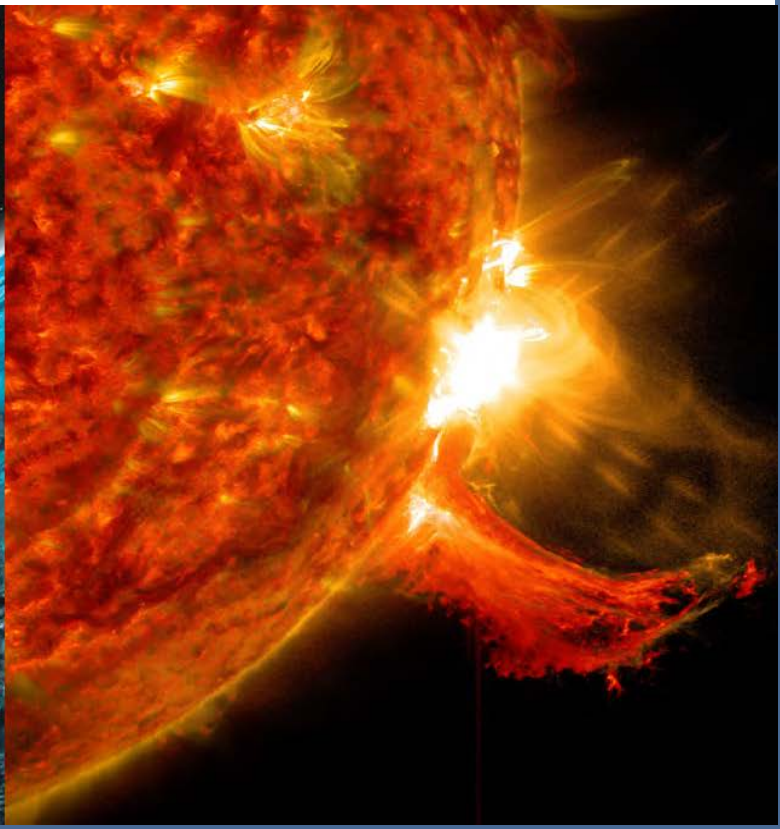
National Operational Processing Centers 2nd Observational Data Workshop

Summary Report



COMMITTEE FOR OPERATIONAL PROCESSING CENTERS (COPC)

WORKING GROUP FOR OBSERVATIONAL DATA (WG/OD)

Cover images

Upper left: Automated Surface Observing System (ASOS) installation, courtesy NOAA. Image aspect ratio has been changed.

Upper right: NOAA Agulhas Return Current (ARC) Buoy Ocean Climate Station on the edge of the warm ARC southeast of South Africa at 38.5 S Latitude, 30 E. Longitude. Image aspect ratio has been changed.

Lower left: Weather satellite, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce..

Lower right: NASA's Solar Dynamics Observatory captured this image of a solar flare on Oct. 2, 2014. The solar flare is the bright flash of light on the right limb of the sun. A burst of solar material erupting out into space can be seen just below it. Image Credit: NASA/SDO

NATIONAL OPERATIONAL PROCESSING CENTERS
2nd OBSERVATIONAL DATA WORKSHOP

Office of the Federal Coordinator for
Meteorological Services and Supporting Research

1325 East-West Highway (SSMC 2), Suite 7130
Silver Spring, MD 20910

www.ofcm.gov

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Foreword

Since the first Operational Data Workshop in 2012, the quantity, quality and variety of formats of observational data has increased significantly. The agencies of the Federal Weather Enterprise strive to ensure that these data are optimally collected, presented, and processed in order to produce timely and relevant analyses and forecasts. To further these efforts, we conducted the second Operational Data Workshop for three days in May 2018. At this gathering, representatives from the nation's operational processing centers and affiliated federal agencies met to discuss their environmental data management roles, responsibilities, capabilities and challenges.

The high-level discussions at this workshop included discussions of significant observational data challenges, including data latency, observational gaps, and changes to data formatting requirements. Participants reached consensus on a number of issues, which will be assembled and addressed as follow-up actions for the Working Group for Observational Data (WG/OD).

I extend my thanks to the members of the WG/OD for planning and conducting this successful and needed event. I believe that I echo the statements of their parent organizations, the Interdepartmental Committee for Meteorological Services and Supporting Research as well as the Committee for Operational Processing Centers when I express our gratitude and appreciation for a job well done. Additionally, the staff of the Office of the Federal Coordinator for Meteorology and the National Weather Service's National Centers for Environmental Prediction, Offices of International Affairs, Observations and Dissemination, provided outstanding logistical and content support. We look forward to continued efforts in ensuring quality data availability for the best possible analyses and forecast products for the nation.

William Schulz
Federal Coordinator for Meteorological Services
and Supporting Research

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Key Takeaways from the Workshop

- Close collaboration must be maintained between U.S. interagency partners and the NWS offices of International Affairs, Observations, Dissemination, as well as NCEP/NCO and the FAA, to best implement new WMO and ICAO meteorological data management standards as they evolve (e.g., WIGOS for the WMO and IWXXM for ICAO).
- To ensure all interagency partners stay abreast of emerging issues and recent developments, observational data workshops like this one should be held more frequently, perhaps annually.
- Continue drafting the Federal Meteorological Data Management Practices document to assist U.S. meteorological data managers in the transition to WIGOS. This transition will impose a significant coding workload on the U.S. OPCs. Even if needed funding and staff resources are provided, development of new codes at the OPCs to replace outdated software for processing observational data will require a period of several years.
- AF/A3W is now the formal focal point for all Air Force interagency coordination. Any requests for Air Force interagency meeting participation or interagency agreements including the Air Force must go through the AF/A3W front office.
- For the implementation of WIGOS ID's, there needs to be a way of identifying observation platform type (e.g., different types of ocean observing platforms). Issues include whether new platforms can be required to use the existing JCOMM station identifier convention in the WIGOS ID.
- The cost-sharing business model used by private companies does not always allow the federal agencies to share these data with other government agencies or the international partners without contract modification or additional charges. This causes conflicts with the principle of free and open exchange of meteorological data critical to weather and climate prediction.
- Incomplete, inconsistent, or incorrect data documentation (e.g., erroneous metadata) impairs data usage and archiving. A centralized knowledge bank of improved, standardized observing station metadata is essential to efficient data usage and data sharing. OSCAR/Surface is intended to be the WIGOS implementation of such a knowledge bank. However, in its current form, OSCAR/Surface is incomplete, lacks transparency, and does not have clear procedures for correction and updating. Resolving all of these issues will be critical to successful WIGOS implementation.
- Challenges for OPCs include planning for future satellite launches and requirements and transitioning unplanned data sources into operations (e.g., data from new research satellites and sensors).
- Interagency partners need to identify and implement security measures that don't cause unacceptable data latency or unacceptable cost. Current security measures are resource intensive and time consuming.
- Security vetting for skilled workers who are foreign-born or not citizens is increasingly challenging. A related problem is the lack of career development paths in specialized fields. Replacing highly educated, experienced personnel is a continuing challenge for all of the OPCs. Overall, there is a need for incentives for recruiting and retention of skilled professionals to work with observational data.

- Compared to conventional and satellite observing systems for Earth meteorology, the space weather observing infrastructure is tenuous. Space weather observing networks are sparsely populated and critical satellite assets lack robust back-up and replacement support.

