Copernicus on the Job – Forestry
Final Report

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FPCUP-Action 2020-2-1

terranea

1. Objectives

There exist many examples which underline that forest management can greatly benefit from Earth observation (EO). Applications such as tree species classifications, time series and trend analysis or damage assessments can support short term interventions and long-term planning. However, the adoption of remote sensing techniques varies significantly in forest management. This is partly due to limited awareness of the potential applications of EO and particularly Copernicus data and services. Moreover, there is a lack of professionals in the forestry sector who are trained to work with remote sensing data. Furthermore, financial and technical resources are often insufficient to implement Earth observation workflows. According to a survey conducted by the German Thünen Institute, there is a need for better information on the potential applications of remote sensing in forestry, particularly on data and products from the Copernicus program, as well as training opportunities. This is even more relevant when considering, that forests cover about one-third of Germany's land area and nearly half of Austria's. Thus, the aim of the *Copernicus on the Job – Forestry* action was, to develop, conduct and evaluate a training program for forestry practitioners in Germany and Austria on how to exploit Copernicus services products and satellite data in operational forestry procedures with the overall intention to increase the use of Copernicus-based services in operational forestry.

2. Design of training formats and training content

The objective of the course was to deliver information that is immediately relevant and directly applicable to the participants. They should be enabled to work with Copernicus products in their day-to-day routines and to define further in-depth analyses or products which could be delivered by specialized service providers.

The training was designed in a blended format. This means a face-to-face seminar followed a previous e-learning component. The e-learning seminar taught the EO and Copernicus basics while the face-to-face seminar was used for further in-depth demonstrations and discussions.

The combination of meting face-to-face and the online seminars enabled the participants to learn in a personalised way online as well as in a group together with the other participants and the trainers.

2.1. E-learning seminar

The aim of the e-learning unit was to acquire a basic understanding of the potentials of remote sensing and services of the Copernicus programme. To achieve this, the technical background of remote sensing was taught first. In two further modules, the Sentinel satellite programme and the Copernicus services were introduced. A final module included application examples.

Accompanying training materials, which summarised the essential points of the online session were made available to the participants as a script (PDF). In the end of the online seminar, the

participants were encouraged to propose specific topics and use cases from practice to be included in the curriculum of the face-to-face seminar.

The qualification objectives of the e-learning unit can be summarised as follows:

- Participants know the Copernicus programme, its actors, services and contacts in Germany and Austria as well as possible applications and corresponding service activation mechanisms.
- Participants get to know the Sentinel satellites and services.
- Participants are familiar with practical examples and know which forest-related data can be used, how they can be ordered and how they can be used for forestry applications. The added value and need for in-situ data were explained and a combination of different types of data was presented using examples.
- Participants know the potentials and limitations of remote sensing technologies and applications and understand when and how the use of imaging data can be useful in forestry.
- Participants know the value of specific Copernicus services, e.g. Copernicus Land Service and Copernicus Emergency Management Service, to answer forestry related questions and to use them in professional practice.
- Participants have networked with each other and can exchange and apply what they have learned. Moreover, they can get in touch and support each other in case of issues.

2.1.1. Module 1

Module 1: Remote sensing basics	ca. 90 Min
Objective: Participants are introduced to remote sensing. A concise overview is given to help interpret images visually. Moreover, information about technical and physical concepts are provided which are also necessary to understand the limitations of remote sensing.	
By the end of the module, participants will know, ▪ that remote sensing is more than colourful images and can capture information beyond the visible range; o Basic knowledge of physical principles and electromagnetic radiation, spectral ranges and spectral ranges used especially in forest remote sensing; o The passive satellite (Sentinel-2) records the reflected radiation in spectral channels or bands (influenced by clouds, atmosphere, time of day). ▪ How a typical reflectance curve of vegetation looks like and understand why grass is green and why healthy vegetation or vegetation under drought stress can be detected with the satellite;	

