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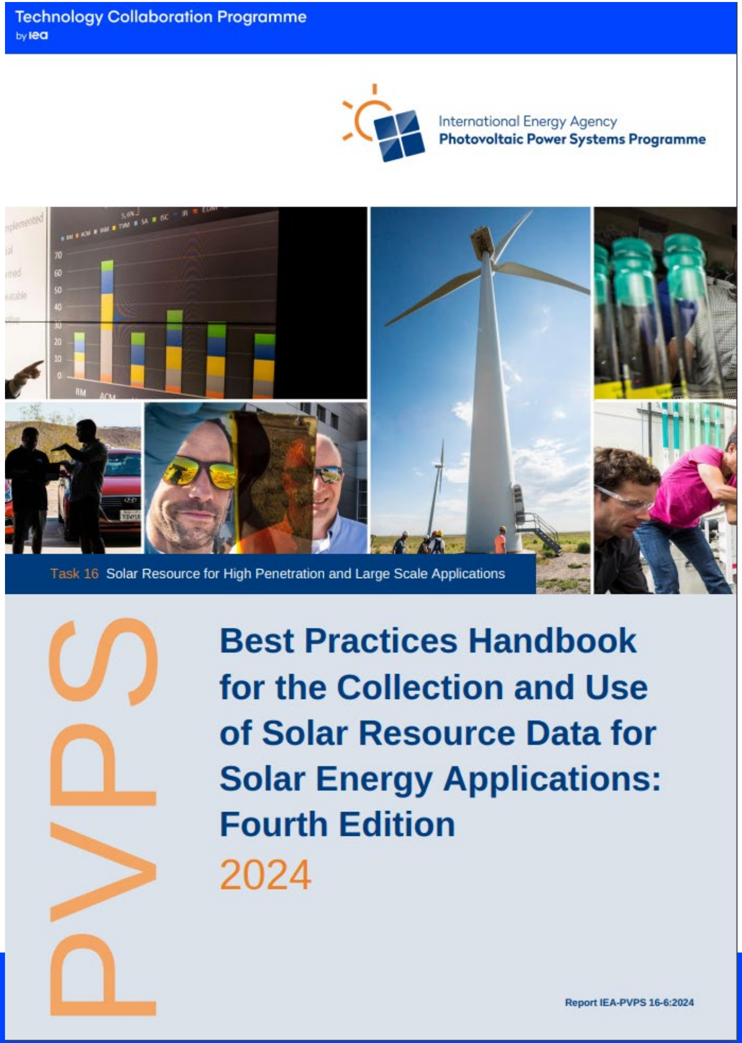
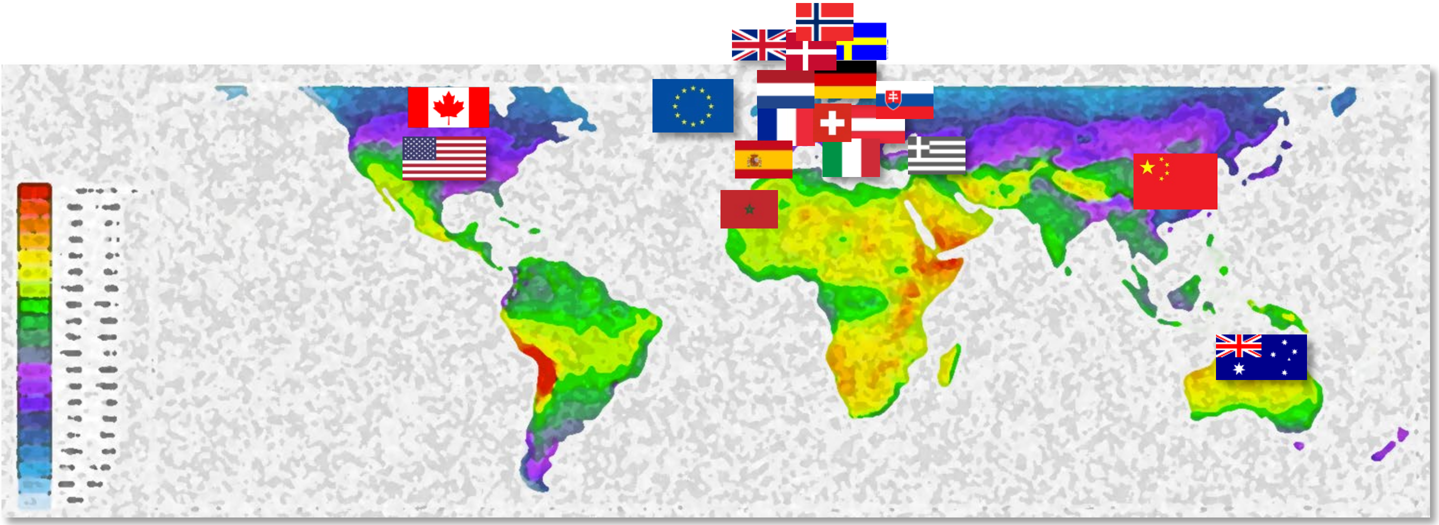
Overview of IEA PVPS Task 16 activities

Kristian Pagh Nielsen,
Danish Meteorological Institute (DMI)
Helsinki, Finland, the 9th of October, 2024



Current status of team

- Universities, research organizations, met services, and service providers
- 19 countries, 47 organizations, 81 experts



Global horizontal irradiance. Source: www.meteonorm.com Version 8.0

Current status of team

47 institutions

Science (labs and universities)

Met Services / utilities

Data providers

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Work plan phase III (2023-2026): activities & leads

