Nature Ref: 2002-11165A (Mudelsee et al.)

Supplementary Information (Part 1 from 4)

Elbe flood record

Year	Month	Season [S, W]	n	Cause [I, S, C, R]	Maximum flood stage [cm] Pillnitz	Dresden	Meißen	Runoff [m**3/s] Dresden	Magnitude	CLIMDAT [+, -]
1059	Sep	S	2						2	
1118	Sep	S	4						2	
1141		W?	2						2	
1163		S?	1						2	
1275	Aug	S	1	R					2	
1306		W?	1						2	
1315	Jul	S	4	C					3	
1316		S	2	R					3	
1342	Feb	W	2	I?					2	
1342	Jul	S	3						3	
1343	Feb-Mar	W	4	I					2	
1367		W?	2						2	
1400	Jul	S	1?						1	
1404	Feb	W	2						1	
1413	Aug	S	3	R					2	
1422	Apr	W	2						1	
1428	Feb	W	1?						2	
1428	Jul	S	1?						1	
1431			1?						1	
1432	Feb	W	5						2	
1432	Jul	S	12	R					2	
1433	Jan	W	1	I					2	
1433	May-Jul	S	1						2	
1434	Jun-Jul	S	2						3	
1435		W	1	I					2	
1437	Mar	W	2						1	
1443		W	6	I					1	
1445	Apr-May	S	2						1	
1446		S?	4						1	
1449	Apr-May	S	2						1	
1451	Jun	S	1?						1	
1454	Apr	W	2	I					1	
1480		S?	1						2	

1481	Jun	S	3				2		
1488	Feb	W	1	S			2		
1491	Jun	S	3				1		
1493	Jun-Jul	S	1				1		
1495	Aug	S	3	C			1		
1496	Aug	S	2	C			1		
1497	Jan-Feb	W	3				1		
1498	Apr	W	1?				1		
1498	Jun	S	3				2		
1501	Dec!	W	1	I?			1		+
1501	Aug	S	17		866	703	3		+
1502	Apr	W	3				1		-
1503	Apr	W	5				1		-
1504	Mar-Apr	W	5				2		+
1506		W	2	I			1		-
1508	Apr	W	1?				1		-
1510	Mar	W	2		838		2		-
1511	Jul	S	2				1		+
1512		S?	1				1		-
1515	Jul-Sep	S	5		838		2		+
1517		W?	1	I?			1		-
1518		S?	3				2		+
1519			1?				1		-
1523		S	2				1		+
1524		W	1				1		+
1525	Dec!	W	1				1		+
1525	May	S	2				1		+
1529		S?	4	R?			2		+
1530	Mar-Apr	W	2				2		+
1531	May	S	9		753	590	2		+
1537	Feb	W	2	I			1		+
1537	May	S	4	R	753		2		+
1538	May	S	2				1		+
1539	Sep-Oct	S	2				1		+
1541	Mar	W	1				1		+
1542	Feb	W	1				1		+
1546	Jan	W	2	I			2		+
1549	Jun	S	2				1		+
1551		W	2	I			1		+
1552	Jan	W	1	I			2		-
1556	Feb	W	1	I?			1		-
1557	Feb-Mar	W	5	I			1		+

