Two weather types classifications for precipitation and for temperature over France.

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Introduction :

Here, a "weather regimes classification" is only based upon the use of a large scale parameter (for western Europe and eastern Atlantic) whilst a "weather type classification" is based upon both a large scale parameter and a local parameter (for a country or a region). Recently, the european project Action Cost 733[1] (2004-2010) produced an interesting review of existing weather regimes classifications over Europe and an inventory of methods and validation techniques. Moreover, research on climate model downscaling has shown interests of weather types classification, for past, present and future climate [Boé, 2008 ; Najac, 2008]. DCLIM from Météo-France has produced since 1985 an operational weather regimes classification [Bénichou, 1985] and is now developping new products of weather types classifications adapted to local parameters over France (i.e.,precipitation, temperature, wind).

1 http://cost733.met.no/ and http://geo21.geo.uni-augsburg.de/cost733wiki/

Data and Method :

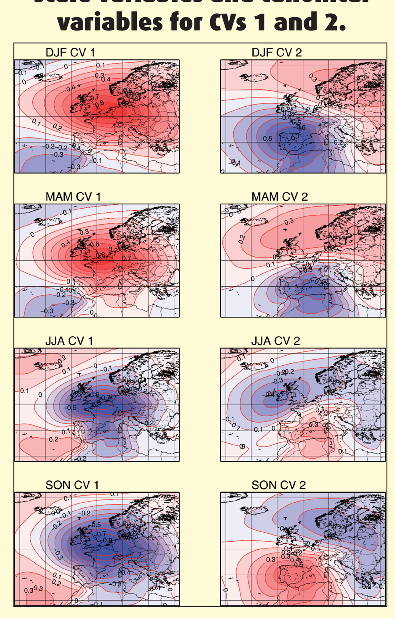
The two classifications are based on a daily large scale parameter obtained from 1958-2001 ERA-40 re-analysis and in-situ data from meteorological stations over France (30 stations for temperature and 90 stations for precipitations). These two groups of variables are submitted to a canonical correlation analysis (CCA). Previous studies used only groups of independent EOFs. CCA facilitate the choice of the large scale parameter (best correlations between original variables and canonical variables) and also the choice of the domain for the large scale parameter (spatial extension of kernels of correlations). See figures 1 and 3. Eight large scale parameters where tested: Z500, Z700, MSLP, TPW850, Z2PVU, TR850, FQ850, FQ700. The classification itself is made from a selection of canonical variables.

We tried first a k-means method (testing multiple random initial centers and a large range of number of classes). With this method we have several techniques to choose the appropriate number of classes: silhouettes [Rousseeuw, 1987], classifiability et reproducibility [Michelangeli and al. 1995], concordance [Joly and Bourdette, 2008].

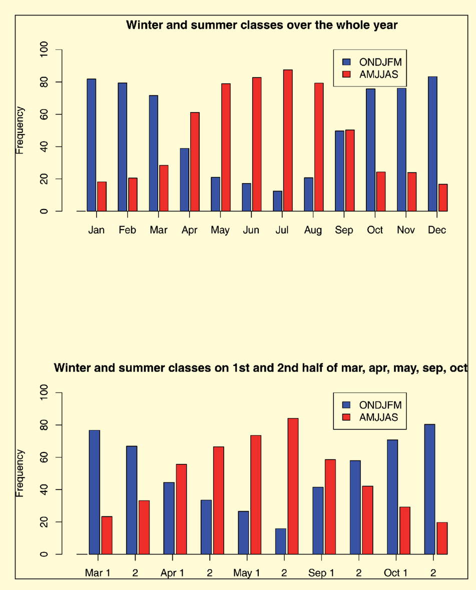
We decided to use as final method a 3-level hybrid classification: k-means – hierarchical cluster analysis (HCA) – k-means. Repeated experiences of the first level k-means permits to identify groups of elements always aggregated together (high density clusters, see Wong, 1982).

