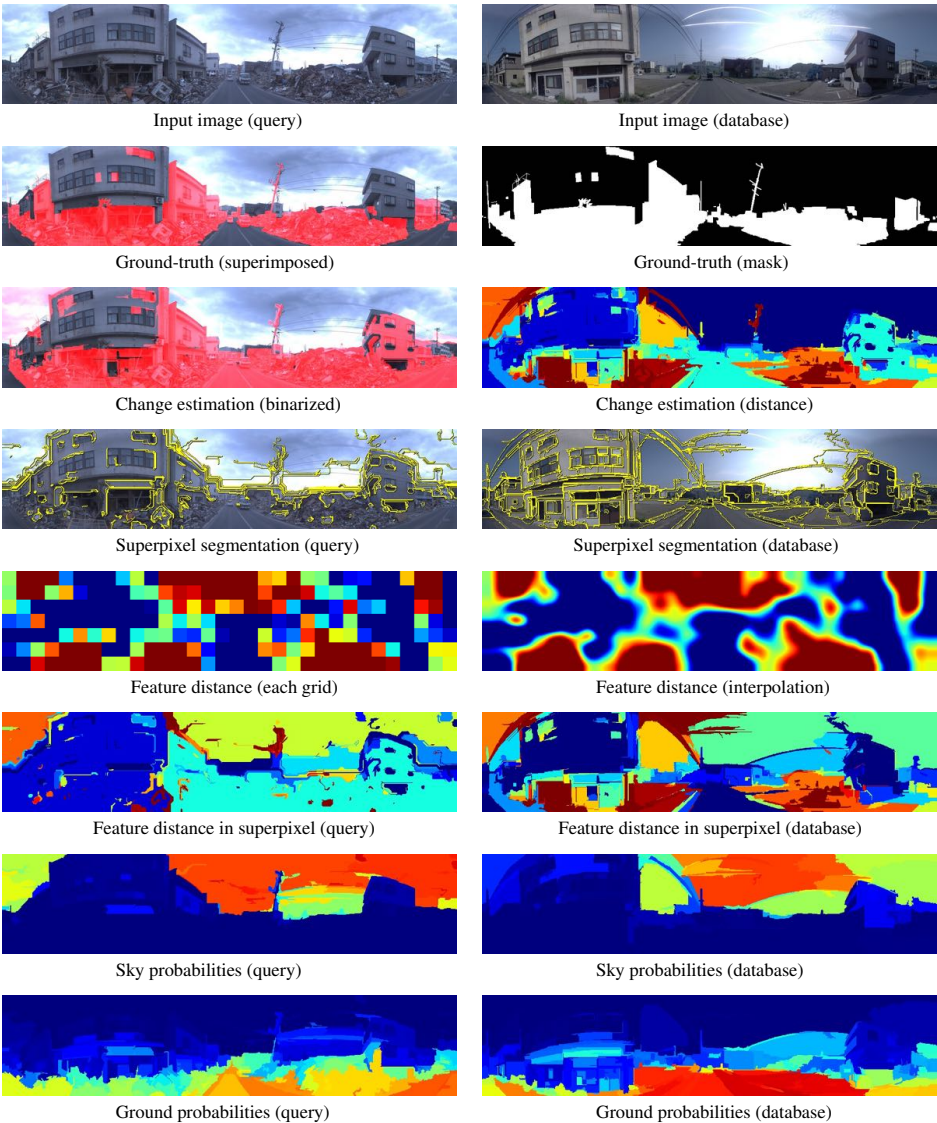


Figure 62: Results of change detection using pool-5 feature of CNN (Frame No. 62/100 in change detection dataset of tsunami)

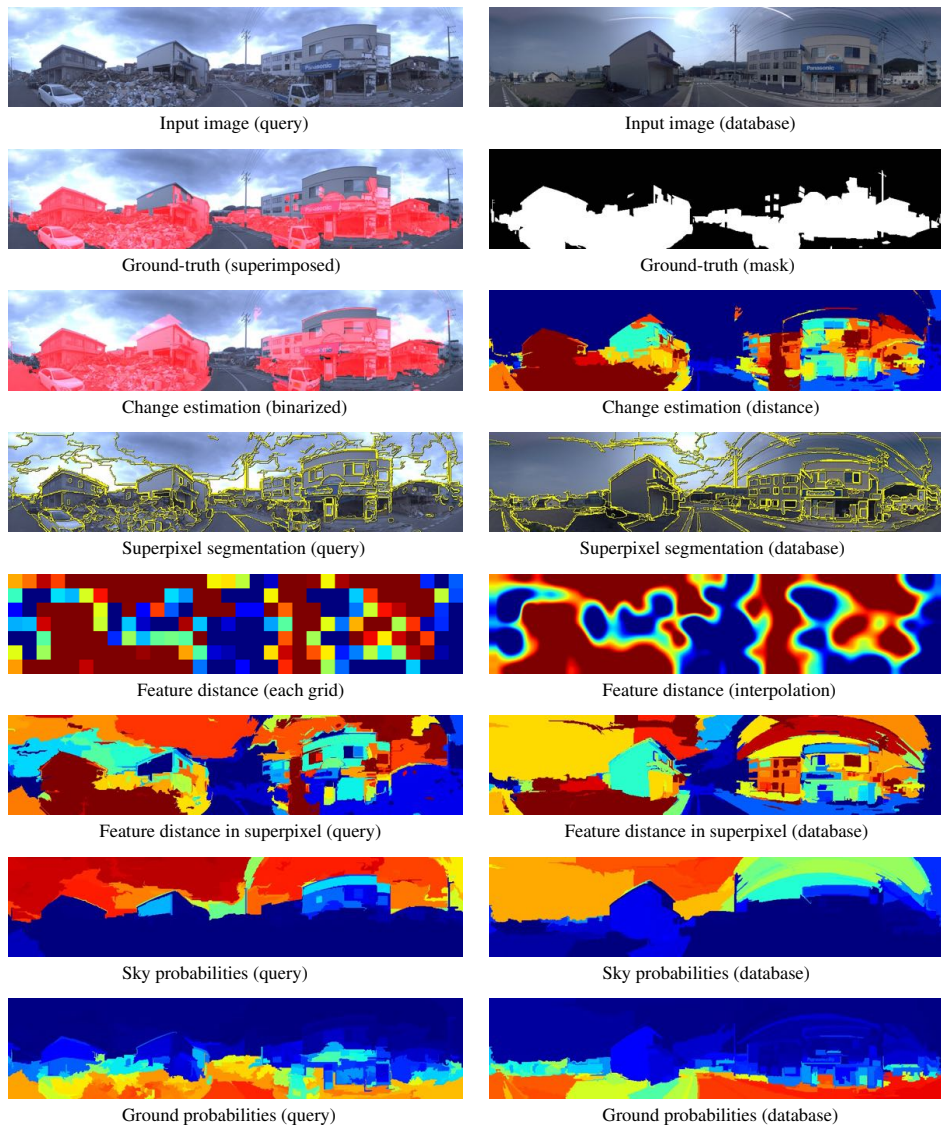


Figure 63: Results of change detection using pool-5 feature of CNN (Frame No. 63/100 in change detection dataset of tsunami)

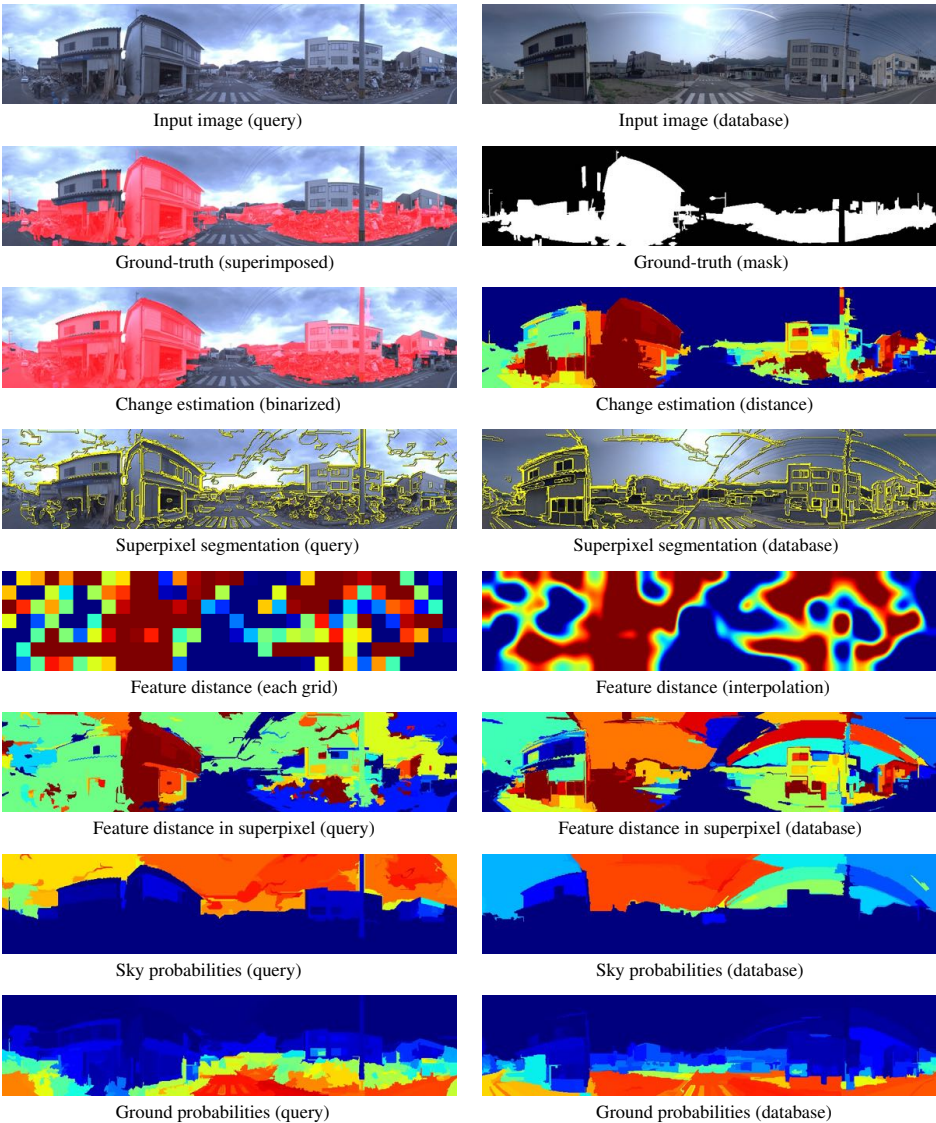


Figure 64: Results of change detection using pool-5 feature of CNN (Frame No. 64/100 in change detection dataset of tsunami)

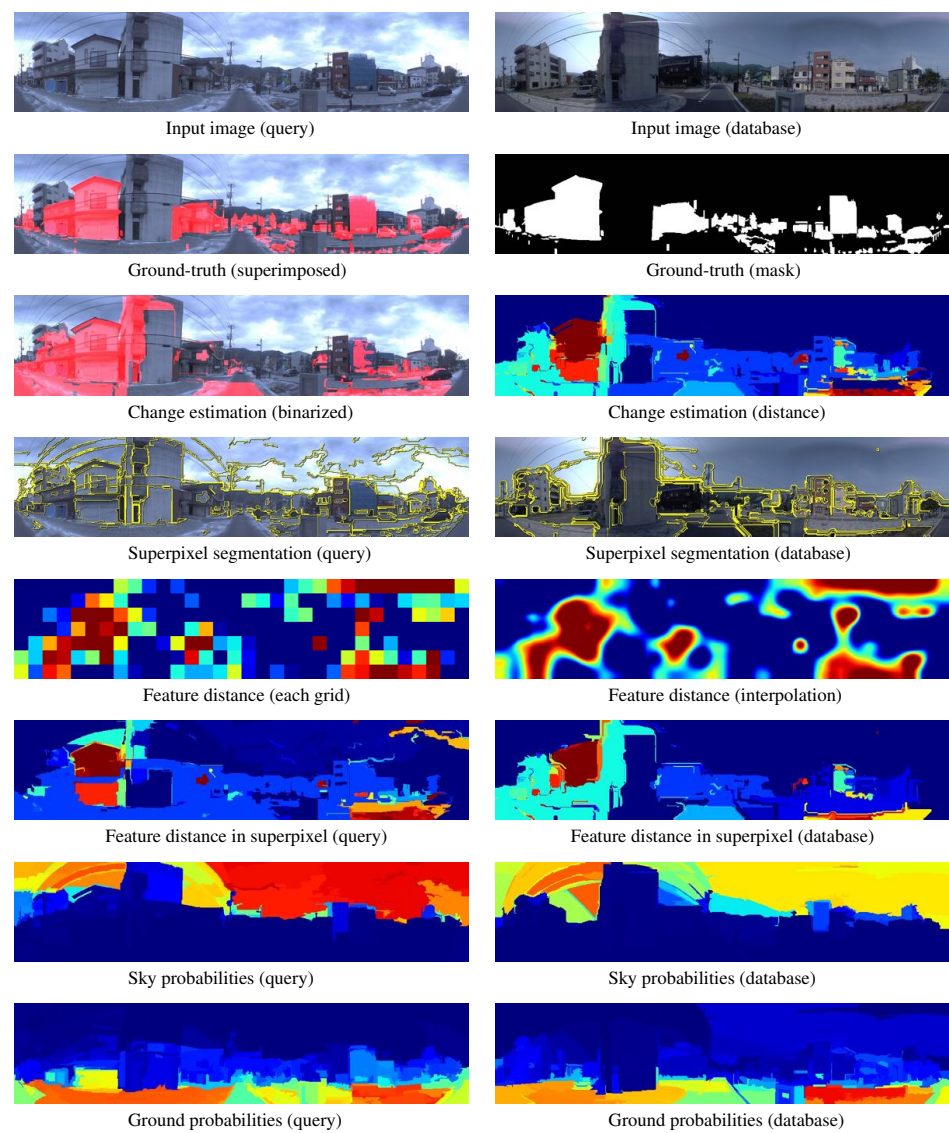


Figure 65: Results of change detection using pool-5 feature of CNN (Frame No. 65/100 in change detection dataset of tsunami)

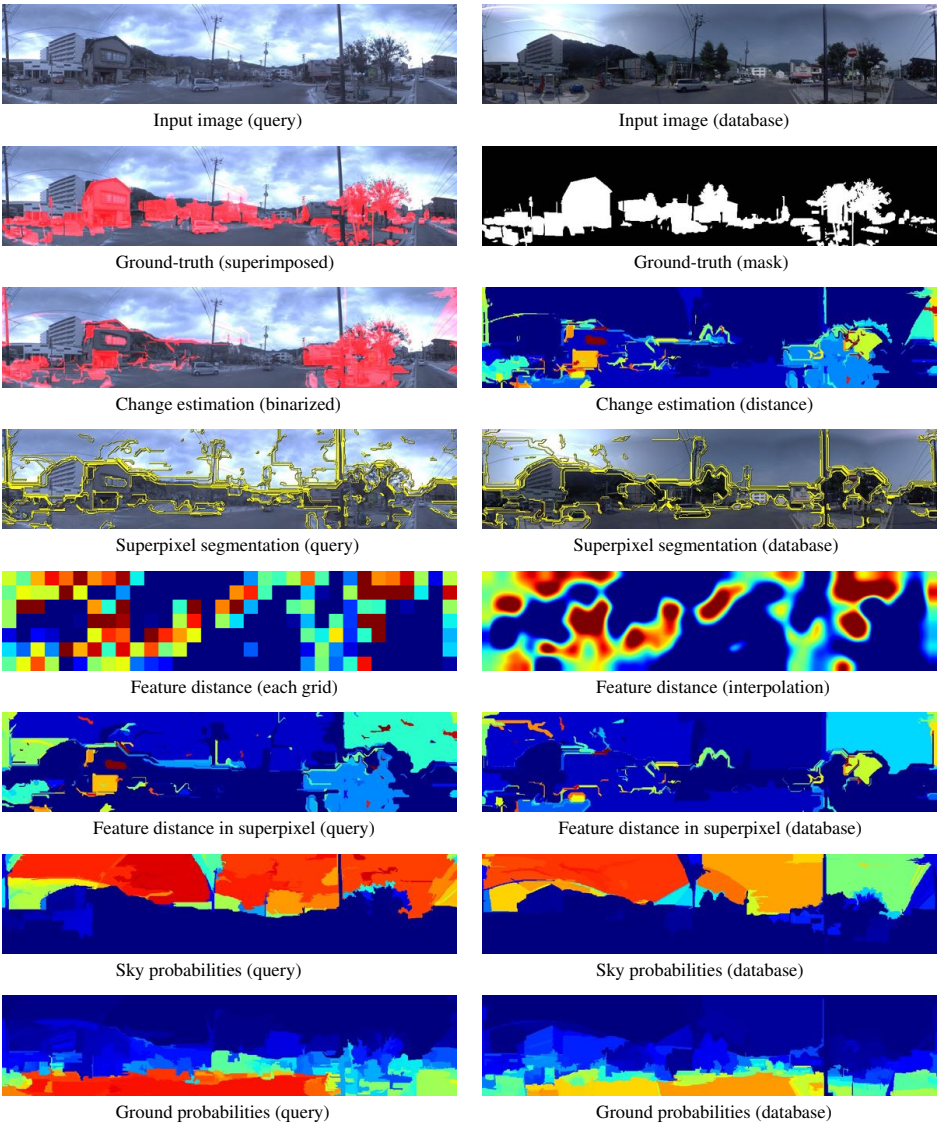


Figure 66: Results of change detection using pool-5 feature of CNN (Frame No. 66/100 in change detection dataset of tsunami)

