Operation of an ultralight weightshift aircraft for environmental research: Properties, advantages and lessons learned

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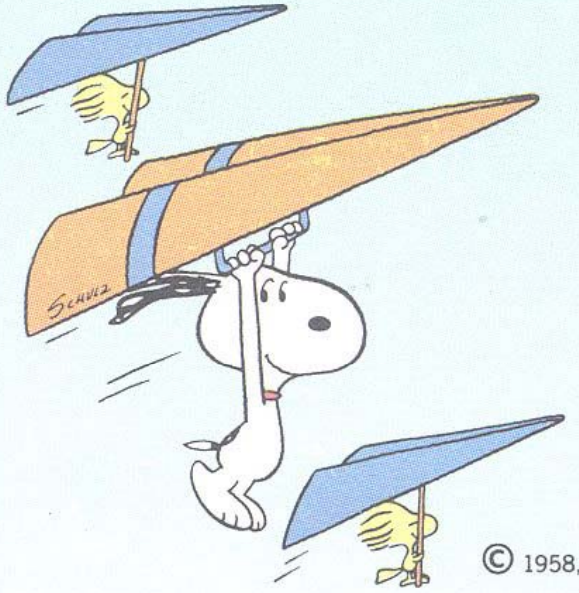
Operation of an ultralight weightshift aircraft for environmental research: Properties, advantages and lessons learned

PROBLEM TO BE ADRESSED

RADIATION TRANSFER MODULATION OF OPTICAL PROPERTIES BY CLOUDS AND AEROSOLS

MEASUREMENT OF
RADIATION QUANTITIES (λ)
TEMP / rH, OZONE
OPTICAL PROPERTIES
PRESS / GPS / ALT

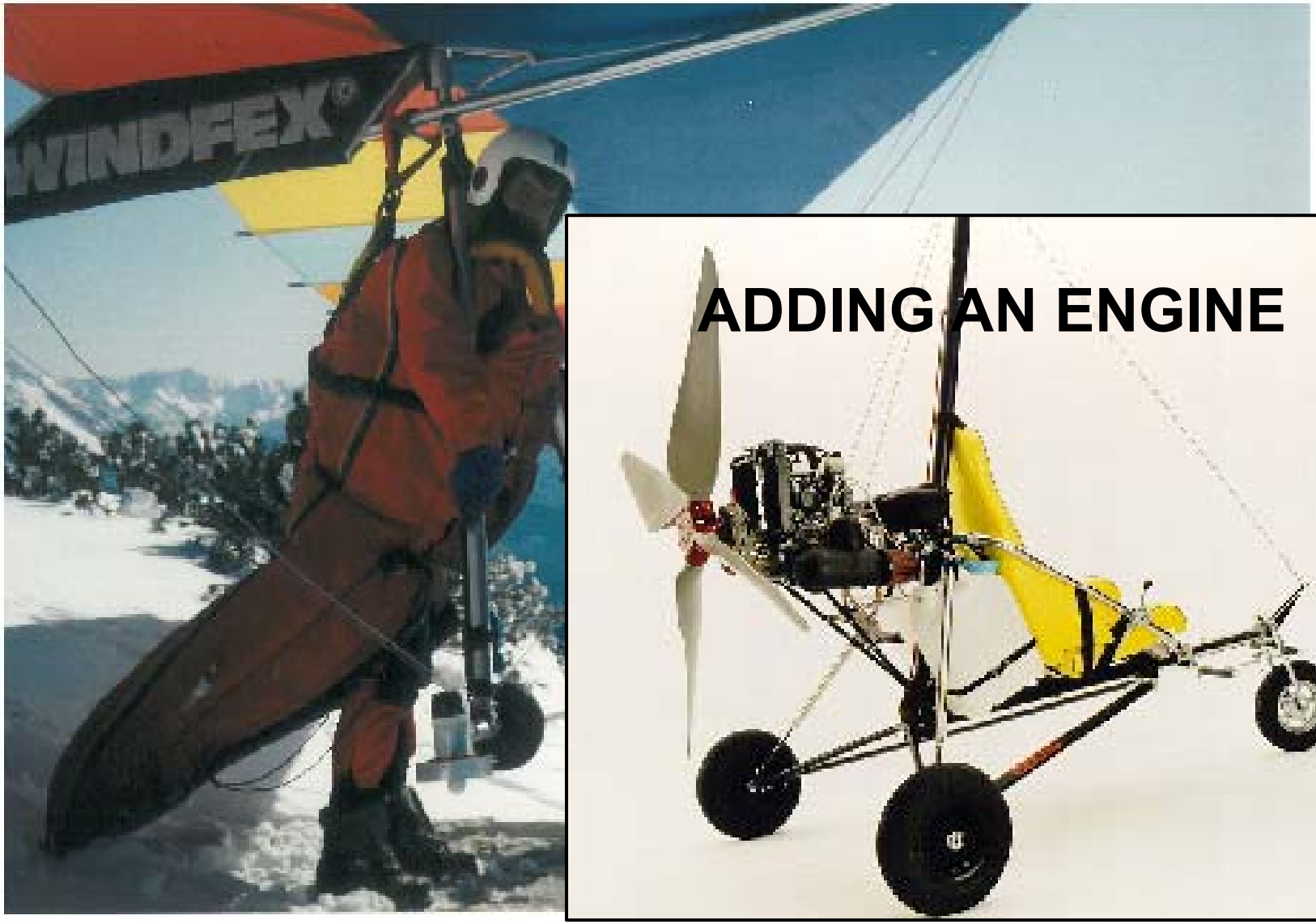


KEEP IT SIMPLE

THE FIRST APPROACH

THE FIRST APPROACH

THE SECOND APPROACH



THE SOLUTION

THE SOLUTION (1998)

