

Use of a modern 4D aviation weather application for pilots to increase flight safety: Case studies from flight operations



Martin Gerber – Pilot / Project Manager – Swiss International Air Lines

Weather planning preflight: what (most) pilots are using today

The bare legal minimum...

Airport Weather Forecast in Text Format

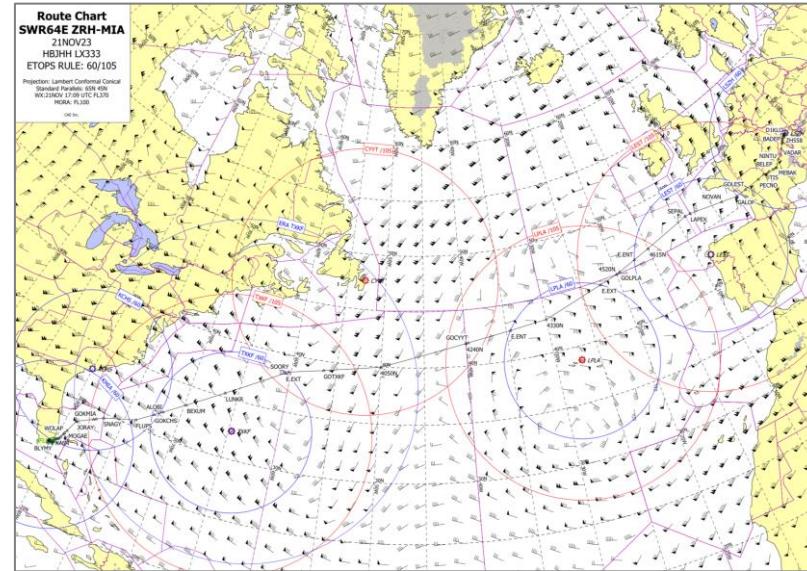
Miami Intl
DEST - 21:13 - 23:13
IA - 22:08 - 22:13

211353Z 10014KT 10SM SCT031 27/18 A3006
RMK AO2 SLP178 T02720183=

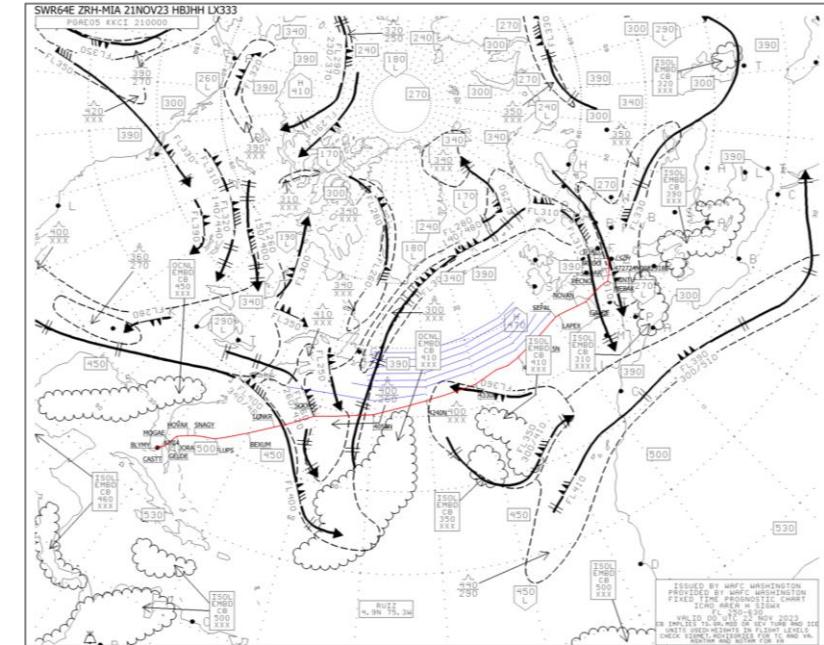
TAF

211120Z 2112/2218 10012KT P6SM FEW030 SCT050
FM211400 11015G22KT P6SM FEW025 SCT035
FM212000 11012KT P6SM FEW030 SCT250
FM220100 11008KT P6SM SCT030 SCT250
FM220600 13006KT P6SM SCT030 SCT250=

2D Wind Charts



2D Significant Weather Charts (SWC)

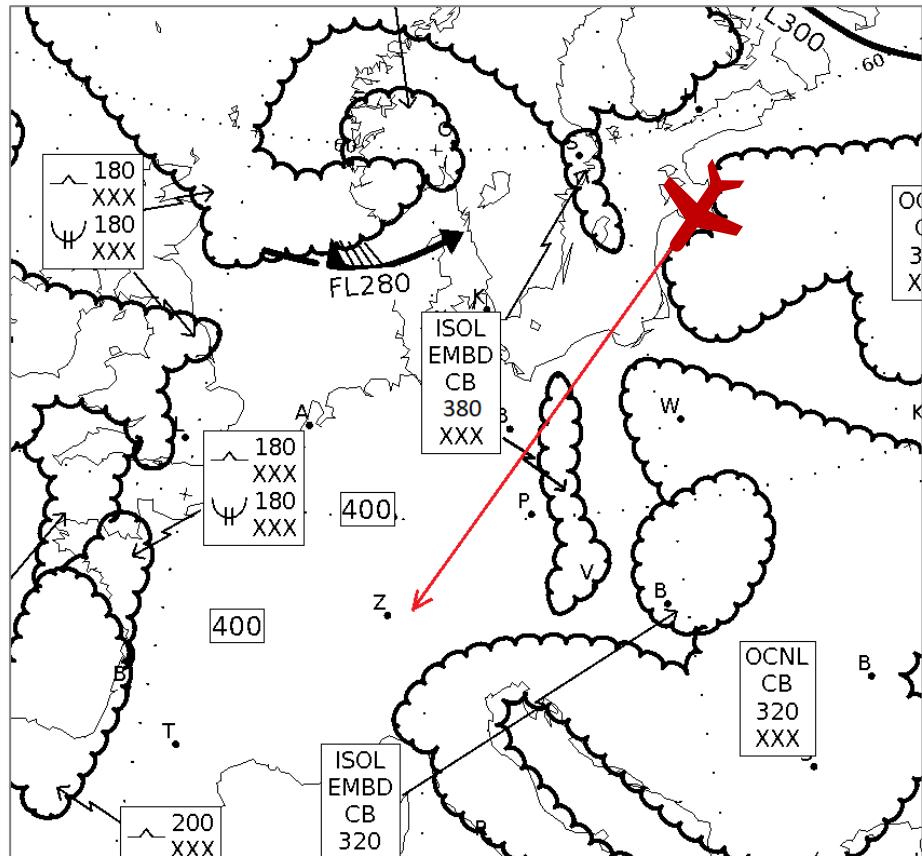


The problem

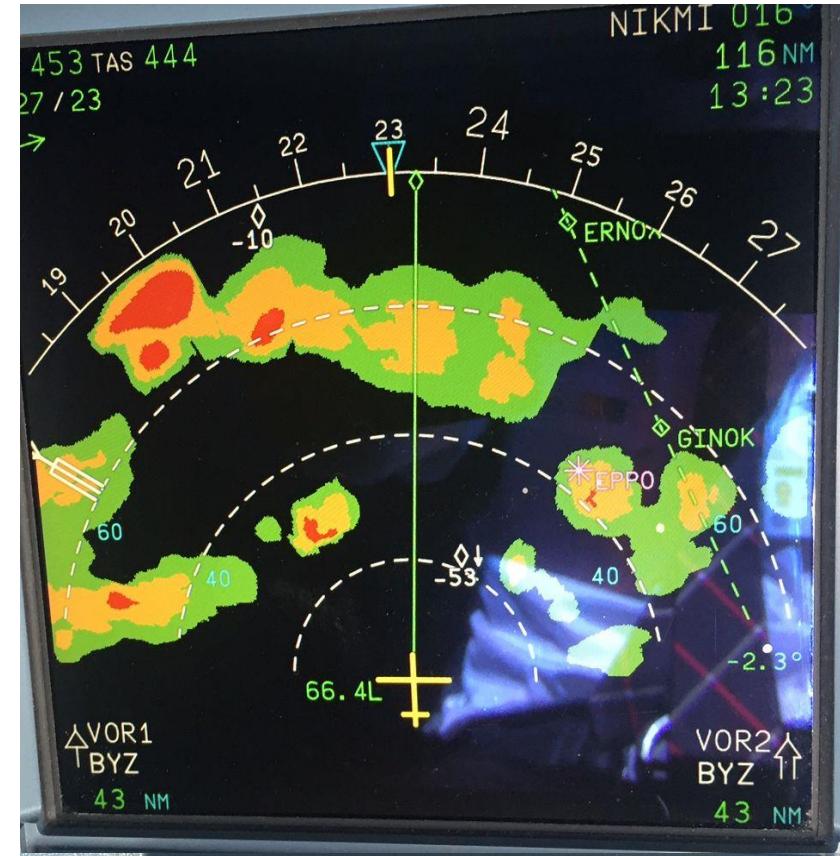
Pilots use spot information (a few selected airports) and a very simplified weather chart (SWC) which displays the forecast information. This information is static and has a low spatial resolution. This does not allow to mitigate severe weather preflight.

Weather mitigation inflight: what (most) pilots are doing today

Or what happens if you rely on the preflight weather package only...



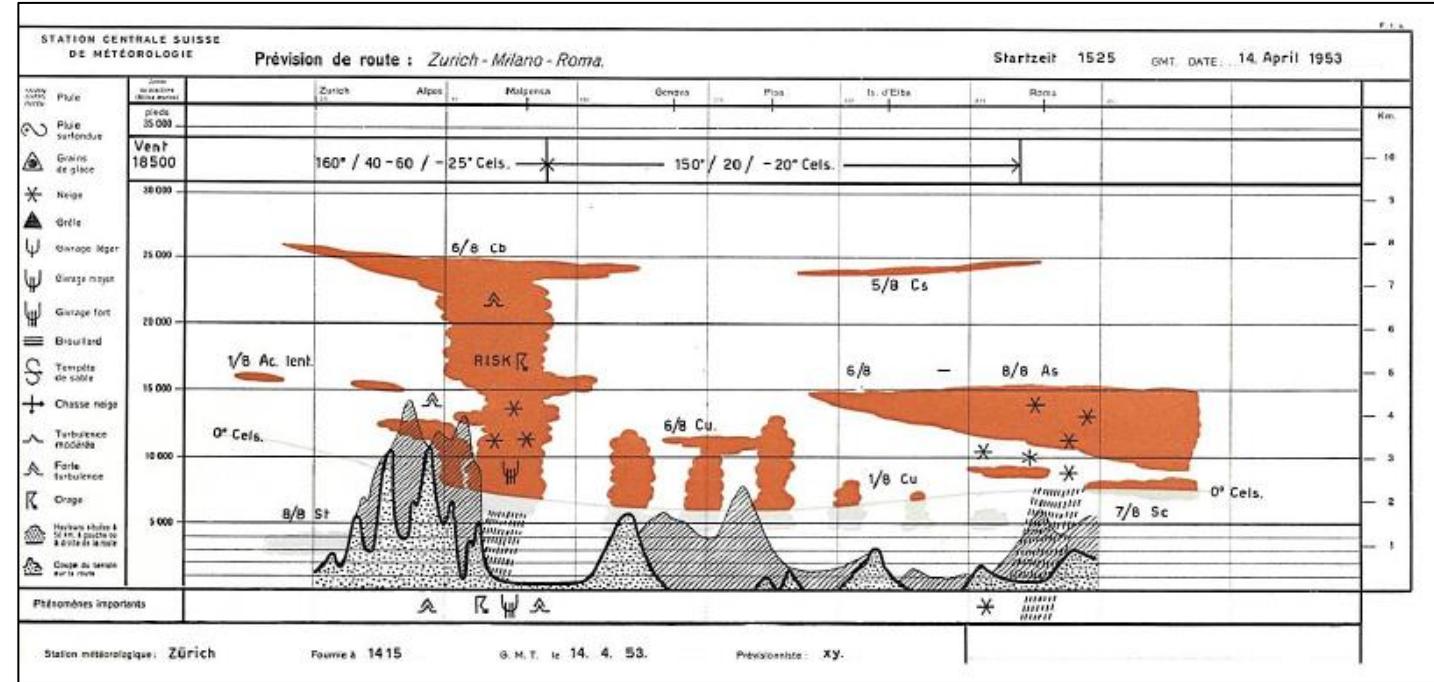
What you expect...



... and what you get.

Was everything better in the old days?

