

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



airframe:

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

wingspan: 80 cm

length: 75 cm

weight: 580 g

electric powered, motor time
per flight: \approx 25 min

maximum ascent rate: 15 m/s

average ascent rate: 7-10 m/s

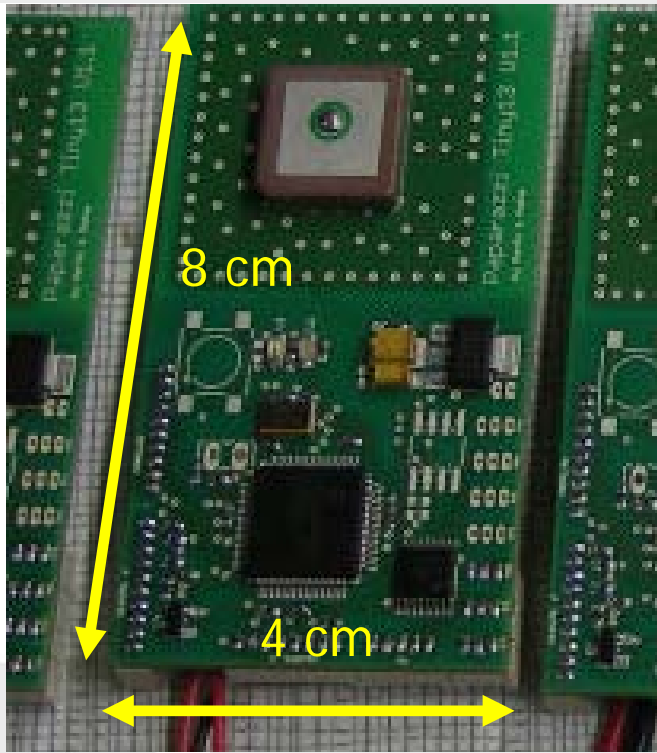
maximum air speed: 35 m/s

average air speed: 12-18 m/s

maximum altitude above
ground: 3.5-(6) km

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 $\pm 2\%$

Pressure Sensor (SPC1000 by VTI Technologies)

