ASSESSMENT OF SATELLITE AND GROUND-BASED ESTIMATES OF SURFACE CURRENTS

G. K. Carvajal[1], *M. Wozniak*[1], *C. Heuze*[2], *L. E. B. Eriksson*[1], *Kronsell Johan*[3] *and Bengt Rydberg*[4]

[1]Department of Earth and Space Sciences, Chalmers University of Technology, Sweden
[2]Department of Marine Sciences, University of Gothenburg, Sweden
[3]Oceanographic Unit, Swedish Meteorological and Hydrological Institute, Gothenburg, Sweden
[4]Möller Data Workflow Systems AB, Gråbo, Sweden

ABSTRACT

Estimation of surface currents still presents a challenge. In this work validates surface current estimates from the Maximum Cross Correlation (MCC) method, that uses spaceborne radiometer data, against ground-based retrievals from a High Frequency (HF) radar system. Moreover, these datasets have been compared with surface current data from two assimilated satellite products and four weather prediction models. The comparison shows large differences in the spatial resolution and the location of specific features. It is concluded that the variation of the observations may be due to the difference between the measuring or estimated method used in each case and the forces driving them.

Index Terms— Maximum Cross Correlation, ground-based radar, surface currents

1. INTRODUCTION

Ocean currents are an essential part of dynamical oceanography. However, they are highly variable and complex since they are affected by diverse factors as the earth circulation, surface winds, and variations in temperature and salinity.

Many areas around the world still lack real time data of surface currents. In some cases existing monitoring systems for currents are based on buoys but there are only few of these operating. Sea surface current fields can be estimated using the maximum cross-correlation (MCC) method on satellite infrared data worldwide. Moreover, ground-based High Frequency (HF) radar systems can be used to provide surface currents estimates with high reliability in coastal areas. Since HF radars have a limited range in low saline water, e.q. the Baltic Sea, the possibility to use satellite data instead has the potential to be an important tool if a validation can be made successfully. It is also important to learn more about HF radar systems, and the possibilities and limitations they have. Thus, in this work compares the surface current estimates from both the MCC method and the HF radar measurements with data from two satellite assimilated products and from four weather prediction models.

2. DATA

Figure 1 shows an example of an AVHRR image on a cloudless day in Skagerrak together with the coverage of the CODAR system.

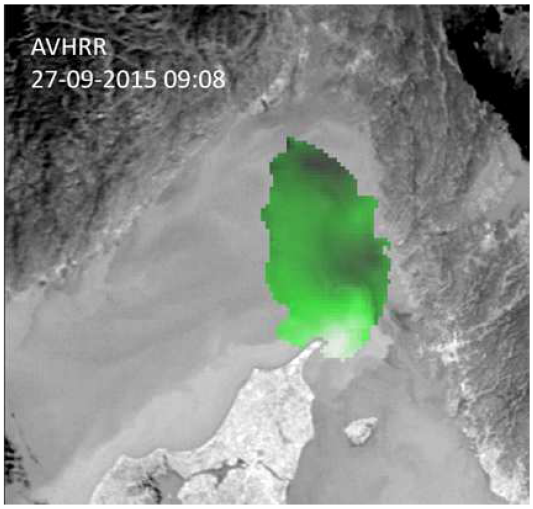

Fig. 1. Example of an AVHRR image with the coverage of CODAR data in green.

2.1. AVHRR

Data from the Advanced Very High Resolution Radiometer (AVHRR) instrument were used. The AVHRR instrument flies on several satellites operated by the National Oceanic and Atmospheric Administration (NOAA) and Eumetsat (MetOp-A and MetOp-B). Level 1b products were downloaded from Comprehensive Large Array-data Stewardship System (CLASS) with 1.1 km pixel resolution. The data were processed using the BEAM software from the European Space Agency (ESA). For each month there were about 350 images, but most of them were covered by clouds (see Fig.

2).