Workshop Organizers and Participating Agencies

Organizers

Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR)
Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM)
Committee for Operational Processing Centers (COPC)
Working Group for Observational Data (WG/OD)

Dates: 22-24 May 2018

LOCATION:

Days 1 and 2: Office of the Federal Coordinator for Meteorological Services and Supporting Research, 1325 East-West Highway (SSMC 2), 7th Floor Conference Room number 7224, Silver Spring, MD 20910

Day 3: NOAA Center for Weather and Climate Prediction, College Park, MD

Participating Agencies

Air Force (AF)

- Headquarters AF/A3W, Pentagon, Washington, DC
- 557th Weather Wing, Offutt AFB, NE
    - 2d Systems Operations Squadron, Offutt AFB, NE
    - 2d Weather Squadron, Offutt AFB, NE
    - 14th Weather Squadron, Asheville, NC

Navy

- Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, CA
- Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, MS
- Naval Research Laboratory (NRL)-Marine Meteorology Division, Monterey CA

National Oceanic and Atmospheric Administration (NOAA)

- National Environmental Satellite, Data, and Information Service (NESDIS)
    - Office of Satellite and Product Operations (NESDIS/OSPO), Suitland, MD
    - National Centers for Environmental Information (NCEI)
        - Center for Weather and Climate
- National Weather Service (NWS), Silver Spring, MD
    - National Centers for Environmental Prediction (NCEP), College Park, MD

        - Environmental Modeling Center (EMC)
        - NCEP Central Operations (NCO)
        - Space Weather Prediction Center
    - Office of International Affairs
    - Office of Observations
        - Surface and Upper Air Division
        - National Data Buoy Center (NDBC)
    - Analyze, Forecast, and Support Office, Forecast Services Division, Aviation and Space Weather Services Branch
    - Office of Dissemination
- NOAA/Office of Oceanic and Atmospheric Research

Joint Center for Satellite Data Assimilation (JCSDA) Headquarters, College Park, MD

U.S. Integrated Ocean Observing System (IOOS)

Federal Aviation Administration (FAA)

National Science Foundation (NSF)

Workshop Synopsis

Overview

OFCM hosted the 2nd Operational Data Workshop (ODW). The workshop addressed a comprehensive range of federal and global meteorological data management topics including the acquisition (collection), processing, exchange, and management of observational data and metadata among the federal agencies, the national Operational Processing Centers (OPCs), and intergovernmental organizations such as the World Meteorological Organization (WMO) and the International Civil Aviation Organization (ICAO). The scope of such data and metadata extends across the satellite, conventional, ocean, and space weather data sectors.

During the workshop, representatives of the OPCs, Federal agency offices and entities, and others presented briefings detailing their respective agency's unique data management operations, roles and responsibilities, capabilities, and unique challenges in meteorological data management.

Objectives

The ODW presentations were structured to address the following workshop objectives:

- Clarify meteorological data management roles and responsibilities following recent organizational restructures, including those at NOAA/NWS and the AF
- Review U.S. implementation of new WMO data management standards and procedures: WMO Integrated Global Observing System (WIGOS), OSCAR (WMO's observing station metadata tool), and the WMO Information System (WIS)
- Discuss interagency meteorological data management issues and explore methods to resolve them
- Identify data gaps and discuss plans and methods to improve coverage
- Identify future meteorological data systems, sources, and evolving changes to existing data to be better able to transition to new capabilities and communicate internationally

Organizing Committee

Workshop Facilitators: Mr. Anthony Ramirez, Executive Secretary, WG/OD, and Mr. Kenneth Barnett, Executive Secretary, COPC.

Rapporteur: Mr. Floyd Hauth, OFCM/Science and Technology Corporation.

Session Moderators: Mr. William Bolhofer, NWS/Office of International Affairs, Mr. Jeffrey Ator, NWS/NCEP, Mr. Danny Illich, NAVOCEANO, Mr. Vincent Tabor, NESDIS, Mr. James Vermeulen, FNMOC.

Presentations

There were a total of 30 presentations delivered during the six sessions of the workshop. Summaries of each presentation and the key points raised during the ensuing discussions (session takeaways) are provided in the session-specific sections of this report as list in the table below.

Presentation	Agency/Presenter
1	OFCM-Federal Coordinator's Update / Dr. William Schulz
2	OFCM-Draft WG/OD Terms of Reference / Mr. Anthony Ramirez
Session 1	**International/WMO, U.S./Federal**
3	NWS/Office of International Affairs / Mr. William Bolhofer
4	NWS/Office of Observations / Dr. Kevin Schrab
5	NWS/Office of Dissemination / Dr. Andrea Hardy
6	NWS/NCEP/Environmental Modeling Center / Mr. Jeffrey Ator
7	NWS/NCEP/Central Operations / Ms. Rebecca Cosgrove
8	U.S Federal Meteorological Data Management Practices Guide / Dr. Robert Katt
Session 2	**Operational Processing Center Updates**
9	NESDIS / Mr. Vincent Tabor
10	NESDIS/NCEI / Mr. Matthew Menne
11	FNMOC / Dr. Justin Reeves, Mr. James Vermeulen
12	NAVOCEANO / Mr. Danny Illich, Mr. Bruce McKenzie
13	Headquarters AF/A3W / Lt Col Robert Branham
Session 3	**Conventional Data**
14	NWS/Office of Observations/Surface and Upper Air Division / Mr. Mark Miller
15	FAA/NWS Aviation Weather Data and IWXXM / Mr. Pat Murphy
16	NWS /Aviation and Space Weather Services Branch / Mr. Mark Zettlemoyer
17	NWS/NCEP/EMC / Mr. Jeffrey Ator

Presentation	Agency/Presenter
18	FNMOC/NRL / Dr. Justin Reeves and Dr. Patricia Pauley
19	AF/557th Weather Wing / Mr. Doug Wilkerson
Session 4	**Ocean Data**
20	NWS/Office of Observations/NDBC / Mr. Kevin Kern
21	IOOS / Ms. Kathleen Bailey
22	NAVOCEANO / Mr. Danny Illich
23	Marine Data Concerns / Dr. Bradley Ballish
Session 5	**Space Weather Data**
24	NCEP/Space Weather Prediction Center / Mr. Rodney Viereck
25	AF/2d Weather Squadron/ Lt Col Justin Erwin
Session 6	**Satellite Data**
26	NESDIS/ Mr. Vincent Tabor
27	JCSDA / Dr. James Yoe
28	FNMOC / Mr. James Vermeulen
29	AF/557th Weather Wing / Mr. Mark Surmeier
30	NAVOCEANO / Mr. Bruce McKenzie

Additional Participants

- NWS/Office of International Affairs: Ms. Courtney Draggon, Mr. Daniel Muller
- NWS/Office of Observations Ms. Alix Rolph
- NWS/Office of Dissemination: Ms. Kari Sheets
- NWS/NCEP: Mr. Walter Smith, Mr. Richard Robinson, Ms. Cynthia Jones, Ms. Julie Hayes, Mr. Christopher Hill
- AF/557th Weather Wing: Mr. Theodore Vroman,
- AF/14th Weather Squadron: Mr. Randy Haeberle, Mr. George Moody
- National Science Foundation: Ms. Alexandra Isern

Opening Presentations and Remarks

Opening Remarks: Mr. Anthony Ramirez opened the meeting by welcoming the participants, providing administrative information and reviewing the agenda.

Federal Coordinator's Update: Dr. William Schulz, Federal Coordinator for Meteorological Services and Supporting Research, presented an update on OFCM activities. The update included an overview of the Weather Enterprise Infrastructure, recent Federal Committee for Meteorological Services and Supporting Research (FCMSSR) and ICMSSR meeting outcomes and subsequent Federal coordination activities, implementation of the *2017 Weather Act* (Public Law 115-25, Title IV-Federal Weather Coordination, Section 402), the *FY 2019 Federal Weather Enterprise Budget and Coordination Report*, and FCMSSR approval of the *FY 2018–2022 Strategic Plan for Federal Weather Coordination*.

Terms of Reference (ToR): Mr. Ramirez summarized proposed changes to the working group ToR to explicitly include WMO and ICAO interactions, updates to working group membership, added procedures to include data and metadata management, and oversight and management of the *U.S. Federal Meteorological Data Management Practices* guide (under development). He requested member concurrence with these changes, so that the revised ToR can be sent to the ICMSSR for approval.

Session 1: International, WMO, and U.S./Federal Context

Session Facilitator: **Mr. William Bolhofer**, NWS Office of International Affairs.

1. NWS Office of International Affairs

Mr. William Bolhofer presented an overview of international meteorological data management activities and roles, including information on the roles and responsibilities of the NWS Office of International Affairs. He explained the background and structure of the WMO, including the activities and functions of the WMO Congress, Executive Council, regional associations, and technical commissions.

