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OSI SAF

Ocean and Sea Ice

Validation Report for the Atlantic High Latitude Radiative Fluxes

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Document Change Record

Version	Date	Change	Description	Responsible
1.0	14 April 2011	Major	Preparation for separate dissemination of High Latitude Fluxes from the OSISAF High Latitude Centre.	Øystein Godøy
1.1	15 April 2012	Minor	Correction of illustrations as requested by review and refinement of text.	Øystein Godøy

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1 Introduction

1.1 Scope

The purpose of this report is to document the level of agreement between the OSISAF HLC radiative flux products and in situ observations.

1.2 Overview

Surface Radiative Fluxes for the North Atlantic Ocean are produced by the Ocean and Sea Ice SAF (OSISAF) High Latitude Centre (HLC). The products are described in a dedicated Product User Manual available through <http://osisaf.met.no/>. The High Latitude processing facility is operated in cooperation by the Norwegian Meteorological Institute and the Danish Meteorological Institute.

The radiative fluxes produced by HLC were previously merged with Low and Mid Latitude fluxes by Meteo-France and distributed by Meteo-France as a Merged Atlantic Product. this product is now being removed and HLC products are distributed separately.

The report is separated in chapters describing the in situ validation data and the results obtained. The OSISAF HLC products are not described, users are referred to the Product User Manual.

Updated information about the products as well as access to products are provided through <http://osisaf.met.no/>. General information on the Ocean and Sea Ice SAF is provided through <http://www.osi-saf.org/>.

1.3 Applicable documents

[RD.1] EUMETSAT OSISAF CDOP Product Requirement Document, v1.2

[RD.2] EUMETSAT OSISAF Product Manual for the High Latitude Radiative Fluxes, v1.0

[RD.3] Description of the osihdf5 format, v1.1

2 Validation datasets

2.1 Overview

An overview of stations with an observational programme for surface radiative fluxes is shown in Figure 1.

The green circles identify Bioforsk stations (described below) where data is received in real time at the Norwegian Meteorological Institute.

The brown circles identify stations established during the International Polar Year at meteorological stations operated by the Norwegian Meteorological Institute. Information from these stations are also received in real time and further description is provided below.

The blue circles identify offline stations from which data may be received with delay. The full circles identify stations where data at some point have been received, either for the current validation or previously for algorithm development. The half circles are stations known to be available but which yet not have been utilised actively either due to too long delay in data delivery or quality of the data received. More stations than listed here have been utilised for algorithm development, but these are stations which are actively pursued currently.

Compared to the validation stations used for geostationary products, none of the validation stations used for polar orbiting products fulfil the surface homogeneity requirement. Most stations are located in coastal areas with complex terrain.

2.2 Brief description of datasets

2.2.1 Bioforsk datasets

Bioforsk (<http://www.bioforsk.no/>) maintains a number of agricultural research stations covering Norway are measuring surface shortwave irradiance. Selected stations (Table 1) are used for validation of OSISAF SSI products. In situ measurements are received in real time or near real time at the Norwegian Meteorological Institute.

These stations observe surface shortwave irradiance only, but includes a number of meteorological parameters as well. Of especial importance are the measurements of direct insolation as it can be used to validate the NWCSAF PPS cloud type product as well.

Table 1 shows the full list of stations observing surface shortwave irradiance. Bioforsk have renovated most of their stations and in that process the number of stations actually observing surface shortwave irradiance have increased. Not all stations are however included in the OSISAF validation setup yet. A full review of the validation stations to use is scheduled for completion in 2011.

Bioforsk stations are only used for validation of the cloud mask and Surface Shortwave Irradiance (SSI).