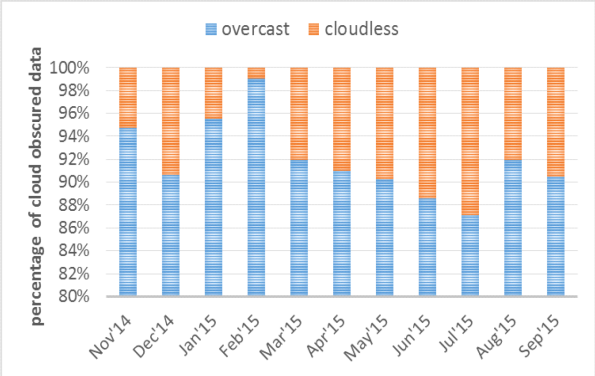

Fig. 2. Percentage of cloud covered data in each of the studied months.

2.2. CODAR

Data from the CODAR Ocean Sensors Seasonde system operating at 13.50 MHz has been used. The system was composed of two antennas installed on the islands Måseskär and Väderöarna from October 2014 to December 2015.

3. DETERMINATION OF SURFACE CURRENTS

3.1. MCC on infrared radiometer

The MCC method has so far mainly been used for satellite images in the thermal infrared (TIF) frequency band. This method utilizes the cross-correlation between two images, with a time separation of a few hours, to determine the motion of features thermal features on the ocean surface [1, 2]. When the MCC method is used for TIR images these temperature patterns are an estimate of the surface currents. TIR images are sensitive to cloud cover and provide relatively low spatial resolution. Nevertheless these data may still be useful since they are acquired relatively often (several times per day) over large areas.

3.2. CODAR

The electromagnetic signal transmitted by the CODAR system propagates at the electrically conductive ocean water surface, travels beyond the line-of-sight and is not affected by rain or fog. The back-scattered signal received by the two platforms at Måseskär and Väderöarna gives at least hourly averaged 2-dimensional surface current fields with resolutions of 1-3 km.

4. COMPARISON BETWEEN MCC AND HF-RADAR SURFACE CURRENTS

Figure 3 shows the comparison between surface current estimates from the MCC algorithm with respect to the CODAR retrievals. Both datasets were resampled to a common resolution. The datapoints correspond to cloudless days with standard statistical measures: number of samples (N), mean value of each variable and bias (mean(y-x)), standard deviation (StDev(y-x)) and root mean square error (RMSE(x,y)) between the datasets. The left panel in Fig. 3 shows the comparison between u and v components with a time gap of 1 to 5 hours, while the right panel shows the results for a time gap of about 5 hours. Analyzing the statistics of the results we noticed that time separations of around 5 hours (Fig. 3, right panel), show a significant improvement of the RMSE from 7 cm/s for the u and 4 cm/s for the v components of the current field.

5. EXTERNAL DATASETS

5.1. Assimilated products

- AVISO (http://www.aviso.altimetry.fr/): This ocean circulation product is derived from altimeter measurements. Altimetry enables observations of such phenomena as high variations in the sea surface level.

- OSCAR (http://www.oscar.noaa.gov/): Near real time global ocean surface currents derived from satellite altimeter and scatterometer data. The surface currents are computed directly from the gridded surface topography and surface wind analyses employing a straightforward linear combination of geostrophic and wind-driven Ekman motion.

5.2. Weather prediction models

1. Mercator Ocean: Daily Global Physical product at 1/12°.

2. UK Met Office GloSea (50 km): GloSea4 stands for Met Office Global Seasonal forecasting system version 4.

3. HBM (5.5 km): DMI operates a regional 3D ocean model HBM for the North Sea Baltic.

4. FOAM AMM7 (7 km), Atlantic Margin Model (AMM): The model is located on the European NorthWest continental Shelf (NWS), from 40°N, 20° W to 65°N, 13°E, on a regular latlon grid with 1/15 latitudinal resolution and 1/9 longitudinal resolution (approximately 7km square).

