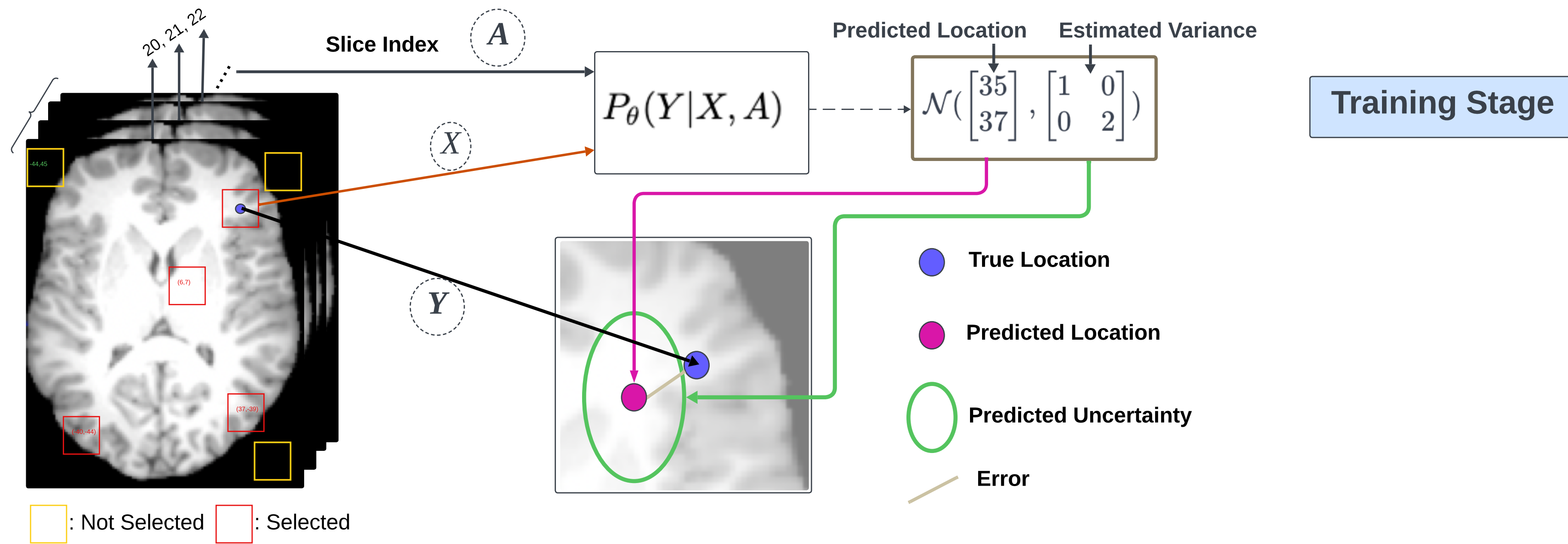


Learning Framework

- Unsupervised detection and localization of brain lesions in MRI neuroimages (T1 and T2)
- Location of the input patch, given axial/traverse/horizontal slice and its index, is 2D Gaussian distribution.
- Model trained to predict the mean and variances using **only normal data**.



