# Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR)

Meeting 2018-4

Room 7224, SSMC2 1325 East West Highway, Silver Spring, MD

Dial-in 1-888-680-9581, passcode 535430# GoToMeeting: https://global.gotomeeting.com/join/293418653

November 27, 2018, 2:00 p.m. EST

## **Opening Remarks**

## Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR)

Dr. Jack Kaye (NASA) Chair, ICMSSR

- Welcome
- Roll Call
- Approve Agenda & Record of Action.
- Meeting will be recorded

#### Today's Agenda

- OPENING REMARKS: Jack Kaye (NASA)
- ADMIN REMARKS: Michael Bonadonna (OFCM)
- FEDERAL COORDINATOR'S UPDATE: Michael Bonadonna (OFCM)
- NOAA's S2S REPORT TO CONGRESS:
   David Dewitt (NOAA) or Timothy Schneider (NOAA)
- COPC UPDATE: Chris Finnigsmier (USAF ACC 557 WW)
- ARCTIC METEOROLOGICAL INTERAGENCY COORDINATION.
   David Kennedy (NOAA), Jen Pizza, (NOAA), Iris Ferguson (USAF)
- OPEN DISCUSSION
- ACTION ITEM REVIEW: Michael Bonadonna (OFCM)
- CLOSING COMMENTS / ADJOURN

#### **Administrative Info**

- Facilities
- Telecon / GoToMeeting
  - Dial-in 1-888-680-9581, passcode 535430#
- GoToMeeting: https://global.gotomeeting.com/join/293418653
- Slides posted at: <a href="http://www.ofcm.gov/icmssr/meetings.htm">http://www.ofcm.gov/icmssr/meetings.htm</a>
  - Please advise us of any sensitivities





Michael Bonadonna Acting Federal Coordinator









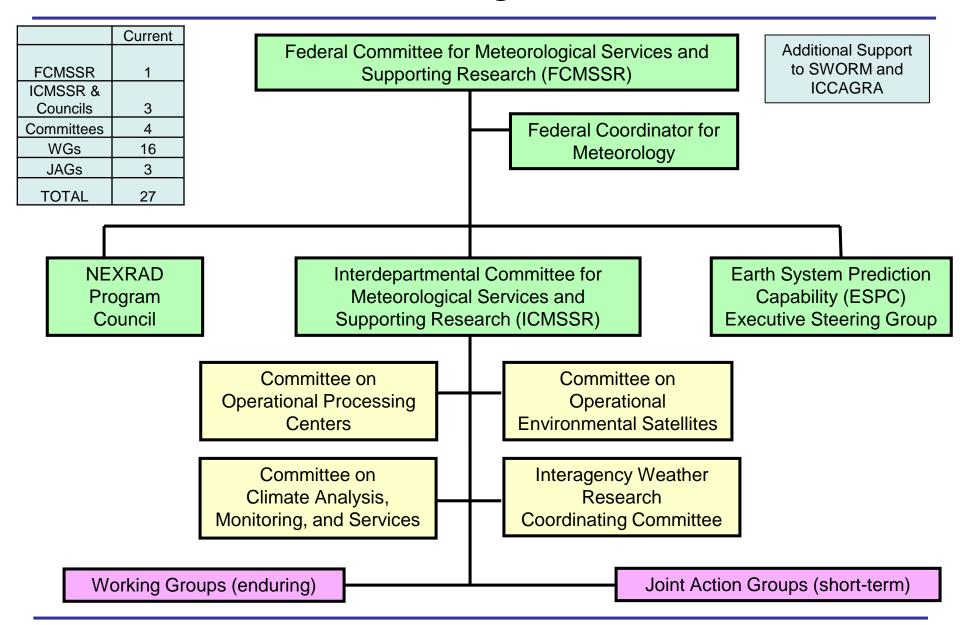








#### **FWE Coordinating Infrastructure**



#### **FCMSSR Meeting Recap**

- Conducted on Oct 22, 2018
- Chaired by Bill Lapenta (NOAA) for Neil Jacobs (NOAA)
- Approved FWE Strategic Plan Update for new R2O2R Objective
- Presentations:
  - NOAA's Next Generation Global Prediction System (NGGPS) as a possible framework for broader enterprise implementation.
  - National ESPC's HPC Working Group provided a briefing on high performance computing requirements for future Earth System Prediction Capability needs.
- 4 New Action Items (See Al Review)