1560	Dec!	W	1				2	-
1560	Jul	S	3	R?			1	-
1563	May-Jun	S	3	R			1	+
1564	Mar	W	3	I			2	+
1565	Mar	W	8	I			2	+
1566	Jan-Mar	W	15	I		866	3	+
1569	Mar	W	2	I?			1	+
1569	Jun-Jul	S	6	R			2	+
1570	Jan-Feb	W	13	I			3	+
1571	Dec!-Feb	W	3	S			1	+
1572	Mar-Apr	W	3	S			2	+
1573	Feb	W	4	I		753	2	+
1573	Aug	S	4	C			2	+
1575	Apr	W	1				1	-
1577	Nov!	W	1	I			1	-
1578	Mar	W	1	I?			1	-
1578	Aug	S	1				1	-
1579	Jun	S	4	R?			1	-
1580		S?	1				1	-
1581	Feb	W	1	I			1	-
1582	Jan	W	1				1	+
1582	Jun	S	5				2	+
1583	Mar	W	1				1	-
1584	Jan	W	4				2	+
1585	Jul	S	2	R			2	-
1587	Mar	W	1	I			1	-
1587	Jun	S	4	C?			2	-
1593	Jun-Jul	S	2	R			1	-
1594	Mar	W	1				2	-
1595	Feb-Mar	W	21	I			3	+
1595	Aug	S	1	R?			1	+
1597		W	3	I			1	+
1597	Aug	S	1?				1	-
1598	Mar	W	9	I		810	3	+
1598	Aug	S	5	R			2	+
1599	Feb-Mar	W	11	I		852	3	+
1599	Jul	S	1	R			1	-
1601	Jun	S	1?				1	-
1602	Dec!-Jan	W	5	S			1	+
1603	Dec!-Jan	W	2	I			1	-
1605			1?				1	+
1607	Mar	W	1	S?			1	-

1610	Dec!	W	3	I				1	-
1611		W	1	I?				1	-
1612	Jul	S	1					1	-
1613	Jul	S	2	C?				1	+
1614		W?	1	R				1	-
1615	Jun	S	1	R?				1	+
1617	Feb	W	2	I				2	-
1618	Feb	W	5	I				2	-
1620		W	1?					1	-
1621	Mar	W	1	I				1	+
1622	Feb	W	1	I				1	-
1622	Jun-Jul	S	5					1	+
1624	Jul	S	1					1	-
1625	Mar	W	4	R				1	+
1625	Oct	S	2					1	-
1627	Mar	W	2	I				1	-
1627	Jul	S	3					1	-
1629	Oct	S	5		753			1	+
1631			1					1	-
1633	Jan	W	2					1	-
1635		W	5	I				1	+
1638			4					1	-
1640	Feb	W	1	I				1	-
1640	Sep	S	2	R				1	-
1645	Mar	W	1?					1	-
1650	Jun	S	2	C				1	+
1651	Jan-Mar	W	14	I	753			3	+
1652	Feb	W	4	I				1	+
1652	Jul	S	1	R?				1	-
1654		S?	1	R?				1	-
1655	Feb	W	22	I	897	680		3	+
1655	Jun-Jul	S	3	C				1	+
1658	Feb	W	8	I				2	-
1659	Dec!	W	2					1	-
1661	Jan	W	1	R				1	-
1661	Aug	S	3	R				1	-
1665	Feb-Mar	W	2					1	+
1665	Jun	S	1?					1	-
1666	Jun	S	2	C				1	-
1668	Jul	S	2	C?				1	-
1669		W?	1					1	+
1670	Mar	W	2	I				2	-

1674	Mar	W	7	I				2	+
1675	Jan	W	1?					1	-
1675	Jun-Jul	S	10			810	505	3	+
1677		W?	1	I?				1	+
1678		S?	1	R?				1	-
1682	Jan	W	8	R		758	571	2	+
1684	Mar	W	1?	I				1	+
1686	Aug	S	1?					1	-
1688	Jul	S	2					1	-
1693		W	2	I				1	-
1693		S	1					1	-
1694	Feb	W	2	I				1	-
1694	Jun	S	2	C				2	+
1695	Jun	S	1?					1	+
1697	Mar	W	1	I?				1	-
1698	Jan-Feb	W	4					1	+
1698	Jun-Jul	S	6	R		786	602	3	+
1703	Aug	S	5					2	-
1706	May	S	3	C				1	-
1709	Feb-Mar	W	9	I				2	+
1711			1					1	-
1712	Apr	W	9	S, C		786	505	2	+
1714	Jun	S	1	C				1	-
1715	Mar	W	1?	I				1	+
1721		S?	1					1	-
1722	Jan	W	1?					1	-
1729	Mar-Apr	W	3	I				1	+
1731	Mar	W	2	I				1	+
1732		W?	1					1	-
1734		S	2					1	+
1735		S	1	R?				1	-
1736	Jun-Jul	S	10	R	487		473	2	+
1740	Mar	W	5	I		753		1	+
1741	Dec!-Jan	W	2	I				1	-
1745	Dec!-Jan	W	1?	I				1	-
1746	Mar	W	4	I				1	-
1748	Dec!	W	4	S	444			1	+
1748	Mar-Apr	W	4	S		774		2	-
1749	Dec!	W	1	R				1	-
1750	Feb	W	3	I	408			1	+
1750	Jun-Jul	S	2	R				1	+
1751	Dec!	W	1?	S				1	-

