Effects of climate change adaptation scenarios on perceived spatio-temporal characteristics of drought events

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To better reflect its missions, Cemagref becomes Irstea

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European Geosciences Union General Assembly (EGU 2012), 23-27 April 2012, Vienna, Austria

Outline

- ClimSec project
- 3 research questions
- Methods
  - – Datasets
  - – Standardized drought indices
  - – Spatio-temporal drought events
- Results
  - – Validation on present-day climate
  - – Projections in future climate
- Conclusions

ClimSec project

"Impact of climate change on drought and soil moisture in France", funded by Fondation MAIF (2008-2011)

Partners:

Irstea, Météo-France (Climatology Department), CNRM/GAME, CERFACS, UMR Sisyphe

Website

www.cnrm-game.fr/projet/climsec

Two steps:

1. Reconstructing spatio-temporal meteorological, agricultural and hydrological drought events over the last 50 years

   Vidal *et al.* (2010) Multilevel and multiscale drought reanalysis over France with the Safran-Isba-Modcou hydrometeorological suite. *Hydrology and Earth System Sciences*, 14, 459-478.

   ▶ Norbert Gerbier-Mumm international award 2011 from WMO

2. Assessing the impact of climate change on drought event characteristics

Research questions

1. Are downscaled climate projections able to reproduce spatio-temporal characteristics of meteorological and agricultural droughts in France over a present-day period?

2. How such characteristics will evolve over the 21st century?

3. How to use standardized drought indices to represent theoretical adaptation scenarios?

Tools and data

Safran atmospheric reanalysis

- 1958-2008, 7 variables, daily, 8km grid (Vidal *et al.*, 2010)

  ⇒ **monthly gridded precipitation 1958-2008**

Downscaled climate projections

- Météo-France ARPEGE GCM (Gibelin & Déqué, 2003)
- Control run: 1958-2000
- Future runs: 2000-2100 under A2, A1B and B1 emissions scenarios (**proxys for mitigation scenarios**)
- Statistical downscaling with a weather type method (Boé *et al.*, 2006)

  ⇒ **monthly gridded precipitation control run + 3 x future runs**

Isba land surface scheme

- Computation of water and energy budgets (Noilhan & Mahfouf, 1996)

$$SWI = \frac{w - w_{wilt}}{w_{fc} - w_{wilt}}$$

- w : water content
- w_{wilt} : wilting point
- w_{fc} : field capacity

⇒ **monthly gridded SWI reanalysis 1958-2008**
⇒ **monthly gridded SWI control run + 3 x future runs**

Standardized drought indices

Two levels of the hydrological cycle

- Standardized Precipitation Index (**SPI**)
- Standardized Soil Wetness Index (**SSWI**)
  - Same computation as for SPI but with average SWI (Vidal *et al.*, 2010)

Two time scales

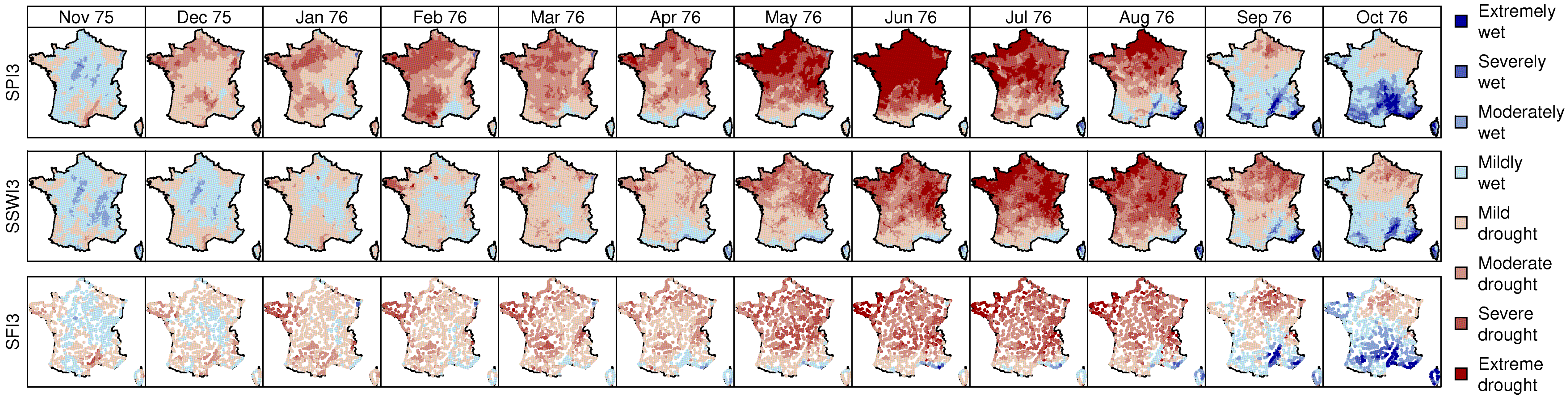
- **3** months (short droughts)
- **12** months (long droughts)

