U.S. NAVAL RESEARCH LABORATORY

Atmospheric Research for Arctic Regions at the Naval Research Laboratory

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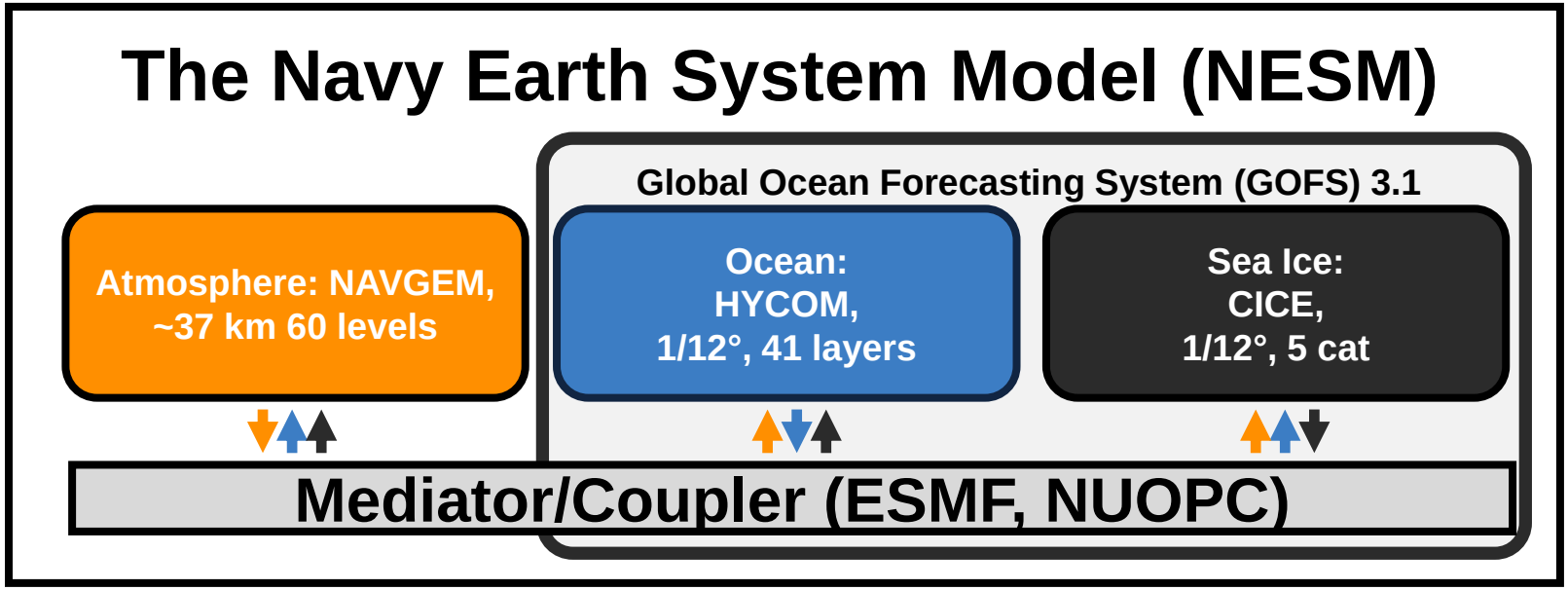
National ESPC
EARTH SYSTEM PREDICTION CAPABILITY

