Winter Very Long Dry Spells over the Mediterranean Basin

Florian RAYMOND[1], Albin ULLMANN[1], Pierre CAMBERLIN[1] & Philippe DROBINSKI[2]

[1] CRC, Biogéosciences, CNRS/University of Burgundy, Dijon, France
(florian.raymond@univ-Grenoble-alpes.fr)
[2] IPSL/LMD, Palaiseau and Paris, France

S2. Regional Hydroclimate Projects
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Objectives and data

Different ways to apprehend dryness (rain deficit, number of dry days, statistical index, etc.)

- long sequences without precipitations (temporal distribution of precipitations)

Very Long Dry Spell events (VLDS) variability between the end of the 20th century and the end of the 21th century

→ **Very Long Dry Spell events are considered as climatic objects**
(spatial and temporal grid-point grouping)

→ **Winter period = "rainy season" > September to April (242 days).**

Data used: 1971-2005 (historical) and 2066-2100 (RCP4.5 and RCP8.5)

- E-OBS v10.0 (European Climate Assessment & Dataset): daily precipitation amount (0.25° resolution);

- Regional simulations: 4 HyMeX/Med-CORDEX and 4 Euro-CORDEX models (basic resolution at 0.44° but resampled onto the E-OBS grid at 0.25° resolution, with the nearest neighbours method);

How to detect Very Long Dry Spells events? (1/2)

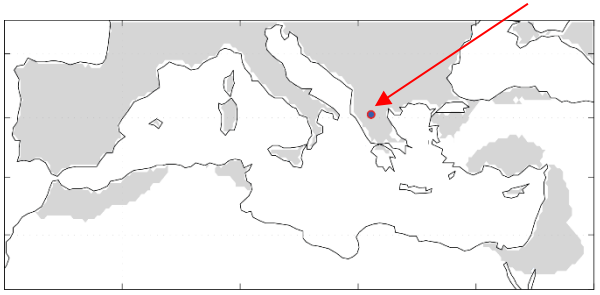
Method: for each grid point

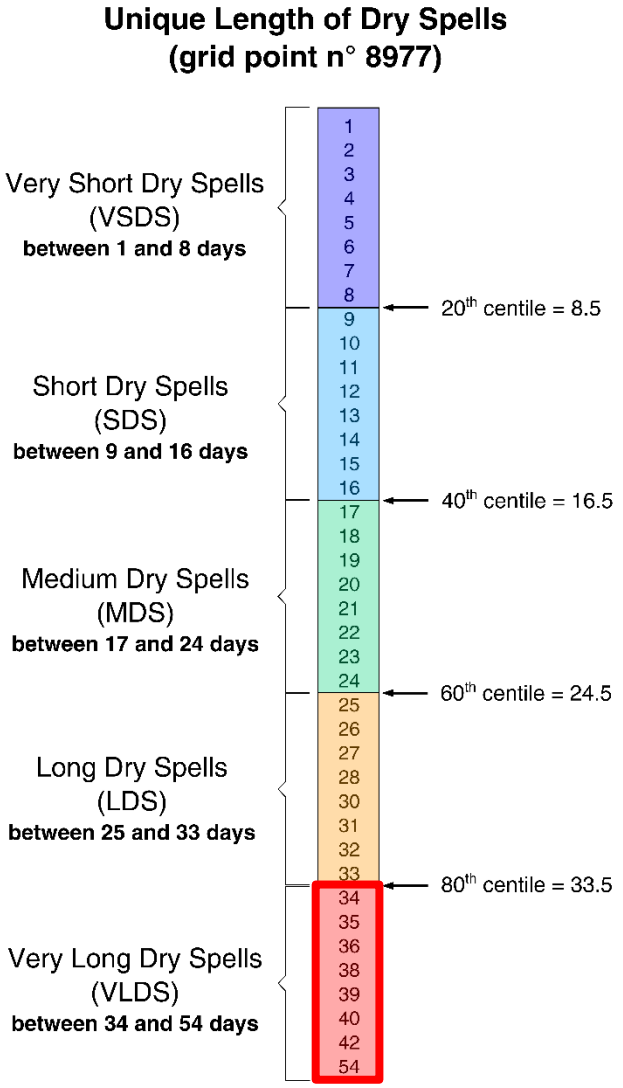
- dry spells length → number of consecutive dry days (1 mm threshold) ;
- centiles are apply on the unique value of dry spells length (1971-2005 historical period);

- Very Short Dry Spells: **VSDS** < 20th centile ;
- Short Dry Spells: 20th centile < **SDS** < 40th centile ;
- Medium Dry Spells: 40th centile < **MDS** < 60th centile ;
- Long Dry Spells: 60th centile < **LDS** < 80th centile ;
- Very Long Dry Spells: **VLDS** > 80th centile ;

Example:

Grid Point n°8977 (40.125°N & 21.125°E)





How to detect Very Long Dry Spells events? (2/2)

Binary matrix to detect historical and future VLDS :

value "0" > rainy grid points or grid points where dry spells are shorter than the 80th centile ;
value "1" > all grid points belonging to dry spells longer than the 80th centile.

Sliding scan to obtain spatially and temporally coherent events:

to the 8228 days:

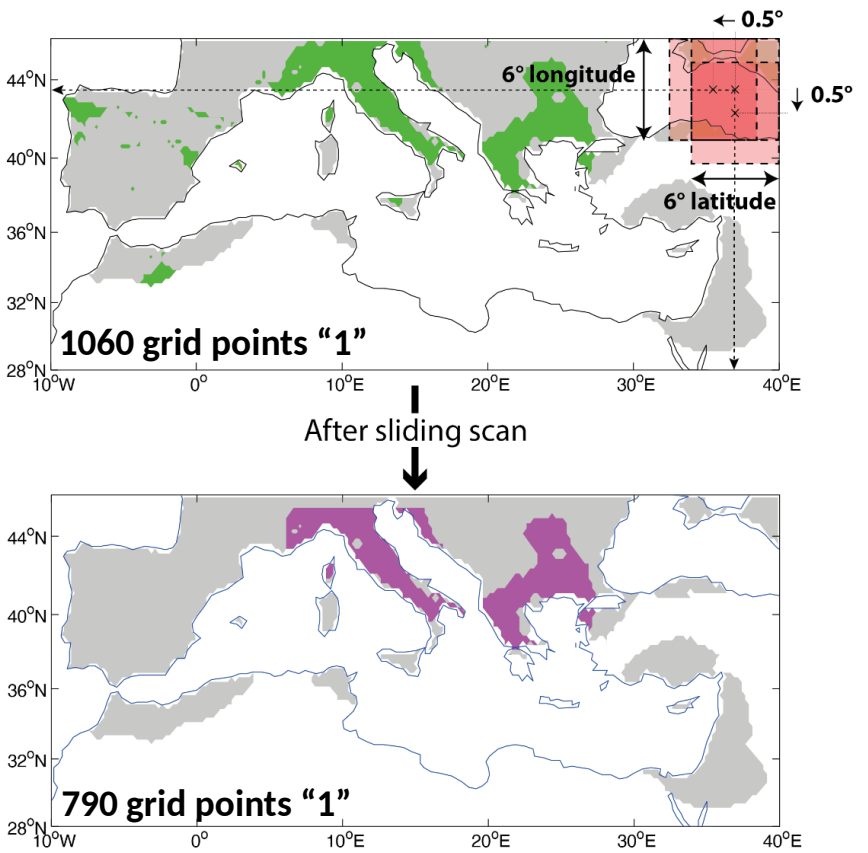
- square of 6 degree longitude/latitude ;
- sliding by 0.5° longitude/latitude increment ;
- sea grid points and grid points without data not taken into account.

VLDS day: if 50% of the grid points contained in at least one square have the value "1".

VLDS event "object" is characterized by location, spatial extension and duration.

