SECLI FIRM

RSE Ricerca Sistema Energetico

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Forecasting electricity demand in the short-term and prospective extension at seasonal scale

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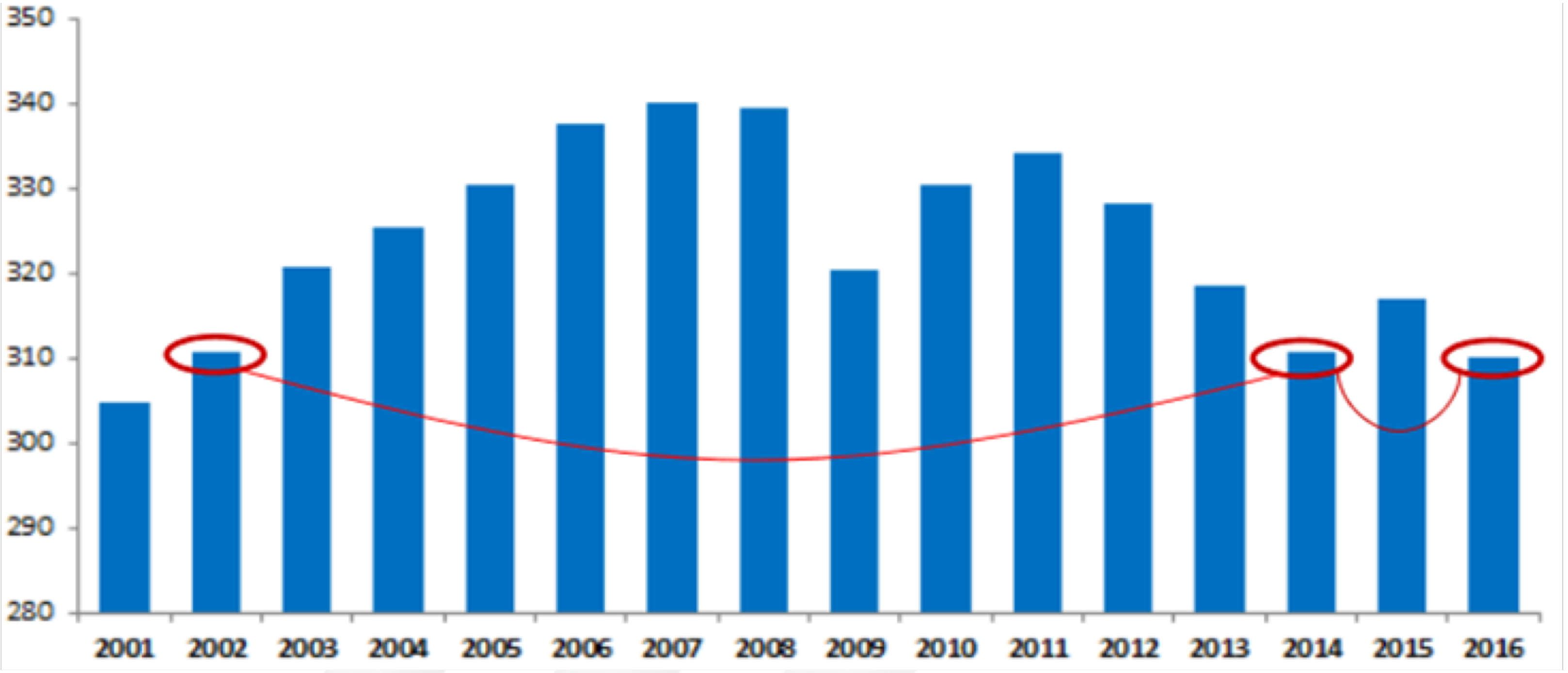
Introduction

- Predicting the electrical load is essential for daily operation and planning activities of power network operators (grid stability, energy market etc.)
- The electrical load strongly depends on the weather conditions (e.g., high demand for cooling in summer)
- Weather forecasts can be used to link relevant weather variables with the electrical load using statistical post-processing methods
- A short-term probabilistic forecast system for electricity demand is developed to generate day-ahead probabilistic load forecasts
- Long-term degree-days projections are elaborated to provide information useful in planning electro/energetic system
- Prospective extension of short-term application at seasonal scale

