



TURNING INFORMATION INTO PROFITS

iMETOS Golf Course System

A professional suite of IoT and software solutions for a modern nested approach to golf course management, turf grass health maintenance, and playing conditions assessment



Overview

iMETOS GOLF COURSE ECOSYSTEM

BENEFITS OF iMETOS GOLF COURSE SYSTEM

HARDWARE SOLUTIONS

SOFTWARE, DIGITAL & CLOUD SOLUTIONS

iMETOS Golf Course Ecosystem

It is important that course managers recognize turf grass's requirements in a timely manner, and support it with appropriate soil and irrigation management, fertilizers application, weed, insect and disease controls. The Nested Approach to IoT Golf course management, is a new way that establishes the maintenance of the complex ecosystems of golf courses, green areas, parkland, but keeps the process simple and efficient so that every aspect is under full remote control for various stakeholders.

With the iMETOS Golf Course System, every cm/inch of the golf course is closely monitored. The data METOS hardware captures is analysed in FieldClimate and visualised in TurfVIEW, a premium service within FieldClimate that was especially developed for golf applications, which allows golf course managers to have full remote control in a visual form. The power of IoT and the real time data stored in the cloud provides remarkable insight with a simple glance at the phone, tablet or computer screen. The iMETOS Golf Course system gives fast access to all important and valuable information for quick decision making.

From the simple operator of the mower, the superintendent, the management in the office to players, iMETOS Golf Course System helps satisfy every individual's, and turf's needs.

Benefits of iMETOS Golf Course System

From turf grass health to enviable playing conditions, iMETOS Golf Course System brings your whole golf course performance to brand-new dimensions.

iMETOS Golf course system 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 modeling and insect control, to providing the best playing conditions and letting players know when there are hazardous conditions.

While hardware installations are spread out strategically through the golf course to measure all the important parameters and enriched with portable spot readings of important data sets, FieldClimate 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, machine data and offers other insights as well, such as salinity index, asset mapping, soil nutrition, insect pressure, turf grass health, and many more.



HOLISTIC SOLUTIONS FOR GOLF COURSE MANAGEMENT

WHAT DOES IMETOS GOLF COURSE SYSTEM DO FOR YOU?

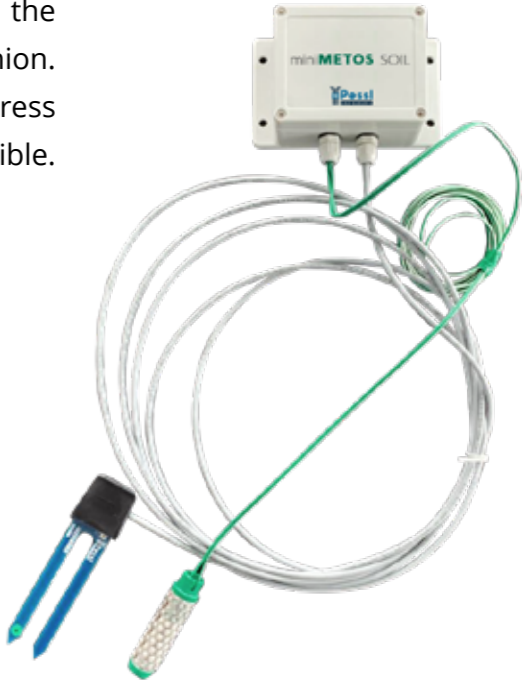
- Provides actual weather conditions and future weather on your course and fairway
- Gets you an insight of water and heat stress immediately and permanently in near real-time
- Allows you to see disease and pest risks before they become a visible problem
- Playing conditions of the golf course are always in the palm of your hand, anytime and from any location
- 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 needs to be feed
- Lets you know where your equipment and your workers are at anytime
- Know how many hours the mower and other equipment were used, to keep ahead of preventive maintenance
- Gives you immediate answers on-hand, with hard facts, to answers questions from Members and Golf Course Management
- Save costs, save the environment - with a peace of mind and no risks
- Gives you a bird's eye view of your golf course from the sky every 5 days

MiniMETOS SOIL “Underground”

MiniMETOS SOIL is a combination of sensors that measure soil temperature & Volumetric Water Content (VWC) (Pestl Instruments Soil moisture sensor) and soil moisture (Watermark sensors) permanently and in near real-time wherever you want on your course (Tees, Fairways, Greens...). The device provides you information about the exact amount of moisture and the soil temperature in each inch of grass to help you plan the irrigation event and possible stress points in a timely fashion. With MiniMETOS SOIL all the potential issues and stress events can be identified before they occur or become visible.

KEY FEATURES:

- Permanent measurement of the soil moisture and soil temperature at any location on your course
- Invisible to the players so it doesn't affect the playing conditions or possible vandalism
- No solar panel needed as fully battery powered due latest power harvesting technology
- 1 year of battery autonomy and quick installation
- Cost-effective and durable



Hardware

Extensive selection of IoT solutions for a complete control



Cutting out the lawn tiles Laying the cable - inserting the sensors in the main turf root zone MiniMETOS SOIL installation: Preparation of the irrigation box for the data logger



Insert the lawn tile - re-install the lawn tiles to cover sensors 14 days later - "invisible"

iMETOS SoilGuard

The new iMETOS SoilGuard solution is the perfect mobile tool for measuring soil moisture and temperature in turf grass, wherever you want/need and combine it with permanent readings and your own good feelings. Due to its portability and simplicity of use it enhances the efficiency, and helps to optimise work planning and water management. Once in place, it measures soil moisture right in the root zone. The readings are stored on the device and whenever needed - GuardMap the mobile app sends point data to Fieldclimate and within a few seconds data is visible for any other stakeholder. Together with the permanent readings and the mobile application and the spot readings from iMETOS SoilGuard you will get a complete picture of the golf course's moisture profile, the temperature readings on the various points of the green in a form of a heat map for easier understanding and further decision-making.

