Utilización del *Standardized Precipitation Evapotranspiration Index (SPEI)* en el análisis y monitorización de las sequías: características, recomendaciones y comparación con otros indicadores

Application of the *Standardized Precipitation Evapotranspiration Index (SPEI) for drought analysis and monitoring: characteristics, recommendations and comparison with other indices*

Sergio M. VICENTE-SERRANO
Santiago BEGUERÍA
Natalia MARTÍN-HERNÁNDEZ
Miquel TOMÁS-BURGUERA
César AZORÍN-MOLINA

Consejo Superior de Investigaciones Científicas
(Spanish National Research Council – Spain)

THE COMPLEXITY OF DROUGHT QUANTIFICATION AND ANALYSIS

- **Droughts are difficult to pinpoint in time and space given different economic sectors and natural systems affected.**

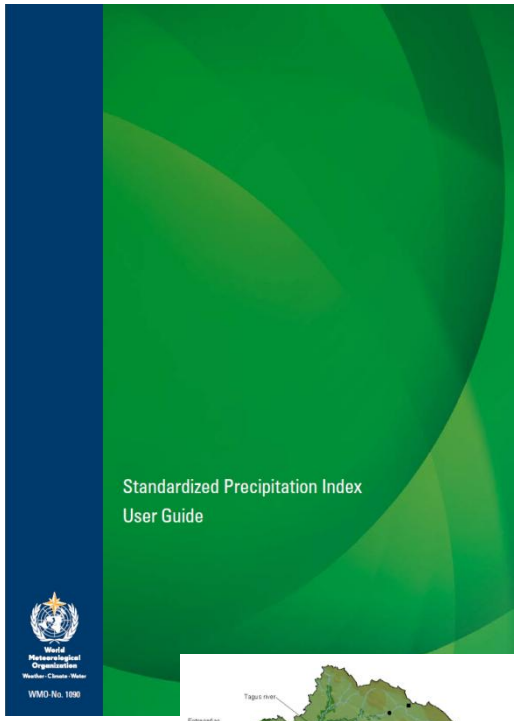
- **We identify a drought by its effects or impacts on different types of systems (agriculture, water resources, ecology, forestry, economy, etc.), but there is not a physical variable we can measure to quantify droughts.**

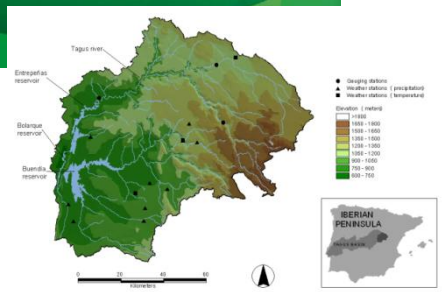
- **Long-term drought objective metrics (streamflows, soil moisture, lake levels, etc.) are commonly not available. Moreover, using only objective metrics other relevant variables to determine drought severity (e.g. the atmospheric water demand) are not taken into account.**

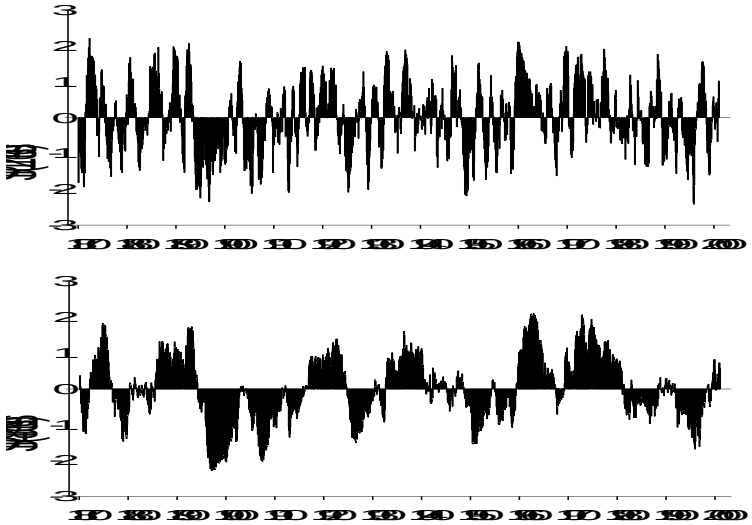
- **We use the so-called "DROUGHT INDICES" for drought quantification and analysis.**

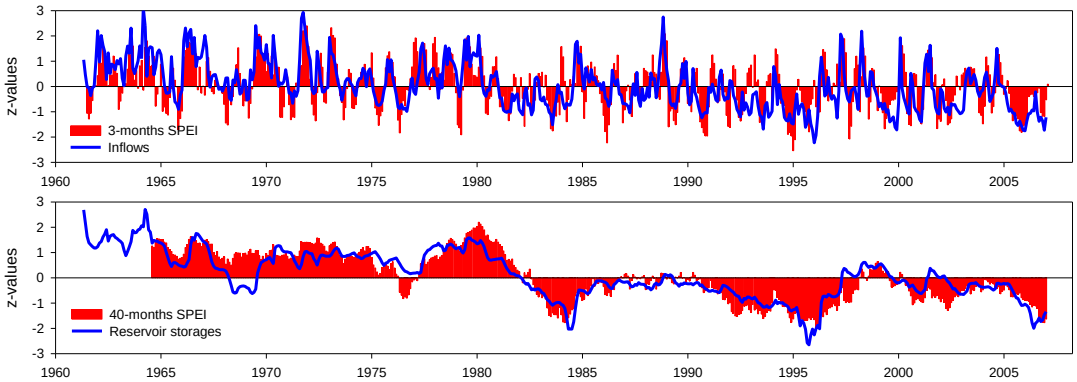



EXISTING DROUGHT INDICES









EXISTING DROUGHT INDICES

Precipitation-based drought indices, including the SPI, rely on two assumptions:

1) The variability of precipitation is much higher than that of other variables, such as the atmospheric water demand
2) The other variables are stationary (i.e., they have no temporal trend).

In this scenario, the importance of these other variables is negligible, and droughts are controlled by the temporal variability in precipitation.

Is this scenario plausible nowadays?



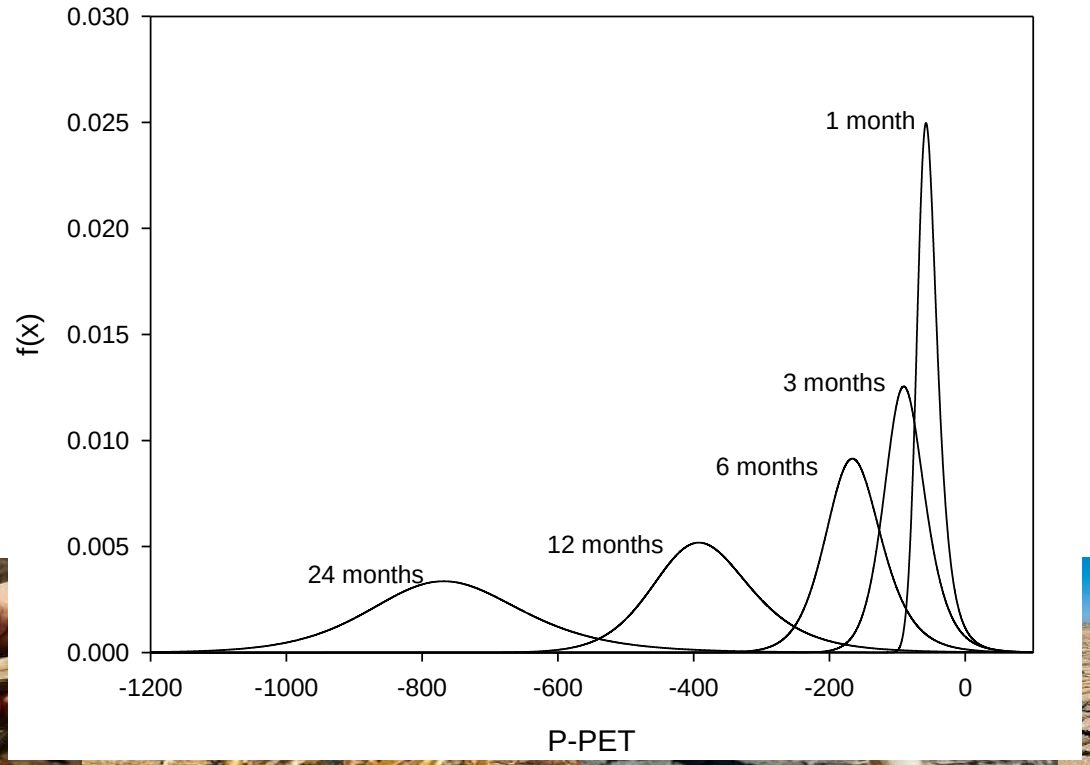

STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)

The SPEI uses the difference between precipitation and ETo. This represents a simple climatic water balance which is calculated at different time scales to obtain the SPEI.

