A 15-Year Climatology of Warm Conveyor Belts

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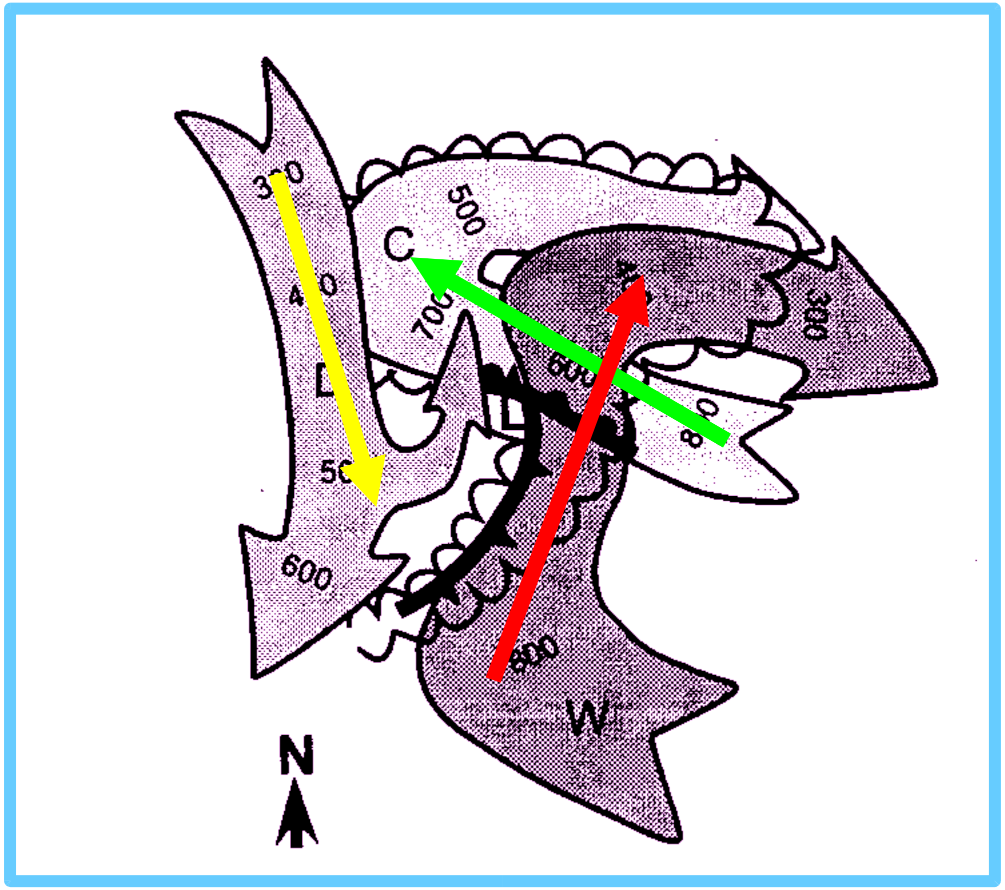
Quasi-Lagrangian Cyclone Model



Cooper (2001)

after Carlson (1980)

