

# Karuna Technology

A view of Earth from space, showing the curvature of the planet and the atmosphere. The sun is rising over the horizon, creating a bright orange glow and a blue atmospheric layer. The background is a dark, starry space.

From orbit with love

**GREENWAY**



Vegetation Health  
Soil-Moisture

**ForSense**



Analysis of forest areas

**Peatway**



Differentiation of soil types



# Cost pressure

Staff shortage

Resource  
Conservation

Water shortage

Regulatory  
requirements



# Why Satellites?

- Quality Assured
- 3m Resolution
- Daily
- 5 years historical images

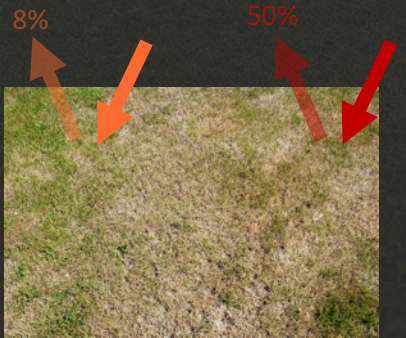


**GREENWAY**

# Use of multispectral imaging

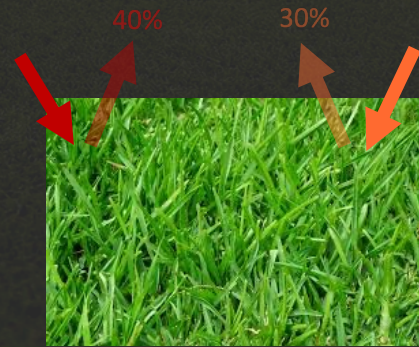


Visible Infrared      Near Infrared

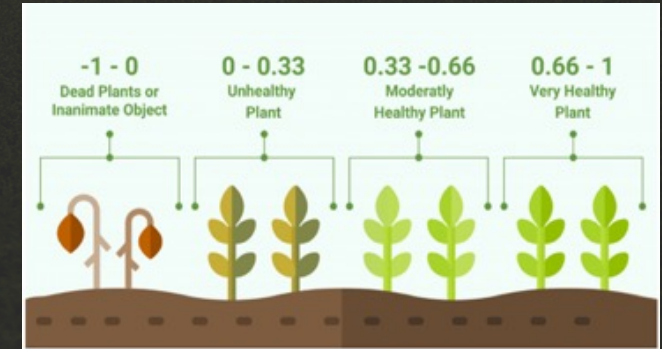


$$\frac{(0,40 - 0,30)}{0,40 + 0,30} = 0,14$$

Near Infrared      Visible Infrared



$$\frac{(0,50 - 0,08)}{0,50 + 0,08} = 0,72$$

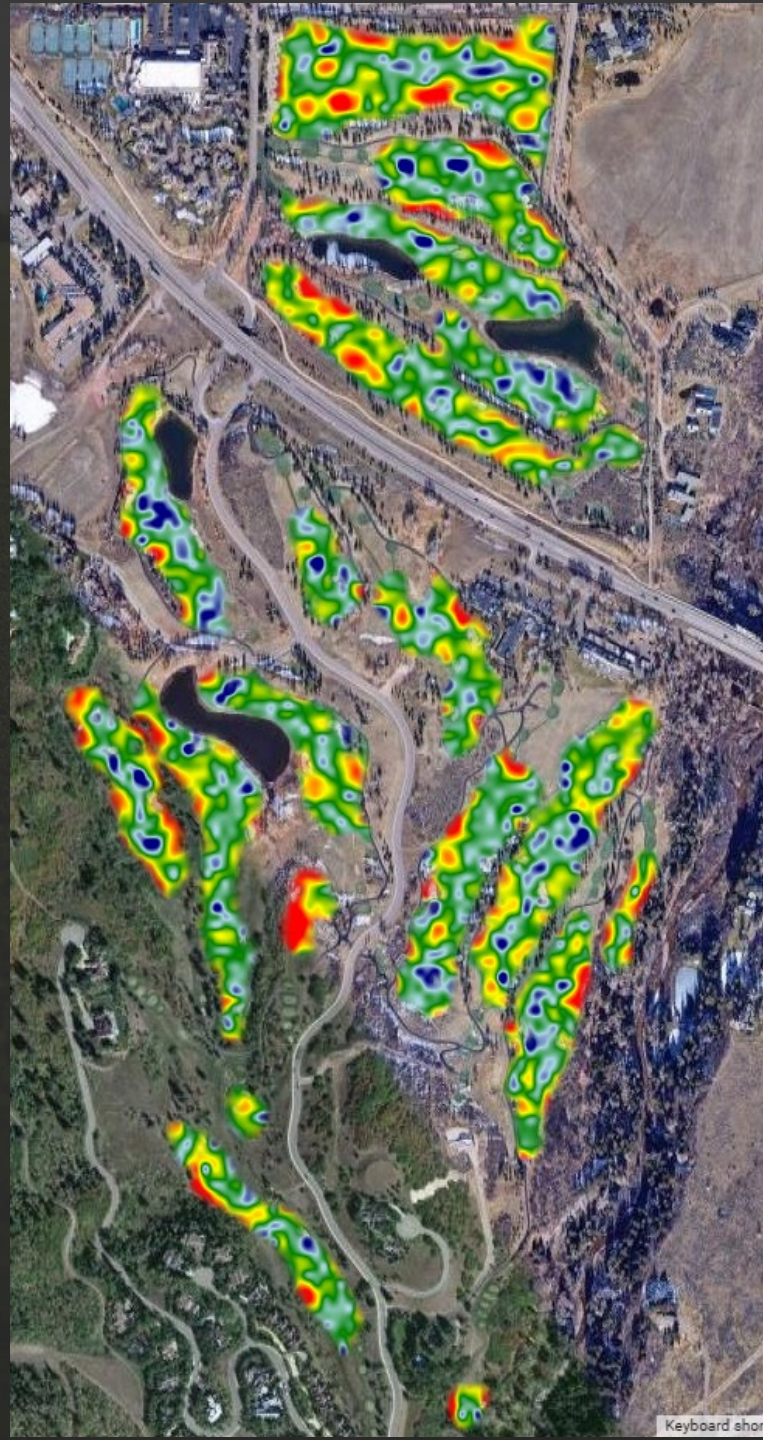


