A LAGRANGIAN ANALYSIS OF THE MOISTURE TRANSPORT DURING DROUGHT EPISODES IN THE DANUBE RIVER BASIN

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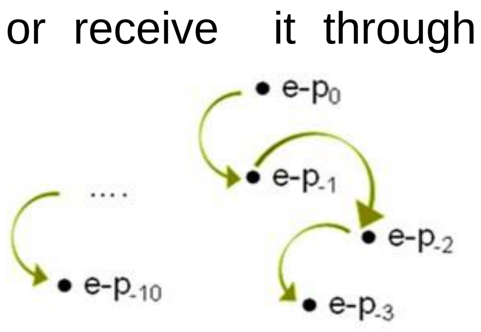
MOTIVATIONS AND OBJECTIVES

In this study, we apply a Lagrangian approach to investigate changes in the moisture transport over Danube River Basin (DRB) during drought episodes. It uses the outputs of the FLEXPART model integrated with the ERA-Interim data set. The most important drought episodes in the DRB in the period from 1980 to 2014 have been identified and characterized via the Standardized Precipitation Evapotranspiration Index (SPEI). Forward and backward in time experiments have been done in order to investigate possible changes in the moisture transport from and toward the DRB during these episodes.

I. LAGRANGIAN METHOD

- ✓ FLEXPART v9.0 model + ERA-Interim reanalysis data (available every 6 hours at a 1° horizontal resolution on 61 vertical levels)
- ✓ The atmosphere divided into approximately 2.0 million air particles with constant mass
- ✓ The transport time of the particles limited to 10 days (averaged period of residence of the water vapour in the atmosphere)
- ✓ Changes in specific humidity (q) with time help us to identify those particles that lose moisture through precipitation (p) or receive it through evaporation (e).



II. DETERMINATION OF THE DROUGHT EPISODES IN THE DANUBE RIVER BASIN

- ✓ **Determination** though the **SPEI-6**
- ✓ **Drought events reached the peak of -1.5**
- ✓ **Multiscalar events**
- ✓ **Most intensive events (intensity=severity/duration)**

- ✓ **1989-1992: Dry conditions during the extended Winter season (Oct-Mar)**
- ✓ **2003-2005: Dry conditions during the extended Summer season (Apr-Sep)**

Dry conditions identified through SPEI-6 (using values which reached the peak of -1.5 in March for winter and September for summer season in period 1980-2014)

