Linking paleofloods to precipitation extremes at Lake Mondsee (NE Alps)

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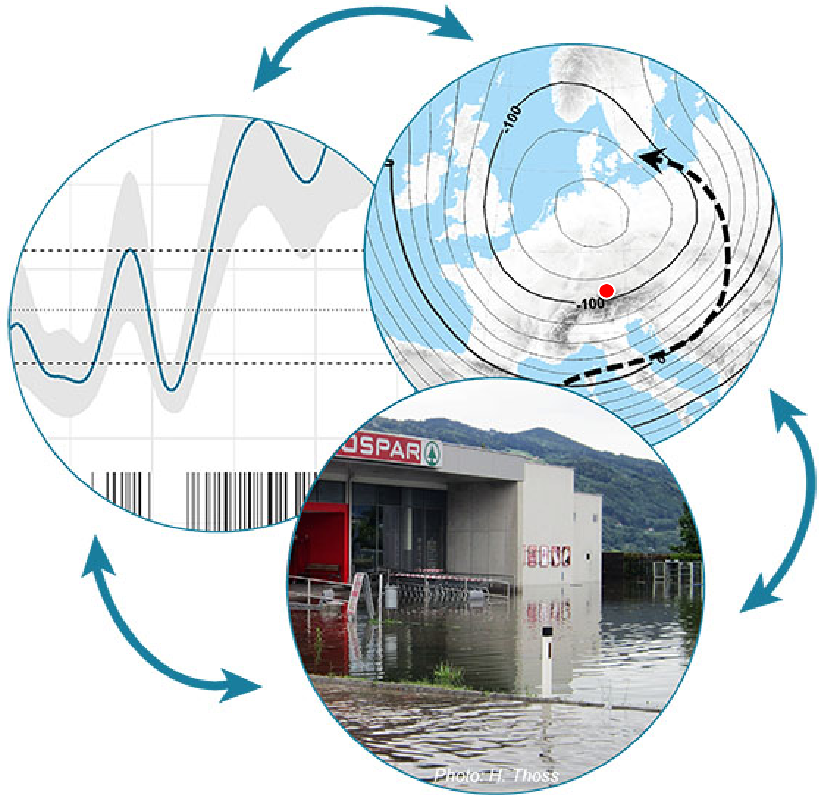
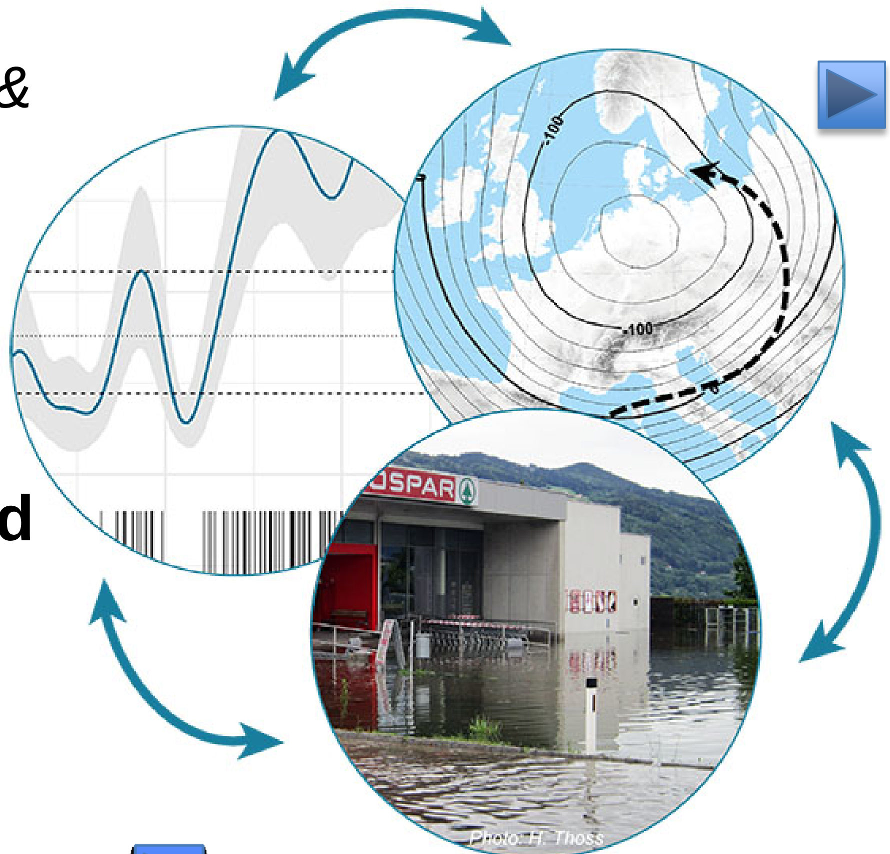


FloodRisk – 7000 (https://floodrisk.joanneum.at)

