

**NOAA-MOF JOINT PROJECT AGREEMENT
PROJECT PROPOSAL**

Panel name:	Ocean Research Panel	Project year:	2021
Project name:	Collaborative Air-Sea Interaction Measurements in Tropical Cyclones (TCs): Enhancing Understanding and Improving Future Forecasts		

Lead project contacts for ROK and U.S.:

ROK lead:	Sok Kuh Kang, Kyeong Ok Kim	U.S. lead:	Joseph J. Cione,
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Other project participants (name, organization, email) – (if applicable):

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PROJECT ABSTRACT INFORMATION (TO BE INCLUDED IN AGREEMENT)

Title: Collaborative Air-Sea Interaction Measurements in TCs: Enhancing Understanding and Improving Future Forecasts

Duration/Place/Participant (noting ROK and/or US travel for the year):

*1 week /Korea/1 NOAA PI

*1 week/US/2 Korean PIs

Abstract (should be limited to one paragraph):

The roles of ocean thermal structure, exchanges of momentum, heat, and mass between the air-sea interface need to be investigated more accurately to better predict TC RI. KIOST will be conducting an open ocean air-sea experiment to improve understanding of air-sea interaction processes, using the research vessel *Isabu*. Similarly NOAA will be conducting its annual TC field program in 2021 that will include small unmanned aircraft to better observe air-sea processes in hurricanes. Observations by KIOST will consist of shipboard ocean and near-surface atmospheric measurements, surface drifter and Argo float deployments, and deployment/recovery of wave and underwater gliders. NOAA and KIOST are discussing collaborative efforts that use air-sea measurements from both field campaigns to help improve operational models that predict RI, accurate initial conditions, and advanced validation. As an initiative for collaborative research between NOAA and MOF, we would like to (1) investigate currently available and new atmospheric and oceanic boundary layer data to improve understanding in tropical cyclones; (2) cooperate to improve predictive skill for RI tropical cyclone

events; (3) continue collaboration on a joint NOAA/KIOST air-sea interaction peer-reviewed manuscript using data from the KIOST TC air-sea annual field program and new airborne observations from small unmanned aircraft. To continue ongoing collaborations Dr. Cione (NOAA PI) will visit KIOST in 2021. Both Kang and Kim also plan to visit NOAA in 2021. The visit will likely be in Florida to visit the Hurricane Research Division, National Hurricane Center and possibly the Aircraft Operations Center (in Lakeland Florida). The data analyses from both field campaigns, as well as review of previous studies, will enable the KIOST/NOAA team to define observational gaps to improve our understanding of air-sea interaction under RI tropical cyclones for better forecasting of RI tropical cyclones in 2021 and beyond.

FULL PROJECT INFORMATION	
Purpose: (1-4 sentences) <i>describing the overall purpose of the project.</i>	The purpose of this project is to advance our knowledge of rapidly intensified tropical cyclones in the Northwestern Pacific (NWP) through supporting air-sea component observations to be carried out by KIOST/NOAA while at the same time promoting collaboration between investigators in Korea and the U.S.
Research necessity: (1-3 sentences) <i>state what the need or gap that this project addresses. This may be different for Korea and the U.S.--in such a case, include both.</i>	Both Korea and the U.S. have overlapping research interests in the understanding and better prediction of RI tropical cyclone in the NWP that could be better addressed through more coordinated scientific collaboration. The goals of this proposal address these needs though joint analyses of available and new data of mutual interest in air-sea components, cooperation for skill improvement for RI tropical cyclone forecasting, and conducting 2021 field experiments to increase understanding of severe air-sea interaction.
Project objectives: <i>paragraph form or bulleted list of specific objectives to be achieved by the project and in what year (if not the current year).</i>	<ol style="list-style-type: none"> 1. Joint analysis of available and new data of mutual interest in air-sea components and publication of research results by Korean and U.S. Investigators 2. Cooperation for prediction skill improvement for rapidly intensified tropical cyclones in the Northwestern Pacific, using the available observation data and through field experiments on air-sea field interaction, for the purpose of strengthening cooperation between Korean and U.S. investigators. 3. Continue work on a Joint air-sea TC manuscript for peer review publication.
How does this project address MOF and NOAA priorities: (1-4 sentences) <i>explain how this activity will address organizational priorities/objectives for MOF and NOAA. All JPA activities should be helping to fulfill the missions of MOF and NOAA, and/or the ROK & U.S.</i>	<ol style="list-style-type: none"> 1. The Northwestern Pacific Ocean is a region of interest to both NOAA and MOF since the tropical cyclones frequently affect the countries and people who live there, with gradually stronger cyclones occurring in relation to global warming. It is also a region of severe air-sea interaction that affects the rapid intensification of tropical cyclones up to category 4 or 5. The proposed research activities will help bring greater focus to this critical area of the world ocean with the strongest TCs. 2. The proposed KIOST cruise region for 2021 is close to a KIOST

