Mechanisms behind salinity anomaly signals of the northern North Atlantic

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Hydrographic time series from the Subarctic Gyre of the North Atlantic throughout the 20th century show oscillations in temperature and salinity at more or less regular intervals. The Great Salinity Anomalies described during the 1970s (Dickson *et al.*1988) and during the 1980s (Belkin *et al.* 1998) have particularly large amplitudes, and both of them were described as low salinity anomalies. Inspection of the propagation speeds of the two great anomalies shows a distinct feature: They started out with a high propagation speed in the Greenland-Labrador region and slowed down considerably as they reached the Nordic Seas. Further inspection of time series from the northeast Atlantic and the northwest Atlantic over the past century shows, however, several other distinct negative anomalies of lesser amplitudes. Additionally, a number of high salinity anomalies can be identified where the propagation speeds are opposite of the low anomalies: The high salinity anomalies started out with a low propagation speed in the Labrador region and increased when it reached the Nordic Seas.

The present paper analyses further the propagation of the negative and positive anomalies and links them together, and shows that the Great Salinity Anomalies are artefacts and not caused by one single mechanism, but is the result of two separate events following each other in time on each side of the North Atlantic. It is shown that they have varying speeds of propagation, and that the varying speeds are correlated across the North Atlantic (Table 1 and Figure 1). A high propagation speed of high salinity anomaly in the Northeast Atlantic corresponds in time with a high propagation speed of a low salinity anomaly in the Northwest Atlantic. Conversely, a low speed of a low salinity anomaly in the Northeast Atlantic corresponds in time with a low speed of a high salinity anomaly in the Northwest. The varying volume fluxes of the Subarctic Gyre are proposed to be the causal mechanism behind the anomaly signals, and the North Atlantic Oscillation (NAO) might partly explain the flux variations described. Periods of large decadal-scale amplitudes of the NAO coincide with periods of large decadal-scale oscillation in the marine climate. High propagation speeds between the North Atlantic and the Arctic tend to dominate during periods of high NAO Indices while low propagation speeds tend to dominate during periods of low NAO Indices (Figure 2). The correlation coefficient, r^2, between the NAO Indices and the propagation speeds of the anomalies is 0.41 for all the anomaly events analysed during the 20th century. The events during the beginning of the 20th century are based on proxy data. When these proxy data are excluded the correlation coefficient increases to 0.62. These new consideration about the anomalies will contribute to improve the predictions based on lags of the climate signals of the North Atlantic. As an example, an extreme low salinity (and cold) anomaly takes about 3 years to propagate from the Faroe-Shetland region to the Barents Sea, while an extreme high salinity (and warm) anomaly takes less than 1.5 years.

Table 1. Periods of high and low salinity anomalies in the northeast Atlantic and the northwest Atlantic and their speeds of propagation 1947-1990.

	NORTHEAST ATLANTIC Faroe/Shetland – Kola Section			NORTHWEST ATLANTIC Fylla Bank – Station 27		
PERIOD	SALINITY ANOMALY	PROPAGATION SPEED	PERIOD	SALINITY ANOMALY	PROPAGATION SPEED	NAO PHASE
47 - 50	No clear signal	**	47 - 50	HIGH	2,6 cm/s	LOW -> HIGH
50 - 52	No clear signal	**	50 - 52	LOW	4,0 cm/s	HIGH
58 - 60/61	HIGH	3,0 cm/s	57/58 - 60	LOW	3,2 cm/s	LOW -> HIGH
62 - 66	LOW	1,9 cm/s	61 - 65	HIGH	2,0 cm/s	LOW
66/67 - 69	HIGH	3,6 cm/s	69/70 - 71/72	LOW	4,0 cm/s	HIGH -> LOW
75 - 79	LOW	2,3 cm/s	79 - 82	HIGH	2,6 cm/s	LOW
82/83 - 84	HIGH	5,5 cm/s	82 - 83/84	LOW	5,3 cm/s	HIGH
85/86 - 88/89	LOW	2,6 cm/s	87 - 89/90	HIGH	3,2 cm/s	LOW

