

Evaluation of ERA-40 Reanalysis Data on a Regional Scale - Total Cloud Cover in the North Sea Area

N. H. Schade, BSH, Hamburg, Germany, M. Stengel, R. Hollmann, DWD, Offenbach, Germany
H. Heinrich, BSH, Hamburg, Germany, G. Rosenhagen, DWD, Hamburg, Germany

Departmental Research Programme

- National Meteorological Service in Germany (DWD)
- German Maritime and Hydrographic Agency (BSH)
- German Federal Institute of Hydrology (BfG)
- German Federal Waterways Engineering and Research Institute (BAW)

www.kliwas.de

Background

- Existing climate models have difficulties in reproducing the spatial variability, e.g. of clouds, in the North Sea area. Especially, no regional coupled atmosphere-ocean models (RCAOMs) are available to describe their complex interactions with solar radiation, that influence momentum, freshwater and heat fluxes, and subsequently the SST. Therefore, within the KLIWAS research programme, three RCAOMs are actually implemented for in-depth analyses.
- Reference data are needed for validation purposes, and can be based on high quality controlled in-situ observations, satellite data and/or reanalyses. Since marine in-situ observations are unevenly distributed in space and time, satellite data provide the sole homogeneous observational data source over the North Sea.
- In this study, we use long-term cloud property data sets derived by the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF, www.cmsaf.eu) to investigate differences to ERA-40 reanalysis cloud cover data. ERA-40 is used to drive the hindcast runs of the regional models.

The Data

CM SAF AVHRR CDR (Satellite product)

Total Cloud Cover (TCC)
Temporal resolution: Daily mean
1982-2009
Spatial resolution: 0.25° x 0.25°
Coverage: Global
CM SAF satellite-based climate data records (e.g. Karlsson et al., 2012)

ERA-40 (Re-analysis)

Total Cloud Cover (TCC)
Temporal resolution: 6H mean
1957-2002
Spatial resolution: 1.125° x 1.121°
Coverage: Global
ECMWF 40 Year Re-analysis data archive (e.g. Uppala et al., 2005)

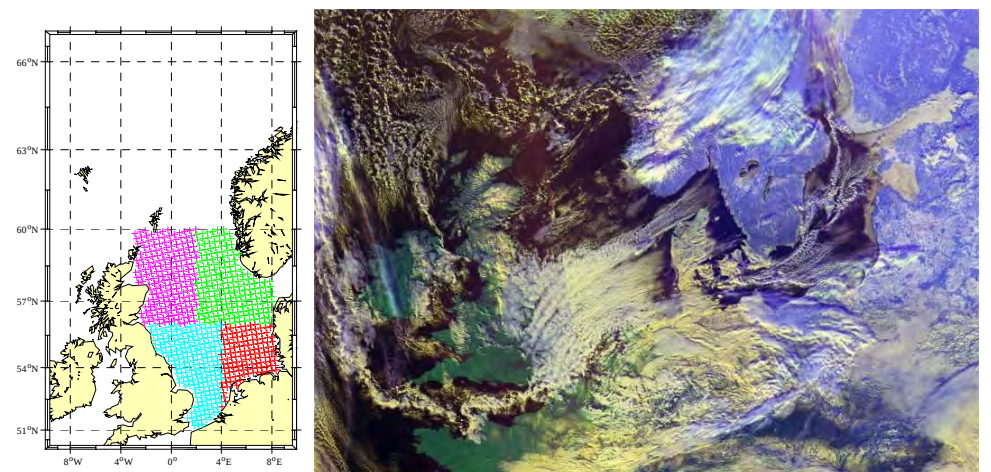


Fig.1: 0.25° grid points marking the four investigated North Sea boxes (left). Warm water effect over the North Sea, January 6th, 2003, resulting in cloud formation: AVHRR composite of two visible and one infra red channel (right)
Source: http://www.keestloor.nl/artikelen/meteorol/lake-effect_noordzee, 30.04.2012.

CM SAF AVHRR CDR vs. ERA-40

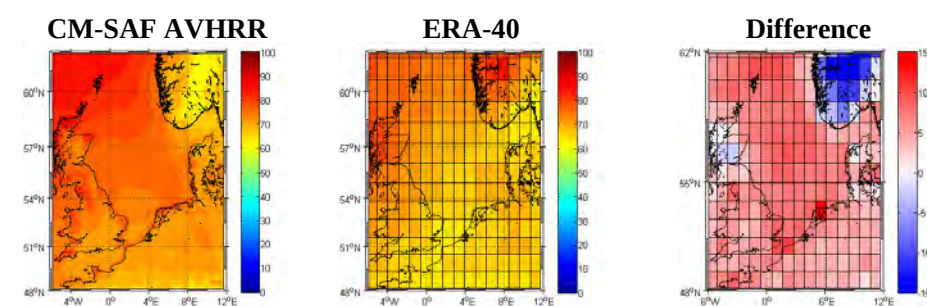


Fig.2: Mean CM SAF AVHRR CDR and ERA-40 cloud covers in % in the North Sea area for the period 1982-2002 (left, middle) and the difference (right)

CM SAF AVHRR CDR cloud cover data have been validated against globally distributed synoptic observations on airports and other satellite products (available on demand: Contact.Cmsaf@dwd.de). Here, they are interpolated on the ERA-40 grid to calculate mean values for the period 1982-2002, and are compared to ERA-40 cloud cover data in the four North Sea boxes displayed in Figure 1.

