Exploitation of high resolution reanalyses concerning renewable energy applications

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Regional Reanalyses

- **Developed within the Hans-Ertel-Centre for Weather Research (HErZ)**
- **Two COSMO-based reanalyses**
  - **COSMO-REA6**
    - CORDEX EUR-11 domain
    - 20 years (1995 – 2014)
    - 6 km horizontal res., 40 vertical layers
  - **COSMO-REA2**
    - Extended COSMO-DE domain
    - 8 years (2007 – 2014)
    - 2 km horizontal res., 50 vertical layers
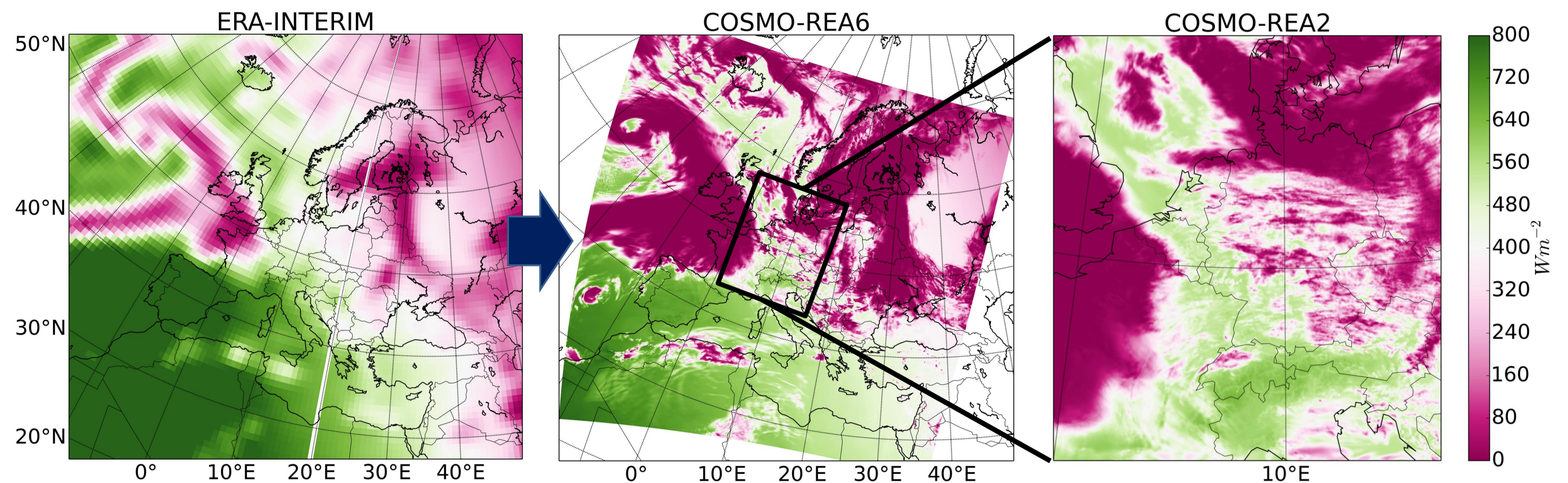
Corresponding Publication: Bollmeyer et al.

