UNIVERSITAEA DE VEST DIN TIMISOARA

Instrument de prognoza a puterii PV pe termen scurt

Prezentarea rezultatelor proiectului

PN-II-P2-2.1-PED-2019-3942

All-sky imager-based solar power forecasting system for smart-grid operation

20 MAI 2022

Solar Energy Research Group

DOMENII DE CERCETARE

- Fizica transferului radiativ in atmosfera
- Estimarea si prognoza radiatiei solare
- Modelarea sistemelor PV
- Prognoza productiei de energie PV

ECHIPA

- Forta echipei izvorăște sinergic din specializarea membrilor echipei, diversitatea preocupărilor si entuziasmul tinerilor

http://solar.physics.uvt.ro

Platforma Solară

- In funcțiune din **noiembrie 2008**
- **Unica stație radiometrică din Romania** care monitorizează sistematic radiația solară pe suprafețe orientate spațial;
- 4 secunde – rata de eșantionare
- Baza de date radiometrice / PV cu una dintre cele mai mari granularitati din Europa;

Instrumentatie:

- Statia radiometrica (pyranometre Kipp and Zonen, EKO Instruments, clasa A ISO9060/2018)
- Statii meteorologice standard (Delta T si EKO)
- Standuri PV experimentale complet monitorizate
- Stand de testare a modelelor de prognoza a puterii PV complet monitorizat.
- In iunie 2022 va fi data in functiune **Platforma Solara ICAM** cu dotari la cele mai inalte standarde: all sky imager 3D, fotometru solar inscris in AERONET si spectrofotometru solar cu rezolutie 1nm.

Proiectul PN-II-P2-2.1-PED-2019-3942, ASIFOR

Titltu: All-sky imager-based solar power forecasting system for smart-grid operation

Durata: Noiembrie 2020 – Iunie 2022

Obiectiv: Dezvoltarea unui instrument pentru prognoza productiei de energie a centralelor PV la orizonturi de timp sub-orare.

Structura: Instrumentul este alcatuit din 3 module:

(1) Modulul de calcul, unde sunt implementate aplicatiile de prognoza dezvoltate in proiect si care controleaza in timp real procesul de prognoza,

(2) Modulul de monitorizare a centralei PV care furnizeaza date de putere PV, radiometrice si meteorologice masurate in-situ necesare pentru rularea aplicatiilor de prognoza,

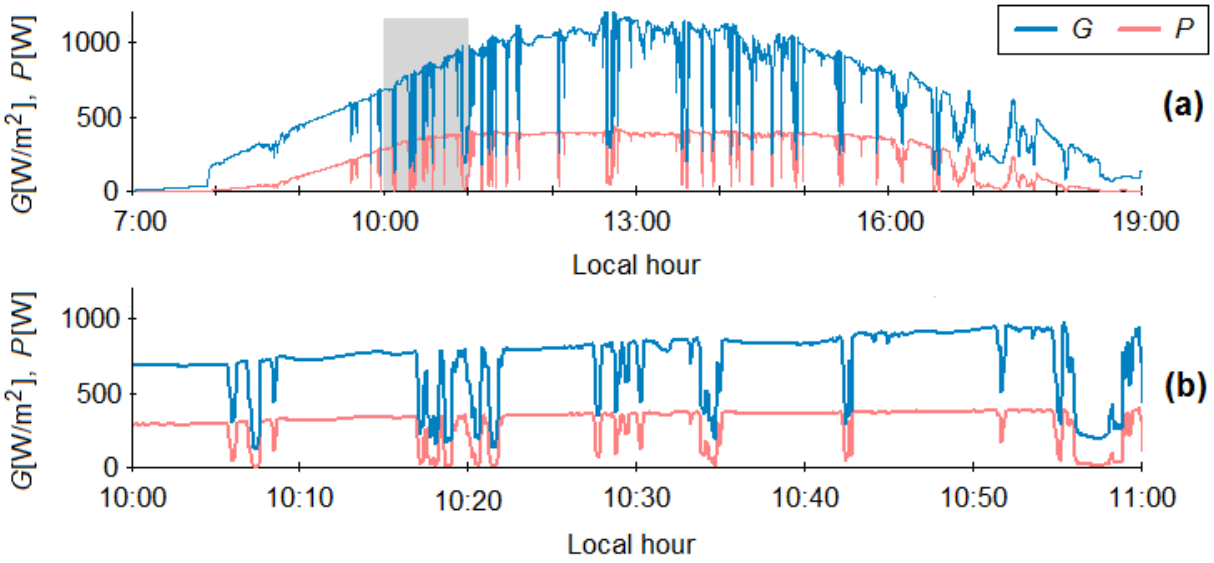
(3) Sistemul de monitorizare a starii cerului care cuantifica si prognozeaza pozitia relativa soare / nori prin procesarea imaginilor cerului luate cu o camera fisheye.

