Nested scale approach to characterizing the climate contribution to vineyard terroirs in the context of climate change

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Life

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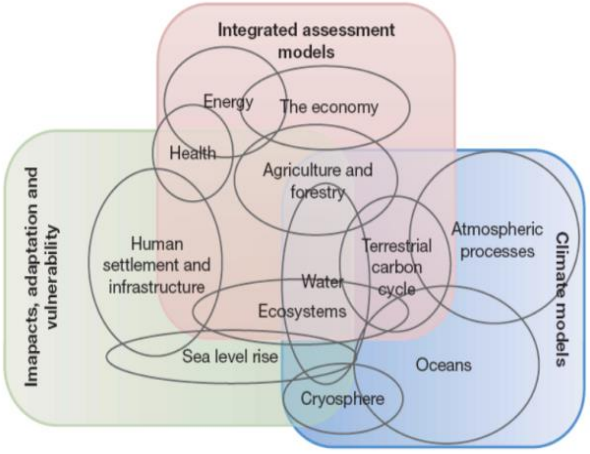
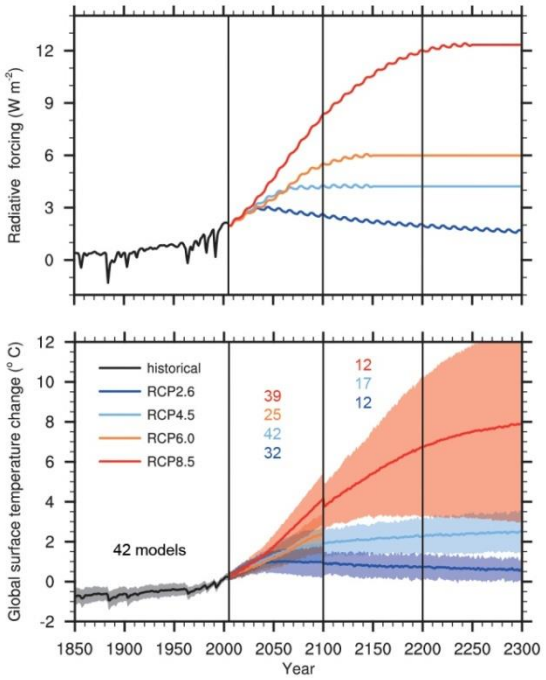
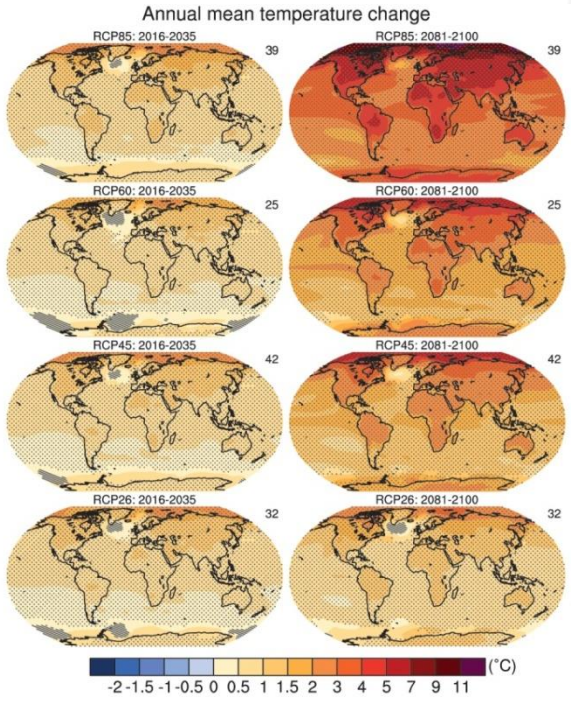
Introduction: Research Context

- Climate change scenarios show a rise of mean temperature during the XXI Century
- Global climate models include the influence of both natural and anthropogenic phenomena
- They are used to estimate future climate everywhere on the globe at low resolution (~300 km)