### Implementing Weather Act of 2017§402

Mandate: The 2017 Weather Act directs OSTP to establish "an Interagency Committee for Advancing Weather Services (ICAWS)," with duties including identifying, prioritizing, and coordinating top forecast needs, and sharing needs and improvements across agencies.

#### **Proposal:**

- Rename FCMSSR as ICAWS, combine ICAWS duties and existing FMCSSR duties into one ICAWS charter.
- OSTP and NOAA co-chair ICAWS
- OSTP submits legislative change request to make OFCM Director the ICAWS Exec.
   Sec. (vice co-chair.)

#### **Status:**

- FCMSSR approved recommending this plan to OSTP at the April 2018 FCMSSR.
- OSTP received recommendation from FCMSSR via OFCM in May 2018.
- OSTP Director (President's Science Advisor) nominee awaiting confirmation. OSTP staff will hold approval of this plan until a Director is confirmed and can review.
- In addition, OSTP is in discussion with Congressionals to ensure a clean implementation of establishing an ICAWS; we hope to be able to report back soon.

#### **ICMSSR Chair Rotation for 2019**

- Per ICMSSR Terms of Reference, ICMSSR Chair rotates among several willing agencies each year.
- Willing agencies identified in 2017 as DoD, DOC, NASA, USGS, and FAA
  - 2016: Mr. Scott Livezey (DoD-USN)
  - 2017: Craig McLean (DOC-NOAA/OAR)
  - 2018: Jack Kaye (NASA-SMD)
- USGS declined invitation to serve as Chair for 2019
- FAA Nominates Dr. William Bauman to serve as 2019 ICMSSR Chair
- If unresolved by this meeting, Current Chair will issue a call for nominations.
- Next ICMSSR meeting will be February 2019

## **Budget and Coordination Report FY20**

- Working Group for BCR formed.
- Terms of Reference approved.
- Initial guidance to agencies for FY20 in draft; has been discussed at agency working levels.
- Formal request for FY20 budget information will be issued in December.
- Due date for getting budget information to OFCM will be ~2 weeks after release of FY20 President's Budget Request.
- DoD Entry point identified as OUSD R&E
  - Mr. Ormand serves as DoD FCMSSR member
  - OSD will task the Service Branches for input
  - A courtesy "heads up" copy will go from the WG/BCR to the DoD Service POCs



## RECAP OF THE ATMOSPHERIC TRANSPORT AND DISPERSION WORKING GROUP

- Hosted the 2018 Special Session, 22nd Annual George Mason University (GMU) Atmospheric Transport and Dispersion (ATD) Conference.
- Agencies provided briefings on the history of Interagency Modeling and Atmospheric Assessment Center (IMAAC), what is currently being done at IMAAC by DTRA, and the operational use of the HYSPLIT model at the NWS FO's.



- OFCM recommended possibly starting two new working groups, one on updating plans that have not been updated since 2004 and another working group to discuss urban modeling. Possibly making just one working group to accomplish both shortfalls.
- Working with Tom Watson, from Brookhaven Labs, to write point paper on why a working group is needed.
- Attended 2018 AMS Urban Climate and Dispersion conference to meet others working in the modeling and urban dispersion modeling and get volunteers to join working group

## RECAP OF THE ATMOSPHERIC TRANSPORT AND DISPERSION WORKING GROUP

## So where does the ATD working group go from here?

- The most current OFCM plans relating to ATD are FCM-R17-2002 called Atmospheric Modeling of Releases from Weapons of Mass Destruction for Homeland Security, from 2002, and FCM-R23-2004 Federal Research and Development Needs and Priorities for Atmospheric Transport and Diffusion Modeling from 2004.
- Both of these publications are outdated and need revision.