Stadiul final: Instrumentul de prognoza ASIFOR este dezvoltat in stadiul de produs experimental validat pe Platforma Solara a Universitatii de Vest din Timisoara. (TRL 3).

De ce este nevoie de prognoza productiei PV?

- Ponderea energiei solare si eoliana in mixul energetic creste continuu. In Romania ponderea energiei solare in consum este in jur de 4%.

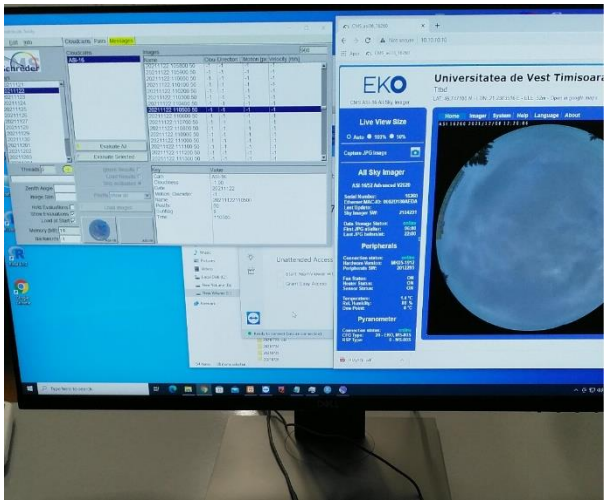
- Datorita norilor pasageri iradianta solara poate varia eratic.

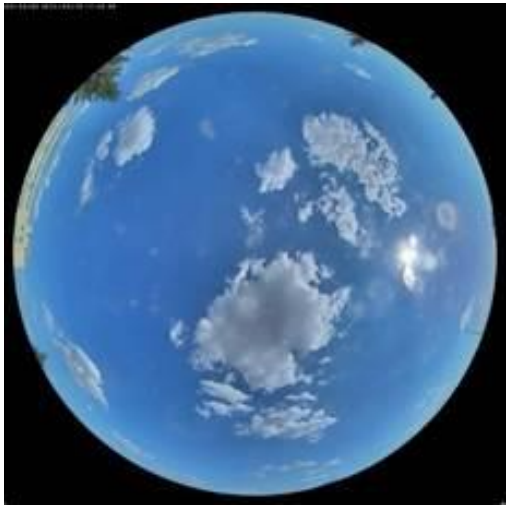


(a) Variatia densității fluxului de energie solara *G* si a puterii PV *P* masurate pe Platforma Solara in ziua de 2 septembrie 2020.
(b) Zoom in intervalul orar 10:00 – 11:00.

Rezultate – dezvoltarea infrastructurii de cercetare

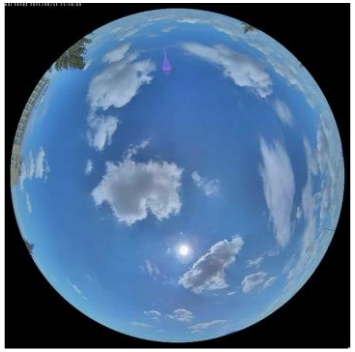
- Sistem ASIFOR echipat cu All Sky Imager EKO ASI-16
- Sistem PV 540 Wp, full monitorizat, destinat testarii modelelor de prognnoza