Reference for standardization

- Reanalysis: **reanalysis 1961-1990 period** (WMO, 2007)
- Climate projections: **GCM control run 1961-1990**

Computation for each grid cell (8602)

Spatio-temporal drought events



Definition

- **Sequence of spatially contiguous and temporally continuous areas where the drought index is under a given threshold value**
- Recursive identification algorithm for taking account of merging or breaking up areas (adapted from Andreadis *et al.*, 2005), drought threshold = 20%

Summary characteristics

- Mean duration
- Mean area
- Total magnitude

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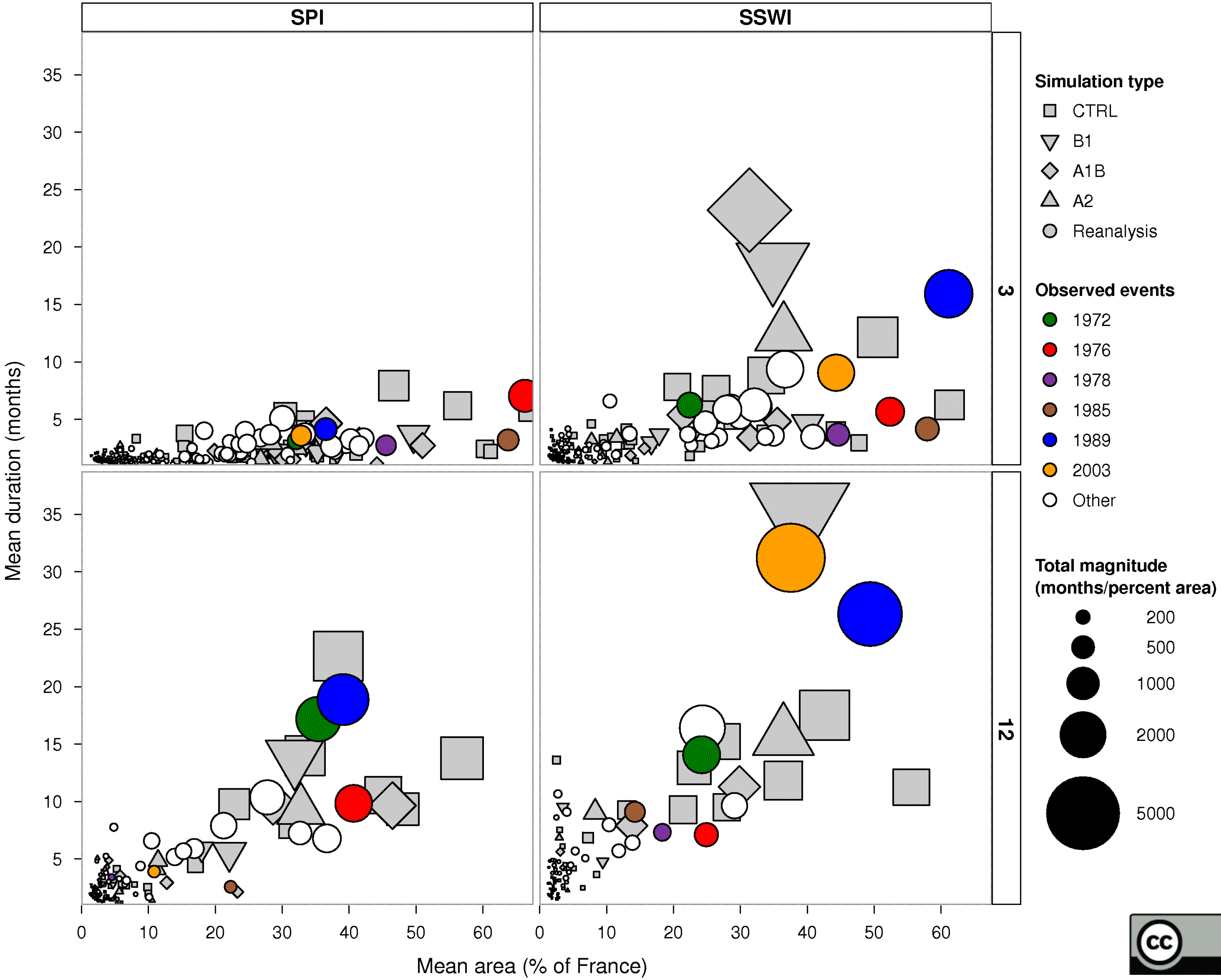
Validation on present-day climate: 1958-2008



Theoretical adaptation scenarios

Proposition

- Theoretical adaptation to **changing *normal* conditions**
- No adaptation to potentially changing variability (only first order)

Implementation

- **Evolving baseline value** of standardized drought indices
- Co-evolving drought threshold value (and thus drought event characteristics)