  - Plants (chlorophyll) reflect Green and Near Infrared, Red is absorbed for photosynthesis; thus, healthy vegetation appears green;
  - Water content is detectable in SWIR;
  - Drought stress: higher reflection of Blue and Red, decreased reflection in Near Infrared;
    => Band combinations allow us to derive this information.
- Know the terms *spatial, temporal* and *spectral resolution* and know the differences, advantages and disadvantages of VHR, HR and LR image data;
  - Spatial: the smallest spatial object or ground area that the satellite can "resolve";
  - Temporal: defined as the time it takes the satellite to revisit the same location to acquire data (Sentinel-2: 2-5 days);
  - Spectral: refers to the bands of a sensor and their sensitivity to detect an electromagnetic signal (Sentinel-2: 13 bands);
- Understand the different colour representations of satellite images.
  - True colour R-G-B, "what the eye sees";
  - False colour composite NIR-R-G;
- Know the relevance of in-situ data in this context;
  - Are necessary to process satellite data;
  - Can complement information from satellite;
  - Should be widely available in the forestry sector;
- Know the potentials and also limitations of remote sensing;
  - See above: spatial, temporal, spectral resolution; cloud cover;
  - Spatial coverage;
  - "Standard product" available globally;
  - Time series;
- Can visually interpret sample images and know, how vegetation is represented (e.g. differences between deciduous and coniferous trees);
  - See above: typical reflectance curve of vegetation, true colour, false colour composites.
- Know the differences between aerial photographs and satellite imagery.
  - See above: spatial, temporal, spectral resolution;

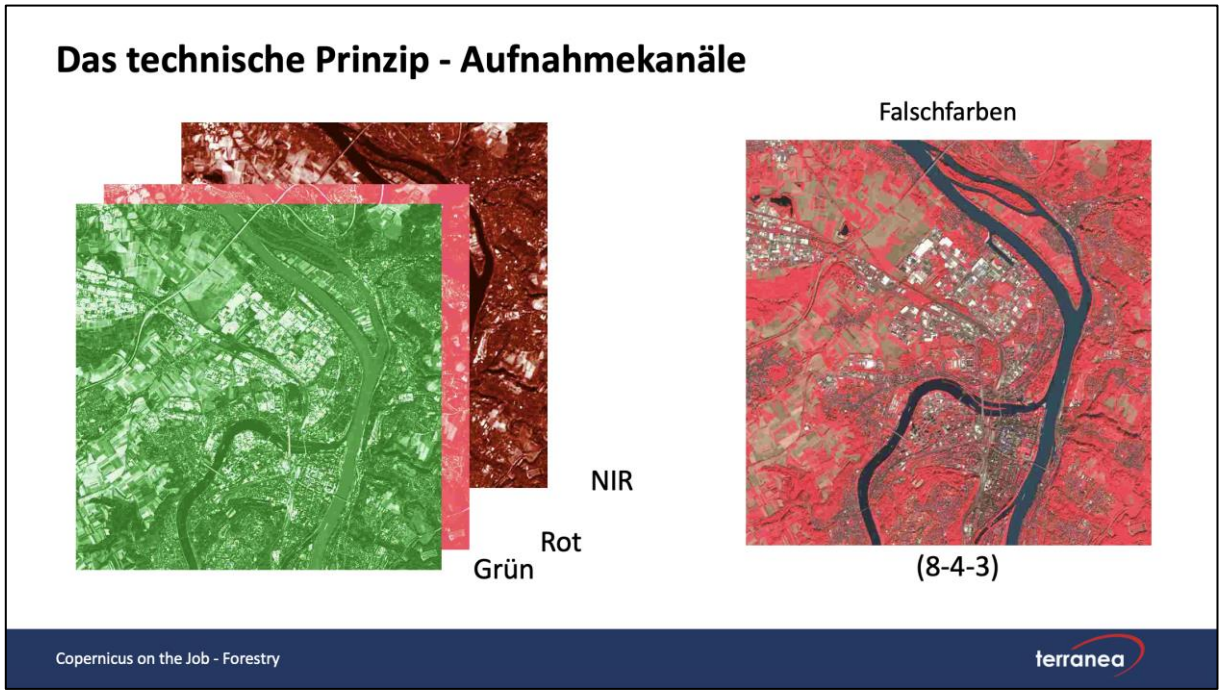

Figure 1 – Modul 1 False colour band combinations

2.1.2. Module 2

Module 2: The Sentinel satellites	ca. 45 Min
Objective: The participants know the Sentinel programme.	

