GOBIERNO DE ESPAÑA
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO
AEMet Agencia Estatal de Meteorología

The Meteorological Drought Monitoring System in AEMET based on SPI

Antonio Mestre

AEMET

Drought in Spain

- The factors that influence the climate of the Iberian Peninsula and the Insular Spain are so varied that in an area of almost 500000 Km2 one cand find very different types of sub-climates.
- One of the common features of all these subclimates is the frequent ocurrence of long drought periods that are connected with anomalies of the atmospheric circulation.
- The Iberian Peninsula is located in the southern extreme of the zone over which flows the northern hemisphere´s circumploar vortex. So, the Peninsula´s weather depends on wave shape (upper circulation) and the jetstream location.
- A shift toward the north of this vortex lead to the consequence that the fronts associated with the atlantic low pressure systems will affect just to the northern part of Spain, where they produce abundant rain while the rest of the Spanish territory remains under the influence of the high pressure systems and has dry weather.

Drought in Spain

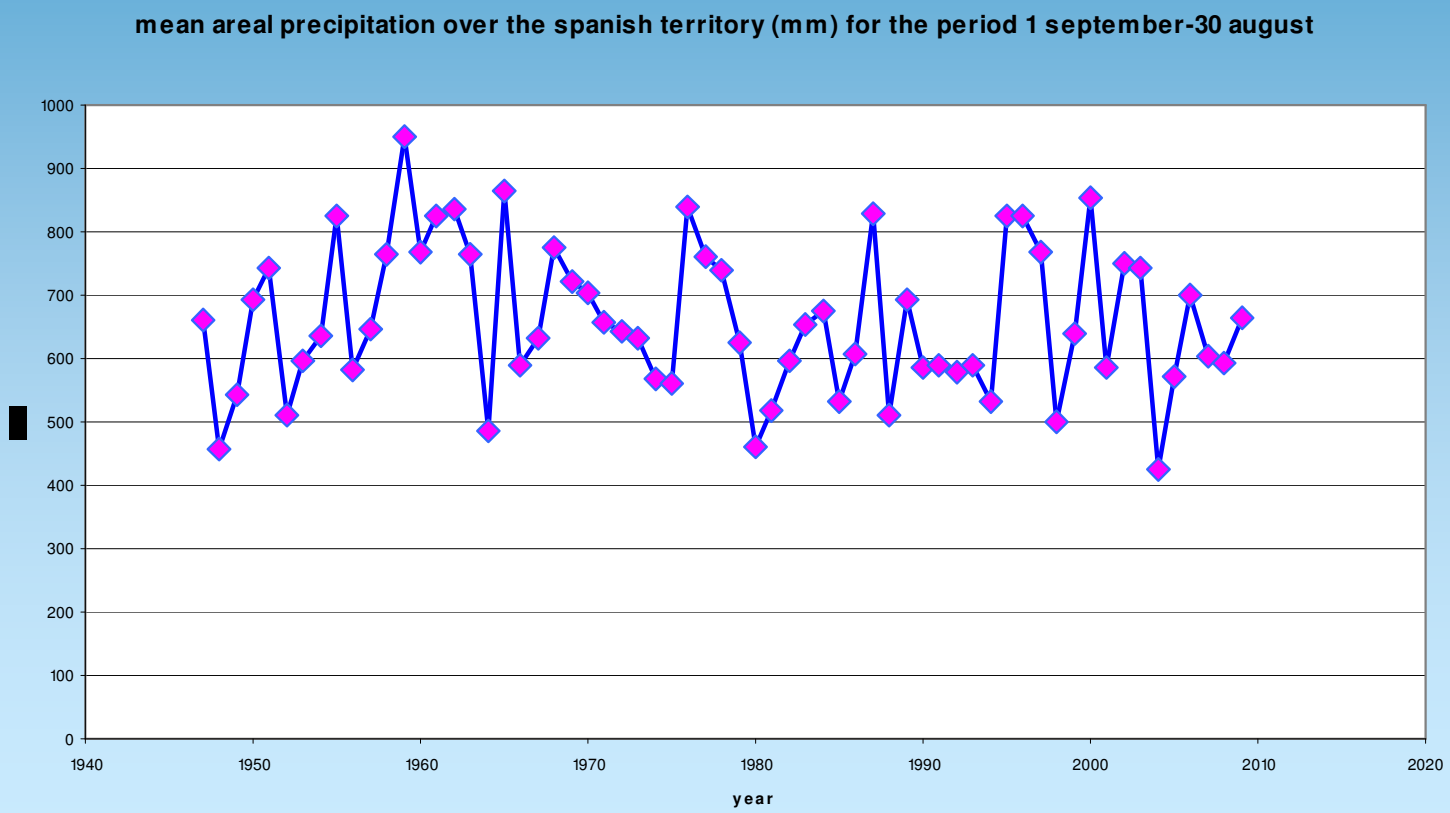
- So, in Spain there is a high recurrence of droughts that in some cases have greatly affected the activity of various productive sectors and caused important economic losses and severe environmental damages.

- As an example of this, it could be mentioned the severe drought of the first half of the 90´s in southern Spain leading to:
- Heavy impact on the water resources sector: domestic water supply problems, reduction of irrigated land, decrease of the hydroelectrical energy production.

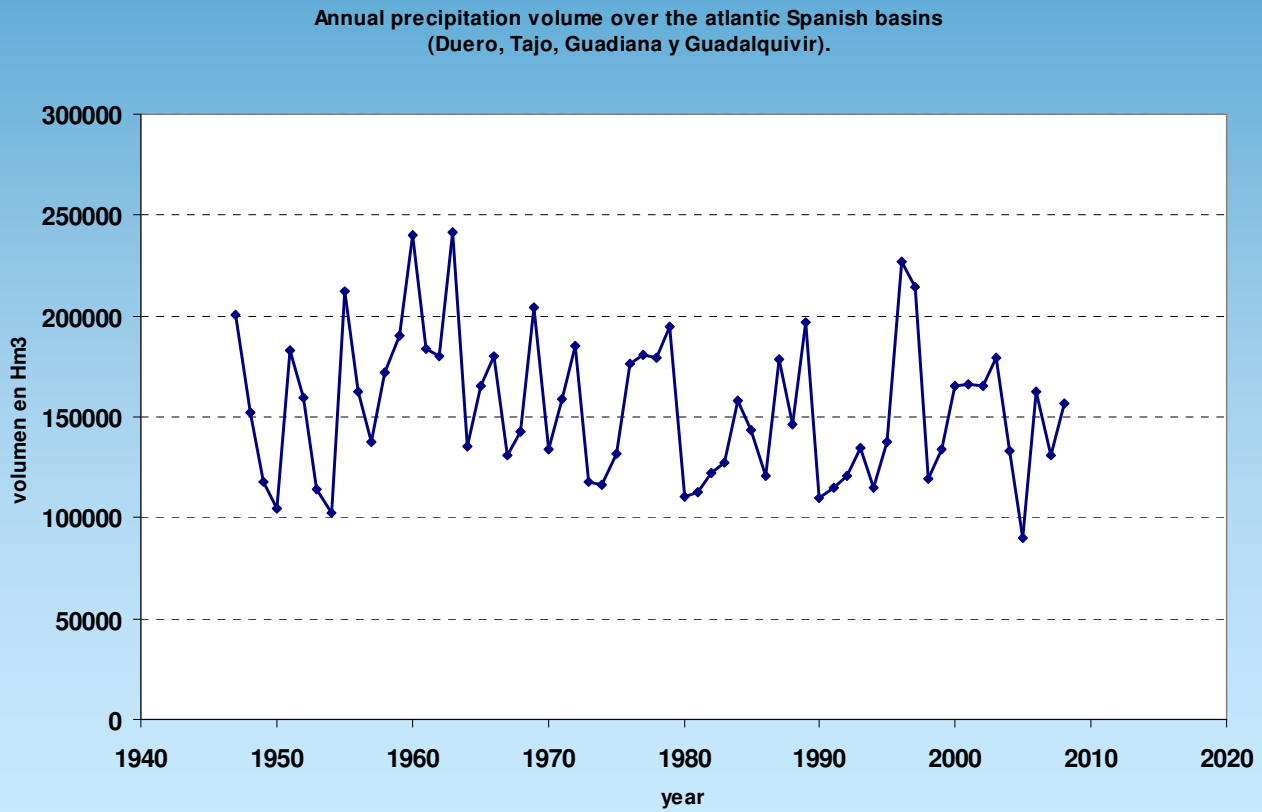
- Great repercusion on the agrarian sector: Main crops affected were irrigation herbaceous crops, particularly cereals (30% yield reduction). There was also a 20% reduction in olive oil production and 40% reduction in wine production. Catle production was also affected by the decrease in the capacity of pasture lands to sustain cattle.

- This prolonged drought severely affected the forested areas in South Spain, where it casued a high mortality of Pinus Pinaster and severe withering symptoms in oak groves, scrub, gall oaks, stone pines (Pinus pinea) and cork oak. In this part of Spain the area affected by forest fires increased a 63% in comparison with the mean of the previous ten-years.

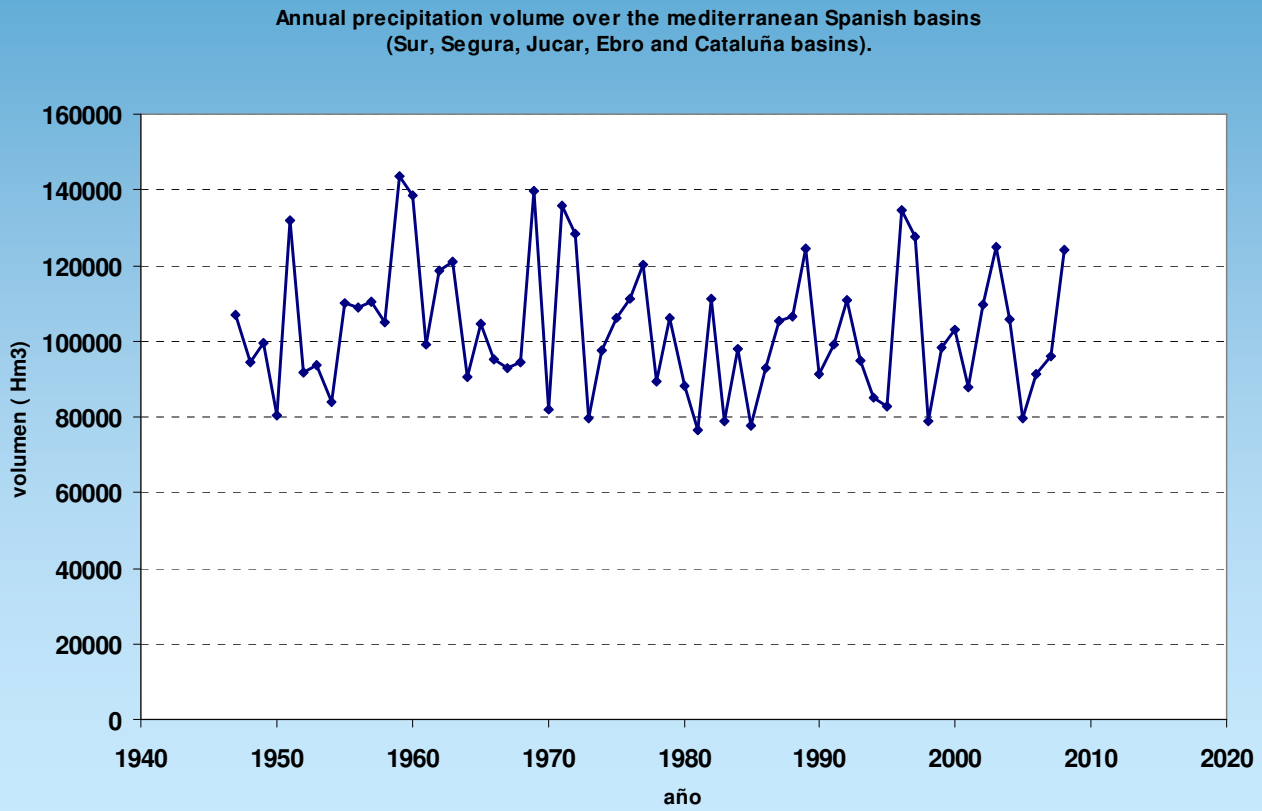
Interannual variability of the precipitation in Spain



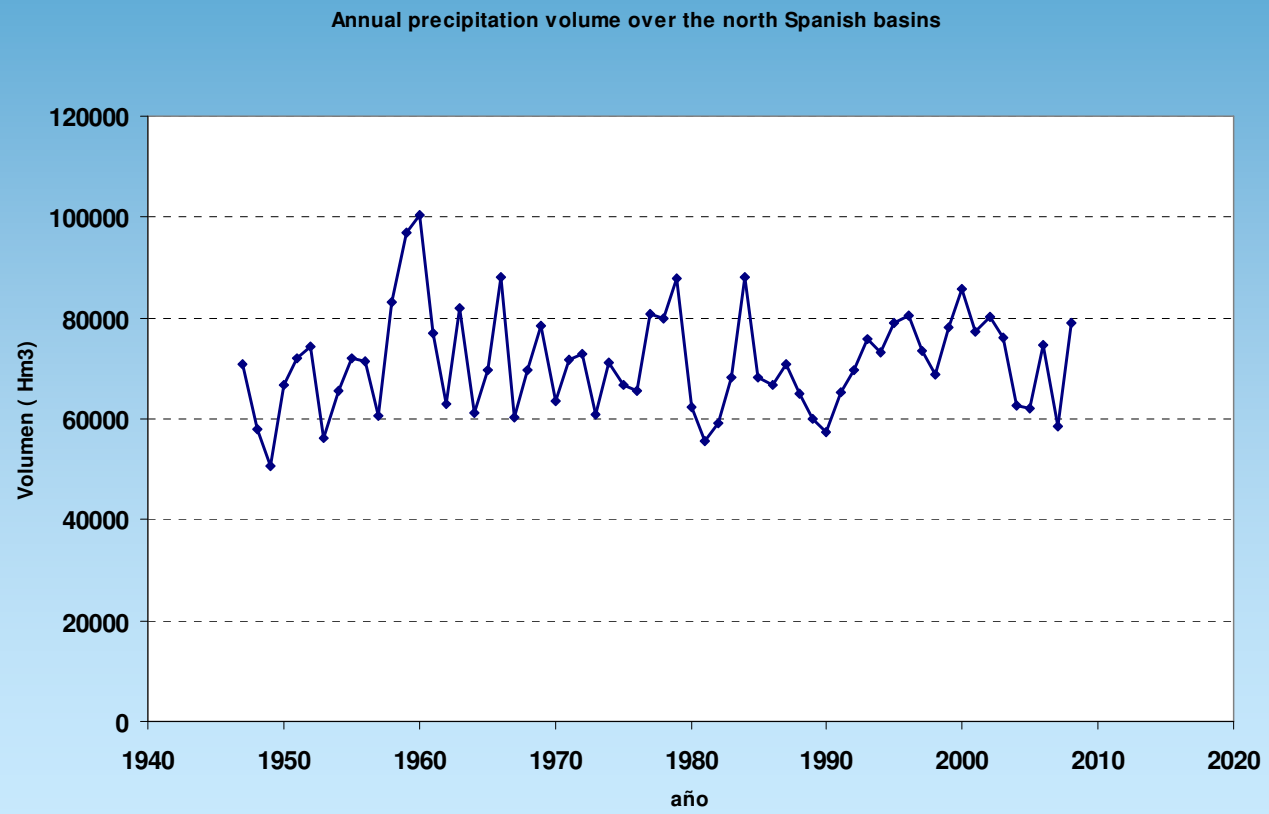
Interannual variability of the precipitation in the atlantic Spanish basins.



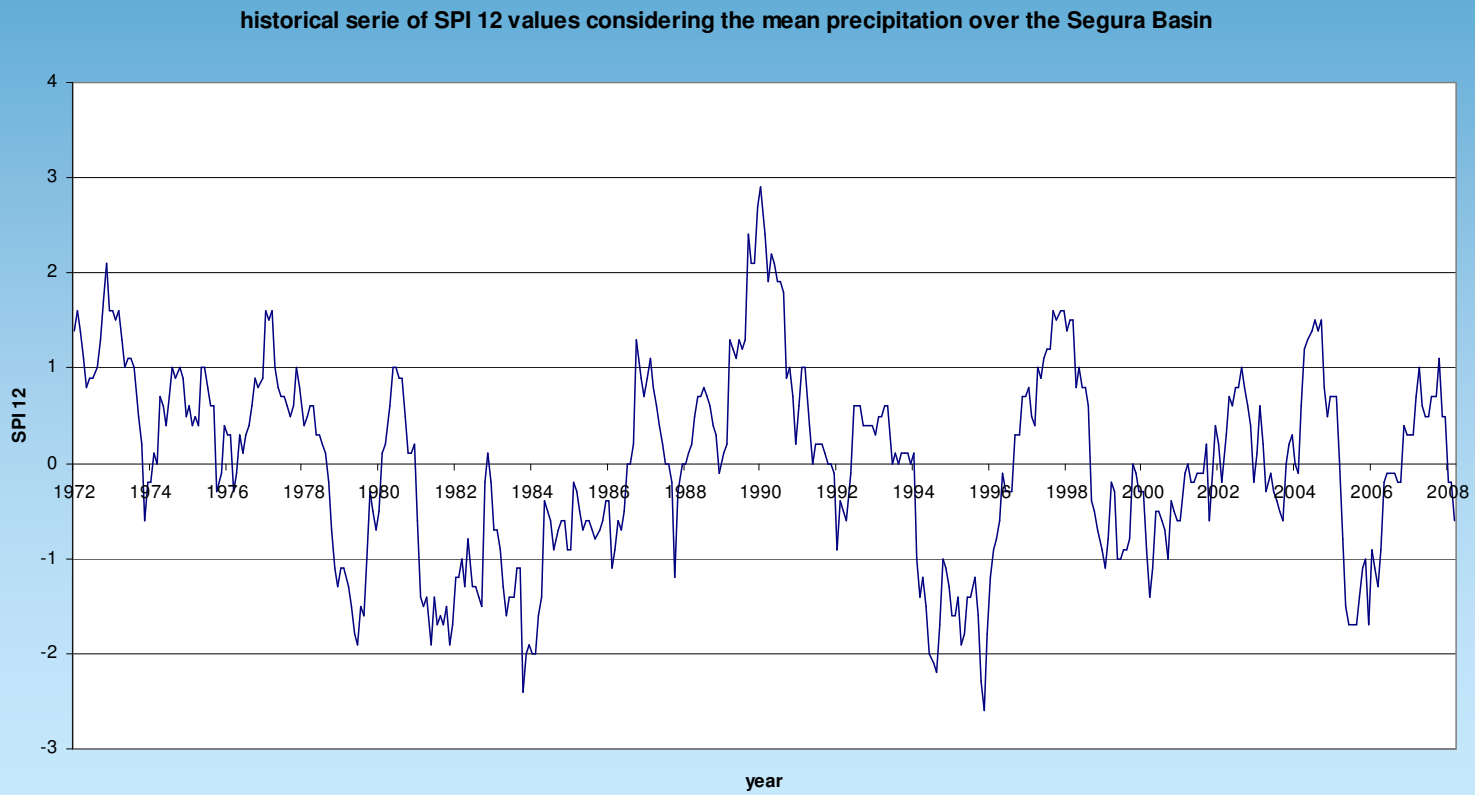
Interannual variability of the precipitation in the mediterranean Spanish basins.



Interannual variability of the precipitation in north Spanish basins.



Interannual variability of the SPI 12 values



Drought in Spain

- Due to the upmost importance of this climate hazard there is a need to develop and implement drought monitoring programmes in Spain.
- Planners should be aware of these climatic features and risks and it is the role of climatologists to provide them with the best information to understand and to plan for drought.
- In this respect an operational water balance was developped in AEMET and it is currently runnig. The main features of this Water Balance will be described as well as the SPI-based system for drought monitoring which is one of the modules of this application.

The AEMET Water Balance: Objectives and general characteristics.

The soil moisture estimation is an important tool for decision-making in different sectors, particularly for farmers (irrigation needs evaluation, soil workability, drought assessment and early warning), forestry services (forest fires risk assessment and controlled burning authorisation) and hydrology.

AEMET developed in 1997 a 0,2°resolution gridded national water balance aimed at providing a daily assessment of soil moisture conditions in order to meet the specific needs of the different users.

Water balance general characteristics

a) The water balance model inputs are: 10-m wind, 2m-temperature and surface pressure from the analysis of HIRLAM 0,2° plus synoptic data in real time of sunshine and precipitation as well as physiographical and edaphological information.

b) The water balance outputs are a set of variables like soil moisture content, soil moisture percentage with respect to the field capacity, reference and actual Evapotranspiration, precipitation…etc. All these outputs are issued in a grid of 0,2° resolution.

c) The incoming rainwater and the atmosphere extraction are not considered as direct processes but dependent on the previous soil moisture content.

d) To handle all the information a raster GIS is used.

Assesment of the water balance´s terms

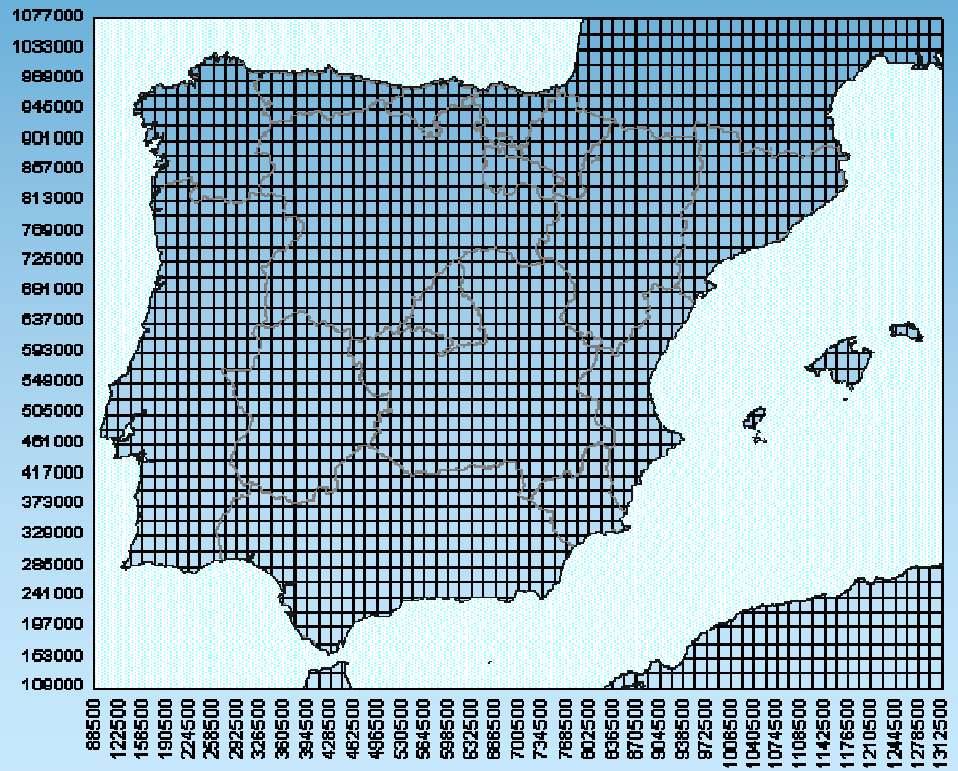
a) The maximum soil water retention values are calculated at the original resolution of the physiographical files and then upscaled to the water balance grid resolution, based on the soil texture and land-use classes.

b) Daily precipitation is the main input in the balance and it is divided in two components, the effective precipitation (the fraction of total precipitation that feeds the soil moisture) and the surplus (runoff and groundwater infiltration).

c) To calculate the effective precipitation, the total precipitation value is assigned to each grid point by interpolation of the synoptic stations data. A simplified model based on the concept of Curve Number (Soil Conservation Service) is applied to estimate the surplus as a function of precipitation, evapotranspiration, maximum soil water retention and adimensional coefficients.

d) The real evapotranspiration is evaluated as dependent of the reference evapotranspiration (obtained form Penman-Monteith approach) and the ratio between actual soil humidity and maximum soil water retention. The soil rising resistance to loose water when its moisture decreases is also taken into account. To this respect a non-lineal water extraction function has been used .

The Water balance grid.



Water balance products.

All the different variables that take part in the water balance can be displayed as maps or as numeric values for an specific place and date.

In particular maps and tables (for spanish synoptic stations) for accumulated precipitation, reference and actual evapotranspiration, soil moisture content and ratio (%) of the soil moisture to maximum soil retention are routinely produced.

