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A systematic analysis of the performance of the IPSL-CM5A-LR model for decadal temperature predictions over Europe

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Scientific questions

- Does a Decadal Climate Prediction (**DCP**) system significantly performs better in some specific contexts rather than in others? If yes, in which ones?
- Does the **statistical de-biasing** implies skill improvement?
- How these information can be used to support **climate services**?

Main objective

To systematically analyze the skills of the IPSL-CM5-LR DCP system in simulating air temperature over Europe in different contexts, *i.e.* by varying epochs, lead times and seasons.

Overview

We comprehensively analysed the potentiality of the IPSL DCP system in predicting the 1-10 years air temperature over Europe. We found that the prediction skill strongly depends on the season considered, with spring-summer temperature simulated with more accuracy than autumn-winter temperature. Predictions are also sensitive to the lead-times, likely because averaging over longer periods increase the signal-to-noise ratio. Also, there exist windows of opportunity, *i.e.* periods over which the DCP appears to perform better. Finally, the use of de-biased simulation show a slight increase of the prediction skill. Overall, these information can be useful for the development of a climate service based on DCP.

Data and Methods

1) We used the IPSL-CM5-LR DCP system (both raw and de-biased simulations)

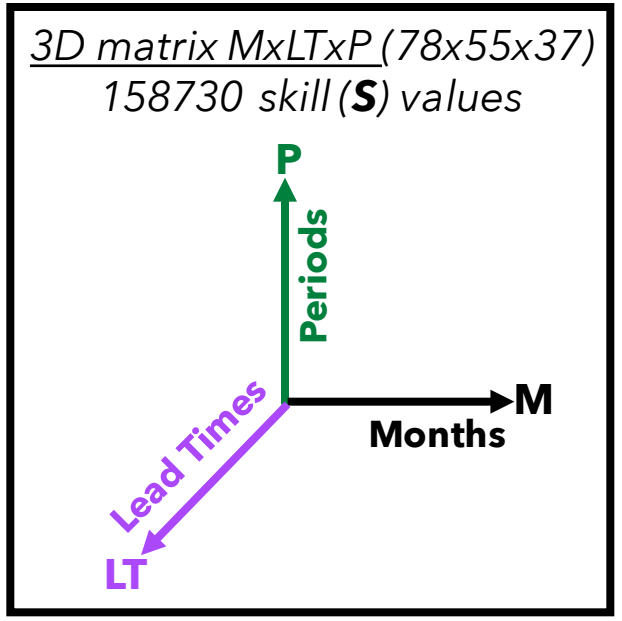
- Anomaly initialisation method for **SST**
- Initialisation every year from **1961 to 2013**
- Number of members = **3**
- The **de-biased data** → CDTf method (variant of **quantile-quantile** method, **multiple learning periods**, projection on **IPSL grid**)

2) We systematically calculate the prediction skills S over Europe, *i.e.* ACC and RMSE of the de-biased and de-trended air temperature hindcast *vs* de-trended NOAA-20CR for:

- All the possible combinations of consecutive **months M**
- All the possible combinations of consecutive **lead-times LT**
- Each combination of **periods P** of 26 and 44 years lengths λ

3) We study the pattern of S = f (M,LT,P)

- Identification of the best skill in terms of M, LT and P
- Comparison with a reference configuration
- Regional analysis (here we show the example of Iberia)



Skill over Europe

Reference contexts

M=Jan-Dec
LT=1-5 yrs

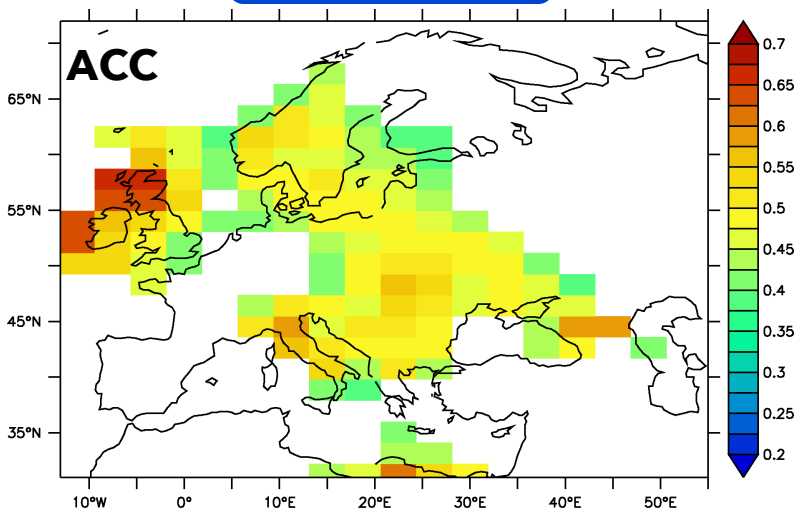
Among all the combinations of months M, lead times LT and periods P, we defined a **reference context** for each λ

λ	M	LT	P	Reference
26	78	55	27	P=1961-1986 LT=1-5 yrs M=Jan-Dec
44	78	55	10	P=1961-2004 LT=1-5 yrs M=Jan-Dec