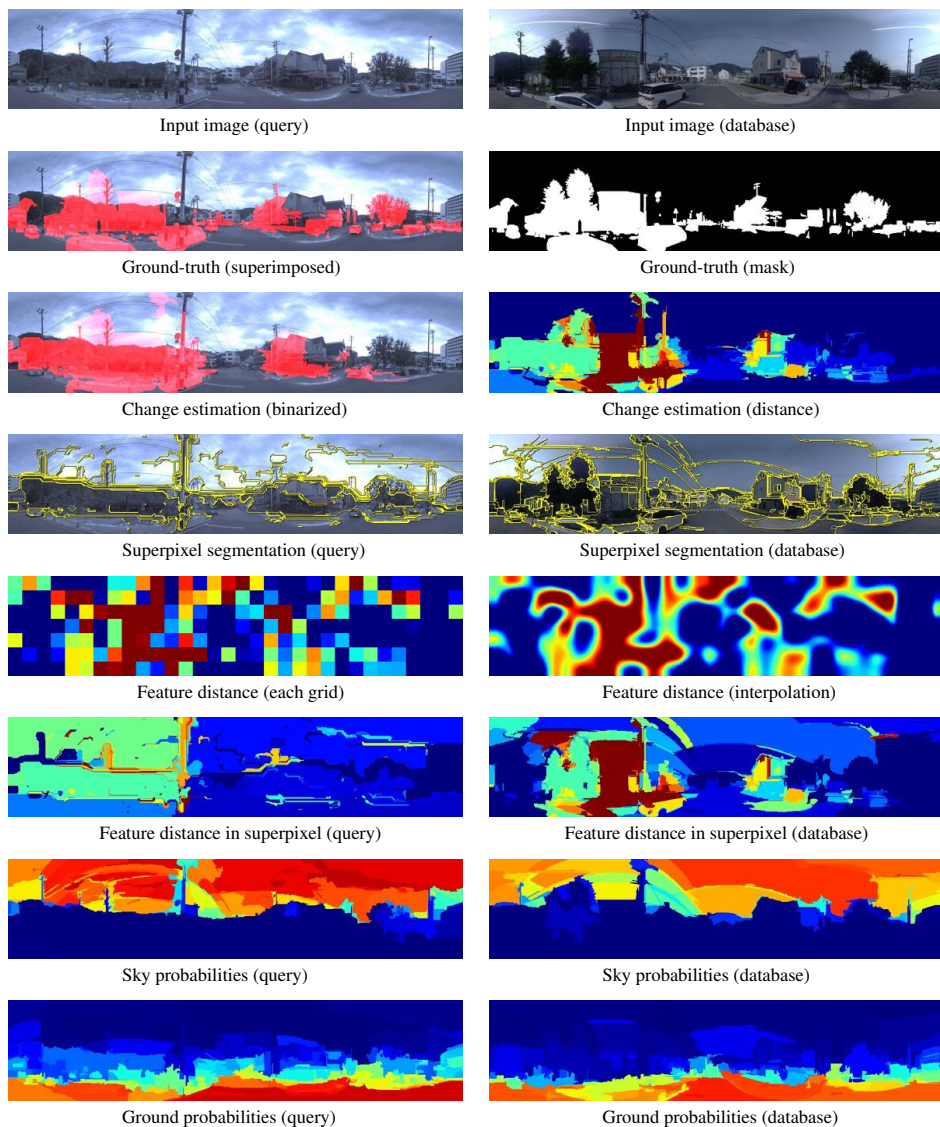


Figure 67: Results of change detection using pool-5 feature of CNN (Frame No. 67/100 in change detection dataset of tsunami)

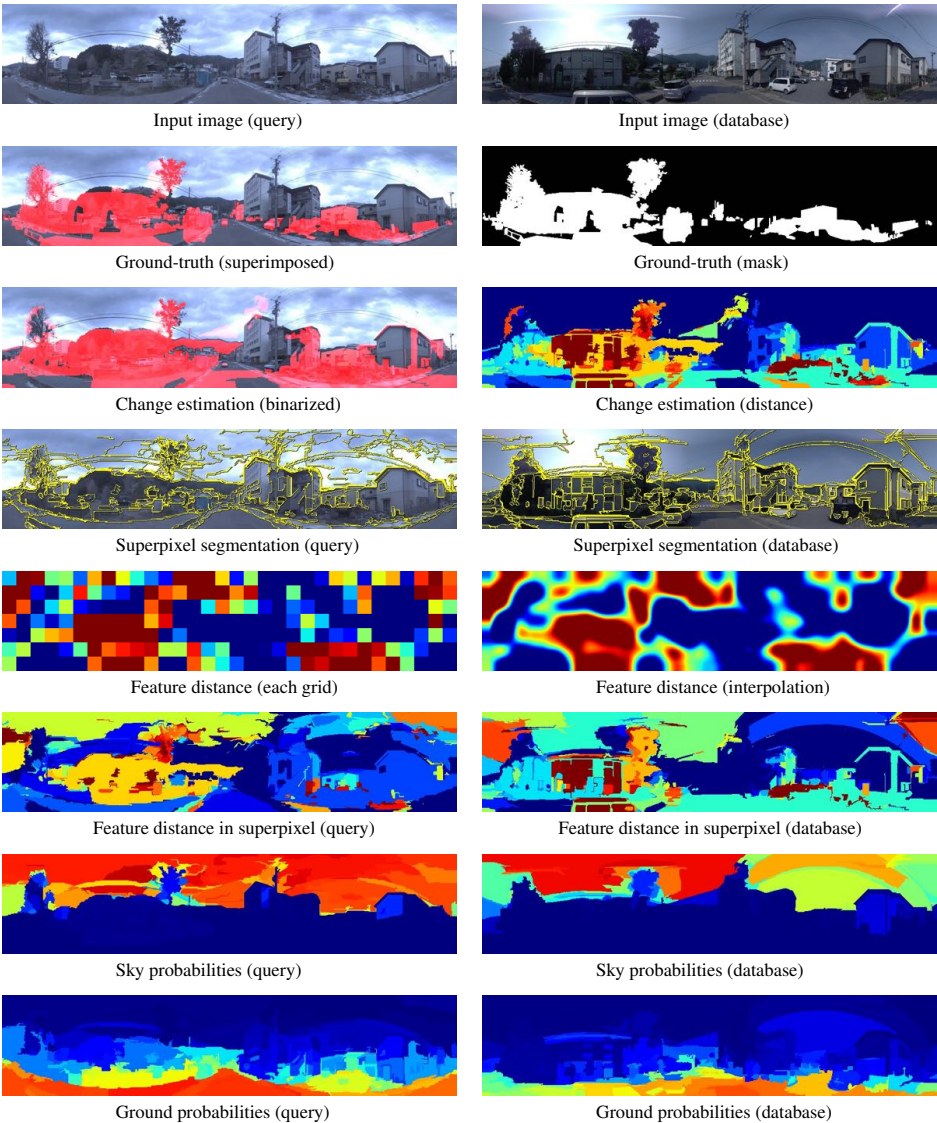


Figure 68: Results of change detection using pool-5 feature of CNN (Frame No. 68/100 in change detection dataset of tsunami)



Input image (query)



Input image (database)



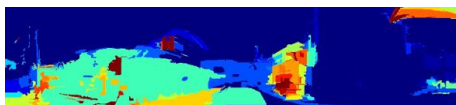
Ground-truth (superimposed)



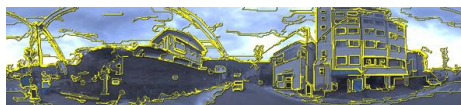
Ground-truth (mask)



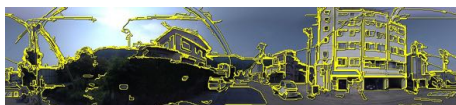
Change estimation (binarized)



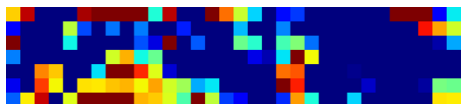
Change estimation (distance)



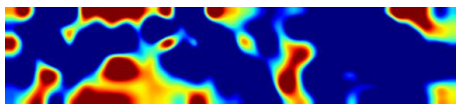
Superpixel segmentation (query)



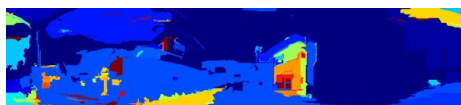
Superpixel segmentation (database)



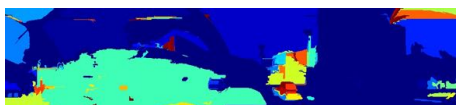
Feature distance (each grid)



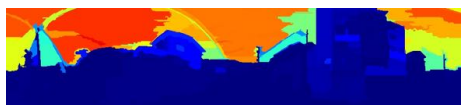
Feature distance (interpolation)



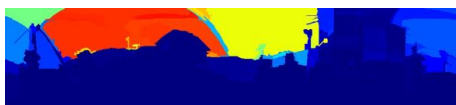
Feature distance in superpixel (query)



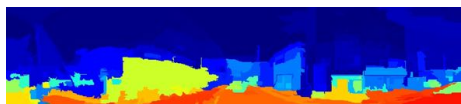
Feature distance in superpixel (database)



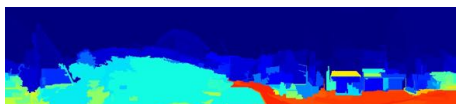
Sky probabilities (query)



Sky probabilities (database)



Ground probabilities (query)



Ground probabilities (database)

Figure 69: Results of change detection using pool-5 feature of CNN (Frame No. 69/100 in change detection dataset of tsunami)

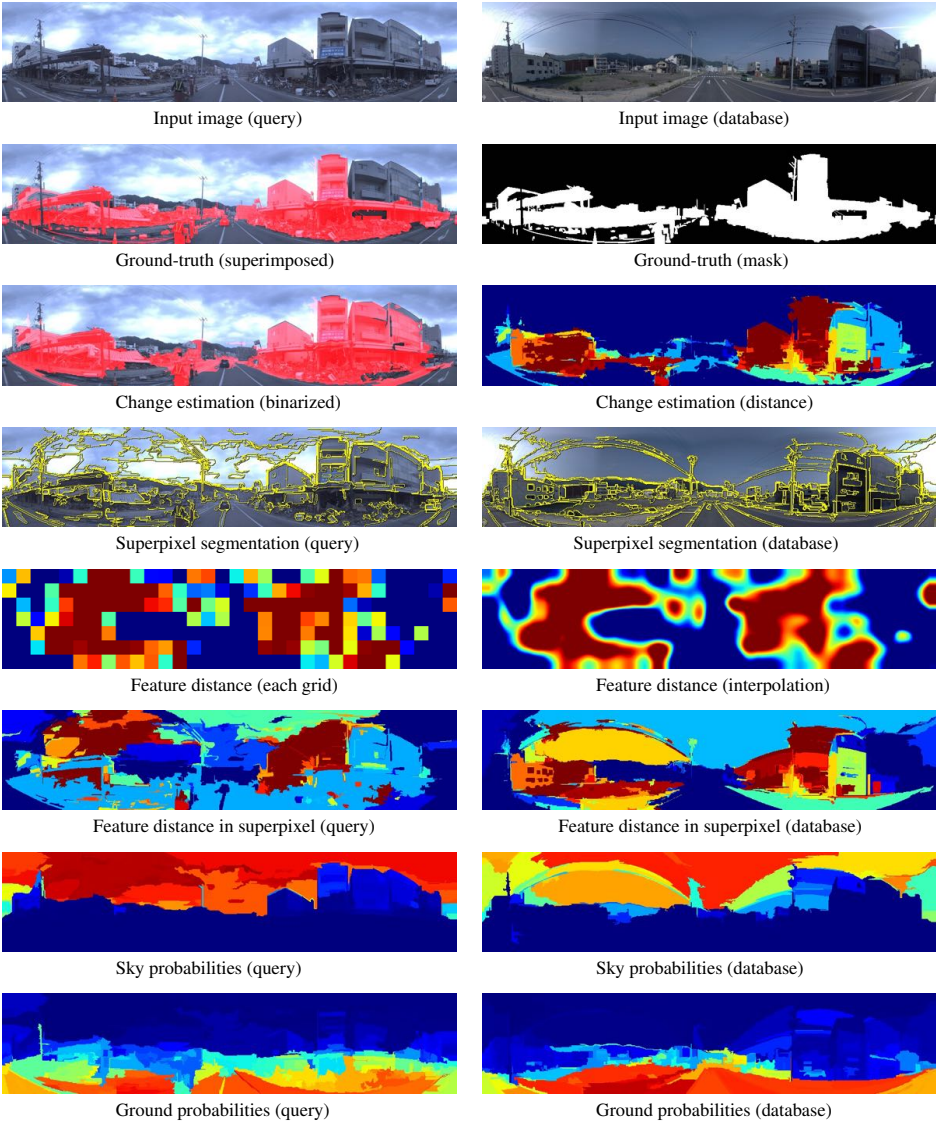


Figure 70: Results of change detection using pool-5 feature of CNN (Frame No. 70/100 in change detection dataset of tsunami)

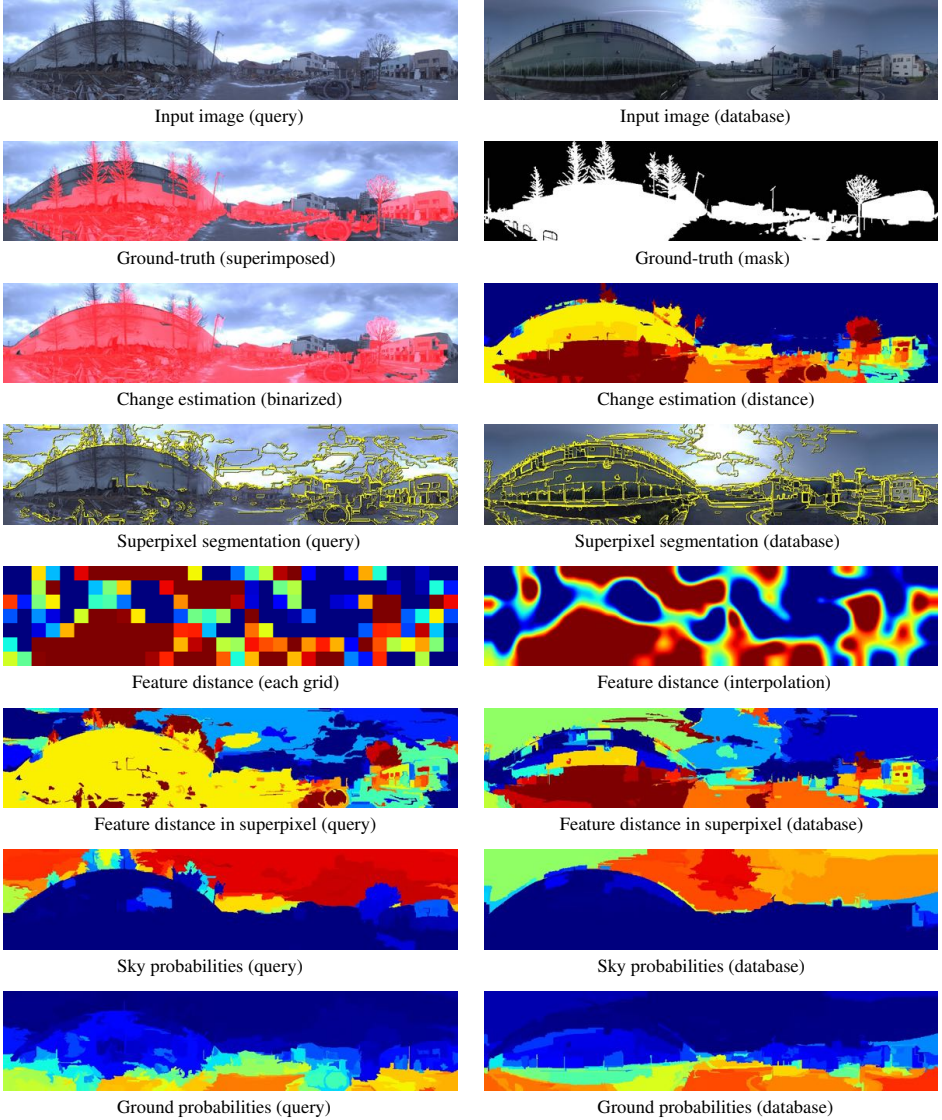


Figure 71: Results of change detection using pool-5 feature of CNN (Frame No. 71/100 in change detection dataset of tsunami)