Outline

- *Motivation & Study Area*
- *Summary*
- **Paleoflood dynamics**



- **Cyclone tracks**
  Extreme precip.
  Floods
  Sediment layers

- **Damage loss potentials** *(Outlook)*

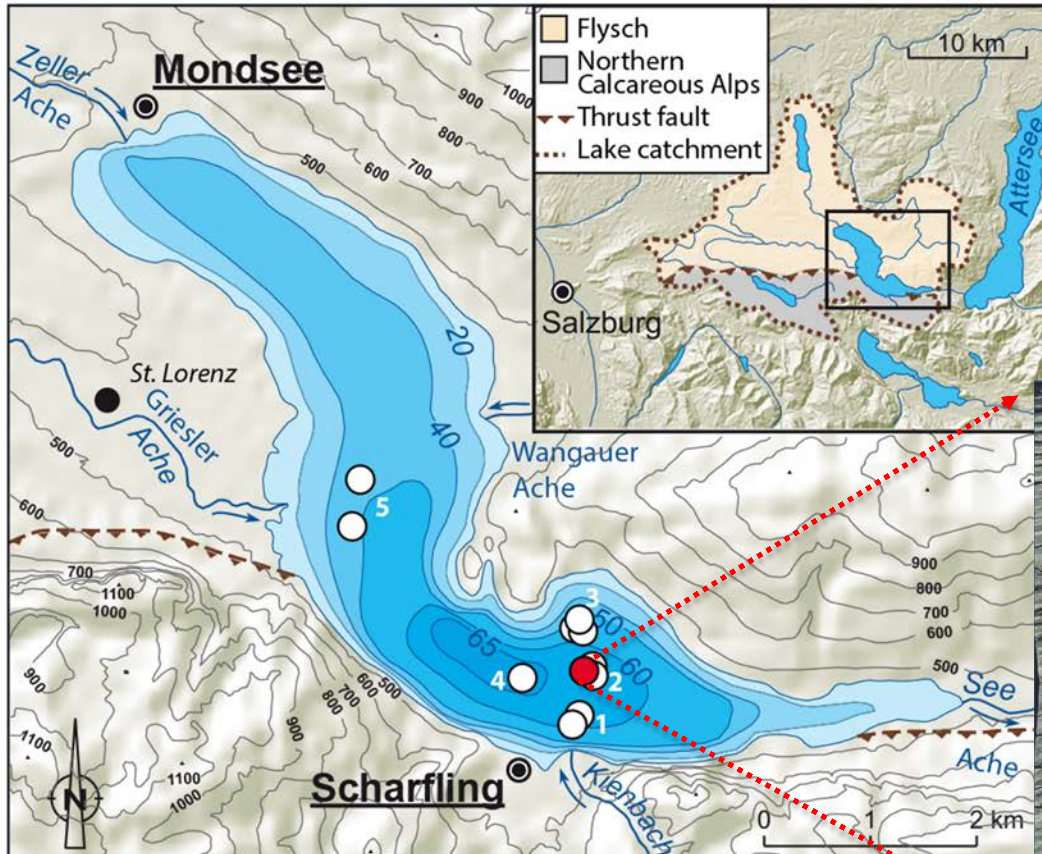
(see Prettenthaler et al. -> EGU NH9.2
Costs of Natural Hazards)

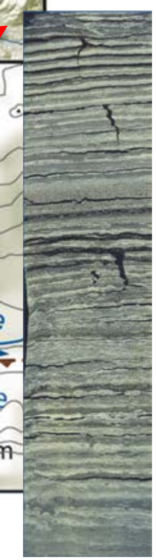
Motivation & Study Area

Floods in Mondsee: June 2013

Fotos: Heiko Thoss (GFZ)

Motivation & Study Area





Altitude: 481 m asl

Lake surface: 13.8 km²

Depth (max): 68 m

Catchment: 247 km²

Mean Q_d: 4 m³/s

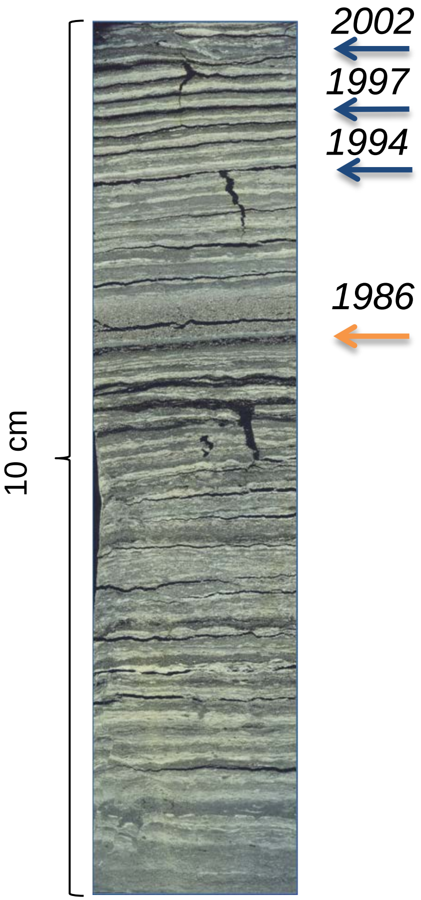
Max. Q_{100}: 137 m³/s

Coring locations

○ 11 Short Cores (42-103 cm)

● 1 Composite Core (15 m)