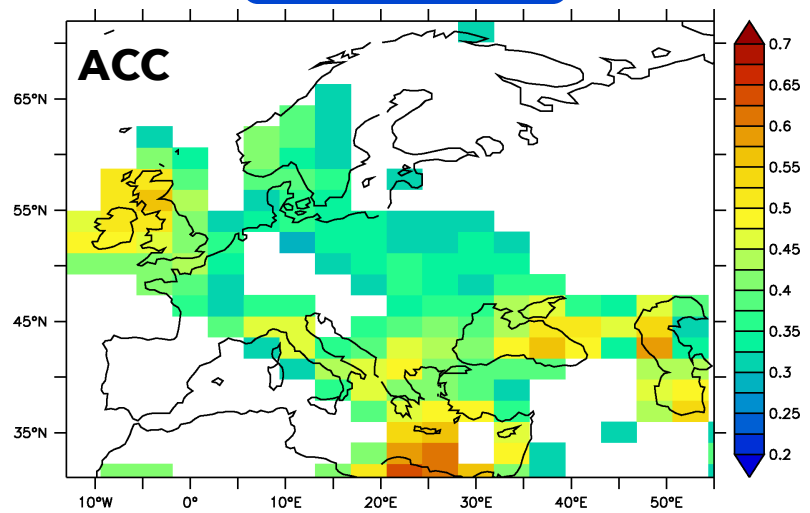
For these configurations of M, LT and P, temperature predictions appear to be:

- skilled over the U.K., eastern part of Scandinavia, eastern Mediterranean
- not skilled over Iberia, eastern Scandinavia and Russia

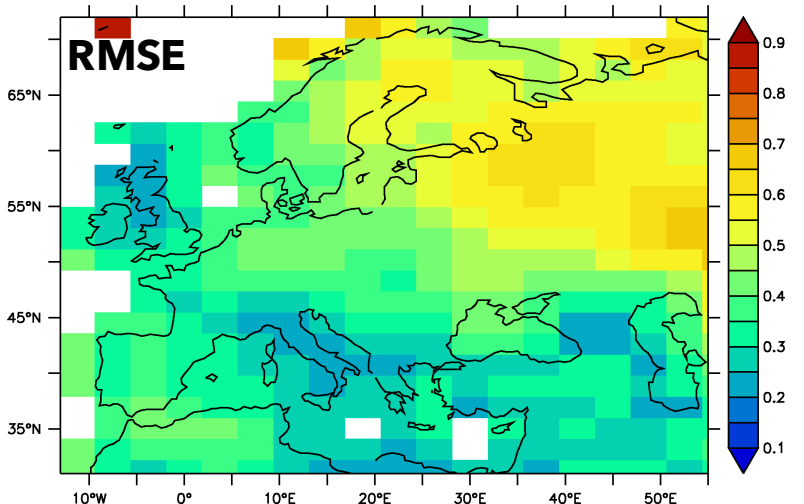
λ=26 → P= 1961-1986

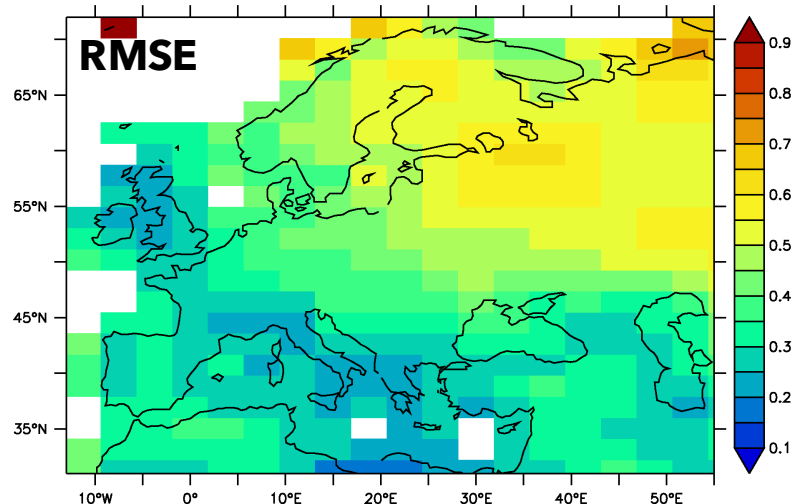


λ=44 → P= 1961-2004



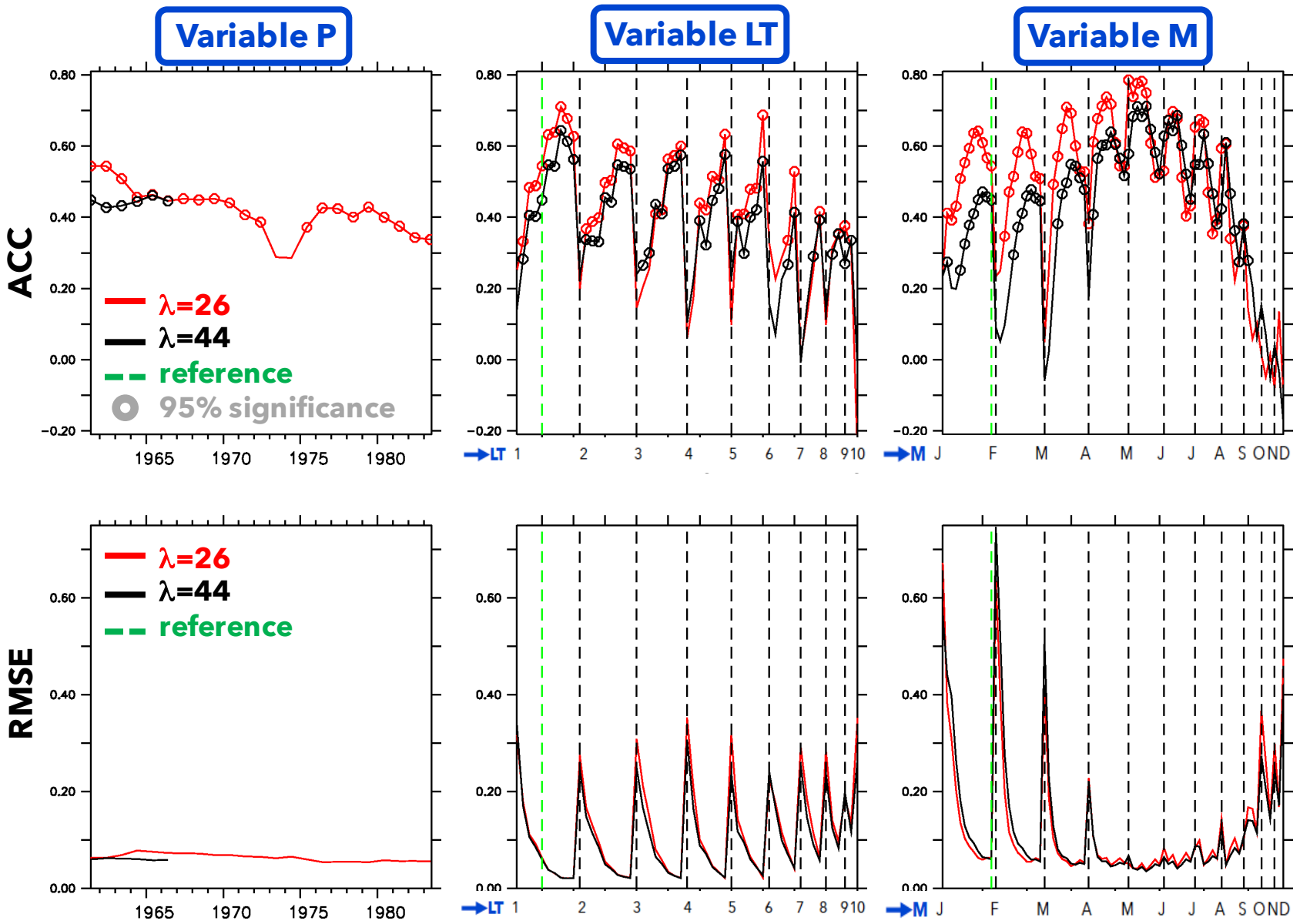
N.B. only correlations significant at 95% level have been displayed





