

Air-sea interactions and diabatic processes in the Gulf Stream region and their role in the life-cycle of a blocking anticyclone: a case study of European Blocking in Feb 2019

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February 2019 Heatwave

An episode of European blocking that took place in the period between 20 and 27 of February 2019 was accompanied by a record-breaking warm spell bringing temperatures above 20°C to the United Kingdom, Netherlands, and Northern France.

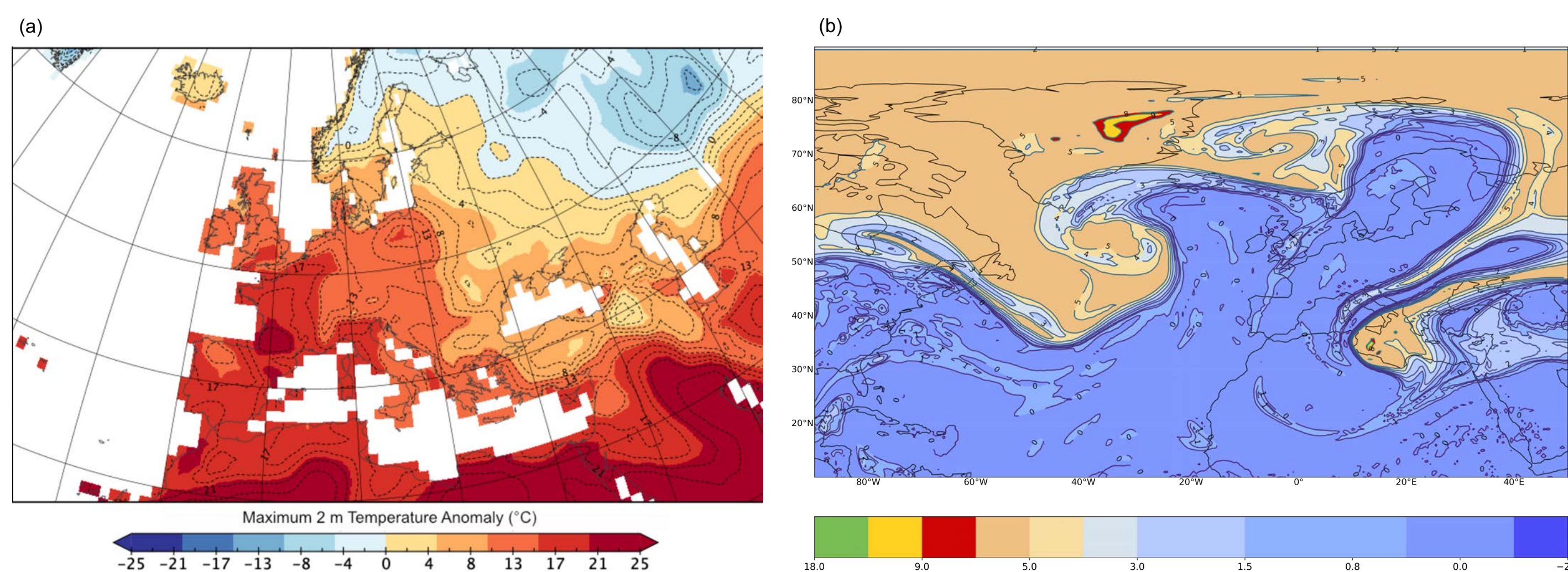


Fig.1. (a) Maximum 2 m temperature anomaly on 26.02.2019, source: Berkeley Earth Surface Temperature Project, <https://cds.climate.copernicus.eu/>. (b) Potential vorticity at the isentropic level of 315 K (ERA5).

Methods

Lagrangian trajectories computed using LAGRANTO (Sprengr & Wernli, 2015) and ECMWF ERA5 (Hersbach et al., 2020) reanalysis:

- Trajectories are run 10 day backward with an interval of 3 h from the negative potential vorticity anomaly objects (VAPVA, Schierz et al. 2004) forming the Feb. 2019 European Blocking for the period of 18.02.2019 09:00 to 28.02.2019 12:00.
- Trajectories are run 10 day forward with an interval of 3 h from the Gulf Stream (GS) SST front for the whole month of Feb 2019.

