

Abstract

- Heterogeneous Earth Observation data
- Distribution shifts at inference time



Sensor changes

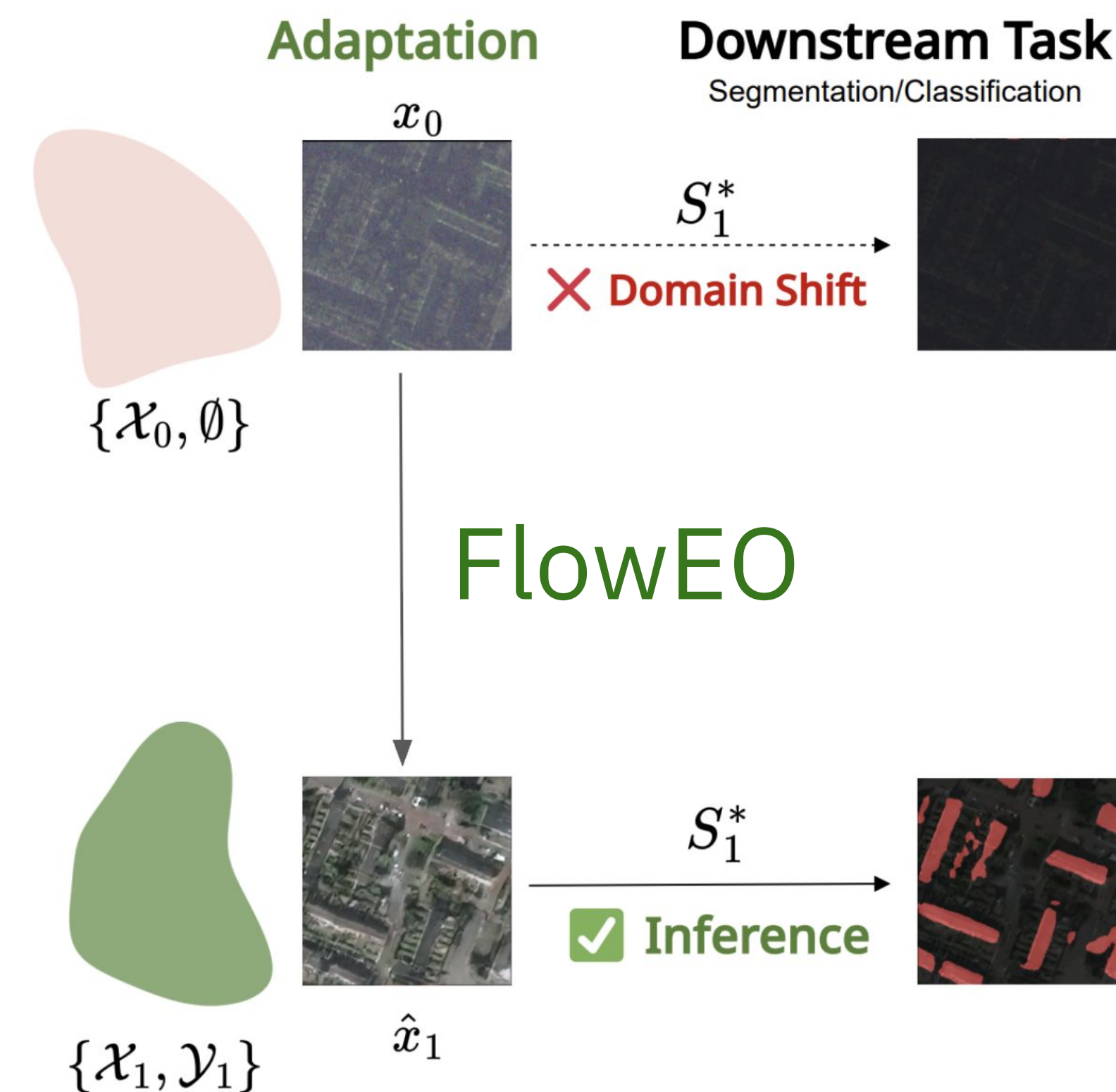
Flooding

→ **Obstacle to the use of pretrained models**

We want a domain adaptation method that is:

- Unsupervised
- Independent of the predictive model used at inference time
- In pixel space (+ dense downstream tasks, + explainability + visual control)

