Drought and water resources

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with contributions from the HyMeX Drought & Water Resources Science Team

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The HyMeX program

Objectives

Improve the understanding of extremes in the **water cycle** of the Mediterranean (fully coupled system).

Assessing the vulnerability of society and the economic system in extreme events and their adaptability.

HyMeX follows a multidisciplinary and multi-scale approach.

Water Resources and Drought

- HyMeX has been working on land-surface processes since it was created (WG2 - Continental Water Cycle).
- The structure of HyMeX is evolving.
- A new **Water Resources and Drought** Science Team was created in September 2015.
- This team organized its first **workshop** in Zaragoza (Spain), April 2016.
  - Consolidate a strategy and foster the community

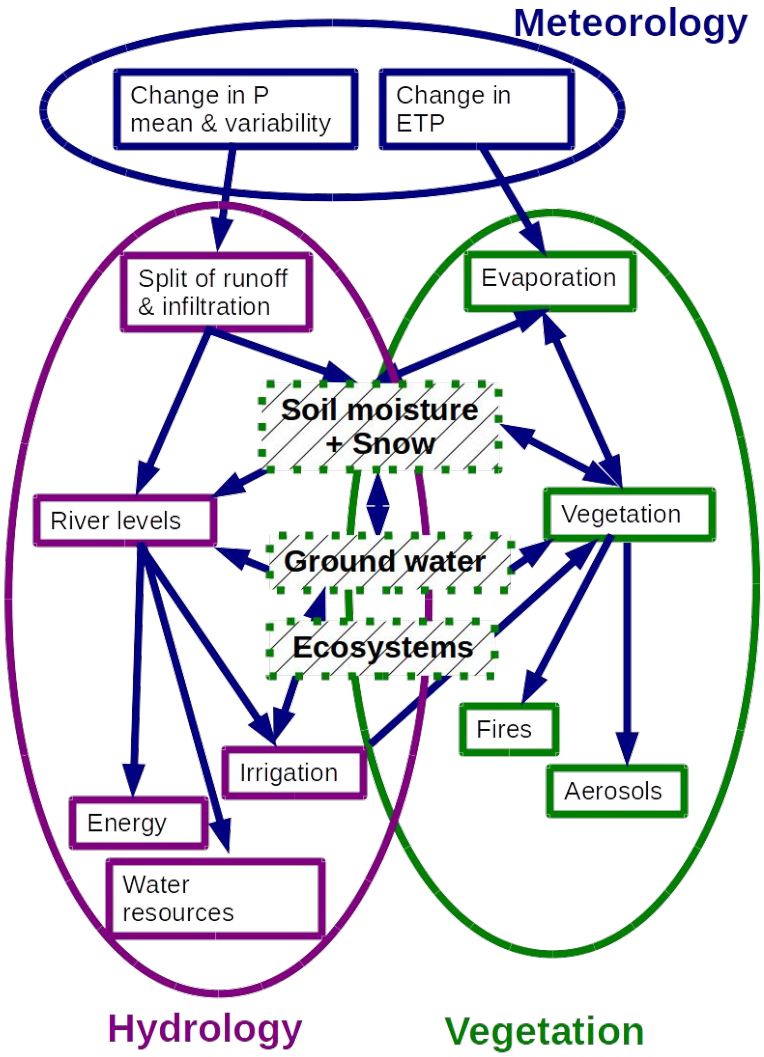
The main objectives of this workshop were to present the state-of-the-art in drought and water resources research done in the Mediterranean region, coordinate and strengthen the HyMeX community in this area and discuss the future lines of work.

Drought and water resources.