A selection criterium of an ascent of 500 hPa anytime throughout the trajectories is applied to both datasets. In the post processing backward trajectories that passed over GS SST front prior to ascending into the blocking are selected.

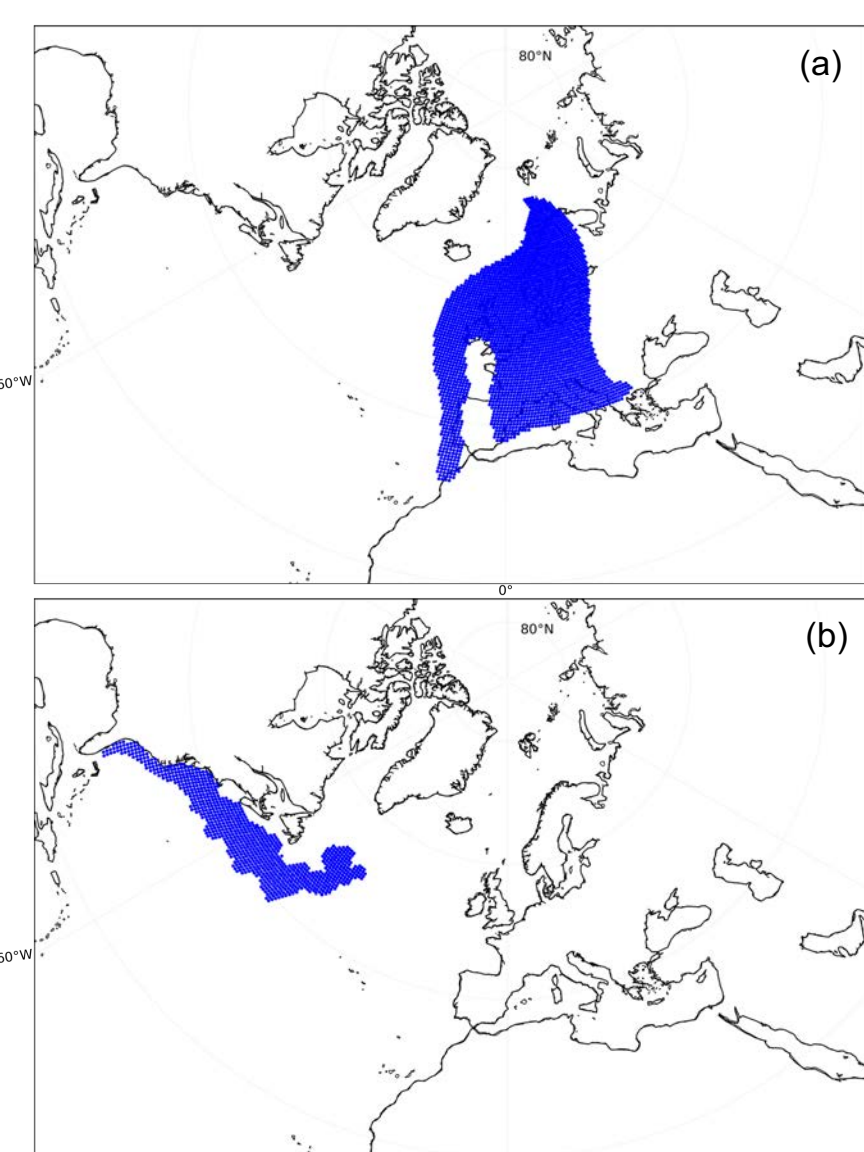


Fig.2. (a) Starting points for backward trajectories. (b) starting points for forward trajectories.

Identification of different airstreams

Trajectories characterized by different processes are selected from the initial trajectory dataset based on the following criteria:

- ❖ **WCB**- warm conveyor belt (Madonna et al. 2014), ascent of 600 hPa within 48h
- ❖ **Dry Intrusion** (Raveh-Rubin, 2017), descent of 400 hPa within 48h
- ❖ **CAO**- cold air outbreak (Papritz and Spengler, 2016), $\theta_{SST} - \theta > 4 (K)$
- ❖ **DH**- diabatic heating (Pfahl et al., 2015), $\Delta\theta(K) > 2$

Rapidly Intensifying Cyclones

The formation of the blocking is accompanied by several (two shown), rapidly intensifying cyclones originating in the Gulf Stream region and traversing the North Atlantic.

