The inter-comparison of cloud properties retrieved from AVHRR and MODIS

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Background

- Main goal of Cloud_cci: The generation of two consistent global datasets for cloud property including uncertainty estimates based on:

  1) AVHRR heritage measurements of MODIS, AATSR, AVHRR
  2) Combined AATSR + MERIS measurements
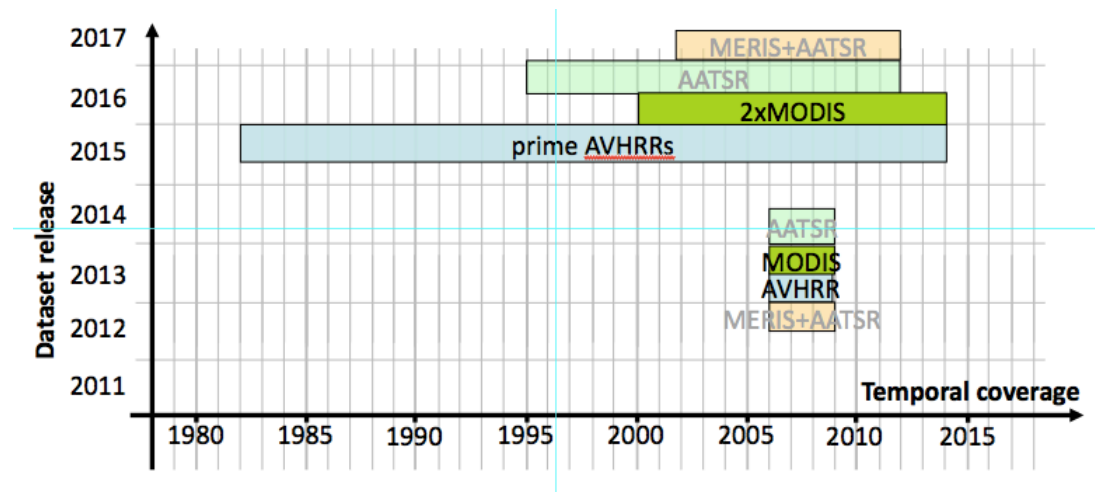
- See Cloud_cci related presentations by M. Jerg, S. Stapelberg, C. Carbajal-Henken, J. Bojanowski

- The development of two coherent physical retrieval frameworks are guided by the outcomes of a validation and intercomparison exercise called Round Robin

