Technische Universität Braunschweig

Institute of Aerospace Systems

Preliminary Results of M²AV Measurements during BLLAST 2011

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Outline

- M²AV technology
- Available flight data
- Flight patterns
- Initial results
- Conclusion / Outlook

Meteorological Mini Aerial Vehicle (M²AV)

- Twin engine unmanned aircraft
- Wingspan: 2 m
- Cruising speed: ~ 22 m/s
- Automatic flight with autopilot
- Meteorological sensors mounted on nose
- Weight: 6 kg (incl. 1.5 kg payload)
- Flight duration ~ 50 min
- Telemetry up to 5 km

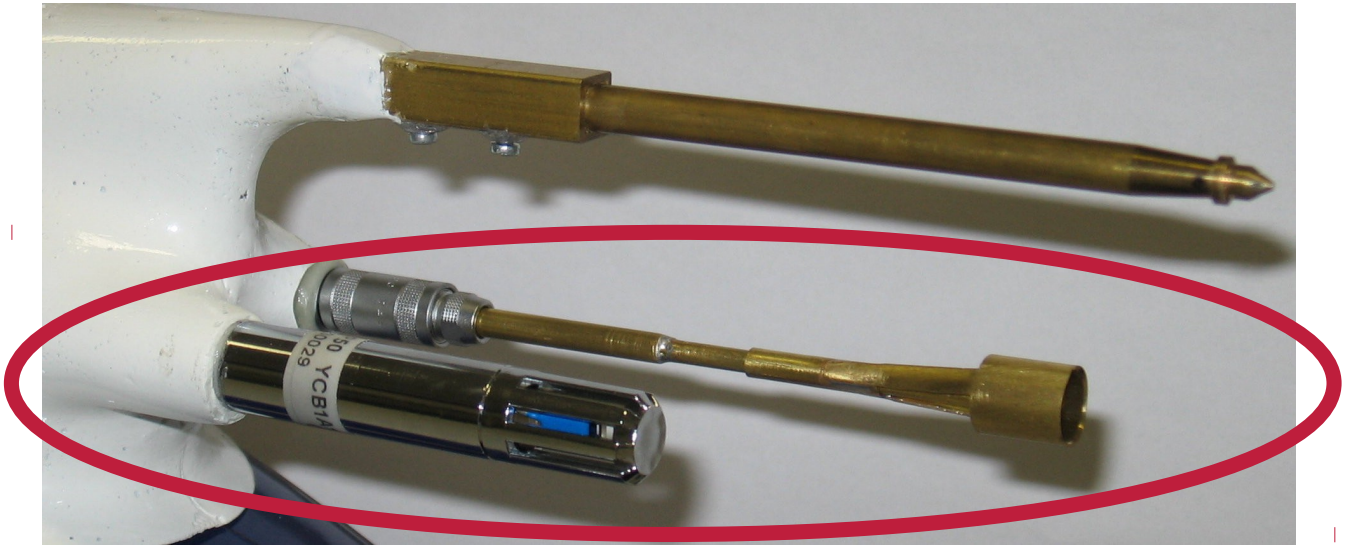
Meteorological Sensors: temperature and humidity

Vaisala Humicap HMP50

- Temperature from -40 to +60 °C
- Relative humidity from 0 to 98 %
- Slow response (~ 1 Hz)
- High long-term accuracy

Thermocouple

- Temperature from -40 to +60 °C
- Fast response (~ 30 Hz)
- Poor long-term stability