1751	Mar	W	2	I		732		1	+
1752	Aug	S	1					1	+
1754	Dec!	W	1	R				1	-
1757	May	S	1?					1	-
1758	Mar	W	2					1	-
1760	Jan-Feb	W	2	I				1	-
1761	Dec!	W	1?	R				1	-
1761	Feb	W	7	I	472	696	479	2	+
1762	Feb	W	3	I				1	-
1764	Jan	W	5					1	+
1768	Nov!-Dec!	W	4	R	444			1	+
1768	Feb	W	6	I	408			1	+
1769	Jun-Aug	S	5	R				2	+
1770	Dec!-Apr	W	13	S	408			2	+
1770	Aug	S	4	R	448			1	-
1771	Jan-Apr	W	18	I?	514	706	516	2	+
1771	May-Aug	S	9	R	514	715	519	2	+
1772			1?					1	-
1775	Jan-Feb	W	6	I	444	640	432	1	+
1776	Feb	W	8	I			555	2	+
1777	Dec!-Mar	W	6	I	354	635	533	2	+
1779	Jan	W	1?	I				1	-
1780	Dec!	W	3					1	-
1780	Feb-Mar	W	5	I	455	682	463	1	+
1781	Feb	W	5	I	463	685	460	1	-
1783	Jan-Feb	W	6	I	467	692	472	1	-
1783	Jun	S	1?	C				1	-
1784	Feb-Mar	W	32	I	670	859	703	3	+
1785	Apr	W	16	I		737	548	2	+
1786		W	2					1	-
1786	Aug-Sep	S	2					1	-
1789	Jan-Apr	W	4	I		682	434	1	+
1794	Feb-Mar	W	3	R		654		1	+
1794	Aug	S	2	C?				1	-
1795	Feb	W	2	I		635	312	1	-
1799	Feb	W	17	I	616	829	786	3	+
1804	Jan	W	3			649		1	
1804	Jun	S	5	R		685		1	
1805	Jan-Mar	W	9	I		708		2	
1806	Jan-Mar	W	2	R?		647		1	
1807	Feb-Mar	W	2	I		633		1	
1808	Apr	W	1	R		612		1	