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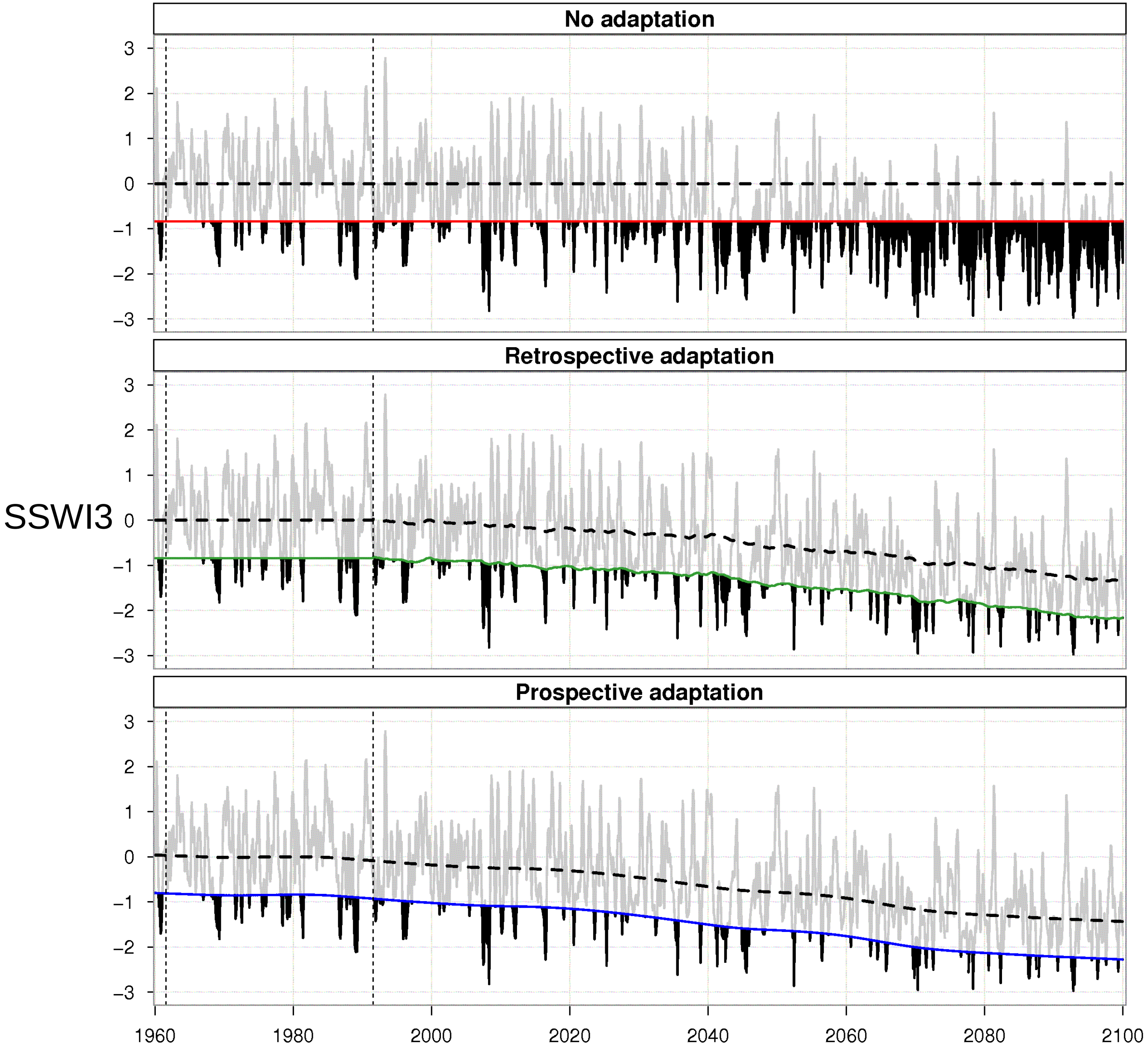
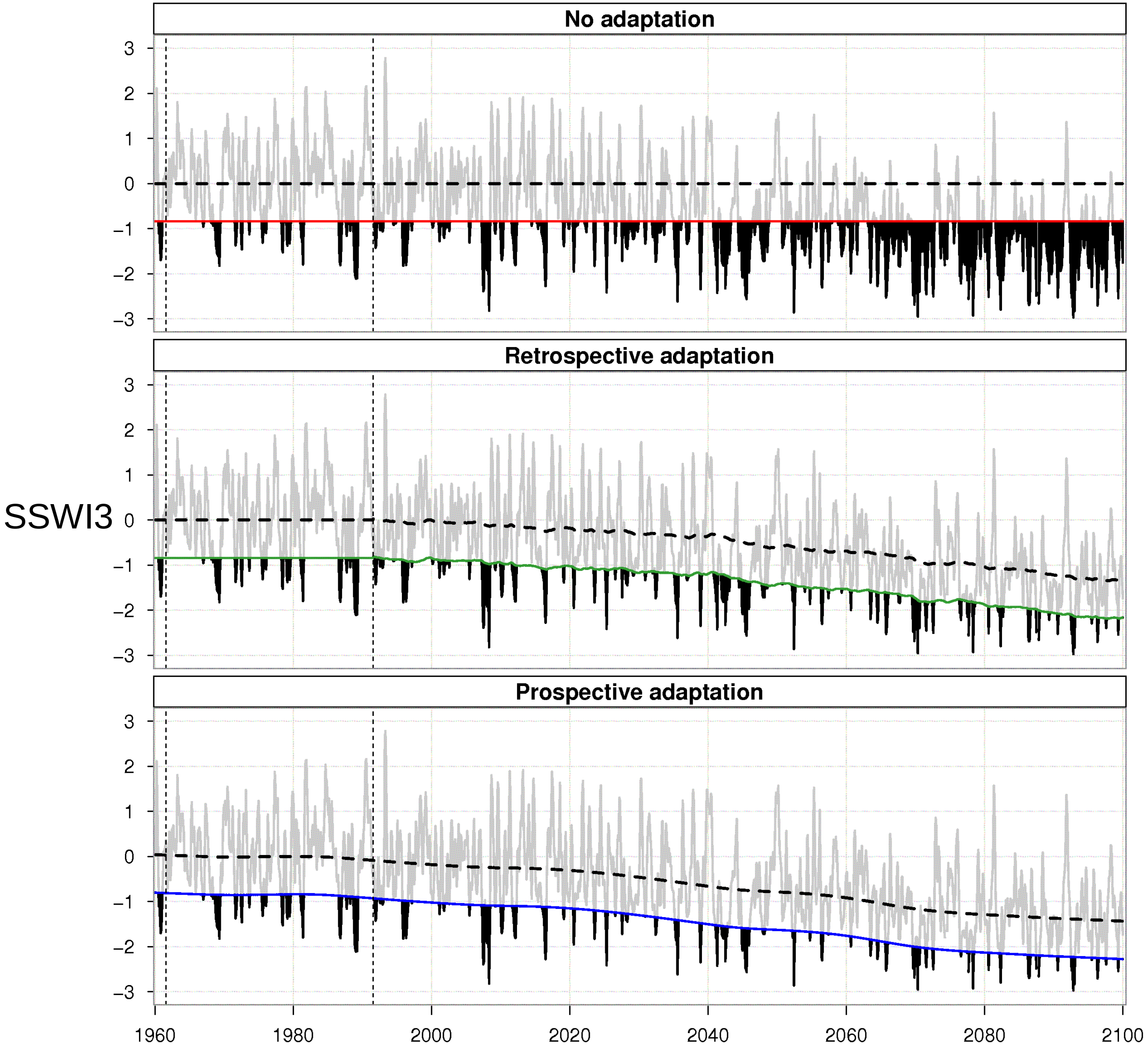
Scenario name	Drought index baseline
No adaptation	Zero
Retrospective adaptation	Rolling mean of previous 30 yr
Prospective adaptation	Smooth spline optimized for minimal deviation from zero over the reference period

