



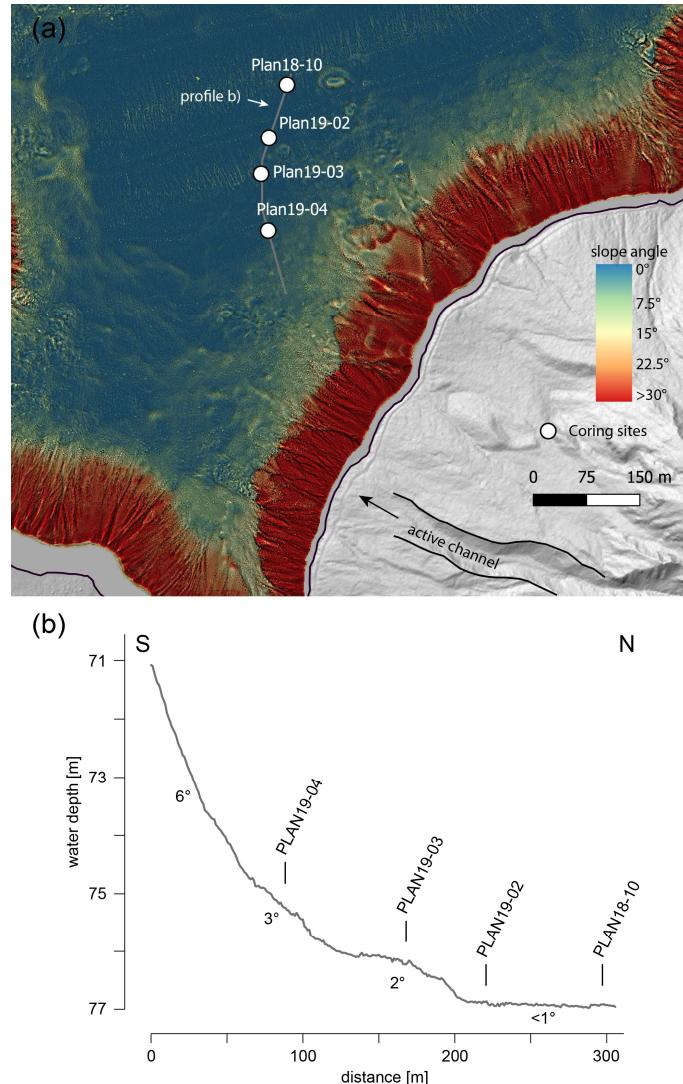
*Supplement of*

## **A 4000-year debris flow record based on amphibious investigations of fan delta activity in Plansee (Austria, Eastern Alps)**

**Carolin Kiefer et al.**

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**Fig. S1:** Transect of short cores at proximal (Plan 19-04) to distal (Plan 18-10) locations with respect to the juvenile fan. a) Bathymetric slope gradient map showing the coring sites of the transect and the spur of profile b. b) Vertically exaggerated topographic profile from the proximal fan delta in the South across the short core transect towards the depocentre. Note that although the cores are relatively closely spaced (50–75 m) there is almost 2 m height difference between the most proximal to the most distal core. Onshore DEM derived from Land Tirol (data.tirol.gv.at).

