Supplement of Atmos. Chem. Phys., 22, 9483–9497, 2022
https://doi.org/10.5194/acp-22-9483-2022-supplement

Atmospheric Chemistry and Physics
Open Access
EGU

Supplement of

Distribution of hydrogen peroxide over Europe during the BLUESKY aircraft campaign

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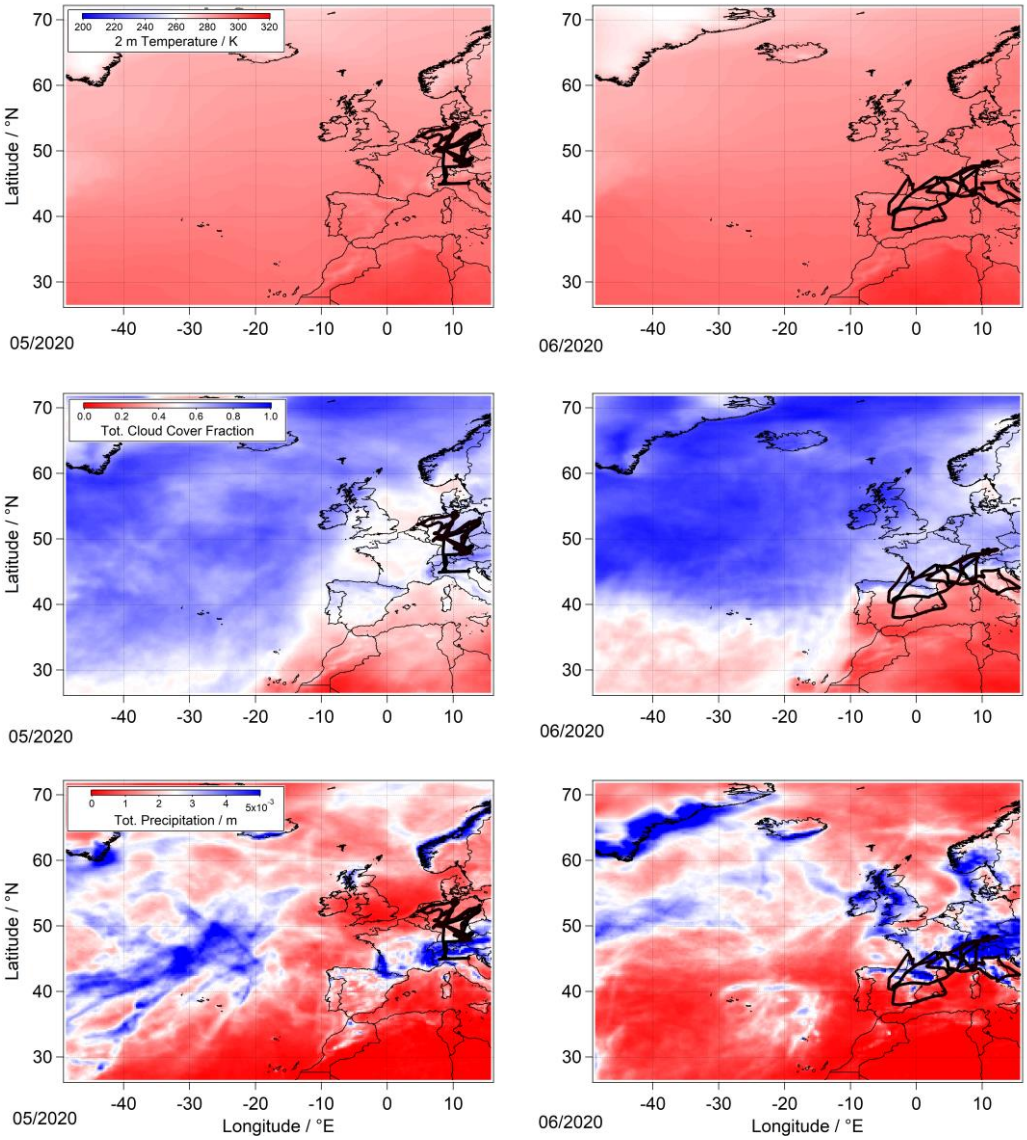