Background
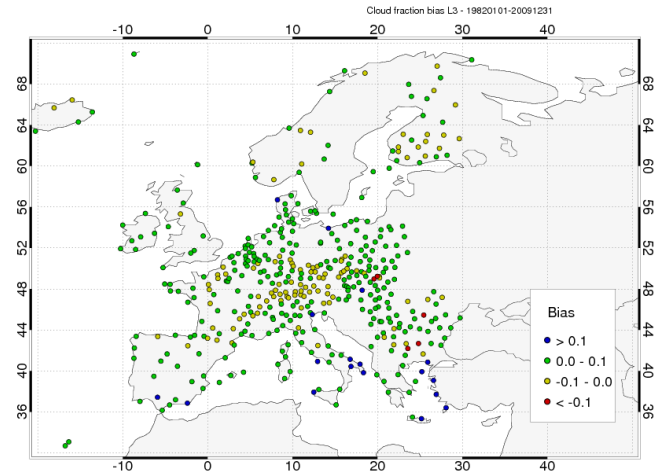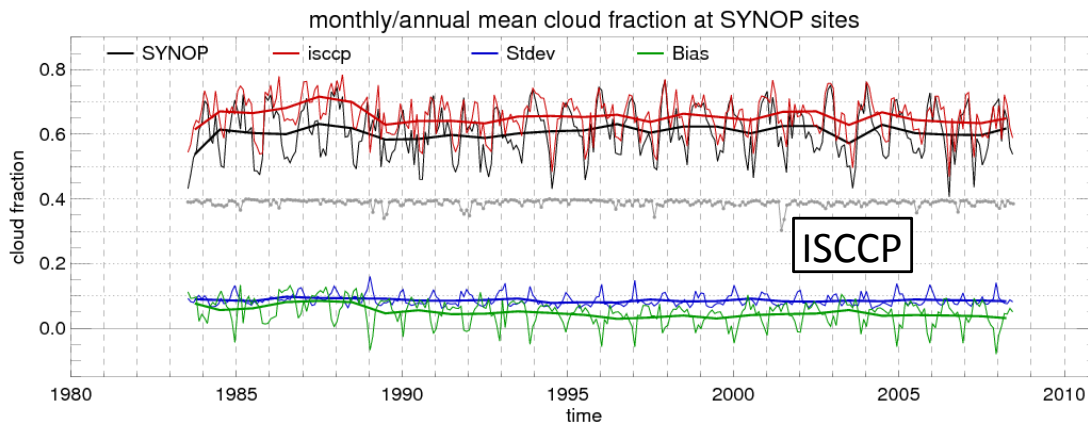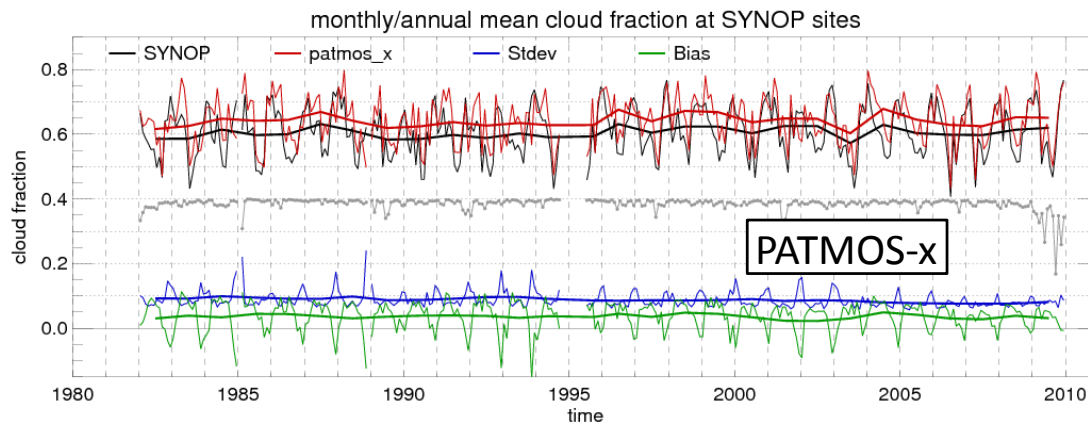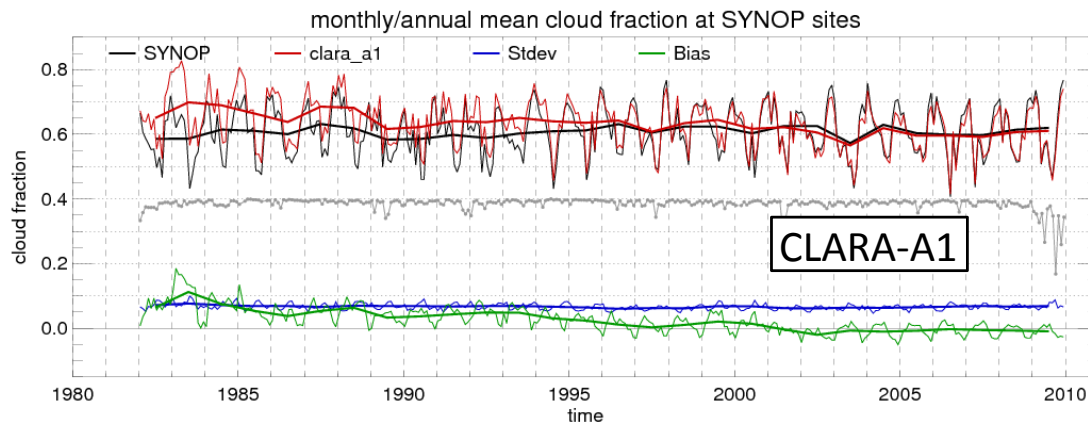
Comparing cloud fraction
at European SYNOP sites

Intercomparison - Motivation

- Cloud CCI may shed some light on why we see deviations among the datasets => Motivation for this **intercomparison study** and for generating datasets based on an state-of-art OE scheme.

