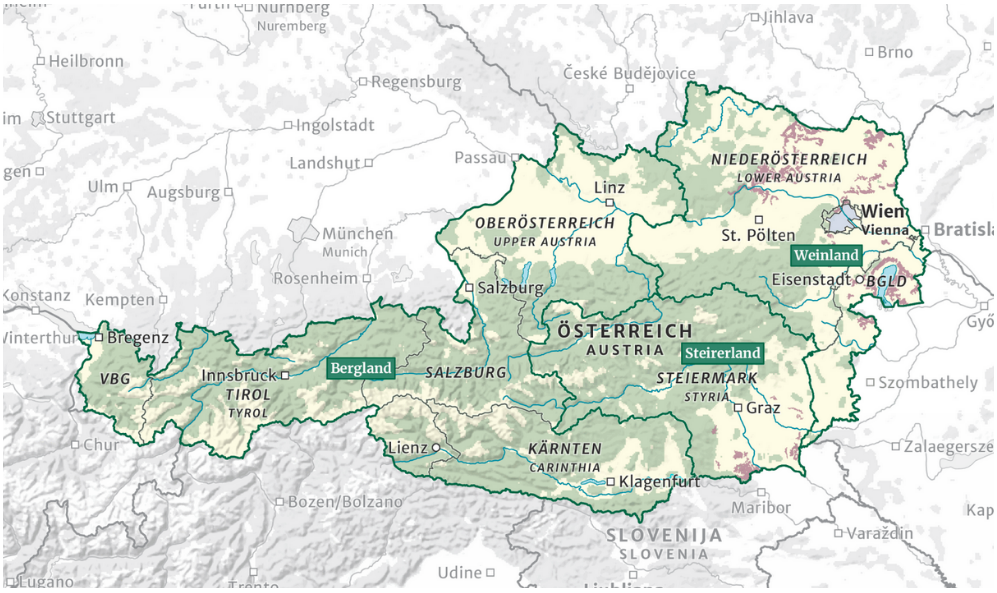
Aarhus University

Faculty of Arts

Using Remote Sensing Technology to Objectify the Assessment of Wine Vintage Ratings of Austrian Rieslings



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Spatial Analytics Exam Paper

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Find all relevant code on Github repository: https://github.com/1Steinthal/SA_exam

To assess individual work in the report note the associated acronyms:

Snorre Alsted Søndergaard {SAS}

Thomas Frederiksen Steinthal {TFS}

All code has been equally developed by both authors

Char-count (ex. abstract): 27.889 (11,6 np)

ABSTRACT

The wine world is infamous for being opaque and inaccessible for everyday consumers and the wine industry itself is largely entrenched in tradition-bound practices resisting modern technological advancements. However, the public availability of databases containing spatial remote sensing data, may offer ways of rendering otherwise esoteric information more intuitive and accessible. This study explores the potential of remote sensing, using the Normalised Difference Vegetation Index (NDVI), to assess vineyard health in Austria's Kremstal region from 2017 to 2023. Utilising freely available data from the Austrian Vineyards database and Copernicus satellite imagery, the study examines the correlation between vine health and vintage ratings. No visual statistical significance was found, highlighting the limitations inherent in the subjectivity of vintage ratings and the uncertainty of vine health as an indicator of wine quality. Nevertheless, the study underscores the importance of accessible data in demystifying the wine industry.

Key words: *wine, NDVI, vintage ratings, remote sensing*

1 Introduction {SAS}

Modern technology has made its entrance into the world's wine production. Due to the complexity of managing vineyards with manual labour, the potential for using technology to make productions more effective seems evident, such as using agricultural robotics (Fountas et al., 2020), LIDAR for tracking canopy (Sanz et al., 2018), water tracking (Gutiérrez et al., 2018), nutrition-tracking (Diago et al., 2016), yield-prediction (Aquino et al., 2016) and disease-detection (Gao et al., 2016). While all these means show potential aiding wine producers battle changing climate demands and varying customer preferences, they are all centred around the vineyard and less focussed on other contributors to the wine industry.

The spatial field of remote-sensing takes another approach in aiding general agriculturists and has lately shown potential in the agricultural sector, such as field preparation, in-season application to harvesting etc. (e.g. Khanal et al., 2020). The great advantage of remote-sensing is that it does not require deployment of expensive equipment: It relies on multi-spectral satellite imagery that is freely available - making the multi-spectral images a great data resource for everyone! (GisGeography, 2024a). These images contain, among others, bands of light reflectance with unique physical properties and the Normalised Difference Vegetation Index (NDVI) measures the state of vegetation health based on how plants reflect some of this light (GisGeography, 2024b). It might therefore prove a simple, but effective tool in gaining insight into the health of vines across years. While the NDVI is already aiding the world's wine production (Barriguinha et al., 2022; Vélez et al., 2019), there is no reason why it should not be able to aid other contributors to the wine industry.

Despite the norm of digitalisation of data across industrial sectors, data and information regarding the wine industry remains opaque and non-accessible, especially in tradition-bound wine countries such as France, where data on the many meticulously classified wine regions and vineyards has proven extremely inaccessible. In fact, this data opacity is not new from a historical perspective and makes it tough for the customers to actually identify what is in their bottles: The relation between the producer and the customer is a study in itself (Hvelplund, 2003: 47:50). Tradition is, unfortunately, still slowing down the modernisation of the world's wine industries.

However, the Austrian Wine Marketing Board (AWMB), a national service body for the Austrian wine industry, has created a database called Austrian Vineyards (AWMB, 2021). The database consists of an interactive map of every individual vineyard, called *ried*, in Austria, each with accompanying data and information. This database allows for the selection of specific rieds with comparable climate and soil.

The potential for remote sensing and the relatively sparse data sources in the wine industry - combined with the fact that many consumers struggle to understand the opaque classification standards of the wine industry and the constant strategic adaptations from the market (Hvelplund, 2003: 47; Vrontis et al., 2011) - makes an ideal study to use modern technology to showcase a consumer friendly framework that uses objective criteria to distinguish wine areas.

In this study we utilised the Austrian Vineyards database to map specific top rieds in the Kremstal region of Austria to quantify their vegetation health in the period 2017-2023, using satellite images displaying NDVI scores from the Copernicus database (2024). These measurements will be compared to recognised vintage recommendations on the wine market to investigate the correlation between NDVI and vintage ratings. Ultimately, this study does primarily aim to showcase how data correlation can help objectivise a traditional and commercial branche for the customer's point of view.

2 Problems and Background

The Austrian Wine Industry {TFS}

In 1985, the Austrian wine industry caused what a local village mayor called: “The worst disaster to hit this region since World War II.” (Tagliabue (NY Times), 1985) Colloquially known as The Austrian Antifreeze Wine Scandal, it was spurred on by the discovery of diethylene glycol in Austrian wines, a component also used in antifreeze products. The diethylene glycol was used as an artificial sweetener to meet the growing demand for sweet wines. The scandal tarnished the reputation of the Austrian wine industry, resulting in the foundation of the Austrian Wine Marketing Board (AWMB) in 1986, to ensure quality, restore prestige of Austrian wines and save the industry (AWMB, 2024a). Therefore, Austria proves to be an ideal case for a showcasing study, since it uses accessible wine data that is not found equally anywhere else in Europe. Hopefully, more consistent data from the entire world’s wine industry will be collected and made available in the future, laying the foundations for more comprehensive studies.

Kremstal, Austria {SAS}

We focus on the region of Kremstal in Austria, located in the Danube Basin in Lower Austria. The region is known for its steep slopes of weathered rock going down to the Danube and its tributaries, making it suitable for the Riesling grape. The river valley protects the rieds from the cool winds from the north, while the warmer winds from the east pass through the valley, creating a climate that is slightly warmer than neighbouring regions (Haecker, 2016: 248; AWMB, 2024b).

Riesling {TFS}

We focus on one grape variety, the Riesling, in order to ensure comparability across vintage ratings and NDVI. Riesling is chosen because it is widely planted in Austria and acknowledged for its quality potential. In the book *Riesling Rediscovered* (2016) John Winthrop Haeger describes the grape, noting that it is known for reflecting *terroir* and *vintage*; the taste of the wine reflects the soil composition and that year’s weather conditions (Robinson et al., 2012: 888). He writes: *“Riesling, as a variety and as a vehicle for the expression of terroir, is almost universally exalted by wine professionals.”* (Haeger 2016: 11). For this reason, the Riesling grape variety is well suited for investigating how NDVI correlates with vintage ratings. Because the varietal properties of Riesling include late budding and late ripening it has: *"high tolerance for cold winters, considerable drought resistance [...] high adaptability to a wide range of meso climates and soil types."* (Ibid.), it is a grape equipped for the precarity of unpredictable weather.

Climate Change {SAS}

One of the greatest difficulties facing the wine industry is climate change: *"Viticulture is famously sensitive to climate and changes in wine production have been used as a proxy to elucidate past climate change"* (Hannah et al. 2013). This is because individual winegrape varieties have very narrow climate ranges (e.g the Pinot Noir grape growing climate range is 2˚C) meaning that climatic changes can result in big geographical redistributions of wine production (Mozell & Thach, 2014). Climate is reflected in the taste of the wine: *"Colder [...] temperatures lead to incomplete ripening with high acid, low sugar, and unripe flavours (whereas) warmer-than-normal temperatures create overripe fruit with low acid, high sugar, high alcohol and cooked flavours"* (Hannah et al., 2013.). Considering the sensitivity of wine grapes to small climatic changes, this makes ideal climate directly comparable with ideal wines. Therefore, NDVI could prove to be an objective tool for measuring vintages.

Normalised Difference Vegetation Index {TFS}

NDVI is a simple and effective way of quantifying the health of plants (GisGeography, 2024b). The more chlorophyll in the plant, the greener it is, and the more red light it absorbs, the more near-infrared light it reflects. Calculating the difference between reflected red light and near-infrared light gives an NDVI value between -1 and 1, where -1 is likely the NDVI score of a water surface and 1 is the surface of dense green leaves. NDVI is therefore used in agriculture for precision farming, measuring biomass, and as an indicator of drought, along with other climatic analysis (Abbes et al., 2018; Panuju et al., 2012). However, wine production differs from many other agricultural practices, in some potentially crucial ways. Vines are often grown in harsh conditions, such as nutrient poor soils and steep slopes with poor water retention, as opposed to other agricultural products (Gilby, 2020). This study assumes wine to be a regular agricultural product for the analysis, but the efficiency of using NDVI in regards to the health of vines is still uncertain (see DAG in fig 1).

3 Methods / Approach

It is a cliché, but it is evident that statistical testing with regular frequentist statistics show an undesired and non-nuanced tendency to split studies into truth and falsification, which is not ideal (Ioannidis, 2005)! Relying on the frequentist framework for testing, this study aims to disclaim all choices along the way and to differentiate between the causality and correlational findings! Therefore, this study considers visual analysis a valid way of inference.

Disclaimer of causality and hypothesis declaration {SAS}

To investigate whether there is a correlation between a given vintage in a wine region and the NDVI of the plants, the authors of this study had to simplify the conceptual thought of actually measuring every single Riesling-vine across Austria(!) It is probable, that a vine's NDVI must affect the final rating of a wine somehow, since it is a measure of plant photosynthesis, but to measure this effect, this study finds it relevant to declare causality with a DAG:

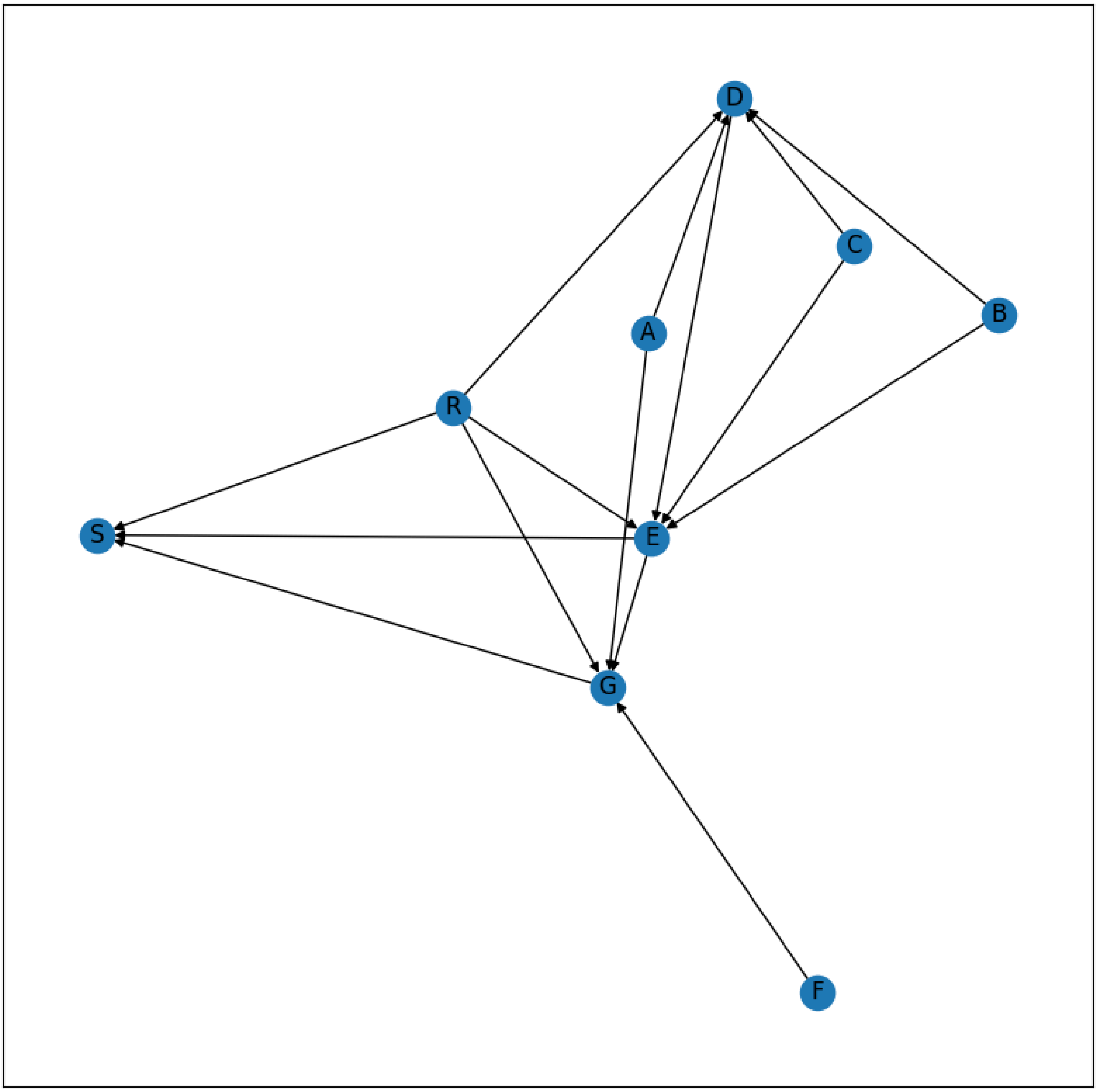


Fig 1 - DAG of the proposed causality. Start reading from S and backwards
A: Customer demands (measured through the proxy of the wine producer's working)
B: Terroir (available through AWMB, 2021)
C: Weather conditions (available through Geosphere.at
D: Plant health (measured through the proxy of NDVI)
E: Grape quality and properties (harder to quantify)
F: Vinification traditions (and hereby the expectations to the vinification process)
G: The actual vinification process (expressed through the wine producer's choices)
S: The final vintage-rating of the wine
R: Residuals

Even if this graph alone expressed the sole causal relation between NDVI and vintage rating, it is clear that the causal properties are spurious to track all the way between *D*, NDVI, and *S*, vintage ratings. Taking the immense effect of residuals into account reveals a couple of causal 'backdoors' (McElreath, 2015: 191) that disrupts the main causality (e.g. through 'A: Customer demands'). Since it is only possible to condition on parts of the variables in a complete statistical analysis, this section mainly expresses the caution for denouncing these results as truthful!

This study aims to investigate the correlation between NDVI's of given Riesling-vines in Kremstal and the vintage rating of the area's top produced Riesling-wine. If such a correlation exists, the methods of this study could be supplementary means of studying whether a given season's vine health indicates the coming ratings at wine release! We will see that ratings vary notably between wine recommenders, they are tough to find, often subject to payment, and thereby influenced by commercial factors. This analysis aims to display a different (or supplementary) mean to rate a vintage. In a further study, this study could serve as an inspiration for an analysis that could be done - see attached GitHub-repo.

Software and hardware {TFS}

We have used the software language Python 3, v. 3.12.2 (Van Rossum & Drake, 2009) with Visual Studio Code, v. 1.89 (Microsoft, 2024). The code was developed and ran locally on a Lenovo-Yoga 7 with a 13th Gen Intel(R) Core(TM) i7-1360P, 2.20 GHz-processor and 16 GB RAM with Windows 11 Home (23H2), while all data was downloaded directly from the listed sources without any need of VPN-software. Complimentary, we mainly utilised the packages listed in Table 1 for the code (alternatively see the requirements.txt of the github-repo for the full requirement-list)

Package	Version	Acknowledgement
pandas	2.2.0	McKinney et al., 2010
matplotlib	3.8.3	Hunter, 2007
numpy	1.26.4	Harris et al., 2020
seaborn	0.13.2	Wascom et al., 2017
statsmodels	0.14.2	Seabold et al., 2010
networkx	3.3	Hagberg et al., 2008

Table 1 - Influential package dependencies

4 Data Acquisition and Processing {SAS}

Wine data is immensely difficult to gather, yet this study proposes different methods of actually measuring the variables that ultimately decides what wine consumers find in their bottles.

