# HyMeX - “Drought” science team

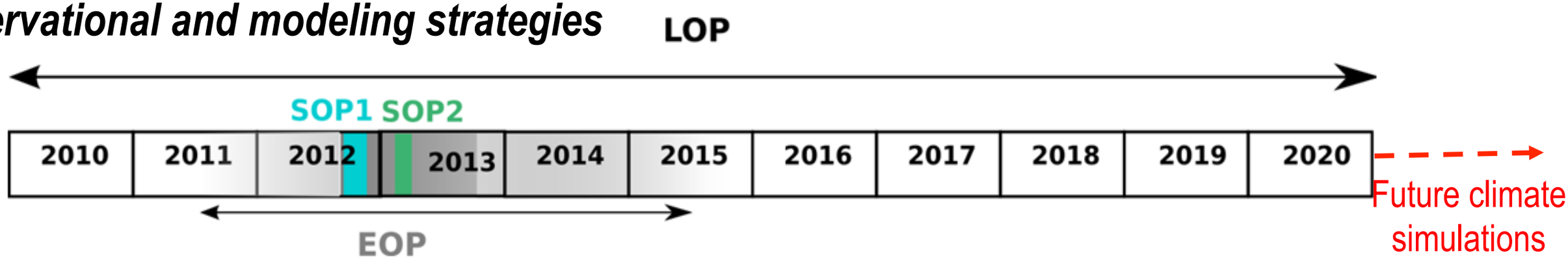
Lead: P. Quintana-Segui, J. Polcher

## *HyMeX main objectives (see Drobinski et al., BAMS, 2014)*

- to improve our understanding of the water cycle, with emphases on the predictability and evolution of intense events by monitoring and ***modelling the Mediterranean coupled system*** (atmosphere-land-ocean), ***its variability*** (from the event scale, to the seasonal and interannual scales) and characteristics over one decade (2010-2020) in the context of global change

- to evaluate the societal and economical vulnerability to extreme events and the adaptation capacity

## *Observational and modeling strategies*

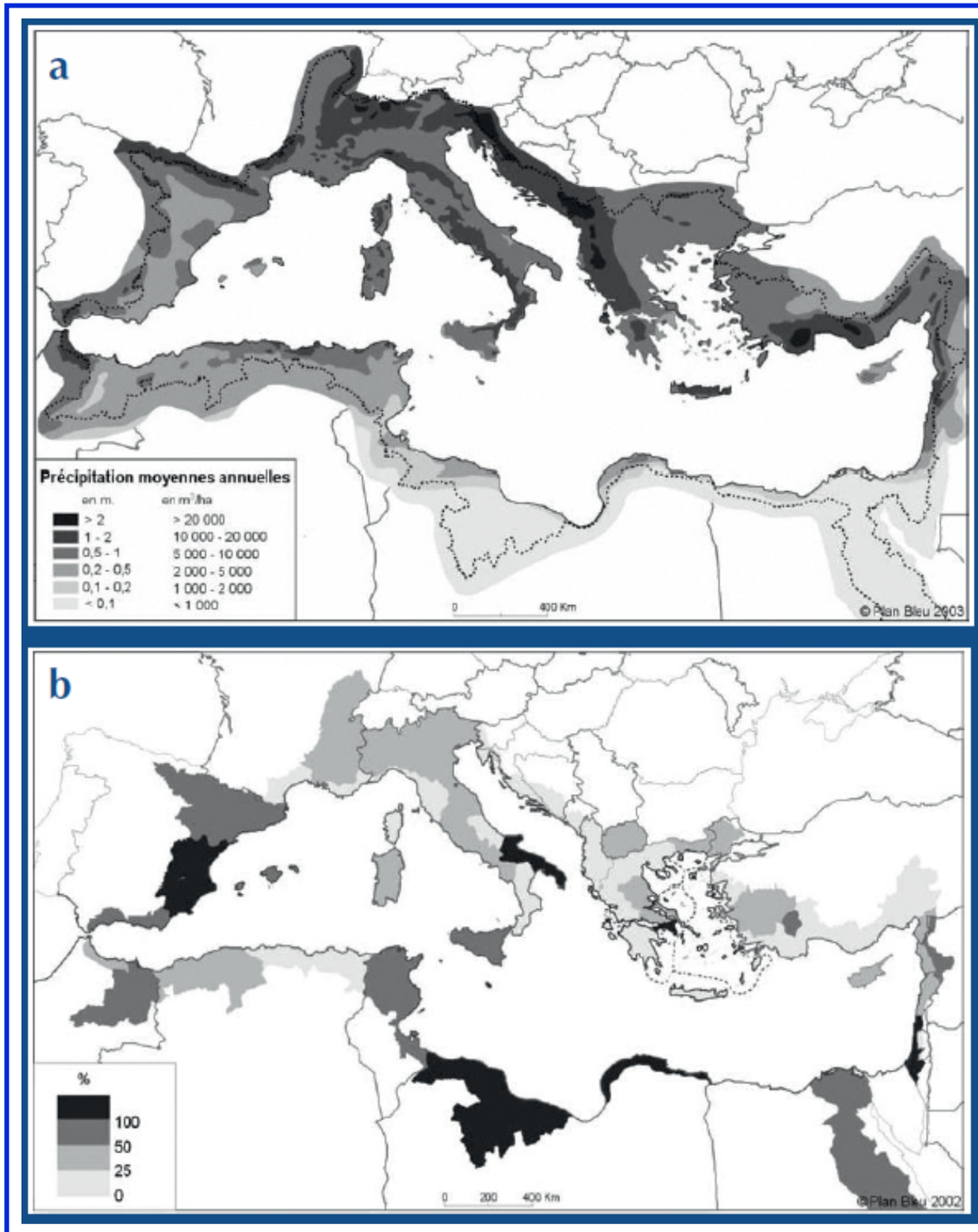



- LOP Long Observation Period over the whole basin (2010-2020)
- EOP : Enhanced Observation Period over 3 régions (2011 - 2015)
- SOP1 - SOP2 : Special Observation Periods over the North-Western Mediterranean region (2012 and 2013)

# Water related issues the Mediterranean

## *Two reasons to investigate the Mediterranean water cycle ...*

*Critical water resources and droughts*




- *Demand multiplied by 2 since 1950*
- *60 million inhabitants lacking water*
- *20 million inhabitants without access to drinkable water*

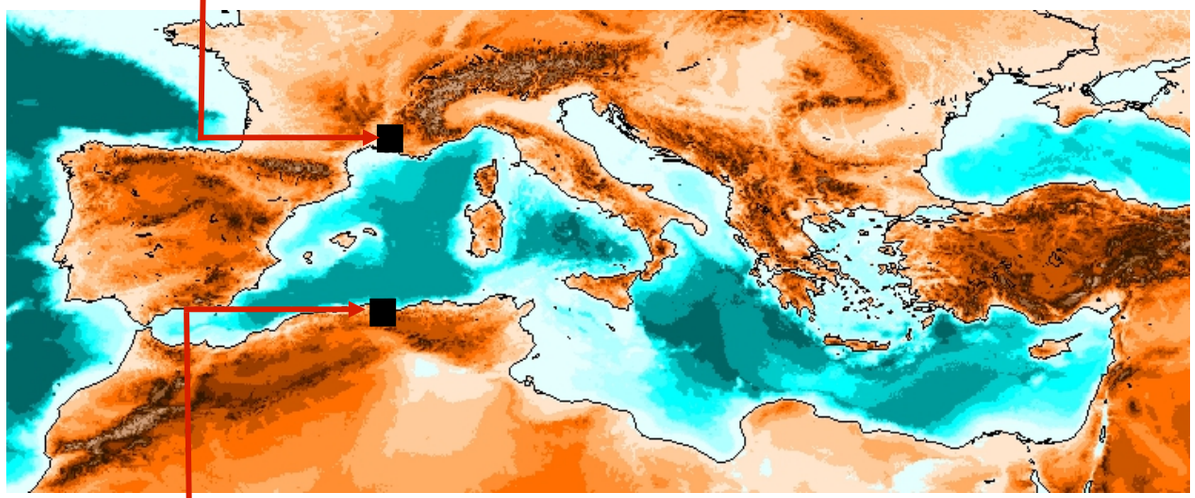
**Source: Plan Bleu (2002)**

# Water related issues the Mediterranean

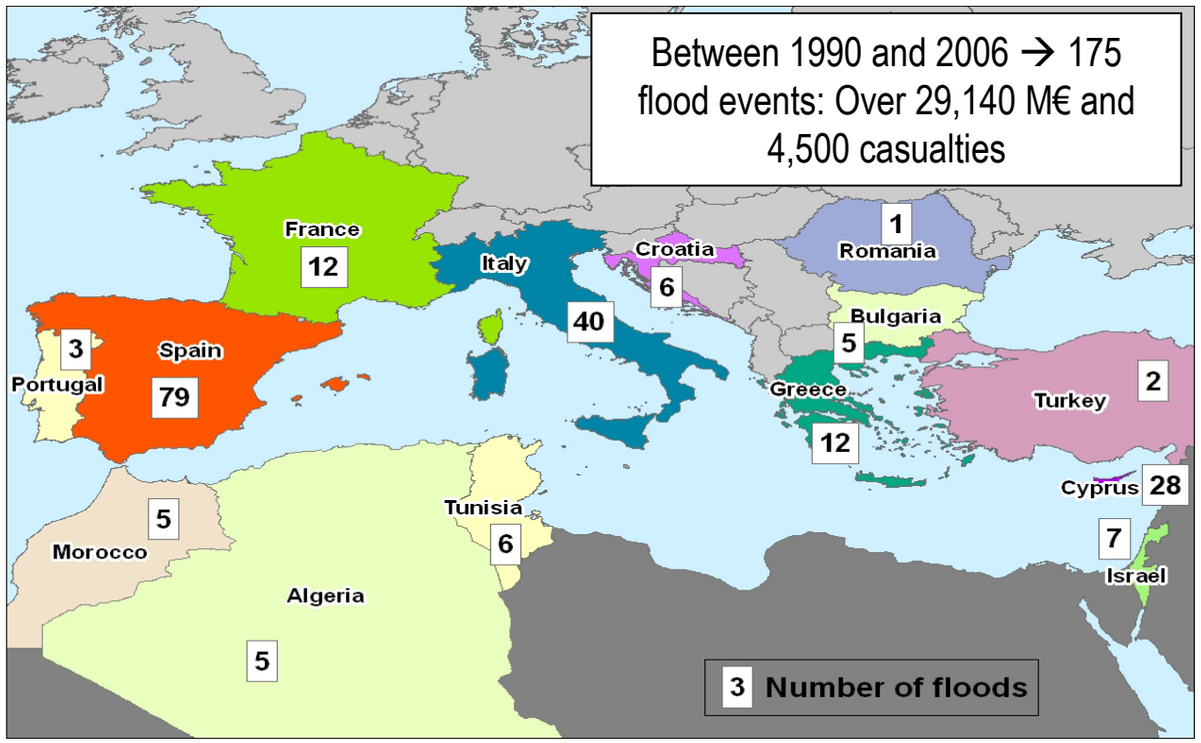
## *Heavy precipitation and floods*

Between1990 and 2006
- more than 175 flood events
- more than 29 140 M€ damages and 4 500 deaths