- Mean Cloud Cover values show similar distribution over the investigated area (Fig.2) but about 10 % more clouds for the satellite data, except for mountainous areas
- The annual cycle (Fig.3) shows more clouds in the winter and less in the summer months for both data sets but an obvious underestimation in the reanalysis TCC during the whole year with maximum difference in the summer months of about 10-12 % and better agreement in the winter months with about 5 %. Standard deviations of both data sets vary between 40 % in the winter and 70 % in the summer months.
- Frequency Distributions (Fig.4) based on monthly means show a shift to higher cloud amounts for the satellite data with maximum values at 70-75 % TCC for ERA-40 compared to the satellite data peaking at 75-80 % CFC. Daily mean frequency distributions show a large underestimation of overcast situations and an overestimation of all situations between 30 and 95 % TCC for ERA-40.

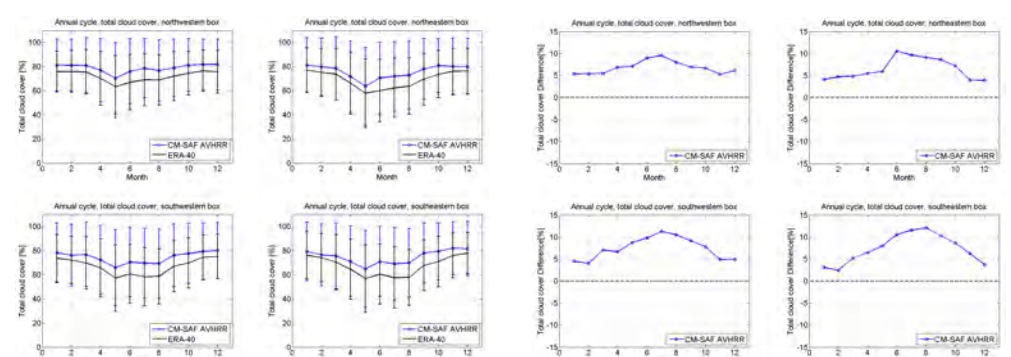


Fig.3: Left four graphs: Annual Cycle of total cloud cover from CM SAF AVHRR CDR satellite data (blue) and ERA-40 (black) for the period 1982-2002. The whiskers show the daily mean standard deviations. Right four graphs: Difference of the annual cycle (CM SAF - ERA-40)

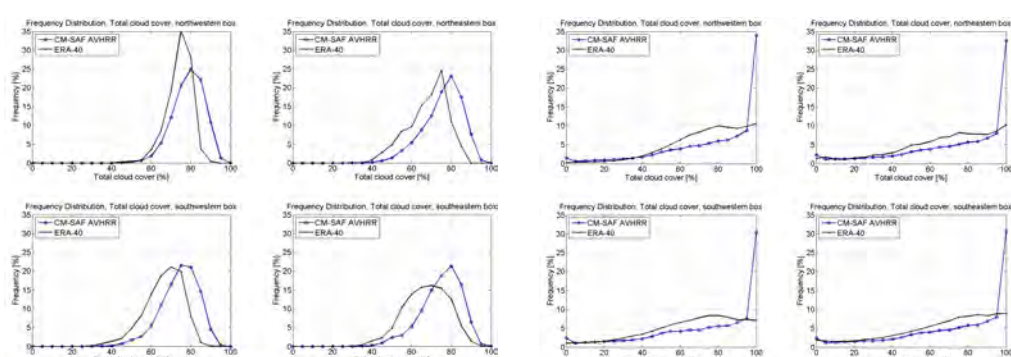


Fig.4: Frequency Distribution of CM SAF AVHRR CDR and ERA-40 monthly mean (left four graphs) and daily mean (right four graphs) data for the period 1982-2002

Summary & Conclusion

- For the validation of regional climate models, high quality observations, satellite data and/or reanalyses data, are needed as reference of the actual climate's conditions.
- Comparisons of daily mean CM SAF AVHRR CDR total cloud covers (TCC) with ERA-40 data show an underestimation of the reanalysis TCC of about 10 % in the monthly mean values, less in the winter, more in the summer months. This can be seen in all four North Sea regions and may be caused by the parameterisation of humidity processes in the reanalysis and/or the coarse resolution.
- Monthly mean frequency distributions show a shift to lower cloud amounts by ERA-40. Due to the pathways and the velocity of low pressure systems crossing the North Sea area, maximum TCC values are lower for monthly means than for daily means in both data sets.
- The mismatch in the overcast situations in daily mean frequency distributions may result from the modelled positions of the clouds / cloud layers inside the ERA-40 grid boxes.
- Further investigations will involve comparisons with in-situ measurements and solar global radiation data. The influence of ERA-40 driving regional models will also be in focus.

Contact:
Dr. Nils H. Schade

German Maritime and Hydrographic Agency (BSH)
Bernhard-Nocht-Strasse 78
D-20359 Hamburg, Germany

Tel.: ++49 (0) 40 6690 1264
Fax: ++49 (0) 40 6690 1954

Email: nils.schade@bsh.de

www.bsh.de / www.dwd.de

Literature: Karlsson, K.G., et al. (2012): The CM SAF cloud and radiation data set from 28 years of global AVHRR data. *In preparation*.
Uppala, S.M. and co-authors (2005): The ERA-40 re-analysis. *Quart.J.R. Meteorol. Soc.*, **131**, 2961-3012.