Aims of the intercomparison study

- Confronting different schemes (that are used for climate dataset generation) with high quality reference observations (A-Train)
- Using common validation framework (selection of reference data, collocation approach, quality filters)
- Identify strengths weaknesses of different approaches
- Use this information as input to Cloud_cci developments
- Prescribing the same Level 1 data:
  - AVHRR-NOAA18: VIS calibration of Heidinger et al. (2010)
  - MODIS-AQUA: Collection 5 data (AVHRR channels only)
- Retrieval schemes fixed

Intercomparison – retrieval schemes

- **NWC SAF/CM SAF:** EUMETSAT Satellite Application Facility on Nowcaasting / Climate Monitoring; CPP (Cloud Physical Properties; Roebeling et al., 2006) algorithm developed at KNMI and PPS (Polar Platform System; Dybbroe et al., 2005a, 2005b) developed at SMHI -> **CLARA-A1** record

- **ORAC/CC4CL:** (Oxford RAL Retrieval of Aerosol and Cloud) algorithm (Poulsen et al., 2010; Watts et al., 1998) developed at Oxford University and Rutherford Appleton Laboratory (RAL) -> **Grape** record (**Cloud_cci** record)
(COT threshold as cloud mask)
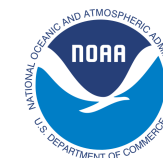
- **CLAVR-x:** Cloud from AVHRR Extended processing scheme hosted at NOAA at University of Wisconsin (Heidinger et al., 2013) -> **Patmos-X** record

Intercomparison

- Setup
  - 5 Golden days in 2008 (20 Mar, 13 Jun, 20 Jun, 21 Oct, 20 Dec)
  - Cloud mask (CMa), Cloud top height (CTH), Cloud phase (CPH), Liquid water path (LWP), Ice water path (IWP)
  - Instruments used: AVHRR/NOAA-18, MODIS/AQUA (AVHRR heritage channels, with two configurations: 1.6µm/3.7µm)
  - Reference: CALIPSO, AMSR-E, DARDAR (CALIPSO+CloudSat)

	AVHRR/NOAA18	MODIS/AQUA 1.6µm	MODIS/AQUA 3.7µm
CALIPSO	CMa, CTH, CPH	CMa, CTH, CPH	CMa, CTH, CPH
AMSR-E	LWP	LWP	LWP
DARDAR	IWP	IWP	IWP

Collocations maps

a) AVHRR/CALIPSO collocations, parameter: CMa

b) MODIS/CALIPSO collocations, parameter: CMa

c) AVHRR/CALIPSO collocations, parameter: CTH/CPh

d) MODIS/CALIPSO collocations, parameter: CTH/CPh

e) AVHRR/AMSRE collocations, parameter: LWP

f) MODIS/AMSRE collocations, parameter: LWP

g) AVHRR/DARDAR collocations, parameter: IWP

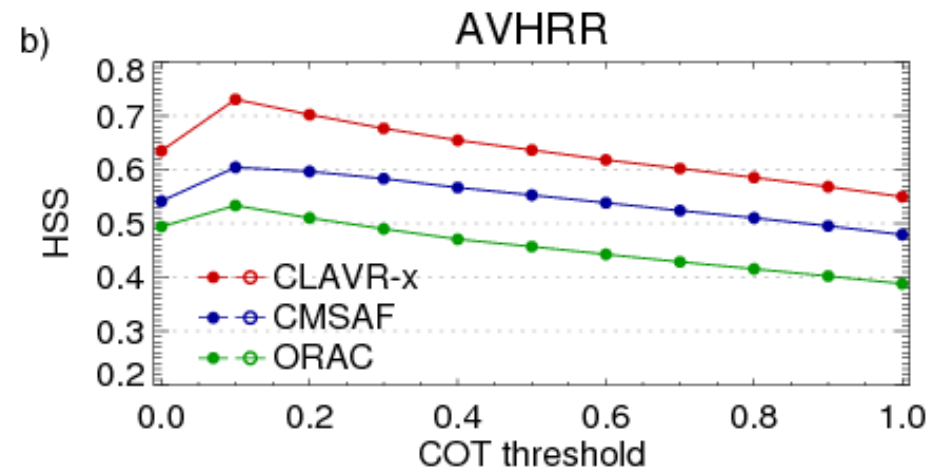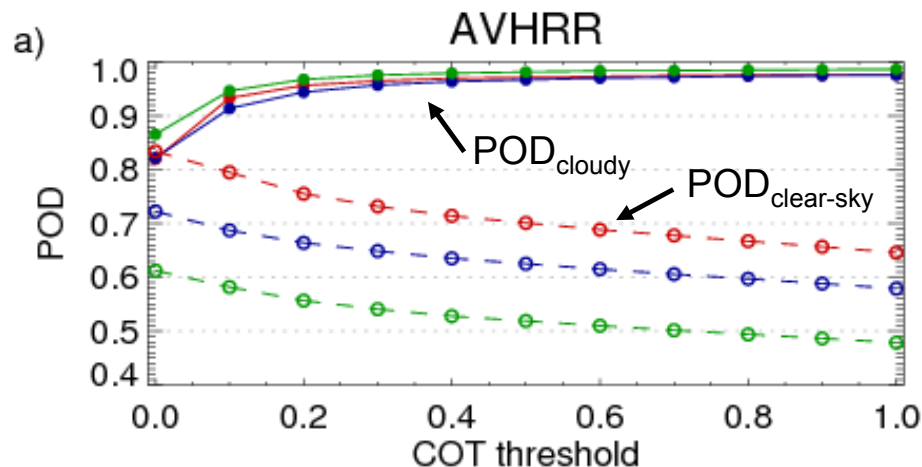h) MODIS/DARDAR collocations, parameter: IWP

