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Ministry of Transport, Public Works and Water Management

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A two-day working meeting was held on 7-8 July, 2014 at ECMWF with the objective to assess the approach of modeling the foam coverage using wave model output in support of radiative transfer simulations for RTTOV. Drs Anguelova and Bettenhausen from NRL met with Louis-Francois Meunier (Météo-France), Peter Janssen (ECMWF) and Stephen English (ECMWF).

The rationale for the meeting was a successful initial study (Meunier et al., 2014) to assess the feasibility of deriving foam coverage from a wave model, rather than the instantaneous wind speed, in order to improve the simulations of microwave imager data by RTTOV. This proved that foam coverage was broadly consistent with the foam coverage calculated by RTTOV from instantaneous wind speed, but there were some notable differences, and some biases changed. The study concluded that the approach was interesting but as yet unproven. The meeting gathered scientists working in the field of ocean surface emissivity and whitecapping and provided the possibility to describe and discuss current status and future collaborative work.

Several presentations were first given during the two-day meeting to set the stage for the discussion. Louis-Francois Meunier presented the outcomes of the initial study with the major points being whitecap fraction parameterization, its impact on simulated T_B in IFS, and whitecap fraction retrieval made as a tool to evaluate biases of whitecap fraction parameterizations. This study revealed the need to revise foam emissivity parameterization in FASTEM.

Magdalena Anguelova presented whitecap fraction parameterizations based on photographic and radiometric measurements of whitecaps and their comparisons with the ECMWF parameterization from the wave model dissipation term. Also, the approaches for retrieving whitecap fraction from satellite radiometric observations as made by NRL from WindSat data and ECMWF from several microwave sensors (e.g., SSMIS and TMI) were compared. Finally, foam emissivity models developed and used by ECMWF and NRL were compared.

Michael Bettenhausen presented comparisons between ocean surface emissivity models developed by ECMWF (Fastem 4 and 5), NRL (WindSat model developed by Bettenhausen), and RSS (Meissner and Wentz, 2012). Differences and similarities between models were discussed.

On the basis of the information presented, Peter Janssen led a discussion on interpretation of the results and new ideas for improved whitecap/foam diagnostic from the wave model. Possibilities for collaboration and exchange of data to evaluate and enable a revised implementation of the whitecap parameterization from the wave model and whitecap retrievals from microwave observations were discussed at length. Parameters in both whitecap parameterization and whitecap

retrievals were identified for a sensitivity study and modifications using the NRL whitecap fraction retrievals and foam emissivity model comparison.

Stephen English presented the work done during Dr. Kazumori visit to ECMWF regarding the modeling of wind speed directionality in FASTEM 6. This opened a discussion on broader issues regarding ocean surface emissivity modeling and formulation of background and observation error matrices in the ECMWF assimilation system.

The deliverables of this meeting are relevant to NWP SAF because RTTOV is a key NWP SAF deliverable that is used widely for the simulation of a satellite observations for assimilation or other analysis. A whole class of instruments – microwave imagers – rely very strongly on accurate emissivity modelling of the ocean surface. When whitecapping occurs and there is foam coverage it is likely that RTTOV simulations are prone to error. A consensus emerged regarding the need of a coordinated effort to evaluate the use of FASTEM versions in RTTOV and CRTM.

The overall conclusions of the meeting and work plan for further work were established as follows.

It was agreed that the whitecap fraction parameterisation based on the wave model needs to be further evaluated and improved. The whitecap fraction retrievals calculated at NRL (see [Anguelova and Webster, 2006]) can be used as an independent reference. Contrary to in situ measurements, the satellite-based retrieval provides data on a global scale and with good time resolution, which matches very well with the output of the parameterisation based on the wave model. The whitecap fraction retrievals (readily available over the year 2006) will be provided by NRL (M. Anguelova). We will use these data to evaluate the current version of the whitecap fraction parameterisation but also to evaluate refinement that will be suggested by P. Janssen. This should aim at an improvement of the whitecap fraction parameterisation in areas where deficiencies were identified in a previous study (e.g. in sheltered areas, see [Meunier et al, 2014]).

Retrievals based on IFS outputs indicate problems in the way the foam emissivity is modelled in FASTEM (see [Meunier et al, 2014]). It was agreed that this should be revised. The emissivity model of the foam developed at NRL (see [Anguelova and Gaiser, 2013]) can provide physically-based emissivity estimates. M. Anguelova will provide emissivities calculated by the current version of this model for TMI and SSMI/S incidence angle (53°) and frequencies (ranging from 11 GHz to 90 GHz for the H and V polarisations). These new emissivities will be tested in the IFS based whitecap fraction retrieval. Further tuning will probably be necessary. It will be done in collaboration with M. Anguelova who will provide the necessary sets of emissivities obtained with different settings of the foam emissivity model (we will especially focus on the tuning of the foam void fraction at the air-foam interface and the foam thickness distribution). The foam emissivity model is too slow to be used directly in a fast radiative transfer model. Therefore, once proper settings are determined for the physically-based emissivity model, a simplified parameterisation of the foam emissivity model will be derived for all frequencies and incidence angles in the FASTEM range of applicability.

Finally, both the revised whitecap fraction parameterisation and the new emissivity parameterisation should be implemented into the IFS 4D-var in order to evaluate their impact on the data assimilation system.

ECMWF and Météo-France agreed to run short experiments to compare scatterometer and passive microwave radiometer wind increment studies.

Time frame:

- By the end of 2014, come up with preliminary results for the new whitecap fraction and on the foam emissivity.

- Discuss these first results at the beginning of 2015 and start a second round of improvements and evaluations eventually leading to a test in the IFS 4D-var system. This should provide results for the draft of a paper.

- By the end of summer 2015, organise a wrap-up meeting and finalise the paper.

Notes:

From M. Bettenhausen comparison of FASTEM, RSS and NRL/Windsat emissivity models, it has been agreed that the use of wave model outputs in the large scale correction of the two scales approximation (see [Liu et al., 2011]) should also be investigated. However, in the time frame of this study we have decided to focus exclusively on the whitecap fraction/foam emissivity problem.

There is no coordinated international effort on the accurate emissivity models (e.g. two scale) that underpin fast models like Fastem. The accuracy of a model like Fastem is limited by the accuracy of these models. It is recommended to bring this to the attention of the NWPSAF and JCSDA steering groups to consider possible coordination and support.