



METOS[®] TURF
BY PESSL INSTRUMENTS

TURNING INFORMATION INTO PROFITS

METOS[®] TURF MANAGEMENT

*An extensive set of advanced solutions
for a smart approach to turf management*



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www.metosturf.com



Overview

METOS® TURF by Pessi Instruments

Benefits of METOS® TURF

Key Features of METOS® TURF

METOS® TURF Solutions

All Your Course Needs

Hardware Solutions

Software Solutions

API Interface to Turf Management Software Solutions

Satisfied Customers

Use Case: Satellite Observation

METOS® TURF by Pessl Instruments

It is important that turf managers recognize turf grass's needs in a timely manner, and support it with appropriate soil and irrigation management, fertilizers application, and weed, insect and disease controls. With the **METOS® TURF by Pessl Instruments** solutions, every aspect of turf management is under full remote control.

With our solutions, every inch of various sports courses are closely monitored. All the data of METOS® hardware captured, are analysed in TurfClimate. The power of IoT, and data stored in the cloud, gives remarkable insight with a simple glance at the phone, tablet or computer screen. The METOS® TURF by Pessl Instruments gives fast access to all important and valuable information for quick decision-making.

From greenkeepers to end user's requirements, **METOS® TURF by Pessl Instruments** helps satisfy every individual's, and turf's, needs.

Benefits of METOS® TURF by Pessl Instruments

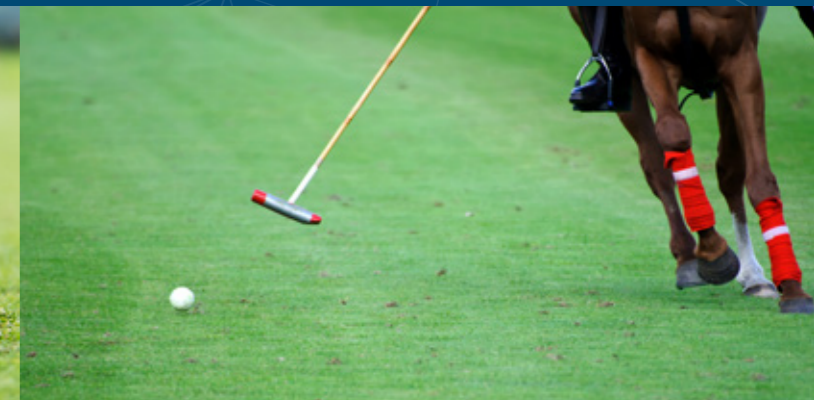
From turf grass health to enviable playing conditions, METOS® TURF by Pessl Instruments brings your whole course performance to brand-new dimensions.

METOS® TURF by Pessl Instruments provides a unique visualisation of all the conditions on the course which allows you to make quicker, more precise, and better decisions - from irrigation and fertilization management, disease modelling and insect control, to provide the best playing conditions.

Hardware installations are strategically placed throughout the course to measure the local weather forecast and enriched with portable spot readings of important parameters. The TurfClimate application provides the freedom of accessing multiple data sets measured at any given location in near real-time. This way decisions can be made on the spot, without worrying about changes in variables by the time one reaches the stressed area.

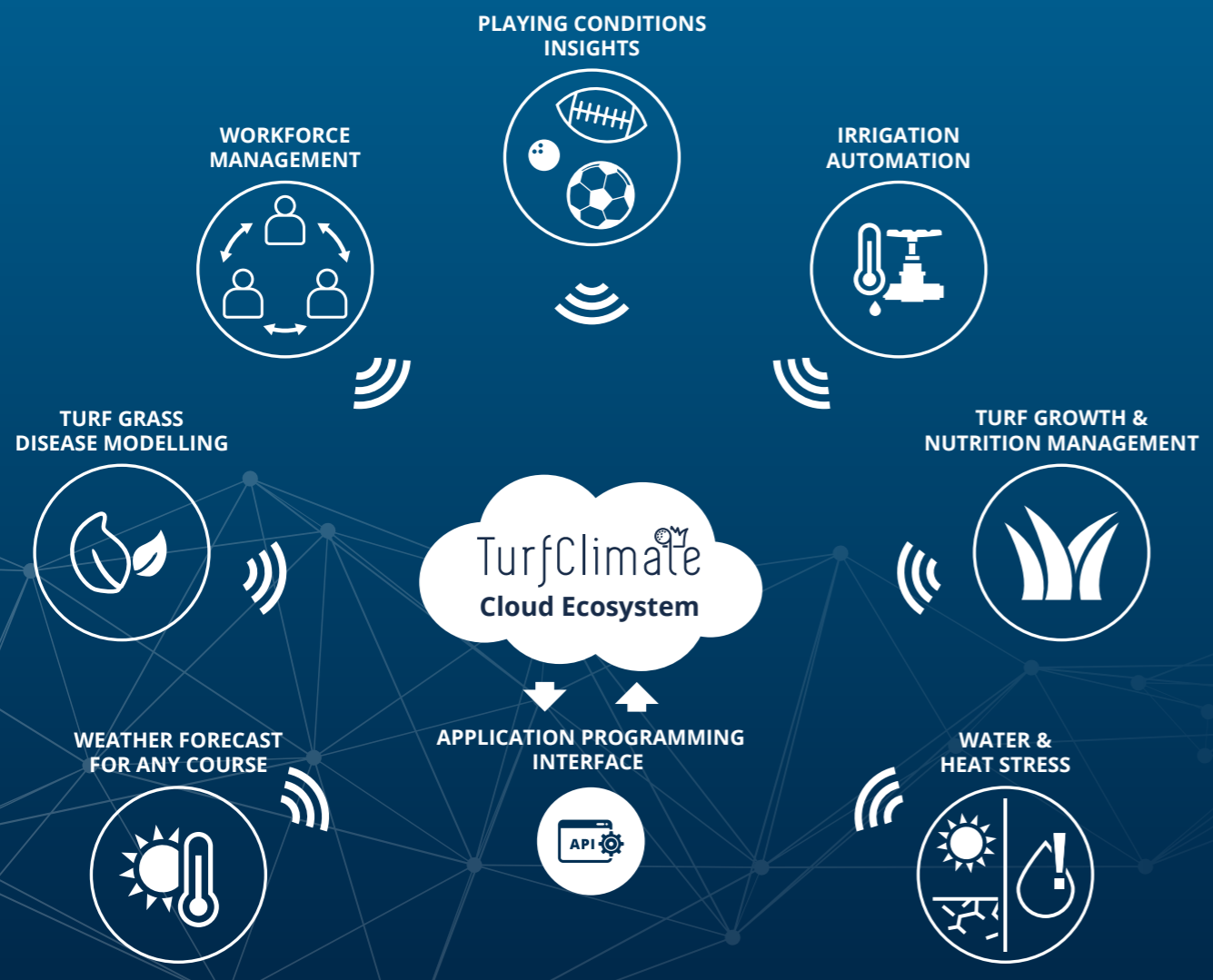
The system catches multiple key variable information, such as soil moisture, soil and air temperature, relative humidity, wind speed, and machine data and offers other insights as well, such as salinity index, asset mapping, soil nutrition, insect pressure, turf grass health, spraying conditions, and many more.