Subtask/Activity	Lead
Subtask 1: Current methodologies for solar data generation:	Stefan Wilbert, DEU and Manajit Sengupta, USA
Activity 1.1: Radiation measurements	Stefan Wilbert, DEU
Activity 1.2: Radiation models	Manajit Sengupta, USA
Activity 1.4: Benchmarking solar datasets	Anne Forstinger, DEU
Activity 1.5: Additional meteorological parameters	Vicente Lara Fanego, SVK
Subtask 2: Enhancement of data & value-added products	Philippe Blanc and Lionel Menard, FRA
Activity 2.1 Data quality and format	P. Blanc, Lionel Menard, FRA
Activity 2.4 Climate change and long-term variability	Kristian Nielsen, DNK
Activity 2.5 Products for the end-users	Manajit Sengupta, USA
Activity 2.7: Products of upcoming, integrated technologies	Philippe Blanc, FRA & Cristina Cornaro, ITA
Subtask 3: Solar forecasting	Elke Lorenz, DEU
Activity 3.2 PV power forecasting at different spatio-temporal scales	Elke Lorenz, DEU
Activity 3.3 Probabilistic solar forecasting	Philippe Lauret, FRA and Rodrigo Amaro e Silva, FRA
Activity 3.4 Cloud image based nowcasting (0-6 hours)	Andreas Kazantzidis, GRE and Wilfried van Sark, NLD
Activity 3.5 Firm PV power generation	Richard Perez, USA
Subtask 4: Dissemination and Outreach	Jan Remund, CHE and Adam Jensen, DNK
Activity 4.3 Webinars, workshops, publications and trainings	Jan Remund, CHE
Activity 4.4 Update of solar resource handbook	Aron Habte, USA
Activity 4.5: Practical guide to solar data processing and modeling	Adam Jensen, DNK
Activity 4.6: Update basic knowledge for a broad public (e.g. Wikipedia)	Jan Remund, CHE

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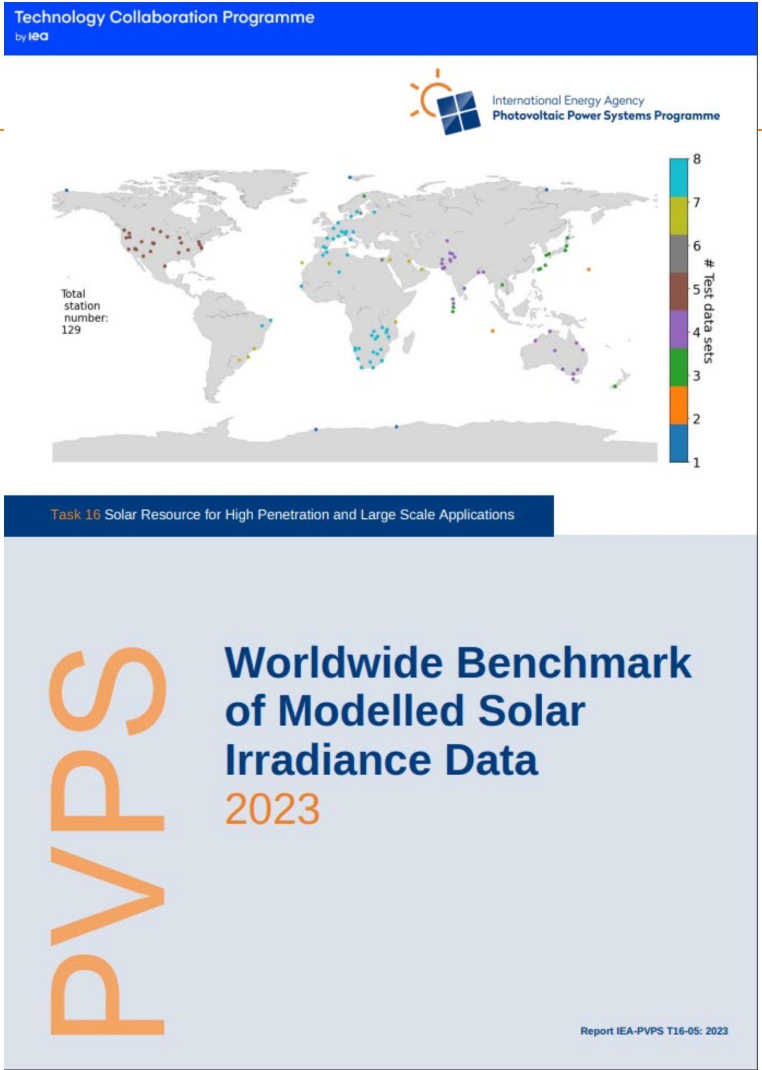

- Anne Forstinger et al. (2023)
- Solar irradiance data benchmarking
- Based on global QC'ed data

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Forecasting solar resources and power

