



Sea Ice CCI+



ESA CCI+ CLIMATE CHANGE INITIATIVE
PHASE 1: NEW R&D ON CCI ECVs

Contract number:
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CCI+ Sea Ice ECV ESMR SEA ICE CONCENTRATION PRODUCT VALIDATION AND INTERCOMPARISON REPORT (PVIR-ESMR)

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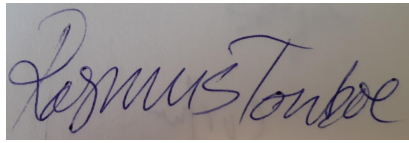

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<p>Contract PHASE 1 OF THE CCI+ CLIMATE CHANGE INITIATIVE NEW R&D ON CCI ECVs SEA ICE ECV</p>	<p>Deliverable D4.1-ESMR</p>
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1 INTRODUCTION

1.1 Purpose

This document is the Name of Document for sea ice concentration for the Sea Ice ECV within CCI+ PHASE 1 - NEW R&D ON CCI ECVs, which is being undertaken by a METNO-led consortium. It presents the validation of the NIMBUS 5 ESMR sea ice concentration product over open water.

1.2 Scope

This document presents the validation of the NIMBUS 5 ESMR sea ice concentration product over open water. The algorithms are not part of this document, but the ATBD (Ref. 1), and the description of the dataset is part of a separate report, the PUG (Ref. 2).

1.3 Document Status

This PVIR for ESMR is describing the NIMBUS 5 ESMR sea ice concentration dataset validation at the end of the ESA CCI+ Phase 1 project.

1.4 Applicable Documents

Table 1 below lists the Applicable Documents referred to in this document.

Table 1: Applicable Documents

Document ID	Document referred to
Ref. 1	The ATBD for sea ice concentration for the Sea Ice ECV within CCI+ PHASE 1 - NEW R&D ON CCI ECVs
Ref. 2	The ESMR PUG for sea ice concentration for the Sea Ice ECV within CCI+ PHASE 1 - NEW R&D ON CCI ECVs

1.5 Acronyms and Abbreviations

The table below lists the acronyms and abbreviations used in this volume.

Table 2: Acronyms and Abbreviations. Acronyms for the deliverable items (URD, etc...) and partner institutions (AWI,..) are not repeated.

Acronym	Meaning
AMSR-E / AMSR2	Advanced Microwave Scanning Radiometer (for EOS / #2)
AOGCM	Arctic Ocean General Climate Model
AR5, AR6	WMO IPCC Assessment Report series

ASAR	Advanced Synthetic Aperture Radar
C3S	EU Copernicus Climate Change Service
CCI	Climate Change Initiative
CDR	Climate Data Record
CMEMS	EU Copernicus Marine Environment Monitoring Service
CMIP5, CMIP6	Coupled Model Intercomparison Project series
CMUG	Climate Modelling User Group
CRG	Climate Research Group
CS-2	ESA's CryoSat-2
DEWG	CCI Data Engineering Working Group
EASE grid	Equal-Area Scalable Earth Grid
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
ENVISAT	ESA's Environmental Satellite
EO	Earth Observation
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ESMR	Electrically Scanning Microwave Radiometer
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FoV (<i>alt</i> FOV)	Field-of-View
FY3	Feng Yun 3
FYI	First Year Ice
GCOS	WMO's Global Climate Observing System
GCW	WMO's Global Cryosphere Watch
ICDR	Interim Climate Data Record
IMB	Ice Mass Balance buoy
IPCC	WMO's Intergovernmental Panel on Climate Change
L1b, L2, L3C, ...	Satellite data processing Level (Level-1b, ...)
MERIS	MEdium Resolution Imaging Spectrometer
EPS, EPS-SG	EUMETSAT's Polar System, EPS Second Generation
MIZ	Marginal Ice Zone
MODIS	Moderate Resolution Imaging Spectroradiometer
MWI	MicroWave Imager (EPS-SG)
MWRI	Micro-Wave Radiation Imager (Feng Yun 3)
MYI	Multi-Year Ice

