Current UAV-assisted Wind Energy Research Projects at the University of Tuebingen with the In-House built MASC Aircraft

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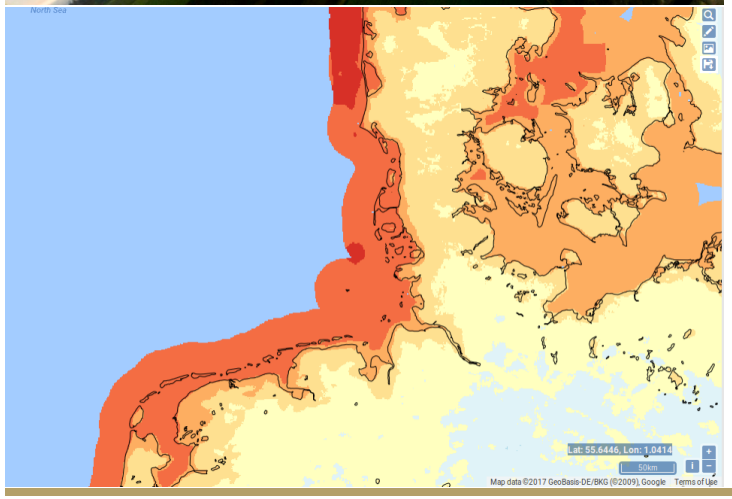


Outline

1. MASC UAV and Sensor System
2. HeliOW
3. WINSENT
4. HeliOW and WINSENT: Measurement Strategies

MASC: Multi-purpose Airborne Sensor Carrier

operated at **University of Tübingen**

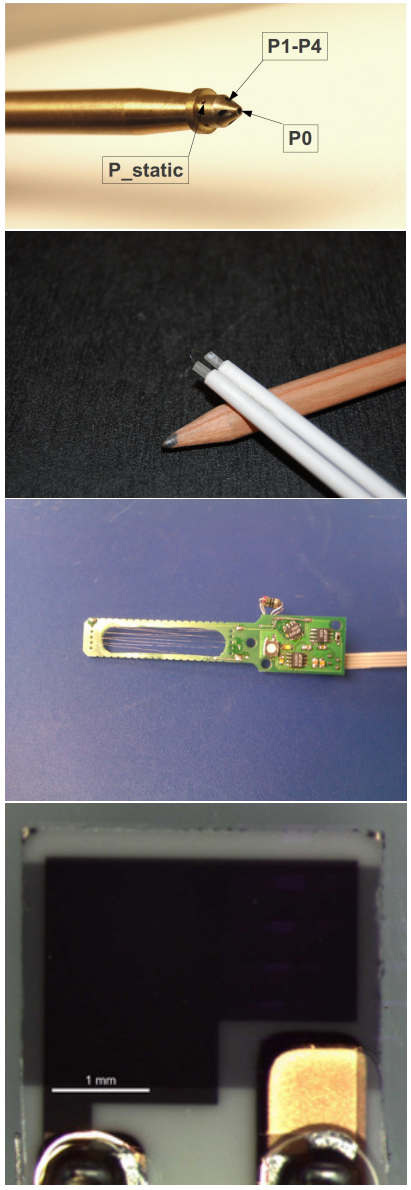
Met UAV MASC at the KonTest campaign
Baden-Württemberg, Schnittlingen, 2016

wingspan:	2.7...3.5 m
total weight:	< 6 kg
incl. sci. payload:	1.5 kg
cruising speed:	25 m/s
endurance:	≈ 1 hour
electrical engine	pusher
autopilot:	Uni Stuttgart

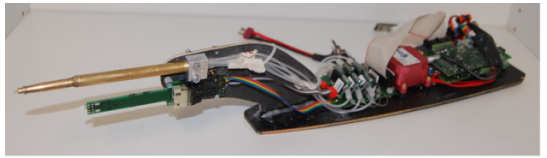
Measurements:

