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Unusual sea temperature conditions in the Adriatic in summer 1992

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Extremely high sea surface temperatures appeared along the Eastern Adriatic coast in summer 1992. At the same time lower layers in the open sea were colder than the long-term averages. It was assumed that stable conditions prevailed causing poorer grade of vertical mixing due to the lack of winds. Stable condition is related to the unusual absence of Karachi depression. Coastal upwelling once generated by a local wind, should be more evident from sea surface temperature temporal changes.

Summer 1992 appeared as extremely hot and dry season over the entire Adriatic Sea region. August was particularly warm, dry and sunny in the whole Croatia, including the Adriatic coast (Hidrometeorološki bilten, 8/92). In continental Croatia (Zagreb) this month was the warmest month since 1861 when measurements started.

Among the other phenomena sea surface temperature in the coastal region was exceptionally high, as for example in Split.

Split sea surface temperature has been mesured since 1951 (twice a day in the Institute harbour).

Table 1. Average August sea surface temperature (^{0}C) at Split, Marjan Cape

YEAR	AUGUST MEAN	YEAR	AUGUST MEAN
1951	23.0	1972	23.4
1952	24.7	1973	23.5
1953	23.3	1974	24.2
1954	22.8	1975	21.9
1955	22.7	1976	21.7
1956	25.2	1977	23.8
1957	23.6	1978	22.3
1958	24.3	1979	23.1
1959	23.3	1980	24.2
1960	23.1	1981	22.7
1961	22.9	1982	24.5
1962	24.6	1983	23.1
1963	24.6	1984	23.2
1964	22.2	1985	24.6
1965	23.6	1986	24.9
1966	24.9	1987	24.4
1967	25.0	1988	24.1
1968	22.6	1989	23.8
1969	23.3	1990	23.3
1970	23.5	1991	22.8
1971	24.2	**1992**	**25.8**
		AVERAGE	23.7

From Table 1 it is evident that in 1992 the average sea surface temperature in August was highest for the entire period of 42 years.

All the other stations along the eastern coast showed exceptionally high temperatures, as well. Satelite infrared images showed that the Adriatic Sea surface temperature in August 1992 was for about 3^{0}C higher than in August 1991 (Borzelli, personal comunication).

On the contrary, vertical temperature distribution, showed low temperatures below 10 m depth. Figs. 1 and 2 present long-term averages of the vertical temperature distribution in August and values for 1992 for permanent stations Stončica and Kaštela Bay (for data source see Zore-Armanda *et al.*, 1991).

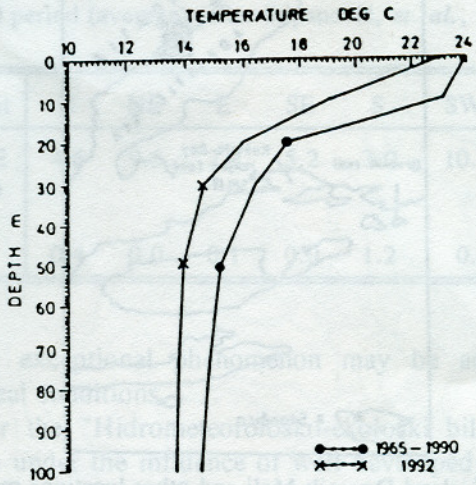

Fig. 1. Average vertical temperature distribution in August at permanent station Stončica (single sampling every August in the period 1965-1990) and values for August 1992

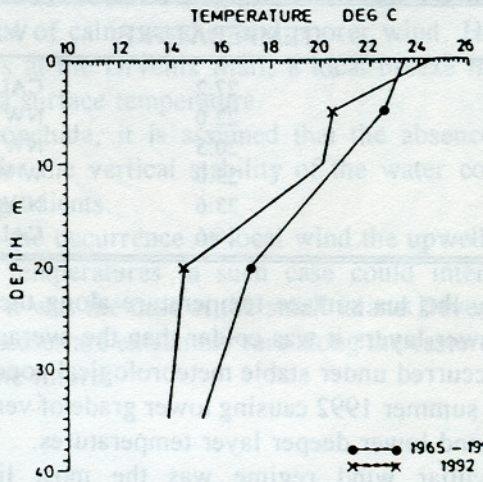

Fig. 2. Average vertical temperature distribution in August at permanent station Kaštela Bay (collected in the period 1965-1990) and values for August 1992

Sea surface temperature was also very high at the island Drvenik Mali (see Fig. 3). However, unusually great temperature drop occurred all of a sudden.