# Example – Maroon Creek Club

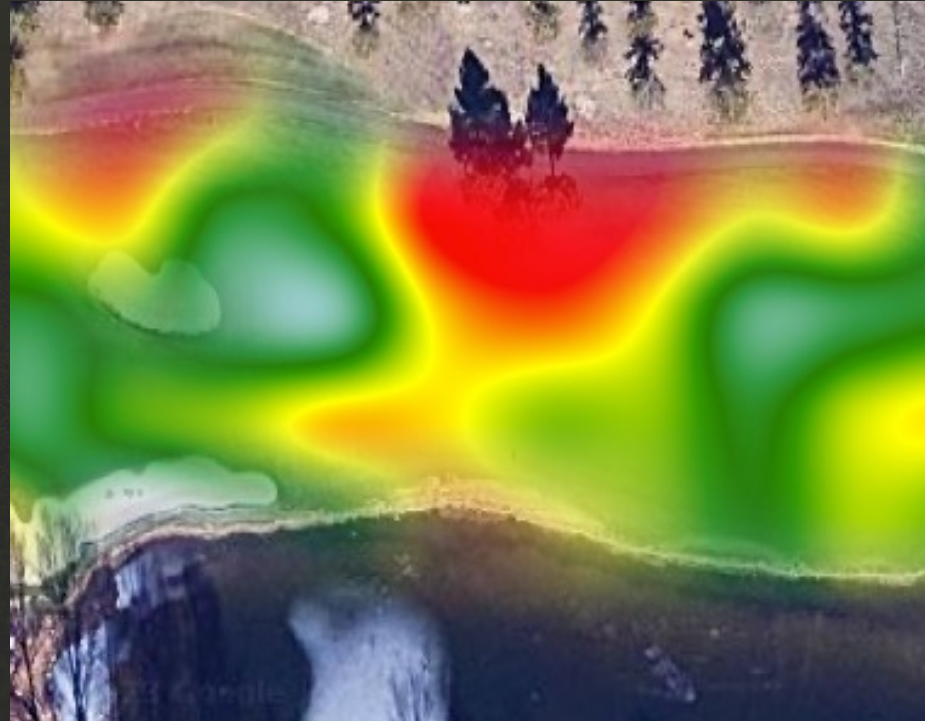
Maroon Creek Club

All holes

2023



# Example – Maroon Creek Club



Maroon Creek Club

Dry Spot monitored vs.  
expected

Spring 2023

# Example – Maroon Creek Club



Maroon Creek Club

Wet Spot monitored vs.  
expected

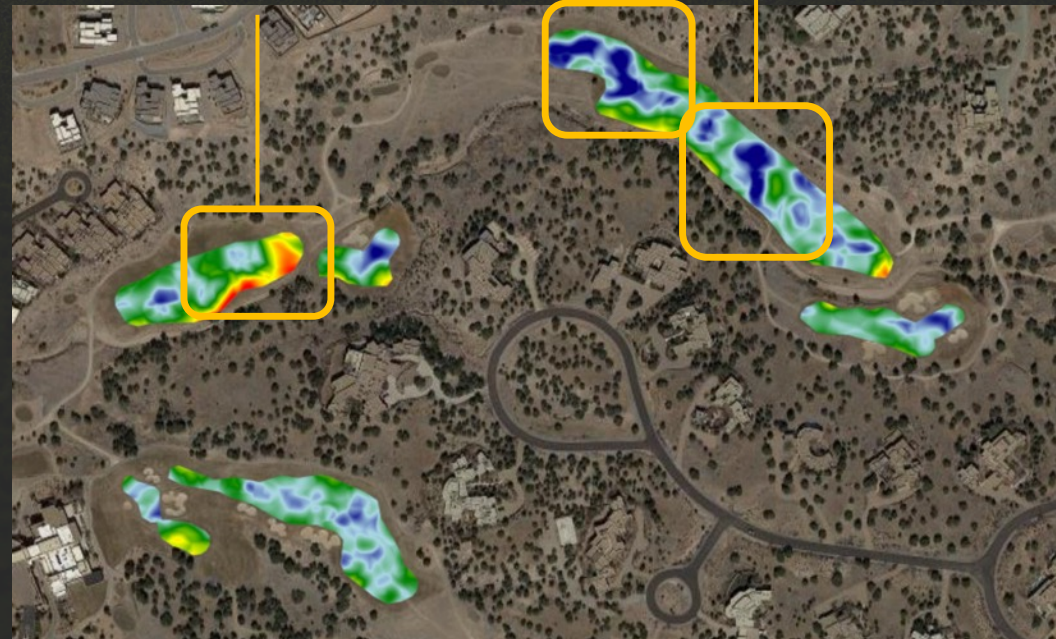
Spring 2023



# Example – Las Campanas

Dry spots of the old irrigation system

Wet spots of the old irrigation system



Las Campanas

Sunrise

Fairway #1-2

Spring 2022

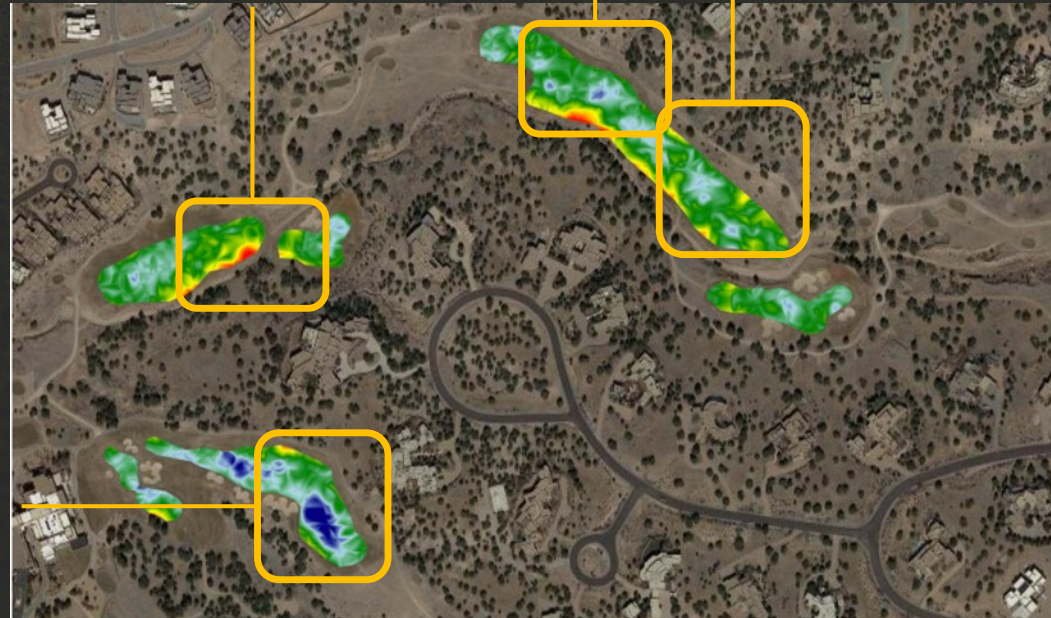