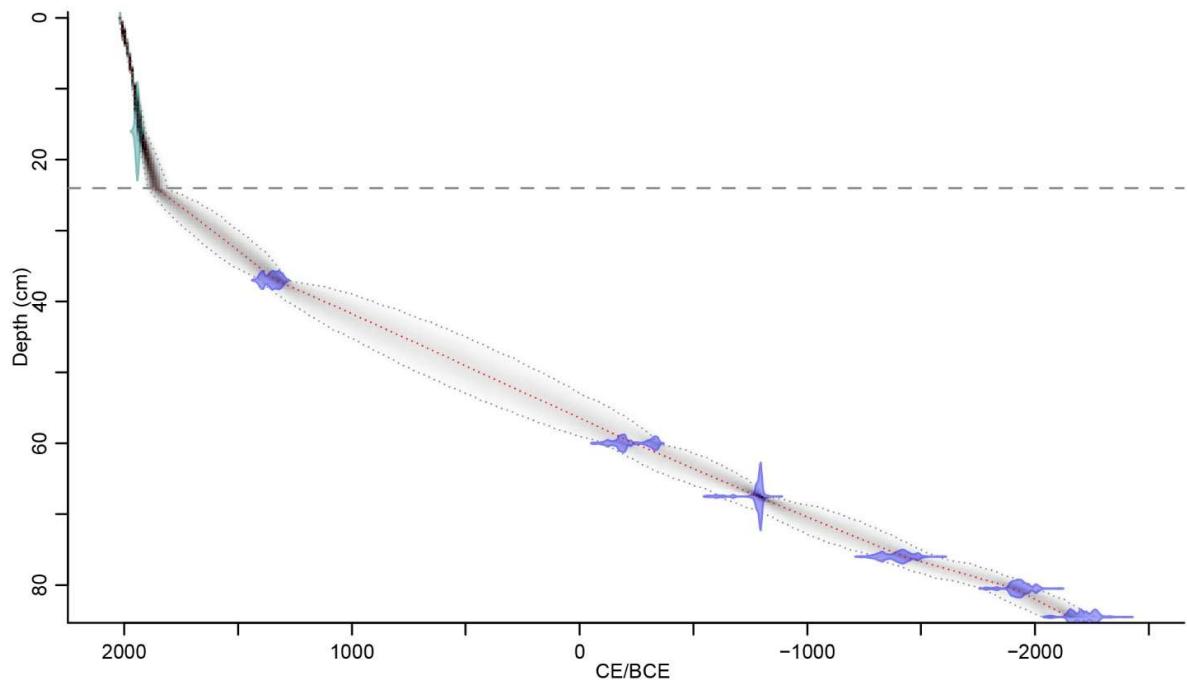
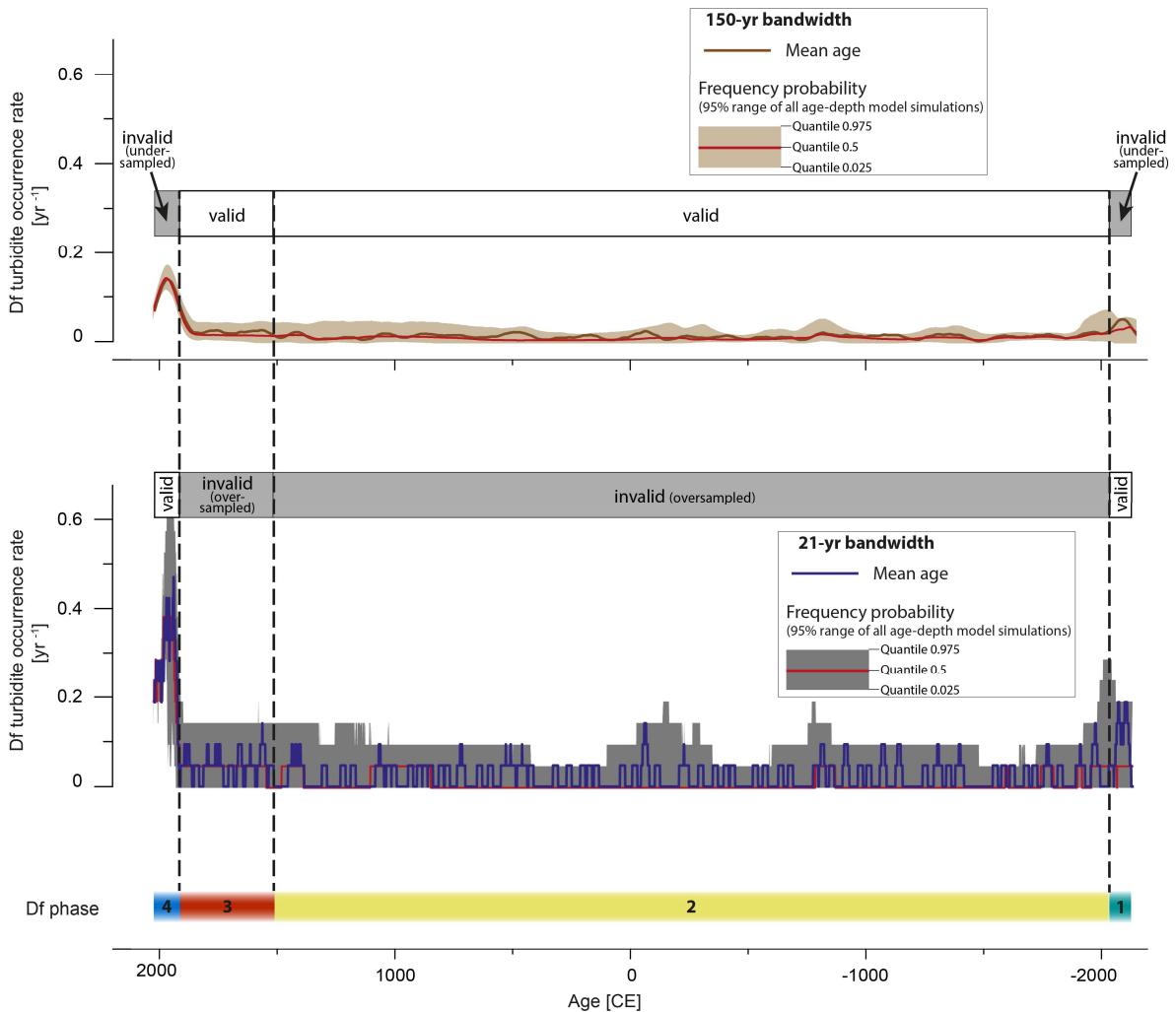