With a value for ETo, the difference between the precipitation (*P*) and *PET* for the month *i* is calculated according to:

$$D_i = P_i\text{-}ETo_i,$$

The calculated *D* values are aggregated at different time scales



STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)

Vicente-Serrano S.M. et al., (2010) A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. Journal of Climate 23: 1696-1718.

Vicente-Serrano, S.M. et al. (2010): A new global 0.5° gridded dataset (1901-2006) of a multiscalar drought index: comparison with current drought index datasets based on the Palmer Drought Severity Index. Journal of Hydrometeorology. 11: 1033–1043

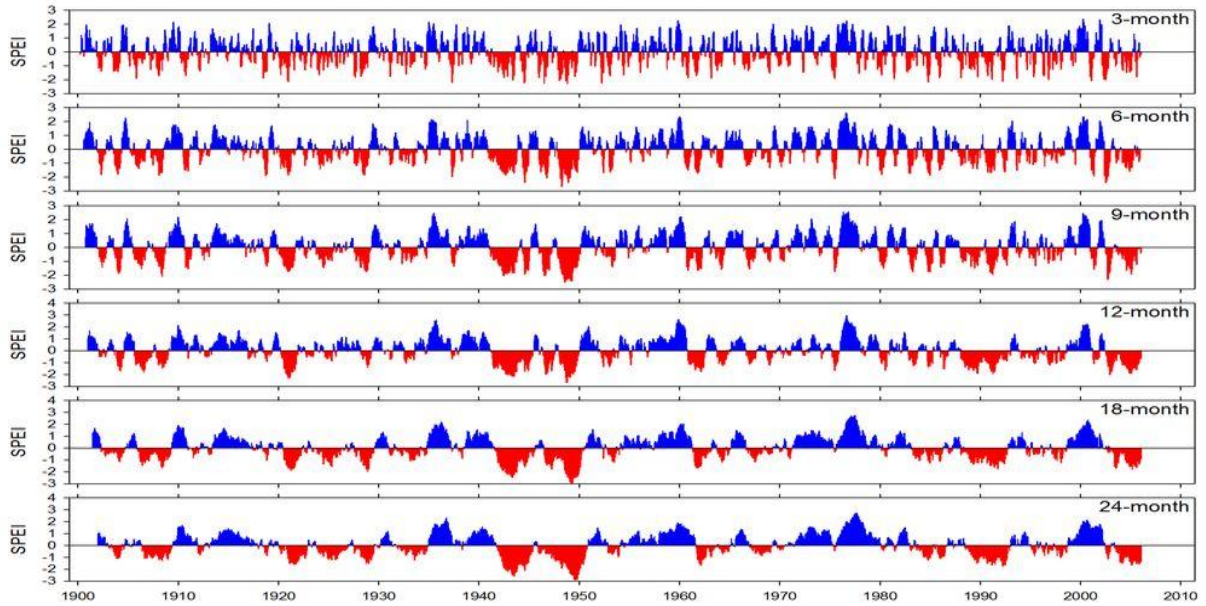
Beguería, S. et al., (2010): A multi-scalar global drought data set: the SPEIbase: A new gridded product for the analysis of drought variability and impacts. Bulletin of the American Meteorological Society. 91, 1351-1354

Vicente-Serrano, S.M. et al., (2011). Comment on "Characteristics and trends in various forms of the Palmer Drought Severity Index (PDSI) during 1900-2008" by A. Dai. Journal of Geophysical Research-Atmosphere. 116, D19112, doi:10.1029/2011JD016410

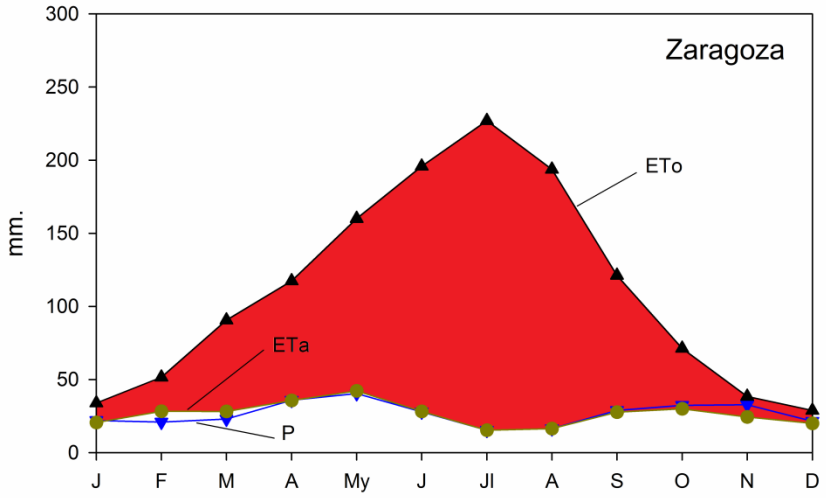
Vicente-Serrano, S.M. et al., (2012). Performance of Drought Indices for Ecological, Agricultural, and Hydrological Applications. Earth Interactions. 16:10.

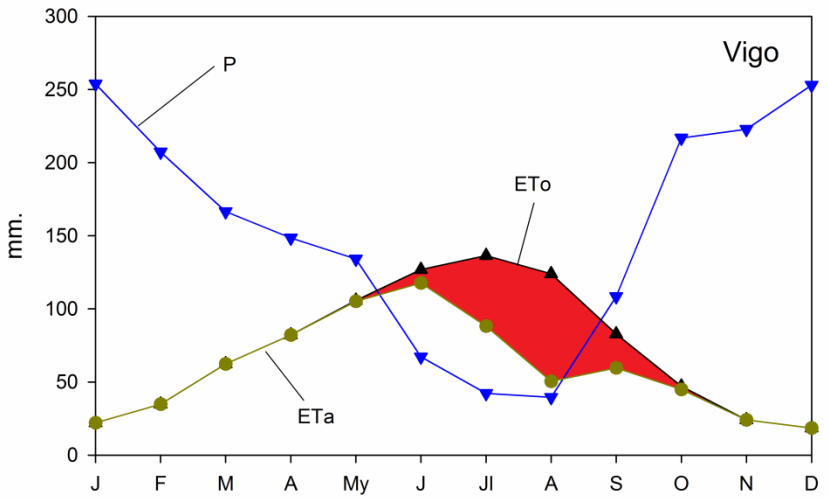
Beguería, S., et al. (2014). Standardized Precipitation Evapotranspiration Index (SPEI) revisited: parameter fitting, evapotranspiration models, kernel weighting, tools, datasets and drought monitoring. International Journal of Climatology, 34: 3001–3023.

Vicente-Serrano, S.M., Gerard Van der Schrier, Santiago Beguería, Cesar Azorin–Molina, Juan-I. Lopez–Moreno. Contribution of precipitation and reference evapotranspiration to drought indices under different climates. Journal of Hydrology. In press.

