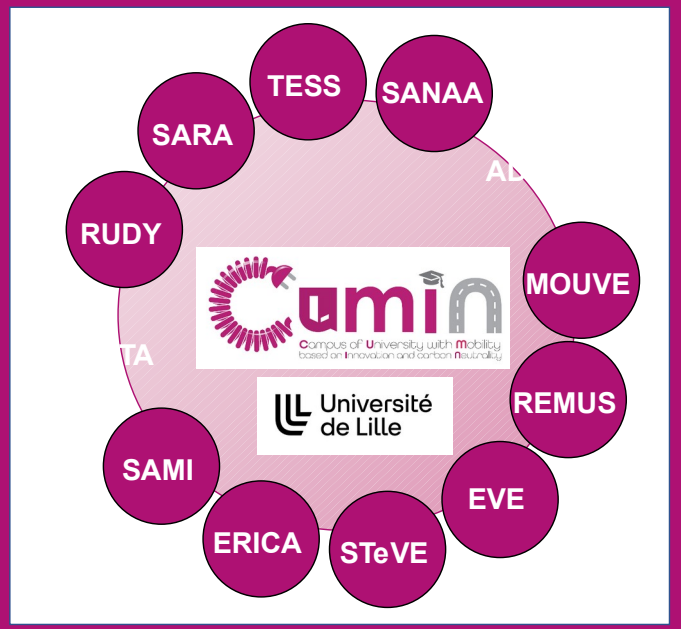
https://cumin.univ-lille.fr/



CUMIN - GRETA

Generation using **R**enewable **E**nergy
for **T**ransport **A**ctivities of an eco-campus

Measurement and analysis of Surface Solar Radiation in Lille and beyond

Nicolas FERLAY

LOA
LABORATOIRE D'OPTIQUE ATMOSPHÉRIQUE

(Université de Lille/ CNRS)

Outline

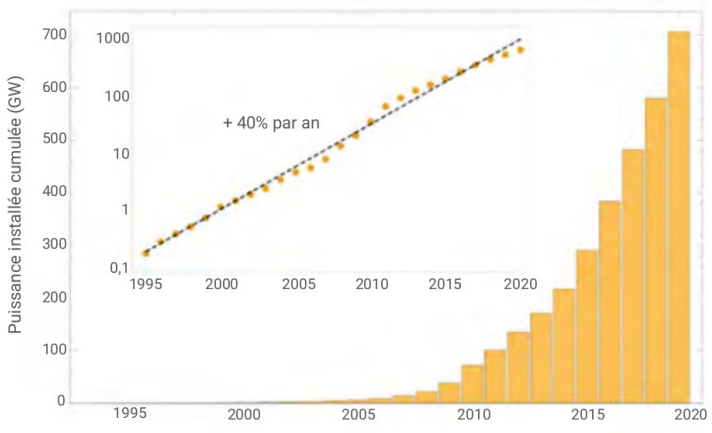
1. LOA research project about SSR, facilities
2. Recent results about the analysis of surface solar radiation
3. Current work within CUMIN and perspectives

1 LOA research project about SSR (Surface Solar Radiation) , facilities

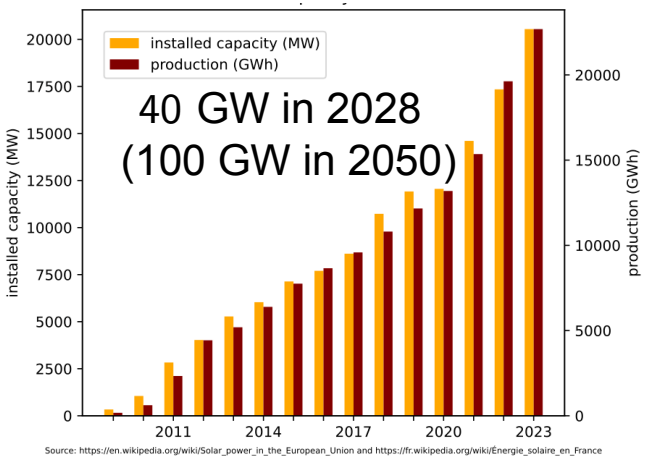
Motivation : contribute to a better knowledge about SSR for its exploitation

Why?
Increasing used of the sun as a renewable energy source

Installed PV capacity (world)



Installed PV capacity and production (France)



objective of neutral carbon emission in 2050 … or so

75 or 80% of CO_2 emission associated with energy (production and consumption)

PV electricity : associated with relatively low CO_2 emission (~50 g CO_2/kWh in France

(x 8 for gas)

(/ 5 for nuclear

1 LOA research project about SSR (Surface Solar Radiation) , facilities

Motivation : contribute to a better knowledge about SSR for its exploitation

Surface solar energy:
Tightly linked with climate and meteorology:

Predictable (night&day, rough seasonal variability, for clear sky or very cloudy periods)
but
not easily predictable otherwise at short time scale
→ will call for adapted management of electric network or/and storage

Can be very intermittent when clouds are in the sky
Can be very varying spatially and temporally