All these tests are done for 2, 3 and 4 seasons (2 seasons= ONDJFM, AMJJA, 3 seasons= DJF, MAMSON, JJA, 4 seasons= DJF, MAM, JJA, SON). To choose the final partitioning of the year we test all months with all classes for all seasons. If the partition is good, the classes prevail only during a given season. Then a better choice of the date for season changes is possible from partitioning half of transition months. See figures 2 and 4.

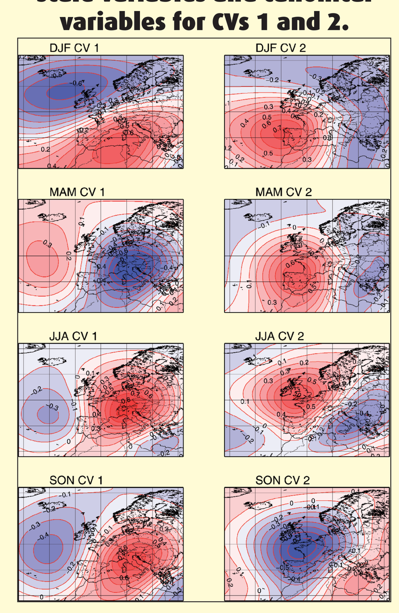
Four seasons precipitation/MSLP CCA : Correlations between large scale variables and canonical variables for CVs 1 and 2.



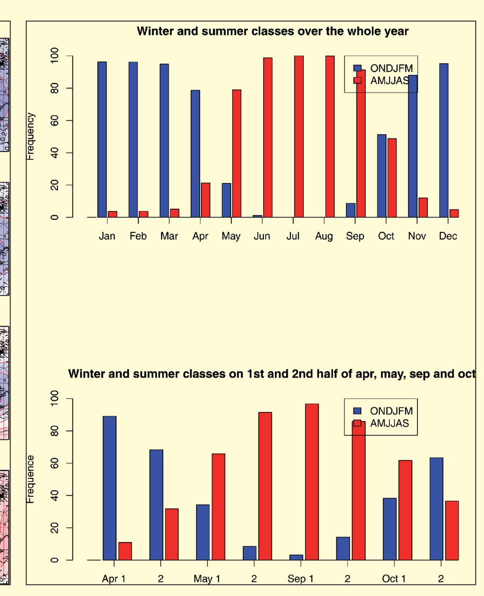
Partitioning in 2 seasons for precipitations classification.



Four seasons temperatures/Z700 CCA : Correlations between large scale variables and canonical variables for CVs 1 and 2.



Partitioning in 2 seasons for temperatures classification.



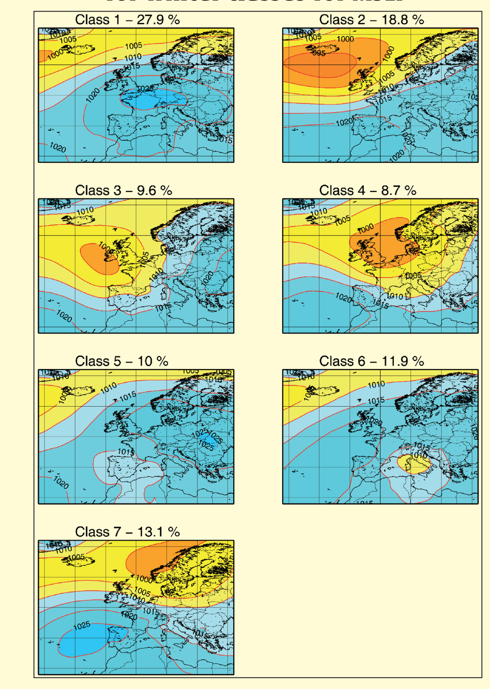
Results :

The best classification for precipitation uses MSLP as large scale parameter for the 70°N-30°N-30°W-30°E domain. A two-season partitioning prevails (Winter : 16th sept-31th marsh, Summer : 1st april-15th sept) with 7 classes in winter and 6 classes in summer.

