SUMO: A Small Unmanned Meteorological Observer for atmospheric boundary layer research

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Motivation

lack of cost-efficient measurement systems in the boundary layer for the horizontal range 100 m ... 10 km

- high spatial and temporal resolution
- capability of taking vertical profiles and horizontal surveys
- small and applicable in remote areas with minimal infrastructure

poorly understood BL processes/phenomena have to be addressed by targeted measurement strategies (e.g. stable boundary layers, entrainment zone)

increasing demand for ABL measurements, e.g. with respect to validation of fine-scale numerical simulations and test and improvement of the underlying BL parameterization schemes

measurements in urbanized areas (street canyons), wind parks ?

SUMO – Technical data

wingspan: 80 cm
length: 75 cm
weight: 580 g

electric powered, motor time per flight: ≈25 min

maximum ascent rate: 15 m/s
average ascent rate: 7-10 m/s

maximum air speed: 35 m/s
average air speed: 12-18 m/s

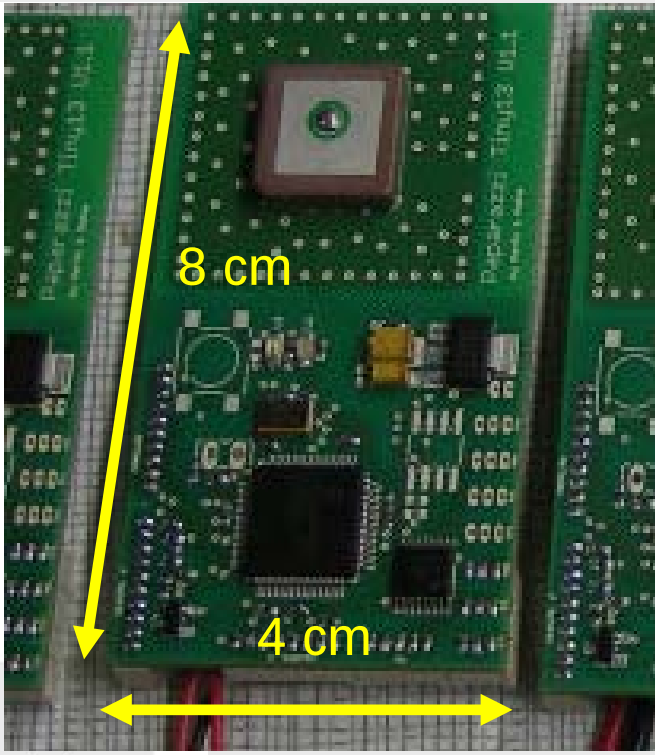
maximum altitude above ground: 3.5-(6) km

airframe:
EPP model construction kit FunJet by Multiplex (ca. 150 €)

