

Florence.Habets@upmc.fr



#### Water deficit:

- Low flows
- Soil drought
- Groundwater resource

#### Water excess:

- Heavy precipitation events
- Flash floods
- Centennial floods





### Climate change impact on the low flows



→ Mitigation has an important impact on the low flows in France

PhD Gildas Dayon, 2015, CNRS CERFACS

![](_page_2_Picture_5.jpeg)

### Climate change impact on the low flows

#### Uncertainty analysis on two snowy mountainous basins

![](_page_3_Figure_2.jpeg)

#### Historical evolution of soil drought

Monitoring of mean annual drought area in France as climate change index

![](_page_4_Figure_2.jpeg)

Vidal et al., HESS, 2012

**METEO FRANCE** 

#### Climate change impact on soil drought

#### Evolution of the part of France that is affected by soil drought

![](_page_5_Figure_2.jpeg)

![](_page_5_Picture_3.jpeg)

Vidal et al., HESS, 2012

![](_page_5_Picture_5.jpeg)

#### **Climate change impact on groundwater**

![](_page_6_Figure_1.jpeg)

### Climate change impact on groundwater Evolution of groundwater-fed extension

![](_page_7_Figure_1.jpeg)

![](_page_7_Figure_2.jpeg)

Groundwater is projected to be impacted on the long term → No return to present day level

![](_page_7_Picture_4.jpeg)

Habets et al., to submit

Warning levels and Crisis levels are used by stakeholders to manage groundwater abstraction

# → Evolution of the duration of the groundwater crisis in 2050

![](_page_7_Figure_8.jpeg)

# Impact of climate change on groundwater **Evolution of groundwater-fed wetlands extension** perennials Can be recover with Seine aquifers lower pumping Dry out Upper Rhine Graben aquifer Permanent loss of groundwater-fed wetlands is projected to reach 2% metis

UMR 7619 Habets et al., to submit

![](_page_8_Picture_2.jpeg)

#### Water deficit:

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![](_page_9_Picture_9.jpeg)

![](_page_9_Picture_10.jpeg)

## **Heavy Precipitation Events**

![](_page_10_Picture_1.jpeg)

![](_page_10_Picture_2.jpeg)

### **Heavy Precipitation Events**

#### Number of events with daily precipitation above 200mm/day between 1958-2000

![](_page_11_Figure_2.jpeg)

# Analysis of trend in extreme daily rainfall in southern France

#### **Observed increase between 1985-2014**

![](_page_12_Figure_2.jpeg)

### Evolution of heavy precipitation event in a context of climate change

Cévennes

**METEO FRANCE** 

Languedoc-Roussillon

![](_page_13_Figure_3.jpeg)

2070-2100 (mm/day)

**Present day**, 3 types of HPE (mm/day)

![](_page_13_Figure_5.jpeg)

PhD Jeanne Colin, 2011, Météo-France

![](_page_13_Picture_7.jpeg)

### Evolution of heavy precipitation event in a context of climate change

![](_page_14_Figure_1.jpeg)

![](_page_14_Figure_2.jpeg)

Number of events as a function of maximum daily rainfall

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![](_page_14_Figure_4.jpeg)

Evolution of the rainfall intensity as a function of maximum daily rainfall

#### PhD Jeanne Colin, 2011, Météo-France

See also : Tramblay et al., Hydrol. Process. 2012; PhD Elizabeth Haralder, 2015 Colmet Daage et al., 2015 MISTRAL

![](_page_14_Picture_8.jpeg)

#### **Evolution of the intense precipitation (above Q95)**

#### Uncertainty associated to downscaling

RCM

3 downscaling methods

![](_page_15_Figure_4.jpeg)

## Evolution of 10-year return period flood in term of flow →Uncertainty associated to downscaling

![](_page_16_Figure_1.jpeg)

**METEO FRANCE** *Quintana-Seguì, Habets, Martin, 2011, NHESS* 

![](_page_16_Picture_3.jpeg)

# Evolution of cost associated to 100-year return period flood →uncertainty associated to downscaling

![](_page_17_Figure_1.jpeg)

![](_page_17_Picture_2.jpeg)

Dumas et al., NHESS, 2013

![](_page_17_Picture_4.jpeg)

# Analyzing the human response during a flash flood in order to make progress in forecasting human vulnerability

![](_page_18_Figure_1.jpeg)

Difficulty is exacerbated in small basin with fast response time. In 2010 although a weather alert was given, only 20% of the people was trying to get inform

Time evolution of the percentage of respondents by type of activity and corresponding areal rainfall intensity and time of peak flows over the study area (196 km<sup>2</sup>). Time step is 15 min.

Ruin et al. (2014). Social and Hydrological Responses to Extreme Precipitations : An Interdisciplinary Strategy for Postflood Investigation. <u>Weather, Climate & Society,</u>

Conclusions:

- Intensity of extreme droughts and extreme floods are projected to increase at least in part of France
- Uncertainty remains, associated to several issues: GHG scenarios, GCM, Downscaling methods

![](_page_19_Picture_4.jpeg)

![](_page_19_Picture_5.jpeg)

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