1809	Jan-Feb	W	7	I		777		2
1809	Apr-May	S	2	R		600		1
1810	Feb-Mar	W	4	I, C		746		2
1811	Feb	W	3	I		753		2
1812	Apr	W	2			645		1
1812	Aug	S	2	R		645		1
1813	Feb	W	1?	I		604		1
1814	Feb-Mar	W	14	I		739		2
1814	Jun-Aug	S	2					1
1815	Jan-Feb	W	2	I		633		1
1815	Jul-Aug	S	3	R				1
1816	Jun	S	1	R?				1
1820	Dec!-Jan	W	8	I		682		1
1820	Mar-Apr	W	4	S?				1
1821	Mar	W	6	I		739		2
1821	Aug	S	4	R				1
1824	Mar	W	3			781		2
1824	Jun	S	8	R	522	753	552	2
1827	Mar	W	8	S?		746		2
1827	Jun	S	1	C				1
1828	Dec!-Jan	W	4	I				1
1829	Dec!	W	1	R				1
1829	Apr	W	1	C				1
1829	Jun	S	1					1
1830	Mar	W	15	I		798		3
1832	Nov!	W	1?	R				1
1832	Jan	W	4	I				1
1833	Feb	W	1	I				1
1834	Dec!-Jan	W	2	R?		668		1
1836			1?					1
1837	May	S	1	R				1
1838	Mar	W	6	I				2
1839	Jan-Feb	W	1					1
1839	May	S	1	R?				1
1840	Jan	W	1?					1
1841	Jan-Mar	W	5	I				1
1843	Jan	W	1	R?				1
1843	Jul	S	1?	C				1
1844	May-Jun	S	3					1
1845	Mar-Apr	W	28	I	694	877	756	3
1846	Jan	W	5	S		725		2
1847	May	S	1?					1

1848	Feb	W	5	I					2	
1849	Feb	W	1?						1	
1850	Feb	W	3	I		706			2	
1852	Feb	W				654		1980	1	(-)
1853	Apr-May	S				633		1980	1	(-)
1854	Feb	W						1670	1	(-)
1855	Dec!	W				588		1630	1	(-)
1855	Mar	W				692		2500	1	(1)
1856	Jan-Feb	W				661		2200	1	(-)
1858	Aug	S				590		1640	1	(-)
1860	Apr	W						2570	1	(1)
1862	Feb	W			642	824	609	4490	3	(2)
1865	Apr	W				748		3480	2	(2)
1867	Jan-Apr	W				713		2850	2	(1)
1868	Mar	W				626		1980	1	(-)
1871	Feb-Mar	W				654		1590	1	(-)
1872	May	S				647		1630	1	(-)
1876	Feb-Mar	W			574	784	589	3290	2	(1)
1877	Feb	W				669		2200	1	(-)
1880	Jan	W				598		1800	1	(-)
1880	Mar	W				598		1800	1	(-)
1881	Mar	W				726		3090	2	(1)
1883	Nov!-Jan	W			490	722	506	2960	2	(1)
1886	Mar	W				730		2930	2	(1)
1886	Jun	S				574		1710	1	(-)
1888	Mar-Apr	W				720		2820	2	(1)
1889	Mar	W				575		1660	1	(-)
1890	Sep	S			668	837	651	4450	3	(2)
1891	Nov!	W				662		2160	1	(-)
1891	Mar	W				702		2560	1	(1)
1892	Feb	W						1620	1	(-)
1895	Mar-Apr	W				735		3040	2	(1)
1896	May	S						3070	2	(1)
1897	May	S						1700	1	(-)
1897	Aug	S						2840	2	(1)
1899	Sep	S						2050	1	(-)
1900	Jan-Apr	W						3100	2	(1)
1909	Feb	W						2170	1	(-)
1915	Mar	W						2270	1	(-)
1915	Oct	S						2280	1	(-)
1917	Jan	W						1990	1	(-)
1917	Apr	W						2210	1	(-)