NASA	National Aeronautics and Space Administration
NOAA	US National Oceanic and Atmospheric Administration
NSIDC	US National Snow and Ice Data Centre
OE	Optimal Estimation
OIB	Operation Ice Bridge
OSI SAF	EUMETSAT Ocean and Sea Ice Satellite Application Facility
OWF	Open Water Filter
PMR	Passive Microwave Radiometer
PMW	Passive Microwave
RA	Radar Altimeter
RRDP	Round Robin Data Package
SIC	Sea Ice Concentration
SIT	Sea Ice Thickness
SAR	Synthetic Aperture Radar
SIRAL	Synthetic Aperture Radar (SAR) Interferometer Radar Altimeter
SOA	Service Oriented Architecture
SMMR	Scanning Multichannel Microwave Radiometer
SMOS	Soil Moisture and Ocean Salinity
SSM/I	Special Sensor Microwave/Imager
SSMIS	Special Sensor Microwave Imager/Sounder
ULS	Upward Looking Sonar
WMO	World Meteorological Organization
WSM	Wide Swath Mode

1.6 Executive Summary

The NIMBUS 5 ESMR PVIR presents results obtained at the end of the CCI+ Sea Ice project (Year 3) for the Sea Ice Concentration (SIC) variable. The validation results are presented as histograms for the SIC data prepared at the end of the CCI+ Sea Ice project. Two years, 1973 and 1974, have enough data points for making a meaningful validation: the northern hemisphere SIC open water bias is less than 1.2% and the mode of the distribution is close to the zero mean. For all years data points are within $\pm 12\%$. On the southern hemisphere the bias is less than 0.6% and the mode of the distribution is close to the zero mean. For all years data points are within $\pm 8\%$.

2. Evaluation of the NIMBUS 5 ESMR period (Dec. 11, 1972 - May 16., 1977)

The first version of the NIMBUS 5 ESMR sea ice concentration data-set has been validated over open water in the SIC0 points (Fig. 1) using the same procedure as for the SMMR, SSMI and AMSR SIC data. The open water validation has been done for every year in the record (1972-1977) and for the northern and southern hemispheres. There was no synthetic aperture radar data available from the 1970s to check for ice convergence and to produce a SIC1 reference data set. Therefore, there is no SIC1 validation for NIMBUS 5 ESMR.

The number of points used in the validation of ESMR SIC over open water on the northern hemisphere and the bias (reference - observation), the root mean square error (rmse), and the mean total standard uncertainty (mtsu) which is the mean uncertainty estimate provided along with the SIC in the data files is shown in Fig. 2. Note that the statistics is based on a small number of points in 1972, 1975, 1976, and 1977. The bias in Fig. 2 is small, less than 3%, and there is no apparent trend over the years from 1972-77. The rmse and the mtsu follow the same pattern but they are offset by about 7-11%. The rmse varies from about 7% in 1974 to about 12% in 1977 and the mtsu varies from about 16% in 1973 to about 23% in 1977. That the bias is low is expected because the open water tie-point (0% SIC) is adjusted dynamically to the open water signature.

The number of points used in the validation of ESMR SIC over open water on the southern hemisphere and the bias (reference - observation), the root mean square error (rmse), and the mean total standard uncertainty (mtsu) which is the mean uncertainty estimate provided along with the SIC in the data files is shown in Fig. 3. Note that the statistics is based on a small number of points in 1972, 1975, 1976, and 1977. The bias in Fig. 3 is small, less than 5%, but it is more variable from year to year than in the northern hemisphere. The rmse and the mtsu follow the same pattern but they are offset by about 8-10%. The rmse varies from about 5% in 1972 and 1975 to about 8% in 1977 and the total standard uncertainty - mtsu varies from about 14% in 1975 to about 18% in 1973 and 1974 which means that the product uncertainty is larger than the validation rmse.