The United States is part of WMO Region IV, and the NWS interacts with many of the WMO technical commissions and related programs. Mr. Bolhofer covered key issues for the United States, including implementation of WIGOS. He also described ICAO's mission, standards, and recommended practices.

He closed by providing a summary of his office's activities, key contacts, and focal points and a list of WG/OD members representing the United States on WMO teams.

Workshop participants noted OFCM's role in obtaining interagency consensus on issues requiring U.S. positions in meetings of the various WMO councils, commissions, or other deliberating groups. They also requested routine feedback to the WG/OD following WMO Executive Council and other key WMO meetings on the actions taken by the WMO that impact operations or data practices in the United States.

2. NWS Office of Observations

Dr. Kevin Schrab provided detailed information about the NWS organizational structure, the position of the Office of Observations in that structure, its portfolio organization and management, his role as the U.S. focal point for WIGOS. He also provided an update on recent WIGOS developments.

The Office of Observations is responsible for the collection of space, atmosphere, water, and climate observational data owned or leveraged by the NWS to support the mission of providing weather, water, and climate data forecasts for the protection of life and property and for the enhancement of the U.S. economy.

Dr. Schrab summarized the portfolio activities of the Front Office, the Radar Operations Center, the NDBC, and the Surface/Upper Air Division. Each of these includes programs to upgrade or replace their supporting observing systems. He also covered investments in the satellite observation systems.

Two cross–Line Office boards provide guidelines and input into the portfolio management process. These are the NOAA Observing Systems Council (NOSC), which is the principal advisory body to the NOAA Administrator, and the Observing Systems Committee, which is a subcommittee of NOSC. He explained the process of collecting and analyzing user and system requirements.

Dr. Schrab closed by summarizing the WIGOS Information Resource (OSCAR) requirements and applications of OSCAR, as well as the WIGOS Data Quality Monitoring System (WDQMS), which is under development.

He asked that issues related to WIGOS discovered by WG/OD members be addressed to his office for action/resolution.

3. NWS Office of Dissemination

Dr. Andrea Hardy and Ms. Kari Sheets presented the structure of this office, along with its roles and responsibilities and the key points of contact (POCs) for interagency collaboration. They noted that they are the U.S. Focal Point for the WMO Information System/Data Access and Retrieval (WIS/DAR) and described global and regional Global Telecommunication System (GTS) data dissemination paths to and from U.S entities. Their portfolio includes networks, the dissemination infrastructure, and the NWS weather information dissemination systems.

The WMO and U.S. interagency POCs within the Office of Dissemination are Ms. Kari Sheets and Ms. Nancy Helderman.

The Region IV core partners with the United States are located in Tokyo, Melbourne, Exeter (UK), Pretoria, Brasilia, and Canada. Germany is planning to become a core partner in June 2018. The core partners have “direct connections” but not a dedicated network; they exchange data directly by running similar software. If a partner wants a U.S. dissemination product, it contacts the NCEP Central Operations Data Manager[1] to request that the product be added to that partner’s direct GTS line.

There are two ways to exchange data. Most data are exchanged using sockets—a constant open connection “pipe”—to push data to the recipients. The other method is to use FTP (file transfer protocol), in which a partner must log in to the data provider’s FTP website and “pull” (select for download) the datasets that the partner wants to receive.

4. NWS National Centers for Environmental Prediction (NCEP)

NCEP and the EMC: Mr. Jeffrey Ator, NCEP/EMC presented a briefing on NWS/NCEP and the EMC. He summarized the mission and structure of NCEP and the EMC, and then described the EMC’s observational data processing activities, including engagement with international groups.

The mission of NCEP is to deliver national and global operational weather, water, and climate products and services essential to protecting life, property, and economic well-being. The EMC is responsible for model development and for implementation and applications for global and regional weather, climate, oceans, and space weather. NCEP/NCO is responsible for super computer, workstation, and network operations.

[1] The NCEP Central Operations Office role was described further in the presentation by Ms. Rebecca Cosgrove, summarized below.

Mr. Ator provided an overview of individual EMC modeling systems and the NGGPS FV3-based Unified Modeling System. The EMC reorganization in May 2017 was designed to more effectively manage model development and operations for the new Unified Modeling Framework.

The EMC's observations processing engagement with international groups currently includes the WMO Interprogramme Expert Team on Codes Maintenance (IPET-CM), the WMO Expert Team on Aircraft-Based Observations (ET-ABO), the WMO Task Team on WIGOS Data Quality Monitoring System (TT-WDQMS), and the Global Data Exchange (GODEX-NWP).

The WDQMS is one of the components envisioned for WIGOS. It includes the new schema for station identifiers for all types of reporting platforms under WMO's purview and the OSCAR/Surface (Observing Systems Capability Analysis and Review Tool) repository for site metadata, replacing the old publication, WMO No.-9, Vol A, for surface-based sites.

NCEP/NCO: Ms. Rebecca Cosgrove presented an update on NCEP/NCO. The NCO mission is to run the NWS networks, procure and operate the NWS supercomputers and the NCEP production suite, and develop and maintain software. It also conducts continuous (24/7) operational monitoring and support and procures and operates the Integrated Dissemination Program (IDP) computer system.

The NWS Telecommunications Gateway does the primary ingest and dissemination of data for the NWS and operates the GTS and other supported telecommunications. It also provides monitoring support for Automated Surface Observing System (ASOS) sites and NEXRAD radar sites.

Ms. Cosgrove closed by providing NCO points of contact for dataflow and data management teams.

5. WIGOS IDs AND THE U.S. Federal Meteorological Data Management Practices guide

Dr. Robert Katt, OFCM Technical Writer, presented an overview of the preliminary work being undertaken by the WG/OD to prepare for the U.S. transition to new WIGOS station identifiers. He described the draft document being prepared by the WG/OD to provide information on federal meteorological data management practices in general and particularly the new guidelines being developed for the new U.S. WIGOS identifiers.

WG/OD members noted that these guidelines are preliminary and pointed out several areas that need to be expanded or clarified. When the first draft is completed, the ICMSSR will be informed about this document; its assistance will be requested to coordinate the document with ICMSSR members' respective agencies for further comment and recommendations. The consensus was to continue to draft the guidance document.

Session 1 Takeaways

- The WMO is transitioning to a new station identifier format (WIGOS Station Identifiers) for use in GTS data communication.
- U.S. interagency guidance is being developed by the WG/OD to assist U.S.

meteorological data managers in this transition.

- This transition will impose a significant coding workload on the U.S. OPCs.
- It is important for OPCs to preserve legacy naming patterns where possible in the fourth (Local Identifier) segment of WIGOS IDs.
- Close collaboration must be maintained between U.S. interagency partners and the NWS offices of International Affairs, Observations, Dissemination, as well as NCEP/NCO and the FAA:
    - To best implement new WMO and ICAO meteorological data management standards as they evolve.
    - To receive feedback from WMO Executive Council sessions on key issues that impact operations or data practices in the U.S.
    - To ensure all interagency partners stay abreast of emerging issues and recent developments, observational data workshops like this one should be held more frequently, perhaps annually.
- Because the NWS Office of Observations is the U.S. Focal Point for WIGOS, unresolved WIGOS issues should be sent there for resolution.
    - It is important to finalize the position of U.S. Focal Point for OSCAR/Surface and clarify the roles and responsibilities of this position.

Session 2: Operational Processing Centers

1. National Centers for Environmental Prediction

The NCEP update was presented in Session 1.

2. National Environmental Satellite and Data Information Service

Mr. Vince Tabor provided information about the NESDIS mission, vision, and organization. He also described the organization, recent accomplishments, and future plans of NESDIS/OSPO, as well as distribution mechanisms, satellite products and services, and future satellite missions and events.

