Universitat de Barcelona,
Departament Fisica Aplicada

Akaflieg Frankfurt e.V.

Goethe-Universität
Institut für Atmosphäre und Umwelt

Exploring gravity waves in the Pyrenees by ground based observations, in-flight measurements, and model analysis

Elena Mascus

OSTIV Met Panel

2nd - 3rd of February, 2018

Bremen

CONTENTS

1. The campaign *La Cerdanya 2017*

2. Model evaluation using observations and flight data - Bachelor Thesis

3. In-flight measurements - Akaflieg Frankfurt Wave Research Camp

1

The campaign
La Cerdanya 2017

The study site
La Cerdanya Valley

- 1100 m MSL
- eastern Pyrenees

IBERIAN PENINSULA

CATALONIA

LA CERDANYA

Project ATMOUNT

ATmosphere-surface interactions in **MOUNT**ain areas

OBJECTIVES

- to study the dynamics of the **precipitation processes** influenced by orographic effects
- to improve the **knowledge of mountain waves** and associated processes
- to analyze the **interaction of gravity waves** with cloud structures and its influence on **precipitation**.

Project ATMOUNT

ATmosphere-surface interactions in **MOUNT**ain areas

Météo France

Meteo Catalunya

University of Barcelona

University of Portsmouth

University of the Balearic Islands

La Cerdanya 2017 field experiment

ATMOUNT

October November Dezember January February March April

LA CERDANYA 2017 FIELD EXPERIMENT

GWOP'17

Gravity Waves and Orographic Precipitation

CCP'17

Cerdanya Cold Pools

INSTRUMENTATION

LIDAR
(METEO-FRANCE)

UHF RADAR
(METEO-FRANCE)

MWR RADIOMETER
(METEO-FRANCE)

WINDRASS
(METEOCAT)

RADIOSONDE
(METEOCAT)

AUTOMATIC MET. SURFACE STATIONS
(UB, METEOFRANCE)

TETHERED BALLOON
(UIB)

EDDY COVARIANCE STATION
(METEOCAT)

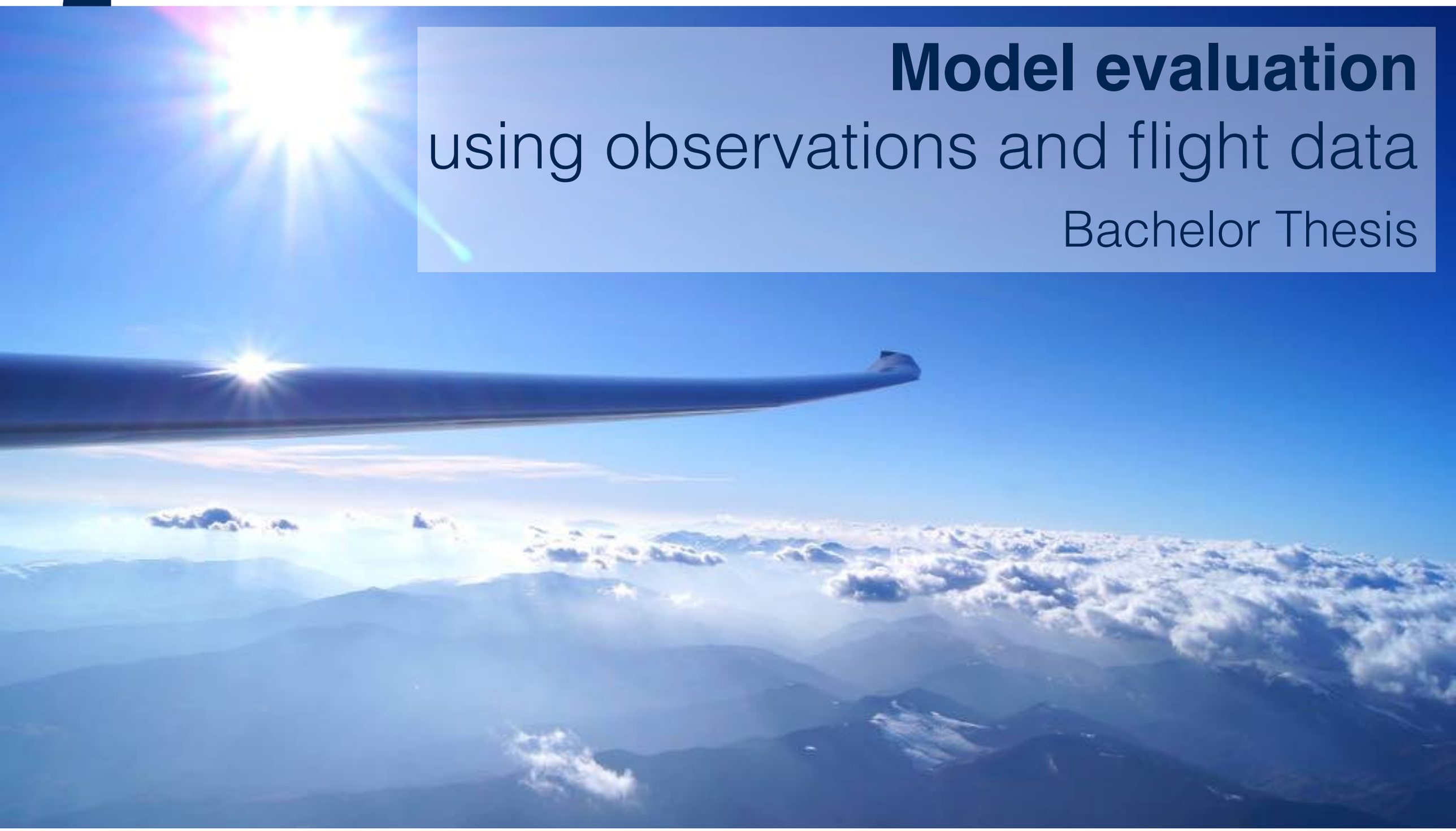
MRR (Micro Rain Radar)
(UB)

DISDROMETER
(UB)

CEILOMETER
(Laboratoire d'Aerologie)

2

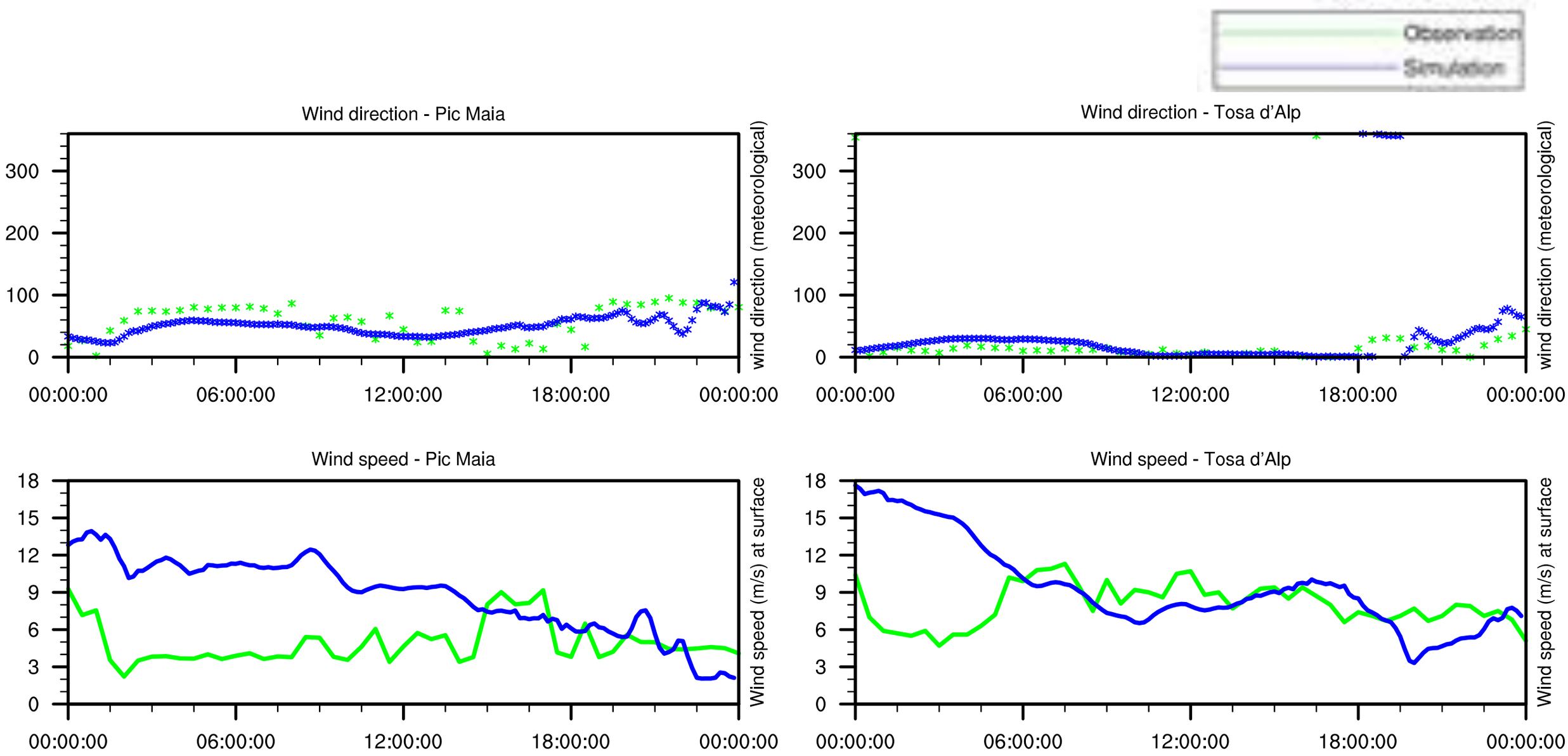
Model evaluation
using observations and flight data
Bachelor Thesis