ROTAX 582
CEILING FL 120
CRUISE 50 kt
END 4h

VERTICAL PROFILES OVER THE PO-VALLEY

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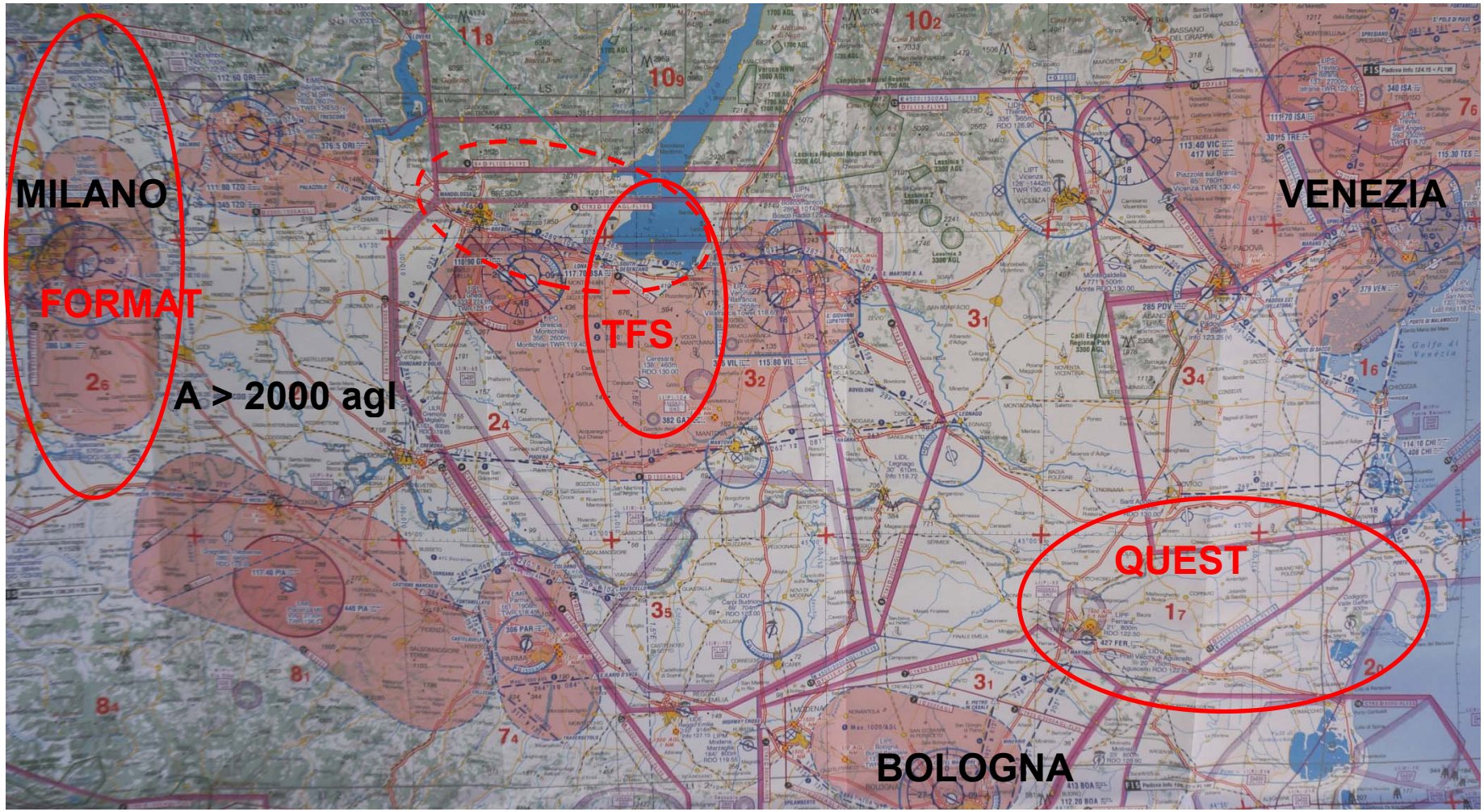
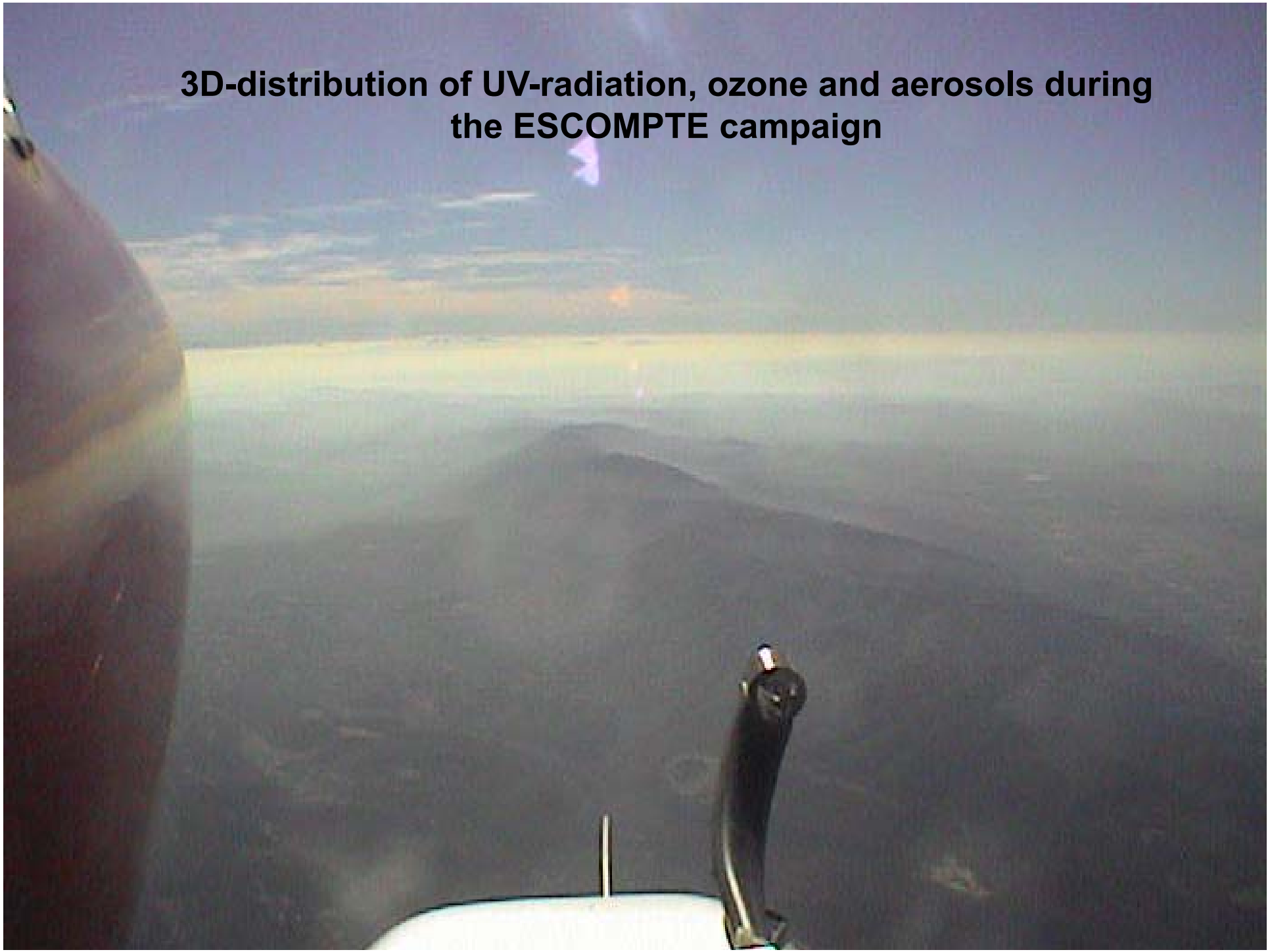
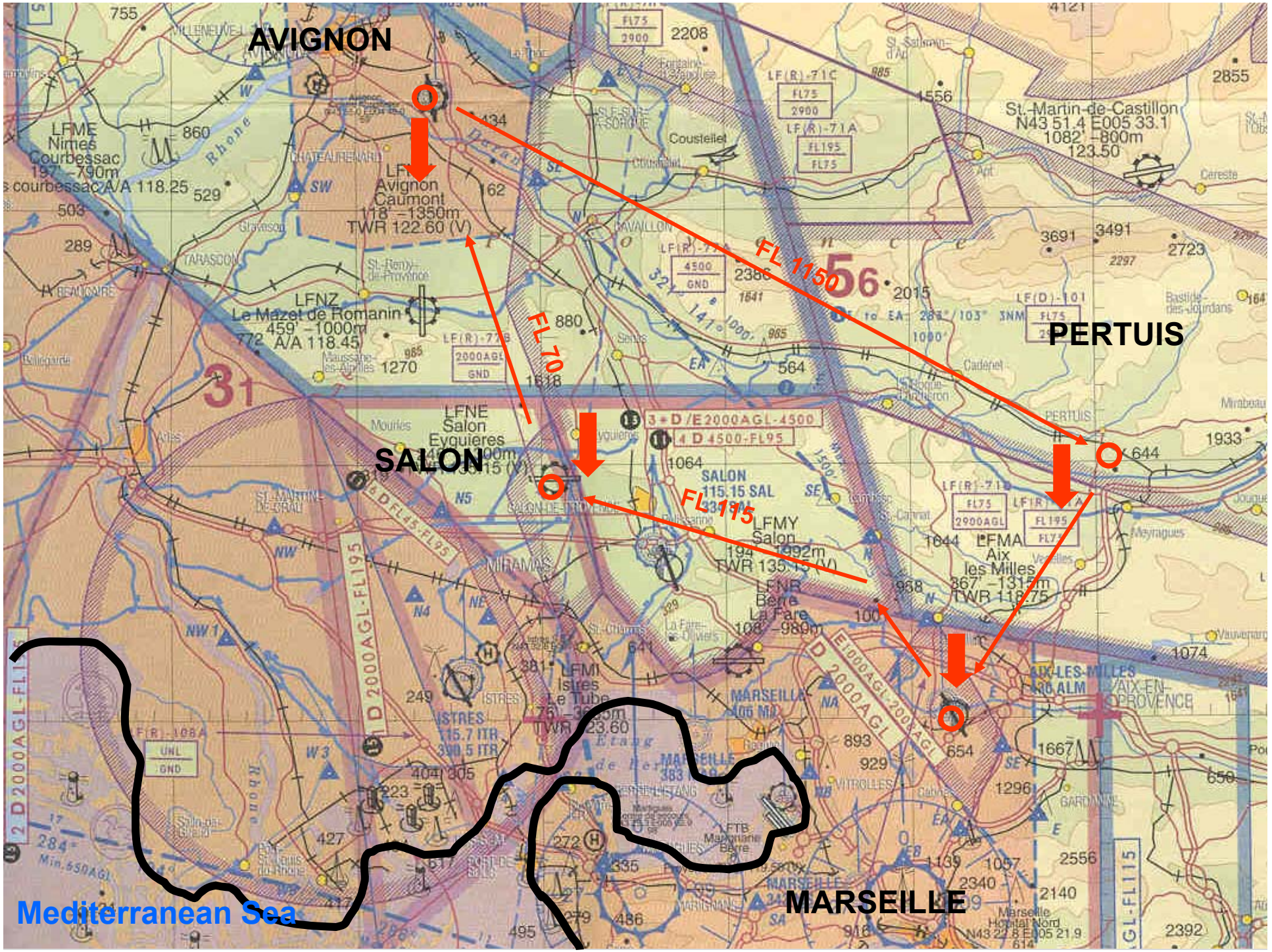
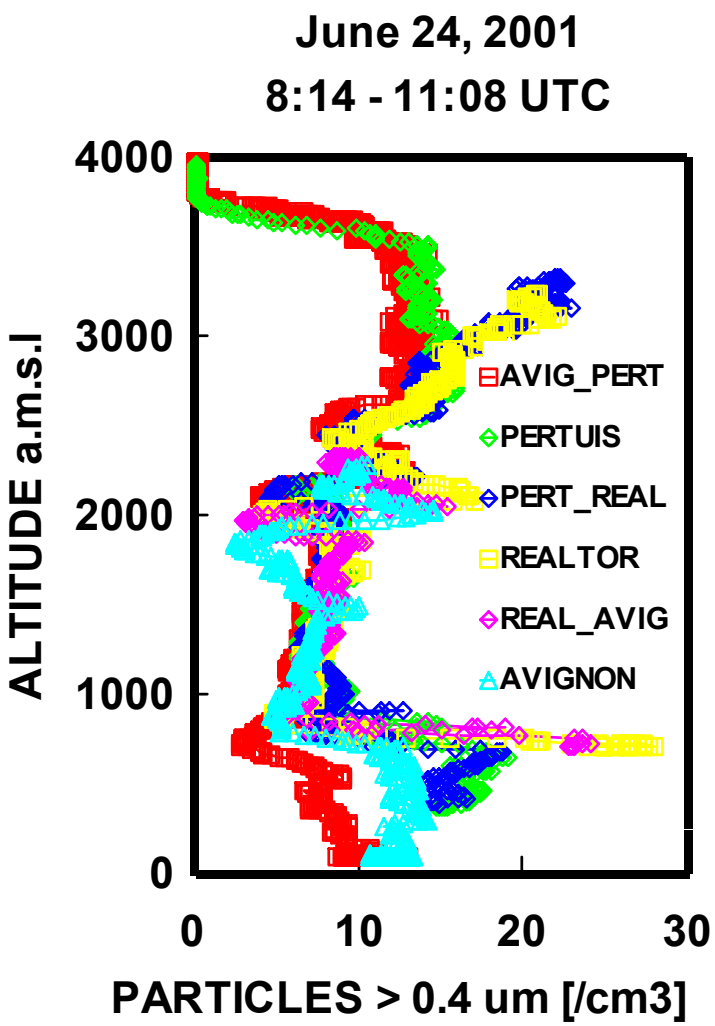
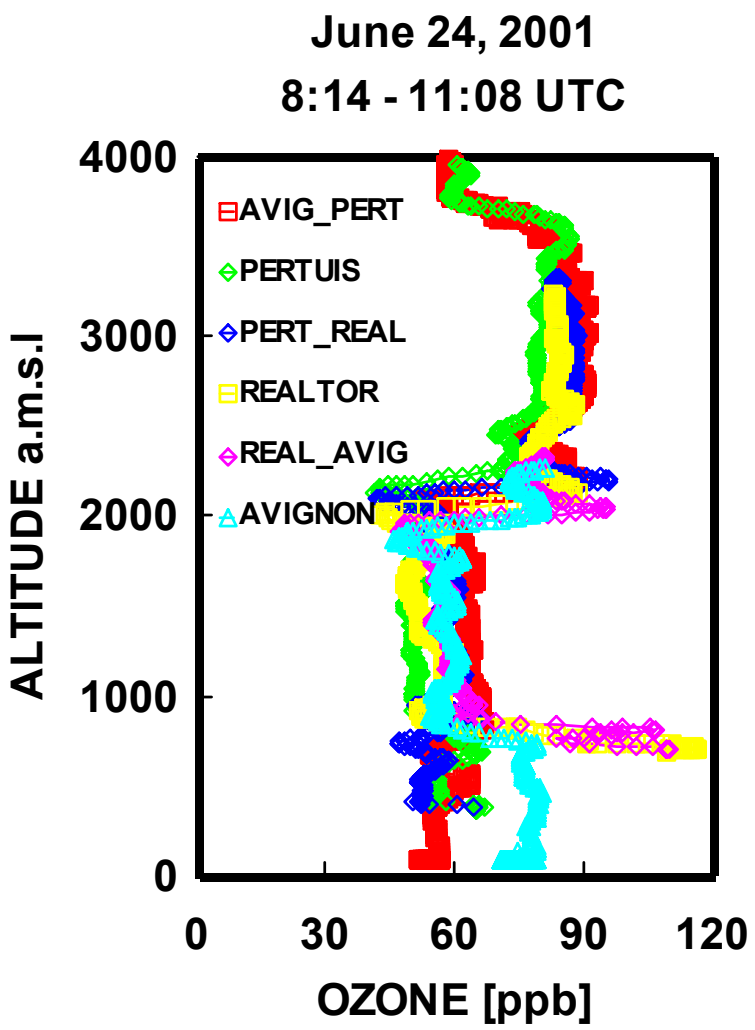
IMK-IFU, Garmisch-Partenkirchen, Germany


MILANO
FORMAT
A > 2000 agl
TFS
VENEZIA
QUEST
BOLOGNA


3D-distribution of UV-radiation, ozone and aerosols during
the ESCOMPTE campaign

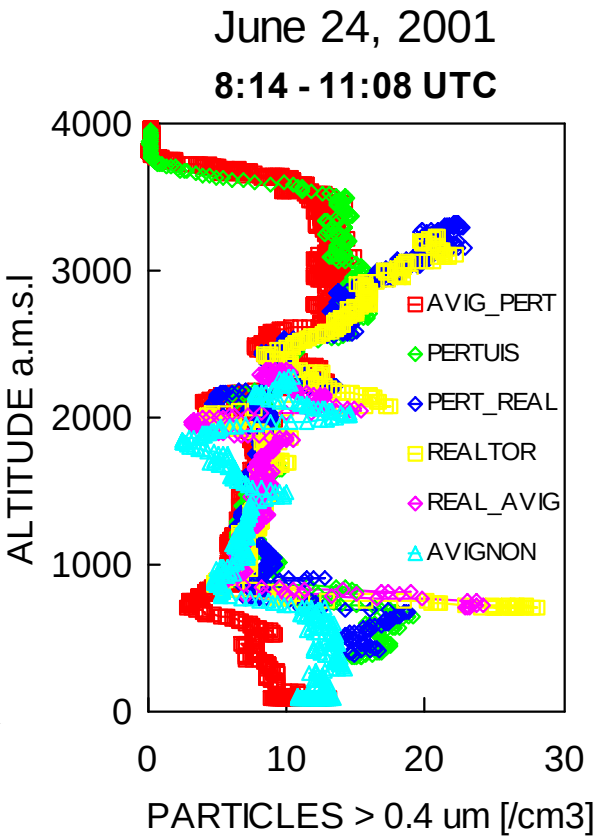

AVIGNON
PERTUIS
SALON
MARSEILLE
Mediterranean Sea
FL 115
FL 70
FL 115
LFME
Nimes
Courbessac
LFNZ
Le Mazet de Romanin
LFNE
Salon
Eyguieres
LFMY
Salon
LFNR
Berre
La Fare
LFMI
Istres
Le Tube
LFMA
Aix
les Milles
St.-Martin-de-Castillon
N43 51.4 E005 33.1
1082' -800m
123.50
Marseille
Hopital Nord
N43 22.8 E005 21.9

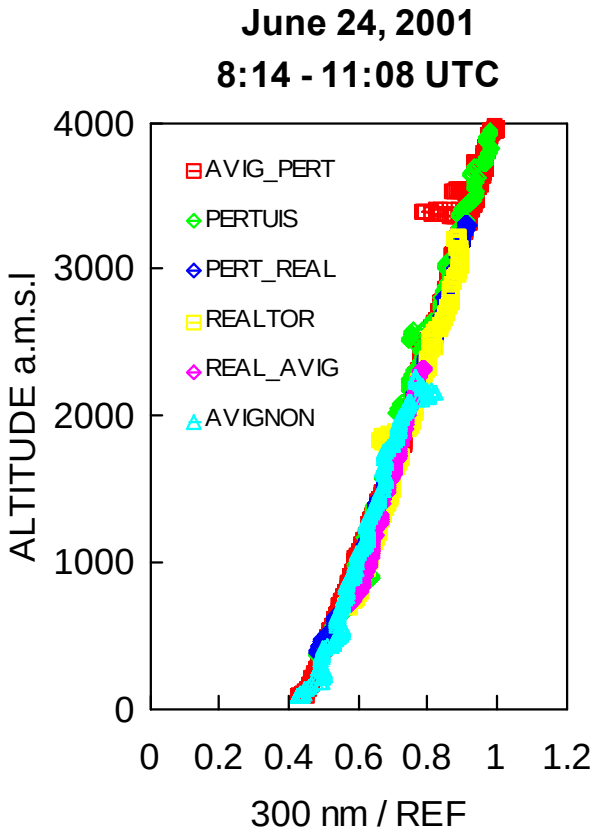

June 24, 2001
8:14 - 11:08 UTC
ALTITUDE a.m.s.l
4000
3000
2000
1000
0
0
10
20
30
PARTICLES > 0.4 um [/cm3]
AVIG_PERT
PERTUIS
PERT_REAL
REALTOR
REAL_AVIG
AVIGNON