# Example – Las Campanas

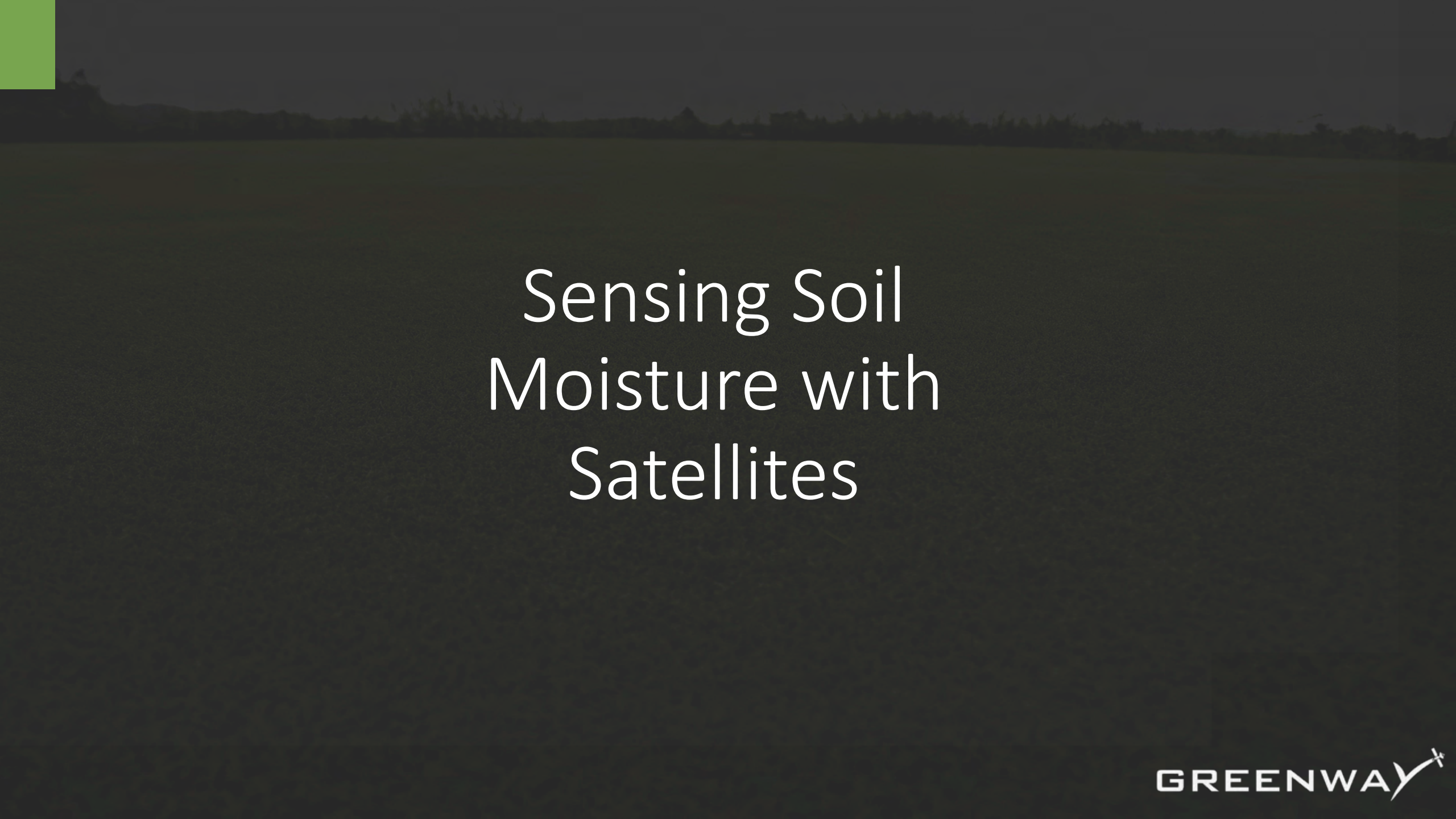
No wet spots of the old irrigation system

No dry spots of the old irrigation system

Las Campanas  
Sunrise  
Fairway # 1 - 2  
Spring 2023

Reference hole shows even more wet spots, compared to the year before.



The background of the slide is a dark, atmospheric landscape, possibly a field or a forest at dusk or dawn. A solid green square is located in the top-left corner. The main title is centered in white text.