#### 2018 Space Weather Enterprise Forum

- When: 25 July from 1200-1600
- Where: Library of Congress
- Sponsor: Representative Ed Perlmutter (D-CO)
- Support: NASA and Secure World Foundation
- Small-SWEF concept
  - Half-day on the Hill to Raise Congressional interest (150 attendees)
- Theme: "Advancing National Space Weather Research and Forecast Capabilities"

#### • Panel Sessions:

- Understanding and managing risks and impacts associated with SWx
- Implementation of activities across the space weather enterprise for the protection of critical infrastructure
- Broad Government, Commercial, Academic Partnership support
- Coordinated with State Dept. "Space Weather as a Global Challenge" event Embassy of Japan on 24 July to help raise international participation
- Presentations, audio transcripts, and report available through online OFCM.GOV



#### 2019 SWEF Proposal





- Big-SWEF concept
  - Full-day near the National Mall
  - Large venue (250+ attendees)
  - Engage the SWx Community and public
- USGS has offered use of Interior Main Building auditorium
- Target Date Window: Early June
- Secure World Likely to support as usual
- WG/SWEF will meet in January to beginning planning

## Federal Weather Enterprise Coordination Session at the AMS Conference

Monday, Jan 7, 2019 02:00 PM

35th Conference on Environmental Information Processing Technologies Session 3A Interagency Coordination within the Federal Weather Enterprise Co-chairs: William J. Schulz Jr., USN-ONR, and C. Sim James, OFCM

- WIGOS Transition Justin M. Reeves, FNMOC
- NextGen Executive Weather Panel John Egentowich, FAA
- National ESPC: Coordinating Across Time Scales, across Agencies Jessie C. Carman, NOAA OAR
- The Committee for Operational Environmental Satellites (COES) Ajay Mehta, NESDIS
- Comparing Satellite Architecture Studies Using Standard Taxonomy Approach Justin Goldstein, NOAA/NESDIS
- The National Space Weather Partnership (NSWP): Michael F. Bonadonna, OFCM
- Adding Value to NDBC Weather Buoy Observations through Enhanced Data Management Practices:
   Karen Grissom, NDBC
- Expanding Emergency Communications Resources across NWS Western Region to Support Continuity of Operations and IDSS: Matt Solum, NWS, Salt Lake City, UT

#### 2019 Tropical Cyclone Operations and Research Forum

What: 2019 Tropical Cyclone Operations and Research Forum (TCORF) and 73d Interdepartmental Hurricane Conference (IHC)

When: Tuesday and Wednesday March 12 &13, 2019

Where: Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

Who: OFCM, UCAR, and the WG/TCOR

How: With funding support from the NOAA, USN,

NSF

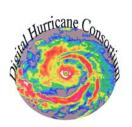
Why: Focus on Tropical Cyclone Research, Transition to Operations, and Update of the annual National Hurricane Operations Plan





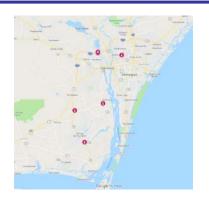


#### **2018 Hurricane Response Deployments**



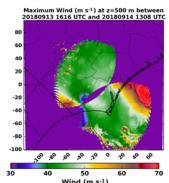
OFCM-coordinated data collection deployments of the Digital Hurricane Consortium (DHC) and several U.S. Government observing assets to FLORENCE and MICHAEL through the Working Groups for Disaster Impact Assessments (WG/DIAP) and COASTAL Act Support (WG/CAS)