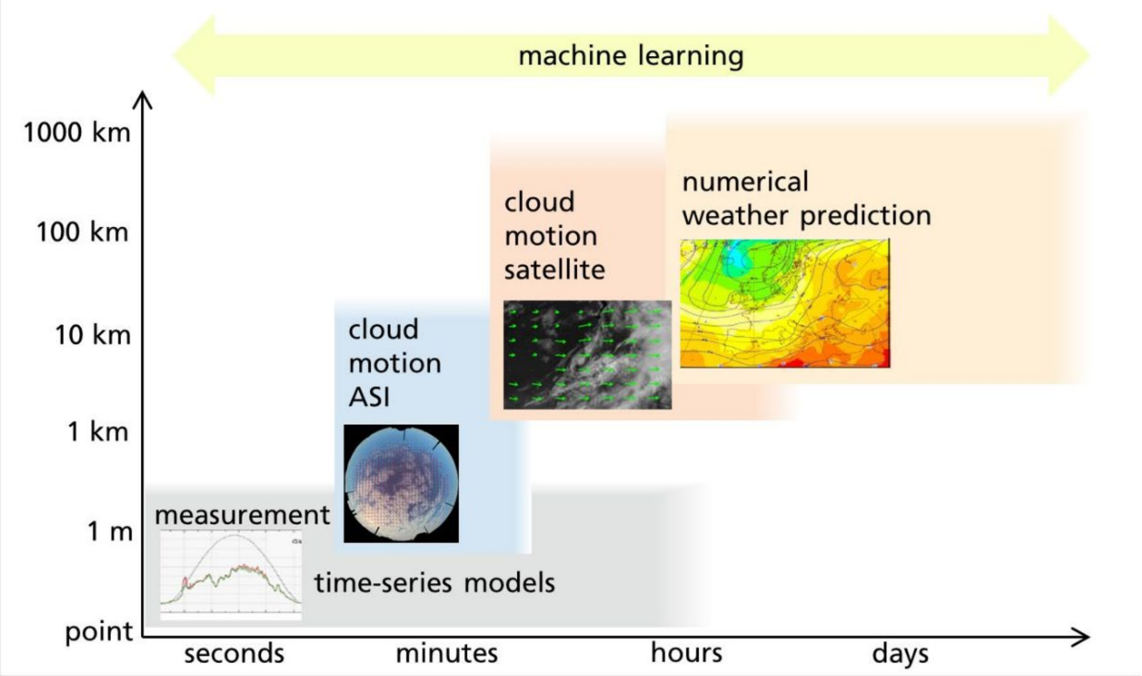

Figure 9-1. Different forecasting methods suitable for various spatial and temporal scales

Empirical and/or physical models are combined with statistical and/or ML models for forecast optimization. The spatial scales of the forecasting methods are defined by spatial resolution and spatial coverage. The temporal scales are defined by temporal resolution, update frequency, and forecast horizon.

Image by Fraunhofer ISE

Geostationary satellite-based forecasting

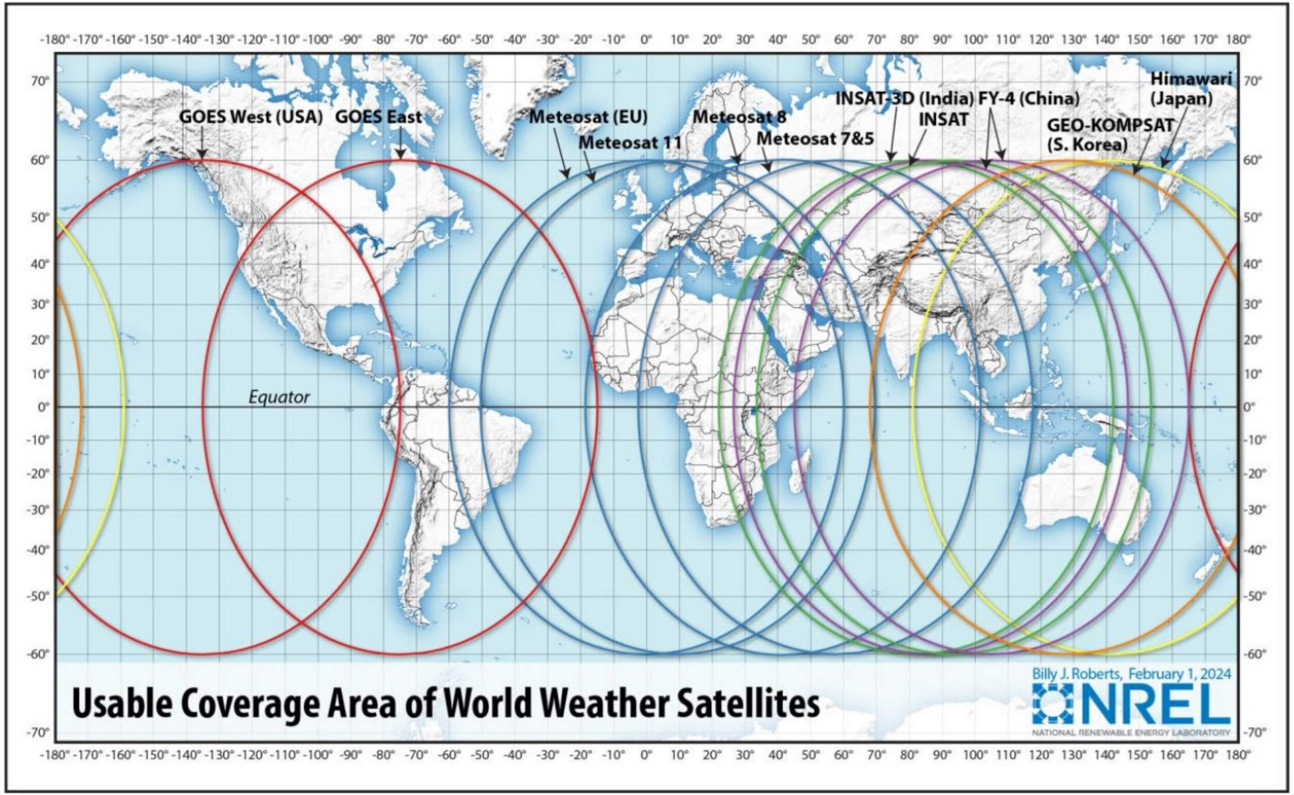

Figure 7-3. Location of the current geostationary satellites providing coverage around the globe

Image by Billy Roberts, NREL

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Forecasting solar resources and power