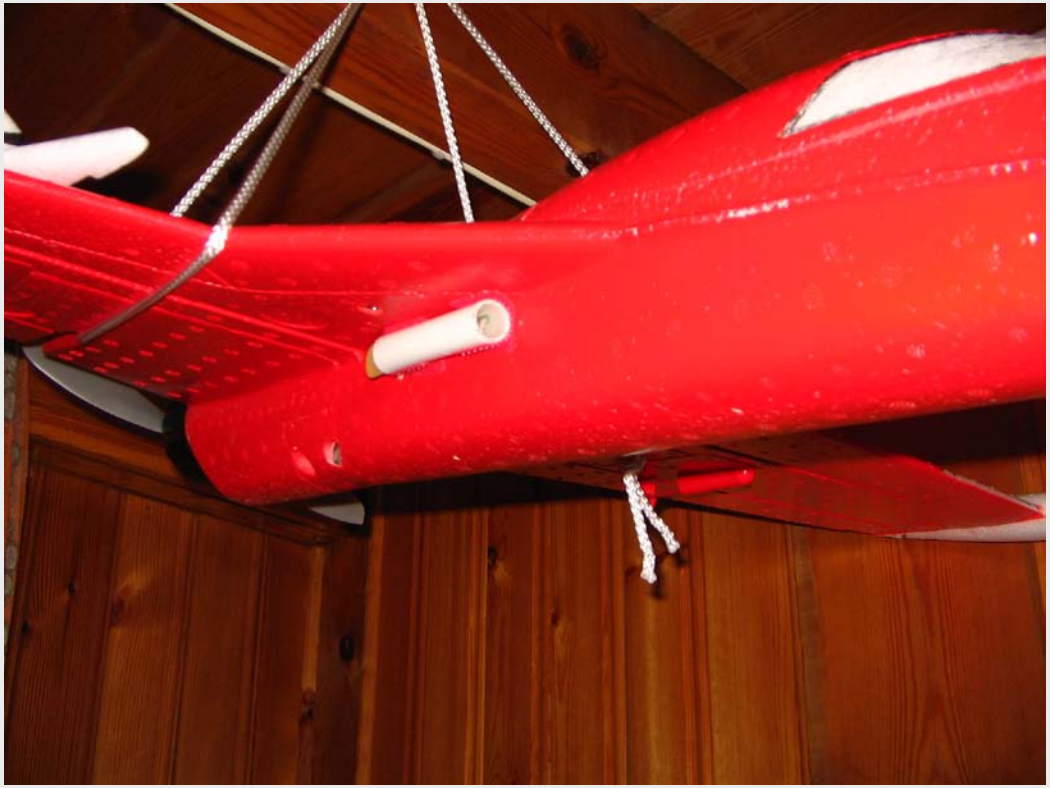
Paparazzi autopilot system

open source (hardware and software) autopilot system hosted by the Ecole Nationale de l'Aviation Civile (ENAC), Toulouse, France

software based on Debian Linux



SUMO – meteorological sensors



data logging

analog and digital input channels
resolution: 12 bit
sampling rate: 4(-60) Hz
4 Hz online data transfer (2.4 GHz)

2 Sensors T, rh

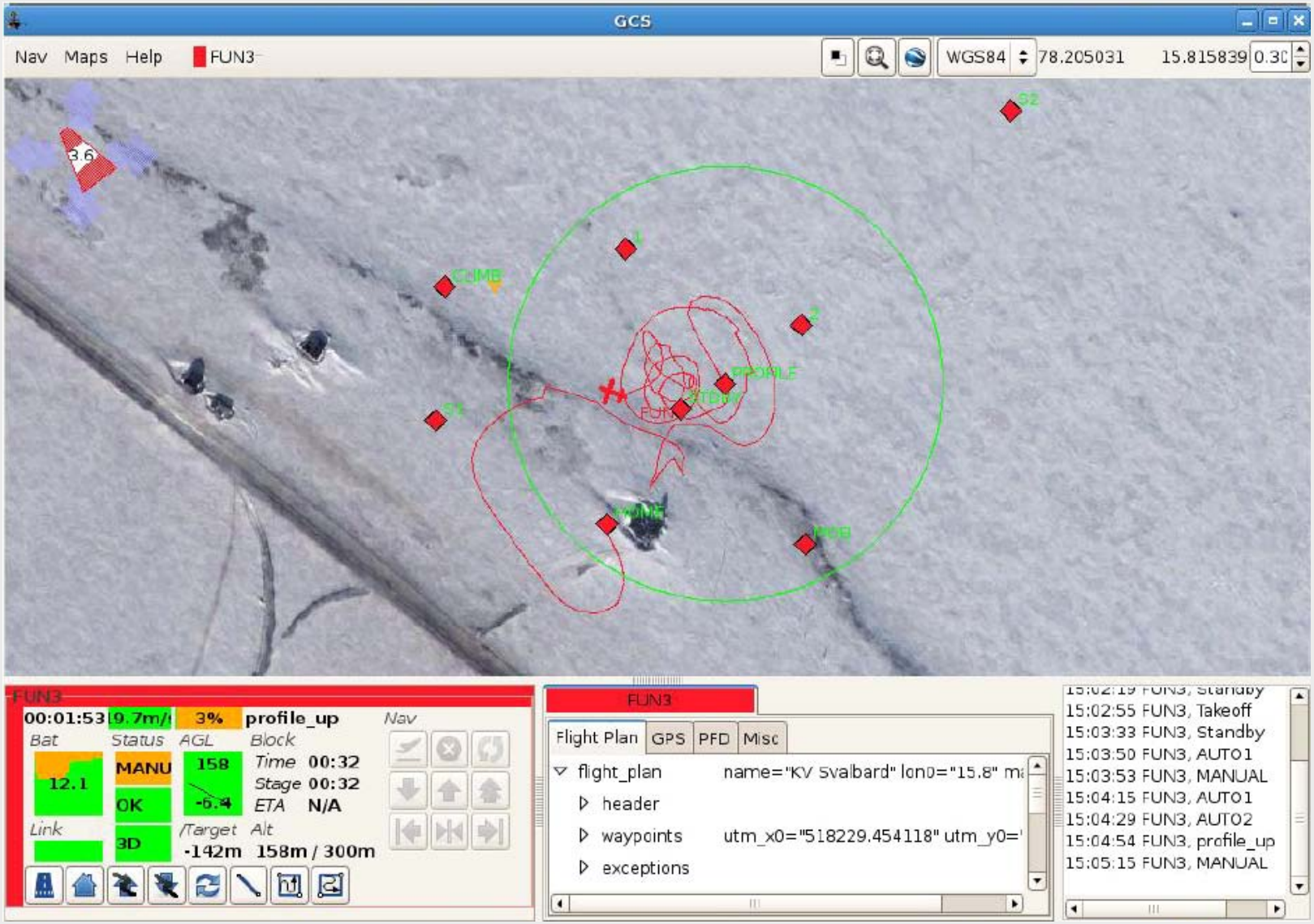
(SHT75 by Sensirion)