HOLISTIC SOLUTIONS FOR GOLF COURSE MANAGEMENT



Key Features of METOS® TURF by Pessl Instruments

- Provides actual weather and future weather on your course
- Gets you an insight of water stress and turf risk stress immediately and permanently in real time
- Allows you to see disease risks before they become a problem
- Playing conditions are always in the palm of your hand, anytime and from anywhere you are
- You have full traceability of all work, ready for management and other reporting purposes
- See and forecast fertilizer needs before the grass even knows it
- Lets you know where your equipment and your workers are at anytime
- Save costs, save the environment - with a peace of mind and no risks
- Gives you a bird's eye view of your course from the sky every 5 days



METOS® TURF Ecosystem

Don't let anything get in the way of a perfect course.

TurfClimate Desktop and Mobile app - real-time localised data just a click away

**Possibility: Interface with any major turf management platform*



METOS® TURF Solutions

*An extensive selection of solutions
for complete turf management, work
optimisation and control*

1 Weather Forecasting

Specialised weather forecasts are an important aspect of each sports course. It helps manage risks, maximize profits and help you stand out from other similar courses. In order to offer the best conditions for enjoyable play, each course has to consider the forecasted weather and respond to it in a timely manner.

BENEFITS:

- Know when to seed the turf grass
- Know when and how much to irrigate
- When to apply fertilizers and pesticides
- Monitor accurate site-specific meteorological parameters to predict playing conditions
- Monitor accurate site-specific meteorological parameters to define opening hours and public events
- Define disease pressure, water and fertilizer needs
- Defining workflow process
- Watch real-time weather to predict damaging winds
- Warn players on the course in case of nearby thunderstorms
- Save resources, time, and money

RECOMMENDED EQUIPMENT AND SUBSCRIPTIONS:

- METOS® VWS (basic)
- LoRAIN Rain Only/nMETOS 100 (basic)
- nMETOS TURF (intermediate)
- iMETOS 3.3 (advanced)
- *Subscriptions:*
 - Weather forecast subscription
 - Satellite Imagery Subscription



2 Irrigation Management & Irrigation Automation

The lack of good irrigation can easily affect the quality of play, therefore, weather stations and other data loggers present an important aspect of the maintenance process on every sport course. With soil moisture levels and localised weather forecasts, you can avoid over and under-irrigation and resource losses. Well-planned irrigation management reduces maintenance costs, increases efficiency and makes irrigation more sustainable.

Data from METOS® equipment is pushed to TurfClimate, which can be connected with irrigation automation software to ensure the highest irrigation efficiency.

BENEFITS:

- Water savings – better timing and potential reduction of water use
- Better quality of turf grass
- Saving on fertilizers
- Reducing Runoff
- Security - real-time alerting on a number of parameters like broken pipes
- Save time – rationalization of business operations
- Lower environmental impact – less water use and groundwater contamination
- Better playability of the course
- Trigger for automation can be evapotranspiration and/or soil moisture on the golf course
- Understand and avoid turf stress due to multiple measurement points

RECOMMENDED EQUIPMENT AND SUBSCRIPTIONS:

- LoRAIN Rain only/nMETOS (basic)
- METOS® VWS (basic)
- nMETOS TURF (intermediate)
- miniMETOS (intermediate)
- iMETOS 3.3 (advanced)
- ICA10
- SoilGuard
- *Subscriptions:*
 - Weather forecast subscription
 - Satellite Imagery Subscription



3 Disease Control

Some diseases are difficult to control and the timing of fungicide application is crucial in keeping them under control. With plant protection, including disease modelling, turf managers avoid over-fertilization and overuse of pesticides, which keep the turf grass in perfect condition and protect the environment at the same time.

AVAILABLE DISEASE MODELS FOR TURF GRASS:

- Pythium Blight
- Dollar Spot
- Brown Patch
- Snow Mold
- Overseeding
- Anthracnose



RECOMMENDED EQUIPMENT AND SUBSCRIPTIONS:

- nMETOS TURF (intermediate)
- iMETOS 3.3 (advanced)
- *Subscriptions:*
 - Weather forecast subscription
 - Turf Disease Model Subscription



4 Pest Control

In order to maintain a uniform playing surface and green colour of the turf grass, good pest management is important. Both mentioned qualities of turf grass can be infected by insects and mites that feed on grass.