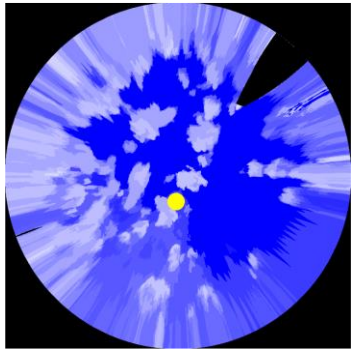


- Fotografie fisheye a starii cerului inregistrata de ASI-16

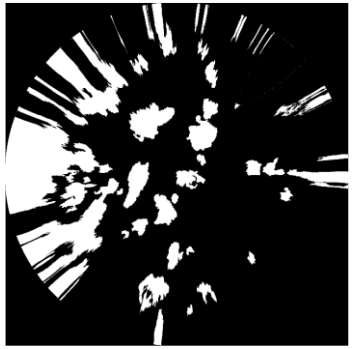
Prognoza sunshine number



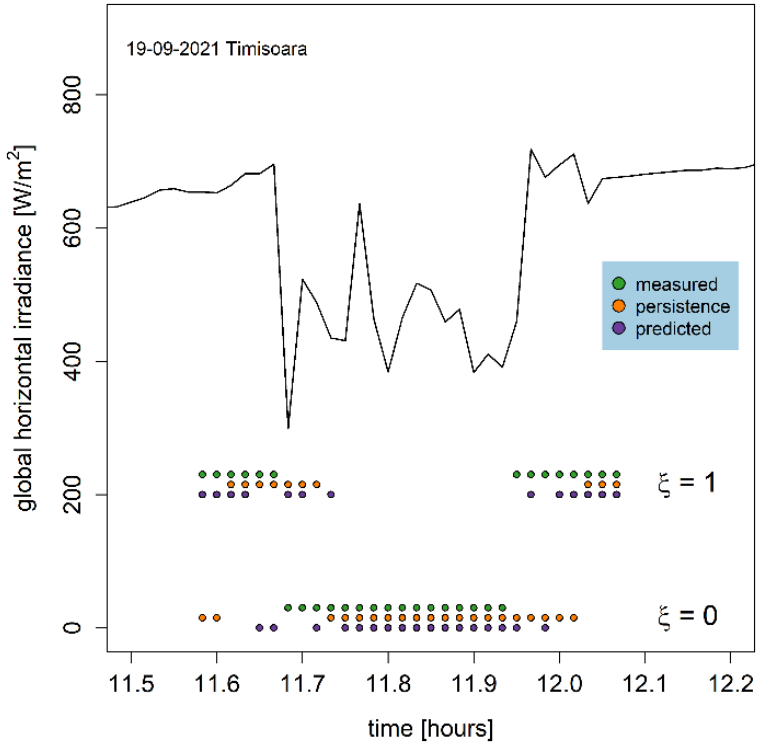
Fisheye photo



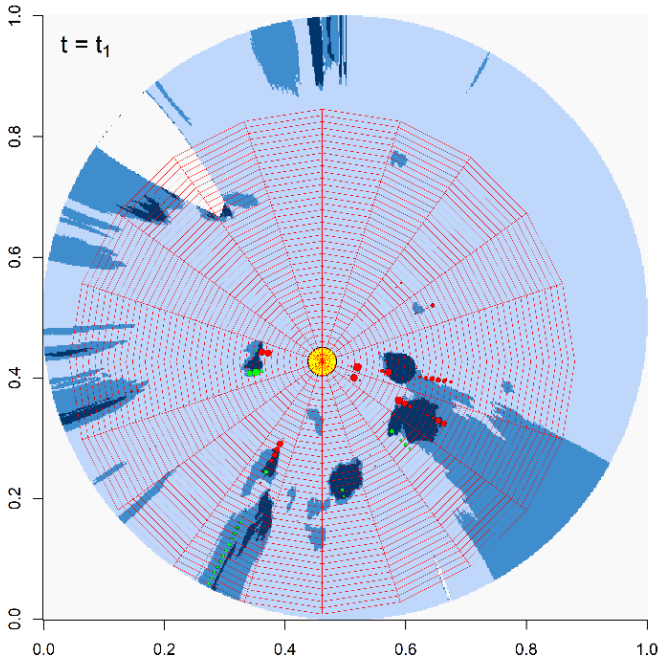
Plane projection



Binary image