	<p>Core Research Zone with lots of mesoscale eddies in the Northwestern Pacific along 17.5-21°N; Existence of warm eddies is expected to induce the rapidly intensified tropical cyclones, but the detailed linked process between warm ocean and rapid intensification of TCs have seldom been investigated, since observations for air-sea interactions have not been possible in the past due to limitations in observation capabilities under severe TCs as strong as category 4 or 5. Development of new technologies such as ocean robotics such as argo floats, wave gliders, and underwater gliders now make these observations possible.</p> <ol style="list-style-type: none"> 3. Using high response rate near surface atmospheric and oceanic observations obtained from R/V <i>Isabu</i> in addition to drifter data obtained in high wind conditions Korean and NOAA researchers hope to garner an improved understanding the regional features of momentum flux, latent flux, and mass flux, for intensity change of RI TC in the Northwestern Pacific Ocean. This proposal invites Korea and U.S. to join the integrated research for the understanding of severe air-sea interaction and improvement of prediction skills of RI tropical cyclones in the NWP where severe TCs often occur. 4. MOF-NOAA Partnership, will contribute significantly to the understanding the air-sea interaction under rapidly intensified tropical cyclones in the Northwestern Pacific during the study which is planned by KIOST at least through 2021.
<p>Project period: <i>(estimated start and end dates)</i></p>	<p>January 1 – December 31, 2021, including a 6-8 week (Aug.-Sep.) cruise aboard the R/V <i>Isabu</i>. In parallel, we will conduct analysis of available and new data (including sUAS) from NOAA TC field work in 2021; and cooperative work for prediction skill improvement for rapidly intensified tropical cyclones in the NWP during year.</p>
<p>Project description: <i>(1-3 paragraphs) description of the project, noting specifically what activities/actions the PIs will take in implementing the project</i></p>	<p>This project will (1) investigate currently available (both available and new) data for the better understanding of air-sea interaction in the Northwestern Pacific ; (2) cooperate on prediction skill improvement for rapidly intensified tropical cyclones in the Northwestern Pacific; and (3) continue writing a joint NOAA/KIOST air-sea interaction peer reviewed manuscript using data from the ongoing KIOST TC air-sea annual field program.</p>
<p>Expected results or achievements: <i>(If applicable, especially include how project will lead to advancing scientific knowledge or conservation</i></p>	<p>We expect that the proposed scientific collaboration will produce peer reviewed publication(s) that expand our understanding of air-sea interaction in rapidly intensified tropical cyclones in the Northwestern Pacific, as well as our understanding of advanced parameterizations in severe range of wind speed over 50m/s through direct observations of air and sea components from ship</p>

<i>practices.)</i>	measurements as well as from small unmanned aircraft observations. These observations when combined will hopefully significantly improve our ability to improve future forecasts of TC RI. The cooperative experiments for air-sea interaction will help to focus and energize the research communities in Korea and U.S. to address problems of mutual scientific interest and great socio-economic consequence. Collectively, these activities will also contribute to cooperative joint research in various research areas, such as bio-chemical processes by TCs.
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BUDGET INFORMATION