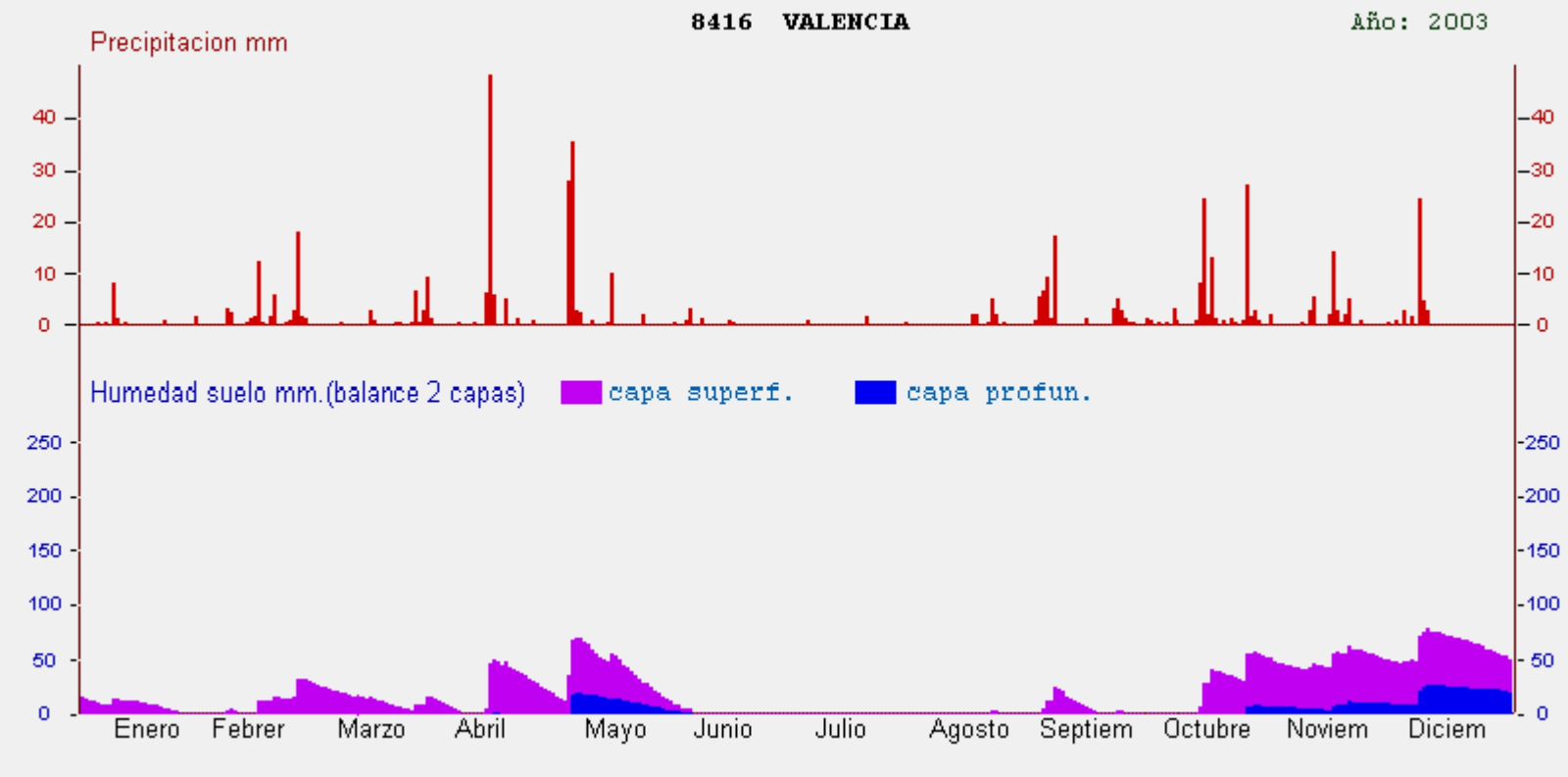
Time series for any location or pixel for any water balance variable can be also generated.

A two soil-layers water balance was developed and it is operationally running, allowing the separate evaluation of the surface moisture contempt.

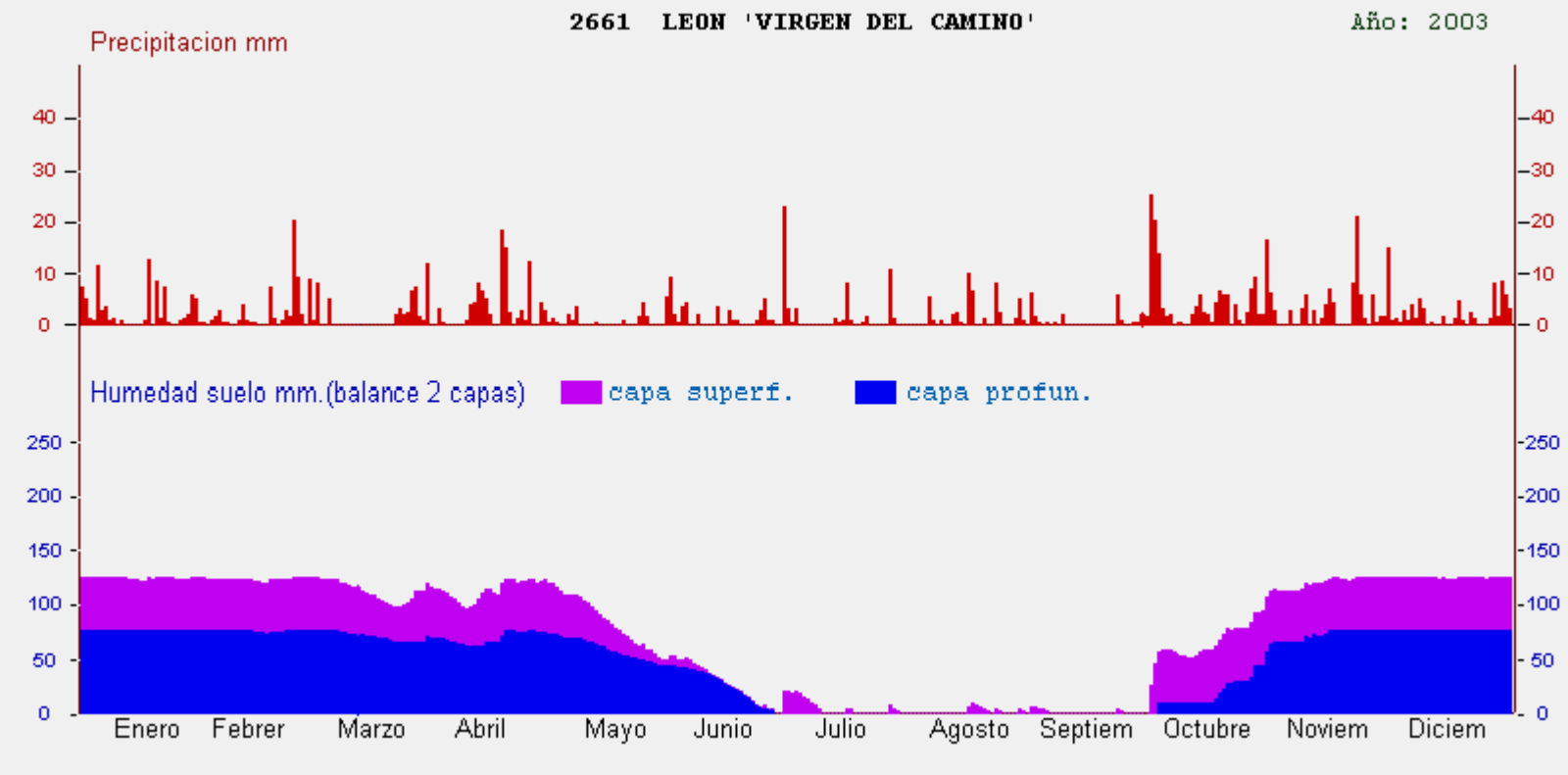
An additional module for SPI based drought assessment that use information and data from the water balance terms has also been implemented and will be described in more detail.

Some of the maps produced by the Water Balance application are available through the AEMET web page and a specific Bulletin based on the water balance outputs is produced every ten days.

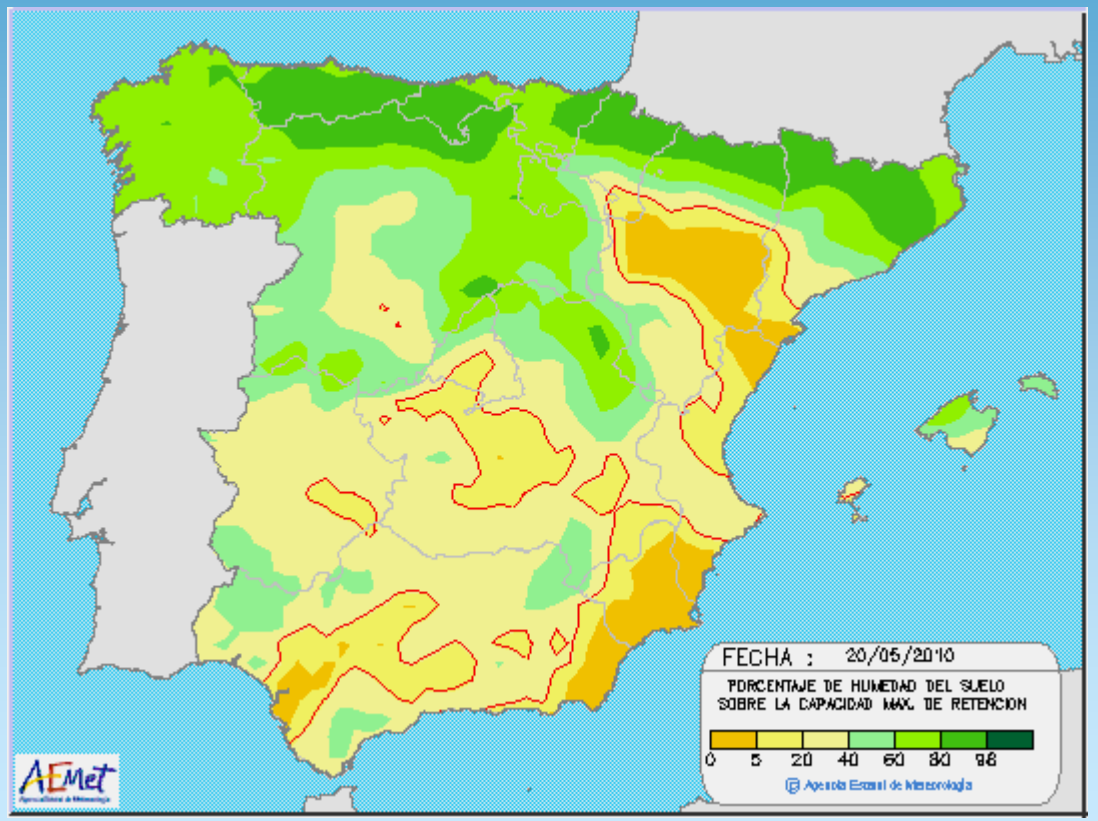
Water balance products:
Time series of water balance outputs



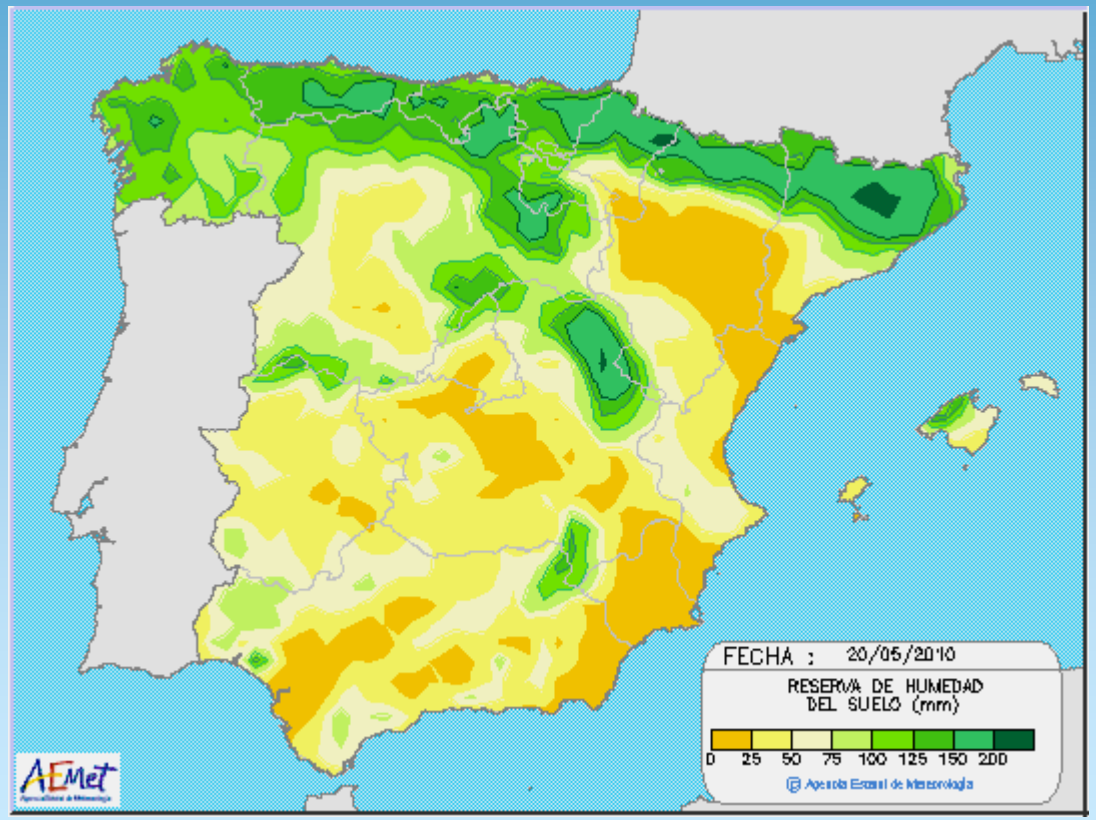
Water balance products:
Time series of water balance outputs



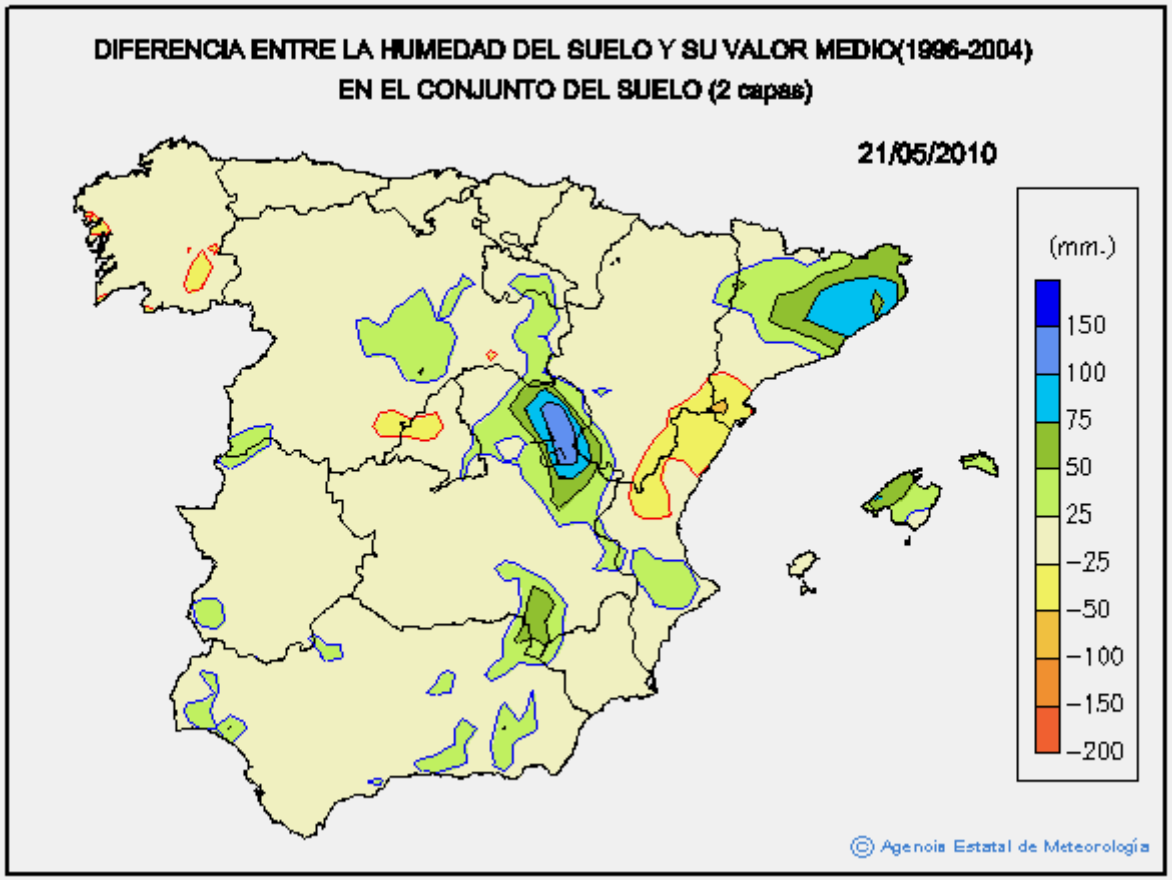
Water balance products: Soil moisture content (%).



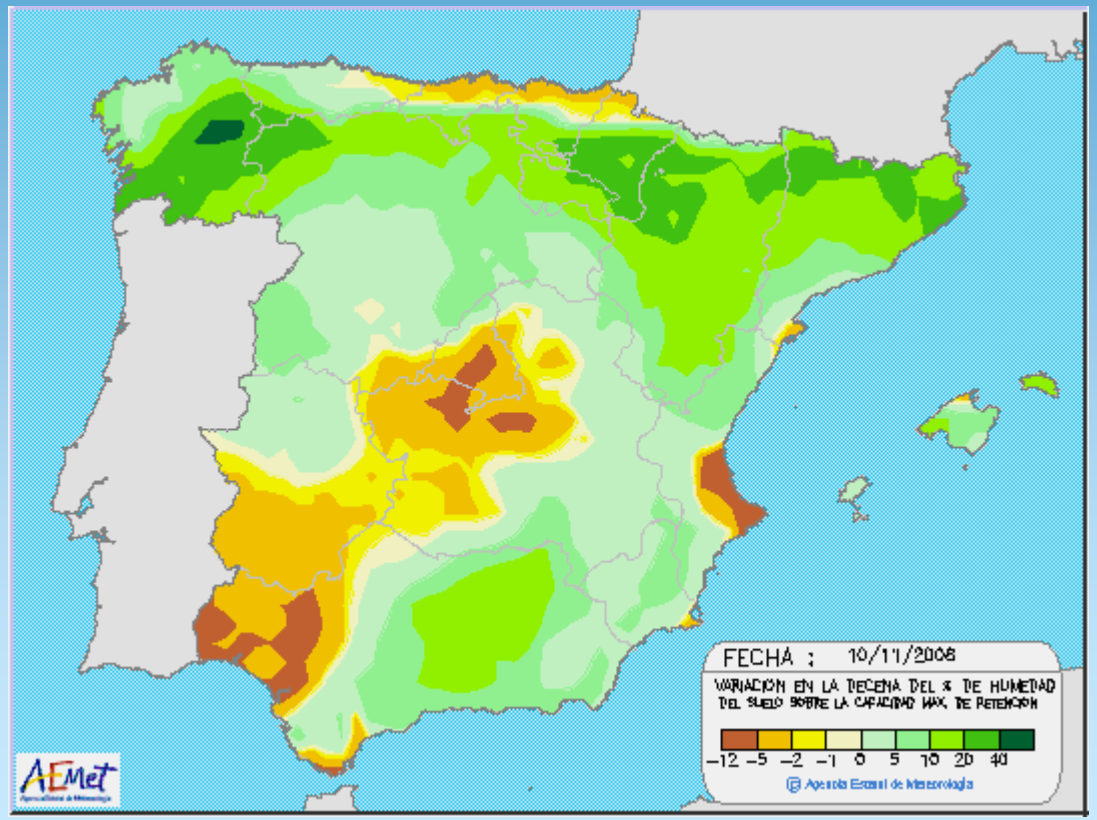
Water balance products: Soil moisture content (mm).



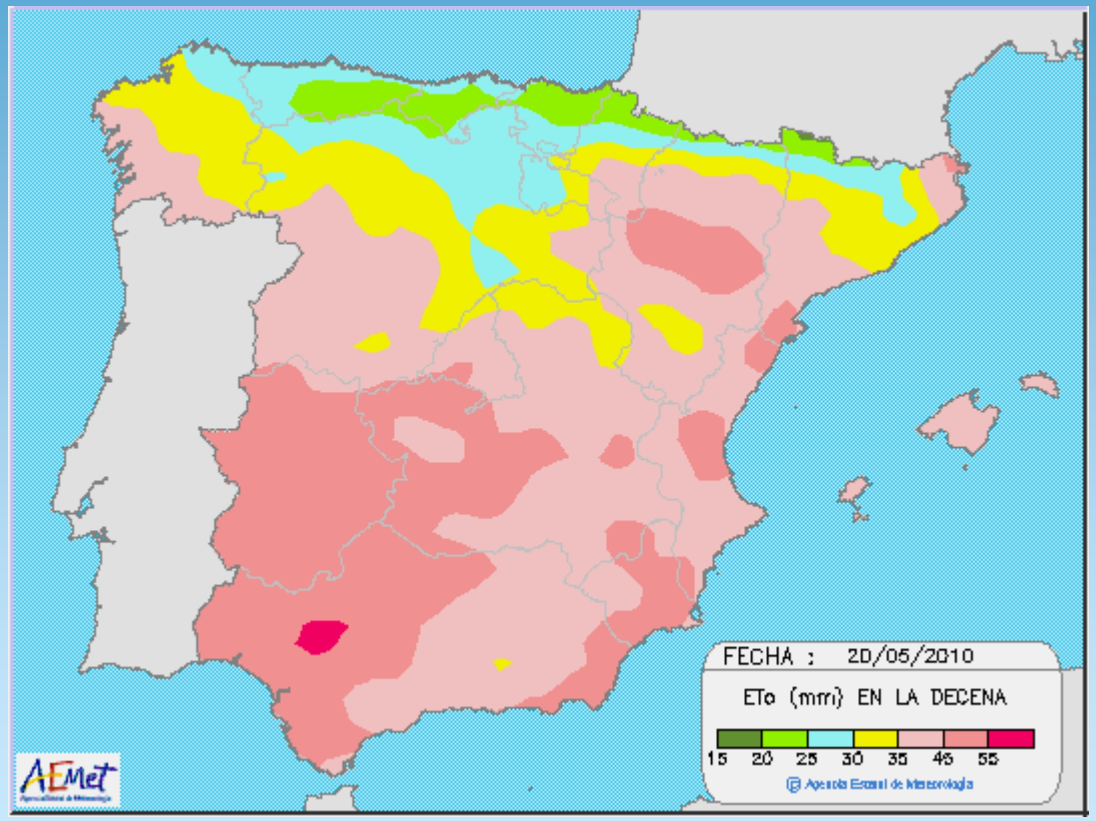
Water balance products: Soil moisture anomaly



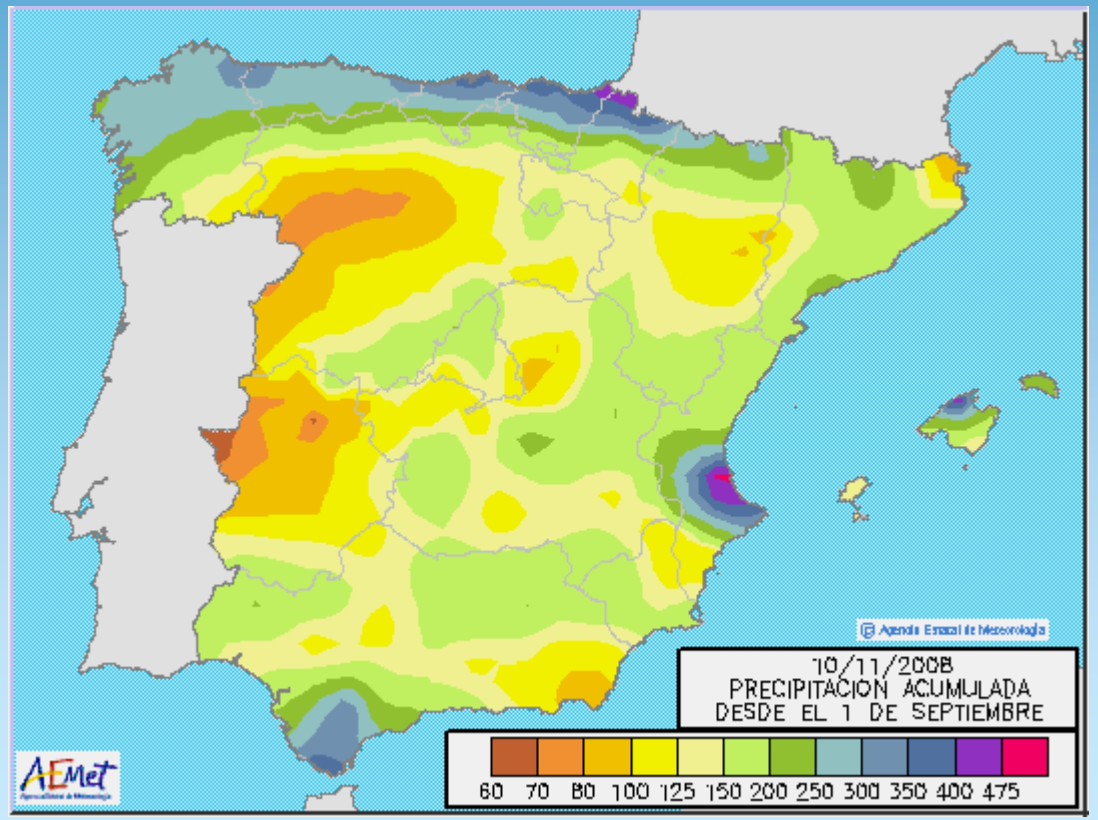
Water balance products: Soil moisture variation