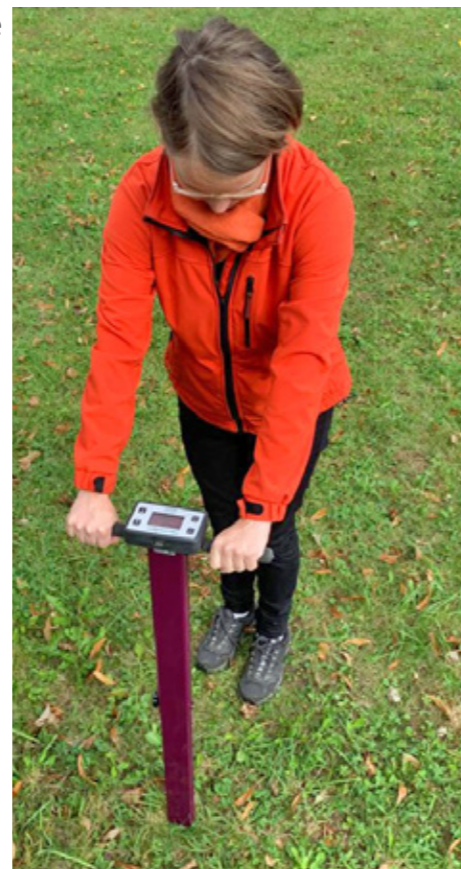
iMETOS SoilGuard:

- easy to use mobile and rapid measurements
- easy-readable backlit display to see the values immediately
- provides up to 50,000 measurements, all with their specific GPS coordinates
- has an ergonomic design with a telescoping tubular frame
- comes with integrated Bluetooth and internal GPS therefore no additional connectivity components are necessary
- **it provides accurate measurements of:**
 - soil moisture (Volumetric Water Content %)
 - electrical conductivity (salts)
 - turf grass surface temperature

For improved performance and accurate measurements, you can choose between multiple lengths of measuring probes - 3.8 cm, 7.5 cm, 12 cm and 20 cm.



iMETOS SoilGuard with transport bag



LoRAIN (LoRaWAN® / NB-IoT)

LoRAIN is a professional weather station ideal for your golf course which works great because of its compactness, accuracy and affordability. Measurements of temperature, humidity and precipitation are sent every 15 minutes to FieldClimate TurfVIEW or the mobile phone app. This allows all authorised persons access to near real-time information about course conditions, which allows timely management decisions. The compact construction and the appealing design allows the station to be installed quickly and anywhere without disturbing the aesthetics of a golf course. The device can easily be connected to an existing LoRaWan network or can be supplied with NB-IoT SIM which is truly "Plug and Play". In addition to the data on precipitation, temperature and humidity an installation of multiple LoRAIN's can provide evapotranspiration calculations for your fairways so that irrigation can be better planned, which saves water, money and time.

In addition to the meteorological data, spraying and work plan windows can also be calculated to determine the best periods to apply plant protection and to schedule maintenance work.

THE MAIN FEATURES ARE:

- Precise measurements across the course
- Weather forecast
- Modeling of diseases
- Help to automate irrigation
- Help with workforce planning



LoRAIN SOIL (LoRaWAN® / NB-IoT)

LoRAIN SOIL is the extension of the LoRAIN family with two soil moisture sensors and the grass temperature at 5 cm. It is a compact and affordable solution for every golf course. The compact construction and the appealing design allow the station and sensors to be quickly installed without disturbing the aesthetics or beauty of the golf course. LoRAIN Soil can easily be connected to an existing LoRaWan® network or can be supplied with an NB-IoT SIM. In addition to the data on precipitation, temperature and humidity, LoRAIN Soil is equipped with two soil moisture sensors and a grass temperature sensor at 5 cm. LoRAIN Soil also calculates evapotranspiration values for your fairways every 15 minutes thereby improving irrigation scheduling, saving water, time and money.

In addition to the meteorological data, spray and work planning windows can also be calculated to determine the best time periods for applying crop protection and to schedule maintenance work.

WITH THE COLLECTED DATA YOU WILL RECEIVE:

- Real-time stress data on grass temperature and soil moisture levels on either the green or fairway
- Disease Risk Models
- Infection data for turf grass
- Weather forecasts
- Help to automate irrigation
- Help with workforce planning