Model evaluation

Comparison with ground based observations

SURFACE STATIONS



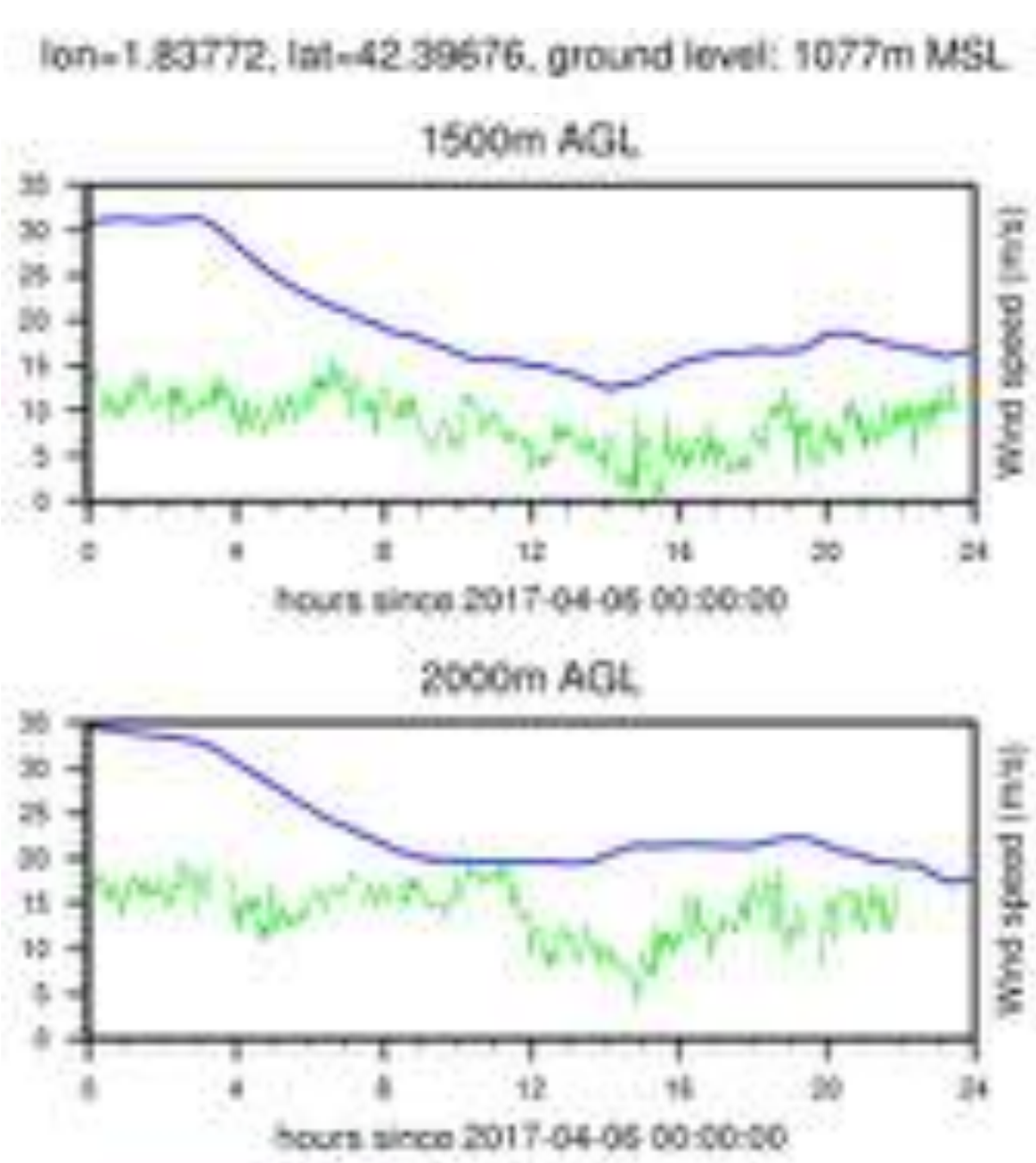
Pic Maià: 2614m

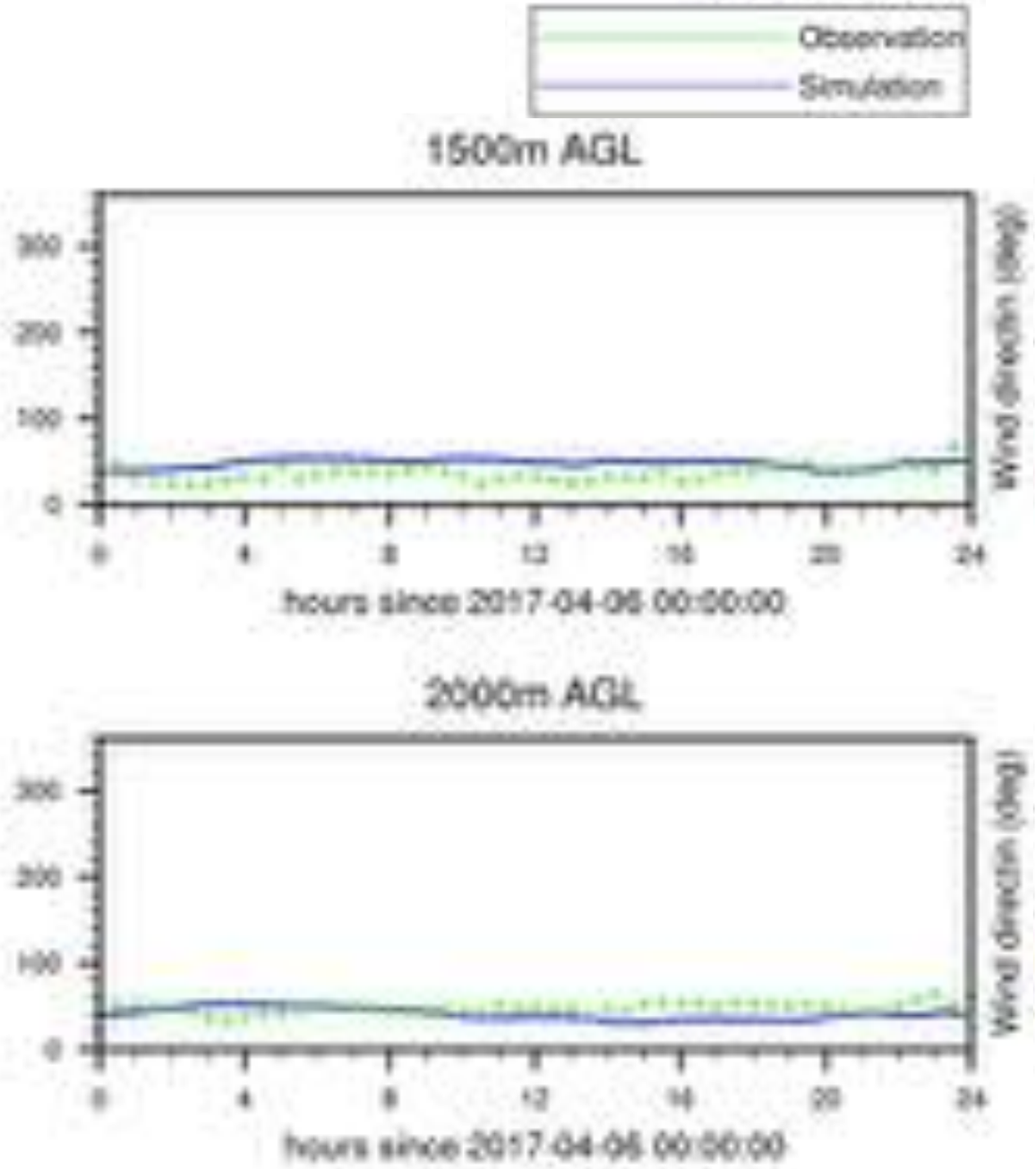
Tosa d'Alp: 2478m

Model evaluation

Comparison with ground based observations

ULTRA HIGH FREQUENCY WIND PROFILER

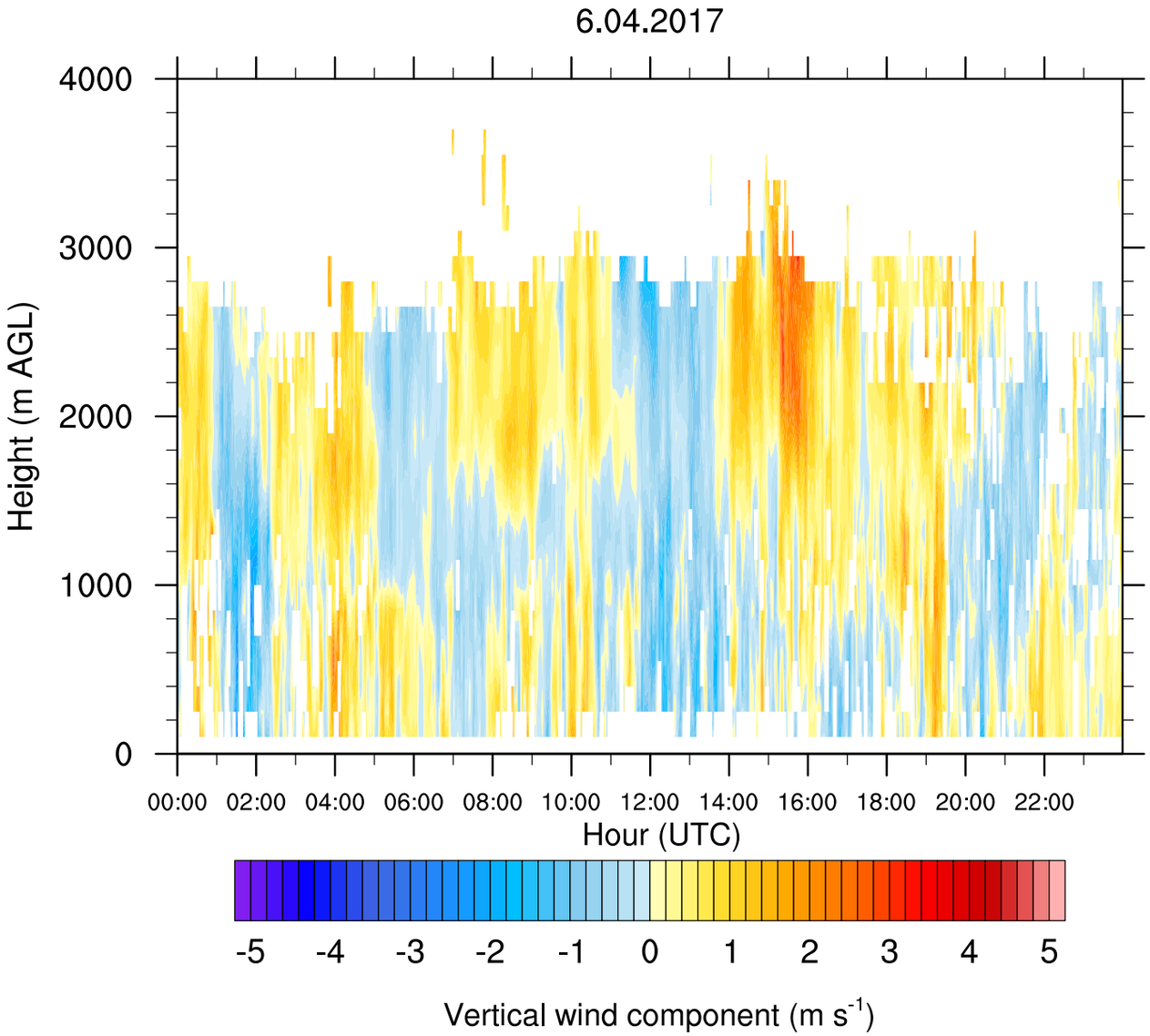




