# Analysis of groundwater level historical data to detect climate change impact in France

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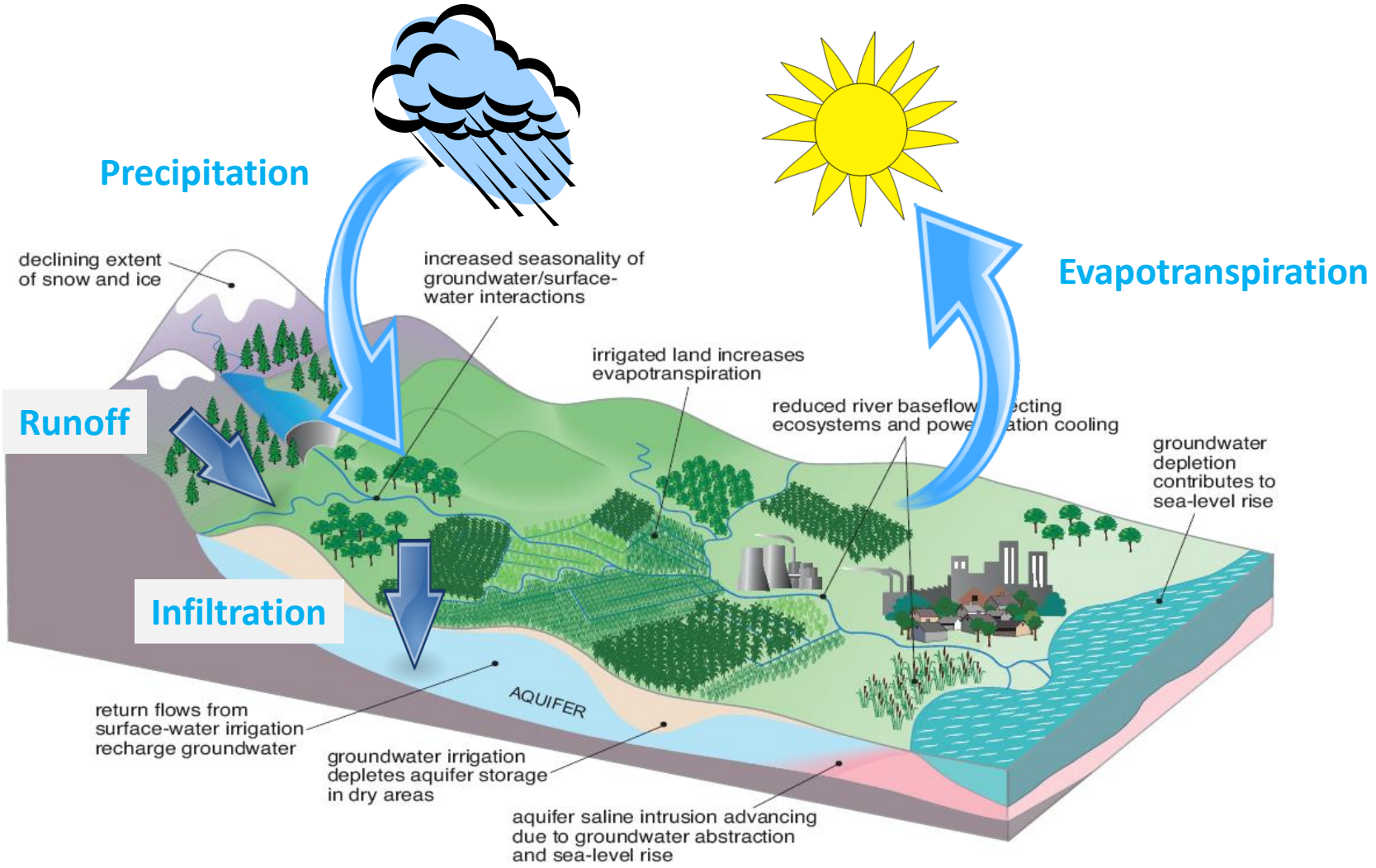
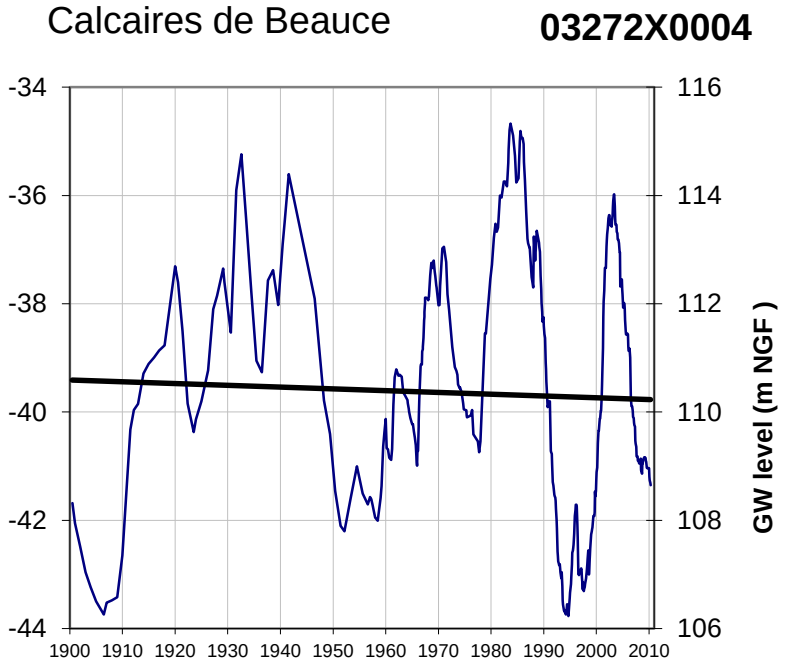
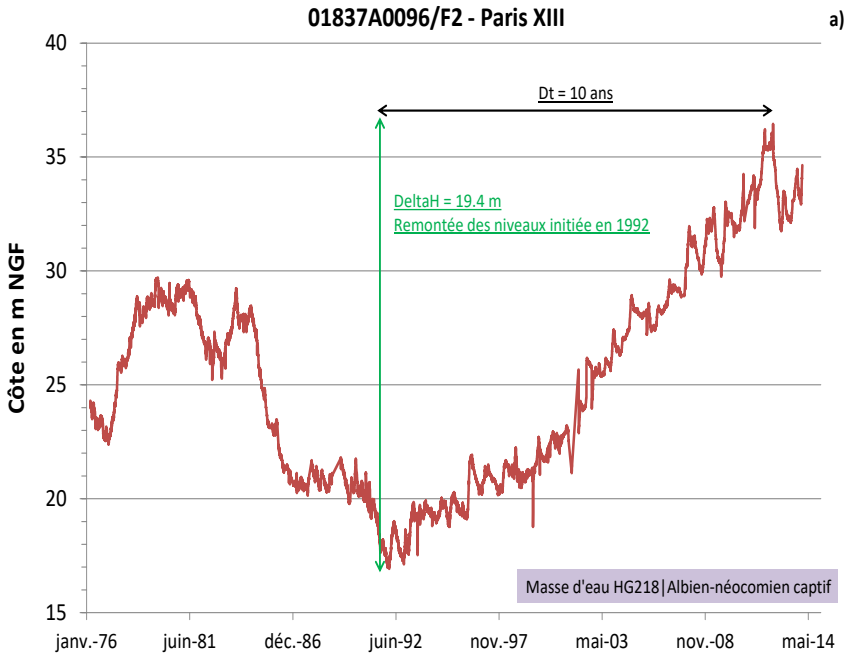
# Interactions between CC and GW




