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

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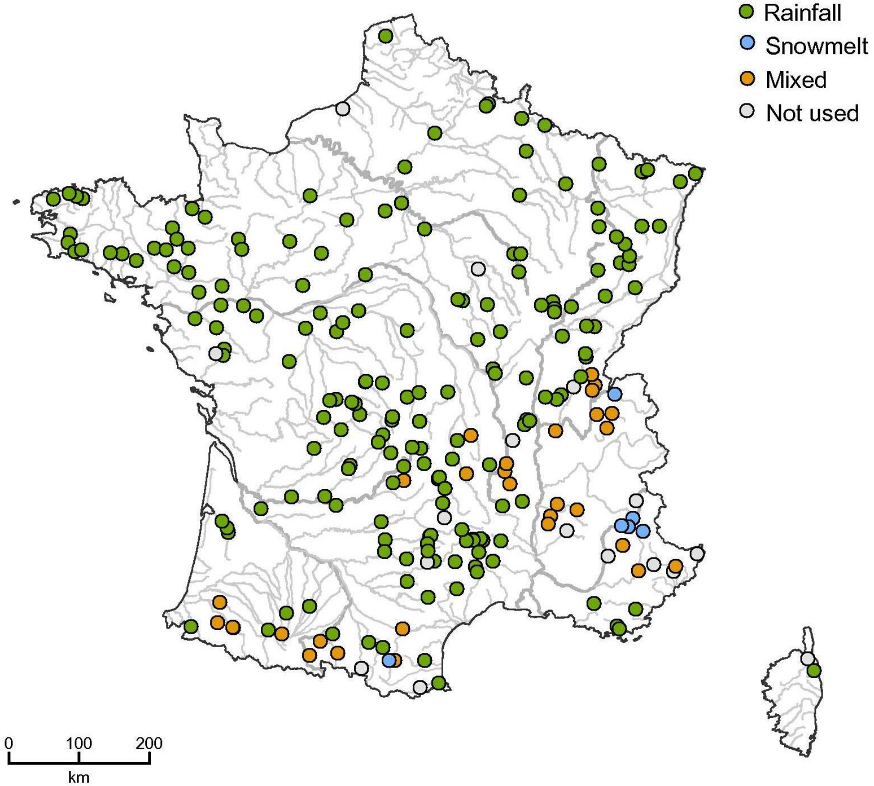
Outline

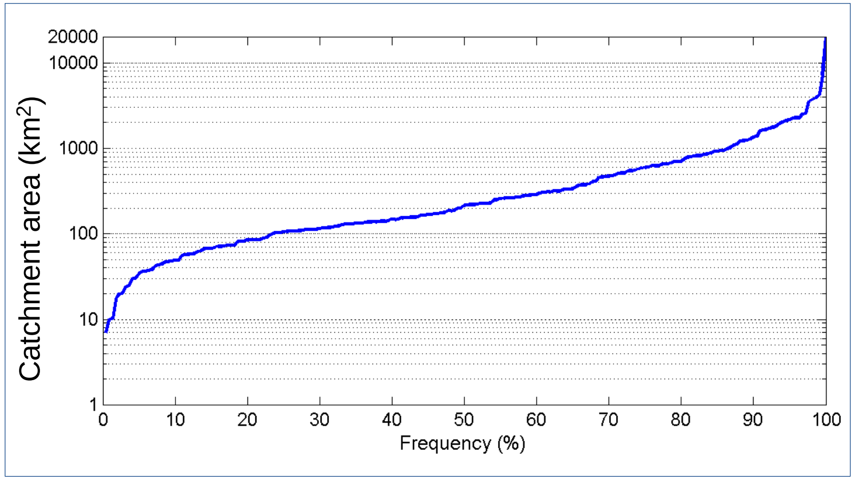
- Low flow benchmark network (R2SE)
- Climate and drought indices
- Methods
- Results
  - Annual scale
  - Stability of correlations
  - Seasonal scale
- Conclusions

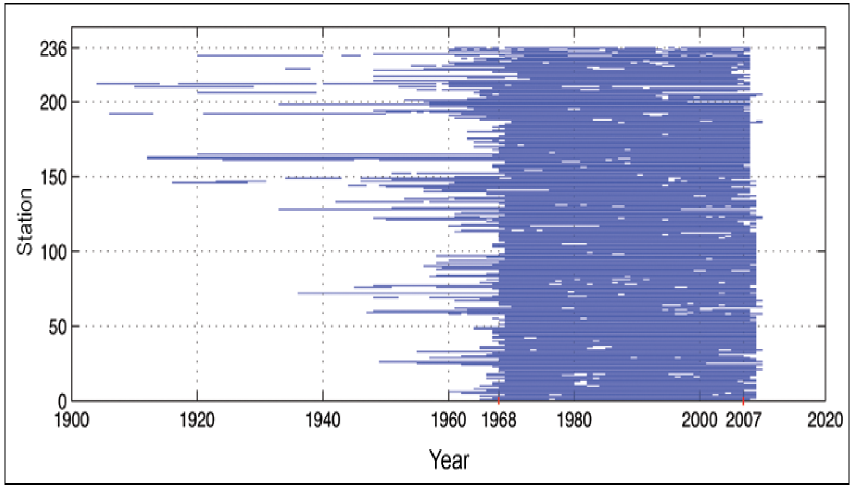
Low Flow Benchmark Network (R2SE)

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

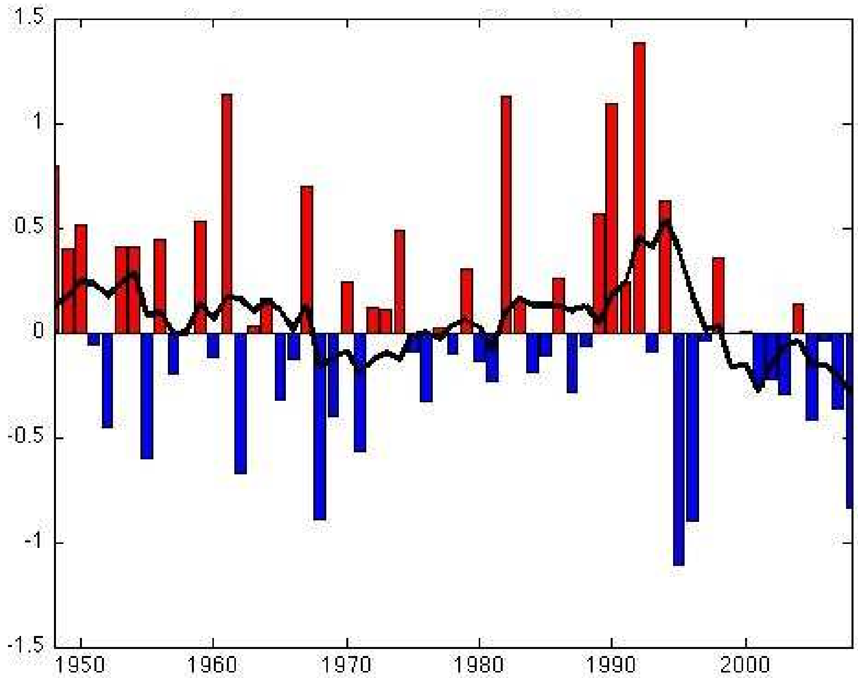
NAO

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

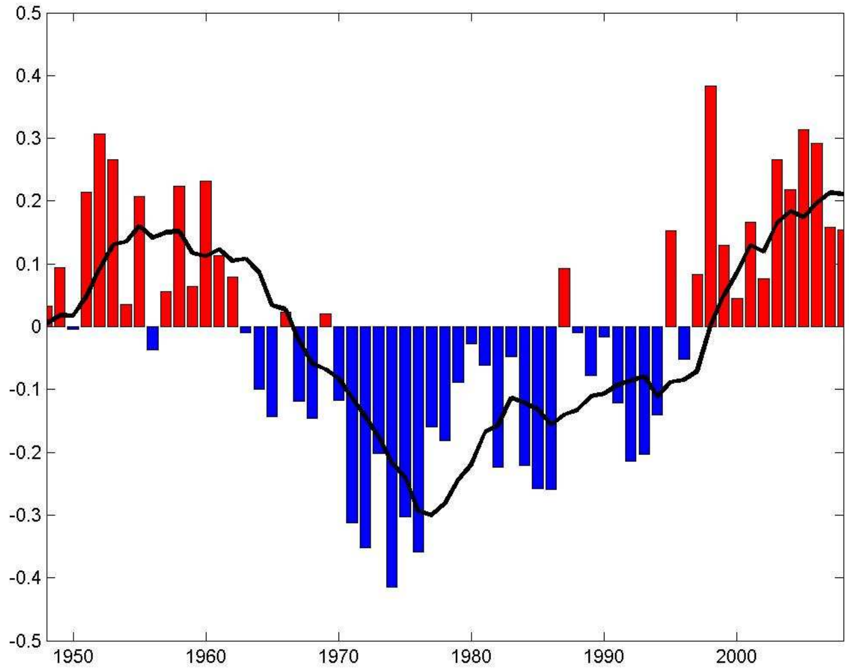
AMO

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

NAO 1948-2008



AMO 1948-2008

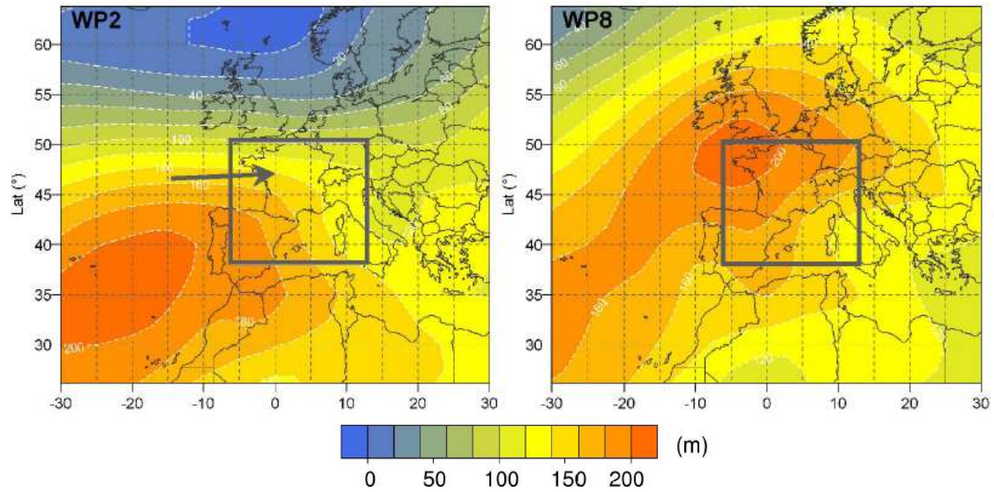


Climate indices – Regional scale

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

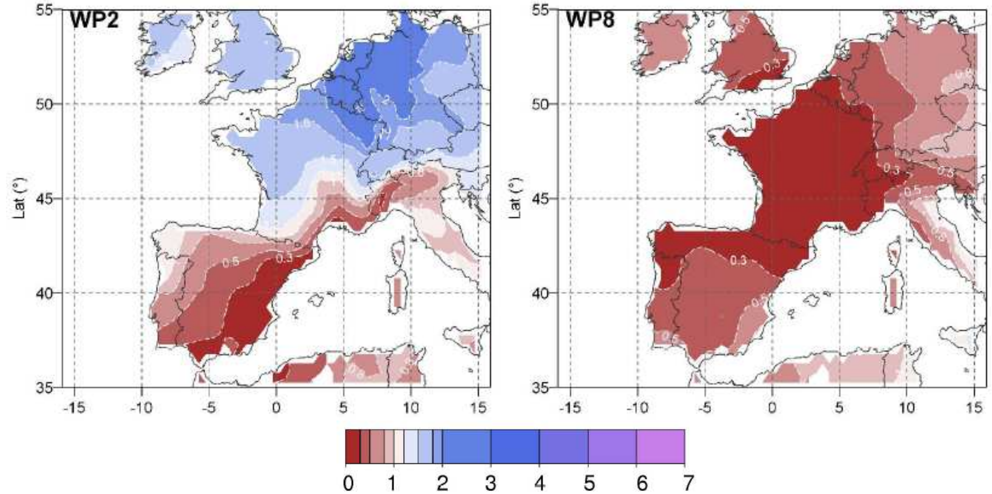
- 8 weather patterns based on precipitation over France (bottom-up approach)
- 2 most frequent: WP2 and WP8