Dry Airstream

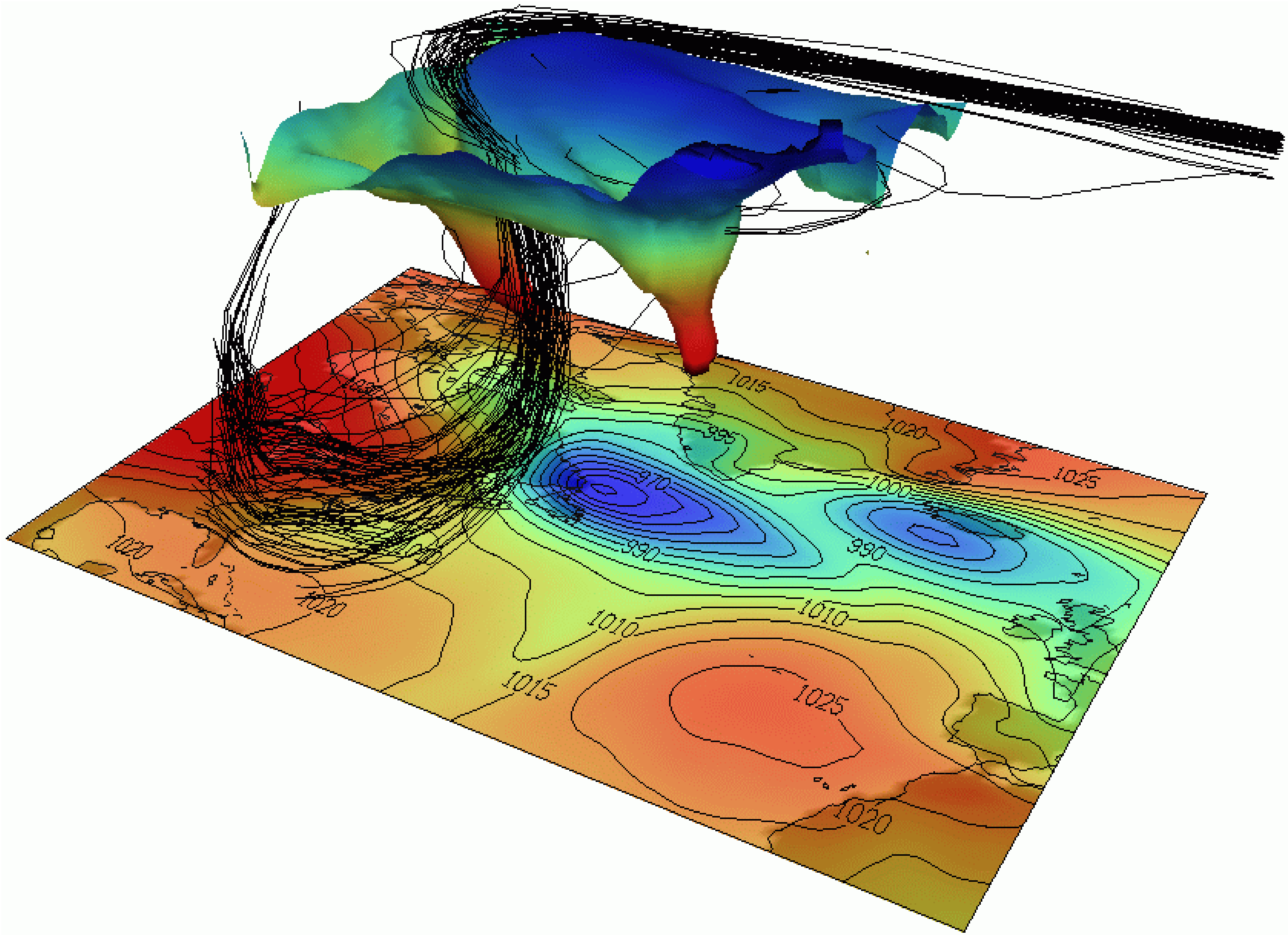
Desecending air stream

Cold Conveyor Belt

Moderately ascending air stream

Warm Conveyor Belt

Rapid ascent ahead of the cold front



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995
1020
1000
1025
970
990
990
1020
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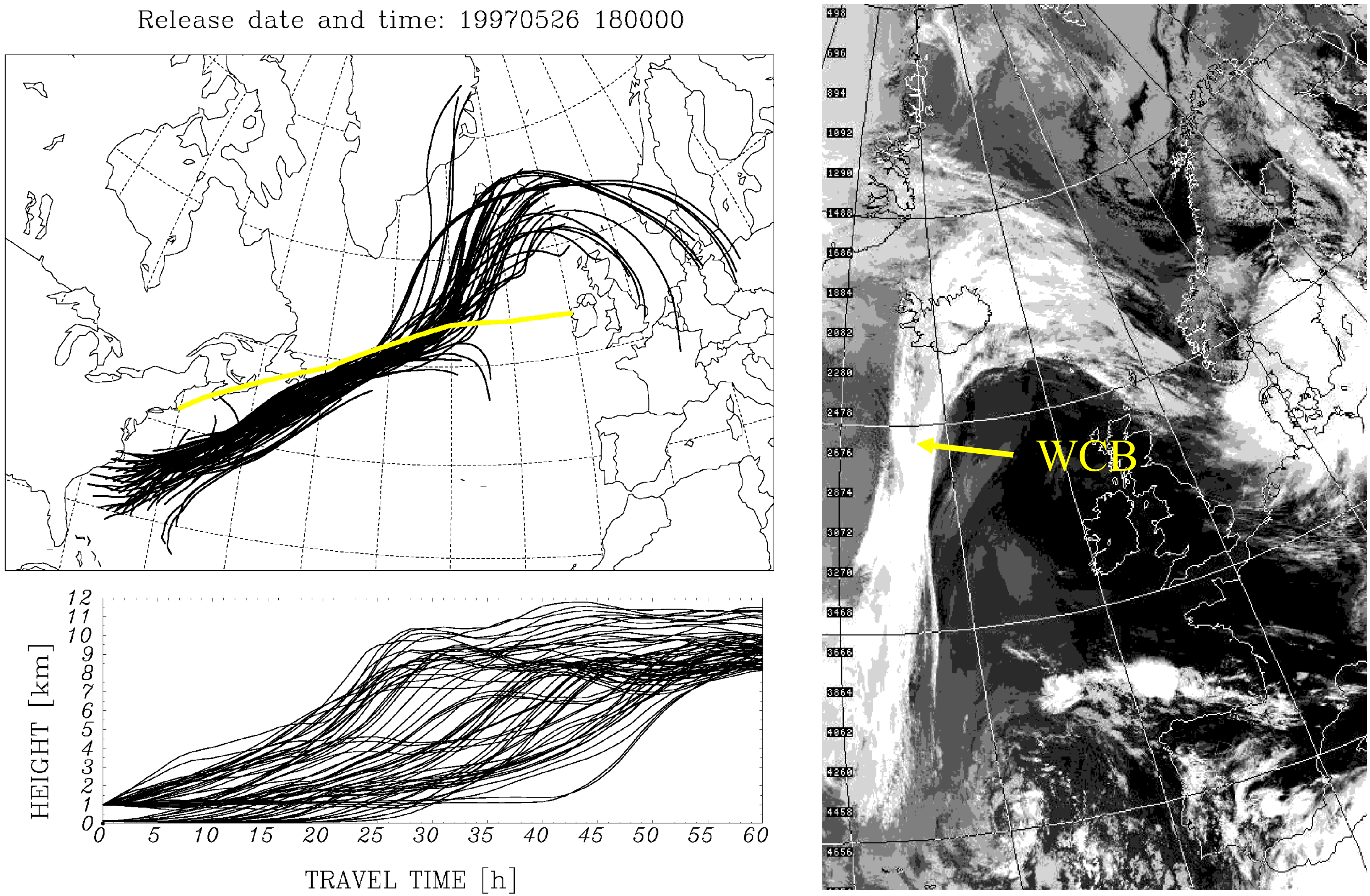

Release date and time: 19970526 180000
HEIGHT [km]
0
1
2
3
4
5
6
7
8
9
10
11
12
TRAVEL TIME [h]
0
5
10
15
20
25
30
35
40
45
50
55
60
WCB