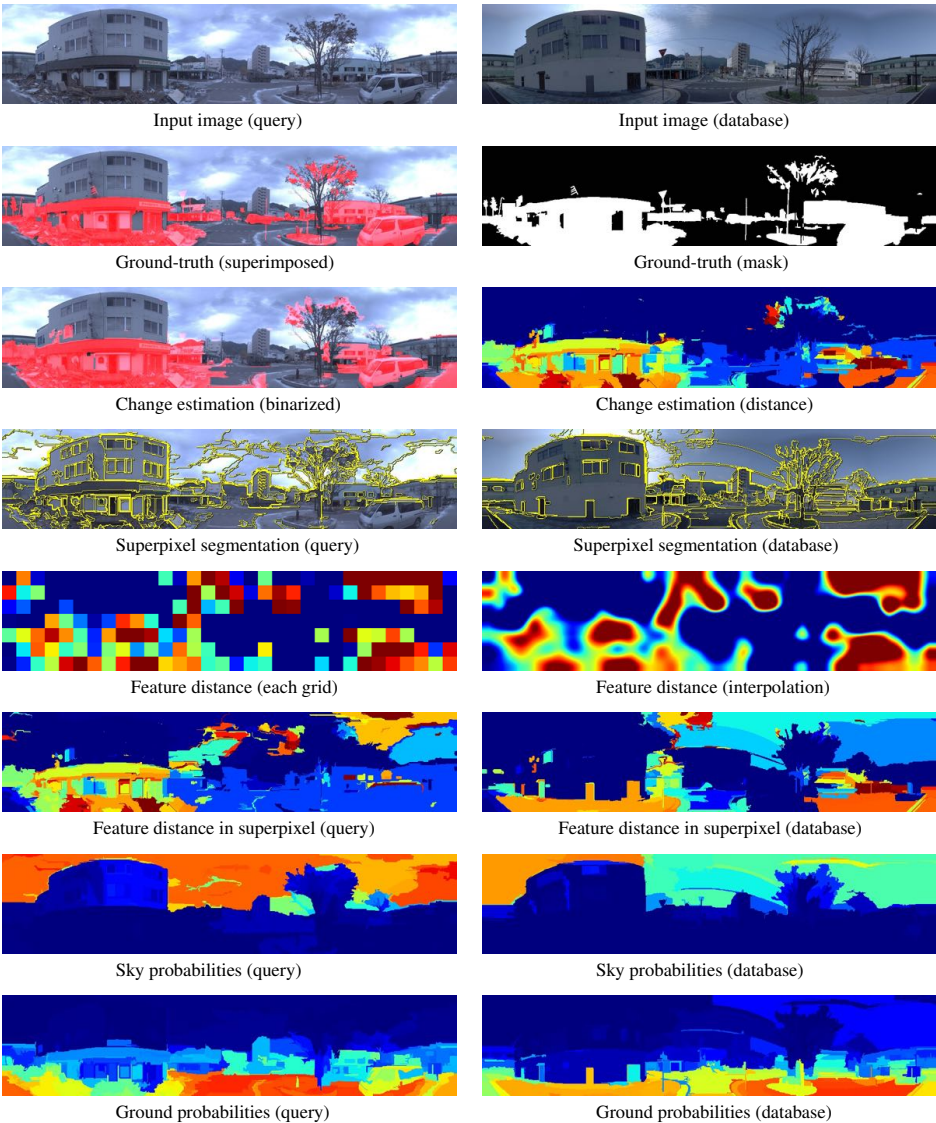


Figure 72: Results of change detection using pool-5 feature of CNN (Frame No. 72/100 in change detection dataset of tsunami)

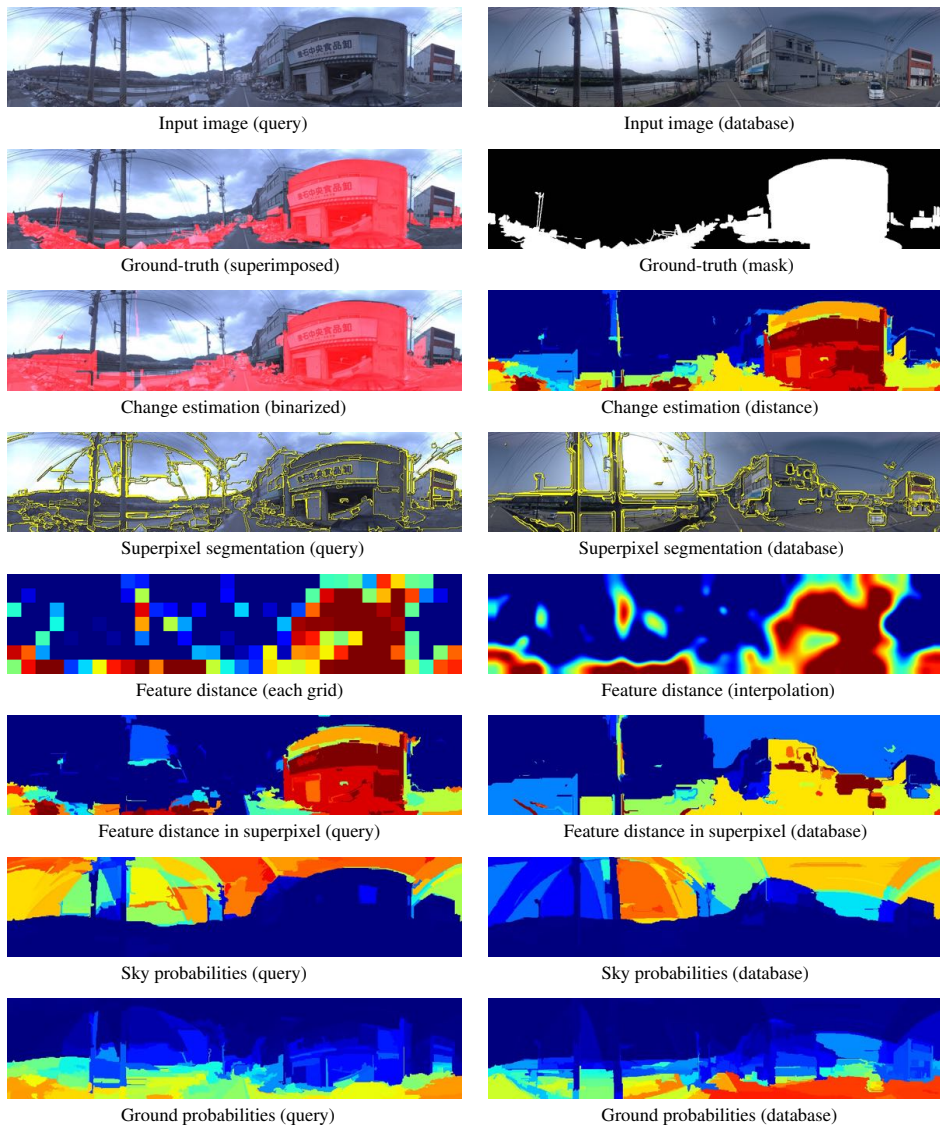


Figure 73: Results of change detection using pool-5 feature of CNN (Frame No. 73/100 in change detection dataset of tsunami)

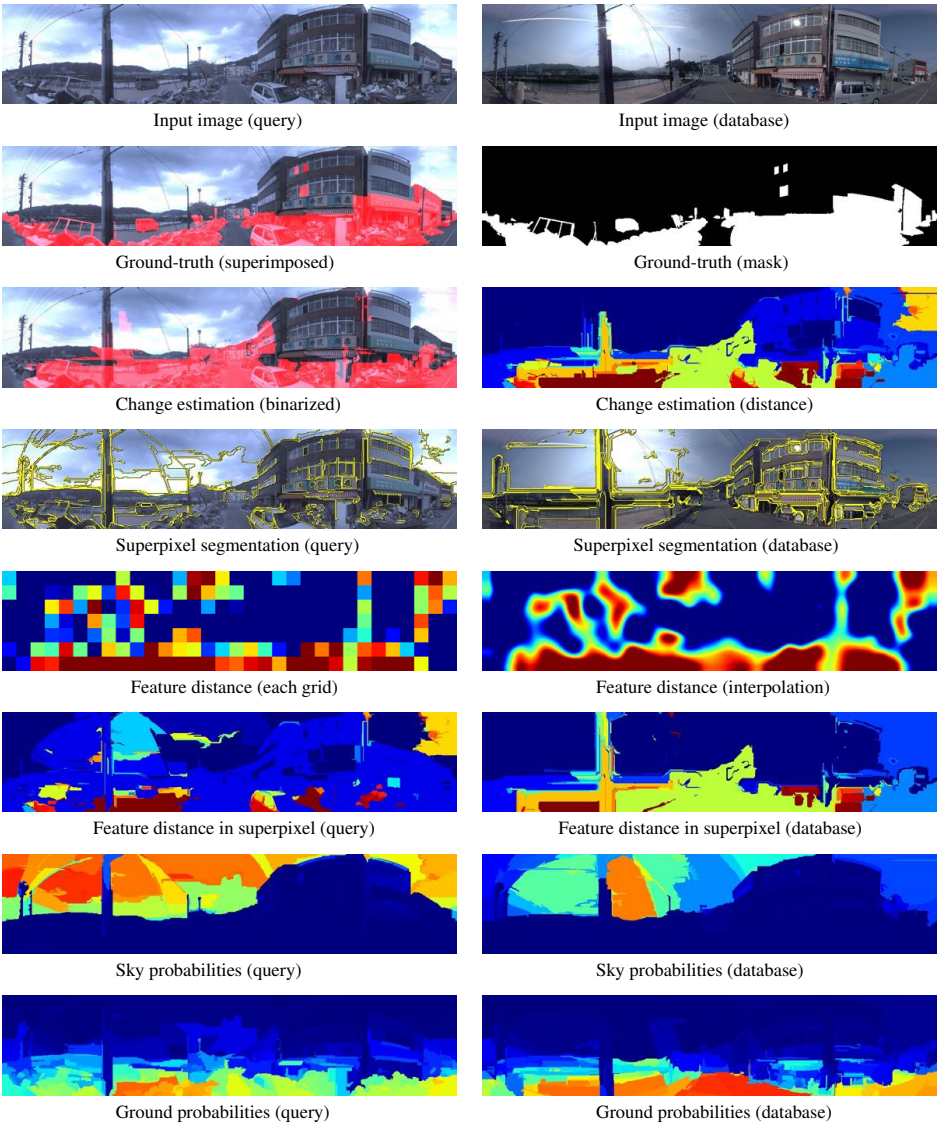


Figure 74: Results of change detection using pool-5 feature of CNN (Frame No. 74/100 in change detection dataset of tsunami)

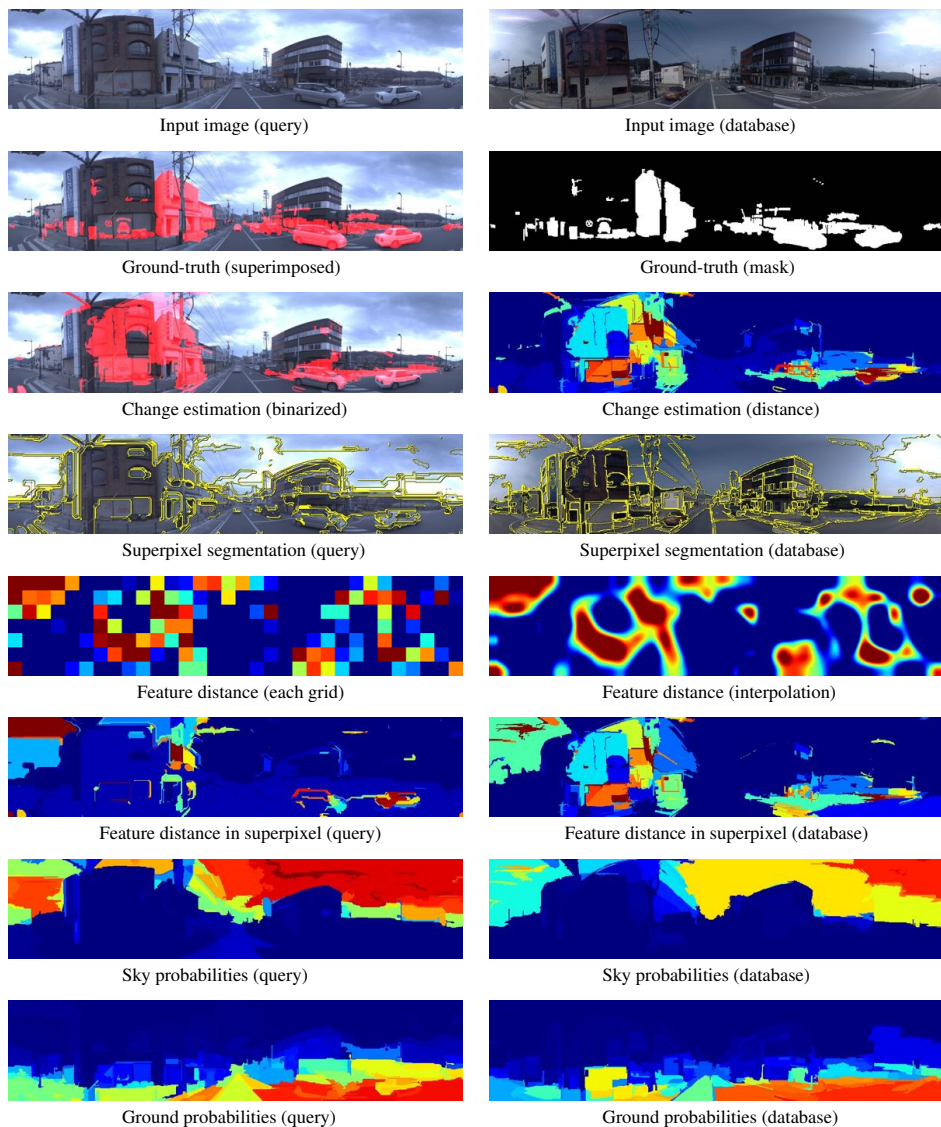


Figure 75: Results of change detection using pool-5 feature of CNN (Frame No. 75/100 in change detection dataset of tsunami)

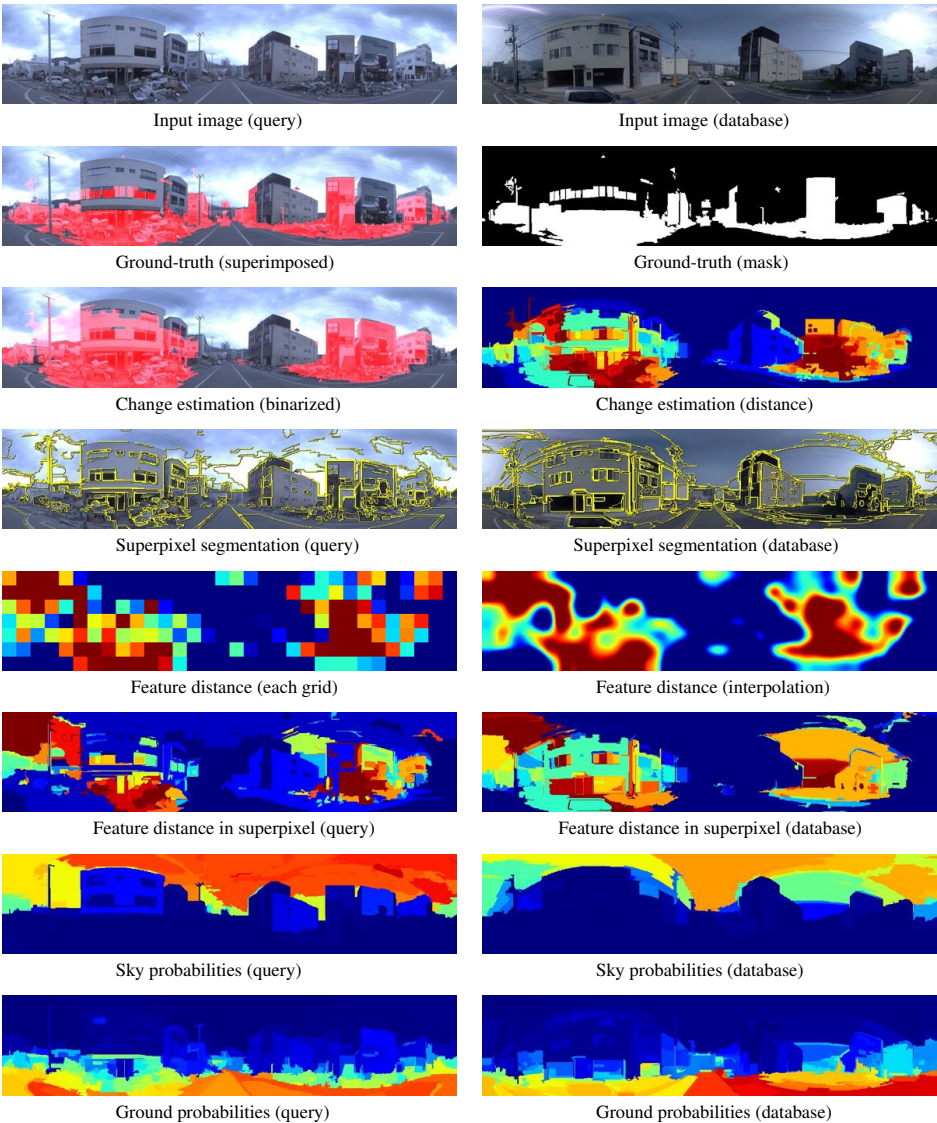


Figure 76: Results of change detection using pool-5 feature of CNN (Frame No. 76/100 in change detection dataset of tsunami)