The NESDIS mission is to provide secure and timely access to global environmental data and information from satellites and other sources, in order to promote and protect the Nation's security, environment, economy, and quality of life. OSPO performs command and control of U.S. operational weather satellites, operates ground-based receptor sites for command and control and for data acquisition/re-transmission, produces products derived from satellite observations, and distributes the data and products to authorized users in near real-time or for archive use by the scientific community.

In the past 2 years, NOAA in conjunction with its partners launched three new weather satellites (GOES-16, NOAA-20, and GOES-17), which provide greater environmental monitoring capabilities for users. These satellites provide higher spectral, spatial, and temporal resolution and significant data volume increases.

Mr. Tabor summarized the GOES-16 post-launch product validation schedule and the science product validation status.

Over the upcoming 6-12 months, NOAA-20 (JPSS-1) will become the primary satellite in the afternoon (PM) orbit, GOES-17 will be taking over West operations from GOES-15, and MetOp-C will be launching in September 2018 and taking over the morning (AM) orbit. He also provided future plans for enterprise systems, cloud services, and commercial partnerships. He closed with updates on the Search And Rescue Satellite Aided Tracking system, the National Ice Center, and a listing of future missions and events.

3. National Center for Environmental Information

Mr. Matthew Menne summarized the organizational chart for NCEI and noted that there are approximately 250 data input streams archived according to specifications outlined in submission agreements (known as “Common Ingest’). NCEI archives all NOAA data including forecast models and provides official information for courts.

Conventional data streams that get further processing increasingly fall into several big, integrated data pots:

- Integrated Global Radiosonde Archive (IGRA; Radiosonde).
- Global Historical Climatology Network (GHCN; Land Station Data).
- International Comprehensive Ocean-Atmosphere Data Set (ICOADS; Marine Surface).

Further processing is where WIGOS becomes important to NCEI.

Mr. Menne described the various types of observation stations, their data, and their archives. Digital archives have datasets covering three different time resolutions for land stations and were developed and have evolved independently (and are among the most popular of all NCEI products).

NCEI's Station History Database/Web Service is located on the NCDC website.

4. Fleet Numerical Meteorology and Oceanography Center

Dr. Justin Reeves's presentation covered the Command Overview and Operational/Warfighter Focus; Global Deterministic and Ensemble/Long-range Atmospheric Models; Regional Coupled Modeling; Global, Regional, and Tactical scale Ocean Modeling; Specialized Ocean Modeling; Wave-Watch Modeling; Tropical Forecasting; and GBS/Product Push.

FNMOC supports naval and other military operations with a range of modeling and forecast products (for example, ocean acoustic forecasting, aircraft routing OPARS, electro-optical forecasts, operational climatology, tropical cyclone forecasts, and seven others) produced by a diverse team of highly educated, technically proficient, and warfighting-experienced sailors, civilians, and contractors. One of the upcoming challenges is replacing the 40% who will be eligible to retire within 5 years.

Dr. Reeves described each of the modeling and forecasting activities in the N5 Department and the inventory of models available for operational support of naval missions over land, ocean, and ice; under water; and in the air. He noted the current and future capabilities of global, regional, and a range of specialized models that provide the resolution and accuracy required for mission success. Examples included coastal/near-shore wave forecasting, tidal currents models, and ocean drift forecasting.

He closed by summarizing storm surge forecasting, tactical oceanographic assessment, and GBS product delivery. GBS is a passive-push data subscription service that is most useful in the comms-limited environment on ships.

5. Naval Oceanographic Office

Mr. Bruce McKenzie presented an update on NAVOCEANO, highlighting its history and milestones. The NAVOCEANO mission is to optimize sea power by applying relevant oceanographic knowledge in support of U.S. national security. NAVOCEANO's vision is to ensure the Navy's oceanographic knowledge superiority and reduce risk by providing the forecast battlespace through smart collection (antisubmarine warfare, mine warfare, naval special warfare, and expeditionary warfare needs), focused analysis (direct support), and responsive delivery (decreased turnaround time).

He noted that naval oceanography includes oceanography, bathymetry, hydrography, meteorology, surveillance and acoustics, geophysics, astrometry, and precise time. These specialties are supported by ocean engineering, operational supercomputing, and operations research. Seventy-four percent of the NAVOCEANO workforce falls in scientific and technical areas.

Core disciplines at NAVOCEANO include ocean science and application areas. All their data are geospatial. The warfare areas each receive uniquely tailored products that use this information to apply to that area's specific mission.

NAVOCEANO uses several different assets, platforms, and vehicles to collect data. The most important capital assets are their ships, but there are numerous other ways NAVOCEANO collects data, such as airplanes that use light detection and ranging (LIDAR) to map coastal areas and shallow water, unmanned underwater vehicles, and satellite imagery.

He provided information about the TAG-S oceanographic survey ships, hydrographic survey launches, ocean gliders, and the Airborne Coastal Surveys Program Coastal Zone Mapping and Imaging Lidar (CZMIL).

NAVOCEANO is in the data management business and stores very large amounts of data; much of the data it collects is used for numerical modeling of the oceans. The large numerical models are run at the Navy Department of Defense (DoD) Supercomputing Resource Center (Navy DSRC). Through an agreement with the DoD High Performance Computing Modernization Program, the Commander, Naval Meteorology and Oceanography Command (CNMOC) reserves up to 15% of the Navy DSRC's computing capacity to use for operations. The remaining 85% is used by Army, Navy, Air Force, and defense agency high performance computing research and development (R&D) users.

Effective Theater Security Cooperation activities are a form of extended deterrence, creating security and removing conditions for conflict through the broad cooperation of partner nations. NAVOCEANO strengthens existing relationships and establishes regional partnerships necessary to provide collective security across a region.

Information was also provided about the Fleet Survey Teams (FSTs), which are specialized teams of military and civilian experts providing hydrographic and oceanographic knowledge of the littoral environment to support safety of navigation.

Because of these unique capabilities, FSTs have deployed to areas of combat such as the Middle East to perform near-shore surveys that collect data to aid in the safe navigation of U.S. forces and supplies traversing the area. FST members have also played significant roles in charting areas affected by natural disasters.

6. U.S. Air Force and the 557th Weather Wing

Lt Col Robert Branham presented an overview of Air Force Weather (AFW) roles and responsibilities, which have significantly changed since the recent restructure. He described the AFW mission, Headquarters Air Force/A3W interagency footprint, 557th Weather Wing roles and responsibilities, and desired OFCM coordination procedures with AFW.

He explained that the AFW mission is to support global power, global reach, air operations, agile combat, Army operations, global vigilance, special operations, and space weather. This is done through data collection in non-permissive environments, use of cyber compliant tools, and global numerical weather modeling. Focus areas include environmental effects data for military operations and automated observing.

Following restructuring, A3W functions include all of the following:

- AFW focal point for Headquarter AF and Major AF Command compliance standards (Standards and Evaluation)
- AFW scientific services/weather training
- Plan, program, and field new AF weather systems
- Focal point for AF/Army weather requirements
- Test and sustain fielded weather systems
- Interagency coordination
- Weather system certification and accreditation
- Weather system information technology (IT) architecture and design
- Coordinate IT requirements with external agencies
- Manage AFW contracting activities
- Plan environmental support for the AF weather functional area
- Lead weather integration with the intelligence community (IC)
- Exploit weather support opportunities by capturing emerging requirements and translate them into future capabilities
- Direct link between IC partners and 2d Weather Squadron intelligence flights
- Oversee integration of weather technology into C4I (command, control, communications, computing, and intelligence) and modeling systems
- Prepare answers for congressional inquiries (SBEM, NDAA, weather-related bills)
- Support the Assistant Secretary of the Air Force, Installations, Environment and Energy (SAF/IE)
- Collaborate on environmental support issues with federal and nongovernmental stakeholders

The A3W Interagency footprint is extensive and includes activities coordinated with other Federal agencies, including the State Department, Global Water Strategy, Office of Science and Technology Policy, FAA, NWS, and NESDIS.