Introduction

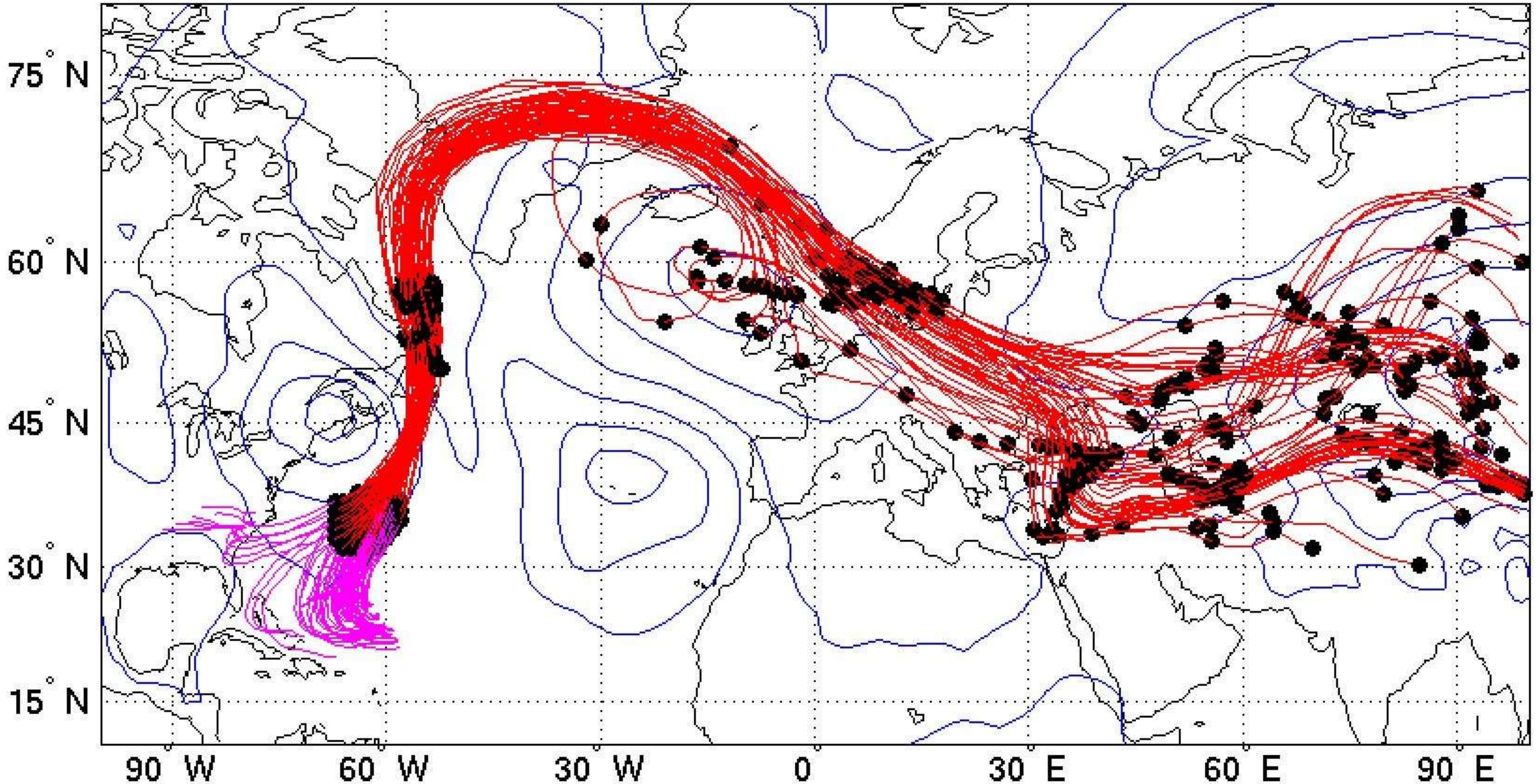
From a dynamical standpoint, WCBs are important for the evolution of the cyclone they pertain to....

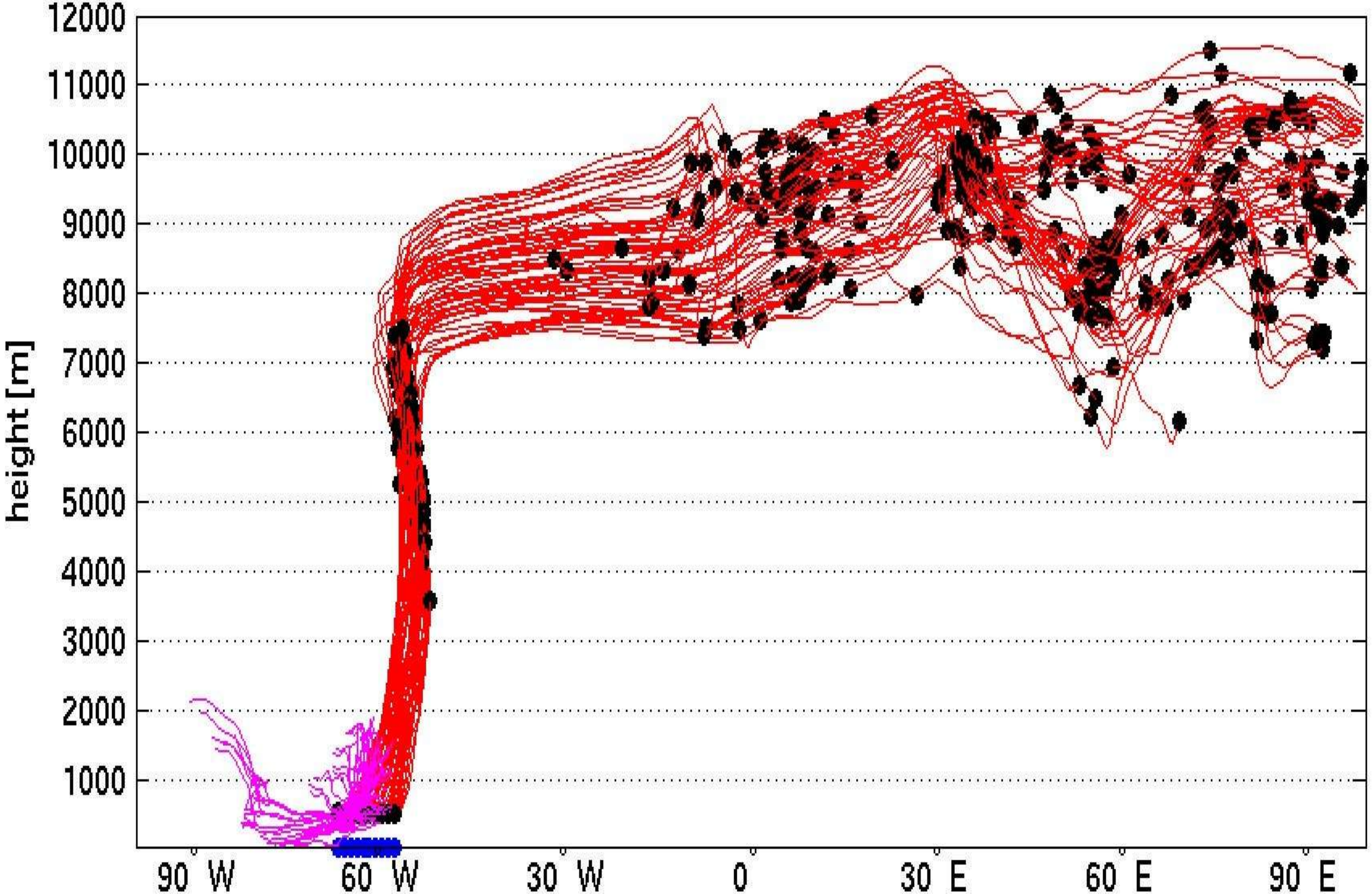
WCBs constitute a Lagrangian manifestation of the impact of latent heat release on cyclone development.