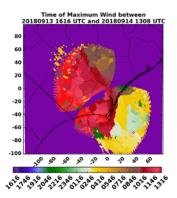
| Response Entities                              | System or Capabilities  |
|--|---|
| USGS OSW and<br>USGS Coastal Storm Team        | Storm-tide network, Rapid Deployment Gages,<br>Storm Surge/Wave sensors, Flood Event Viewer<br>(FEV), High Water Marks  |
| National Severe Storms Lab                     | mobile mesonet - also serves as a radiosonde launch vehicle   |
| University of Florida                          | Instrumented towers – wind and rain monitors  |
| University of Illinois                         | Small wx stations   |
| University of Notre Dame                       | 10 Water Level Gauges   |
| Texas Tech University                          | 48 portable weather stations Stick Nets   |
| Oklahoma University                            | mobile C-band dual-pol SMART Radar, four PIPS (portable surface met stations with Parsivel II disdrometers), experimental all-in-one weather sensor from Campbell Scientific. |
| DOC/NIST                                       | Post-storm investigative teams, windstorm investigations  |
| NSF/Structural Events Recon<br>(StEER) Network | Rapid (door to door) Damage Assessments   |
| NWS/Operations Center                          | Sharing of collected data and information with national centers and forecast offices  |





SR2- Ground-based Hurricane Hunter





#### Status of the OPM 1340 Meteorologist Qual. Standard

- ICMSSR agreed to propose a change to the 1340 (Meteorologist) Qualification Standard on 14 August:
  - Changed Option B standard to require MOST educational requirements plus experience.
- The proposed language did not meet merit system protection requirements according to NOAA/DOC's legal and HR professionals
- Current discussions involve streamlining the prescriptive and ancillary components of existing standard to focus on what is most important to the future federal weather workforce
  - USAF A3W wants to include option to qualify if the applicant has a B.S. or higher in Meteorology or Atmospheric Science from an accredited school
- As FCMSSR Chair, NOAA leadership recognizes need to refine the 1340 standard and is determined to find a satisfactory solution for all parties through the interagency process as quickly as possible.

#### Today's Agenda

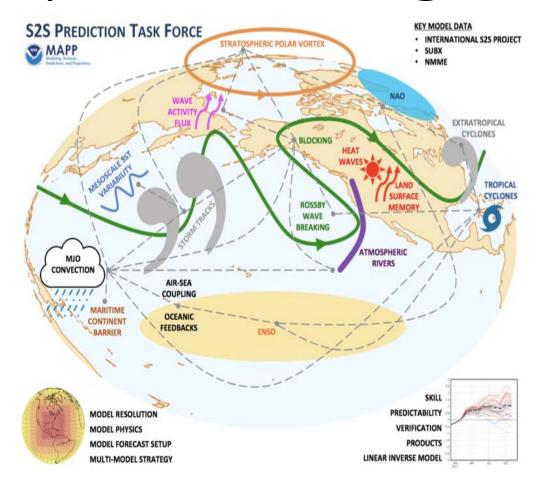
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## Report to Congress





Subseasonal and Seasonal Forecasting Innovation:
Plans for the Twenty-First Century





## Report to Congress

The Undersecretary shall submit to Congress (relevant House and Senate Committees) a report including:

- An analysis of how NOAA's S2S forecasts are used for public planning and preparedness,
- NOAA plans for the continued improvement of an S2S forecasting capability, including products to meet the need described in 1, and
- An identification of the needed research, monitoring, observing and forecasting requirements for number 2

The Undersecretary shall consult with relevant Federal, regional, State, tribal, local government agencies, research institutions, and the private sector in the development of this report







- Cross line-office S2S planning panel with three subgroups working in parallel
  - Use of current S2S products and services
  - Goals and Plans for Continued Development
  - Research, monitoring, observing and forecasting requirements
- Community engagement
  - AMS and AGU town halls
  - Structured interviews
  - Canvassing stakeholders and engagi
- Writing team generated draft report
  - Draft report provided to ICMSSR for review
- Annotated outline was available (NWS PNS) for public review and comment