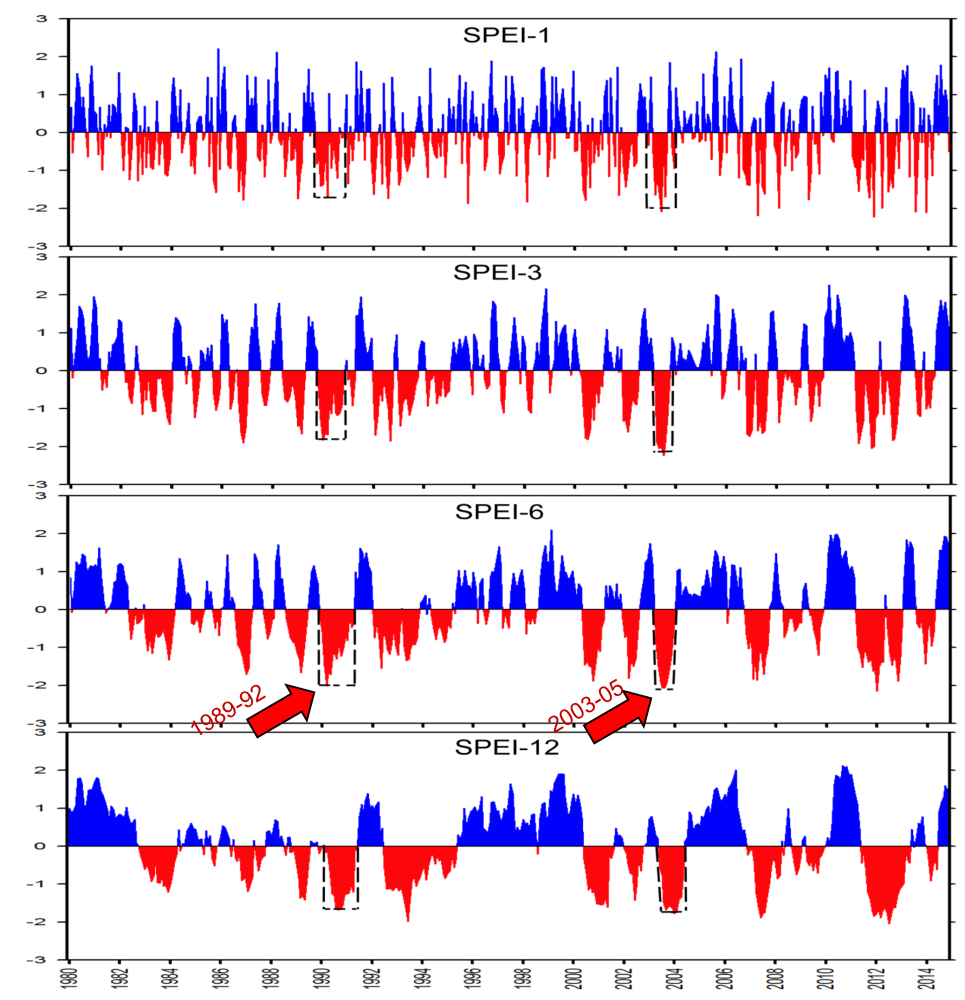


Figure 1. Time series of SPEI-1, SPEI-3, SPEI-6, SPEI-12

III. METHOD

- ✓ **We track (E-P) from Danube River Basin *backward* and *forward* in time along the trajectories.**
- ✓ ***Backward tracking:* identifies where the particles gain humidity along their trajectories towards the target area (sources of moisture E-P > 0).**
- ✓ **DRB (Danube River Basin) receives moisture from seven different moisture source regions: North Atlantic Ocean (NATL), North Africa (NAF), Mediterranean Sea (MED), Black Sea (BS), Caspian Sea (CS), Danube River Basin (DRB) and Central and Eastern Europe (RestL).**
- ✓ ***Forward method:* identifies those particles that leave the basin and follows them to find where they lose moisture (areas presenting E-P < 0).**

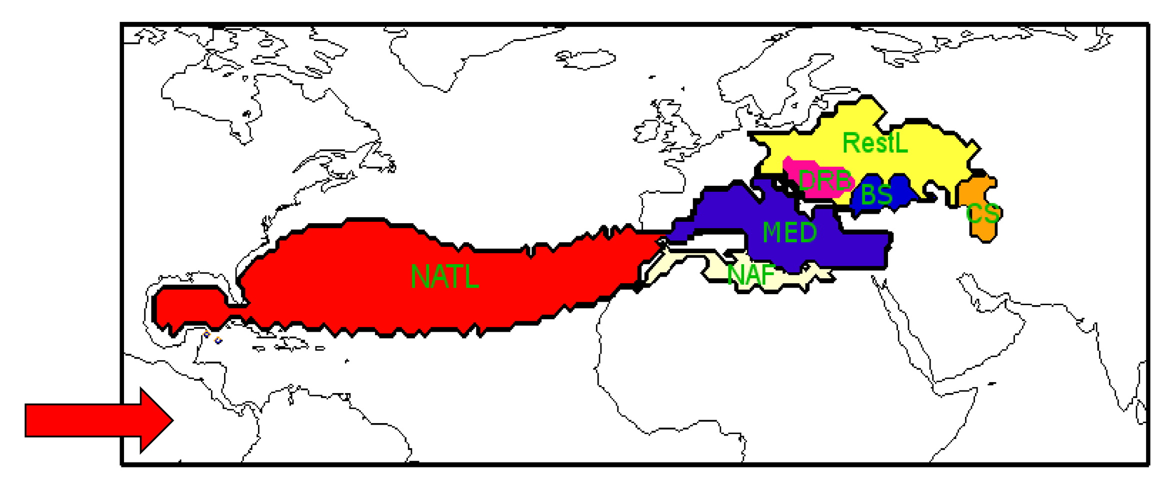


Figure 2. Schematic moisture sources obtained from backward DRB experiment. The black contour line indicates the sources (selected via the 90th percentile of the (E-P)>0 values: 0.06 mm/day).

IV. Drought events 1989-1992 and 2003-2005

- ✓ Events identified through the monthly SPEI-1, SPEI-3, SPEI-6, SPEI-12, and SPEI-24 time series

Table 1. Characteristics of the drought events 1989/1992 and 2003/2005

Drought events	SPEI timescale	Drought episodes inside of the event	Duration (month)	Severity	Intensity	Month of peak value
Oct 89 to Feb 92	SPEI-1	Oct-89 to Mar-90	6	6,12	1,02	Mar-90 (-2,01)
		May-90 to Aug-90	4	3,22	0,80	
		Jan-91	1	1,36	1,36	
	SPEI-3	Nov-89 to Nov-90	13	13,68	1,05	
	SPEI-6	Dec-89 to Apr-91	17	16,88	0,99	
	SPEI-12	Mar-90 to Jun-91	16	16,24	1,01	
	SPEI-24	Dec-89 to Feb-92	27	20,68	0,76	
Feb 03 to Apr 05	SPEI-1	Feb-03 to Aug-03	7	8,8	1,25	Jul-03 (-2,24)
	SPEI-3	Mar-03 to Oct-03	8	12,03	1,50	
	SPEI-6	Mar-03 to Jan-04	11	14,01	1,27	
	SPEI-12	Jun-03 to May-04	12	16,5	1,37	
	SPEI-24	Apr-03 to Apr-05	25	20,6	0,82	

