Using MATLAB to Empower Modern Numerical Weather Forecasts

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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

- Satellite
- Aircraft
- Radar
- Balloons
- Weather Station
- Laser
- Sound/Microwave

PBL* up to 1.5 km
Limited Data

Trigger for Storms
Low Stratus
Fog

* PBL = Planetary Boundary Layer
Improving Data Situation

- Satellite
- Aircraft
- Radar
- Meteodrone
- Balloons
- Weather Station
- Laser
- Sound/Microwave

* PBL = Planetary Boundary Layer
Our Milestones

- **2012**: Start with AM2S
- **2013**: First Prototype
- **2014**: Passed Total Hazard & Risk Analysis
- **2015**: BVLOS Approval
- **2016**: Product Readiness
- **2017**: Roll-Out Switzerland
- **2018**: First Projects with NSSL/NOAA
- **2019**: EVLOS Approval
- **2020**: Full System Test
- **2021**: Proof of Concept
- **2022**: First Commercial Flight Campaign
Our mobile systems allow highly flexible missions.
Meteodrone Sensors & Flight Profile

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

**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

Temperature
- Accuracy: 0.1 °C
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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
Amlikon 21. – 22.09.17

Temperature

Visualization done in MATLAB

White dots indicate the drone flight track.
Relative Humidity

Visualization done in MATLAB
Wind Speed & Direction

Amlikon 21. – 22.09.17

Visualization done in MATLAB
Amlikon 05. – 06.06.17

Temperature

Ground Inversion

Relative Humidity

100% RH

Shallow Fog: Up to 150 m
Morning Fog at Lake Constance 05.04.17, 7 am & 8 am

Satellite Cloud Cover

Swiss1k Without Meteodrone Data
- Shallow Fog
- No Fog

Swiss1k With Meteodrone Data
- Shallow Fog
- Shallow Fog Resolved
- No Fog
- Shallow Fog Resolved

Meteodrones in Schaffhausen, Amlikon and Marbach until 5 am
Thunderstorms in St. Gallen 29. – 30.05.17

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

Primary Data and Control Link

Secondary Data and Control Link

Ground Station

Control Center

Customer

API

FTP/E-Mail

Production

Model Output, GRIB/NETCDF

Sea & Lake Surface Temperature

Satellite Information

Weather Station

Meteodrone Data

WRF
Weather API

Open Source Connectors
User Requests

Internet

*Excel *Python *MATLAB ...
*PHP *Google Maps *C++
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

Languages and Tools:
- MATLAB
- Golang
- Google Earth
- Google Sheets
- Python
- Tableau Software
- CesiumJS
- Power BI
- R
- JS
- Java
- Excel
Weather API in MATLAB File Exchange

Meteomatics Weather API Connector

version 2.0.0.0 (371 KB) by Martin Fengler

This package contains samples to query any meteorological data from the Meteomatics Weather API.
https://api.meteomatics.com

Accessing any weather, ocean or environmental data should be simple and convenient: Meteomatics provides a RESTful 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

5 stars

Demo trees beth!

Sabrina Burger
21 Aug 2017

5 stars

Nice documentation and great weather data

Sabrina_Bu
21 Aug 2017

5 stars

Easy to use, great results

Daniel Kastl
15 Aug 2017

5 stars

Linda Roth
14 Aug 2017

5 stars

Very easy to use, I did not need much time to get the first weather data with the good documented code. Thanks!
Weather API in MATLAB

```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

```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:

datandomain_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
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Thank You

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