Fig. S2: Age-depth model of the most distal core Plan 18-10 (recalibrated after Oswald et al., 2021), established by Bayesian age-depth modelling of radiocarbon ages (dark blue) and short-lived radionuclide dates (light blue) using the R-software Bacon v 2.4.3. Horizontal dashed line depicts the stratigraphic boundary between Phase 2 and Phase 3 and facilitates the age-depth model to abruptly change the sedimentation rate if required by the dates.



15 **Fig. S3:** Complete documentation of the annual df turbidite frequency showing the 150-yr bandwidth (top) and 21-yr bandwidth (bottom), the mean age derived from the age-depth model and the 95 % range of frequency probability derived from the calculation of quantiles (0.025 and 0.975) on all individual age-depth model simulations. Based on the bandwidth selection test after Sheather & Jones (1991) the 21-yr and 150-yr frequencies are only valid for certain periods and are over- or undersampled for the other periods. Therefore, the time periods assigned as ‘invalid’ should not be considered and are herein only displayed for a complete data presentation.

20 **Table S1: Coring locations**

Core ID	X UTM	Y UTM	Water depth (m)
Plan 18-10	635618	5258915	77
Plan 19-01	635595	5259023	77
Plan 19-02	635593	5258841	76
Plan 19-03	635582	5258791	75

**Table S2: Radiocarbon and short-lived radionuclide samples of Plansee**

Core ID	Sample no.	Core depth in core Plan 18-10 (cm)	Radiocarbon age (CE/BCE $\pm 1\sigma$ )	95 % calibrated age range (cal a CE/cal a BCE)	Material
Plan 18-10	-	4.5	-	1986 cal a CE	$^{137}\text{Cs}$ peak
Plan 18-10	-	8.5	-	1963 cal a CE	$^{137}\text{Cs}$ peak
Plan 18-L1A-0-1.5	ETH-101431	55.5	$1355 \pm 35$ CE	1296 cal to 1412 cal a CE	leaf and conifer needle remains
Plan 18-L1A-0-1.5	ETH-101432	85	$204 \pm 24$ BCE	231 to 108 cal a BCE	leaf and conifer needles
Plan 18-10	ETH-94774	92.5	$641 \pm 22$ BCE	806 to 770 cal a BCE	needle and conifer cone piece
Plan 18-L1A-0-1.5	ETH-101433	106.5	$1186 \pm 43$ BCE	1499 to 1291 cal a BCE	conifer needle remains
Plan 18-L1A-0-1.5	ETH-103730	112	$1631 \pm 26$ BCE	2022 to 1881 cal a BCE	conifer needle
Plan 18-L1B-1-2.5	ETH-103731	*	$1832 \pm 24$ BCE	2292 to 2137 cal a BCE	conifer cone scale and needle remains

