Multimodel analysis of solar radiation over Iberian Peninsula for energy purposes

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ICRC-CORDEX, Stockholm 17-20 May 2016

SCOPE

Increase of **renewable energies** installed capacity over the world :

- **Economic** reasons to reduce external dependency on fossils fuels. Decrease in technology prices attracts investors.
- **Environmental** reasons to reduce greenhouse gas emissions and fulfill government's requirements.

Conventional electricity systems are designed for **centralized** generation and renewable energies integration presents some difficulties regarding **variability** of resources.

VARIABILITY OF RENEWABLE ENERGIES

- Renewable resources are not available at convenience: **intermittency**.
- Electricity demand and availability of resources: **not synchronised**.

Understanding spatio-temporal features of the resources is needed for **management of the electricity system**.

IBERIAN PENINSULA

Photovoltaic (PV) generation

- Singular area: great variety of climates.
- High insolation, high potential for solar energy production.
- Regarding electric power, Iberian Peninsula is not well-connected with the rest of the continent.

DATA

RCMs and satellite data

RCMs are needed to analyse future trends and projections of climate change.

Two **RCMs** are validated against **CM-SAF** (Climate Monitoring Satellite Application Facility) data:

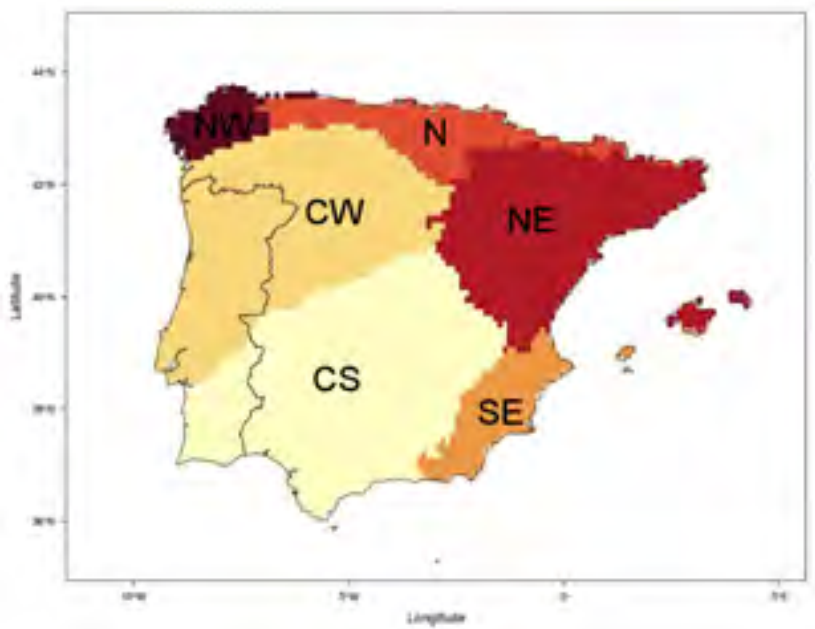
- Period: 1989-2008 daily irradiation data (forced by ERA-INTERIM)
- Spatial Resolution: CORDEX EUR-11 (12.5 km)
- RCMs:
  - ALADIN
  - PROMES

CLUSTERING

kmeans algorithm

Clustering provides a regionalization of the data. Each cluster of the optimal partition has the similar time evolution of the variable analized.

- **PCA** to reduce dimensionality.
- **Kmeans** algorithm
- **Optimum** number of clusters: Validity Index Calinski-Harabasz