CMa

CTH/CPh

LWP

IWP

MODIS

AVHRR

Cloud mask evaluation

- Reference data:
  CALIPSO CAL_LID_L2_05kmCLay-Prov-V3-01 (Feature Classification Flag as
  cloud mask; Feature Optical Depth for 532 nm for **optical depth**)

- Assessing the sensitivity of cloud mask agreement wrt. COT

	AVHRR		
	CLAVR-x	CM SAF	ORAC
POD-cloudy	0.82	0.82	0.87
POD-clear	0.83	0.72	0.61
HSS	0.63	0.54	0.49
HSS (COT > 0.1)	0.73	0.60	0.53

Table: Cloud mask evaluation scores (given as probability of detection, POD, and Heidke Skill Score, HSS) for clear-sky and cloudy scenes using CALIPSO as reference for AVHRR (38,112 samples).

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Cloud top height evaluation

- Reference data:
  CALIPSO CAL_LID_L2_05kmCLay-Prov-V3-01 (Feature Classification Flag
   for **height**; Feature Optical Depth for 532 nm for **optical depth**)

- Assessing the sensitivity of CTH agreement wrt. COT and cloud type

low tr.: low overcast transparent,   sc tr: transition stratocumulus
ac. tr.: altocumulus transparent,   as. op.: altostratus opaque
ci. tr.: cirrus transparent,   dc. op.: deep convective opaque