*Adapted from IAH serie « Global Change & Groundwater »*

# GW level historical data

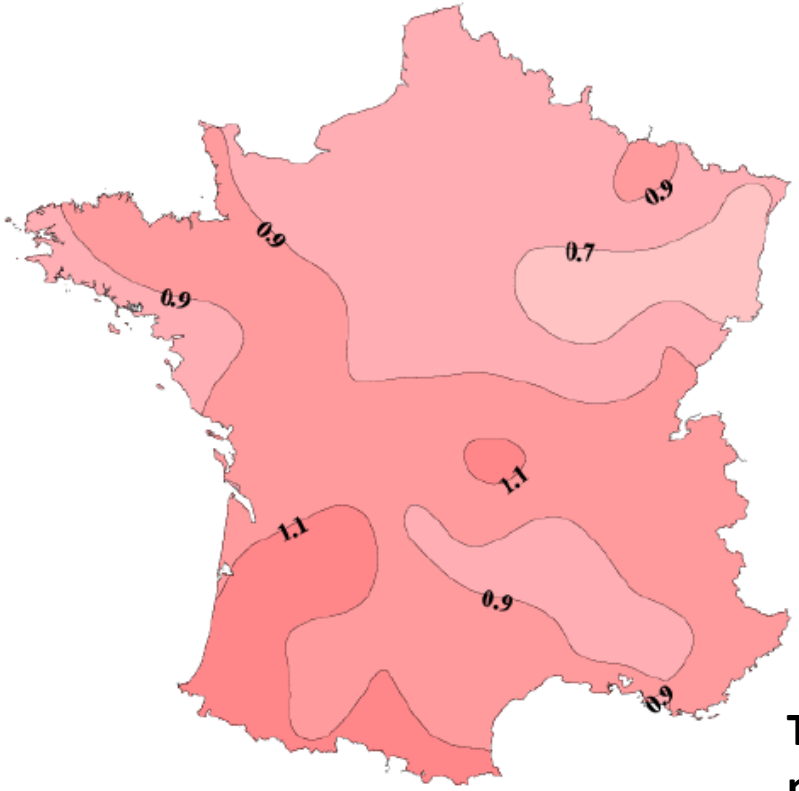


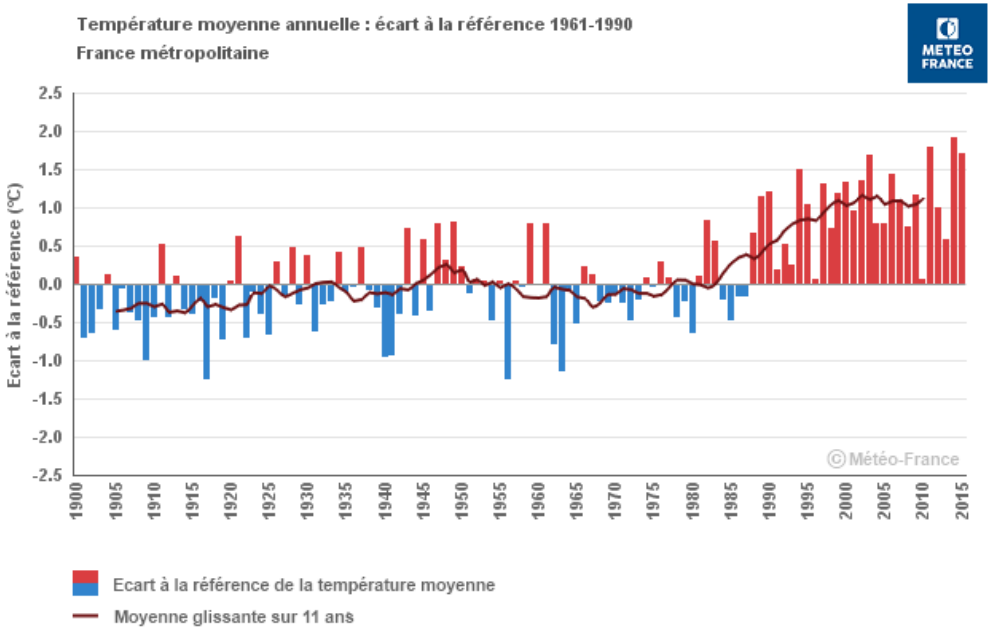
# Climate change during 20th century

## Temperature

Trends 1901-2000 (°C/century) of mean temperature (from 70 series)



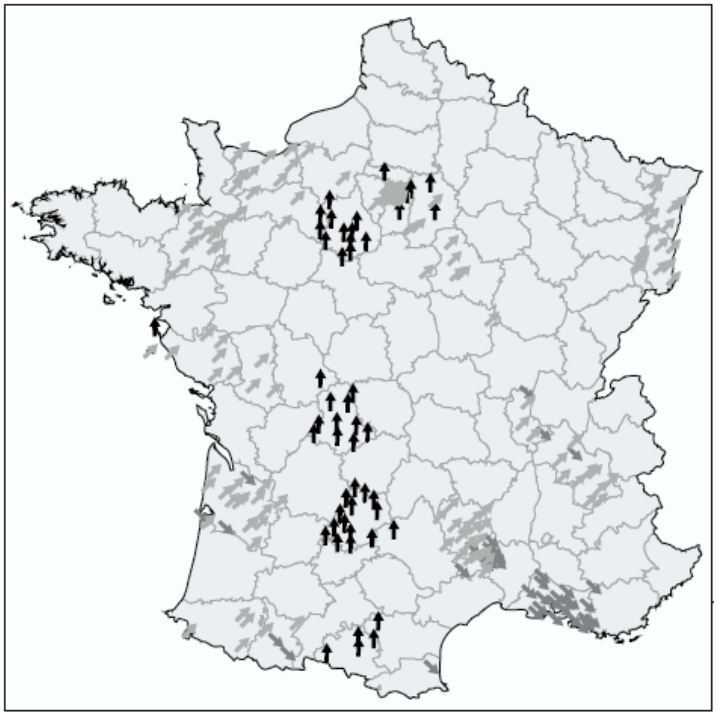

*Source : ONERC, Météo France*




**The positive trend of mean temperature is significant**

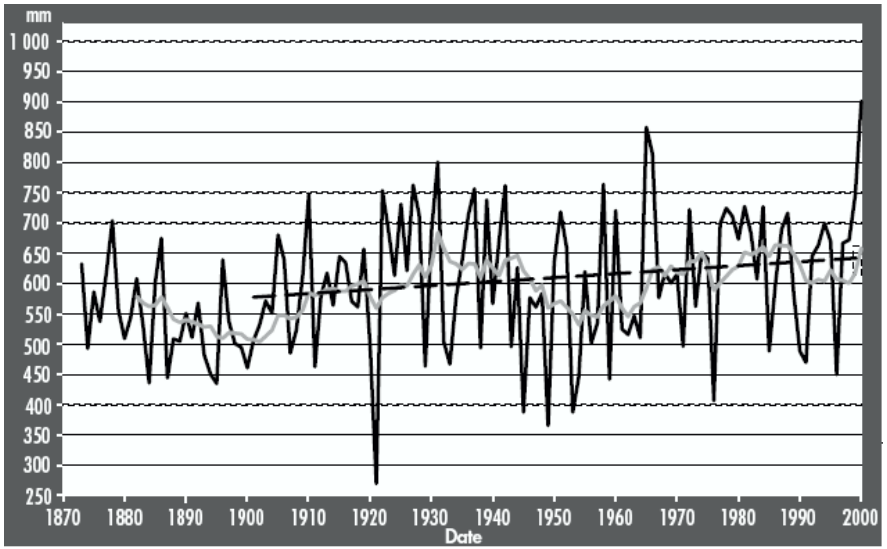
# Climate change during 20th century
## Precipitations

Spearman coefficient for annual precipitations 1901-2000 (226 series)



*Moisselin et al., 2002*
*See also Vidal et al., 2009 (1959-2000 period)*

Annual precipitation for Paris
Trend is +9 cm/siècle.