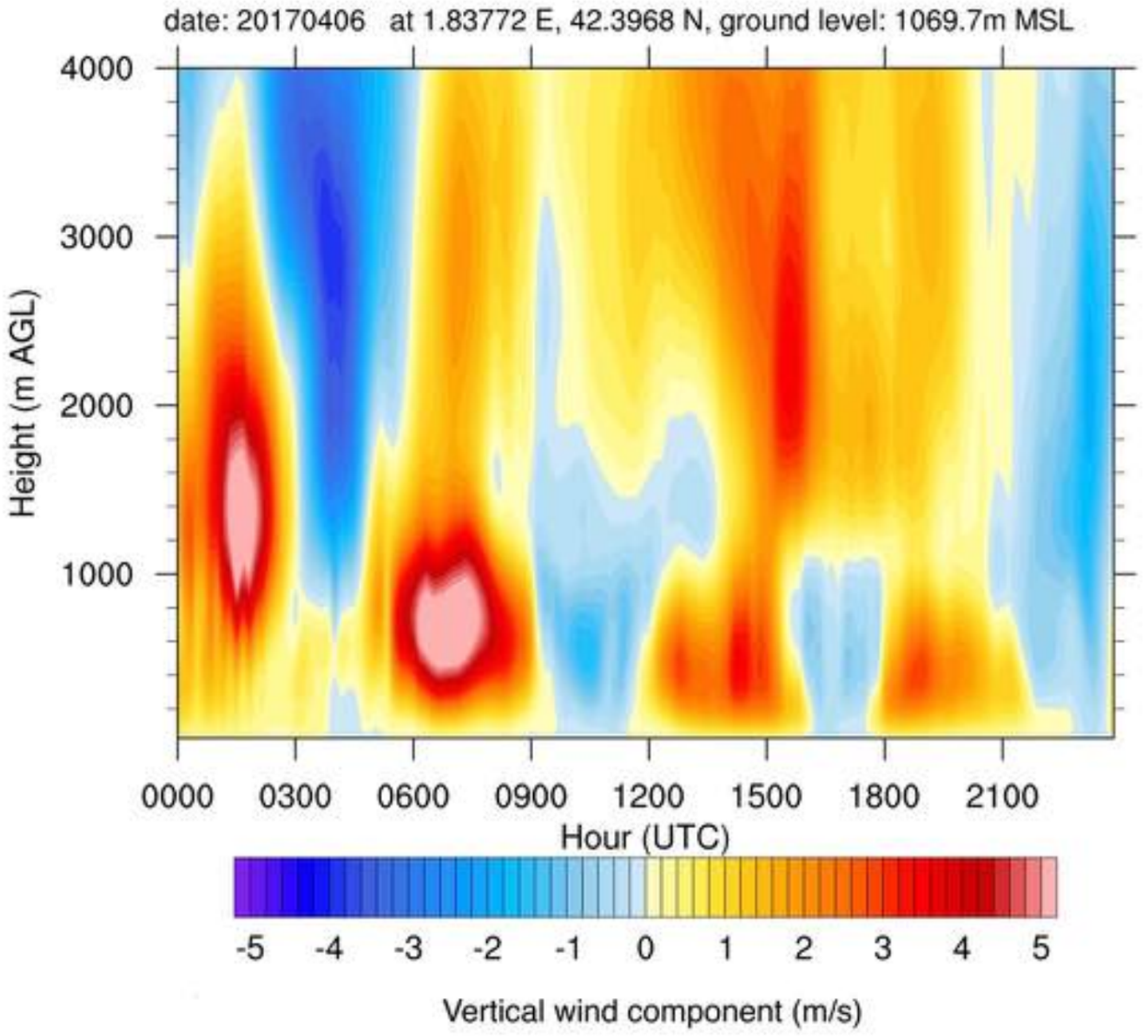
Model evaluation

Vertical velocity

UHF MEASUREMENTS



WRF MODEL

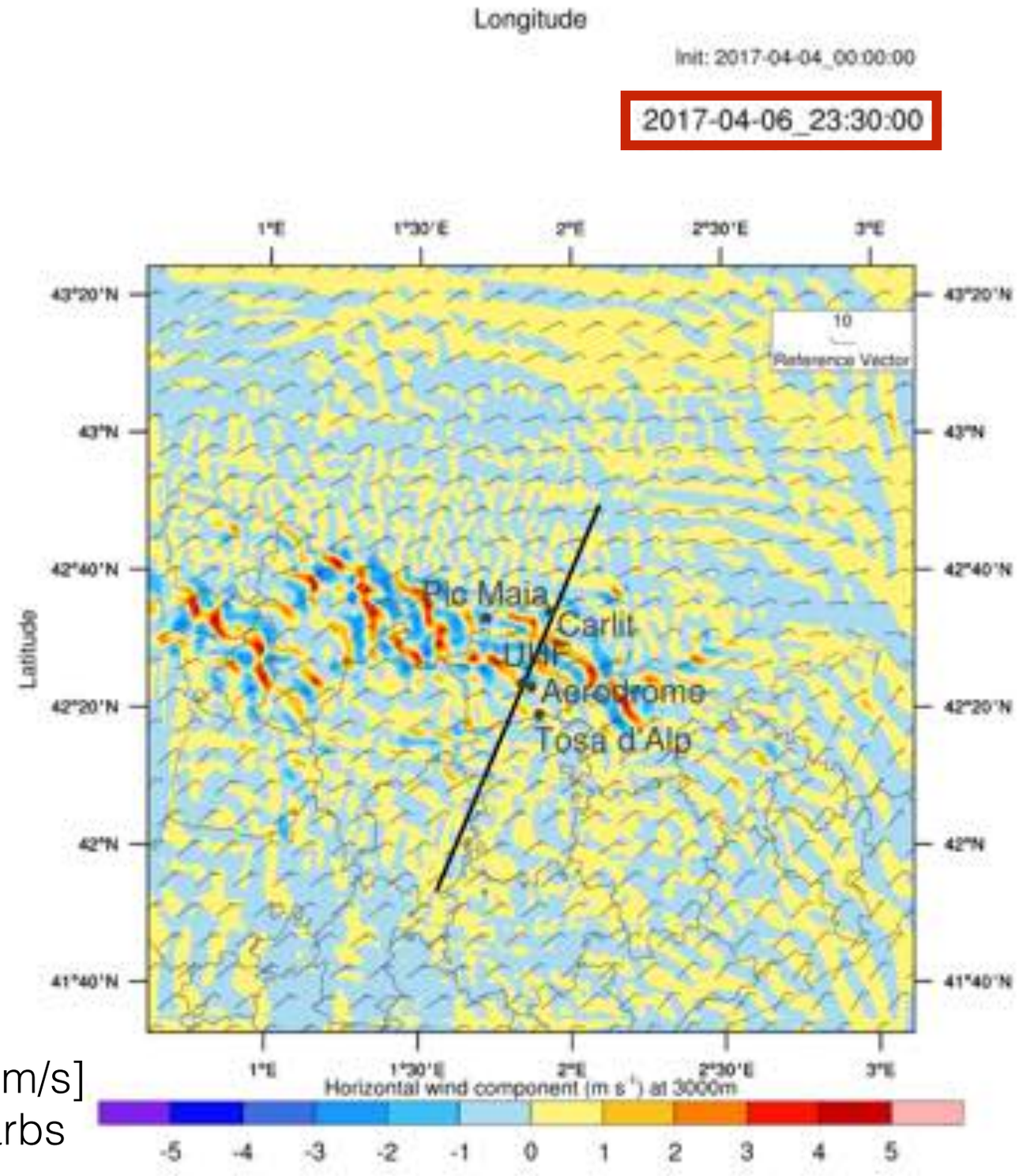


→ Overestimated and temporally displaced simulated vertical velocity as a consequence from the exaggerated horizontal wind speed especially during the first half of the day

