Technical Skills Course TS-02:

Monitoring and prediction of environmental changes

Dagmar Schröter (IIASA, Vienna, Austria)

Thomas Glade (University of Vienna, Austria)

12. September 2012 – Buzău County, Romania

Part 1: Focusing on monitoring hazards
Thomas Glade

Part 2: Focusing on scenarios of change
Dagmar Schröter

12. September 2012 – Buzău County, Romania

Focusing on monitoring hazards

13.30 – 14.00	**Monitoring landslides: what we know and where research needs to go** (Jean-Philippe Malet)
14.00 - 14.30	**Monitoring flash floods: the challenges and future options** (Thomas Glade)
14.30 - 15.00	**Monitoring of water levels and flood discharge – where should we focus on** (Thom Bogaard)
15.00 - 15.10	**Synthesis of hazard monitoring techniques - commonalities and future challenges** (Thomas Glade)
15.10 - 15.30	**Questions/discussion on hazard monitoring** (Moderation: Thomas Glade)

Monitoring of Flash Floods

Thomas Glade (University of Vienna)

Technical Skills Course TS-02: **Monitoring and prediction of environmental changes**

Part 1: Focusing on monitoring hazards

12. September 2012 – Buzău County, Romania

UK floods disrupt transport, cut power and damage homes

Rail services between Scotland and England cancelled as engineers work to restore power in northern England and Ireland

Press Association
guardian.co.uk, Friday 29 June 2012 09.04 BST
Jump to comments (...)

Article history

Scenes of flooding after severe storms and rain cause roads and railway lines to be closed and hundreds of homes evacuated Link to this video

Major traffic disruption is expected for a second day as severe storms and torrential rain cause flash floods in parts of the UK.

Rail services between Newcastle and Edinburgh were cancelled on Friday after heavy rain caused landslides and fallen trees to block lines.

...eing swept away by a flooded

UK news
Weather · Northern Ireland · Rail transport · Scotland

World news
Ireland

More news

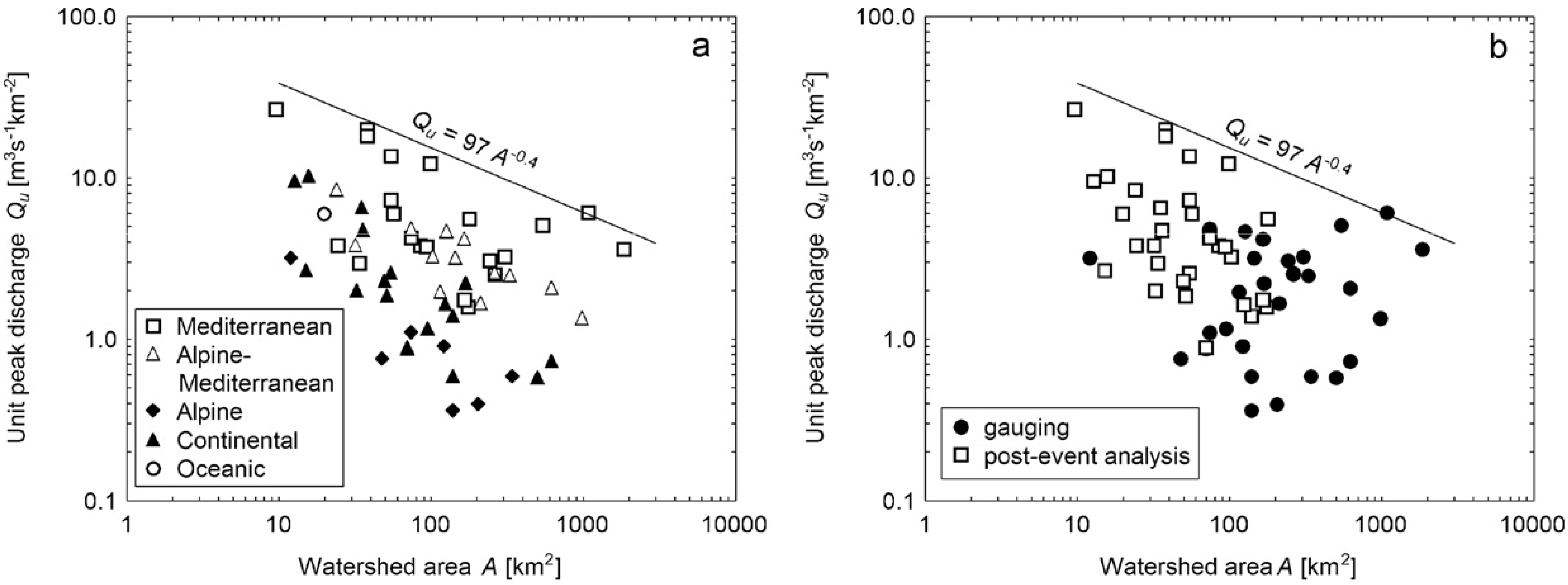
More on this story

Content

1. Characteristics of flash floods
2. Monitoring options
3. Regional examples
4. European assessments
5. Management strategies
6. Challenges
7. Weblinks and additional information

Characteristics

Relationship between catchment area and unit peak discharge



Unit peak discharges versus drainage areas; the envelope curve derived from Gaume et al. (2009) is also reported. (a) Climatic regions; (b) discharge assessment method.

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844.

Characteristics

- Association to complex orography
  - precipitation and convection
  - relief and streamflow
- Initial soil moisture conditions determine magnitude of extreme flash floods
  - effects on runoff
  - land-surface response to extreme rainfalls
- Changes of land cover / surface modification

Table 1 – Summary statistics of runoff coefficient for different antecedent wetness conditions.

Antecedent wetness class	No. of cases	Mean	Standard deviation
Dry	17	0.31	0.20
Normal	30	0.35	0.17
Wet	11	0.40	0.13

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844.