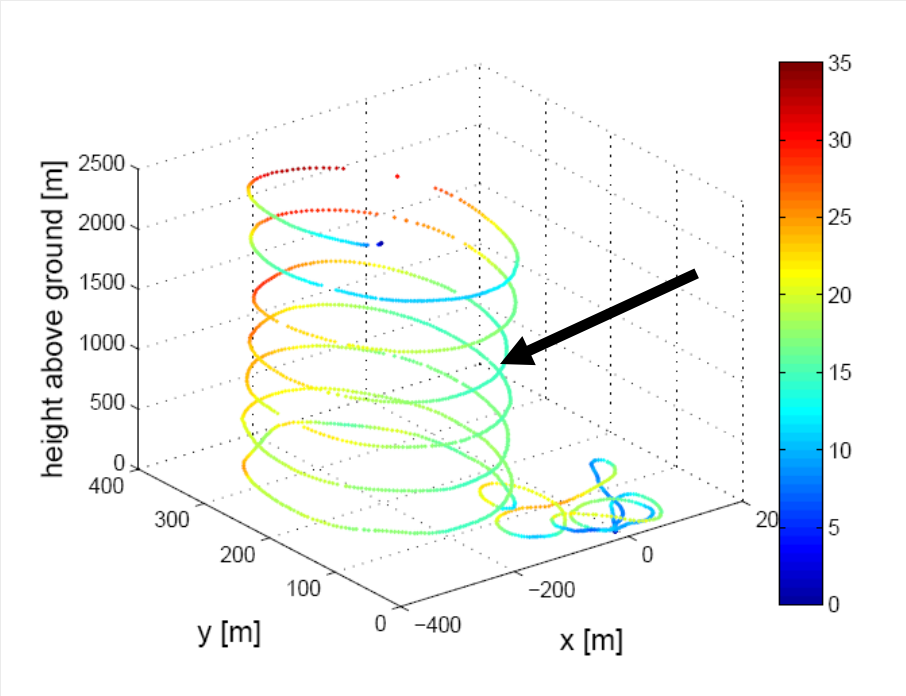
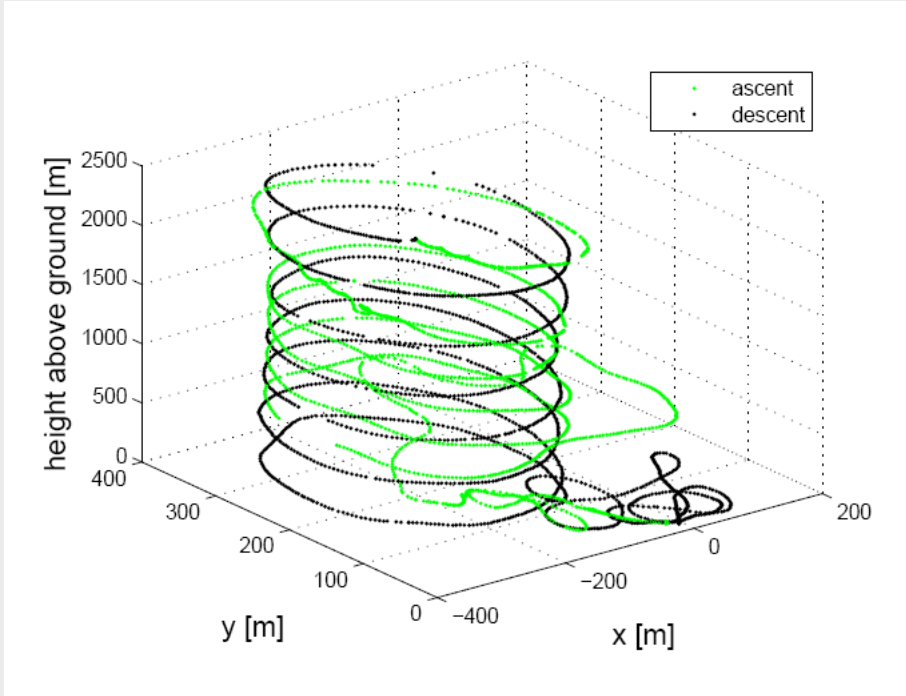
range: 1100..200 hPa
p accuracy: ± 0.5 hPa

