Low flows in France and their relationship to large scale climate indices

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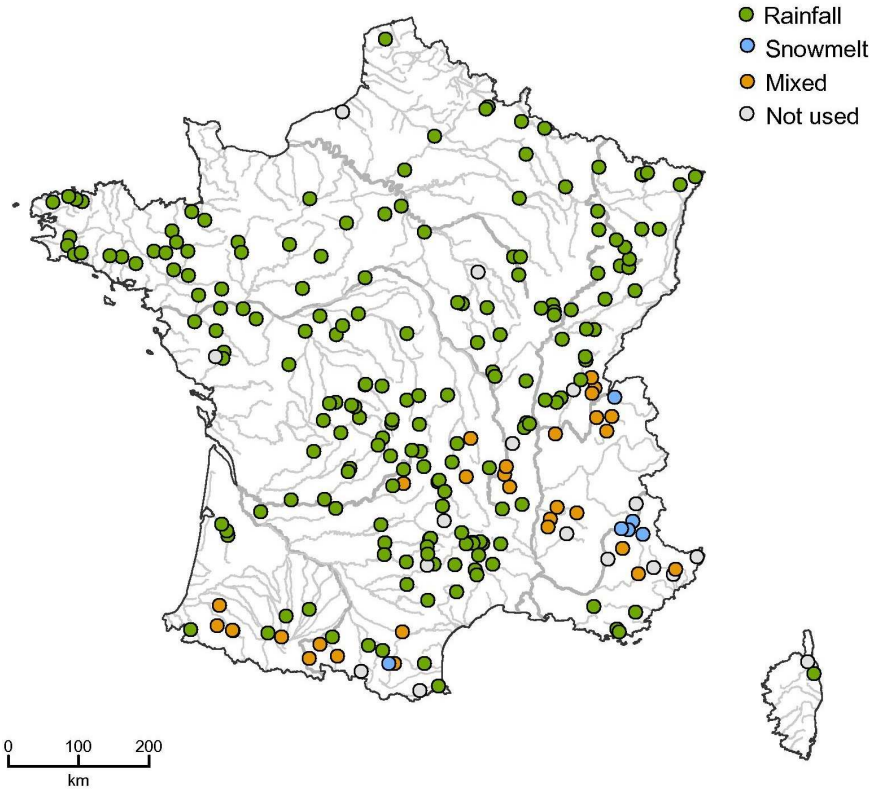
Outline

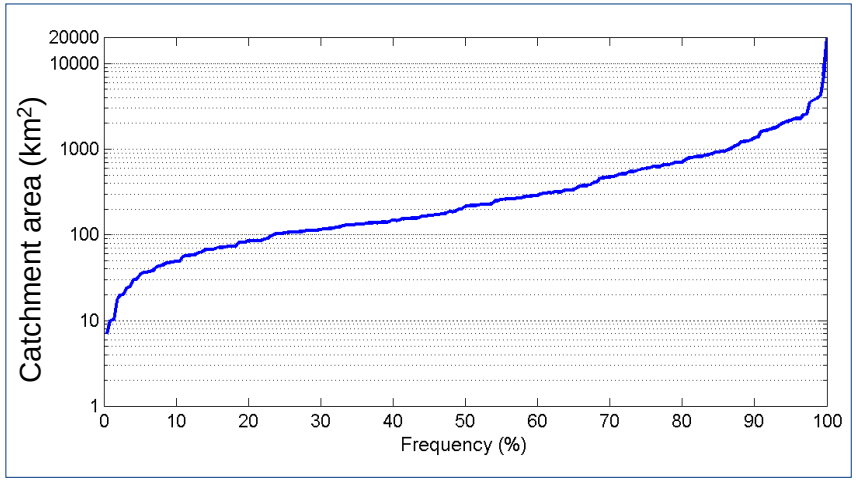
- Low flow benchmark network (R2SE)
- Climate and drought indices
- Methods
- Results
  - Annual scale
  - Stability of correlations
  - Seasonal scale
- Conclusions
- Perspectives and open research questions

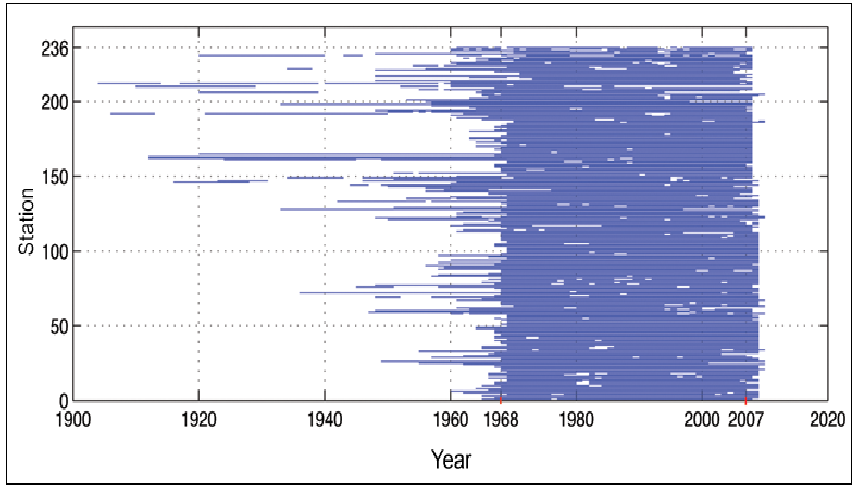
Low Flow Benchmark Network (R2SE)

236 hydrometric stations

- At least 40 years of streamflow data
- Near-natural catchment
- Good quality of low flow measurements







→ 220 stations used here given the availability over the 1968-2008 period

Climate indices – Large scale

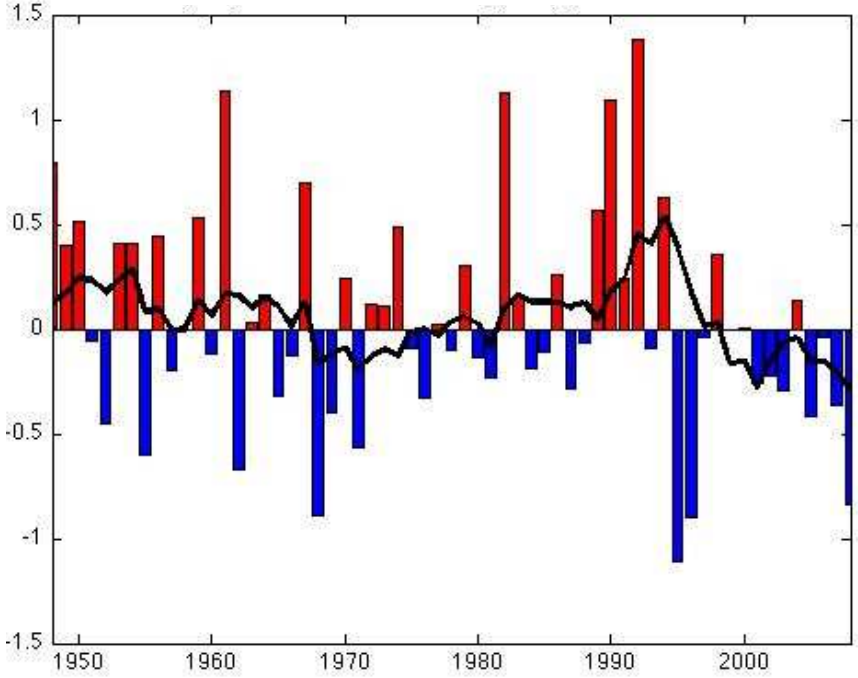
NAO

- North Atlantic Oscillation
- Standardized pressure difference between Gibraltar and Iceland (Jones *et al.*, 1997)

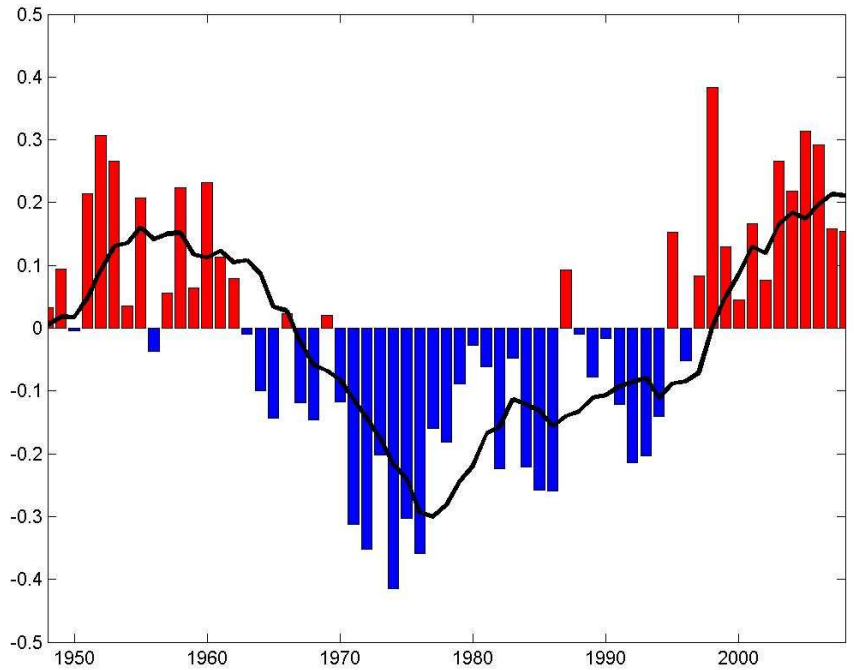
AMO

- Atlantic Multidecadal oscillation
- Detrended North Atlantic SST (Enfield *et al.*, 2001)

NAO 1948-2008



AMO 1948-2008

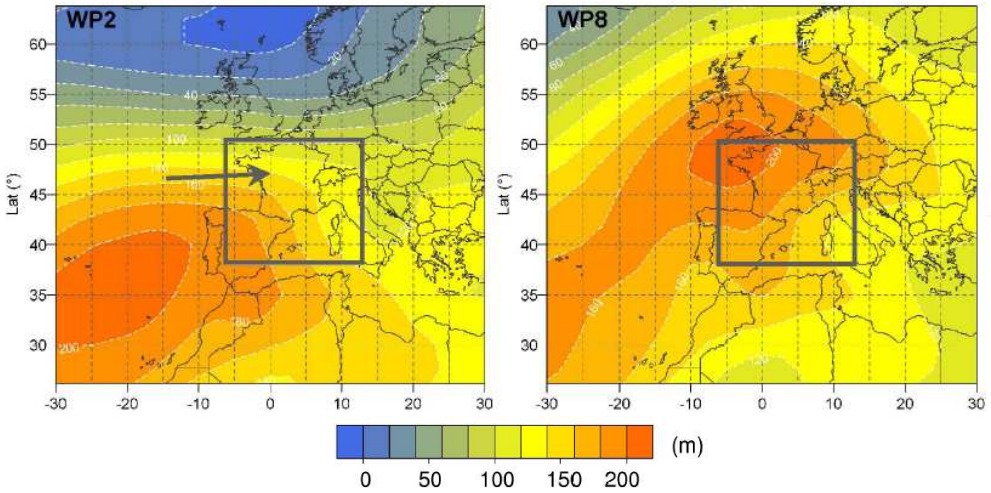


Climate indices – Regional scale

Frequency of EDF Weather Patterns (Garavaglia *et al.*, 2008)

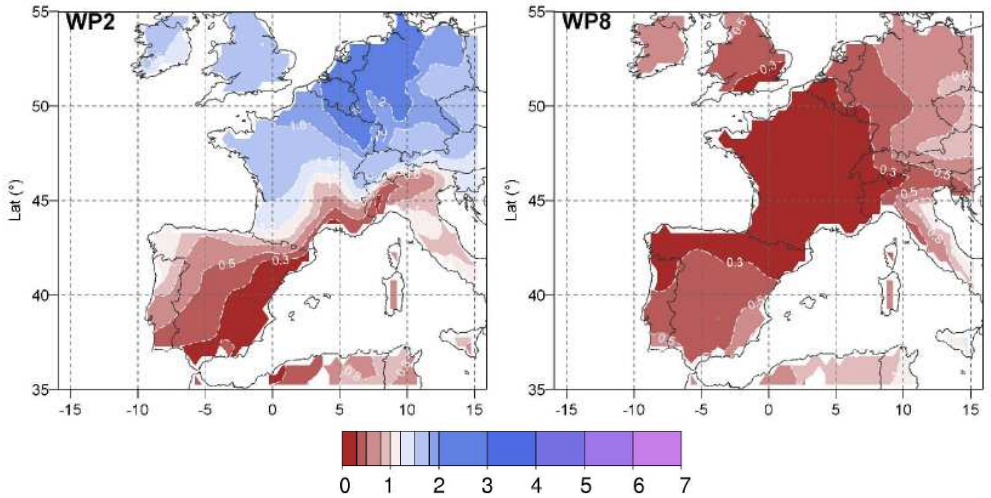
- 8 weather patterns based on precipitation over France (bottom-up approach)
- 2 most frequent: WP2 and WP8

