Water Quality Continuum Atmospheric Correction Recommendations

Questionnaire Results

Water-ForCE

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History of Changes		
Date	**Version**	**Comments**
27.11.2022	V0	First draft by 3edata for feedback from VITO
2.12.2022	V1	Modifications by VITO
5.1.2023	V2	Minor modifications by VITO

List of Acronyms	
AC	Atmospheric Correction
AE	Adjacency Effect
CAL/VAL	Calibration and Validation
BRDF	Bidirectional Reflectance Distribution Function

Table of Contents

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1.- Questionnaire description

The questionnaire was based on 36 recommendations formulated by the atmospheric correction (validation) experts who were invited to give a presentation during the online Water-ForCE Water Quality Continuum Atmospheric Correction workshop on 20 October 2022. The recommendations were further grouped into 4 main categories:

- Atmospheric Correction PROCESSING (13 recommendations received)
- IN SITU DATA for Atmospheric Correction CAL/VAL (14 recommendations received)
- Atmospheric Correction and CAL/VAL (4 recommendations received)
- Atmospheric Correction and SENSORS (5 recommendations received)

The questionnaire was sent to all participants (55) of the workshop. The respondents were asked to score the recommendations from 0 to 10, showing 0 as low priority and 10 as high priority.
We obtained 21 valid replies which were further analyzed, both aggregated by category as well as a whole.

2.- Recommendations by category

2.1.- Recommendations regarding AC PROCESSING

Figure 1 gives an overview of the average score for each AC processing recommendation. The 13 recommendations provided by the experts are listed in the table below.

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Table 1: List of recommendations regarding AC processing.

AC PROCESSING
1 - Develop an indicator to quantify adjacency effects (AE) and develop a clear definition of the parameters to quantify adjacency effects.
2 - Develop atmospheric correction (AC) algorithms that include adjacency effect correction.
3 - Flag pixels with a risk of adjacency effect contamination if NOT corrected for.
4 - Flag pixels with a risk of adjacency effect contamination if corrected for.
5 - Evaluate the impact of adjacency effects (from snow, land, vegetation) on each AC algorithm to have a better understanding of the different impact of AE on the various AC algorithms.
6 - Provide uncertainty estimates of the values in measurement units (e.g. using uncertainty propagation or characterization).
7 - Develop approaches to normalize measurements for solar and viewing conditions, including BRDF effects.
8 - Separately assess and correct for sky glint.
9 - Indicate the amount of sun glint contribution that is removed if a pixel has correctable (moderate) sun glint.
10 - Improve the representativeness of aerosol models (particularly absorbing aerosols) in AC.
11 - Improve the methodology for removing sky/sun glint.
12 - Select AC processors according to the specific scientific objective and application as there is no single solution for global studies of inland and coastal waters.
13 - Identify optimal constituent retrieval algorithms for each AC processor due to the varying sensitivities of constituent retrieval algorithms and (systematic) biases of AC processors.

The minimum average score in this category was 7.00 for recommendation 7. The maximum average score (8,81) was given to recommendation 2 (**Develop atmospheric correction (AC) algorithms that include adjacency correction**).

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Above the median value of the average score (8,05), so considered the most important in this category, were recommendation 1, 2, 3 and 12, highlighting the need and importance of the **correction for adjacency effects.**