Electricity demand in Italy

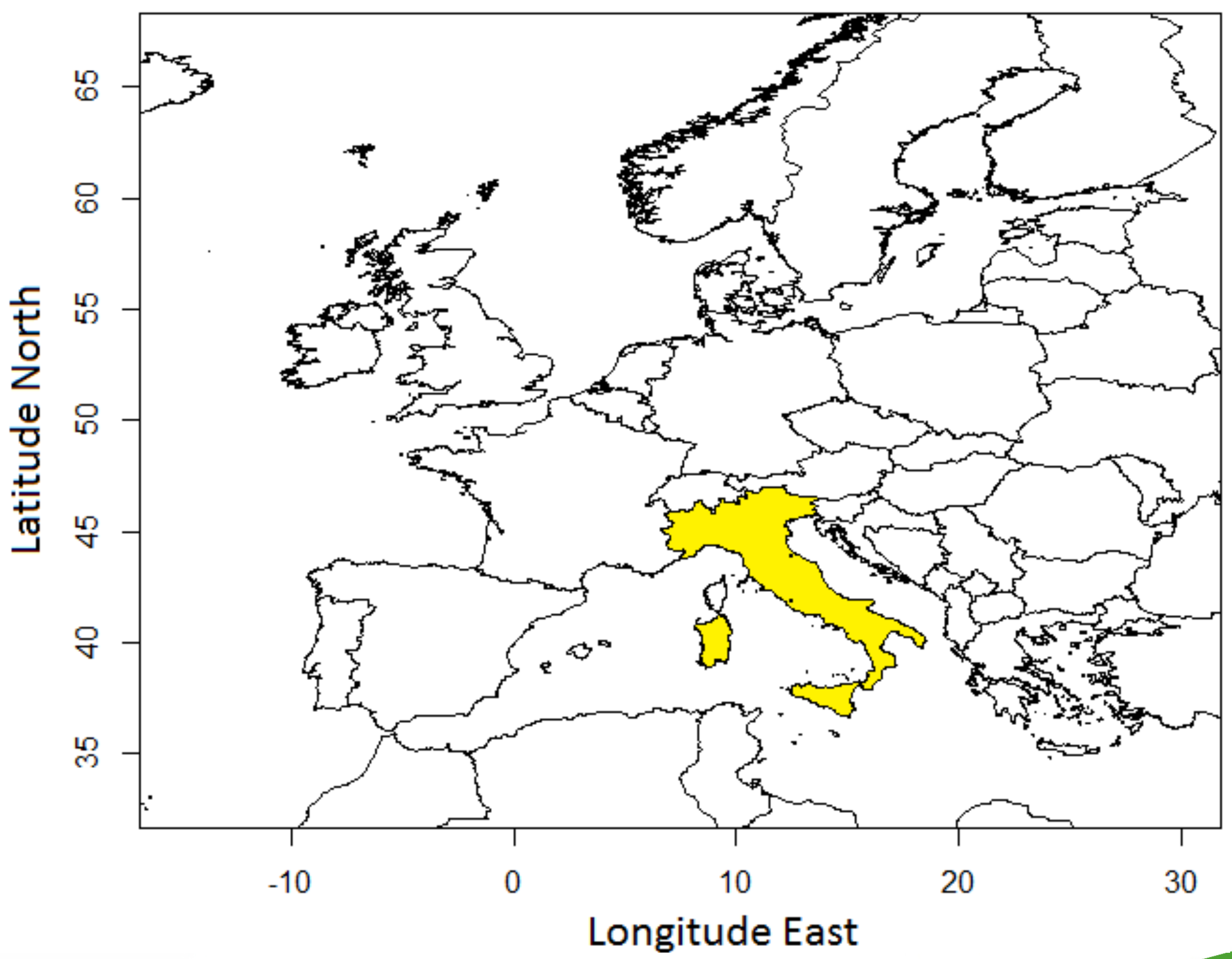


A2A, 2017

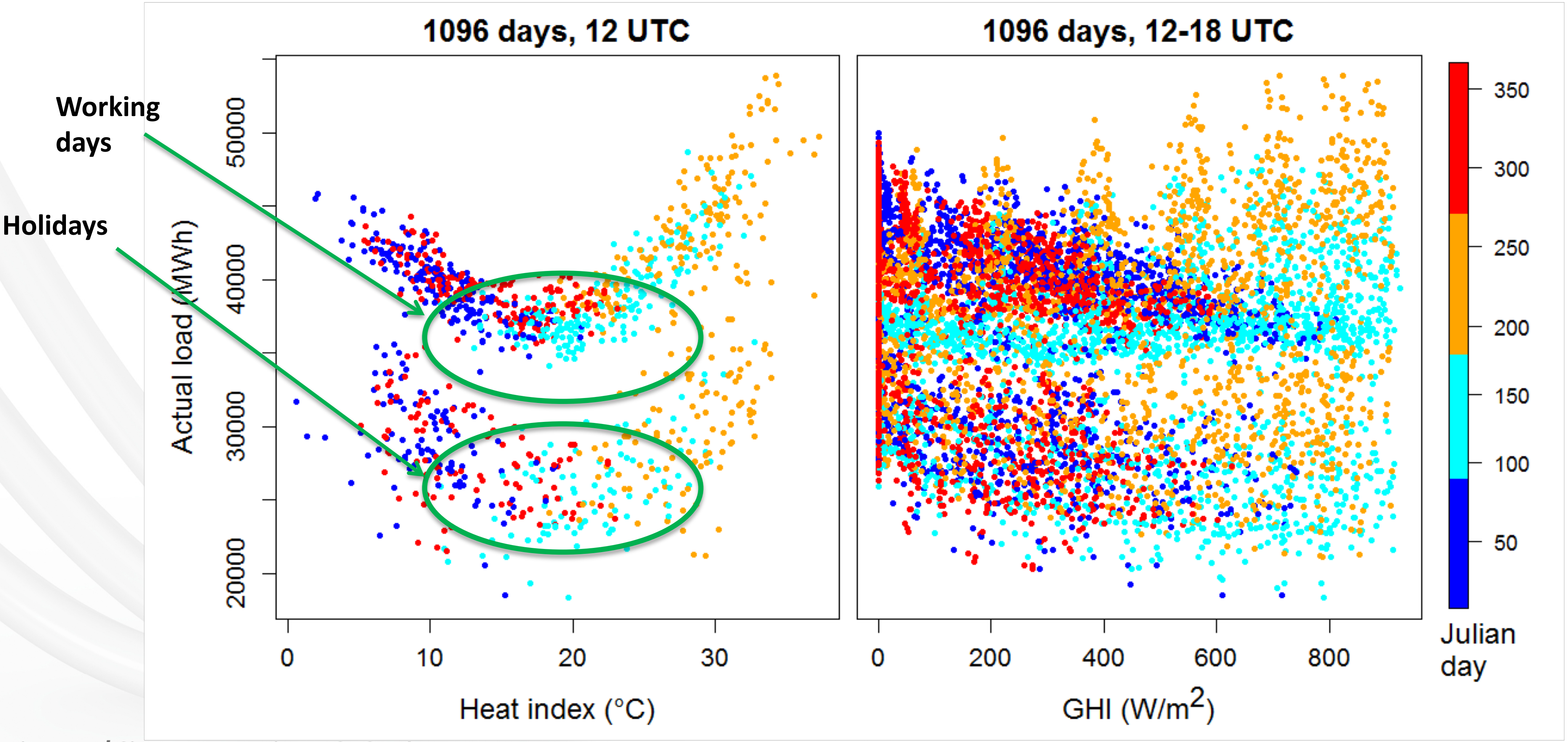
- 2015: +2% over 2014 (hot summer)
- 2014, 2016 lowest since 2002
- 2017 = ~ 320 TWh (again +2%)
- January – September 2018: 242 TWh (+0.6%)