WP2
steady oceanic
23%



WP8
Anticyclonic
28%

wet weather

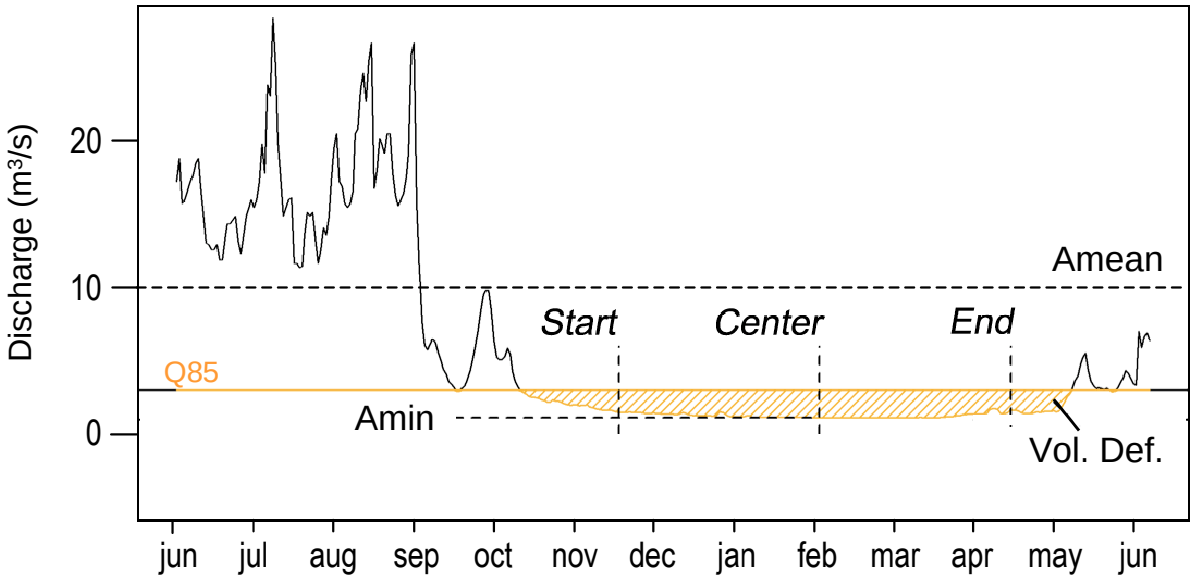


dry weather

Drought indices

Hydrological years

- **Feb.→Jan.** for rainfall regime
- **May → Apr.** for snowmelt regime



Drought severity indices

- **Amean**: annual mean flow
- **Amin**: annual minimum flow
- **Vol. Def**.: volume deficit under Q85

Drought timing indices

- **Start**: day for which the volume deficit reach 10% of its annual value
- **Center**: idem for 50%
- **End**: idem for 90%

Methods

Rank correlation (Kendall Tau) between drought indices and covariates: time and climate indices

1. Annual scale (synchronous correlation)
   - 1968-2008
   - Years, annual AMO, annual NAO, annual WP2, annual WP8

2. Stability over time
   - Subset of 28 long series over 3 periods:
     - 1948-1988
     - 1968-2008
     - 1948-2008
   - Years, annual AMO, annual NAO, annual WP2, annual WP8

3. Seasonal scale (asynchronous correlation)
   - 1968-2008
   - Years/Season (DJF, MAM, JJA, SON), seasonal NAO, seasonal WP2, seasonal WP8

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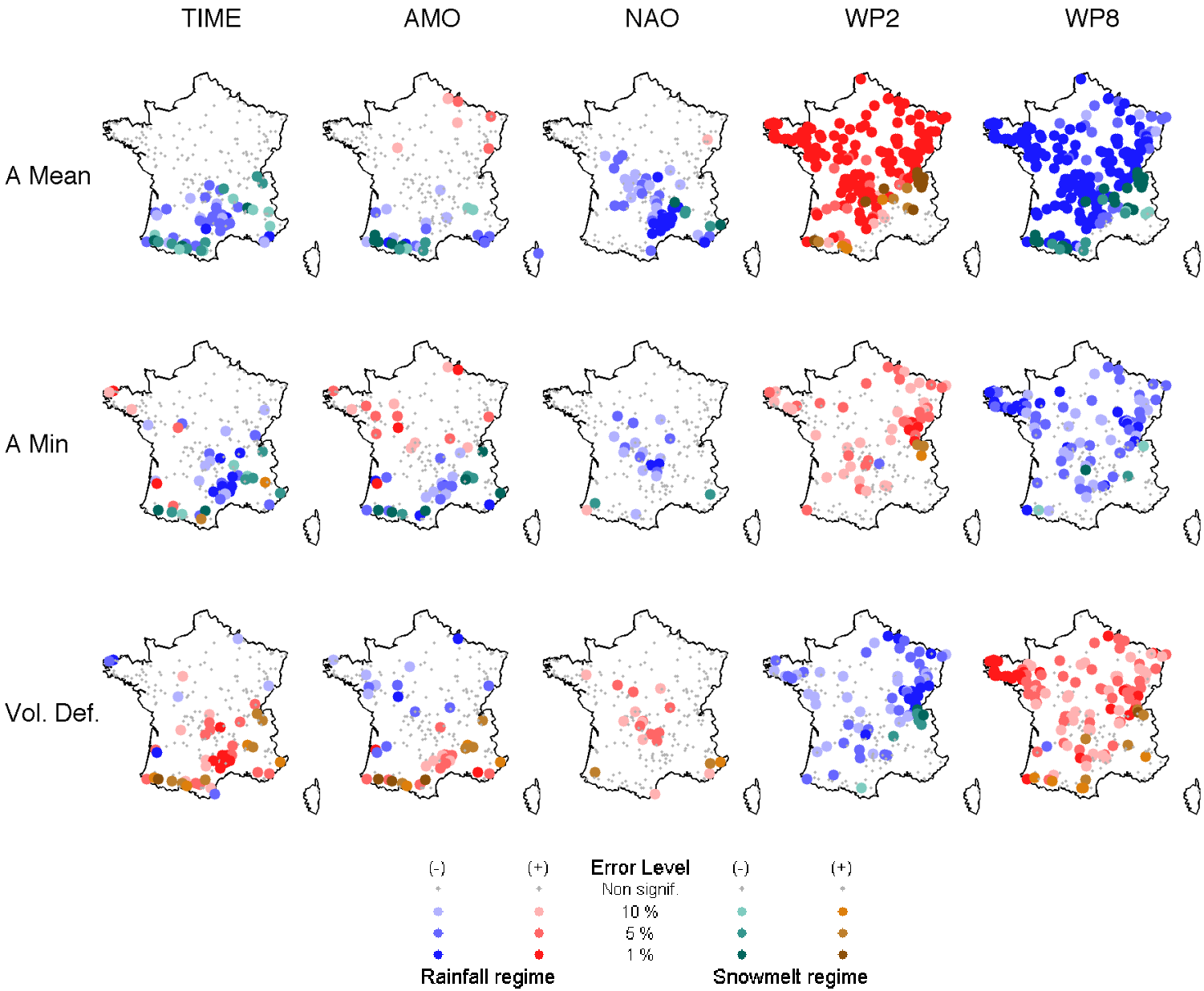
Results – Annual scale

Drought severity indices



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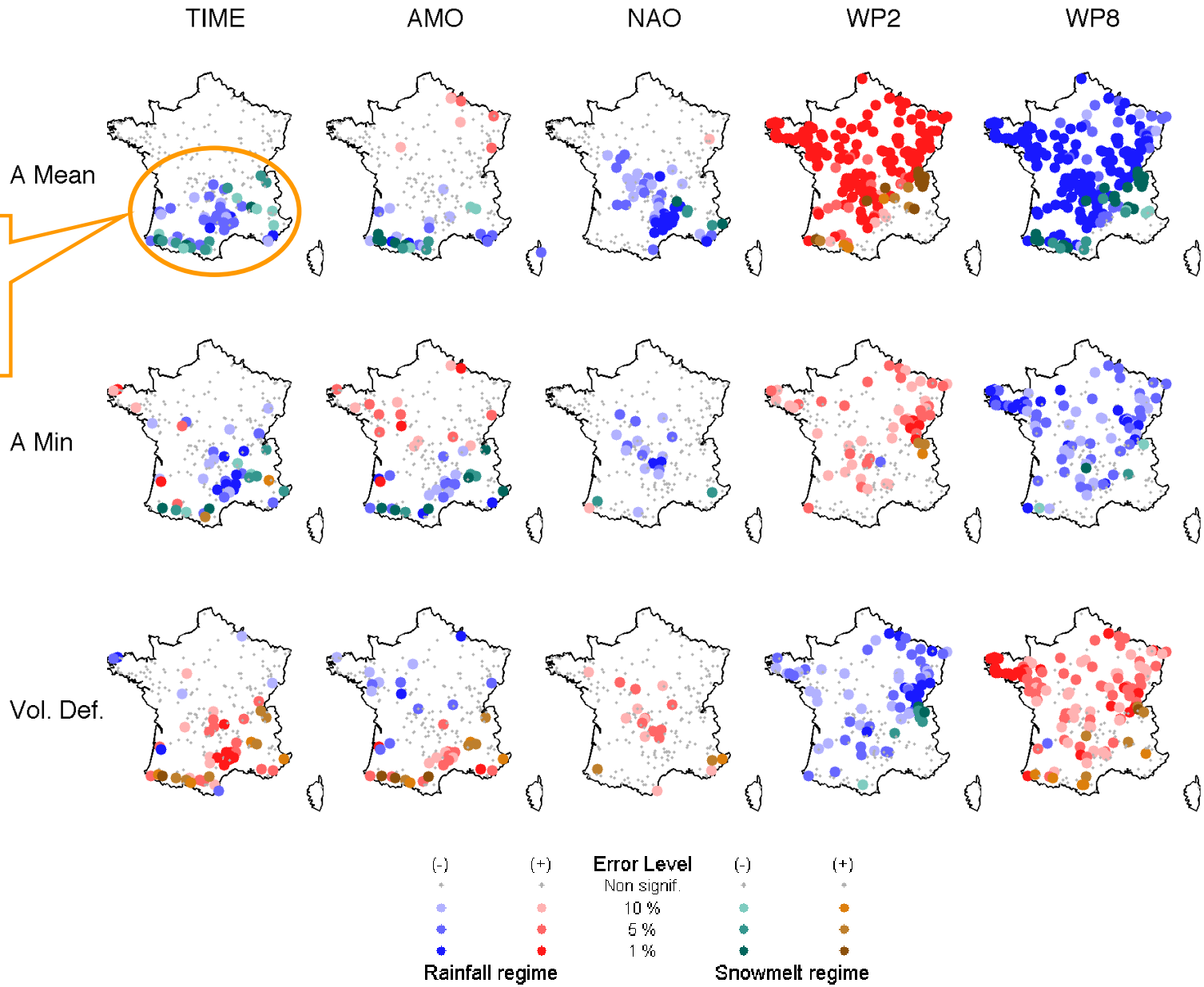
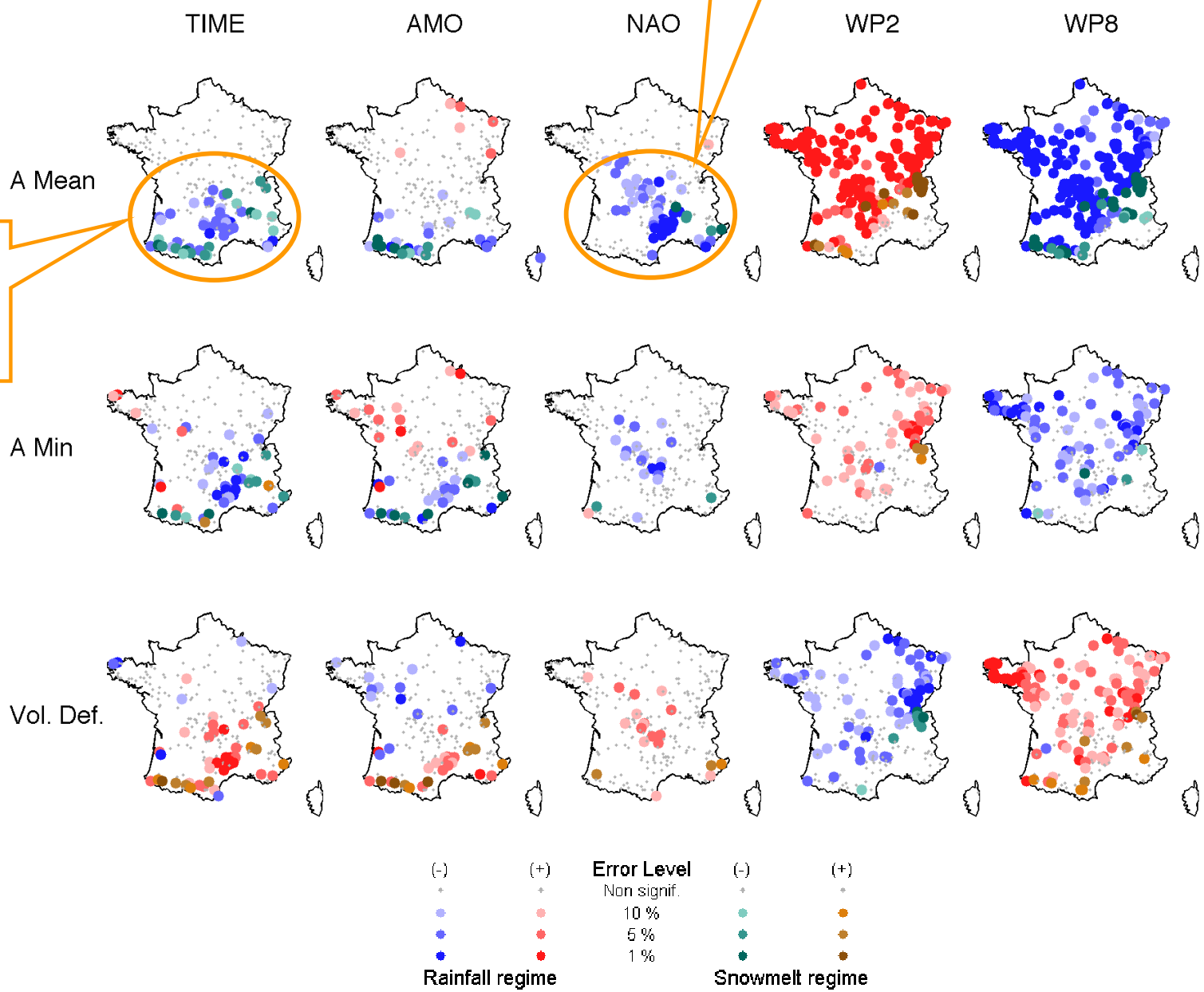


