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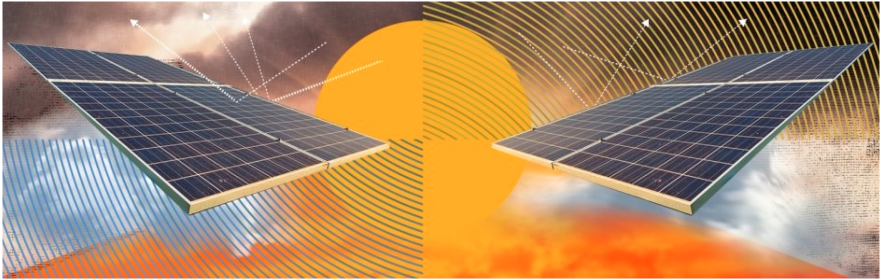

Impacts of climate intervention/geoengineering by stratospheric sulfate injection on solar power in Spain

J. A. AÑEL, S. BAYO-BESTEIRO, J. C. ANTUÑA-MARRERO, L. DE LA TORRE – ICEM 2023

Funding

GOBIERNO DE ESPAÑA
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

Financiado por la Unión Europea
NextGenerationEU

Plan de Recuperación, Transformación y Resiliencia

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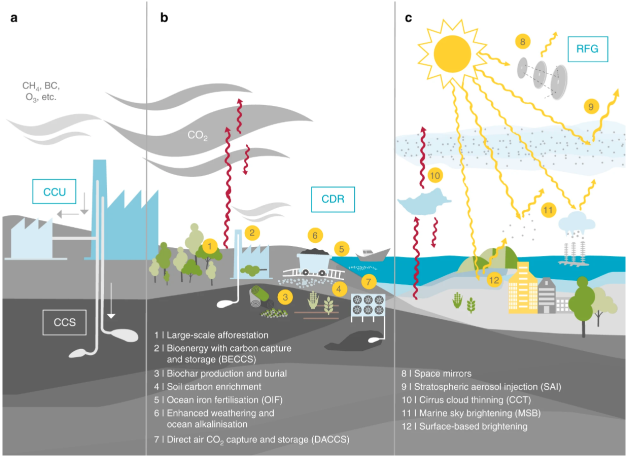
THE STATE UNIVERSITY OF NEW JERSEY



Lawrence et al. (2018) Nat. Commun.

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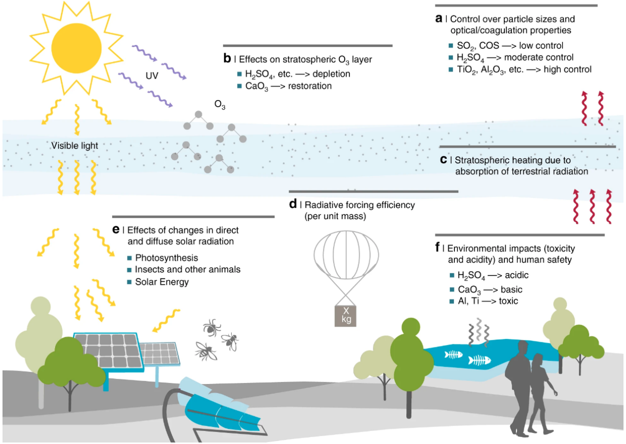
- SAI is about decreasing solar radiation coming into the troposphere.
- Therefore, SAI could be a risk for solar power production and energy security.
- Despite it, little work has been done on this.