Monitoring challenges

Flash flood

- Short lead time
- Extreme change of river flow / discharge in a few seconds / minutes
- Combination of different hydrographs
- Water flow as well as transported materials (e.g. drift wood, debris, “waste”)

Trigger

- Forecasting of convection
- Local forecasts needed

Integration into risk management

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844

Monitoring options

- Extreme rainfall monitoring using weather radar
- Assimilation of radar data into numerical weather prediction
- Flash flood forecasting
  - FFDI – Flash Flood Diagnostic Index
- Flash flood hazard assessment
- Flash flood risk management
  - Information, organization, protection
  - Individual, communal, provincial, national level
  - Institutional challenges

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844

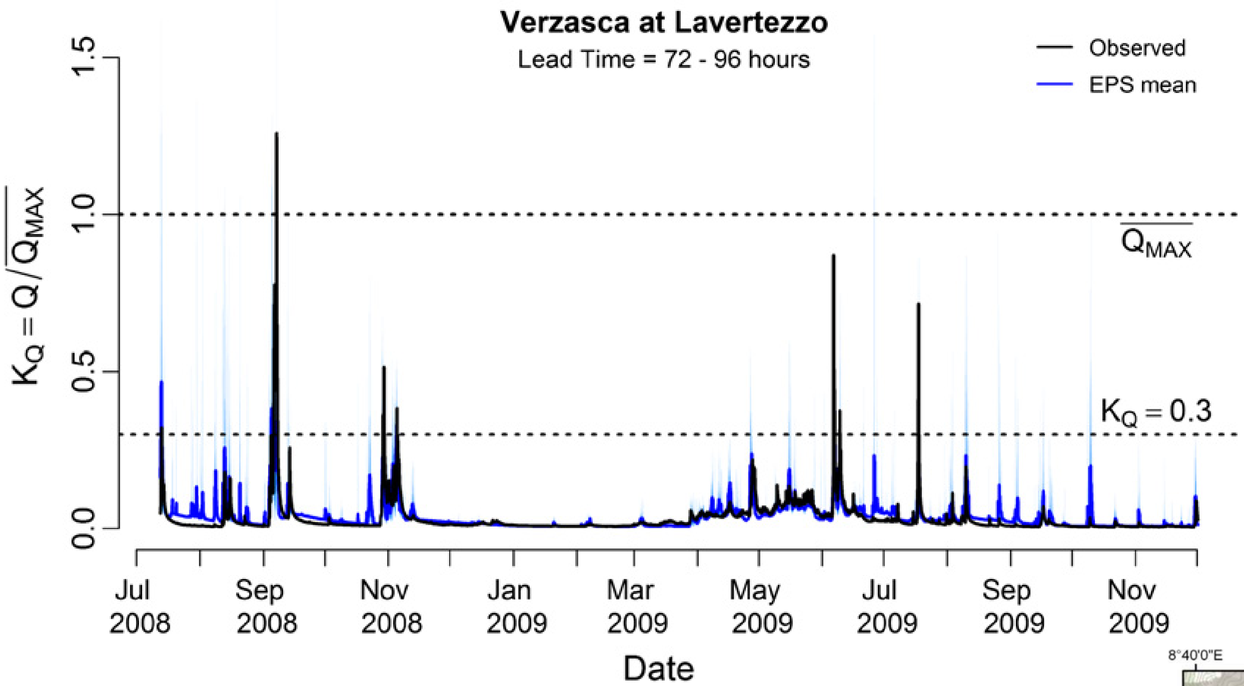
Flash flood forecasting

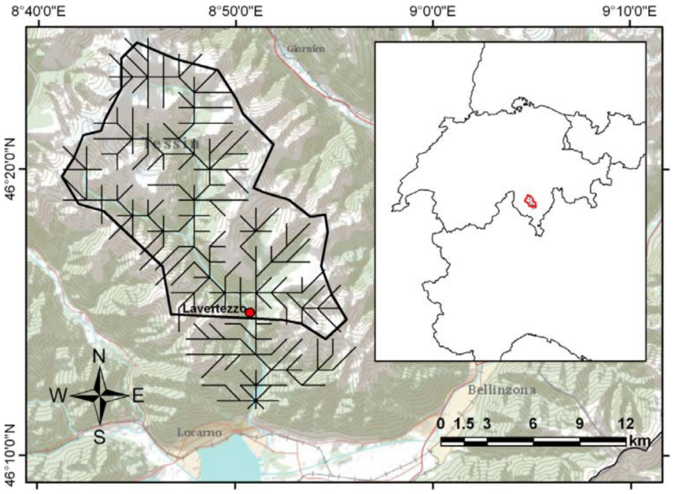
FFDI – Flash Flood Diagnostic Index

- Combines the Flash Flood Guidance approach (Norbiato *et al*. 2008, 2009) with a method of model-based threshold runoff computation
- Improves the accuracy of flash flood forecasts at ungauged locations
- Communication of the uncertainty
- Advancement: Assimilation of local conditions (precipitaion, streamflow / slope stability) (Blöschl 2008)

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844

Regional examples





Normalized observed and simulated ensemble discharges at Lavertezzo (Southern Switzerland), for the simulation period (4 day lead-time).
EPS = Probabilistic ensemble forecast

Alfieri L., Thielen J., Pappenberger F. (2012): Ensemble hydro-meteorological simulation for flash flood early detection in southern Switzerland, Journal of Hydrology 424-425, 145f

European assessments

Alpine-Carpathian range

Table 2
Number of stations used for the seasonality assessment in different countries. The first value represents the number of stations, the second the median of the record length (years) in the period 1961–2000. All stations have more than 20 years of observations and catchment size is less than 500 km^2.

Country	Extreme precipitation	Extreme floods
Austria	520/37	190/40
France	47/40	22/33
Germany	169/40	16[a]/40
Hungary	17/40	16/35
Italy	582/30	14/23
Romania	82/40	126/38
Slovakia	56/40	62/38
Switzerland	461/38	128/36
Ukraine	11/40	3/39

[a] Catchments in Germany are larger than 500 km^2.

Parajka J., Kohnová S., Bálint G., Barbuc M., Borga M., Claps P., Cheval S., Dumitrescu A., Gaume E., Hlavcová K., Merz R., Pfaundler M., Stancalie G., Szolgay J., Blöschl G. (2010): Seasonal characteristics of flood regimes across the Alpine-Carpathian range, Journal of Hydrology 394, 80