The general picture is that condensational heating leads to the production of positive potential vorticity (PV) anomalies in the lower/middle troposphere and finally to an enhancment of cyclone development that is otherwise determined by dry dynamics.

This suggests that the occurrence of a prominent WCB in the vicinity of an extratropical cyclone hints at a rapid storm development, potentially also leading to explosive genesis of so-called bombs.

Case Study, January 23, 1987





12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
height [m]
90 W
60 W
30 W
0
30 E
60 E
90 E

Results of Case Study

1. During the first 2 days the trajectories were organized as a coherent bundle, and jointly traveled in a wavelike manner

2. At the beginning, the trajectory ensemble was located to the southeast of a cyclone's center.

3. The WCB's moisture flux is about 59 % of the flow in the Amazon river

4. Almost 100 % of the moisture inflow is preciptated out.

WCB Selection Criteria

(automatic, objective identification of WCB from 1979 until 1993)

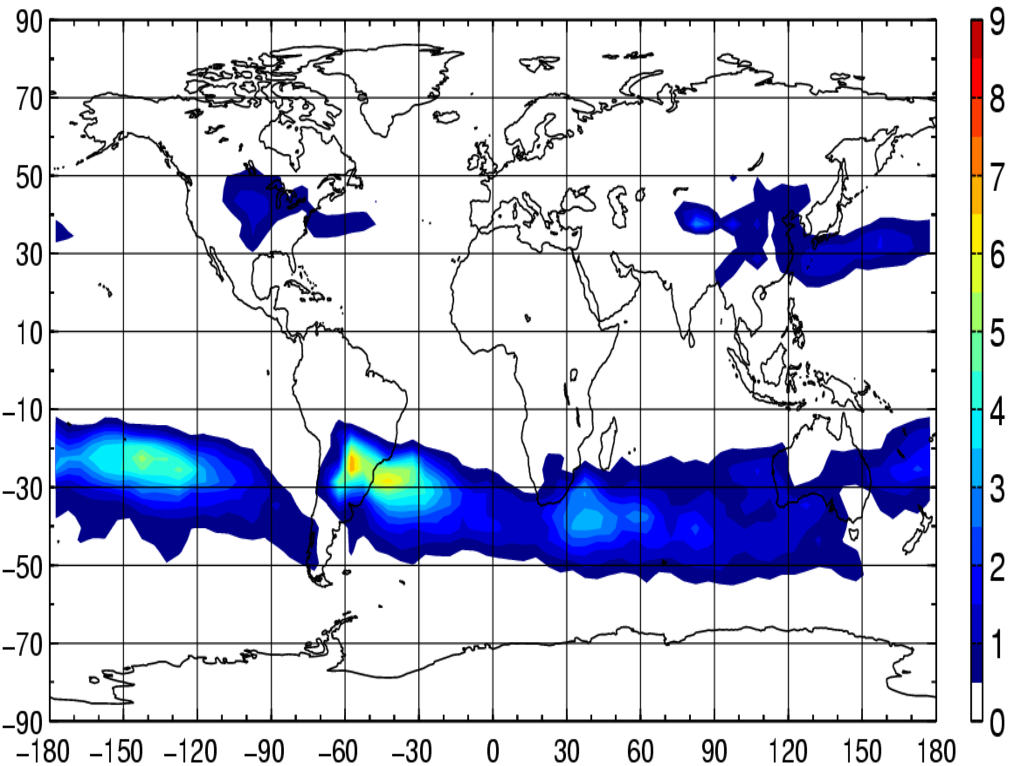
A trajectory was classified as a WCB trajectory if during the first 2 days

1. it traveled more than 10 degrees longitude to the east and more than 5 degrees latitude to the north