Adapted from Stefanon *et al.*, 2012

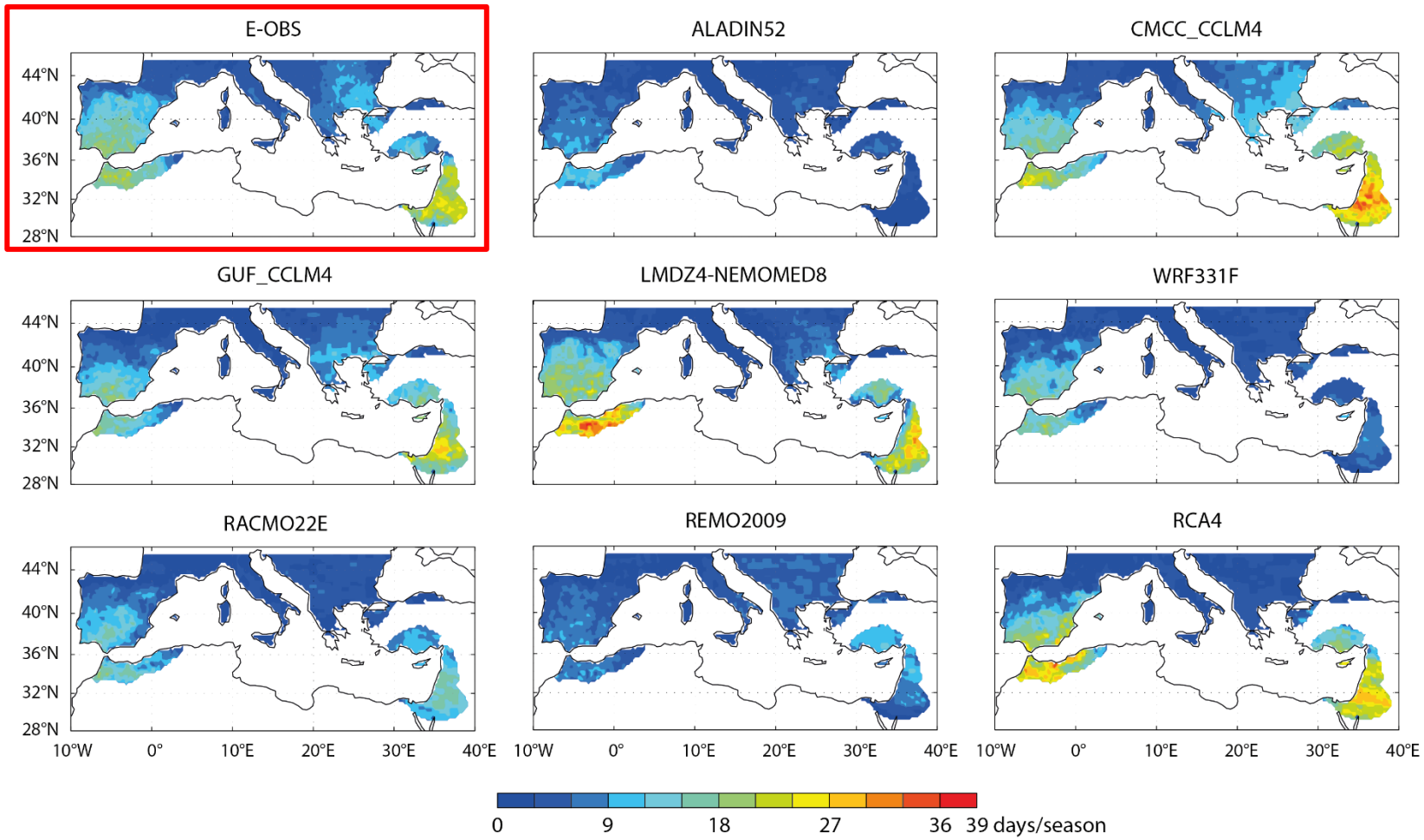
Sliding scan example (01/01/1989)



To detect VLDS in the 2066-2100 period, I used the 80th centile values calculated during the historical period

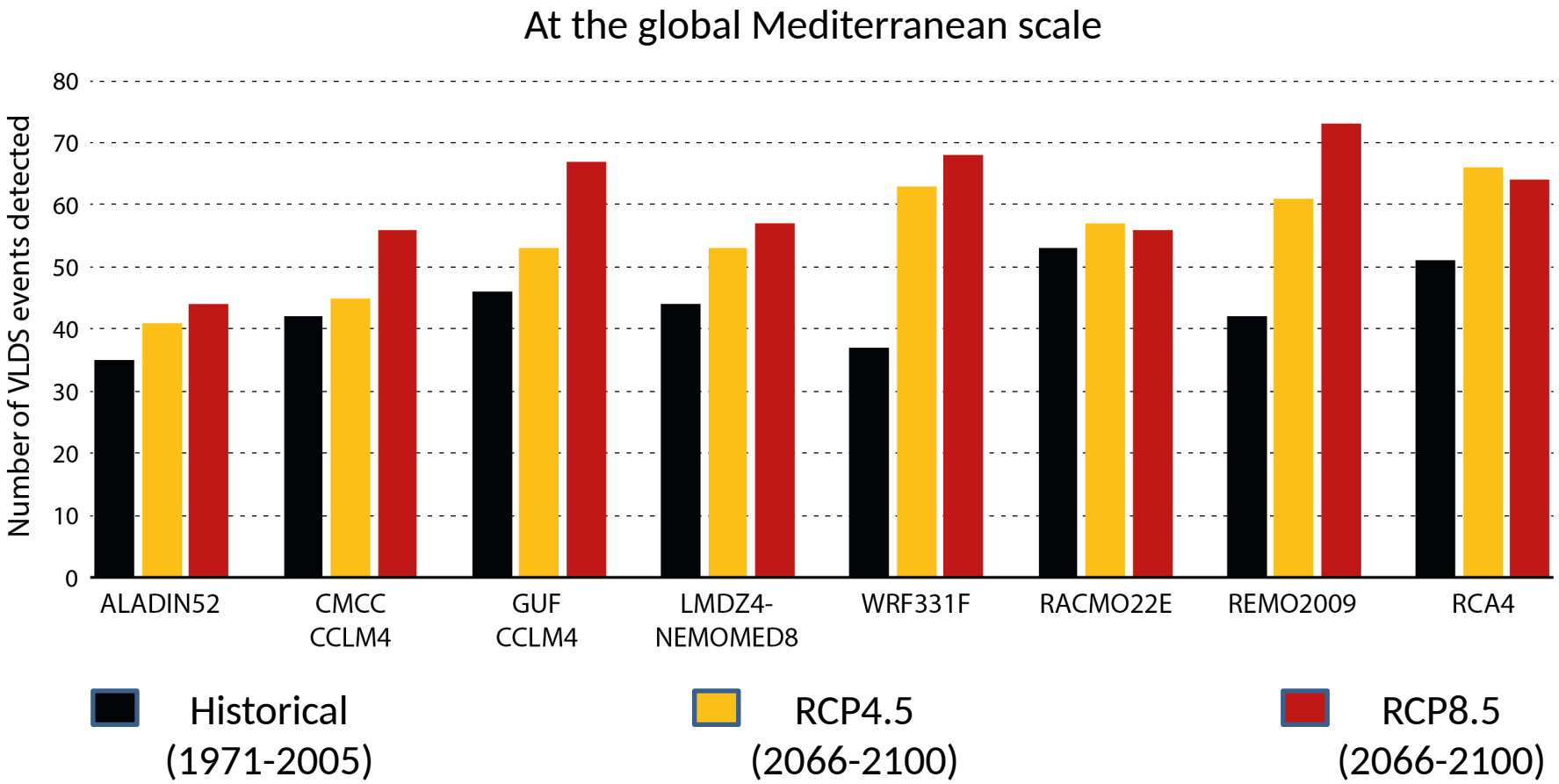
Historical diagnostic (comparison observation and simulations)