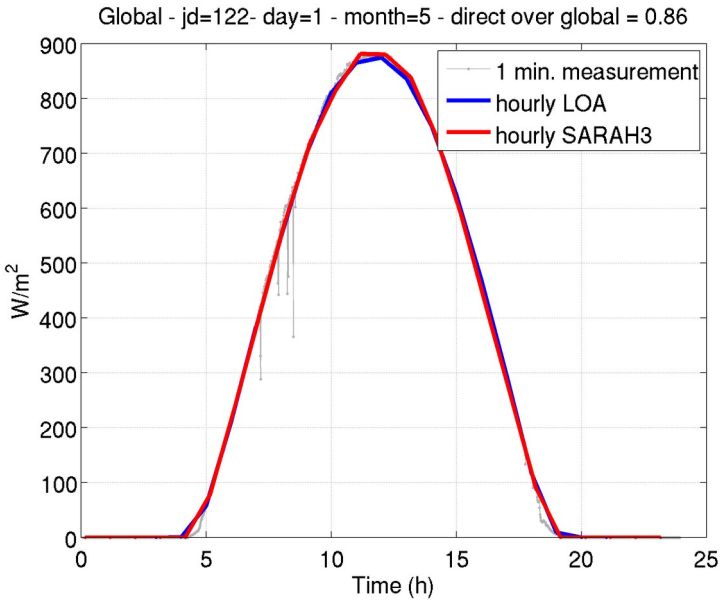
A very good idea to estimate SSR from space (from ***R***, get ***T***) but a challenge

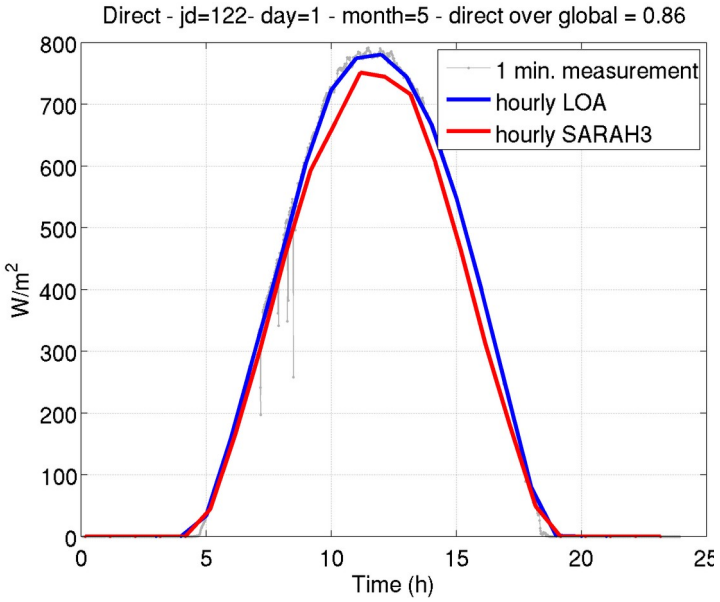
1 LOA research project about SSR (Surface Solar Radiation) , facilities

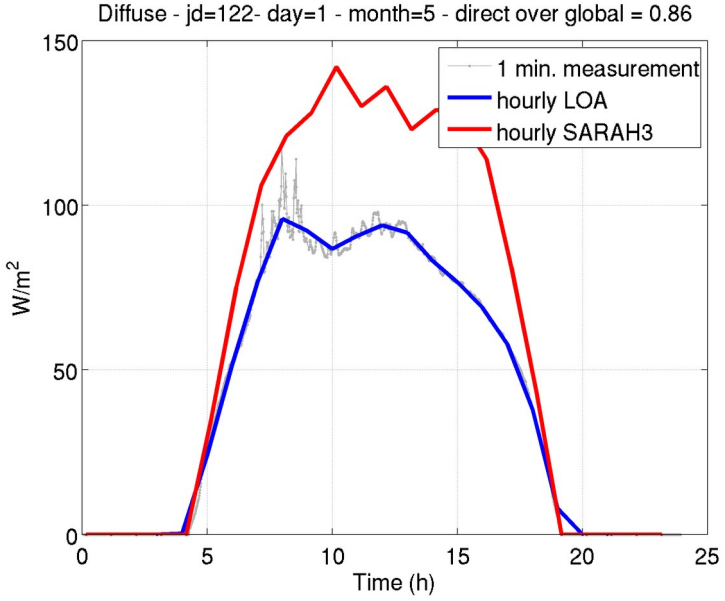
Motivation : contribute to a better knowledge about SSR for its exploitation

Surface solar energy:
A very good idea to estimate SSR from space (from ***R***, get ***T***) but a challenge

eg clear sky day in 2016: global is very accurate; the partition direct/diffuse is quite right