The weather package 70 years ago



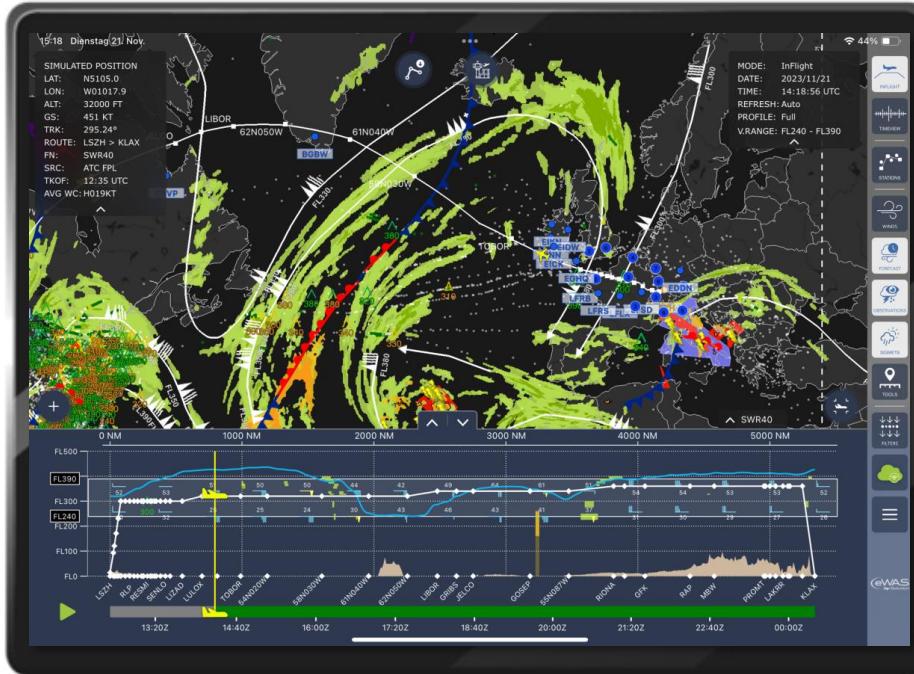
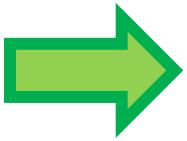
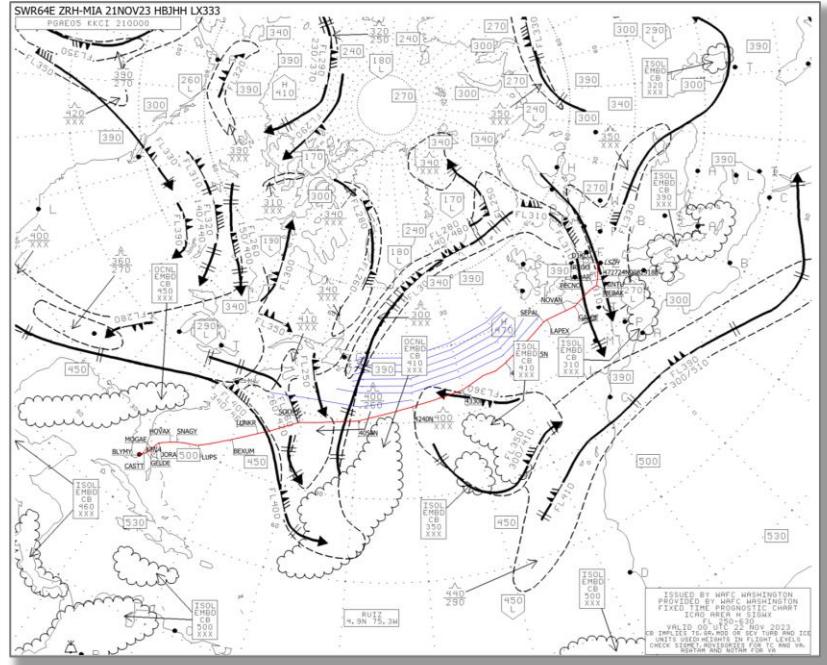
Quelle: Direktion der Öffentlichen Bauten des Kantons Zürich – Bericht 'Interkontinentaler Flughafen Zürich', 1953

Flight weather information in 1953

Aeronautical weather information based on observations and forecasts, including a hand-drawn vertical profile!
Example from Swissair's flight from Zurich – Milano - Roma, 14 April 1953.

The future starts now: Weather Application SITA eWAS

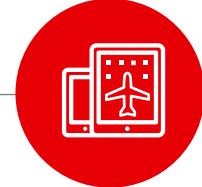
“That’s one small step from 1953, one giant leap from black and white weather charts”



4D real-time weather visualization, aggregated from multiple sources



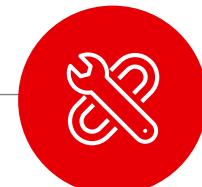
Flight plan overlay and vertical profile view



Flexible filtering of weather information and validity highlighting



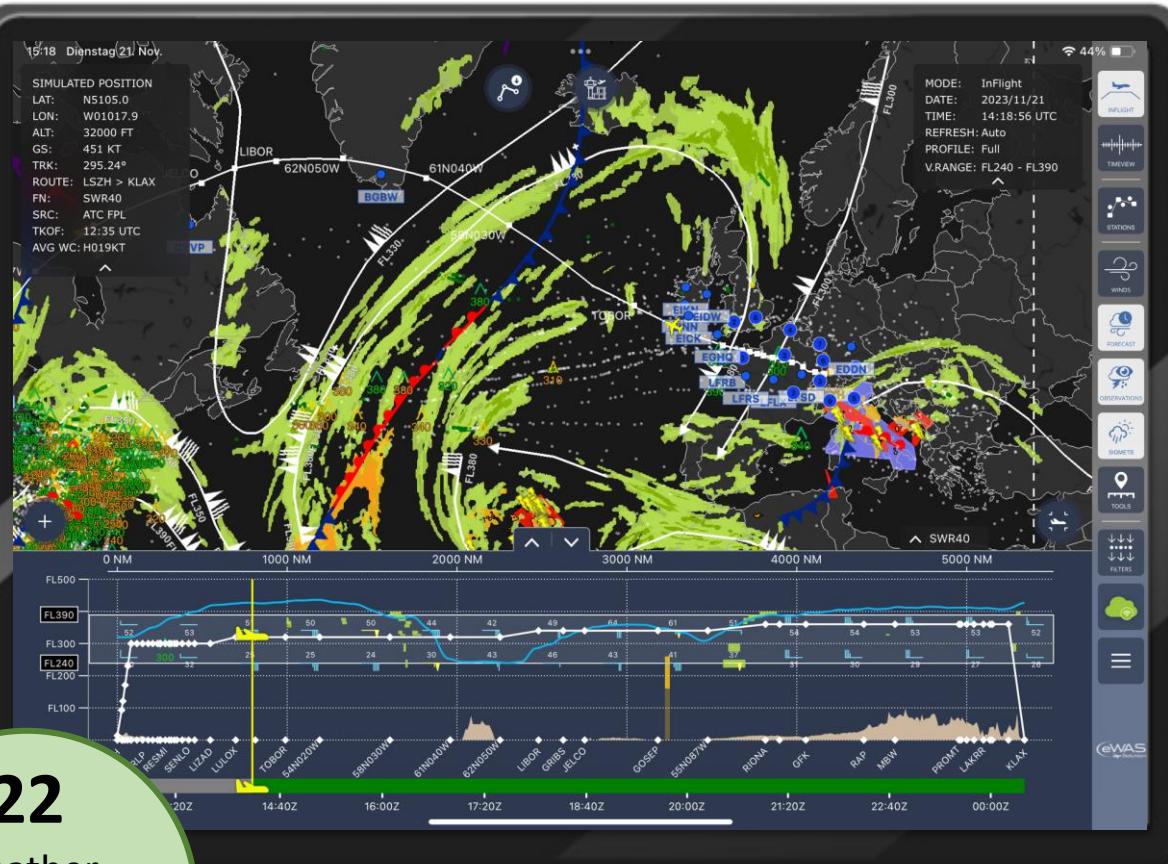
In-situ turbulence observation & hi-res forecast



Intuitive HMI app with time view & replay mode

SITA eWAS

Weather products selected by SWISS



22

weather
sources
selected by
SWISS

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1. Observations

- Convection 2h Nowcast (satellite observation)
- Convection 30min Nowcast incl. precipitation (ground radar based)
- Lightning Strike Cells (up to 40 min history)
- Cloud Top Height
- Ice Crystals
- Real-Time Turbulence Measurements (EDR from IATA, 4h history)
- PIREPs
- Volcanic Ash Advisory
- Tropical Storm Advisory
- SIGMETs
- PIREPs
- Textual airport weather (METAR, D-ATIS)

2. Nowcast

- Convection (30 min and 2 hours with DWD product)

3. Forecast

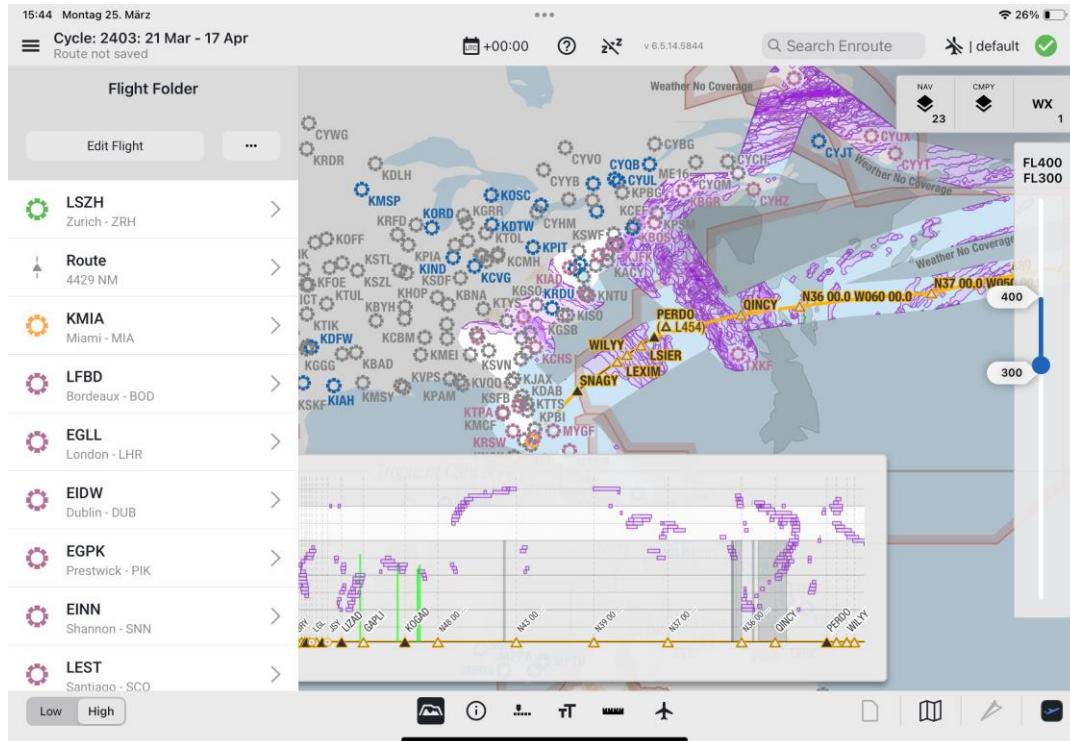
- Turbulence (numerical forecast for CAT, MTW and CIT)
- Convection
- Icing
- Surface Fronts
- Sandstorms/Dust storms
- Temperature and Tropopause
- Textual airport weather (TAF)
- Other hazards (Space WX)

Aviation weather is driving developments in EFB applications

Lufthansa Systems Lido eRoute Manual and Pacelab Flight Profile Optimizer

Lido eRoute Manual

- DWD Convection NowcastSat
- DWD Turbulence Forecast EDP
- DWD Icing Forecast
- IATA Turbulence Data (EDR)
- SIGMET (incl. VA und TC)
- METAR / TAF / D-ATIS



Pacelab FPO

- DWD Turbulence Forecast EDP (high-res)
- Vertical Profile and 2D Map
- DWD Convection NowcastSat
- Wind
- Temperature



EASA Recommendations

Weather Information to Pilots Strategy Paper 2018: 9 Recommendations

- 1) **Training:** Require specific **education and training on weather hazards and associated mitigation means, including optimum use of on-board weather radars and new services.**
- 2) **Wx Briefing Presentation:** Promote improvements to the presentation of weather information in flight briefing packages by **promoting use of intuitive, interactive displays**, appropriate use of standardised colour graphics and symbols, and **intelligent filtering of information**.
- 3) **Inflight Wx Updates:** Promote the **use of the latest information available** – what is available is as – if not more – valuable in the cockpit to ensure up to date situational awareness. **Encourage the development and introduction of in-flight weather information applications on EFBs.**
- 4) **Pan-EU Hi-Res Forecasts:** **Support the pan-European developments** regarding the provision of **high-resolution forecasts** for aviation hazards (eg, CAT, icing, surface winds, CB, winter weather).
- 5) **Use of supplementary WX information:** Develop the necessary provisions to support the **use of supplementary' 'Tier 2' meteorological information by pilots.**
- 6) **Develop and enhance A/C sensors:** **Promote the development of intrinsic aircraft capabilities** to facilitate the recognition and, if required, the avoidance of hazardous weather. (e.g. **on-board sensors for turbulence**, sand / dust / volcanic ash, ice crystals).
- 7) **Connectivity to support IF updates:** Promote deployment of **connectivity solutions** (uplink and downlink) to support the distribution of meteorological information to pilots.
- 8) **Provision of enhanced MET info:** **Promote provision of high-resolution observed and forecast meteorological information**, particularly data with high spatial and temporal resolution such as imagery derived from satellite and ground weather radar sources.
- 9) **Latest generation of onboard Wx-Radar:** Promote the installation of the **latest generation of on-board weather radars**, with emphasis on including capability for wind shear and turbulence detection.



How severe weather is mitigated by novel weather products in eWAS

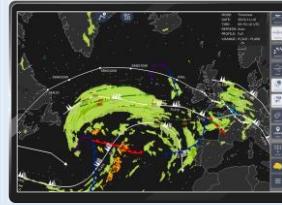
Be warned, you never want to go back to the old weather briefing package after that...

