Study of cirrus cloud properties and occurrence over Europe during the COVID-19 based on the lidar measurements of CALIPSO

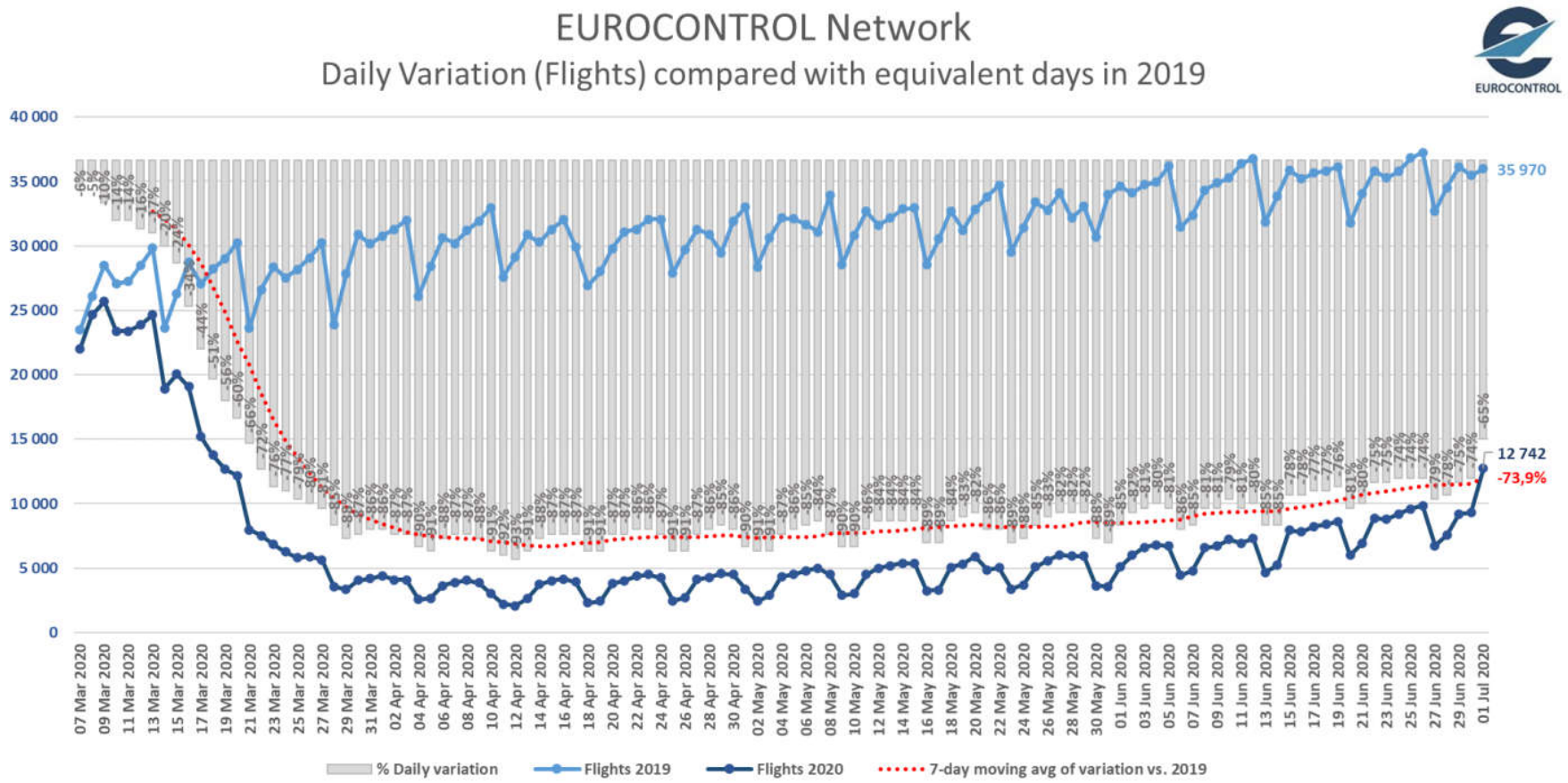
Qiang Li and Silke Groß

Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institute of Atmospheric Physics, Oberpfaffenhofen, Germany

Contact: Qiang.Li@dlr.de

vEGU21: Gather online April 27, 2021
Session GI4.2: Lidar remote sensing of the atmosphere

Reduction of aviation over Europe in 2020



⇒ During the COVID first lockdown in Europe, the civil aviation (flights) was significantly reduced: up to more than 90% reduction in April 2020 compared with the equavilent days in 2019.

⇒ The lockdown period provides an unique condition to study the effect of air traffic on cirrus cloud occurrence and their properties.

Lidar measurements with the CALIPSO satellite over Europe

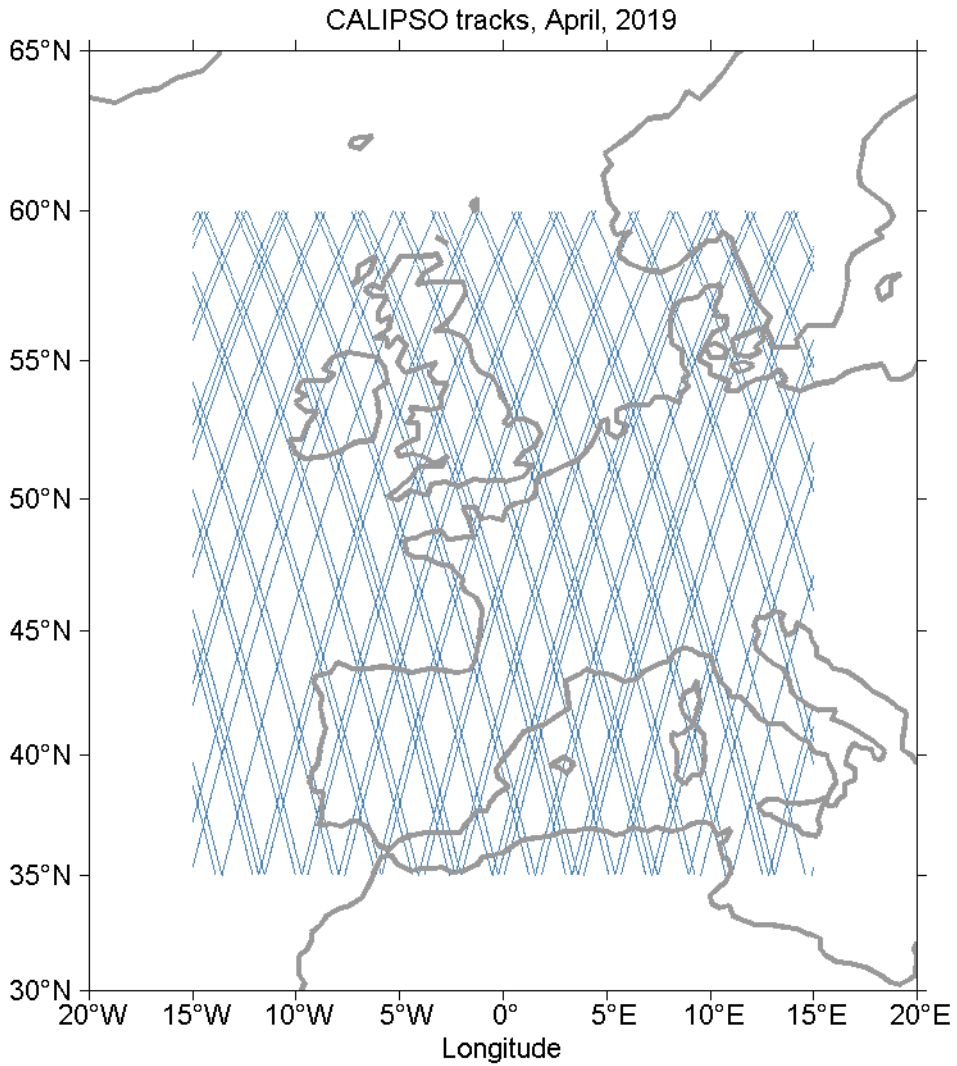
⇒ The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) launched on April 28, 2006 as part of NASA A-Train.