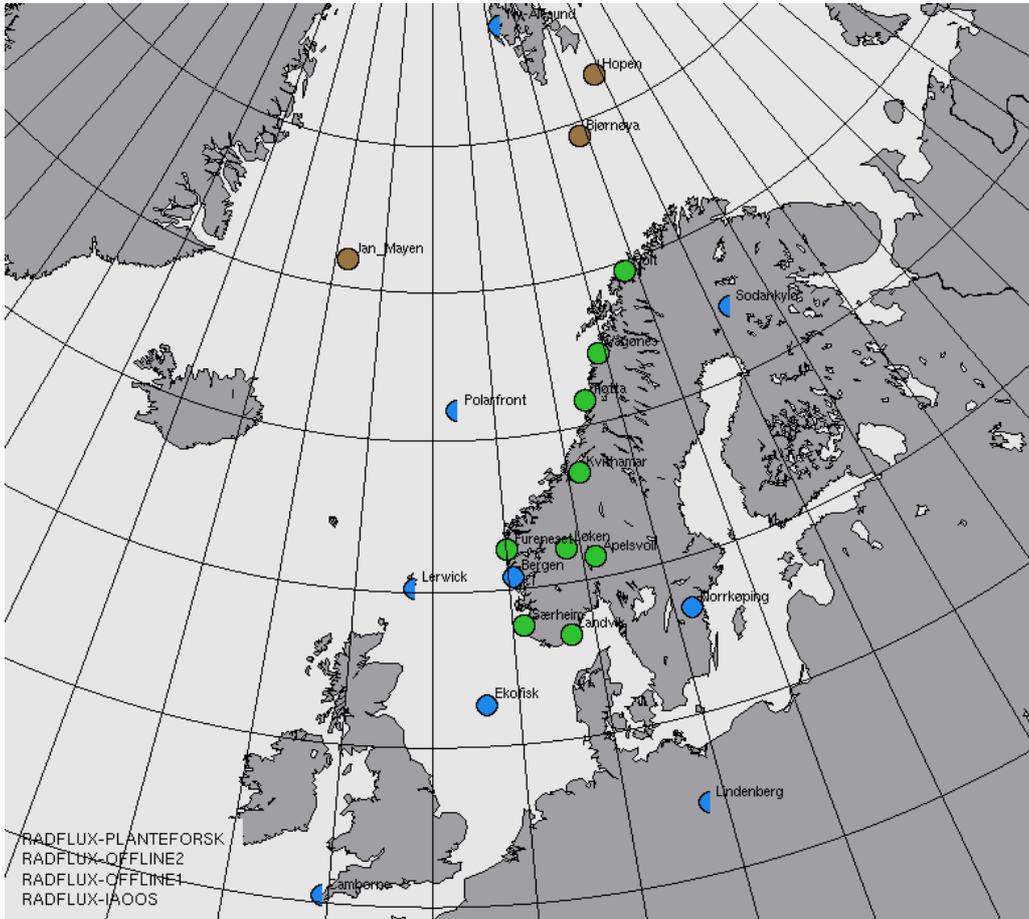


Figure 1: Potential validation sites for Ocean and Sea Ice SAF High Latitude radiative flux products.

Table 1: BIOFORSK stations used for validation of OSISAF radiative fluxes.

Station name	Station number	Comment
Apelsvoll	11500	Included in current validation. Typical inland station. Identified with black circle in illustrations.
Fåvang	13150	Typical inland station.
Folldal	09160	Typical inland station.
Frosta	69655	
Fureneset	56420	Included in current validation. Coastal station with relatively complex terrain. Identified with open cyan square in illustrations.
Holt	90400	Included in current validation.
Kise	12550	
Kvithamar	69150	Included in current validation. Coastal station in relatively homogeneous terrain around Trondheimsfjorden. Usually snow covered in winter time. Identified with pink vertical flipped triangle in illustrations.
Landvik	38140	Included in current validation. Coastal station with relatively (for Norway being) homogeneous terrain. Usually little

Station name	Station number	Comment
		snow cover. Identified with green plus sign in illustrations.
Løken	23500	Included in current validation. typical inland station. Identified with red triangle in illustrations.
Pasvik	99460	
Rakkestad	03290	
Roverud	05660	
Sande	26990	
Særheim	44300	Included in current validation. Coastal station with relatively (for Norway being) homogeneous terrain. Usually not covered by snow in winter time. Identified with blue x in illustrations.
Tjøtta	76530	Included in current validation. Coastal station with relatively complex terrain and heavily influenced by snow during winter time. Identified with yellow square containing a x in illustrations.
Udnes	04920	
Ullensvang	49490	
Vågønes	82260	Included in current validation. Coastal station with relatively complex terrain. Identified by grey star in illustrations.

2.2.2 Norwegian Meteorological Institute

During the International Polar Year (IPY), the Research Council of Norway funded measurements of the surface radiative fluxes at the meteorological stations operated by the Norwegian Meteorological Institute at Jan Mayen, Bjørnøya and Hopen. These observations were funded as part of the IPY projects iAOOS-Norway and IPY-THORPEX.

These stations are maintained by the operational crew at the Arctic stations and include both Surface Shortwave Irradiance (SSI) and Downward Longwave Irradiance (DLI) measurements.

Near real time presentation of the time series are available at <http://dokipy.met.no/projects/iaoos-norway/radflux.html>. Data is received in real time in Oslo.

The stations have been provided with the station numbers of the meteorological stations as they are collocated. Jan Mayen has station number 99950, Bjørnøya 99710 and Hopen 99720.

All these stations are located on islands and in harsh environments. The station at Hopen is located quite close to a mountain which certainly affects the radiation observed, some shadows from surrounding buildings may also occur. However, Hopen is visited by many Polar Bears each year and the instrumentation is located thinking on the safety of the personnel maintaining them. So far instruments have not been attacked by Polar Bears. Hopen is much of the time located within sea ice.

The station at Bjørnøya is also visited quite frequently by Polar Bears. Twice the cables have been eaten. Bjørnøya is much of the time located close to the sea ice edge.

Jan Mayen has a harsh environment with volcanic sand rubbing the instruments constantly. The station may experience some shadow effects.

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A more thorough study of the quality of each station is currently ongoing.

2.2.3 University of Bergen datasets

University of Bergen (Norway) represented by the Geophysical Institute runs a laboratory for measurement of radiative fluxes in the city of Bergen and at the oil rig Ekofisk in the North Sea. Both stations observe both surface shortwave and downward longwave irradiance at the surface.

These measurements are received in delayed mode and has primarily been used during algorithm development, but are as of 2011 being included in the updated validation setup. Within this report only the dataset from Ekofisk have been used. The dataset from Bergen is subject to a highly complex terrain. The station at Ekofisk is referred to using station number 76920 in the illustrations. All numbers used for stations are internal station number at the Norwegian Meteorological Institute and not WMO numbers. This is the station number of the meteorological station which it is located close to. The instrumentation is located close to the helipad and is subject to shadows caused by control tower and cranes, but this is the only truly maritime station available for validation.

A more thorough study of the quality of the Ekofisk station is currently ongoing.

2.2.4 Swedish Meteorological and Hydrological Institute

The Swedish Meteorological and Hydrological Institute (SMHI) operates a number of stations which observes surface radiative fluxes. Previously data from the station in Norrköping has been used for algorithm tuning. Other stations have been updated and SMHI data will be requested for validation purposes.

2.2.5 Finnish Meteorological Institute

The Finnish Meteorological Institute (FMI) operates a station observing surface radiative fluxes in Sodankylä. No data has been received so far as the quality was reported to be dubious when requested. A new request will be submitted in 2011.

2.2.6 University of Southampton

The University of Southampton (UK) had equipment for observing surface radiative fluxes at the ocean weather ship Mike (Polarfront) in the Norwegian Sea. The weather ship was cancelled January 2010, but data from 2008 and 2009 was received. However, due to a technical failure, these data are dubious and have yet not been used for neither algorithm development nor validation. A more thorough analysis is currently ongoing and data suitable will be used for future algorithm development.