With iSCOUT® Mobile, turf managers can take picture of the insects present in the course and act in a timely manner. This way both insect damage and over-fertilization can be avoided.

BENEFITS:

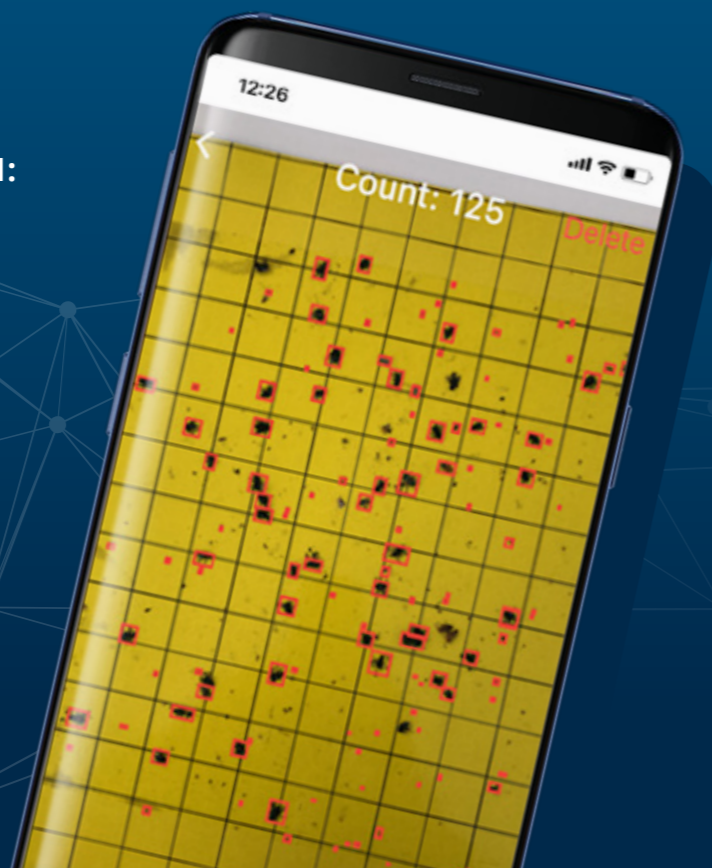
- Act before the insects cause irreparable damage
- Supporting decision on when to start spraying
- Monitor the first occurrence in the field/flight into the field
- Determine seasonal/yearly population dynamics – thresholds for pest management strategies
- Get an overview of insects in the field/area
- Reimburse and protect biodiversity
- Determine insect species

LIST OF CATCHABLE PESTS:



RECOMMENDED SUBSCRIPTION:

- iSCOUT® Mobile



5 Spray Quality & Drift Control For Plant Protection Applications

Good distribution of plant protection products to achieve maximum biological effectiveness and minimum exposure to plant protection products for humans and the environment is important in the courses. With good spray quality monitoring, course managers can lower the risks of mistakes and ensure better quality at lower costs and at full traceability.

They can track the distribution of equipment used, act upon current and forecasted weather conditions, know the best time for spraying, see the environmental conditions at the time of treatment and their impact on distribution quality, and more.

BENEFITS:

- Lower the risk of a mistake
- Lower the costs
- Coverage and delivery of the product to the target
- Timing on application
- Lower the impact on the environment
- Reimburse and protect biodiversity
- Avoid off-target contamination due to spray drift
- Have full traceability for executed work the authorities

RECOMMENDED EQUIPMENT AND SUBSCRIPTIONS:

- WorkTrack & WorkTrack Tag
- AOS IsoBus
- nMETOS TURF
- LoRAIN Rain Only/nMETOS 100
- *Subscriptions:*
 - WorkTrack subscription
 - Weather Forecast

6 Asset & Equipment Tracking

Asset & equipment tracking is made to optimize daily activities, and monitor machinery usage, work quality, assets, machinery location, and more. With knowing the exact location of working buggies in the sports course, managers can track how many hours were actually spent on a particular part of the course and can adapt future activities, including when it is time for regular service and maintenance.

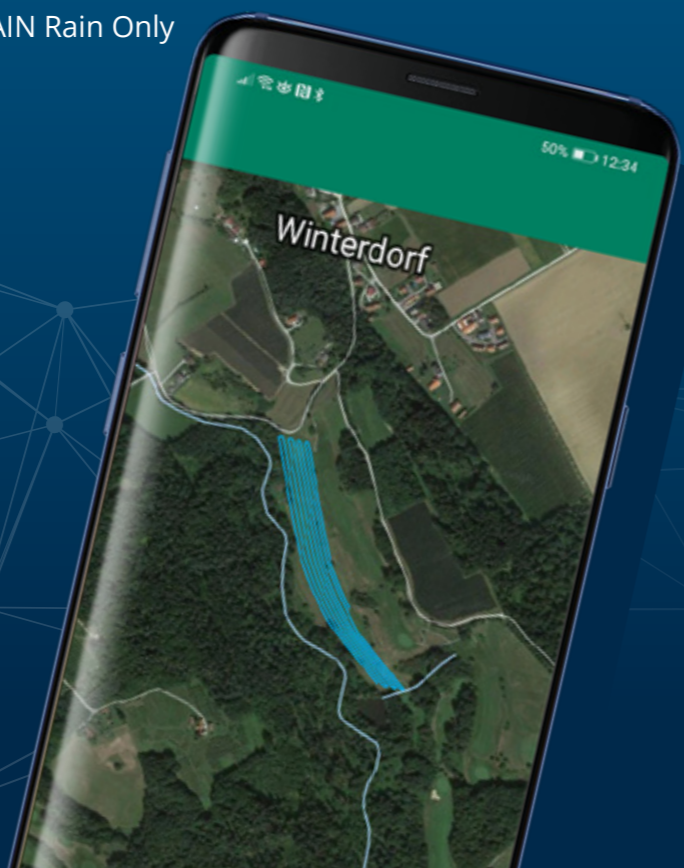
With an overview in the TurfClimate map, a manager can easily see where each machinery reported its last GPS position and in what state it is (moving or stationary). With assets tracking work execution is on point.