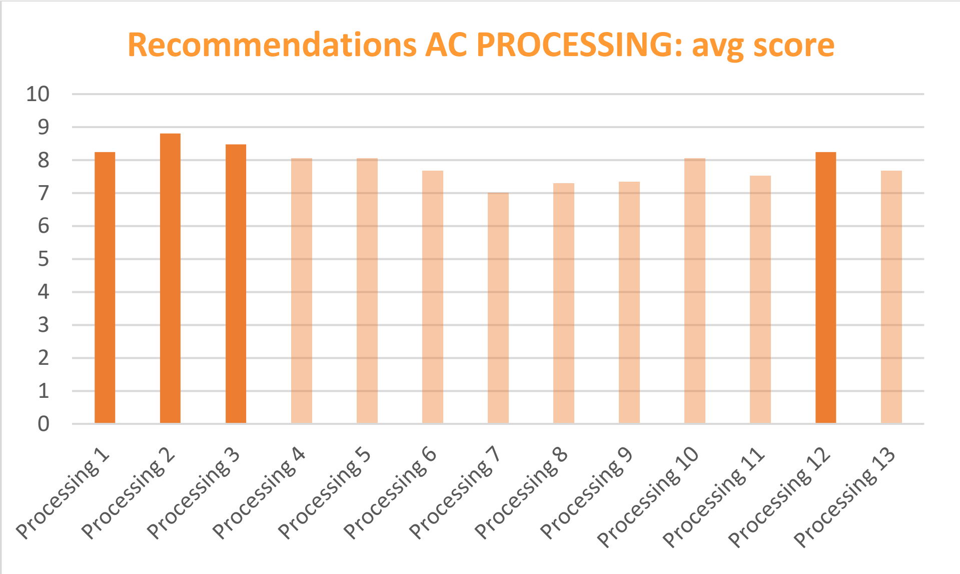

Figure 1: Average score for the recommendations regarding AC PROCESSING (recommendations with average score above the median are indicated with a darker color).

2.2.- Recommendations regarding IN SITU DATA for AC CAL/VAL

Figure 2 gives an overview of the average score for each IN SITU DATA for AC CAL/VAL recommendation.

The 14 recommendations given by the experts are listed in the table below.

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Table 2: List of recommendations regarding IN SITU DATA for AC CAL/VAL.

IN SITU DATA for AC CAL/VAL
1 - Need for automated fixed station measurement networks, which are geographically well-distributed and represent different water types to support AC validation activities for both coastal and inland waters.
2 - Need for automated ships-of-opportunity measurements to collect in situ data along optical and shore to open water transects, for cal/val.
3 - Need for networks with centralized services (data calibration, handling, reduction, processing, quality control, uncertainty, archiving, distribution).
4 - Need for standardization of network components such as instruments, measurement protocols, and processing.
5 - Use of autonomous hyperspectral spectroradiometers for the acquisition of remote sensing reflectance (Rrs) to assess AC uncertainties.
6 - Include autonomous Rrs systems in regular monitoring programmes.
7 - Need for long-term funding programs to support automatic measurement networks.
8 - Space agency/Copernicus should (continue to) support measurement intercomparison exercises and radiometer calibration/characterization, e.g. FRM4SOC.
9 - Need for open-source tools and open access to in situ data (including uncertainty estimation) for validation of AC (need for improved data sharing/distribution).
10 - Establish an international data set for adjacency correction algorithm testing (seasonal, water type, water body type/size, environment type).
11 - More in situ data are needed to characterize uncertainties in AC due to algorithm, sensor, water type, observation angle, adjacency effects, atmospheric composition (need high data volume, transects to untangle effects).
12 - Measure microscale variations (e.g. in close proximity to the shore, vessels) with drones.

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13 - Measure atmospheric conditions alongside Rrs to better attribute AC correction uncertainties.
14 - Develop strategies to combine high data volumes of automated high-frequency data with low volumes of manual data collection, to avoid geographic bias.

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The minimum average score in this category was 6,24 for recommendation 12. The maximum average score (8,95) was given to recommendation 7 (**Need for long-term funding programs to support automatic measurement networks**). Above the median value of the average score (8,55), so considered the most important in this category, were recommendations 1, 3, 4, 7, 8, 9 and 11 highlighting the need for **more open in situ data and tools to characterize uncertainties in AC due to algorithm, sensor, water type, observation angle, adjacency effects, atmospheric composition (need high data volume, transects to untangle effects) including in situ automated standardized networks covering inland and coastal waters with centralized data supported by long-term funding programmes and continued support by space agencies/Copernicus for intercomparison exercises and Fiducial Reference measurements.**