Source : Moss et al, 2010

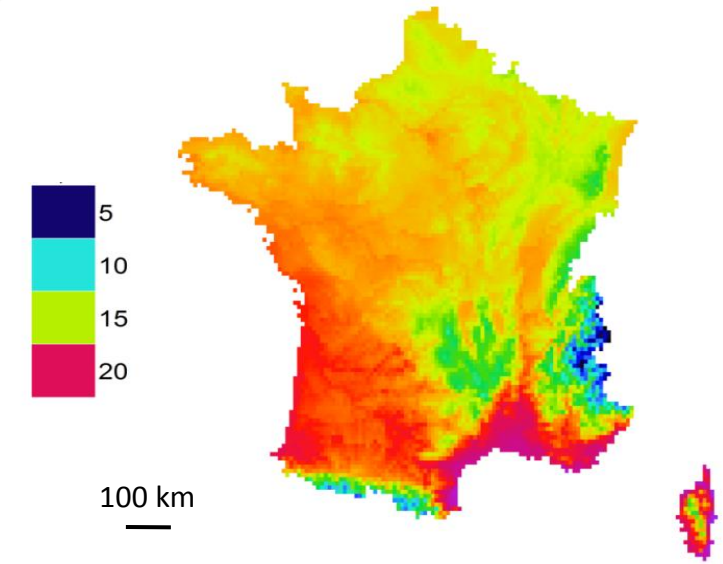




Source : IPCC, 2013

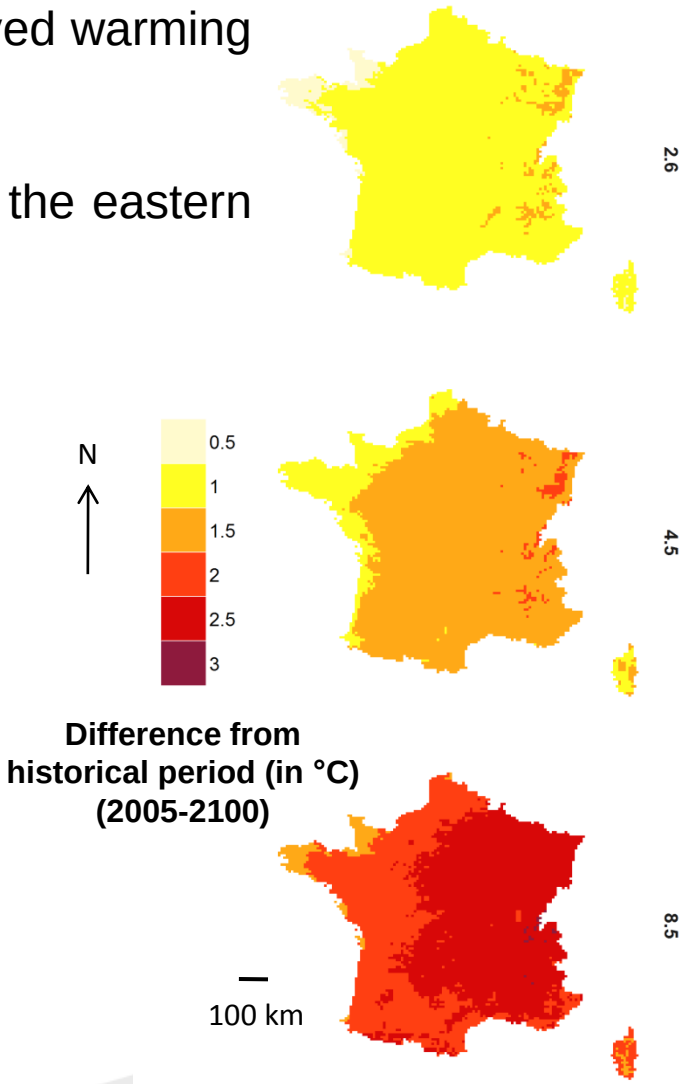
Introduction: Research Context

- All of France is concerned by the observed warming trend
- More significant warming is expected in the eastern parts of the country



Mean temperature for historical period 1950-2005

Data : DRIAS



Difference from historical period (in °C) (2005-2100)

Introduction: Research Context

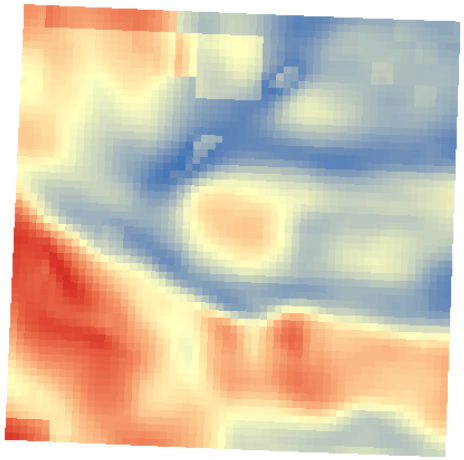
- Climate, especially temperature, has a important impact on grapevine behaviour, through its influence on:
  - Grapevine growth and development (phenological stages, …)
  - Climatic hazards (heat waves, spring frost, …)
  - Wine characteristics (alcohol, acidity, …)
- Several bioclimatic indexes are based on temperature, including:
  - Winkler index
  - Huglin index