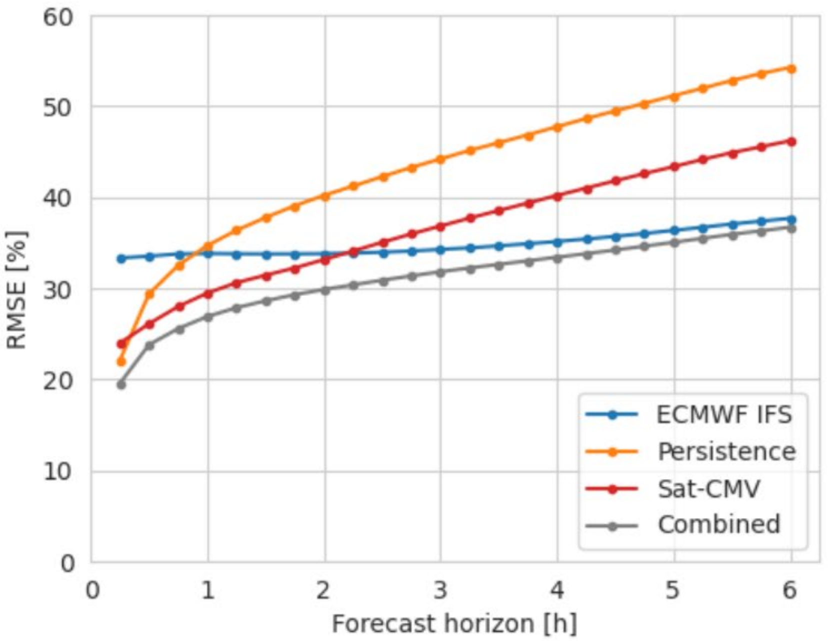
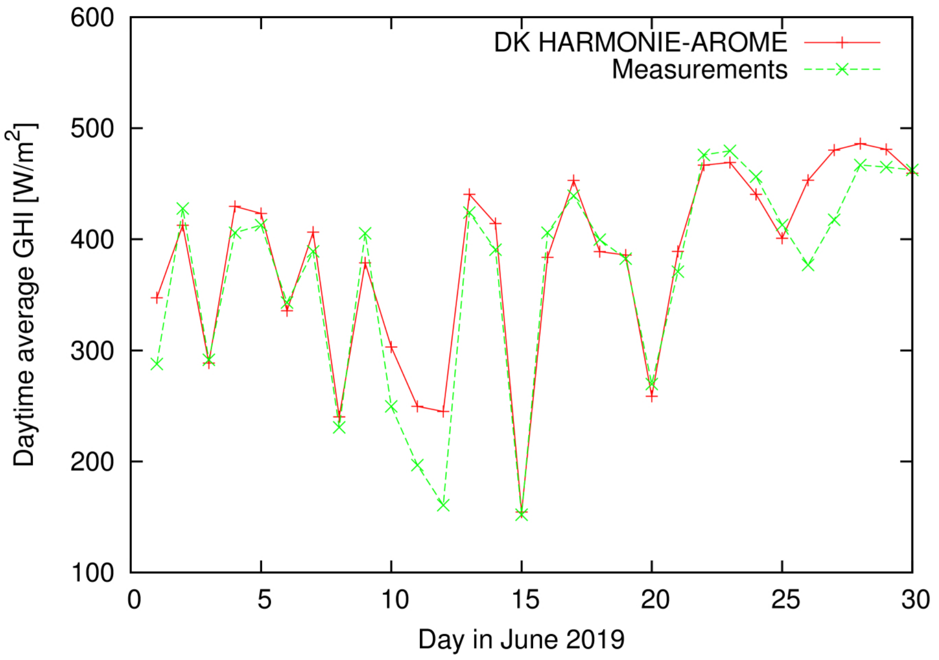


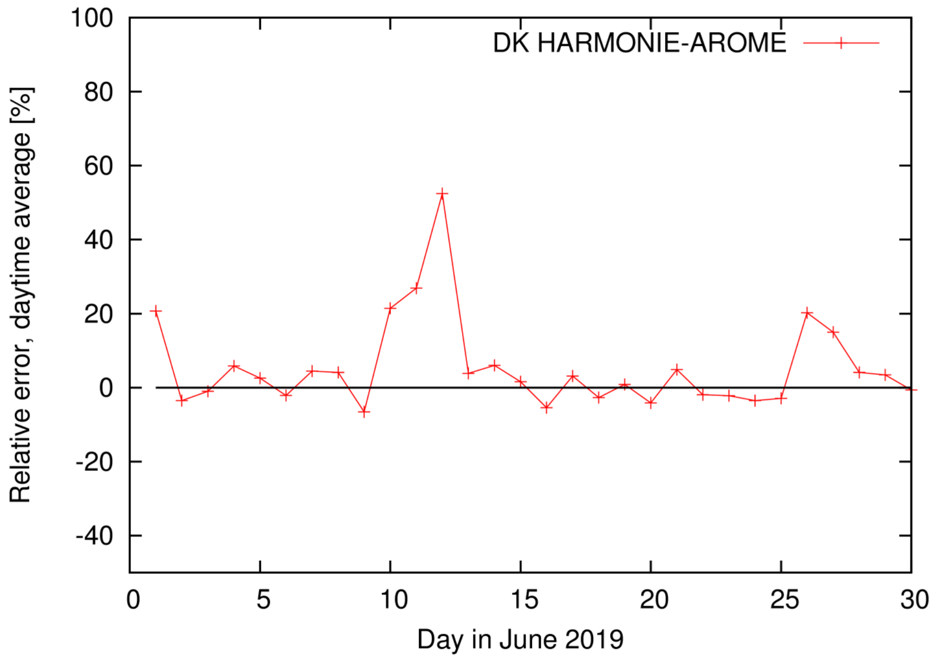
Figure 9-20. Relative RMSE (normalized to the average GHI) of 15-minute-resolution GHI forecasts over lead times up to 6 hours ahead for ground-based scaled persistence (persistence), satellite-based CMV forecasts (Sat-CMV), ECMWF IFS irradiance, and a combination of the three (combined)

Data: Eighteen sites in Germany operated by the German Weather Service during 2018.

Image by Fraunhofer ISE

Solar test case: 11-12 June 2019





Original 2.5 km HARMONIE-AROME forecast performance

Solar test case: 11-12 June 2019

“During 3 days in june, four year ago, the electricity shortage in Germany’s high voltage cables was so excessive that the grid, according to the German authorities, was about to collapse”

DR Nyheder

https://www.dr.dk/nyheder/penge/danske-elhandlere-fik-advarsler-da-tysklands-elnet-var-taet-paa-kollaps