⇒ Data used in this study: the Level 2 5-km Cloud profile products including particle linear depolarization ratio.

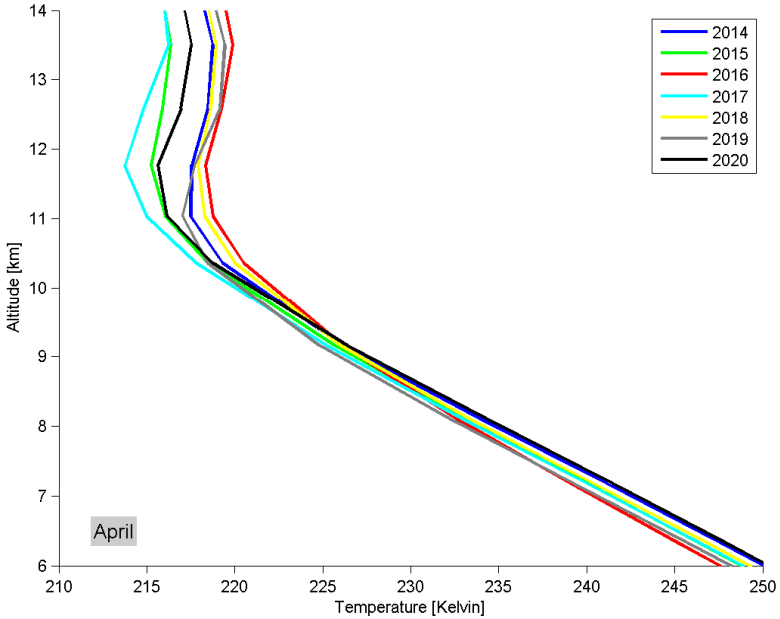
⇒ Data stored as half orbits from north to south and separeted by day and night. Both are used in this study.

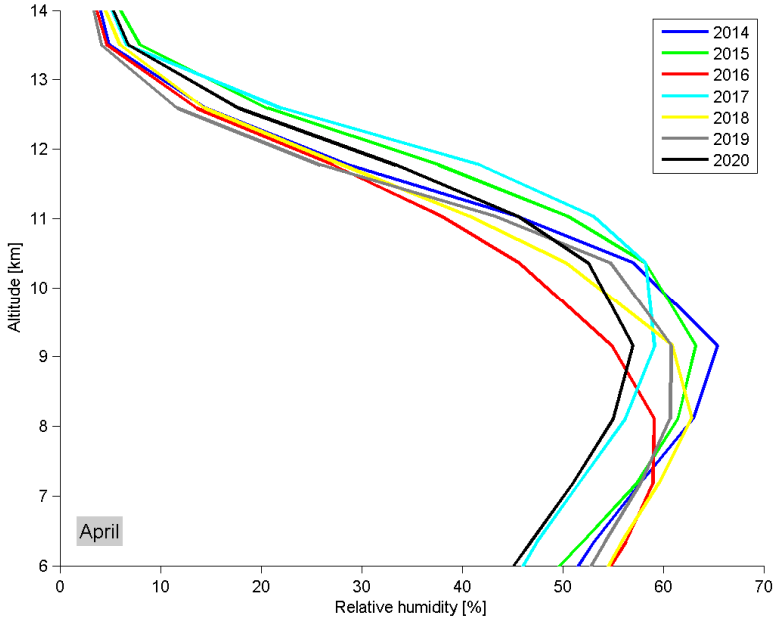
⇒ Europe: 35°N-60°N; 15°W-15°E.

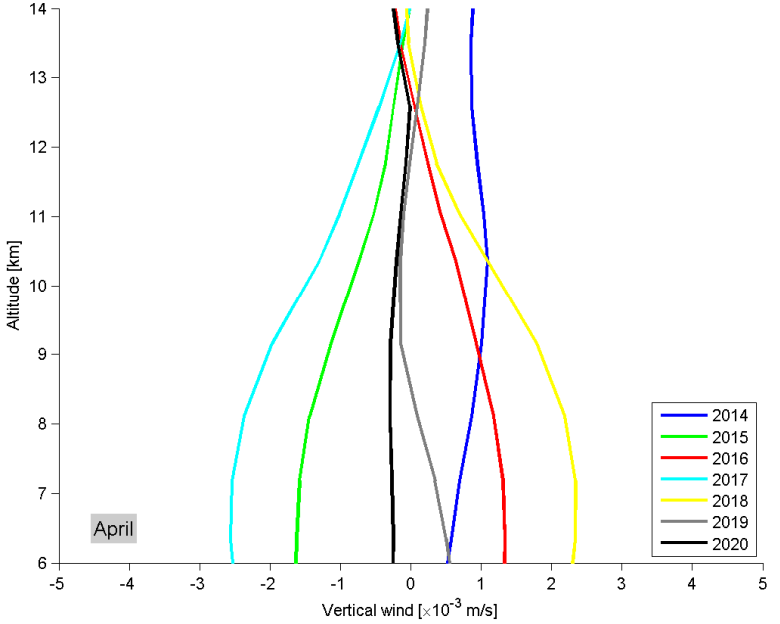
Altitude range (km)	Horiztontl resolution (km)	Vertical resolution (m)
30.1–40.0	5.025	300
20.2–30.1	1.675	180
8.2–20.2	1.005	60
-0.5–8.2	0.335	30