Phase evaluation

- Reference data:
  CALIPSO CAL_LID_L2_05kmCLay-Prov-V3-01 (Feature Classification Flag
   for **phase**; Feature Optical Depth for 532 nm for **optical depth**)
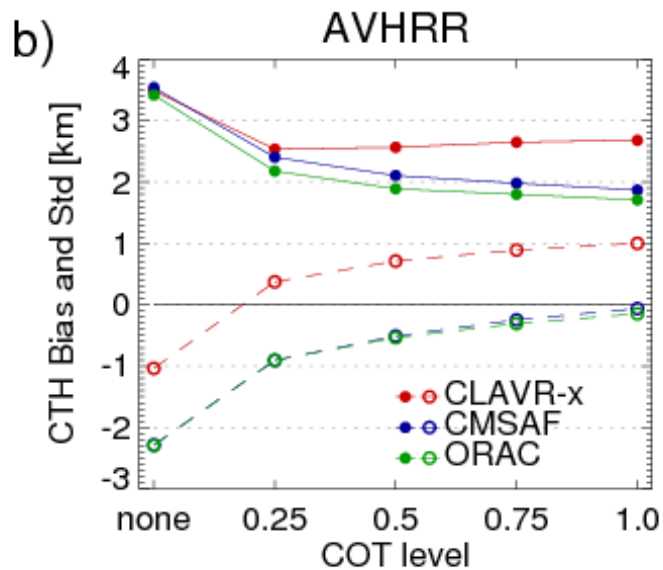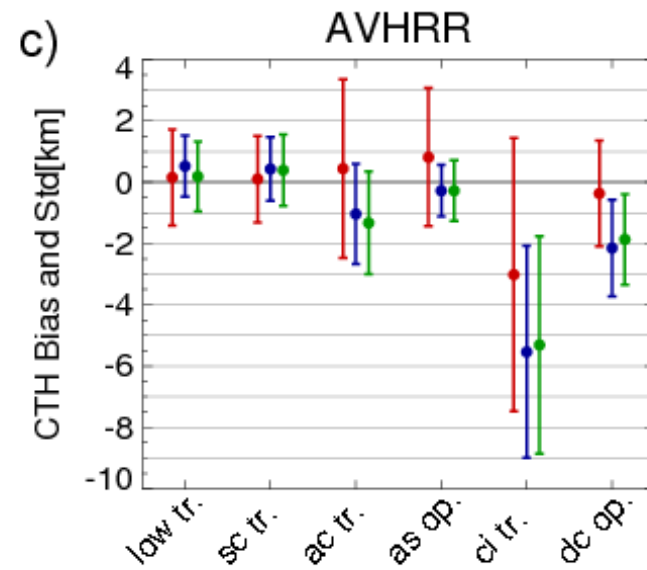- Assessing the sensitivity of phase agreement wrt. COT
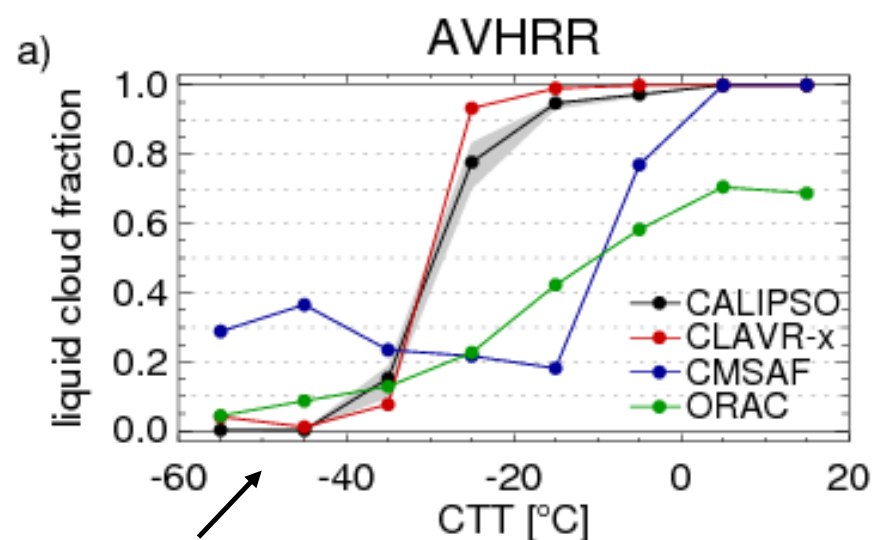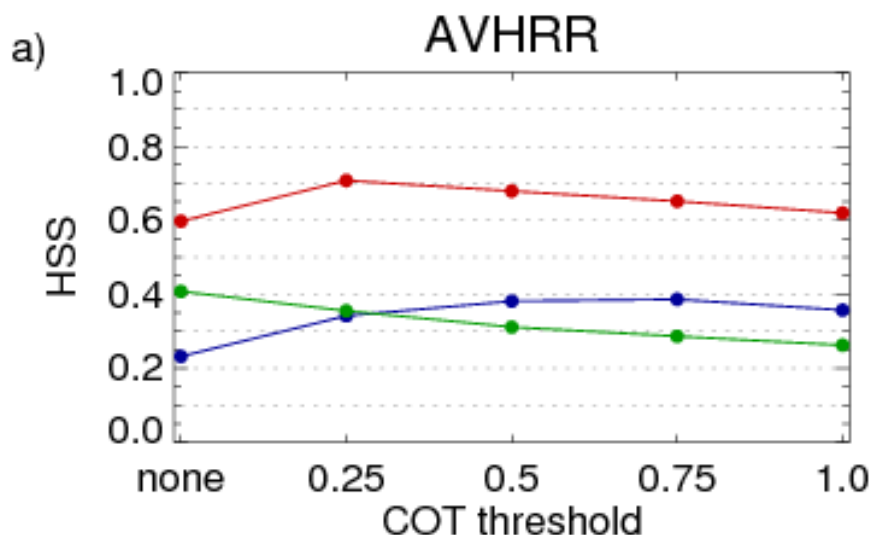
Reference phase is taken from 0.25 level-to-cloud-top COT.

