

Solar Energy Meteorology: Research and international co-operations

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Energy and Semiconductor Research Laboratory (EHF)
Solar Energy Meteorology Group



Energy and Semiconductor Research Laboratory



Laboratory for Chalcogenide
Photovoltaics (LCP)



Organic and Hybrid
Photovoltaics



Experimental Physics of
Complex Systems



Nanochemistry



Physics of Interfaces



Energy Meteorology



Energy Storage
Technologies



Optoelectronic
Organics



Postgraduate Programs
Renewable Energy

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Postgraduate Programs
Renewable Energy

Head: Prof. Dr. Jürgen Parisi

Scopes:

- ▶ Fundamental science of transport phenomena (near-field processes, charge transport)
- ▶ Material science with focus on energy applications (photovoltaics, storage)
- ▶ Photovoltaic science & engineering (organic & inorganic nano bulk compounds)

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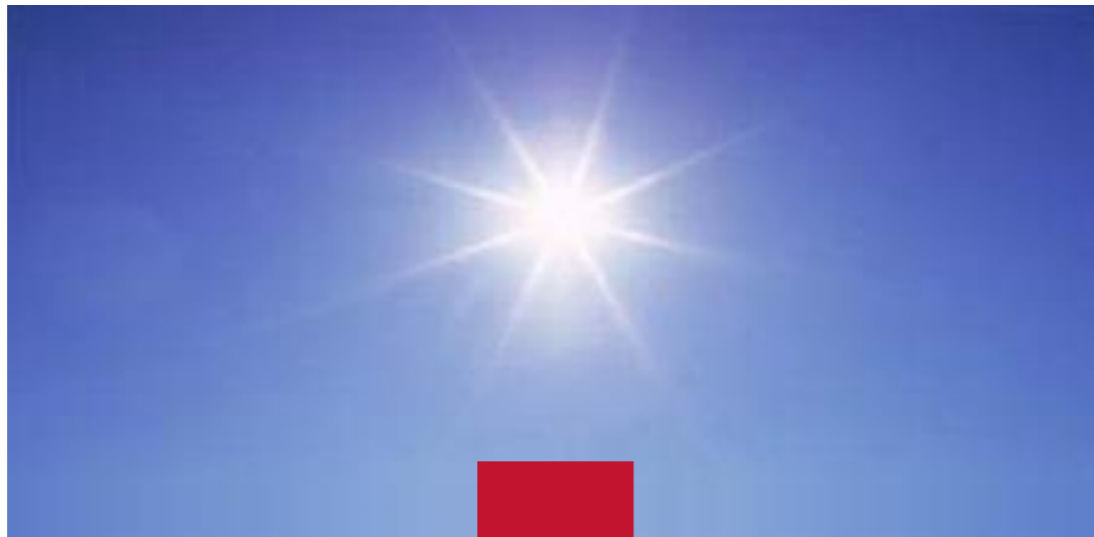
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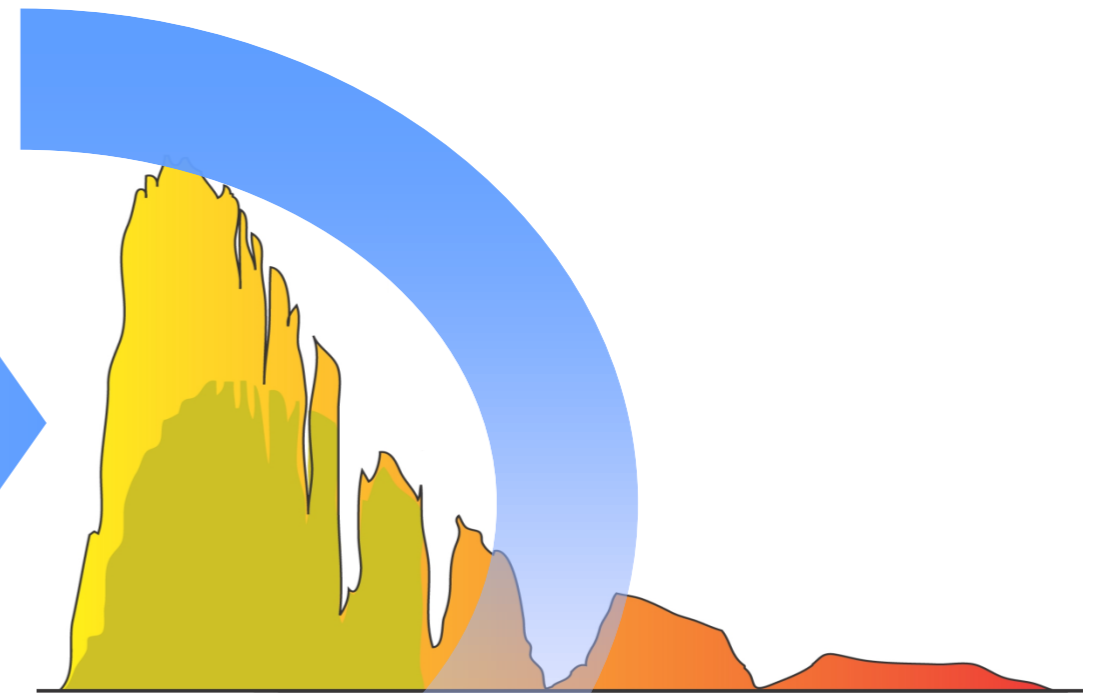
Why Energy meteorology ?

conventional energy conversion:

- ▶ controllable
- ▶ demand driven



Why Energy meteorology ?



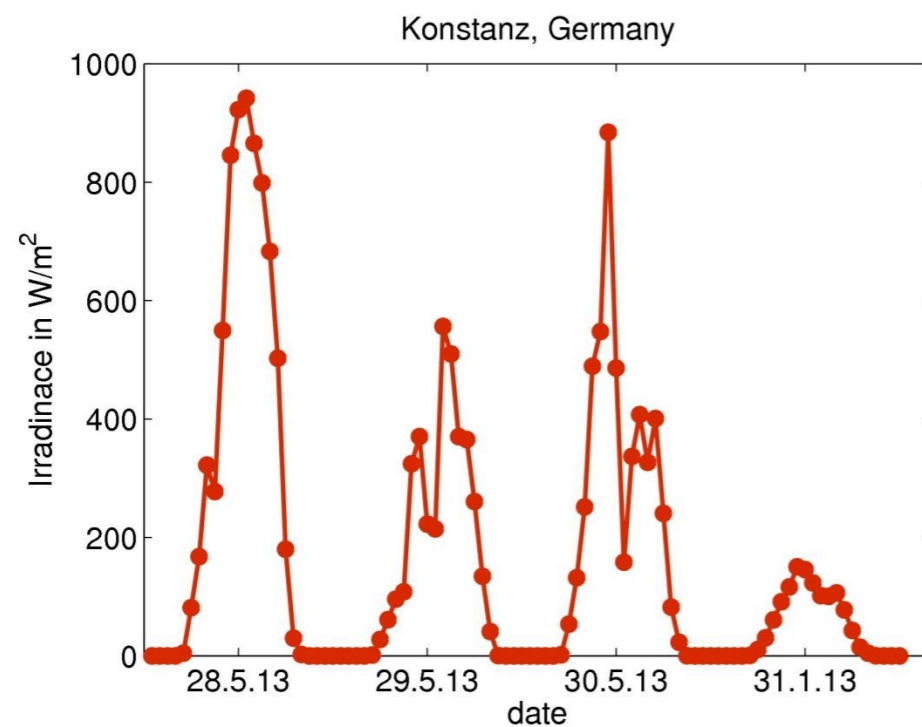
solar energy:

- ▶ weather dependent
- ▶ supply driven

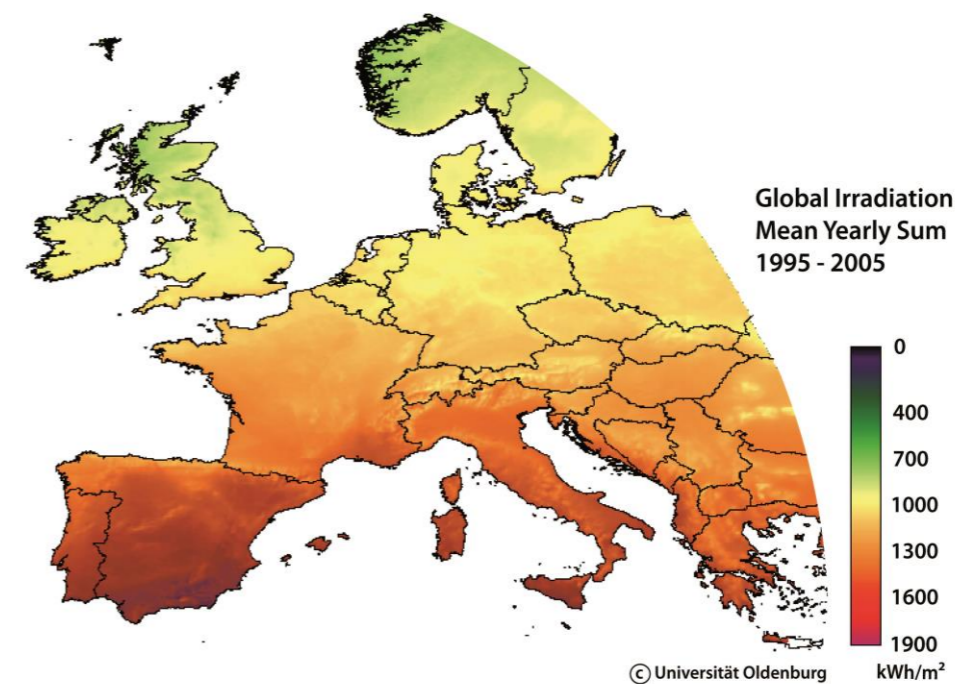
Energy and Weather

An important – and new – constraint for the future energy supply system is the **variability of production rates**.

temporal variability



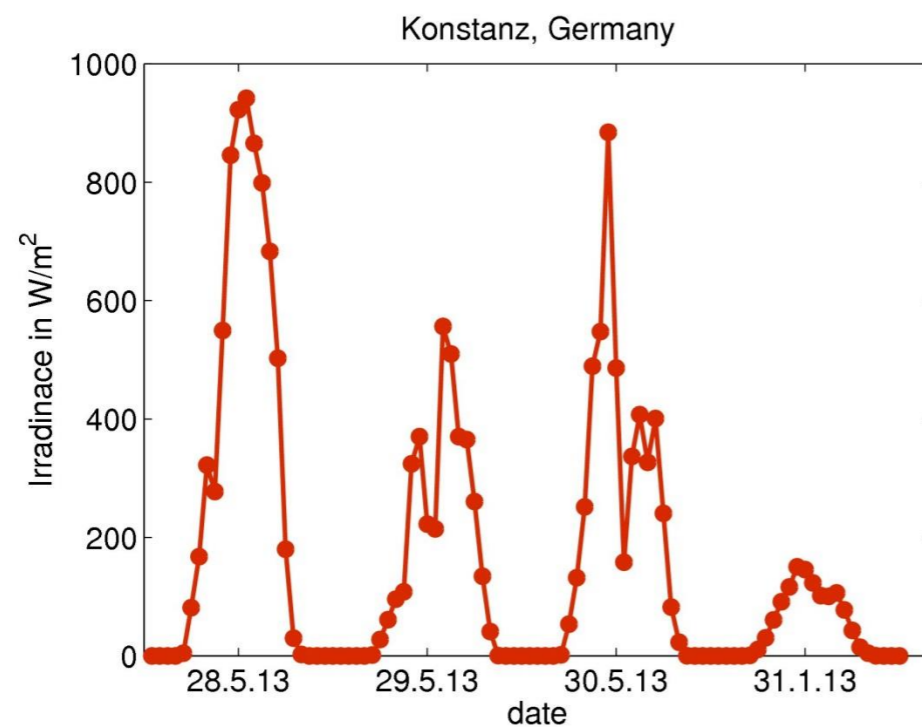
spatial variability



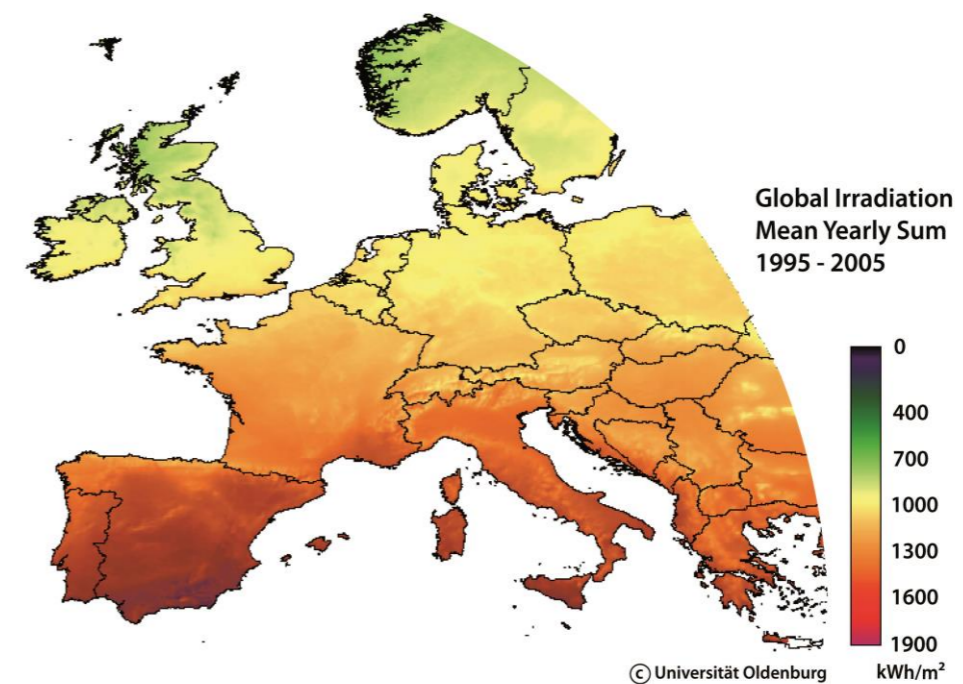
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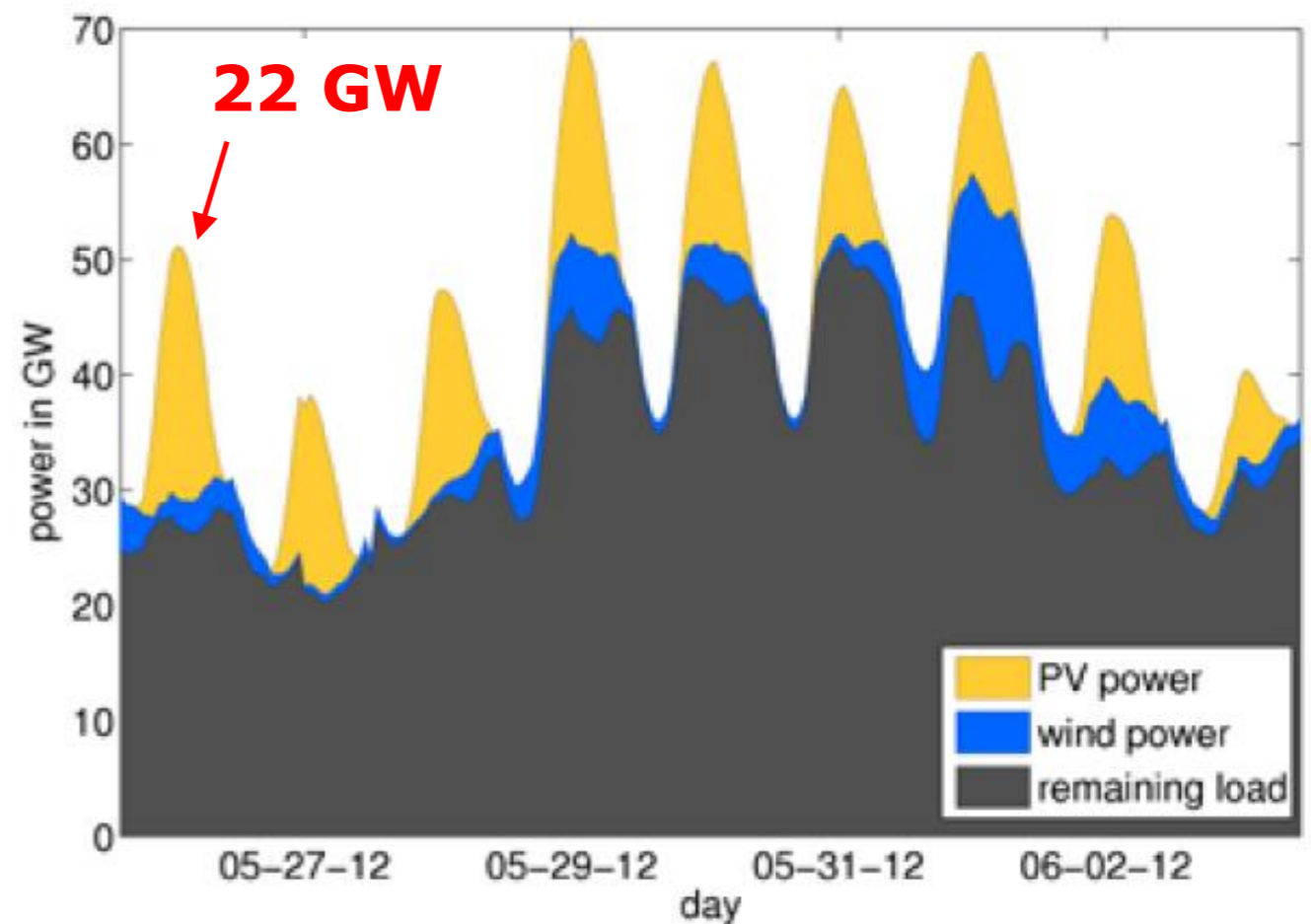
➔ **Information on the available resource is essential** for the integration of solar energy to the energy supply system.