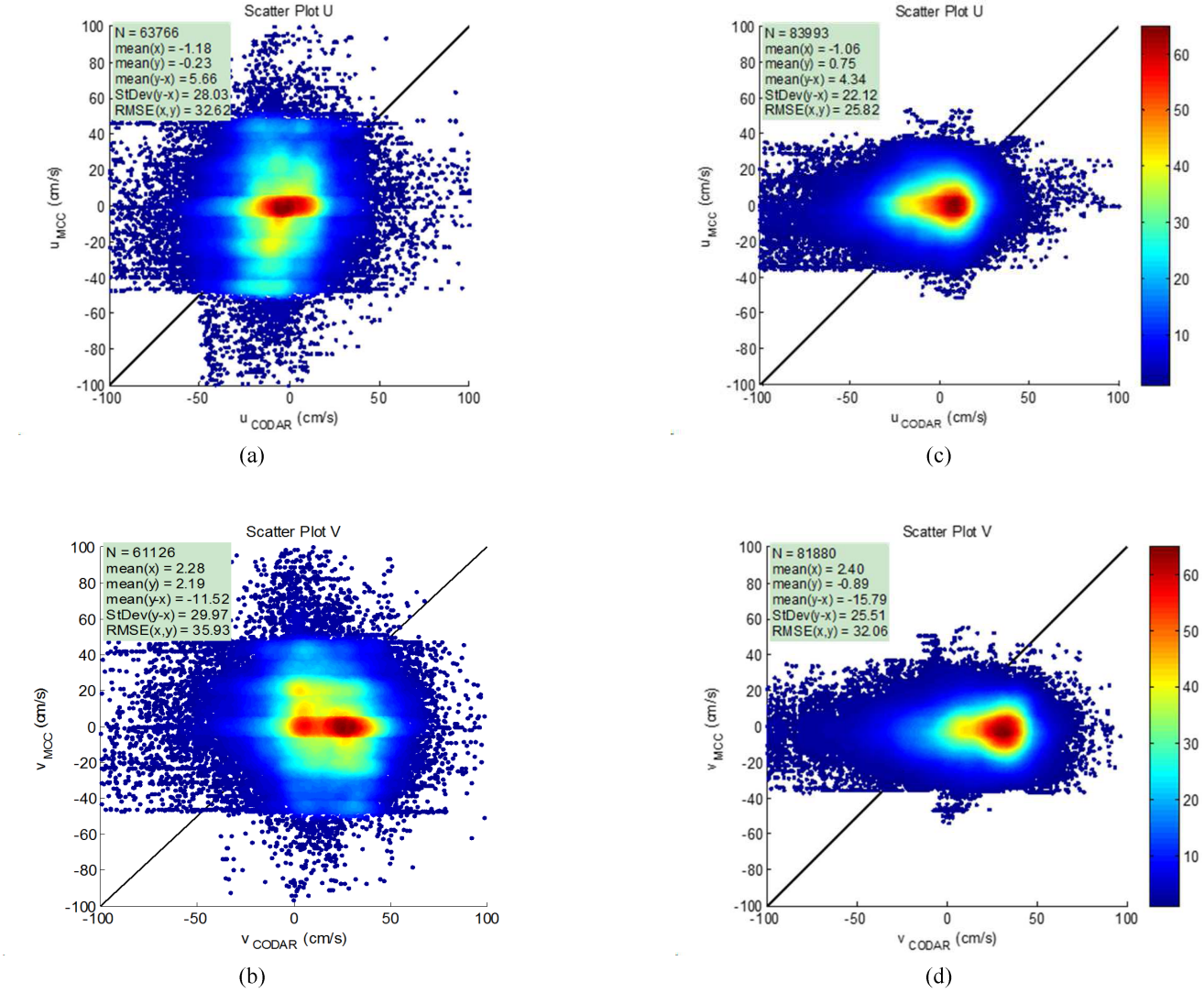

Fig. 3. Comparison between u and v component generated from the HF-radar and estimated with the MCC algorithm. Left panel (a-b): data for a time gap between 1 and 5 hours. Right panel (c-d): data for a time gap around 5 hours.

