Climate Change & The Agricultural Sector

Copernicus for Climate Change Adaptation and Mitigation
Climate change poses a direct challenge to agriculture.
Farmers across Europe are already experiencing effects of climate change including:
- Climate induced stresses
- Pests and diseases
A plan is essential for the agricultural sector to grow and adapt.

**Copernicus Climate Change Service (C3S)**, operated by ECMWF, can provide data and tools to help
- understand climate change impacts
- inform policy and decision-making
- planning for mitigation and adaptation
- ensure resilience in the future
In 2015, ECMWF commissioned 7 proof of concept projects, working with different sectors to develop the C3S:

- Water (x2)
- Energy (x2)
- Agriculture
- Health & Infrastructure
- Insurance

This presentation is based on the prototype Agriculture Sectoral Information System (SIS), also known as “AgriCLASS”. 

https://climate.copernicus.eu/sectoral-information-system
The Agriculture SIS is based on requirements from our local partners, working with end users, including growers and policy makers.

- Focus on 3 case studies: vines, olives and forests.

- These woody perennial crops can take >10 years to become established and productive, with an average productive life span of 50 years.

- They can have “climate memory” and are responsive to cumulative change in climate conditions.

- They are highly vulnerable to climate change and therefore require a long-term management strategy.
For climate impact on agriculture, a key concept is **Phenology**:

1: *a branch of science dealing with the relations between climate and periodic biological phenomena (such as bird migration or plant flowering)*

2: *periodic biological phenomena that are correlated with climatic conditions*  
(Merriam-Webster)

Examples from case studies:

- **Grape** vine growth advances with **accumulation of temperature** above 10°C, especially between April and September (different for each variety)
- **Olive** fruit fly pest activity increases with warmer winter **minimum temperature**
- **Forest** tree growth (ring width) decreases in **drought** years

Features of the climate that are relevant to agriculture and crop phenology can be represented as **Bioclimatic Indicators**.
VINES CASE STUDY

- **Viticulture** is a well developed agri-industry in more than 60 nations globally. The EU leads the global wine market with 45% of wine-growing areas, 65% of production by volume, 57% of global consumption and 70% of exports.

- **Grapevine phenology** is critical to the wine industry and is sensitive to climate change, shifting harvest dates, changing sugar/acid content, alcohol strength and flavour.

- A key bioclimatic indicator for vine development is the integration of temperature over time, commonly expressed in **Growing Degree Days**.

- Changes in this indicator directly affect the vine phenology, hence the wine quality, taste and yield.

- Harvest date can shift by several weeks, resulting in higher sugar content and affecting the wine typicality associated with the local region.
Case Study Location: Buzet Appellation d'Origine Contrôlée (AOC), S.W. France.

Like other AOCs, it has strict a geographical boundary as well as compulsory technical specifications (allowed grape varieties, maximum yield, regulation of irrigation, control of alcohol content, etc.)

Climate change poses a real challenge to Buzet business...

“We are experiencing the impacts of climate change strongly – our wines contain more and more alcohol consequently we have to harvest earlier to keep this alcohol content low but in the meantime it is becoming now difficult to reach full grain maturity necessary to have a good wine quality. So the information provided by AgriCLASS is of high interest for us in order to select today the grape varieties suitable for the future climate conditions and to start adapting our production process.”

Sébastien Labails
Viticulture Innovation at the Cave des Vignerons de Buzet
The case study considered 4 key stages in grape vine phenology:

1. **Bud Break**
2. **Flowering**
3. **Veraison**
4. **Maturity**

- First, using data from historical observations, a mathematical model was developed to correlate the Day of Year (DOY) reaching each stage, with the accumulated temperature, measured in Growing Degree Days.

- Then, using simulated future daily weather from climate projections, it was possible to predict how the DOY of each stage might change in future.
VINES CASE STUDY – RESULTS

Pessimistic Scenario (RCP 8.5) | Optimistic Scenario (RCP 2.6) | Stabilisation Scenario (RCP 4.5)

Phenological Stages: ● Budbreak  ● Flowering  ● Veraison  ● Harvest
18 annual **Bioclimatic Indicators** were computed for 1950-2100 on a 25 km grid.

**Growing Degree Days** (base 10°C)
Many organisms respond to the accumulation of growing degree days. If the target amount to reach a particular phenological stage is known, then it is possible to predict the Day of Year (DOY) when this will occur.

**Specialised Indicators**
- Huglin Index (Viticulture)
- Spring Flight (Olive pest)
- Standardised Precipitation-Evapotranspiration Index (Drought)

**Monthly Weather Features**
- Mean $T_{\text{max}}$
- Max $T_{\text{max}}$
- Min $T_{\text{max}}$
- Mean $T_{\text{min}}$
- Max $T_{\text{min}}$
- Min $T_{\text{min}}$
- Mean DTR ($T_{\text{max}} - T_{\text{min}}$)
- Mean Temp (estimated)
- Frost Days ($T_{\text{min}} < 0^\circ$C)
- Ice Days ($T_{\text{max}} < 0^\circ$C)
- Hot Days ($T_{\text{max}} > 30^\circ$C)
- Rain Days (precip >= 0.2mm)
- Wet Days (precip >= 1.0mm)
- Total Precip (mm)
Bioclimatic Indicators can be used to model the impact of climate change on agricultural crops.