At the end of the module, participants will know,
• that the Sentinel programme is long term; current plans extend beyond 2035;
• that all image data is freely available;
• that there are seven Sentinel missions with different imaging capacities (see Module 1);
• that there are currently seven Sentinel satellites in orbit;
• that Sentinel-2 can be an important source for forestry applications in particular;
  ○ passive sensor; twin mission;
  ○ temporal coverage;
  ○ spatial resolution (10m, 20m, 60m);
  ○ spectral resolution;
• have heard that there is complementary data from Landsat but also from private providers such as Planet;
• have seen examples of Sentinel-1, Sentinel-2, Sentinel-3;
• are aware of access points (CODE-DE, EODC, Copernicus Data Space (DIAS));
• can interpret Sentinel-2 images in true and false colours (see Module 1);
• know the limitations of Sentinel-2;
  ○ spatial & temporal resolution;	

- know that computer-based analysis is used for large-scale analysis in addition to visual analysis;
- Can search for images in the CODE-DE browser and visualise them in different ways;
- Can export the images from the CODE-DE Browser/Finder;

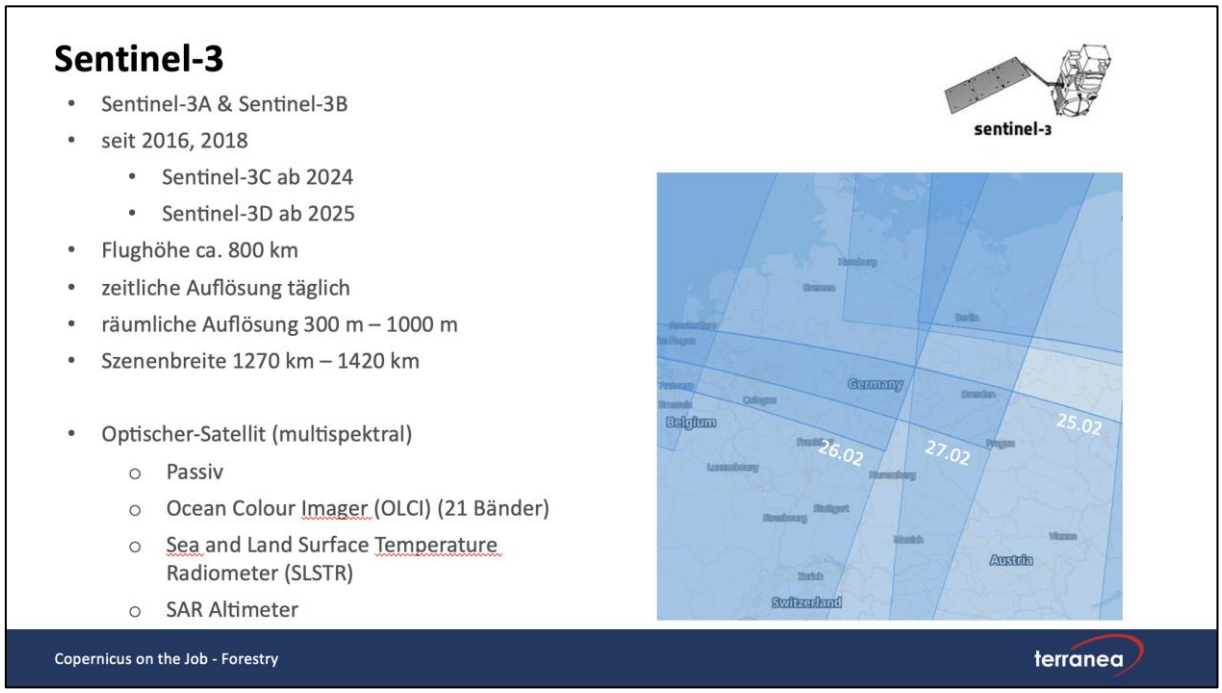

Figure 2 – Modul 2 Introduction of Sentinel-3

2.1.3. Module 3

Module 3: The Copernicus programme	ca. 30 Min
Objective: Participants will get an overview of the Copernicus services.	
At the end of the module, participants will know, ▪ that Copernicus is a user-driven programme; ▪ that there exist six core services; ▪ they know the services with forest-relevant data products; o CLMS and CEMS and sample data: HRL Forest, CLC and CLC+, Phenology and Productivity, Natura 2000; o CEMS Rapid Mapping products: Forest Fires and Storm Damage; o CEMS Risk and Recovery products, e.g. on soil erosion and delineation of burnt areas; o European Forest Fire Information System; o (limited use: C3S service with climate change info).	