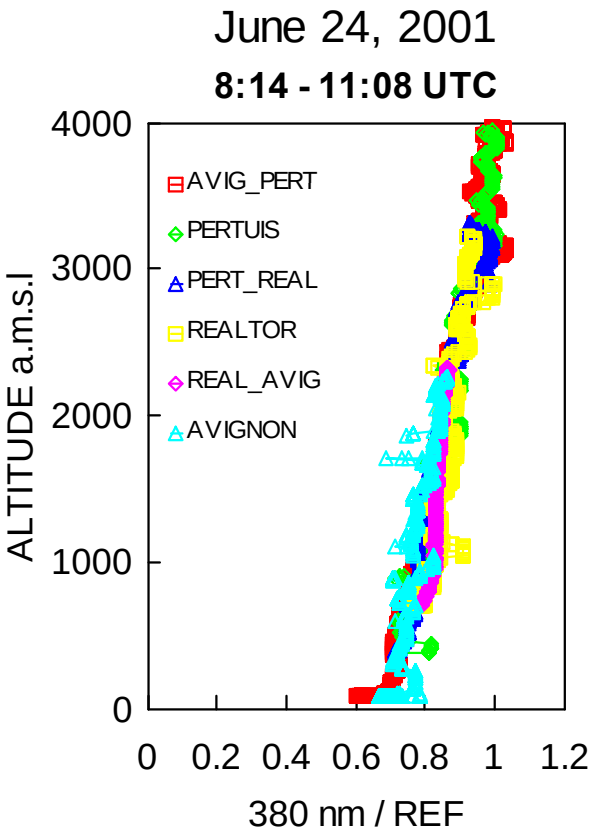

June 24, 2001
8:14 - 11:08 UTC
ALTITUDE a.m.s.l
4000
3000
2000
1000
0
0
30
60
90
120
OZONE [ppb]
AVIG_PERT
PERTUIS
PERT_REAL
REALTOR
REAL_AVIG
AVIGNON

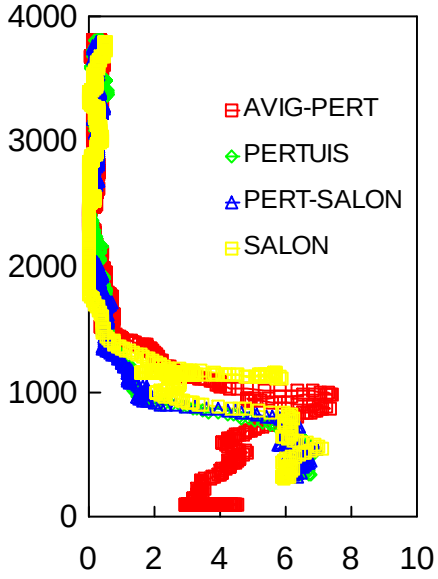
D-MIFU

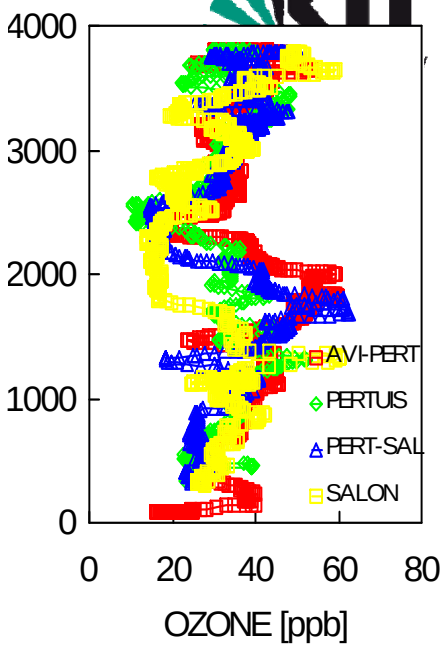
Southern France, Provence, hazy, AOT 340 nm 0.48, 500 nm 0.42