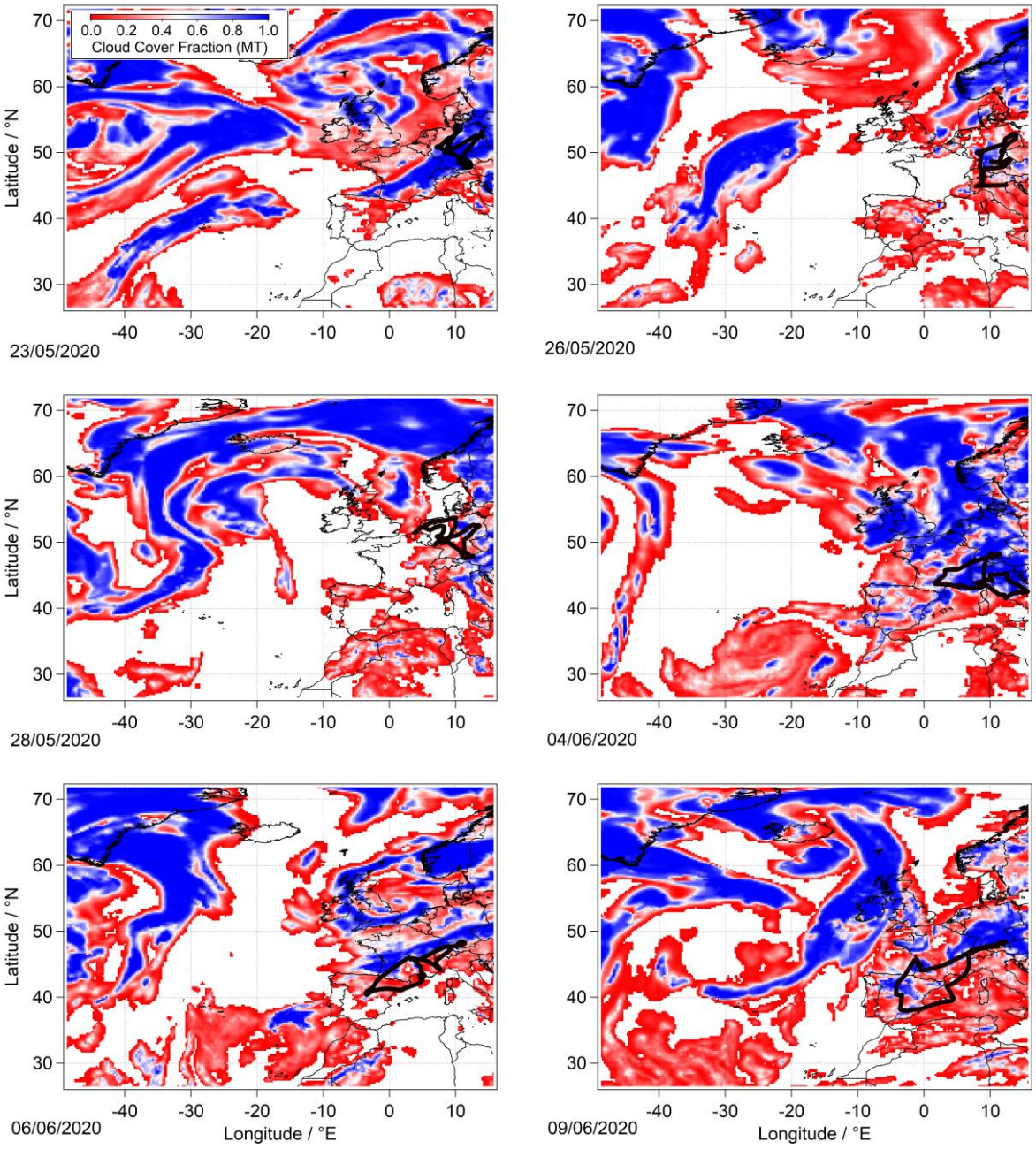
Figure S1: Average monthly 2 m temperature (top panel), total cloud cover fraction (middle panel) and total precipitation (bottom panel) during May (left row) and June (right row) derived by ERA 5 reanalysis generated using Copernicus Climate Change Service information (Hersbach et al. 2019).[1] Flight tracks of measurement flights are plotted in black.

[1] Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2019): ERA5 monthly averaged data on single levels from

Table S1: General median (bottom) and mean (± 1 sigma; top) overview of hydrogen peroxide during the campaigns UTOPIHAN-ACT II/III, HOOVER II and CAFE-EU/BLUESKY (Stickler et al. 2006; Colomb et al. 2006; Klippel et al. 2011).

Campaign	**Time period**	**Latitudinal range**	**Mean (Median) Mixing Ratio / ppb_v**		
			UT	MT	BL
			6 – 14 km	2 – 6 km	0 – 2 km
UTOPIHAN-ACT	03&07/03	40°N – 65°N	0.47±0.36 (0.47)	1.74±0.97 (1.80)	1.65±0.16 (1.32)
HOOVER II	07/07	30°N – 75°N	0.67±0.43 (0.56)	1.49 ±0.71 (1.33)	1.59 ±0.78 (1.48)
BLUESKY	05– 06/20	35°N – 60°N	0.28±0.22 (0.24)	0.42±0.25 (0.37)	0.48±0.17 (0.48)

1979 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). (Accessed on < 04-05-2021 >), 10.24381/cds.f17050d7



30 **Figure S2: Hourly cloud cover fraction at middle altitudes (2 – 7 km; 12:00 UTC) during the performed flights (black tracks) in agreement with ERA5 reanalysis generated using Copernicus Climate Change Service information (Hersbach et al. 2018)[2].**

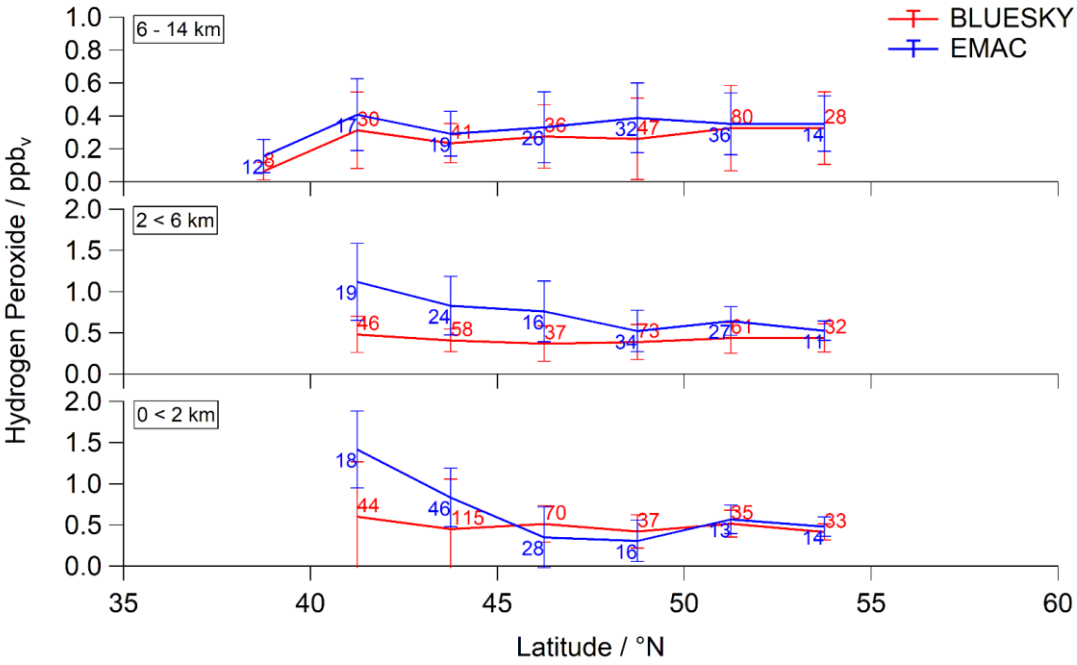


Figure S3: Latitudinal distribution of hydrogen peroxide in comparison to model EMAC (red: BLUESKY; blue: EMAC). The data was subdivided into three atmospheric layers, upper troposphere, middle troposphere and boundary layer (from top to bottom) with mean values binned for 2.5° of latitude for each tropospheric layer. The corresponding numbers indicate the total amount of data points per bin.

