



meteomatics

Your Experts in Weather Data Processing.

# Using MATLAB to Empower Modern Numerical Weather Forecasts

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Dr. Martin Fengler

CEO

# World Class Talent in Meteorology, Data Science, Drone Development and Service Delivery

We are proud of Meteomatics' fair, hardworking, 'can-do' culture and a highly skilled multi-disciplinary team who rise to the challenge with our customers in a positive fashion. Creativity is a core skill whether it be in thinking, design, architecture or science.



# Why Does Weather Matter?

It affects our daily life.



Better understanding of the weather helps reducing business costs.



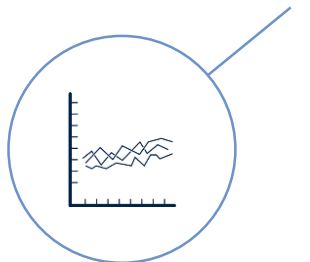
It affects our business.



Better understanding of the weather improves predictive maintenance.



It is highly variable.



Better understanding of the weather reduces the impacts of natural hazards.



# Key Takeaways

## Weather API & MATLAB

enable us to:

- ... model gathered drone data
- ... simulate new measurement techniques
- ... implement physical parametrizations
- ... visualize meteorological data
- ... carry out statistical analyses
- ... enrich training of machine & AI learning with weather data
- ... give deeper insights into your weather related business

# Key Challenges

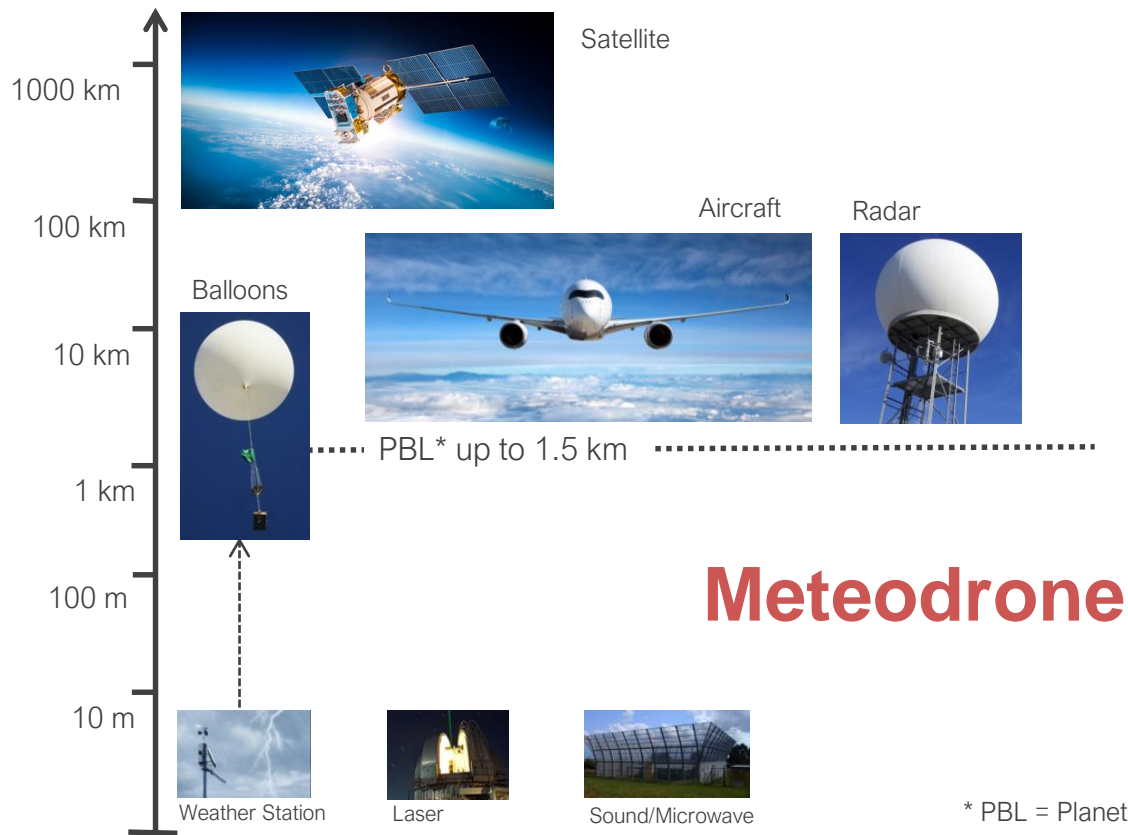


- Inaccuracy of Forecasts
- Access to Historical Data
- Huge Amount of Data
- Inconsistent Data Formats