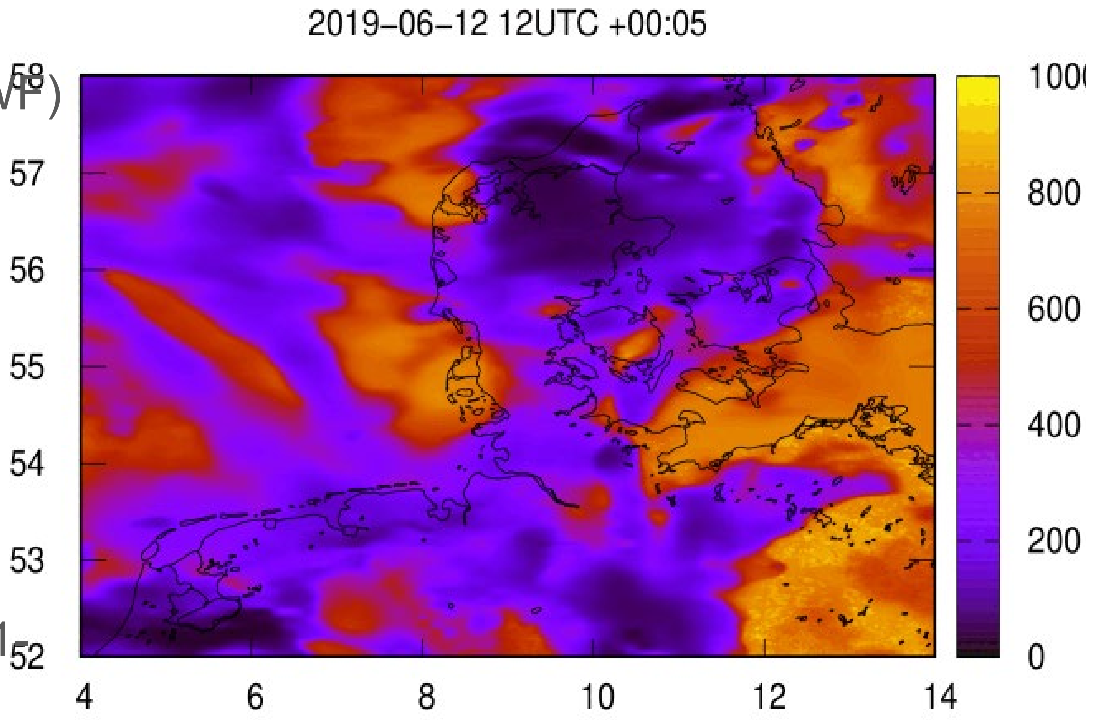
Solar test case: 11-12 June, 2019

Destination Earth (ECMWF)

On-Demand Extremes

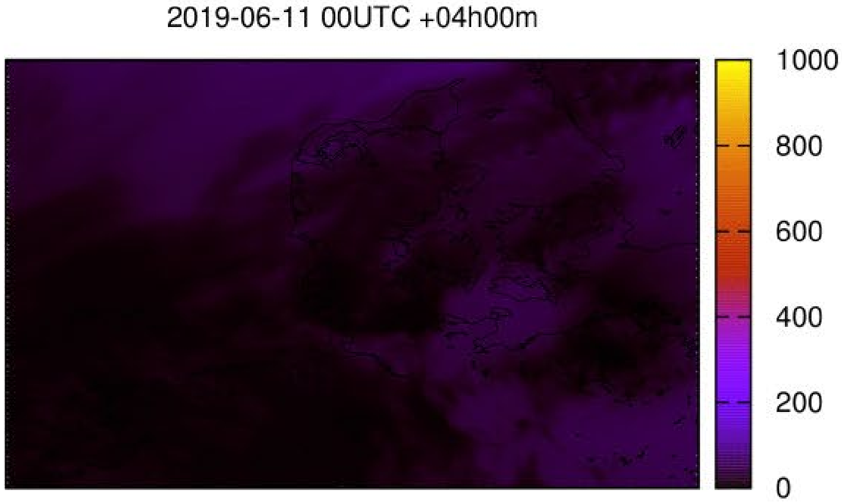
Digital Twin test case

- 5 minute weather model output
- 750 m resolution
- Much less bias on 11-12 June 2019

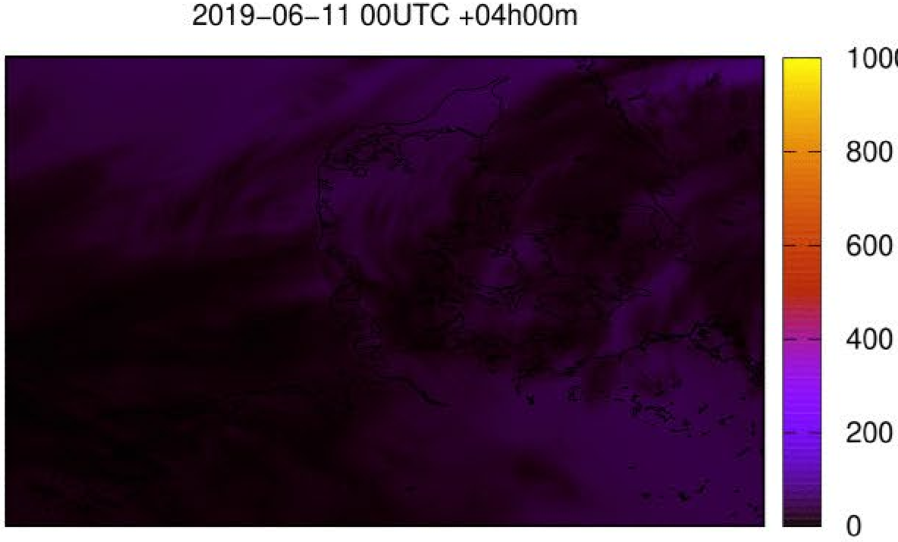


Solar test case: 11-12 June, 2019

Original 2.5 km run (NEA)