T accuracy: 0.2 K
rh accuracy ±2%

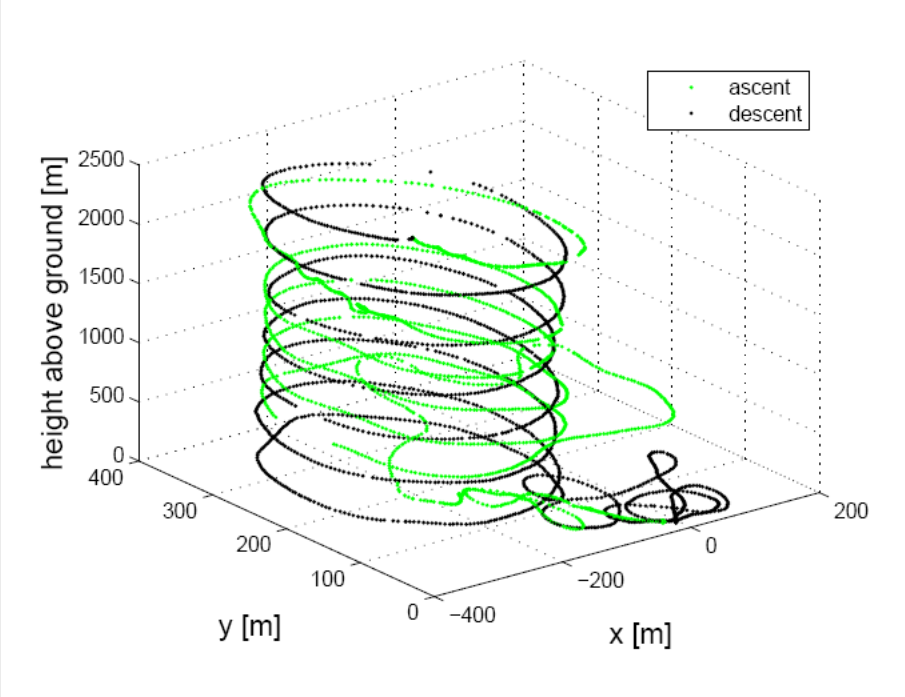
Pressure Sensor

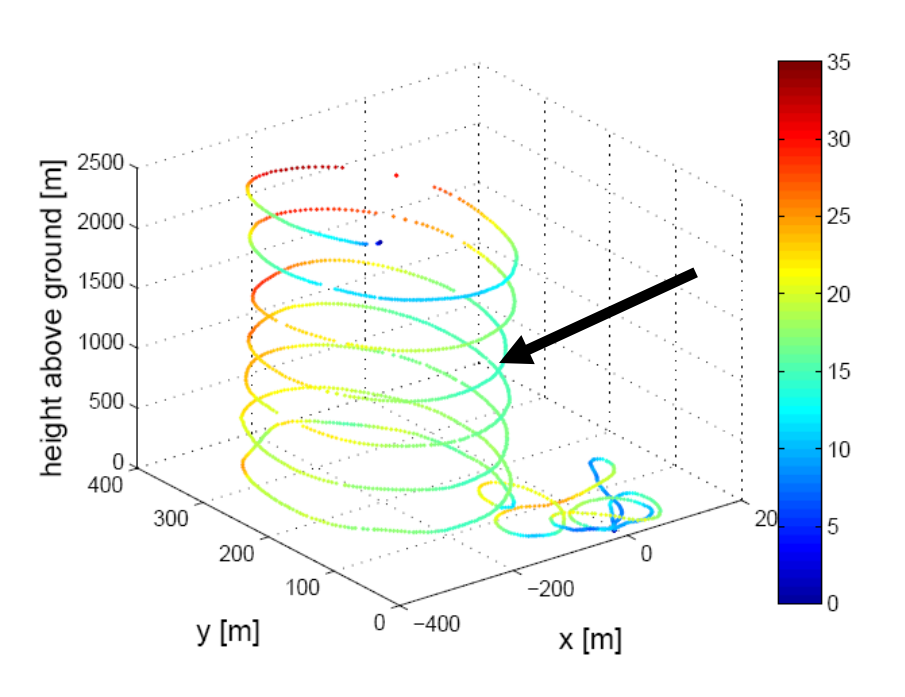
(SPC1000 by VTI Technologies)
range: 1100..200 hPa
p accuracy: ± 0.5 hPa

