Satellite-Driven Crop Type Classification with Deep Generative Models

Confirmation Assessment Presentation

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Outline

Research Aims & Objectives

- **Research Problem:** Variability induced by geographical and temporal changes impedes the generalizability of the existing deep crop type classification models.
- **Hypothesis:** Non-probabilistic deep models cannot identify the underlying generative process that should be sufficiently flexible to account for the variability in observed data.

Research Aims & Objectives

- **Research Gap:** There is almost no work on probabilistic deep models for SITS-based crop type classification.
- **Contributions of My PhD Research:** Developing crop type classification algorithms that are more generalizable in terms of geographical and temporal variations and more data efficient with latest developments in deep generative models.

Literature Review:
SITS-based Crop Analytics

Conventional Machine Learning Algorithms: Support Vector Machines (SVMs), Random Forests (RFs), Probabilistic Graphical Models (PGMs);

Deep Learning Models: Recurrent Neural Networks (RNNs), Temporal Convolution Neural Networks, Transformers, and the hybrid models.

Literature Review: Deep Generative Models

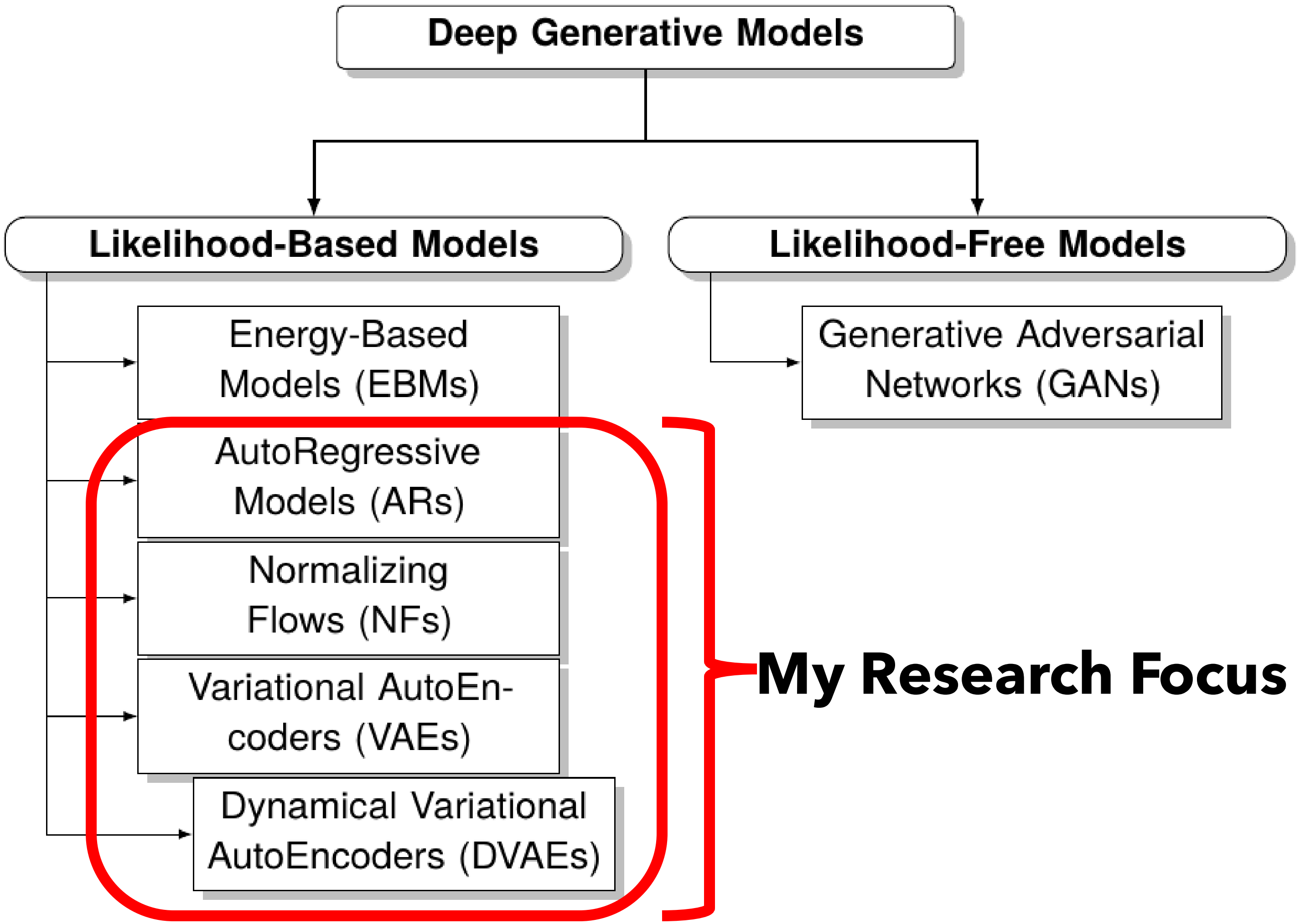
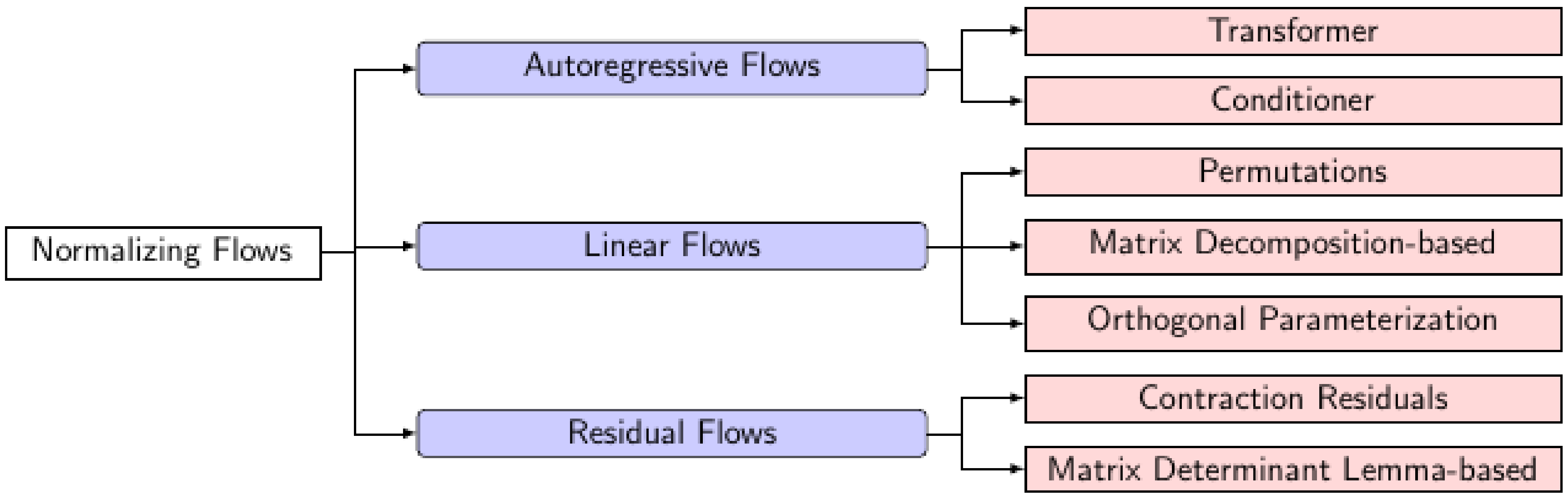