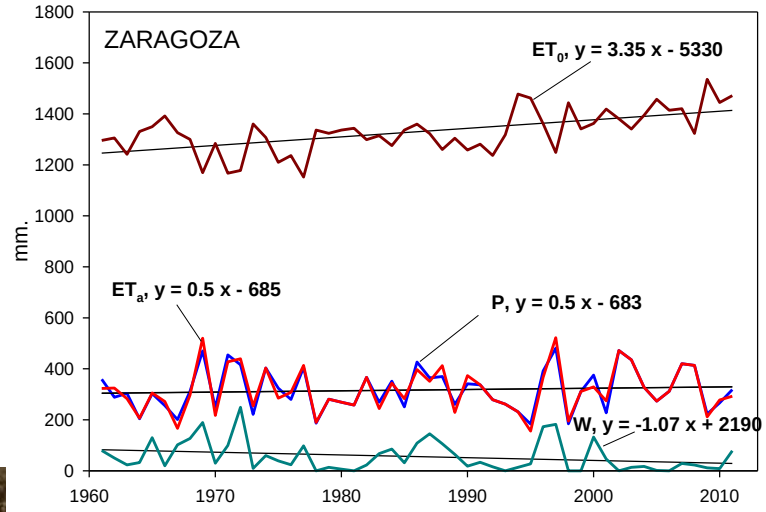


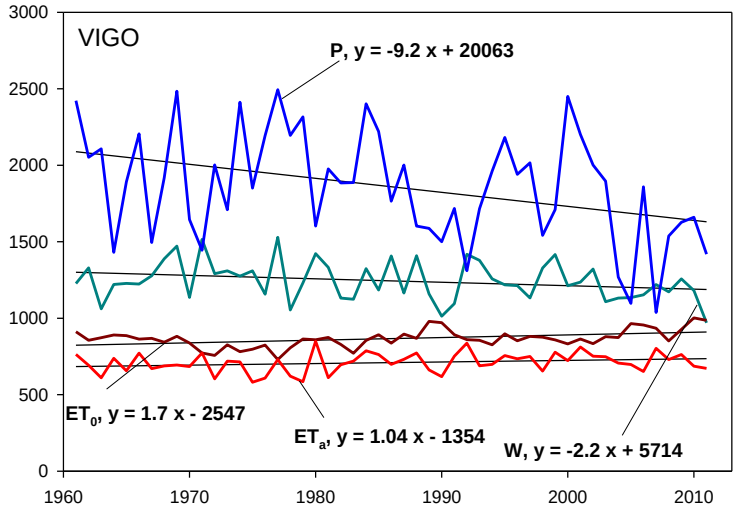
STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)

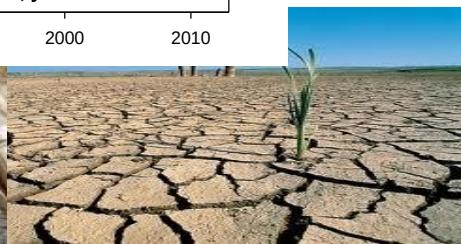




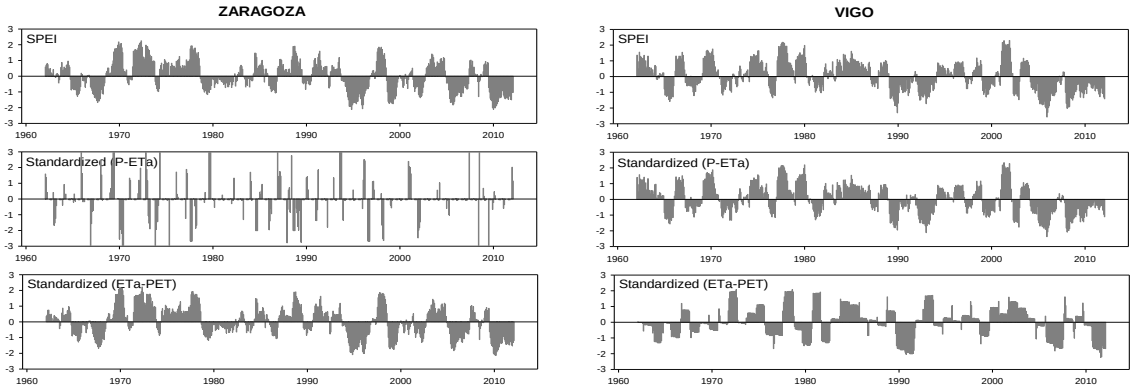
Beguería et al. (2014): International Journal of Climatology. 34: 3001–3023



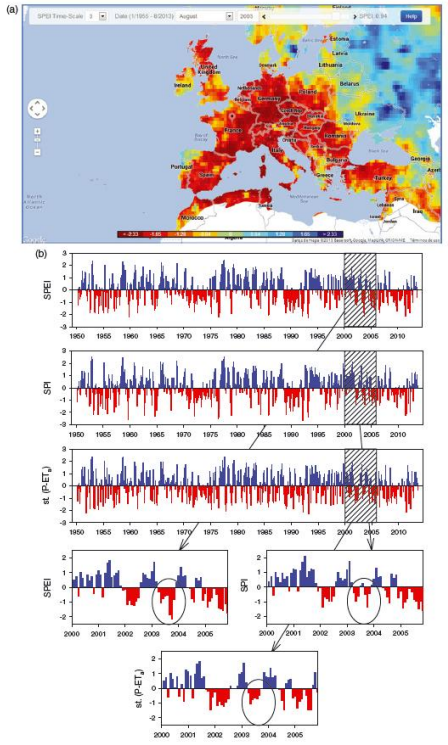


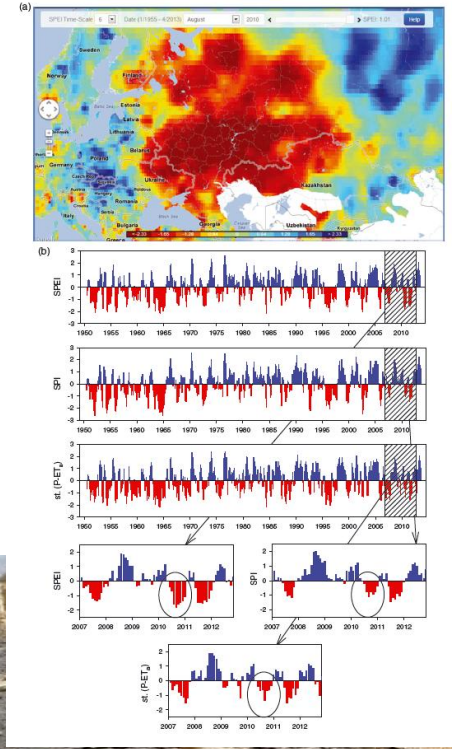


STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX (SPEI)



Beguería et al. (2014): International Journal of Climatology





ADVANTAGES IN COMPARISON TO OTHER INDICES

• The SPEI solves the problems of spatial comparability of the PDSI.

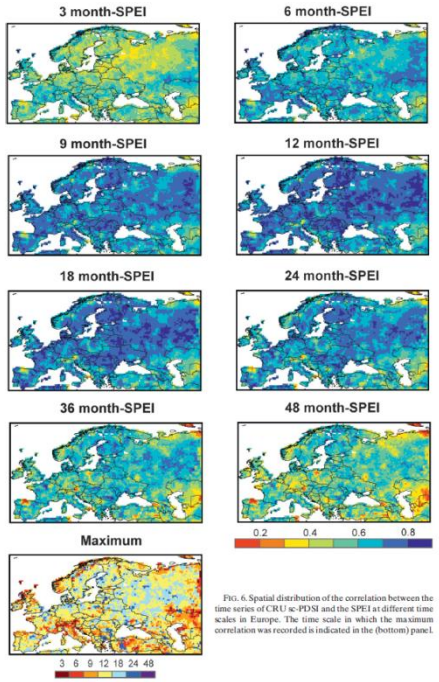


FIG. 6. Spatial distribution of the correlation between the time series of CRU sc-PDSI and the SPEI at different time scales in Europe. The time scale in which the maximum correlation was recorded is indicated in the (bottom) panel.