$$P_{\theta}(Y|X, A) = \mathcal{N}(\mu^{\theta}(X, A), \Sigma^{\theta}(X, A)),$$

X : Patch

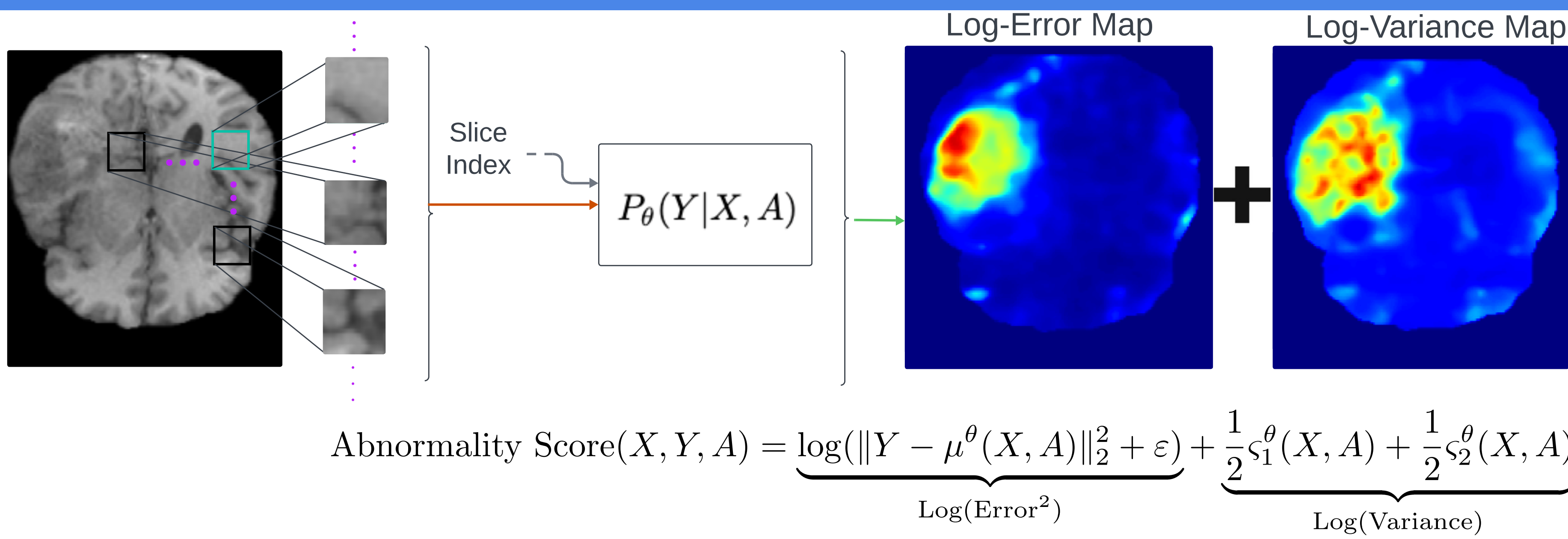
A : the slice location

$\mu^{\theta}(X, A)$: The 2D mean.