Animation

Plane section in 3000m MSL

Development of the vertical and horizontal wind speed during 24 h

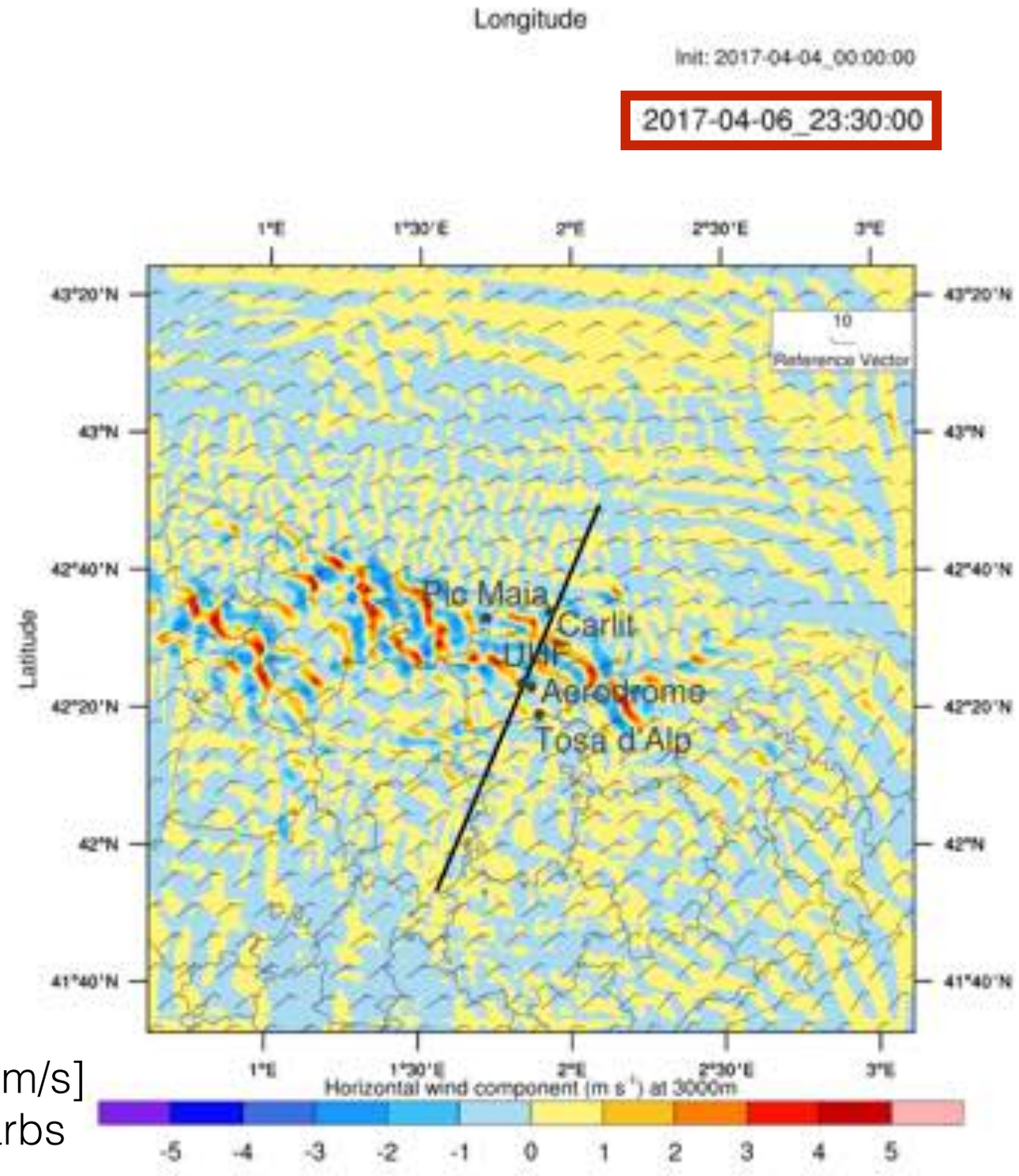


Vertical speed = shaded [m/s]
Horizontal wind = wind barbs

Animation

Plane section in 3000m MSL

Development of the vertical and horizontal wind speed during 24 h

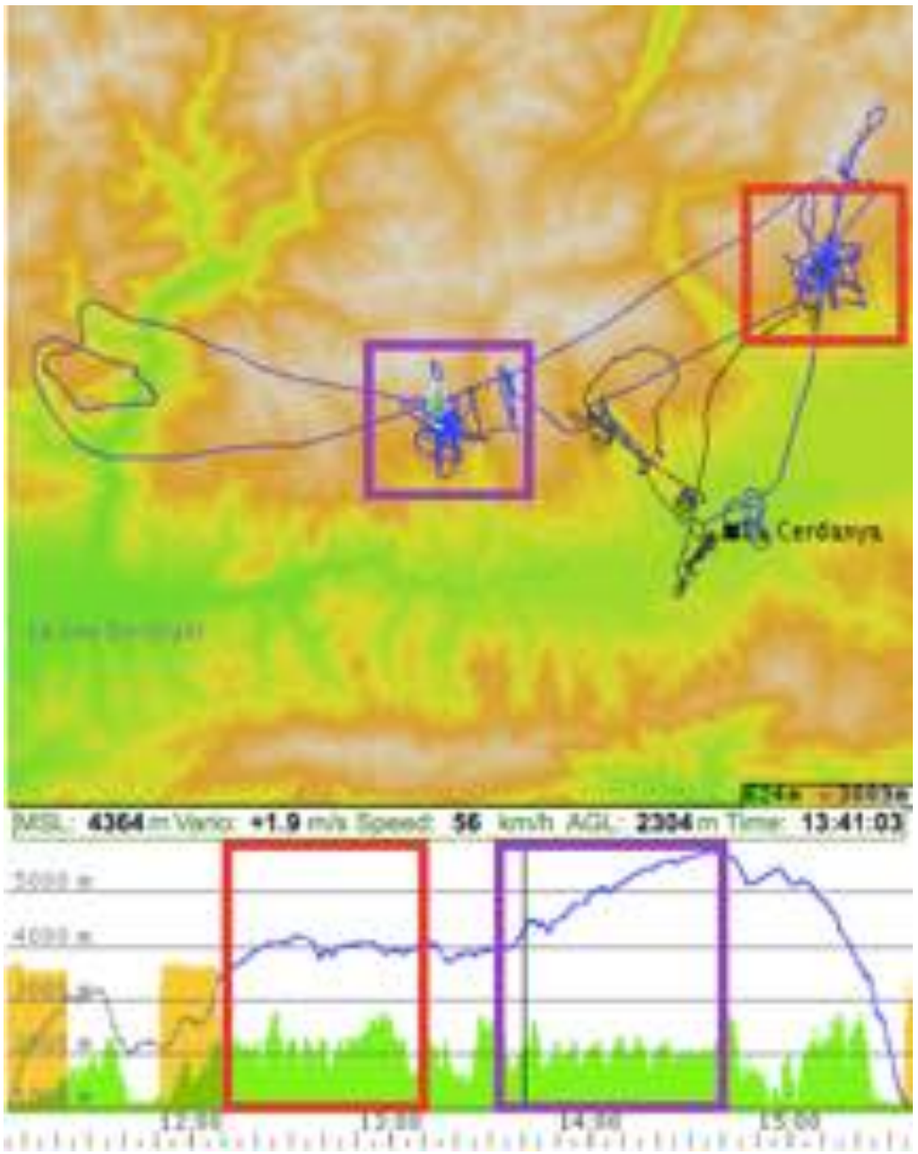


Vertical speed = shaded [m/s]
Horizontal wind = wind barbs

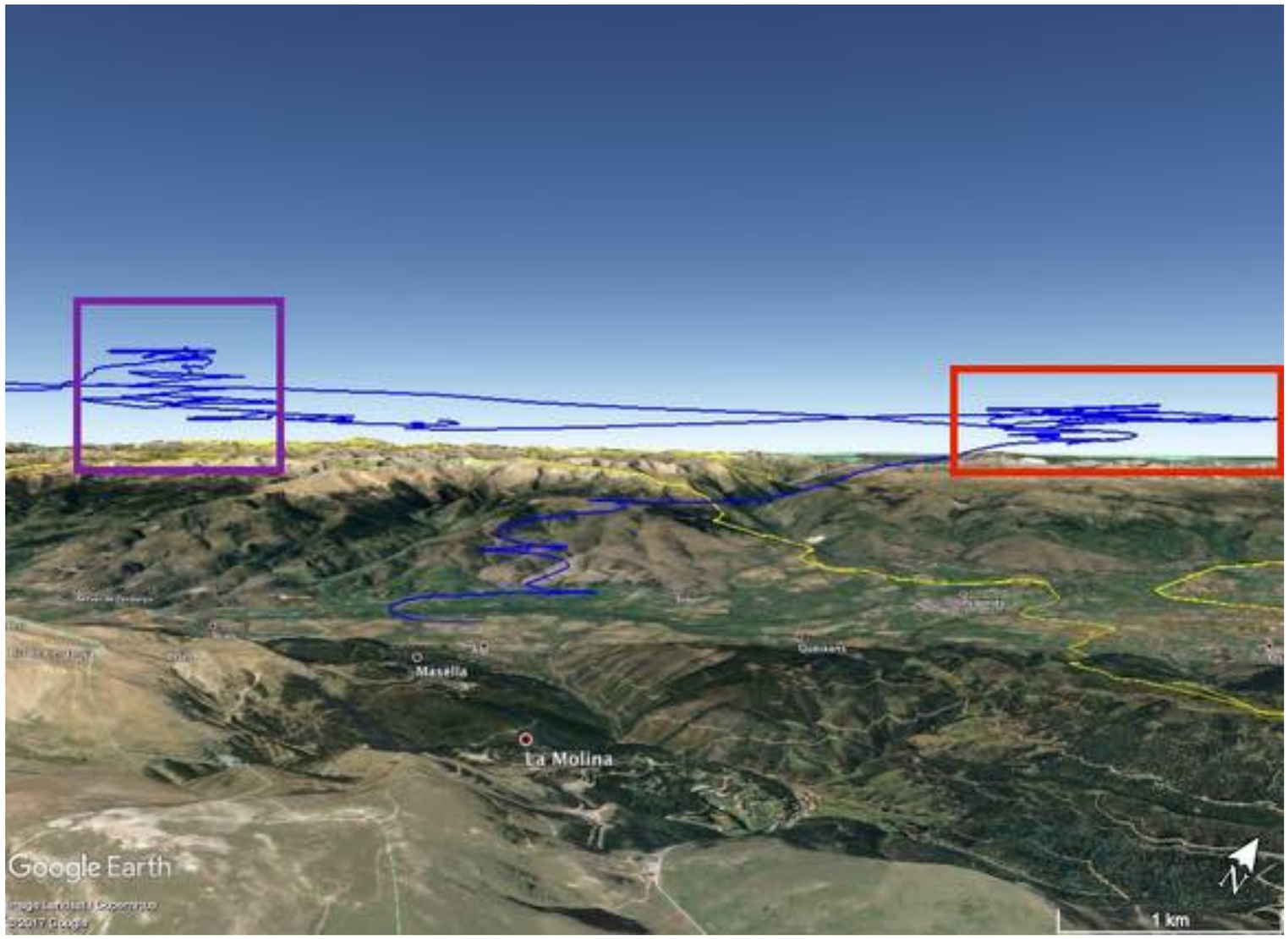