The case study methodology was based on statistical correlation of bioclimatic indicators with observed crop behaviour.

Machine Learning techniques included Principle Component Analysis and Generalised Linear Regression. A similar approach can be applied to many other agricultural crops and pests.

For further information please visit: [https://agriclass.climate.copernicus.eu](https://agriclass.climate.copernicus.eu)
PROOF OF CONCEPT SIS DEMO – PRODUCTS

https://agriclass.climate.copernicus.eu/

**Products**

The principal products are gridded bioclimatic data datasets, which are available as NetCDF files covering specific location. These datasets can be obtained via the Copernicus AgriClass website, and are primarily based on the E-OBS dataset with additional regionalization of agricultural data and crop models to assess site-specific impacts.

All products are available conveniently online via this website.

**How to use this Catalogue**

The products are grouped into three families:
- Growing Degree Days
- Monthly Features
- Specialised Indicators

**GDD targets (base 10°C)**

Growing Degree Day represents the integration over time of air temperature above a base temperature, in this case 10°C. The target number of GDD is known, and it is required to find the Day of Year (DOY) when this is reached.

- 25 targets at intervals of 100 degree-days
- Base temperature 10°C
- Estimated from daily minimum temperature (tasmin) and daily maximum temperature (tasmax) using simple average method
- Befix 1st January

**Consensus**

The ensemble consensus for the projected period 2001 - 2100 is presented here as mean and spread (computed as standard deviation).

**Scenario**

- RCP 8.5
- RCP 4.5
- RCP 2.6
PROOF OF CONCEPT SIS DEMO – DAY OF YEAR / DEGREE DAYS

Map showing cumulative growing days with a graph indicating the mean of days to reach 1000 GD10 (days) with coordinates Lon: 0.7304092925714283, Lat: 44.55264955215232.
PROOF OF CONCEPT SIS DEMO – HUGLIN INDEX
There are now two projects addressing the Agricultural Sector:

**Proof of Concept SIS**
- ECMWF contract in 2015 with Telespazio Vega UK Ltd
- 18 Bioclimatic Indicators as gridded datasets over Europe
- 3 case studies on woody perennials: vines, olives and beech forests
- Completed and currently available via C3S web site
- Caveat: no quality control!

**Global Agriculture Service**
- ECMWF contract in 2017 with Wageningen Environmental Research (NL)
- 4 data streams: indicators based on Climate Data, Earth Observation and Water; forcing data for agricultural impact models
- Planned ongoing operational service via the Climate Data Store (CDS)
- In development, coming soon...
Climate Change

CLIMATE DATA STORE (BETA)

Climate Data Store: Search results

<table>
<thead>
<tr>
<th>Type</th>
<th>Overview</th>
<th>Downloaded data</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator</td>
<td>As part of the Copernicus Climate Change Service the Agri available, high-quality climate and agricultural data and maps specific products useful to the agricultural sector. These users with the information they need to understand how affected by climate change in the future and to aid in changes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>The Huglin Index (HI) is an indicator specifically aimed at grain crops, it is defined using daily averaged temperature and precipitation for days in the period 1 April to 30 September. For this index, see here. Please note that this specialized index is defined in France and although it has not yet been computed for other geological periods.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scenario</td>
<td>Spring Flight is a day of first annual appearance of S. oleracea for variety in fall. The cumulative degree day of 279.02 is from our case study in Italy and although it has been computed for other crops.</td>
<td></td>
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</tr>
<tr>
<td>Keywords:</td>
<td>Huglin Index, Spring Flight</td>
<td></td>
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<tr>
<td>Data description</td>
<td>Specialised indicators are tailored products that may be specific to the user's needs.</td>
<td></td>
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<tr>
<td>Temporal resolution:</td>
<td></td>
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Climate Change

SUMMARY

- Climate change is likely to have a **major impact** on agri-businesses, therefore it is important to assess climate change impacts to ensure future sustainability

- **Copernicus Climate Change Service (C3S)** is addressing the Agricultural Sector, providing information for adaption and mitigation

- A **proof of concept SIS** has been developed and is available via the C3S website

- A suite of **18 bioclimatic indicators** is available as gridded data sets at 25 km resolution from 1950 to 2100

- **3 case studies**, including viticulture in SW France, demonstrate how these data can be used to project climate impact on agriculture

- An operational **Global Service for Agriculture** is in development, and will be built on the new C3S Climate Data Store (CDS)