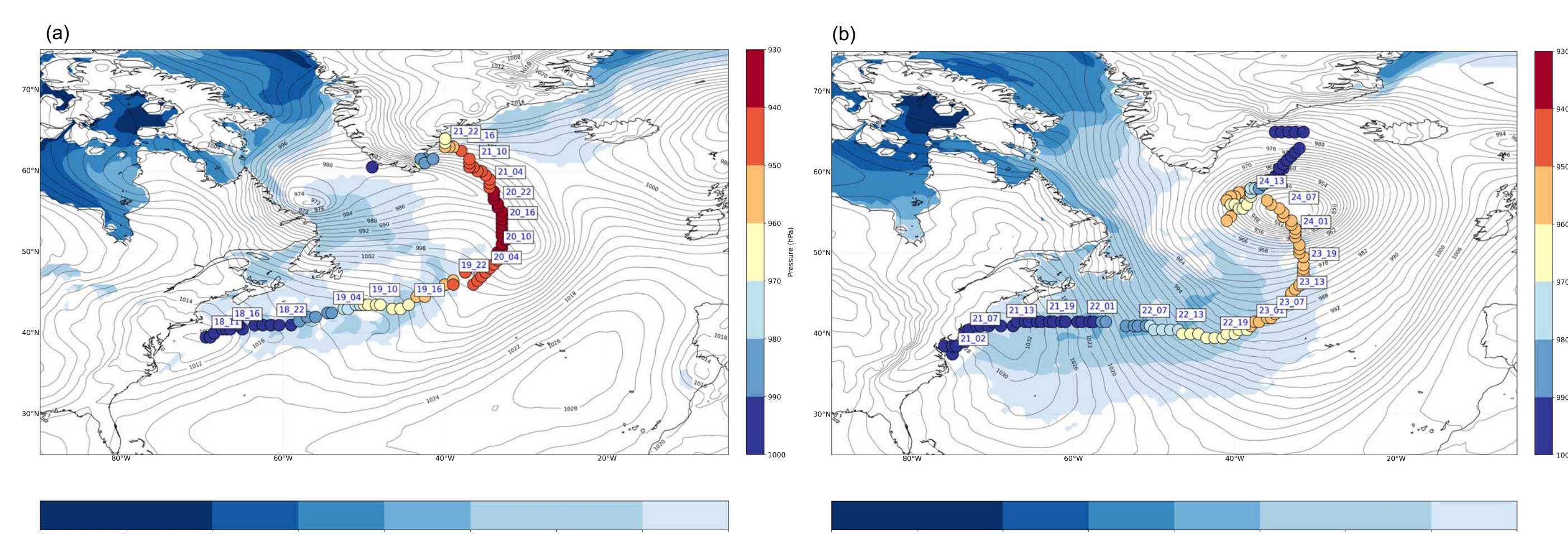


Fig. 3. Pressure coloured dots show the track of a cyclone formed on (a) 18.02.2019, 11:00 and (b) 21.02.2019 02:00, coloured contours denote cold air outbreak and black contours mean sea level pressure on (a) 18.02.2019, 12:00 and (b) 21.02.2019 00:00.

