Shortcomes in ultrafine particle measurement and source attribution, a review

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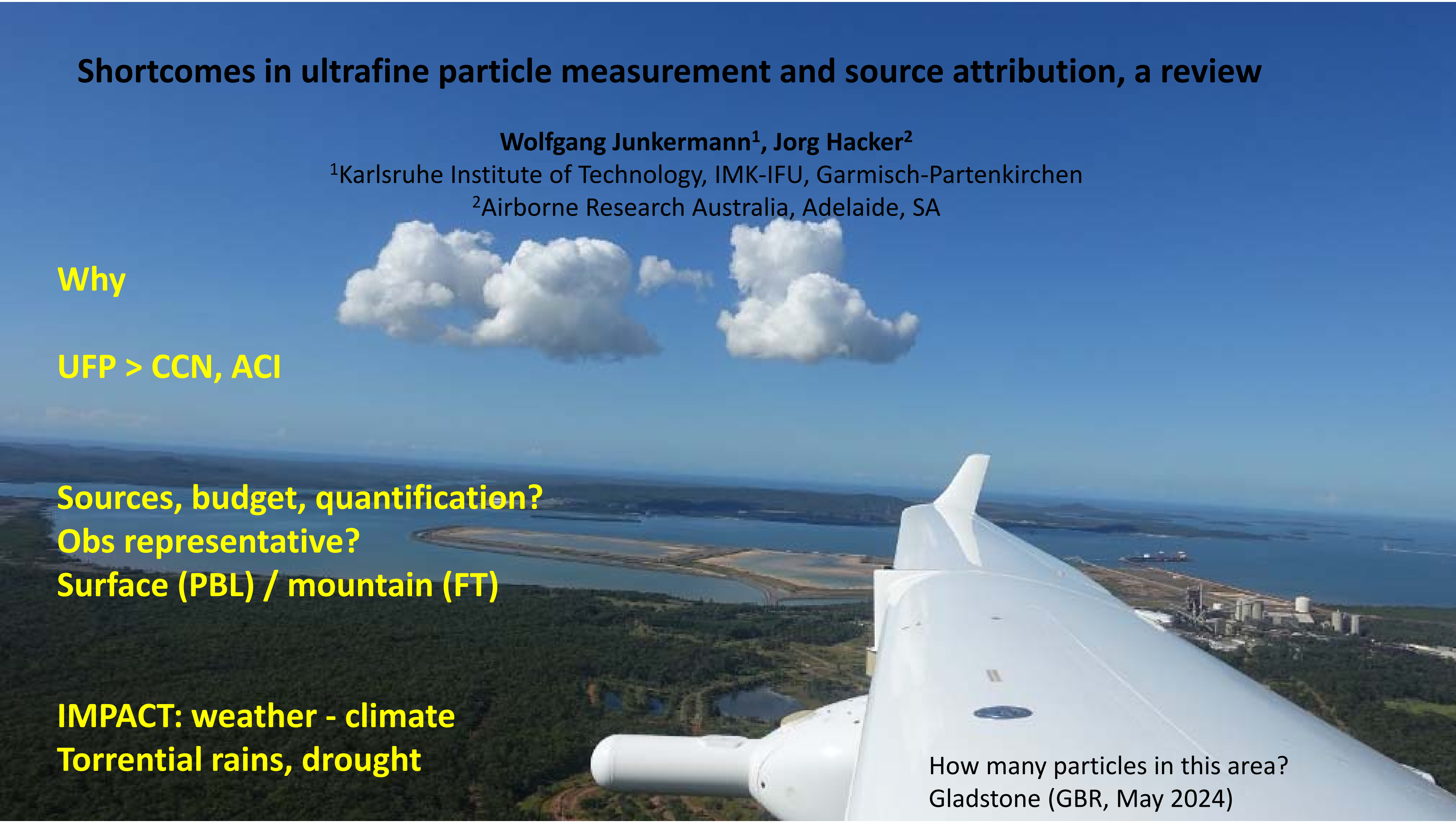


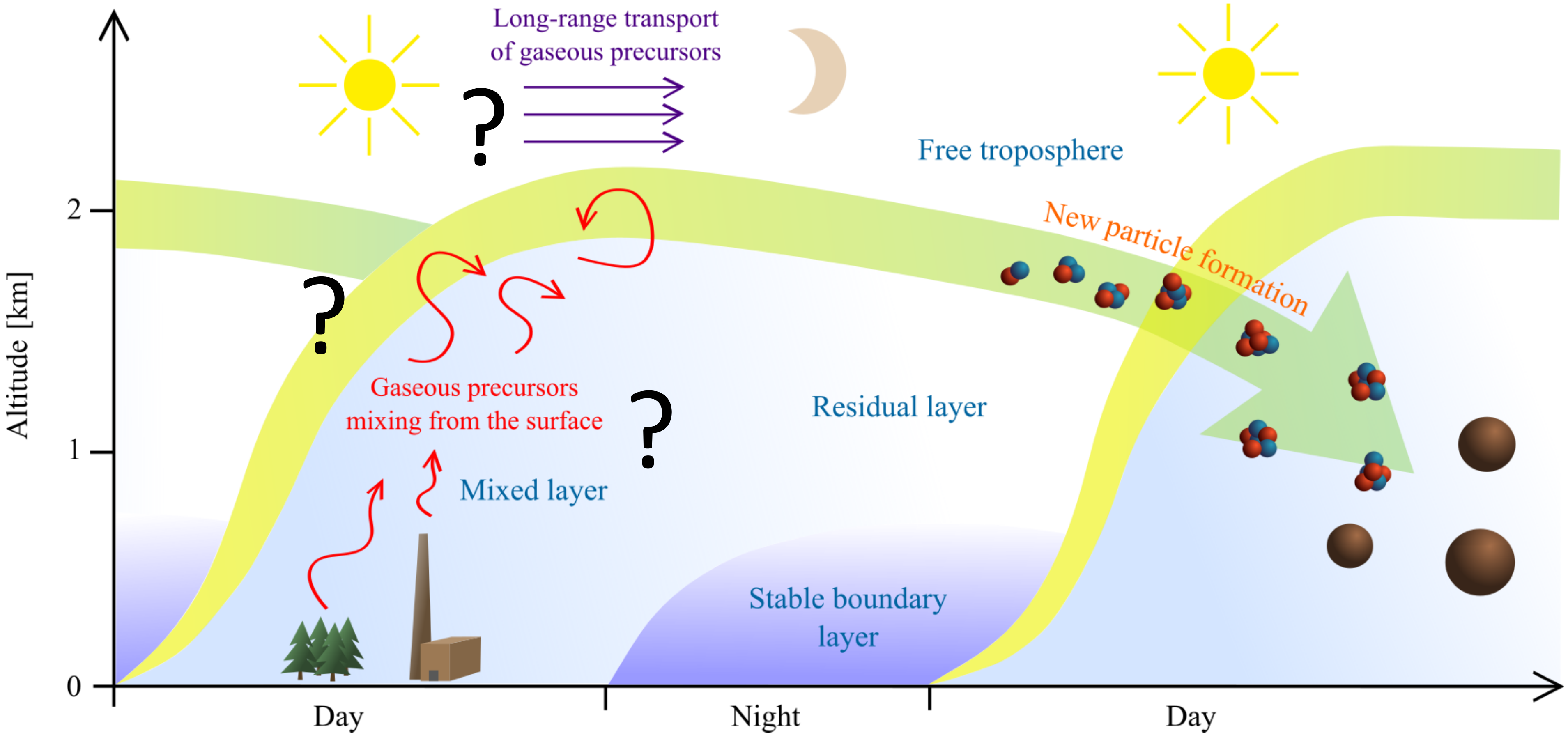
Why

UFP > CCN, ACI

Sources, budget, quantification?
Obs representative?
Surface (PBL) / mountain (FT)

IMPACT: weather - climate
Torrential rains, drought

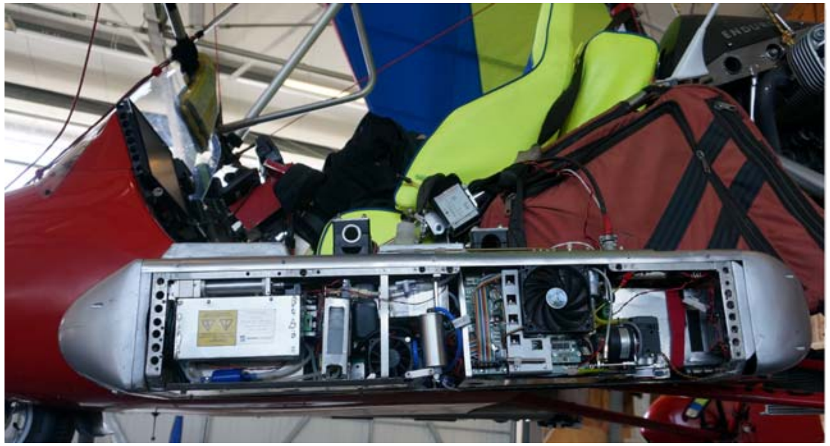
How many particles in this area?
Gladstone (GBR, May 2024)



LAMPILAHTI, 2021, ACP

> 42% of all Nano-Particle Events

see also Buzorius et al, 2001



KIT-Campus Alpin

IMK-IFU: Atmospheric Environmental Research

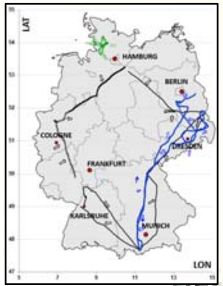
KIT

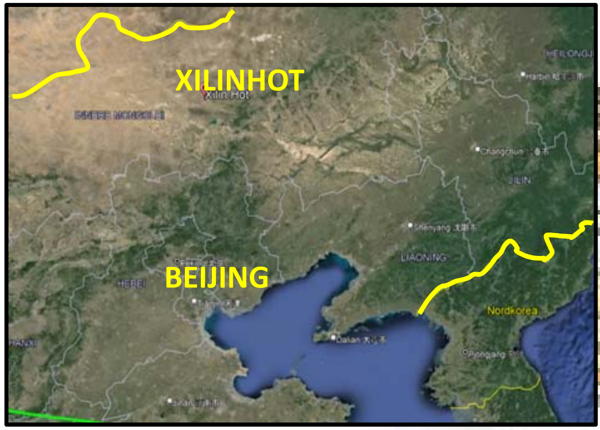
Karlsruhe Institute of Technology

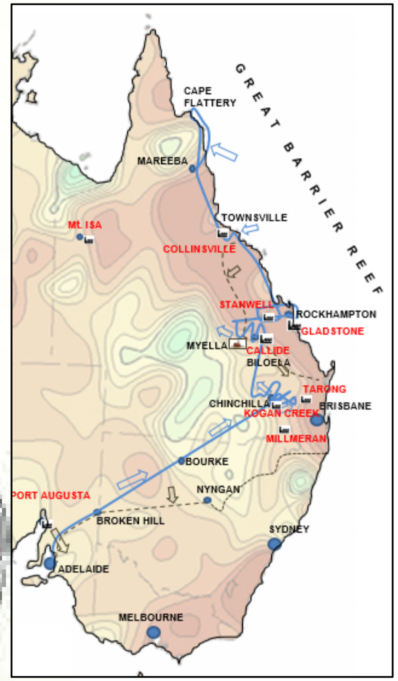
Aerosols, CPC, OPC, SMPS
Size distribution 4.5 nm – 20 um

WHERE IN THE WORLD ?