➢ *Gard, Sept. 2002: ~700 l/m²*
*20 deaths; 1 200 M€ damages*



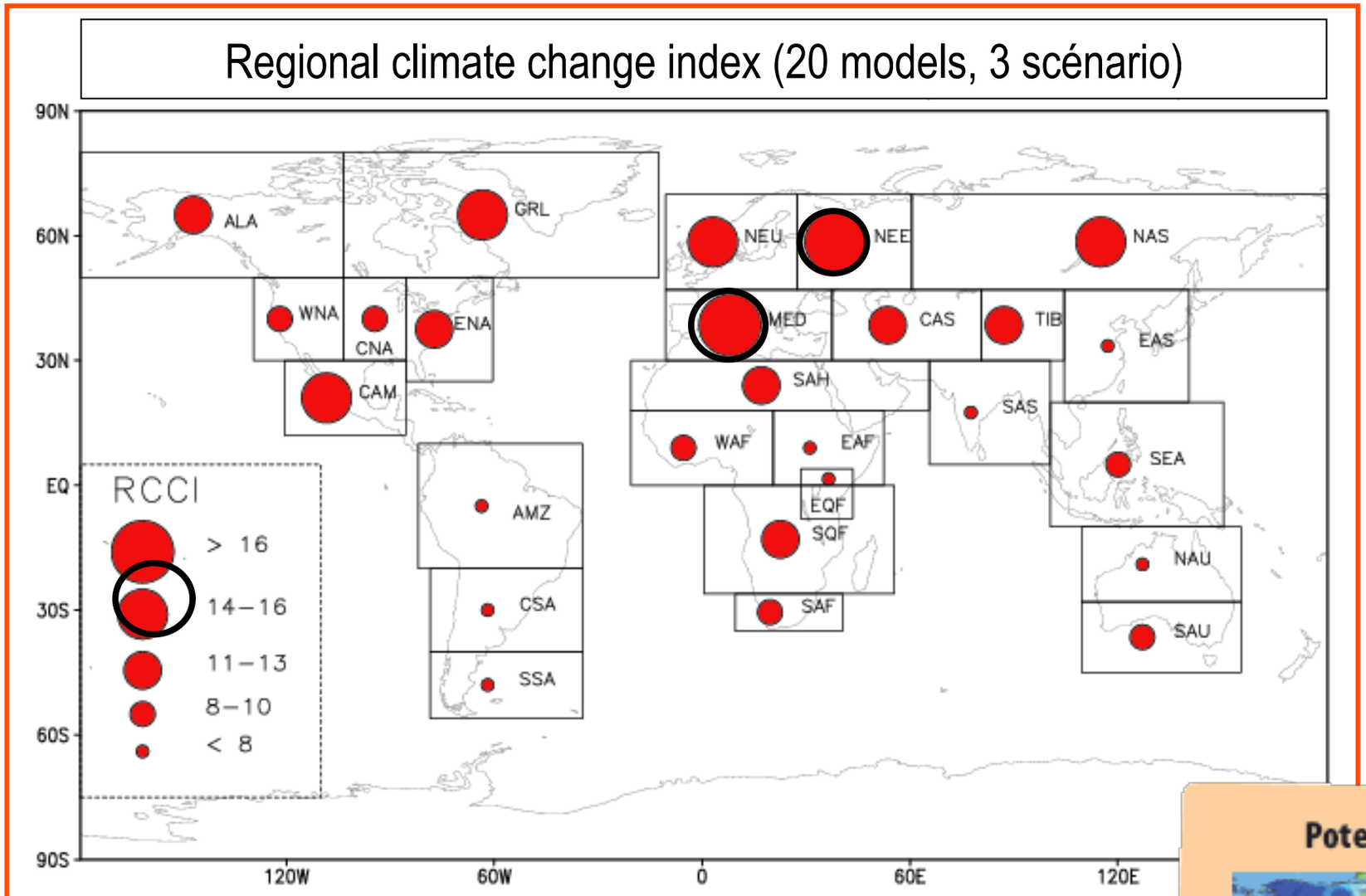
➢ *Alger, nov. 2001: ~260 l/m²*
*886 deaths; 4 000 M€ damages*

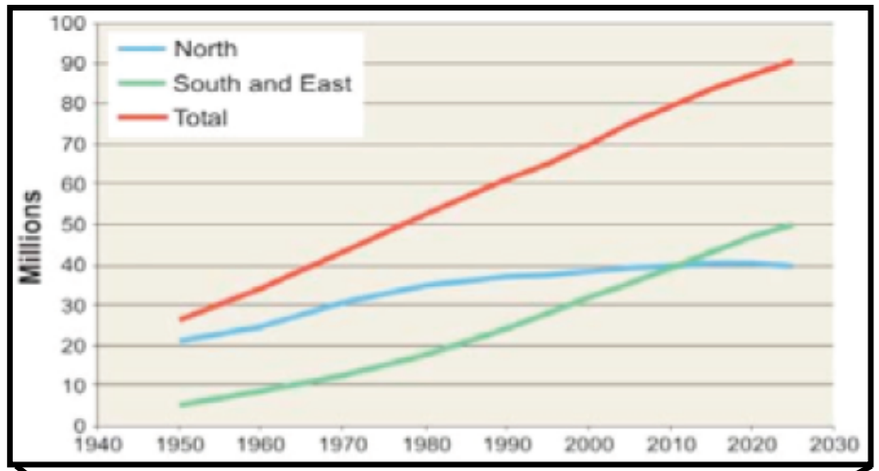


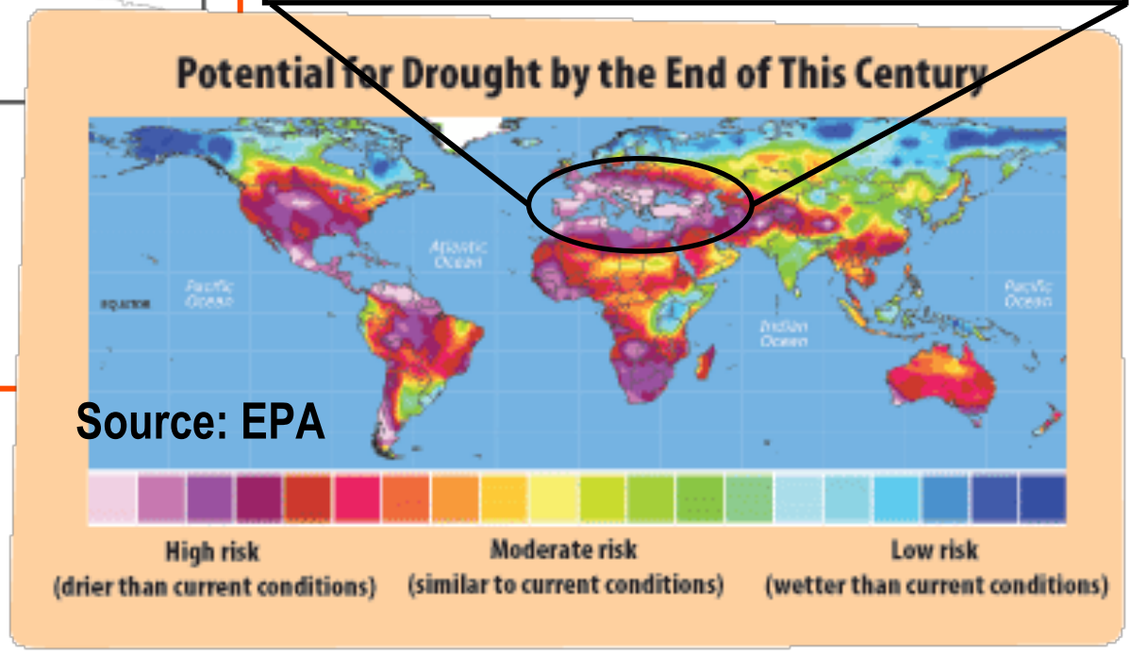

**Source: C. Llasat**

# Water related issues the Mediterranean

## *… in a global climate change context*



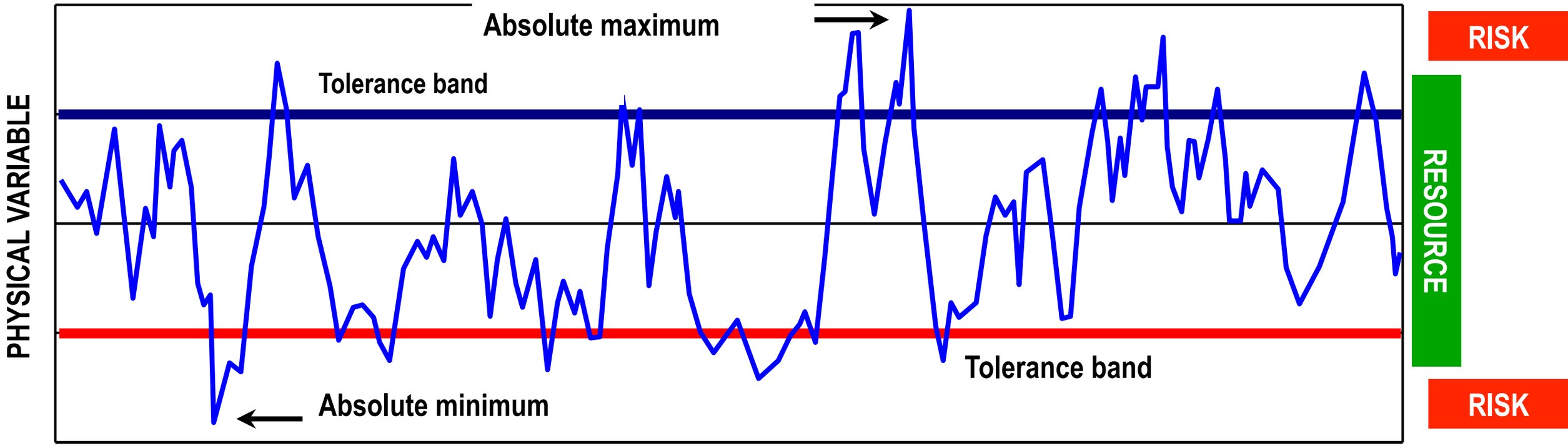




- *Strong regional response to climate change*
- *Projections: significant warming (between +1.4 et +5.8°C in 2100), decrease of the mean annual rainfall and increase of rainfall variability*