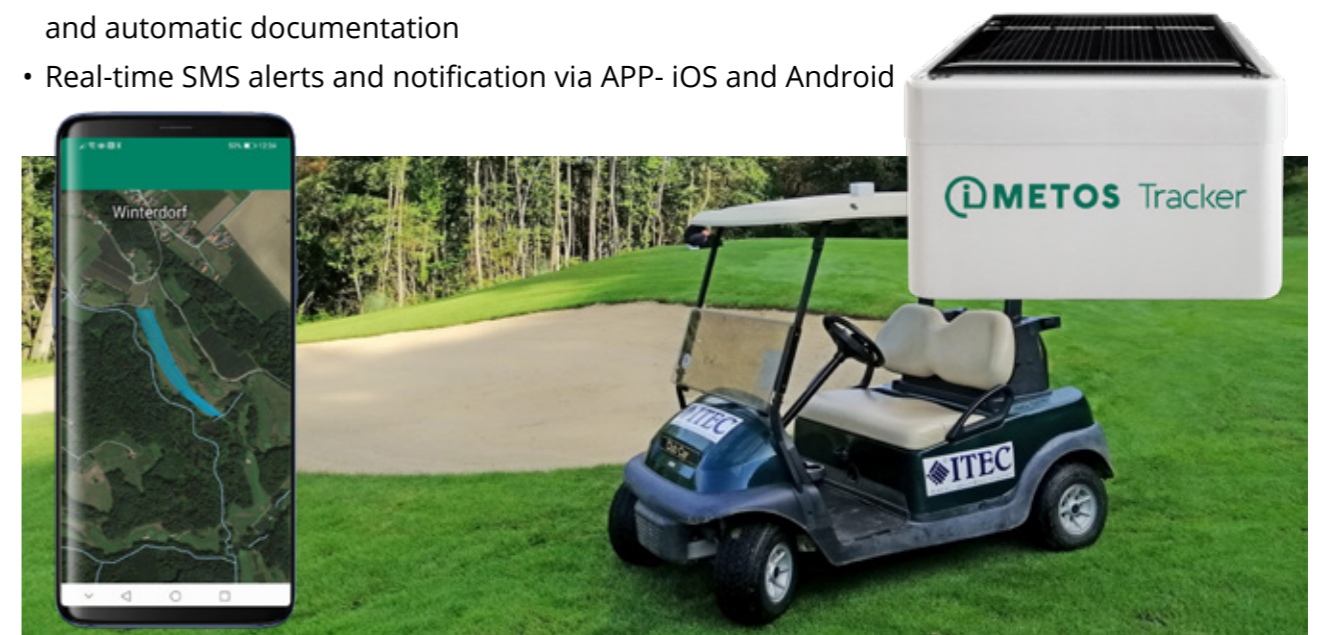


iMETOS Tracker (NB-IoT)

iMETOS Tracker can be mounted on any asset (golf carts, mowers, aeration and vertication equipment, turf sprayers, turf & utility vehicles) as no external power is needed. All our asset & equipment trackers are battery powered and solar charged and mounted in seconds on the device. Once moved from the original location it gets automatically active and sends its data on the position and time to FieldClimate. In order to use the iMETOS Tracker as an active tracker (measurement every 5 seconds), the user needs to add the converter cable and connect it to the battery of the asset. Then the upload to the server takes place every 5 minutes. All stakeholders have access to the data and immediately know the actual location, the daily activities, monitor machinery usage, work quality, assets, machinery location, and more. With knowing the exact location of all equipment, including the golf carts from the players on the golf course, managers can track how many hours were actually spent on a particular part of the golf course and can adapt future activities, including when it is time for regular service and maintenance. Reduce waiting hours for the mower operator by knowing where flights are currently playing. This way mowing can take place only where no players are, and becomes more efficient and lowers the waiting time. With an overview in the FieldClimate map, a manager can easily see where each asset reported its last GPS position and in what state it is (moving or stationary) - improving security and efficiency.

BENEFITS:

- Detailed activity report about where, when, and how much mower, utility vehicles or any other assets has been operational
- Current position of all active machines (buggies, sprayers, mowers, golf carts etc.)
- Any time access to the position of each piece of equipment (moveable or stationary – the later for theft control or not permitted areas)
- Optimization and enhancement of work and workforce planning, preventive maintenance, and automatic documentation
- Real-time SMS alerts and notification via APP- iOS and Android



iMETOS MobiLab

Soil Analysis For Healthy Turf

In order to keep the turfgrass healthy and green regular sap and soil-analysis are necessary. Find the hotspots with nutrition problems and allow for fine tuned use of fertilizers and pesticides while keeping the ecological footprint small. Furthermore, soil analysis is becoming mandatory not only in agriculture but for every other sector that has a direct impact on soil and water quality, this also includes golf courses and parks. The SoilGuard App is combined with the soil sampling APP and hence soil moisture, soil temperature and soil and sap sampling is all one device it makes it easy to return to the same place as all information is stored with the last sampling and GPS position.

BENEFITS:

- Laboratory precision analysis for Nmin (mineral nitrogen) from soil
- A vast array of other nutrients (like CA, Potassium, Phosphorus, MG and many others) measured from sap
- Measurements are fast and reliable, therefore you save time and money
- Soil analysis can be done on site, this prevents degradation of the sample and assures meaningful results
- Price and workflow allow to analyse every sample point of your golf course and get high resolution nutrient map and know where nutrients are missing

This mapping is done via the smartphone app SoilGuard which also geo-references each and every sample and has also the data and readings from the portable soil moisture and soil temperature device iMETOS SoilGuard.



iMETOS IMT300 full weather station for ET₀, Growing degree days with Ultrasonic Wind Sensor

iMETOS IMT300 is a complete weather station for monitoring all the important environmental parameters that help you make the right decision at the right time. It is able to closely monitor wind speed and direction during spraying of the course, and because it uses the ultrasonic wind sensor the measurements are immediate and extremely precise. All the data is sent, stored and analysed in FieldClimate for faster decision-making.

With alarms set for possible heat stress, high rainfall events, strong winds, thunderstorms, and other unfavourable circumstances, any possible damage can be prevented.