Historical period (1971-2005): mean number of VLDS days/season



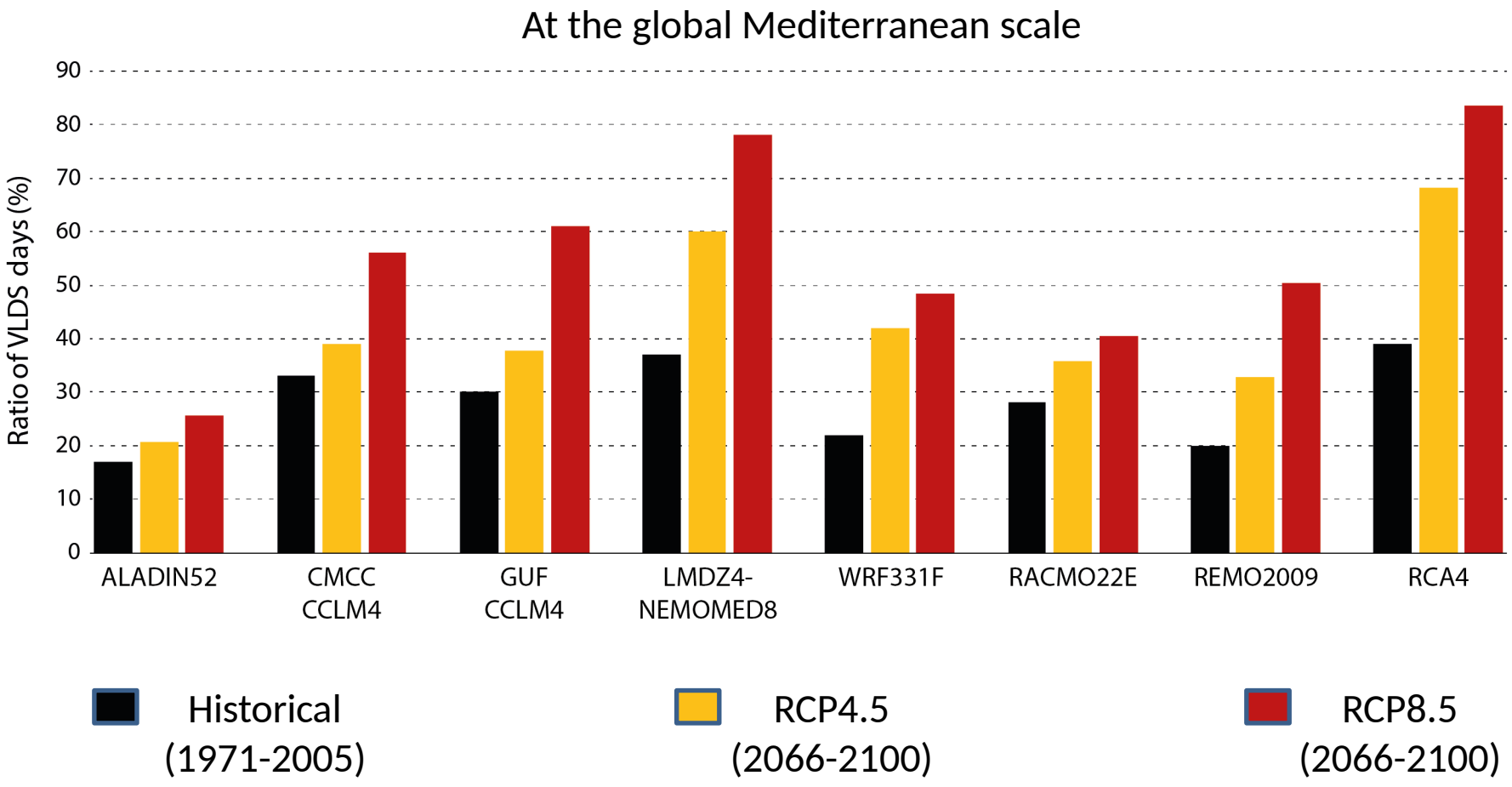
➢ **Western and eastern basin are mainly affected by VLDS (models pretty well simulate this dipole)**

Future VLDS : evolution of the number of VLDS events detected



➢ **All the models show an increase of the number of VLDS between the 34 wet seasons of the historical period and the 34 wet seasons of the RCP periods**

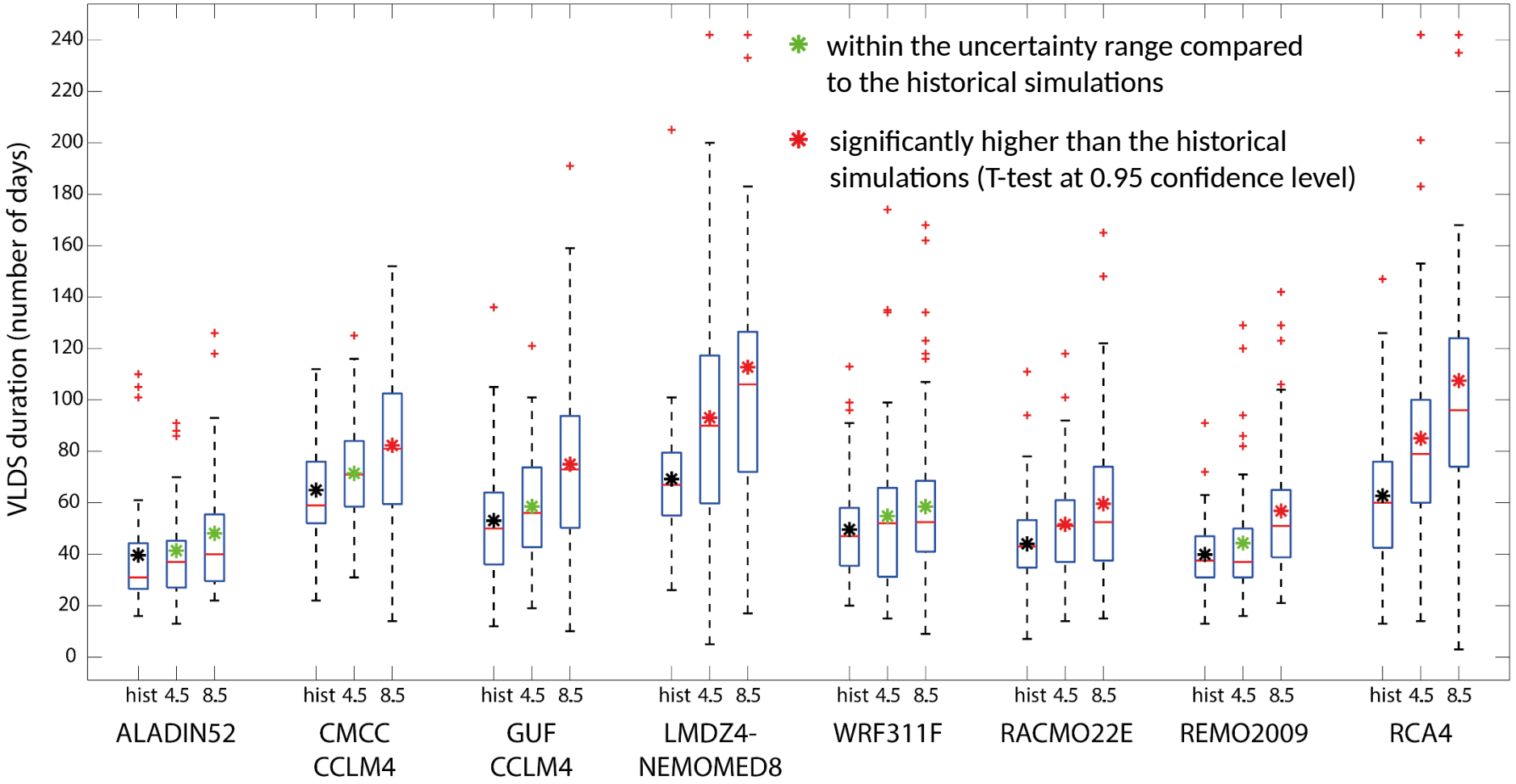
Future VLDS : evolution of the length ratio of VLDS days



- All the models show an increase of the ratio of VLDS days between the 34 wet seasons of the historical period and the 34 seasons of the RCP periods ;
- Always stronger for the RCP8.5 scenario than for the RCP4.5

VLDS in the end of the 21st century: mean duration evolution?

