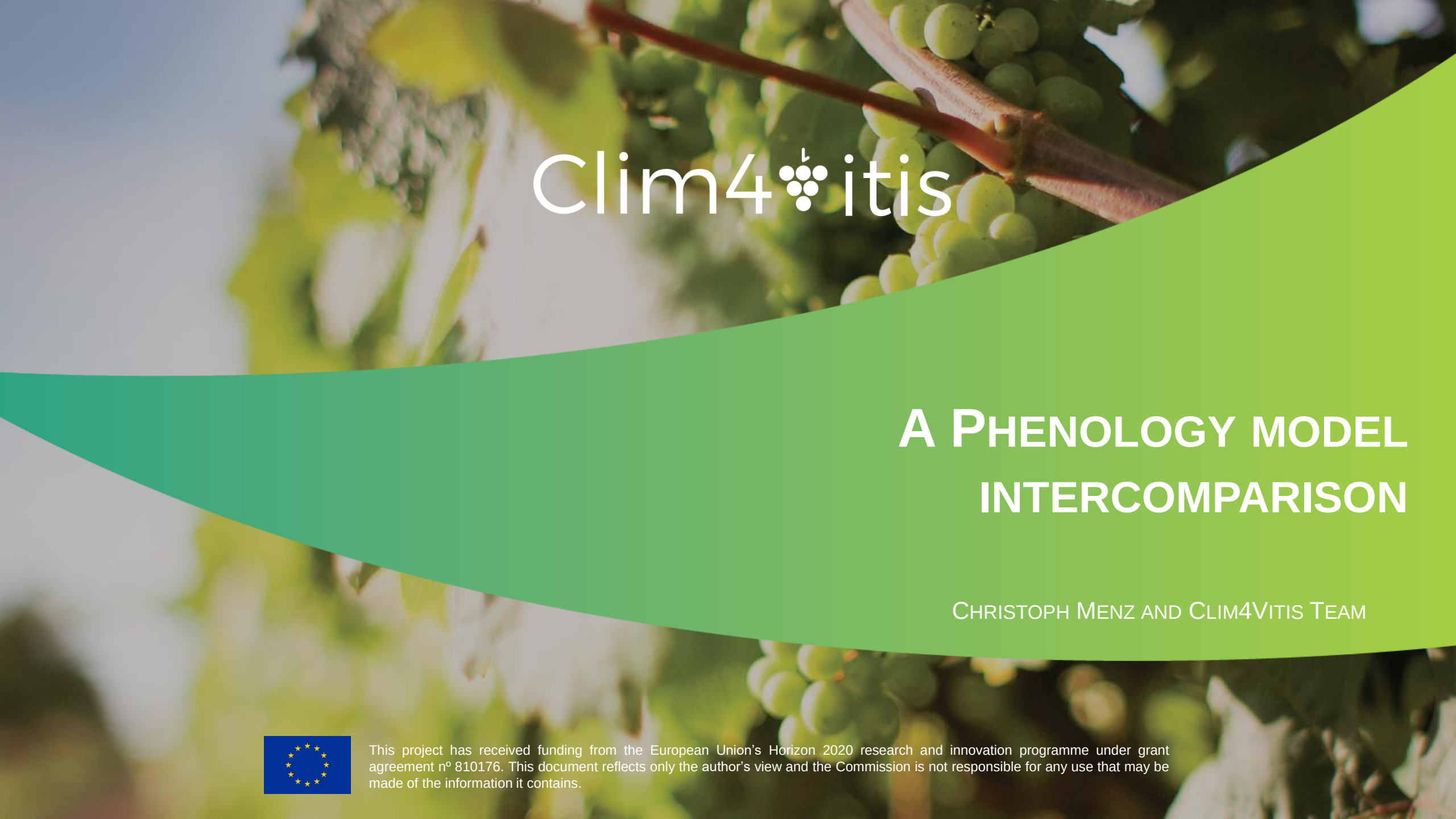

Clim4vitis

A Phenology model intercomparison

Christoph Menz and Clim4Vitis Team

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 810176. This document reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains.

Introduction

Motivation

- Model intercomparisons common in other research fields
  - CMIP, ScenarioMIP, CORDEX, AgMIP, ISIMIP, …

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  - Quantify bounds for model uncertainty
  - Guide subsequent impact modelers/practitioners

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  - Models initially developed for single sites/varieties
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LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

UNIVERSITÀ DEGLI STUDI FIRENZE

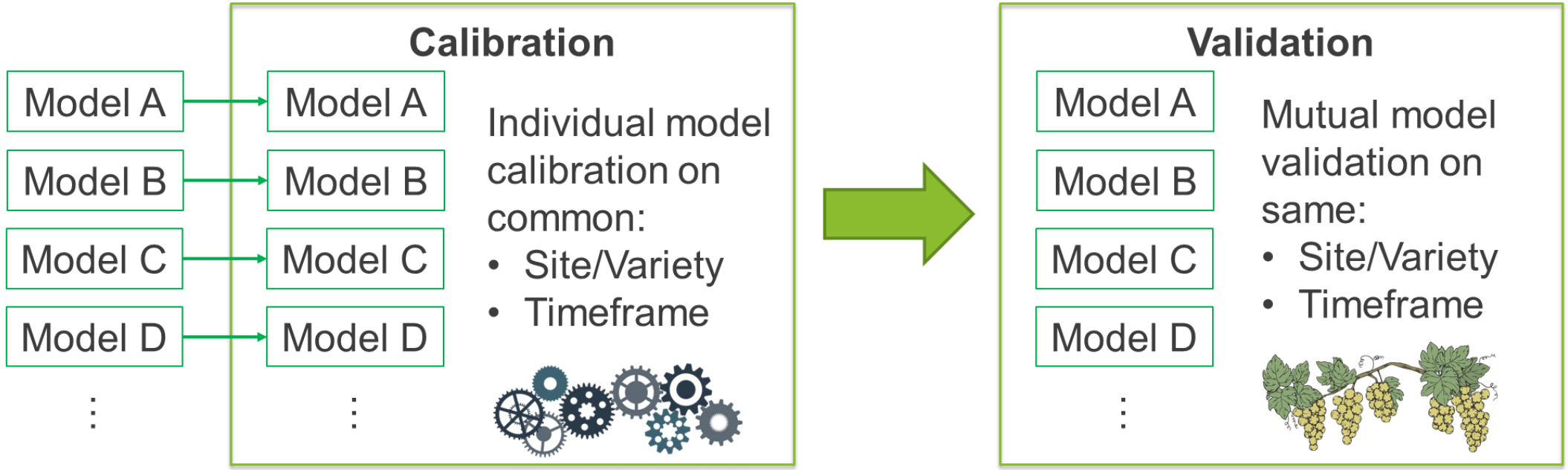
PIK

Introduction

Intercomparison Framework

Create a **Framework** for **unified** model calibration and validation

- **Multiple models** able to simulate the same variety, site and phenological phases
- **Multiple sites/varieties** to calibration and validate the models
- **Long time frames** to conscientiously test model sensitivities (30+ years)



Models and Data

Participating Models

- 5 compound models based on accumulation of GDD

Model A

Model B

Model C

Model D

⋮

STICS	GDD and BRIN	Temperature
vineyard	GDD (add. Thresholds)	Temperature
UniFi-C1	Sigmoid GDD and Gaussian-like GDD	Temperature
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PhenologyVvMoth	GDD (add. Thresholds), approx. daily cycle	Temperature Precipitation Global Radiation Evapotranspiration

Models and Data

Participating Models

Standard: $GDD = \max(T - T_{lower}, 0)$

- 5 compound models based on accumulation of GDD
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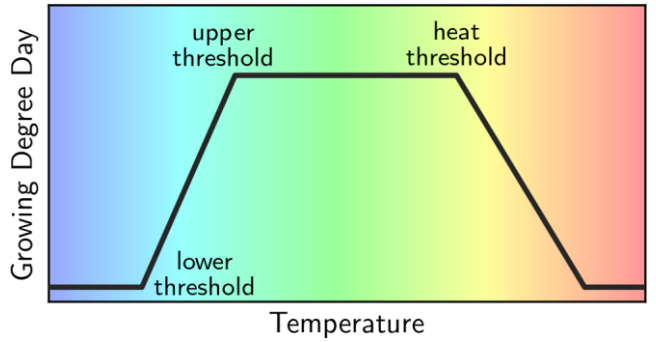
Additional Thresholds



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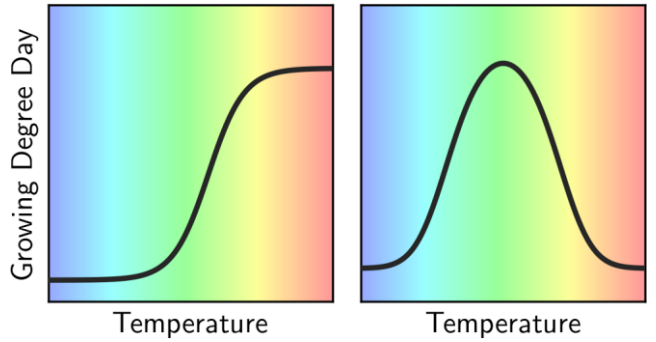

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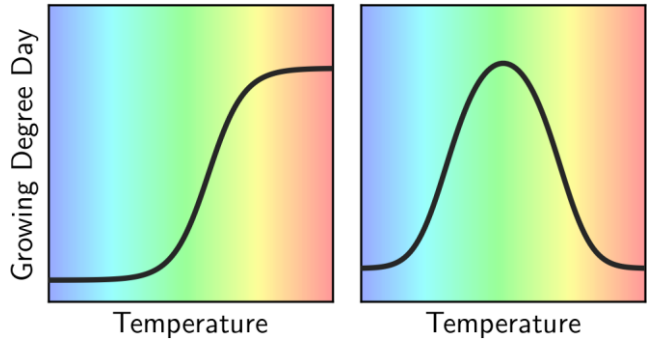

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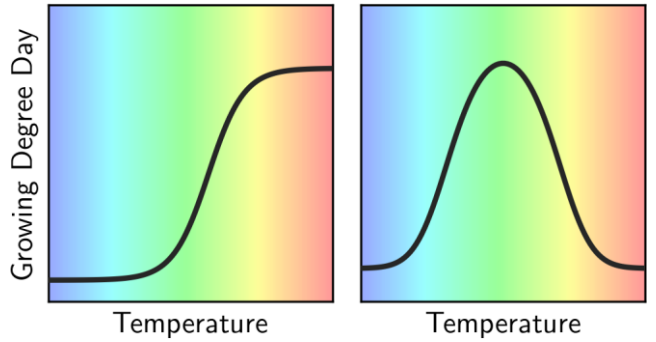

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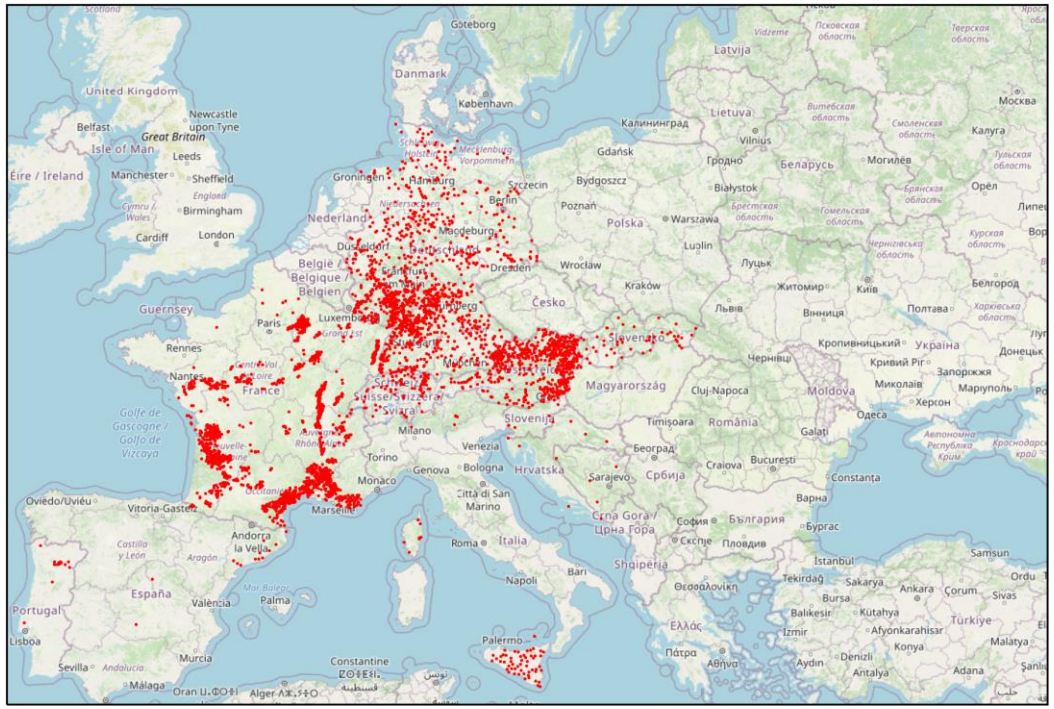
Models and Data

Sites and Varieties

- Multiple sites/varieties with long-term observations needed
- Several vineyard observations collected



Sites	3801
Countries	16
Varieties	123

Calibration

- Model A
- Model B
- Model C
- Model D
- ⋮

Individual model calibration on common:

- Site/Variety
- Timeframe

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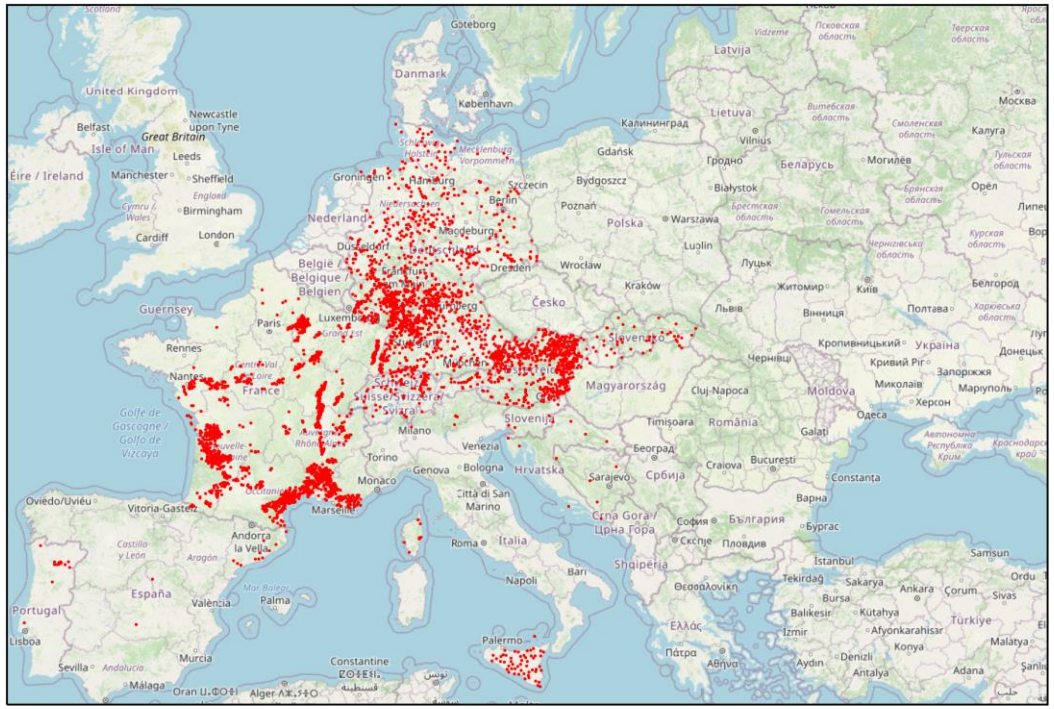

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- Each station covers 7 BBCH stages on average
- On average 98.9% missing data
- On average less than 7 years

Models and Data

Sites and Varieties

- Multiple sites/varieties with long-term observations needed
- Several vineyard observations collected