WP2
steady oceanic
23%



WP8
Anticyclonic
28%

wet weather

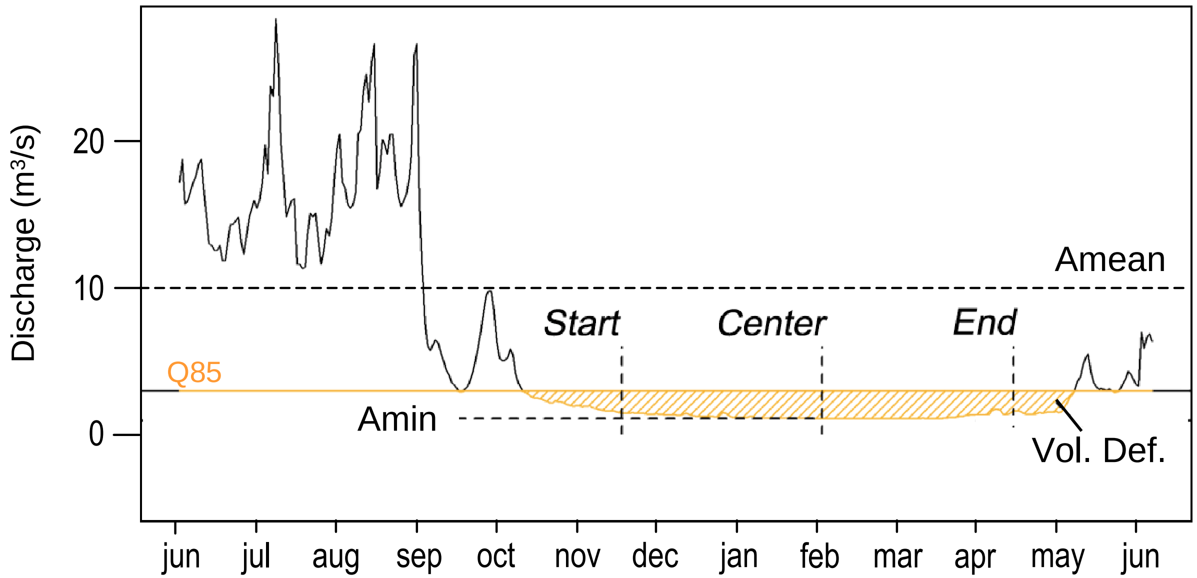


dry weather

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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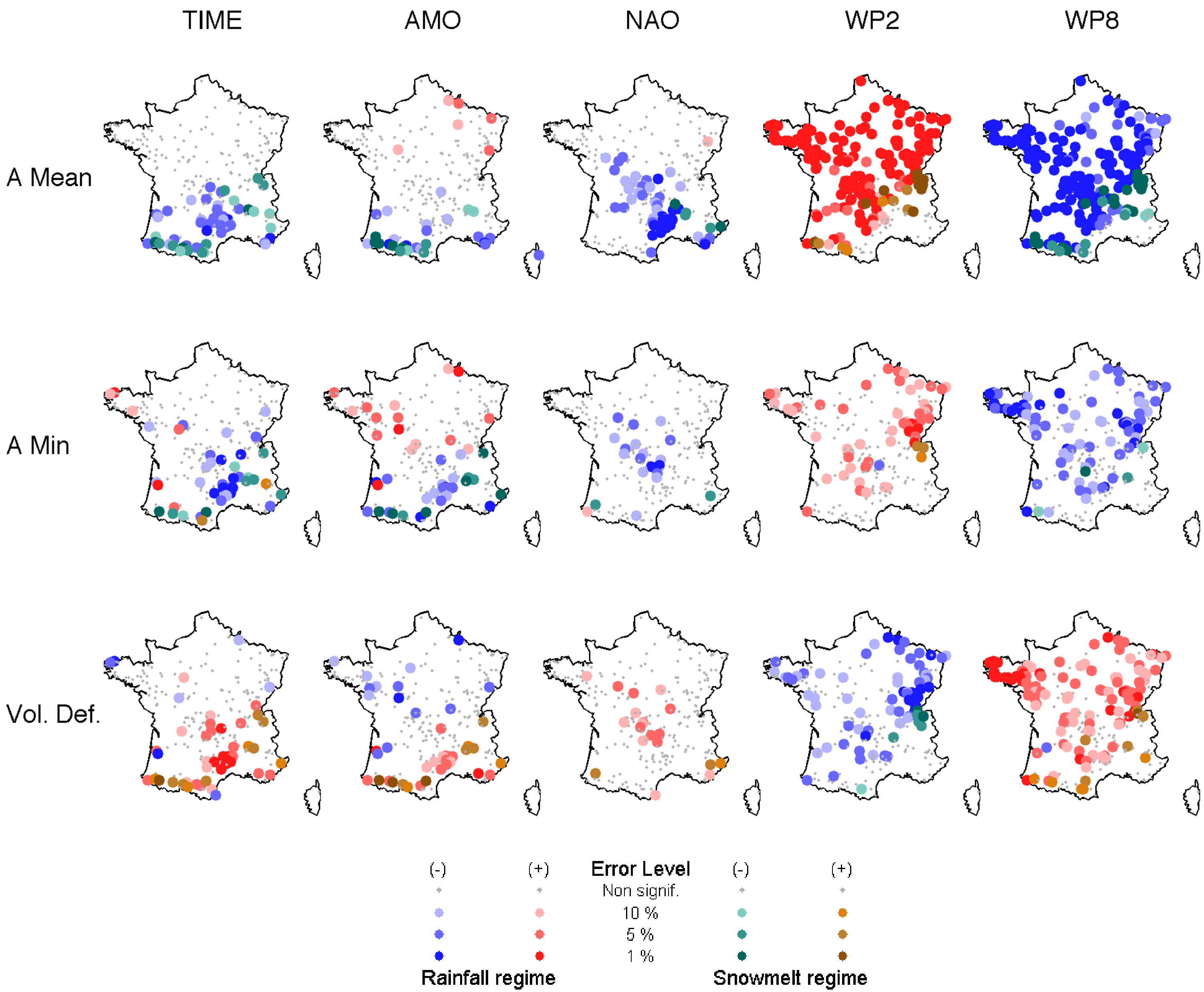
Results – Annual scale

