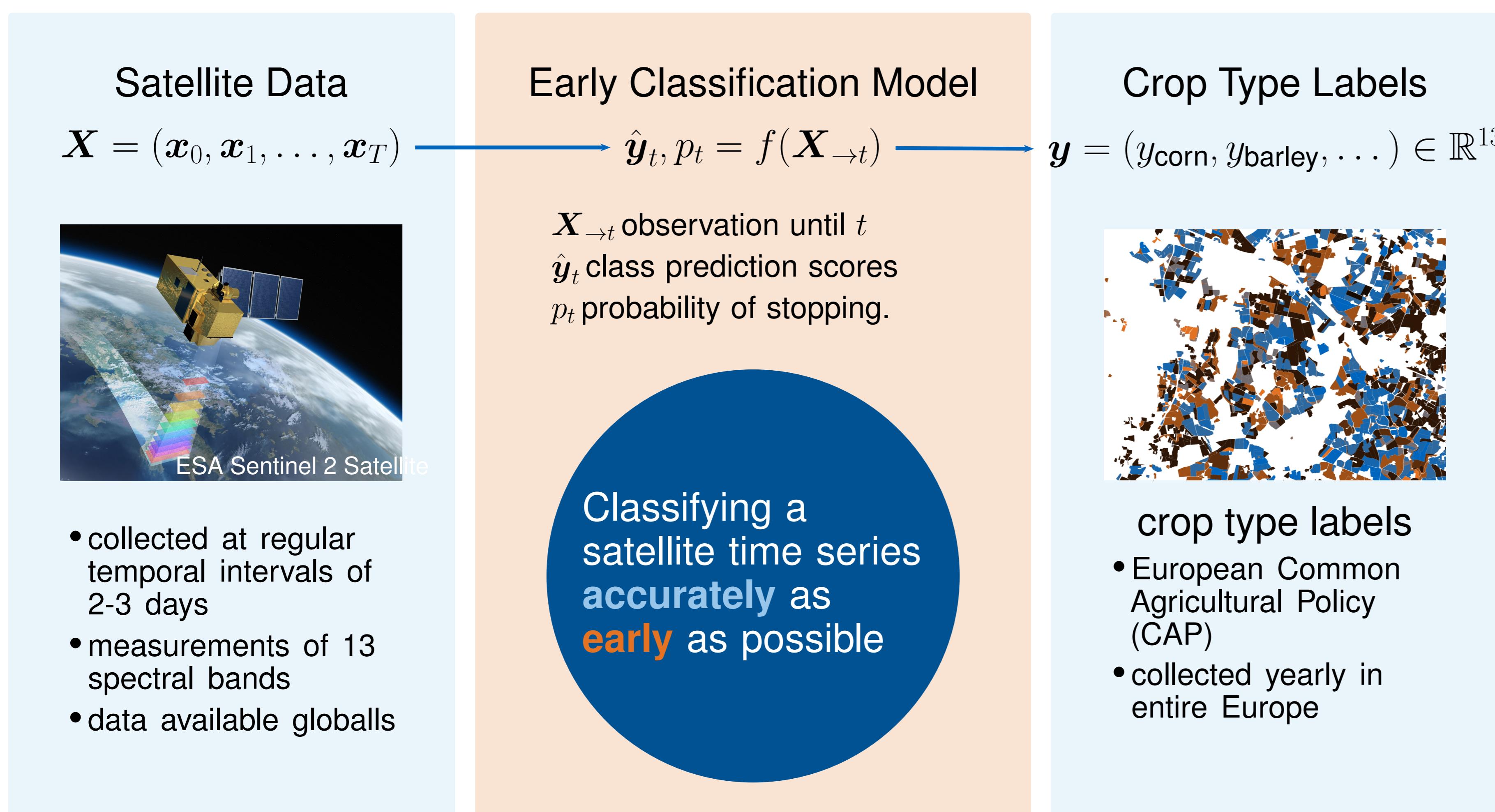


Early Classification for Agricultural Monitoring from Satellite Time Series

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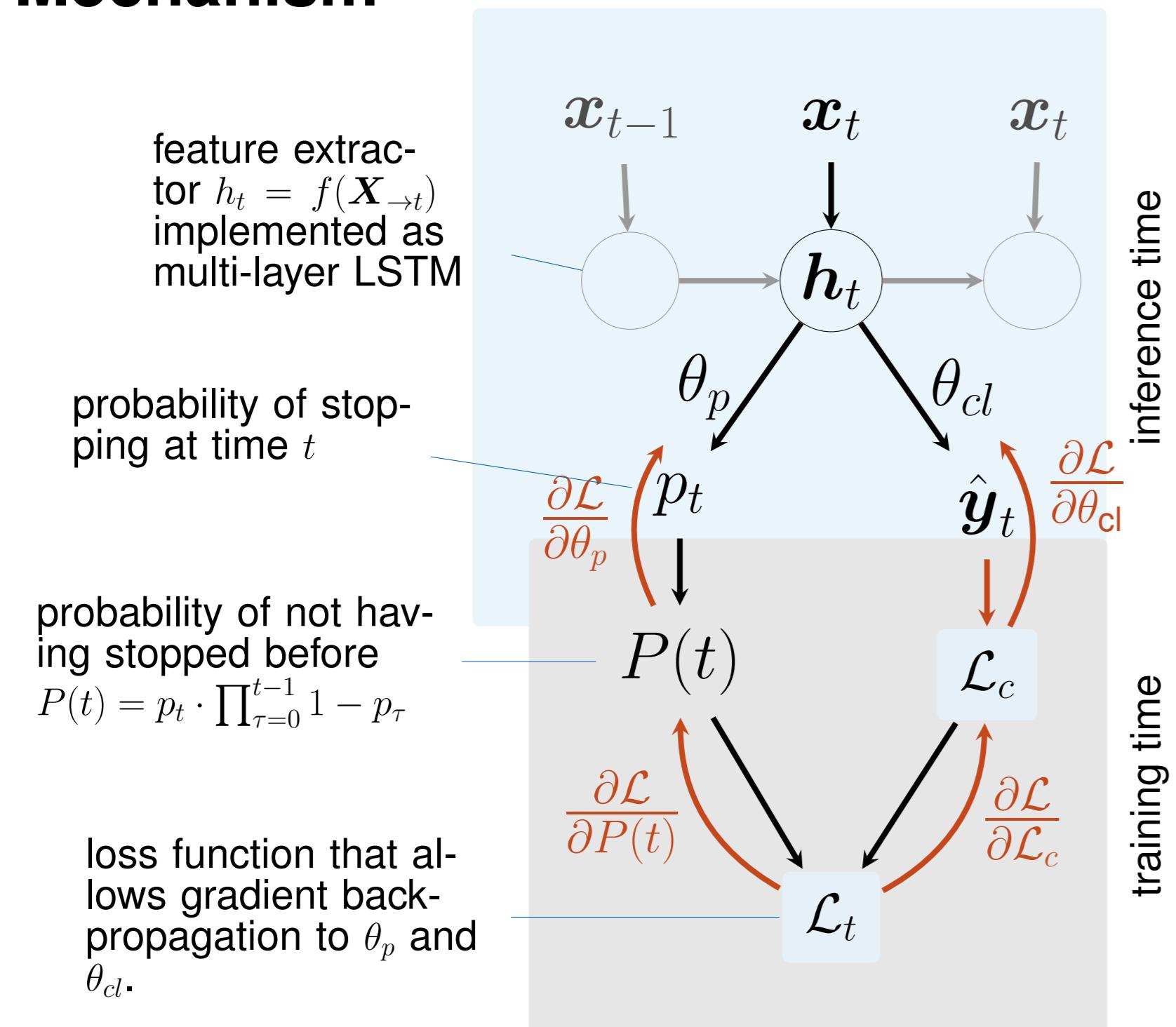
Objective



Method

Based on previous work (Rußwurm et al., 2019) applied to crop type mapping from remote sensing data.

Mechanism



Rußwurm, M., Lefèvre, S., County, N., Emonet, R., Körner, M., and Tavenard, R. End-to-end learning for early classification of time series. arXiv preprint arXiv:1901.10681, 2019.