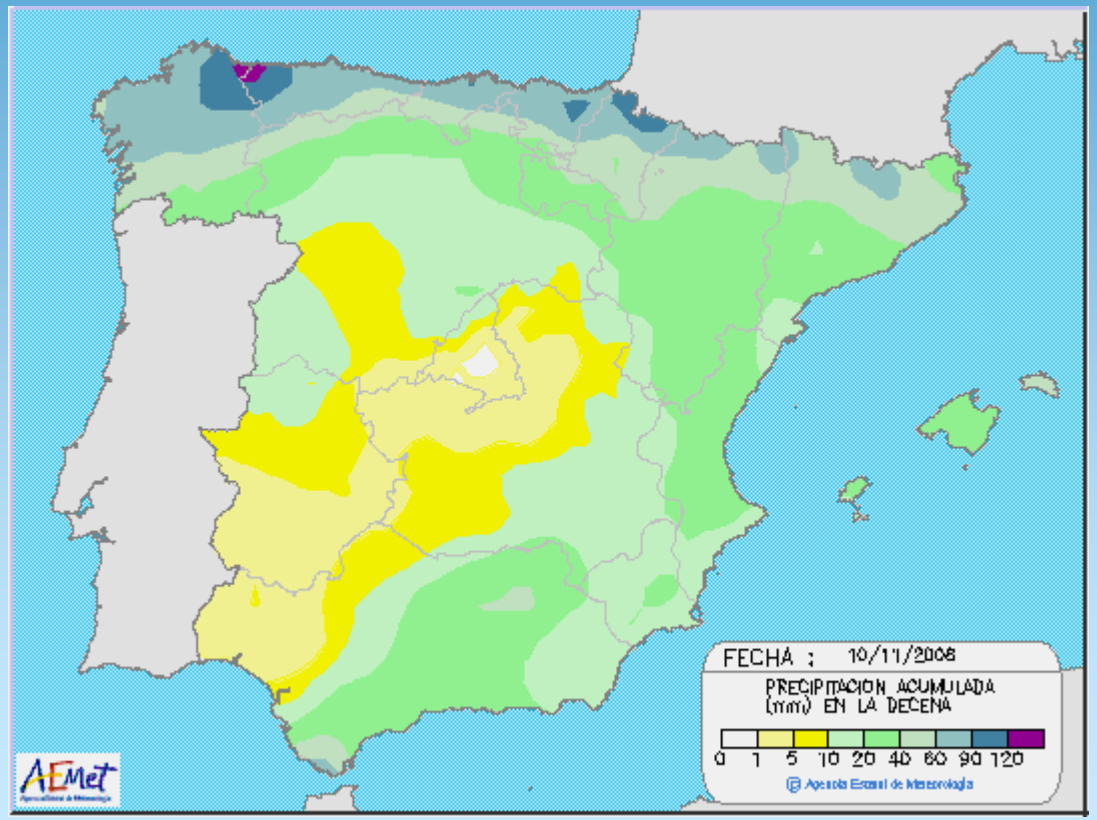
Water balance products: ETo



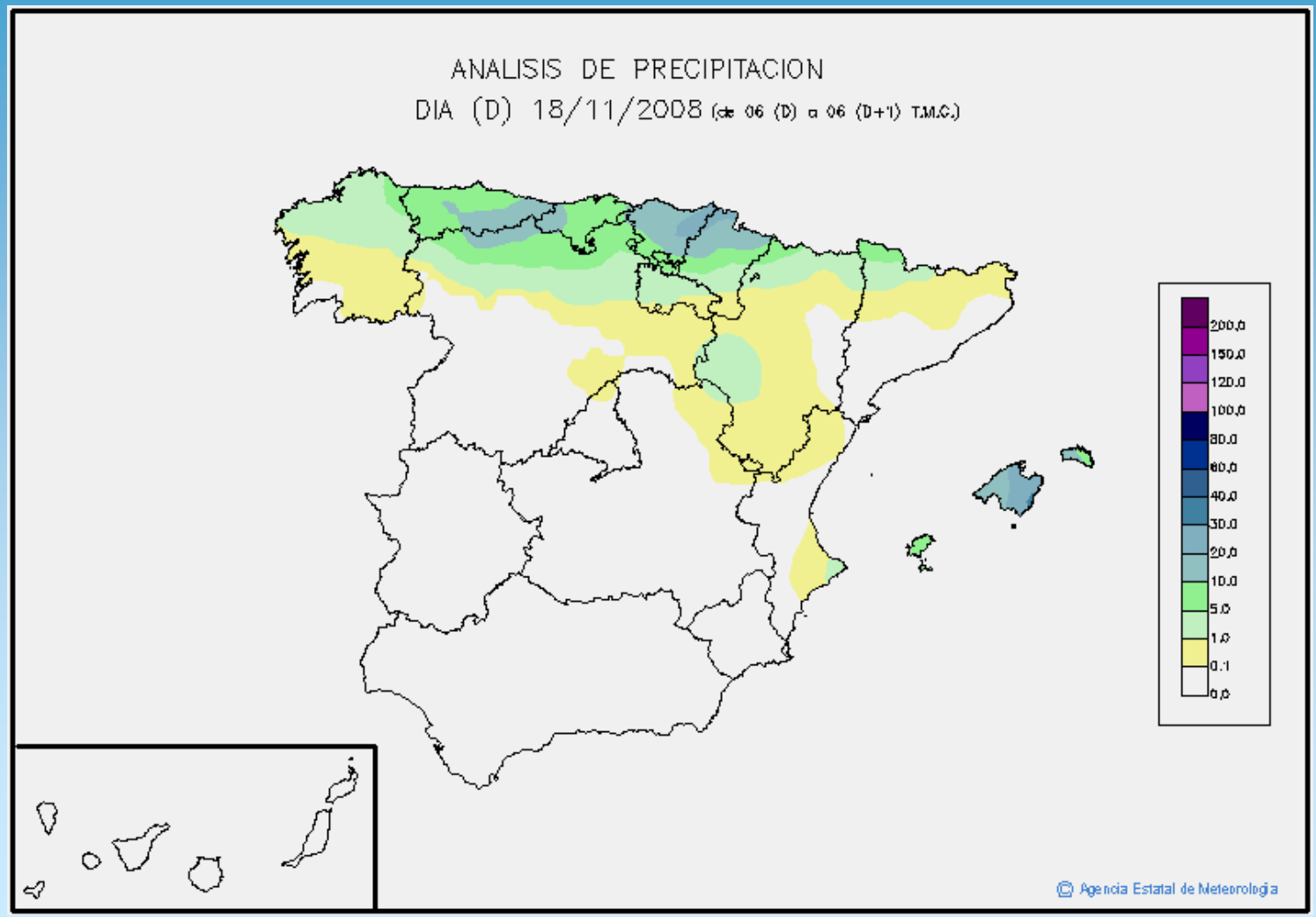
Water balance products: precipitation accumulated for a certain period



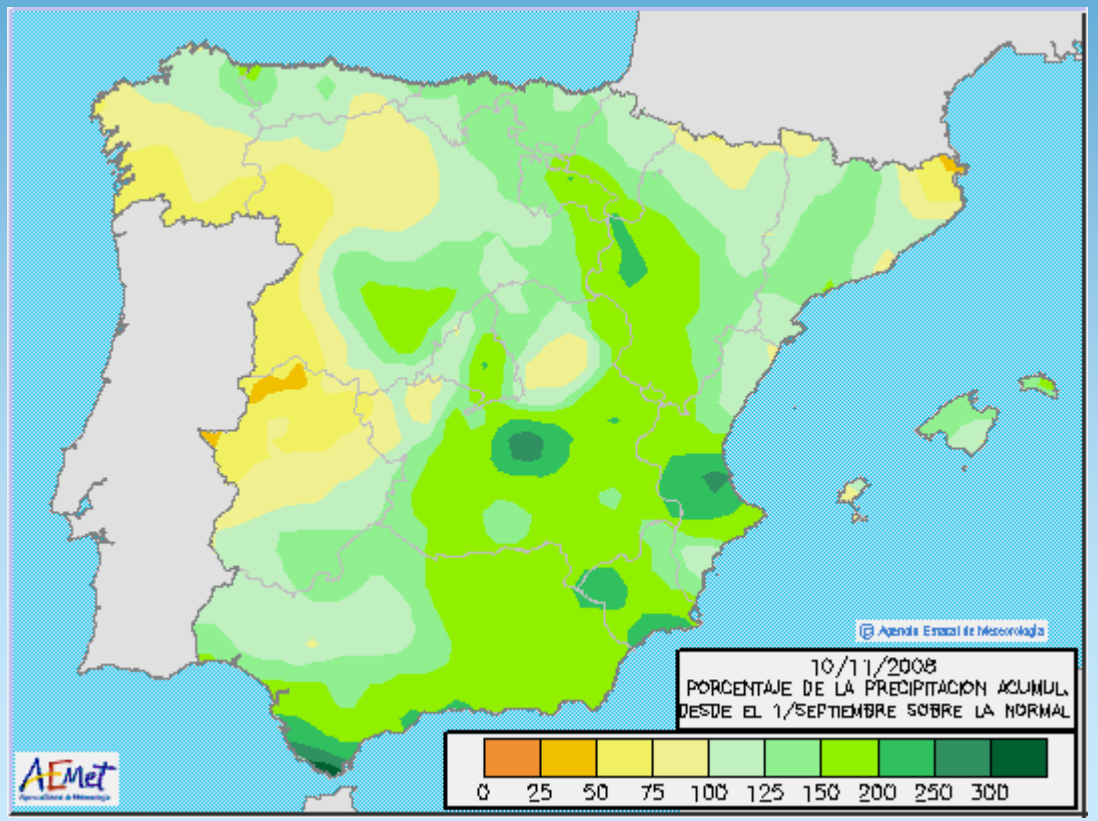
Water balance products: decadal precipitation



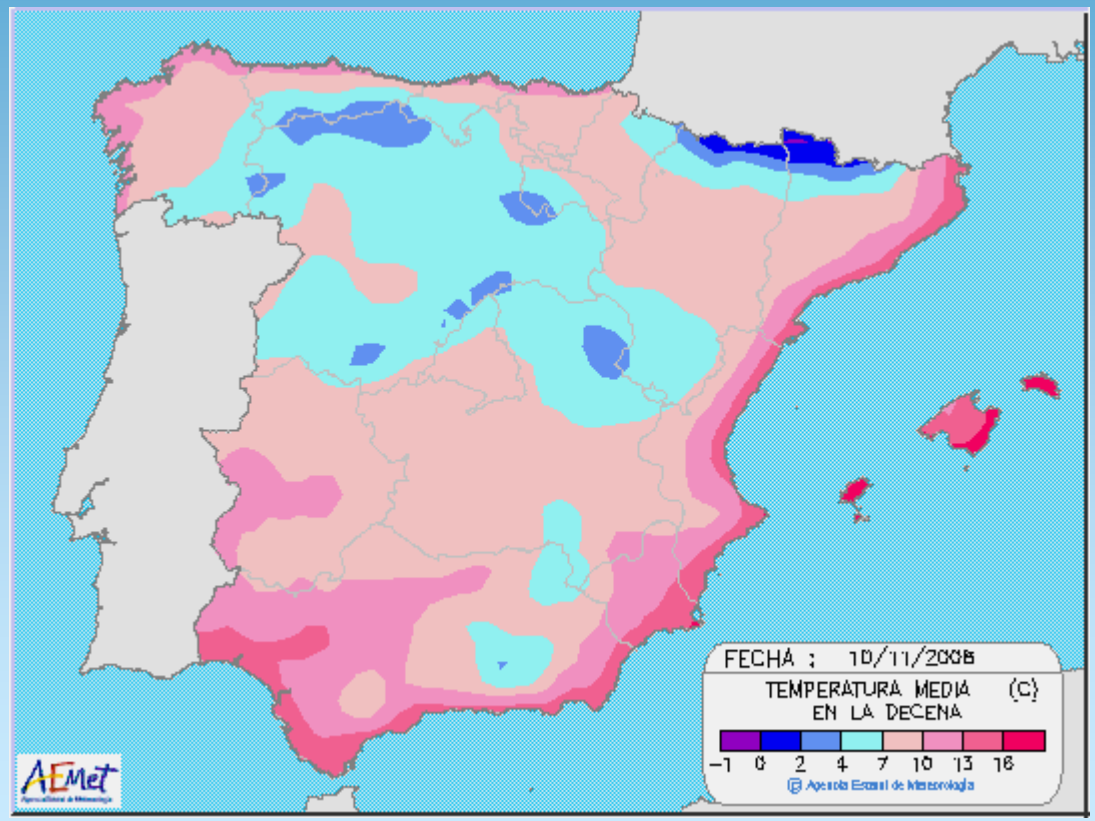
Water balance products: daily precipitation



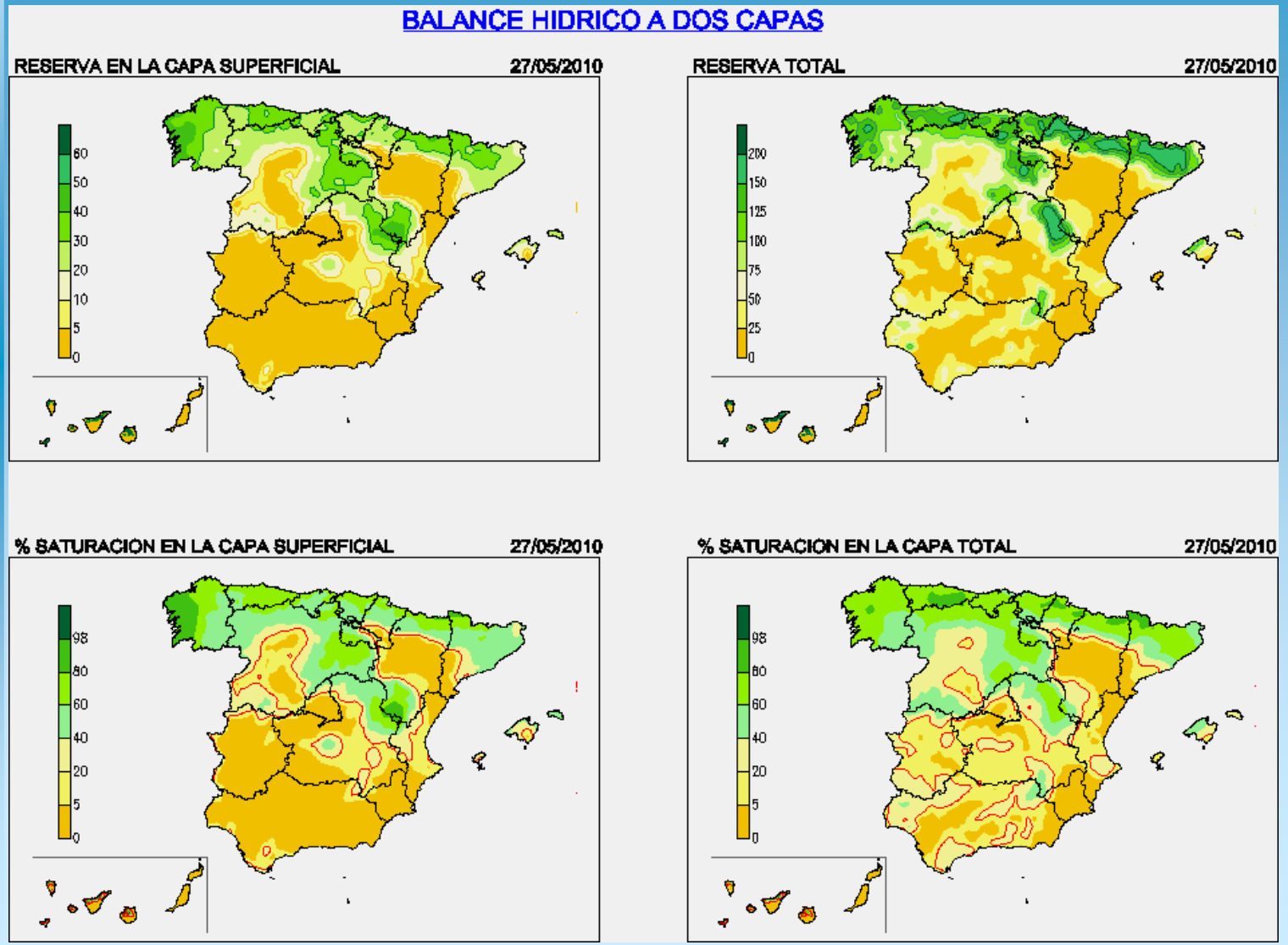
Water balance products: precipitation anomaly



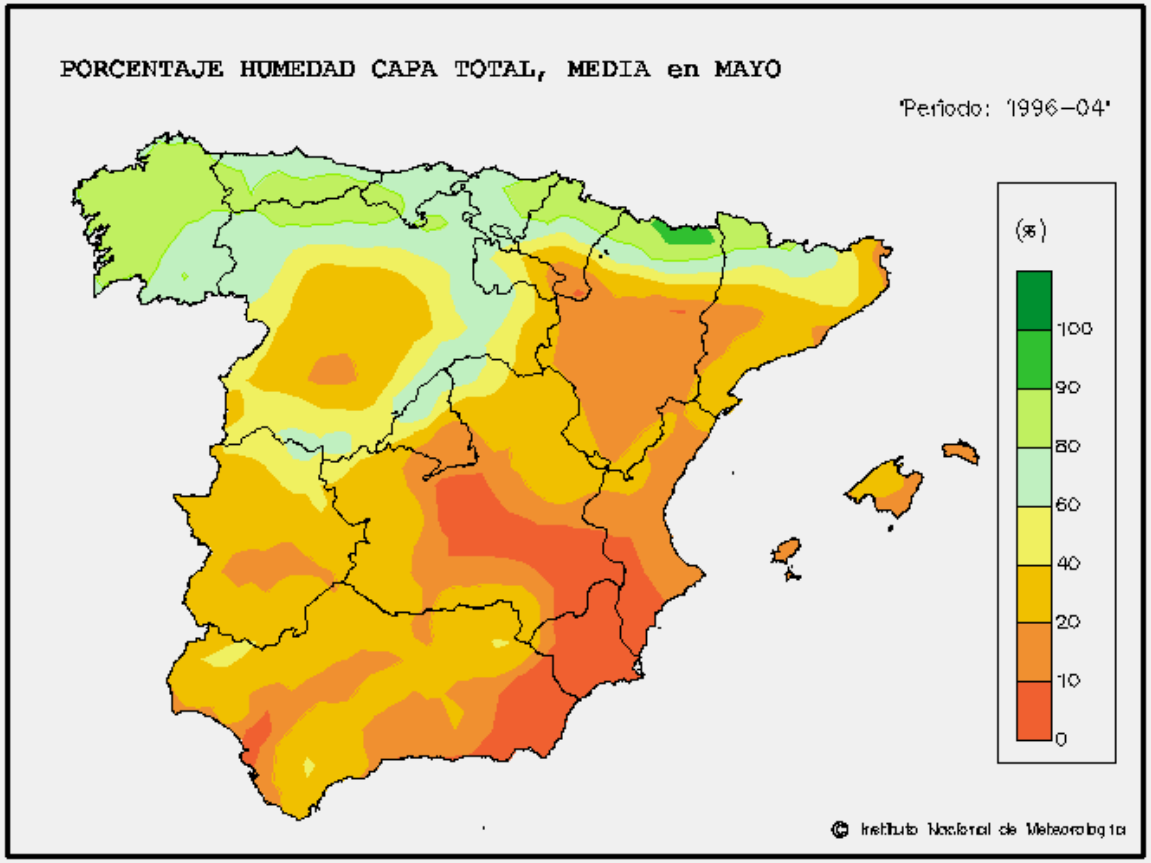
Water balance products: Mean Temperature



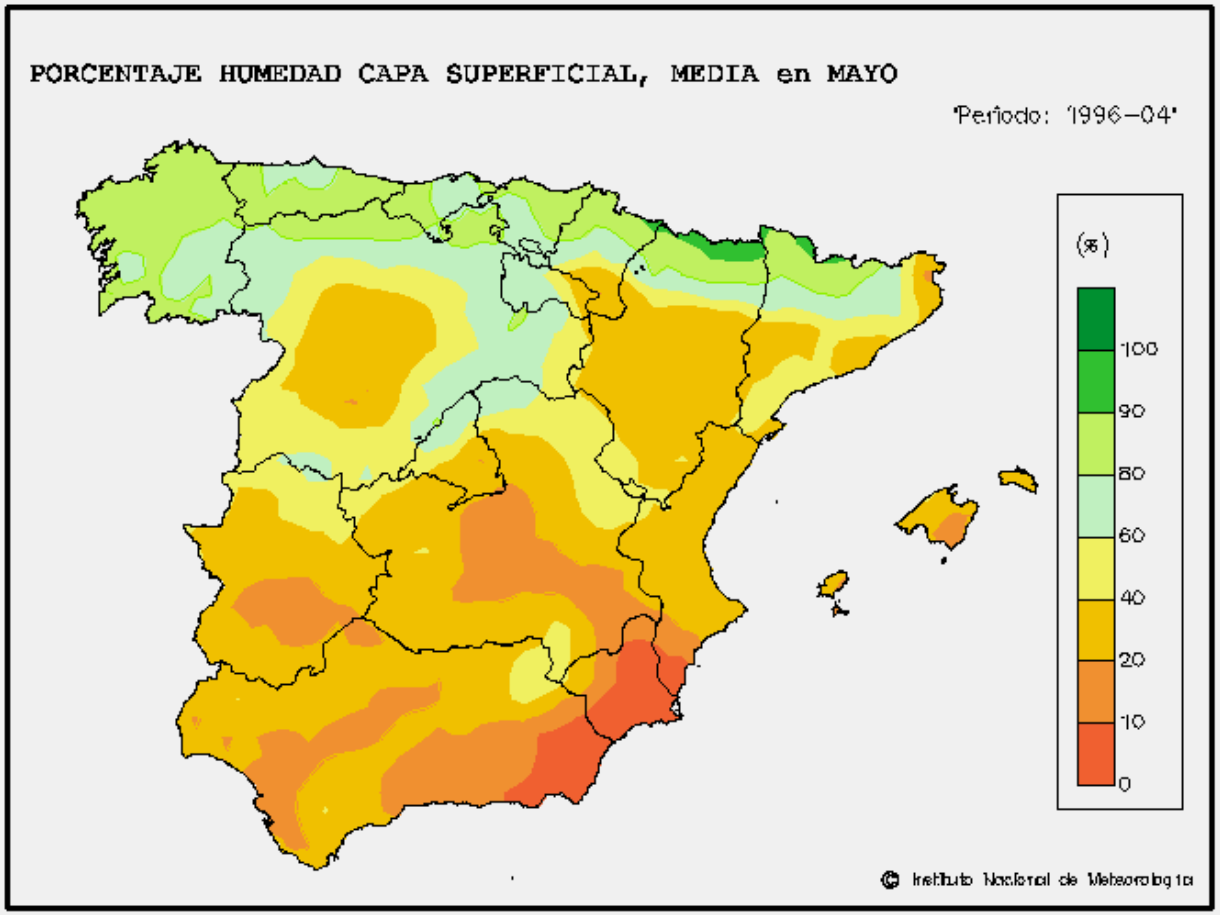
Water balance products: Double layer balance



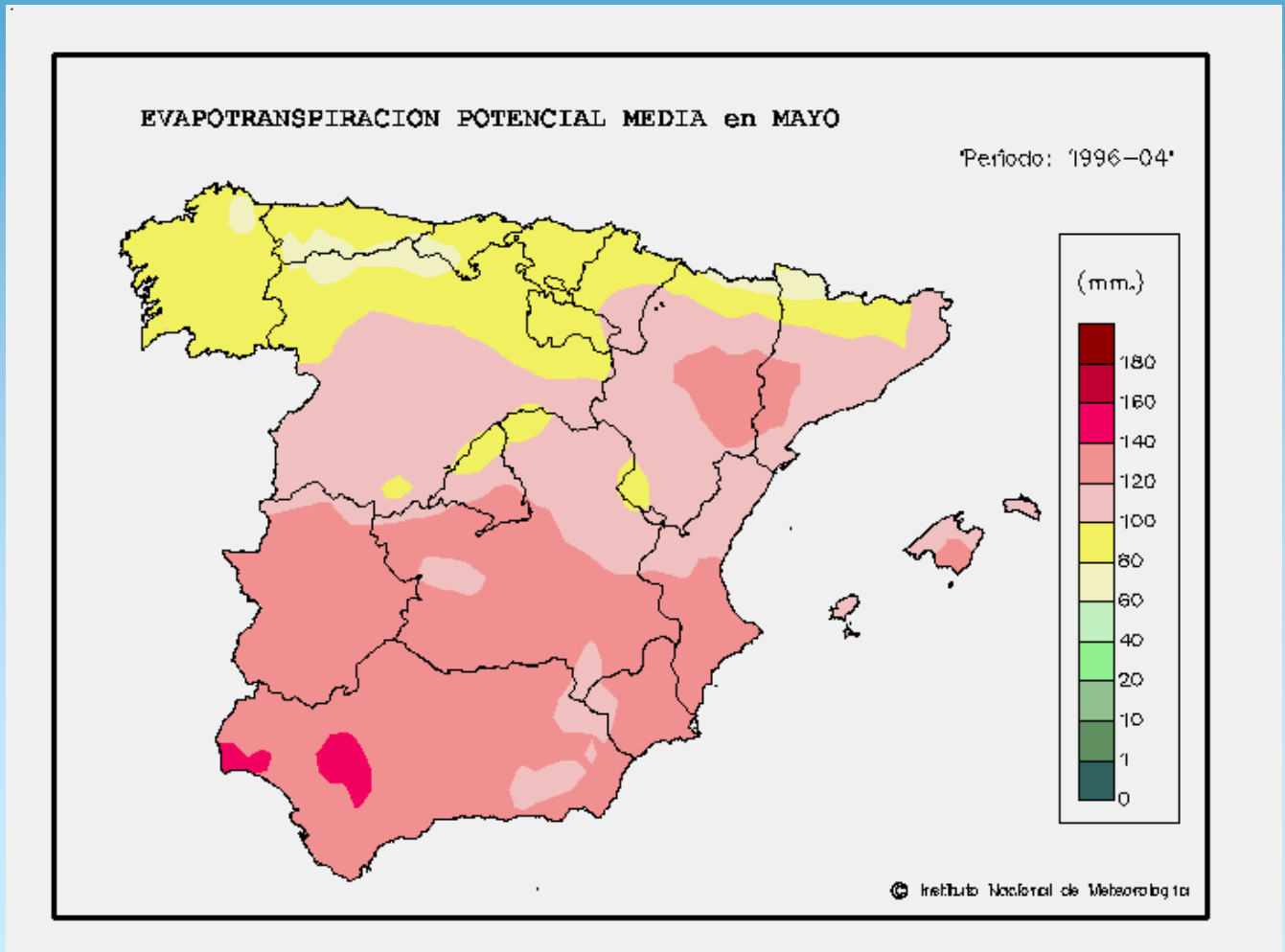
Water balance products: soil moisture climatology



Water balance products: surface soil moisture climatology



Water balance products: ETo climatology



Current actions to improve the water balance

To carry out soil water content monitoring in non irrigated areas.