This study decided to focus on the wine region of Kremstal, which has produced some of the best rated Rieslings the past years. Since Riesling is a grape that expresses the vintage well, this study has chosen 6 rieds. All 6 Kremstal-rieds, has produced Riesling scorings higher than 90 points from recognised wine critic, James Suckling (Suckling, 2024) within the recent years, and have a majority of Riesling planted on them (since all rieds are split into different plots owned by different producers they are never only monovarietal). For measuring the region (2267 ha) (AWMB, 2024b), we have chosen two rieds from each three sub areas spread over Kremstal: Senftenberg represent the narrow, steep valleys of inland Kremstal, Loibenberg represent the steep rieds along the river Danube and Langenlois represents the flatter inland Kremstal with bigger raised plateaus (Haecker, 2015: 248-274). The reason for subsuming an area like Kremstal (2267 ha) by just 6 rieds (~100 ha) is the comparability of the study: General vintage ratings are normally only available per region. Furthermore, it helps smooth out extremely local weather phenomena. By choosing top rieds, we ensure to get the most serious wines that express the general vintage ratings and the producers who aim to express the uniqueness of the area best.

Area	**Ried**	**Size, ha**	**Distribution of Riesling-vines**	**Elevation, m.a.s**	**Aspect, percent round the clock**	**Slope**	**Dist to water/ river**
Senften-berg	Hochäcker *Nigl Privat, Riesling, 2021: 100 points* *Proidl, Riesling, 2021: 97 points, 2022: 96 points*	15	0.72	249-381 (ø 324)	S-SW (.79)	3-35° (ø 19°)	> 500 m
Senften-berg	Ehrenfels *Proidl, Riesling, 2021: 98 points, 2022: 94 points, 2020: 95 points*	2	0.57	249-321 (ø 276)	S (.54)	15-44° (ø 29)	> 500 m

Loiben-berg	Steinertal *F.X Pichler, Riesling, 2019: 98 points, 2021: 99 points, 2022: 98 points*	4.3	0.49	230-282 (ø 248)	S-SW (.60)	3-32° (ø 15)	> 500 m
Loiben-berg	Grillenparz *Stadt Krems, Riesling, 2022: 94 points, 2021: 95 points, 2020: 93 points*	7.6	0.49	262-335 (ø 313)	S-SE (.47)	0-31° (ø 12°)	> 1000 m
Langen-lois	Steinmassl *Weingut Bründlmayer, Riesling, 2021: 94 points* *Loimer, Riesling, 2021: 93 points*	23	0.57	245-344 (ø 289)	S-SW (.74)	0-33° (ø 7°)	> 500 m
Langen-lois	Heiligstein *Weingut Bründlmayer, Riesling, 2022: 94 points,* *Topf, Riesling, 2021: JS 92 points, 2020: 91 points, 2016: 94 points*	43	0.85	213-349 (ø 267)	S-SW (.78)	0-32° (ø 13°)	> 500 m

Table 2 - The 6 rieds of the study. All ratings in the Ried-column are conducted by wine critic, James Suckling, and all further data originate from the Austrian Wine Board. See appendix 3

Through the gathered data of table 2, it has been assessed that the rieds are comparable and express somewhat similar terroir for comparison, see appendix 3 for further.

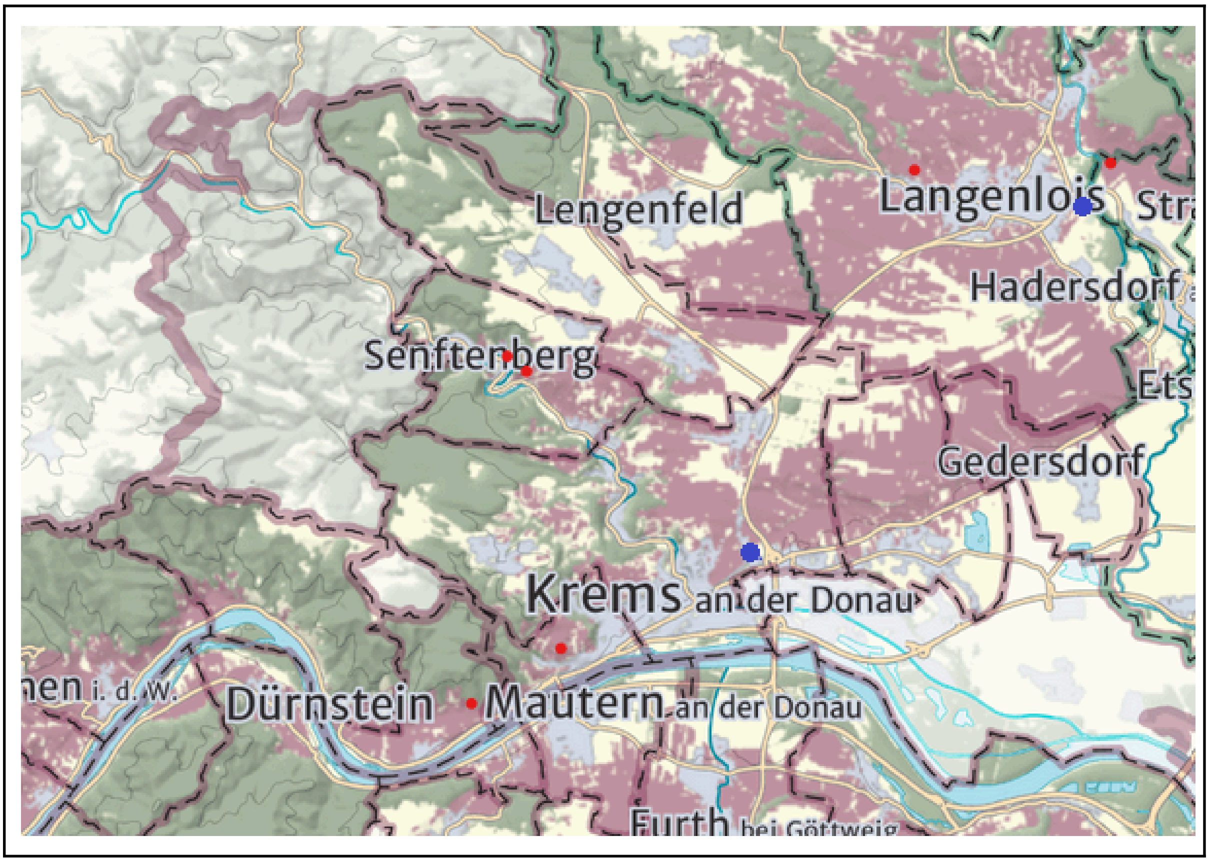


Fig 2 - Overview of Kremstal (roughly contained by map), indicating the study's ried's with small red dots. Senftenberg in the upper left, Loibenberg in the bottom and Langenlois in the upper right. The two weather stations, Krems, and Langenlois, are shown in blue. Adapted from AWMB's website

Using the variables of the DAG (fig 1), the study has gathered data from different sources. What is notable is how much data is freely available but how analytical results are not easily found (data is widely spread, difficult to interpret and gather, sometimes hidden behind paywalls etc.). This study only uses freely available data:

B: Terroir Data

The terroir data includes the geological elements of the rieds. The data was acquired through AWMB's specific measurements of individual rieds (see appendix 3). Visually investigating the geological compositions of the rieds concluded that they were comparable for this analysis. It is an inevitable component that needs to be conditioned in a further study! It is important to note that alone the soil type's reflective properties can affect the NDVI (Montandon & Small, 2009)

C: Weather Data

The weather data includes avg. hours of sunshine and monthly precipitation [mm]. The data was acquired through Wetter Data Geosphere.at, the Austrian national institute for weather observation (GeoSphere.at, 2024). The weather data was included to assess variations that clearly would influence the results. All rieds assessed in the study are covered by two weather stations (see fig 2).

D: NDVI

The NDVI-data was acquired through Copernicus (2024) and includes the mean measures of NDVI registered for a spatial polygon in time. By ensuring the rieds' span with AWMB's spatial tools, a spatial polygon was drawn in Copernicus data and weekly NDVI was extracted for non-cloudy days. The oldest vintage included was 2017, simply for the reason that Copernicus' data only goes back to 2016. Ultimately, the data was downsampled monthly. 7 data points were unavailable due to cloudiness and they were linearly interpolated using the surrounding measures (as Jaquin et al., 2010)

S: Vintage ratings

The vintage ratings were obtained from 4 different distributors of wine ratings for Austrian Riesling. It is worth noting that vintage ratings are often delivered by companies who have interest in promoting specific vintages, and use non standardised measures (often just text or arbitrary categories). It is interesting whether NDVI can supplement the available vintage ratings in an objective and meaningful way. The four raters are:

- Wine Spectator (2021), internationally acknowledged wine magazine
- Austrian Wine (2023), Austria's own denoter of wine vintages
- Moevenpick-wein (2024), a German wine shop
- Silkes Weinkeller (2023), German commercial wine grossist

Data preprocessing: {TFS}

Since the NDVI-data was a sequence of observations collected at regular time intervals it is considered to be a time series. Since each pixel from Copernicus contains a value, the extracted value contains a mean (with other standardised measures), which expresses the distribution of measurements, these are assumed to be normally distributed around the mean value.

The NDVI-variable was assessed to be a result of different components that all aid explaining the variability in the data: (see empirical results for this choice)

- *Base level*: The base level of NDVI reflected from Riesling-vines
- *Trend*: The difference between vintages express the trend
- *Seasonality*: Since vines follow a yearly cycle an element of seasonality express differences between months
- *Residuals*: All the remaining variables (see DAG). The only thing we know about them is that they are ideally randomly distributed

The entire preprocessing is explained in steps in the .ipynb-notebook contained in the GitHub-repo, but in brief the data was preprocessed in the following steps:

1. Create a DAG explaining the causal relations for the study
2. Preprocess the weather data to make it fit to merge ried-data
3. Preprocess ried-data and merge with weather-data
4. Check assumptions for data distributions (see appendix 1 and 2)
5. Decompose and quantify the NDVI-variable (see fig 4)

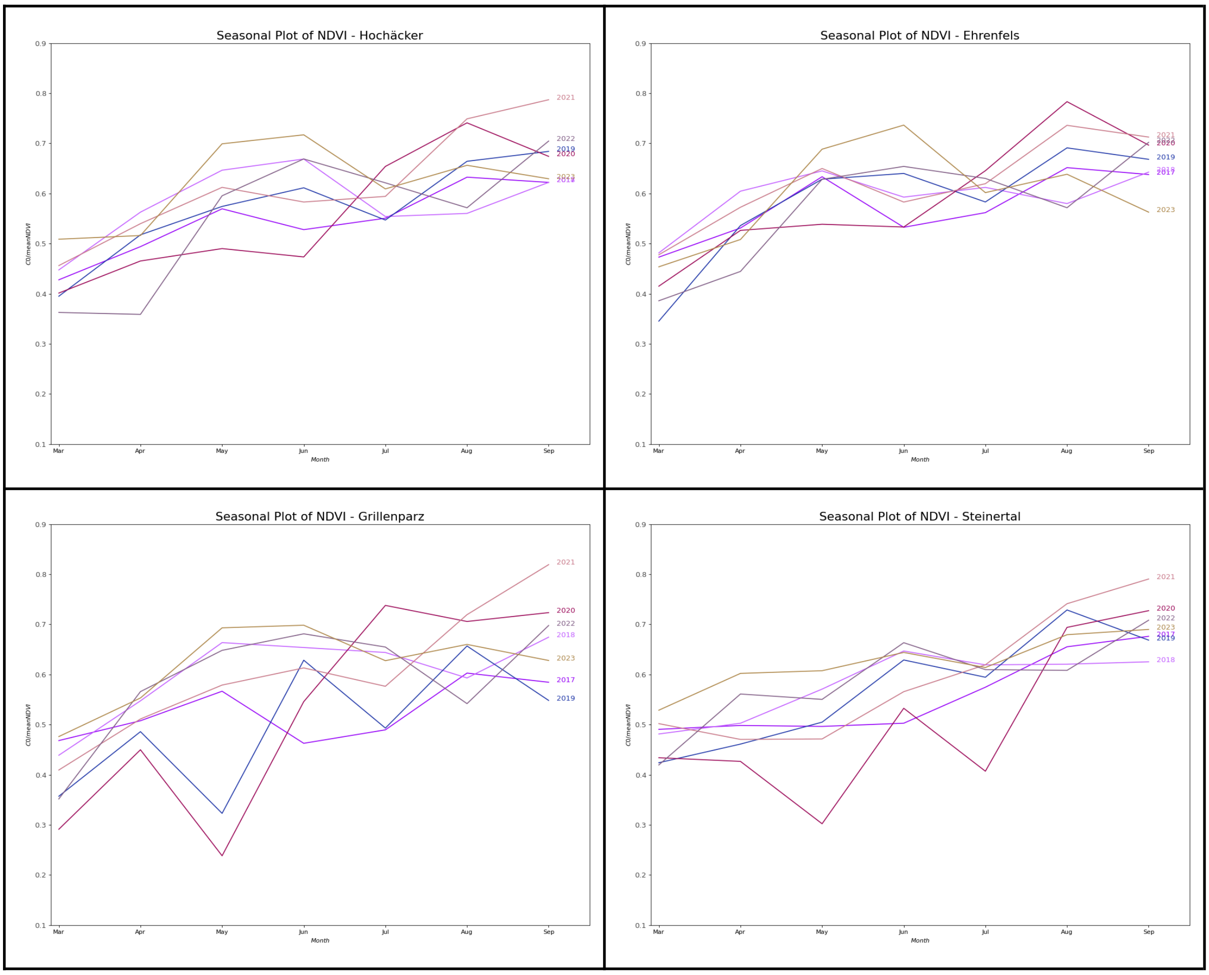
6. Assume additive decomposition and box plot the rieds with relevant influencing factors (see fig 5)

Assessing assumptions about the data

This section displays how the assumptions about statistical analysis are met on a respectable basis. It is noted that general statistical analysis generally requires a large sample of data, and that ideally the study should have had more data-points.

Assumption 1: Ried individuality

We assume all rieds to represent a similar trend. That is, they're all sampled from a comparable population of rieds in Kremstal, which represent an individuality in themself. By plotting the general NDVI-score for each ried, it seems evident that this is the case. Indeed, there is a seasonal and base-line-factor in the data, but the residuals make each plot different from one another. It is assumed that this makes the rieds comparable since there are no big unexplainable trends across the data.



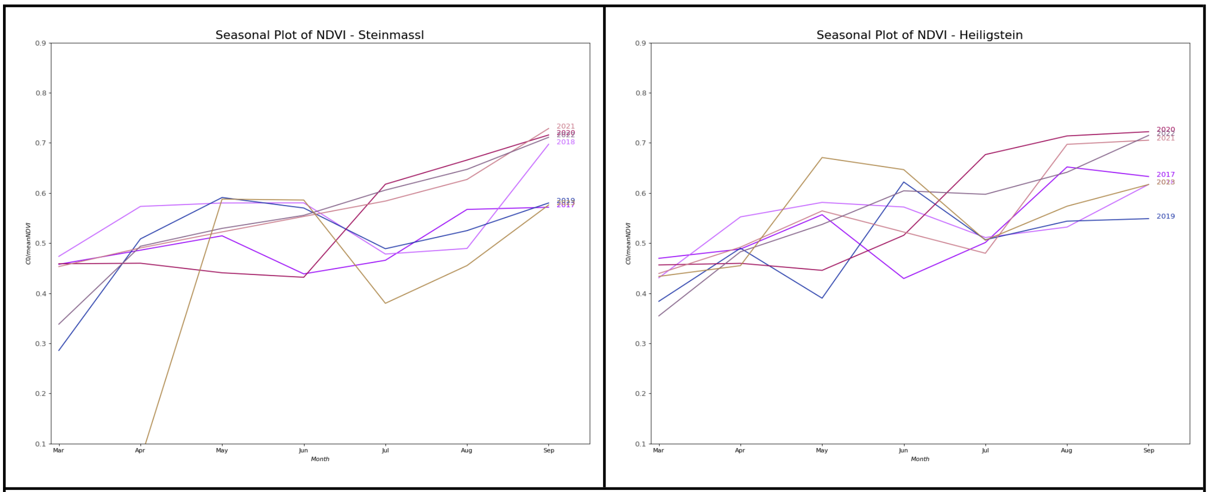


Fig 3 - Assessing individuality on the ried's

Assumption 2: Data homoscedasticity and distribution

Another assumption for statistical data analysis is data-homoscedasticity and normal distribution. To assess the data's homoscedasticity, all rieds was assessed for their variation of standard deviations: Does the standard variation of all data points from a given ried from Copernicus show equal variance in their NDVI-values? This was assumed to be the case (see appendix 1).

We have already discussed the normal distribution of data, but to make sure that the analysis data was normally distributed, all data-points used for the analysis were assessed monthly to ensure that the monthly measurements were sampled from a population of all the rieds. This was also approximated to be the case (see appendix 2).

