Mistral and Tramontane in MedCORDEX Simulations: Present Day and Future Climate

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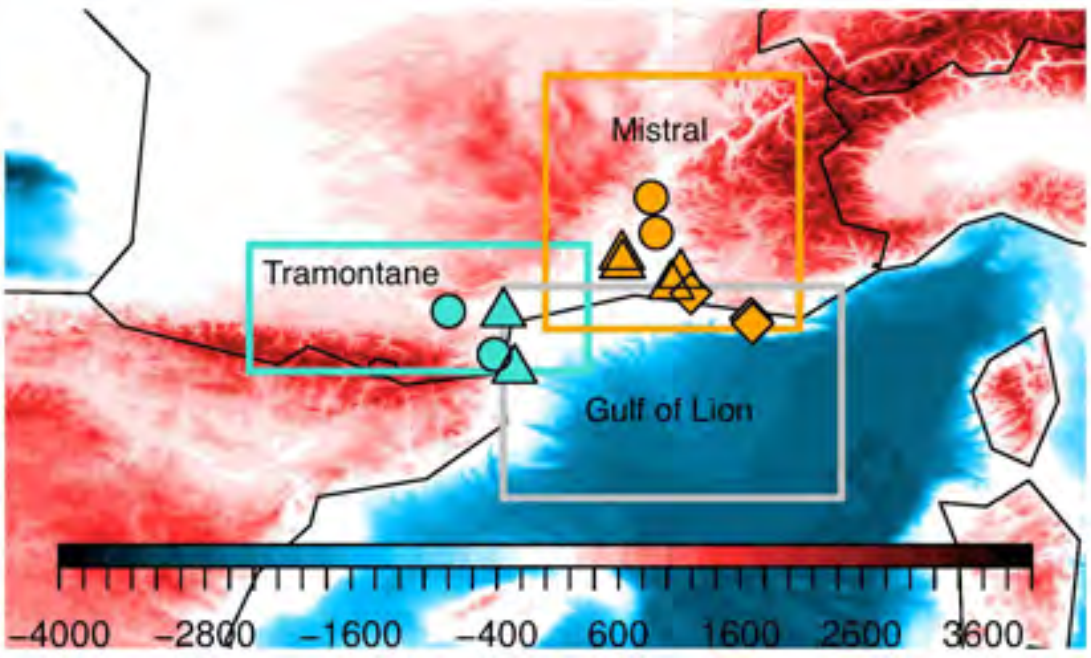
Mistral and Tramontane



Altitude (m) and station locations.

- regional cold and dry north to north-westerly winds
- causing deep-water generation
- important for modeling the Mediterranean Sea circulation

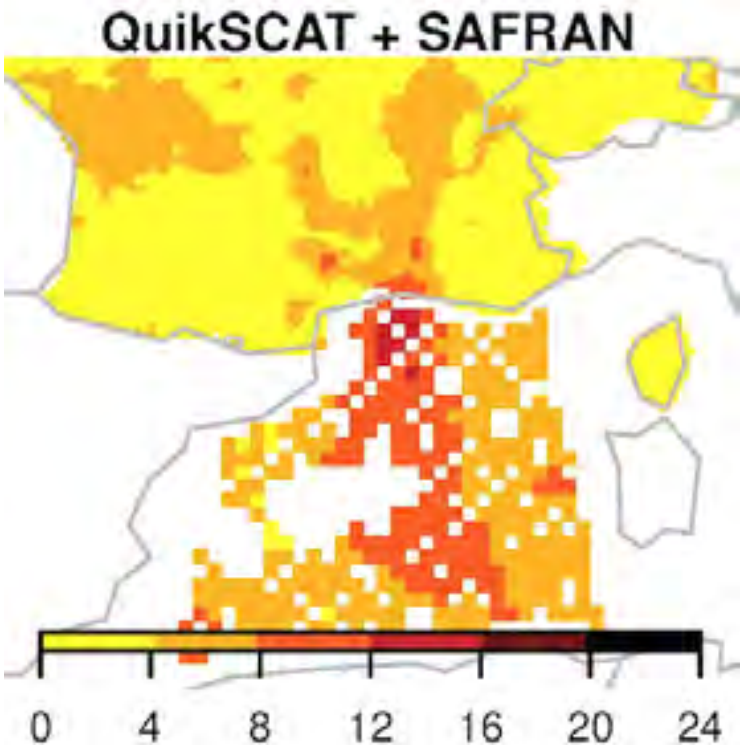
On which days does Mistral/Tramontane occur?