To make use of different measurement systems to estimate soil volumetric wetness.

To compare real value of soil water content with those estimated from different daily water balances, calculated from the meteorological stations data.

To determine which modifications in the water balance will lead to improve estimations.

To gain spatial resolution from 0,16° to 0,05°.

To improve to accuracy of the gridded precipitation estimation.

Experimental Campaigns

Periodic measurements of soil water content by the gravimetric method (cylinder extractions and sample drying) at three different sites:

- Guadalajara Observatory
- Barajas Station
- Colmenar Station

Flat environment with grassland vegetation

Drought monitoring modules´s description

- The drought module has been developed as an independent module in the framework of the National Water Balance, operational in its current scheme since 1997. Climate data as well as daily precipitation data entering in cuasi-real time are its input data. The SPI, Mckee et al, (1993) is drought index currently used

- The operational application allows to generate, on a monthly basis a set of graphics and tabulated products related to the SPI for periods ranging from 1 month to 3 years. Input data for this application are local data from AEMET´s synoptic stations plus precipitation volumes calcutated for the main hydrographic basins.

- Monthly series of precipitation for a total of 90 synoptical stations and monthly series of mean areal precipitation for the 12 geographical areas defined by the broader spanish water basins are used as a basis information of the System. For the stations the data are obtained from the National Climate Database; the gaps have been filled by interpolation in the corresponding monthly grid. The recent data come from the pluviometric data for the National Water Balance.

Drought monitoring modules´s description

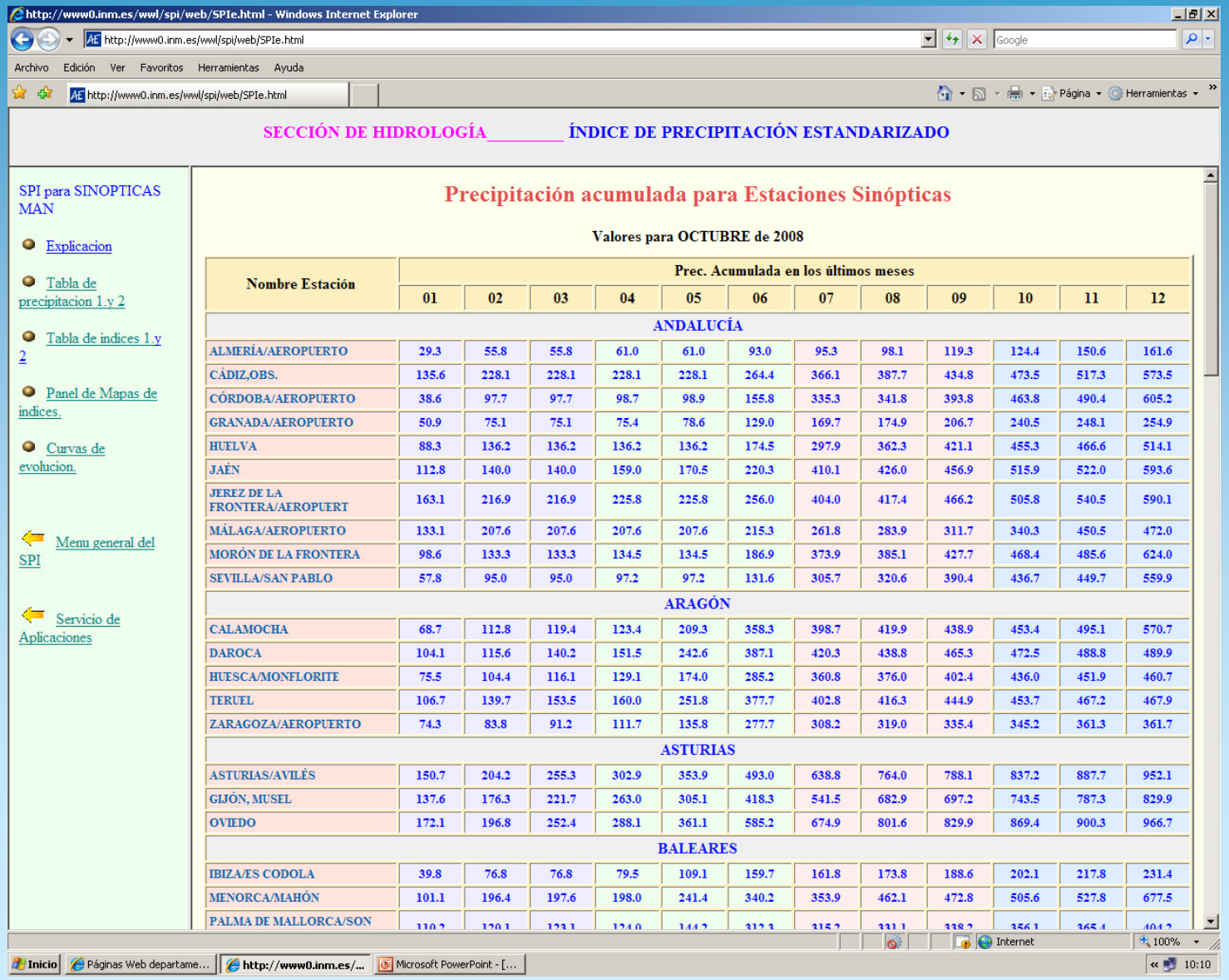
- For each water basin, data are obtained from the precipitation volume series which calculus started in 1947. Recent data come from the AEMET National Water Balance. Precipitation volumes are estimated by integrating pluviometric data into the 0,16° grid. Further on in the process, these provisional volumes are replaced by more precise estimations once pluviometric data from the whole set of AEMET´s climatological stations are available at the National Climate Database, (usually with a delay of 1-2 months).

- From monthly precipitation series, we get accumulated values for periods ranging from 1 month to 36 months.

- Data for every month, station or water basin are fitted to Gama distribution in order to get the corresponding series of values of SPI index. In AEMET web page (internal page), the SPI values appear separatedly for every station and water basin. For some accumulation times: 1, 3 and 6 months (representative of short temporal scale) and 1,2 and 3 years (representative of long temporal scale) there are graphical pesentations.

- In the attached graphics some of the products from the drought monitoring system are shown.

The outputs from the Drought Monitoring System



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- Panel de Mapas de indices.
- Curvas de evolucion.

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Precipitación acumulada para Estaciones Sinópticas

Valores para OCTUBRE de 2008

Nombre Estación	Prec. Acumulada en los últimos meses											
	01	02	03	04	05	06	07	08	09	10	11	12
ANDALUCÍA												
ALMERÍA/AEROPUERTO	29.3	55.8	55.8	61.0	61.0	93.0	95.3	98.1	119.3	124.4	150.6	161.6
CÁDIZ,OBS.	135.6	228.1	228.1	228.1	228.1	264.4	366.1	387.7	434.8	473.5	517.3	573.5
CÓRDOBA/AEROPUERTO	38.6	97.7	97.7	98.7	98.9	155.8	335.3	341.8	393.8	463.8	490.4	605.2
GRANADA/AEROPUERTO	50.9	75.1	75.1	75.4	78.6	129.0	169.7	174.9	206.7	240.5	248.1	254.9
HUELVA	88.3	136.2	136.2	136.2	136.2	174.5	297.9	362.3	421.1	455.3	466.6	514.1
JAÉN	112.8	140.0	140.0	159.0	170.5	220.3	410.1	426.0	456.9	515.9	522.0	593.6
JEREZ DE LA FRONTERA/AEROPUERT	163.1	216.9	216.9	225.8	225.8	256.0	404.0	417.4	466.2	505.8	540.5	590.1
MÁLAGA/AEROPUERTO	133.1	207.6	207.6	207.6	207.6	215.3	261.8	283.9	311.7	340.3	450.5	472.0
MORÓN DE LA FRONTERA	98.6	133.3	133.3	134.5	134.5	186.9	373.9	385.1	427.7	468.4	485.6	624.0
SEVILLA/SAN PABLO	57.8	95.0	95.0	97.2	97.2	131.6	305.7	320.6	390.4	436.7	449.7	559.9
ARAGÓN												
CALAMOCHA	68.7	112.8	119.4	123.4	209.3	358.3	398.7	419.9	438.9	453.4	495.1	570.7
DAROCA	104.1	115.6	140.2	151.5	242.6	387.1	420.3	438.8	465.3	472.5	488.8	489.9
HUESCA/MONFLORITE	75.5	104.4	116.1	129.1	174.0	285.2	360.8	376.0	402.4	436.0	451.9	460.7
TERUEL	106.7	139.7	153.5	160.0	251.8	377.7	402.8	416.3	444.9	453.7	467.2	467.9
ZARAGOZA/AEROPUERTO	74.3	83.8	91.2	111.7	135.8	277.7	308.2	319.0	335.4	345.2	361.3	361.7
ASTURIAS												
ASTURIAS/AVILÉS	150.7	204.2	255.3	302.9	353.9	493.0	638.8	764.0	788.1	837.2	887.7	952.1
GIJÓN, MUSEL	137.6	176.3	221.7	263.0	305.1	418.3	541.5	682.9	697.2	743.5	787.3	829.9
OVIEDO	172.1	196.8	252.4	288.1	361.1	585.2	674.9	801.6	829.9	869.4	900.3	966.7
BALEARES												
IBIZA/ES CODOLA	39.8	76.8	76.8	79.5	109.1	159.7	161.8	173.8	188.6	202.1	217.8	231.4
MENORCA/MAHÓN	101.1	196.4	197.6	198.0	241.4	340.2	353.9	462.1	472.8	505.6	527.8	677.5
PALMA DE MALLORCA/SON	110.2	120.1	123.1	124.0	144.2	312.3	315.2	331.1	338.2	356.1	365.4	404.2

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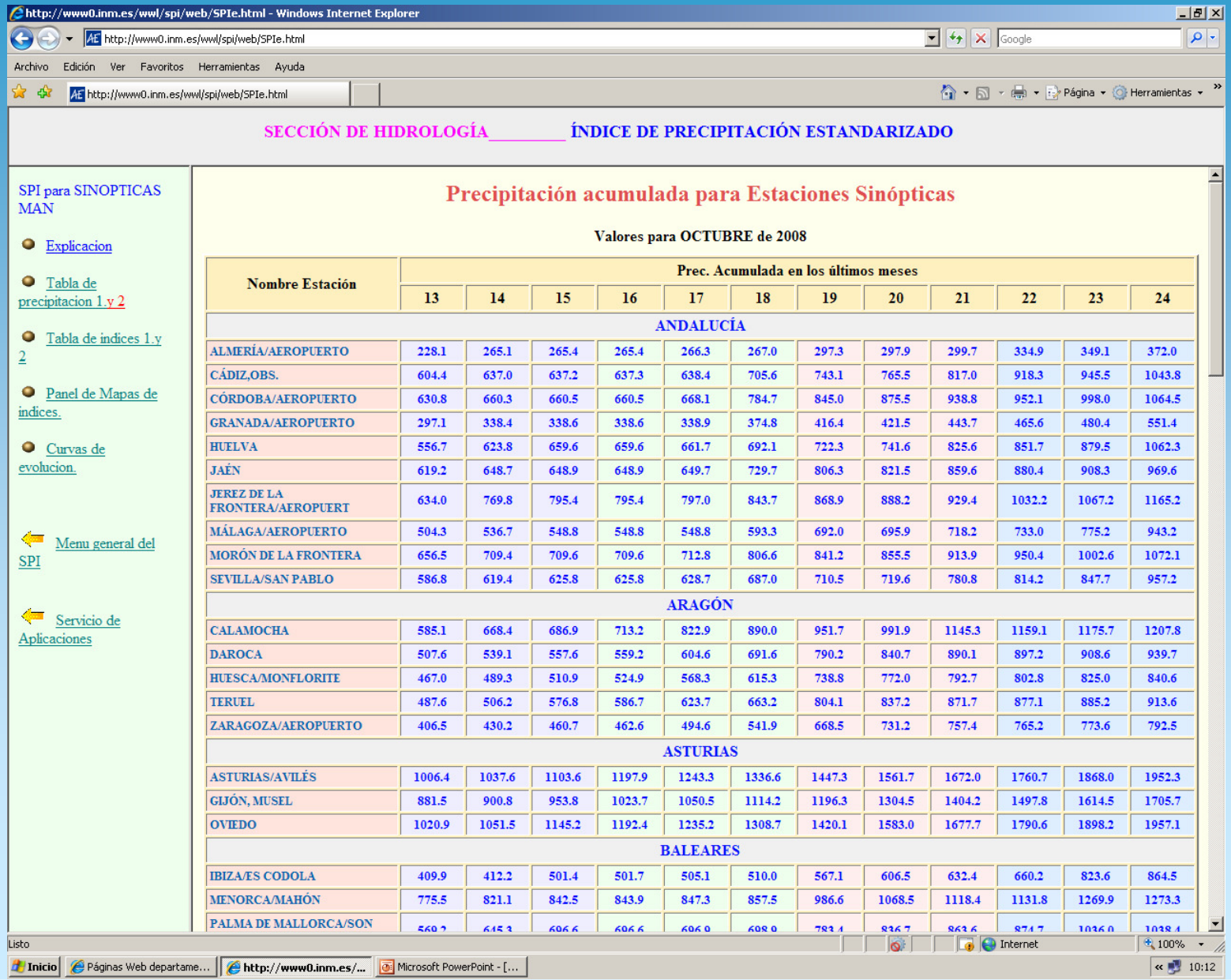
The outputs from the Drought Monitoring System



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	13	14	15	16	17	18	19	20	21	22	23	24
ANDALUCÍA												
ALMERÍA/AEROPUERTO	228.1	265.1	265.4	265.4	266.3	267.0	297.3	297.9	299.7	334.9	349.1	372.0
CÁDIZ,OBS.	604.4	637.0	637.2	637.3	638.4	705.6	743.1	765.5	817.0	918.3	945.5	1043.8
CÓRDOBA/AEROPUERTO	630.8	660.3	660.5	660.5	668.1	784.7	845.0	875.5	938.8	952.1	998.0	1064.5
GRANADA/AEROPUERTO	297.1	338.4	338.6	338.6	338.9	374.8	416.4	421.5	443.7	465.6	480.4	551.4
HUELVA	556.7	623.8	659.6	659.6	661.7	692.1	722.3	741.6	825.6	851.7	879.5	1062.3
JAÉN	619.2	648.7	648.9	648.9	649.7	729.7	806.3	821.5	859.6	880.4	908.3	969.6
JEREZ DE LA FRONTERA/AEROPUERT	634.0	769.8	795.4	795.4	797.0	843.7	868.9	888.2	929.4	1032.2	1067.2	1165.2
MÁLAGA/AEROPUERTO	504.3	536.7	548.8	548.8	548.8	593.3	692.0	695.9	718.2	733.0	775.2	943.2
MORÓN DE LA FRONTERA	656.5	709.4	709.6	709.6	712.8	806.6	841.2	855.5	913.9	950.4	1002.6	1072.1
SEVILLA/SAN PABLO	586.8	619.4	625.8	625.8	628.7	687.0	710.5	719.6	780.8	814.2	847.7	957.2
ARAGÓN												
CALAMOCHA	585.1	668.4	686.9	713.2	822.9	890.0	951.7	991.9	1145.3	1159.1	1175.7	1207.8
DAROCA	507.6	539.1	557.6	559.2	604.6	691.6	790.2	840.7	890.1	897.2	908.6	939.7
HUESCA/MONFLORITE	467.0	489.3	510.9	524.9	568.3	615.3	738.8	772.0	792.7	802.8	825.0	840.6
TERUEL	487.6	506.2	576.8	586.7	623.7	663.2	804.1	837.2	871.7	877.1	885.2	913.6
ZARAGOZA/AEROPUERTO	406.5	430.2	460.7	462.6	494.6	541.9	668.5	731.2	757.4	765.2	773.6	792.5
ASTURIAS												
ASTURIAS/AVILÉS	1006.4	1037.6	1103.6	1197.9	1243.3	1336.6	1447.3	1561.7	1672.0	1760.7	1868.0	1952.3
GIJÓN, MUSEL	881.5	900.8	953.8	1023.7	1050.5	1114.2	1196.3	1304.5	1404.2	1497.8	1614.5	1705.7
OVIEDO	1020.9	1051.5	1145.2	1192.4	1235.2	1308.7	1420.1	1583.0	1677.7	1790.6	1898.2	1957.1
BALEARES												
IBIZA/ES CODOLA	409.9	412.2	501.4	501.7	505.1	510.0	567.1	606.5	632.4	660.2	823.6	864.5
MENORCA/MAHÓN	775.5	821.1	842.5	843.9	847.3	857.5	986.6	1068.5	1118.4	1131.8	1269.9	1273.3
PALMA DE MALLORCA/SON	569.2	645.3	696.6	696.6	696.9	698.9	783.4	836.7	863.6	874.7	1036.0	1038.4

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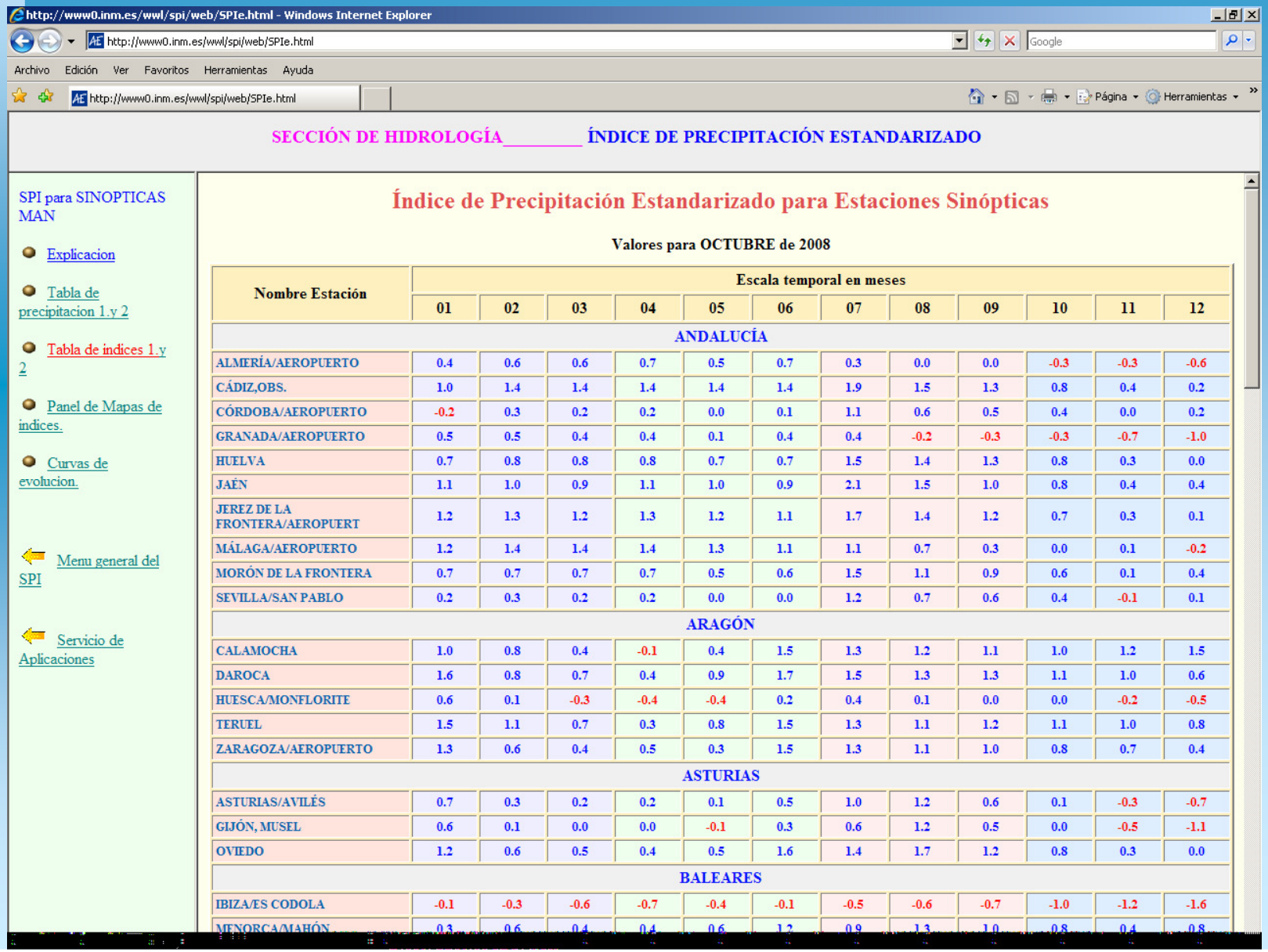
The outputs from the Drought Monitoring System



http://www0.inm.es/wwl/spi/web/SPIe.html - Windows Internet Explorer

http://www0.inm.es/wwl/spi/web/SPIe.html

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Página Herramientas

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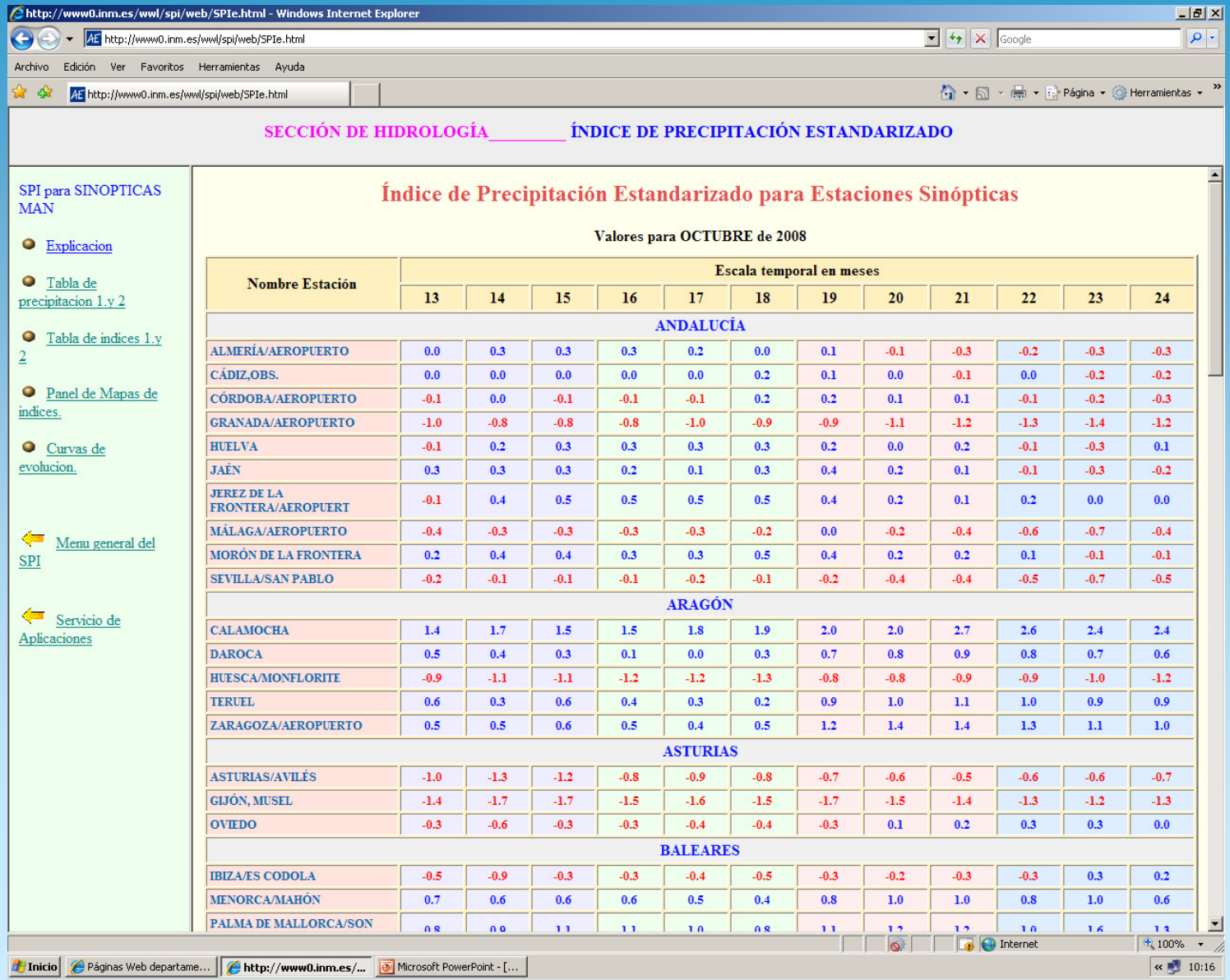
Valores para OCTUBRE de 2008

