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Earth Sciences Department
Climate Prediction Group

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Impact of resolution increase on Arctic sea ice modes of variability

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KNMI, Utrechtseweg 297
NL-3731 GA De Bilt
The Netherlands
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HORIZON 2020 | MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC-CNS) is the premium HPC center in Spain at the **Universitat Politècnica de Catalunya (UPC)** north campus in Barcelona

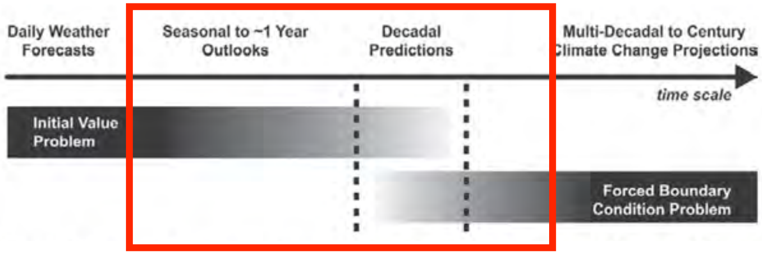
More than 450 members (from more than 30 countries) are organized in 6 departments:

- → Computer Sciences
- → **Earth Sciences**
  - Atmospheric composition
  - **Climate prediction**
  - Earth System Services
  - Computational Earth Sciences
- → Life Sciences
- → Computer Applications
- → Operations
- → Management

MareNostrum III (housed in the former chapel Torre Girona) is one of the most powerful supercomputers in Europe (48,128 processors with 1.1 Pflops peak performance)