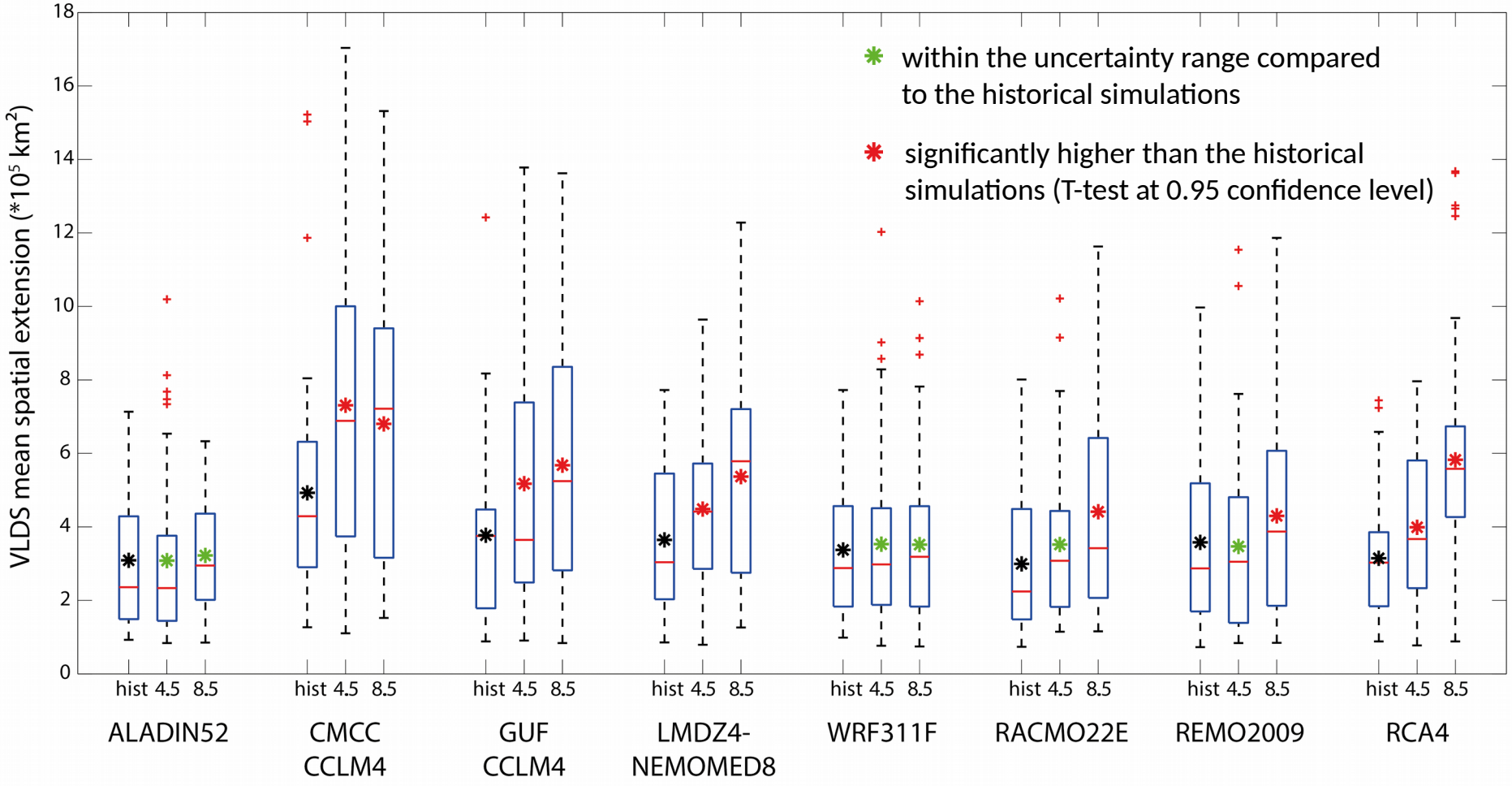
At the global Mediterranean scale



➢ **All the models simulate an increase (weak or strong) of the VLDS duration in the future (significant or not)**

VLDS in the end of the 21st century: mean spatial extent evolution?

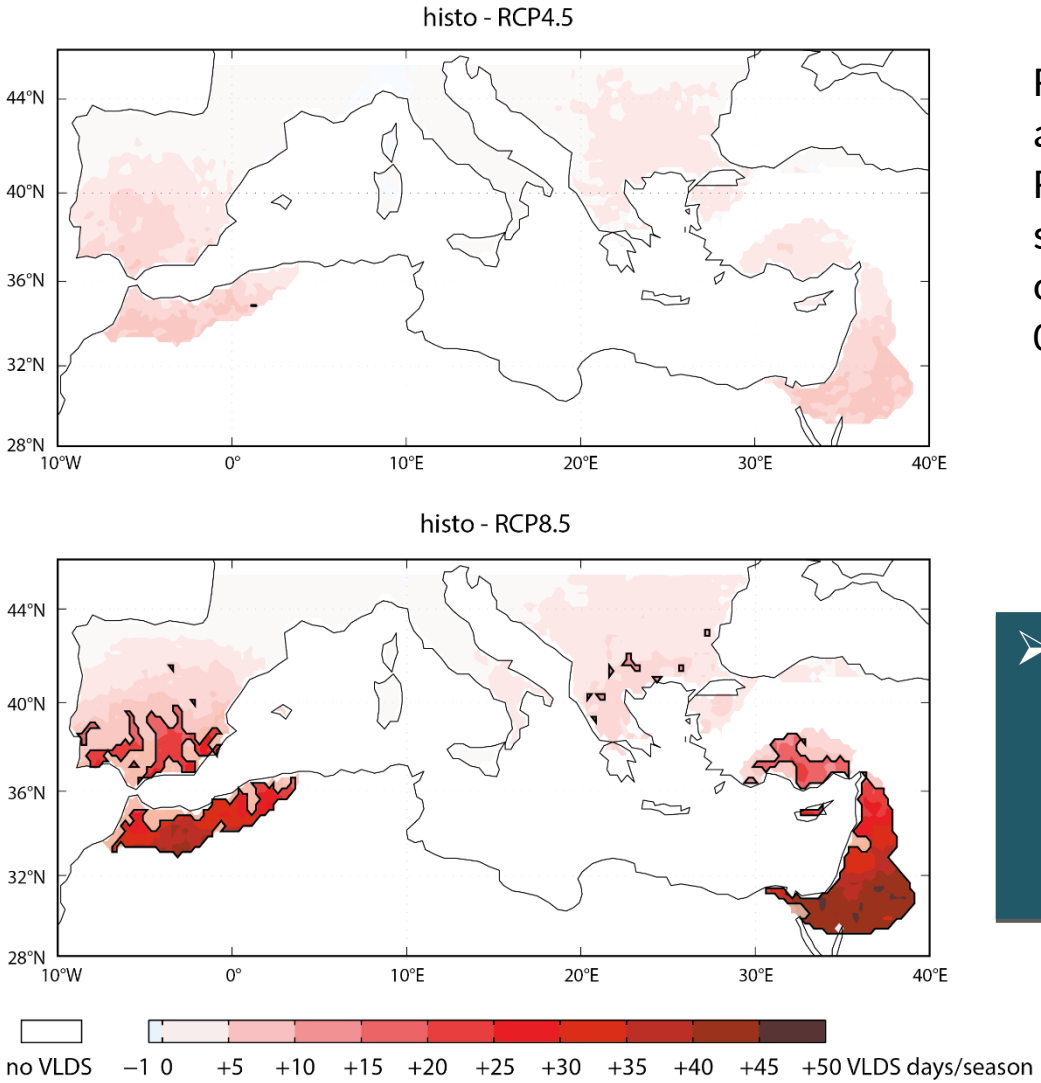
At the global Mediterranean scale



➢ **Almost all the models simulate an increase of the spatial extent of the VLDS in the future (most often significant)**

VLDS by the end of the 21st century: which regions would be affected?

