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Editorial

INDESO project: Results from application of remote sensing and numerical models for the monitoring and management of Indonesia coasts and seas

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1. Introduction

Superlatives are needed to describe the challenges faced by Indonesia for the management of its maritime domain. Blessed by enormous marine resources and tremendous marine biodiversity, Indonesia is confronted to important pressing problems. Indonesia has the world's sixth most extensive exclusive economic zone (~6.025,000 km^2, http://www.marineregions.org/eez.php), which harbors thousands of islands (numbers varied between 13,000 and 18,000) and represents about 56,000–80,000 km length of coastline. Indonesia has to monitor with limited law enforcement and technical capabilities an ever-intensifying marine traffic and significant illegal fishing. Indonesia must account for a growing population with low income who rely highly on subsistence fishing, a diverse variety of ethnicities and cultures, and limited technical capability and capacity for socio-ecological monitoring. Furthermore, the change in Indonesia's marine policy over the last two decades has resulted in a complex and sometimes inconsistent legal framework, especially pertaining to land–sea interactions (Ferrol-Schulte et al., 2015; Ilman et al., 2016).

Most indicators point at the degradation of the ocean health in Indonesian Seas and increased severity of threats throughout the marine domain, with special concerns for coral reefs, mangroves and fishery stocks. As a consequence, these changes affect not only the livelihoods of remote rural coastal populations (Mangubhai et al., 2012, Ferrol-Schulte et al., 2015, Ilman et al., 2016) but also the coastal populations next to mega-cities such as Jakarta (Farhan and Lim, 2012, Breckwoldt et al., 2016). Despite numerous initiatives mostly funded by foreign initiatives in the previous decades (1970–2000), Indonesia lags in implementing successful and sustained integrated management practices for its coastal zones, seas, and oceans (Farhan and Lim, 2010, 2013; Ferrol-Schulte et al., 2015). However, the recent years have seen stronger political will from the central government, in coordination with the provinces (Patlis, 2005). There is now a marked impetus to move forward with the staged goals described in National Medium-Term and Long-Term Development Plans. These plans aim to maximize the income from a – ideally – sustainable exploitation of resources while at the same time trying to adopt a line of conduct more consistent with the Blue–Green Economy concepts, both for terrestrial and marine realms. In theory, reduction of plastic waste, emissions at sea, and marine pollution would be associated with sustainable development and exploitation. However, the policy focus remains on economic growth and development. Practically, this means that there is a long road ahead before meeting the full agenda, especially for sustainable development (Anderson et al., 2016). Implementation of new actions also poses numerous coordination problems. The policy framework for marine and coastal resource management in Indonesia is complex, with more than 15 laws for the management of natural resources pertaining to coastal and marine management and several national laws for the ratification of international conventions (such as the Convention for the Prevention of Pollution from Ships, MARPOL). Governance of marine resources is the primary responsibility of the state, under the Ministry of Marine Affairs and Fisheries (MMAF) and the Ministry of Environment and Forestry (MOEF), but other governmental bodies are also involved, including nine other Ministries and agencies, one coordinating Ministry, and four government agencies related to research, mapping, technology, or development planning. Furthermore, because Laws No. 22/1999, No. 32/2004, and No. 23/2014 were implemented (Patlis, 2005; Berdej and Armitage, 2016), jurisdiction concerning coastal resources (up to 12 nautical miles off the coastline) is shared by province, district, and city competences. Nevertheless, as part of the necessary development stages, capacity building for monitoring marine

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ecosystems and resources is nationally recognized as a priority.

Launched in 2013, the INDESO project (for INfrastructure Development for Space Oceanography, http://www.indeso.web.id/indeso_wp/index.php) has developed remote sensing and modelling-based applications to support the monitoring and sustainable development of Indonesian marine resources. INDESO has targeted seven applications: (1) real-time detection of oil spill, (2) real-time monitoring of illegal unreported and unregulated (IUU) fishing, (3) tuna fishery stock assessment, (4) coral reef monitoring, (5) mangrove monitoring, (6) shrimp farming management, and (7) seaweed farming production assessment. During INDESO, various useful products were developed in these seven application fields. These products have been, or will be shortly, turned into the hands of Indonesian relevant governmental agencies, in particular the MMAF. This includes both operational applications for the entire EEZ and pilot applications for a variety of selected coastal sites in different Indonesian provinces. The eight papers published in this issue illustrate the INDESO outcomes in terms of applied research.

In this introduction to the special issue on "*Application of remote sensing and numerical models for the monitoring and management of Indonesia seas*", we first present the INDESO project and its architecture, and then summarize the results published in this issue and elsewhere, and their contexts. Finally, we emphasize that most of the results presented in this collection of papers were achieved by Indonesian PhD students trained in France (including overseas in New Caledonia), their advisors, and the staff of their PhD-hosting institutions, as part of the INDESO capacity building program.