Anomalies over the DRB during the 1989/1992 and 2003/05 events

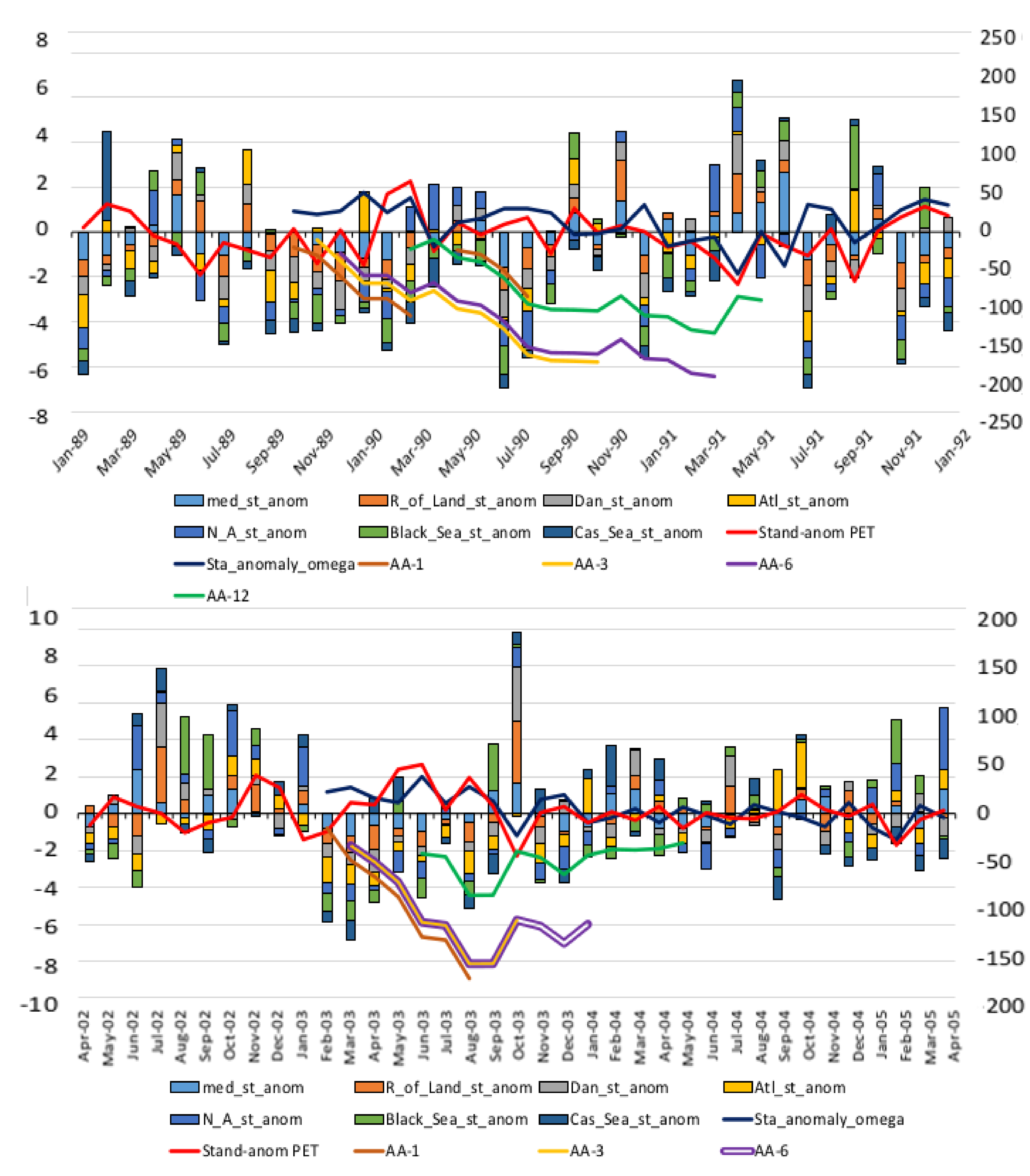


Figure 3. Standardized anomalies of the moisture contribution from the sources over DRB obtained via forward experiment (bars) with standardized anomaly of CRU potential evapotranspiration (PET, red lines), and of ERA-Interim omega at 500hPa (Omega500, dark blue). The AA lines indicate the anomalies of the CRU precipitation accumulated during the SPEI episodes in the different time scales (1, 3, 6,12) shown in the Table 1.

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