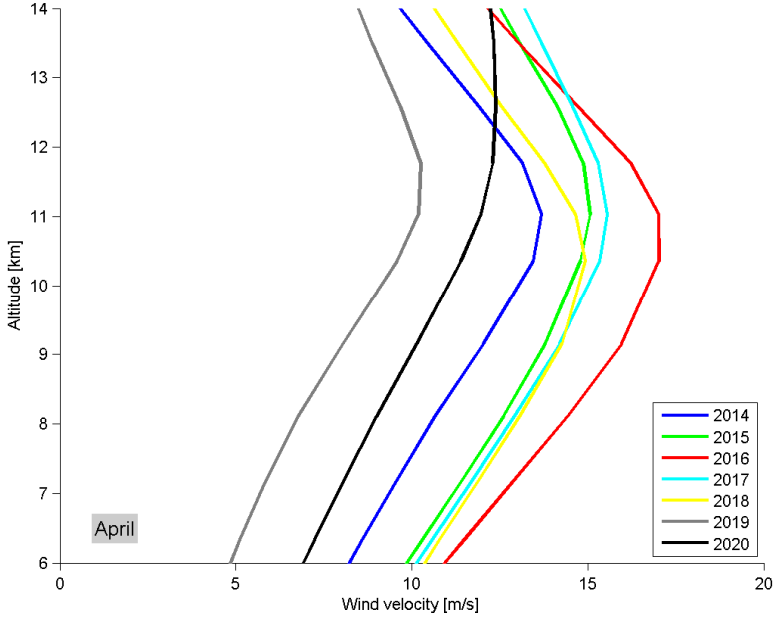


Meteorological analysis with ECMWF: Mean values

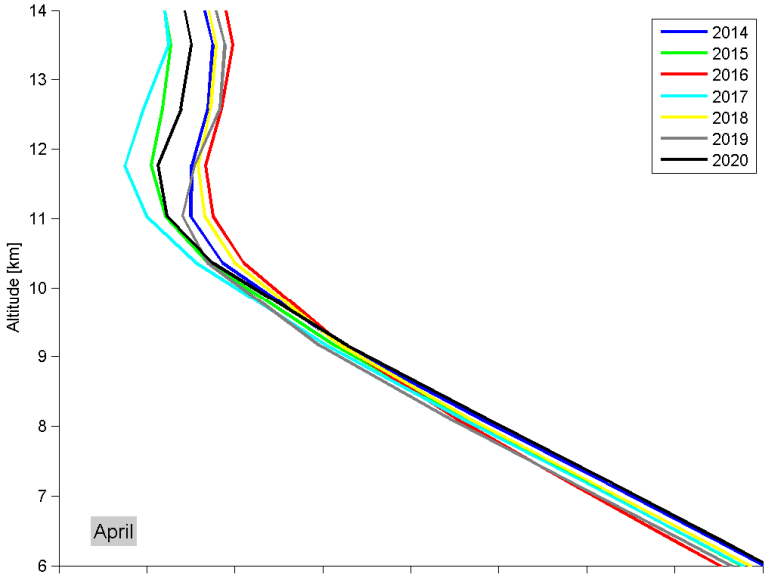


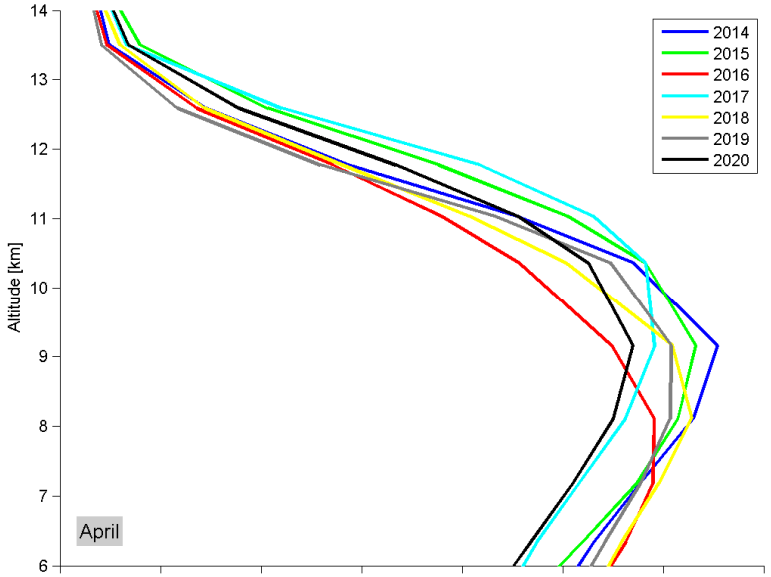






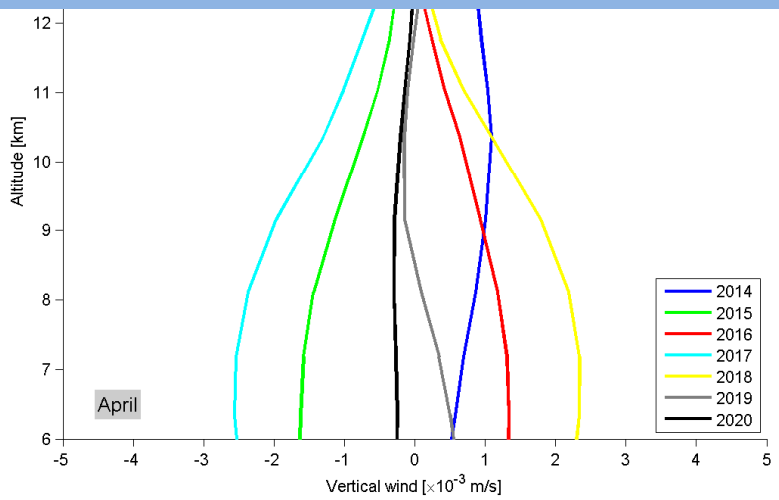
Meteorological analysis with ECMWF: Mean values