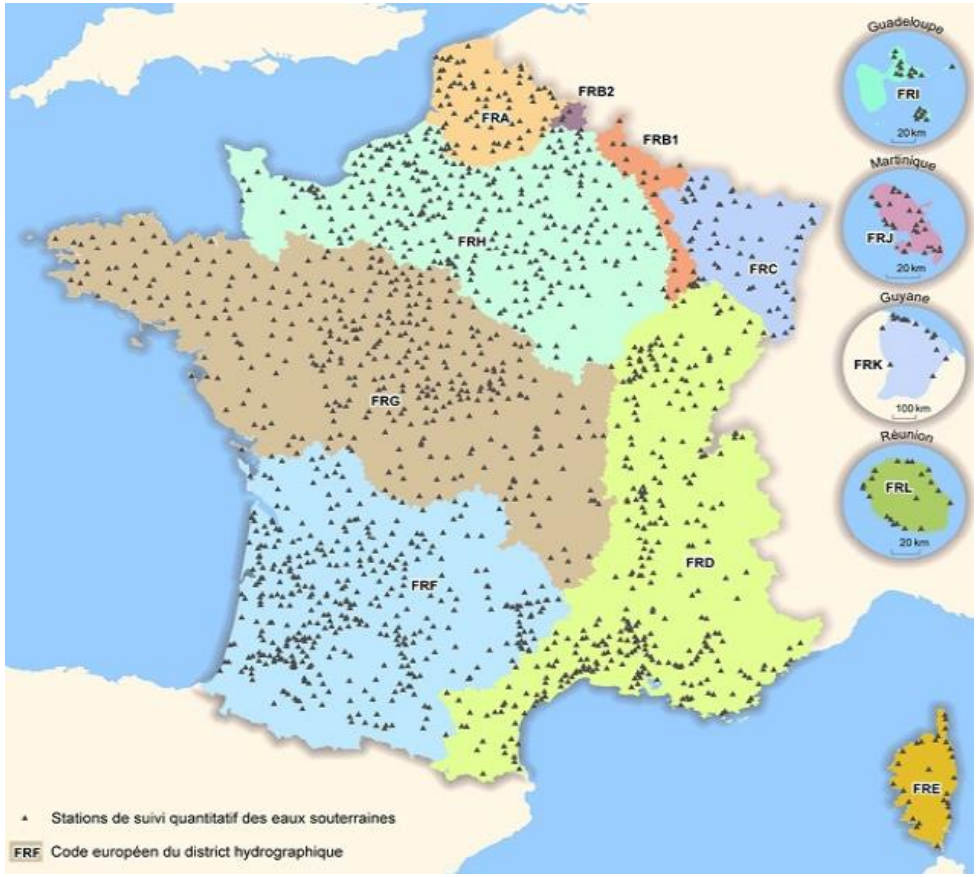



**Rainfall exhibits more contrasted but generally positive trends**

# Objective of the study

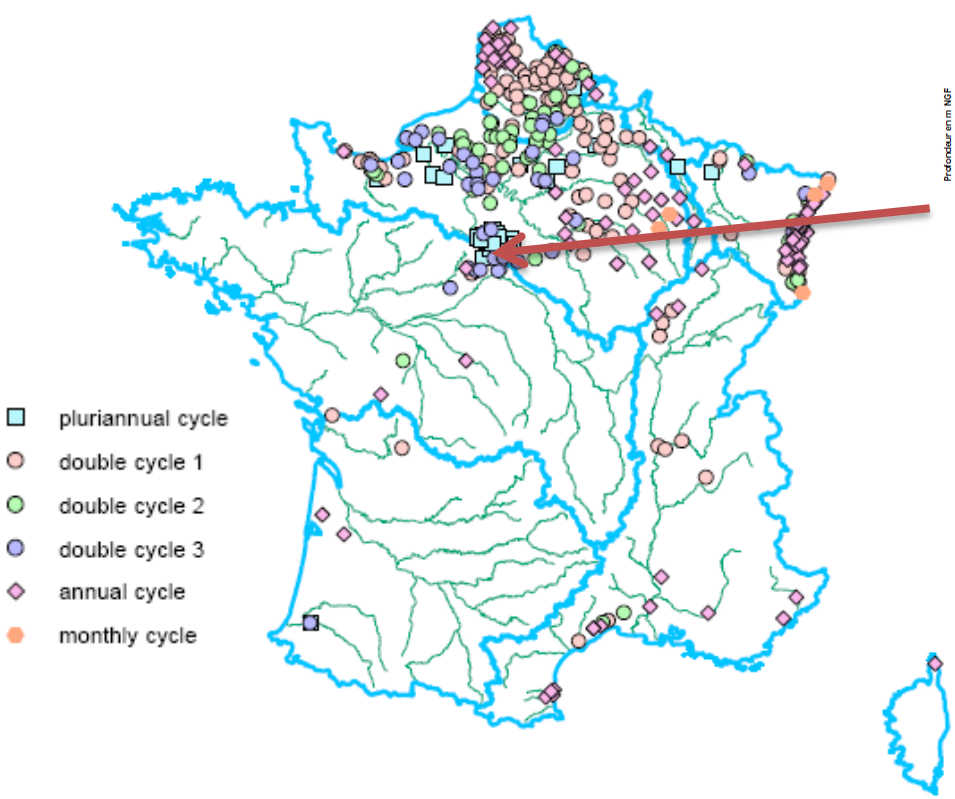
- Detection of trends on groundwater levels historical series in relation with climate change
- Design of a piezometric network for long term monitoring of climate change impact
- Study realised between 2010 and 2014 (convention ONEMA-BRGM)

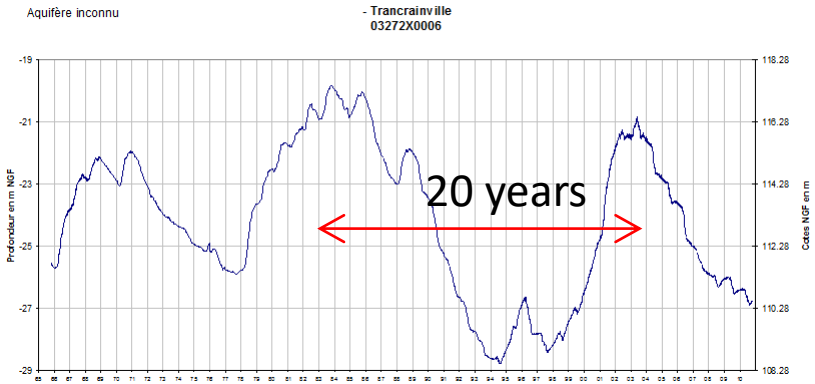
# Groundwater levels historical series



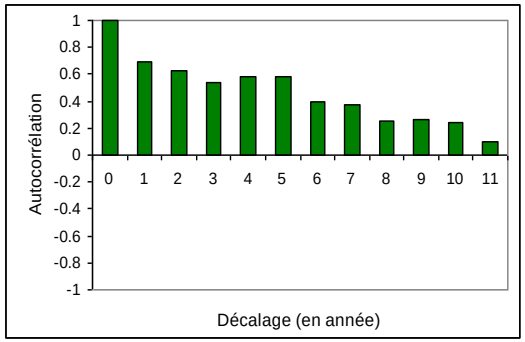

- More than 3000 GW level series in ADES http://www.ades.eaufrance.fr/
- Selection criteria
  - unconfined aquifer
  - More than 25 years of data
  - Anthropic influence
  - Water table behavior
  - Data quality