- Understand the benefits and limitations of the services offered for forestry purposes;
  - CLMS: large-scale information, limited scale, limited temporal resolution;
  - CEMS: can be requested in case of emergency as well as for re-analysis;
  - EFFIS: daily updated information on forest fire risk and active fires.
- Know that all core service data is freely available and where the data can be obtained.
  - portals (e.g. CODE-DE, EODC);
  - access and licenses;
  - available formats;
  - download options;
- They know the Copernicus contact persons in Germany and Austria;
- They know how to activate the CEMS in Germany and Austria;

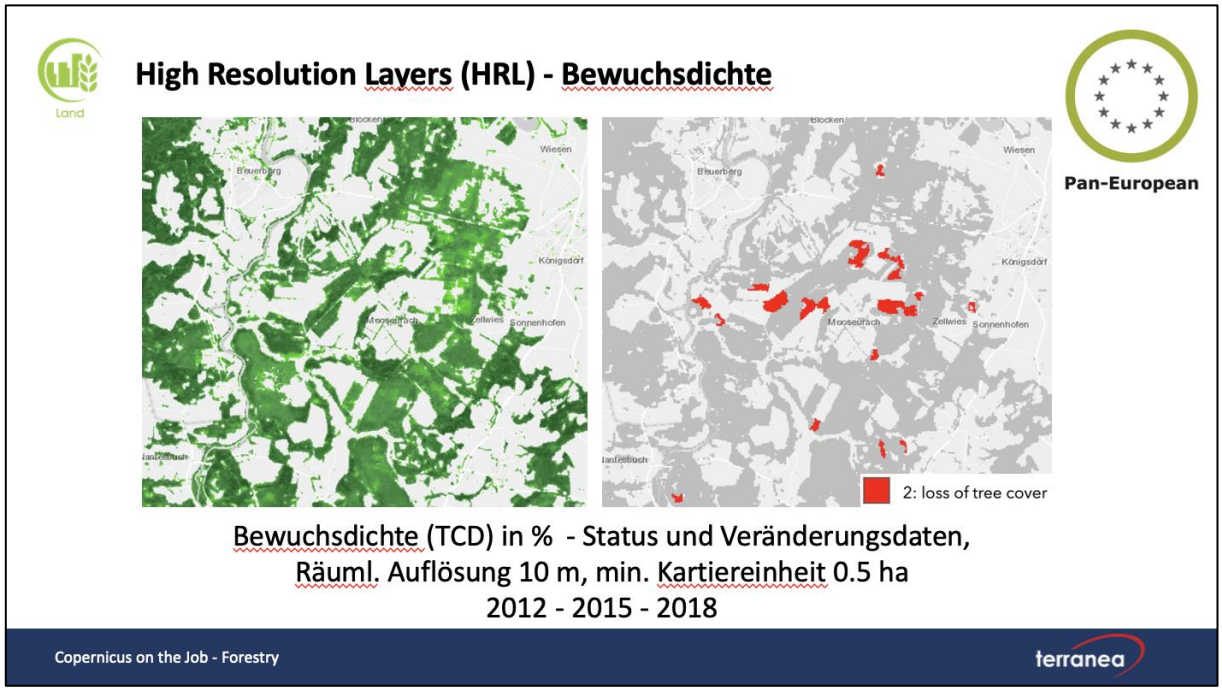

Figure 3 – Modul 3 Introduction of Copernicus Land Monitoring Services – HRL Tree Cover Density

2.1.4. Module 4

Module 4: Use-cases	ca. 30 Min
Objective: Sample use cases will be presented and hands-on material provided	
At the end of the module, participants will know, ▪ that band math and band indices are simple but robust tools to analyse vegetation and forests in particular; ▪ how to conduct an analysis of damaged forest using change detection; ▪ where to find necessary in-situ data; ▪ how to calculate NDVI and NBR; ▪ how to evaluate the results;	