# Current Data Situation

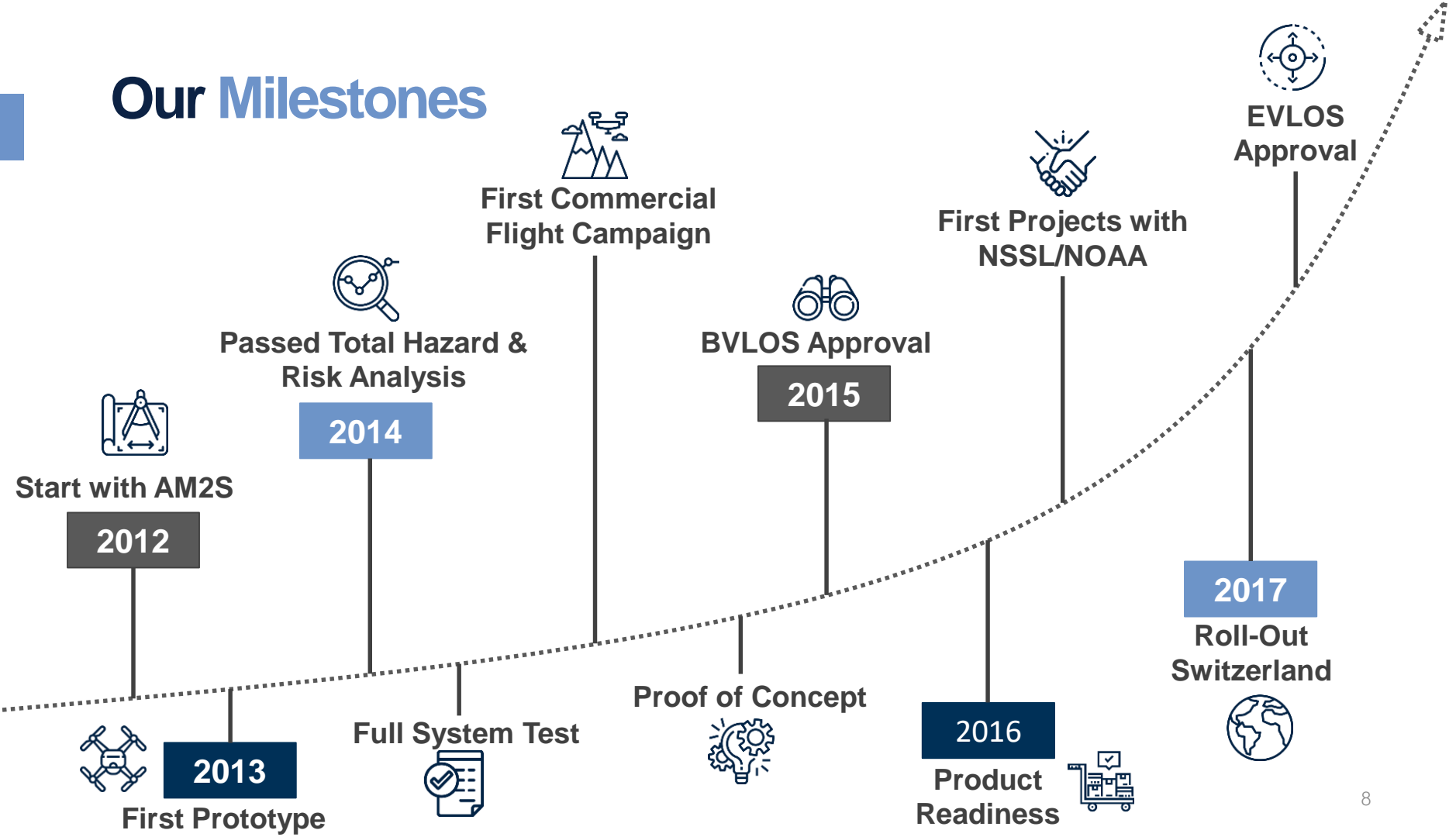


# Improving Data Situation



\* PBL = Planetary Boundary Layer

# Our Milestones







**Our mobile systems allow highly flexible missions.**

# Meteodrone Sensors & Flight Profile



## Pressure

Accuracy: 0.1 hPa  
Response Time: 250 ms



## Dew Point

Accuracy: 0.2 °C  
Response Time: < 4 s



## Temperature

Accuracy: 0.1 °C  
Response Time: 1 s



## Relative Humidity

Accuracy: < 2 %  
Response Time: < 4 s

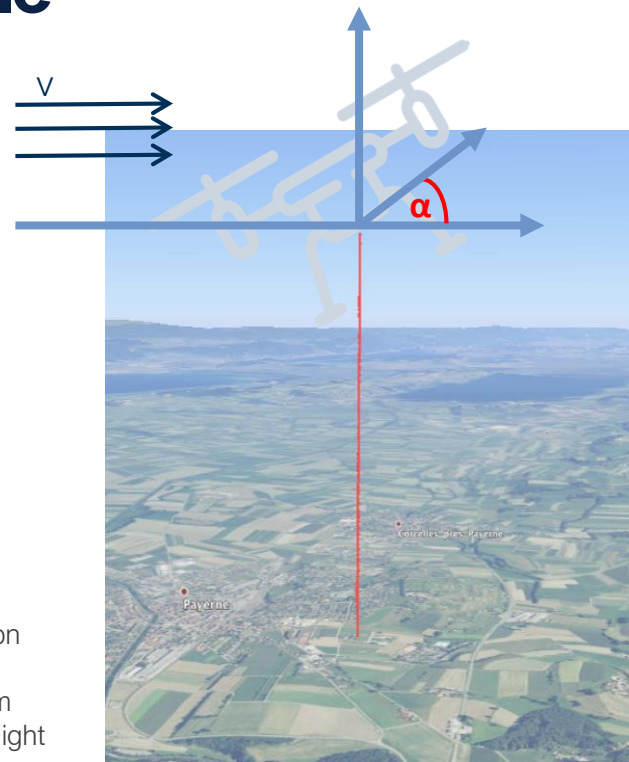


## Wind Speed & Direction

Accuracy: < 1 m/s  
Response Time: 250 ms

The aircraft automatically compensates wind drag:

- Compute wind speed and direction from roll & nick angle
- Vertical flight profile up to 3'000 m
- Currently working on increasing flight altitude to 6'000 m



Prototyping done in MATLAB  
Modelling & Simulation

Sensors are radiation-shielded and mounted in the rotor downwash.

# Modelling & Simulation of Meteodrone

## Input

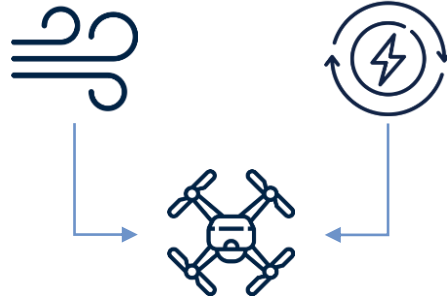
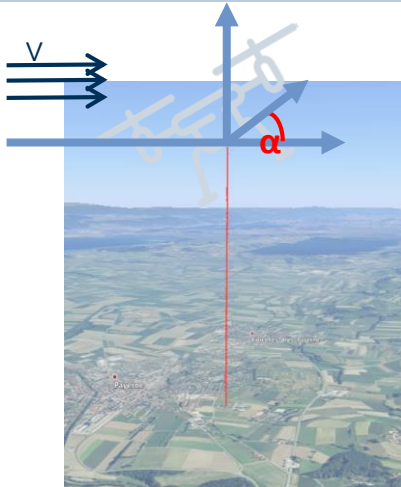
- Roll and Pitch angle
- Power Consumption

## Drone Model

- Physics based
- Automatic wind drag compensation
- Comparison to wind tunnel and outside conditions
- Postprocessing and calibration
- MATLAB / C++
- Deployed on ARM Processor

