Aero

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

AIRCRAFT DESIGN AND SYSTEMS GROUP (AERO)

Aviation and the Environment

Dieter Scholz Hamburg University of Applied Sciences

University of Naples

2024-03-22

https://doi.org/10.5281/zenodo.xxxxxxx

Università degli Studi di Napoli Federico II

AVIATION AND THE ENVIRONMENT

Friday, 22 March 2024 (14:30 – 17:30)

AULA IA-4 Complesso di Agnano, Via Nuova Agnano, 30 - NAPOLI

(Per gli studenti di PhD il seminario vale 1 CFU)

Prof. Dieter Scholz

Hamburg University of Applied Sciences (HAW Hamburg)

Dieter Scholz is a professor in Aircraft Design, Flight Mechanics, and Aircraft Systems at HAW Hamburg, where he is head of the Aircraft Design and Systems Group (AERO). He studied at the University of Hannover and at Purdue University (USA). He was a systems engineer at Airbus in Hamburg and a temporary lecturer at Queens University Belfast, UK. He obtained his PhD at the Hamburg University of Technology. His academic interests also include Flight Testing and questions related to Aviation & Society. (http://cv.profscholz.de)

Seminar Agenda

- **Welcome and Opening Speech**
- **Decoding Aviation's Climate Challenge**
  In this section, Prof. Scholz will engage with ten pressing questions that shape the dialogue on aviation's environmental impact:
  - Are aviation emissions relevant?
  - *Fuel consumption* or *emissions*?
  - What climate goals does aviation have?
  - What climate goals does the EU have for aviation?
  - How do we get from oil to new aviation energy sources?
  - Can fuel consumption and emissions be reduced?
  - What are the fuel consumption and emissions of passenger aircraft?
  - Which is better for the environment – *plane* or *train*?
  - What ideas and possible solutions are there?
  - What can we actually do ourselves?
- **Calculating Aviation's Environmental Footprint**
  In this section, Prof. Scholz will delve into the technical aspects with discussions on:
  - Equivalent CO_2 mass calculation: how to measure the carbon footprint of flying.
  - Contrail formation and management.
  - The impact of *flying lower*.
- **Coffee Break**
- **EASA's Environmental Stewardship**
  This final session will give a detailed look at the EASA's *Environmental Label Programme*.
- **Q&A Session**
- **Final Considerations**

For more information, please contact Prof. Fabrizio Nicolosi (E-mail: fabrizio.nicolosi@unina.it)

Opening Speech

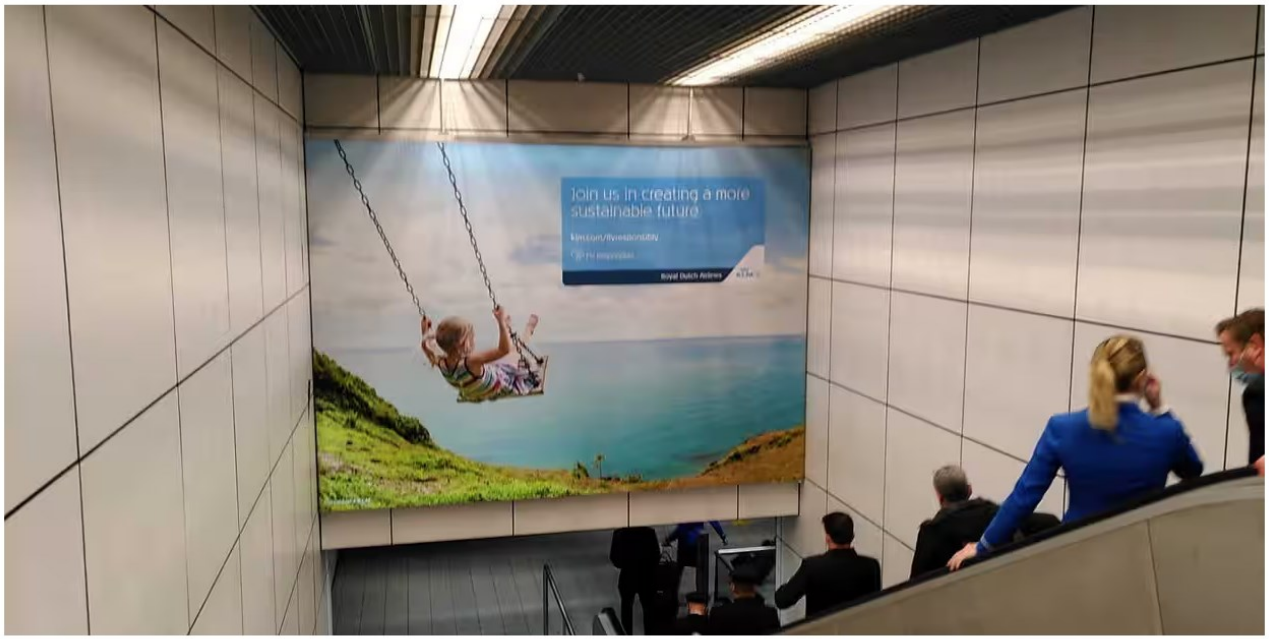
KLM advertisement from 2019 to 2022


FOSSIELVRIJ NL
THERE'S NO SUCH THING AS SUSTAINABLE FLYING
KLM's misleading ads make us believe that we can fly sustainably. But this is an illusion. That's why we are taking KLM to court.

Dutch airline KLM misled customers with vague green claims, court rules

The Guardian

Operator also found by Amsterdam court to have painted 'overly rosy picture' of sustainable aviation fuel



Ad at Schiphol airport. The court ruled that its message did not explain how flying with KLM related to any environmental benefit. Photograph: c/o Client Earth

https://www.theguardian.com/world/2024/mar/20/dutch-airline-klm-misled-customers-green-claims-court-rules

Reuters, 2024-03-21: Dutch court finds KLM ads were misleading in 'greenwashing' case. Article and **Video** available from: https://www.reuters.com/business/aerospace-defense/dutch-court-rule-klm-greenwashing-case-2024-03-20.
Archived: https://perma.cc/4BS7-37HY

Contact

For Media
mediarelations@klm.com

Newsroom

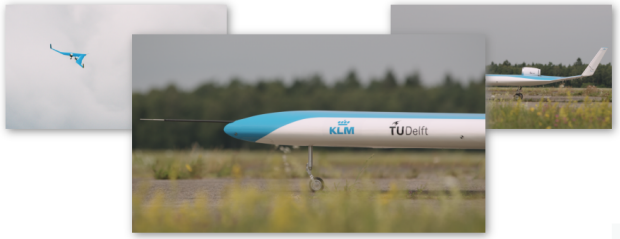
Share this page

KLM and TU Delft present successful first flight Flying-V

KLM's News Channels

Amstelveen, 01 September 2020

KLM and TU Delft present successful first flight Flying-V



The scale model of the Flying-V – the energy-efficient aircraft of the future – has flown for the first time. A year and a half ago TU Delft and KLM announced the start of the design of the Flying-V during IATA 2019 and after extensive wind tunnel tests and ground tests it was finally ready. The first successful test flight is a fact.

Last month a team of researchers, engineers and a drone pilot from TU Delft travelled to an airbase in Germany for the first test flight. "We were very curious about the flight characteristics of the Flying-V. The design fits within our Fly Responsibly initiative, which stands for everything we are doing and will do to improve our sustainability. We want a sustainable future for aviation and innovation is part of that. KLM has been among the top three most sustainable airlines worldwide in the Dow Jones Sustainability Index for many years. We want to continue to do so in the future. We are therefore very proud that we have been able to achieve this together in such a short period of time," says Pieter Elbers, President and CEO of KLM.

Click here for the footage of the flight.

The Flying-V is a design for a very energy-efficient long-haul aircraft. The design of the aircraft integrates the passenger cabin, cargo hold and fuel tanks in the wings, creating a spectacular V-shape. Computer calculations have predicted that the improved aerodynamic shape and reduced weight of the aircraft will reduce fuel consumption by 20% compared to today's most advanced aircraft.

Collaboration and Innovation

KLM presented the scale model for the first time during KLM's 100th anniversary in October 2019. Several partners are now involved in the project, including manufacturer Airbus. Elbers: "You can't make the aviation sector more sustainable on your own, but you have to do it together," says Elbers. Collaborating with partners and sharing knowledge takes us all further. That's why we will further develop the Flying-V concept with all partners. The next step will be to fly the Flying V on sustainable fuel".

For more information about the test flight:

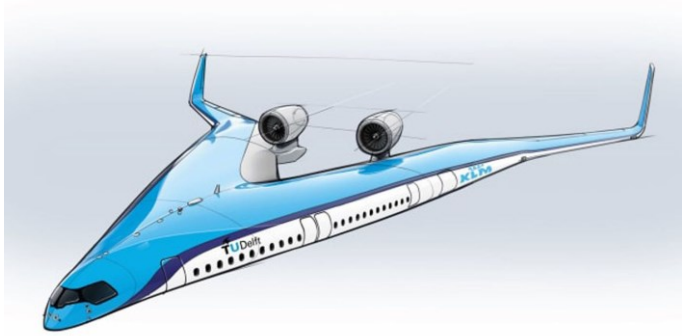
Today, Dr. Roelof Vos and Prof. Henri Werij of TU Delft showed how the test flight went via a webcast. Pieter Elbers, CEO KLM and Daniel Reckzeh, Senior Manager R&T in Airbus commented. The recording of the webcast can be viewed here.

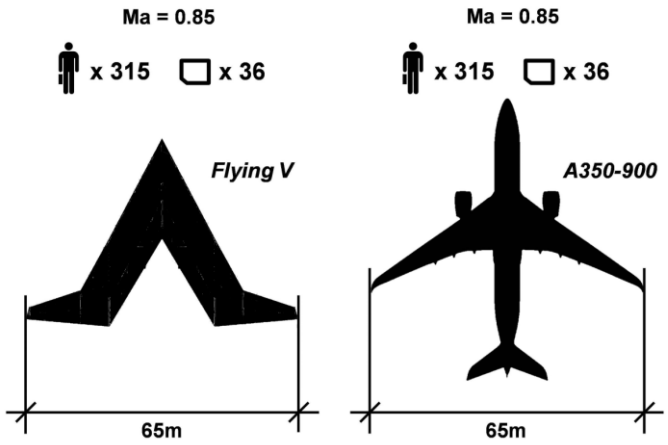
> *The design fits within our Fly Responsibly initiative, which stands for everything we are doing and will do to improve our sustainability. We want a sustainable future for aviation and innovation is part of that*
> **KLM President & CEO Pieter Elbers**

Post

HAW HAMBURG

Flying V





https://perma.cc/6E7Q-2F22


ICS: A VISION FOR 2020
Meeting society's needs and winning global leadership
REPORT OF THE GROUP OF
JANUARY 2001
European Commission
Fly the Green Deal
Europe's Vision for Sustainable Aviation
Report of the Advisory Council for Aviation Research and Innovation in Europe (ACARE)
European Commission
Flightpath 2050
Europe's Vision for Aviation
Report of the High-Level Group on Aviation Research

There is a nice scientific presentation by the inventor Justus Benad. In 2015, students took part in the German Aerospace Congress (https://doi.org/10.25967/370094). Due to the lower ratio of wetted area to wing area, Benad assumes a 10% higher glide ratio, without giving any further calculation or argument. The operating empty mass remains about the same size. Through the snowball effect the fuel savings at the end of the iteration be greater than 10%. Of course, this still does not make a climate-neutral aircraft, but this was not required back in 2015. Consideration is given by TU Delft to use sustainable aviation fuels (SAF). Surely, SAF can also be used with other configurations.

"This report assessed every public climate target which the international aviation industry set itself since 2000.

We found that all but one of over 50 separate climate targets has either been missed, abandoned or simply forgotten about.

Overall, the industry's attempts to regulate its emissions and set its own targets suffered from a combination of unclear definitions, shifting goalposts, inconsistent reporting, a complete lack of public accountability and, in some cases, [goals] being quietly dropped altogether."

URL: https://www.wearepossible.org/our-reports-1/missed-target-a-brief-history-of-aviation-climate-targets

Archived: https://perma.cc/4SYC-UL93

Question:

The EU is calling for 70% Sustainable Aviation Fuel (SAF) by 2050 (a blend of 70% SAF and 30% kerosene). Let's assume SAFs "produce around 80 percent less CO2" (Airbus).

a) To what percentage are CO2 emissions left?

b) It is estimated that aviation will have grown by a factor of 2.9 by 2050. Based on this: How much more CO2 will be emitted in 2050 compared to today?

