
## Workshop on

# Remote Sensing for Studying the Ocean-Atmosphere Interface

**13 - 15 March 2018, Potomac, Maryland, USA**

# Book of Abstracts and Programme

# Remote Sensing for Studying the Ocean-Atmosphere Interface

# Book of Abstracts and Programme

## TABLE OF CONTENTS

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# LOCAL INFORMATION

The maps below will give you a general idea of the Washington DC area. The lower map gives more detail about the workshop venue:

**William F. Bolger Center,**

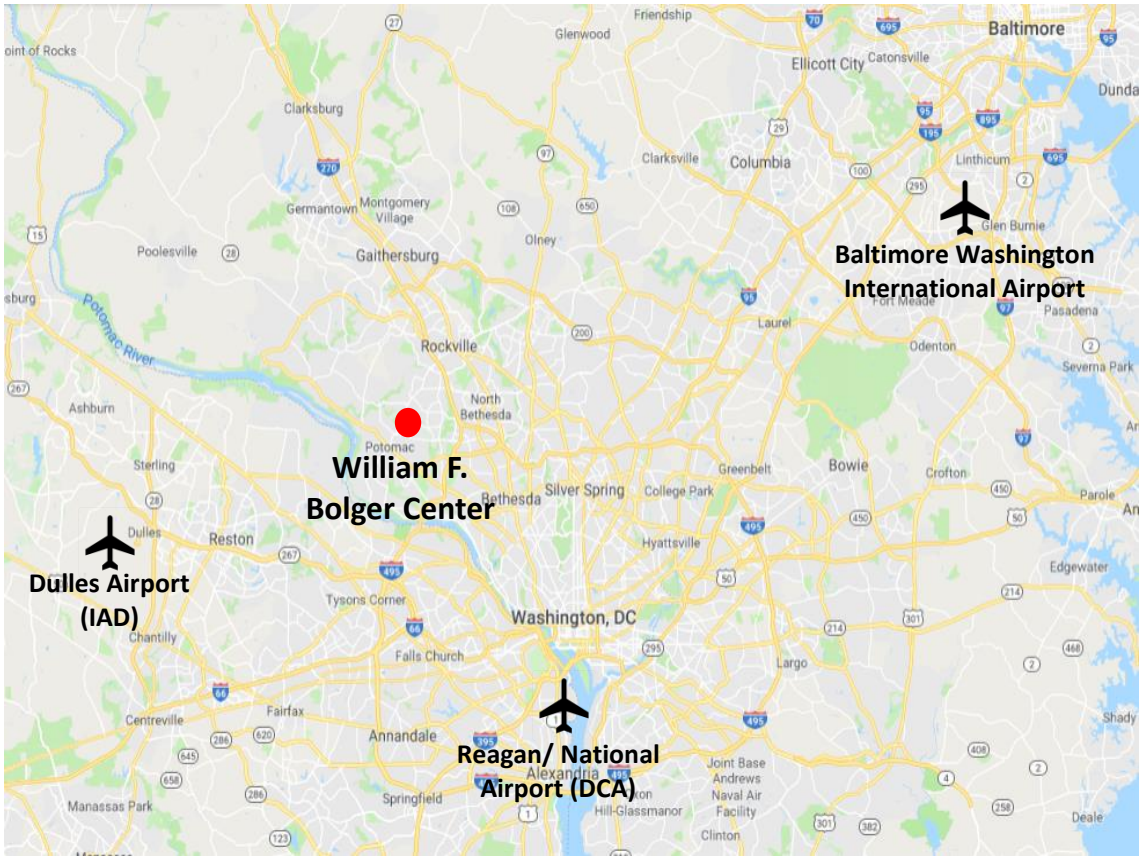
**9600 Newbridge Drive, Potomac, MD 20854, USA.**

Phone: 301-983-7000; E-mail: sales-bolgercenter@aramark.com

http://www.bolgercenter.com/

## Travel to the William F. Bolger Center (return)

Location of the Willian F. Bolger Center and local airports




### By car:

From Washington **Dulles** International Airport (IAD)

- Take the Dulles Access Road (Toll Road 267) towards Washington, DC.
- Take I-495 North towards Frederick/Baltimore.
- At the I-495/I-270 split, take I-270 North.
- Take Exit 1 for Democracy Boulevard and turn left at the end of the ramp.
- The William F. Bolger Center is on the left-hand side, approximately 2 miles from

the exit.
Distance: 15 miles; Estimated travel time: 28 minutes

From **Ronald Reagan** Washington National Airport (DCA)

- As you exit the airport, head North on the George Washington Parkway.
- Bear right onto I-495 North towards Frederick/Baltimore.
- At the I-495/I-270 split, take 270 North.
- Take Exit 1 for Democracy Boulevard and turn left at the end of the ramp.
- The Bolger Center is on the left-hand side, approximately 2 miles from the exit.
  Distance: 14 miles; Estimated travel time: 27 minutes

From **Baltimore** Washington International Airport (BWI)

- Exit airport on 195 towards 05
- Take 95 South towards Washington, D.C
- Take 495 West towards Northern Virginia and Silver Spring, MD
- Exit Old Georgetown Road and turn right at the end of the ramp
- Move into your far left lane
- Take left on Democracy Boulevard
- The Bolger Center will be on your left hand side in approximately 5 miles
- Follow signage to guest registration
  Distance: 40 miles; Estimated travel time: 50 minutes

**Parking:**

There is no assigned parking at the Bolger Center. You may park in any parking lots (see William F. Bolger Center overview map). When all lots are full, park where directed by Security or Grounds Staff.

**By taxi:**

Official taxis are available at all airports.

- From Washington **Dulles** International Airport (IAD)
  Distance: 15 miles; Estimated travel time: 28 minutes
  Estimated taxi fare: $50.00 (one way)
- From **Ronald Reagan** Washington National Airport (DCA)
  Distance: 14 miles; Estimated travel time: 27 minutes
  Estimated taxi fare: $50.00 (one way)
- From **Baltimore** Washington International Airport (BWI)
  Distance: 40 miles; Estimated travel time: 50 minutes
  Estimated taxi fare: $80.00 (one way)

## Other Transportation:

**Train Station**

- Union Station Amtrak Terminal (22 miles from Bolger Center)
- Bethesda Metro Station (7 miles from Bolger Center)

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The Bolger Center provides complimentary shuttle service to the Bethesda Metro Station and the Montgomery Mall. Please call Guest Services at 301-983-7000 to make your complimentary shuttle reservation based on the shuttle times (schedule www.bolgercenter.com/services-en.html).

**Shuttle Service**

SuperShuttle offers service to most locations from Ronald Reagan National Airport, Washington Dulles International Airport (28 USD per person and 10 USD for every additional person), and Baltimore-Washington International Airport (37 USD per person and 12 USD for each additional person). Please contact SuperShuttle directly to arrange for a shuttle by calling 800-258-3826 or visit SuperShuttle's website (www.supershuttle.com).

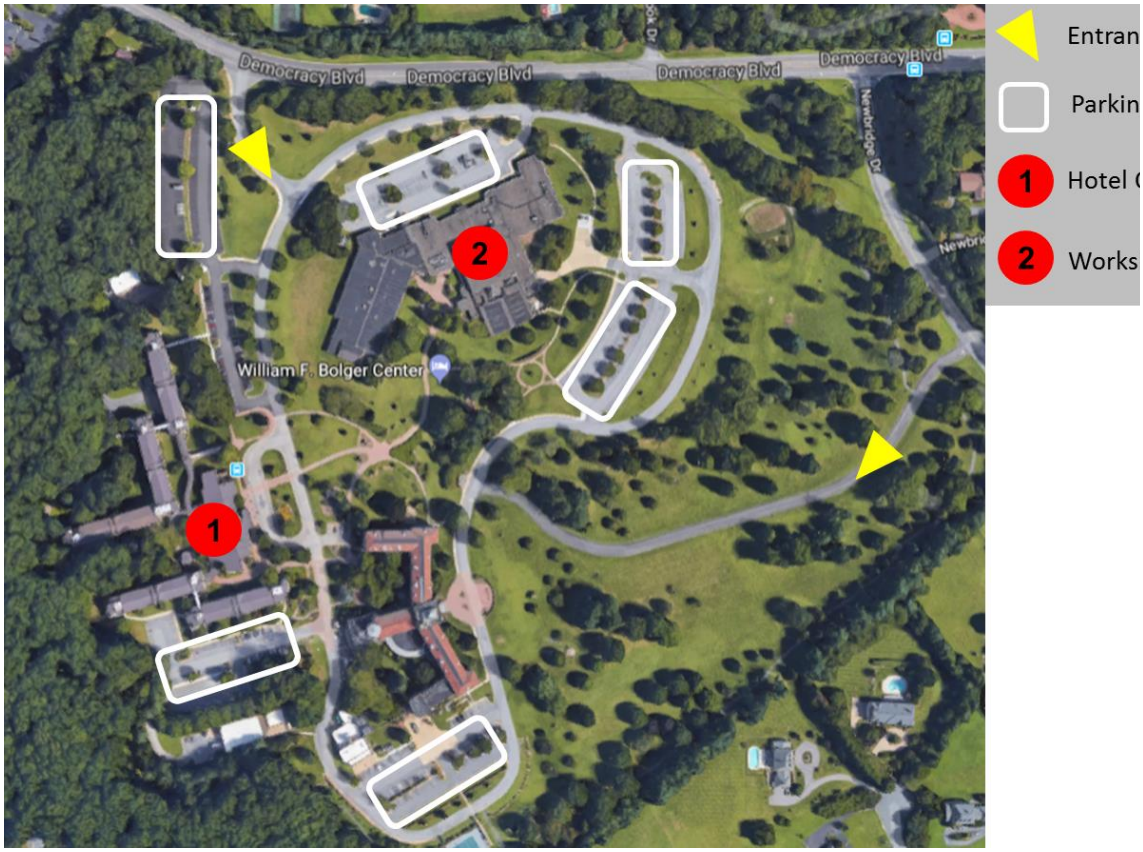
## Accommodation and Workshop Venue

- **Staying overnight:**
  - Check-in at the Front Desk in the **Hotel Check-In Building** (William F. Bolger Center overview map, position **1**).
  - **Please bring a credit card!** This will be either charged to pay your hotel nights or only used for being 'on hold'.
  - Your overnight stay and the meeting package include continental breakfast, morning break, lunch, afternoon break, and dinner, all in buffet style.

- The workshop will take place in the William F. Bolger Center's **Franklin Building** (William F. Bolger Center overview map, position **2**)

- **Day participants:**
  - Will receive the day meeting package which includes a morning break, lunch, and afternoon break, all in buffet style.
  - 'Day tickets' for lunch and coffee breaks will be provided on a day to day basis.
  - You can join the 'light breakfast' (at the break station) each morning.