5 Empirical Results {SAS}

We expect the NDVI to be a component consisting of four variables: Base level, trend, seasonality and residuals. The relation between these variables are unknown to us, but it is suspected that they either add up additively or multiply, meaning that we ideally could present two formulas for expressed NDVI. According to Abbes et al (2017), the formula 1 is a simple, acknowledge quantification of NDVI for general vegetation known as STL (Season Trend Loess), while formula 2 express a relationship for comparison suggested by Panuju & Trisasongo (2012) for complex NDVI-composition (here rain forests). It is noted that there exists more complicated decompositions of NDVI (Abbes et al., 2017), but that none has been used on vines (as known by the authors). Therefore this study considers two decompositions:

1. $NDVI = B + T + S + e$
2. $NDVI = B * T * S * e$

Where B is the base level of Riesling-vines' NDVI-emission, T is the trend (the vintage), S is the seasonal factor and e is the residuals. As we've already seen, the residuals are ideally randomly distributed, meaning that we can use them as a mean for investigating which of the formulas fit our theory best:

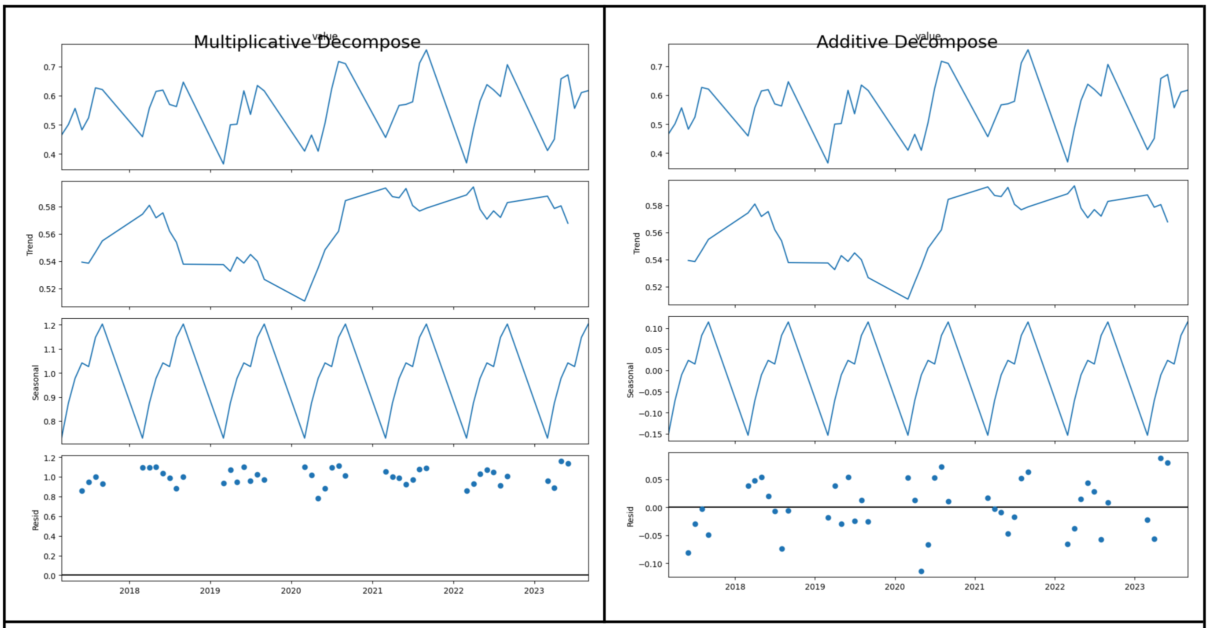
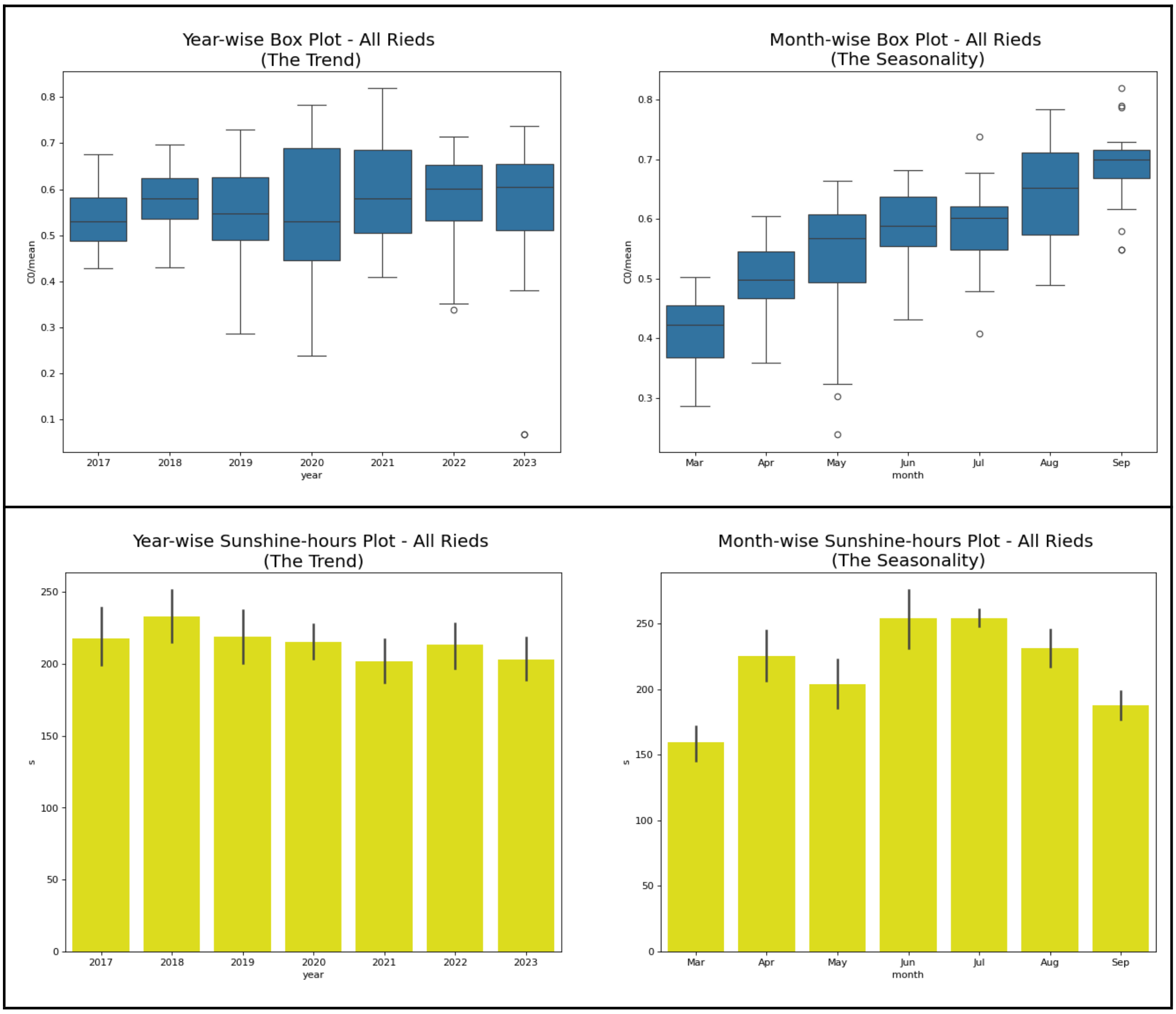


Fig 4 - Decomposition of the NDVI-variable (multiplicative and additive)

As seen in the figure, the additive decomposition of the NDVI-factor looks to ideally approach our expected decomposition. It seems reasonable that the seasonal factor is consistent each year, and that the residuals are equally distributed around zero. Looking at the trend, which expresses the vintage, reveals that there is a trend in the data between the vintages. Simply plotting the NDVI vintage-wise as a box plot does reveal a similar pattern, even though it is clear that the differences between vintages are not statistically significant!



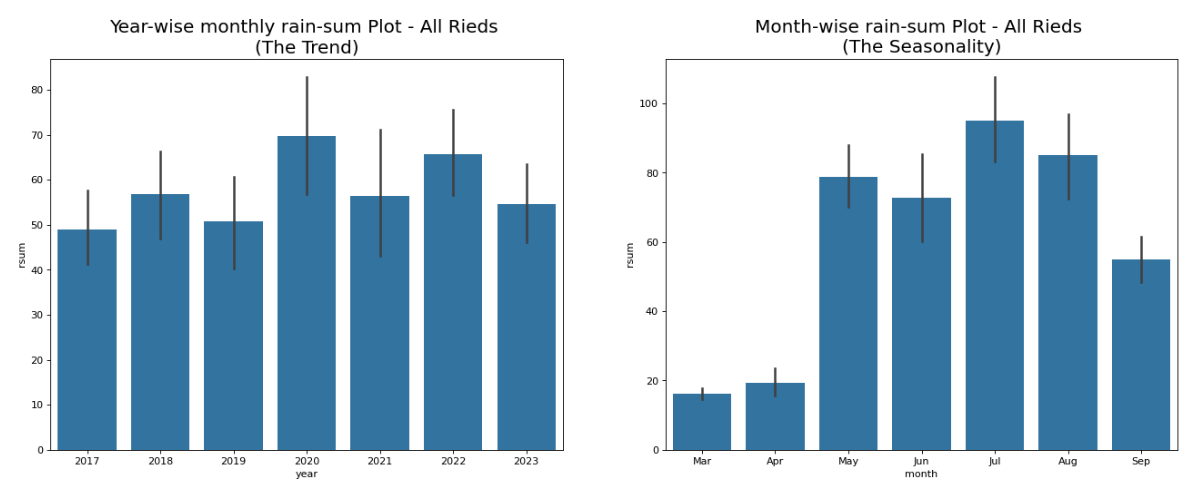


Fig 5 - Vintage trends in NDVI, sunshine and precipitation

We do see a general trend of the yearly NDVI rising and falling between the years 2017-2023, but it is non-significant. We are able to observe a 'drop' in NDVI-average in the vintages 2019 and 2020, not explained by the seasonality or residuals. The 2020 vintage is, however, explained by the relatively high amount of rain this season, but taking vintage 2022 into account this mainly seems to be spurious relations - especially taking Riesling's relative resistance against rain into account.

The NDVI-trend is compared with the vintages in the table 3 below, which also tends to downrate 2020, looking at Wine Spectator (perhaps the most objective) with Austrian wine tending to avoid the use of superlatives for this season. We observe that the warmth of Austrian wine's ratings correlates with the hours of sunshine in '17 and '18, while the ideality of 2019 and 2021 is not captured by the NDVI-trend. It is again noted that there are no significant NDVI-differences found in this study.

Source	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Wine Spectator	94	93	95	92	95	NA	NA
Austrian wine	Very warm, rich vintage	Warm, variable quality	Fully ripe, great vintage	Classic vintage	Historical great vintage	Well balanced vintage	Ripe fruit vintage
Moevenpick	Excellent	Gut bis sehr	Excellent	Gut bis sehr	Excellent	Gut bis sehr gut	Gut bis sehr gut

		gut		gut			
Silkes-weinkeller	Excellent	Good	Excellent	Very good	Excellent	NA	NA

Table 3 - Commercial available vintage ratings

Further assessment

We are able to compute reliable correlational measures of NDVI on a yearly basis, but it is not possible for this study to assess whether the NDVI represents any meaningful value for the vintage ratings.

It would be interesting to gather data from even more rieds in Kremstal and also correlate these with the soil-composition and e.g. whether the producers of a ried prefer to grow ecologically or not.

In this case, it would be ideal to request the AWMB for a direct data extraction, which would allow a further study to easily gather much more data in a short amount of time - for now the data is mainly available in a PDF-format and need to be manually rewritten to another format. Another variant could be to gather explicit information about wine's chemical properties and correlate these with the NDVI (as Vélez et al., 2019) or simply growing vines in a laboratory.

6 Critical evaluation {TFS}

There are several possible explanations for the non statistical significance. We have already discussed the statistical properties that could explain some of it. More conceptually other could be:

The subjectivity of vintage ratings

Vintage ratings are limited by their inherent subjectivity, which is illustrated by the considerable variation in ratings of the same vintages. One wine critic might love a vintage, while the other dislikes it. This subjective premise is particularly limiting when only a few vintage ratings are considered, as is the case in this study. However, were it possible to find large datasets of ratings of the same vintages, it might be possible to deduce a trend in which vintages are widely recognised as good and which vintages are not.

NDVI as an indicator of quality

Another explanation for no statistical significance between vintage ratings and NDVI, is that the health of the vines does not necessarily reflect the quality of the vintage, because wine production differs from other agricultural practices. While agricultural products benefit from being cultivated in fertile soil, rich in nutrients and with plenty of water, vines are often cultivated in harsher conditions, and it is recognised that the best wines come from less fertile soils (Gilby, 2020). Master of Wine Caroline Gilby explains that under harsh conditions, the vine focuses its resources on the grapes rather than on growing leaves, in order to ensure that seeds are being produced and spread (Ibid.). Following this logic, a vine with a high NDVI score because of its dense green leaves, might indicate it is being cultivated in too fertile conditions, resulting in less tasteful grapes and a poorer vintage. While NDVI is useful for agricultural purposes as an indicator of the productivity of the crops and their quantitative output, it might not be useful as an indicator of the qualitative taste of the crop.

Further studies might reveal ways to battle these considerations by conditioning on more variables. It is noted that this study has not conditioned on any variables, because of the sparse amount of data and the still relatively unclear correlation between NDVI's composition (as noted by Abbes et al. 2017) and wine quality.

7 Conclusions {SAS & TFS}

In this study, NDVI measures have been correlated with the vintage ratings of six different rieds in Kremstal, Austria between 2017 and 2023. No visual statistical significance was found. The study showcases how the availability of databases such as Austrian Vineyards, presenting intuitive and transparent information on winemaking, can function as a point of departure for making the otherwise esoteric nature of the wine world more accessible and consumer friendly.

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B - Required Metadata

Table 4 – Software metadata

Nr	Software metadata description	*Please fill in this column*
S1	Current software version	*Python v. 3.12.2 and Visual Studio Code v. 1.89*
S2	Permanent link to your code in your Github repository	https://github.com/1Steinthal/SA_exam
S3	Legal Software License	*None*
S4	Computing platform / Operating System	*Lenovo-Yoga 7 with a 13th Gen Intel(R) Core(TM) i7-1360P, 2.20 GHz-processor and 16 GB RAM with Windows 11 Home (23H2)*
S5	Installation requirements & dependencies for software not used in class	*See requirements.txt of GitHub-repo or table 1*

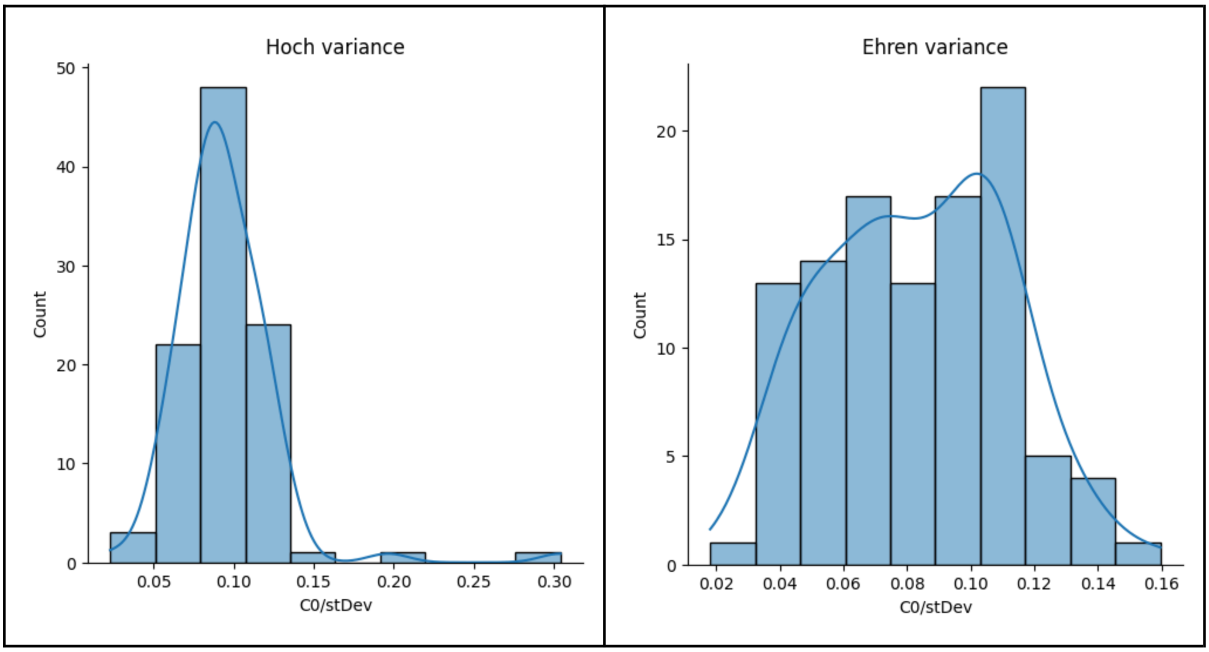
S6	If available Link to software documentation for special software	
S6	Support email for questions	202107680@post.au.dk or 202106196@post.au.dk

Table 5 – Data metadata

Nr	Metadata description	***Please fill in this column** (you can link to license and metadata descriptions online; where relevant remember to articulate data provenance and quality)*
D1	Data License	*None (freely available)*
D2	Dataset name: *Geochem_dk.grid*	*All data available through GitHub-repo* *Copernicus sampled from: https://www.copernicus.eu/en/access-data* *Wetter data sampled from: https://data.hub.geosphere.at/dataset/* *AWMB spatial data sampled from: https://www.austrianvineyards.com/* *Vintage ratings sampled from: See table 3*

Appendix 1: Assumption of data homoscedasticity

See Github-repo for code. It is noted that all variances appear normally distributed around the same standard deviations (0.1) and that the variations of rieds mainly concerns the low amount of data points