Application

Agriculture

Early Crop Detection

- early assessment of cultivated crops
- basis for early crop yield estimation

Extraction of Crop Phenology

- extraction of vegetation specific events
- monitoring time of classification
- regional or temporal variations

Generalization

- end-to-end trainable
- applicable globally
- no region-specific expert knowledge

Loss function

composite loss function

$$\mathcal{L}(\mathbf{x}, \mathbf{y}) = \sum_{t=0}^T P(t; \delta_{\rightarrow t}) \mathcal{L}_t(\mathbf{X}_{\rightarrow t}, \mathbf{y})$$

A Loss function including accuracy and earliness

$$\mathcal{L}_t(\mathbf{X}_{\rightarrow t}, \mathbf{y}) = \alpha \mathcal{L}_c(\mathbf{X}_{\rightarrow t}, \mathbf{y}) - (1 - \alpha) \mathcal{R}_e(t, \hat{y}_t^+)$$

$$\mathcal{L}_c = -\log(\hat{y}_t^+)$$

cross entropy loss for accurate classifications

$$\mathcal{R}_e(t, \hat{y}_t^+) = \hat{y}_t^+ (1 - \frac{t}{T})$$

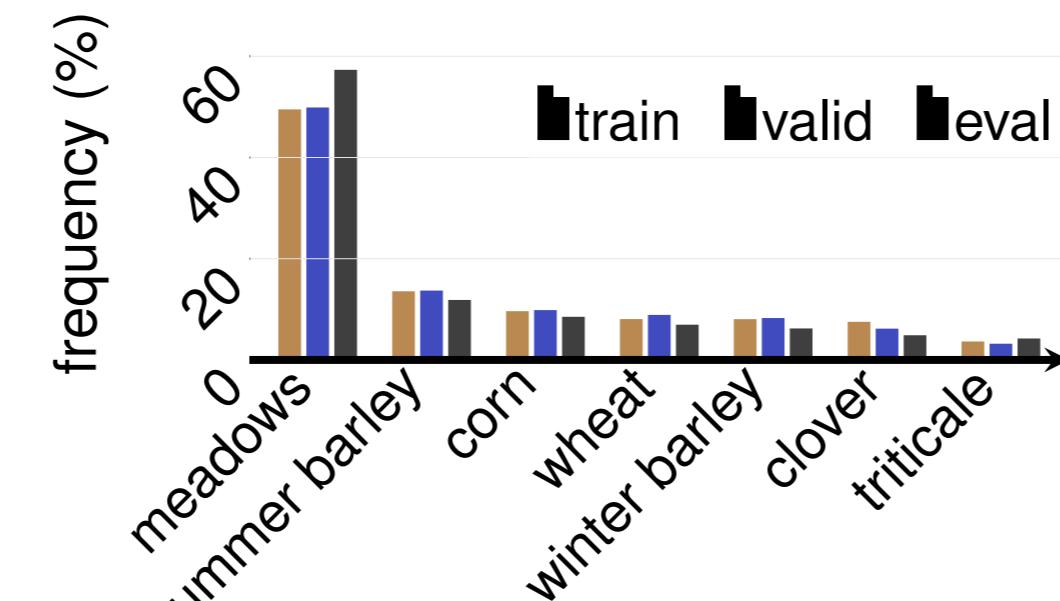
reduces loss for earlier classifications $1 - \frac{t}{T}$ if the correct class \hat{y}_t^+ has been predicted with a high score