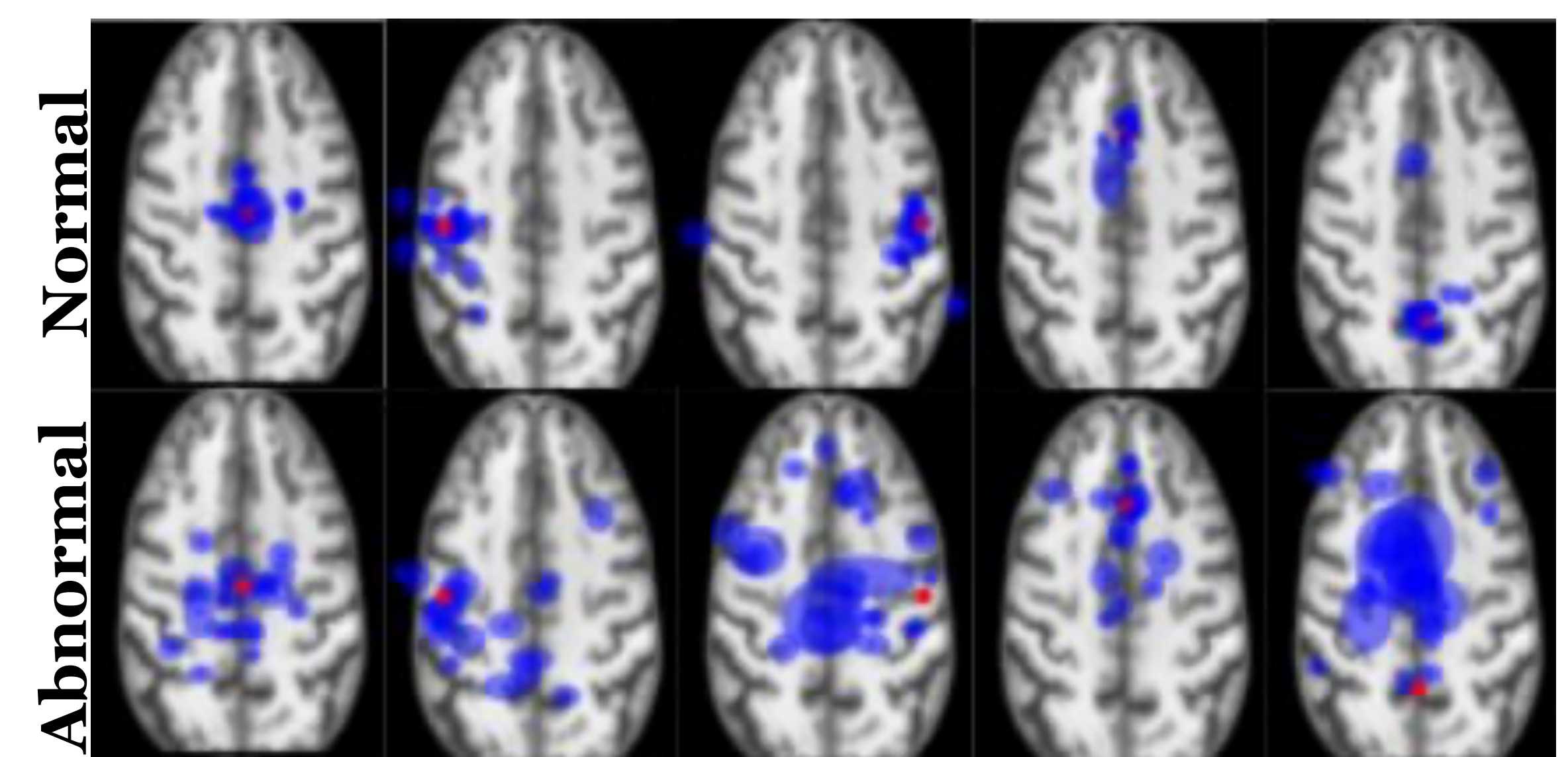
Y : The Estimated Location

$\Sigma^{\theta}(X, A)$: The covariance matrix.

Abnormality Score and Heatmap (Inference)