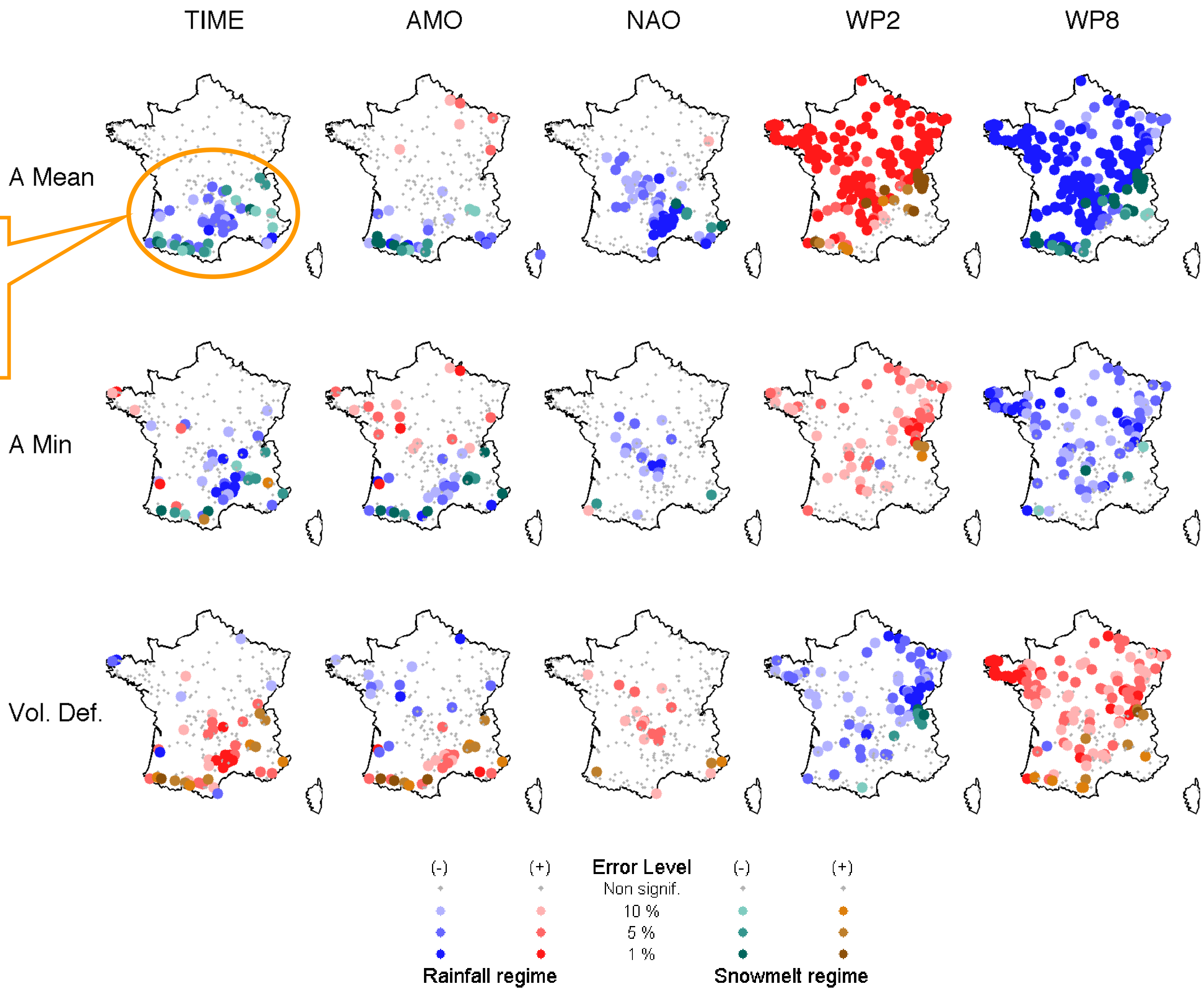
Drought severity indices



Results – Annual scale

Drought severity indices

Downward trend of annual mean flow

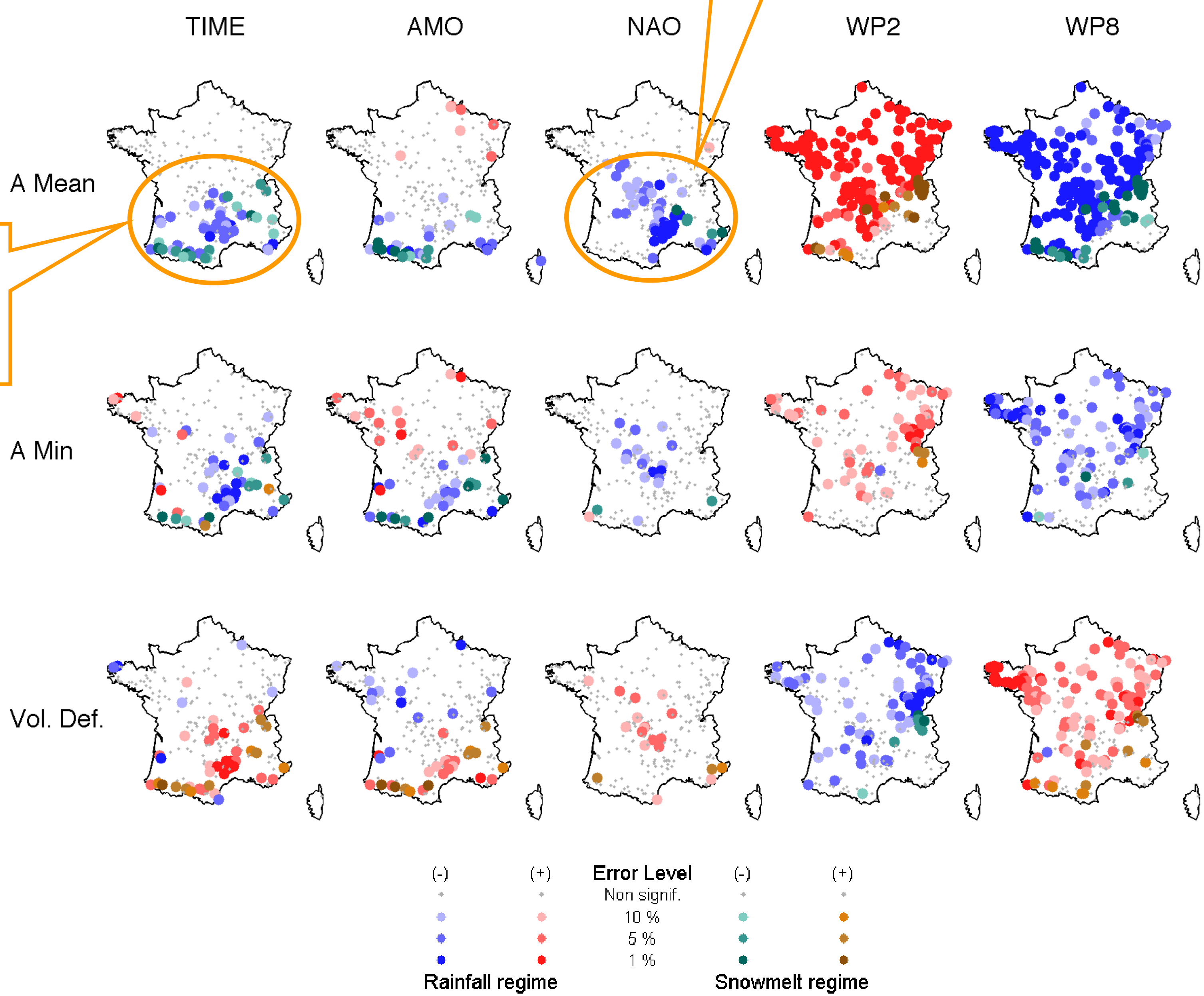


Results – Annual scale

Drought severity indices

Negative correlation of annual mean flow with NAO

Downward trend of annual mean flow



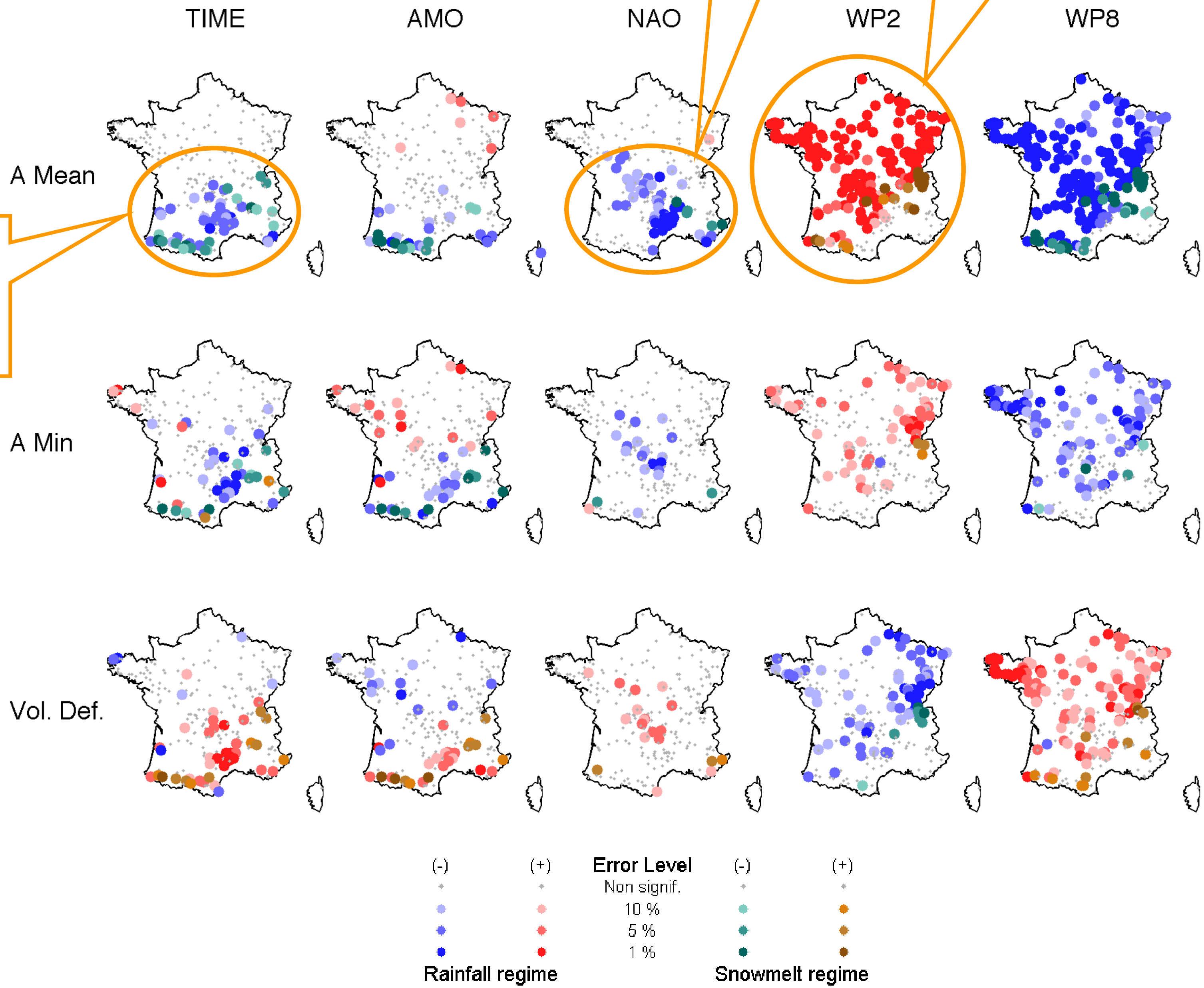
Results – Annual scale

Drought severity indices

Negative correlation of annual mean flow with NAO

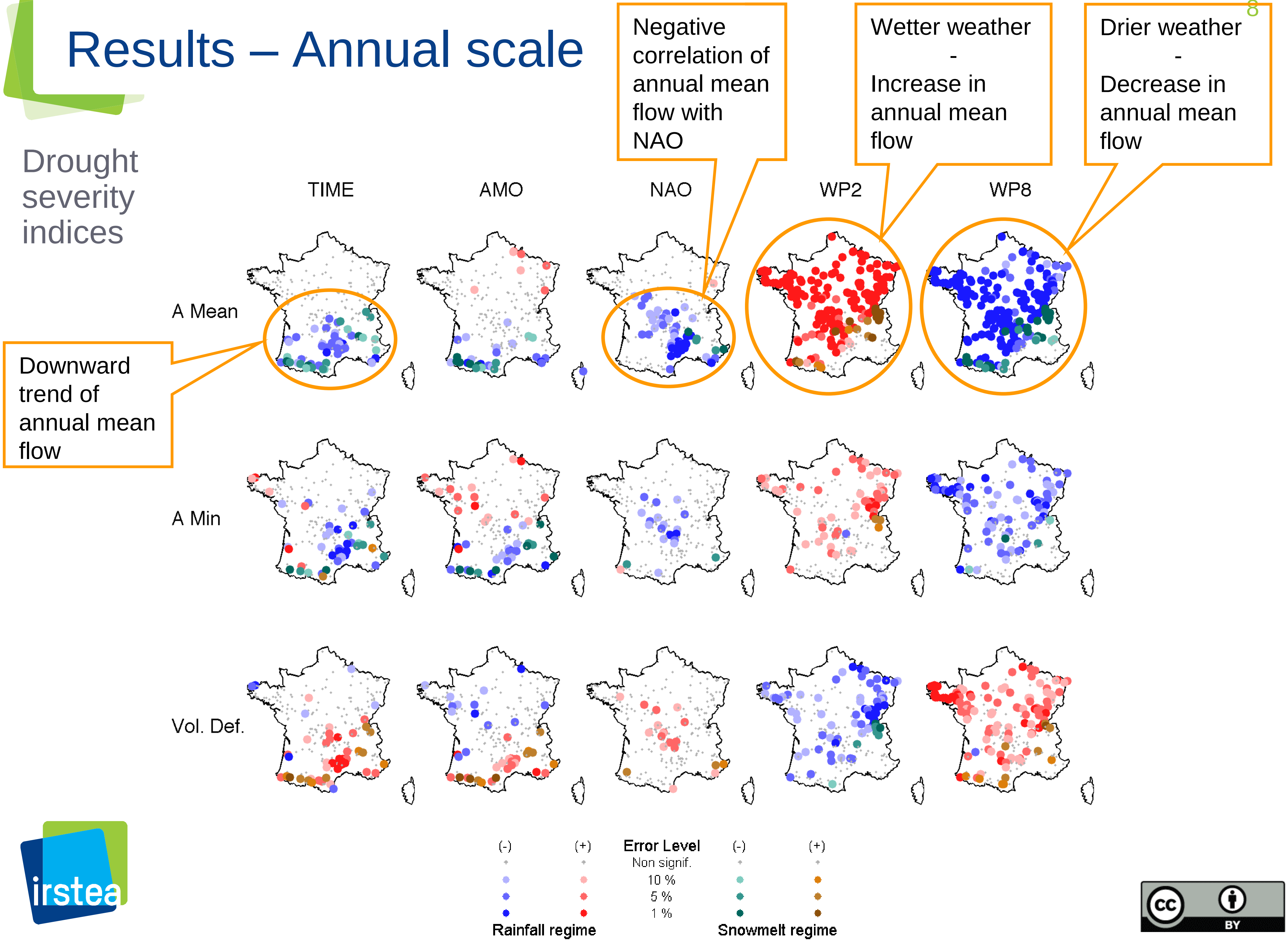
Wetter weather - Increase in annual mean flow