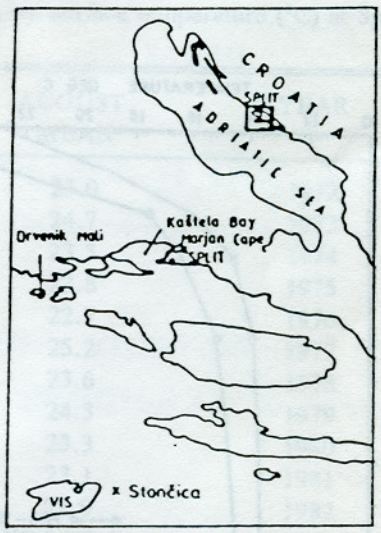

Fig. 3. Location of island Drvenik Mali and other locations mentioned in the article

Table 2. Sea surface temperature (^{0}C) recorded at the island Drvenik Mali at 5 p.m. in August 1992

1992	TEMPERATURE	WIND CONDITIONS
12.08.	27.2	CALM
13.08.	22.0	NW WIND (MAESTRAL)
14.08.	20.5	NW WIND (MAESTRAL)
15.08.	23.0	W WIND
17.08.	23.6	NW WIND (MAESTRAL)
20.08.	26.6	CALM

Generally, the sea surface temperature along the coast was unusually high and in the lower layers it was colder than the average.

All this occurred under stable meteorological conditions over the entire Adriatic region in summer 1992 causing lower grade of vertical mixing resulting in higher surface and lower deeper layer temperatures.

Quite peculiar wind regime was the most likely cause of such conditions.

This refers to the apparent prevalence of calms, and particularly the absence of bura (NE) and SW wind which is a local wind related to etesian maestral (a NW wind over the open Adriatic). This is particularly evident if the average August wind values, exceeding 3 Bf for the 1945-1970 period, are compared to August 1992 values (Table 3).

Table 3. Direction frequencies (%) for winds exceeding 3Bf at station Split for the 1945-1970 period (average) (after Stipanović, *et. al.*, 1972) and for August 1992.

Station Split	N	NE	E	SE	S	SW	W	NW	C
AVERAGE 1945-1970	4.6	9.5	2.9	5.2	3.0	10.7	0.6	1.7	61.8
1992	0.4	0.0	0.1	0.0	1.2	0.7	0.1	0.0	97.5

This exceptional phenomenon may be accounted for by peculiar meteorological conditions.

After the "Hidrometeorološko-ekološki bilten" in August 1992 the weather was under the influence of well developed Azores anticyclone which established a "blocking" situation (Figure 4.). Globally, the high pressure zone developed at 35th parallel spreading from the Atlantic to the Eurasian continent (Himalaya), which is normally under the influence of Karachi depression. High positive anomalies of monthly mean sea-level air pressure (Fig. 5) show that Karachi Low was absent in August 1992. This situation resulted presumably in a long interval of calm weather and poorer wind. However, as shown by the measurements at the Drvenik Mali, a local breeze may cause local upwelling and lower sea surface temperature.

To conclude, it is assumed that the absence of wind is presumably responsible for the vertical stability of the water column and higher vertical temperature gradients.

With the occurrence of local wind the upwelling seems to be possible. Lower deep temperatures in such case could intensify the phenomenon of upwelling as it was the case at the small island Drvenik Mali.

Such cases are extremnly rare along the eastern Adriatic coast and worth studying in the future.