Vicente-Serrano, S.M., et al. (2010). Journal of Hydrometeorology. 11: 1033–1043

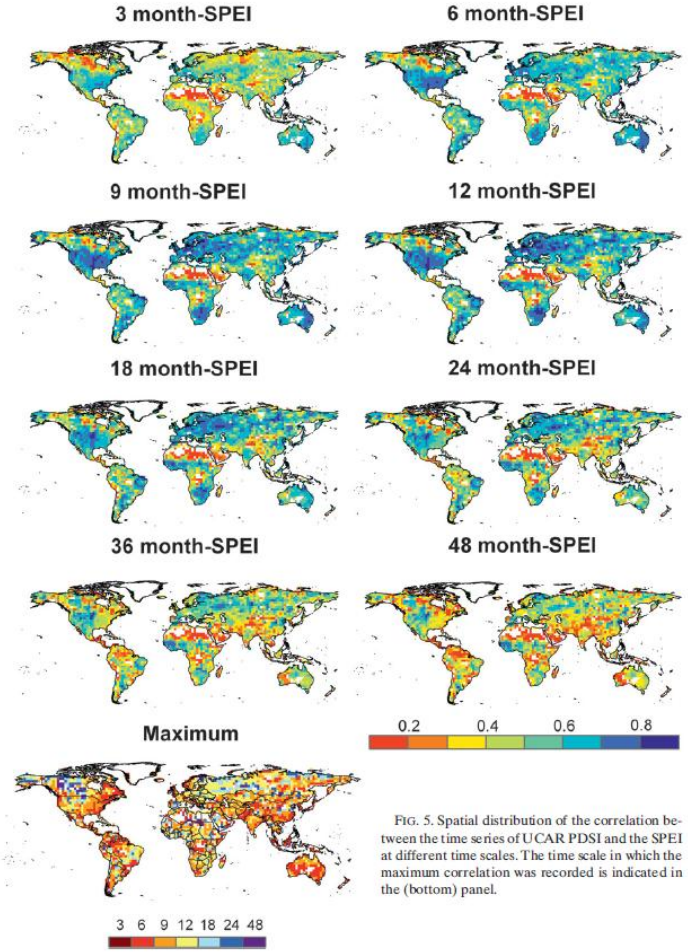
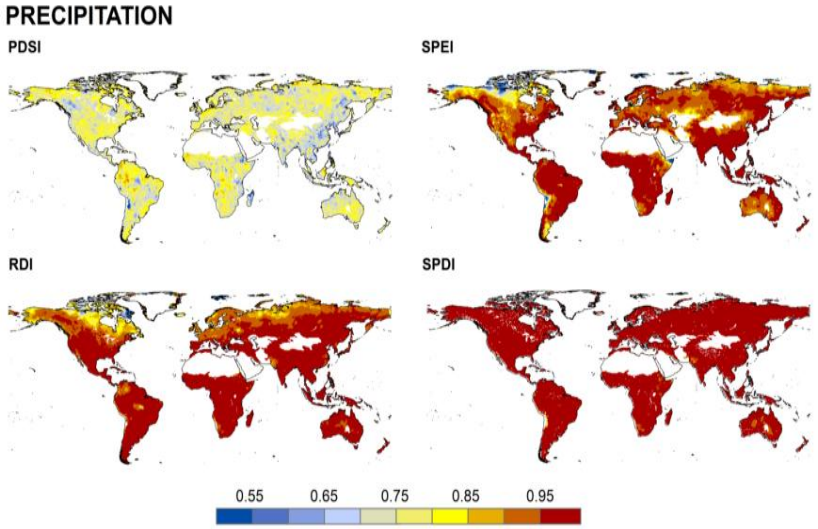
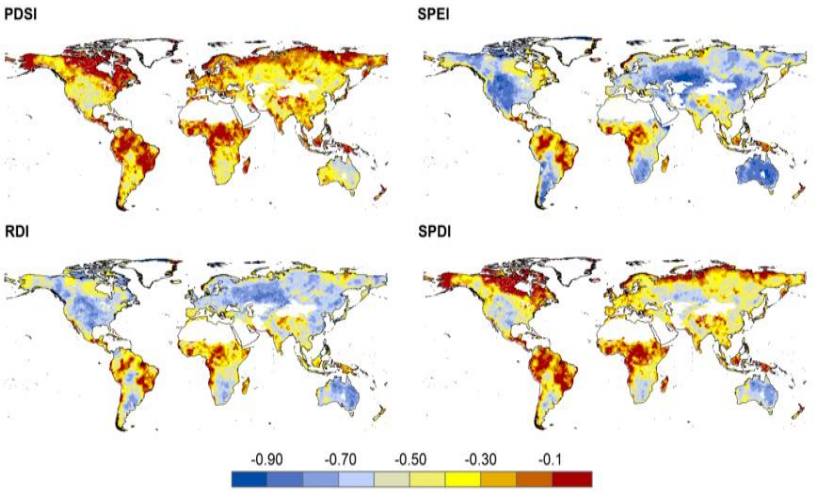
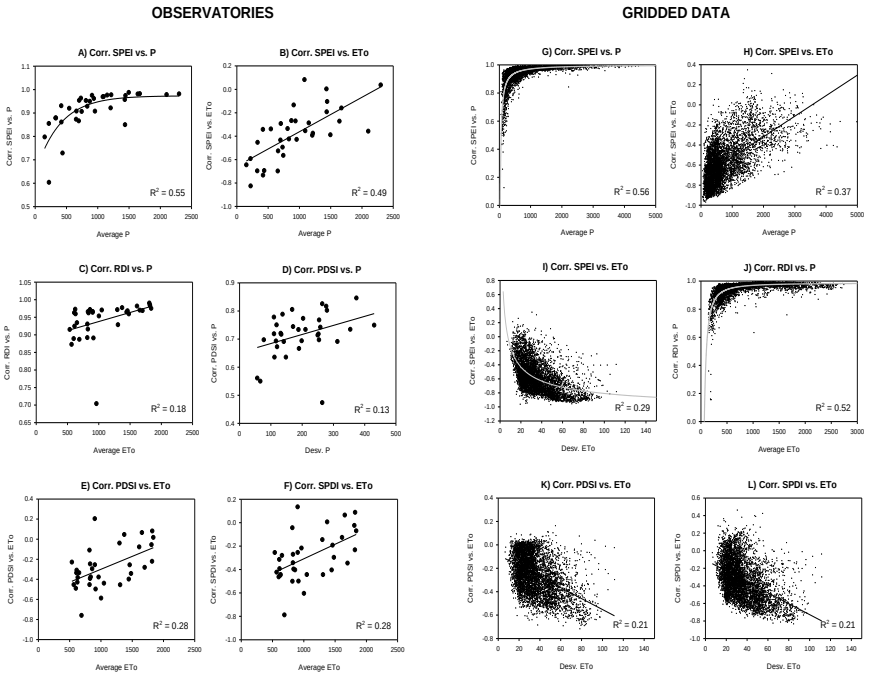


FIG. 5. Spatial distribution of the correlation between the time series of UCAR PDSI and the SPEI at different time scales. The time scale in which the maximum correlation was recorded is indicated in the (bottom) panel.