- More than 30 years
- Same phenological BBCH stages

Calibration

Model A
Model B
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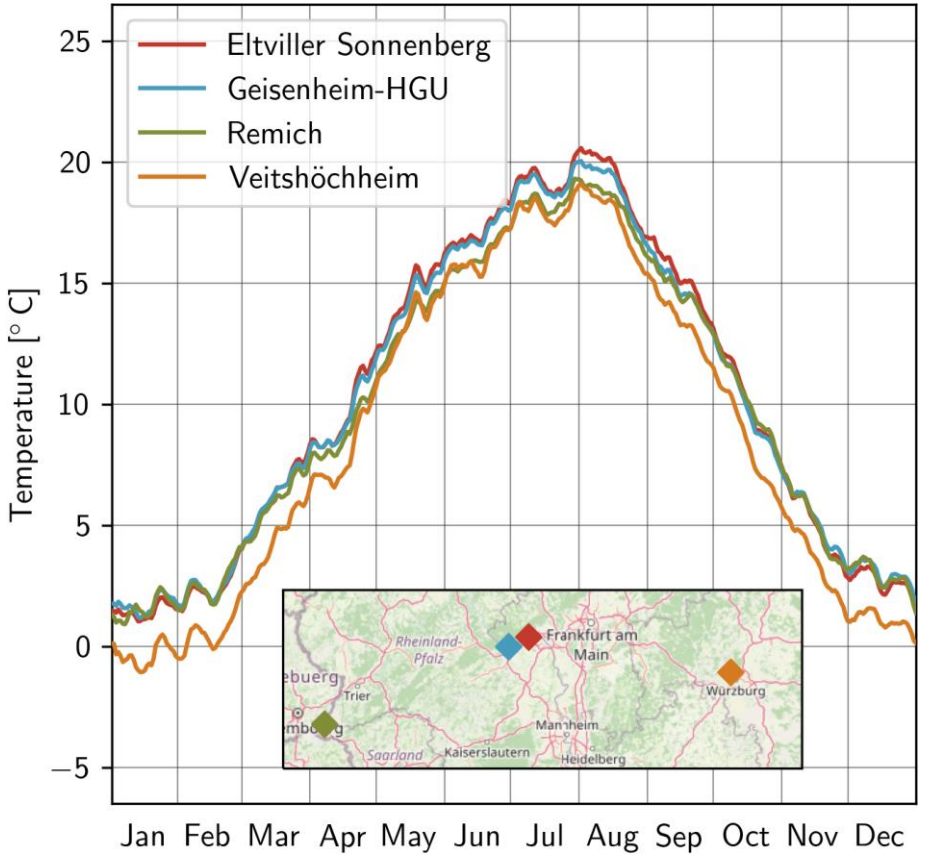
Models and Data

Sites and Varieties

- 4 Central European sites representing temperate climate
- Cover almost 50 years of phenological observations for each site
- 3 different white wine varieties

Site	Timeframe	# BBCH	Variety
Eltviller Sonnernberg	1955 – 2020	8	MT, R
Geisenheim-HGU	1951 – 2003	7	R
Remich	1968 – 2020	6	MT
Veitshöchheim	1968 – 2020	21	MT, R, S



Müller-Thurgau - MT

Rosenzweig (CC BY-SA 3.0)

Riesling - R

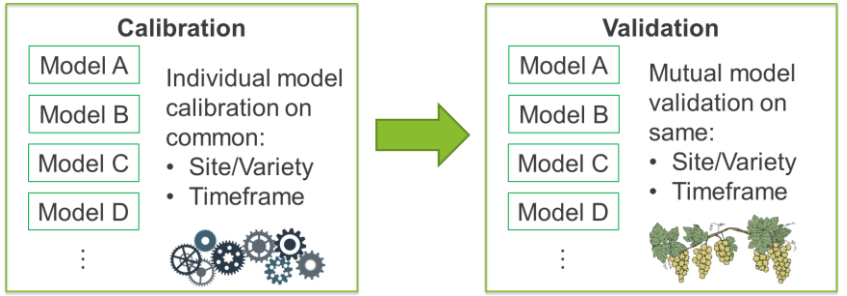
Bauer Karl (CC BY 2.0 AT)

Silvaner - S

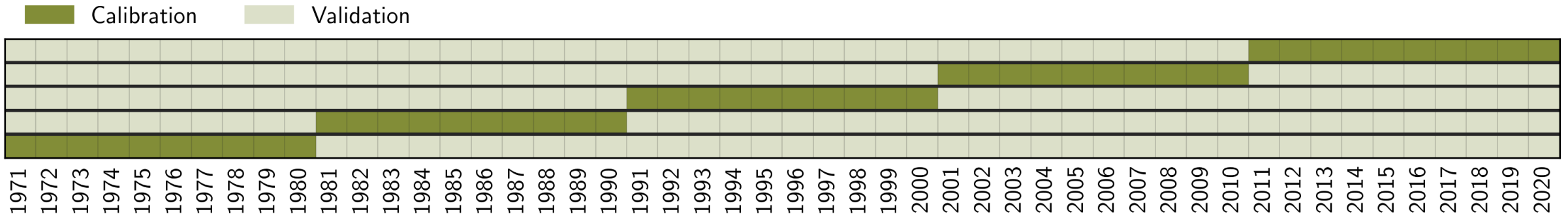
Däisd (CC BY-SA 3.0)

Simulations

Cross-Validation



- Multiple separate calibration and validation timeframes



- 5 timeframes for each period length (5-fold cross-validation)
- 10a, 20a and 30a calibration period lengths
- 7 site/variety combinations

= 105 Simulations of each individual models
= 76263 years in total

Results

	BBCH
bud break	09
flowering	68
begin ripening	81
end ripening	89

Results

Research Questions

	BBCH
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Model developer:

- Model performance for different Sites/Varieties
- Model performance for different BBCH phases

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Research Questions

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- Model performance for different Sites/Varieties
- Model performance for different BBCH phases

Practitioners:

- How does the length of calibration period affect model performance?
- How well do the models perform in climate change conditions?

	BBCH
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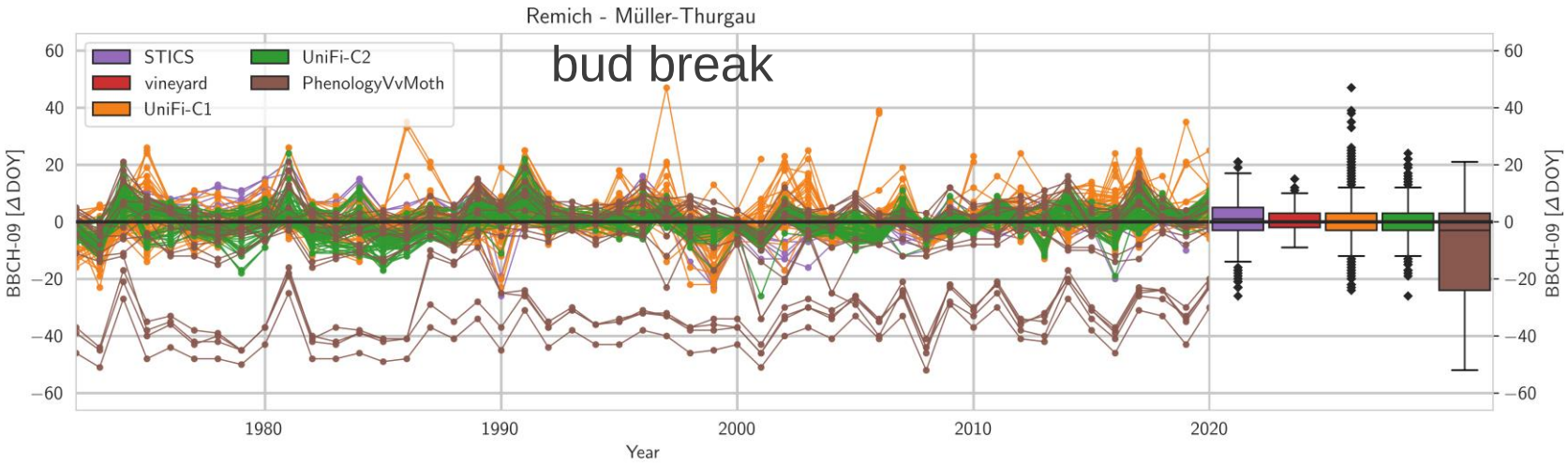
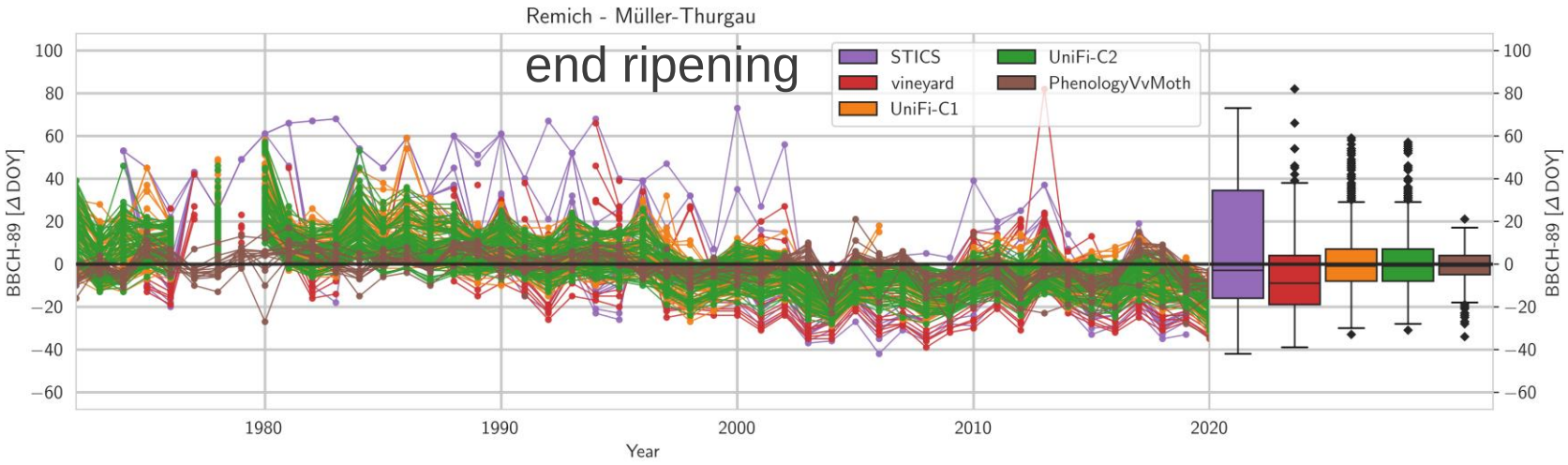
Results

Overview





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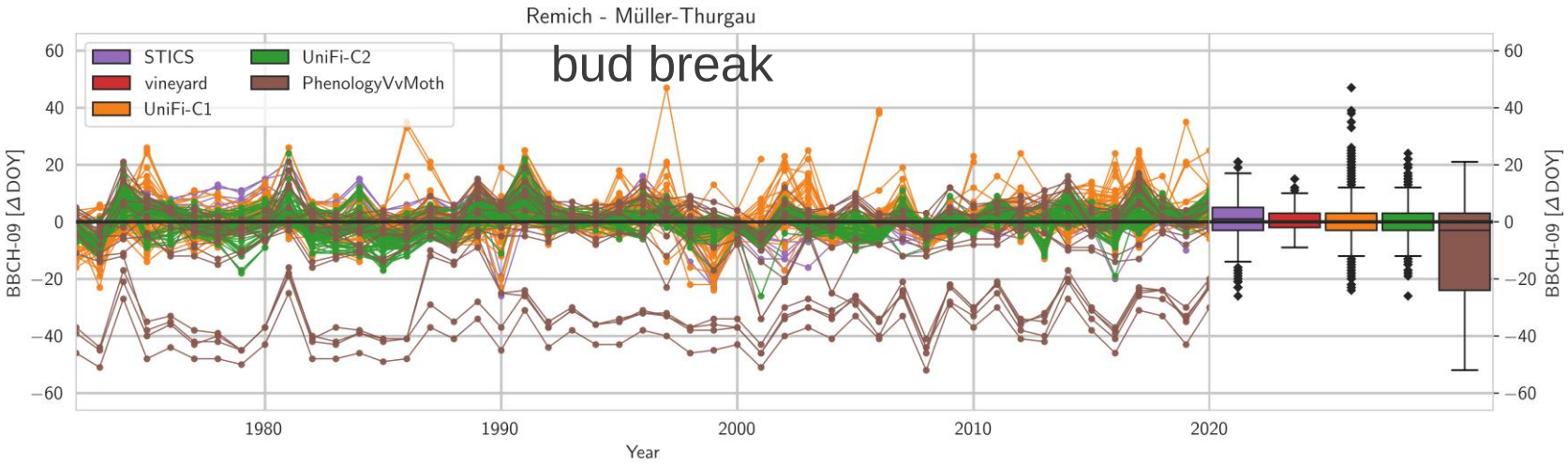

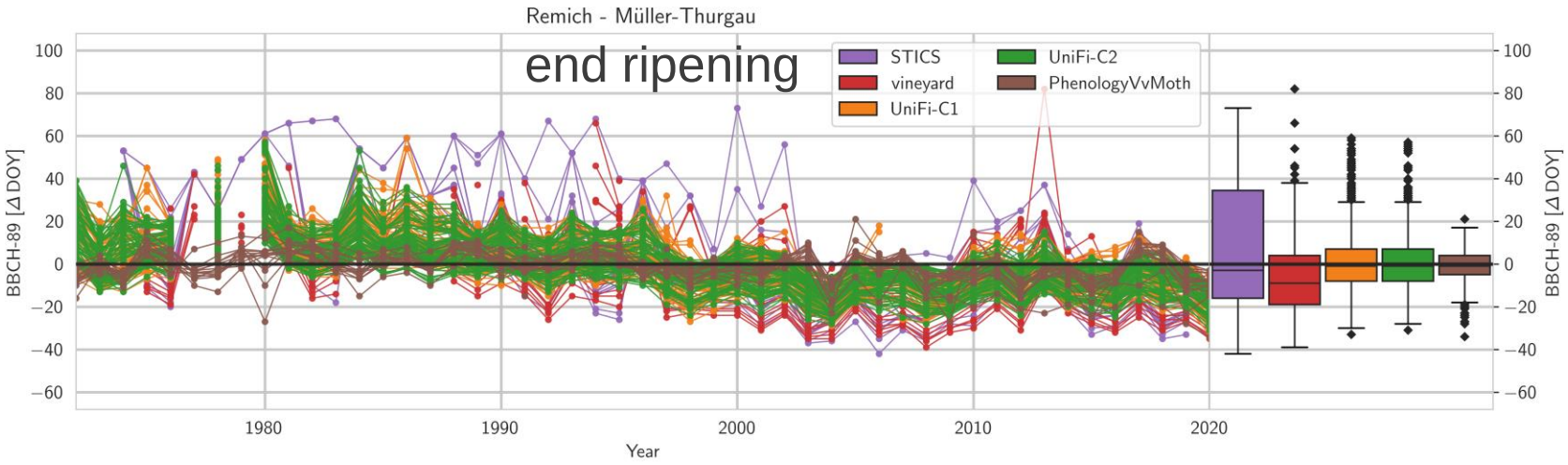

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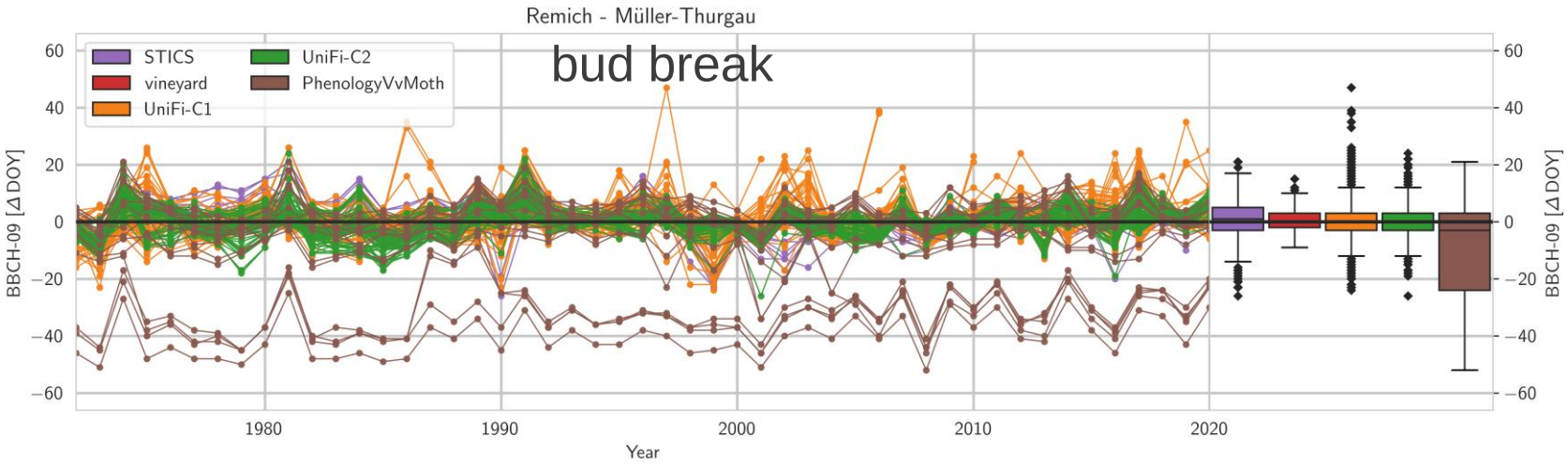