➠ upgrade next year: **MareNostrum IV**

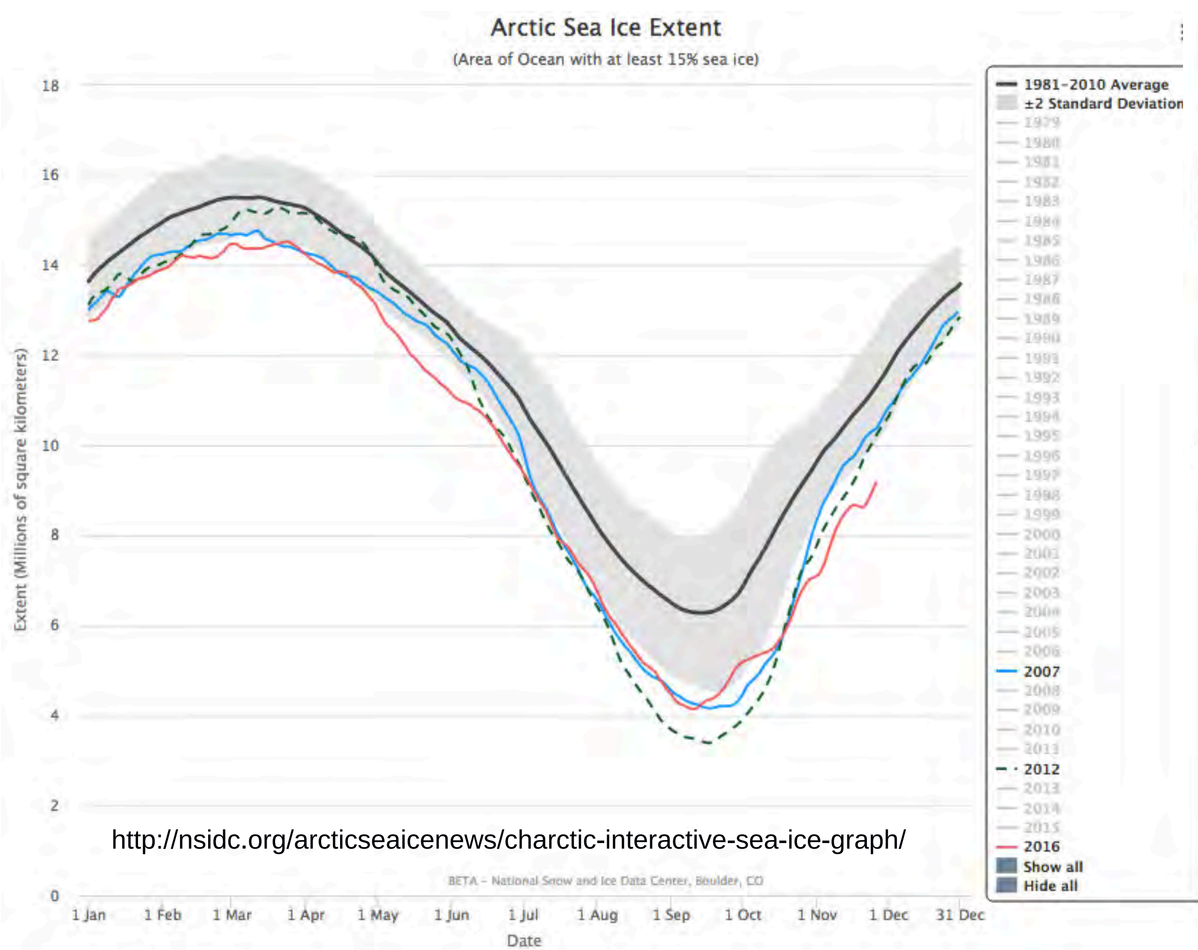
→ Climate Prediction Group



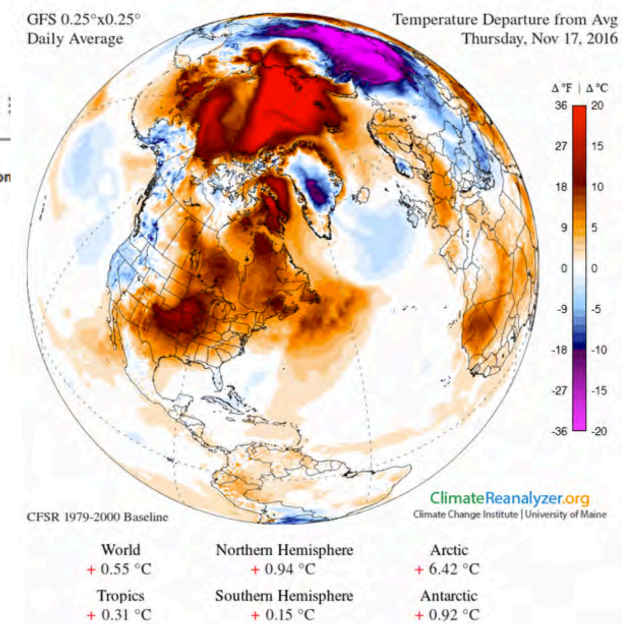
Focus on sub-seasonal to multi-decadal range of forecast horizons when memory of initial state (IC) and boundary forcing (BC) are both important

→ reanalyses/reconstructions critical for understanding climate evolution and IC

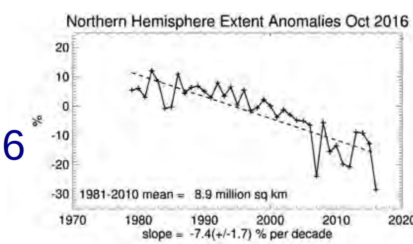
- **Observed changes in Arctic**



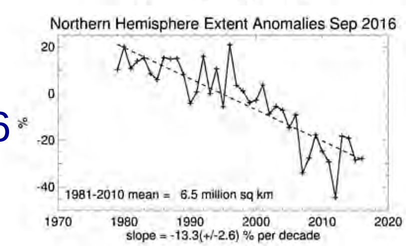
http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/



