

**COST Action ES1206 - GNSS4SWEC**  
Advanced GNSS Tropospheric Products for  
monitoring Severe Weather Events and Climate

# **WG1: Advanced GNSS Processing Techniques (AGNSS)**

Jan Douša (GOP, Czech Republic)

Galina Dick (GFZ, Germany)

# WG1: Main Goals

**The main goals of the WG1 are defined in four main domains:**

- Coordinating of development advanced tropospheric products in support of weather forecasting (ultra-fast products, asymmetry monitoring, tomography, multi constellation processing)
- Reprocessing and model assessment in consistent tropospheric products for climatology
- Exploiting numerical weather data in precise GNSS positioning (mapping functions, a priori ZHD modeling, tropospheric gradients, tropospheric models for real-time positioning, parameter conversions)
- Stimulating transfer of knowledge, tools and data exchange in support of new analysis centres and new networks setup

# WG1: Schedule

## **1. WG1 invited presentations** (*introduction of new WG1 members*)

- Trimble applications to study troposphere (*R. Charara*)
- GFZ Repro2 product & GPS+GLO+GAL+BDS processing (*Z. Deng*)

## **2. WG1 status summary** (*chairs - J. Douša, G. Dick*)

- Objectives & achievements
- Sub-WG status and plans

## **3. WG 1 topics for wide inter-WG discussions**

- Advanced products for WG2 - UT-RT and ASYM (*H. Brenot, G. Dick*)
- NWM-based tropo models from WG2 (*F. Zus, J. Douša*)
- Benchmark (*M. Kačmařík, J. Douša*)
- Support for PPP - optional topic (*P. Václavovic, J. Douša*)?

# WG1: Organisation

**ASYM:** Asymmetry monitoring – gradients & slant delays

**BENCH:** Benchmark – preparation, coordination and evaluation

**EVAL:** ZTD/IWV conversion & evaluation in RT and NRT

**GNSS:** Preparing and validating multi-GNSS processing

**MODEL:** Improving tropospheric modeling for GNSS applications

**NEW:** Support for new analysis centre and new network setup

**PPP:** Fostering and promoting use of PPP in GNSS-meteorology

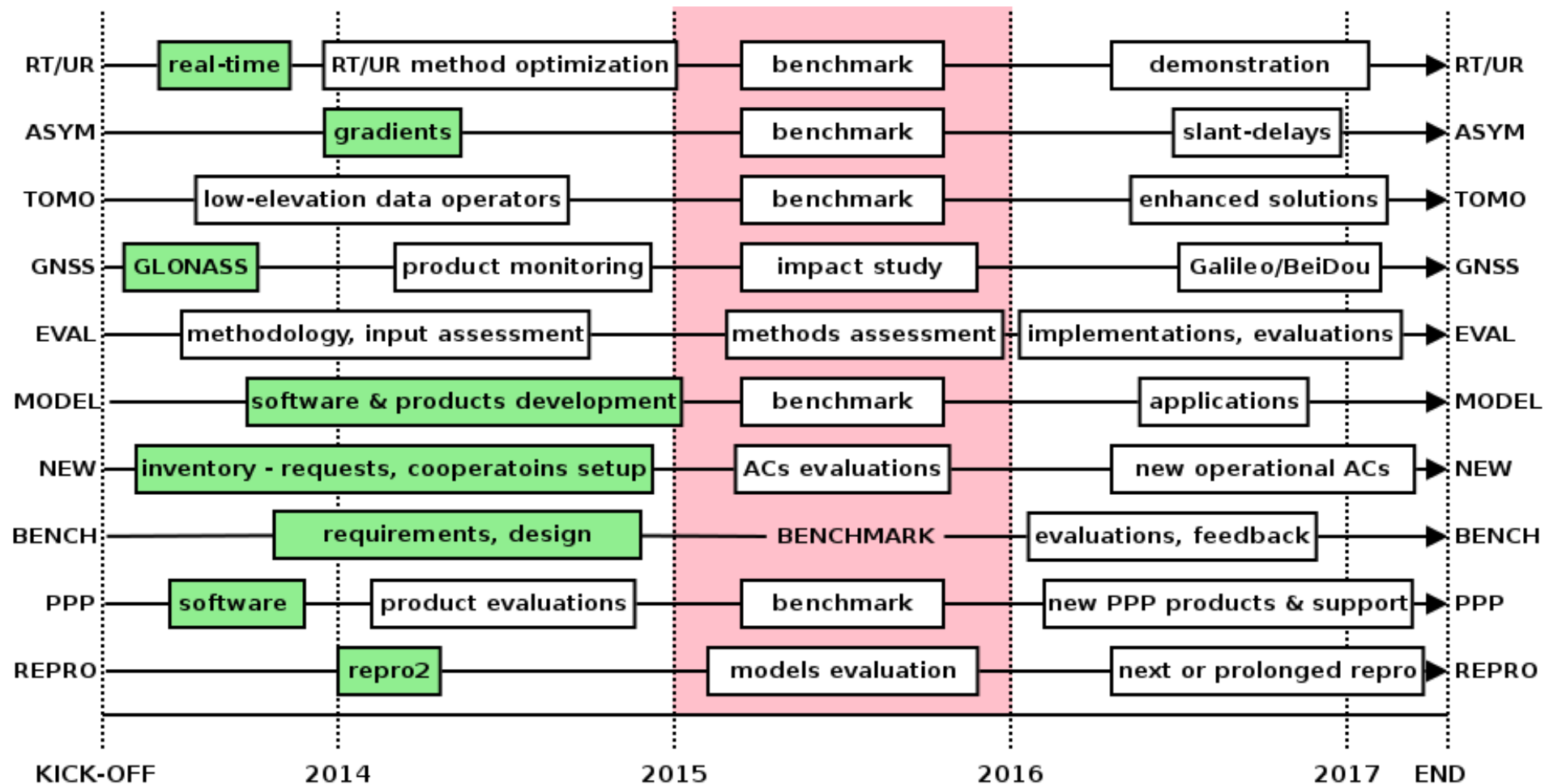
**REPRO:** Reprocessing ZTD analyses & optimizing GNSS model