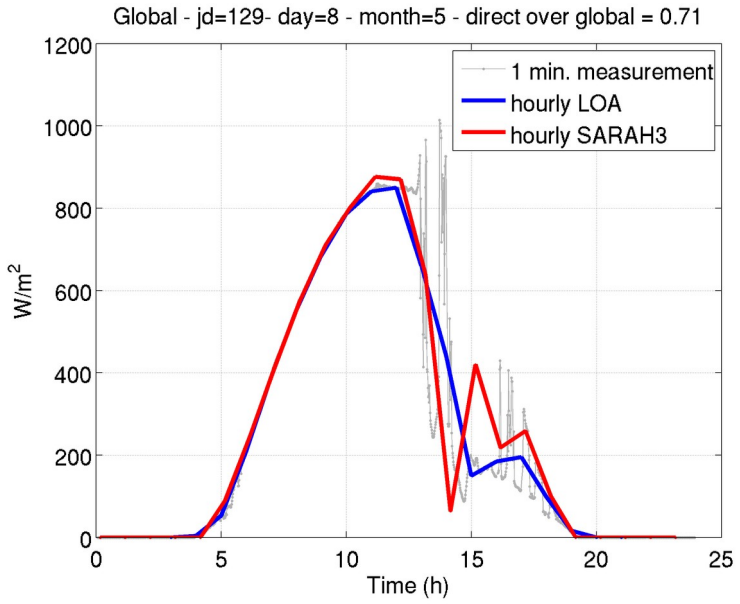


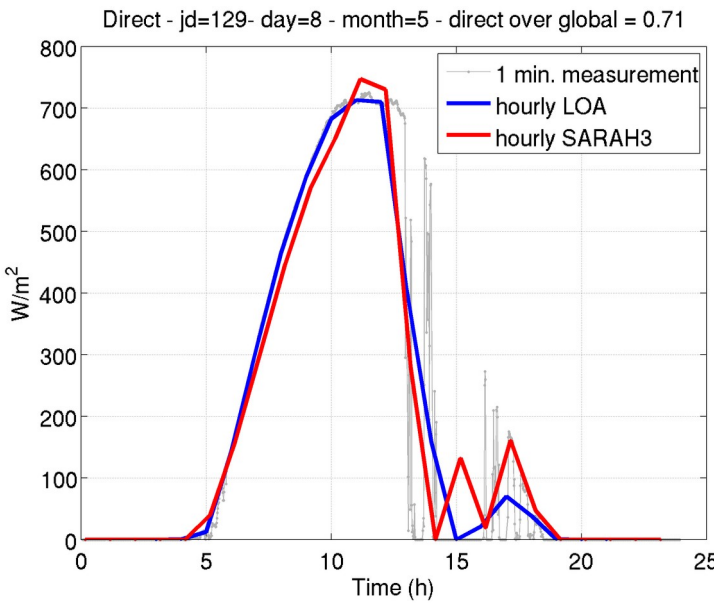
1 LOA research project about SSR (Surface Solar Radiation) , facilities

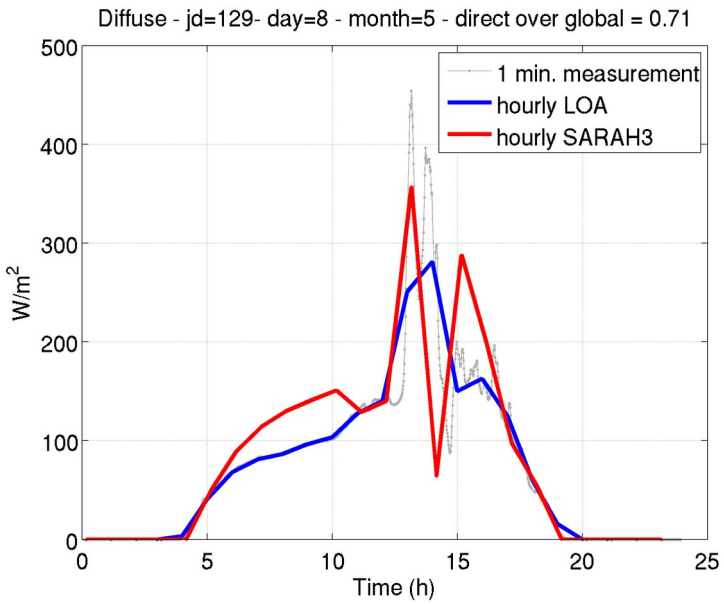
Motivation : contribute to a better knowledge about SSR for its exploitation

Surface solar energy:
A very good idea to estimate SSR from space (from ***R***, get ***T***) but a challenge