- Drought is a multifaceted and complex concept with no single definition.
  - Multi-scale (in time and space)
  - Physical processes.
    - Land surface - atmosphere coupling plays an important role.
  - Impact.
  - Depends on the context.
- Links between drought indices and impacts must be understood.
  - Top-down and bottom-up.
- Something similar happens with water resources

Research priorities

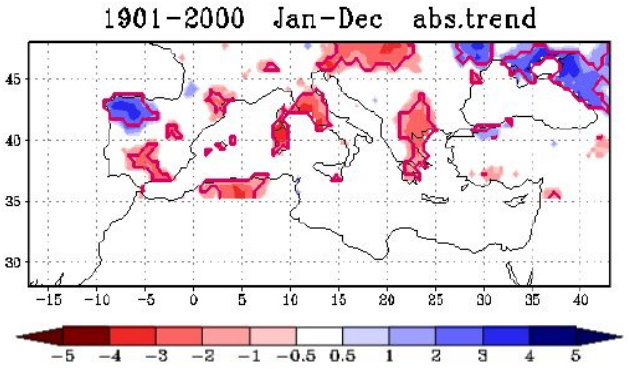
- Description of Mediterranean droughts:
  - Datasets, models and societal impacts of past droughts
- Understanding of drought processes:
  - Drought propagation within the system, feedbacks, interactions with climate change and water resources, aerosols, vegetation, etc.
- Predicting drought:
  - Data assimilation, seasonal forecasting, model improvement, impacts of climate change, and links with policy.



Description of drought

- Drought duration, frequency and intensity is probably increasing in the Mediterranean.

It is necessary to improve our understanding of these trends and their causes and consequences at the Mediterranean scale.



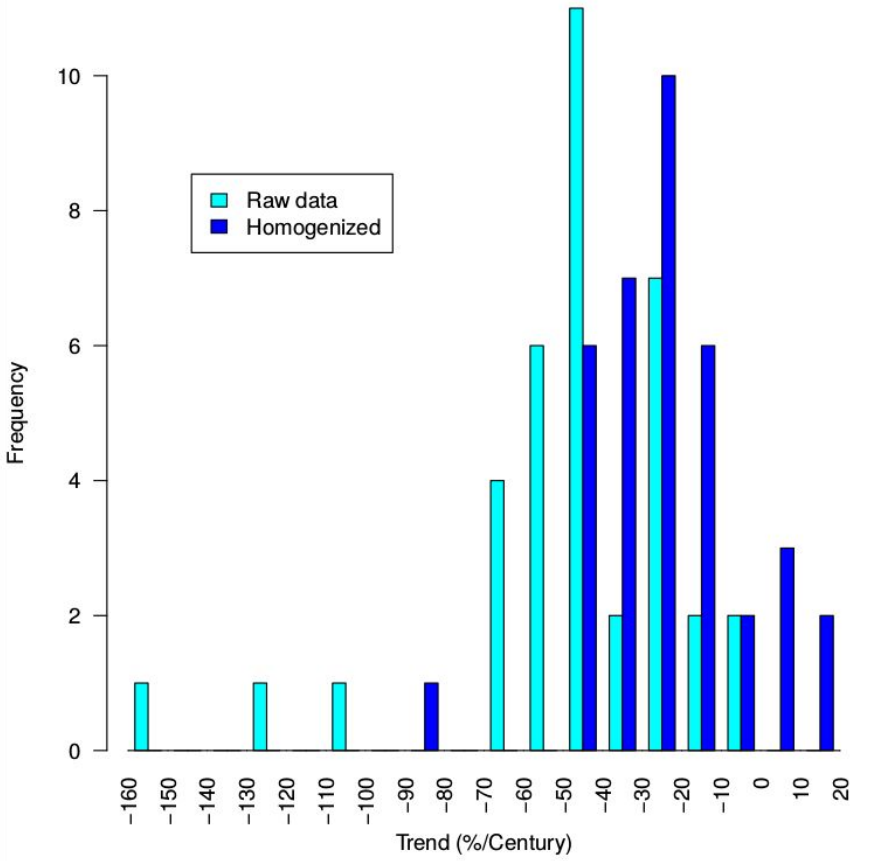
scPDSI trends in the Mediterranean
from presentation by R. García-Herrera

Data availability and quality

- Good data is necessary in order to understand drought.
  - Data control and homogenization is necessary in order to understand physical processes, especially in a context of climate and global change
- In the Mediterranean data is fragmented, its quality is very variable and it is often not accessible.
- A common dataset is probably not a realistic objective.
- But sharing methods and knowledge on data quality, homogenization, etc. is realistic.
  - i.e. CLIMATOL software in R (GPL).