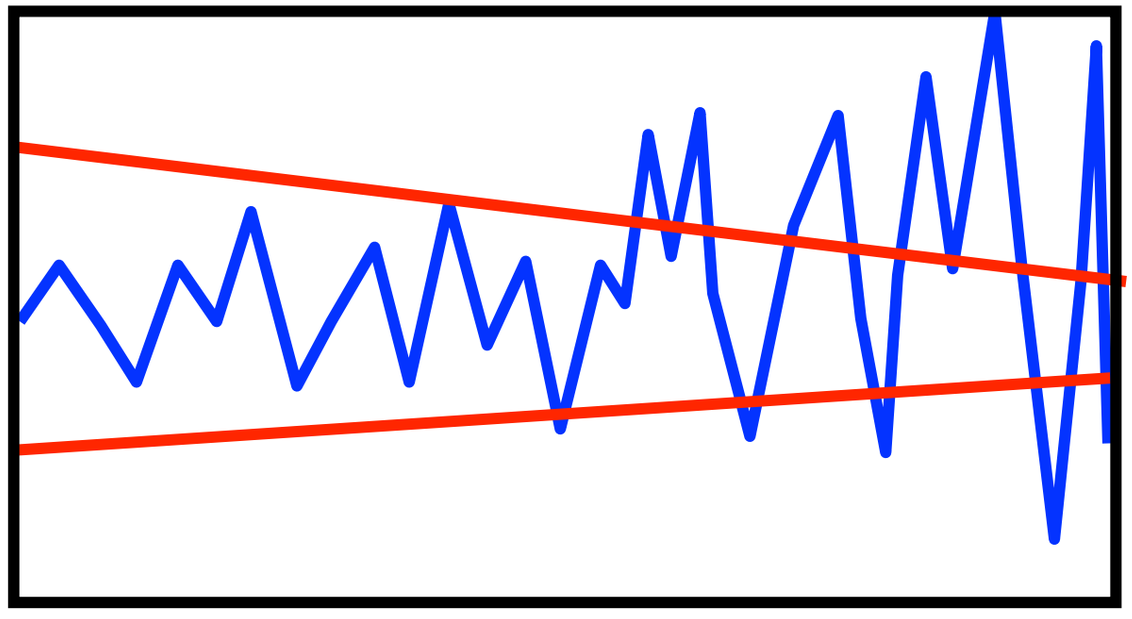
**Source: Giorgi (2006)**

# Risk, hasard and vulnerability

Risk= hazard x vulnerability




Water is a vital resource but outside the acceptable thresholds it is a risk



The last IPCC points to an increase of extremes

The band of tolerance seems to decrease

# Risk, hasard and vulnerability

HyMeX water cycle extremes related vulnerability issues

| | Flood | Drought |
|---|---|---|
| Hazard | High rainfall, sea storm, ice melting,… Geomorphological features of the basin, hydraulic infrastructures, etc. | Water scarcity (low precipitation, high temperatures, negative water balance, etc. |
| Vulnerability | Occupation of flood-prone areas, imprudent activities, warning systems, low educational level of the population, poverty, etc. | Water resources planning, increase in individual use, new uses (private swimming-pools), etc. |
| Risk | Casualties, damages to infrastructures and cars, injured people, agricultural and economic losses, etc. | Restrictions in water supply, environmental and agricultural losses, impact in tourism, economic losses,etc. |
| Perception | Mass-media information Previous experiences with floods, interest for protection measures, education and sensibilization, identification of risk zones | Mass-media information Participation of the population (campaigns on environmental education), orientation of the articles in mass media, confidence in authorities (in the context of political discussions) |

Llasat et al. (2009)

# Drought within HyMeX

## *Global objectives*

**HyMeX is improving land-surface models at different scales.**

- Taking into account anthropogenic processes like irrigation and dams are key in the Mediterranean area.

**New EO products are a great opportunity.**

- Reconstruction of the Mediterranean water cycle.
- Validation.
- Data fusion.

**Improvement of RCMs**

- Fully coupled system (with river flows)
- High resolution (up to 12 km).
- This should improve extremes.

**Drought**

- The HyMeX land-surface community is planning to focus on droughts and their impact on water resources.

**Towards a model inter-comparison**

- Different projects related to HyMeX are doing model inter-comparison in different sites.
- We are systematizing and putting together this simulations in a LSM intercomparison.
- Future GLASS-GHP project within GEWEX

## *Specific objectives*

**Bottom-up approach: social vulnerability monitoring**

**Top-down approach: Land-surface processes, drought and climate**

- Underground water.
- Vegetation.
- Soil moisture.
- Human influence (dams and irrigation).
- Estimation of the total runoff towards the Mediterranean Sea.
- LSM intercomparison.

**Drought, fires and water cycle**

REMEMBER

eartH2Observe

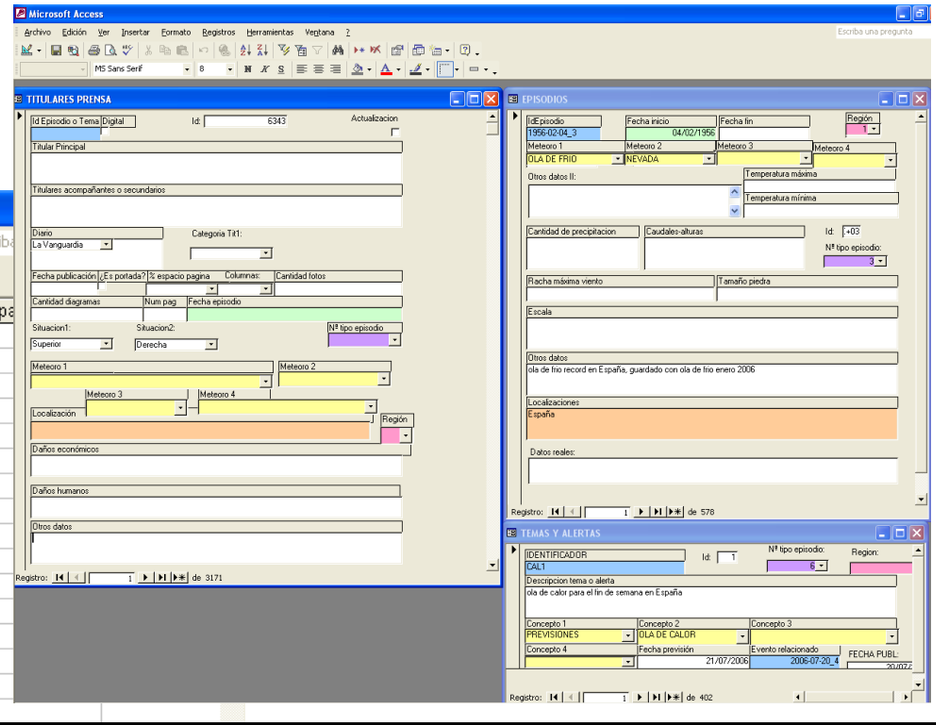
MARCO proyecto

# Drought within HyMeX

## *Press and droughts in Catalunia*

## Press news database 1982-2007

Analyzed more than 14,000 news for the period 1981-2010 and introduced in an ACCESS database




Microsoft Access - [NOTICIAS PRENSA 2006 : Tabla]

Archivo Edición Ver Insertar Formato Registros Herramientas Ventana ?

| Id | IDENTIFICADOR | Digital | ¿Es portada? | Fecha public: | Titular Principal | Titulares acomp | Diario | Espa |
|---|---|---|---|---|---|---|---|---|
| 1513 | 2003-06-20_4B | ☐ | ☐ | 21/06/2003 | Un incendi forestal obliga a tallar la N-2 al Pla de l'Estany | | El Periódico | |
| 1537 | 2003-06-20_4B | ☐ | ☐ | 21/06/2003 | Un incendio forestal obliga a desalojar masías y a cortar la N-II cerca de Girona | | La Vanguardia | |
| 1515 | 2003-06-20_4B | ☐ | ☐ | 22/06/2003 | El foc obliga a tallar la N-2 a Vilademuls | | El Periódico | |
| 1514 | PREV117 | ☐ | ☐ | 22/06/2003 | El Meteocat peveu tres dies més amb màximes de 40ºC | | El Periódico | |
| 1517 | ALERT116 | ☐ | ☐ | 22/06/2003 | Alto riesgo de incendios forestales en las comarcas de la Catalunya central y Girona | | La Vanguardia | |
| 1516 | 2003-06-01_4 | ☐ | ☐ | 22/06/2003 | Calor africano para la verbena | | La Vanguardia | |
| 1518 | 2003-06-20_4 | ☐ | ☐ | 23/06/2003 | El calor porta els primers incendis de l'estiu | | El Periódico | |
| 1519 | 2003-06-01_4 | ☐ | ☐ | 23/06/2003 | Barcelona registra el mes de juny més càlid de l'últim segle | | El Periódico | |
| 1520 | 2003-06-01_4 | ☐ | ☐ | 24/06/2003 | El calor i la por dels incendis presideixen la revetlla de Sant Joan | | El Periódico | |
| 1521 | 2003-06-01_4C | ☐ | ☐ | 24/06/2003 | La sequedat manté l'alerta als boscos | | El Periódico | |
| 1522 | 2003-06-24_1 | ☐ | ☐ | 25/06/2003 | La pluja alleuja el nord d'Espanya i gairebé no es nota a Catalunya | | El Periódico | |
| 1523 | 2003-06-24_1 | ☐ | ☐ | 25/06/2003 | Las tormentas acaban con la ola de calor | | Metro Directe | |
| 1524 | 2003-06-24_1 | ☐ | ☐ | 25/06/2003 | Tormenta histórica | | 20 Minutos de | |
| 1525 | 2003-06-27_1 | ☐ | ☐ | 28/06/2003 | Pluja i calamarsa alleugen el calor a l'interior de Catalunya | | El Periódico | |
| 1527 | 2003-06-30_2 | ☐ | ☐ | 01/07/2003 | Tres banyistes moren ofegats al litoral català per l'onatge | | El Periódico | |
| 1526 | 2003-06-01_4 | ☐ | ☐ | 01/07/2003 | El juny més sufocant | | El Periódico | |
| 1529 | 2003-06-01_4 | ☐ | ☐ | 03/07/2003 | El día más caluroso desde 1880 | | | |
| 1528 | 2003-06-30_2 | ☐ | ☐ | 03/07/2003 | Dos ofegats més eleven a cinc les morts per la mala mar | | | |
| 1538 | 2003-07-13_4 | ☐ | ☐ | 14/07/2003 | Dos incendis disparen l'alarma a Sils i a Castellbell i el Vilar | | | |
| 1531 | 2003-07-13_4 | ☐ | ☐ | 14/07/2003 | Dos incendis al Bages i La Selva cremen més de 400 hectàrees | | | |
| 1532 | 2003-07-14_4 | ☐ | ☐ | 14/07/2003 | Todo el norte de Italia podría quedarse sin luz por la sequía | | | |
| 1539 | 2003-07-13_4 | ☐ | ☐ | 15/07/2003 | L'incendi del Bages, controlat 29 hores després | | | |
| 1540 | 2003-07-15_2 | ☐ | ☐ | 16/07/2003 | Tres morts per un temporal al sud-oest de França | | | |
| 1541 | 2003-07-15_2 | ☐ | ☐ | 17/07/2003 | 7 morts pel temporal a França | | | |
| 1534 | 2003-07-18_4 | ☐ | ☐ | 19/07/2003 | Tallada la N-2 per un foc | | | |
| 1533 | 2003-07-17_4 | ☐ | ☐ | 19/07/2003 | Evacuats 8.000 turistes a la Costa Blava per un incendi (archivado en 14/ | | | |
| 1542 | 2003-07-19_4 | ☐ | ☐ | 20/07/2003 | Un incendi crema 200 hectàrees a Talamanca | | | |
| 1547 | 2003-06-01_4 | ☐ | ☐ | 23/07/2003 | El calor de juny va disparar la mortalitat i les urgències | | | |
| 1548 | 2003-06-01_4C | ☐ | ☐ | 27/07/2003 | Lleida afronta restriccions en l'aigua a causa de la calor | | | |
| 1536 | 2003-07-29_7 | ☐ | ☐ | 30/07/2003 | Un terratrèmol sacseja part d'Andalusia | | | |
| 1535 | 2003-07-28_4B | ☐ | ☐ | 30/07/2003 | Devastadors incendis causen quatre morts al sud de França (arhivado en | | | |
| 1543 | 2003-07-17_4 | ☐ | ☐ | 31/07/2003 | La Costa Azul en llamas | | | |
| 1544 | 2003-07-30_4 | ☐ | ☐ | 01/08/2003 | Tempesta de calamarsa a Anglès i la Cellera de Ter | | | |
| 1549 | 2003-06-01_4 | ☐ | ☐ | 02/08/2003 | El calor bat el rècord de l'any, amb temperatures de 46º a Andalusia | | | |
| 1550 | 2003-06-01_4 | ☐ | ☐ | 02/08/2003 | Dos personas mueren víctimas del asfixiante calor en Sevilla y Córdoba | | | |
| 1551 | 2003-06-01_4 | ☐ | ☐ | 03/08/2003 | El calor baixa però les màximes al sud d'Espanya arriben als 42 ºC | | | |
| 1554 | 2003-07-28_4 | ☐ | ☐ | 04/08/2003 | Mueren nueve personas en los incendios de Portugal | | | |
| 1555 | 2003-07-28_4 | ☐ | ☐ | 04/08/2003 | Los incendios forestales obligan a evacuar a 2,000 personas en Extremad | | | |
| 1553 | 2003-06-01_4 | ☐ | ☐ | 04/08/2003 | Ya son siete los muertos en Andalucía por la ola de calor | | | |
| 1552 | 2003-07-28_4 | ☐ | ☐ | 04/08/2003 | El calor causa quatre morts més i aviva el foc a Extremadura | | | |
| 1556 | 2003-07-28_4 | ☐ | ☐ | 05/08/2003 | Plan de choque en Portugal contra la oleada de incendios | | | |
| 1557 | 2003-06-01_4 | ☐ | ☐ | 06/08/2003 | El calor llena las urgencias de los hospitales... | | | |
| 1558 | 2003-06-01_4 | ☐ | ☐ | 06/08/2003 | Cinco muertos en los dos últimos días elevan a doce las víctimas en Esp | | | |
| 1559 | 2003-06-01_4 | ☐ | ☐ | 06/08/2003 | La ola de calor no aflojará durante los próximos días | | | |
| 1560 | 2003-07-28_4 | ☐ | ☐ | 06/08/2003 | Portugal pide hidroaviones y helicópteros a la OTAN para frenar el avance | | | |
| 1561 | 2003-07-28_4 | ☐ | ☐ | 06/08/2003 | El fuego arrasa 15,000 hectáreas en la región | | | |
| 1565 | 2003-06-01_4 | ☐ | ☐ | 07/08/2003 | Una anciana de Coria, primera víctima del calor en Extremadura | | | |
| 1562 | 2003-06-01_4 | ☐ | ☐ | 07/08/2003 | El calor obliga a avançar dues setmanes la verema a Raimat | | | |