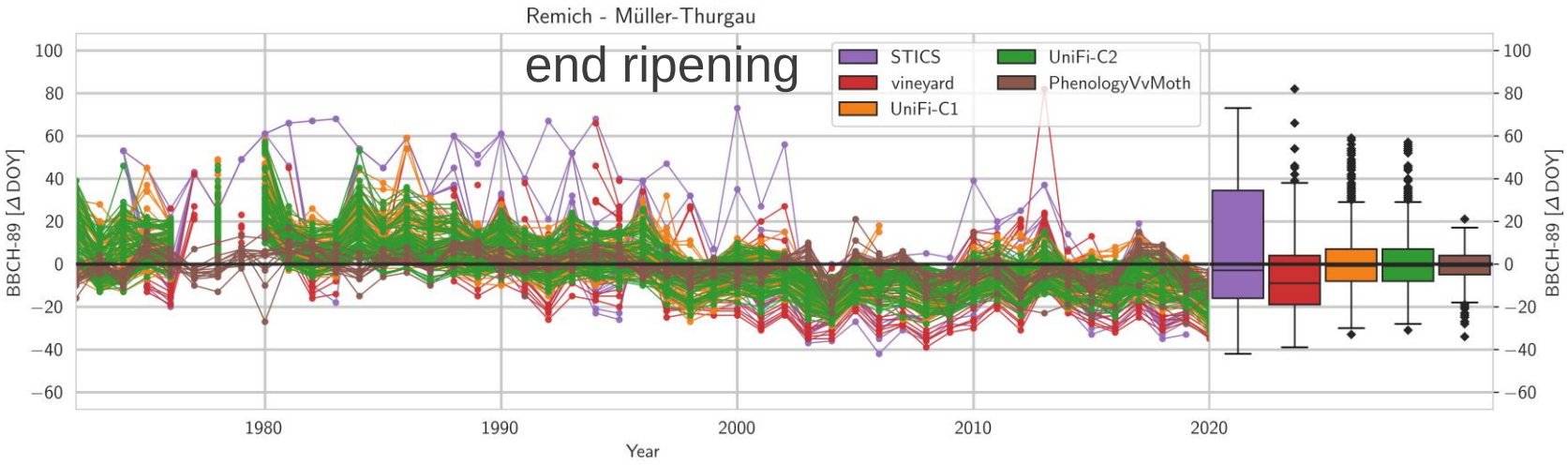

- Performance differ from model to model
- Low bias for most years and models

Results

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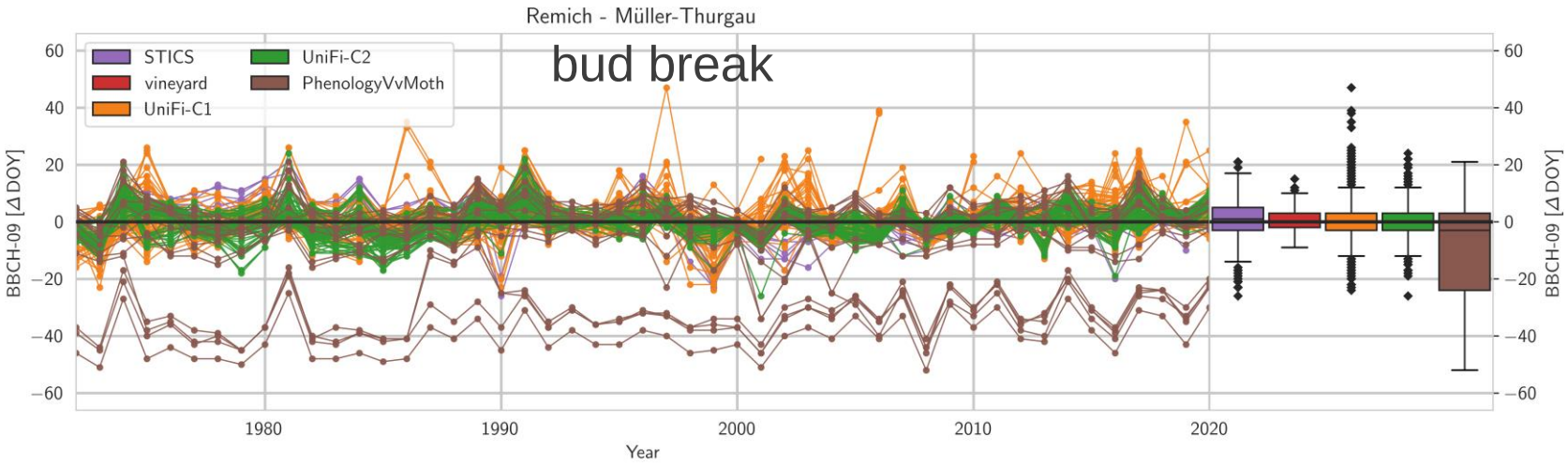

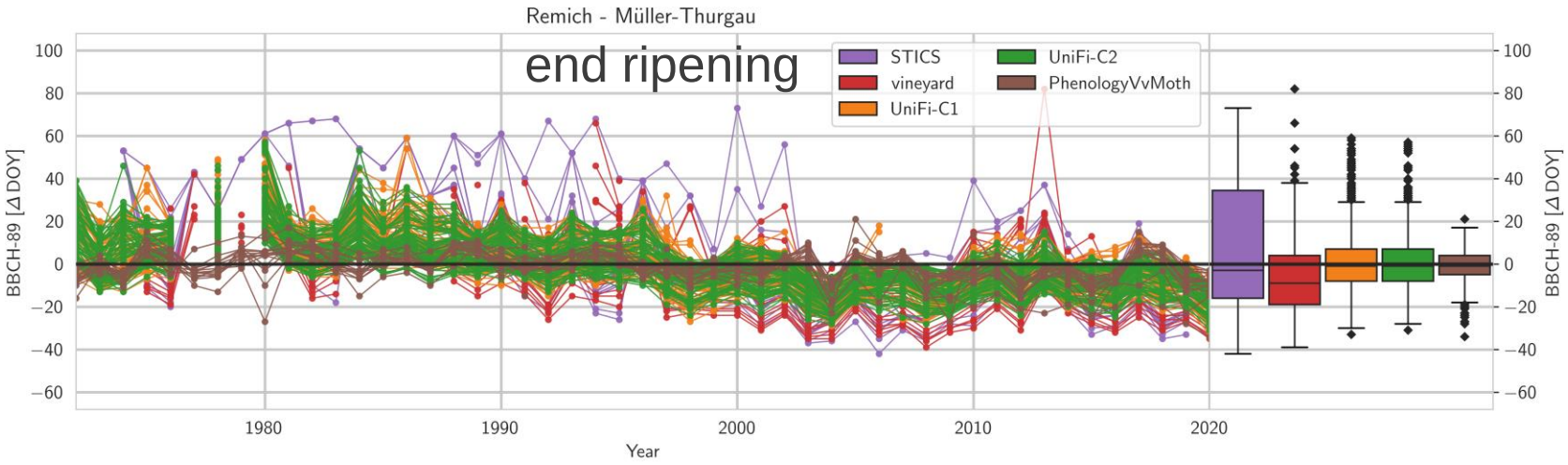

- Performance differ from model to model
- Low bias for most years and models
- Calibration has a significant impact
- Outliers due to unique years or wrong calibration

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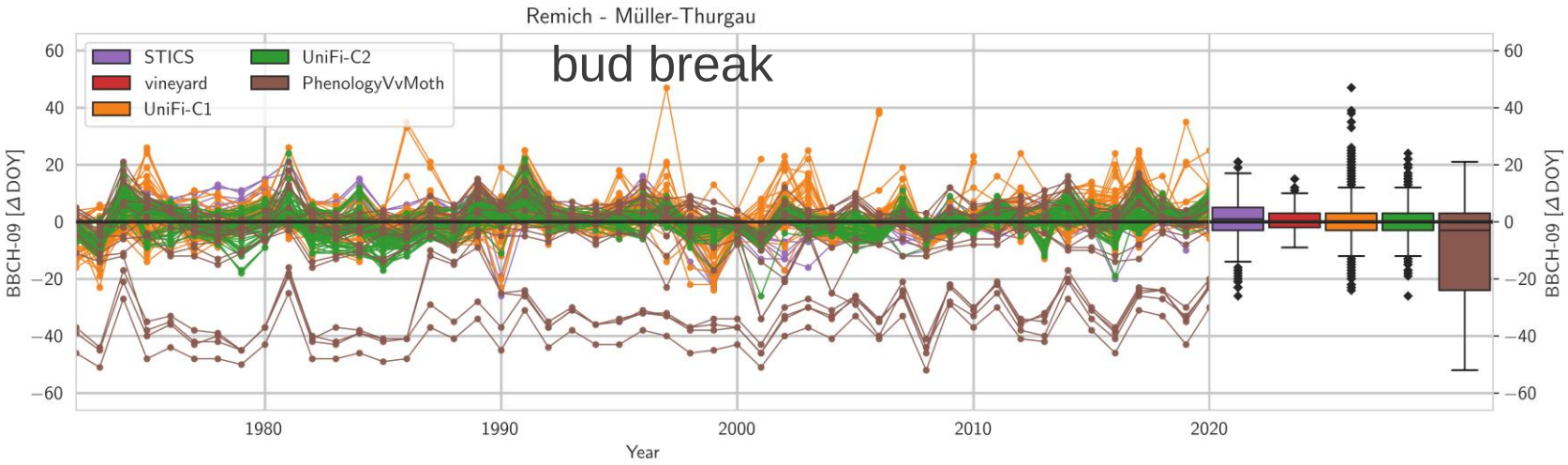
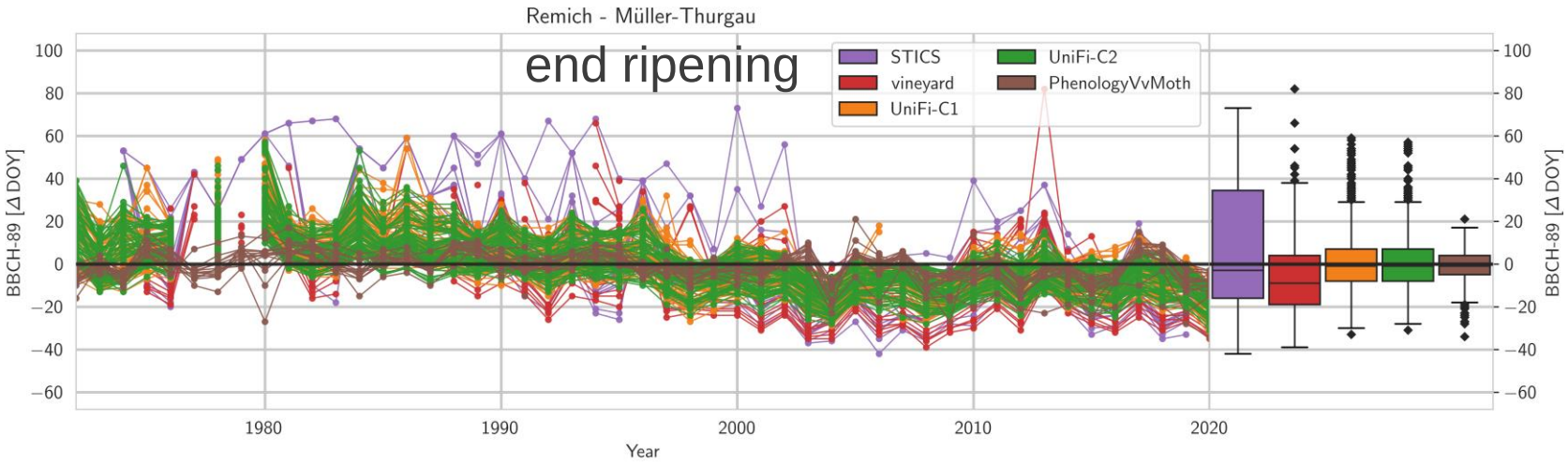
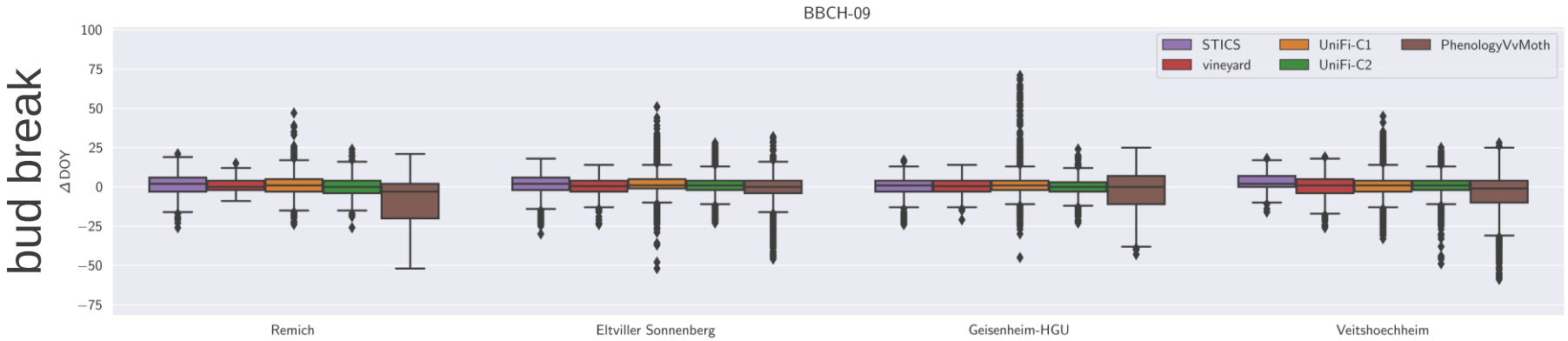




- Performance differ from model to model
- Low bias for most years and models
- Calibration has a significant impact
- Outliers due to unique years or wrong calibration
- Bias trend for BBCH-89

Results

Model Performance for different Sites/Varieties



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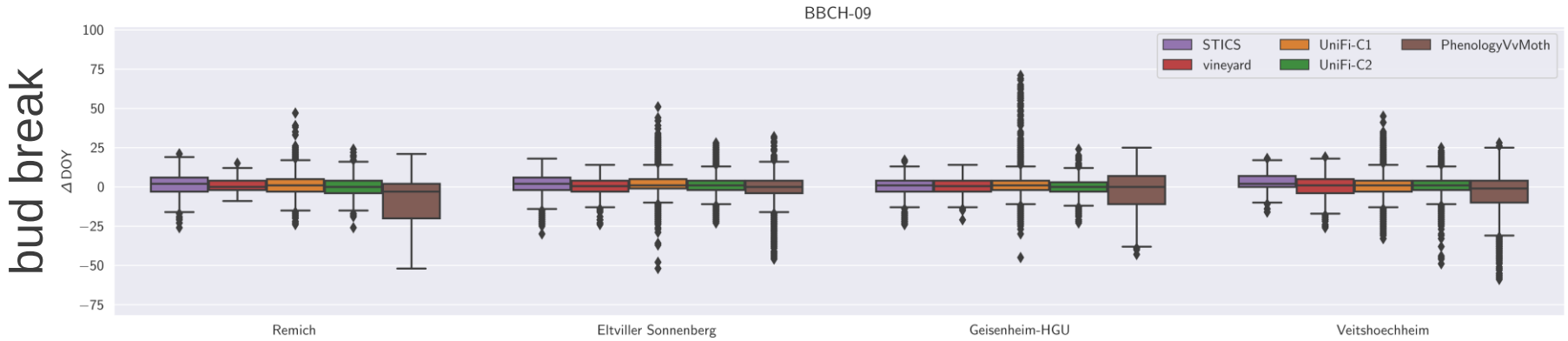

- Low sensitivity in general
- Mostly seen for outliers

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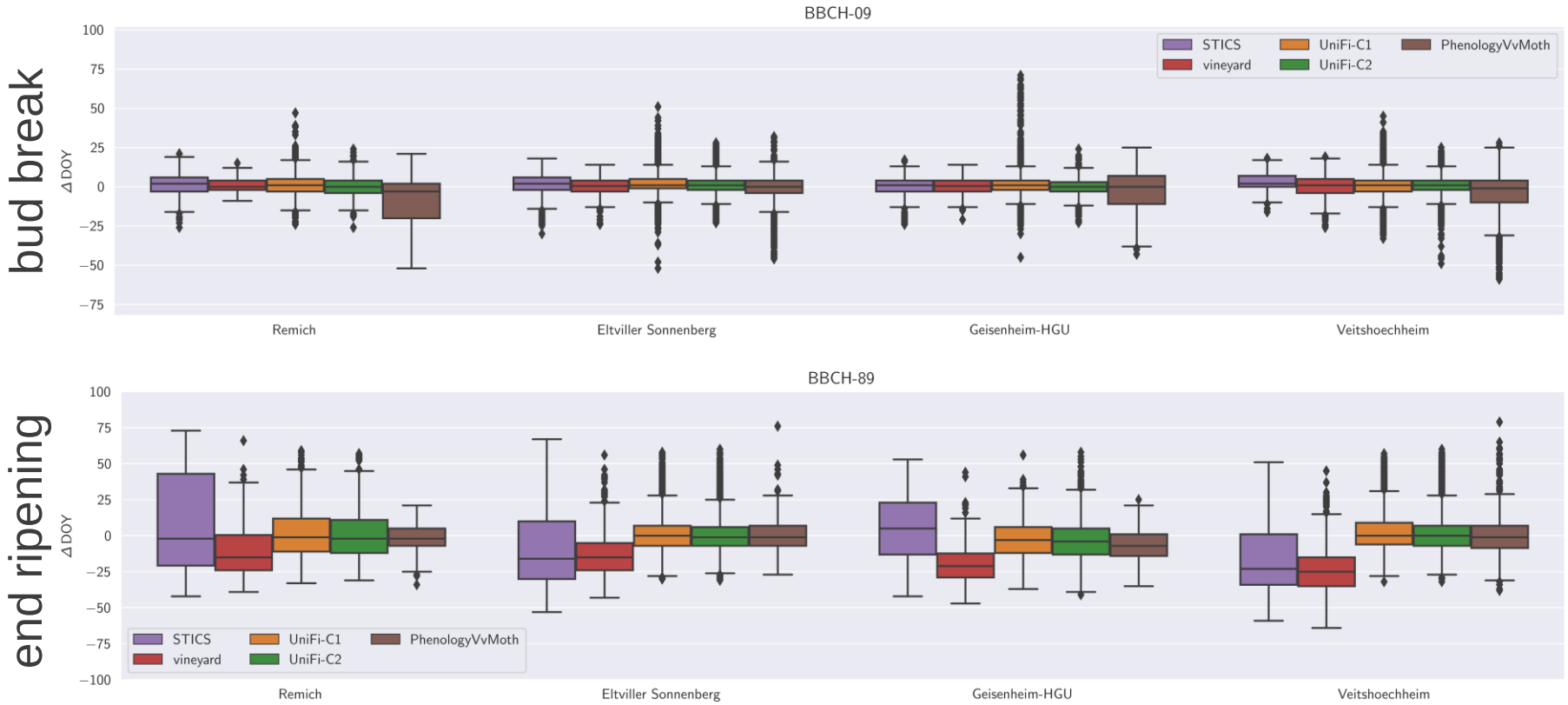