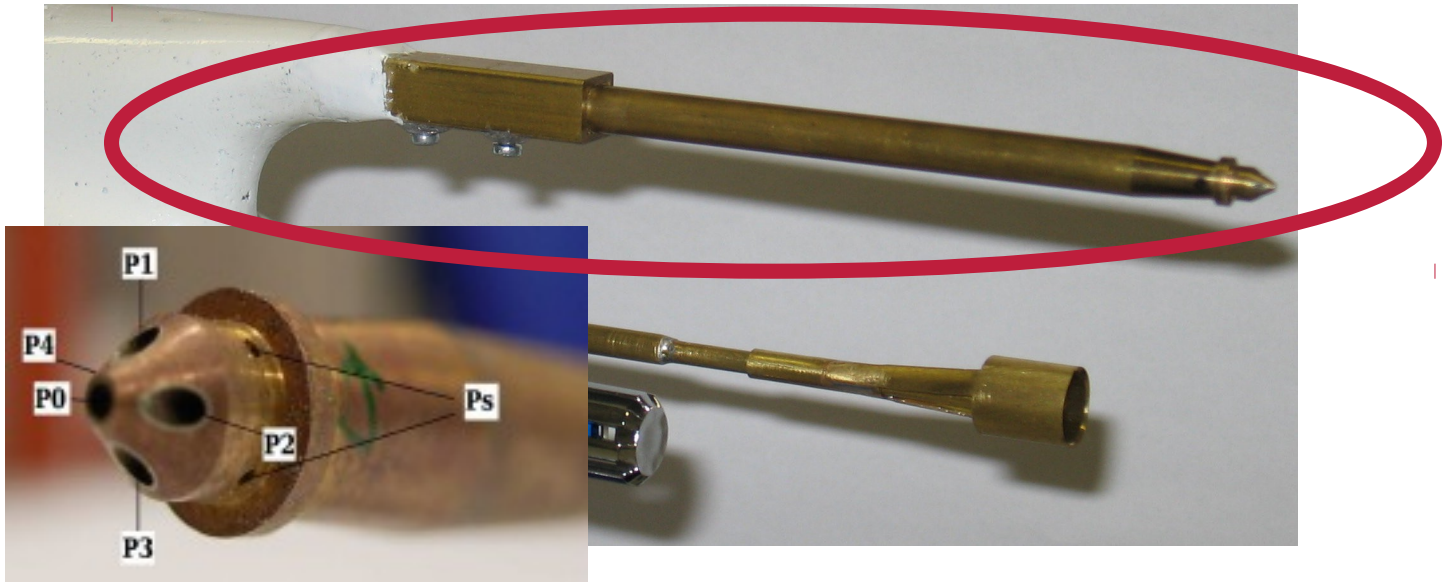
Meteorological Sensors: 3d wind vector

Five-hole probe

- Angles of attack and sideslip: ± 20° (airframe coordinate system)
- Fast response (~ 30 Hz)
- Small (Ø 6 mm) and lightweight (22 g)

Wind vector calculation

- GPS and inertial measurement unit (IMU)
  - ➔ Precise location and attitude
  - ➔ Converting angles of attack and sideslip from airframe coordinates to wind vector