Your iMETOS IMT300 will provide reliable and accurate weather data over many years. Data that will allow you to make the best management decisions, whether your responsibilities include insect, disease or pest management for turf's health, ensuring the best possible playing condition, or sending weather warnings to players while on the course or on their way there.

iMETOS IMT300 COMES WITH ALL THE SENSORS FOR EVAPOTRANSPIRATION, HEAT STRESS, DEGREE DAY SUMMARIES AND DISEASE MODELS CALCULATION:

- Air temperature sensor
- Relative humidity sensor
- Rain gauge
- Global radiation
- UVA/B for player's protection and warnings
- Ultrasonic wind speed and direction sensor

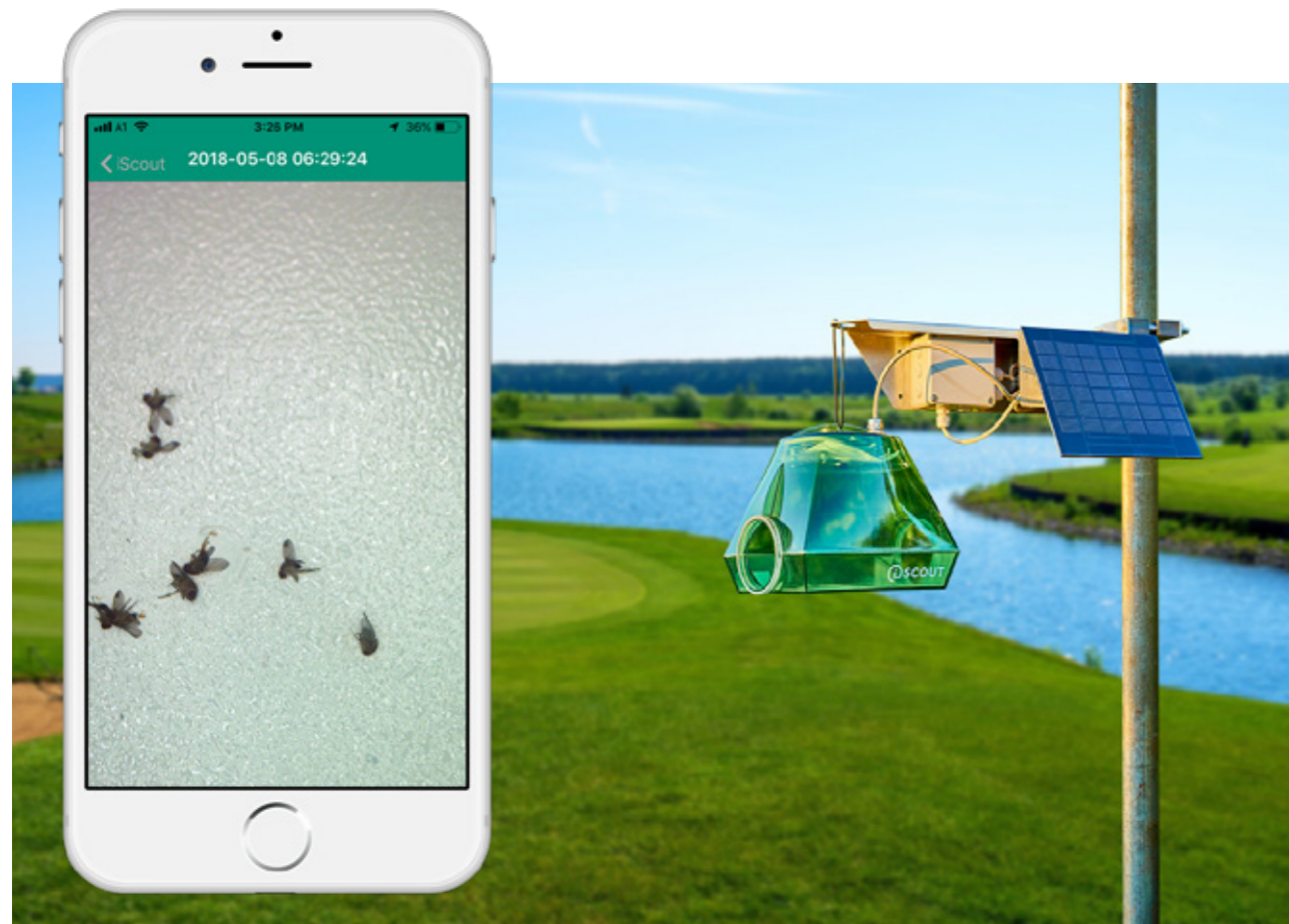


iSCOUT

iSCOUT can continuously monitor the insect pressure on your course. This automatic “high tech” insect trap is solar-powered and can be installed wherever there is a risk of harmful insects. Using selected pheromones, the insects are lured into the trap where a high resolution photograph is taken and sent to the FieldClimate TurfVIEW for further processing. Our computer vision software, powered by AI (artificial intelligence), automatically detects the insects, counts the intensity of the flight and automatically alerts the greenkeeper. It is an important device that keeps an eye on all the inhabitants of your golf course, no matter how small.