SUMO – Ground control station

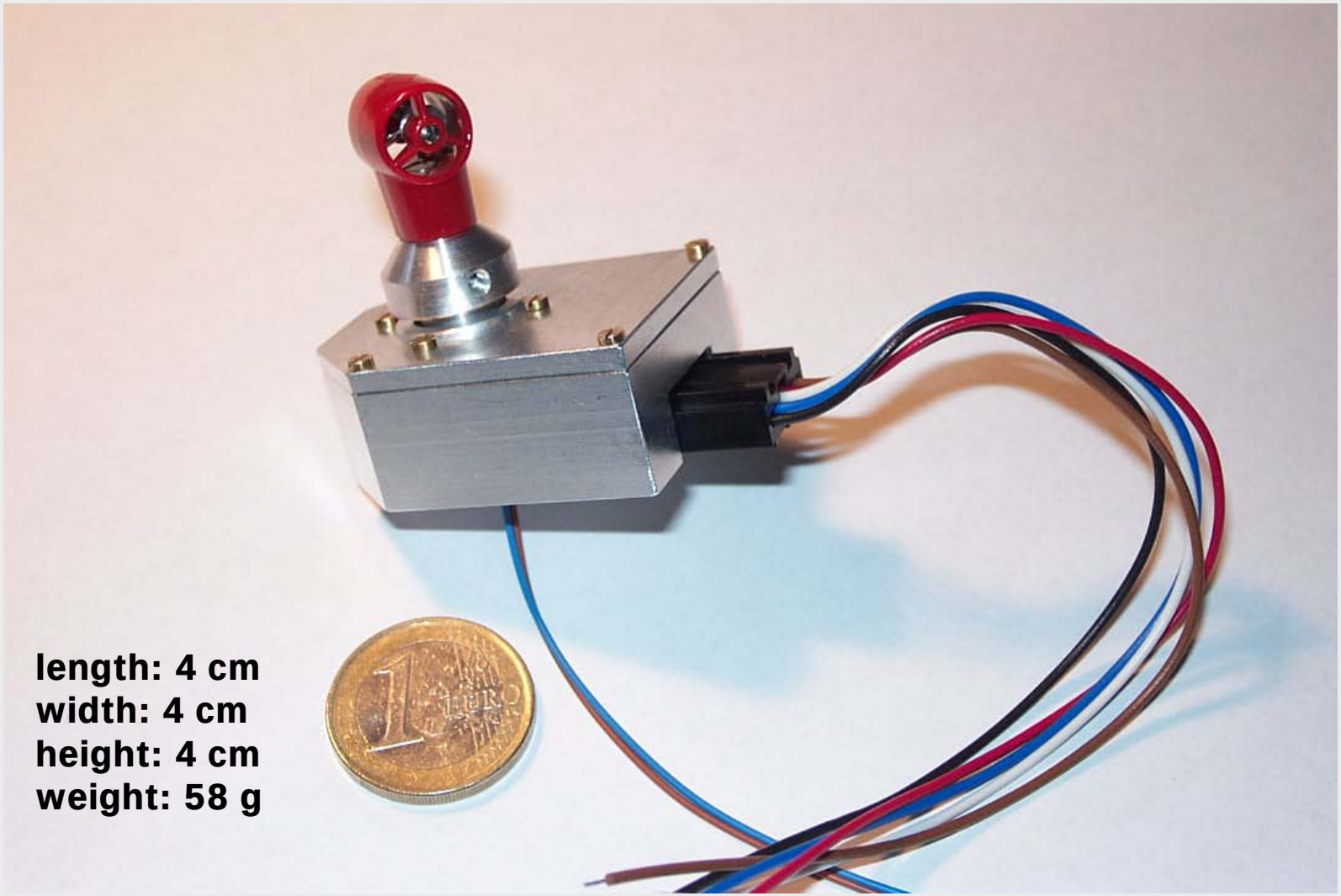


SUMO – operation for atmospheric profiling

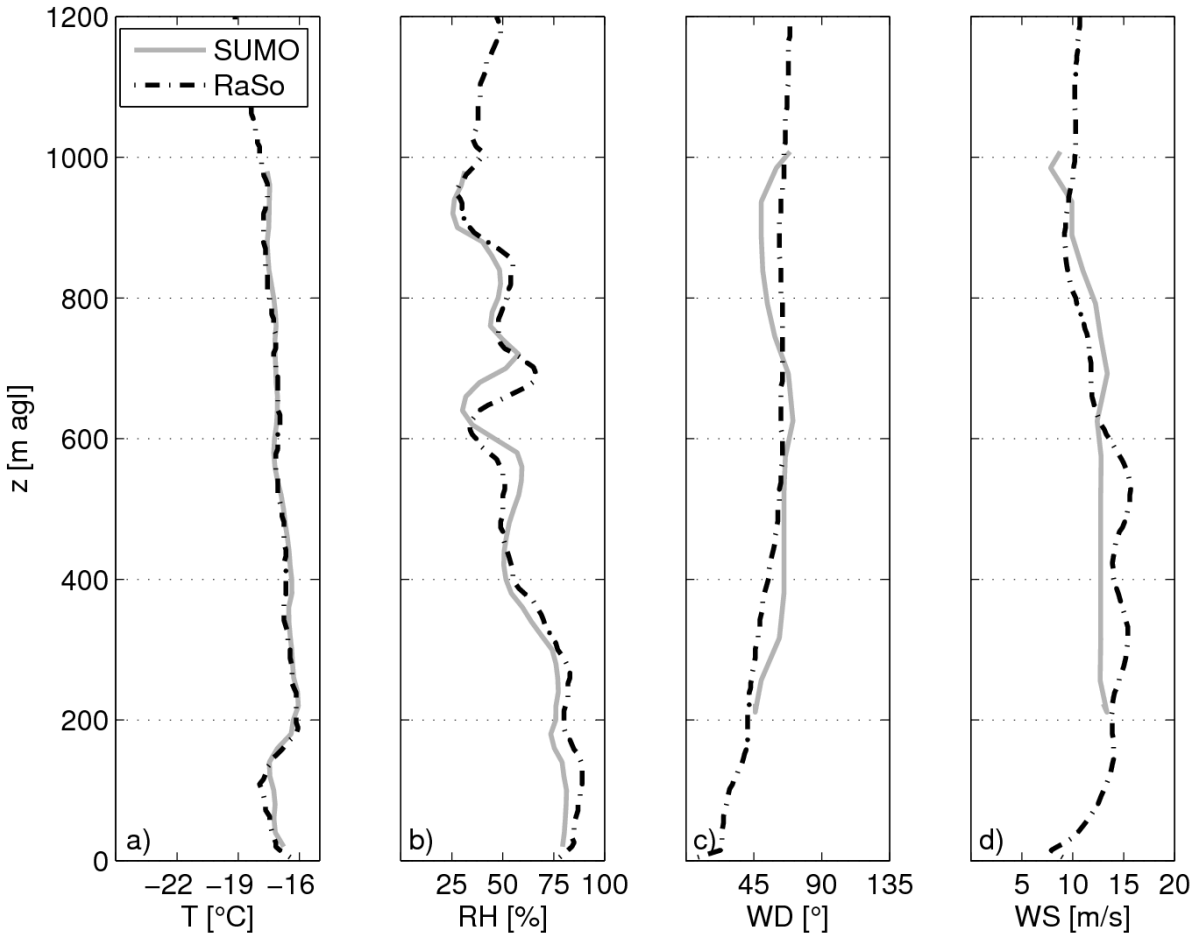




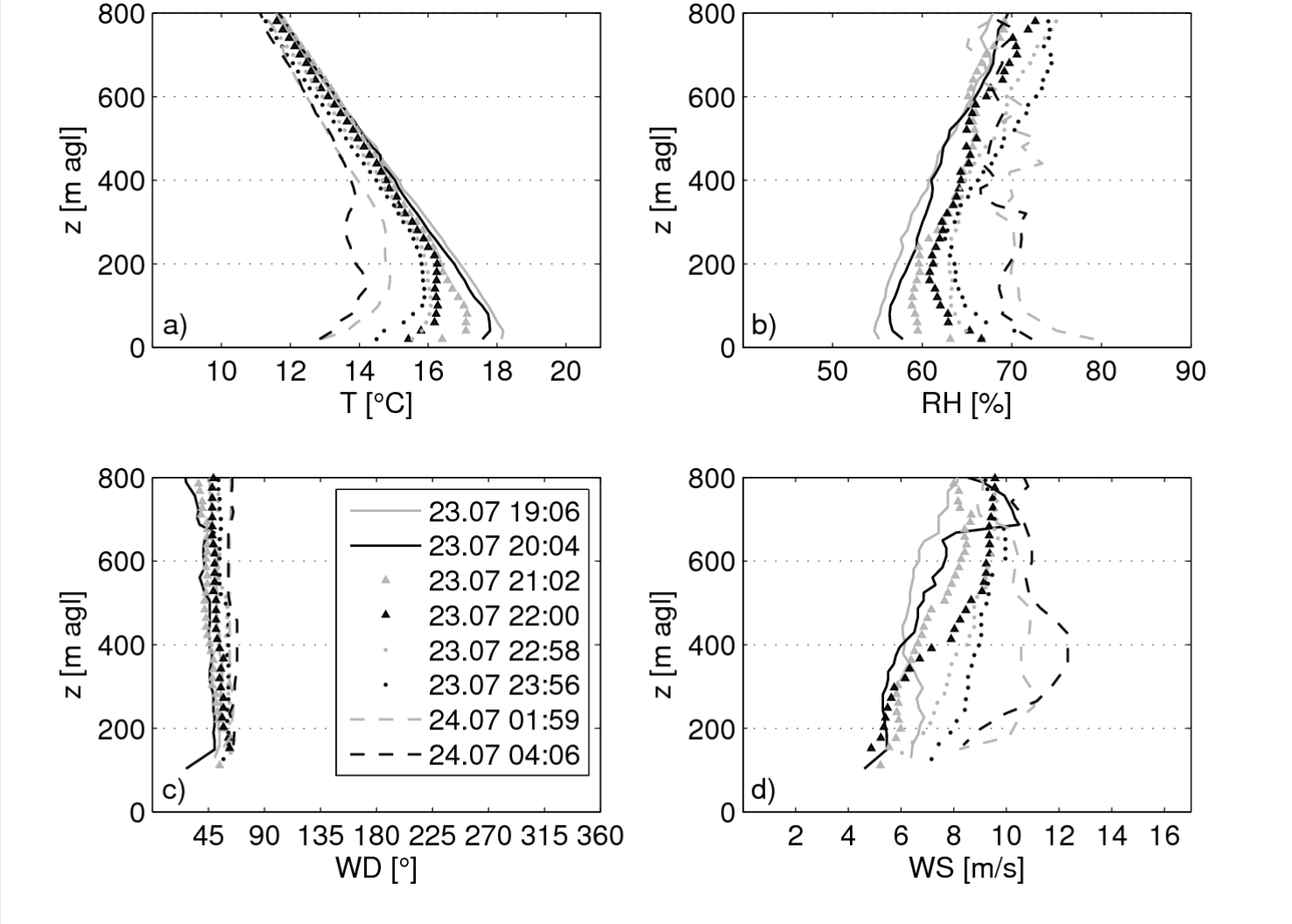
Miniaturized anemometer



SUMO – Intercomparison with radiosonde



SUMO – Development of nocturnal boundary layer



Outlook – Fine scale model validation

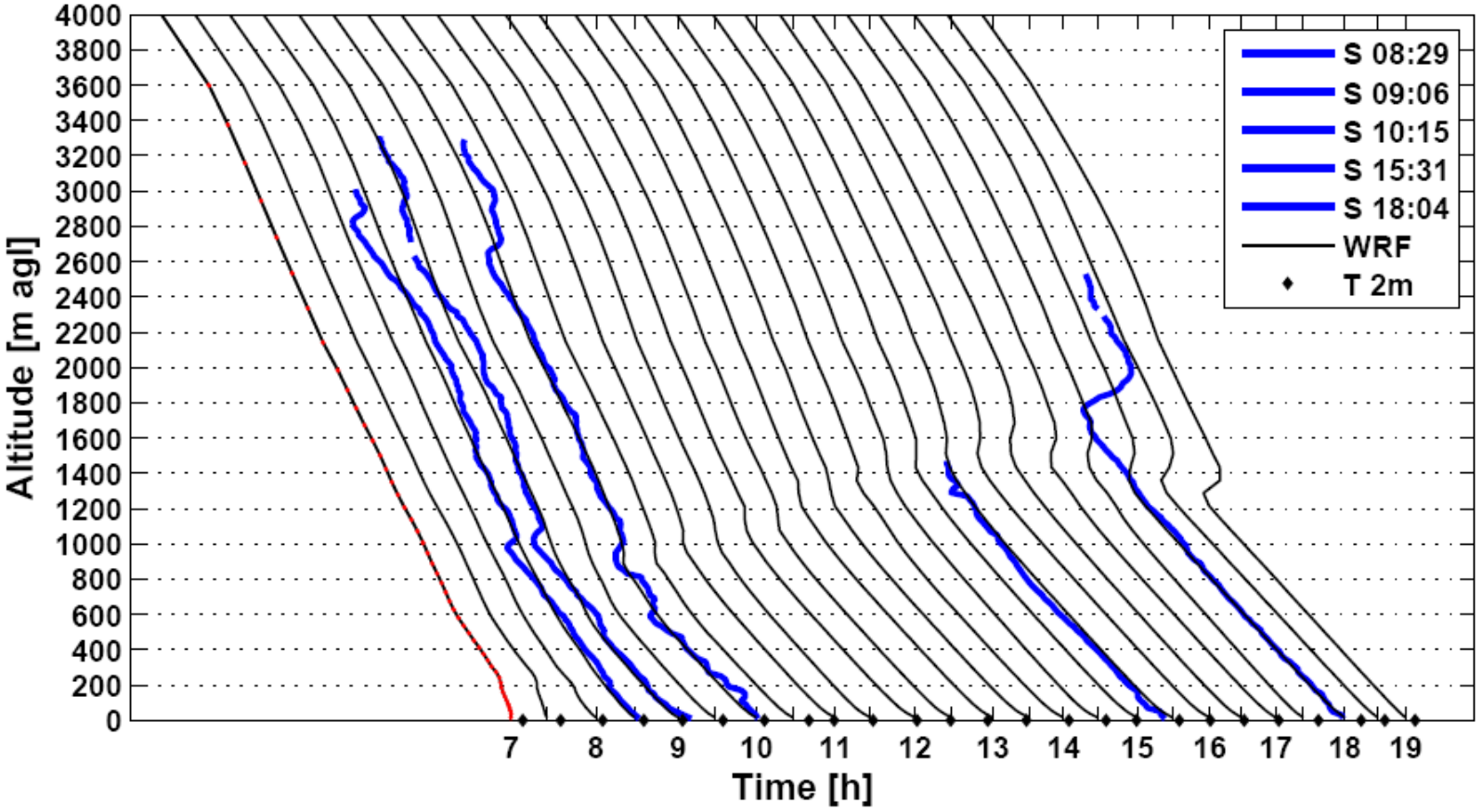