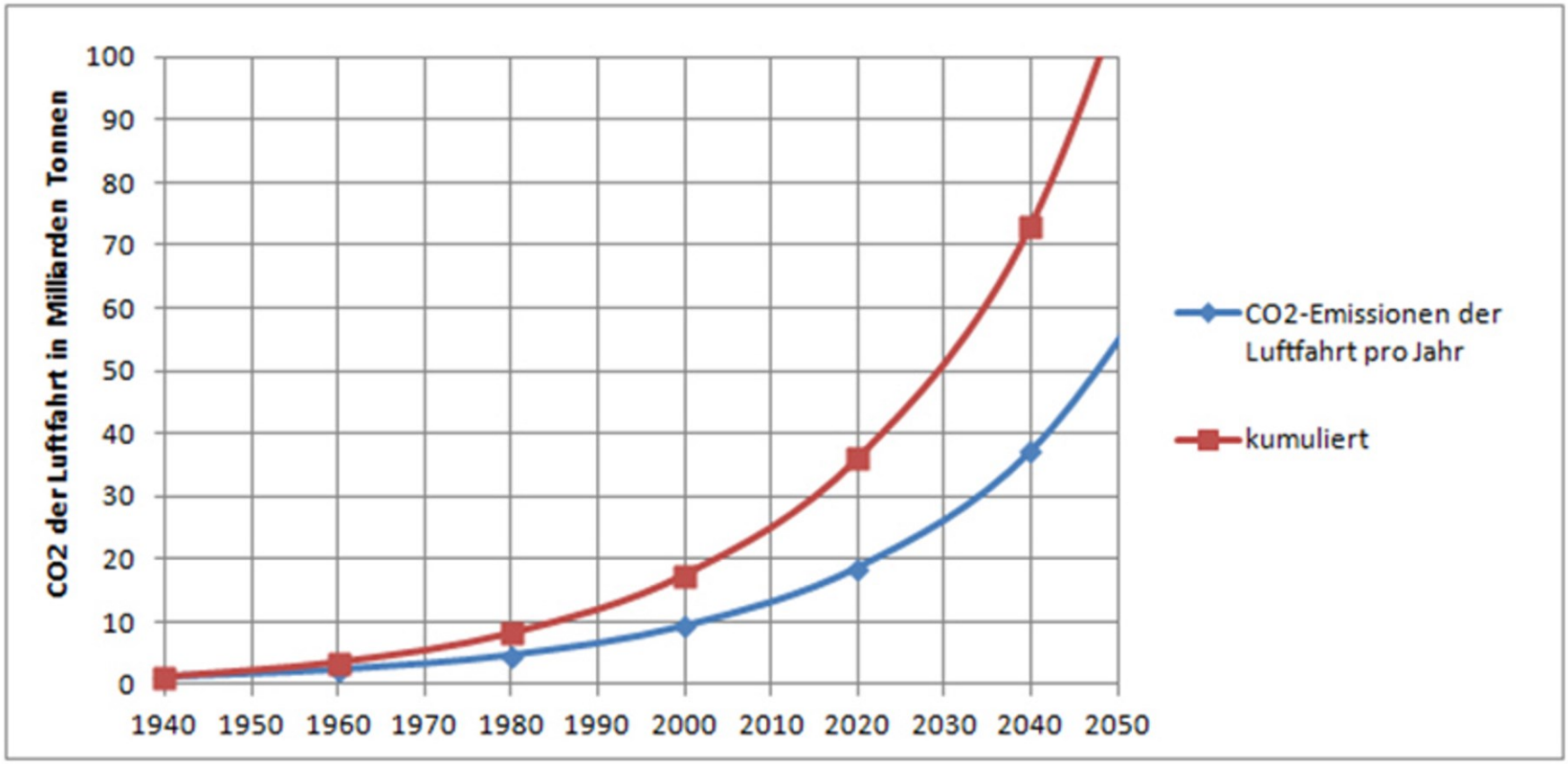
Answer:

a) The 70% SAF are 35% from biofuel (CO2-efficiency 80%) hence as good as 0.8 · 35% = 28%. The other 35% are from e-fuel, which may be considered to have a CO2-efficiency of 100%. Together SAF is as good as 63%. The fuel in the tank is producing CO2 as 37% of the kerosene before.

b) Due to traffic growth, the 37% become 37% · 2.9 = 107%. This means CO2 emission in 2050 are increased(!) by about 7% compared to today (despite the ambitious introduction of SAF).

https://www.fzt.haw-hamburg.de/pers/Scholz/Aero/AERO_PR_Cessna525_at_Sylt/AERO_PR_Cessna525_at_Sylt_23-06-07.html

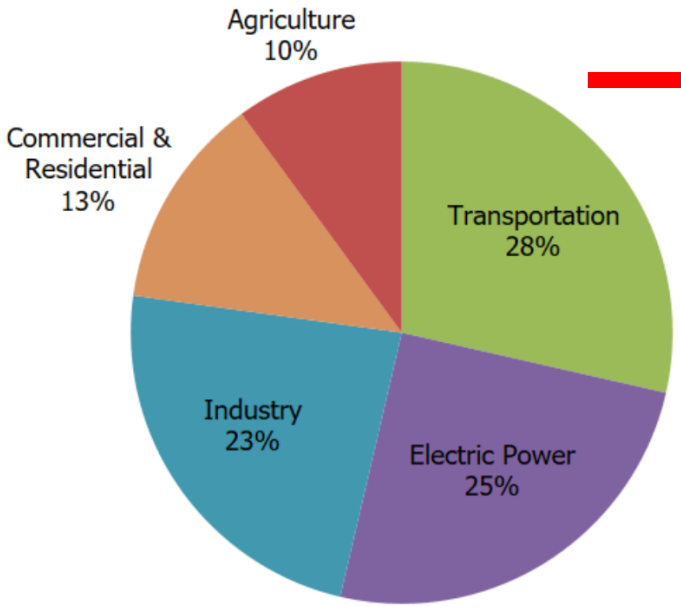
Decoding Aviation's Climate Challenge

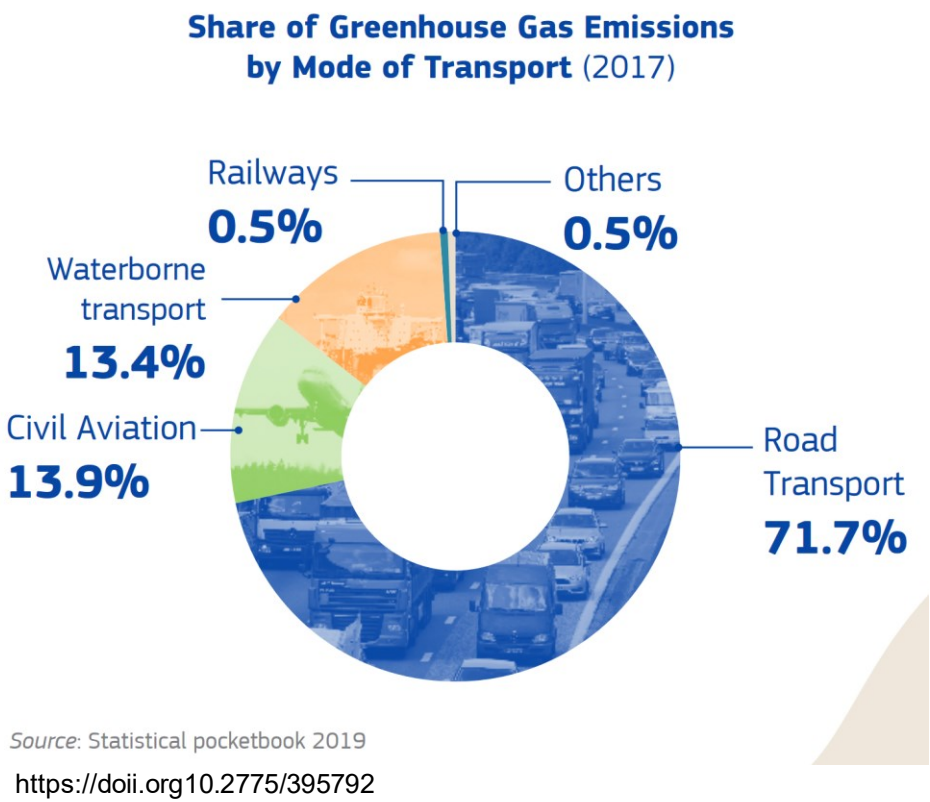


5% aviation growth per year. This is exponential growth.
1.5% energy reduction per seat: 0.5% due to technology,
1% due to higher load factor and more seats in a plane.

Aviation is "only" responsible for 2.4% of man-made CO2 emissions!

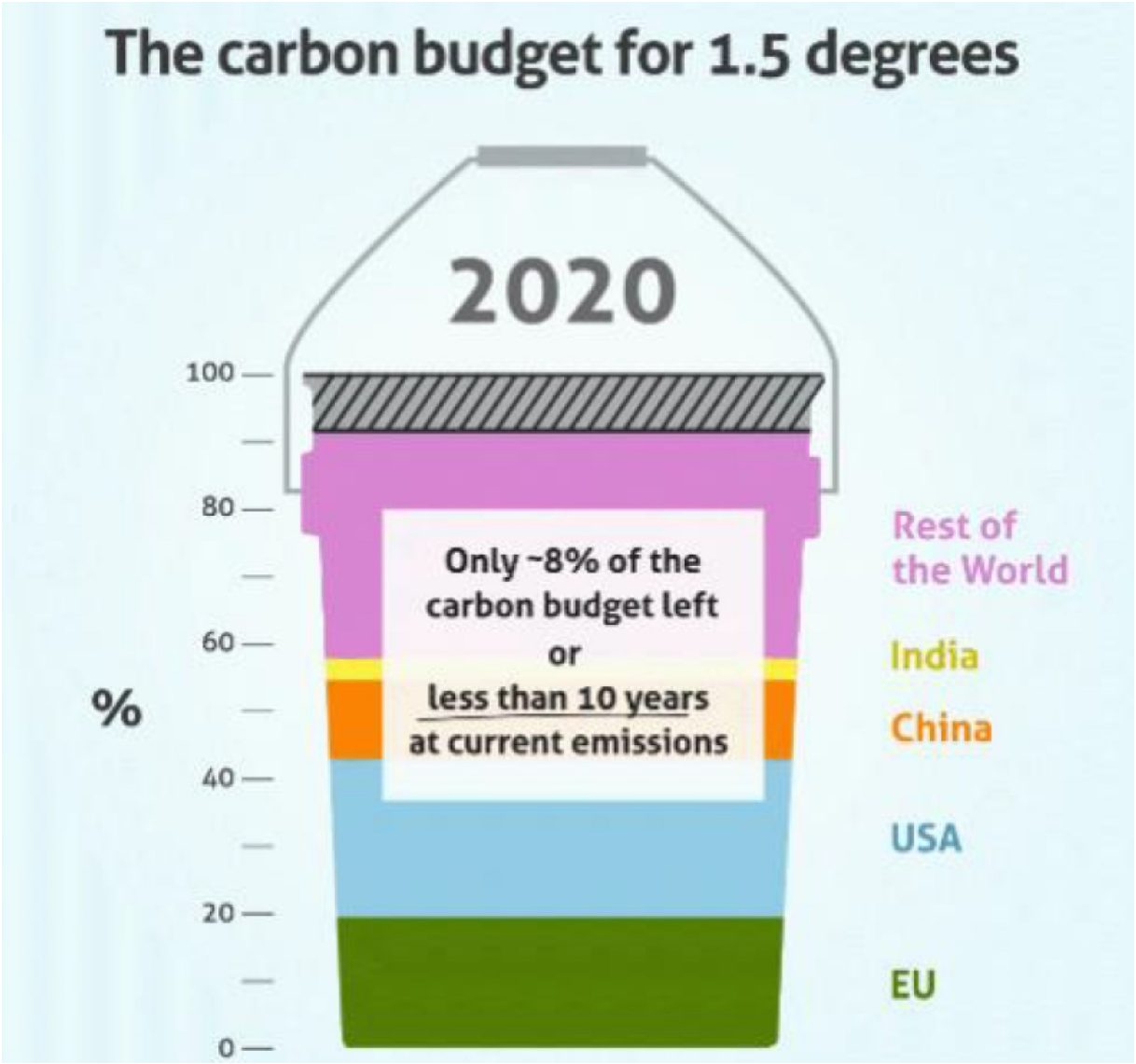
Based on what ?
What is 100% ?

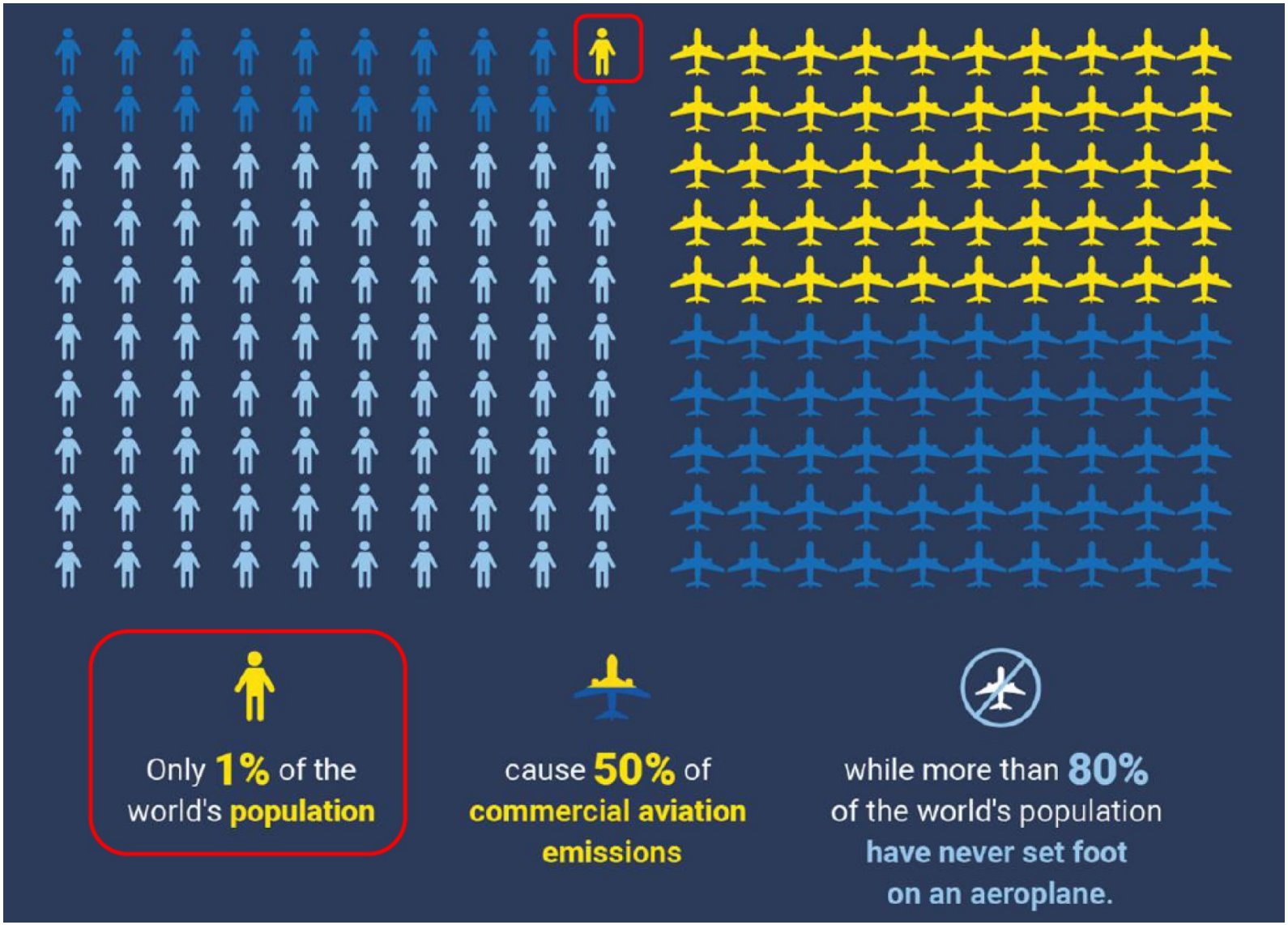




https://doii.org10.2775/395792

https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions


The carbon budget for 1.5 degrees
2020
100
80
60
40
20
0
%
Only ~8% of the carbon budget left or less than 10 years at current emissions
Rest of the World
India
China
USA
EU


Only 1% of the world's population
cause 50% of commercial aviation emissions
while more than 80% of the world's population have never set foot on an aeroplane.