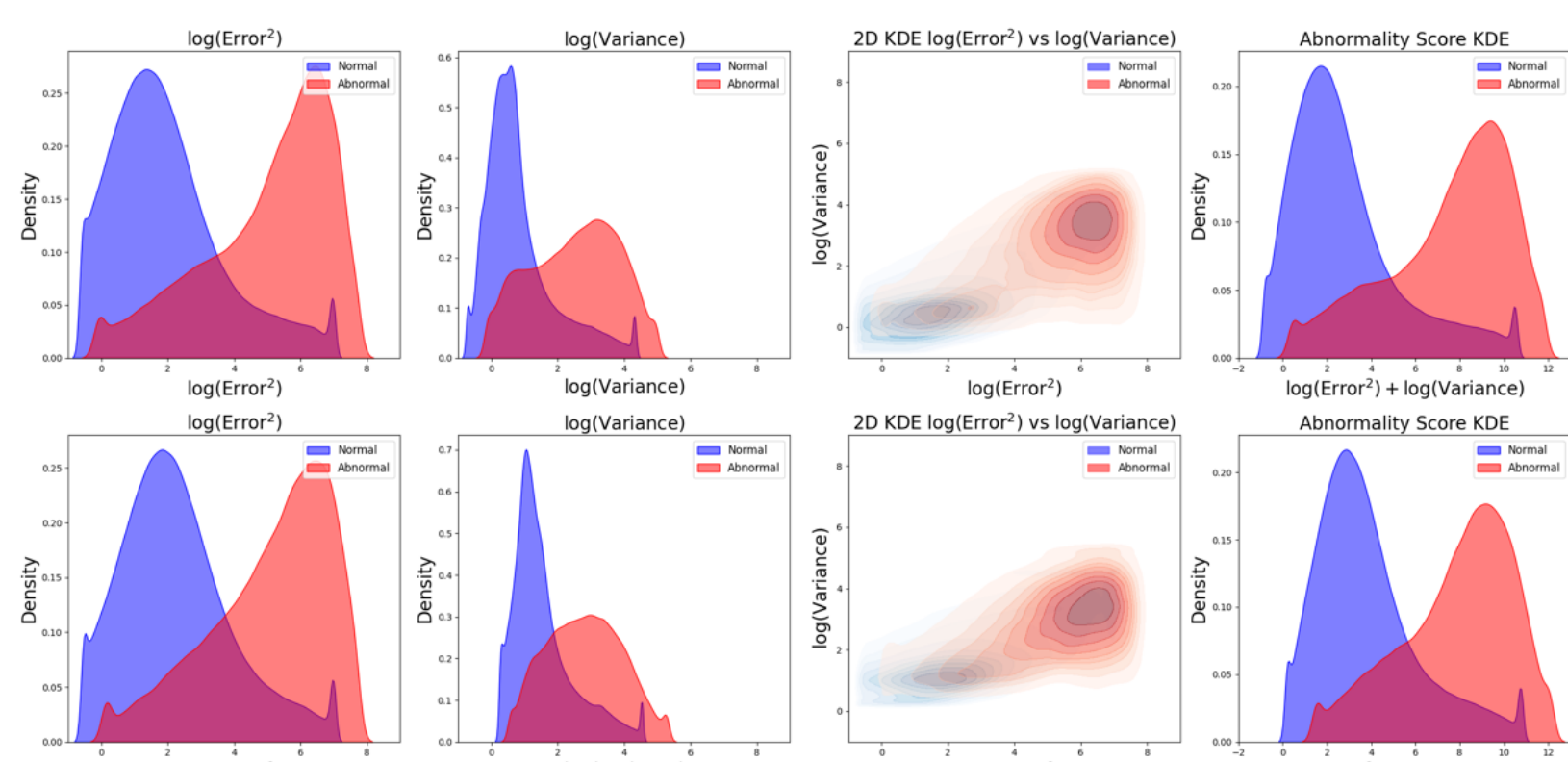
Example Path2Loc Predictions



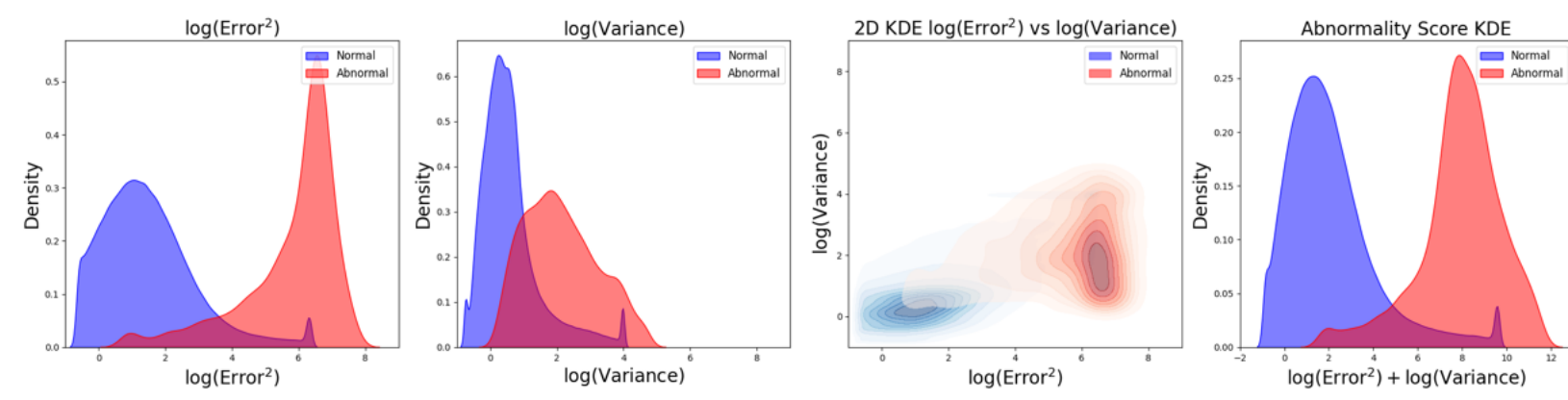
Predicted distribution for patches sourced from the same location (per column) from different subjects. Abnormal patches have high