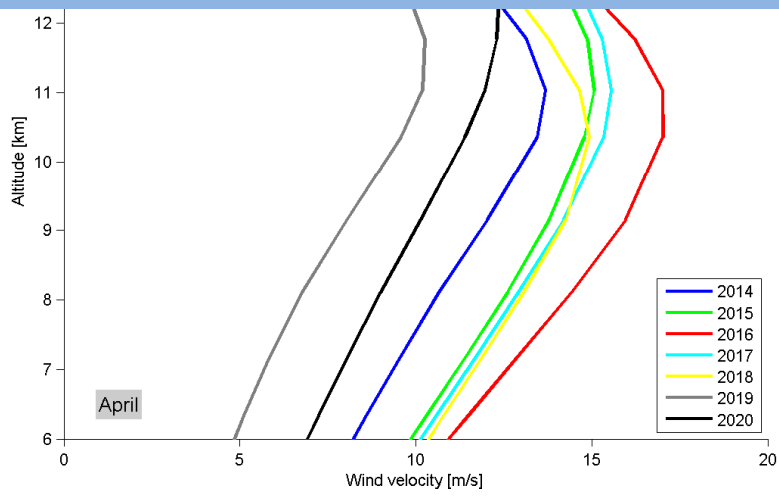




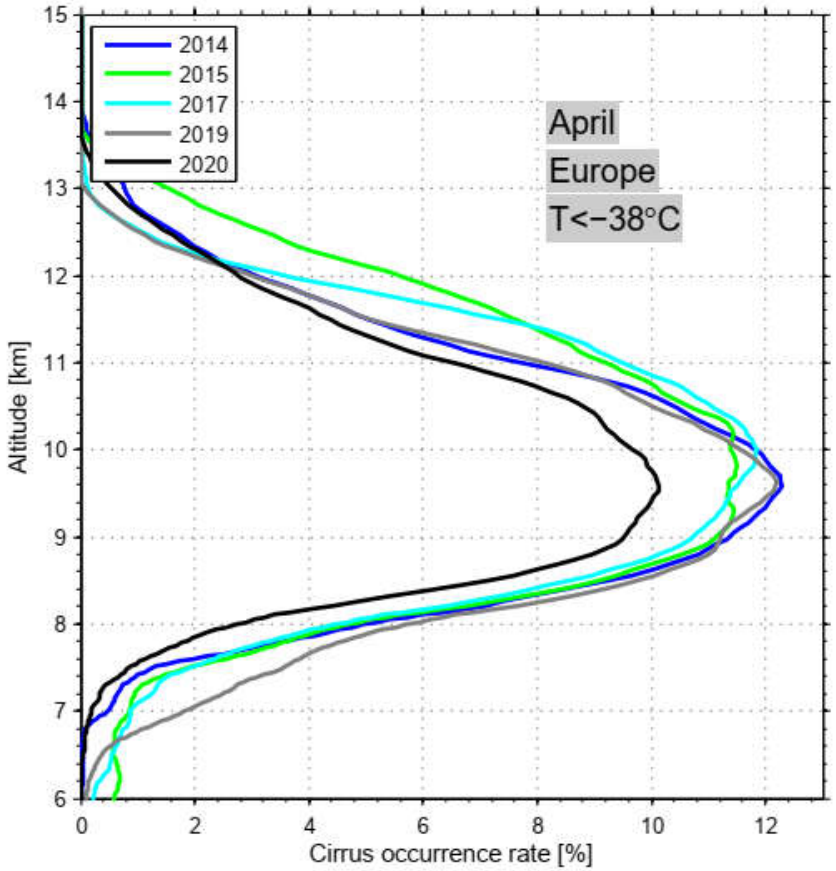
⇒ The meteorological conditions of April in 2014, 2015, 2017, and 2019, are comparable with the conditions in 2020. So these four years are selected as reference years.

⇒ In 2016 and 2018, temperatures are higher and airmasses are drier.





Cirrus occurrence rate in April

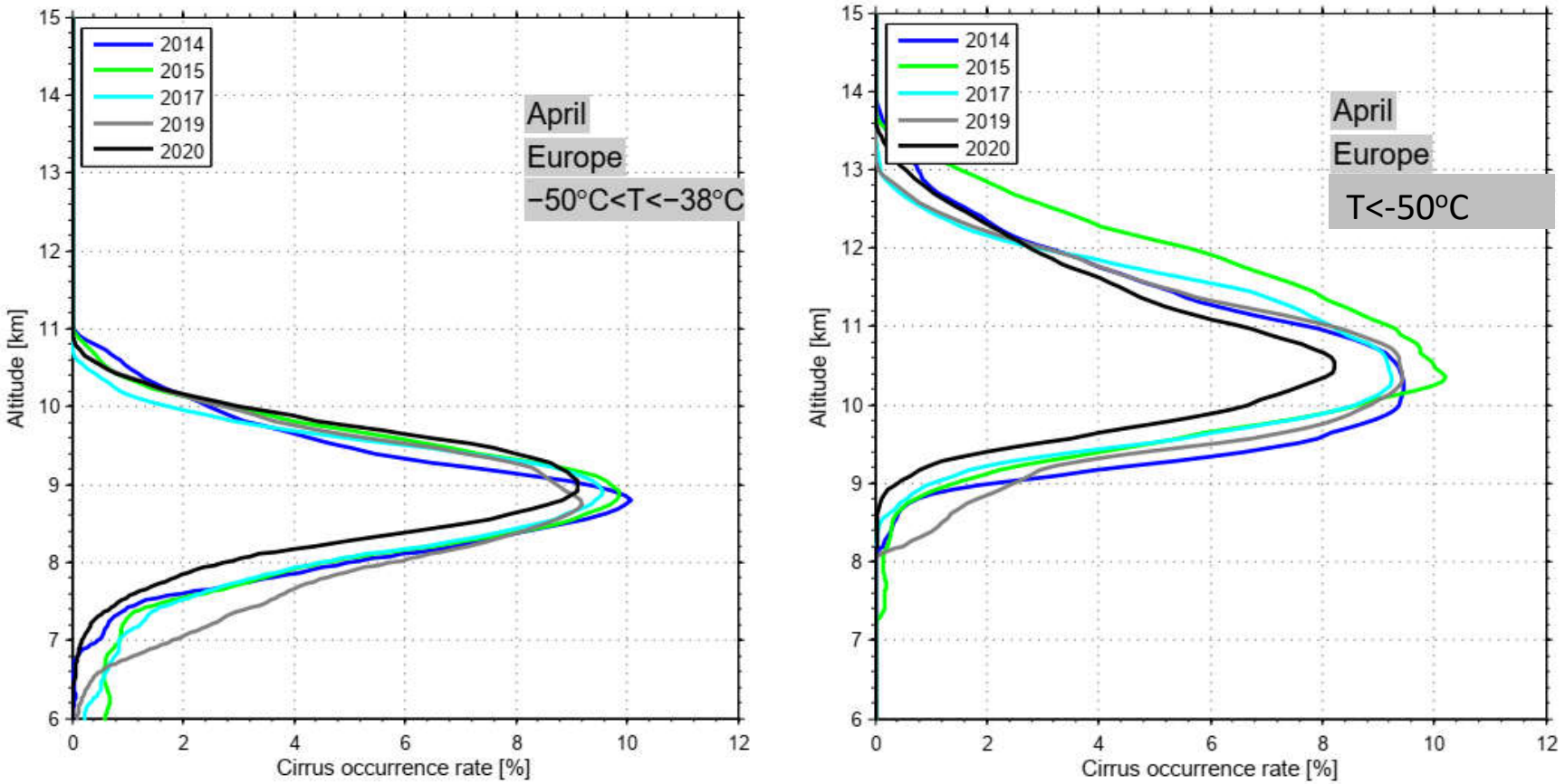


Li and Groß, 2021, in review

⇒ Lower occurrence rate of cirrus clouds in April, 2020;

⇒ T=-50°C is one of the threshold conditions for contrail formation (*Schumann*, 1996).