. . .

switch to report

Dieter Scholz, 2021

Environmental Protection in Aviation

Background and Arguments for the Current Discussion

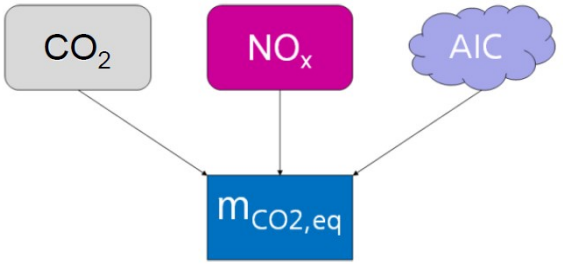
We hope to slowly emerge from the corona pandemic. This means that air traffic could continue where it came to an abrupt end in 2020. But wasn't there something to do with climate change? Flight shame? Can we really fly again like we used to with a clear conscience in times of proven global warming? In any case, after Corona we have gained one new insight. The unthinkable is possible. Planes can actually sit on the ground in rows. Organizations like Stay Grounded (https://stay-grounded.org) had already propagated this before Corona, but their demands were hardly taken seriously. After Corona, the basis for discussion has shifted. The EU has fleshed out the "Green Deal" with the "Fit for 55" package of measures. In Germany, policies with an environmental focus are given a chance of gaining a majority. Heavy rain events show that climate change has reached us. Aviation questions have become part of the news. Should short-haul flights be replaced by train journeys? Many citizens have the feeling that their own lifestyle also needs to be questioned. Spaceship Earth is finite in its dimensions. At some point the atmosphere will be full of CO2 and other greenhouse gases. One climate-relevant process then triggers the next and the climate tips over like a row of dominoes.

Calculating Aviation's Environmental Footprint

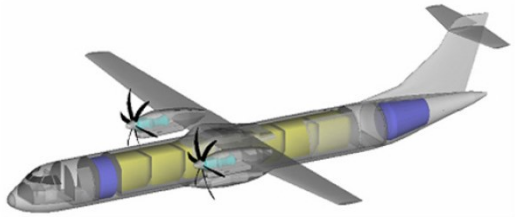
Aero

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

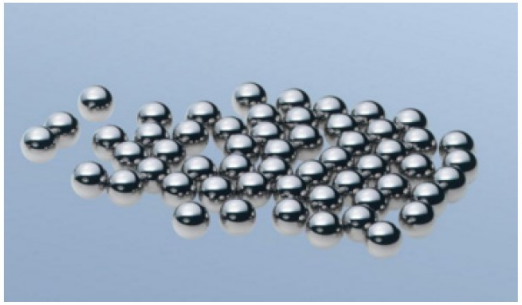
AIRCRAFT DESIGN AND SYSTEMS GROUP (AERO)



Aviation and the Climate – An Overview

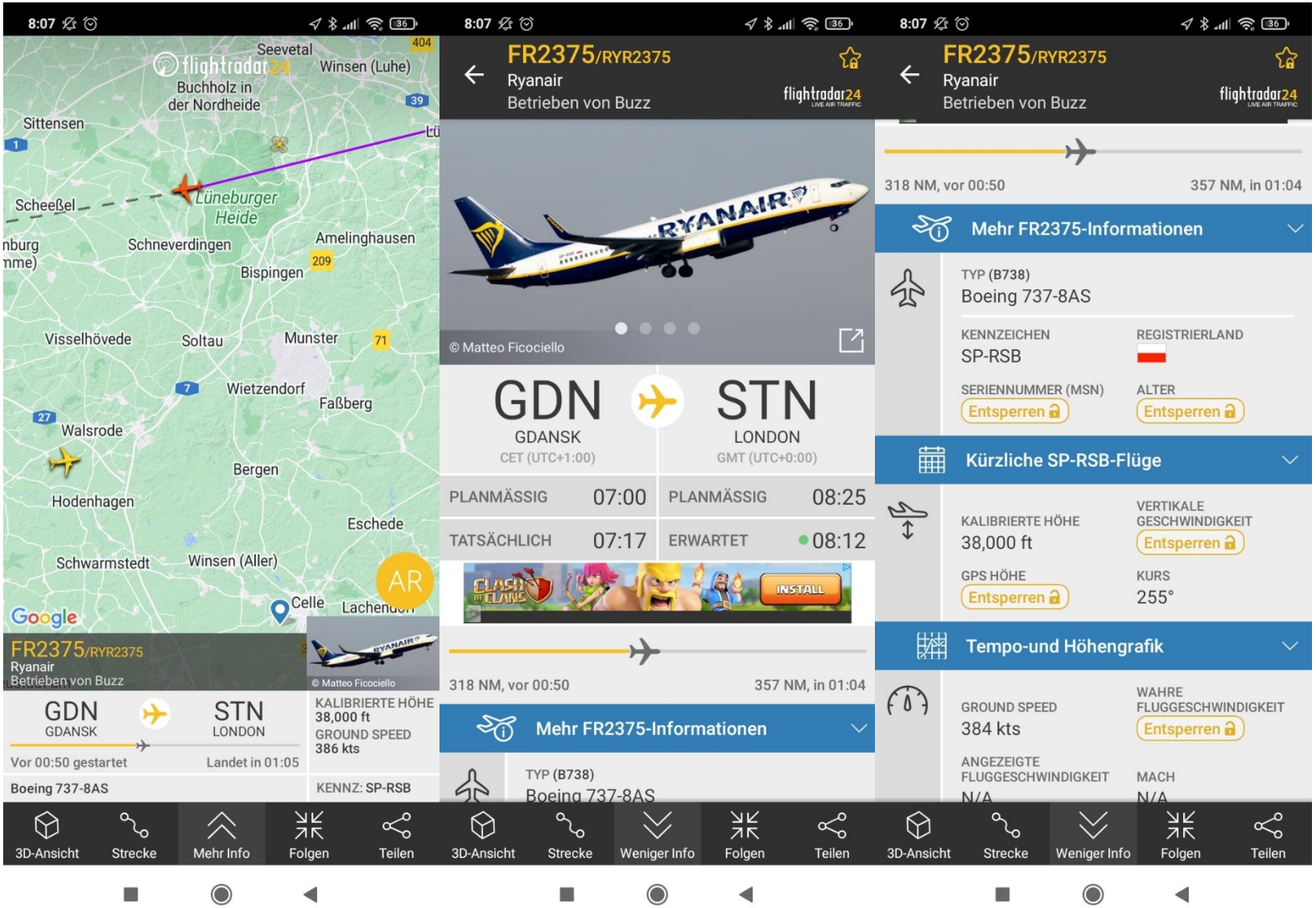


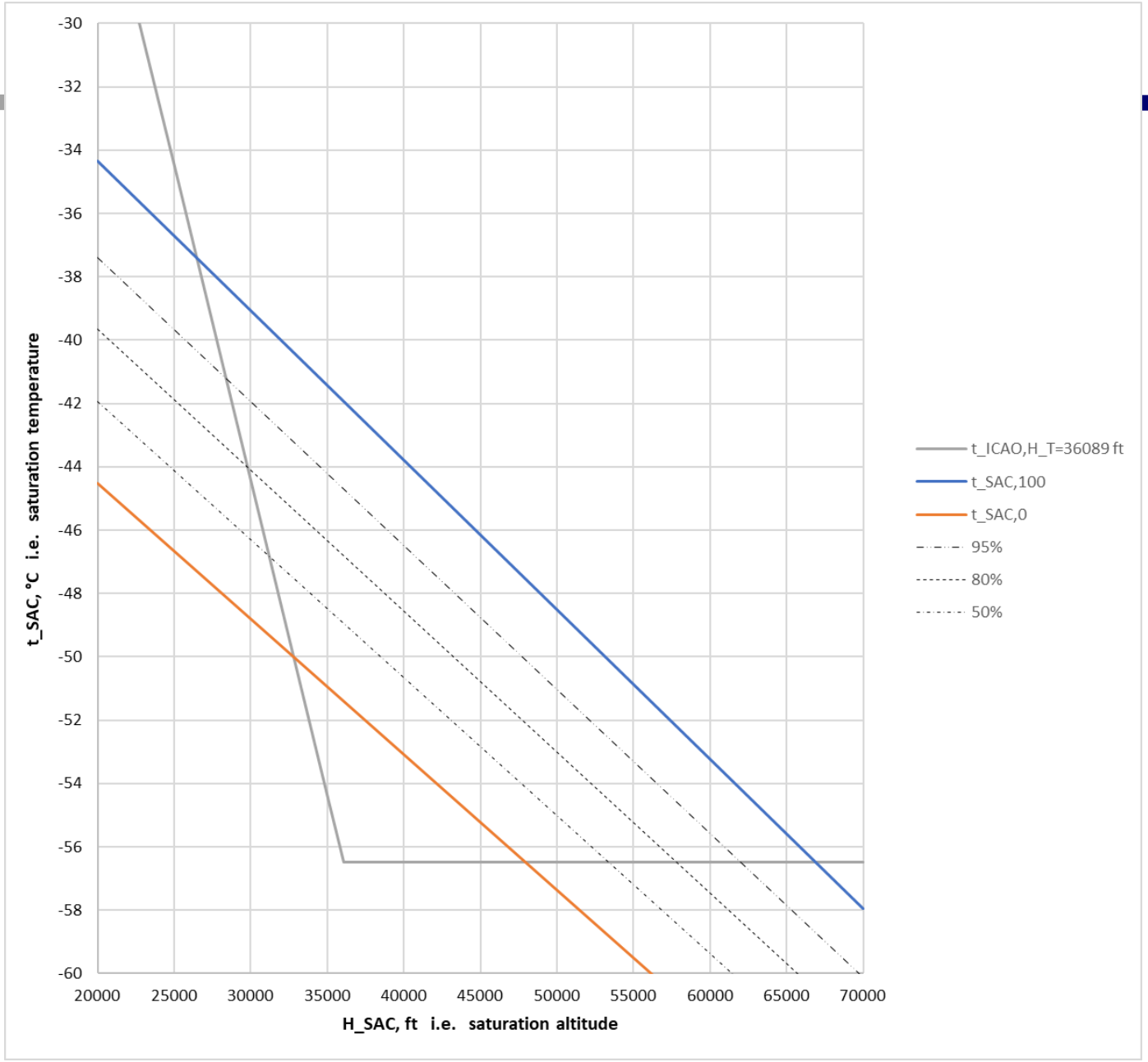
Dieter Scholz Hamburg University of Applied Sciences