BENEFITS:

- Detailed activity report about where, when, and how many mowers, buggy or any other assets has been operational
- Current position of all active machines (buggies, sprayers, mowers etc.)
- Anytime access to the position of each piece of equipment (moveable or stationary – the later for theft control)
- Optimization and enhancement of work and workforce planning, preventive maintenance, and automatic documentation
- Real-time SMS alerts and notification via APP- iOS and Android

RECOMMENDED EQUIPMENT AND SUBSCRIPTIONS:

- WorkTrack & WorkTrack Tag
- METOS® VWS or nMETOS 100 or LoRAIN Rain Only
- *Subscriptions:*
 - WorkTrack subscription
 - Weather Forecast



7 Playing Conditions

Green grass is not only a visual aspect but an indicator of good playing conditions on the course. With the lack of good irrigation, turf grass disease management, grass becomes tough and can even perish. Damaged grass has a direct impact on playability for weeks, even months.

BENEFITS:

- A complete control over play conditions in the golf course
- Adjust and easier estimate the timing of opening/closing of courses (i.e. morning frost, heavy rain on parts of the course etc.)
- Inform members and visitors in advance about the weather and grass conditions in the courses

RECOMMENDED EQUIPMENT AND SUBSCRIPTIONS:

- METOS® VWS or LoRAIN Rain Only or nMETOS 100
- nMETOS TURF
- *Subscriptions:*
 - Weather forecast
 - Turf Grass Disease Models



All Your Course Needs

Visit metos.at/hardware for an extensive presentation of all METOS® hardware solutions