Nombre Estación	Escala temporal en meses											
	01	02	03	04	05	06	07	08	09	10	11	12
ANDALUCÍA												
ALMERÍA/AEROPUERTO	0.4	0.6	0.6	0.7	0.5	0.7	0.3	0.0	0.0	-0.3	-0.3	-0.6
CÁDIZ,OBS.	1.0	1.4	1.4	1.4	1.4	1.4	1.9	1.5	1.3	0.8	0.4	0.2
CÓRDOBA/AEROPUERTO	-0.2	0.3	0.2	0.2	0.0	0.1	1.1	0.6	0.5	0.4	0.0	0.2
GRANADA/AEROPUERTO	0.5	0.5	0.4	0.4	0.1	0.4	0.4	-0.2	-0.3	-0.3	-0.7	-1.0
HUELVA	0.7	0.8	0.8	0.8	0.7	0.7	1.5	1.4	1.3	0.8	0.3	0.0
JAÉN	1.1	1.0	0.9	1.1	1.0	0.9	2.1	1.5	1.0	0.8	0.4	0.4
JEREZ DE LA FRONTERA/AEROPUERT	1.2	1.3	1.2	1.3	1.2	1.1	1.7	1.4	1.2	0.7	0.3	0.1
MÁLAGA/AEROPUERTO	1.2	1.4	1.4	1.4	1.3	1.1	1.1	0.7	0.3	0.0	0.1	-0.2
MORÓN DE LA FRONTERA	0.7	0.7	0.7	0.7	0.5	0.6	1.5	1.1	0.9	0.6	0.1	0.4
SEVILLA/SAN PABLO	0.2	0.3	0.2	0.2	0.0	0.0	1.2	0.7	0.6	0.4	-0.1	0.1
ARAGÓN												
CALAMOCHA	1.0	0.8	0.4	-0.1	0.4	1.5	1.3	1.2	1.1	1.0	1.2	1.5
DAROCA	1.6	0.8	0.7	0.4	0.9	1.7	1.5	1.3	1.3	1.1	1.0	0.6
HUESCA/MONFLORITE	0.6	0.1	-0.3	-0.4	-0.4	0.2	0.4	0.1	0.0	0.0	-0.2	-0.5
TERUEL	1.5	1.1	0.7	0.3	0.8	1.5	1.3	1.1	1.2	1.1	1.0	0.8
ZARAGOZA/AEROPUERTO	1.3	0.6	0.4	0.5	0.3	1.5	1.3	1.1	1.0	0.8	0.7	0.4
ASTURIAS												
ASTURIAS/AVILÉS	0.7	0.3	0.2	0.2	0.1	0.5	1.0	1.2	0.6	0.1	-0.3	-0.7
GIJÓN, MUSEL	0.6	0.1	0.0	0.0	-0.1	0.3	0.6	1.2	0.5	0.0	-0.5	-1.1
OVIEDO	1.2	0.6	0.5	0.4	0.5	1.6	1.4	1.7	1.2	0.8	0.3	0.0
BALEARES												
IBIZA/ES CODOLA	-0.1	-0.3	-0.6	-0.7	-0.4	-0.1	-0.5	-0.6	-0.7	-1.0	-1.2	-1.6
MENORCA/MAHÓN	0.3	0.6	0.4	0.4	0.6	1.2	0.9	1.3	1.0	0.8	0.4	0.8

The outputs from the Drought Monitoring System



http://www0.inm.es/wwl/spi/web/SPIe.html - Windows Internet Explorer

http://www0.inm.es/wwl/spi/web/SPIe.html

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Valores para OCTUBRE de 2008

Nombre Estación	Escala temporal en meses											
	13	14	15	16	17	18	19	20	21	22	23	24
ANDALUCÍA												
ALMERÍA/AEROPUERTO	0.0	0.3	0.3	0.3	0.2	0.0	0.1	-0.1	-0.3	-0.2	-0.3	-0.3
CÁDIZ,OBS.	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	-0.1	0.0	-0.2	-0.2
CÓRDOBA/AEROPUERTO	-0.1	0.0	-0.1	-0.1	-0.1	0.2	0.2	0.1	0.1	-0.1	-0.2	-0.3
GRANADA/AEROPUERTO	-1.0	-0.8	-0.8	-0.8	-1.0	-0.9	-0.9	-1.1	-1.2	-1.3	-1.4	-1.2
HUELVA	-0.1	0.2	0.3	0.3	0.3	0.3	0.2	0.0	0.2	-0.1	-0.3	0.1
JAÉN	0.3	0.3	0.3	0.2	0.1	0.3	0.4	0.2	0.1	-0.1	-0.3	-0.2
JEREZ DE LA FRONTERA/AEROPUERT	-0.1	0.4	0.5	0.5	0.5	0.5	0.4	0.2	0.1	0.2	0.0	0.0
MÁLAGA/AEROPUERTO	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	0.0	-0.2	-0.4	-0.6	-0.7	-0.4
MORÓN DE LA FRONTERA	0.2	0.4	0.4	0.3	0.3	0.5	0.4	0.2	0.2	0.1	-0.1	-0.1
SEVILLA/SAN PABLO	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.2	-0.4	-0.4	-0.5	-0.7	-0.5
ARAGÓN												
CALAMOCHA	1.4	1.7	1.5	1.5	1.8	1.9	2.0	2.0	2.7	2.6	2.4	2.4
DAROCA	0.5	0.4	0.3	0.1	0.0	0.3	0.7	0.8	0.9	0.8	0.7	0.6
HUESCA/MONFLORITE	-0.9	-1.1	-1.1	-1.2	-1.2	-1.3	-0.8	-0.8	-0.9	-0.9	-1.0	-1.2
TERUEL	0.6	0.3	0.6	0.4	0.3	0.2	0.9	1.0	1.1	1.0	0.9	0.9
ZARAGOZA/AEROPUERTO	0.5	0.5	0.6	0.5	0.4	0.5	1.2	1.4	1.4	1.3	1.1	1.0
ASTURIAS												
ASTURIAS/AVILÉS	-1.0	-1.3	-1.2	-0.8	-0.9	-0.8	-0.7	-0.6	-0.5	-0.6	-0.6	-0.7
GIJÓN, MUSEL	-1.4	-1.7	-1.7	-1.5	-1.6	-1.5	-1.7	-1.5	-1.4	-1.3	-1.2	-1.3
OVIEDO	-0.3	-0.6	-0.3	-0.3	-0.4	-0.4	-0.3	0.1	0.2	0.3	0.3	0.0
BALEARES												
IBIZA/ES CODOLA	-0.5	-0.9	-0.3	-0.3	-0.4	-0.5	-0.3	-0.2	-0.3	-0.3	0.3	0.2
MENORCA/MAHÓN	0.7	0.6	0.6	0.6	0.5	0.4	0.8	1.0	1.0	0.8	1.0	0.6
PALMA DE MALLORCA/SON	0.8	0.9	1.1	1.1	1.0	0.8	1.1	1.2	1.2	1.0	1.6	1.3

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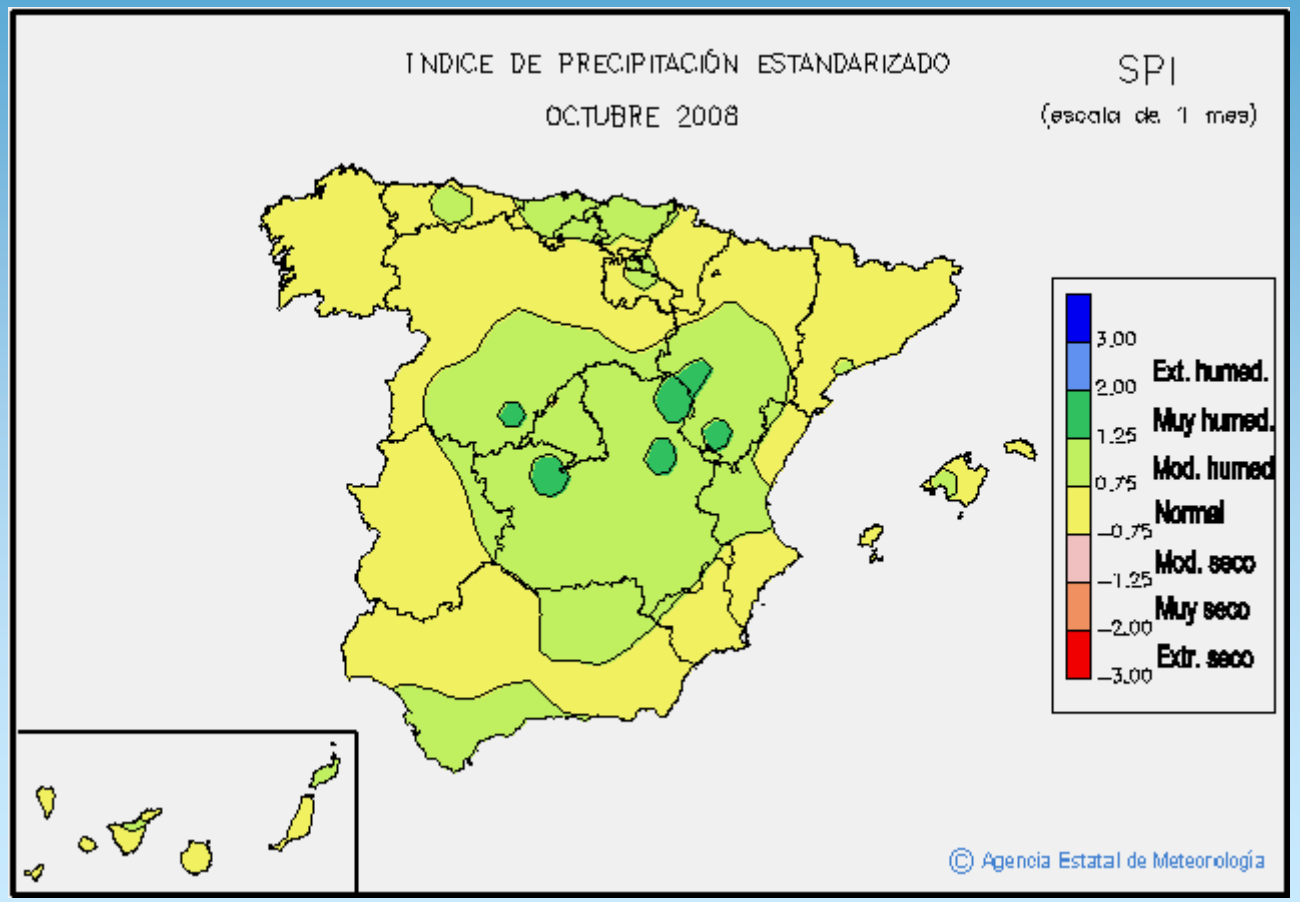
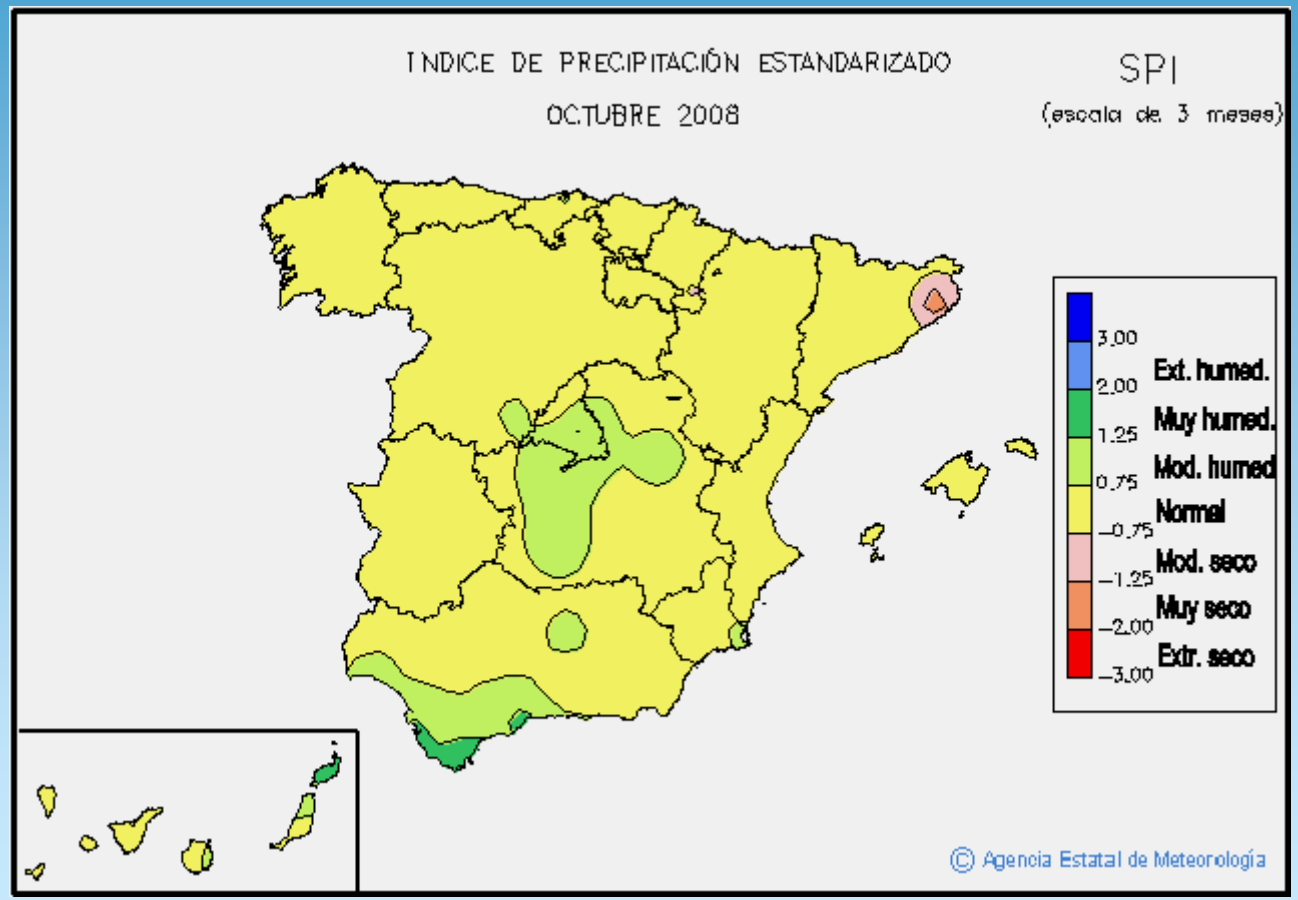
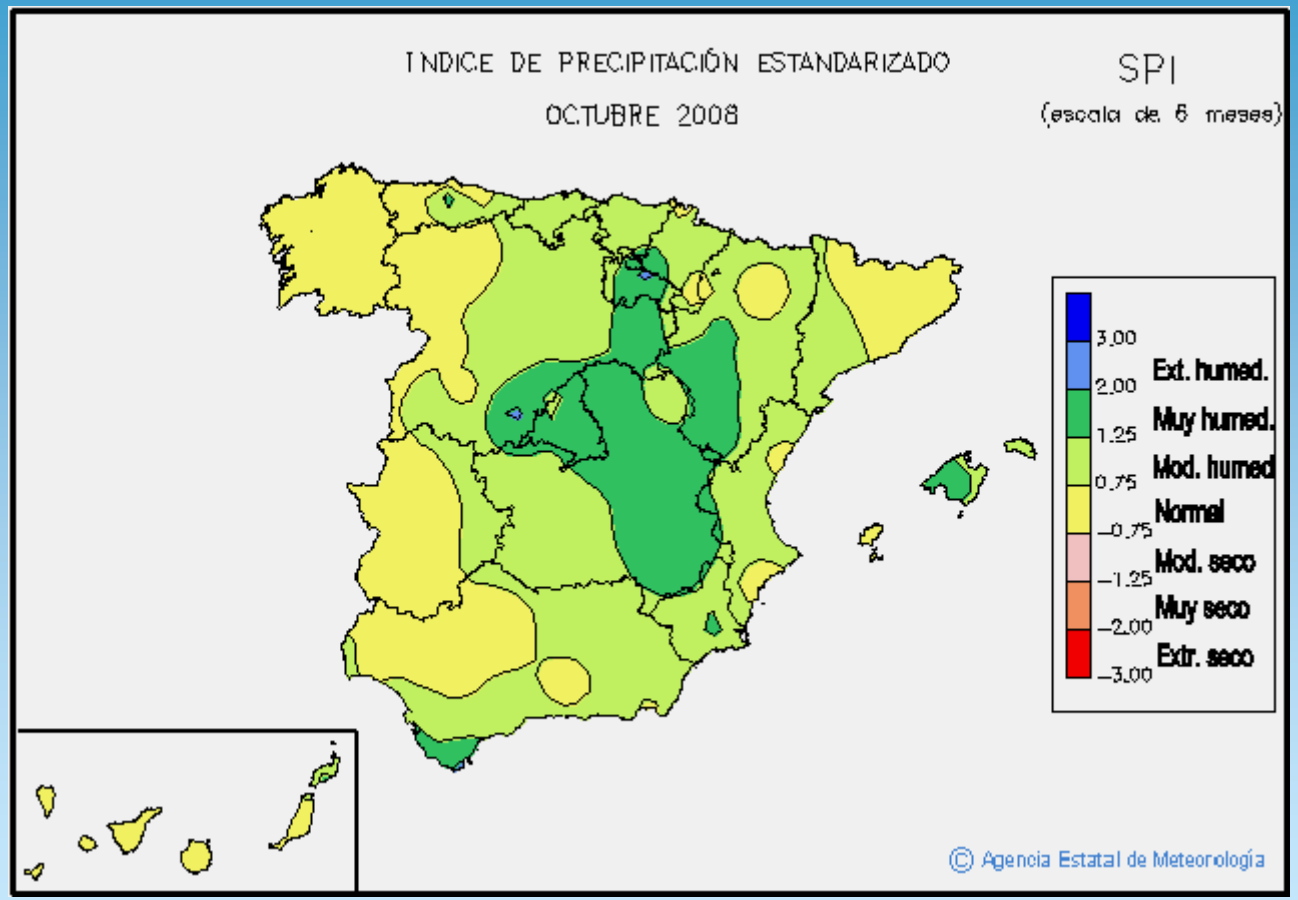
The outputs from the Drought Monitoring System



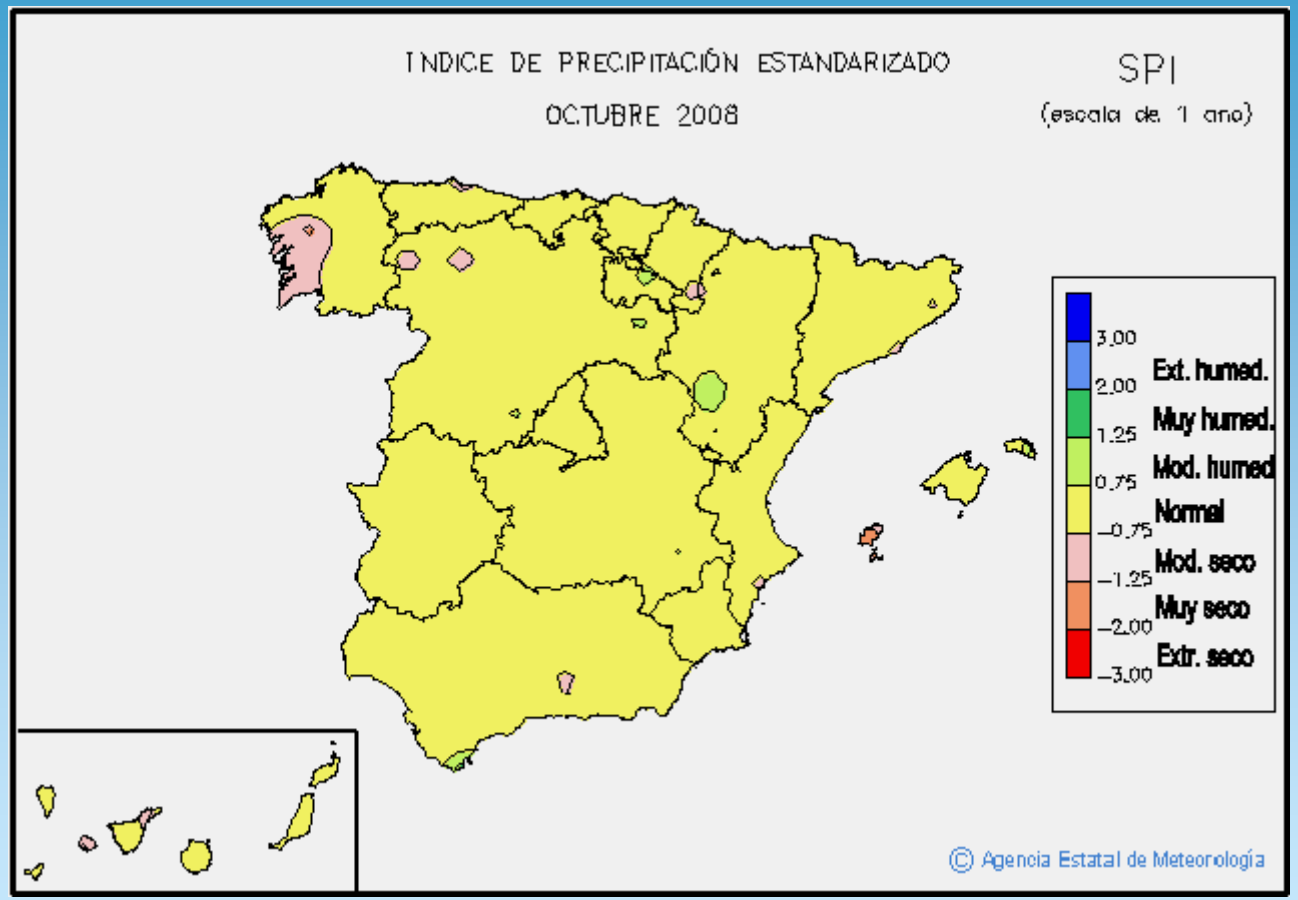
The outputs from the Drought Monitoring System