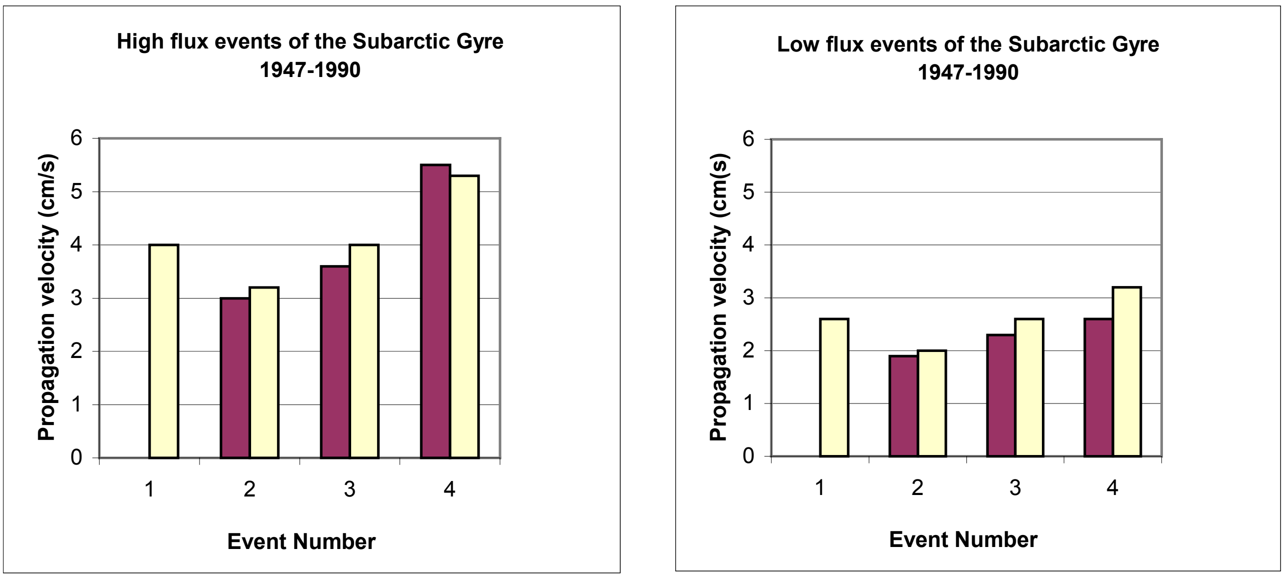

Figure 1. Propagation speeds of salinity anomalies in the Northeast Atlantic (light bars) and the Northwest Atlantic (dark bars) for high flux events (left) and low flux events (right). See Table 1.

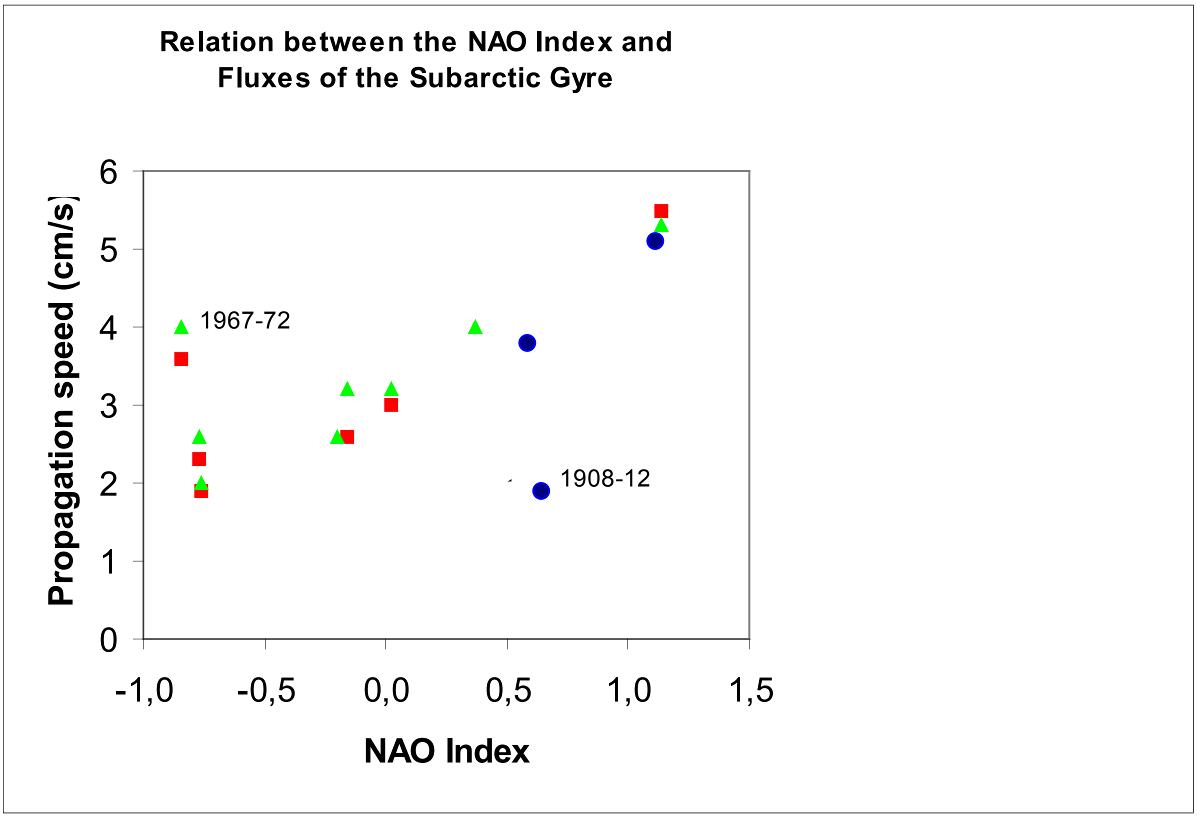

Figure 2. Relation between the propagation speeds of the high and low climate anomalies of the 20th century and the 3-years running mean NAO Index three years earlier. *Triangles*: Fylla Bank – Station 27. *Squares*: Faroe/Shetland- Kola. *Circles*: Faroe/Shetland-Kola 1904-14.