Contribution of PV systems to electricity supply in Germany

- ▶ installed PV power (end 2014):
38.5 GW_{peak} in Germany

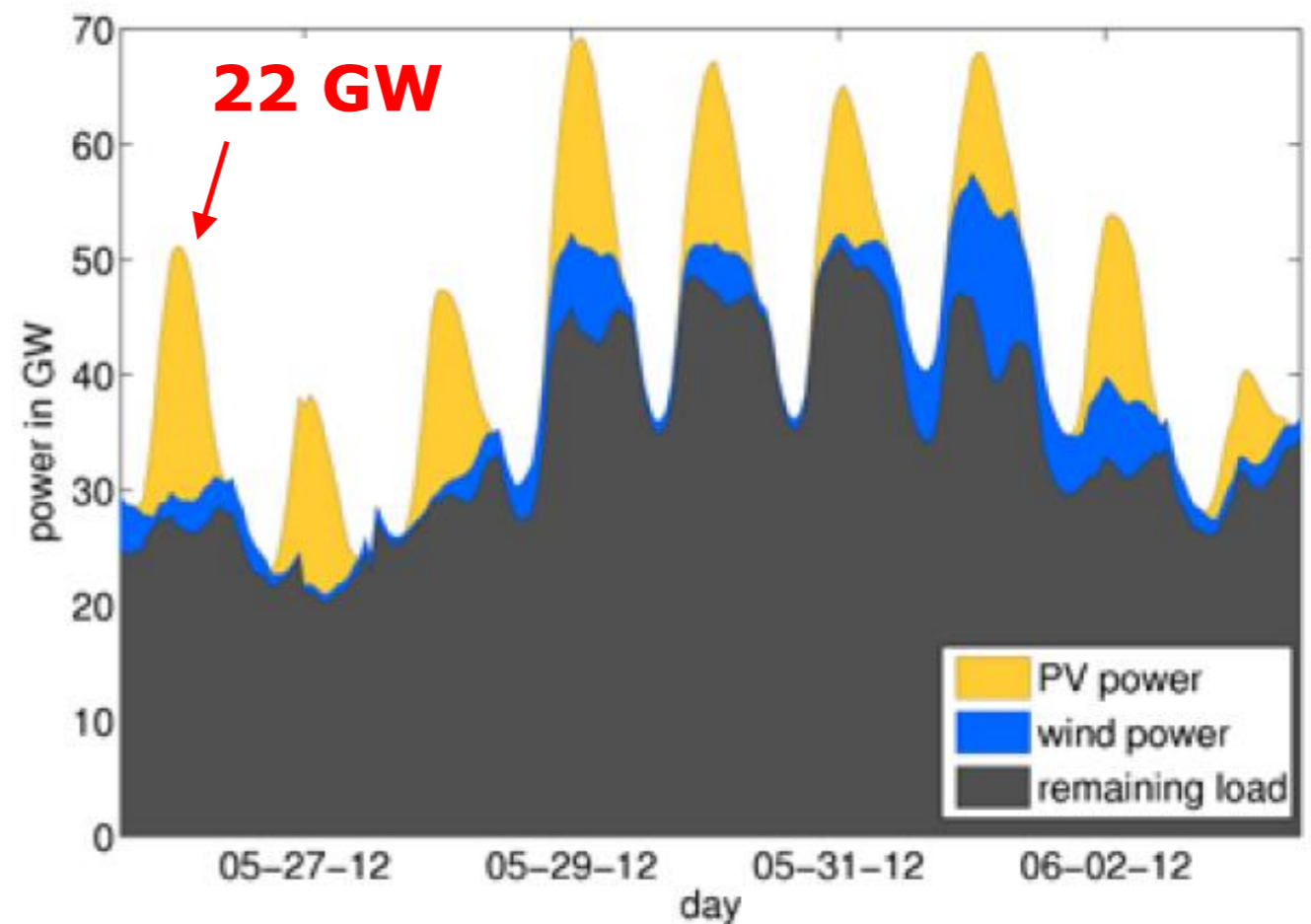
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Contribution of PV systems to electricity supply in Germany

- ▶ installed PV power (end 2014):
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- ▶ up to **50%** of electricity demand from PV
- ▶ strong variability of solar and wind power



Energy meteorology and resource assessment

.. are necessary for:

- ▶ **Planning and monitoring of solar and wind power plants**
precise knowledge of the resource at a given location
- ▶ **Economic operation of these plants and grid integration of large shares of solar and wind power**
forecasts of solar and PV power
- ▶ **Planning of the future energy supply system**
knowledge of spatial-temporal variability of available energy
- ▶ **Development of next generation of systems and technology**
detailed specification of relevant meteorological conditions