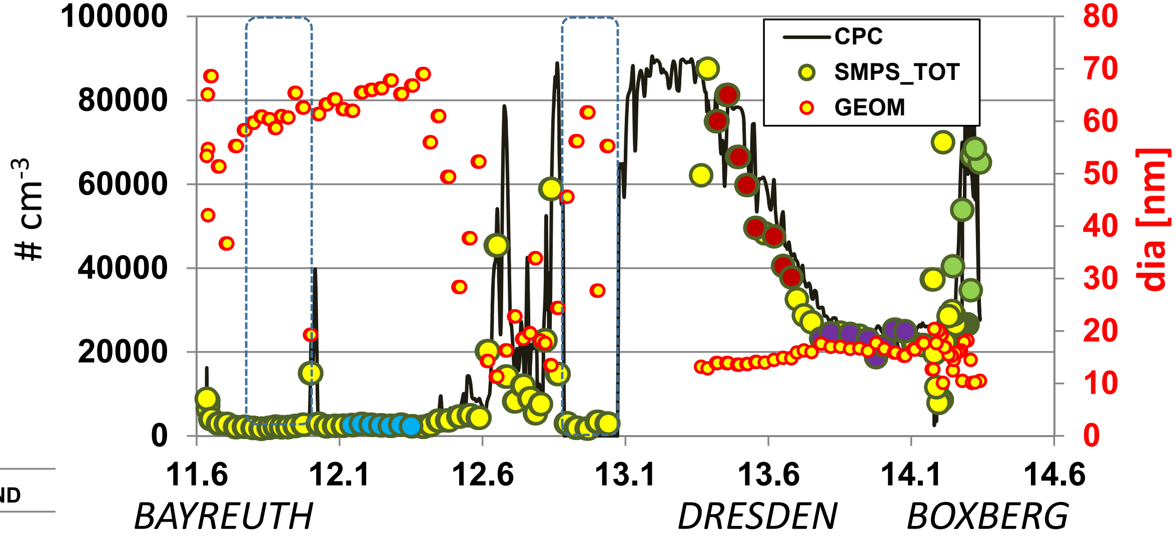
F, GB, F, I, AUS

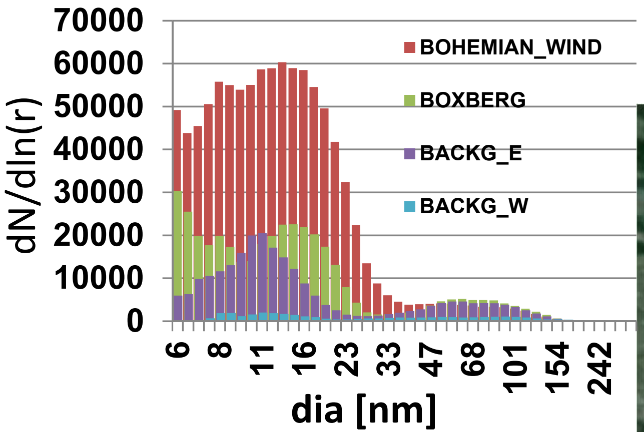


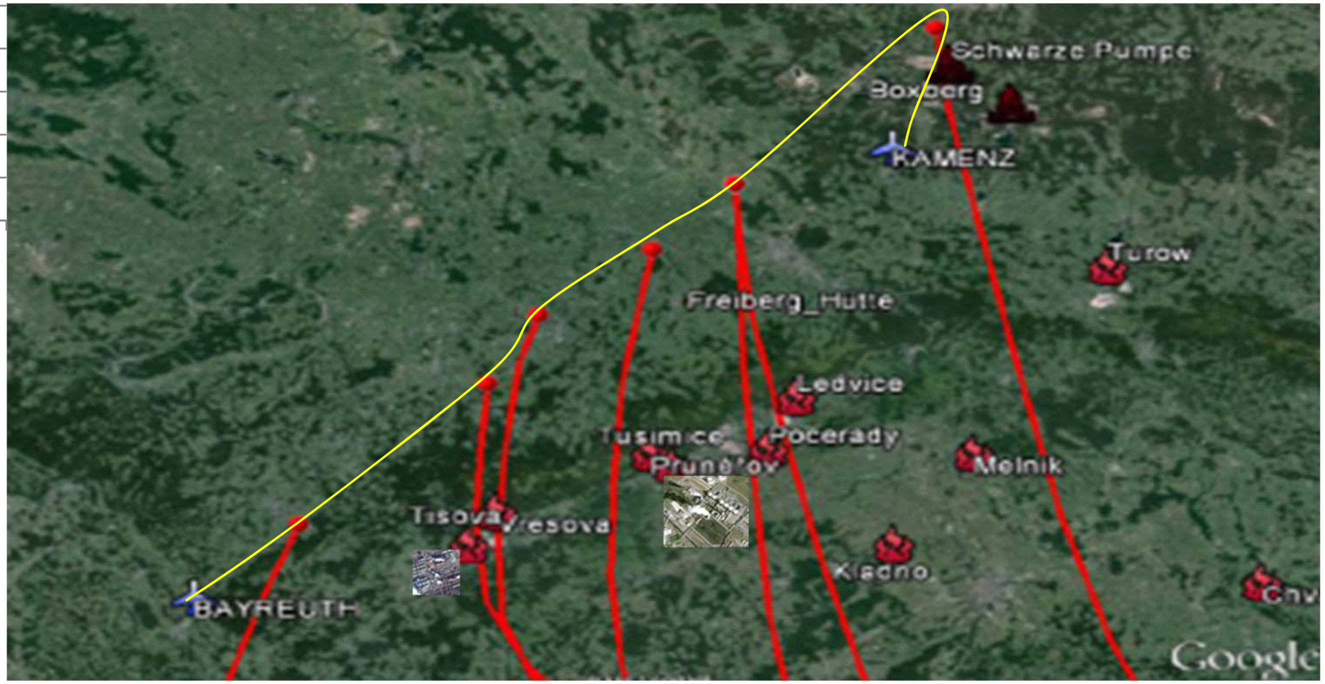




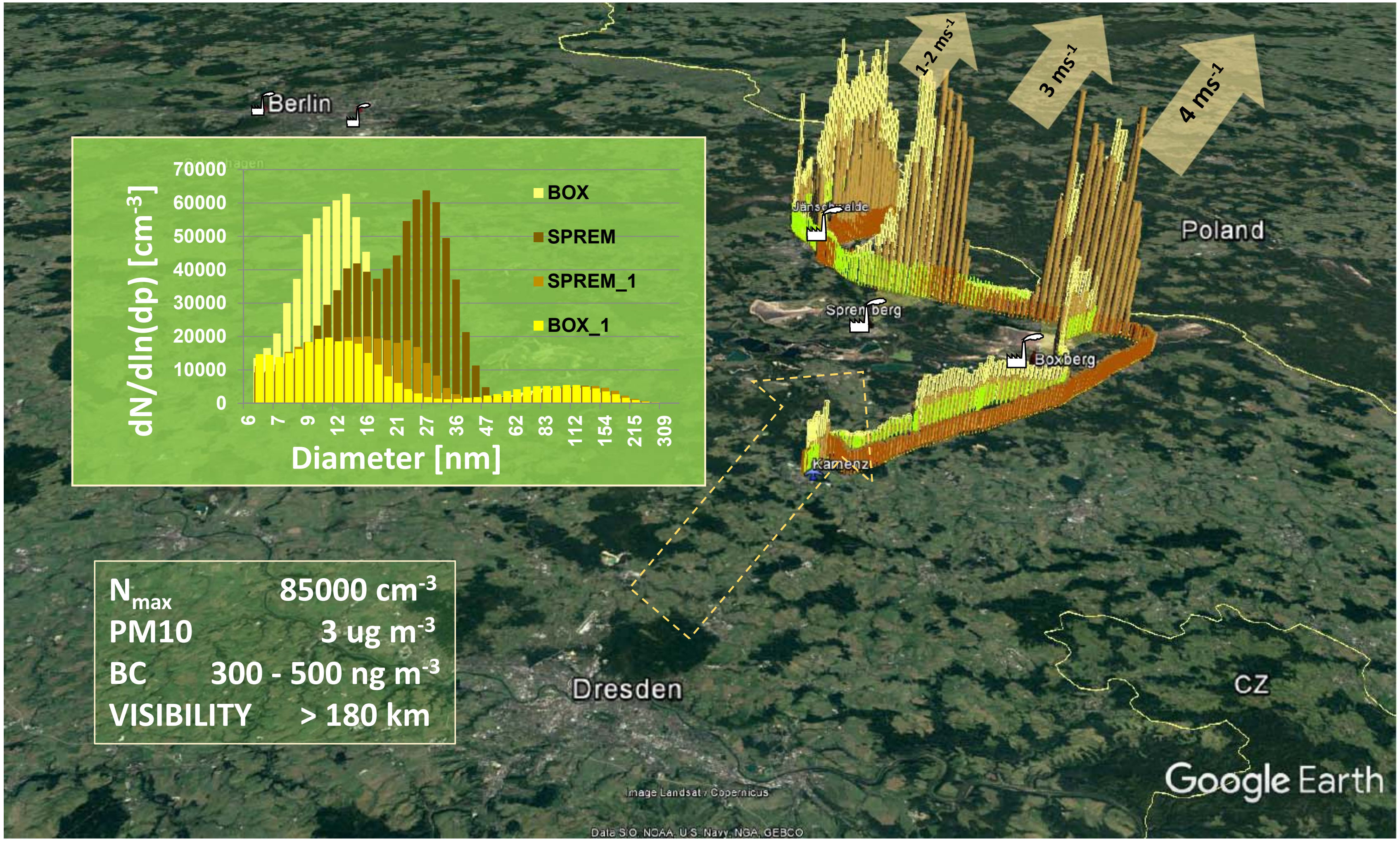
εὕρηκα



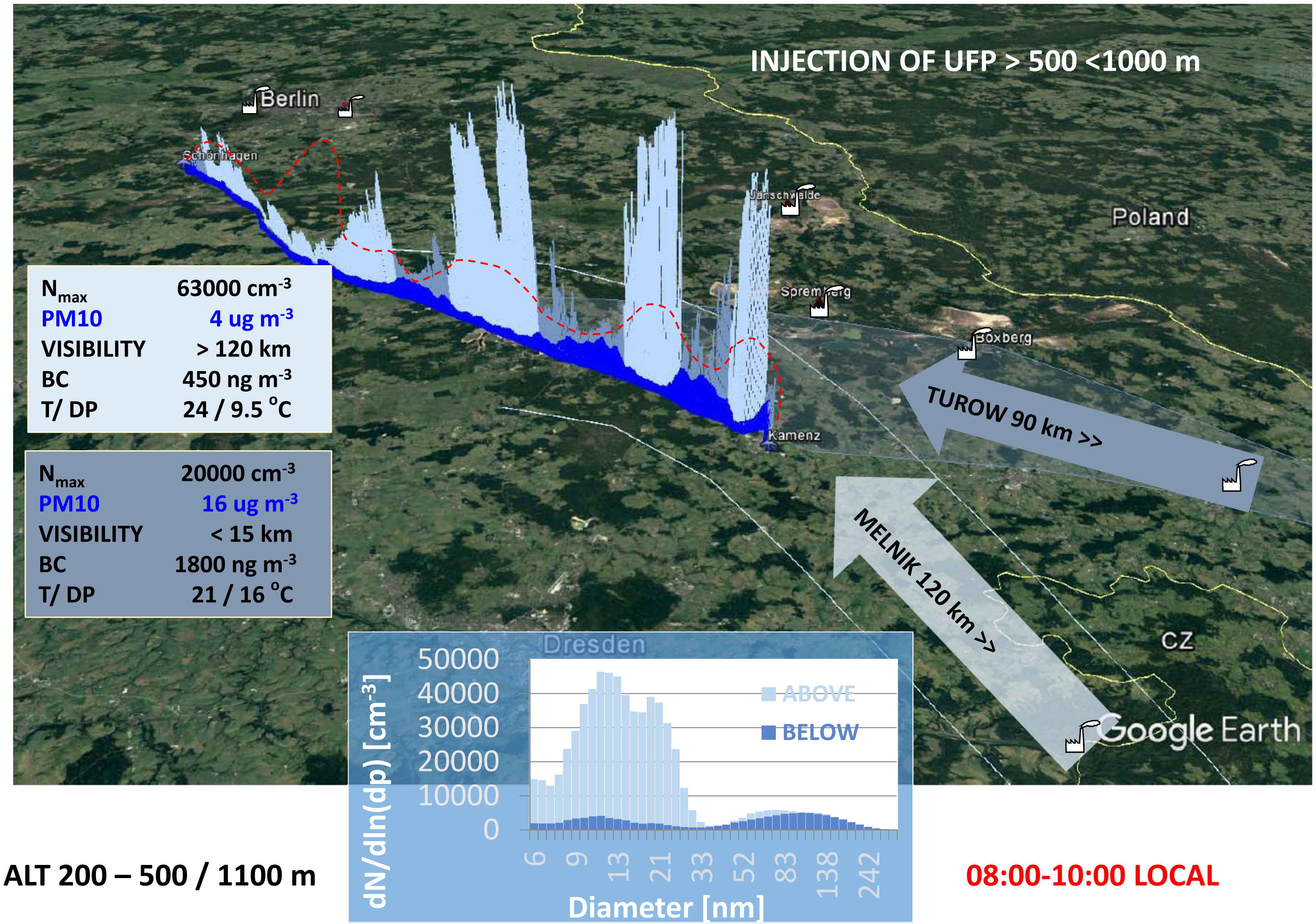




Karlsruhe Institute of Technology



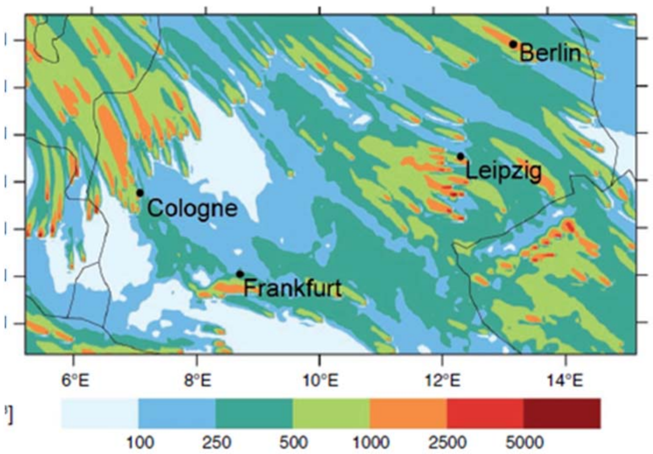
ALT 500 / 1000 m **11:00-14:00 LOCAL**