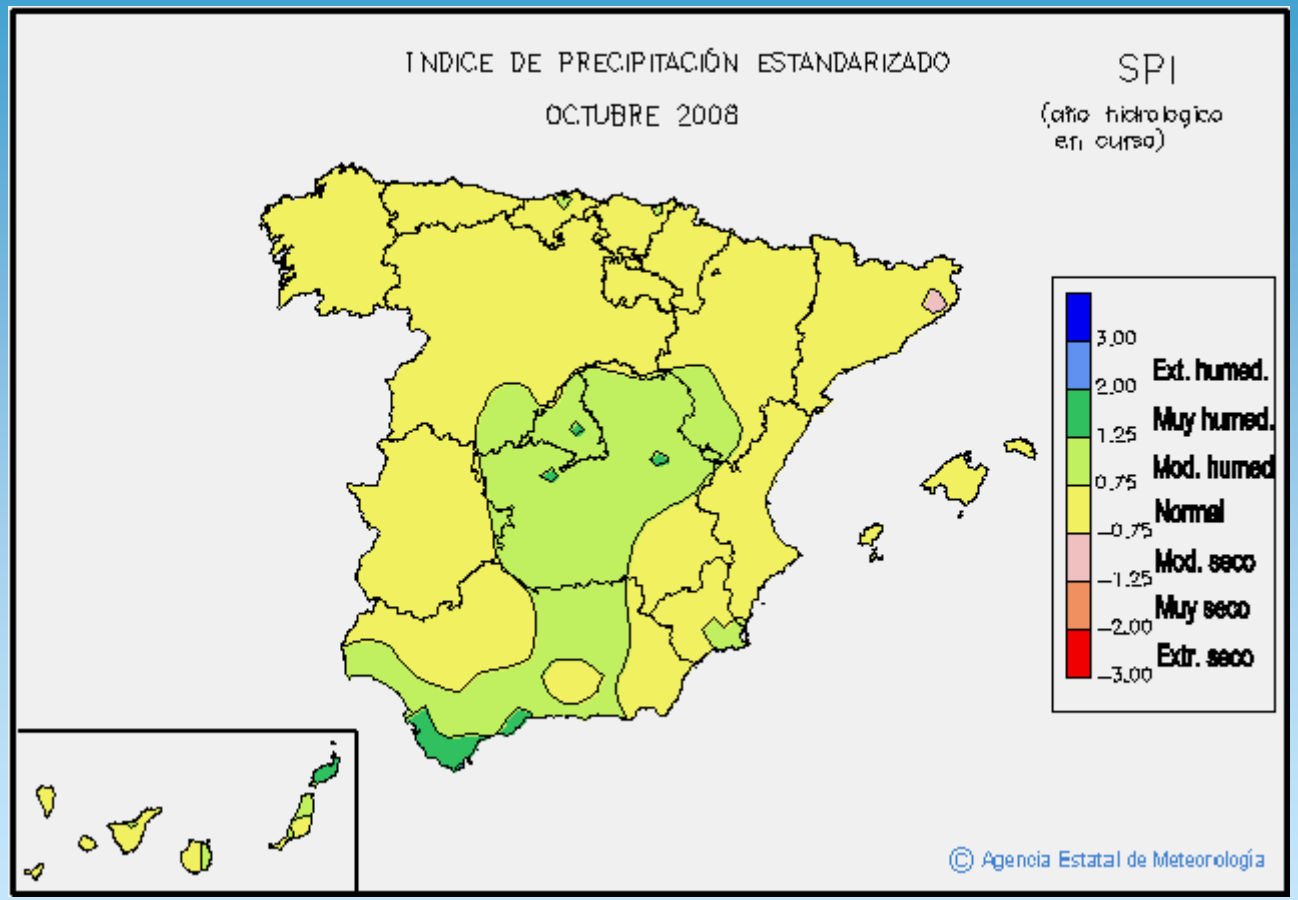
The outputs from the Drought Monitoring System



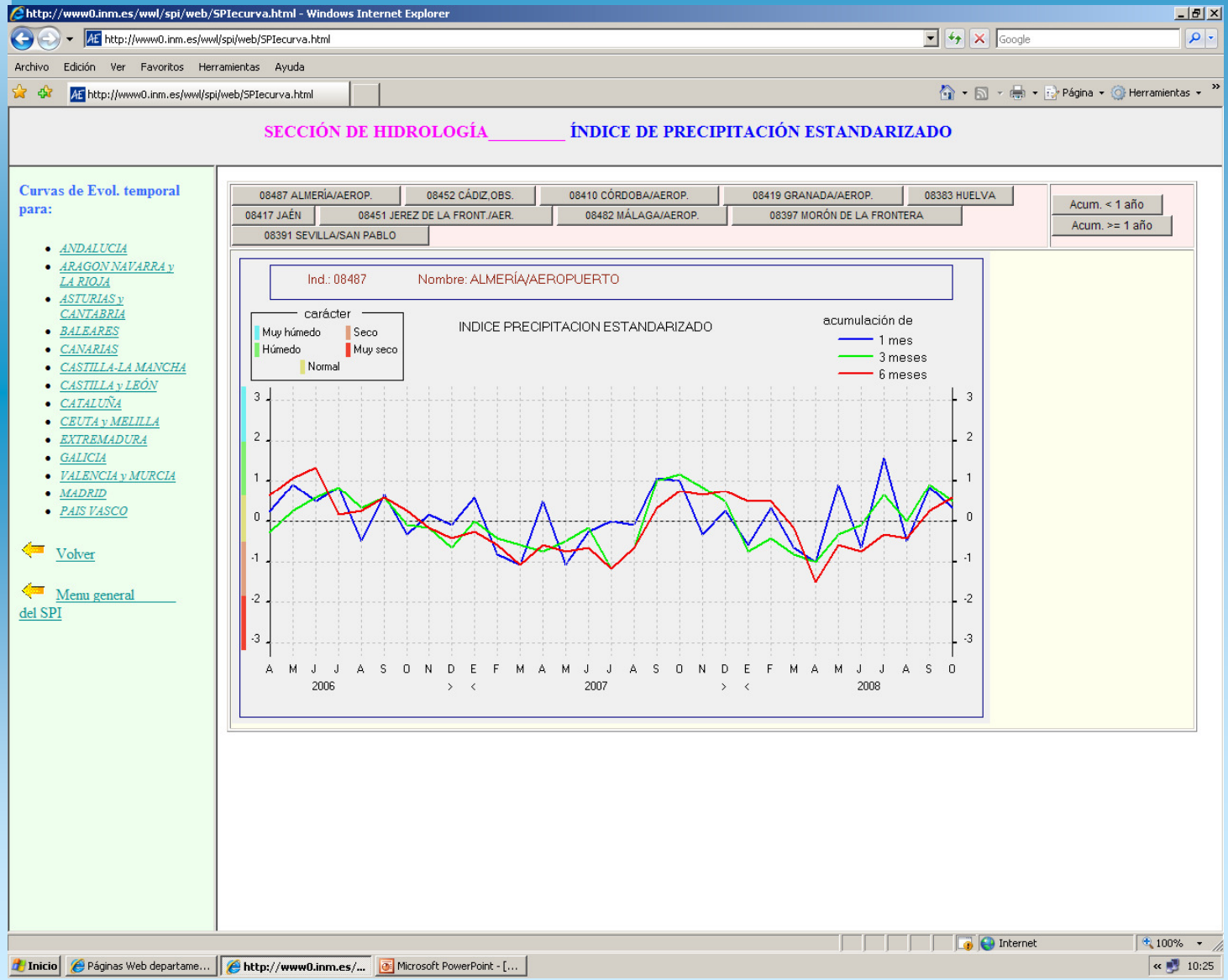
The outputs from the Drought Monitoring System



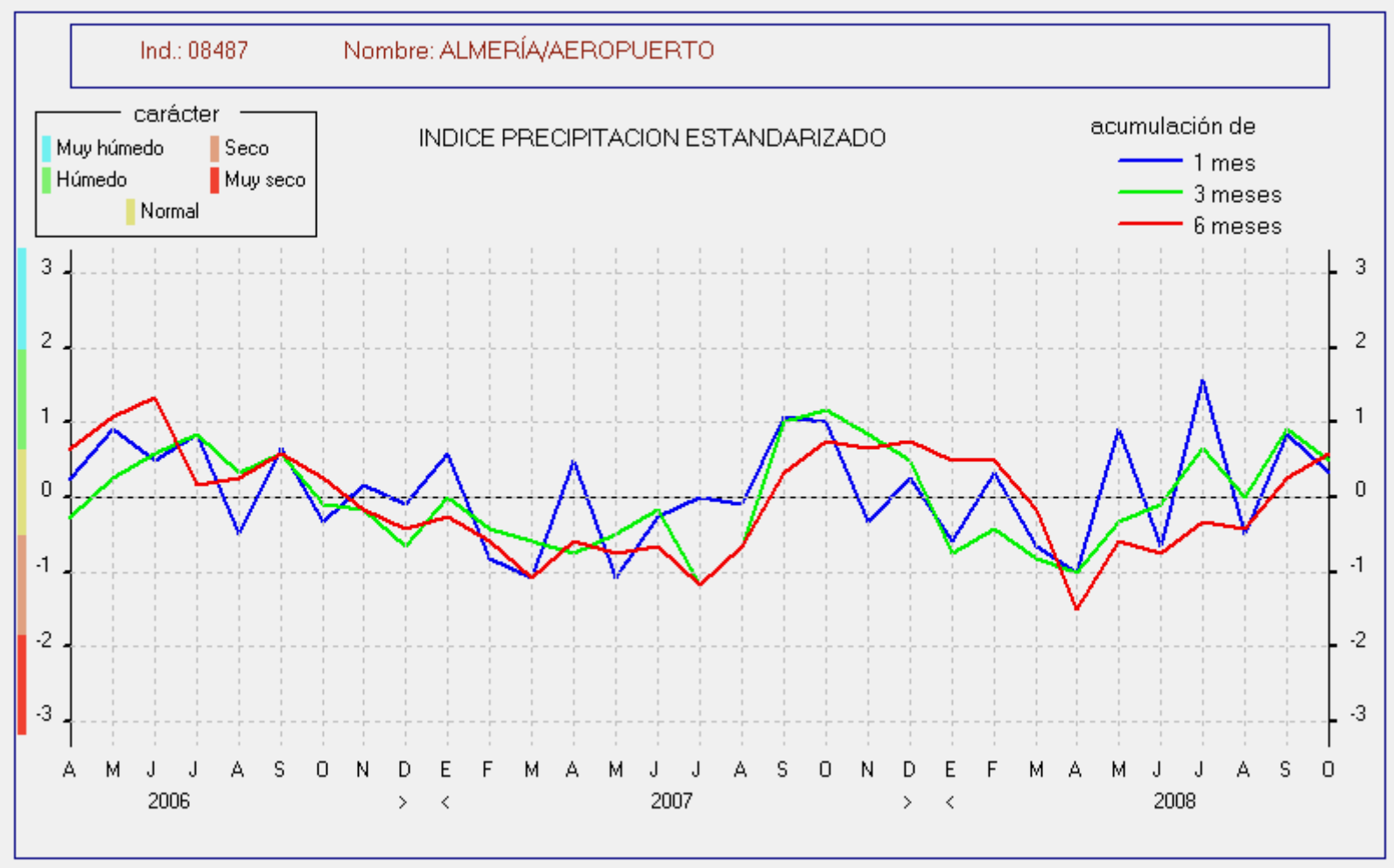
The outputs from the Drought Monitoring System



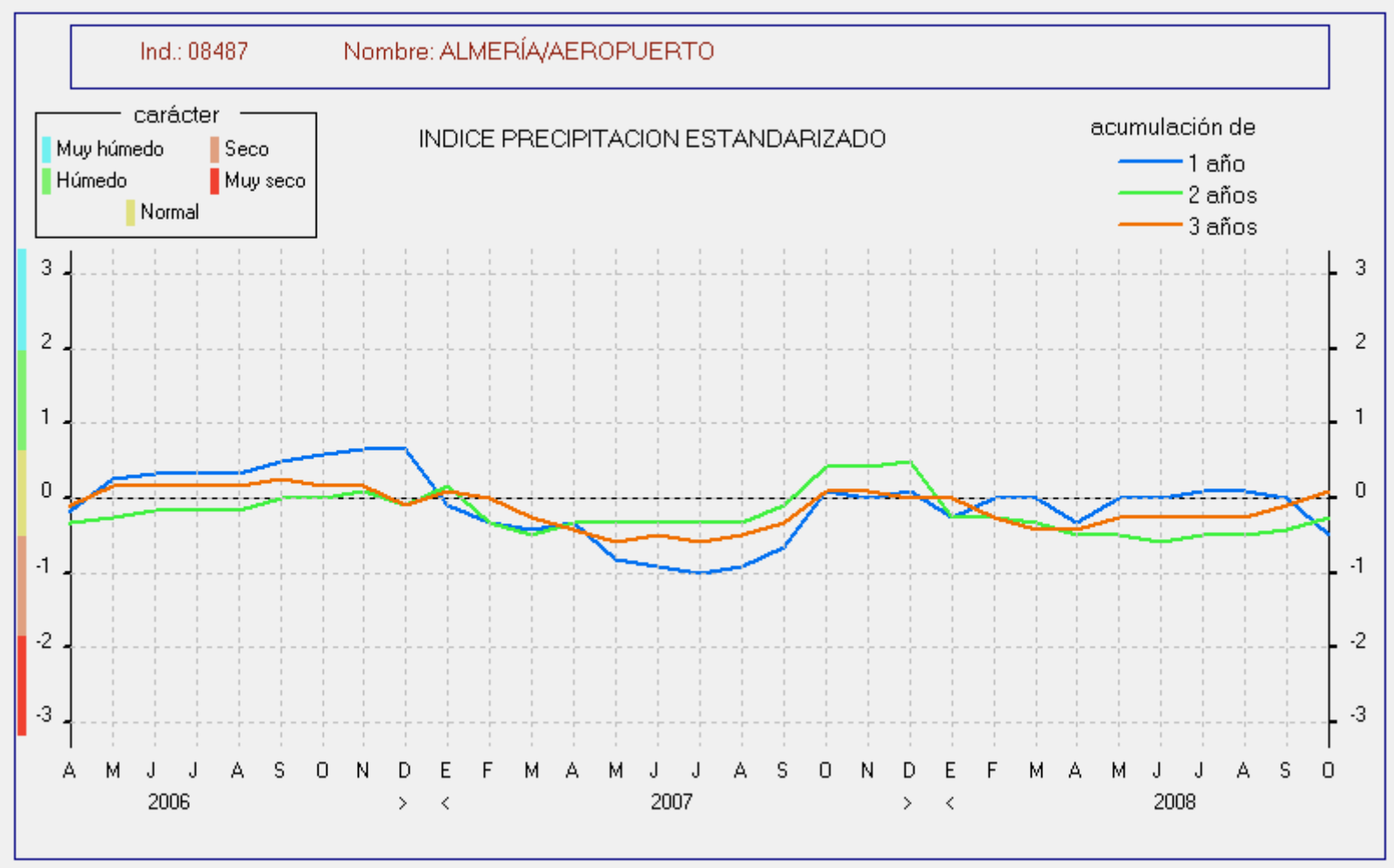
The outputs from the Drought Monitoring System



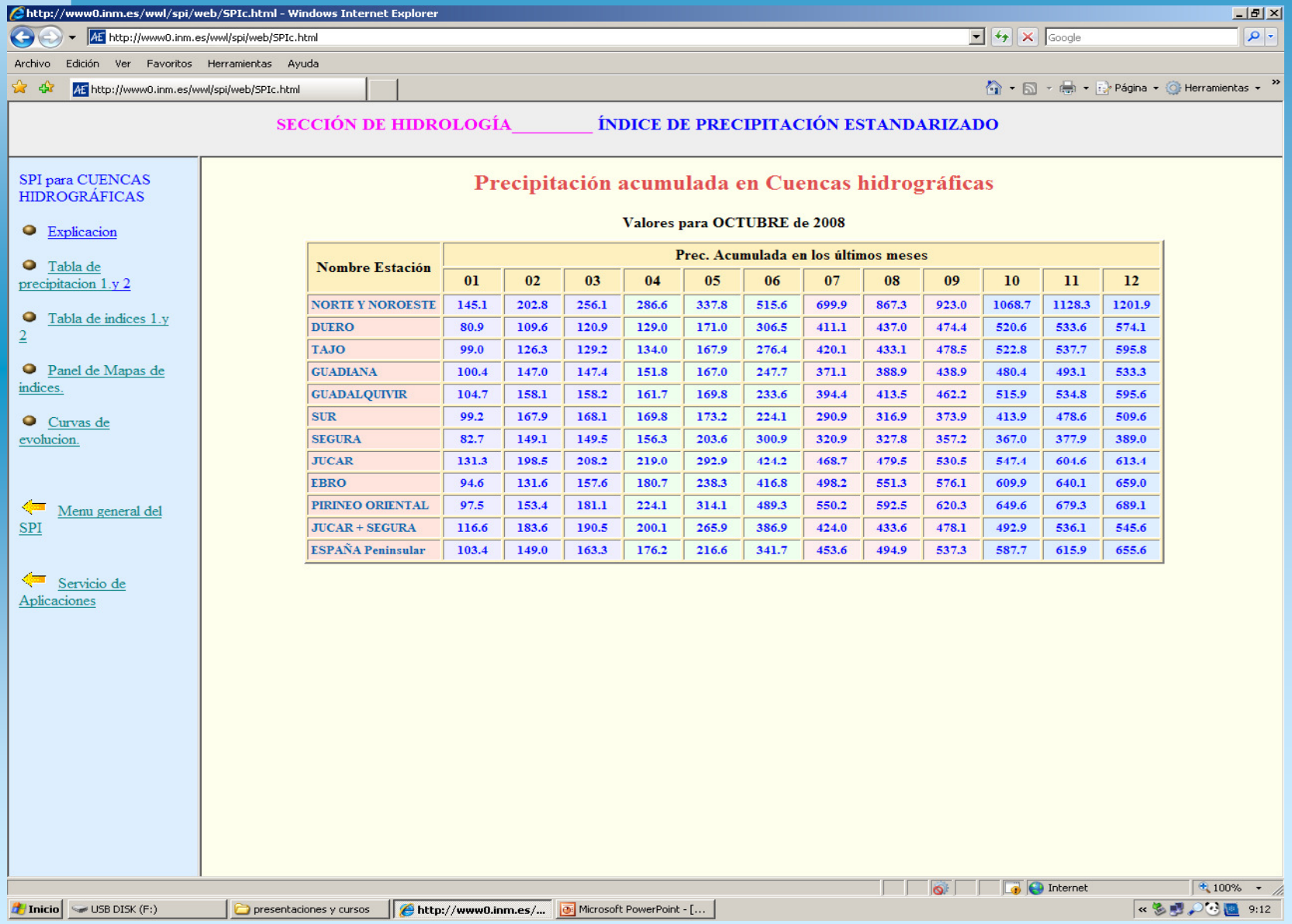
The outputs from the Drought Monitoring System



The outputs from the Drought Monitoring System



The outputs from the Drought Monitoring System



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http://www0.inm.es/wwl/spi/web/SPIc.html

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Precipitación acumulada en Cuencas hidrográficas

Valores para OCTUBRE de 2008

Nombre Estación	Prec. Acumulada en los últimos meses											
	01	02	03	04	05	06	07	08	09	10	11	12
NORTE Y NOROESTE	145.1	202.8	256.1	286.6	337.8	515.6	699.9	867.3	923.0	1068.7	1128.3	1201.9
DUERO	80.9	109.6	120.9	129.0	171.0	306.5	411.1	437.0	474.4	520.6	533.6	574.1
TAJO	99.0	126.3	129.2	134.0	167.9	276.4	420.1	433.1	478.5	522.8	537.7	595.8
GUADIANA	100.4	147.0	147.4	151.8	167.0	247.7	371.1	388.9	438.9	480.4	493.1	533.3
GUADALQUIVIR	104.7	158.1	158.2	161.7	169.8	233.6	394.4	413.5	462.2	515.9	534.8	595.6
SUR	99.2	167.9	168.1	169.8	173.2	224.1	290.9	316.9	373.9	413.9	478.6	509.6
SEGURA	82.7	149.1	149.5	156.3	203.6	300.9	320.9	327.8	357.2	367.0	377.9	389.0
JUCAR	131.3	198.5	208.2	219.0	292.9	424.2	468.7	479.5	530.5	547.4	604.6	613.4
EBRO	94.6	131.6	157.6	180.7	238.3	416.8	498.2	551.3	576.1	609.9	640.1	659.0
PIRINEO ORIENTAL	97.5	153.4	181.1	224.1	314.1	489.3	550.2	592.5	620.3	649.6	679.3	689.1
JUCAR + SEGURA	116.6	183.6	190.5	200.1	265.9	386.9	424.0	433.6	478.1	492.9	536.1	545.6
ESPAÑA Peninsular	103.4	149.0	163.3	176.2	216.6	341.7	453.6	494.9	537.3	587.7	615.9	655.6

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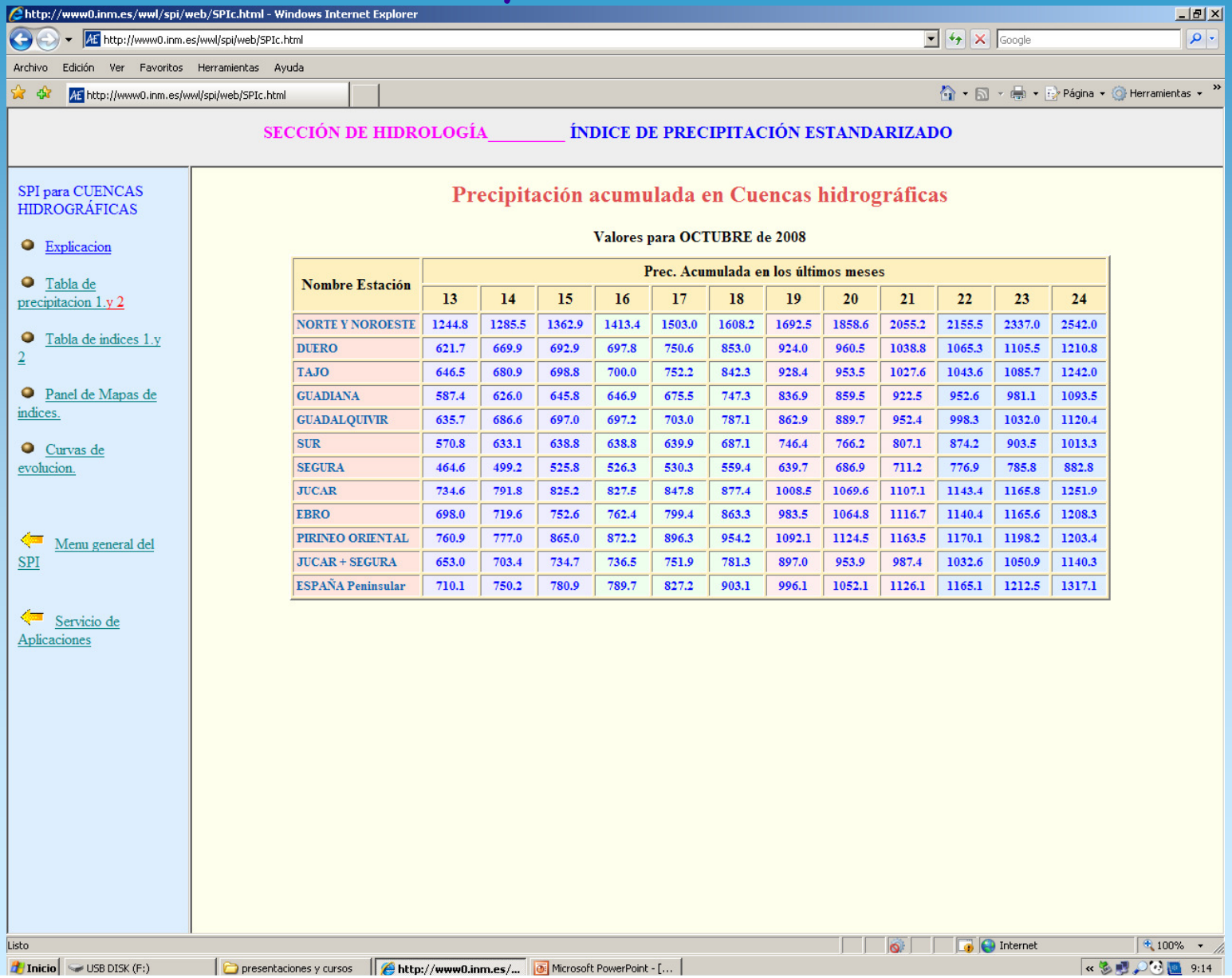
The outputs from the Drought Monitoring System



http://www0.inm.es/wwl/spi/web/SPIc.html - Windows Internet Explorer

http://www0.inm.es/wwl/spi/web/SPIc.html

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Precipitación acumulada en Cuencas hidrográficas

Valores para OCTUBRE de 2008

Nombre Estación	Prec. Acumulada en los últimos meses											
	13	14	15	16	17	18	19	20	21	22	23	24
NORTE Y NOROESTE	1244.8	1285.5	1362.9	1413.4	1503.0	1608.2	1692.5	1858.6	2055.2	2155.5	2337.0	2542.0
DUERO	621.7	669.9	692.9	697.8	750.6	853.0	924.0	960.5	1038.8	1065.3	1105.5	1210.8
TAJO	646.5	680.9	698.8	700.0	752.2	842.3	928.4	953.5	1027.6	1043.6	1085.7	1242.0
GUADIANA	587.4	626.0	645.8	646.9	675.5	747.3	836.9	859.5	922.5	952.6	981.1	1093.5
GUADALQUIVIR	635.7	686.6	697.0	697.2	703.0	787.1	862.9	889.7	952.4	998.3	1032.0	1120.4
SUR	570.8	633.1	638.8	638.8	639.9	687.1	746.4	766.2	807.1	874.2	903.5	1013.3
SEGURA	464.6	499.2	525.8	526.3	530.3	559.4	639.7	686.9	711.2	776.9	785.8	882.8
JUCAR	734.6	791.8	825.2	827.5	847.8	877.4	1008.5	1069.6	1107.1	1143.4	1165.8	1251.9
EBRO	698.0	719.6	752.6	762.4	799.4	863.3	983.5	1064.8	1116.7	1140.4	1165.6	1208.3
PIRINEO ORIENTAL	760.9	777.0	865.0	872.2	896.3	954.2	1092.1	1124.5	1163.5	1170.1	1198.2	1203.4
JUCAR + SEGURA	653.0	703.4	734.7	736.5	751.9	781.3	897.0	953.9	987.4	1032.6	1050.9	1140.3
ESPAÑA Peninsular	710.1	750.2	780.9	789.7	827.2	903.1	996.1	1052.1	1126.1	1165.1	1212.5	1317.1

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Inicio USB DISK (F:) presentaciones y cursos http://www0.inm.es/... Microsoft PowerPoint - [...