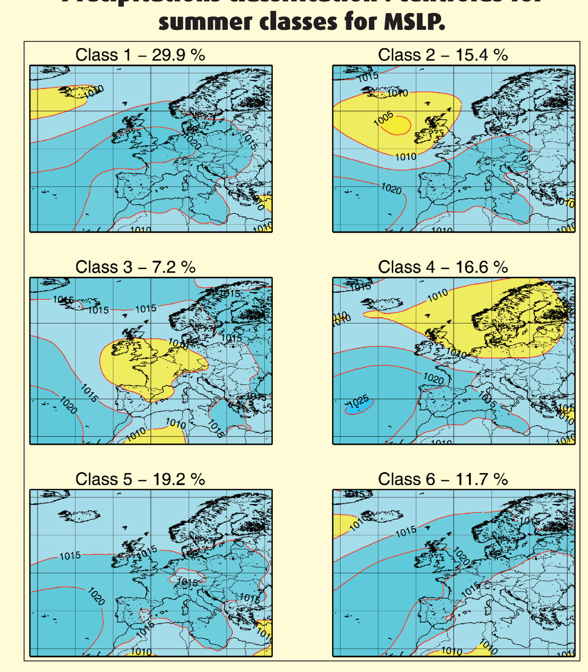
The best classification for temperatures uses Z700 as large scale parameter for the 70°N-30°N-30°W-30°E domain. A two-season partitioning prevails (Winter : 16th oct-30th april, Summer : 1st may-15th oct) with 6 classes in winter and 6 classes in summer.

Both classifications show large scale structures having synoptic meanings.

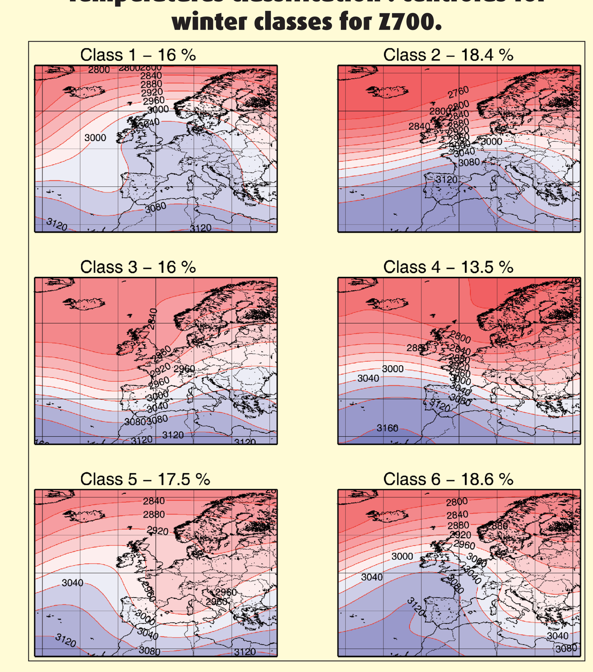
Precipitations classification : centroids for winter classes for MSLP



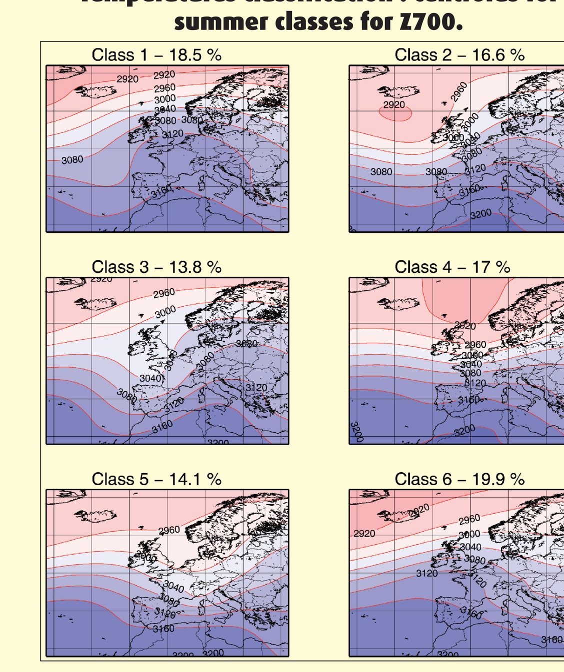
Precipitations classification : centroids for summer classes for MSLP.