Theoretical adaptation scenarios



Theoretical adaptation scenarios

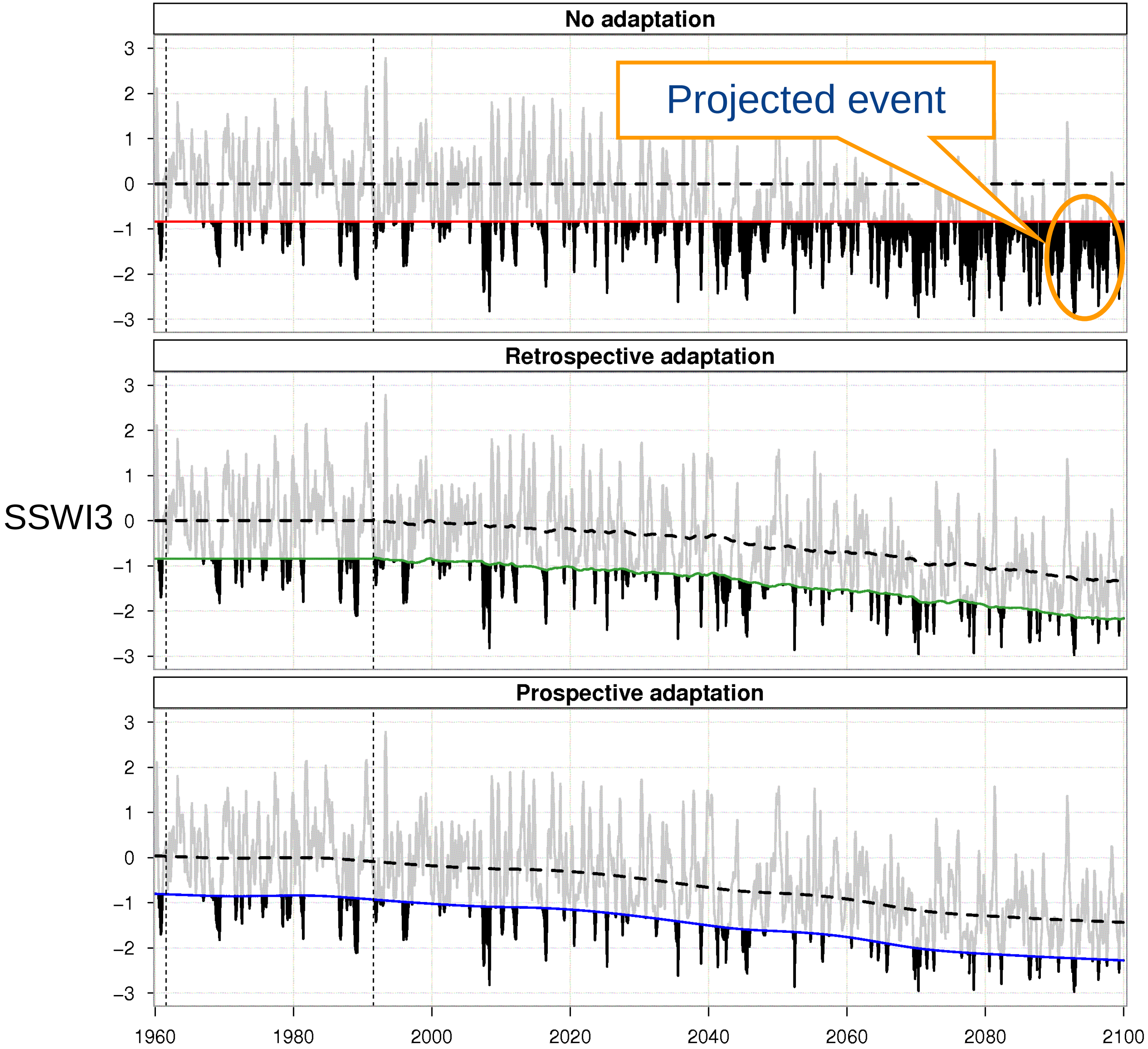


- Dramatic decrease of drought index values

  2080s median value = 20% probability value in 1961-1990 distribution