# Selection of piezometers (366)




Pluriannual cycles : problem of autocorrelation



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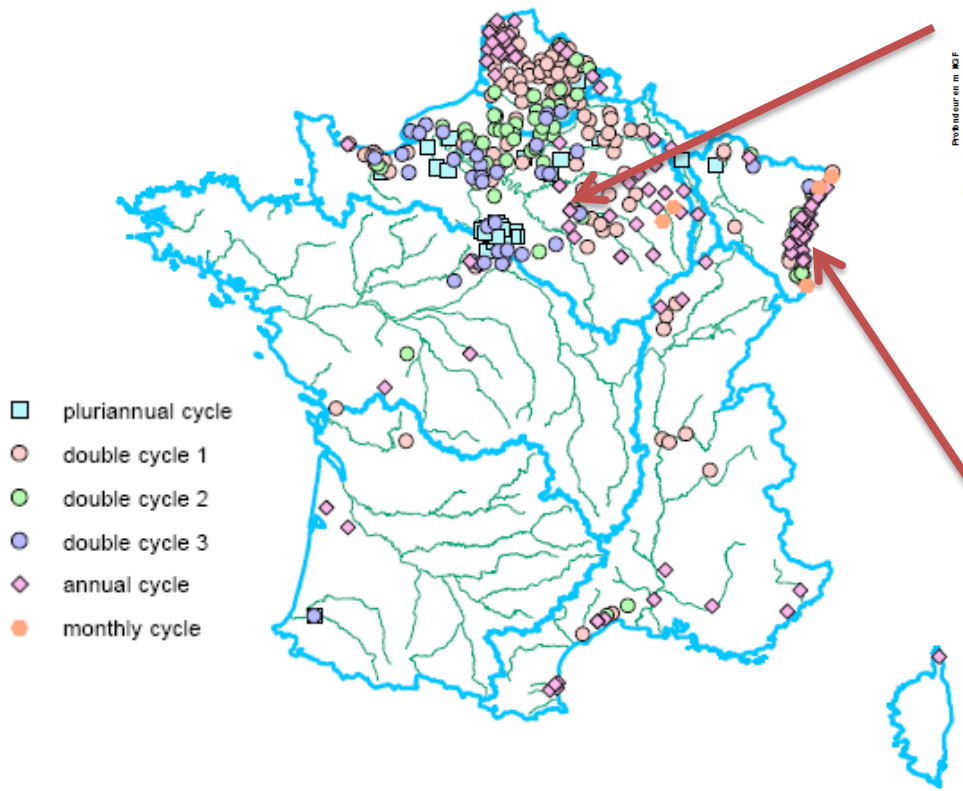
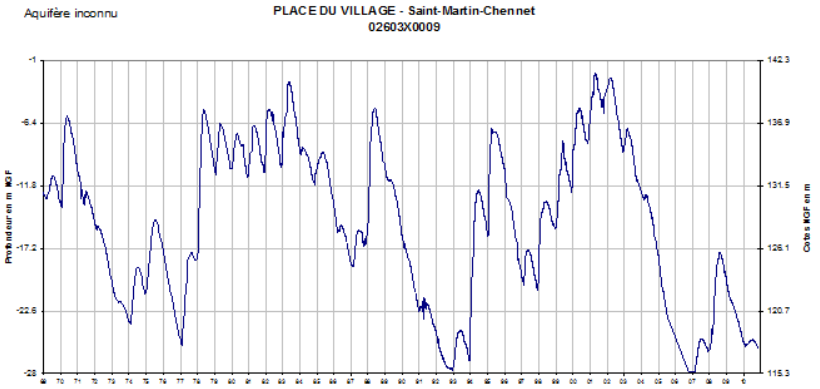
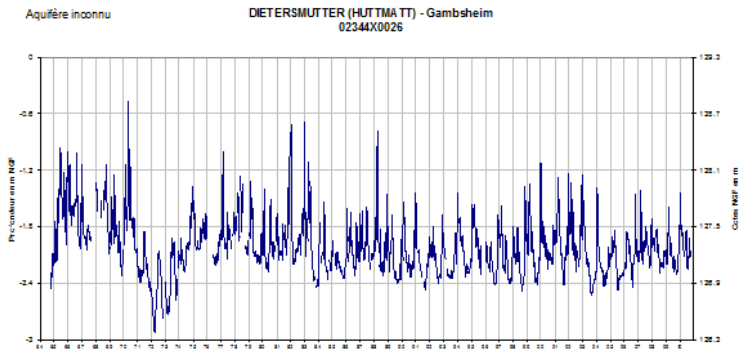



Double cycle



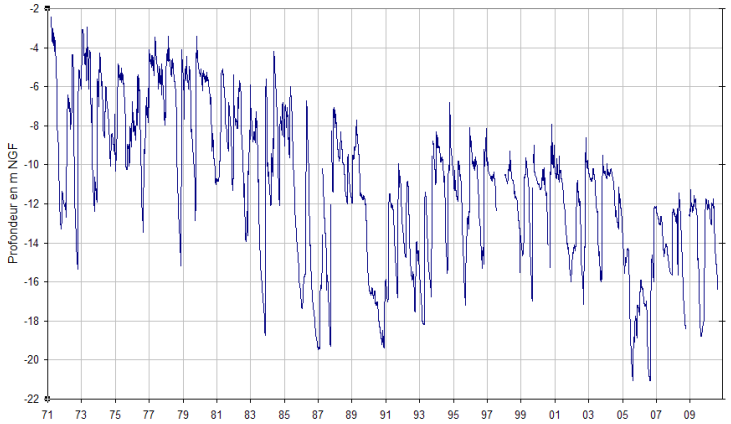

Annual cycle

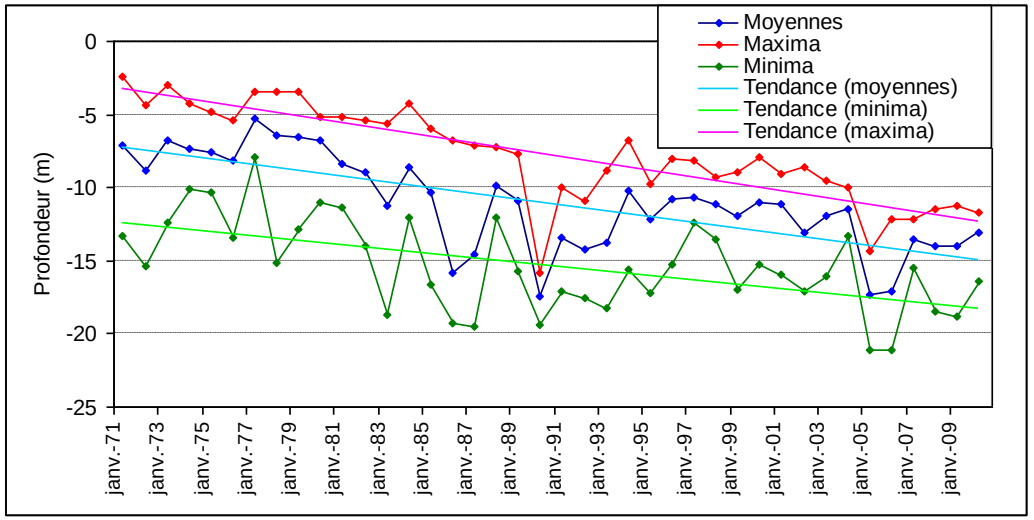
# Non-stationarity tests

- For trend detection
  - Linear regression
  - Modified linear regression (if autocorrelation)
  - Mann Kendall test
  - Modified Mann Kendall test (if autocorrelation)
- For rupture detection
  - Petitt test
- Input data : daily data
- Variables :
  - annual average values
  - maximum average values
  - minimum average values

# Example

## Piezometer 09724X0023

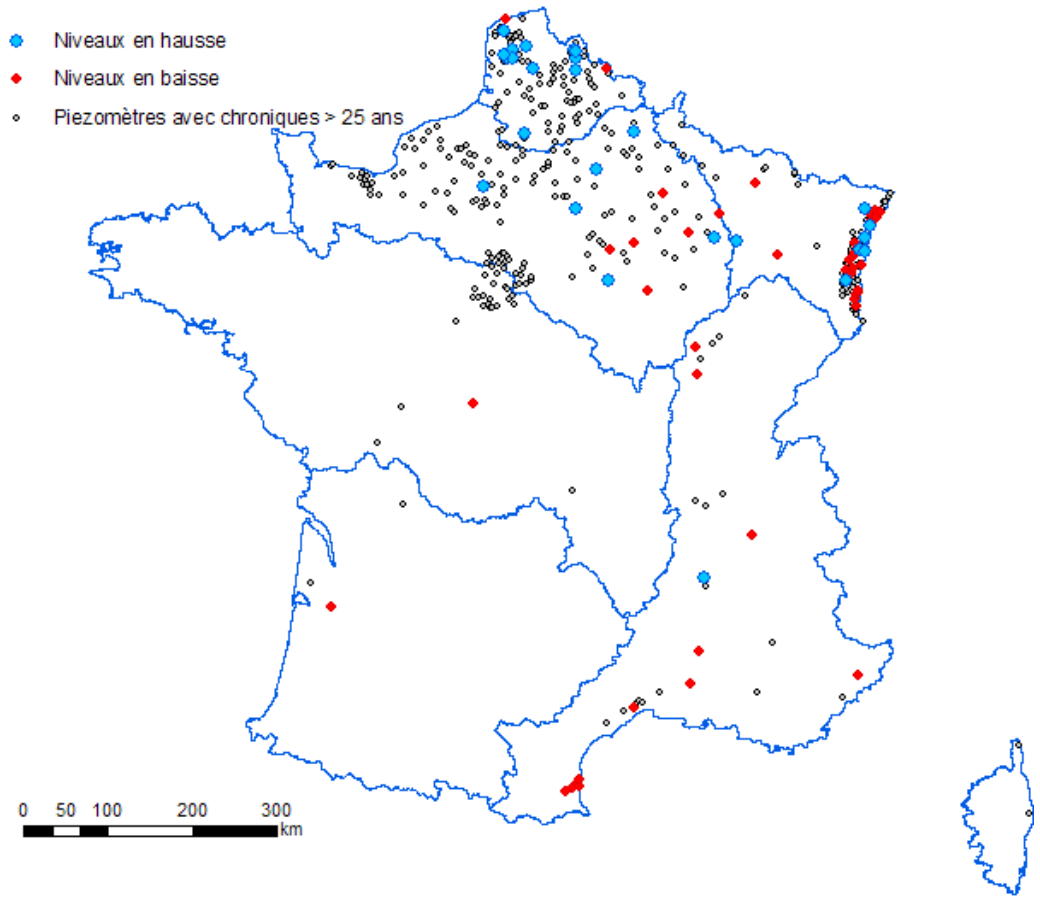



| | Autocorrélation | Test "modifié" | Significativité Régression | Significativité Man-Kendall | Test de Pettitt (rupture) |
|---|---|---|---|---|---|
| Valeurs moyennes | oui | oui | oui, au seuil 1% | oui, au seuil 5% | oui, au seuil 1% (en 1986) |
| Valeurs maximales | oui | oui | oui, au seuil 1% | oui, au seuil 1% | oui, au seuil 1% (en 1986) |
| Valeurs minimales | non | non | oui, au seuil 1% | oui, au seuil 1% | oui, au seuil 1% (en 1986) |
| Moyenne des maxi. | oui | oui | oui, au seuil 1% | oui, au seuil 5% | |
| Moyenne des mini. | oui | oui | oui, au seuil 1% | oui, au seuil 5% | |
| Valeurs moyennes de Déc. | non | non | oui, au seuil 1% | oui, au seuil 1% | |

Avec l'option 2, les 2 tests (régression et Mann-Kendall), concluent pour toutes les variables à des tendances toutes significatives au seuil de risque de 1%.