**RT/UR:** Development of real-time & ultra-fast ZTD products

**STUDY:** Additional studies for improving existing products

**TOMO:** 3D water vapor reconstruction through GNSS tomography

# WG1 - activity progress/planning



# Sub-Group TOMO **now merging with WG2**

*Witold Rohm*

## **Goals: Assess the potential of tropospheric parameter vertical resolutions based on GNSS data**

- MS1: correlation of gradients from space geodetic technique analysis and numerical weather models
- MS2: ingest of new slant delay observations in the tomography models
- MS2: develop with RT/UR new products for nowcasting (vertical and horizontal WV fluxes)
- LINKS: **ASYM, WG2, GNSS, RT/UR** (data, comparisons, requirements, ...)
- BENCH – impact study of new observations, consistency check with NWP/RS, nowcasting products radar validation
  - rather specific resuquirements
- **WUELS, BIRA, ETH, UBI, TUW, MUT, TU Ostrava, GFZ**

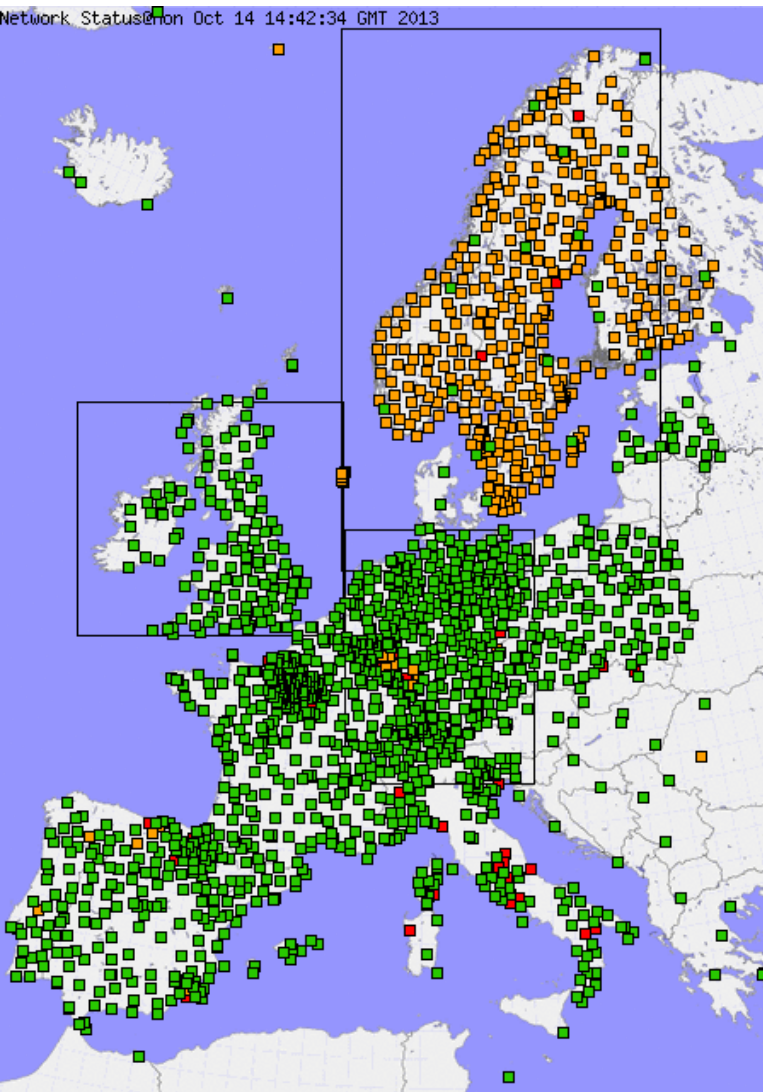
# Sub-Group NEW

*Karolina Szafranek*

**Goals: Support transfer of knowledge, data exchange for improving coverage of tropospheric products in Europe**

- MS1: inventory of interests/offers for exploiting new networks and settings new analysis centers
- MS1: planning for efficient transfer of knowledge, support of data exchanges (Letter of Intent) etc.
- MS2: support for specific tools, processing/strategy knowledge etc
- MS2: filling gaps via setting new ACs, external data processing etc.
- LINKS: **EUPOS, EPOS, E-GVAP** ...
- BENCH: possible evaluation of new AC developments
- **Various – next slide**

# New networks / analysis centres



**Austria:** TUV – new data/AC (→ E-GVAP ... planned in COST)

**Bulgaria:** SU – new data/AC (UL and GOP support)

**EUPOS:** Letter of Intent → new data ??

**Estonia:** ??? – no data, no partner

**France:** LGG – new data (ORPHEUS) ??

**Greece:** AUT – new data/AC (GOP setup → E-GVAP)

**GRUAN:** GFZ – new data (NRT ongoing → E-GVAP)

**Hungary:** BUTE + FOMI – new data (→ E-GVAP ??)