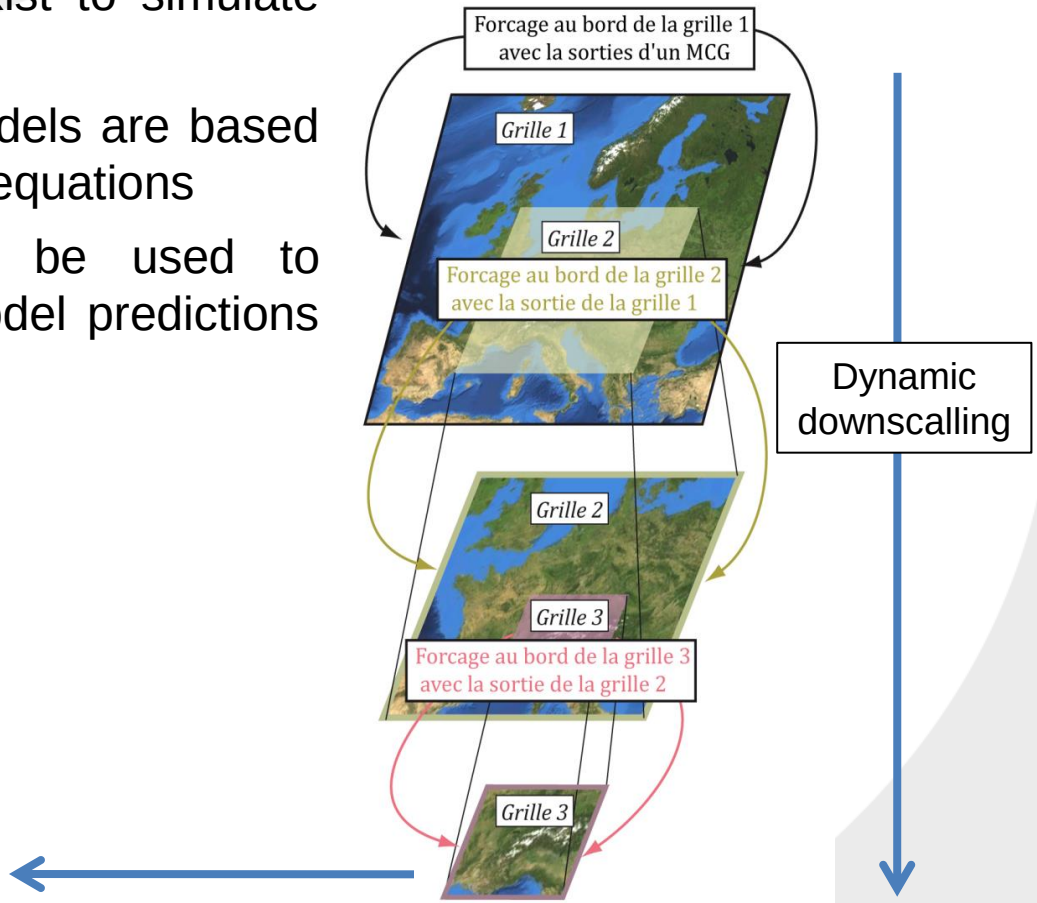
Introduction: Research Context

- Climate is a part of terroir and each vineyard has its own specific temperature distribution
- Local climate is a result of mutliple interactions between climate processes of varying scale: global, regional and local
- At vineyard scale, temperature is influenced by local topography (elevation, slope and aspect)

Materials and Methods

- Differents kinds of model exist to simulate climate at different scales
- Dynamical regional-scale models are based on fundamental atmospheric equations
- Several nested grids can be used to downscale global climate model predictions to a finer resolution