\*not cored in Plan 18-10. Sample directly below eq3 and projected from longcore after Oswald et al. (2021)

**Table S3: Geochemical data**

<b>Core</b>	<b>Sediment depth sample range from xx to yy [cm]</b>	<b>d<sup>13</sup>C<sub>TOC</sub></b>	<b>wt% TN</b>	<b>wt% TOC</b>	<b>TOC/TN<sub>molar</sub></b>	<b>Interpretation</b>
Plan 18-10	22-23	-29.2	0.22	2.2	12	eq
Plan 18-10	23-24	-28.8	0.22	2.3	12	eq
Plan 18-10	24-25	-28.7	0.21	2.2	12	eq
Plan 18-10	25-26	-28.8	0.22	2.2	12	eq
Plan 18-10	95-96	-27.7	0.13	1.7	15	eq
Plan 18-10	96-97	-27.7	0.12	1.4	14	eq
Plan 18-10	113-114	-27.3	0.09	1.0	14	df
Plan 18-10	116-117	-27.5	0.10	1.3	14	df
Plan 18-10	119-120	-27.7	0.12	1.4	14	eq
Plan 18-10	120-121	-27.2	0.11	1.3	14	eq
Plan 18-10	121-122	-27.3	0.12	1.5	14	eq
Plan 18-10	122-123	-27.6	0.10	1.6	18	eq
Plan 19-02	0-1	-28.3	0.11	1.5	15	background
Plan 19-02	3-4	-29.9	0.22	2.1	11	df
Plan 19-02	6-7	-28.0	0.12	1.8	16	df
Plan 19-02	9-10	-29.2	0.14	2.0	15	df
Plan 19-02	12-13	-28.7	0.15	2.0	16	background
Plan 19-02	15-16	-27.9	0.15	2.2	17	df
Plan 19-02	18-19	-28.7	0.19	2.2	13	df
Plan 19-02	23-24	-29.2	0.19	2.3	14	df
Plan 19-02	28-29	-28.5	0.15	1.9	14	background
Plan 19-02	38-39	-30.4	0.20	2.3	13	background
Plan 19-02	43-44	-29.6	0.19	2.2	14	background
Plan 19-02	48-49	-28.5	0.18	2.3	15	background
Plan 19-02	53-54	-28.4	0.17	1.8	12	df
Plan 19-02	55-56	-28.6	0.19	2.2	13	df
Plan 19-02	58-59	-27.9	0.12	1.7	17	df
Plan 19-02	63-64	-29.7	0.20	2.6	15	df
Plan 19-02	68-69	-27.4	0.11	1.9	20	df
Plan 19-02	78-79	-29.5	0.17	2.3	15	df
Plan 19-02	83-84	-27.7	0.09	1.5	21	df
Plan 19-02	84-85	-28.6	0.15	2.0	16	df
Plan 19-02	88-89	-28.5	0.11	1.9	21	df
Plan 19-02	93-94	-28.9	0.15	1.9	15	df
Plan 19-02	98-99	-29.2	0.16	2.2	17	background
Plan 19-02	103-104	-28.3	0.15	2.3	18	background
Plan 19-02	113-114	-27.8	0.12	1.2	12	eq
Plan 19-02	114-115	-27.8	0.11	1.7	17	eq
Plan 19-02	115-116	-28.1	0.11	1.7	17	eq
Plan 19-02	116-117	-27.7	0.10	1.5	16	eq
Plan 19-02	117-118	-28.6	0.10	1.4	16	eq
Plan 19-02	118-119	-28.5	0.10	1.3	15	eq
Plan 19-02	119-120	-28.0	0.10	1.7	19	eq
Plan 19-02	123-124	-28.0	0.08	1.5	22	df
Plan 19-02	128-129	-27.8	0.13	1.6	14	df
Plan 19-03	3-4	-28.5	0.11	1.2	13	df