Gust time series combined of 9 stations for Mistral and 4 stations for Tramontane:

1981-2010	Tramontane	no Tramontane	
Mistral	1382	368	1750
no Mistral	2129	7078	9207
	3511	7446	10957

How well do RCMs simulate M/T patterns?

- QuikSCAT: 0.25° scatterometer data
- SAFRAN: gridded daily mean wind speed



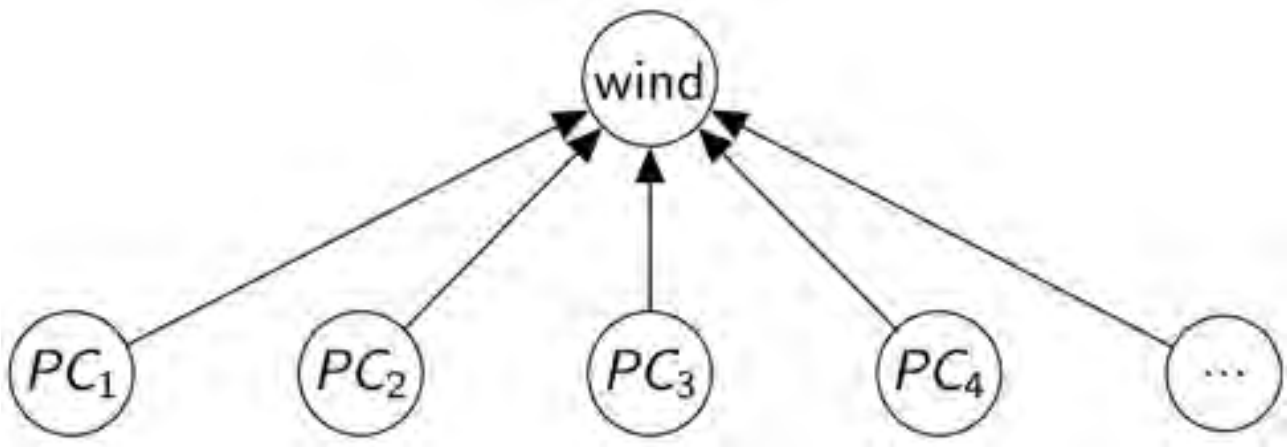
Wind speed (m/s) March 24th, 2002.

Simulations with 5 RCMs of MedCORDEX framework driven by ERA-Interim:

Model	Group	Version	Grid
ALADIN	CNRM	v5.2	50 km 12 km
WRF	IPSL	311	50 km 20 km
PROMES	UCLM		0.44° 0.22°
COSMO-CLM	GUF	4-8-18	0.44° 0.088°
	CMCC	4-8-19	50 km
LMDZ	LMD	4	0.44°

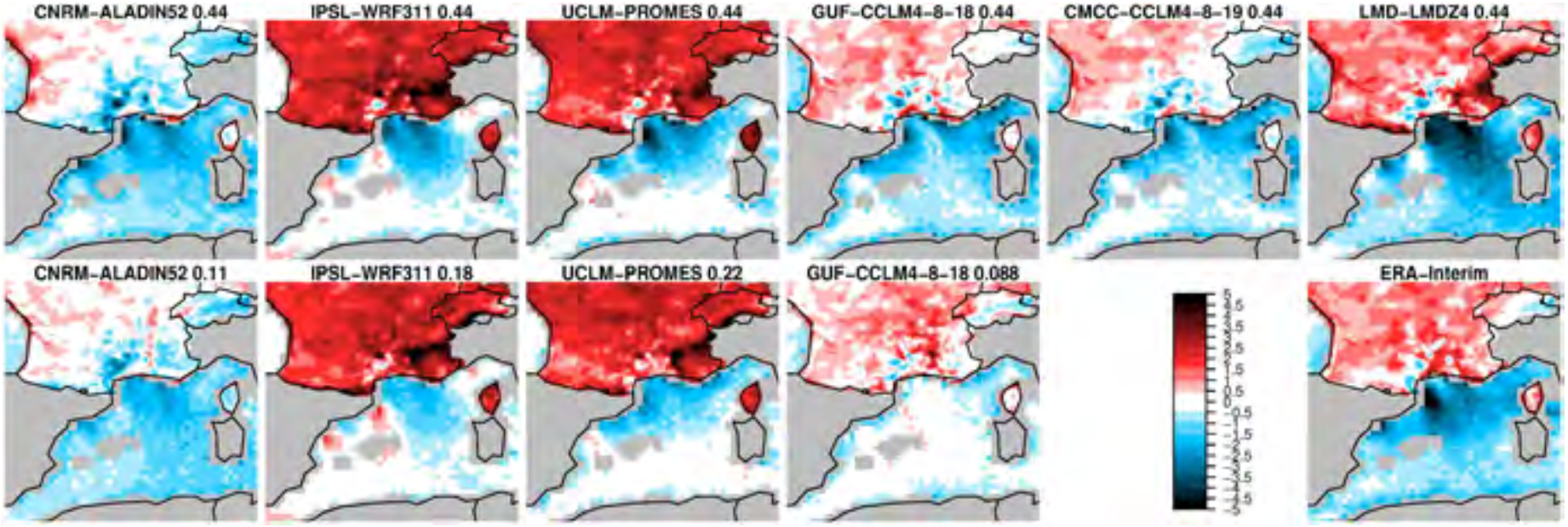
Find days with well simulated M/T pressure patterns