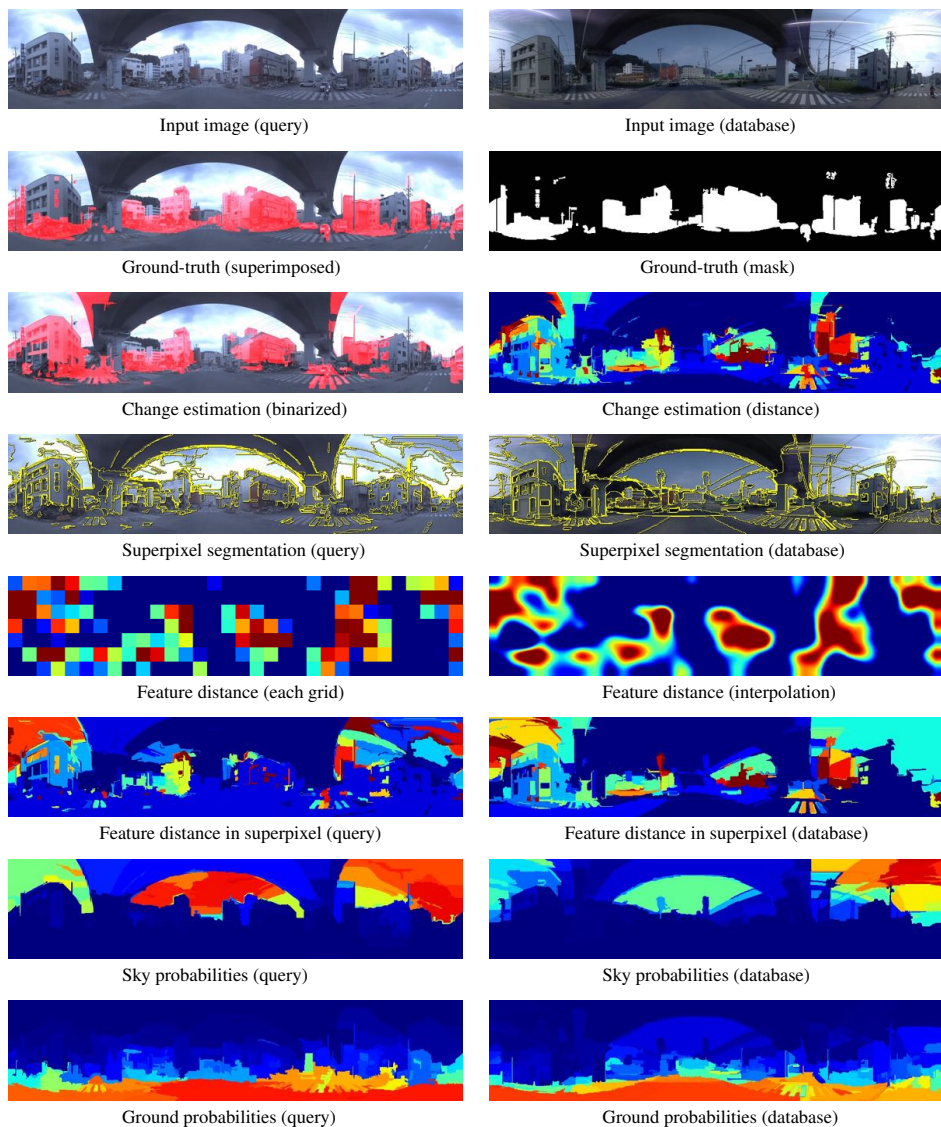


Figure 77: Results of change detection using pool-5 feature of CNN (Frame No. 77/100 in change detection dataset of tsunami)

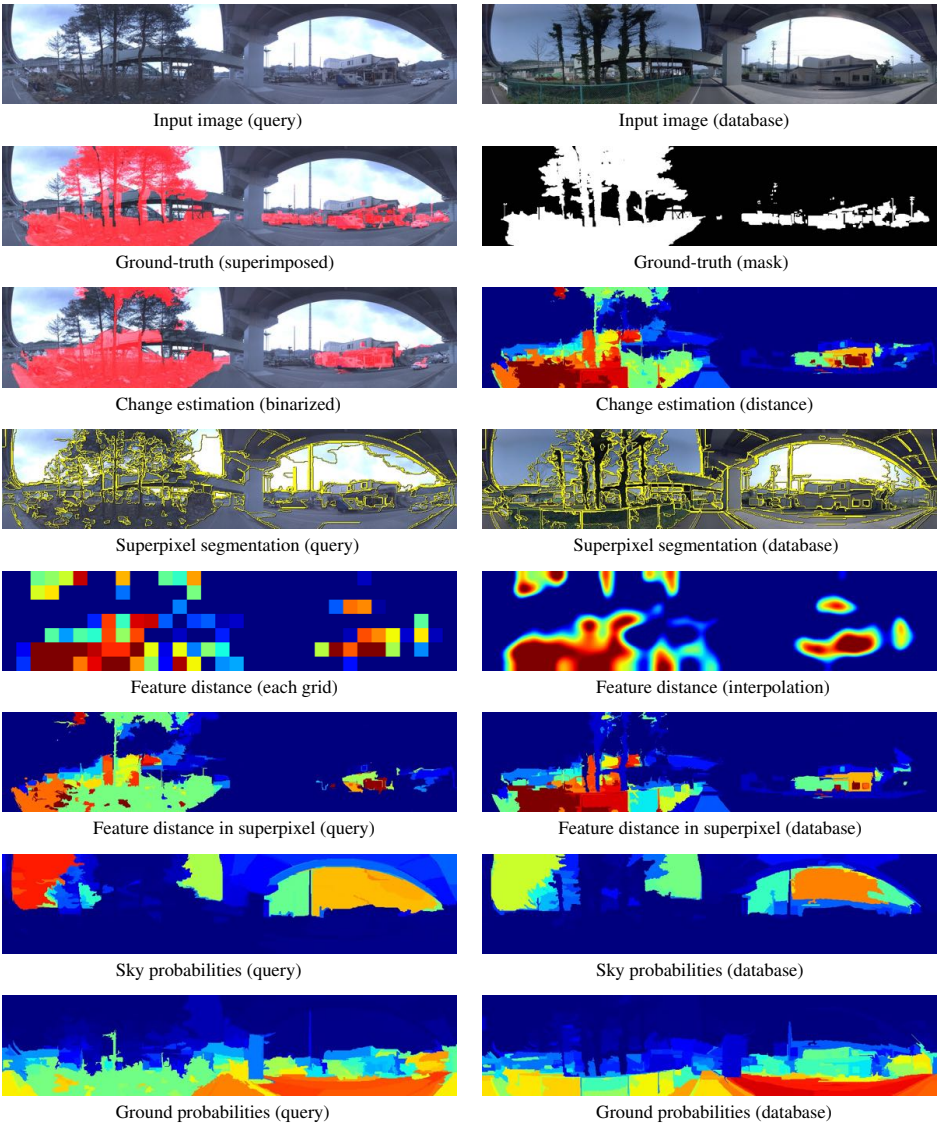


Figure 78: Results of change detection using pool-5 feature of CNN (Frame No. 78/100 in change detection dataset of tsunami)

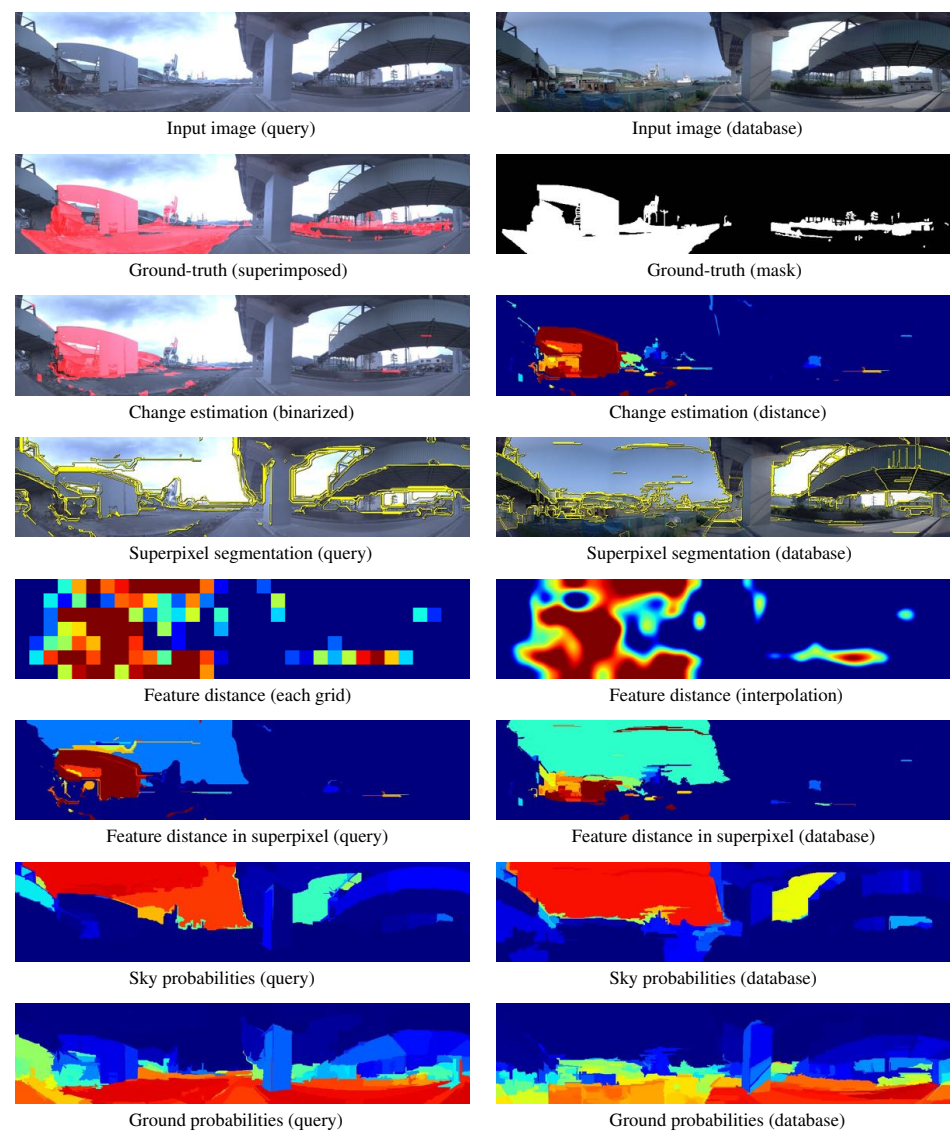


Figure 79: Results of change detection using pool-5 feature of CNN (Frame No. 79/100 in change detection dataset of tsunami)

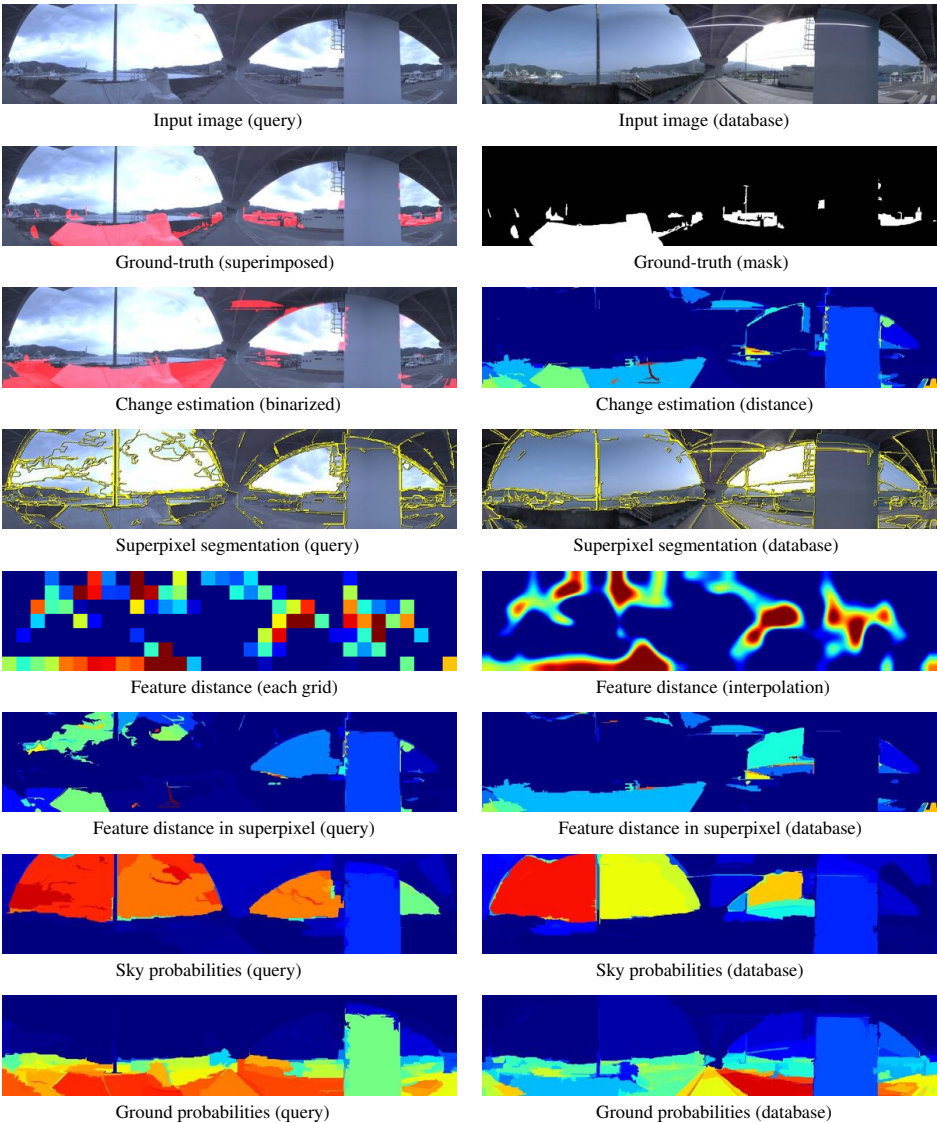


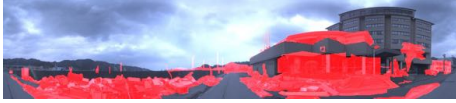
Figure 80: Results of change detection using pool-5 feature of CNN (Frame No. 80/100 in change detection dataset of tsunami)



Input image (query)



Input image (database)



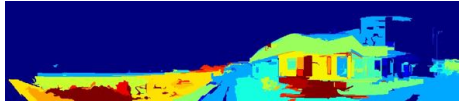
Ground-truth (superimposed)



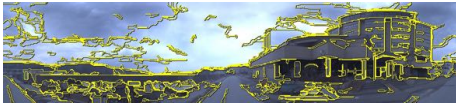
Ground-truth (mask)



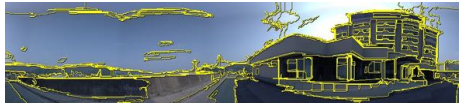
Change estimation (binarized)



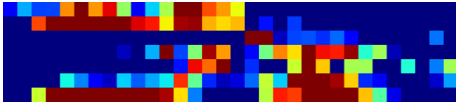
Change estimation (distance)



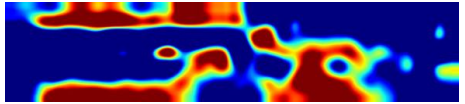
Superpixel segmentation (query)



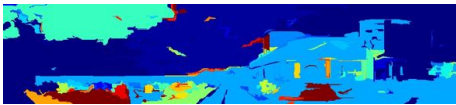
Superpixel segmentation (database)



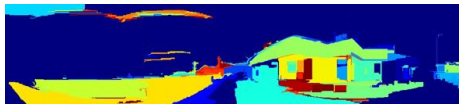
Feature distance (each grid)



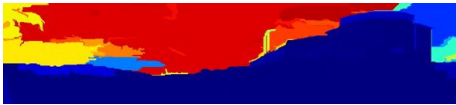
Feature distance (interpolation)