ADVANTAGES IN COMPARISON TO OTHER INDICES

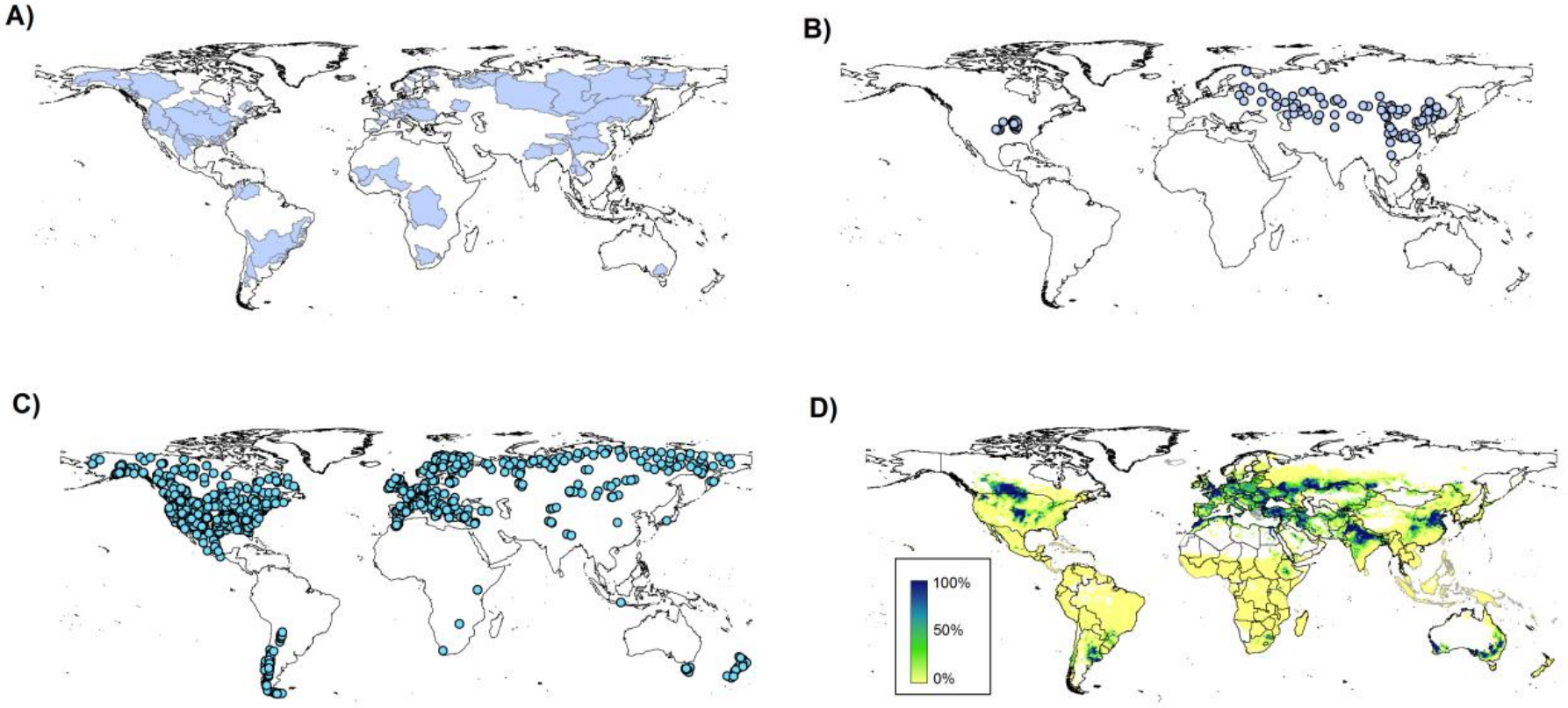






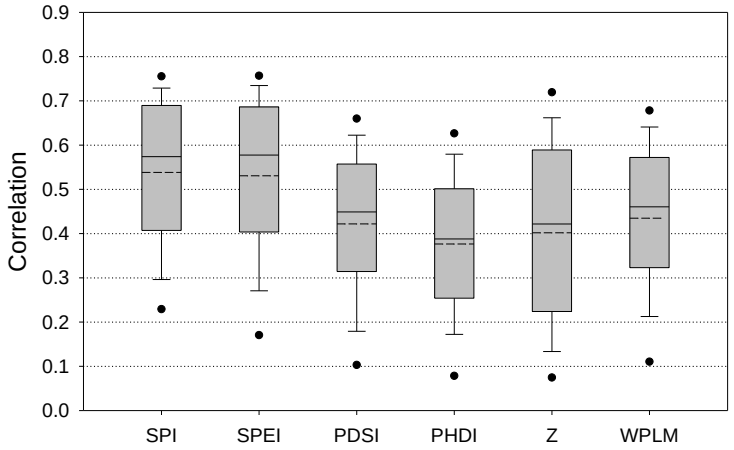
Vicente-Serrano, S.M., Gerard Van der Schrier, Santiago Beguería, Cesar Azorin–Molina, Juan-I. Lopez–Moreno. Contribution of precipitation and reference evapotranspiration to drought indices under different climates. Journal of Hydrology. In press

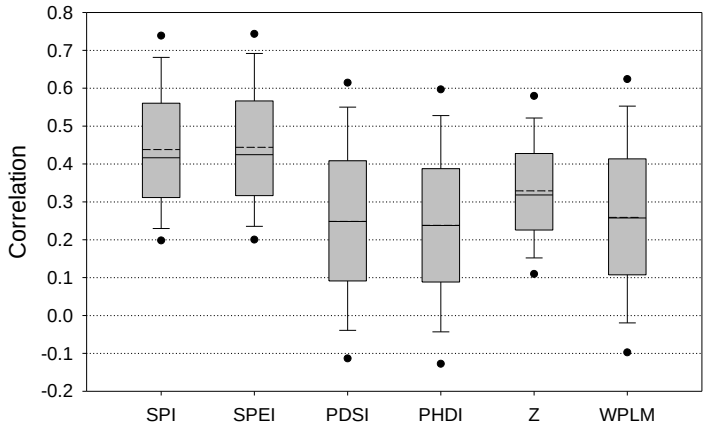
ADVANTAGES IN COMPARISON TO OTHER INDICES



Vicente-Serrano, S.M., et al. (2012) Performance of drought índices for ecological, agricultural and hydrological applications. Earth Interactions 16, 1–27.

ADVANTAGES IN COMPARISON TO OTHER INDICES





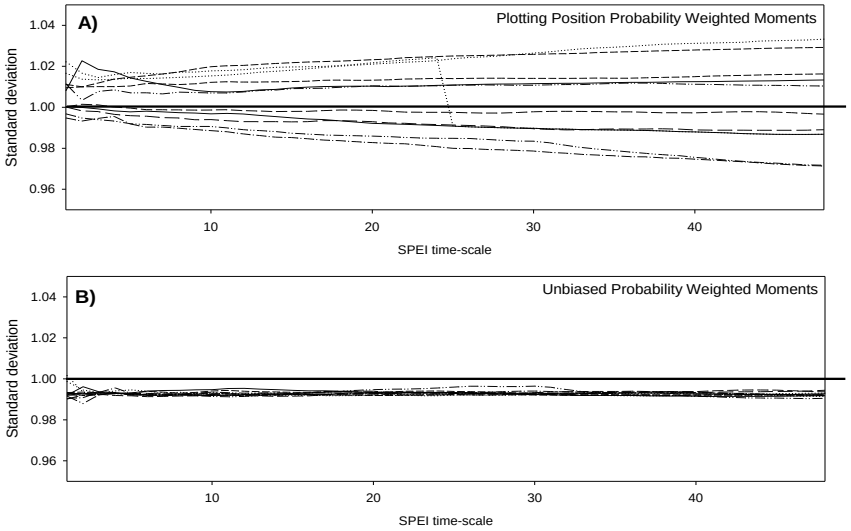
	CONTINUOUS	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
SPI	38.4	49.0	57.6	52.3	48.3	37.1	31.8	33.8	29.8	42.4	57.6	59.6	53.0
SPEI	44.4	33.1	31.1	37.7	40.4	52.3	54.3	47.0	53.0	43.0	31.8	32.5	30.5
PDSI	4.0	0.7	2.0	3.3	3.3	2.0	4.0	4.6	6.0	2.6	1.3	2.6	2.0
PHDI	0.0	2.0	1.3	1.3	2.0	1.3	2.0	2.0	2.0	2.6	0.7	1.3	2.6
Z-Index	7.3	13.9	4.0	4.0	5.3	4.6	5.3	6.0	4.0	5.3	5.3	2.6	10.6
WPLM	6.0	1.3	4.0	1.3	0.7	2.6	2.6	6.6	5.3	4.0	3.3	1.3	1.3

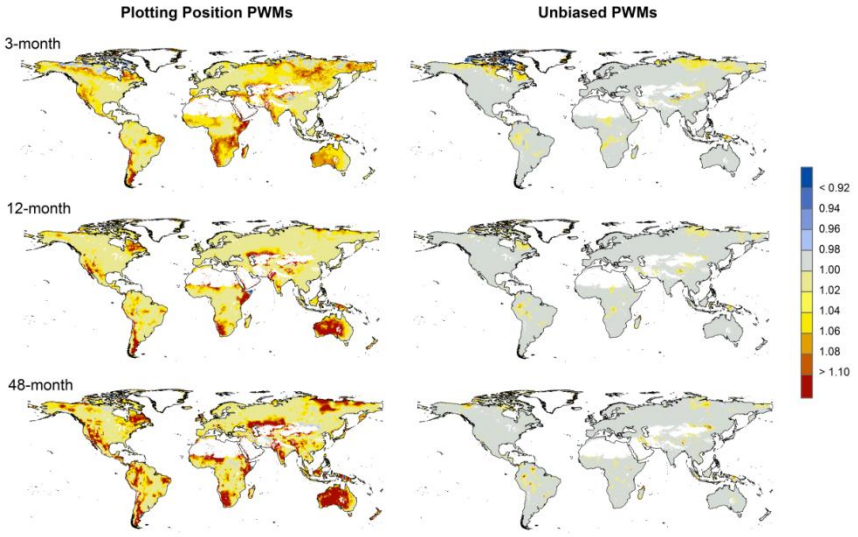
DROUGHT INDEX	April.	May	June	July	August	September	October
SPI	48.3	43.1	44.8	31	31.9	32.8	42.2
SPEI	44.0	46.6	44.8	56	51.7	49.1	44.0
PDSI	4.3	3.4	2.6	6.9	5.2	3.4	3.4
PHDI	0.9	2.6	3.4	0.9	3.4	3.4	2.6
Z	1.7	2.6	2.6	1.7	4.3	6.0	3.4
WPLM	0.9	1.7	1.7	3.4	3.4	5.2	4.3

Vicente-Serrano, S.M., et al. (2012) Performance of drought índices for ecological, agricultural and hydrological applications. Earth Interactions 16, 1–27.