Results – Annual scale

Drought severity indices

Negative correlation of annual mean flow with NAO

Downward trend of annual mean flow



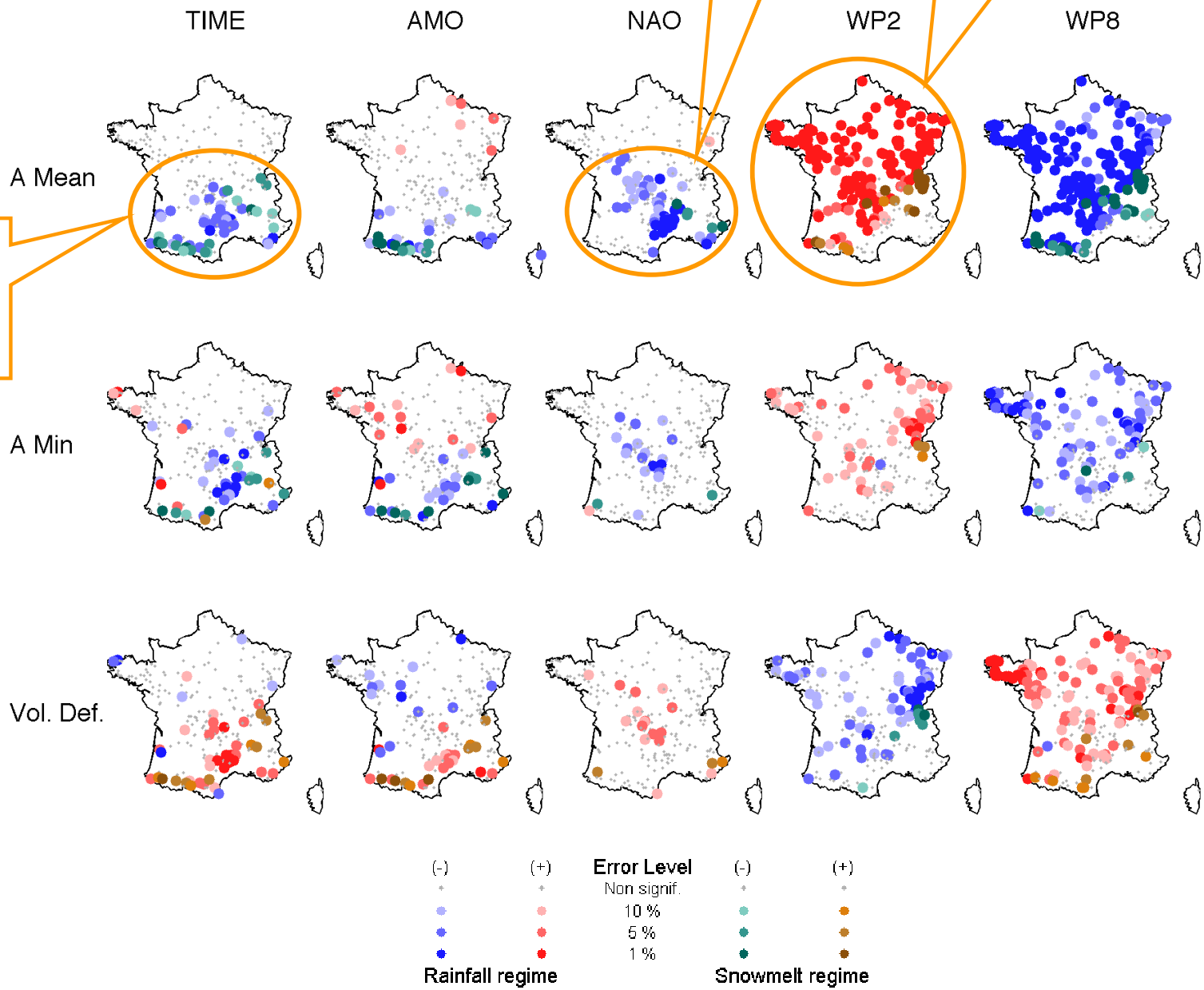
Results – Annual scale

Drought severity indices

Negative correlation of annual mean flow with NAO

Wetter weather - Increase in annual mean flow

Downward trend of annual mean flow



Results – Annual scale

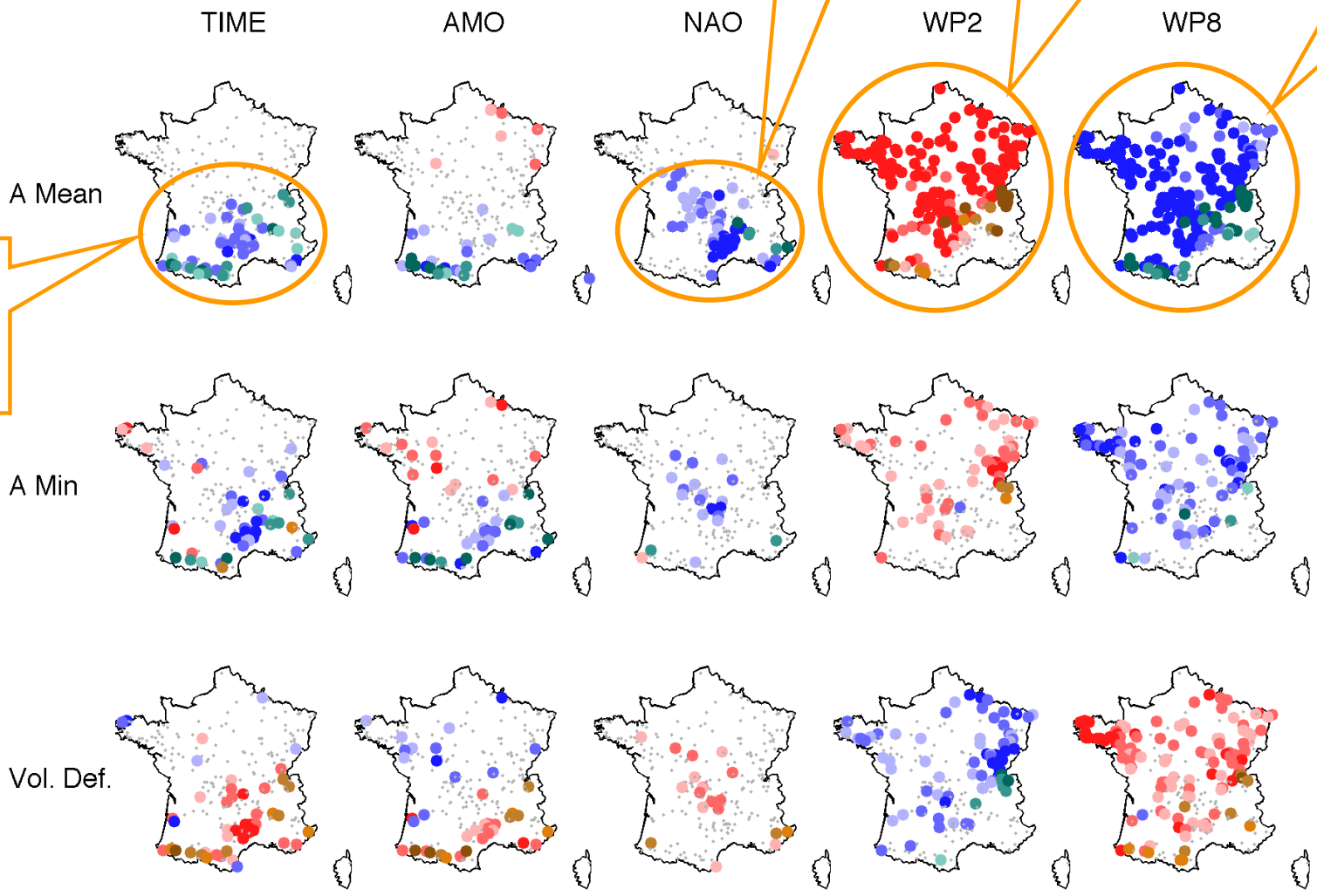
Drought severity indices

Negative correlation of annual mean flow with NAO