Downward trend of annual mean flow



Results – Annual scale

Drought severity indices



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Results – Annual scale

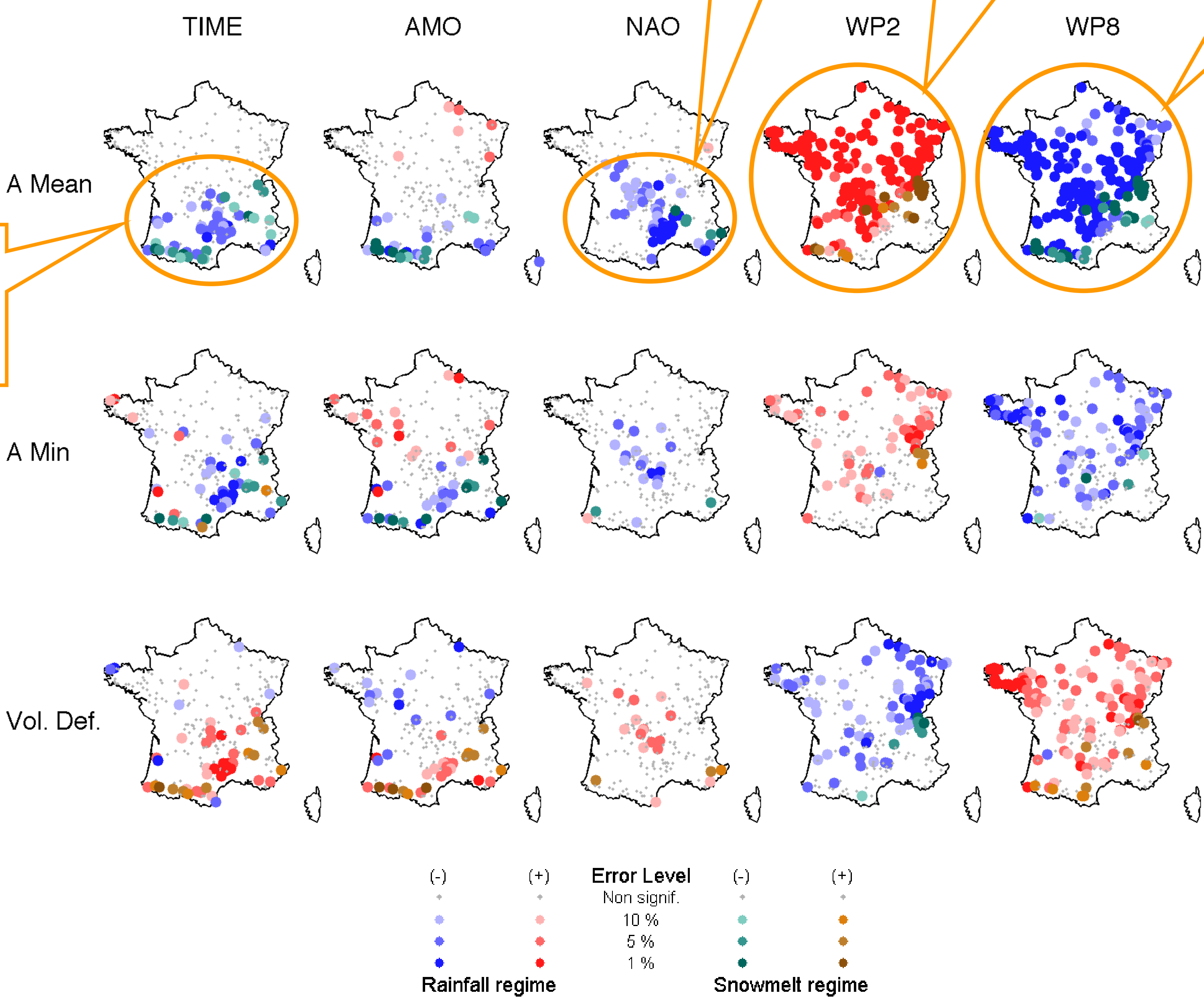
Drought severity indices

Negative correlation of annual mean flow with NAO

Wetter weather - Increase in annual mean flow

Drier weather - Decrease in annual mean flow

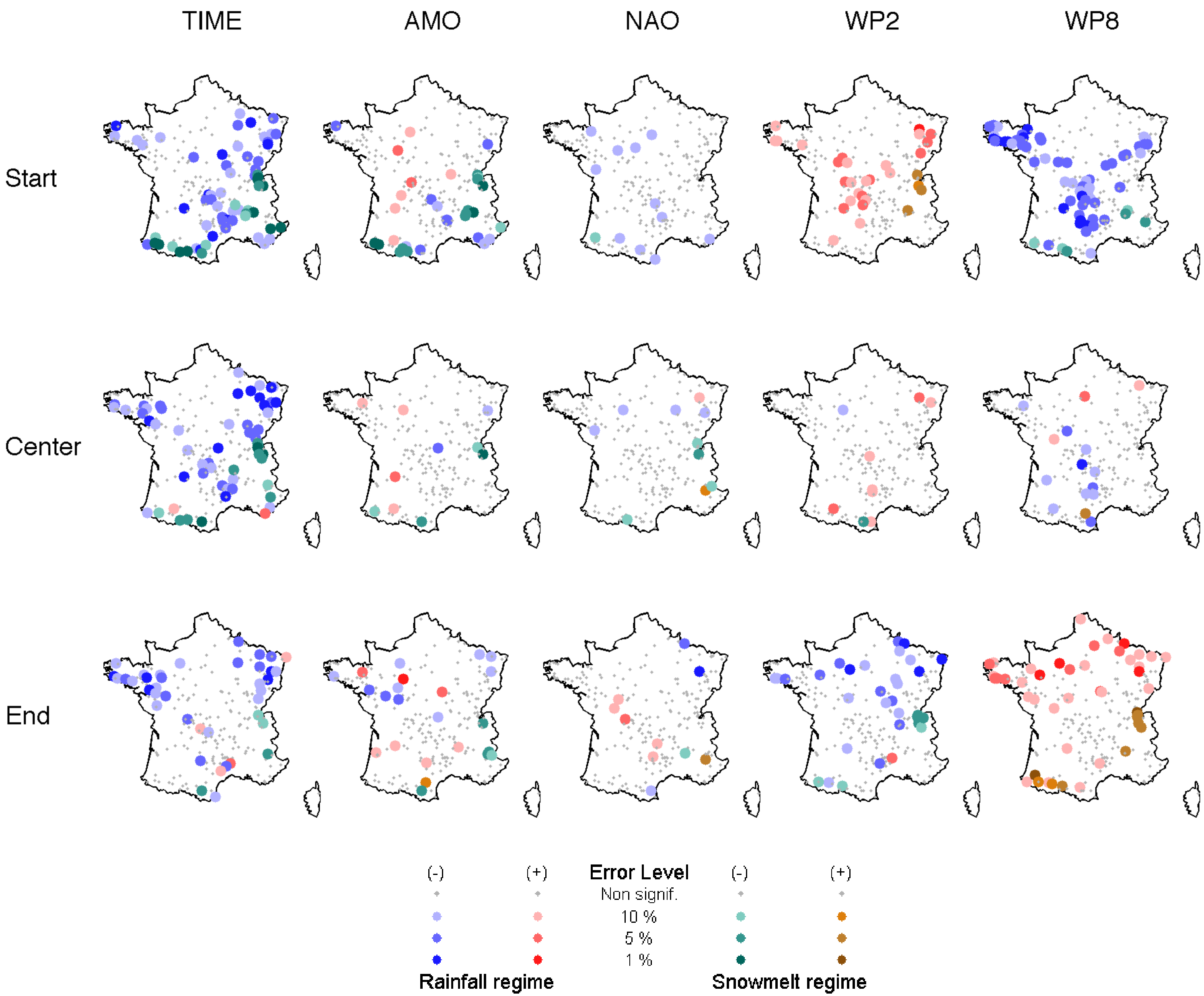
Downward trend of annual mean flow



Similar patterns for other severity indices

Results – Annual scale

Drought timing indices



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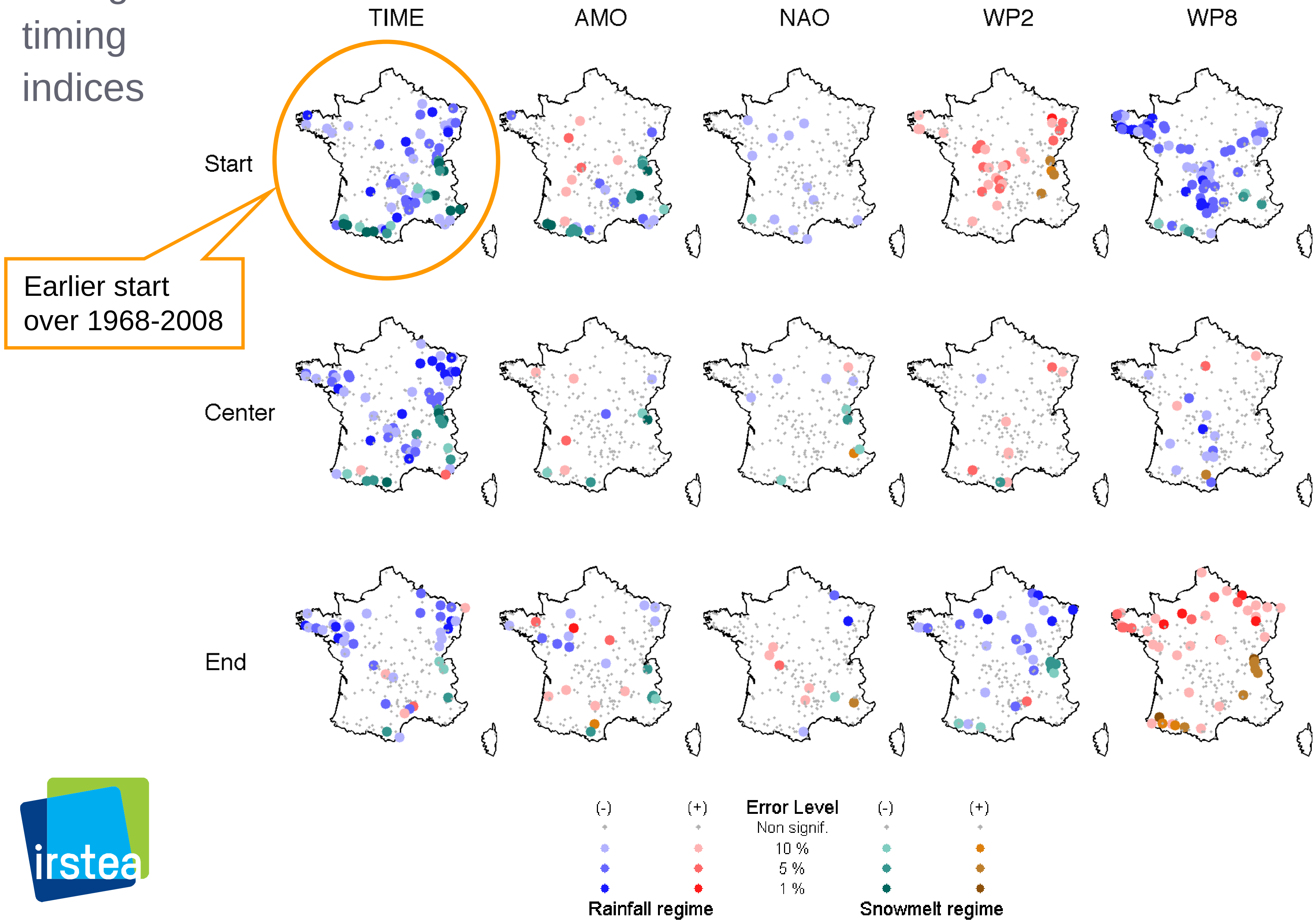
Results – Annual scale