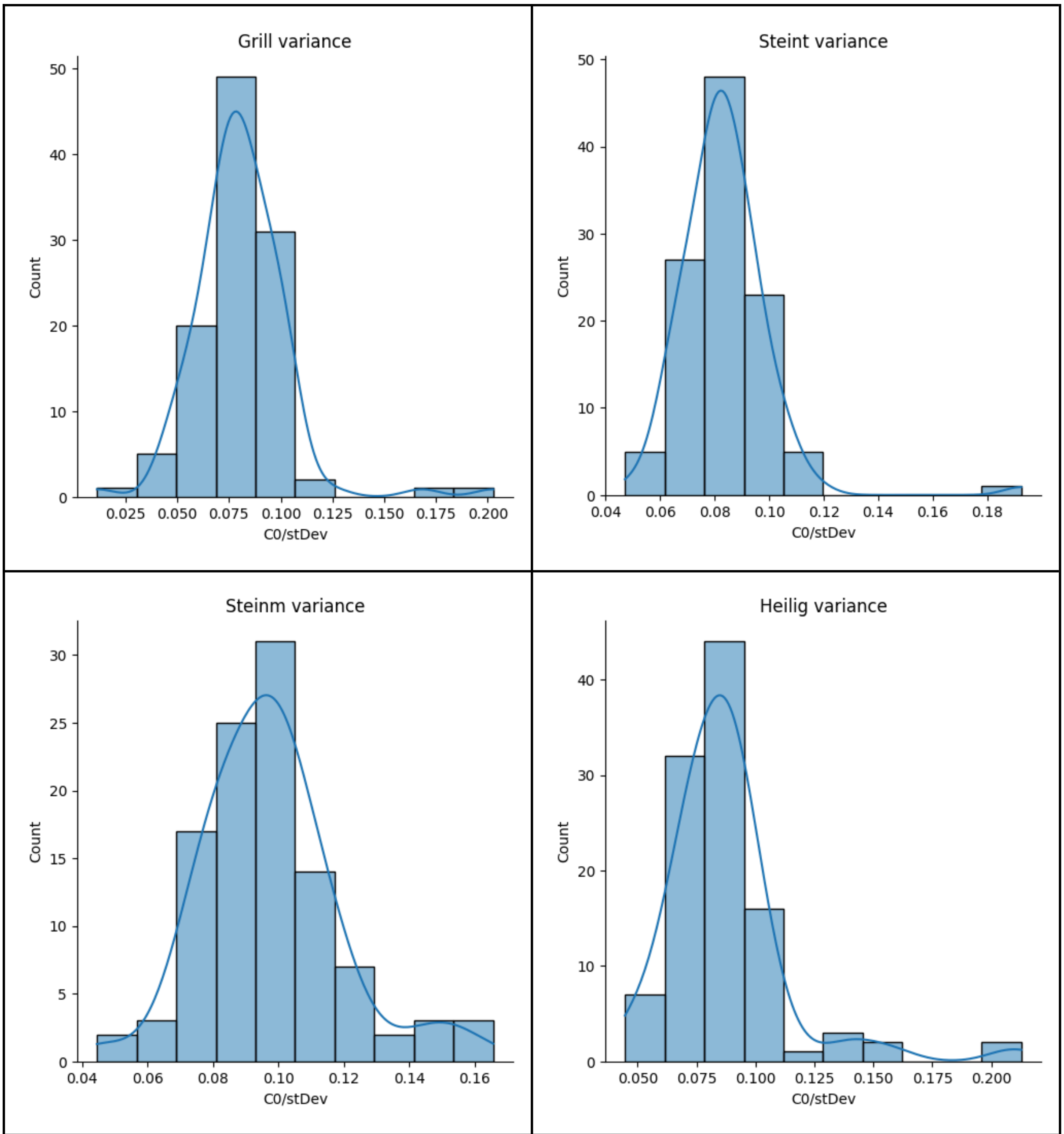
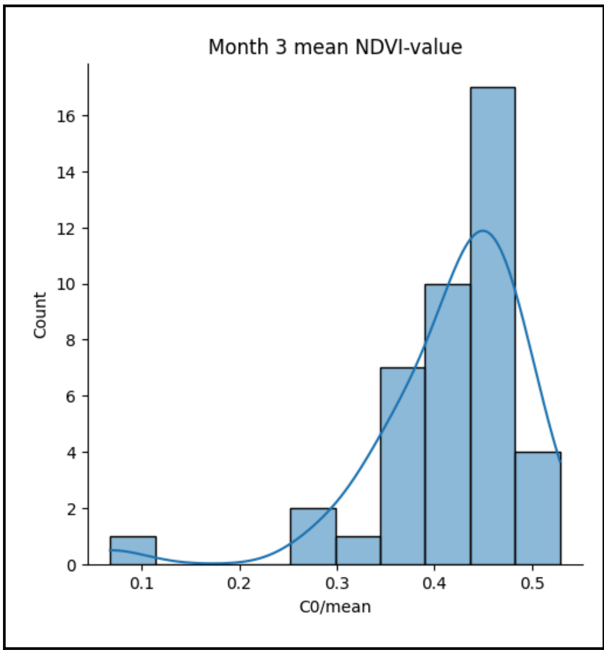
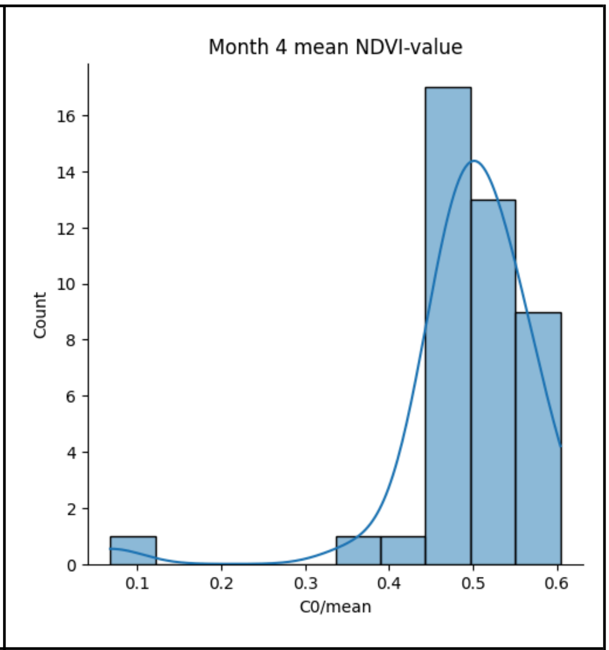


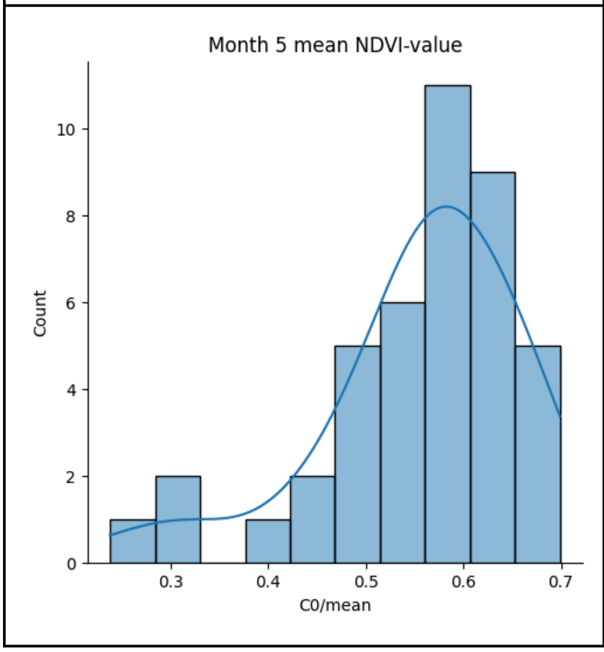
Fig 6 - The data homoschedasticity was assessed by comparing all standard deviations of all ried's NDVI-measurements. Since all standard deviations seems to be normally distributed around 0.1 this appears to be somewhat the case

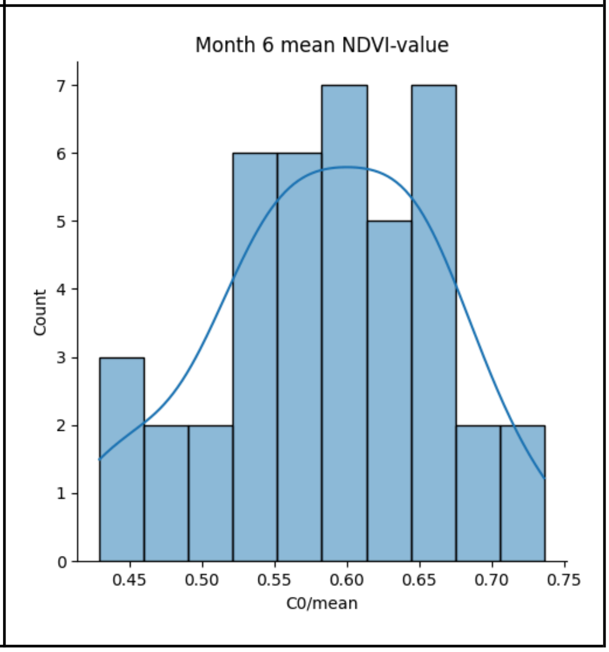
Appendix 2 - Assessing the normal distribution of analysis data

See Github-repo code for code. It is concluded that the analysis data is relatively normally distributed and the main skew is a result of few data points .


Month 3 mean NDVI-value
Count
C0/mean


Month 4 mean NDVI-value
Count
C0/mean


Month 5 mean NDVI-value
Count
C0/mean


Month 6 mean NDVI-value
Count
C0/mean

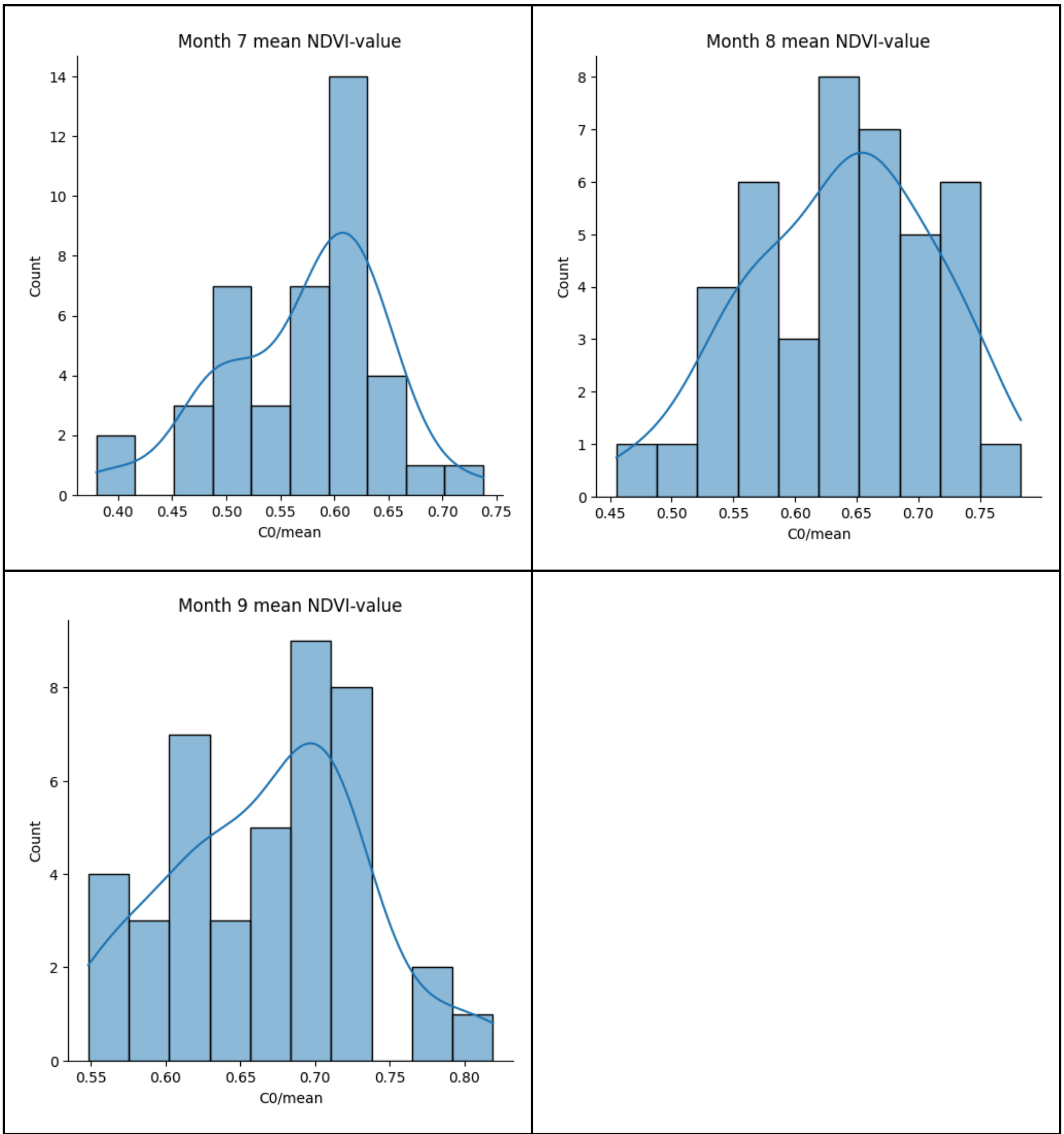
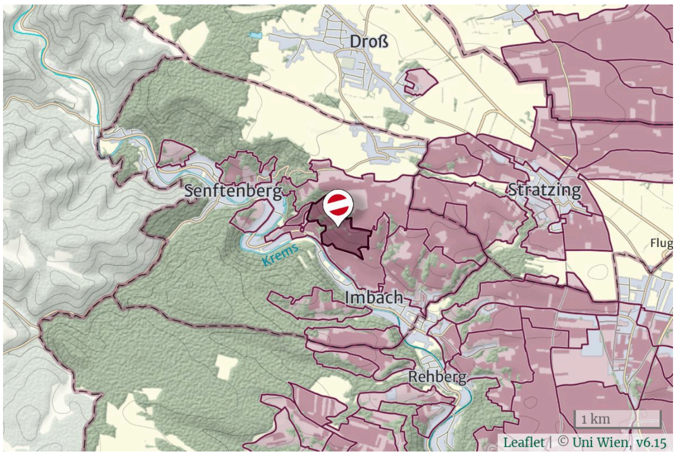


Fig 7 - Assessing the normal distribution of each monthly value. While it appears that the total mean develops over the months, each months seem to be somewhat normally distributed

Appendix 3 - AWMB-ried data

All data are gathered directly from https://www.austrianvineyards.com/ as they are available PDF's. It is noted that the website is currently updating regularly with new functionality (data was sampled the 6th of June, 2024)

Hochäcker, © RWK Kremstal / Robert Herbst



© UniWien, IfGR

Area under vine: 15 ha (94 % terr.)

Aspect: South-southwest

Elevation: 249-381 m (ø 324 m) **Gradient:** 3-35° (ø 19°)

Origin:

Winegrowing country: **Österreich**
Winegrowing area: **Weinland**
Generic winegrowing regions: **Niederösterreich**
Specific winegrowing regions/DAC: **Kremstal**
Large collective vineyard site: -

Ortswein («villages» wine): **Senftenberg**
Winegrowing municipality: **Senftenberg**
Winegrowing cadastral municipality: **Senftenberg**
Ried (single vineyard): **Hochäcker**
Ried within a Ried: -

Description:

Ried Hochäcker lies on a rocky plateau above Ried Pellingen at an elevation of roughly 240 to 390 metres. The wide terraces of the vineyards mainly face south-west, with a few parts also facing south. The vineyards have an extraordinarily thick humus layer and good water storage capacity. The parent material in this soil is a residue of loess that has survived on the plateau. The loess on the steep hillsides that drop down towards Krems has been carried off, revealing almost bare outcrops of hard crystalline rocks (paragneiss, mica schist and intercalations of amphibolite and marble). An acidic, sandy and dry soil prevails here. The first documented mention dates back to 1425, when a Mr Stephan Zebinger bequeathed a Joch (a unit of measurement equalling around 11,520 m2) of vineyard in the "hohe Acker" (meaning "high field") to the convent in Minpach, nowadays the village of Imbach (belonging to Senftenberg). As can be deduced from the name, this referred to the highest terraces below the flat plateau on the way towards Langenlois and Krems. The main variety planted here is Riesling, which benefits from optimal conditions here in terms of the soil and climate.