Backward Trajectories Characteristics

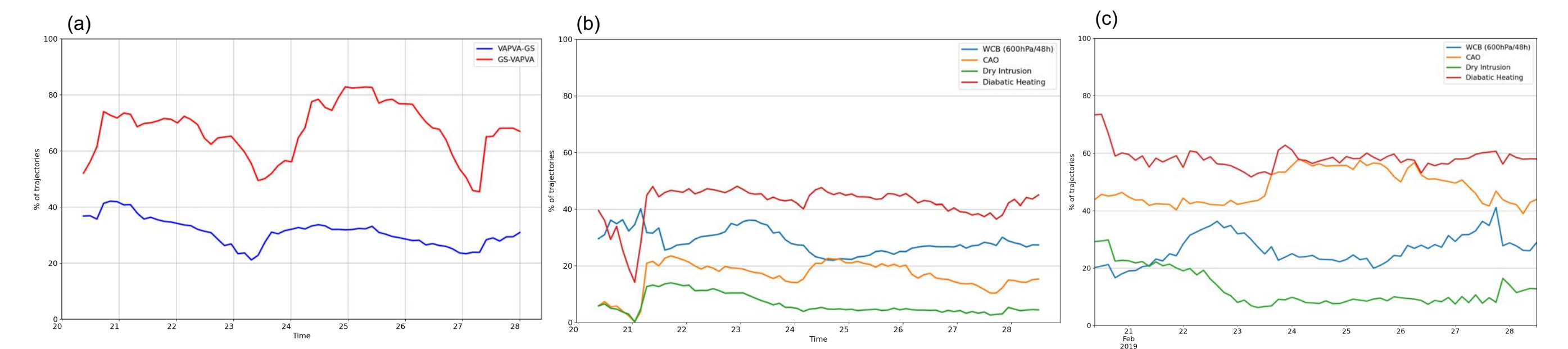


Fig.4. Fraction (%) of trajectories (a) that started from VAPVA objects and passed over GS and started from the GS and ascended into VAPVA (b), and fractions of different airstreams in all backward trajectories (b) and those backward trajectories that passed over GS.

- ❖ The onset of the blocking is accompanied by increasing contribution of the trajectories that passed over GS SST front, prior to their ascent into the blocking region.
- ❖ On average – more than 40% (20% of all) of those trajectories have undergone CAO and more than 50% - diabatic heating.
- ❖ More than 50% and up to 80% of forward trajectories from the GS end up in the upper level negative PV anomalies.