# 70 piezometers with significant trend




**Downward trend (43)**

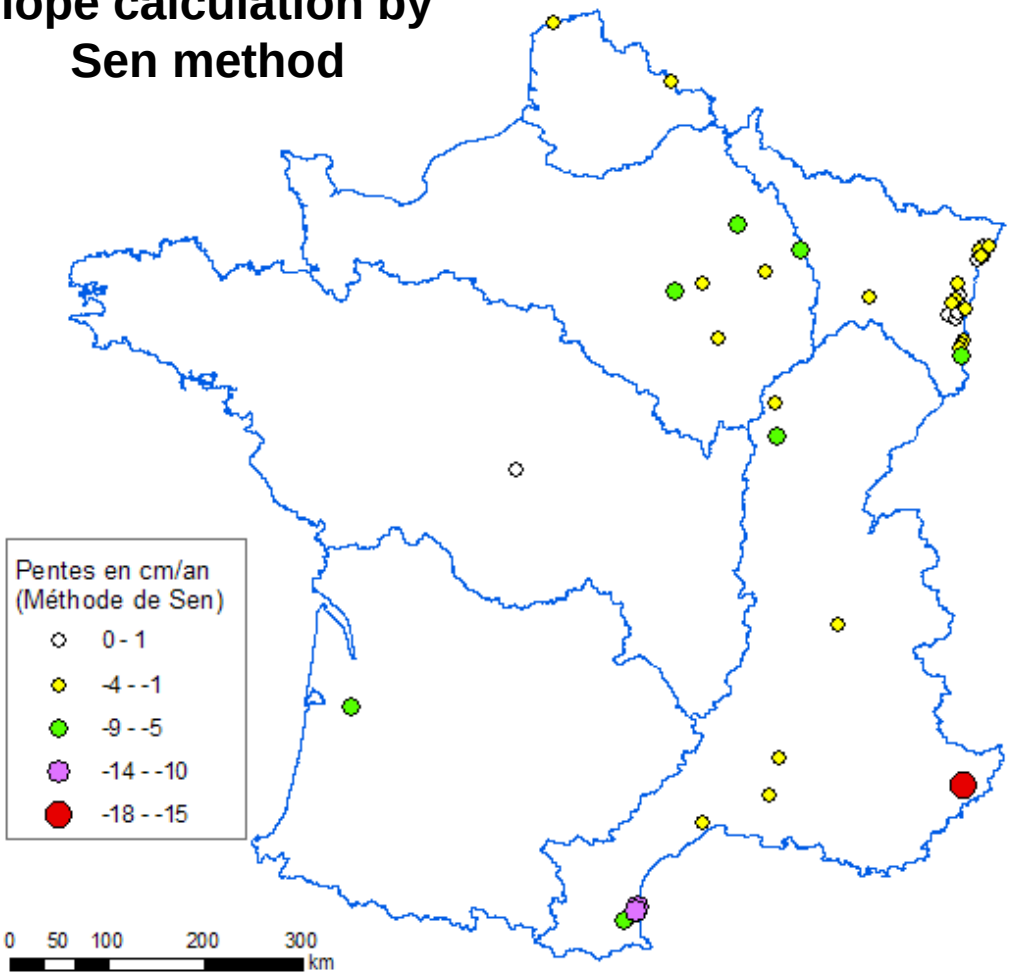
- Annual cycles : 31 % (alluvial aquifers : Roussillon, Alsace, Rhône, Var)
- Double cycle 1 : 5 % (carbonate aquifers : east of Paris basin)
- Double cycle 2 & 3 : 0 %
- Pluriannual cycle : 0 %

**Upward trend (34)**

- Annual cycles : 12 % (alluvial aquifers : Alsace)
- Double cycle 1 : 8% (carbonate aquifers : Paris basin)
- Double cycle 2 : 0 %
- Double cycle 3 : 3 % (carbonate aquifers : Paris basin)
- Pluriannual cycle : 0 %

# Downward trend

**Slope calculation by Sen method**

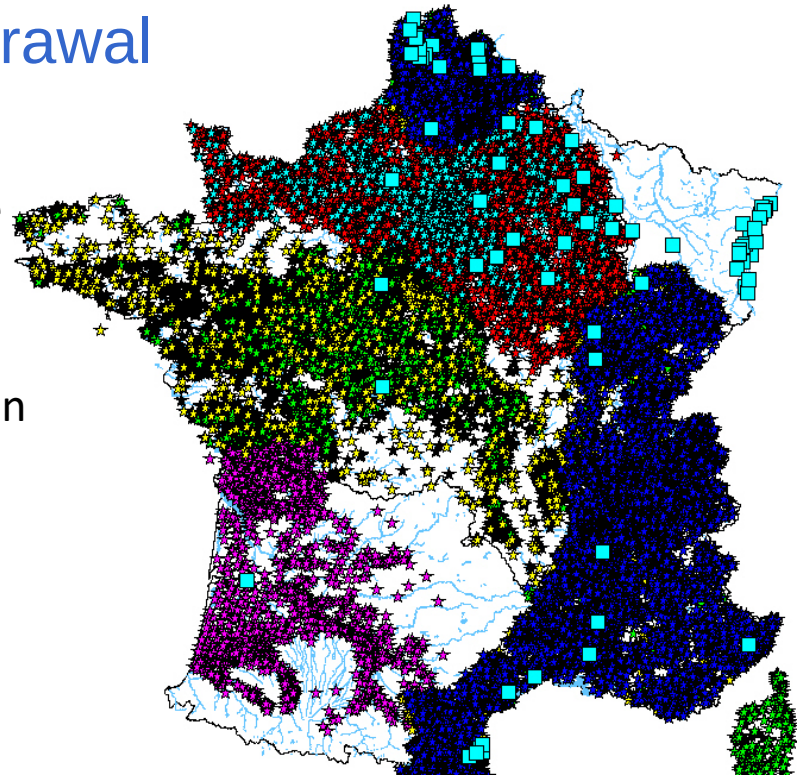


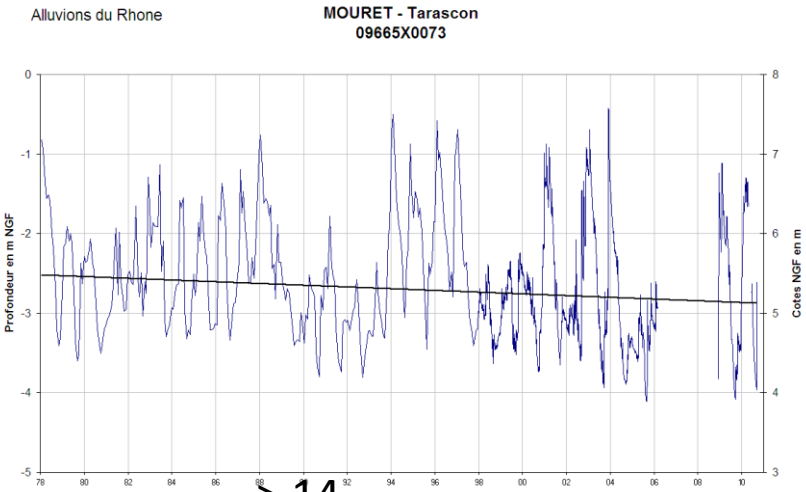

+ Pettitt test to detect change point :