Figure 1: The taxonomy of deep generative models.

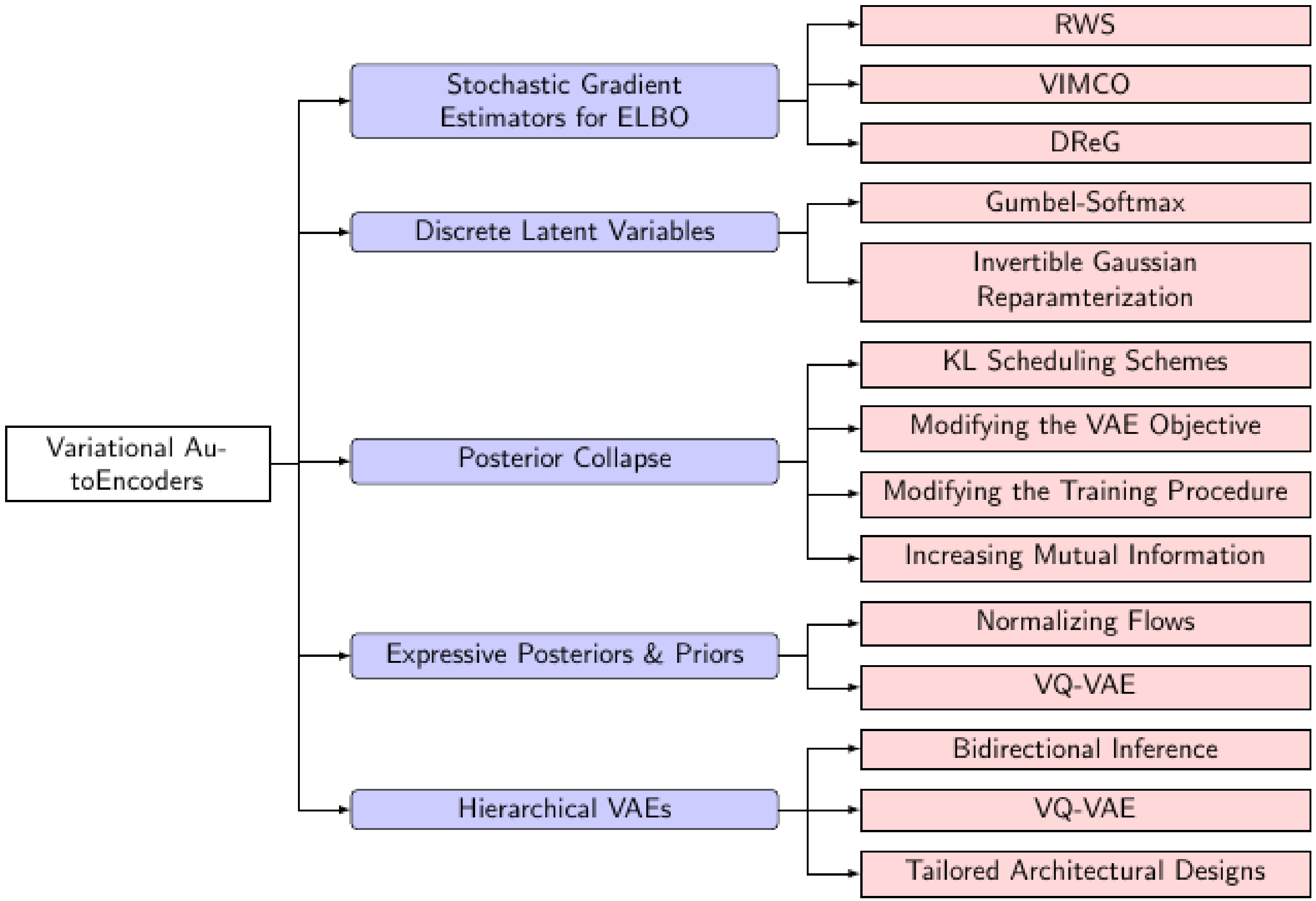
Literature Review: Deep Generative Models

