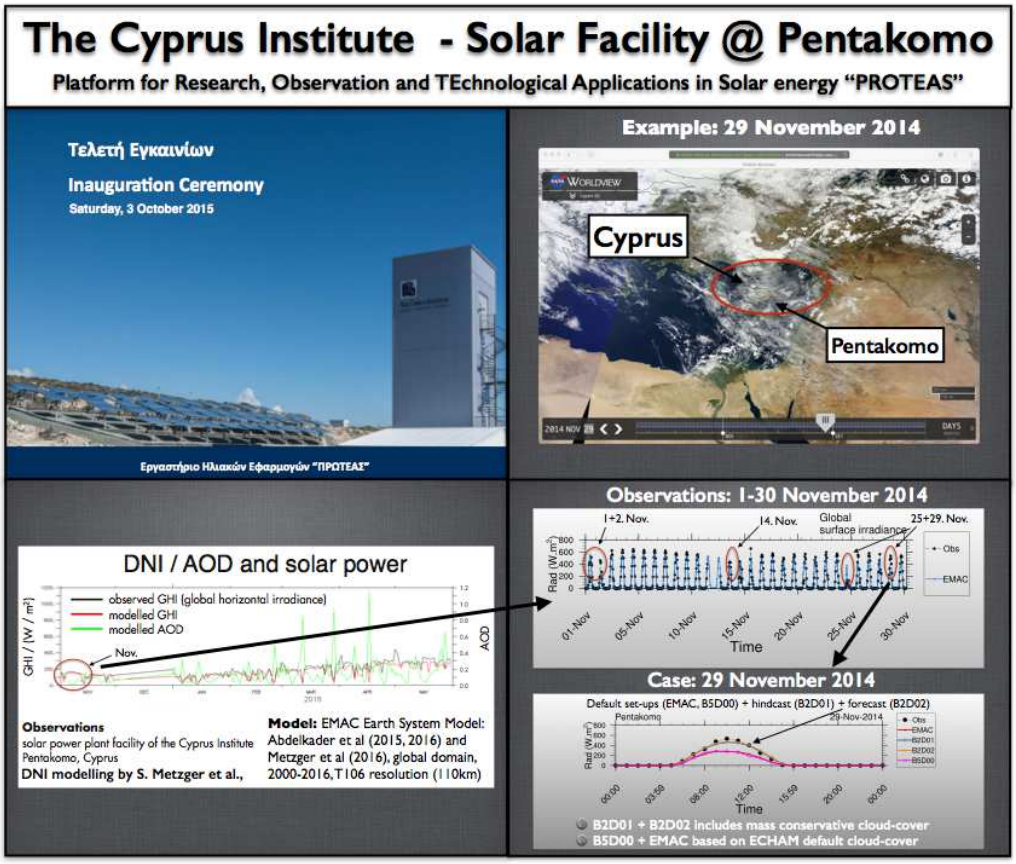

Figure 1: Map of Cyprus and model forecasts. Daily means of long-term observations (black) of the global horizontal irradiance (GHI) obtained at The Cyprus Institute's Solar Research Facility "PROTEAS", Pentakomo, and model calculations with the EMAC atmospheric chemistry-climate model (red). Overlaid (green) are the EMAC results for the Aerosol Optical Depth (AOD) − the AOD peaks nicely coincide with the GHI/DNI troughs. The high AOD peaks in spring 2015 are caused by strong outflow events of mineral dust, which is captured rather well by this high-resolution version of EMAC, which has been nudged to www.ECMWF.int ERA-Interim reanalysis data. Our EMAC aerosol version is developed and maintained at the Cyprus Institute (www.CyI.ac.cy), in close collaboration with the Max Planck Institute for Chemistry (www.MPIC.de).