Wave Flight Track

Wind: north-east

Take-off aerodrome: La Cerdanya



Source: onlinecontest.org

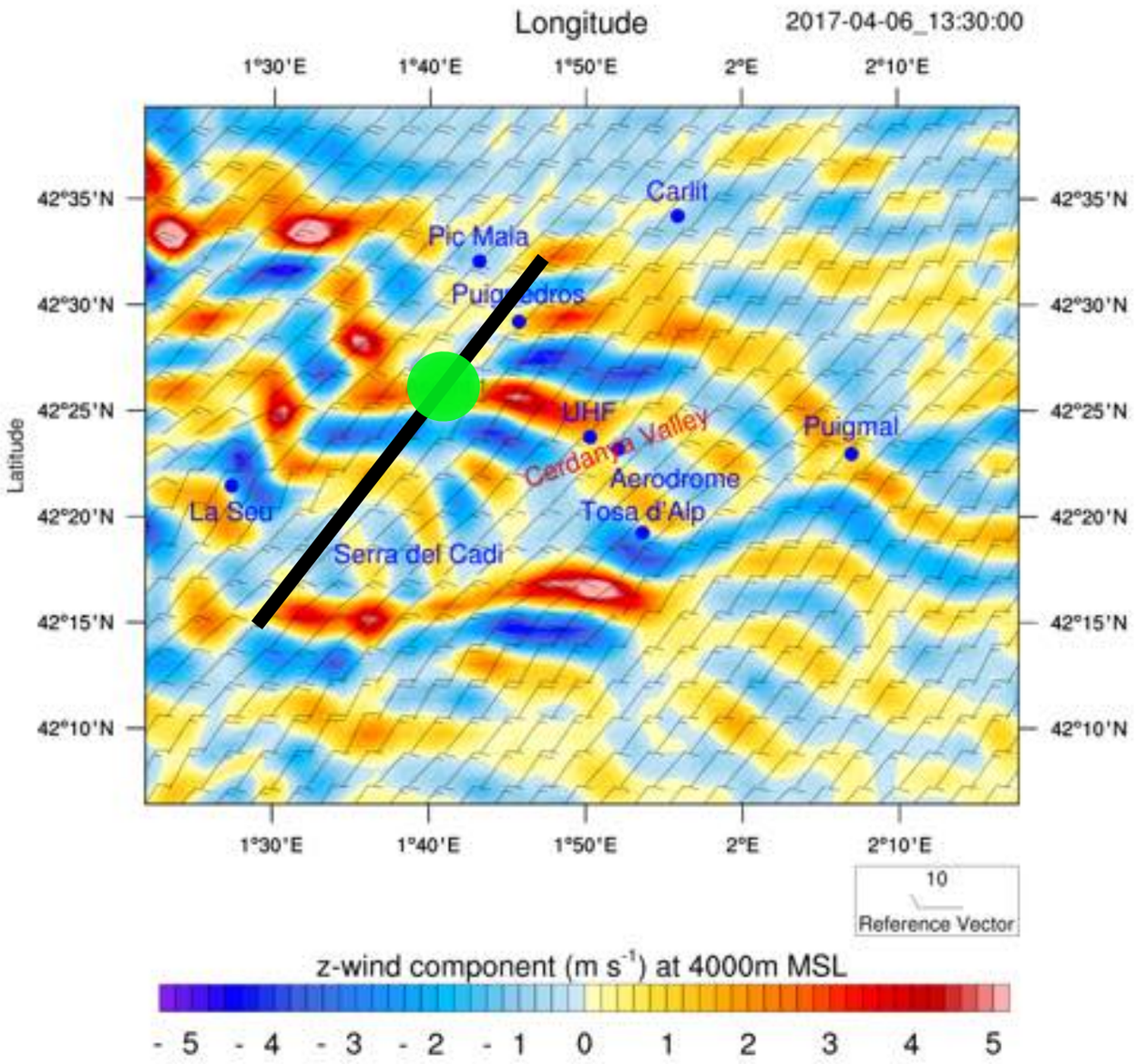


Source: Google Earth

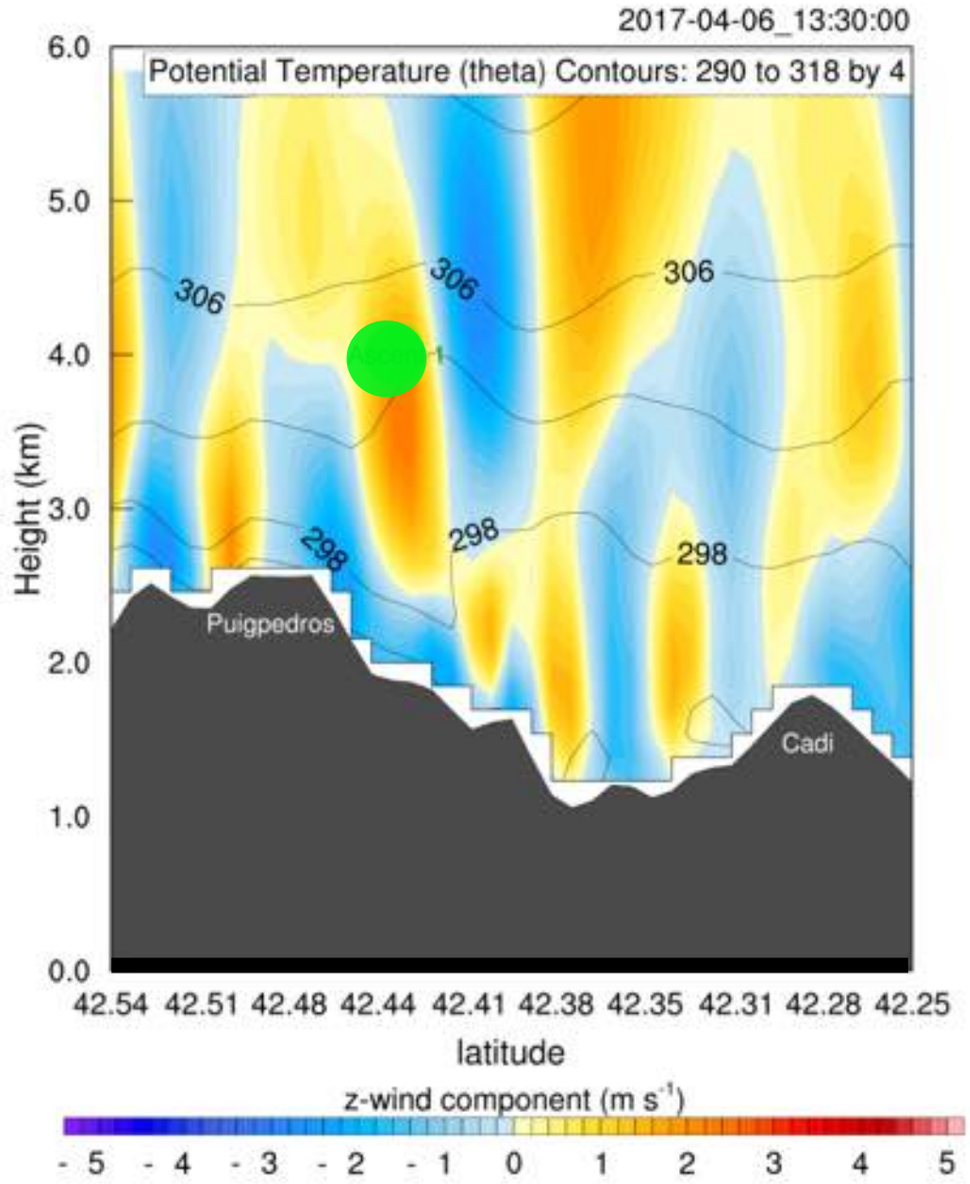
Model evaluation

Comparison of the simulated vertical velocity with flight data

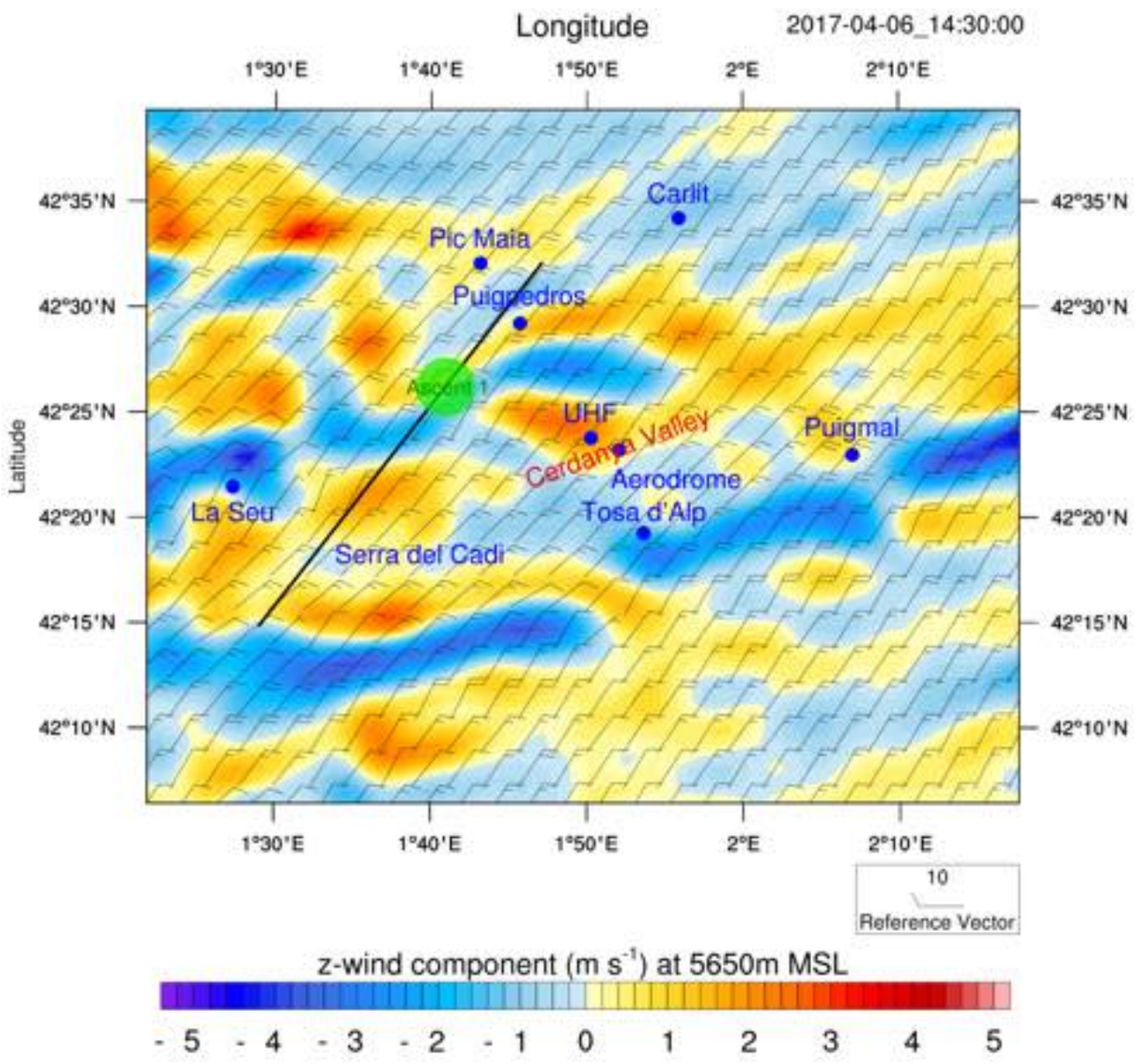
PLANE SECTION 4000M MSL

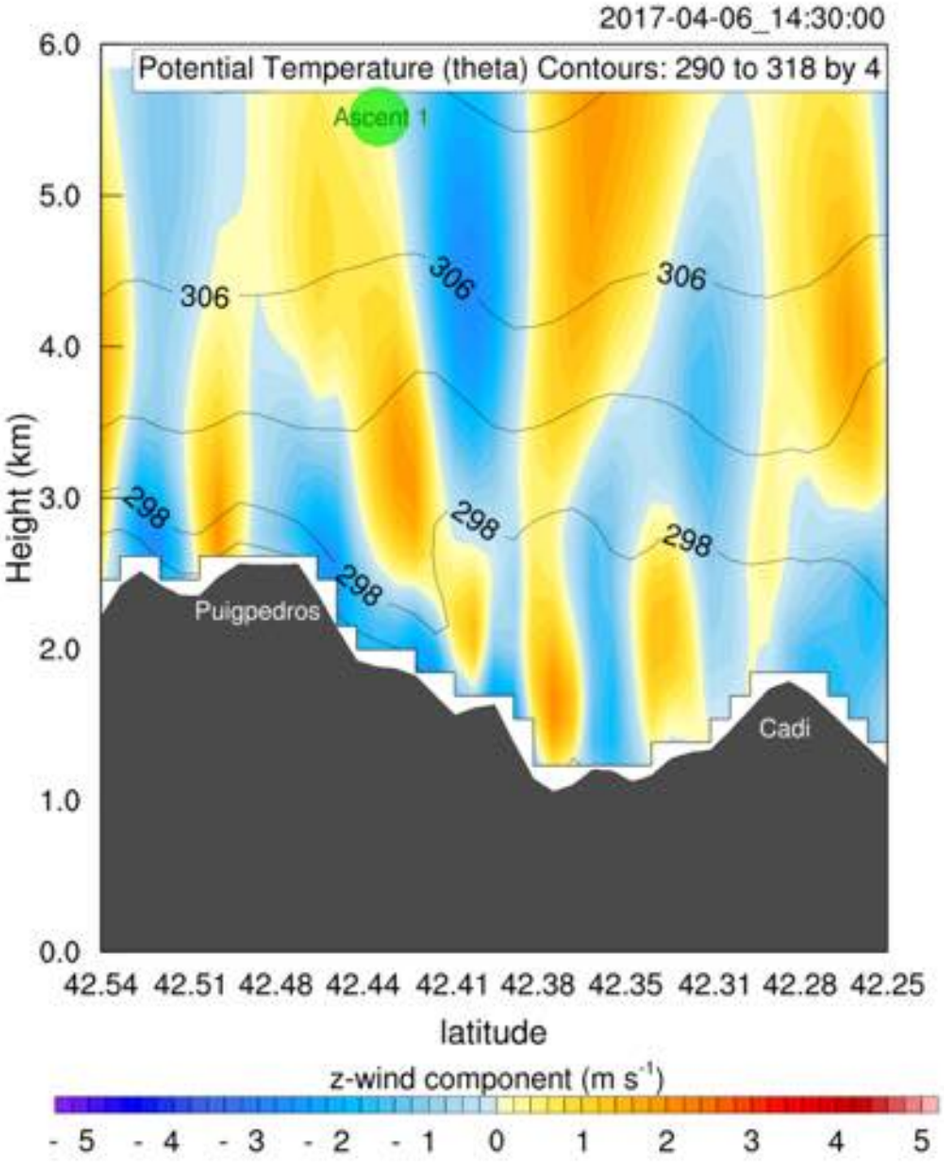


CROSS SECTION