SUMO – Ground control station

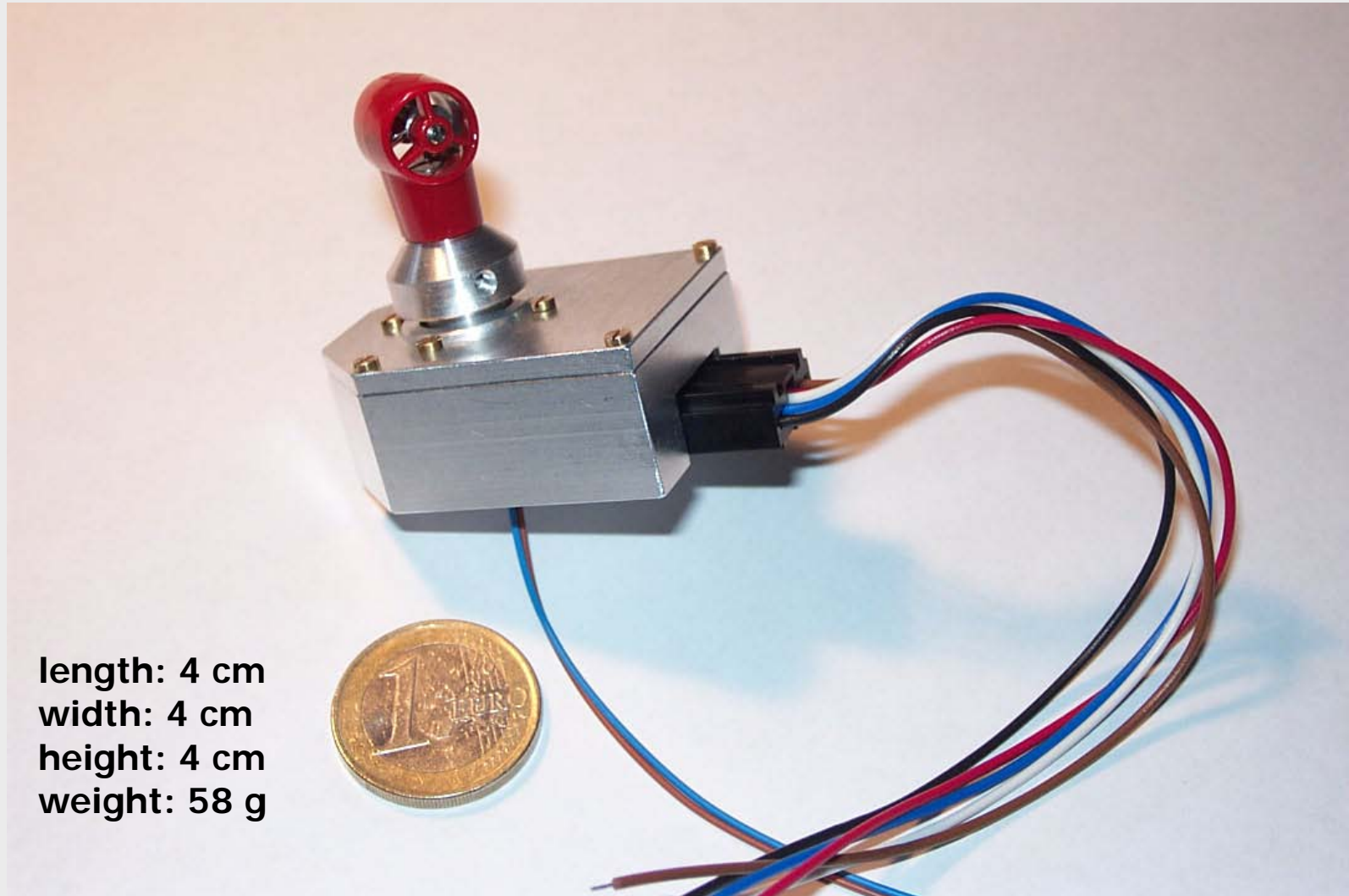
The screenshot displays the SUMO GCS interface with the following components:

- Top Bar:** Window title 'GCS', menu items 'Nav Maps Help', and a red status indicator for 'FUN3'. On the right, there are icons for map operations and coordinate data: 'WGS84', '78.205031', '15.815839', and a zoom level of '0.30'.
- Map View:** Aerial imagery showing a flight path with red lines and waypoints marked with red diamonds. A green circle highlights a specific area. A red triangle in the top left corner contains the number '3.6'.
- Left Panel (FUN3):**
 - Time: 00:01:53
 - Bat: 12.1
 - Status: MANU
 - AGL: 158
 - Block: 3%
 - Time: 00:32
 - Stage: 00:32
 - ETA: N/A
 - Link: 3D
 - Target Alt: -142m 158m / 300m
- Right Panel (FUN3):**
 - Flight Plan: GPS, PFD, Misc
 - flight_plan: name="KV svalbard" lon0="15.8" mi
 - header
 - waypoints: utm_x0="518229.454118" utm_y0=
 - exceptions
- Log Panel:**
 - 15:02:19 FUN3, Standby
 - 15:02:55 FUN3, Takeoff
 - 15:03:33 FUN3, Standby
 - 15:03:50 FUN3, AUTO1
 - 15:03:53 FUN3, MANUAL
 - 15:04:15 FUN3, AUTO1
 - 15:04:29 FUN3, AUTO2
 - 15:04:54 FUN3, profile_up
 - 15:05:15 FUN3, MANUAL