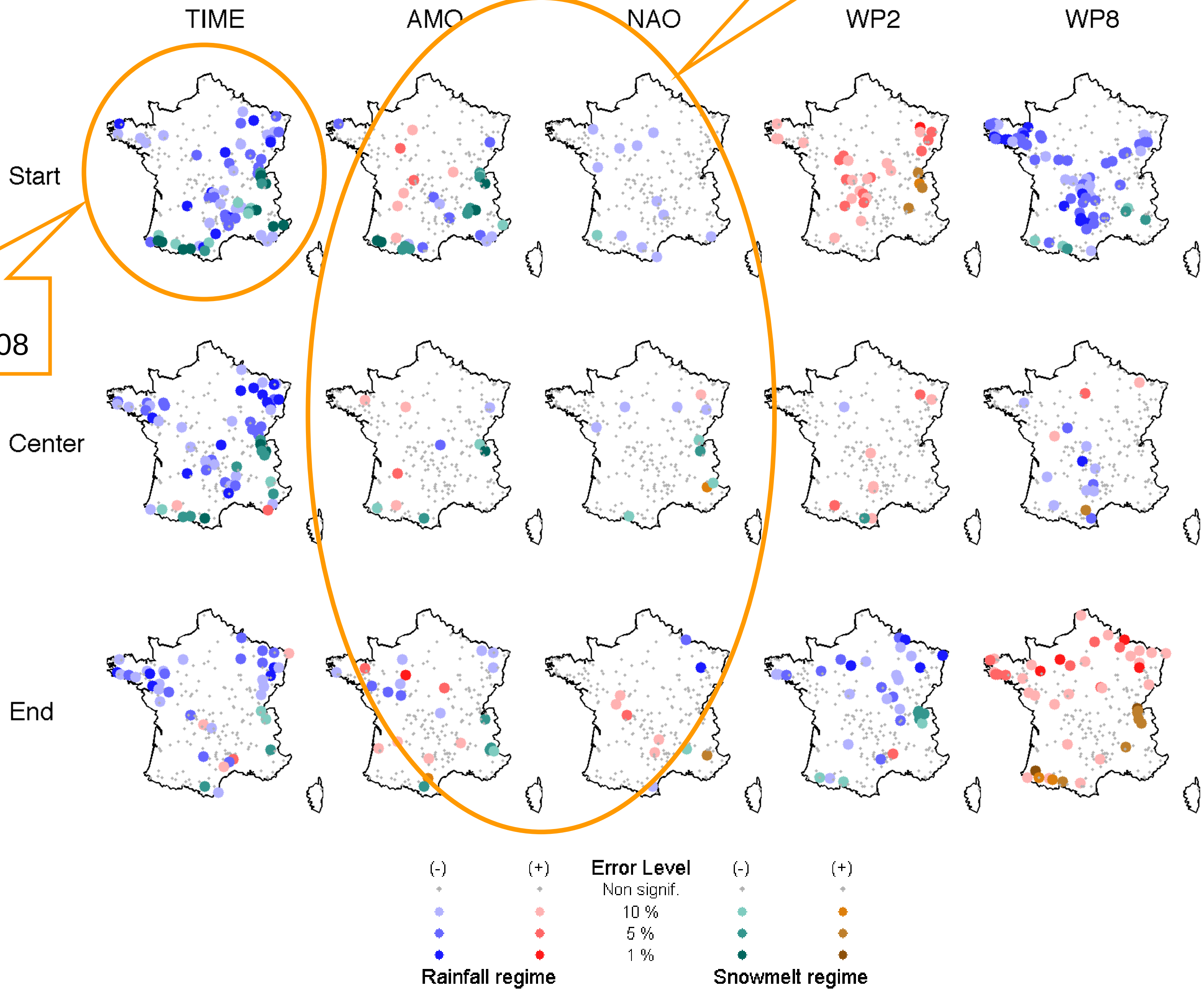
Drought timing indices



Results – Annual scale

Drought timing indices

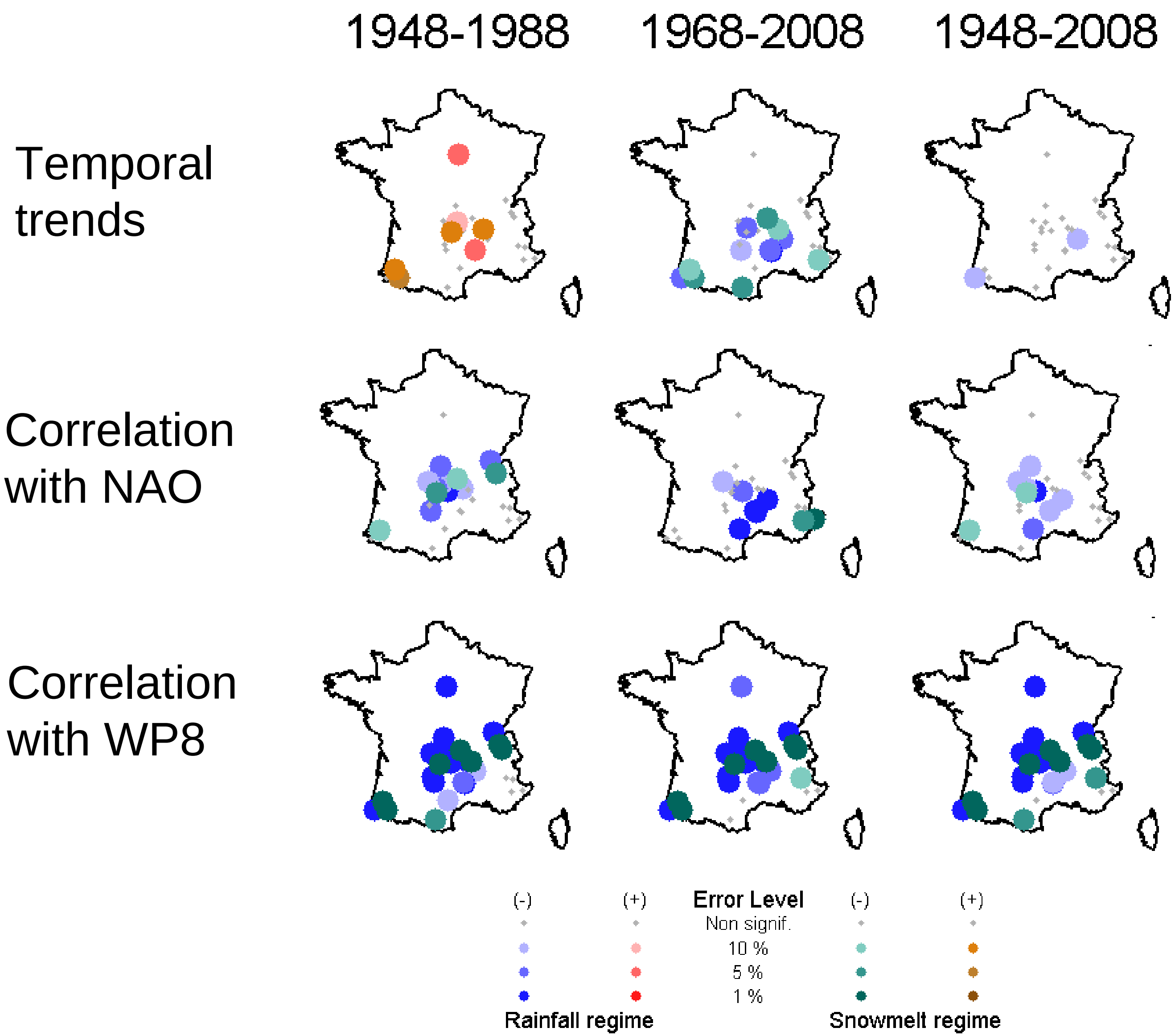
No correlation for AMO and NAO



Earlier start over 1968-2008

Results – Stability of correlations

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



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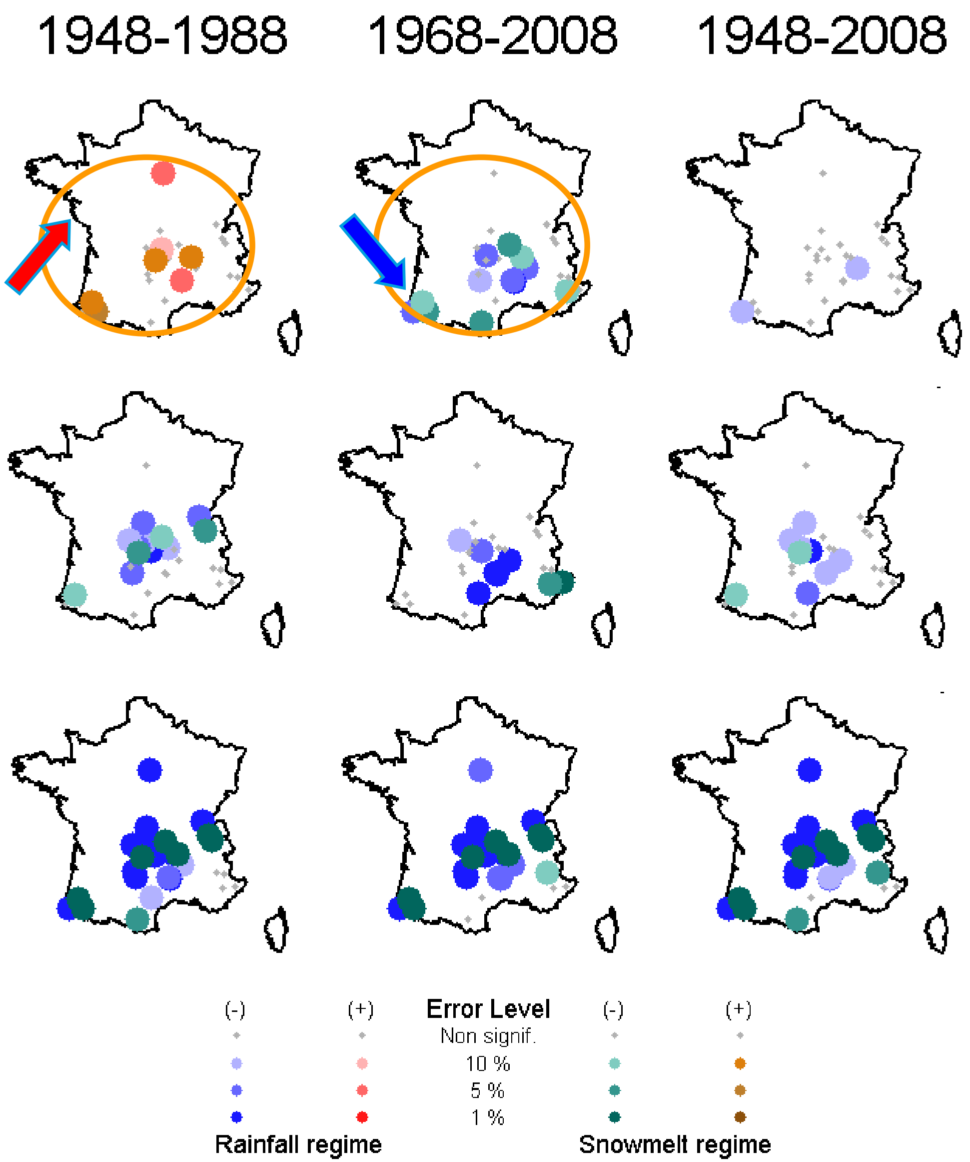
Results – Stability of correlations

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

Temporal trends

Correlation with NAO

Correlation with WP8



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

Results – Stability of correlations

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

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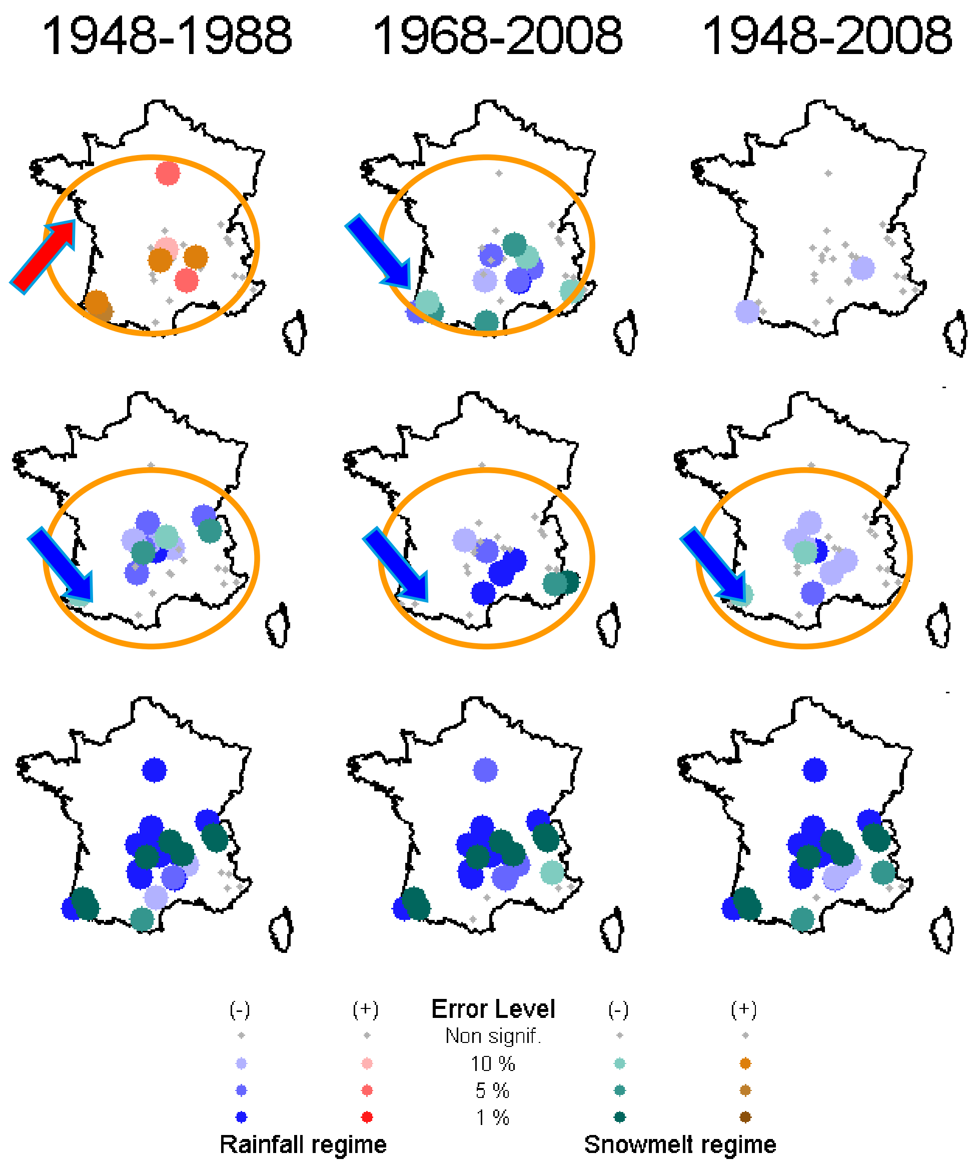
Correlation with NAO