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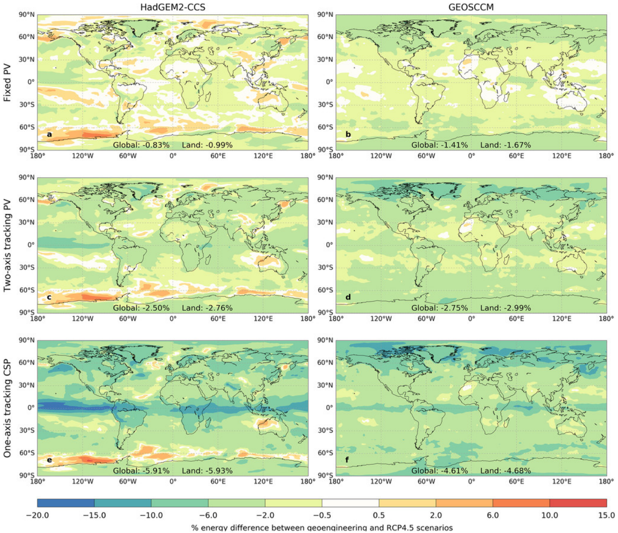
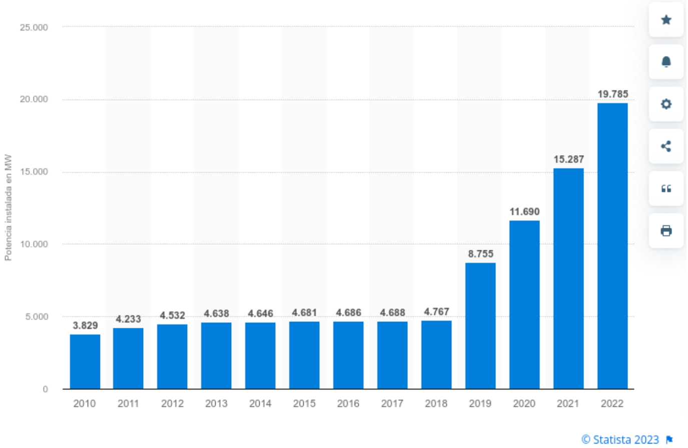
2040-2059 SAI vs 1980-2005
RCP4.5 + SAI (10 Tg/year (left) and 5 Tg/year (right)) at tropics



Smith et al. (2017) J. Appl. Meteorol. Climatol.

What does it mean for Spain and who cares?

Motivation



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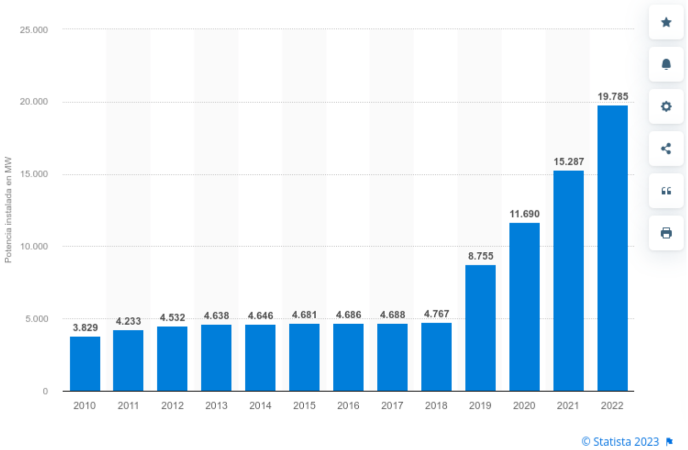

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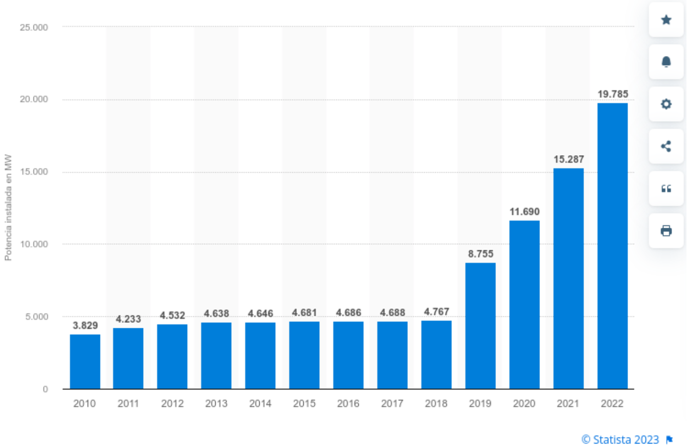

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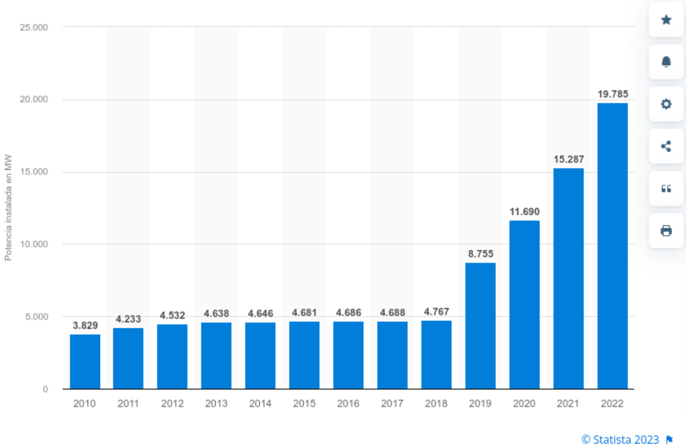

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- **Socioeconomical:**
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  - SAI could impact future ability to export energy, electricity and green hydrogen.
- **Scientific/gaps:**
  - Little previous research on the topic (one paper, few models, one member...).
  - Previous work is global, not regional.
  - Information available only up to 2050.
  - Low top models.
  - RCP4.5 scenario.
  - 1 single point injection.
  - PV output reported with assumptions, not the resource.
  - Comparisons to a world that is not counterfactual.