Wetter weather
-
Increase in annual mean flow

Drier weather
-
Decrease in annual mean flow

Downward trend of annual mean flow



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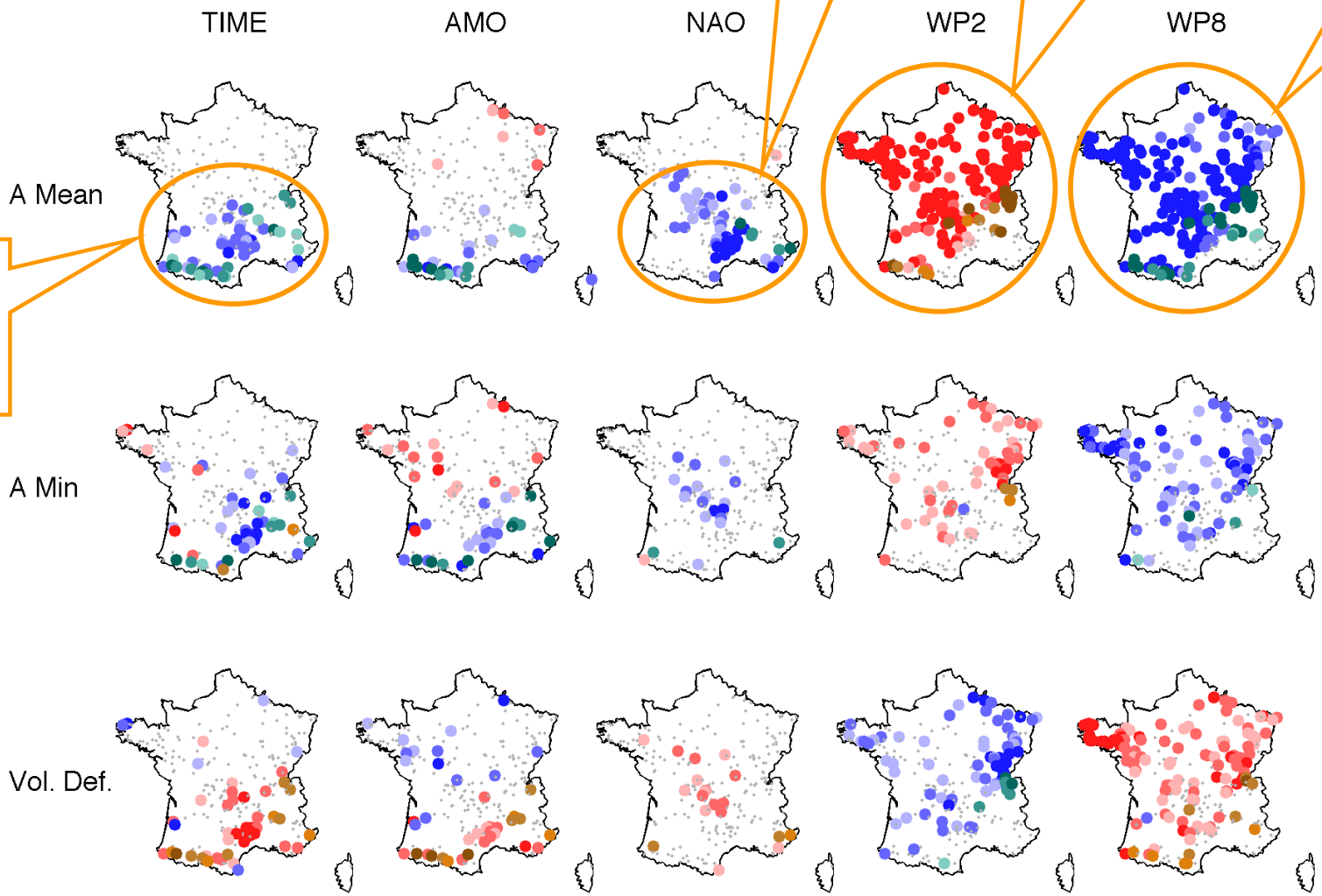
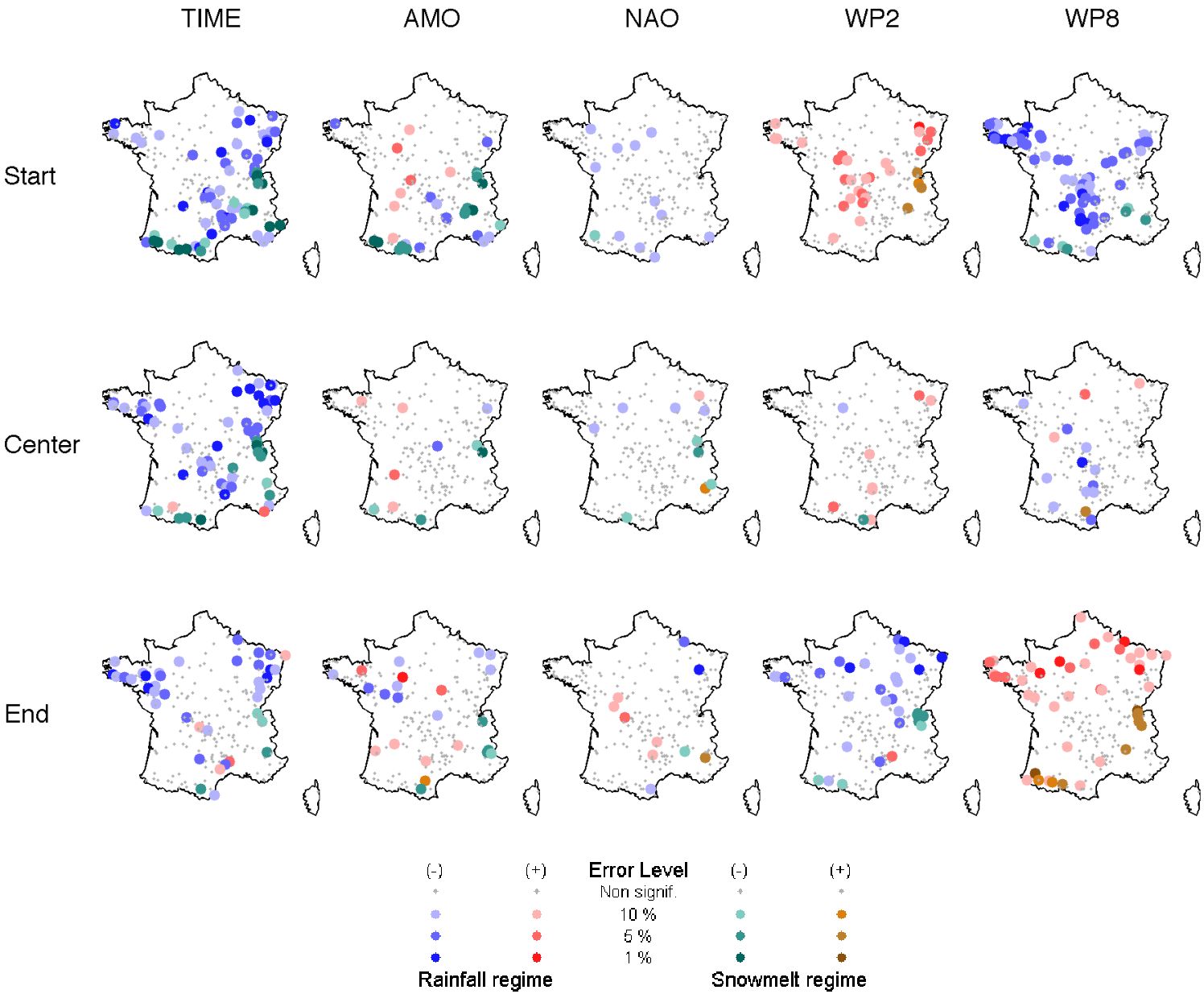


Similar patterns for other severity indices

Results – Annual scale

Drought timing indices



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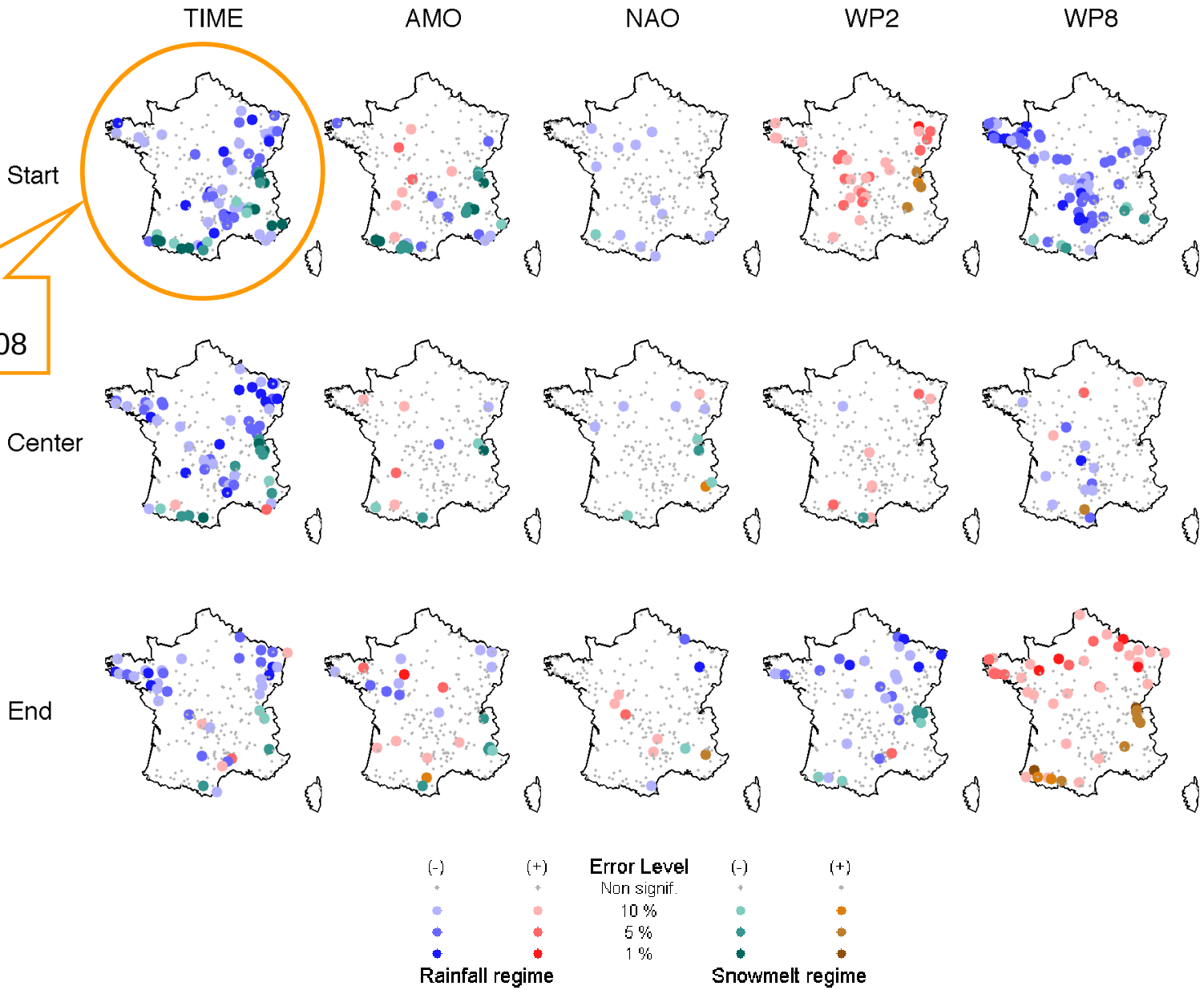
Drought timing indices