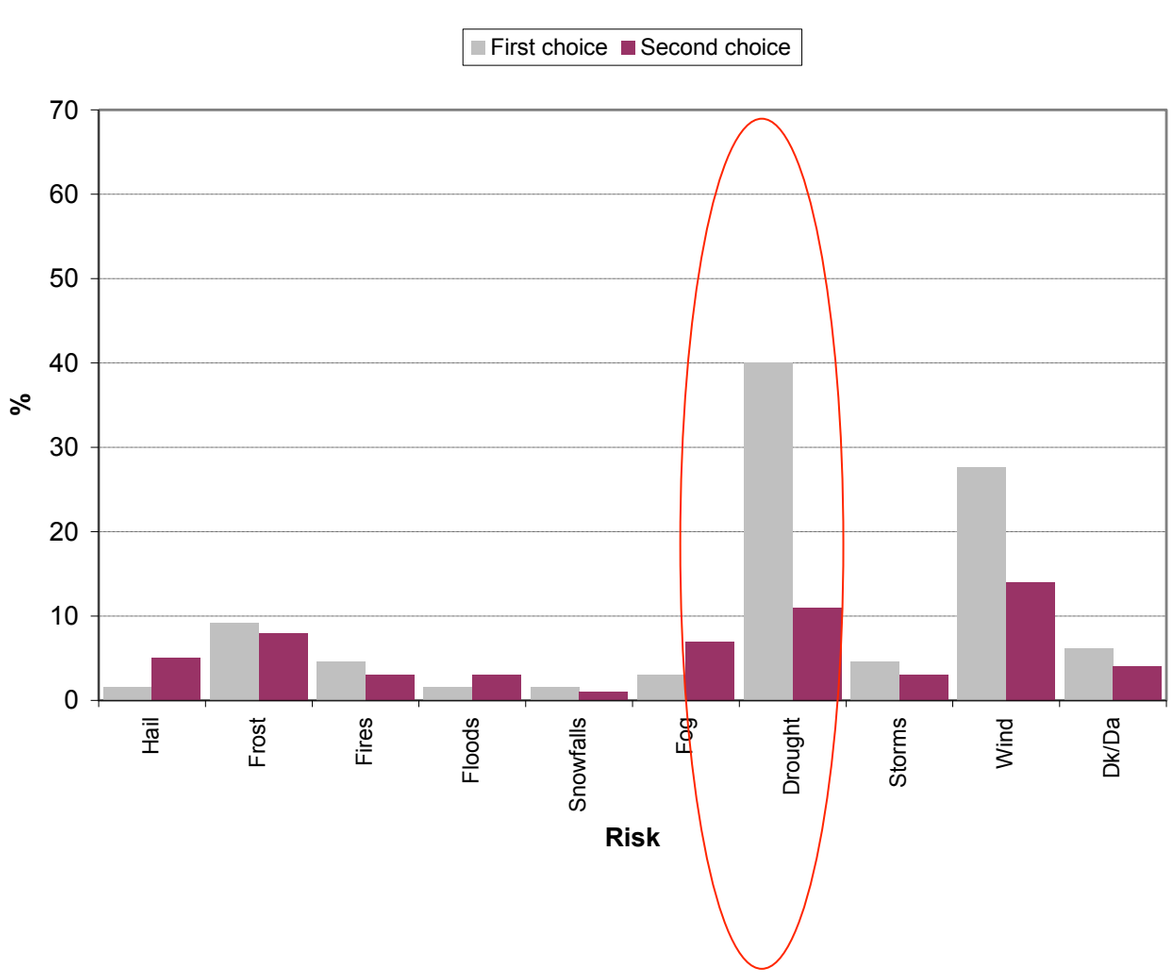
Registro: 1 de 3171

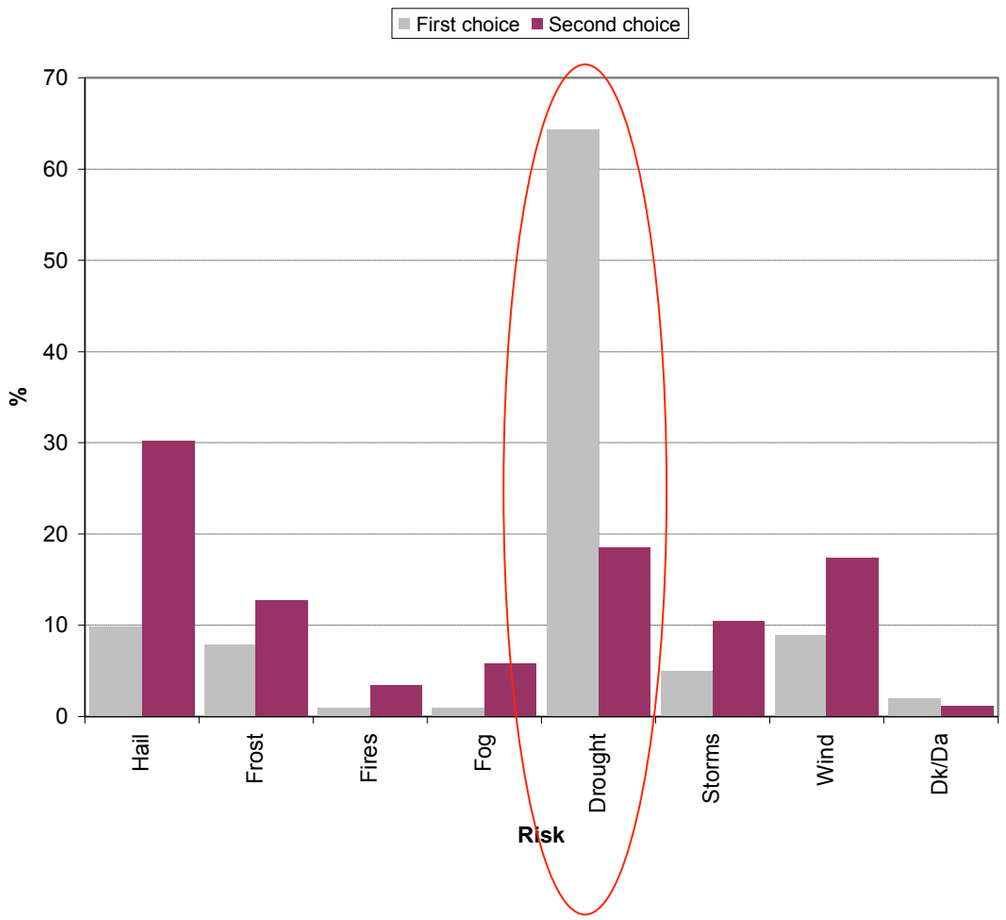
La del diario

| Code | Type and description |
|---|---|
| 1 | **Flood**: Heavy rainfalls, floods and landslides |
| 2 | **Wind storms**: Storm, gale, tornado, hurricane, dust storm |
| 3 | **Snow and cold**: Snowfalls, cold waves, snow avalanches |
| 4 | **Agrometeorological risks**: Forest fires, drought, hail, heat waves, frost |
| 5 | **Sustainable development**: Climatic change, pollution |
| 6 | **Alert chain**: Training, statistics, alerts, forecasts |
| 7 | **Others**: Earthquake, volcanoes |