Dataset and Area of Interest

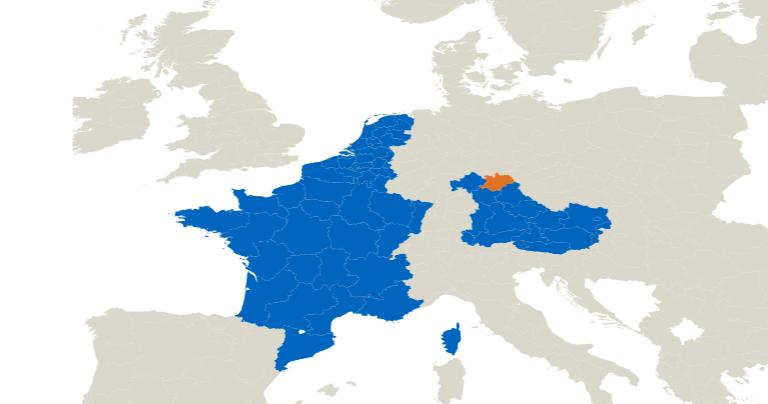
Hollfeld region Bavaria

- 49k field parcels
- 6 main crop types
- covering 40 by 30 km
- central germany

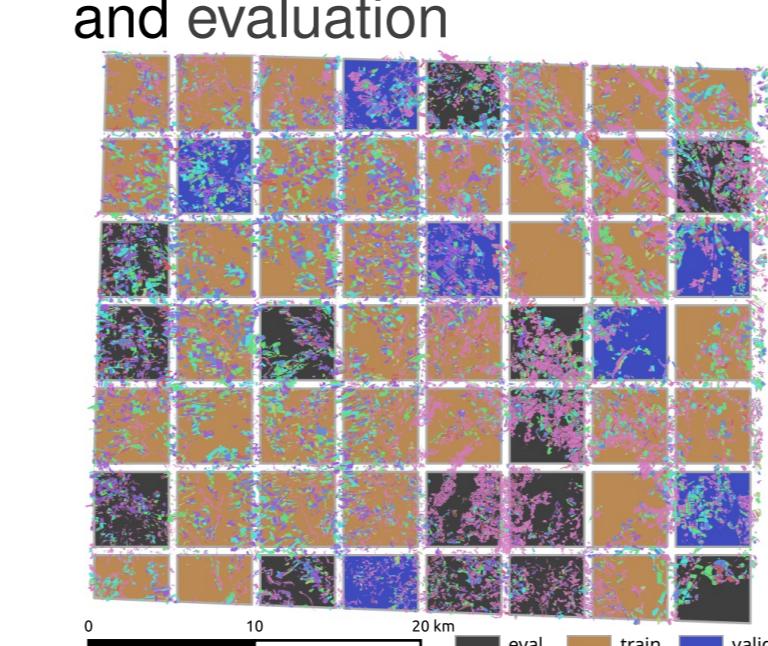