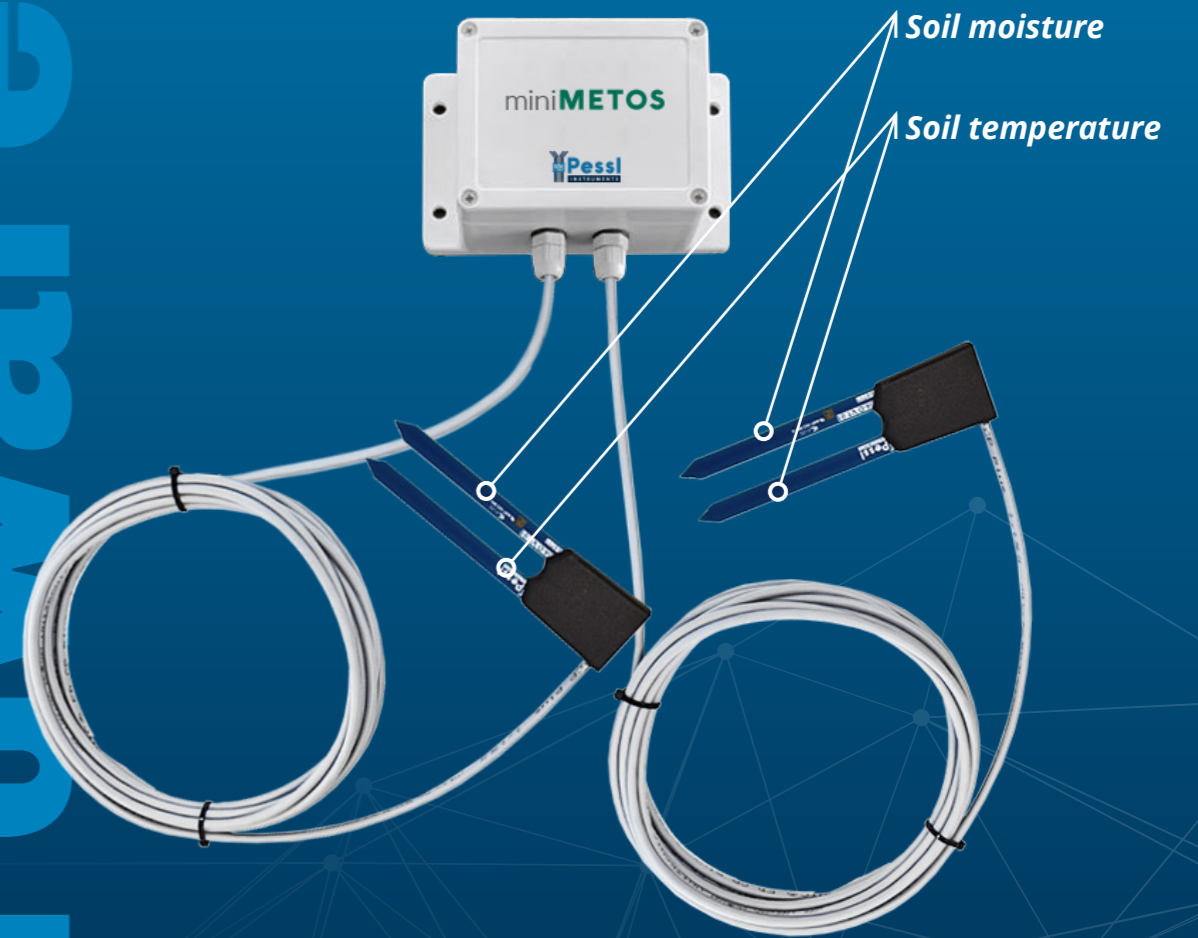


miniMETOS



WATER MANAGEMENT

Hardware



N-Pilot

Portable NDI Measurement



FERTILIZATION APPLICATION



ICA10

Automate Anything from Remote



WATER MANAGEMENT



IRRIGATION AUTOMATION



SoilGuard

Portable Soil Moisture, Soil Temperature & Electrical Conductivity Measurement



WATER MANAGEMENT



WORK PLANNING



Soil moisture, soil temperature, electrical conductivity

Hardware

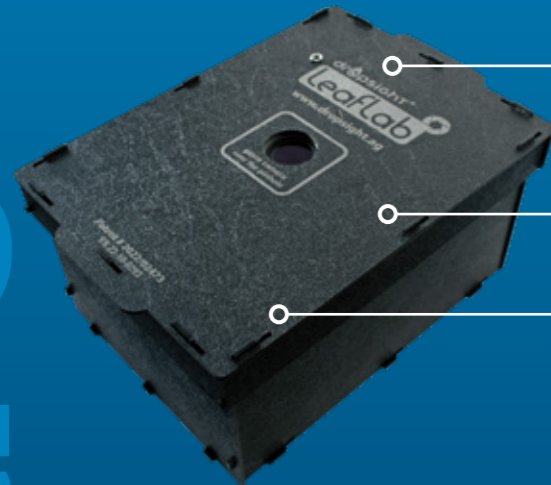
Hardware

DropSight

Spray Quality Assessment in Real Time



SPRAY DEPOSITION EFFICIENCY



Specialized background

UV LED lighting

UV lens filter

WorkTrack & WorkTrack Tag

Automatic Tracing of People & Assets



MACHINERY TRACKING



WORKFORCE MANAGEMENT



GPS

Beacon



METOS® VWS

with Turf Grass Disease Model

Knowing the Best Timing



WEATHER FORECASTING



DISEASE MODELING

No physical sensors



Hardware

Hardware

LoRAIN RainOnly/nMETOS 100



WEATHER FORECASTING



Precipitation

Hardware

nMETOS TURF



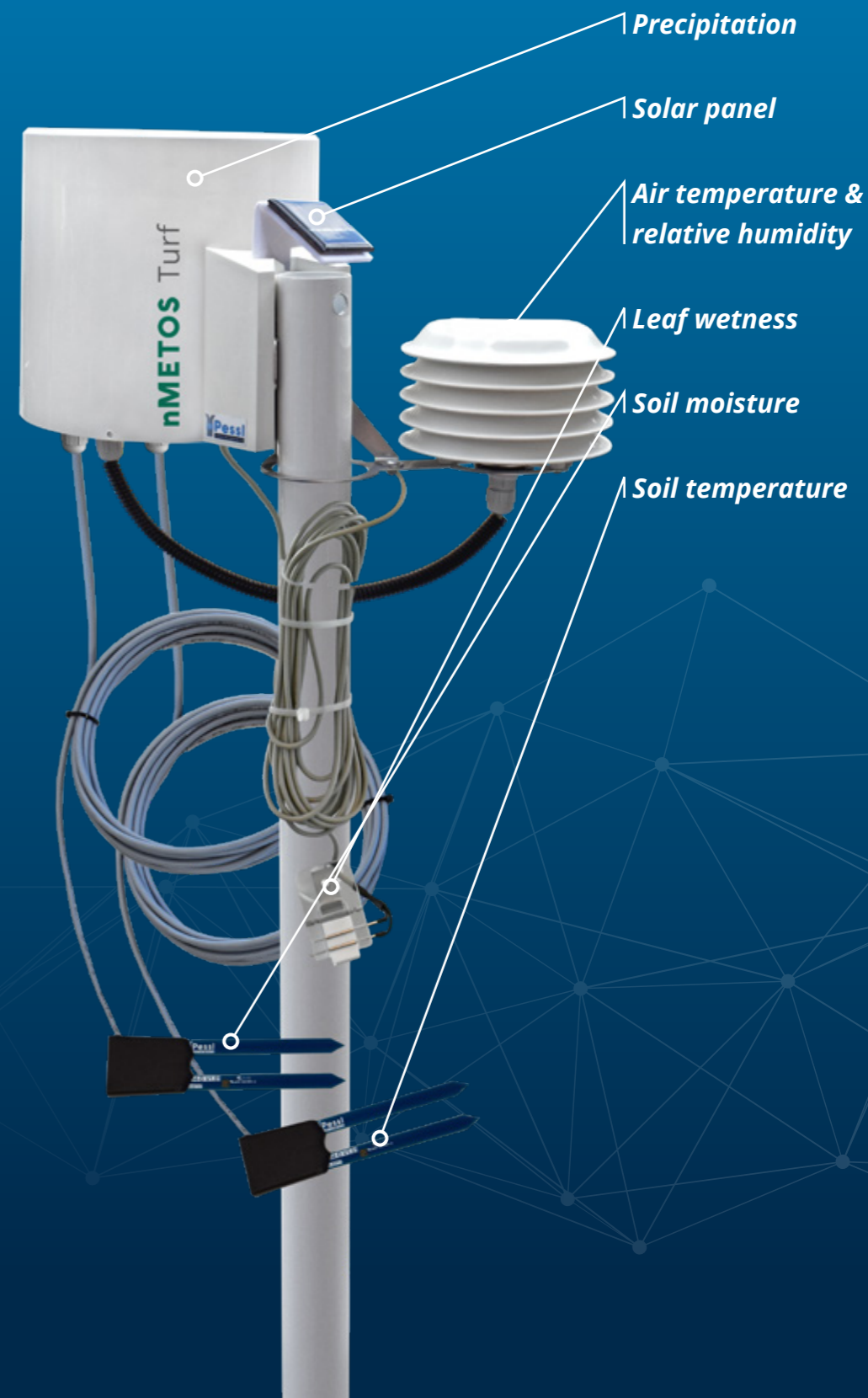
WEATHER FORECASTING



DISEASE MODELING



IRRIGATION AUTOMATION



Precipitation

Solar panel

Air temperature & relative humidity

Leaf wetness

Soil moisture

Soil temperature

Hardware

iMETOS 3.3

The Flagship Weather Station



WEATHER MONITORING



WEATHER FORECASTING



WATER MANAGEMENT