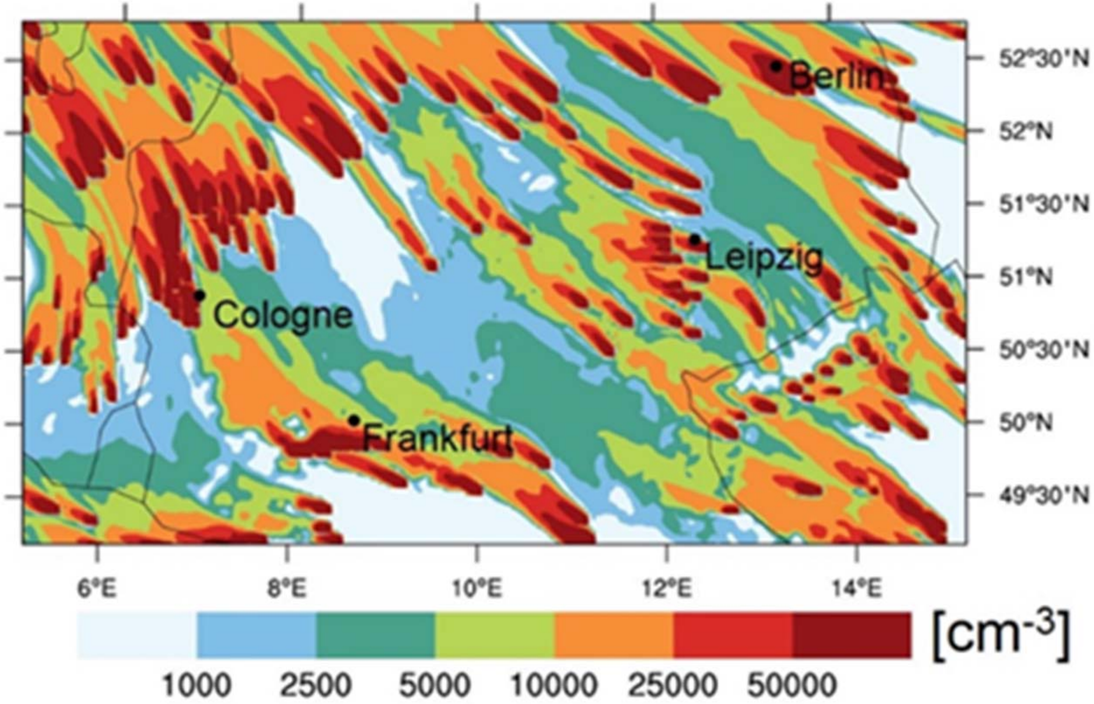


ALT 200 – 500 / 1100 m

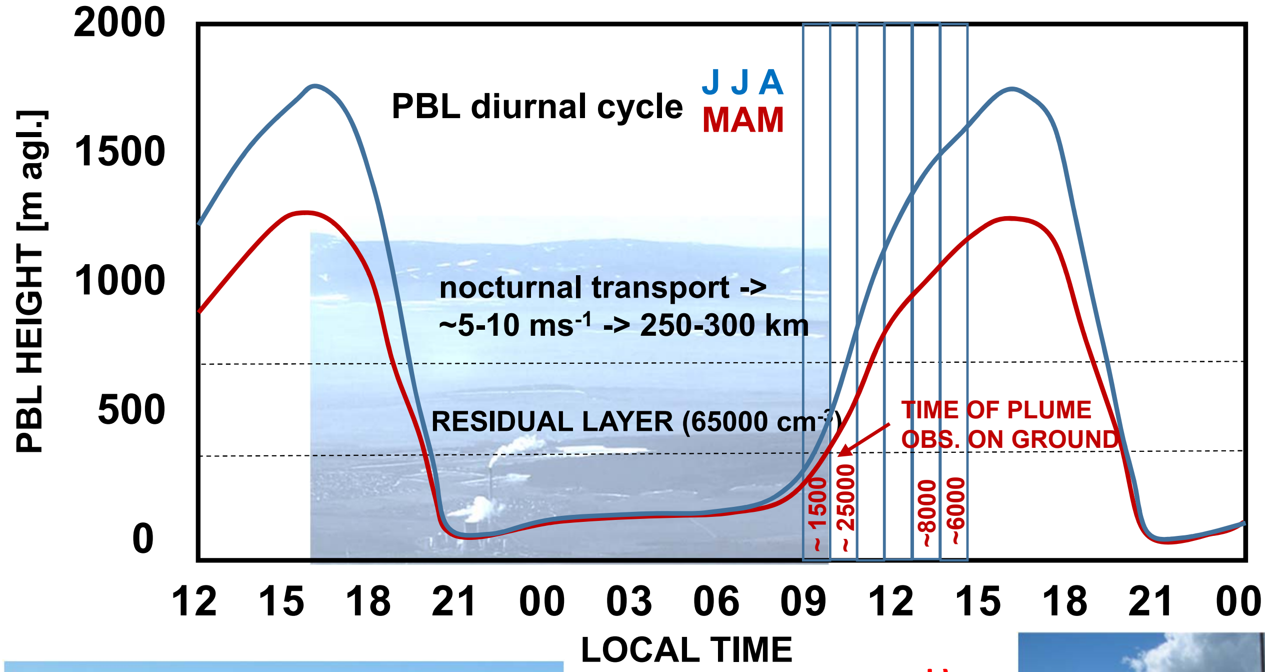
08:00-10:00 LOCAL

PATCHWORK BLANKET OF UFP OVER NORTHERN GERMANY 500 m agl (COSMO_ART)
Junkermann et al, 2016



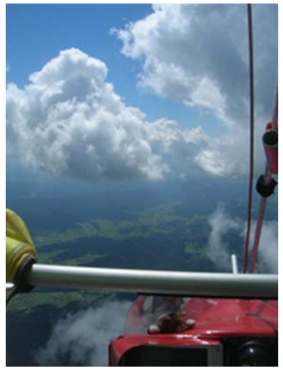


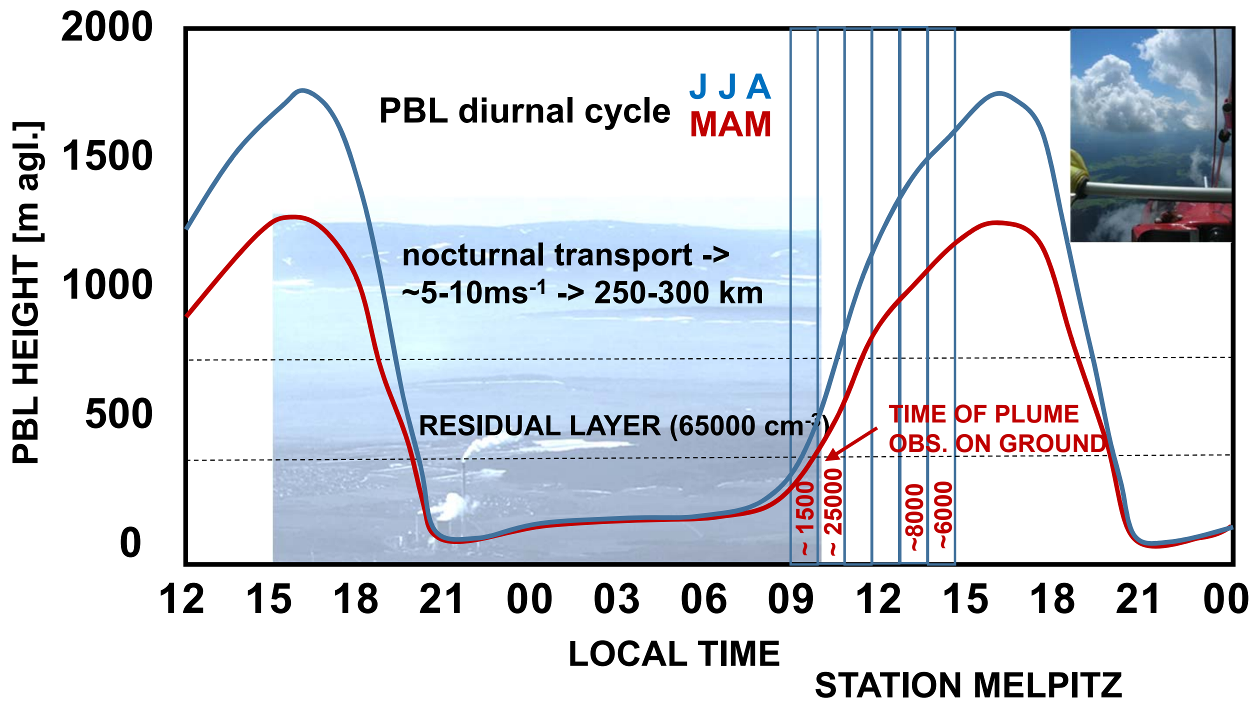
Diurnal PBL-Cycle (SGP) and emission into residual layer or noct. FT