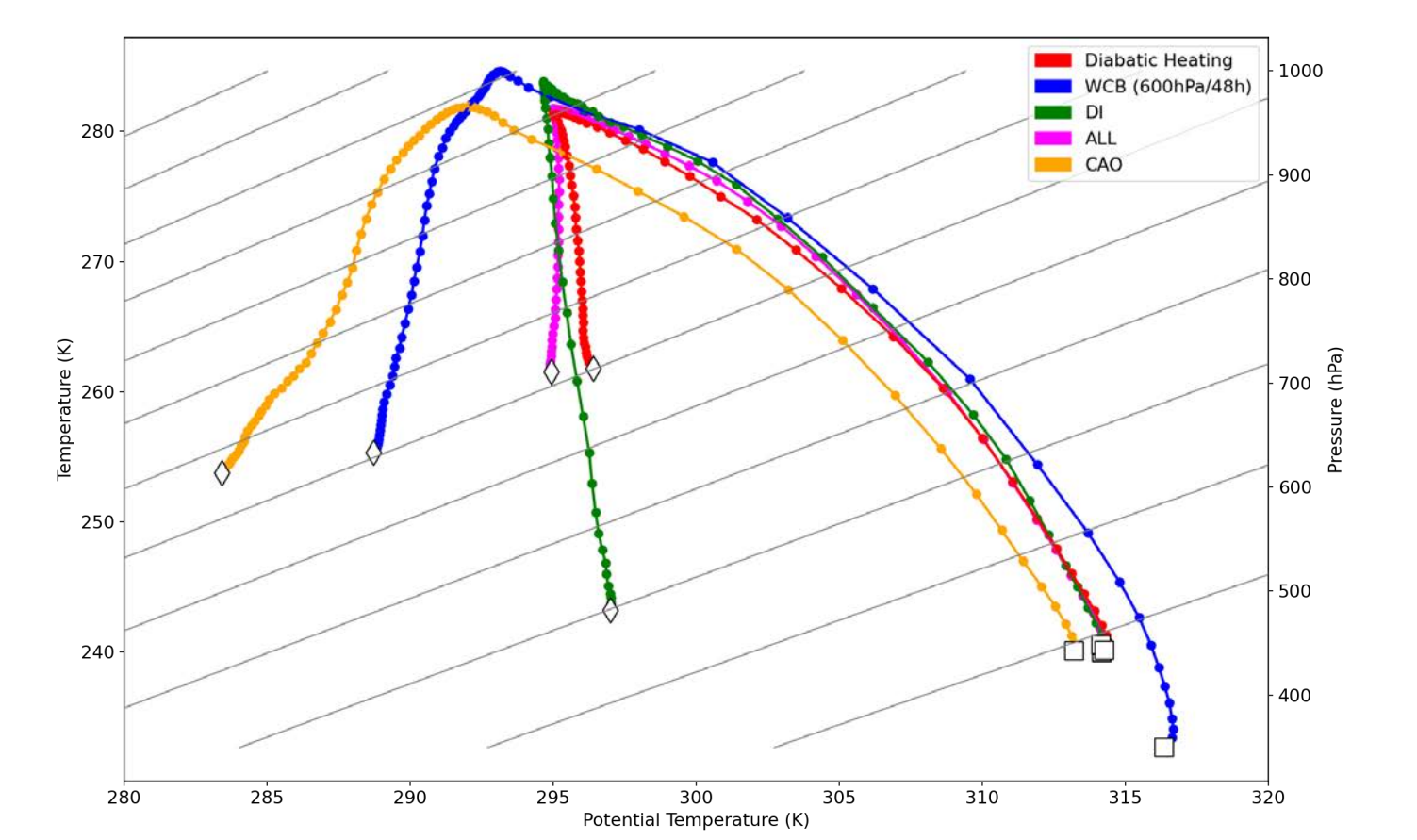


Fig.5. The T-θ diagram for different air streams in the 10 day backward trajectories that passed over GS, diamonds indicate the end of the trajectory and squares – the starting points.

Sources of moisture for trajectories

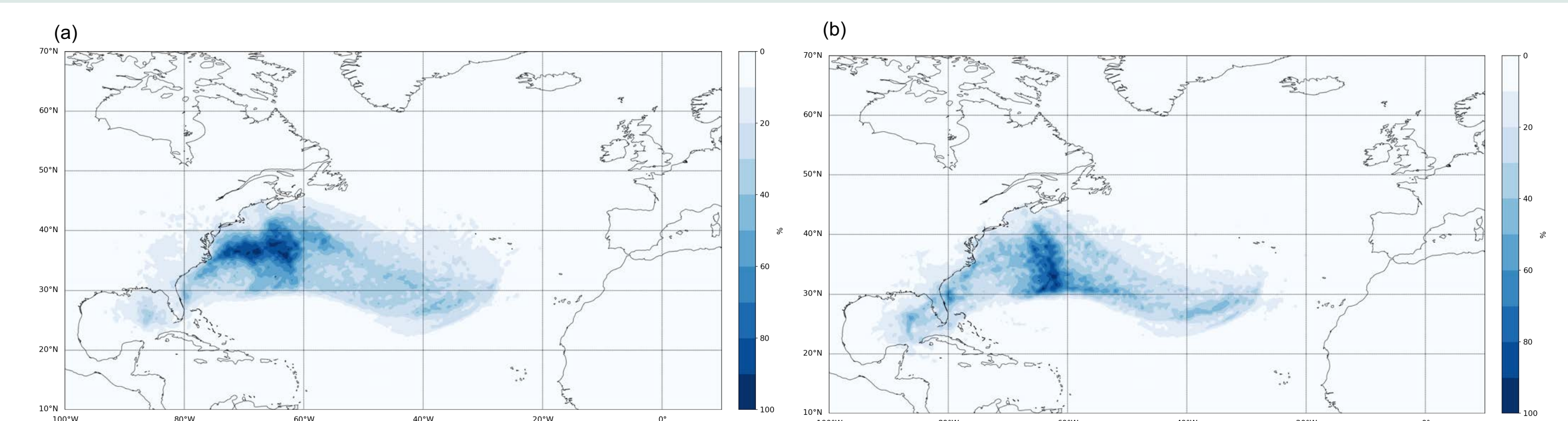


Fig.6. Locations of air parcels which specific humidity increased by 0.2 kg/kg compared to previous time step, (a) trajectories that have undergone CAO, (b) trajectories identified as WCB.