[2] Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2018): ERA5 hourly data on single levels from 1979 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). (Accessed on < 04-05-2021 >), 10.24381/cds.adbb2d47

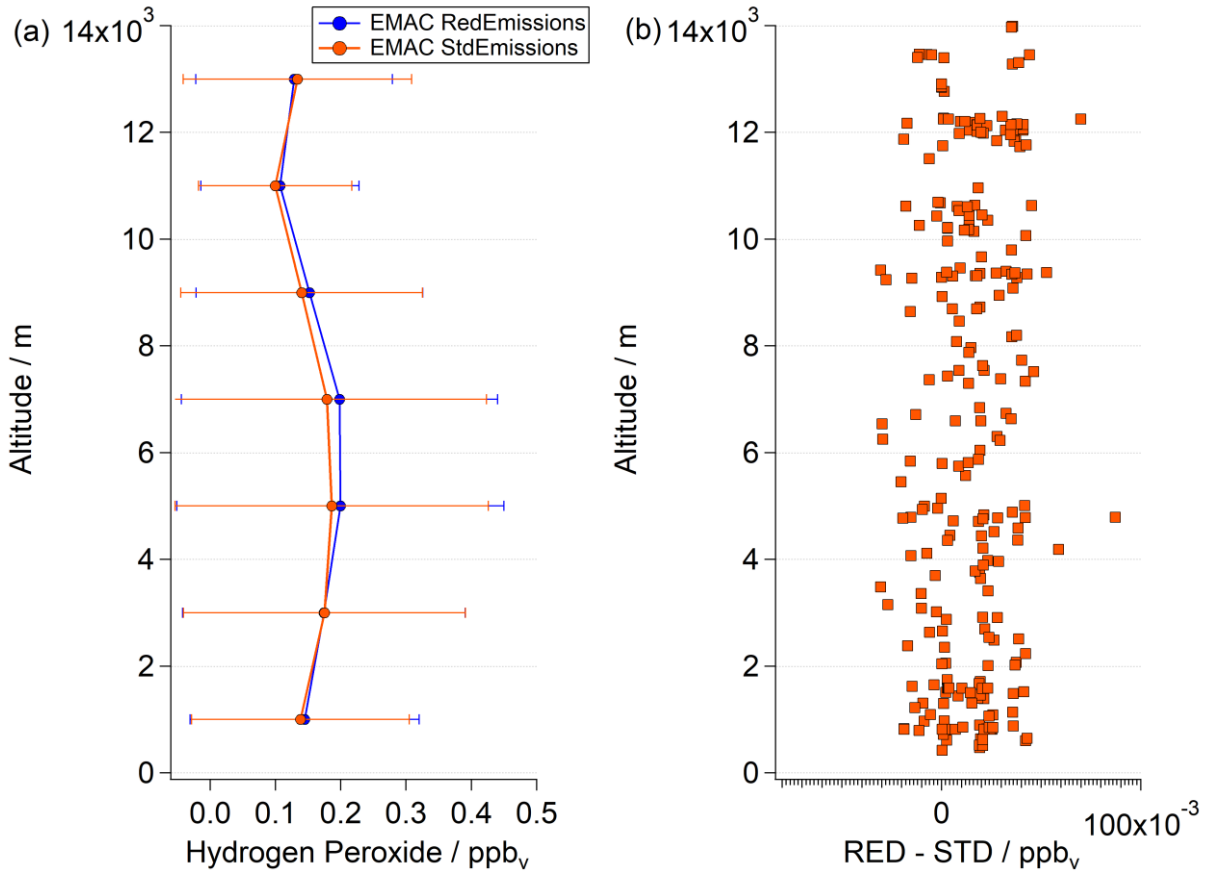
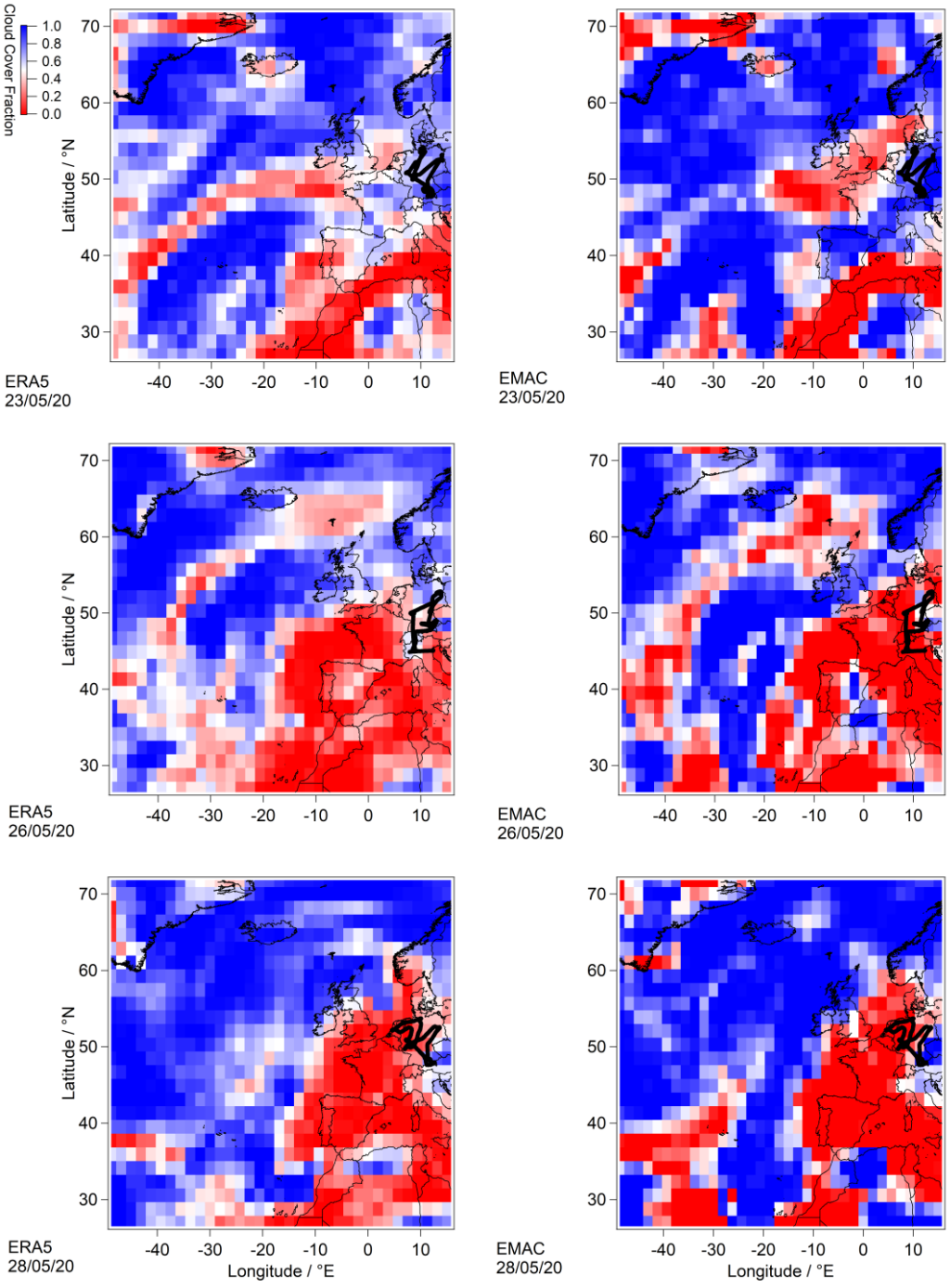
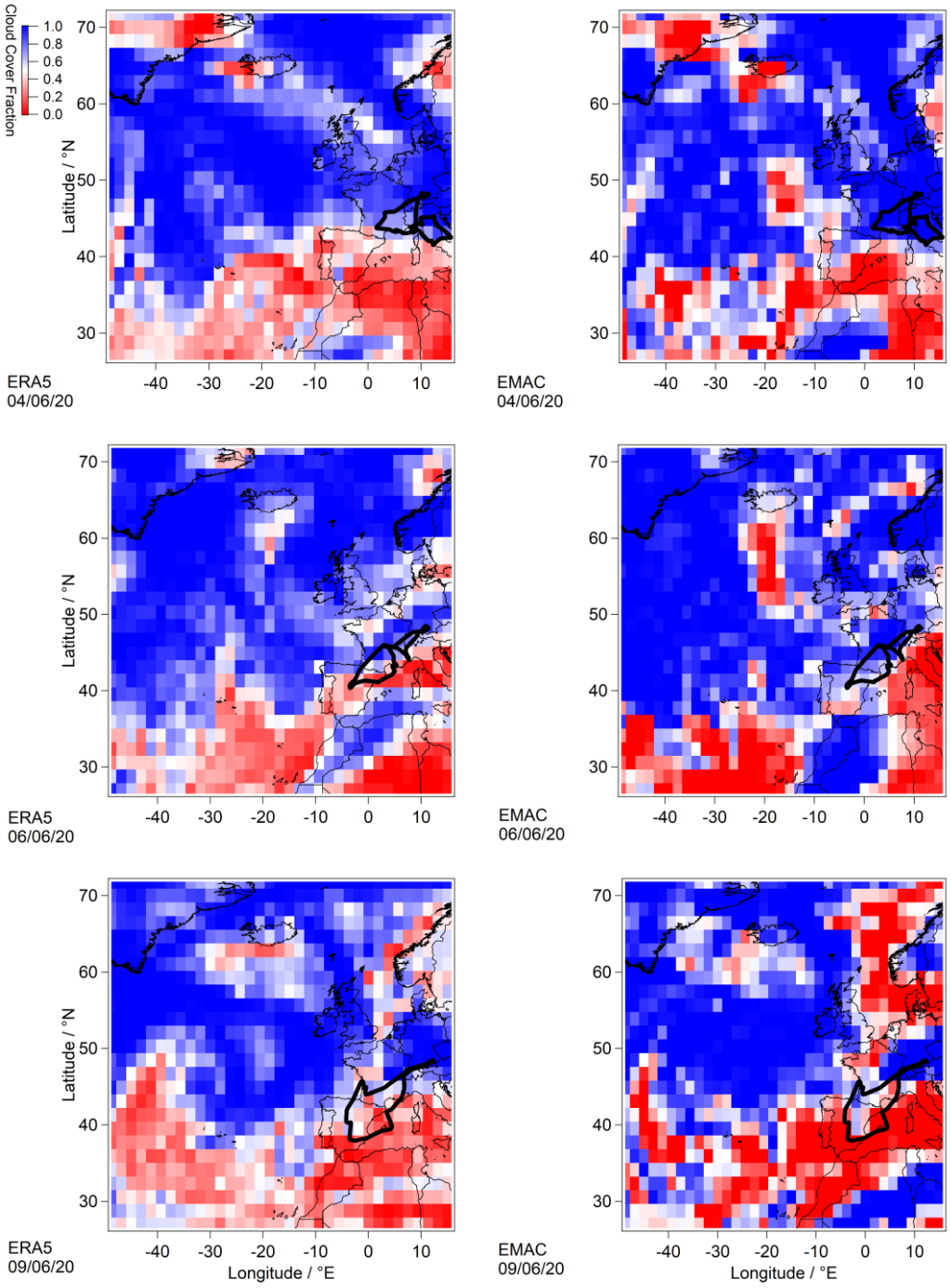


Figure S4: Vertical profiles of hydrogen peroxide with (blue) and without (orange) the CORONA lockdown emission reductions (a) and absolute difference of the modelled mixing ratios (b). In order to examine the impact of the reduced emissions on the budget of H_2O_2, the entirety of both datasets provided by EMAC was used. Please note that the data was not filtered analogously to the procedure described in Sect 3.1.