Multi-model evolution of the mean number of VLDS days per wet season



Robust results are framed in black and appearing in bright colours: at least 6 RCMs among the 8 RCMs detect significant increase of the mean number of VLDS days per wet season (T-test at 0.95 confidence level).

- Robust increases are simulated for the western and the eastern Mediterranean basin (between +20 VLDS days/wet season +50 VLDS days/wet season, in average).

Conclusion

- There is an important variability between the 8 models studied, in term of VLDS simulation…

… but models are agree to show that:

- the number of VLDS should increase by the end of the 21th century;
- the mean duration of the future VLDS should be longer than those observed at the end of the 20th century (for both RCP4.5 and RCP8.5 scenarios);
- the mean spatial extent of the future VLDS should increase, compared to the VLDS observed at the end of the 20th century;
- The western and the eastern part of the Mediterranean basin would be the main Mediterranean sub-regions the most affected by the VLDS evolutions during the 21th century.

These results confirm that the observed drying up of the Mediterranean basin during the 20th century should continue during the 21th century

Thank you for your attention.

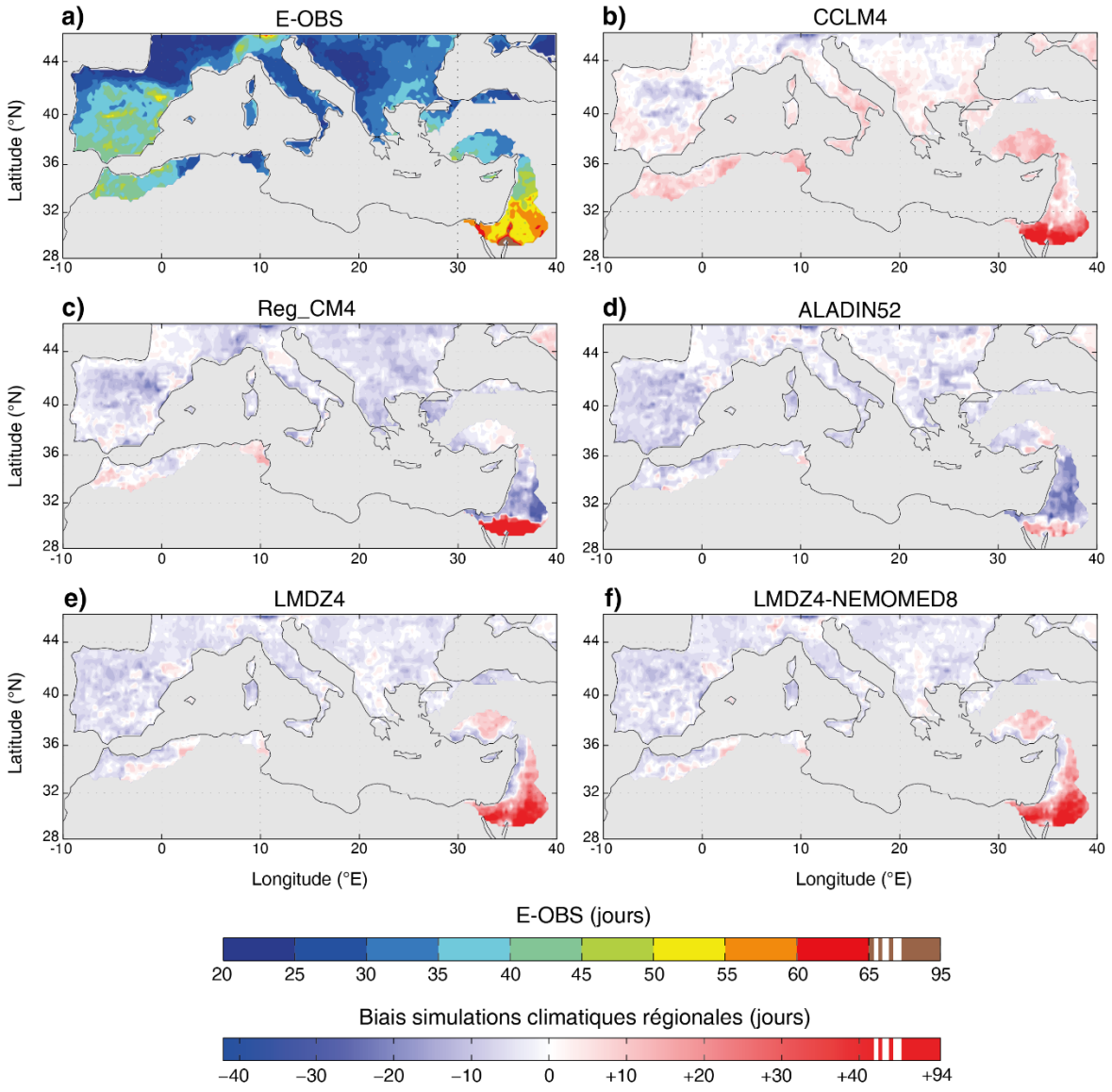
Associated publications:

- Raymond F., Drobinski P., Ullmann A. and Camberlin P. (2018) Extreme dry spells over the Mediterranean Basin during the wet season: assessment of HyMeX/Med CORDEX regional climate simulations. *International Journal of Climatology*, DOI: 10.1002/-joc.5487

- Raymond F., Ullmann A., Camberlin P., Oueslati B. and Drobinksi P. (2017) Atmospheric conditions and weather regimes associated with extreme winter dry spells over the Mediterranean basin. *Climate Dynamics*, DOI: 10.1007/s00382-017-3884-6

- Raymond F., Ullmann A., Camberlin P., Drobinksi P. and Chateau Smith C. (2016) Extreme dry spell detection and climatology over the Mediterranean Basin during the wet season. *Geophysical Research Letters*, 43, 7196-7204