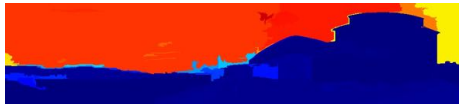
Feature distance in superpixel (query)



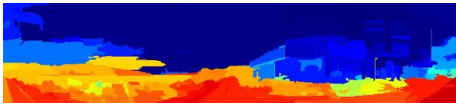
Feature distance in superpixel (database)



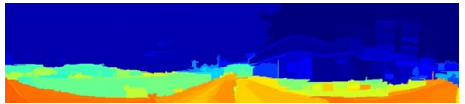
Sky probabilities (query)



Sky probabilities (database)



Ground probabilities (query)



Ground probabilities (database)

Figure 81: Results of change detection using pool-5 feature of CNN (Frame No. 81/100 in change detection dataset of tsunami)

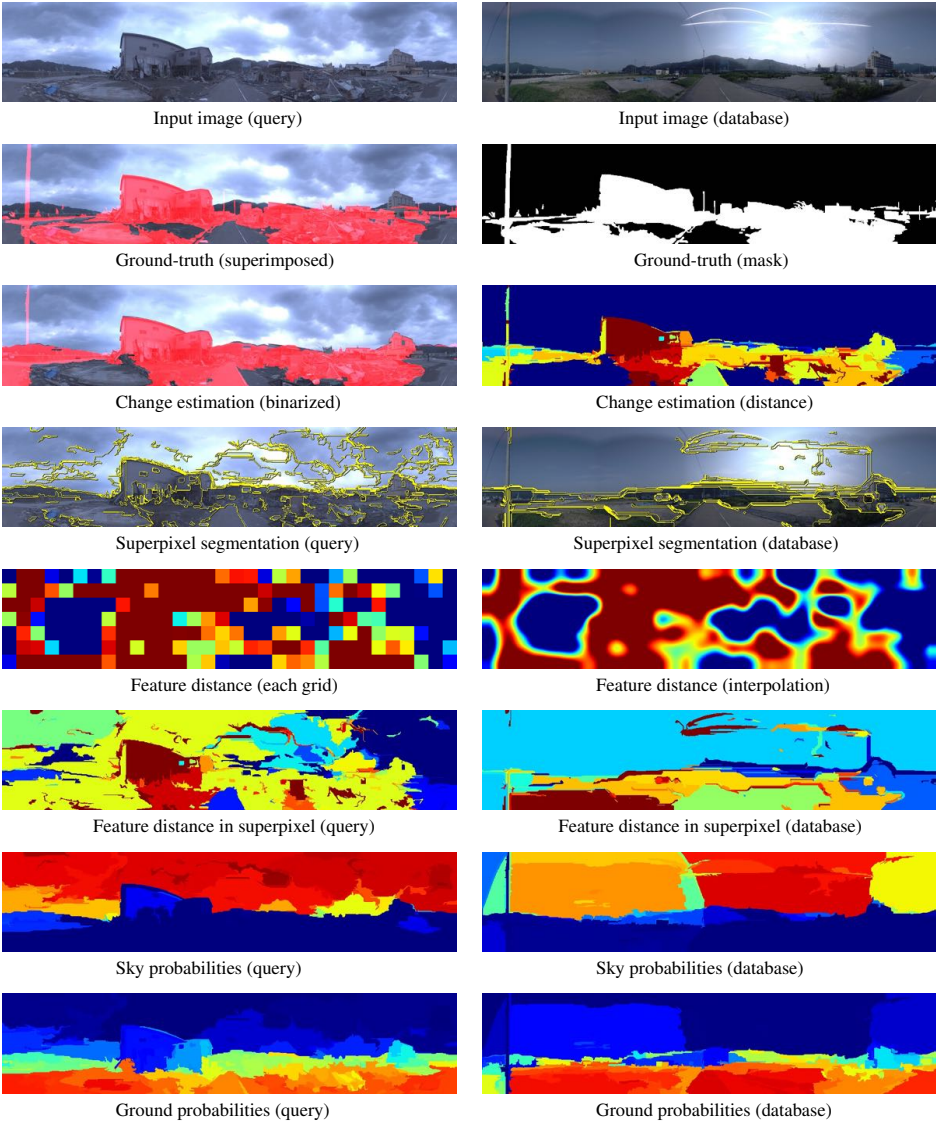


Figure 82: Results of change detection using pool-5 feature of CNN (Frame No. 82/100 in change detection dataset of tsunami)

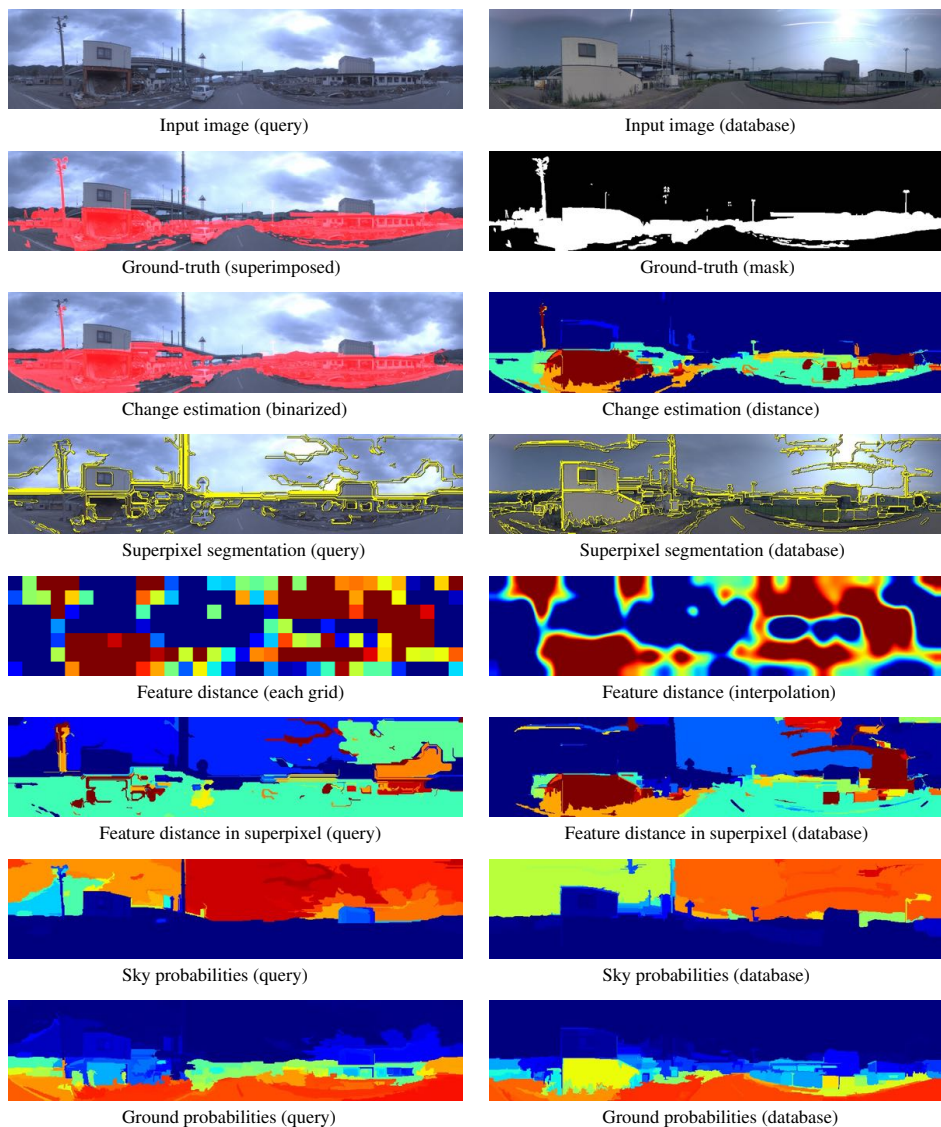


Figure 83: Results of change detection using pool-5 feature of CNN (Frame No. 83/100 in change detection dataset of tsunami)

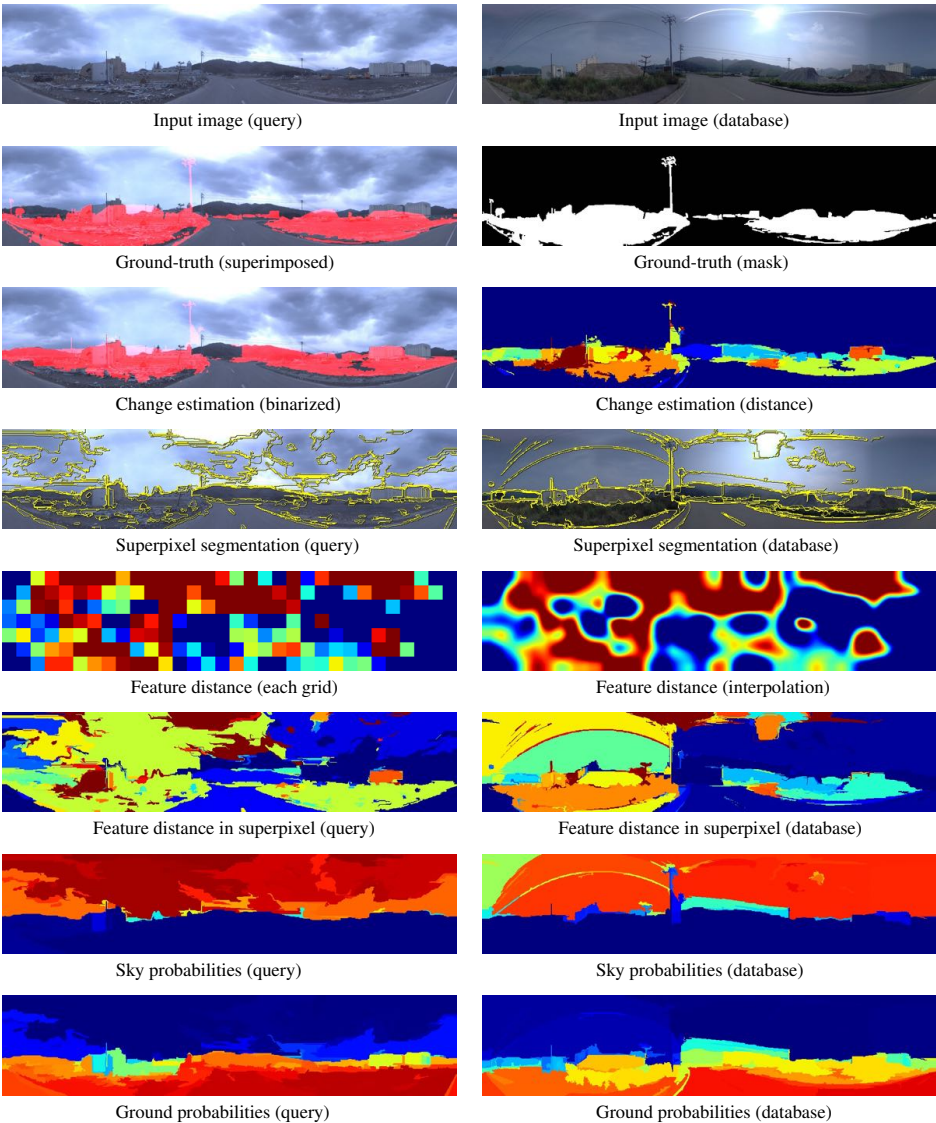


Figure 84: Results of change detection using pool-5 feature of CNN (Frame No. 84/100 in change detection dataset of tsunami)

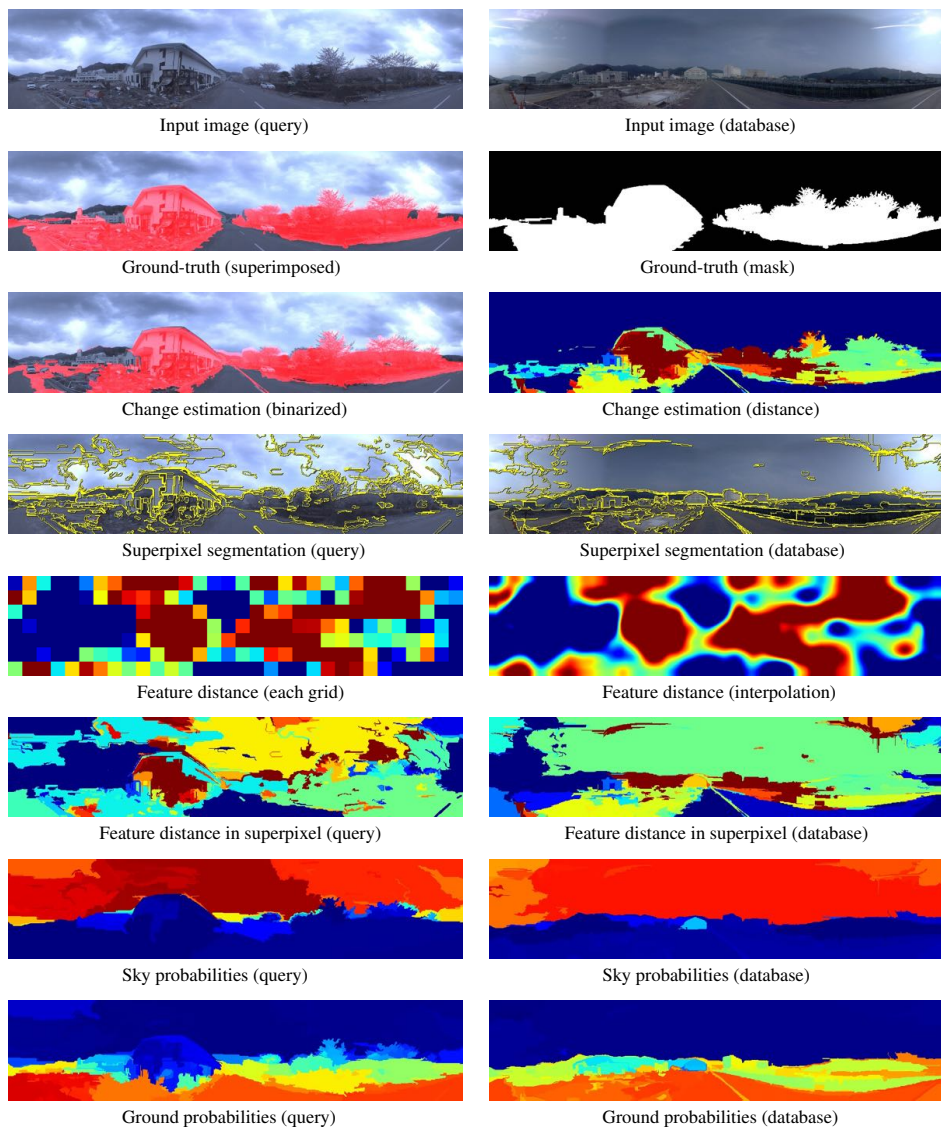


Figure 85: Results of change detection using pool-5 feature of CNN (Frame No. 85/100 in change detection dataset of tsunami)

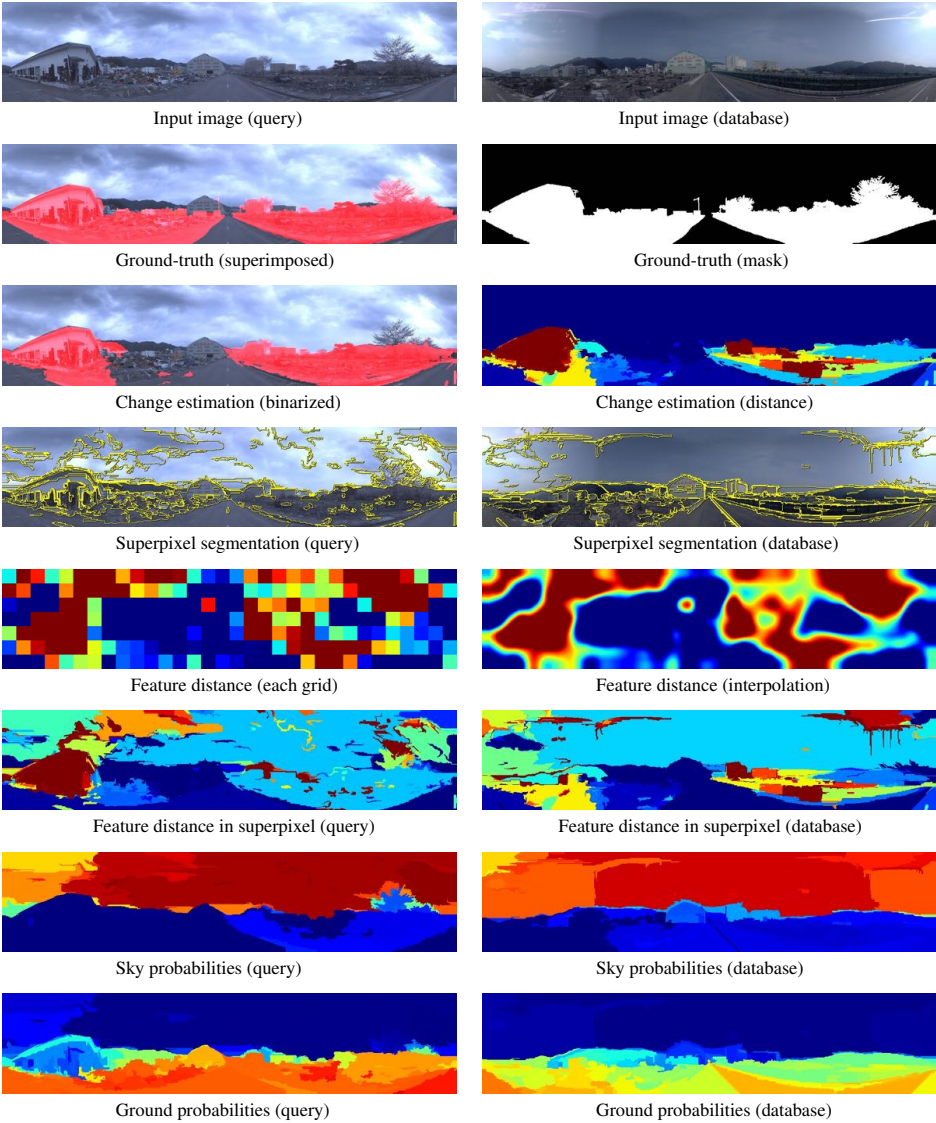


Figure 86: Results of change detection using pool-5 feature of CNN (Frame No. 86/100 in change detection dataset of tsunami)