SUMO – operation for atmospheric profiling

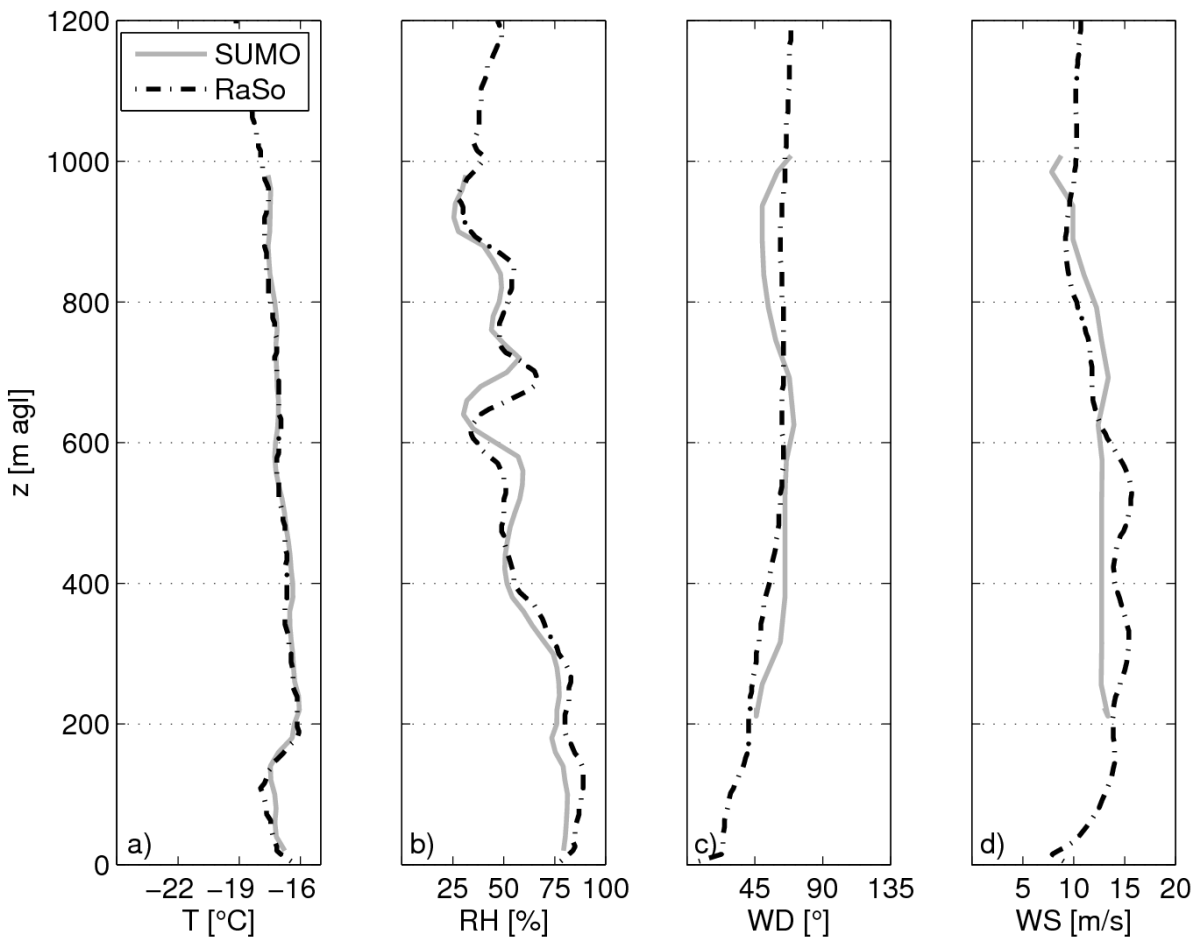


Miniaturized anemometer

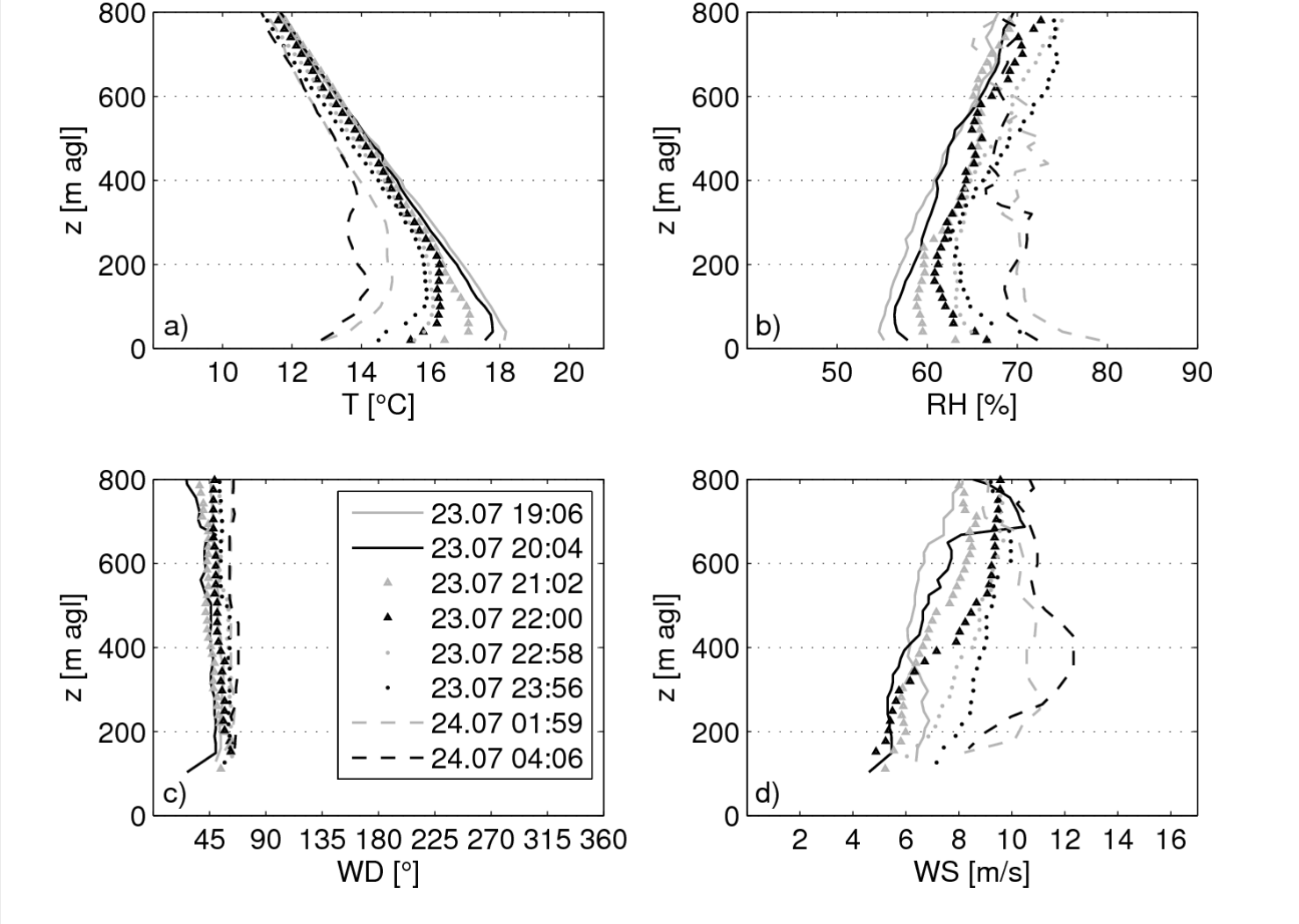


length: 4 cm
width: 4 cm
height: 4 cm
weight: 58 g

SUMO – Intercomparison with radiosonde