Skill dependence on P, LT and M

1D analysis

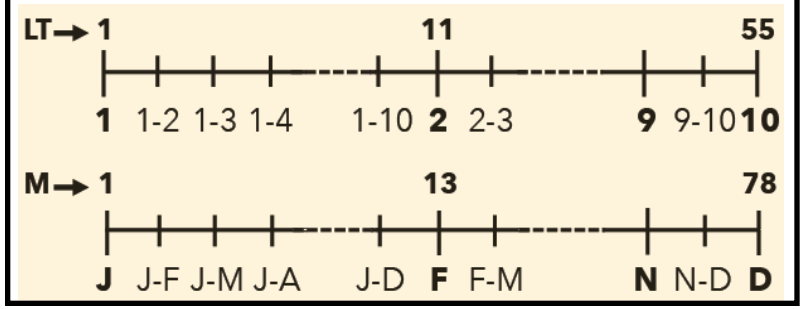


From the reference configurations we defined, we vary, in turn, P, LT and M and calculated the ACC and RMSE for the whole European region, *i.e.* from 12°E to 45°W and from 35°N to 70°N. We find that:

- Skill S changes with P, LT and M, *i.e.* **S = f (P,LT,M)**
- Major S variability associated with varying M

How to read the axes in the figure

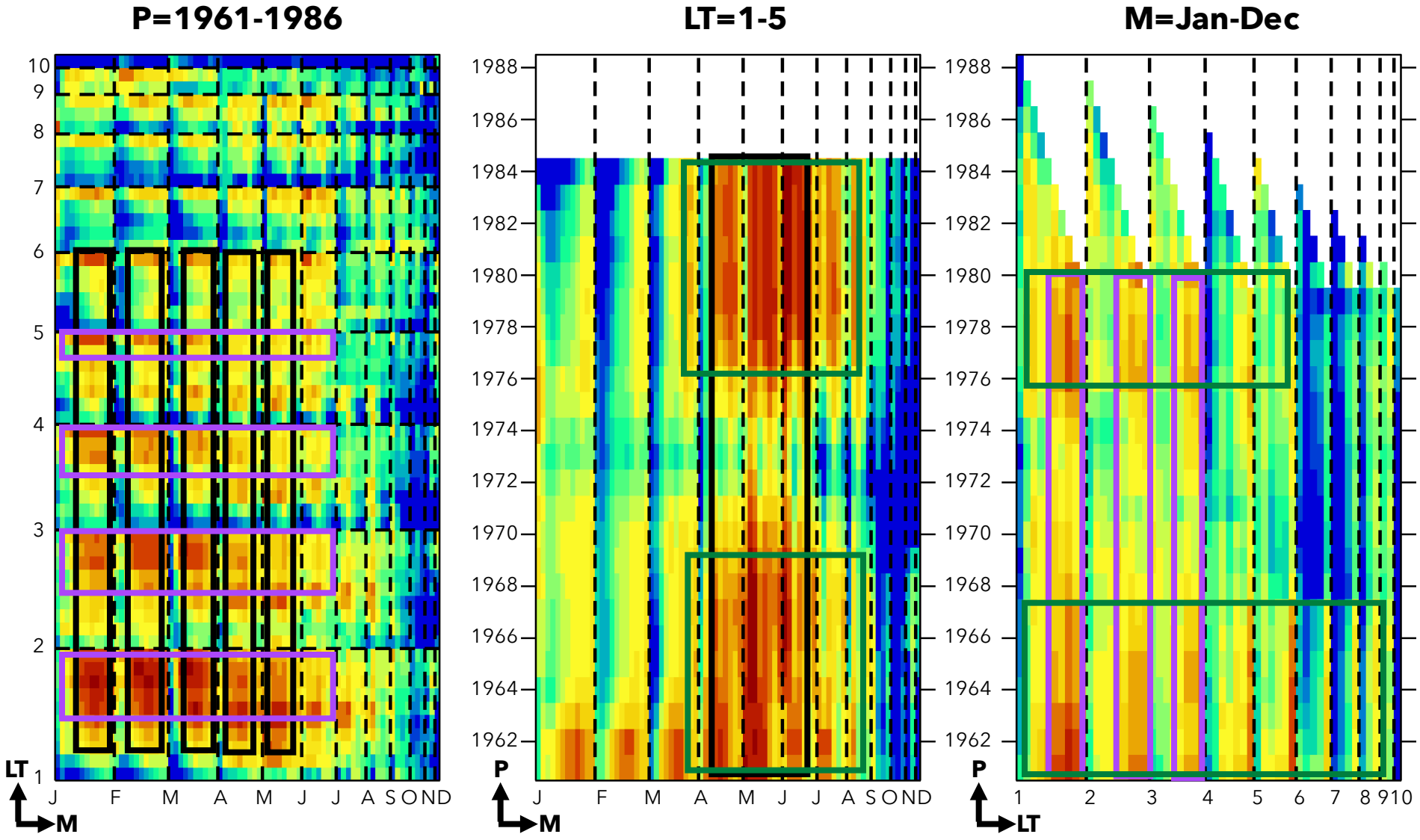
LT (M) axis: all the 55 (78) combinations of consecutive lead-times (months) sorted such that we start with all the combinations starting from LT=1 yr (M=Jan), *i.e.* LT=1 yr (M=Jan); LT=1-2 yrs, (M=Jan-Feb), etc., followed by all the combinations starting with LT=2 yrs (M=Feb), *i.e.* LT=2 yrs (M=Feb); LT=2-3 yrs (M=Feb-Mar), etc., and so on till LT=10 yrs (M=Dec).