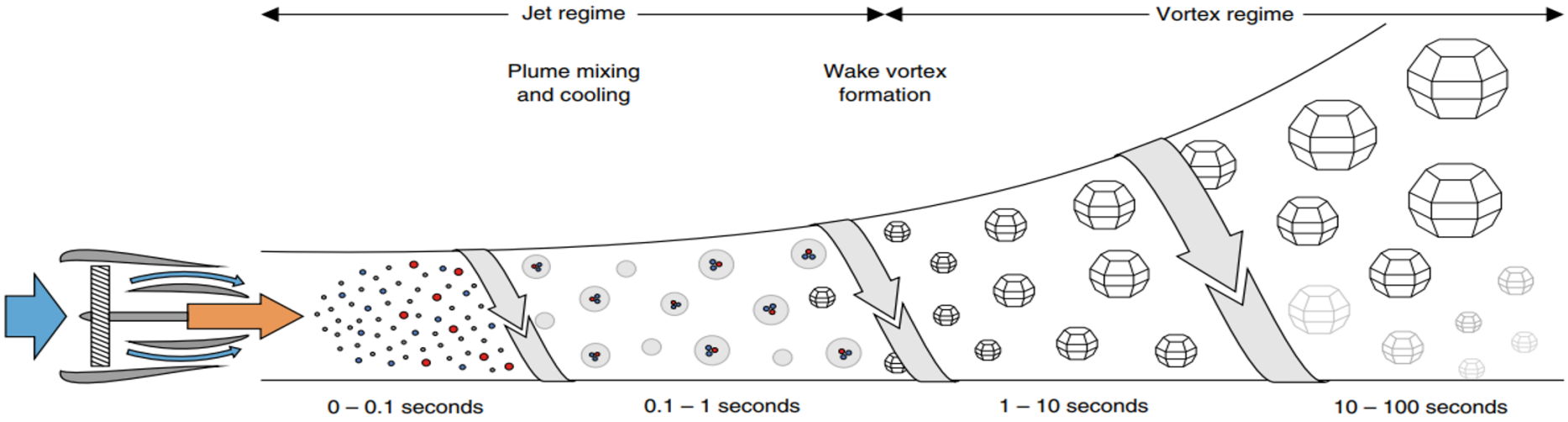


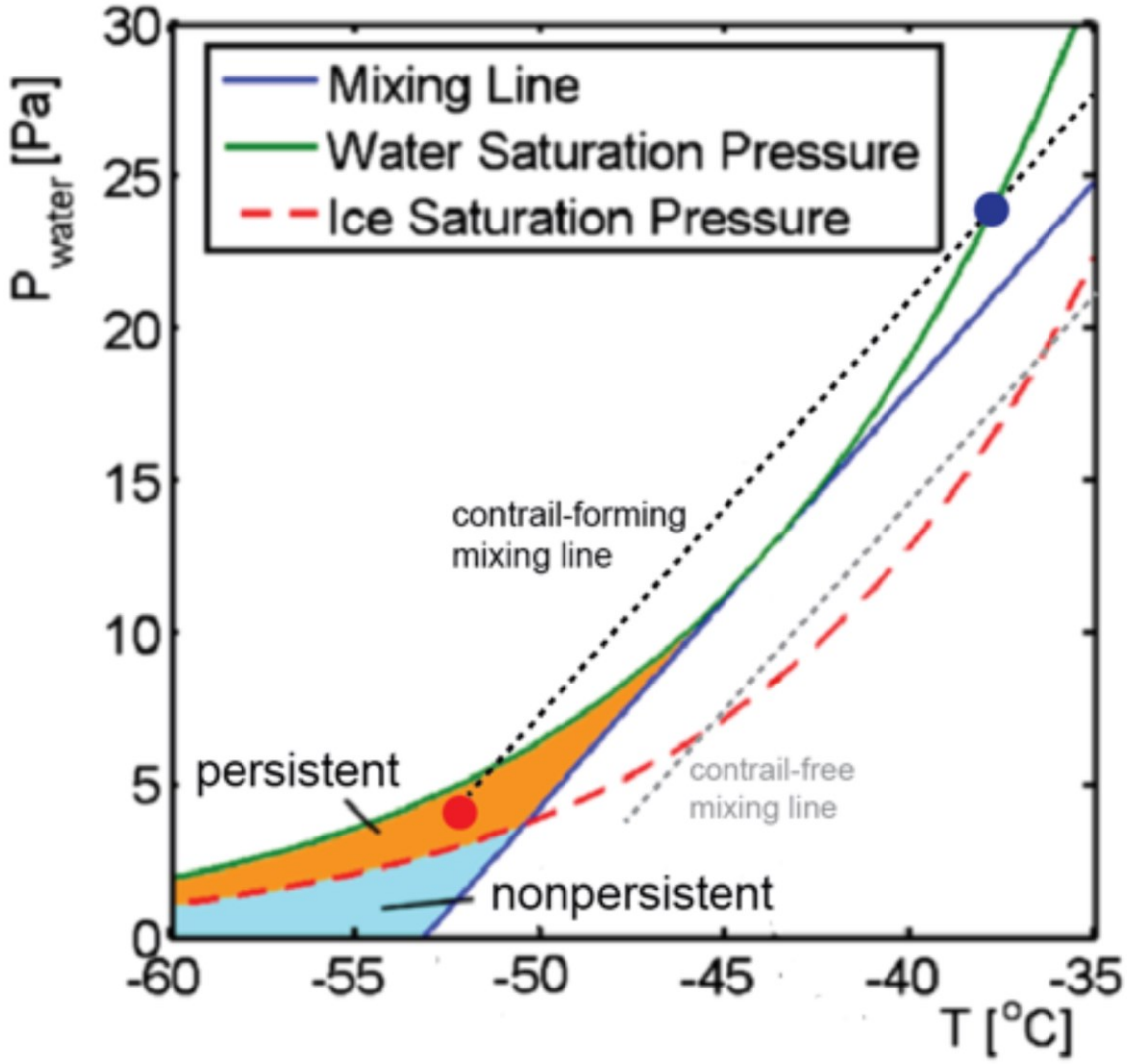
Hamburg Aerospace Lecture Series (AeroLectures)
DGLR, RAeS, VDI, ZAL, HAW Hamburg
Online, 27 January 2022
https://doi.org/10.5281/zenodo.xxxxxxx

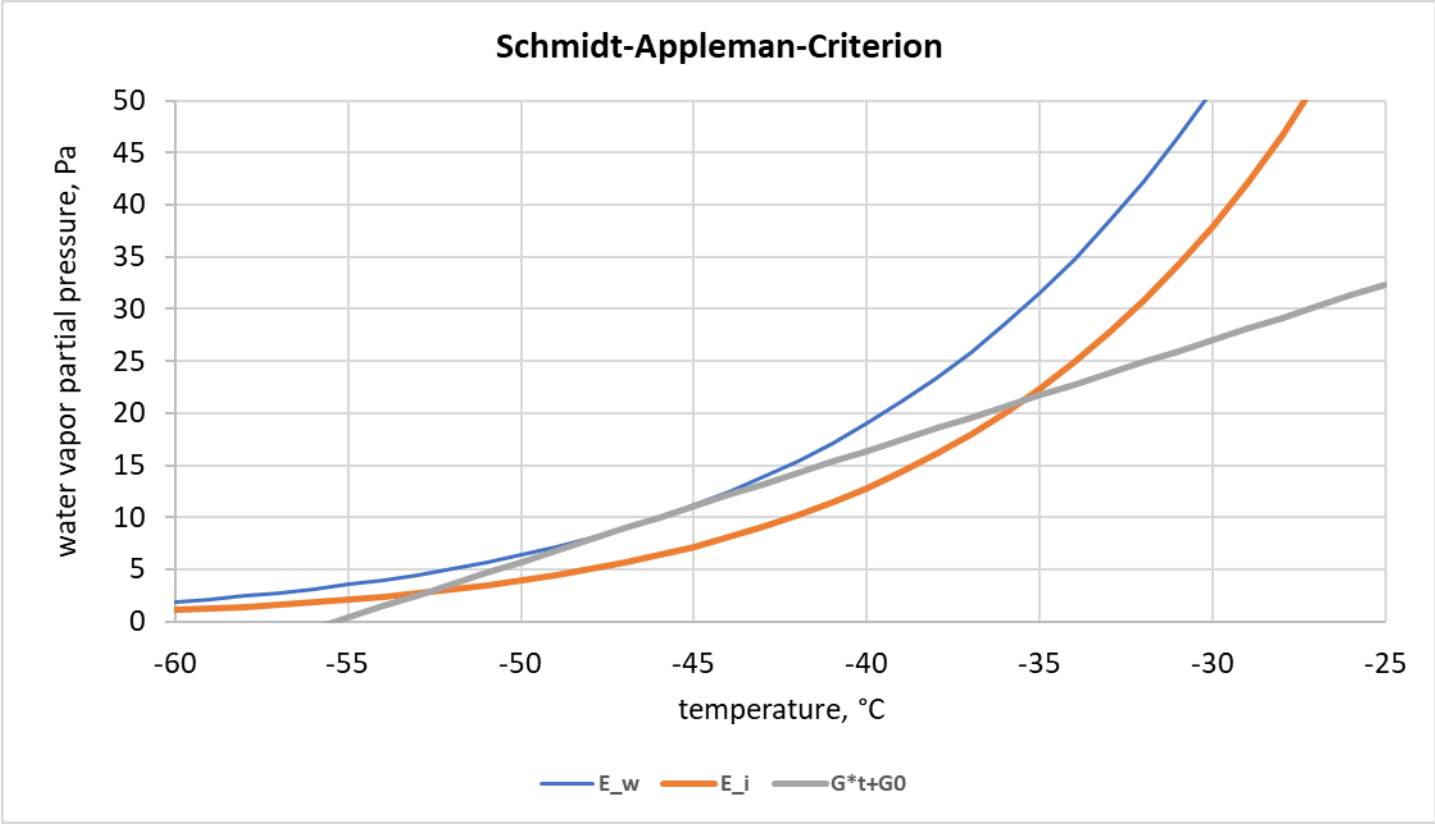
Warming Contrails and Their Avoidance

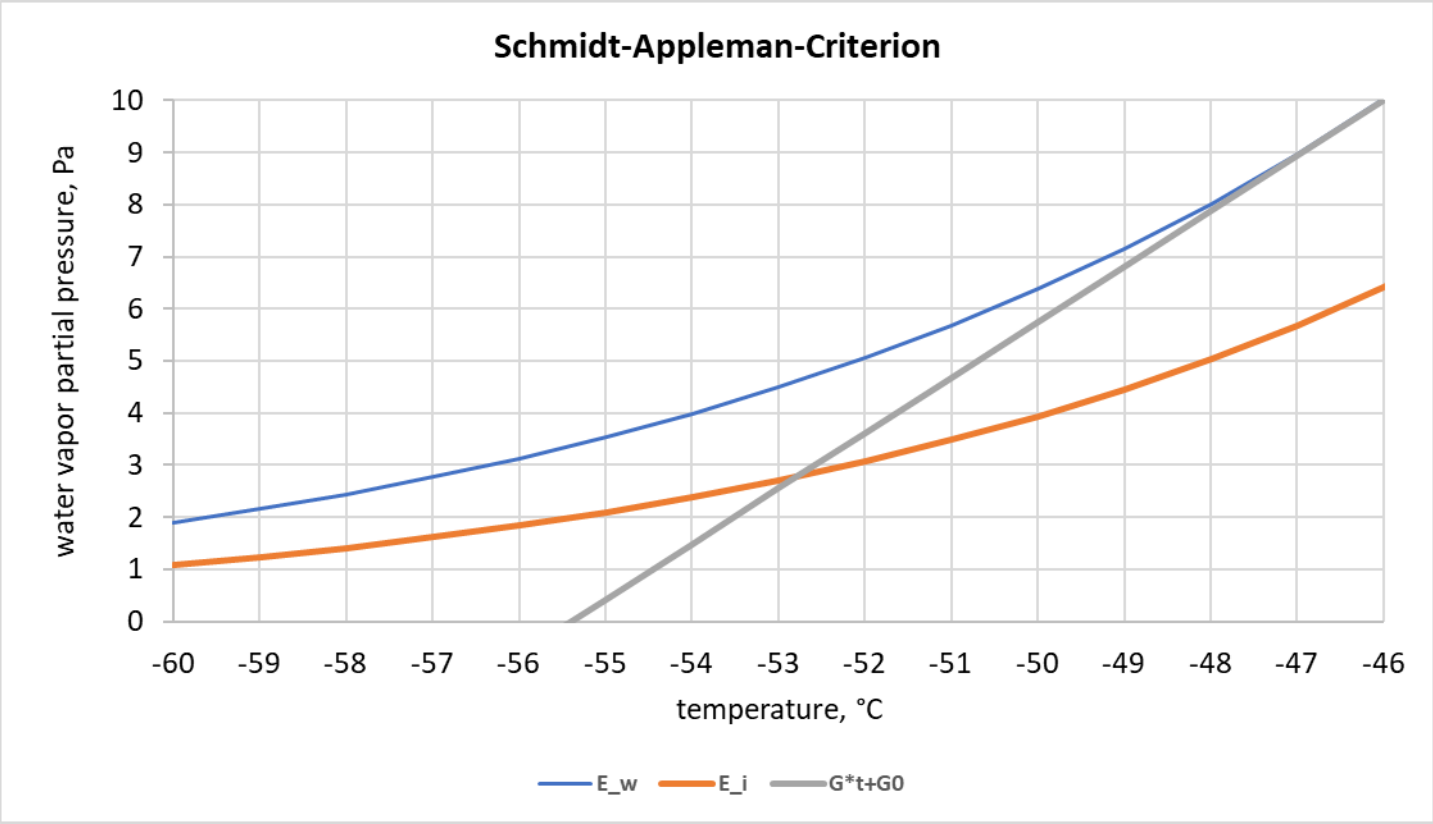

8:07
flightradar24
Seevetal
Winsen (Luhe)
Buchholz in der Nordheide
Sittensen
Lüneburger Heide
Scheeßel
Schneverdingen
Amelinghausen
Bispingen
Visselhövede
Soltau
Munster
Wietzendorf
Faßberg
Walsrode
Bergen
Hodenhagen
Eschede
Schwarmstedt
Winsen (Aller)
Celle
Google
FR2375/RYR2375
Ryanair
Betrieben von Buzz
© Matteo Ficociello
GDN
GDANSK
STN
LONDON
Vor 00:50 gestartet
Landet in 01:05
Boeing 737-8AS
KALIBRIERTE HÖHE
38,000 ft
GROUND SPEED
386 kts
KENNZ: SP-RSB
FR2375/RYR2375
Ryanair
Betrieben von Buzz
flightradar24
RYANAIR
© Matteo Ficociello
GDN
GDANSK
CET (UTC+1:00)
STN
LONDON
GMT (UTC+0:00)
PLANMÄSSIG 07:00
TATSÄCHLICH 07:17
PLANMÄSSIG 08:25
ERWARTET 08:12
CLASH OF CLANS
INSTALL
318 NM, vor 00:50
357 NM, in 01:04
Mehr FR2375-Informationen
TYP (B738)
Boeing 737-8AS
FR2375/RYR2375
Ryanair
Betrieben von Buzz
flightradar24
318 NM, vor 00:50
357 NM, in 01:04
Mehr FR2375-Informationen
TYP (B738)
Boeing 737-8AS
KENNZEICHEN
SP-RSB
REGISTRIERLAND
SERIENNUMMER (MSN)
Entsperren
ALTER
Entsperren
Kürzliche SP-RSB-Flüge
KALIBRIERTE HÖHE
38,000 ft
VERTIKALE GESCHWINDIGKEIT
Entsperren
GPS HÖHE
Entsperren
KURS
255°
Tempo-und Höhengrafik
GROUND SPEED
384 kts
WAHRE FLUGGESCHWINDIGKEIT
Entsperren
ANGEZEIGTE FLUGGESCHWINDIGKEIT
N/A
MACH
N/A
3D-Ansicht
Strecke
Mehr Info
Folgen
Teilen
3D-Ansicht
Strecke
Weniger Info
Folgen
Teilen
3D-Ansicht
Strecke
Weniger Info
Folgen
Teilen