Alpine-Carpathian range

Topography and precipitation stations

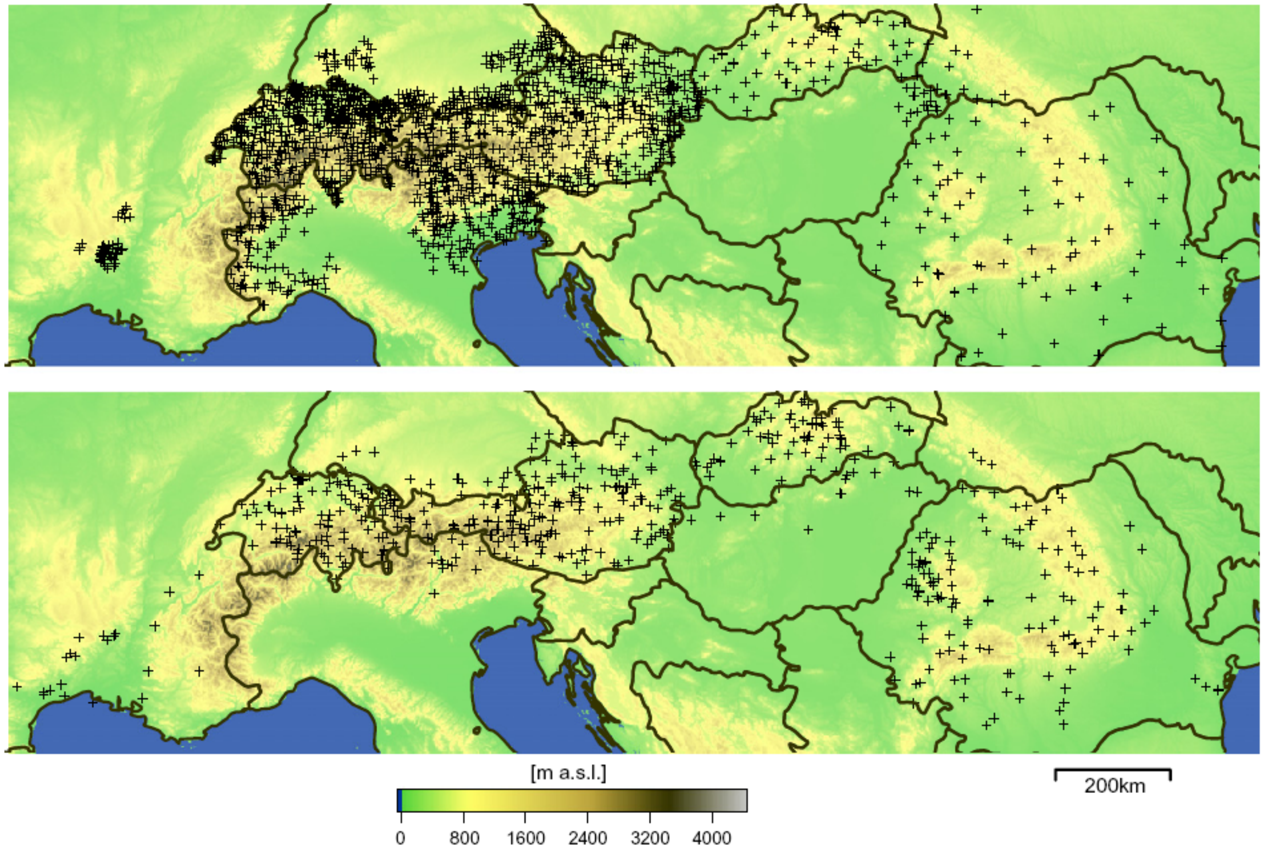
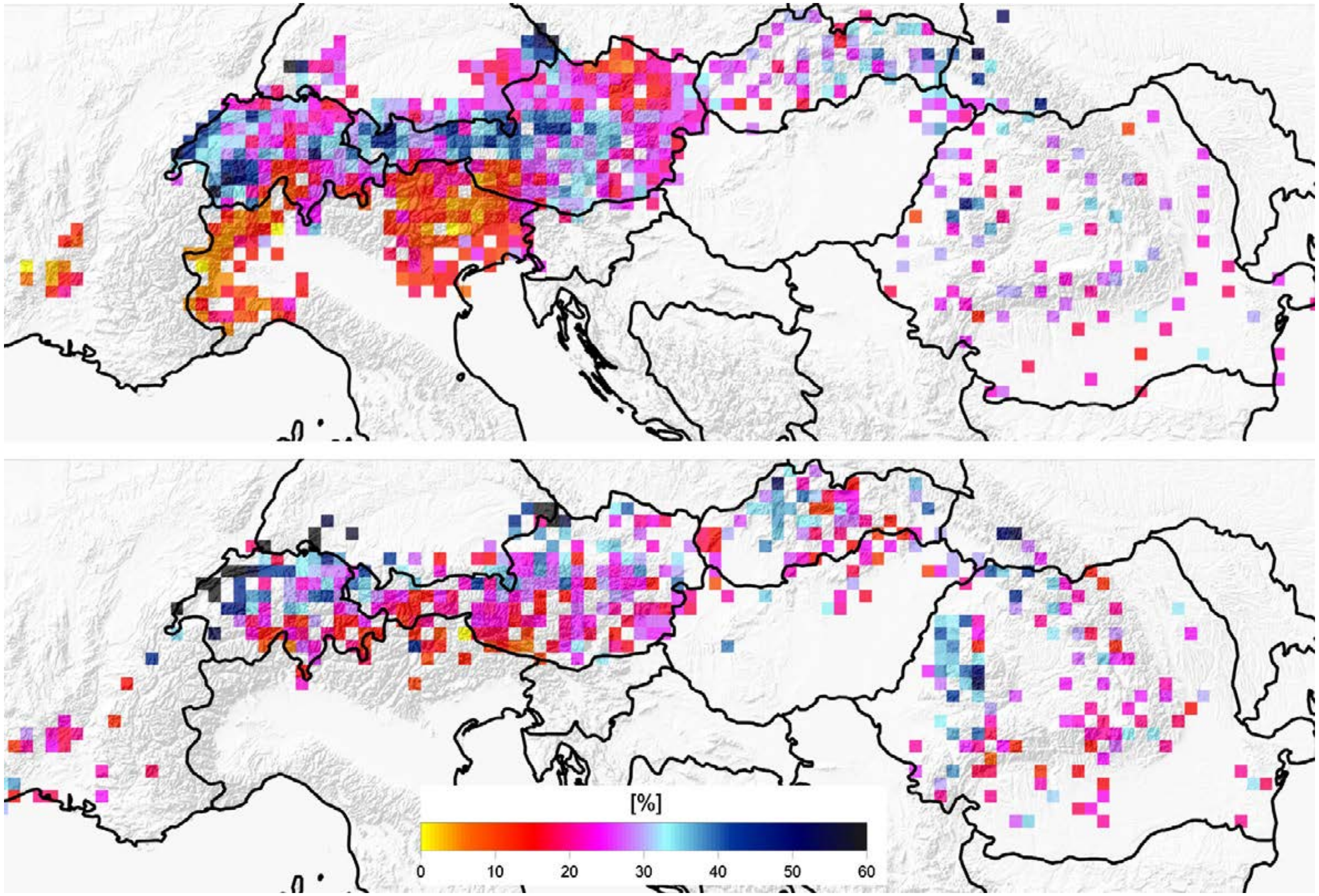


Fig. 1. Topography along the chain of Alps and Carpathians and the location of precipitation stations (top) and streamflow gauges (bottom).