Figure 1: Direct solar radiation (13.04.2013) at surface level for ERA-INTERIM (left, avg 12-15 UTC), COSMO-REA6 (middle, avg 12-13 UTC) and COSMO-REA2 (right, avg 12-13 UTC) domain
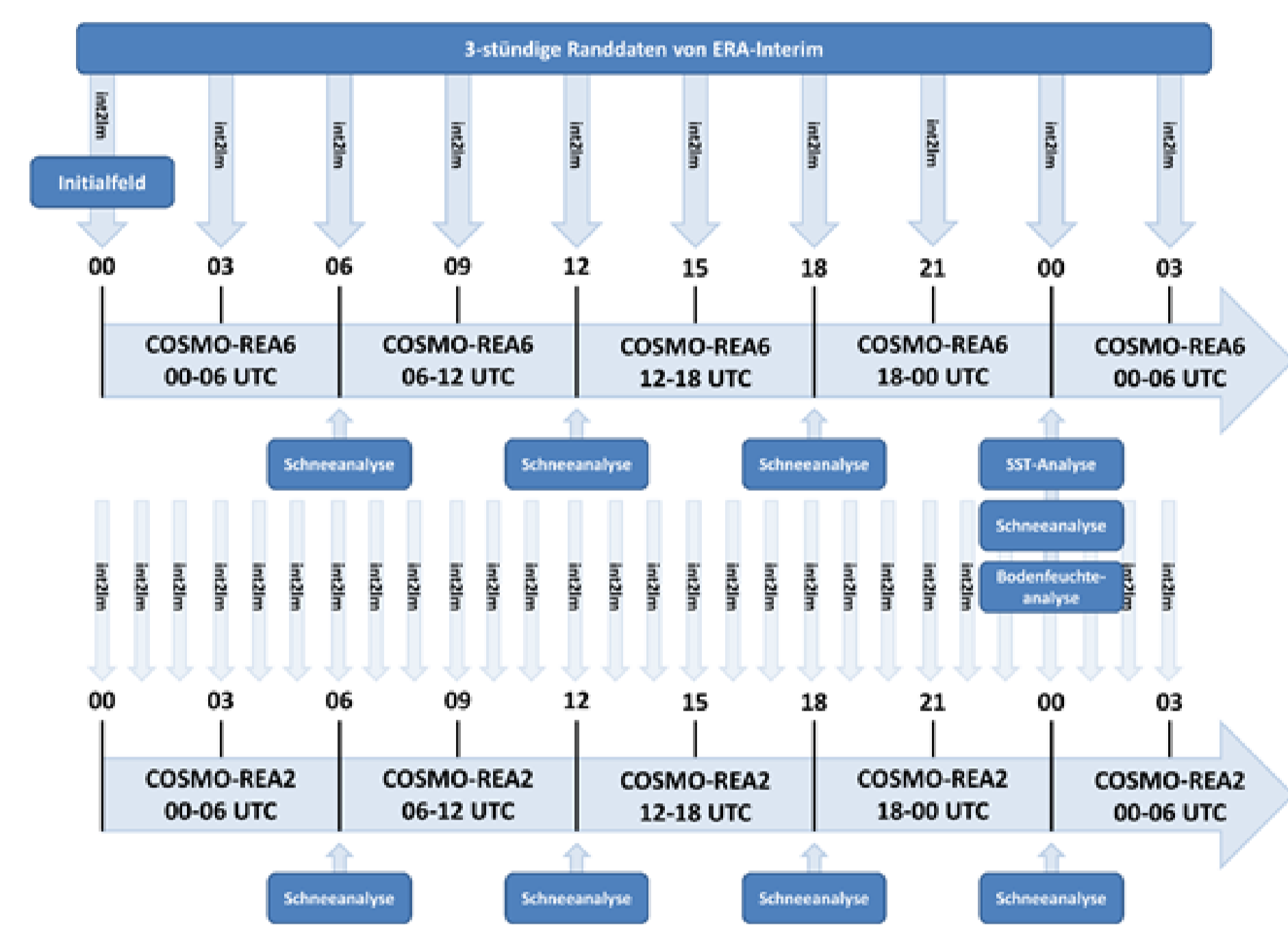

Figure 2: Process cycle of COSMO-REA6 and COSMO-REA2

- **Data Assimilation**
  - Nudging scheme: SYNOP, SHIP, PILOT, TEMP, AIREP, AMDAR, …
  - REA2 contains additional latent heat nudging (LHN) of weather **RADAR**

- **Output:** 150 atm. and surface variables
  - Interval: 15 min (2D), 60 min (3D)
  - Physically consistent variables in space and time

Central Question:

Added value of regional reanalyses for renewable energy applications?