eg clear sky morning in 2016: more issues in the afternoon





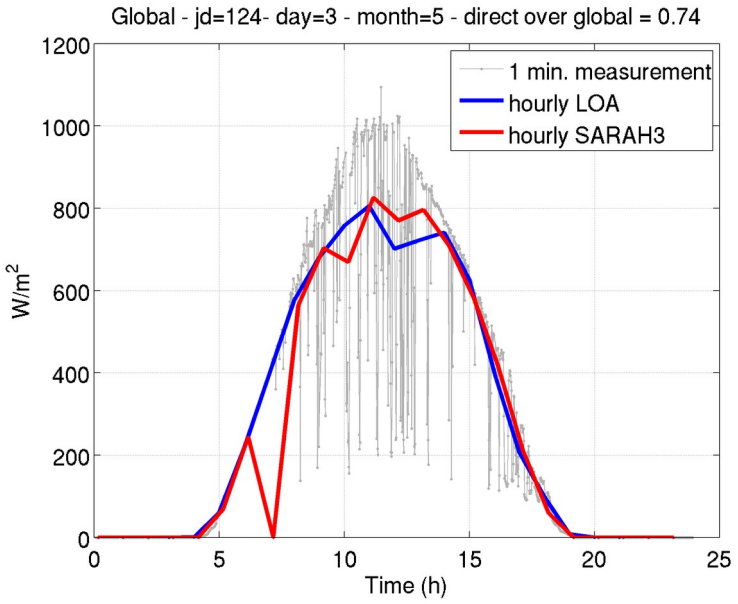


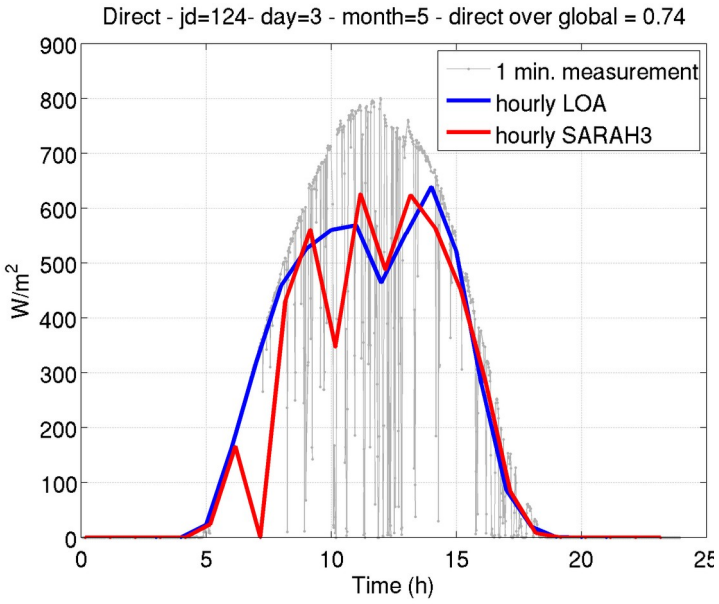
1 LOA research project about SSR (Surface Solar Radiation) , facilities

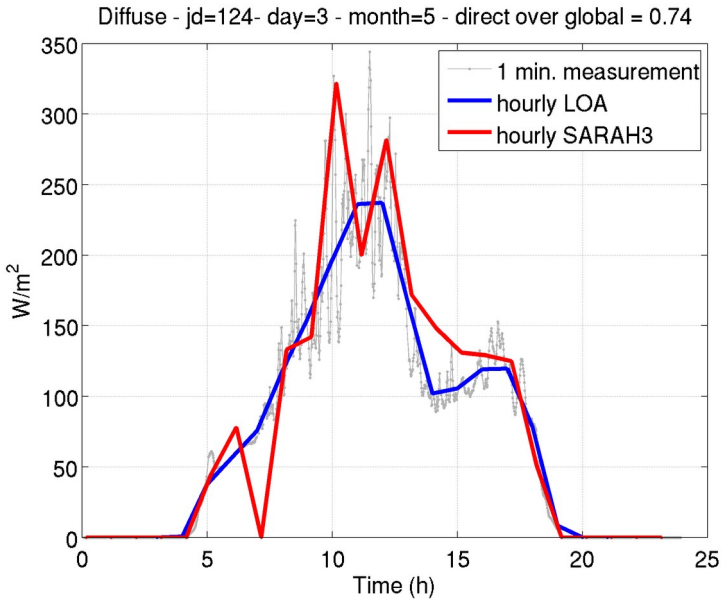
Motivation : contribute to a better knowledge about SSR for its exploitation

Surface solar energy:
A very good idea to estimate SSR from space (from ***R***, get ***T***) but a challenge

eg partly covered day in 2016: compensation between highs and lows but *plenty is missing*





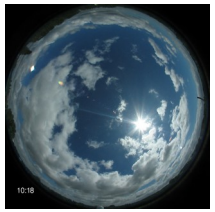


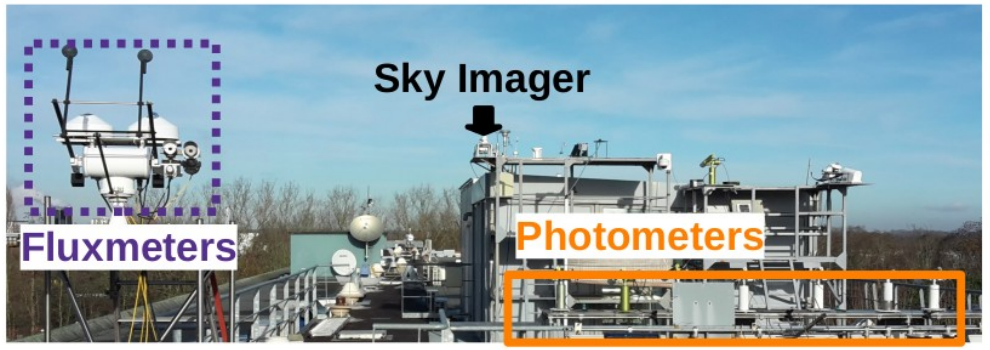
What is important for what application?

1 LOA research project about SSR (Surface Solar Radiation) , facilities

Our contribution: exploit and develop facilities in order to help to analyze and characterize the SSR variability

Measurements from the multilaboratory platform ATOLL (**AT**mospheric **O**bservations in **LiL**le)





View of the instrumental platform ATOLL (Atmospheric Observations in Lille) located on the roof of the P5 building of the University of Lille, Villeneuve d'Ascq, campus Cité scientifique.