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



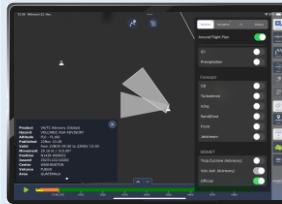
Turbulence Mitigation

Hi-Res Forecasts, real-time measurements & PIREPs



Volcanic Ash Mitigation

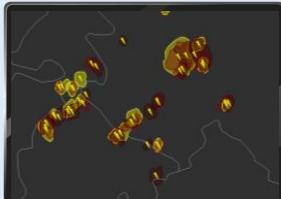
Avoiding AOG



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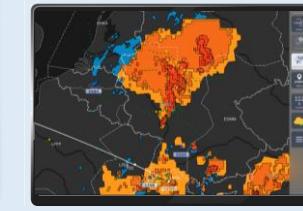
Lightning Strike Avoidance

Hi-Res Forecasts, real-time measurements & PIREPs



Thunderstorm Mitigation

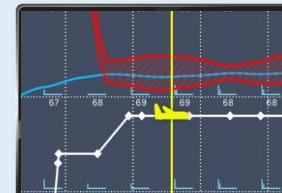
Short-term forecast (nowcast) based on radar and satellite observation (works without IF connectivity)



Deutscher Wetterdienst
Wetter und Klima aus einer Hand

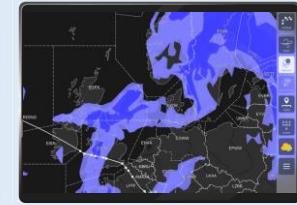
Cold Temp Mitigation

Avoiding AOG



Inflight Icing Avoidance

Anticipation of airframe icing with high-resolution forecast models



 SWISS

Latest developments in the field of turbulence mitigation

Turbulence measurement: an important source for real-time avoidance and model tuning

Yesterday: PIREP

“If you can still drink your coffee, it’s light turbulence.”



→ subjective, aircraft-dependent

Now: Automated turbulence reports



=EDR .34

Avionics Bus

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11000011110 00000001 00011110  
001 100 0101101000000  
0110111001 0001 00 100100 1  
00001000 00000111 00010010
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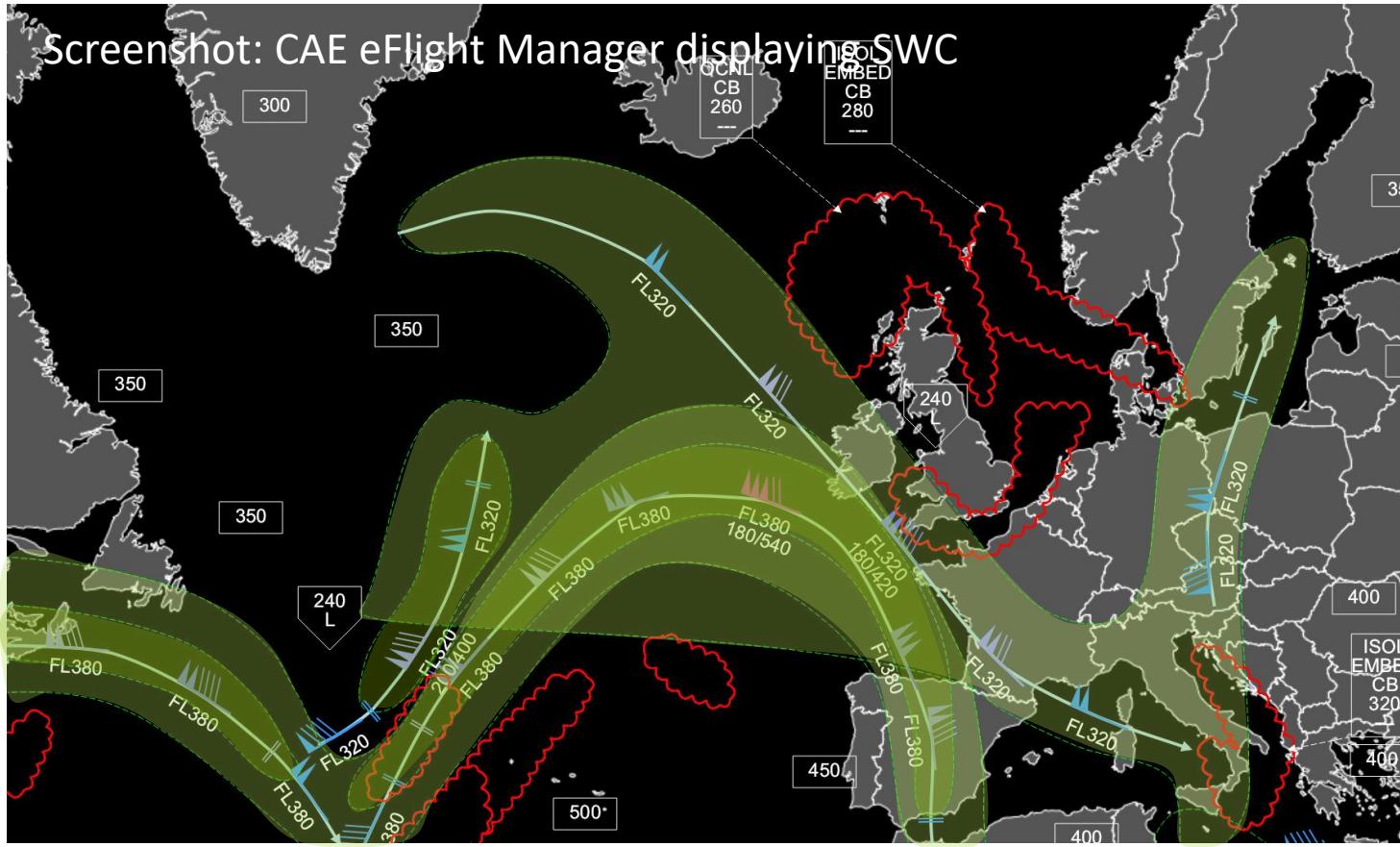
TAS: 447kn
AoA: 3.9°



→ objective, aircraft-independent

Latest developments in the field of turbulence mitigation

Turbulence measurement: an important source for real-time avoidance and model tuning



Example 10 November 2023: Significant Weather Chart (SWC) North Atlantic, in green CAT area moderate and severe

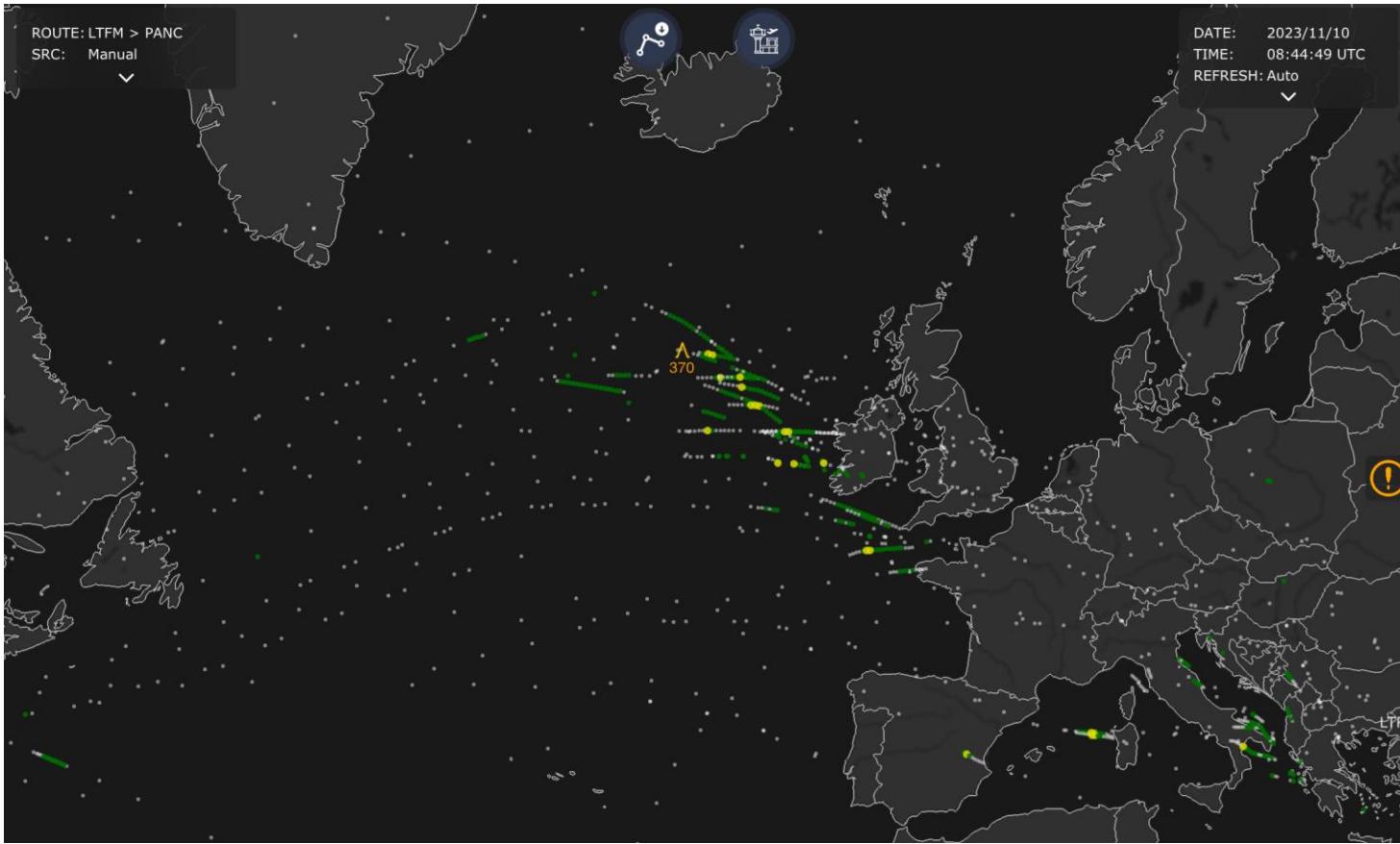
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SWISS

Latest developments in the field of turbulence mitigation

Turbulence measurement: an important source for real-time avoidance and model tuning



EDR measurements



- In-situ measured EDR data from previous 4 hrs
- Shared by IATA
- Displayed in weather application eWAS
- Color coding applied:
 - NIL: 0.00 – 0.05 (grey)
 - LIGHT: 0.06 – 0.20 (green)
 - MODERATE: 0.21 – 0.44 (yellow)

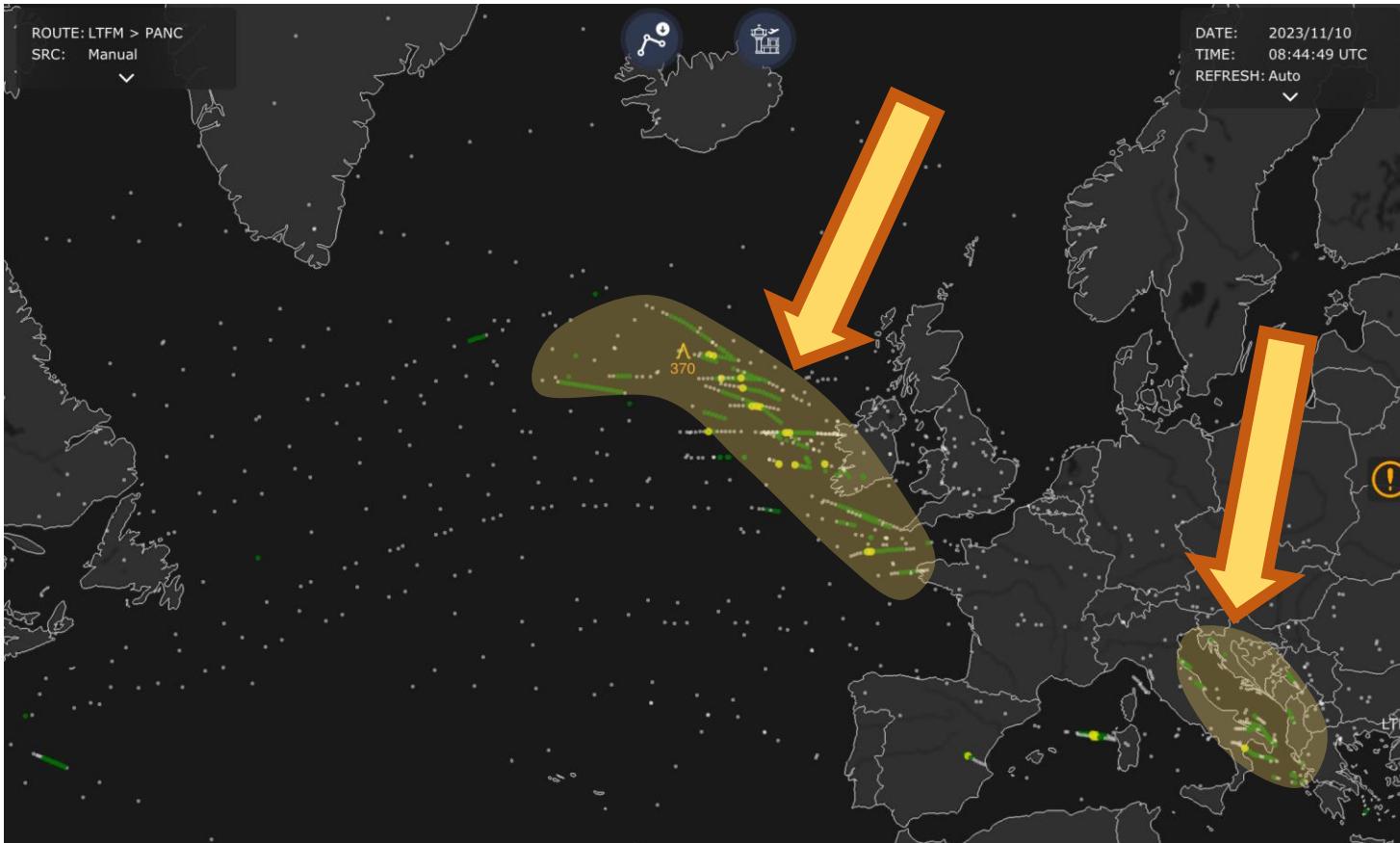


20 Feb 2019: First EDR to IATA reporting aircraft in Europe, SWISS B777 modified using the NCAR algorithm implemented by Boeing. Software update now offered free of charge by Boeing.