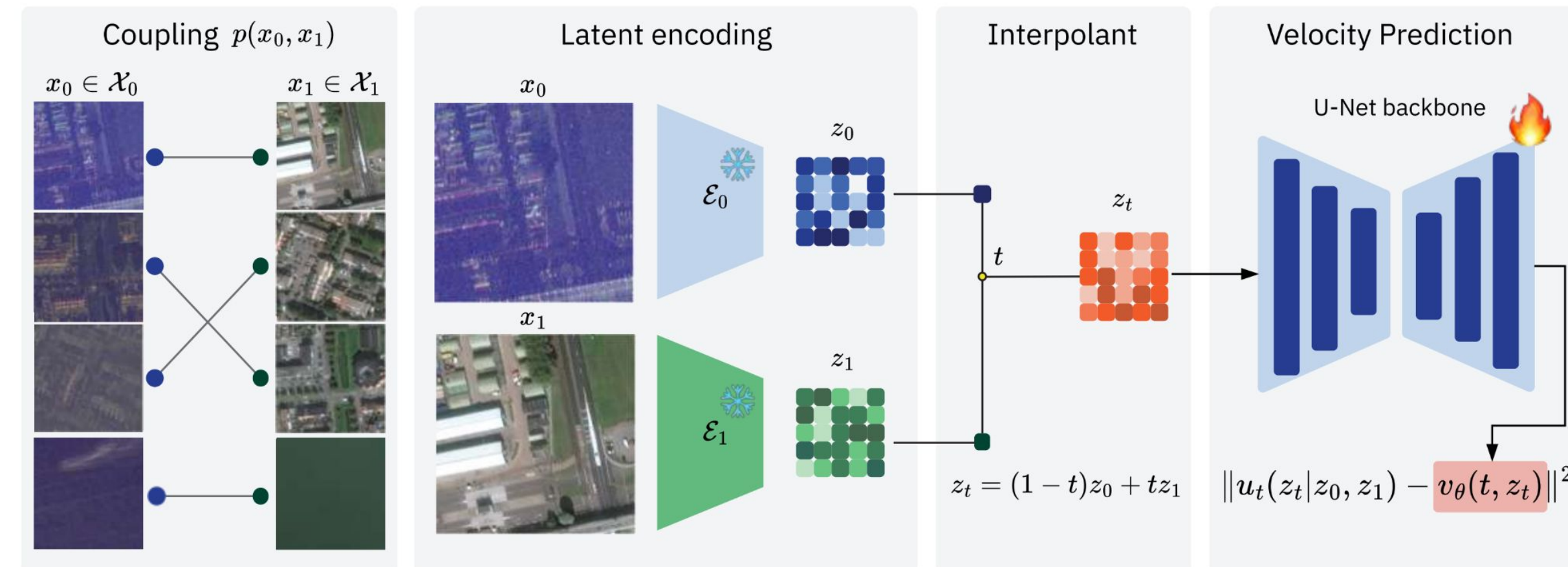
→ **IDEA: latent flow matching for UDA**