Additional measurements: **+ a lidar to get an atmospheric vertical profile**

- **Sky imager since 2009 + spectral content of direct/diffus (EKO MS711)**
- **Surface concentrations (PM_{10} et $PM_{2.5}$, ATMO-HdF) and chimical composition of NR-PM_1 by an ACSM (SO4, NO3, NH4, Org) and aethalometer (BC)**

AEROSOLS

Photometer CIMEL AERONET/PHOTONS

- **Aerosol Optical Depth (AOD) and Angström Exponent (AE) in Clear-sun conditions**
- **Inversions of the size distribution and absorption properties of aerosols**

SOLAR ENVIRONMENT

Kipp & Zonen fluxmeters (since 2009) – 1-min resolution

Pyrheliometer (CH1)
Direct incident radiation, DNI

Pyranometer (CMP 22)
Diffuse irradiance, DHI

↓

Beam horizontal irradiance (BHI) = cos(Θs)*DNI

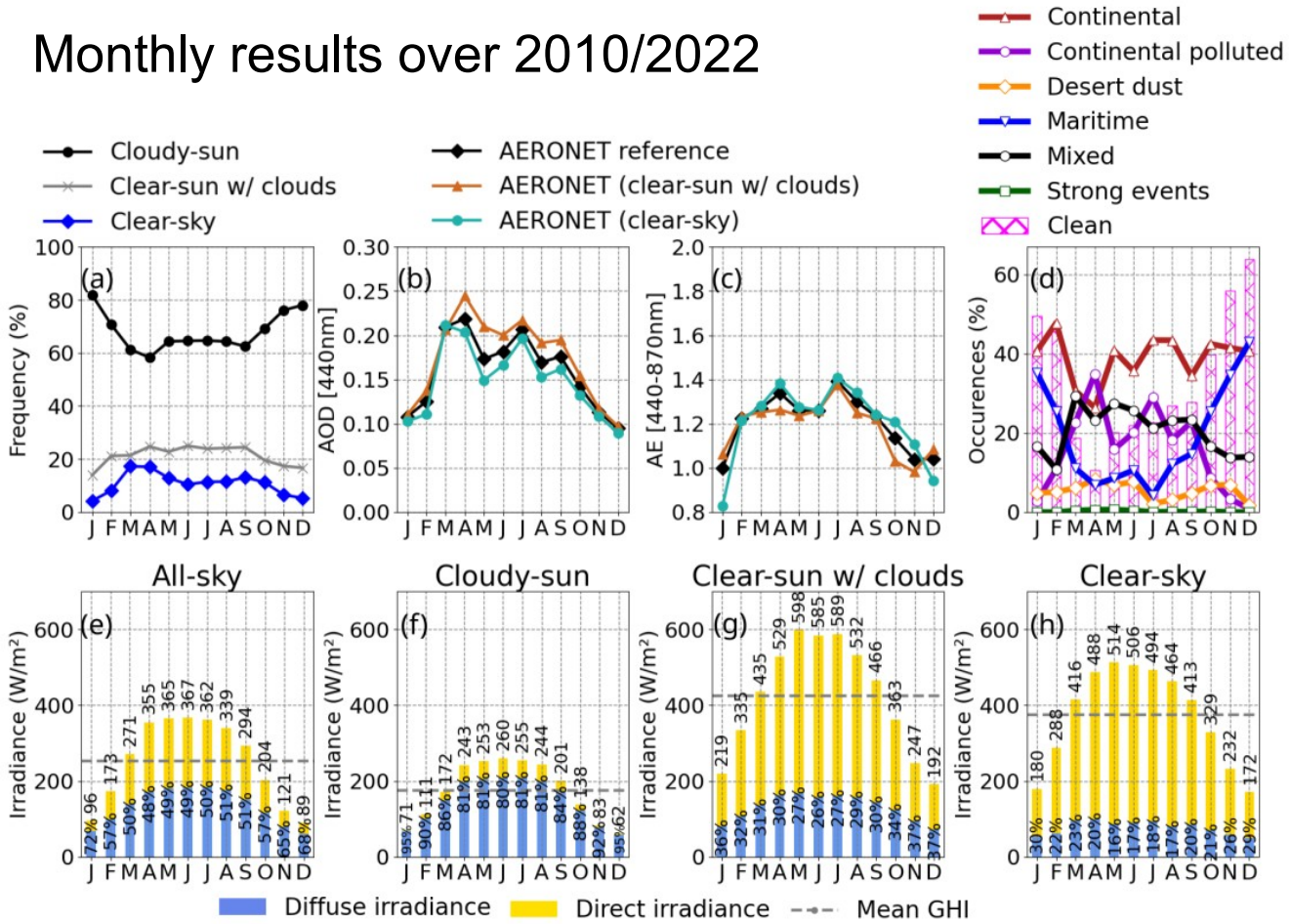
→ Global irradiance, GHI = BHI + DHI

Development of SSR tool (SOLARDECO) and exploitation of atmospheric modeling outputs

2 Recent results about the analysis of surface solar radiation

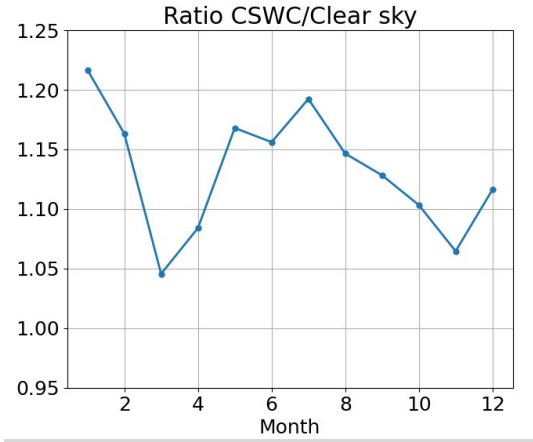
Methodology to analyze the SSR and sky content co-variabilities

Monthly results over 2010/2022



Spring :
More clear sun and clear sky while more aerosols

Clear-sun-with-cloud situations:
On average as bright (or more) as clean atmosphere with no clouds