Forecasted solar irradiance



System of coordinates attached to the Sun

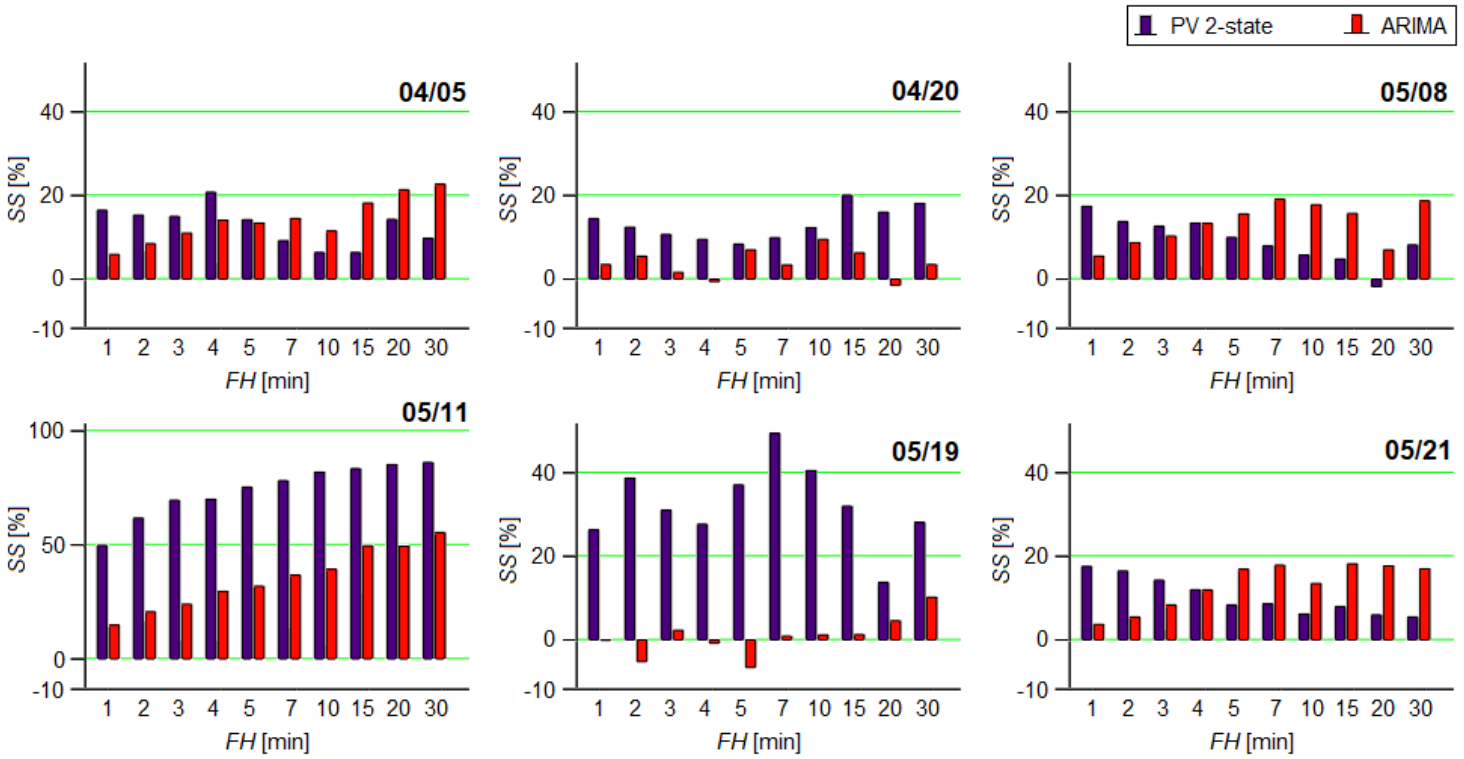
Blaga R, Dughir C ()2022 Sunshine number nowcasting based on all sky images. Presented at TIM 20/21 Physics Conference. To be published by the American Institute of Physics Conference Proceedings.