- Theoretical scenarios:
  - hardly accessible in practice
  - represent an **upper limit of adaptation efforts**

Theoretical adaptation scenarios



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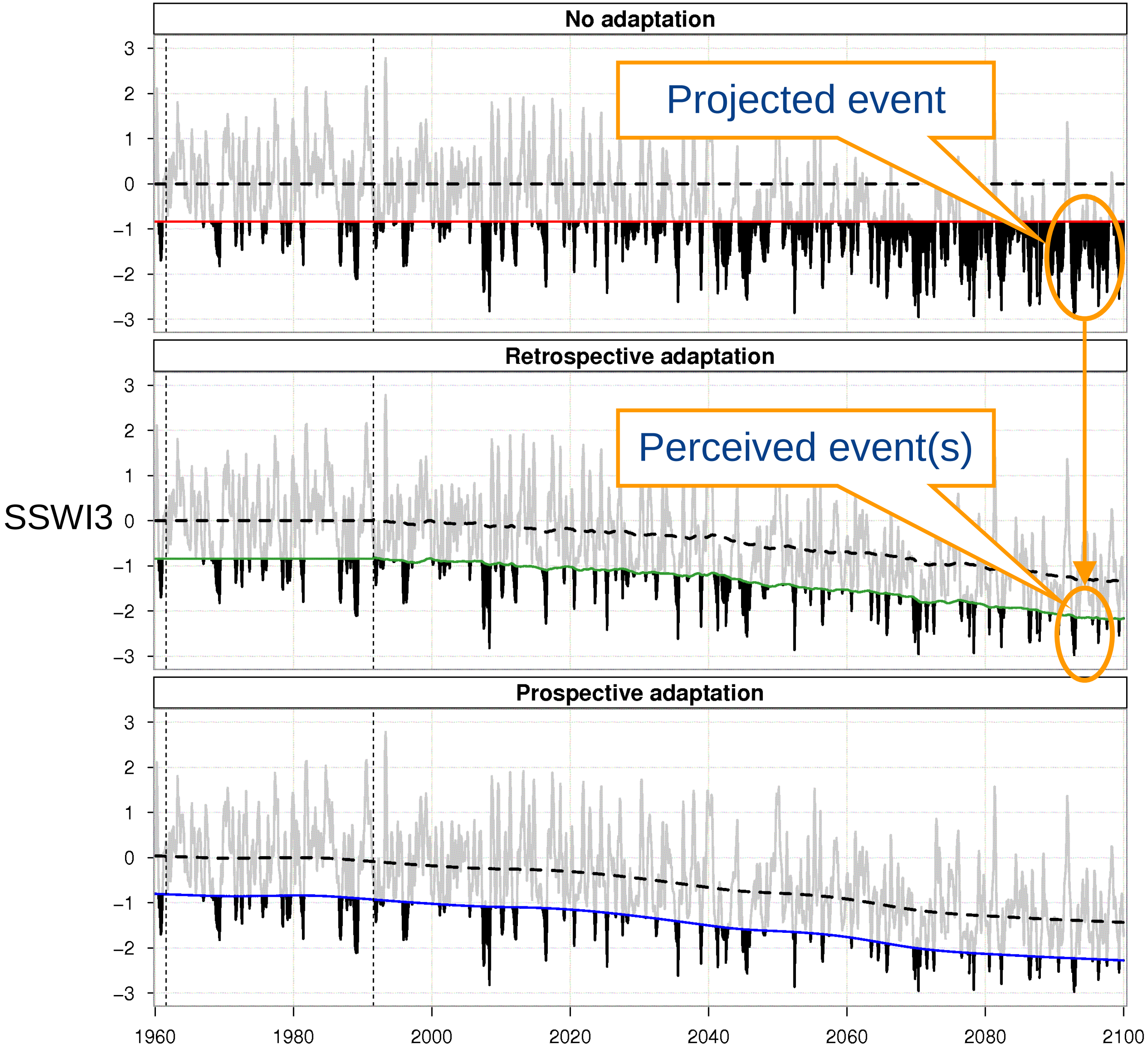