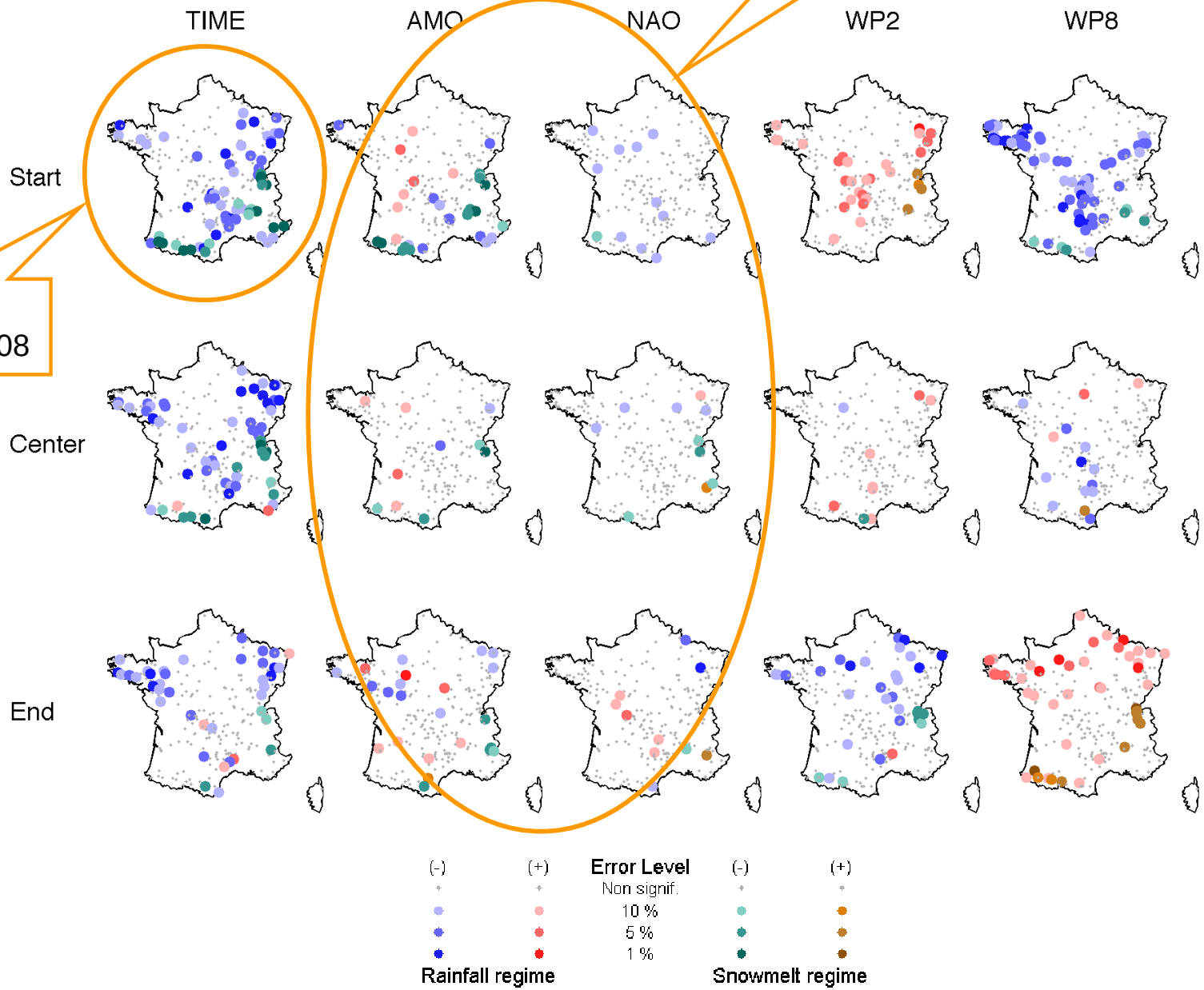


Results – Annual scale

Drought timing indices

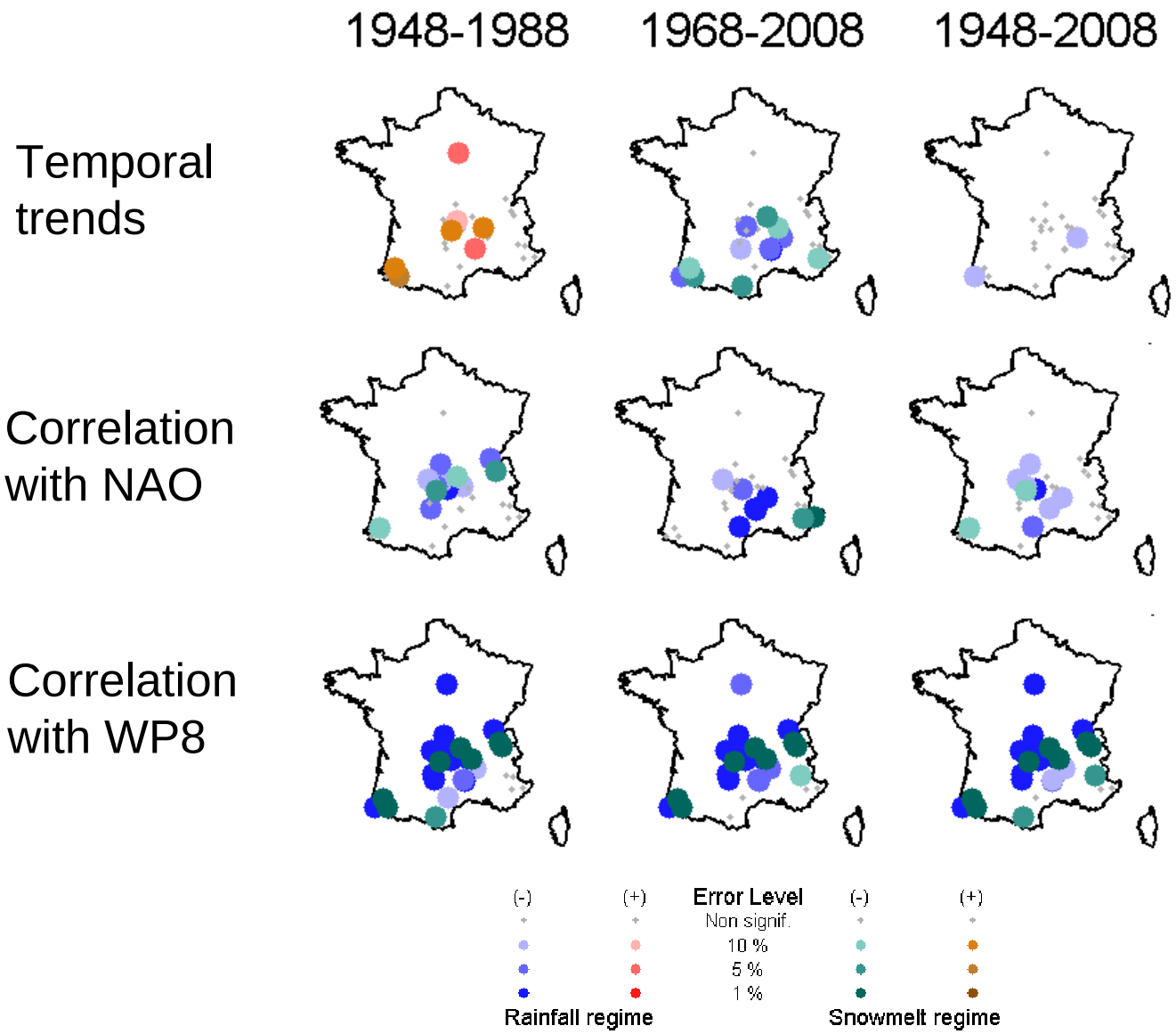
No correlation for AMO and NAO

Earlier start over 1968-2008



Results – Stability of correlations

Annual mean flow (Amean) against time, NAO and WP8



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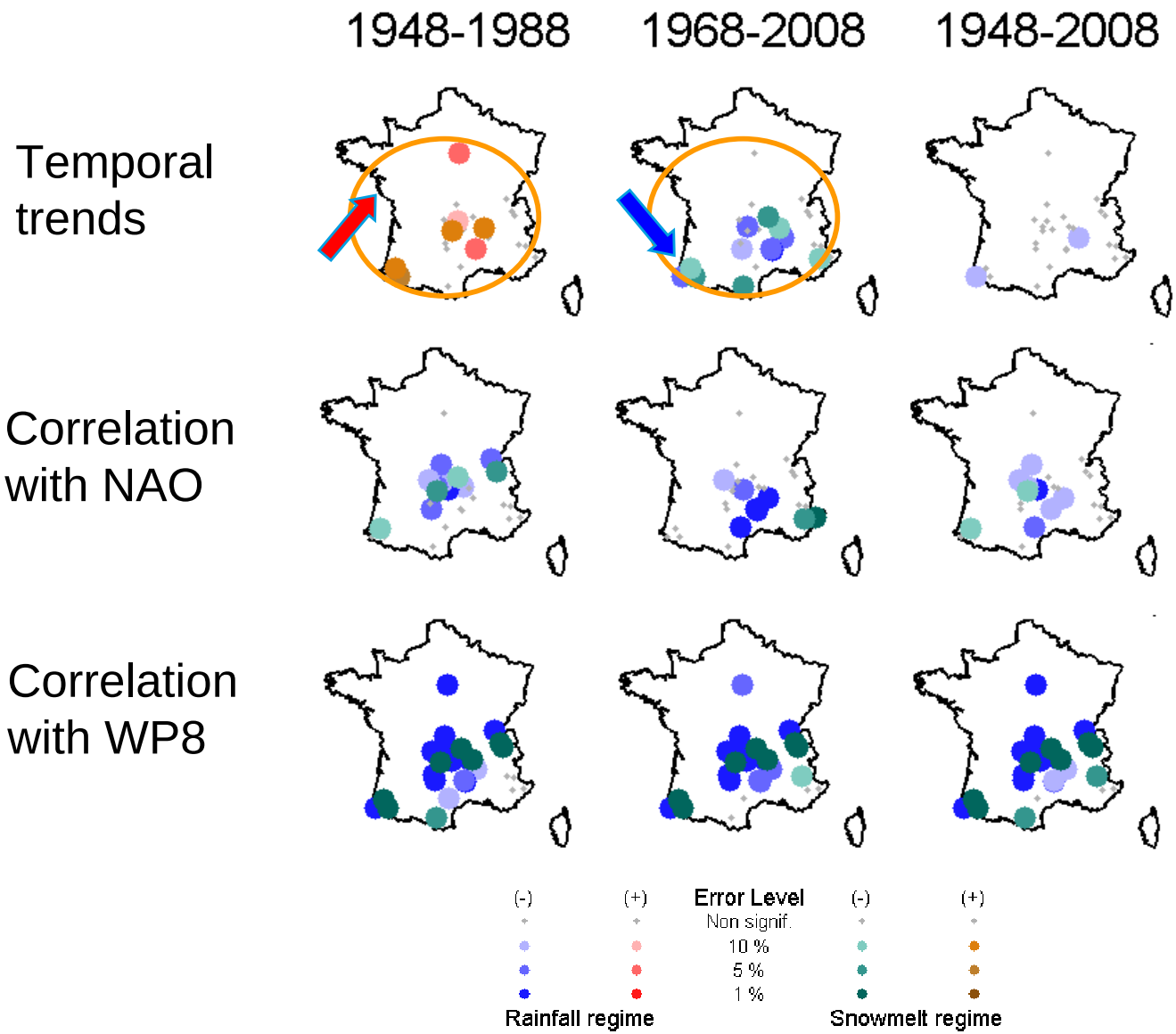

Increase then decrease, and no substantial temporal trends over the whole period

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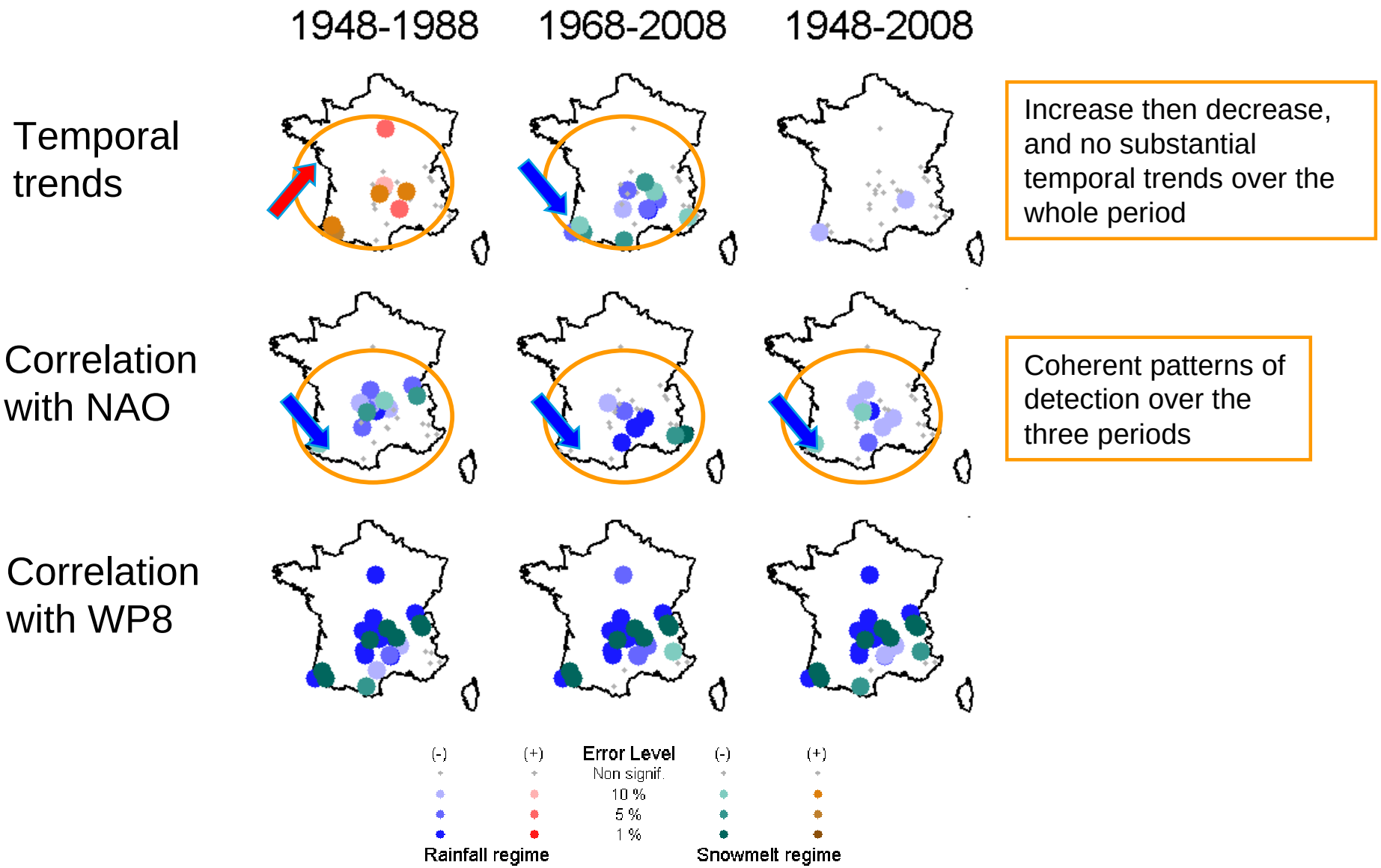