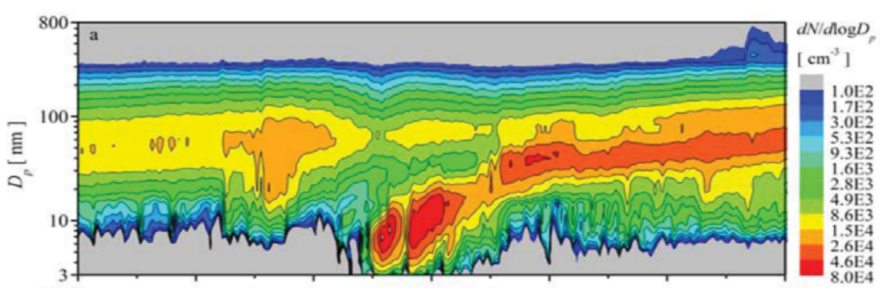
JUNKERMANN AND HACKER, 2018, BAMS

Vertical transport





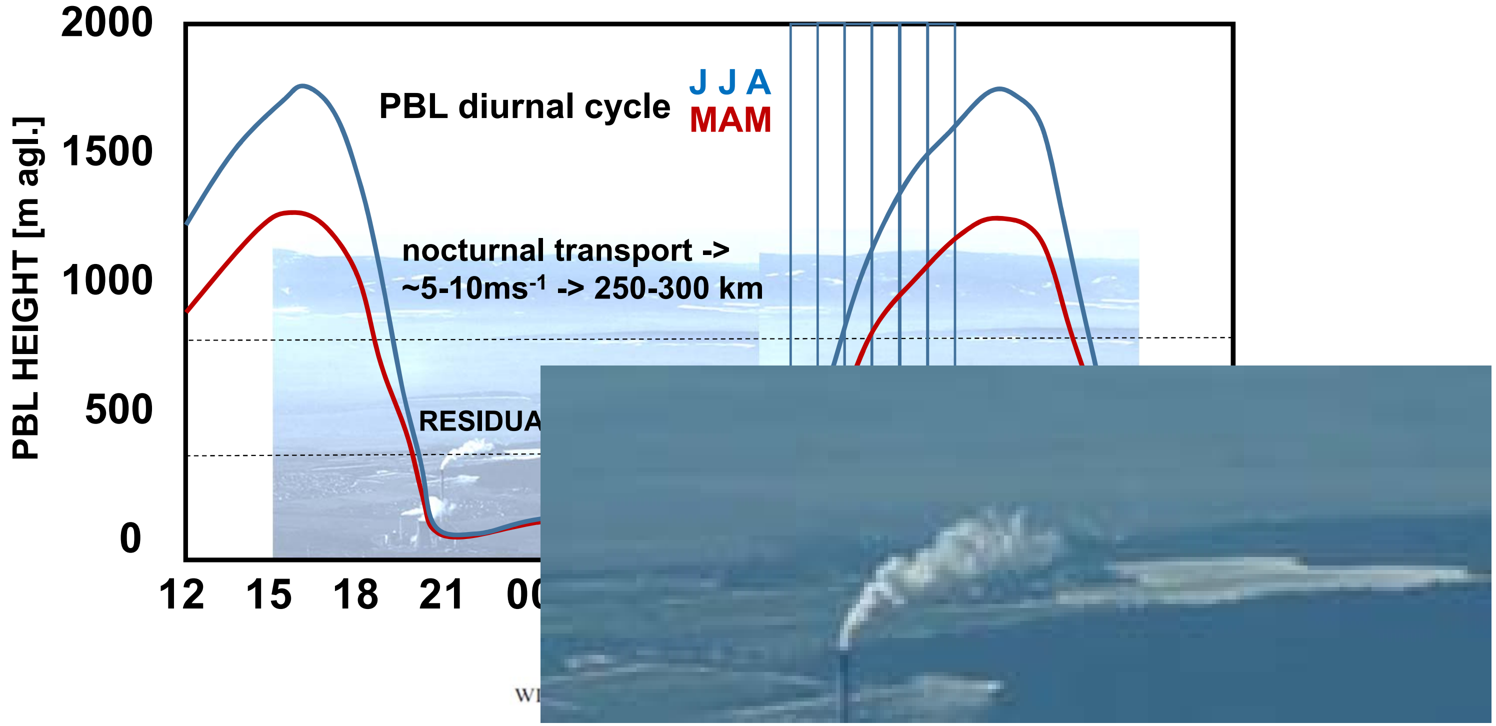
WIEDENSOHLER ET AL.: RAPID PARTICLE GROWTH AND CCN ACTIVITY



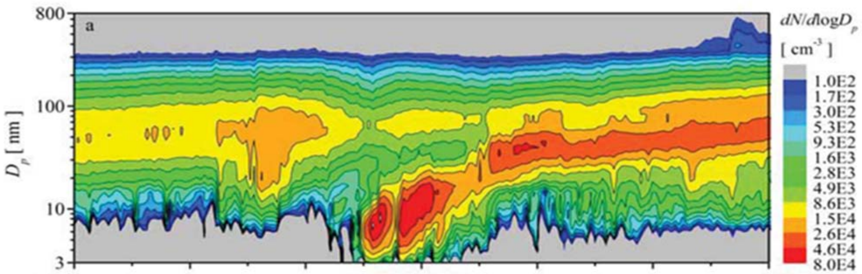
NPE

OUT OF

THE BLUE



INVISIBLE

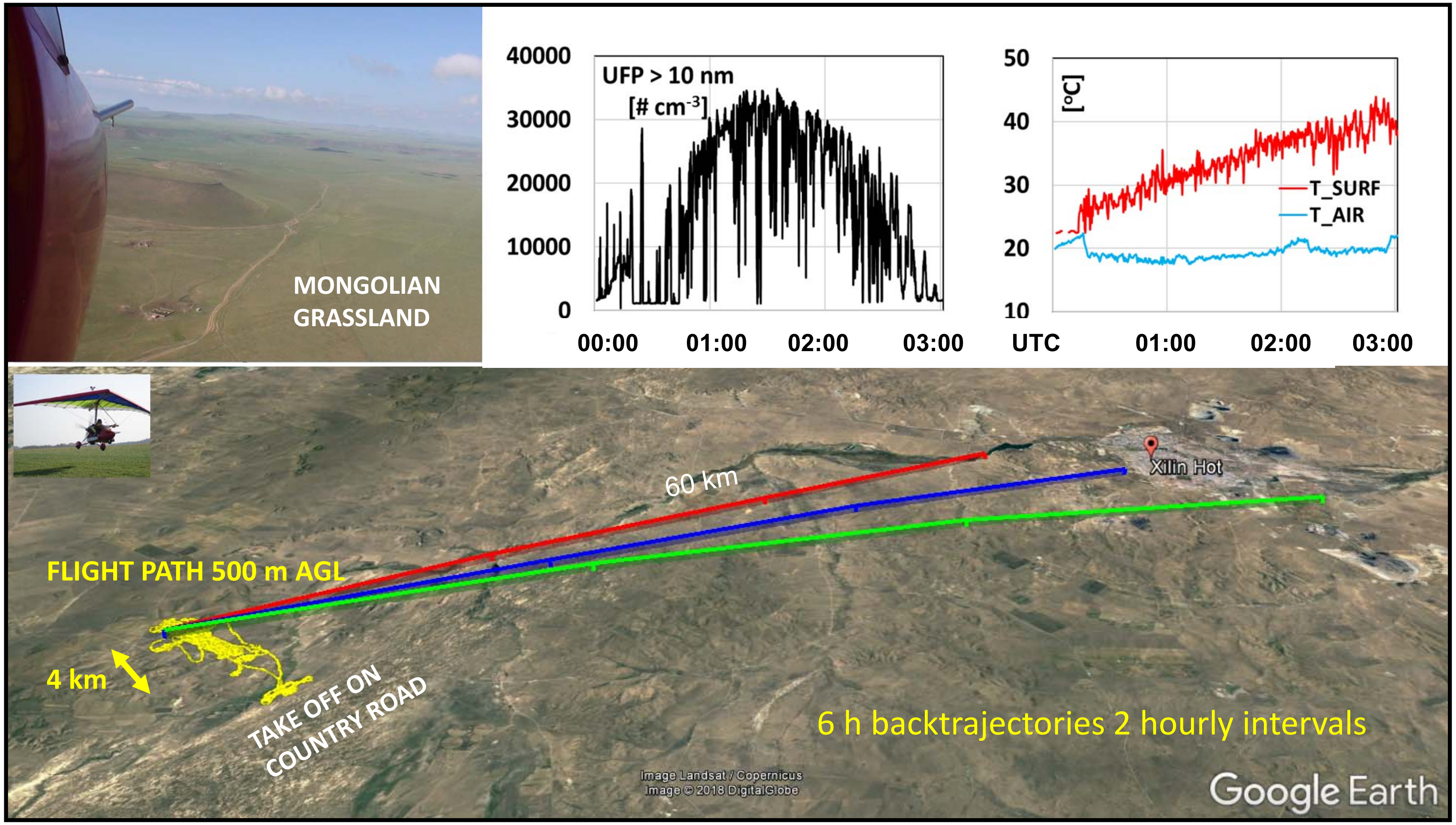


BANANAS?

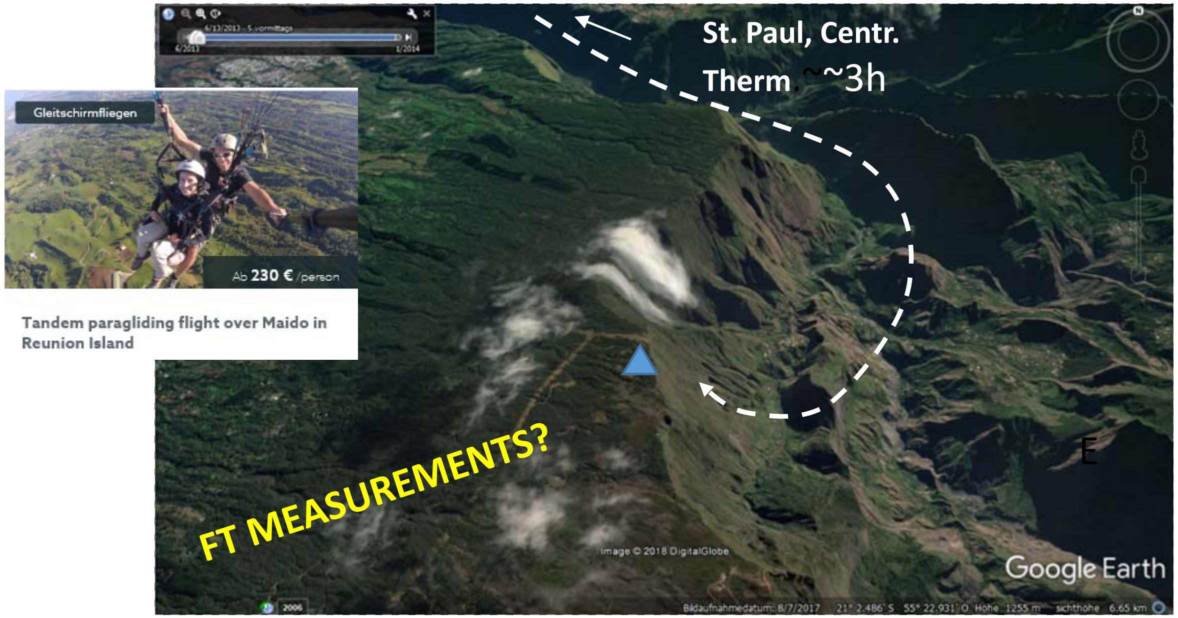
Lampilahti, 2020 /21

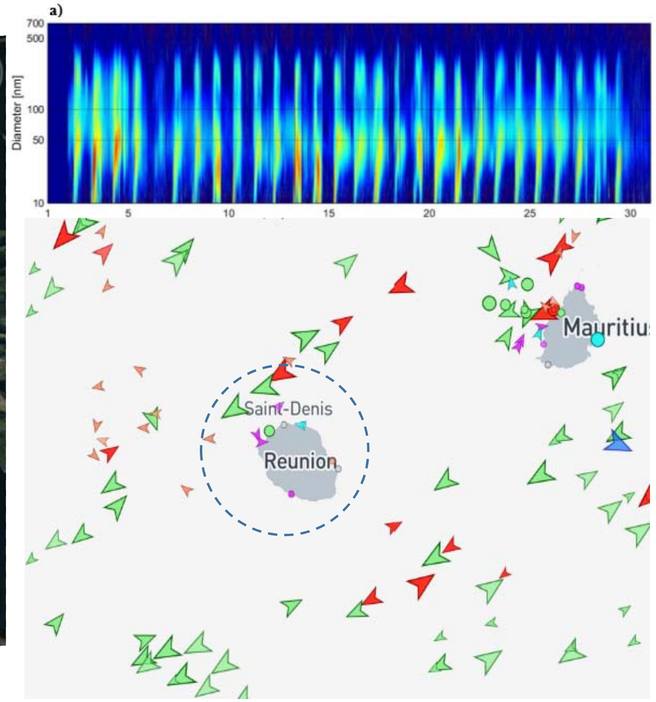
1D > 40%
3D ?
DIURNAL AVG?
Horiz- homog?
add. GPC

UFP event - veering plume, well mixed PBL, cloud base ~ 2500 m, 3.7.2009



horizontal and vertical (diurnal) transport (4D) >> **Mountain?**

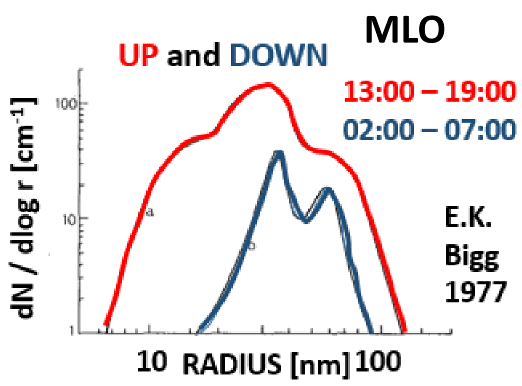




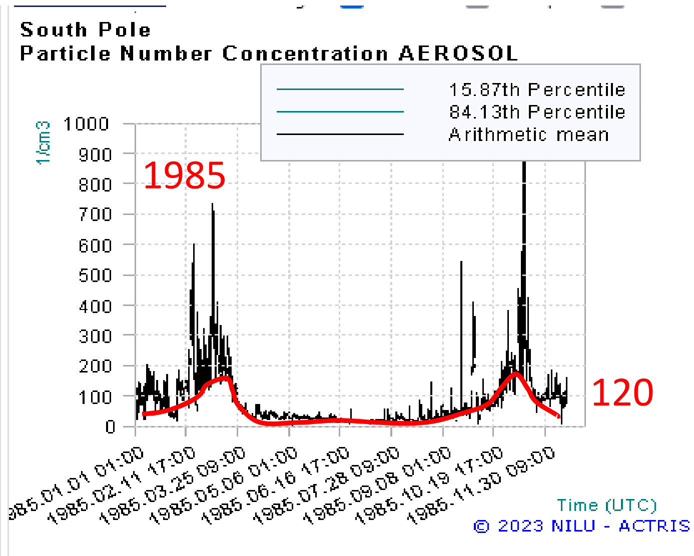
In the daytime, valleys and canyons act as chimneys pumping pollutants from lowest layers and transporting them upward, possibly to Piton Ma¨ıdo

D. Lesou¨ef et al. 2011:

CONTRIBUTION TO FT BUDGET ???