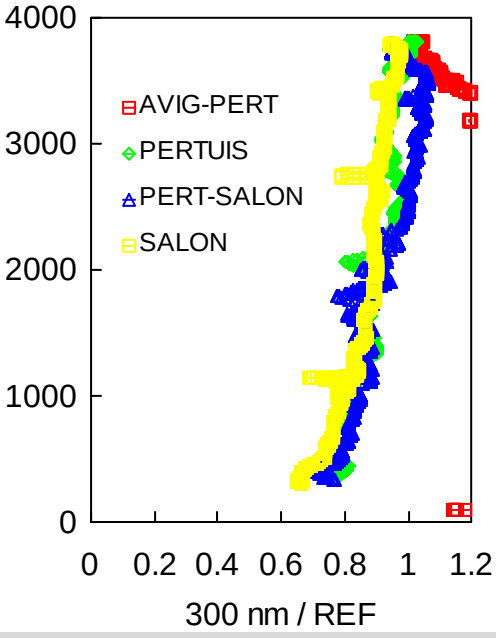


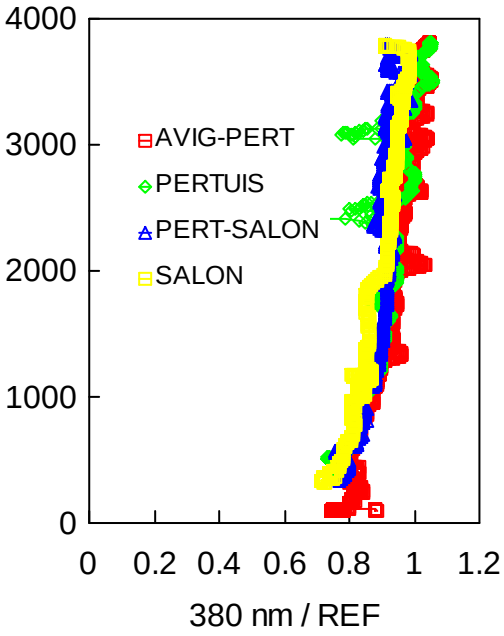
12.7. 6:30 - 10:00 UTC

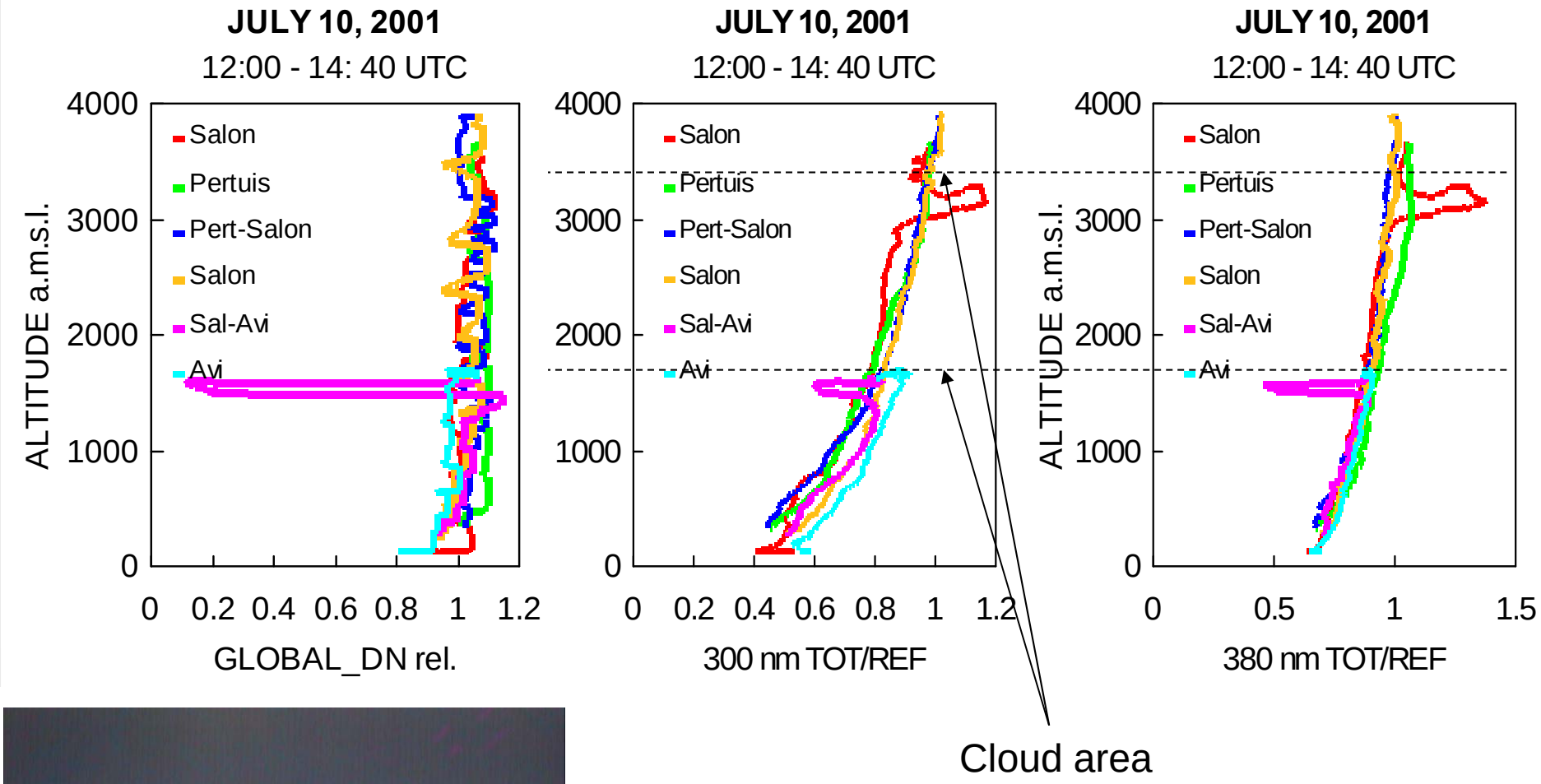
ESCOMPTE, France, 2001

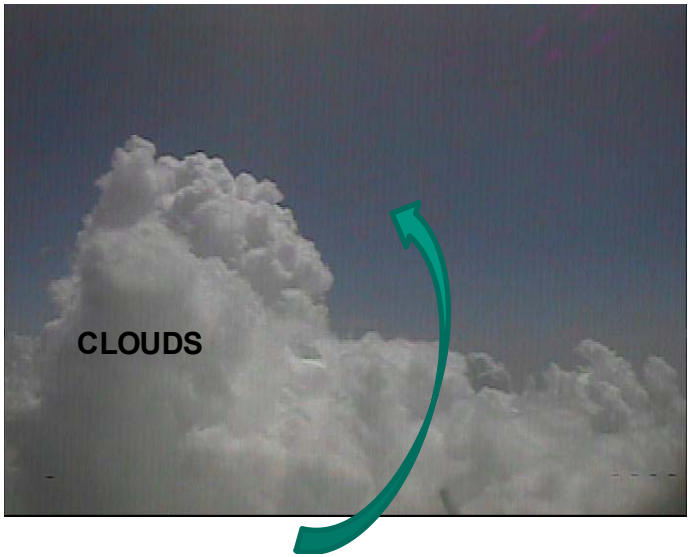
AVIGNON-PERTUIS-SALON

AOT 340 nm BDL, 500 nm, 0.092









AOT 340 nm 0.52, 500 nm 0.44

Aerosols over the Mediterranean

DESERT DUST
Climate impact: affecting shortwave and longwave? radiation

NO FERRY FLIGHT OVER OPEN WATER

Take a ferry

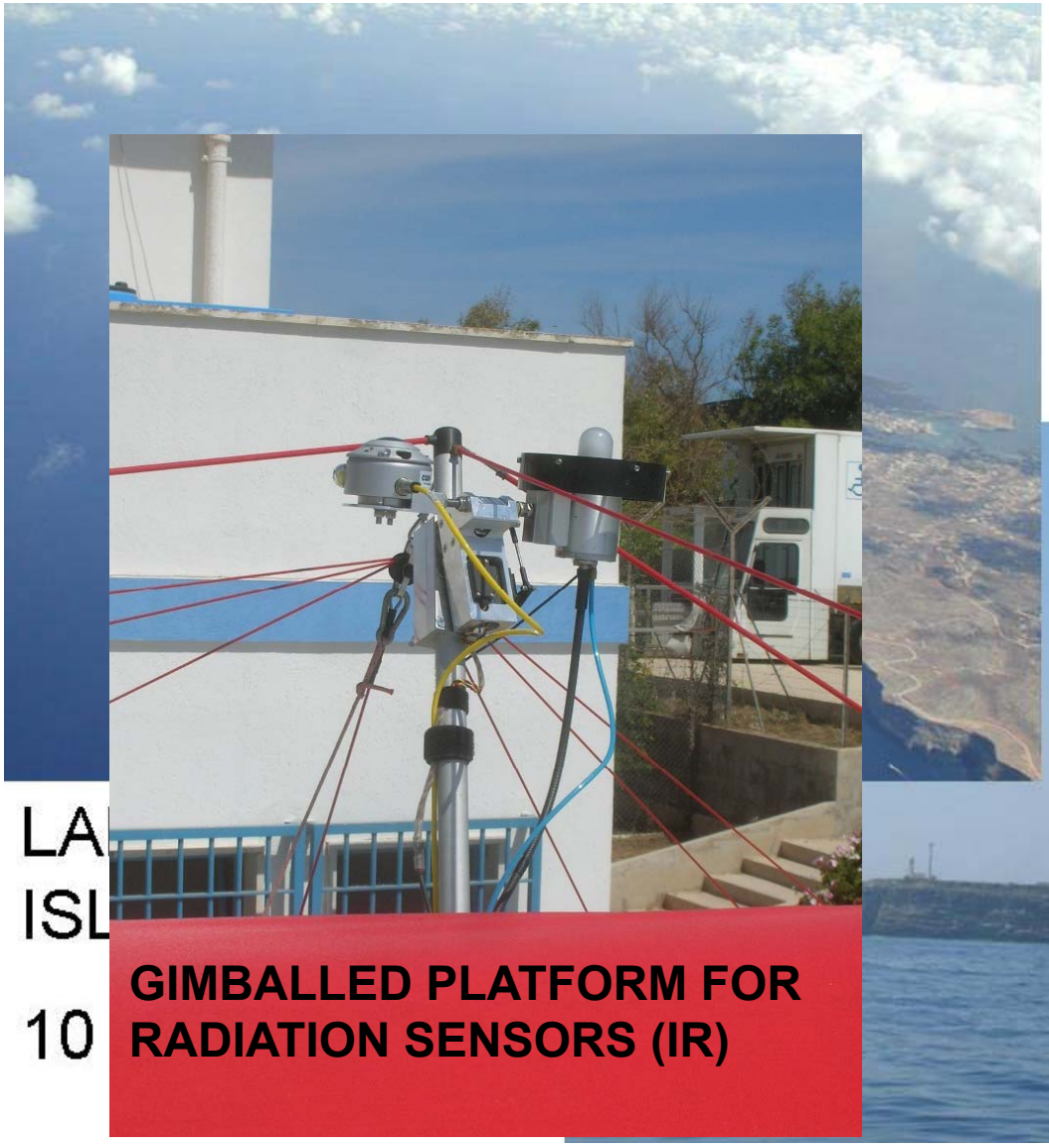
VERTICAL PROFILES ABOVE THE SEA UP TO 4000 m

LAMPEDUSA ISLAND (50 m)

10 km * 3 km

1999 SW
2004 SW
2008 LW

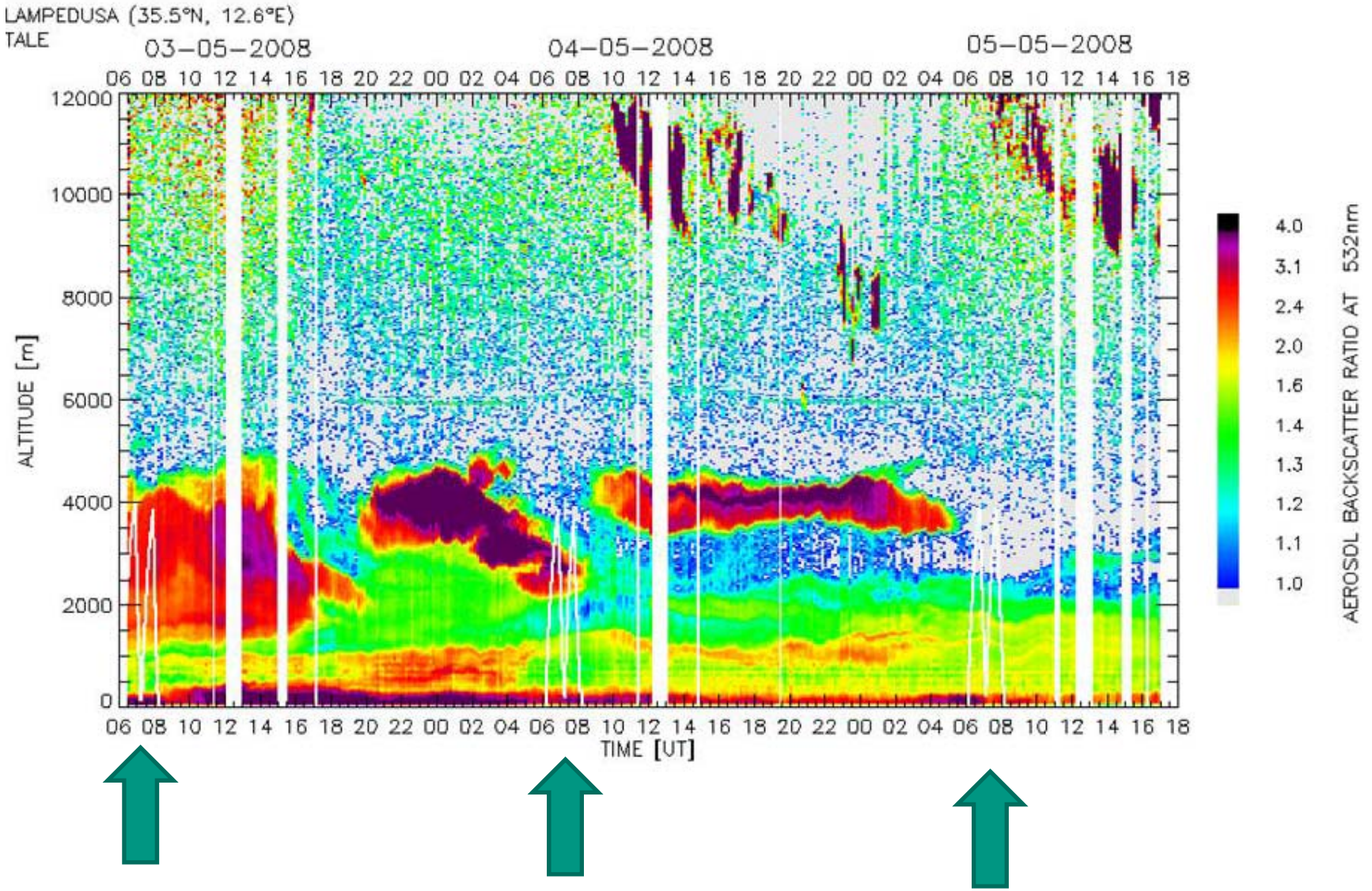
Special permit from Palermo ULM & CA (NOTAM)



VERTICAL PROFILES ABOVE THE SEA UP TO 4000 m

GIMBALLED PLATFORM FOR RADIATION SENSORS (IR)

1999 SW
2004 SW
2008 LW



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IMK-IFU, Garmisch-Partenkirchen, Germany

RADIATION/CLOUD/AEROSOL

ACTINIC UV RADIATION, O3 AND AEROSOL ~HOMOGENEOUS OVER THE AREA

AEROSOL VERTICAL DISTRIBUTION CONTROLS RADIATION PROFILE,

ATTENUATION (4000 - 0 m) UP TO 60 %

MAJOR PARAMETERS: PBL HEIGHT, AOD.

CLOUD ALBEDO ~IN AGREEMENT WITH CURRENT MODELS

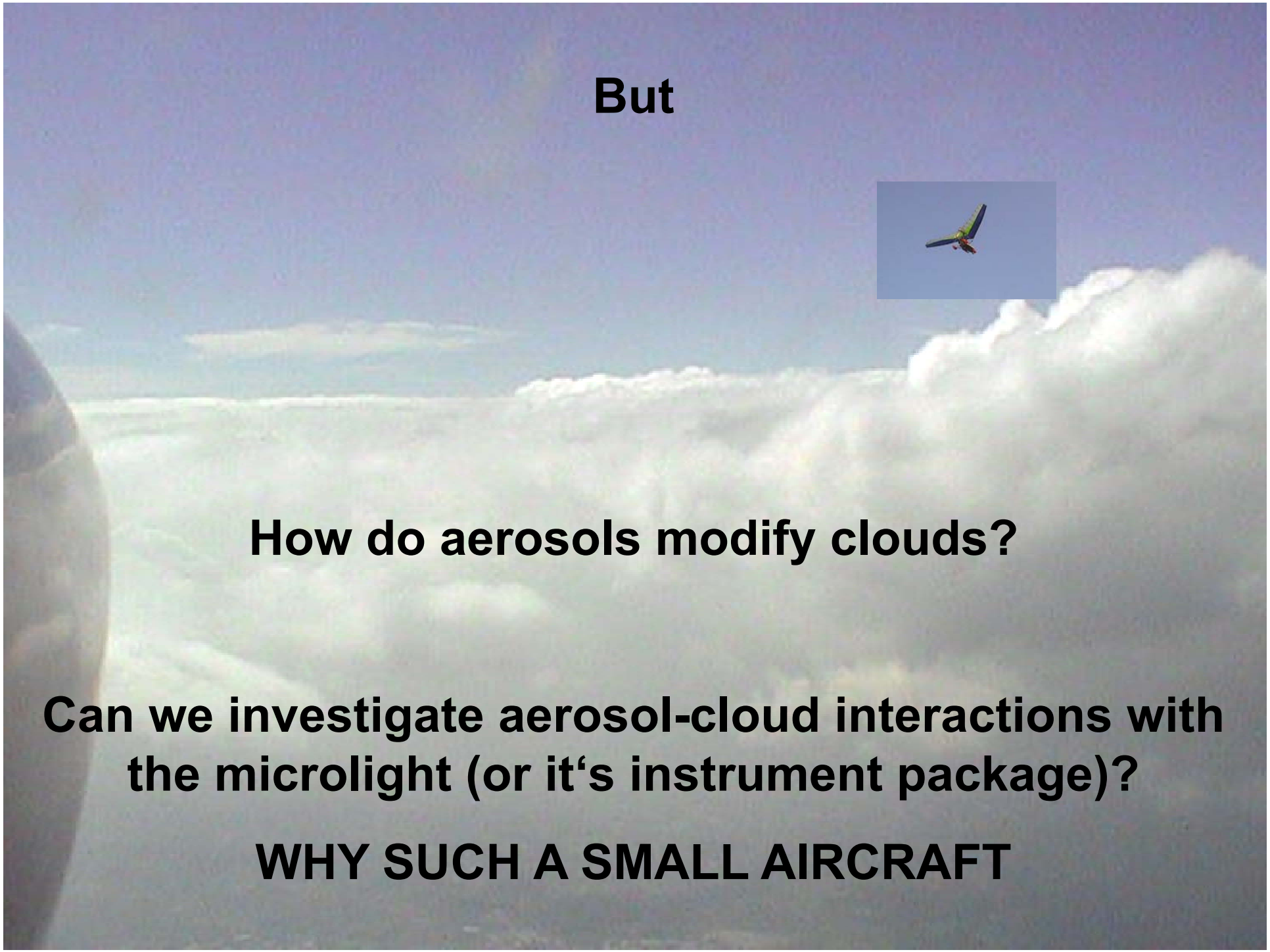
HAZE AROUND (BETWEEN) BROKEN CLOUDS

AEROSOL EFFECTS MASK 3D CLOUD FEATURES, REDUCTION BELOW CLOUD 30 - 50 %

But

How do aerosols modify clouds?

Can we investigate aerosol-cloud interactions with the microlight (or it‘s instrument package)?


But
How do aerosols modify clouds?
Can we investigate aerosol-cloud interactions with the microlight (or it‘s instrument package)?
WHY SUCH A SMALL AIRCRAFT

How do aerosols modify clouds?

NUMBER CONC. OF CLOUD CONDENSATION NUCLEI

SIZE AND CONC. OF CLOUD DROPLETS

>> CLOUD ALBEDO, LIFETIME, RAINDROP PRODUCTION

BLACK CARBON ABSORPTION

GIANT CCN TRIGGERING ICE NUCLEATION

How do aerosols modify clouds?

