# CC4CL: The Community optimal estimation based Cloud retrieval For CLimate

# *Evaluation results of the AVHRR heritage data set CC4CL*

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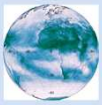
*In 2010 the ESA Climate Change Initiative (CCI) Cloud project was started with the objectives of generating a long-term coherent data set of cloud properties. The cloud properties considered are cloud mask, cloud top estimates, cloud optical thickness, cloud effective radius and post processed parameters such as cloud liquid and ice water path. During the first phase of the project 3 years of data spanning 2007 to 2009 have been produced on a global gridded daily and monthly mean basis. Next to the processing an extended evaluation study was started in order to gain a first understanding of the quality of the retrieved data. This study compared L2 and L3 data to independent ground based Measurements (Synop), established satellite climatologies (CM SAF CLARA-A1, MODIS Science Team (collection 5)) as well as to active satellite observations (CloudSat/ Calipso). This presentation will give an overview of the main results, for more detailed results please refer to the Cloud_cci website and the Product Validation and Intercomparison Report (PVIR).*

## Level 3



| | Coll5 - **Aqua** | | Coll5 - **Terra** | |
|---|---|---|---|---|
| | CFC | CTP | CFC | CTP |
| Bias | ~ -9 % | ~ -40 hPa | ~ -8 % | ~ -37 hPa |
| BC-RMSE | ~ 9 % | ~ 68 hPa | ~ 9 % | ~ 72 hPa |

| | CLARA-A1 – **NOAA-15** | | CLARA-A1 – **NOAA-16** | |
|---|---|---|---|---|
| | CFC | CTP | CFC | CTP |
| Bias | 0.5 % | 8 hPa | 0.4 % | 14 hPa |
| BC-RMSE | 11 % | 56 hPa | 11 % | 55 hPa |
| | CLARA-A1 – **NOAA-17** | | CLARA-A1 – **NOAA-18** | |
| | CFC | CTP | CFC | CTP |
| Bias | -4.8 % | 31 hPa | -2.7 1% | 7 hPa |
| BC-RMSE | 10 % | 50 hPa | 11 % | 48 hPa |

Table 1: Bias and Bias Corrected RMSE for each of the processed satellites compared to CLARA-A1 and Collection 5 MODIS.

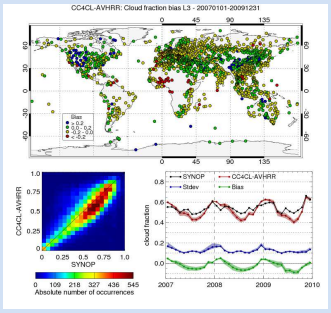



Figure 1: Comparisons of CC4CL-AVHRR L3S cloud fraction against SYNOP. Upper panel: Bias of monthly mean CC4CL-AVHRR cloud fraction against SYNOP observations for each individual SYNOPs site. The shaded areas in the time series (lower right panel) indicate the variability among the individual CC4CL-AVHRR L3C products. (Fig. M.Stengel)

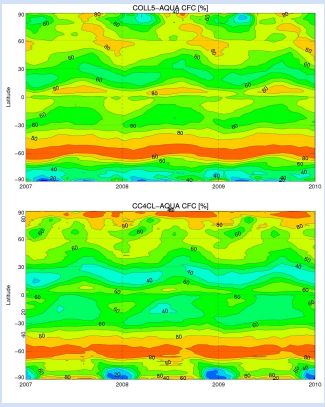



Figure 2: Hovmoeller Diagrams from 2007-2009 of Cloud Fraction for CC4CL-Aqua (lower Image) and Coll5-AQUA (upper Image).

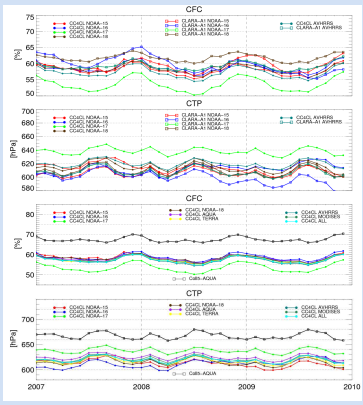
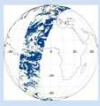



Figure 3: Time series of cloud fraction and Cloud Top Pressure for all processed satellites compared to CLARA-A1 (upper both) and Coll5-AQUA.