Core	Sediment depth sample range from xx to yy [cm]	$\delta^{13}\text{C}_{\text{TOC}}$	wt% TN	wt% TOC	TOC/TN <sub>molar</sub>	Interpretation
Plan 19-03	6-7	-29.2	0.16	1.9	14	df
Plan 19-03	9-10	-27.9	0.15	2.1	16	df
Plan 19-03	12-13	-28.9	0.18	2.1	14	df
Plan 19-03	15-16	-29.5	0.20	2.2	13	df
Plan 19-03	18-19	-27.8	0.18	2.0	13	df
Plan 19-04	3-4	-25.5	0.11	1.8	18	df
Plan 19-04	6-7	-28.7	0.17	2.1	15	df
Plan 19-04	12-13	-29.5	0.19	2.1	13	df
Plan 19-04	15-16	-27.6	0.17	2.2	15	df
Plan 19-04	23-24	-28.8	0.17	2.3	15	df
Plan 19-04	33-34	-28.3	0.12	2.2	21	df
Plan 19-04	36-37	-28.8	0.18	2.8	18	df
Plan 19-04	38-39	-28.0	0.14	2.3	19	background
Plan 19-04	48-49	-28.2	0.17	2.8	19	df
Plan 19-04	53-54	-28.2	0.10	1.9	17	df
Plan 19-04	58-59	-29.2	0.15	2.3	18	df
Plan 19-04	60-61	-27.7	0.13	1.8	16	df
Plan 19-04	68-69	-27.2	0.11	1.7	16	df
Plan 19-04	78-79	-26.9	0.06	1.3	17	df
Plan 19-04	83-84	-27.9	0.10	1.7	14	df
Plan 19-04	93-94	-27.2	0.05	1.1	24	df
Plan 19-04	103-104	-27.5	0.06	1.4	21	eq
Plan 19-04	108-109	-27.3	0.05	0.7	13	eq
Plan 19-04	113-114	-27.1	0.07	0.9	13	eq
Plan 19-04	118-119	-26.9	0.07	0.9	13	eq
Plan 19-04	123-124	-28.0	0.06	0.8	10	eq
Plan 19-04	128-129	-27.1	0.07	1.0	12	eq
Plan 19-04	133-134	-26.9	0.05	0.7	18	eq