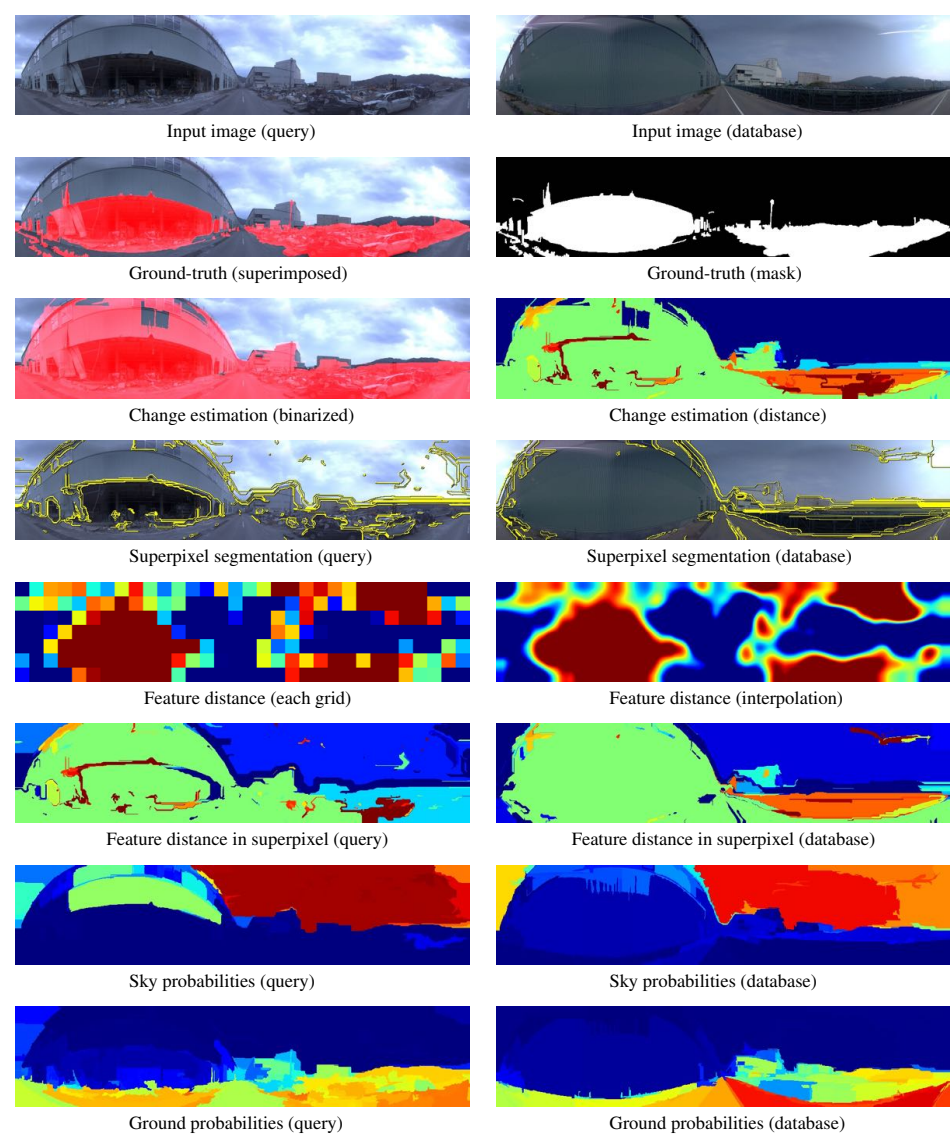


Figure 87: Results of change detection using pool-5 feature of CNN (Frame No. 87/100 in change detection dataset of tsunami)

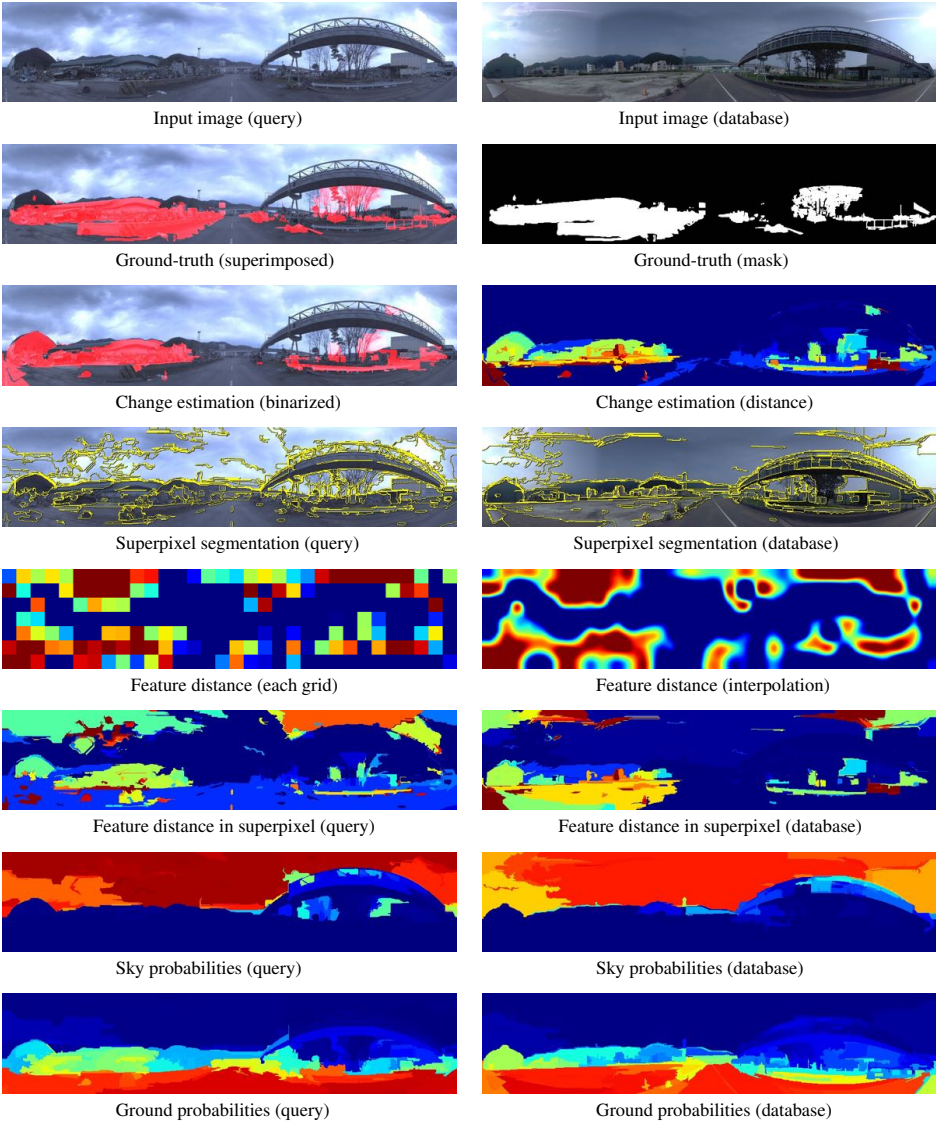


Figure 88: Results of change detection using pool-5 feature of CNN (Frame No. 88/100 in change detection dataset of tsunami)

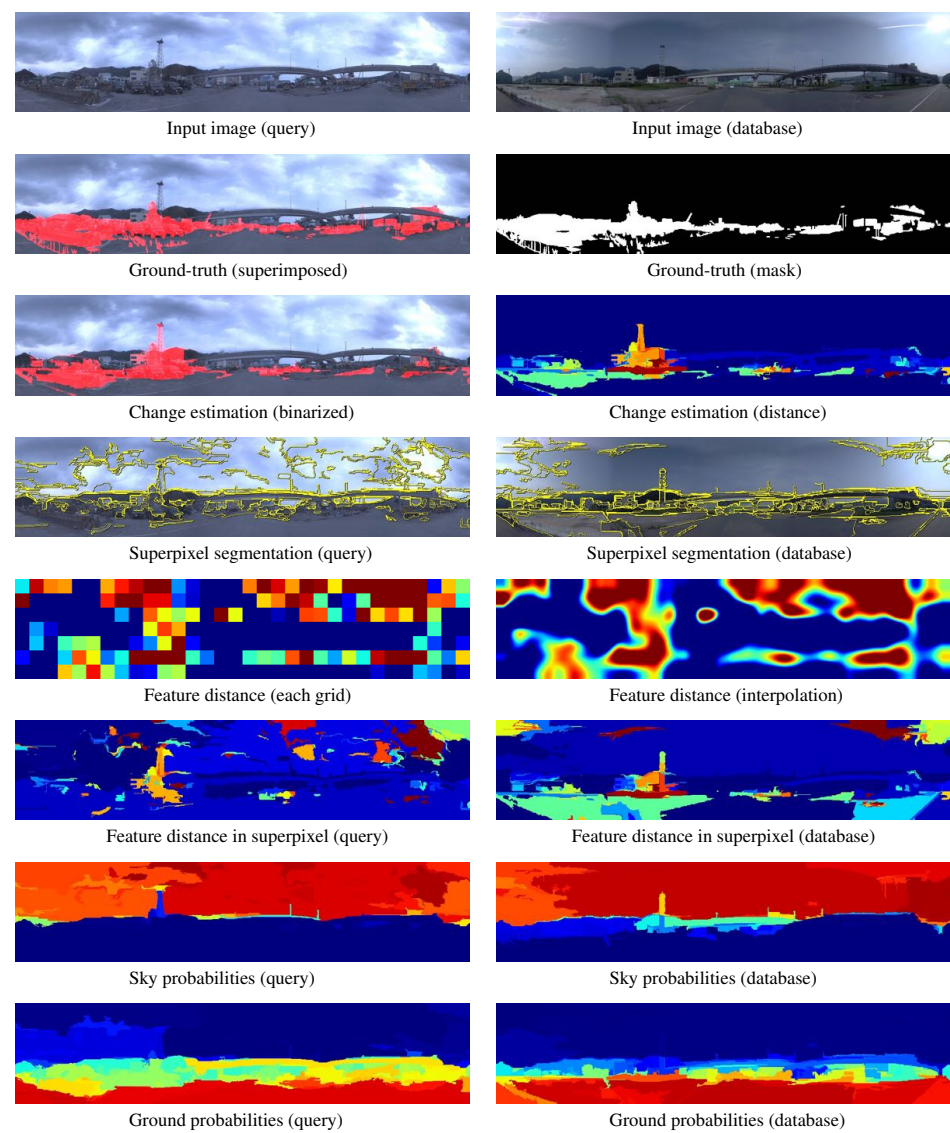


Figure 89: Results of change detection using pool-5 feature of CNN (Frame No. 89/100 in change detection dataset of tsunami)

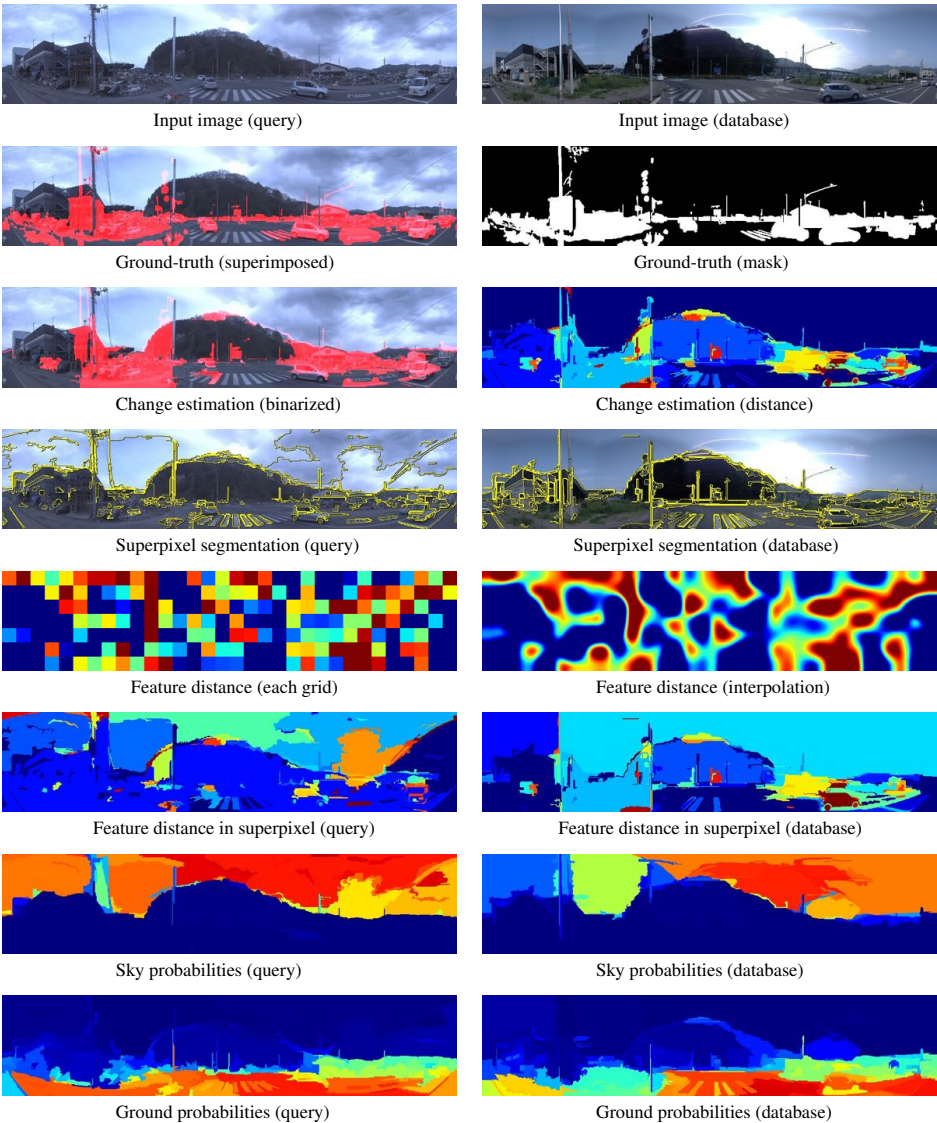


Figure 90: Results of change detection using pool-5 feature of CNN (Frame No. 90/100 in change detection dataset of tsunami)