**Italy:** E-GEOS/ASI – data densification (ongoing → E-GVAP ok)

**Iceland:** Met Office – new data/AC ??

**Latvia:** GIA – new data (analysed by GOP for E-GVAP)

**Lithuania:** ??? – new data (GFZ processing/help ...)

**Luxembourg:** UL – new data/AC (E-GVAP testing)

**Norway & N. Sea:** ??? – oil platforms, new data/AC ??

**Poland:** WUELS – new data/AC (E-GVAP ok)

**Portugal:** IPMA – new data (METO help ...)

**Slovakia:** SUT – new data (E-GVAP status, )

**Sweden:** SHMI → Lantmateriet (plan)

**Tunisia:** OMC - new data (IGN/LAREG) ??

**Turkey:** KTU - new AC (GOP setup → E-GVAP)

**E-GVAP (ok):** CH, CZ, DK, GE, FI, LU, NL, NO, PL, SE, SP, UK



# Sub-Group GNSS

*Z. Deng*

**Goals: Development, integration and consistency check of multi-GNSS constellations (GPS, GLONASS, Galileo, BeiDou)**

- MS1: GLONASS integration
- MS1: monitoring new observations, QC tools development, RINEX 3.x
- MS2: assessment of relevant product support (orbit & clocks), precise models (PCV, ...), systematic errors, ...
- MS2: preparation for Galileo integration, BeiDou processing (Deng)
- MS3: optimal exploitation of new signals from multi-GNSS constellations
- LINKS: ASYM, TOMO, RT/UR, WG2
- BENCH – assessment of consistency, impact study on various products
- GFZ, GOP, BKG, ...

# Multi-GNSS

## *responses from E-GVAP ACs*

### **IGN (Spain)** *by Sánchez Sobrino José Antonio*

- IGE\_ - GPS (Bernese 5.0) – official product
- **IGE2 - GPS+GLO** (Bernese 5.2) – testing product , new models, no serious assessment (-> E-GVAP)

### **GOP (Czech Rep)** *by Jan Douša, Pavel Václavovic*

- GOP1 - GPS (Bernese 5.0) – official regional product
- GOPG - GPS (Bernese 5.0) – official global product
- **GOP2 - GPS+GLO** (Bernese 5.0) – testing regional product + assessment + switch to BSW5.2 ready
- **GOPR - GPS+GLO** (G-Nut/Tefnut) – testing global+regio RT product for selected stations