- **Normalizing Flows (NFs)**



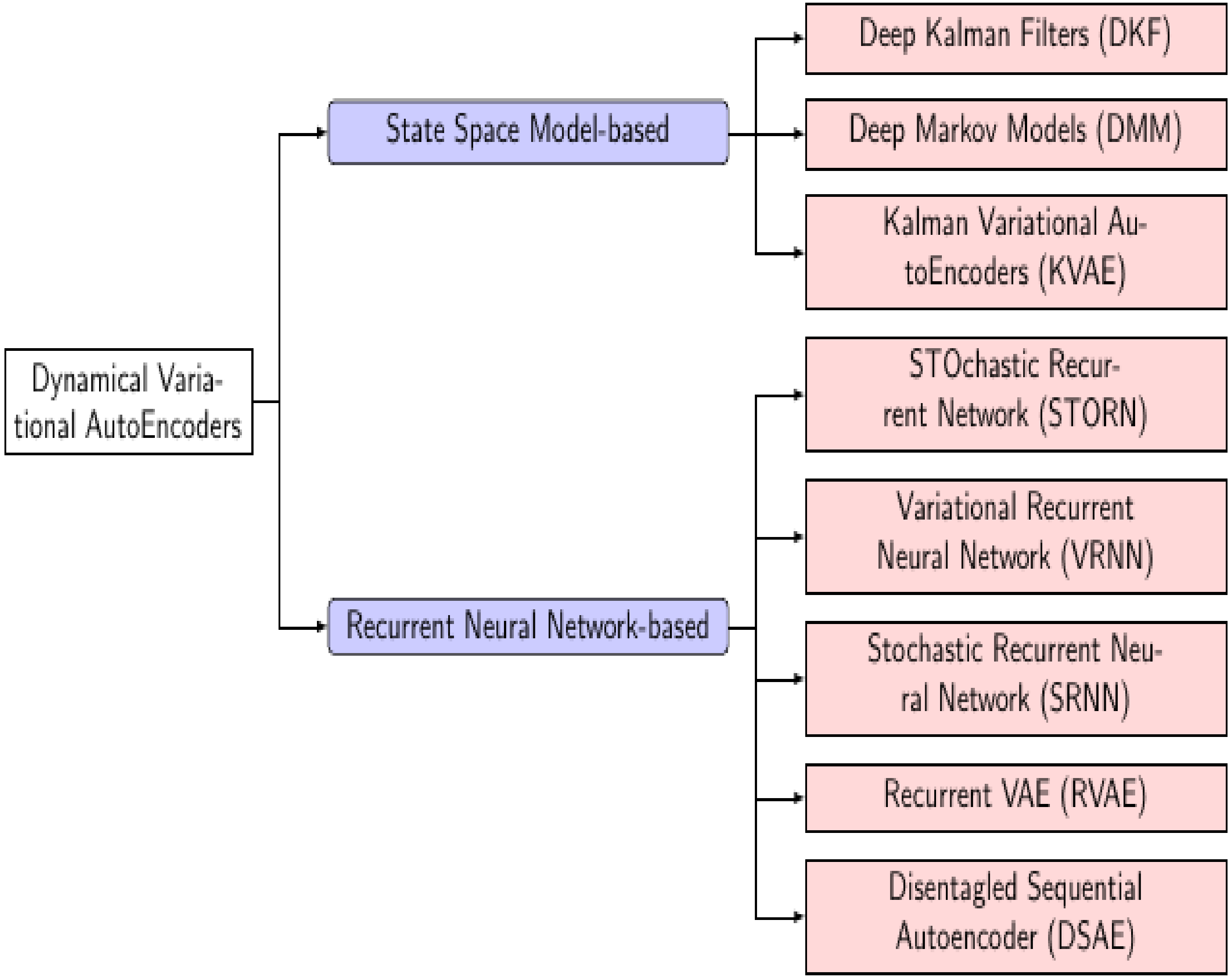
Literature Review: Deep Generative Models

- **Variational AutoEncoders (VAEs)**



Literature Review: Deep Generative Models

- **Dynamical Variational AutoEncoders (DVAEs)**

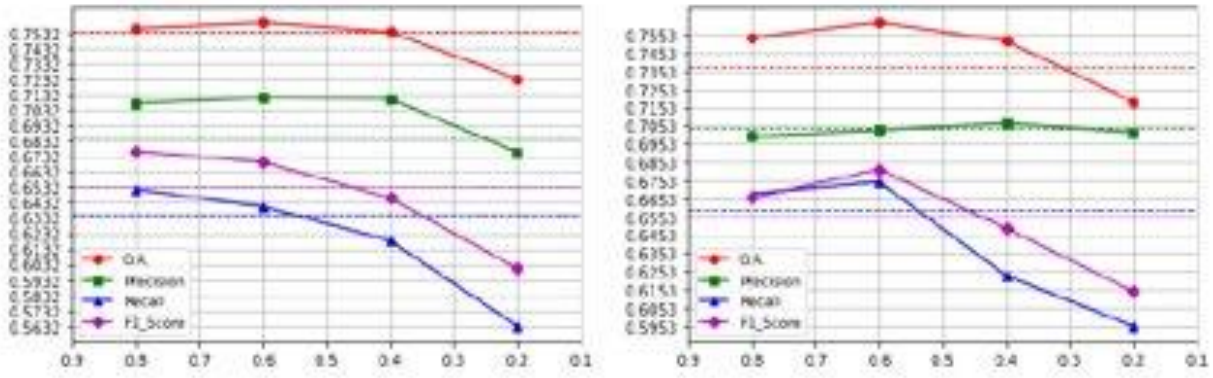


A Preprint Paper on VAEs

- Applying VAEs with discrete latent variables to improve accuracy for crop type classification and extend the model to perform semi-supervised learning.
- Making technical improvements in mitigating posterior collapse problem.