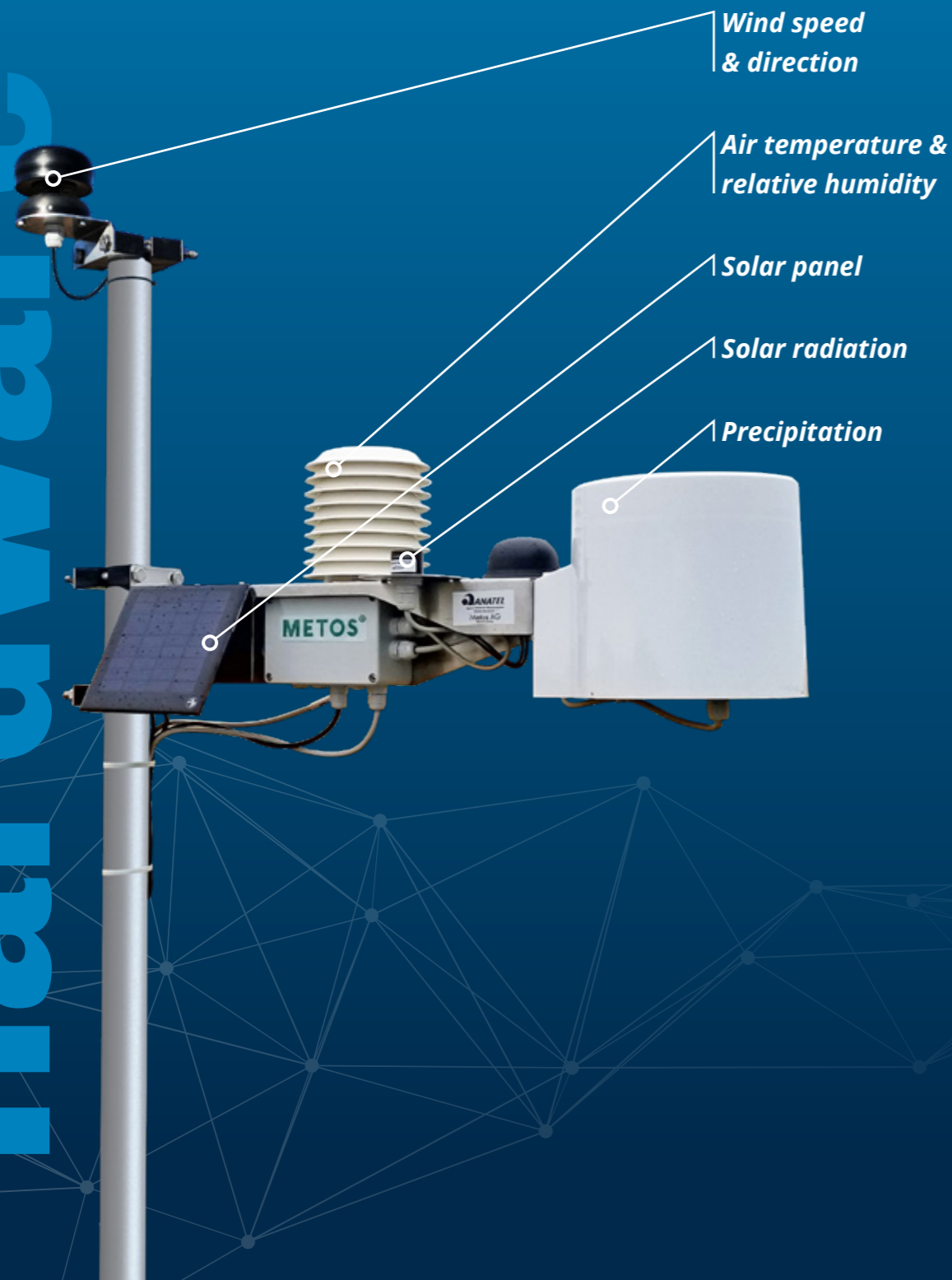


DISEASE MODELING



IRRIGATION AUTOMATION

Hardware



Wind speed & direction

Air temperature & relative humidity

Solar panel

Solar radiation

Precipitation

METOS® AOS

Sprayer Mounted



IN-FIELD WEATHER



CROP HEALTH MONITORING



WORK TRACKING

Hardware



Wind speed & direction

Air temperature & relative humidity

ISOBus terminal

Bluetooth for mobile phone

TurfClimate



Extend TurfClimate with METOS® Subscriptions for Weather Forecast, Disease Models and Satellite Imagery

METOS® Turf Offers State of the Art Open API Interfaces

The industry requires open data interfaces to avoid double entries. We offer a series of easy to access API´s (Access Point Interfaces) for many applications:

1. Interfaces to management software platforms like: Onlink from John Deere, Punctus, Turfkeeper and many more for staff management, task planning, machinery management, inventory control, chemical applications planning, recording and budgeting & expense management etc.
2. Automatic Irrigation management with interfaces to the major players here
3. Interfaces to Golf Course Webpages for real data display on current and future weather conditions on the course for opening management
4. Interfaces to ERP and CRM (Microsoft AZURE, Amazon Web Services, SAP and many more)