Methodology

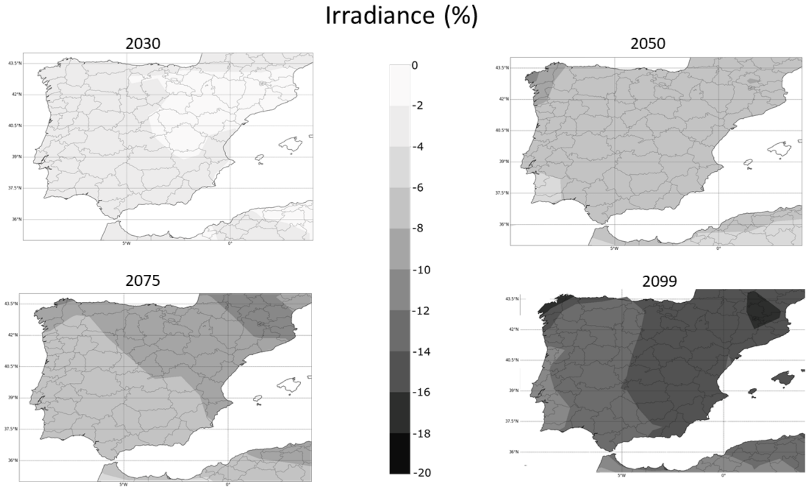
Data

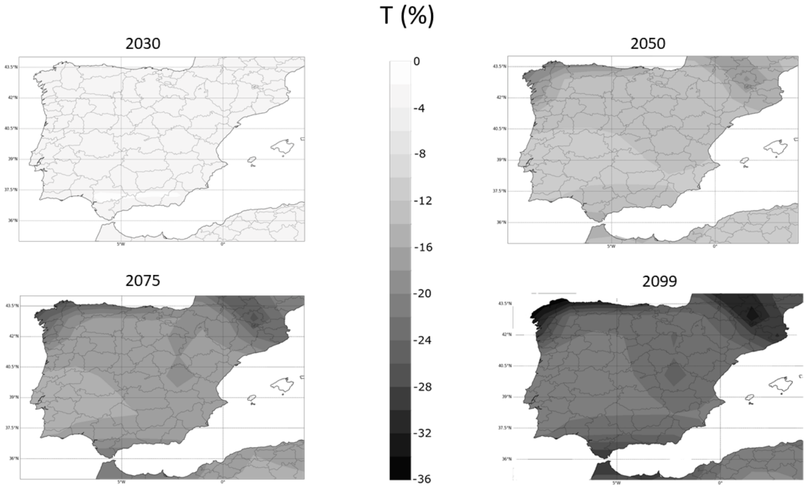
- GLENS data (Tilmes et al., 2018).
- WACCM4 - high top model.
- 21 ensemble members.
- Realistic and dynamic SAI to keep 2020 conditions.
- Maintain interhemispheric and equator-to-pole surface temperature gradients.
- RCP8.5.
- 4 points injection (15° and 30°).
- Simulations up to 2099.

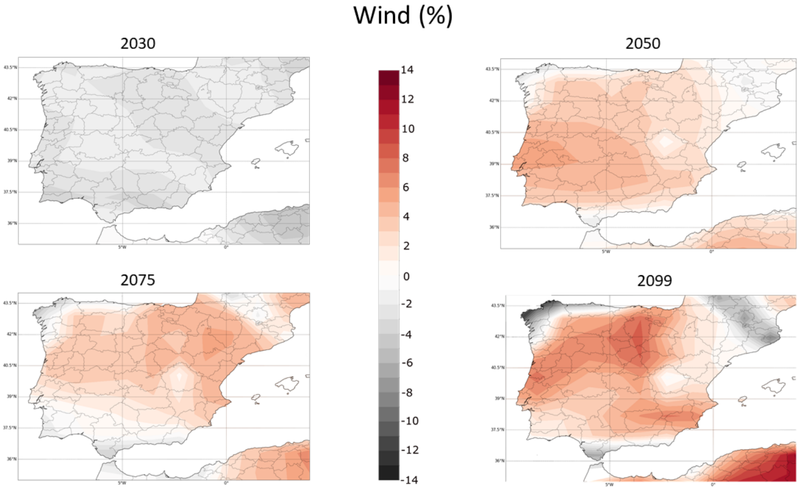
PV_{res} computation (Jerez et al., 2015)