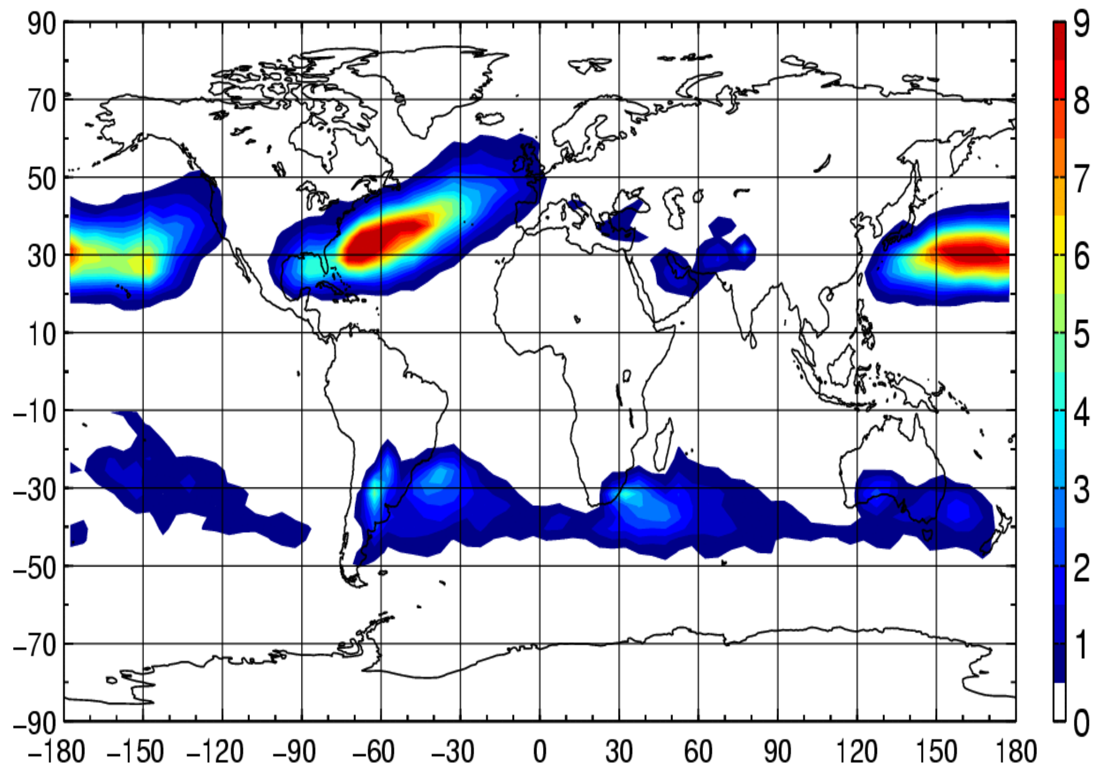
2. it ascended by more than 60 % of the zonally and climatologically averaged tropopause height at the trajectory's latitudinal position after 2 days

The second criterion accounts for the fact that WCBs start in the ABL and rise within about 2 days to the upper troposphere