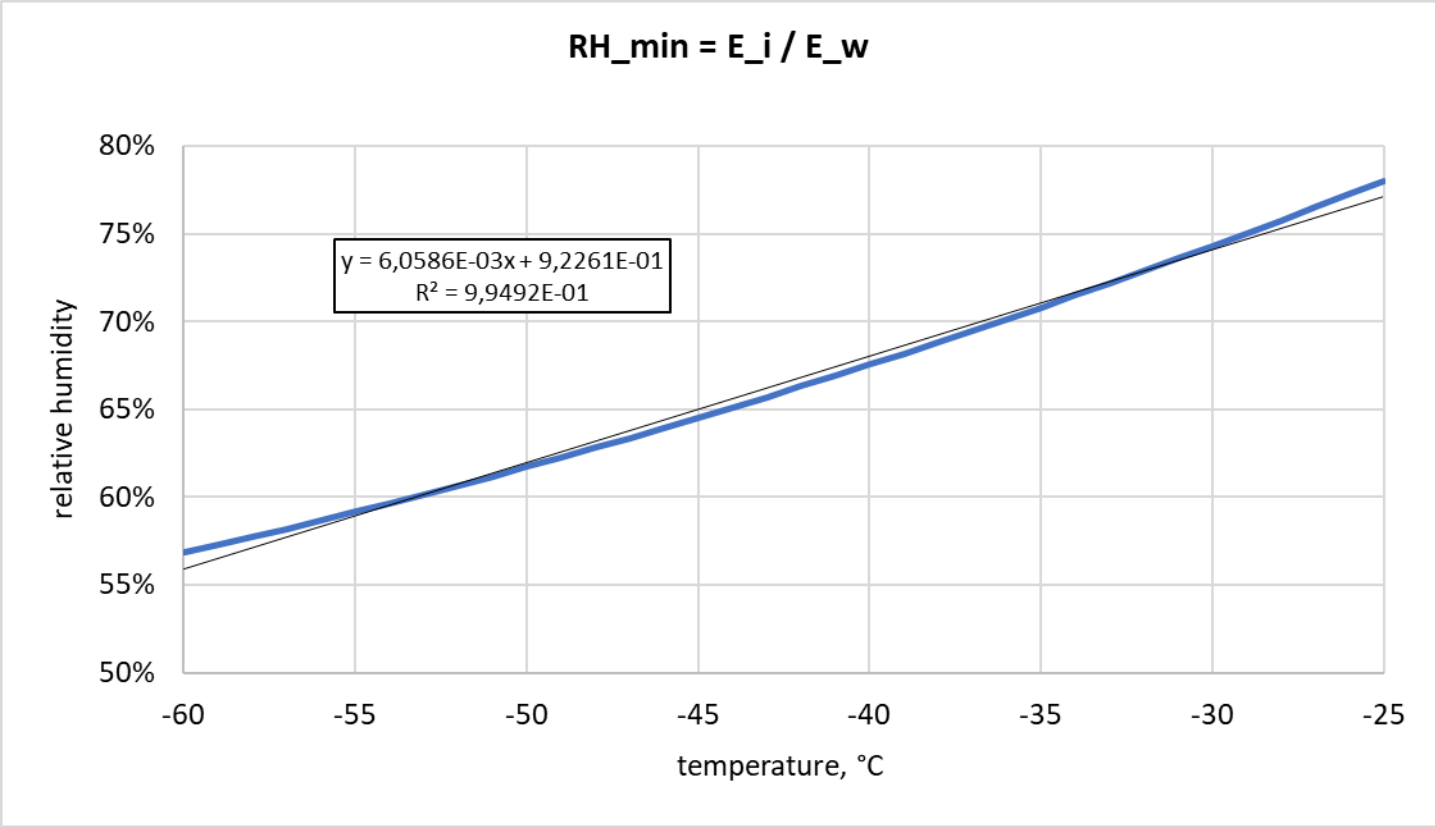

-30
-32
-34
-36
-38
-40
-42
-44
-46
-48
-50
-52
-54
-56
-58
-60
t_SAC, °C i.e. saturation temperature
20000
25000
30000
35000
40000
45000
50000
55000
60000
65000
70000
H_SAC, ft i.e. saturation altitude
t_ICAO,H_T=36089 ft
t_SAC,100
t_SAC,0
95%
80%
50%


Jet regime
Vortex regime
Plume mixing and cooling
Wake vortex formation
0 – 0.1 seconds
0.1 – 1 seconds
1 – 10 seconds
10 – 100 seconds


Mixing Line
Water Saturation Pressure
Ice Saturation Pressure
P_{water} [Pa]
30
25
20
15
10
5
0
-60
-55
-50
-45
-40
-35
T [°C]
contrail-forming
mixing line
contrail-free
mixing line
persistent
nonpersistent

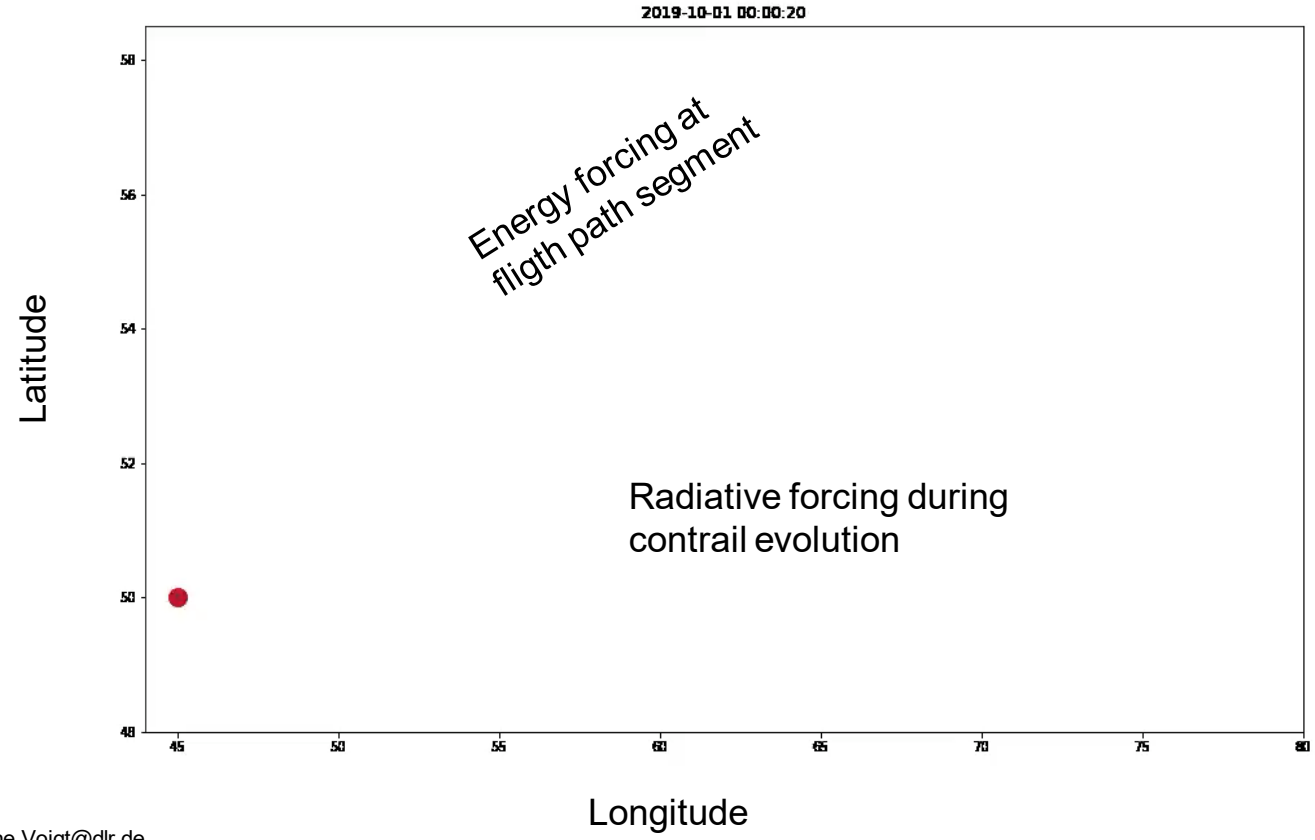

Schmidt-Appleman-Criterion
water vapor partial pressure, Pa
50
45
40
35
30
25
20
15
10
5
0
-60
-55
-50
-45
-40
-35
-30
-25
temperature, °C
E_w
E_i
G*t+G0


Schmidt-Appleman-Criterion
water vapor partial pressure, Pa
10
9
8
7
6
5
4
3
2
1
0
-60
-59
-58
-57
-56
-55
-54
-53
-52
-51
-50
-49
-48
-47
-46
temperature, °C
E_w
E_i
G*t+G0


RH_min = E_i / E_w
y = 6,0586E-03x + 9,2261E-01
R² = 9,9492E-01
relative humidity
80%
75%
70%
65%
60%
55%
50%
-60
-55
-50
-45
-40
-35
-30
-25
temperature, °C

Contrail-Cirrus Prediction Tool (CoCiP) – Flight segment contrail climate forcing

Flight on 10 Jan 2019
0:00 to 6:00 h

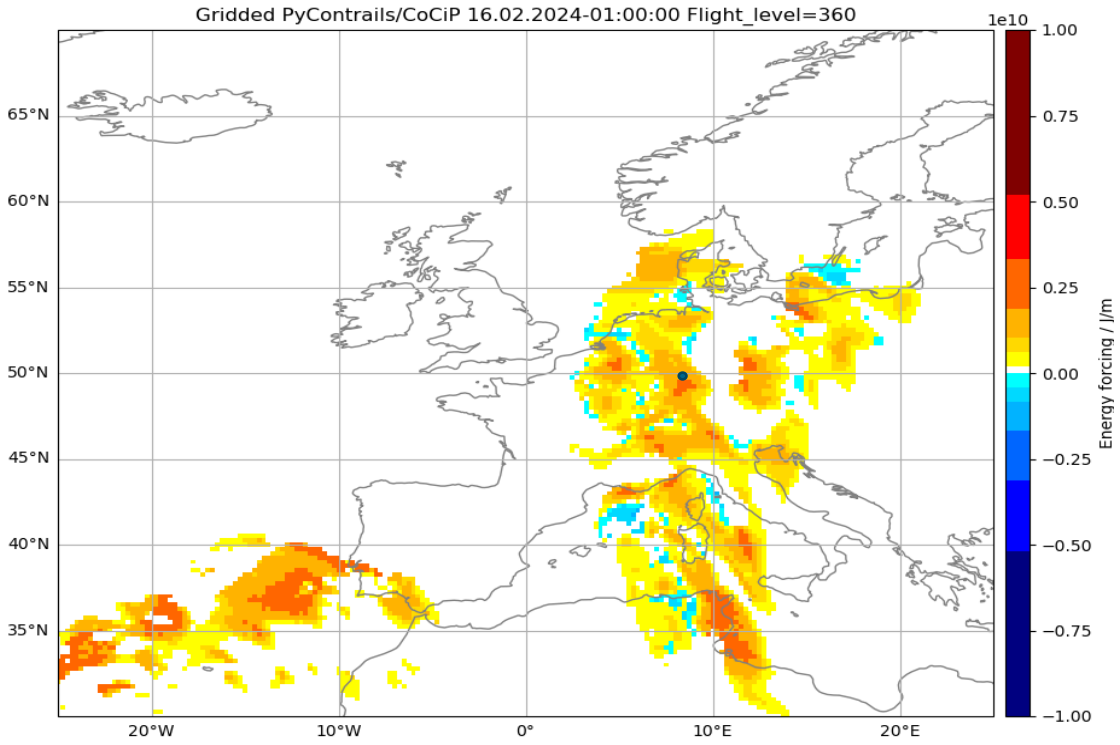


> Christiane.Voigt@dlr.de

https://py.contrails.org

Vorhersage von Regionen mit Kondensstreifen

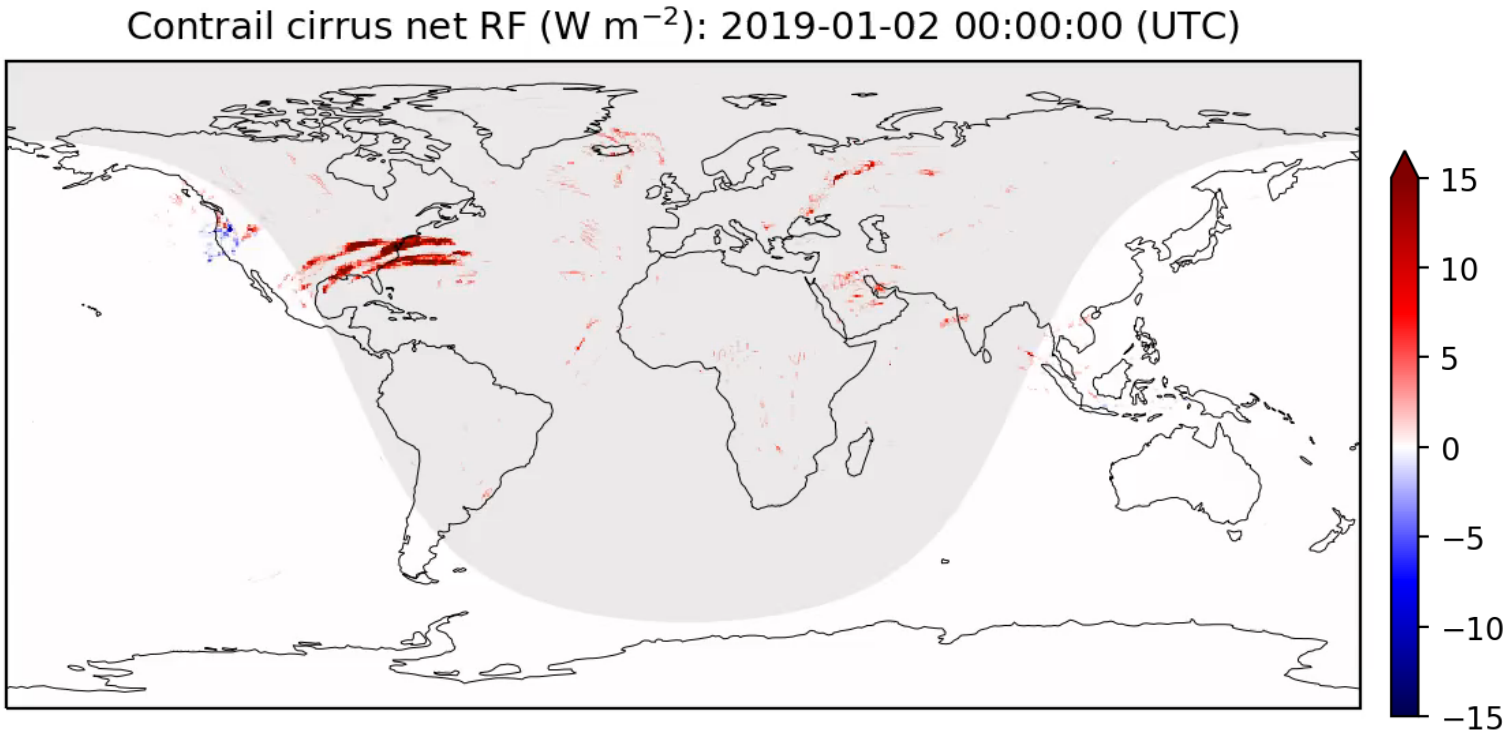
16.2.2024, Flugfläche 360, stündliche Vorhersage