## Share Results

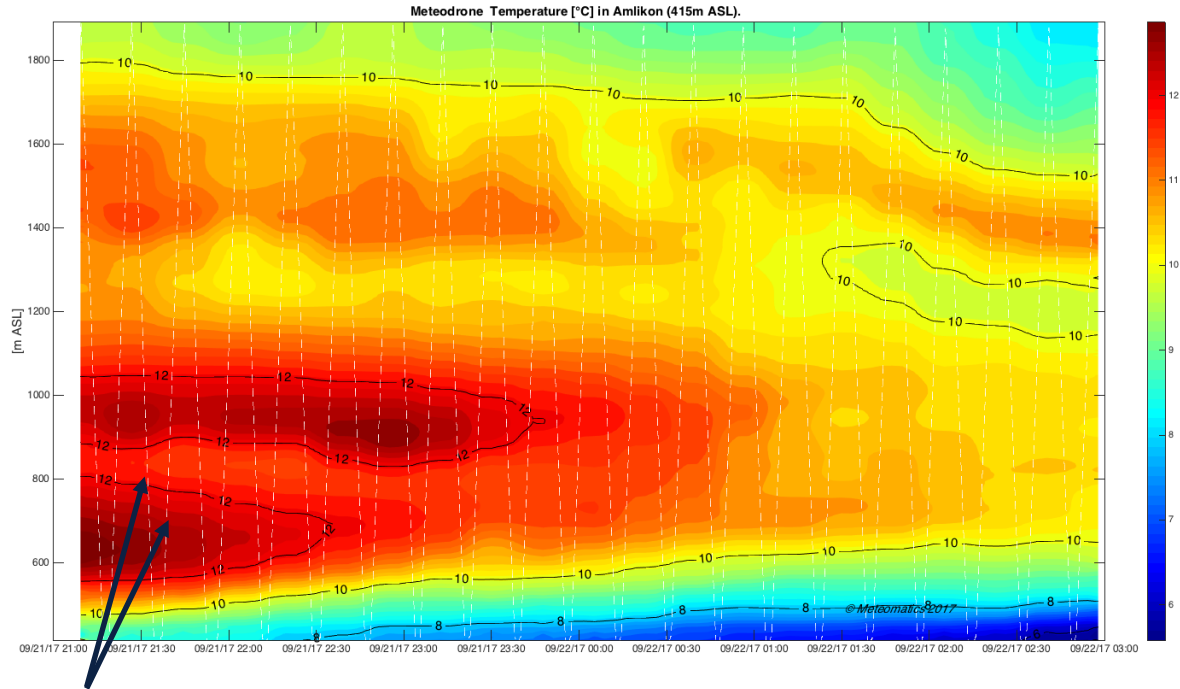
- Send data in real-time to ground station
- Post-processing / WRF model-input
- Weather API



```
Editor - /Users/mfengler/Desktop/Meteodrone
EDITOR PUBLISH VIEW Insert fx fx Breakpoints Run Run and Advance Run and Time
New Open Save Compare Go To Comment Indent Breakpoints Run Run and Advance Run and Time
FILE TOOLBARS EDIT BREAKPOINTS RUN
1 function [dn,data]=query_time_series_from_weather_api(user,password,model,start_date,period)
2 % Function to query gridded data from the Meteomatics Weather API.
3 %-----
4 % Input:
5 %
6 % start_date: as Matlab datenum
7 % period: string according to ISO date format , e.g. P2DT3H = 2 days, 3 hours
8 % resolution: string according to ISO date format , e.g. PT1H = hourly resolution
9 % lat: latitude in decimal degree
10 % lon: longitude in decimal degree
11 %
12 % [dn,data]=query_time_series_from_weather_api(user,password,model,start_date,period, reso
13 %
14 %
15 %
16 %
17 % Output:
18 %
19 % dn: date vector containing Matlab datenums
20 % data: vector/matrix containing the requested parameter values
21 %
22 % See also the documentation under https://api.meteomatics.com
23 %
24 %-----
25 % This Matlab code is under BSD license. Martin Fengler, St. Gallen, 2017
```

# Amlikon 21. – 22.09.17

## Temperature

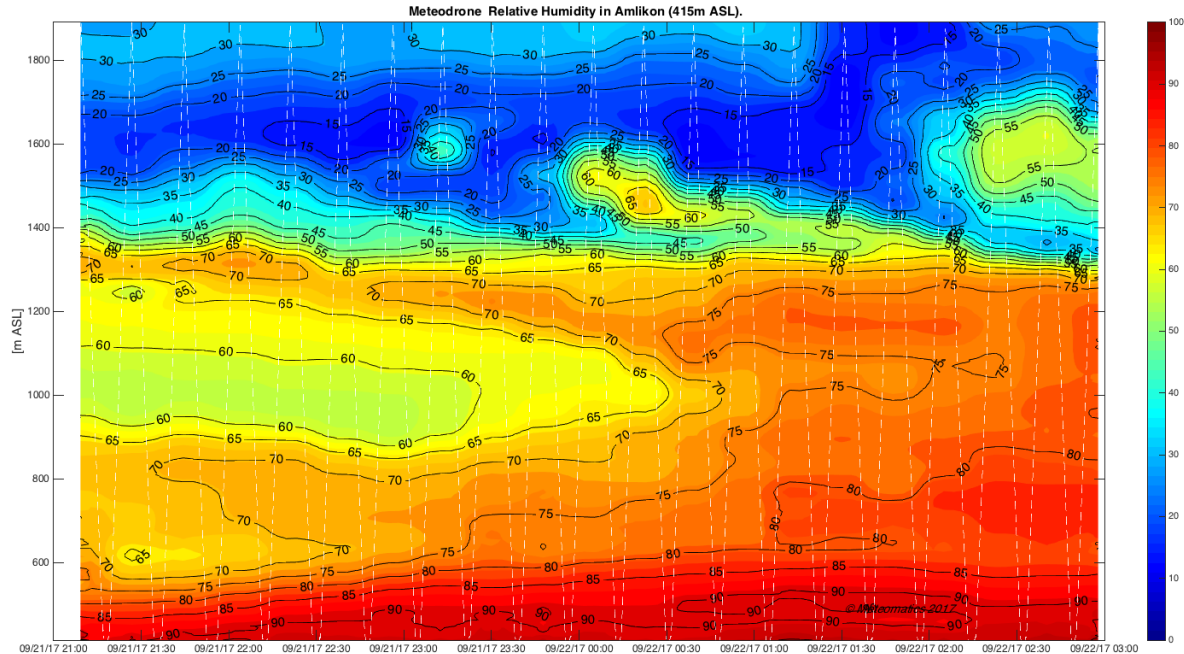


White dots indicate the drone flight track.