THE ADVANTAGES OF REMOTE MONITORING OF INSECT PRESSURE ARE:

- Save time with early warning and 24/7 information on pest dynamics
- Optimize the use of resources
- Prevent damage to the golf course
- Reduce the use of pesticides or insecticides
- Environmental Protection



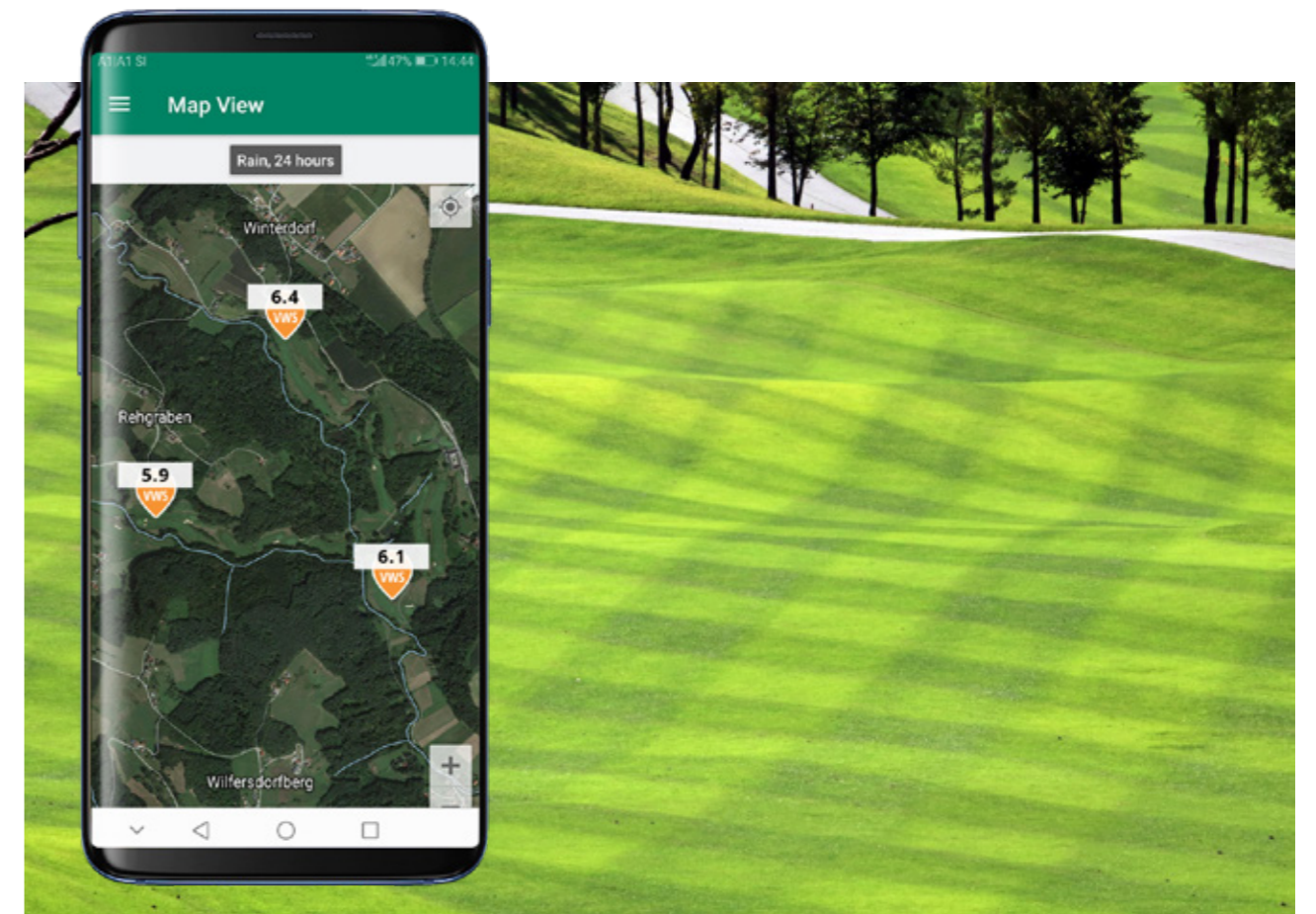
iMETOS VWS

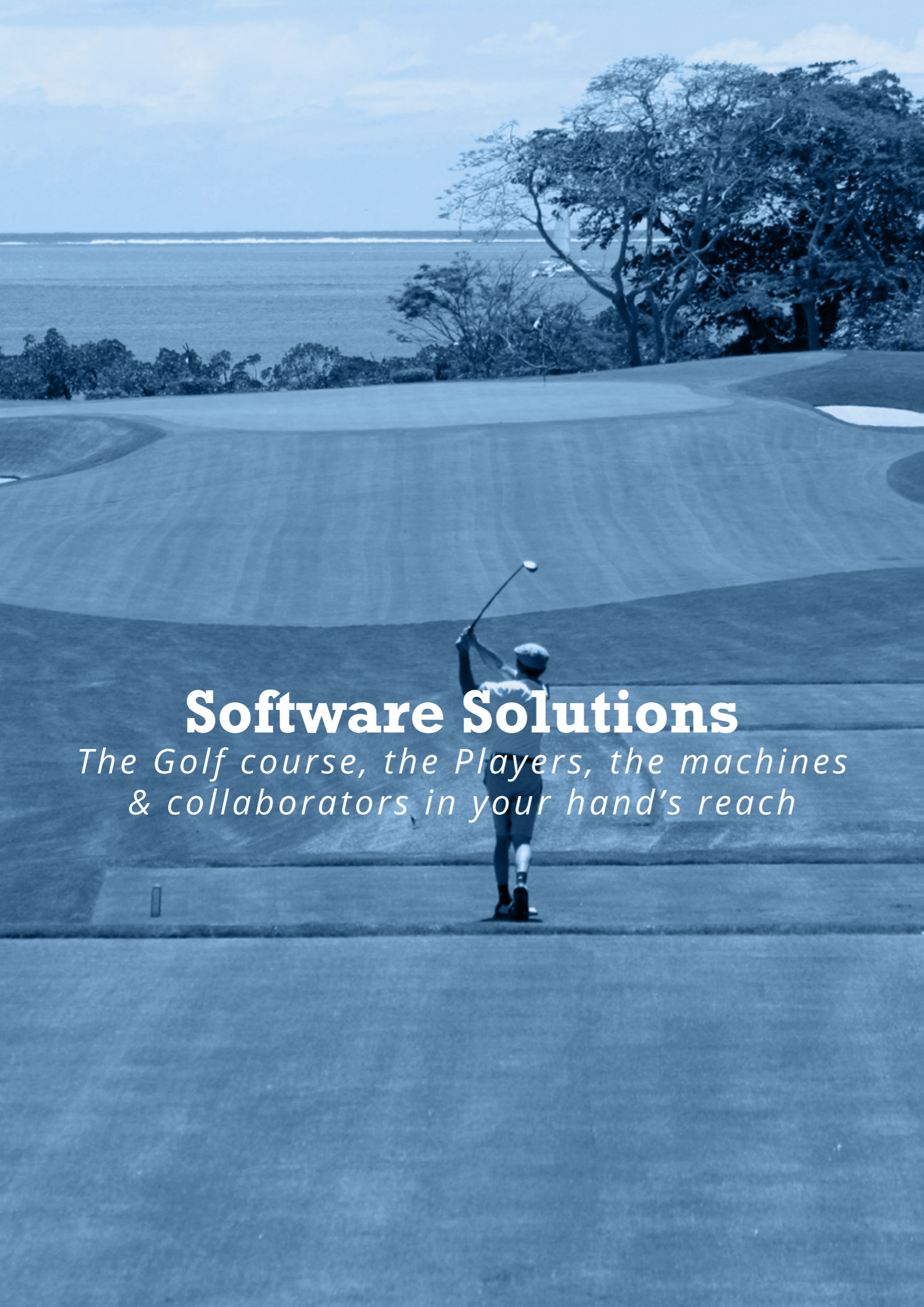
Virtual Weather Station

iMETOS VWS is a virtual weather station that provides you with a site specific weather forecast without an installation of a physical weather station. The geographic resolution of the modelled weather data is 3 x 3 km however the “look and feel” of the presented data is the same as our physical stations. This is the easiest and least expensive way to start using our FieldClimate TurfView, needing only a software activation. Since no measurements are taken from your golf course, the accuracy is not as precise or localized as a physical measurement, however the data provides all the essential parameters needed for a complete decision support service.

IT OFFERS:

- Weather forecast
- Disease models
- Workforce planning





Software Solutions

The Golf course, the Players, the machines & collaborators in your hand's reach

FieldClimate TurfView