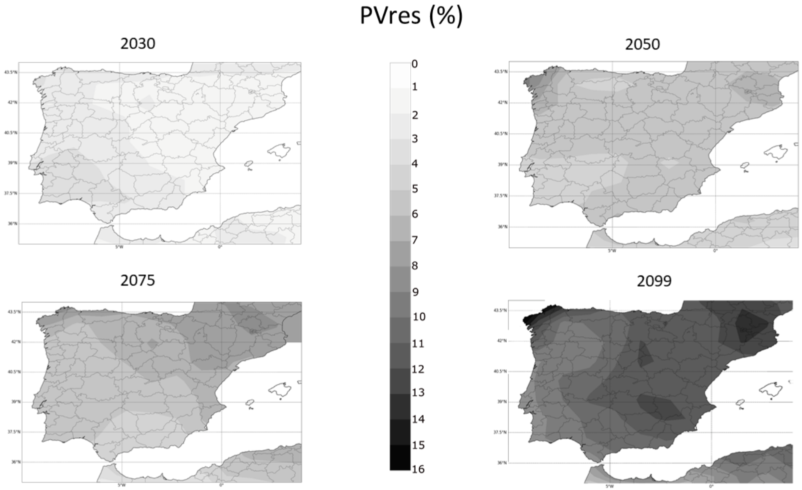
$$\text{PVpot}=\alpha_1\ \text{RSDS} + \alpha_2\ \text{RSDS}^2 + \alpha_3\ \text{RSDS} \cdot \text{TAS} + \alpha_4\ \text{RSDS} \cdot \text{scfWind}$$

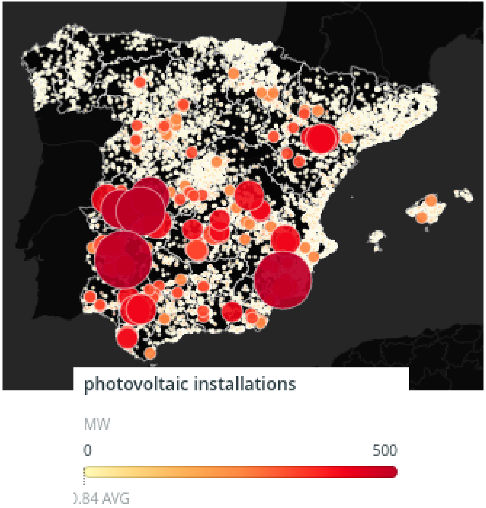
Comparing each year with its counterfactual year without SAI


Irradiance (%)
2030
2050
2075
2099
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20


T (%)
2030
2050
2075
2099
0
-4
-8
-12
-16
-20
-24
-28
-32
-36


Wind (%)
2030
2050
2075
2099
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14


PVres (%)
2030
2050
2075
2099
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


photovoltaic installations
MW
0
500
).84 AVG

Acknowledgements

Overview

Methodology

Results

Conclusions

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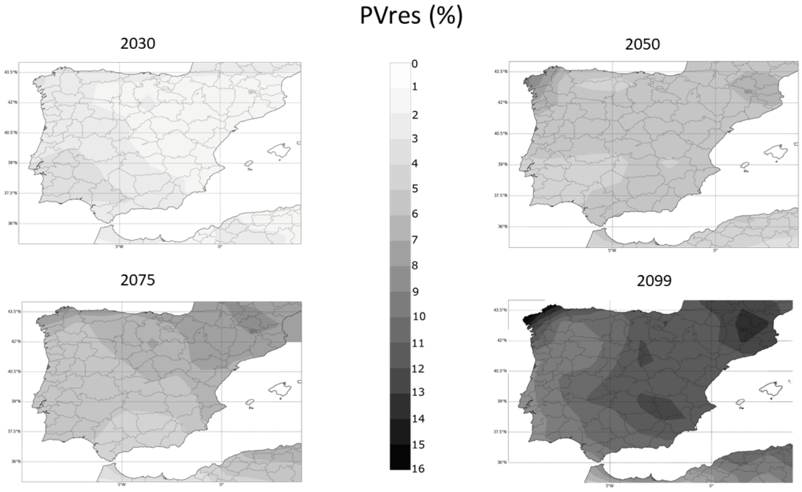

Conclusions

- Under SAI changes in irradiance continue to be the main driver for PV_{res}.
- Considerable lost happens even for the near-term (2030).
- Lost of up to 10% for the mid-term and up to 16% for the long-term.
- Eastern and Northwestern coast are the regions more affected.
- Critical locations with large PV installations are some of the ones suffering "lower" changes.