DEPARTMENT OF THE NAVY
ONR
Science & Technology

NRL Marine Meteorology Division

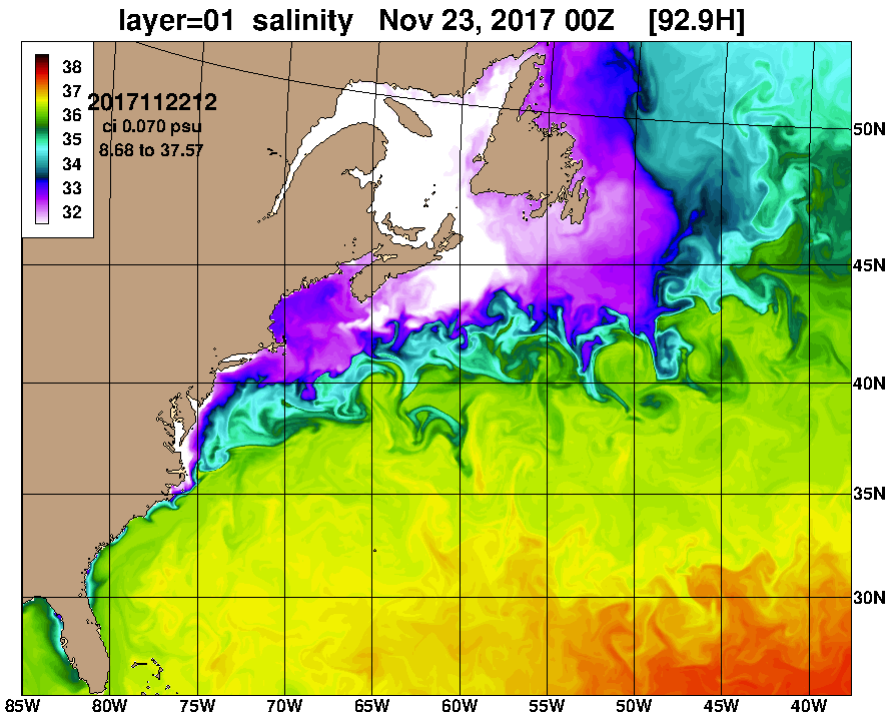
- Mission
  - Conduct a broadly based multidisciplinary program of scientific research and advanced technological development directed toward environmental information superiority for the Navy/Marine Corps and DoD
- Support development and upgrades of numerical atmospheric systems and related user products
- Model Development:
  - Global
    - NAVGEM (NAVy Global Environmental Model)
  - Mesoscale
    - COAMPS® (Coupled Ocean/ Atmosphere Prediction System)
  - Operational Partner
    - FNMOC (Fleet Numerical Meteorology and Oceanography Center).

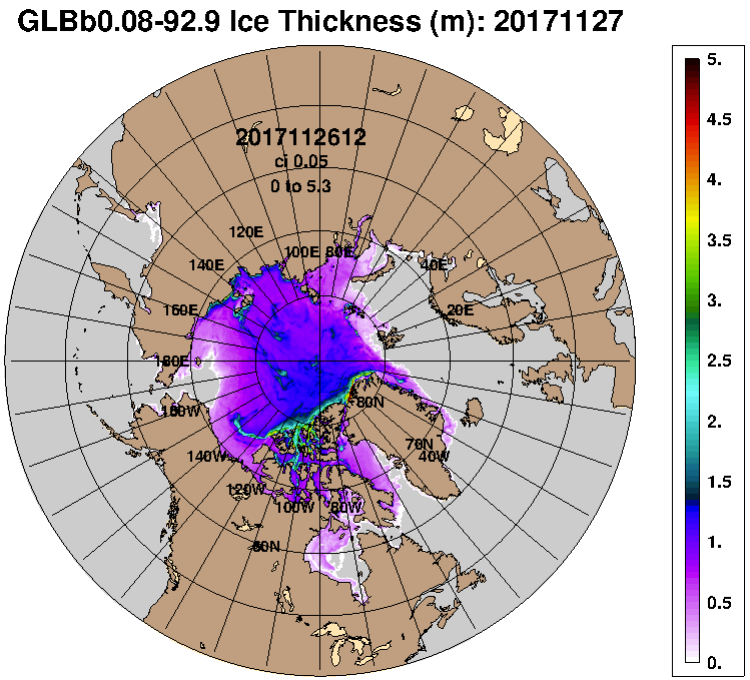
Global Model Development at NRL



- Strong collaboration between Marine Meteorology and Oceanography Division
- Currently used in seasonal (Sea Ice Outlook) and subseasonal intercomparision (NMME-SubX) projects

Uniqueness of NESM: Global High Ocean Resolution

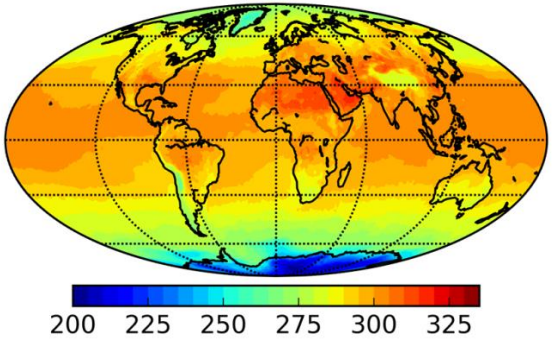




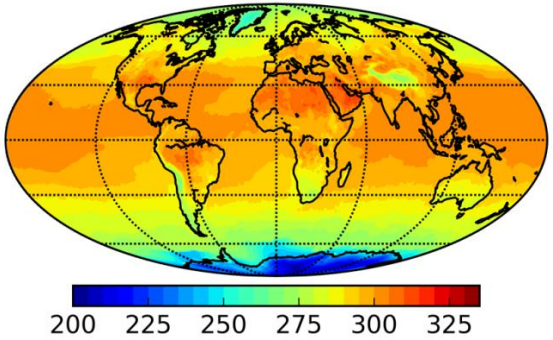
- High fidelity forecasts needed for Atmosphere, Ocean, and Sea Ice