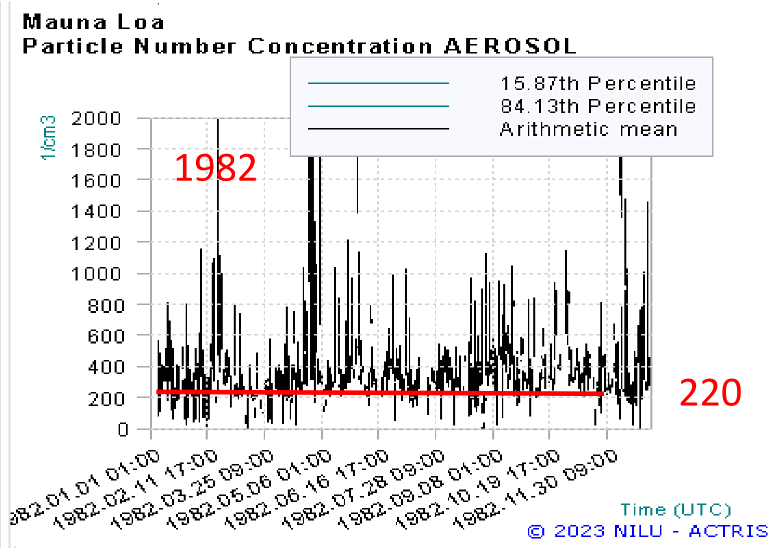
See also:
JUNGFRAUJOCH
SCHAUINSLAND
ZUGSPITZE
STORM PEAK
CHALCATAYA
and Kulmala et al, 2011

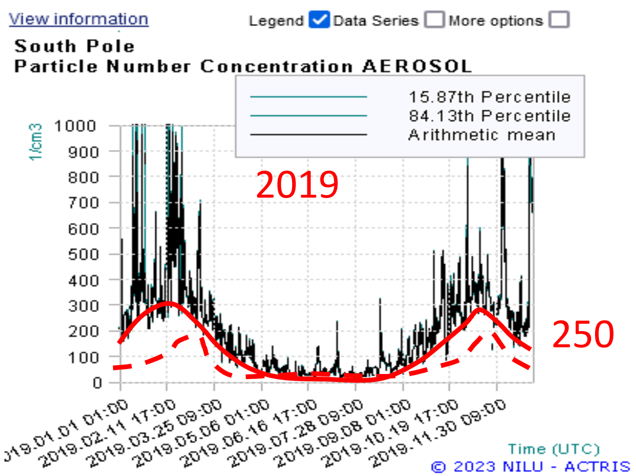


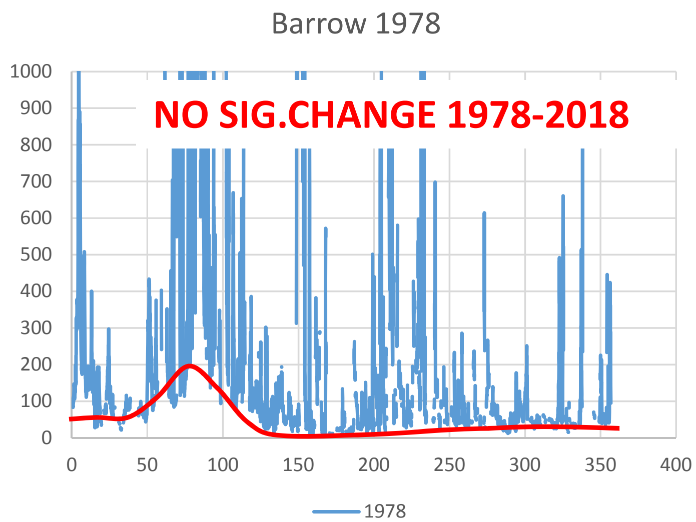
MONITORING NETWORKS

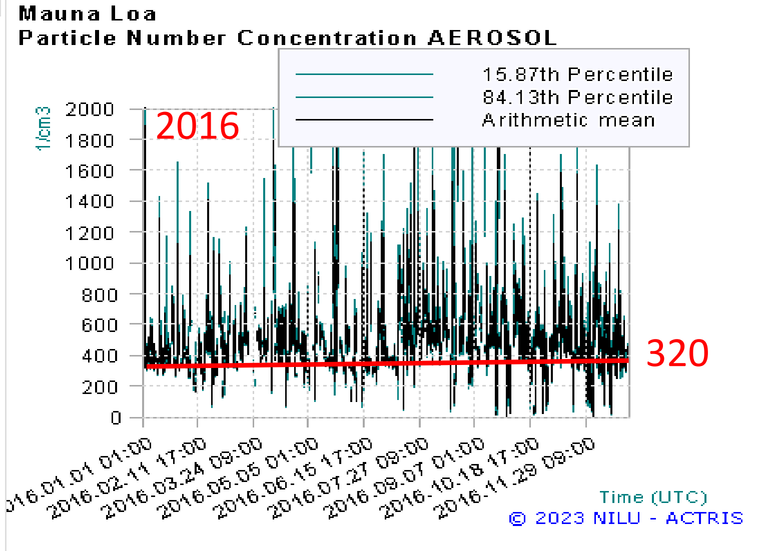
MLO BRW SAM SPO,
GUAN, ACTRIS……

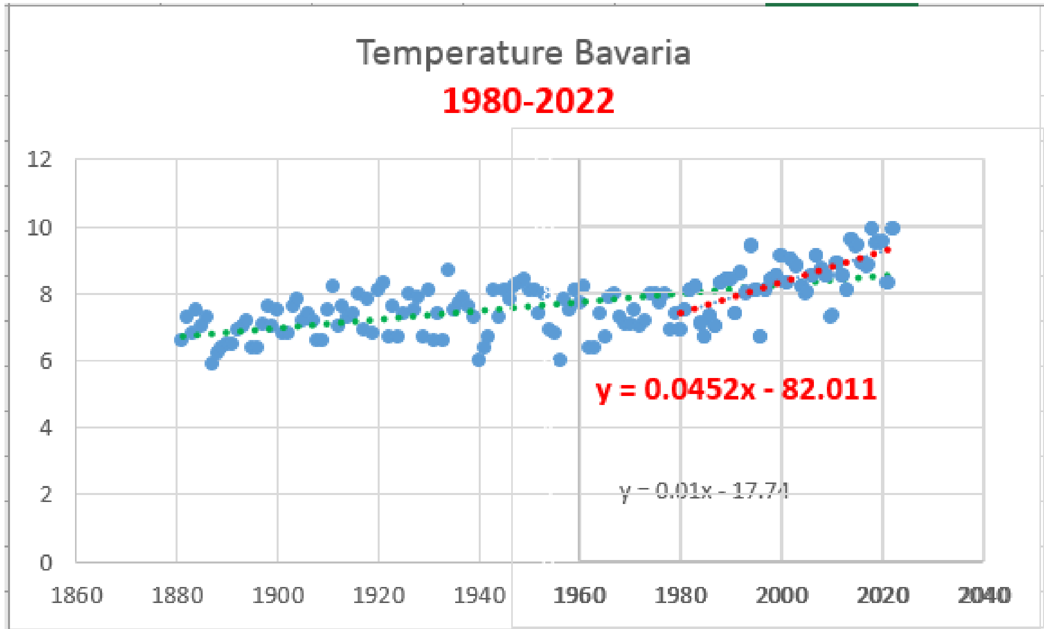
LONG TERM TRENDS /
NOTICABLE PATTERNS
Trend (SPO, MLO)
Annual patterns (BRW), BRW – Zep?