*Visualization done in MATLAB*

# Amlikon 21. – 22.09.17

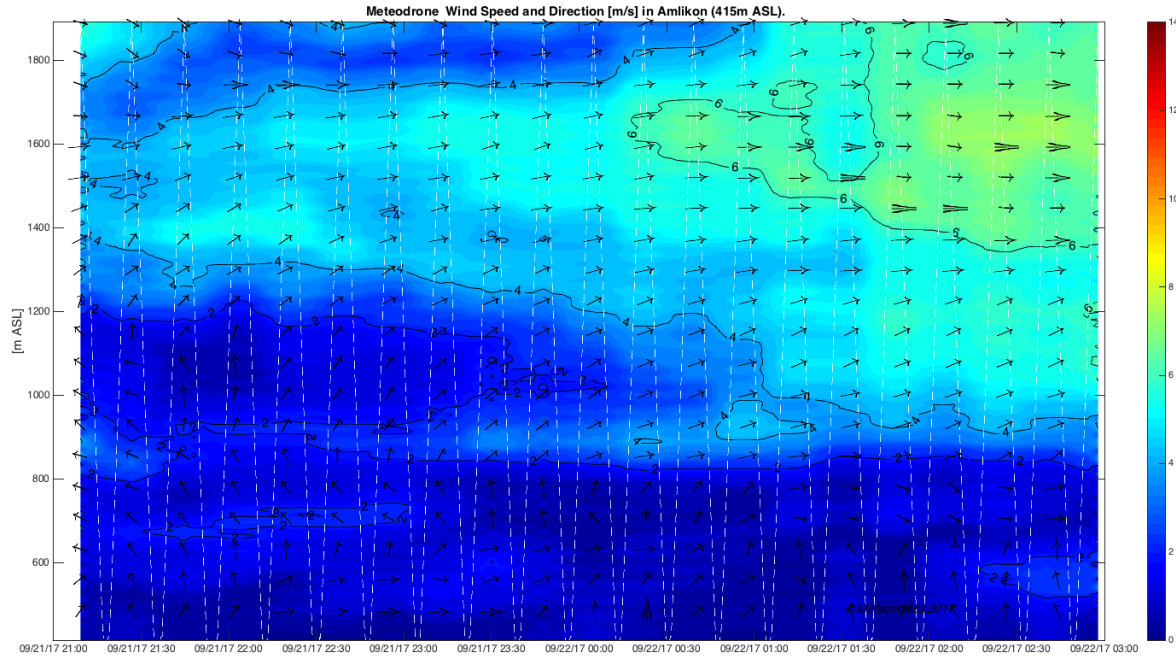
## Relative Humidity



Visualization done in MATLAB

# Amlikon 21. – 22.09.17

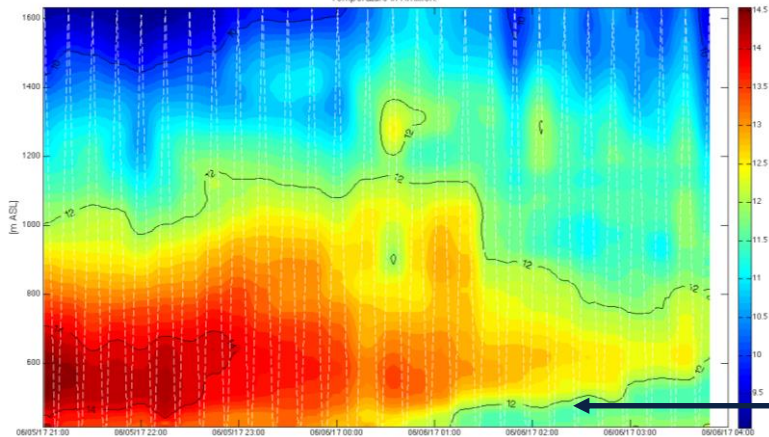
## Wind Speed & Direction



Visualization done in MATLAB

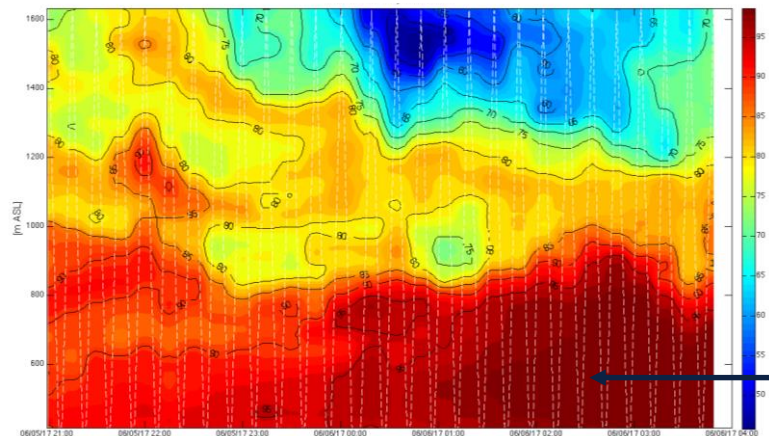
# Amlikon 05. – 06.06.17

Temperature in Amlikon.



Temperature

Ground Inversion



Relative Humidity

100% RH



Shallow Fog:  
Up to 150 m

**Fully  
automated**



**Customized  
to your needs**



**New dimension  
in precision**



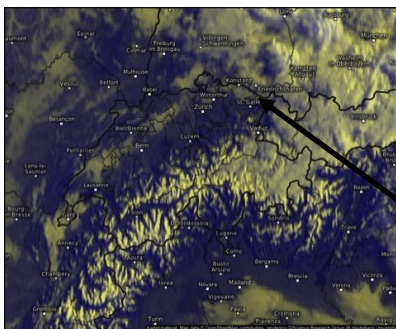
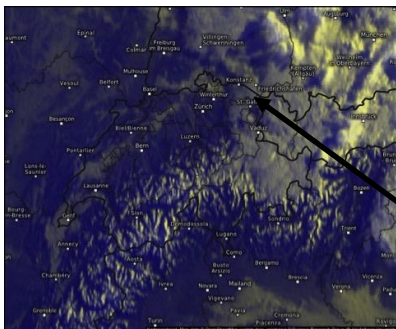
**Maximum  
flexibility**