EoCoE WP2.3

Compare state-of-the-art weather prediction at the local scale with the ones developed, demonstrating the additional value [CyI]

by S. Metzger et al.,

Summary

Within the European Commission HORIZON 2020 project, www.EoCoE.eu, task WP2.3, Optimal Operation of Concentrated Solar Power (CSP) under Weather Uncertainty, The Cyprus Institute, has generated day-ahead forecasts of the direct normal irradiance (DNI) for the Pentakomo CSP field facility that are based on a sophisticated coupling of WRF-solar with a “solar” version of EMAC. The augmented EMAC model results — a high resolution Earth System Model with fully coupled aerosol-chemistry-cloud-radiation feedbacks [1-3], which has been developed by S. Metzger, and colleagues at CyI and MPIC — shows improved model results of the Aerosol Optical depth (AOD) [4] and the Global Horizontal Irradiation (GHI), as shown in Figure 1-3. These improvements help to improve the DNI forecasting, since GHI and DNI are strongly related to the AOD. Both radiative properties are largely influenced by the aerosol hygroscopic growth and the associated aerosol water (AW) mass, which often controls the atmospheric visibility, haze and the formation of clouds, especially optically thin clouds. To allow an efficient application of a research model, we have aimed to reduce the complexity of the required aerosol chemistry and AW thermodynamics of our EMAC version to a minimum [5-7], so that numerical forecasts can be obtained. Subsequently, we have coupled the AOD values of EMAC [4], based on a sophisticated calculation of aerosol-chemistry, dust emissions and chemical aging of mineral particles [1-3], with the cloud and radiation of WRF-solar (Figure 2) to improve DNI forecasting with WRF-solar. Our coupled EMAC-WRF-solar results have been compared against point observations at Pentakomo, and reference simulations of WRF-met from the Cyprus met-office (Figure 4). Additionally, we have generated 48 day-ahead forecasts (each a 48 hours prediction with a one-hour moving initialization), shown in Figure 5. The coupled WRF-solar results show a considerable sensitivity to the AOD values provided by EMAC, and can help to improve the DNI forecasting for certain conditions, i.e., when aerosol loadings become dominant. Further improvements of the EMAC-WRF-solar coupling might be required for DNI forecasting, which are, however, beyond the scope of this WP2.3 contribution.[1]

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[1] The forecasts, reference simulations and observations have been delivered to RWTH Aachen — WP2.3 task of CyI. The PROTEAS facility in Cyprus has been utilized to optimize predictions for local atmospheric conditions (turbidity / visibility, humidity), as these affect the (nontrivial) irradiation attenuation relevant to GHI/DNI forecasting. The aerosol and 4-dimensional radiative model output can be further used to enhance predictions of the optimal energy storage schedules, subject also to market spot prices (by J. Cumptson, A. Mitsos, www.AVT.RWTH-Aachen.de) in order to minimize costs for grid and utility operators, as well as for the general public. This collaborative work also forms the first attribution of uncertainty in plant operation to a physical cause, in this case to minimize the mirror surface error.

