Breakout groups:

Today's emphasis: The present status, challenges and opportunities for improved predictions, building from today's presentations, i.e., identify high-priority issues

Tomorrow's discussion will focus much more heavily on actions

Start with a service perspective, i.e., services as a driver; let NOAA services have a first voice.

Ola Persson (OAR), Wayne Weeks (NWS), and Hal Ritchie (EC):

Start from Services:

What are primary prediction challenges for services now? What are the critical variables or fields?

- Public not being aware of some of the products being out there – outreach needed; some communities may not have an "emergency manager;" some of the folks in these communities may not be native English speakers, may not have a computer at home, may not even be literate. They want and need input as to what's happening, where's flooding, etc., too.
- Villages work on VHF and ham radio – no equivalent to WX Radio Sea ice prediction is dependent on wind, wave height – if you improve one, you improve others

- Top challenge – getting good wx prediction

- What are forecast variables or events for which there is a large demand, i.e., break-up of land-fast ice
- Need to know wind, waves, how much rain/snow to produce flooding, storm surge
- River melt and flooding
- Fire weather forecasting
- Sea ice prediction is dependent on wind, wave height – if you improve one, you improve others. Overall goals to support communities, safety in navigation
- Coastal erosion and storm systems – open water led to long fetches
    - Complex
    - Evacuation of communities?

- **Of the services we provide now, what are the ones has the lowest reliability, forecast busts, etc?**
- **Models have coarse resolution, poor measuring of Bering Sea inflow**
- **Freezing spray, Snow cover , Fog**

- **Coupling to the ice, Dynamics, wind forcing, air-ocean temperatures, etc.**

- **Mixing scheme not correctly implemented – changes to heat content before, during, and after storm**
- **Understanding upper structure**
- **Reliability of products? Yes and No. Forecast verification is "burr" in saddle, i.e., vessel icing model, no verification, no observations. Sea ice model/sea ice drift – 20 years of verification.**
- **Is there a similar call to predict polar low within 6 hours?**

What advances in predictions are most needed to address these challenges (lead times, spatial resolution, etc.)?

- Improved lead times (three-fold improvement)
- Improve vertical and horizontal resolution – for aviation and nearshore
- Improvements in model physics

What new prediction products are likely to be required between now and 2020?

- Prediction of ice-free season (onset and end, breakup, and length) – for oil exploration
- Passability of the Northwest and Northeast Passages – teach users about probabilistic forecasts
-

What are the drivers and where is the demand for new products coming from?

- Arctic communities, oil exploration, aviation, renewable energy, minerals, marine, tourism, fisheries, ice road viability

Consider modeling next:

What are the primary challenges for model predictions in the Arctic now?

- Wave, ice, and tides/interactions and dynamic processes need to be implemented into model
- Lots of unknowns about where to make improvements – need validation/testing of various components of models, i.e., in atmosphere, forcing over sea ice, do we know if forcing is correct? Atmospheric radiation due to clouds – impacts on net surface flux? There are case studies we can do; there are some improvements to buoys, putting wind measurements.
- Winds
- Ice drift
- Need to examine and verification coupled systems; flux corrections between the atmosphere and ocean

- #1 challenge -- Validation and observations!!!!!!!!!! How can we get remote based obs that match model forecasts that are well linked to sensible forecasts? Alaska is not going to get $40 million for an obs network!

What is required to address these challenges (improved representation of key processes, data assimilation, higher horizontal or vertical resolution, etc.)?

- Yes to everything in paren
- Vertical mixing in ocean and atmosphere
- Handling of leads in land-fast ice
- Higher resolution models for both atmosphere and ocean
- Representation of clouds and radiative impacts

What advances in observations or process understanding would likely have the largest impacts on improving predictions of the Arctic coupled system?

- RAOBs over the Arctic
- Arctic COSMIC
- Flying Global Hawk 3 times a week

Processes and Observations:

What are the major gaps in process understanding in the Arctic?

- For coastal regions, anchoring process in land-fast ice
- ** Dynamics and thermodynamic processes air-ice-wave-sea-tides interaction
- Processes in marginal ice zone we don't really understand
- ** Impact of river input into Arctic Ocean
- Impact of heat advected through Bering Strait and from Atlantic Ocean
- E-P
- ** Clouds and radiative impact
- ** Ice concentration
- ** Snow depth – hugely affects albedo
- SST in marginal ice zone
- ** Aerosol forcing
- Ice-ocean-snow albedo feedback process in the coupled ice-ocean model – melt pond
- ** **We don't know how any one of these things affect the skill of our forecasts**

** "Major"

What are observations needed to improve this understanding and steps that would accelerate transfer of this knowledge into prediction model improvements?

- Density of surface obs and remote sensing obs
- Dropsondes from Global Hawk over water

- Field campaigns for validation data and studies on these processes
- Novel instrumentation for improved observation over the Arctic Ocean – UAS, AUV, NTM
- Measurement and parameterization of melt ponds – UAV

What are the major gaps in Arctic observations limiting predictions?

- Funding
- People
- Autonomous Insitu Sensing
- International agreements for instrument deployment and data sharing
- Interagency data sharing
- Referred to obs above
- Common access, easy navigability, documentation of data collected

What steps can NOAA take between now and 2020 to help optimize the observing system?

- An Act of Congress – funding, authority (mandate)
- Common access, easy navigability, documentation of data collected – an offline NOAA group to discuss
- Encourage improvement of models in the processes defined above
- Encourage filling the observational gaps defined above