7000-year flood series from Mondsee sediments



<u>Laminated Mondsee sediments (varves):</u>

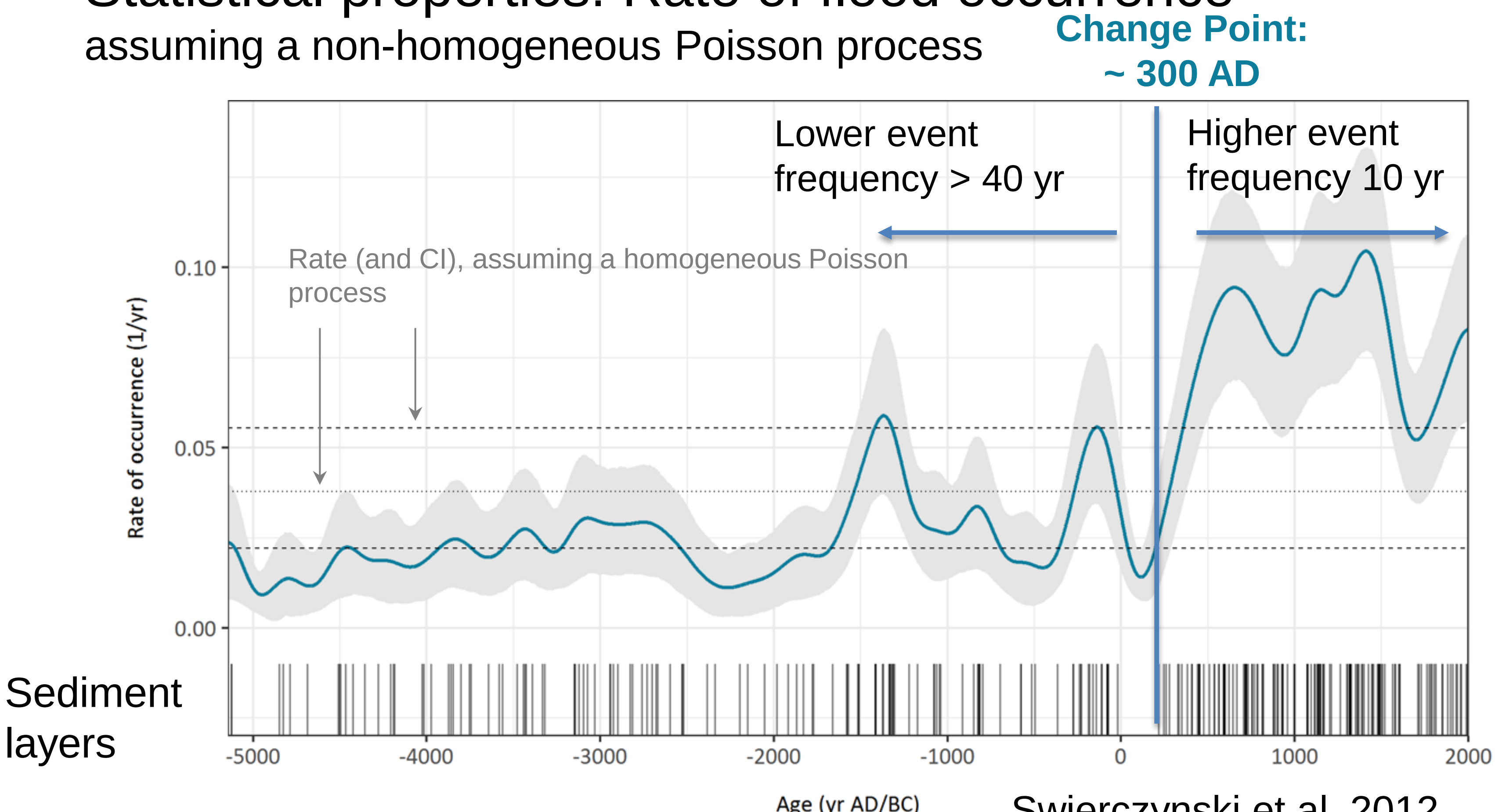
- Spring/Summer calcite layer, diatoms (algaes)
- Autumn/Winter clastic debris
- Abundant event layers
  - → Flood layers
  - → debris flows layers

<u>Event layer reconstruction:</u>

Extreme precipitation in summer causes floods and debris flows that lead to detectable sediment input into the lake