Example 10 November 2023: Real-time turbulence measurement EDR (Eddy Dissipation Rate) from last 4 hrs

Latest developments in the field of turbulence mitigation

Turbulence measurement: an important source for real-time avoidance and model tuning



Areas of EDR measurements



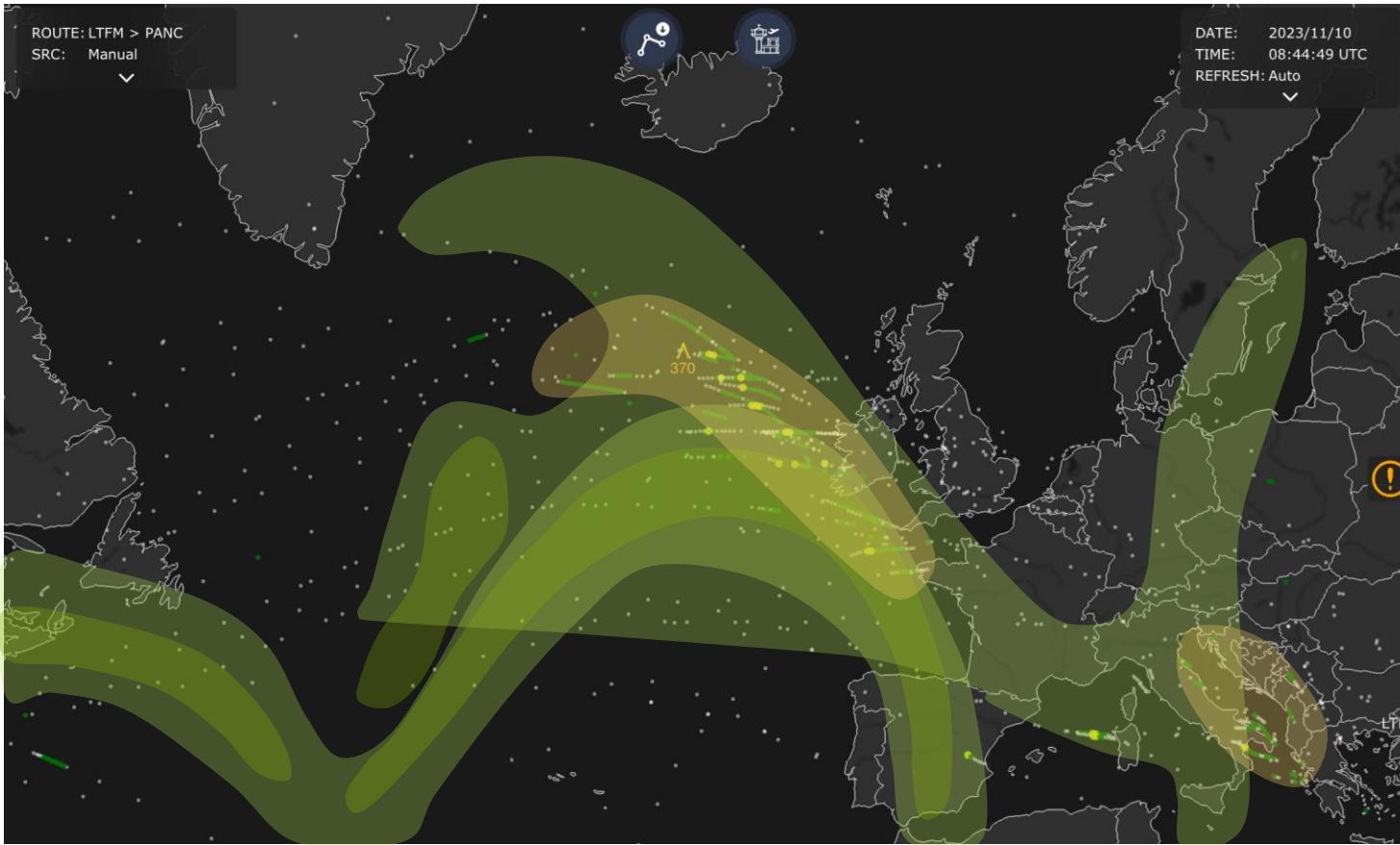
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Note: Lower threshold for display of LIGHT turbulence in eWAS changed from 0.15 to 0.06 as requested by SWISS to better identify turbulent areas.

Example 10 November 2023: Real-time turbulence measurement EDR (Eddy Dissipation Rate) from last 4 hrs

Latest developments in the field of turbulence mitigation

Turbulence measurement: an important source for real-time avoidance and model tuning



Example 10 November 2023: Real-time turbulence measurement EDR (Eddy Dissipation Rate) from last 4 hrs

Areas of EDR measurements

Does it match with the SWC CAT areas?

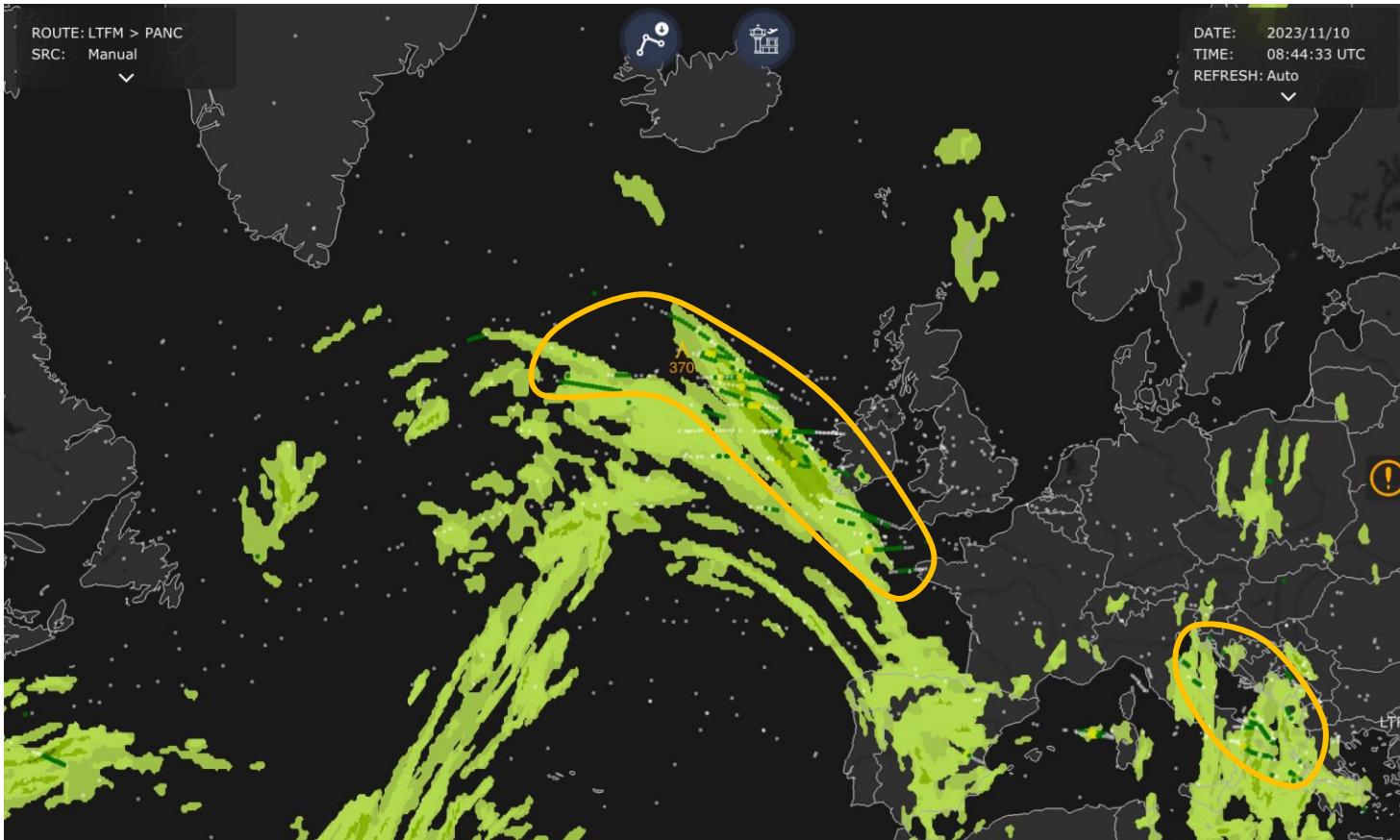


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Latest developments in the field of turbulence mitigation

Turbulence measurement: an important source for real-time avoidance and model tuning



Example 10 November 2023: EDR and numerical turbulence prediction from German Weather Service EDP model

Areas of EDR measurements

Compare with numerical high-res forecast

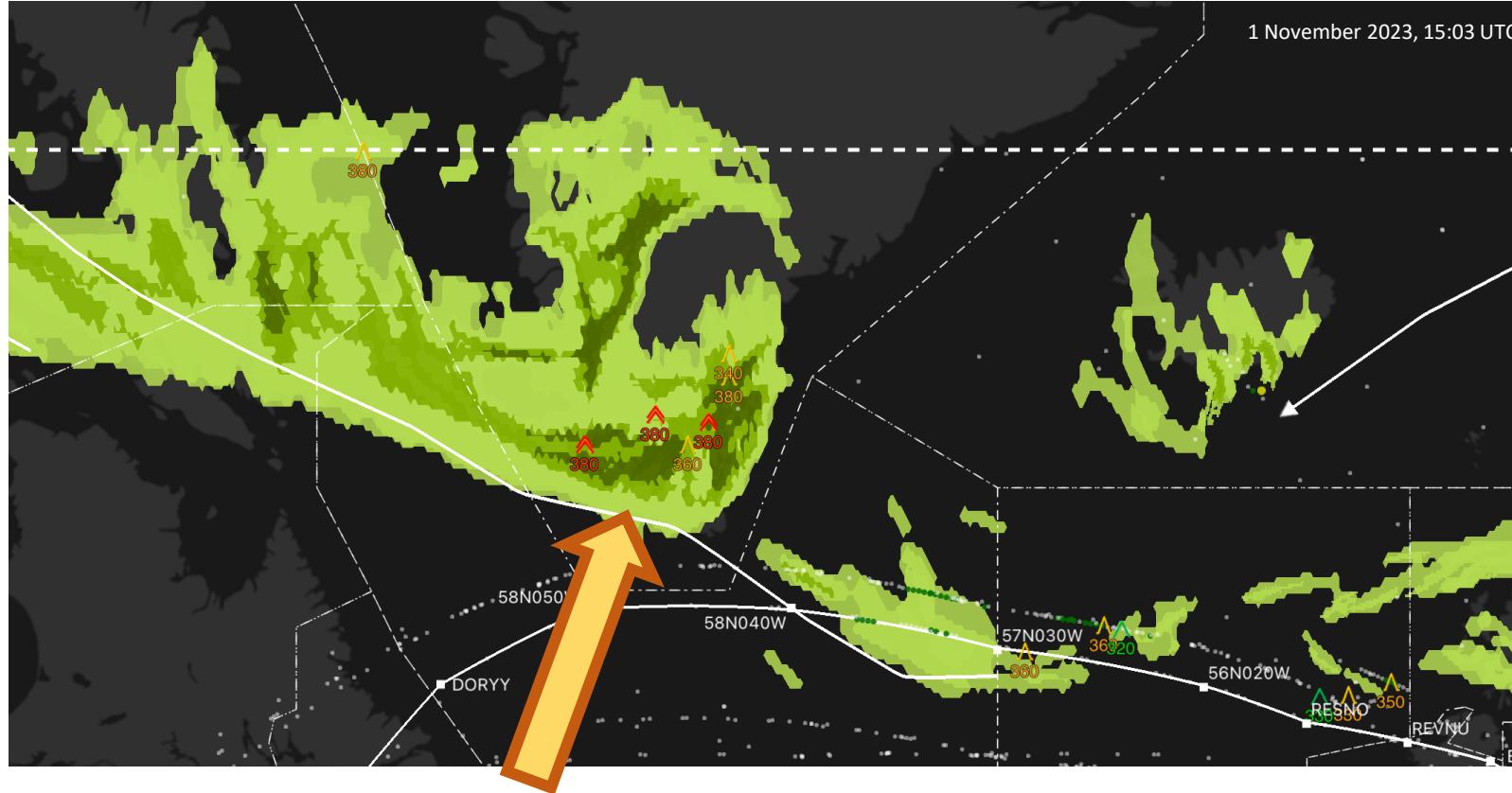


Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Numerical turbulence forecast model: **Eddy Dissipation Parameter (EDP)**
- Available in 1'000 ft vertical resolution
- Predicts clear air turbulence (CAT), mountain wave turbulence (MTW), and convection-induced turbulence (CIT)

Latest developments in the field of turbulence mitigation

Turbulence measurement: an important source for real-time avoidance and model tuning



PIREPs: still an important addition, especially on aircraft without EDR reporting! Observe matching with DWD EDP!