Cloud Cover Fraction
1.0
0.8
0.6
0.4
0.2
0.0
Latitude / °N
70
60
50
40
30
-40
-30
-20
-10
0
10
Longitude / °E
ERA5
23/05/20
EMAC
23/05/20
ERA5
26/05/20
EMAC
26/05/20
ERA5
28/05/20
EMAC
28/05/20

60



65 **Figure S5: Average total cloud coverage over Europe and North Atlantic during the measurement period (73 - 28°N, -50 – 15°E) provided by ERA5 (left panel; modified Copernicus Climate Change Service information; left panel; Hersbach et al. 2018) and EMAC (right panel).**

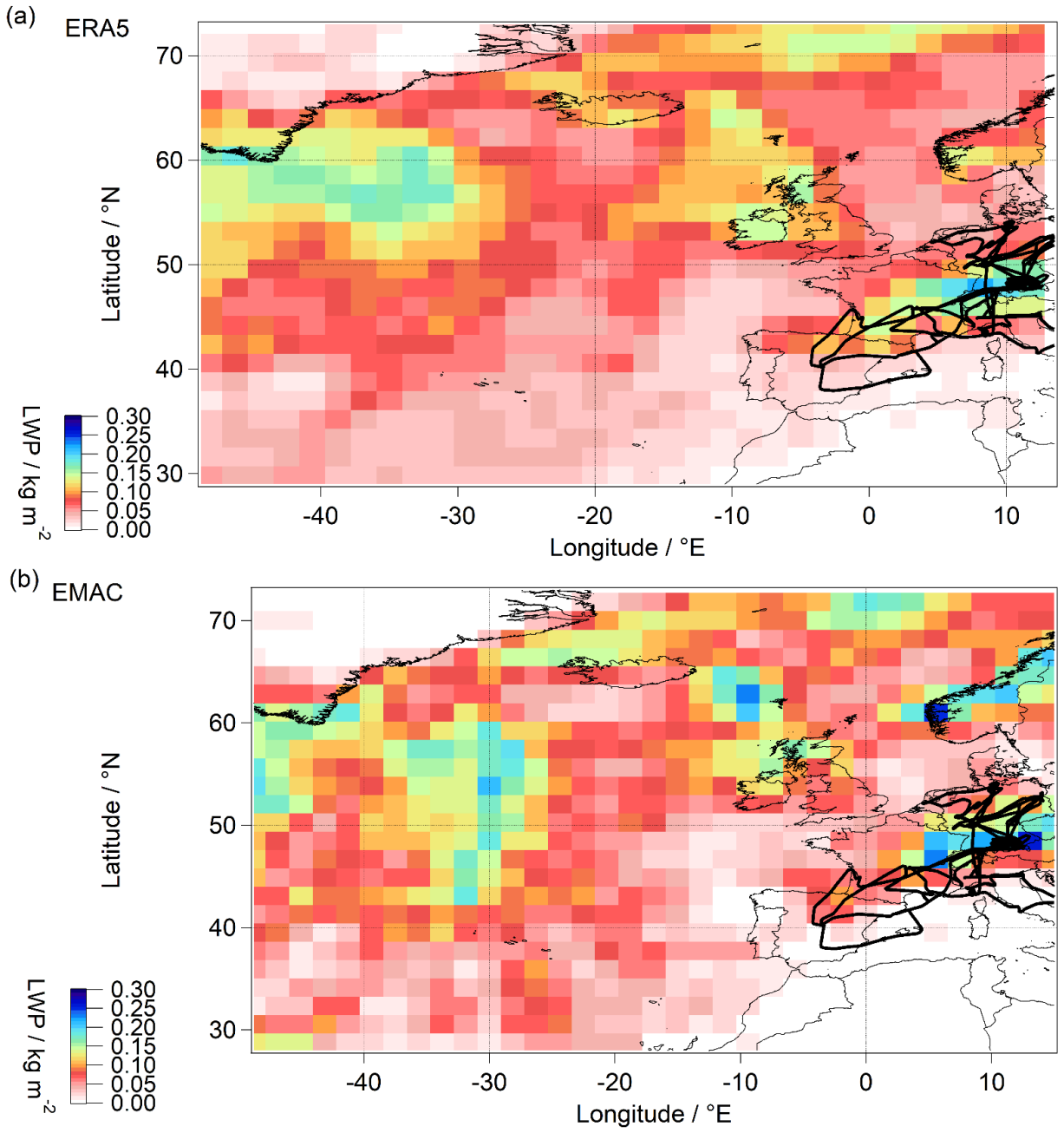
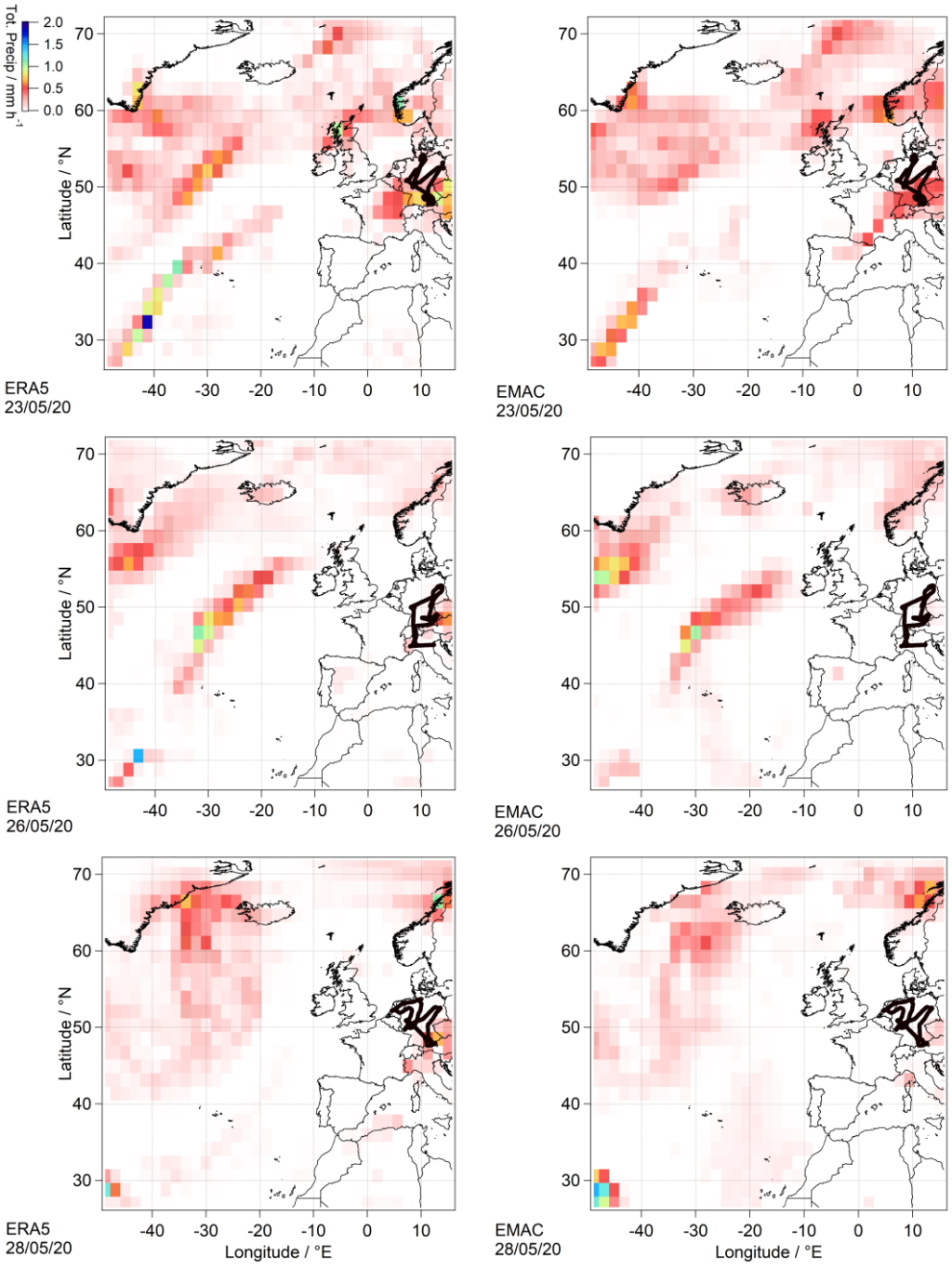