Figure 5.1: *SUMO and WRF temperature profiles, 18.08.2007 Ingolfsskáli. Corresponding ground data are given by black dots. The vertical layers in the model are indicated by red dots on the 07:00 profile.*

Summary and outlook

- SUMO operates as “recoverable radiosonde”; easy to operate, cost efficient, low infrastructural requirements
- SUMO provides profiles of temperature and humidity in comparable quality to established radiosonde systems; wind algorithm has potential for improvement
- ongoing work on an alternate wind sensor (miniaturized anemometer)

- open source autopilot system easily adaptable to other airframes
- potential of parallel operation of several aircrafts
- measurements of low platform impact (capping inversions)
- aircraft as “turbulence probe”

- **Important task: definition, homogenization of rules for (really legal) UAV operation**

COST Action ES0802

COST Action ES0802:
“Unmanned aerial systems (UAS) in atmospheric research”

The main objective of the proposed action is the coordination of ongoing and the conception of future research on the development and application of unmanned aerial systems (UAS) to provide a cost-efficient, trans-boundary method for the monitoring of the atmospheric boundary layer and the underlying surface of the Earth.

- Norway, France, United Kingdom, Germany, Spain, Poland, Iceland, Sweden, Netherlands, Finnland, Switzerland, Cyprus

- Official start with kick-off meting on 20.11.