Table 5: Comparison of our proposed and state-of-the-art models on DENETHOR test dataset.

	O.A.%	Precision%	Recall%	F1 Score%
PSE+TAE [8]	64.95	–	–	54.50
PSE+L-TAE [7]	67.25	–	–	58.12
PTST	70.29	61.27	56.72	56.14
VAE-PTST	**73.78**	**70.37**	**65.96**	**65.50**



(a) South Africa (b) Germany/DENETHOR

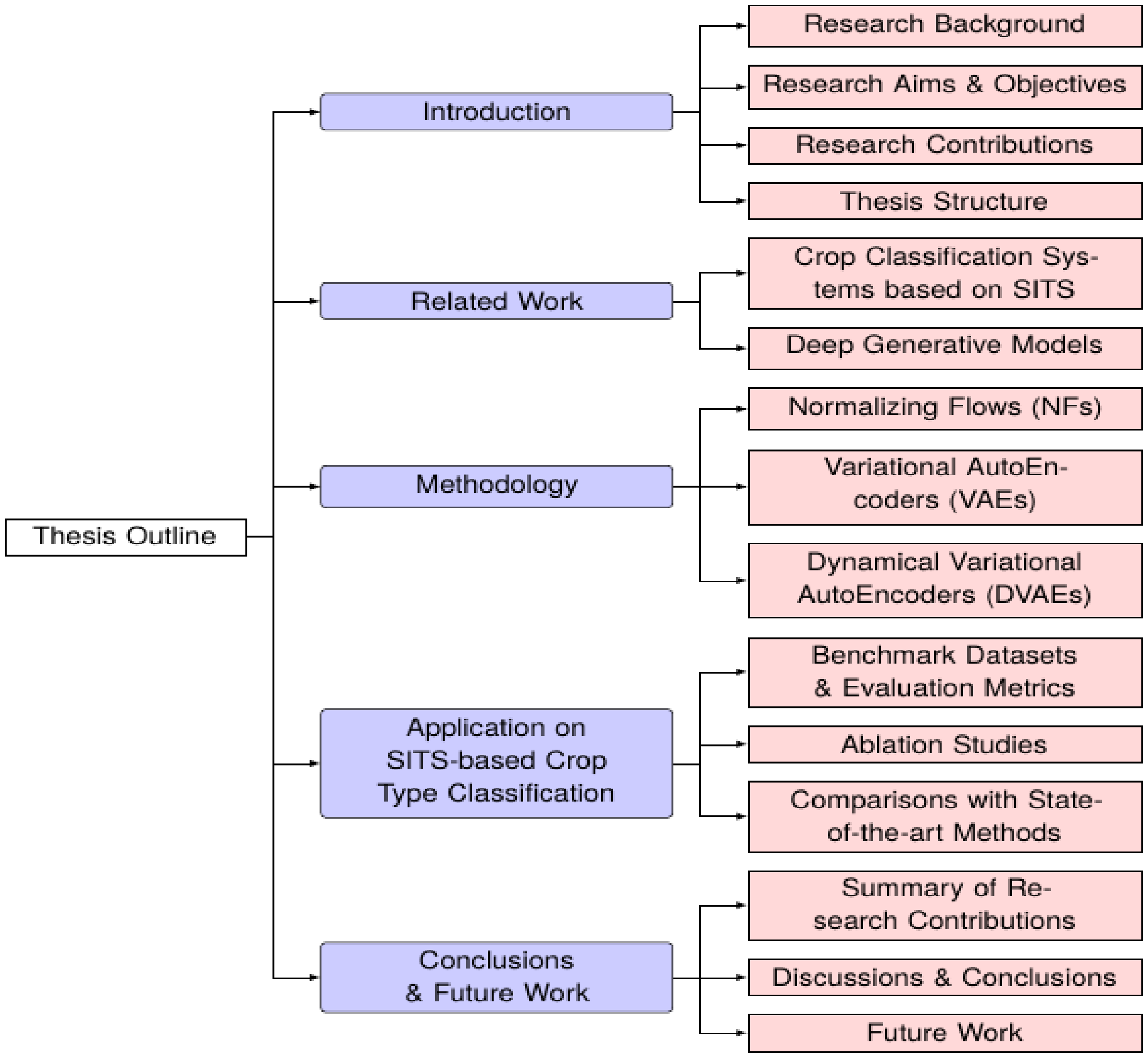
Fig. 1: Classification performance of VAE-PTST on South Africa and Germany test datasets with partially labelled data. N.B., figures are based on predictions of the recognition component. Please refer to Tab. 3 and 4 in the Supplementary Material for detailed results.