Christiane.Voigt@dlr.de

Kirschler, DLR

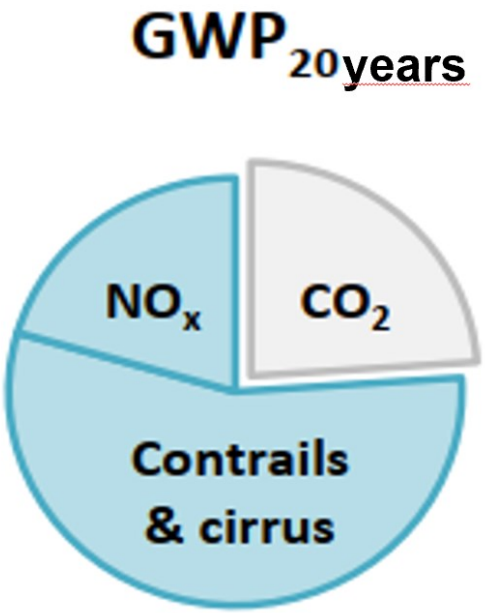
Contrail avoidance by flight routing

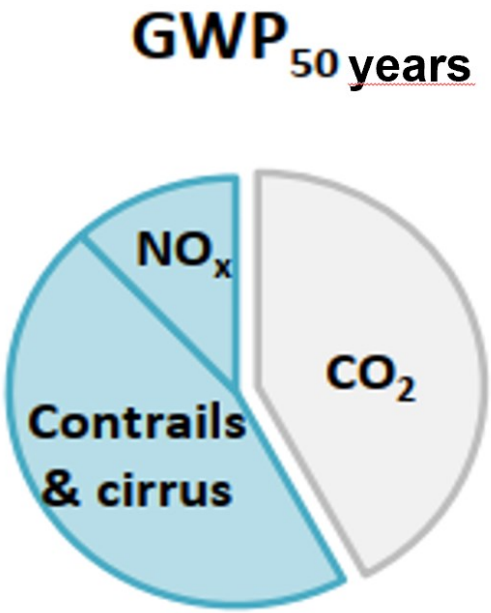


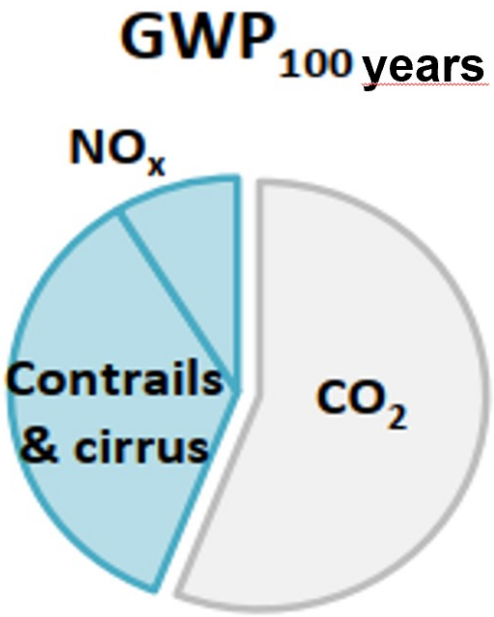
open source https://py.contrails.org

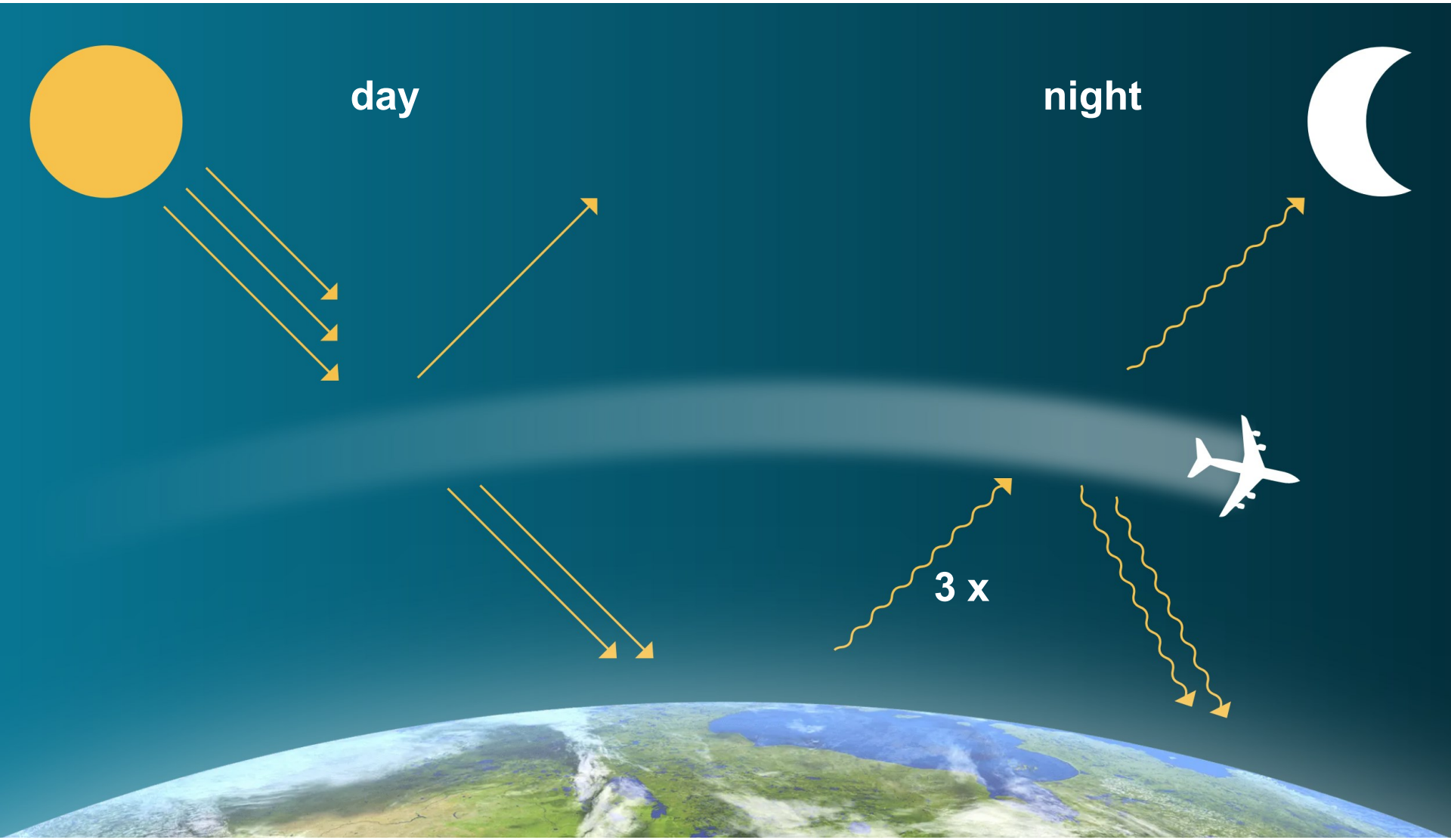
Teoh, Stettler, Imperial College, Shapiro, Breakthrough Energies, Schumann, Voigt, DLR

> Christiane.Voigt@dlr.de


GWP 20 years
NOx
CO2
Contrails & cirrus


GWP 50 years
NOx
CO2
Contrails & cirrus


GWP 100 years
NOx
Contrails & cirrus
CO2

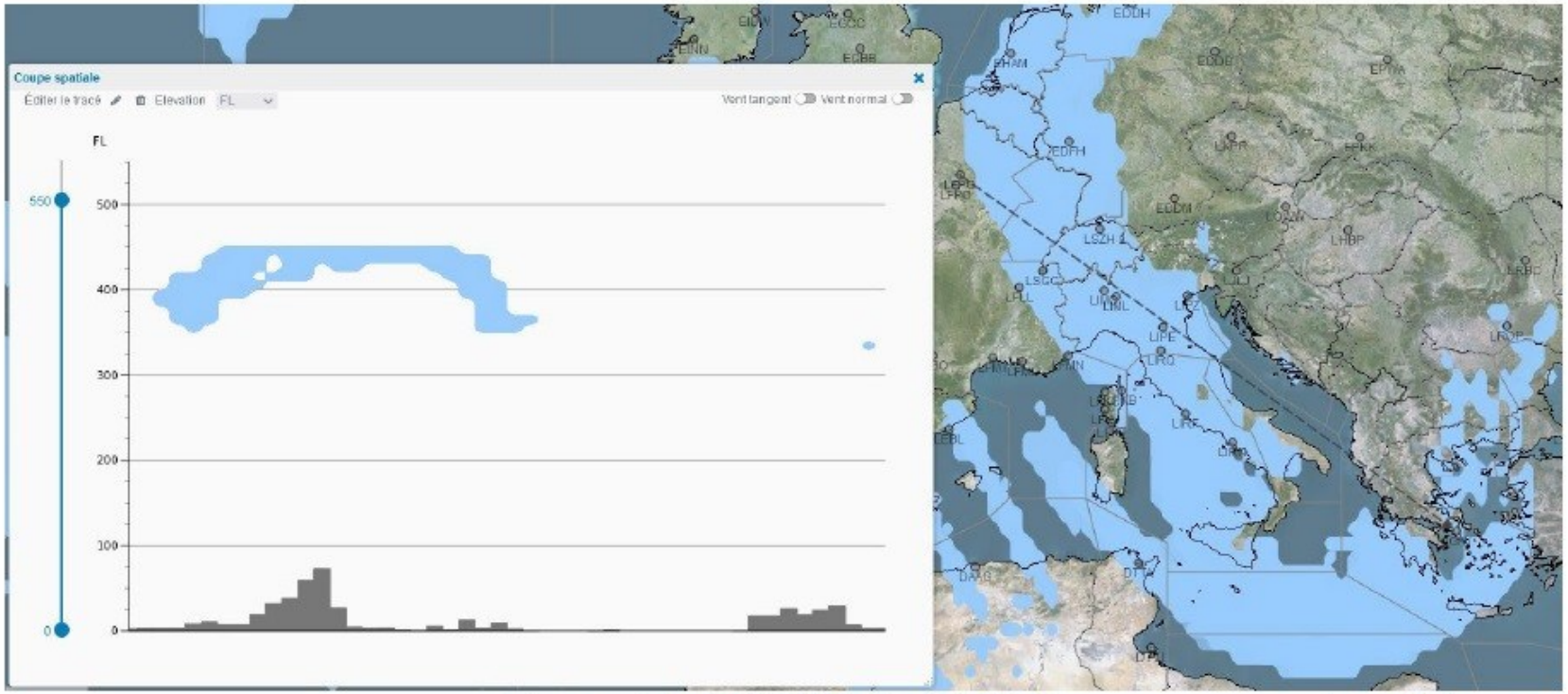

day
night
3 x

	C / SKC	D / N	R / NR	⇒ W / C / I
1.	C	D	R	I
2.	C	D	NR	I
3.	C	N	R	I
4.	C	N	NR	I
5.	SKC	D	R	I
6.	SKC	D	NR	C
7.	SKC	N	R	W
8.	SKC	N	NR	W

C : cloud (ovc)
SKC : sky clear
D : day
N : night
R : reflective
NR : non-reflective
W : warming
C : cooling
I : indifferent
OVC : overcast

Reason:
1. to 4. : Clouds are present, contrail does not make difference
5. : Surface is reflective, (reflective contrail —— " ——)
6. : NR e.g. ocean "swallows" sun's radiation, contrail precludes this
7. to 8. : No radiation from the sun. Reflection back to earth of long wavelength radiation due to contrail is important.