William F. Bolger Center overview map



**Workshop on Remote Sensing for Studying the Ocean-Atmosphere Interface**

# PROGRAMME

## Day 1: Tuesday, 13 March 2018

8:00-9:00 Registration; Oral presentation submission

### Opening session

9:00-9:15 Welcome and overview of the workshop
**Peter Minnett**, SOLAS SSC, USA

9:15-9:30 SOLAS overview
**Lisa Miller**, SOLAS SSC Chair, Canada

### New and future relevant satellite missions

9:30-10:00 *Invited*: NASA's Study of Earth System Processes and Components Relevant to the Surface Ocean-Atmosphere Interface - **Jack Kaye**, NASA HQ, USA

10:00-10:30 *Invited*: The ESA EO Scientific Exploitation Programme: Opportunities for SOLAS - **Diego Fernández-Prieto**, ESA ESRIN, Frascati, Italy

10:30-11:00 **Coffee break**

### Novel platforms and sensors

11:00-11:20 NASA's Plankton, Aerosol, Clouds, ocean Ecosystems (PACE) mission: Opportunity for collaborative science across the ocean-atmosphere interface - **Lorraine Remer**, University of Maryland Baltimore County, USA

11:20-11:40 The NASA Cyclone Global Navigation Satellite System (CYGNSS)
**Chris Ruf**, University of Michigan, USA

11:40-12:00 The HARP (Hyperangular Imaging Polarimeter) and use of nanosatellites for the measurment of aerosols, clouds and the ocean surface properties
**J. Vanderlei Martins**, University of Maryland Baltimore County, USA

12:00-12:20 Ocean-Atmosphere Remote Sensing using Hyperspectral Satellite Spectrometers - **Diego Loyola**, DLR, Germany

12:20-12:30 Discussion

12:30-14:00 **Lunch**

14:00-14:20 Sea Surface Scanner: Linking remote and in situ observations of the ocean-atmosphere interface - **Oliver Wurl**, University of Oldenburg, Germany

## Challenging properties and processes

14:20-14:50 *Invited*: Aerosol remote sensing: why so difficult? - **Kirk Knobelspiesse**, NASA GSFC, USA

14:50-15:10 Studying the sensitive regimes and active regions of aerosol indirect effect for the ice clouds over the global oceans by using long-term satellite observations - **Xuepeng Zhao**, NOAA NESDIS, USA

15:10-15:30 In cloud alteration of desert dust and its impact on surface ocean and lower atmosphere - **Cemal Saydam**, Hacettepe University, Turkey

15:30-16:00 **Coffee break**

16:00-16:20 Using Remote Sensing Observations to Estimate Dust Deposition into Tropical Atlantic Ocean - **Hongbin Yu**, NASA Goddard Space Flight Center, USA

16:20-16:40 Characterization of the reflectance coefficient of skylight from the ocean surface and implications to Ocean Color - **Alexander Gilerson**, City College of New York, USA

16:40-17:00 Dropsonde-Based Validation of Satellite-Derived Near-Surface Air Temperature and Specific Humidity Products - **Gary Wick**, NOAA, USA

17:00-17:20 Observations of seabed methane inputs to the lower atmosphere in the Arctic in winter using IASI satellites data - **Leonid Yurganov**, University of Maryland Baltimore County, USA

17:30-18:00 Discussion

# Day 2: Wednesday, 14 March 2018

**Posters available throughout the day!**

## Challenging properties and processes - continued

8:00-8:45 Poster setup; Oral presentation submission

| | |
|---|---|
| 9:00-9:20 | Airborne remote sensing of the upper ocean turbulence - **Ivan Savelyev**, US Naval Reseach Laboratory, USA |
| 9:20-9:40 | The 2015-2016 El Niño and the response of the carbon cycle: Findings from the Orbiting Carbon Observatory-2 (OCO-2) mission - **Abhishek Chatterjee**, NASA Goddard Space Flight Center, USA |
| 9:40-10:00 | Assessment of export efficiency equations in the Southern Ocean applied to satellite-based net primary production - **Lionel Artega**, Princeton University, USA |
| 10:00-10:20 | A deterministic inverse method for ocean skin temperautre profile re-trevals from M-AERI measurements - **Prabhat K. Koner**, University of Maryland, USA |
| 10:20-10:30 | Discussion |
| 10:30-11:00 | **Coffee break** |

## Air-sea fluxes

| | |
|---|---|
| 11:00-11:30 | *Invited*: Remotely Sensed Data Requirements for Turbulent Heat Flux Determination - **Abderrahim Bentamy**, IFREMER, France |
| 11:30-11:50 | An improved estimation of satellite derived surface humidity and air-sea latent heat flux - **Hiroyuki Tomita**, ISEE - Nagoya University, Japan |
| 11:50-12:10 | Improving Indian Ocean surface heat and freshwater flux estimates based on ocean measurements - **James Carton**, University of Maryland, USA |
| 12:10-12:30 | Effect of a Sea Spray Layer on Remote Sensing of Ocean Surface - **Magdalena D. Anguelova**, Naval Research Laboratory, Washington, DC, USA. |
| 12:30-14:00 | **Lunch** |

## Challenging conditions

| | |
|---|---|
| 14:00-14:30 | *Invited*: Observation of Arctic sea ice breakup and floe size during the winter-to-summer transition - **Phil Hwang**, SAMS, UK |
| 14:30-14:50 | The Multi-sensor Improved Sea-Surface Temperature: Continuing the GHRSST partnership and improving Arctic Data - **Chelle Gentemann**, Earth and Space Research, USA |
| 14:50-15:30 | Discussion |

| | |
|---|---|
| 15:30-16:00 | **Tea break** |
| 16:00-16:10 | Formation of breakout groups |
| 16:10-17:30 | Breakout session I |
| 17:30-18:00 | Breakout session I reports |
| 19:30-21:00 | Poster session |

## Day 3: Thursday, 15 March 2018

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|---|---|
| 9:00-9:10 | Formation of breakout groups |
| 9:10-10:30 | Breakout session II |
| 10:30-11:00 | **Coffee break** |
| 11:00-11:30 | Breakout session II reports |
| 11:30-12:15 | Plenary summary and future plans |
| 12:15-12:30 | Closing remarks |
| 12:30-14:00 | **Lunch** |

# SPEAKERS' ABSTRACTS

The abstracts in this section are arranged in order of their appearance in the workshop programme. I = Invited Speaker; C = Contributed Talk

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## Day 1: Tuesday, 13 March 2018

### NASA'S STUDY OF EARTH SYSTEM PROCESSES AND COMPONENTS RELEVANT TO THE SURFACE OCEAN-ATMOSPHERE INTERFACE [I]

J. A. Kaye[1]

NASA carries out studies of the Earth System that utilize a mix of satellite observations, field campaigns, surface-based measurements, and computational modeling to understand the behavior of Earth's components and the interactions among them. The NASA program has numerous aspects that are relevant to the Surface-Ocean Lower Atmosphere Study (SOLAS). NASA satellites make many measurements of the properties of the ocean surface (temperature, topography, surface winds, ocean color, salinity, sea ice extent) as well as of the overlying atmosphere (temperature, trace gas constituent, aerosol, and cloud properties). Field campaigns, including a mix of airborne and ship-based platforms provide process-knowledge that helps us understand the nature of the couplings between the surface and the atmosphere. Modeling efforts, including data assimilation and reanalysis, help provide an integrating structure for different types of data sets and provide consistent products that can be used for scientific study. In this talk, a summary of NASA's current and future efforts (both those currently in progress as well as those suggested under the recently completed Decadal Survey from the National Academies of Science, Engineering, and Medicine) that are relevant to SOLAS's science will be presented, along with examples of recent accomplishments.

[1] Earth Science Division, NASA HQ, Washington, DC, USA

**THE ESA EO SCIENTIFIC EXPLOITATION PROGRAMME: OPPORTUNITIES FOR SOLAS [I]**

D. Fernández-Prieto [1]

In the years to come, Earth observation from space will enter into a new era characterised by a growing number of increasingly advanced and sophisticated satellite missions. These will provide scientists with an unprecedented capacity to observe and monitor the Earth system and its dynamics from local to global scales with different new and complementary techniques.

From the ESA perspective, this new era has already started with the successful launch of the first Earth Explorer missions (GOCE, SMOS, CryoSat, Swarm), which deliver new and unique data to the scientific community and six new ones under development. The EU Copernicus Sentinel satellites are already revolutionising the EO science and applications arena, providing operational long-term data to establish critical information services for Europe and globally, but also offering a key source of observations for scientists worldwide. The future of the Sentinel series has just started with a new set of novel satellites missions to be studied as candidates to complement the current Sentinel series. These observation capacity is complement by the meteorological European satellites, the Meteosat and Metop series which ensure a continuous provision of data for operational meteorology and science.

The full exploitation of this growing capacity in terms of enhanced and new observations represents both a major scientific challenge and a unique opportunity for innovation and research. It will enable huge synergies offered by this multi-mission observational potential together with the continuous advances in Earth system models and in-situ observation networks.

This presentation will provide an overview of the ESA EO Programme and its plans as well as an insight into the Scientific Exploitation Programme launched in 2017 and the opportunities offered to the SOLAS community for research and science.

[1] EO Science, Applications and Climate Department, European Space Agency, Italy

**NASA'S PLANKTON, AEROSOL, CLOUDS, OCEAN ECOSYSTEMS (PACE) MISSION: OPPORTUNITY FOR COLLABORATIVE SCIENCE ACROSS THE OCEAN-ATMOSPHERE INTERFACE [C]**

L. A. Remer, E. Boss, the First PACE Science Team

The Plankton, Aerosol, Clouds, ocean Ecosystems (PACE) mission, aiming to launch in 2022, will pursue oceanic and atmospheric scientific objectives using innovative space-based sensors. The Ocean Color Instrument (OCI) will be a broad spectrum hyperspectral radiometer spanning from the ultraviolet (UV) to the near-infrared supplemented by an additional eight channels in the short wave infrared. PACE OCI measurements will reveal the diversity of phytoplankton, not just the chlorophyll concentrations of previous space-based sensors. With spatial resolution nominally at 1 km, OCI will provide the finest resolution UV imagery from any space borne sensor, allowing for high quality aerosol characterization and improved retrieval of oceanic parameters. In addition to OCI, PACE will carry one or more Multi-Angle Polarimeters (MAPs). The PACE MAP(s) will characterize aerosol properties much beyond aerosol loading, add to characterization of cloud properties and introduce the ocean community to new information-laden parameters such as polarized water leaving radiance as a function of angle. Beyond the hardware, PACE will play a key role in bringing the oceanic and atmospheric science communities together for collaborative science. Already the first PACE Science Team (2015-2018) has found common interests and developed an interdisciplinary culture. They have addressed the need for benchmarked coupled ocean-atmosphere vector radiative transfer codes, a first step in creating algorithms to retrieve both atmospheric and oceanic parameters. Such codes will be necessary for both discipline independent retrievals, as well as future joint retrievals that will return both ocean and atmosphere parameters simultaneously. As the team addressed PACE science issues they found themselves reaching across disciplines for new ideas, help with long-standing issues and new joint endeavors.

[1] University of Maryland Baltimore County, USA
[2] University of Maine, USA

**THE NASA CYCLONE GLOBAL NAVIGATION SATELLITE SYSTEM (CYGNSS) [C]**

C. Ruf[1]

The CYGNSS constellation of eight satellites was successfully launched on 15 December 2016 into a low inclination (tropical) Earth orbit. Each satellite carries a four-channel bi-static radar receiver that measures GPS signals scattered by the ocean, from which ocean surface roughness, near surface wind speed, and air-sea latent heat flux are estimated. The measurements are unique in several respects, most notably in their ability to penetrate through all levels of precipitation, made possible by the low frequency at which GPS operates, and in the frequent sampling of tropical cyclone intensification and of the diurnal cycle of winds, made possible by the large number of satellites. Engineering commissioning of the constellation was successfully completed in March 2017 and the mission is currently in the early
phase of science operations.

Level 2 science data products have been developed for near surface (10 m referenced) ocean wind speed, ocean surface roughness (mean square slope) and latent heat flux. Level 3 gridded versions of the L2 products have also been developed. A set of Level 4 products have also been developed specifically for direct tropical cyclone overpasses. These include the storm intensity (peak sustained winds) and size (radius of maximum winds), its extent (34, 50 and 64 knot wind radii), and its integrated kinetic energy. Assimilation of CYGNSS L2 wind speed data into the HWRF hurricane weather prediction model has also been developed.