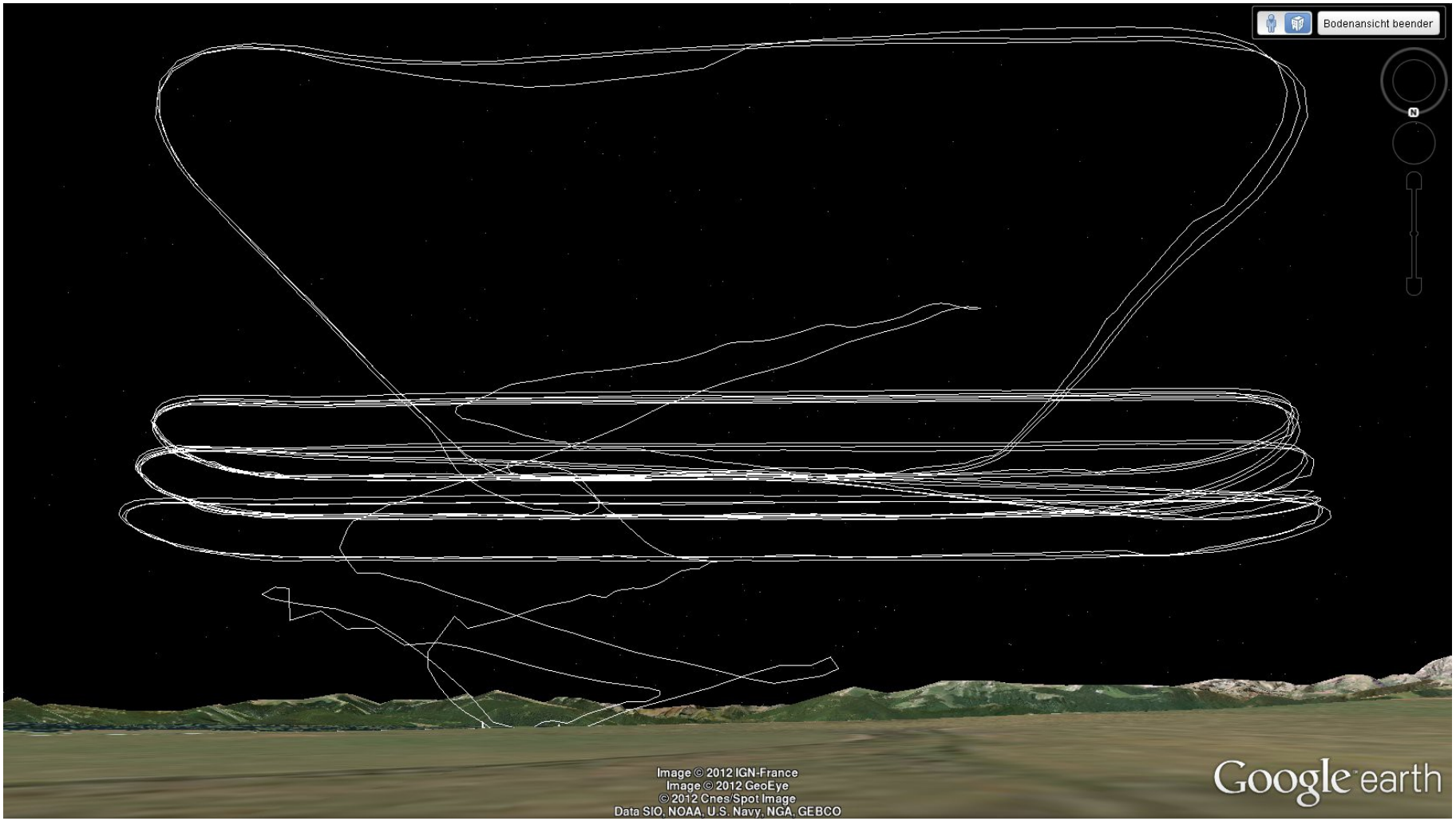
Available flight data

Date	Takeoff (UTC+2)	Altitudes (m agl)
30 June	19:22	200, 400
30 June	20:44	200, 400
01 July	16:27	300
01 July	20:47	200, 250, 300
02 July	**16:19**	**200, 250, 300**
02 July	**18:27**	**200, 250, 300**
02 July	**20:13**	**200, 250, 300**
02 July	**22:20**	**150, 200, 250**
05 July	14:25	200, 250, 300
05 July	16:25	250, 325, 400
05 July	17:40	250, 325, 375, 400, 500
05 July	19:10	250, 375, 500
05 July	20:30	250, 375, 500