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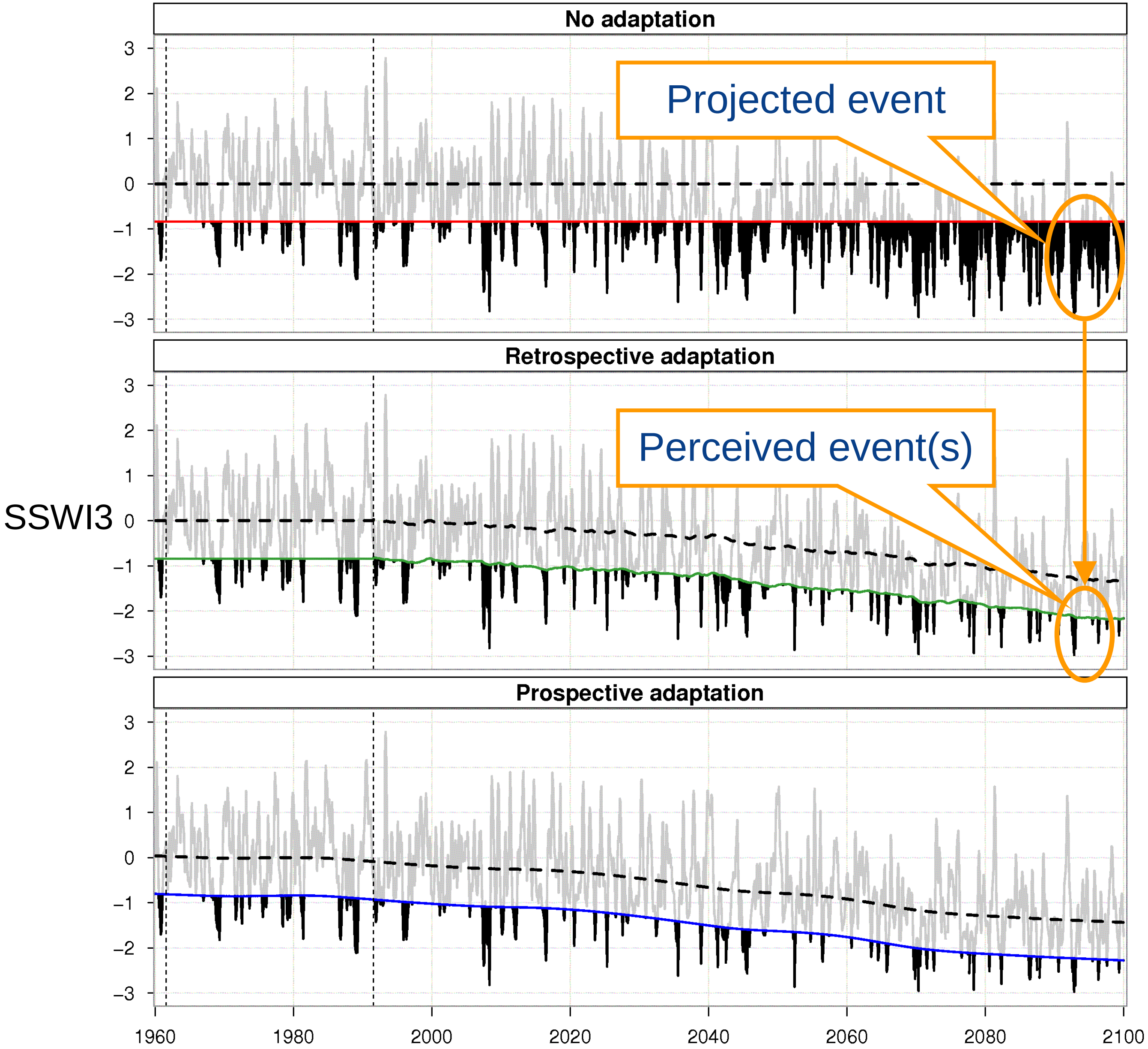