Data and geographical reference area

- Hourly Actual Load (AL) data, i.e., the production units' injections of power into the grid, including grid losses. Imports are not included
- Period: 2015-2017
- Weather forecasts: WRF-ARW 3.9, 4 km horizontal resolution, 12 UTC, +84 h
- Weather variables averaged by municipality and then aggregated at national level



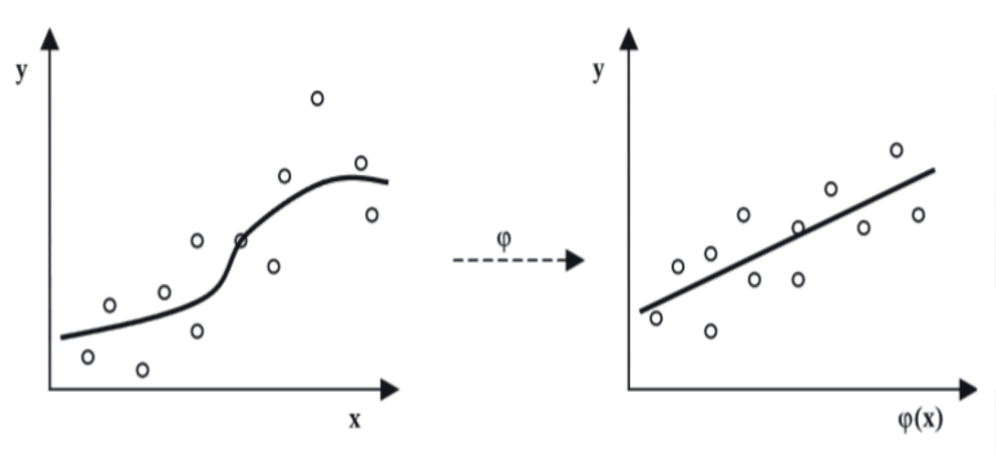
Electricity demand and relationship with meteorology



Post-processing algorithms

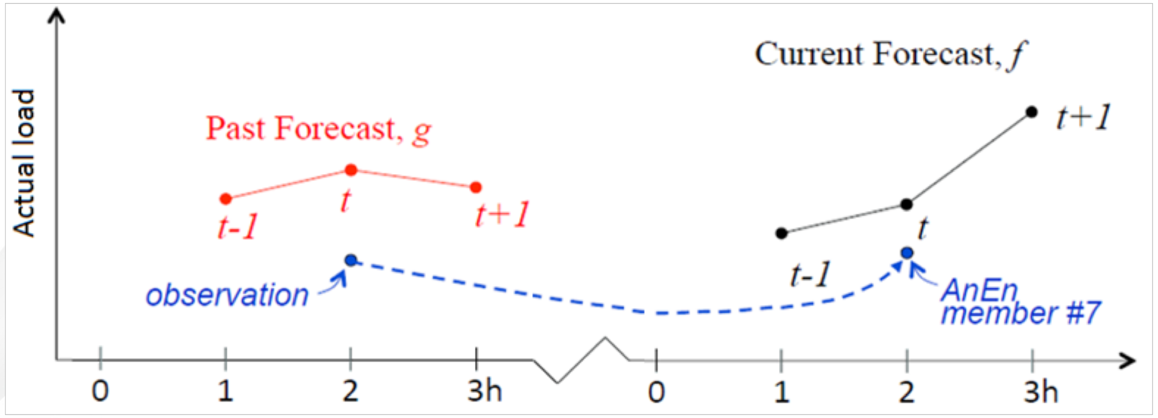
- Support Vector Regression (SVR)

Machine-learning tool that uses a kernel function (e.g., RBF) to transform the data into a feature space where a non-linear problem can be solved linearly.