Starting points of WCBs

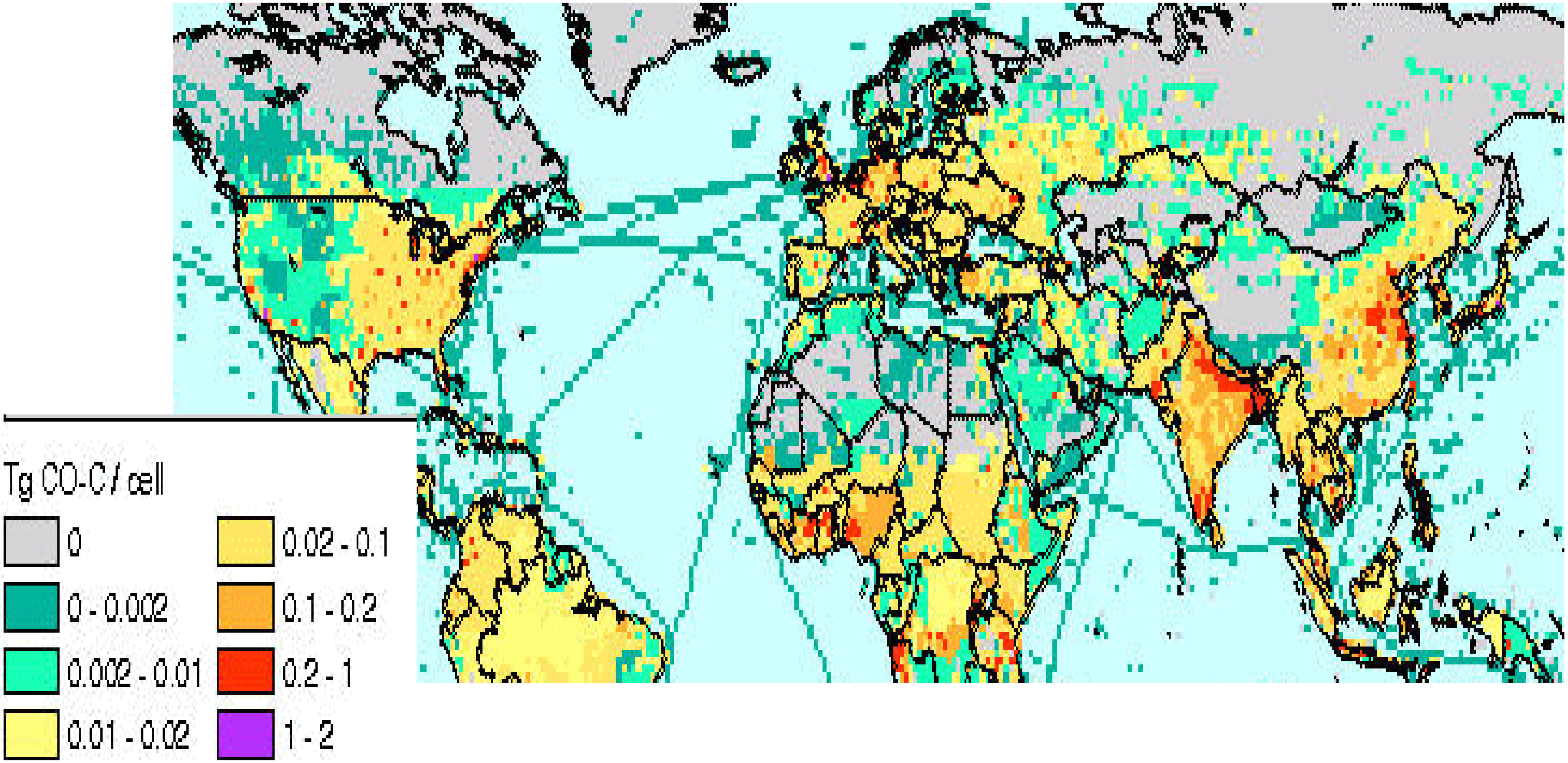


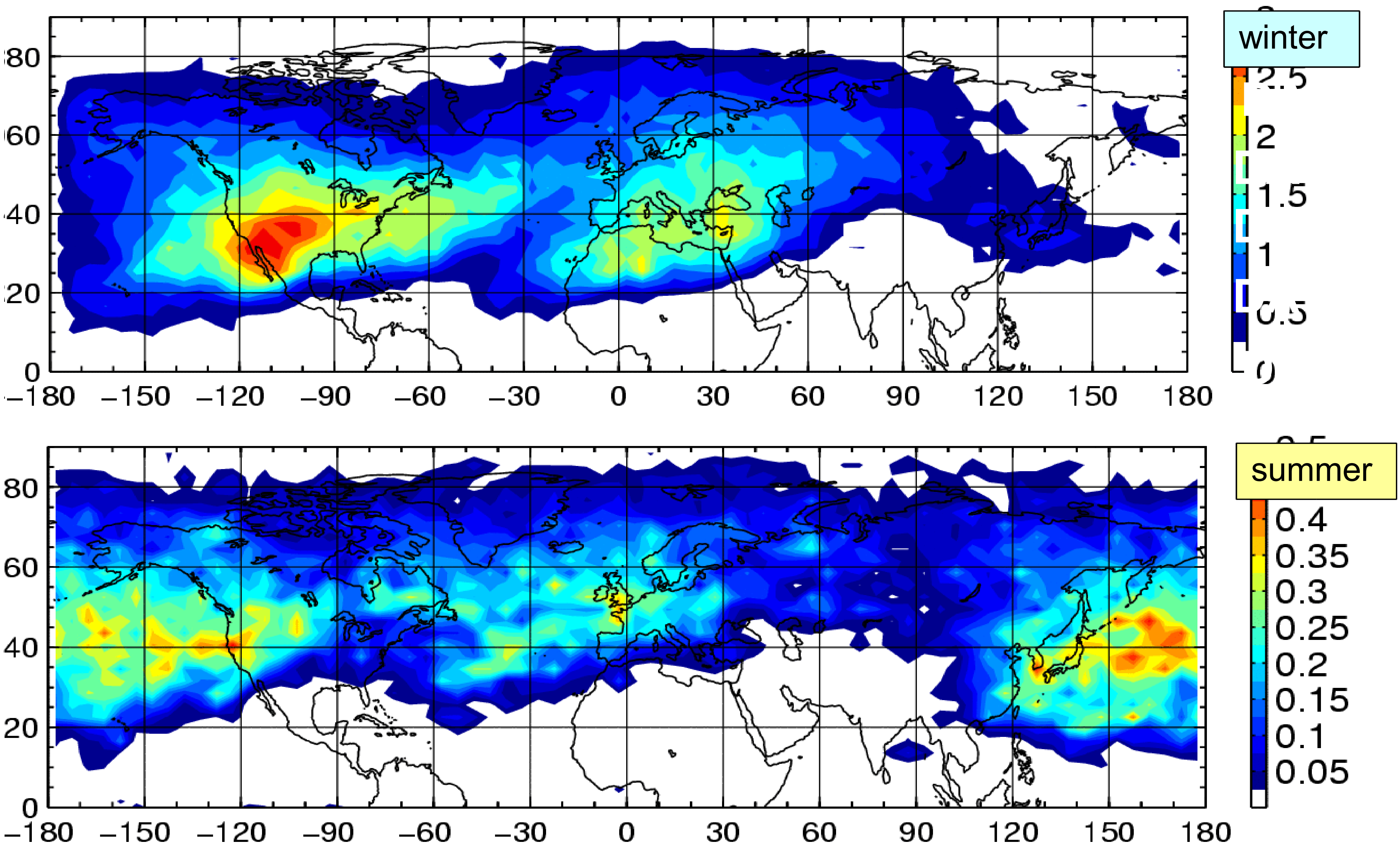
JJA, +0 h



DJF, +0 h

Warm Conveyor Belts and Emissions





winter
summer

Some results