Oct 2016



Sep 2016



NSIDC Sea Ice Index v2

Impact on an increase in horizontal resolution

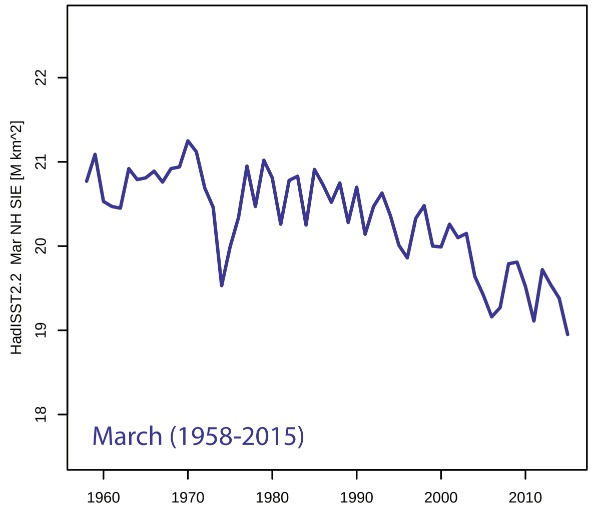
- Within the framework of PRIMAVERA project here we explore the benefit of *increased horizontal resolution in ocean and sea ice* for the fidelity of climate variability and change on global and regional scales
- We examine change in physically relatable patterns/modes of the NH sea ice variability on seasonal to interannual time scales (disentangled from a long-term climate change) as we increase resolution *4x*

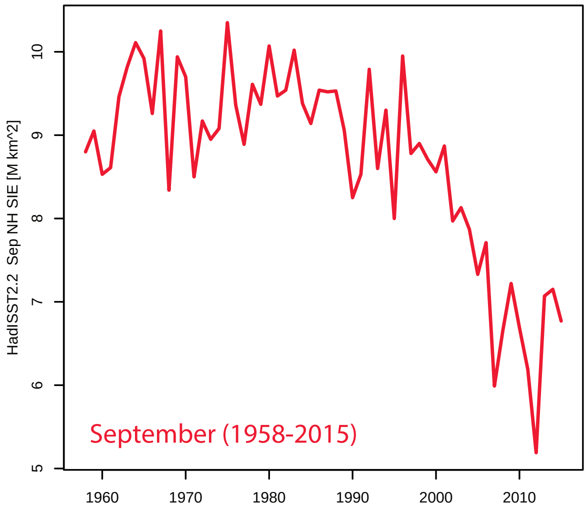
  → *adapt new statistical framework for study of sea ice variability based on the concept of weather regimes and clustering methodology*

  Wilks D (2011) Statistical methods in the atmospheric sciences, 3rd edn. Academic Press, London, p 704

HadISST 2.2.0.0

www.metoffice.gov.uk/hadobs/hadisst2/





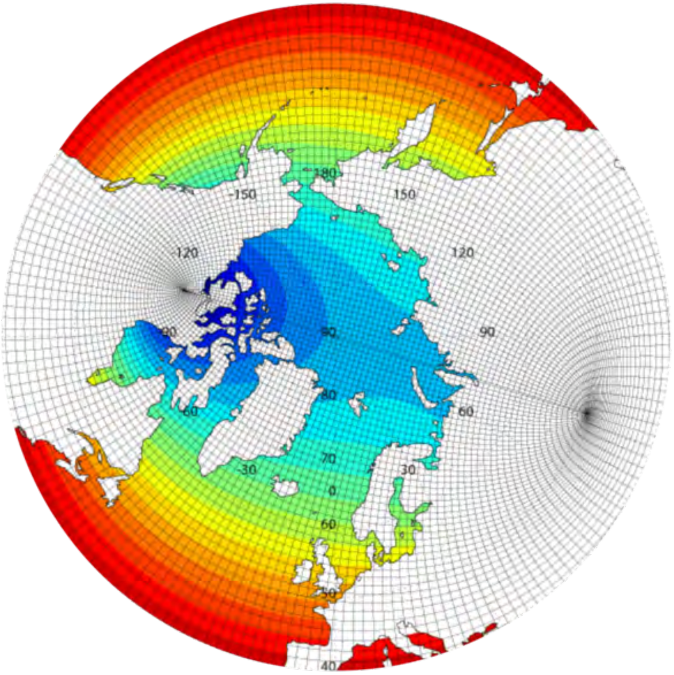
Forced ocean-sea ice general circulation model