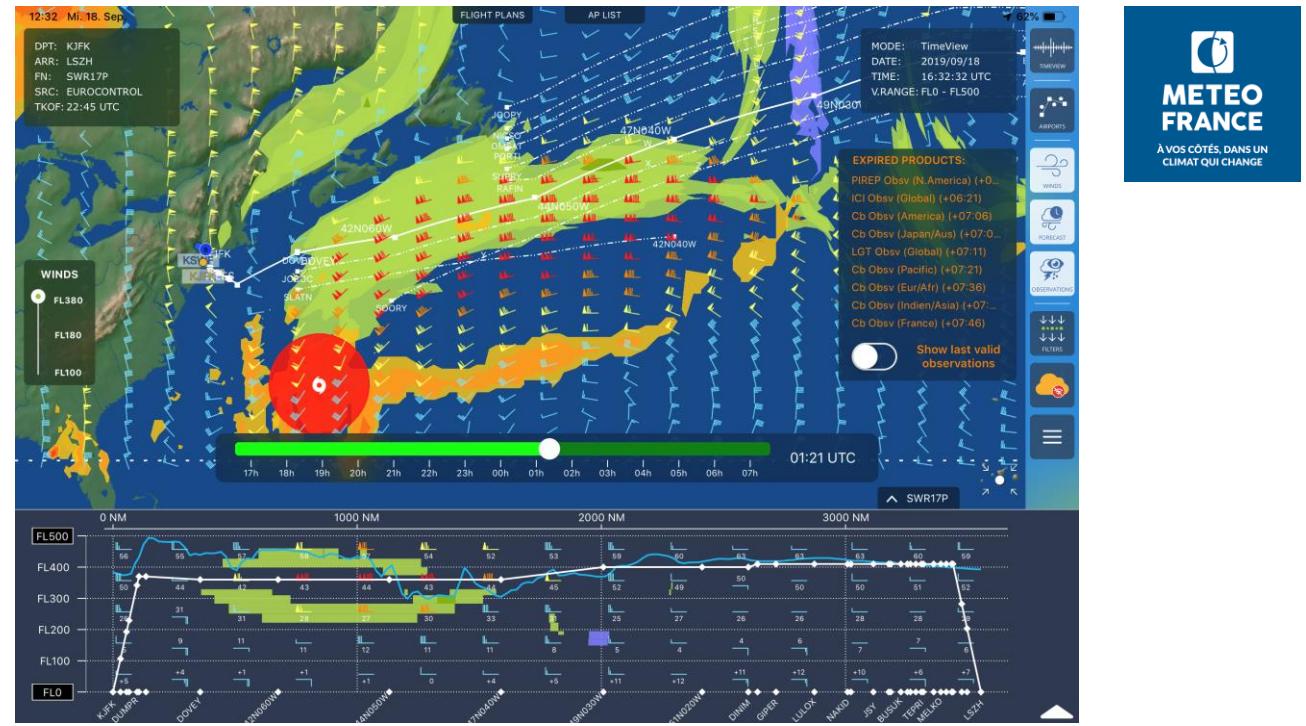
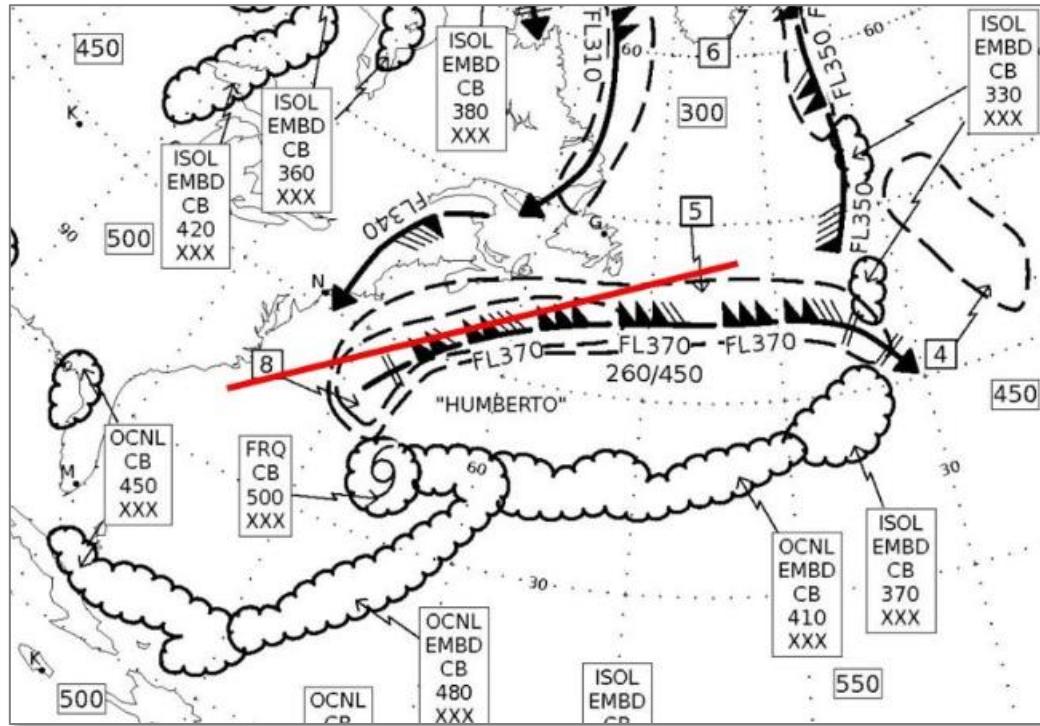
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 SWISS

Case Study #1: Preflight Turbulence Mitigation

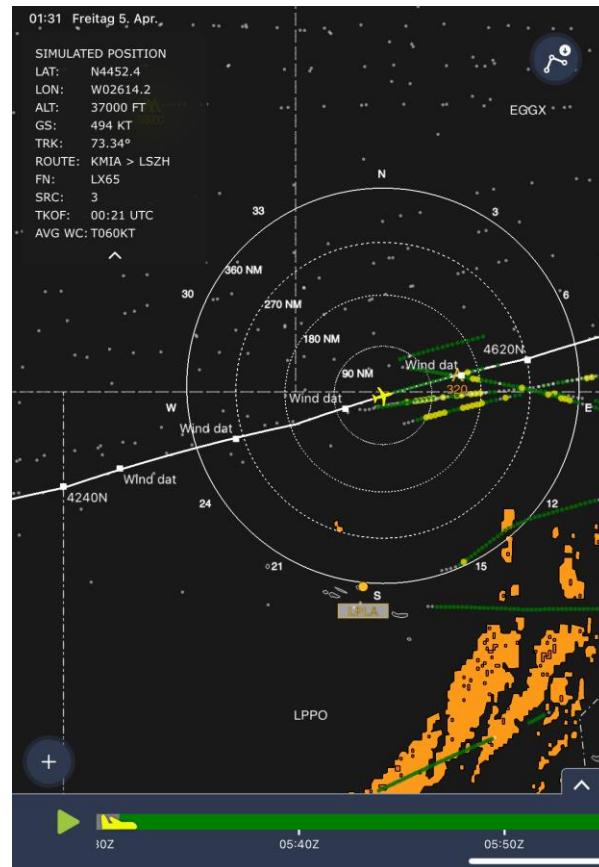
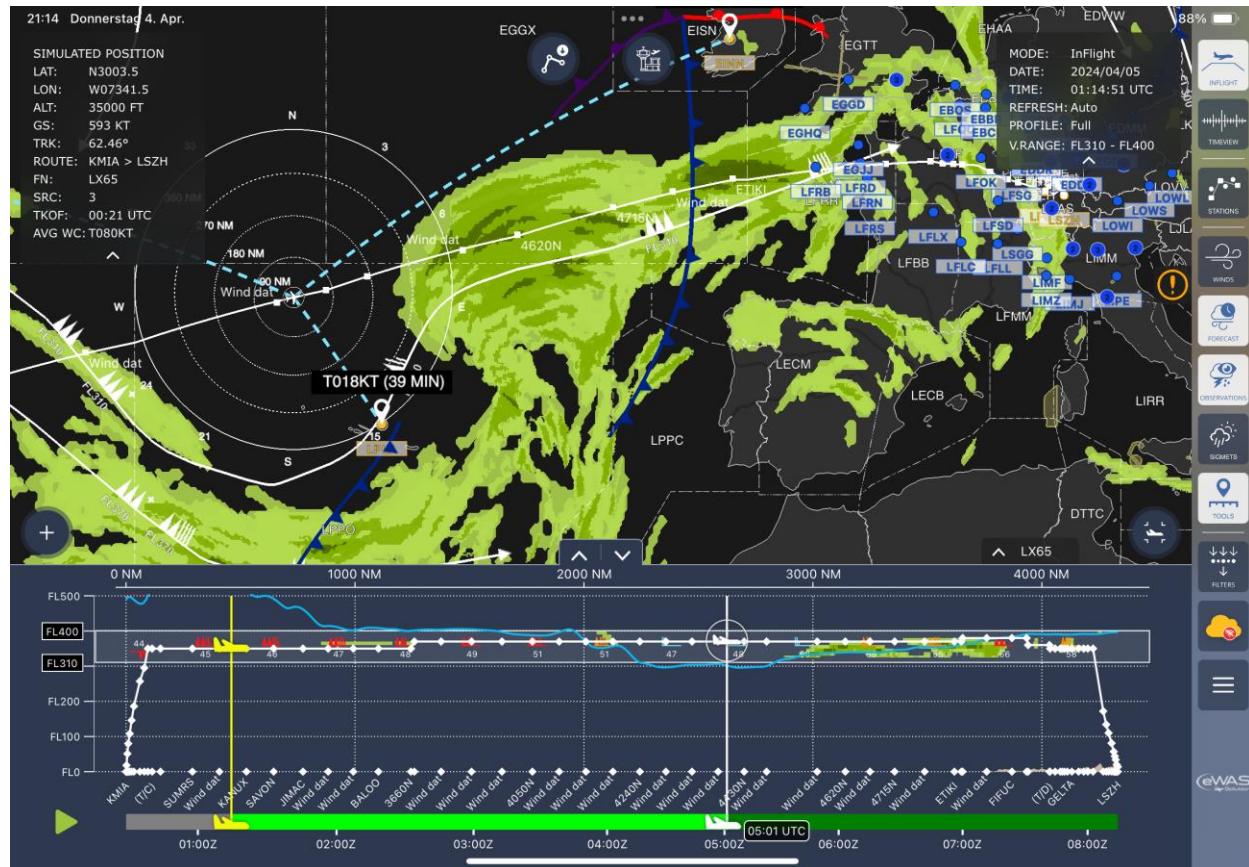
Flight LX65 Miami – Zurich, 18 Sep 2018: How the numerical forecast enabled a smooth flight



Vertical Profile: eWAS showed a smooth flight level (within the jetstream) despite the SEV turbulence predicted in the SWC!

Case Study #2: Inflight Turbulence Mitigation

Flight LX65 Miami – Zurich, 4 April 2024: Turbulence over Atlantic mitigated on time



