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INTERNAL DOCUMENT 244

I.O.S.

Maximum levels at Bridge of Earn, Tay Estuary.

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Bidston, Birkenhead, U.K.

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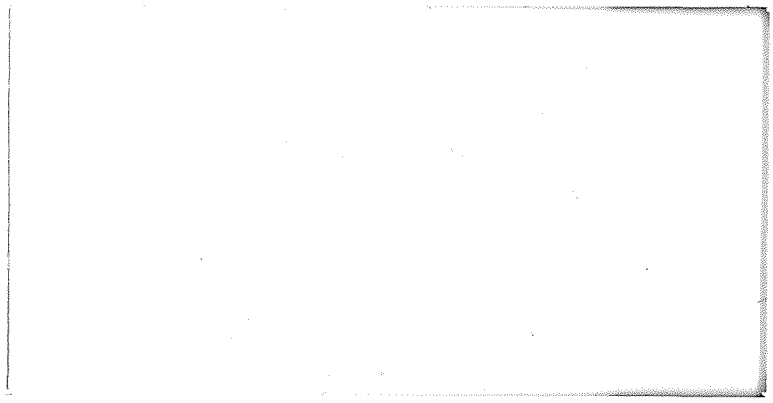

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Method

Maximum levels have been estimated by combining the predicted High Water (HW) at Newburgh (56°21'N 03°14'W) with the corresponding nearest hourly surge elevation.

Hindcast HW was computed at Newburgh using height and time differences based on Aberdeen, as given in the Admiralty Tide Table volume I and reproduced in Table 1. A linear interpolation for both time and height was used to compute differences to apply to HWs occurring outside the Mean High Water times and range.

Surges in the Tay Estuary (56°27'N 02°58'W ie near Dundee, see Fig 1) were estimated by multiplying observed hourly surges at Aberdeen by 1.1. This is the scaling factor of (S^{+}_{max})Tay/(S^{+}_{max})Aberdeen obtained from a numerical model simulation of storm surges in the North Sea (Flather, 1979). The time taken for a surge to travel between two sites is similar to that taken by the diurnal tidal wave (Heaps, 1967). The phase difference between the O_1 and K_1 tidal constituents at Aberdeen and Dundee is approximately equivalent to 1.3 hours, so the scaling factor was applied to surges occurring at Aberdeen one hour before the appropriate HW time at Newburgh. For the events of 1974, 1981 and 1982, observations were available for Aberdeen which had been processed by IOS; but for 1984, surges were extracted from the charts of storm surge elevation issued by the Storm Tide Warning Service. No observations from either IOS or STWS were available for the June 1985 event.

The surge estimates have not been adjusted for any possible amplification due to propagation up the Tay estuary. For a significant amplification of surges, the estuary length needs to be approximately 1/4 the wavelength of the surge wave. Assuming the surge period is 24 hours and the water depth is 4 metres, then the $1/4\lambda$ will be approximately 120 km. As the estuarine length from Dundee to Bridge of Earn is approximately 25 km, no significant amplification is expected.

Local wind action could raise or lower the observed level due to set-up or set-down. The simplest model for wind-induced level variations along a channel assumes a balance between the wind stress component along the channel and the pressure gradient associated with the elevation difference. Then

$$g \frac{d\zeta}{ds} = \frac{\tau_s}{\rho D},$$

where ζ is surge elevation, g is acceleration due to gravity, s is distance along channel, τ_s is component of wind stress along the channel, ρ is water density, D is total water depth.

Assuming channel length (S_2-S_1) = 25 km, mean depth = 4m, wind stress (say force 8 wind) $\doteq$ 0.8 N/m^2, ρ = 1025 kg/m^3, and g = 9.8 m/s^2, then ζ = 0.5 metre. No allowance has been made for this possible effect.

Results

All estimates of levels are given in metres to Admiralty Chart Datum at Newburgh. Subtract 1.30m for levels to Ordnance Datum (Newlyn), or Subtract 1.56m for levels to mean sea level.

	High Water time (GMT)	Estimated level (metres)
1974 Jan 30	0727	2.5
	1930	1.9
31	0817	3.0
	2028	3.1
Feb 01	0923	2.6
	2144	2.7

	High Water time (GMT)	Estimated level (metres)
1981 Sep 25	1344	3.9
26	0154	3.9
	1420	4.0
27	0234	3.9
	1457	3.9
1982 Dec 18	0459	3.7
	1659	3.7
19	0537	3.2
	1733	4.1
20	0621	3.5
	1811	4.2
1984 Nov 26	0518	4.0 (Tide only, no
	1725	4.0 surge data available)
27	0608	3.8
	1806	4.2
28	0700	3.9
	1852	3.5 (Tide only, no surge data available)

References

Flather, R.A., 1979. "Recent results from a storm surge prediction scheme for the North Sea". 385-409 in Marine Forecasting (J.C.J. Nihoul, Ed.), Elsevier, Amsterdam.