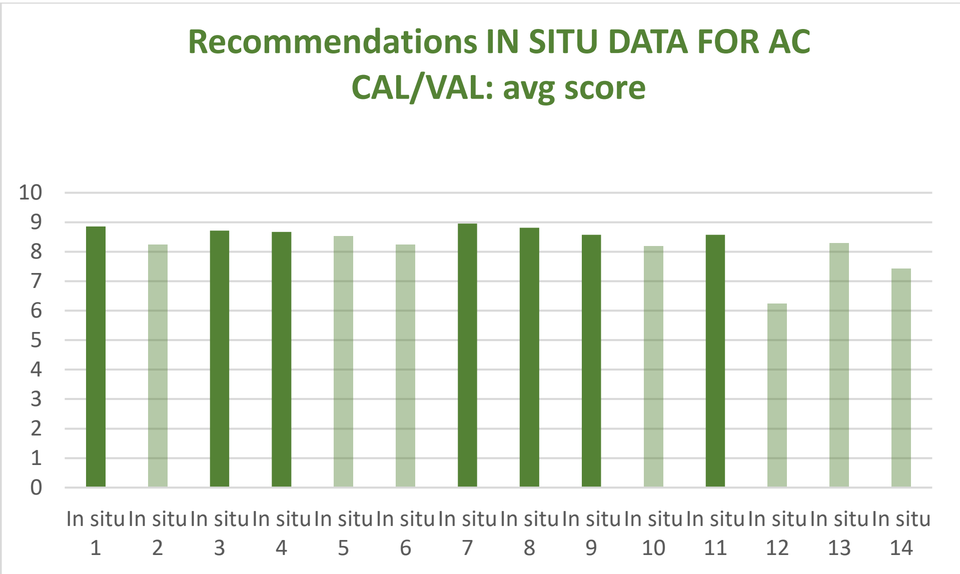

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Figure 2: Average score for the recommendations regarding IN SITU DATA for AC CAL/VAL (recommendations with average score above the median are indicated with a darker color).

2.3.- Recommendations regarding AC and CAL/VAL

Figure 3 gives an overview of the average score for each AC and CAL/VAL recommendation.

The 4 recommendations given by the experts are listed in the table below.

Table 3: List of recommendations regarding AC and CAL/VAL.

AC and CAL/VAL
1- Need for AC round robin exercises with focus on validation of AE correction using *in situ* data for validation
2 - Need for atmospheric correction round robin exercises with focus on validation of AE correction using image-based analyses (e.g. Image based consistency analyses).
3 - Need for AC round robin exercises with focus on validation of sun glint correction using image-based analyses (e.g. Image based consistency analyses).
4 - Need for AC round robin exercises with focus on AC validation under different atmospheric and water conditions

The minimum average score in this category was 7,76 for recommendation 3. The maximum average score 8,76 was given to recommendation 1 (**Need for atmospheric correction round robin exercises with focus on validation of AE correction using in situ data for validation**). Above the median value of the average score (8,38), so considered the most important in this group, were recommendations 1 and 4, **highlighting the need for round-robin**

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intercomparison exercises for AC (including AE correction validation using in situ data) for different atmosphere and water conditions.

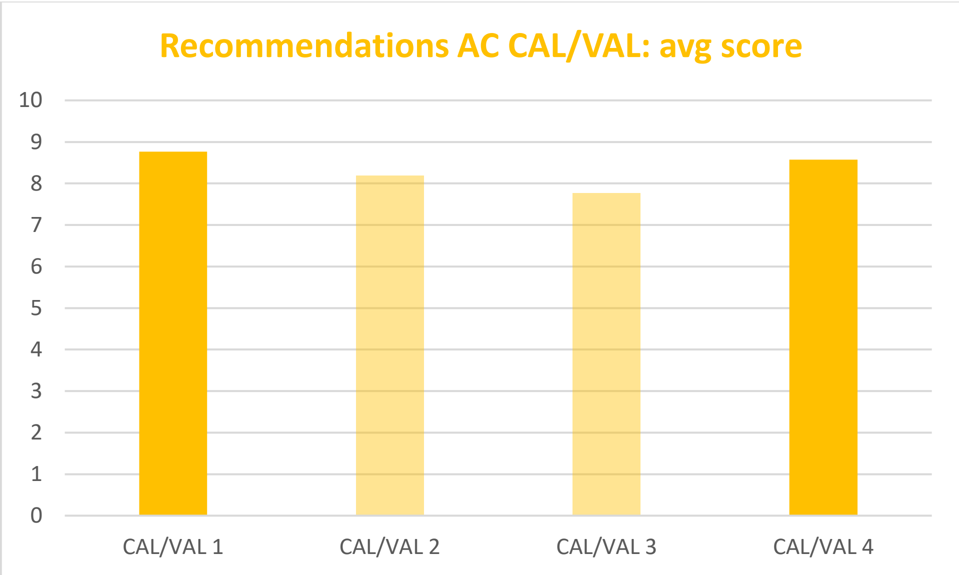

Figure 3: Average score for the recommendations regarding AC and CAL/VAL (recommendations with average score above the median are indicated with a darker color).

2.4.- Recommendations regarding AC and SENSORS

Figure 4 gives an overview of the average score for each AC and SENSORS recommendation.

The 5 recommendations given by the experts are listed in the table below.

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Table 4: List of recommendations regarding AC and SENSORS.