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- Higher sensitivity for BBCH-89

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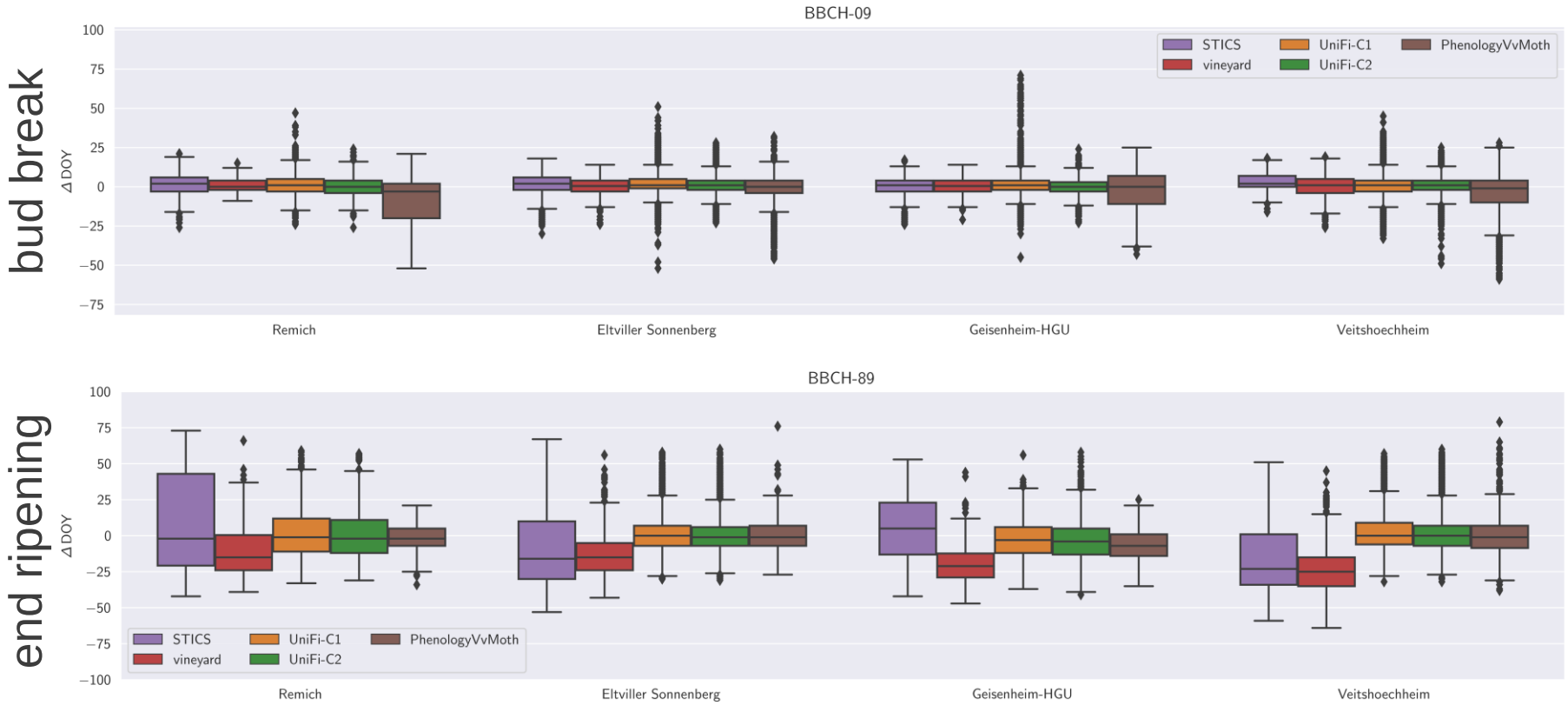

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- STICS, vineyard and PhenologyVvMoth show higher sensitivity

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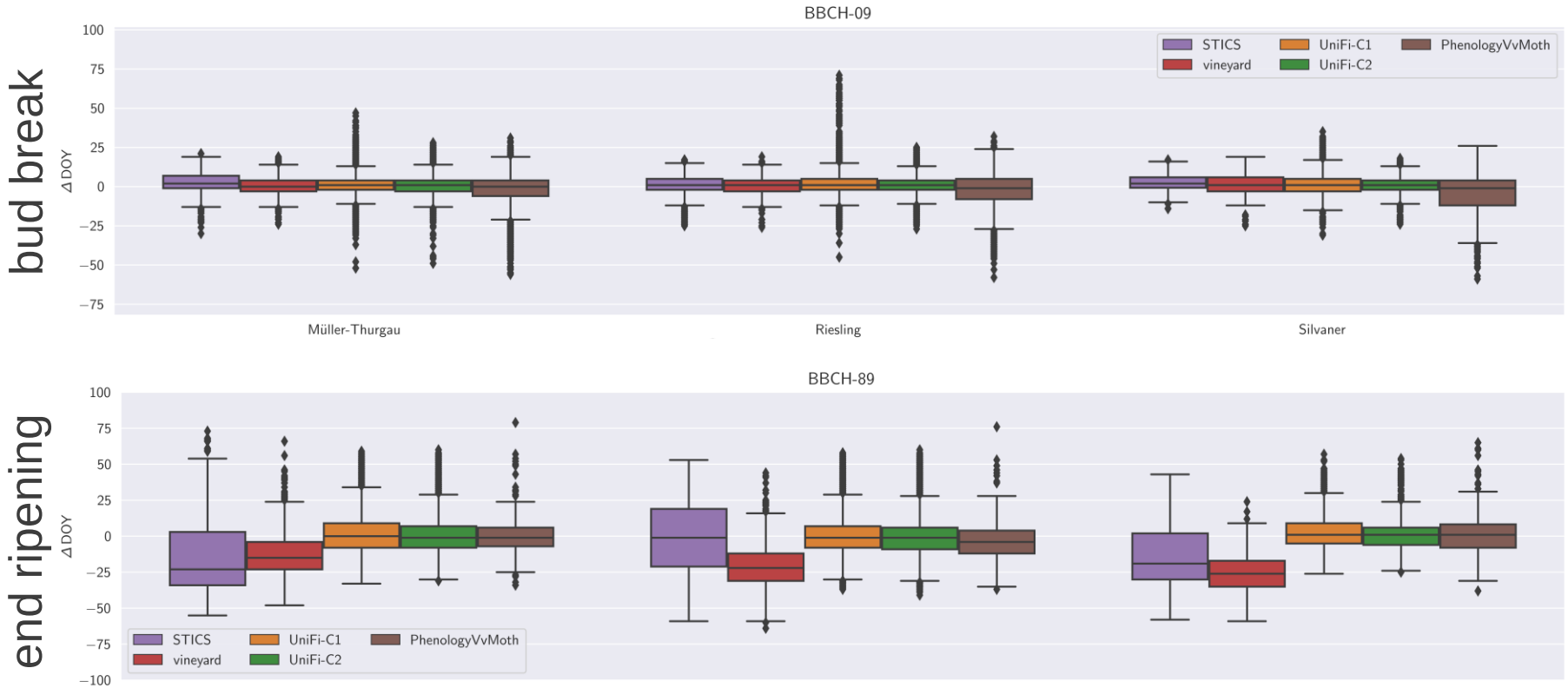

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Müller-Thurgau

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Riesling

Bauer Karl (CC BY 2.0 AT)

Silvaner

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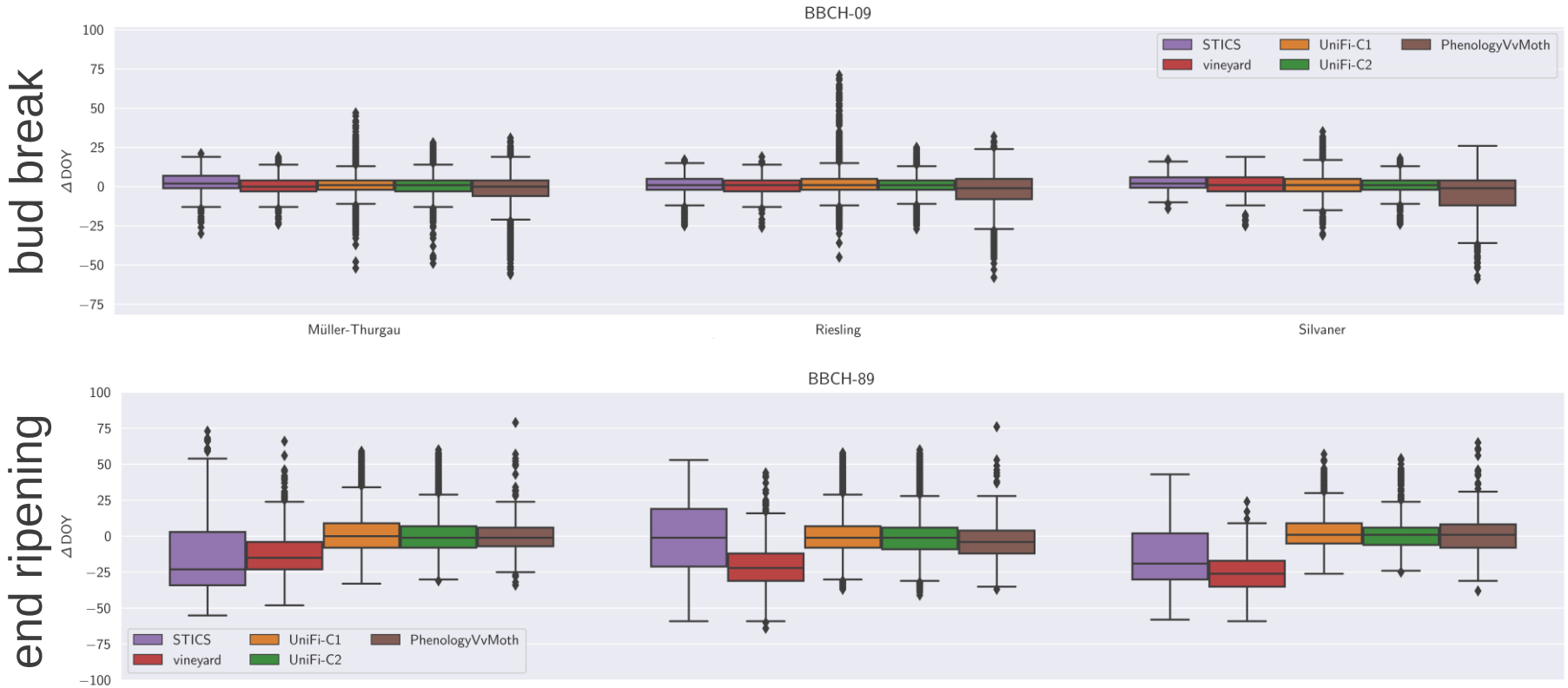

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- Low sensitivity in general
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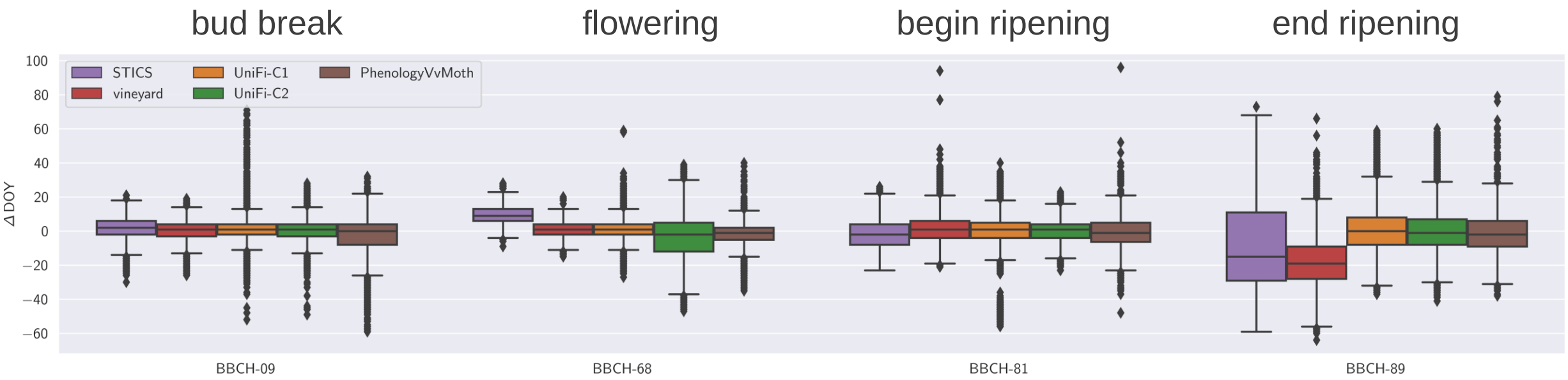
- Models generalize over different sites and varieties

Results

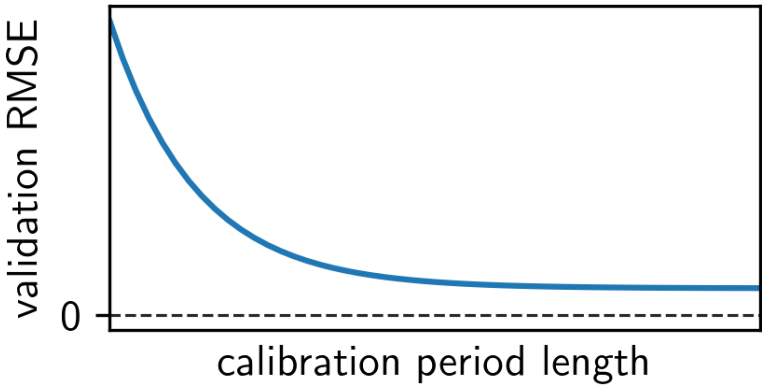
Model performance for different BBCH phases



- Model performance differs from phase to phase
- Bias compensation from one phase to another
- Slight qualitative change from BBCH-09 to BBCH-89

Results

How does the length of calibration period affect model performance?