	AVHRR		
	CLAVR-x	CM SAF	ORAC
POD ice cloud	0.89	0.68	0.86
POD liq. cloud	0.88	0.72	0.61
HSS	0.71	0.34	0.36

Table: Cloud phase evaluation scores for both CALIPSO vs. AVHRR (7374 samples). All score are calculated using CALIPSO phase retrieval at that level below the cloud top, for which the level-to-cloud-top COT exceeds 0.25.

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Liquid water path evaluation

- Reference data:
  Version 06 Level 2B Ocean product suite (Wentz & Meissner; 2000,2004)

Table: Liquid water path evaluation scores for both AMSR-E vs. AVHRR (98,481 samples). Standard deviation (Std) and bias values are given in g/m2.
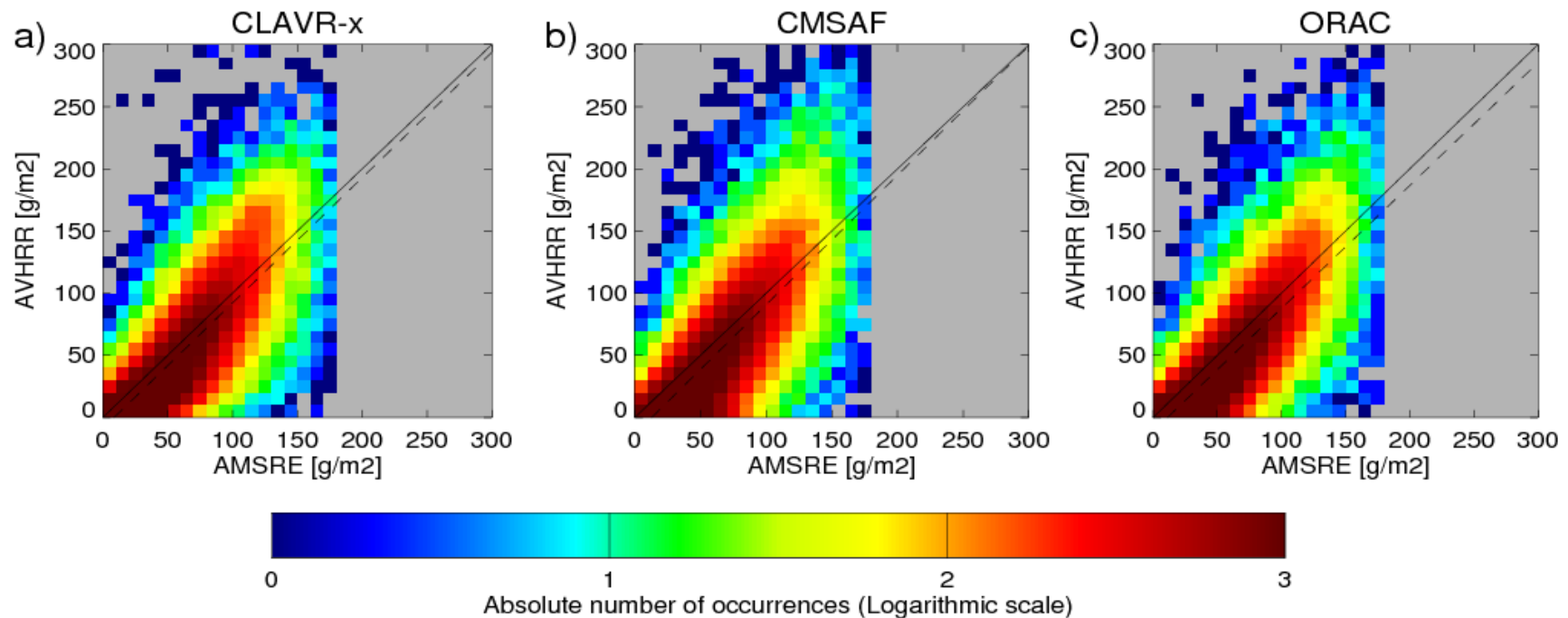
	AVHRR		
	CLAVR-x	CM SAF	ORAC
Std	25.5	27.7	24.3
Bias	−8.3	−11.1	−11.7
Corr.	0.79	0.78	0.80

