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NASA OCEAN SCIENCE AND TECHNOLOGY ACTIVITIES IN 2010-2011

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Working Paper Abstract (corresponding to ca ½ a page)

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1 INTRODUCTION

NASA [acronyms are defined in the Appendix] conducts a program of breakthrough research to advance fundamental knowledge on the most important scientific questions on the global and regional integrated Earth system. The oceans are a major component of the global integrated Earth system, continually interacting with land and the atmosphere. NASA's goal is to understand the changing ocean environment and its interaction with life.

NASA's ocean research program is unique because it encompasses the development of observational techniques and the instrument technologies needed to implement them; laboratory testing and demonstrations from an appropriate set of surface-, aircraft-, and space-based platforms; development and operation of satellite missions and production and dissemination of resulting data products; research to increase basic process knowledge; incorporation of observations and research results into complex computational models that can be used to more fully characterize the present state of the environment and contribute to predictions of future evolution of the global integrated Earth system; and, development of partnerships with other national and international organizations that can use the generated information in environmental forecasting and in policy, business and management decisions.

2 NASA SATELLITE OCEAN MEASUREMENTS

NASA has 15 on-orbit satellite missions: ACRIMSAT, Aqua, Aquarius/SAC-D, Aura, CALIPSO, CloudSat, EO-1, GRACE, Jason-1, Landsat-7, OSTM/Jason-2, QuikSCAT, SORCE, Terra, and TRMM. Many missions involve instruments from international partners: Argentina [Aquarius/SAC-D]; Brazil [Aqua]; Canada [CloudSat, Terra], Finland [Aura], France [CALIPSO, Jason-1, OSTM/Jason-2], Germany [GRACE], Japan [Aqua, Terra, TRMM], Netherlands [Aura]; and United Kingdom [Aura].

NASA current ocean measurement capabilities [with launch date] are:

- Chlorophyll-*a* concentration (Aqua [4 May 2002]; Terra [18 December 1999])
- Clouds (Aqua [4 May 2002]; CALIPSO [28 April 2006]; CloudSat [28 April 2006]; Terra [18 December 1999]; TRMM [27 November 1997])
- Ocean gravity (GRACE [17 March 2002])
- Rainfall (Aqua [4 May 2002]; TRMM [27 November 1997])
- Sea ice (Aqua [4 May 2002]; Terra [18 December 1999])
- Sea surface salinity (Aquarius [10 June 2011])

Sea surface temperature (Aqua [4 May 2002]; Terra [18 December 1999]; TRMM [27 November 1997])

Sea surface topography (Jason-1 [7 December 2001]; OSTM/Jason-2 [20 June 2008])

Sea surface wind speed (Aqua [4 May 2002])

Sea surface wind vector (QuikSCAT [19 June 1999 – 23 November 2009; then for radar backscatter measurements for cross-calibration activities, as described below])

Sea surface radiative fluxes ([Aqua [4 May 2002]; CALIPSO [28 April 2006]; TRMM [27 November 1997])

NASA, in recording approximately 4 terabytes of data every day, maintains the world's largest scientific data and information system for collecting, processing, archiving, and distributing Earth system data to worldwide users. The foundation of NASA's data policy is free and open data distribution with minimum time delay. NASA provides its current and previous data through science-discipline data active archive centers:

PO.DAAC (http://podaac.jpl.nasa.gov) for ocean surface wind vectors, sea surface salinity, sea surface temperature, sea surface topography, and sea surface wind speed data

GES DAAC (http://daac.gsfc.nasa.gov) for chlorophyll-*a* and rainfall data

LaRC DAAC (http://eosweb.larc.nasa.gov) for aerosols, clouds and sea surface radiative flux data

GRACE Tellus (http://grace.jpl.nasa.gov/) for ocean gravity data

ASF (http://www.asf.alaska.edu) and NSIDC (http://www.nsidc.org) for sea ice data

3 NASA OCEAN RESEARCH AND TECHNOLOGY MANAGEMENT

NASA ocean research and technology are organized under an interdisciplinary mix of science, satellite instrument, and satellite mission themes (http://science.nasa.gov/earth-science/oceanography/), such as: Ocean Biology and Biogeochemistry; Carbon Cycle Science; Biodiversity; Physical Oceanography; Ocean Salinity Science Team; Ocean Vector Winds Science Team; Ocean Surface Topography Science Team; IceBridge Research; Modeling, Analysis and Prediction; Weather; Computational Earth System Models and Data; Interdisciplinary Research; Satellite Calibration; Connections for Earth System Science; Earth System Data Records; Uncertainty Analysis; Computational Modeling Algorithms; Gulf of Mexico Decision Making; Information Technology; Instrument Technology; and Component Technology. Funds are distributed through open requests for proposals (http://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={9636473D-602B-F49F-ABDC-5A26F36D08CD}&path=open), which are evaluated through a peer review process; the latter website contains information on cognizant individuals who are responsible for management of NASA ocean science and technology activities.