- **Weather conditions** exert strong **influences on** dispatch of **power plants** as well as on **electricity infrastructure**
- Regional reanalyses **provide relevant quantities** at high spatiotemporal resolution

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Wind – Generate data set of renewable energy potential – Solar

Wind

- General approach to estimate energy potential P

$$P = 0.5 \, c_p \, \rho \, \pi \, R^2 \, v^3$$

- **Use German mean values** for power coefficient c_p and blade radius R
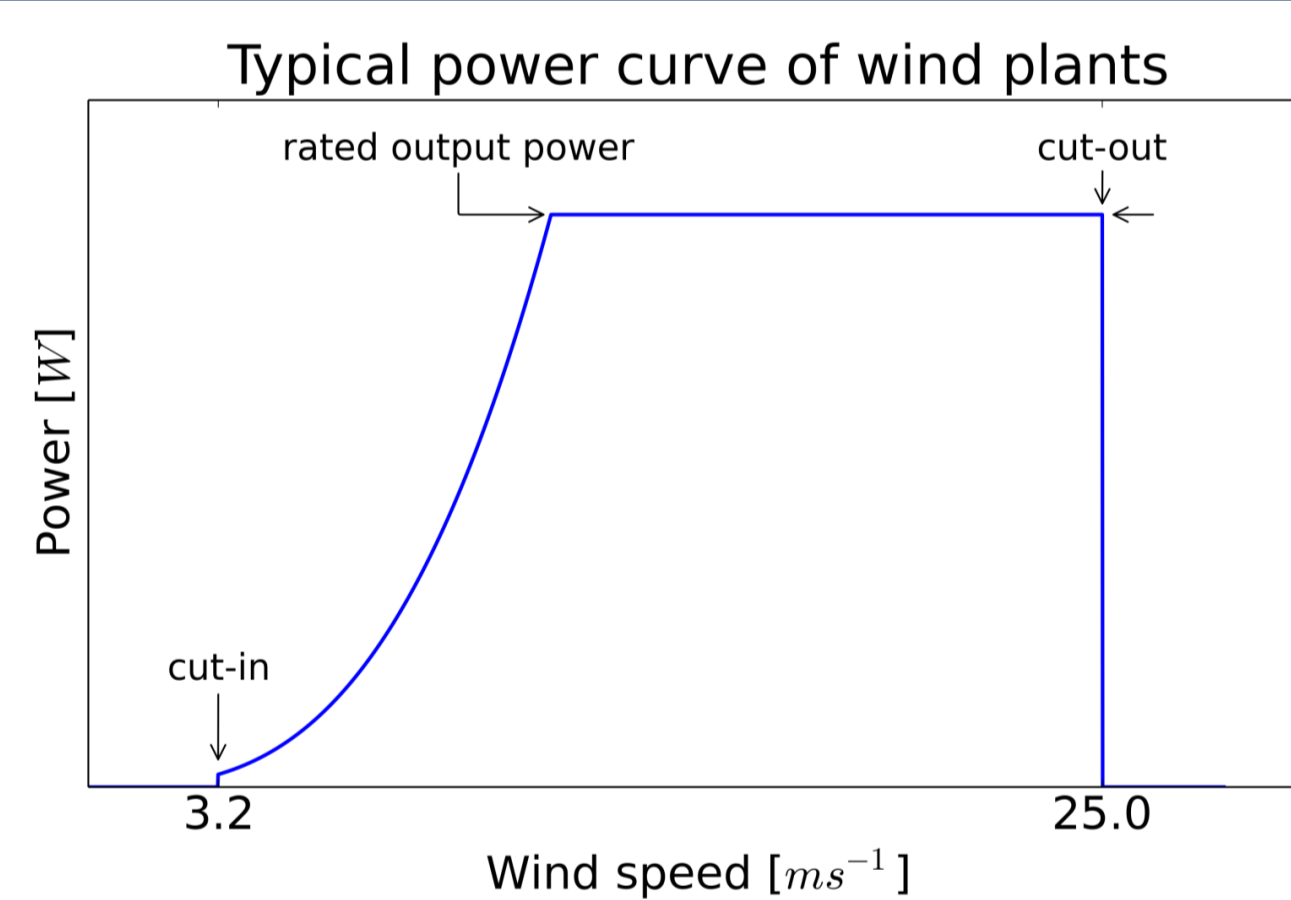- Air density ρ and wind speed v are interpolated from model layers to hub height