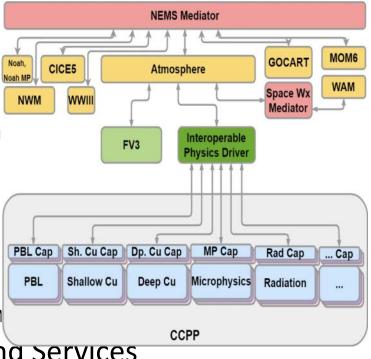






## Report Outline

- I. Introduction
- Background
- Scope
- Enhancing S2S Forecasts and Products: Mea
- Organization of this Report
- II. Current S2S Products and Services
- Summary of Current Products
- Usage in Public Planning and Preparedness
- Dissemination, Communication and Coordin
- III. Plans for Improving S2S Products and Services
- Modeling
- Communication
- Near Term Science Goals for Improving S2S Forecasts and Their Utilization by Stakeholders



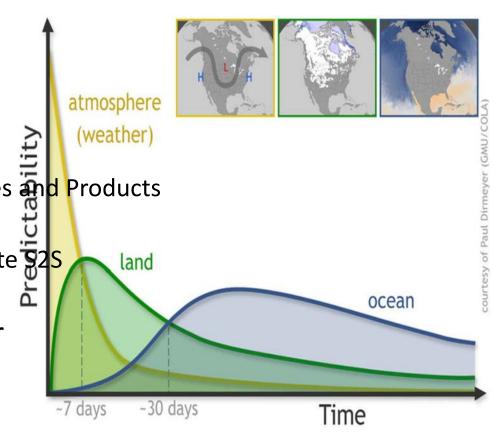




## Report Outline

#### IV. Requirements for Improving S2S Products and Services

- Background
- Forecast Requirements
- Research Requirements
- Observational Requirements
- Monitoring Requirements
- Advancing S2S Forecast Capabilities and Products
- Forecast/Product Requirements
- Regional Pilot Projects to Accelerate \$25
   Predictive Skill
- V. Process and Consultation for Developing this Report
- Process
- Consultation





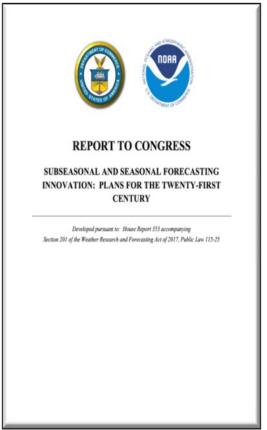


### **Current Status**

• Full report and executive summary have been

drafted

Sent to Line Offices for review



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## Committee for Operational Processing Centers (COPC)

## COPC Update to ICMSSR

Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) Meeting
November 27, 2018
(OFCM – Silver Spring, MD)

Presented by:
Mr. Chris Finnigsmier
Technical Director
557th Weather Wing
(COPC member)

#### Overview

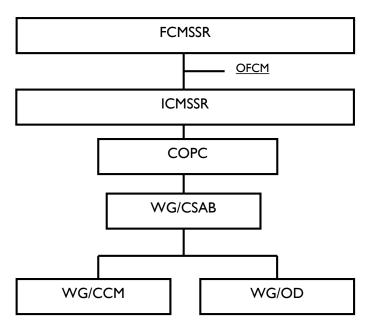
- Terms of Reference
- Background
- Activities, Monitoring, and Going Forward
- Conclusion

## COPC Terms of Reference (ToR)

- Purpose: The Committee for Operational Processing Centers (COPC) shall advance the goals of the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) to achieve actionable interagency coordination between member meteorological and oceanographic operational processing centers regarding cooperative data exchange and increased effectiveness of products and services for their customers.
- COPC facilitates the cooperative support and exchange of observational data, modeling products, and backup of services between the member organizations:
  - NWS National Centers for Environmental Prediction (NCEP), College Park, MD
  - NESDIS Office of Satellite and Product Operations (OSPO), Suitland, MD
  - 557th Weather Wing (557 WW), Offutt Air Force Base, NE
  - Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, CA
  - Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, MS
- COPC is finalizing an update to the ToR and will submit it for ICMSSR approval at the next meeting.
  - Admin updates to be consistent with the ICMSSR and other Committee ToR formats

## Background

- COPC was a working group in the early 80's and became a standing Committee for ICMSSR in 1988.
- COPC meets twice a year (spring and fall), rotating the meeting location between the 5 Centers.
- COPC has 3 supporting working groups:
  - The Working Group for Cooperative Support and Backup (WG/CSAB) serves as the executive agent for the COPC.
  - The Working Group for Centralized Communications Management (WG/CCM) coordinates communications issues between the OPCs.
  - The Working Group for Observational Data (WG/OD) facilitates the acquisition, processing, exchange, and management of observational data and metadata among the Federal Agencies, the OPCs, the World Meteorological Organization, and other related data centers.