The bottom line is that AF/A3W is the gatekeeper for all AFW interagency coordination, and the 557th Weather Wing now exclusively concentrates on the AFW operational mission. Therefore, any requests for participation in meetings, working groups, etc., or for coordination of agreements must go first to the AF/A3W front office (email to <usaf.pentagon.af-a3.mbx.a3w-weather-workflow@mail.mil>). In turn, AF/A3W will request participation support from the 557th Weather Wing through appropriate Air Combat Command channels.

Lt Col Branham closed by summarizing key environmental data exchanges between the 557th Weather Wing and other OPCs.

Workshop participants discussed the importance of aircraft data and ways that more could be obtained and shared. They also determined that there is no pressing need to update the OPCs' consolidated observational data inventory that was created following the first ODW. Participants also determined that there is a process to determine what information is available from the NESDIS Production Distribution and Access (PDA) system.

7. Joint Center for Satellite Data Acquisition (JCSDA)

For the JCSDA presentation, see Session 6.

Session 2 Takeaways

- Over the next 6-12 months, the following major changes will be implemented in the Earth observing satellite architecture. NOAA-20 (JPSS-1) will become the primary satellite in the afternoon (PM) polar orbit, GOES-17 will be taking over West operations from GOES-15 (in geosynchronous orbit), and MetOp-C will be launching in September 2018 and taking over the morning (AM) polar orbit.
- Much of the large amounts of data collected and stored by NAVOCEANO is used for numerical modeling of the oceans. The large numerical models are run at the Navy DSRC, and CNMOC reserves up to 15% of Navy DSRC's computing capacity for naval operations. The remaining 85% is available for the other military services and defense agencies.
- Following the AF restructuring, AF/A3W is the formal focal point for all interagency coordination. Any requests for participation in meetings, working groups, etc., or for coordination of agreements must go first through the AF/A3W front office (email to <usaf.pentagon.af-a3.mbx.a3w-weather-workflow@mail.mil>). If support or participation from the 557th Weather Wing is being sought, AF/A3W will request that support through appropriate Air Combat Command channels.
- Replacing highly educated, experienced personnel is a continuing challenge for all of the OPCs.

Session 3: Conventional Data

Session Facilitator: **Mr. Jeffrey Ator**, NWS/NCEP/Environmental Modeling Center.

1. NWS/Office of Observations/Surface and Upper Air Division

Mr. Mark Miller presented an update on the Office of Observations organization, programs and data buys, and current initiatives on the Automated Surface Observing System (ASOS), upper air observations, and aircraft-based observations (ABO).

The Office of Observations portfolio includes the Radar Operations Center, NDBC, and the Surface/Upper Air Division.

The division's mission is to execute and manage the development, operations, and maintenance of national surface and upper air systems and leverage observational data to support the NWS mission to protect life and property. This is done by managing the end-to-end life cycle of current and future surface and upper air observational systems or platforms.

Observation programs include ASOS, radiosondes (U.S. and Caribbean network), the Cooperative Observer Program, Voluntary Observing Ship (VOS) Program, and Meteorological Assimilation Data Ingest System (MADIS).

Data buys/leverage include the Mesonet; Aircraft-Based Observations (ABOs); lightning detection networks; GPS-Met; Marine Reporting Stations; the Community Collaborative Rain, Hail & Snow Network (CoCoRaHS), and many others that are leveraged at no cost.

Current initiatives and updates are the ASOS Service Life Extension Program, Radiosonde Frequency Migration Project, ABO, and the Caribbean Hurricane Upper Air System.

NCEP/EMC has acted as a WMO Lead Centre for ABO monitoring for years. ABOs are the most abundant form of conventional meteorological data with approximately 850,000 Aircraft Meteorological Data Relay (AMDAR) reports now received daily—a threefold increase since 2013.

Future activities include refreshing new/updated/upgraded sensing on existing platforms and infrastructure.

No new deployments are on the horizon for sensing and infrastructure on a national level (e.g., a LIDAR network). An increase in data leveraging will be used to fill data gaps as new technologies come to fruition.

After nearly 2 years of field-testing weather balloon autolaunch technology in Kodiak, Alaska, NWS has initiated a demonstration of autolaunchers in Alaska, with two of the state's 13 upper-air sites already using them. The technology will be installed across Alaska's remaining 10 balloon launch sites over the next 2 years. The Alaska autolaunch demonstration is part of a broader agency initiative to move the signal used to transmit weather balloon data out of the radio frequency now used by NOAA's new GOES satellites. Proceeds from the sale of government radio spectrum are funding new ground station equipment at all 92 weather balloon sites across the United States, and autolaunchers can be used at roughly 25 percent of them, to ready the upper-air program for the frequency migration. NWS is evaluating potential locations outside Alaska to receive the remaining balloon autolaunch systems.

Workshop participants discussed their concerns about the increased use of weather data from private sources. They noted that the cost-sharing business model used by private companies does not always allow for sharing of their data with other government agencies or the international partners without contract modification or additional charges. The United States and its international partners typically share weather data openly, a policy that enables NOAA and international weather agencies to run forecasting models with the best available data possible. While citing a need to comply with WMO Resolution 40—which calls for free and open exchange of meteorological data critical to weather and climate prediction and to which the United States is a party—NOAA officials acknowledged that there are some difficulties in reconciling this data-sharing principle with the restrictions inherent in the use and redistribution of privately owned weather data. This is a concern not only for international partners but also for U.S. DoD OPCs. In addition, weather forecasts are a public good, and NOAA officials have underscored the importance of ensuring the validity, reliability, and security of the data ingested into NOAA's weather forecasting models.

2. FAA/NWS Aviation Weather Data and the ICAO Meteorological Information Exchange Model (IWXXM)

Mr. Pat Murphy (FAA) presented information on IWXXM status, issues, and global and U.S. implementation. IWXXM is the ICAO-sponsored format for exchanging weather information using extended markup language (XML). The IWXXM's markup language defines a set of rules for encoding weather information documents intended for exchange among ICAO participants.

IWXXM version 2.1 was implemented in April 2017; IWXXM version 3.0 will be implemented in March 2019. Products include TAF, METAR & SPECI, SIGMET, AIRMET, Volcanic Ash Advisory, Tropical Cyclone Advisory, Space Weather, and SIGWX. In the future IWXXM will be data-centric rather than product-centric.

ICAO Annex 3, November 2020, Amendment 78 will make the international exchange of IWXXM products a "mandatory" practice after November 2020 for ICAO participants.

Why IWXXM? Many ICAO standards and recommended practices (SARPs) and formats are based on the limited technical capabilities of legacy communications systems. XML, specifically IWXXM, overcomes these technical limitations and enables the exchange of more meaningful (weather) information. IWXXM also uses the WMO Meteorological Community Exchange Model (METCE) and is compatible with System Wide Information Management (SWIM) concepts, which separate the exchange of the information from the use of the information. SWIM allows more efficient data sharing among aviation stakeholders. A global approach on information management is essential to ensure global interoperability and standardization across all data domains.

IWXXM efforts in the United States include the following:

- An OFCM group is developing the U.S. IWXXM Transition Plan (membership represents NWS, NOAA, DoD, FAA, U.S. Geological Survey [USGS]).
- FAA Common Support Services—Weather (CSS-Wx) will distribute weather information within FAA.

- NWS is the ICAO OPMET Data Bank and provides Dual Product Generation in both IWXXM and TAC or translates TAC to IWXXM.

Mr. Murphy closed by showing examples of TAC and IWXXM observations.

Mr. Mark Zettlemoyer, NWS Analyze, Forecast, and Support Office, Aviation and Space Weather Services Branch, presented information about the NWS Office of Dissemination and its role in leading the cross-portfolio team to implement XML. The main challenges are TAC parsing; state of issue (routine, COR, CANX, AMD); and short and long term domestic and international dissemination. He also described the FAA Next Generation Air Transportation System (NextGen) IT web services and common support services.

3. Operational Processing Centers—Conventional Data

NCEP: Mr. Jeff Ator presented a review of and takeaways from the Spring 2018 COPC meeting and the top three NCEP conventional data challenges.