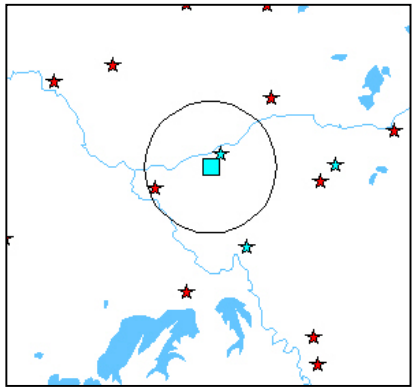
- 28 / 37 piezometers (annual cycle) with downward trend
- 18 / 26 piezometers with upward trend
- Can be related with climatic events

# Piezometers influenced by withdrawal

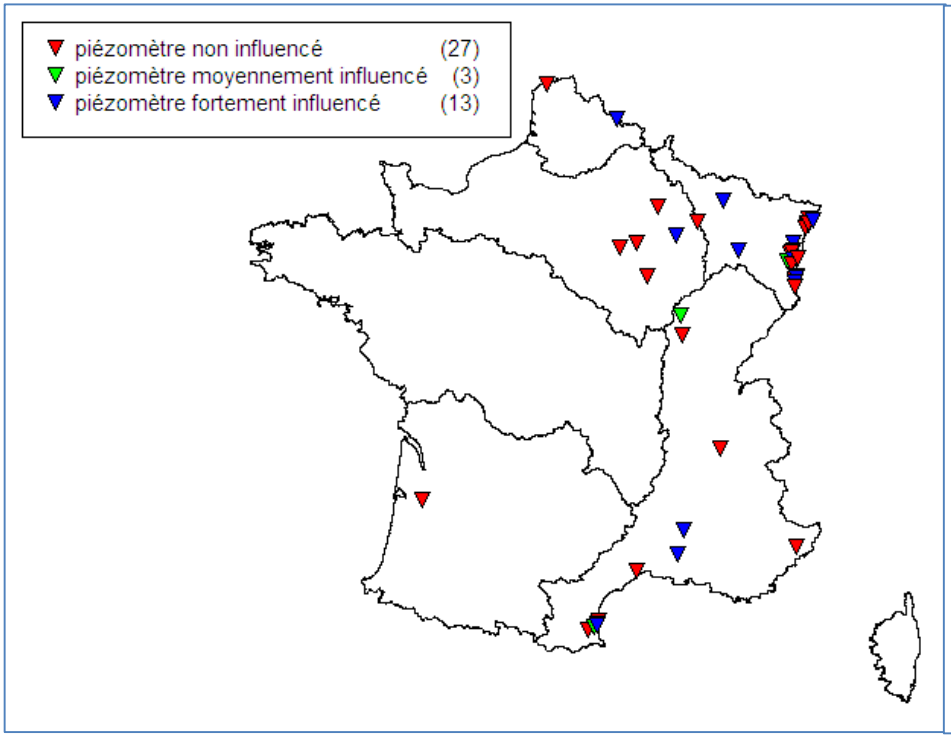
- Data of water agencies
- Research within a 5 km radius around the piezometer
- Aquifer checking
- Estimation of drop in water level in relation with withdrawal
- 43 points with very little influence
- 11 points with moderate influence
- 16 points with strong influence