An overview and the current status of the mission will be presented, together with highlights of early on-orbit performance and scientific results.

[1] Climate and Space Dept., University of Michigan, Ann Arbor, MI USA

**THE HARP (HYPERANGULAR IMAGING POLARIMETER) AND USE OF NANOSATELLITES FOR THE MEASUREMENT OF AEROSOLS, CLOUDS AND THE OCEAN SURFACE PROPERTIES [C]**

J. V. Martins[1,2,3], H. M. J. Barbosa[1,2,4], R. Fernandez-Borda[1,2,3], B. McBride[1,2,3], L. Remer[1,2,3]

The HARP (HyperAngular Rainbow Polarimeter) is a 3U CubeSat sensor designed for the measurement of aerosol, clouds and surface properties with a wide FOV that enables nearly global coverage from multiple wavelengths and tens of different along track viewing angles. HARP's science focuses on the measurement of detailed properties of aerosol and cloud particles in suspension in Earth's atmosphere and their potential effect on climate. Understanding and predicting climate change is the world's number one Earth Science and environmental priority. Accurate multi-angle polarization measurements over a broad spectral range (UV to SWIR) are the next frontier in measuring aerosols from space. The French POLDER instrument has pioneered the use of polarization in multiple viewing angles for the retrieval of aerosol and cloud microphysical parameters, followed by the HARP (Hyperangular Rainbow Polarimeter) CubeSat that is currently in preparation for launch in 2018. HARP is a technology demonstration funded by NASA that intends to show how nanosatellites can measure the detailed microphysical properties of aerosol, cloud particles, and surface angular properties.

The HARP CubeSat satellite will carry a VNIR version of the HARP sensor with four wavelengths (440, 550, 670 and 870nm) and up to 60 along track viewing angles. HARP's capability includes the hability to measure aerosol and cloud microphysics as well as to characterize the surface BRDF properties. In particular, over the ocean, HARP provides information simultaneously maximizing the glint and off glint geometries. At the same time, the detailed aerosol characterization provided by HARP can provide important parameters to support the atmospheric correction needed for a more accurate retrieval of the ocean properties. Data from the aircraft simulator for HARP will be presented and discussed here.

[1] Department of Physics, UMBC, Maryland, USA
[2] Earth and Space Institute, UMBC, Maryland, USA
[3] Joint Center for Earth Systems Technology, UMBC, Maryland, USA
[4] Instituto de Física, Universidade de São Paulo, São Paulo, Brasil

**OCEAN-ATMOSPHERE REMOTE SENSING USING HYPERSPECTRAL SATELLITE SPECTROMETERS [C]**

D. Loyola[1]

During the last two decades Europe developed unique hyperspectral satellite spectrometers for atmospheric composition measurements like GOME, SCIAMACHY, GOME-2, and OMI. These sensors cover the UV, VIS, NIR, and SWIR spectral region with a relative high spectral resolution.

The drawback of those missions for applications on Ocean-Atmosphere remote sensing was their relative coarse spatial resolution.

In this presentation we will explore the possibilities of the new generation of hyperspectral spectrometers developed as part of the European Copernicus program. The first atmospheric composition Sentinel mission Sentinel-5 Precursor was launched in October 2017 with the TROPOMI instrument onboard. TROPOMI provides more than four thousand spectral measurements with spatial resolution of 3.5x7 $km^2$.

[1] German Aerospace Center (DLR), Germany

**SEA SURFACE SCANNER: LINKING REMOTE AND IN SITU OBSERVATIONS OF THE OCEAN-ATMOSPHERE INTERFACE [C]**

O. Wurl[1], N. I. H. Mustaffa[1], C. Stolle[1], M. R. Ribas[1]

The Sea Surface Scanner ($S^3$) is a remote-controlled catamaran to collect sea-surface microlayers (SML) with an adjustable thickness of 50-100 µm. $S^3$ utilizes the rotating glass disk technique to automate the sampling of the SML, overcoming the disadvantages of conventional manual techniques as low volume sampling and ex situ measurement of the SML. With the automatic sampling and implementation of flow-through sensors, $S^3$ has the capability to scan the SML at high resolutions. Currently, $S^3$ measures fluorescent dissolved organic matter, chlorophyll-a, pH, conductivity and temperature both in the SML and as reference in the underlying mixed bulk water (1 m depth). We will present data on high-resolution measurements (~5 meters and ~10 seconds) supporting new insights in the spatiotemporal dynamics of the SML and processes of enrichment. With sampling a thickness close to the penetration depth of satellite's radiation energy, we believe $S^3$ is the first generation of technology with the capability to provide "true" and representative calibration and validation data for satellite products.

[1] University of Oldenburg, Institute for Chemistry and Biology of the Marine Environment, Germany

**AEROSOL REMOTE SENSING: WHY SO DIFFICULT? [I]**

K. Knobelspiesse[1]

Atmospheric aerosols have both direct and indirect (via interaction with clouds) radiative forcing effects, and rank among the largest sources of uncertainty in climate models. This uncertainty is largely driven by remote sensing challenges. Aerosols also interfere with observations of things underneath them, and are, for example, at the heart of 'atmospheric correction' for Ocean Color remote sensing. Aerosol remote sensing has seen several decades of continuous improvement, but is fundamentally underdetermined with regards to the parameters needed to improve climate models or atmospherically correct Ocean Color observations. I will discuss the source of these issues and efforts to resolve them with new instrument designs and algorithm developments. I will also describe some universal challenges, such as instrument calibration and validation, data interpretation, and maintaining continuity over climatically relevant timescales.

[1] Ocean Ecology Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

**STUDYING THE SENSITIVE REGIMES AND ACTIVE REGIONS OF AEROSOL INDIRECT EFFECT FOR THE ICE CLOUDS OVER THE GLOBAL OCEANS BY USING LONG-TERM SATELLITE OBSERVATIONS [C]**

X. Zhao[1]

Cloud microphysical structures and properties provide a critical link between the energy and hydrological cycles of Earth's climate system. Atmospheric aerosol is the major source of cloud condensation nuclei (CNN) and ice nuclei (IN) that are critical for the formation of cloud microphysical structures and properties. Aerosol changes due to anthropogenic emissions will result in the modification of CCN/IN and cloud microphysical properties and eventually cause the changes of Earth's climate. In this study, we will investigate the effect of aerosol on the cloud microphysical properties of marine ice cloud by using more than 30-years climate data records (CDRs) of aerosols and clouds derived from NOAA operational AVHRR satellite observations. The objective is to identity the aerosol indirect effect (AIE) signatures contained in the long-term satellite observation. Our study focuses on identifying the regimes and regions that the positive and negative AIE may clearly manifest in a sense of long-term average over the global oceans.

[1] National Centers for Environmental Information (NCEI), NOAA/NESDIS, USA

**IN CLOUD ALTERATION OF DESERT DUST AND ITS IMPACT ON SURFACE OCEAN AND LOWER ATMOSPHERE [C]**

C. Saydam[1]

Recent advances both in satellite derived imageries and ease of access to processed data in near real time opened a new era for the scientific community. Immense amount of data also deepened the gap amongst scientists who utilize different aspects of the remote sensing data. Those who use ocean colour data never thought about the wet dust precipitation. Those who concentrated on wet precipitation did not consider the dust transport event. For those who concentrated on sporadic algal blooms over vast oceans phytoplankton blooms is something that is related with oceanic circulation dynamics rather than atmospheric activities. NASA and ESA have managed to design most sophisticated sensors that pours down vast amount of data intact but at ground level we have managed to slice them into pieces and while doing so lost the integrity of mother nature. Thus, with this presentation we would like to show how desert dust and cloud interactions triggers a chain reaction within clod droplets via the action of oxalate released by the prokaryotes upon contact with cloud water. This umbrella process results with the formation of reduced iron as well as all essential amino acids and upon wet precipitation onsets the phytoplankton blooms over the surface ocean via iron fertilization, provided that the solar radiation is above a threshold level that varies latitudinally. The time necessary for the proliferation of various types of phytoplankton was and still misleading the scientific community. Satellite data archives and related layers such as dust transport and wet precipitation events allow us to match phytoplankton blooms and wet dust precipitation events blessed by desert dust on a global basis. Thus, it can be suggested that surface ocean and lower atmosphere is linked via wet dust precipitation. The cycle is completed by the release of DMSP by phytoplankton's that enhances the formation of clouds via DMSP-DMS-MSA- $SO_4$ cycle. One can interfere with such mechanism since we have the technology to seed the clouds with proper dust and control phytoplankton blooms over the surface ocean.

[1] Environmental Engineering Department, Hacettepe University, Turkey

**USING REMOTE SENSING OBSERVATIONS TO ESTIMATE DUST DEPOSITION INTO TROPICAL ATLANTIC OCEAN [C]**

H. Yu[1], M. Chin[1], Q. Tan[2,3], Z. Zhang[4], D. Kim[1,5], T. Yuan[1,4], A. Omar[6], D. Winker[6], L. Remer[4], R. Levy[1], R. Kahn[1], O. Kalashnikova[7], L. Crepeau[8], V. Capelle[8], A. Chedin[8]

Massive dust emitted from North Africa can transport long distances across the tropical Atlantic Ocean, reaching the Americas. Dust deposition along the transit adds essential nutrients to marine ecosystem, which could increase the productivity of the ecosystem and $CO_2$ uptake, modulate biogeochemical cycle, and influence climate. Assessment of the dust-biogeochemistry–climate interactions has been hindered in part by the paucity of dust deposition measurements particularly in open oceans, and large uncertainties associated with representing dust processes in models. Currently there are several remote sensing capabilities of measuring aerosol optical depth (AOD) and particle size and shape properties (e.g., fine-mode fraction from MODIS, non-spherical fraction from MISR, depolarization ratio from CALIOP), which can be used to distinguish dust from other types of aerosol. Atmospheric infrared sounders such as IASI and AIRS with high spectral-resolution thermal channels can measure dust but not combustion aerosol. In this study, we combine CALIOP 3-D distributions of dust with dust optical depth (DOD) from MODIS, MISR, and IASI to quantify dust transport and deposition over the tropical Atlantic Ocean. On the basis of 2007-2014 average, the estimated yearly dust deposition is 89-117 Tg and 22-40 Tg into tropical Atlantic Ocean and Caribbean Basin, respectively. The dust deposition shows large inter-annual variability, which shows a negative correlation with prior-year Sahel rainfall anomaly to some extent. The satellite observations also yield an estimate of regional dust loss frequency of 0.056 ~ 0.086 $d^{-1}$, which is substantially smaller than model simulations.

[1] Earth Sciences Division, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA
[2] Bay Area Environmental Research Institute, Petaluma, California, USA
[3] NASA Ames Research Center, Moffett, California, USA
[4] JCET, University of Maryland Baltimore County, Baltimore, Maryland, USA
[5] USRA, Columbia, Maryland, USA
[6] NASA Langley Research Center, Hampton, Virginia, USA
[7] NASA Jet Propulsion Laboratory, Pasadena, California, USA
[8] Laboratoire de Météorologie Dynamique, Palaiseau, France

**CHARACTERIZATION OF THE REFLECTANCE COEFFICIENT OF SKYLIGHT FROM THE OCEAN SURFACE AND IMPLICATIONS TO OCEAN COLOR [C]**

A. Gilerson[1], C. Carrizo[1], R. Foster[2], E. Herrera[1], A. El-Habashi[1]

The differences in aerosol optical thickness (AOT) measured by AERONET – Ocean Color (OC) and retrieved from satellite data show a noticeable dependence on the wind speed indicating possible dicrepancies associated with the ocean – atmosphere interface. The values and spectral dependence of the reflectance coefficient of skylight from wind-roughened ocean surfaces is thus critical for determining accurate water leaving radiance and remote sensing reflectance from shipborne, AERONET-OC and satellite observations. Using a vector radiative transfer code, spectra of the reflectance coefficient and corresponding radiances near the ocean surface and at the top of the atmosphere (TOA) are simulated for a broad range of parameters including flat and windy ocean surfaces with wind speeds up to 15 m/s, aerosol optical thicknesses of 0-1, wavelengths of 400-900 nm, and variable Sun and viewing zenith angles. Significant impact on the reflectance spectra of all these parameters together with the small amount of Sun glint which is often unavoidable is demonstrated. Results match well field measurements conducted with the novel snapshot hyperspectral imager from the ocean platforms in NYC area and in Duck, NC with various ocean and atmospheric conditions, Sun angles and wind speeds. Potential changes in measurement procedures and data processing schemes for above surface and satellite observations are discussed.