Fieldclimate TURFVIEW is the main software solution where data is stored and made visible for actionable decision making. It is more than just a webpage on the cloud and an app that stores your data and makes it available to the various parties/stakeholders. It takes over the responsibility for the long time accessibility and storage of all the measured data on your golf course that helps you better plan all your activities and effective workforce planning.

Developed by a company with 36 years of experience with integrated state of the art technologies, FieldClimate TURFVIEW is simple and easy to use, and connects you with your golf course 24/7/365.

KEY FEATURES:

- Localised weather monitoring & forecast
- Irrigation monitoring
- Water stress alerts
- Alerts about unfavorable playing conditions
- Opening hours scheduling decision support
- Asset tracking & workforce management
- Satellite monitoring
- Drift control during spraying
- Plant protection
- Remote insect monitoring
- Soil and sap analysis to help with nutrient management
- Player information before and during the play
- Record keeping for management and governmental agencies to show sustainable stewardship



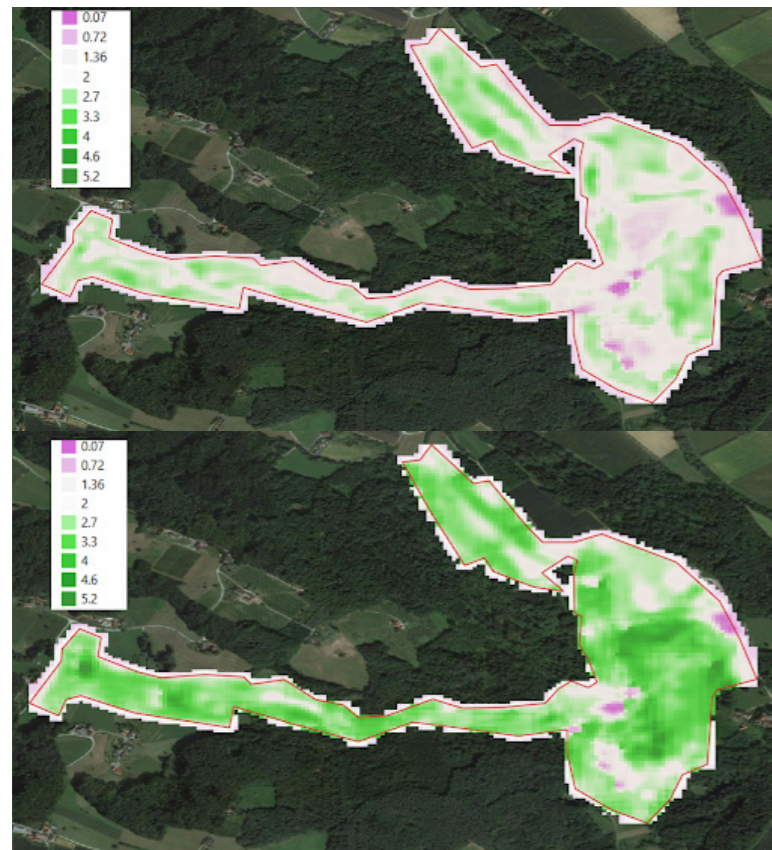
Satellite imagery on FieldClimate TurfView