Description of drought

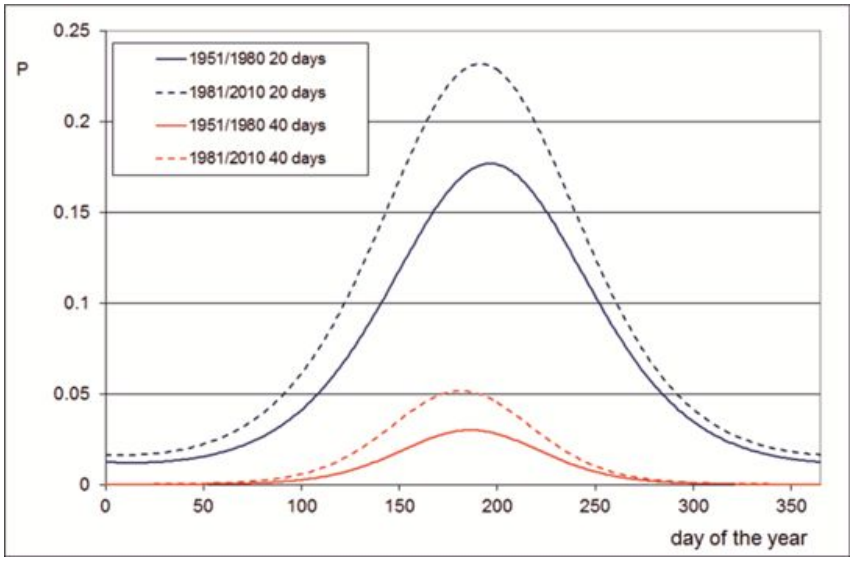
It is important to work with correctly homogenized data.



Comparative histograms of annual precipitation trends in 37 locations of the Barcelona area (1951-2010) derived from raw and homogenized series.

José A. Guijarro (AEMET)

Trends of dry spells studied by means of a stochastic model in Calabria (Italy).



Dry spell lengths ≥ 20 days:
the probability values evaluated by the syntetic data generated from the real data of the sub-period 1981-2010 increase up to about 33% than those relative to the previous sub-period

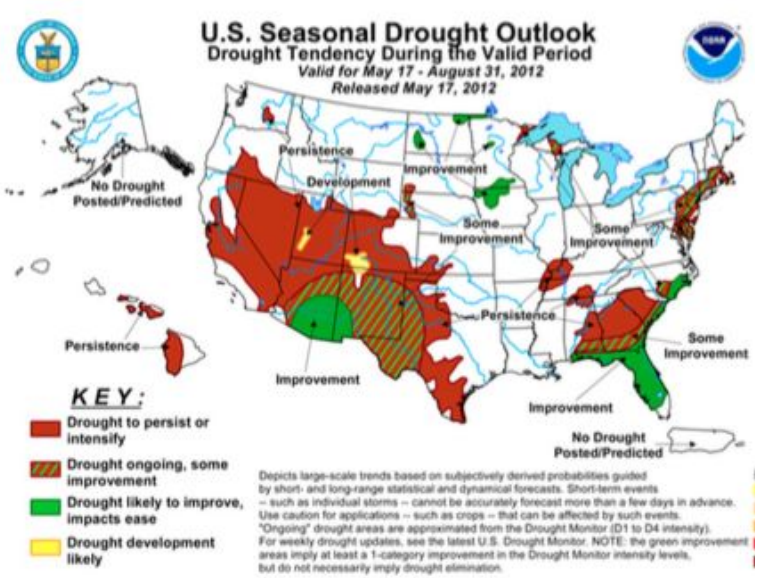
Dry spell lenghts ≥ 40 gg:
increases up to about 70%

Sirangelo et al. (2015)