AC and SENSORS
1 - Future mission concepts/designs should consider inclusion of observation modalities (polarimetry) to improve the discrimination and/or characterization of aerosol types, heights, and/or optical thickness.
2 - Future mission concepts/designs should consider inclusion of observation modalities (multiangular) to improve the discrimination and/or characterization of aerosol types, heights, and/or optical thickness.
3 - Future mission concepts/designs should consider inclusion of observation modalities (hyperspectral radiometry) to improve the discrimination and/or characterization of aerosol types, heights, and/or optical thickness.
4 - Future mission concepts/designs should consider inclusion of observation modalities (ranging/profiling) to improve the discrimination and/or characterization of aerosol types, heights, and/or optical thickness
5 - Add high-fidelity radiometric measurements in the deep blue and/or ultraviolet regions to further constrain the solution space for estimating aerosol contribution.

The minimum average score in this category given by the experts was 7,45 for recommendation 4. The maximum average score 7,77 was given to recommendation 1 (**Future mission concepts/designs should consider inclusion of observation modalities (polarimetry) to improve the discrimination and/or characterization of aerosol types, heights, and/or optical thickness**). Above the median value of the average score (7,64), so considered the most important in this group, were recommendations 1 and 5, highlighting **the importance of polarimetry and hyperspectral radiometry including the blue and UV wavelength region to accurately characterize the aerosol contribution.**

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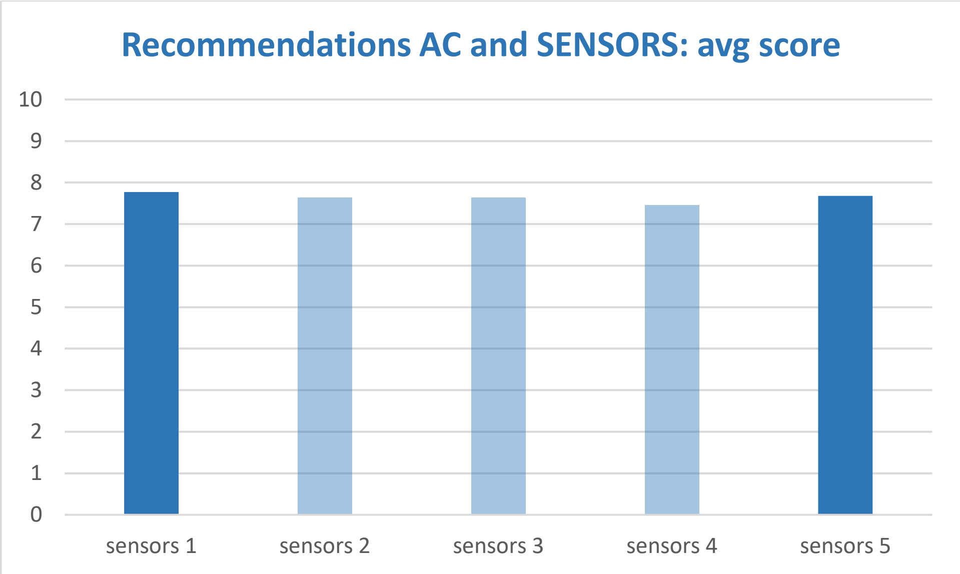

Figure 4: Average score for the recommendations regarding AC and SENSORS (recommendations with average score above the median are indicated with a darker color).

3.- Recommendations as a whole

When analyzing the entire list of 36 recommendations and average scores as a whole, several patterns can be distinguished (Figure 5). First, that **79% of the recommendations with an average score above the median value of the average score (8,19) was related to category IN SITU DATA for AC CAL/VAL (while this category had 39% of the total number of recommendations).**

The highest average score was given to these 10 recommendations (from high to low priority):

- **Need for long-term funding programs to support automatic measurement networks**

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- Need for automated fixed station measurement networks, which are geographically well-distributed and represent different water types to support AC validation activities for both coastal and inland waters
- Develop atmospheric correction (AC) algorithms that include adjacency effect correction
- Space agency/Copernicus should (continue to) support measurement intercomparison exercises and radiometer calibration/characterization, e.g. FRM4SOC.
- Need for AC round robin exercises with focus on validation of AE correction using in situ data for validation
- Need for networks with centralized services (data calibration, handling, reduction, processing, quality control, uncertainty, archiving, distribution).
- Need for standardization of network components such as instruments, measurement protocols, and processing.
- Need for open-source tools and open access to in situ data (including uncertainty estimation) for validation of AC (need for improved data sharing/distribution).
- More in situ data are needed to characterize uncertainties in AC due to algorithm, sensor, water type, observation angle, adjacency effects, atmospheric composition (need high data volume, transects to untangle effects).
- Need for AC round robin exercises with focus on AC validation under different atmospheric and water conditions