1. WCBs occur more frequently during winter than during summer

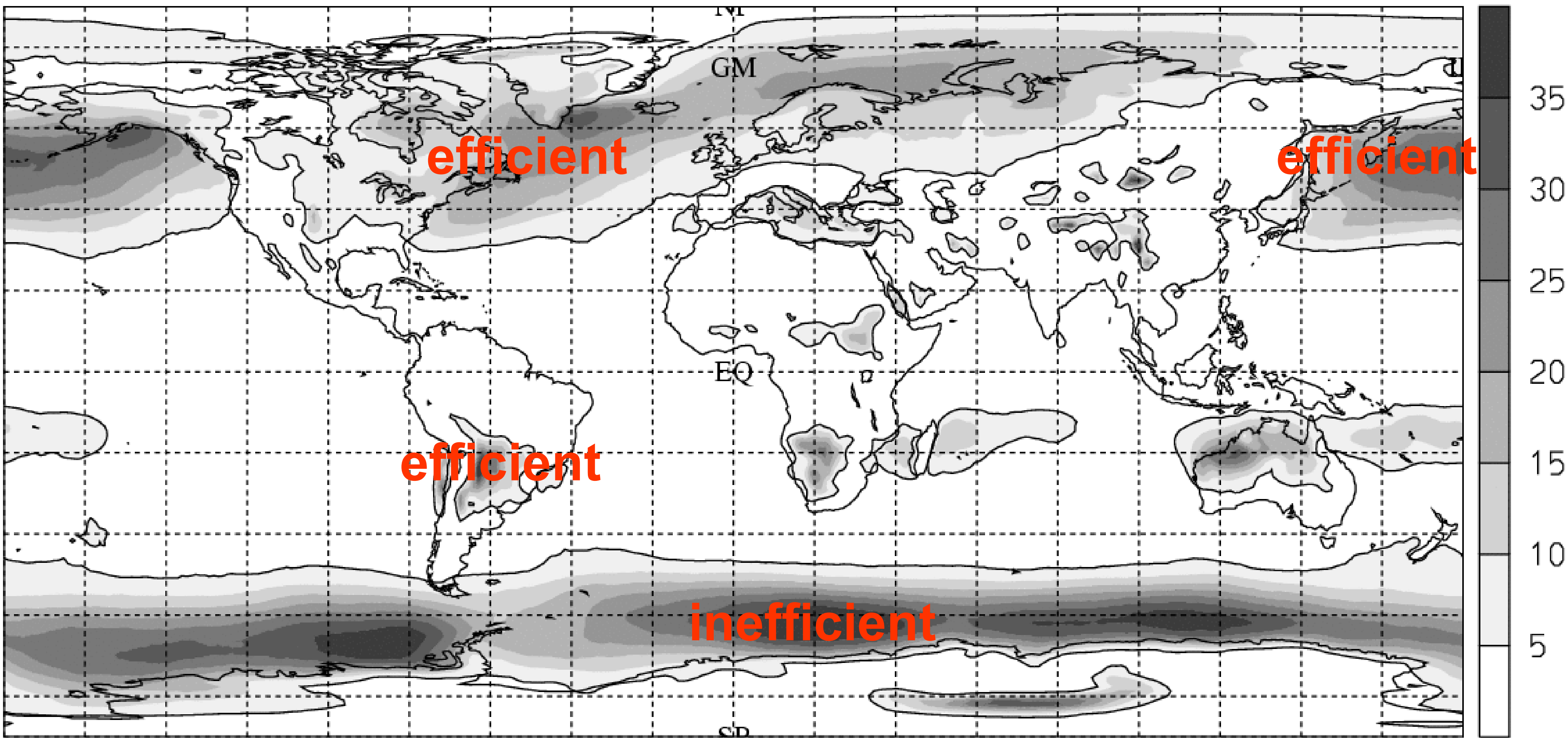
2. This seasonal cycle is particularly strong over the North Atlantic and North Pacific (with about eight times more WCBs during winter than during summer)