4 SELECTED OCEAN RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS, 2010-2011

In 2010-2011, all satellite missions continued successful on-orbit operations.

In September 2011, the biennial NASA process for on-orbit mission extension approved 2-year extensions for the production of standard data products from all operating missions that had been operating beyond the primary mission period.

In 2010, about 390 individual science and technology research projects were funded for an approximate cost of US$78 million. Research projects have a typical duration of 3 years. Many research projects continued in 2011, and new ones were added.

On 9 June 2011, NASA launched the Argentine SAC-D satellite with NASA's Aquarius sea surface salinity instrument.

Important time series of global integrated Earth system science parameters have been maintained for decades, e.g., Arctic sea ice extent (http://nsidc.org/data/seaice_index/) and global mean sea level (Figure 1). The latter time series is representative of a successful transition of the research NASA-CNES sea surface topography measurement capability to the operational NOAA-EUMETSAT (with contributions by CNES and NASA) sea surface topography measurement capability.

On 13 July 2010, CNES, EUMETSAT, NASA, and NOAA established a memorandum of understanding for roles and responsibilities of each partner in the development and operation phases of Jason-3, which would continue the high accuracy, well calibrated, high precision, global sea surface topography measurement capability (Figure 1) to study eddy- to basin-scale ocean circulation processes and climate change.

NASA QuikSCAT scatterometer backscatter measurements are contributing to the calibration of ISRO's OSCAT data.

NASA conducted its first ocean expedition, called ICESCAPE-I, in 15 June – 24 July 2010 to explore how changes in Arctic sea ice extent and thickness are altering the biogeochemistry and ecology in the western Arctic Ocean. The interdisciplinary suite of biological, chemical and physical oceanographic measurements revealed that ocean current horizontal advection of nutrient-rich water strongly contributed to the observed increase in primary production, which was observed in NASA satellite data.

NASA conducted ICESCAPE-II on 25 June – 29 July 2011 to observe inter-annual variability in measurements recorded in the same locations as those in ICESCAPE-I; to determine the source of the nutrient-rich water; and to collect optical data to improve satellite instrument algorithms.

NASA responded to the Gulf of Mexico Deepwater Horizon oil spill, which began on 20 April 2010, by compiling satellite observations from its on-orbit missions, both pre- and post-incident, and by conducting airborne campaigns to describe the characteristics and motion of the oil on the sea surface and its impacts on the ocean ecosystem and coastal wetlands (http://www.nasa.gov/topics/earth/features/oilspill/index.html).

After the ICESat satellite ceased operation on 11 October 2009, NASA established the IceBridge airborne mission (http://www.espo.nasa.gov/oib) to mitigate the loss of ICESat data. Aircraft measurements were made over Greenland and the Arctic Ocean in 22 March – 28 May 2010 and 14 March – 20 May 2011 using NASA's B200 and P3 aircrafts. Similar measurements were

made over the Antarctica in 19 October – 22 November 2010 with the DC8 aircraft. The aircraft flew along thousands of kilometers of ICESat tracklines in the Arctic and Antarctic. In the Antarctic, critical data were collected by radar and gravity methods to map sea floor structures underlying floating ice shelves; the structures provide access routes for warmer water to penetrate under the ice. IceBridge is planned to continue with annual measurements during March-May in the Arctic and October-November in the Antarctic until the launch of ICESat-2 in 2016. NASA established a data archive for IceBridge data at NSIDC.

NASA satellite altimeter, chlorophyll-*a*, sea surface wind speed, sea ice, and sea surface temperature data are routinely assimilated into ocean analyses systems, harmful algal bloom forecasts, and numerical weather prediction centers, both in the United States and elsewhere.

On 25 October 2011, NASA plans to launch the NPP satellite mission, which will measure aerosols, chlorophyll-*a*, clouds, sea ice, and sea surface temperature, among other types of measurements.

In 2011, the GPM, ICESat-2 and SWOT satellite missions continue in mission design and development for launch in 2013, 2016 and 2019-2010, respectively. JAXA and NASA are partners in GPM. CNES and NASA are partners in SWOT, which will provide insight into the movement and distribution of Earth surface freshwater and oceans.

NASA continues with plans to develop the PACE mission for ocean color measurements and initiate a GRACE Follow-on mission for launch in 2017.

NASA chairs OOPC since 2009.

NASA will become chair of CEOS SIT in November 2011.

NASA actively participates in numerous international groups that enhance coordination and collaboration of ocean science and technology activities, including CGMS, GEO, and the CEOS virtual constellations for ocean surface vector winds, sea surface temperature, ocean color, and sea surface topography.