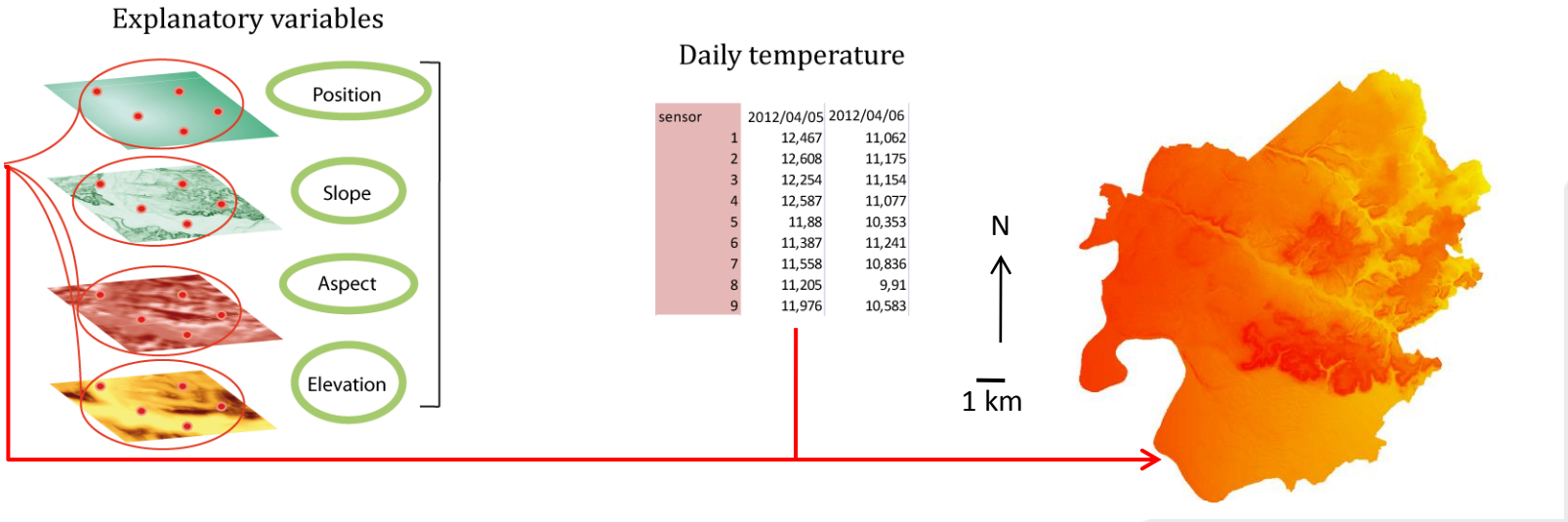




- Temperature map at kilometre resolution

Materials and Methods

- Statistical models are also available to simulate climate at these different scales
- Statistical local-scale models are based on empirical relationships identified between predictor and predicted variables
- In this case, the model is based on the observed relationship between temperature and environmental variables (topography, spatial correlation)



Materials and Methods

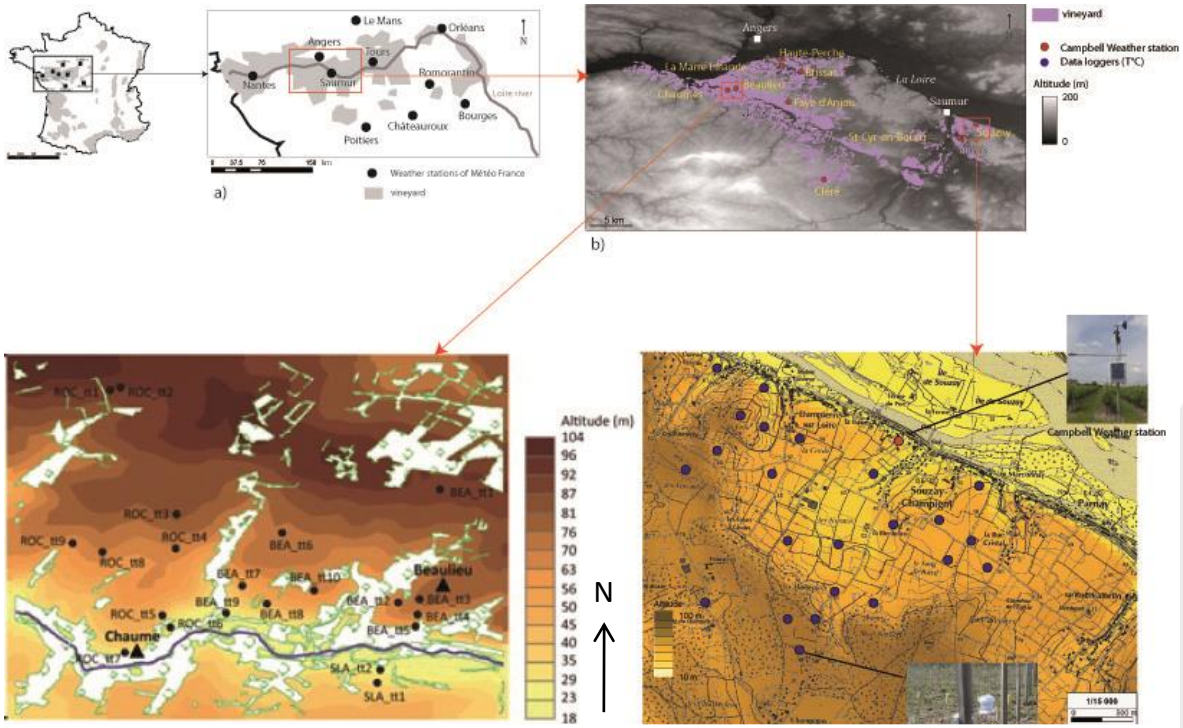
- Using these different approaches to modeling and predicting climate change, a key research question is:

How can we evaluate and simulate the impact of climate change at the scale of a vineyard or a viticultural terroir?