Climate:

Seasons					
Temperature	10,4	20,1	9,7	0,9	ø 10,3 °C
Precipitation	130	234	112	61	∑ 537 mm
Sunshine hours	6,2	7,9	3,7	2,1	ø 5,0 h/d

Reference weather station: Krems
Data: Geosphere, Values 1990-2023

GRAPE VARIETIES

Hochäcker (Ried (single vineyard))

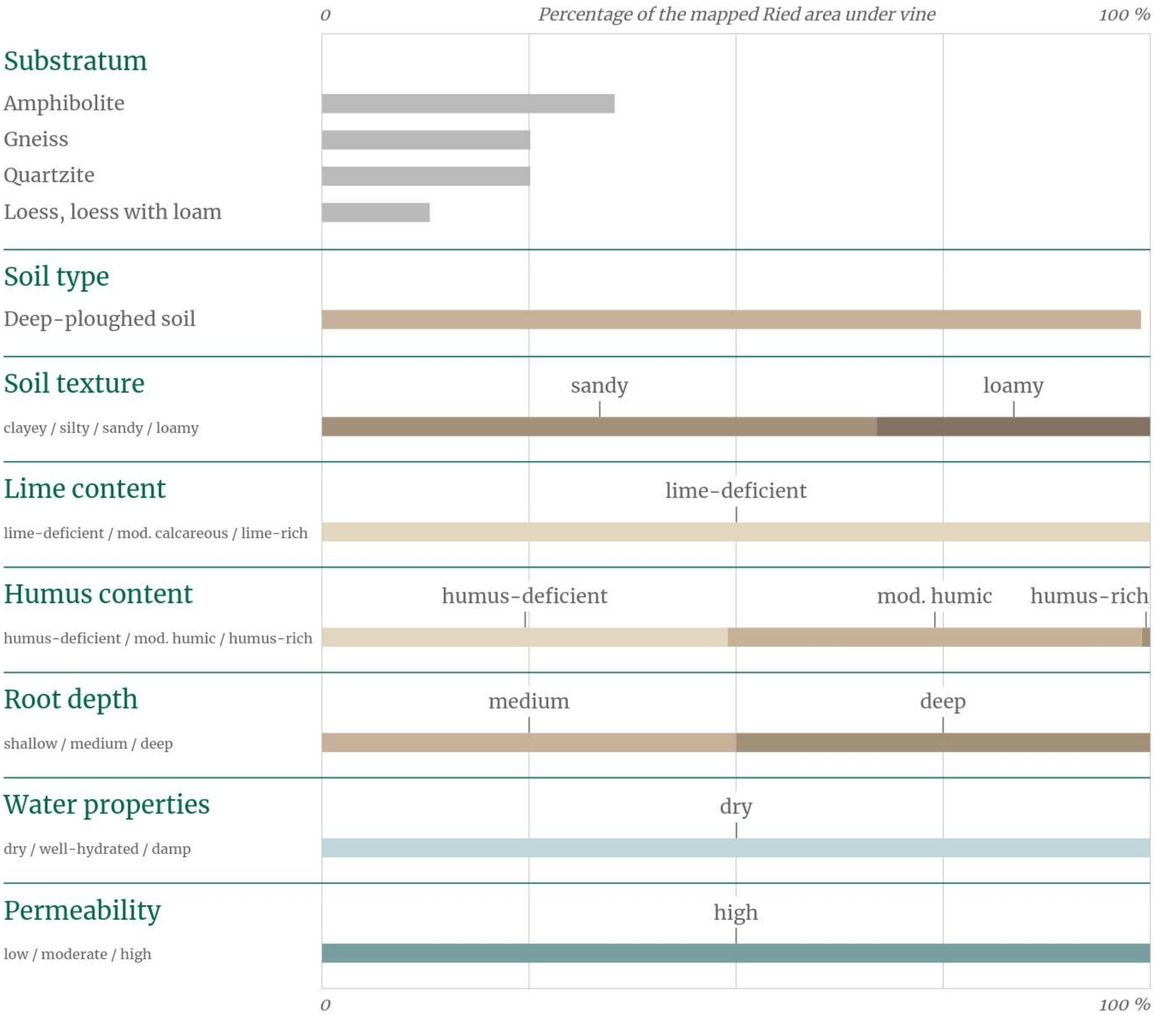
WHITE

100% (15 ha)

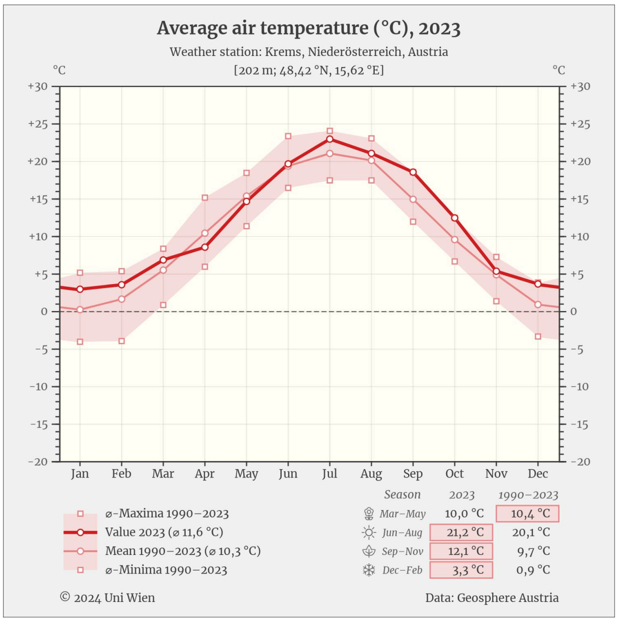
		0 – 100%	[ha]
1.	Riesling	72%	11
2.	Grüner Veltliner	15%	2.3
3.	Sonstige Weiß	5%	0.8
4.	Muskateller	3.8%	0.6
5.	Müller-Thurgau	2.5%	0.4
6.	Pinot Gris	1.2%	0.2

GEOLOGY AND SOIL

Hochäcker (Ried (single vineyard))

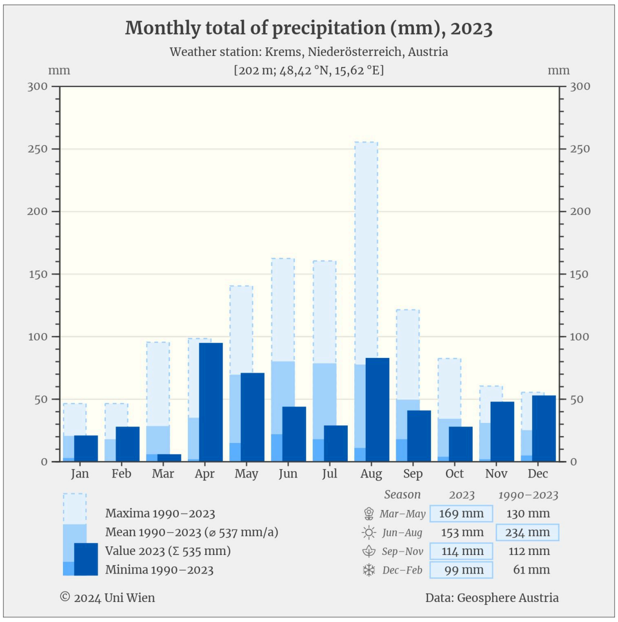


Data basis: GK50/GEOFAST50 - GeoSphere Austria (substratum), eBOD (Digital Soil Map of Austria) – BFW (all soil parameters)
Degree of geological mapping of the Ried area under vine: 100 %
Degree of pedological mapping of the Ried area under vine: 88 %
Note: to be eligible for evaluation, at least 75% of a Ried's area under vine must be geologically or pedologically mapped.
Evaluation methodology: described at www.austrianvineyards.com under Information/Data



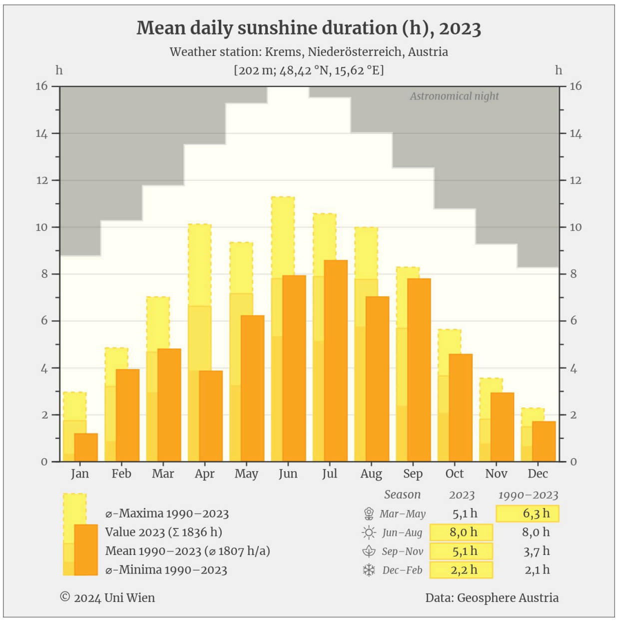
Temperature:

The climagraph of **air temperatures** shows the curve of average monthly temperatures for the most recent year of measurement in bold print. For comparative purposes, the fine line also shows the curve of the long-term average temperatures for the last approx. 20 years, as well as the range of deviation for the minimum and maximum average temperatures for each month during this same period (pale shading).



Precipitation:

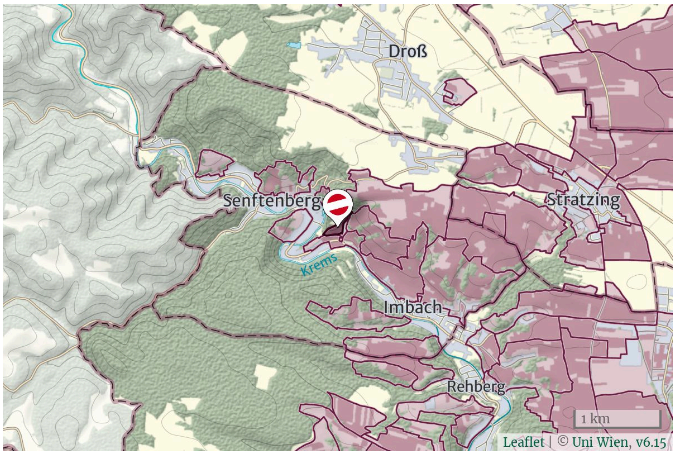
The current **precipitation** levels for the last year of measurement are shown for each month as dark blue bars on the climagraph. For comparative purposes, the long-term average monthly precipitation vales for the last approx. 20 years are portrayed in a lighter colour; the other two bars show the minimum and maximum amounts of precipitation during the period of measurement.



Sunshine hours:

The diagram shows the average daily sunshine hours for each month of the current year of measurement in orange. The long-term average for the last approx. 20 years is shown in a lighter colour. Alongside this, the long-term minimum and maximum values are shown in yellow. The white areas in the diagram show the maximum possible daily sunshine hours for each month.

Ehrenfels, © RWK Kremstal / Robert Herbst



© UniWien, IfGR

Area under vine: 2,0 ha (100 % terr.) **Aspect:** South **Elevation:** 249-321 m (ø 276 m) **Gradient:** 15-44° (ø 29°)

Origin:

Winegrowing country: **Österreich**
Winegrowing area: **Weinland**
Generic winegrowing regions: **Niederösterreich**
Specific winegrowing regions/DAC: **Kremstal**
Large collective vineyard site: -

Ortswein («villages» wine): **Senftenberg**
Winegrowing municipality: **Senftenberg**
Winegrowing cadastral municipality: **Senftenberg**
Ried (single vineyard): **Ehrenfels**
Ried within a Ried: -

Description:

Ried Ehrenfels is a very steep south- and south-east-facing vineyard below the Senftenberg ruins, at an elevation of roughly 240 to 330 metres. The humus layer on the steep terrain is very thin, the soil stony and meagre. The rocky substratum is made up of hard crystalline rocks such as acidic mica schist and amphibolite. There may be some localised lime content as a result of residual loess or alterations that occur due to the weathering of amphibolite. These Rieds, known to have existed since 1437 and surely the steepest and most meagre in the region, ceased to be cultivated in 1945 and fell into oblivion. Enquiries made after 1986 at best met with astonishment and amazement. However, encouraged by the affirmation from a few elderly winegrowers "Fü griagst net, oba guat is" (You don't get much, but it's good), at the end of the 1980s, some winegrowers began to clear the mountain of the scrub and forest and plant it with vines once again. Grüner Veltliner and Riesling are the predominant varieties grown here.

Climate:

Seasons					
Temperature	10,4	20,1	9,7	0,9	ø 10,3 °C
Precipitation	130	234	112	61	∑ 537 mm
Sunshine hours	6,2	7,9	3,7	2,1	ø 5,0 h/d

Reference weather station: Krems
Data: Geosphere, Values 1990-2023

GRAPE VARIETIES

Ehrenfels (Ried (single vineyard))

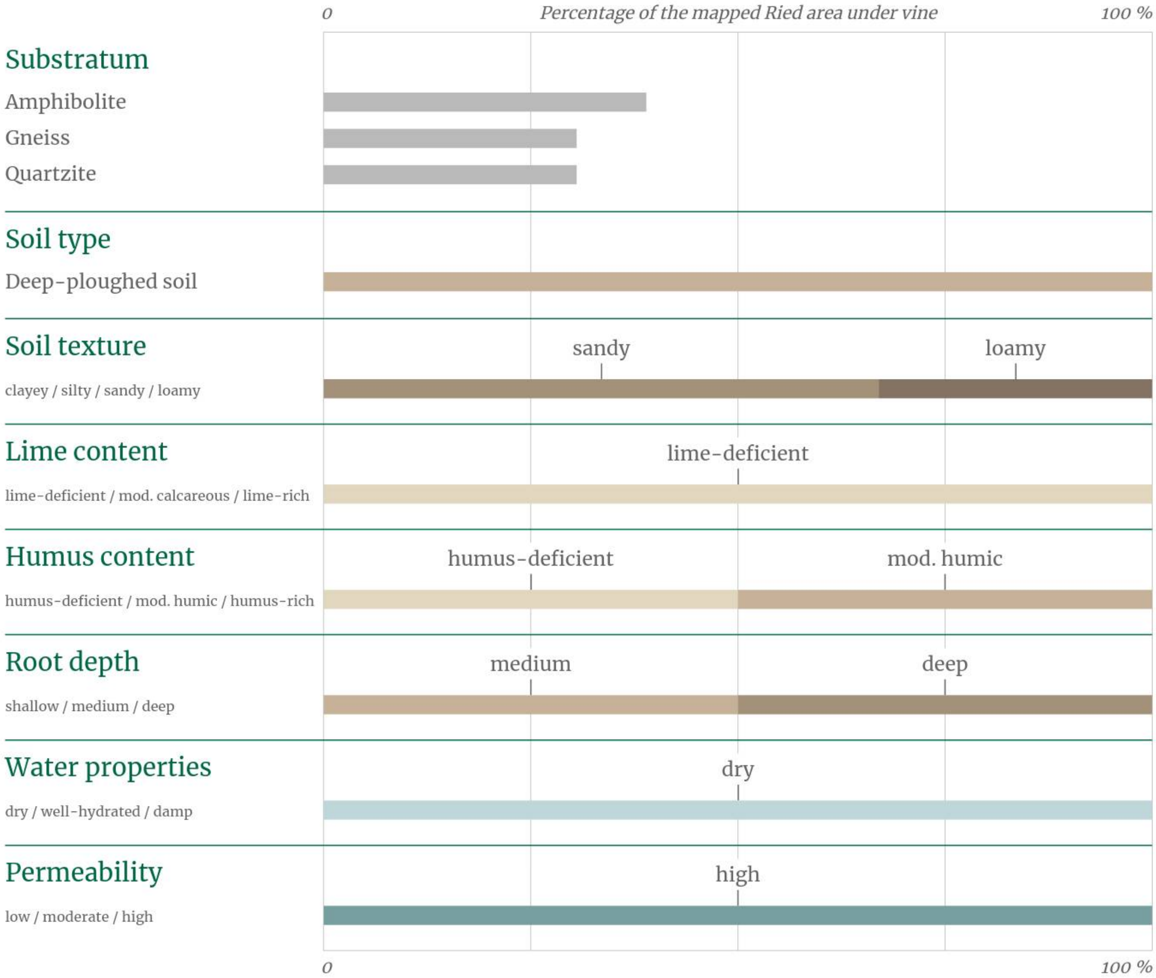
WHITE

100% (2 ha)

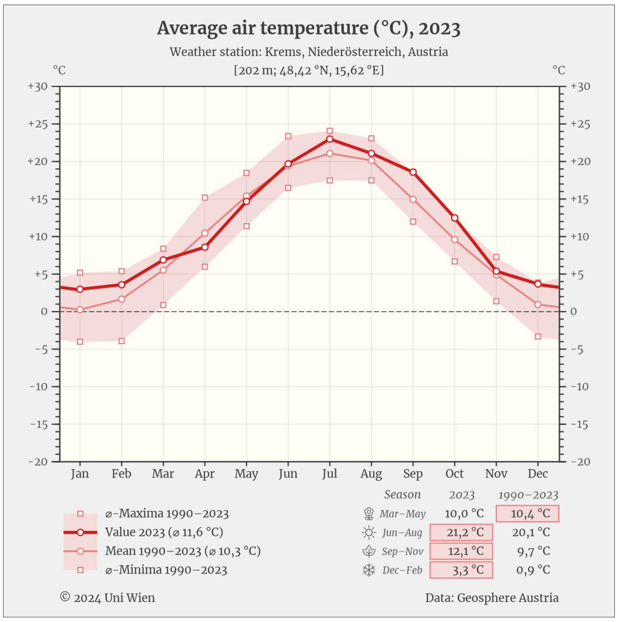
		0 — 100%	[ha]
1.	Riesling	57%	1.2
2.	Grüner Veltliner	43%	0.9

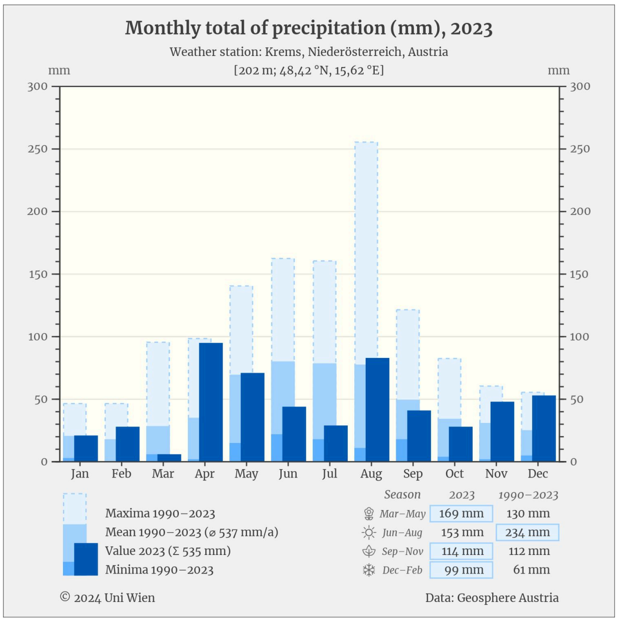
GEOLOGY AND SOIL

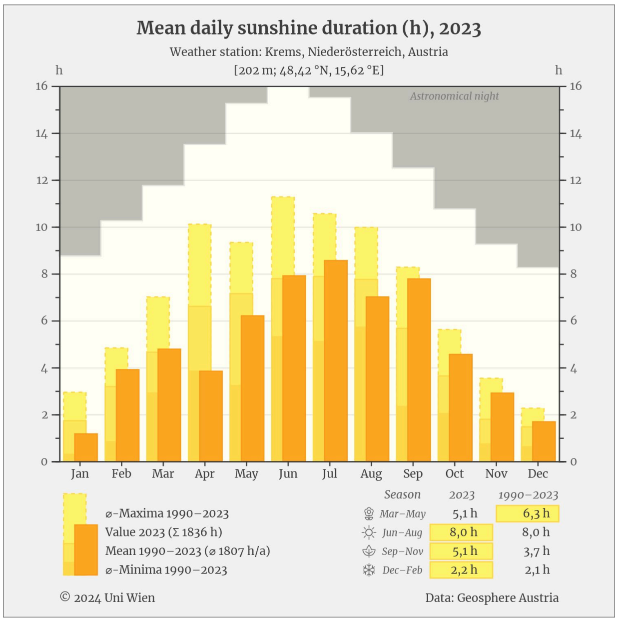
Ehrenfels (Ried (single vineyard))



Data basis: GK50/GEOFAST50 - GeoSphere Austria (substratum), eBOD (Digital Soil Map of Austria) – BFW (all soil parameters)
Degree of geological mapping of the Ried area under vine: 100 %
Degree of pedological mapping of the Ried area under vine: 79 %
Note: to be eligible for evaluation, at least 75% of a Ried's area under vine must be geologically or pedologically mapped.
Evaluation methodology: described at www.austrianvineyards.com under Information/Data







Temperature:

The climagraph of **air temperatures** shows the curve of average monthly temperatures for the most recent year of measurement in bold print. For comparative purposes, the fine line also shows the curve of the long-term average temperatures for the last approx. 20 years, as well as the range of deviation for the minimum and maximum average temperatures for each month during this same period (pale shading).