COST ES0802 Organisation – 5 Working Groups

WG 1: UA systems (electric and aircraft engineering, micro electronics, communication technology, informatics)

airframes, autopilot systems, propulsion, battery, ground stations, data transmission

WG 2: UAS sensors for atmospheric research (electric engineering, micro electronics, meteorology)

WG 3: High resolution 3D atmospheric measurements (meteorology, climatology, informatics, statistics)

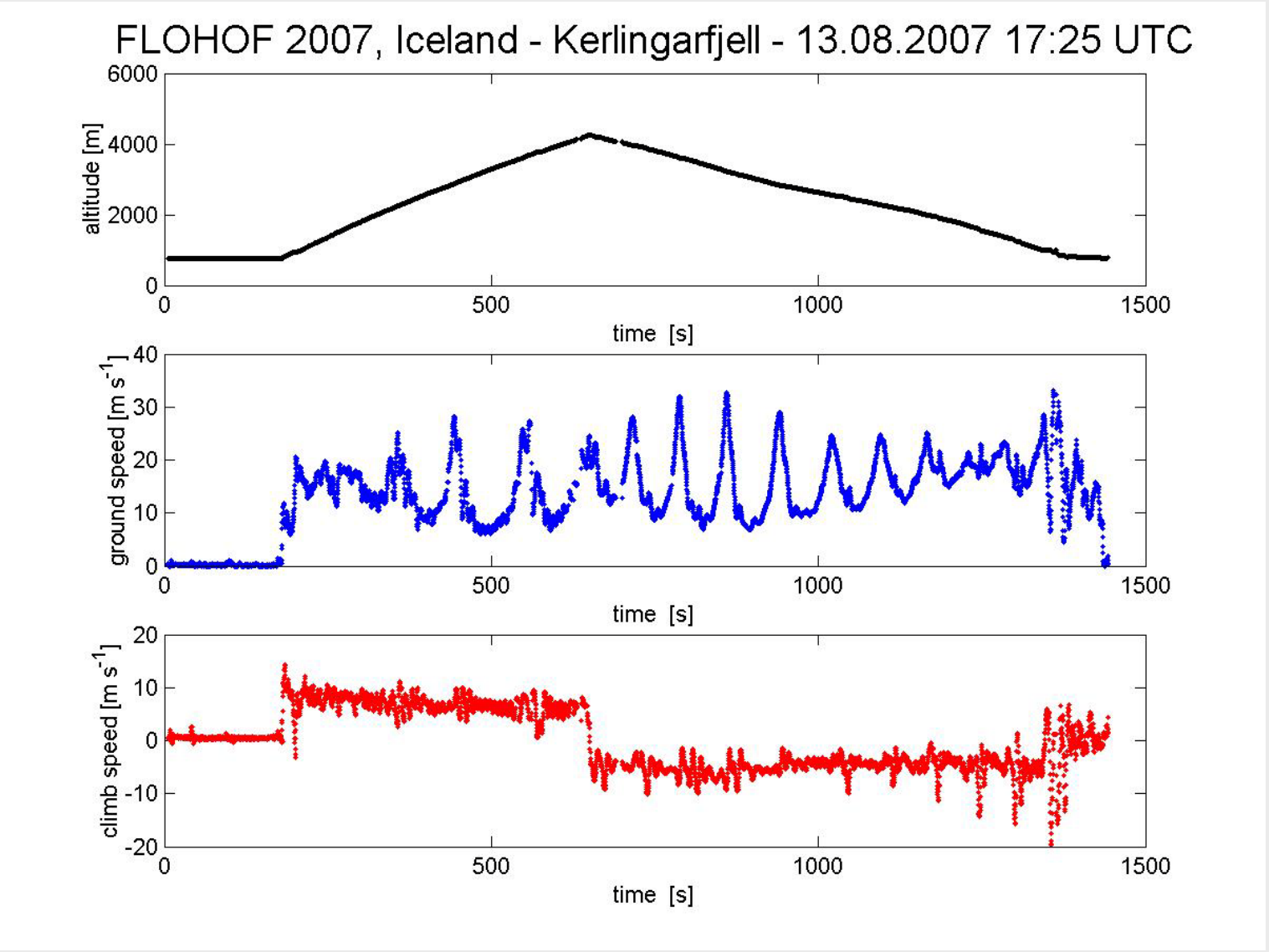
WG 4: UAS operation (law, air traffic control, electric and aircraft engineering, meteorology)

legal aspects of UAS operation; UAS operation in extreme/dangerous/hazardous environments

WG 5: the future of UAS in atmospheric research (all above)

Next time you hear SUMO.....

SUMO – aircraft parameters during profile flight



SUMO – sensor time lag correction