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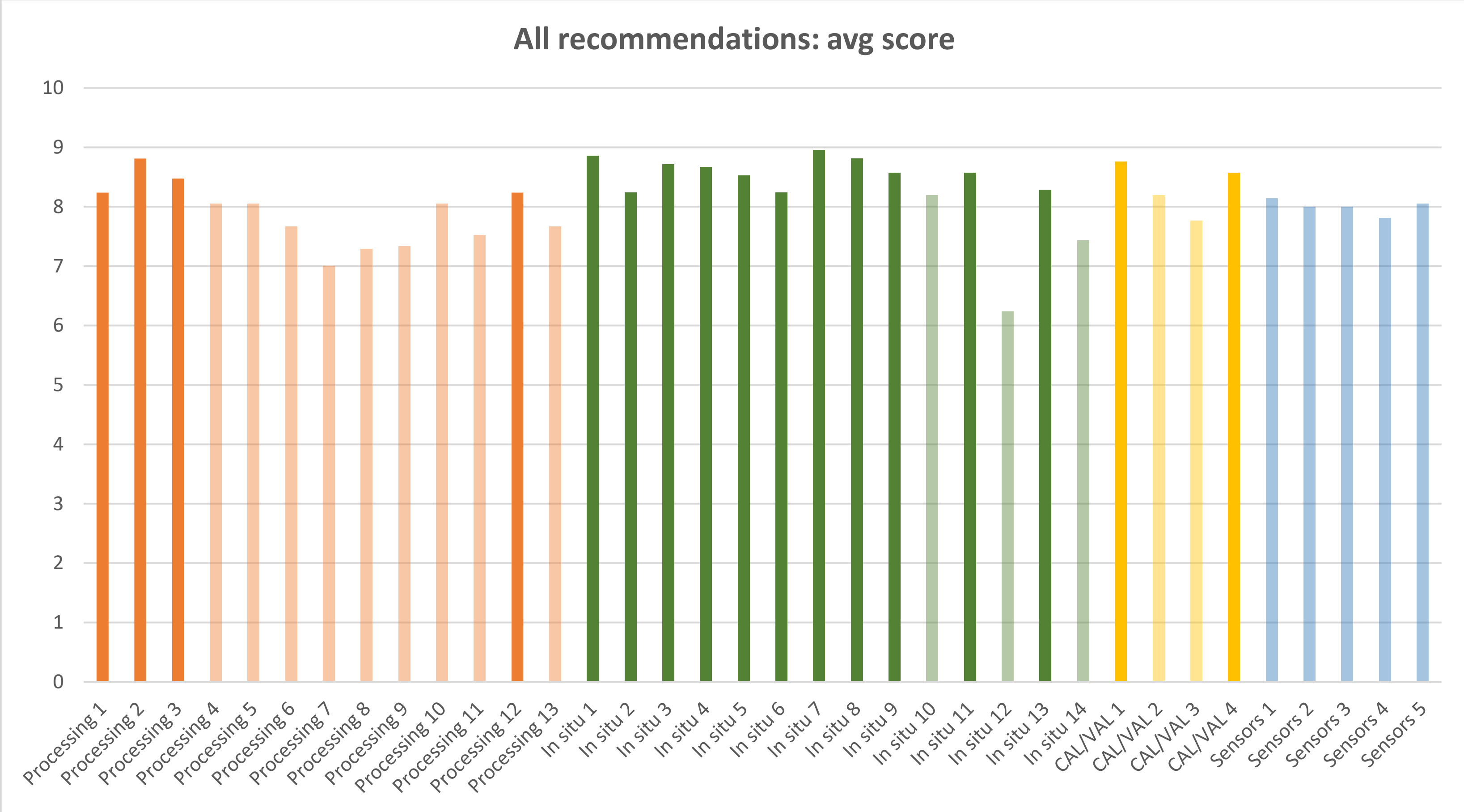

Figure 5: Average score for all recommendations (recommendations with an average score larger than the median average score (8,19) are indicated with a darker color).

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The results of the questionnaire are integrated in Water-ForCE deliverable D2.3 (Atmospheric Corrections) and will serve as an input to the Water-ForCE Roadmap.

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