# Exploitation of high resolution reanalyses concerning renewable energy applications

**Christopher Frank**[1,2], J. Keller[2,5], C. Ohlwein[3,2], F. Höffler[4], S. Crewell[1]

[1] *Institute of Geophysics and Meteorology, University of Cologne, Germany*

[2] *Hans-Ertel-Zentrum für Wetterforschung, DWD, Germany;* [3] *Meteorological Institute, University Bonn, Germany*

[4] *Institute of Energy Economics, University of Cologne, Germany;* [5] *German Meteorological Service, DWD, Offenbach*

Hans-Ertel-Zentrum für Wetterforschung
Deutscher Wetterdienst

## 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.**

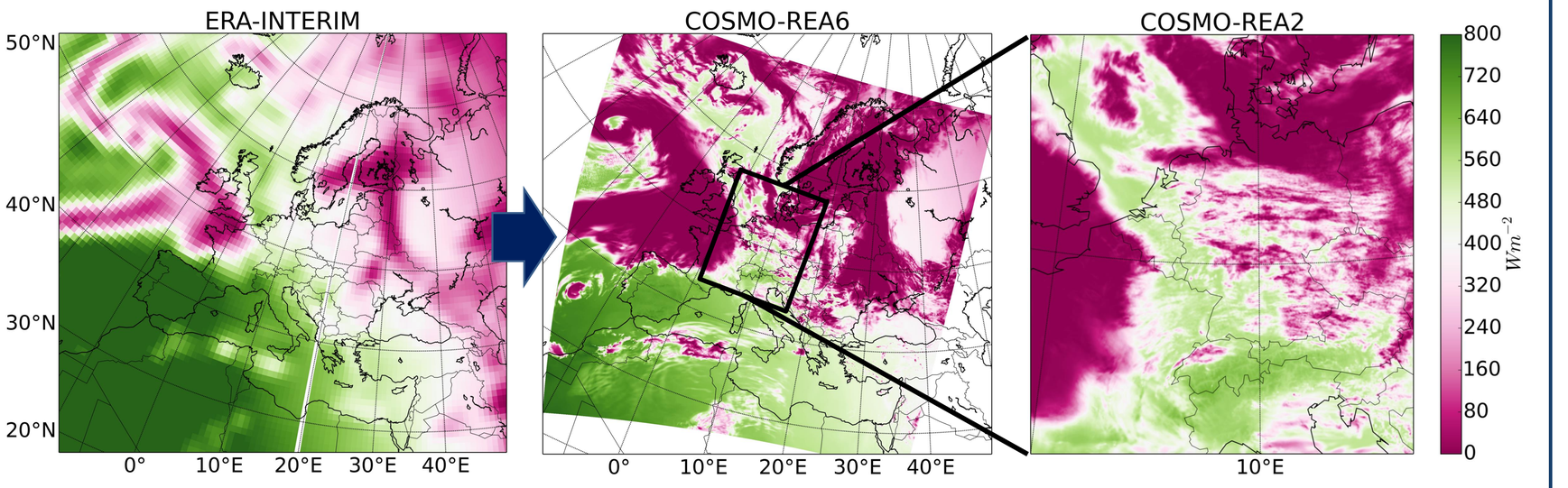


**Figure 1:** Direct solar radiation (13.04.2013) at surface level for ERA-INTERIM (left, avg 12-15 UTC), COSMO-REA6 (middle, avg 12-13 UTC) and COSMO-REA2 (right, avg 12-13 UTC) domain

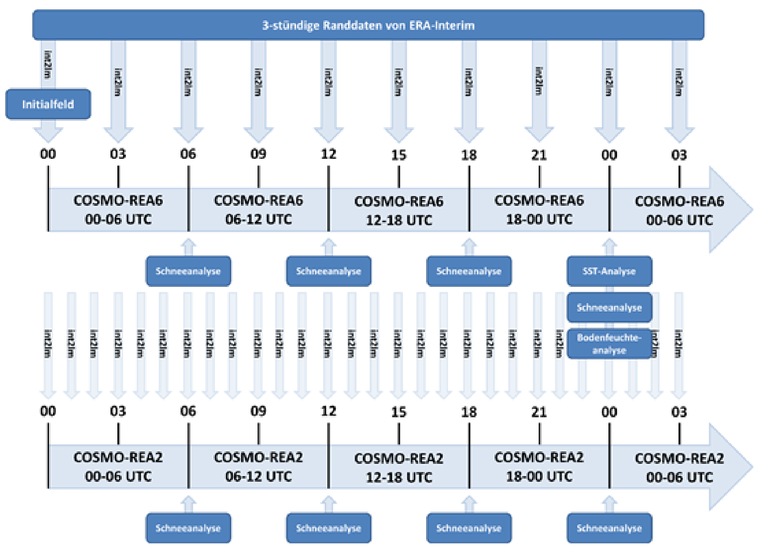


**Figure 2:** Process cycle of COSMO-REA6 and COSMO-REA2

- **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

## **Wind** – Generate data set of renewable energy

- 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 $\rho$ and wind speed $v$ are interpolated from model layers to hub height