NESM Compared to NAVGEM

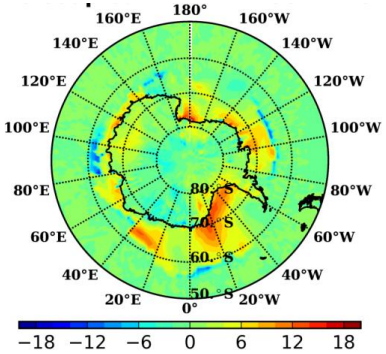
NESM



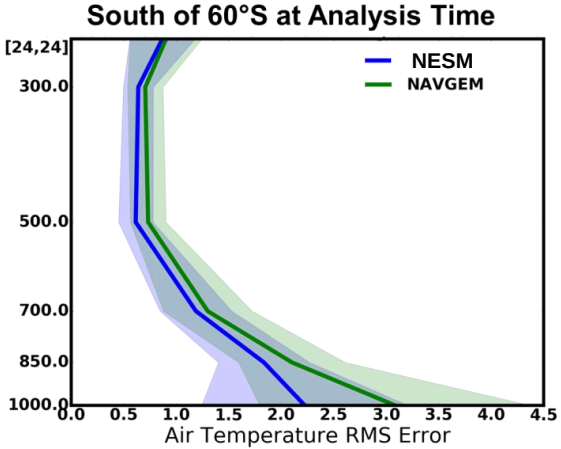
NAVGEM

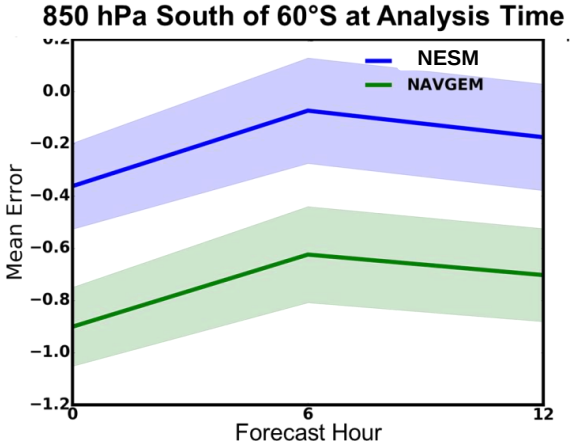


NESM minus NAVGEM



- Experiment
  - July to October 2015
  - NESM Versus NAVGEM version 1.4
- Few Differences
- Lower low-level temperatures in coupled model
- Better comparison to radiosondes



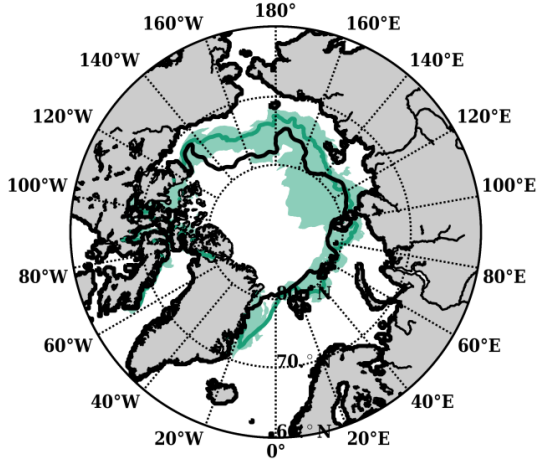


NESM participating in Sea Ice Outlook (SIO)

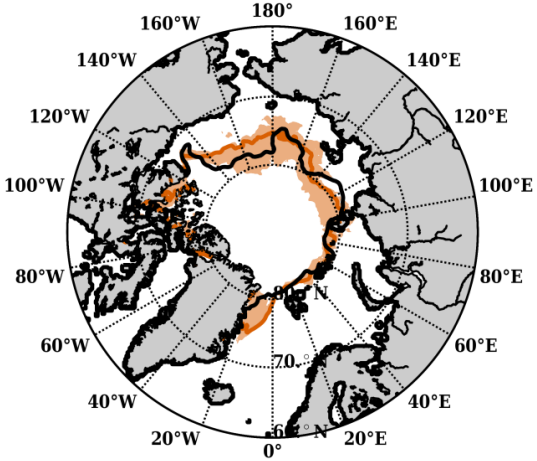
September Mean Sea Ice Edge Predictions for the 2017 Sea Ice Outlook