Benchmark Datasets

Table 1: An overview of publicly available benchmark datasets for crop type mapping. "TS" and "ST" in the column "Format" stand for *Time Series* and *Spatio-Temporal*, respectively. "S1", "S2", "PF", "M", and "T" in the column "Modality" denote *Sentinel-1, Sentinel-2, Planet Fusion, Meteorological Data, and Topographic Data*, respectively.

Source	Area of Focus	Format	Modality	# Fields	Temporal Density	Temporal Shift
BREIZHCROPS [98]	France	TS	S2	6.1×10^5	$\geq$ 5 days	✓
TimeSen2Crop [99]	Austria	TS	S2	1.1×10^6	$\geq$ 5 days	✓
DENETHOR [1]	Germany	ST	S1+S2+PF	4.5×10^3	Daily	✓
EUROCROPS [100]	EU Member States	TS	S2	8×10^5	$\geq$ 5 days	✓
CropHarvest [101]	Global	TS	S1+S2+M+T	9×10^4	Monthly	✓

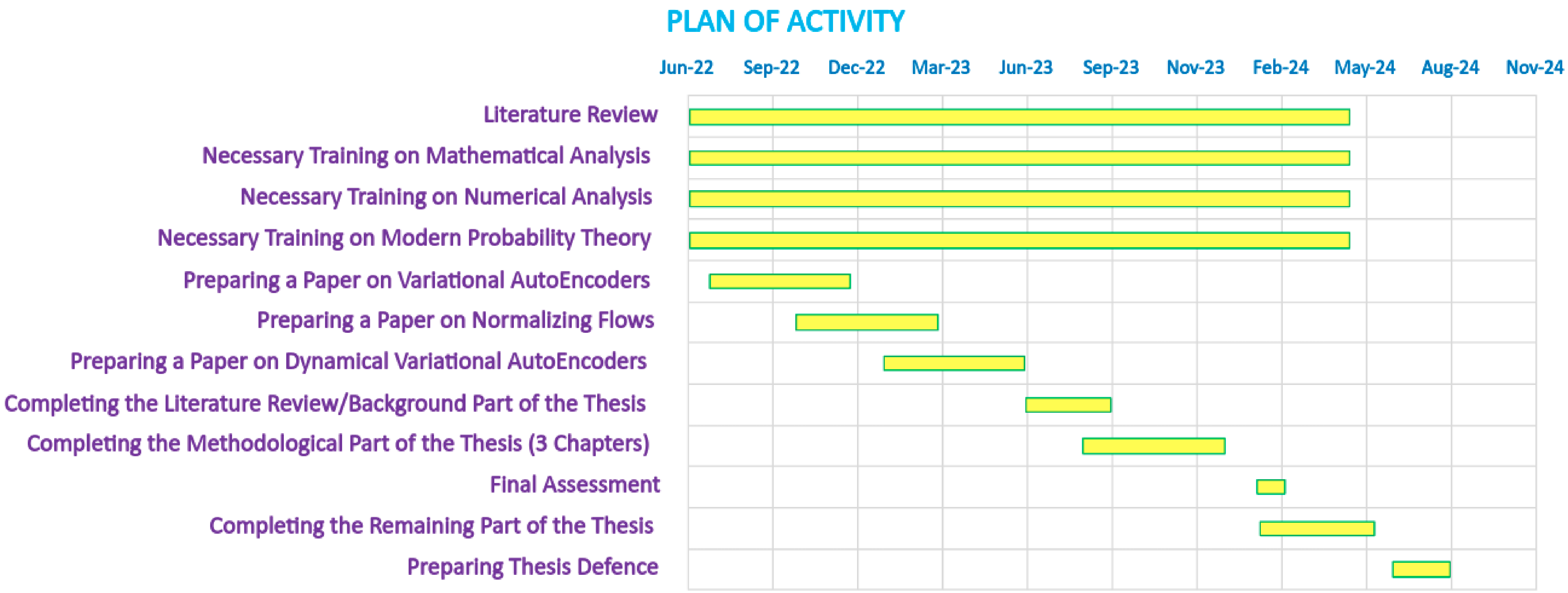
Thesis Outline



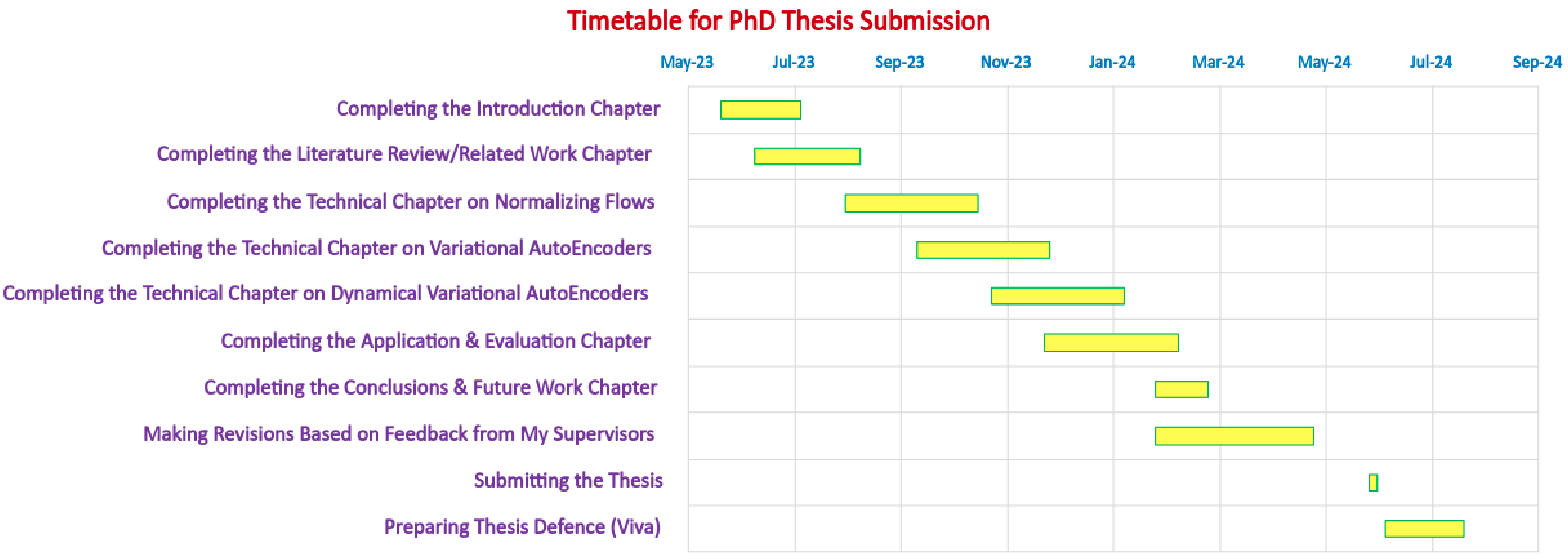
Work to Date

- Conducted a literature review on crop type classification, SITS analysis, deep generative models, deep semi-/un- supervised learning, and deep neural architecture designs;
- Acquired an intermediate level of knowledge and skill in performing parallel training of deep neural nets on SLURM-based High-Performance Computing (HPC) facilities;
- Built a pipeline to process raw SITS for crop type classification;
- Participated in AI4Food Security Challenge and submitted final solutions;
- Had a preprint entitled "Tampered VAE for Improved Satellite Image Time Series Classification" on arXiv.