3. Very few WCBs originate from Eurasia and western North America

WCBs and Extratropical Cyclones

Most (90%–100% in the NH, 77%–86% in the SH) of the WCBs were found within 1000 km of a cyclone center. The reverse comparison revealed that moving cyclones are normally (more than 60% of them) accompanied by a strong WCB only in the NH winter. In the SH, many of the WCBs are related to quasi-stationary cyclones at rather low latitudes (e.g., over South America). On the other hand, practically no strong WCBs are found around Antarctica, where cyclones are globally most frequent. These cyclones are, thus, less influenced by diabatic processes, in agreement with their smaller growth rates. The large interhemispheric differences of the relationship between cyclones and strong WCBs also reveal considerable differences between the general circulation in the two hemispheres.

Not every cyclone is equally efficient in producing deep WCB transport into the UTLS



Interannuelle Variablilität

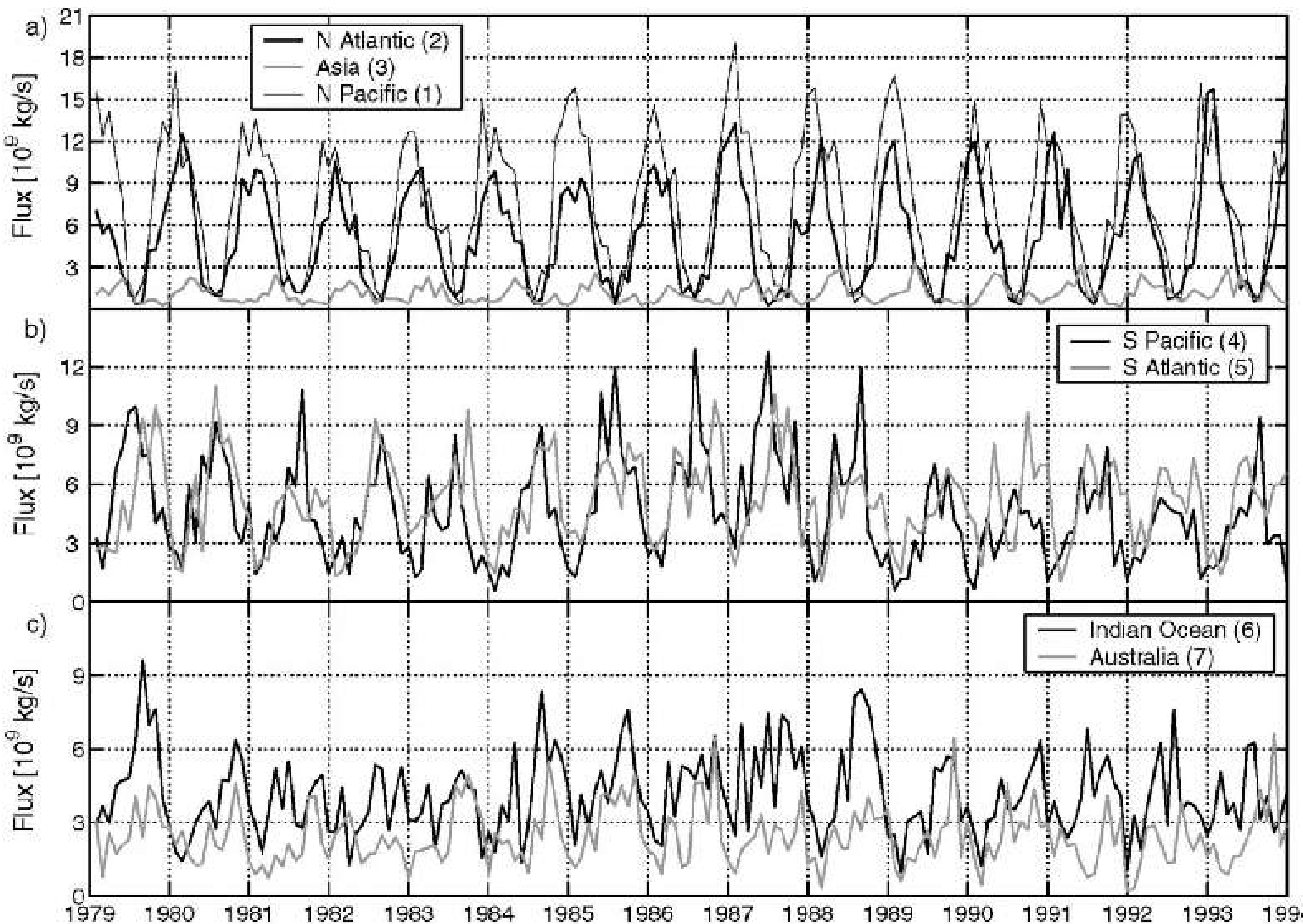


FIG. 12. Fifteen-year time series of monthly WCB mass fluxes (10^9 kg s^{-1}) for the (a) NH, (b) eastern SH, and (c) western SH for the seven boxes shown in Fig. 3.

Nordatlantische Oszillation (NAO)

NAO-

NAO+

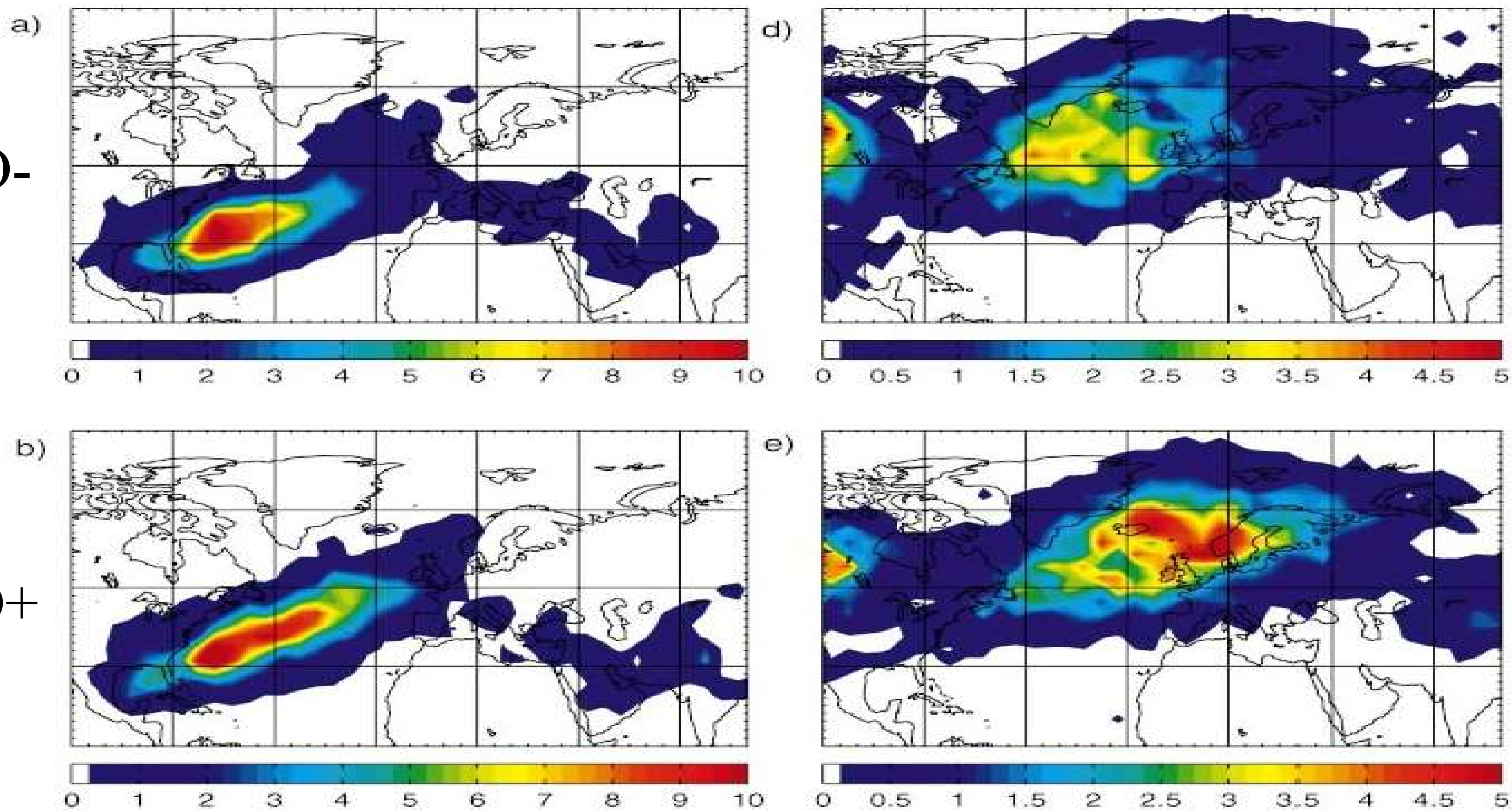


FIG. 14. The relation between WCBs and the NAO index: Spatial distribution of the frequency (in percent of all trajectories) of (a) and (b) WCB trajectory starting points and (d) and (e) WCB trajectory positions after 48 h for ensembles of the nine winter months (three Dec, three Jan, three Feb) associated with the (a) and (d) lowest and the (b) and (e) highest values of the NAO index during the 15-yr period from 1979–93. Correlation analysis was performed for each grid cell between WCB frequency and NAO index (for 15 winters). (c) and (f) Correlation coefficients of the NAO index and WCB frequency for (c) WCB trajectory starting points and (f) WCB trajectory positions after 48 h for all winter months. Correlation coefficients greater (smaller) than 0.29 (−0.29) are statistically significant on the 95% confidence level.

In the winter, there is a highly significant correlation between the North Atlantic Oscillation and the WCB distribution in the North Atlantic: In months with a high NAO index, WCBs are about 12% more frequent and their outflow occurs about 10° latitude farther north and 20° longitude farther east than in months with a low NAO index. The differences in the WCB inflow regions are relatively small between the two NAO phases.

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