Looking at the years 1973 and 1974 in Fig. 4 (northern hemisphere open water) where there are more than 500 data points used in the validation the bias is less than 1.2% and the mode of the distribution is close to the zero mean. For all years, also those where the data points are less than 500 data points are within $\pm 12\%$.

Looking at the years 1973 and 1974 in Fig. 5 (southern hemisphere open water) where there are more than 300 data points used in the validation the bias is less than 0.6% and the mode of the distribution is close to the zero mean. For all years data points are within $\pm 8\%$.

For comparison, using the same validation method, modern SIC records from the AMSR radiometer (CCI+ Sea Ice ECV sea ice concentration validation and intercomparison report - PVIR) have open water SIC standard deviations less than 3% and bias less than $\pm 3\%$. The differences between ESMR and the AMSR records validation results can be explained by lower instrument noise on the AMSR compared to ESMR and also more accurate ERA5 re-analysis data in the 2000s than in the 1970s. The re-analysis data are used for regional noise reduction in both records.

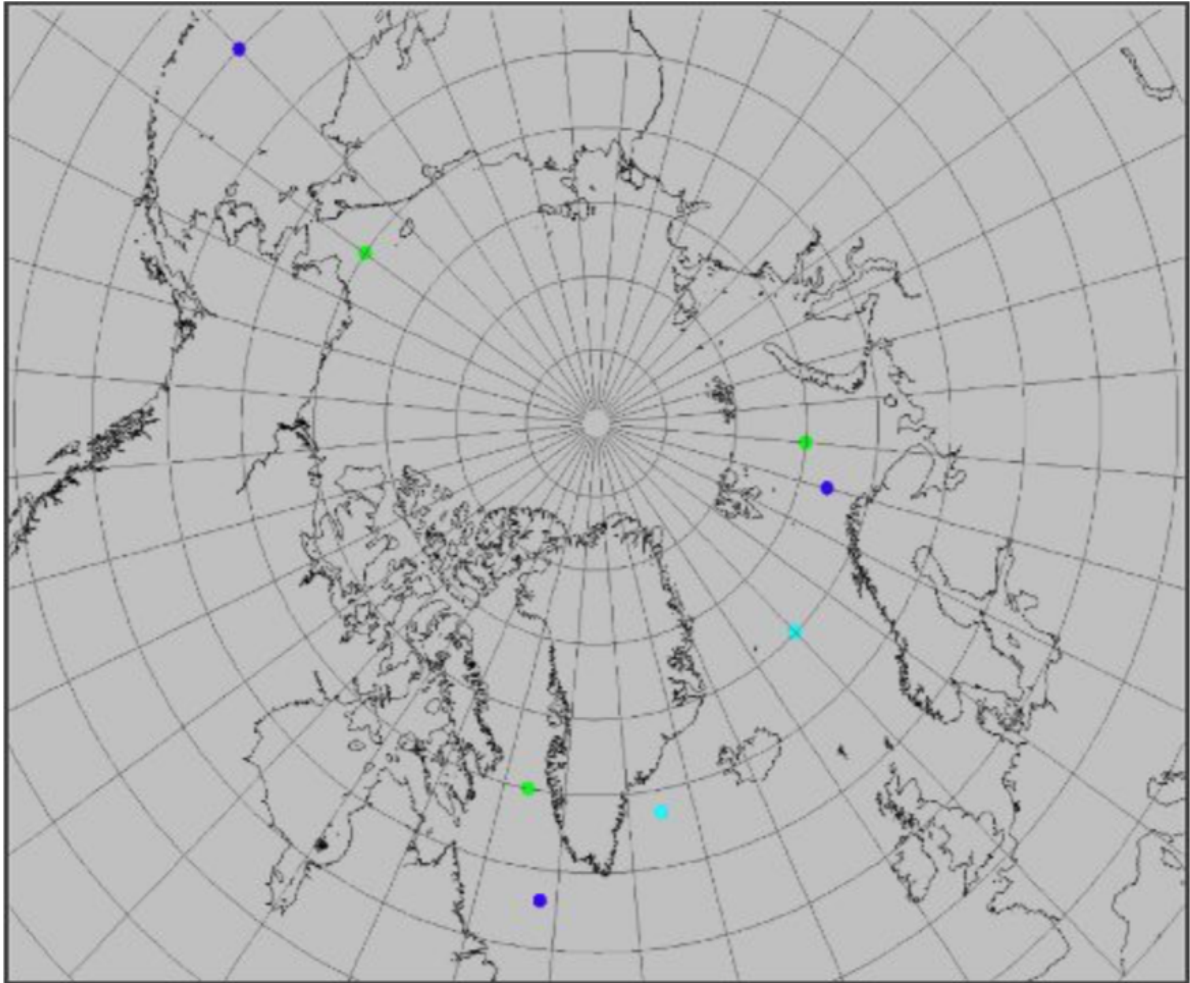


Figure 1: Location of the data points used for the open water validation.

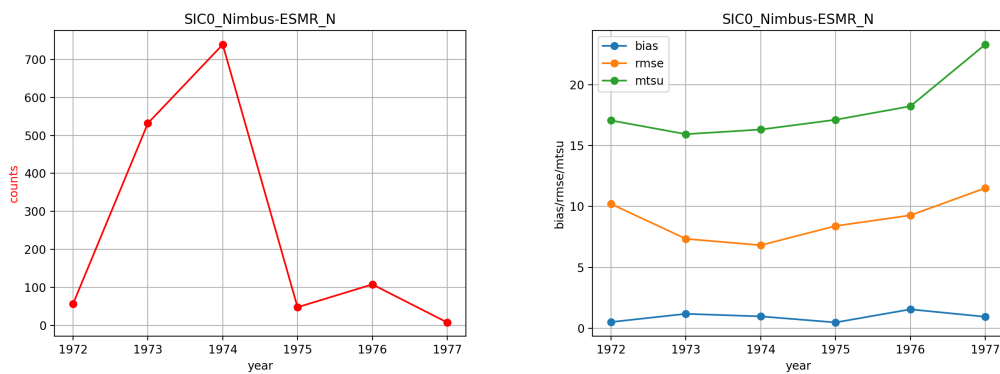


Figure 2: The number of points used in the validation of ESMR SIC over open water on the northern hemisphere (left) and the bias (reference - observation), the root mean square error (rmse), and the mean total standard uncertainty (mtsu) which is the mean uncertainty estimate provided along with the SIC in the data files (right).

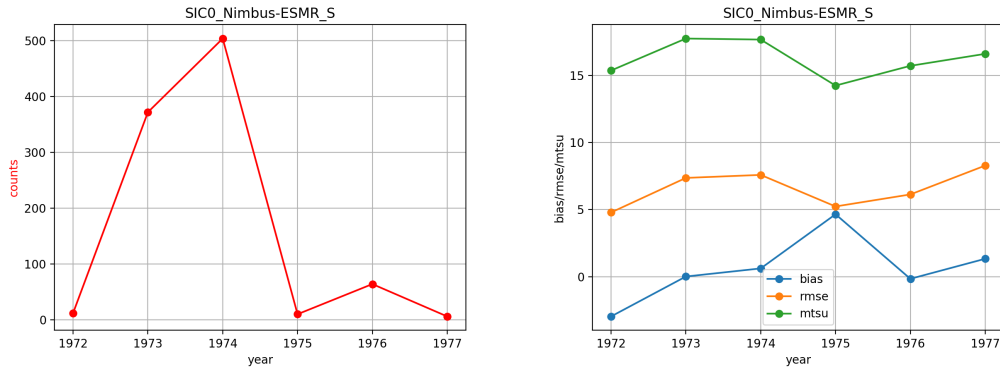


Figure 3: The number of points used in the validation of ESMR SIC over open water on the southern hemisphere (left) and the bias (reference - observation), the root mean square error (rmse), and the mean total standard uncertainty (mtsu) which is the mean uncertainty estimate provided along with the SIC in the data files (right).