2017

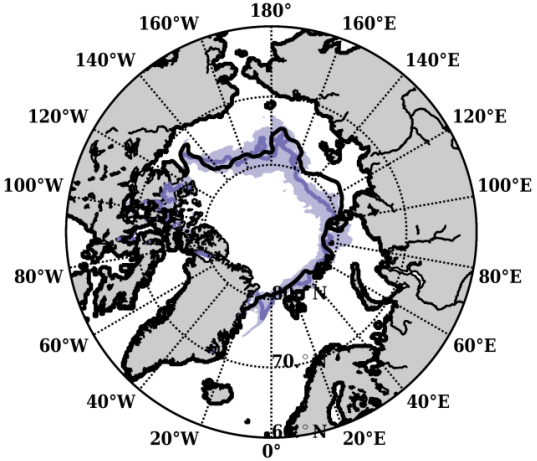
May Ensemble



June Ensemble



July Ensemble



(black) observations from NASA; (light color) NESM ensemble; (bold color) NESM mean

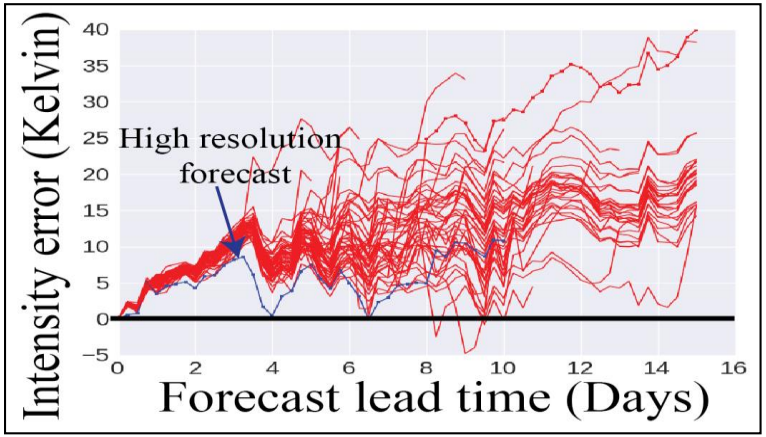
- **Ensemble range (light color shaded) captures observed ice edge (black contour)**
- **Ensemble range shrinks, and ensemble mean (bold color contour) becomes more accurate, as lead time decreases.**

ONR's Departmental Research Initiative on Prediction of Polar Cyclones FY18-22

Title: Overcoming the Barrier to Extended Range Prediction over the Arctic: Understanding and Predicting the Impact of the Tropopause Polar Vortex (TPV)

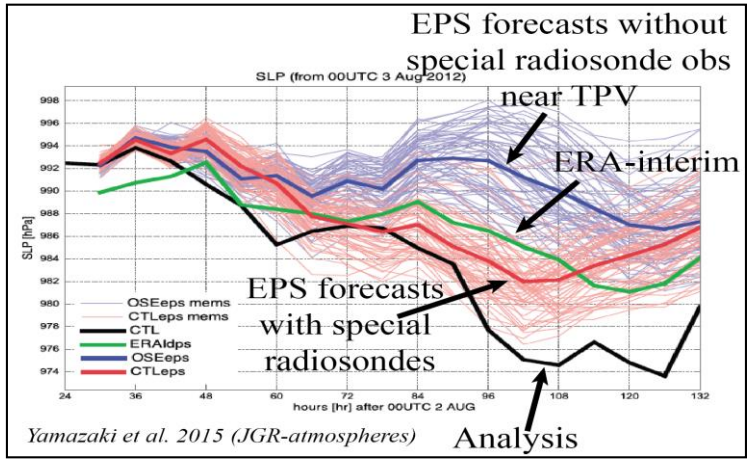
Motivation

Multi-Model Ensemble Predicts Weak TPV



- Average forecast error of about 10 K around 3 days
- Intensity forecast diverge around 1 week
- Best forecast is the high resolution member (blue line)