6. COMPARISON BETWEEN SURFACE CURRENT ESTIMATES

Figure 4 compares sea surface currents estimates from the sources presented in sections 3 and 5 for 3 days. Although all the datasets are collocated in time and space, a large variability in terms of resolution and the presented features can be noticed. However:

- On the 21st of April 2015 the MCC algorithm, the CODAR retrieval, and the modelled fields from Mercator and HBM show a similar counter clock wise circulation. This circulation was confirmed by in-situ measurements.
- In the second row, with data from 8th of August 2015 there are two main distinctive patterns to be noticed. A circulating eddy at about 58°N and 11°E and a current field with a speed between 0.3 and 0.6 m/s close to the coast line of Skagerrak. The eddy can be easily distinguished in the CODAR, AVISO, Mercator Ocean and HBM plots. The resolution and the gaps in the retrievals did not allow noticing the eddy in the MCC plot. But it did allow getting an accurate estimation of the current magnitude.

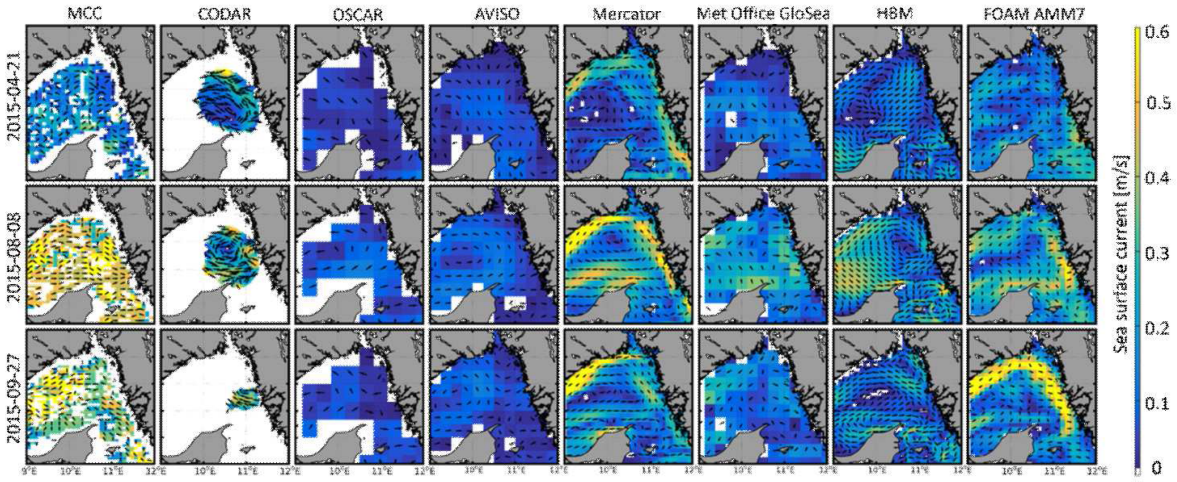

Fig. 4. Comparison of sea surface currents estimates from different sources in three days.

- In the third row there are estimates from 27th of September 2015. Even though for this date the coverage of the CODAR measurements was quite restricted geographically, the determined surface field shows a pattern with large similarities to the MCC retrievals at the same area. In this case also the magnitude of the MCC retrievals can be easily related to the other data sources.

Here it can be inferred that the variation between the datasets may derive from the nature of the physical parameters that dominate their behavior.

7. CONCLUSIONS

Assuming the HF radar data as a reference measurement one can agree that there is a large variability among the surface currents estimates given by other datasets. This brings up a need to investigate the main reasons for this diversity. Therefore it is important to understand which intrinsic features of the surface current are predominant in each case..

Products derived from assimilated satellite measurements provide a framework for contributions of MCC surface current retrievals in terms of temporal and spatial resolution. In addition the variation between surface currents estimates from weather prediction models and satellite and ground-based retrievals should give and insight into physical parameters that may be considered or adjusted for a more accurate weather prediction performance.

8. ACKNOWLEDGEMENT

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9. REFERENCES

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