2.2.7 Baseline Surface Radiation Network

Stations located in Cambourne, Lerwick, Ny-Ålesund and Lindenberg observe surface radiative fluxes and report these through the Baseline Surface Radiation Network (BSRN). Only data from Ny-Ålesund have to a certain extent been examined due to very long delay before data are available. In 2011, requests for more regular access to data from these stations

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will be filed. BSRN data will primarily be used for algorithm development purposes and secondarily for validation. The quality of BSRN stations is anticipated to be better than the many of the stations currently used, however regular access to data have proven difficult.

3 Validation methodology

3.1 Parameters to be validated

The OSISAF HL Radiative fluxes contains two set of parameters to validate. These are downward irradiance in the shortwave and longwave bands, respectively 0.3-3 μ m and 4-50 μ m. Each of these parameters are estimate on both passage basis and on a daily basis.

3.2 File formats

The satellite estimates are available in HDF5 format. The in situ measurements are available in a number of file formats ranging from various ASCII formats to NetCDF/CF.

All in situ measurements are reformatted to a ASCII format which share the same structure although the number of parameters may differ according to the measurement programme at the station.

The output validation format is currently a ASCII format which in time will be reformatted to NetCDF/CF using NetCDF4.

3.3 Collocation strategy

In order to compare satellite based estimates with in situ measurements some choices have been made on how the collocation is performed.

First, these two types of data differ in the perspective. While the satellite observes top down, the surface based measurements observe upwards. The area covered by each instrument is not necessarily identical.

For the validation, remote sensing estimates in a box spanning approximately 20 km around the station have been used.

Validation stations report data in either hourly intervals, 10 or 1 minute intervals. Stations not reporting in hourly intervals have been averaged to hourly values using a R-package (ncradflux). All illustrations have been produced using a specific OSISAF HLC R-package (osisaf).

3.4 Validation requirements

The target accuracy of products are for downward longwave irradiance and surface shortwave irradiance is provided below.

DLI	
monthly relative bias	5%
monthly relative Std. Deviation	10%

SSI	
monthly relative bias	10%
monthly relative Std. Deviation	30%

4 Validation results

4.1 Surface Shortwave Irradiance

4.1.1 Passage estimates

Validation of OSISAF SSI passage estimates against surface observations performed by Bioforsk in Norway is shown in Figure 2. Five different panels are used in the validation. For all panels monthly mean values for each station are provided along with a mean value for all stations (thick solid line and solid dots).

The uppermost panel shows the number of observations for each station. It is observed that the number of observations is lowest during winter months and highest during summer. This is due to the solar angle dependence of the SSI product.

The next panel shows the mean observed irradiance. This is high during summer and small during winter due to the annual variation of insolation at high latitudes. Some of the stations are located within the Arctic Night and have no values during wintertime.

The third panel shows the mean bias for each station and all stations. It is readily observed that the bias is largest during winter months and lowest during summer months. The main reason for this is the snow covered ground during winter months, a feature currently not handled by the processing scheme. This is further illustrated in the fourth panel which shows the relative bias compared to the monthly mean observed irradiance at each station. From this panel it is readily observed that the relative bias in passage products are less than 10% during months May-September. During these months, the surface is usually not covered by snow at the stations examined here. The final panel shows the relative standard deviation for the passage products. This is quite good in the absence of snow on the ground.

Results would be better if some of the stations were removed from the validation procedure as problems were experienced at some of the stations in 2010. Currently work is ongoing to find new validation stations and when this work is completed, some of the old stations with known issues will be removed.

4.1.2 Daily estimates

Validation of daily estimates against Bioforsk stations are shown in Figure 3. The panels used are the same as in Figure 2. Furthermore, the same features as in Figure 2 are recognised, although as the relative bias is quite high during winter months, the lowermost panel shows some drastic features in winter months. The overall relative bias get quite bad, but when broken down into bias for individual stations and analysed with the knowledge of the

conditions at the various stations it looks better. The reason for the bad overall relative bias is due to all data are missing at some stations. Missing values are handled individually for each station, but the overall estimate is currently not handling this well. An effort is ongoing to fix this, but finding new validation data has had priority.

Basically the results of Figure 3 compares well with the results illustrated in Figure 4. Basically some of the inland stations and northernmost stations perform worse than the coastal stations. It is clearly seen that the coastal stations located in rather homogeneous terrain performs best. Best results are achieved for the coastal stations in southern Norway where snow cover usually do not affect the coastal stations.

A scatter plot also including the overall statistics of the daily validation of SSI products is provided in Figure 5. The overall bias for daily products is -6.84 W/m^2 for a mean observed daily irradiance of approximately 113 W/m^2 .

The daily SSI estimates are also validated against the stations operated at the Arctic meteorological stations and Ekofisk. Results are shown in Figure 6. It is observed that results are better for Ekofisk than the Arctic stations. One major reason for this is the lower solar irradiance observed at these stations which drastically affects the relative bias, but also some issues with the shortwave irradiance measurements at these stations (shadow effects, sand deterioration of domes etc) that are hard to compensate (e.g. for safety reasons due to polar bears).

It is observed that the bias is relatively constant during April through September when snow starts affecting the results at land stations again. Similar results are observed in passage products.

Daily products are generated using passage products as cloud factor indices. As polar orbiting satellites are near sun synchronous with morning and afternoon orbits the daily estimate lacks knowledge on cloud conditions part of the day.

Concerning the target accuracy of the daily surface shortwave irradiance estimates, the relative bias and standard deviation should be less than 10% and 30% respectively. Within the current data material this is fulfilled for some stations (and seasons) but violated for others as a consequence of the in stations location and quality. This is further discussed in the final chapter.