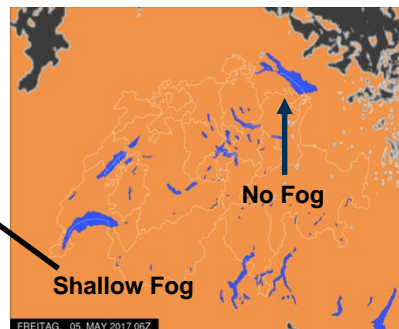
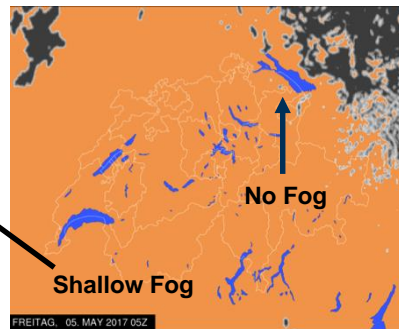


# Morning Fog at Lake Constance 05.04.17, 7 am & 8 am

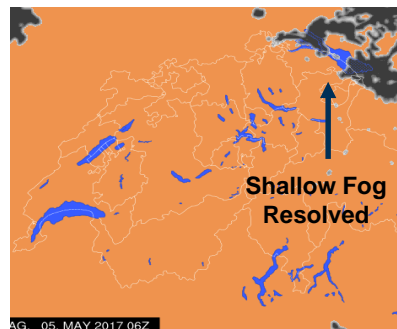
Satellite Cloud Cover



Swiss1k **Without**  
Meteodrone Data



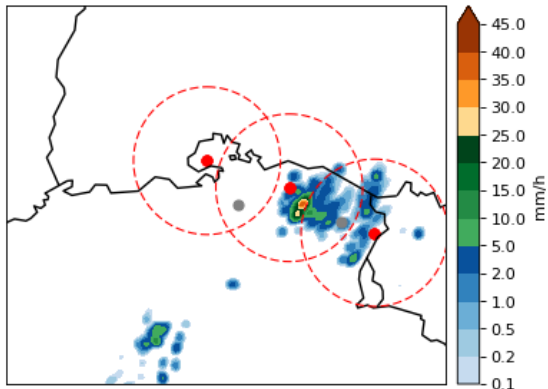
Swiss1k **With**  
Meteodrone Data



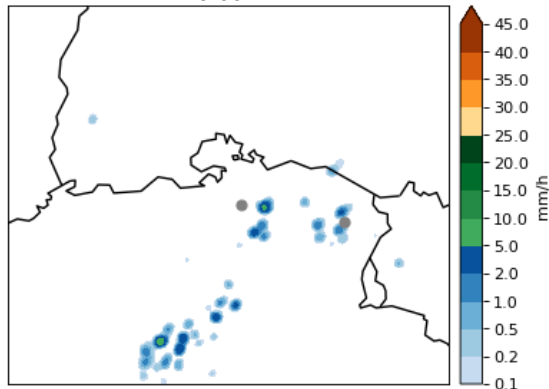
Meteodrones in Schaffhausen, Amlikon and Marbach until 5 am