# Drought within HyMeX

## *Press and droughts in Catalunia*



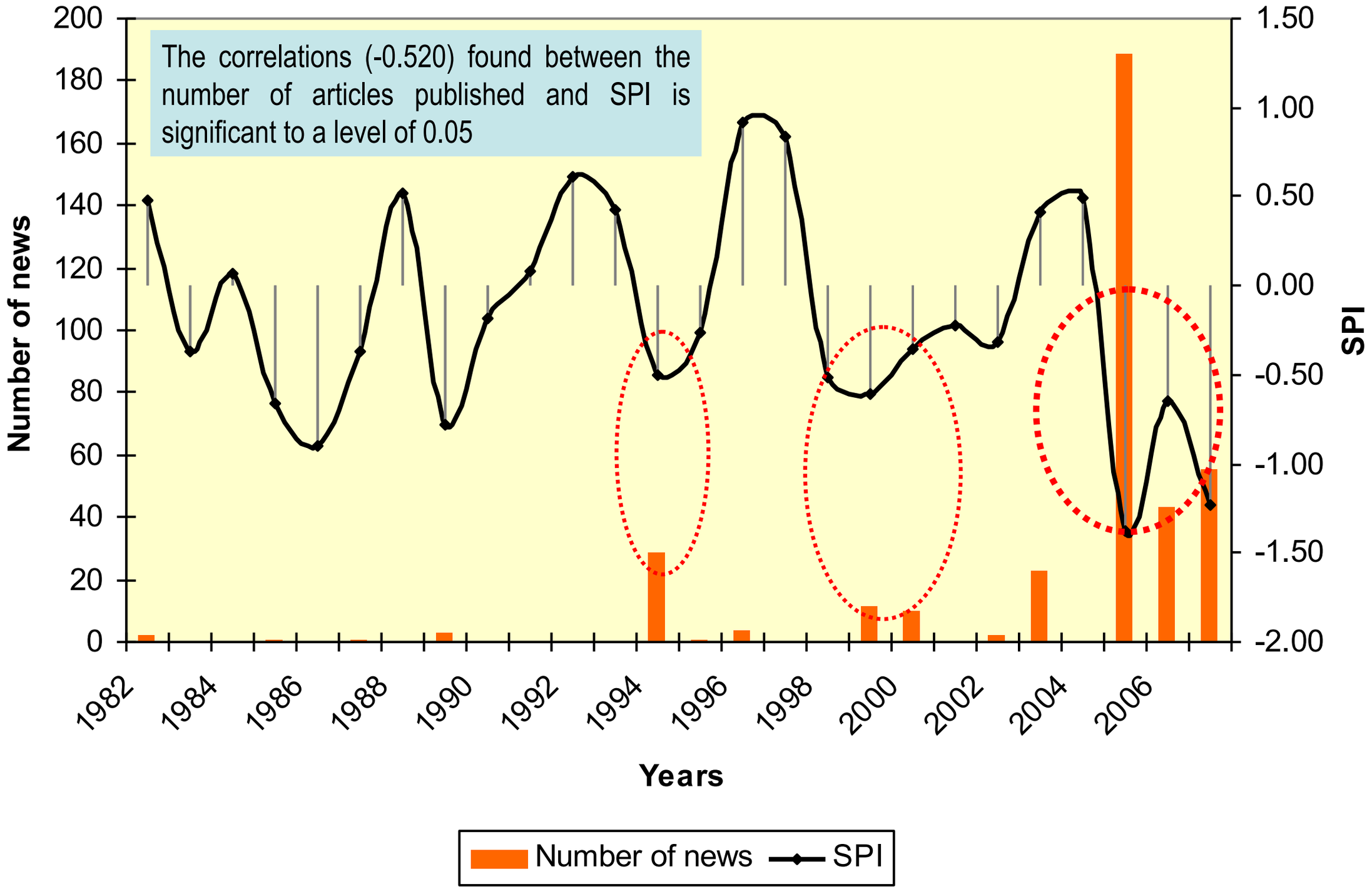

*Importance of meteorological risks as perceived by the population (1st and 2nd), evaluated by conducting questionnaires in (a) Zaragoza (urban area),( b) Alcañiz (rural area)*

The societal perception of the drought in rural areas is higher than in urban areas.

# Drought within HyMeX

## *Press and droughts in Catalunia*

SPI drought index compared to the press database

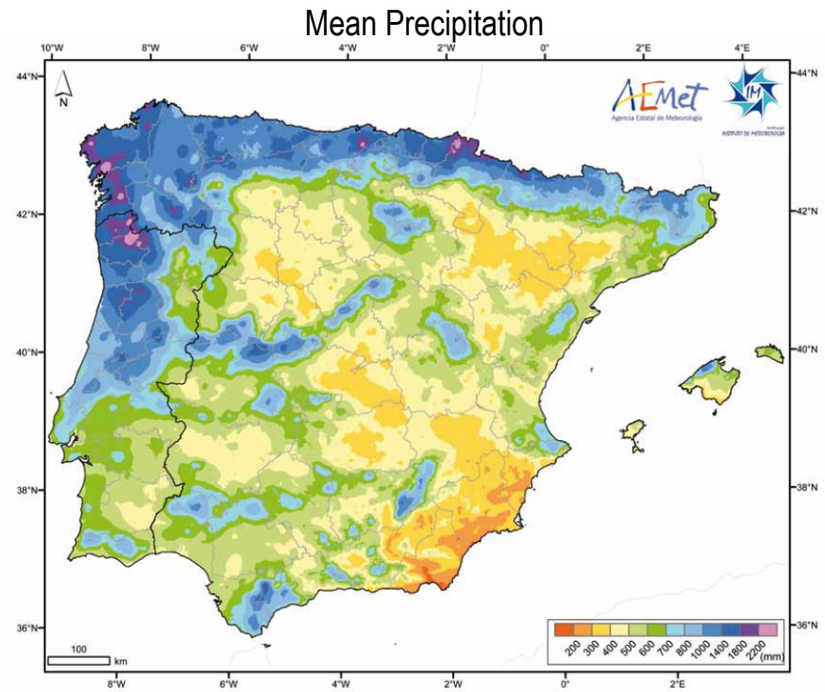


# Drought within HyMeX

## *Underground water and drought in Spain*

- Uneven spatial distribution of water availability.
- High temporal variability (seasonal and interannual).
- High pressure on water resources.
- Water scarcity.

- Long tradition of hydraulic works.
  - Nowadays, Spain is the fifth country in the world with the highest number of large dams
- The problem is aggravated by climate change.



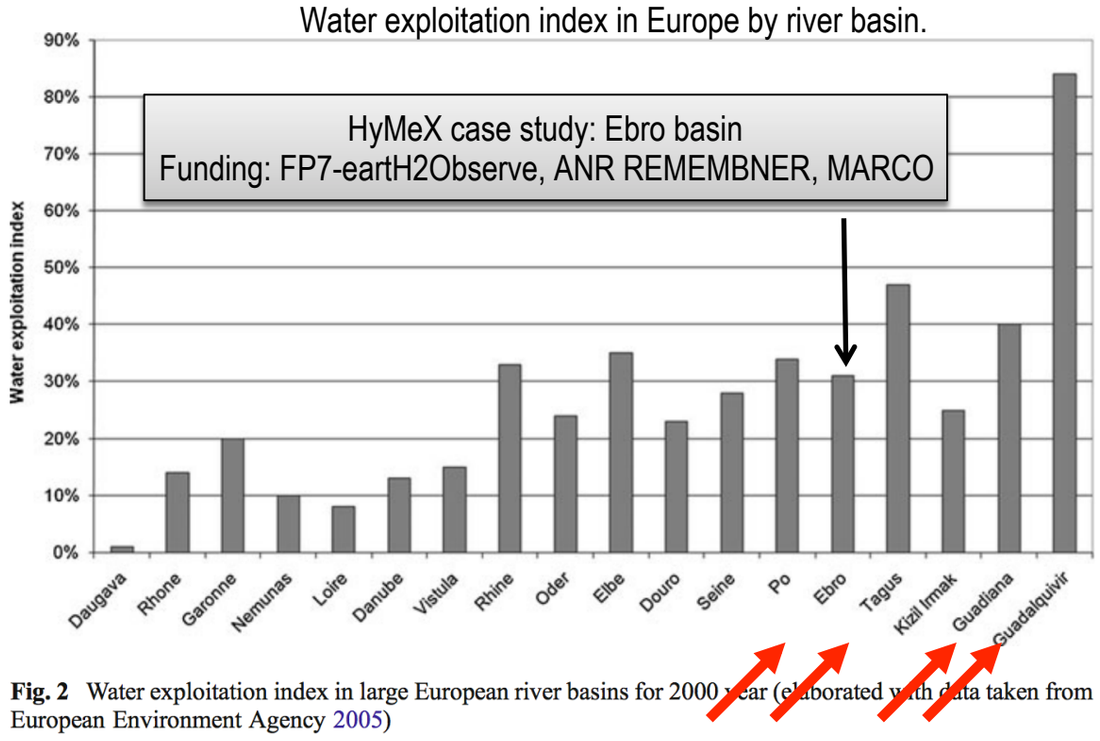



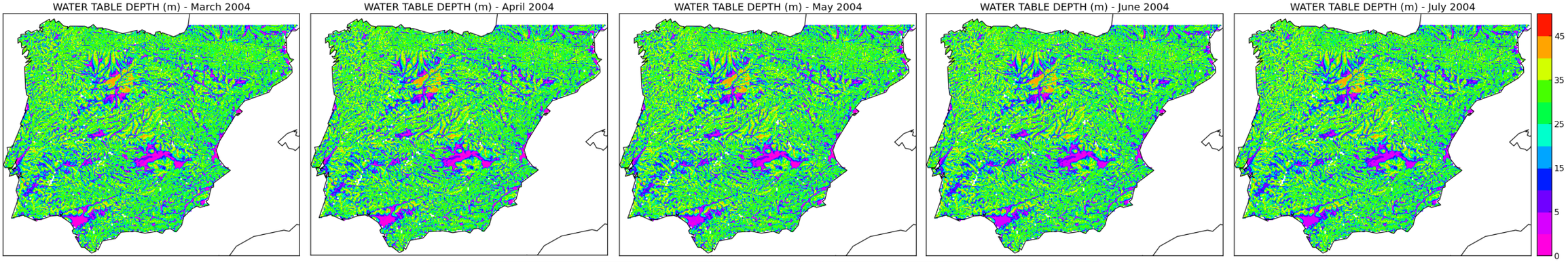

**Fig. 2** Water exploitation index in large European river basins for 2000 year (elaborated with data taken from European Environment Agency 2005)

Estrela and Vargas (2012)