[1] The City College of New York, CUNY, New York, NY 10031, USA
[2] Remote Sensing Division, Naval Research Laboratory, Washington, DC 20375, USA

**DROPSONDE-BASED VALIDATION OF SATELLITE-DERIVED NEAR-SURFACE AIR TEMPERATURE AND SPECIFIC HUMIDITY PRODUCTS [C]**

G. A. Wick[1], D. L. Jackson[1,2]

The accuracy of satellite-derived estimates of the turbulent air-sea heat fluxes are critically dependent on the quality of estimates of the near-surface air temperature (Ta) and specific humidity (qa). Retrievals of those parameters from satellite observations are highly indirect and subject to substantial uncertainty. While a great deal of progress has been made in improving the accuracy of the retrievals through novel methods and use of multiple sensor types, the uncertainty remains rather poorly quantified, especially in regions of extreme and anomalous conditions. Traditional in situ observations from research vessels used to validate the products are very limited in their distribution. Observations from buoys are somewhat more diverse, but have associated concerns with their uncertainty, particularly in more extreme conditions.

A unique opportunity to further validate the satellite-derived Ta and qa retrievals in diverse and extreme conditions is provided by dropsondes deployed from weather research aircraft. A large set of dropsonde observations spanning several years and collected using both manned and unmanned aircraft have been used to validate multiple current Ta and qa products. These observations are based in large part on sampling of tropical cyclones and winter storms to improve forecasts of these high-impact weather events. The results provide a fully independent assessment of the uncertainty of the product retrievals and enable an important assessment of the degree to which the retrievals are reliable in the adverse conditions in the environment of tropical cyclones and major oceanic storms. This presentation will highlight the identified accuracy of the various products compared with other validation activities, and demonstrate how the uncertainty varies as a function of parameters such as wind speed, precipitable water, and liquid-water content that help characterize the harshness of the environment.

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# Day 2: Wednesday, 14 March 2018

## AIRBORNE REMOTE SENSING OF THE UPPER OCEAN TURBULENCE [C]

I. Savelyev[1]

One of the primary limitations of conventional in situ ocean turbulence measurements is the lack of horizontal spatial coverage. Turbulence microstructure is often measured as a vertical profile, which is then assumed to be isotropic and homogeneous within some study area. This notion, as arguable as it was to start with, has been challenged by recently invigorated research on submesoscale oceanic eddies and fronts, which appear to actively interact with smallest scale turbulence and hence modulate vertical mixing across the upper ocean. It is imperative, therefore, that upper ocean turbulence observations should include the means to resolve spatial structure of surrounding turbulence to place point measurements from high fidelity in-situ turbulence sensors in context. While satellite remote sensing is a promising tool for this purpose, pixel resolution and/or revisit times have to increase further to become useful beyond anecdotal examples. Meanwhile, this study heavily relies on airborne remote sensing and explores the extent to which the upper ocean turbulence can be mapped with state-of-the-art imaging sensors. Results from multiple field campaigns presented here demonstrate ocean surface imagery acquired with typical swath resolutions of ~1-10 meter/pix, ~1000 pixels across swath, ~10 km long swaths, and ~10min revisit time intervals. Types of sensors include visible to near infrared hyperspectral push broom sensors, short-, mid-, and long-wave infrared cameras, and a multichannel synthetic aperture radar. Airborne platforms used in these experiments include fixed-wing manned aircrafts, as well as multi-rotor drones. All airborne observations presented here were collected in coordination with dedicated in situ experiments facilitated by research vessels. The aircraft was treated as one of a number of tools available to oceanographers in experiment planning, execution, and data analysis and interpretation stages. Some hydrodynamic structures, such as eddies, fronts, windrows, etc. are immediately obvious in raw or low level airborne data products. However, relating these remotely obtained signals to usable oceanographic parameters is always a great challenge, which this study places much effort on. As such, detailed knowledge of surface meteorology, wave conditions, and subsurface profiles obtained either by the research vessel or by other assets it deployed, as limited in spatial coverage as they are, is critical for the successful interpretation of the airborne imagery.

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**THE 2015-2016 EL NIÑO AND THE RESPONSE OF THE CARBON CYCLE: FINDINGS FROM THE ORBITING CARBON OBSERVATORY-2 (OCO-2) MISSION [C]**

A. Chatterjee[1,2], M. M. Gierach[3], A. J. Sutton[4,5], R. A. Feely[4], P. Landschützer[6], D. Crisp[3], A. Eldering[3], M. R. Gunson[3], R. F. Keeling[7], B. B. Stephens[8], D. S. Schimel[3]

The El Niño Southern Oscillation (ENSO) is the most important mode of tropical climate variability on interannual to decadal time scales. Correlations between atmospheric $CO_2$ growth rate and ENSO activity are relatively well known but the magnitude of this correlation, the contribution from tropical marine vs. terrestrial flux components, and the causal mechanisms, are poorly constrained in space and time. The launch of NASA's Orbiting Carbon Observatory-2 (OCO-2) mission in July 2014 was rather timely given the development of strong ENSO conditions over the tropical Pacific Ocean in 2015-2016. In this presentation, we will discuss how the high-density observations from OCO-2 provided us with a novel dataset to resolve the linkages between El Niño and atmospheric $CO_2$. Results from this initial study, which were published in Science, confirm the hypothesis that an early reduction in $CO_2$ outgassing from the tropical Pacific Ocean is later reversed by enhanced $CO_2$ emissions from the terrestrial biosphere. Our current work builds upon the initial findings and examine in detail the spatiotemporal structure of the ocean carbon cycle response to the 2015-2016 El Niño event. By integrating information from in situ observations of $\Delta pCO_2$ from NOAA's Tropical Atmosphere Ocean (TAO) project and atmospheric $CO_2$ from the Scripps $CO_2$ Program, our ongoing analyses provides both qualitative and quantitative knowledge of the mechanisms responsible for the magnitude and phasing of the observed ENSO-ocean $CO_2$ correlations. We expect these results to improve our understanding of the marine vs. terrestrial partitioning of tropical carbon fluxes during an El Niño event, their relative contributions to the global atmospheric $CO_2$ growth rate, and consequently provide important clues into the sensitivity of the carbon cycle to climate forcing on interannual time scales.

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**ASSESSMENT OF EXPORT EFFICIENCY EQUATIONS IN THE SOUTHERN OCEAN APPLIED TO SATELLITE-BASED NET PRIMARY PRODUCTION [C]**

L. Arteaga[1], N. Haëntjens[2], E. Boss[2], K. Johnson[3], J. L. Sarmiento[1]

Carbon export efficiency (e-ratio) is defined as the fraction of organic carbon fixed through net primary production (NPP) that is exported out of the surface productive layer of the ocean. Recent observations for the Southern Ocean suggest a negative e-ratio vs. NPP relationship, and a reduced dependency of export efficiency on temperature, different than in the global domain. In this study, we complement information from a passive satellite sensor with novel space-based lidar observations of ocean particulate backscattering to infer NPP over the entire annual cycle, and estimate Southern Ocean export rates from five different empirical models of export efficiency. Mean NPP during the 2005–2016 period for the region south of 50°S is 2.7 (± 0.6) Pg C $yr^{-1}$, which falls within the range of previous estimates. We find that an export efficiency model that accounts for silica(Si)-ballasting, which is constrained by observations with a negative e-ratio vs. NPP relationship, shows the best agreement with in-situ based estimates of annual net community production (ANCP) (annual export of 2.7 ± 0.6 Pg C $yr^{-1}$ south of 30°S). By contrast, models based on the analysis of global observations with a positive e-ratio vs. NPP relationship predict annually integrated export rates that are ~ 33 % higher than the Sidependent model. Our results suggest that accounting for a negative e-ratio vs. NPP relationship and Si-induced ballasting are important factors for the estimation of carbon export in the Southern Ocean.

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## A DETERMINISTIC INVERSE METHOD FOR OCEAN SKIN TEMPERATURE PROFILE RETRIEVAL FROM M-AERI MEASUREMENT [C]

P. K. Koner[1], E. W. Wong[2], P. J. Minnett[3]

A very thin temperature boundary layer (~10 $\mu$m skin layer) between the turbulent ocean and atmospheric layers plays very important role in many geophysical applications, *e.g.* atmospheric models, weather forecasting, climate change models, and energy balance calculations etc. Although a significant research work is carried on the determination of skin temperature, it presents a challenge to physical modelling because of the complexity of many controlling factors, *e.g.* wind speed, solar radiation, air temperature, surface vapor pressure, breaking waves, small-scale kinetic eddies and surface emissivity etc. It is also extremely challenging to make measurements in this very thin layer using *in-situ* instruments. On the other hand, the passive remote sensing of infrared (IR) emission can be used for the determination of thermal skin temperature because the IR electromagnetic (EM) skin layer has comparable thickness to the thermal skin layer. According to the literature, the inversion of the hyperspectral IR spectrometers measurement to determine the skin temperature is highly ill-conditioned and nonlinear that requires some ad-hoc assumptions as well as solution is first guess dependent. As reliable first guess profile is difficult to get for dynamic ocean surface region, we propose a new inverse method based on regularizedtotal- least-squares (RTLS) for ocean skin temperature profile retrieval from hyperspectral IR measurement, *i.e.* Marine–Atmospheric Emitted Radiance Interferometer (M-AERI). The solution of proposed method is independent of the first guess profile and doesn't require additional physical assumption. The confidence of the proposed method will be validated by comparison with prevalent method using simulated retrieval due to lack of truth.

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**REMOTELY SENSED DATA REQUIREMENTS FOR TURBULENT HEAT FLUX DETERMINATION [I]**

A. Bentamy[1], J. F. Piollé[1], A. Grouazel[1], F. Paul[1], H. Azelmat[1], P. P. Mathieu[2], K. von Schuckmann[3], S. Sathyendranah[4], H. E. K. King[4], R. Danielson[5], I. Esau[5], J. Johannessen[5], S. Gulev[6], C. A. Clayson[7], R. T. Pinker[8], S. Grodsky[8], M. Bourassa[9], S. R. Smith[9], K. Haines[10], Maria Valdivieso[10], C. Merchant[10], B. Chapron[1], A. Anderson[11], R. Hollmann[11], J. Simon[12]

Latent (LHF) and sensible (SHF) heat fluxes over global oceans require the knowledge of high accurate surface and atmospheric parameters such as surface winds, humidity, air and sea surface temperatures. The latter are retrieved from scatterometer and radiometer instruments onboard polar satellites. Several scientific groups have been developing air-sea heat flux information over global oceans. This paper aims at providing a new insight of the quality and error characteristics of daily turbulent heat flux estimates at various spatial and temporal scales. The study is performed within the European Space Agency (ESA) Ocean Heat Flux (OHF) project. The quality of all products, namely IFREMER, HOAPS-3, OAFlux, SeaFlux V1, J-OFURO 3, ERA Interim, CFSR, and MERRA, contributing to the OHF project is first determined through comprehensive comparison with daily-averaged LHF and SHF estimated from in-situ (moorings and ships) and from dedicated scientific campaign measurements. The results are investigated with respect to various oceanic and atmospheric parameters and conditions. They allow the determination of the required improvements of radar and radiometers retrievals.