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Ice water path evaluation

- Reference data:
  In this study the IWC data of DARDAR (raDAR/liDAR cloud parameter retrievals) products (Delanoë and Hogan; 2008, 2010)
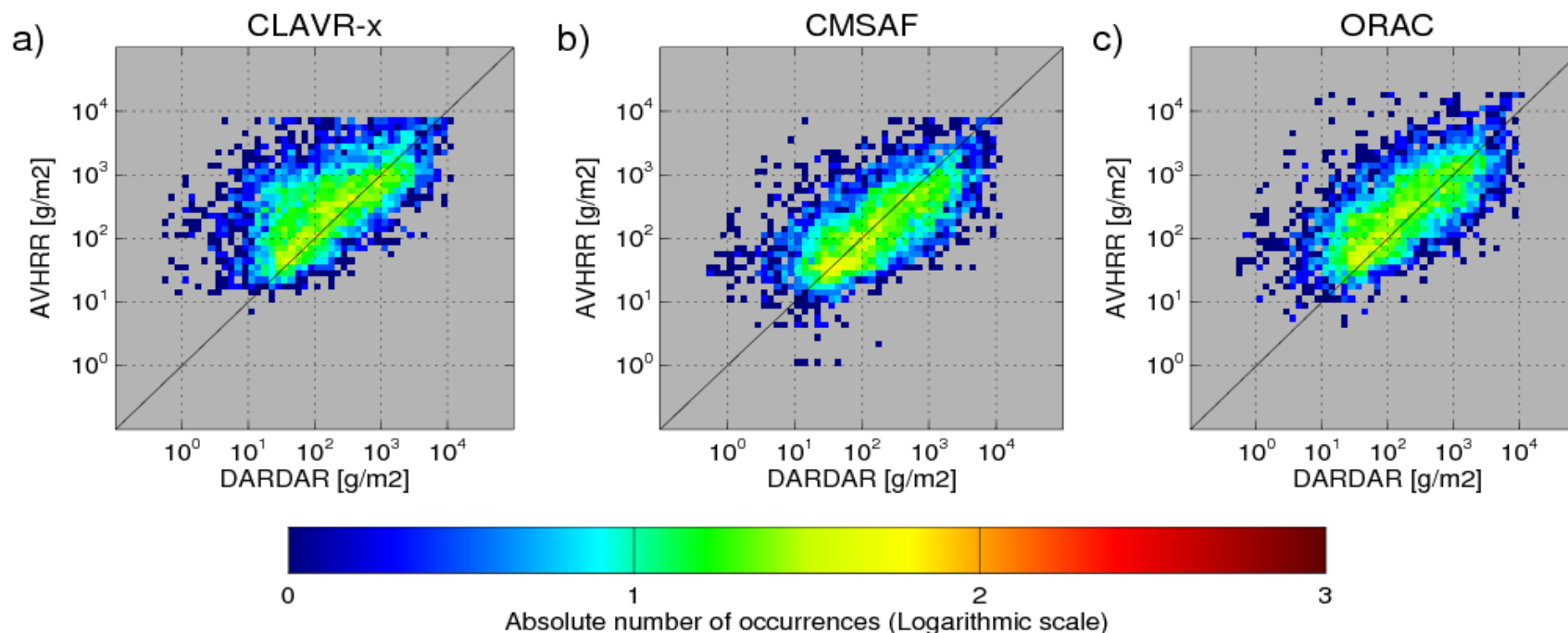
	AVHRR		
	CLAVR-x	CM SAF	ORAC
Std	1058	879	1364
Rel. Std	2.0	1.7	2.6
Bias	168	−160	162
Corr.	0.48	0.53	0.48

Table: Ice water path evaluation scores for AVHRR (5478 samples) using DARDAR-IWP as reference. Standard deviation (Std) and bias values are given in g/m2. Also, the relative standard deviation (Std divided by mean DARDAR IWP) and correlation coefficients are reported.

Summary

- What we did: Intercomparing AVHRR and MODIS retrieval results of three schemes based on same L1 data
(Auxiliary data deviated; were seen as part of the schemes; limited to 5 days)

- Results gave validation results for all schemes, which are comparable since a common framework and multi-collocation were used

- Also investigated: MODIS 3.7 and MODIS 1.6 (AVHRR heritage channels) retrieval results (very similar to the AVHRR in most aspects)

- MODIS 3.7 vs. MODIS 1.6 retrievals: slightly better agreement with the reference datasets found for 1.6 than 3.7. Significant differences, however, were only found for LWP (reduced bias) and IWP (reduced standard deviations).