Skill dependence on P, LT and M

λ=26

2D analysis - ACC

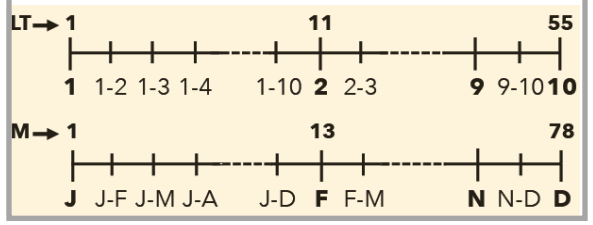


For varyig **M**: Best skills for those combinations of months including the **spring/summer** seasons, *e.g.* May-Sep.

For varying **LT**: Best skills for those combinations implying an average over **long lead times**, *e.g.*, 2-9. This is likely to a reduction of the noise within the signal.

For varying **P**: Best skills for simulations initialized before 1969 and after 1976.

Reminder on LT and M axis



Skill dependence on P, LT and M

λ=44

Best performance over Europe

From the 3D matrix it is possible to identify in which context the DCP provides the best skills. For λ =44, this is :

P=1964-2007
LT=1-6 yrs
M=Jun-Sep

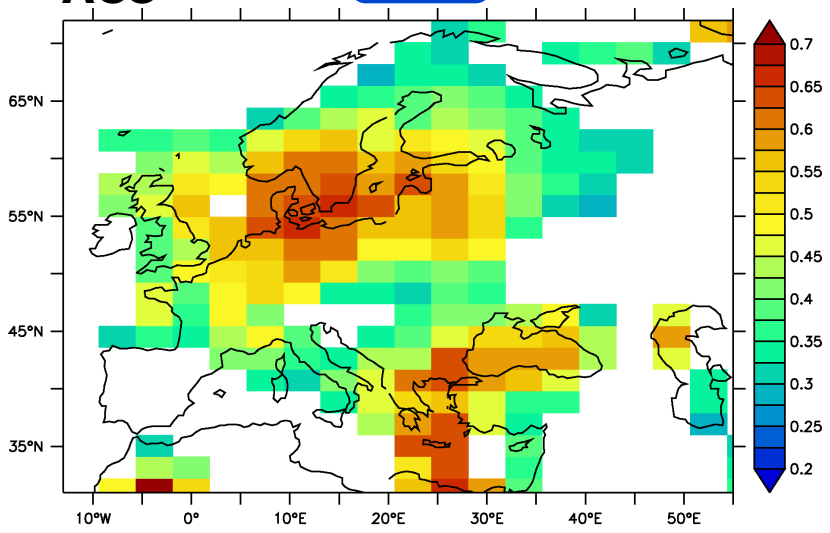
If we compare the regional structure of this context with the one found for reference context (P=1961-2004; LT=1-5 yrs; M=Jan-Dec), we find:

- A general skill improvement
- More skills over Scandinavia
- More skills over the Mediterranean sector
- More skills over the Atlantic sector
- Still no skill over Iberia