## Level 2



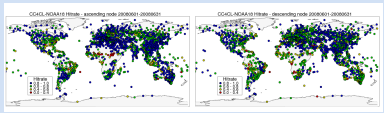


Figure 4: June 2008; Cloud mask hitrate scores for CC4CL-NOAA18 vs. SYNOP for ascending (left) and descending node (right). (Fig. M.Stengel)

| | DAY | TWILIGHT | NIGHT |
|---|---|---|---|
| **TROPICAL Ocean** | -23.0 | - | -18.5 |
| **TROPICAL Land** | -25.2 | - | -22.3 |
| **MID-LATITUDE Ocean** | -16.2 | - | -11.5 |
| **MID-LATITUDE Land** | -20.5 | - | -13.4 |
| **HIGH-LATITUDE Ocean** | -6.3 | 0.1 | 1.3 |
| **HIGH-LATITUDE Snow-free Land** | -18.5 | -16.8 | -16.9 |
| **HIGH-LATITUDE Snow-cover Land** | -11.5 | 2.2 | -5.1 |
| **POLAR Ice-free Ocean** | -7.6 | -4.8 | -11.2 |
| **POLAR Ice-cover Ocean** | 3.8 | 15.1 | 14.8 |
| **POLAR Snow-cover Land** | -20.8 | 3.6 | -19.2 |
| **POLAR Snow-free Land** | -7.6 | -16.0 | 10.3 |

Table 2 [1] : Unfiltered CC4CL-NOAA18 results (mean error) compared to CALIPSO.

[1] Table 2 and Figure 9 base on 87 matched full global orbits 2007-2009 for NOAA-18/CALIPSO with a SNO time difference less than 15 seconds, a Max time deviation approx. 2 minutes. Calipso Data ; Combining 1 km and 5 km CALIPSO cloud layer datasets (method described by Karlsson and Johansson, 2013, AMT) (Table and Figure by K.G. Karlsson)

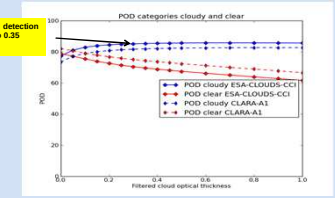



Figure 5 [1] : Results plotted as function of filtered cloud optical thickness (i.e., CALIPSO-detected clouds below this threshold treated as cloud-free). Gives information about when a cloud detection scheme reaches its optimal performance (i.e. when most clouds are detected)

## JCH

Joint Cloud optical thickness, Cloud top pressure histograms.

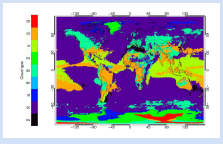


Figure 6: Map illustrating the most frequent cloud type (2007-2009).

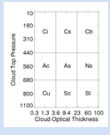



Figure 7: ISCCP Cloud Type Definition

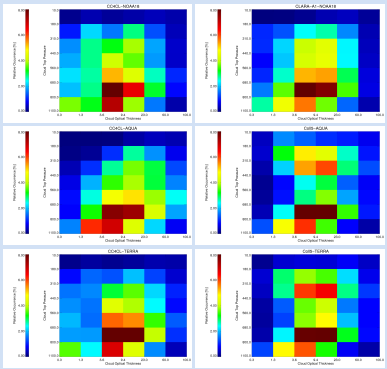


Figure 8: JCH for 2007-2009 : CC4CL versus CLARA-A1 NOAA-18 (top images), Coll5-AQUA (middle) and Coll5-TERRA. Compared to Coll5-MODIS, CC4CL mainly underestimates the high clouds, in particular cirrostratus clouds. The most frequent cloud type is stratocumulus, which is consistent with all reference climatologies.

**Summary:**

Using a variety of reference data sets, extensive validation studies were conducted to verify and validate the ESA Cloud_cci prototype products of the Community optimal estimation Cloud retrieval For CLimate (CC4CL) generated within phase I of the project. In order to assess the accuracy of the algorithms for instantaneous retrievals, they were compared to simultaneous measurements of MSG-SEVIRI and active sensors, namely CloudSat-CPR and CALIPSO-CALIOP. Moreover, the cloud detection efficiency was analysed with the help of SYNOP data. To cover the validation of the Cloud_cci level 3 data CC4CL data was compared to other well-established cloud climatologies, extensive comparisons were made with CM SAF CLARA-A1 and MODIS collection 5 level 3 data. (PVIR)

**Main Findings:**

The cloud mask algorithm performs similarly well as comparable algorithms with the exception of twilight conditions. Moreover, latitudinal biases were observed, with underestimations of cloud amount for tropical conditions and positive deviations for high latitudes, due to the frequent misclassification of snow and ice surfaces as clouds. The cloud height validation revealed similar results as compared to the validation of comparable algorithms. Comparing SYNOP reports of cloud amount generally revealed a good agreement. Only a few regions with larger disagreements were found in North America, the Sahel zone and parts of Asia. (PVIR)

**Outlook:**

In Phase 2 of the Cloud_cci project the CC4Cl data set will be extended to meet the time span from 1982 – 2014. Further Validation and Intercomparison studies will be undertaken using additional reference data sets like PATMOS-X and ISCCP or available updated data sets like CLARA-A2 and MODIS collection 6.

## Consortium

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