Prediction of Drought

- If describing drought is difficult, predicting it is even harder.
- Predicting drought at multiple scales time and space scales.
  - From local to Mediterranean scale.
  - From seasonal to climate scales.
  - Are there scale mismatches, for example, between drought and seasonal forecasting?
- Seasonal forecasting.
  - Difficult at our latitudes.
  - High return on investment.
  - The memory of the system can be exploited (soil moisture, underground water, …)
  - A first step would be to demonstrate the feasibility of our methodologies in order to gather interest from decision makers.
  - It is necessary to explain uncertainties correctly and with honesty.

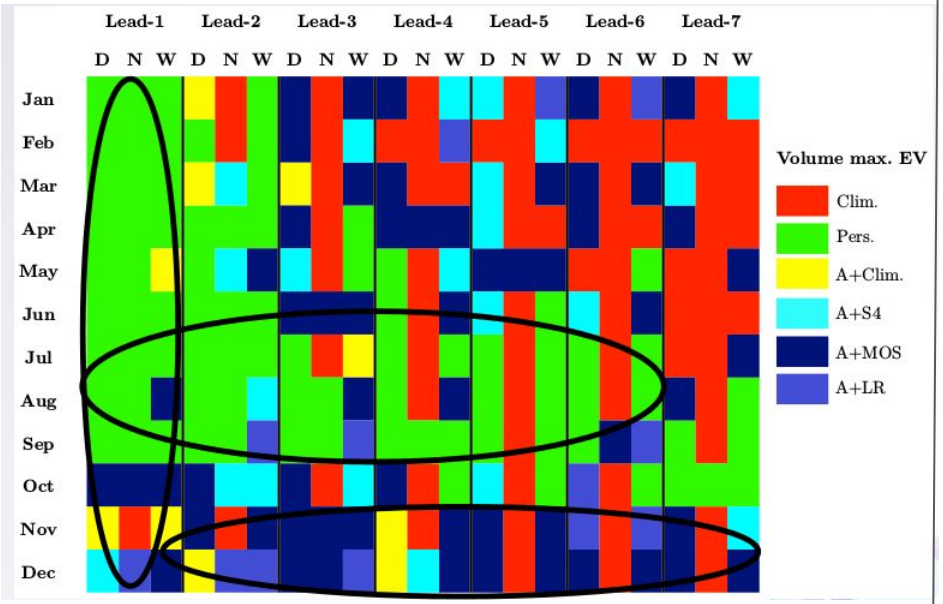
- User needs
  - One size does not fit all.
  - We should not aim at generic projections.
  - Projections should be for relevant indicators for a given context.
  - Iterative discussion with stakeholders, which is often difficult.



Drought forecast has demonstrated to be an achievable task, and often shows more skill than precipitation prediction

Prediction of Drought

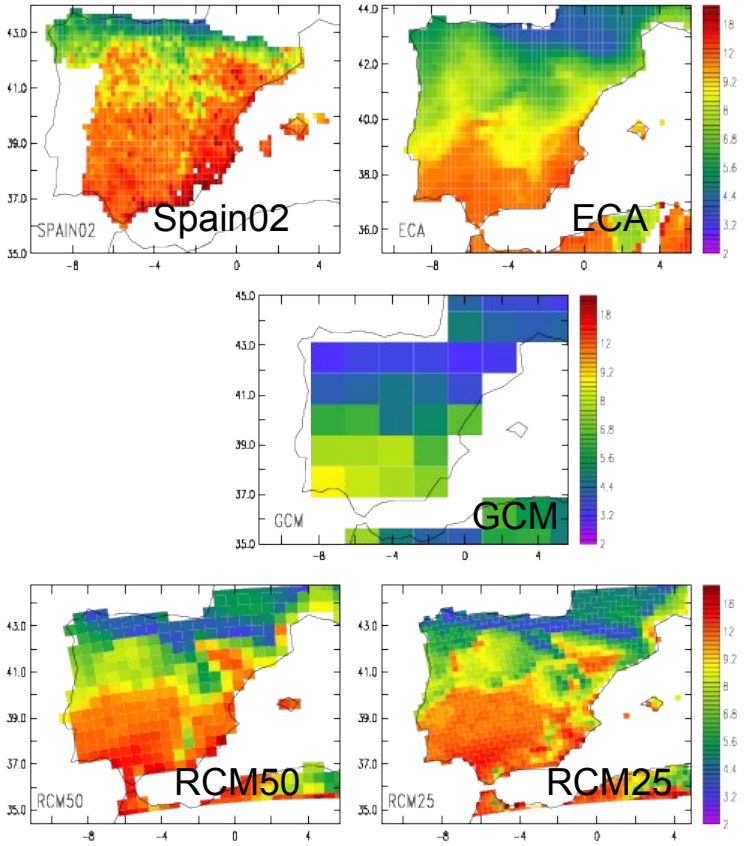
Seasonal forecasts of dam volume (Boadella dam, Spain) have some skill up to a minimum of 4 months ahead.