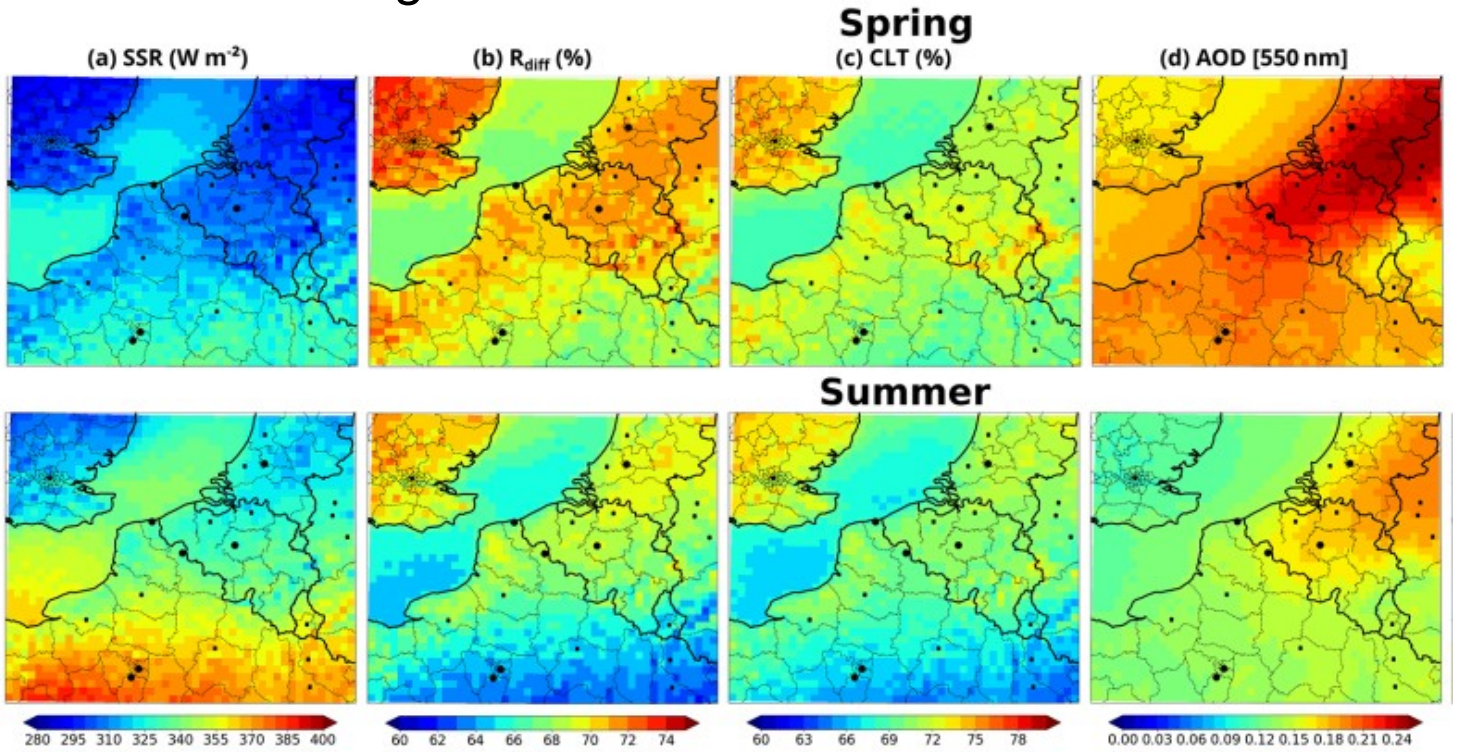


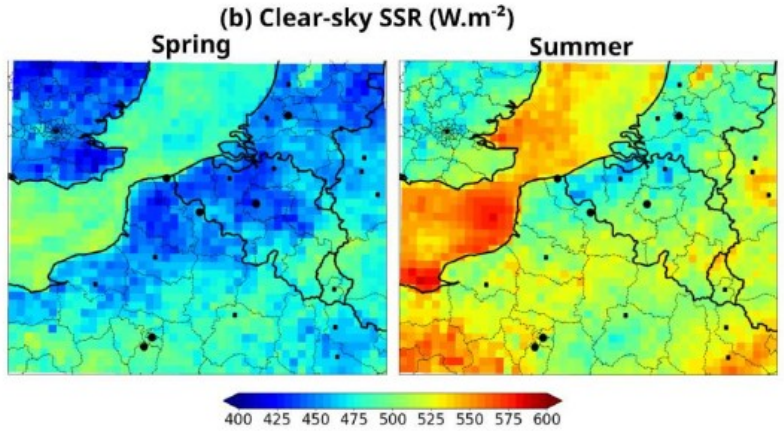
From *Chesnoiu et al (2024): About multiple influences on SSI variability in northern France*

2 Recent results about the analysis of surface solar radiation

Regional modeling of SSR+aerosol+clouds over northern France and Benelux (present and future)

Seasonal averages over 2010/2022





Spatial variability:
Over the influence of clouds and of pollution

From *Chesnoiu et al (2025): Regional modeling of SSR over northern France and Benelux*

3 Current work and perspectives in particular within CUMIN

Assimilate information about the cloud fraction coming from skyimager

Extent the analysis of SSR variabilities per cloud cover regimes

Exploitation of a second LOA skyimager located on the ESPRIT building

- Use it for cloud triangulation
- Use of a sequence of infered cloud cover and cloud mask to improve the short-term forecast of PV production (*collab. B. François, A. Tannous*)