# Thunderstorms in St.Gallen 29. – 30.05.17

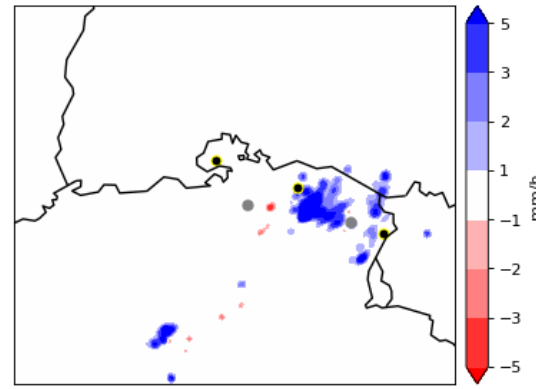
With Meteodrone  
29.05.17



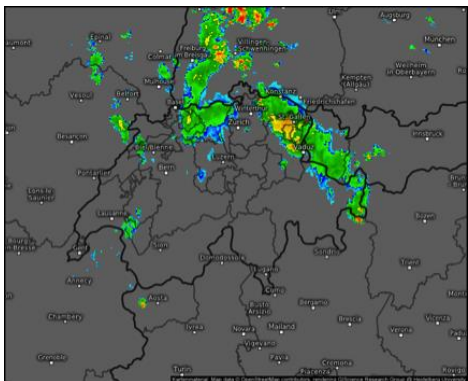
Without Meteodrone  
29.05.17



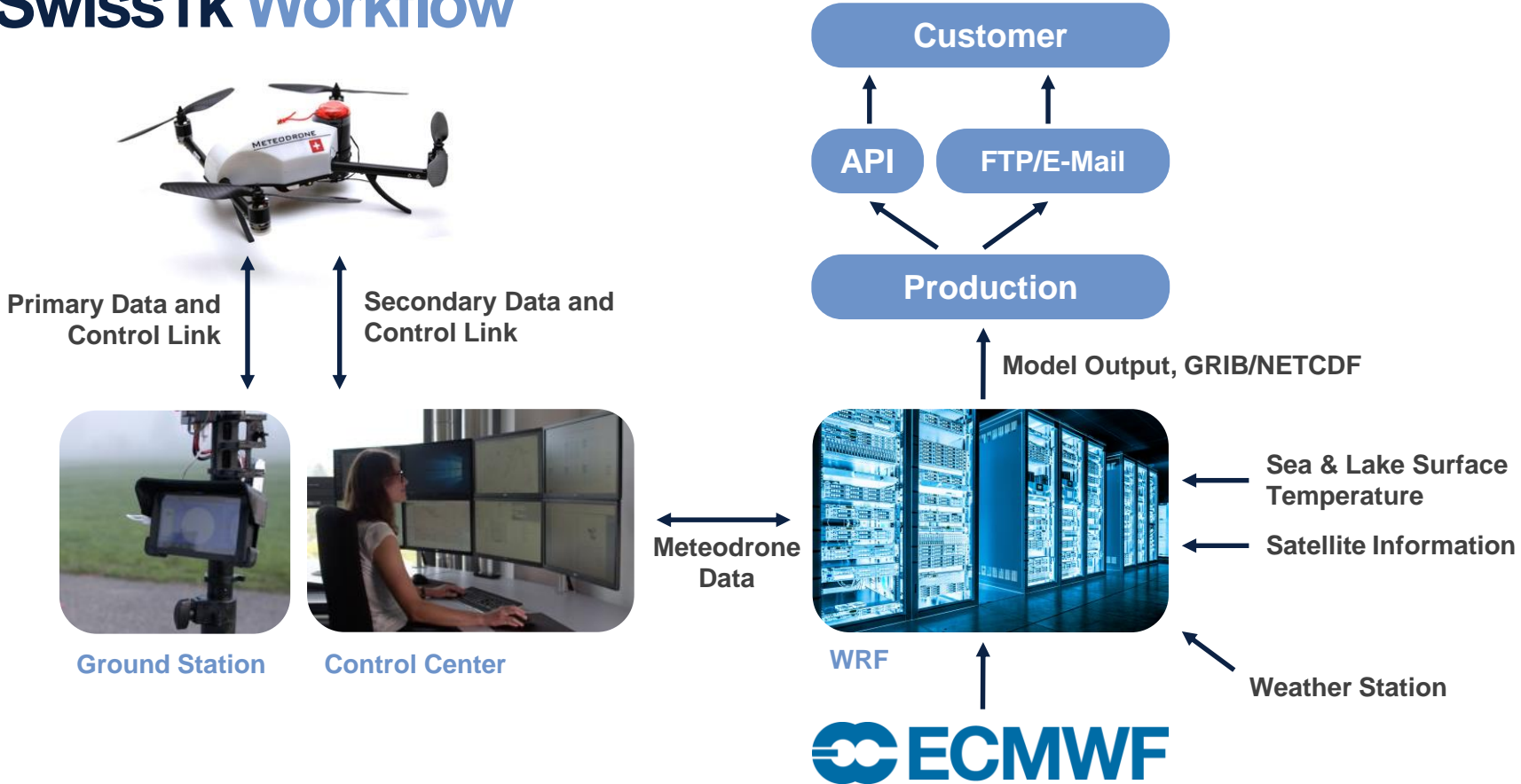
Difference  
29.05.17

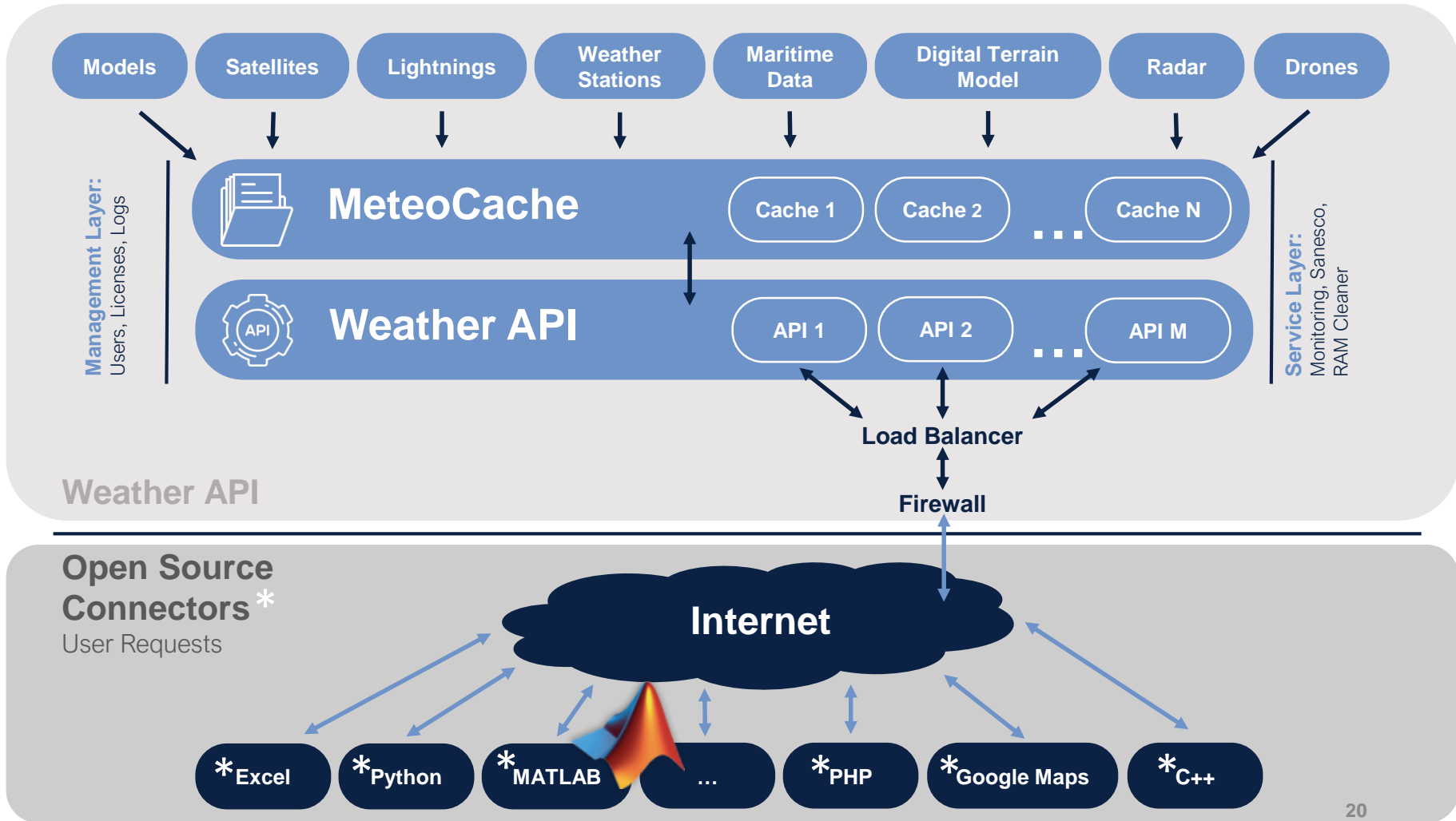


Swiss1k was the only model to capture these storm cells and forecasted them 23 hours ahead!



