

#### The use of satellite data assimilation methods in regional NWP for solar irradiance forecasting

Frederik Kurzrock, Sylvain Cros, Nicolas Sébastien, Fabrice Chane-Ming, Laurent Linguet, Roland Potthast, Gilles Lajoie

#### ► To cite this version:

Frederik Kurzrock, Sylvain Cros, Nicolas Sébastien, Fabrice Chane-Ming, Laurent Linguet, et al.. The use of satellite data assimilation methods in regional NWP for solar irradiance forecasting. European Geosciences Union General Assembly 2016, Apr 2016, Vienna, Austria. 18, pp.EGU2016-15821-1, 2016, 2016, Geophysical Research Abstracts. hal-01483991

#### HAL Id: hal-01483991 https://hal.science/hal-01483991

Submitted on 6 Mar 2017

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# The use of satellite data assimilation methods in regional NWP for solar irradiance forecasting



## 3. Indirectly influencing cloud evolution

In common state-of-the-art data assimilation procedures, primarily applied to global NWP models, all types of available observations are assimilated using the established methods (e.g. 3D-Var, 4D-Var, ENKF). The ultimate goal is to find the optimal initial conditions regarding the model's state variables. The typically assimilated satellite observations are radiances and atmospheric motion vectors (AMVs). Assimilating such observations using variational data assimilation or Ensemble Kalman Filter methods affects the model state variables in the first place and therefore influences the representation and evolution of clouds indirectly.

## 5. Outline

Progress being made regarding the assimilation of cloud-affected radiances into limited-area NWP models (Stengel et al., 2013). However, the indirect assimilation of quantities like radiances or AMVs has not been exploited so far in regional NWP regarding solar irradiance forecasting. The main reason for this is a number of problems that have to be overcome for each individual model domain: the choice of satellite channels, optimal thinning, bias correction, observation and background error estimation.

Future investigations address:

- the combination of both the classical "indirect" assimilation methods with methods that explicitly assimilate cloud physical properties (e.g. cloud top height, cloud emissivity, ...).
- the impact of such methods on different lead times, since the information from the driving global model is expected to predominate at a certain point.
- the influence of domain size and grid spacing in connection with satellite data assimilation in regional NWP.
- the use of different limited-area models and satellites, and respectively the application to different geographical regions (e.g. mid-latitudes and tropics).
- The ultimate goal is an assimilation strategy that can be used independently of the model and satellite and which can

### References

• Schomburg, A., Schraff, C., & Potthast, R. (2015). A concept for the assimilation of satellite cloud information in an Ensemble Kalman Filter: single observation experiments. Quarterly Journal of the Royal Meteorological Society, 141(688), 893-908. n, P., Collier, C., & Kleissl, J. (2013). A high-resolution, cloud-assimilating numerical weather prediction model for solar irradiance forecasting. Solar Energy, 92, 47-6 • Pour Biazar, A., T. McNider, R., & Doty, K., (2011). Assimilation of Satellite Observed Clouds in WRF, International Workshop on Air Quality Forecasting Research, Washington DC, USA. • Schipper, J. and Mathiesen, P., (2015). Advanced Cloud Simulations for Improved Dayahead Solar Power Forecasts, 5th Solar Integration Workshop, Brussels, Belgium. • Stengel, M., Lindskog, M., & Gustafsson, N. (2013). The impact of cloud affected IR radiances on forecast accuracy of a limited area NWP model. Quarterly Journal of the Royal Meteorological Society, 139(677), 2081-2096.

Frederik Kurzrock<sup>1,2,3</sup>, Sylvain Cros<sup>2</sup>, Nicolas Sébastien<sup>2</sup>, Fabrice Chane-Ming<sup>3</sup>, Laurent Linguet<sup>4</sup>, Roland Potthast<sup>5</sup> and Gilles Lajoie<sup>1</sup> <sup>1</sup>UMR 288 ESPACE-DEV, Université de La Réunion, France, <sup>2</sup>Reuniwatt SAS, France, <sup>3</sup>UMR 8105 Laboratoire de l'Atmosphère et des Cyclones (LACy), Université de La Réunion, France, <sup>4</sup>UMR 288 ESPACE-DEV, Université de Guyane, France, <sup>5</sup>University of Reading, UK

## 1. Motivation

Photovoltaic energy offers an intermittent production. PV production forecasts are necessary to permit a safe integration into the electricity grids. The correct simulation of cloud evolution is essential to forecast accurately irradiance reaching the ground level. Besides solar power forecasting, accurate short-term forecasts of precipitating and non-precipitating clouds are important for various meteorological applications. Regional NWP is the state-of-the-art tool to provide highly resolved cloud forecasts for lead times beyond 6h. Clouds are currently rather poorly represented in NWP models. The precise simulation of cloud evolution requires accurate atmospheric analyses which are obtained by exploiting atmospheric observations using data assimilation methods. In this work we focus on the assimilation of geostationary satellite data into regional NWP models with the goal of improving short-term cloudiness forecasts at high spatial resolutions.





In the recent years, different approaches aimed at deriving atmospheric analyses for limited-area models with most realistic cloud features, using geostationary satellite observations. The focus is mostly set on the assimilation of cloud-top information (e.g. cloud top temperature), since optical and thermal sensors are not able to capture information inside clouds (Figure 2). Table 1 sums up recent advances and their main limitations. Although the listed methods generally provide improved intraday (and even day-ahead) cloud cover forecasts in mid-latitudes, a major limitation for all methods is that only clear-sky or completely cloudy cases can be considered. This is because fractional clouds cause a measured signal mixing cold clouds and the warmer Earth surface.

derived eters	Influenced model variables	Assimilation method	Applied regional NWP model	Satellite sensors	Main limitation of the procedure	Reference
sk, cloud on, height	Relative humidity, cloud-top height, cloud fractions	Assimilation of pseudo-obser- vations using a LETKF	COSMO	MSG-SEVIRI	Method requires radiosonde humidity soundings	Schomburg et al. (2014)
sk, cloud- rature	Water vapour profile	Direct modification of model fields (water vapour profile)	WRF	GOES-N Imager	Modified model fields have to be smoothed horizontally and vertically to avoid numerical instability	Mathiesen et al. (2013)
ire and by OCA Cloud roduct)	Water vapour profile	Direct modification of model fields (water vapour profile)	WRF	MSG-SEVIRI	Multi-layered cloud structures cannot be reconstructed in the model	Schipper and Mathiesen (2015)
ire and do	Vertical velocity and divergence	1-D Var for horizontal wind, nudging of model winds	WRF	GOES-N Imager	Method triggers dissipation/creation of model clouds but not their vertical extent and structure	Pour Biazar et al. (2011)



Compared to other sources of observations, geostationary satellites provide many advantages regarding continuous solar irradiance forecasting:

- large spatial coverage ; high spatial and temporal resolution
- lack of measured data around islands
- satellite radiances are reliable radiometric signatures
- of cloud presence, properties and evolution
- constant accuracy in space and time
- comprehensive observations
- for large parts of the world
- future-oriented