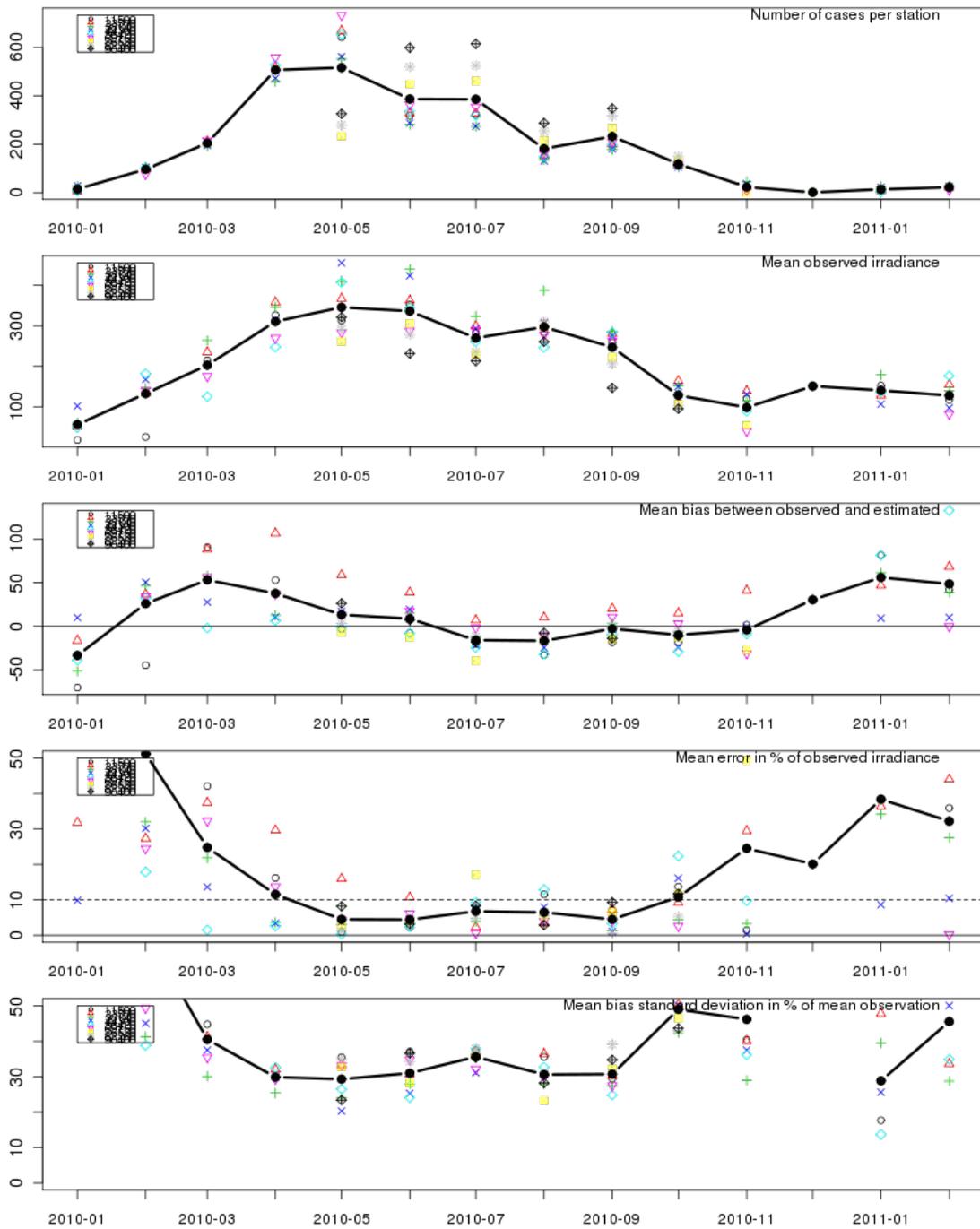


Figure 2: Validation of SSI passage products against Bioforsk stations. See text for details.