error (far away from the true location denoted by a red dot) and higher variance (i.e., larger ellipse)

Results

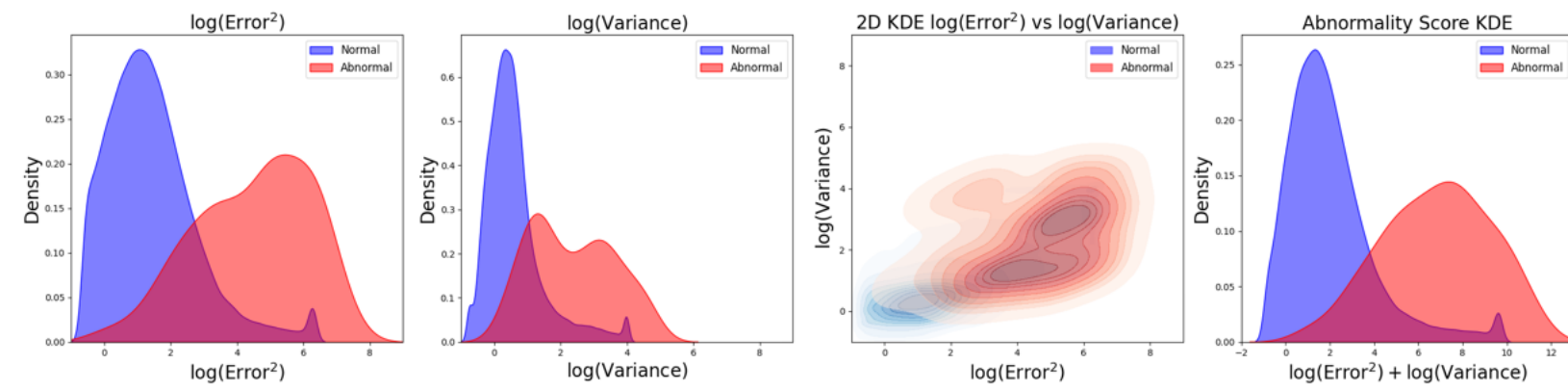
BraTS21 (T1 & T2), adult brain glioma, (Menze et al., 2015; Baid et al., 2021) n=1152