Satellite imagery is an important part of effective and accurate irrigation decision-making and vegetation control for every golf course. It is used to accurately identify stressed areas. With the help of FieldClimate TURFVIEW, one gets a visualisation of these areas with a simple glance at the phone screen. This way the greenkeeper knows exactly where the problems are and can effectively address them. FieldClimate TURFVIEW, a unique service which combines permanent, spot readings with Sentinel-2's satellite data and provides access to these information and imagery.

SENTINEL-2'S SATELLITE DATA:

- Sentinel-2 satellites monitor every location on Earth at 10 m spatial resolution. In the 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, NDVI and LAI are computed with help of neural network analyses
- Help distinguish between different vegetation types
- Help monitor vegetation development in time
- Can distinguish inhomogeneities within the course in areas larger than 30x30 m

Golf course Freiberg – Austria, FarmView Satellite



An 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.

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

Weather Forecast

Specialised high resolution, site specific weather forecasts are an important aspect of each golf course. This is accomplished by the combination of measured data for weather stations on the actual golf course and digital forecasts from Meteoblue which update every 15 minutes. It helps manage risks, maximize profits and helps you stand out from the competing neighbouring golf courses which are not possible by public forecasts. In order to offer the best conditions for enjoyable play, each golf course has to consider the forecasted weather and respond to it in a timely manner. Not only for defining operating hours, courses are highly dependent on weather information for applying chemical and other treatments to prevent diseases and pest infections of turf grass. It affects workforce planning, irrigation, spray planning, playing conditions, and all other day-to-day maintenance and operational activities activity.

BENEFITS:

- Know when to seed the turf grass
- Know when and how much to irrigate
- When to apply fertilizers, pesticides
- Monitor accurate site-specific meteorological parameters to **predict playing conditions, to define operational hours and occasional events & to warn players of severe weather conditions**
- Define disease pressure, insect's development, water and fertilizer needs
- Defining workflow process
- Watch real-time weather to predict damaging winds (falling trees, branches...)
- Save resources, time, and money



Early detection of Diseases - Risk models

Some diseases are difficult to control and timing the fungicide application is crucial in keeping them under control. Knowing the conditions you can forecast them, mitigate the risk and avoid the impact due to early detection before they become even visible. With our highly sophisticated AI driven plant protection models we have brought a new dimension disease modelling. How? Due to the suit of technology from Pessl Instruments the golf course managers can see the problem before they start to avoid stress, spray only risky areas and hence reduce overuse of pesticides and fertilizer while keeping 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



PEST CONTROL

In order to maintain a uniformed 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 on the golf course, managers can keep a close watch on which insects are present, population dynamics 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 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

CATCHABLE PESTS:

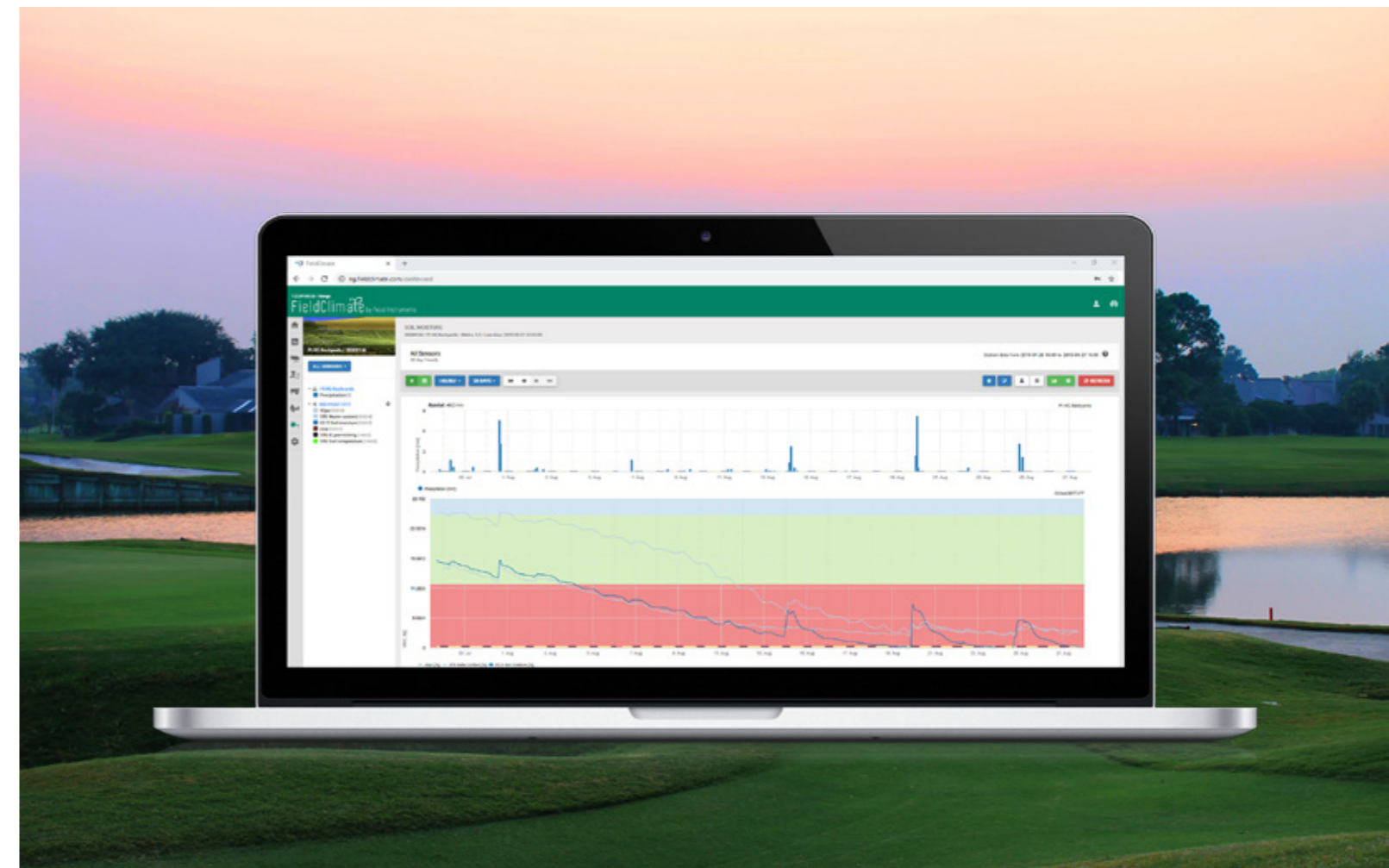
- | | | |
|---------------------------------|---------------------------|--------------------|
| • Aphids | • Fall webworm moth | • Sawfly |
| • Bagworm moth | • Flea beetle | • Sod webworm moth |
| • Boxelder bugs | • Fungus gnats | • Spittlebug |
| • Chinch bug | • Japanese beetle (adult) | • Thrips |
| • Eastern tent caterpillar moth | • June beetle (adult) | • Whiteflies |
| | • Midges | |