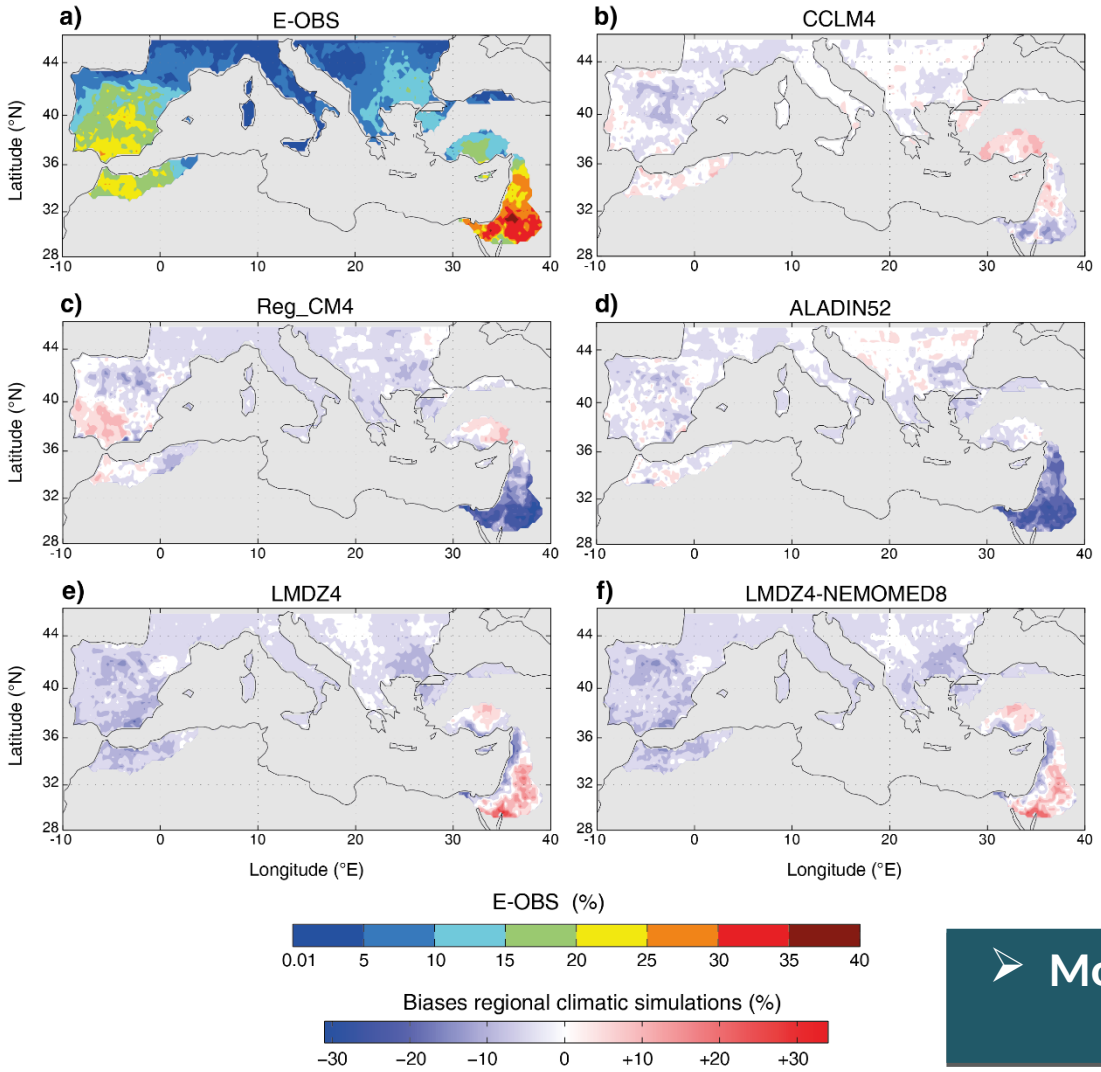
Centile 80 biases



Med-CORDEX models capacity to reproduce the VLDS events

Ratio of VLDS days

"evaluation" simulations (1979-2009; forced by ERA-Interim)



VLDS days Ratio:
For each data set, fraction of VLDS days at each grid point, with respect to the total number of VLDS days

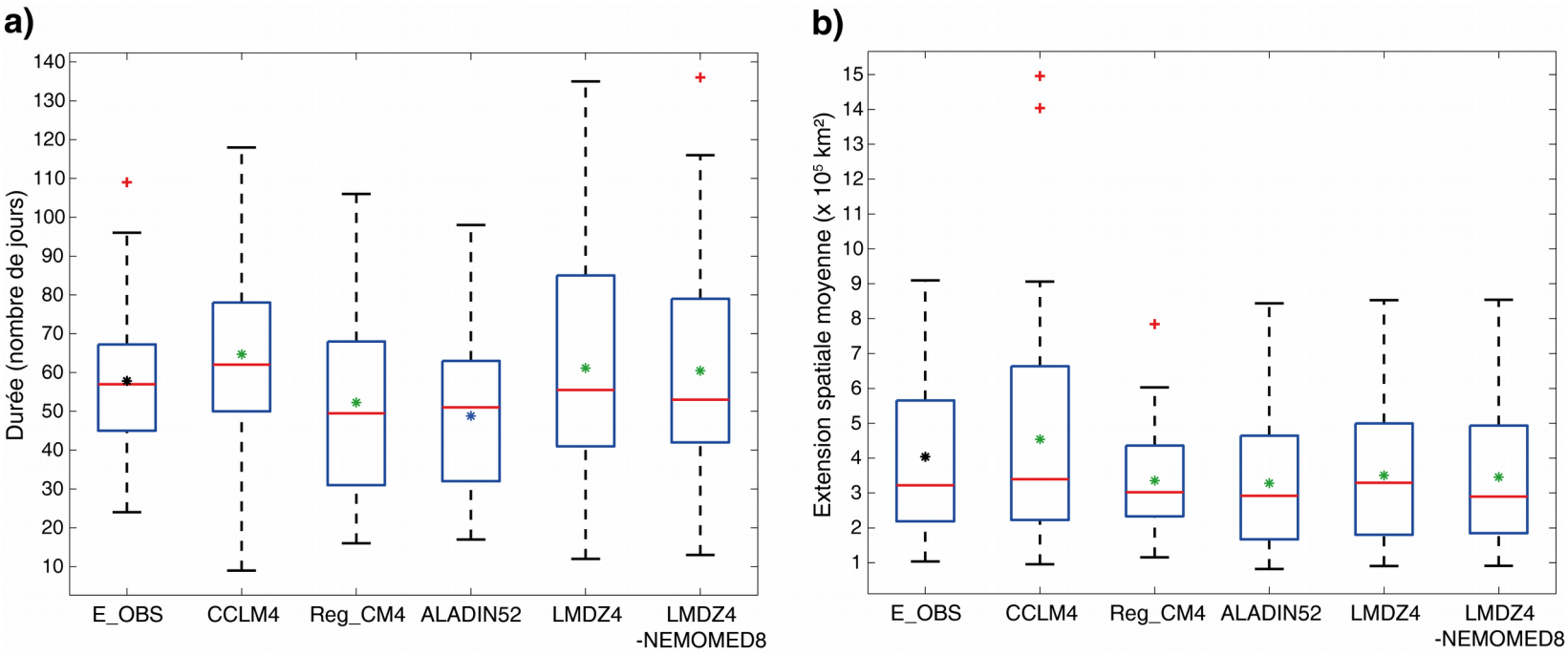
Reg_CM4 and ALADIN52 underestimate the ratio of VLDS days in the Levant

On the contrary, LMDZ4 and LMDZ4-NEMOMED over-estimate the ratio of VLDS days in the Levant

More than 70% of the VLDS detected with the regional climatic simulations are in common with E-OBS events