Research Topics

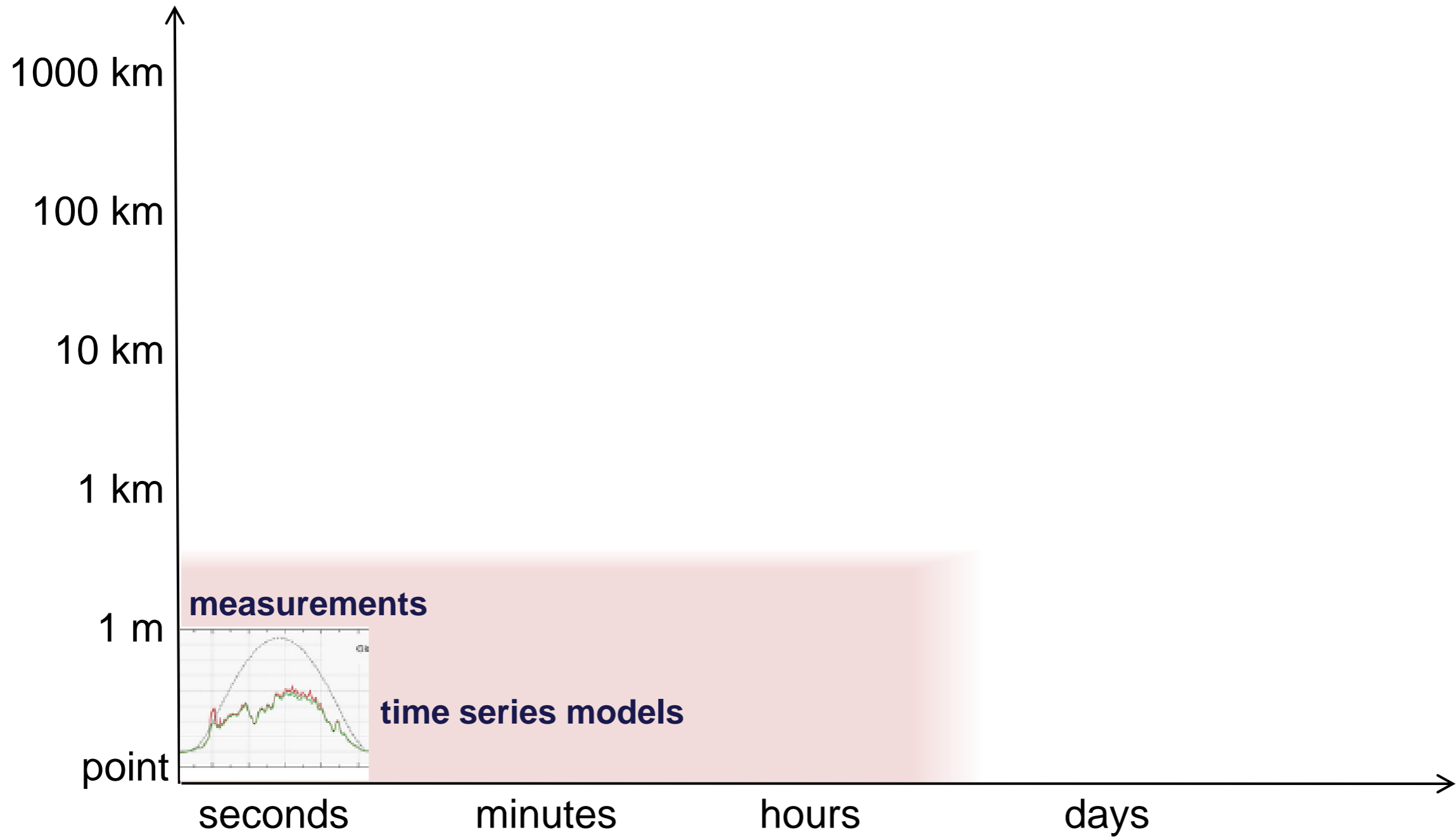
Solar

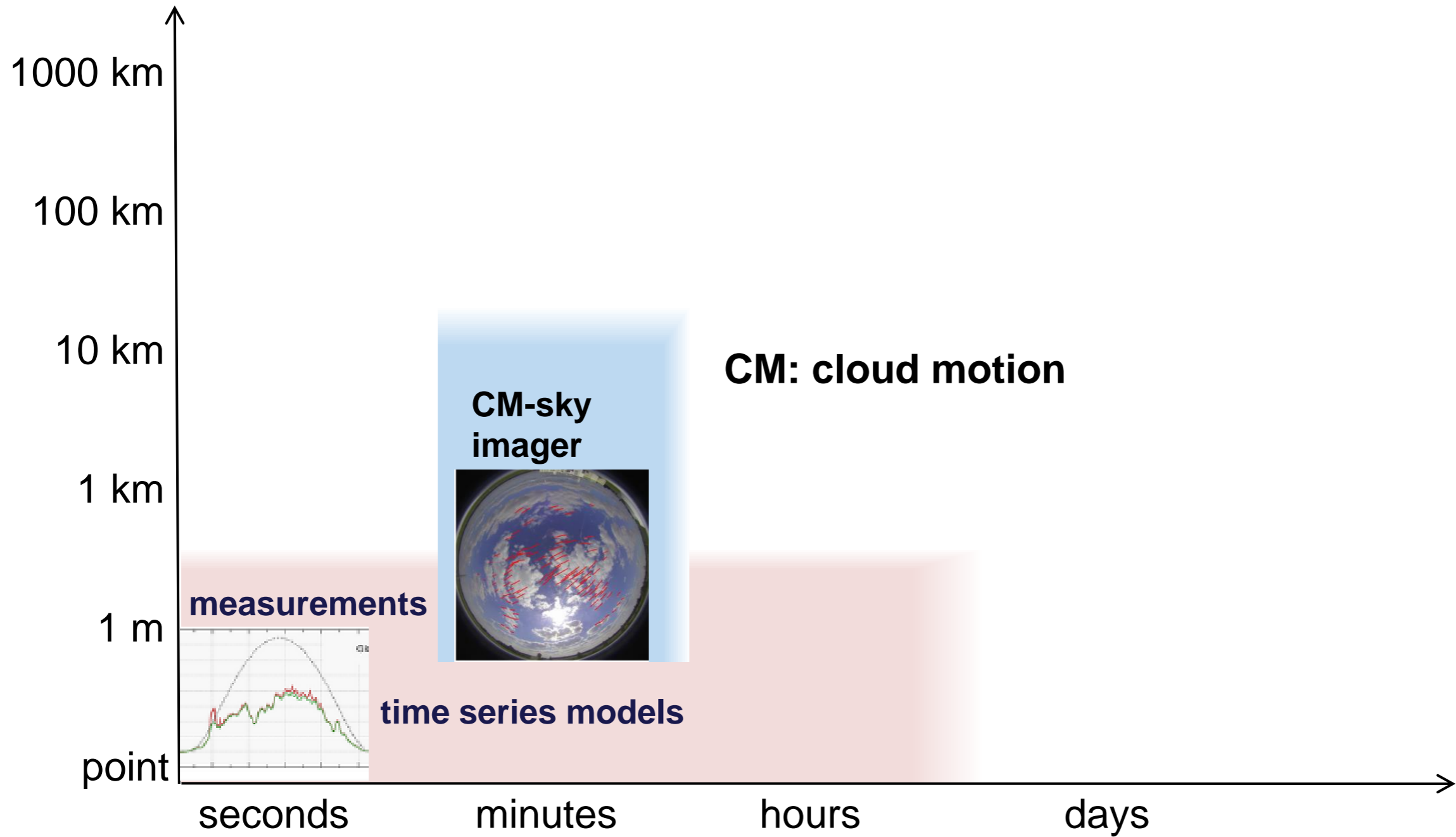
- ▶ Solar power forecasting
- ▶ Satellite-based solar resource assessment
- ▶ Small-scale irradiance modelling based on sky imager data
- ▶ Measurement and modelling of solar spectral irradiance and its influence on PV