- Bayesian Network trained with ERA-Interim sea level pressure PCs and observed time series
- input: daily values of model PC_1 to PC_{100}
- output: continuous number related to likeliness of day being a Mistral or Tramontane day
- output transformed to a TRUE/FALSE variable



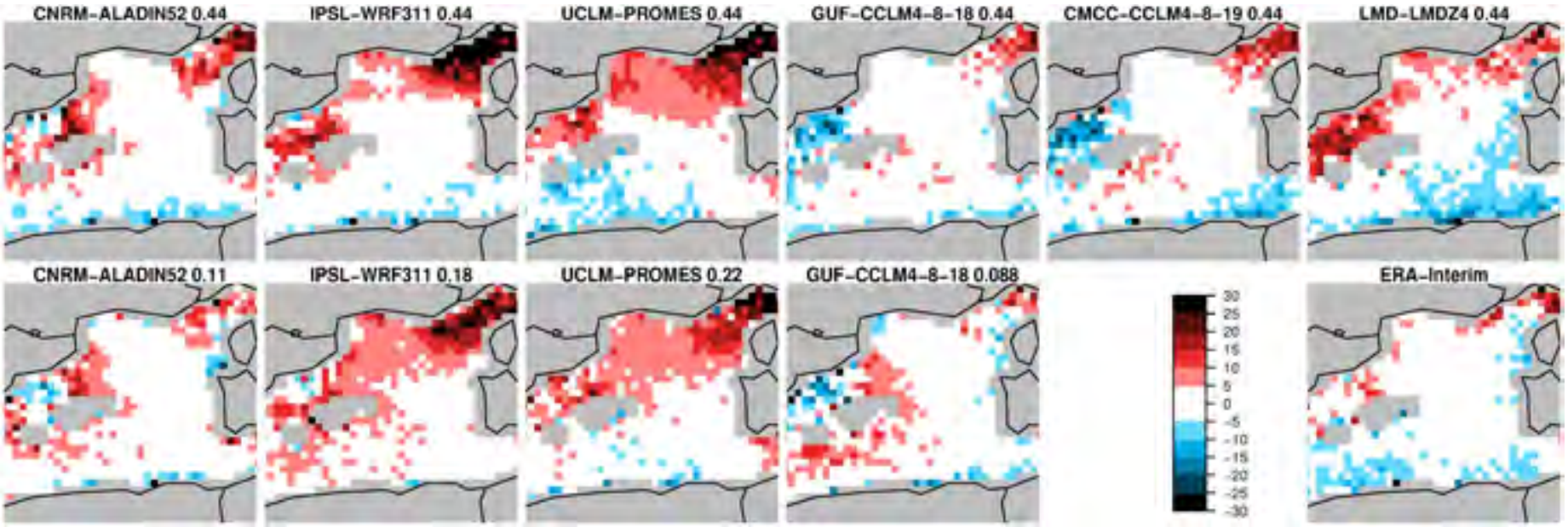
$\Rightarrow$ M/T patterns correctly predicted in 74 to 82 percent of the cases

Wind speed bias (m/s)



- wind speed over Mediterranean Sea underestimated.
- bias stronger at borders of main flow than at the center.