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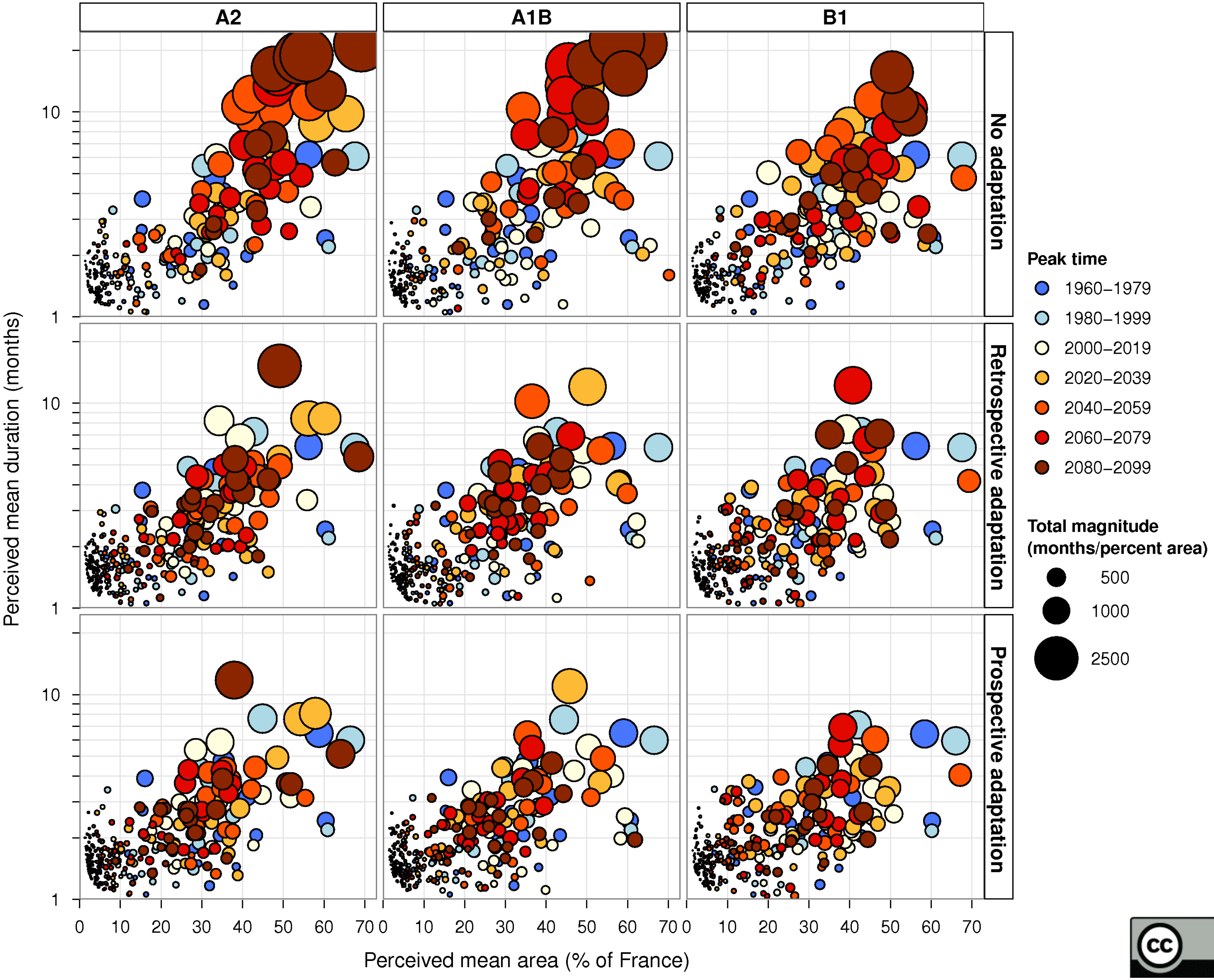
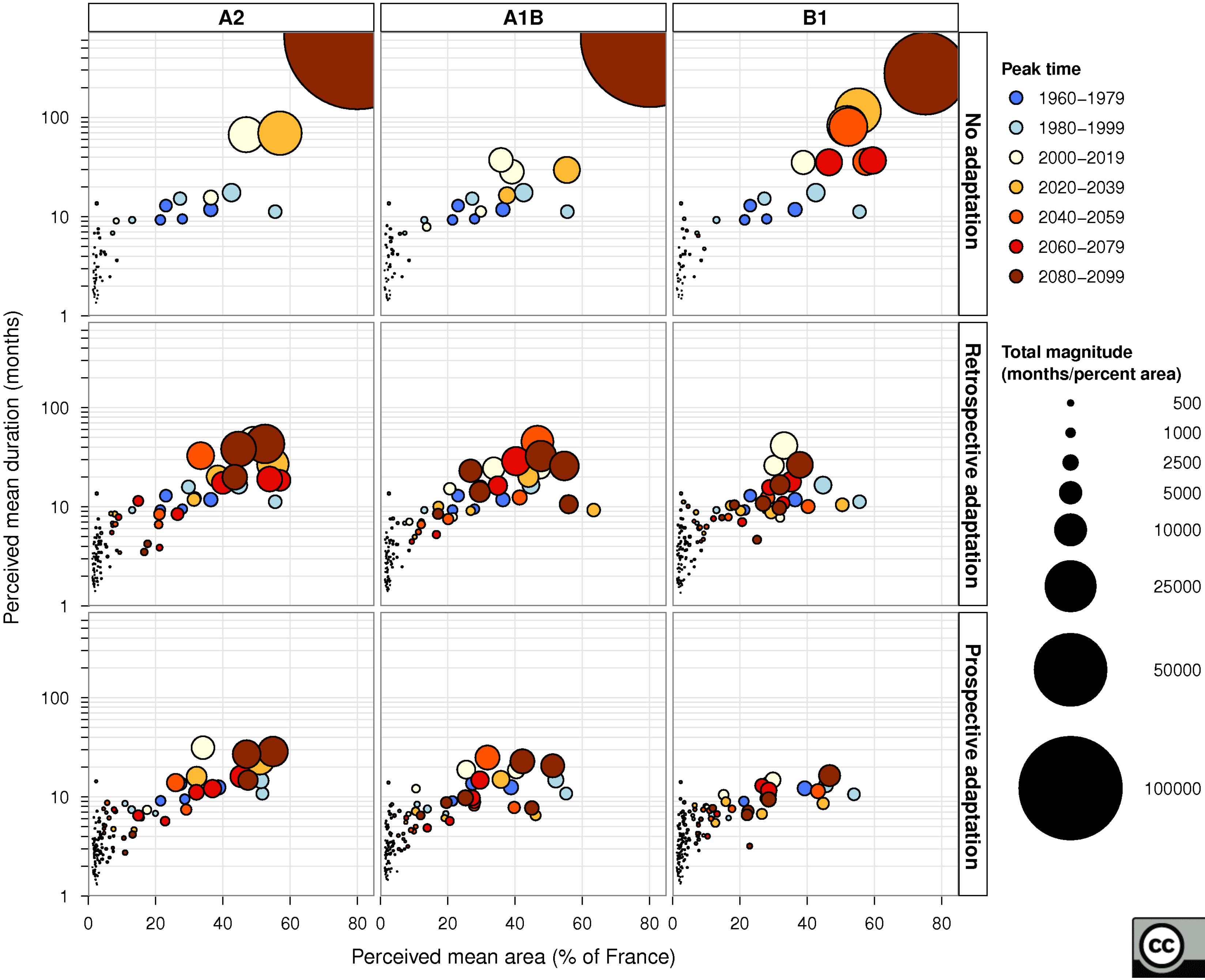
- Notion of perceived drought characteristics