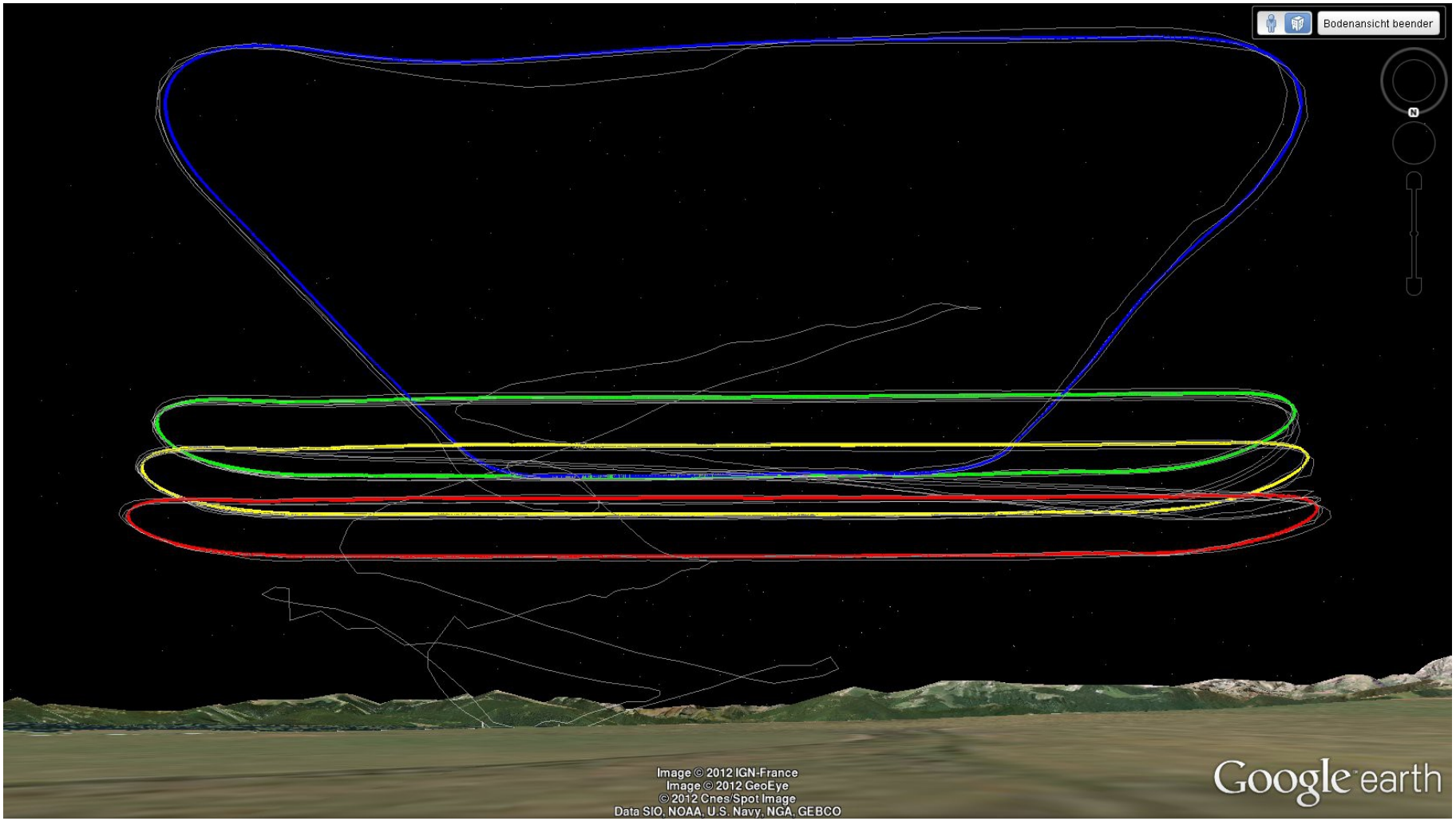
Flight pattern seen from above

Flight pattern seen from above

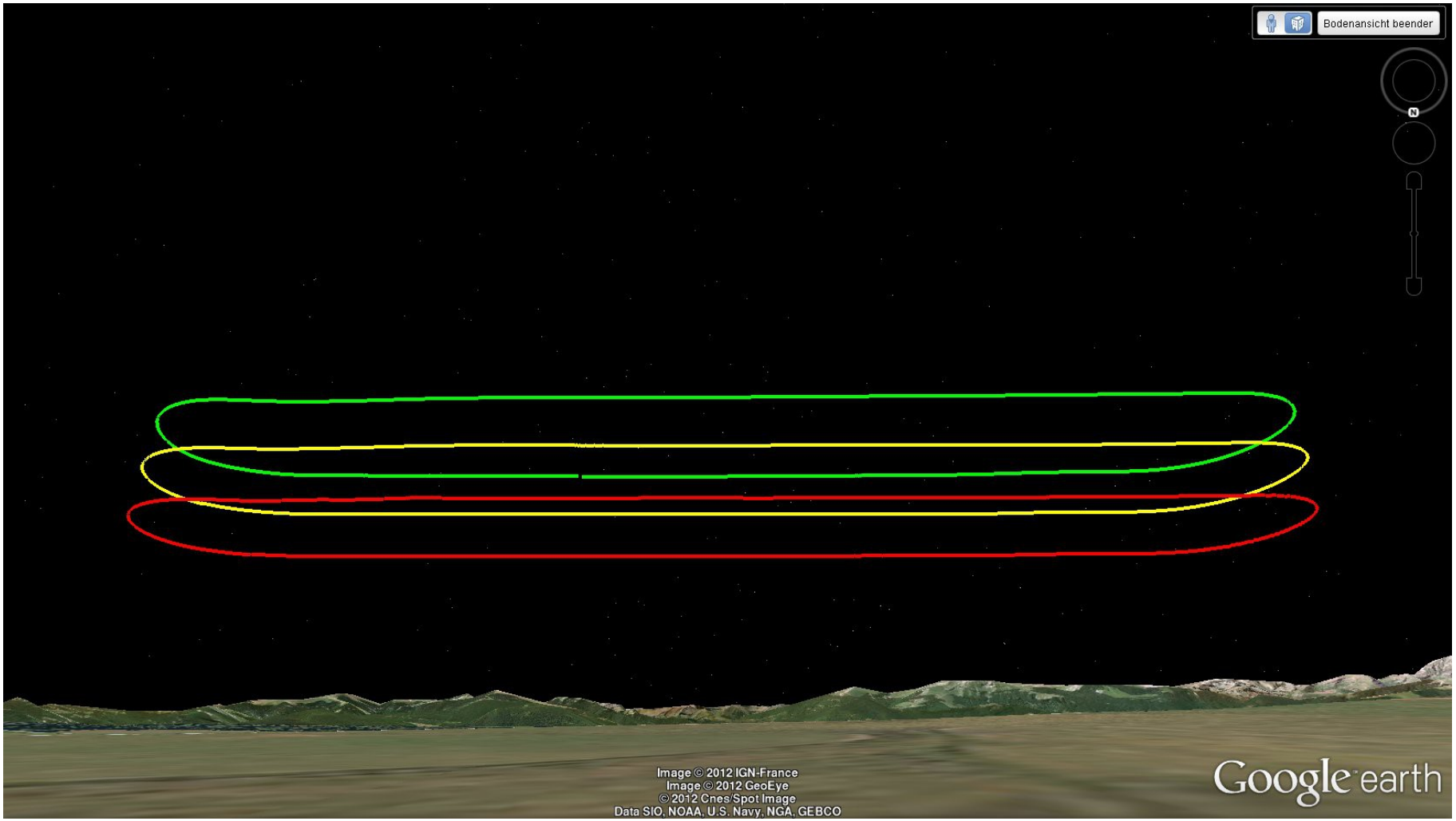
Flight pattern seen from the ground