- Analog Ensemble (AnEn)

After finding the n strongest analogs, each of the n AnEn members is taken as the verifying observation from each analog.



Delle Monache et al., 2013

Hourly Electrical Load Prediction with MEteorology

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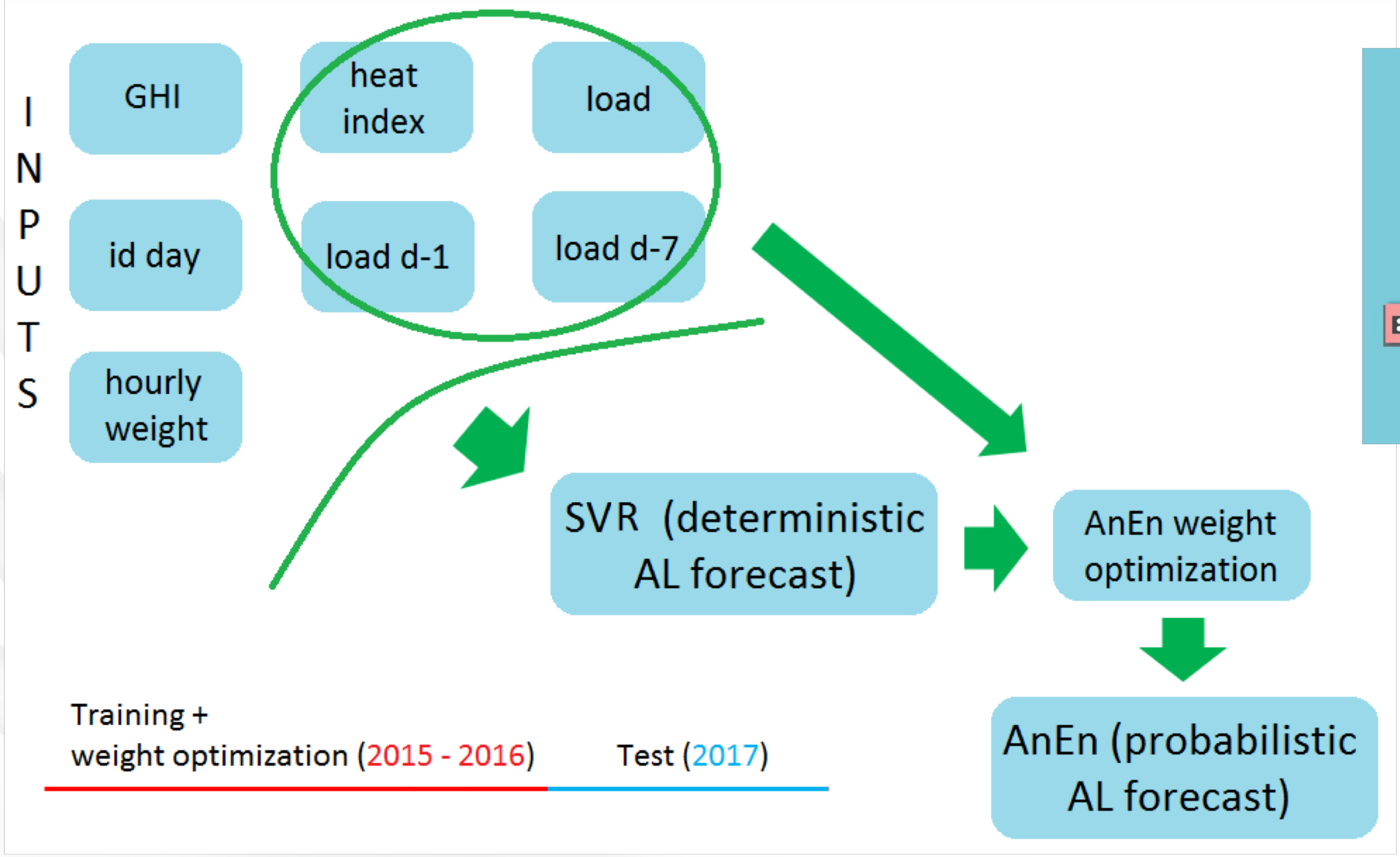
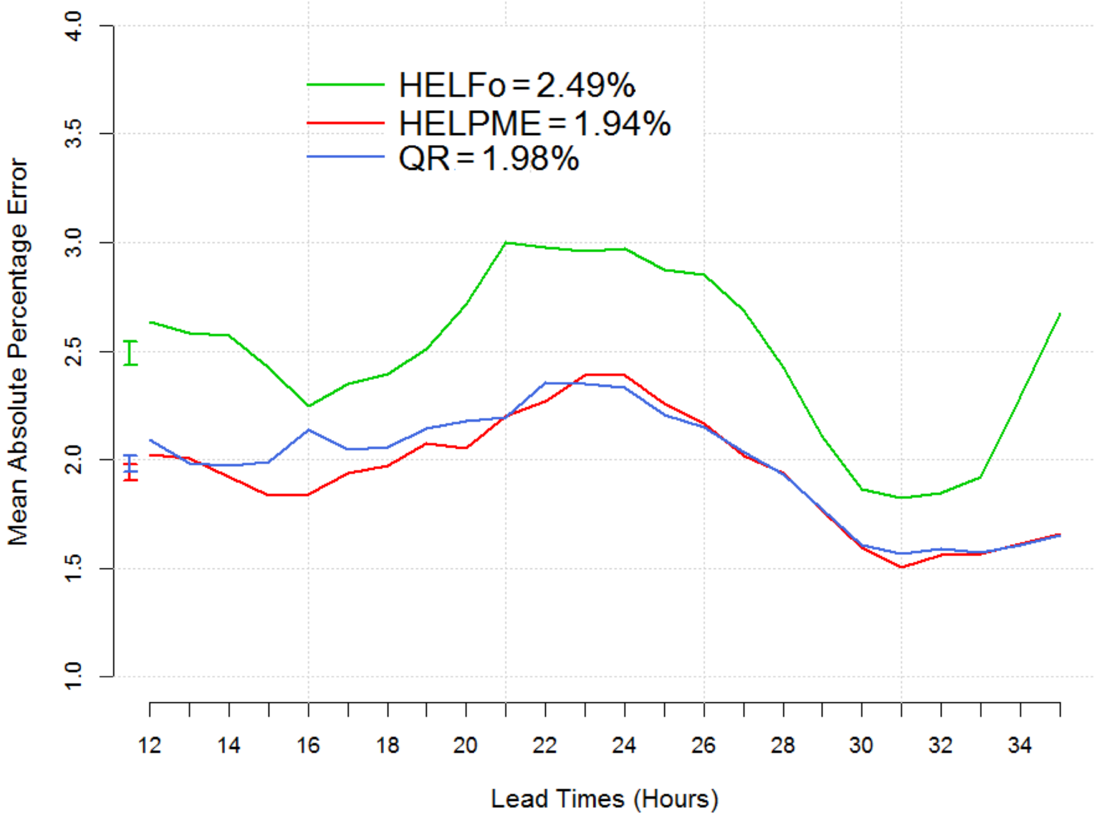