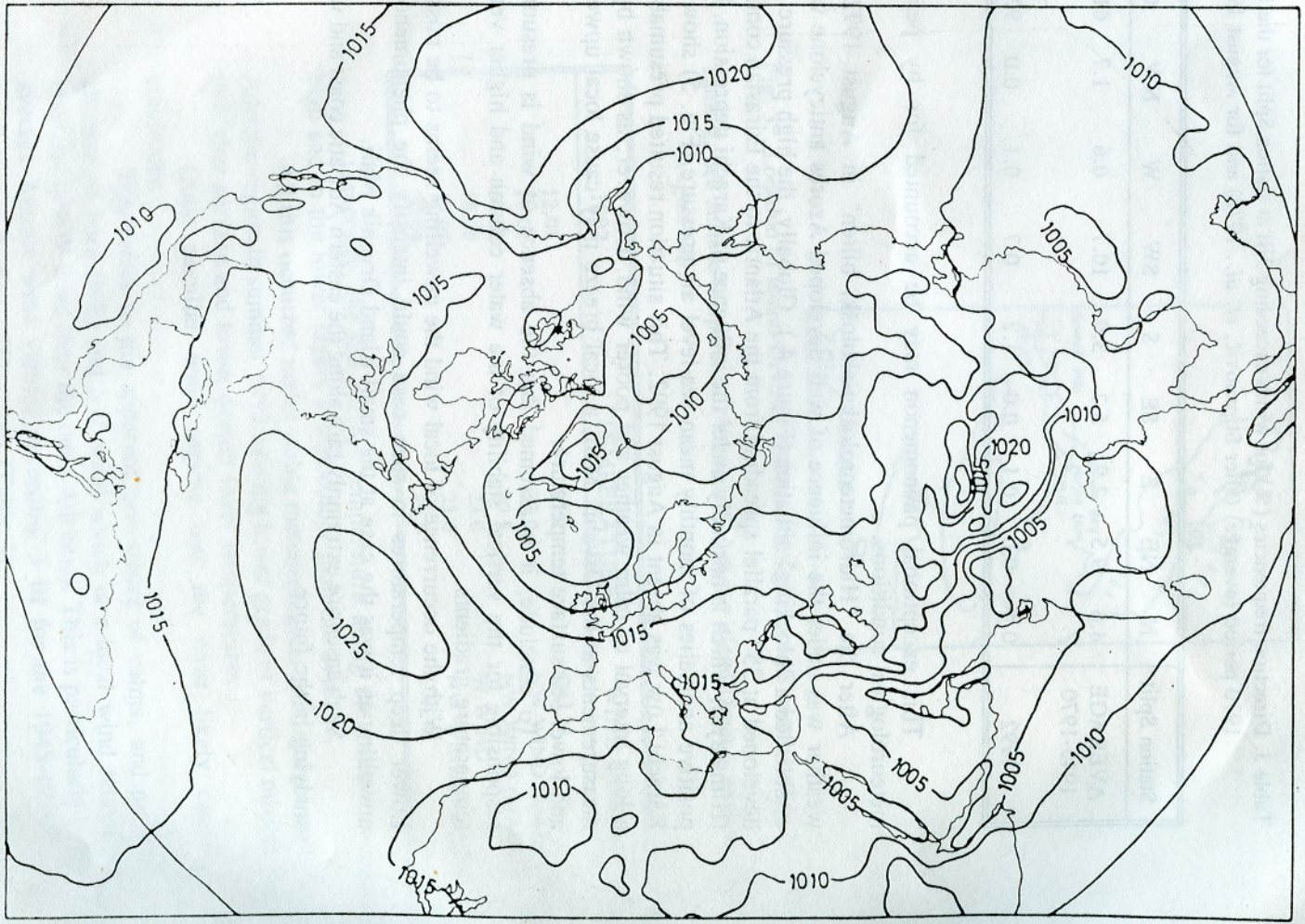

Fig. 4. Mean sea-level air pressure in August 1992 after Grosswetterlagen Europas. Unusually high pressure was