Cirrus occurrence rate in April

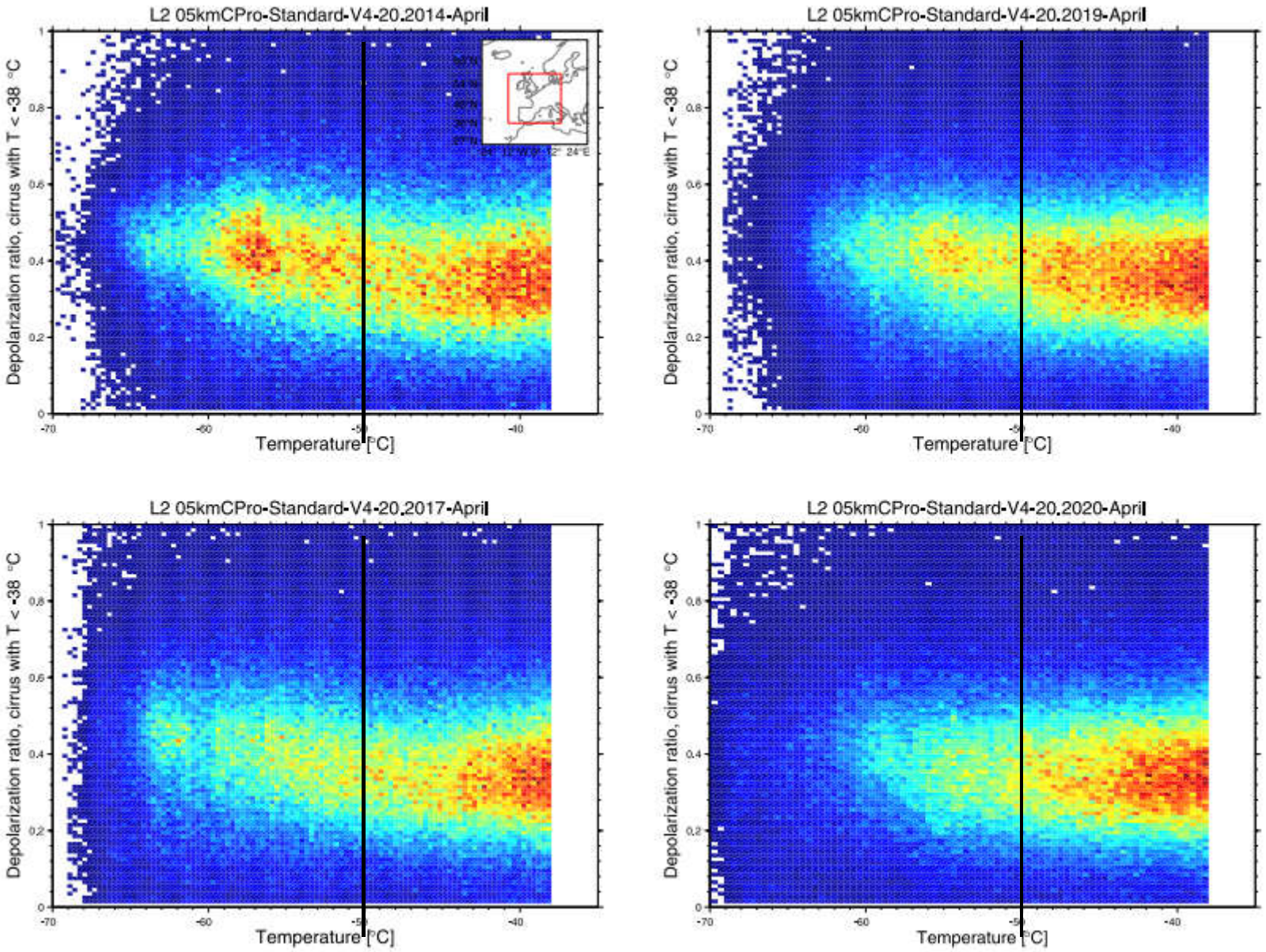


⇒ At temperatures fall within -50°C and -38°C, the occurrence rates of cirrus clouds are very close, only with small variations along the altitudes;

⇒ At colder temperatures than -50°C, there are reduced cirrus occurrence in 2020 within the all altitude range from 8 to 12 km which is the main cruising altitudes for aircrafts.

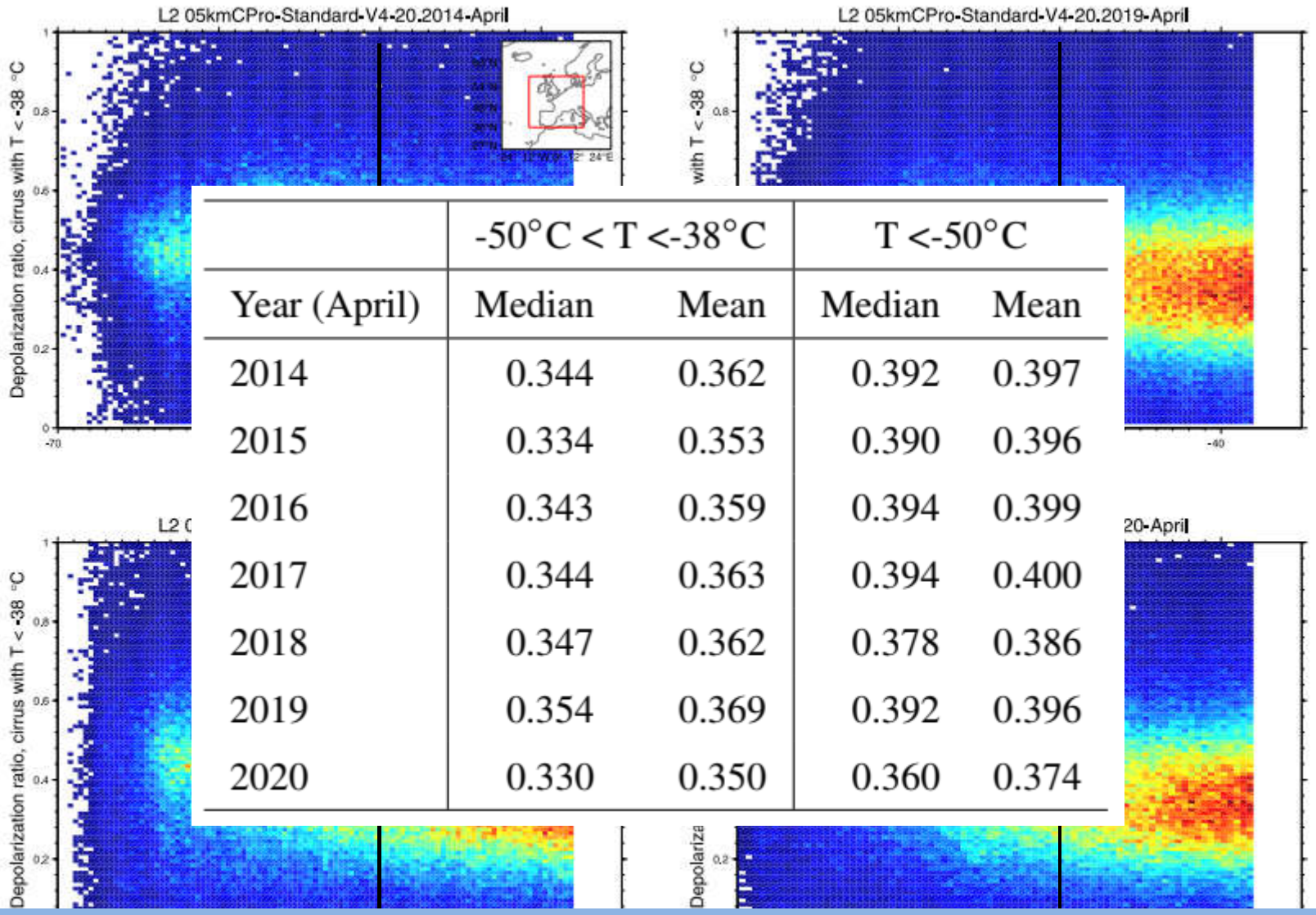
⇒ The reduced contrail length was found for a 6-month period (Mar-Aug) over Europe in 2020 compared with 2019 (*Schumann et al.*, 2021).