NUMBER CONCENTR N OF CLOUD CONDENSATION NUCLEI CON ES NUMBER AND SIZE OF CLOUD DROPLETS

>> CLOUD ALBEDO, LIFETIME, RAINDROP PRODU

BLACK CARBON ABS

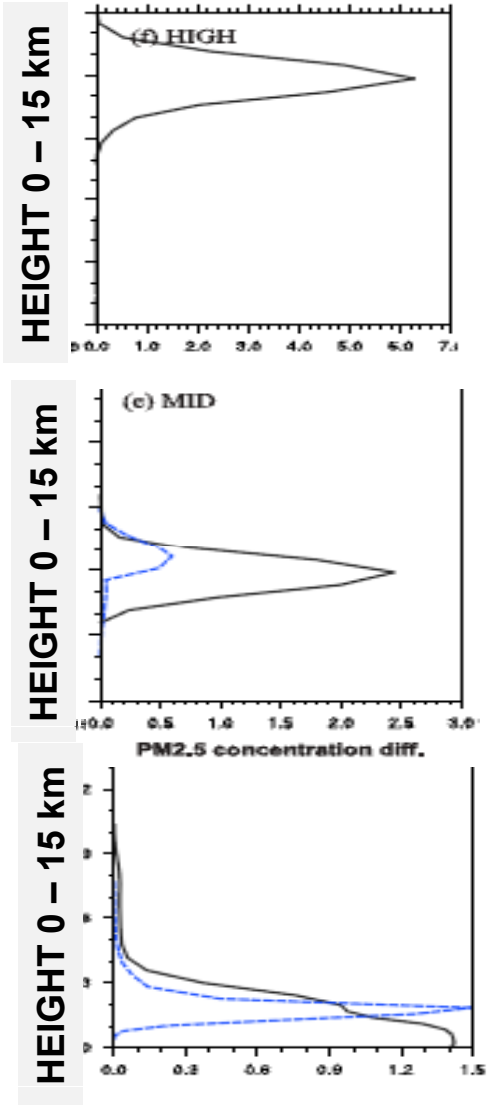
GIANT CCN TRIGGERING ICE N ATION

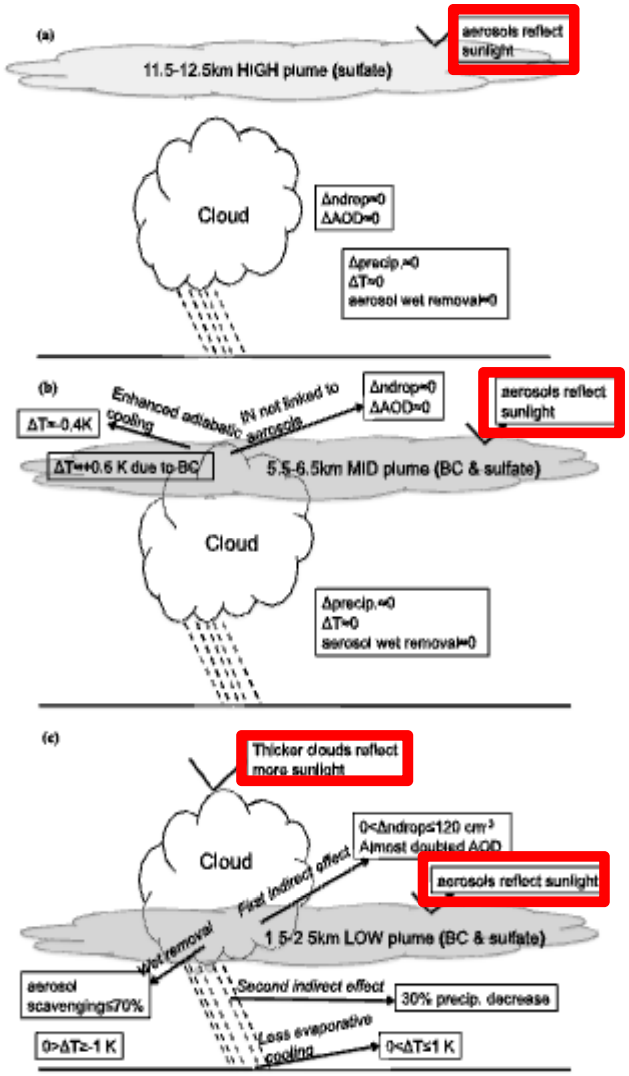
BELOW CLOUD BASE

PBL EMISSIONS
BELOW CLOUD BASE

BELOW AND ABOVE CLOUD

AEROSOLS AND CLOUDS, Zhao et al, 2012
ALTITUDE DEPENDENCE



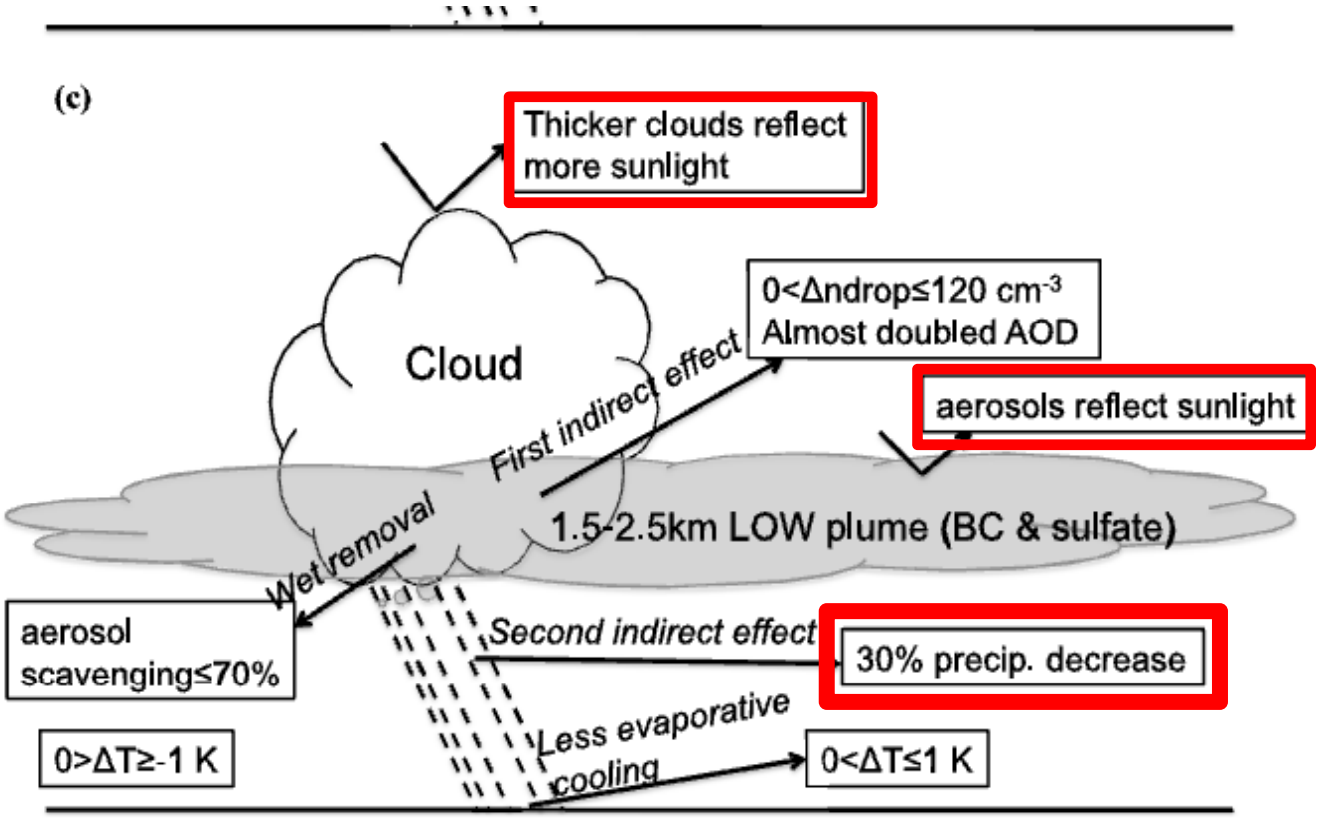


RADIATIVE EFFECTS

RADIATIVE EFFECTS

CLOUD MICROPHYSICS EFFECTS

Aerosols and Clouds, Zhao et al, 2012



Climate impact:

Affecting Clouds and rainfall (-30 % regional scale)

MEASUREMENTS BELOW CLOUDS

AEROSOL SOURCES

SPATIAL AND TEMPORAL RESOLUTION?

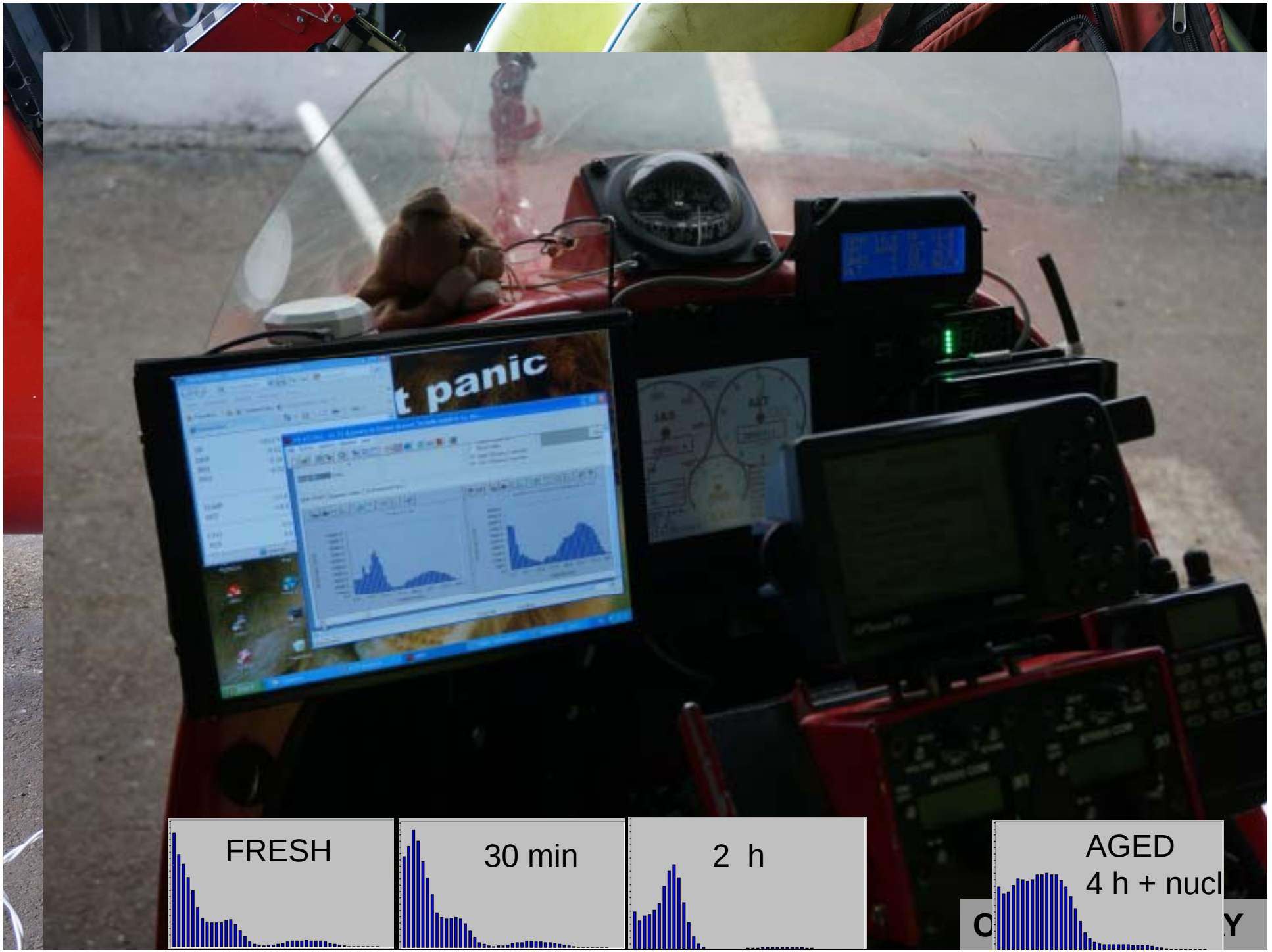
INSTRUMENTATION?