# Sensing Soil Moisture with Satellites

# Study participants



## Scientific Participants (selection):



**Prof. Dr. Bernd Leinauer**



**Dr. Fritz Lord**



**Brett Klahr**  
CGCS, CGIA, CLIA,  
QWEL



**Daniel Lüttger**

## Participating Golf Courses:

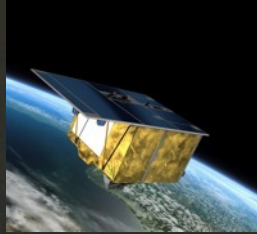
- Sankt Leon-Rot
- Las Campanas
- Maroon Creek Club
- Another 20 international courses

# Architecture

## Soil Moisture Model



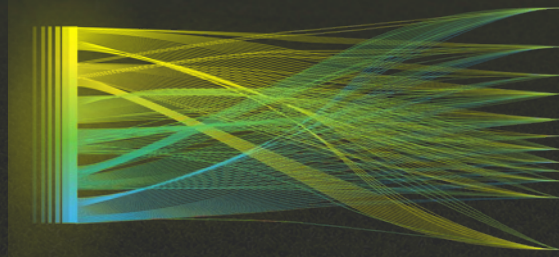
SAR Satellite Data



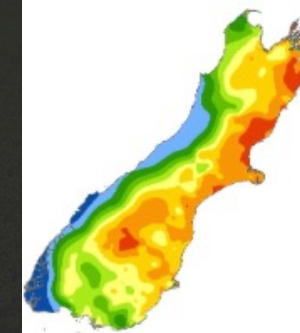
Multispectral satellite data

- Playing elements
- Weather and climate data
- Soil Type
- Cutting height

Input data

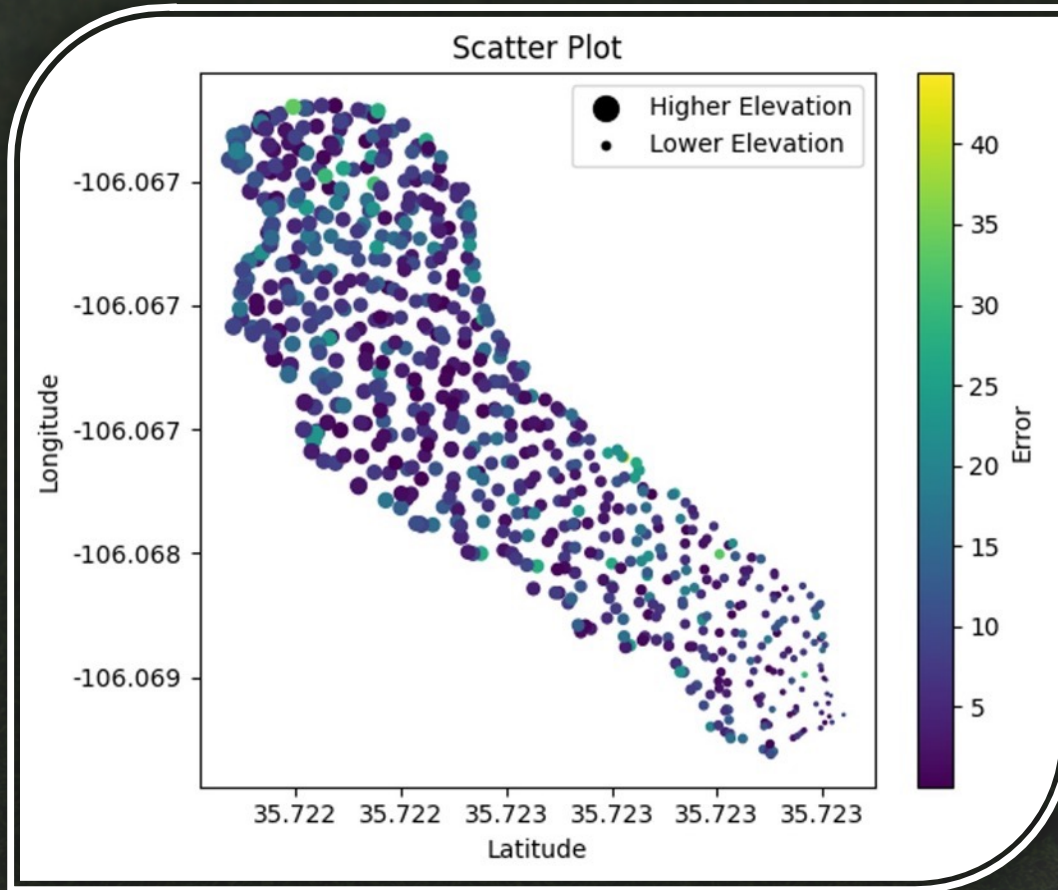


AI-Model  
For the fusion of  
data points



- ✓ 5-9 years history
- ✓ Measuring point density: 10m
- ✓ Historical data available
- ✓ <4 % RMSE VSMC