The COPC meeting covered key elements of the transition from GOES-15 to GOES-17 and issues related to U.S. WIGOS identifiers.

NCEP's top three conventional data challenges:

- The majority of processing code for conventional observations was written in FORTRAN77 during the 1980s and 1990s; the software is not parallelized or ready for future large datasets.
- Pending approval of funding for necessary technology and contractor support, the plan going forward is to:
  - Reengineer the entire suite of codes using Python, with modular design and modern software engineering techniques; and
  - Store observations in a high-performance geospatial database structure, which will enable fast and customized retrievals.
- Development would occur over a period of several years, with current staff providing experiential guidance while also maintaining the existing processing until the new system is ready to take over.

FNMOC: Dr. Justin Reeves and Dr. Patricia Pauley presented FNMOC's top three conventional data challenges:

- TAC to BUFR Migration
  - Level-of-effort difference between decoding (easy) and assimilating (hard); example: WIGOS Implementation
  - Cross-domain solution challenges (FNMOC needs to support three enclaves)
  - Discovery of existing (or new) BUFR bulletins (replacing TAC bulletins)
  - Educating U.S. Navy/U.S. Marine Corps observers on the advantages of collecting/submitting observations in BUFR format (e.g., high-density radiosondes)
- Limited access to R&D products for evaluation (decoding & assimilation) prior to transitioning operational products
  - Reason: lack of notification/engagement or information assurance (IA) and/or

networking challenges
    - Example: access to updated-algorithm GOES-16 Feature Track Winds (FTW) from NESDIS Center for Satellite Applications and Research (STAR)

- Minimizing single points of failure
    - Operationally use GTS, NOAAPort, PDA, Moving Weather, NAVOCEANO, Joint Observations Submission (J-OBS), and Message Traffic to mitigate loss of observational data.
    - Will continue to strongly advocate for data availability on multiple distribution systems.

557th Weather Wing: Mr. Doug Wilkerson presented the 557th Weather Wing's top three conventional data challenges:

- Data Coverage Challenges and Mitigation
    - Incomplete, inconsistent, or incorrect data documentation impairs data exploitation and archiving (e.g., erroneous metadata).
    - Observations from poorly developed countries require significant quality control (QC); problem is exacerbated with nation unrest.
    - A centralized knowledge bank and better, standardized documentation would improve data usage and enhance data sharing.

- Data Processing and Assimilation Challenges
    - Many sites are currently sending both TAC and BUFR observations, but they often contain disparities (e.g., lat/long, temperature, pressure); substantial workarounds are required to properly process data.
    - Inconsistencies in reporting practices (e.g., reporting from mesonets) lead to data being stored incorrectly or not at all.

- Other Challenges
    - New WIGOS identifiers will impact historical databases, quality control, data assimilation, space weather observations, downstream users, etc.
    - Consideration of a "shared" standardized dataset for verification.

Session 3 Takeaways

- No new deployments are planned for sensing and infrastructure on a national level. Instead, an increase in data leveraging will be used to fill data gaps.
- ABOs remain the most abundant form of conventional meteorological data. Approximately 850,000 AMDARs are now received daily—a threefold increase since 2013.
- Weather balloon autolaunch technology is part of a broader agency initiative to move the signal used to transmit weather balloon data out of the radio frequency now used by new GOES satellites. NWS is evaluating potential locations outside Alaska to receive the autolaunch systems purchased with part of the proceeds from the sale of radio spectrum bands previously reserved for government operations.
- The cost-sharing business model used by private companies does not always allow the

federal agencies to share these data with other government agencies or the international partners without contract modification or additional charges. This causes conflicts with the principle of free and open exchange of meteorological data critical to weather and climate prediction.

- A global approach for data sharing among aviation stakeholders is essential to ensure global interoperability and standardization across all data domains and all stakeholders.
- Even if needed funding and staff resources are provided, development of new codes at the OPCs to replace outdated software for processing observational data will require a period of several years.
- TAC to BUFR migration continues to be a challenge.
- Data availability on multiple distribution systems is critical to minimize single points of failure that result in loss of observational data.
- Incomplete, inconsistent, or incorrect data documentation (e.g., erroneous metadata) impairs data exploitation and archiving.

Session 4: Ocean Data

Session Facilitator: **Mr. Danny Illich**, NAVOCEANO.

1. NWS/Office of Observations/National Data Buoy Center

Mr. Kevin Kern presented an introduction to the data management roles of the NDBC. Its mission is to provide quality observations in the marine environment in a safe and sustainable manner to support understanding and predicting changes in weather, climate, oceans, and coast.

He described the NDBC organizational structure and gave a system overview. NDBC performs automated QC prior to releasing data files to GTS and manual QC prior to archiving at NCEI. He provided a list of data that are released to the GTS via the NWS Telecommunications Gateway.

NDBC's WMO/GTS activities include handling the assignment for the United States of WMO Station Identifiers for moored buoys, drifting buoys, Argo floats, gliders, and subsurface profiling and coastal automated meteorological stations (NWS/NDBC C-MAN, NOS NWLON, etc.) using NWS Location Identifiers. NDBC serves as the gateway to the GTS for the U.S. Integrated Ocean Observing System (IOOS). It also participates on task teams for WIGOS metadata, data management, wave measurement and testing, and moored buoys. It serves as the WMO Region IV Regional Marine Instrumentation Centre (RMIC).

NDBC is currently targeting the end of July/August to release BUFR. Future work will include full support of 7-digit WMO IDs within all NDBC systems.

NDBC's top three ocean data challenges:

- BUFR template for gliders and tsunami stations
- WMO identifier changes/impacts
- Clarification of WMO/GTS guidance while planning (i.e., proper headers)

Information was also presented on the Sea Snatcher software project.

2. Integrated Coastal Ocean Observing System (ICOOS)

Ms. Kathleen Bailey described the ICOOS global, national, and regional components.

The ICOOS Regional Associations (RAs) operate a variety of observing assets and leverage others from state, local, and tribal governments; academia; nonprofit organizations; and industry. Forty-five percent of the network of coastal moorings is operated by the RAs. This includes Federal and non-Federal moorings, such as those operated by the NDBC.

High frequency radar (HFR) stations measure surface currents. The HFR Network is a national network supported by IOOS. All 140 stations are operated by academic institutions, so this is an entirely non-Federal observing network. The operators send their data to a data assembly center that does QC and delivers the data to NOAA for archival. These data are distributed by a server at the Scripps Institute, as well as through an operational node at NDBC.

The underwater glider network is also a national network supported by IOOS. The profiling gliders are mainly operated by IOOS Regional Partners and academic institutions funded by a variety of Federal and State dollars. Similar to the HFR Network, the data are delivered to a data assembly center and distributed through a server at Rutgers University.

ICOOS top three ocean data challenges:

- QC—implementing QARTOD (Quality Assurance of Real-Time Oceanographic Data)
  - Climatology tests, how to display flags, managing QC for principal investigators versus QC for RAs
- Open data access via the web versus closed access on GTS
  - Ensuring RA modelers have access to the same datasets as NCEP modelers
  - Need to build an open-access mirror of the GTS through services
  - Data availability in NCEP data tanks; tracking availability
  - Marketing these data to the modelers
- Metadata—presentation and consistency of attribution; ensuring providers use the same vocabularies and definitions (room for interpretation).

3. NAVOCEANO

Mr. Danny Illich introduced the NAVOCEANO Real Time Data Handling System (RTDHS) and its mission to provide real-time physical oceanographic data to Navy numerical forecast models and the NAVOCEANO oceanographic data archive.

For the implementation of WIGOS Identifiers, there needs to be a way of identifying observation platform type (e.g., expendable bathy/thermograph [XBT], profiling float, ships, drifting and moored buoys). Issues to be resolved include whether new platforms can be required to use the existing WMO ID convention in the WIGOS Identifier. Other issues to be resolved include observations reported with an incorrect quadrant and the bulk dump of marine animal data at certain times of the year.

