GROUND-BASED CLASSIFICATION METHOD FOR DIRECT NORMAL AND GLOBAL HORIZONTAL IRRADIANCE

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Motivation

- Clouds and aerosols: main factors influencing the solar irradiance variability.
- Clouds can cause strong variation on times scales as short as 1-min
- Identifying short-term variability is relevant for solar power systems operation, irradiance models, forecasting services, etc.





DHI

Diffuse Horizontal Irradiance (DHI)

SOLY

 $GHI = DNI * cos(\theta_Z) + DHI$

Direct Normal

Irradiance (DNI)

Global Horizonzal Irradiance (GHI)

Reference Database – Carpentras, year 2012

 BSRN-Carpentras, 2012 (south of France). 1-min data, 280 hours manually classified as:

Class 1 – Clear sky

Class 2 – Close to clear sky (e.g. thin cirrus and aerosols)

Class 3 – Sky with medium variability, close to the clear sky

(e.g. cirrus clouds)

Class 4 – Variable sky with large variability, close to the clear cisky in some intervals

- Class 5 Sky with medium variability
- Class 6 Thick/broken clouds with large variability
- Class 7 Partly overcast sky

Class 8 – Overcast sky

Time-window for classification: 1 hour (using 1-min data)

Schroedter-Homscheidt et al. (2018)



Example variability classes 1-8

Hours being classified, 1-min resolved data, 10 min moving average

Reference database for GHI-based classification



Reference database for GHI-based classification





Reference database for GHI-based classification





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Variability Indices (VIs)

- Quantifies the variability information in the time window under study
- 13 different VIs are applied to classify hourly time-windows in one of the 8 classes



VI. 1) kc_mean



VI. 2, 3, 4) del_kc_mean, del_kc_std and del_kc_max



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VI. 5) Number of Changes in the Sign of the First Derivative (CSFD)



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VI. 6, 7, 8) Integral Methods: Upper Minus Clear (UMC),

Upper Minus Lower (UML), Lowe Minus Abscissa (LMA)





Units for integral methods: W/m2 * min Normalized by the Top of Atmosphere (TOA) irradiation

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VI. 9, 10) Stein and Coimbra

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VI. 11, 12, 13) Over clear sky (3%, 5% and 10%)



Classification Algorithm





Classification Algorithm – Discrimination filter

Solves about 70% of cases already



Classification Algorithm – PDF based method

Solves about 20% of cases



Classification Algorithm – PDF based method



Representability of the ref. database



Classification Algorithm – Distance from median

Applied only for remaining cases (10%)



Results for DNI – Carpentras Reference Database

New model **Previous model** (descrimination filter + PDF approach) Schroedter-Homscheidt et al. (2018) 1.0 Accuracy DNI PDF model - 90.4% Accuracy DNI msh model (6 VIs) - 80.0% 0.97 class1 0.87 0.13 0 0 0 0.033 0 0 0 Ω 0 0 0 0 0 class1 0.8 0.8 database) database class3 database class3 0.26 0.68 0.053 0 Ω 0 0 0 0 0.97 0 0 0.032 0 0 0 class3 0.067 0.067 0.7 0.13 0.033 0 0 0 0.2 0 0 0.76 0.04 0 0 0 ref. 0.6 ref. 0.6 True labels (Carpentras results) Class2 class2 class2 class2 Carpentras Carpentras Class2 0.062 0 0.19 0.75 0 0 0 0 0.062 0.56 0.062 0.31 0 0 0 0 0.062 0.094 0 0.72 0.062 0.062 0 0 0 0.054 0 0.054 0.027 0 0.86 0 0.4 0.4 True labels (classo 0.73 0.18 0.02 0.078 0 0 0 0 0.02 0.02 0.92 0.039 0 0 0 0 0.82 0.067 0.11 0 0 0 0 0 0.023 0 0 0 0 0.98 0 0 0.2 0.2 0 1 class8 0 0 0 0 0 0 0.079 0.92 class8 0 0 0 Ω \cap 0 class7 class2 class3 class4 class5 class6 class8 class1 class4 class6 class7 class8 class1 class2 class3 class5 Predict labels (msh model) Predicted labels (PDF model)

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Results for GHI – Carpentras Reference Database

Previous model Schroedter-Homscheidt et al. (2018)



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New model (descrimination filter + PDF approach)





Running the model for other locations (application/operation of the model worldwide)

Results for Alice Springs, Australia, 2018 (GHI model)

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Check for plausibility (diffuse radiation vs. clearness index)

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Results for BSRN-TAT, Japan, 2018 (GHI model) Check for plausibility (diffuse radiation vs. clearness index)

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Results for BSRN-TAT, Japan, 2018 (GHI model) Check for plausibility (diffuse radiation vs. clearness index)

All data All data 1.0 1.0 Class 5 Class 6 0.8 0.8 Diffuse ratio Diffuse ratio 0.2 0.2 0.0 0.2 0.2 0.4 0.6 0.8 0.0 0.4 0.6 0.8 Clearness index **Clearness index** All data All data 1.0 1.0 Class 7 Class 8 0.8 0.8 Diffuse ratio Diffuse ratio 0.2 0.2 0.0 0.2 0.2 0.4 0.6 0.8 0.0 0.6 0.8 0.4 Clearness index Clearness index

Thank you for your attention! diego.rodriguesdemiranda@dlr.de