1920	Jan	W				3190	2 (1)
1923	Feb	W				2690	2 (1)
1924	Mar-Apr	W				2140	1 (-)
1926	Jan	W				1930	1 (-)
1926	Jun-Jul	S				2590	1 (1)
1932	Jan	W	NI			1620	1 (-)
1932	Jun	S				1760	1 (-)
1940	Dec!	W	NI			2010	1 (-)
1940	Mar	W	I			3110	2 (1)
1941	Nov!	W	NI			1620	1 (-)
1941	Feb-Apr	W	NI			2650	2 (1)
1941	Jun	S				1590	1 (-)
1942	Mar	W	NI			1630	1 (-)
1944	Apr	W	NI			2000	1 (-)
1946	Feb	W	NI			2190	1 (-)
1947	Mar	W	I			2340	1 (1)
1948	Dec!-Feb	W	NI			2160	1 (-)
1954	Jul	S				2300	1 (1)
1955	Dec!	W	NI			1580	1 (-)
1955	Mar	W	NI			1660	1 (-)
1956	Mar	W	NI			1860	1 (-)
1958	Jul	S				2010	1 (-)
1965	Jun	S				1820	1 (1)
1975	Dec!-Jan	W				1914	1 (1)
1977	Aug	S				1896	1 (1)
1980	Jul	S				1734	1 (1)
1981	Mar	W				2186	1 (1)
1981	Jul	S				2238	1 (1)
1982	Jan	W				1800	1 (1)
1987	Jan-Apr	W				1780	1 (1)
1988	Mar	W				2010	1 (1)
1994	Dec!	W				1610	1 (1)
1999	Nov!	W				1630	1 (1)
1999	Mar	W				1740	1 (1)
2002	Aug	S			940	4700	3 (3)

Notes:

(1) Year
Year A.D. (Gregorian calendar).

(2) Month

!   : Alerts when month = Nov or Dec and season = W (see Note (3)).

(3) Season
W   : Winter, from November of preceding year to April of year.
S   : Summer, from May to October of year.

Separated flood events are listed when an influence of the first on the
second event can be excluded, otherwise they are counted as one event.

?   : indirect information (from nearby region, tributary, etc.).

(4) n
For the interval up to 1850:
Number of different sources reporting Elbe flood event
between Litoměřice and Magdeburg.

?   : doubtful flood event (possibly misrecorded, or
        of only local extent): n = 1, the source is non-contemporary
        and no indirect support (from nearby region, tributary, etc.) exists.

(5) Cause
For the interval up to 1850:
C   : cloudburst,
R   : long rain,
I   : ice and thawing,
S   : snow and thawing (not I),
?   : indirect information (from nearby region, tributary, etc.).

For the interval 1930 to 1970:
I   : ice and thawing,
NI   : not I.

(6) Flood stage
Stages before 1501 are not listed due to uncertain values.
Dresden zero stage set to recent value (Preußische Landesanstalt
für Gewässerkunde und Hauptnivellements 1938),
that is, the stage used by
Weikinn (1958-2002), Pötzsch (1784-1800), Schäfer (1848) and
Königliche Elbstrombauverwaltung (1898),
increased by 300 cm.

(7) Runoff

Runoff values (flood peaks), as provided by GRDC, were inferred via measured water stage and determined stage-runoff relations. These relations were established using explicit measurements of runoff (by means of velocity measurements across the river cross-section).
The accuracy of a flood record at a particular station depends on (1) the accuracy of the stage–runoff relation at upper (flood) values, (2) how frequent relations were updated and (3) how stable stage–runoff relations are over time.

Helms et al. (2002) analysed Elbe stations in Germany with regard to above accuracy requirements. From six middle Elbe stations analysed (Dresden, Torgau, Wittenberg, Aken, Barby, Magdeburg) Dresden, followed by Barby, was of highest quality in terms of above requirements. Note, however, that updating of stage-runoff relation was less frequent before 1960 and that stage-runoff ratio exhibited a slow increase over the last decades. This may lead to minor systematic errors in inferred runoff for the early period.

It is assumed that, taking into account the widths of magnitude classes (see Mudelsee et al.), this had no major effect on the reconstructed Elbe flood magnitude record.
For further information on stage-runoff relations for the Elbe, see also
Bundesanstalt für Gewässerkunde (2000) and
Sächsisches Staatsministerium für Umwelt und Landwirtschaft (2002).

(8) Magnitude
1 : minor flood event,
2 : strong flood event,
3 : exceptionally strong flood event.

For the interval 1852 to 2002, the resulting magnitude is also given when assuming a constant reservoir size at present level (in parentheses, '-' denoting 'no flood event'). The time-dependent total size of the reservoirs is listed in Table 8.1 below.
The difference in size at a time point, relative to the present, is subtracted from the flood peak (integrated runoff).
See Mudelsee et al. for further details.