**Table S4: Event age and thickness of debris-flow (df) turbidites in Plan 18-10**

Df turbidite No.	Modelled event age [CE/BCE]			Turbidite thickness [cm]	Df turbidite No.	Modelled event age [CE/BCE]			Turbidite thickness [cm]
	mean age CE/BCE	min age	max age			mean age CE/BCE	min age	max age	
1	2016	2019	2014	0.2	70	591	1075	122	1.2
2	2014	2017	2012	0.4	71	536	987	105	0.2
3	2011	2013	2009	0.7	72	515	964	96	0.2
4	2009	2011	2007	0.5	73	495	950	85	0.4
5	2005	2008	2003	0.6	74	467	930	68	0.2
6	1999	2001	1997	0.7	75	446	915	54	0.9
7	1992	1995	1989	0.4	76	419	895	28	0.2
8	1990	1993	1987	0.3	77	315	820	-96	0.2
9	1988	1991	1985	0.2	78	257	710	-114	0.5
10	1984	1987	1981	1.3	79	199	608	-136	0.9
11	1976	1978	1974	0.2	80	170	569	-153	0.2
12	1975	1977	1973	0.4	81	141	532	-182	1.1
13	1970	1973	1967	0.3	82	30	359	-259	0.5
14	1967	1971	1964	0.7	83	-22	247	-274	0.4
15	1966	1970	1963	0.2	84	-59	171	-285	0.2
16	1966	1969	1963	0.2	85	-66	156	-287	0.4
17	1965	1969	1962	1.4	86	-73	142	-289	1.3
18	1961	1965	1958	1.3	87	-118	59	-303	0.3
19	1956	1963	1946	1.1	88	-221	-70	-355	0.2
20	1951	1963	1934	0.2	89	-241	-99	-377	0.4
21	1951	1962	1933	0.3	90	-302	-144	-458	0.2
22	1946	1957	1931	0.3	91	-364	-169	-546	0.4
23	1945	1955	1929	0.4	92	-410	-185	-617	0.2
24	1942	1953	1925	0.3	93	-437	-192	-659	0.3
25	1939	1951	1921	0.5	94	-534	-302	-747	0.4
26	1937	1950	1918	0.3	95	-576	-381	-755	0.3
27	1934	1949	1914	0.3	96	-642	-481	-768	0.6
28	1931	1948	1909	0.3	97	-683	-522	-777	0.3
29	1929	1946	1905	1.3	98	-790	-608	-841	0.2
30	1926	1945	1900	0.2	99	-815	-625	-882	0.2
31	1923	1944	1896	1.0	100	-822	-632	-892	0.2
32	1904	1939	1849	0.6	101	-858	-664	-943	0.4
33	1880	1936	1784	0.3	102	-915	-705	-1046	0.4
34	1869	1935	1755	0.8	103	-922	-710	-1059	1.3
35	1839	1932	1676	0.7	104	-980	-752	-1171	0.2
36	1799	1905	1631	0.5	105	-1016	-776	-1243	0.4
37	1784	1897	1620	0.5	106	-1073	-809	-1358	0.2
38	1762	1888	1602	0.3	107	-1080	-812	-1372	0.2
39	1749	1884	1584	0.8	108	-1140	-890	-1421	0.2
40	1736	1879	1564	0.5	109	-1148	-904	-1422	0.5
41	1693	1841	1529	0.5	110	-1255	-1080	-1447	0.9
42	1658	1813	1503	0.4	111	-1302	-1148	-1461	0.4
43	1652	1809	1498	0.4	112	-1317	-1169	-1466	0.2
44	1620	1793	1458	0.5	113	-1355	-1218	-1481	0.4
45	1601	1779	1429	0.5	114	-1394	-1259	-1510	0.1

Df turbidite No.	Modelled event age [CE/BCE]			Turbidite thickness [cm]	Df turbidite No.	Modelled event age [CE/BCE]			Turbidite thickness [cm]
	mean age CE/BCE	min age	max age			mean age CE/BCE	min age	max age	
46	1570	1736	1414	0.3	115	-1409	-1274	-1524	0.1
47	1558	1727	1406	0.2	116	-1553	-1442	-1648	0.2
48	1549	1720	1400	0.2	117	-1589	-1481	-1682	0.2
49	1522	1701	1375	0.3	118	-1625	-1518	-1717	0.2
50	1440	1549	1342	0.4	119	-1685	-1574	-1778	0.3
51	1424	1532	1333	0.5	120	-1721	-1604	-1816	0.2
52	1408	1522	1320	0.3	121	-1769	-1641	-1866	0.3
53	1393	1496	1314	0.3	122	-1781	-1650	-1880	0.3
54	1296	1384	1207	0.3	123	-1828	-1685	-1935	0.8
55	1217	1359	1033	0.3	124	-1905	-1758	-2014	0.2
56	1174	1348	934	0.2	125	-1923	-1787	-2024	0.2
57	1069	1288	822	0.9	126	-1969	-1857	-2058	0.4
58	1054	1281	803	0.4	127	-1975	-1865	-2063	0.3
59	1023	1269	762	0.3	128	-1987	-1880	-2074	1.3
60	1000	1261	727	0.4	129	-2045	-1944	-2137	5.4
61	930	1237	593	0.4	130	-2068	-1962	-2168	0.2
62	892	1224	519	0.2	131	-2074	-1965	-2177	0.2
63	869	1217	473	0.3	132	-2079	-1969	-2185	0.4
64	846	1203	440	0.3	133	-2085	-1972	-2194	0.5
65	800	1155	415	0.4	134	-2097	-1978	-2212	0.7
66	774	1140	397	0.6	135	-2102	-1981	-2221	0.5
67	722	1115	342	0.2	136	-2108	-1983	-2231	0.3
68	709	1109	324	0.4	137	-2113	-1986	-2240	0.4
69	637	1084	211	0.2	138	-2119	-1988	-2250	0.9