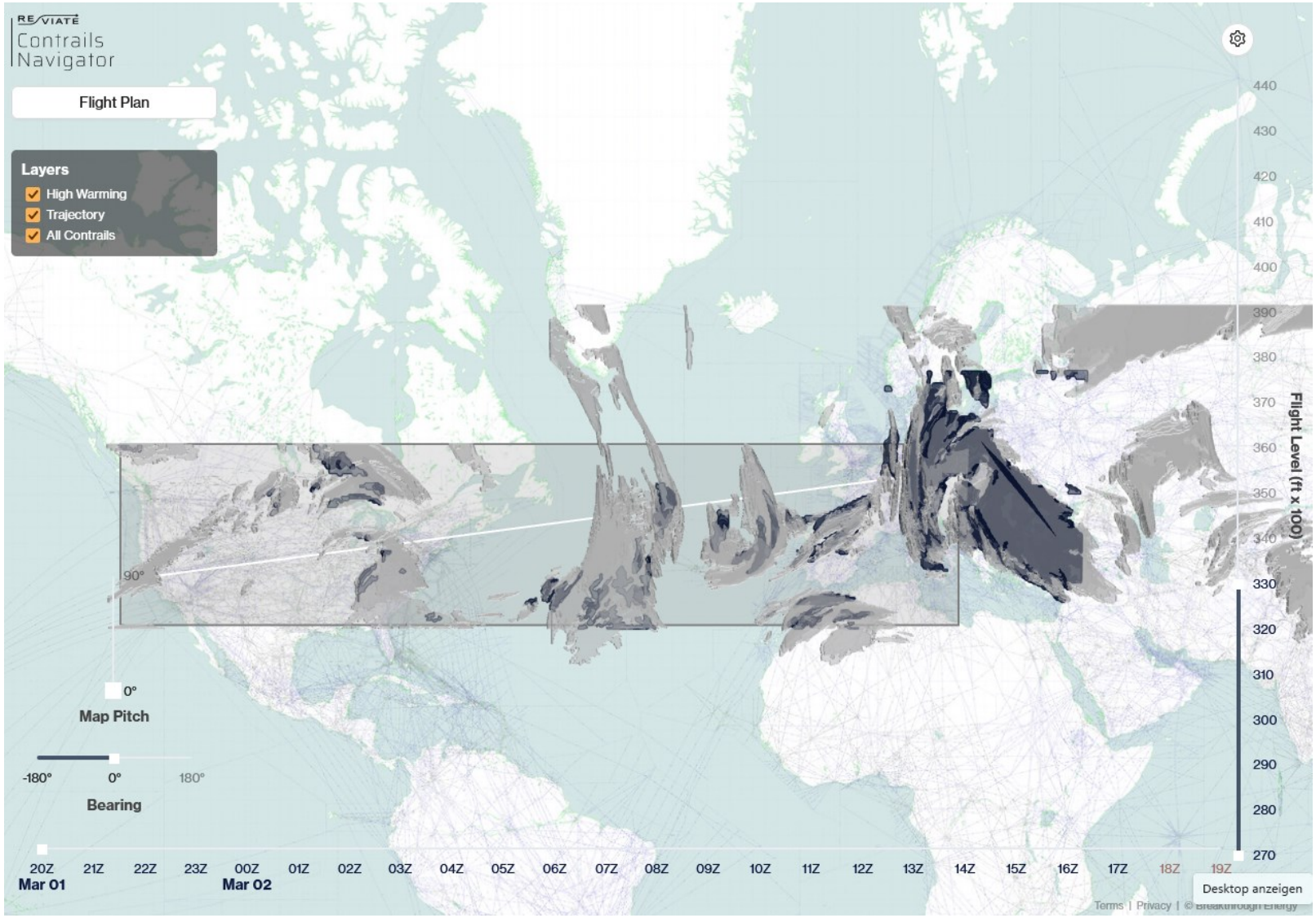
WIMCOT - Demonstration



Forecast for 04/09/2023 at 10UTC
From 03/09/2023 12UTC
Cross section from Paris to Athens

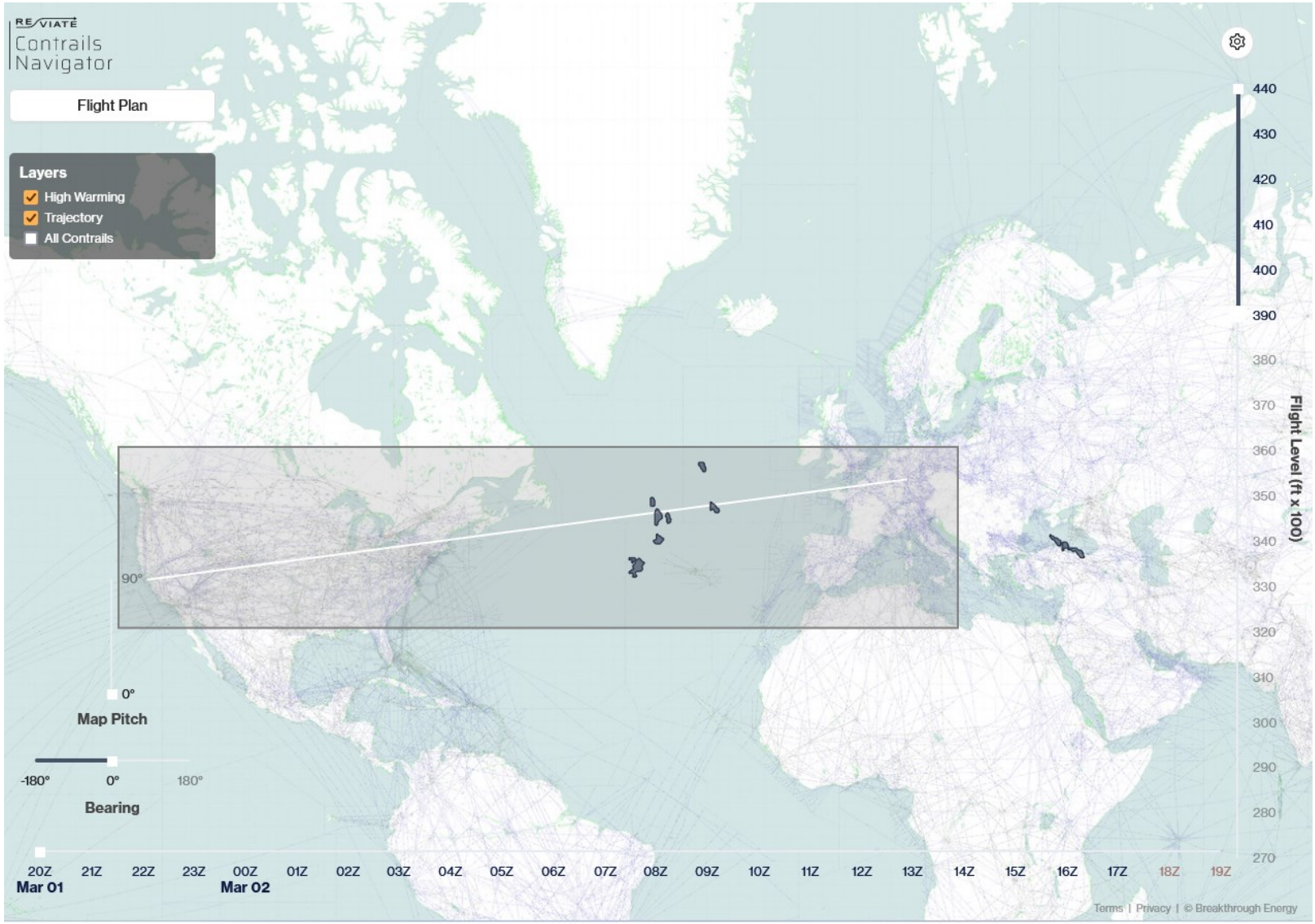
Risk area

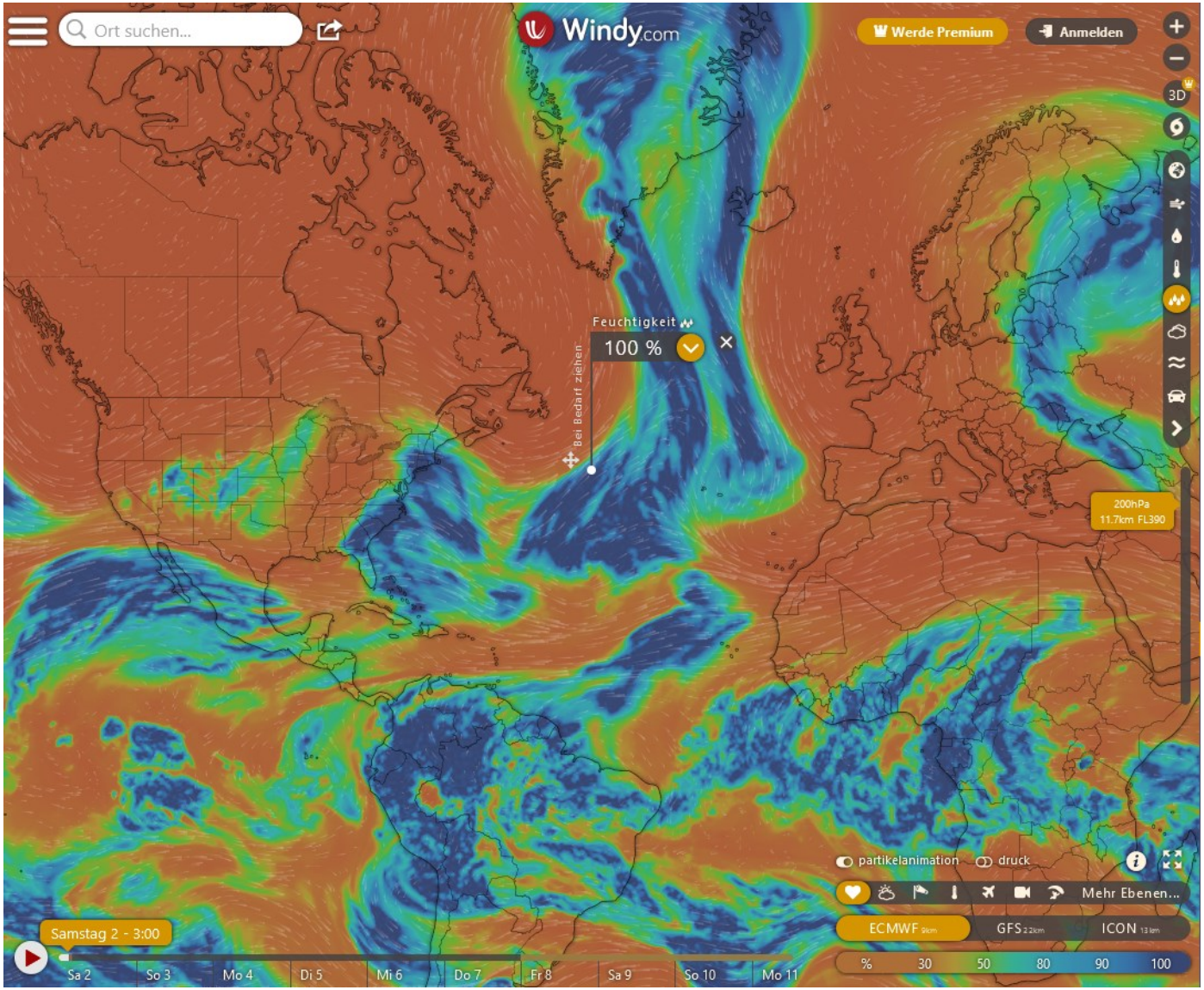
SHARE CONTRAILS RISK AREAS WITH PILOTS

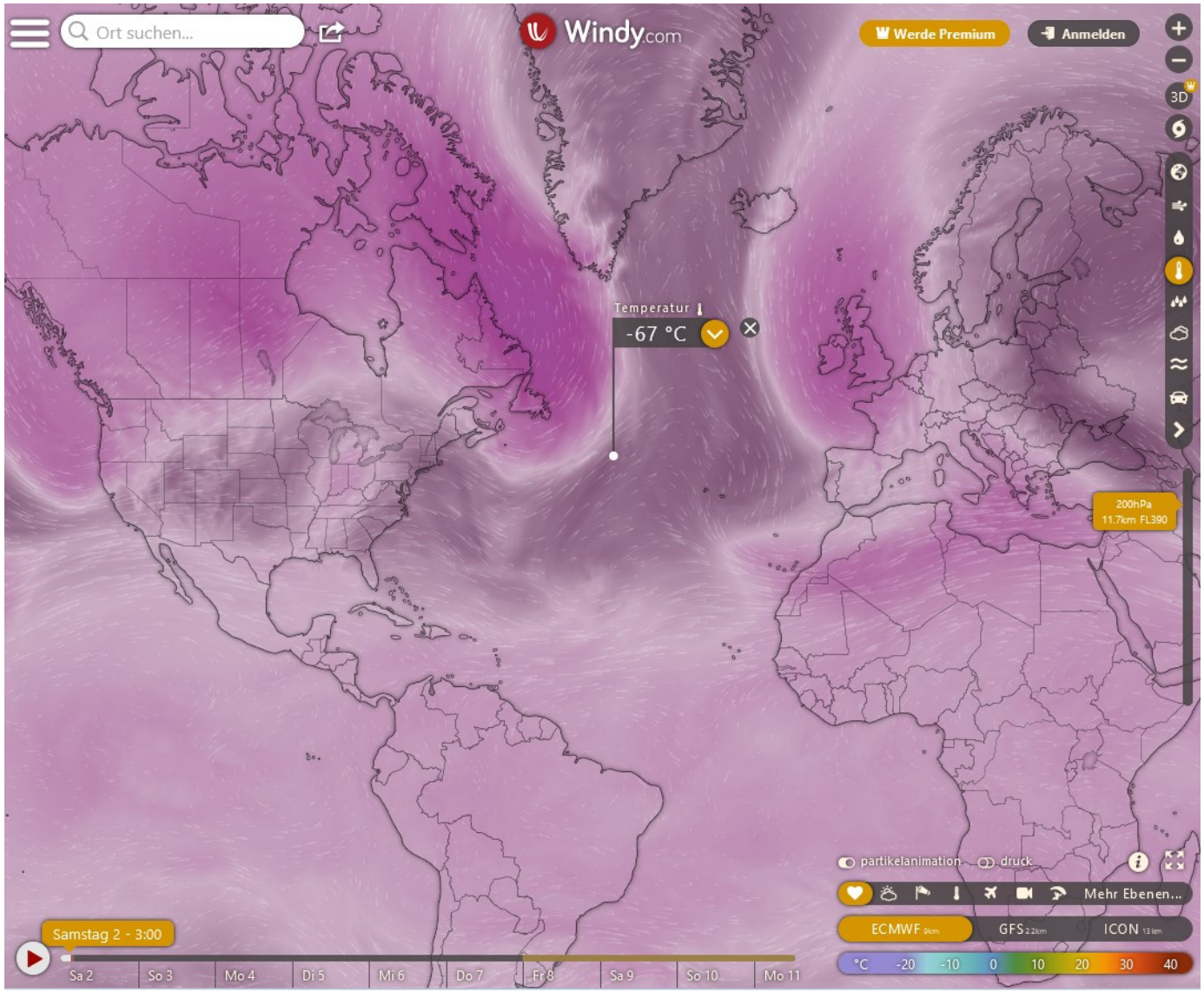

RE/VIATE
Contrails Navigator
Flight Plan
Layers
High Warming
Trajectory
All Contrails
90°
0°
Map Pitch
-180°
0°
180°
Bearing
20Z
21Z
22Z
23Z
00Z
01Z
02Z
03Z
04Z
05Z
06Z
07Z
08Z
09Z
10Z
11Z
12Z
13Z
14Z
15Z
16Z
17Z
18Z
19Z
Mar 01
Mar 02
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
Flight Level (ft x 100)
Desktop anzeigen
Terms | Privacy