# Swiss1k Workflow





# Weather API

## USP



Weather data as a single version of truth



On the fly calculation for most up-to-date forecasts



Hyperlocal forecasts delivering enhanced temporal and spatial resolution



Variety of formats and connectors in different programming languages



Detailed and up-to-date documentation

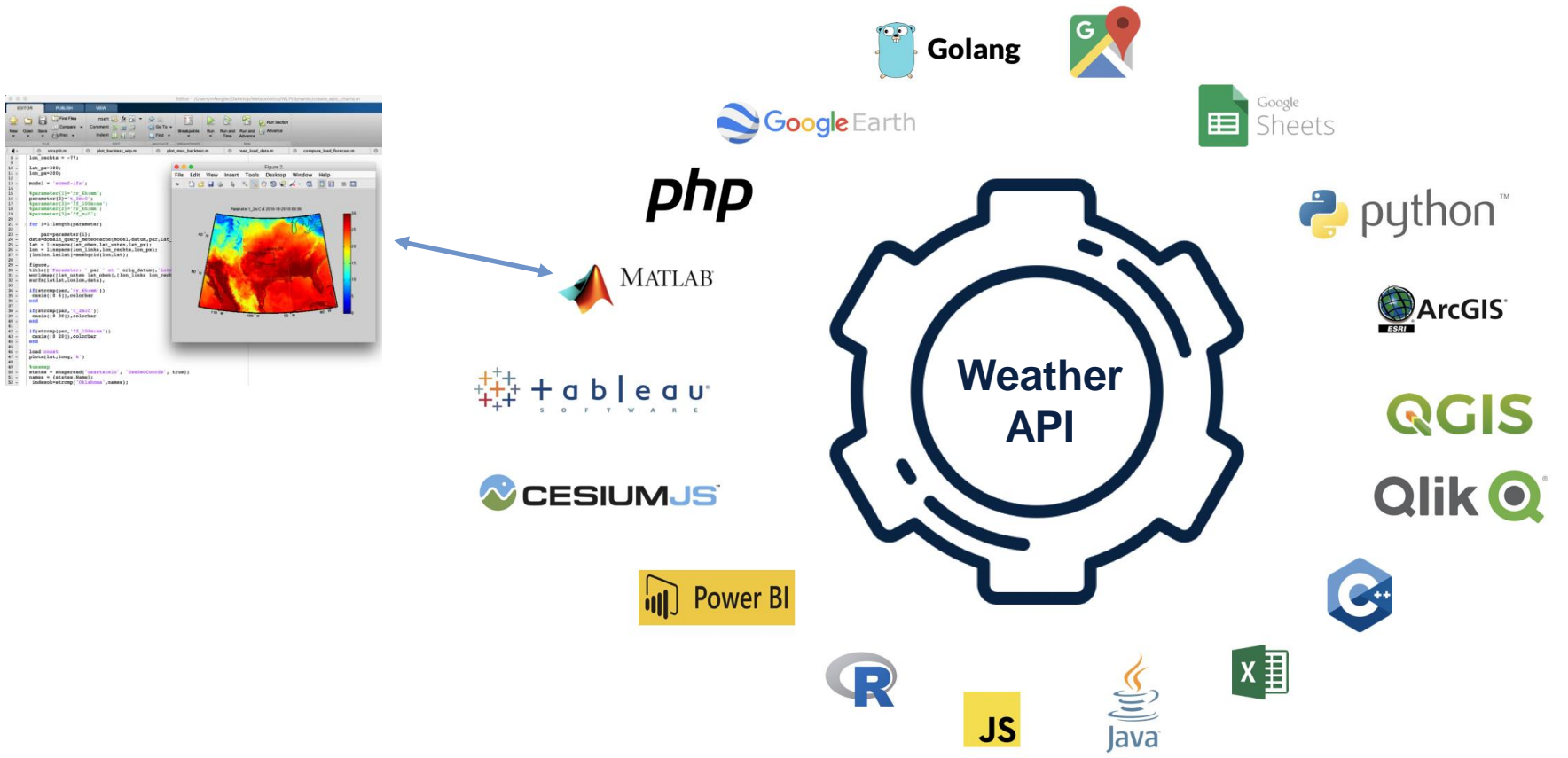


Flexible & fast integration & usage



Simple one-stop access to high quality weather data worldwide

# Variety of Possible Integrations



# Weather API in MATLAB File Exchange

MathWorks® Products Solutions Academia Support Community Events

Get MATLAB

File Exchange

Search File Exchange

MATLAB Central Files Authors My File Exchange Contribute About

**Meteomatics Weather API Connector**

version 2.0.0.0 (371 KB) by Martin Fengler

This packages contain samples to query any meteorological data from the Meteomatics Weather API.  
<https://api.meteomatics.com>

★★★★★ 10 Ratings  
23 Downloads  
Updated 14 Sep 2018  
[View License](#)

+ Follow Download

Overview Functions

Accessing any weather, ocean or environmental data should be simple and convenient: Meteomatics provides a REST-full API to global historical, current and forecast data. This includes derived data from different centers (GFS, ECMWF, UK MetOffice, Env. Canada etc...), radar data, satellite, observational, lightning, land usage, digital terrain model data. Moreover, you can get also derived parameters like wind power and solar power data and forecasts for a given geolocation. The API provides time series as well as spatial data. The latter is also offered through a WMS/WFS-compatible interface. This package includes some examples to enable a quick start when dealing with this API. An online documentation is available through <https://api.meteomatics.com>.

## Comments and Ratings (12)

- Pham Van Tien** 25 Dec 2018 ★★★★★ demo tres bien!
- Sabrina Burger** 21 Aug 2017 ★★★★★ Nice documentation and great weather data
- Sabrina\_Bu** 21 Aug 2017 ★★★★★
- Daniel Kästli** 15 Aug 2017 ★★★★★ easy to use, great results
- Livio Roth** 14 Aug 2017 ★★★★★ Very easy to use, I did not need much time to get the first weather data with the good documented code. Thanks!