New Observations aid in Predicting Arctic Cyclones



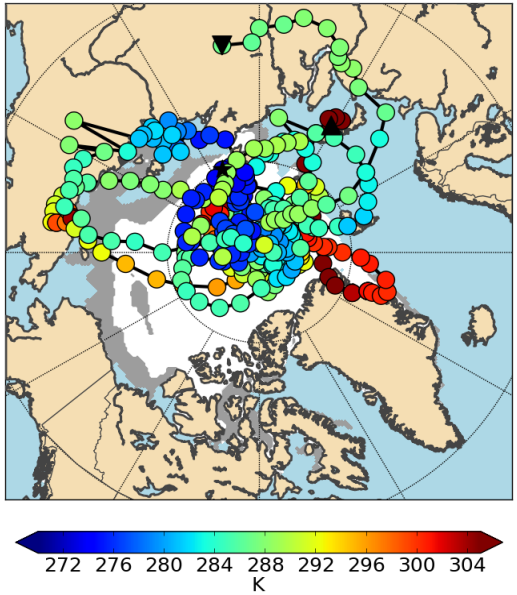
- Strength of TPV is low in all forecasts
- New radiosonde data lead to an improvement in the forecast

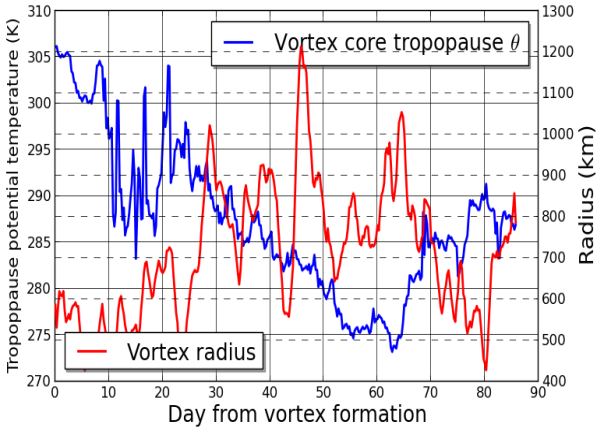
Motivation

- **NWP skill** in **Arctic** is **lacking** compared to other regions
  - Inadequate **observations**
  - Lack of understanding of **key processes** and limited representation in models
- **The Tropopause Polar Vortex (TPV) dominates** the **circulation** over the pole
  - Long-lived feature-> offers the possibility of extended range predictability
  - Barrier to extended range prediction
- **Downstream** Consequences of Miss-Representing **TPVs**
  - TPV controls **Polar Lows** (small, short-lived intense storms)
    - Genesis ***not well predicted*** or understood
    - Greater than ***25% of polar lows can be missed*** in forecast systems
  - Connection with **mid-latitudes**
  - Limits the ability to predict **sea ice**
  - **Seasonal** behavior of **TPV** may explain annual **variability** in **sea ice** cover
    - Small number of poorly predicted but ***energetic*** summer and fall stores
    - Coupled ***atmosphere/ocean/ice*** issue

Tropopause Polar Vortex (TPV)