4. Special Presentation—Marine Data Concerns

Dr. Bradley Ballish presented a report of his discovery of several marine data concerns and the development of a new Track-Checking QC Code. NWS/NCEP needs operational automated QC for marine data due to many location errors and stuck-data problems. The NRLACQC aircraft track-checking QC code has too much complex logic, so a new Marine Track-checking Quality Control (MTQC) was developed that uses something like a computer minimization scheme to decide which observations to delete when there are track-checking errors. The new MTQC was tested with both artificial and real data and then applied to aircraft data, which allowed comparison with the NRLACQC. In studying the MTQC applied to both ship and buoy data, it appears that there is a need for better-quality marine data, QC, and feedback to data providers. NCEP needs to implement the new MTQC when it is ready.

Session 4 Takeaways

- For the implementation of WIGOS ID’s, there needs to be a way of identifying observation platform type (e.g., XBT, profiling float, ships, drifting & moored buoys). Issues include whether new platforms can be required to use the existing JCOMM station identifier convention in the WIGOS ID.

- There is a need for better-quality marine data, QC for marine data, and feedback from users to data providers.
- The variety of observing assets from state, local, and tribal governments; academia; nonprofit organizations; and industry are also impacted by WIGOS implementation. Including these observing assets in WIGOS also presents additional challenges for a universal, centralized knowledge bank such as OSCAR/Surface.

Session 5: Space Weather Data

1. NCEP Space Weather Prediction Center

Mr. Rodney Viereck presented an update on the Space Weather Prediction Center, its organization and customers, sources of data (space-based and ground-based data), data for models, data assimilation challenges, and challenges in data gaps. “Space weather” refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space- and ground-based technological systems, as well as endanger life or health. The three primary types of space weather are solar flares, solar energetic protons, and geomagnetic storms.

The Space Weather Prediction Center has a forecast office and a prediction testbed. Critical customers include electric utilities, aviation, communication systems, GPS navigation, and space systems. Mr. Vierick described primary space weather satellites and ground-based observations from State and Federal agencies.

The Global Total Electron Content (GloTEC) assimilative model combines space-based (COSMIC 2) GPS radio occultation data and ground-based GPS/GNSS line-of-sight total electron content observations to create a 3D map of the total electron content in the ionosphere.

The Whole Atmosphere Model is an extended global forecast system (GFS) (up to 600 km). It is coupled with an ionosphere model and imports terrestrial weather structures onto the ionosphere. Forecasts of ionospheric/thermosphere conditions support users of GPS/GNSS, HF radio, and satellite communications. They also support modeling of satellite drag.

The ionosphere-thermosphere system is a strongly driven system, and data assimilation is challenging. For the upper atmosphere (>120 km) and ionosphere, assimilation techniques require further research.

Top three Space Weather Prediction Center challenges:

- Coronagraph. The center is currently using SOHO LASCO, launched in 1996 (for a 5-year mission); Plans are to add a coronagraph to GOES U and to include a coronagraph on the next solar wind satellite to be stationed at L1.
- Solar wind. A follow-on is needed to DSCOVR by 2024; current schedule (funding) has significant risk.
- Better support for USGS. Challenges include more real-time ground magnetometers, better global coverage for the magnetometer network, completing the Ground Conductivity Survey, and electric field observations.

Lt Col Justin Erwin presented an update on the 557th Weather Wing, 2nd Weather Squadron space weather mission, structure, roles and responsibilities. The 2nd Weather Squadron provides mission-tailored analyses, forecasts, and warnings of system-impacting space weather to DoD operators, warfighters, and decision-makers and to the intelligence community. It performs operations (collect and analyze data, predict environment, integrate with users), and conducts operational- and tactical-level collaboration with other centers.

The top three challenges for the 2nd Weather Squadron parallel those of the 557th Weather Wing:

- Data Coverage Challenges & Mitigation
  - Energetic charged particle (ECP) data from dozens (and growing) of in-orbit assets (GPS, commercial, and classified platforms, etc.) are not readily available or not able to reach the 2nd Weather Squadron due to inadequate infrastructure—involves outreach and data acquisition issues.
  - Aging equipment in the Radio Solar Telescope Network (RSTN) and the Solar Observing Optical Network (SOON) is prone to maintenance outages and does not leverage latest capabilities—need to refurbish and/or upgrade.
  - Next-generation Ionosonde (NEXION) and Ionospheric Scintillation TEC [Total Electron Count] Observer (ISTO) networks to measure ionosphere are sparse—need to field more sites, use oblique soundings and commercial sources.
  - Aging satellites that support space weather (ACE, SOHO, STEREO) have no known replacements.
- Data Processing and Assimilation Challenges
  - Insufficient classified processing and assimilation capability for ECP and ionospheric data from classified sources—requires infrastructure investment.
- Other Challenges
  - Limited archive of space weather data
  - Very little international data sharing (even with allies)
  - Consideration of a “shared” standardized dataset for verification and a “shared processing algorithm library”

Session 5 Takeaways:

- The ionosphere-thermosphere system is a strongly driven system, and data assimilation is challenging. For the upper atmosphere (>120 km) and ionosphere, data assimilation techniques require further research.
- Compared to conventional and satellite observing systems for Earth meteorology, the space weather observing infrastructure is tenuous. Space weather observing networks are sparsely populated and critical satellite assets lack robust back-up and replacement support.

Session 6: Satellite Data

Session Facilitators: **Mr. Vincent Tabor**, NOAA/NESDIS/OSPO, and **Mr. James Vermeulen**, FNMOC.

1. NOAA/NESDIS

Mr. Vincent Tabor presented the top three challenges facing NESDIS:

- How do we deal with the large increases in data due to increases in spatial, temporal, and spectral resolution? New systems are like a fire hose of data. The pipes of data coming into NESDIS and going out for dissemination are of increasing concern.
- How do we implement security without causing unacceptable data latency or unacceptable cost? New data have to be scanned, increasing latency, and may not be acceptable. Security is eating up resources.
- How do we transition unplanned data or satellites into operations (i.e. SCATSAT)? Buying commercial data and adding data from NASA satellites and international sources will complicate transition processes. Data evaluation could be done by commercial companies; data sharing partners and researchers could assist with evaluations.

2. JCSDA

Dr. Jim Yoe presented an update on JCSDA partners, mission and vision, management structure, concept of operations (CONOPS), project and project management, the new Joint Effort for Data assimilation Integration (JEDI), and the top three JCSDA satellite data challenges.

The JCSDA mission is to accelerate and improve the quantitative use of research and operational satellite data in weather, ocean, climate, and environmental analysis and prediction models. The management structure comprises Agency executives, a Management Oversight Board, and the Executive Team.

The JCSDA CONOPS is primarily the reaffirmation of the central role of the Executive Team to guide science activities and ensure a high level of collaboration and of the role of the Management Oversight Board to provide management-level oversight and strategic decisions. The scope of activities of JCSDA is collaborative, interdependent activities documented in the annual operating plan.

JCSDA projects include New and Improved Observations (NIO); Impact of Observing Systems (IOS); Community Radiative Transfer Model (CRTM); Sea-ice, Ocean, Coupled Analysis (SOCA); and JEDI. JEDI is a collaborative development between JCSDA partners to develop a unified data assimilation system.

Dr. Yoe described the processes involved in abstract design of models, including abstract interfaces, model space interfaces, and observation space interfaces. The JEDI Unified Forward Operator (UFO) introduces standard interfaces between the model and observation worlds. Observation operators are independent of the model and can easily be shared, exchanged, and compared. JEDI governance is about management maintaining control and deciding what features should be in the system. Code reviews are about quality (effectiveness and efficiency) of the code.

In summary, JEDI is critical to next-generation data assimilation development (hence to NWS's Next Generation Global Prediction System [NGGPS]). It provides scalability/reusability to support multiple applications, users, and contributors and builds off successful examples such as the Object Oriented Prediction System (OOPS) used by the European Center. The data assimilation grand challenges include observations, models, data assimilation algorithms, and workforce.

He closed by stating that JCSDA is improving its operations to enhance satellite data acquisition to support the OPCs and by advertising an upcoming JCSDA workshop and colloquium.