### **METO (UK)** *by Jonathan Jones*

- METO - GPS (Bernese 5.0) – official regional product, this year update to BSW5.2 + **intro GLONASS**
- METG - GPS (Bernese 5.0) – testing global product

### **BKG (Germany)** *by Yueksel Altiner*

- BKG\_ - GPS (Bernese 5.0) – official regional product, no plan to experiment with GLO for next months
- **BKGR – GPS+GLO** (BNC, GMON) – testing real-time solution, providing GPS+GLO CLK products

**OTHERs ?**

# Sub-Group EVAL

*Samuel Nahmani*

## **Goals: Homogenize strategies for troposphere parameter evaluation and NRT/RT ZTD to IWV conversion**

- MS1: contribute to the methodology for parameter conversions with focus on NRT/RT aspects
- MS1: evaluate quality of meteorological parameters including available in-situ data
- MS2: methodology (e.g. tropospheric ties) for evaluation with external data sources (radiosondes, WVR, NWM, ...)
- MS2: implement and evaluate conversion methods in for RT/NRT
- LINKS: **WG2 (inputs), WG3 (methodology)**
- BENCH: evaluation with external data sources, conversion strategies, ...
- **IGN, GOP, WUELS, ROB/BIRA/RMI**

# Sub-Group REPRO

*Elmar Brockmann*

**Goals: Prepare state-of-the-art homogeneous tropospheric product for climate (1996-2013)**

- **MS1: Repro2 production – European, regional, national, global**
- **MS2: assess GNSS models, strategies and products**
- **MS3: refine strategies for climate applications, based on long-term study**
- **BENCH: potential reference tropospheric products, evaluate models, different strategies & software**
- **WG1 responsibility: production & refinement ...**
- **WG3 responsibility: requirements, QC, assessment, conversion & feedback**
- **WG3+WG1: Product database – distinguish evaluation vs. archive DB ?**
- **LPT, GOP, GFZ, ...**

# Sub-Group ASYM

*Hugues Brenot*

**Goal: Optimize monitoring tropospheric horizontal anisotropy using space geodetic techniques**

- MS1: correlation of gradients from space geodetic technique analysis and numerical weather models or direct observations (WVR)
- MS1: study the impact of introducing gradients on ZTD values
- MS2: comparison of strategies for gradient estimation procedures including multi-GNSS, cut-off angle etc.
- MS2: comparison of strategies for retrieving slant delay and accuracy assessment
- LINKS: **TOMO, MODEL, WG2** (requirements, feedback, benchmark, ...)
- BENCH: – assessment of gradients, slant delays, strategies, software
- **BIRA, GFZ, GOP, ROB, ESGT, WUELS, TUW, IGN, ASI**

# Sub-Group MODEL

*Florian Zus, Marcelo Santos*

## **Goals: Advanced exploitation of NWM data in precise GNSS analyses**

- MS1: development of software to handle NWM data as source
- MS1: development of augmentation models for real-time positioning
- MS2: information from NWM – tropospheric gradients, pressure (ZHD)
- MS2: assessment of augmentation models and a priori values from NWM
- LINKS: **WG2, ASYM, PPP, REPRO, ..**
- BENCH: assessment external tropospheric products and geodetic solutions exploiting them
- **GFZ, TUW, WUELS, GOP, BIRA, ASI, UWM**

# Precise Point Positioning

*Pavel Václavovic, Pawel Wielgosz*

## **Goals: Support of the exploitation of PPP in future tropospheric estimations**

- **MS1: PPP software development** & comparisons
- **MS1: monitoring/evaluation of IGS RTS orbit and clock products**
- **MS1: assessment of IGS RTS in near real-time solutions**
- MS2: impact of ambiguity resolution on tropospheric estimates
- MS2: monitoring /developing/consolidating products in support of PPP (orbit & clocks, ...)
- LINKS: **RT/UR, ASYM, GNSS, NEW, IGS**
- BENCH: SW/strategy comparisons, PPP kinematic solutions
- **UL, GOP, GFZ, BKG, WUELS, UWM, SMHI, MUT, IGN, ..**