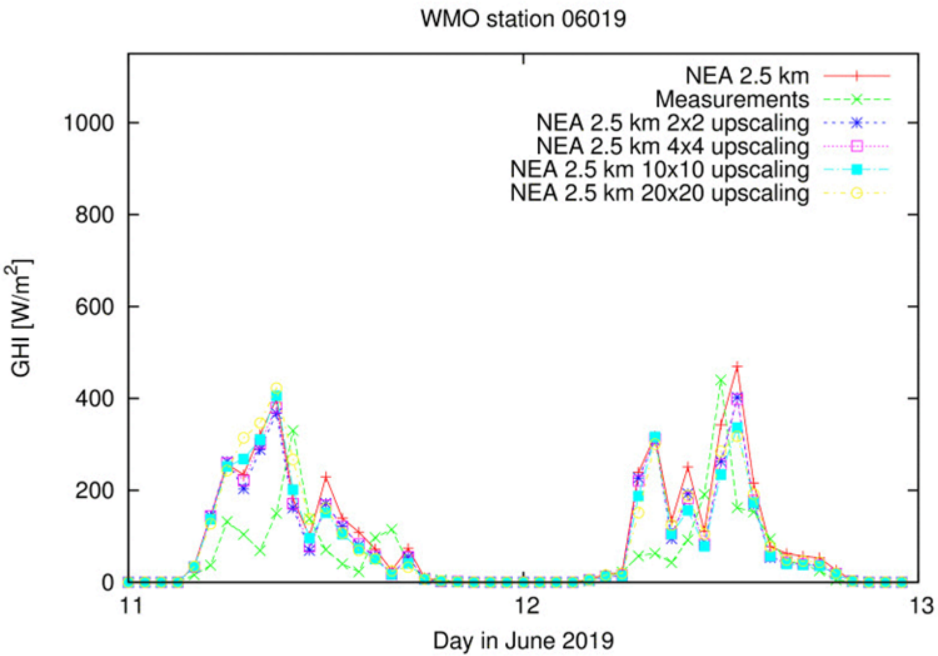
DEODE v0.1 750 m run



Solar test case: 11-12 June, 2019

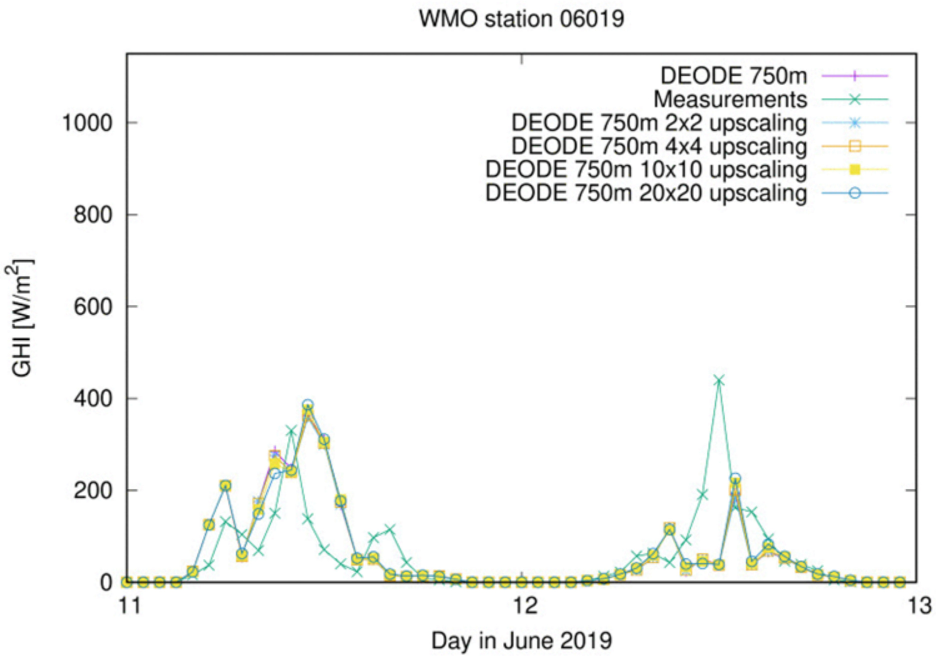
Original 2.5 km run (NEA)