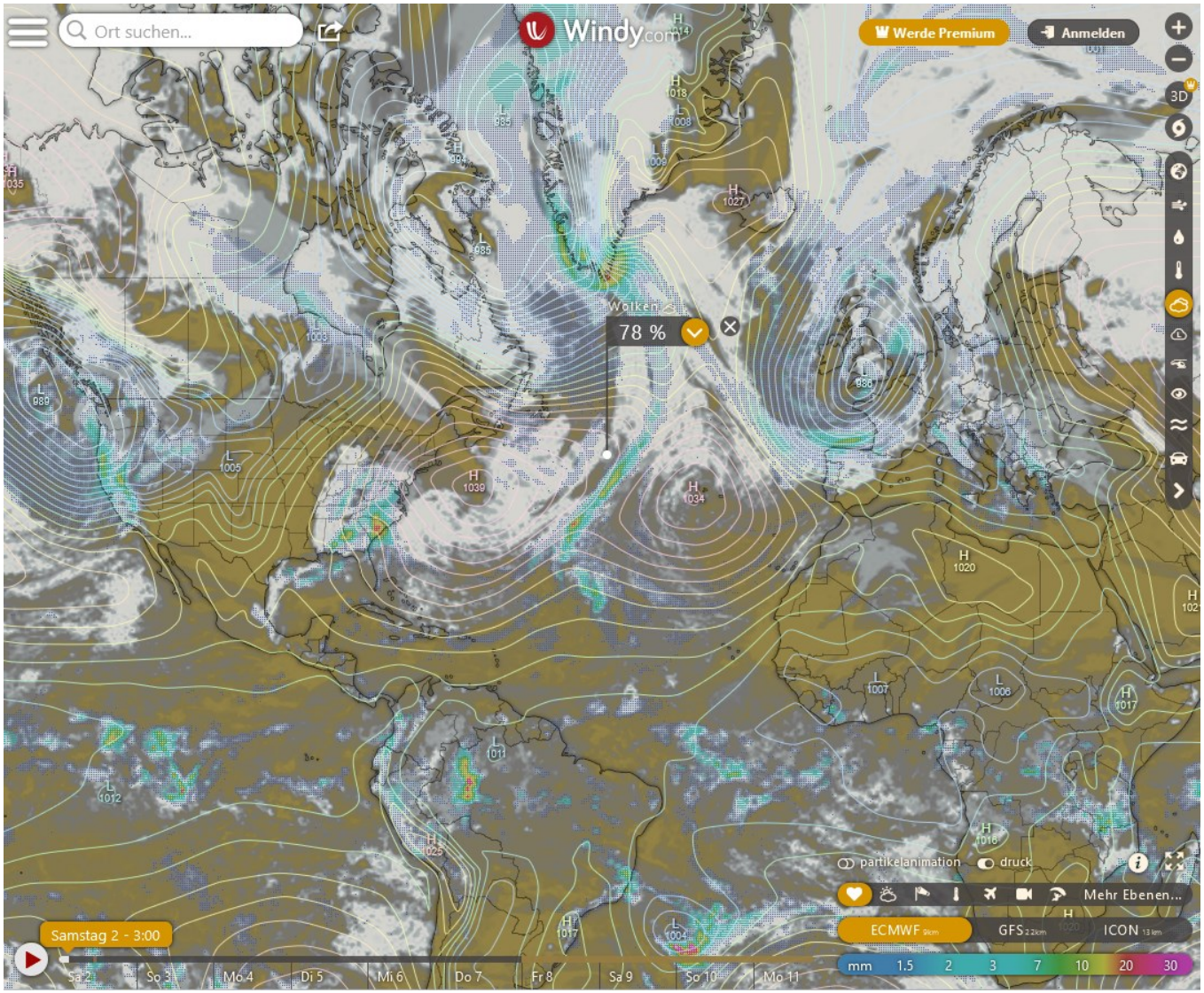

RE/VIATE
Contrails Navigator
Flight Plan
Layers
High Warming
Trajectory
All Contrails
90°
0°
Map Pitch
-180°
0°
180°
Bearing
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
Flight Level (ft x 100)
20Z
Mar 01
21Z
22Z
23Z
00Z
Mar 02
01Z
02Z
03Z
04Z
05Z
06Z
07Z
08Z
09Z
10Z
11Z
12Z
13Z
14Z
15Z
16Z
17Z
18Z
19Z
Terms | Privacy | © Breakthrough Energy


RE/VIATE
Contrails Navigator
Flight Plan
Layers
High Warming
Trajectory
All Contrails
90°
0°
Map Pitch
-180°
0°
180°
Bearing
20Z
Mar 01
21Z
22Z
23Z
00Z
Mar 02
01Z
02Z
03Z
04Z
05Z
06Z
07Z
08Z
09Z
10Z
11Z
12Z
13Z
14Z
15Z
16Z
17Z
18Z
19Z
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
Flight Level (ft x 100)
Terms | Privacy | © Breakthrough Energy


RE/VIATE
Contrails Navigator
Flight Plan
Layers
High Warming
Trajectory
All Contrails
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
Flight Level (ft x 100)
90°
0°
Map Pitch
-180°
0°
180°
Bearing
20Z
21Z
22Z
23Z
00Z
01Z
02Z
03Z
04Z
05Z
06Z
07Z
08Z
09Z
10Z
11Z
12Z
13Z
14Z
15Z
16Z
17Z
18Z
19Z
Mar 01
Mar 02
Terms | Privacy | © Breakthrough Energy


Ort suchen...
Windy.com
Werde Premium
Anmelden
3D
Feuchtigkeit
100 %
Bei Bedarf ziehen
200hPa
11.7km FL390
partikelanimation
druck
Mehr Ebenen...
ECMWF
GFS
ICON
%
30
50
80
90
100
Samstag 2 - 3:00
Sa 2
So 3
Mo 4
Di 5
Mi 6
Do 7
Fr 8
Sa 9
So 10
Mo 11


Ort suchen...
Windy.com
Werde Premium
Anmelden
3D
Temperatur
-67 °C
200hPa
11.7km FL390
partikelanimation
druck
Mehr Ebenen...
ECMWF
GFS
ICON
°C -20 -10 0 10 20 30 40
Samstag 2 - 3:00
Sa 2 So 3 Mo 4 Di 5 Mi 6 Do 7 Fr 8 Sa 9 So 10 Mo 11


Ort suchen...
Windy.com
Werde Premium
Anmelden
3D
Wolken
78 %
partikelanimation
druck
Mehr Ebenen...
Samstag 2 - 3:00
ECMWF
GFS
ICON
mm 1.5 2 3 7 10 20 30
Sa 2 So 3 Mo 4 Di 5 Mi 6 Do 7 Fr 8 Sa 9 So 10 Mo 11

Tactical avoidance

Adjust flight trajectory en-route to avoid contrails as they are observed

Based on contrail "nowcast"

- Issue real-time guidance
- Restrict avoidance to maneuvers within fuel burn limits
- ATC responsiveness

Long-term vision:

Convergence of concepts:

- Strategic elements to support fuel burn planning
- Tactical elements to maximize precision of guidance

Strategic avoidance

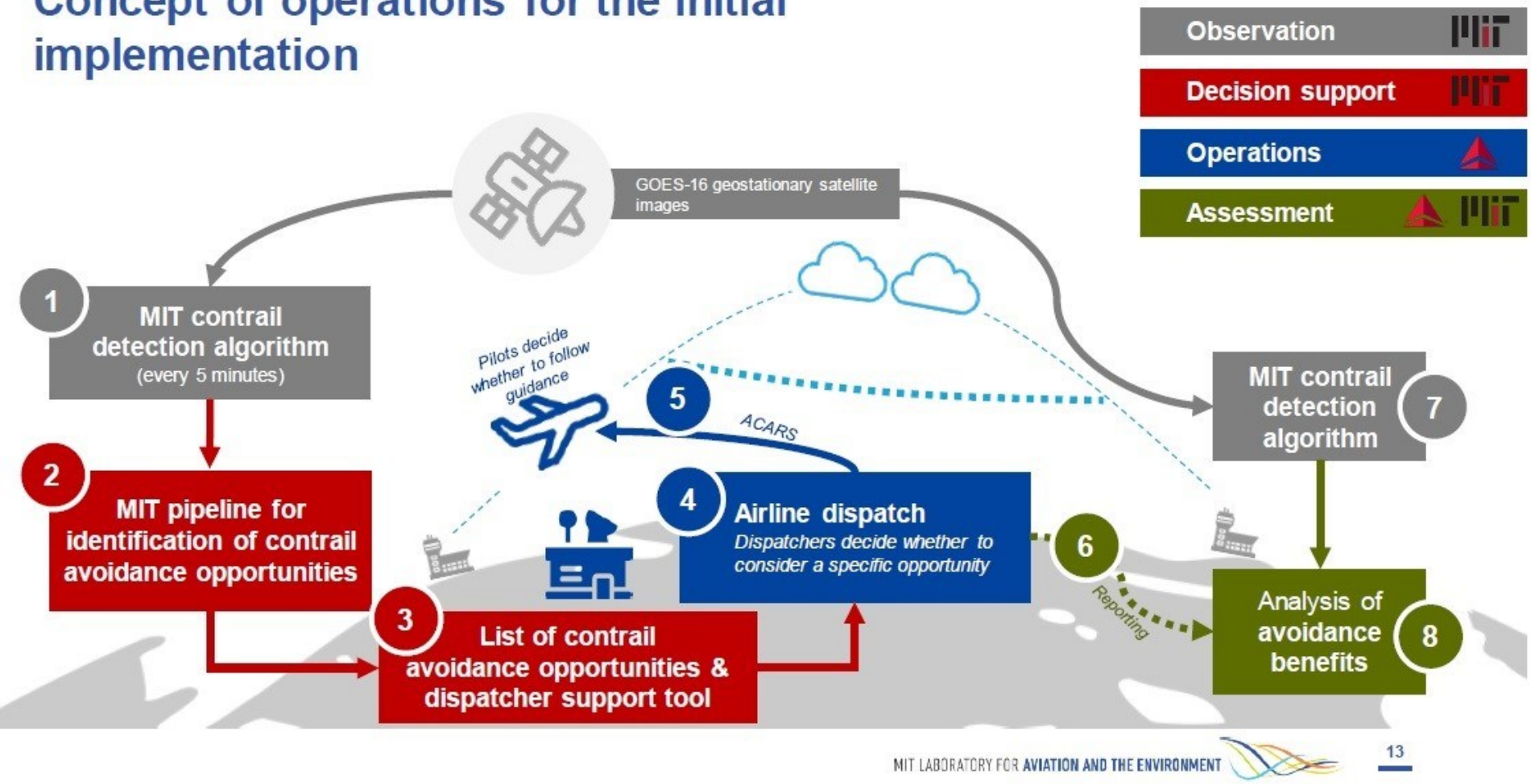
Flight trajectories are planned to avoid expected contrails along the route

Based on contrail forecast

- Reliable forecast of PCC regions
- Minimal deviation flightplan vs. flown trajectory
- ATC clearance

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

Concept of operations for the initial implementation



Coffee Break

EASA's Environmental Stewardship

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

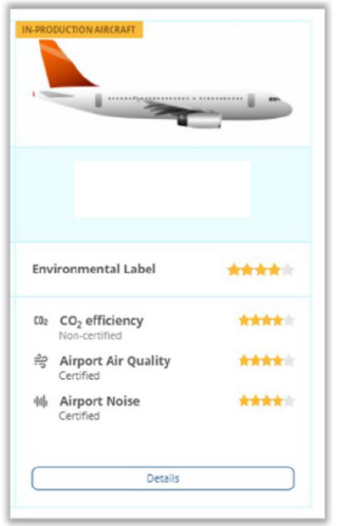
AIRCRAFT DESIGN AND SYSTEMS GROUP (AERO)

EASA's Proposed Environmental Label Programme – Benefits and Shortcomings

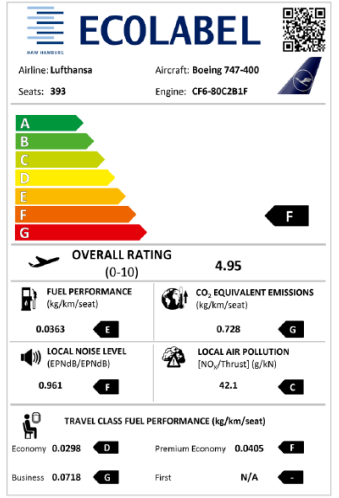
Dieter Scholz Hamburg University of Applied Sciences

German Aerospace Congress
Stuttgart, 19-21 September 2023

EASA (idea)



HAW (ready)




2022: 1/3rd OF
PAKISTAN
UNDERWATER

MODAL SHIFTS


TOURISM:
PROVIDING SOME RELIEF...
TO THE GREAT BARRIER REEF...
REAL SUSTAINABLE AVIATION MEANS:
THERE WILL BE A REEF TO VISIT IN THE FUTURE

Q & A

These lecture notes: **http://ProfScholz.de**

Contact: **info@ProfScholz.de**

Abstract

Containedin the published version ...