July-September 2006: Long-lived TPV over the Arctic





TPV Anomaly

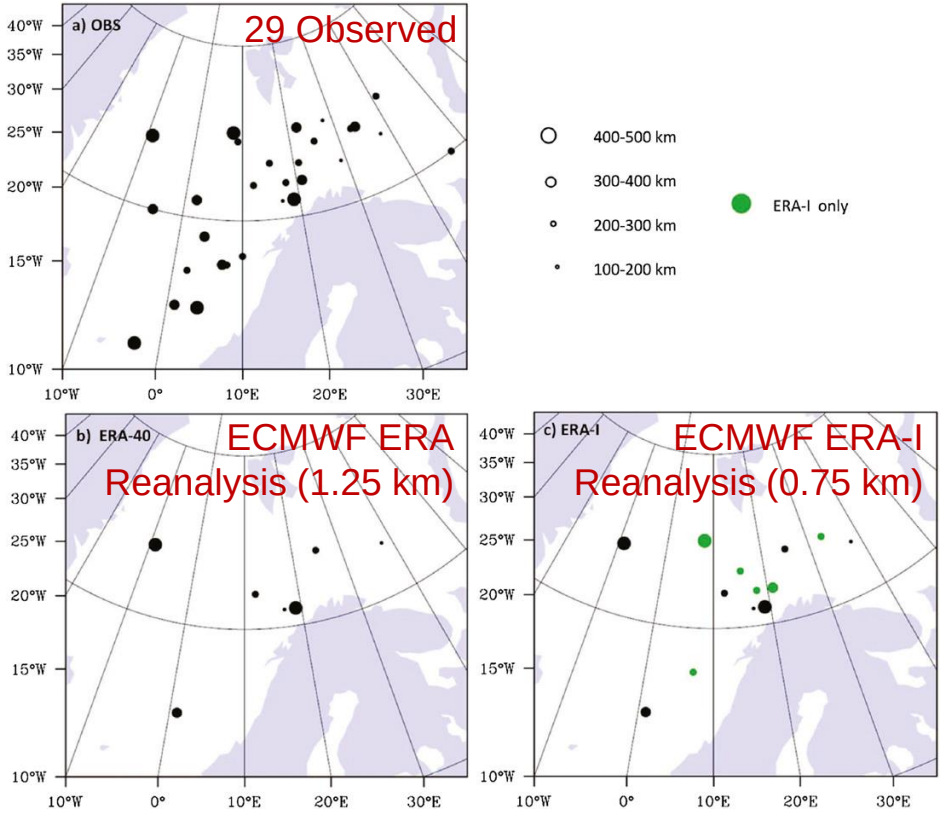
→

Surface Cyclone (e.g., Polar Low)

→

Sea Ice Forcing TPV Radiatively Intensifies Isolation

Poor Model Prediction of Polar Lows



Laffineur et al. (2014)

Many polar lows are missing in some of the best reanalysis products

Key Science Questions

TPV Dynamics, Processes, Predictability

- What are the key processes that influence **TPV development and intensification**? How important are cloud-radiative processes? What allows TPVs to be **long lived events**?
- What processes link **TPVs** to extreme arctic cyclones and **sea ice changes**?
- How do **air-sea-ice interaction processes** occurring at the lower boundary **respond to the influence of high-latitude cyclones**?
- Can new **multi-scale models** (MPAS, NEPTUNE) be used to bridge the climate/weather domain inhabited by TPVs and **increase predictability** of this seasonal driver of smaller scale forcing events?

Arctic Cyclone Dynamics, Processes and Predictability

- What is the **relationship to** the larger-scales and **TPVs**?
- What are the ***key genesis processes***? How does the ***ice edge influence genesis***? What are the **instability mechanisms**? Is *Wind-Induced Surface Heat Exchange (**WISHE**)* operating? PV instabilities?
- What **processes** contribute to the intensification, properties, precipitation, and evolution of Arctic cyclones and their **interactions** with clouds & boundary layer?
- What factors influence the **predictability** of **high-latitude cyclones** and what are the **most important parameters and observations** required for skillful forecasts of high-latitude cyclones and polar lows?

NSF proposal: THINICE

Troposphere High latitude INhibitors to multi-scale sea ICE Predictability

PIs: Steven Cavallo and David Parsons (both from University of Oklahoma)

Objectives:

- Overcome the barrier ***to extended range prediction over the Arctic***
- New understanding of the ***key processes governing the development and evolution of Arctic cyclones***, and their influence on ***coupled air-sea-ice processes***.

Multi-Agency Programmatic Components:

- Office of ***Naval Research Department Research Initiative*** (FY18-22) (already funded); observing campaign planned for FY19/20
- ***NSF*** Program with ***observing campaign*** in FY20 (to be proposed)
- Possible collaborators:
  - UK Scientists (U. East Anglia, U. Reading) (to be proposed):
  - NOAA/NASA Global Archer Program (Summer of 2018 or 2019)
  - NASA ARISE II; NASA-Langley EVS-3; European AC3
  - MOSAiC (2019/20), YOPP (2018-20), CEASAR/COMBLE (winter 2020)

Conclusions

Navy Earth System Model (NESM)

- Atmosphere and Ocean Centric Model
  - Very high resolution ocean and sea ice model, eddy resolving
- Currently used in subseasonal and seasonal prediction intercomparision
- Initially transferred to operational centers in 2018. Full upgrade of system around ~2022

ONR DRI: Overcoming the Barrier to Extended Range Prediction over the Arctic

- Motivated by models inability to predict polar lows and subseasonal prediction in sea ice
- Will examine relationships between Tropopause Polar Vorticities (TPV) and polar lows
- Funded and started

NSF THINICE Proposal

- Multi-agency collaboration to observe Arctic region with the goal to improve the understanding of polar storms and sea ice

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