Statistical properties: Rate of flood occurrence

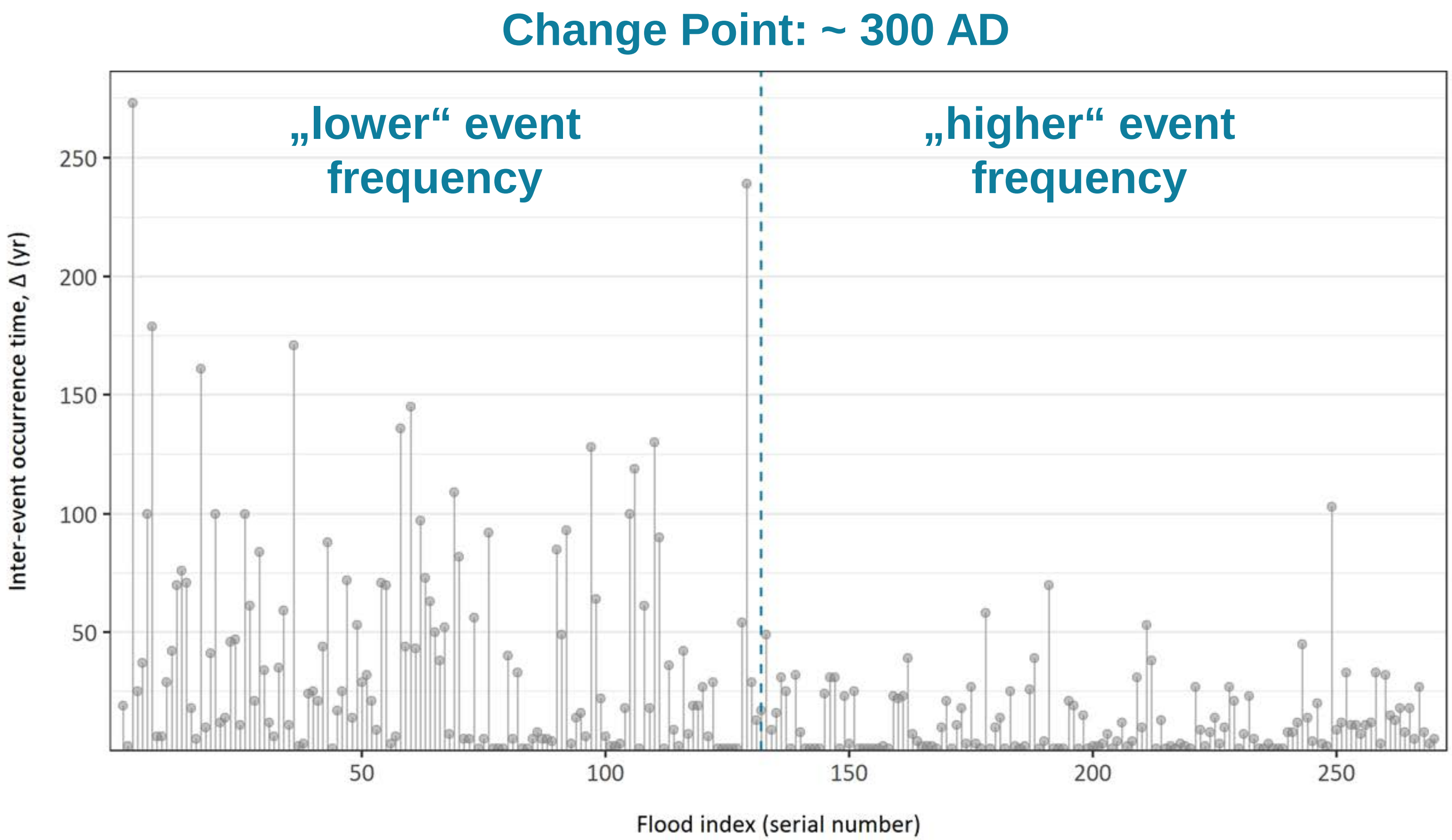
assuming a non-homogeneous Poisson process