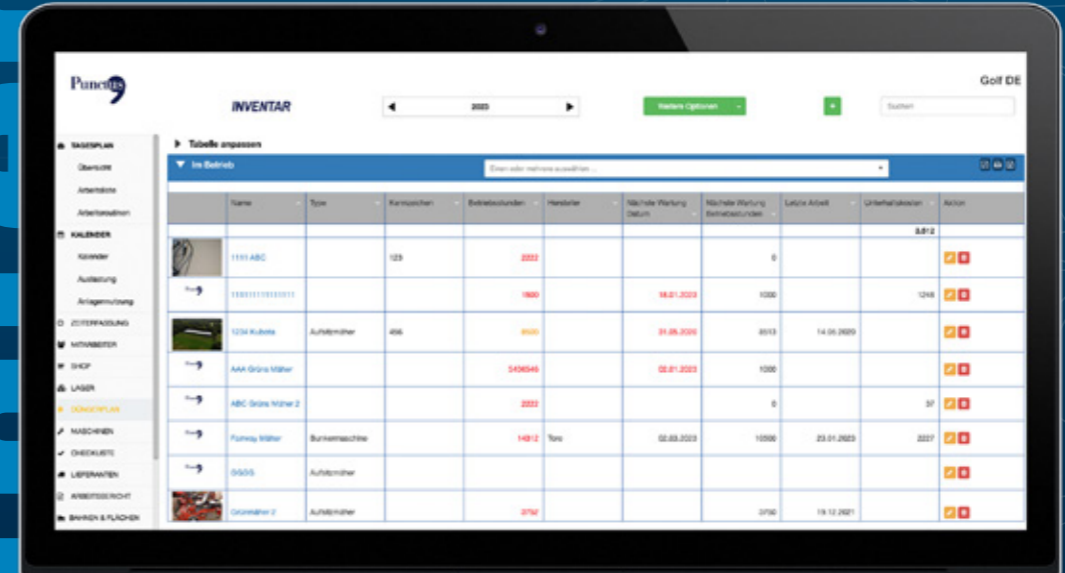
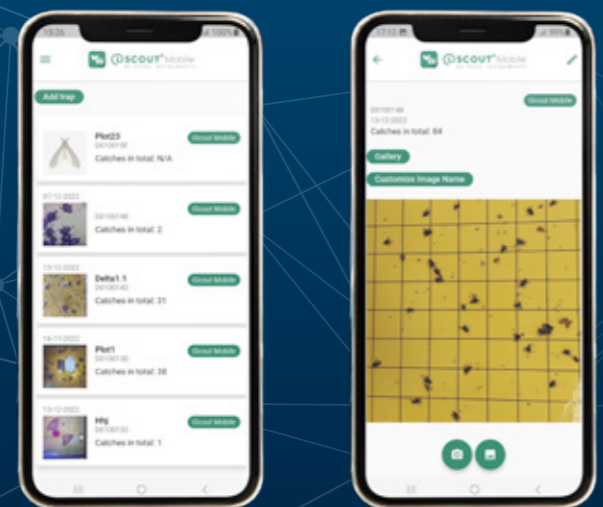
Software

Interfaces

iSCOUT® Mobile



INSECT MONITORING

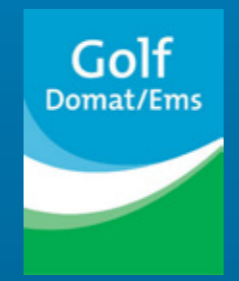




Satisfied Customers



Eton College
Distinguished partner



Golfclub Domat EMS
Switzerland
iMETOS 3.3. station ET
Cooperating since 2009



Kennemer Golf & Country Club
Top Golf Club in Netherlands
7 METOS® stations



Vidago Palace
Portugal
4 METOS® stations
Cooperating since 2010



Golfclub Moosburg
Austria
iMETOS 3.3. station ET
Cooperating since 2008



Golfclub Frauenthal
Austria
µMETOS station
Cooperating since 2003



Golfclub Zeewolde
Netherlands
iMETOS 3.3. and iMETOS ECO D3
Statera Project 2015



Cale Bigelow

Professor of Horticulture from Turfgrass Science at Purdue University

Anyone who deals with turf knows that proper turf grass management is of key importance to achieve proper playing conditions on every sports course. Cale Bigelow, professor of Horticulture from Turfgrass Science at Purdue University, shared his valuable insights on the topic in one of our METOS® KNOWS webinars.



Additionally, Derek Brazda, a former colleague of METOS® USA by Pessi Instruments team, hosted Dr Cale Bigelow in his United we Ag podcast in which they talked about the applied research Dr Bigelow is doing at Purdue Agriculture around turf management. He gave us a glimpse at some of the amazing programs they offer for students interested in agriculture and went through a list of the top myths we've all heard about the proper way to manage and treat turf grass.



"It has proved to be an important tool in our integrated pest management program. Information from the METOS® helped our timing to scout for disease, insect activity and better irrigation scheduling. It is a powerful tool and the uses and applications are limited to your imagination – that's what makes this tool so exciting!"

Dan Dinelli

Superintendent North Shore Country Club Chicago, IL

The \$4,000 cost of the METOS® system can be realized in savings in one day. One of our Pythium applications, for example, can be as high as \$6,000. We can use a scientifically developed disease model and be able to more accurately say whether the disease pressure merits spraying. In the past our good feeling may have pushed us to spray. Now, this tool can tell us [information like] it needs to get 5 degrees warmer, or it needs to get 3 degrees hotter for another three hours."

The "Statera" project on the Zeewolde golf course started in mid- 2015. The project is a collaboration in the Netherlands between Zeewolde golf course, NL consultants, Pessi Instruments, Lumbricus and Bayer. The project includes new avenues for future-oriented maintenance (Climate Change, Green Deal NL, golfers demand).

Regular maintenance is compared with new modified maintenance on tee, fairway and green. The intervention in water permeability, fertilization timing and irrigation based on current data from a weather station present on the runway already shows positive differences in quality.