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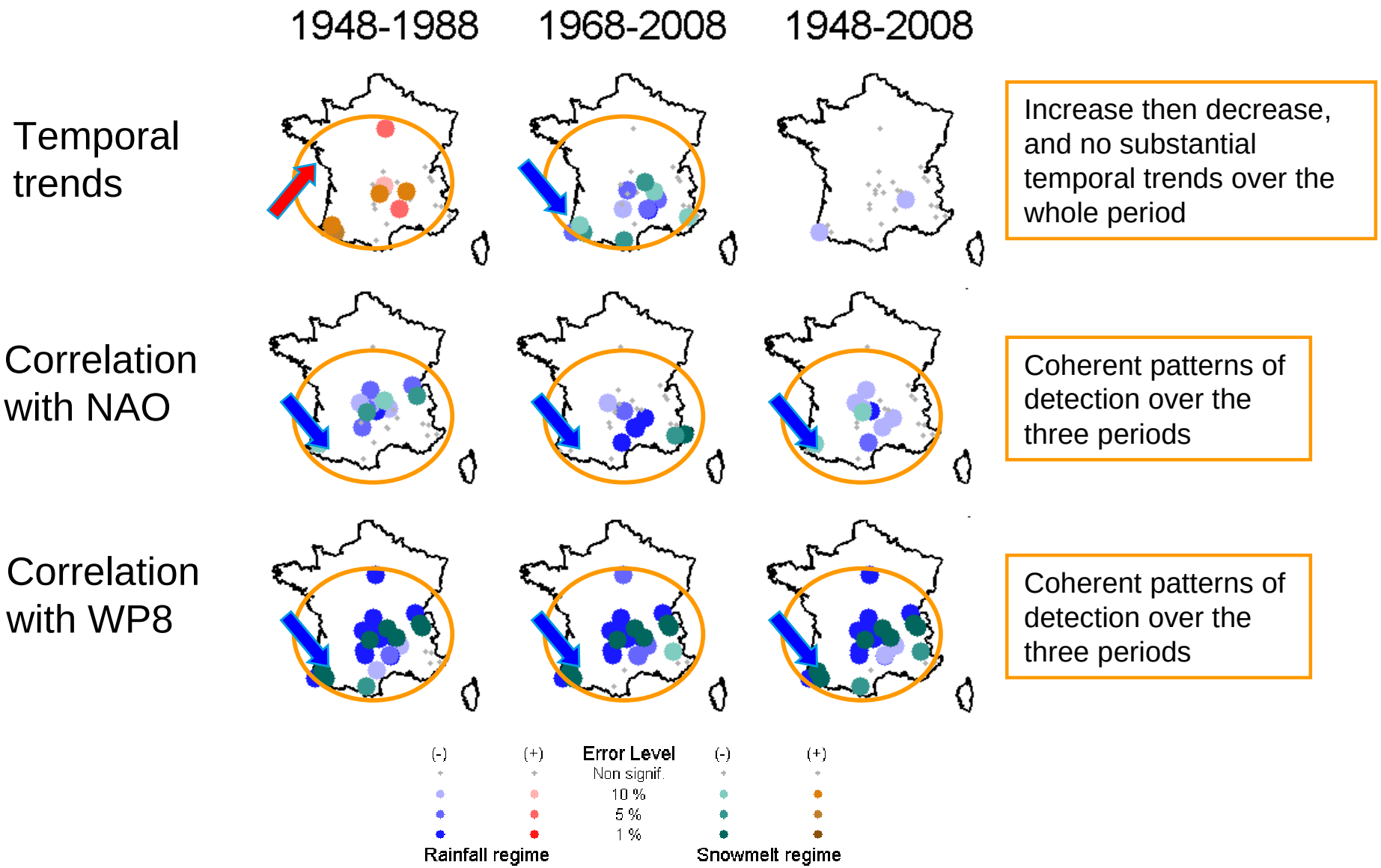
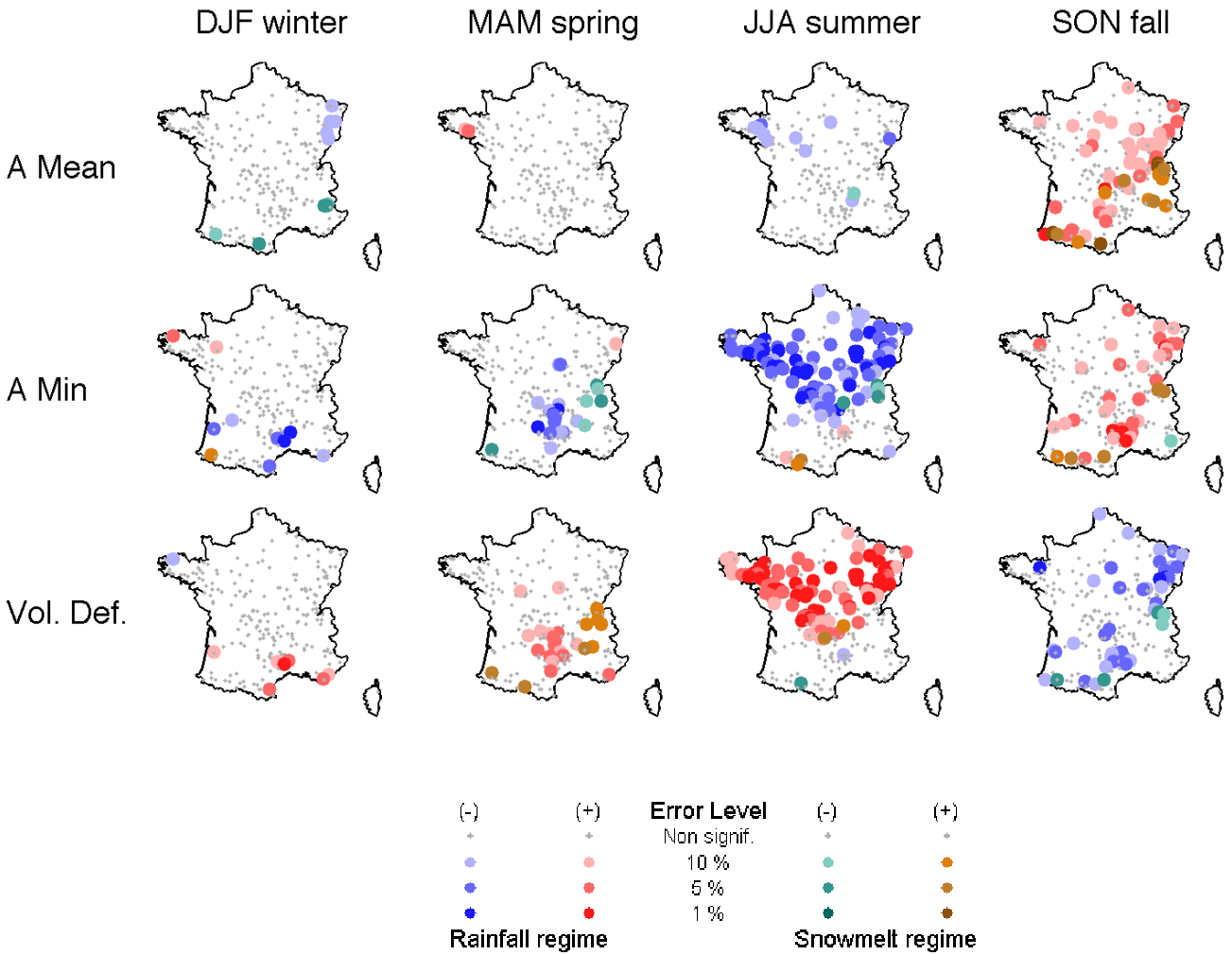


Results – Seasonal scale

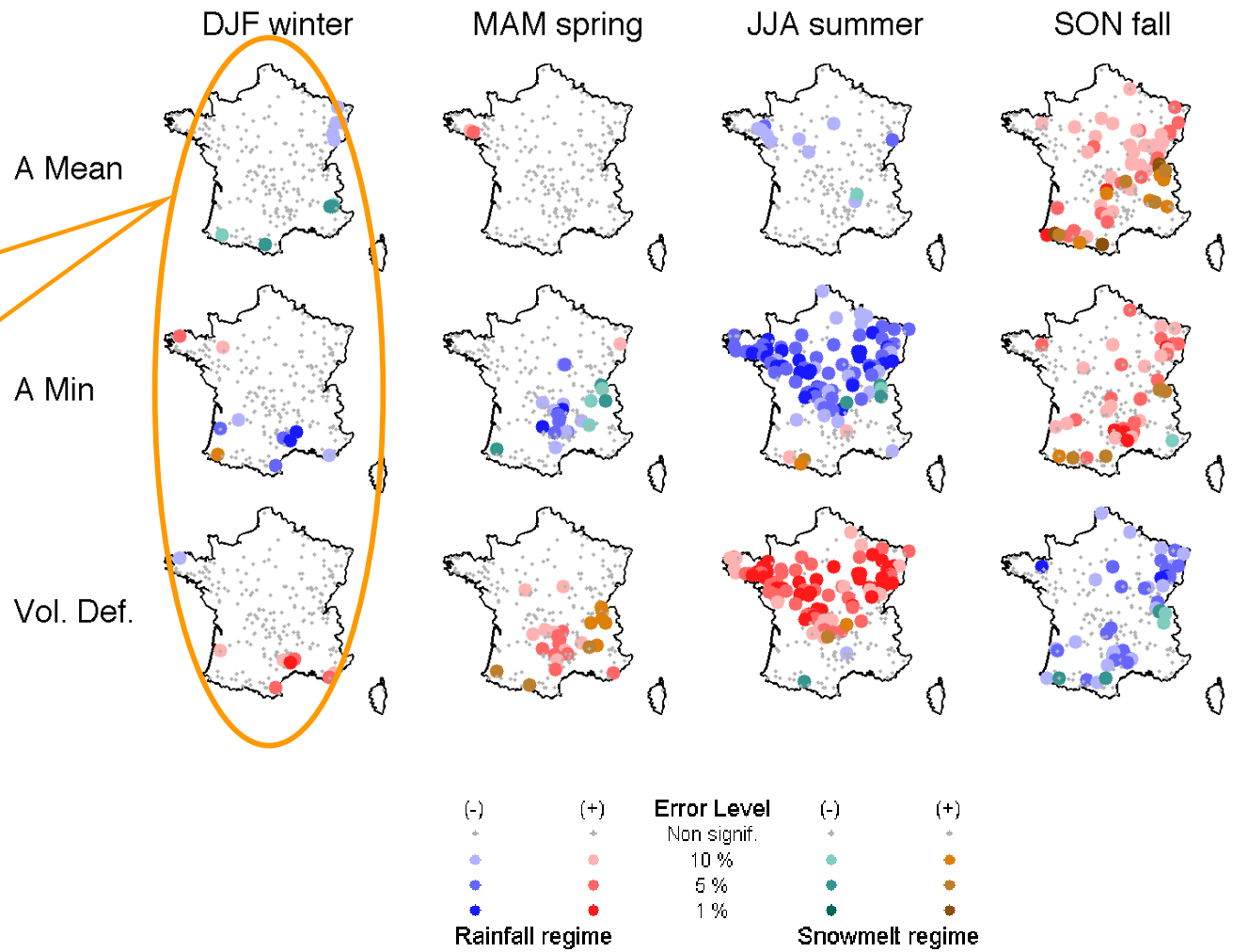
Seasonal NAO



Results – Seasonal scale

Seasonal NAO

Very little information from winter NAO (unlike Northern and Southern Europe)