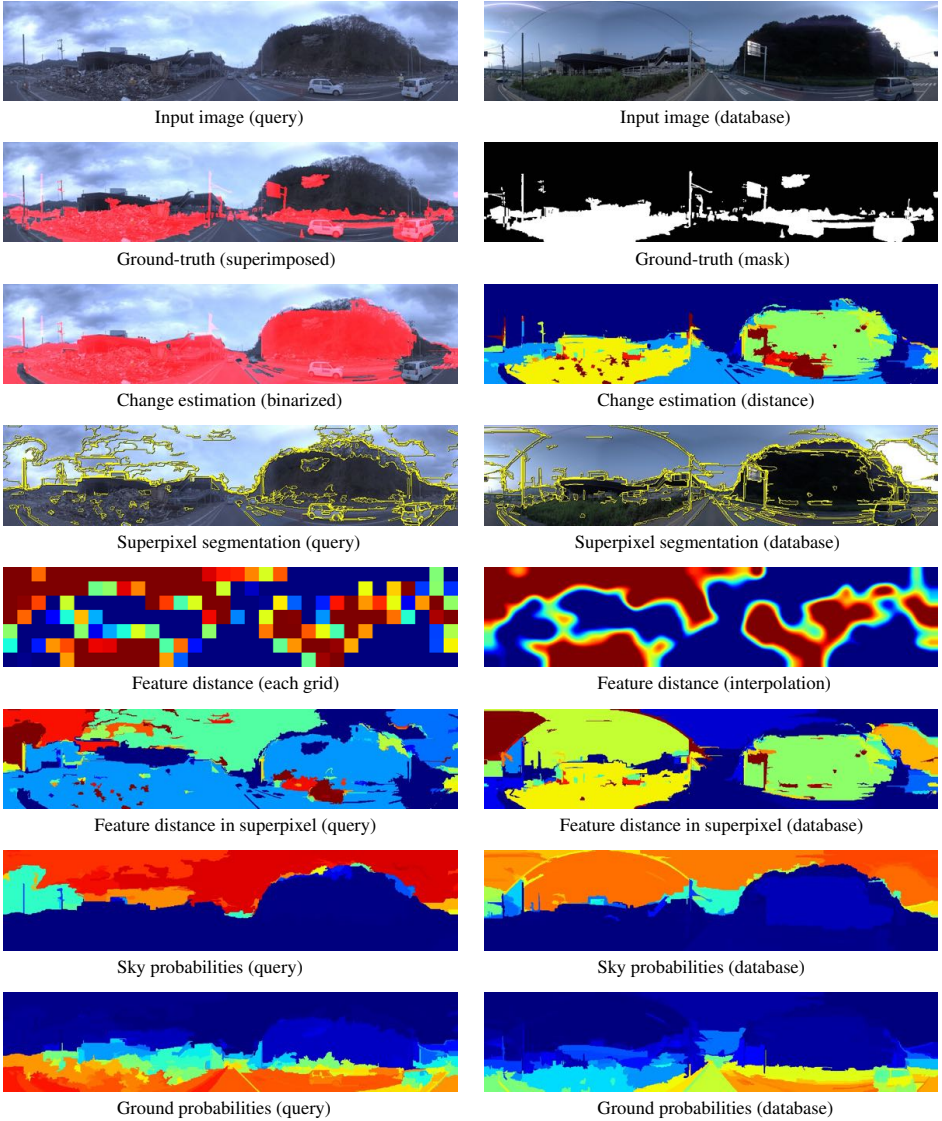


Figure 91: Results of change detection using pool-5 feature of CNN (Frame No. 91/100 in change detection dataset of tsunami)

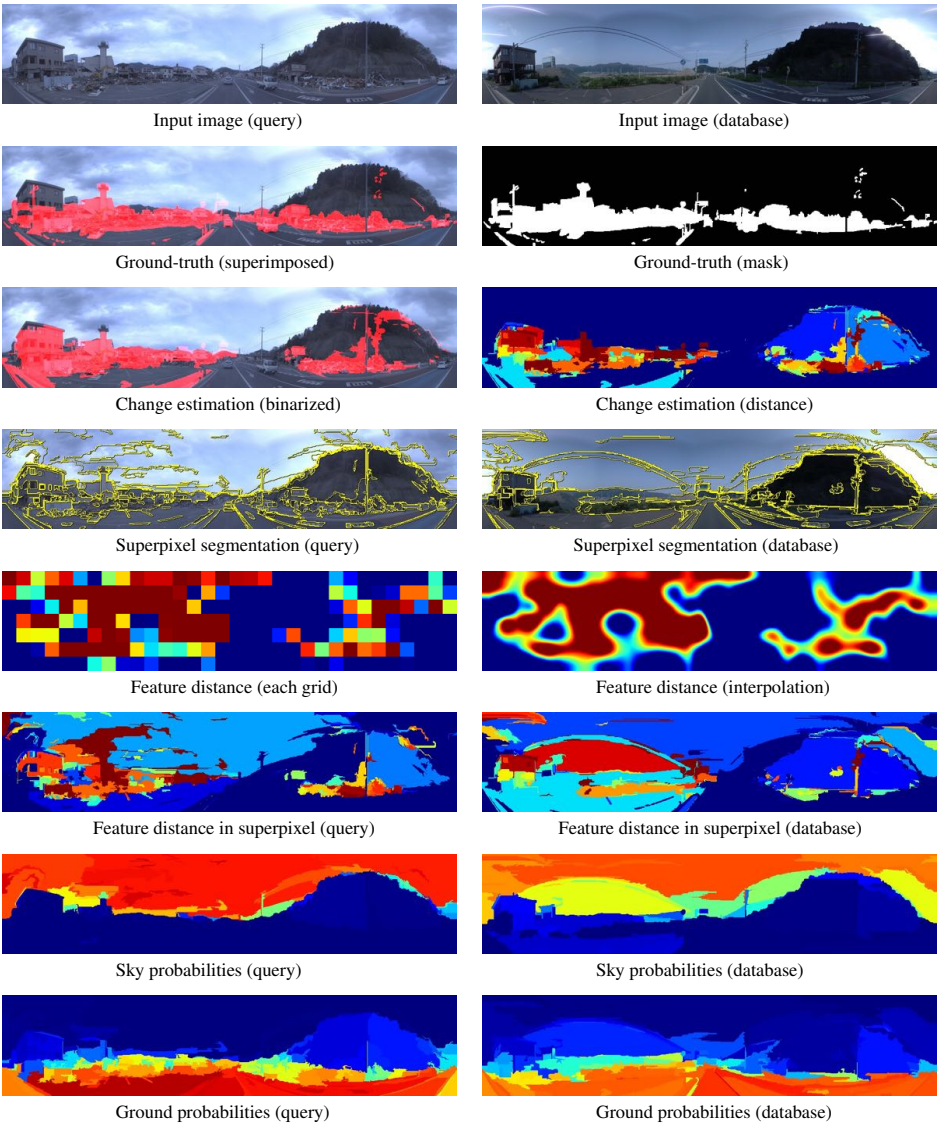


Figure 92: Results of change detection using pool-5 feature of CNN (Frame No. 92/100 in change detection dataset of tsunami)

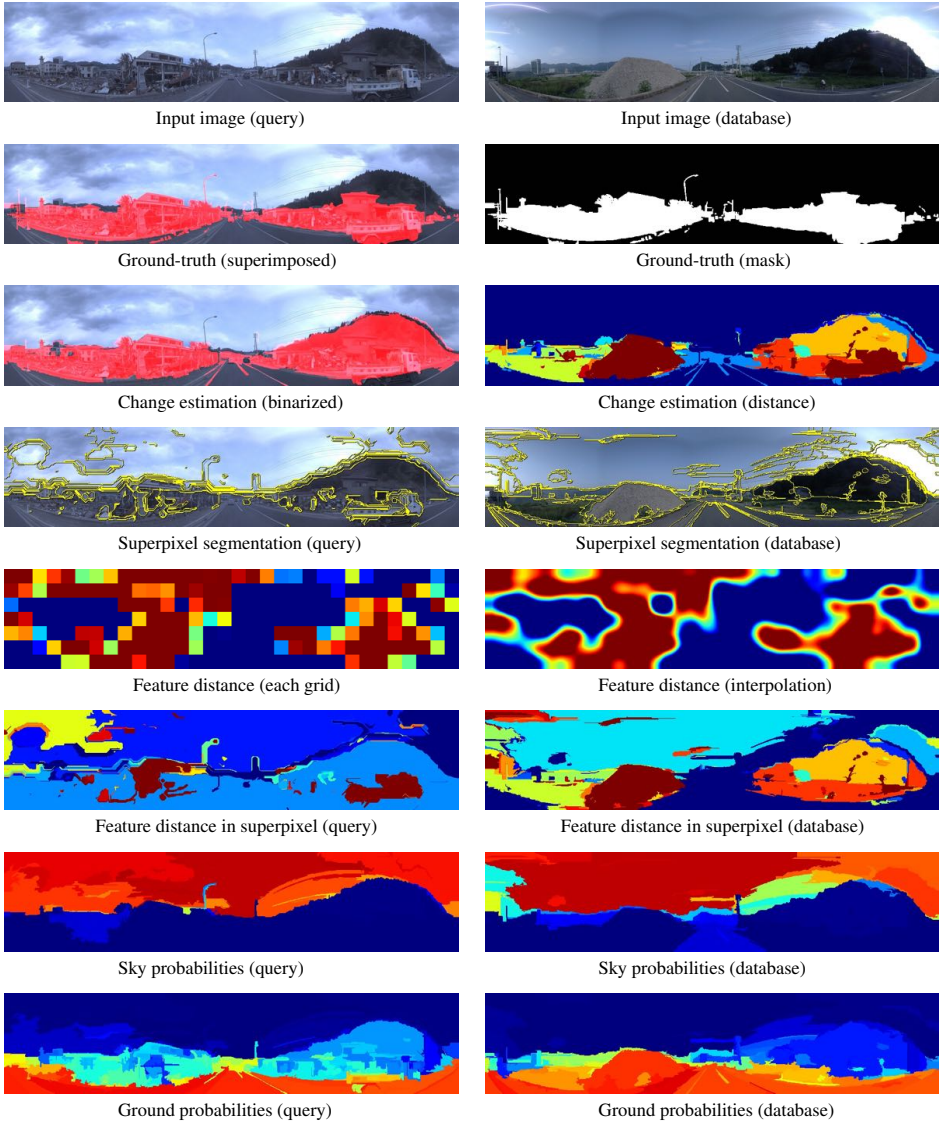


Figure 93: Results of change detection using pool-5 feature of CNN (Frame No. 93/100 in change detection dataset of tsunami)

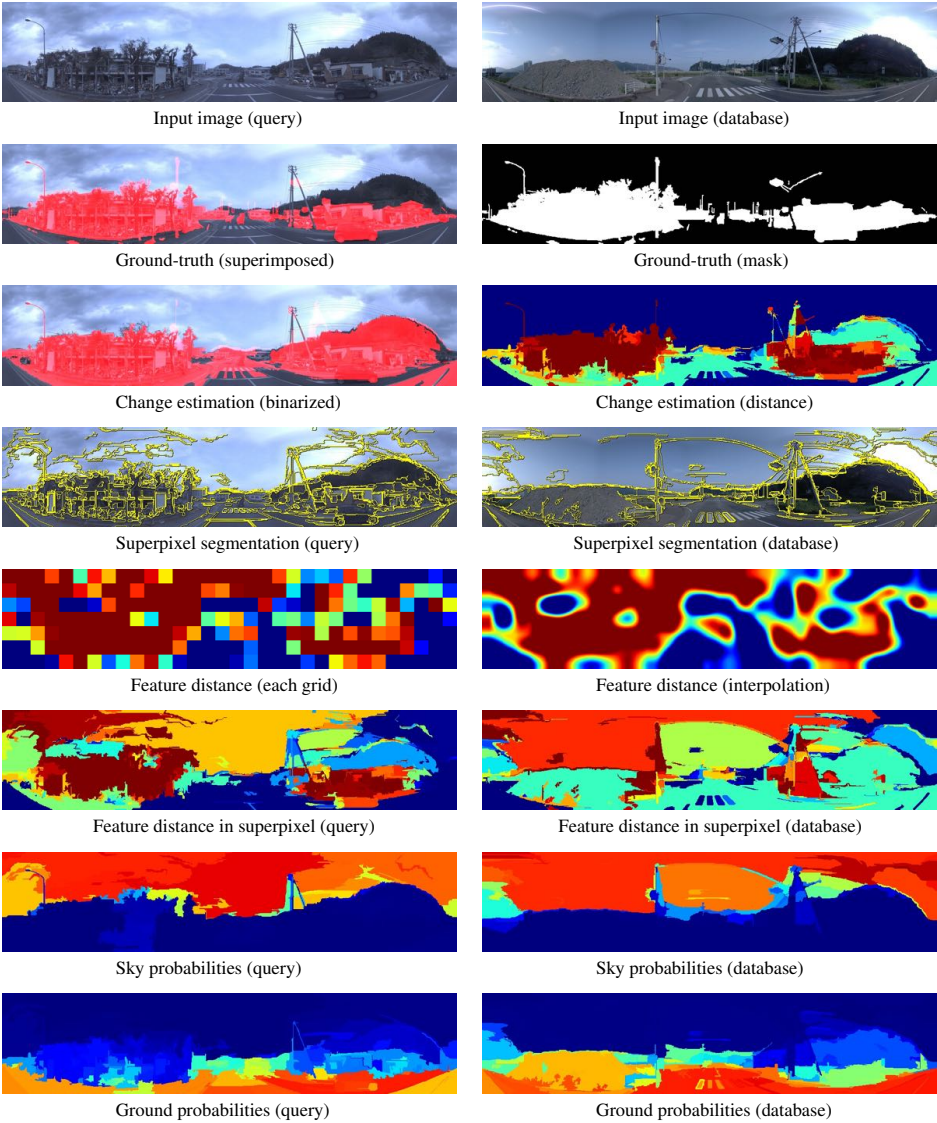


Figure 94: Results of change detection using pool-5 feature of CNN (Frame No. 94/100 in change detection dataset of tsunami)

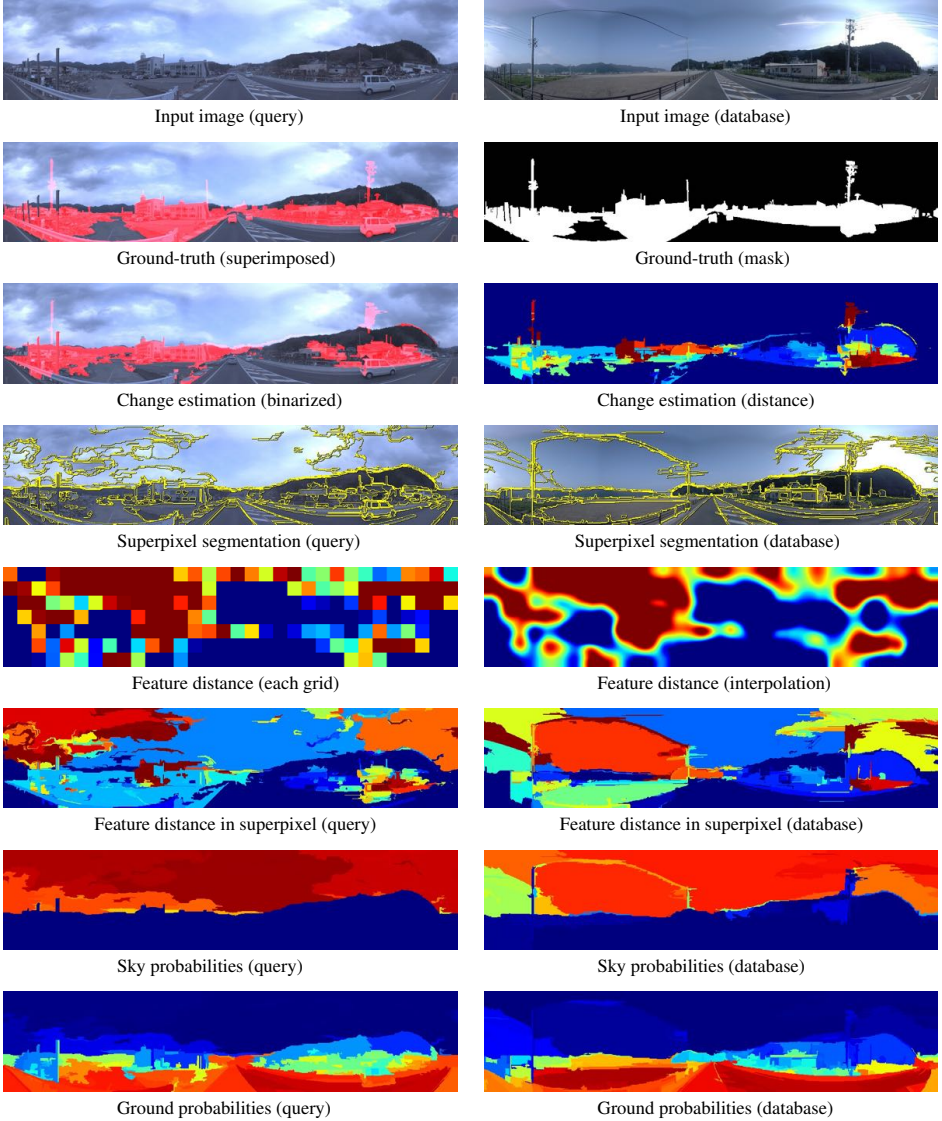


Figure 95: Results of change detection using pool-5 feature of CNN (Frame No. 95/100 in change detection dataset of tsunami)