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[2] European Space Agency (ESA/ESRIN)
[3] Mediterranean Institut of Oceanography (MIO), France
[4] Plymouth Marine Laboratory (PML), UK
[5] Nansen Environmental and Remote Sensing Center (NERSC), Norway
[6] P. P.Shirshov Institute of Oceanology (IORAS), Russia
[7] Woods Hole Oceanographic Institution (WHOI), USA
[8] University of Maryland, USA
[9] Florida State University (FSU), USA
[10] University of Reading (UR), UK
[11] European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)
[12] National Oceanography Center (NOC), UK

**AN IMPROVED ESTIMATION OF SATELLITE DERIVED SURFACE HUMIDITY AND AIR-SEA LATENT HEAT FLUX [C]**

H. Tomita[1], T. Hihara[2], .M. Kubota[3]

An accurate estimation of the air-sea fluxes is crucial for studies of the global climate system. Estimating surface flux using satellite remote sensing techniques is one possible answer to this challenge. Surface air specific humidity is one of essential climate variables and is also a key variable in the estimation of air-sea latent heat flux and evaporation from the ocean surface. Current remote sensing techniques are problematic and a major source of errors for flux and evaporation. Here, we propose a new method to estimate surface humidity using satellite microwave radiometer instruments (SSMI, SSMIS, AMSR-E, TMI, and AMSR2), based on a new finding about the relationship between multi-channel brightness temperatures measured by satellite sensors, surface humidity, and vertical moisture structure. Satellite estimations using the new method were compared with in situ observations to evaluate this method, confirming that it could significantly improve satellite estimations with high impact on satellite estimation of latent heat flux and evaporation. Finally, multi-satellite global air-sea latent heat flux was calculated over 1988-2015 as a part of the third-generation data set of Japanese Ocean Flux Data Set with Use of Remote-Sensing Observations (J-OFURO3). A general quality and improved features of the data set were investigated. J-OFURO3 data are of outstanding quality, facilitating a clearer understanding of more fine-scale ocean-atmosphere features and more long-term flux variation based on multiple satellite observations.

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[3] Institute of Ocean Research and Development, Tokai University, Japan

**IMPROVING INDIAN OCEAN SURFACE HEAT AND FRESHWATER FLUX ESTIMATES BASED ON OCEAN MEASUREMENTS [C]**

J. A. Carton[1], S. A. Grodsky[1], R. Pinker[1], A. Bentamy[2]

Currently net surface heat and freshwater flux estimates are based on in-situ and remotely sensed meteorological observations, and in the case of atmospheric reanalysis closure of complicated atmospheric heat and freshwater budget equations. Recent improvements in Indian Ocean observing systems (ARGO and RAMA particularly) together with the simplicity of the ocean heat and freshwater budget equations (low speeds, and no radiative or phase change terms) suggests that closing the ocean heat budget as well can yield improved estimates of net surface flux. In this talk we implement this suggestion, presenting results using the Simple Ocean Data Assimilation V3 to examine imbalances in the ocean heat and freshwater budgets when the ocean is forced with popular surface flux estimates in the Indian Ocean. We then modify the fluxes based on the ocean imbalances and show that the modified fluxes lead to improved agreement with the ocean observing system observations.

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**EFFECT OF A SEA SPRAY LAYER ON REMOTE SENSING OF OCEAN SURFACE [C]**

M. D. Anguelova[1], M. H. Bettenhausen[1]

Satellite-based passive and active remote sensing observations provide global, long-term data useful for studying and forecasting hurricanes, including ocean surface wind speed, precipitation, sea surface temperature, and salinity. Remote sensing techniques using GPS signals of opportunity complement observations from radiometers and scatterometers at microwave frequencies (1-90 GHz) by providing data through hurricane rain bands at high temporal resolution. Such data enable the observation and study of hurricane genesis and evolution. The injection of sea spray into the air under gale force winds alters the atmospheric profiles of momentum, moisture, and enthalpy (sensible plus latent heat). The processes within the spray layer affect the intensity and structure of hurricanes. Therefore, the ability to recognize and evaluate the effect of sea spray on remote sensing signals has the potential for better observing and forecasting hurricane intensification.

The wind speed determines the sea spray concentration, while turbulent transport, gravitational settling, and spray evaporation control the droplet heights. Depending on the sea spray production, the signal detected at microwave frequencies from rough ocean surface covered with whitecaps could be either augmented or completely masked. To assess the sea spray effect, we have developed a radiative transfer (RT) model computing the electromagnetic properties (namely, reflectivity and emissivity) of a vertically stratified sea spray layer at GPS frequencies. Effective medium theory is used to obtain the dielectric properties of the sea spray in terms of spray layer thickness and seawater content. This presentation describes the principle of remote sensing using GPS signals, the use of this technique to measure processes taking place within a sea spray layer, and the RT model developed to simulate and quantify these processes for winds up to 60 m $s^{-1}$.

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**OBSERVATION OF ARCTIC SEA ICE BREAKUP AND FLOE SIZE DURING THE WINTER-TO-SUMMER TRANSITION [I]**

P. Hwang[1]

The recent retreat of Arctic sea ice has had considerable impacts on Arctic physical environments, local ecosystems, oil and shipping industries, and local and global communities. One of the biggest changes caused by this dramatic sea ice decline is the subsequent expansion of the marginal ice zone (MIZ), an area of low ice concentration that consists of discrete ice floes of various sizes. This MIZ is projected to expand to an even greater extent in the future, covering almost 90% of summer ice by 2080. A key inherent process within this emerging MIZ is the floe freeze-up/breakup/melt evolution: the freeze-up of summer ice floes to winter ice, followed by the breakup of winter ice into discrete floes and the subsequent lateral melting of the floes in summer. Understanding this seasonal feedback and incorporating it into sea ice/climate models are crucial in achieving accurate projection of Arctic climate and the associated ramifications. However, existing sea ice-ocean/climate models oversimplify this important floe freeze-up/breakup/melt process of the MIZ, mainly due to a lack of observational data sets, which are required to gain a better understanding of this annual progression of ice floes and the coupled processes. In this talk, I will present the results from the recent field and remote sensing experiment, conducted as part of the U.S. Office of Naval Research Marginal Ice Zone Directed Research Initiative programme (MIZ DRI). This experiment allowed us to closely examine the winter-to-summer floe breakup/size evolution, following four sets of autonomous drifting buoys with dedicated satellite observations. This unique study revealed two important insights: (i) winter ice types and deformation (resulting leads/cracks) affect the summer floe size evolution; (ii) while floe breakup events are typically associated with strong wind events, floe breakup can occur due to severe (vertical) melting of thinner ice types serving as weak fracture points even with relatively moderate wind forcing. These results indicate how important it is to measure and quantify how winter ice types/features and deformations transform into spring ice floes, and how these spring ice floes evolve through summer floe breakup and melt.

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## THE MULTI-SENSOR IMPROVED SEA-SURFACE TEMPERATURE: CONTINUING THE GHRSST PARTNERSHIP AND IMPROVING ARCTIC DATA [C]

C. L. Gentemann[1], P. Minnett[2], M. Steele[3]

In 2018, (if funded) the Multi-sensor Improved Sea Surface Temperature: continuing the GHRSST partnership and improving Arctic data project will start. The objectives of this new project are on improving (i) satellite SST data distribution and international partnership activities, (ii) access to Arctic in situ SST data, (iii) the accuracy of satellite-derived SSTs in the Arctic, and (iv) our understanding of air-sea-ice interactions in the Arctic.

The Arctic Seas were until recently ice-covered for all or most of the year, so studies of Arctic Sea Surface Temperature (SST) were not particularly interesting. This has changed dramatically in recent years, owing to extreme seasonal sea ice melt-back and other climate impacts. In fact, this is now one of the most exciting areas of the world to study SST, in order to understand a variety of phenomena including heat exchange in the coupled air-sea system. However, satellite SST products in this region are presently very poorly validated, and are generally tuned to lower latitude in situ observations. The time is right to address these problems, given new observations that have been collected in recent years, in concert with the advantages that come from multiple passes of polar orbiting satellites at high latitude.

Improving our understanding of dynamical processes in the Arctic requires improving both the accuracy and characterization of observations used. To address this gap, this project proposes to collect, quality control, and re-distribute a large number of existing 'research' Arctic in situ datasets that have not been included in broadly used SST databases. These existing and new Arctic in situ data will be integrated into existing satellite-in situ matchup databases. As these matchup databases are the basis for most satellite SST algorithm development and uncertainty assessments, the addition of these new in situ data will greatly improve SST accuracy and uncertainty estimates in the Arctic. All satellite data, in situ data, and matchup databases developed in this project will be distributed publicly, to benefit this project, our international partners, and the wider scientific community.

Most researchers use global, gap-free, daily SST analyses, or Level-4 (L4) SSTs. L4 SSTs not only have large uncertainties in the Arctic but can vary by several degrees depending on which product is selected. The errors in L4 SSTs are partially due to the L4 analysis procedures (different handling of SSTs in the Marginal Ice Zone (MIZ), different bias corrections, different filtering of data, etc.) and partially due to errors in the orbital Level-2 (L2) satellite SSTs that are used to create the L4 SSTs. Improvements in L2 data accuracy, characterization and quality control, combined with better understanding of air-sea interactions and other processes, will feed through into better high-latitude L4 SST analyses that underpin so much Arctic research.

While improving SST data in the Arctic is important, the ability to reach the scientific community who will use the data is just as important. This project proposes to evolve (along with our international partners, in coordination with the GHRSST Project Office)

from the existing centralized data distribution approach to a more distributed approach that reduces redundancies and will improve the user experience.

Finally, within this project, research into diurnal warming in the Arctic, SST variability in the MIZ, and air-sea-ice interactions are all planned. These research topics directly benefit this project by improving our understanding of different dynamical processes that affect flagging of SST retrievals, accuracy of SST observations, and how to construct daily SST averages.

The GHRSST international collaboration of scientists is an important component of this project. Through the proposed work, new in situ data, matchup databases, SST algorithms, and processing capabilities will be developed both within this project and jointly with international partners. This project will increase availability of Arctic in situ data, accuracy of Arctic SSTs, distribution of satellite SST data, and understanding of Arctic SST variability, resulting in substantial improvements in our understanding and prediction of the Arctic environment.

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# POSTER ABSTRACTS

The abstracts in this section are arranged in alphabetical order by the family name of the first author. The presenting author's name is underlined.

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## NEAR-REAL TIME OCEAN-ATMOSPHERE SKIN TEMPERATURE AS PART OF NASA GMAO ATMOSPHERIC DATA ASSIMILATION SYSTEM

S. Akella[1,2], M. Suarez[1], R. Todling[1]

The Global Modeling and Assimilation Office (GMAO) at NASA, GSFC is developing an integrated Earth system analysis (IESA). Integral to this IESA are ocean-atmosphere interface states, such as the skin SST. Recently the GMAO's near-real time operational weather analysis and prediction system implemented an analysis for skin SST along with the meteorological analysis (Akella et al., 2017; doi:10.1002/qj.2988) since Jan, 2017. The skin SST is modeled and constrained using infrared radiometric observations. This poster describes some of the details of this development, its impact on forecasts, current and future developments towards the inclusion of microwave data (e.g. GPM-GMI).