Rezultate – PV 2-state model. Acuratete

SSN prognozat statistic

Model equation

$$\hat{P}_t = \begin{cases} \alpha_{cs} P_{0,t} & \text{IF } SSN_t = 1 \\ \gamma_c P_{0,t} & \text{IF } SSN_t = 0 \end{cases}$$

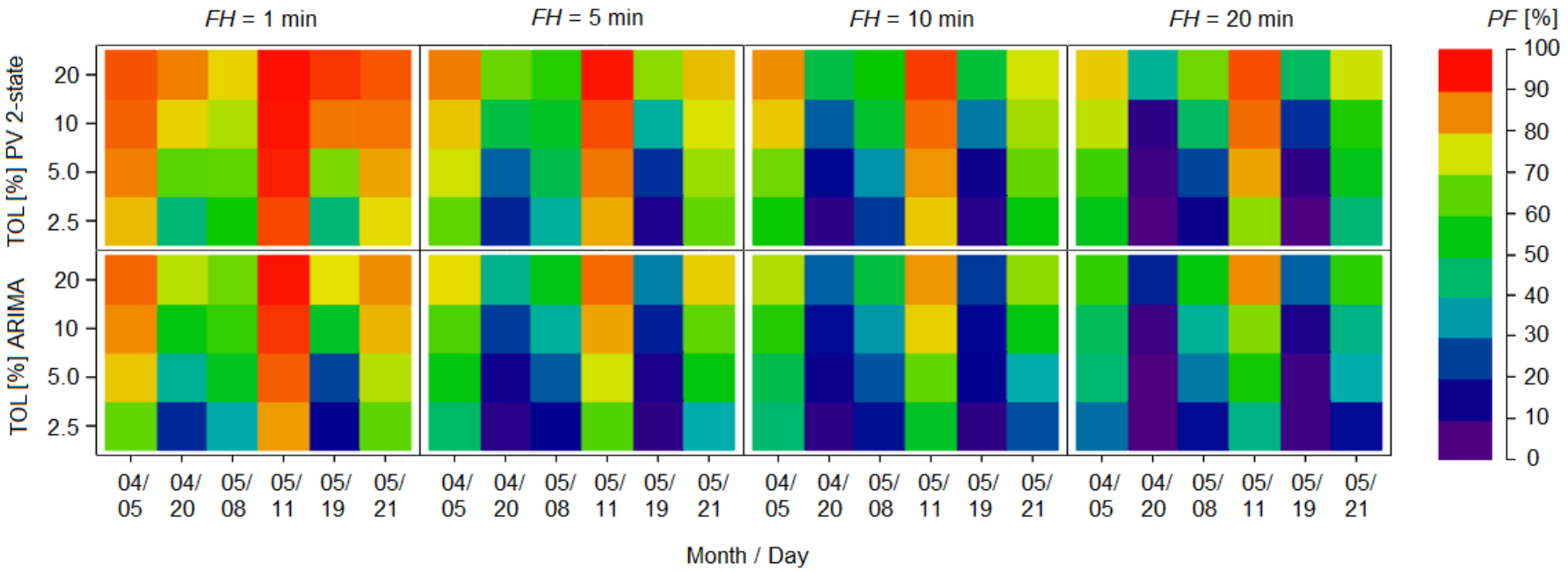


Performance of PV2-state and ARIMA models evaluated in terms of skill score *SS* at different forecast horizons *FH* in the test days: 04/05/2020 a sunny day with a moderate instability, 04/20 with instability installed on a cloudy background, 05/08 with a highly variability in the state-of-the-sky, 05/11 a stable clear-sky day, 05/19 a stable overcast day and 05/21 a day sunny and stable in the morning and variable in the afternoon.

Paulescu M, Stefu N, Dughir C, Sabadus A, Calinoiu D, Badescu V (2022) A simple but accurate two-state model for nowcasting PV power. Renewable Energy. https://doi.org/10.1016/j.renene.2022.05.056.

Paulescu M, Mares O, Paulescu E, Stefu N, Pacurar A, Calinoiu D, Gravila P, Pop N, Boata R, Nowcasting solar irradiance using the sunshine number, Energy Conversion and Management 79 (2014) 690-697.