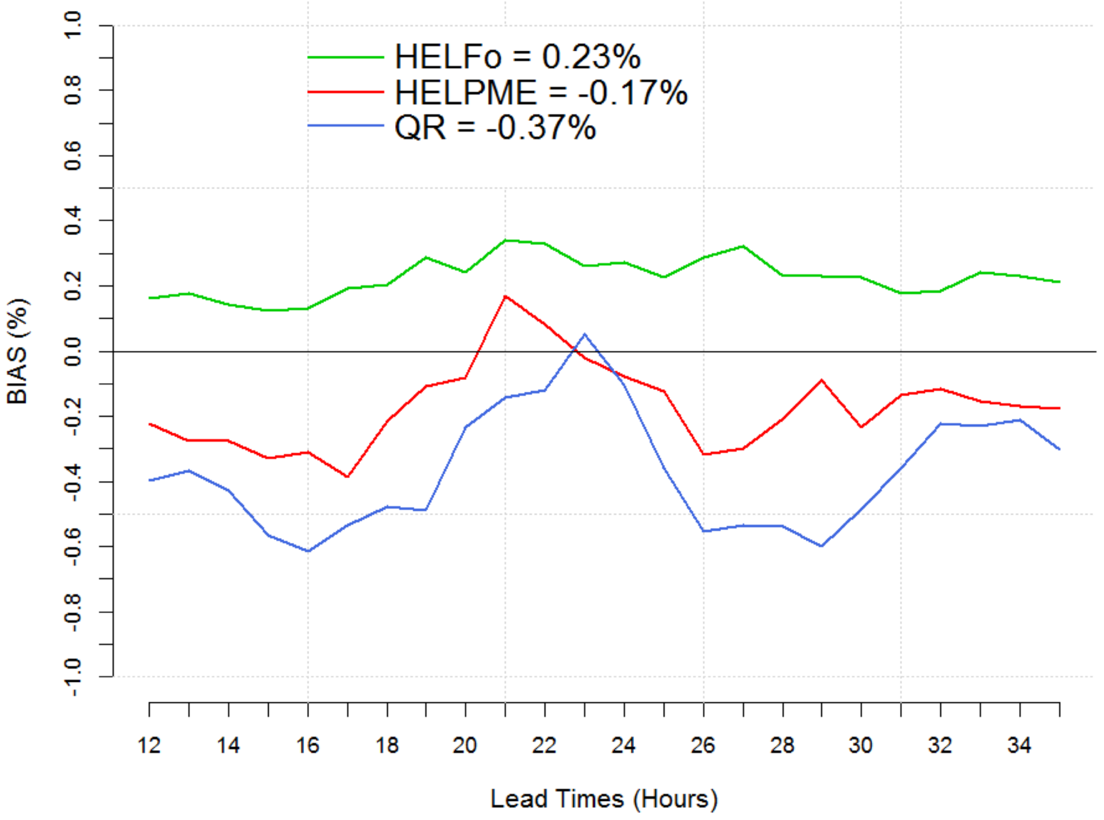
(10-member distribution)