Swierczynski et al. 2012

Statistical properties: Change point analysis

indicated by inter-event occurrence times



Statistical properties: Change point analysis

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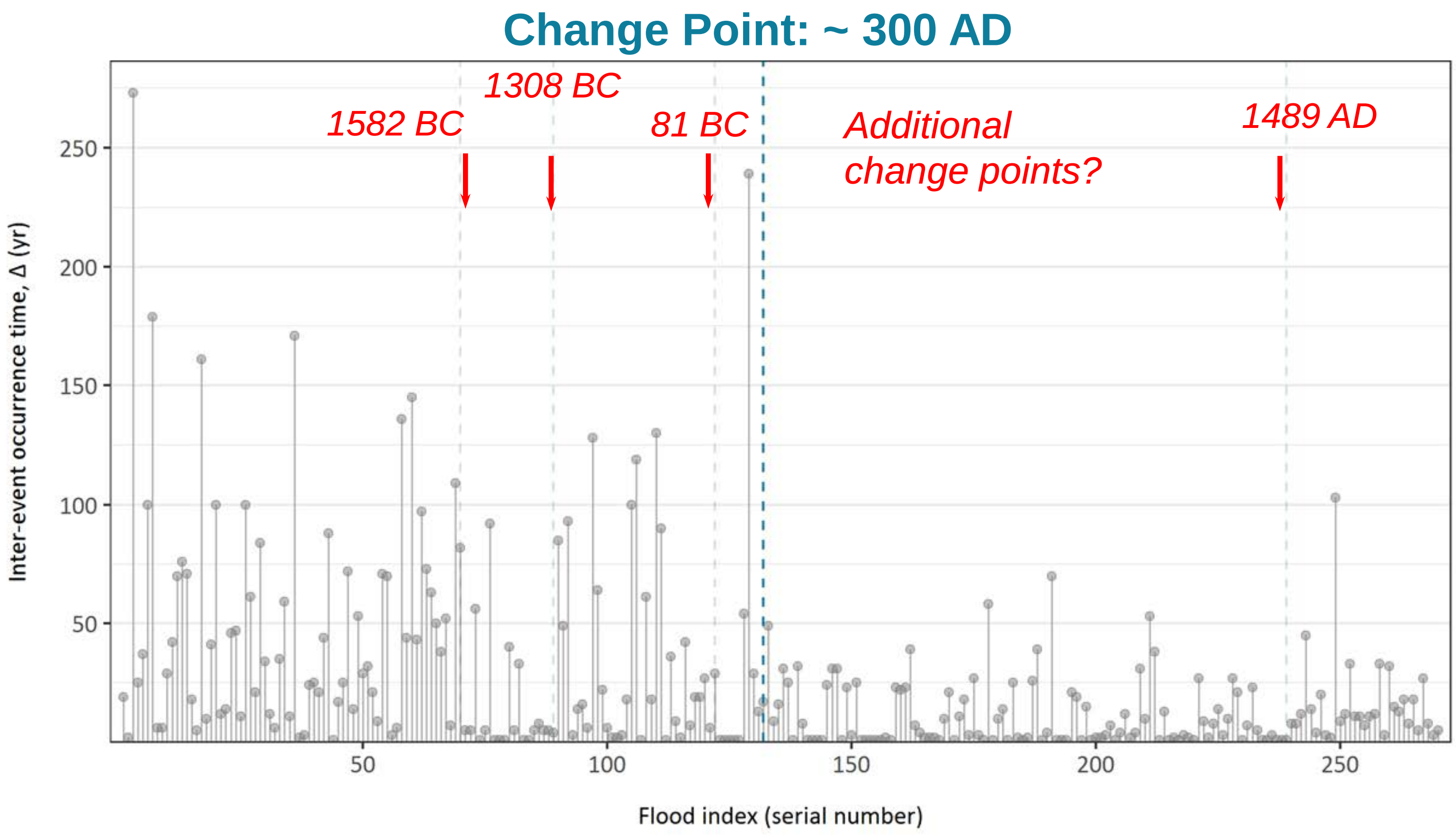
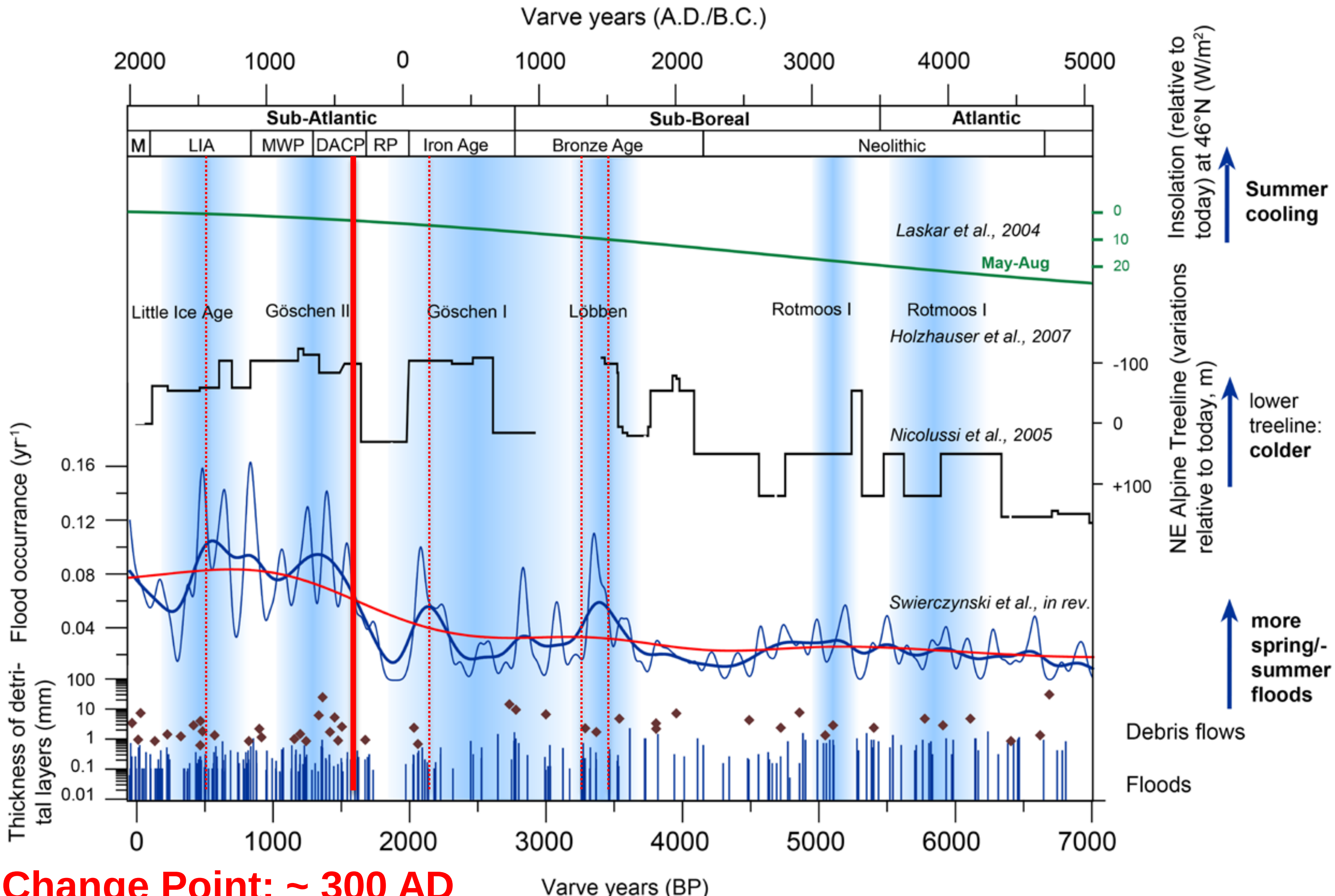