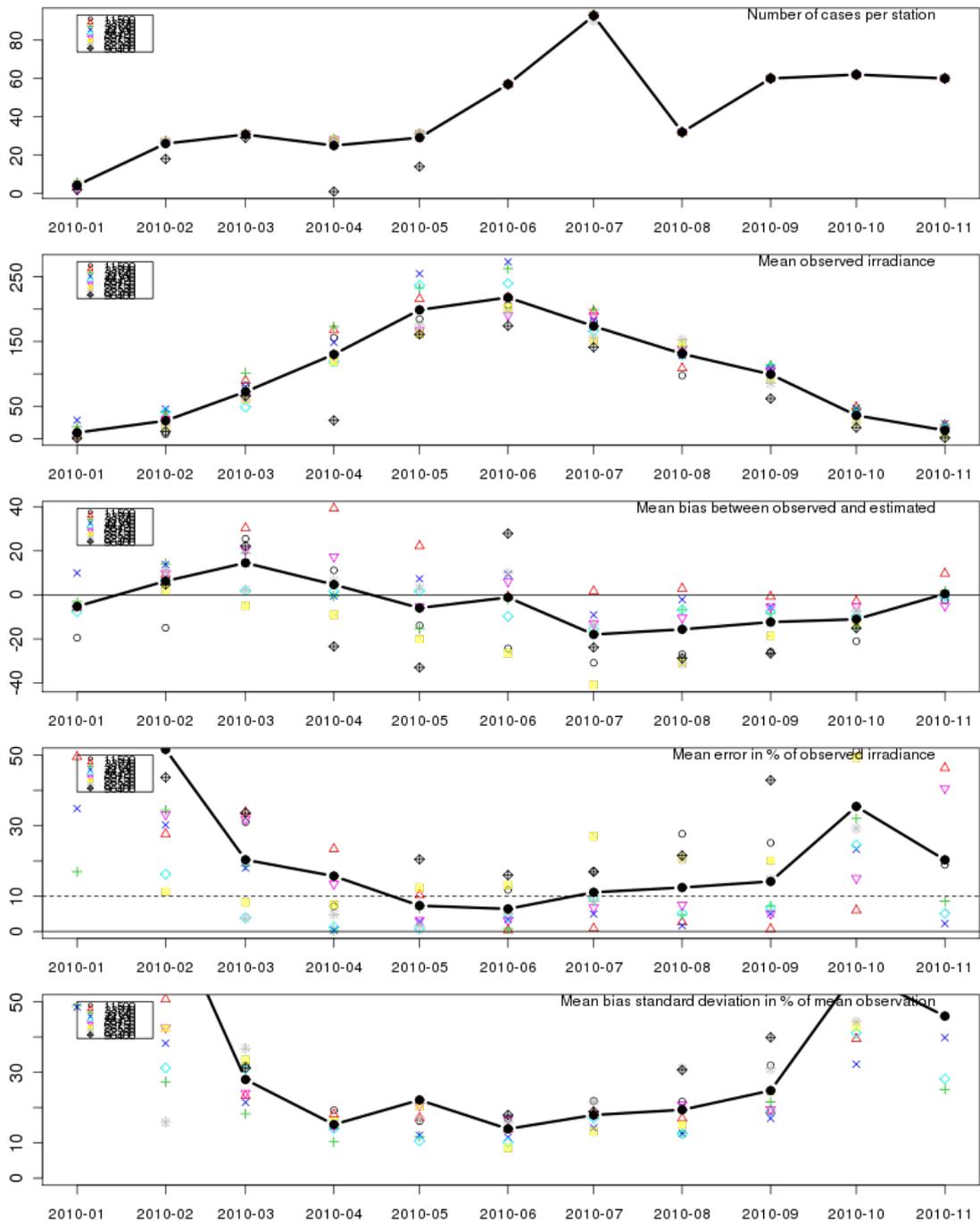


Figure 3: Validation of SSI daily estimates against Bioforsk stations. See text for details.

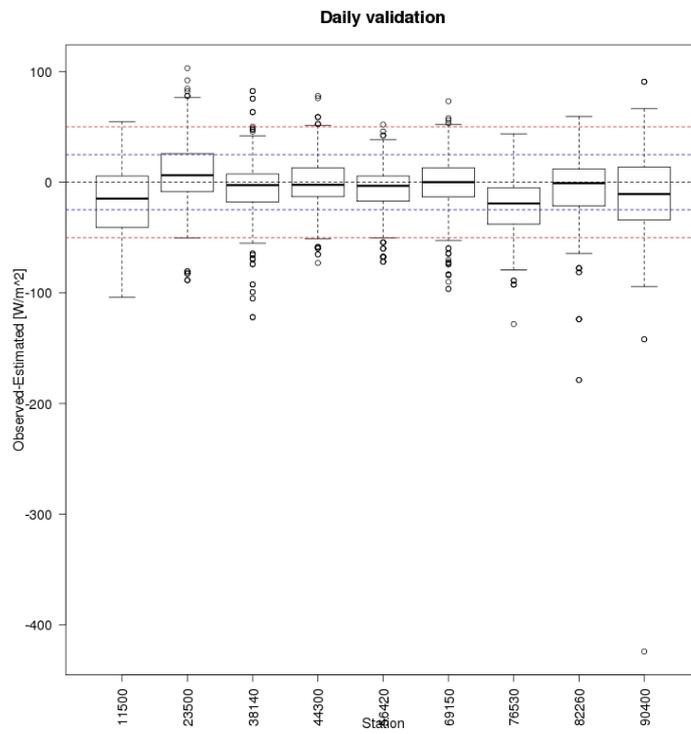


Figure 4: Daily validation statistics broken down on stations.

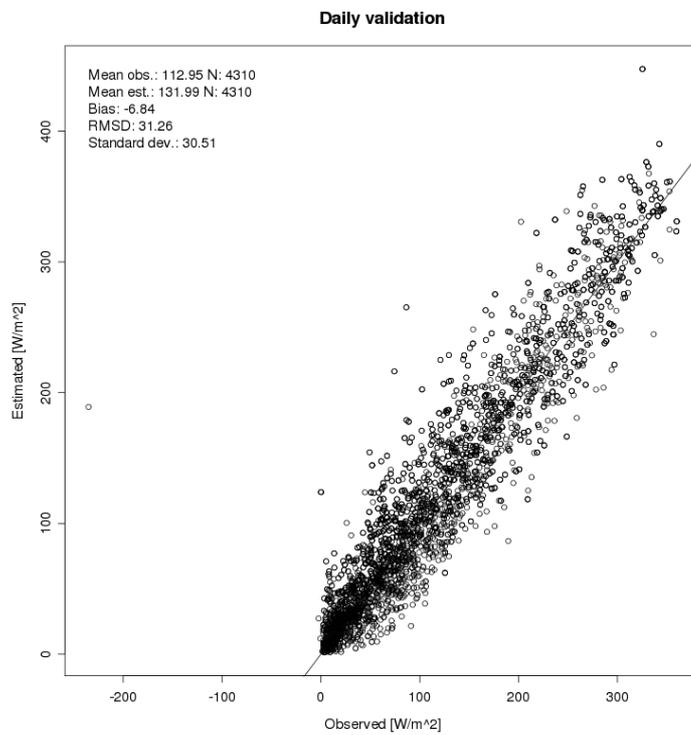


Figure 5: SSI daily validation against Bioforsk stations, scatterplot including overall statistics.