Correlation with WP8

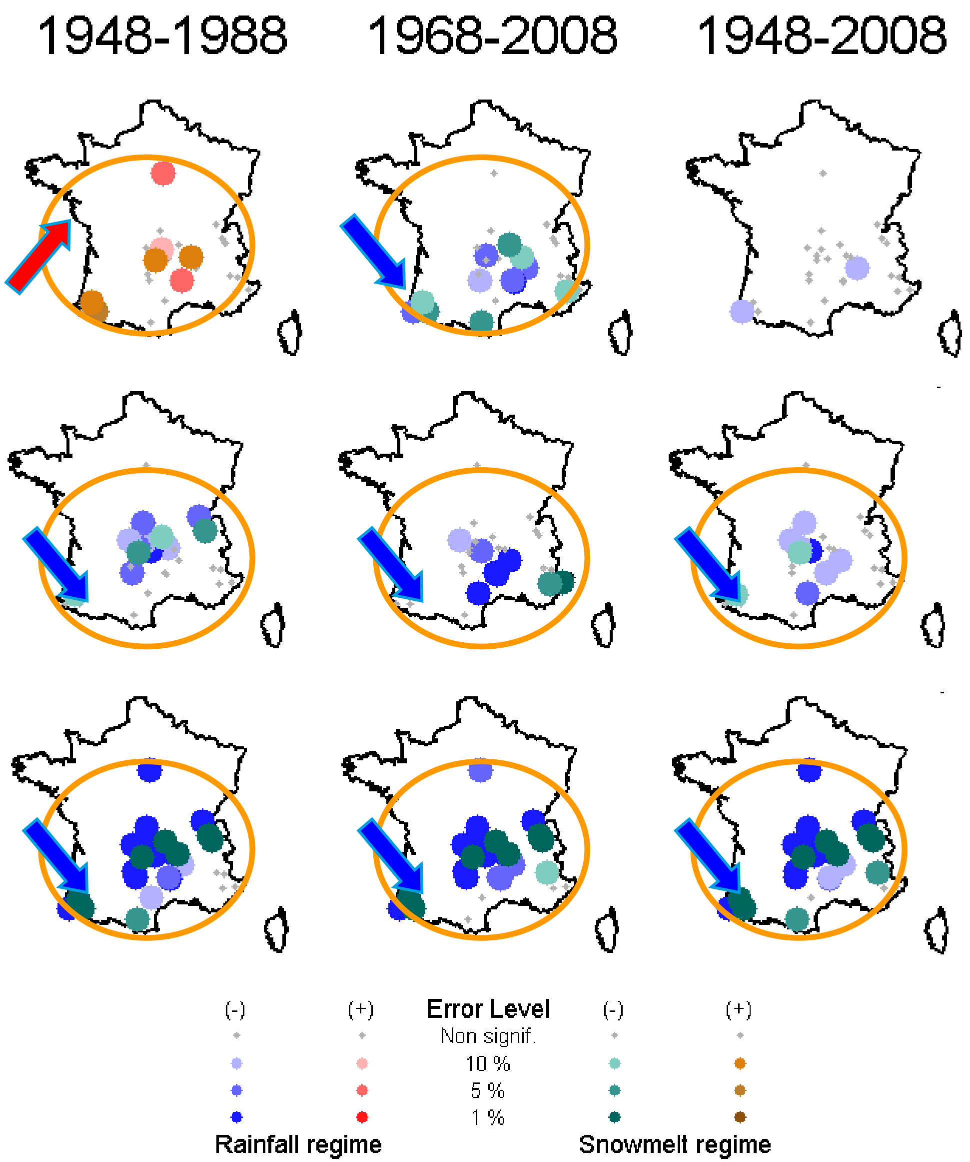


Increase then decrease, and no substantial temporal trends over the whole period

Coherent patterns of detection over the three periods

Results – Stability of correlations

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



Temporal trends

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

Correlation with NAO

Coherent patterns of detection over the three periods

Correlation with WP8

Coherent patterns of detection over the three periods

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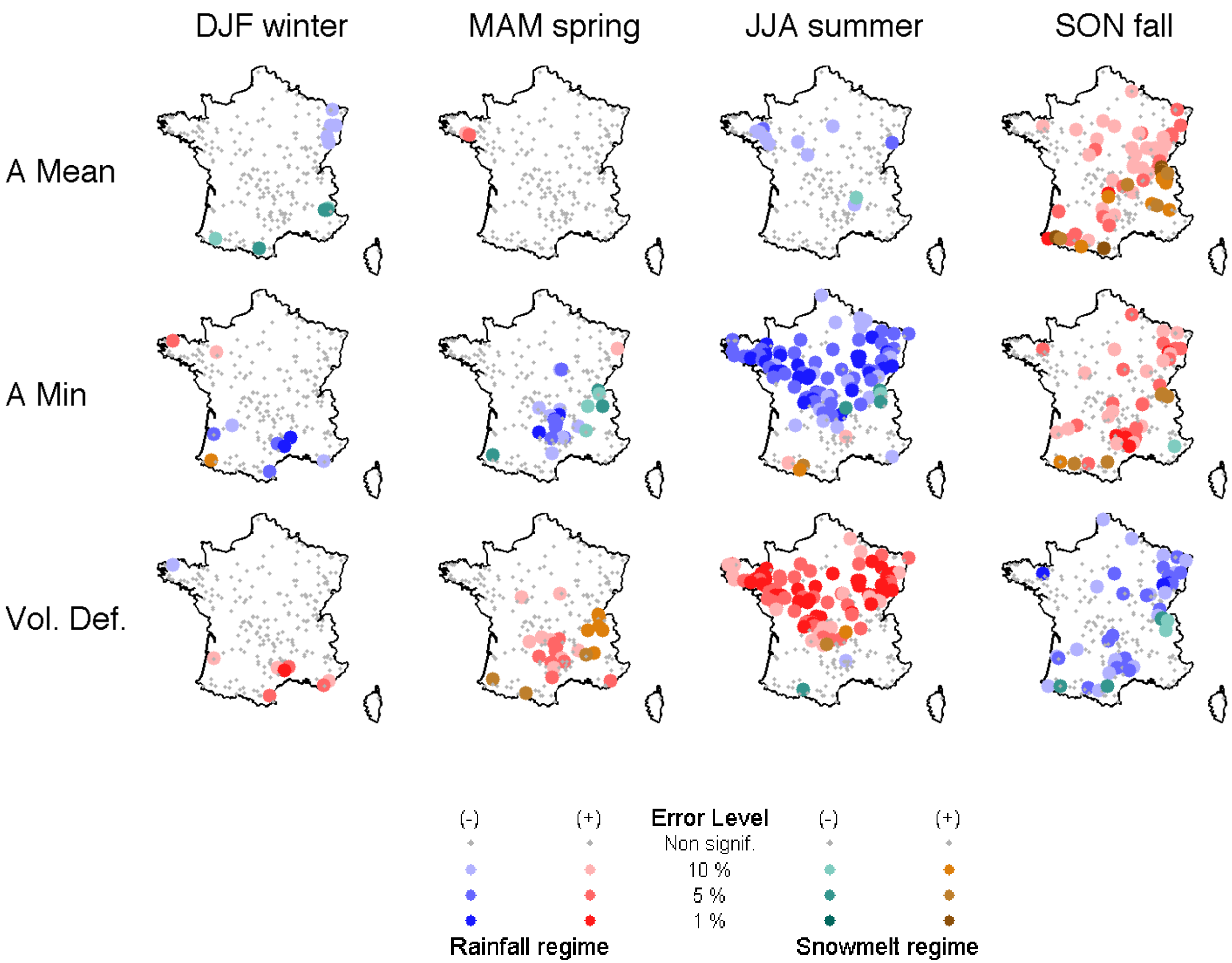
Results – Seasonal scale