Forecast verification: deterministic metrics

$$MAPE = 100 \cdot \left\langle \frac{|obs - forecast|}{obs} \right\rangle$$

$$BIAS = \langle forec \rangle - \langle obs \rangle$$

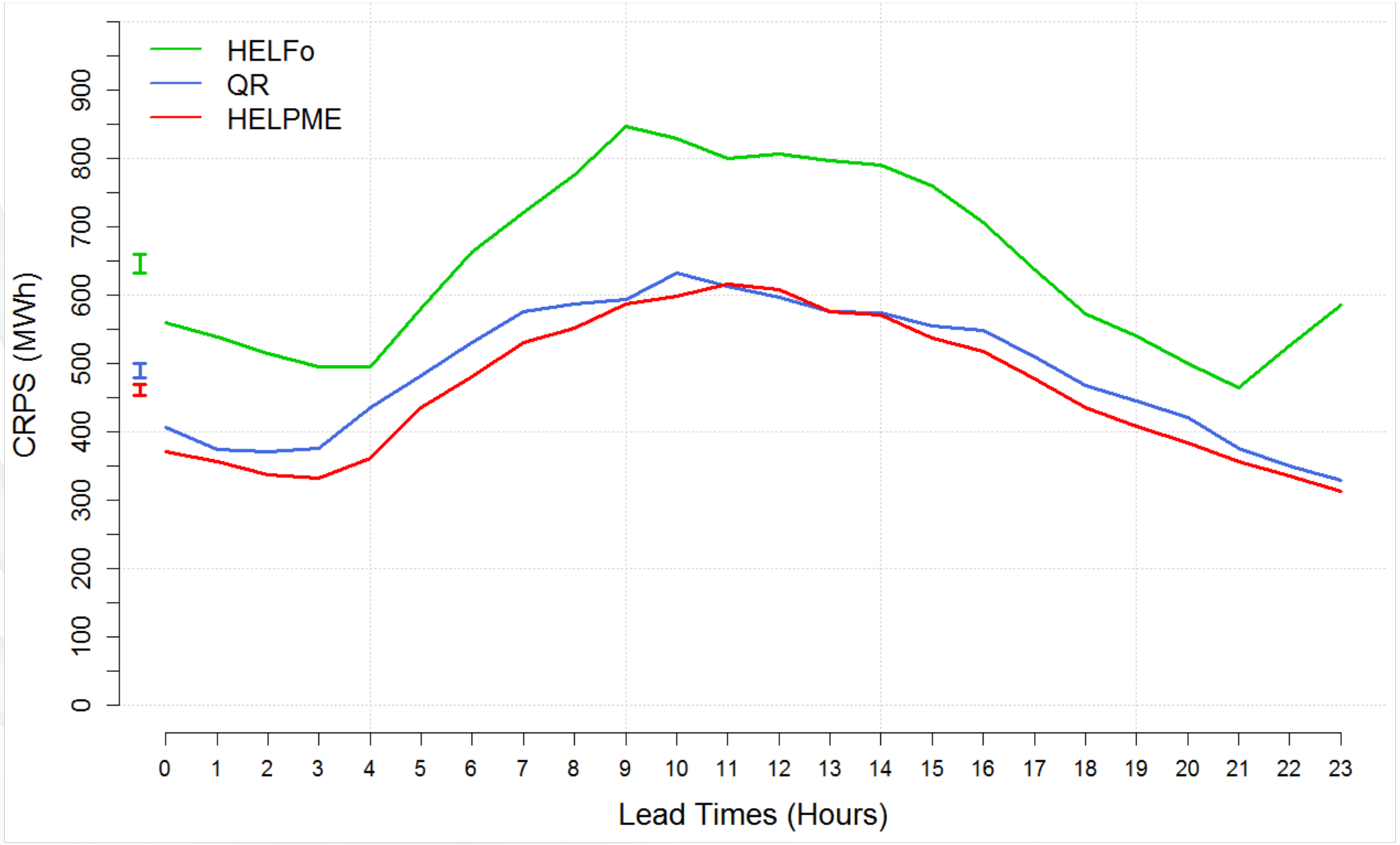




Quantile **R**egression (QR, Bremnes, 2004)

Hourly **E**lectrical **L**oad **Fo**recasting (HELFo, Apadula et al., 2018)

Forecast verification: probabilistic metrics



$$CRPS = \frac{1}{N}\sum_{i=1}^{N}\int_{-\infty}^{\infty}(F_i^f(x) - F_i^a(x))^2\,dx$$

Compares a full probabilistic distribution with the observations, when both are expressed as CDF