Green: Measurements

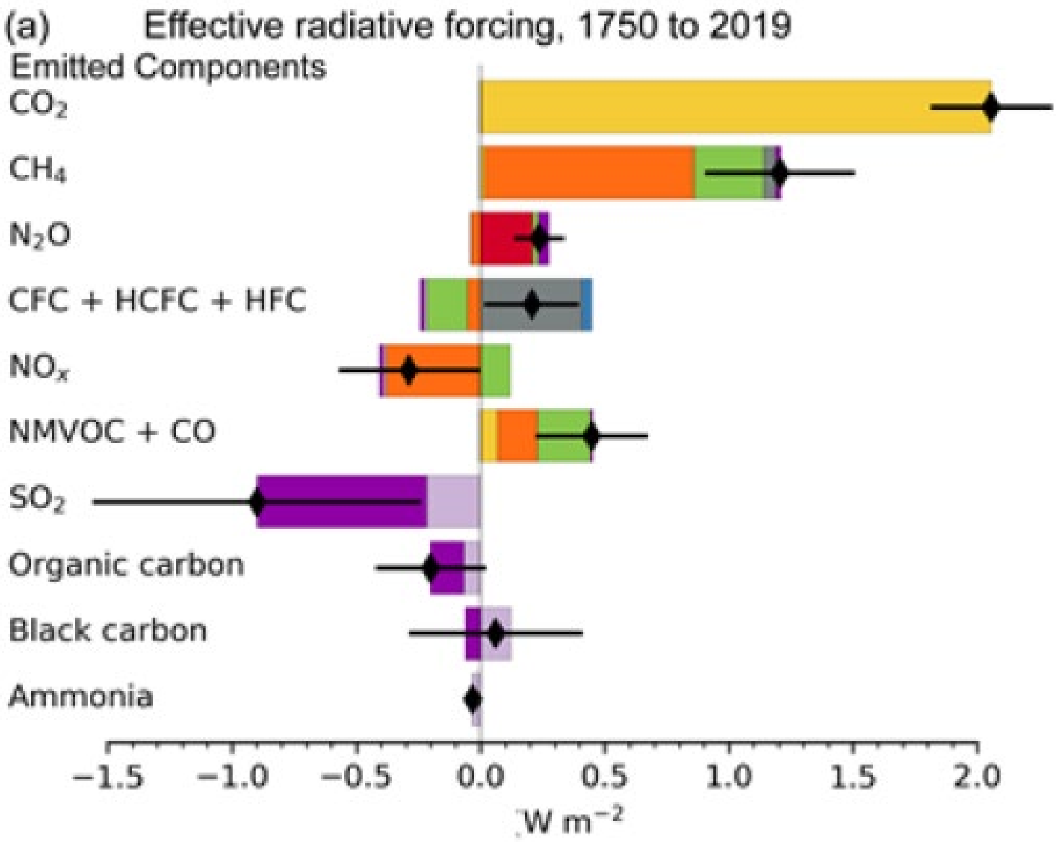


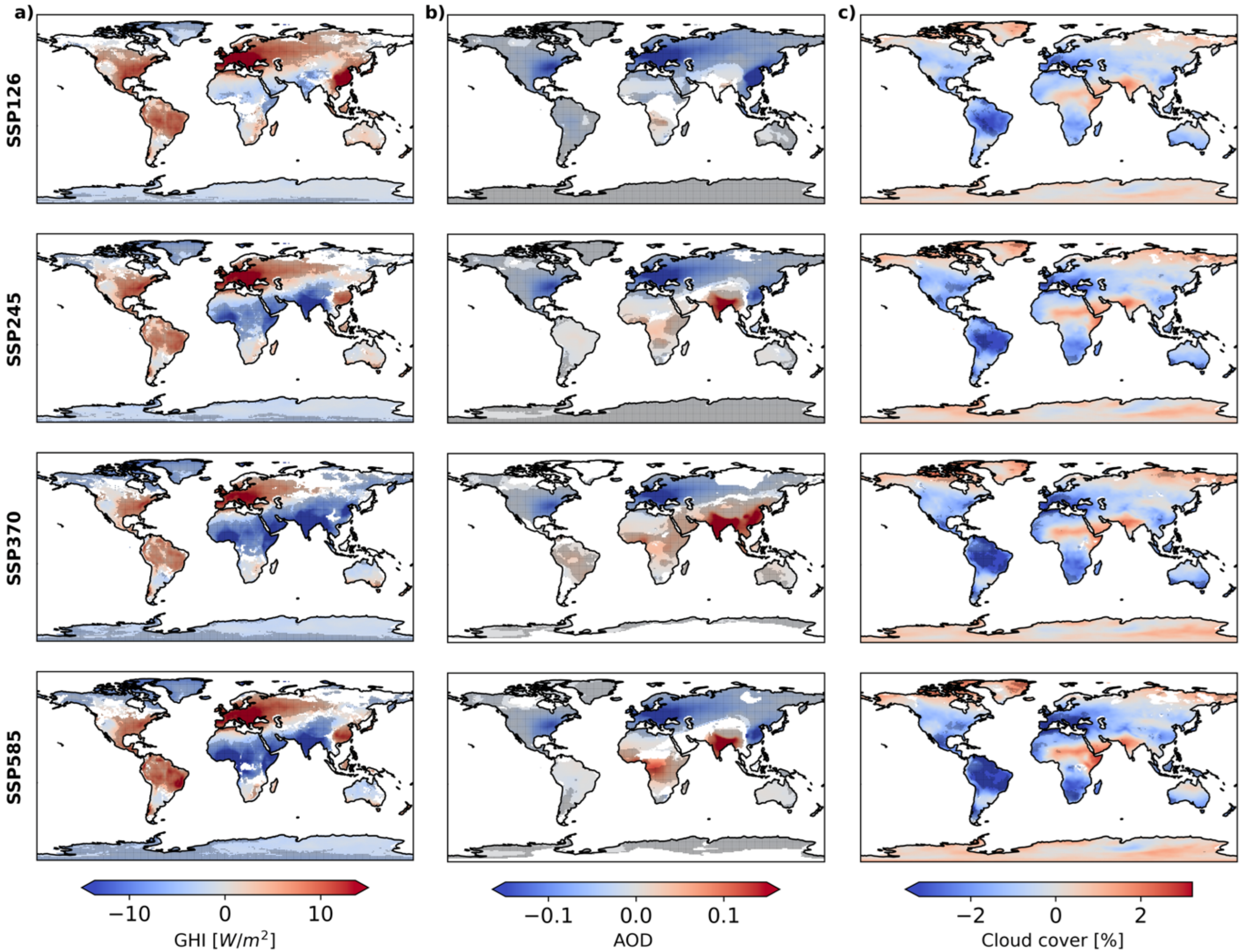
DEODE v0.1 750 m run

Green: Measurements



The IPCC AR6 report – radiative forcing





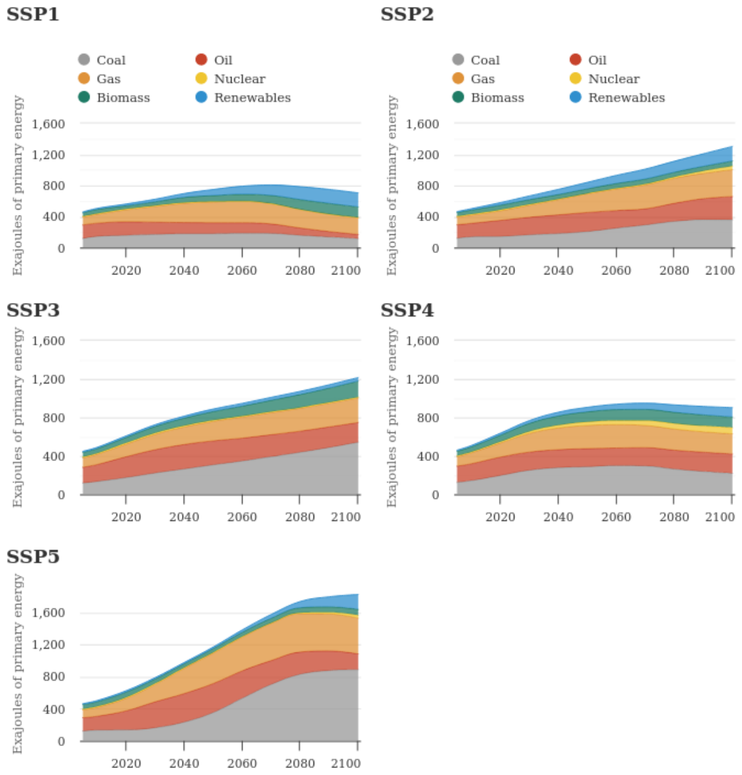
Solar resource climate scenarios

From Isaza et al. (2023); https://dx.doi.org/10.2139/ssrn.4415904

Shared Socioeconomic Pathways (SSPs)