Ozone	UV-Photometer
CO_2/H_2O 20 Hz	IRGA
RADIATION	
Act. Rad. 300 nm JO1D	2 Filterradiometers
Act. Rad. 380 nm JNO2	2 Filterradiometers
Global radiation	2 LICOR Pyranometers
Albedo 400, 550, 650, 990 nm (NDVI)	2 four channel irradiance sensors
Infrared	2 CGR4 Pyrgeometers
METEOROLOGY	
Temperature	Pt 100 /fast Thermocouple
Humidity	Chilled mirror
Pressure	
Position	GPS
Wind (horizontal) 10 Hz	GPS/Compass/INS
Surface / Sky Temperature	IR sensors
AEROSOL	
CN / number	CPC4 (> 4.5 nm)
Aerosol / size distr.	OPC, 300 nm – 20 um
Submicron aerosol size distribution (SMPS) 4.5-350 nm	
Scatt. coeff. / visibility	HSS-AVMIII, 870 nm
Absorption coefficient (BC)	7 wavelength Aethalometer
Cloud Condensation Nuclei (CCN)	Roberts CCN Spectrometer
CLOUD DROPLET SPECTRA	FSSP-100
μ-METEOROLOGY	
Turbulence, 3D windvector	5 hole noseboom probe
Attitude / Heading	Oxford Tech. INS

Karlsruhe Institute of Technology

2014


AEROSOL-SIZE DISTRIBUTION
4.5 nm – 20 um, 2 min / > 300nm 6 s / # 1 s
ONLINE_DISPLAY


t panic
FRESH
30 min
2 h
AGED
4 h + nucl

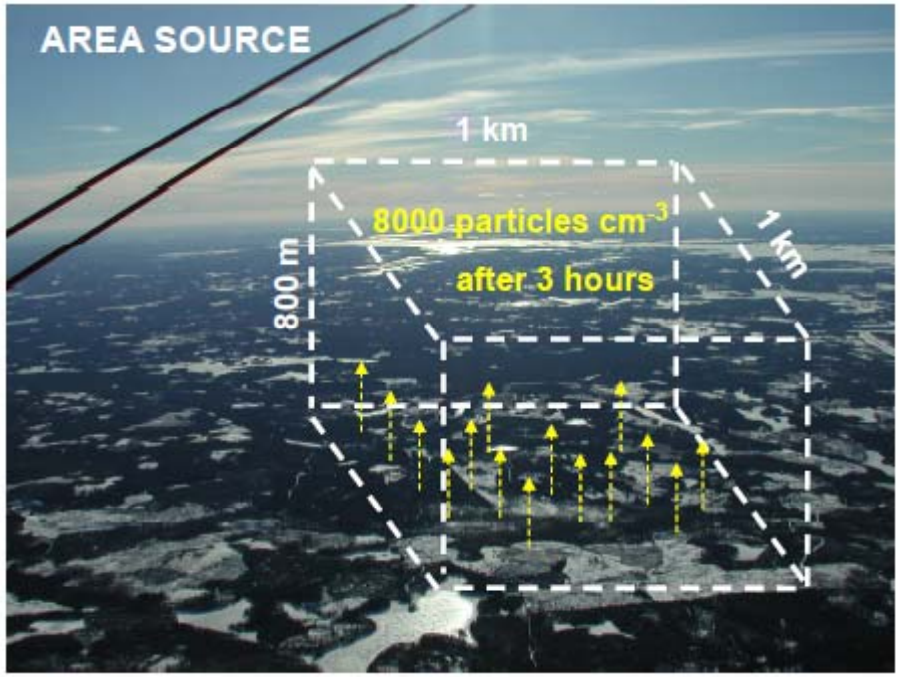

THE WORK PLACE
AIRCRAFT
GPS
RADIO
S- MODE
TRANSPONDER

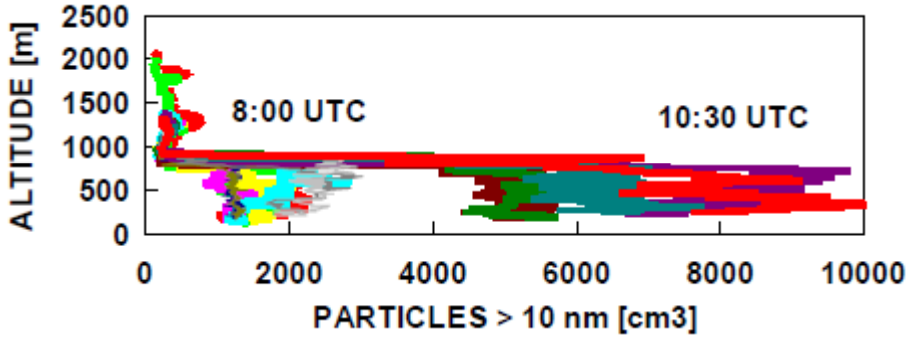

FLYING LOW AND SLOW

SOURCES FOR CLOUD RELEVANT PARTICLES

INVISIBLE PARTICLES
UFP / CCN
WITHIN THE PBL

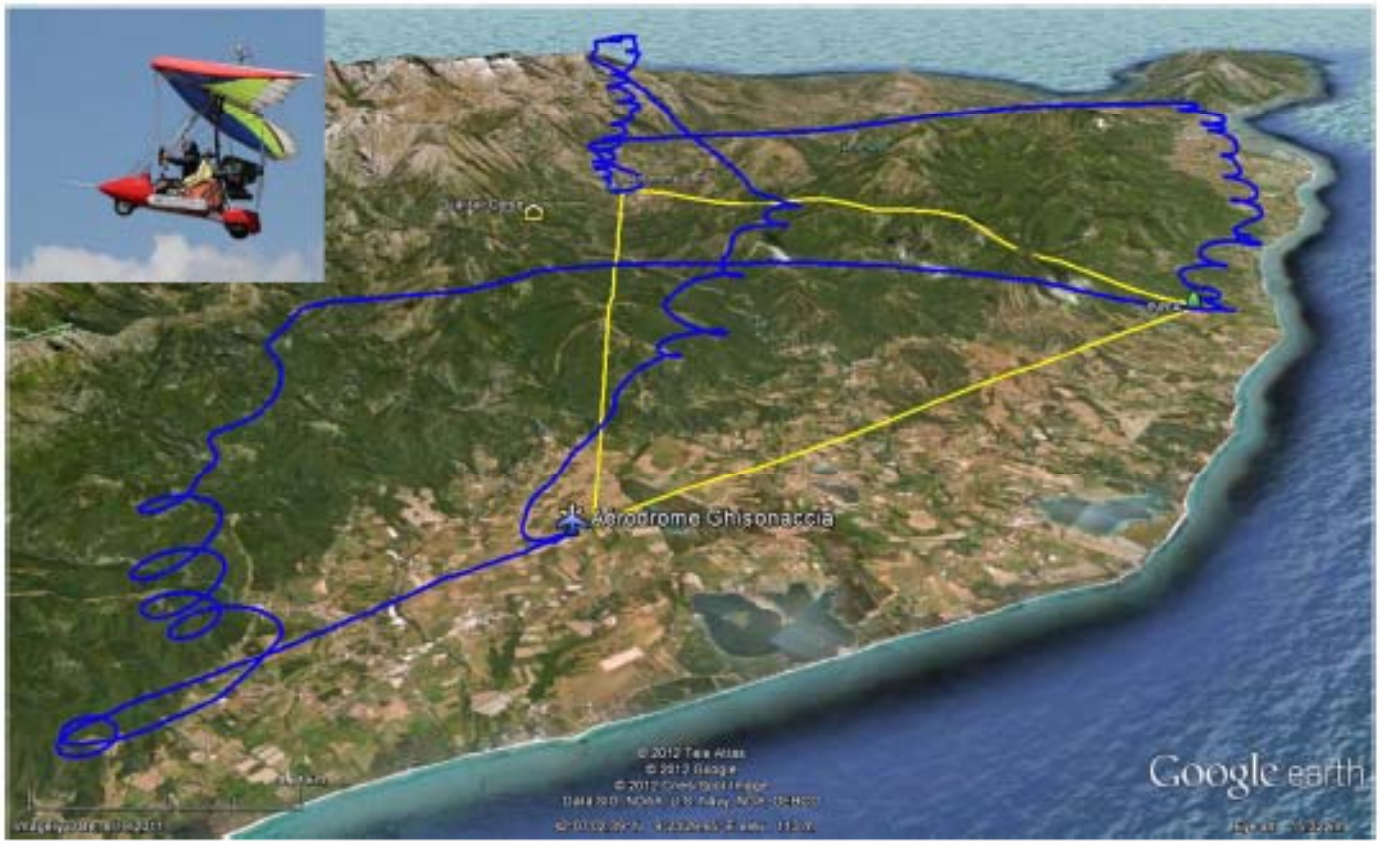
SOURCES FOR CLOUD RELEVANT PARTICLES





FINLAND MARCH 2003
Winter operation ~10 °C

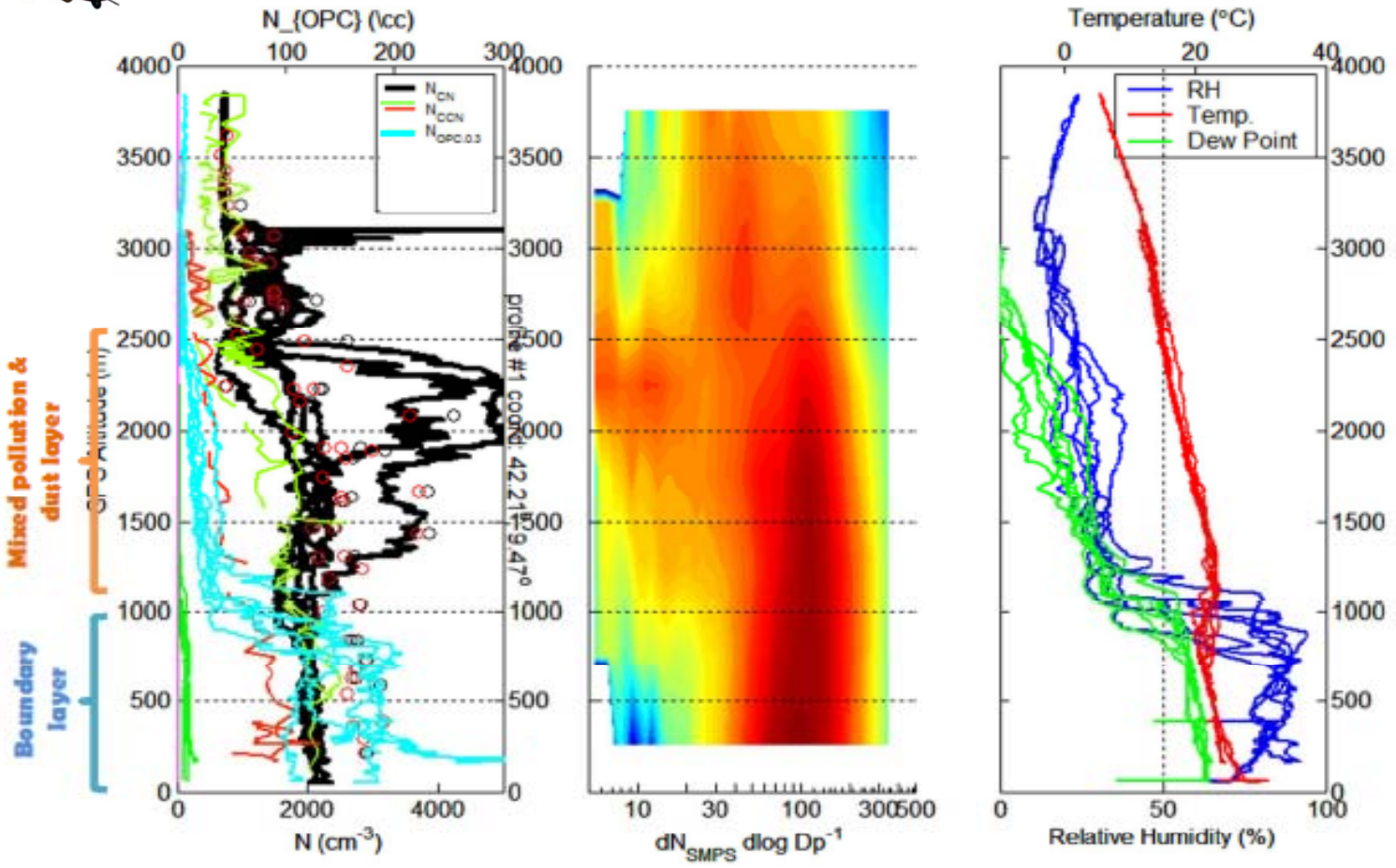
Typical VESSAER Flight



Vertical profiles over Corte, San Giuliano (INRA), and Ghisonaccia / Solenzara

Aerosols over Corsica

Vertical profiles (8 July)