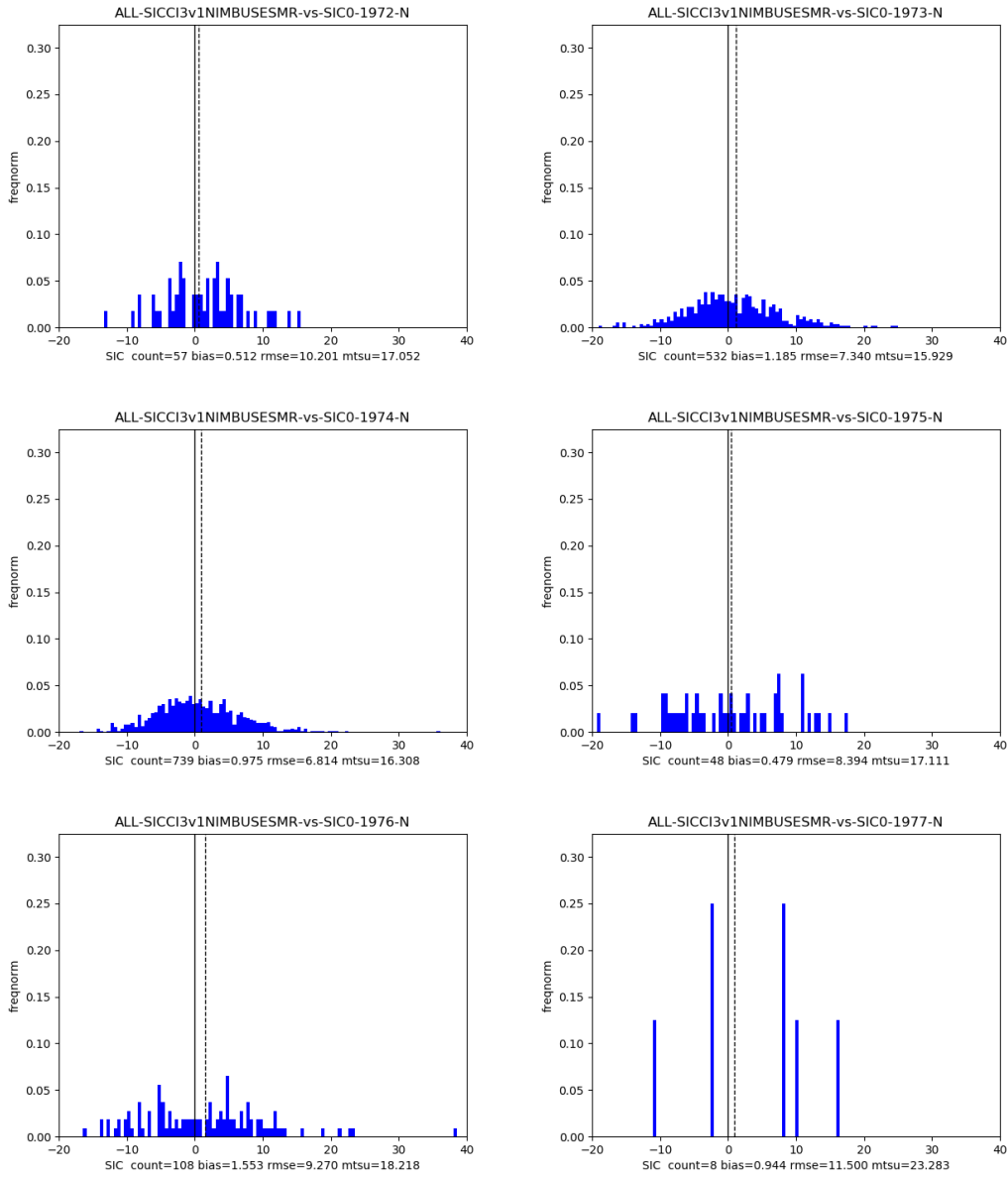


Figure 4: Histograms showing the frequency of ESMR SIC around zero sea ice concentration for all years of operation (1972-77) and for the northern hemisphere.