#### Activities

- Completed the FCM-P14-2018 Federal Plan for Cooperative Support and Outage Mitigation Among Operational Processing Centers.
- Conducted the 2nd Observational Data Workshop with a documented Summary report of findings/outcomes.
  - Summary Report available online:
    <a href="https://www.ofcm.gov/publications/odwr37/r37">https://www.ofcm.gov/publications/odwr37/r37</a> odw.pdf
- Joint Region Security Stack (JRSS) testing data latency between NAVO and the other OPCs.
- Investigating communication/networking options to Mission Partner Gateway/NIPRNET Federated Gateway (MPG/NFG).

#### Activities

- Developing U.S. concept/strategy for implementation of new WIGOS station IDs.
- Effort to develop a template for OPCs to catalog data exchanges and estimate future bandwidth requirements.
- Progress on testing the alternate dedicated circuits and implementing automated failover.
- Success of MSG migration off DOMSAT and transition to GOES-16/17.
  - AF modified antennas to receive GOES Rebroadcast (GRB); MIVB servers ingest/process data for use at 557 WW (files can be passed to Navy OPCs via COPC circuits).
  - FNMOC is targeted for GRB data ingest in June 2019.

## Monitoring

- Cyber security impacts on OPC data exchange
- Understand how the Commercial Weather Data Acquisition Programs will impact the OPCs
  - Monitoring progress on Commercial Weather data provisions of the Weather Forecast Improvement Act of 2017
  - Monitoring Commercial Weather Data Pilot programs in NOAA, DOD, and NASA
- OPC desires to begin sharing plans/strategies for migrating to the cloud

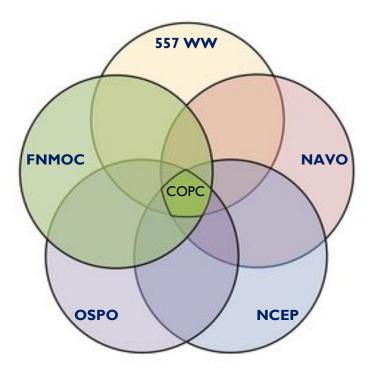
## Monitoring

- Stay informed of COES efforts with information about research satellite capabilities
- Stay informed of the Earth System Prediction Capability's (ESPC) future of High Performance Computer (HPC) efforts that included a potential interagency study on developing a dedicated-to-earth-system-prediction HPC asset
- Tracking on the Indian Ocean Data Coverage (IODC) efforts between USAF and NOAA

## Going Forward

- COPC continue to address pertinent goals and objectives identified in the Strategic Plan for Federal Weather Enterprise coordination
  - Provide interagency forum to discuss/improve exchange of observational data and global observing capabilities
  - Strengthen interoperability among interagency forecasting centers to make federal forecasting process more resilient
- Does ICMSSR have any guidance or direction for COPC?
  - Increased emphasis on existing efforts or new areas for investigation

#### Conclusion



COPC and the active working groups provide a forum for issue discovery and consistent work to maintain and improve an interagency cooperative and coordinated approach to benefit our Nation through shared efficiencies and leveraging joint mutual exploitation of capabilities.

## Questions / Discussion

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#### Arctic Maritime Symposium 14-16 August 2018

Northwest Passage Central Arctic Shipping Route





Northern Sea Route

CLASSIFICATION:

The unpredicted rapidly changing environment in the Arctic and the increased presence of great power competitors at the seams of multiple combatant commands challenges U.S. security and prosperity.

#### (U) 2009 National Security Presidential Directive 66:

...the United States must be prepared to safeguard its National Security interests in the Arctic."