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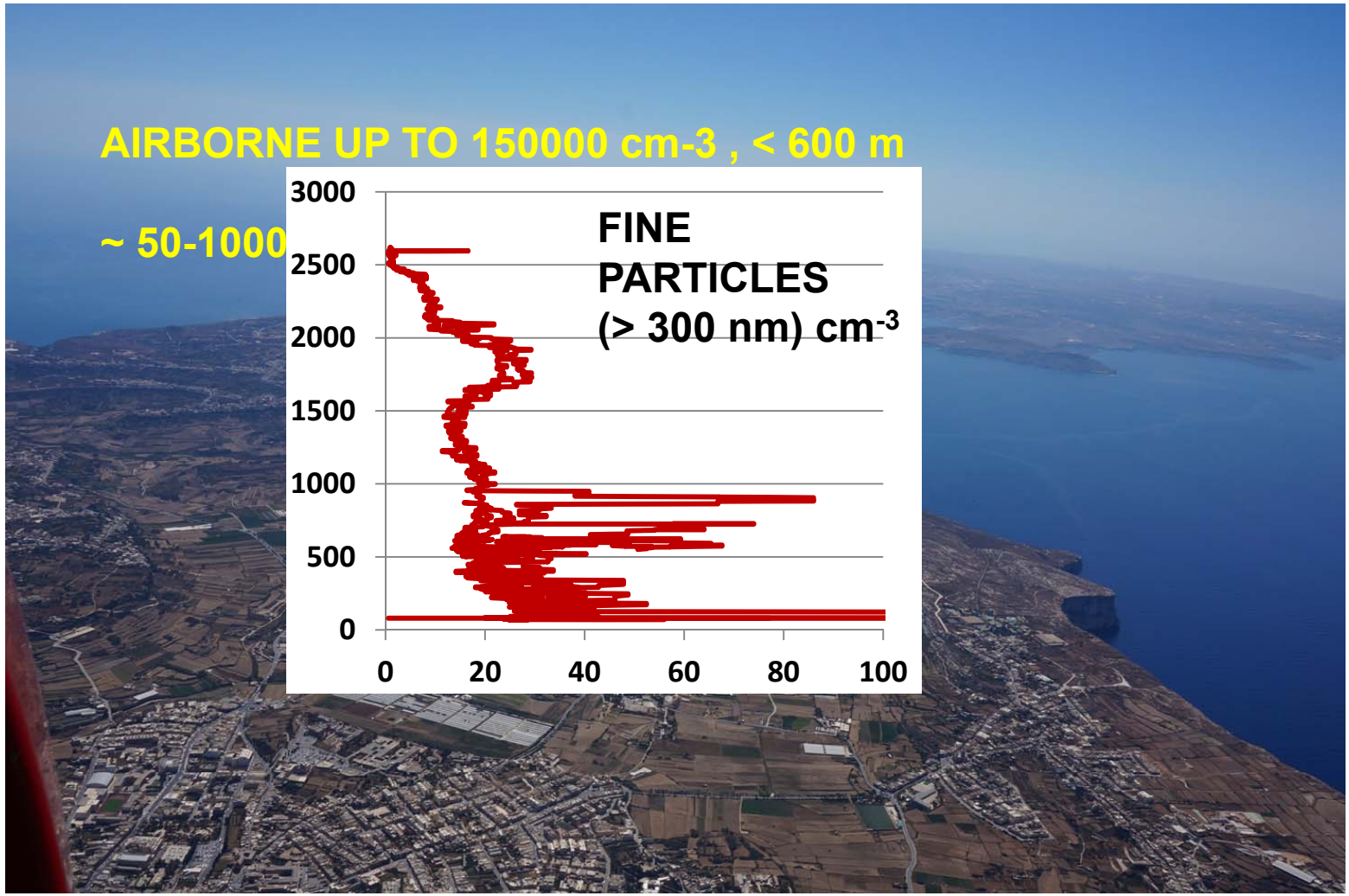
Wolfgang Junkermann, KIT, IMK-IFU, Garmisch-Partenkirchen

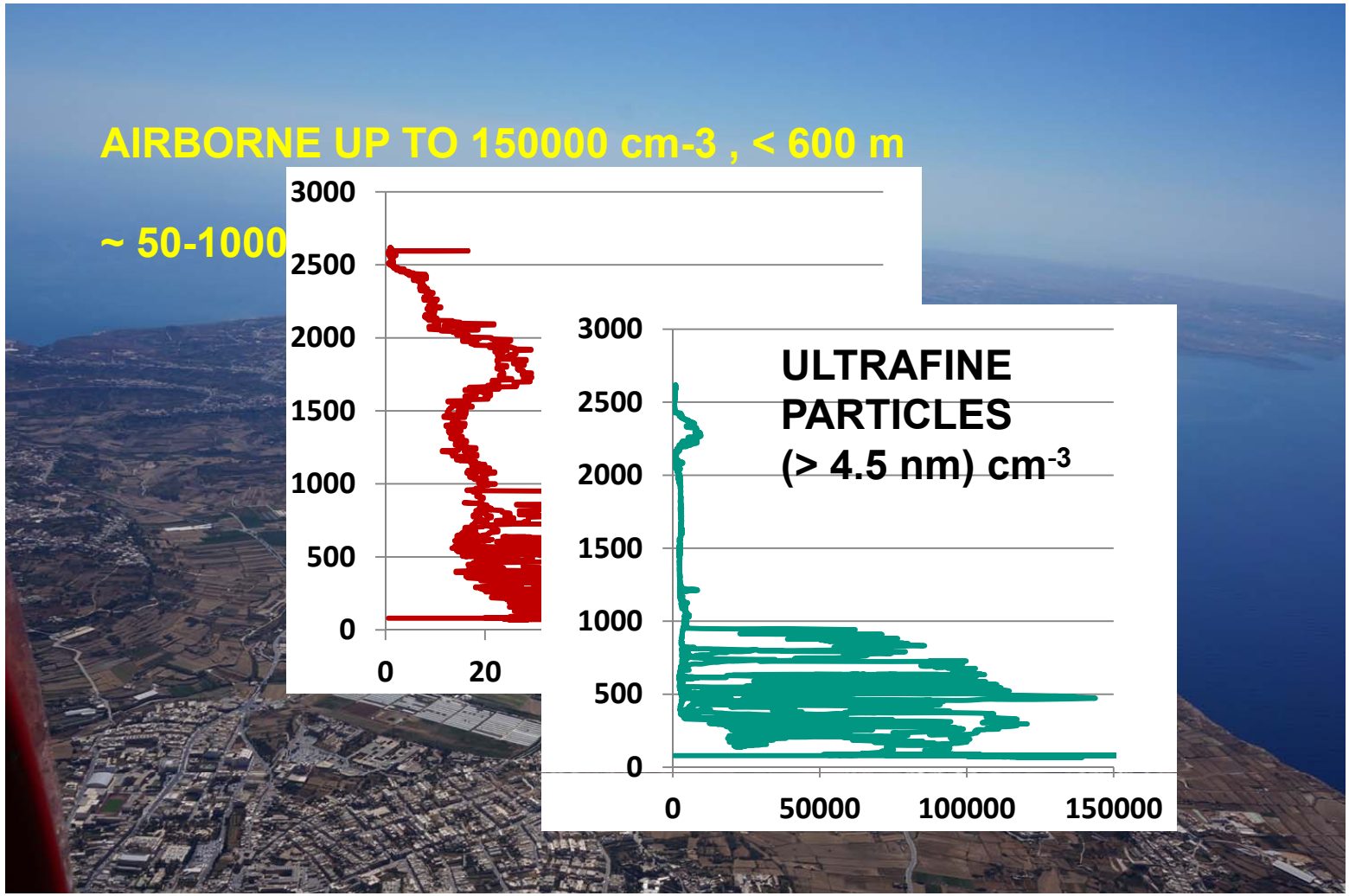
IMK-IFU, Garmisch-Partenkirchen, Germany