Wind direction (°)

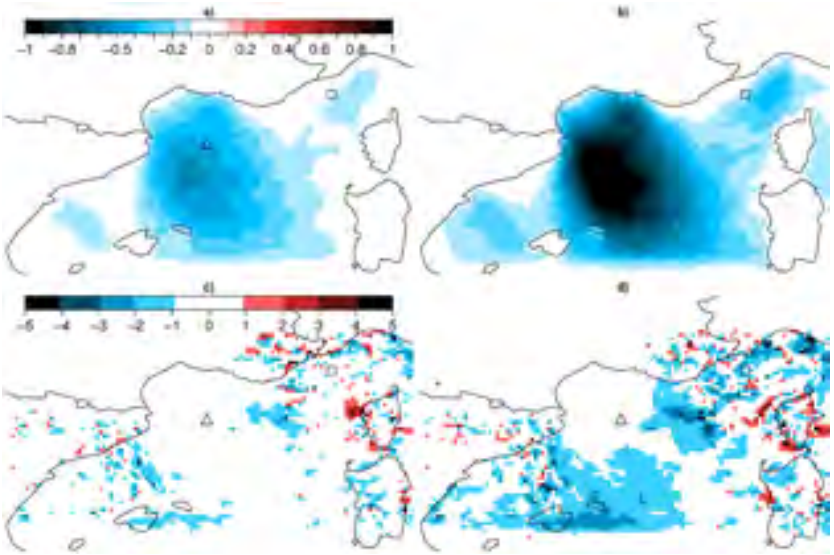


- bias changes from clockwise to counterclockwise from north to south.
- bias stronger at borders of main flow than at the center.

Influence of roughness length

Charnock formula in CCLM: $z_0 = \alpha \cdot \frac{u_*^2}{g}$, $\alpha = 0.0123$

$\alpha = 0.025$ $\alpha = 0.05$



MOD-REF difference of 10-m wind speed (upper row, in m/s) and direction (lower row, in °).

- higher values of $\alpha \Rightarrow$ lower wind speeds in the main flow and counterclockwise rotation of the wind at sides of main flow.
- change in the balance between the wind speed dependent Coriolis force and pressure gradient force
- corner effects, Coanda effect

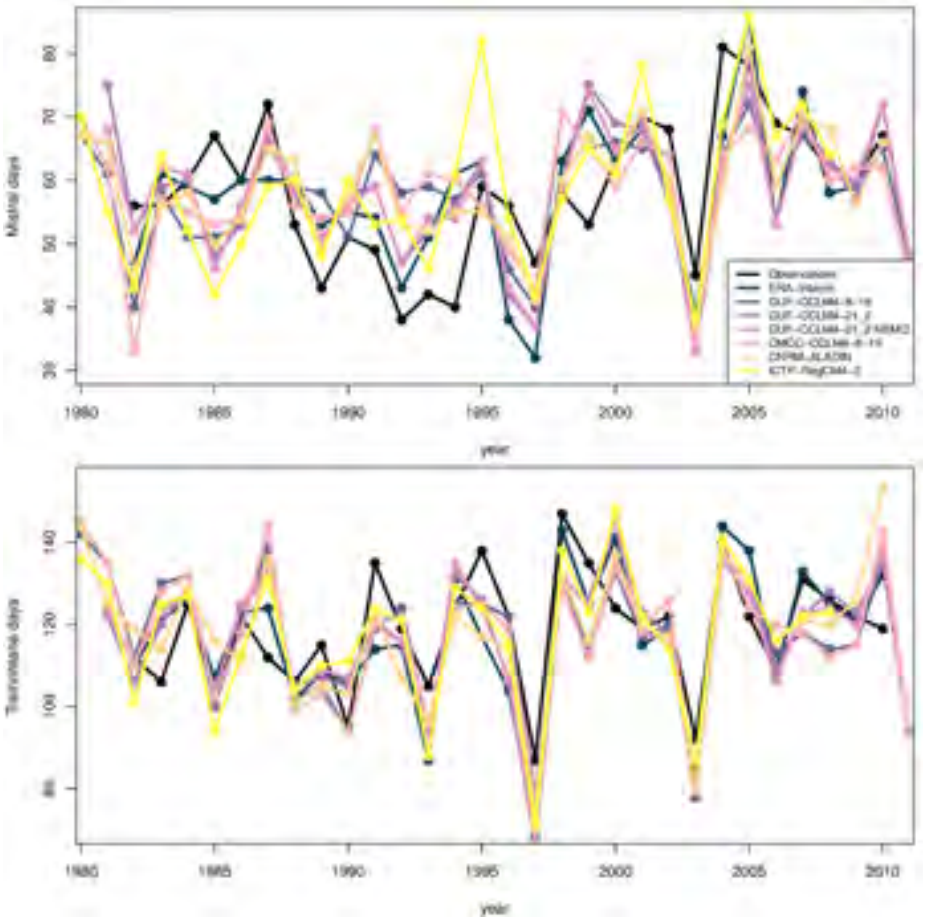
Do the characteristics of M/T events change in climate projections?