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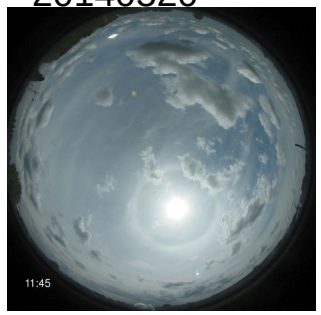

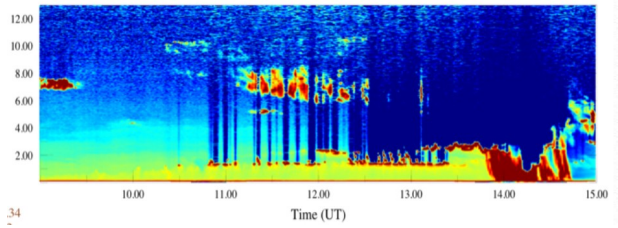

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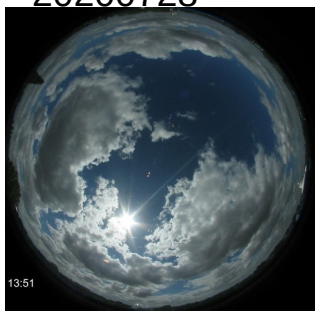
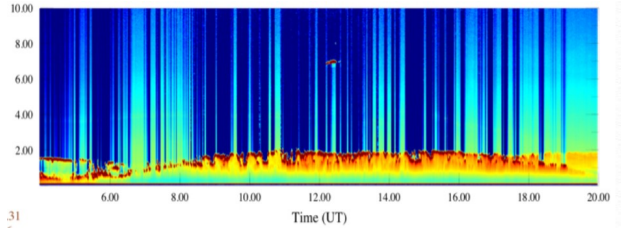
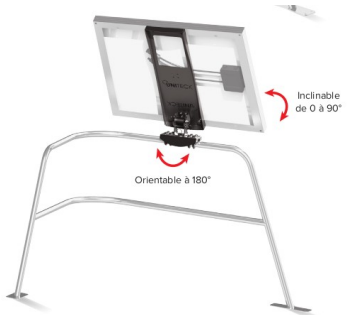




Install our own PV toolkit (*collab. L2EP*)



Explore the interest of organic solar cells on public transport, develop modeling

https://cumin.univ-lille.fr/

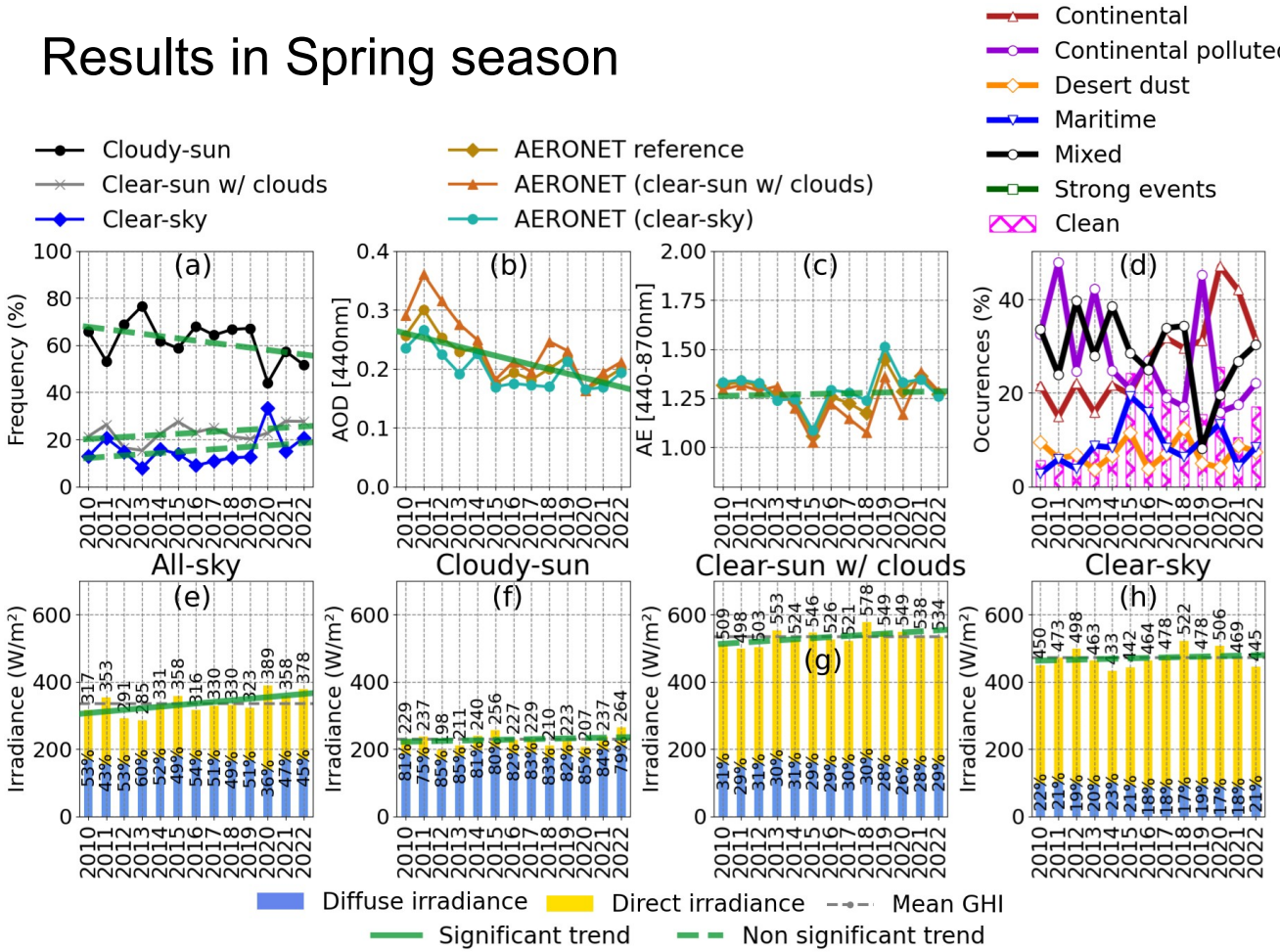
Thank you for your attention :-)