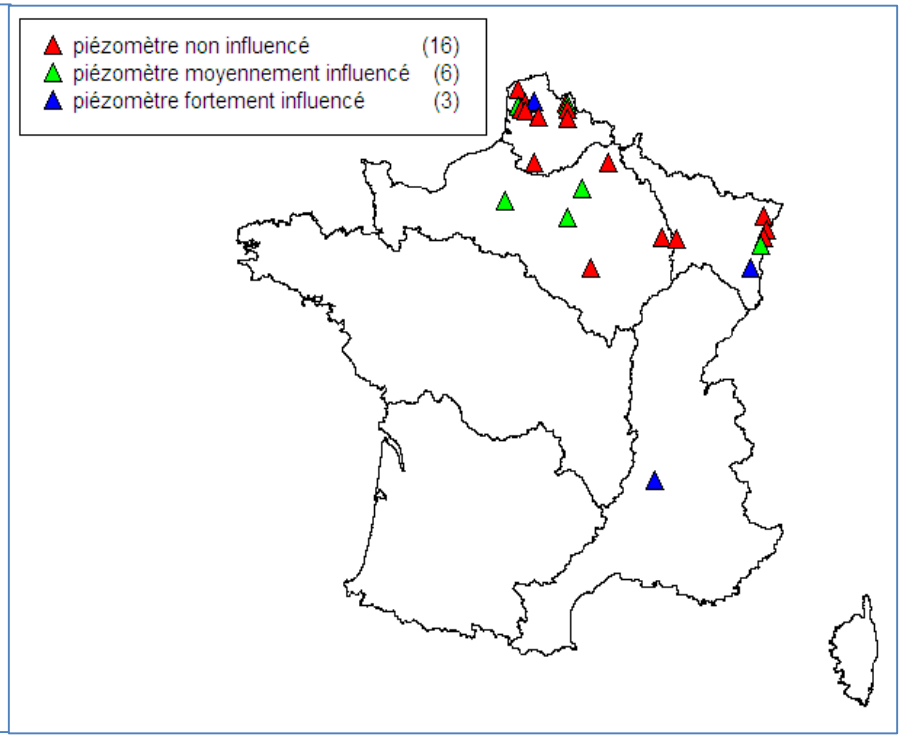




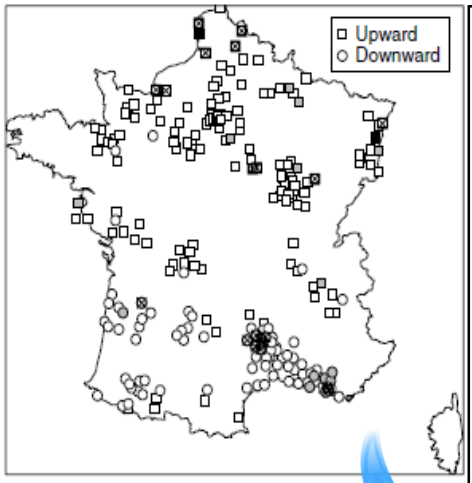



# Piezometers influenced by withdrawal



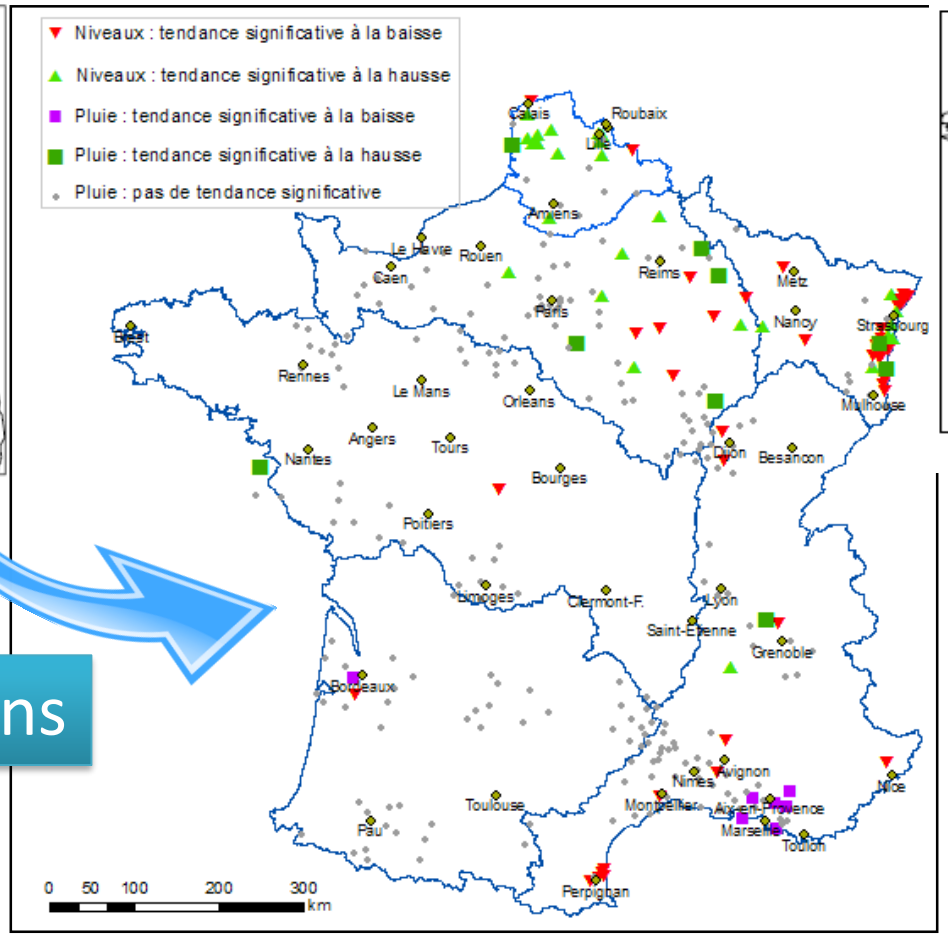
# Comparison with climatic data

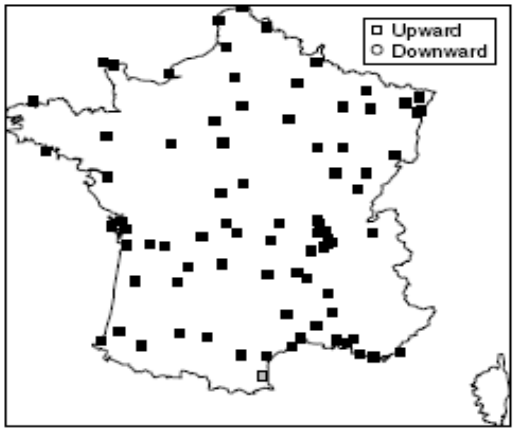



P stations (239)

*Vidal et al., 2009*

Precipitations




TX stations (82)

*Vidal et al., 2009*

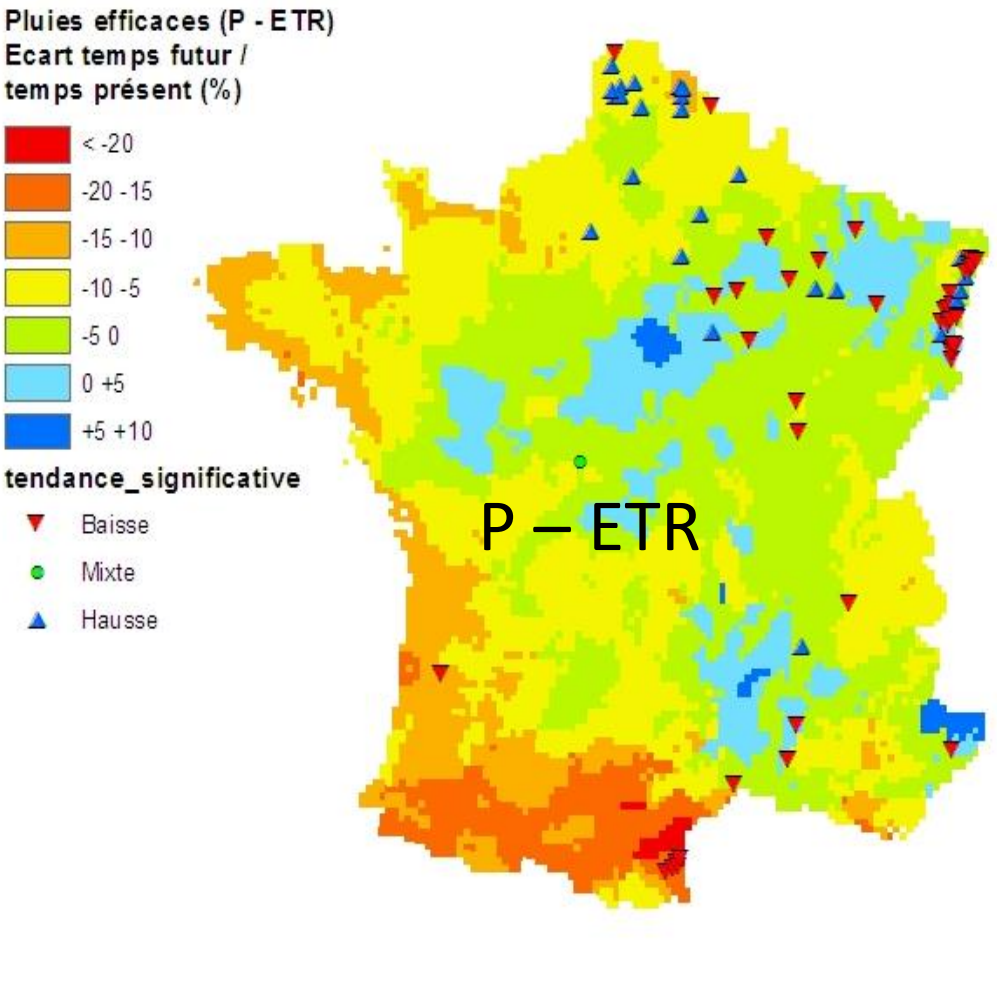
Temperature

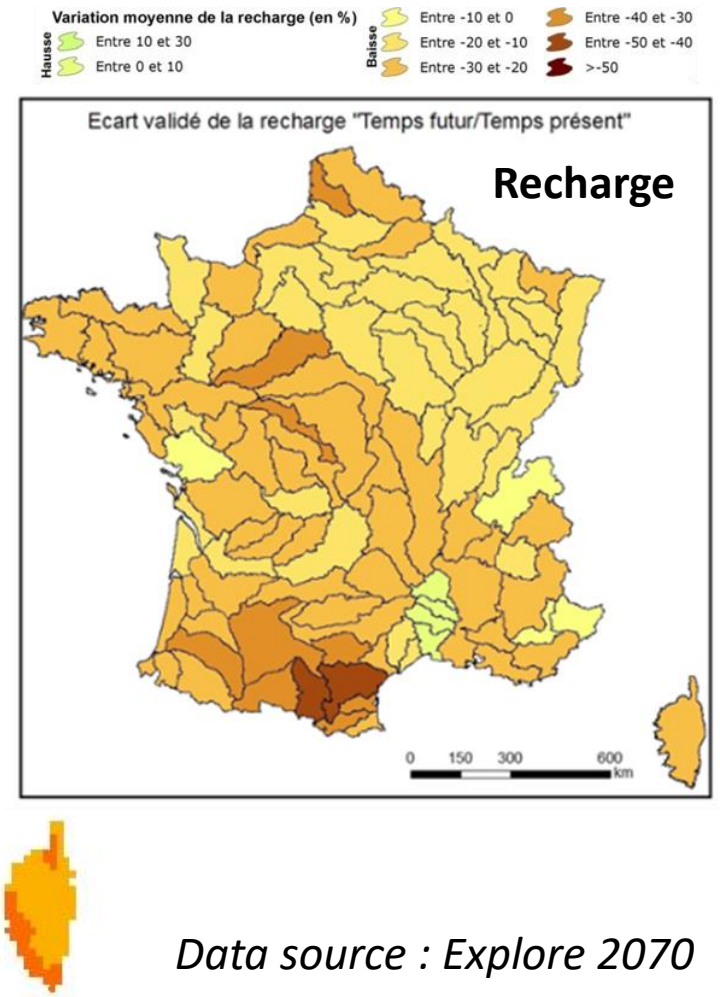
**No evidence of a relation between climate change and groundwater level**

# A reference piezometric network for the monitoring of climate change impact on groundwater

- Criteria for the definition of the network
  - parameters likely to characterize the potential impact of climate change
  - hydrogeological parameters to select aquifers
- Criteria for the selection of piezometers
  - duration of measurement period
  - low influence by water withdrawals
  - durability of the piezometer
  - belonging to a drought monitoring network