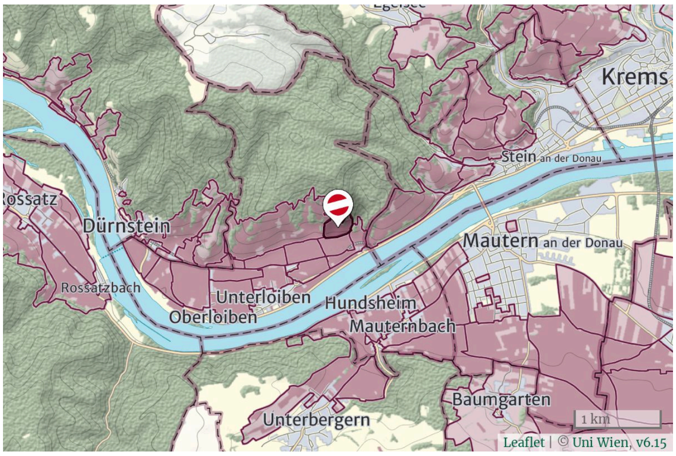
Precipitation:

The current **precipitation** levels for the last year of measurement are shown for each month as dark blue bars on the climagraph. For comparative purposes, the long-term average monthly precipitation vales for the last approx. 20 years are portrayed in a lighter colour; the other two bars show the minimum and maximum amounts of precipitation during the period of measurement.

Sunshine hours:

The diagram shows the average daily sunshine hours for each month of the current year of measurement in orange. The long-term average for the last approx. 20 years is shown in a lighter colour. Alongside this, the long-term minimum and maximum values are shown in yellow. The white areas in the diagram show the maximum possible daily sunshine hours for each month.

Steinertal, © RWK Wachau / Robert Herbst



© UniWien, IfGR

Area under vine: 4,3 ha (78 % terr.) **Aspect:** South

Elevation: 230-282 m (ø 248 m) **Gradient:** 3-32° (ø 15°)

Origin:

Winegrowing country: **Österreich**
Winegrowing area: **Weinland**
Generic winegrowing regions: **Niederösterreich**
Specific winegrowing regions/DAC: **Wachau**
Large collective vineyard site: -

Ortswein («villages» wine): **Dürnstein, Loiben**
Winegrowing municipality: **Dürnstein**
Winegrowing cadastral municipality: **Unterloiben**
Ried (single vineyard): **Steinertal**
Ried within a Ried: -

Description:

Seen from the east, the Steinertal is the first steep vineyard of the wine region. The view also reveals the trench character of this vineyard, as suggested by the old name "Steingraben" (stony trench), forming an amphitheatre with an open view of the winescape of the Wachau region.

Climate:

Seasons					
Temperature	10,4	20,1	9,7	0,9	ø 10,3 °C
Precipitation	130	234	112	61	∑ 537 mm
Sunshine hours	6,2	7,9	3,7	2,1	ø 5,0 h/d

Reference weather station: Krems
Data: Geosphere, Values 1990-2023

GRAPE VARIETIES

Steinertal (Ried (single vineyard))

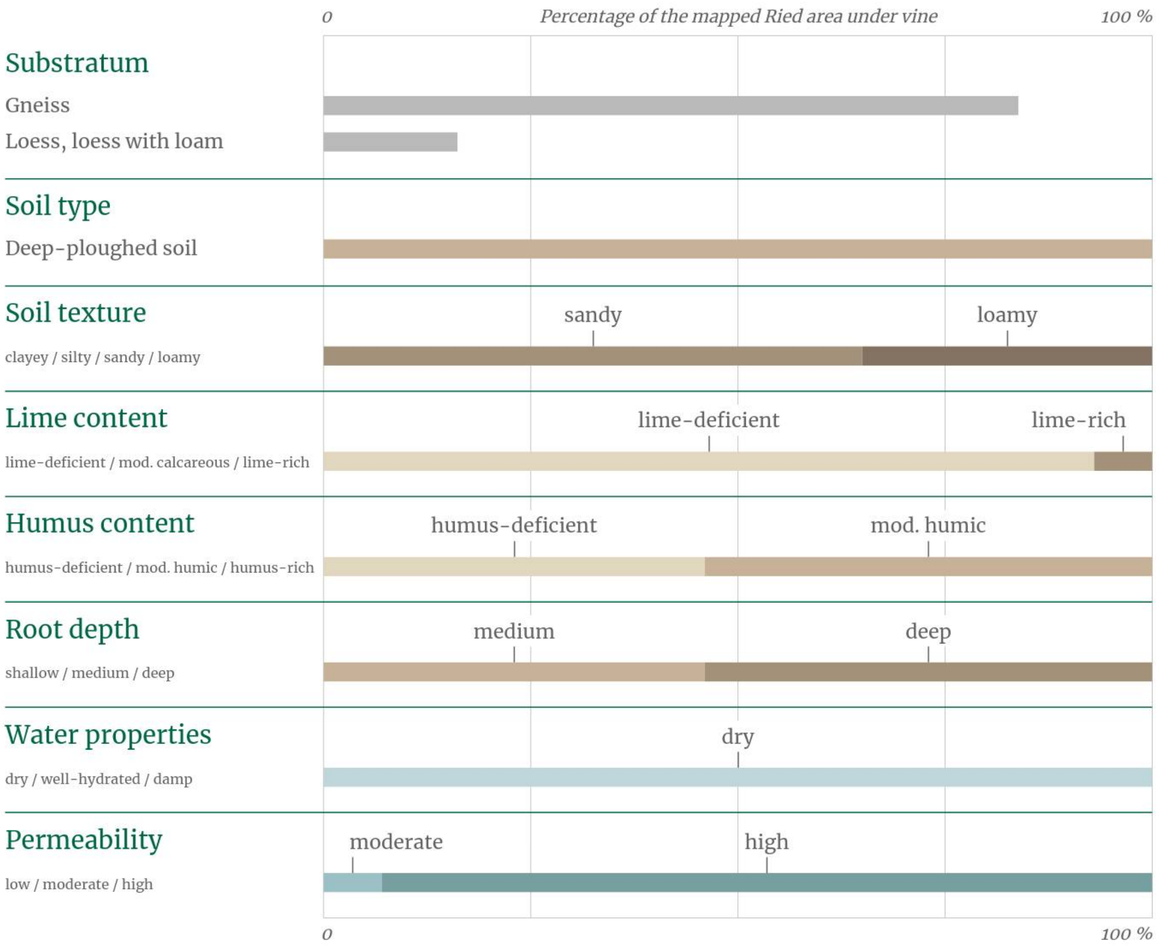
WHITE

100% (4.3 ha)

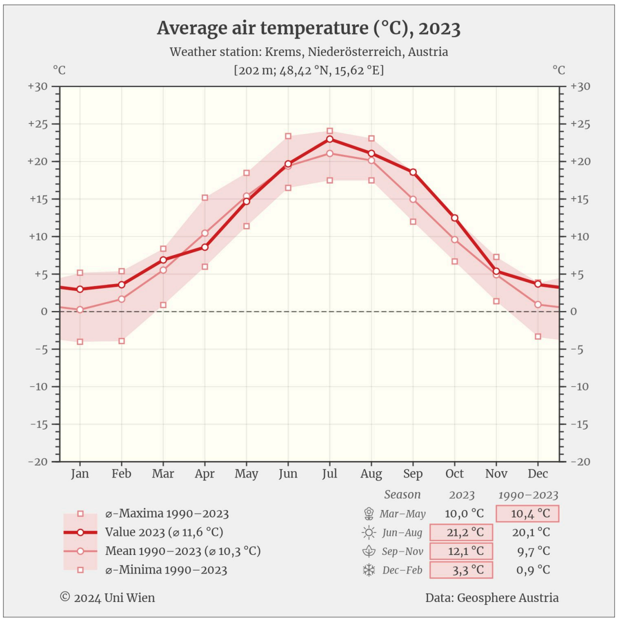
		0 — 100%	[ha]
1.	Riesling	49%	2.1
2.	Grüner Veltliner	47%	2
3.	Muskateller	3.6%	0.2

GEOLOGY AND SOIL

Steinertal (Ried (single vineyard))

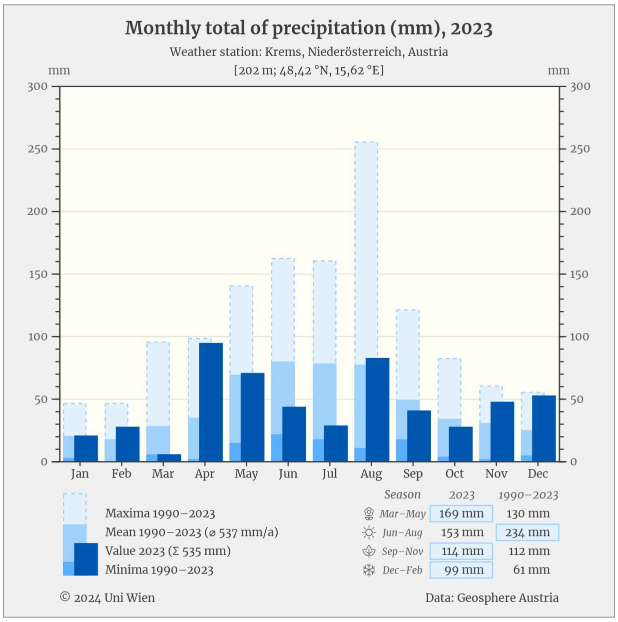


Data basis: GK50/GEOFAST50 - GeoSphere Austria (substratum), eBOD (Digital Soil Map of Austria) – BFW (all soil parameters)
Degree of geological mapping of the Ried area under vine: 100 %
Degree of pedological mapping of the Ried area under vine: 100 %
Note: to be eligible for evaluation, at least 75% of a Ried's area under vine must be geologically or pedologically mapped.
Evaluation methodology: described at www.austrianvineyards.com under Information/Data



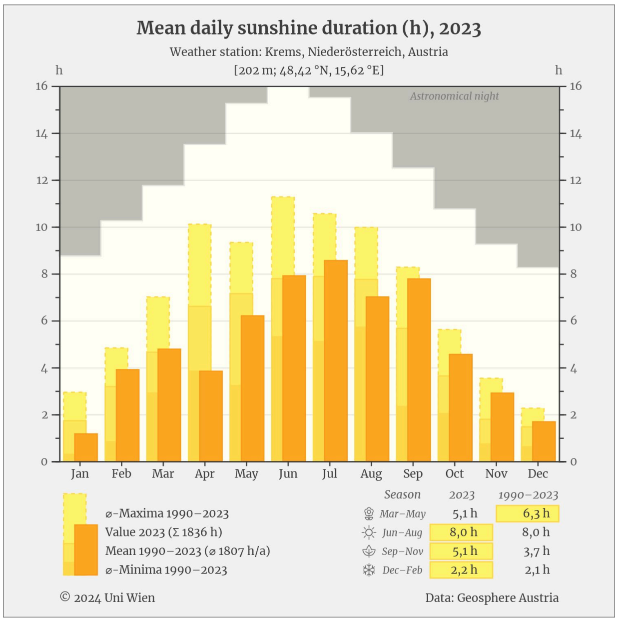
Temperature:

The climagraph of **air temperatures** shows the curve of average monthly temperatures for the most recent year of measurement in bold print. For comparative purposes, the fine line also shows the curve of the long-term average temperatures for the last approx. 20 years, as well as the range of deviation for the minimum and maximum average temperatures for each month during this same period (pale shading).



Precipitation:

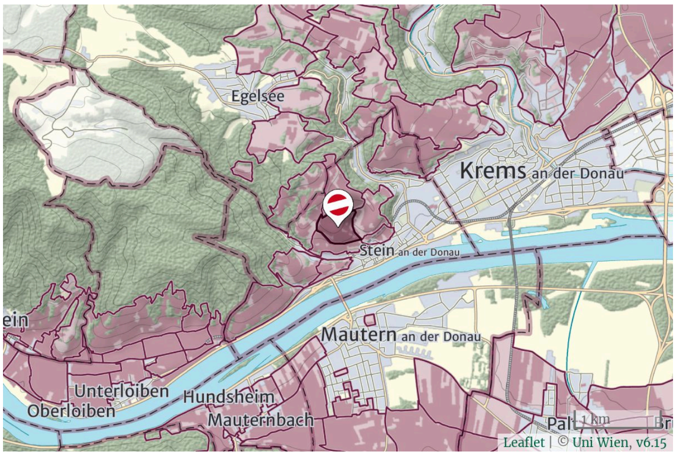
The current **precipitation** levels for the last year of measurement are shown for each month as dark blue bars on the climagraph. For comparative purposes, the long-term average monthly precipitation vales for the last approx. 20 years are portrayed in a lighter colour; the other two bars show the minimum and maximum amounts of precipitation during the period of measurement.



Sunshine hours:

The diagram shows the average daily sunshine hours for each month of the current year of measurement in orange. The long-term average for the last approx. 20 years is shown in a lighter colour. Alongside this, the long-term minimum and maximum values are shown in yellow. The white areas in the diagram show the maximum possible daily sunshine hours for each month.

Grillenparz, © RWK Kremstal / Robert Herbst



© UniWien, IfGR

Area under vine: 7,6 ha (69 % terr.) **Aspect:** South-southeast **Elevation:** 262-335 m (ø 313 m) **Gradient:** 0-31° (ø 12°)

Origin:

Winegrowing country: **Österreich**
Winegrowing area: **Weinland**
Generic winegrowing regions: **Niederösterreich**
Specific winegrowing regions/DAC: **Kremstal**
Large collective vineyard site: **Kremser Kreuzberg**

Ortswein («villages» wine): **Stein**
Winegrowing municipality: **Krems an der Donau**
Winegrowing cadastral municipality: **Stein**
Ried (single vineyard): **Grillenparz**
Ried within a Ried: -

Description:

Ried Grillenparz is a terraced vineyard with a south-eastern exposure that lies behind the old town of Stein. The vineyards are located at an elevation of roughly 260 to 340 metres. The parent material of the mostly stony soils are gneiss and mica schist, chalky conglomerate from the Hollenburg-Karlstetten formation and loosely cemented Danube gravel – all lying closely together in a confined space. It is covered by a little loess in places. The Ried was first mentioned in 1180 as “ad grillenporce”. The soil is very stony, which, however, means that it warms up very quickly and continues to give off heat long after the sun has gone down – making it a perfect habitat for crickets! Ried Grillenparz is a steep, fiercely steep vineyard, which is only held in place by ancient terrace walls. The terraces are narrow and difficult to cultivate as you very quickly strike hard rock. Riesling is the predominant variety grown here.