Future Research Activities



Timeline of Completing PhD Thesis

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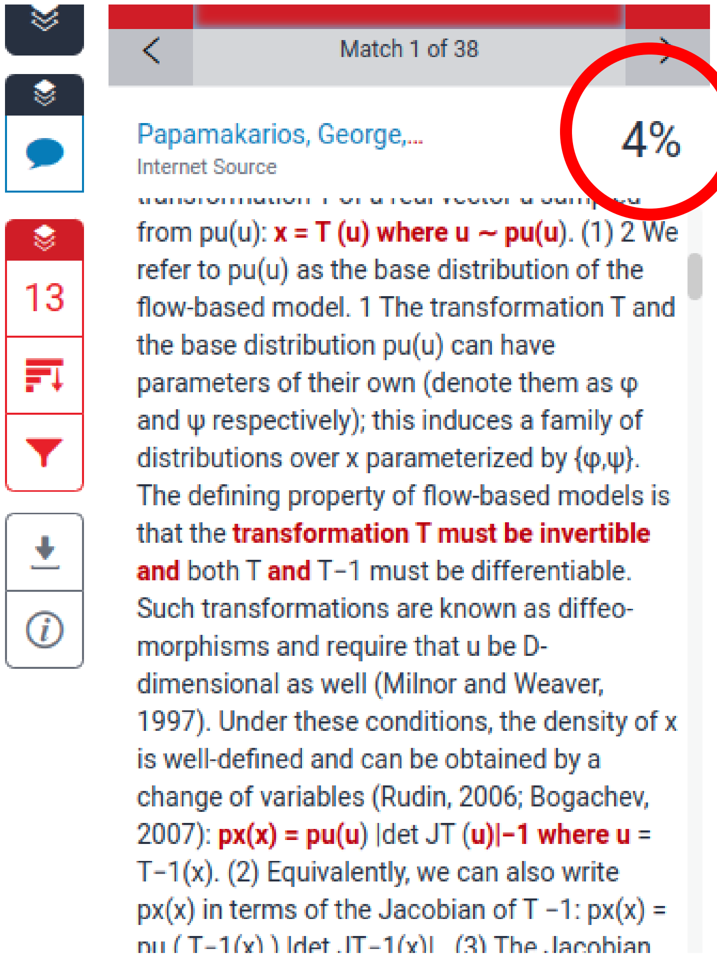

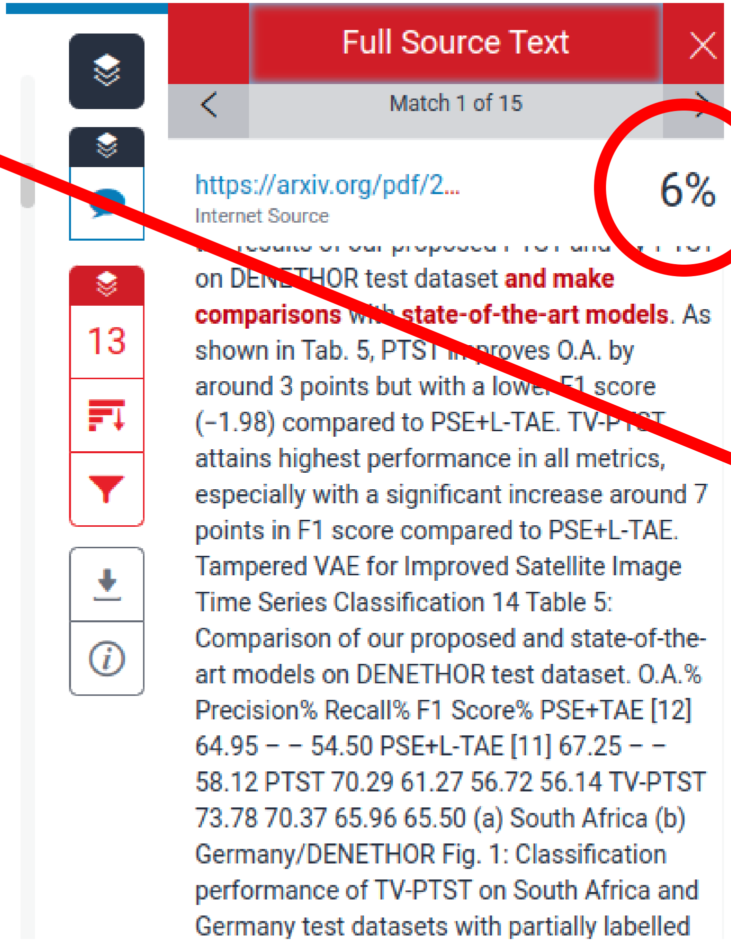

- Tampered VAE for Improved Satellite Image Time Series Classification (https://arxiv.org/abs/2203.16149)
- Normalizing Flows for Probabilistic Modeling and Inference (https://arxiv.org/abs/1912.02762)