Marcos et al. (2016)

RCMs can reproduce the spatial structure of dry spells.

Mean dry spell length (1961-1990).
Sánchez et al. (2011).



Drought processes and water resources

Evapotranspiration

- ET is probably the most elusive problem.
- ET and ETP are often decoupled in the Mediterranean.
- Physical models are the right tools to study ET.
- Data is needed in order to validate the models. Instrumented sites are necessary.
- Vegetation is key and it is often not well represented by LSMs in semi-arid areas.
- Land-Use and Land-Cover Change must be correctly described. Maps are often not good enough and to describe the change in time.
- Remote sensing offers new opportunities.

Humans as part of the system.

- Irrigation modifies vertical and horizontal water flows.
  - changes ET and thus has an impact onto the atmosphere.
  - Dams.
  - Underground water.
- Feedbacks.
- We are strong on physical processes, we are just starting to learn how to take the human component into account.

HyMeX should be an integrator of communities (without forgetting where our strengths are):

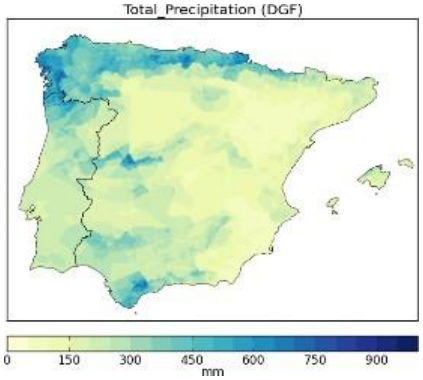
- climate, hydrology, socio-economic sciences, end-users).