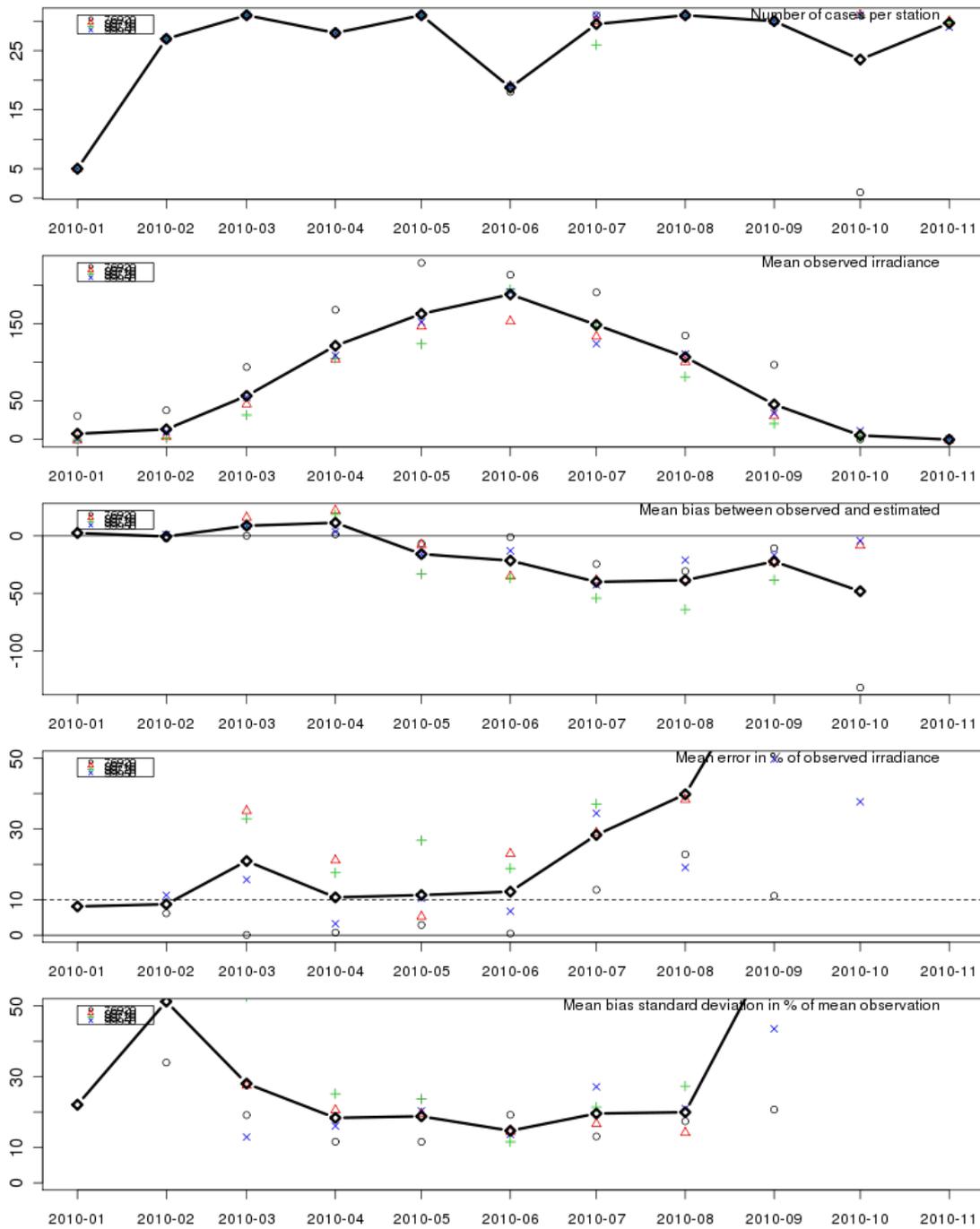


Figure 6: Validation of daily SSI estimates against METNO (Jan Mayen, Bjørnøya and Hopen) and UiB station Ekofisk.

4.2 Downward Longwave Irradiance

4.2.1 Passage estimates

Validation of downward longwave irradiance is only possible in the current setup against stations located at the Arctic meteorological stations Jan Mayen, Bjørnøya and Hopen along with the oil rig Ekofisk in the North Sea. Validation results are illustrated in Figure 7. Panels are the same as for SSI products. It is observed that the seasonal dependence observed in SSI is not affecting the DLI passage products.

DLI is less affected by the complex terrain surrounding the stations than SSI. However, the instrumentation is more fragile than the SSI instrumentation and require more maintenance.

4.2.2 Daily estimates

Validation results for daily estimates are shown in Figure 8. Results are similar to the results achieved for passage products. The relative bias is less than 10%.

Concerning the target accuracy of downward longwave irradiance of relative bias and standard deviation of 5% and 10% respectively, this is generally fulfilled for Ekofisk and somewhat for the Arctic stations where the relative bias some months exceeds 5% although the relative standard deviation is less than 10%.