Challenge: Class imbalance



regions with labels and location of dataset

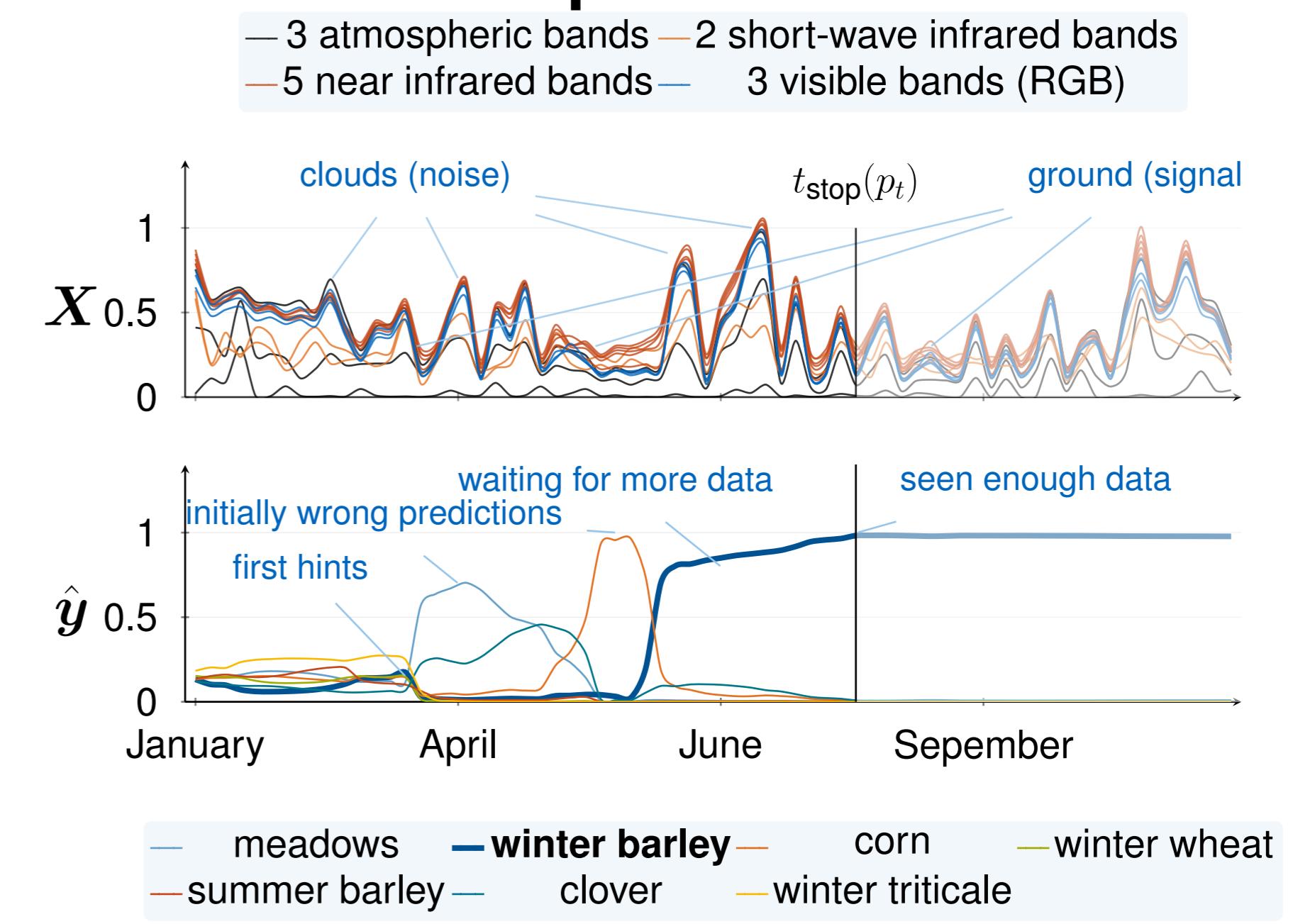


partition in train, validation, and evaluation



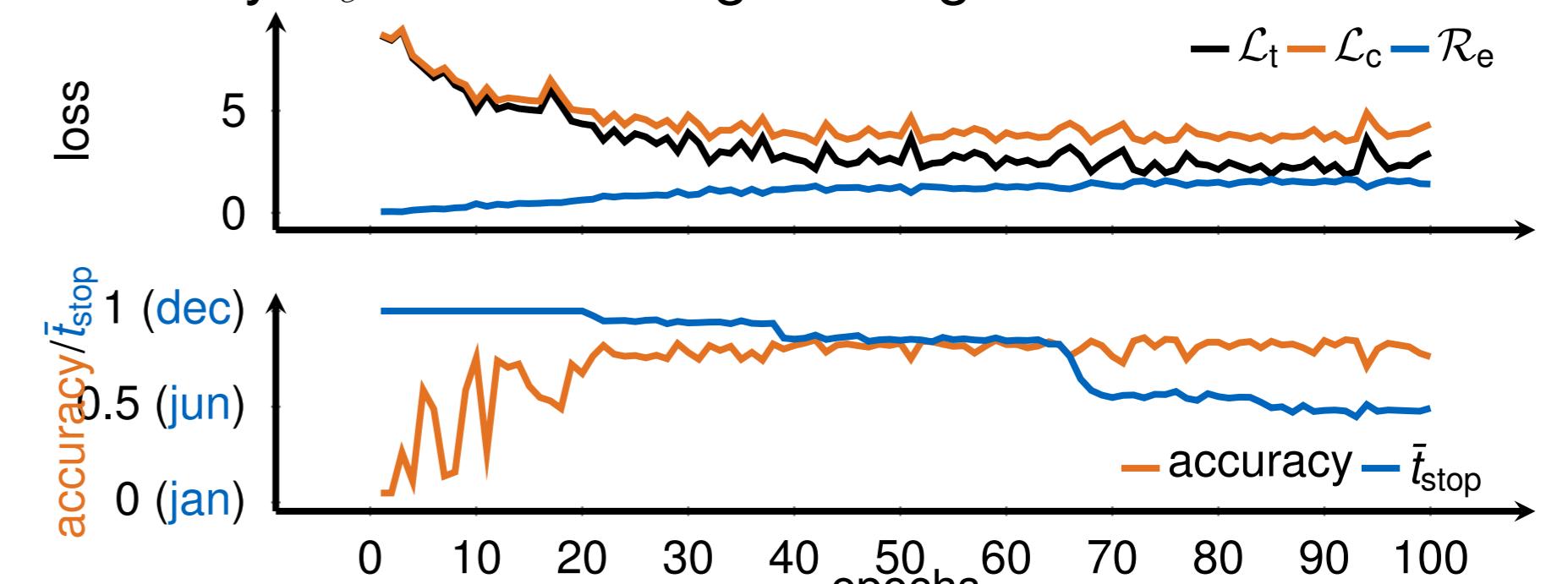
