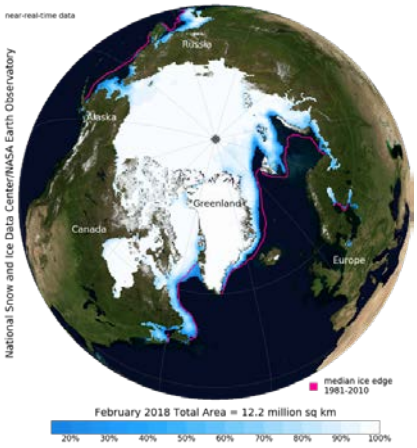
DOE ARCTIC SEA ICE MODELING

The Arctic region is changing faster than any place on Earth. This is most strongly reflected in the continuing retreat of arctic sea ice. In fact, the Arctic Ocean is transitioning from a state of permanent ice cover to one that is virtually ice-free in summer. This will increase demands for environmental intelligence from national stakeholders, including energy, shipping and tourism industries, native communities, national defense, and policymakers.

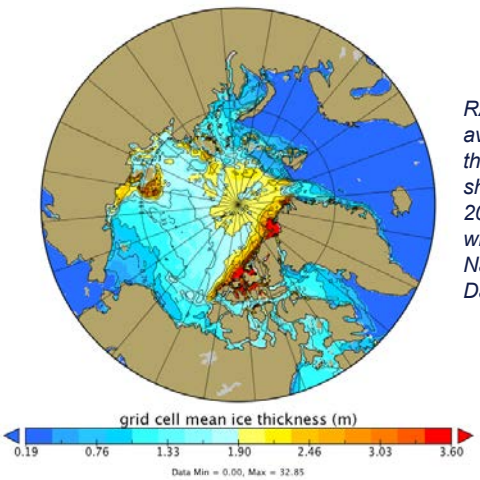
The U.S. Department of Energy (DOE) Biological and Environmental Research (BER) program provides this intelligence through its ongoing support of arctic sea ice modeling, analysis, and predictability efforts using some of the world's most powerful high-performance computing (HPC) resources. DOE research efforts aim not only to project sea-ice change, but also to understand complex interactions between sea ice and other parts of the Earth system.



Monthly average Northern Hemisphere observed sea ice area is shown for February 2018. The red contour line represents the median February ice edge.

CICE CONSORTIUM

The world's best-known sea ice model is CICE, led by Los Alamos National Laboratory. Since its development by DOE in the early 1990s, many of the world's top climate and weather centers have adopted the code. The recently established CICE Consortium is an interagency alliance led by DOE that enables the use and further development of the model by international centers.



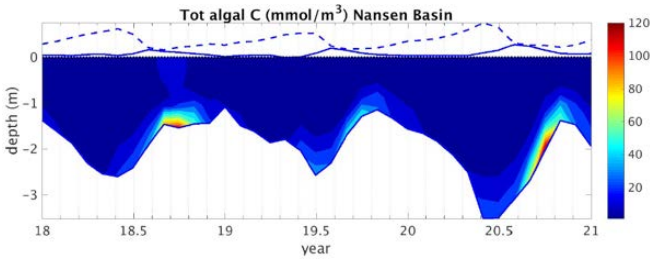
RASM monthly average sea ice thickness and area is shown for February 2018 for comparison with the February 2018 National Snow and Ice Data Center image.

REGIONAL ARCTIC SYSTEM MODEL (RASM)

RASM is an Arctic-focused regional model that is jointly supported by DOE and multiple U.S. agencies. This regional model allows the representation of complex arctic earth system processes with unprecedented detail. RASM is currently participating in the Sea-Ice Prediction Network, which makes seasonal predictions of summer sea ice.

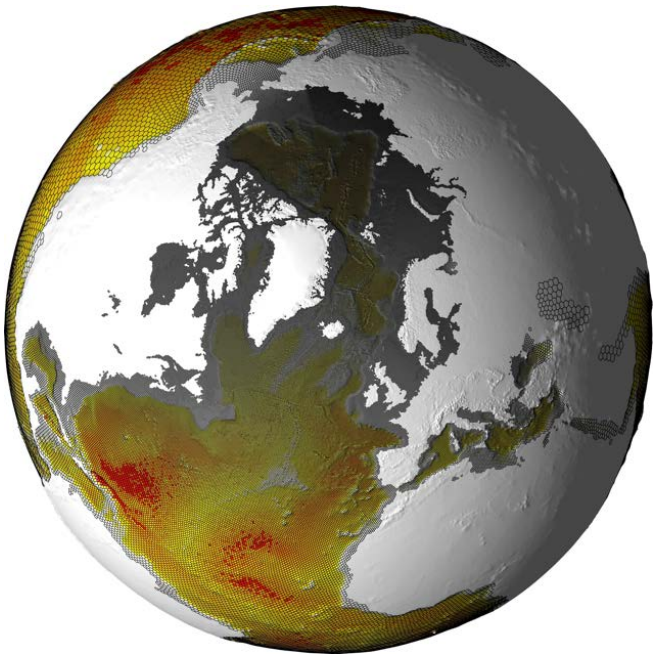
HIGH-LATITUDE APPLICATION AND TESTING OF EARTH SYSTEM MODELS (HiLAT)

Arctic sea ice is strongly influenced by other earth system components, like the atmosphere, ocean, and even the biosphere. HiLAT studies the Arctic earth system from an integrative, multidisciplinary perspective. For example, it studies the role of algae blooms in sea ice to understand



Algae blooms in arctic sea ice, as simulated by the Los Alamos National Laboratory sea ice model CICE.

the impact on sea ice thermodynamics and permeability. In addition, HiLAT has performed analyses to determine what causes changes to sea ice.



A prototype is depicted for the E3SM arctic regionally refined ocean/sea ice grid with high resolution in the Arctic and North Atlantic Oceans.

ENERGY EXASCALE EARTH SYSTEM MODEL (E3SM)

DOE manages some of the most powerful supercomputers in the world, and BER is harnessing these resources to enhance scientists understanding of the earth system.

One of the best uses of this computational power is the DOE's global Energy Exascale Earth System Model (E3SM). The first version of this model was released in April 2018 and offers researchers unprecedented opportunities to improve modeling of the arctic earth system.

The E3SM team is collaborating with the HiLAT and RASM teams to develop a unique arctic-focused modeling capability. The resulting global model will resolve fine-scale Arctic processes and interactions while still operating in a global context.

NEXT-GENERATION SEA ICE MODELS

While increasing DOE's computer power allows scientists to refine the representation of processes in models, it also requires rethinking traditional modeling paradigms. Sea ice is a case in point: on large scales, sea ice can be accurately treated as a layer of deformable material. On a smaller scale, sea ice is better represented as a collection of floating ice pieces interspersed by areas of open water. This approach is explored by a SciDAC—Scientific Discovery through Advanced Computing—project (DEMSI) that explicitly treats this new physics treatment for deformation and flow of ice.

FUTURE DIRECTION OF DOE ARCTIC RESEARCH

With its unique focus on high-performance computing and support of projects like E3SM, HiLAT, RASM, DEMSI, and the CICE Consortium, DOE is on the leading edge of arctic research and is optimally positioned to advance knowledge and predictability of the arctic system. DOE is also committed to fostering strong interagency collaborations, which includes leadership in the Interagency Arctic Research Policy Committee (IARPC) connecting federal and non-government researchers and other stakeholders to solve scientific challenges.

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