Paleoflood dynamics



Change Point: ~ 300 AD

Conclusion – Change Point Analysis:

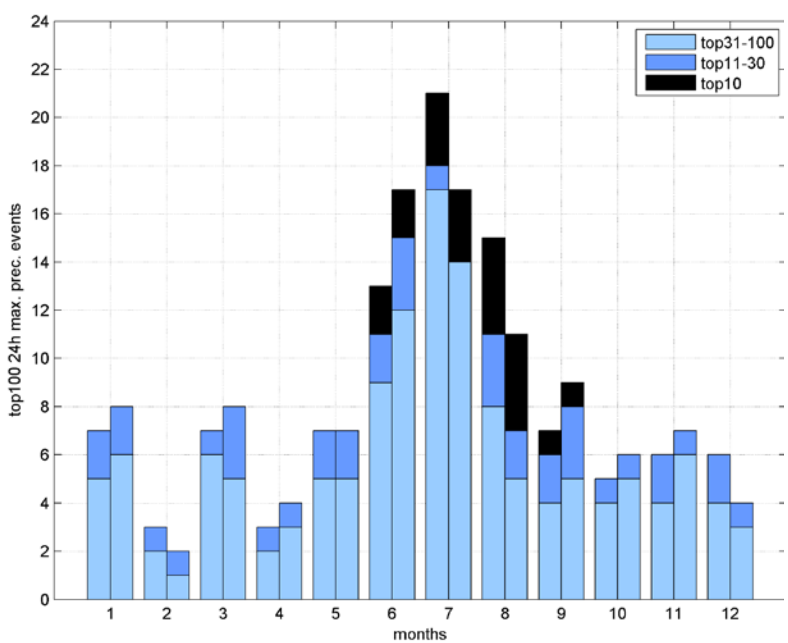
Change point in Lake Mondsee 7000-year flood series:
ca. 300 AD

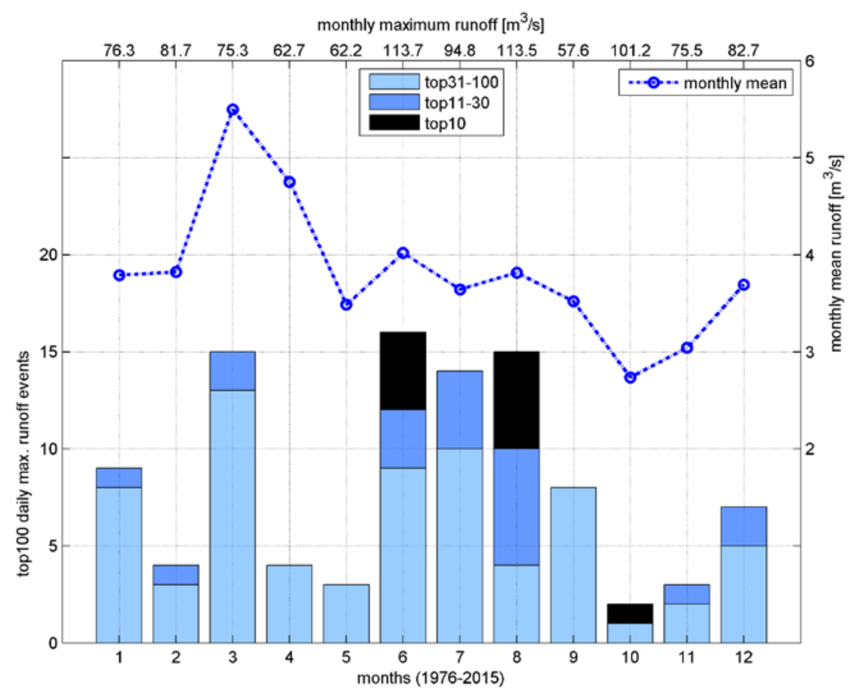
- **Two different flood regimes** at Lake Mondsee
triggered by hydroclimatic changes?

- **Two different parameters for exponential interevent times**
improves probability in damage modeling

Extreme Daily precipitation and runoff events (1976-2015)

Seasonality of TOP Events (10/30/100)





TOP 10/100 Daily precipitation events and sediment layers (1976-2015)