# Sub-Group RT/UR:

*Norman Teferle*

**Goals: Develop and assess ultra-fast tropospheric product suitable for nowcasting**

- MS1: development and assessment of real-time or sub-hourly tropospheric solutions
- MS1: optimization of the strategy according to the required timelines and accuracy
- MS2: Demonstration campaign for real-time (European & global)
- MS3: preparing routine provision of ZTD, conversion to IWV ?
- LINKS: **WG2** (requirements, formats, feedback, ...)
- BENCH: assessment of various strategies, software, simulated mode
- **BKG, GOP, UL, WUELS, GFZ, UWM, ASI**



# Real-time demonstration campaign (planning)

- Idea of setting up well coordinated demonstration campaign of selected stations within WG1 of GNSS4SWEC project
- Using real-time GNSS data flow and RT precise products
- How E-GVAP is interested to be involved:
  - Immediately or later (i.e. after demonstration)?
  - What is interest for potential users?
  - Monitoring via E-GVAP web-page, using test data pool?
  - Selection of limited number of stations station:
    - E-GVAP super-sites? (at least those RT/anonymous)
    - Regional or global?

# Sub-Group BENCH

*Michal Kačmařík*

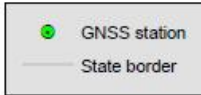
**Goals: Design a common benchmark campaign for evaluations and inter-comparisons of individual solutions**

- MS1: inventory of data, contributions, specific requirements and interests from individual sub-working groups
- MS1: benchmark design, planning and data collection
- MS2: contributions (2015-2016)
- MS3: evaluation, feedback, interpretations (2015-2016)
- LINKS: **almost all other sub-groups + WG2, WG3**
- **WG2** – requirements for **interesting periods & area**
  - **Quiet & Severe weather condition**

# Benchmark campaign (planning)

- Idea of collecting a well documented data set for various WG1 activities within GNSS4SWEC project
- Collect not only GNSS, but also other data sources)
- Main focus on WG1 activity for:
  - Optimizing development towards new products
  - Inter-comparison of solutions as a feedback to providers (new products or new providers)
  - Assessment of new products
  - Study of NWM in support of GNSS real-time positioning

- More than **250 GNSS** reference stations are available in total
- Most likely hierarchically organized dataset (in support of various activities)



# Benchmark - time domain selection

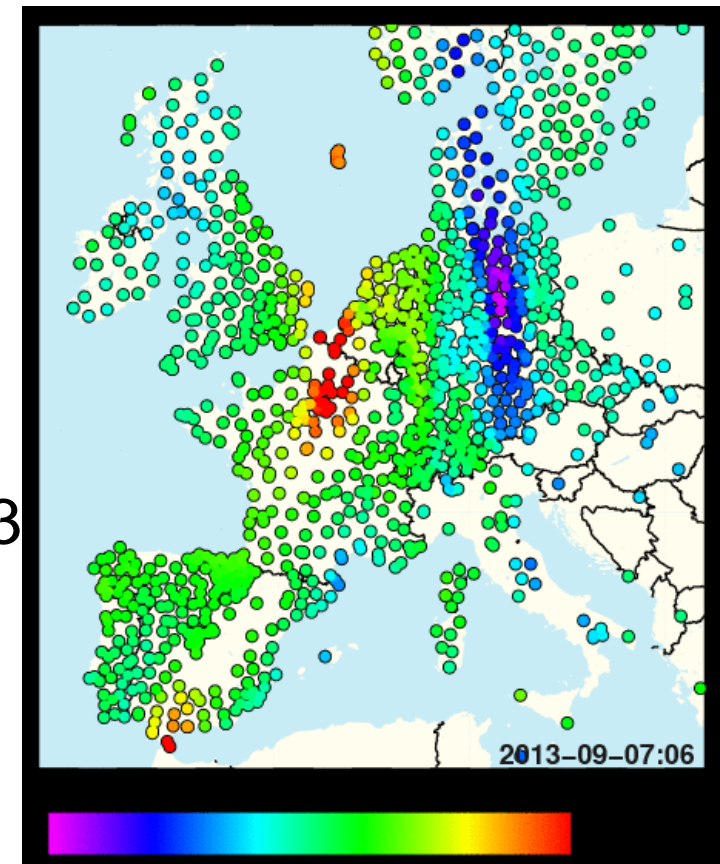
Looking into monthly animations EW/NS  
gradients (using tools developed by  
Florian Zus, GFZ) and generated  
from ECMWF's ERA-Interim

Pre-selected 6 weeks in different  
seasons with strong asymmetry  
pattern (gradients)