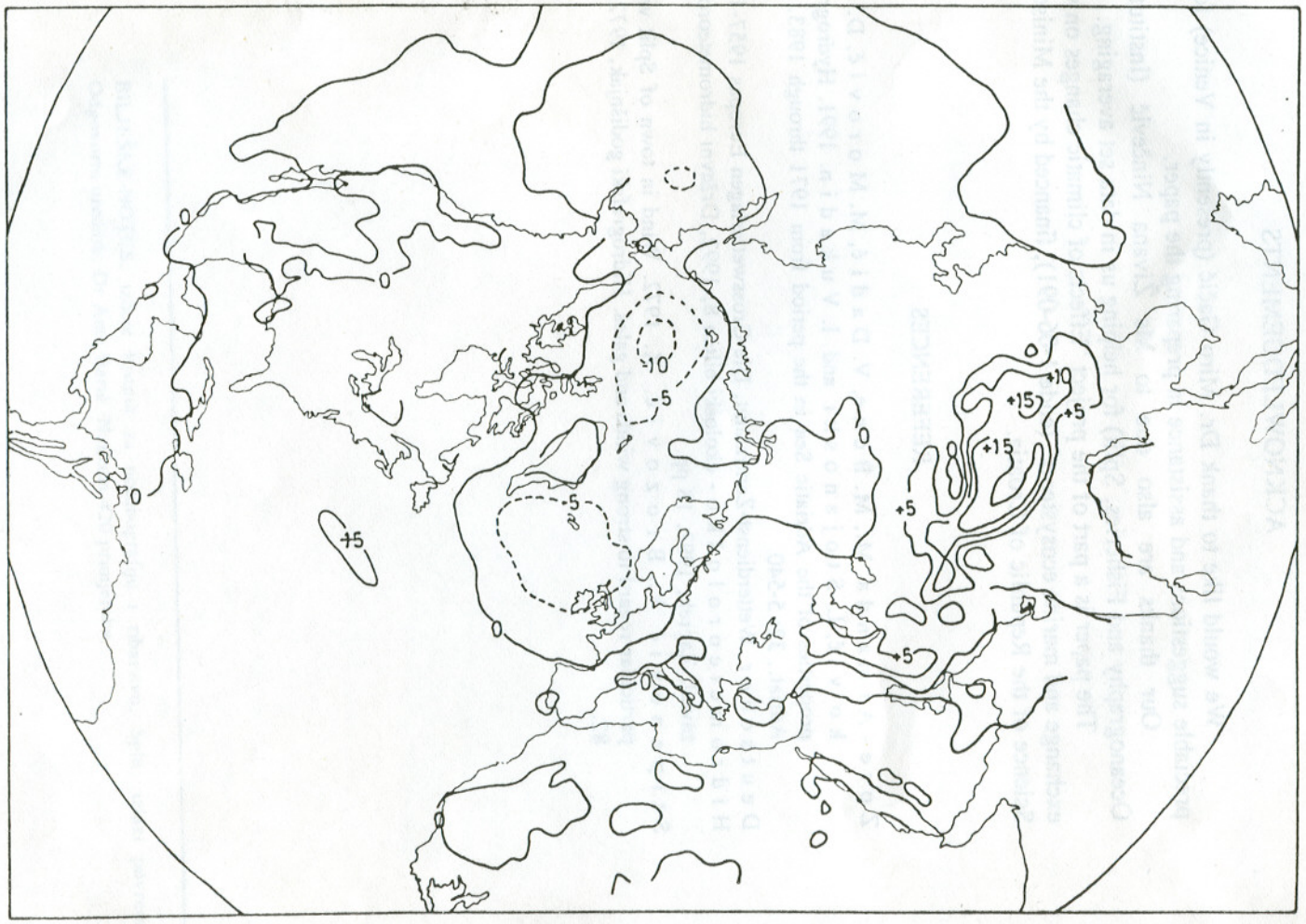

Fig. 5. Departures of monthly mean sea-level air pressure (1900-1939) for August in 1992 after Grosswetterlagen Europas. Extremlly rare air pressure conditions are clear from high positive anomalies spreaded over the south Eurasian continent causing the large zone of gradientless field in the subtropic belt from Atlantic over the Mediterranean towards Indian subcontinent

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