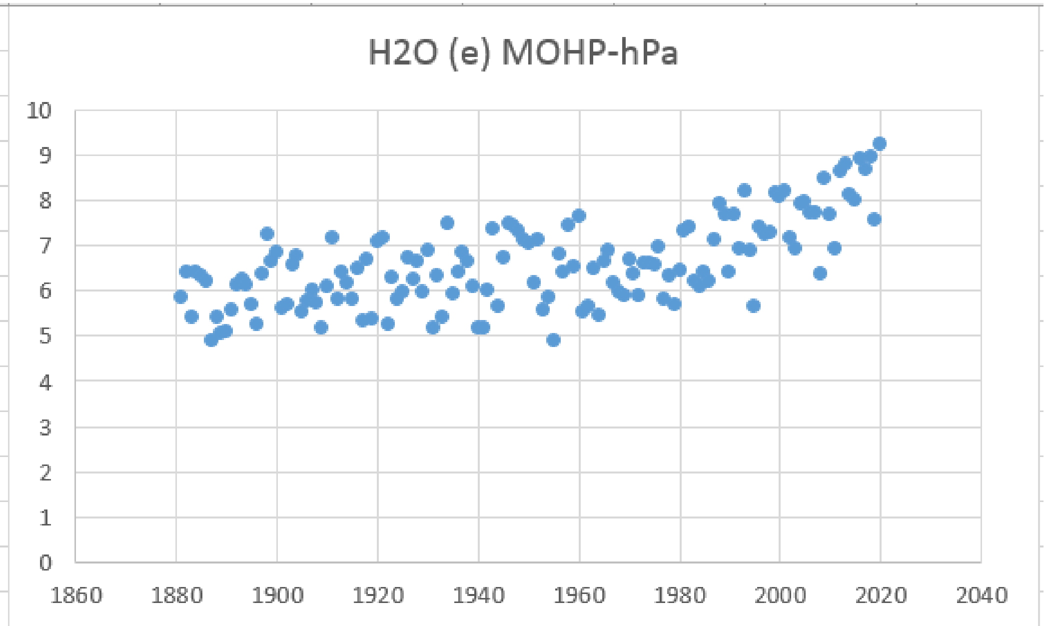


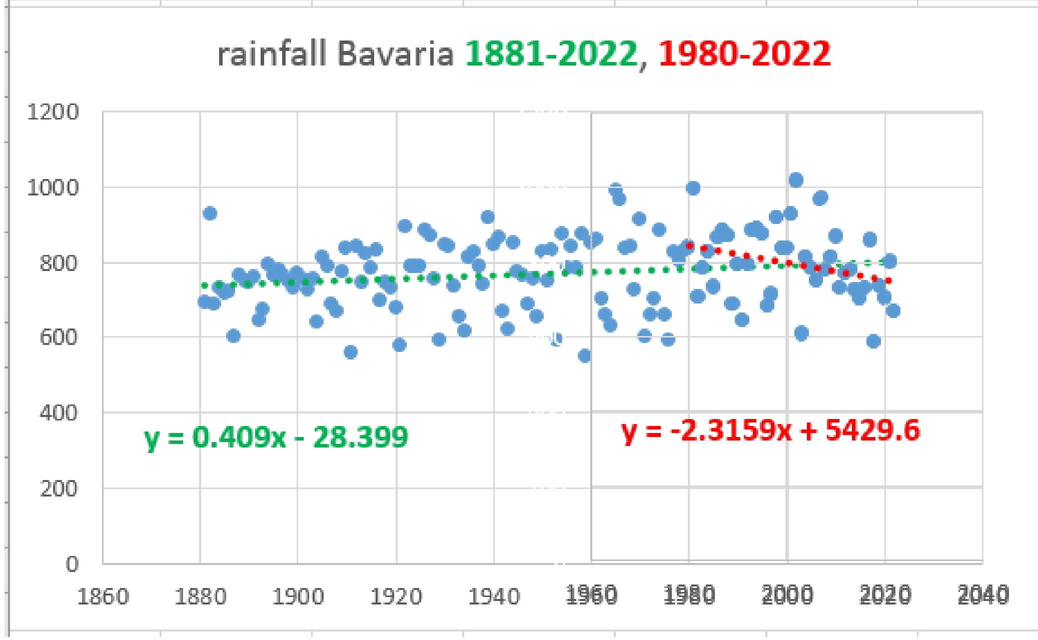


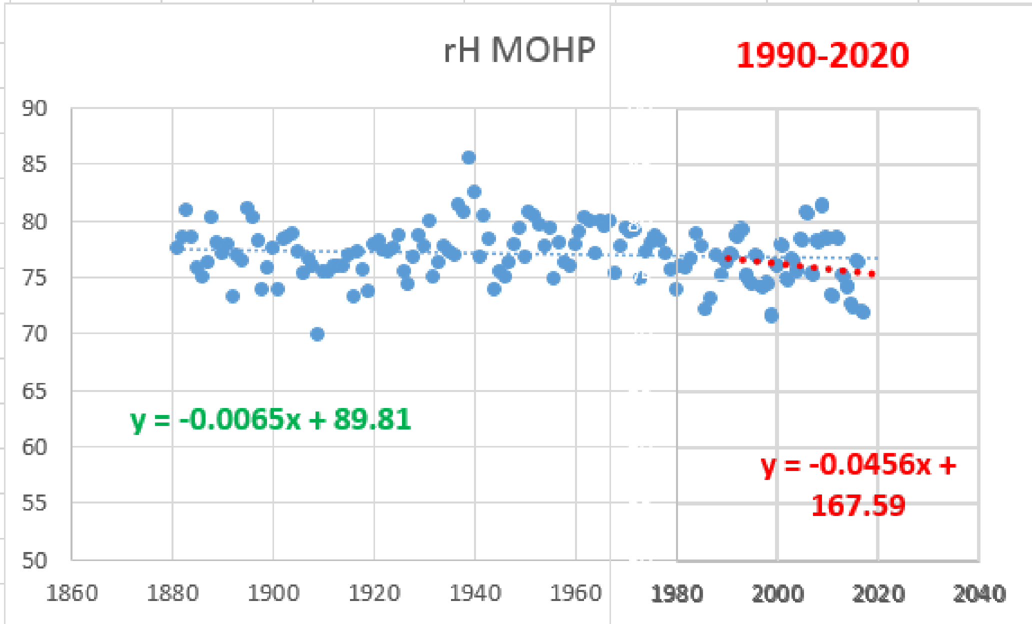


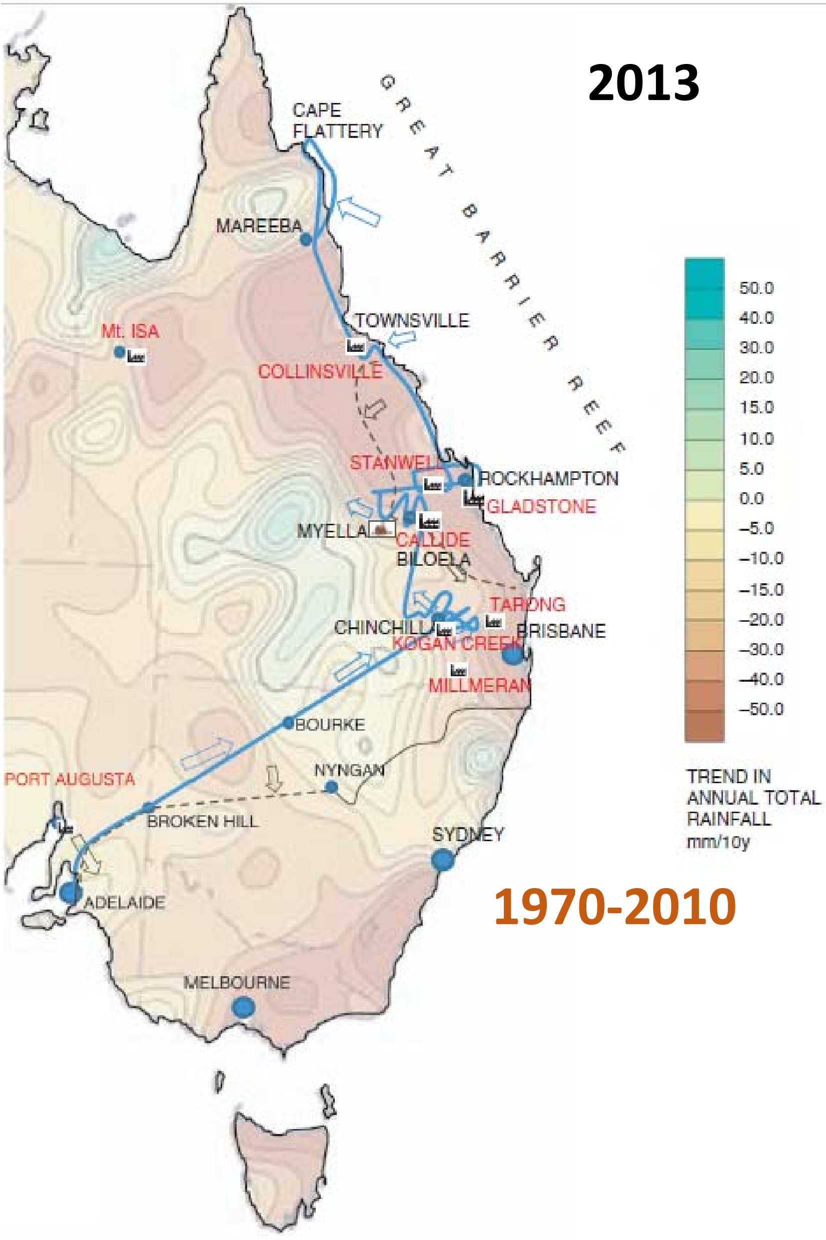


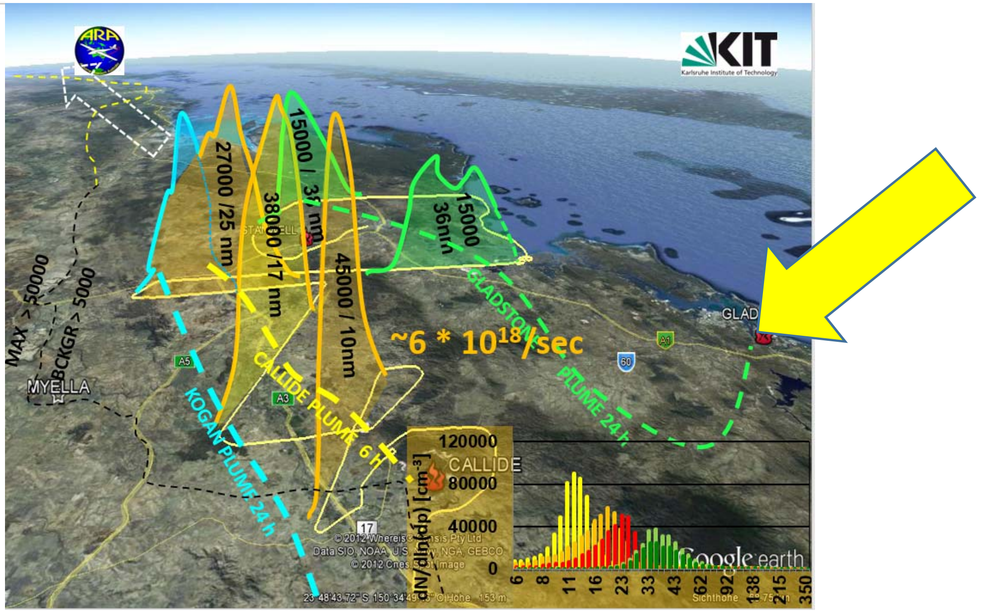

Temperature Bavaria
1980-2022
y = 0.0452x - 82.011
y = 0.01x - 17.74
0
2
4
6
8
10
12
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040

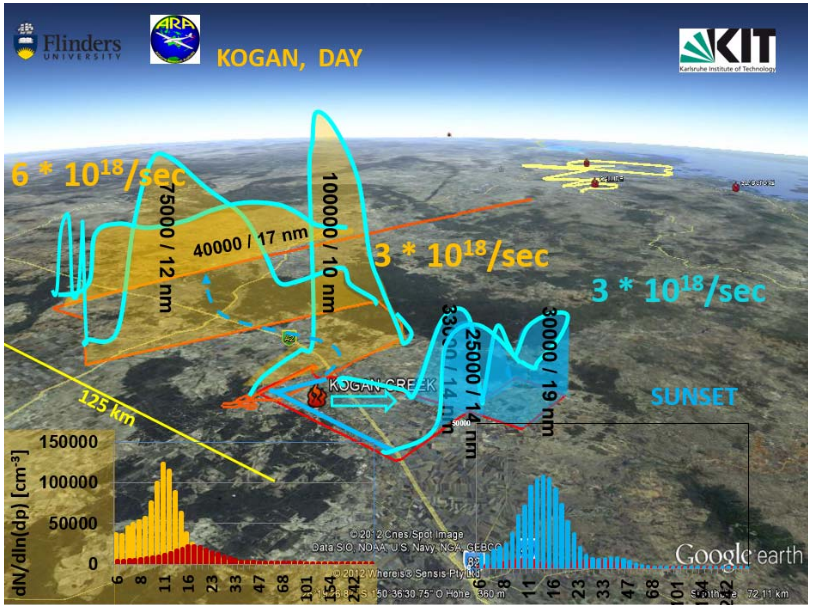

H2O (e) MOHP-hPa
0
1
2
3
4
5
6
7
8
9
10
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040

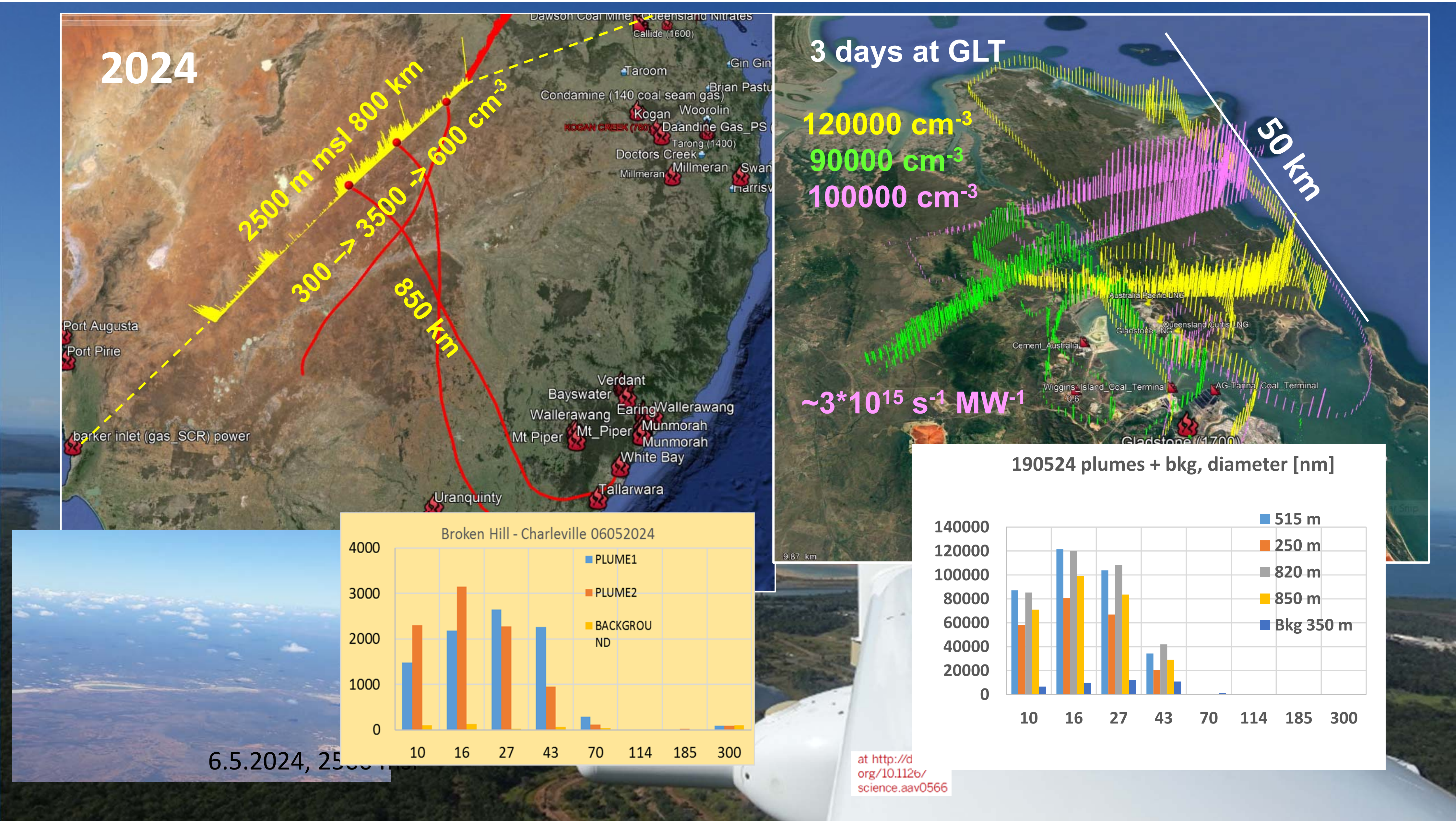

rainfall Bavaria 1881-2022, 1980-2022
y = 0.409x - 28.399
y = -2.3159x + 5429.6
0
200
400
600
800
1000
1200
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040

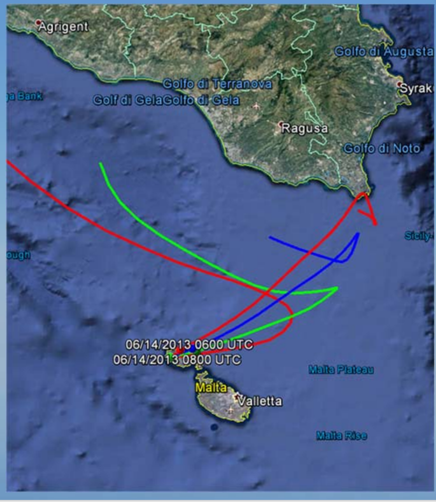

rH MOHP
1990-2020
y = -0.0065x + 89.81
y = -0.0456x + 167.59
50
55
60
65
70
75
80
85
90
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040