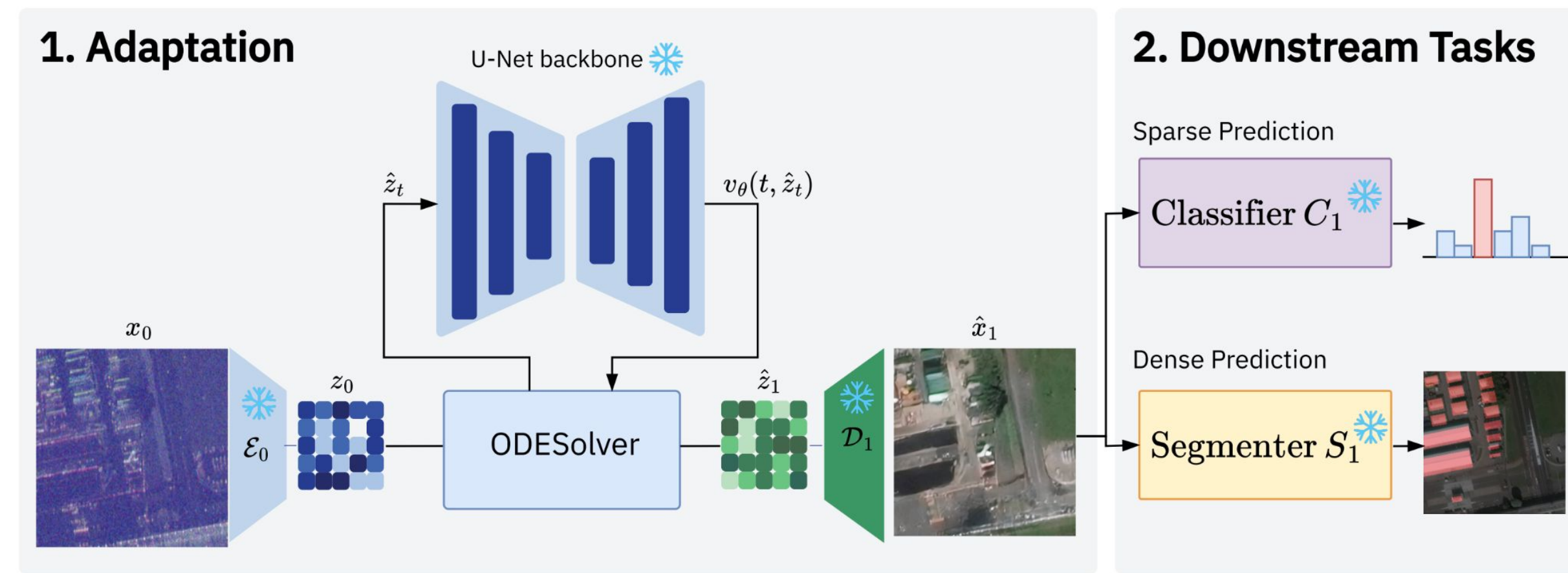
FlowEO

- Unsupervised Domain Adaptation
- Image-to-image translation
- Data-dependent coupling
- Latent flow matching

Training



Inference



Evaluation

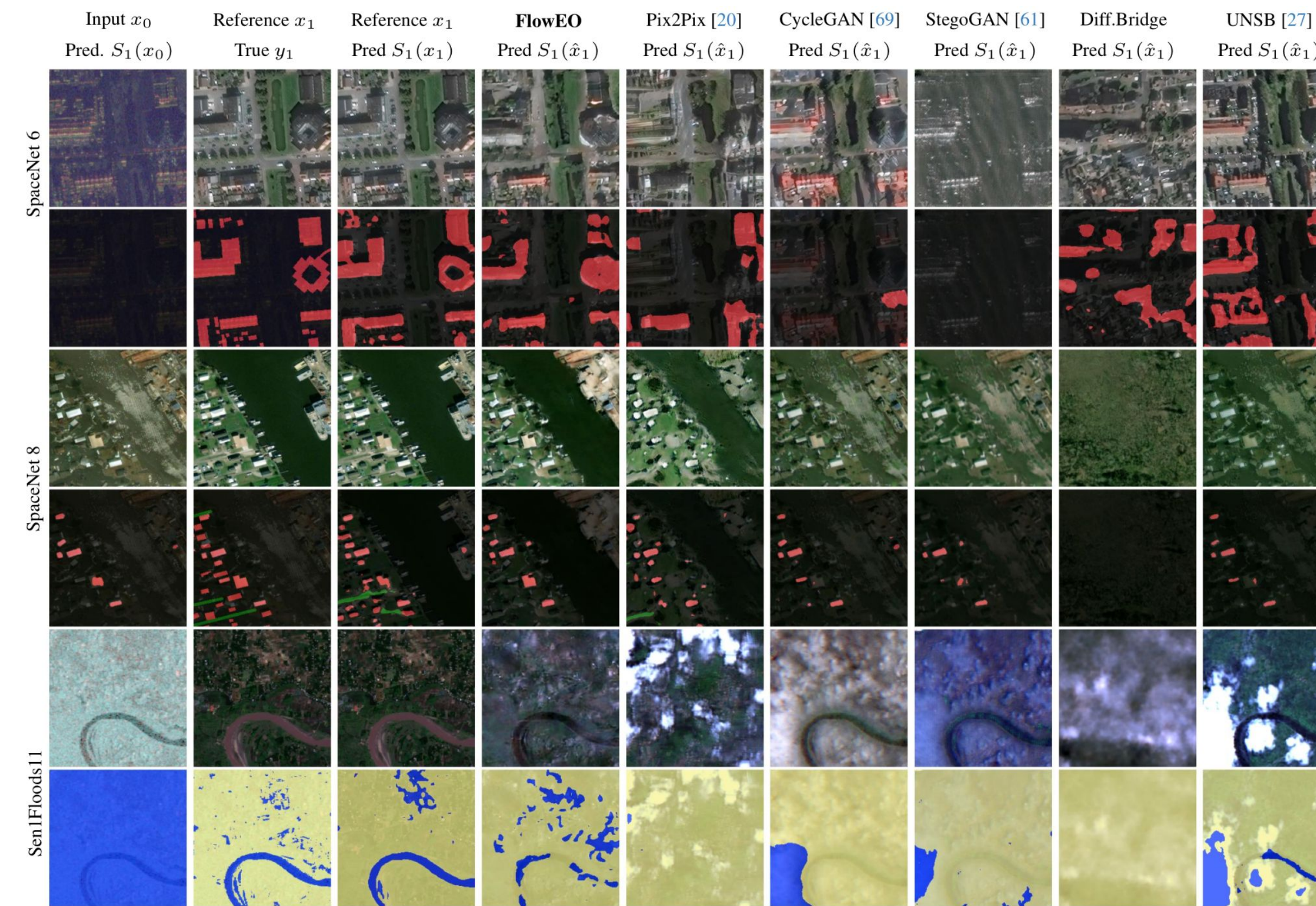
Domain adaptation metrics:

1. Transfer initial image with FlowEO
2. Inference with pretrained predictive model
3. Compute segmentation (mIoU, mAcc) or classification metrics (AP, F1 score)

Generative Metrics:

1. Transfer initial image with FlowEO
2. Compute LPIPS with reference image, compute FID

Results



Quantitative results

Strongly aligned datasets

Datasets	Sen1Floods1				SpaceNet 6				ReBEN					
	SAR → Optical	FID	LPIPS	mIoU	mAcc	FID	LPIPS	AP ^M	AP ^M	SAR → Optical	F1 ^M	FID	LPIPS	
No adaptation	06.22	49.72	297.22	84.84	31.94	41.01	275.05	79.48	17.46	17.43	02.31	01.31	339.36	85.99
Upper bound	55.14	71.28	00.00	00.00	84.94	90.74	00.00	00.00	79.26	65.28	74.28	62.84	00.00	00.00
Pix2Pix	51.50	62.31	20.64	31.33	56.48	63.43	130.42	41.89	41.09	27.88	43.93	25.79	62.84	17.56
CycleGAN	42.12	48.47	20.97	36.35	50.01	55.85	132.75	50.72	26.09	19.79	26.93	15.75	81.54	19.67
UNSB	42.69	48.85	23.01	35.01	52.43	61.04	72.48	45.81	25.61	20.71	29.52	19.45	113.73	35.64
Diffusion Bridge	42.41	50.31	18.71	39.93	51.22	58.37	94.15	46.37	18.44	15.79	24.43	05.80	80.97	20.74
StegoGAN	43.37	49.75	41.06	31.87	44.87	50.02	306.50	56.62	26.13	22.16	29.49	20.28	81.15	22.32
FlowEO	54.92	69.04	12.96	29.21	65.07	72.33	94.02	39.96	37.16	32.14	36.04	25.72	75.80	15.51

Weakly aligned datasets

Datasets	SpaceNet 8				SpaceNet 8 Germany				SpaceNet 8 Louisiana						
	Post-flood → Pre-flood	mIoU ↑	mAcc ↑	FID ↓	LPIPS ↓	Post-flood → Pre-flood	mIoU ↑	mAcc ↑	FID ↓	LPIPS ↓	Post-flood → Pre-flood	mIoU ↑	mAcc ↑	FID ↓	LPIPS ↓
No adaptation	40.05	42.40	75.62	63.66	37.09	39.08	89.54	63.27	36.51	38.85	96.60	63.80	63.80	63.80	63.80
Upper bound	63.10	72.09	00.00	00.00	55.27	66.77	00.00	00.00	66.91	75.97	00.00	00.00	00.00	00.00	00.00
Pix2Pix	34.73	36.08	98.22	50.95	32.92	34.25	98.38	55.75	38.79	40.86	92.23	47.05	47.05	47.05	47.05
CycleGAN	40.70	43.35	54.31	55.70	39.35	41.79	62.80	59.46	42.39	45.14	52.80	52.92	52.92	52.92	52.92
UNSB	39.35	42.67	68.30	55.35	38.25	40.62	66.62	56.84	40.67	43.87	73.72	53.04	53.04	53.04	53.04
Diffusion Bridge	37.50	39.36	115.70	53.13	33.91	35.27	177.23	58.53	39.05	41.37	105.27	51.25	51.25	51.25	51.25
StegoGAN	38.62	40.58	66.61	58.07	36.74	38.78	90.42	63.50	40.14	42.29	68.56	54.58	54.58	54.58	54.58
FlowEO	44.65	48.79	60.32	45.50	41.27	45.29	82.74	53.63	47.19	52.30	59.65	41.95	41.95	41.95	41.95

Discussion

- FlowEO achieves the best domain adaptation scores for segmentation datasets
- FlowEO is competitive on classification datasets
- FlowEO is robust to weakly aligned training pairs, e.g. before/after flooding datasets:



Future Work

- New couplings for unaligned datasets (e.g.. geographical domain adaptation)
- FlowEO in new scenarios:
 1. Missing modality: generate the missing modality to leverage multi-modal predictive models
 2. Data-augmentation with generated data

Bluesky

ArXiv