ERA-Interim period:

Model	Group	Version	Mean period length	
			M	T
ERA-Interim	ECMWF		2.1	3.3
CCLM	GUF	4-8-18	2.0	2.9
CCLM	GUF	4-21-2	2.1	3.1
CCLM-NEMO	GUF	4-21-2	2.1	3.1
CCLM	CMCC	4-8-19	2.0	2.9
ALADIN	CNRM	v5.2	2.2	2.9
RegCM	ICTP	4-3	2.3	3.5
Observation	METEO-FRANCE		1.7	2.5

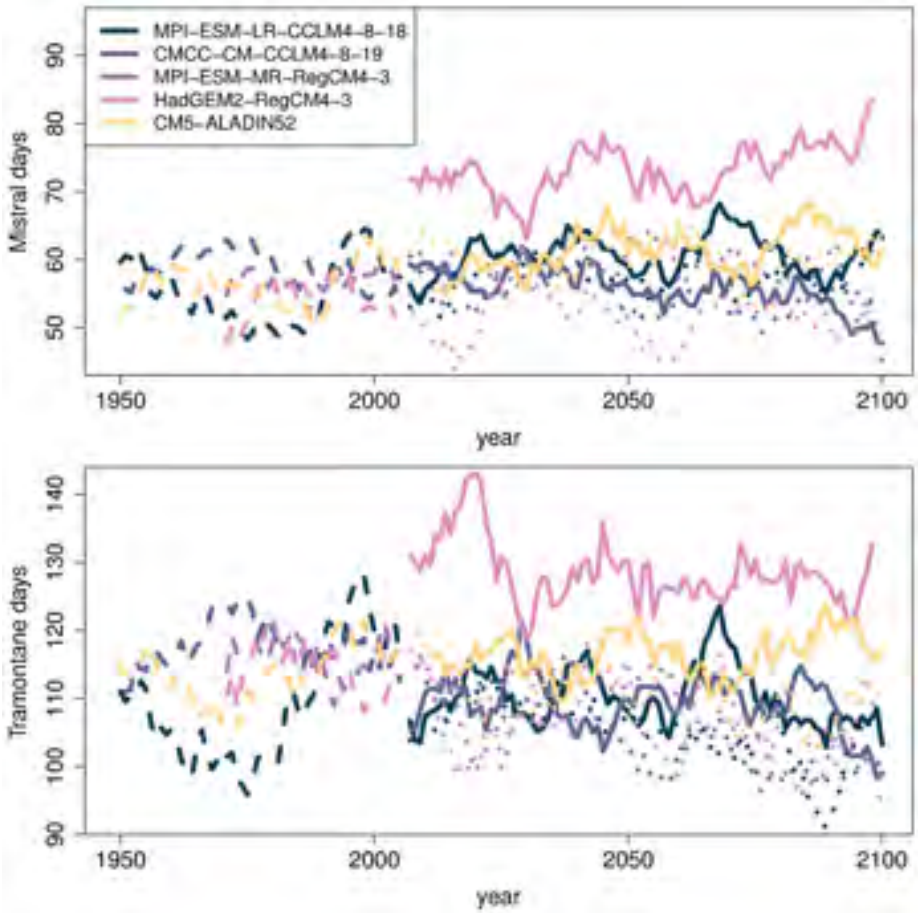
- correlation $0.44 - 0.57$ for M and $0.67 - 0.78$ for T
- period length overestimated
- seasonal distribution reproduced in models

M/T days per year:

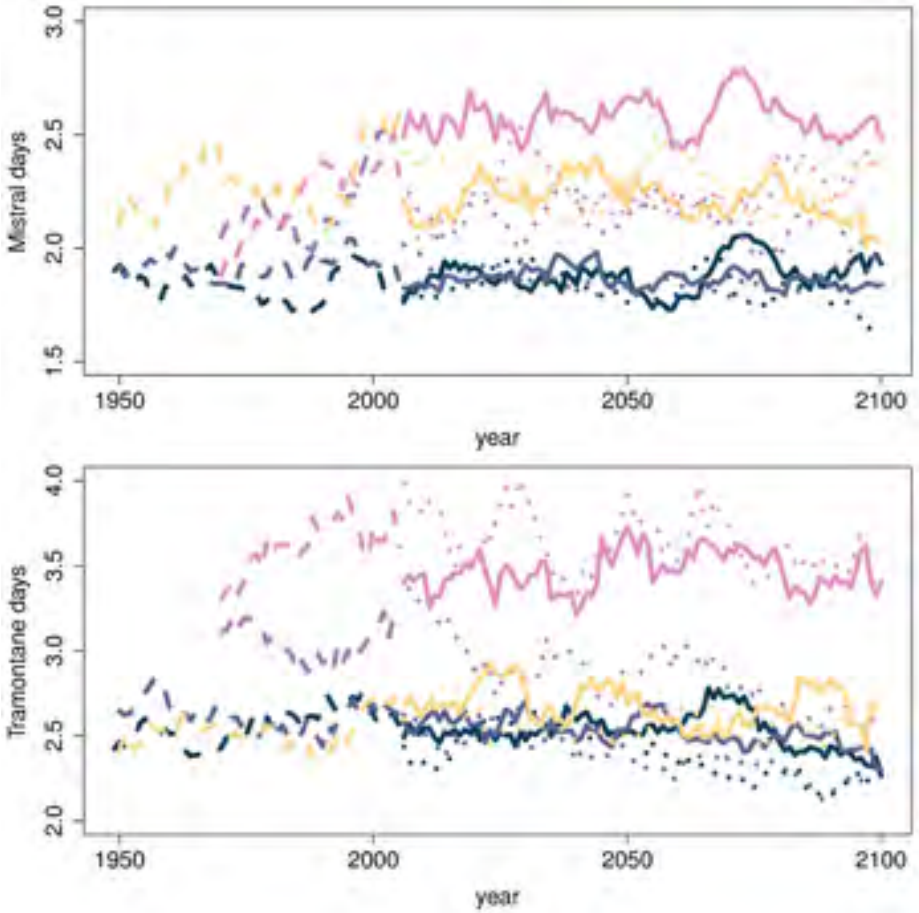


Historical and projection runs

M/T days per year



Period length (days)



10-year running mean, dashed: historical, full: RCP 4.5 dotted: RCP 8.5

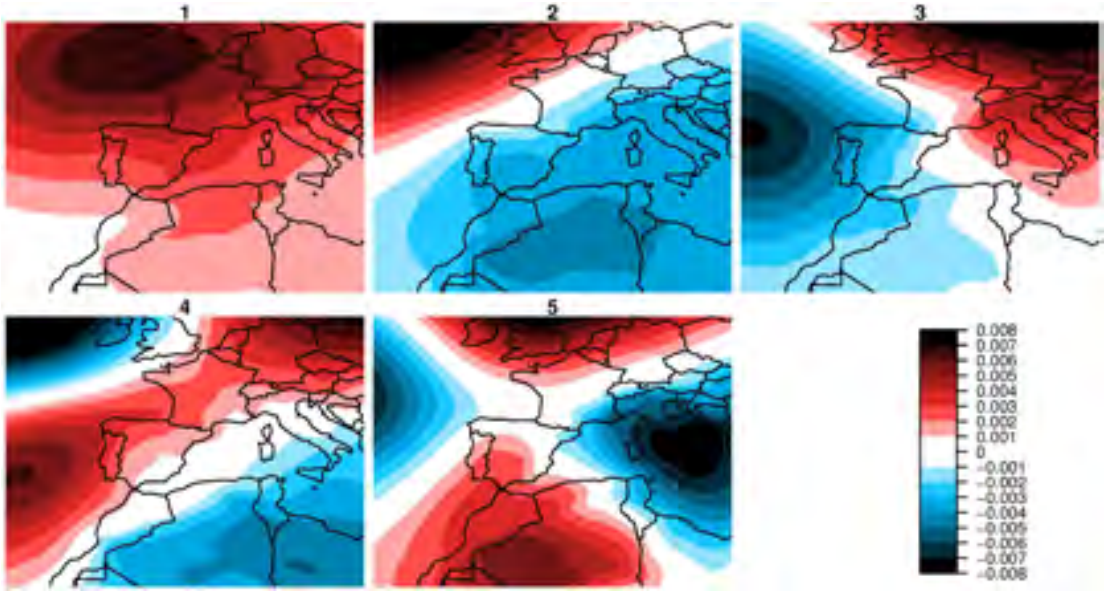
Mean number of M/T days per year

Model	Run	1981–2010		2011–2040		2041–2070		2071–2100	
		M	T	M	T	M	T	M	T
CNRM-CM5-ALADIN52	hist	56.88	115.71						
	rcp85			60.20	110.23	62.40	113.70	58.50	107.40
	rcp45			58.65	115.48	62.53	116.13	62.37	117.80
MPI-ESM-LR-CCLM4-8-18	hist	56.88	116.36						
	rcp85			58.70	110.00	56.90	**104.93**	57.50	**101.40**
	rcp45			60.03	109.63	61.70	113.17	60.67	107.60
CMCC-CM-CCLM4-8-19	hist	56.68	116.20						
	rcp85			56.40	110.23	54.73	**103.30**	53.40	**99.43**
	rcp45			57.50	111.17	55.43	108.93	53.63	**107.07**
HadGEM2-RegCM4-3	hist	54.96	113.79						
	rcp85			52.87	107.23	51.00	109.77	51.50	104.82
	rcp45			**70.30**	**129.50**	**72.5**	**128.43**	**76.46**	**127.25**
MPI-ESM-MR-RegCM4-3	hist	55.92	115.96						
	rcp85			58.43	107.80	60.20	110.47	57.07	**101.07**
Observation		58.28	118.41						