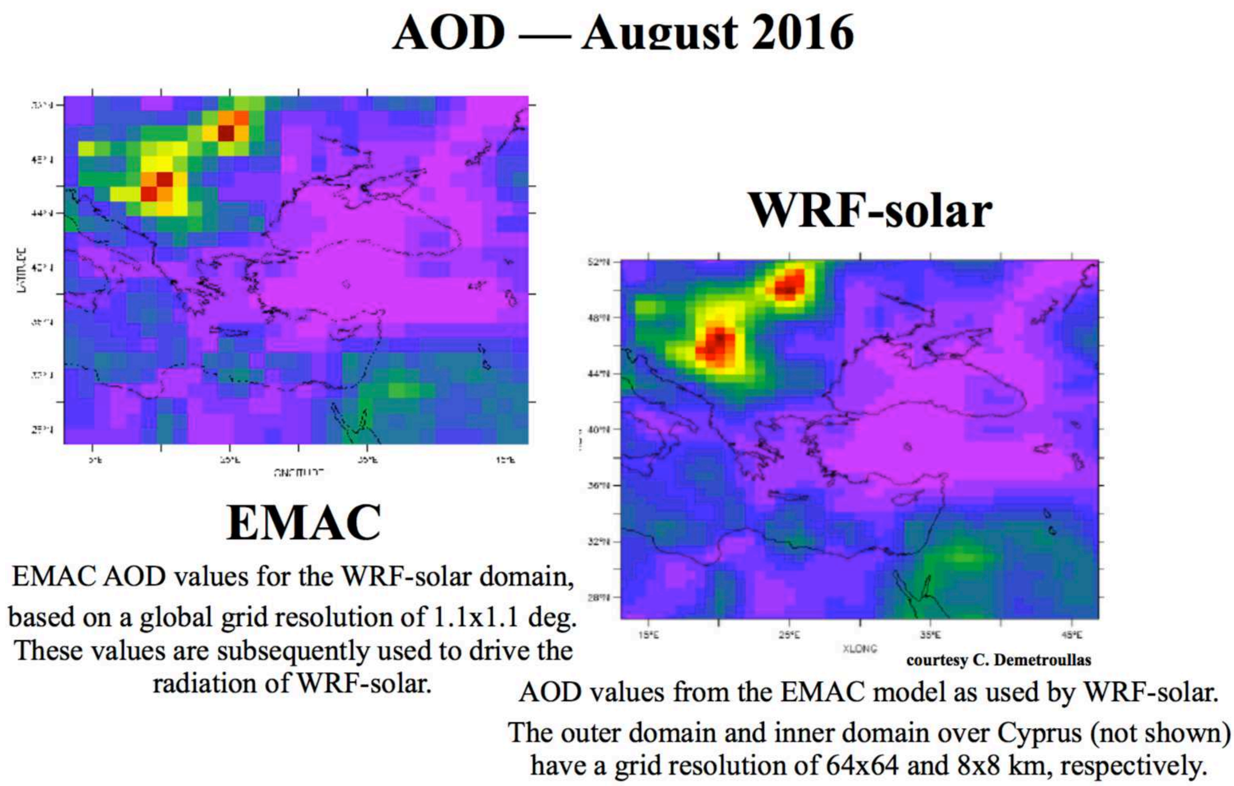

Figure 2. Coupling of EMAC and WRF-solar through AOD.