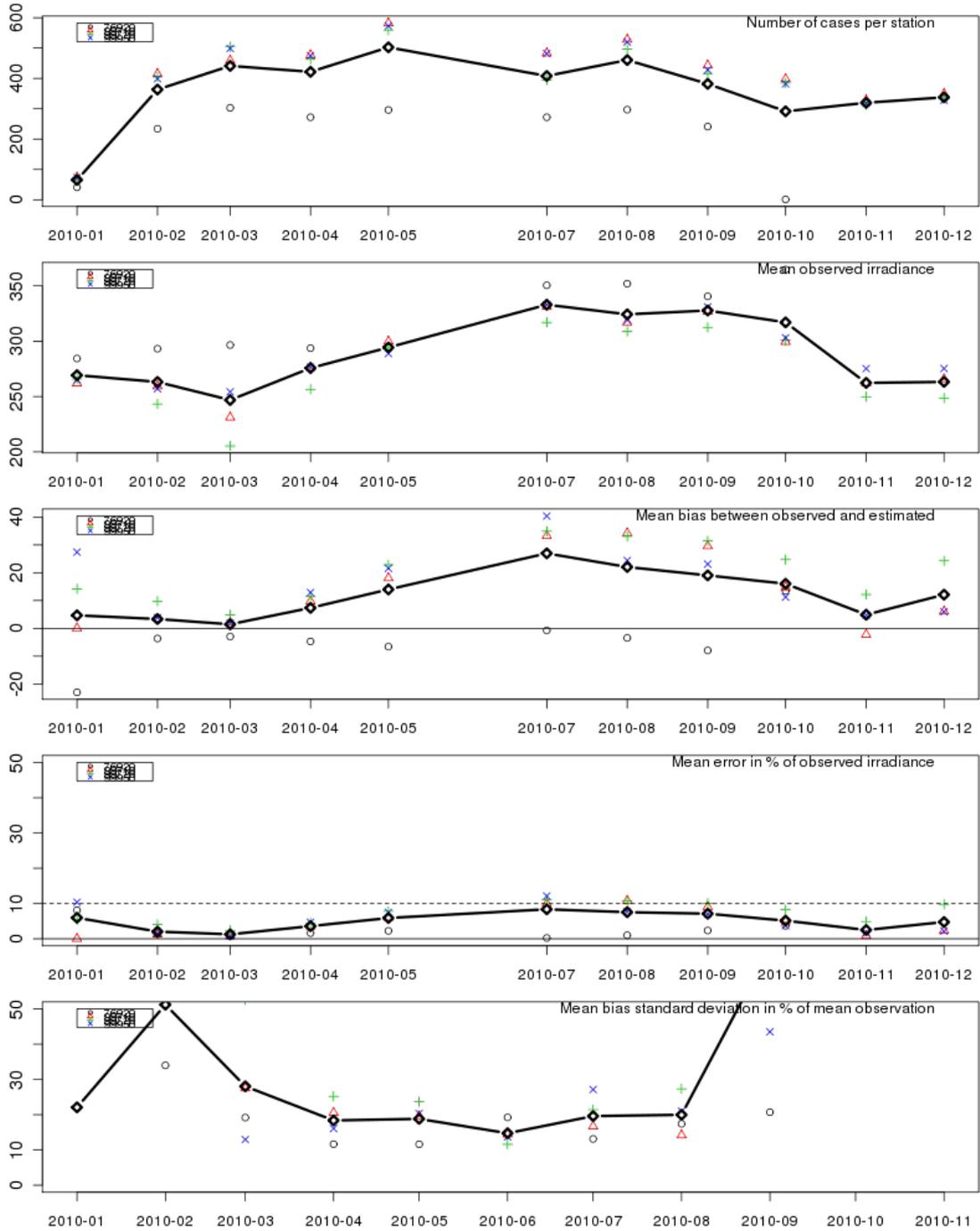


Figure 7: Validation of passage longwave estimates.