Rank	Date	24h_prec_pct	24h_max_prec	Cyclone Track	Season	Sediment	Sediment	Qh (max.)
1 to 10	yyyy-mm-dd	1 = 100%	mm	Vb, EA, X-N, X-S, MED,STR, ATL, POL, CON, TRZ	Su (Apr-Aug) Wi (Sep-Mar)	Proximal cores	Distal core (7000 years)	m^3/s
TOP 1-10 Precipitation events (1976-2015, annual)								
1	1977-07-31	1,00	94,2	Vb, XS, POL, TRZ	Su	-	-	77,1
2	1997-07-05	0,92	86,3	Vb, X-S	Su	x	x	88,2
3	2002-08-07	0,89	84,2	X-N, ATL, POL, TRZ	Su	x	x	105,6
4	2013-06-02	0,88	82,6	CON, TRZ	Su	x	x	102,8
5	1985-08-06	0,81	76,1	Vb	Su	x	-	84,2
6	2002-08-12	0,77	72,8	Vb	Su	x	x	113,5
7	1981-07-19	0,77	72,8	Vb	Su	x	-	74,8
8	2007-09-06	0,75	71,1	XS, TRZ	Wi	-	-	57,6
9	1991-08-02	0,73	68,4	CON, TRZ	Su	x	-	94,9
10	2009-06-23	0,71	66,7	Vb	Su	x	-	70,2
TOP 11-100 Precipitation events (1976-2015, ranked Apr-Aug events) in a year of sediment layer (distal core)								
11	2010-06-02	0,64	60,2	Vb, X-S, MED	Su	x	x	113,7
15	2006-08-06	0,55	52,2	Vb, ATL	Su	x	x	40,1
16	1994-04-13	0,55	51,9	Vb, CON	Su	x	x	62,7
21	2010-07-24	0,47	43,9	X-N, TRZ	Su	x	x	41,5
22	2010-07-05	0,46	42,9	X-S	Su	x	x	12,7
24	2002-06-07	0,44	41,6	Vb, MED, TRZ	Su	x	x	23,2
25	1997-07-19	0,44	41,6	Vb, XS	Su	x	x	94,8
27	1994-05-19	0,43	40,3	Vb	Su	x	x	62,2

TOP 10/100 Daily runoff events and sediment layers (1976-2015)

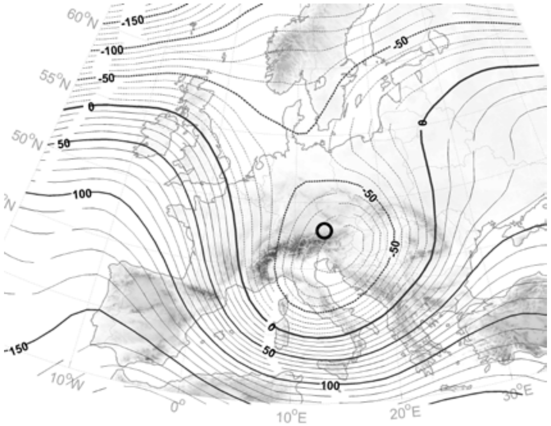
Rank	Date	24h_run_pct	24h_max_runoff	Intensity	Season	Sediment	Sediment	24h_max_prec
1 to 10	yyyy-mm-dd	1 = 100%	m^3/s	Qh > 80 m3/s	Su (Apr-Aug) Wi (Sep-Mar)	Proximal cores	Distal core (7000 years)	mm
TOP 1-10 Runoff events (1976-2015, annual)								
1	2010-06-02	1,00	113,7	8	Su	x	x	60,2
2	2002-08-12	1,00	113,5	14	Su	x	x	72,8
3	2010-06-03	0,99	112,8	8	Su	x	x	60,2
4	2014-08-04	0,96	109,8	3	Su	NaN	NaN	45,6
5	2002-08-07	0,93	105,6	5	Su	x	x	84,2
6	2013-06-02	0,90	102,8	2 (27)	Su	x	x	82,6
7	2014-10-23	0,89	101,2	1	Wi	NaN	NaN	48,7
8	2002-08-06	0,87	99,6	5	Su	x	x	84,2
9	2013-06-01	0,87	99,1	24 (27)	Su	x	x	82,6
10	1991-08-02	0,83	94,9	15	Su	x	-	68,4
TOP 11-100 Runoff events (1976-2015, ranked Apr-Aug events) in year of sediment layer (distal core)								
11	1997-07-19	0,83	94,8	3	Su	x	x	41,6
14	*1997-07-06*	*0,78*	*88,2*	*0*	*Su*	*x*	*x*	*86,3*
28	1994-04-18	0,55	62,7	0	Su	x	x	33,0
29	*1994-05-19*	*0,55*	*62,2*	*0*	*Su*	*x*	*x*	*40,3*
36	*1997-07-05*	*0,53*	60,5	*0*	*Su*	*x*	*x*	*86,3*
44	*1997-04-17*	*0,46*	51,92	*0*	*Su*	*x*	*x*	*33,0*
> 52	2006-08-06	0,35	40,1	0	Su	x	x	52,2

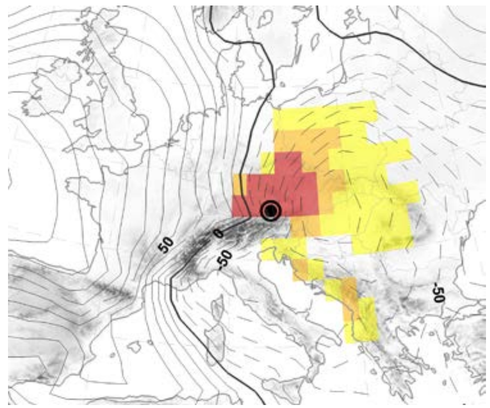
Cylone tracks & Extreme Precipitation & Floods