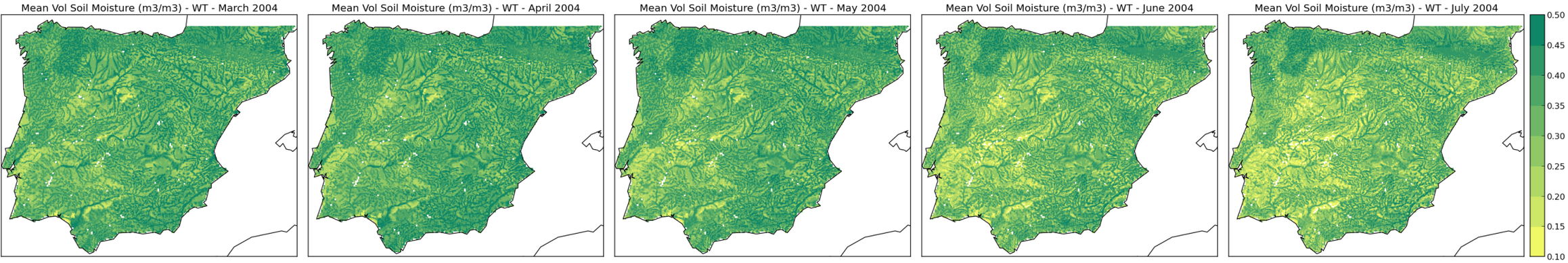
# Drought within HyMeX

## *Underground water and drought in Spain*

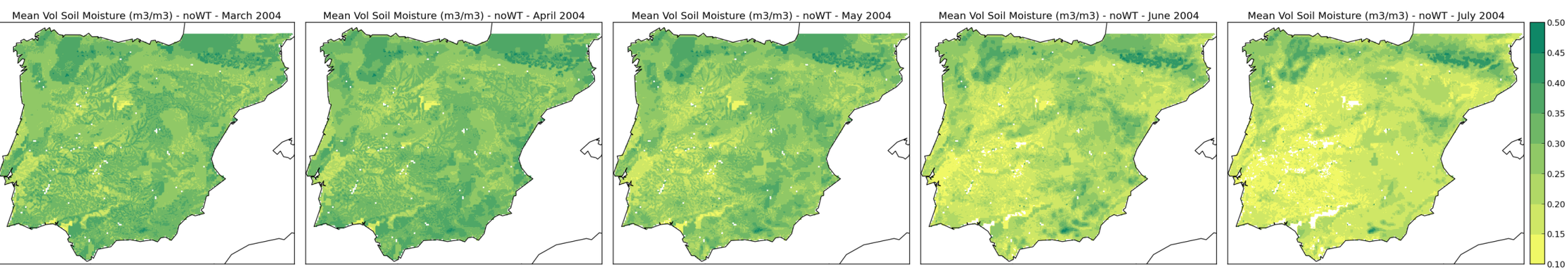
## Groundwater persistence translates to soil moisture memory




The water table evolves slowly




By wetting the soil from below the water table pattern is reflected in the soil moisture pattern: wetter soils where the water table is shallow

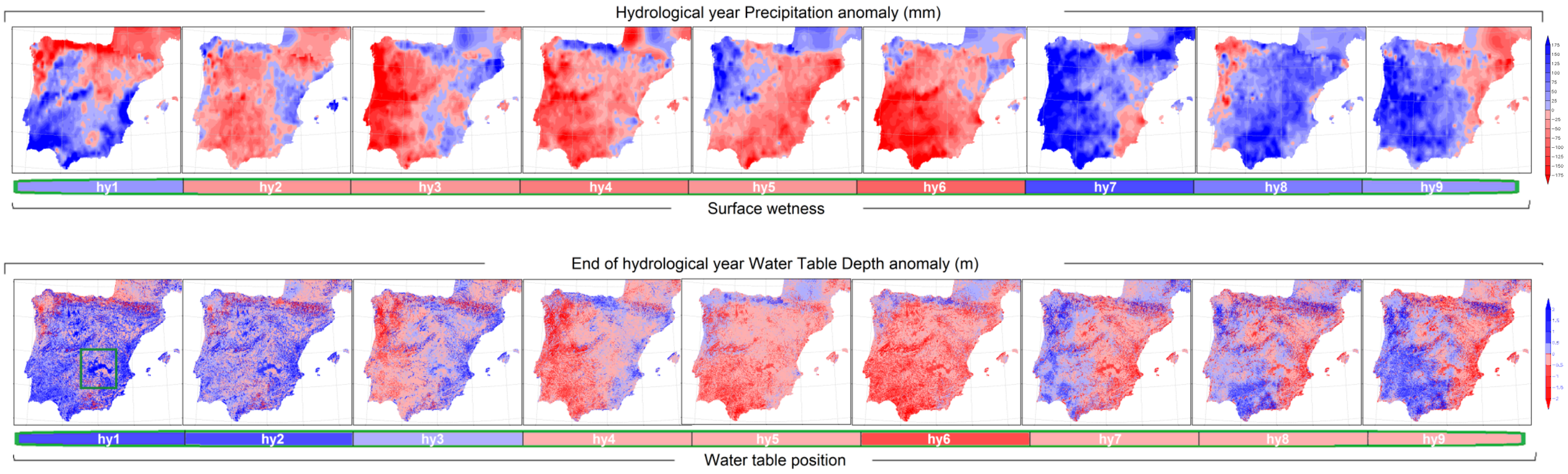



Without groundwater, soil moisture depends only on climate, soils dry too much in summer

# Drought within HyMeX

## *Underground water and drought in Spain*

## Memory introduced into the soil moisture by groundwater



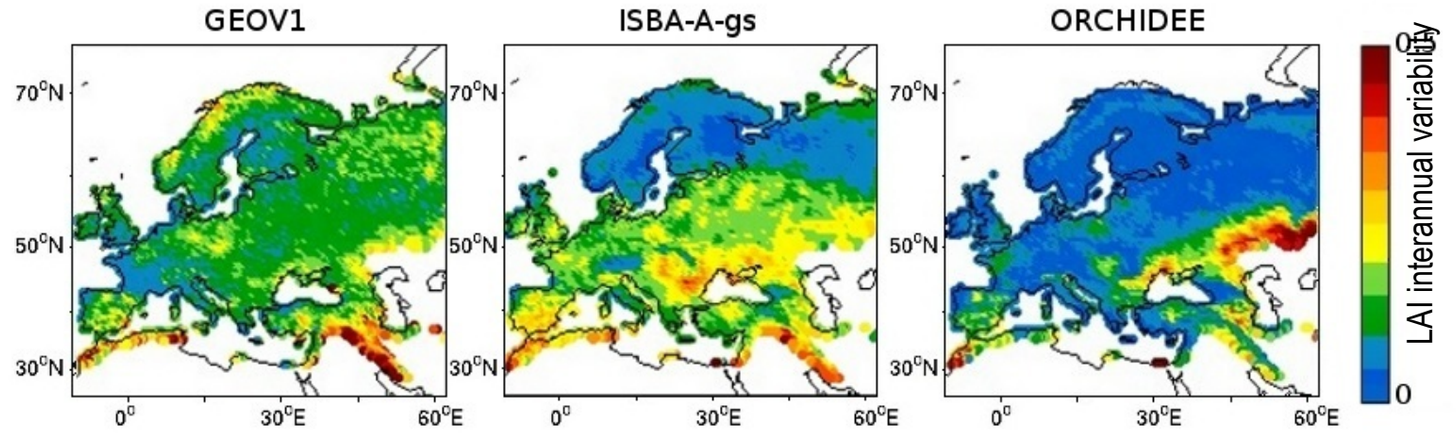

Large yearly precipitation anomalies are “remembered” for 1-2 years into the future by the water table

# Drought within HyMeX

## *The role of vegetation in drought processes*

- Remote sensing is a very valuable source of data related to vegetation.
- LSMs are improving and are able to simulate more vegetation related processes.
- Data assimilation is a powerful tool in order to improve LSM simulation using remotely sensed data.
- We still do not understand well what will be the impact of human activities on vegetation… and how this will affect drought.

Climate impact on vegetation is still poorly simulated




LAI interannual variability (std/mean) over the 1991-2008 period: SURFEX & ORCHIDEE vs. satellite data

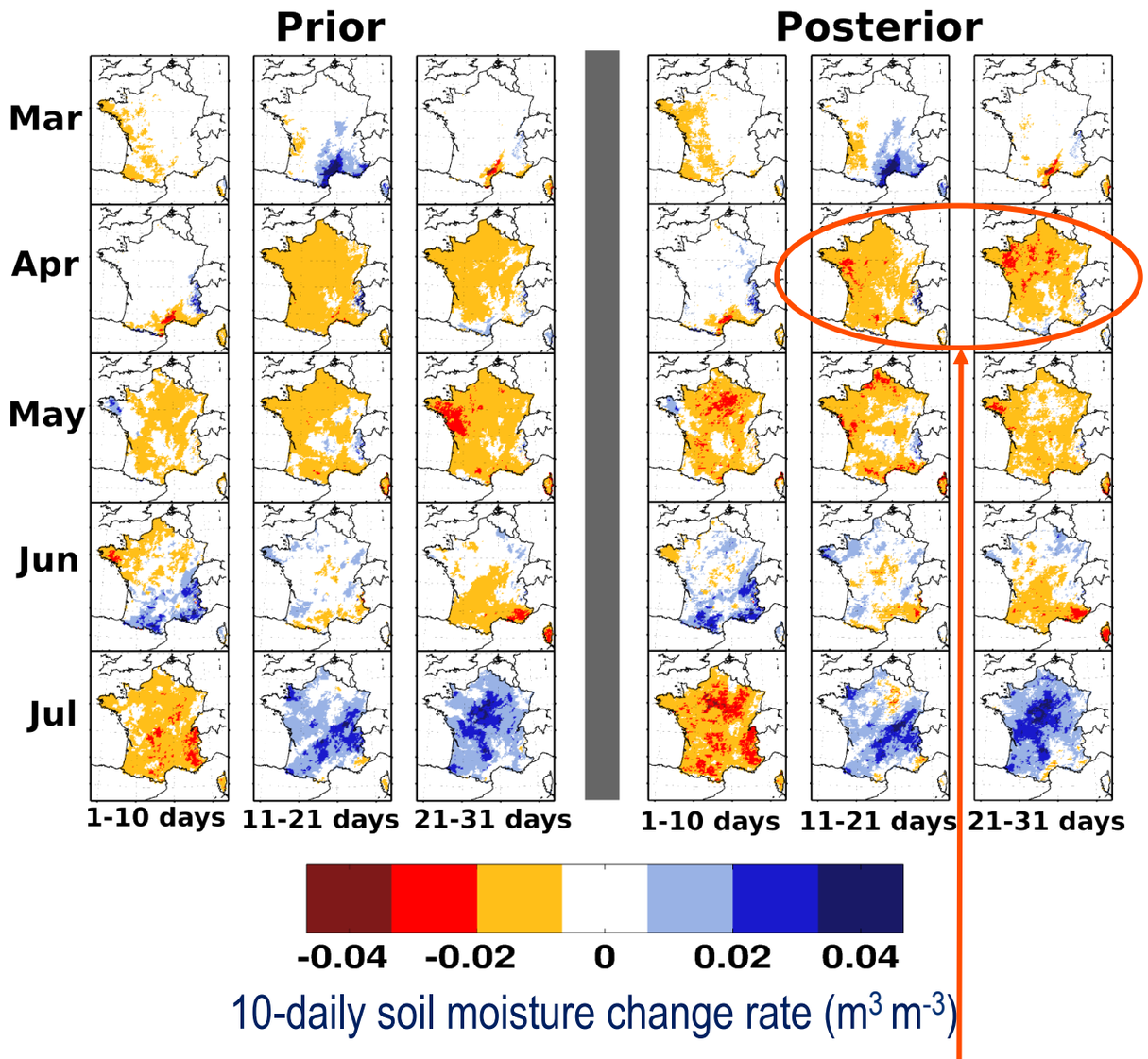
Szczypta et al. (2014)