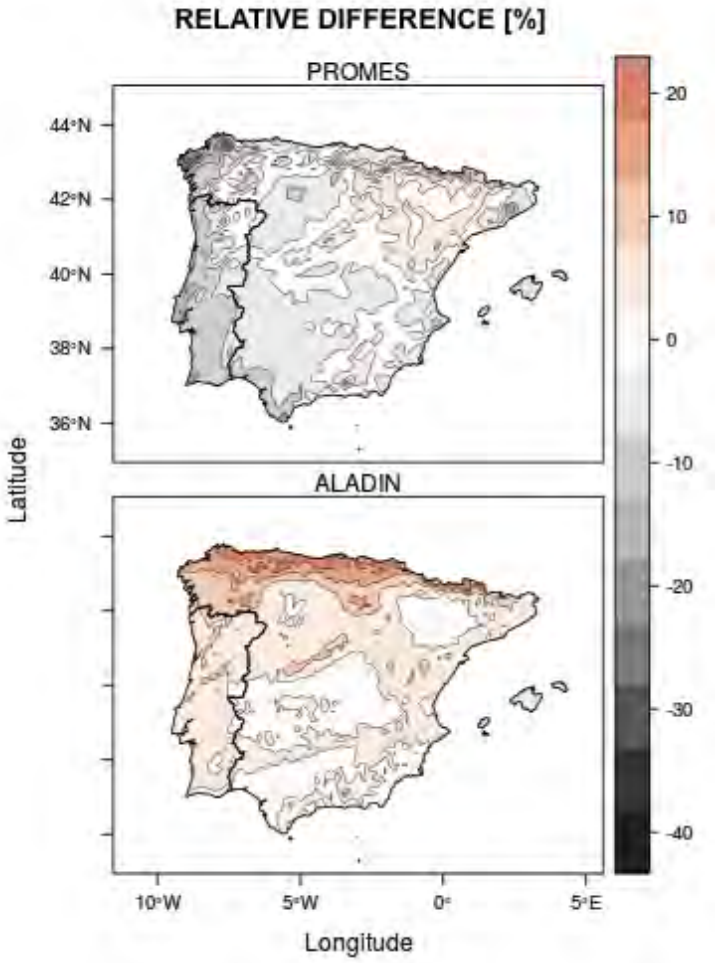


BIAS CORRECTION

quantile mapping method

RCMs can present **sistematic bias** in some variables, that could lead to a wrong interpretation. A `quantile mapping` method is applied to correct the bias

- "qmap" package in R



VARIABILITY AND COMPLEMENTARITY BETWEEN CLUSTERS

Interannual variability

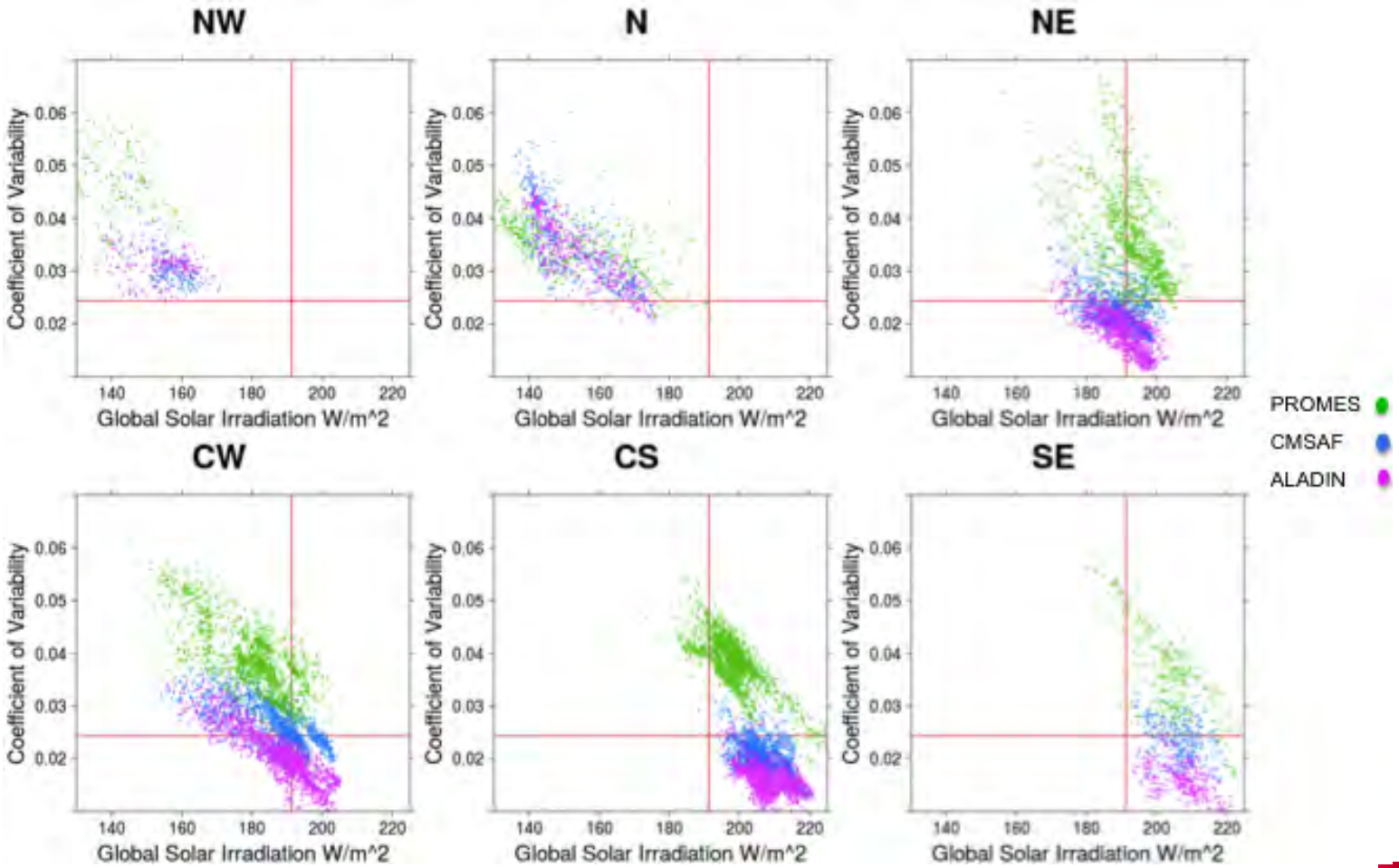
We assess the variability of the solar resource on an interannual scale with the **coefficient of variability**:

- Interannual variability of **annual mean** of daily irradiation
- Interannual variability of **monthly mean** of daily irradiation

We look for complementarity between zones with the **correlation coefficient** of monthly time series.

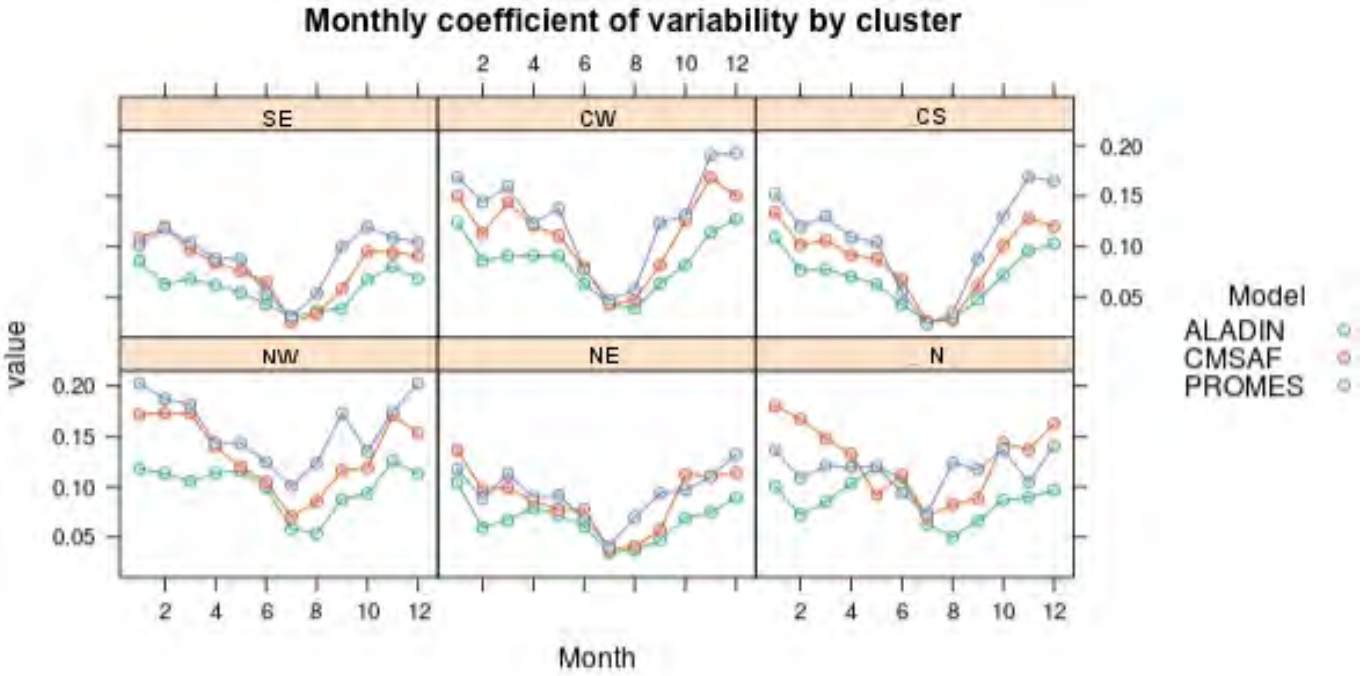
Interannual variability and solar resource