Figure S6: Average liquid water path (LWP) over Europe and the North Atlantic (73°N- 28°N, -50°E – 15°E) during the flight days of the campaign based on ERA5 (a;contains modified Copernicus Climate Change Service information; Hersbach et al. 2018) in comparison to EMAC (b).


Tot. Precip / mm h-1
2.0
1.5
1.0
0.5
0.0
Latitude / °N
Longitude / °E
ERA5
23/05/20
EMAC
23/05/20
ERA5
26/05/20
EMAC
26/05/20
ERA5
28/05/20
EMAC
28/05/20

75

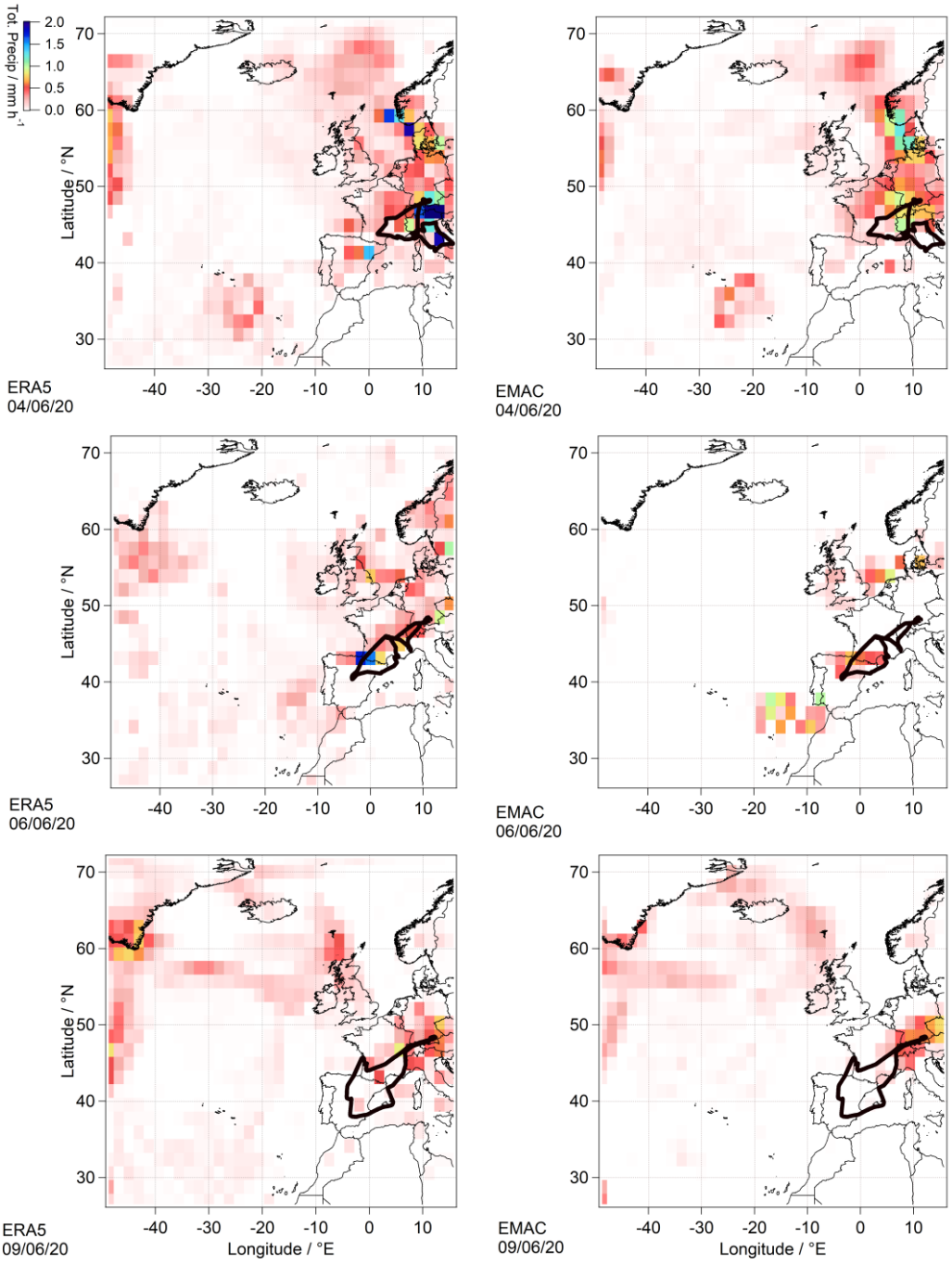


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Figure S7: Average total precipitation over Europe and North Atlantic during the campaign BLUESKY (73°N- 28°N, -50°E – 15°E) provided by