(8.1) Reservoir size

Year	Total manageable reservoir size (above Dresden) (Bundesanstalt für Gewässerkunde 2000)	
	winter	summer
	V (10**6 m**3)	V (10**6 m**3)
1853	0.52	0.52
1912	1.35	1.35
1914	3.60	3.60
1915	4.84	4.84

1916	5.91	5.91
1919	11.83	11.83
1926	12.05	12.05
1927	12.25	12.25
1934	15.55	15.55
1935	18.85	18.85
1938	20.10	20.10
1939	22.91	22.91
1955	23.47	23.47
1957	40.93	40.93
1959	41.98	41.98
1960	72.38	52.98
1961	85.90	56.84
1962	86.70	57.64
1963	148.73	119.67
1964	163.62	123.36
1966	164.28	124.02
1967	164.78	124.52
1968	204.14	163.88
1969	221.49	181.23
1975	222.29	182.03
1978	227.81	187.55
1980	228.71	188.45
1981	235.14	193.40
1983	235.40	193.66
1984	236.07	194.33
1988	236.75	195.01

(9) CLIMDAT
Cross-check with documentary database CLIMDAT of Militzer (1998). This compilation is based mainly on original sources. Geographical focus is central and eastern Germany, Poland and the Czech Republic. It covers the time interval 1500 to 1799. CLIMDAT was constructed at the Historical Institute, University of Leipzig, Germany.

+ : agreement, that means, CLIMDAT mentions flood constructed from Weikinn’s records
- : no agreement.

CLIMDAT lists three Elbe floods not contained in the Weikinn source texts:
January 1555, spring 1724 and (presumably spring) 1792, all assessed here as of magnitude 1.

(10) Observation intervals, data sources and data types

For measured data, the gauge station is given in brackets.

Interval	Source	Data type
ca. 1021 to Dec 1850	Weikinn (1958-2002)	documentary, flood stage [Pillnitz, Dresden, Meißen]
1501 to 1784	Pötzsch (1784-1800)	documentary, flood stage [Dresden]
1501 to 1846	Schäfer (1848)	documentary, flood stage [Dresden]
1501 to 2002	Sächsisches Staatsministerium für Umwelt und Landwirtschaft (1999, 2002)	flood stage, flood runoff [Dresden]
1501 to 1895	Königliche Elbstrombauverwaltung (1898)	flood stage [Pillnitz, Dresden, Meißen]
Jan 1850 to Jul 1891	Königliche Elbstrom-Bauverwaltung (1892)	monthly maximum water stage [Dresden, Mühlberg, Torgau, Wittenberg, Rosslau, Barby, Magdeburg]
Jan 1852 to Nov 1999	GRDC (2001)	daily runoff [Dresden]
Nov 1887 to Oct 1990	GRDC (2002)	daily runoff [Děčín]
Nov 1899 to Dec 1999	GRDC (2002)	daily runoff [Barby]
1853 to 1999	Bundesanstalt für Gewässerkunde (2000)	total reservoir size [above Dresden]
1930 to 1970	Preußische Landesanstalt für Gewässerkunde und Hauptnivellements (1933-1937, 1938); Landesanstalt für Gewässerkunde und Hauptnivellements (1940-1942); Forschungsanstalt für Schiffahrt, Gewässer- und Bodenkunde (1949, 1950-1951); Meteorologischer und hydrologischer Dienst der Deutschen Demokratischen Republik (1952-1957, 1958-1961, 1963); Institut für Wasserwirtschaft (1964-1979)	ice conditions
Nov 1998 to May 2002	http://www.dresden.de	flood stage [Dresden]
Feb 2001 to Sep 2002	http://www.wetteronline.de	daily water stage [Dresden]
Aug 2002	Bundesanstalt für Gewässerkunde (2002)	flood runoff [Dresden]

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