## MATLAB Release Compatibility

Created with R2015a  
Compatible with any release

## Platform Compatibility

Windows  macOS  Linux

## Tags

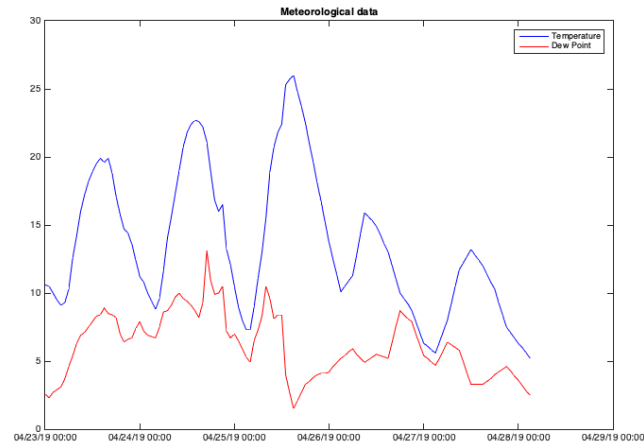
api ecmwf meteorology solar weather wind

## Others Also Downloaded

- NetCDF/GRIB reader** 82 Downloads ★★★★★
- zoharby/plot\_google\_map** 216 Downloads ★★★★★
- TopoToolbox** 66 Downloads ★★★★★

# Weather API in MATLAB

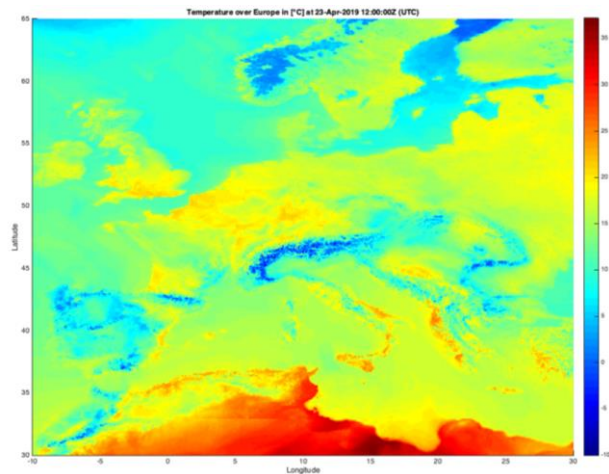
```
% -----  
% Sample to query weather data at a certain location time series  
% -----  
  
lat = 50.123;  
lon = 10.843;  
  
start_date = floor(now); % Could be anything like a datenum |  
period = 'P5DT3H15M'; % period of 5 days, 3 hours, 15 min  
resolution = 'PT1H'; % 1h resolution  
  
parameters = 't_2m:C,d_2m:C'; % Temperature and Dew Point at 2m  
  
[dn,data]=time_series_query_meteocache(user,password,'mix',start_date,period,resolution,parameters,lat,lon);
```



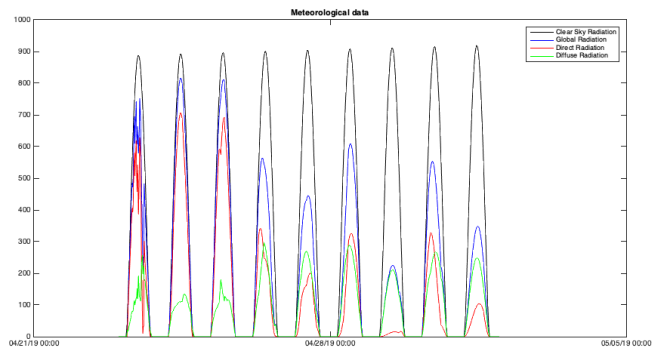


# Weather API in MATLAB

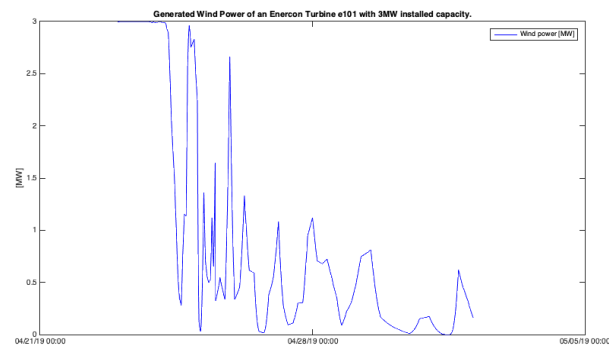
```
% -----  
% Sample to Query a domain for temperature  
% -----  
  
% Define corners of a rectangular domain in decimal degrees  
lat_top = 65;  
lon_left = -10;  
lat_bottom = 30;  
lon_right = 30;  
  
% Define Pixel resolution  
lat_px = 300;  
lon_px = 600;  
  
% Create Lat/Lon grid for visualization  
lat = linspace(lat_bottom,lat_top,lat_px);  
lon = linspace(lon_left,lon_right,lon_px);  
[lons,lats] = meshgrid(lon,lat);  
lats = flipud(lats);  
  
% Set date  
validdate = floor(now)+0.5; % datenum(2016,12,24,15,35,0);  
  
parameter = 't_2m:C';  
  
% Query the grid:  
data=domain_query_meteocache(user,password,'mix',validdate,parameter,lat_top,lon_left,lat_bottom,lon_right,lon_px,lat_px);  
  
figure, surf(lons,lats,data,'EdgeColor','none')
```



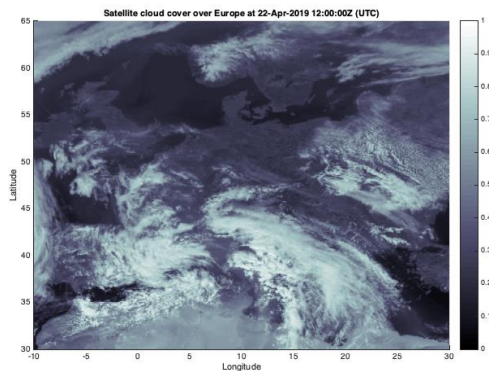
# Weather API in MATLAB



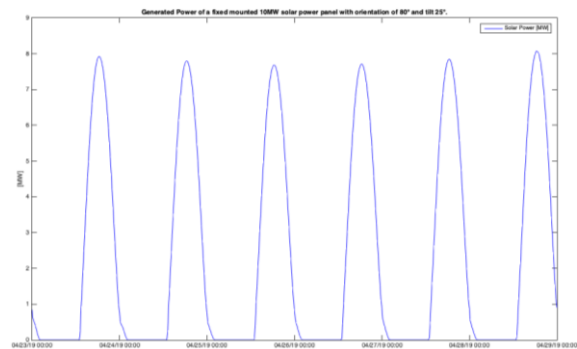
Global, diffuse, direct and clear sky radiation



Wind Power



MSG Satellite Data



Solar Power

# Key Takeaways

## Weather API & MATLAB

enable us to:

- ... model gathered drone data
- ... simulate new measurement techniques
- ... implement physical parametrizations
- ... visualize meteorological data
- ... carry out statistical analyses
- ... enrich training of machine & AI learning with weather data
- ... give deeper insights into your weather related business

# Thank You



## Your Contact

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