Irrigation Management

The lack of good golf course irrigation can easily affect the quality of play, therefore, weather stations offer an important aspect of the maintenance process on golf courses. With soil moisture levels (permanent and spot readings) and localised weather forecast, you can avoid over and under irrigation and resource losses. Well-planned irrigation management reduces maintenance costs, increases efficiency and makes the irrigation more sustainable.

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



iMETOS MobiLab Sampler & SoilGuard App

The brand new android and iOS apps do not just allow labelling and georeferencing of samples taken, be it plant sap or soil, but also presents the results to the user. The data is synced automatically with FieldClimate and shared with the MobiLab Sampler and iMETOS SoilGuard App windows software. This software in turn organizes the entire workflow of the measurements.

WITH THESE EXACT DATA YOU:

- Avoid over-fertilization
- Prevent money loss
- Prevent leaching of nutrients
- Avoid under-fertilization
- Make sure you reach the full potential of your turfgrass all year round



Special Notifications

Not just for greenkeepers, the environmental data is useful for everyone connected to the golf course. With the help of special notifications, you can improve your golf course's communication with every member of the team, club members and other visitors.

Alerts are available in FieldClimate, ready to be used and displayed on the official web page or sent to member's phones.

SPECIAL NOTIFICATIONS:

- Keep individuals safe during emergency situations
- Define playing conditions in the golf course at any given time
- Alert players about the increased UV radiation
- Show air quality on the golf course
- Alert about thunderstorms and possible lightning strikes
- Inform members if the event is cancelled or delayed due to unfavourable weather conditions
- Alert members about closed parts due to work or repairs
- Help save time and money for both golf course managers and visitors
- Help keep turf grass in best health so the playability of the course is not impacted
- Easily adjust the timing of operation hours (i.e. morning frost, heavy rain on parts of the course, etc.)

REAL TIME - FAST - SIMPLE



Conclusion

Golf course management is more than meets the eye – a nice looking turf grass. Before every swing of the golf club happens, a long line of carefully planned steps must be carried out. A proper golf course management can make a difference in golfer's play – from lowering the golf scores to reducing handicaps.

DON'T LEAVE THE PLAYING CONDITIONS OF YOUR GOLF COURSE TO CHANCE AND TURN TO iMETOS GOLF COURSE SYSTEM FOR HELP:

- FieldClimate turns your iOS or Android smartphone or tablet into a powerhouse which connects you with your golf course 24/7.
- Data acquisition and logging are done automatically.
- You set your alarms and thresholds, are wirelessly connected with your sprayer, mower, buggy, with your green 9, your fairway 5, and they will talk to you when they need to
- The app displays real-time analytics and assessments of rainfall, air and soil temperature, turf/soil moisture, salinity and assets positions in close to real-time, which allows timely reactions and risk mitigation to conditions that could lead to costly problems.
- Certain situations that require immediate attention, while you are on the golf course or absent, are permanently measured and critical alerts advise you how to act in a timely manner when such situations occur.
- Easily synchronize data with Fieldclimate Cloud and unleash unprecedented insight and analysis with your preferred supplier (supply of chemicals and fertilizer on time, preventative services before the machine is down... and many more).
- Data and configurations can be shared with co-workers and all other important members of the team, e.g. the preferred suppliers. This management allows efficient and traceable task share.

*Trust iMETOS Golf Course System and be at ease when it comes to management.
Your peace of mind is our priority.*