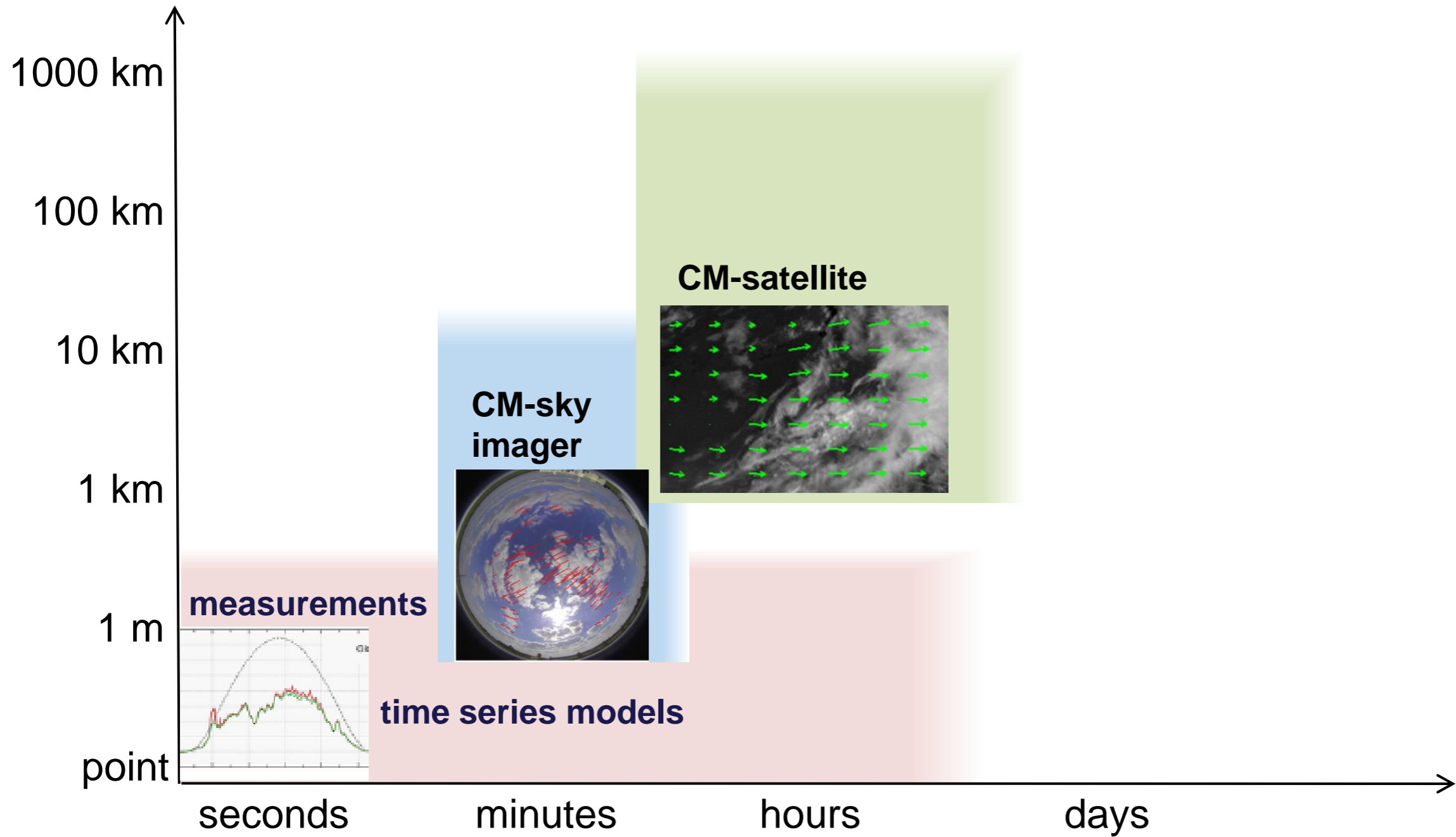
Wind

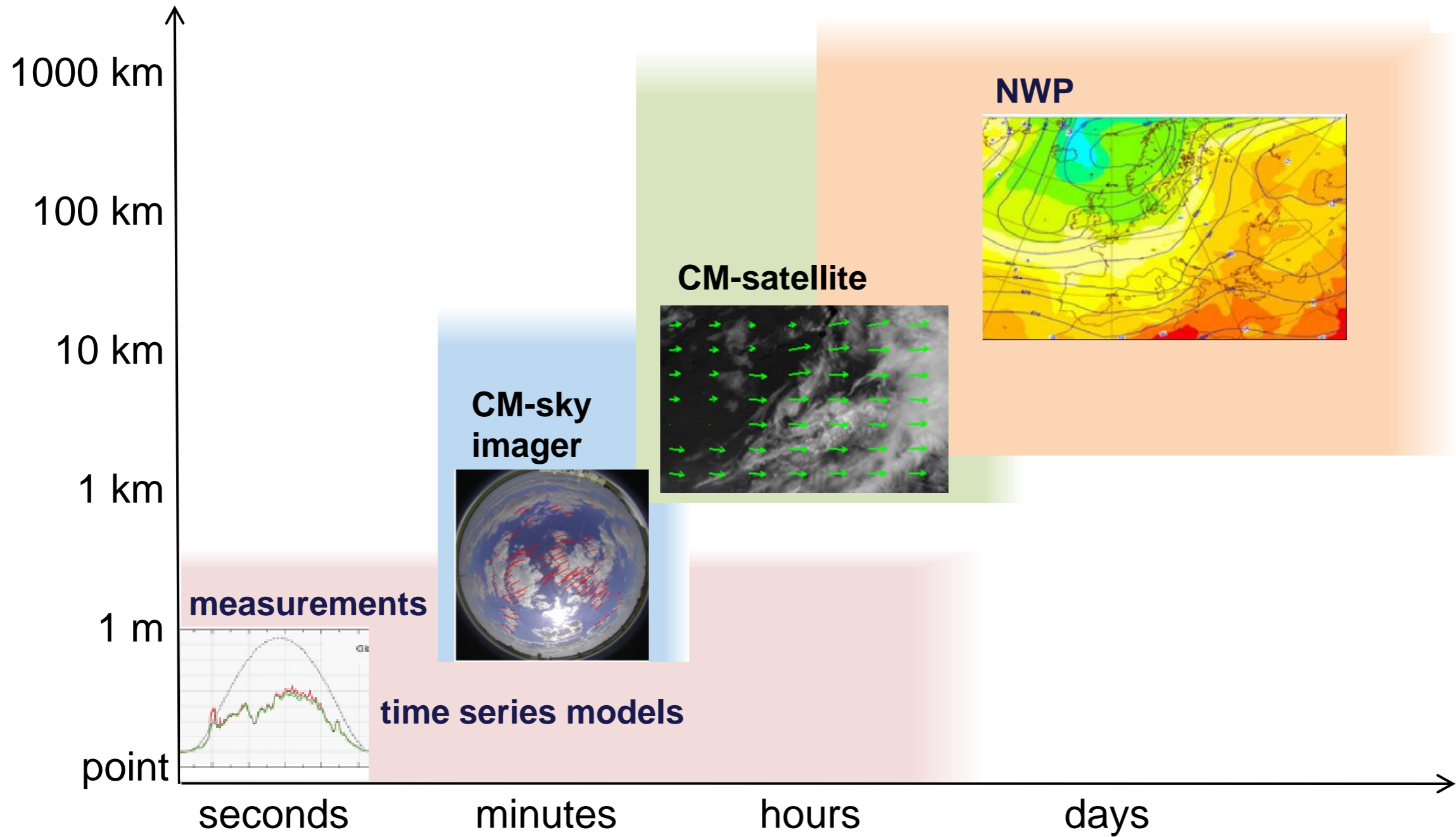
- ▶ Wind power forecasting
- ▶ Meso-scale wind resource modelling
- ▶ Wake modelling
- ▶ Large eddy simulation
- ▶ Small scale turbulence
- ▶ Boundary layer flow modelling
- ▶ Extreme winds