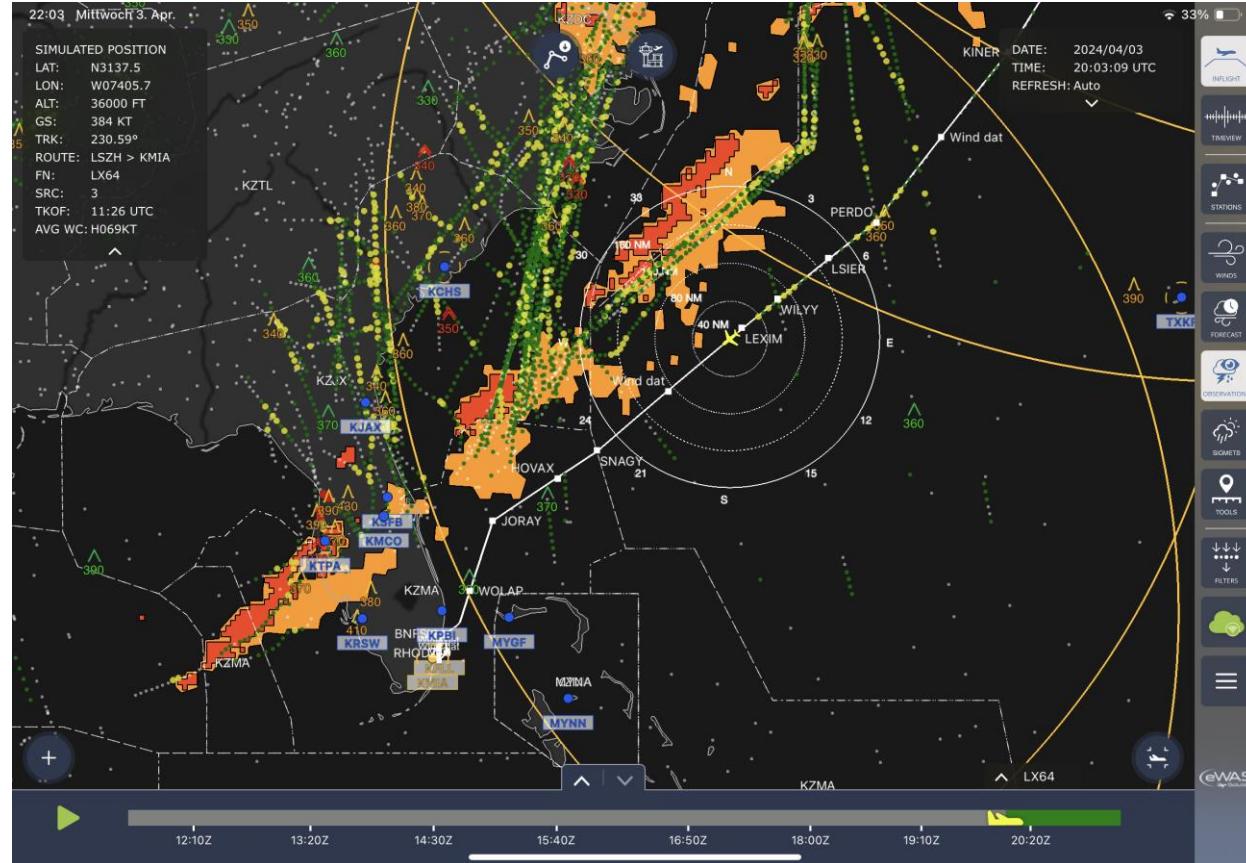
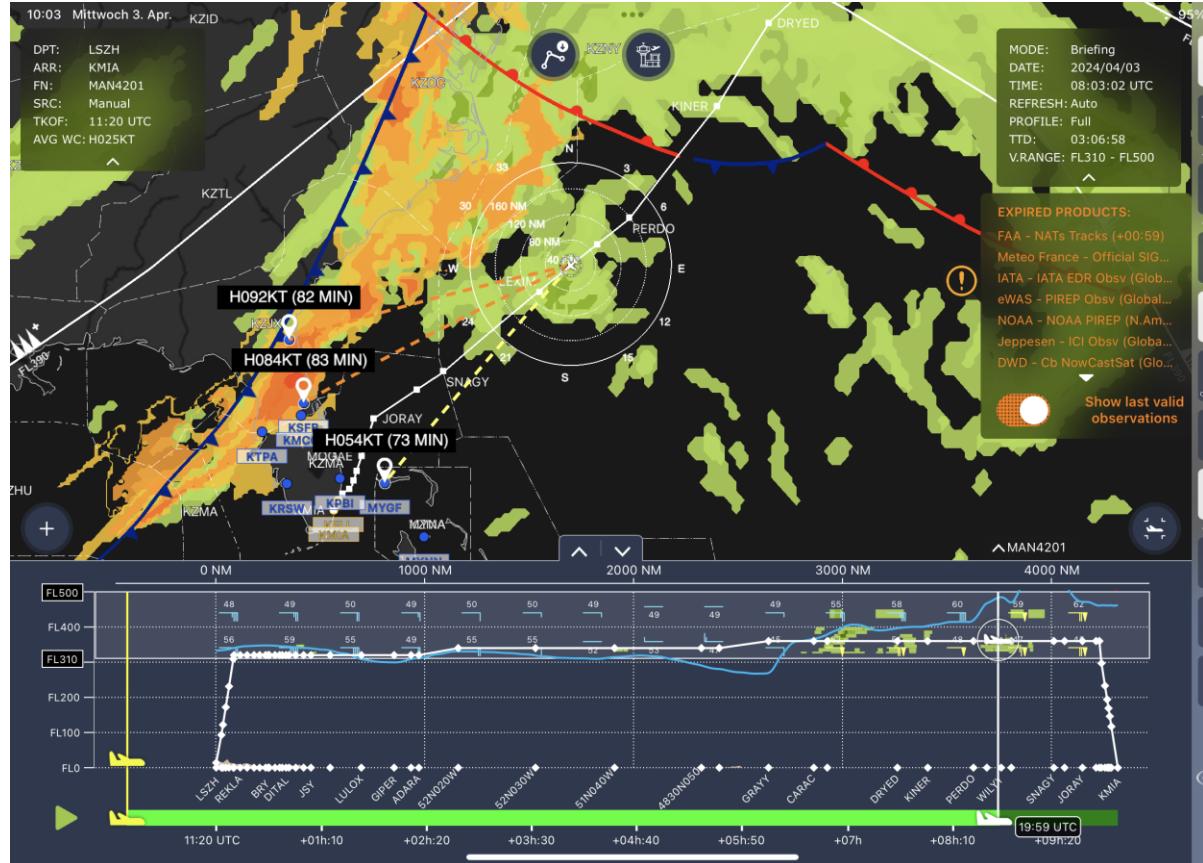
Severe CAT forecast and measurement ahead of current position:

SEAT BELTS ON

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Case Study #3: Preflight Thunderstorm Mitigation

Flight LX64 Zurich – Miami, 3 April 2024: Will the airport be closed in 12h?



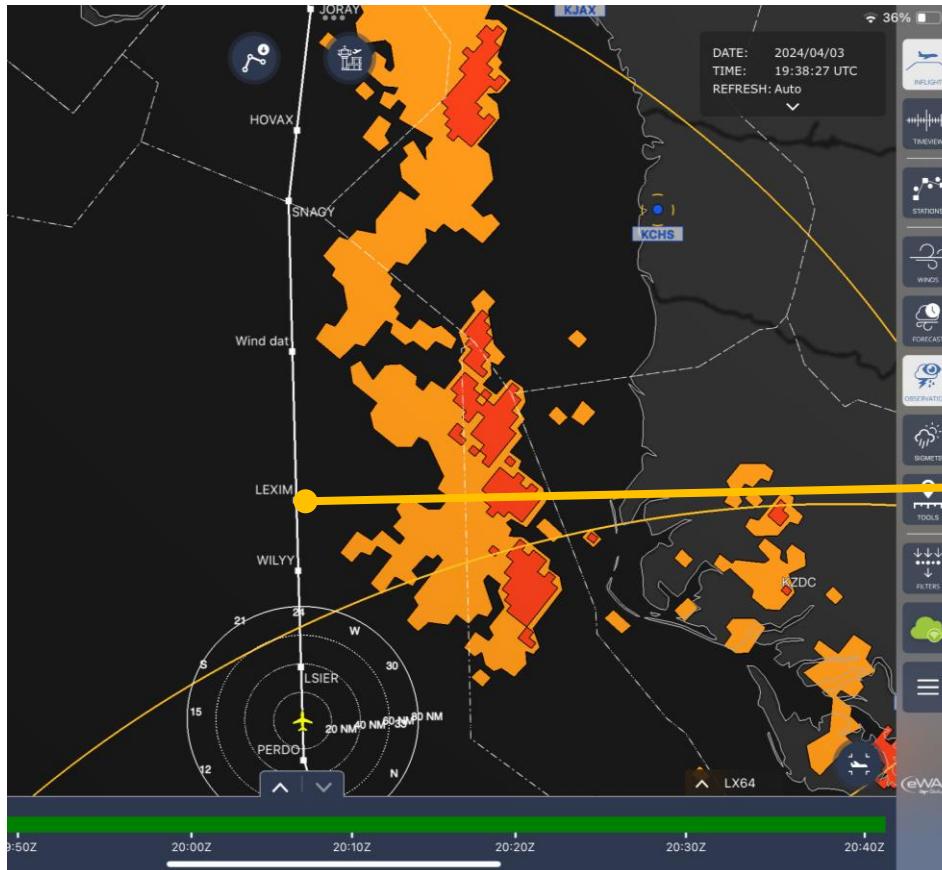
12h before planned landing time: The long-term convection forecast from DTN predicts an arrival ahead of the squall line.

1.5h before planned landing time (inflight):
Actual situation using DWD NowcastSat perfectly matches the DTN long-term forecast. Note: observe the MOD turbulence observed behind squall line.

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Case Study #3: Preflight Thunderstorm Mitigation

Flight LX64 Zurich – Miami, 3 April 2024: Will the airport be closed in 12h?



1.5h before planned landing time:
Actual situation using DWD NowcastSat



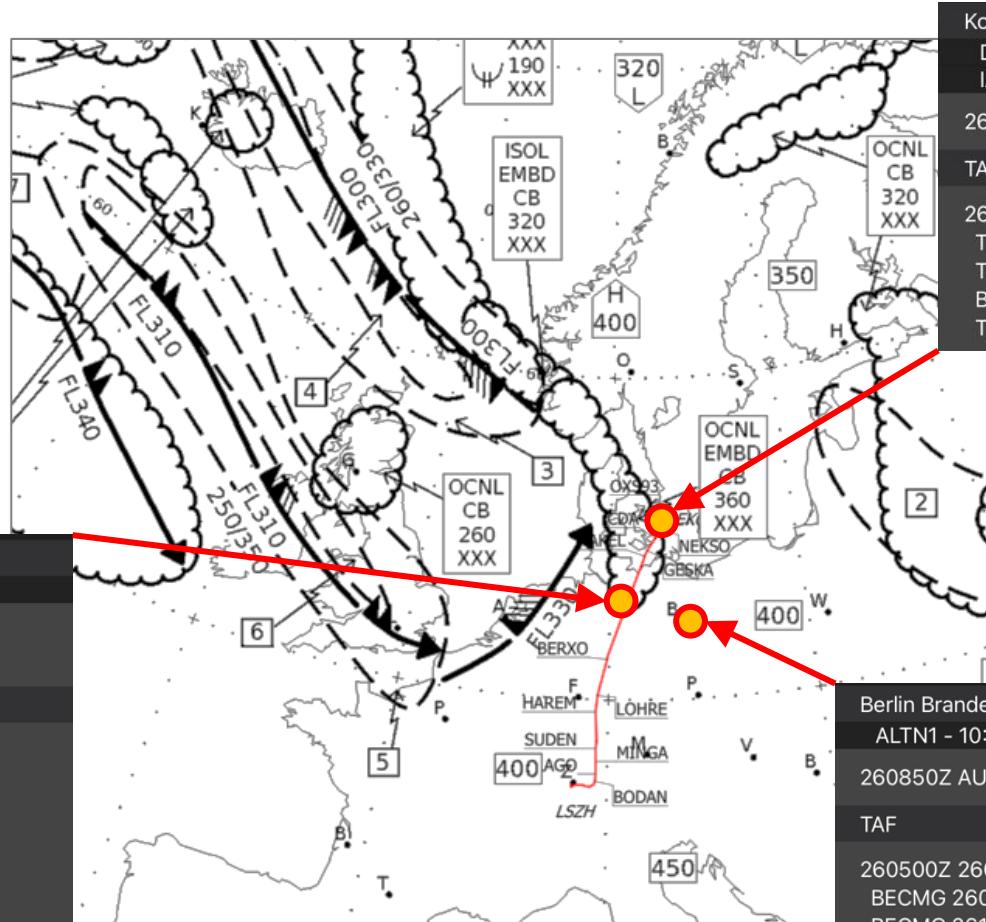
Actual situation on weather radar

Case Study #4: Pre- and Inflight Thunderstorm Mitigation

Flight LX1270 Zurich – Copenhagen, 26 June 2023: What we normally used to use for planning

Hamburg
IA - 11:36 - 11:54
260850Z AUTO 18009KT CAVOK 27/17 Q1010
BECMG 24012KT=

TAF
260500Z 2606/2712 16007KT CAVOK
BECMG 2607/2610 27010KT
BECMG 2610/2613 29015KT
TEMPO 2610/2613 29015G25KT SHRA BKN014CB
TEMPO 2613/2618 29015G30KT
BECMG 2618/2621 27008KT
PROB30 TEMPO 2620/2708 BKN012
BECMG 2708/2710 28013KT
TEMPO 2708/2712 SHRA SCT014CB BKN020
TEMPO 2710/2712 28015G30KT=



Kobenhavn/Kastrup
DEST - 10:56 - 12:56
IA - 11:52 - 11:56
260850Z AUTO 14013KT 9999 NCD 23/15 Q1012 NOSIG=