Cirrus particle linear depolarization ratio (PLDR) vs temperature



Li and Groß, 2021, in review

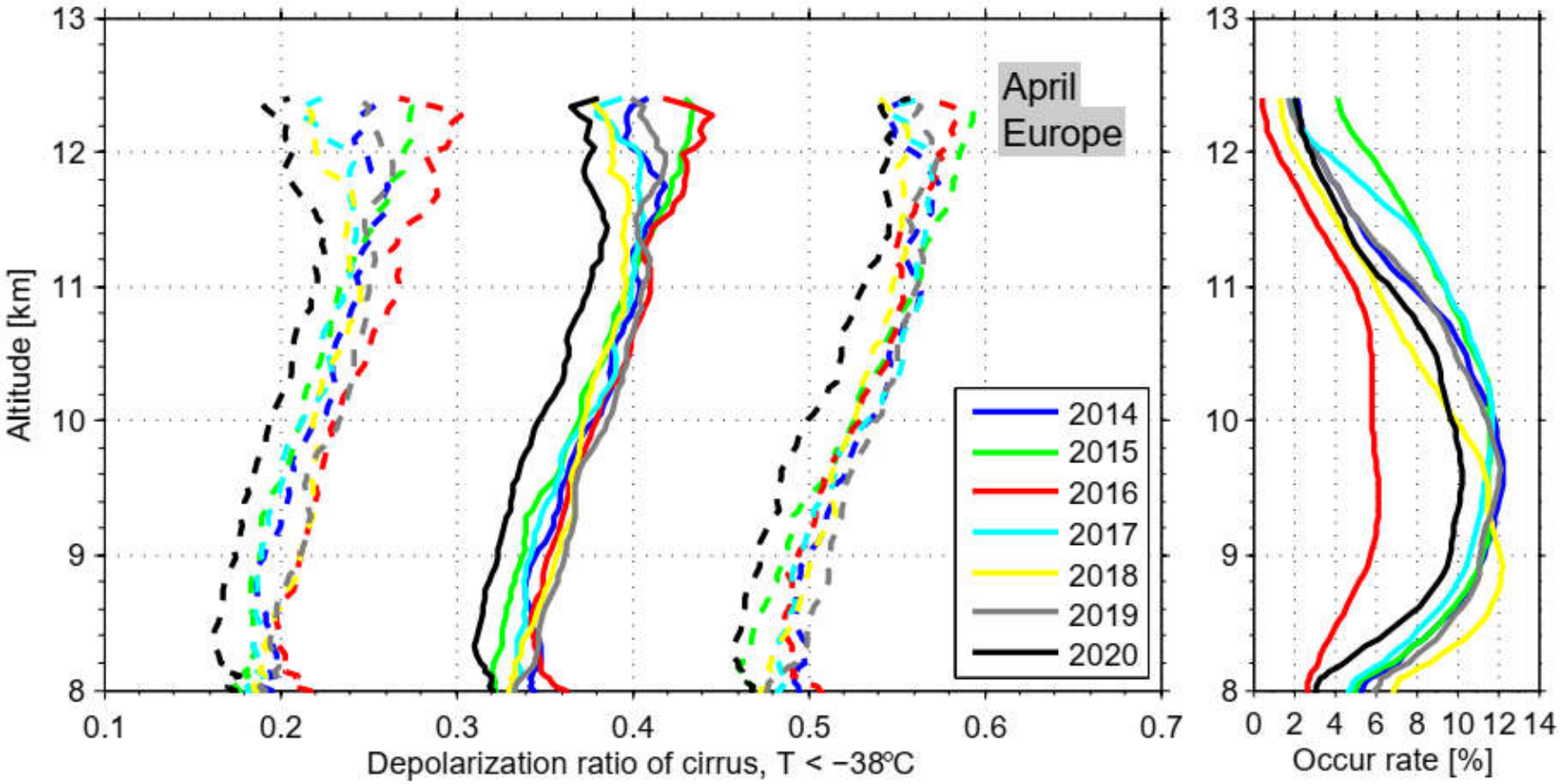
Cirrus particle linear depolarization ratio (PLDR) vs temperature



	-50°C < T <-38°C		T <-50°C	
Year (April)	Median	Mean	Median	Mean
2014	0.344	0.362	0.392	0.397
2015	0.334	0.353	0.390	0.396
2016	0.343	0.359	0.394	0.399
2017	0.344	0.363	0.394	0.400
2018	0.347	0.362	0.378	0.386
2019	0.354	0.369	0.392	0.396
2020	0.330	0.350	0.360	0.374

⇒ The distibutions of PLDR at higher temperatures, are in good agreement for all the cases;
⇒ At temperatures < -50C, PLDR shows a significant reduction in April 2020.