➢ **Models rather well reproduce the VLDS events**

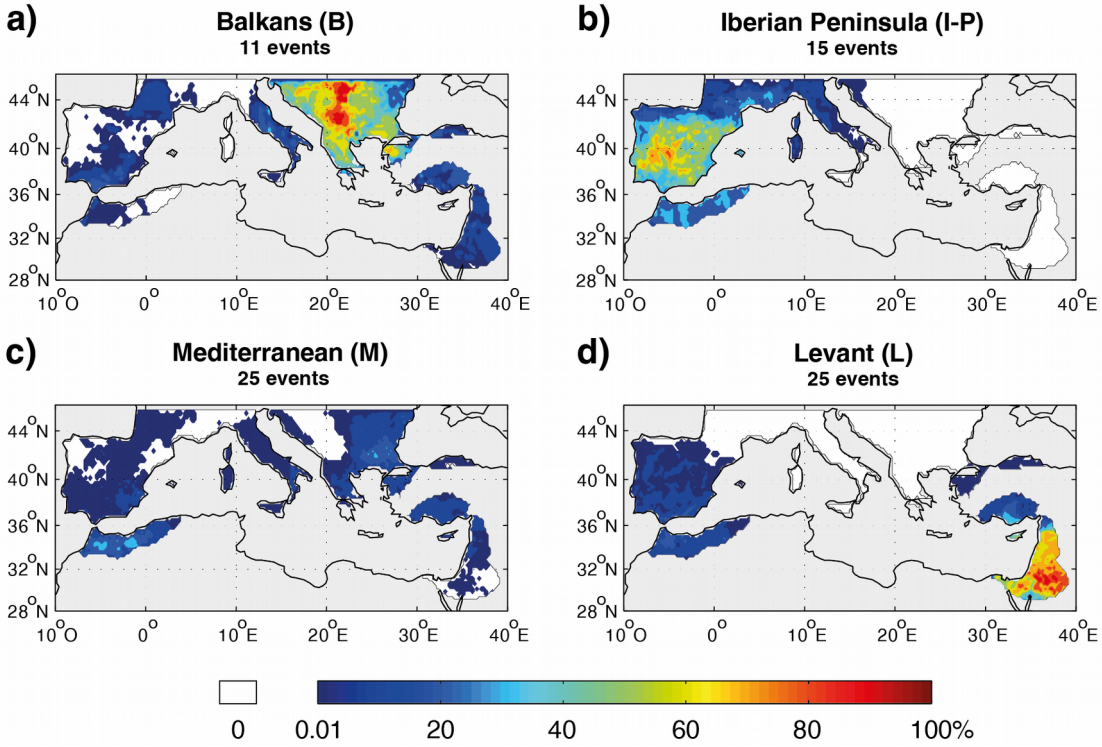
Box plot on duration and spatial extent

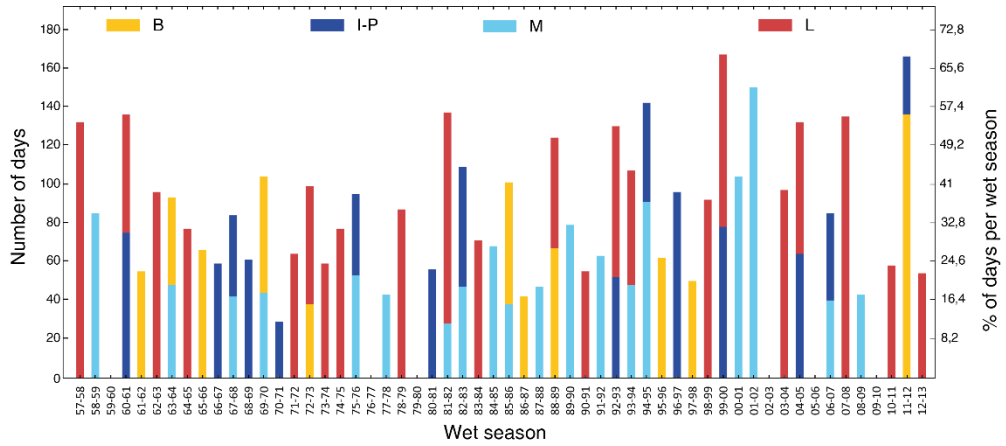


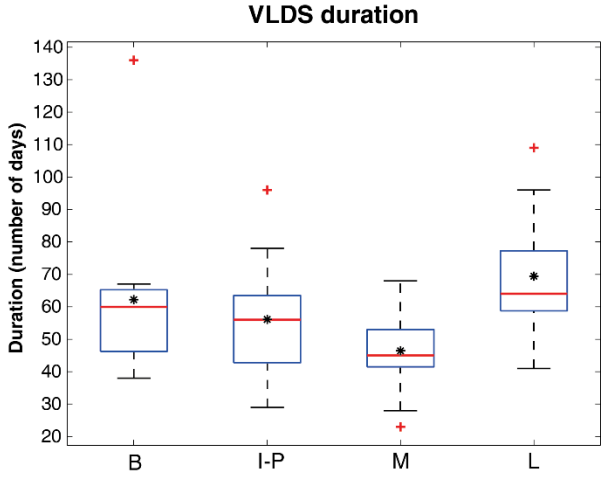
VLDS characteristics on Med-CORDEX models

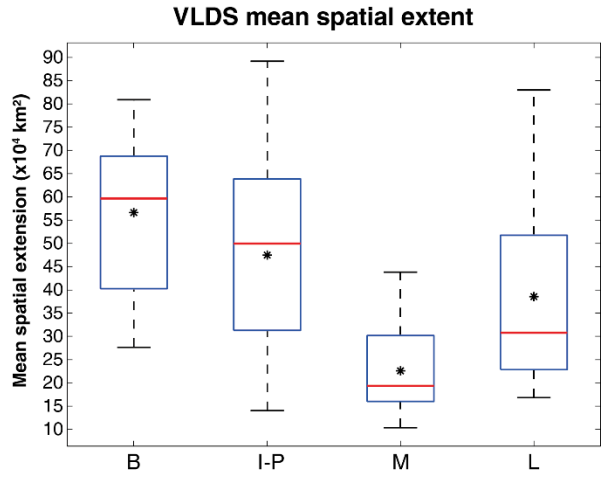
		E-OBS	CCLM4	Reg_CM4	ALADIN52	LMDZ4	LMDZ4-NEMOMED8
Durée moyenne des TLES (jours)	Maghreb	52	59	55	48	49	54
	Péninsule Ibérique	52	57	53	44	47	51
	France	35	42	31	37	38	37
	Italie	43	41	26	35	30	30
	Balkans	43	48	30	37	37	35
	Anatolie	48	60	43	46	52	54
	Levant	59	75	54	44	80	75
Extension spatiale moyenne ($x10^4$ km^2)	Maghreb	11.7	10.7	8.8	10.3	10.3	10.2
	Péninsule Ibérique	23.3	21.1	23.4	20.9	22.4	23.9
	France	8.2	6.7	5.1	6.4	5.8	6.4
	Italie	11.8	13.9	5.9	10.5	8.4	7.4
	Balkans	26.1	24	21.5	23.9	23.7	20.2
	Anatolie	7.6	13	9.4	8.8	7.4	8.7
	Levant	22.9	23.4	14.1	13.6	20.4	21.1