Questions?

2 Recent results about the analysis of surface solar radiation

Methodology to analyze the SSR and sky content co-variabilities

Results in Spring season



Shows some significative increasing SSR trend (4 W/m2/year) over 2010/2022

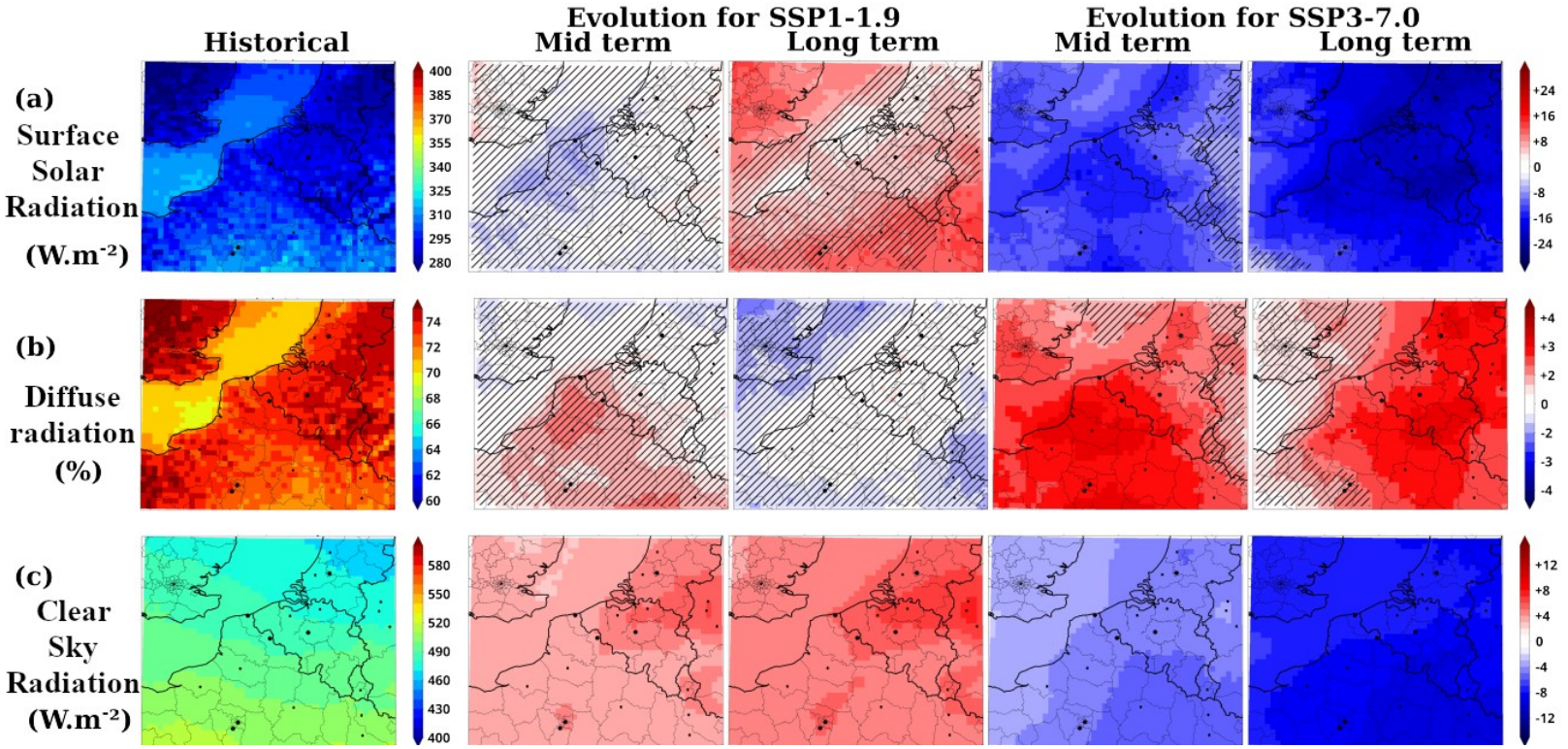
25% due to decrease in particle pollution
70% due to changes in sky conditions (more clear sun)

Illustration from *Chesnoiu et al (2024) About multiple influences on SSI variability in northern France*

2 Recent results about the analysis of surface solar radiation

Regional modeling of SSR+aerosol+clouds over northern France and Benelux (present and future)

Projection in 2050 and 2100 for climate scenario



<u>Large difference in 2100:</u>

Combined effect of more clouds and more aerosol in the SSP3 7.0 scenario

From *Chesnoiu et al (2025): Regional modeling of SSR over northern France and Benelux*