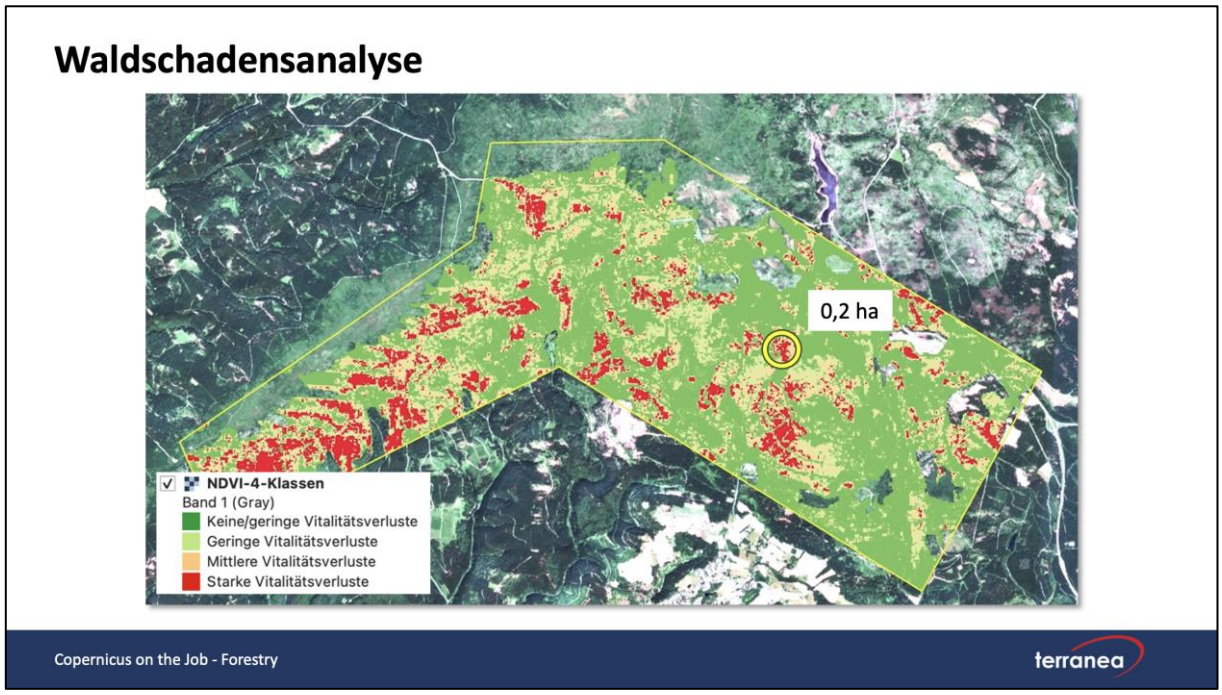

Figure 4 – Modul 4 Forest damage assessment using NDVI-time series

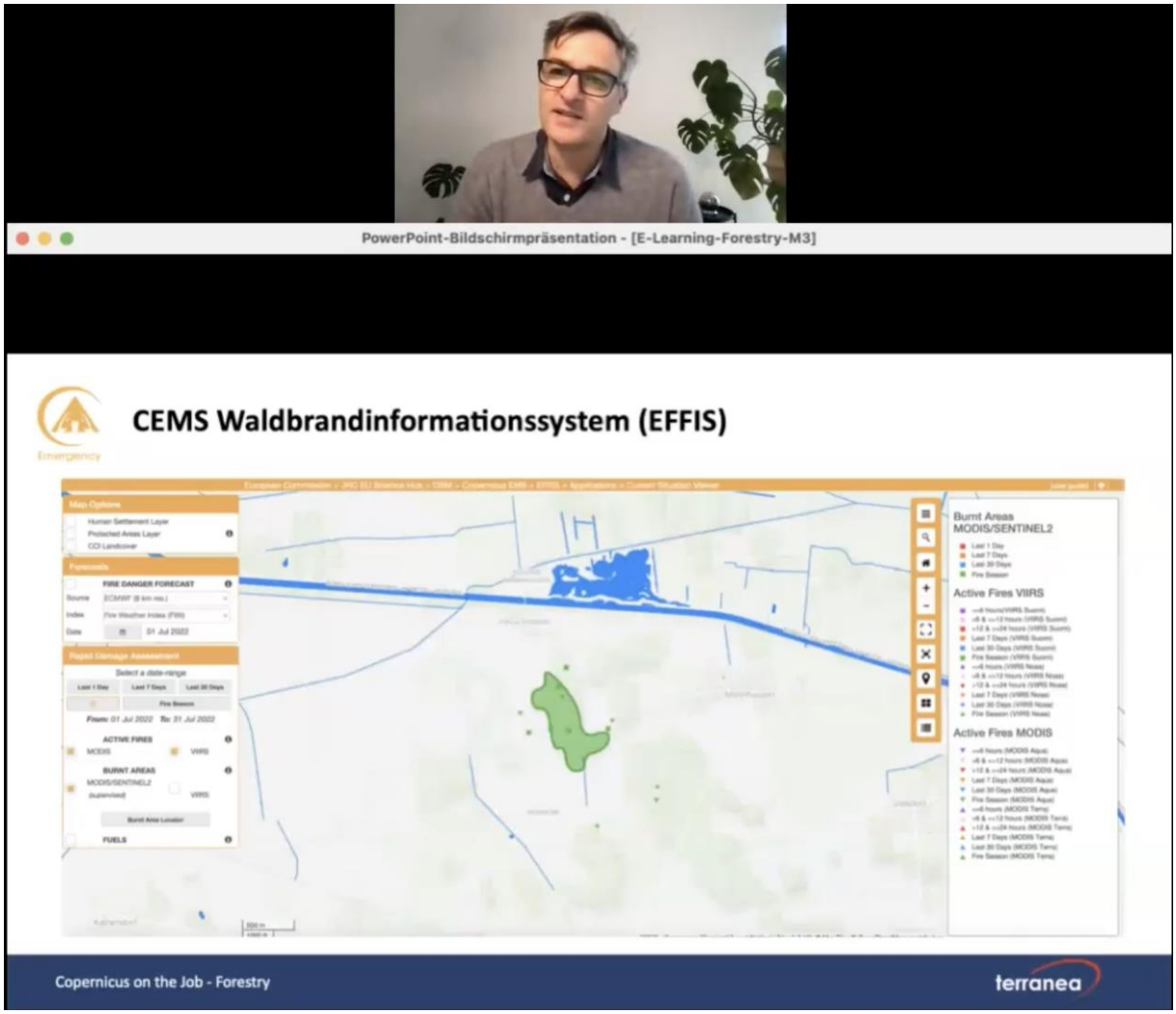

Figure 5 – Screenshot from the e-learning seminar

Nineteen participants attended the e-learning seminar on 9 March 2023. They are affiliated to the following institutions:

- Landeszentrum Wald Sachsen-Anhalt DE
- Nordwestdeutsche Forstliche Versuchsanstalt DE
- Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg DE
- Hochschule Weihenstephan-Triesdorf DE
- Niedersächsische Landesforsten DE
- Ostdeutsche Gesellschaft für Forstplanung mbH DE
- Regierungspräsidium Freiburg, Referat 85 - Forsteinrichtung und Forstliche Geoinformation DE
- Forstliches Forschungs- und Kompetenzzentrum Gotha DE
- Österreichische Bundesforste AT
- Amt der steiermärkischen Landesregierung AT
- Amt der Tiroler Landesregierung AT

2.2. In-person seminar

The e-learning seminar in combination with the face-to-face training allowed the participants aimed to acquire actionable knowledge to be able to use Copernicus products to solve problems of their professional practice.

The objective of the in-person seminar was to deepen the participants' knowledge through additional presentations from different stakeholders so that they better understood the potential of remote sensing data and how it can be applied in their own environments.

The qualification objectives can be summarised as follows:

- Learn from others: teaching of competences for the use of data and services of the Copernicus programme in professional practice.
- The participants get to know examples of EO applications from different stakeholders in the forestry domain.

Afterwards the participants will understand,

- how data can be used to answer specific forest related questions;
- which EO services are already applied in forestry;
- where some of these services can be obtained;