Parajka J., Kohnová S., Bálint G., Barbuc M., Borga M., Claps P., Cheval S., Dumitrescu A., Gaume E., Hlavcová K., Merz R., Pfaundler M., Stancalie G., Szolgay J., Blöschl G. (2010): Seasonal characteristics of flood regimes across the Alpine-Carpathian range, Journal of Hydrology 394, 80

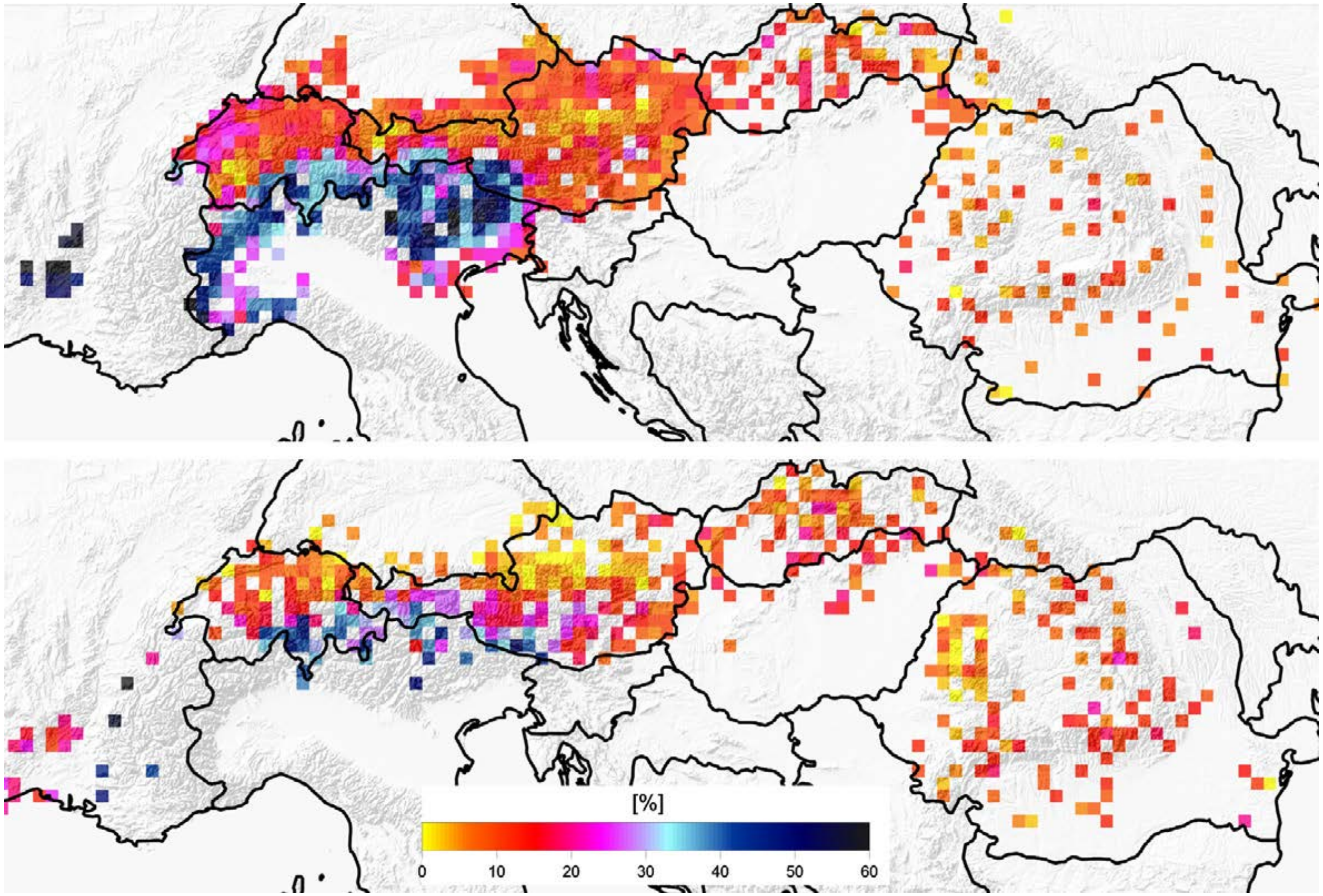
Alpine-Carpathian range



Relative frequency of annual maximum precipitation (top panel) and floods (bottom panel) that have occurred during the Zonal West weather circulation situation in the period 1961–2000.

Parajka J., Kohnová S., Bálint G., Barbuc M., Borga M., Claps P., Cheval S., Dumitrescu A., Gaume E., Hlavcová K., Merz R., Pfaundler M., Stancalie G., Szolgay J., Blöschl G. (2010): Seasonal characteristics of flood regimes across the Alpine-Carpathian range, Journal of Hydrology 394, 84

Alpine-Carpathian range



Relative frequency of annual maximum precipitation (top panel) and floods (bottom panel) that have occurred during the Meridional South-East and South weather circulation situation in the period 1961–2000.

Parajka J., Kohnová S., Bálint G., Barbuc M., Borga M., Claps P., Cheval S., Dumitrescu A., Gaume E., Hlavcová K., Merz R., Pfaundler M., Stancalie G., Szolgay J., Blöschl G. (2010): Seasonal characteristics of flood regimes across the Alpine-Carpathian range, Journal of Hydrology 394, 84

European assessments

Hydrate database

- Flash flood data center: Detailed data for a number of flash flood events in Europe since 1994
  - spatially-detailed rainfall patterns, flow type processes, hydrographs, peak discharges
- Flash flood primary data (free access!)
  - reported flash flood events in Spain, France, Italy, Greece, Slovakia, Romania
  - occurrence data, location, precipitation, peak discharge, basin characteristics

http://www.hydrate.tesaf.unipd.it/index.asp?sezione=FFDCPresentation

Hydrate database

Table 1
Content of the hydrate flash flood database (required data for all events in normal style and optional additional data in italics).