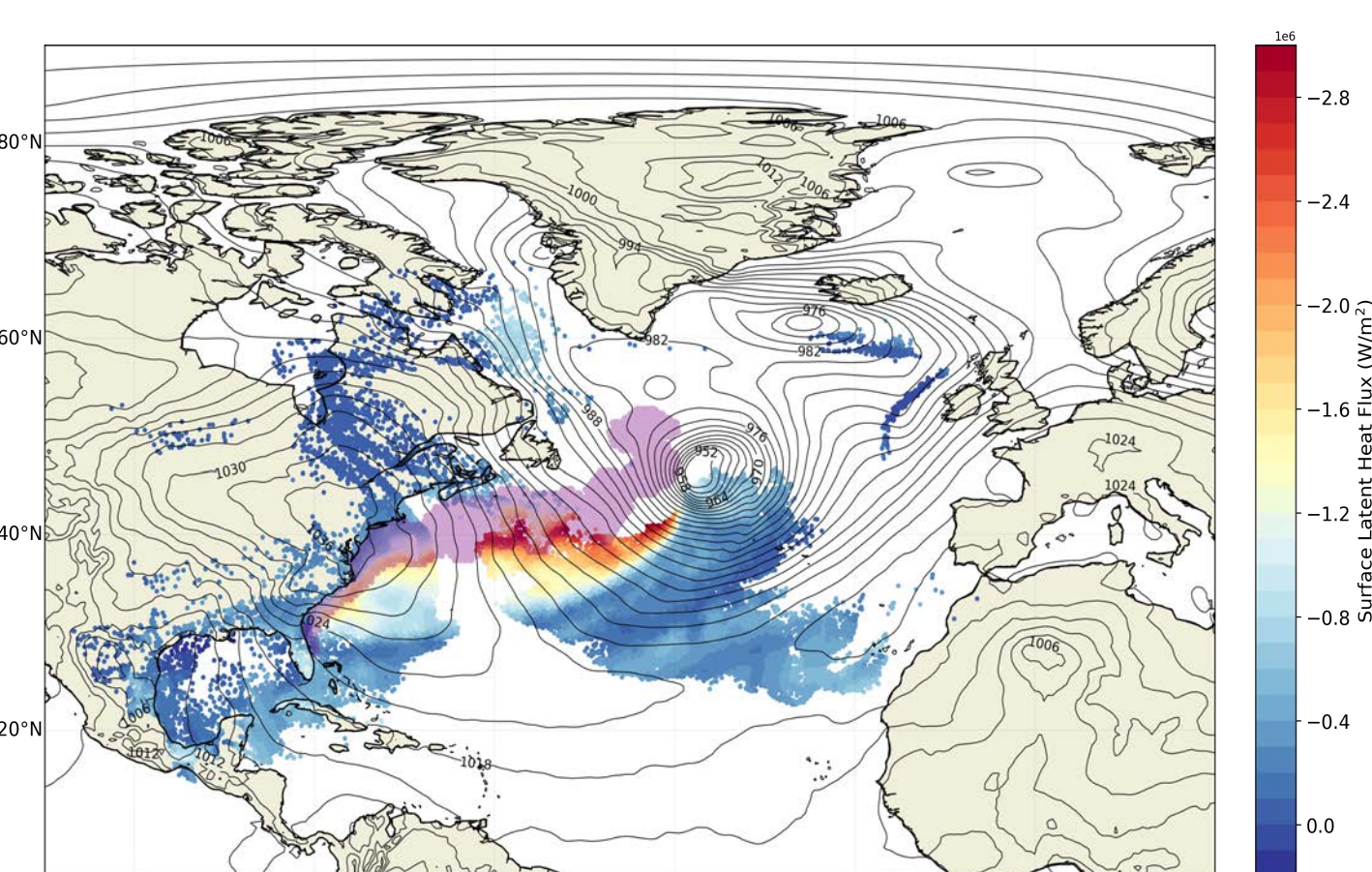


Fig.7. Surface latent heat flux (3h) of air parcels in the inflow stage of the WCB (800-400 hPa) on 2019.02.20 00:00, purple shading- GS SST front.

- ❖ Trajectories that later ascent into the blocking region pick up moisture along, and to the south of the Gulf Stream SST front.
- ❖ Passage of rapidly intensifying cyclones drives the cold, continental air across the SST front creating conditions for large exchange of moisture between ocean and the atmosphere, highlighting the importance of CAO and associated air-sea interactions.
- ❖ Those moist particles transport low PV air into the upper troposphere as they ascent in the warm sector of the cyclone.