Heaps, N.S., 1967. "Storm surges". Oceanogr. Mar. Biol. Ann. Rev., 5, 11-47.

	Time differences High Water (GMT)		Height differences (metres) MHWS	MHWN
ABERDEEN	0000 and 1200	0600 and 1800	4.3	3.4
NEWBURGH	+0212	+0203	-0.2	-0.4

TABLE 1

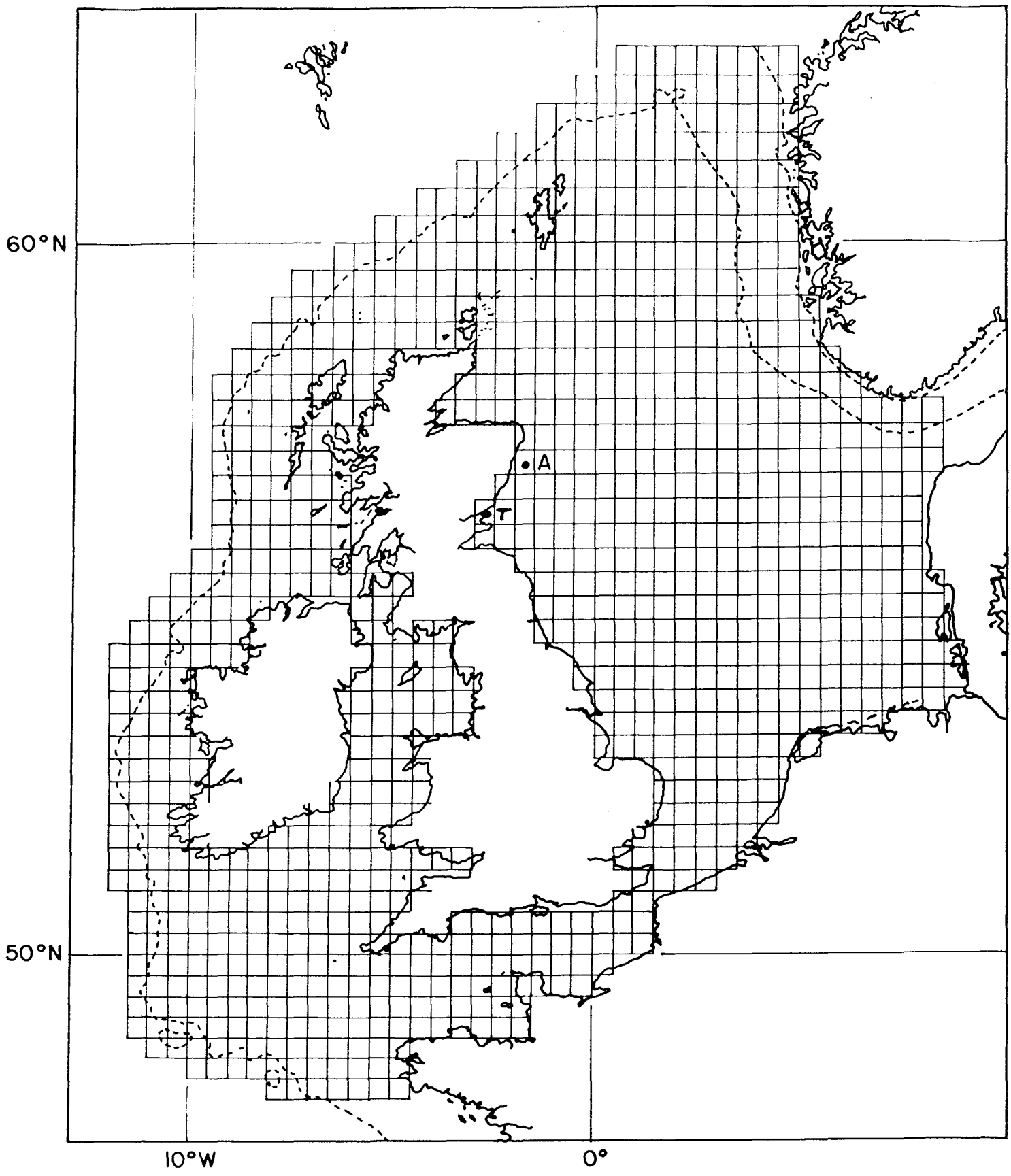

Figure 1 Finite difference grid of the Continental Shelf Model (CSM) with points referred to in the text.