Proposal discussed at WG1&WG2  
joined meeting in Varna, Bulgaria

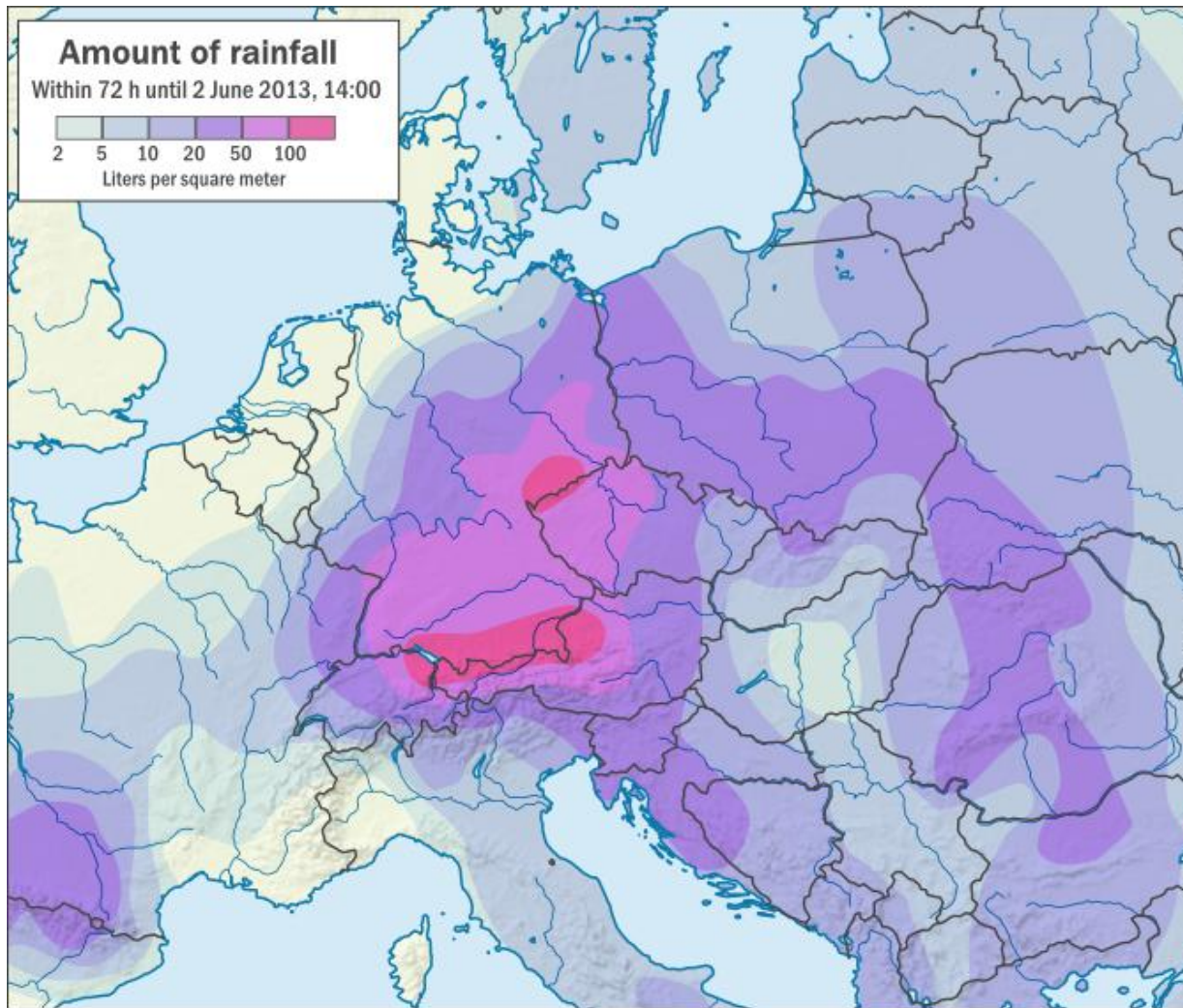
In conclusion, selected May/June 2013  
with focus on WG1 activity

Study-cases will be proposed by WG2  
for covering their primary interests





# Heavy rainfalls and floods in Central Europe



**Severe weather occurrence during the time period proposed for benchmark source:**

[http://en.wikipedia.org/wiki/2013\\_European\\_floods#mediaviewer/File:Central\\_Europe\\_72h\\_rain\\_fall\\_at\\_2.6.2013\\_en.png](http://en.wikipedia.org/wiki/2013_European_floods#mediaviewer/File:Central_Europe_72h_rain_fall_at_2.6.2013_en.png)