Rezultate – PV 2-state model. Precizie

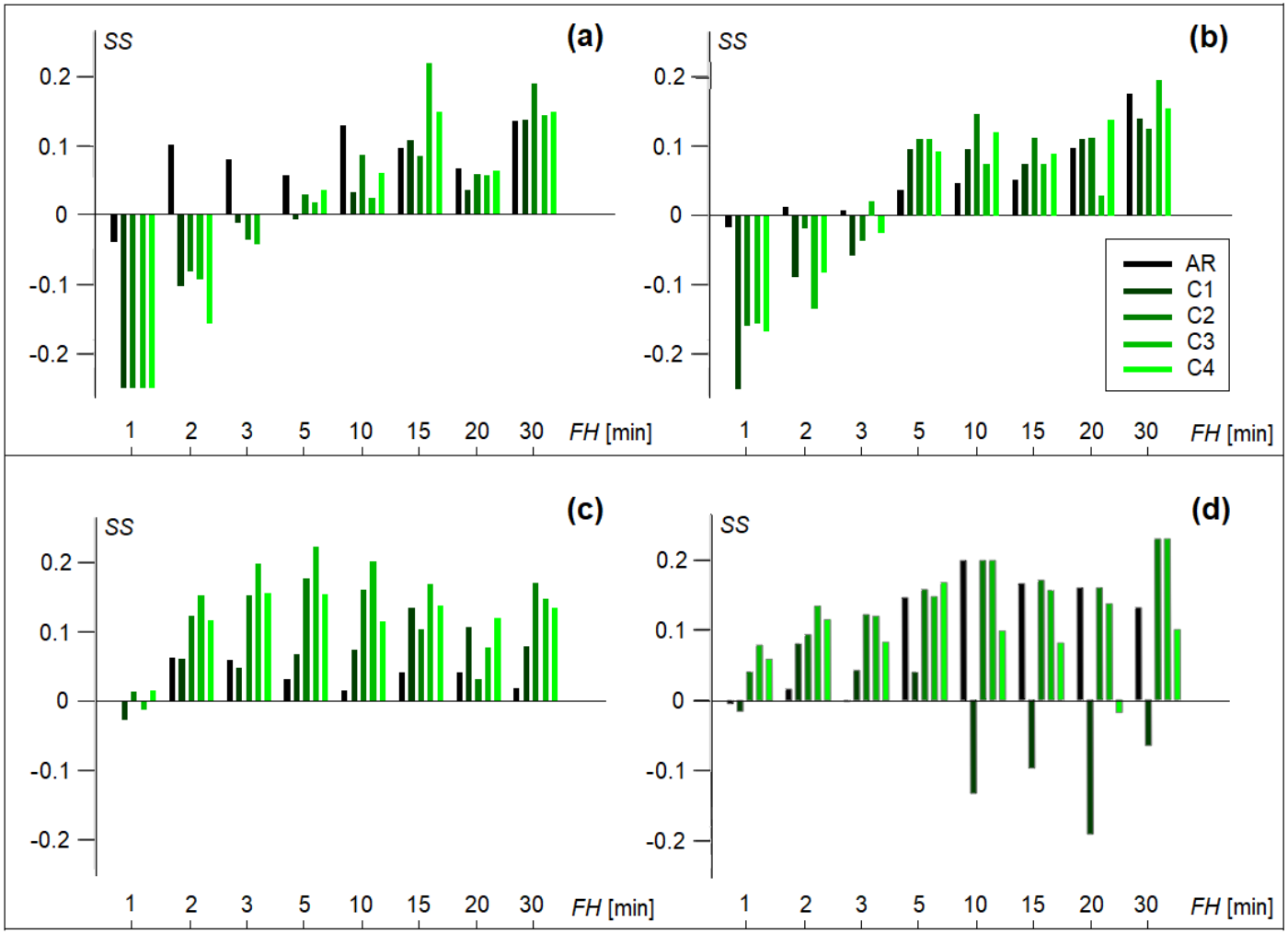


$$\hat{P}_t = \begin{cases} \alpha_{cs} P_{0,t} & \text{IF } SSN_t = 1 \\ \gamma_c P_{0,t} & \text{IF } SSN_t = 0 \end{cases}$$

Percentage of forecasts PF [%] accurate to within a given tolerance interval TOL [%] centered on measurements at different at four forecast horizons FH = 1min, FH = 5 min, FH = 10 min and FH = 20 min.

Paulescu M, Stefu N, Dughir C, Sabadus A, Calinoiu D, Badescu V (2022) A simple but accurate two-state model for nowcasting PV power. Renewable Energy. https://doi.org/10.1016/j.renene.2022.05.056.