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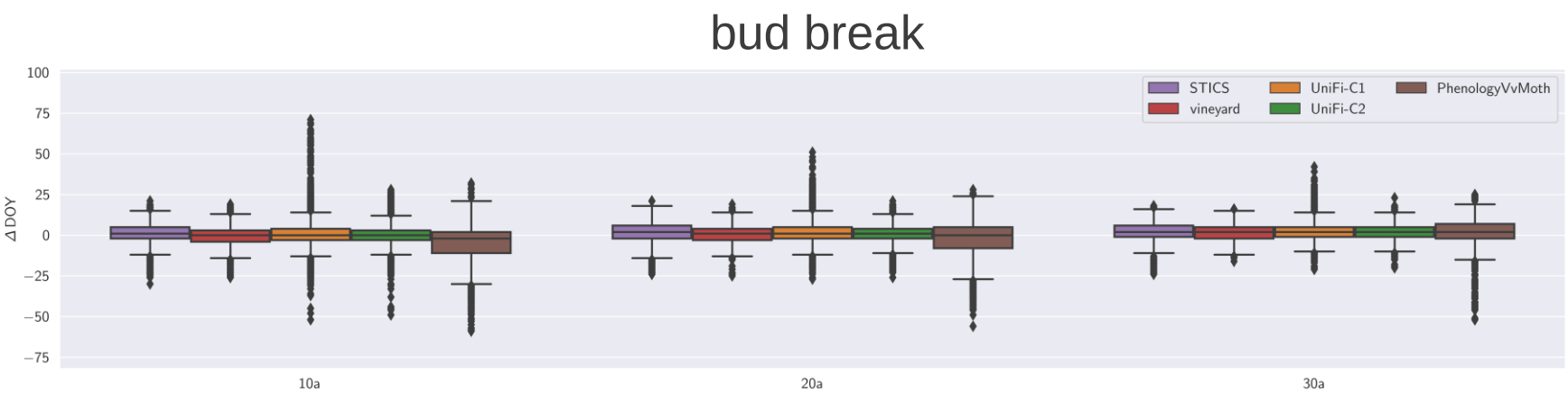

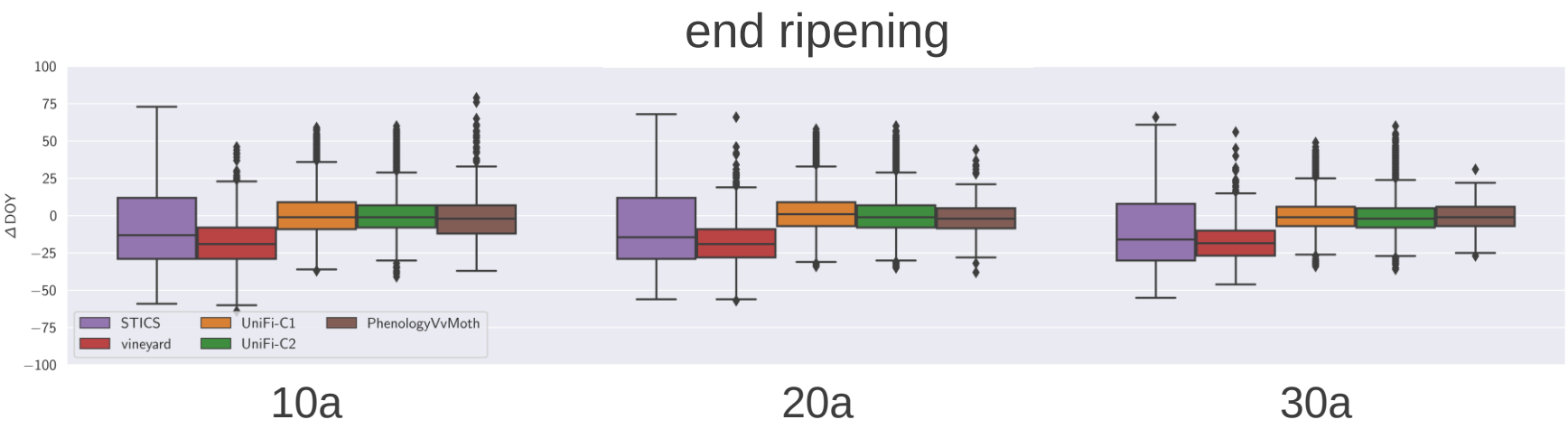

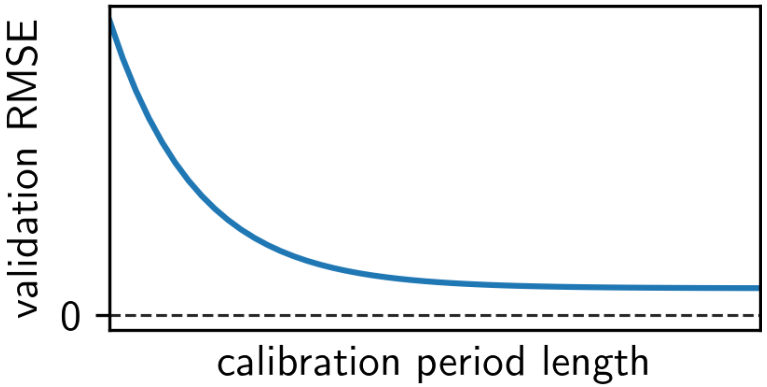

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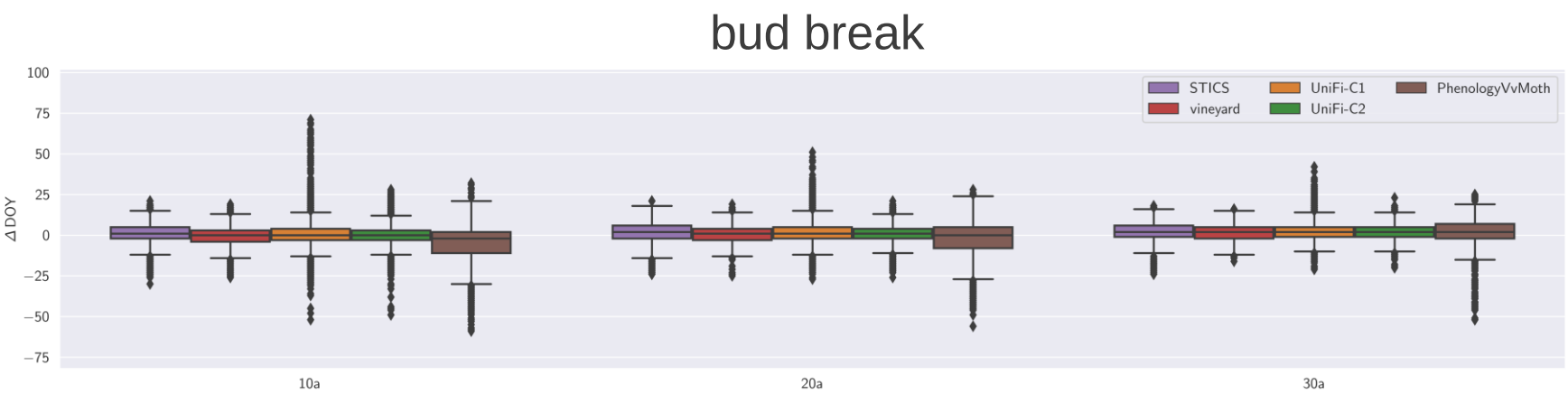

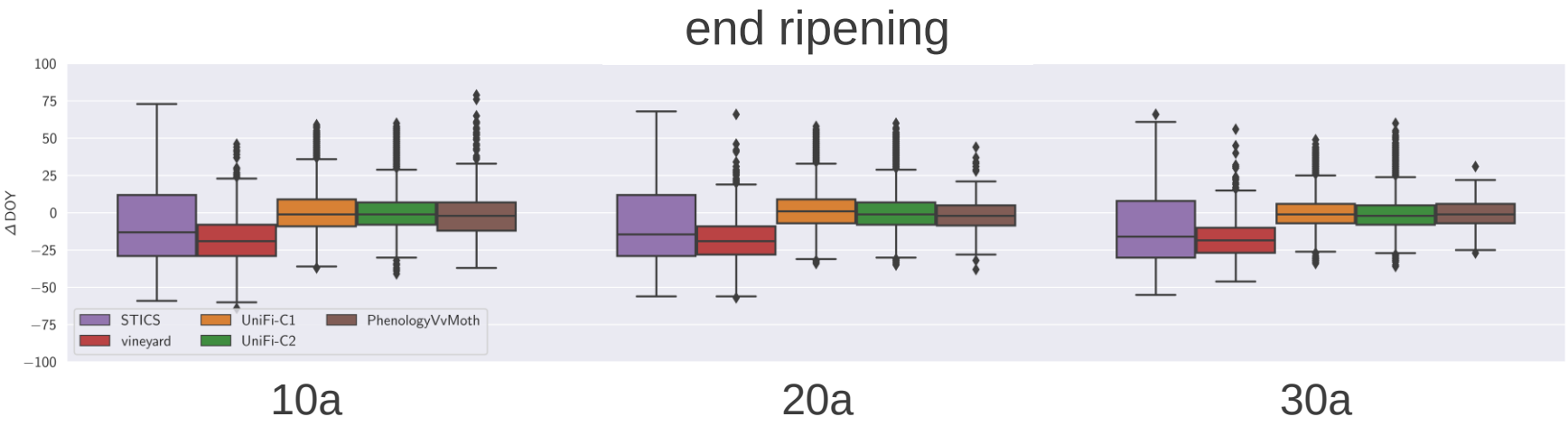

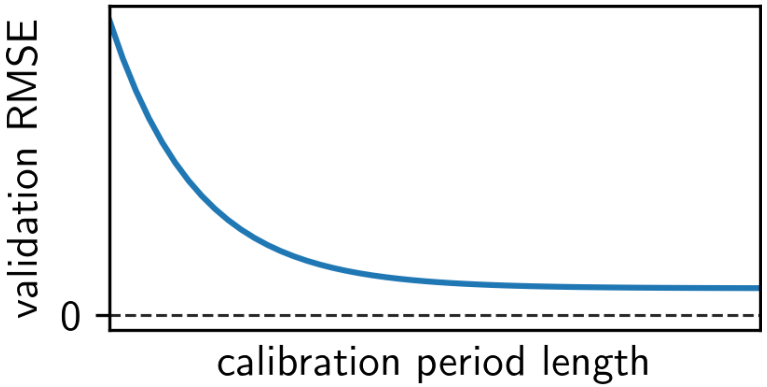

- Bias does not reduce significantly with increasing calibration period length

Results

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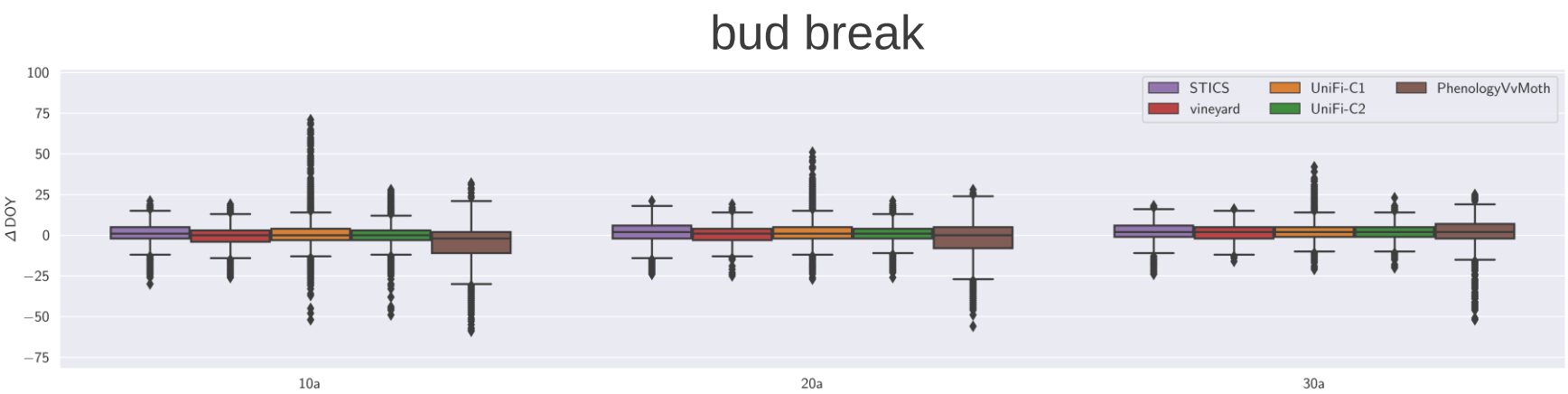
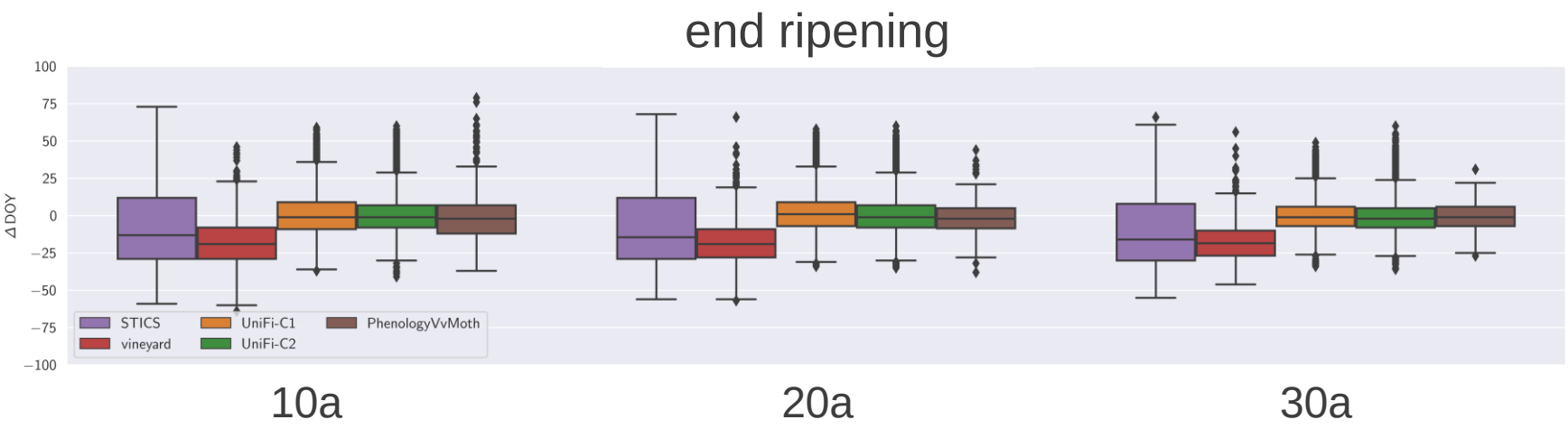
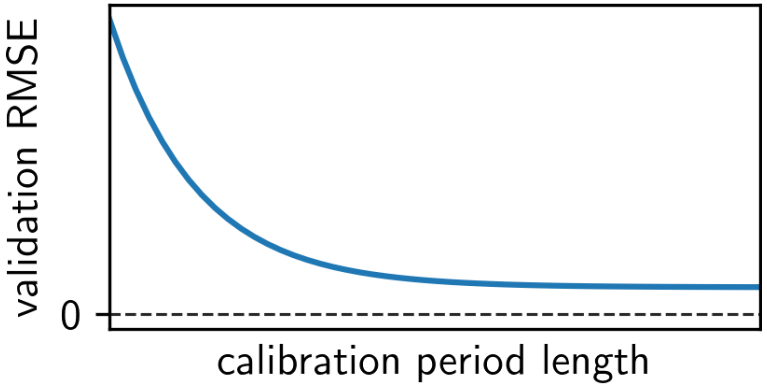






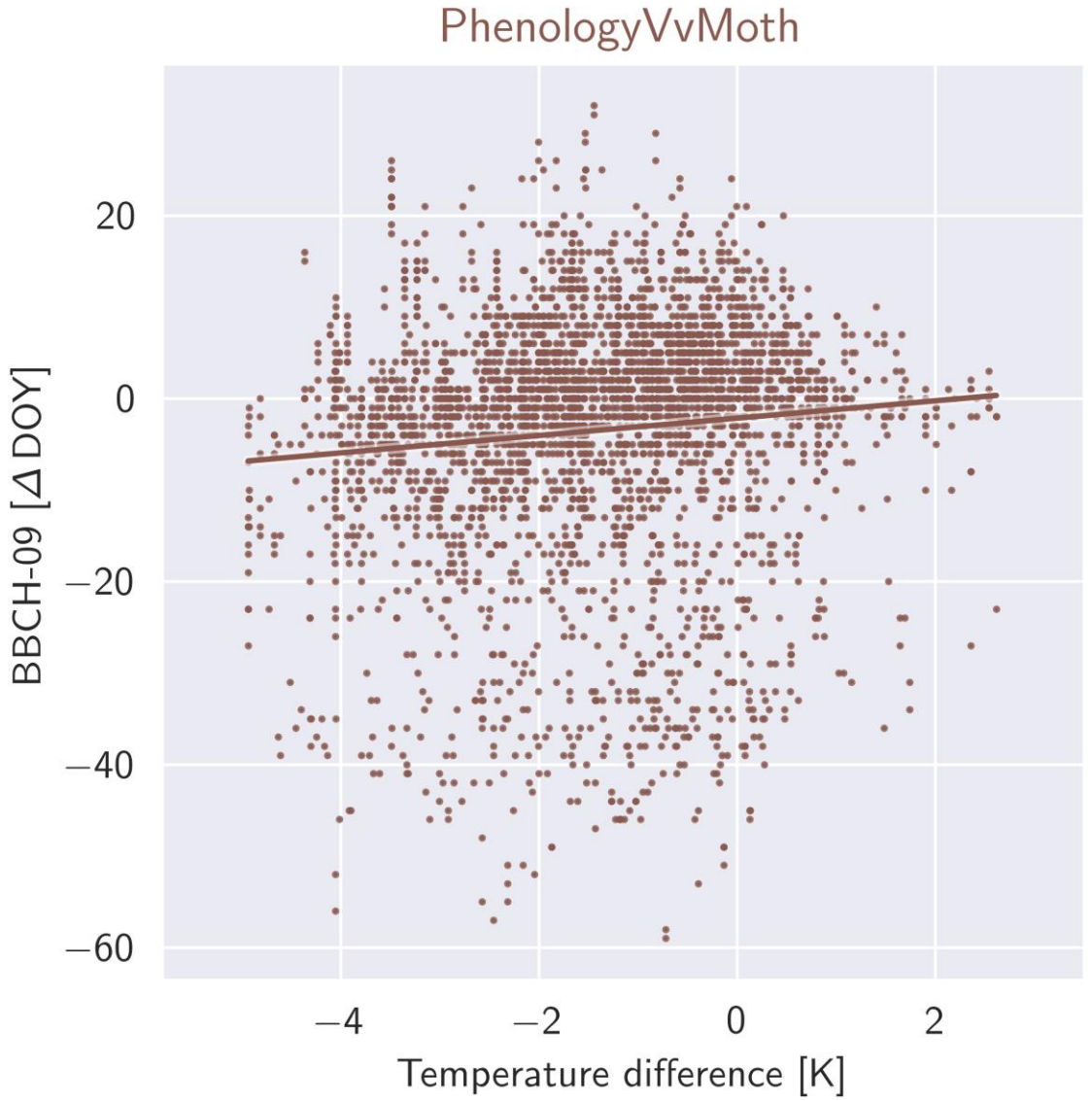
- Bias does not reduce significantly with increasing calibration period length
- Less than 10 years seem to be sufficient

Results

How well do the models perform in climate change conditions?