Aerosols over the Malta / Gozo



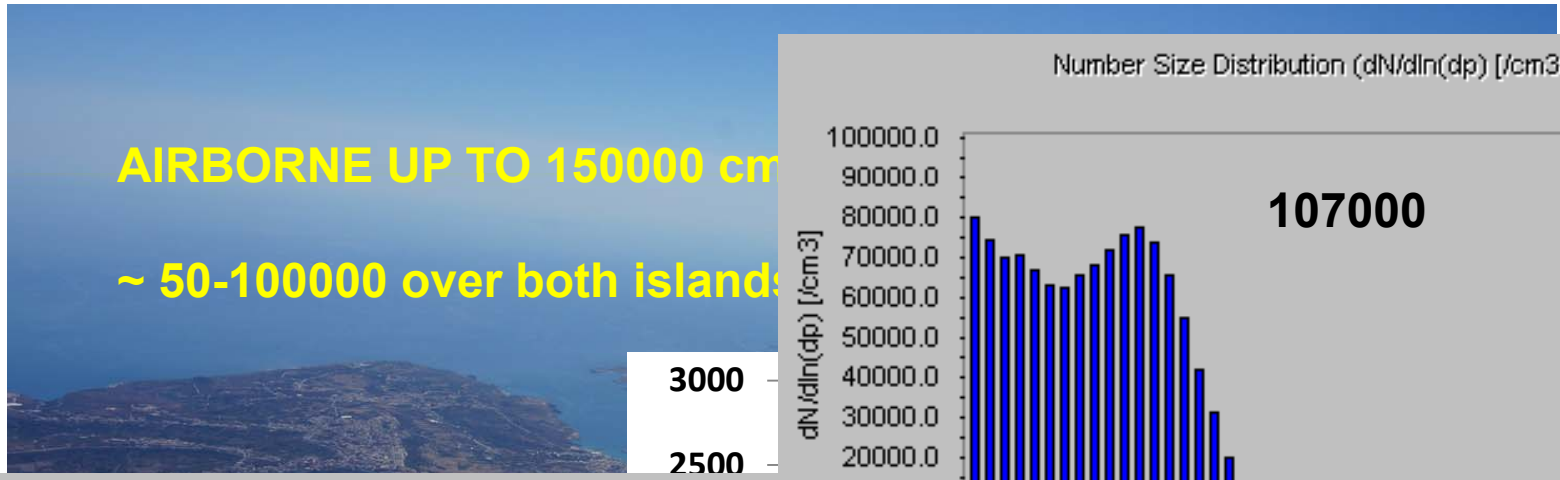
MALTA, 2013, CHARMEX

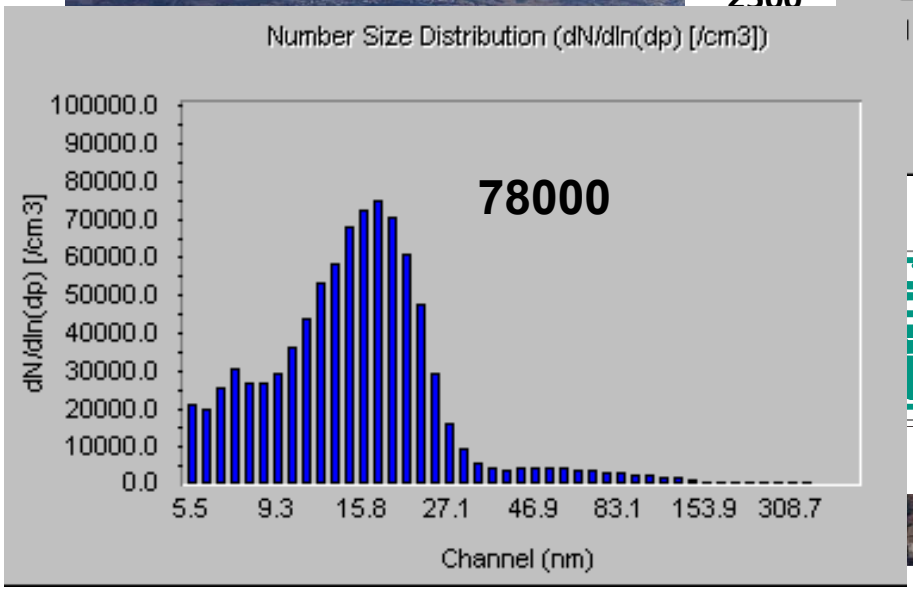
Aerosols over the Malta / Gozo

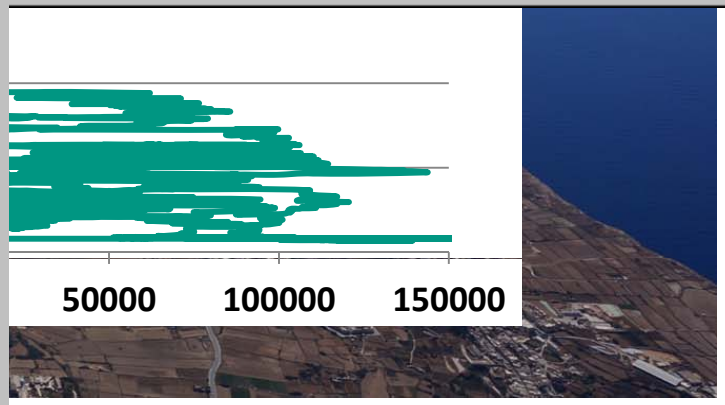


MALTA, 2013, CHARMEX

Aerosols over the Malta / Gozo

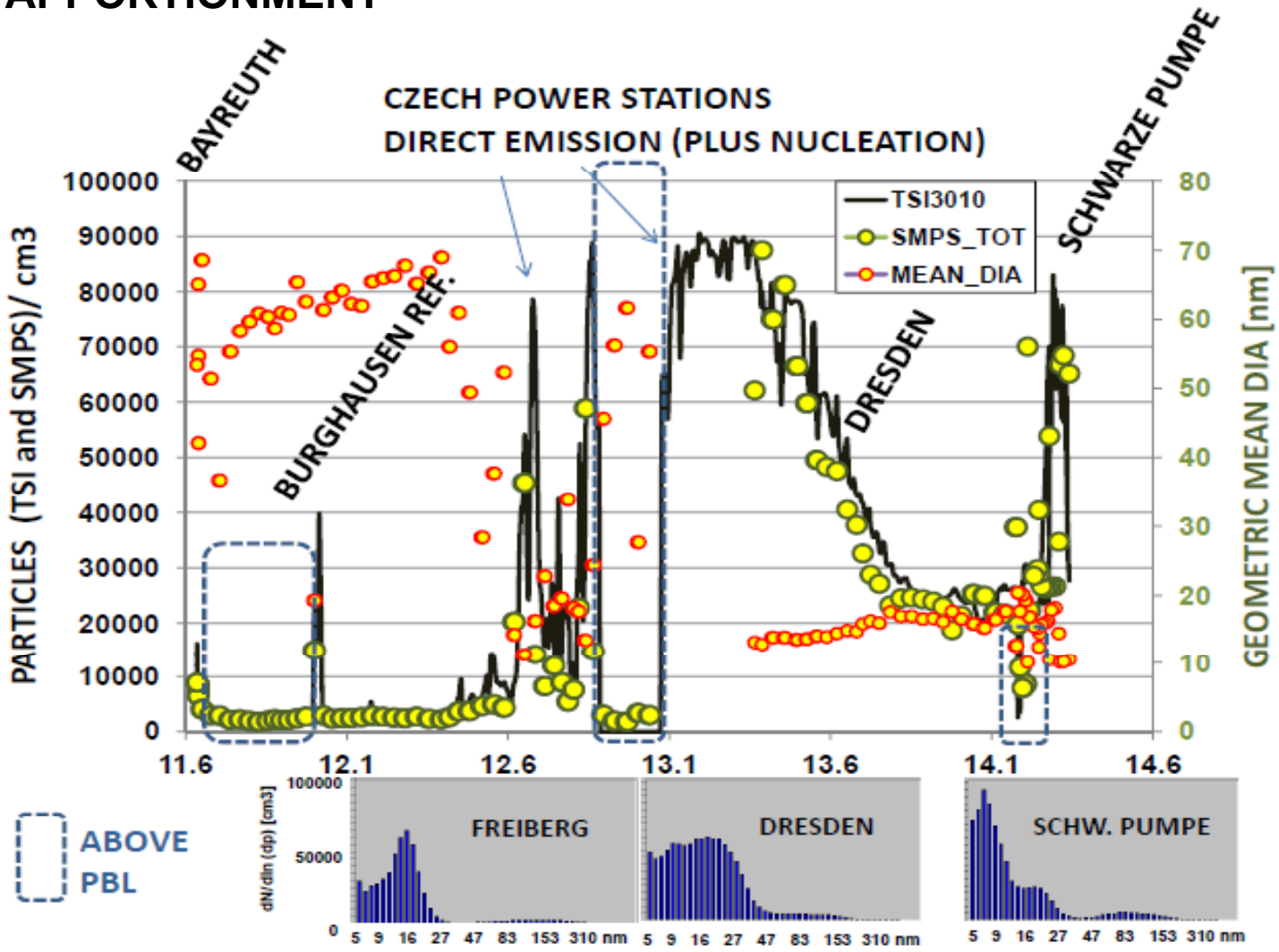






MALTA, 2013, CHARMEX

SOURCE APPORTIONMENT



SOURCE APPORTIONMENT

PBL < 600 m agl

SOURCE APPORTIONMENT?

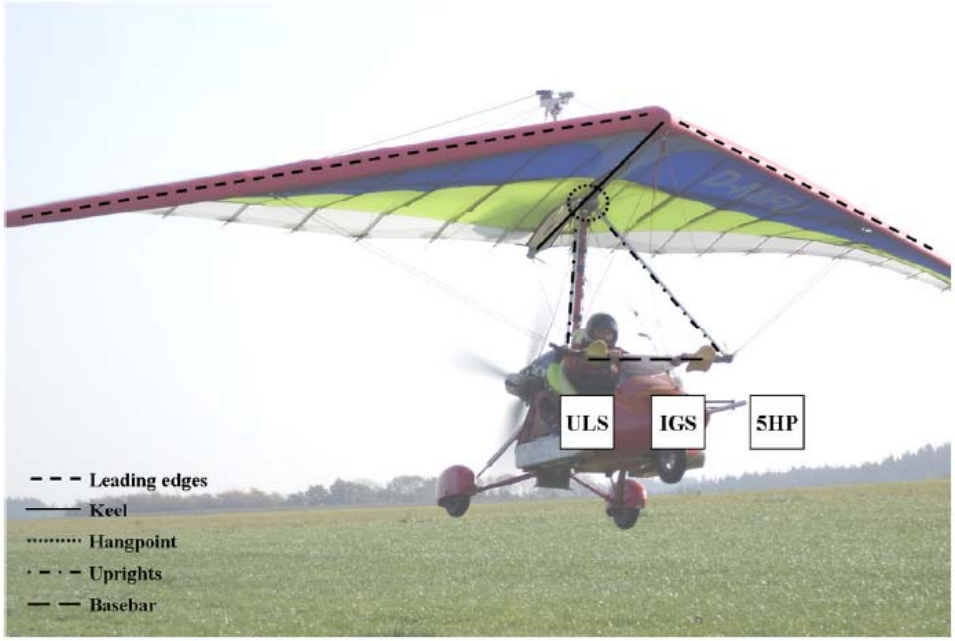


Fig. 1. Weight-shift microlight research aircraft D-MIFU, aircraft structural features are highlighted by dash-dotted lines. Sensor locations of wind-measuring five hole probe (5HP), inertial measurement and global positioning system (IGS, inside aircraft nose) and universal laser altitude sensor (ULS, below pilot seat) are indicated. Figure modified after Metzger et al. (2011, Appendix B).

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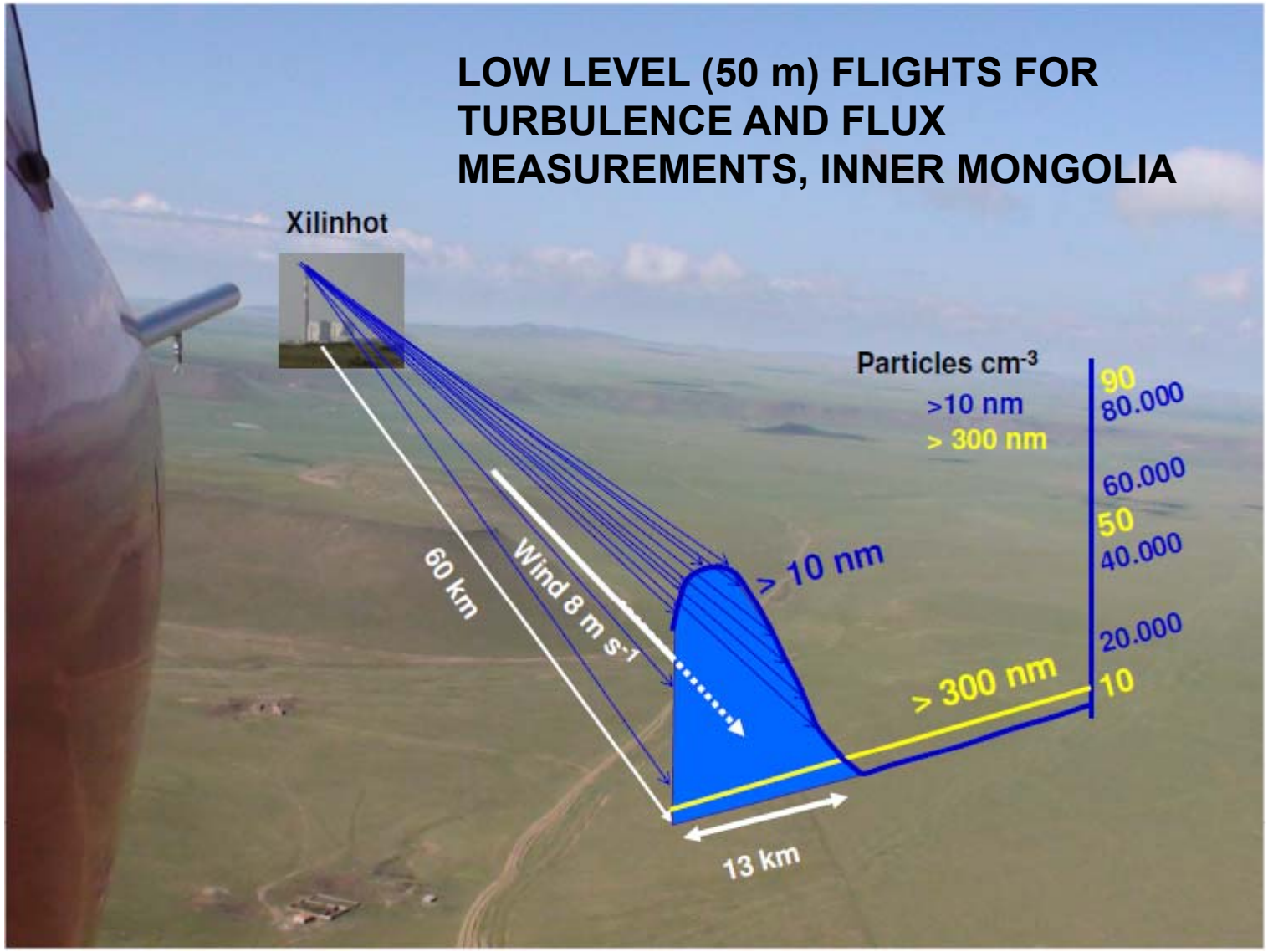
SOURCE APPORTIONMENT

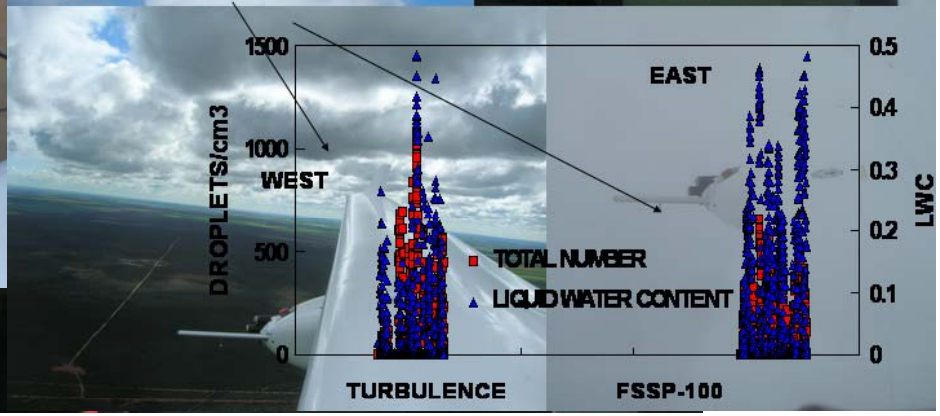


LIMITS

LIMITS

MEASURING THE CLOUD DROPLET SIZE DISTRUBUTION

AVG DIA 6 / 8 µm



LIMITS

WINDS /GUSTS

Max ground wind speed 15 kt

LIMITS

LIMITS

LIMITS

PERMITS

Switzerland
Spain
Italy....

ADVANTAGES

SIMPLE REGULATIONS,
CERTIFICATION ETC.

FEDERAL REPUBLIC OF GERMANY

REPRESENTATIVE OF THE
MINSTRY OF TRANSPORT

CERTIFICATE OF AIRWORTHINESS
FOR
AIR SPORT EQUIPMENT

TYPE OF AIR SPORT EQUIPMENT

MICROLIGHT D-MIFU

ADVANTAGES

Pusher Configuration

Simple inlet systems

Versatile modular instrument system also for other platforms

ADVANTAGES

SIMPLE WORLDWIDE TRANSPORT

CHINA INNER MONGOLIA

AIR FREIGHT MEXICO (PUEBLA)

ROAD

ADVANTAGES

STOL, LOW REQUIREMENTS ON LANDING STRIP

ADVANTAGES

STOL, LOW REQUIREMENTS ON LANDING STRIP

COST

DIS-ADVANTAGES

Sensitive to orographic turbulence

Sensitive to weather (hangar required)

Low gliding angle
In case of emergency

Legislative limits (Switzerland/Italy/Spain)

Availability of pilots

SUMMARY

VERSATILE PLATFORM WITH HIGLY MODULAR INSTRUMENT SYSTEM

Requires small size instruments compatible with UAV

Low speed allows to use ‚slow' instruments

SUMMARY

VERSATILE PLATFORM WITH HIGLY MODULAR INSTRUMENT SYSTEM

Major App.
PBL research
Regional scale

Instrument pods useful also for other platforms

SUMMARY

WSMA COMPLEMENTARY TO OTHER SMALL ENVIRONMENTAL RESEARCH AIRCRAFT (SERA)

COVERING A SPECIAL NICHE AT LOW COST

HOWEVER, FOR CERTAIN PROBLEMS OTHER SERA‘s WOULD BE MORE SUITABLE

THANK YOU FOR YOUR ATTENTION

KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

Wolfgang Junkermann

IMK-IFU, Garmisch-Partenkirchen, Germany