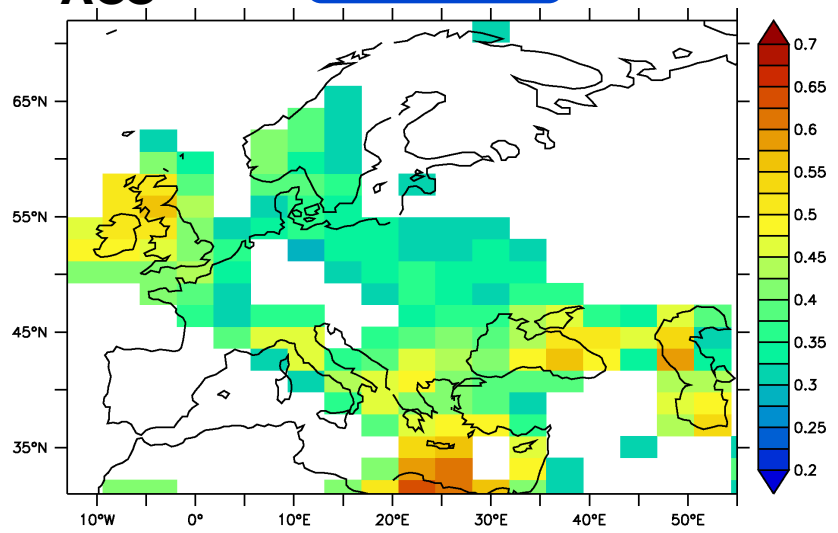
↓

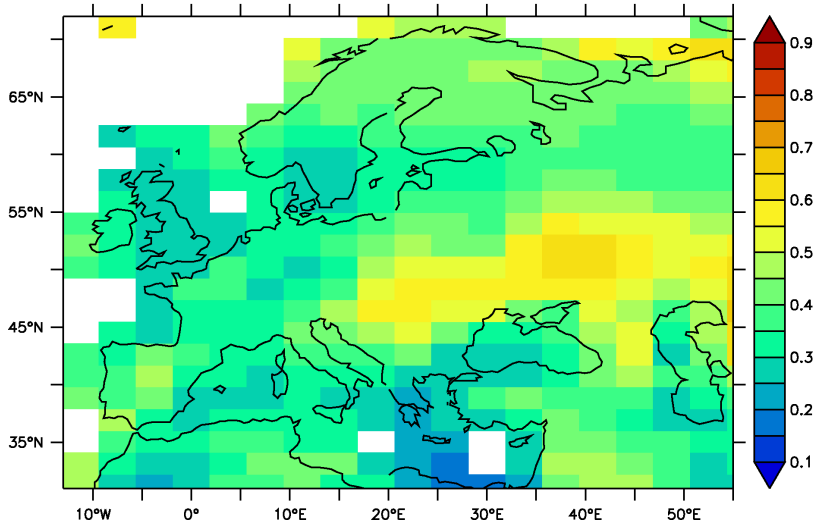
More regional analysis

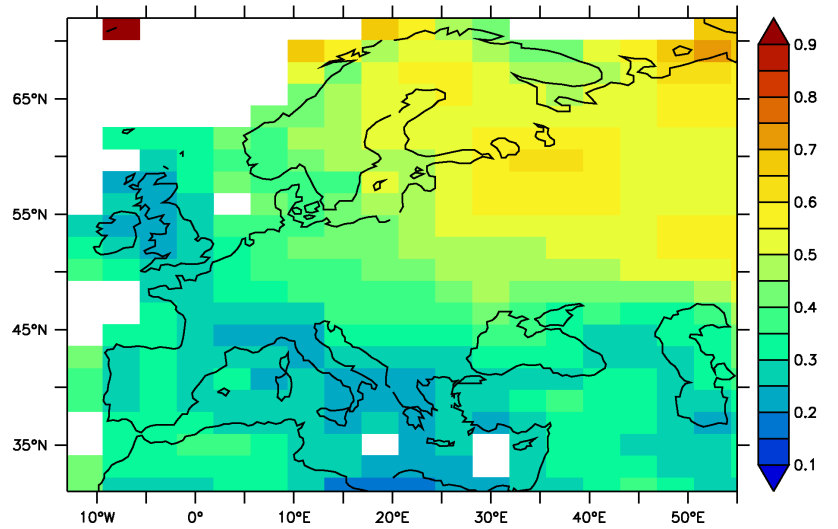
Best



Reference



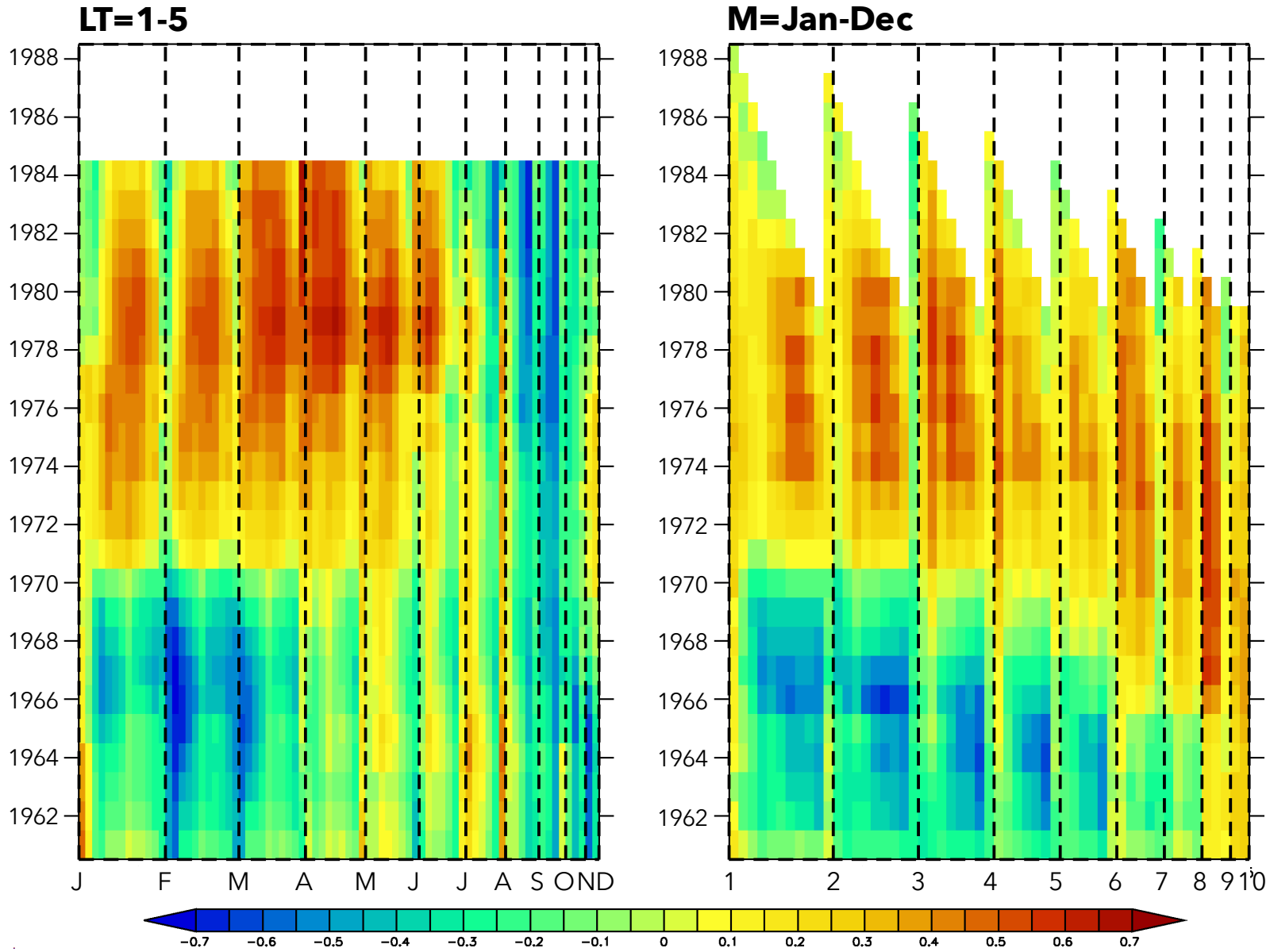




Regional analysis

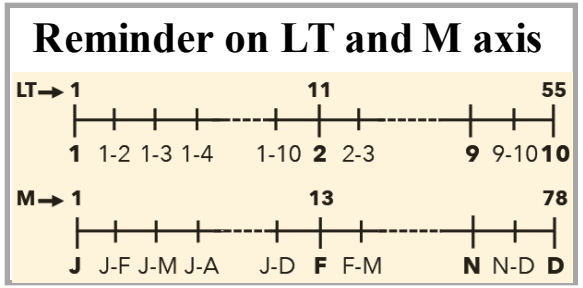
λ=26

ACC over Iberia



For a more detailed investigation, we perform the same systematic analyses over 7 different European sub-regions. Here we show the example of Iberia for which, so far, we have not found any prediction skill. We find:

- A strong dependence on the **period** considered