RECOMMENDATIONS TO CALCULATE THE SPEI





Beguería et al. (2014): International Journal of Climatology. 34: 3001–3023



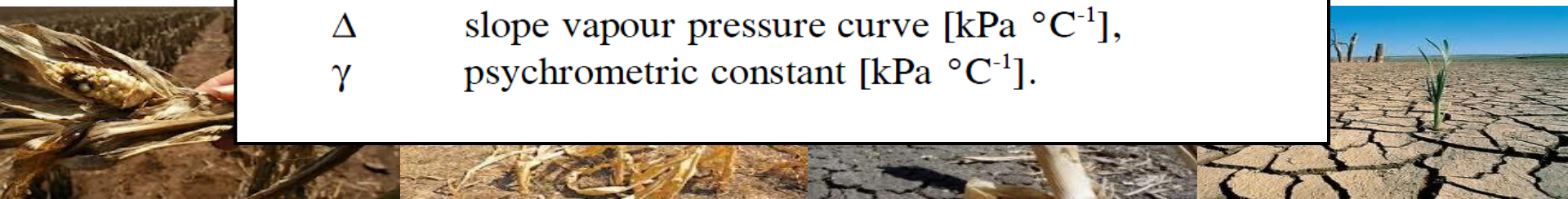

RECOMMENDATIONS TO CALCULATE THE SPEI

Aerodinamic

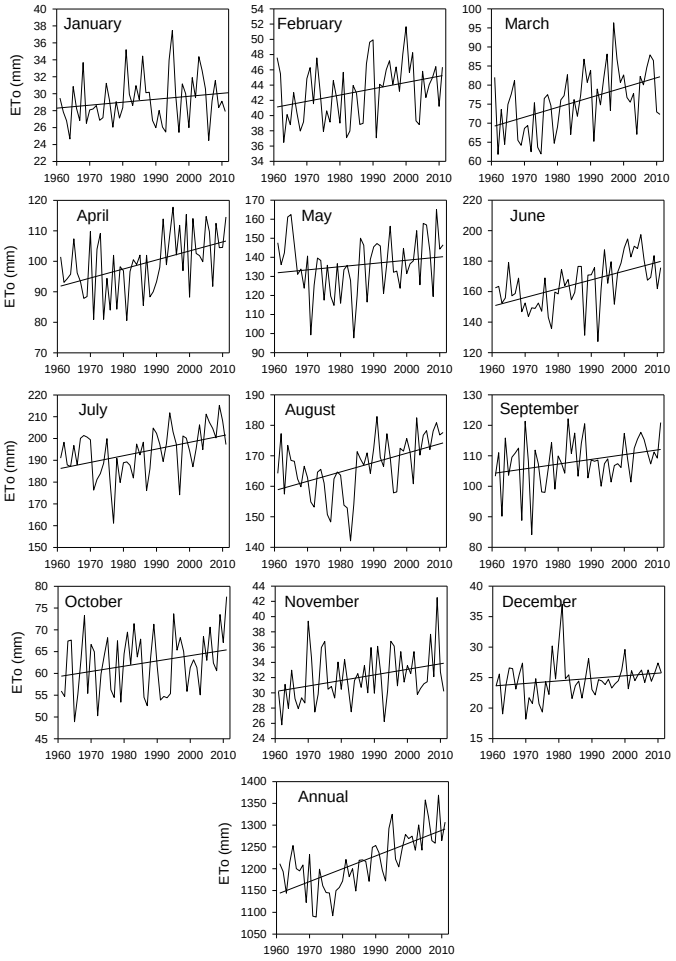
Radiative

$$ET_o = \frac{0.408\,\Delta\,(R_n - G) + \gamma \frac{900}{T+273} u_2\,(e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)}$$

ET_o	reference evapotranspiration [mm day^{-1}],
R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
G	soil heat flux density [MJ m^{-2} day^{-1}],
T	mean daily air temperature at 2 m height [°C],
u_2	wind speed at 2 m height [m s^{-1}],
e_s	saturation vapour pressure [kPa],
e_a	actual vapour pressure [kPa],
e_s-e_a	saturation vapour pressure deficit [kPa],
Δ	slope vapour pressure curve [kPa $°C^{-1}$],
γ	psychrometric constant [kPa $°C^{-1}$].

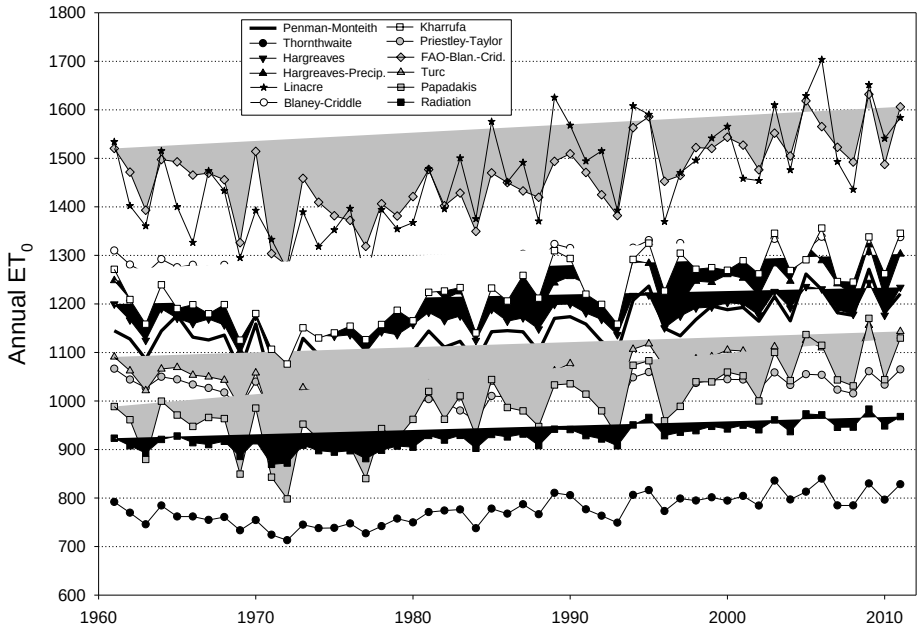


RECOMMENDATIONS TO CALCULATE THE SPEI



Vicente-Serrano, S.M., et al. (2014). Sensitivity of reference evapotranspiration to changes in meteorological parameters in Spain (1961-2011). Water Resources Research.

Vicente-Serrano, S.M., et al (2014). Reference evapotranspiration variability and trends in Spain, 1961–2011. Global and Planetary Change.