Climate:

Seasons	Spring	Summer	Autumn	Winter	
Temperature	10,4	20,1	9,7	0,9	ø 10,3 °C
Precipitation	130	234	112	61	∑ 537 mm
Sunshine hours	6,2	7,9	3,7	2,1	ø 5,0 h/d

Reference weather station: Krems
Data: Geosphere, Values 1990-2023

GRAPE VARIETIES

Grillenparz (Ried (single vineyard))

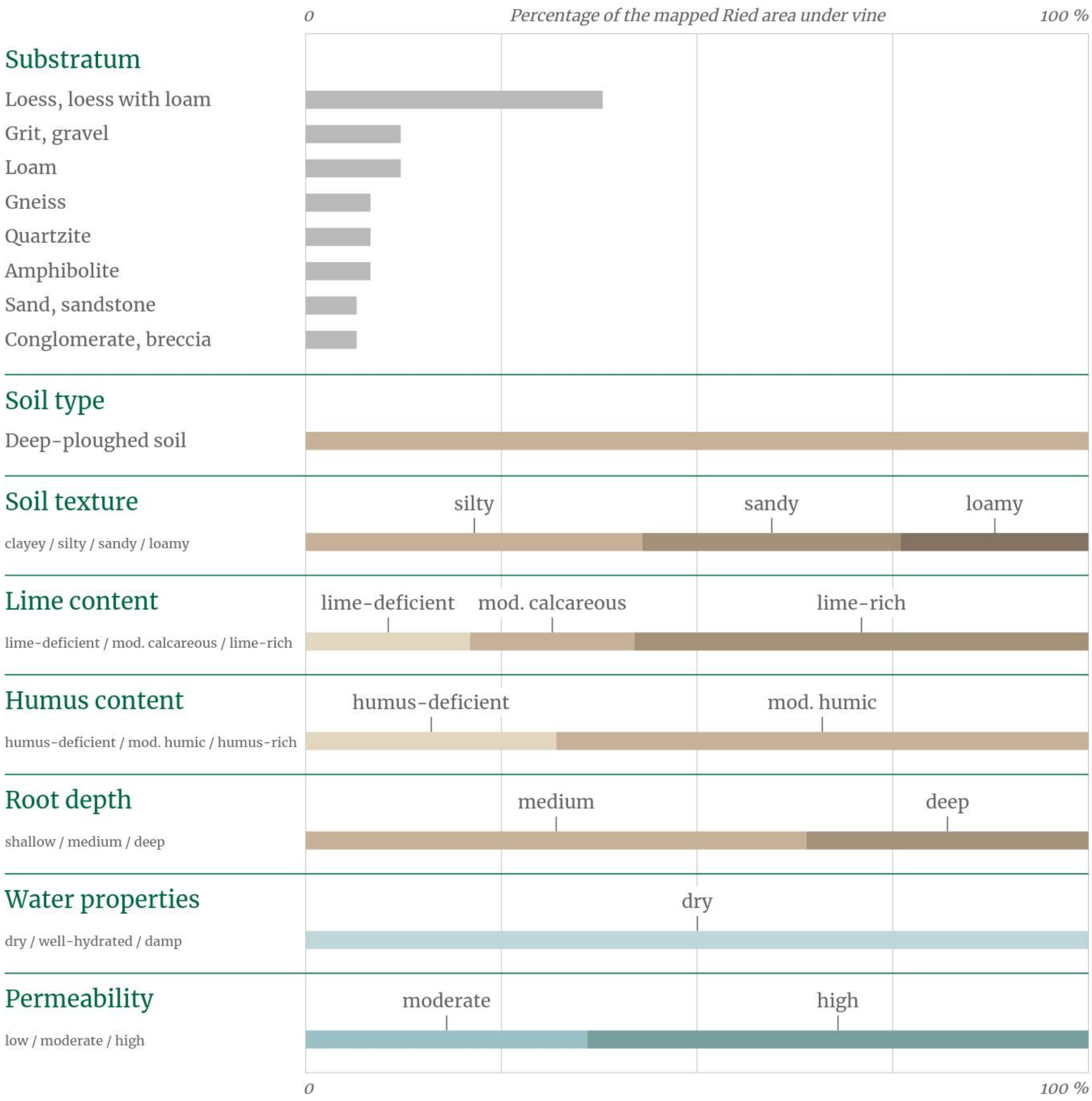
WHITE
96% (7.3 ha)

RED
4% (0.3 ha)

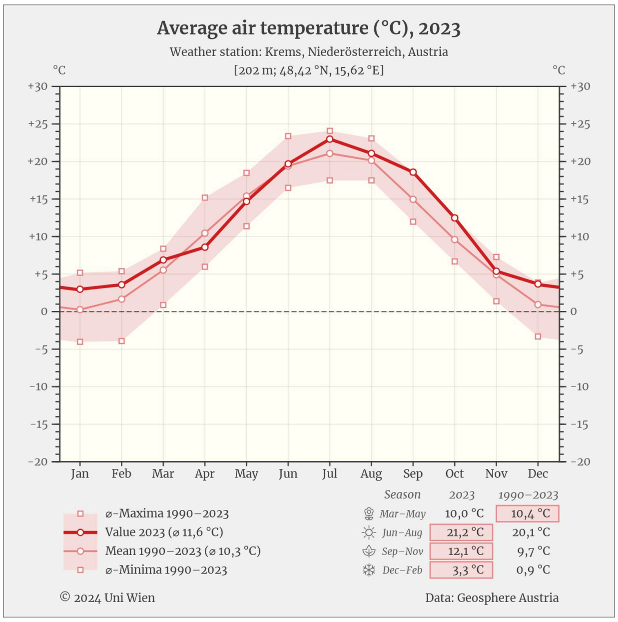
	Variety	0 – 100%	[ha]
1.	Riesling	49%	3.7
2.	Grüner Veltliner	22%	1.7
3.	Müller-Thurgau	18%	1.4
4.	Weißburgunder	3.2%	0.2
5.	Zweigelt	3%	0.2
6.	Sonstige Weiß	1.6%	0.1
7.	Muskateller	1.5%	0.1
8.	Blauburger	1.1%	0.09
9.	Frühroter Veltliner	0.5%	0.04
10.	Neuburger	0.3%	0.02

GEOLOGY AND SOIL

Grillenparz (Ried (single vineyard))

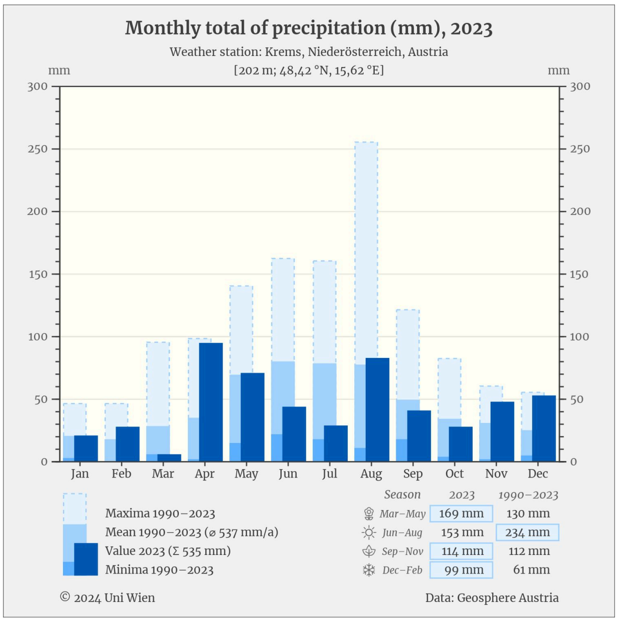


Data basis: GK50/GEOFAST50 - GeoSphere Austria (substratum), eBOD (Digital Soil Map of Austria) – BFW (all soil parameters)
Degree of geological mapping of the Ried area under vine: 100 %
Degree of pedological mapping of the Ried area under vine: 100 %
Note: to be eligible for evaluation, at least 75% of a Ried's area under vine must be geologically or pedologically mapped.
Evaluation methodology: described at www.austrianvineyards.com under Information/Data



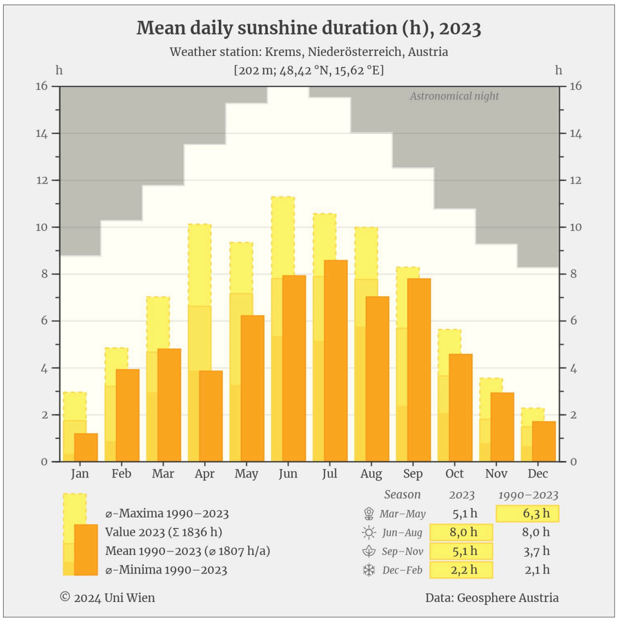
Temperature:

The climagraph of **air temperatures** shows the curve of average monthly temperatures for the most recent year of measurement in bold print. For comparative purposes, the fine line also shows the curve of the long-term average temperatures for the last approx. 20 years, as well as the range of deviation for the minimum and maximum average temperatures for each month during this same period (pale shading).



Precipitation:

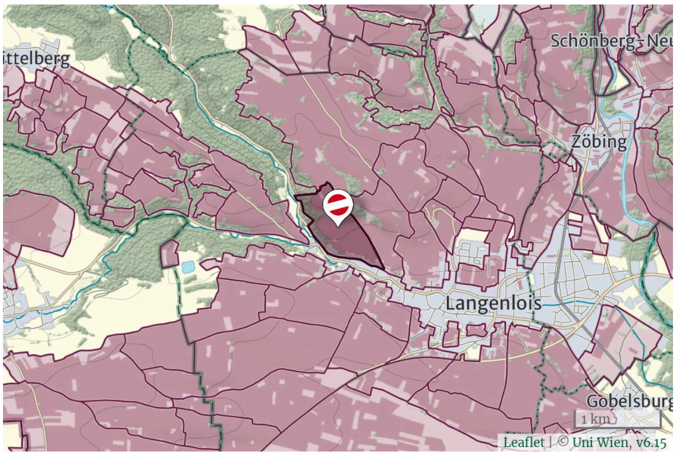
The current **precipitation** levels for the last year of measurement are shown for each month as dark blue bars on the climagraph. For comparative purposes, the long-term average monthly precipitation vales for the last approx. 20 years are portrayed in a lighter colour; the other two bars show the minimum and maximum amounts of precipitation during the period of measurement.



Sunshine hours:

The diagram shows the average daily sunshine hours for each month of the current year of measurement in orange. The long-term average for the last approx. 20 years is shown in a lighter colour. Alongside this, the long-term minimum and maximum values are shown in yellow. The white areas in the diagram show the maximum possible daily sunshine hours for each month.

Steinmassl, © RWK Kamptal / Robert Herbst



© UniWien, IfGR

Area under vine: 23 ha **Aspect:** South-southeast **Elevation:** 245-344 m (ø 289 m) **Gradient:** 0-33° (ø 7°)

Origin:

Winegrowing country: **Österreich**
Winegrowing area: **Weinland**
Generic winegrowing regions: **Niederösterreich**
Specific winegrowing regions/DAC: **Kamptal**
Large collective vineyard site: -

Ortswein («villages» wine): -
Winegrowing municipality: **Langenlois**
Winegrowing cadastral municipality: **Langenlois**
Ried (single vineyard): **Steinmassl**
Ried within a Ried: -

Description:

The ridge runs south-south-east from an elevation of around 350 metres down to 240 metres, characterised by a broad shoulder towards the south-west. The vineyards primarily face south-east and south. Paragneiss and mica schist alongside dark amphibolite and light granite gneiss form the crystalline parent rock of Ried Steinmassl, mostly with dry and stony soils. Relatively strong weathering in places results in thick brown earth soils, up to 1 metre deep in places, which are littered with numerous stones and show some lime content, despite siliceous parent rock. This can probably be traced back to a localised covering of much younger sandy gravel. The Administrativkarte NÖ (administrative map of Lower Austria) shows this plot under vine, labelled with its current name. The name "Steinmeissel" refers to a stone chisel used by a stone mason. Riesling is the predominant variety grown here.

Climate:

Seasons	Spring	Summer	Autumn	Winter	
Temperature	10,2	20,0	9,7	0,6	ø 10,1 °C
Precipitation	123	236	110	55	Σ 524 mm
Sunshine hours	6,3	7,8	3,7	2,1	ø 5,0 h/d

Reference weather station: Langenlois
Data: Geosphere, Values 1990-2023

GRAPE VARIETIES

Steinmassl (Ried (single vineyard))

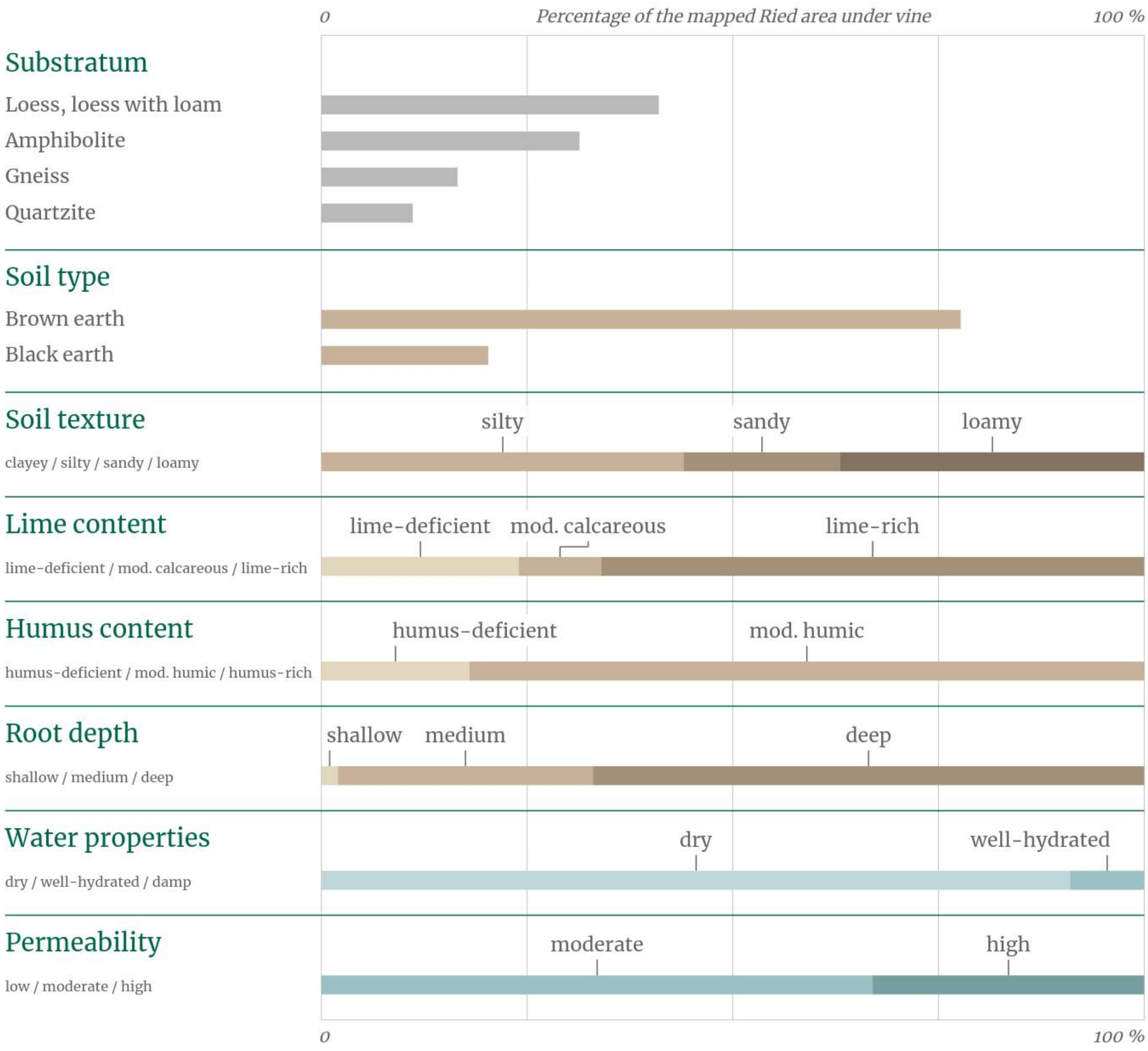
WHITE 96% (21 ha)

RED 4% (1.5 ha)

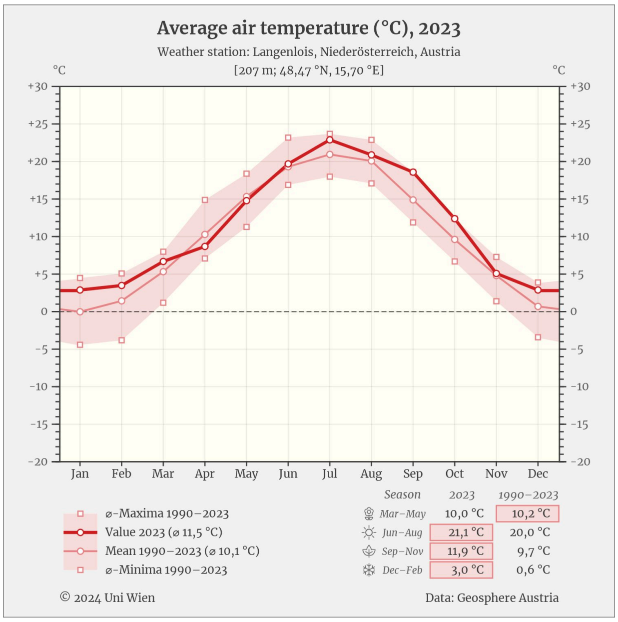
		0 — 100%	[ha]
1.	Riesling	57%	13
2.	Grüner Veltliner	29%	6.4
3.	Zweigelt	4.5%	1
4.	Muskateller	2.9%	0.6
5.	Weißburgunder	2.2%	0.5
6.	Sauvignon Blanc	2%	0.4
7.	Chardonnay	1.2%	0.3
8.	Sonstige Weiß	1%	0.2
9.	Neuburger	1%	0.2