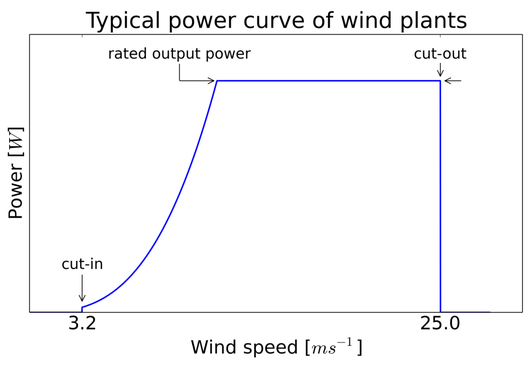


**Figure 3:** Power output as function of wind speed – Use of German mean values

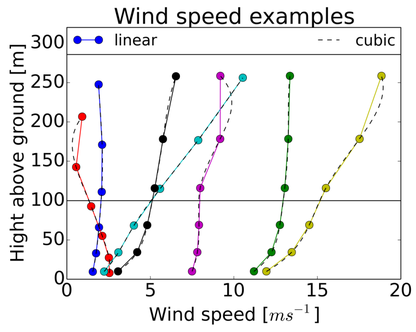


**Figure 4:** Wind speed at 7 sites (see fig. 5) for the lowest 6 layers with two different interpolation methods

- 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

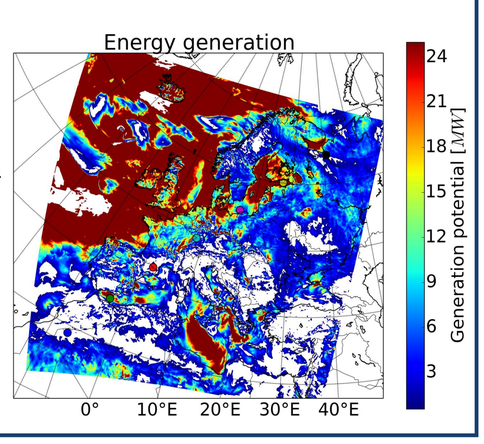


**Figure 5:** REA6 energy generation 01.01.2014 00 UTC, white means no energy generation (see fig. 3)

## **Solar** – Generate data set of renewable energy

- 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

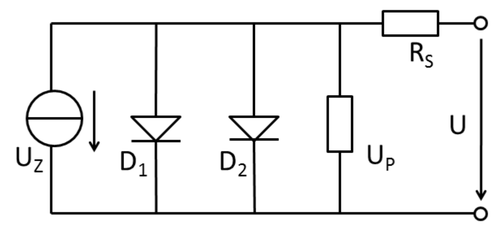


**Figure 6:** Equivalent circuit diagram (Double diode model)

- 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“

## Scale representativeness – Global radiation

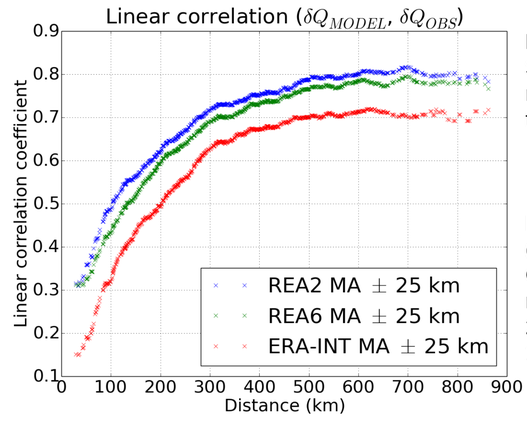


**Figure 7:** Scale representa-tiveness of REA2, REA6 and ERA-INTERIM (Database: Global radiation 2013, avg 12-15 UTC)

Do we have an added value by the use of regional reanalyses and which scales are well represented in the reanalyses ?

$\delta Q = Q_i - Q_j$, (i,j: two sites)

Increasing representativeness from ERA-INT to REA6 to REA2

## Outlook

- **Study availability** of renewable energy focusing on extremes, e.g., persistent low, persistent high, ramps (sudden increase or decrease).
  - **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**)



cfrank@meteo.uni-koeln.de