- Very good skills after 1974, notably for **spring-summer months**



Regional analysis

λ=26

Best performance over Iberia

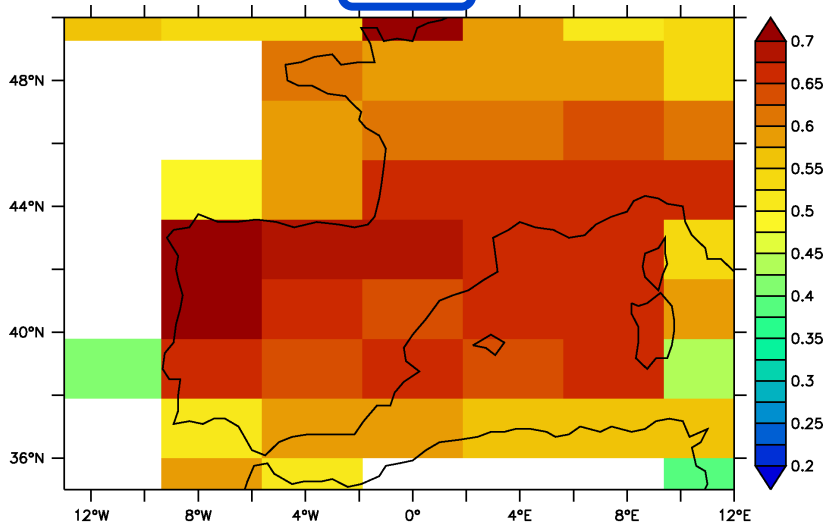
Within the 3D matrix, the best skill (ACC) for λ=26 over Iberia is found for:

P=1980-2005
LT=2-9 yrs
M=Mar-Sep

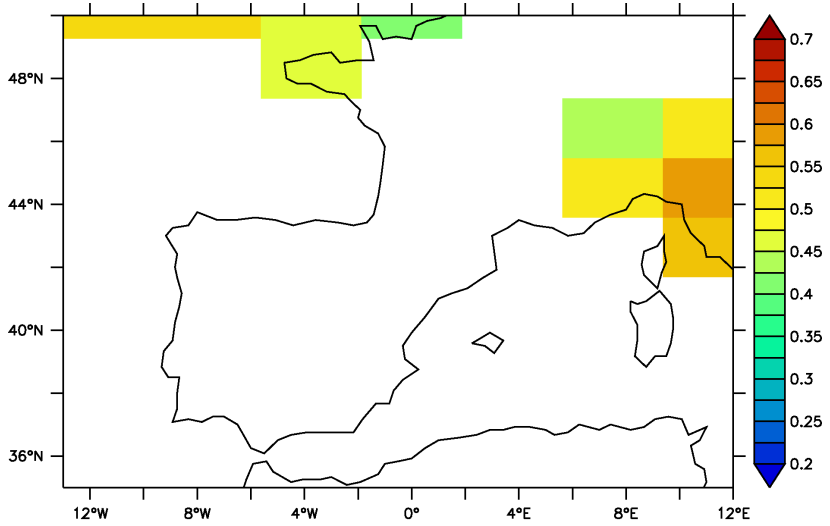
A comparison with the spatial structure for the reference context shows that it is possible to pass **from no skills** over Iberia to **high skills over the whole region.**

Regionalisation is also an important factor to consider in the assessment of the effective potentiality of a prediction.

