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### **Report on STSM “Wave effects on Air-Sea Gas transfer”**

In this STSM, Dr. Christoph Garbe visited the research group of Prof. Kimmo Kahma at the Finnish Institute of Marine Research (FIMR) for one week, from 12.11.-18.11.2007. The overall aim of this STSM was to discuss the effects of waves on air-water gas transfer and to find possible parameterizations. Current results of field experiments of Prof. Kahma were presented. Shortcomings of current measurements and parameterizations were discussed and possibilities of joint measurements on the R/V Aranda were analyzed.

In order for the scientists at the FIMR to better understand the novel measurement techniques developed within my group, I started off my visit at the FIMR by giving a seminar talk about the possibilities of using infrared thermography in research in air-water transport mechanisms. The talk was titled “Thermographic Techniques for Measuring Heat and Momentum Fluxes”. I presented two distinctly different modes of operation: passive and active thermography. From active thermography, the temperature depression across the air water interface can be measured, as well as surface flow fields and the net heat flux between atmosphere and ocean. Also, the transfer velocity of heat can be measured from passive infrared thermography. All these quantities are measured both temporally and spatially highly resolved, limited only by the resolution of the infrared camera. Currently, IR cameras of frame rates of up to 800 Hz and spatial resolution of 256x256 pixels are commercially available. Thus, infrared thermography makes highly resolved measurements directly at the water surface possible for the first time. For passive thermography, a net heat flux needs to be present at the interface, in order to make turbulences visible. This might not always be the case in field experiments. Under these conditions, active thermography is more appealing. This techniques makes it possible to measure the transfer velocity of heat as well as the transport of momentum by novel techniques relying on digital image processing. I detailed these algorithms and implications and presented first results from laboratory measurements. Also, I presented results from a field campaign, in which we used passive thermography for measuring these important parameters of heat transfer. In my talk I related the similarity in between heat and gas transfer and motivated the importance of measuring heat transfer for highly resolved measurements of gas transfer. Researchers at the FIMR were highly interested in these novel thermographic techniques and the need for performing these measurements on a CO<sub>2</sub> cruise on board the R/V Aranda was postulated.

Based on my talk, I discussed together with Prof. Kimmo Kahma and Dr. Heidi Pettersson the details and requirements of the thermographic techniques. We realized that the R/V Aranda was an excellent research vessel for using these techniques in the field during one of the bi-annual CO<sub>2</sub> cruises in the Baltic. We visited the R/V Aranda two times during my visit to take measurements and discuss how to adapt the ship to the thermographic measurement device. Soon, an adequate place was found for mounting the instrument and a practical solution was found for operating the device on the ship. Details of a joint cruise were discussed and a proposal for national funding will soon be submitted.

Apart from details regarding a joint cruise, the current data of wave and CO<sub>2</sub> measurements of the FIMR (field data) and of the University of Heidelberg (laboratory data) were discussed. Although an extensive data set exists at both institutes, the focus has been different. Novel laboratory measurements will be conducted to make results better comparable to the measurements conducted by the FIMR. Also, at the FIMR the instrumentation for performing CO<sub>2</sub> measurements will be improved in order to gain more accurate CO<sub>2</sub> fluxes to supplement the extensive wave measurements. It was determined that the current data set is not sufficient to attempt deriving a better parameterization of CO<sub>2</sub> fluxes. However, it is the goal of joint cruises on board the R/V Aranda in conjunction with novel thermographic techniques to gain a more complete dataset, which will then serve as a solid foundation for an improved such parameterization.

This STSM was highly successful in that all objectives were reached. The research of both research groups (FIMR and University of Heidelberg) was conveyed in detail to both proponents. It was agreed on joint measurements on board the R/V Aranda. This STSM is thus an excellent starting point for a close future collaboration. Shortcomings of current data sets to address current issues in our understanding of air-water interactions were discussed. To this end, our combined measurements will help resolving these shortcomings, which will ultimately lead to a better parameterization of heat and gas transfer.