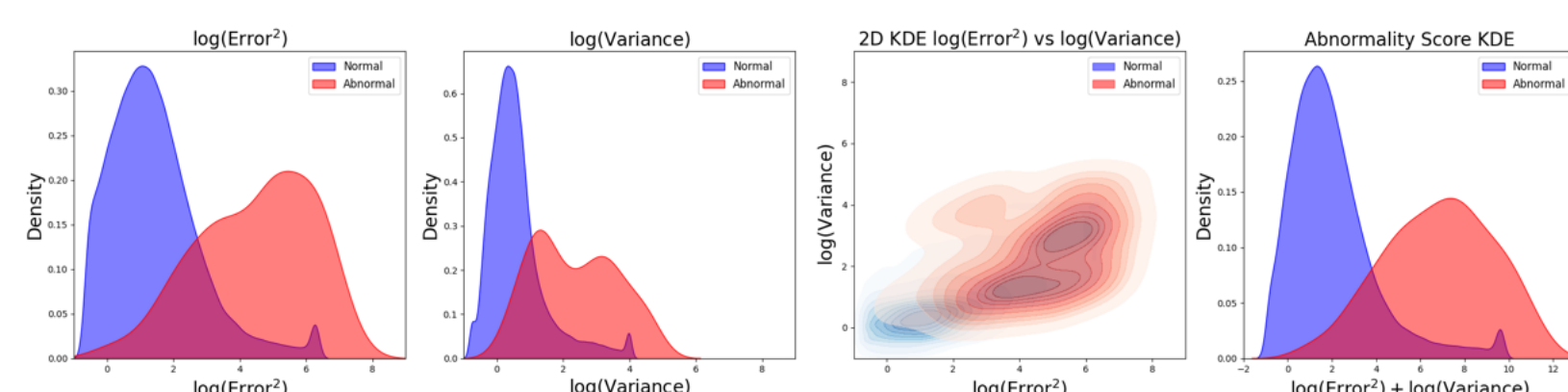
ATLAS, Anatomical Tracings of Lesions After Stroke v2.0 (Liew et al., 2022) n=955