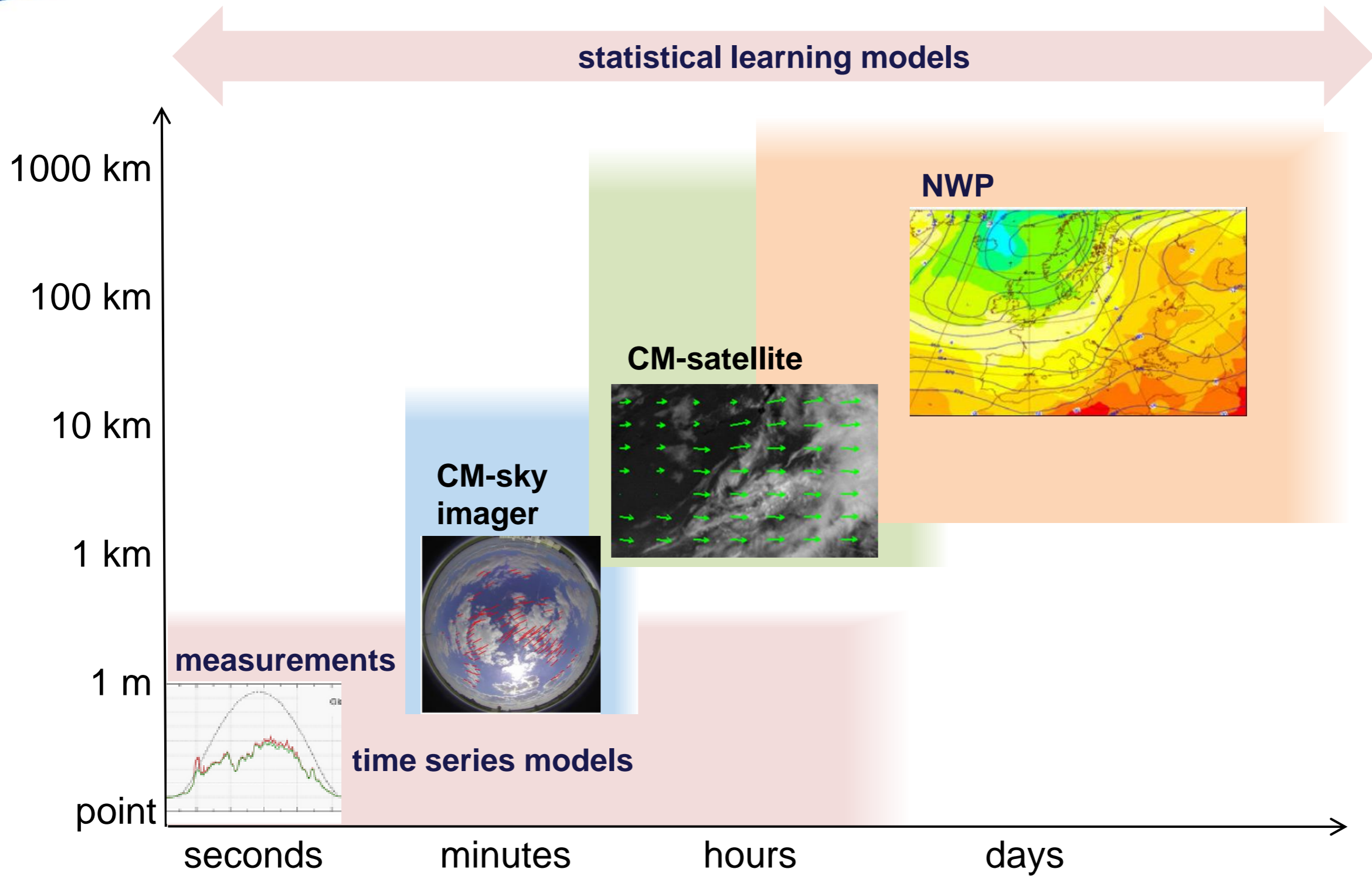
Investigation of combined solar wind power production (balancing)











International Collaborations (solar)

- ▶ International Energy Agency (IEA)
Solar Heating and Cooling (SHC) Task 46
Solar Resource Assessment and Forecasting
world-wide collaboration
- ▶ COST action **WIRE: Weather Intelligence for Renewable Energies**
European network
- ▶ EC funded projects:
 - ▶ **PerformancePlus** (Belgium, Italy, Germany)
 - ▶ ..

IEA SHC Task 46

Solar Resource Assessment and Forecasting

Subtasks:

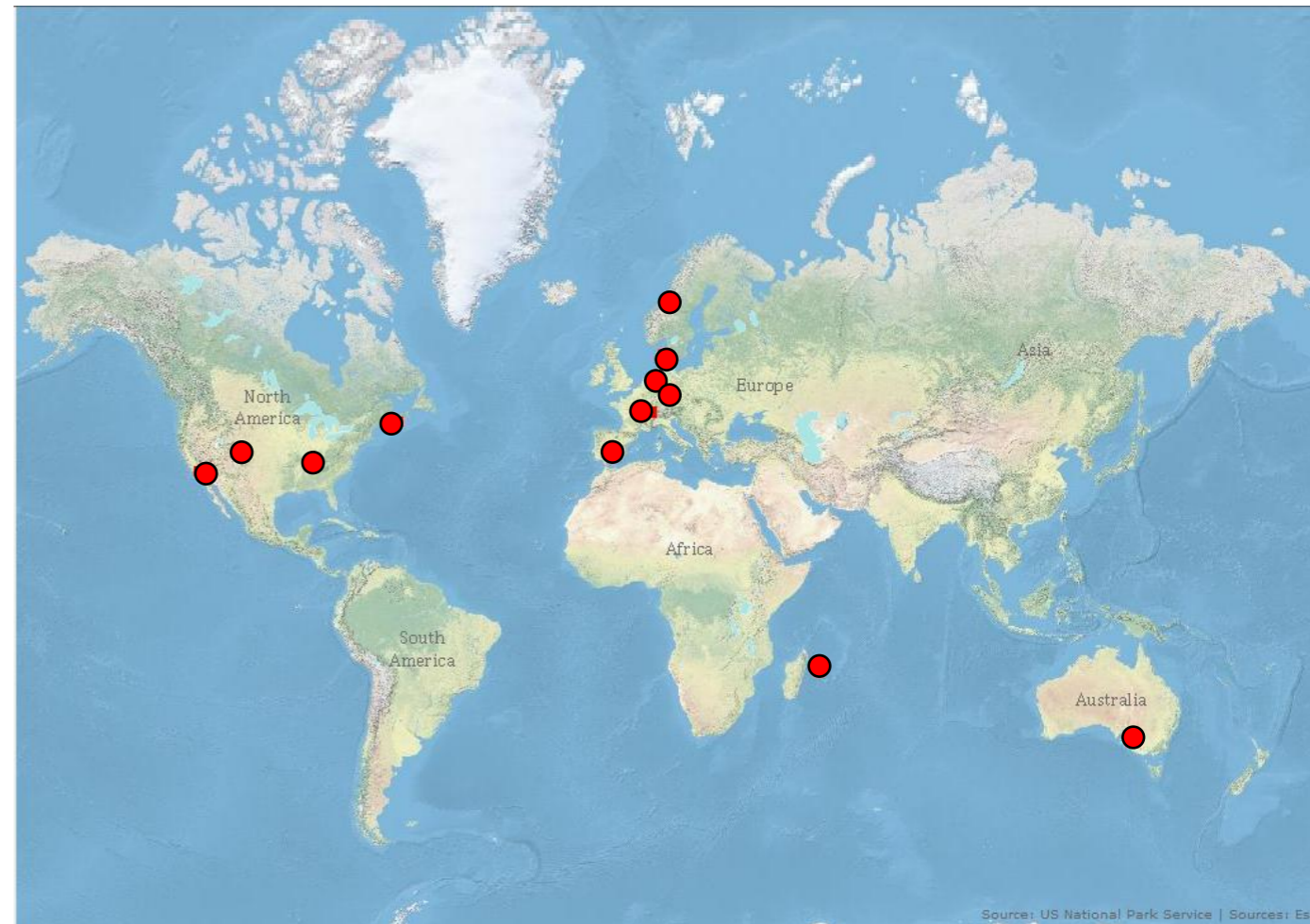
- ▶ Solar resource applications for high penetration of solar technologies
- ▶ Standardization and integration procedures for data bankability
- ▶ Solar irradiance forecasting (Lead: University of Oldenburg)
- ▶ Advanced resource modeling