- Important steps include:
  - Integration of measurements and spatial modeling adapted to the local scale
  - Comparison with regional analysis
  - Comparison with climate change scenarios

Materials and Methods

- Study sites: two sites in the wine growing region of the Loire Valley, France
- Equipment: 60 temperature data loggers
- Set up in 2012

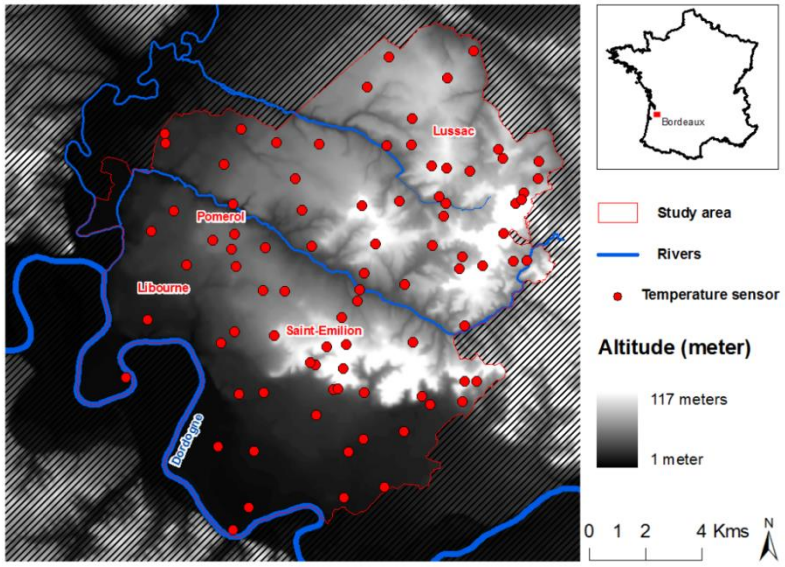


- Coteaux du layon
- Saumur Champigny

Source : Quénol (2014)

Materials and Methods

- Study site: Libournais-Est, France
- Equipment: 90 temperature data loggers
- Set up in 2012
- Set up in relation to topography (slope, elevation, aspect, etc.)

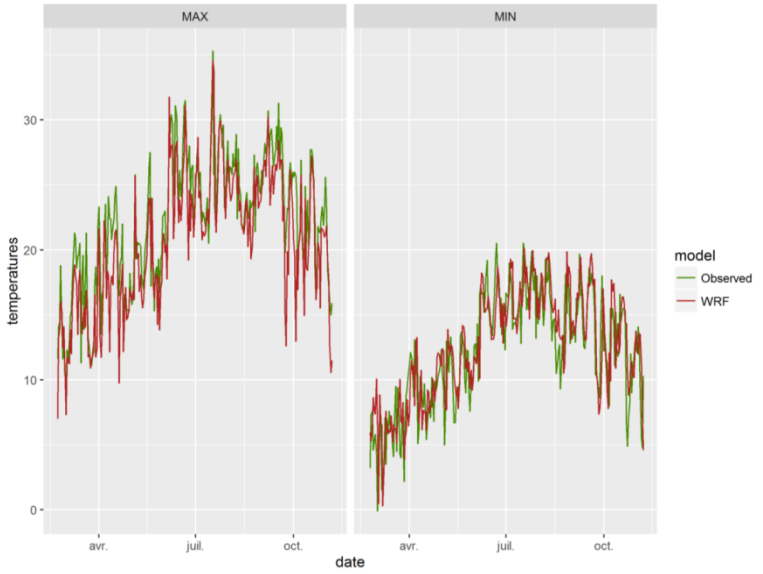


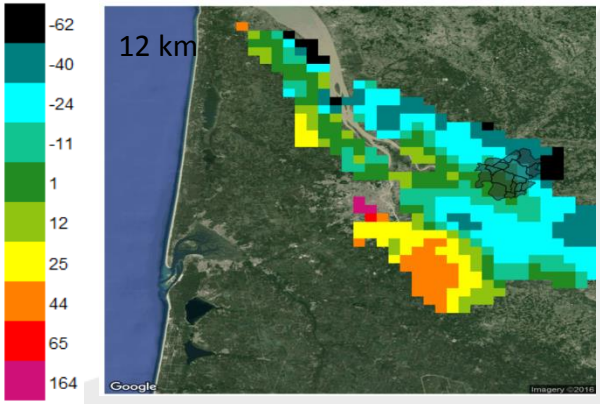
Source : de Résséguier (2014)

Results and Discussion

Regional modeling over the Bordeaux vineyard area using WRF (2014)

- Correlation with Bordeaux weather station shows that WRF provides a good representation of temperature
- WRF allows study of climate in a regional context
- Even if WRF was not developed for the same purpose as climate prediction models, they are based on the same fundamental atmospheric equations