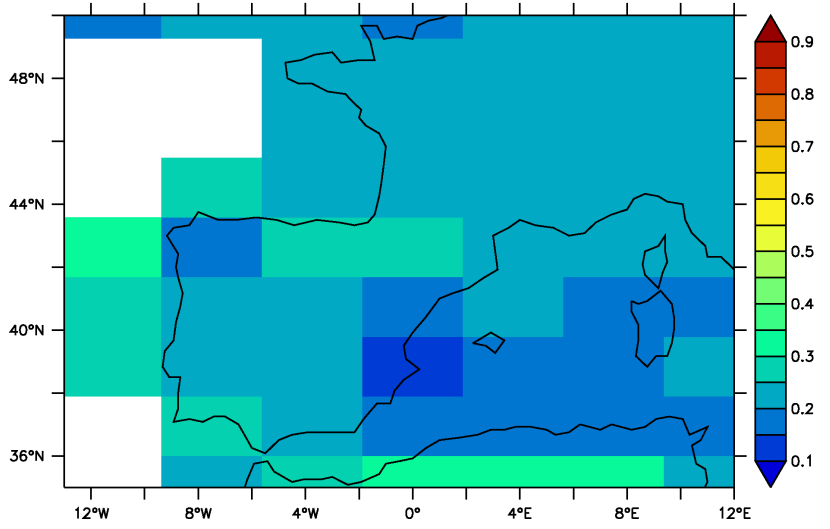
ACC — Best



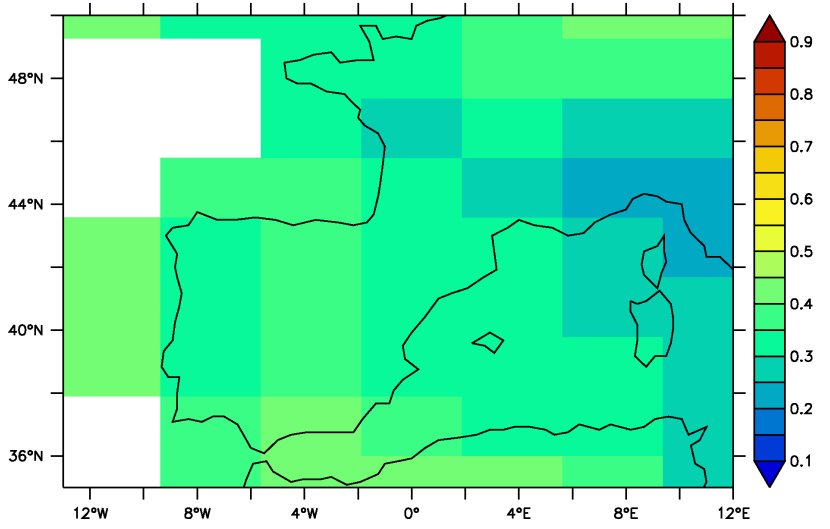
ACC — Reference



RMSE



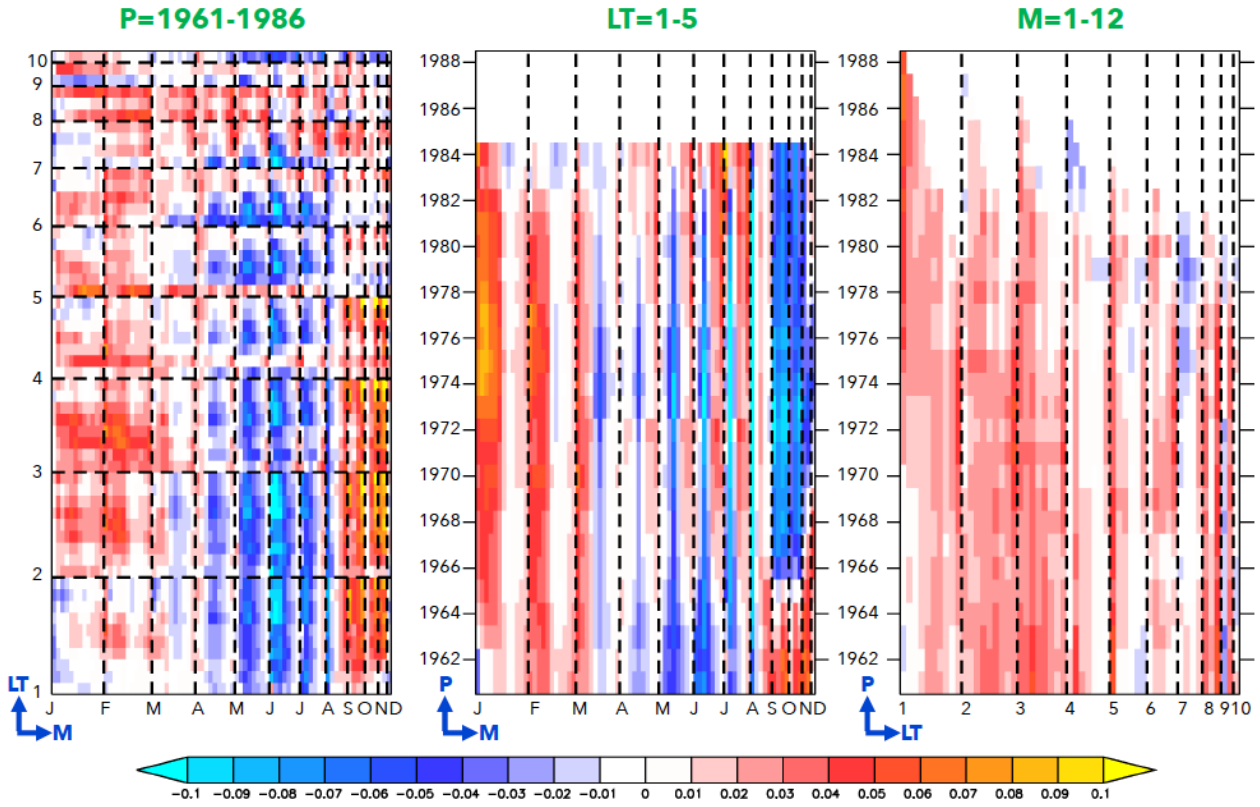
RMSE



De-biased vs Raw data

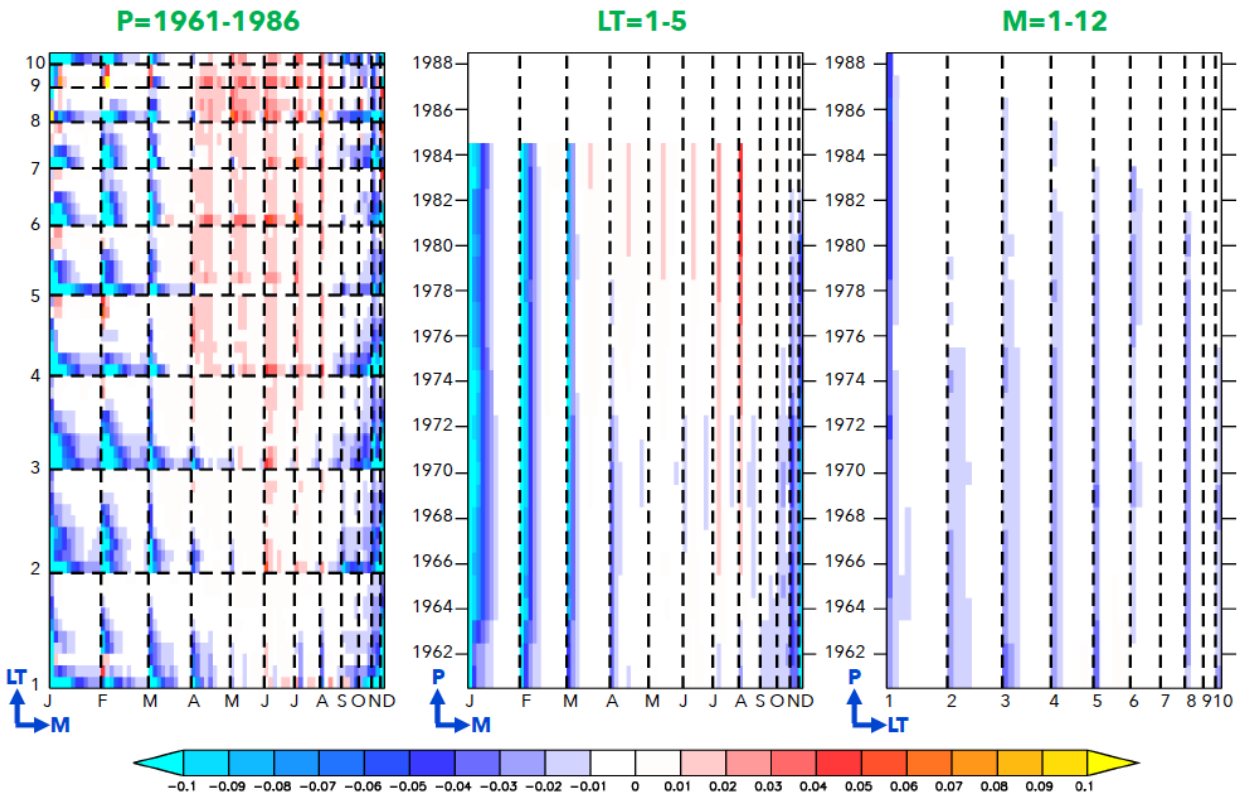
λ=26

ACC



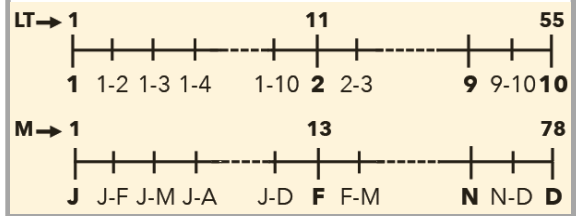
- Slight ACC improvement for those combinations including the first months of the year, while some slight ACC reduction for summer months

RMSE



- A general reduction of the RMSE, notably for the first months of the year

Reminder on LT and M axis



The de-biasing procedure implies an overall slight improvement of the skill

Conclusions

- The skill of the IPSL-CM5A DCP system in predicting **air temperature over Europe** appears to be dependent on **(1)** the season, **(2)** on the lead-time, **(3)** on the period and **(4)** on the specific region considered.
- De-biased simulations appear to generally **reduce the RMSE**, thus implying an overall (slight) skill improvement.
- This kind of study can discloses the degree of accuracy of a DCP when applied to a specific impact analysis.
- For example, concerning the IPSL-CM5A DCP system here analysed, it potentially shows a **skilful applicability for the study of the near-term impacts on viticulture over Europe**. Indeed, the latter is classically analysed by means of temperature-forced phenological models running over the growing season, e.g. March-September, which here appear to be well simulated.
- Therefore, this kind of study, that can be extended to other variables and other DCP systems, represents an useful tool for an **effective optimisation of climate services.**