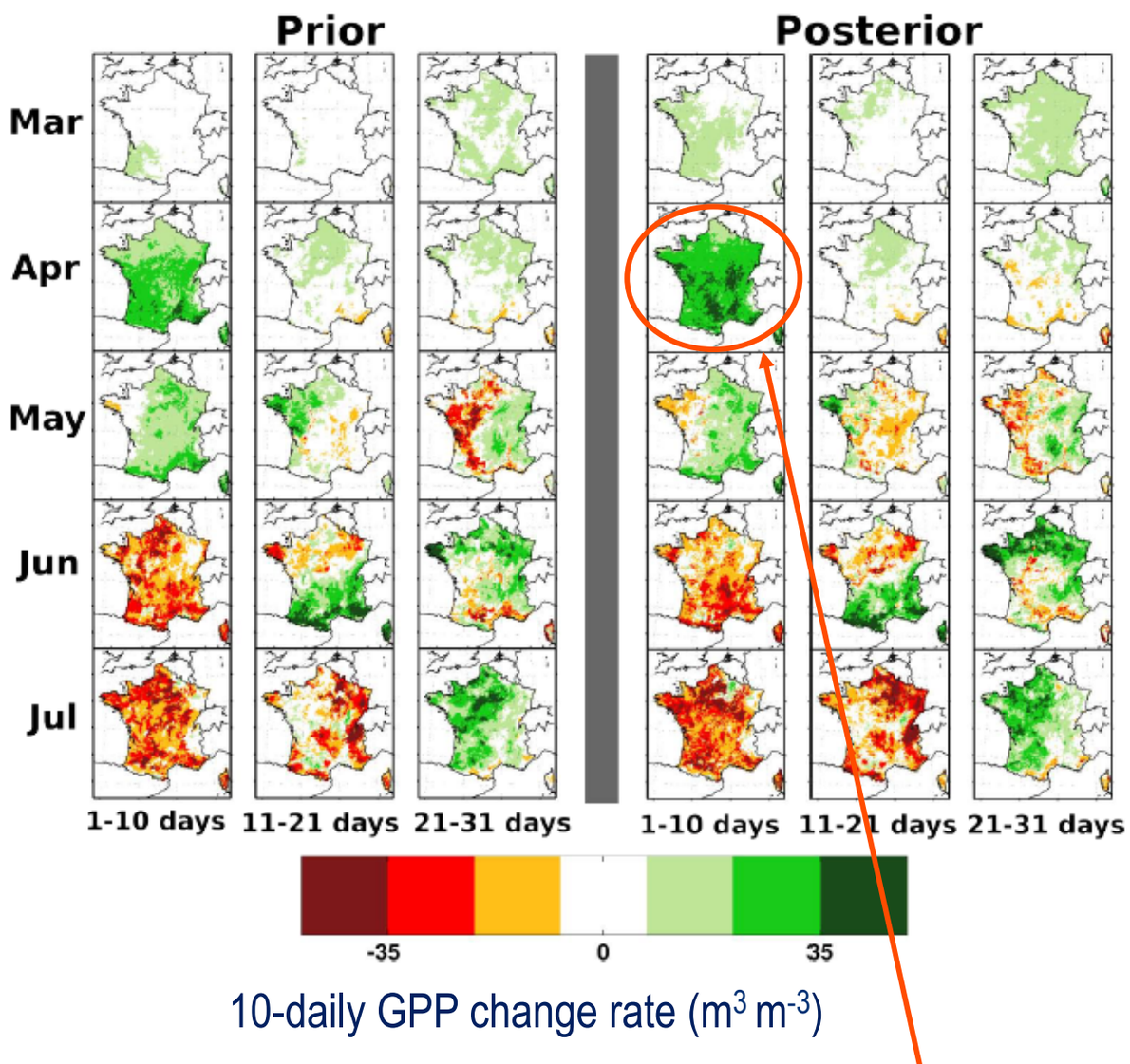
# Drought within HyMeX

## *The role of vegetation in drought processes*

Integrating satellite observations into models improves the monitoring of extreme events

Spring drought of 2011 in France: sequential assimilation of LAI and surface soil moisture into SURFEX




Enhanced drought onset

Enhanced description of the impact of vegetation growth on drought onset

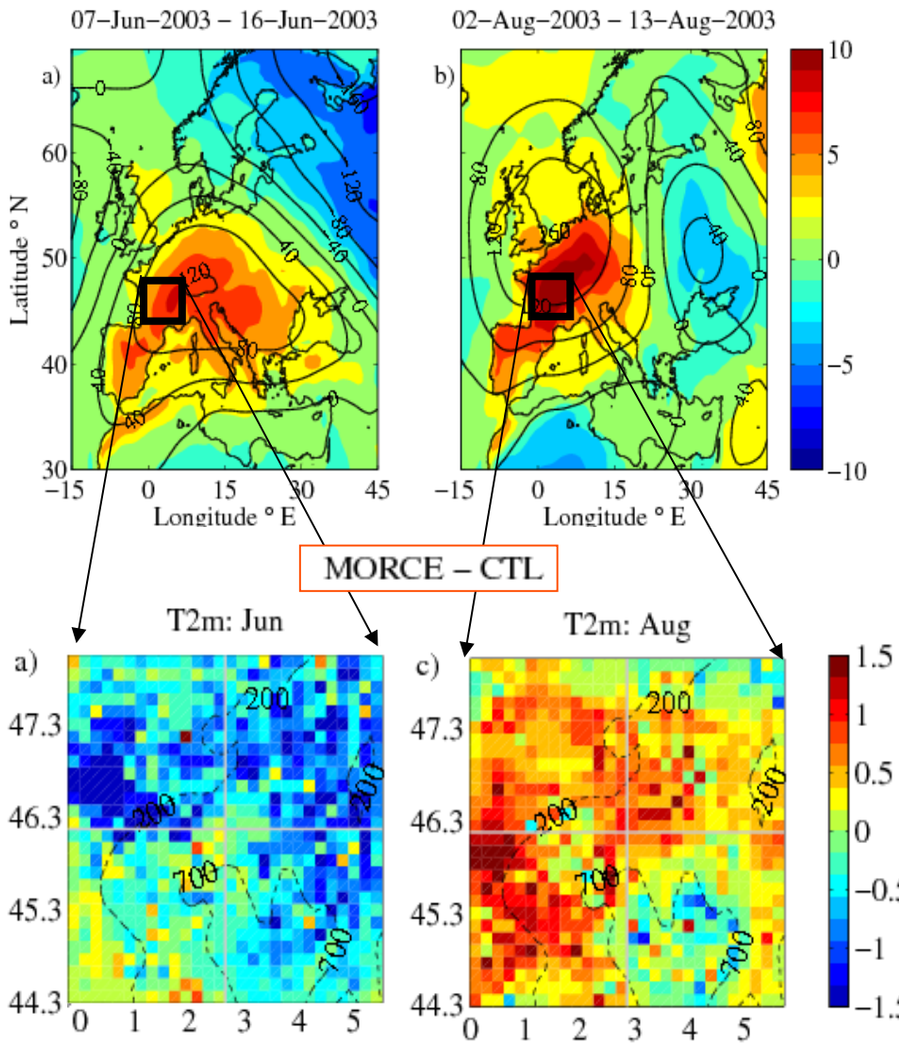
Barbu et al. (2014)

# Drought within HyMeX

## *The role of vegetation in drought processes*

## Vegetation/atmosphere feedbacks

Spring drought of 2003 in France and its impact on summer 2003 heatwave

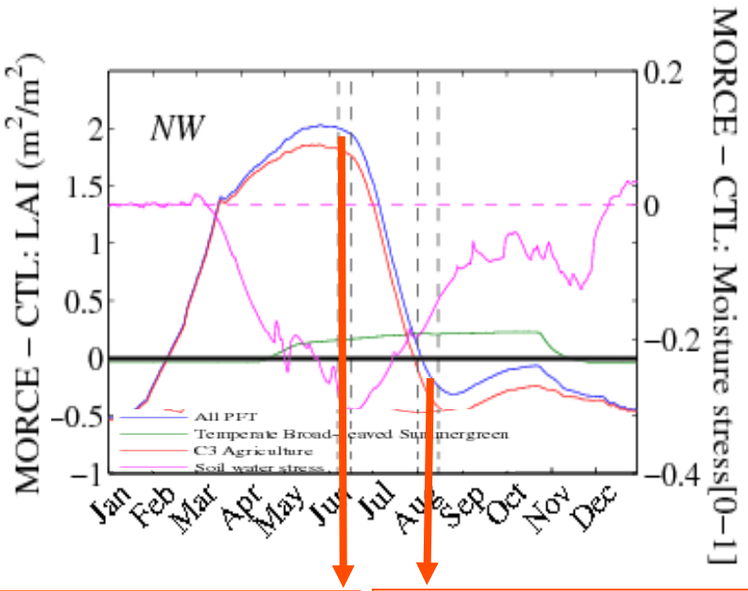



Damping effect of interactive vegetation in June 2003

Amplifying effect of interactive vegetation in August 2003

**Two integrations with WRF/ORCHIDEE**
One with prescribed LAI (CTL)
One with interactive vegetation phenology (MORCE)

Δx =15 km; 2 years (2002-2001) runs
Boundary condition: ERA-Interim
In the CTL run the LAI of 2002 is repeated in 2003



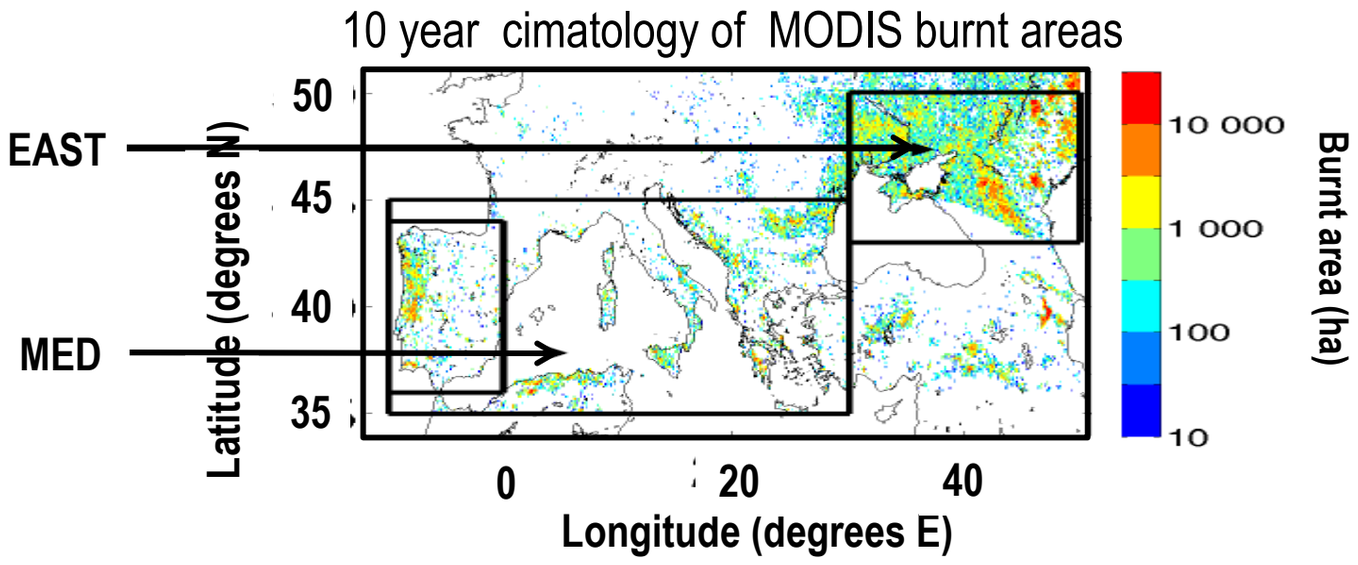

Early vegetation growth caused by springtime meteorological drought → more evaporation and weaker temperature anomaly