ERA5 (left panel; contains modified Copernicus Climate Change Service information; Hersbach et al. 2018) in comparison to EMAC (right panel).

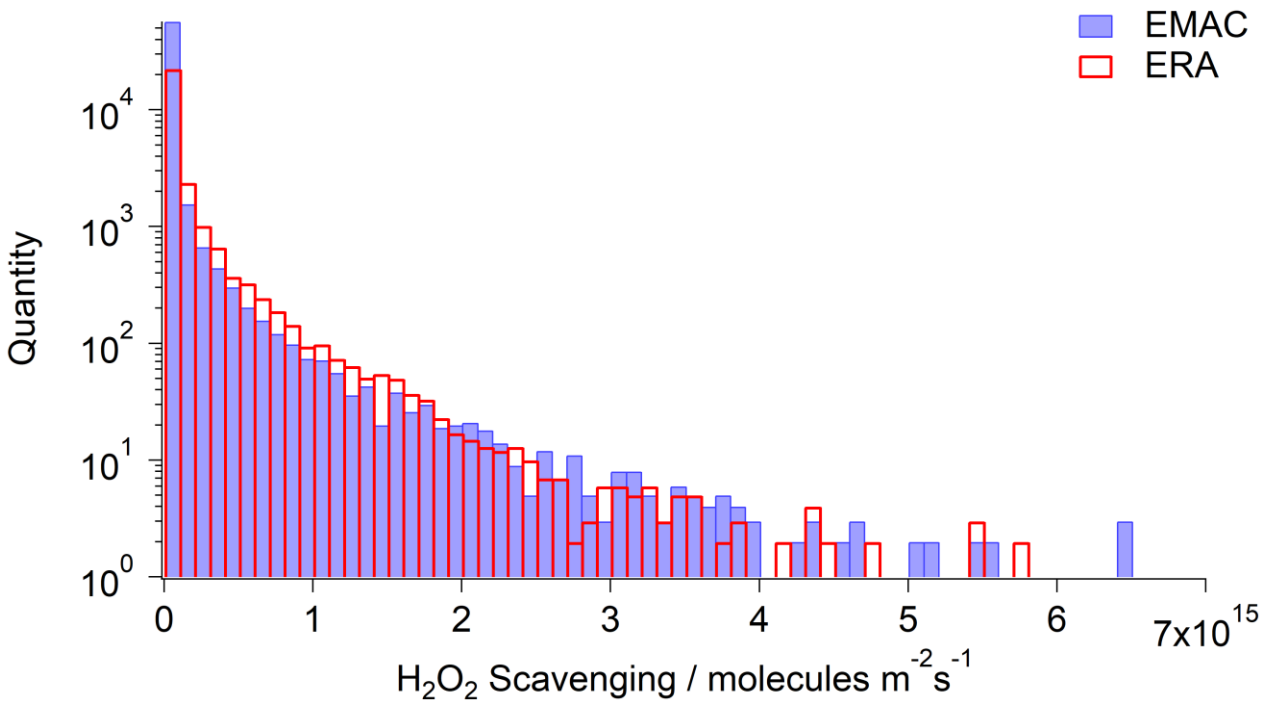

Figure S8: Histogram of the hydrogen peroxide scavenging modelled by EMAC (blue) and the predicted scavenging by ERA5 (red). The scavenging data of ERA5 were obtained by extrapolation based on linear regression between scavenging and precipitation by EMAC.

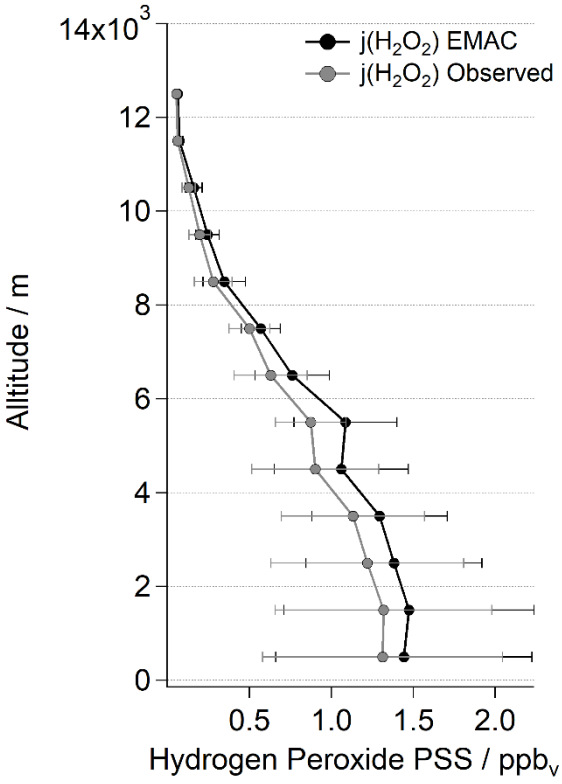

Figure S9: Vertical profiles of hydrogen peroxide mixing ratios under PSS conditions derived from observed (gray) and EMAC simulated (black) photolysis rates of H_2O_2 ($j(H_2O_2)$).