IEA SHC Task 46 Solar Resource Assessment and Forecasting

World-wide network of experts (research and industry)

- ▶ **Germany:** Uni Oldenburg, DLR, SunTrace, HS Ulm
- ▶ **France:** MinesParisTech, PIMENT
- ▶ **Denmark:** DMI/DTU
- ▶ **Austria:** ASIC, BlueSky
- ▶ **Switzerland:** MeteoTest, Uni Geneva
- ▶ **Slovakia:** GeoModel Solar
- ▶ **Norway:** Uni Agder
- ▶ **Spain:** CENER, CIEMAT, Uni Jaen
- ▶ **U.S.:** NREL, UCSD, SUNY, NASA/LaRC
- ▶ **Australia:** BoM, CSIRO, UniSA
- ▶ **Canada:** GPL



COST WIRE Short term scientific missions (STSM):

- ▶ PhD Thomas Schmidt at Mines ParisTech/EDF (2014)
Surface solar irradiance retrieval from sky imager pictures
- ▶ Jorid Badosa from LMD, Ecole Polytechnique (2014)
Satellite-based solar irradiance forecasting on Reunion
Tropical Island
- ▶ Pavel Krc from Inst. of Computer Science, Academy of
Sciences of the Czech Republic (2012)
Modeling Solar Power Production from NWP Outputs

Surface solar irradiance retrieval from sky imager pictures

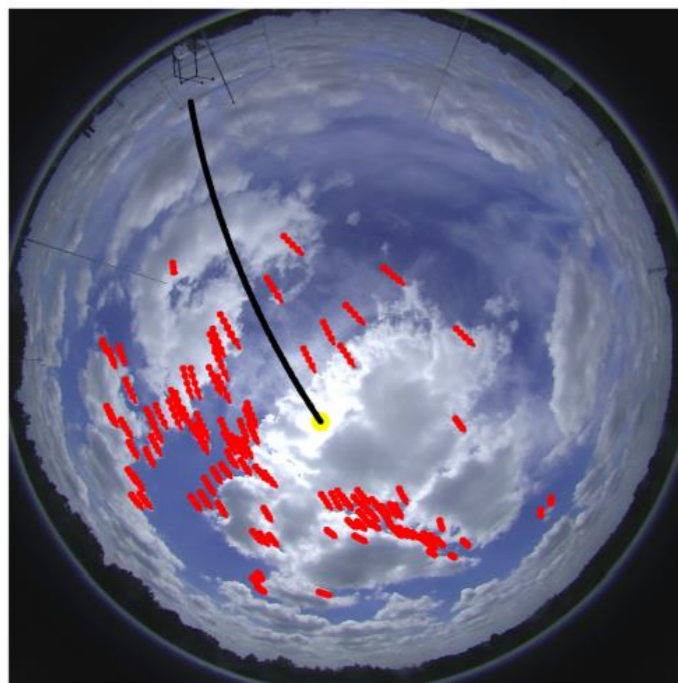
Motivation: High resolution short term forecasting
for solar energy applications

Surface solar irradiance retrieval from sky imager pictures

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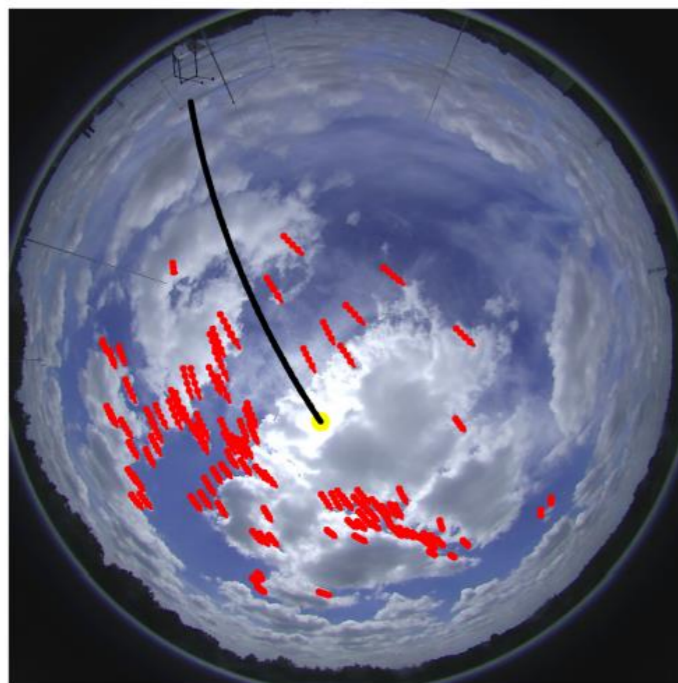
Sky imager pictures



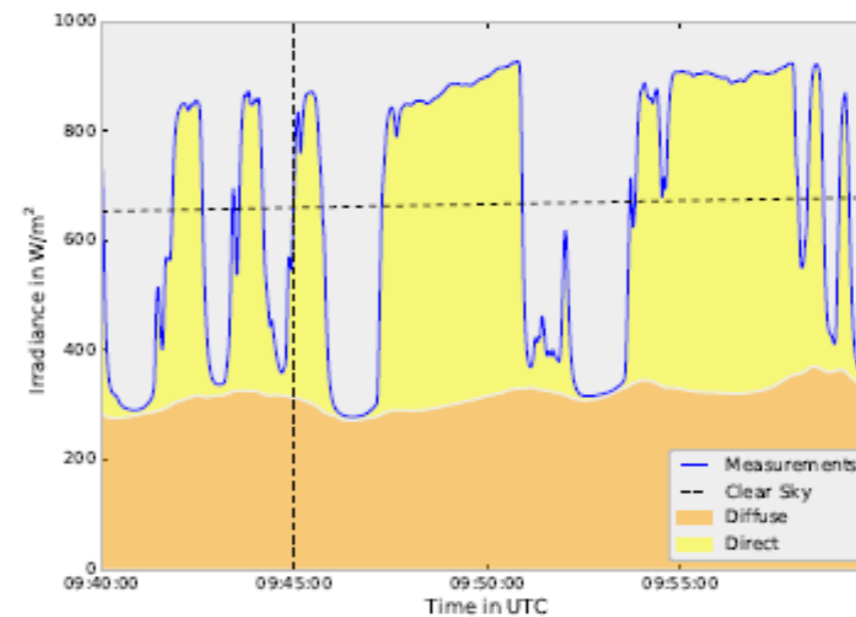
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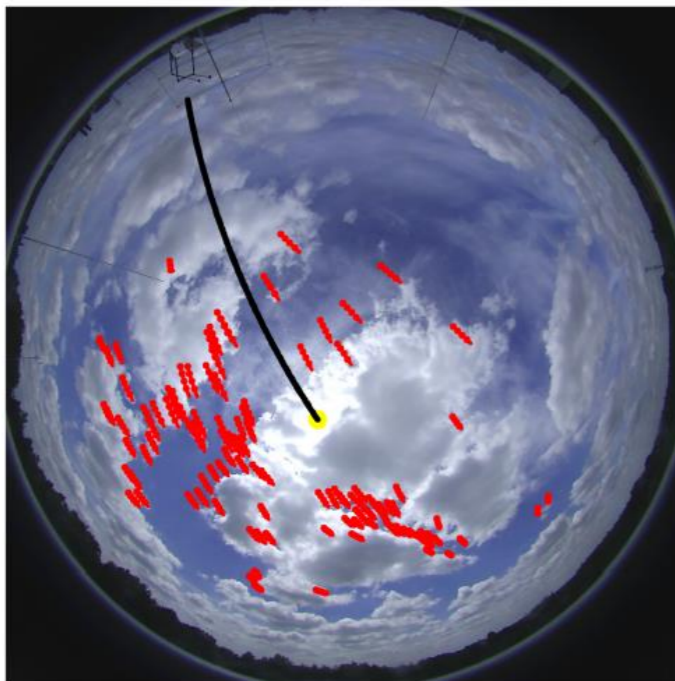
Aim:
Forecast of solar surface irradiance