SUMO – Development of nocturnal boundary layer



Outlook – Fine scale model validation

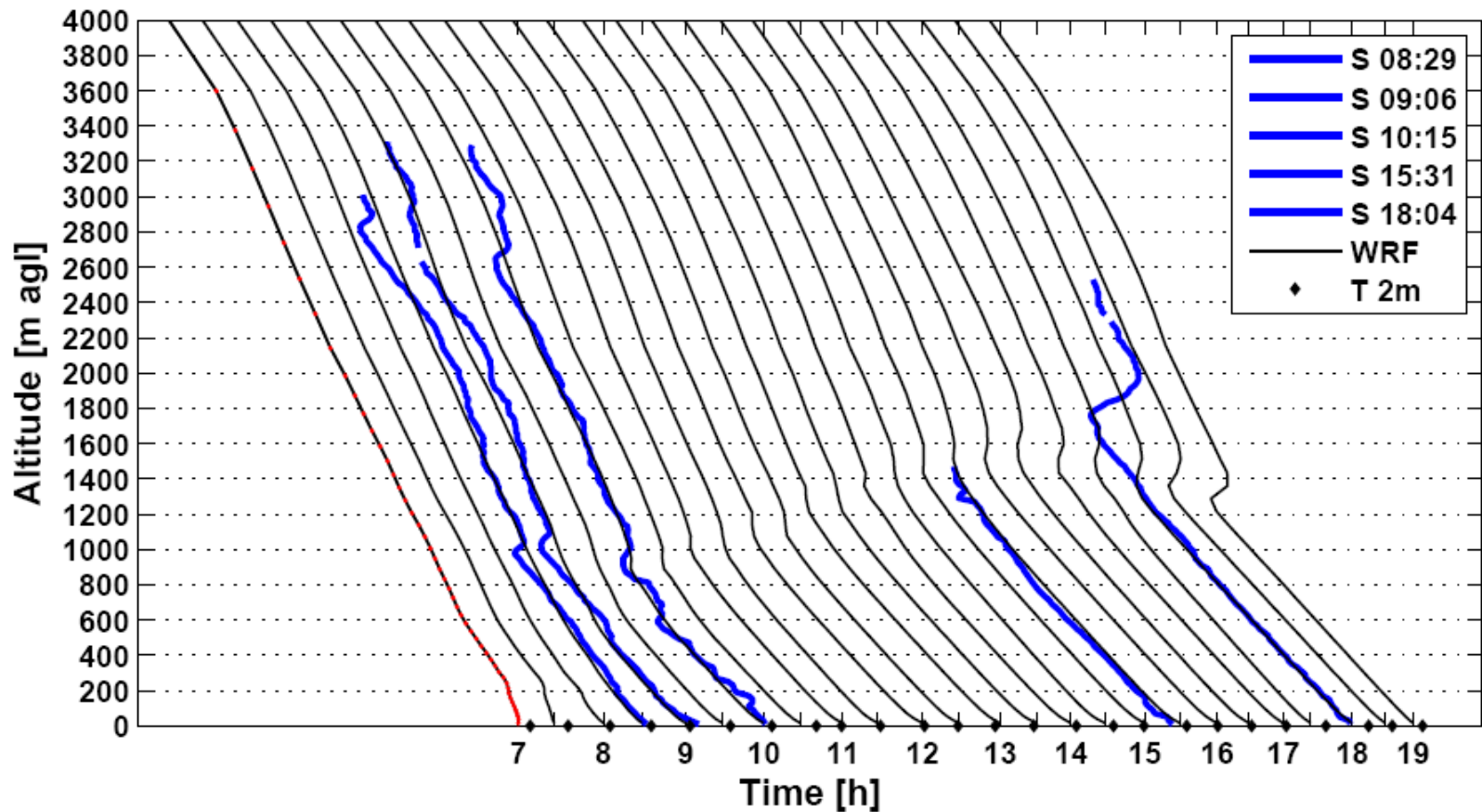


Figure 5.1: *SUMO and WRF temperature profiles, 18.08.2007 Ingolfsskáli. Corresponding ground data are given by black dots. The vertical layers in the model are indicated by red dots on the 07:00 profile.*

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, Finland, Switzerland, Cyprus
- Official start with kick-off meeting 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.....