Figure 3: Power output as function of wind speed – Use of German mean values
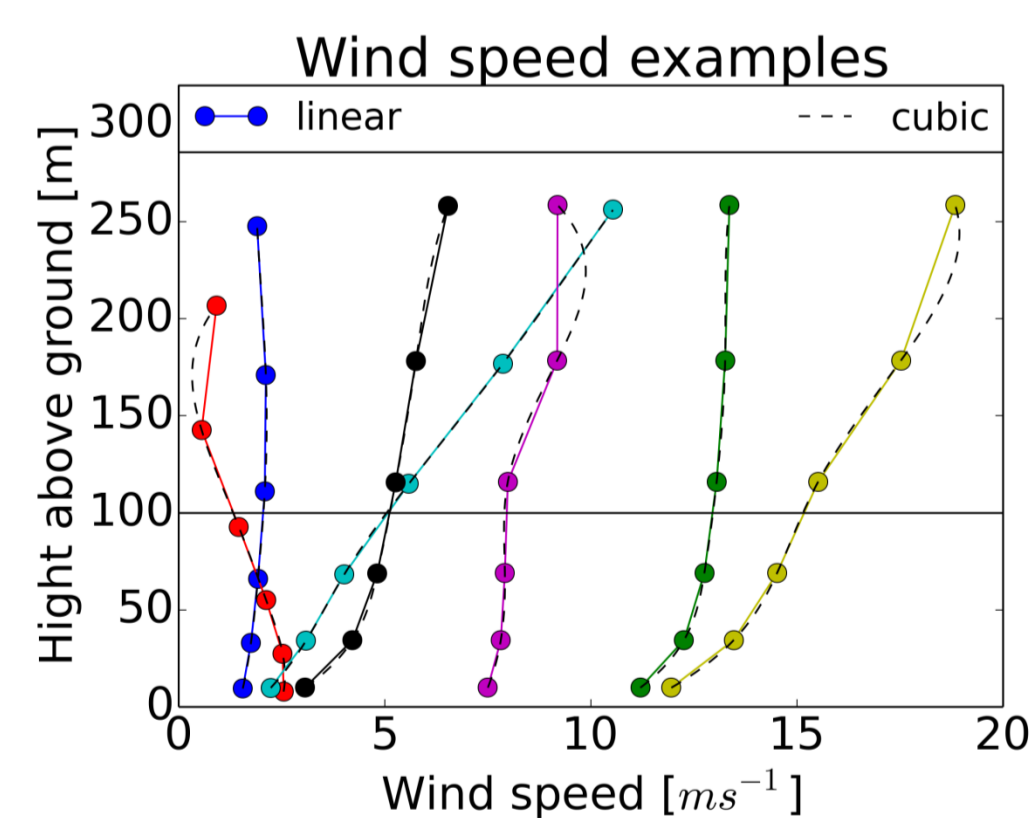

Figure 4: Wind speed at 7 sites (see fig. 5) for the lowest 6 layers with two different interpolation methods

- High vertical resolution reduces uncertainties in interpolation to hub height
- **Validation** of approximations like power law, constant air density…

Key Objective:

Quantify the theoretical potential for renewable energy

- Temporal and spatial dependencies
- Natural limits of renewable energy

Figure 5: REA6 energy generation 01.01.2014 00 UTC, white means no energy generation (see fig. 3)