Altitude profiles of the cirrus PLDR



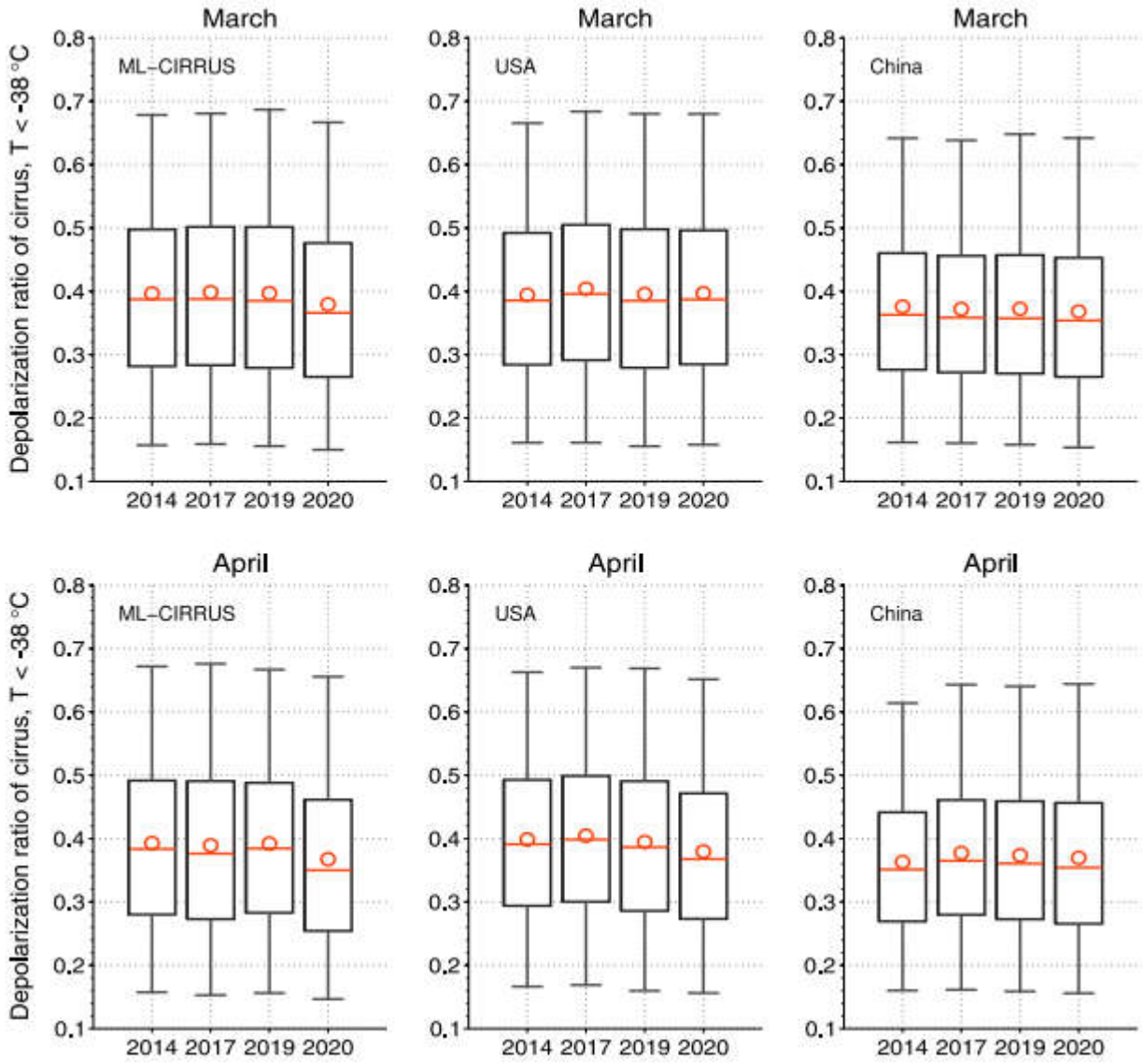
Li and Groß, 2021, in review

⇒ The PLDR values increase with altitudes for all cases;

⇒ A clear reduction of PLDR in 2020 for the entire altitude range from 8 to 12 km;

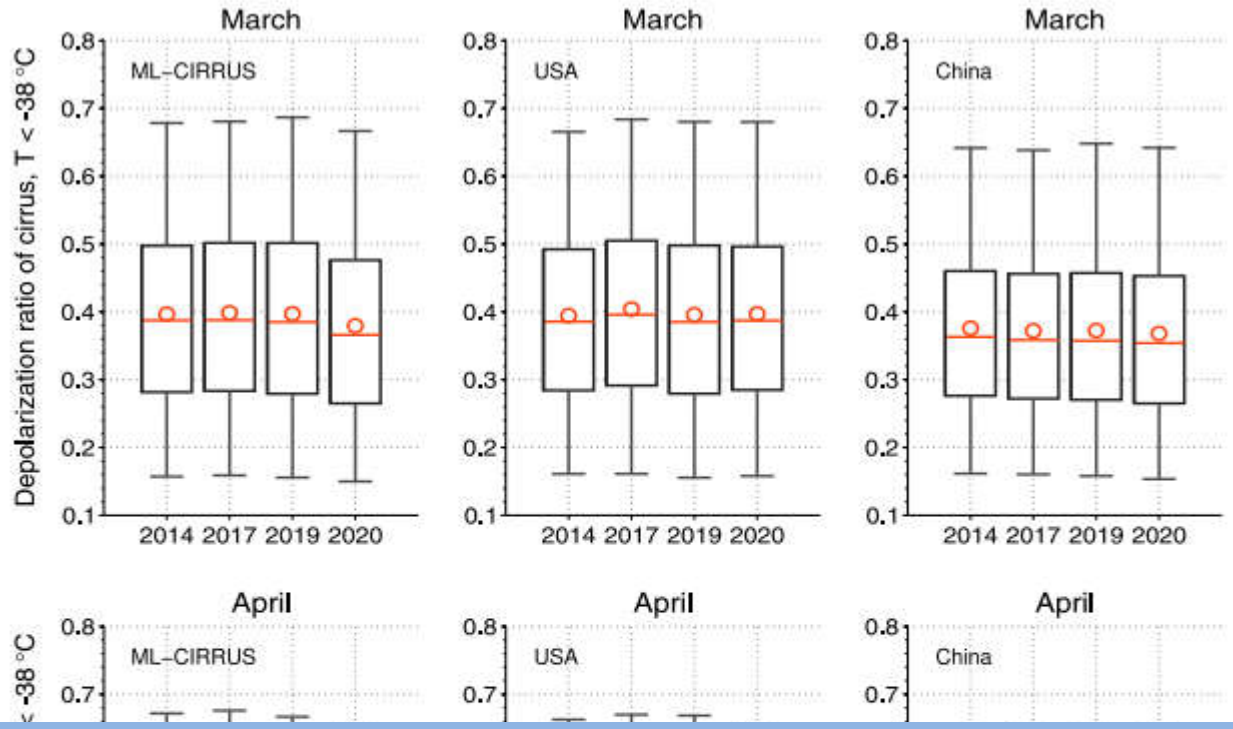
⇒ The cirrus PLDR in 2016 show comparable values under ‚normal' conditions in the previous years, although the cirrus occurrence rate was lower due to higher temperatures and drier airmasses.