Total year budget: US\$ 37,000
 Funds to NOAA: US\$ 29,000
 Funds to KUSCO: US\$ 8,000

Description of how funds will be used:

Amount	Source	Description of expenses (travel, etc.)
\$25,000	NOAA	Purchase and field deployment of 2 small expendable unmanned into the high wind boundary layer environment of a Tropical Cyclone
\$4,000	NOAA	Support travel for one NOAA scientist to Korea (KIOST) for one week-trip in 2021.
\$8,000	KUSCO	Funds for two Korean PIs to travel to US (NOAA laboratories) for one week in the spring or fall of 2021.

Travelers and destinations (include name, phone, and email of any travelers):

Joseph Cione, NOAA PI, for travel from Denver to Korea round trip for collaboration and manuscript preparation and general collaborative interactions in 2020 (one trip).

Sok Kuh Kang and Kyeong Ok Kim, KIOST PIs, for round trip travel from Korea to U.S. to visit NOAA laboratory/other place for one week in fall or spring 2020.

Expendables/Equipment

Purchase 2 small sUAS (using NOAA JPA funds) capable of measuring atmospheric pressure, temperature, moisture, 3D winds, and sea surface temperature in high wind hurricane environments. These expendables will be deployed in an Atlantic basin, Gulf of Mexico or Caribbean Tropical Cyclone as early as 2021 (if opportunities present themselves). The request of \$25,000 includes two (2) sUAS will deployment costs as well as METOC payload testing and installation, as well as all (external to NOAA) engineering and travel support required to deploy the assets in the field.

US and ROK in-kind contributions

NOAA-in kind support would include P-3 flight hour costs of \$60,000 USD (currently \$6K USD/hour). Similarly, ROK funded in-kind support from ongoing annual air-sea cruises should also be noted.

2020 Project Budget Spend Plan

Project Name: Collaborative air-sea interaction measurements in Tropical Cyclones (TCs): Enhancing understanding and improving future forecasts

Project Budget: \$32,000

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
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id Total					\$8,000				\$25,000		\$4,000		\$37,

Full Project Description (1-2 pages)

The three themes of this project are expanded upon below.

1. Joint analysis of available and new data (including proposed small Unmanned aircraft expendables) of mutual interest in air-sea components will be attempted with publication of research results by Korean and U.S. Investigators. The Northwestern Pacific Ocean is a region of interest to both NOAA and MOF since the tropical cyclones frequently affect the countries and people who live there, with a gradually stronger cyclones occurring in relation to global warming. It is also a region of severe air-sea interaction happening that affects the rapid intensification of tropical cyclones up to category 4 or 5. Many types of data are expected to be available.

2. Cooperation for prediction skill improvement for rapidly intensified tropical cyclones in the Northwestern Pacific, using the available observed data through field experiments for air-sea field interaction that will serve to strengthen cooperation between Korean and U.S. investigators. Model error in forecasting of RI tropical cyclones is often large, due to several reasons associated with parameterizations in air and sea interactions and/or initial condition of upper ocean. Cooperative work may lead to better skill development in forecasting.

3. Continue writing a joint NOAA/KIOST air-sea interaction manuscript using data from the ongoing KIOST TC air-sea annual field program. Publication in a peer-reviewed reputable journal is anticipated.

4. KIOST will be conducting a cruise in the Northwestern Pacific to increase the understanding of air-sea interaction of rapidly intensified (RI) tropical cyclones (TC) and for better forecasting of RI TC, based upon the measurements for sea components during the summer season.

5. Similarly, NOAA will be conducting its annual field program to sample TCs in 2021. As noted, in this proposed efforts include deploying small unmanned aircraft capable of measuring upper ocean and lower atmosphere variables necessary to obtain direct fluxes of heat, moisture and momentum in very high wind TC conditions. These data would be joint analyzed by KIOST and NOAA scientists and ultimately be submitted for peer review in reputable international journals.