Members discussed workforce concerns related to skilled workers who are foreign-born or not citizens, for whom security vetting is increasingly challenging. Another concern was the lack of career development paths in specialized fields. There is a need for incentives for recruiting and retention of skilled professionals.

3. FNMOC

Mr. James Vermeulen presented information covering the FNMOC satellite team, primary customers' satellite products, current FNMOC polar/geostationary coverage and data ingest, data assimilation/acquisition needs and requirements, new satellite data issues and considerations, operationalizing satellite processing, CONOPS for satellite products, CONOPS for data ingest/processing/distribution, CONOPS for programs and for future, current, and future imagery (new sensor technology), and FNMOC's top three challenges.

His satellite team has five experts in research, development, and applications of satellite data, backed by a strong support staff. He described the primary customer satellite products and FNMOC models and applications.

He summarized information about the U.S. Operational Low Earth Orbit METSAT Constellation and the polar and geostationary systems. FNMOC requirement priorities include sensor capabilities to obtain data that help models perform calculations using the Radiative Transfer Model (RTM) and help the FNMOC assimilation system fine-tune the values used by the model.

Satellites provide ~85% of the assimilated observations, and satellite observations account for ~60% of the 24-hour forecast error reduction. The number of satellite observations assimilated by the Navy Global Environmental Model (NAVGEM) has more than doubled over the past 5 years. Certain data types add more value, and microwave radiance has made the largest contribution.

FNMOC priorities for imagery: The Special Sensor Microwave Imager/Sounder (SSMI/S) has priority over the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (DMSP/OLS). Future imagery priority is not yet determined, but possibly may be dependent on DoD's Weather System Follow-on (WSF) program.

On new and ongoing satellite data and transitions, Mr. Vermeulen highlighted the importance of the Foreign Satellite Data Dependency Study—which is being conducted by the Office of the Chief of Naval Operations (OPNAV), NRL, and FNMOC—and the spectrum bandwidth sell-off to the cell phone industry.

Satellite data that are provided to NOAA/NESDIS and NOAA/NCEP, with GTS distribution to other global OPCs, include DMSP, SSMI, and Windsat. This relieves dependencies on obtaining data from NOAA and/or NASA and foreign partners (single points of failure; hops, skips, and jumps outside of DoD control) and addresses latency, IA, and continuity of operations contingencies globally.

He showed examples of current and future warfighter-related satellite imagery (e.g., NRL's Geo-located Information Processing System [GeoIPS]) that will be transitioning to operations and FNMOC from NRL.

The top three challenges for FNMOC:

- Planning for future satellite launches and requirements definition (new satellites and sensors data availability and integration)
- Data acquisition from IA sources, CONOPS for data distribution and planning, addressing latency to provide data into the various functional areas FNMOC supports, numerical weather prediction, tactical imagery, reach-back in a system approved for IA, authorization-to-operate (ATO), and continuity of operations.
- Bridging the gap between research and operations (changes in technology, hardware, and software, cubesats, commercial sources, etc.).

4. 557th Weather Wing

Mr. Mark Surmeier presented the top three challenges for Air Force Weather:

- Data Coverage Challenges & Mitigation
    - MET-8 (Indian Ocean area) is just "one-deep" coverage
    - Limited coverage and reduced refresh rate outside of GEO-satellite coverage
    - Increased coordination among agencies would better equip OPCs to leverage and exploit satellite data
    - Many conventional satellites do not include space weather sensors; should they?
- Data Processing and Assimilation Challenges
    - Missing or incorrect metadata (e.g., MET-8 data identified as MET-7 in WIS portal documentation)
    - Currently processing MET-9/10/11 data through DOMSAT/Kencast system—modifying ingest software to work with PDA; PDA latency an issue (vs. DOMSAT).
- Other Challenges
    - Updating software and databases frequently and robustly enough to ingest and use additional new data sources
    - Having enough capacity to process and store GOES-17 and all next-generation satellite data due to file size and bandwidth limitations
    - Consideration of a "shared" standardized dataset for verification and a "shared processing algorithm library"
    - Cybersecurity concerns; unfunded mandate

5. NAVOCEANO

Mr. Bruce McKenzie provided information on what NAVOCEANO does with satellite data. They are responsible for providing ocean observations for assimilation in the Navy models and for direct support to the fleet. Sea surface height from altimeters is the key satellite parameter used in the ocean models. The Jason and Sentinel-3 series of satellites are two of the primary sources of satellite altimetry. Sea surface temperature is the second priority parameter feeding the ocean models using data from national and international polar orbiting and geostationary satellites. Ice concentration is another important satellite parameter for model assimilation, and the satellite data is acquired from DMSP, the Suomi National Polar-operating Partnership (S-NPP) satellite, and Japan’s Global Change Observation Mission—Water (GCOM-W) satellite. Ocean optics products from satellites are provided directly to the warfighter in support of a variety of warfare areas, including diver operations.

NAVOCEANO is working on satellite-based ocean surface bias correction to support coupled modeling. NAVOCEANO relies heavily on NOAA for access to national and international satellite data.

Top three challenges/concerns for NAVOCEANO:

- Reliable and timely satellite data access. Security restrictions can slow access.
- Getting operational access to foreign satellite data.
- A follow-on satellite for GCOM-W, the key source of all-weather sea-surface temperature (SST) and high resolution ice concentration.

6. Technical Reference-1 (TR-1) Update

Mr. Ramirez facilitated discussion regarding the status of TR-1. TR-1 is the primary operational and administrative reference supporting the Environmental Satellite Data Annex (ESDA) under the provisions of the Memorandum of Agreement (MOA) for Data Acquisition, Processing, and Exchange (DAPE). The TR-1 is not authoritative; rather, it documents and describes the environmental satellite data acquisition processing and exchange communications infrastructure, procedures, and operations approved by the COPC. It is routinely updated for the OPCs and managed by NESDIS/OSPO.

Many changes have occurred in systems and formats and are included in this document. Parts of this document may be useful, but the OPCs need to determine whether it is still needed and useful. Parallel action is ongoing by the WG/OD Metadata subgroup to create a technical reference similar to TR-1 for conventional data. Funds for maintaining and administering the TR-1 reference material would be saved if the document is no longer needed in such a robust form.

Members agreed to review and revalidate their specific OPC requirements for this document, considering the content and format that would best suit their needs.

Session 6 Takeaways

- Interagency partners need to implement solutions for the large increases in data due to increases in spatial, temporal and spectral resolution.

- Interagency partners need to identify and implement security measures that don't cause unacceptable data latency or unacceptable cost. Current security measures are resource intensive and time consuming.
- Challenges for OPCs include planning for future satellite launches and requirements and transitioning unplanned data sources into operations (e.g., data from new research satellites and sensors).
- Other top challenges for OPCs include (a) data acquisition from IA sources; (b) CONOPS for data distribution and planning; (c) addressing latency to provide data into the various functional areas that each OPC supports; (d) further improvements to numerical weather prediction and tactical imagery; (e) reach-back in a system approved for IA, ATO, and continuity of operations, while also bridging the gap between research and operations.
- The interagency partners need to review and revalidate their specific OPC requirements for Technical Reference–1 to the Environmental Data Annex, to determine the content and format that would best suit their needs.
- JEDI is critical to next-generation data assimilation development, which in turn is essential to NWS's Next Generation Global Prediction System.
- Security vetting for skilled workers who are foreign-born or not citizens is increasingly challenging. A related problem is the lack of career development paths in specialized fields. Overall, there is a need for incentives for recruiting and retention of skilled professionals to work with observational data.

Workshop Wrap-up

During the brief wrap-up session before the workshop adjourned, Mr. Ramirez asked the participants to suggest what they viewed as key takeaway points from the entire proceedings. The ensuing suggestions and discussion from the participants were summarized in a preliminary list of key takeaway points. Subsequently, this list was reviewed and expanded upon by the WG/OD members as this document was drafted. The final set of key takeaways is presented at the beginning of the document.