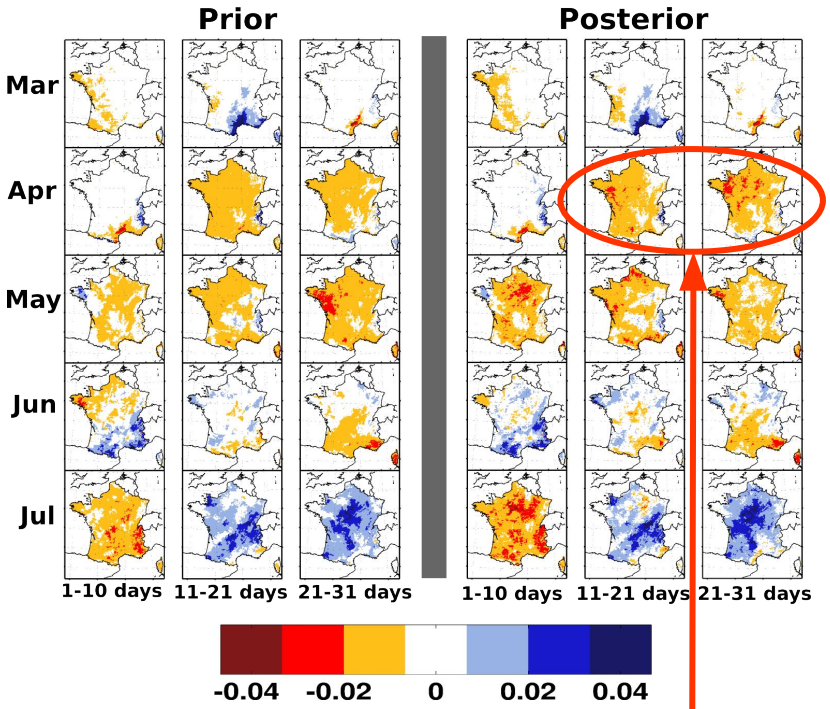
Drought processes and water resources

Some highlights of current LSM related work within HyMeX:

- France (Météo-France)
  - Vegetation processes: assimilation of EO vegetation and SSM data into SURFEX.
  - Inclusion of human processes (irrigation and dams).
- Spain
  - Implementation of SAFRAN-SURFEX-RAPID modeling suite based on a LSM (Ebro Observatory).
    - Planned inclusion of irrigation and dams.
  - Impacts of underground water in drought processes (LEAFHYDRO model, USC).
  - Inclusion of the LEAFHYDRO underground water scheme in SURFEX (AEMET).
  - Propagation of precipitation forcing uncertainty (eartH2Observe).
- Morocco
  - Use of SAFRAN and SURFEX in the Tensift basin.
  - Hydrological simulation of the Oum Er-Bia basin.
- Spain and Morocco
  - Within eartH2Observe collaboration is starting between Spain and Morocco in order to study the benefits of the E2O forcing data in data poor areas, by comparing the data rich Ebro with the Oum Er-Bia.

SAFRAN
5 km res. forcing dataset for LSMs.





10-daily soil moisture change rate ($m^3 m^{-3}$)

Enhanced drought onset

Barbu et al. (2014)

Future orientation and actions for the D&WR ST

- Opportunities:
  - Different communities working together and combining methodologies.
  - Earth Observation.
- We need to be practical and realistic.
  - Work in areas where work is already done.
  - Develop the methodology.
  - Demonstrate it works.
  - Expand.
- Inclusion of humans into the system.
  - *Drought management is inefficient because feedbacks between drought and people are not fully understood. In this human-influenced era, we need to rethink the concept of drought to include the human role in mitigating and enhancing drought (Van Loon et al. 2016).*
  - Link with GEWEX (previous week's workshop).
- Our nested sites could participate in a future GEWEX exercice on this topic.