Rezultate – PV 2-state model



SSN prognozat pe baza ASI

Skill score (SS) for PV power forecasting by the PV2-state model at different forecast horizons (FH). Results from the four test days are displayed: (a) 03/09/2021, (b) 06/09, (c) 18/09 and (d) 19/09.

Paulescu M, Dughir C, Blaga R, Stefu N, Sabadus A, Calinoiu D, Badescu V (2022) Intra-hour PV power forecasting based on sky imagery. Energy Conversion and Management. To be submitted.

Publications

Clear sky models

[1] Blaga R, Calinoiu D, Paulescu M (2021) A one-parameter family of clear-sky solar irradiance models adapted for different aerosol types. Journal of Renewable and Sustainable Energy 13(2), Article Number: 023701. https://aip.scitation.org/doi/abs/10.1063/5.0038619

[2] Paulescu E, Paulescu M (2021) A new clear sky solar irradiance model. Renewable Energy 179, 2094-2103.

Two-state model

[3] Paulescu M, Stefu N, Sabadus A, Dughir C, Bojin S. PV 2-STATE: a simple but accurate short-term PV power forecasting tool. In Proc. of 38th European PV Solar Energy Conference (EUPVSEC), pp 1161 - 1164 (2021).

[4] Blaga R, Dughir C. Intra-hour solar irradiance forecasting based on all sky-image-derived sunshine number. Oral presentation at TIM 20-21 Physics Conference, online, 11-13 November 2021. To be published by American Institute of Physics Conference Proceedings (Indexed by WoS).

[5] Paulescu M, Stefu N, Dughir C, Sabadus A, Calinoiu D, Badescu V (2022) A simple but accurate two-state model for nowcasting PV power. Renewable Energy. https://doi.org/10.1016/j.renene.2022.05.056.

Multumiri

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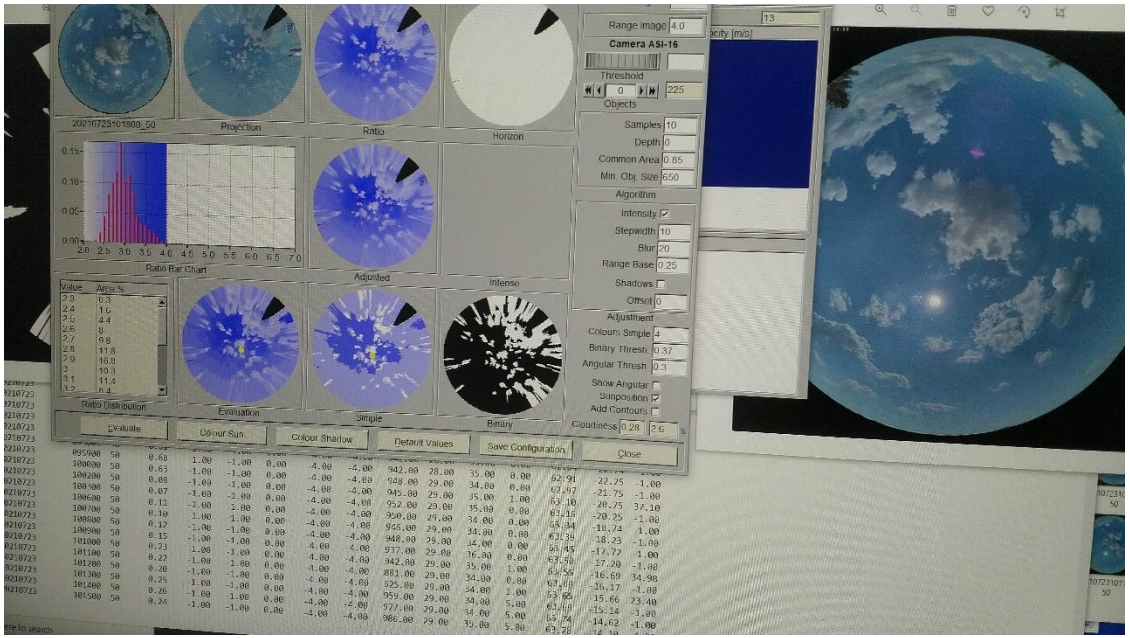

Multumesc pentru atentie!