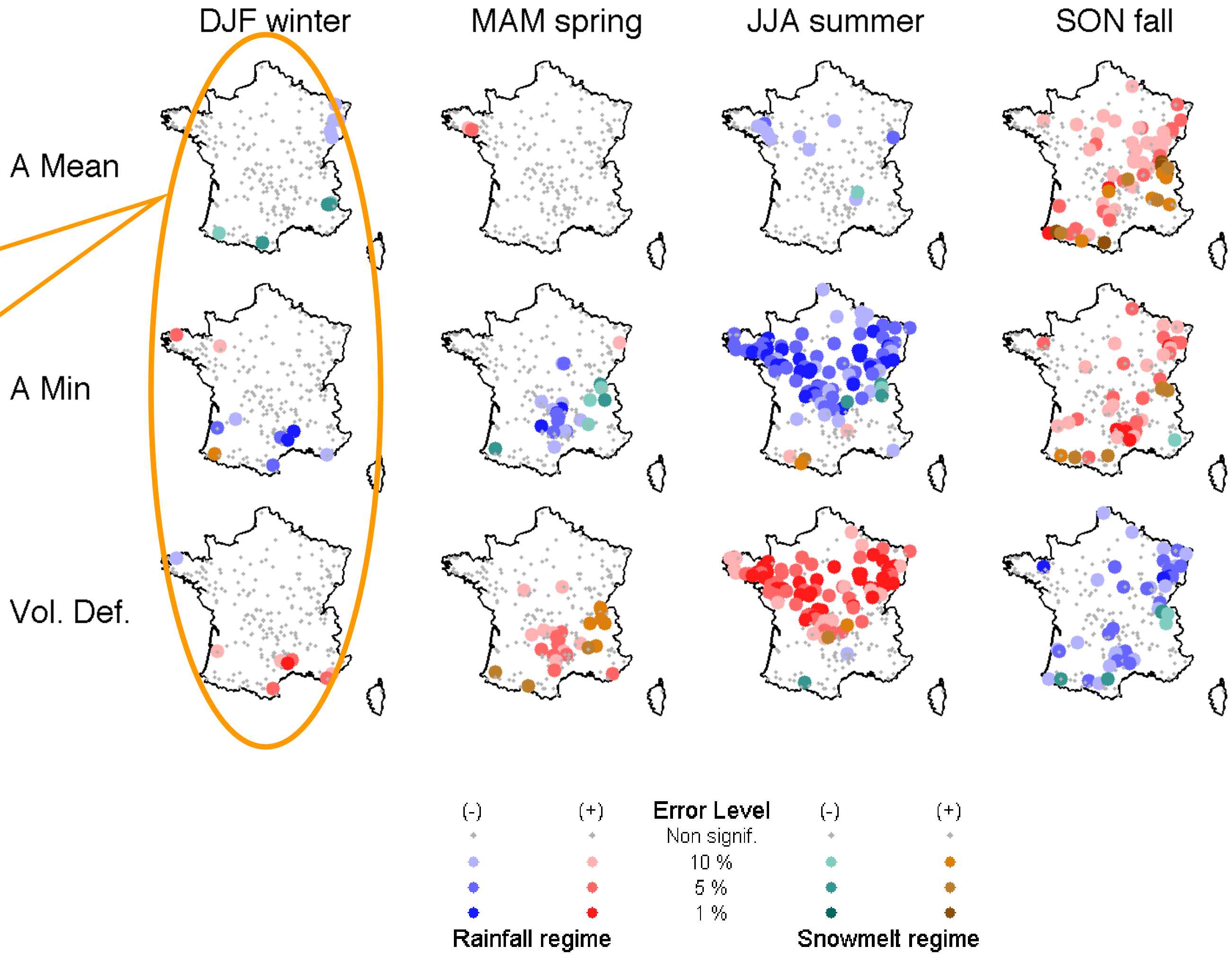
Seasonal NAO



Results – Seasonal scale

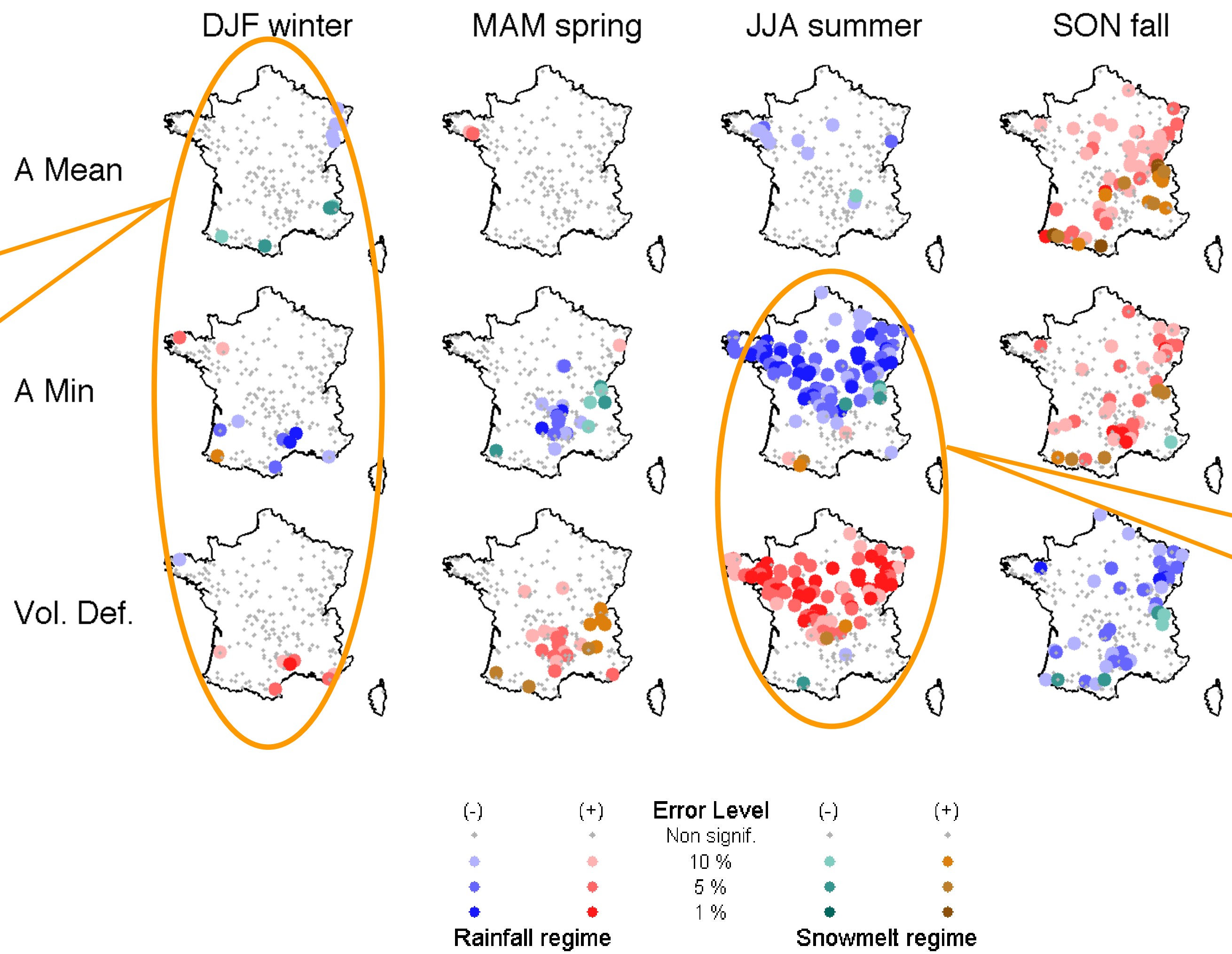
Seasonal NAO

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



Results – Seasonal scale

Seasonal NAO

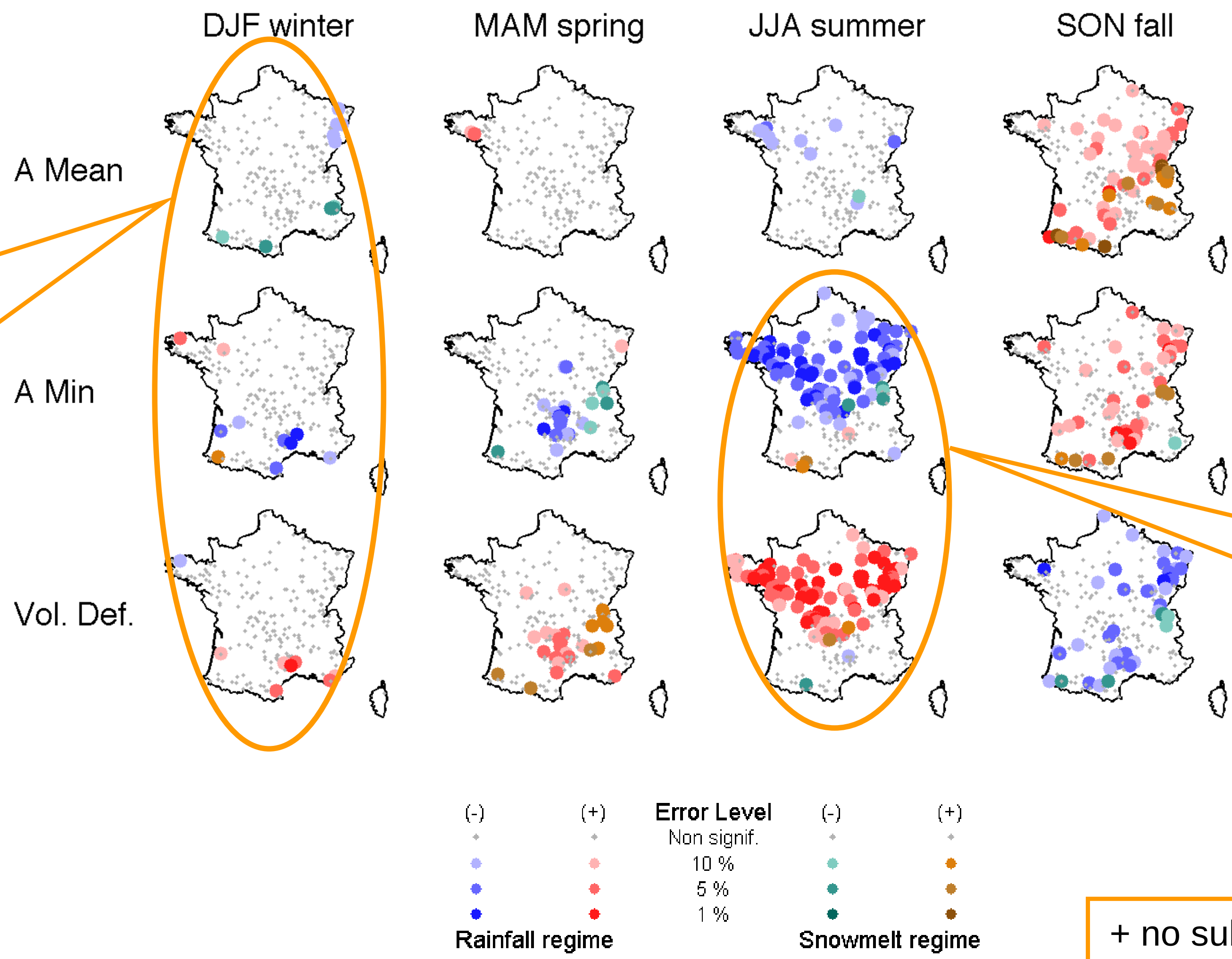


Very little information from winter NAO (unlike Northern and Southern Europe)

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

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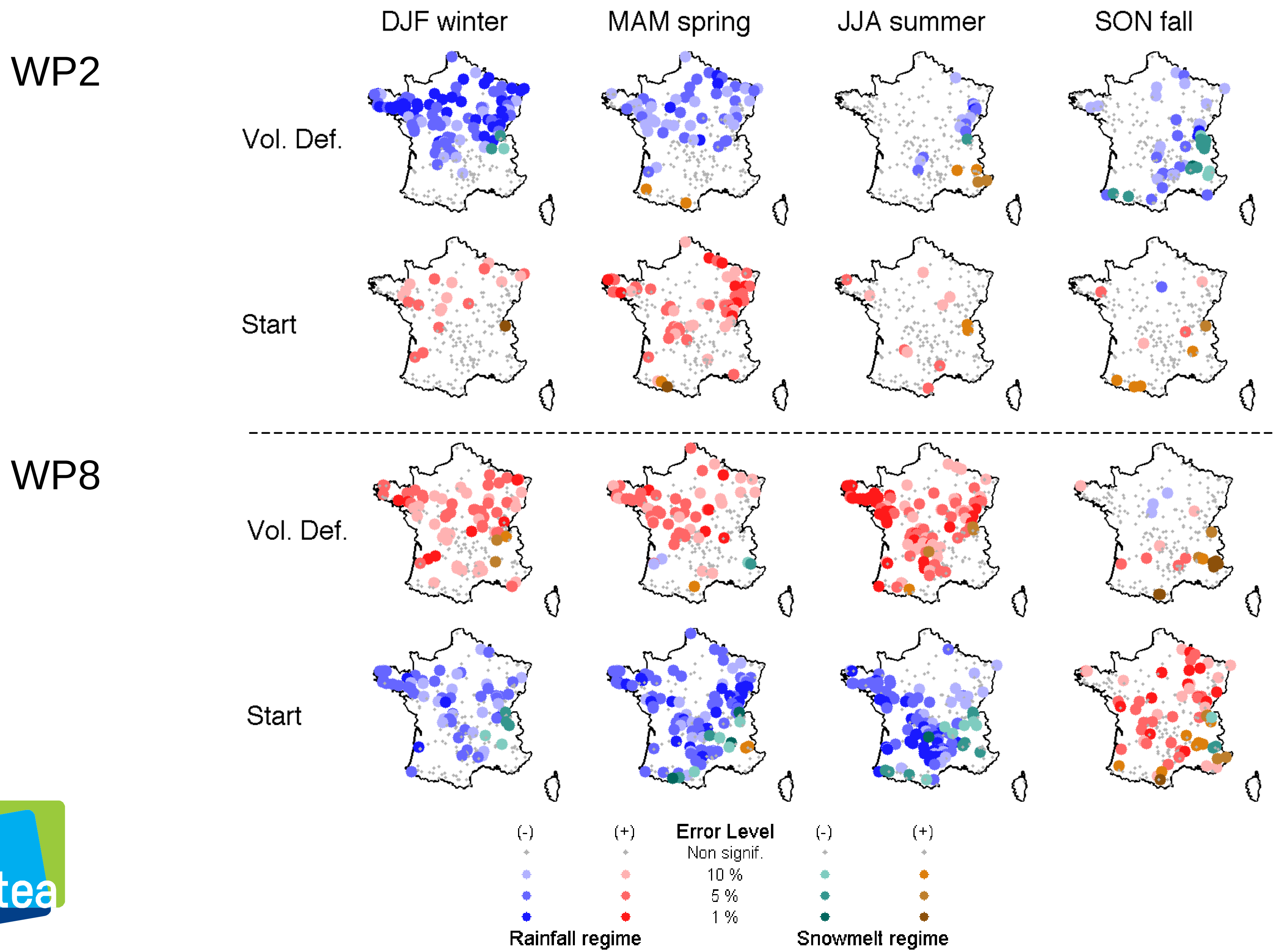
Results – Seasonal scale