Results

Qualitative Example

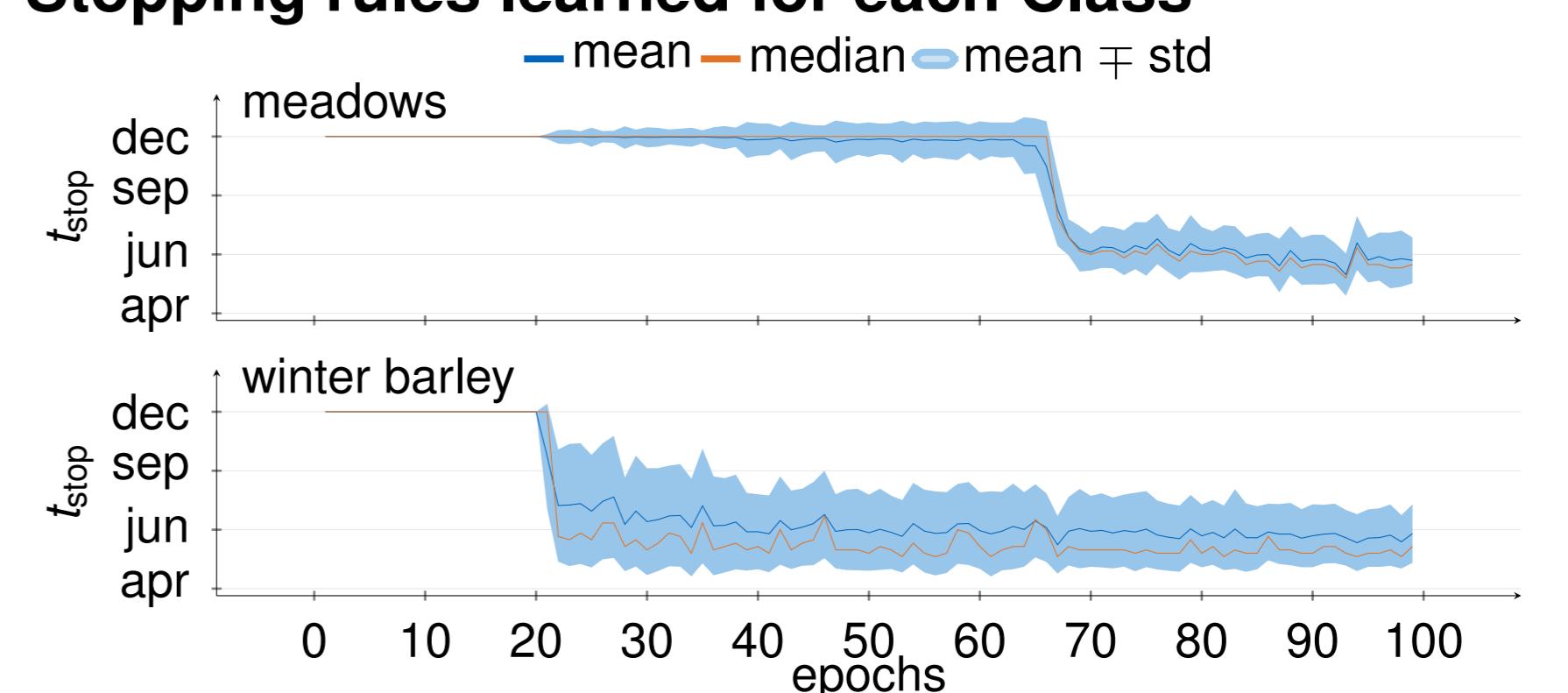


Losses during Training

The combined loss L_t , as well as earliness L_e and accuracy L_c losses during training.