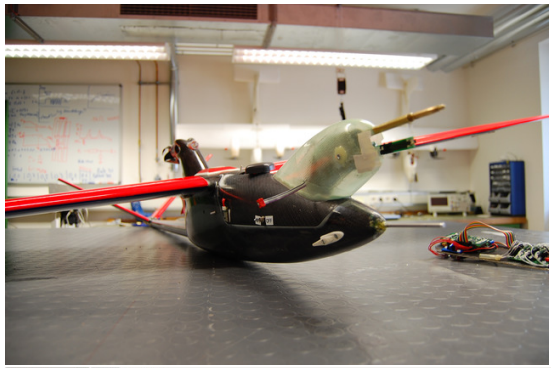
- 3D wind vector
- air temperature
- water vapour
- 100 Hz sampling rate
- data link to ground station

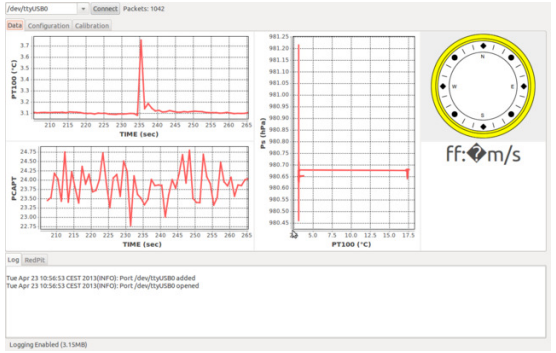
MASC Sensor System

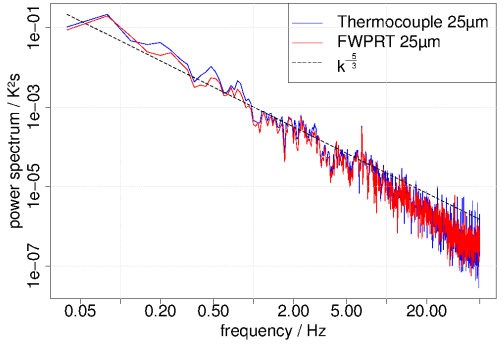


- complete thermodynamic sensor package:
  - fine wire resistance thermometer
  - capacitive humidity sensors
  - flow probe
  - inertial measurement unit (IMU)
  - GNSS position and velocity
- turbulence measurement up to 30 Hz
- live data observation on ground-station computer
- 100 Hz on-board log to SD-card









HeliOW: Helicopter Operations in Offshore Windparks

Joint Research Project

Regulating safety concerns, energie-wende.de

Involved Partners:

German Aerospace Centre
Braunschweig

Institute of Aero- and Gas Dynamics
Stuttgart

Technical University of Munich

Centre for Applied Geoscience
of the University of Tübingen

UAV Measurements

high resolution wind data

resolving detached blade tip turbulence

Wake Simulation

near distance wake

Helicopter Simulation

flight mechanics and trajectories of a helicopter in wake turbulence

offshore-stiftung.de

MASC in front of a WEC

Assort current situation

- Evaluate long term weather data over North Sea area
- Obtain and evaluate Pireps/Aireps and interview helicopter pilots

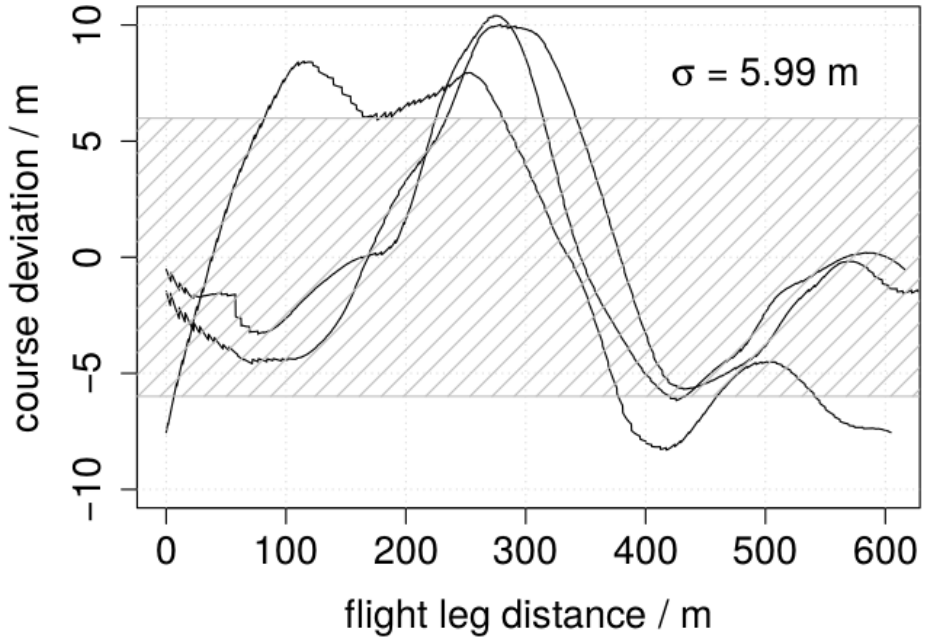
⇒ Correlate with atmospheric conditions and try to identify specific weather phenomena