2013
GREAT BARRIER REEF
CAPE FLATTERY
MAREEBA
Mt. ISA
TOWNSVILLE
COLLINSVILLE
STANWELL
ROCKHAMPTON
GLADSTONE
MYELLA
CALLIDE
BILOELA
TARONG
CHINCHILLA
KOGAN CREEK
BRISBANE
MILLMERAN
BOURKE
NYNGAN
PORT AUGUSTA
BROKEN HILL
SYDNEY
ADELAIDE
MELBOURNE
1970-2010
50.0
40.0
30.0
20.0
15.0
10.0
5.0
0.0
−5.0
−10.0
−15.0
−20.0
−30.0
−40.0
−50.0
TREND IN ANNUAL TOTAL RAINFALL
mm/10y


ARA
KIT
27000 /25 nm
15000 / 37 nm
38000 /17 nm
45000 / 10nm
15000 36nm
MAX > 50000
BCKGR > 5000
MYELLA
~6 * 10¹⁸/sec
CALLIDE PLUME 6 H
KOGAN PLUME 24 h
GLADSTONE PLUME 24 h
GLAD
120000
80000
40000
0
CALLIDE
dN/dln(dp) [cm⁻³]
Google earth


Flinders UNIVERSITY
ARA
KOGAN, DAY
KIT
6 * 10¹⁸/sec
75000 / 12 nm
40000 / 17 nm
100000 / 10 nm
3 * 10¹⁸/sec
3 * 10¹⁸/sec
25000 / 14 nm
30000 / 19 nm
KOGAN CREEK
SUNSET
125 km
150000
100000
50000
0
dN/dln(dp) [cm⁻³]
Google earth

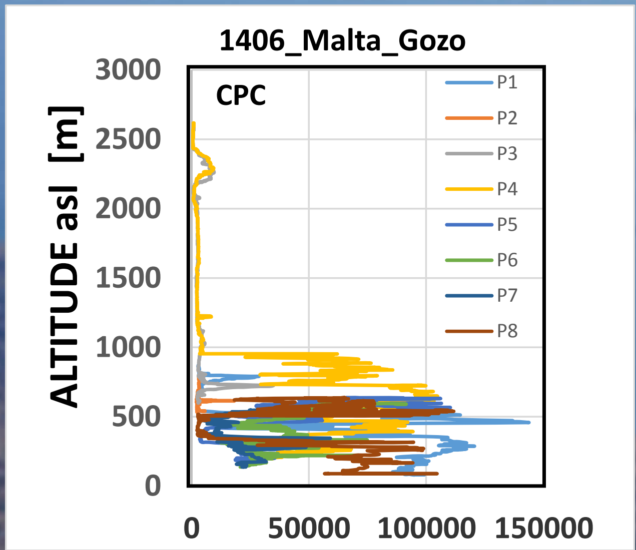

2024
2500 m msl 800 km
300 –> 3500 –> 600 cm-3
850 km
Port Augusta
Port Pirie
barker inlet (gas_SCR) power
Taroom
Condamine (140 coal seam gas)
Kogan
Woorolin
Daandine Gas_PS
Tarong (1400)
Doctors Creek
Millmeran
Swan
Callide (1600)
Verdant
Bayswater
Wallerawang
Mt Piper
Munmorah
White Bay
Tallarwara
Uranquinty
3 days at GLT
120000 cm-3
90000 cm-3
100000 cm-3
~3*10^15 s-1 MW-1
50 km
Australia Pacific LNG
Queensland Curtis LNG
Gladstone LNG
Cement Australia
Wiggins Island Coal Terminal
AG Tanna Coal Terminal
Gladstone (1700)
Broken Hill - Charleville 06052024
4000
3000
2000
1000
0
PLUME1
PLUME2
BACKGROUND
10
16
27
43
70
114
185
300
190524 plumes + bkg, diameter [nm]
140000
120000
100000
80000
60000
40000
20000
0
515 m
250 m
820 m
850 m
Bkg 350 m
10
16
27
43
70
114
185
300
6.5.2024, 25
at http://d
org/10.1126/
science.aav0566

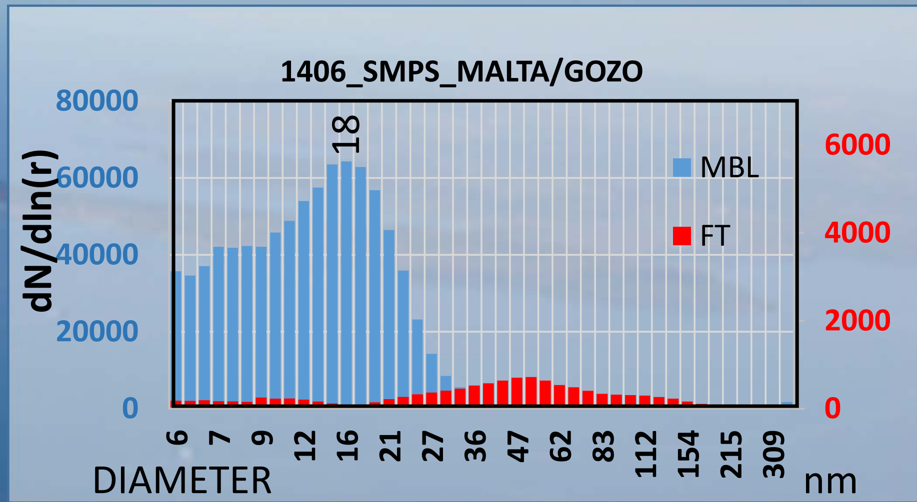


MALTA 2013

$EF_{(n)} > 1.6 \times 10^{16}\ s^{-1}\ km^{-1}$

MBL, AVG # conc, wind



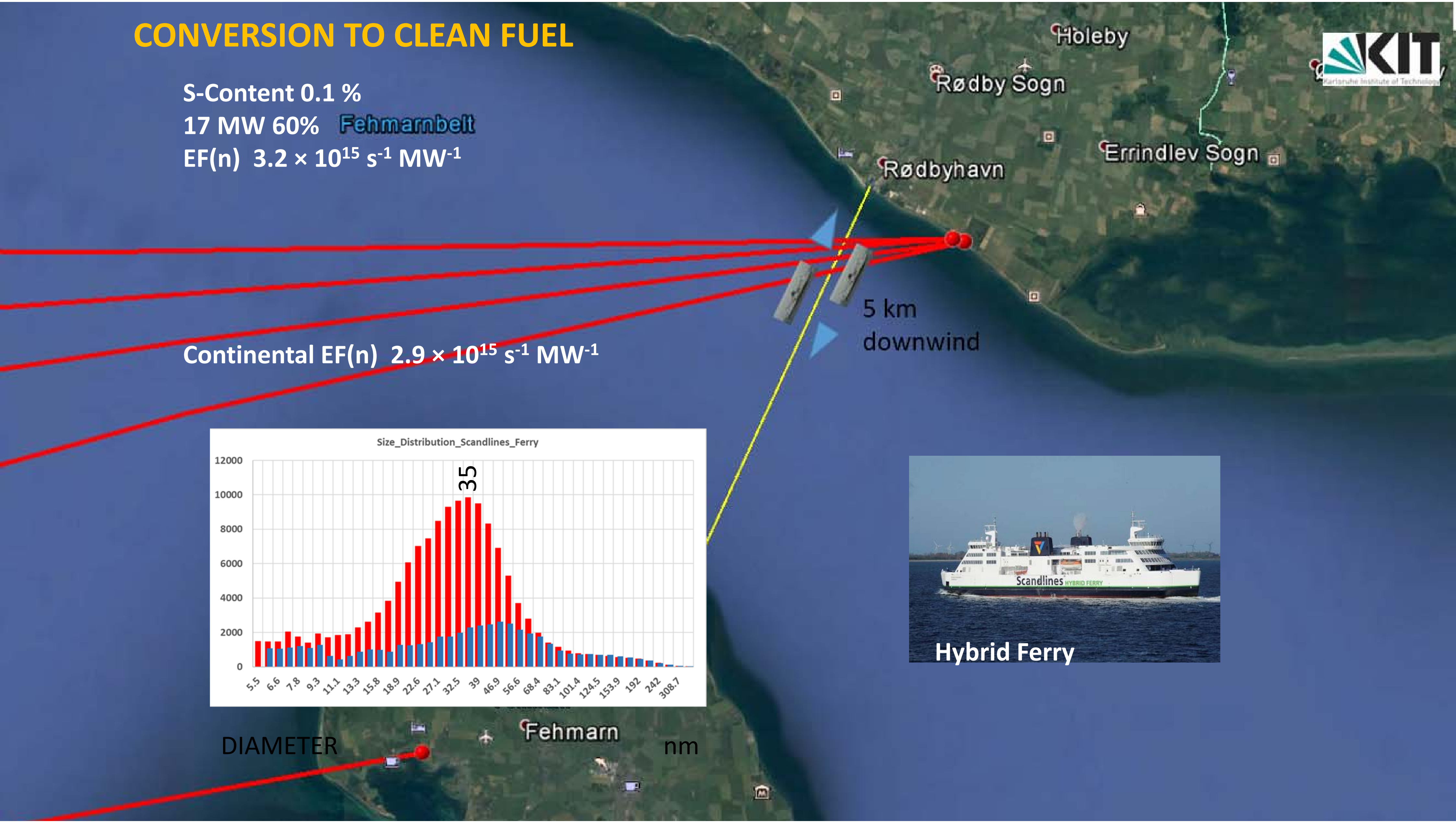


1500 km -> Sicily / Gibraltar ~$2.4 \times 10^{19}\ s^{-1}$

~ 1 PS / 50 km^{-1} / THE BIG EXPERIMENT 2020....

CONVERSION TO CLEAN FUEL

S-Content 0.1 %
17 MW 60%
EF(n) $3.2 \times 10^{15}\ s^{-1}\ MW^{-1}$



A FEW BUDGET ESTIMATES

GLOBAL CCN 10^{21}-10^{22} s^{-1} -> $3*10^{29}$ a^{-1}

Mt ISA CCN $5*10^{17}$ – $5*10^{18}$ s^{-1} pri + sec (Ayers et al 1979)

GLADSTONE CN pri ~ $5*10^{18}$ s^{-1} (MAY 2024)

GLOBAL CN $9*10^{29}$ a^{-1} (Dentener 2006)

GLOBAL CN POWER (300 – 1200 m) ~ $1*10^{30}$ a^{-1} (Junkermann and Hacker, 2022)

GLOBAL CN SHIPS (50-600 m) ~ $6*10^{29}$ a^{-1} (Junkermann, 2022)

GLOBAL UTLS $_{aircraft}$ $8*10^{25}$ a^{-1} (Williamson 2021, ATom)

COMPARE CN / CCN ~ *3 (Andreae 2009)

Xausa et al, 2018, ACP, ***ECHAM-HAM***

Advancing global aerosol simulations with size-segregated anthropogenic particle number emissions

the lower level SO4 (**0-100 m**) is split equally between the **Aitken** and **accumulation** mode **r = 30 nm** **r = 75 nm**
higher level SO4 (**100 m and above**) is **split equally** between the **accumulation** mode and **coarse** mode.

.

NEITHER NANO- NOR AITKEN MODE emissions ABOVE 100 m?