# Early Model



LCP Fairway 2

- Back transformation of VH band
- SAR based
- 1 measurement a week
- Mean abs error: 8.77%
- Variance: 45.27%
- (over 5 days of collection)

# Date Contingent NN Model - Multispectral

Multi-layer Neural network model trained on parameters:

RGB, NIR multispectral bands, elevation, calculated vegetation indices, date, fairway

Separation of training/testing sets by date

5907 training points

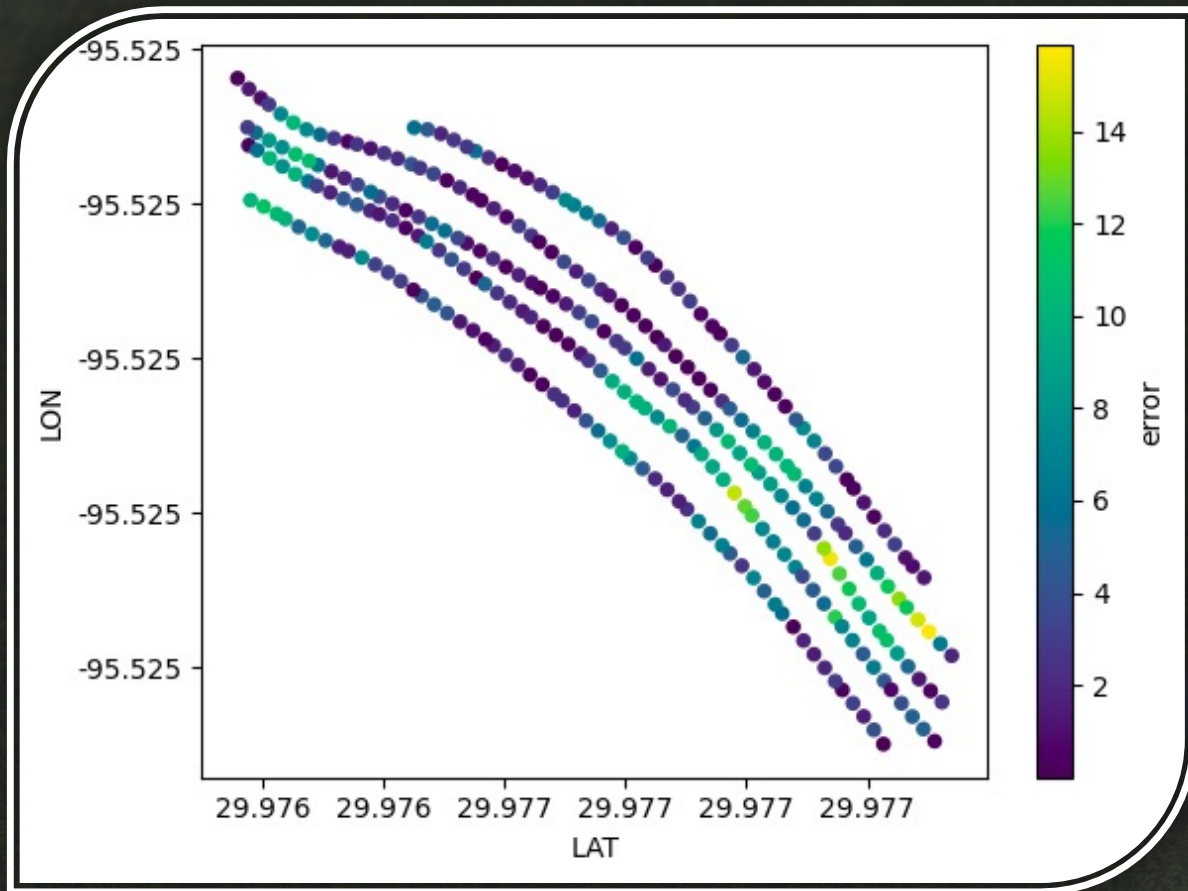
On unreferenced testing set:

Mean abs error: 4.34

Variance: 11.76



# NN Model - Multispectral



Given data from a course on a given day, very low error rates

- Range of error: ~12%
- Mean abs error: 3%
- Variance: 8%





Karuna Technology UG