Regional comparisons of cirrus PLDR in March and April



Li and Groß, 2021, in review

Regional comparisons of cirrus PLDR in March and April



⇒ Cirrus clouds over USA show similar properties in terms of occurrence rates and PLDR compared with Europe; while the results over China are characterized by smaller occurrence and PLDR compared with the other two regions;

⇒ Cirrus clouds show significant changes of PLDR in both March and April over Europe, no changes in both months over China, and significant changes only in April over USA.

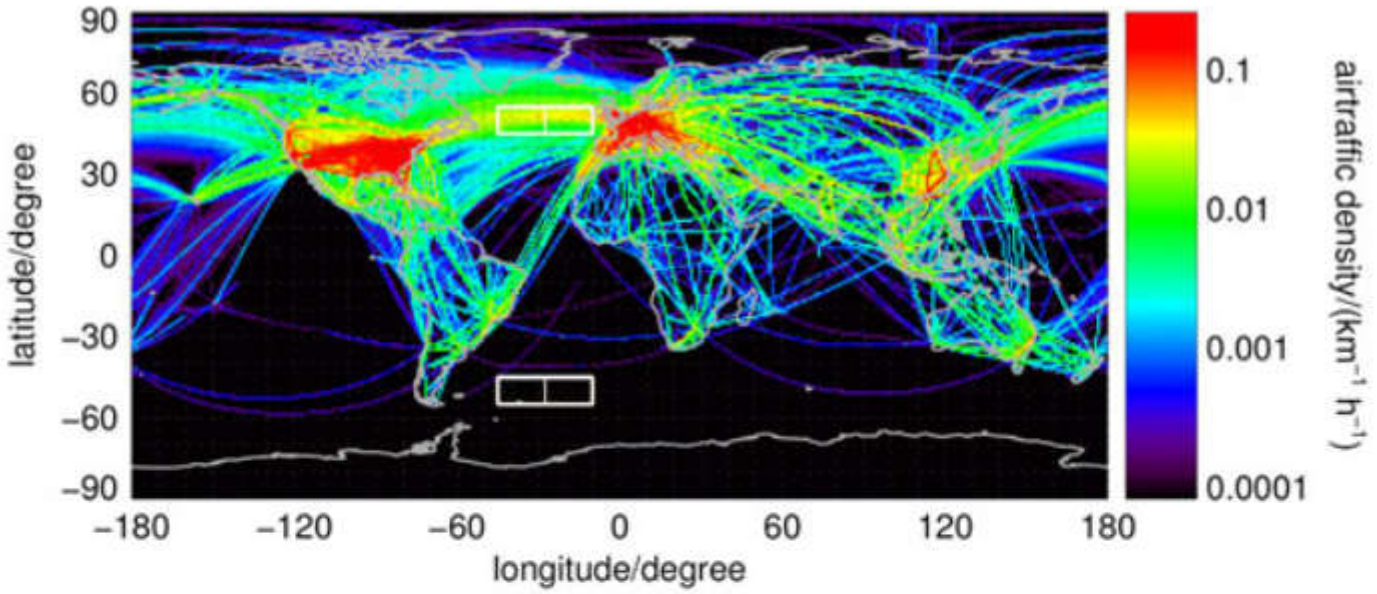
⇒ Besides the regional difference, the changes of cirrus PLDR conform to the timeline of the outbreak of the coronavirus and the consequent restriction of air traffic.

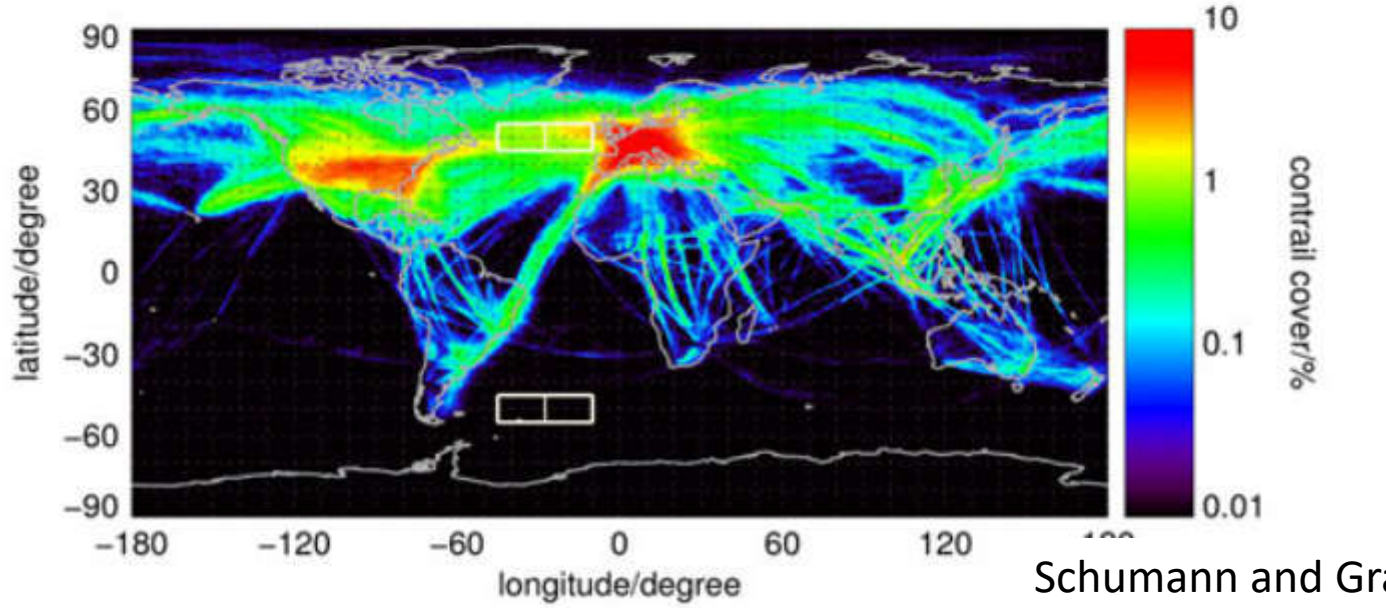
Li and Groß, 2021, in review

Thank you!

vEGU21: Gather online April 27, 2021
Session GI4.2: Lidar remote sensing of the atmosphere

Regional comparisons of airtraffic density and contrail cover





Schumann and Graf, 2013