# Criteria relative to climate change



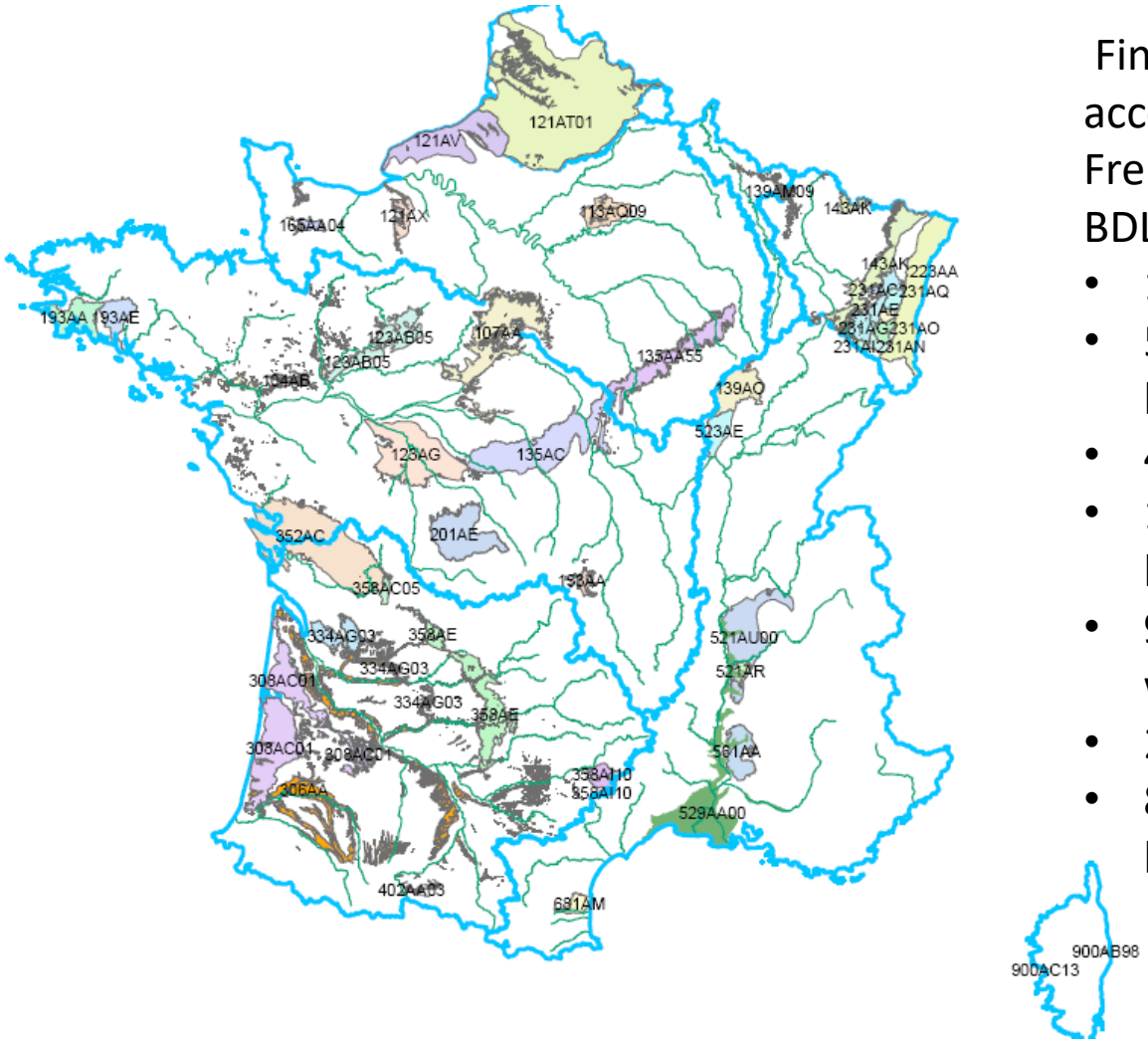




*Data source : Explore 2070*

# A reference piezometric network for the monitoring of climate change impact on groundwater

- Criteria for the definition of the network
  - ~~parameters likely to characterize the potential impact of climate change~~
  - Limited number of aquifers (BDLISA referential)
  - Unconfined aquifers
  - Well knowledge and homogeneity of the aquifer
  - Limited anthropic pressure
  - strategic water resources
  - drop in water level in the future
- Final selection
  - Agreement with partners
  - 39 aquifers

# Selection of aquifers







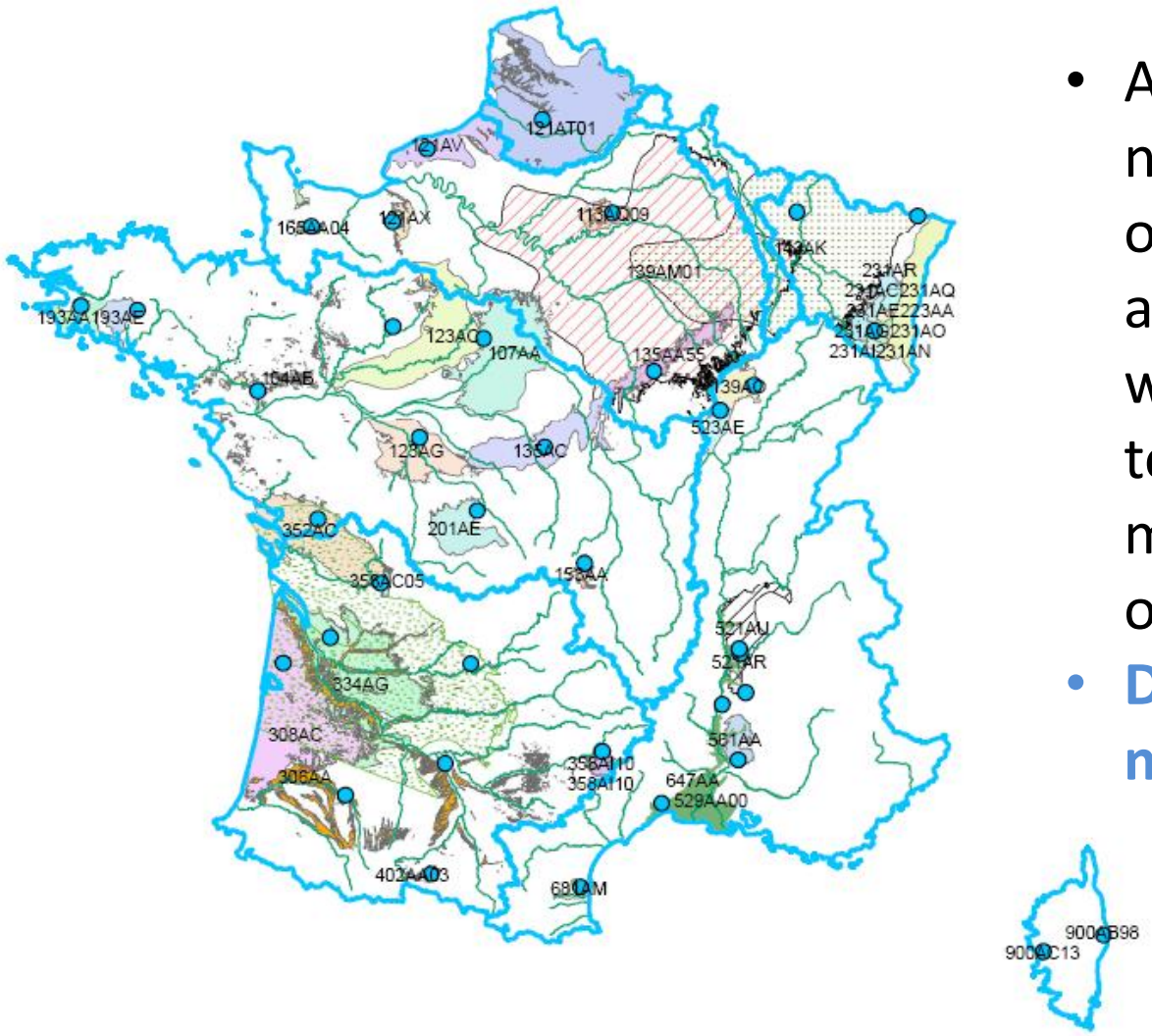
Finally, 39 aquifers were selected, according to the codification of French hydrogeological referential BDLISA :

- 1 in the Artois-Picardie water basin
- 5 in the Seine-Normandie water basin
- 4 in the Rhin-Meuse water basin
- 10 in the Loire-Bretagne water basin
- 9 in the Rhône-méditerranée water basin
- 2 in the Corsica island
- 8 in the Adour-Garonne water basin

# Criteria for the selection of piezometers

- Not influenced by pumping or other anthropic influence
- Only one aquifer, unconfined, responding to climatic fluctuations
- Sustainability of the well
- Relevant information about the well
- No drying up of the well
- Existing data
- Quality of data
- Consistence with the points used for the national hydrological situation report

# Selection of piezometers




- As two aquifers did not followed the rules of selection , 5 springs and 32 piezometers were lately selected to form the monitoring network of climate change.
- **Declared in ADES as a meta-network**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