Hvide Sande (DK), hvidesande.dk

Next Steps

- Finding a substitute WEC at the North Sea shore line (GER/DK)
- Getting flight permissions etc.
- Identify blade tip turbulence

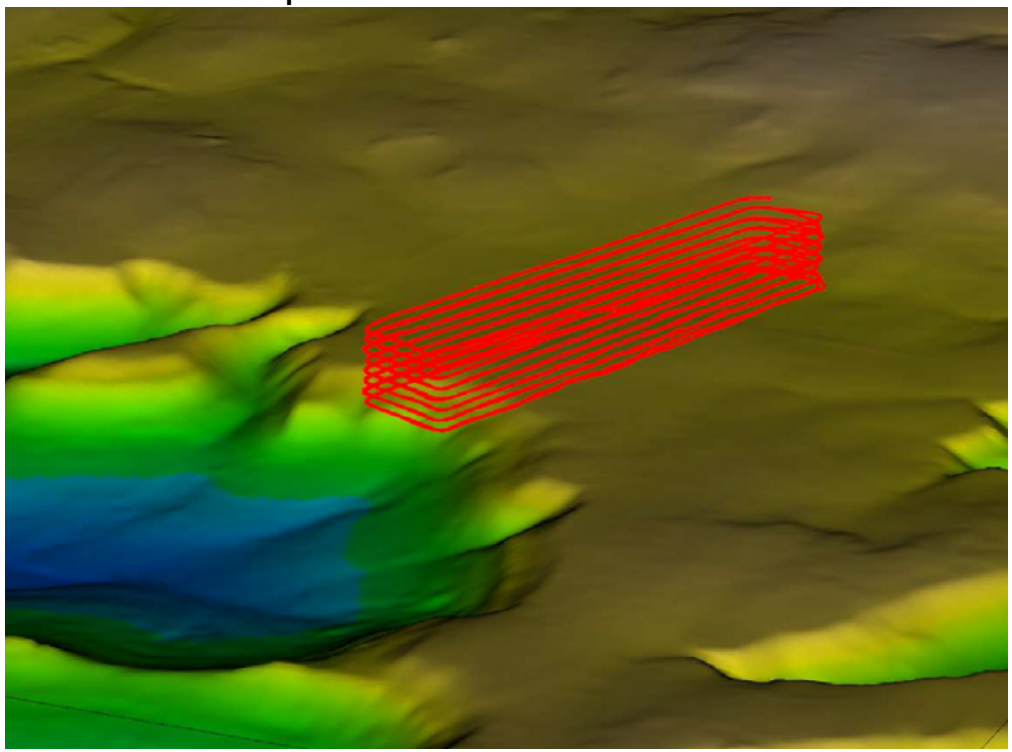
Course deviation inside a WEC wake, Wildmann 2014