Solar
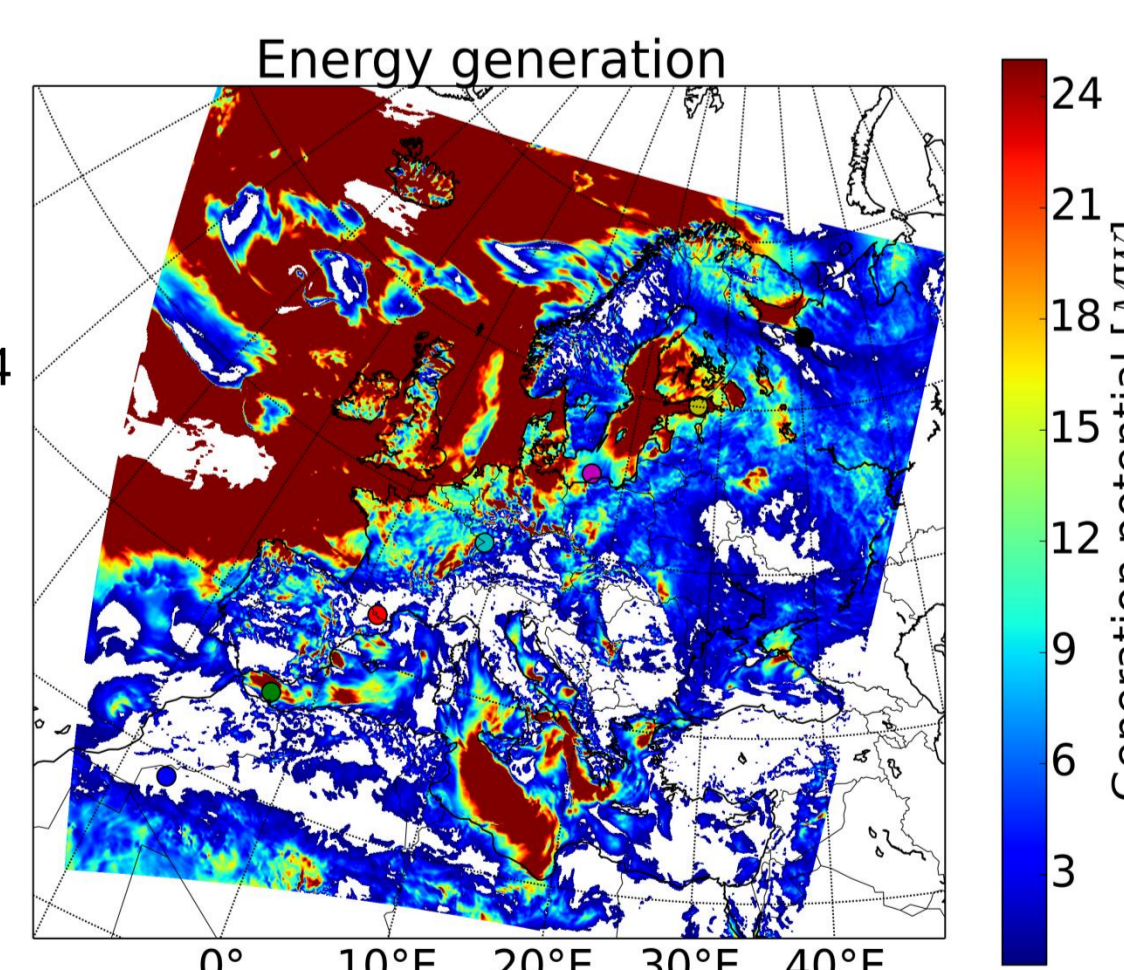
- Development of a **double diode model** to "estimate" power production
- Cooperation with Bonn-Rhein-Sieg University of Applied Sciences