Summary and outlook

Presented results show that:

- ❖ the GS SST front region provides heat and moisture for the air particles that later ascent into the blocking and that this contribution might be essential for the development of European Blocking.

Outlook:

- ❖ An APE budget framework (Novak and Tailleux, 2018) will be applied to study the local energetics of the cyclones associated with the blocking.
- ❖ Similar setup of trajectories is going to be calculated for the whole ERA5 period (1979-2021).

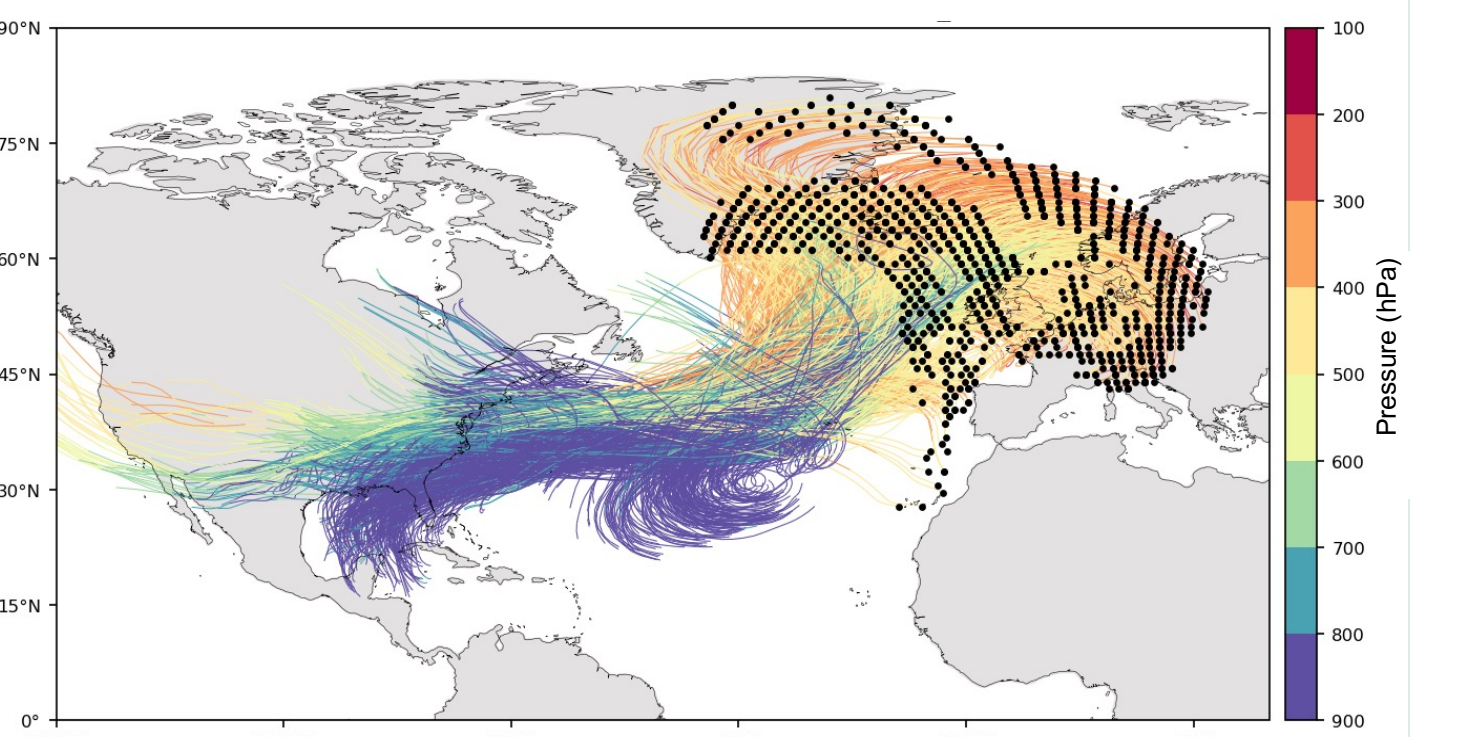


Fig. 8. 5 day backward trajectories started during the onset of the blocking - 20.02.2019 21:00.

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