Temperatures classification : centroids for winter classes for Z700.



Temperatures classification : centroids for summer classes for Z700.



Validation :

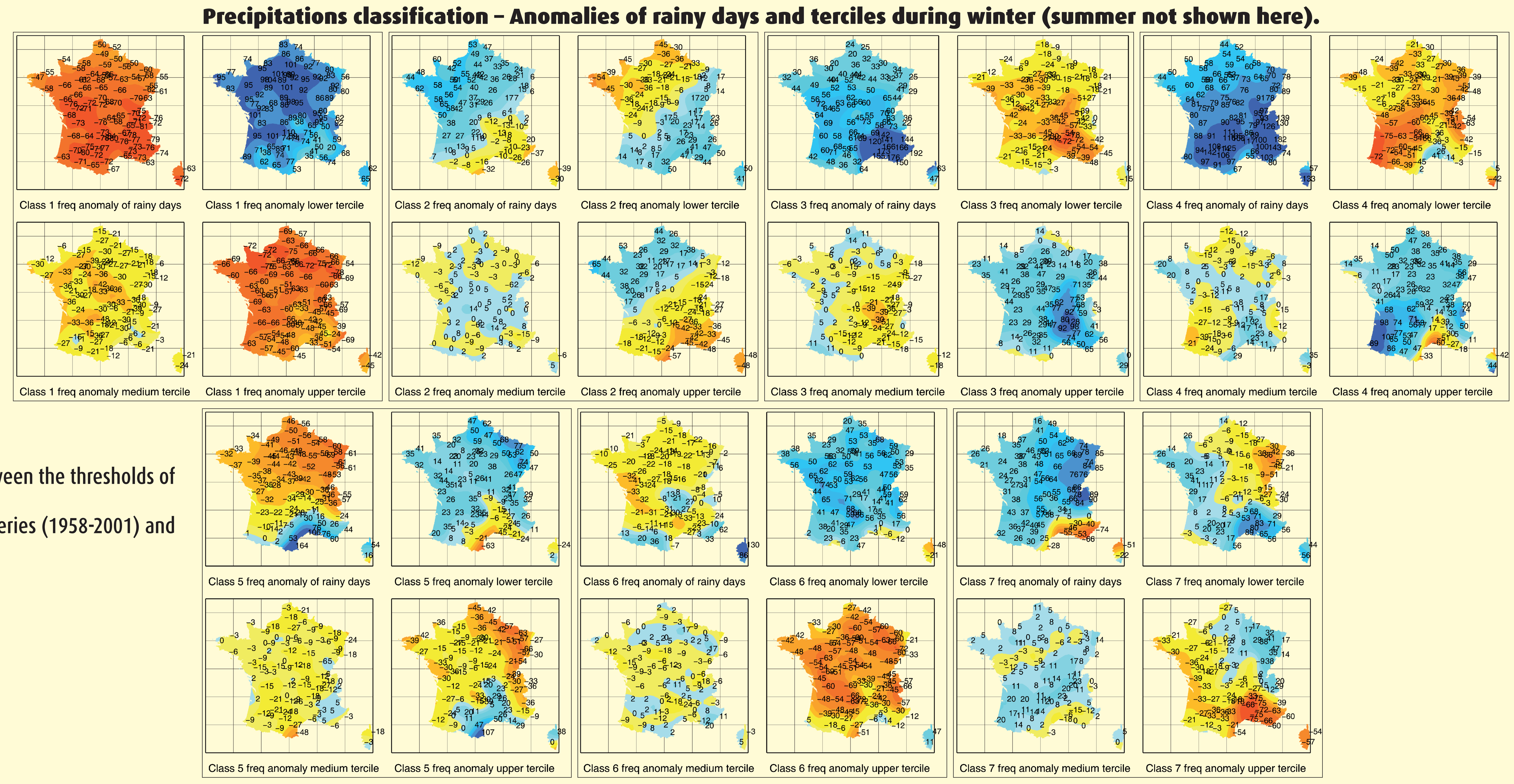
Our goal was first to obtain results at the local scale. We have computed terciles anomalies (for precipitation and for temperature) for each station and for each class. This shows the classes are very different from each other and quite different from the climatology. This technique was used before by Michelangeli [1995] and Plaut [2002]. Other classical indicators are also used so that our final classification is the best choice when compared to others. Among these indicators we have: explained variance, PseudoF, correlation ratio, within type standard deviation [Beck, 2010]. We have tested also another indicator based on a khi2 distance for quintiles:

$$S = \frac{\sum_{1}^{k} \sum_{1}^{n} \sum_{1}^{5} \left(\frac{(F - 20)^2}{20^2} \right)}{k}$$

k = number of classes
n = number of stations
F = frequency (percentage) of observations found for a station and for each class between the thresholds of considered quintiles.

Other results are also computed: stability of frequency of classes all along the time-series (1958-2001) and stability of the frequency of classes along the different months within each seasons.

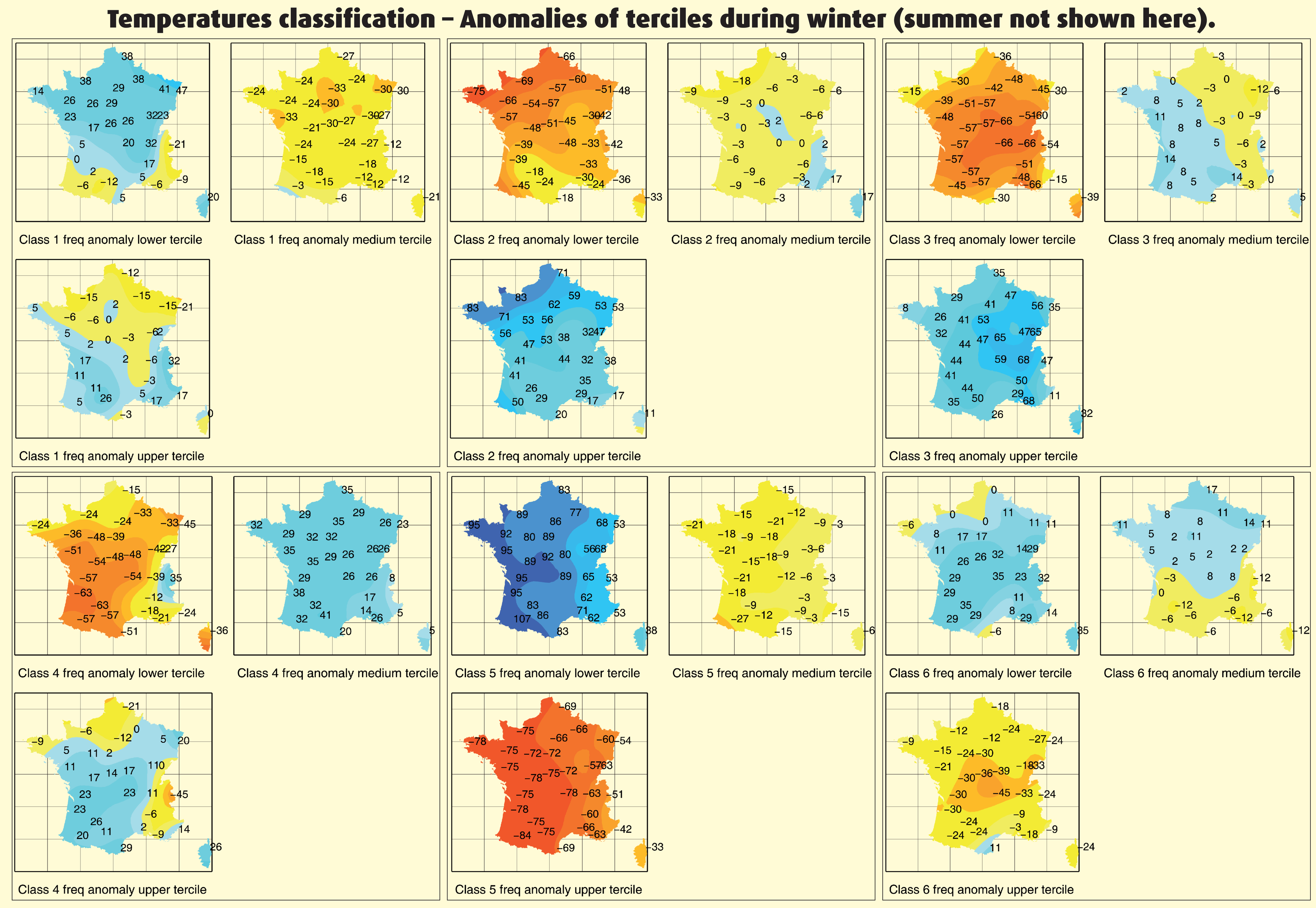
Precipitations classification – Anomalies of rainy days and terciles during winter (summer not shown here).