  What the severity of a given event would be if the anthropogenic hydrosystem could have adapted to changed normals

Projections in future climate: SPI3



Projections in future climate: SSWI12



Conclusions

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   Yes, fairly well (for this single downscaled GCM run)

2. How such characteristics will evolve over the 21st century?

   Dramatic increase in all spatio-temporal characteristics (for this single combination of GCM/downscaling/LSM) even under rather optimistic adaptation scenarios

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   Proposition: expressing potential adaptation in terms of evolving baseline value of standardized indices

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Proof of concept for:

- Assessing changes in spatio-temporal drought characteristics
- Deriving theoretical adaptation scenarios using properties of standardized drought indices

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Thank you for your attention

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References

Vidal et al. (2010a) A 50-year high-resolution atmospheric reanalysis over France with the Safran system. *Int. J. Climatol.*, 30, 1627-1644

Vidal et al. (2010b) Multilevel and multiscale drought reanalysis over France with the Safran-Isba-Modcou hydrometeorological suite. *HESS*, 14, 459-478.

Vidal et al. (2012) Evolution of spatio-temporal drought characteristics: validation, projections and effect of adaptation scenarios. *HESSD*, 9, 1619-1670.

And an open research question: How to derive realistic adaptation scenarios?

– Location dependent (different land use…)
– Seasonal dependent (crops…)
– Step-wise (town and country planning, policies…)