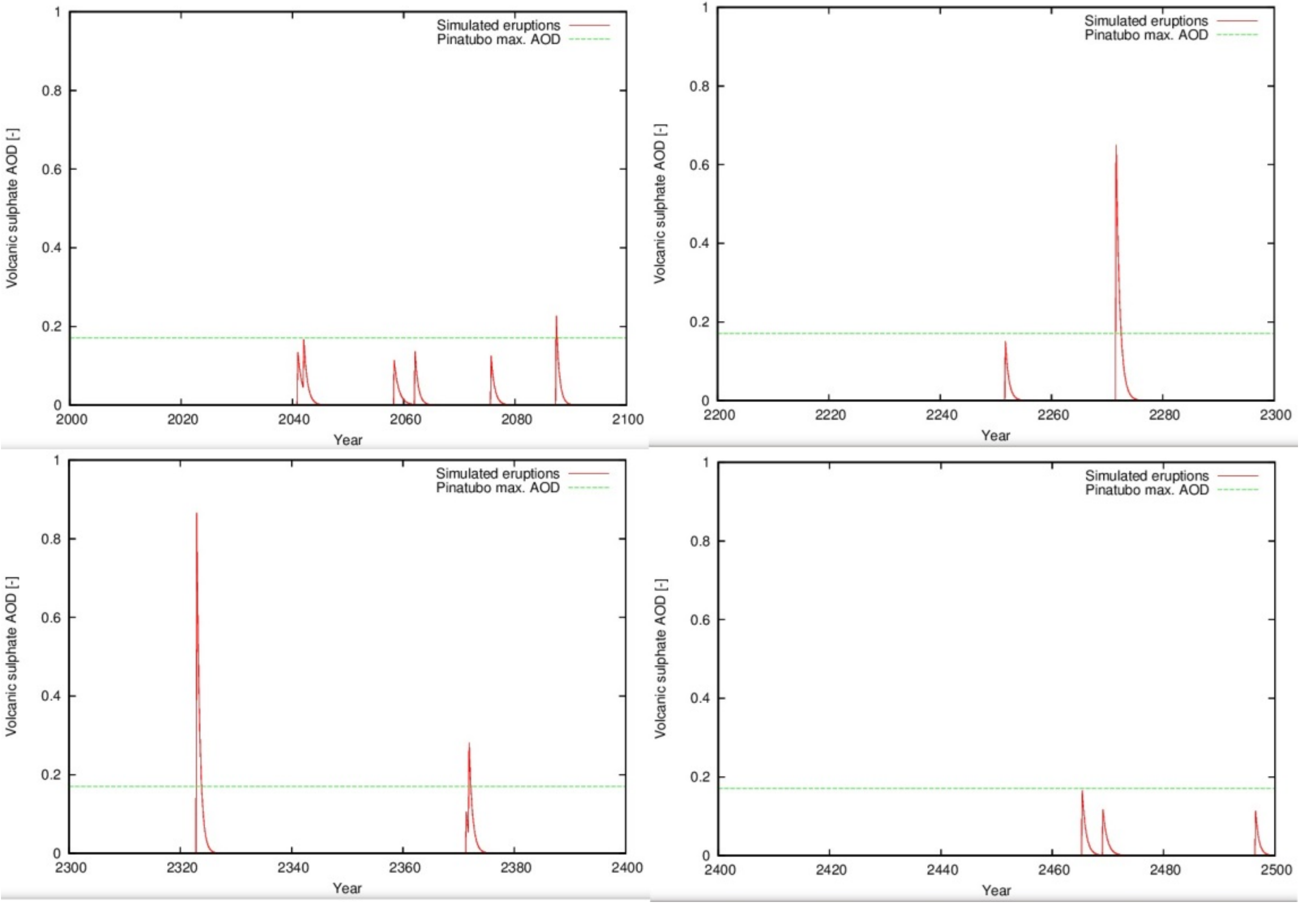
- SSP1: Green future
- SSP2: Middle of the road
- SSP3: World divided
- SSP4: Inequality; high pollution in the poorer regions
- SSP5: Fossil fuel growth; High emissions, but low pollution

- Source: https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/



Global primary energy use by fuel type between 2005 and 2100 in exajoules (EJ) for each SSP baseline marker scenario (IMAGE for SSP1, MESSAGE for SSP2, AIM for SSP3, GCAM for SSP4, and REMIND for SSP5). Data from the SSP database and Riahi et al 2017; chart by Carbon Brief using Highcharts.

Synthetic future volcanic eruptions



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The IPCC AR6 report – volcanic eruptions

- “Before the industrial period, explosive volcanic eruptions were the largest source of forced climate variability globally on interannual to centennial timescales.”

- Future volcanic eruptions are not included in the CMIP6 models.

- Eruptions with effective radiative forcings of -1 W/m^2 (~Pinatubo 1991 scale) have occurred twice every century in average.

- Eruptions with effective radiative forcings of >5 W/m^2 have occurred eight times during the last 2500 years.

- “The volcanic aerosol burden was 14% lower during the 20th century compared to the average of the preceding 24 centuries.”

- Source: *Cross-Chapter Box 4.1: The climate effects of volcanic eruption*

Conclusions

- The IEA PVPS Task 16 expert team tests and documents solar resource datasets and forecasting methods
- Open-source libraries with data processing code are made available
- Hybrid forecasting currently gives the best results
- Forecast uncertainty is not constant;
  - Forecasts can fail in particular situations!
- Decadal changes in solar resources are seen around the world;
  - Climate change scenarios should be accounted for!

Thank you for your attention!

https://iea-pvps.org/research-tasks/solar-resource-for-high-penetration-and-large-scale-applications/

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