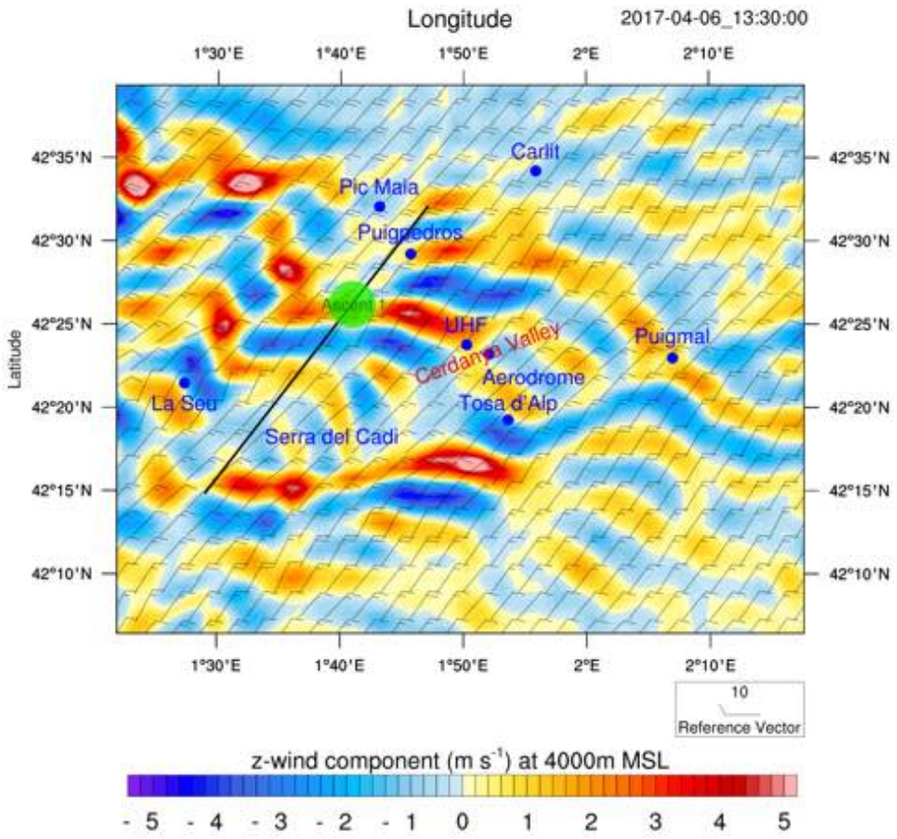


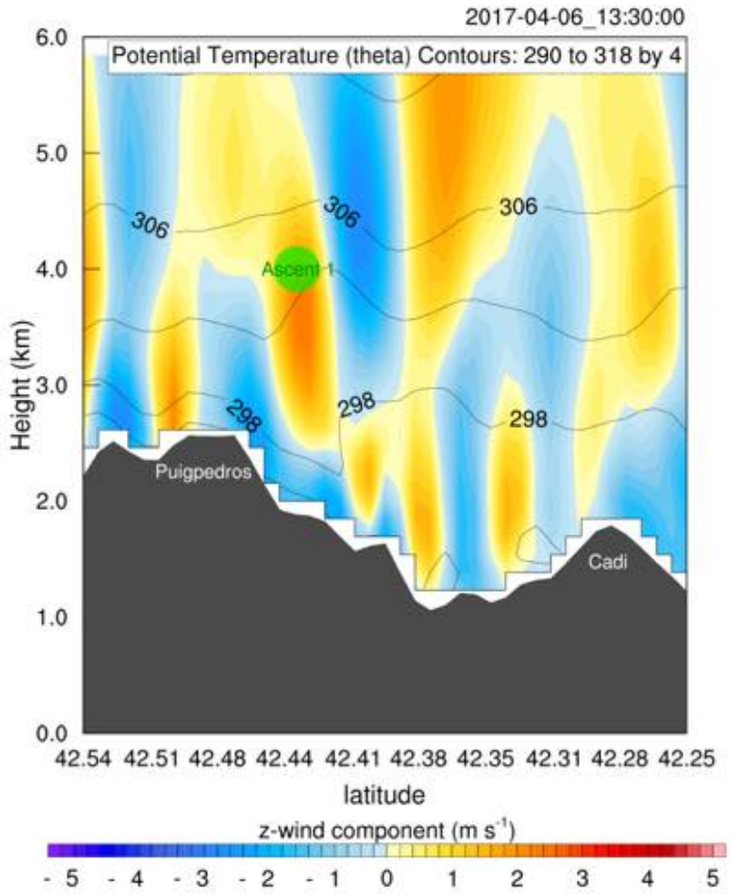
Comparison of the simulated vertical velocity with flight data





Simulated vertical velocity in comparison with flight data





- good performance in high-altitudes
- Model obviously calculates laminar mountain wave flow in low-levels (cross section) which is probably causing the weak performance compared to the surface measurements
  ➔ model configuration