- the possibilities and limitations that arise from using satellite-based products.
- the value of specific Copernicus services (esp. the CEMS);

Participants will also have networked with each other and can apply what they have learned and support each other.

Figure 6 –Group photo at the in-person seminar in Freising-Weihenstephan on 23 March 2023

2.2.1. In Person seminar Agenda

9:00 – 9:15	Welcome and tour de table
9:15 – 10:30	Presentation LWF Bayern (The Bavarian State Institute of Forestry) Applied Forest Remote Sensing and the works of LWF
10:30 – 11:00	Presentation State Forests Rhineland-Palatinate (Landesforsten Rheinland-Pfalz) Applied forest remote sensing at the State Forests of Rhineland-Palatinate
11:00 – 11:30	Coffee break
11:30 – 12:30	Presentation CODE-DE Introduction to CODE-DE, available data and tools, data search, data download and processing
12:30 – 13:30	Lunch
13:30 – 14:00	Presentation BOKU Vienna Recent research in forest remote sensing
14:00 – 14:30	Presentation Federal Office of Civil Protection and Disaster Assistance (BBK) Introduction and overview of the services of the Copernicus Emergency Management Service and its activation
14:30 – 15:00	Presentation Waldmonitor Germany (RSS GmbH) Forest condition assessments and tree species identification
15:00 – 15:30	Coffee break
15:30 – 16:30	Wrap-up and discussion
16:30	End

3. Organisation

3.1. Training material

For each of the e-learning modules accompanying training materials were developed summarizing the essential topics of the online sessions. All documents were made available to the participants and can still be downloaded from the following site: https://cloud.terranea.de/s/rN68Zsx2e62MLs6

For Module 4, test data (vector and raster) was also made available to be able to replicate the different analytical steps that were presented.