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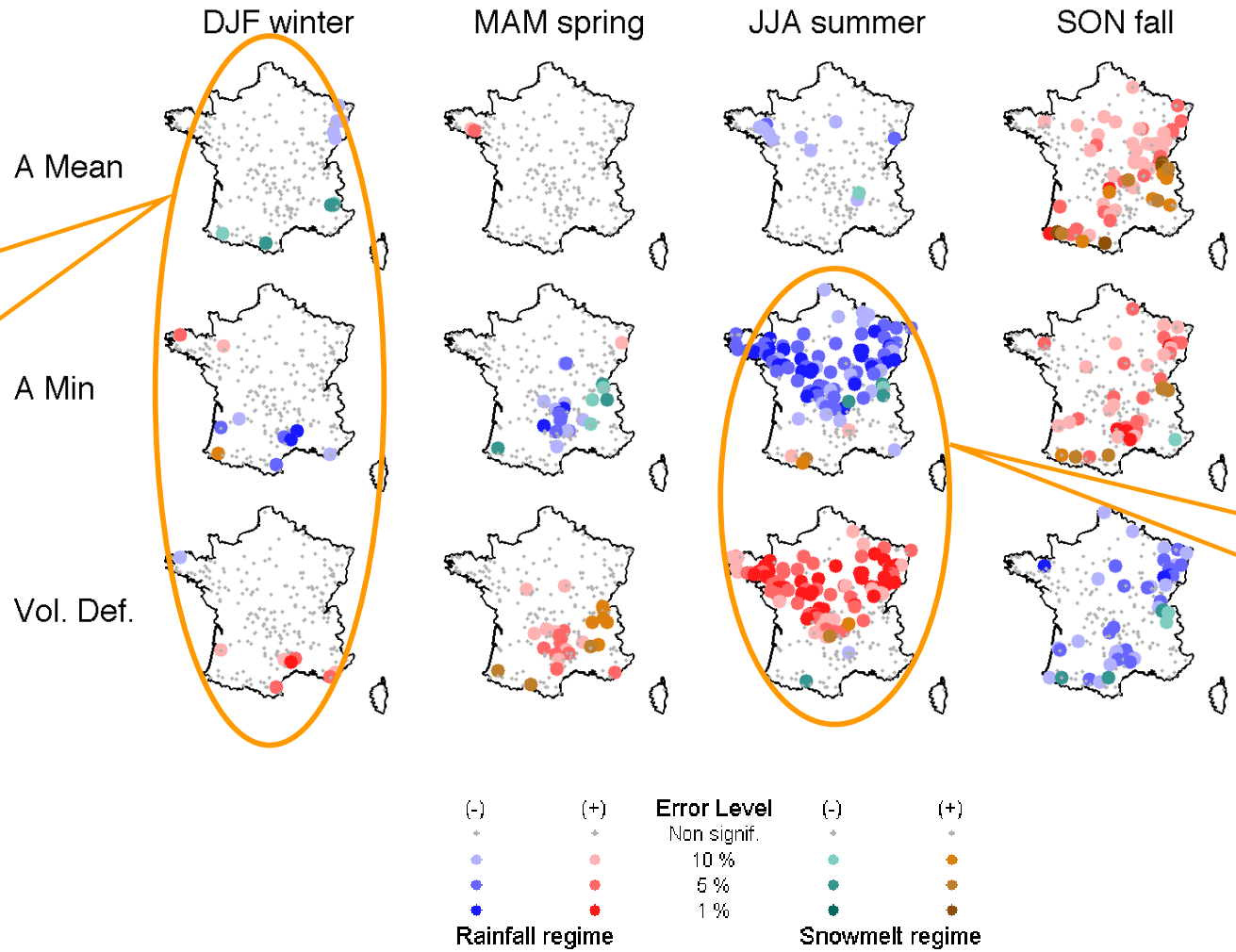

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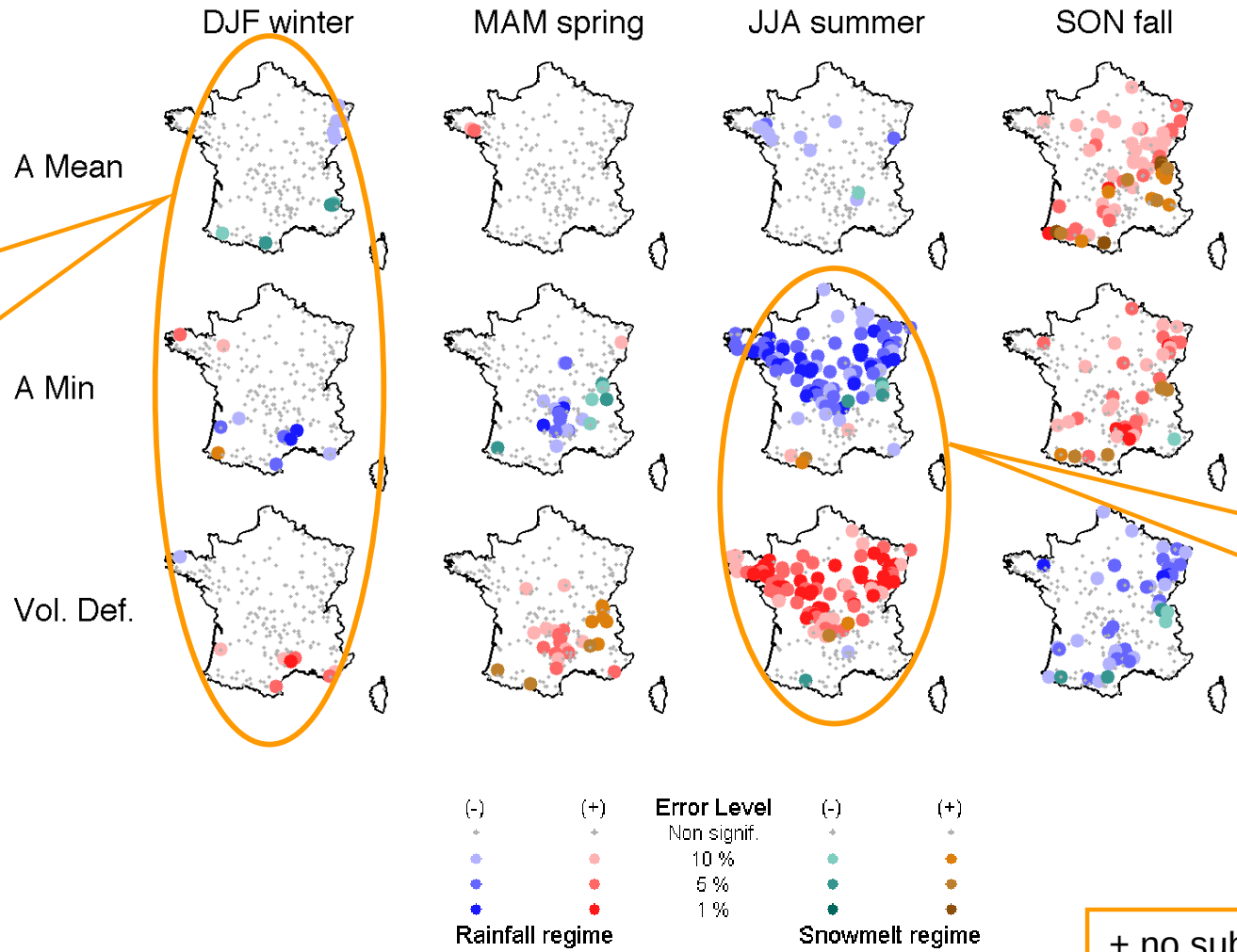
Correlation of low flow severity with summer NAO

Results – Seasonal scale

Seasonal NAO



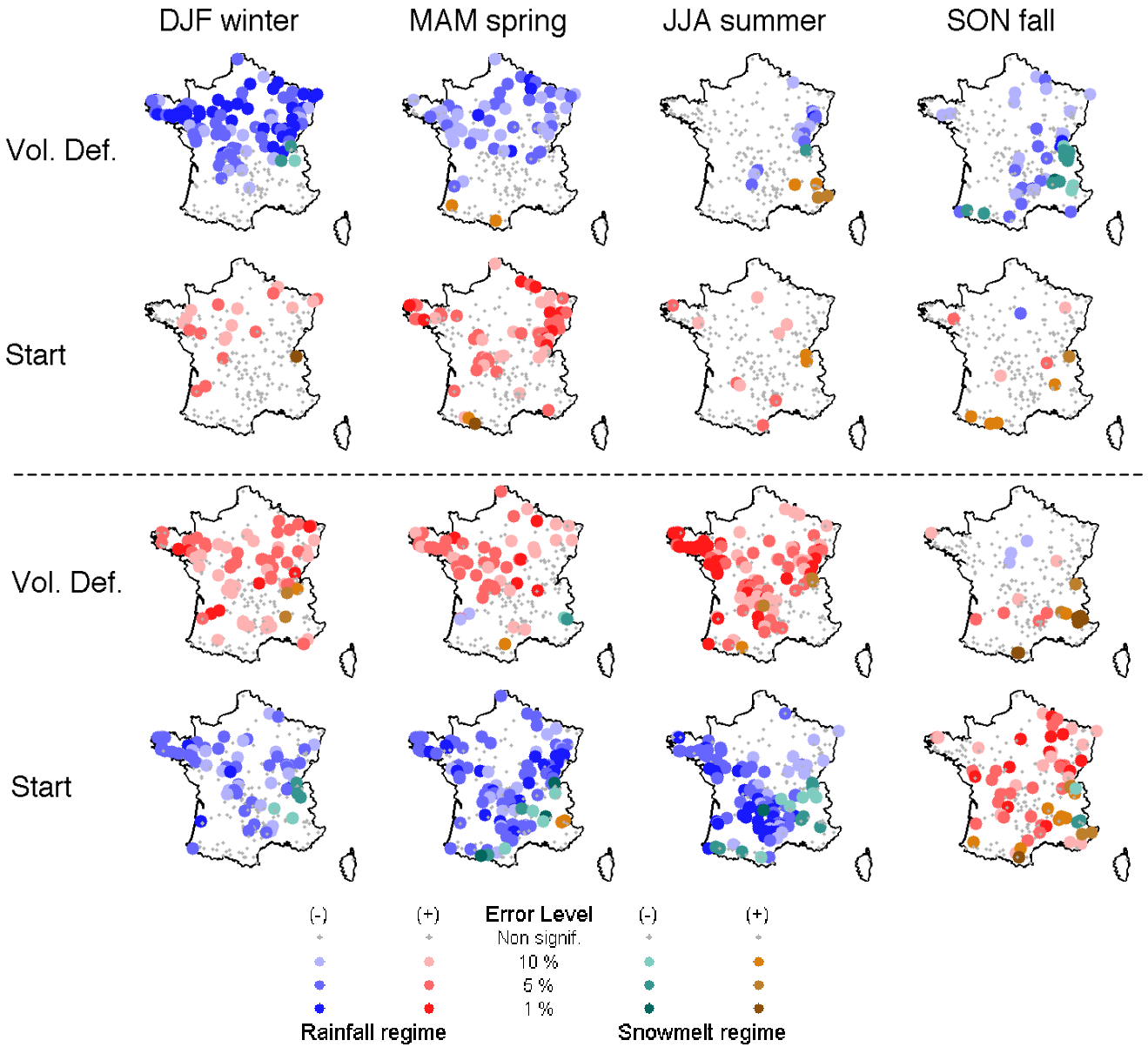
Very little information from winter NAO (unlike Northern and Southern Europe)