Seasonal WP2 and seasonal WP8



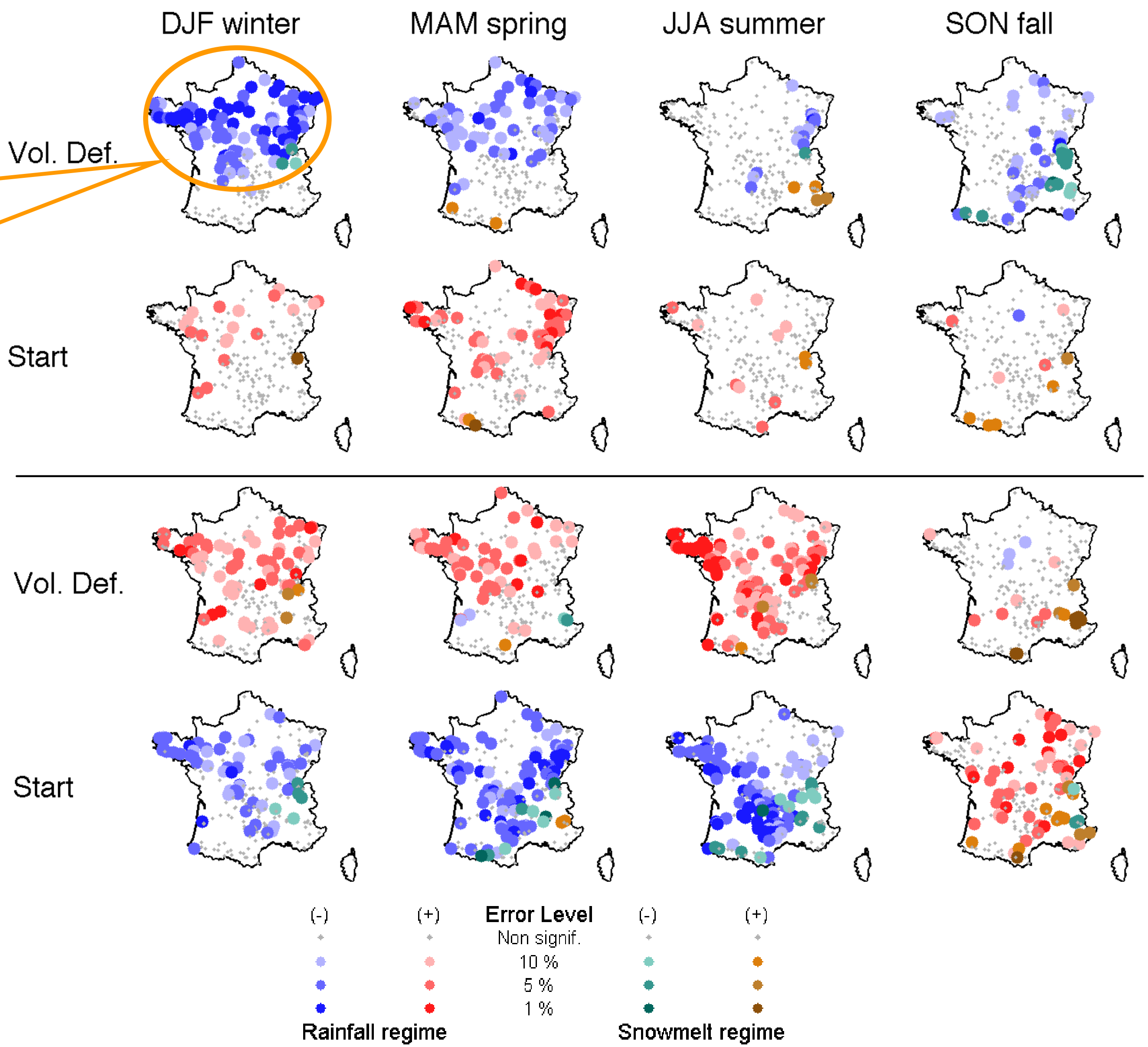
Results – Seasonal scale

Seasonal WP2 and seasonal WP8

WP2

Negative correlation between winter wet weather and drought severity

WP8



Results – Seasonal scale

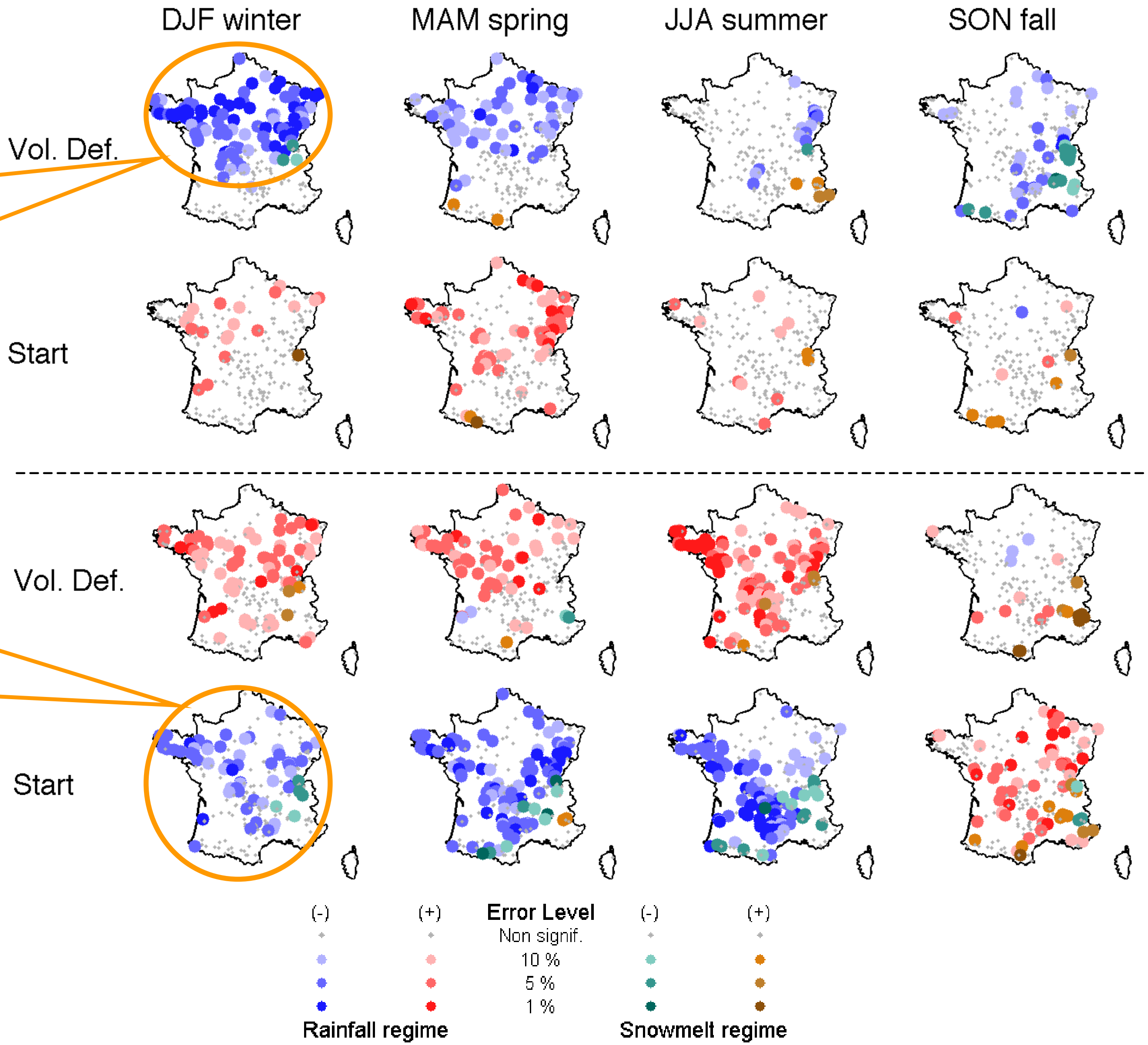
Seasonal WP2 and seasonal WP8

WP2

Negative correlation between winter wet weather and drought severity

WP8

Negative correlation between winter dry weather and low flow start



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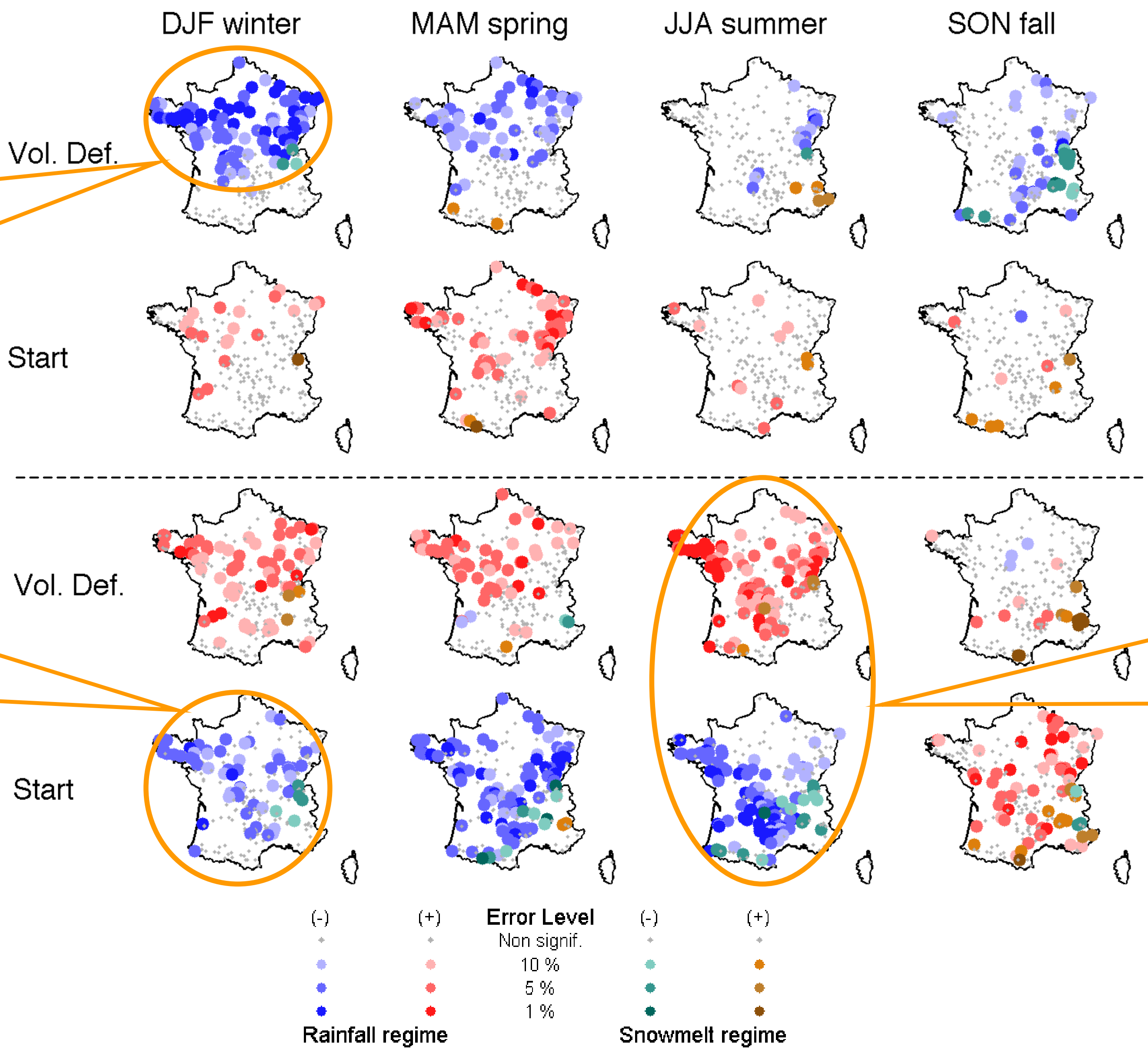
Results – Seasonal scale

Seasonal WP2 and seasonal WP8

WP2

Negative correlation between winter wet weather and drought severity



WP8

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 on drought severity could indeed result (partially) from climate variability**

- Very clear link between mean/low flows and WPs (except Mediterranean area)

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Drought severity – annual covariates

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

  ⇒ **Temporal trends on drought severity could indeed result (partially) from climate variability**

- Very clear link between mean/low flows and WPs (except Mediterranean area)

Drought timing – annual covariates

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

  ⇒ **Temporal trends on drought timing do not seem to result from climate variability**

Conclusions

Stability of correlations

- Temporal trends change across the different time periods
- 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**

Conclusions

Stability of correlations

- Temporal trends change across the different time periods
- 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**

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

⇒ **High potential for statistical seasonal forecasting of droughts, complementary to the hydrological modelling approach (Singla et al., 2012)**

Thank you for your attention

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References

Giuntoli, I., Renard, B., and Lang, M. (2012a). Floods in france. In: *Changes in flood risk in Europe* (Kundzewicz, Z. W., ed.),. IAHS Press.

Giuntoli, I., Renard, B., Vidal, J.-P., and Bard, A. (2012b). Low flows in France and their relationship to large scale climate indices. *Journal of Hydrology*, submitted.