REALITY r = 3-6 nm at 500-700 m

KA Power Station plume

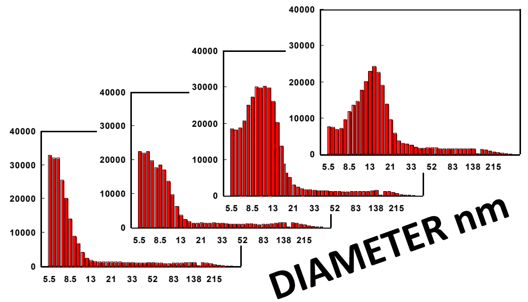
Junkermann et al, 2011

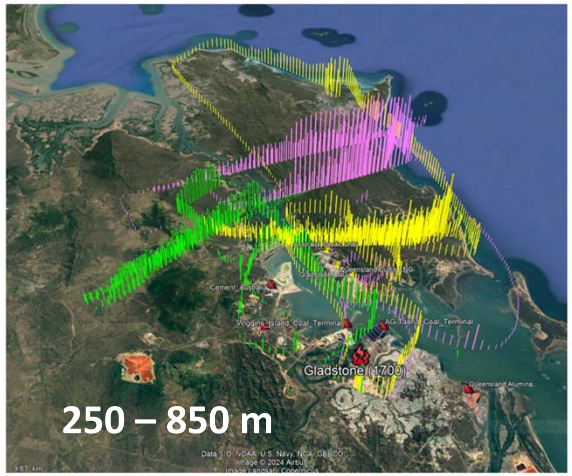
GORDON ET AL 2017

Causes and importance of new particle formation in the present-day and preindustrial atmospheres

***GLOMAP**, Spraklen et al, 2011*

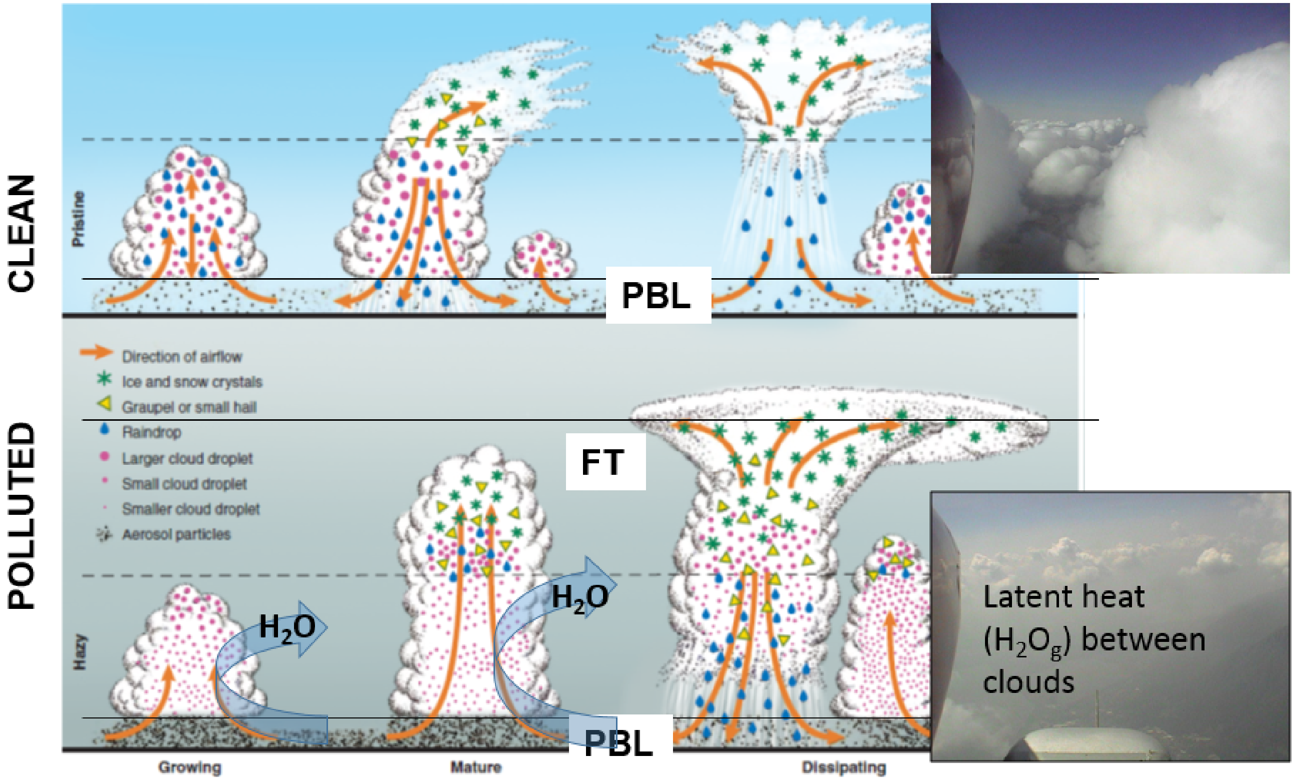
shipping, industry and power-plant emissions: r=500 nm, σ =2.0



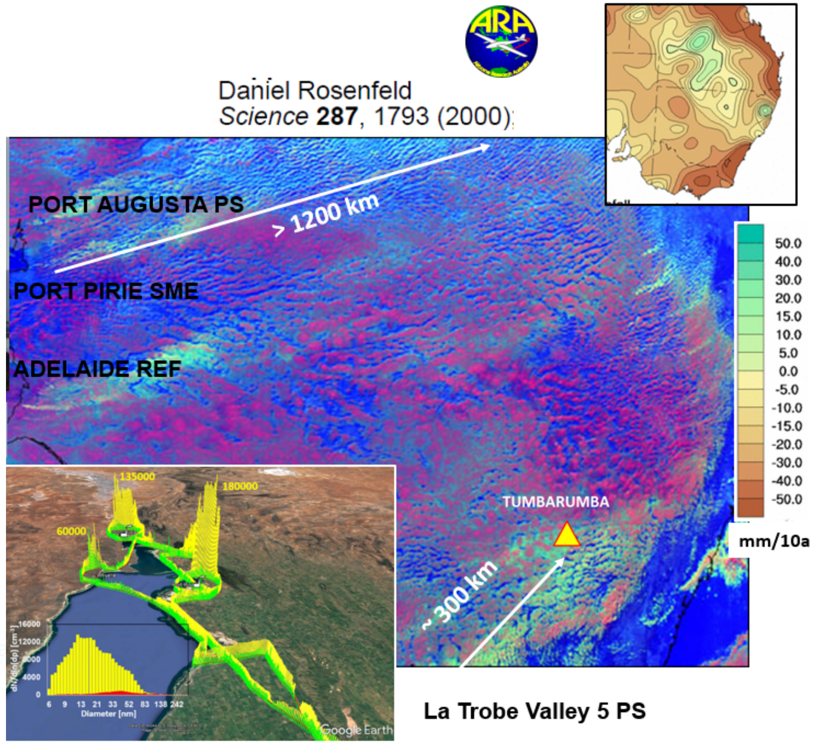


CLIMATE IMPACT (GWP)

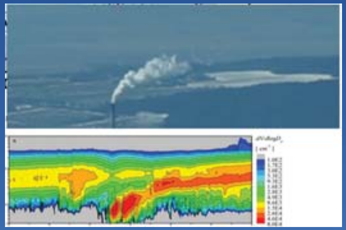
Rosenfeld, 2008



Transport of H_2O into FT via evaporation of smaller droplets, latent heat ↑ redistribution of rainfall



SUMMARY



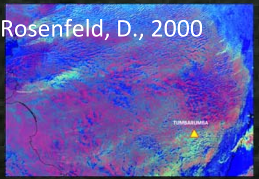
Peak UFP from prim. + sec. Advection aloft
Surface => thermal convection required > NPE

Mountain sites => rare FT cond. at daylight hours
Representative for cloud base?
Models? History?

80-120000 cm^{-3} > 10 nm

Budget - relevance
Impact:
Suppression / delay of rainfall >>> Drought - torrential rains

latent energy ⬆
LWC -30%
H_2O column dens.



Symptoms similar to GW (add. H_2O column) -- diff. timing, altitude

KIT
Karlsruhe Institute of Technology

PLUS

Home > Infrared heating > Application > Infrared ceiling heater

INFRARED CEILING HEATER


KIT
Karlsruhe Institute of Technology
Thank you for your attention

GLOMAP Model, Spracklen et al, 2010, ACP , see also Gordon et al, 2017, JGR

Explaining global surface aerosol number concentrations in terms of primary emissions and particle formation /

Causes and importance of new particle formation in the present-day and preindustrial atmospheres

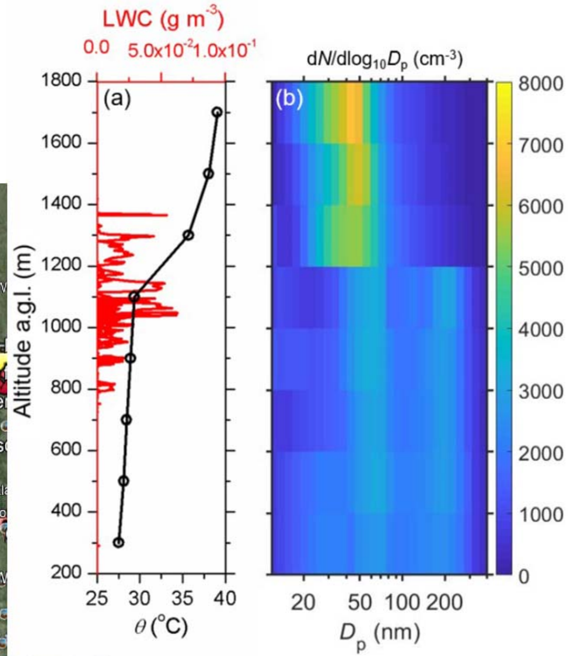
We emit primary sulfate at the rate (2.5% of SO2 emissions) and using the size distribution suggested by AEROCOM (road transport: number median radius, r=15 nm, σ =1.8; **shipping, industry and power-plant emissions: r=500 nm, σ =2.0;**

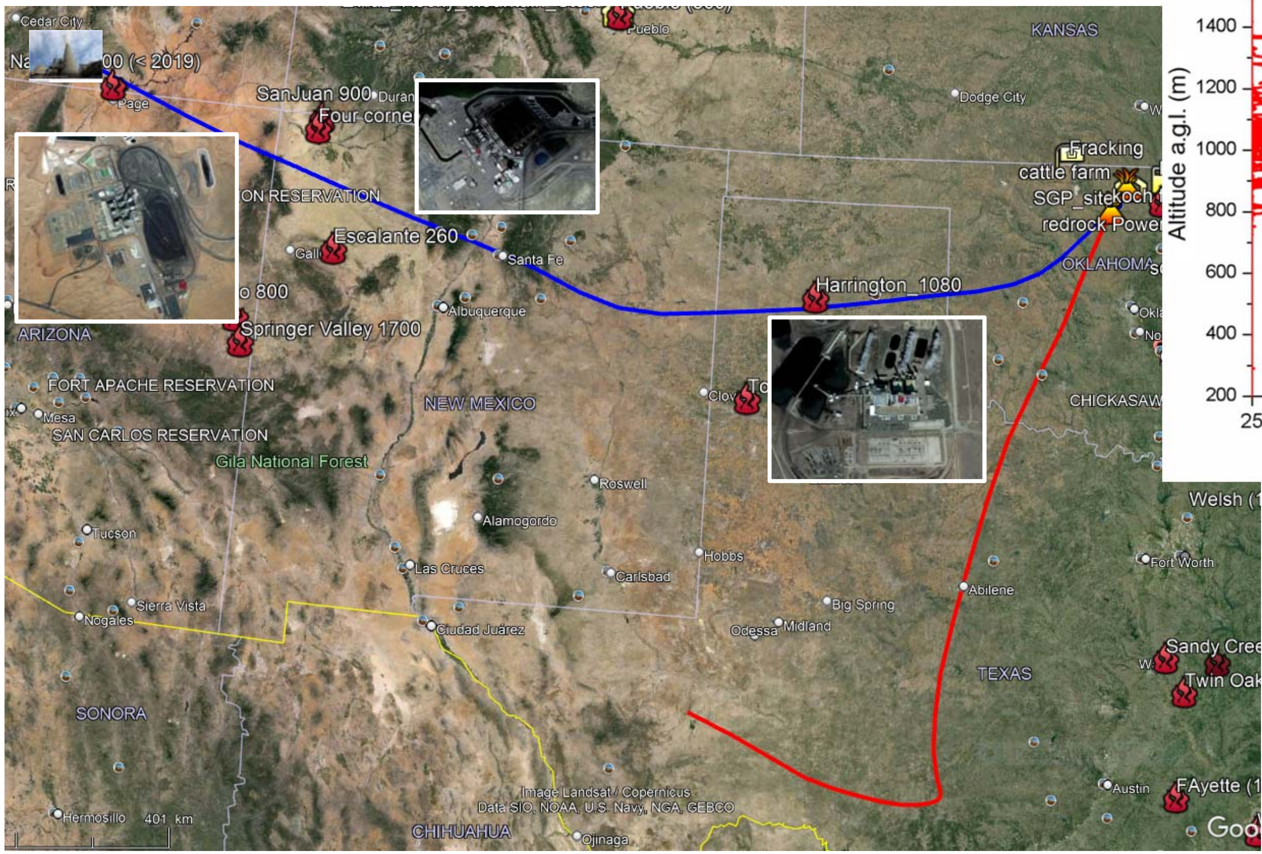
The empirical particle formation mechanism is based on observation of particle formation events made at the surface and there is some evidence to suggest that formation events are less likely in the lower FT (Heintzenberg et al., 2008; O'Dowd et al., 2009).

Additionally, observations of the vertical profile of CN number concentrations typically show maxima at the surface and in the UT and a minimum in the lower FT (Clarke and Kapustin, 2002; Schröder et al., 2002; Singh et al., 2002).

See also Platis 2016, Altstaedter, 2017 and Junkermann 2011, 2015, 2016……..

WANG et al 2023, SGP-NPE





TRA 24h

1600/700 m

https://doi.org/10.5194/acp-23-15671-2023

Weller et al, 2018, ACP
36 h HYSPLIT TRA