Vegetation senescence due to soil moisture drought → less evaporation (less NPP; Ciais et al., 2005) and larger temperature anomaly

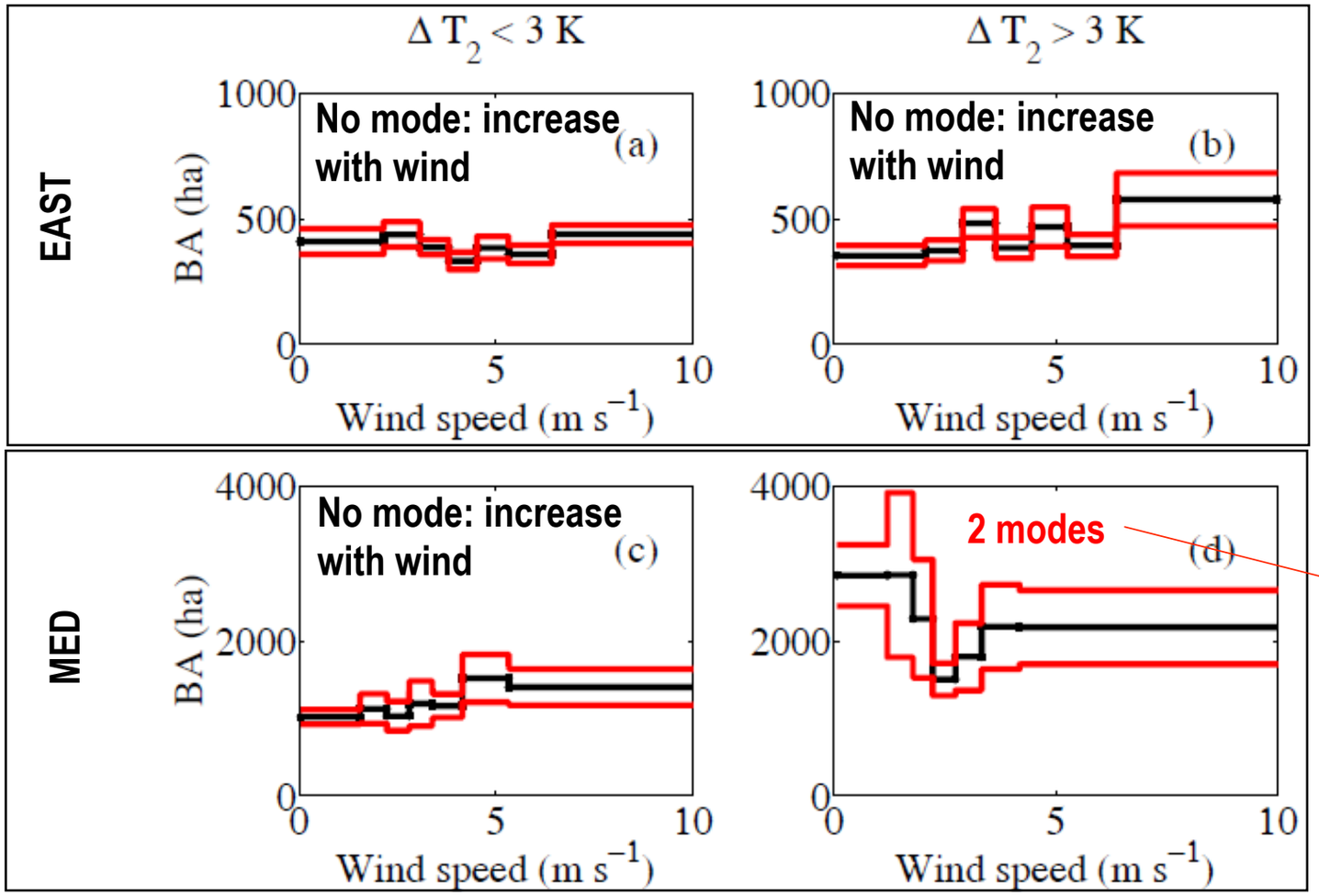
Stéfanon et al. (2012)

# Drought within HyMeX

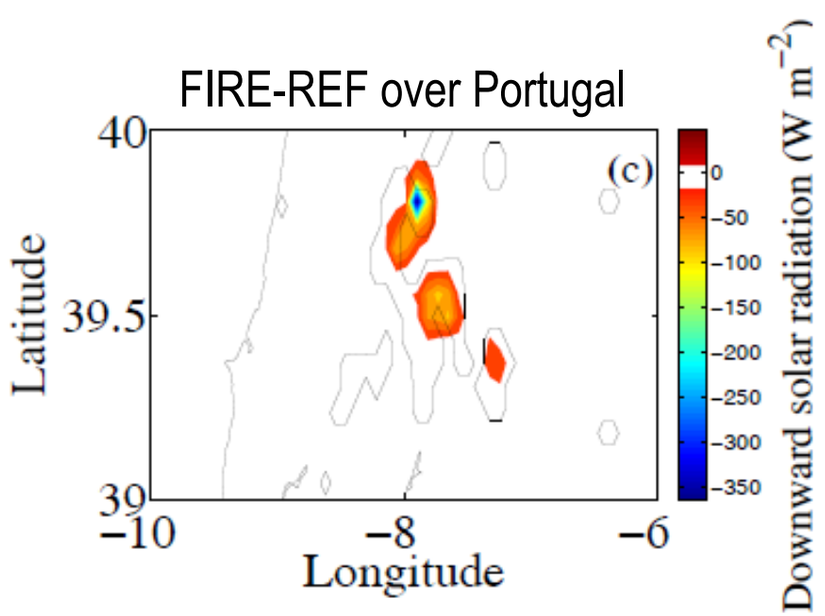
## *Droughts, fires and water cycle*




Modes of fire propagation




Impact of long-term water cycle



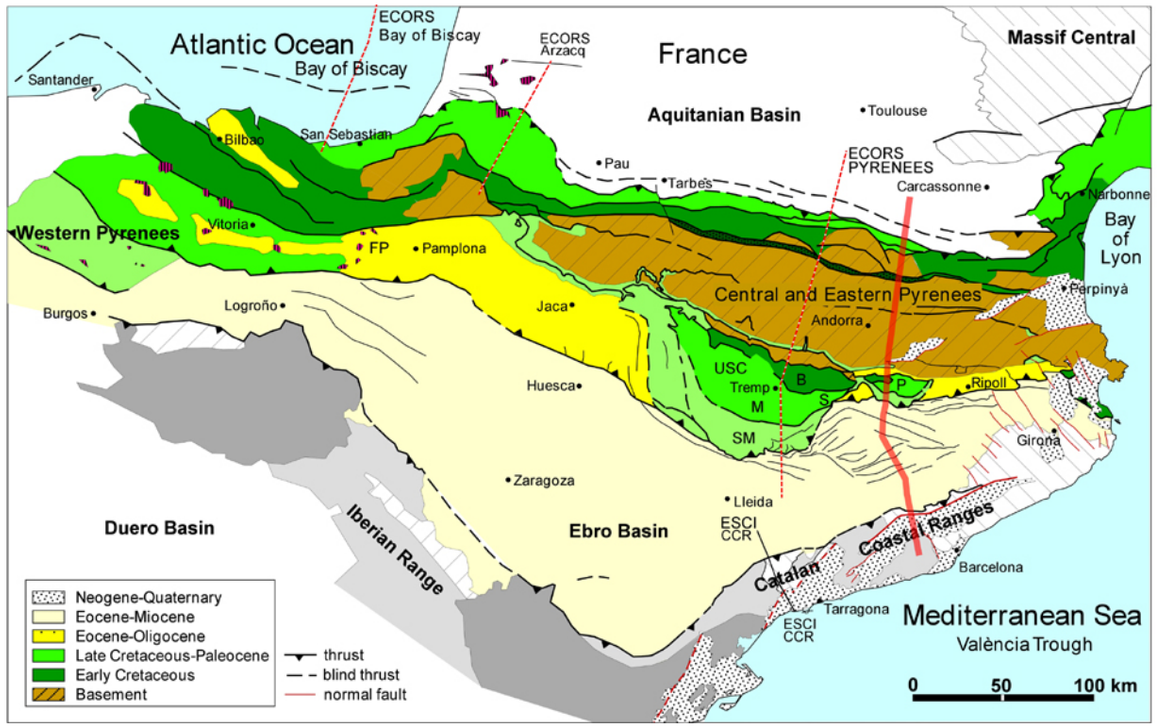

**Probably linked to the heat-wave/drought magnitude**

Hernandez et al. (2014, 2015)

# Drought within HyMeX

## *Towards a LSM intercomparison models*

## Ebro basin




Accounting for human influence in LSM models (irrigation and water regulation):

- Water management intensely affects the water cycle on most Mediterranean basins.
- Dams and irrigation have impacts as important or even more important as climate change.
- Our understanding of the Mediterranean water cycle must include the effects of water management

- Several LSMs are being used in several projects (eartH2Observe, ANR REMEMBER, MARCO) in order to simulate land-surface processes in the Mediterranean.
- Opportunity for model intercomparison.
- Better understanding of our capability to properly simulate different key physical processes
- Integration of irrigation and dams:
  - Irrigation
    - Requires a good understanding of the water demands of crops.
    - Remote sensing is a key data source.
  - Dams
    - Simple dam operation rules can be introduced in the river routing schemes as a first step.
    - This requires to maintain a very close contact with water managers and other stakeholders.
- A first step towards a GEWEX/GLASS-GHP project

# Drought within HyMeX

## *Towards a LSM intercomparison models*

Offline simulations

| Model | Forcing | Resolution | Period length | Time-step | Project |
|---|---|---|---|---|---|
| SURFEX (OE) | Safran | 5 km | 10y, 30y | 3h | E2O, Marco. |
| SURFEX (OE) | E2O (50km) | 5 km | 10y or 30y | 3h | E2O |
| SURFEX (MF) | E2O | 50 km | 30y | ? | E2O, REMEMBER |
| LeafHydro | Safran | 2,5 km | 10y | 1h? | E2O |
| LeafHydro | E2O (50km) | 2,5 km | 10y or 30y | 1h? | E2O |
| Orchidee | Safran | 5 km | 30y | 1h | Marco, REMEMBER |
| Orchidee | E2O | 50 km | 30y | 1h | E2O, REMEMBER |
| Jules | E2O | 50 km | 30y | 1h | E2O |
| HTESSEL | E2O | 50 km | 30y | 1h | E2O |

- Simulations performed during 2015, 2016 and 2017.
- Design of the intercomparison setup in 2015.
- Analysis of the results in 2016 and 2017 (some simulations might be finished in 2017)
- Comparison with coupled simulations (HyMeX/MED-CORDEX).

# Drought within HyMeX

# THANKS FOR YOUR ATTENTION