Flight pattern seen from the ground



Flightlegs relevant for turbulence measurements



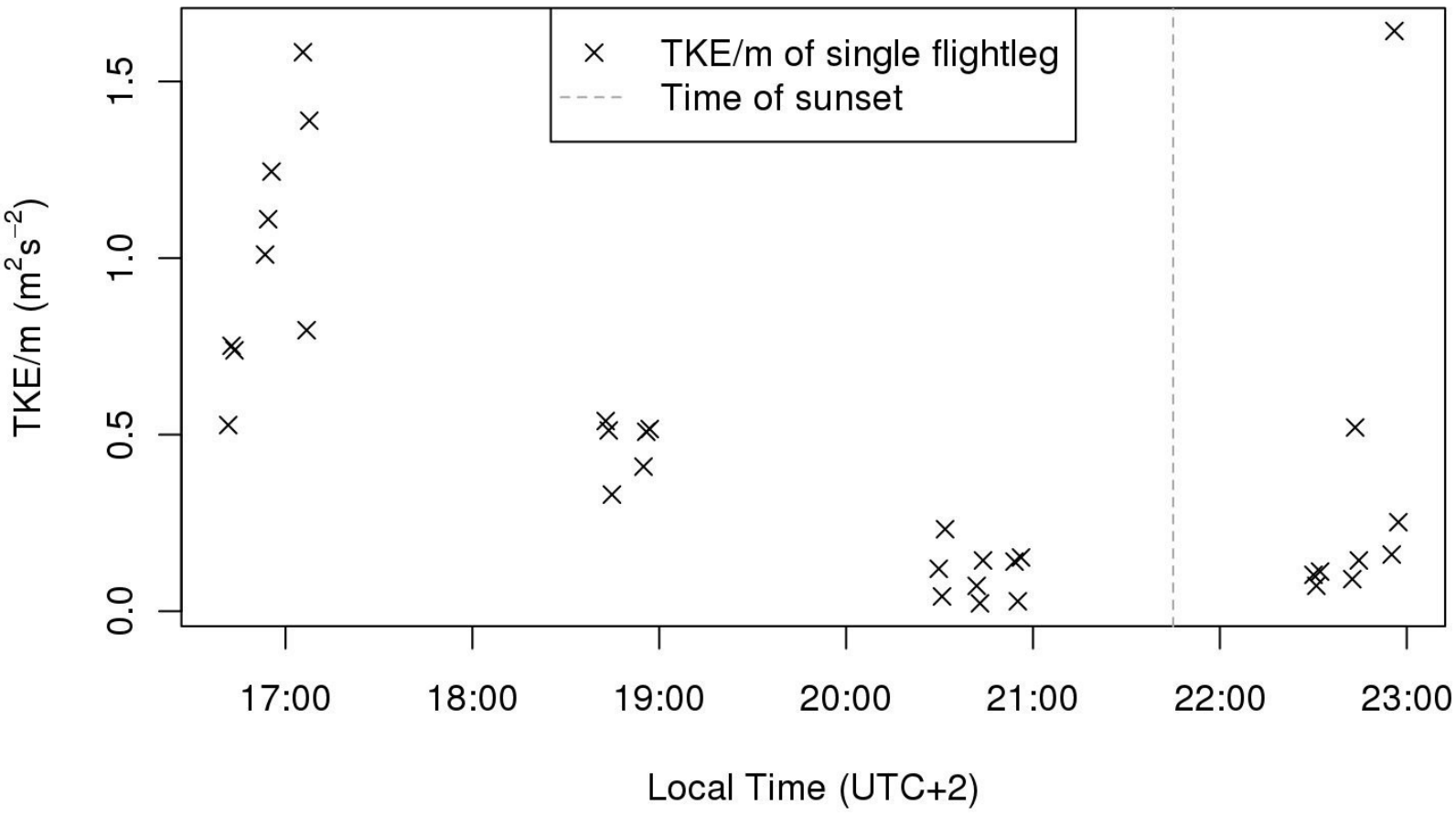
Turbulence Kinetic Energy

- Split wind speed (u, v, w) into mean ($\overline{u}$, $\overline{v}$, $\overline{w}$) and turbulent (u ', v ', w ') parts
  - Mean turbulence kinetic energy (TKE) per unit mass:

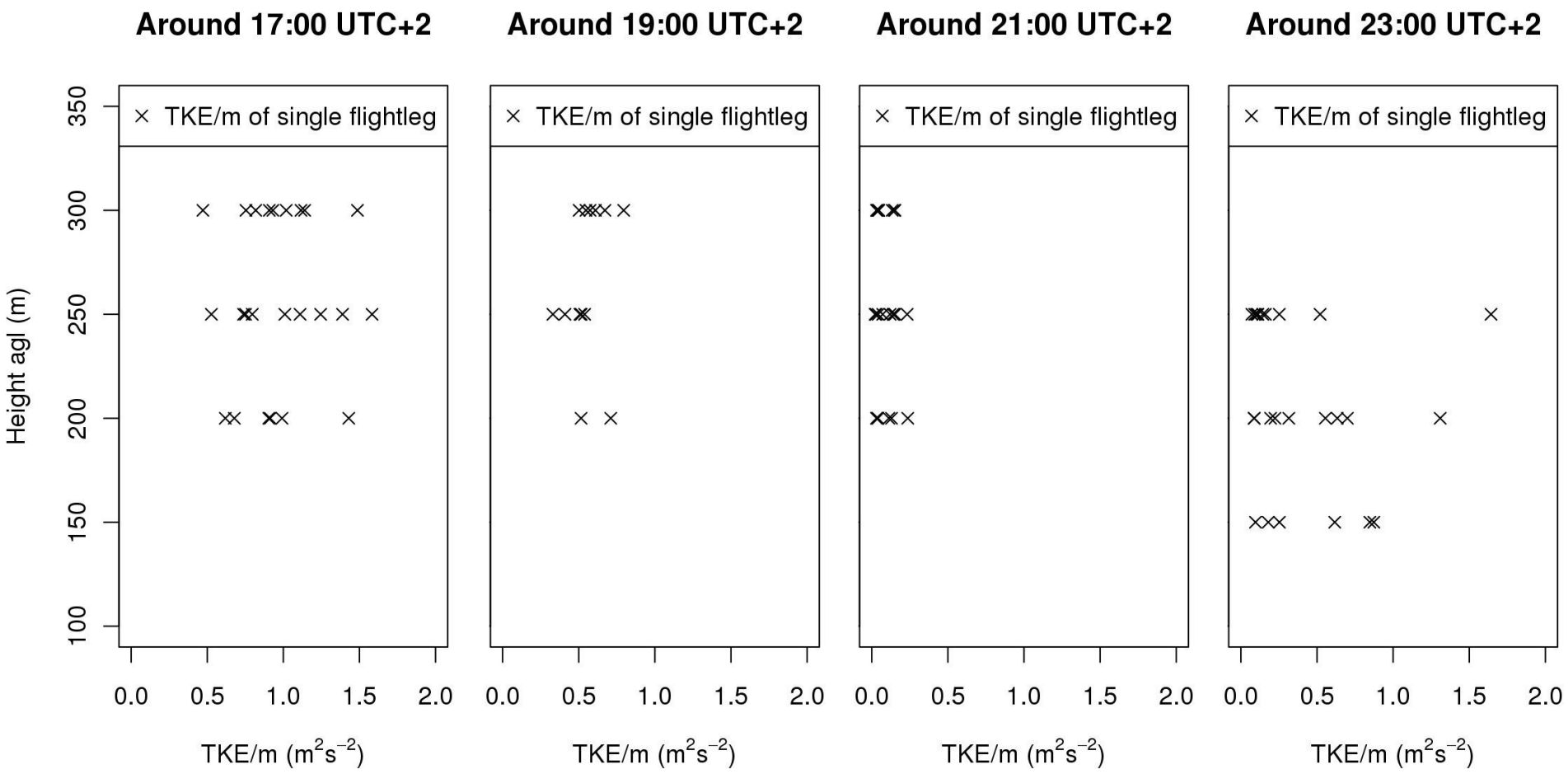
    $TKE / m = \overline{e} = ½ (\overline{u'^2} + \overline{v'^2} + \overline{w'^2})$