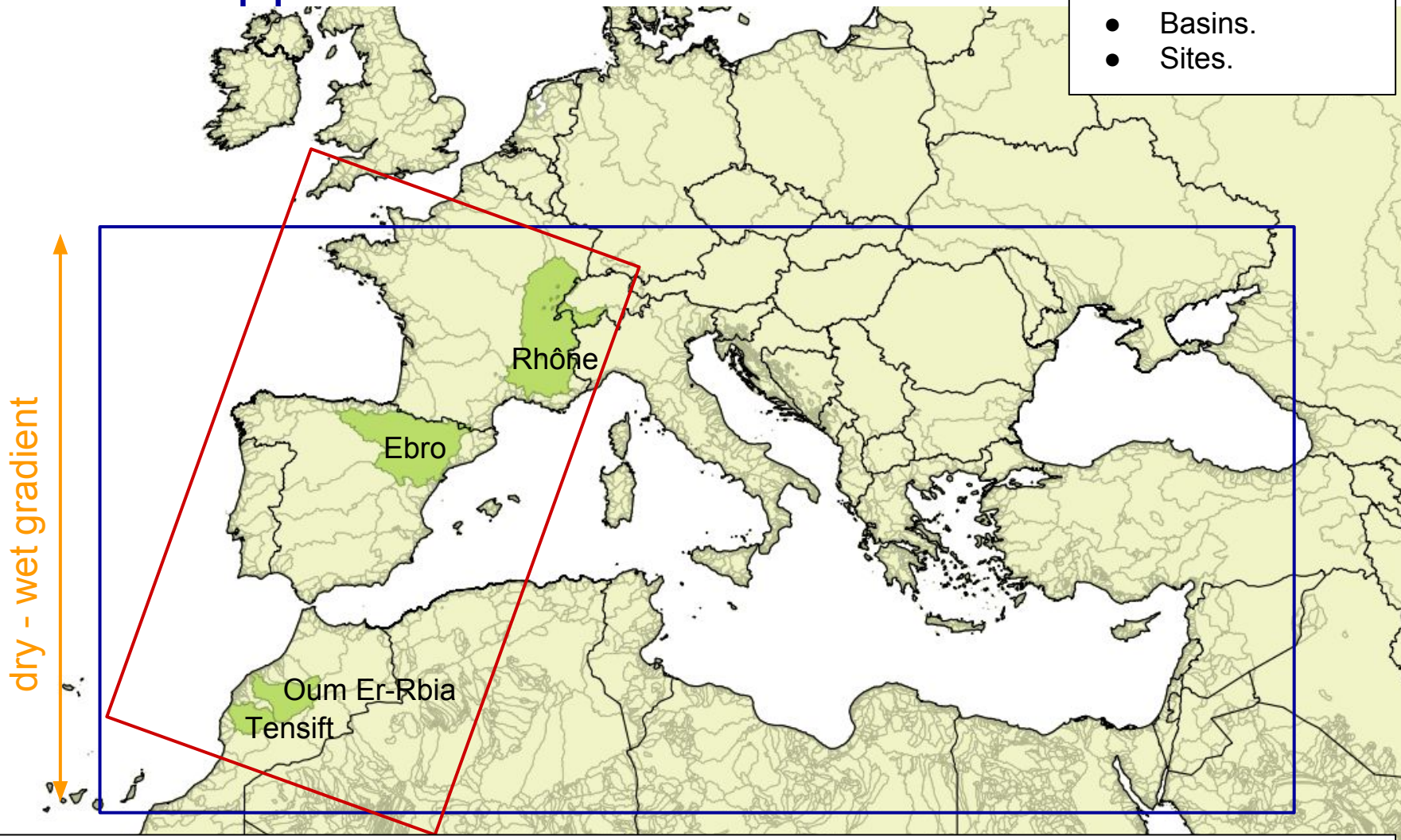
Nested approach

A possible GEWEX exercise on anthropic processes could use these sites and the community working in them (together with other sites in other areas of the world).

Nested approach

Four levels:

- Mediterranean.
- Countries.
- Basins.
- Sites.



The vertical box FR-ES-MA is an area where coordinated work in Land-Surface and Hydrological modeling is currently being done, other vertical transects may be added in the future. Of course, there is work in other countries too. There is flexibility also in terms of selected basins.

Priorities for model improvement

In order to study drought and water resources in the Mediterranean using LSMs we need to improve in the following areas:

1. Irrigation and dam schemes.
2. Land-use and land-cover changes.
3. Physical processes relevant in the Mediterranean: snow, semi-arid areas, extremes, etc.
4. Feedbacks between the human influence and the natural system.

A GEWEX (GLASS & GHP) exercise could be a good opportunity to progress in this direction.



Conclusions

- HyMeX has a strong Drought and Water Resources community.
- Data availability and quality is still a challenge in the Mediterranean.
- Progress is needed in describing and understanding past droughts at several temporal and spatial scales.
- Physical models can help us understand drought processes.
- ET, which is often decoupled from ETP in the Med., is a key process to study.
- Physical models need to improve in terms of Mediterranean physical, vegetation and human related processes.
- Predicting drought at seasonal scales is a challenge but with high rewards for society.
- More studies on climate scenarios are also necessary.
- We have a nested approach of areas of study useful in order to study processes and improve models.
- In terms of human related processes, HyMeX priorities are in line with those we saw in last week's workshop.
- HyMeX could be a site for a GEWEX GLASS&GHP model testing, improving and comparison centred on human related processes.

Thank You