#### (U) 2013 National Strategy for the Arctic Region

...preserve Arctic Region Freedom of the Seas and provide for future energy security."

#### (U) 2016 DOD Arctic Strategy

...need for increased maritime surface and subsurface presence, surveillance, and capabilities."

#### (U) FY18 Senate NDAA pertaining to USN and the Arctic:

...the Secretary of the Navy shall submit to the congressional defense committees a report on the capabilities of the Navy in the Arctic region"

#### USNORTHCOM and ALCOM Nested Lines of Effort

Defense of the Homeland

**Defense Support of Civil Authorities** 

Arctic

Homeland Partnerships

Regional Partnerships

Mission Assurance

Homeland Defense and Civil Support Preparedness

Arctic

Homeland Partnerships

#### Capacity in Concert Expand and Strengthen Federal, State, and Tribal

#### GOALS

- Expand and strengthen relationships between Joint and interagency government organizations, academic and policy institutions, and senior leaders with interests in maritime operations in the Arctic.
- ☐ Improve mutual understanding and appreciation of Arctic maritime operational requirements and opportunities.

"Provide an environment of uncertainty for anyone planning or attempting to execute an attack against the United States." - Maritime Homeland Defense EXORD

average sea ice

minimum ('79 - '07)

Commander, Alaskan Command Lieutenant General Kenneth Wilsbach, USAF

#### US Representatives for Alaska

Senator Lisa Murkowski Senator Dan Sullivan

US House of Representatives Congressman Don Young

#### Combatant Commander

Commander, US Northern Command and North American Aerospace Defense Command General Terrence J. O'Shaughnessy, USAF

#### Keynote Speakers

Former Commander, US Pacific Command Admiral Sam J. Locklear, USN (Ret)

Former Commandant, US Coast Guard Admiral Paul F. Zukunft, USCG (Ret)

"The U.S. must ensure that our adversaries do not dominate the Arctic region." - Secretary Mattis

#### Alaskan Command

CLASSIFICATION:

Guardian of the North

average sea ice

minimum (present)

Force Readiness

Defense of North

Civil Authorities

America and Support to

Arctic Initiatives/Build

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#### **■**OPEN DISCUSSION

- ACTION ITEM REVIEW: Michael Bonadonna (OFCM)
- CLOSING COMMENTS / ADJOURN

### **FCMSSR Action Items**

| AI#      | Text   | Responsible Office      | Comment   | Status | Due Date |
|----------|--|-------------------------|---|--------|----------|
| 2018-1.3 | Review and brief FCMSSR on the impact of 1340-series qualification changes approximately one year after OPM implements the change.   | USAF A3W,<br>NWS        |   | Open   | 10/31/19 |
| 2018-2.1 | With respect to implementation of the new FWE Strategic Plan objective to improve coordination of R2O activities, ensure all elements of the FWE Coordinating Infrastructure consider any potential National Security concerns regarding operational vulnerabilities and core technical capabilities that should be restricted for internal government use only.   |                         |   | Open   | 12/15/18 |
| 2018-2.2 | Ensure input to the WMO Basic Instructional Package for Meteorologists (BIPM) and Basic Instructional Package for Meteorological Technicians (BIPMT) is consistent with the proposed modification to the OPM 1340Draft a new proposal for the 1340 Meteorologist Qualification Standard with support from NOAA and DOC HR. Secure FCMSSR concurrence. Request DOC HR sends the package to OPM. Meteorologist Qualification Standard. | FCMSSR<br>Organizations | 10/24/18: OFCM reviewed the WMO BIPM andBIPMT request and found no impact on revision of the 1340 standard. | Closed | 10/26/18 |