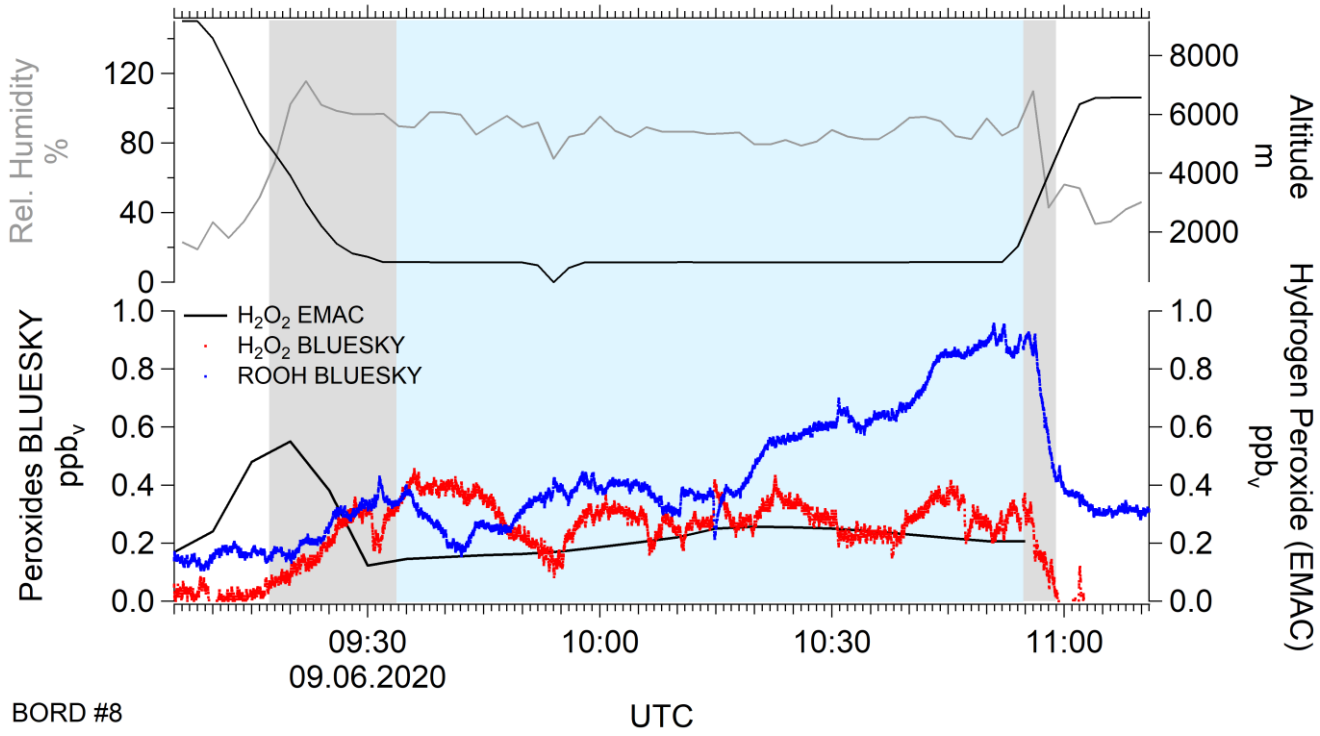

Figure S10: Temporal series of peroxide mixing ratios over the Bordeaux area on 09.06.2020 (red: observed H2O2; blue: observed ROOH; black: simulated H_2O_2, grey: relative humidity; top black: GPS altitude). Cloud scavenging and precipitation are highlighted by gray and light blue shading, respectively. Please note that the observed peroxide data displayed has 1 sec time resolution in comparison to the model resolution of 5 min.

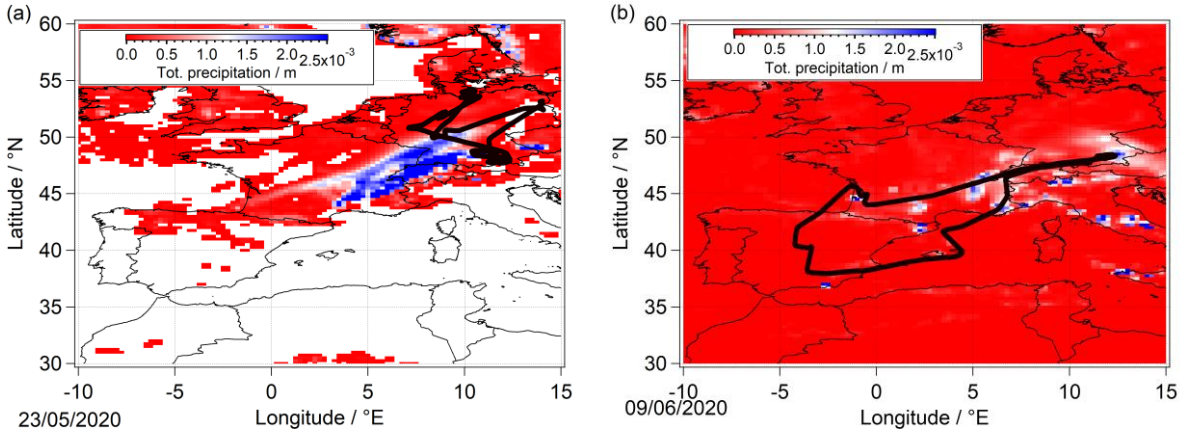

Figure S11: Hourly total precipitation at 12:00 UTC during the measurement flights performed on 23.05.2020 (a) and 09.06.2020 (b) in agreement with ERA5 reanalysis (generated using Copernicus Climate Change Service information; Hersbach et al. 2018)[3].

[3] Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2018): ERA5 hourly data on single levels from 1979 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). (Accessed on < 04-05-2021 >), 10.24381/cds.adbb2d47