- Input variables: Direct, diffuse radiation up and down
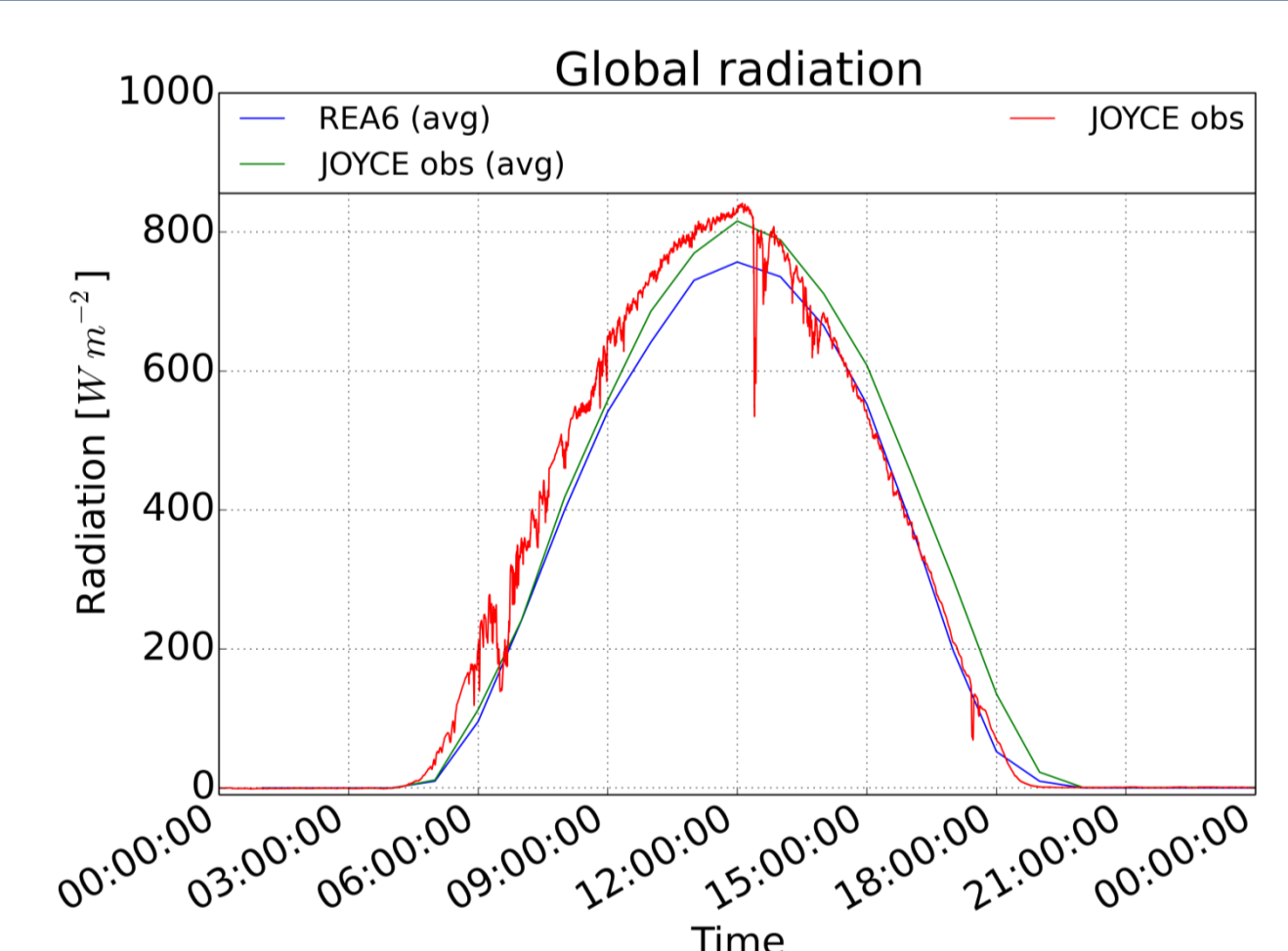- Particularly suitable for silicon PV modules