- Averaged for straight flight legs (~ 1 km)
  - (+/-) 45 sec. averaging time

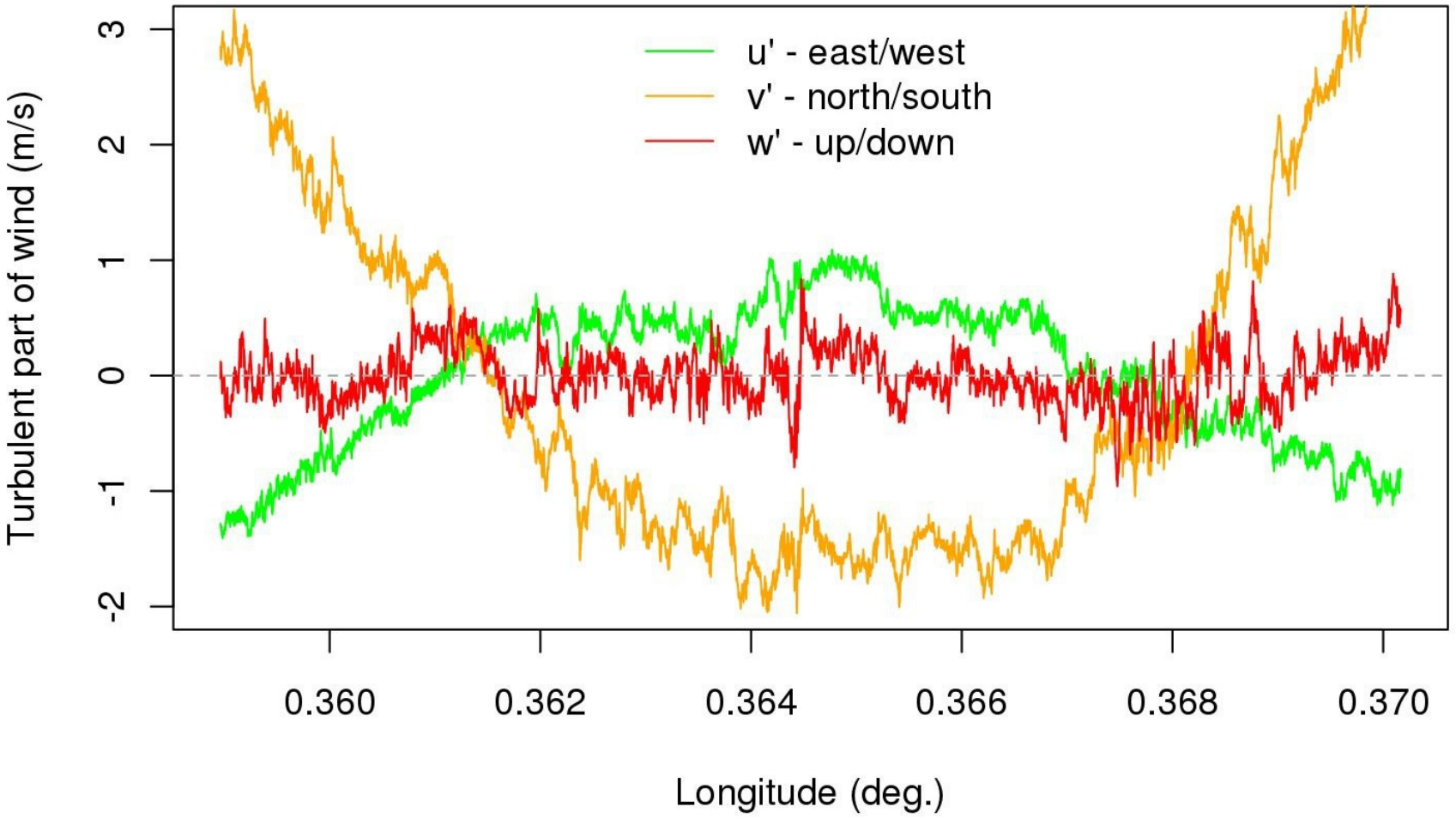
Changes of TKE/m measured at 250 m agl on July 2



Changes of TKE/m measured at different heights on July 2



Turbulent part of wind (outlier at 250 m agl around 23:00 UTC+2)



Conclusion / Outlook

- Decay of TKE observed during late afternoon (as expected)
- Some high TKE values at night due to changes in horizontal wind

- What is 'the best' averaging time for airborne TKE calculation?
  - ➔ Possibility to use multiple legs / add box

- Resolve existing problems with additional flights → increase available data
  - ➔ Upload and share data (finally...) with BLLAST community
  - ➔ Compare / combine with other measurement systems

Thank you for your attention!