GEOLOGY AND SOIL

Steinmassl (Ried (single vineyard))

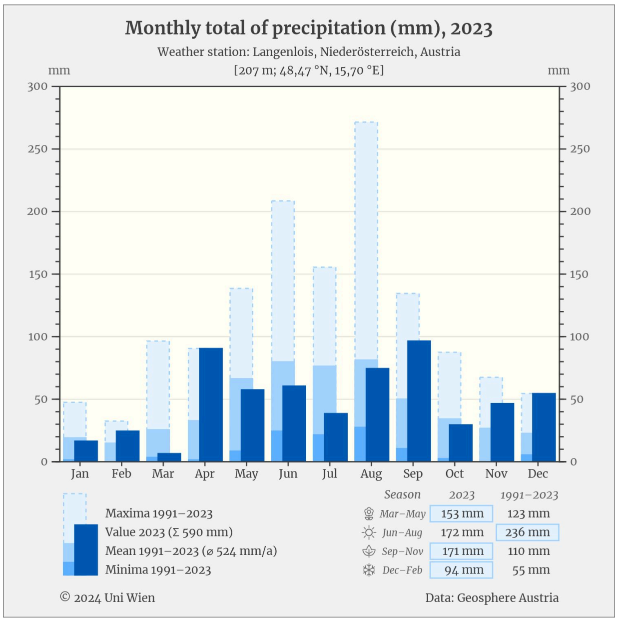


Data basis: GK50/GEOFAST50 - GeoSphere Austria (substratum), eBOD (Digital Soil Map of Austria) – BFW (all soil parameters)
Degree of geological mapping of the Ried area under vine: 100 %
Degree of pedological mapping of the Ried area under vine: 97 %
Note: to be eligible for evaluation, at least 75% of a Ried's area under vine must be geologically or pedologically mapped.
Evaluation methodology: described at www.austrianvineyards.com under Information/Data



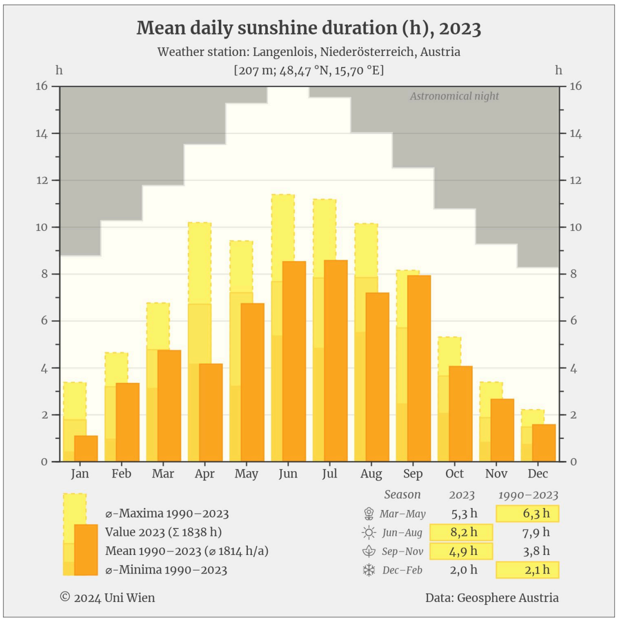
Temperature:

The climagraph of **air temperatures** shows the curve of average monthly temperatures for the most recent year of measurement in bold print. For comparative purposes, the fine line also shows the curve of the long-term average temperatures for the last approx. 20 years, as well as the range of deviation for the minimum and maximum average temperatures for each month during this same period (pale shading).



Precipitation:

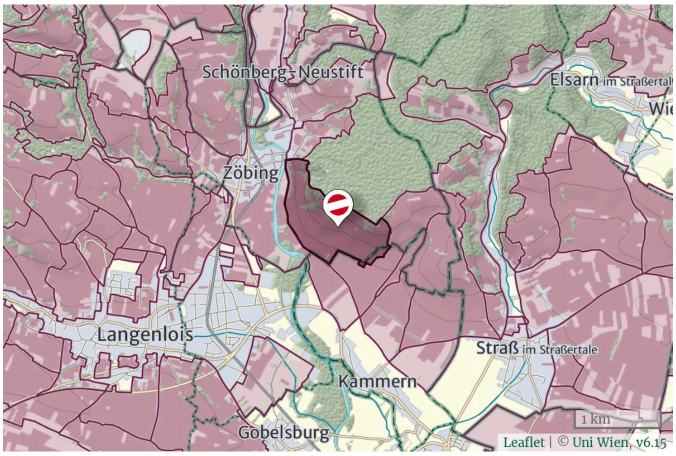
The current **precipitation** levels for the last year of measurement are shown for each month as dark blue bars on the climagraph. For comparative purposes, the long-term average monthly precipitation vales for the last approx. 20 years are portrayed in a lighter colour; the other two bars show the minimum and maximum amounts of precipitation during the period of measurement.



Sunshine hours:

The diagram shows the average daily sunshine hours for each month of the current year of measurement in orange. The long-term average for the last approx. 20 years is shown in a lighter colour. Alongside this, the long-term minimum and maximum values are shown in yellow. The white areas in the diagram show the maximum possible daily sunshine hours for each month.

Heiligenstein, © RWK Kamptal / Robert Herbst



© UniWien, IfGR

Area under vine: 43 ha (61 % terr.)

Aspect: South-southwest

Elevation: 213-349 m (ø 267 m)

Gradient: 0-32° (ø 13°)

Origin:

Winegrowing country: **Österreich**
Winegrowing area: **Weinland**
Generic winegrowing regions: **Niederösterreich**
Specific winegrowing regions/DAC: **Kamptal**
Large collective vineyard site: -

Ortswein («villages» wine): -
Winegrowing municipality: **Hadersdorf-Kammern, Langenlois**
Winegrowing cadastral municipality: **Kammern, Zöbing**
Ried (single vineyard): **Heiligenstein**
Ried within a Ried: -

Description:

Ried Heiligenstein is located on a terraced hillside facing south and south-west with a unique geological structure that has been preserved here due to the fortunes of the Earth's history. The vineyards lie at an elevation of roughly 210 to 350 metres, mainly facing south-west and south, although a few parts also face west. The hard crystalline rocks that crop out on the surface are comprised of reddish-brown sandstones, rich in feldspars, and coarse conglomerates, with siltstones occurring less frequently. The soil is dry, predominantly acidic, with a low to zero lime content. It is composed of loamy or silty sand with a high proportion of coarse particles. The sediments, which are around 250 to 280 million years old, were deposited in lakes, tarns and in periodically active rivers in a desert climate. The rock package includes the remains of petrified plants and volcanic quartz-porphyry pebbles. Only in certain places and in the few shallow indentations in the valley has any loess survived. The Administrativkarte NÖ (administrative map of Lower Austria) already recorded vineyards at this location, referring to the plot as "Heiligen Stein". According to Elisabeth Arnberger (2017), the Ried's name can be traced back to records dating from 1240, which included the reference "Hellenstein". Ried Heiligenstein comprises predominantly dry sites. Riesling and Grüner Veltliner are the main varieties grown here.

Climate:

Seasons	Spring	Summer	Autumn	Winter	
Temperature	10,2	20,0	9,7	0,6	ø 10,1 °C
Precipitation	123	236	110	55	Σ 524 mm
Sunshine hours	6,3	7,8	3,7	2,1	ø 5,0 h/d

Reference weather station: Langenlois
Data: Geosphere, Values 1990-2023

GRAPE VARIETIES

Heiligenstein (Ried (single vineyard))

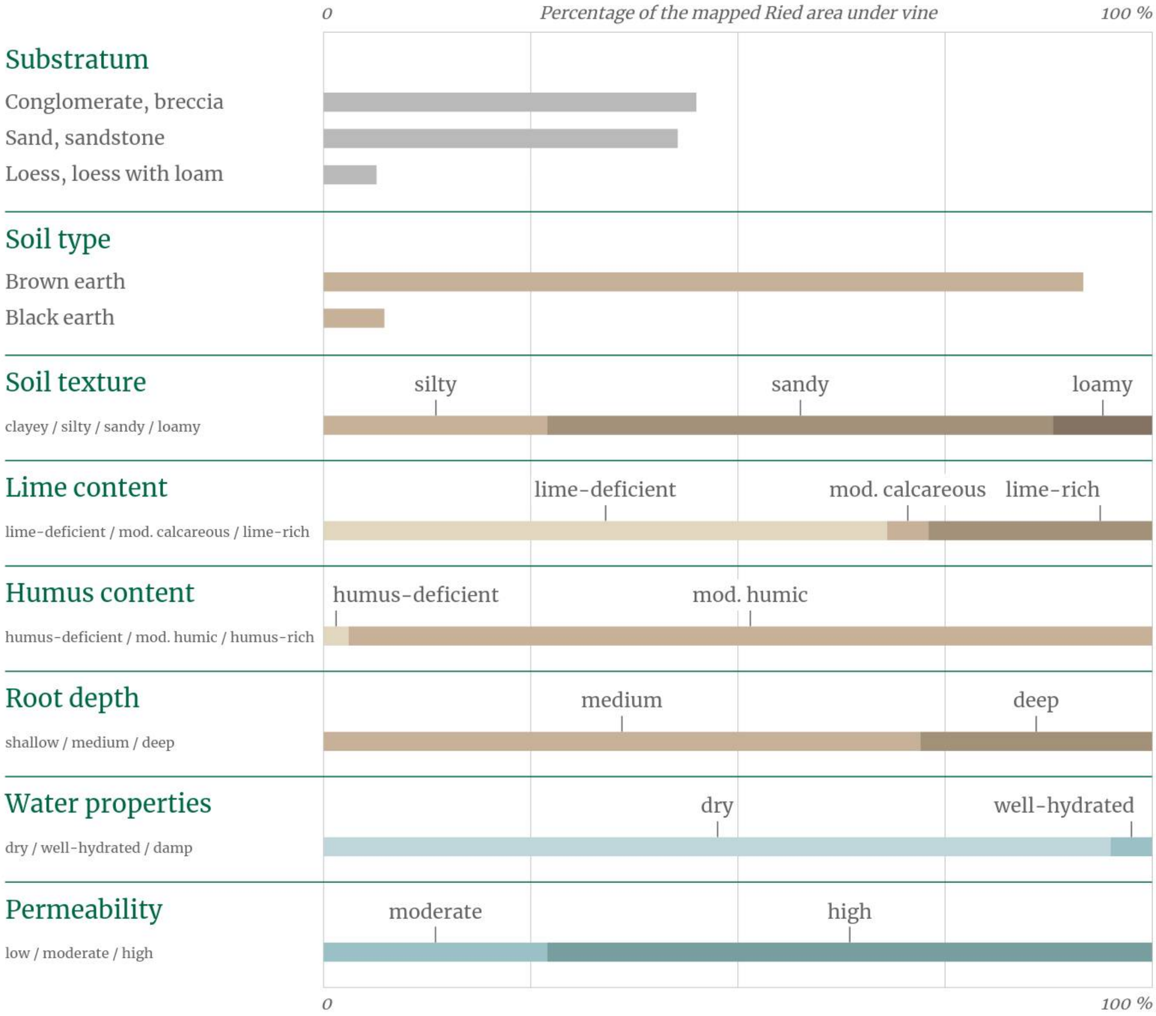
WHITE 97% (41 ha)

RED 3% (1.5 ha)

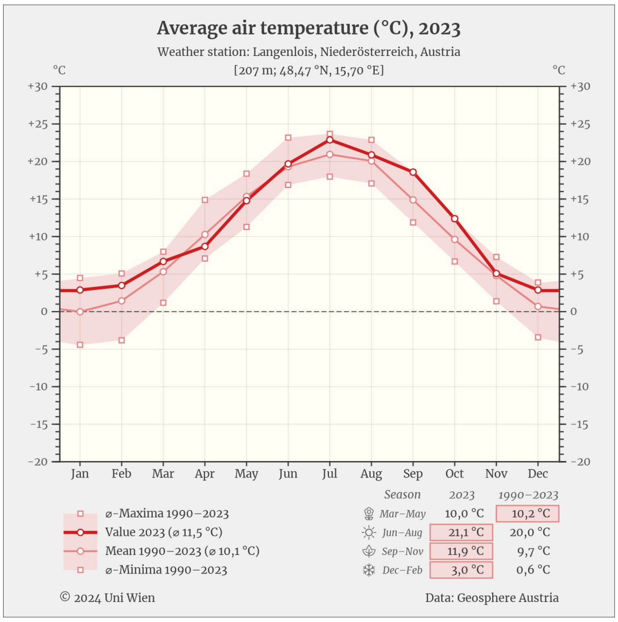
	Variety	% (0–100%)	[ha]
1.	Riesling	85%	36
2.	Grüner Veltliner	8.1%	3.4
3.	Cabernet Franc	2.4%	1
4.	Weißburgunder	1.3%	0.6
5.	Muskateller	0.9%	0.4
6.	Sauvignon Blanc	0.7%	0.3
7.	Zweigelt	0.7%	0.3
8.	Welschriesling	0.6%	0.3
9.	Muskat Ottonel	0.2%	0.1
10.	Cabernet Sauvignon	0.2%	0.1
11.	St. Laurent	0.08%	0.04
12.	Pinot Noir	0.08%	0.03
13.	Chardonnay	0.04%	0.02

GEOLOGY AND SOIL

Heiligenstein (Ried (single vineyard))



Data basis: GK50/GEOFAST50 - GeoSphere Austria (substratum), eBOD (Digital Soil Map of Austria) – BFW (all soil parameters)
Degree of geological mapping of the Ried area under vine: 100 %
Degree of pedological mapping of the Ried area under vine: 87 %
Note: to be eligible for evaluation, at least 75% of a Ried's area under vine must be geologically or pedologically mapped.
Evaluation methodology: described at www.austrianvineyards.com under Information/Data



Temperature:

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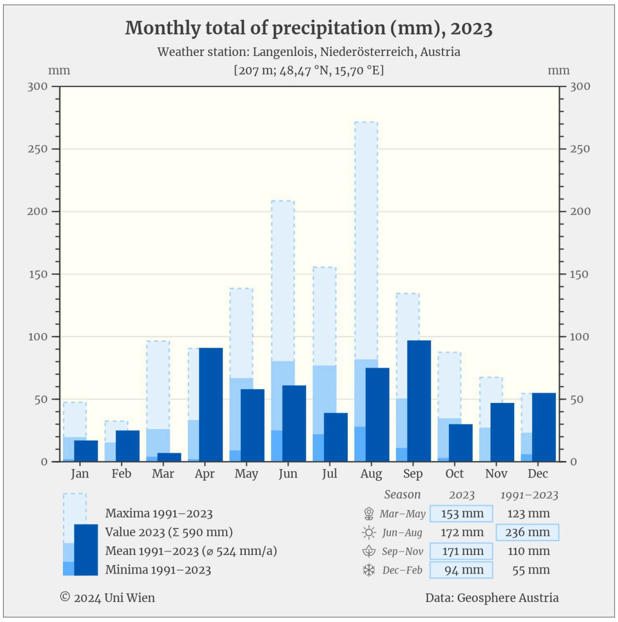
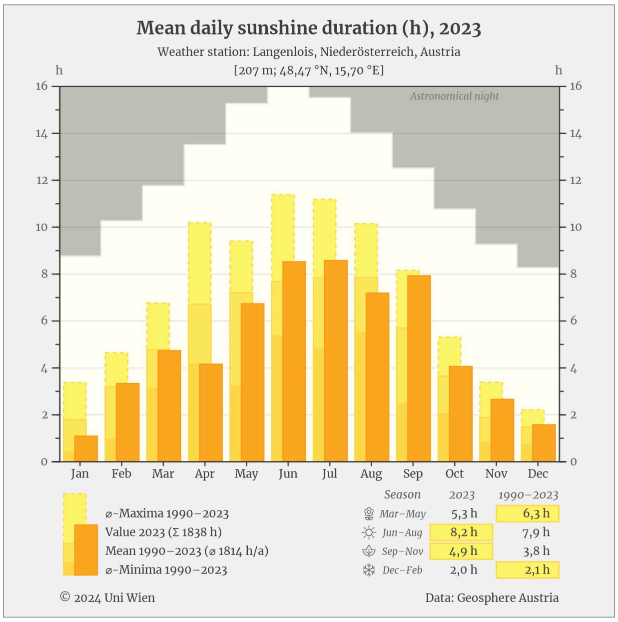


Precipitation:

The current **precipitation** levels for the last year of measurement are shown for each month as dark blue bars on the climagraph. For comparative purposes, the long-term average monthly precipitation vales for the last approx. 20 years are portrayed in a lighter colour; the other two bars show the minimum and maximum amounts of precipitation during the period of measurement.



Sunshine hours:

The diagram shows the average daily sunshine hours for each month of the current year of measurement in orange. The long-term average for the last approx. 20 years is shown in a lighter colour. Alongside this, the long-term minimum and maximum values are shown in yellow. The white areas in the diagram show the maximum possible daily sunshine hours for each month.