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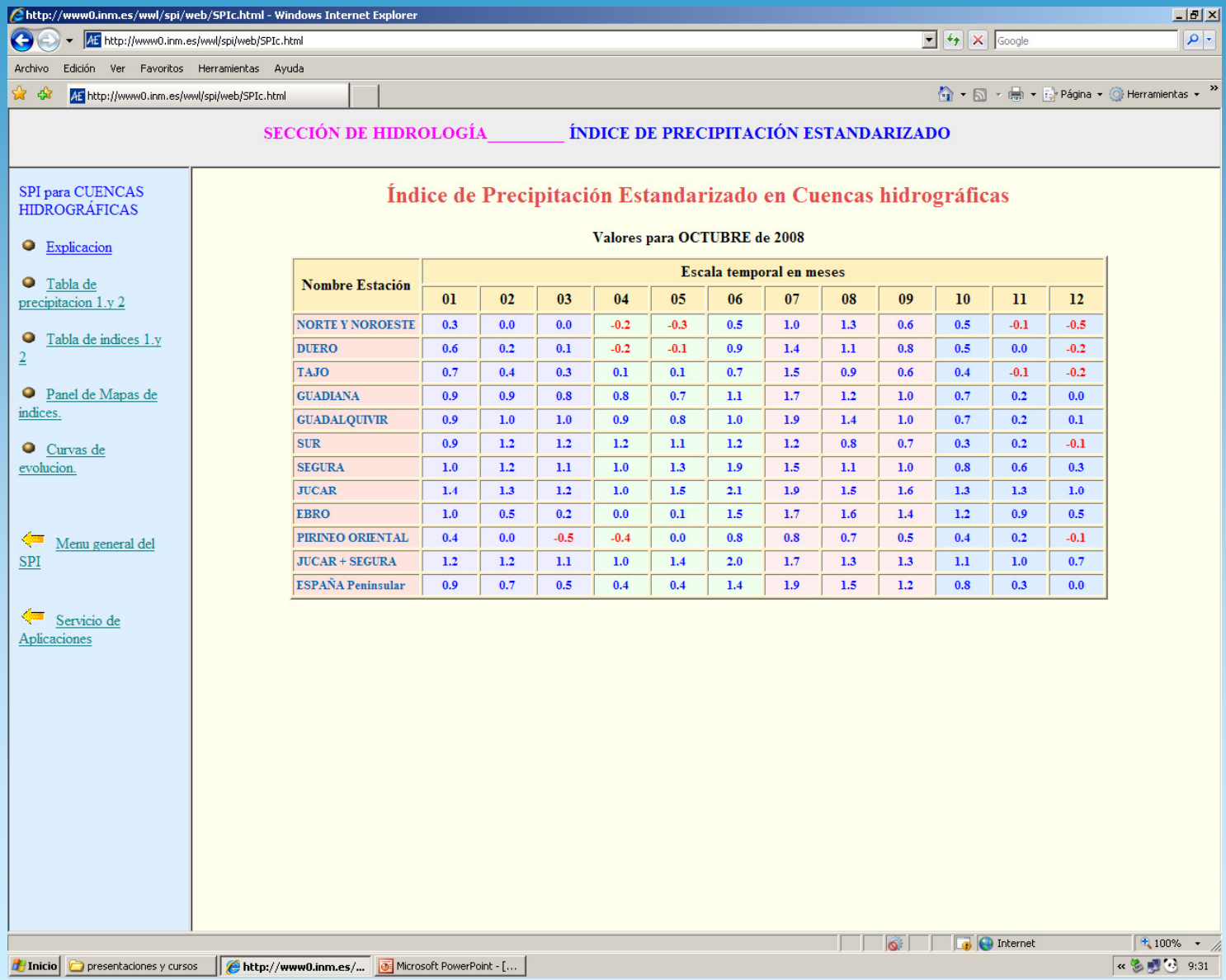
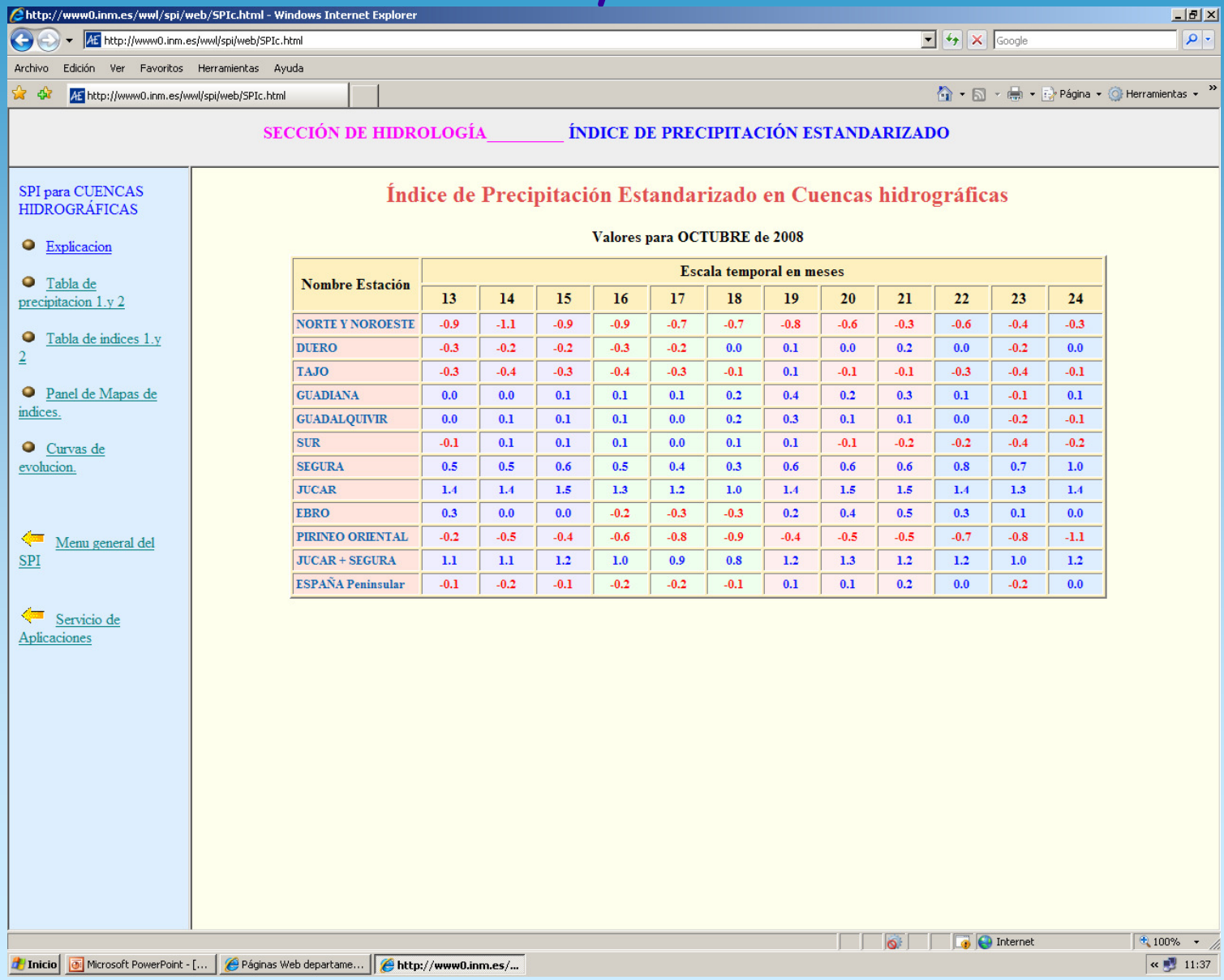
The outputs from the Drought Monitoring System



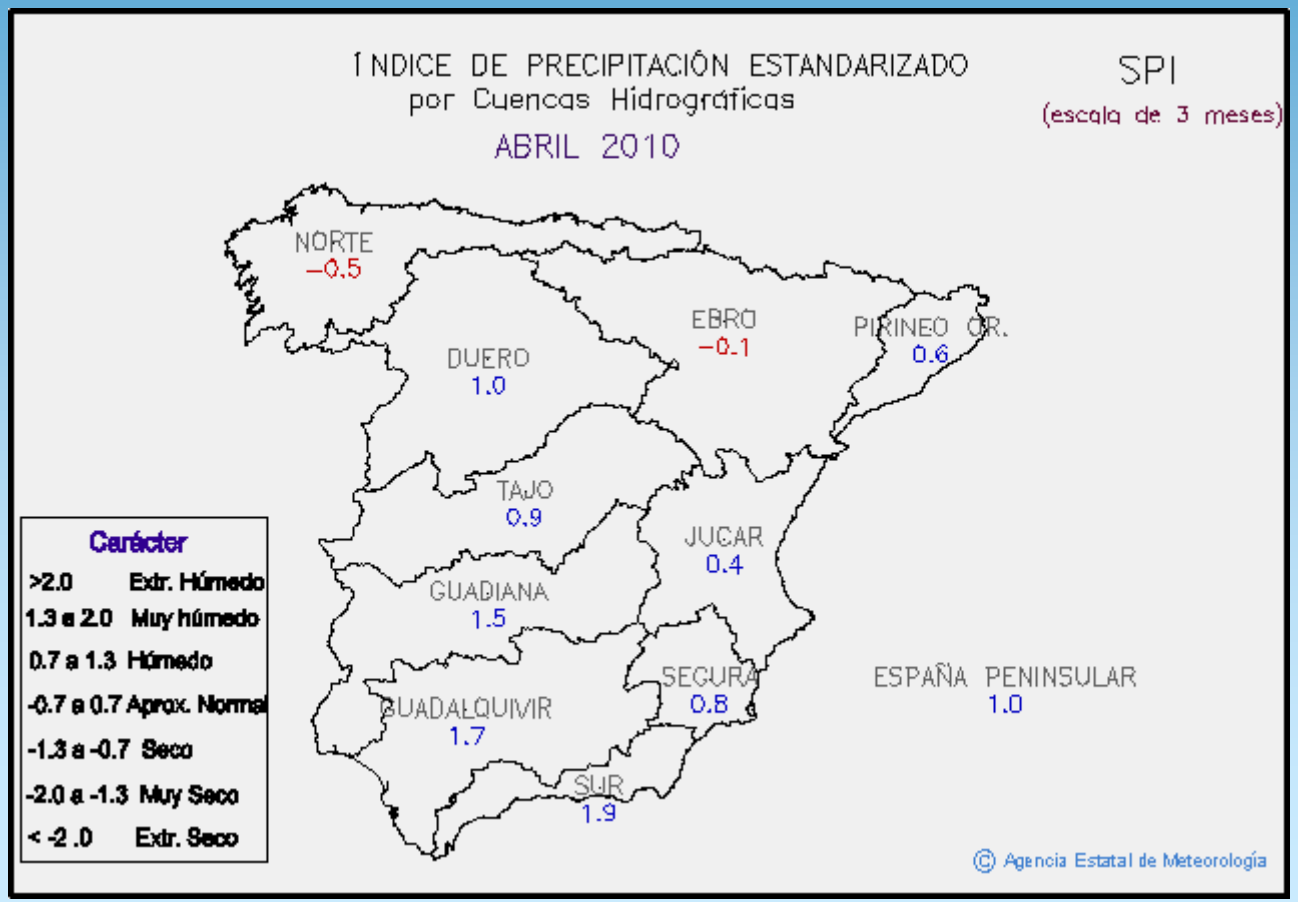
Nombre Estación	Escala temporal en meses											
	01	02	03	04	05	06	07	08	09	10	11	12
NORTE Y NOROESTE	0.3	0.0	0.0	-0.2	-0.3	0.5	1.0	1.3	0.6	0.5	-0.1	-0.5
DUERO	0.6	0.2	0.1	-0.2	-0.1	0.9	1.4	1.1	0.8	0.5	0.0	-0.2
TAJO	0.7	0.4	0.3	0.1	0.1	0.7	1.5	0.9	0.6	0.4	-0.1	-0.2
GUADIANA	0.9	0.9	0.8	0.8	0.7	1.1	1.7	1.2	1.0	0.7	0.2	0.0
GUADALQUIVIR	0.9	1.0	1.0	0.9	0.8	1.0	1.9	1.4	1.0	0.7	0.2	0.1
SUR	0.9	1.2	1.2	1.2	1.1	1.2	1.2	0.8	0.7	0.3	0.2	-0.1
SEGURA	1.0	1.2	1.1	1.0	1.3	1.9	1.5	1.1	1.0	0.8	0.6	0.3
JUCAR	1.4	1.3	1.2	1.0	1.5	2.1	1.9	1.5	1.6	1.3	1.3	1.0
EBRO	1.0	0.5	0.2	0.0	0.1	1.5	1.7	1.6	1.4	1.2	0.9	0.5
PIRINEO ORIENTAL	0.4	0.0	-0.5	-0.4	0.0	0.8	0.8	0.7	0.5	0.4	0.2	-0.1
JUCAR + SEGURA	1.2	1.2	1.1	1.0	1.4	2.0	1.7	1.3	1.3	1.1	1.0	0.7
ESPAÑA Peninsular	0.9	0.7	0.5	0.4	0.4	1.4	1.9	1.5	1.2	0.8	0.3	0.0

The outputs from the Drought Monitoring System

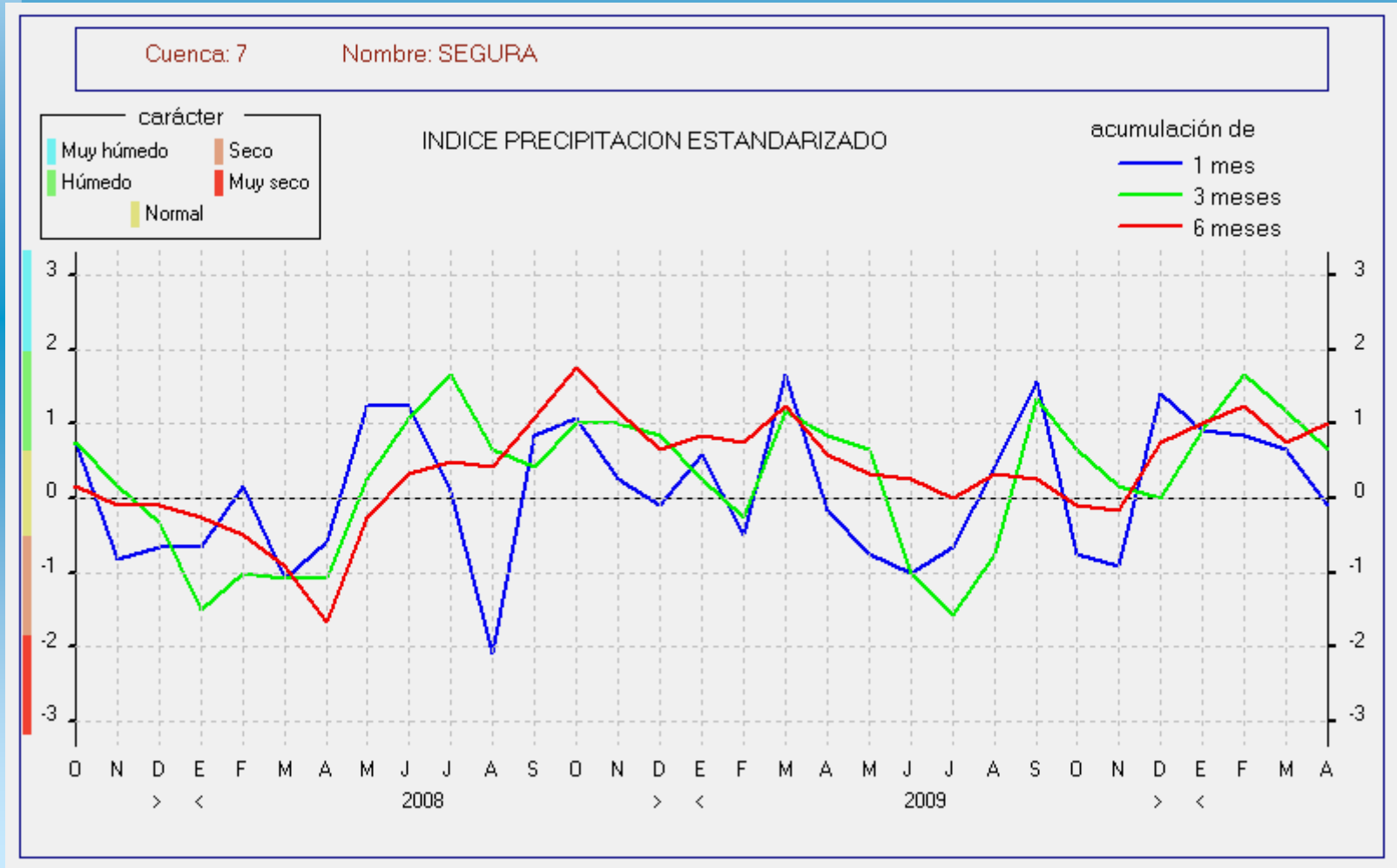


Nombre Estación	Escala temporal en meses											
	13	14	15	16	17	18	19	20	21	22	23	24
NORTE Y NOROESTE	-0.9	-1.1	-0.9	-0.9	-0.7	-0.7	-0.8	-0.6	-0.3	-0.6	-0.4	-0.3
DUERO	-0.3	-0.2	-0.2	-0.3	-0.2	0.0	0.1	0.0	0.2	0.0	-0.2	0.0
TAJO	-0.3	-0.4	-0.3	-0.4	-0.3	-0.1	0.1	-0.1	-0.1	-0.3	-0.4	-0.1
GUADIANA	0.0	0.0	0.1	0.1	0.1	0.2	0.4	0.2	0.3	0.1	-0.1	0.1
GUADALQUIVIR	0.0	0.1	0.1	0.1	0.0	0.2	0.3	0.1	0.1	0.0	-0.2	-0.1
SUR	-0.1	0.1	0.1	0.1	0.0	0.1	0.1	-0.1	-0.2	-0.2	-0.4	-0.2
SEGURA	0.5	0.5	0.6	0.5	0.4	0.3	0.6	0.6	0.6	0.8	0.7	1.0
JUCAR	1.4	1.4	1.5	1.3	1.2	1.0	1.4	1.5	1.5	1.4	1.3	1.4
EBRO	0.3	0.0	0.0	-0.2	-0.3	-0.3	0.2	0.4	0.5	0.3	0.1	0.0
PIRINEO ORIENTAL	-0.2	-0.5	-0.4	-0.6	-0.8	-0.9	-0.4	-0.5	-0.5	-0.7	-0.8	-1.1
JUCAR + SEGURA	1.1	1.1	1.2	1.0	0.9	0.8	1.2	1.3	1.2	1.2	1.0	1.2
ESPAÑA Peninsular	-0.1	-0.2	-0.1	-0.2	-0.2	-0.1	0.1	0.1	0.2	0.0	-0.2	0.0

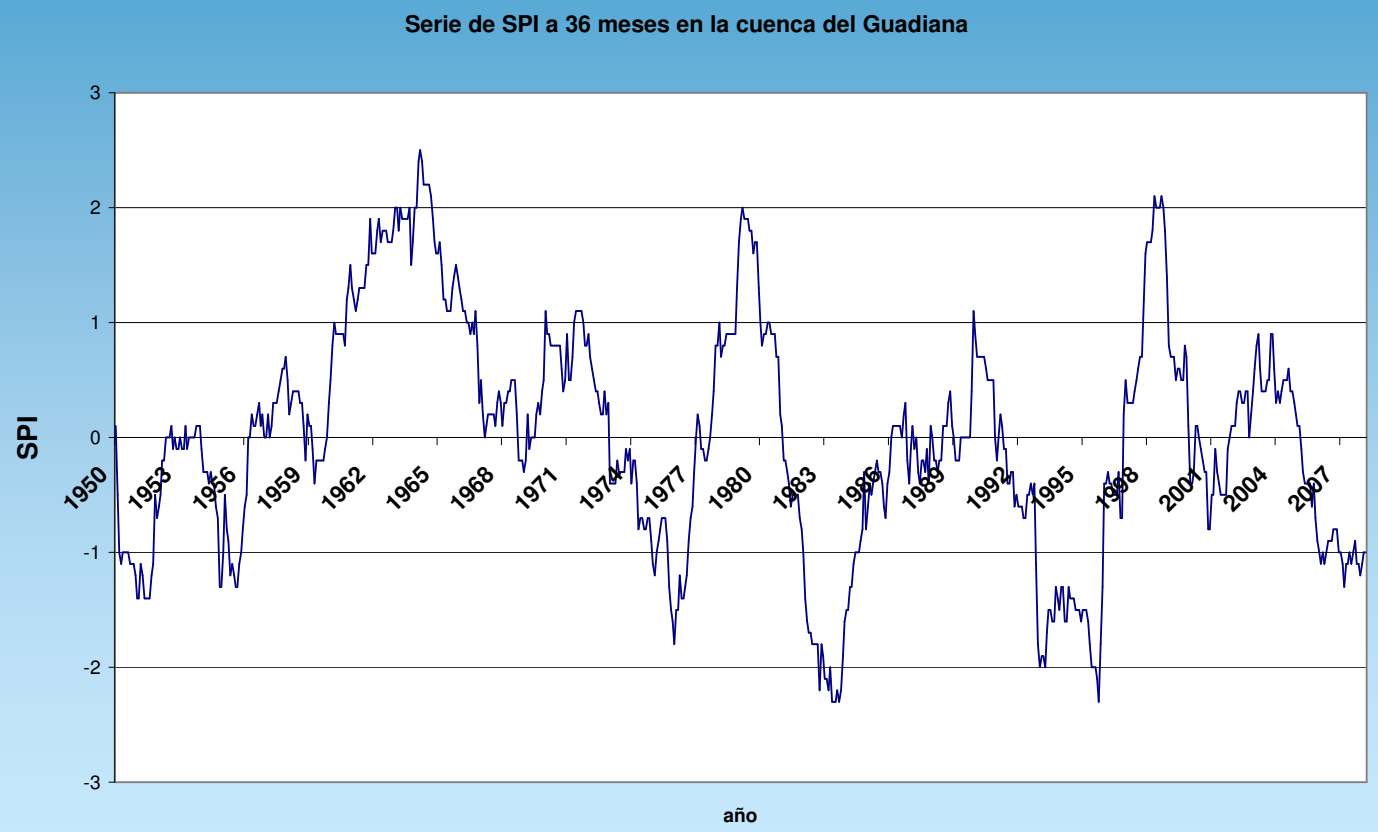
The outputs from the Drought Monitoring System



The outputs from the Drought Monitoring System



Drought monitoring: application to the 1991-95 severe drought in Southern Spain .