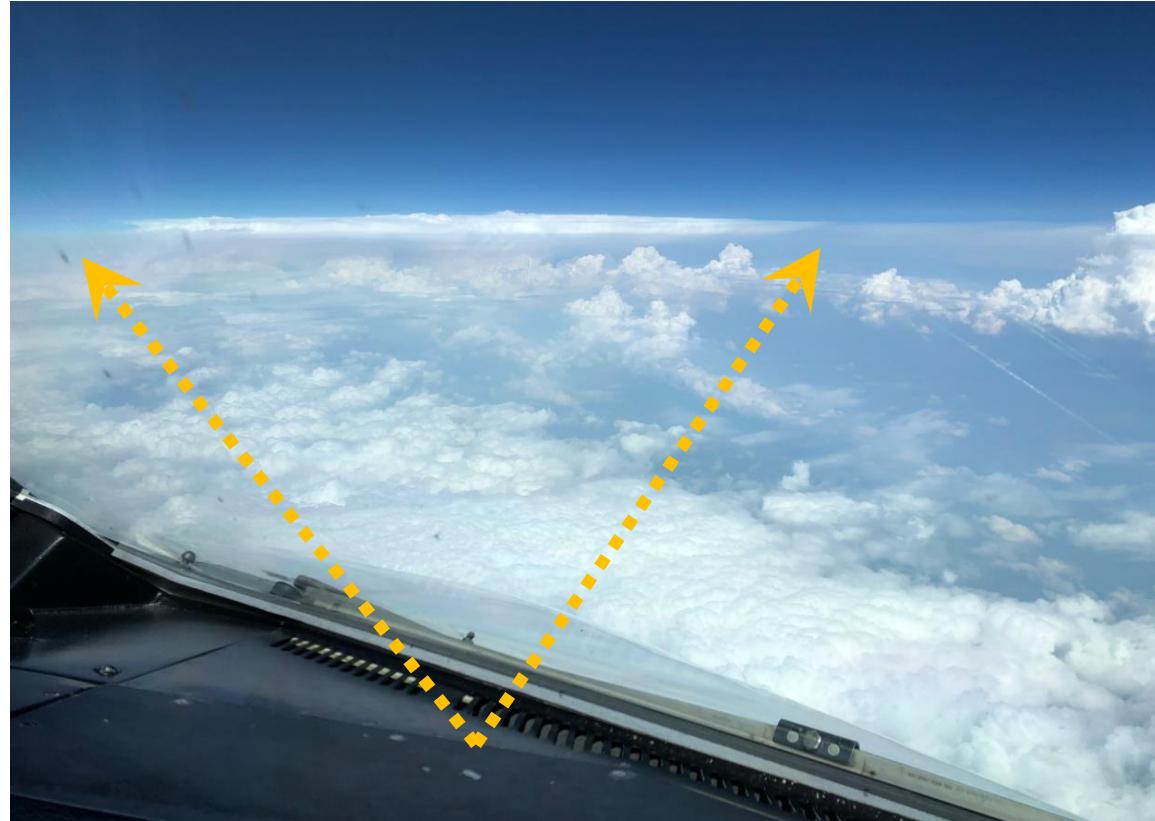
TAF
260505Z 2606/2706 19006KT CAVOK
TEMPO 2610/2613 14015G32KT
TEMPO 2613/2616 24015G25KT 2500 TSRAGR BKN010 BKN030CB
BECMG 2616/2618 25012KT
TEMPO 2616/2618 2500 TSRAGR BKN012 BKN030CB=

Berlin Brandenburg
ALTN1 - 10:56 - 13:43
260850Z AUTO 15007KT 110V190 CAVOK 28/15 Q1013 NOSIG=

TAF
260500Z 2606/2706 14004KT CAVOK
BECMG 2608/2610 19009KT
BECMG 2612/2614 29010KT
TEMPO 2613/2618 32015G30KT 4000 SHRA BKN030CB
PROB40 TEMPO 2614/2616 32025G45KT 1400 +TSGRRA=

Case Study #4: Pre- and Inflight Thunderstorm Mitigation

Flight LX1270 Zurich – Copenhagen, 26 June 2023: Inflight warning from ATC and a decision



Situation: do I go left or right...?



Decision: 30 NM offset to the right

Case Study #4: Pre- and Inflight Thunderstorm Mitigation

Flight LX1270 Zurich – Copenhagen, 26 June 2023: Approaching the destination

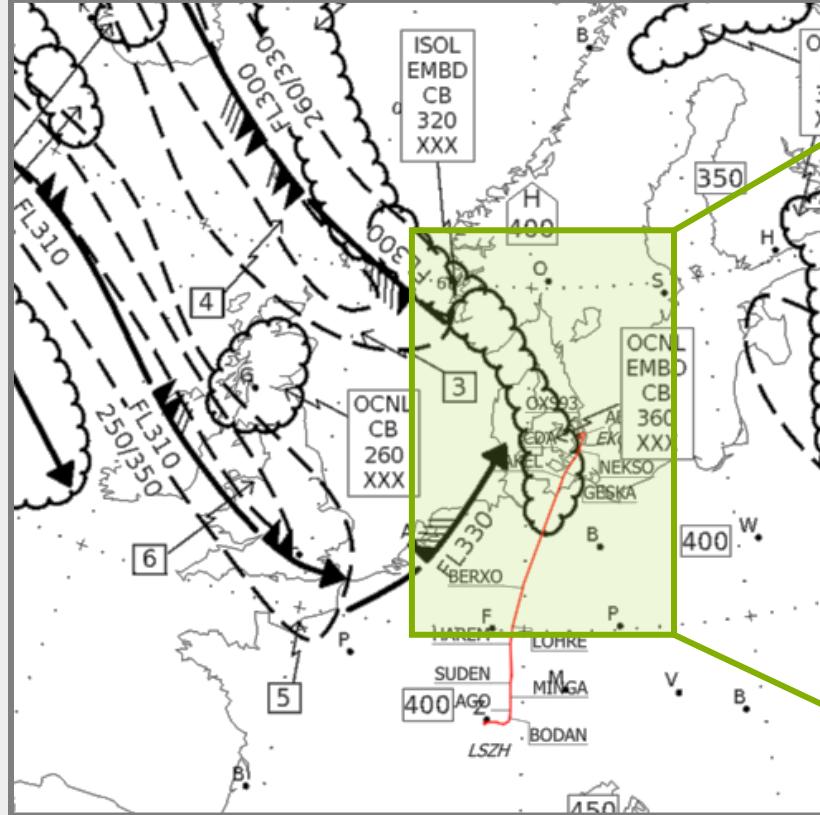


The squall line gets bigger and bigger...

Case Study #4: Pre- and Inflight Thunderstorm Mitigation

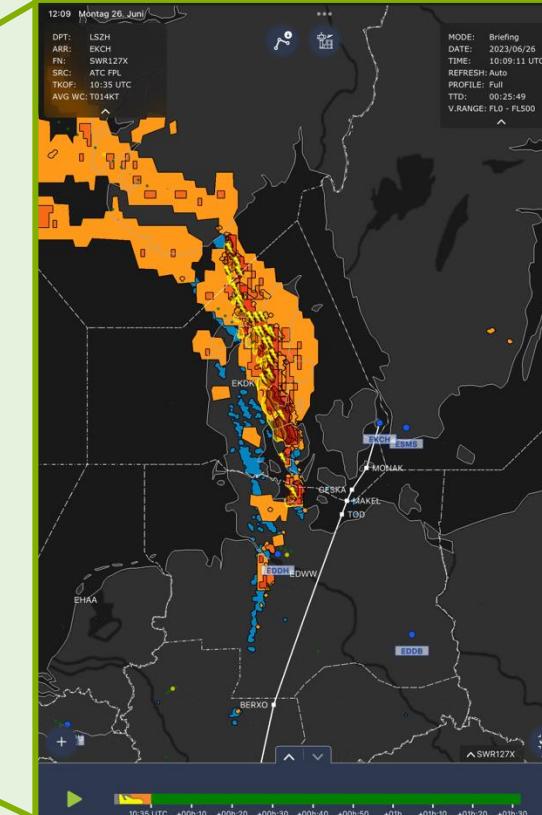
Flight LX1270 Zurich – Copenhagen, 26 June 2023: What we really used during flight planning

Without SITA eWAS

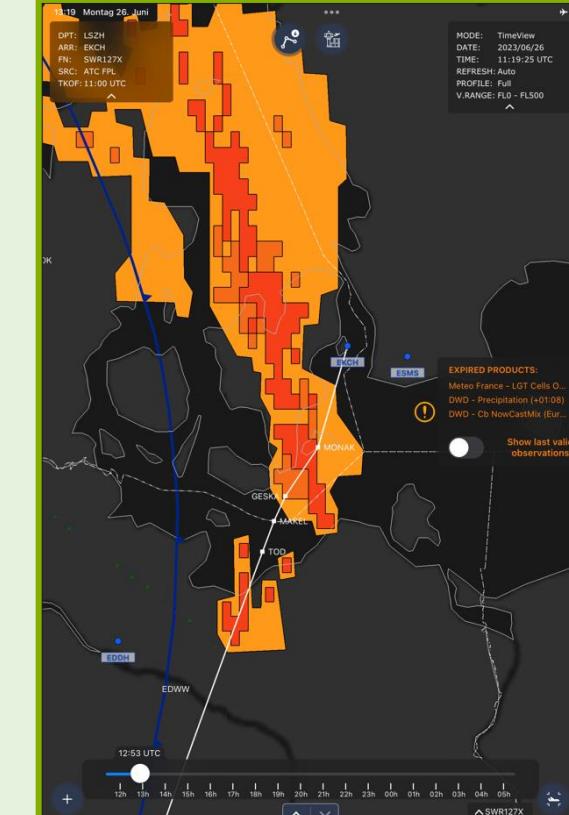


Weather information in standard briefing package

With SITA eWAS and DWD Convection Nowcast



Preflight situation @ EOBT LSZH

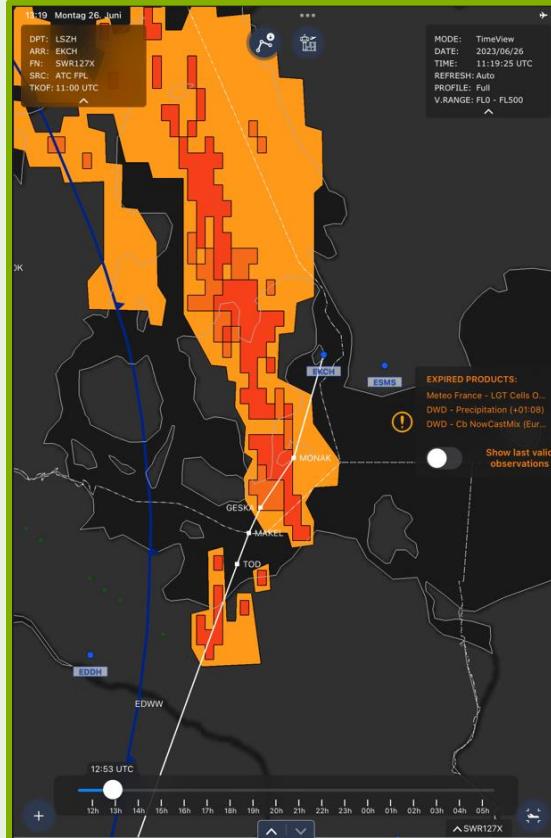


Preflight forecast for ETA @ EKCH

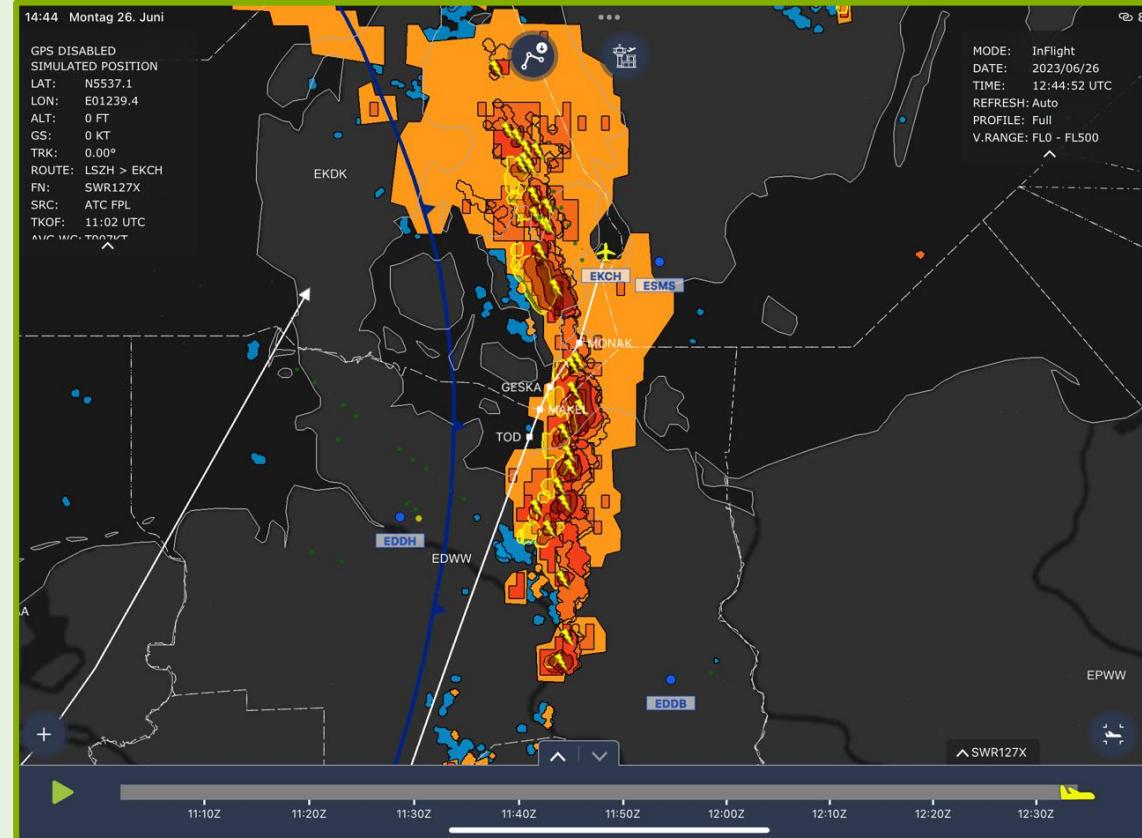
Case Study #4: Pre- and Inflight Thunderstorm Mitigation

Flight LX1270 Zurich – Copenhagen, 26 June 2023: The benefit of convection 2h nowcasting

Preflight forecast for ETA EKCH



Actual situation at time of arrival EKCH



High level of accuracy also without inflight connectivity on short-haul using short-term forecasts!