Comparing models and satellite data



Interannual variability of monthly mean daily irradiation

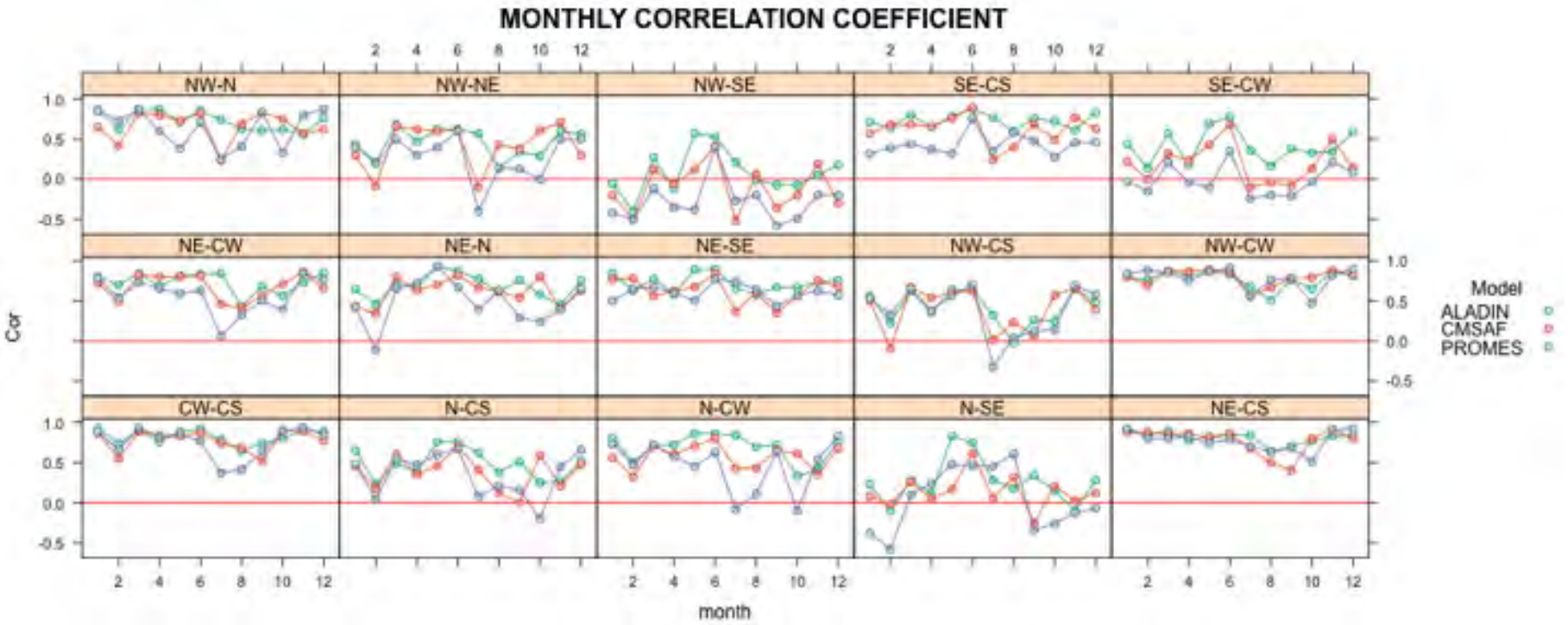
Comparing models and satellite data



- Eastern area shows smaller difference between winter and summer.
- Higher CV in western area.
- N: both models show less CV than CMSAF.