WINSENT: Wind, Science & Engineering Test Site

Joint Research Project

DEM of escarpment at the future test site

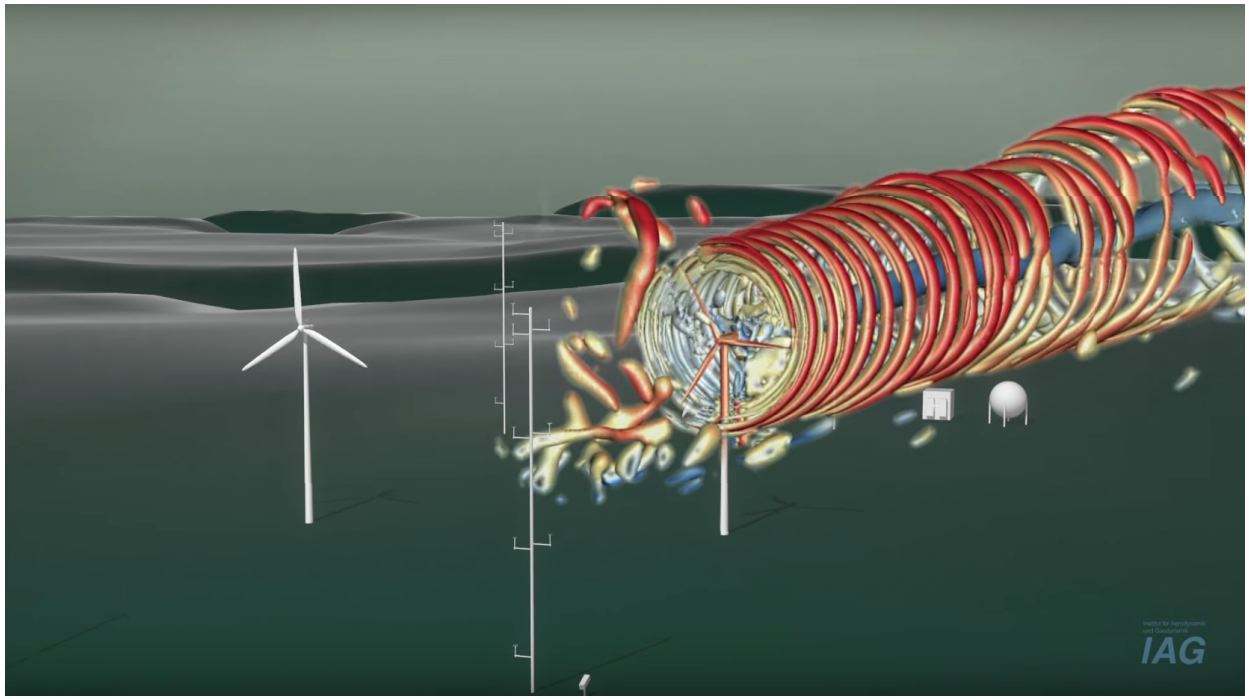


Involved Partners:

- Center for Solar Energy and Hydrogen Research Baden-Württemberg
- Stuttgart Wind Energy
- Technical University of Munich
- Karlsruhe Institute of Technology
- Esslingen University of Applied Sciences
- Centre for Applied Geoscience of the University of Tübingen

Superordinate Goals:

- Installation of a wind energy research test site in complex terrain
- Setting up and validate a model chain for simulation of air flow from meso scale down to rotor blade scale
- Installation of two research wind energy converters, including a virtual simulation environment of the complete test site



On Site:

- Reference wind masts
- Lidar measurements
- in-situ UAV measurements in the near wake (once WEC is installed)

Wake simulation Stöttener Berg by IAG Stuttgart, windfors.de

HeliOW and WINSENT: Measurement Strategies

HeliOW

- Resolving blade tip turbulence in the wake
- Identify region of detached blade tip whirls