Correlation of low flow severity with summer NAO

+ no substantial correlation for timing indices

Results – Seasonal scale

Seasonal WP2 and seasonal WP8

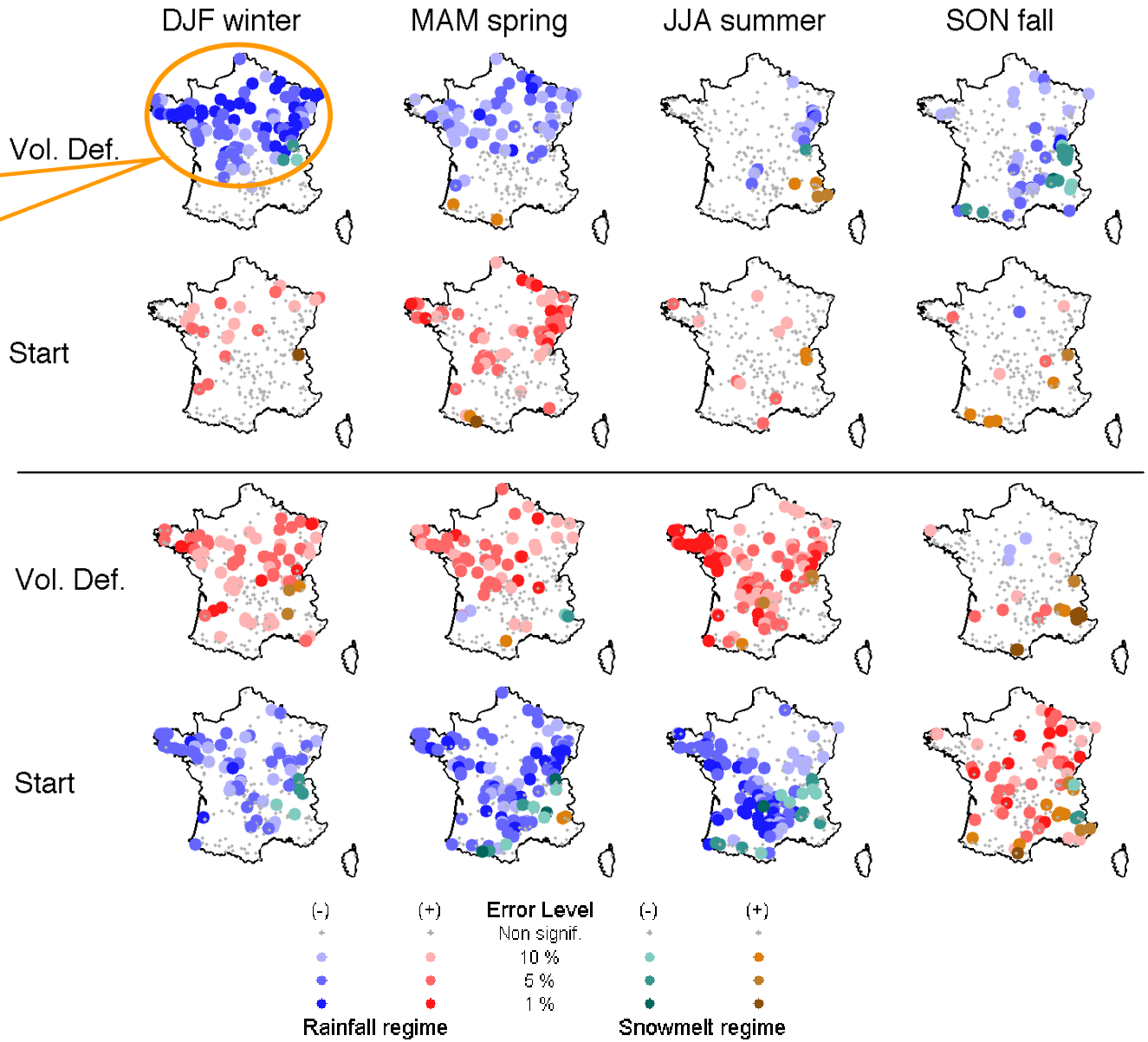


Results – Seasonal scale

Seasonal WP2 and seasonal WP8

WP2

Negative correlation between winter wet weather and drought severity



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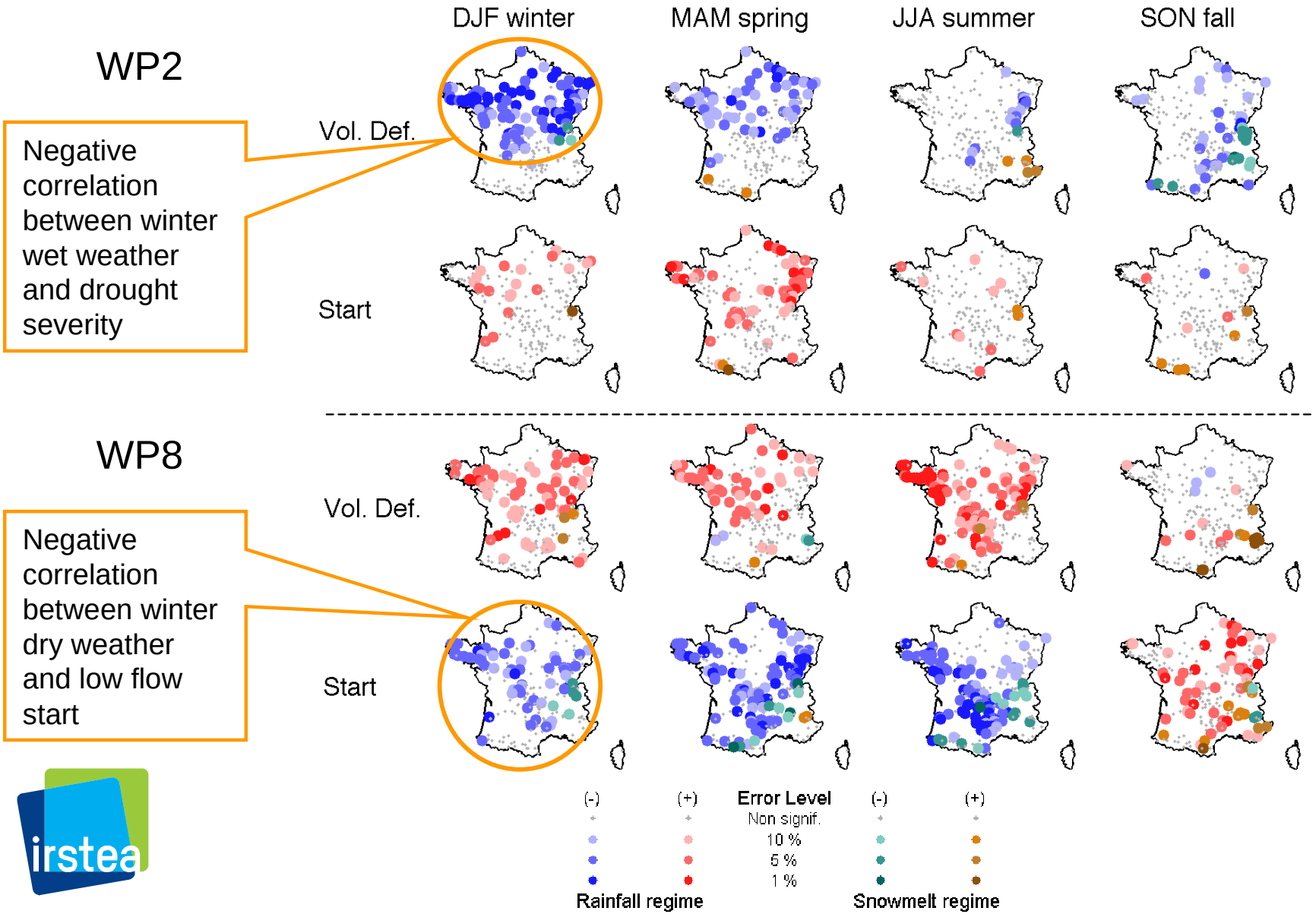

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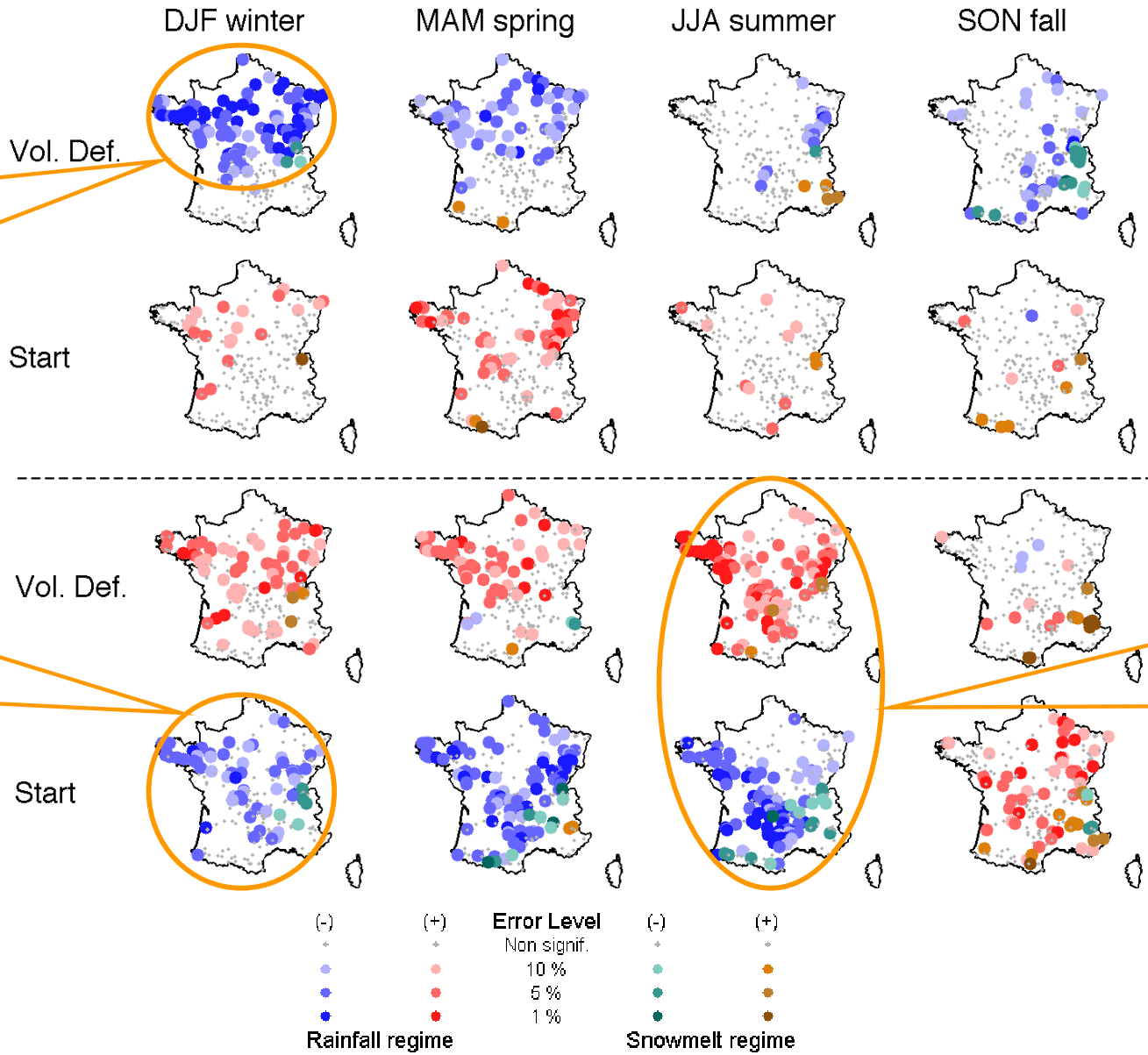

Negative correlation between winter wet weather and drought severity

Negative correlation between winter dry weather and low flow start

Correlation between summer dry weather and low flow severity & start

Conclusions

Drought severity – annual covariates

- North-South split in temporal trends
- Same spatial pattern with AMO and NAO

  ⇒ **Temporal trends could indeed result (partially) from climate variability**
- Very clear link between mean/low flows and WPs (except Mediterranean area)

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- Numerous temporal trends (earlier start)
- Pattern not observed with AMO and NAO

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Stability of correlations

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- Conversely, the relationship with climate indices remains stable across all time periods.

  ⇒ **Time is not to be used beyond purely descriptive purposes, the lack of stability precludes its use as a covariate for forecasting purposes**

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Drought severity and timing – seasonal covariates

- Links between severity and NAO (summer) clearer than at the annual scale
- Very clear links between severity and WP2 (winter to spring, mainly in the North) and WP8 (winter to summer)
- Very clear links between start and WP8 (winter to summer) even in the Mediterranean area

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Perspectives and open research questions

Perspective: statistical seasonal forecasting

- Make use of links between seasonal climate indices / WPs and drought indices in France
- Asynchronous correlation
  - Use information from previous seasons (winter NAO, winter/spring WP2-8)
- Synchronous correlation
  - Require atmospheric seasonal forecasts for low-flow season (summer NAO / WP2-8)
- Complementary to hydrological modelling approach (Singla *et al.*, 2012)

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Open research questions

- Taking account of low frequency (AMO type) in:
  - Frequency analysis
  - Weather generators
- Direct statistical downscaling in climate change context
  - Use of projections of climate indices
  - Potentially only useful for integrated variables

Thank you for your attention

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