3

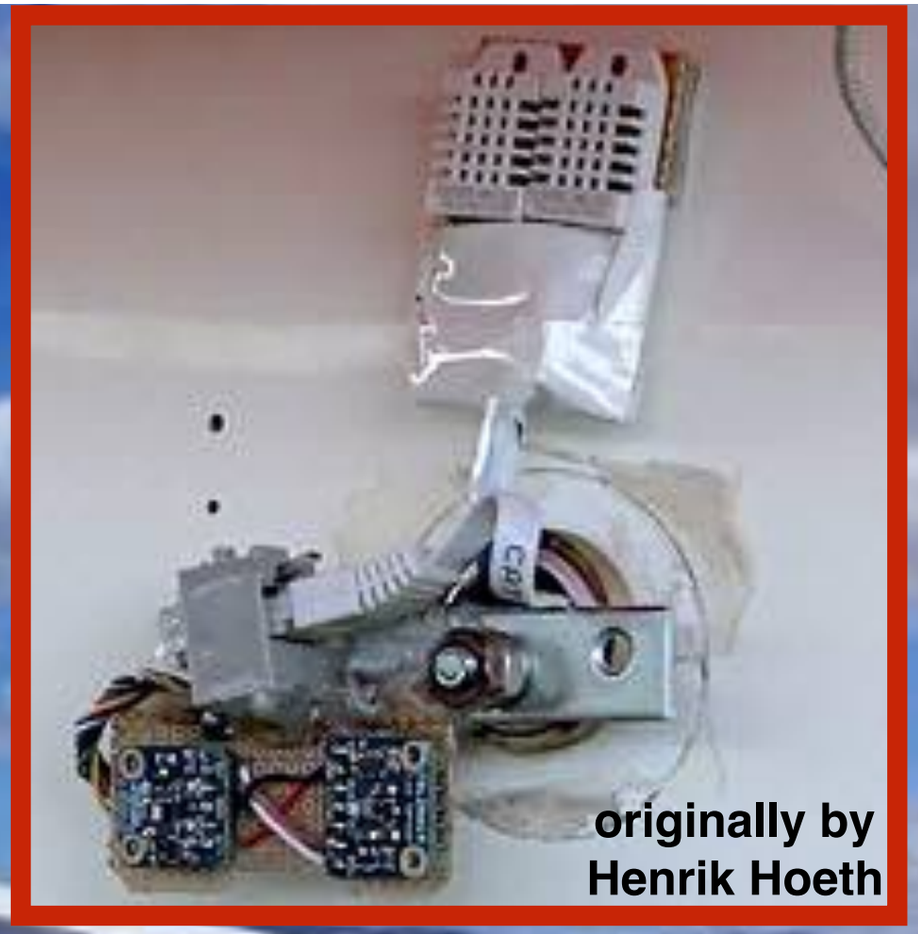
In-flight measurements

Akaflieg Frankfurt
Wave Research Camp

contact: wissenschaft@akaflieg-frankfurt

OPEN GLIDE COMPUTER

BY HENDRIK HOETH



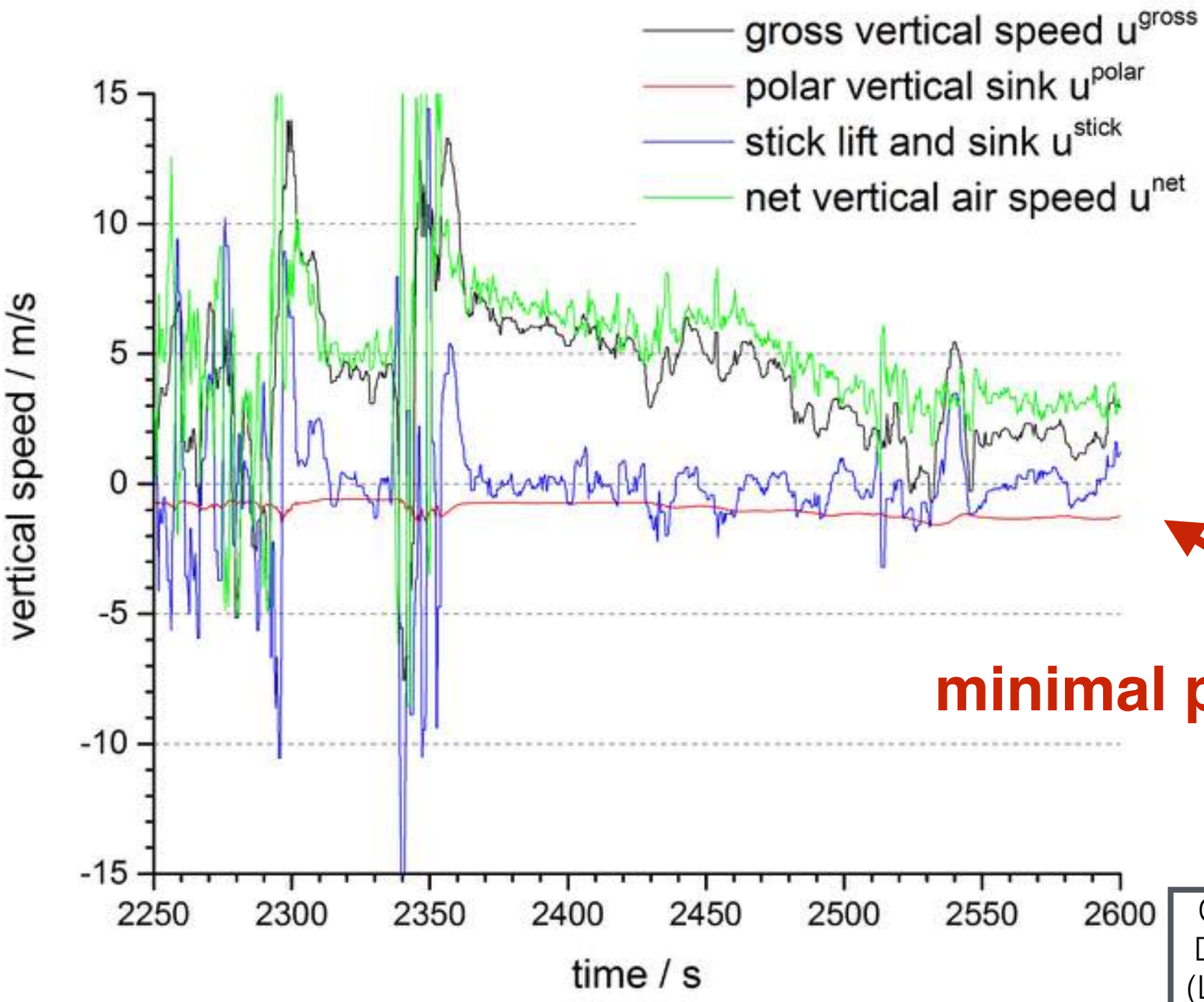
originally by
Henrik Hoeth

SENSORS

- static and dynamic air pressure
- high resolution GPS
- air temperature
- humidity
- 3-axis gyroscope
- 3-axis accelerometer
- 3-axis digital magnetic compass
- real time clock

Measured and calculated vertical speeds

CLIMB MODE



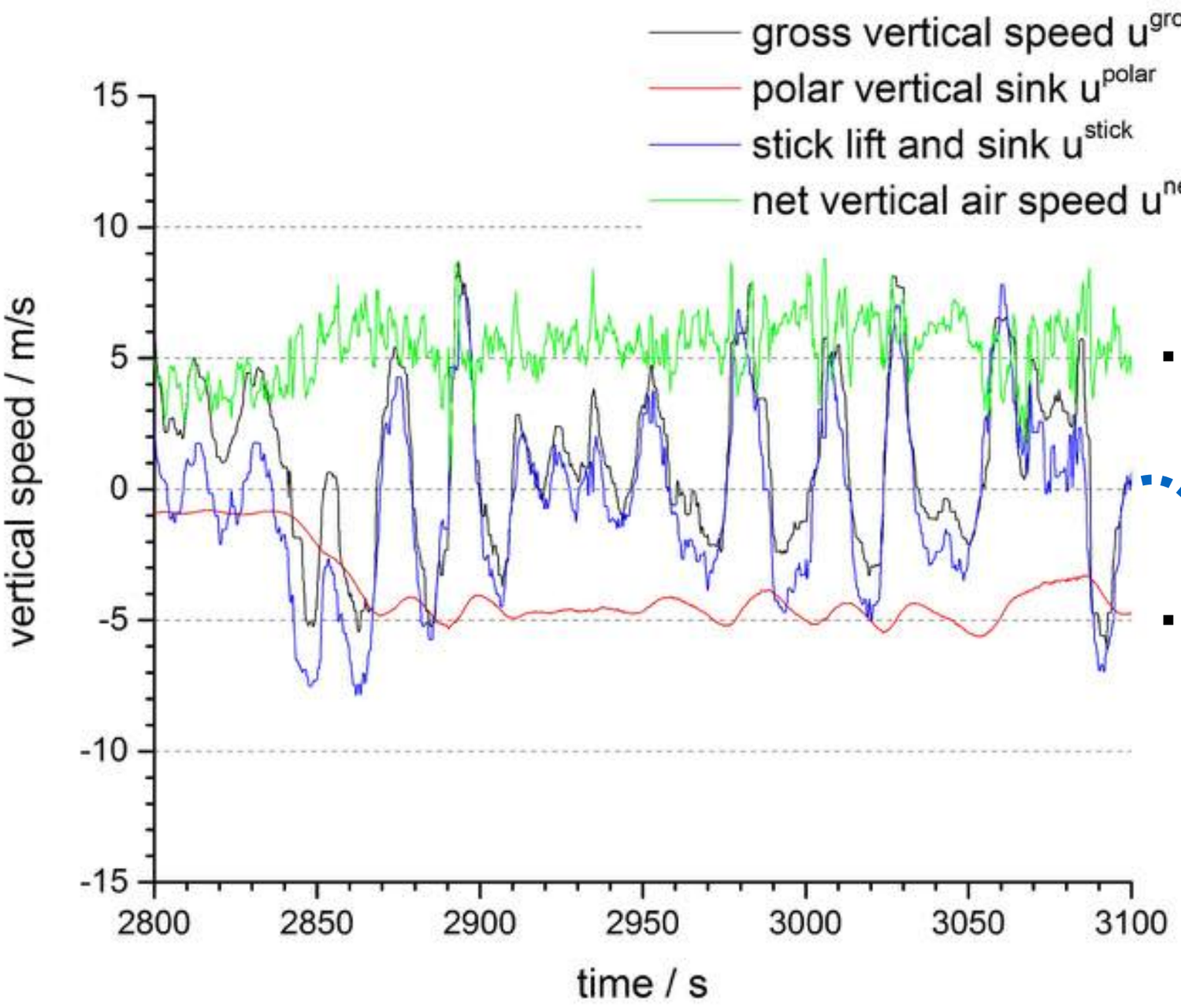
$u_{net} = u_{gross} - u_{polar} - u_{stick}$

minimal polar sink rate

Graphic: A. Ultsch, J. Curtius, and C. Maul, Data Mining for Atmospheric Gravity Waves (LeeWaves), Technical Soaring 40, 25 (2016)