Surface solar irradiance retrieval from sky imager pictures

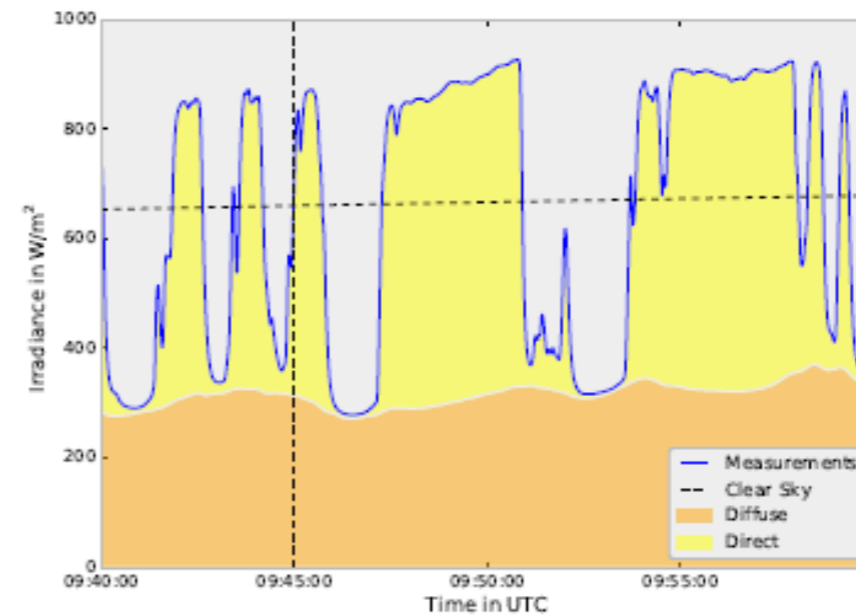
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Basis:
Sky imager pictures



→
method for
irradiance
retrieval

Aim:
Forecast of solar surface irradiance



Surface solar irradiance retrieval from sky imager pictures

Approach:

Use different
image features
to infer irradiance
with statistical methods

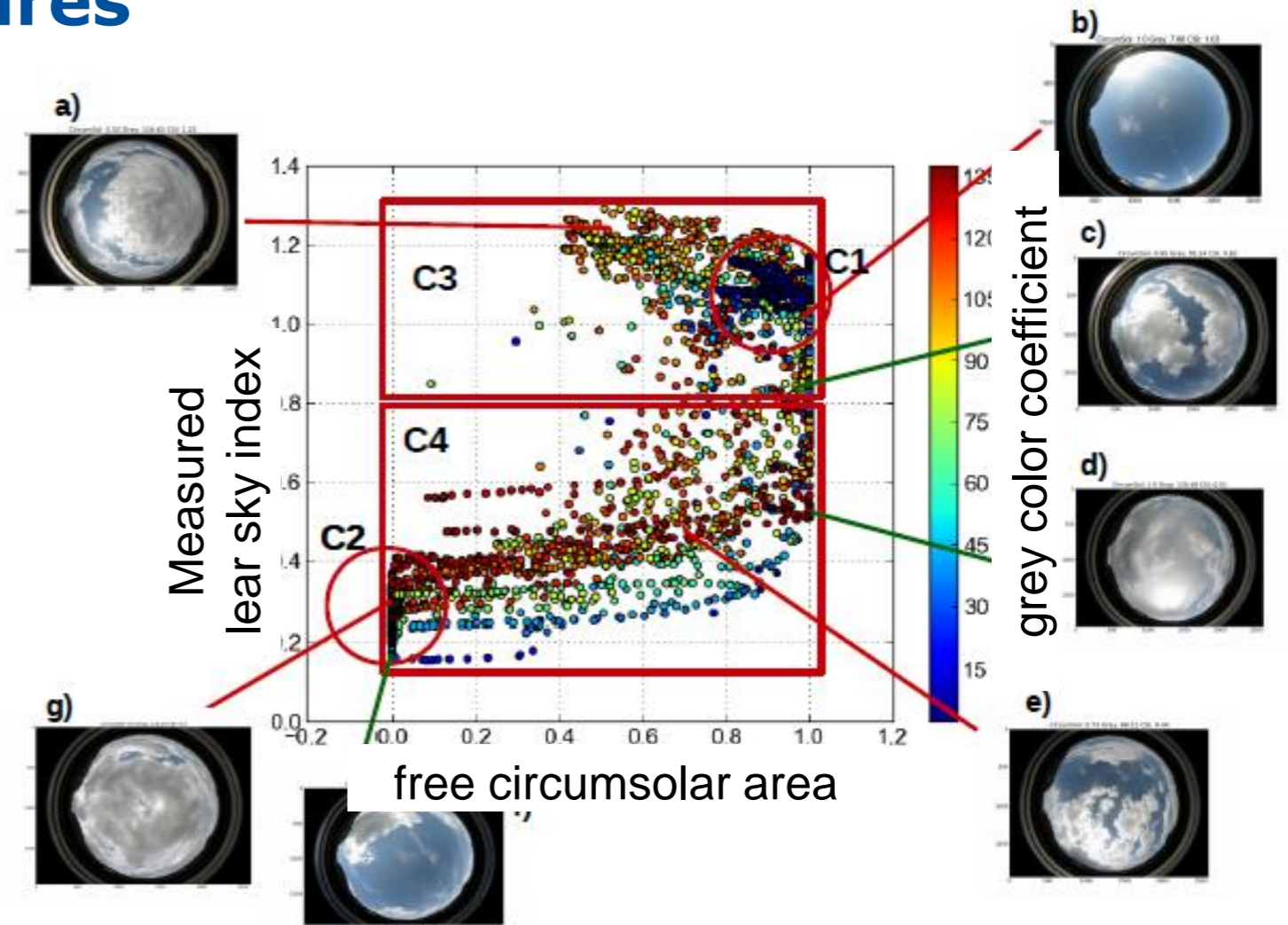


Figure: Sky Imager and Clear Sky Index, STSM at Mines ParisTech/EDF, July 2014

Exchange in the framework of IPID4all

- ▶ Alexander Kies
- ▶ Host University: Aarhus University, Denmark
- ▶ Host Supervisor: Prof. Martin Greiner
- ▶ Exchange Period: 20.04.2015 - 16.05.2015

The effects of optimized distributions of generation capacities for wind and solar power in dependency of the transmission grid on storage and balancing needs in Europe is investigated using a spatially highly resolved weather database, generated at Oldenburg University.

Combining expertise in meteorology (Oldenburg University) and energy system modeling (Aarhus University)