⇒ Small(est) scale air flow resolution

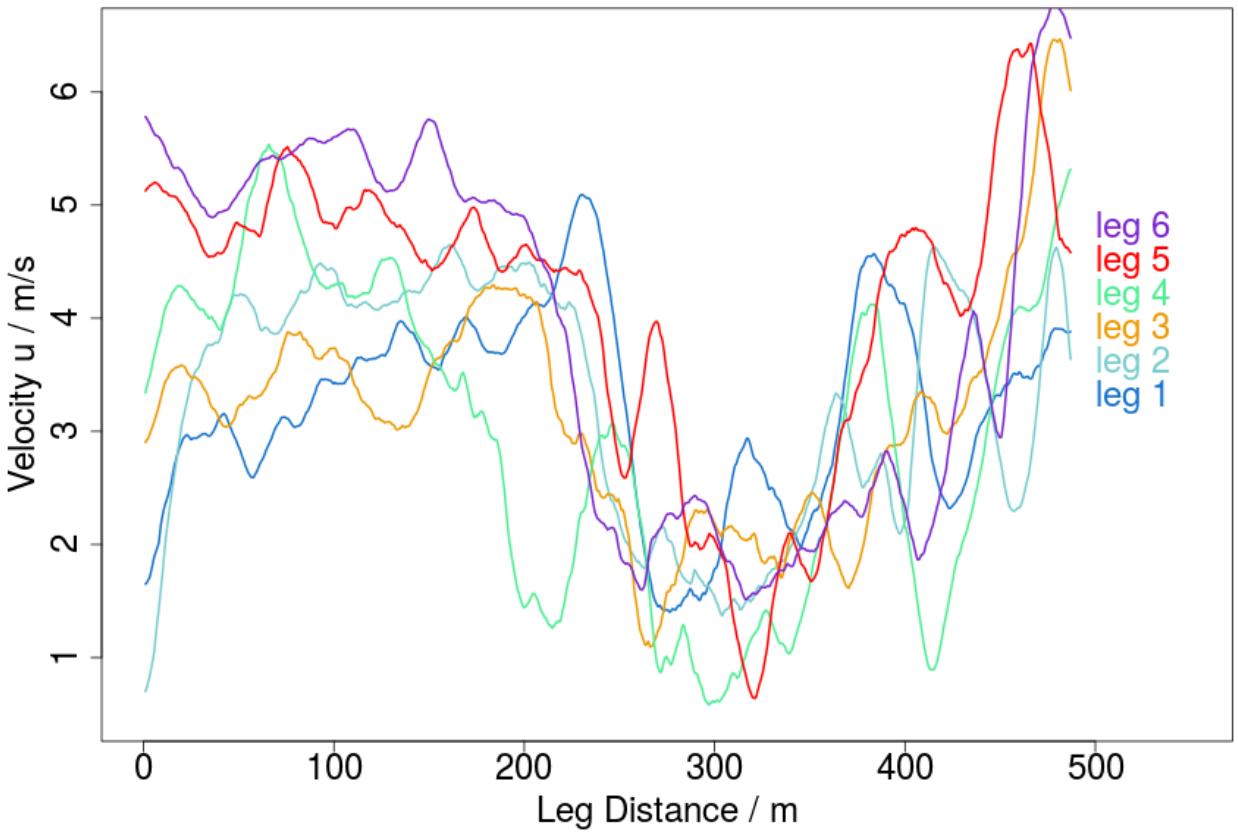
austrianwings.at

WINSENT

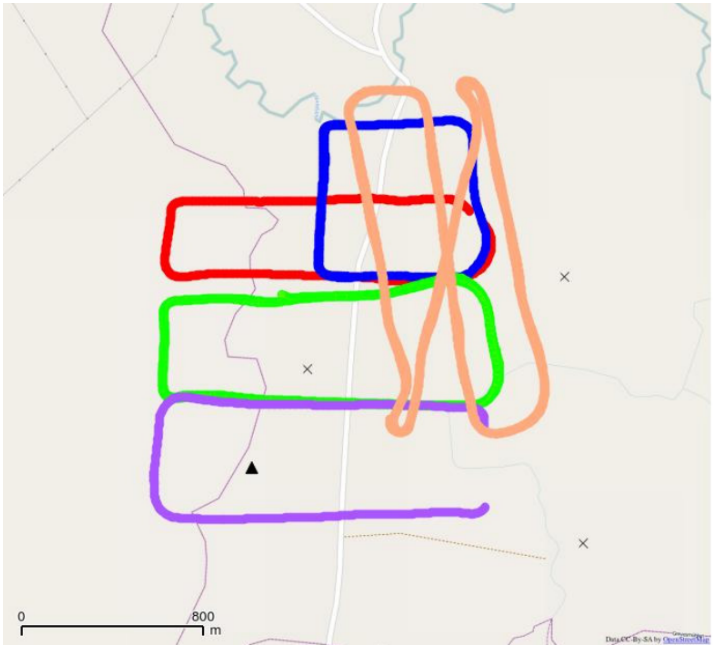
- Systematic and repeatable mapping of the area
- Wind and turbulence data:
  1. inflow from the **valley**
  2. Along the **escarpment**
  3. Inside the **wake** of the research WEC