Measured and calculated vertical speeds

STRAIGHT FLIGHT MODE



..... **net vertical air speed**

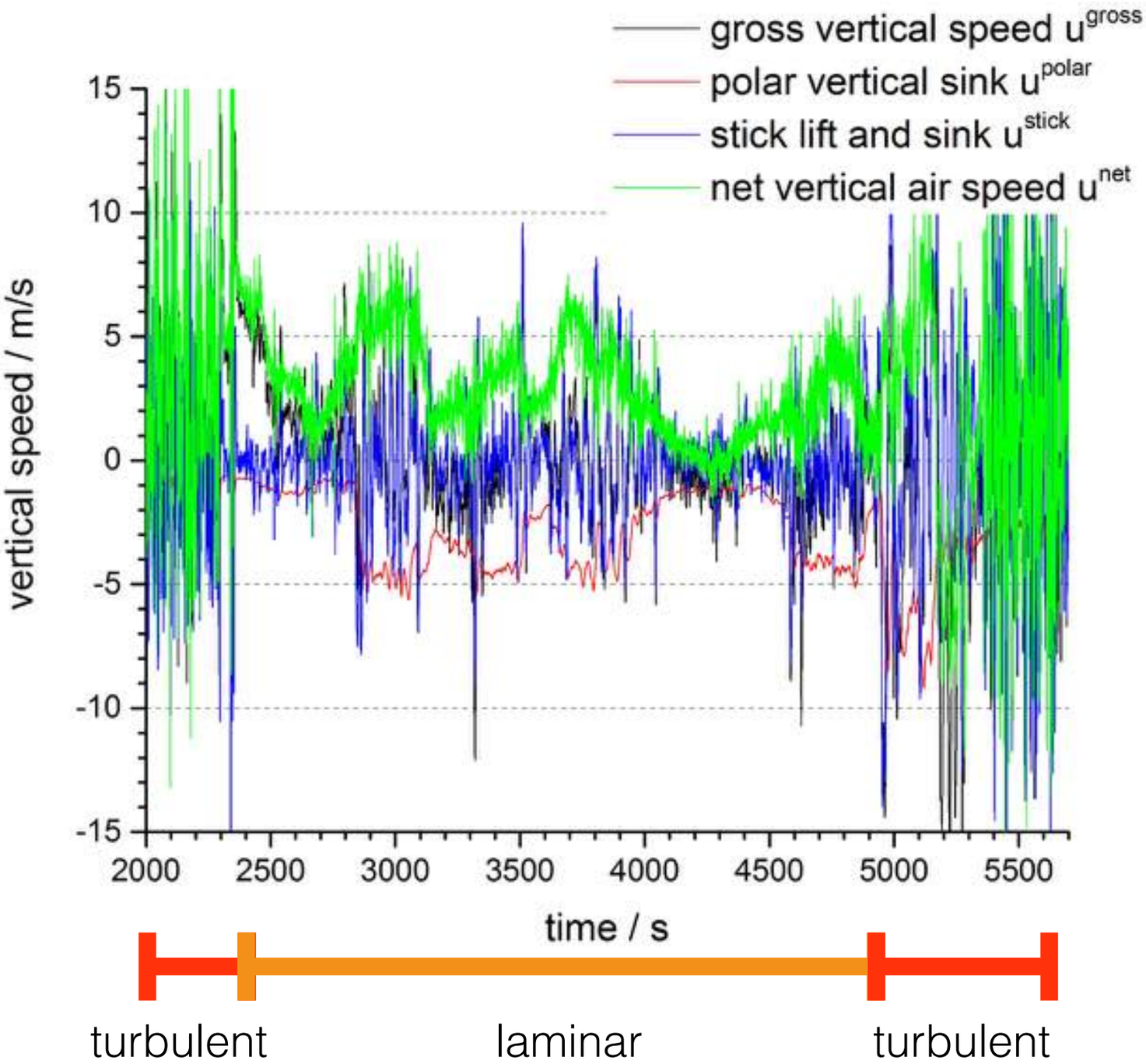
nervous pilot

..... **polar vertical sink**

Graphic: A. Ultsch, J. Curtius, and C. Maul, Data Mining for Atmospheric Gravity Waves (LeeWaves), Technical Soaring 40, 25 (2016)

Measured and calculated vertical speeds

BOTH MOUNTAIN WAVE REGIMES



Graphic: A. Ultsch, J. Curtius, and C. Maul, Data Mining for Atmospheric Gravity Waves (LeeWaves), Technical Soaring 40, 25 (2016)

CONCLUSION

- **More gliders should be equipped with measurement devices since in-flight measurements have a tremendous potential for mountain wave research.**

- **Low cost, small and reasonably accurate measurement equipment already exists.**

- **Mountain wave research requires numerical modeling as well as in-situ measurements. Low-level simulations are yet to be improved and therefore high altitude measurements are necessary.**

ACKNOWLEDGEMENT

Mireia Udina i Sistach
Maria Rosa Soler Duffour

Universitat de Barcelona,
Departament Fisica Aplicada

Alfred Ultsch

Philipps Universität Marburg,
Datenbionik

Akaflieg Frankfurt e.V.
contact: wissenschaft@akaflieg-frankfurt

Christof Maul

Technische Universität Braunschweig,
Institut für Physikalische und
Theoretische Physik

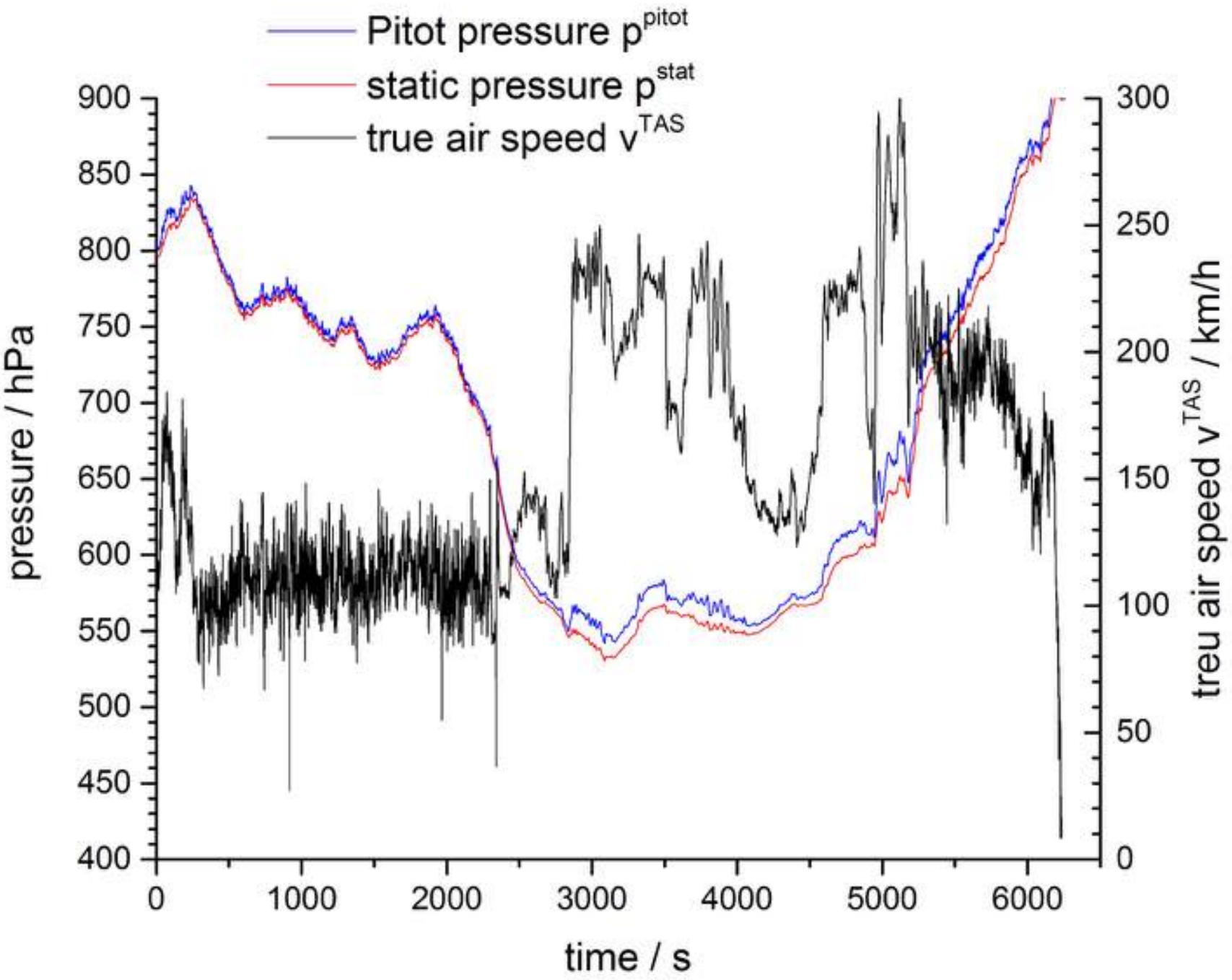
Akaflieg Frankfurt e.V.

Thank you

for your attention !

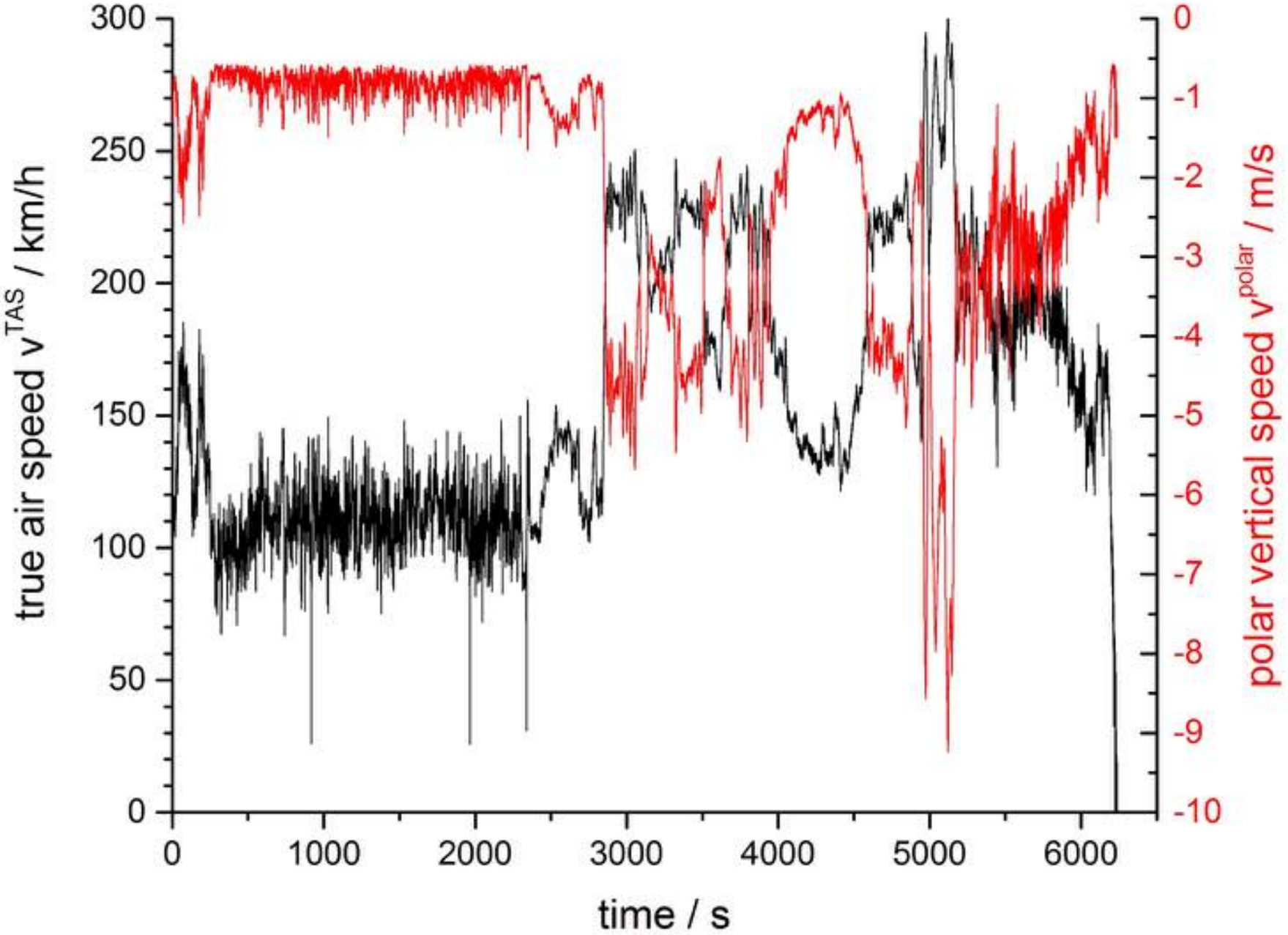
Appendix

Calculated true air speed through the pitot pressure and static pressure



Appendix

Polar vertical speed and true air speed



Appendix

Stick lift velocity and true air speed