- All results detailed in:

Stengel, M., S. Mieruch, M. Jerg, K.-G. Karlsson, R. Scheirer, B.Maddux, J.F. Meirink, C. Poulsen, R. Siddans, A. Walther, R. Hollmann, The Clouds Climate Change Initiative: Assessment of state-of-the-art cloud property retrieval schemes applied to AVHRR heritage measurements, Remote Sensing of Environment (**2013**), http://dx.doi.org/10.1016/j.rse.2013.10.035

Outlook

- What this framework has been used for since

  - Monitoring further developments of PPS (NWCSAF, CMSAF)
  - E.g. PPS2014 cloud mask ('CMSAF-A2'):
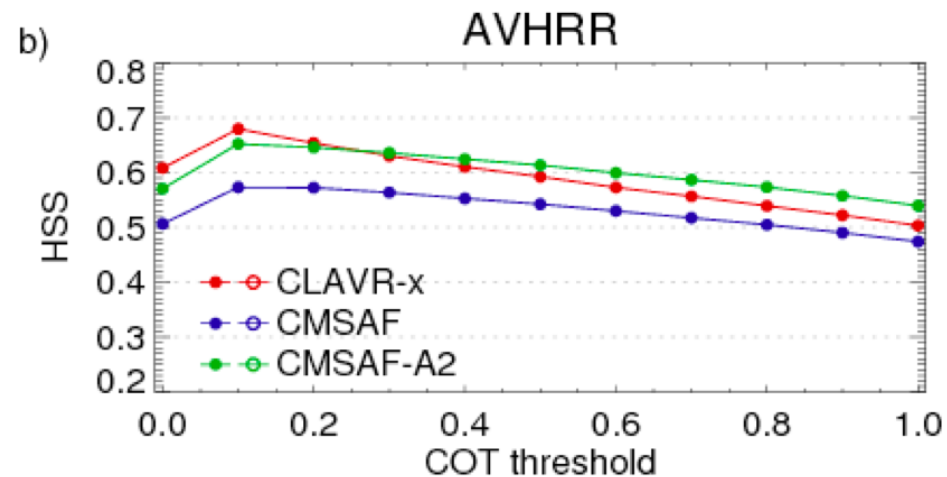
  - Continuously monitoring the Cloud_cci developments using this framework

References

- **Dybbroe**, A., A. Thoss and K.-G. Karlsson, **2005a**: NWCSAF AVHRR cloud detection and analysis using dynamic thresholds and radiative transfer modeling - Part I: Algorithm description, J. Appl. Meteor, 44, pp. 39-54.

- **Dybbroe**, A., A. Thoss and K.-G. Karlsson, **2005b**: NWCSAF AVHRR cloud detection and analysis using dynamic thresholds and radiative transfer modeling - Part II: Tuning and validation, J. Appl. Meteor, 44, 55-71.

- **Heidinger**, A. K., Straka, W. C., Molling, C. C., Sullivan, J. T., & Wu, X. (2010). Deriving an inter-sensor consistent calibration for the AVHRR solar reflectance data record. International Journal of Remote Sensing, 31(24), 6493–6517.

- **Heidinger**, A. K., Foster, M. J., Walther, A., & Zhao, X. (**2013**). The pathfinder atmospheres extended (PATMOS-x) AVHRR climate data set. Bulletin of the American Meteorological Society.

- **Poulsen** C. A., Siddans, R., Sayer, A. M., Carboni, E., Dean, S. M., Grainger, R. G. and Lawrence, B. N., **2010**: Cloud retrievals from satellite data using optimal estimation, evaluation and application to ATSR, in preparation.

- **Roebeling**, R.A., A.J. Feijt and P. Stammes, **2006**, Cloud property retrievals for climate monitoring: implications of differences between SEVIRI on METEOSAT-8 and AVHRR on NOAA-17, J. Geophys. Res., 111, D20210, doi:10.1029/2005JD006990.

- **Watts** P.D., Mutlow C.T., Baran A.J. and Zavody A.M., **1998**: Study on cloud properties derived from Meteosat Second Generation Observations. Eumetsat Report, http://www.eumetsat.de/en/area2/publications/rep_cloud.pdf.