Figure 6: Simulated global radiation of REA6 (1 h avg) and JOYCE obs (5 s and 1 h avg) at 24.04.2013
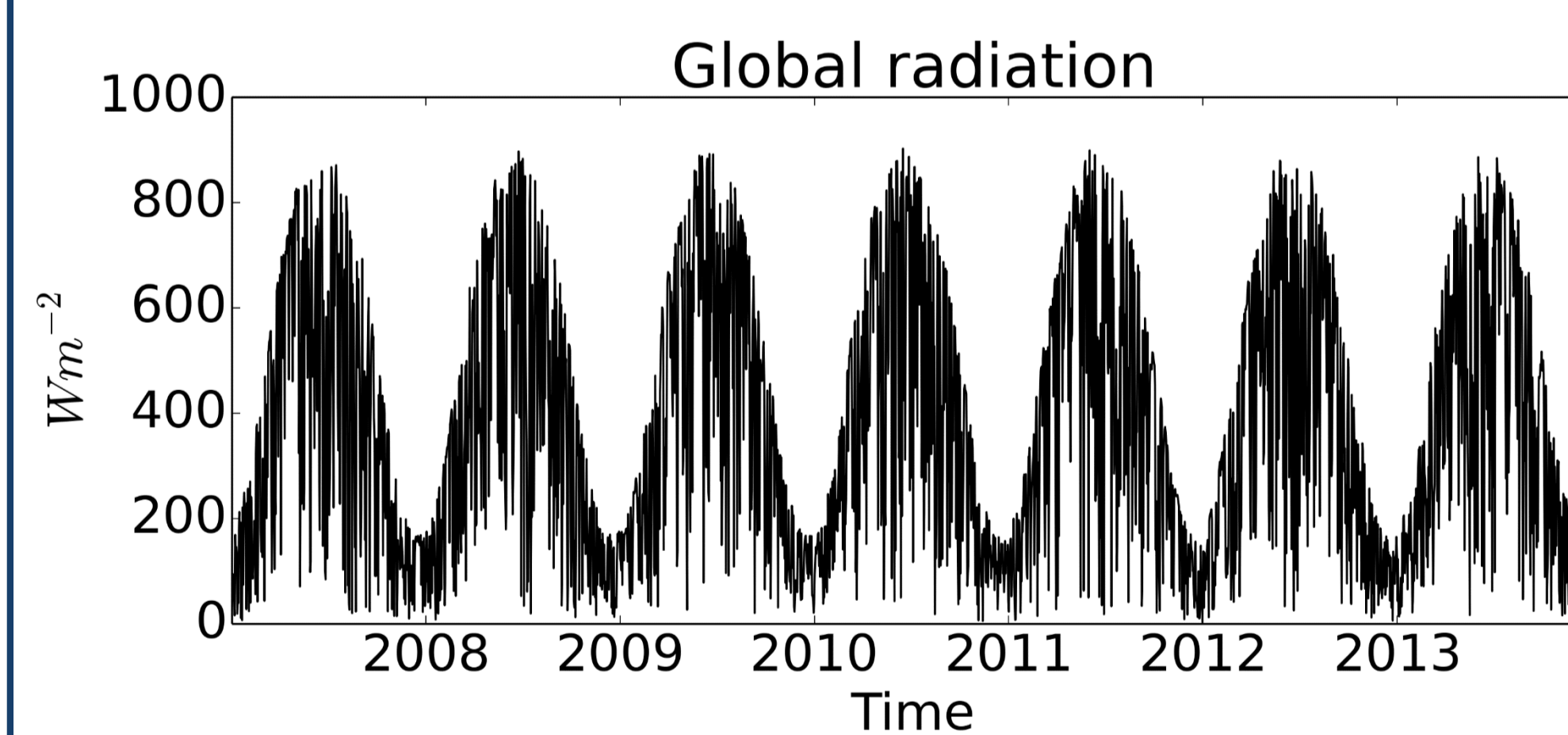
Figure 7: COSMO-REA2 global radiation (avg 12-13 UTC), nearby cologne