Section identification	Basin data	Discharge data	Rainfall data	Damages and casualties
Data				
Event code	Basin area (km^2)	Peak discharge (m^3/s)	Total point rainfall (mm)	*Total damages (€)*
Date of the event	Time of concentration (h)	Estimation method	Rainfall duration (h)	*Displaced persons*
River name	*Minimum elevation (m)*	Estimation quality rate	*Av. rainfall on the basin (mm)*	*Population affected*
Cross-section name	*Maximal elevation (m)*	Regulated stream (y/n)	*No. of raingauges*	*Direct private damages (€)*
Section longitude	*Average elevation (m)*	*Peak discharge Maxi*	*No of raingauges in the basin*	*Direct public damages (€)*
Section latitude	*Average basin slope (%)*	*Peak discharge mini*	*Quality of data*	*Indirect damages (€)*
Section elevation (m)	*Glacial areas (%)*	*10-year discharge (m^3/s)*	*Type of event*	*Origin of the data*
	Land use	*100-year discharge (m^3/s)*	*Spatial extent (km^2)*	*No of casualties*
	Soils	*Sediment processes (y/n)*	*Max. Intens. over Tc (mm/h)*	*No of injured people*
	Av. soil thickness (m)	*Flood duration (h)*	*Hailfall (y/n)*	*Medical causes*
	Geology		*Initial wetness (wet/dry)*	*Circumstances*
			Annual precipitation (mm)	*Timing*
			Observation period (years)	*Gender*
				Age
Attached documents				
Comments and notes				
Photos	*Location map*	*Flood hydrograph*	*Rainfall map*	*Report on the damages*
Attached reports	*Geographical doc.*	*Past-historical floods*	*Radar data*	*Report on casualties*
References list		*Cross-section survey*	*Local IDF curves*	
		Pictures of the section	*Monthly precipitations*	

Gaume E., Bain V., Bernardara P., Newinger O., Barbuc M., Bateman A., Blaskovicová L., Blöschl g., Borga M., Dumitrescu A., Daliakopoulos I., Garcia J., Irimescu A., Kohnova S., Koutroulis A., Marchi L., Matreata S., Medina V., Preciso E., Sempere-Torres D., Stancalie G., Szolgay J., Tsanis I., Velasco D. & Viglione A. (2009): *A compilation of data on European flash floods*, Journal of Hydrology 367, p. 72

Hydrate database

Table 2
Methods of estimating the peak discharge of events (%).

	Number of records	Manning Strickler formula estimation	Extrapolation of calibrated stage–discharge relation	Hydraulic 1D simulation	Hydraulic 2D simulation	Reconstruction from reservoir operation	Direct current meter measurement	Other	Unknown
Catalonia	10	56	11	33	0	0	0	0	0
France	236	20	33	17	0	7	0	0	23
Italy	73	64	23	13	0	0	0	0	0
Slovakia	52	0	73	0	0	0	0	27	0
Greece	21	66	0	0	17	0	17	0	0
Romania	152	0	53	0	0	47	0	0	0
Austria	34	0	94	6	0	0	0	0	0

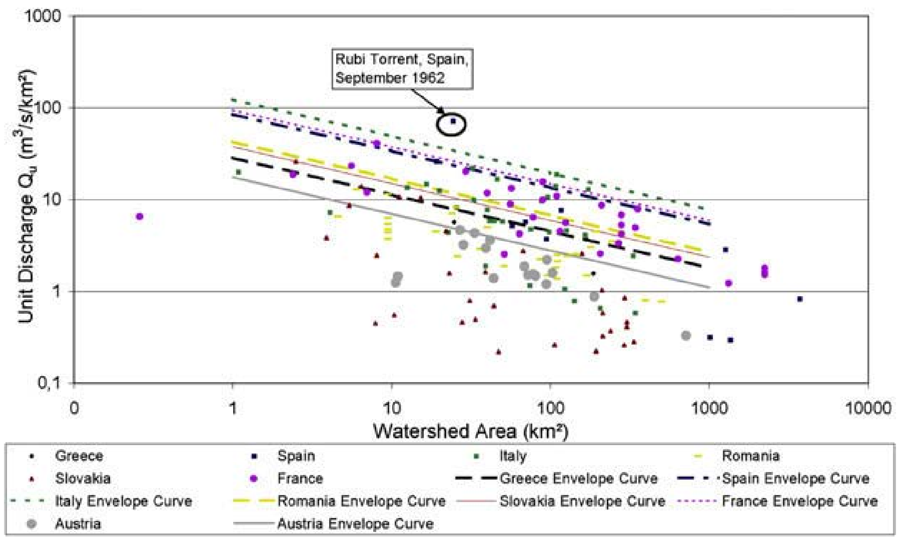
Table 3
Number of flash flood events listed in the Hydrate database for each region.

	Area (km^2)	Nb of events	Dates	Cov[a]	D[b]	Refined number	Dates	Cov[a]	D[b]
Catalonia	32,000	10	1962–2005	1.4	7	9	1971–2005	1.1	8
France	18,000	236	1953–2006	0.9	255	30	1953–2006	0.9	32
Italy	95,000	73	1968–2006	3.6	20	30	1968–2006	3.6	8
Slovakia	49,000	52	1995–2004	0.4	120	30	1995–2004	0.4	70
Greece	132,000	21	1960–2006	6.0	3	4	1989–2006	2.2	2
Romania	240,000	152	1973–2007	8.1	19	30	1979–2007	6.7	5
Austria	85,000	34	1987–2005	1.5	22	17	1987–2005	1.5	11