### **FCMSSR Action Items**

| AI#      | Text  | Responsible<br>Office | Comment  | Status | Due Date |
|----------|---|-----------------------|--|--------|----------|
| 2018-2.3 | Draft a new proposal for the 1340 Meteorologist Qualification Standard with support from NOAA and DOC HR. Secure FCMSSR concurrence. Request DOC HR sends the package to OPM.   |                       |  | Open   | 11/16/18 |
| 2018-2.4 | In order to improve coordination with ongoing National Strategic Computing Initiative (NSCI) activities, contact the NSTC Networking and Information Technology Research and Development (NITRD) Program to obtain a point of contact and invite them to provide an information briefing for the next ICMSSR meeting. | OFCM                  | 11/9: OFCM contacted NIRTD ExecSec who will provide POCs. Schedule briefing fo Spring ICMSSR | Open   | 02/15/19 |

#### **ICMSSR Action Item Review**

| AI#      | Text  | Responsible<br>Office | Comment  | Status | Due Date |
|----------|---|-----------------------|--|--------|----------|
| 2016-4.2 | Provide a copy of the Terms of Reference for the new Committee on Climate Services (CCS) for ICMSSR review.   | OFCM                  | 7/9/18: Waiting for NWS to concur.   | Open   | 02/10/17 |
| 2018-1.5 | Upon FCMSSR approval of the Section 402 implementation plan, submit the recommend plan to Director, OSTP and work with OSTP to submit a legislation change request to identify the Federal Coordinator as the ICAWS Executive Secretary rather than a Co-chair. | OFCM, OSTP            | OSTP Director (President's Science Advisor) nominee awaiting confirmation. OSTP staff will hold approval of this plan until a Director is confirmed and can review. In addition, OSTP is in discussion with Congressional staff to ensure a clean implementation of establishing an ICAWS. | Open   | 05/30/18 |

#### **ICMSSR Action Item Review**

| AI#          | Text  | Responsible<br>Office | Comment   | Status | Due Date |
|--------------|---|-----------------------|---|--------|----------|
| 2018-<br>2.2 | Convene an exploratory meeting to determine a framework (participants, subjects for considerations, timeline, etc.) for an interagency group to deliberate the need for policy or direction on the availability of potentially sensitive operational weather information. |                       | 10/1/18: A3W is developing a position on this.  | Open   | 08/01/18 |
| 2018-<br>2.3 | Convene an exploratory meeting to develop an approach for compiling the description of activities and requirements called for in Section 109 of the Weather Act of 2017.  | OFCM                  | 11/1/18: Member names received, scheduling first introductory meeting ahead of next ICMSSR on 27 November |        | 07/15/18 |











## Wrap Up















#### Proposed OPM 1340 Meteorologist Qual. Standard

A. A Bachelor of Science degree (or higher) in meteorology or atmospheric science.

or

- B. A Bachelor degree in another natural science major that included:
  - At least 24 semester (36 quarter) hrs of credit in meteorology/atmospheric science including a minimum of:
  - 6 sem. hrs of atmospheric dynamics and thermodynamics;\*
  - 6 sem. hrs of analysis and prediction of weather systems (synoptic/mesoscale);
  - 3 sem. hrs of physical meteorology; and
  - 2 sem. hrs of remote sensing of the atmosphere and/or instrumentation.
  - 6 sem. hrs of physics, with at least one course that includes laboratory sessions.\*
  - 3 sem. hrs of ordinary differential equations.\*
  - At least 9 sem. hrs of course work appropriate for a physical science major in any combination of three or more of the following: physical hydrology, statistics, chemistry, physical oceanography, physical climatology, radiative transfer, aeronomy, advanced thermodynamics, advanced electricity and magnetism, light and optics, and computer science.
- \* There is a prerequisite or corequisite of calculus for course work in atmospheric dynamics and thermodynamics, physics, and differential equations. Calculus courses must be appropriate for a physical science major.

or

C. Combination of education and experience – at least 18 semester hours of meteorology or atmospheric science and at least three semester hours in differential equations (or an equivalent course), plus appropriate experience or additional education.

#### **Evaluation of Education:**

Courses acceptable towards meeting the meteorology course requirement in paragraph C must include at least three of the following: atmospheric dynamics and thermodynamics, analysis and prediction of weather systems, physical meteorology, and remote sensing and/or instrumentation.