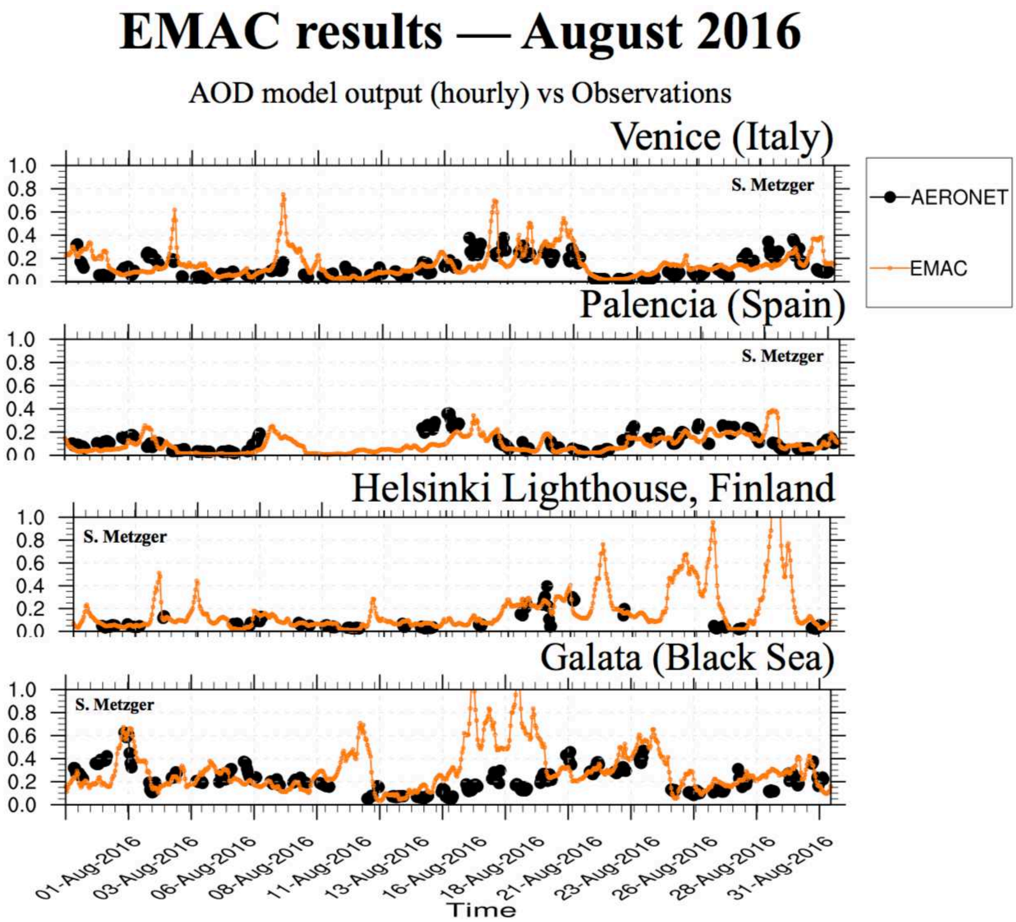

Figure 3. EMAC simulation versus AOD ground station observations.