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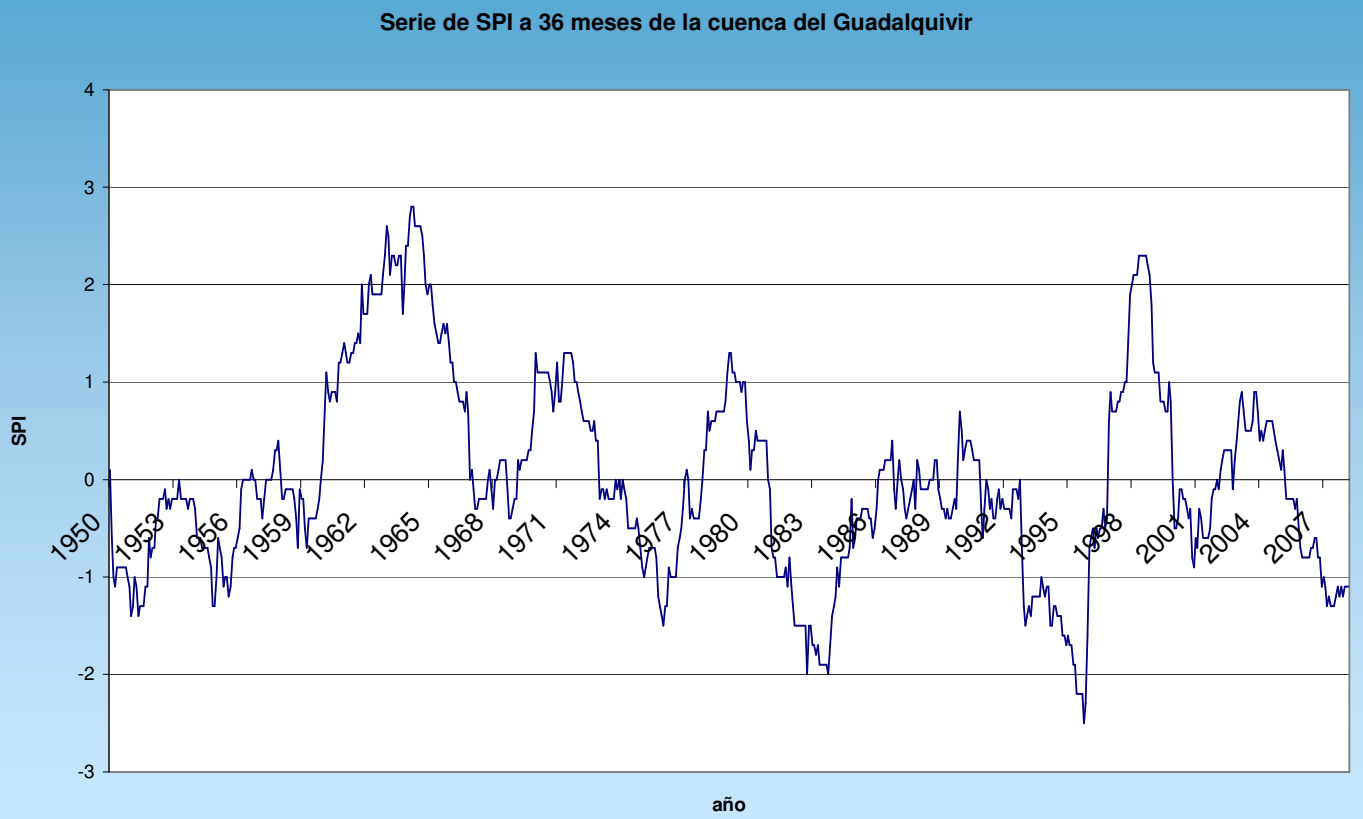

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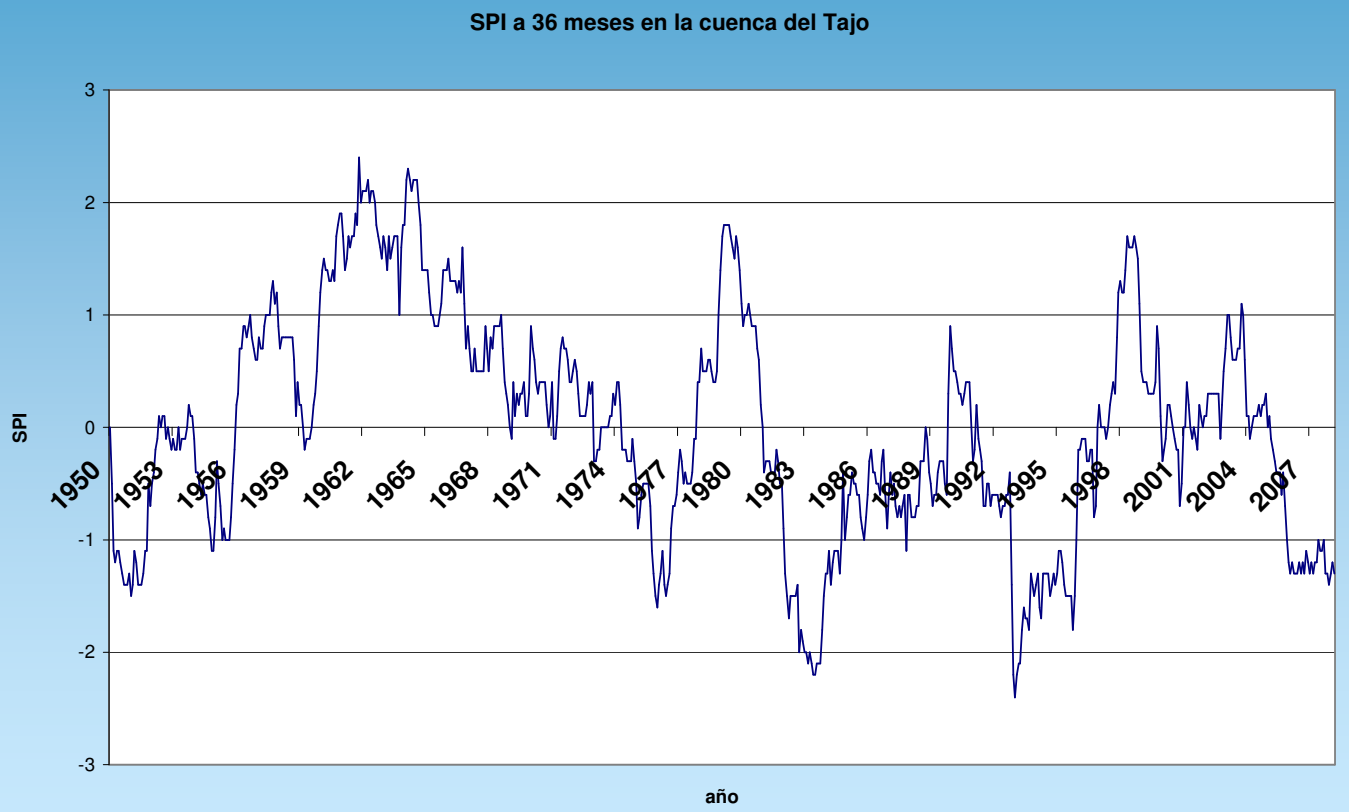
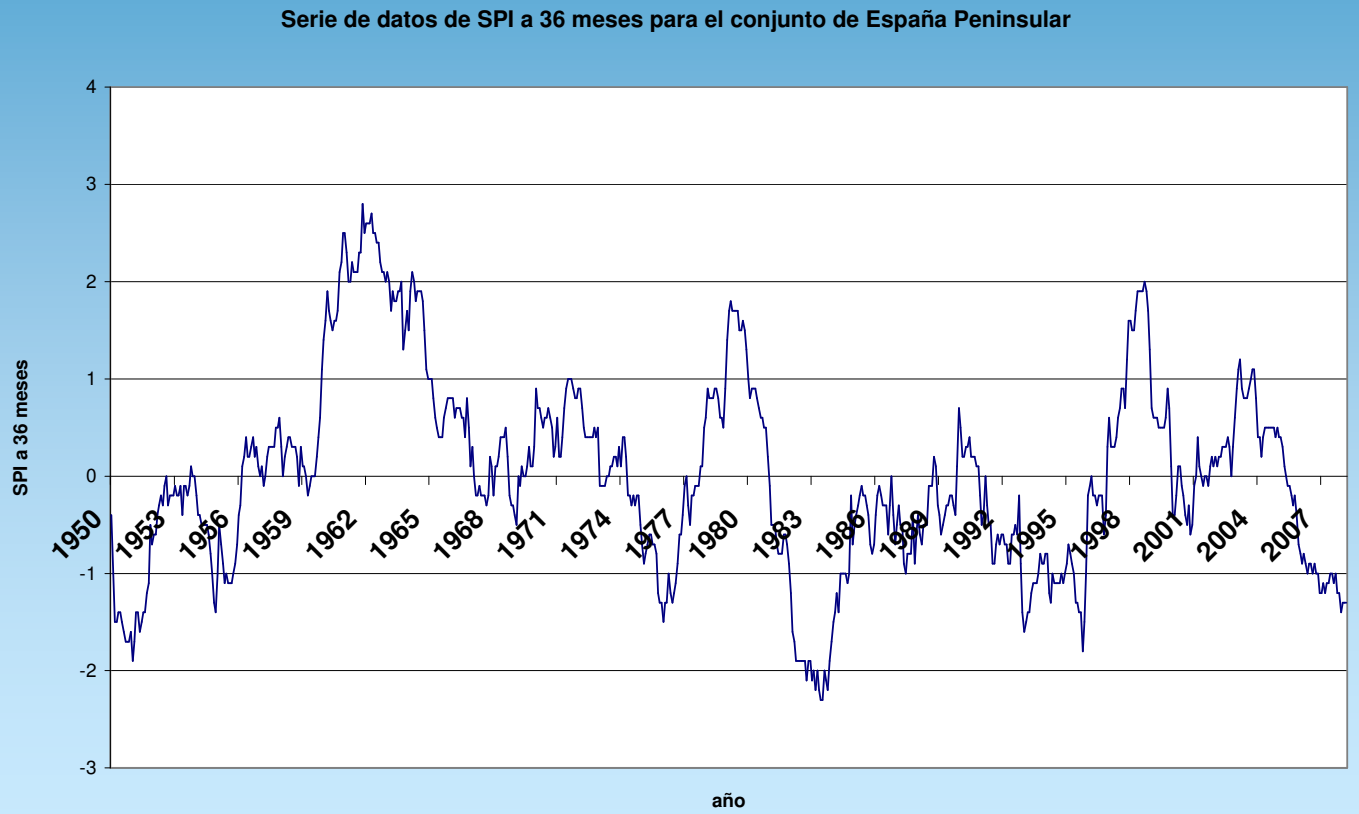
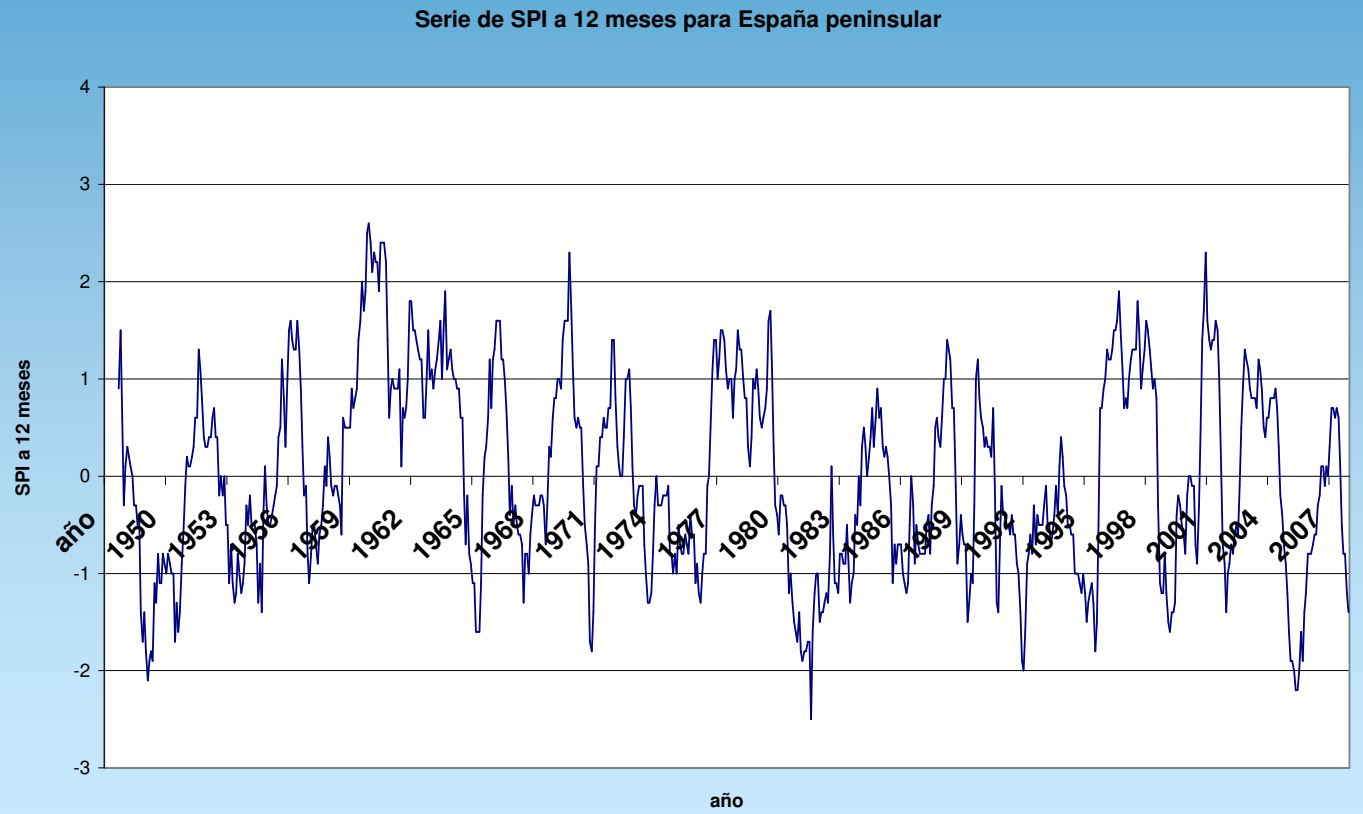


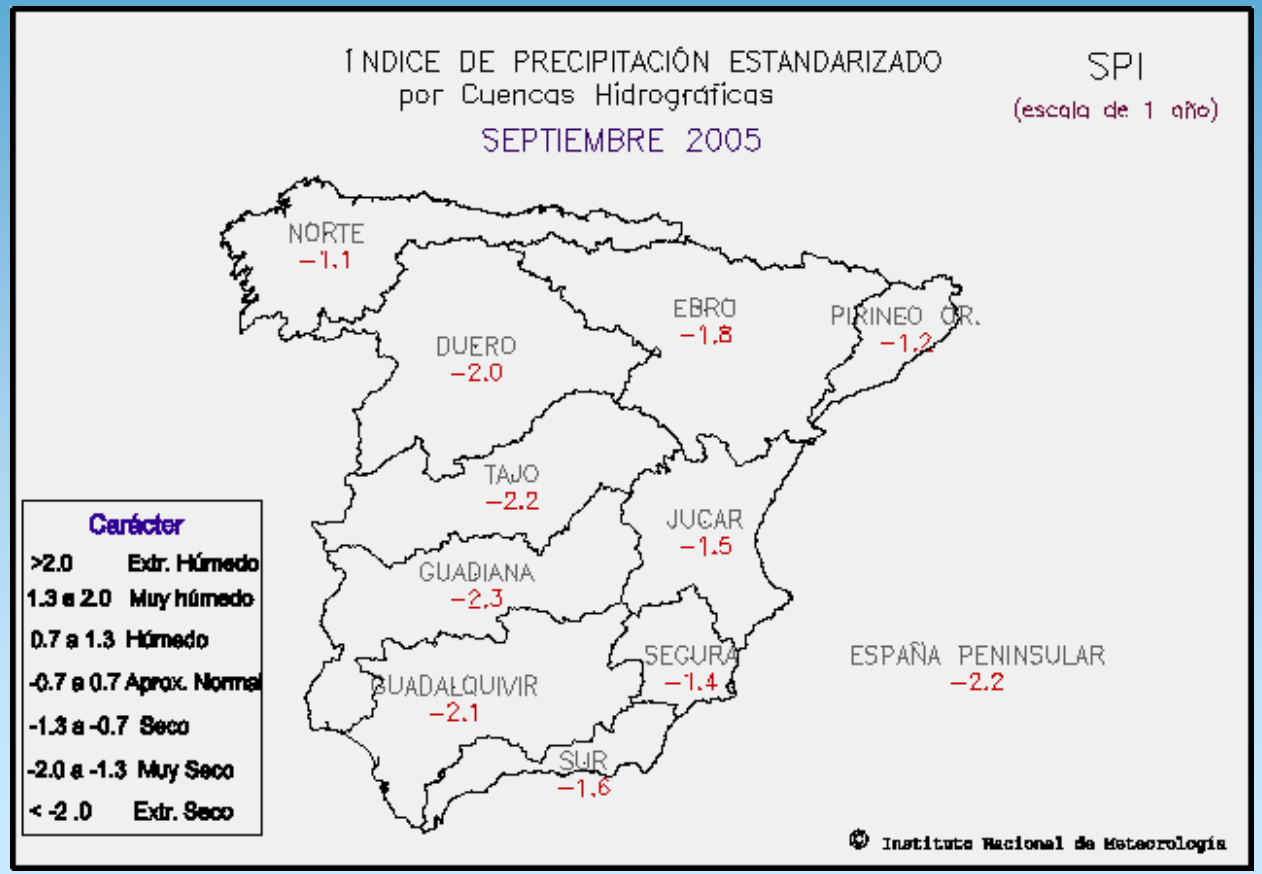
Drought monitoring: application to the 1991-95 severe drought in Southern Spain .



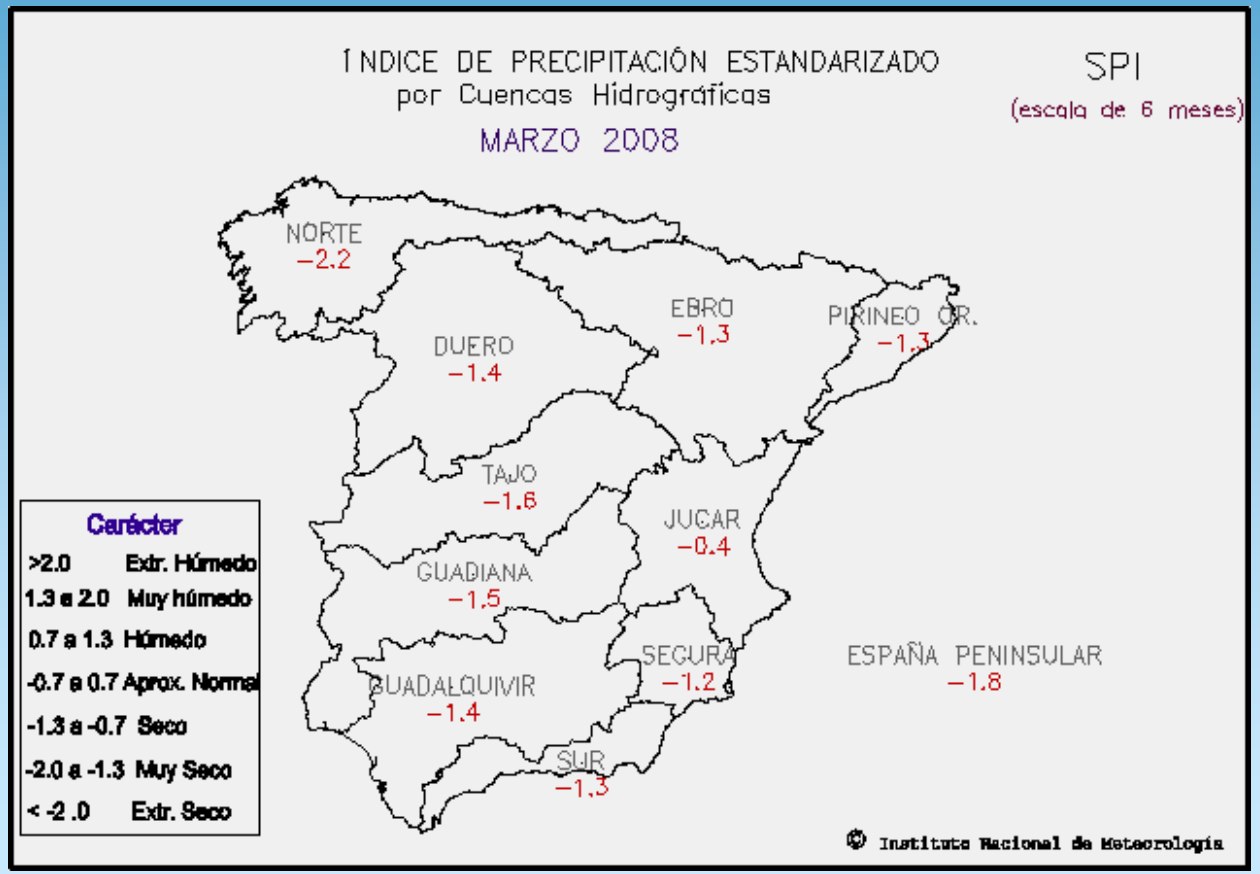
Drought monitoring: application to the 2004-2005 severe drought in Spain .



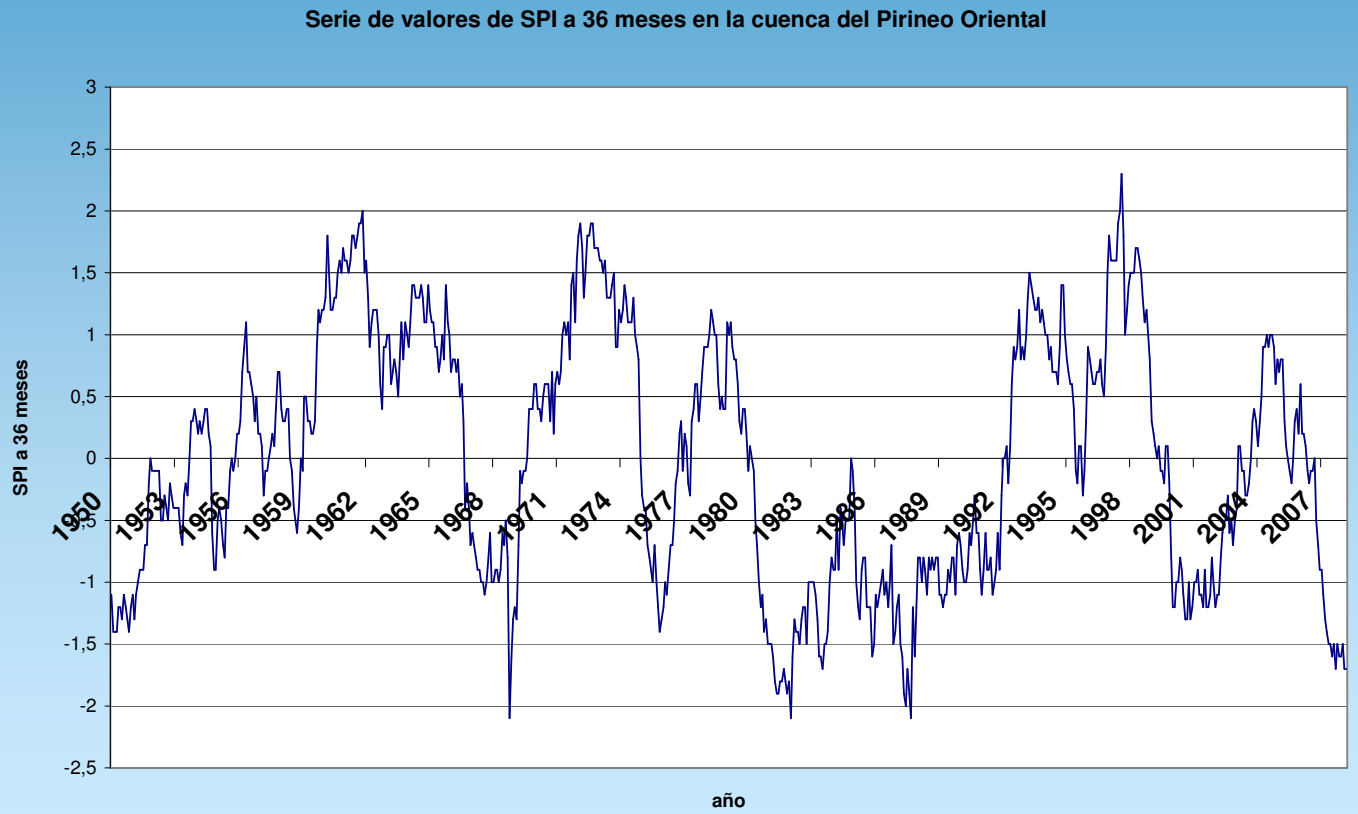
Drought monitoring: application to the 2004-2005 severe drought in Spain .



Drought monitoring: application to the drought of the first half of the 2007-2008 hidrological year in Spain .



Drought monitoring: application to the drought of the first half of the 2007-2008 hidrological year in Spain .



Drought monitoring: application to the drought of the first half of the 2007-2008 hidrological year in Spain .

Conclusions

- The drought is a recurrent climate hazard that affects the territory of Spain, so there is a need to reinforce the meteorological and agricultural drought monitoring programmes currently in operation in Spain.
- The SPI is a very useful tool to establish, from an operational point of view, the start and lasting of a meteorological drought event as well as its extension and severity level. In this regard, the SPI-based drought monitoring system of AEMET has been applied to diagnose some recent events of severe drought.
- In the framework of the National Water Balance there is a need to extend the drought monitoring module in order to include explicitly other sectorial drought indexes (particularly those connected to the agricultural drought taken into account the soil moisture calculations) and to produce drought predictions under a probabilistic approach taking advantage of the recent developments in monthly and seasonal prediction.