Materials and Methods

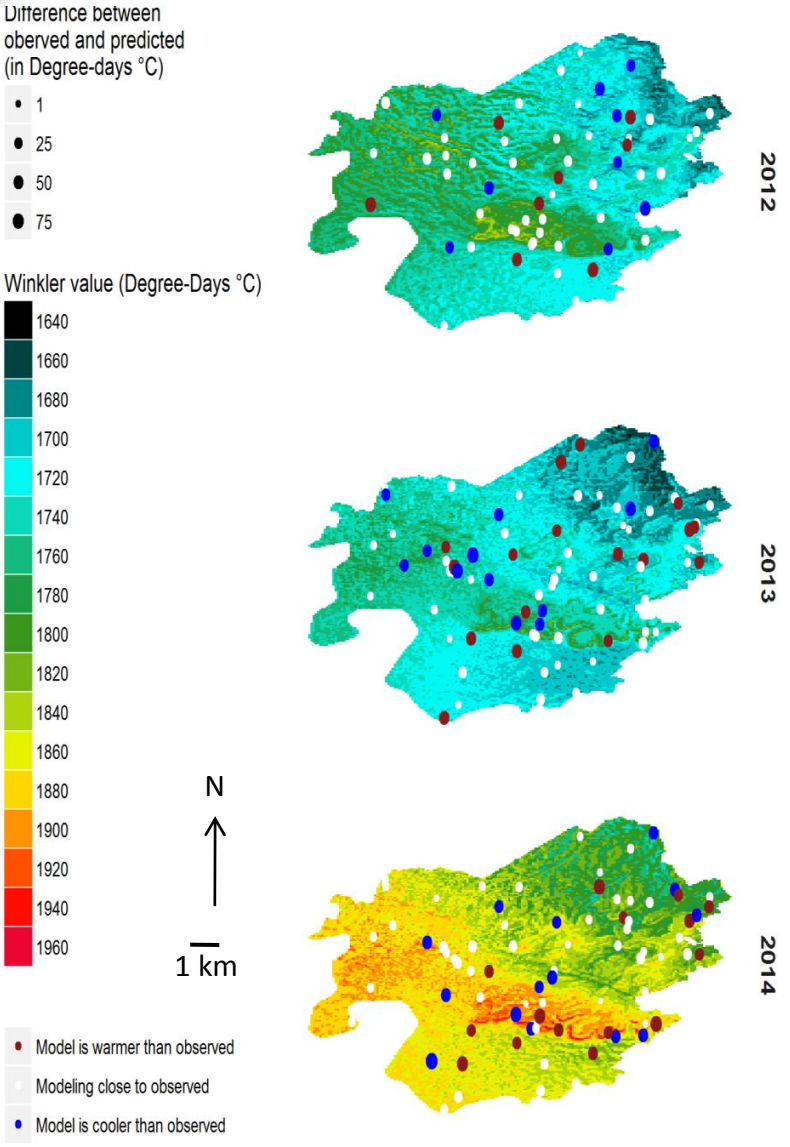
- Using data from the data loggers, a statistical model was set up to evaluate local temperature variability over the study sites
- Maps of daily temperatures were produced (Tmin, Tmax)
- Bioclimatic indices were computed and mapped (Huglin, Winkler)
- Variability of these indexes is compared to regional scale analysis from a regional model (WRF) at 3 km resolution

Results and Discussion

- Winkler index mapping using statistical modeling (Support vector Regression)

- Variability of Winkler index range is important in spatial and temporal aspect (millesime effect)

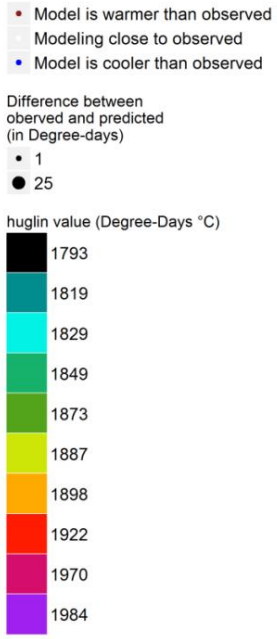
	2012	2013	2014
Model/Indexes	SVR	SVR	SVR
RMSE (degree-day)	32.59	33.11	34.93
MAE (degree-day)	25.37	25.37	28.59
RMSE-MAE	7.22	7.74	6.34
Coeff. of correlation	0.91	0.84	0.84