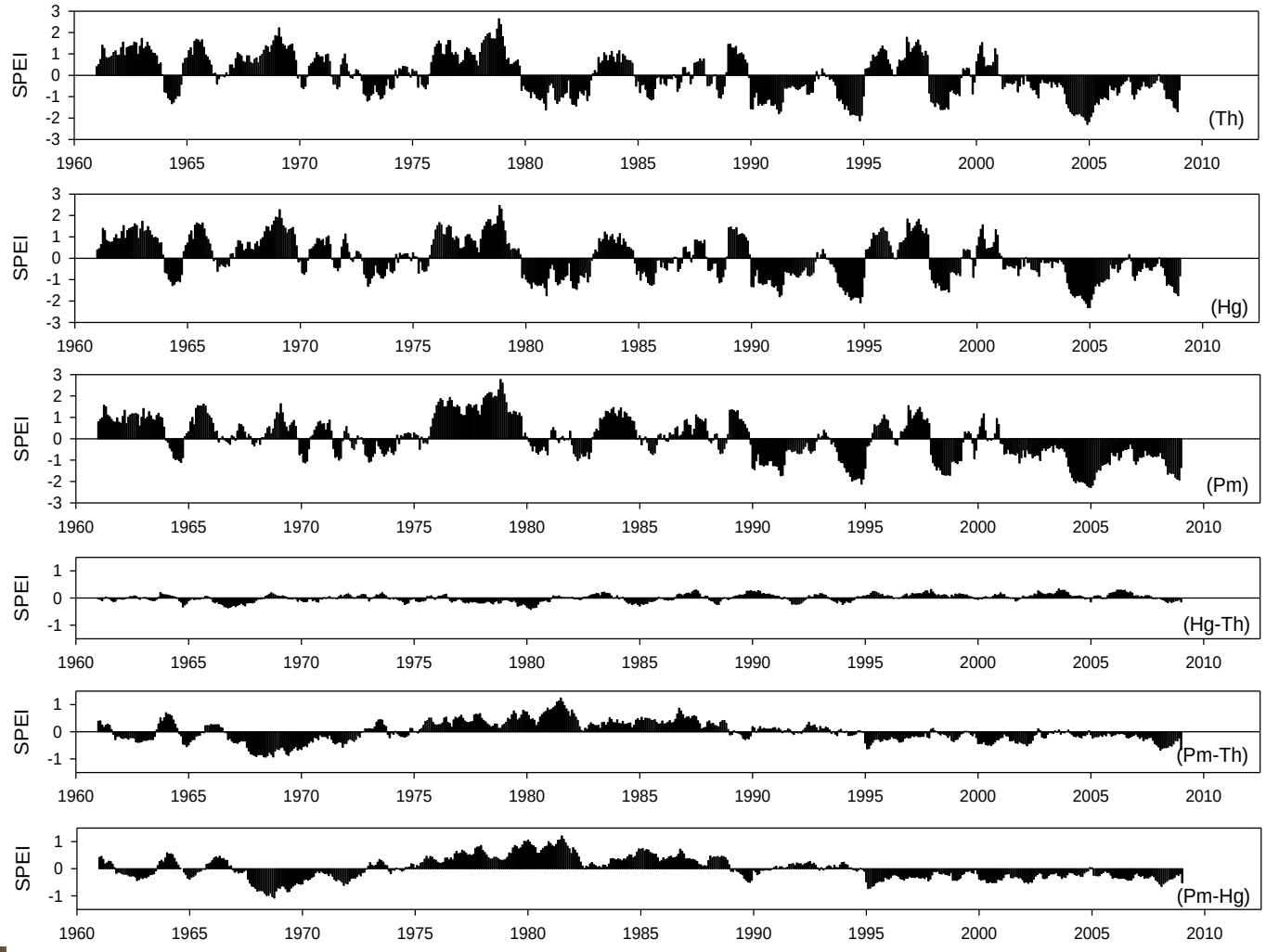
	Annual	Winter	Spring	Summer	Autumn
Penman-Montheith	24.5	1.8	7.3	12	3.5
Thornthwaite	14.3	0	3.5	9.8	1
Hargreaves	15.1	1.9	5.6	6.4	1.3
Hargreaves-pp.	19.2	2.8	7.1	8.2	1.4
Linacre	42.8	7.2	12.4	16.7	7.2
Blaney-Criddle	12.3	1.5	4	5	1.9
Kharrufa	31.6	3	9.7	14.4	4.8
Priestley-Taylor	6.1	0.7	3	2.2	0.5
FAO-Blaney-Criddle	29.7	3.8	9.4	12.8	4
Turc	18.6	2.3	5.4	9.1	2.1
Papadakis	37.3	3.6	8.9	19.7	5.2
Radiation	13.4	1	4.1	6.4	2