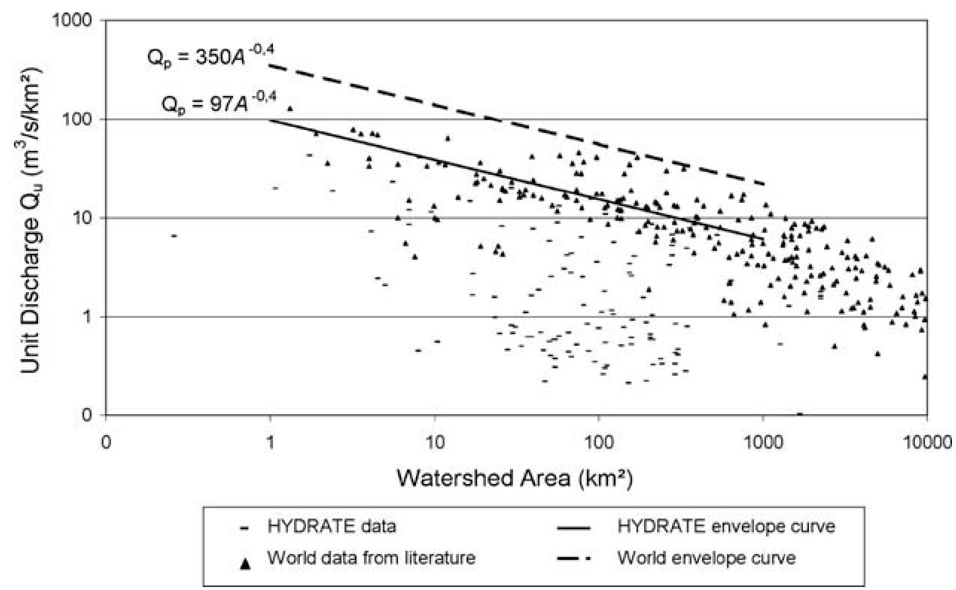
[a] Cov: Coverage in $yr 10^6 km^2$.
[b] D: density in $records/yr/10^6 km^2$.

Gaume E., Bain V., Bernardara P., Newinger O., Barbuc M., Bateman A., Blaskovicová L., Blöschl g., Borga M., Dumitrescu A., Daliakopoulos I., Garcia J., Irimescu A., Kohnova S., Koutroulis A., Marchi L., Matreata S., Medina V., Preciso E., Sempere-Torres D., Stancalie G., Szolgay J., Tsanis I., Velasco D. & Viglione A. (2009): *A compilation of data on European flash floods*, Journal of Hydrology 367, p. 72f

Unit discharges



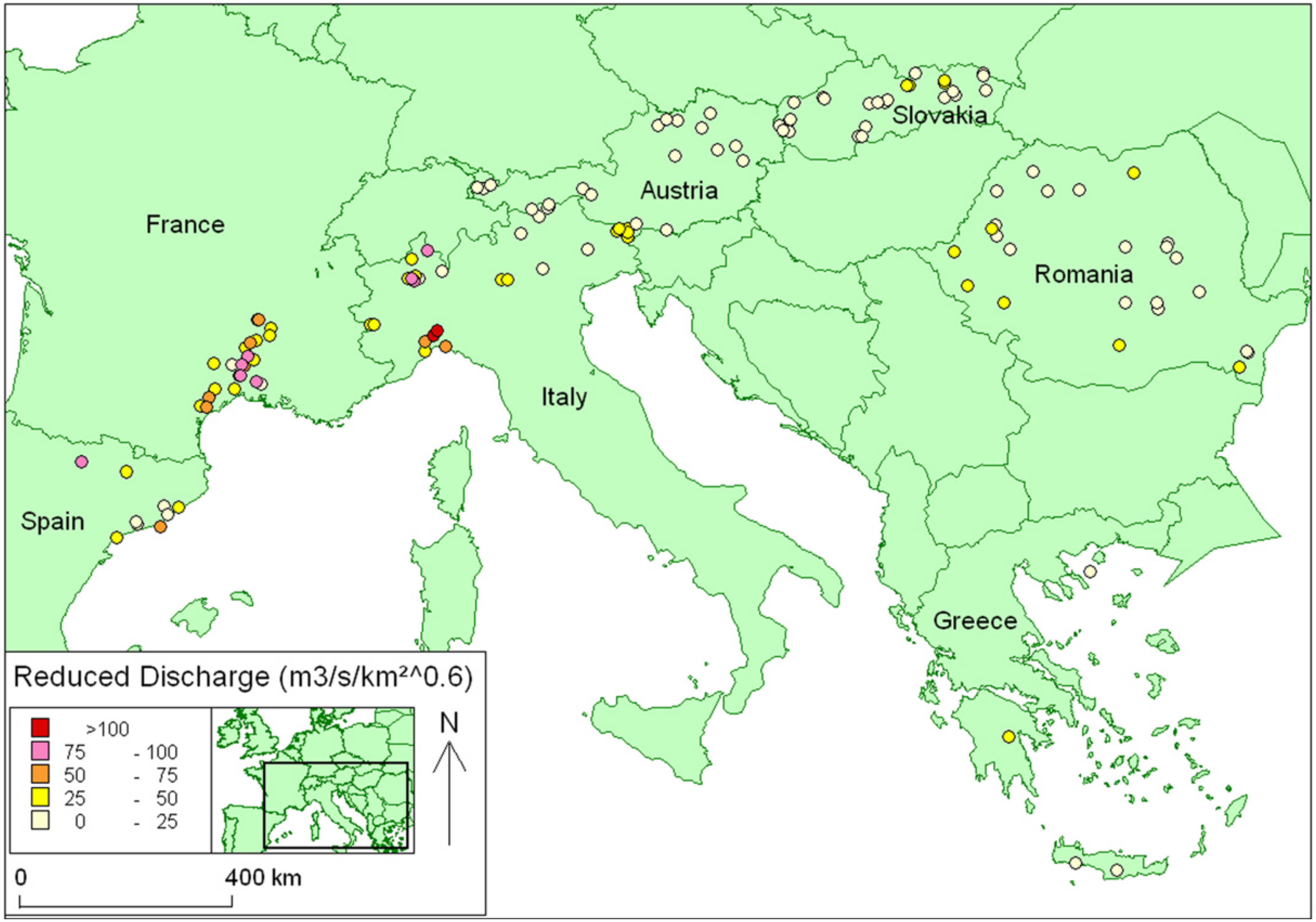
Peak unit discharges of extreme events in the European HOs and envelope curves.



Comparison between the unit discharges collected for this study, Hydrate (the dashes) and the unit discharges reported in literature for the world (triangles).