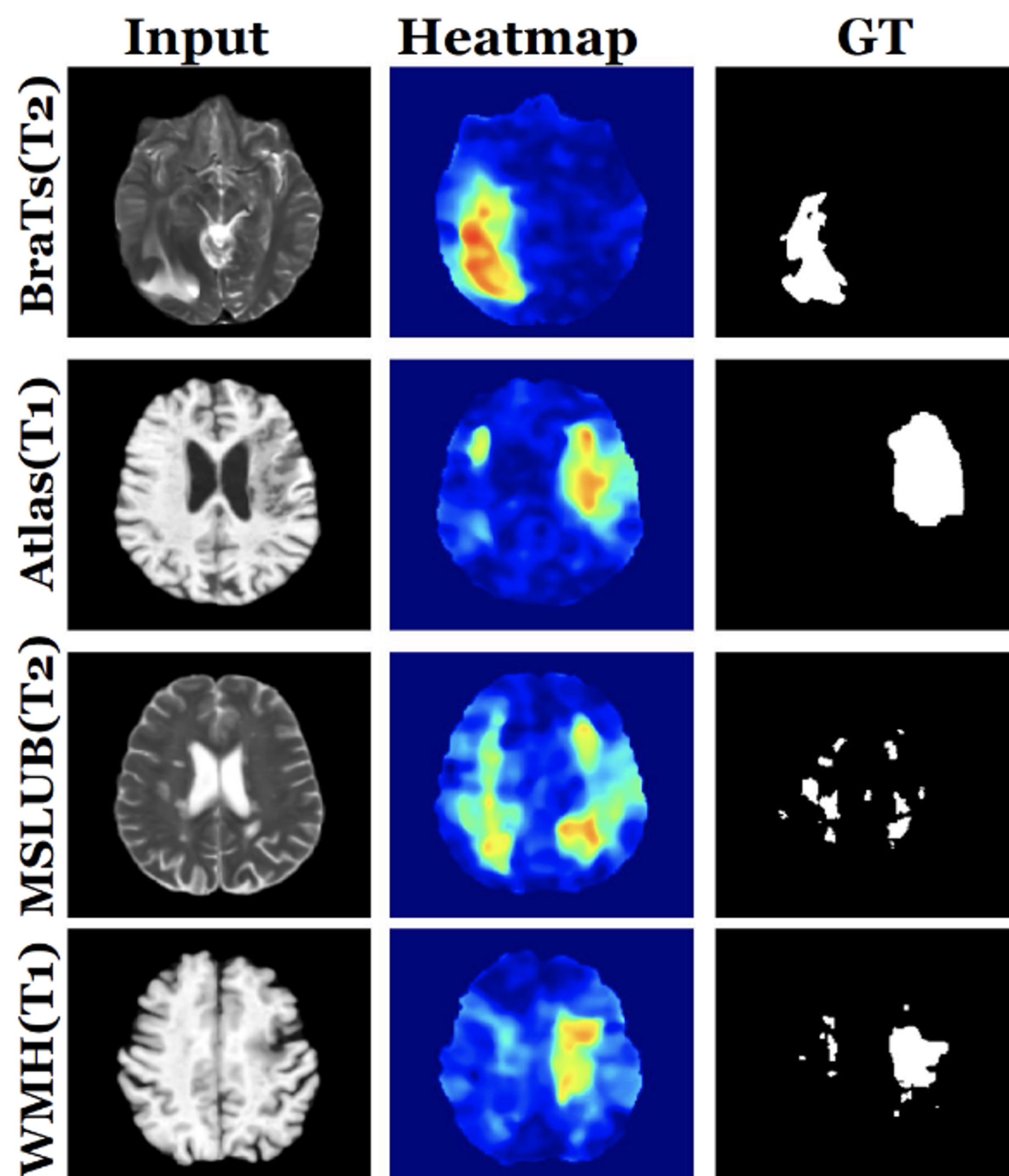
MSLUB, multiple sclerosis, (Lesjak et al., 2018) n=30



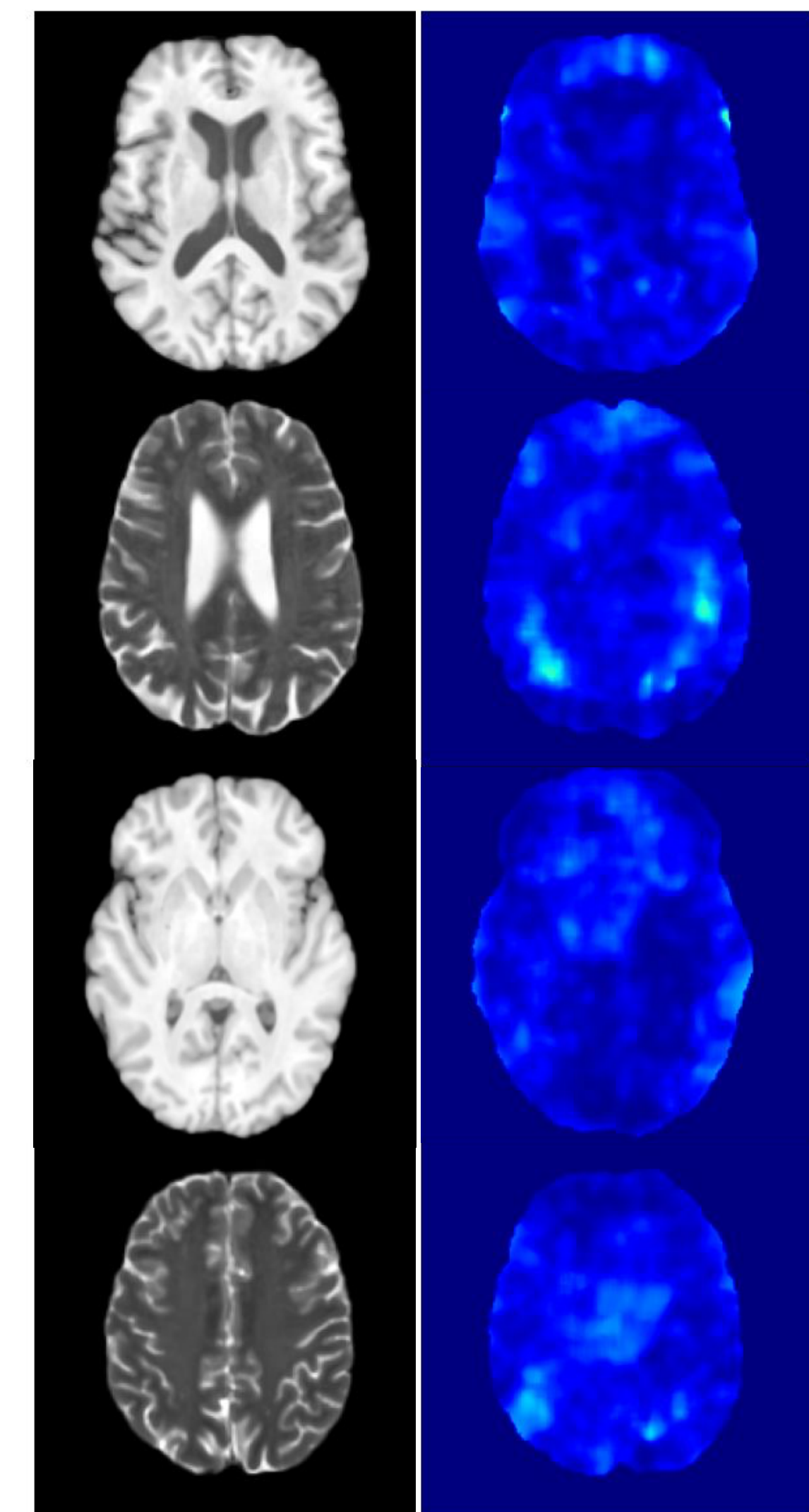
WHM, white matter hyperintensity (Kuijf et al., 2019) n=60