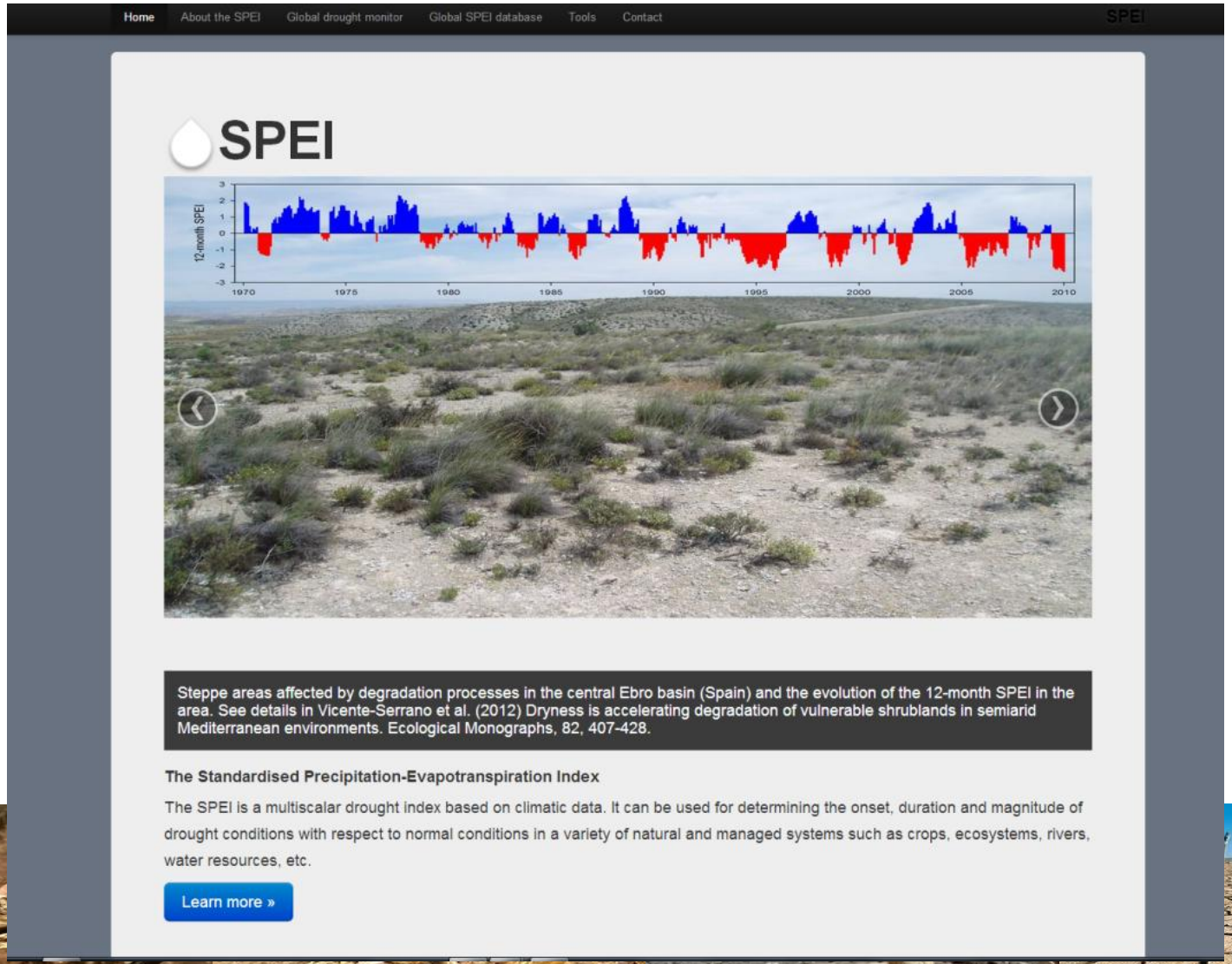
RECOMMENDATIONS TO CALCULATE THE SPEI

Beguería et al. (2014): International Journal of Climatology. 34: 3001–3023



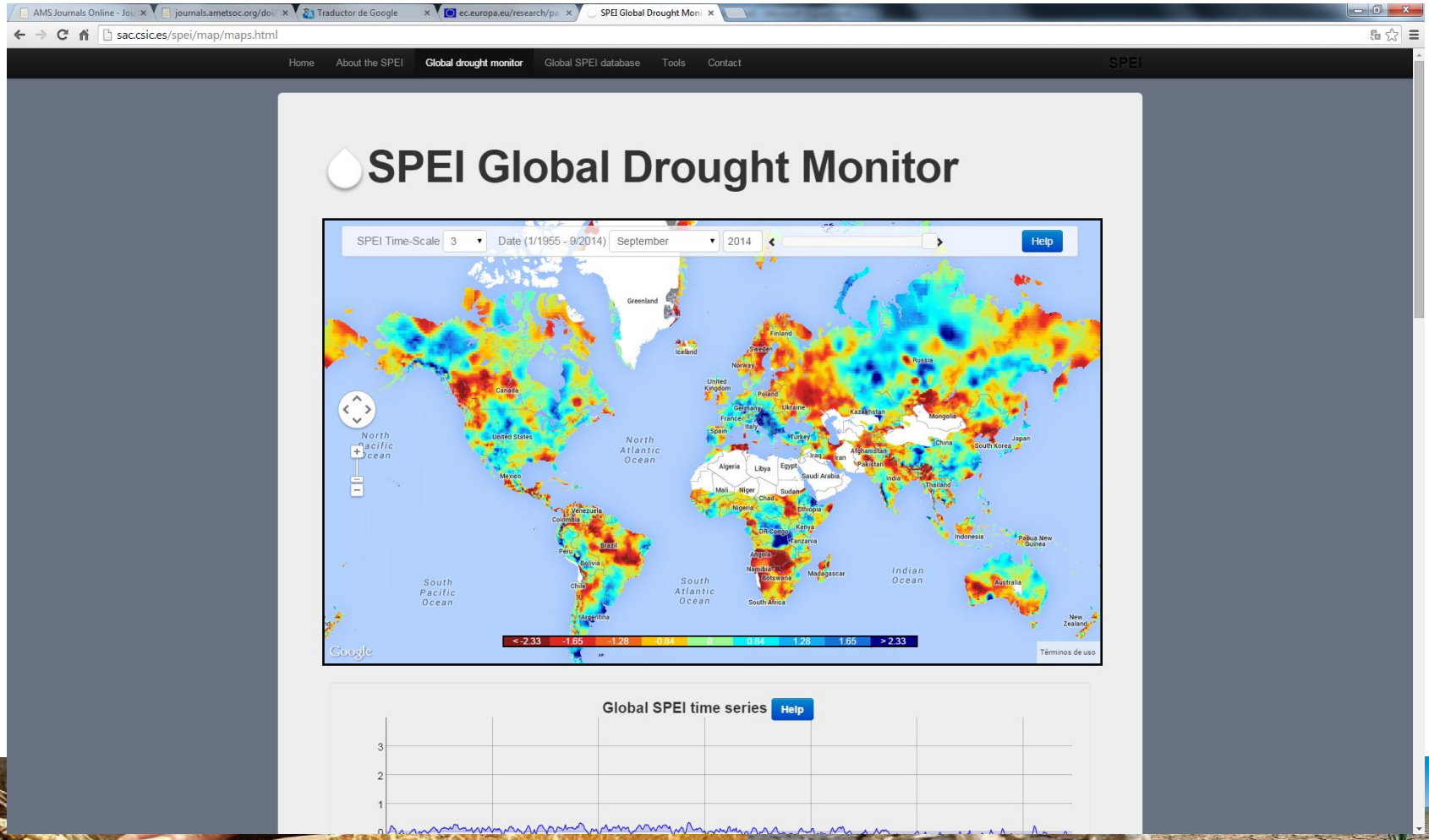
RECOMMENDATIONS TO CALCULATE THE SPEI

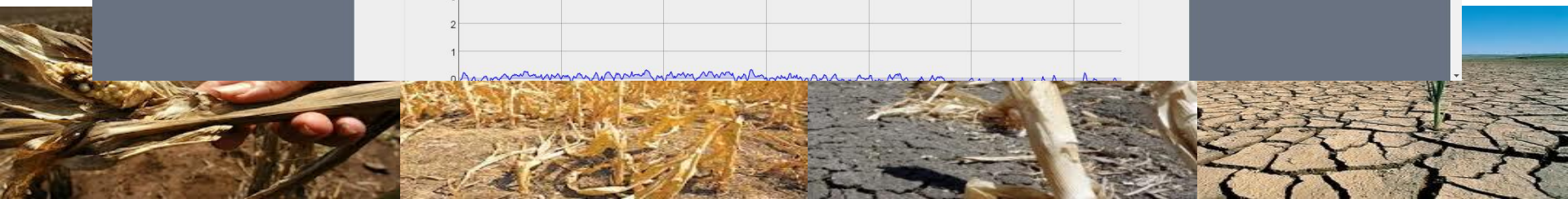
http://sac.csic.es/spei/index.html



RECOMMENDATIONS TO CALCULATE THE SPEI

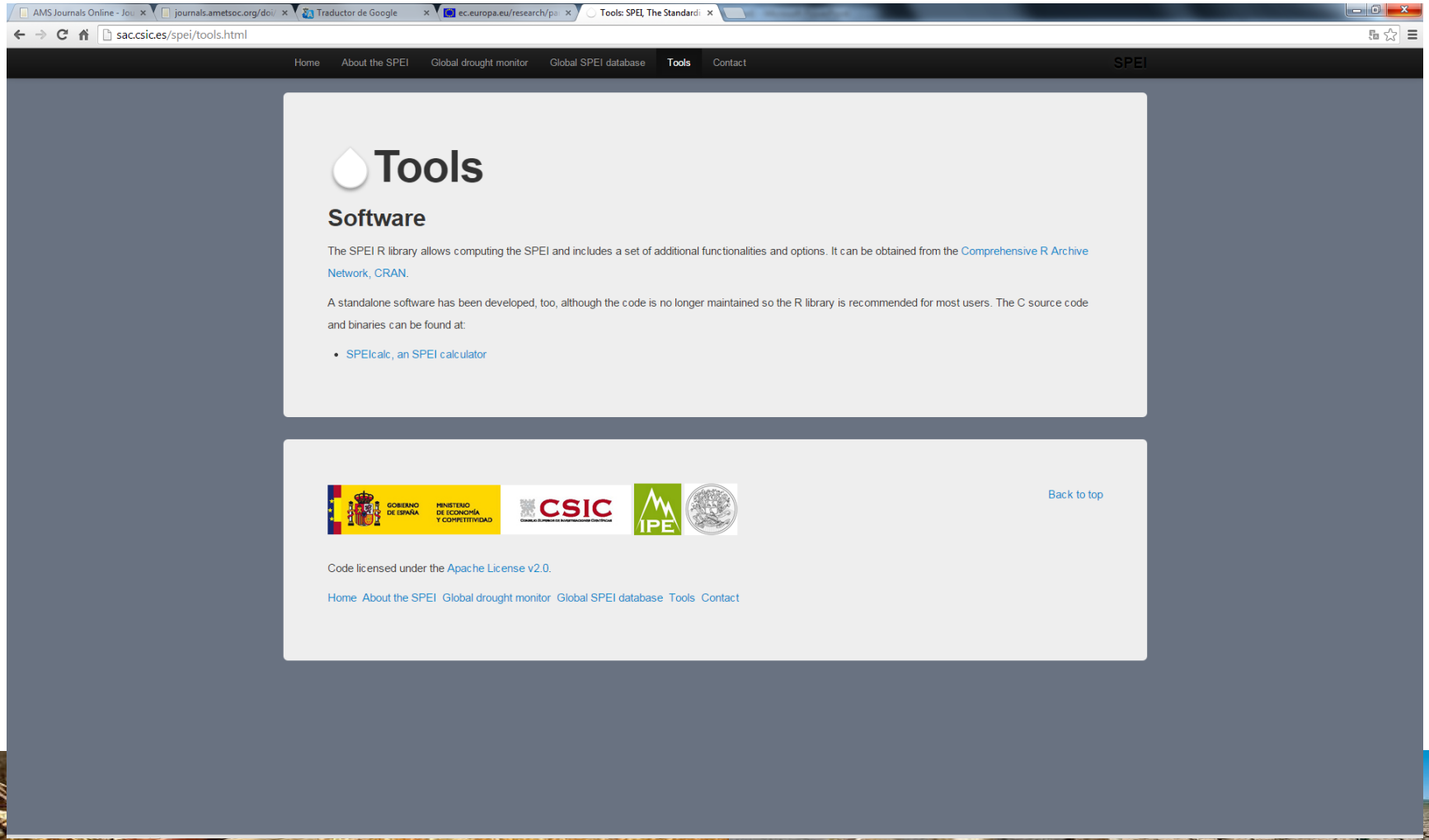
http://sac.csic.es/spei/index.html





RECOMMENDATIONS TO CALCULATE THE SPEI

http://sac.csic.es/spei/index.html






RECOMMENDATIONS TO CALCULATE THE SPEI

http://sac.csic.es/spei/index.html