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Optical Remote Sensing for Detecting Water Quality and Benthic Cover

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Abstract

The color of water reveals valuable information about its constituents, including their concentrations, distributions, and types. It provides crucial insights into key water quality variables such as phytoplankton, suspended sediments, and dissolved organic matter, while also enabling the detection of benthic status through remote sensing platforms. This presentation explores the use of ocean color data for scientific research and real-world applications, including the detection of harmful algal blooms (HABs), benthic mapping for marine deforestation, and productivity estimation of tidal flats. To capture these phenomena across varying spatial scales, a variety of remote sensing platforms were utilized, including satellites, manned aircraft, UAVs, and underwater sensors.

For HAB detection, efforts to accurately quantify the abundance of phytoplankton over large spatial domains are introduced. Traditional methods relying on standard ocean color products for chlorophyll concentration have shown some success in detecting HABs, but challenges remain in precise quantification. To address this, ongoing research aims to develop accurate HAB intensity measurements in physical units. Satellite data from GOCI and GOCI-II are used to create operational detection algorithms for fishery management agencies. Additionally, an aircraft-based system has been developed to complement satellite observations, providing HAB detection capabilities during cloudy conditions when satellite data are unavailable.

Benthic mapping is another critical area requiring advanced ocean color techniques to remove water column interference above benthic habitats. Using hyperspectral and multispectral sensors mounted on aircraft, UAVs, and underwater platforms, our research identifies benthic covers, particularly targeting marine deforestation events. These events are of both scientific and political significance, especially along the east coast and around Dok Island. A dedicated project was conducted to develop an AI training dataset for the spectral reflectance of benthic materials, enhancing classification accuracy. Finally, the presentation will discuss tidal flat monitoring, with a focus on atmospheric correction for tidal flat regions and productivity estimation. Recent progress in this area demonstrates the potential of remote sensing platforms to advance our understanding of these dynamic coastal environments.

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Brief Bio

Dr. Wonkook Kim is an Associate Professor in the Department of Civil and Environmental Engineering at Pusan National University (PNU), specializing in Geomatics and Remote Sensing. He earned his Bachelor's degree in Earth Environmental System Engineering from Seoul National University in 2004. He then pursued graduate studies at Purdue University, obtaining a Master's degree in Geomatics (GIS/Photogrammetry) in 2005 and a Ph.D. in Civil Engineering (Remote Sensing) in 2011, focusing on manifold learning for robust classification of hyperspectral data. Following his doctoral studies, Professor Kim was a Postdoctoral Researcher at the University of Maryland's Department of Geographical Sciences (2011–2013), where he worked on the radiometric calibration and sensor degradation analysis of satellite systems. He then joined the Korea Institute of Ocean Science and Technology (KIOST) as a Senior Research Scientist at the Ocean Satellite Center (2013–2019), contributing to the calibration and algorithm development for geostationary ocean color sensors. In 2019, he joined Pusan National University as an Assistant Professor, and in 2023, he was promoted to his current position as an Associate Professor.

Professor Kim's research focuses on quantitative remote sensing using optical sensors deployed on satellites, aircraft, UAVs, and ships. His expertise lies in the calibration and validation of satellite products and algorithm development using both physical modeling and machine learning approaches. Notably, he made early contributions to the World's first ocean color sensor on a geostationary orbit (GOCI) by participating in the calibration and algorithm development of its core products. His research has since expanded to GOCI-II and airborne platforms, including aircraft and UAVs, with a particular emphasis on coastal remote sensing. His studies encompass phytoplankton dynamics, red tide detection, and marine pollution monitoring.

Professor Kim is an active contributor to the international remote sensing community. He has served as a Scientific Committee Member of the International Ocean Colour Coordinating Group (IOCCG) since 2017. In 2016, he was the Chief Scientist for the Korea-U.S. Ocean Color (KORUS-OC) joint research cruise, collaborating with NASA and other U.S. institutions. Additionally, he serves as an international advisory member of GLIMR, an ocean color sensor on a geostationary orbit over CONUS, which is a part of NASA's Earth Venture Instrument (EVI) program and is the fourth mission selected under this program.

He is currently a Visiting Scientist at NASA Goddard Space Flight Center, where he is developing a red tide detection algorithm for PACE, NASA's new hyperspectral sensor in space. His international collaborations and leadership continue to advance remote sensing and ocean color research.