Heatmap colormap ranges from 0 (blue) to 12 (red).

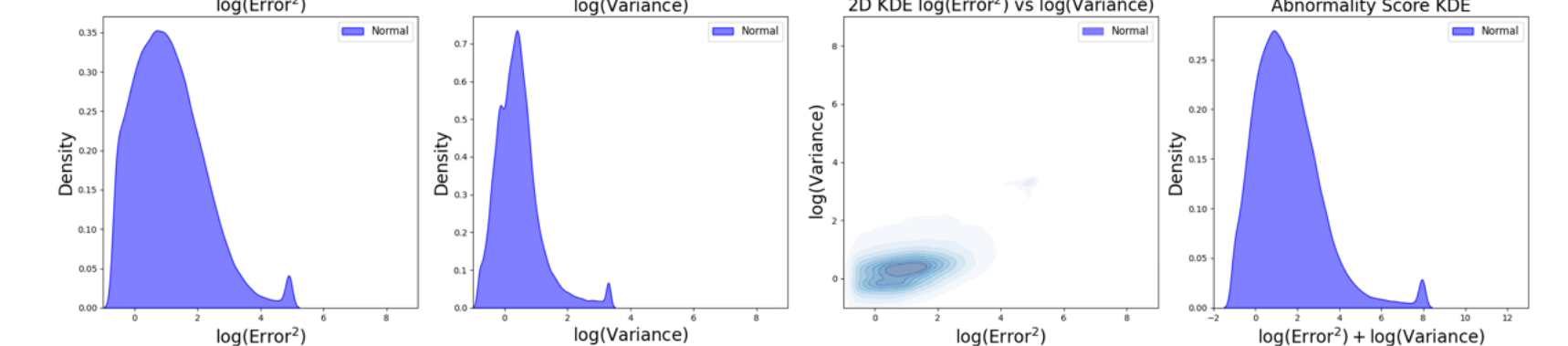


IXI Input Heatmap

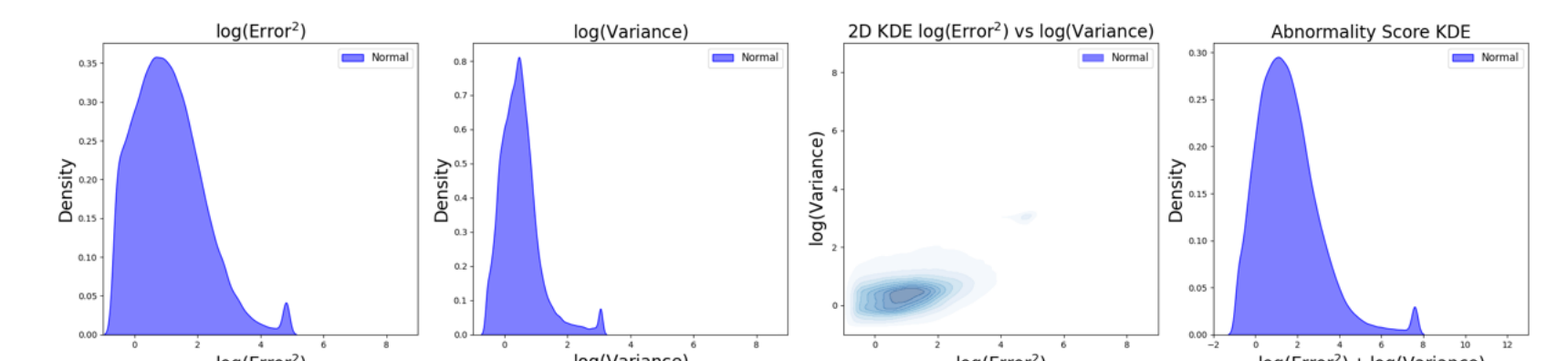


Heatmap colormap ranges from 0 (blue) to 12 (red).

T1 for IXI n=161



T2 for IXI n=161



Acknowledgements

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	BraTS21 (T2)		MSLUB (T2)		ATLAS (T1)		WMH (T1)	
Model	[DICE] [%]	AUPRC [%]	[DICE] [%]	AUPRC [%]	[DICE] [%]	AUPRC [%]	[DICE] [%]	AUPRC [%]
<i>Thresh</i> (Meissen et al., 2022a)	30.26	20.27	7.65	4.23	4.66	1.71	10.32	4.72
VAE (Baur et al., 2021)	33.12 ± 1.12	25.74 ± 1.37	8.10 ± 0.18	4.48 ± 0.18	15.63 ± 0.73	11.44 ± 0.5	7.60 ± 0.28	3.86 ± 0.40
SVAE (Behrendt et al., 2022)	36.43 ± 0.36	30.3 ± 0.45	8.55 ± 0.11	4.8 ± 0.09	10.32 ± 0.53	6.84 ± 0.44	7.18 ± 0.07	2.97 ± 0.06
AE (Baur et al., 2021)	36.04 ± 1.73	28.8 ± 1.72	9.65 ± 0.97	5.71 ± 0.80	14.04 ± 0.6	10.16 ± 0.53	7.34 ± 0.08	3.43 ± 0.14
DAE (Kascenas et al., 2022)	48.82 ± 3.68	49.38 ± 4.18	7.57 ± 0.61	4.47 ± 0.69	15.95 ± 0.69	13.37 ± 0.62	12.02 ± 1.01	8.54 ± 1.02
RA (Bercea et al., 2023b)	16.75 ± 0.51	9.98 ± 0.43	3.96 ± 0.03	1.92 ± 0.04	12.21 ± 0.98	8.75 ± 0.93	6.04 ± 0.45	3.15 ± 0.31
PHANES (Bercea et al., 2023c)	28.42 ± 0.91	21.29 ± 1.06	6.11 ± 0.27	2.98 ± 0.07	17.62 ± 0.41	13.81 ± 0.48	7.55 ± 0.17	3.87 ± 0.13
FAE (Meissen et al., 2022b)	44.59 ± 2.19	43.63 ± 0.47	6.85 ± 0.65	3.85 ± 0.08	17.76 ± 0.16	13.91 ± 0.10	8.81 ± 0.38	4.77 ± 0.26
DDPM (Wyatt et al., 2022)	50.27 ± 2.67	50.61 ± 2.92	9.71 ± 1.29	6.27 ± 1.58	20.18 ± 0.58	17.77 ± 0.47	12.06 ± 0.97	8.89 ± 0.89
pDDPM (Behrendt et al., 2024)	53.61 ± 0.51	55.08 ± 0.54	12.83 ± 0.40	10.02 ± 0.36	19.92 ± 0.24	17.84 ± 0.10	10.13 ± 0.53	7.52 ± 0.56
cDDPM (Behrendt et al., 2025)	56.30 ± 1.25	58.82 ± 1.56	14.04 ± 1.16	10.97 ± 1.17	24.22 ± 1.10	22.22 ± 1.15	11.59 ± 0.93	9.26 ± 1.07
Patch2Loc (Ours)	59.50 ± 1.45	55.40 ± 1.30	14.30 ± 1.40	8.70 ± 1.20	25.50 ± 0.73	22.00 ± 1.70	15.70 ± 1.70	10.10 ± 1.70

Comparison of the evaluated models with the best results highlighted in bold, and second best italicized. For maximum dice score and average (Dice) and the area under the precision-recall curve (AUPRC), the mean±standard deviation across the IXI training folds are reported.