- Due to the long observation time frame, we can estimate the performance for different climate conditions

- Growing season: AMJJAS
- Temperature difference: individual year vs. hottest calibration year
- Bias should be independent of temperature difference



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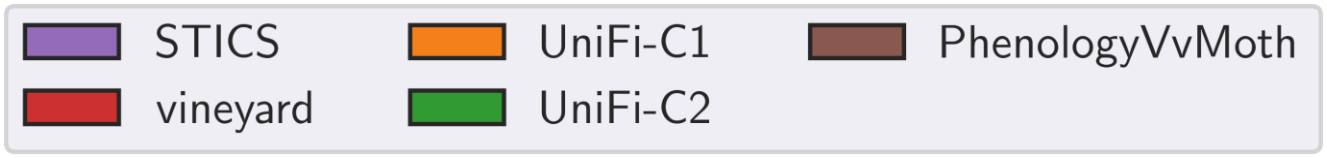
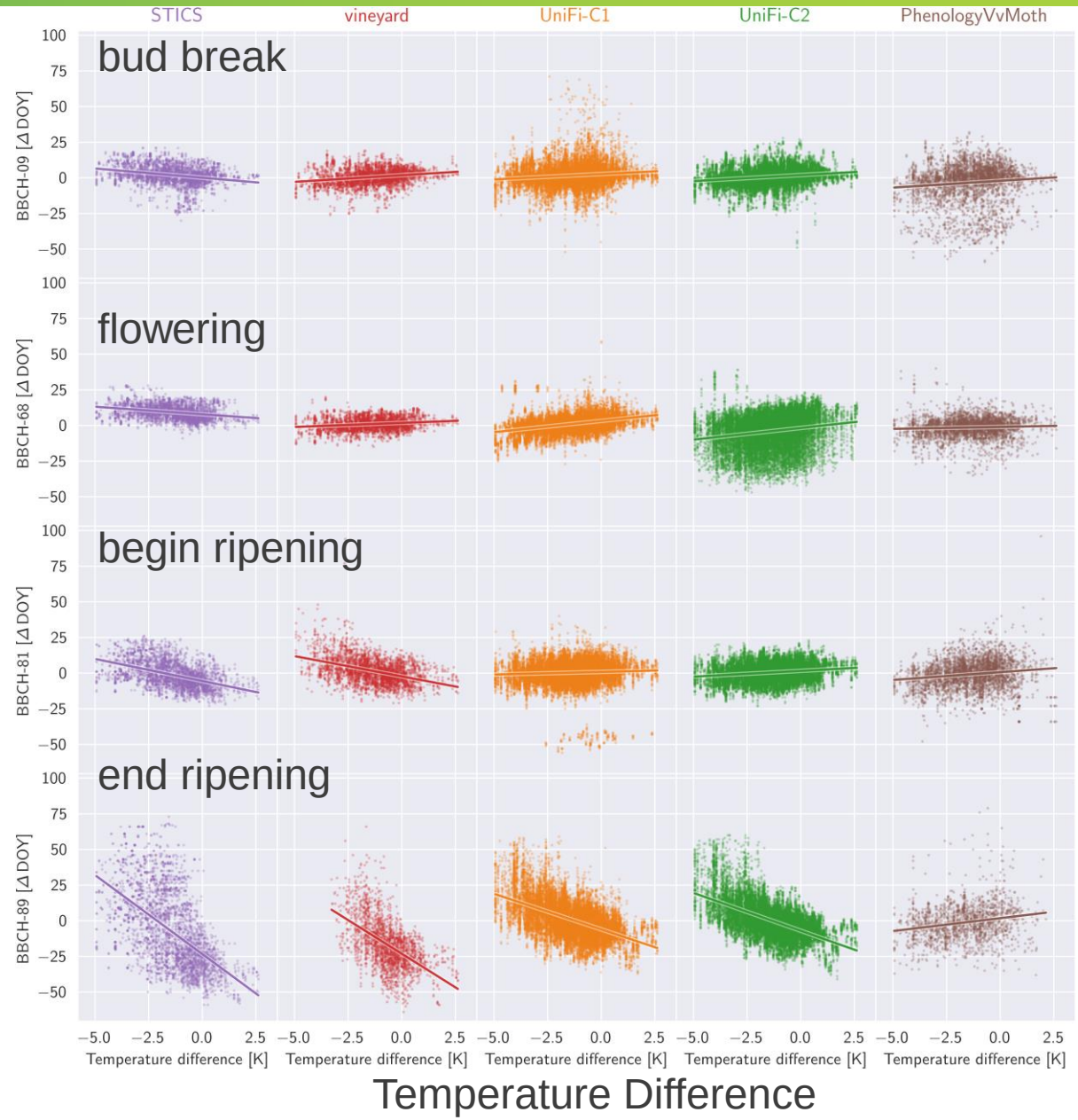


Results

How well do the models perform in climate change conditions?

- Models appear to be applicable under climate change conditions for most phases



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- Later phases show dependency

Results

How well do the models perform in climate change conditions?

- Models appear to be applicable under climate change conditions for most phases
- Later phases show dependency
- Advance of ripening phase might be overestimated by current models under climate change conditions

Conclusion

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UNIVERSITÀ DEGLI STUDI FIRENZE

PIK

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- Particular attention should be given to model calibration
- Model development should concentrate on improving representation of phases rather than different sites/varieties
- 10 years are sufficient for adequate model calibration
- Models permit climate change impact analysis for most phases except for ripening phase
- Current model projection might overestimate the advance of ripening phase

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PIK Potsdam Institute for Climate Impact Research

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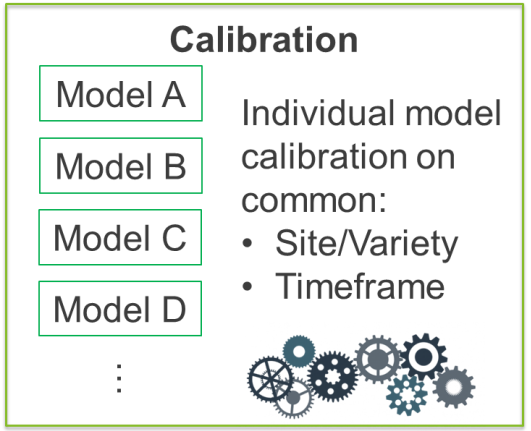
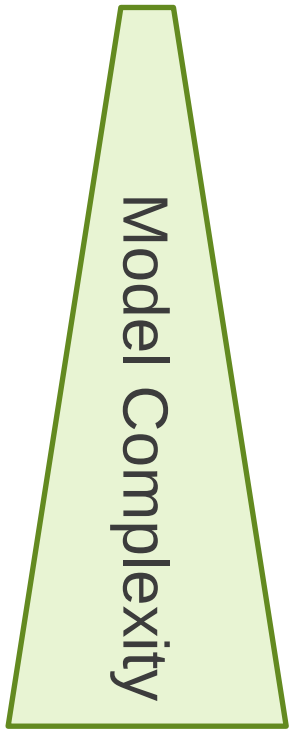
Models and Data

Individual Model Calibration

- Framework prescribes sites/variety and timeframes
- No unified calibration scheme prescribed
- Phases, calibration method and objective function chosen by each modeler

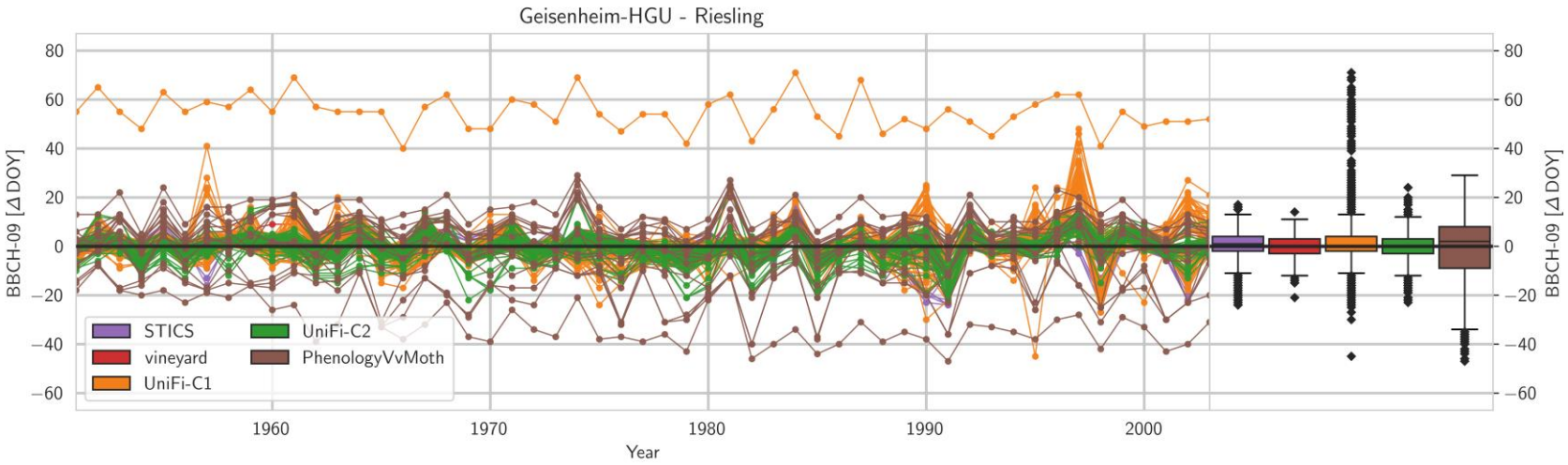


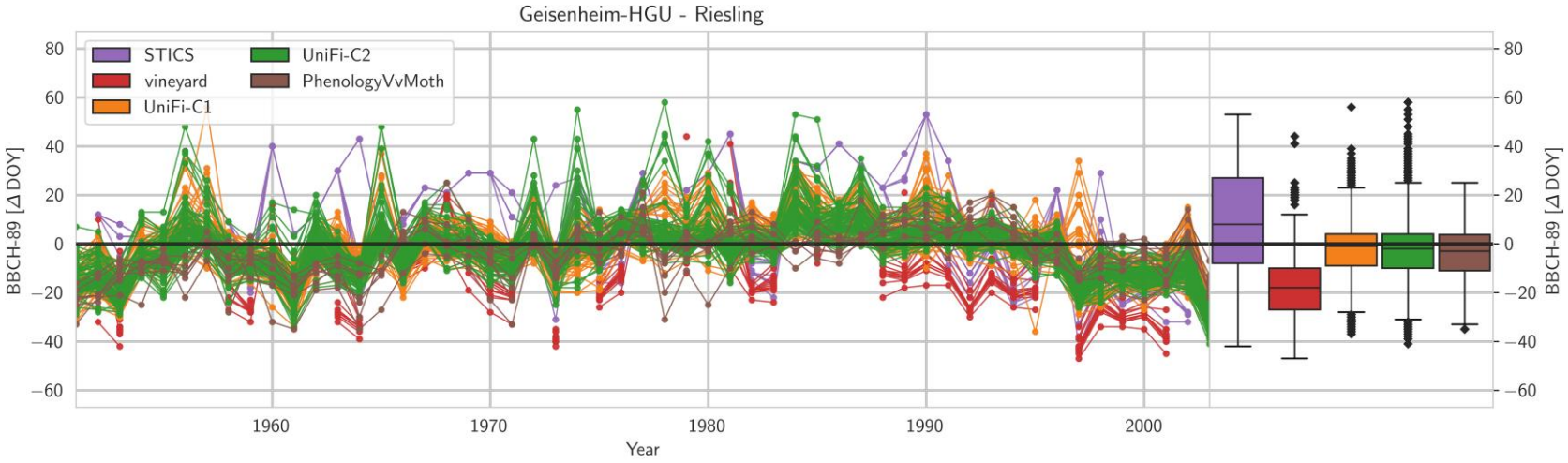


Model	# Parameters	Calibration Method	Objective Function
STICS	3	Grid search	MSE
Vineyard	3	SCE-UA	RMSE
UniFi-C2	12	Random search and simulated annealing	Various
UniFi-C1	17	Random search and simulated annealing	Various
PhenologyVvMoth	39	Simulated annealing and Nelder-Mead	MSE

Results

Overview





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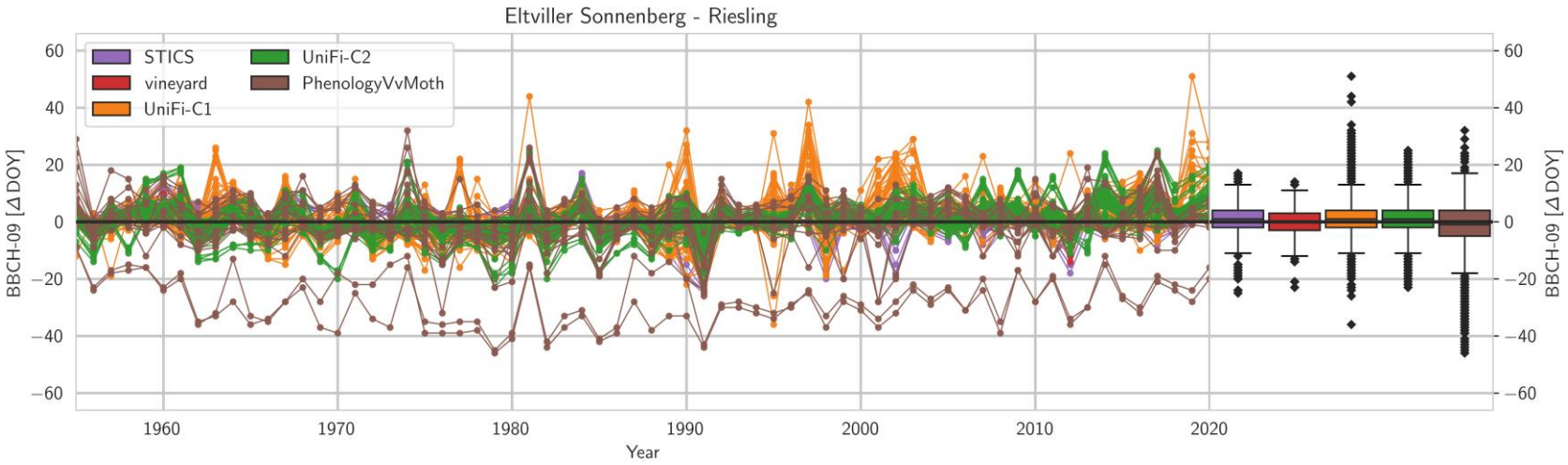