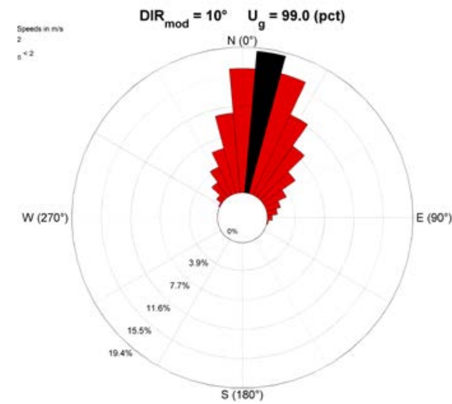
Top-100 heavy precipitation events (24h) at Lake Mondsee 1961-2015

GPH 500hPa | **SLP + vertical lifting** | **surface winds** | **precipitation**

rank 1-10



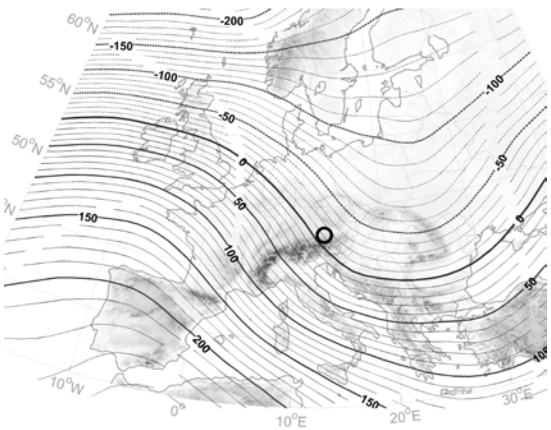


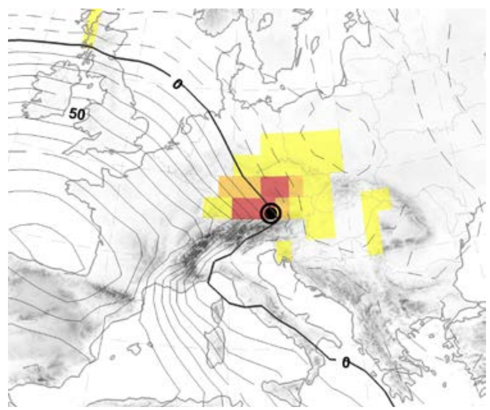


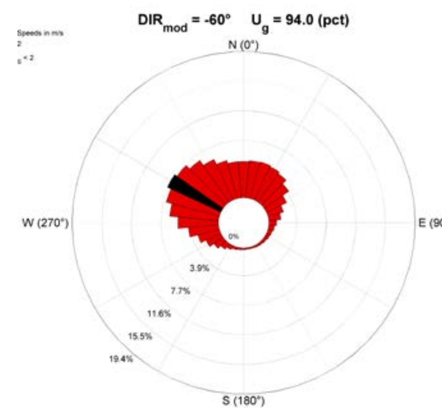
Ø 78 mm
(67-95)

Vb: 6(10)
Season
(Wi/Su): 1/9

rank 21-100







Ø 44 mm
(37-55)

Vb: 11(80)
Season
(Wi/Su): 33/47

FloodRisk-7000 – Calculat ×

https://floodrisk.joanneum.at

FloodRisk-7000

Calculating flood risk with 7000 years of flood frequency data and highly damage relevant cyclone tracks under current & future climatic conditions

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Estimating flood damage potentials

According to EM-DAT floods are the leading cause of economic damages from natural disasters in Austria, accounting for almost 70 % of total damages from natural disasters in the period 1990 to 2015. In terms of economic consequences, the summer floods of 1997, 2002, 2005 and 2013 rank among the most severe events. Due to the comparatively high threat of damages due to flood events in Austria, information on the current and future damage potential is of great importance not only for sustainable flood risk management, but also for public finances as the Austrian risk transfer system currently in place mainly relies on federal grants (Catastrophe Fund).

Worldwide, actuarial (i.e. insurance mathematical) estimations of damage potentials and the resulting

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JOANNEUM RESEARCH

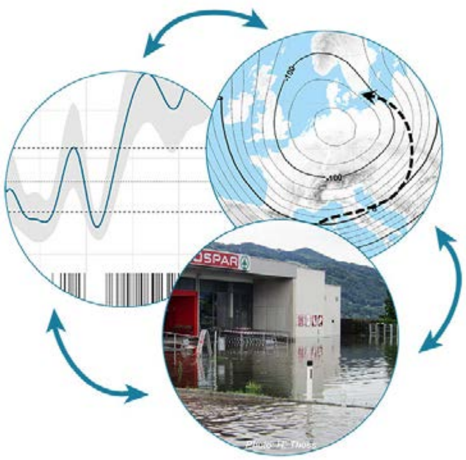
Motivation & Study Area

- Summer flood events and related weather patterns NE Alps
- Estimating damage losses using natural flood frequency (seasonnal resolution)

Paleoflood dynamics

- Siginificant change point ~ 300 AD for flood frequencies

Two different hydro-climatological regimes?



Cyclone tracks & Extreme Precipitation & Floods& Sediment event layers

- Flood events recorded in Lake Mondsee sediments are related to extreme precipitation and Vb events (calibration of TOP10/100 events,1976-2015)
- Specific feature: Cut Off Low at upper atmospheric levels and strong northerly flow at surface

Damage loss potentials (outlook)

(see presentation Prettenthaler et al. at EGU NH9.2 Costs of Natural Hazards)