3.2. Venue

As training venue the Forest Faculty of the Technical University of Munich, Weihenstephan campus was chosen. Eleven participants attended the in-person training. Moreover, three external presenters were present in Weihenstephan together with two people of Terranea (the organisers) and two from DLR and FFG. Three persons provided their presentations through an online connection.

The venue allowed the participants from Germany and Austria to be easily reached by public transport from both countries. The proximity to the Bavarian State Institute of Forestry (LWF) allowed the presence of their presenter.

3.3. Invitation of participants

Participants were invited and selected by DLR and FFG.

4. Evaluation

To assess the learning offers, an evaluation by means of a questionnaire was conducted at the end of the in-person seminar. It aimed to analyse whether the learning objectives were achieved with the theoretical and practical contents conveyed and whether the methodology and didactics used were useful to acquire action knowledge for professional practice.

The following results were determined in the course of the evaluation:

1 To what extent do you think you will be able to use what you have learned in the future?

0 - Very useful and very applicable

8 - Useful and applicable

0 - Less useful and less applicable, because …

The survey aimed to gauge participants' perceptions regarding the future usability of the knowledge they acquired. Out of the eight respondents, all of them indicated that they believe what they have learned is useful and applicable in their future endeavors. This agreement highlights a positive outlook among the participants, suggesting a high degree of confidence in the practicality of the acquired knowledge. None of the respondents considered the knowledge to be less useful or less applicable.

2 To what extent was the participation in the online training series worth the time spent?

0 - Very valuable

8 - Valuable

0 - Less valuable, because …

The survey assessed participants' perception of the value of their participation in an online training series, considering the time invested. All eight respondents found the training to be valuable, indicating unanimous agreement on its worth. Notably, no participants considered their participation to be less valuable. This positive response suggests that the training series successfully delivered value and met participants' expectations. The findings highlight the effectiveness of the training program in providing meaningful content and engaging the learners, reinforcing the importance of well-designed and impactful training programs.

3 How would you estimate your knowledge of remote sensing and Copernicus before the start of the event?

0 - No knowledge available

3 - Little knowledge available

5 - Knowledge available

0 - Advanced knowledge available

The survey assessed participants' self-estimation of their knowledge in remote sensing and Copernicus before the event. Three indicated having little knowledge available, while five acknowledged having knowledge. No participant claimed to possess advanced knowledge nor no knowledge at all. These findings provide valuable insights for tailoring event content to accommodate diverse knowledge levels.

4 How do you assess your learning success after the end of the event?

4 - High knowledge gain

4 - Satisfying knowledge gain

0 - Little knowledge gain, because …

The survey aimed to assess participants' self-assessment of their learning success following the event. Results indicate that an equal number of participants, four each, reported high

knowledge gain and satisfying knowledge gain. This suggests that participants felt they acquired a significant amount of new knowledge and found the event's content beneficial. None of the participants indicated a little knowledge gain. These findings demonstrate the event's effectiveness in facilitating substantial learning outcomes and meeting participants' expectations. The positive responses highlight the event's success in delivering valuable knowledge and promoting a satisfying learning experience for attendees. The feedback on the satisfying knowledge gain can be an indicator that some of the participants had previous knowledge before the training (see question 3).

5 What suggestions do you have to make the online training more effective?

Two responses were given. In the in-person seminar some of the lectures exceeded the schedule. The suggestion was to interrupt those so that the lectures do not have to be shortened at the end. Moreover, it was suggested to include more practical exercises.

6 In your opinion, is an online training a suitable method to get the knowledge on this topic?

All respondents agreed with the above statement. However, it was also indicated by one participant, that in-person training is his preferred choice.