Gaume E., Bain V., Bernardara P., Newinger O., Barbuc M., Bateman A., Blaskovicová L., Blöschl g., Borga M., Dumitrescu A., Daliakopoulos I., Garcia J., Irimescu A., Kohnova S., Koutroulis A., Marchi L., Matreata S., Medina V., Preciso E., Sempere-Torres D., Stancalie G., Szolgay J., Tsanis I., Velasco D. & Viglione A. (2009): *A compilation of data on European flash floods*, Journal of Hydrology 367, p. 75

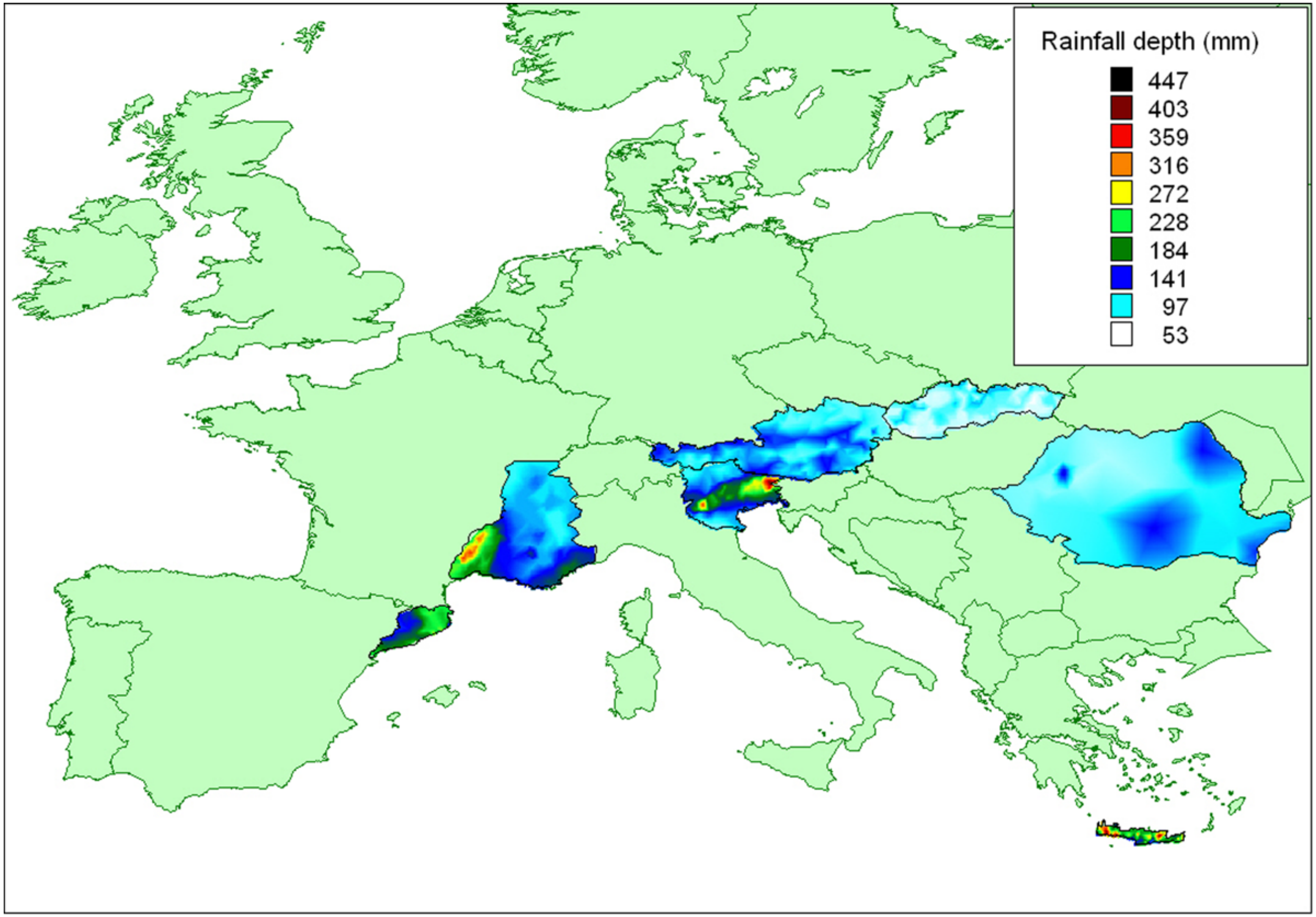
Extreme flash floods in Europe



Atlas of reduced peak discharges of extreme events in Europe.

Gaume E., Bain V., Bernardara P., Newinger O., Barbuc M., Bateman A., Blaskovicová L., Blöschl g., Borga M., Dumitrescu A., Daliakopoulos I., Garcia J., Irimescu A., Kohnova S., Koutroulis A., Marchi L., Matreata S., Medina V., Preciso E., Sempere-Torres D., Stancalie G., Szolgay J., Tsanis I., Velasco D. & Viglione A. (2009): *A compilation of data on European flash floods*, Journal of Hydrology 367, p. 76