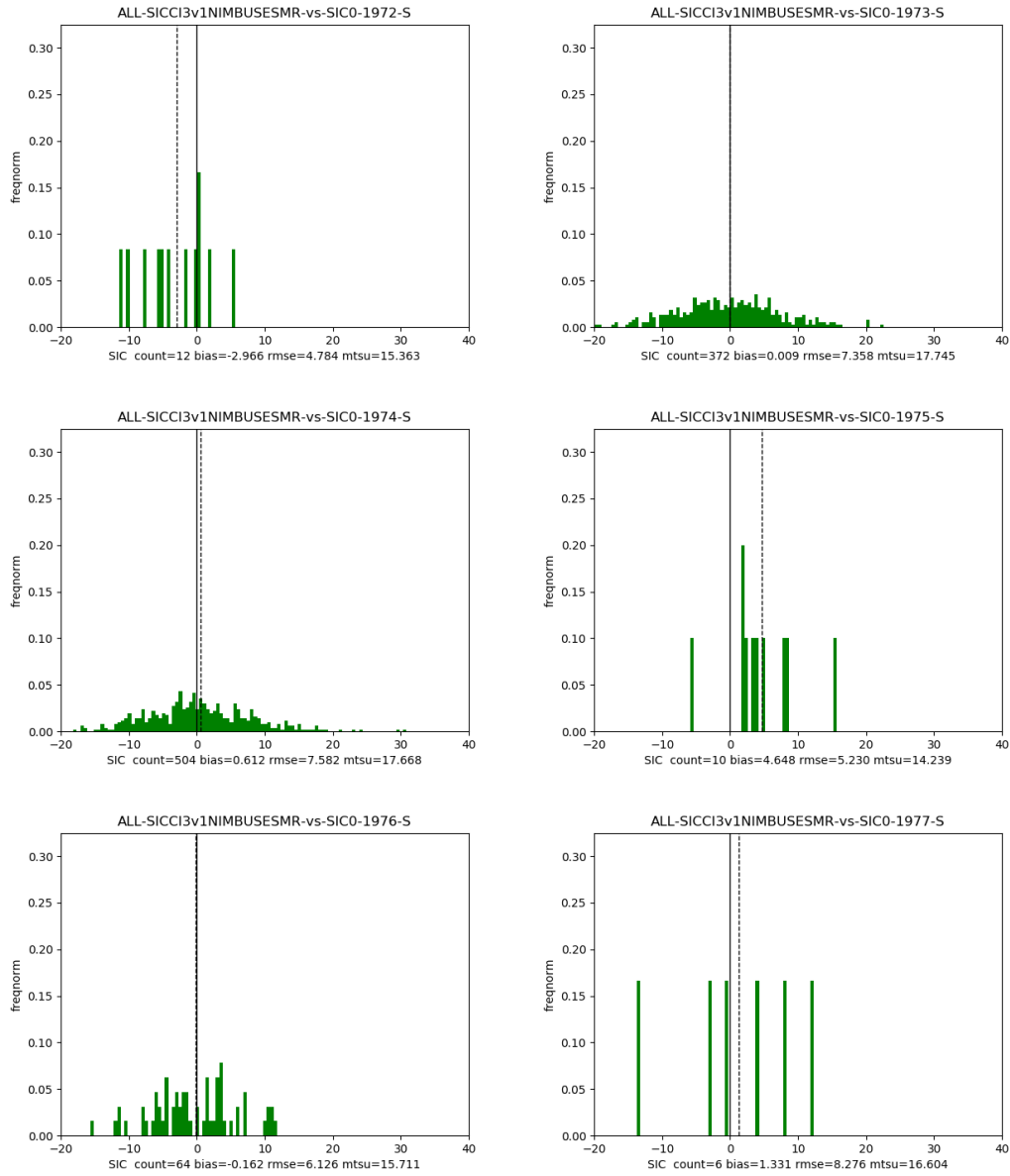


Figure 5: Histograms showing the frequency of ESMR SIC around zero sea ice concentration for all years of operation (1972-77) and for the southern hemisphere.