2. Overview of the INDESO project

INDESO is a MMAF project funded by a loan from the Agence Française de Développement (AFD, French Development Agency) and performed in close collaboration between MMAF and French scientists. Leading contracted French institutions were CLS (Collecte Localisation Satellites), IRD (Institut de Recherche pour le Développement), IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer), and CEVA (Centre d'Etude et de Valorisation des Algues), who all worked closely with various universities and institutions. The Agency for Marine and Fisheries Research and Development at MMAF (Balitbang KP, recently restructured and renamed as Agency for Marine and Fisheries Research and Human Resources, BRSDMKP) managed the project for the ministry.

INDESO project follows the Indonesia Global Observing System (INA-GOOS) project that started in 2005. INA-GOOS had a mission to initiate a comprehensive monitoring and sea state forecasting system for the national waters. The following INDESO project has thus developed an end-to-end satellite observation and ocean modelling system dedicated to the monitoring of the Indonesian marine resources. In addition, pilot applications relevant to inform integrated coastal zone management were developed. Both the natural and man-induced variability are monitored using a combination of *in situ*, remote sensing, and model data. Three of the applications (oil spill, IUU fishing, and tuna stock assessment) worked throughout the Indonesian EEZ, while the coastal applications (seaweed farming, mangrove monitoring, shrimp farming, and coral reef monitoring) worked on selected sites throughout Indonesia (Fig. 1). Several of these pilot applications aimed to bridge gaps between operational oceanography and final end-users.

The INDESO project also included the building of an operational exploitation center in the coastal village of Perancak (West Bali), within the Institute for Marine Research and Observations (part of MMAF). This dedicated infrastructure includes a satellite receiving station; real-time computing and analysis facilities; and offices that host staff dedicated to the technical, information, communication, training, and research

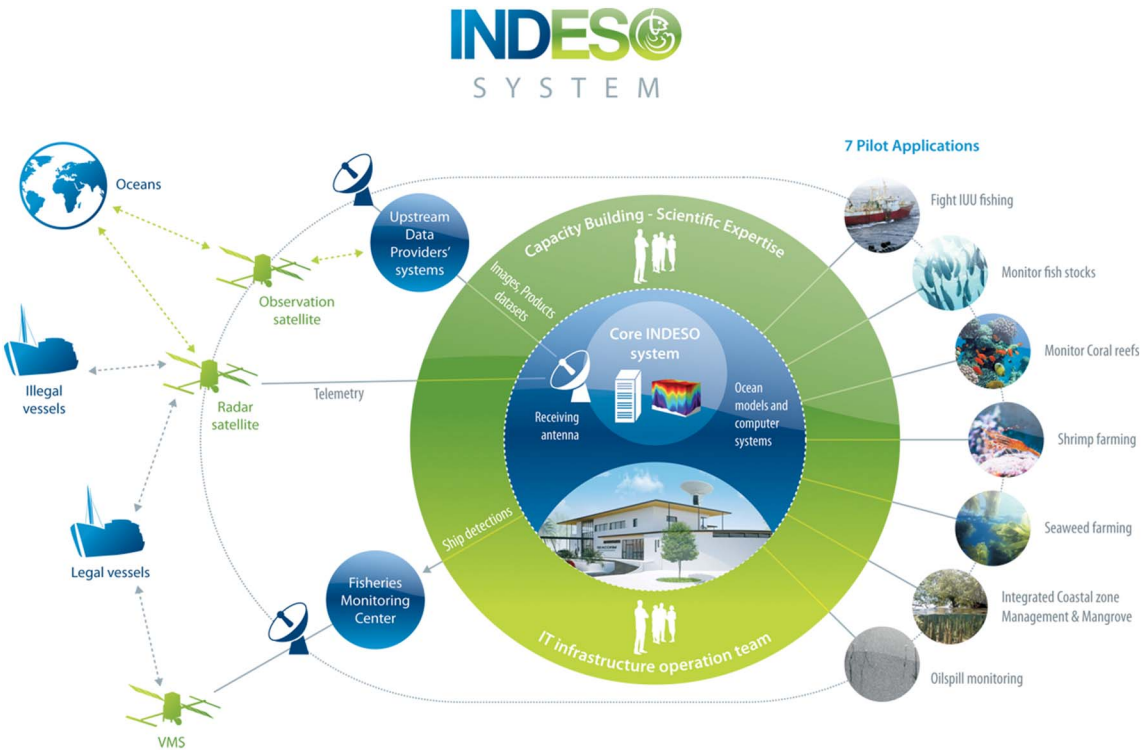

Fig. 1. Conceptual view of INDESO system architecture. Satellites collect data on the ocean state and on ship movements. Satellite data are received in Perancak (Bali), where the core INDESO system is implemented. End-products and images are redistributed to users including scientists and students involved in the seven applications and to different operational monitoring centers.