~ MAE

Extension to longer time scales

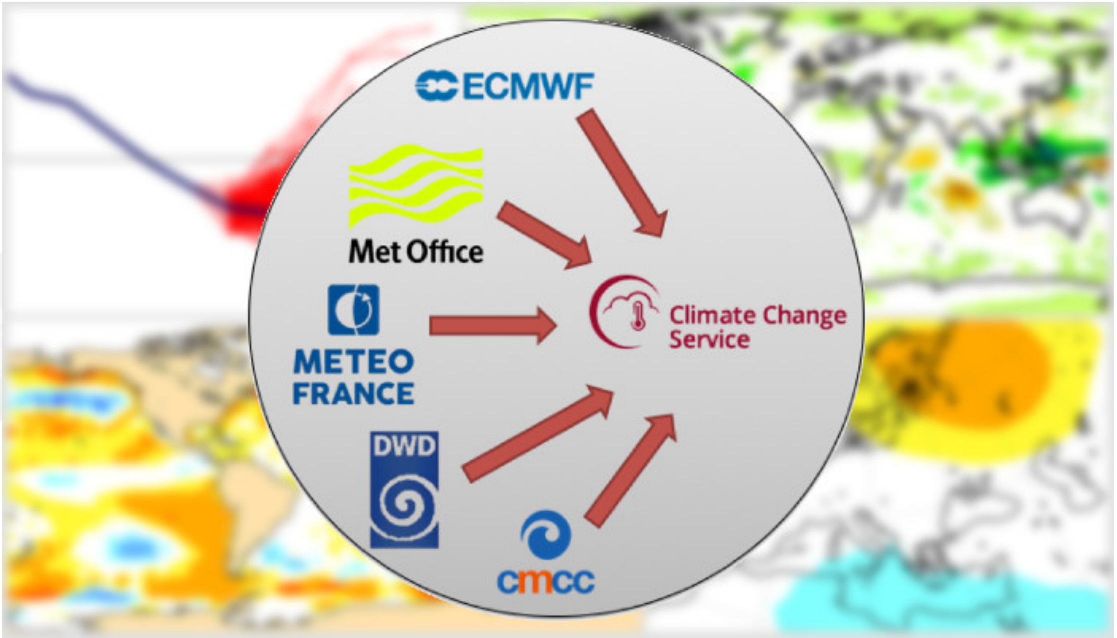
- Beyond a few days, the chaotic nature of the atmosphere limits the possibility to predict precise changes at local scales → long-range forecasts of atmospheric conditions have large uncertainties.
- Long term predictions rely on aspects of Earth system variability which have long time scales (months to years) and are, to a certain extent, predictable (e.g., El Nino Southern Oscillation cycle).
- Like the medium and extended ranges, long range forecasts are produced by the IFS coupled ocean-atmosphere model.
- E.g., the ocean temperatures typically vary on timescales of weeks/months, with an impact on the overlaying atmosphere. This can modify both local and remote atmospheric conditions.

C3S, Copernicus Climate Change Service

Seasonal forecasts

C3S multi-system seasonal forecast service

- Include data and graphical products, updated every month
- Time period: 6 months, horizontal resolution: 1°x 1°
- Forecasts created in real-time (since 2017) and retrospective forecasts (hindcasts) initialized at equivalent intervals during the period 1993-2016
- E.g., for application related to electricity demand:
  - ✓ 2m temperature (6h instantaneous)
  - ✓ Surface solar radiation downwards (24h aggregation)



Climate applications

Degree-Days - *JRC/MARS-EUROSTAT (J)*

hdd = max (T - Tm , 0)* *T* = 18°C if Tm < 15°C*

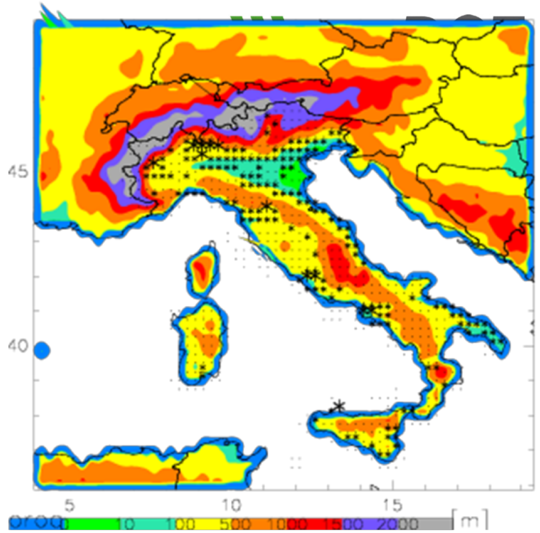
*cdd = max (Tm – T**, 0)* *T** = 21°C if Tm > 24°C*