⇒ Large scale wind mapping

HeliOW: Strategic Starting Point



Flow velocity deficit in hub height (100 m) behind a WEC (ca. 2D) in Grevesmühlen, upper green flight path (s. Fig. to the right)

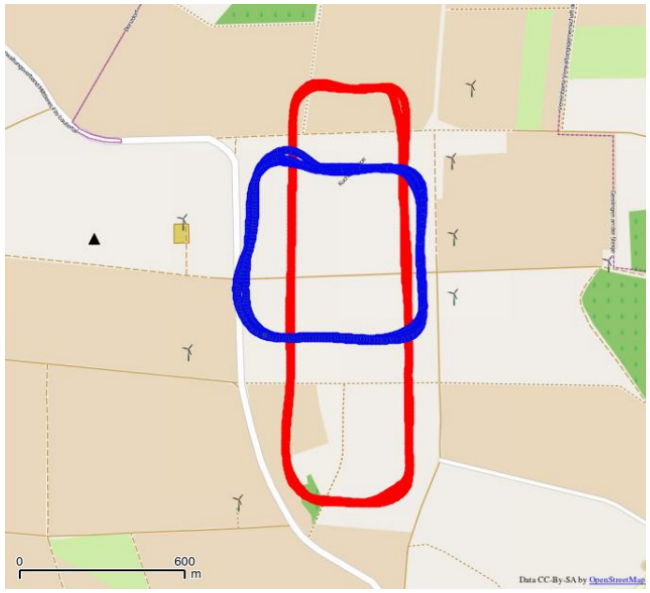


Grevesmuehlen flight paths behind WECs

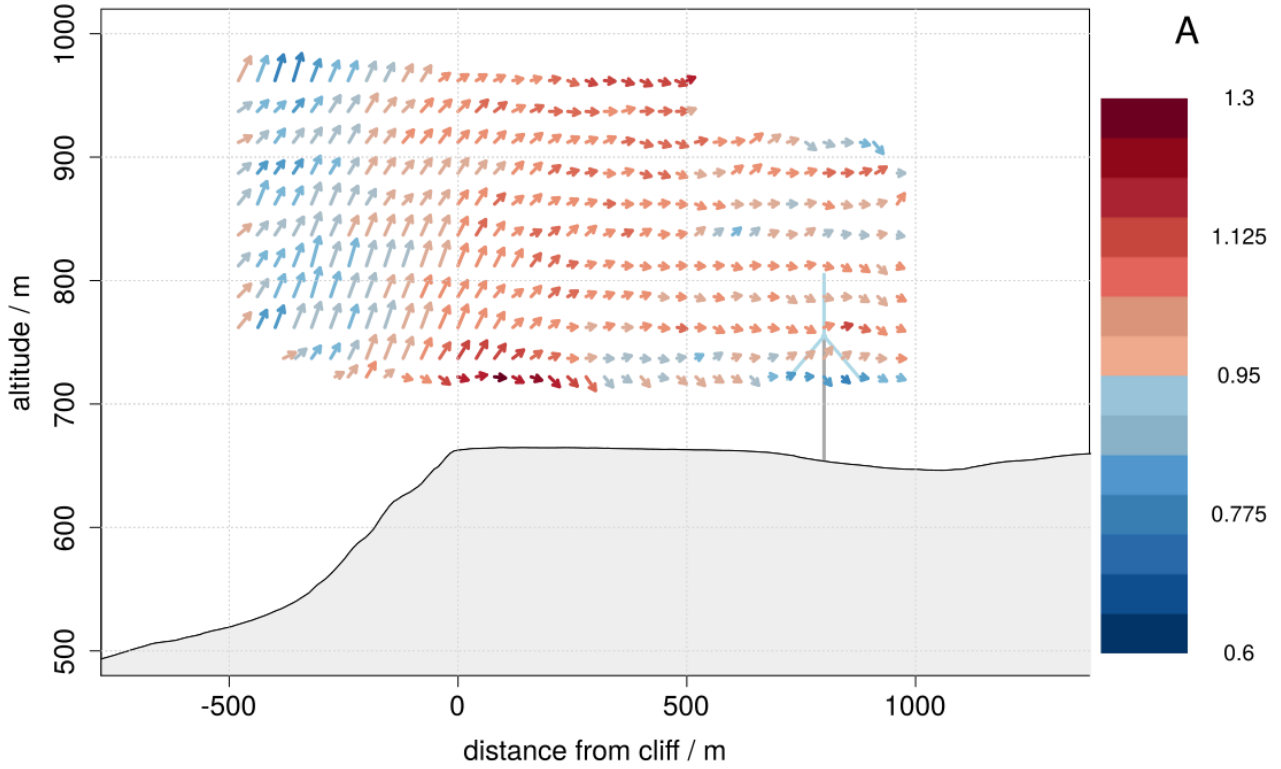
Number of flight legs is vital for statistical relevance and detection