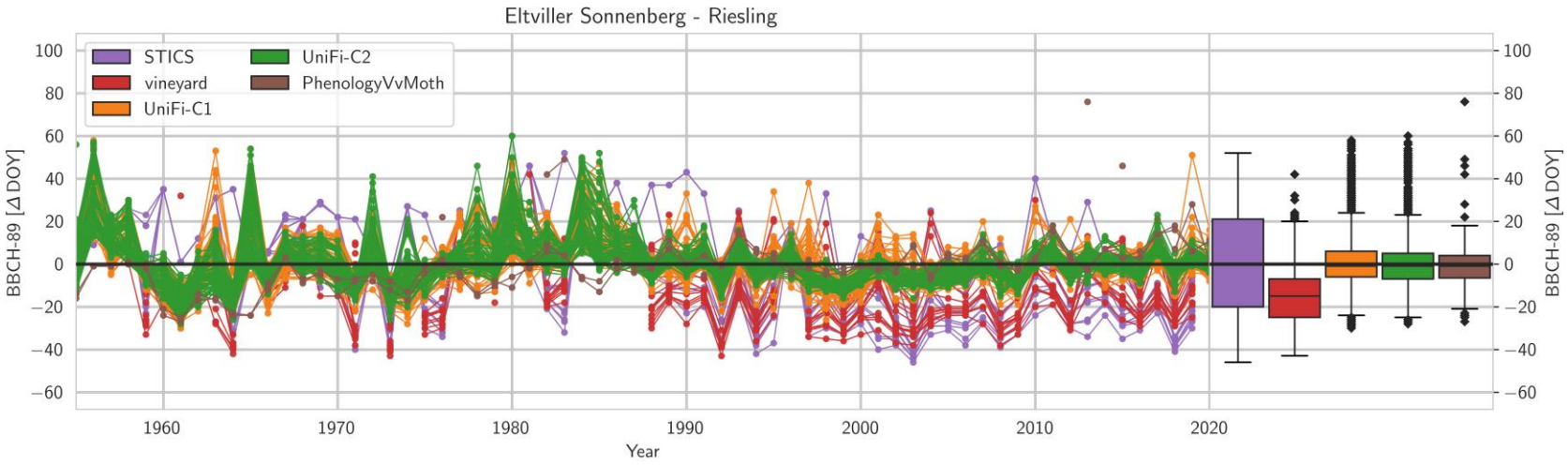

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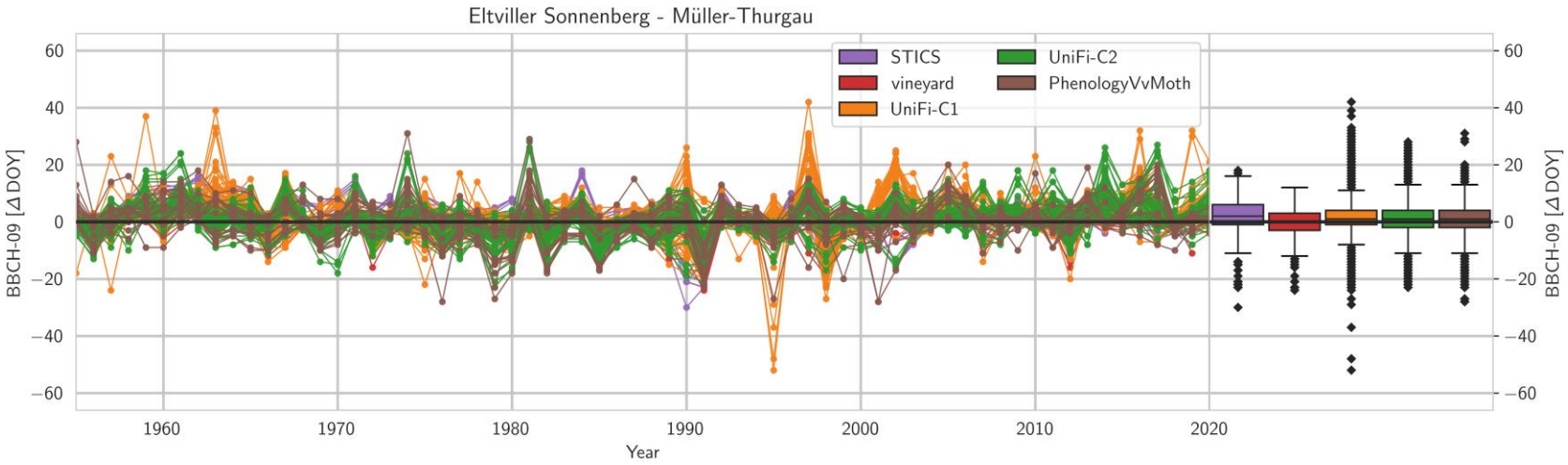

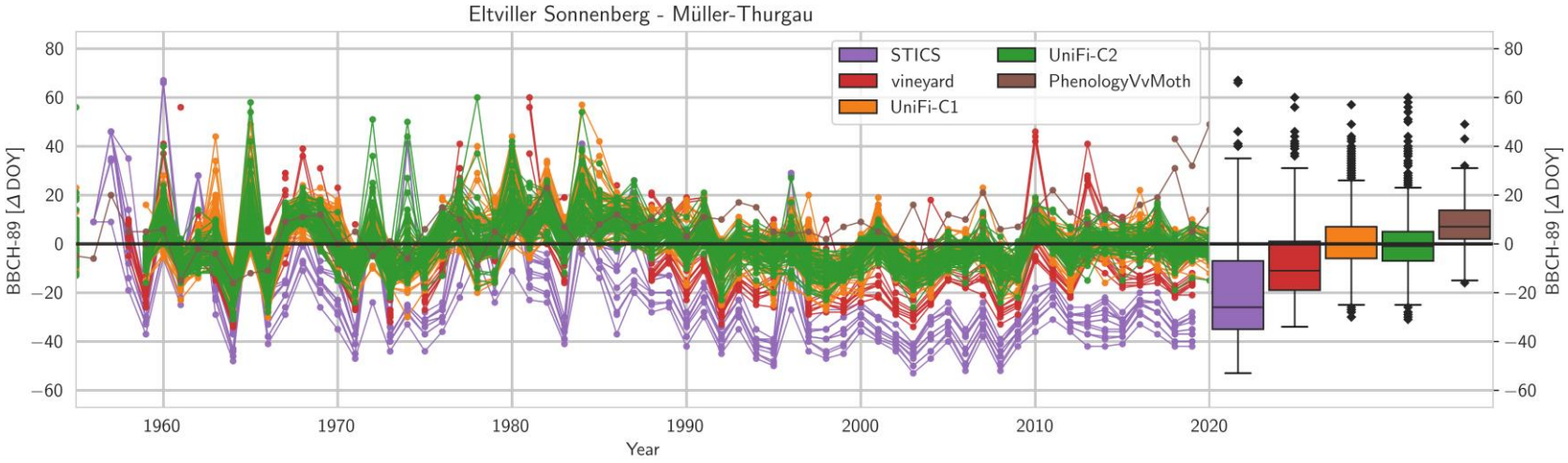

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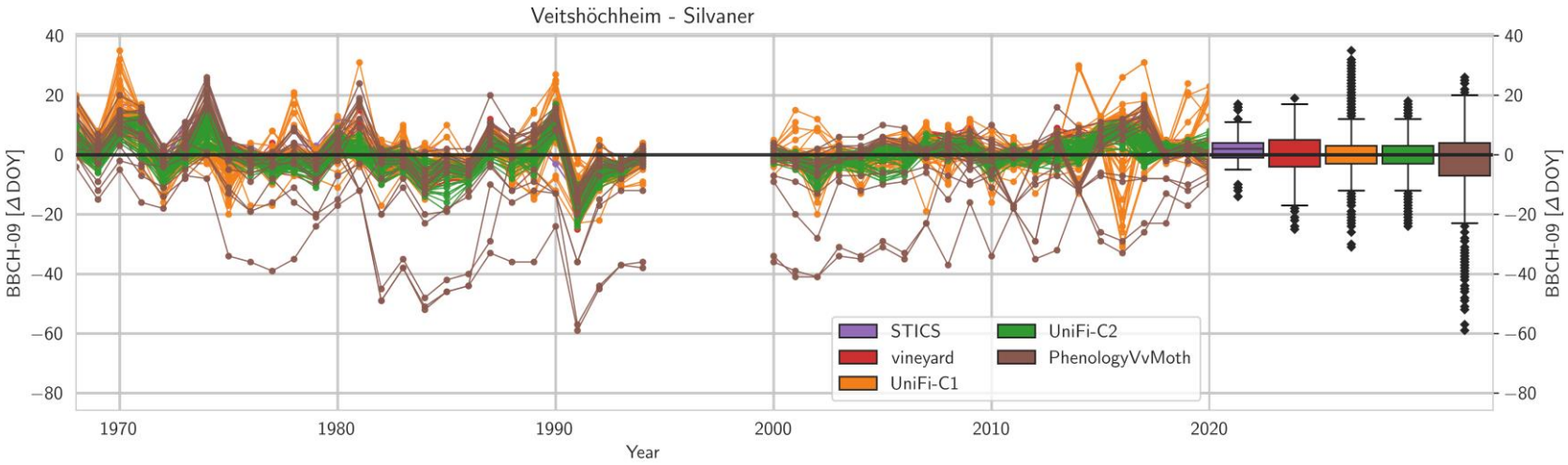

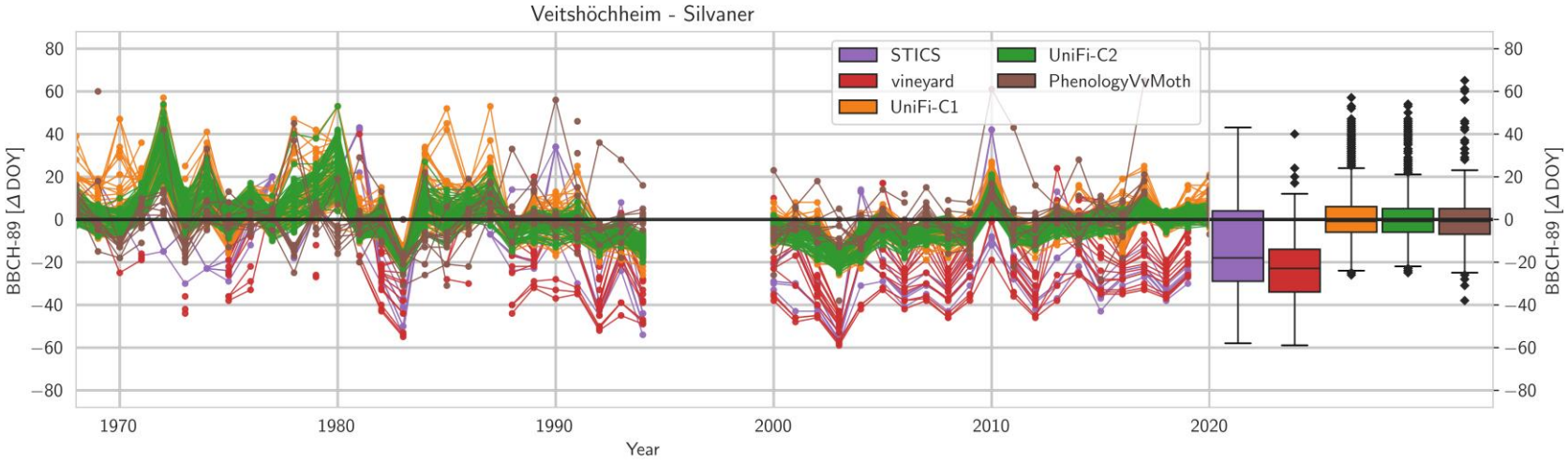

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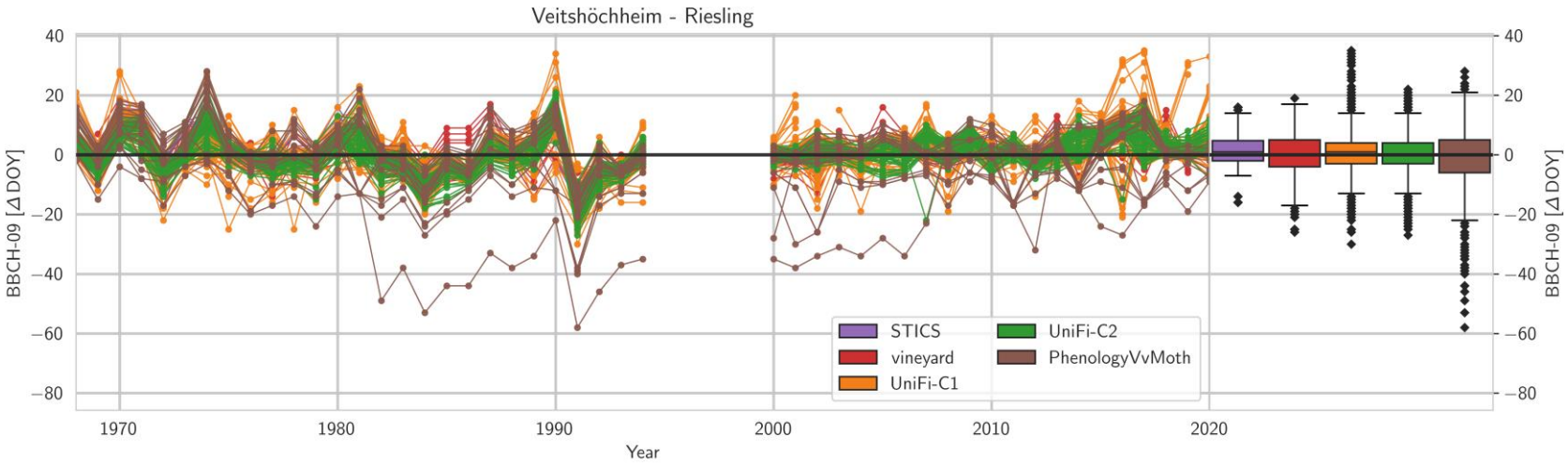

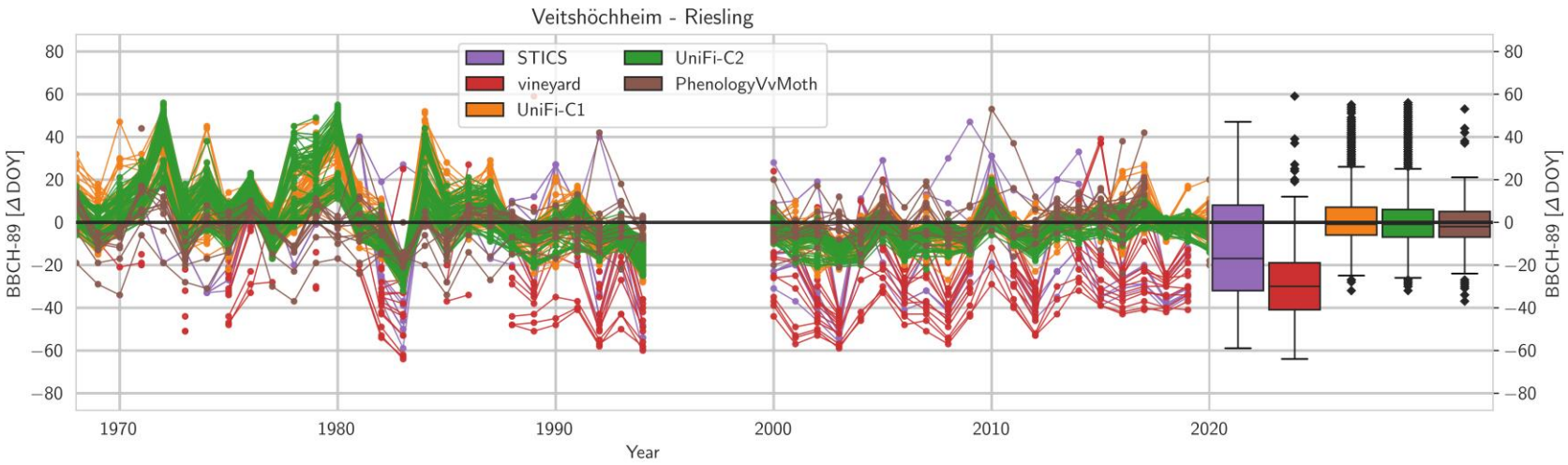

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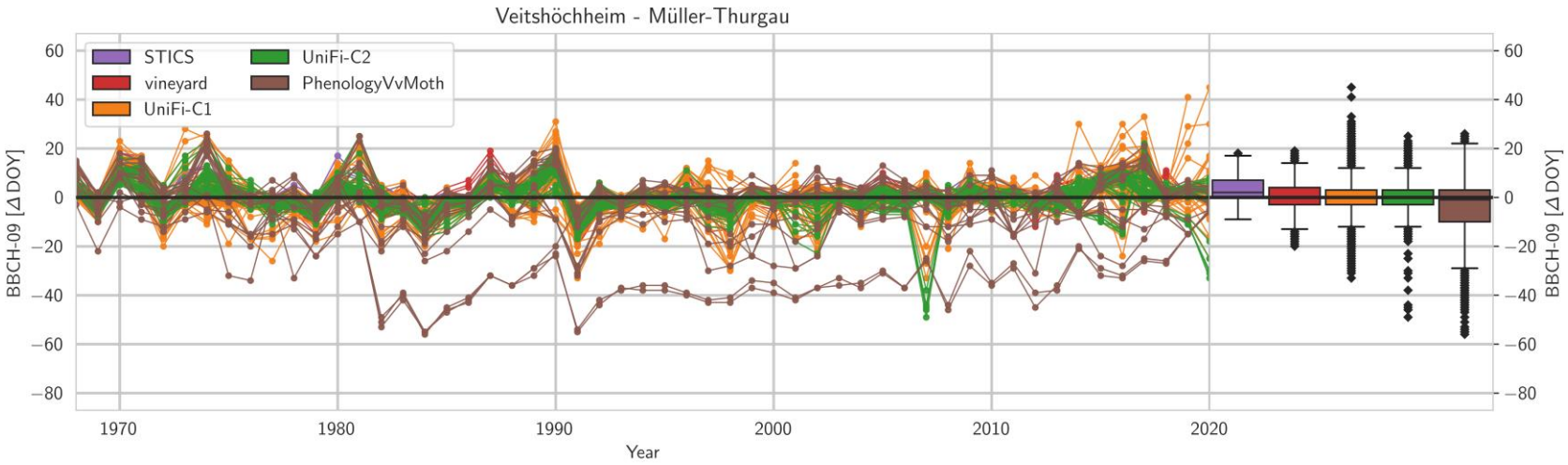