Conclusions and perspectives :

We have computed for each day the distances to all centers of classes using ERA-40 time-series from 1958 until 2001 and data from the operational ECMWF model from 2002 until now. The method can be re-used easily for other local parameters (wind) and for other regions (in the implementing phase for Pyrénées and being considered for french overseas territories with tropical climate). The results are proven useful for many studies when it is necessary to discriminate daily meteorological conditions: hydrology, downscaling of climate models and seasonal forecasts and even for quality control processing of in-situ observations. It is thus easy to test the benefits obtained from a weather types classification with minimum developing costs.

Temperatures classification – Anomalies of terciles during winter (summer not shown here).



References :

[Beck, 2010]
Evaluation and comparison of circulation type classifications for the European domain.
C. Beck A. Philipp 2010 Physics and Chemistry of the Earth.

[Bénichou, 1985]
Classification automatique des configurations météorologiques sur l'Europe occidentale
P. Bénichou O. Le Breton 1985 Météo-France Monographie no 8

[Boé, 2008]
A Weather-Type Approach to AnalyzingWinter Precipitation in France : Twentieth-Century Trends and the Role of Anthropogenic Forcing.
J. Boé L.Terray 2008 J. Climate

[Michelangeli, 1995]
Weather regimes: Reccurrence and quasi-stationarity
P.A Michelangeli R. Vautard B. Legras 1995 American Meteorological Society

[Najac, 2008]
A multi-model ensemble approach for assessment of climate change impact on surface winds in France
J. Najac J. Boe L. Terray 2008 Clim Dyn Springer-Verlag

[Plaut, 2002]
Large-scale circulation classification, weather regimes and local climate over France, the Alps and Western Europe.
G. Plaut E. Simonnet 2002 Journal of International Climate Research

[Philipp, 2009]
COST733CAT - a database of weather and circulation type classifications.
A. Philipp and Al. 2009 Physics and Chemistry of the Earth.

[Wong, 1982]
A Hybrid Clustering Method for Identifying High-Density Clusters
A. Wong 1982 Journal of the American Statistical Association

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