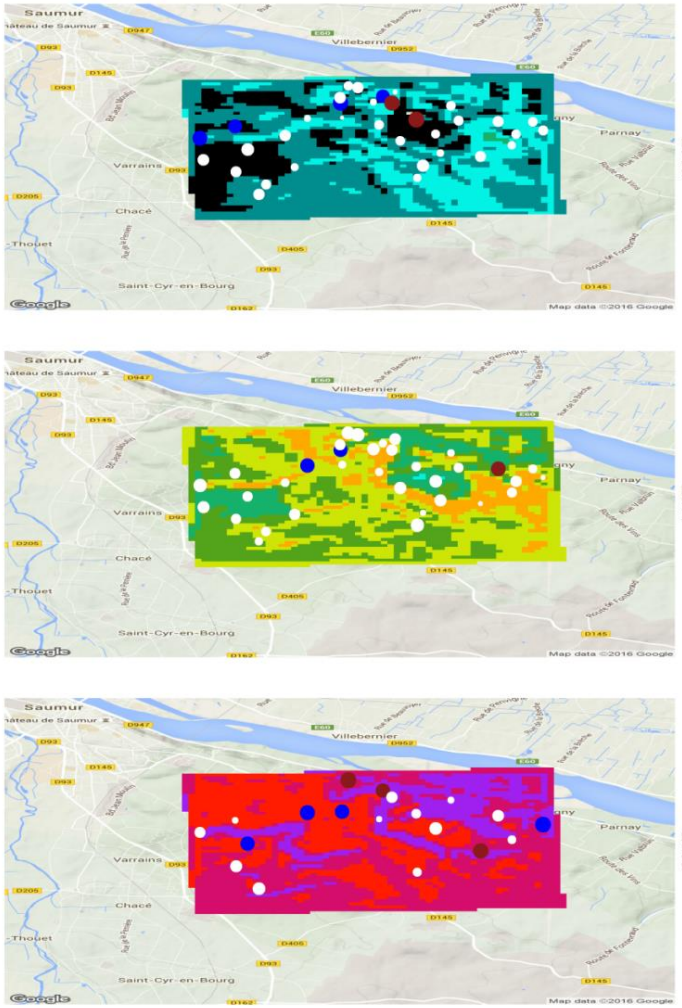


Results and Discussion

- Huglin index mapping using statistical modeling (Support vector Regression)
- SVR modeling seems to be able to produce accurate results on a smaller site under a different regional climate

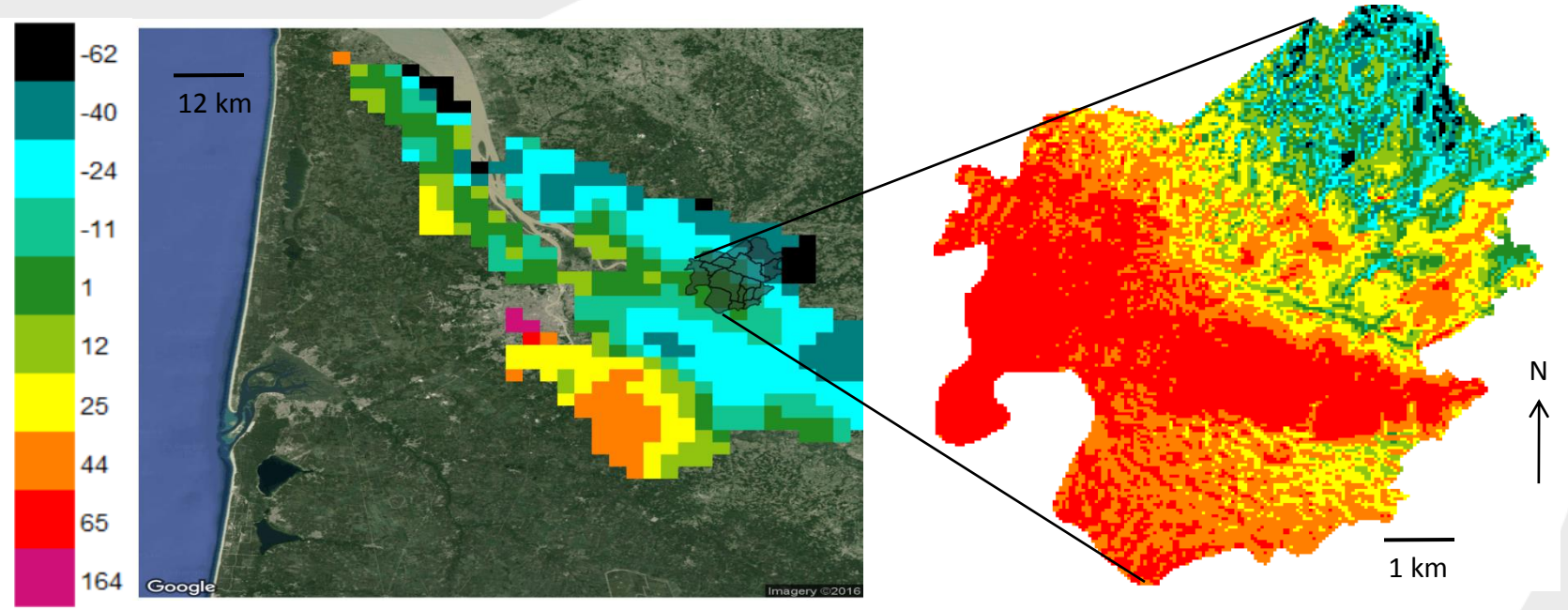
	2013	2014	2015
Model/Indexes	SVR	SVR	SVR
RMSE (degree -days)	20,09	18,61	26,92
MAE (degree -days)	15,92	15,71	22,57
RMSE - MAE	4,17	2,90	4,35
Coeff. of correlation	0,84	0,91	0,94