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[2] SSAI Inc.

## IMAGE PROCESSING FOR SPACE-BORNE WIDE FOV IMAGING POLARIMETERS

H. M. J. Barbosa[1,2], J. V. Martins[2,3,4], B. McBride[2,3,4], R. Fernandez-Borda[2,3,4]

The capabilities of remote sensing instruments to observe aerosols and clouds from space have been continuously pushed as technology and research advances. The measurement of a more complete set of Stokes parameters, for instance, allows obtaining the real part of the refractive index with its link to particle composition and hygroscopicity. Measuring a wide range of scattering angles help constrain particle size, while hyper-angular measurements are necessary to retrieve the full size distribution of both aerosol and cloud droplets. For that reason, the last two Decadal Surveys have made the Aerosol-Clouds-Ecosystems (ACE) mission a priority and recognized the need for a highly accurate multiangle, multiwavelength satellite-borne polarimeter with high spatial resolution.

The Laboratory for Aerosols, Clouds and Optics (LACO) has developed such a sensor, with a very simple but highly effective design with no moving parts. The Hyper Angular Rainbow Polarimeter (HARP) has a wide field-of-view and can simultaneously measure 3 angles of polarization, at 4 different wavelengths, to observe the same target with up to 60 viewing angles. Processing the raw data of any wide-FOV polarimeter is a great challenge per se. Here, we describe our level 1 processing software: the Single-angle Composite Image Processing Pipeline, aka SCIPP. This system is a collection of tightly integrated stand-alone executables, driven by a single script. It accepts as input a range of sequential wide-angle aerial or satellite images, with the associated navigational data. The output is a single HDF5 file containing a series of composite geo-located images at single viewing angles, on a uniform lat-lon grid, corresponding to calibrated stokes parameter data. We will describe the data processing, step-by-step, and present sample level-1 data from the recent LMOS and ACEPOL campaigns.

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**THE NEED OF ACCURATE SST RETRIEVALS FOR STUDYING THE OCEAN-ATMOSPHERE INTERFACE**

B. Boussidi[1], P. Cornillon[1], C. Gentemann[2]

Sea Surface Temperature (SST), defined as the temperature of the ocean at a depth ranging from a few micrometers to few millimeters, is an important indicator of the state of the earth's climate system. Thus, accurate knowledge of SST is essential for studying physical processes at the air-sea interface. To date, different satellite-based instruments provide frequently sampled SST measurements with a dense spatial resolution and global coverage. The SST community has invested considerable effort in developing accurate retrieval algorithms and efficient correction for atmospheric contamination and cloud screening. In this context, our objective is to provide a deeper understanding of the atmospherical, geophysical and instrumental issues behind SST retrievals through comparison of co-located multi-source observations.

The National Aeronautics and Space Administration's (NASA) Aqua platform, launched in May 2002, present some interesting possibilities: it carries both an infrared and a microwave instrument allowing simultaneous retrieval of SST at di_erent spatial resolutions. On one hand, the passive microwave Advanced Microwave Scanning Radiometer - EOS (AMSR-E) instrument measuring SST averaged over approximately the upper 1mm of the water column at 58km resolution, and, on the other hand, the passive infrared MODerate-resolution Imaging Spectroradiometer (MODIS) radiometer degterminin SST from the first micrometer at 1 km resolution.

The Spinning Enhanced Visible and Infra-Red Imager (SEVIRI) on-board the geostationary Meteosat Second Generation (MSG), for its part, provides high-temporal-resolution SST retrievals, an image every 15 min, with a spatial resolution of ≈5 km. Errors in AMSR-E SST fields are primarily due to heavy rain, strong wind speed and radio frequency interference (RFI). MODIS and SEVIRI SST data suffer primarily from cloud contamination. In fact, if the `best' quality MODIS or SEVIRI observations were averaged to the AMSR-E footprint on the AMSR-E grid, one would expect a zero mean randomly distributed bias, with a low variance, when comparing to the AMSR-E field. However, our ongoing research in this area highlights signi_cant patchiness in the infrared/microwave bias on scales of 50 to 100 km. Moreover, although there is a signi_cant bias between the MODIS and SEVIRI _elds averaged to the AMSR-E grid, the variability between the two is very small compared to the variability found when either is compared with the corresponding AMSR-E field. Even using only high quality retrievals from all the datasets, some contaminated pixels are still present leading to misclassification errors; i.e, cloud contaminated MODIS or SEVIRI pixels being misclassified as clear. It is also possible that the AMSR-E retrieval algorithm introduces these errors as part of the retrieval process.

In this study, we investigate the source of those biases using a set of cloud-free co-located SST fields from AMSR-E, MODIS and SEVIRI. Statistical distributions and spatial patterns of the infrared/microwave and infrared/infrared bias differences are then analyzed. Particular emphasis is placed on the study of biases resulting from atmospheric fluctuations. We shall focus on the wide range of length scales present in these fields

and evaluate different scenarios linking the observed biases to atmospheric contamination and the performance of SST retrieval algorithms. This study will provide a comparison of the atmospheric correction and cloud-masking algorithm performances between MODIS and SEVIRI and establish the factors that determine the difference between the infrared and microwave measurements and the degree to which they may be related to a skin/subskin differences in temperature.

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## THE HIGH LATITUDE AND COLD ENVIRONMENT DUST NETWORK

J. E. Bullard [1], R. D. McCulloch[2], S. Gassó[3], T. Thorsteinsson[4], J. Crusius[5,8], C. McKenna Neuman[6], D. Gaiero[7], E. F. Darlington[1]

Dust in the earth-atmosphere-ocean system affects natural and anthropogenic activities. Most research focuses on dust sources in the subtropics, however significant emissions also occur in cold climates and at high latitudes, particularly in proglacial and paraglacial regions. Existing knowledge concerning the impacts of high latitude/cold climate dust in the Earth system is scattered among a diverse group of scientists. This international network will facilitate collaboration among researchers to improve understanding of contemporary and future high latitude dust emissions, focusing on consolidating existing knowledge, identifying research gaps and prioritizing strategic, inter-disciplinary research questions.

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**HOW NASA CAN HELP TO ANSWER AN 800,000 YEAR OLD QUESTION IN PALEOCLIMATE STUDIES? (BONUS: IT WILL CONTRIBUTE SIGNIFICANTLY TO OCEAN BIOLOGY STUDIES TOO)**

S. Gassó[1]

One of the current mysteries in paleoclimate studies is found in ice cores from Antarctica, where a correlation between atmospheric $CO_2$, ambient temperature and dust deposited in snow that spans thousands of years has been observed and not clear explanation is available. Also, in the ocean biology community, the role of blown dust as a medium to bring nutrients to HNLC regions has been the subject of many studies and field campaigns in the last 25 years. Both Antarctica and High Nutrient Low Chlorophyll (HNLC) regions share the feature of being located upwind of high latitude dust (HLD) sources such as the Patagonia desert in South America. Despite significant efforts to address these questions in both communities, there have been no conclusive answers to them because, in grand part, the difficulty of carrying out observational assessments (such as in the Southern Ocean and Antarctica). This poster brings attention to the concept of HLD and their sources (located poleward of 40 degrees). One of the objectives is to make the case that by focusing studies in HLD regions important contributions towards answering the above questions can be obtained. In particular, the Gulf of Alaska is ideally suited for studying the interaction between Aeolian nutrients and corresponding ocean biology response (or lack thereof).

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**HIGH RESOLUTION SATELLITE STUDY OF MULTIPLE STRESSORS IN ARCTIC MARINE SYSTEMS & CORRELATION OF OCEAN-ATMOSPHERE-CRYOSPHERE INTERACTIONS WITH CLIMATE VARIABILITY TO DEVELOP ARCTIC-OCEAN CLIMATE PREDICTING MODELS (AOCPM)**

V. Goswami[1]

There are places on Earth that are so cold that water is frozen solid. These areas of snow or ice compose the cryosphere. The term "cryosphere" comes from the Greek word, "krios," which means cold e.g. Arctic, Greenland & Antarctica regions. The understanding of impacts of multiple stressors on the ocean and the associated risks of abrupt state shifts can be explored through the comprehensive studies of Ocean Systems Interactions, Risks, Instabilities and Synergies (OSIRIS). & Arctic-Ocean Climate Predicting Models (AOCPM).

Lately (Feb'17), Researchers in University of Washington, USA & University of Edinburgh found that the pools underneath the glacier, Thwaites, are draining out at an unprecedented rate and emptying themselves. This unstoppably melting of the glacier into the ocean mainly because of warmer seawater lapping at its underside.

Prof. Peter Clark, OSU attributed that the Glacier retreat was due to rising levels of Carbon Dioxide and other GHG, as opposed to other types of forces. If, this continues then the most of Glaciers would disappear in the next few centuries & the Glaciers loss in future will contributing to rising sea levels & environmental pollution. This ocean-atmosphere-cryosphere (OAC) interaction is more evident on North pole i.e. Arctic regions as the temp raised above freezing point on 20 Dec'15.(Canadian Scientist 01/01/2016-HT) & over Antarctic & Southern Ocean region resulting the significant changes in Climate parameters.

Its imperative to investigate sub mesoscale dynamics of Arctic ice sheet stability, ice and bedrock coring, ice sheet modeling, and ice sheet processes viz. physical, chemical, and biological oceanographic for climate modeling study through the computation of Correlation of Cryosphere Ice Sheet Stability with Sea-level Variability nism ,Sub-Mesoscale Dynamics and Climate variability by developing Ocean Systems Interactions, Risks, Instabilities and Synergies (OSIRIS) & Arctic-Ocean Climate Predicting Models (AOCPM).

Hence, efforts art on Co-evolution of climate and marine life in the Arctic-Sea through the Correlation of Ocean-atmosphere-cryosphere interactions with Climate Variability i.e. to evaluate correlation between the impacts of multiple stressors on the ocean and the associated risks of abrupt state shift , rising of sea level, ,melting of the glaciers, vis-à-vis climate variability.

Next, is to investigate Correlation of Artic- Ocean-Atmospheric-cryosphere (OAC) Variability Mechanism, Sub-Mesoscale Dynamics & its impact on, Climate Variability. Arctic- Ocean regional Variability of the Sub-Mesoscale Dynamics includes to examine High Resolution Satellite Imageries with emphasis on the large scale kinematic and thermodynamic behavior of selected mesoscale convective systems.

The kinematic features of the mesoscale convective systems over Arctic- Ocean regions

would be correlated with ocean-atmosphere-cryosphere variability on time & Space Scales; at the local, regional and global levels through the extracted Sea Surface Temperature (SSTs) over the grid box , attributing the regional change to natural and anthropogenic radiative forcing agents & to bring out a few optimum values of these to develop Ocean Systems Interactions, Risks, Instabilities and Synergies (OSIRIS) & Arctic-Ocean Climate Predicting Models (AOCPM), by using High Resolution Satellite imageries, data access, assimilation; HPC and cloud computing for real-time analysis.

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**IMPACT OF AQUARIUS AND SMAP SEA SURFACE SALINITY OBSERVATIONS ON COUPLED FORECASTS FOR THE TROPICAL INDO-PACIFIC**

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We assess the impact of satellite sea surface salinity (SSS) observations on seasonal to interannual variability of tropical Indo-Pacific Ocean dynamics as well as on dynamical ENSO forecasts. Our coupled model is composed of a primitive equation ocean model for the tropical Indo-Pacific region that is coupled with the global SPEEDY atmospheric model. The Ensemble Reduced Order Kalman Filter is used to assimilate ocean observations to constrain dynamics and thermodynamics for initialization of the coupled model. The baseline experiment assimilates satellite sea level (AVISO, 2013), SST (Reynolds et al., 2004), and in situ subsurface temperature and salinity observations (NODC, 2006). These baseline experiments are then compared with experiments that additionally assimilate Aquarius (V 5.0 Lilly and Lagerloef, 2008) and SMAP (V 2.0 Meissner and Wentz, 2016) SSS. Twelve-month forecasts are initialized for each month from September 2011 to September 2017.