COMPLEMENTARITY BETWEEN CLUSTERS

annual cycle of correlation coefficient of monthly time series



COMPLEMENTARITY BETWEEN CLUSTERS

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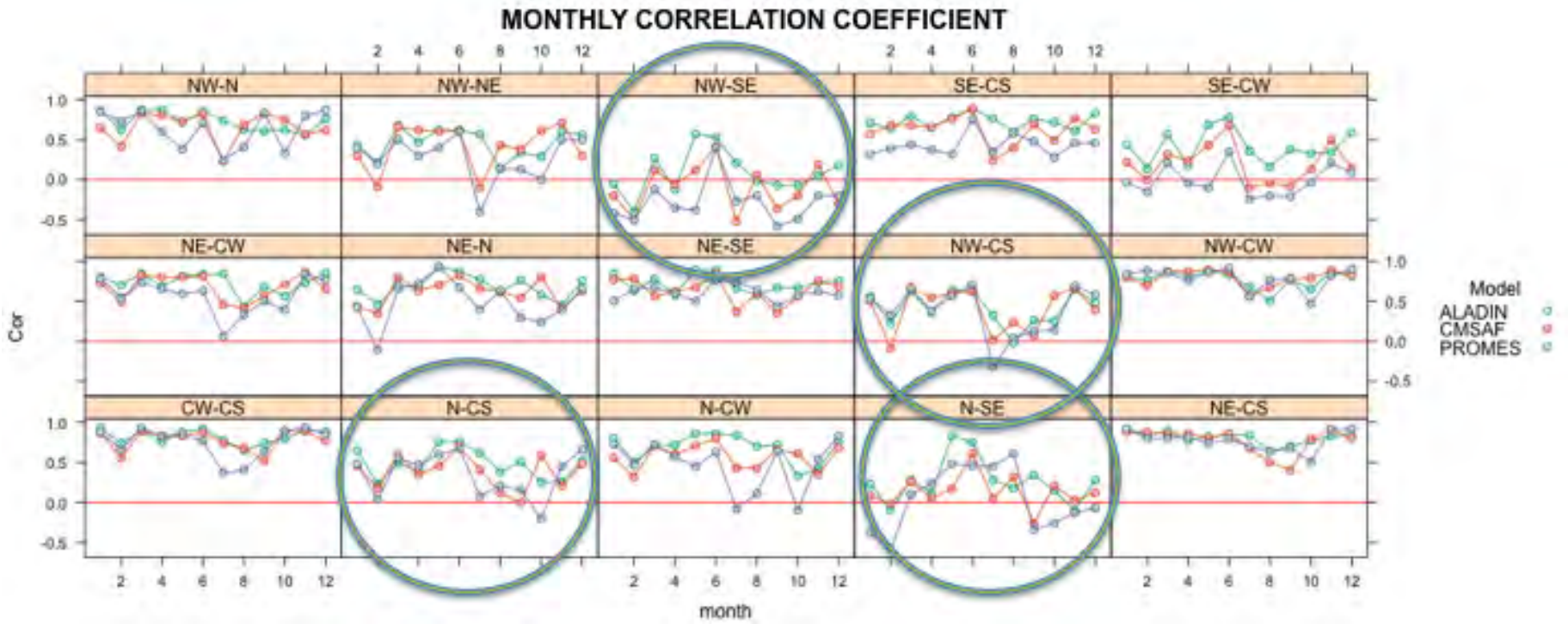
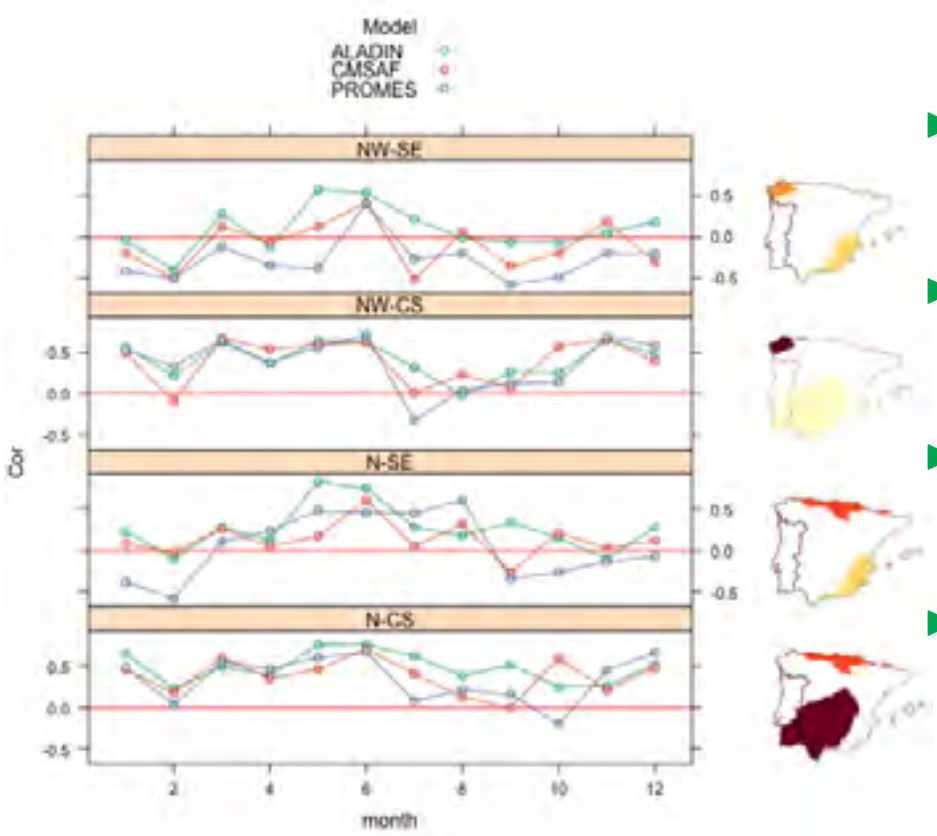