WINSENT: Strategic Starting Point

Starting off with results and recommendations from ’Lidar Complex’ and ’KonTest’



e.g. Flight patterns at the future test site behind a WEC



Mean wind flow over the escarpment in Schnittlingen at the future research test site, Wildmann 2016.

→ Improved autopilot allows catching missing information near the surface.

Summary

Both projects require WEC wake measurements

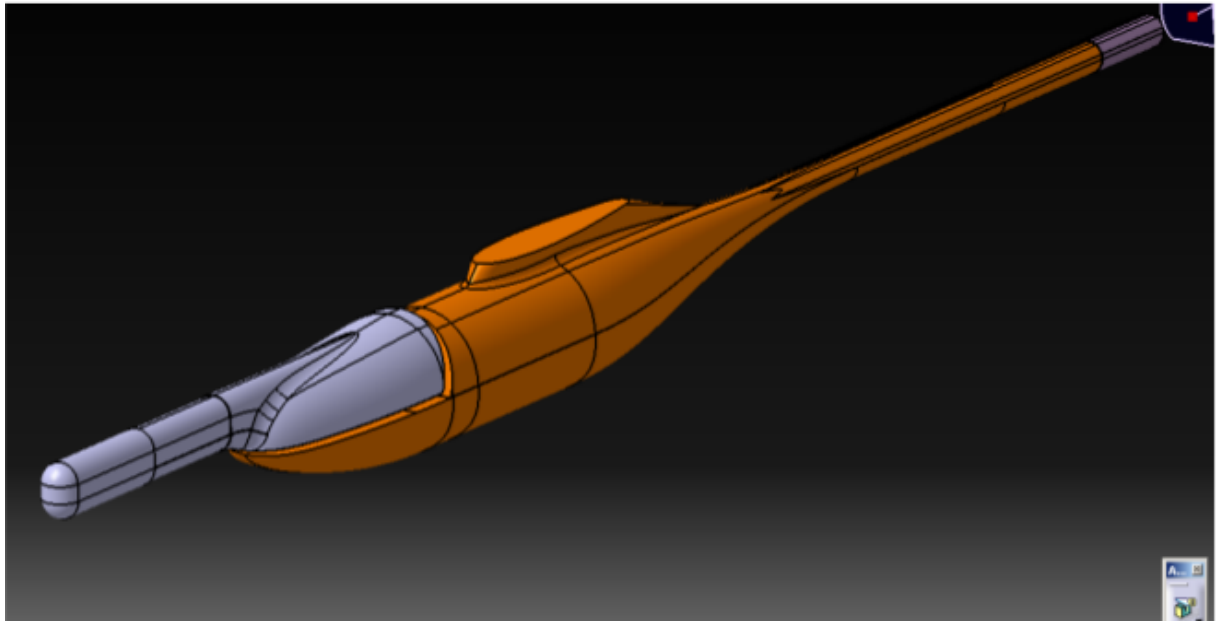
HeliOW: strong focus on resolution

WINSENT: complementing wind map for test site

Implementation of a fast response 5 hole probe

Multi-equipped UAV

Enhance flight statistics

New autopilot

MASC 3.0 ?