Statera project

Golfclub Zeewolde Netherlands



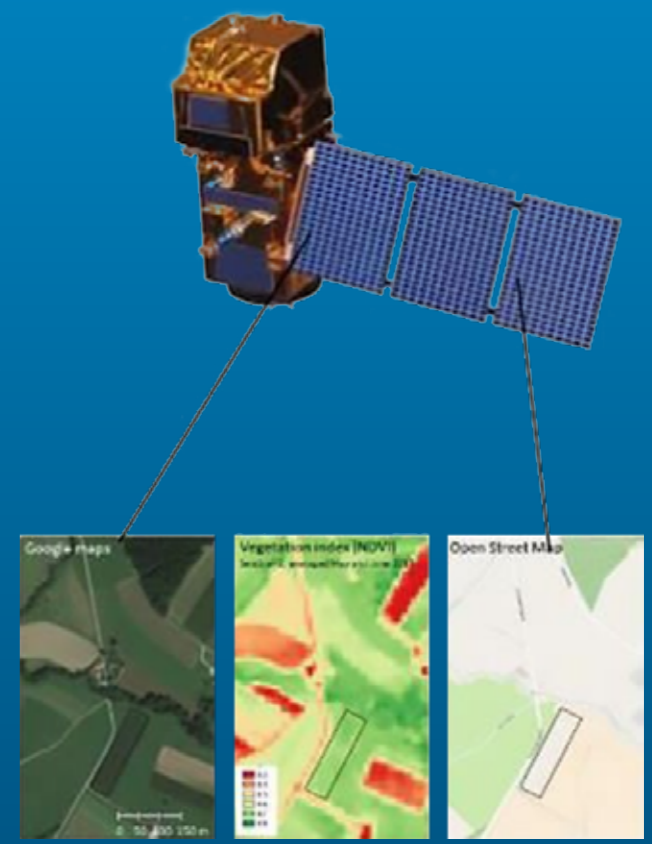


Use Case: Satellite Observation

*Golf course Freiberg –
Austria, FarmView Satellite*

Sentinel-2's Satellite Data

- Sentinel-2 satellites monitor every location on Earth at **10 m spatial resolution**. In EU you get image every **2-3 days**
- Sentinel-2 bands range from optical to shortwave infrared, at least **10 out of 13 bands** showed sensitivity to crop growth
- From Sentinel-2 bands we compute NDVI and LAI with help of neural network analyses
- LAI is a surrogate for **green biomass**
- LAI is an index of particular interest for **productivity** as leaf constitutes the **main surface available for energy**
- LAI can be physically computed as a half the total intercepted leaf area per ground unit



LAI Biomass Analyser



HOW IT WORKS:

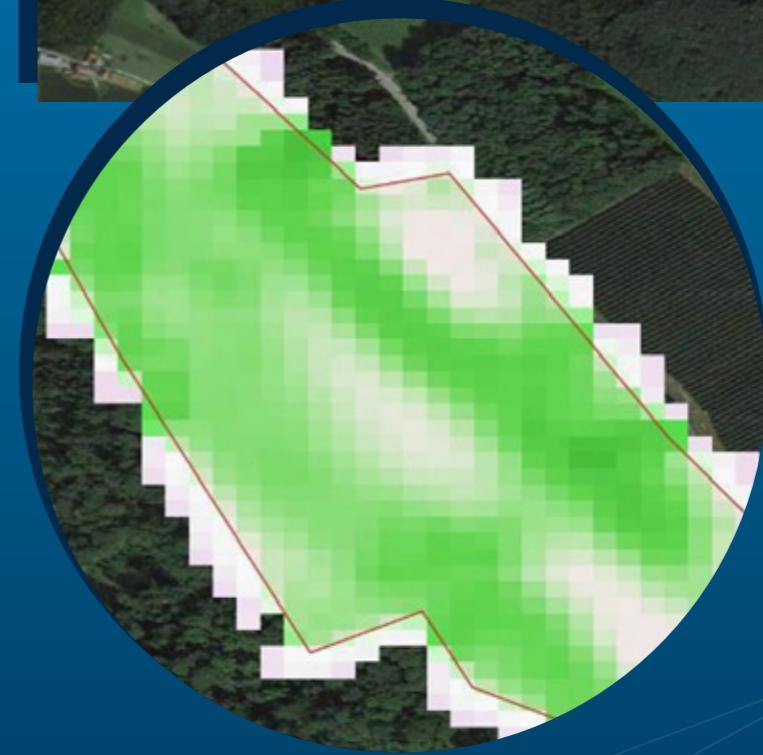
- You provide borders for your Cropzone in **TurfClimate's Farmview**
- For this borders, we request Sentinel-2 data using **Sinergise's API services** (<https://bit.ly/30LqmLF>) at the backend
- **Within few seconds, crop growth status images and graph** for your field is displayed (derived from Terabytes of optical images)



A Snapshot of the image from 17th of April, 2020 representing Biomass (LAI). In general very low biomass around 2-3 LAI. This image represents the general ability of Biomass images to distinguish different vegetation types within the golf course.



A snapshot of the image from 9th of July, 2020 representing Biomass (LAI). Note the development of the biomass of grass apparent in all sections of the golf club when compared to the image from 17th of April. Note also differences between different grass types. Note also the differences within Driving Range. Violet represents water and buildings.



A detailed overview look over Fairway 6 and 7.

CONCLUSION:

- In general, we can distinguish between different vegetation types using Sentinel-2 services.
- We can monitor vegetation development in time.
- In areas larger than 30x30 m we can distinguish inhomogeneities also within the field.
- However, separate fairways are often too narrow to be monitored by Sentinel-2 with 10m spatial resolution. Higher spatial resolution images recommended, e.g. Planet Lab.

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BY PESSL INSTRUMENTS

METOS Turf

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