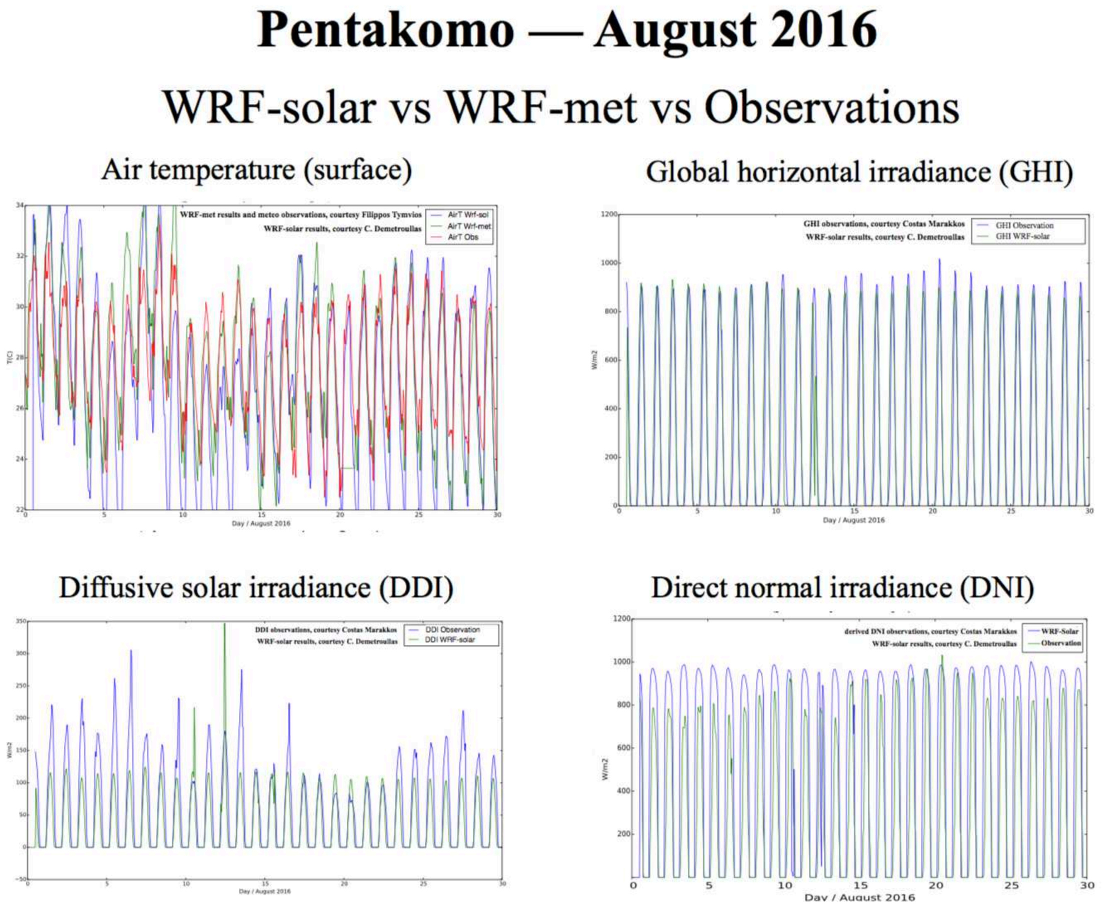

Figure 4. WRF-solar reference simulations versus WRF-met and observations.

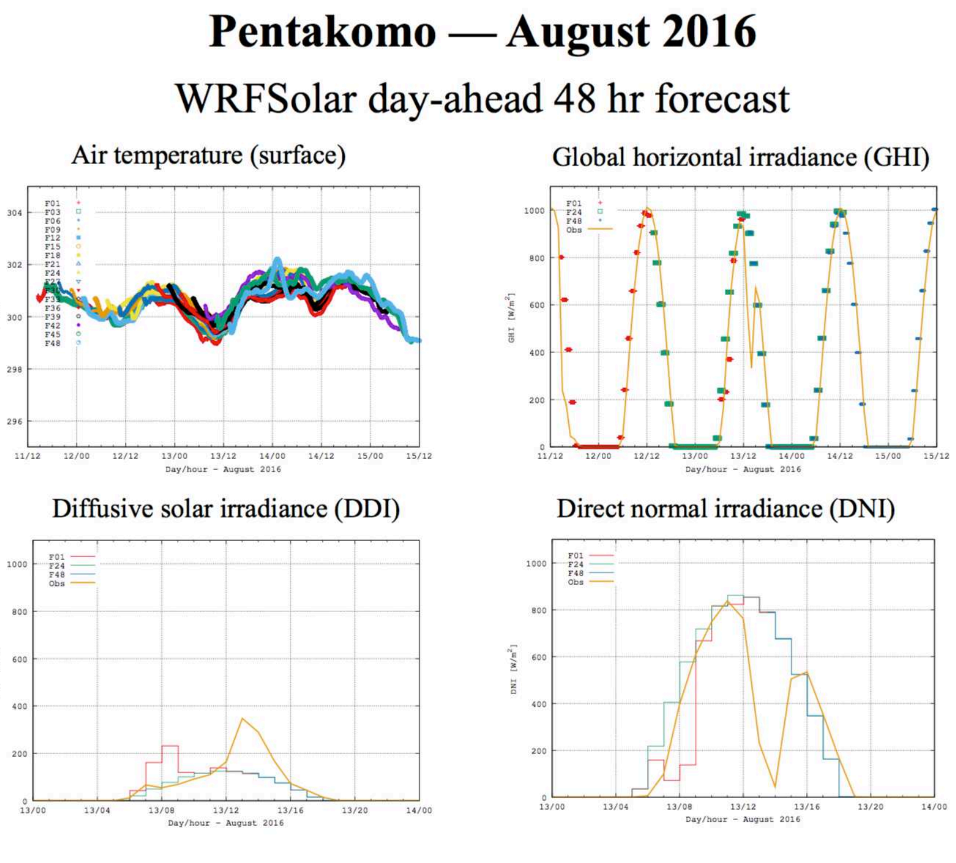

Figure 5. WRF-solar day-ahead forecasts driven by EMAC AOD.

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