Very Long Dry Spells pattern characteristics



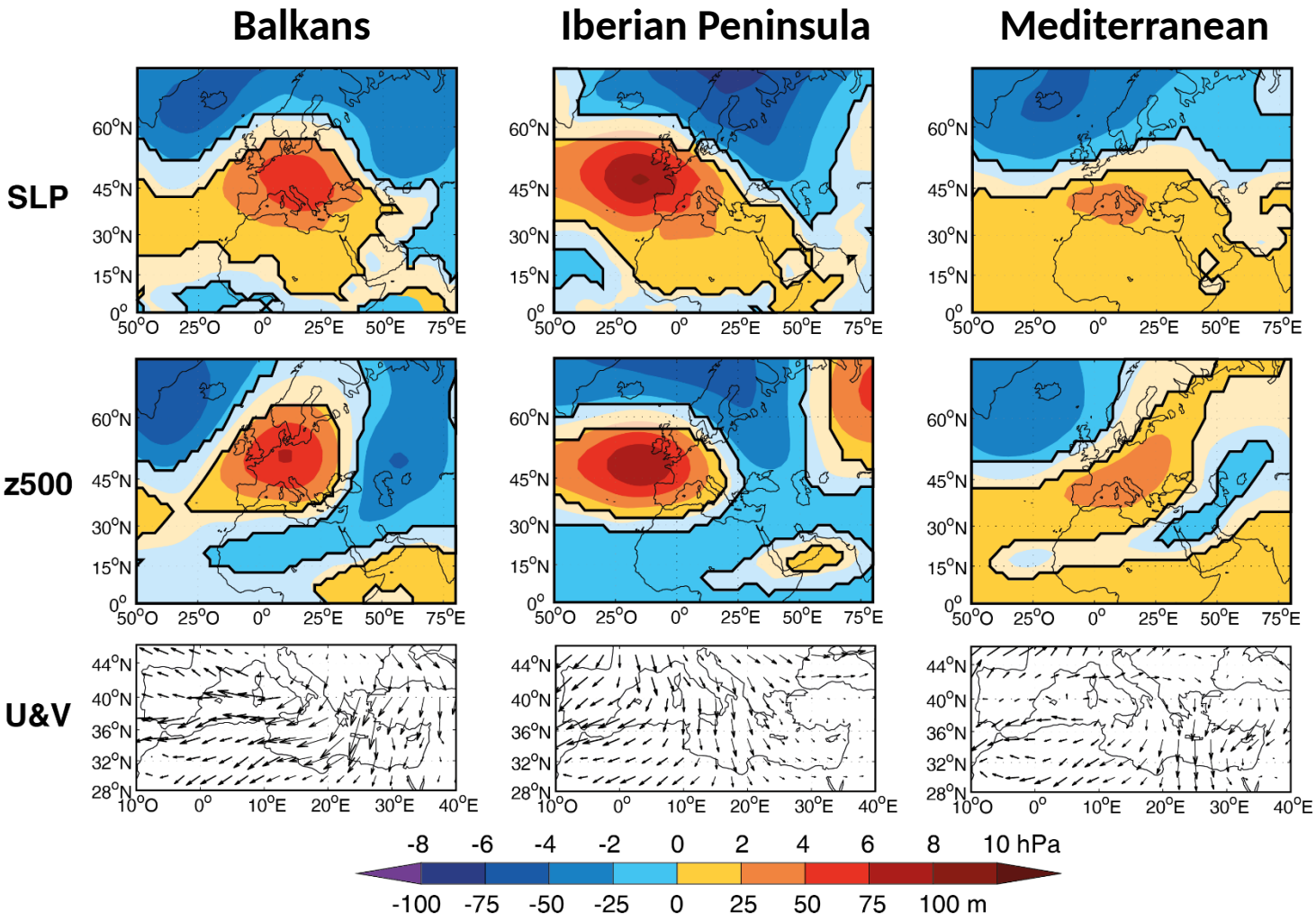






➢ **Slight increase of VLDS days per wet season, but not significant**

Large-scale atmospheric conditions associated



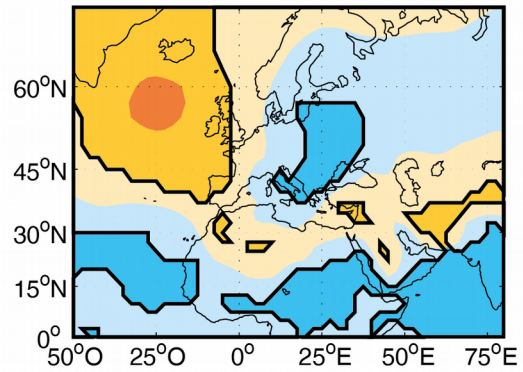
Significant **deseasonalised anomalies** are framed in black and appear in bright colours, according to the Student T-test (0.05 confidence level)

➢ **Anticyclonic conditions associated with the VLDS events (1000 km North-West): blocking high, subsidence and cold and dry advection from boreal latitudes.**

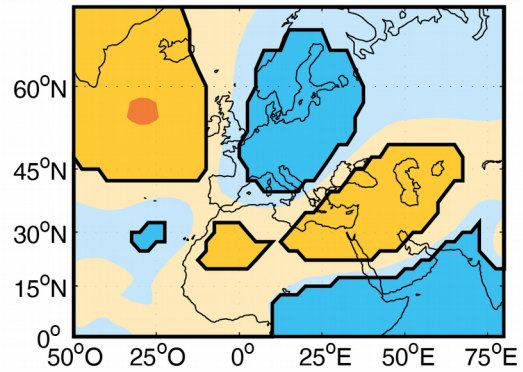
South-East Mediterranean regime : Middle East region

Levant

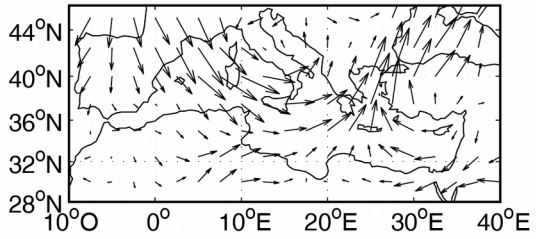
SLP

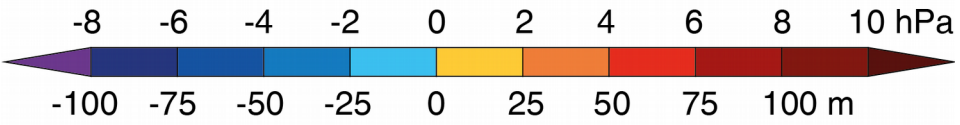


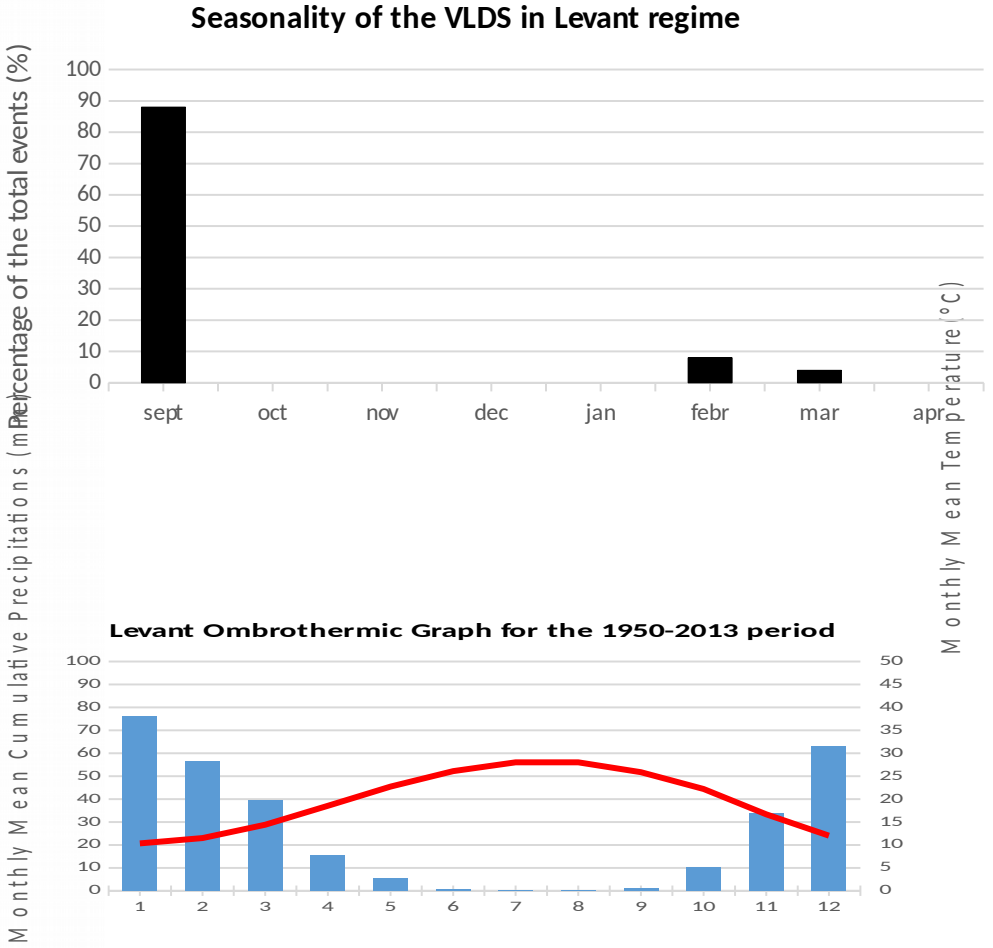
z500



U&V







➢ **Levant regime : not real Very Long Dry Spells but seasonal VLDS…**