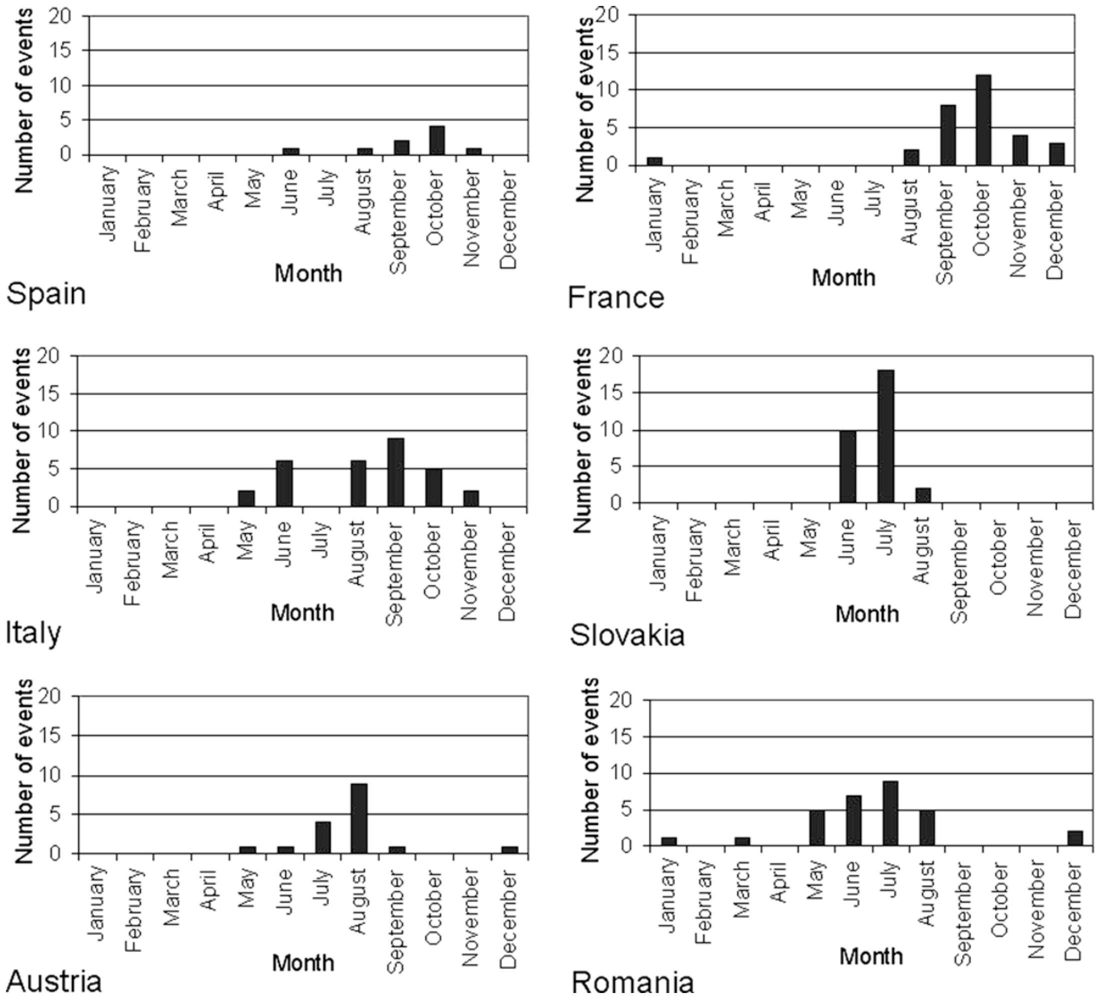
Extreme flash floods in Europe



Distribution of the estimated 100-year return period daily rainfall amounts.

Gaume E., Bain V., Bernardara P., Newinger O., Barbuc M., Bateman A., Blaskovicová L., Blöschl g., Borga M., Dumitrescu A., Daliakopoulos I., Garcia J., Irimescu A., Kohnova S., Koutroulis A., Marchi L., Matreata S., Medina V., Preciso E., Sempere-Torres D., Stancalie G., Szolgay J., Tsanis I., Velasco D. & Viglione A. (2009): *A compilation of data on European flash floods*, Journal of Hydrology 367, p. 77

Extreme flash floods in Europe



Number of flash flood occurrences in each month

Gaume E., Bain V., Bernardara P., Newinger O., Barbuc M., Bateman A., Blaskovicová L., Blöschl g., Borga M., Dumitrescu A., Daliakopoulos I., Garcia J., Irimescu A., Kohnova S., Koutroulis A., Marchi L., Matreata S., Medina V., Preciso E., Sempere-Torres D., Stancalie G., Szolgay J., Tsanis I., Velasco D. & Viglione A. (2009): *A compilation of data on European flash floods*, Journal of Hydrology 367, p. 77

Management strategies

- Integration in general framework of flood risk management
- Recognition of specifics of flash floods
  - Special flood defence infrastructure
  - Multi-hazard nature of flood risk
  - Specific preparedness strategies
- Cooperation of land-use planning and water management / civil protection authorities
- Cycle of preparedness – response – recovery

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 840

Integrative Multi-risk approach

- Combination of bottom-up and top-down approaches
- Participatory framework
- Integration of various management strategies

  retention basins, land-use zoning, flash flood warnings etc.
- Integration of all relevant natural hazards

  flash floods, debris flows, landslides, etc.
- Holistic approach to emergency planning and management

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 840

Challenges – Flash floods

Process investigations

- Long term monitoring data is required
- Combination of different hydrographs
- Gauged versus ungauged catchments / slopes
- Frequency / magnitude investigation of extremes!
- Water flow as well as transported materials (e.g. drift wood, debris, “waste”)
- Trigger …. “Cascading effect”, e.g. landslide blocks river => Lake => dam breach => Flash flood
- Monitoring data: Storage, analysis, combination

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844

Challenges – Flash floods

- Preparatory factors
  - Changes in the catchments
- Trigger
  - Estimation of extremes
  - Scenarios of extremes
- Conditioning factors
  - Changing surfaces (e.g. sealing, etc.)
  - Modifying river channels
  - Reservoirs

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844

Challenges – Flash floods

- Data manipulation
  - Focusing on on-site instruments, monitoring
  - Local forecasts needed
- Information provision
  - What information is available?
  - For whom?
- Decision support
  - Communication
  - Information for uncertainty
  - Local forecasts needed

Borga M., Anagnostou E.N., Blöschl G., Creutin J.-D. (2011): Flash flood forecasting, warning and risk management: the HYDRATE project, Environmental Science & Policy 14, 834-844

Videos

Flash flood/debris flow Southern Utah

- http://www.youtube.com/watch?v=maRRWdscktU&feature=fvst

Pokhara Nepal, 5.5.2012

- http://www.youtube.com/watch?v=nge6zODSmsQ
- http://www.youtube.com/watch?v=6XjhgpV5v6Q
- http://www.youtube.com/watch?v=yC00cd2TzzU

Weblinks

Projects

- HYDRATE: http://www.hydrate.tesaf.unipd.it/
- FLASH: http://flash-eu.tau.ac.il
- FLOODsite: http://www.floodsite.net

Thanks for your attention!

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http://homepage.univie.ac.at/thomas.glade/

SEVENTH FRAMEWORK PROGRAMME · CHANGES Risk=HVA · MARIE CURIE ACTIONS

AUSTRIA GEOMORPHOLOGY ENVIRONMENTAL CHANGE · ENGAGE Geomorphological Systems & Risk Research · universität wien · Department of Geography and Regional Research

Synthesis of hazard modelling techniques
- commonalities and future challenges

Thomas Glade (University of Vienna)

Technical Skills Course TS-02: **Monitoring and prediction of environmental changes**

Part 1: Focusing on monitoring hazards

12. September 2012 – Buzău County, Romania

Synthesis in Challenges

Process studies

- Long term monitoring data is required
- Parameters need to be defined
- Gauged versus ungauged catchments / slopes
- Frequency / magnitude investigation
- Cascading effect
- Local investigation / spatial effects

Management options

- Direct interventions (e.g. dams, nailing, reservoirs)
- Indirect measures (e.g. land-use planning, land cover)
- Combined management

Future developments

- Human interactions
- External forces

Part 1: Focusing on monitoring hazards

Thomas Glade

Part 2: Focusing on scenarios of change

Dagmar Schröter

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