Including satellite SSS significantly improves NINO3.4 sea surface temperature anomaly validation out to ~9 month forecast lead times. For initialization of the coupled forecast, the positive impact of SSS assimilation is brought about by surface freshening near the eastern edge of the western Pacific warm pool and density changes that lead to shallower mixed layer between 10S-5N. In addition, salting near the ITCZ leads to a deepening of the mixed layer and thermocline near 8N. These patterns together provide the background state to amplify equatorial Kelvin waves.

Additional experiments are presented that demonstrate the impact of the SMAP versus Aquarius. This preliminary version of SMAP data shows a salty bias within the equatorial wave-guide and just north of the equator in the eastern Pacific. Removing this bias leads to significantly improved coupled forecasts after 8 month lead-times. These results have relevance in the context of combining Aquarius and SMAP SSS as a continuous climate data record.

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**A STUDY ON DYNAMICS OF PARTS OF ANDHRA COAST MONITORING WITH REMOTE SENSING TOOL, SOUTH EAST COAST OF INDIA : IMPLICATIONS FOR CLIMATE CHANGE**

N. Jayaraju[1], B. Lakshmanna[1]

India has 7,516 km of coastline, of which the mainland accounts for 5,422 km. The shoreline is one of the rapidly changing linear features of the coastal zone which is dynamic in nature. The issue of shoreline changes due to sea level rise over the next century has increasingly become a major social, economic and environmental concern to a large number of countries along the coast, where it poses a serious problem to the environment and human settlements. Shoreline recession as a result of rising sea level has been recognized as a potential near future hazard by a number of countries and this is same for the states of India along the coast. Today the issue of shoreline changes due to sea level rise caused by Globe warming has increasingly become a major issues in terms of its impact on the population along the coastal area. Changes in mean sea level as measured by coastal tide gauges are called relative sea level Changes. In IPCC (Intergovernmental Panel on Climate Change) Third Assessment Report (2001) shows that global average surface temperature is projected to increase by 1.4 to 5.8° C over the period 1990 to 2100. The present study deals with the morphological modification manifested along Ongole Coast, Southeast Coast of India. Satellite imageries of the study area for February 9, 2010, March 18, 2012, May 27, 2014, and April 30, 2016 were used. This study was carried out using multi temporal satellite images of IRS P6 LISS-III and Landsat 8 OLI/TIRS data from 2010 to 2016. Visual interpretation techniques were employed to establish the morphology categories from Satellite Imageries year-wise. The study shows that there is a constant changes of the shore owing to the both natural and anthropogenic activities. The impact of global warming-induced sea level has great significance to India due to its extensive low-lying densely populated coastal zone. This paper attempts to find the time trend of the sea level rise and document the positive, significant and increasing trend for the majority of the monitoring stations along east coast of India. In order to avoid further damage to this coastal fragile ecosystem immediate safety measures have been suggested to the policy makers, public etc., .This paper attempts to provide action plans for the policy makers to frame ideologies for the protection of the coastal environment.

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**SPATIAL OBSERVATION AND MONITORING OF THE NEW OCEAN ATMOSPHERE EXCHANGES, NEW ENERGY BALANCE, NEW ATMOSPHERIC CIRCULATION AND EXTREME METEOROLOGICAL PHENOMENA**

M. S. Karrouk[1]

Cumulating ocean-atmospheric thermal energy caused by global warming has resulted in the reversal of the energy balance towards the poles. This situation is characterized by a new ocean-continental thermal distribution: over the ocean, the balance is more in excess than in the mainland, if not the opposite when the balance is negative inland.

Thanks to satellite observation and daily monitoring of meteorological conditions for more than fifteen years, we have observed that the positive balance has shifted more towards the poles, mainly in the northern hemisphere. Subtropical anticyclones are strengthened and have extended to high latitudes, especially over the Atlantic and Pacific oceans. This situation creates global peaks strengthened in winter periods, and imposes on cosmic cold the deep advection toward the south under the form of planetary valleys "Polar Vortex".

This situation imposes on the jet stream a pronounced ripple and installs a Meridional Atmospheric Circulation (MAC) in winter, which brings the warm tropical air masses to reach the Arctic Circle, and cold polar air masses to reach North Africa and Florida.

This situation creates unusual atmospheric events, characterized by hydrothermal "extreme" conditions: excessive heat at high latitudes, accompanied by heavy rains and floods, as well as cold at low latitudes and the appearance of snow in the Sahara!

This is why climate sciences must deal nowadays with short term prediction of phenomena: weekly, monthly, or seasonly a bit more advanced than meteorology (72 hours) but less advanced than climate models (50-100 years) to allow the policy makers enough time to intervene efficiently in order to protect the populations from extreme meteorological phenomena and to benefit from the opportunities of the new meteorological conditions

These are the characteristics of "New Meteorological Events" resulting from the "New Atmospheric Circulation", caused by the "New planetary Climate" consequence of "Global Warming".

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**REGCM4 SIMULATION IN WEST AND CENTRAL AFRICA DURING EXTREME EVENTS OF ATLANTIC COLD TONGUE**

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This study evaluates the ability of the Regional Climate Model (RegCM4) to reproduce the observed rainfall and wind over West and Central Africa (WCA) during two contrasting years of the Atlantic Cold Tongue (ACT) depicted by the Caniaux's index. Simulations were done at a resolution of 50 km. Results show that the model realistically reproduces the West and Central African precipitation, with a few discrepancies due to the different cumulus convection schemes and the chosen region. The distribution of rainfall in the range of Cameroon highlands and the Bauchi Plateau of Nigeria is poorly captured in the two years. From GPCP data, it is observed that these regions are not significantly affected by the ACT. It is shown that rainfalls of some sub-regions are very sensitive to ACT. The model is capable of reproducing the amount and distribution of the precipitation for the two years in the ACT area. Contrary to the rainfall, it is seen that the model better reproduces the wind distribution in the Sahara region but overestimates it. The model also seems to better simulate the wind speed sensibility to ACT far from the coast in Soudano-Sahel and Nigeria-Cameroon zone. It is observed that during this extreme event in Atlantic Ocean the model adequately mimic the African easterly jet structure.

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**HYPER-ANGLE IMAGING POLARIMETRY FOR MICROPHYSICAL RETRIEVALS OF AEROSOL AND CLOUDS**

B. A. McBride[1,2,3], J. V. Martins[1,2,3], R. F. Borda[1,2,3], H. M. J. Barbosa[4]

Current radiometric retrievals of aerosol and cloud properties are information-limited, and the many assumptions about particle shape, size, and distribution needed by these retrievals can lead to biased conclusions about the underlying atmosphere. In the past two decades, polarimetric remote sensing provided ways of deriving these assumed properties directly and independently. Polarimeters enhance radiometric retrievals, instrument validation and atmospheric correction efforts, and with multi-angle sampling, can perform comprehensive BRDF analyses, stereo cloud height, and single-pixel retrievals from space and aircraft.

The Hyper-Angular Rainbow Polarimeter (HARP) is a wide field-of-view, multi-angle imaging polarimeter instrument developed, calibrated, and operated by the University of Maryland, Baltimore County (UMBC). The HARP suite was designed for atmospheric correction and highly accurate retrievals of cloud and aerosol microphysical properties from space. The instrument is novel in its simultaneous imaging, angular sampling density, optimized optical assembly, and dynamic wavelength selection. The HARP technology was demonstrated twice in 2017 by the aircraft platform, AirHARP, during Lake Michigan Ozone Study (LMOS, on-board the NASA LaRC B200) and Aerosol Characterization from Polarimeter and LIDAR (ACEPOL, NASA ER-2) campaigns. Two future HARP deployments are anticipated: the HARP CubeSat will sample the Earth for one year from ISS orbit starting in May 2018, and HARP2, the most refined HARP instrument to date, will fly aboard the Plankton-Aerosol-Cloud-ocean Ecosystem (PACE) satellite in the early 2020s.

This poster will explore preliminary microphysical retrievals from the AirHARP instrument from LMOS and ACEPOL campaigns and discuss how the upcoming HARP CubeSat and HARP2 instruments will improve upon AirHARP in accuracy, signal-to-noise, and calibration.

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**UNCERTAINTY IN SATELLITE AND MODEL ESTIMATION OF OCEAN/ATMOSPHERE NET HEAT BUDGET IN THE NORTHERN INDIAN OCEAN**

R.T. Pinker[1], A. Bentamy[2], W. Chen[1]

The spatial and temporal variability of the net heat flux (*Qnet*) over the Indian Ocean, with a focus on the Arabian Sea and the Bay of Bengal, are investigated, based on enhanced satellite and reanalysis model estimates. One of the main objectives is the characterization of the seasonal patterns over the basins of interest and evaluation of their accuracy as compared to buoy observations. The former are determined from radiative and turbulent fluxes provided by the University of Maryland (UMD), the Institut Français pout la Recherche et l'Exploitation de la MER (IFREMER V4), the Objective Analysis Fluxes (OAFlux V2), the European Center for Medium Weather Forecasts (ECMWF) ERA Interim, the National centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR) and the NASA MERRA-2 reanalysis. The quality of the estimates from the various sources is investigated using a comprehensive comparison with heat budget estimated from the Research Moored Array for African-Asian-Australian Monsoon Analysis and prediction (RAMA) buoys. In general, the results show a good agreement between daily estimates and the buoy products. Correlation coefficients at each site are quite similar for all products, with ERA Interim showing the best correlation with observations at all buoy locations. The seasonal means of net heat budget fluxes are calculated from daily estimates over the Indian Ocean and for the study period (2005-2008). The various products lead to quite similar spatial patterns of *Qnet*, even though significant departures in magnitude are observed. For instance, the seasonal variability between winter and summer heat flux estimates is less pronounced in ERA Interim and CFSR re-analyses than in IFREMER and OAFlux.

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**CHARACTERIZING OCEAN SURFACE TEMPERATURE DIURNAL CYCLE USING GEOSTATIONARY SATELLITE DATA**

S. Saux-Picart[1] , T. Gianelli [1]

The Ocean and Sea-Ice Satellite Application Facility (OSI SAF) of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) has recently achieved a reprocessing of Sea Surface Temperature (SST) from Spinning Enhanced Visible and Infrared Imager/Meteosat Second Generation (SEVIRI/MSG) archive (2004-2012). The retrieval is based on a non-linear algorithm using infrared channels. A bias correction (Le Borgne et al., 2011) based on Numerical Weather Prediction model is used to remove regional and seasonal biases. The SST retrieved from infrared channels is sensitive to skin temperature which is defined as the temperature immediately below the surface (around 10-20µm deep).

Diurnal variability of the sea surface temperature has been under investigation in the past decades mostly for its importance in the air-sea energy exchanges. It has been observed to reach amplitudes of 3-4 degrees and more in some places. To a first order, the diurnal cycle amplitudes are related to environmental conditions such as wind speed and insulation.

This work make use of the reprocessing of MSG/SEVIRI archive to estimate some characteristics of diurnal cycle. Atlases of amplitude and occurrence of the diurnal cycle are produced and presented.