7 How do you evaluate the possibilities of interaction between tutor and participants in the online training?

5 - An interaction was always possible

3 - An interaction was possible

0 - An interaction was hardly possible

The survey assessed participants' evaluation of the possibilities of interaction between the trainer and participants in the online training. Results indicate that five participants agreed that interaction was always possible. Additionally, three participants agreed that interaction was possible, indicating that there were opportunities for engagement, although perhaps not consistently. No participants indicated that interaction was hardly possible, suggesting that overall, the online training provided a favorable environment for interaction. These findings demonstrate the importance of interactive exchange in online training.

8 How do you rate the time format of the online training?

8 - The time was appropriate

0 - The time was too short

The feedback underlines that the time of the online training was appropriate. The training was held in the afternoon between 15:00 and 17:00. It is appreciated that the participants decided to attend the seminar even though they had already almost a full working day behind them.

9 To what extent is the division of the event into online and face-to-face events useful?

8 - Very useful

0 - Not useful, better would be …

The survey aimed to assess the usefulness of dividing the event into online and face-to-face components. Results indicate that all eight participants agreed that the division was very useful. This suggests that the combination of online and face-to-face events provided valuable benefits and advantages for the participants. No participants expressed the view that the division was not useful or suggested an alternative approach. These findings highlight the success of the event's format in leveraging the strengths of both online and face-to-face interactions, maximizing the learning experience, and meeting participants' needs and expectations. The unanimous agreement underscores the effectiveness of this division and its contribution to the overall success of the event.

10 How did you like the face-to-face event in Freising?

7 - The lectures were interesting and helpful for my own work.

1 - The lectures were interesting, but less helpful for my own work.

2 - I would have liked practical exercises with data and on the computer.

1 - I would have liked a lecture / exercise on the topic:

The survey aimed to gather feedback on the face-to-face event in Freising. Most of the respondents agreed that the lectures were both interesting and helpful for their own work, indicating a positive impact on their professional development. One participant agreed that the lectures were interesting but found them less helpful for their own work, which could be related to previous existing knowledge or that the person is not involved in practical data

analysis. Additionally, two participants expressed a desire for practical exercises with data and on the computer, highlighting a preference for hands-on learning experiences. One participant mentioned that the forest visit, which was part of an earlier training plan, could not be conducted due to the limited time. The findings suggest that the face-to-face event in Freising generally provided valuable and engaging lectures to enhance participants' learning experiences.

11 Would you recommend the event to others?

8 - Yes

0 - No

0 - No, because …

The survey asked participants if they would recommend the event to others. All eight participants responded positively, indicating that they would indeed recommend the event to others. There were no participants who expressed a negative opinion or provided specific reasons for not recommending the event. This agreement highlights the participants' overall satisfaction and positive perception of the event. Their willingness to recommend the event suggests that they found value in the content, format, and overall experience, reinforcing its potential to benefit and engage future attendees.

5. Conclusion

In conclusion, the survey results provide valuable insights into participants' experiences and perceptions of the Copernicus on the job – Forestry training events. The findings demonstrate a positive overall response and highlight the success of the event in delivering valuable content and facilitating learning outcomes.

Participants reported a knowledge gain, indicating that the event effectively enhanced their understanding and knowledge. The high number of agreements regarding a satisfying knowledge gain reflects the event's success in providing valuable learning opportunities. The division of the event into online and face-to-face components was unanimously considered very useful, indicating the advantages of combining different formats to optimize the learning experience. This division allowed for a flexible and dynamic learning environment that catered to participants' needs and preferences.

Participants expressed high levels of satisfaction with the face-to-face event, finding the lectures both interesting and helpful for their own work. This positive response indicates the event's success in providing relevant and impactful content.

However, a subset of participants expressed a desire for more practical exercises with data and on the computer, highlighting a preference for hands-on learning opportunities. Such

exercises were provided in the fourth e-learning module that was held after the in-person event and thus after the survey. Nevertheless, the feedback provides valuable input for future event planning to further enhance participants' learning experiences.

Importantly, all participants indicated that they would recommend the event to others, emphasizing the overall positive impression and perceived value of the event. This reflects their satisfaction and belief in the event's ability to benefit others.

These findings confirm the event's effectiveness in meeting participants' needs, fostering engagement, and facilitating knowledge acquisition. The event's success in delivering valuable content, providing opportunities for interaction, and offering a balanced mix of online and face-to-face elements contributes to its overall positive impact. Future events can build upon these insights to continue delivering exceptional learning experiences and meeting participants' expectations.