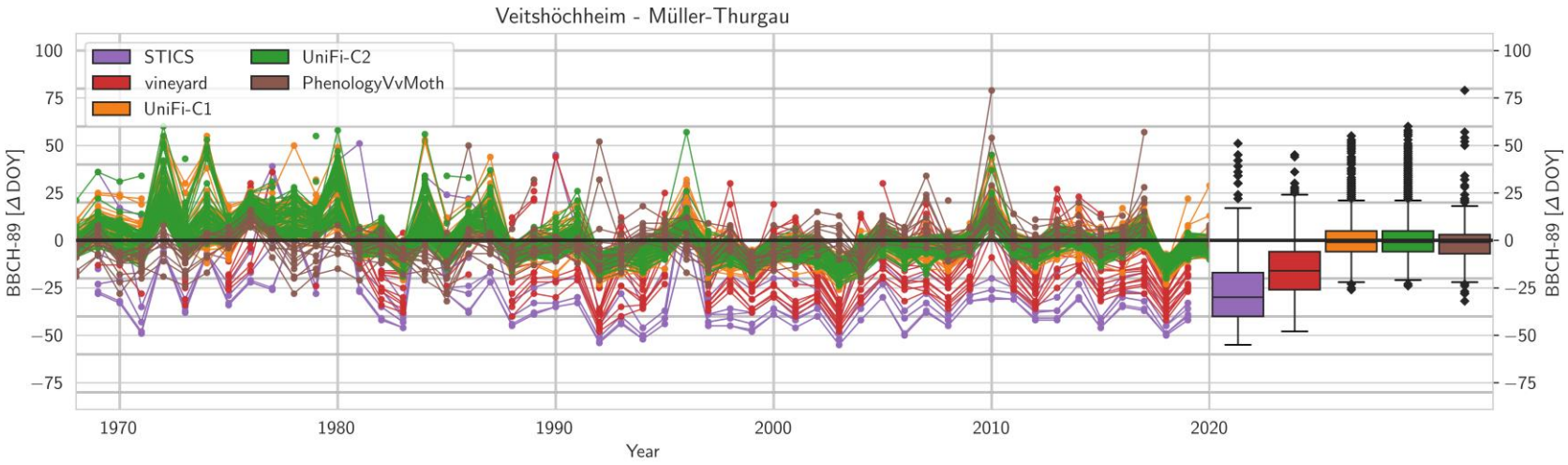

Phenology Dataset Overview

Sources	
PEP725	1940 sites, restricted
TEMPO	1640 sites, registered users only
DWD	949 sites, free
UTAD	15 sites and 2 regions
UniFI	8 sites (France) and 54 sites (Sicily)
LIST	2 sites, Luxembourg
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- ASCII/CSV format

/p/projects/clim4vitis/data/phenology/observations/preprocessed

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- Different formats
- Different quality
- Different type
- Separately preprocessing to check/correct and unify each dataset

Phenology Dataset Overview

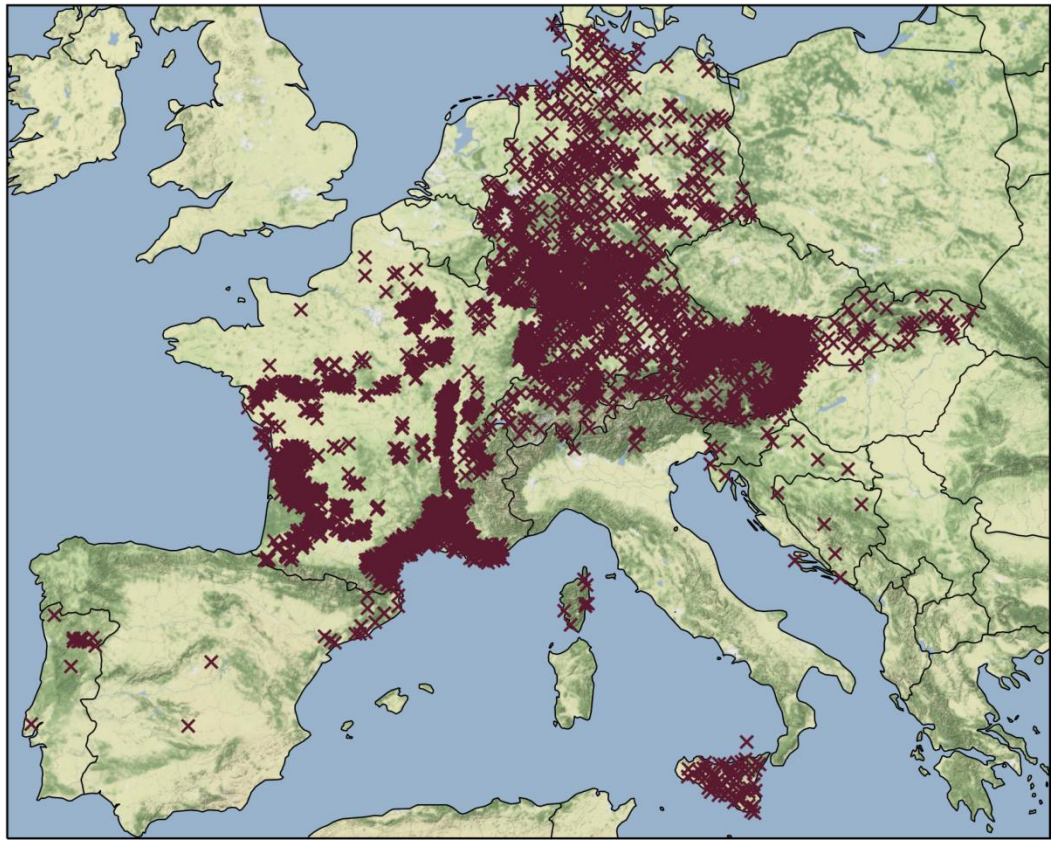
Primary Evaluation Matrix

- Merging of all datasets to get a comprehensive dataset
- Full spatio-temporal coverage and check/complement duplicate sites

Sources	# Sites	# Varieties
Total	3872	123
Known variety	346	116
Unknown variety	3526	7

- 48 different BBCH stages in total Sparsely covered!

/p/projects/clim4vitis/data/phenology/observations/merged/ascii



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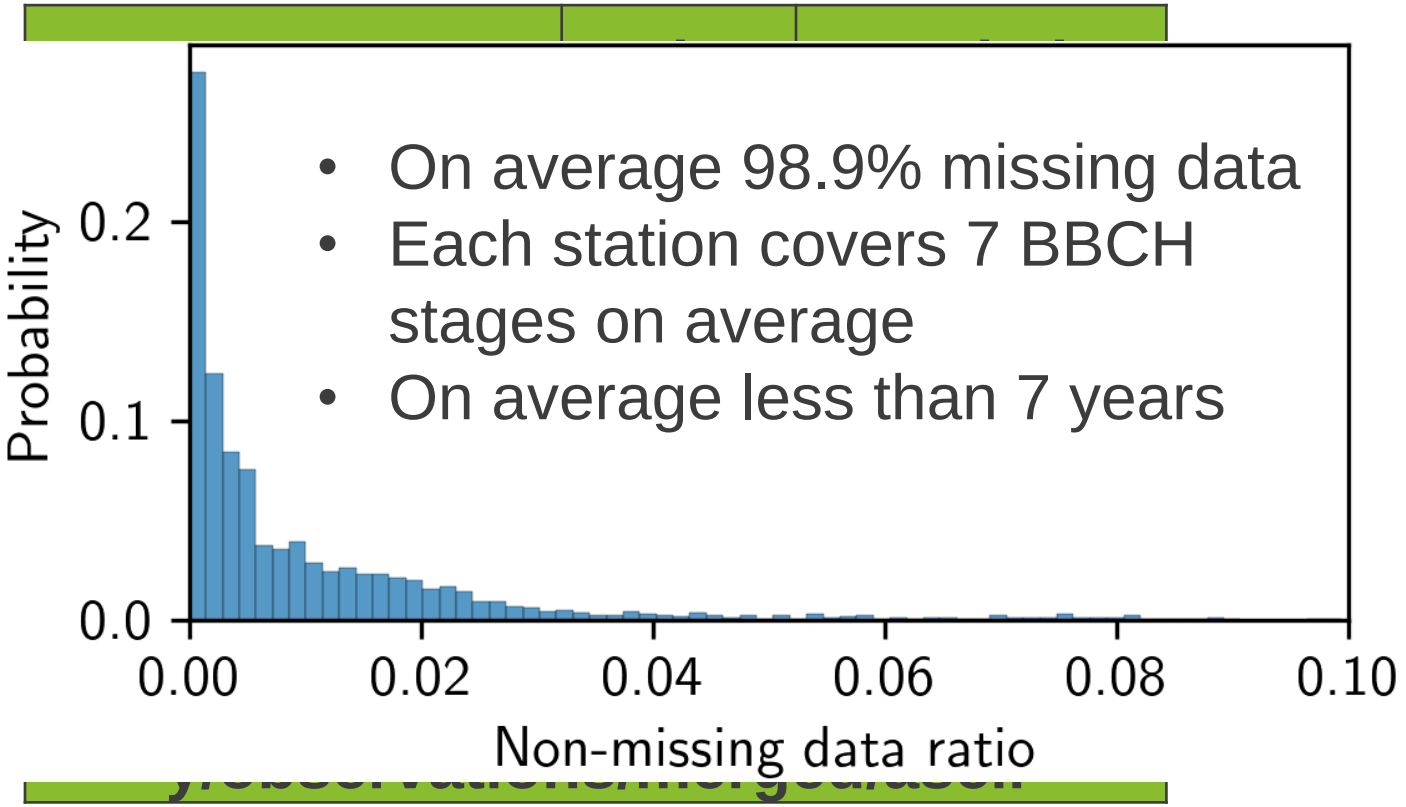
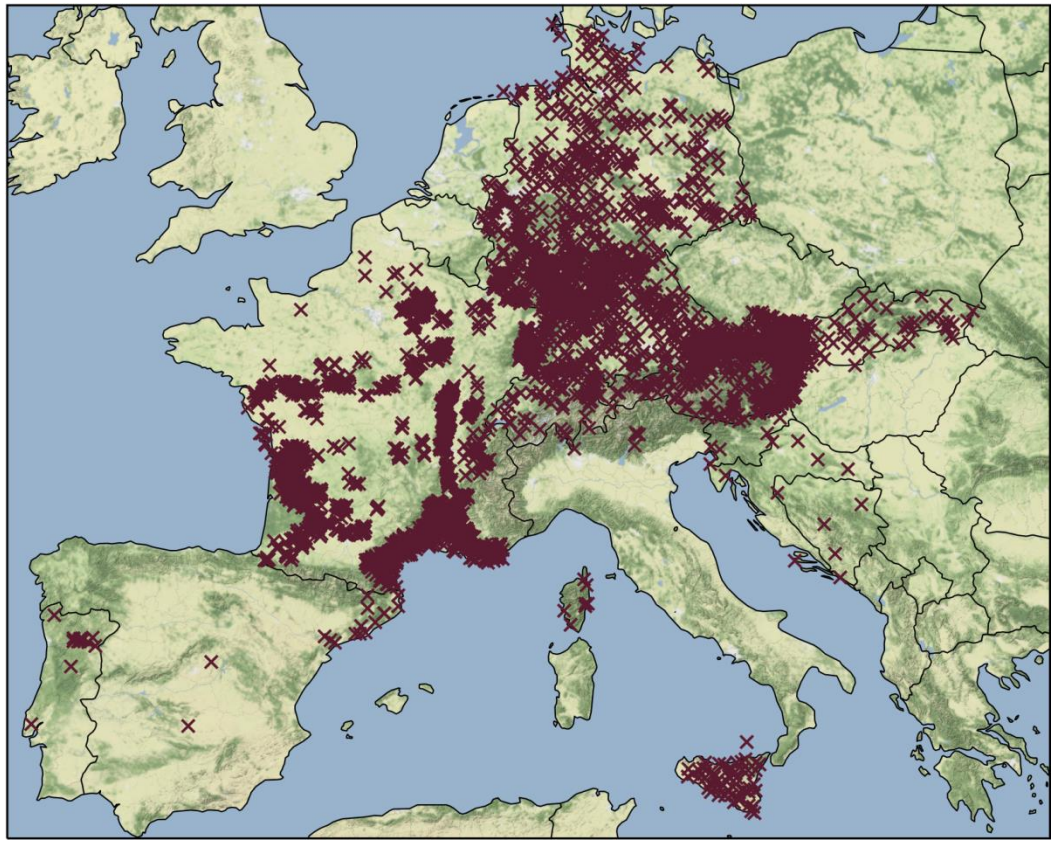


- On average 98.9% missing data
- Each station covers 7 BBCH stages on average
- On average less than 7 years



Model Comparison Framework

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/p/projects/clim4vitis/data/phenology/observations/comparison_study

Model Comparison Framework

Primary Evaluation Matrix

- Primary setup for evaluation
- Robust calibration and statistical significant validation over climatological time scales
- Comparison of phenology model variability

BBCH		7	9	61	63	65	68	69	81	83	85	89
Remich	Rivaner	0	**48**	0	**44**	0	**44**	0	**42**	0	0	0
Eltviller Sonnenberg	Riesling	0	**65**	**65**	0	**64**	**65**	0	**65**	**46**	**45**	**65**
Eltviller Sonnenberg	Müller Thurgau	0	**65**	**65**	0	**65**	**65**	0	**62**	**47**	**42**	**65**
Eltviller Sonnenberg	Spätburgunder	0	**33**	**33**	0	**33**	**33**	0	**33**	**33**	**32**	**33**
Veitshoechheim	Müller Thurgau	**24**	**52**	**26**	**52**	**52**	**52**	**24**	**52**	**24**	**25**	**52**
Veitshoechheim	Riesling	**20**	**47**	**20**	**47**	**47**	**47**	**20**	**47**	**20**	**21**	**47**
Veitshoechheim	Silvaner	**20**	**47**	**20**	**47**	**47**	**47**	**20**	**47**	**20**	**20**	**47**
Geisenheim-HGU	Riesling	0	**53**	0	**53**	**53**	**53**	0	**53**	0	**53**	**53**

Model Comparison Framework

Secondary Evaluation Matrix

- At least 20 years
- At least 3 out of 5 man stages covered
- Trade robustness against spatial coverage
- Comparison of regional and variety representativeness

BBCH		7	9	61	63	65	68	69	81	83	85	89
Remich	Gewuerztraminer	0	**44**	0	**44**	0	**44**	0	**9**	0	0	0
Remich	Riesling	0	**44**	0	**44**	0	**44**	0	**9**	0	0	0
Remich	Pinot Gris	0	**44**	0	**44**	0	**44**	0	**9**	0	0	0
Remich	Pinot Blanc	0	**44**	0	**44**	0	**44**	0	**9**	0	0	0
Remich	Auxerrois	0	**44**	0	**44**	0	**44**	0	**9**	0	0	0
Remich	Elbling	0	**44**	0	**44**	0	**44**	0	**9**	0	0	0
Bordeaux Chateau Lafite	Merlot	**47**	0	**4**	0	**53**	0	0	**4**	0	**53**	**48**
Bergheim	Riesling	**48**	0	0	0	**42**	0	**42**	0	0	**41**	**8**
Bergheim	Pinot Noir	**48**	0	0	0	**42**	0	**42**	0	0	**40**	**8**
Strasburgo INRA Colmar Domaine de Bergheim	Pinot Noir	**48**	0	0	0	**42**	0	**42**	0	0	**40**	**8**
44km off Marseillan	Cabernet Sauvignon	**30**	0	0	0	**21**	0	0	0	0	**19**	**24**
Montpellier Vassal UE	Cabernet Sauvignon	0	**39**	0	0	**26**	0	0	0	0	**32**	0
Montpellier Vassal UE	Syrah	0	**41**	0	0	**26**	0	0	0	0	**26**	0
Lisboa Region	Fernao Pires	0	**25**	**25**	0	0	0	0	0	**25**	0	0
Lisboa Region	Chasselas	0	**25**	**25**	0	0	0	0	0	**25**	0	0
Lisboa Region	Castelao	0	**25**	**25**	0	0	0	0	0	**25**	0	0
Lisboa Region	Aragonez	0	**21**	**21**	0	0	0	0	0	**21**	0	0
Minho Region	Vinhao	0	**23**	**22**	0	0	0	0	0	**22**	0	0
Minho Region	Loureiro	0	**23**	**22**	0	0	0	0	0	**22**	0	0

Introduction

Intercomparison Framework

Create a **Framework** for **unified** model calibration and validation

- Multiple models able to simulate the same variety, site and phenological phases
- Multiple sites/varieties to calibration and validate the models
- Long time frames to conscientiously test model sensitivities