COMPLEMENTARITY BETWEEN CLUSTERS

annual cycle of correlation coefficient of monthly time series



- **NW-SE**: negative correlation in Feb. and July.
- **NW-CS**: positive correlation to no correlation.
- **N-SE**: negative correlation in September.
- **N-CS**: First half of the year positive, decrease for the second half.

ENERGY PRODUCTION

PV productivity

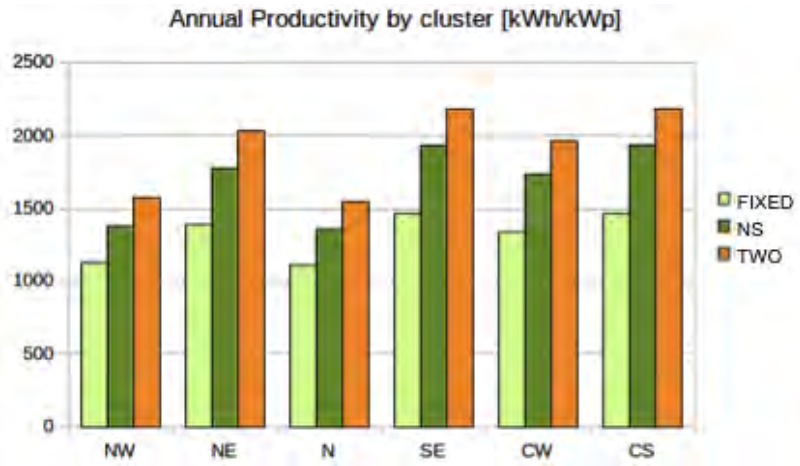
Variability of solar irradiation means **variability** of photovoltaic **energy production**.

Assessment of annual mean **productivity of PV** technology (kWh/kWp) at the domain.

- **Global effective irradiation**, irradiation on the inclined plane of solar generator, and including some losses.
- Productivity is calculated considering the **'tracking system'** of the PV modules.
- R software package is used to do the calculations: `solaR`

Annual mean PVout

Differences between tracking systems and cluster



- Two axis trackers give higher productivity at each area.
- **CS** shows higher difference between fixed and two axis tracking system.
- Productivity increases 45% in this area because of the tracking system.

Summary

- Variability of solar irradiation is higher in western half and north regions of the Iberian Peninsula and in winter season.
- Relationships between clusters show certain grade of complementarity in some areas.
- Differences between the two RCMs ilustrates the interest of using a multimodel ensemble.
- The differences on PV productivity for each tracking system show the importance of taking this into account.

Further work

- Add more RCMs to the analysis.
- Deeper study of cluster's complementarity.
- Analyze future projections to understand solar resource variability trends.

Thank you for your attention