E-OBS http://eca.knmi.nl/dailydata

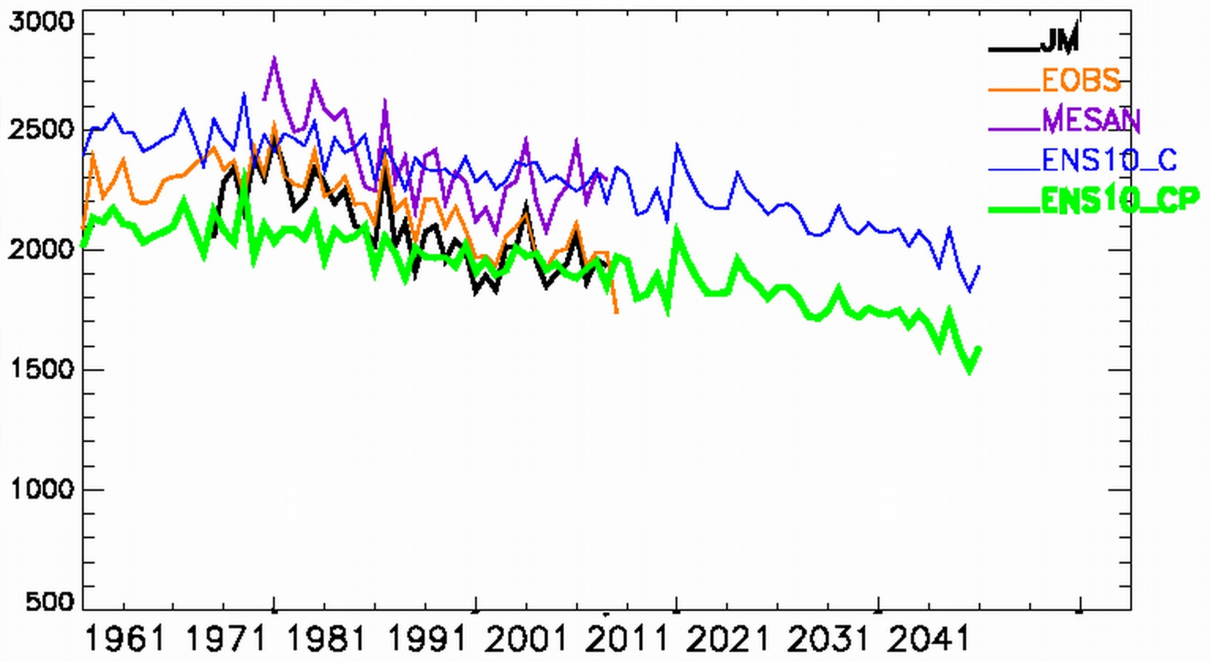
MESAN https://ecds.se/dataset

ENSEMBLES http://ensembles-eu.metoffice.com/data.htm

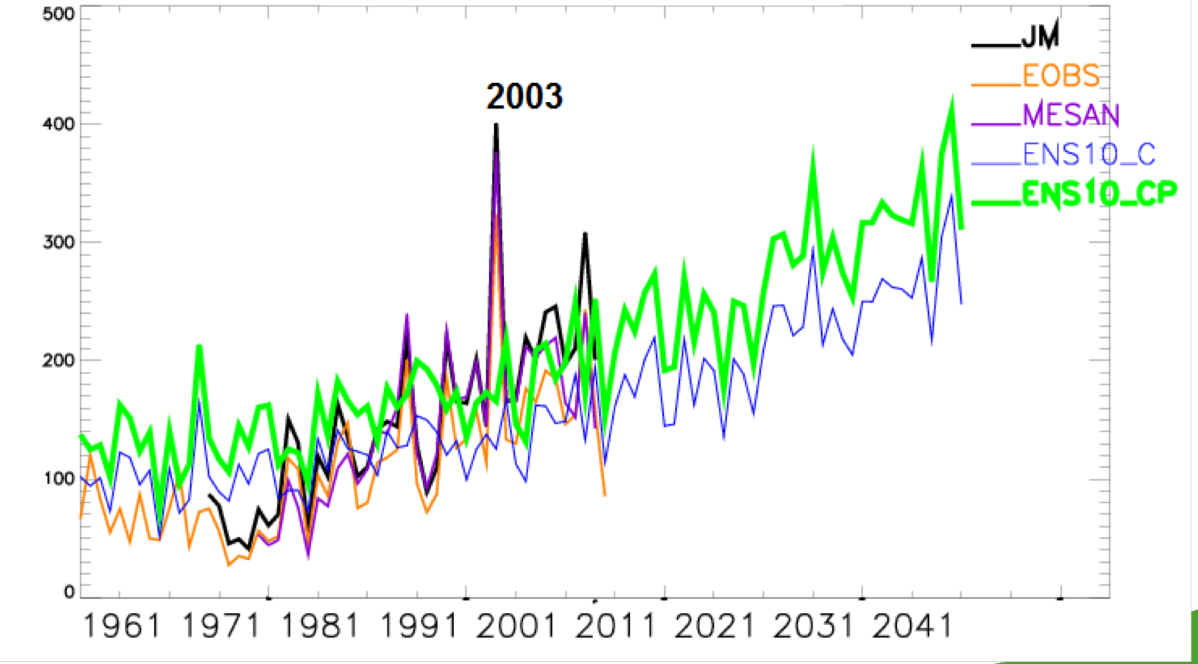
Estimating energy demand for heating and cooling buildings to assess impacts of climate change on the urban environment



Heating Degree Days



Cooling Degree Days



Conclusions

- Predicting the electrical load necessarily requires weather forecasts
- Different forecasting system have been compared on a 730-day long training period and 365-day long verification period over Italy
- The HELPME forecast system can outperform a weighted persistence method and QR
- HELPME short-term forecasts at national level soon available on sunRiSE: http://sunrise.rse-web.it
- Prospective extension at seasonal scale: test with C3S seasonal forecasts and electricity demand data (Terna)

Thanks!

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