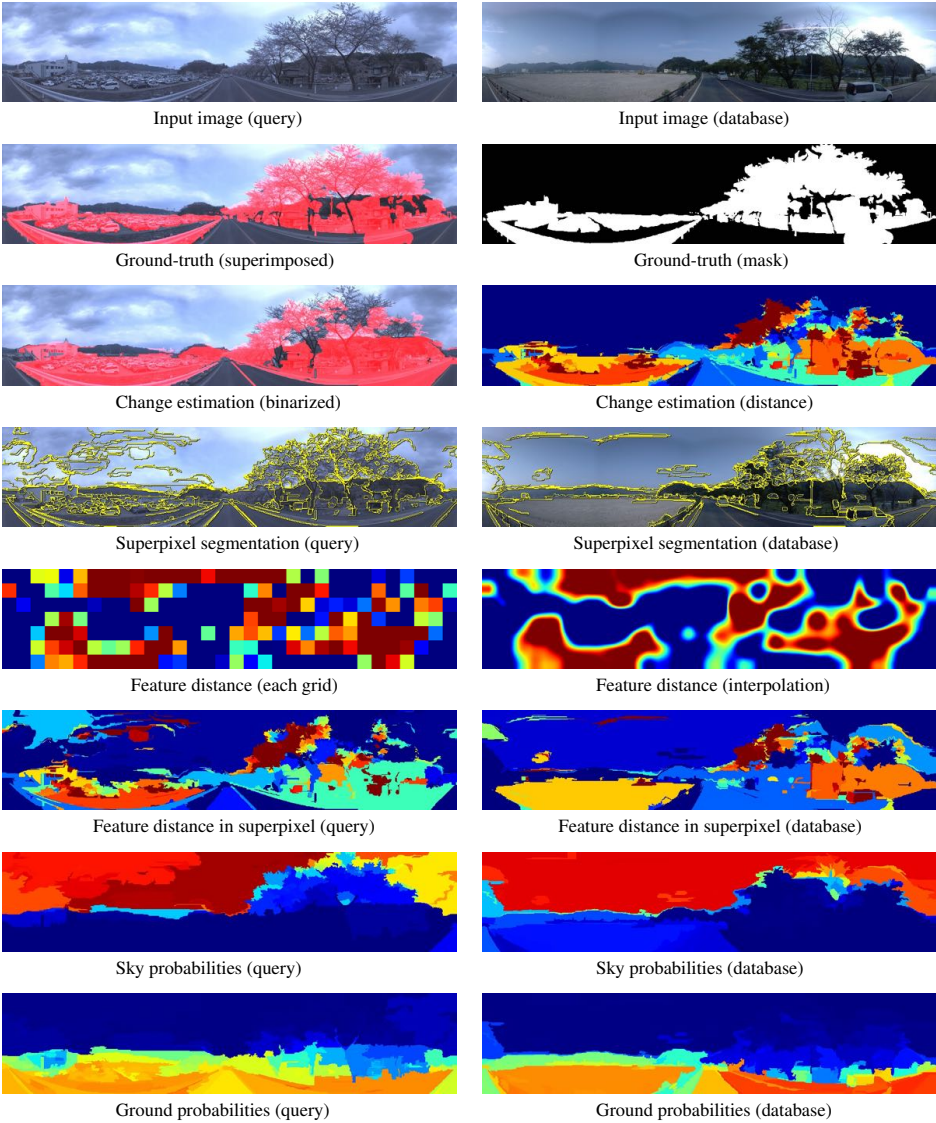


Figure 96: Results of change detection using pool-5 feature of CNN (Frame No. 96/100 in change detection dataset of tsunami)

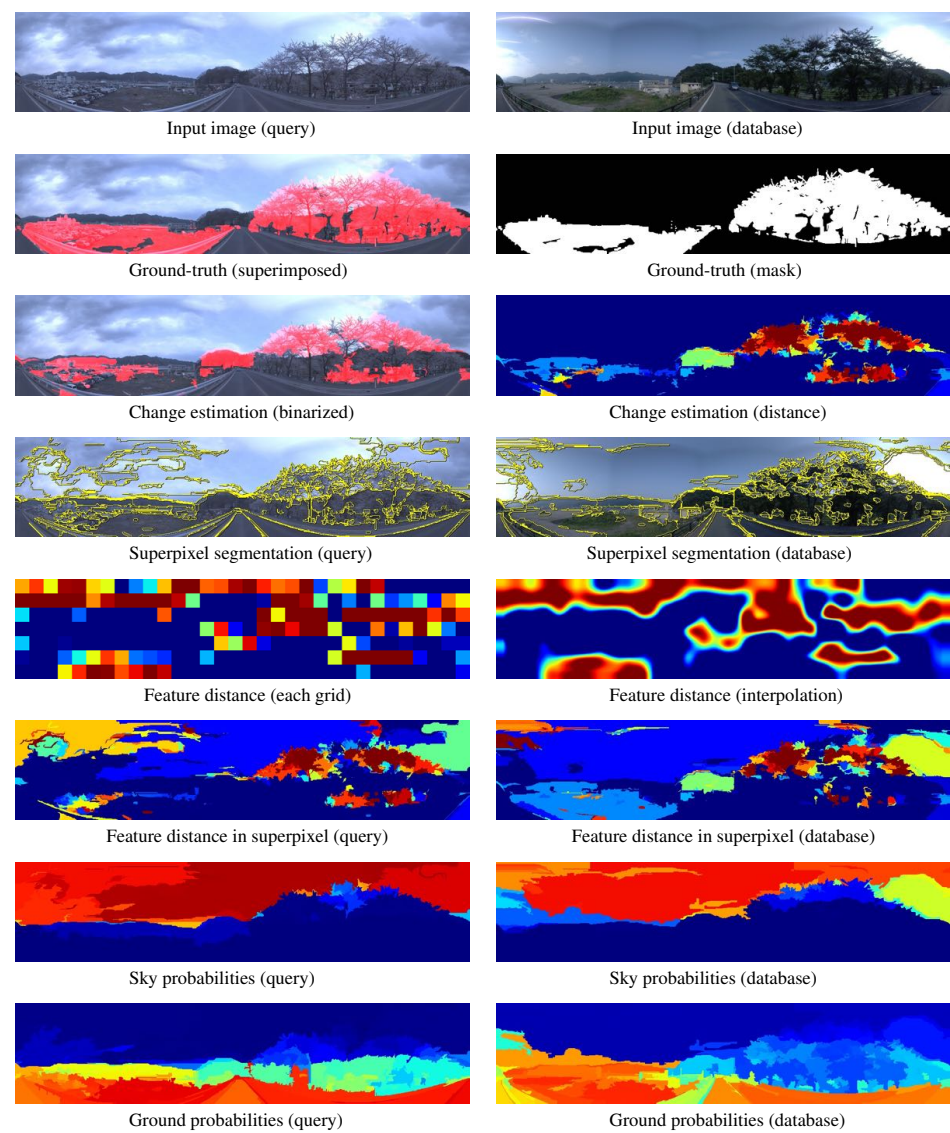


Figure 97: Results of change detection using pool-5 feature of CNN (Frame No. 97/100 in change detection dataset of tsunami)

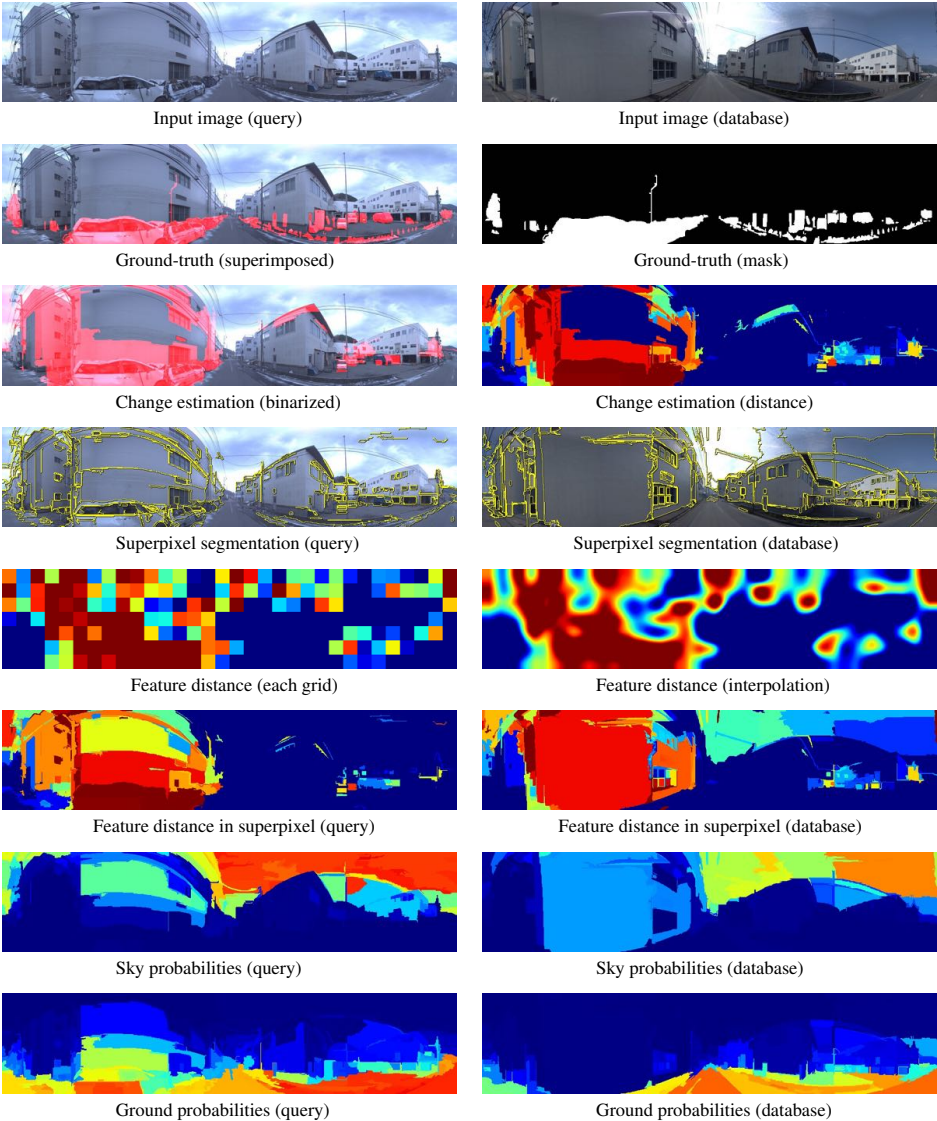


Figure 98: Results of change detection using pool-5 feature of CNN (Frame No. 98/100 in change detection dataset of tsunami)

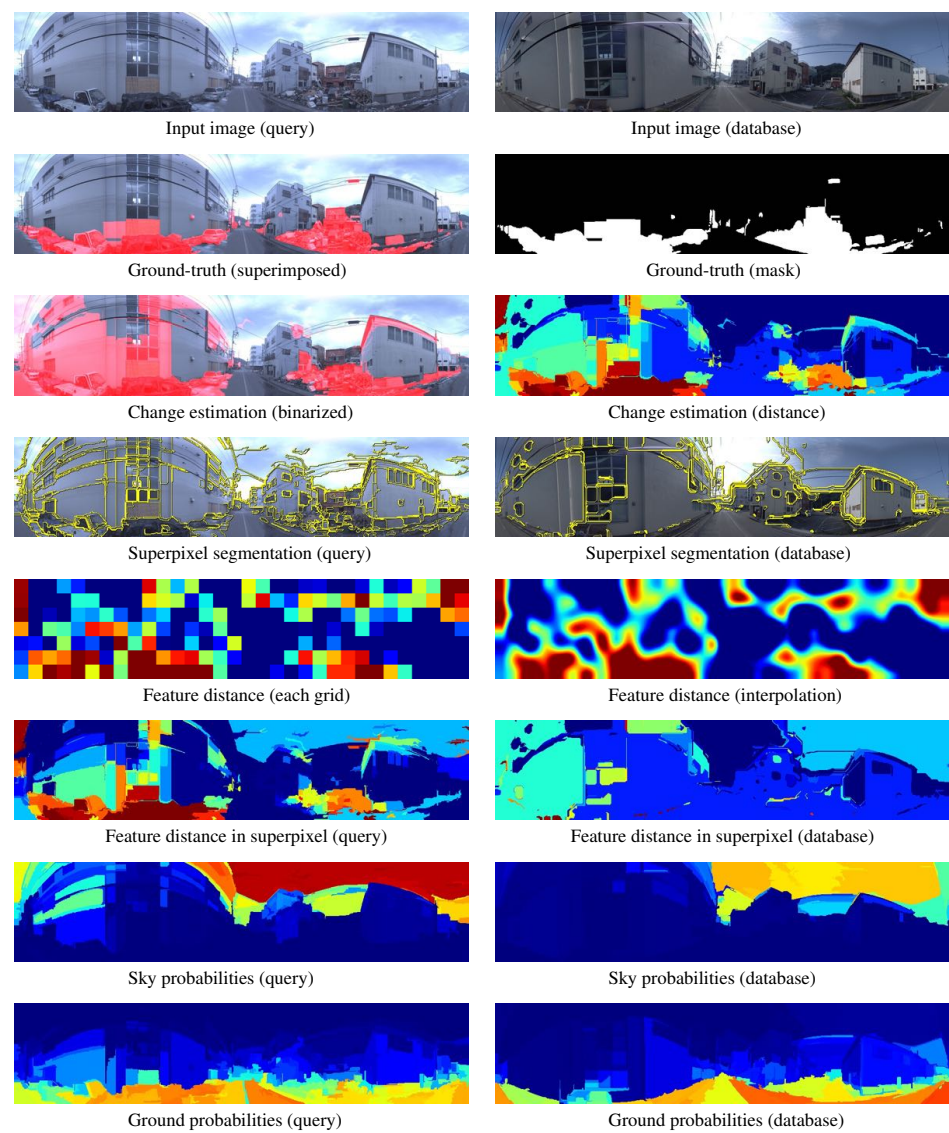


Figure 99: Results of change detection using pool-5 feature of CNN (Frame No. 99/100 in change detection dataset of tsunami)

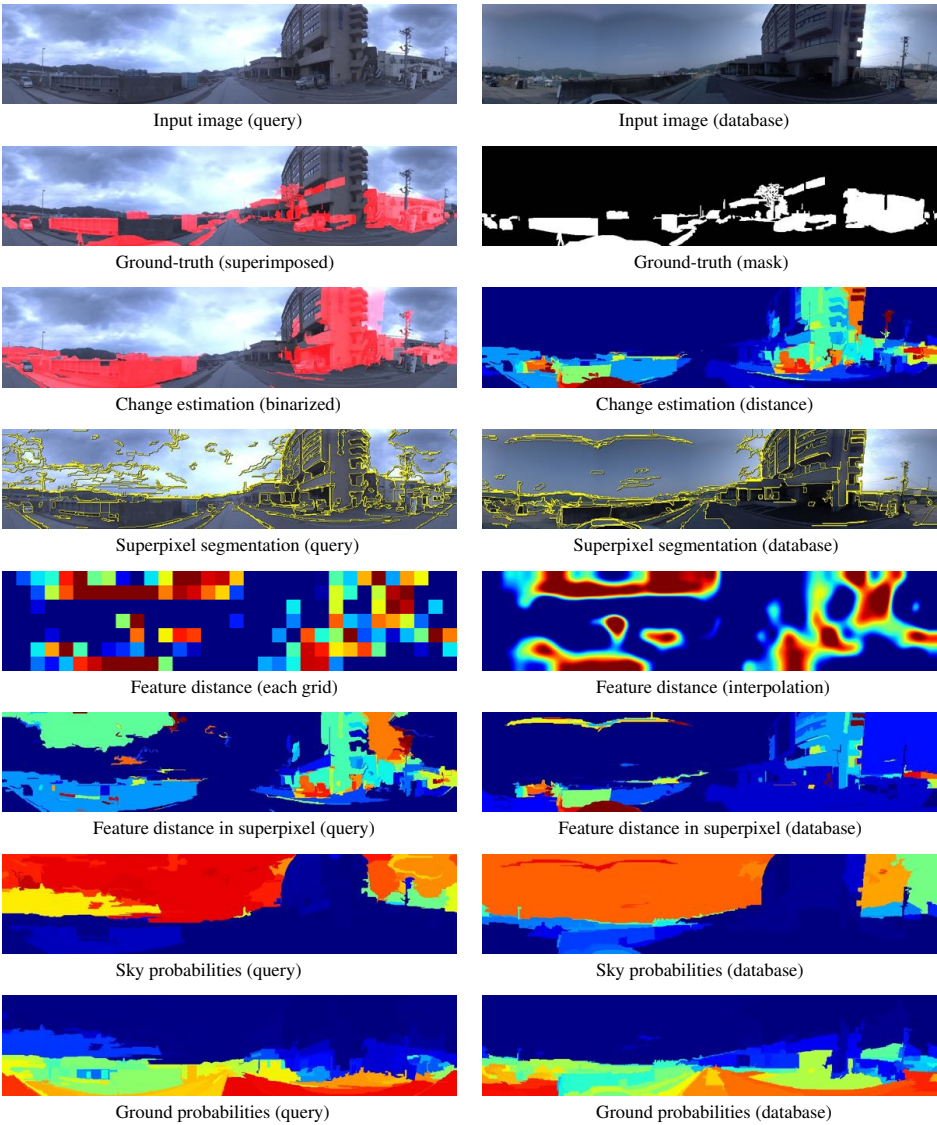


Figure 100: Results of change detection using pool-5 feature of CNN (Frame No. 100/100 in change detection dataset of tsunami)