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Case Study #4: Pre- and Inflight Thunderstorm Mitigation

Flight LX1270 Zurich – Copenhagen, 26 June 2023: At the gate just in time ☺

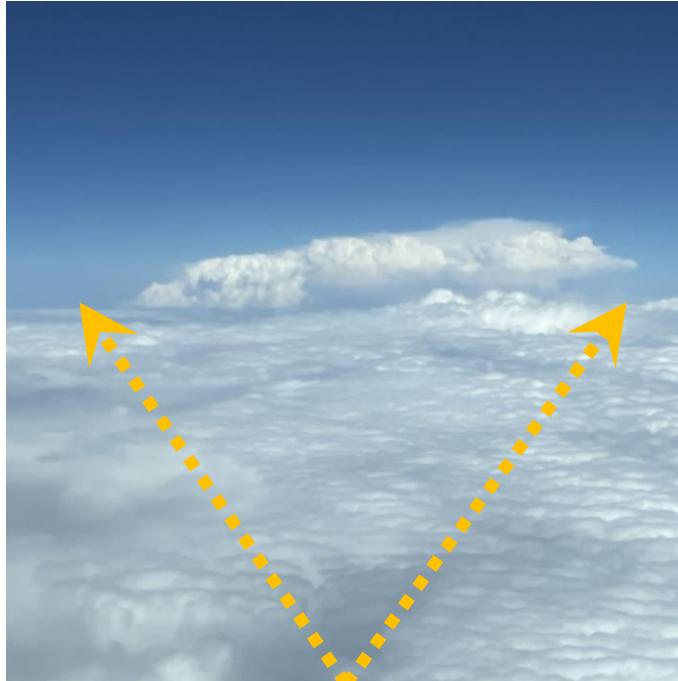


Case Study #5: Inflight Thunderstorm Mitigation

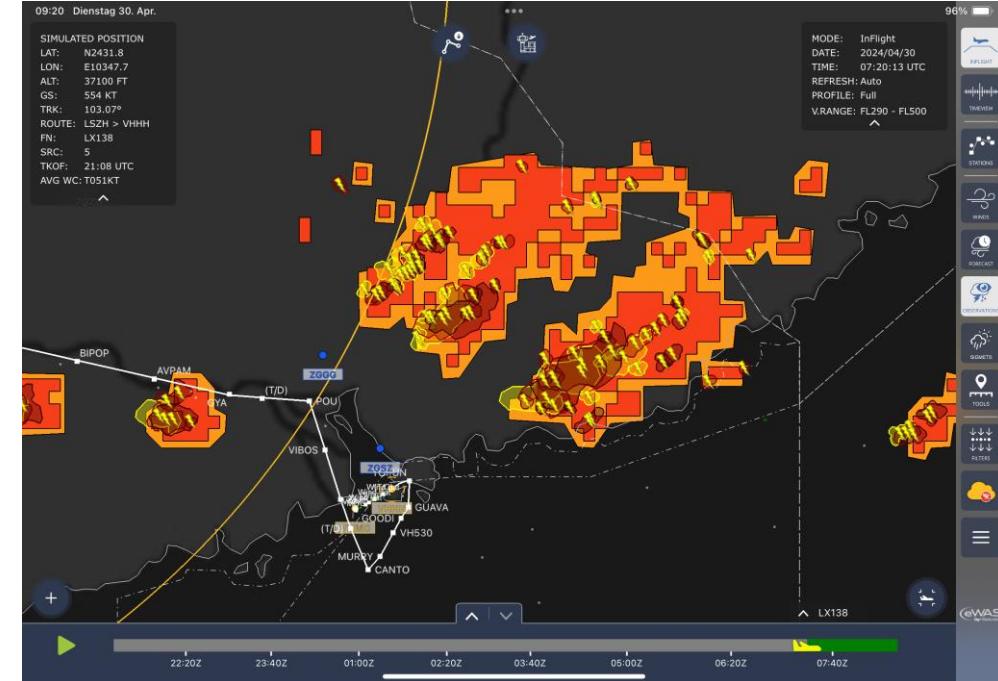
Flight LX138 Zurich – Hong Kong, 30 April 2024: Weather avoidance plan



Looking at the weather radar, echoes 160 NM away, what can we expect as we get closer to our destination?



Tactical decision making: Looking out the window, left or right?



Solution: Check the current situation from satellite observations in DWD NowcastSat from current position to destination to develop a strategic WX avoidance strategy.

Case Study #5: Inflight Thunderstorm Mitigation

Flight LX138 Zurich – Hong Kong, 30 April 2024: Weather Avoidance Plan

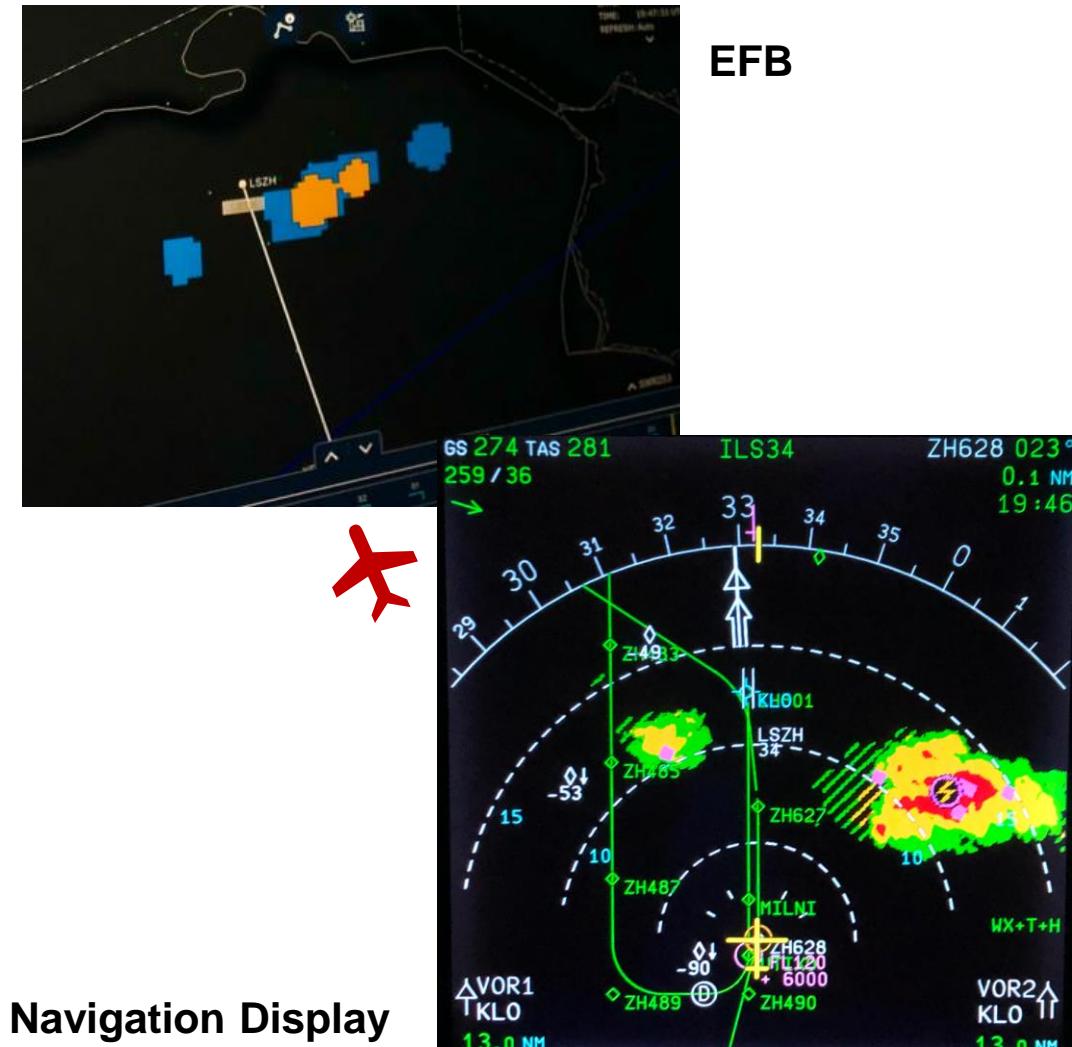


Case Study #6: Low-Level Heavy Precipitation

Flight inbound to Zurich Airport

DWD Aviation NowCastMix

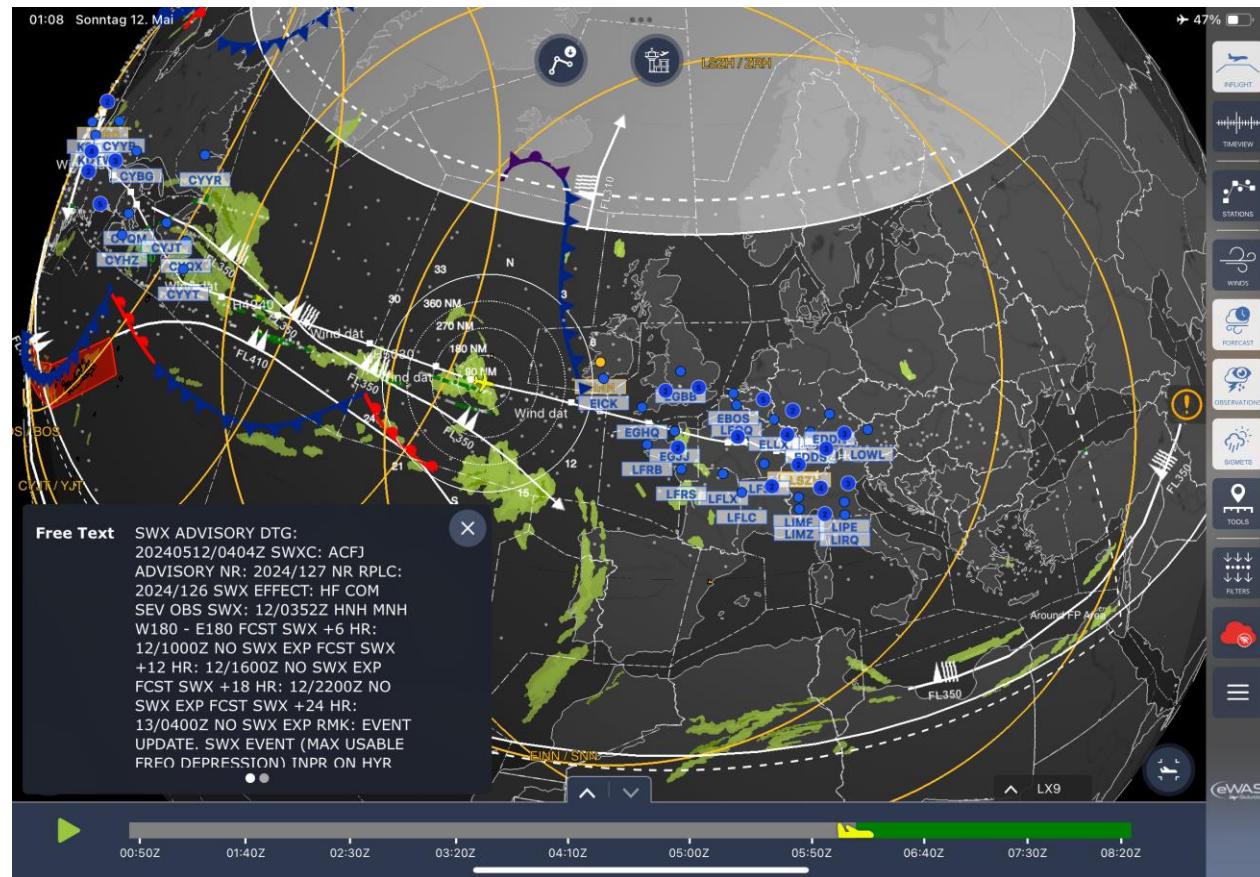
- Complementary product to satellite-based observation: Ground-based radar observation of convective activities and precipitation
- Can show convective low-level weather that is not detected by satellites
- Translates an ATIS 'VCSH' into an actual picture before it is visible on the weather radar
- Hazard levels on ground as a function of predicted CB-induced gusts and precipitation
 - **Light**: gusts < 40 kt
 - **Moderate**: gusts < 55 kt, predicted precipitation < 25 mm/h
 - **Severe**: gusts > 56 kt, predicted precipitation \geq 25 mm/h or hail
 - **Blue**: Measured precipitation > 37 dBz
- **30 min forecast**
→ requires inflight connectivity!



Navigation Display

Case Study #7: Space Weather

Flight LX9 Chicago - Zurich, 12 May 2024



SWX Advisory: HF COM SEV OBS SWX



**Beautiful northern lights observed 😊
(while no communication was possible on HF...)**

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Key criteria considered in selecting a Pilot Weather App

Experience from SWISS

- Driven by passion and innovation
- The user's voice counts
- Agnostic towards weather products from various providers
- High agility to quickly integrate new or upgraded weather products
- Application available for Flight Dispatch / OCC enabling a shared mental model between ground and air
- Very intuitive user interface with easy way to filter the data

«Moving from black and white weather charts to a 4D aviation weather application is like moving from an analogue cockpit to a glass cockpit. It is a game changer»

Quote from a SWISS pilot using eWAS



Thank you!



Contact: martin.gerber@swiss.com

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 **SWISS**