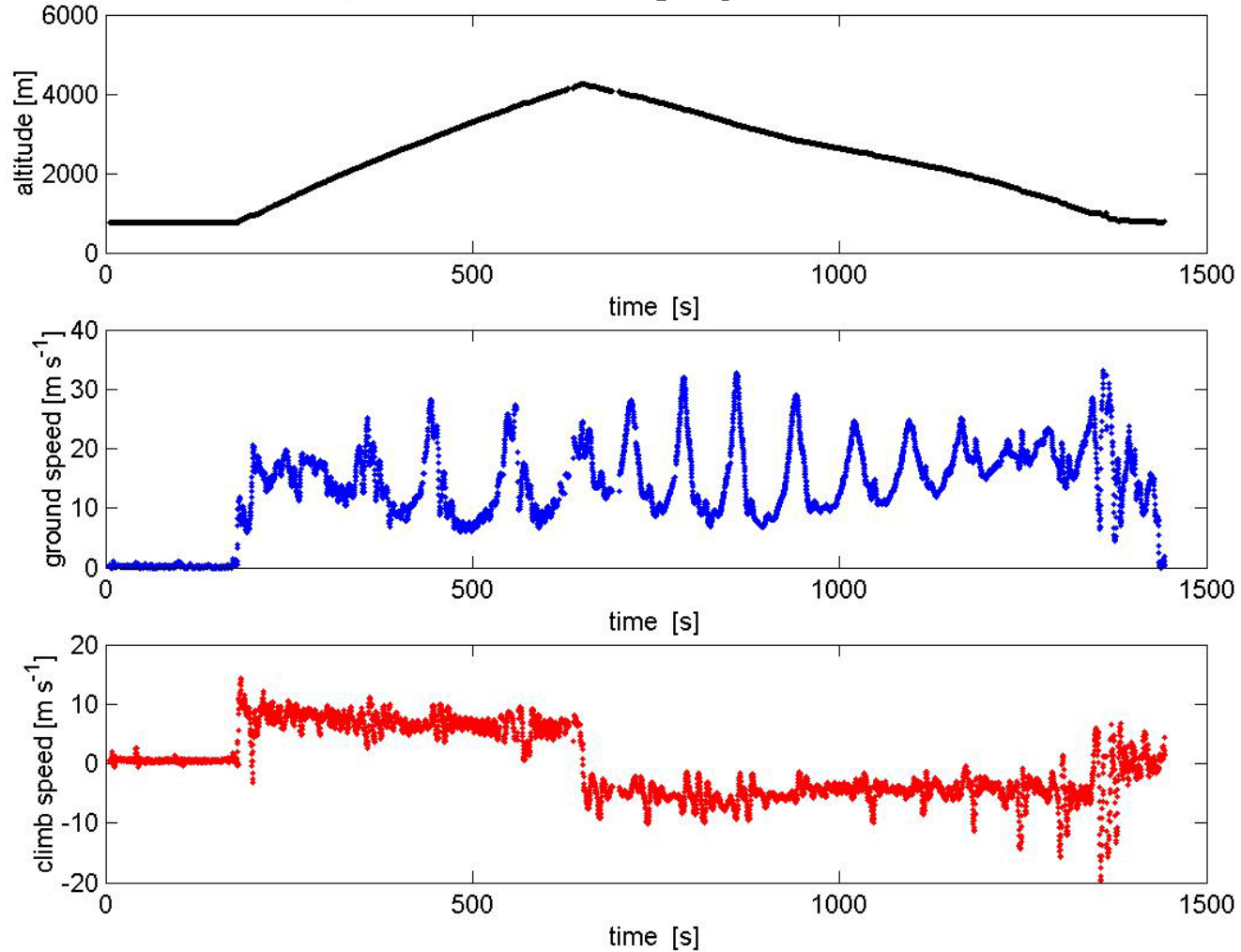
...you should think about flying

Questions ?



SUMO – aircraft parameters during profile flight

FLOHOF 2007, Iceland - Kerlingarfjell - 13.08.2007 17:25 UTC



SUMO – sensor time lag correction