APPENDIX: LIST OF ACRONYMS

ACE	Aerosols-Climate-Ecosystems
ACRIMSAT	Activity Cavity Radiometer Irradiance Monitor SATellite
ASF	Alaska Satellite Facility
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group on Meteorological Satellites
CNES	Centre National d'Edtudes Spatiales
DAAC	Distributed Active Archive Center
EO	Earth Observer
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GEO	Group on Earth Observations
GES	GSFC Earth Science
GPM	Global Precipitation Measurement
GRACE	Gravity Recovery and Climate Experiment
GSFC	Goddard Space Flight Center
ICESat	Ice, Cloud and land Elevation Satellite

ICESCAPE	Impacts of Climate on Ecosystems and Chemistry of the Arctic Pacific Environment
ISRO	Indian Space Research Organization
LaRC	Langley Research Center
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NSIDC	National Snow and Ice Data Center
OOPC	Ocean Observations Panel for Climate
OSCAT	Ocean Scatterometer
OSTM	Ocean Surface Topography Mission
PACE	Pre-ACE
PO.DAAC	Physical Oceanography DAAC
QuikSCAT	Quick Scatterometer
SAC	Satelite de Aplicaciones Cientificas
SORCE	Solar Radiation and Climate Experiment
SIT	Strategic Implementation Team
SWOT	Surface Water and Ocean Topography
TRMM	Tropical Rainfall Measuring Mission

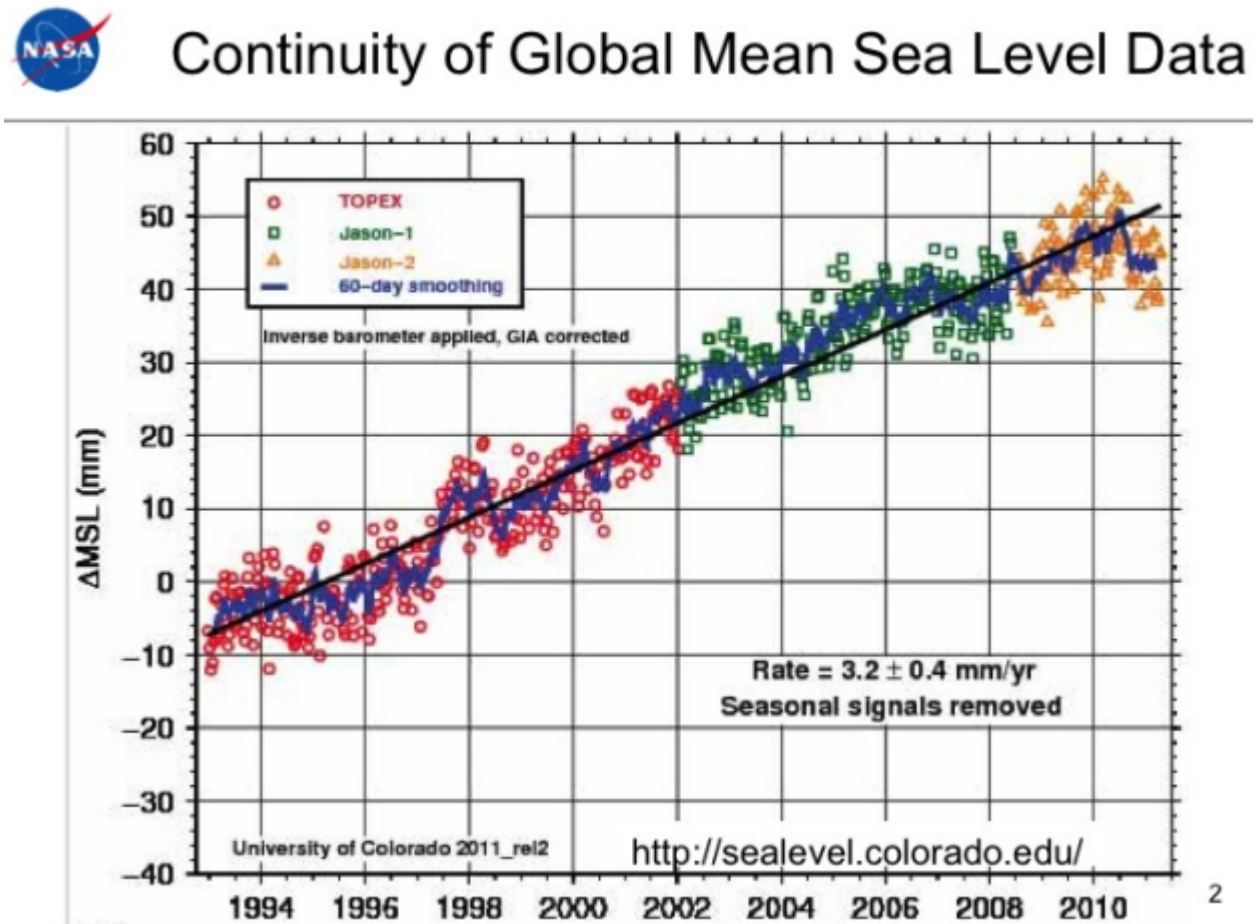

FIGURE 1