Figure 8: COSMO-REA2 histogram of global radiation (avg 12 - 13 UTC)

- Investigate availability of solar energy on various spatio-temporal scales
- Compare estimates of REA-6, REA-2 and ERA Interim
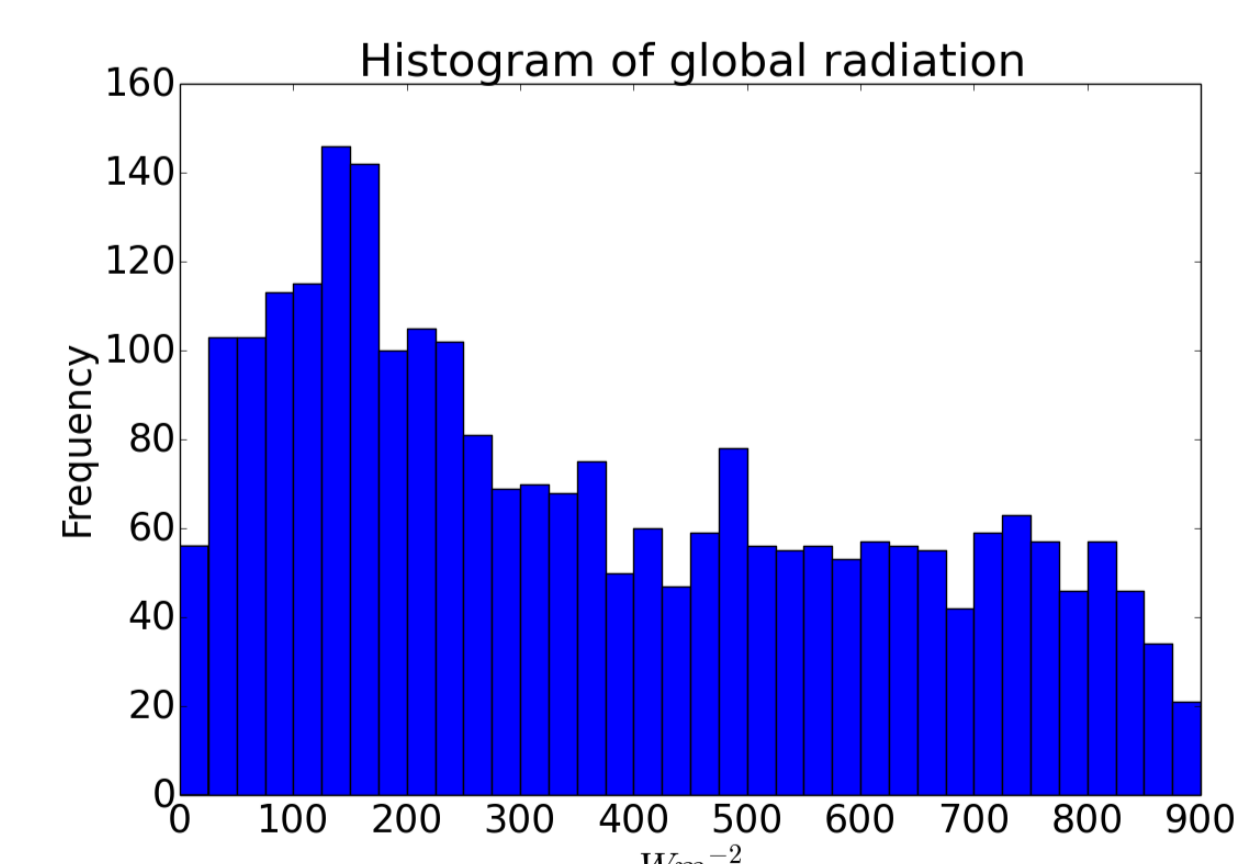- Evaluate with atmospheric supersites (JOYCE), synop stations and "solar consumptions"

Outlook

- **Study availability** of renewable energy limited by **weather related risks**, e.g., non-resolving stratus clouds, snowfall, wind extremes
  - **Compound events** especially **threatening**, e.g., simultaneous reduction of solar, wind and water energy production

→ **Evaluate risks of high-impact weather**
- Identify critical weather constellations and assess their likelihood
- **Investigate** extreme weather events and their **impact on energy potential**

→ **Define constraints for European market**
- Robustness of market/system wrt impact of severe weather events
- Cooperation with **Institute of Energy Economics (EWI)**