Results and Discussion

- Variability of temperature between regional and local scales

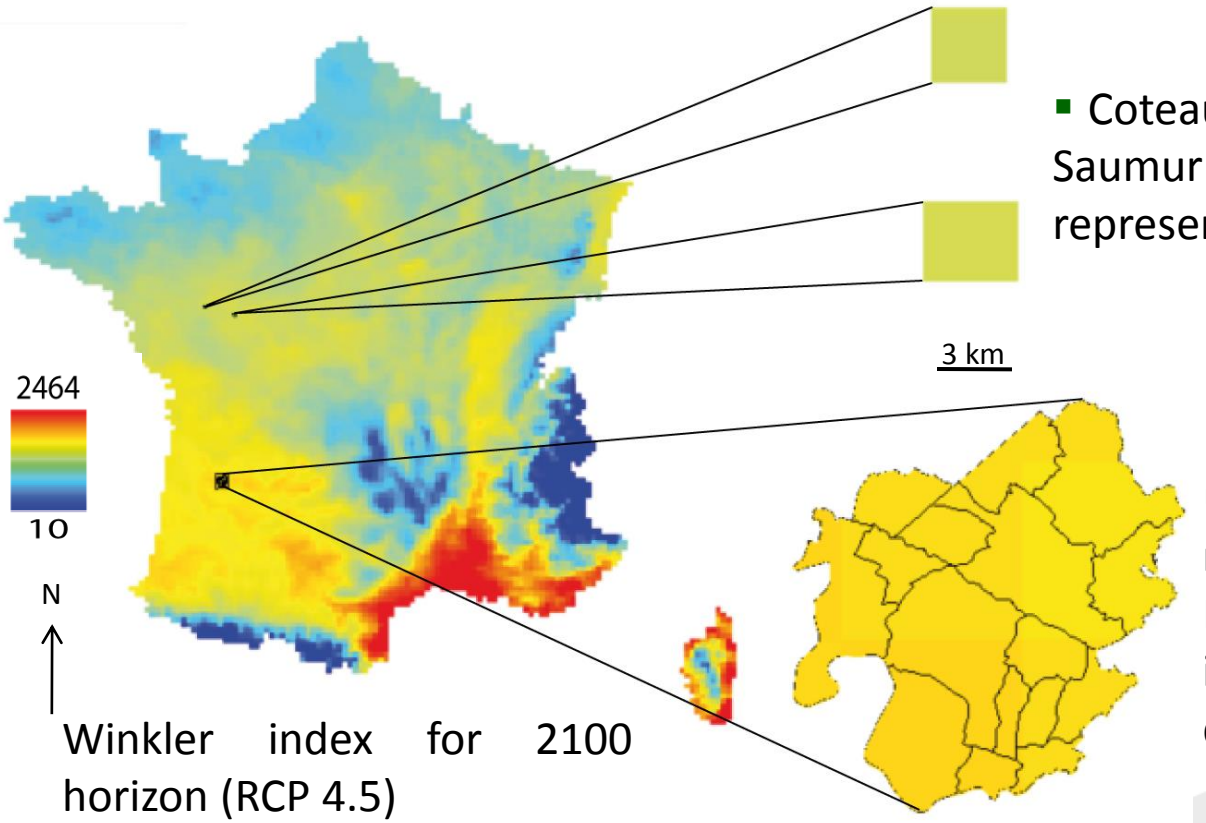


Difference from mean temperature of the Bordeaux wine growing area for Winkler index 2014 (in degree-day)

- Winkler Index variability could could be similar in magnitude at regional and at local scale
- Although WRF reproduced the regional climate well, it was not able to accurately represent the local temperature variability of the Saint-Emilion area (at 1 km)

Summary and Conclusions

- Future climate projections at the local scale
  - Global climate prediction models do not accurately reproduce the local varibility of temperatures



Winkler index for 2100 horizon (RCP 4.5)

- Coteaux du layon site and Saumur Champigny site are only represented by one grid point
- Only 4 grid points represent the Libournais-Est area with a Winkler index range of 50 degree-days

Data : DRIAS

Summary and Conclusions

Conclusions

- The climate of a viticultural terroir is the result of interaction between different climatic scales
- Dynamical models such as WRF are good tools to evaluate regional climate
- Statistical models allow the taking account of local temperature variability
- For now, climate prediction models are not capable of representing future vineyard climates

Summary and Conclusions

Perspectives

- Understanding the relationship between climatic scales is essential to understanding local climate evolution in the future.
- Dowsncaling of dynamical model output is a way to investigate local climate from the regional scale
- Investigating the effect of weather patterns across different scales helps to improve understanding of the impact of synoptic situations at the vineyard scale
- Adapting future scenarios of climate change to the vineyard scale should allow mitigation of impacts of climate change on the wine industry

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Thank you all for your attention

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