Stopping rules learned for each Class



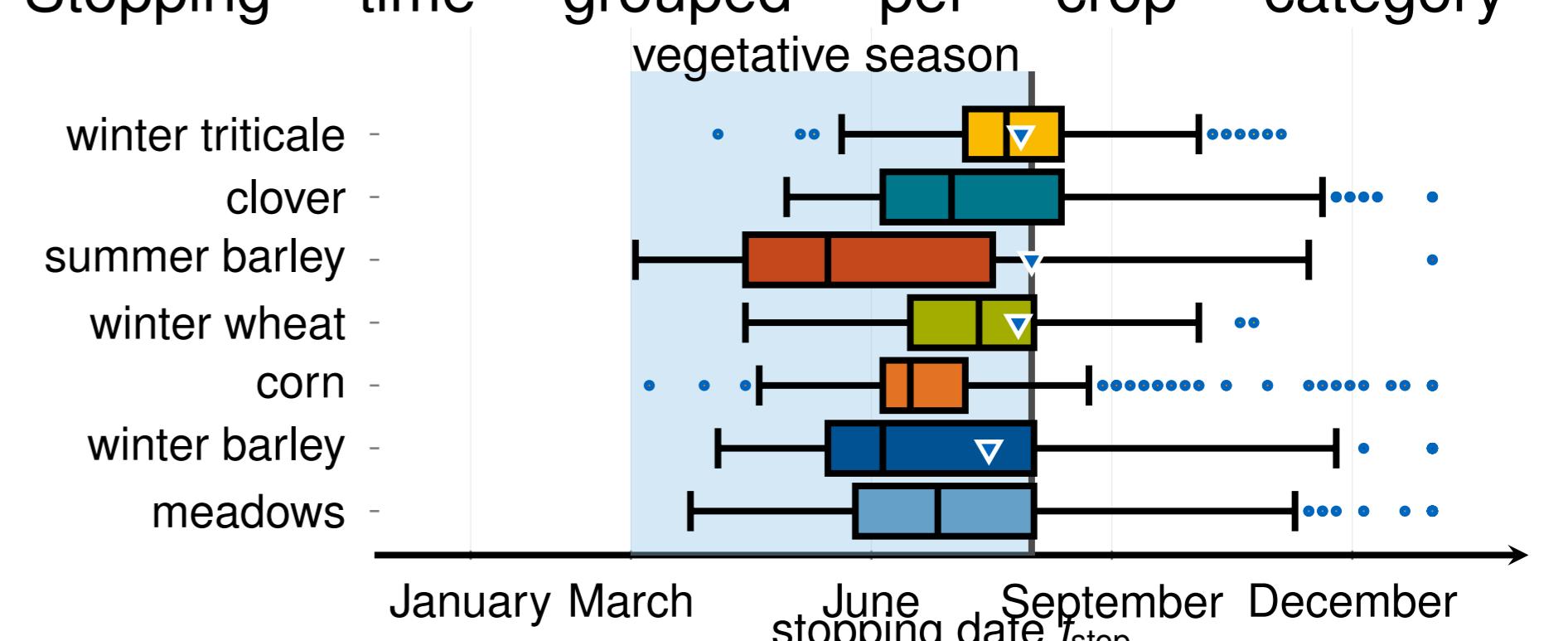
Balancing Earliness and Accuracy

α	accuracy	\bar{t}_{stop}	precision	recall	f_1	κ
.0	.25 ± .22	.10 ± .17	.19 ± .20	.25 ± .17	.16 ± .20	.12 ± .19
.2	.81 ± .03	.40 ± .02	.70 ± .01	.74 ± .01	.71 ± .01	.71 ± .04
.4	.80 ± .09	.47 ± .03	.71 ± .02	.74 ± .01	.71 ± .02	.71 ± .10
.6	.85 ± .02	.88 ± .07	.73 ± .04	.74 ± .03	.73 ± .03	.77 ± .03
.8	.84 ± .01	.93 ± .05	.72 ± .02	.75 ± .01	.73 ± .02	.76 ± .02
1.0	.83 ± .03	1.00 ± .00	.72 ± .03	.75 ± .01	.72 ± .03	.75 ± .04

experiments varying the trade-off factor α and observing the achieved earliness and accuracy.

Extracting Vegetation Characteristics

Stopping time grouped per crop category vegetative season



Data & Code