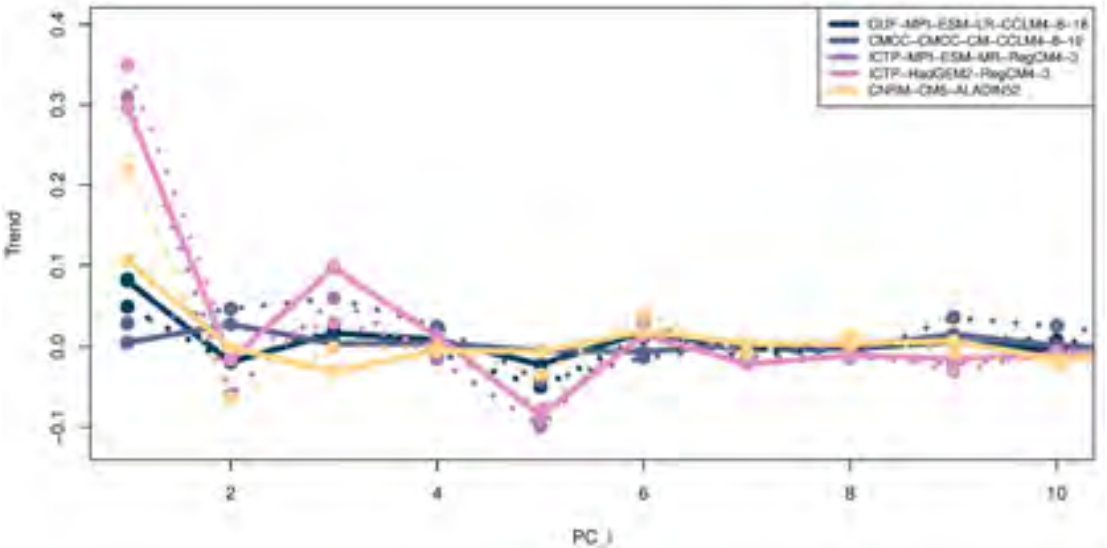
- some simulations show increase in M days per year, some don't
- most simulations show decrease in T days per year
- less M/T days in RCP 8.5 than in RCP 4.5

Large scale circulation changes

EOFs:



Trends in PCs:



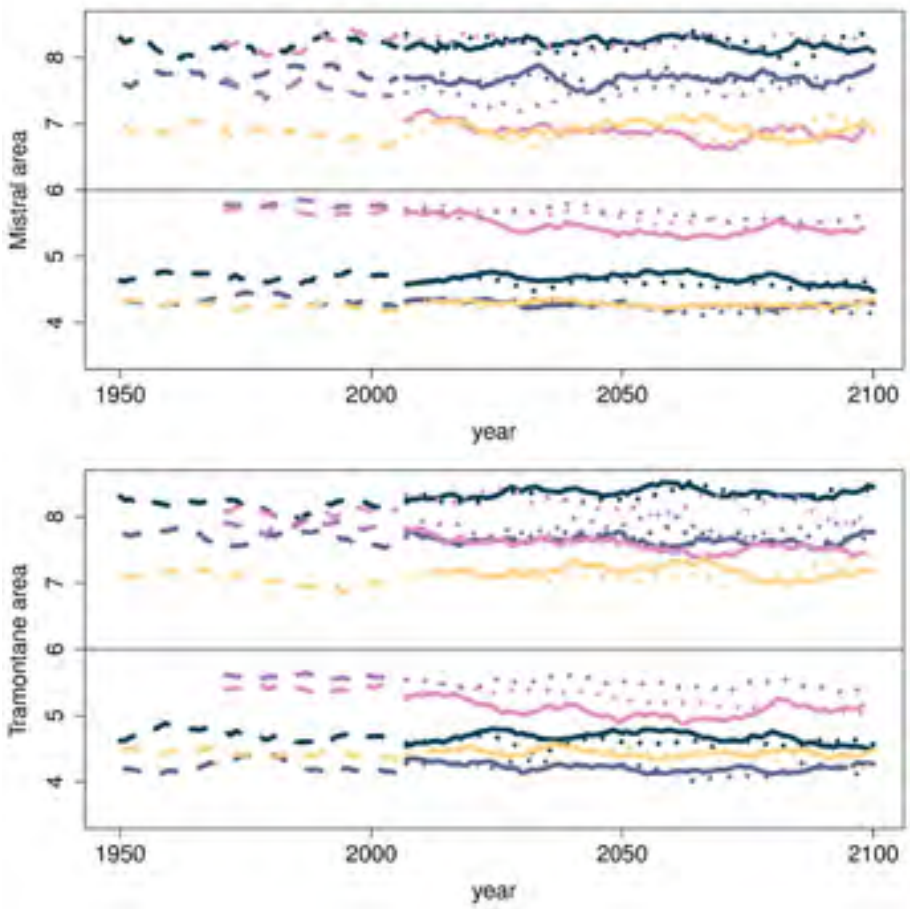
Correlation PCs and M/T events:

PC	M	T
1	0.128	0.052
2	0.127	0.102
3	-0.321	-0.493
4	-0.004	0.074
5	0.224	0.271

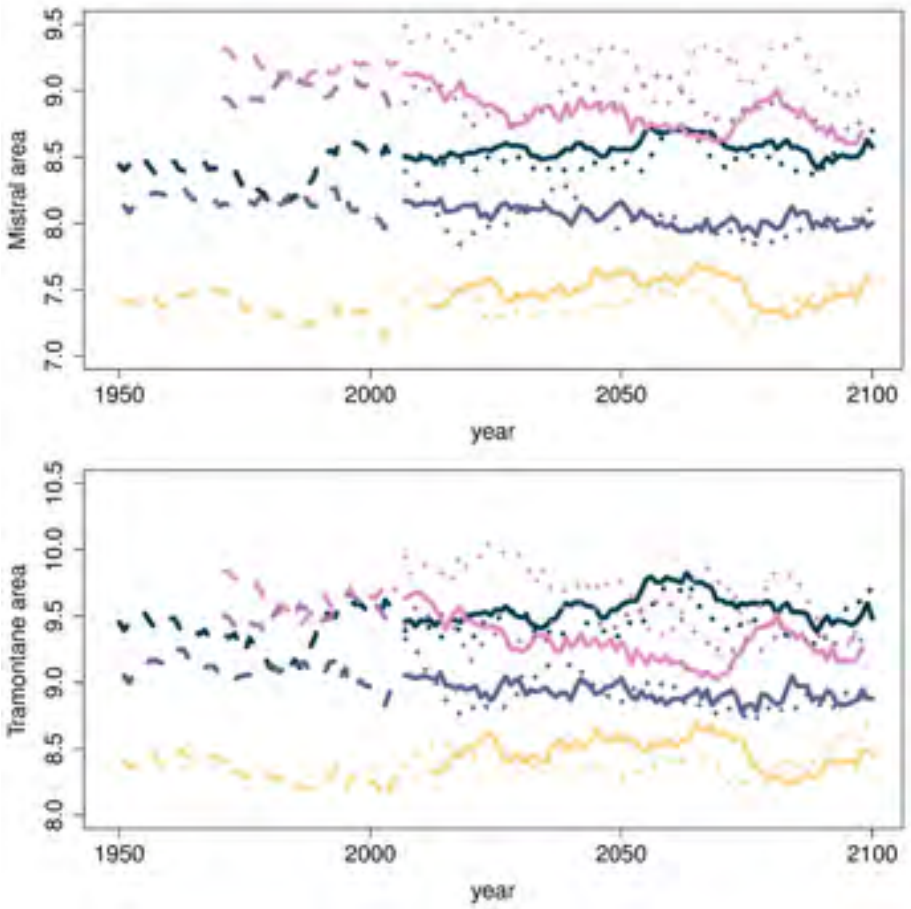
- changes stronger in RCP 8.5 for most models
- positive trends in PC 1 and PC 3
- negative trend in PC 5

Wind speed changes in M/T areas

On (non) M/T days (m/s)



90th percentile (m/s)



Conclusion

How well do RCMs simulate M/T patterns?

- wind speed underestimated
- higher bias at borders of main flow
- days per year well simulated
- overestimation of M/T period length

Do the characteristics of M/T events change in climate projections?

- no significant changes in M days per year
- T days per year decrease
- RCP 8.5 runs show less M/T days per year than RCP 4.5 runs