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**MARITIME AEROSOL NETWORK AS A COMPONENT OF AERONET – CURRENT STATUS AND RELEVANCE TO REMOTE SENSING**

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The paper reports on the current status of the Maritime Aerosol Network (MAN) which is a component of the Aerosol Robotic Network (AERONET). Over 450 cruises were completed within the framework of MAN. MAN deploys handheld sun photometers and utilizes the calibration procedure and data processing traceable to AERONET. A public domain web-based data archive dedicated to MAN activity can be found at http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html. Building upon the AERONET network of stationary ground-based radiometers, the use of mobile sun-photometers in the MAN project has led to substantially increased coverage over the oceans, and its data archive (2006-2018) provides a basis for evaluation and inter-comparison of aerosol optical depth (AOD) retrievals from various spaceborne sensors.

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**FEASIBILITY OF SIMULTANEOUS RETRIEVALS OF SEA-SURFACE TEMPERATURE AND COLUMN WATER VAPOR FROM MODIS MEASUREMENTS WITH OPTIMAL ESTIMATION**

M. Szczodrak[1] and P. Minnett[1]

The Optimal Estimation (OE) approach has recently been applied by a number of investigators to estimate the sea surface skin temperature ($SST_{skin}$) from satellite radiance measurements. The current SST retrieval algorithm applied to MODIS and VIIRS data is built on the Non-Linear SST (NLSST) algorithm with a set of coefficients derived using collocated measurements of SST from drifting buoys (Match-Up Data Base – MUDB). NLSST produces accurate $SST_{skin}$ retrievals in conditions that are similar to those represented in the MUDB but when conditions deviate from typical, the errors are larger. It has been postulated that algorithms based on the OE technique should be more accurate in such conditions. In most cases by design OE also delivers estimates of the total column water vapor (TCWV) in the atmosphere above the sea surface but these TCWV are often deemed unreliable and ignored.

In fall of 2015, during a research on the R/V Alliance we took radiometric $SST_{skin}$ measurements for validating MODIS and VIIRS $SST_{skin}$ retrievals and simultaneous TCWV measurements in both: standard conditions for this region, and also during a Saharan Air Layer (SAL) outbreak. During a SAL outbreak in the northern tropical Atlantic, a typically moist tropical or sub-tropical maritime atmosphere is replaced by
dry air from the African continent resulting in atypical conditions for the NLSST retrieval.

We use the ship based measurements to test the performance of the NLSST algorithm and the OE approach for the retrieval of both SST and the TCWV under these conditions.

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**AIRS-BASED GLOBAL OCEAN SURFACE TURBULENT HEAT FLUXES**

B. Tian[1]

Ocean surface turbulent heat fluxes are two major components of atmospheric and surface energy budgets. Satellite-based global ocean surface heat fluxes are the best flux data sets available now and have provided an important Earth System Data Record. The main error sources for the existing satellite-based ocean surface turbulent heat fluxes are the accuracy of satellite-derived near-surface air temperature (Ta) and near-surface air specific humidity (Qa). The NASA's temperature and humidity sounding system AIRS/AMSU has provided improved global measurements of Ta and Qa at high spatial and temporal resolutions under almost all sky conditions. Here, we propose to produce, and make publicly available, AIRS-based surface turbulent latent and sensible heat fluxes over the global ice-free oceans with a daily temporal resolution and one-degree spatial resolution for the period from September 2002 to September 2016. This new data set will enrich the existing satellite-based ocean surface turbulent heat flux data sets and help the climate community to better understand air-sea interaction, climate processes and hydrological cycle in an energy balanced way at the A-Train period. This new data set will help the AIRS mission to fully reach its scientific goal: to support climate research and improve weather forecasting.

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**VALIDATION AND ANALYSES OF REMOTE SENSED SURFACE PARTICULATE ORGANIC CARBON IN THE YELLOW-BOHAI SEA OVER 2002-2016**

X. Wang[1], H. Fan[1], H. Zhang[2]

The Yellow-Bohai Sea is a semi-closed marginal sea to the east of China, with large variability in physical and biogeochemical processes. In this study, we evaluate and analyse the surface particulate organic carbon (POC) derived from MODIS-Aqua over the period of 2002-2016. There is a general agreement in the magnitude and variability of surface POC between *in situ* measurement and remote sensed value. Overall, POC concentration is significantly higher in the Bohai Sea (315-588 mg m-3) than in the Yellow Sea (181-492 mg m-3), and higher in the nearshore than in the offshore; the higher levels of POC are mainly due to the enhanced primary productivity, terrestrial inputs and/or sediment resuspension. Mean POC is highest in spring in both the Bohai Sea and Yellow Sea because of enhanced biological productivity. The lowest POC is in winter in the Bohai Sea, but in summer in the Yellow Sea. The former is caused by the reduced biological productivity whereas the latter is associated with the Yellow Sea Cold Water Mass. There is an overall decreasing trend in POC prior to year 2012 but upward trend until the end of 2015, which is almost opposite to the temporal variability of chlorophyll, implying that non-biological processes may be responsible for the temporal variability. Our analyses show that POC in the Bohai Sea is only negatively correlated with the North Pacific Gyre Oscillation (NPGO), whereas POC in the Yellow Sea is positively correlated with Pacific Decadal Oscillation and negatively correlated with the NPGO and El Niño-Southern Oscillation. Our study demonstrates that anthropogenic and nature processes interplay over various time scales thus regulate the spatial and temporal variations of surface POC in the Yellow-Bohai Sea.

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**THE RESPONSE OF THE OCEAN THERMAL SKIN LAYER TO VARIATIONS IN INCIDENT INFRARED RADIATION**

E. W. Wong[1], P. J. Minnett[2]

Observed ocean warming coincides with increasing concentrations of atmospheric greenhouses gases. At the ocean surface, most of the incoming infrared (IR) radiation is absorbed within the top micrometers of the ocean's surface where the thermal skin layer (TSL) exists. Thus, the incident IR radiation does not directly heat the upper few meters of the ocean. We investigated the physical mechanism between the absorption of IR radiation and its effect on heat transfer at the air-sea boundary. The hypothesis is that given the heat lost through the air-sea interface is controlled by the TSL; the TSL adjusts in response to variations in incident IR radiation to maintain a constant surface heat loss. This modulates the flow of heat from below the TSL, and hence controls upper ocean heat content. This hypothesis is tested using the increase in IR radiation ate the sea surface from clouds, and analyzing vertical temperature profiles in the TSL retrieved from accurate, remotely sensed, high spectral resolution measurements of sea-surface emission spectra. We find the surplus energy from the absorption increasing IR radiation adjusts the curvature of the TSL such that there is a smaller vertical gradient at the interface between the TSL and the water beneath. This change reduces the upward conduction of heat into the TSL as the additional energy released into the TSL by the absorption of increased IR radiation supports more of the surface heat loss. Thus, more heat beneath the TSL is retained leading to an increase in upper ocean heat content.

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**RECENT INTRODUCTION EFFORT OF EARTH OBSERVATION AND REMOTE SENSING OCEAN SERVICES IN SUSTAINABLE FISHERIES MANAGEMENT IN BENIN: CHALLENGES AND CAPACITIES BUILDING ISSUES**

K. S. Wongla[1]

Marine coastal are facing Impact of global climate change and Benin is part of area is being influencing by: Warming of the ocean, resulting increased stratification and low biological production, reduced productive ocean space conducive for fish growth, pollution of marine water, and many other Ocean and -Atmosphere Interface modifications.

The lack of a strengthen effort for studying the Ocean-Atmosphere Interface and appropriate capacities building policies limit the effort to adapt resources management policies to face the consequences of environment changes.

To help and build capacities in the eastern Atlantic Ocean region, ECOWAS, African Union and European Union had financed and developed with technical support of University of Ghana acquisition of Earth observation services to support National effort for Security and fisheries management in Gulf of Guinee area and particularly in Benin. This Earth Observation data acquisition unit in Benin aims to

1) analyse Chlorophyll A distribution in the ZEE, and Produce potential fishing zones maps from biological and physical oceanographic parameters to cover the EEZ of ECOWAS coastal states include Benin

2) produce a Benin oceanographic climatology atlas derived from regional oceanographic climatology atlas of the eastern Atlantic Ocean region;

3) produce monthly bulletins on oceanic observations of the eastern Atlantic Ocean for the Benin region

The challenges are to strengthen capacities to acquire, analyse and use for sustainable management and insight policies, upwelling process, plankton and radionuclides distribution.

With the support of the African Union and the European Union, the Benin Fisheries Department holds a station to acquire Earth Observation Services to help monitor environment conditions. Currently, we are working with ocean color, sea surface temperature, photosynthetic available radiation at 551nm, chlorophyll A, turbidity (kd at 490nm).

We need to build capacities to improve our ability to use the oxygen cycle, carbon cycle and radionuclides to better design and manage fisheries for present and future generation.

[1] ECOWAS Coastal & Marine Resources Management Project Benin Unit

**Westward migration and intensification of Lakshadweep low and its impact on the upwelling characteristics of the southern Arabian Sea**

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Lakshadweep low (LL) forms during the end of May at the southeastern Arabian Sea with its core at 8$^o$N/77$^o$E. Previous reports show that the LL propagates westwards from its region of genesis and annihilates at the western margin of southern Arabian Sea. But, analyses of recent data of SSH shows that the LL, first propagates northward with a small westward tilt and forms as a circular low at the location 9$^o$N/72$^o$E. This northward propagation is attributed to the weak poleward surface current existing at the southwest coast of India during the southwest monsoon season. Thereafter it propagates south-westward along 70$^o$E and forms as a circular low in SSH at 6$^o$N/67$^o$E. This is attributed to the equator ward flowing WICC in the region. Then LL propagates westward approximately along 5$^o$N with a small southward tilt. Since its westward propagation in October, LL intensifies throughout its track from October to December. In December it reaches up to 60$^o$N where it weakens in intensity as well as in spatial spread. The intensification is caused due to the cyclonic vorticity generated due to the eastward flowing Wyrkti jet existing in the region during September to December. This fact is also strengthened from the high correlation (-0.6 to -0.875) between the cyclonic vorticity and SSH at the core of LL during September to December. Moreover, with the progress of the season the cyclonic vorticity shows a westward propagation along with the westward shifting of the core of the Wyrkti jet. This intensification of LL as well as the upwelling is inferred from the decrease in SSH and also from the uplift of thermocline depth at the core of LL.

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# PRESENTER GUIDELINES

## Poster presentations

**Poster requirements and recommendations:**

- Poster dimensions up to 4 x 8 feet (120 x 240 cm).
- The presentation must cover the material as cited in the abstract.
- Place the title prominently at the top of the poster board to allow viewers to identify your research.
- Highlight the authors' names and contact information in case the viewer is interested in more information.
- Paragraph and figure captions should be at least in a 24-point font (0.9 cm height) and headers at least in a 36-point font (1.2 cm height).
- Include the background of your research followed by results and conclusions.
- Please do not laminate your poster to ensure that it can be recycled.

**Poster setup and removal:**

- **Check-in:** All poster presenters should set up their posters on **Wednesday, 14 March** between **8:00 - 8:45 A.M.**
- Posters must remain up for the entire day.
- Presenters should be available on Wednesday, 14 March.
- Materials (i.e. pins) are available.
- All posters MUST be removed by 9:00 P.M. on Wednesday, 14 March. Posters remaining after this time will be removed and recycled.

## Oral presentations

- **Check-in:** All speakers are required to submit their oral presentations. This can be done **each day** between **8:00 - 8:45 A.M.** in the main meeting room.
- Oral presentations are scheduled to take 20 minutes, which should include 5 minutes for discussion and changeover to the next speaker.
- Presentations can be reviewed again to be certain the fonts etc. are displayed correctly.
- Be considerate of other speakers and the audience by staying within your allotted time.
- Please discuss the material as reported in your submitted and approved abstract.