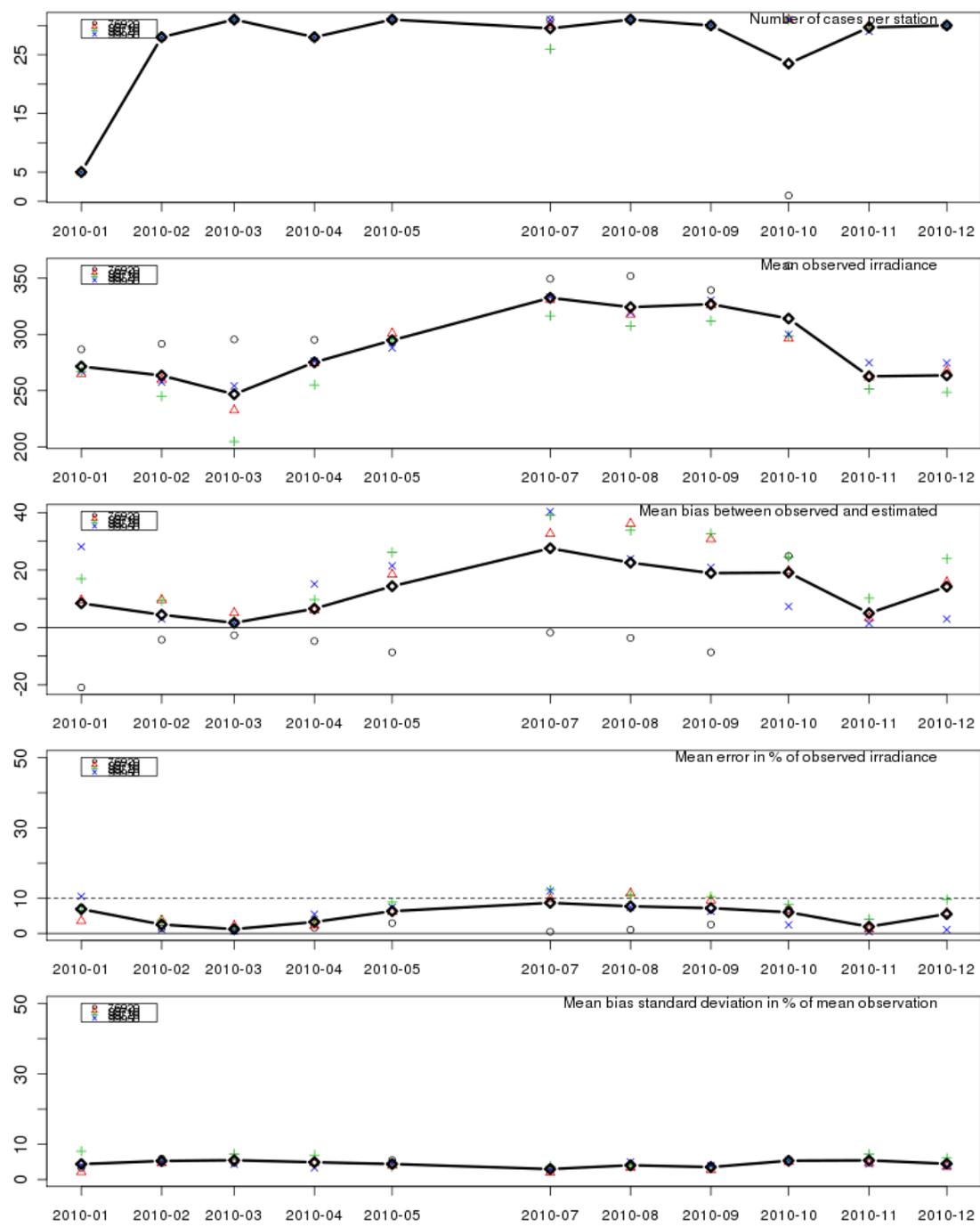


Figure 8: Validation of daily longwave irradiance estimates.

5 Discussion

Ocean and Sea Ice SAF Atlantic High Latitude satellite passage and daily integrated products of surface shortwave irradiance and downward longwave irradiance have been validated against in situ measurements.

The in situ measurements used comes from a variety of sources. The geographical characteristics of each station differs much as do the maintenance programs. In general, none of the stations used in this validation fulfil the homogeneity requirements applied to stations used for validation of the geostationary OSISAF products. On the other side, the stations used spans a wide range of latitudes as well as surface types. Provided the rather complex terrain and climatological conditions in Northern Europe, most validation stations experience some sort influence from the surroundings, whether being shadow effects by mountains or human constructions, seasonal features like snow or weather generated effects like water intrusion or sand deterioration or external damage due to wildlife (e.g. polar bears). This effect is most notable for the SSI products. Only one station can be said to be truly maritime, reflecting the conditions for which the OSISAF products are produced. That is the maritime station of Ekofisk. All other validation stations are located onshore and some of them in quite challenging terrain. A work is currently ongoing to increase the number of validation stations, but as part of this existing stations are also quality controlled. Some of this work is done by master students, so far only SSI measurements at the Arctic stations have been extensively examined. Results will be collected in a separate report to aid the analysis of future validation reports.

Concerning DLI products these performs well at the stations validated. The bias is quite small both for passage and daily products. However, not many stations observe longwave irradiance and it is attempted to increase the number of stations. In future validations some more stations in Scandinavia will be included.

Concerning SSI products, the performance of these varies much between the stations used for validation. This product is highly influenced by the location of the validation stations, its surroundings, the performance of the NWCSAF cloud type product and knowledge of the surface characteristics. Concerning passage products, these are highly influenced by the rapid variation in cloud cover. In this situation an instantaneous satellite product which represents an area is compared with a point measurement which is integrated in time to hourly representation.

In the current validation all available data are being used, however as the number of validation stations increase, it would be wise to filter the stations actually used. So far this has been an luxury not granted as validations stations have been very sparse.

Validation results shows quite poor results for some stations. For some of the stations, the local topography, heterogeneous surfaces within the Field Of View as well as local shadow effects are known to influence the validation results. Generally, the stations located in homogeneous terrain inland, as well as the stations along the rather homogeneous coastal area in southern and mid Norway performs better than the stations in the rugged coastal zone in Northern Norway or those located in complex terrain inland. Similarly it is observed that the performance is better at Ekofisk than at the Arctic stations. It is reassuring that the results at

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the only maritime station available is so good, although this station as well is known to have insufficiencies in both location (e.g. shadow effects by cranes and towers) and regular maintenance as it is located at an oil rig with the requirements thus posed upon it.

For all validation stations located onshore, results are bad during the snow season as the algorithm fails when the surface is covered by snow. However, these products are targeting ocean areas where snow is not influencing the results. Sea ice may influence the results, but the Ocean and Sea Ice SAF sea ice concentration is used to tag pixels contaminated by sea ice.

At the Bioforsk stations, the time of direct insolation at the station is also observed. this can be used in combination with the cloud mask information to examine the influence of the cloud mask on the results. When examining the validation results for overcast and clear sky conditions, as reported by the in situ measurements, the overall biases (observed minus estimated) are -16 W/m^2 and 33 W/m^2 respectively. However, when restricting validation to situations which both the in situ measurement and the satellite reports to be either overcast or clear, the results change to -6 W/m^2 and -3 W/m^2 respectively. Hence, the performance of the NWCSAF PPS cloud mask and type is explaining much of the bias observed in SSI passage products, and in consequence in the daily products. That being said, the current NWCSAF PPS implementation in use is old and the updated version has been implemented and will be used for future production. The performance of the new PPS software is known to be improved according to NWCSAF PPS documentation and personal correspondence with Adam Dybbroe (SMHI). Evaluation of the PPS performance close to sea ice is currently ongoing.

Errors in SSI passage products are propagated through to daily products. SSI products are more sensitive to the cloud mask and type performance than DLI products due to the smaller variability in DLI compared to SSI. The latter has a very strong diurnal and annual cycle which is much less in DLI.

Other issues affecting the validation results are that due to running an old version of PPS, utilisation of new satellites like MetOp and NOAA-19 have not been done. This is part of the prepared upgrade. The major gain from this is an increase in the number observations during a day and through this, better representation of the cloud conditions.

6 Conclusion

DLI products performs well at the stations examined. SSI products are heavily influenced by local conditions at the validation stations as well as the performance of the NWCSAF PPS cloud mask and type products. The quality of SSI products will improve as a consequence of the new cloud mask and type processing that has been implemented, and for future validation validation stations will be filtered as the number of available stations finally increases.