- We use Nucleus for European Modelling of the Ocean model version 3.3 (NEMO3.3) with the embedded Louvain-la-Neuve sea Ice Model version 3 (LIM3) using single sea ice thickness category

- NEMO-LIM3 is forced by the DFS4.3 surface forcing fields from 1958 to 2006 following the CORE bulk formulae

- We compare results of ORCA1L46 (nominal 1° horizontal resolution) and ORCA025L75 (nominal 0.25° horizontal resolution) configurations

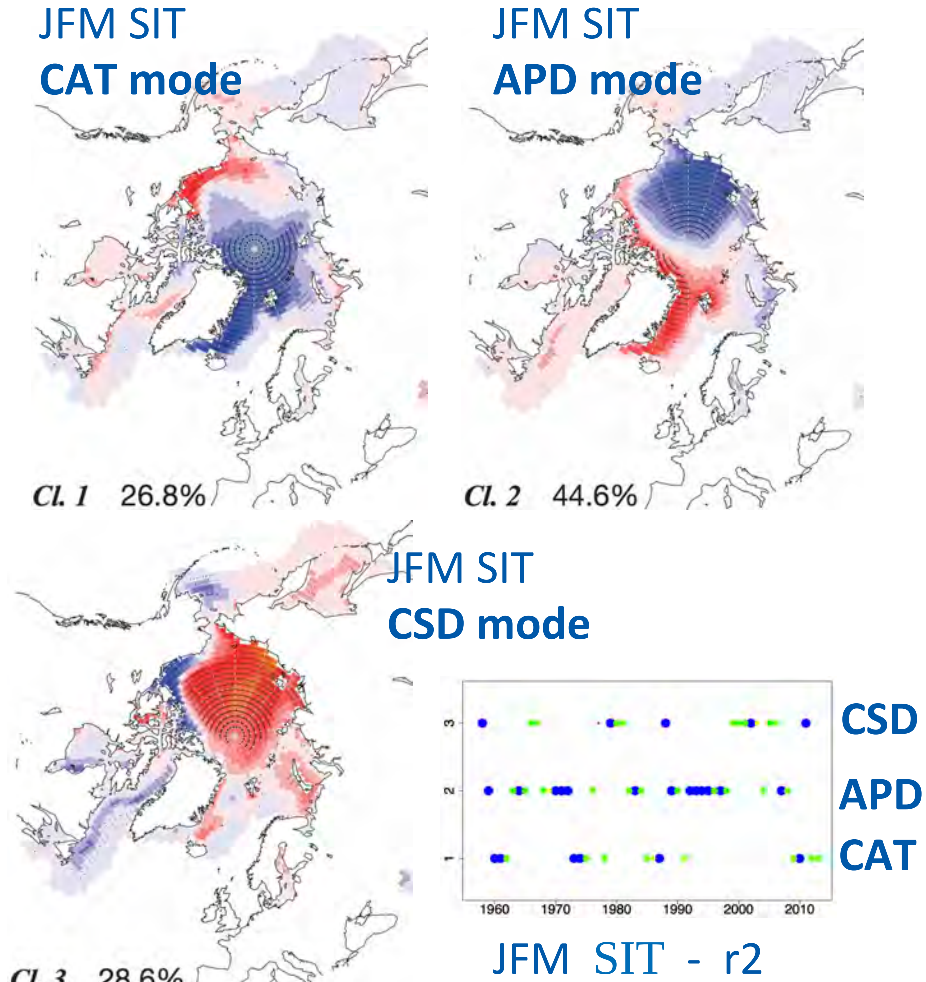
- NEMO-LIM3 simulations are initialized on 1 January 1958 from ensemble-mean of the ECMWF's Ocean Reanalysis System 4 (ORAS4) and the associated ensemble-mean sea ice reconstruction from BSC



● Guemas V, Doblas-Reyes FJ, Mogensen K, Tang Y, Keeley S (2014) Ensemble of sea ice initial conditions for interannual climate predictions. Clim Dyn. doi:10.1007/s00382-014-2095-7

K-means cluster analysis

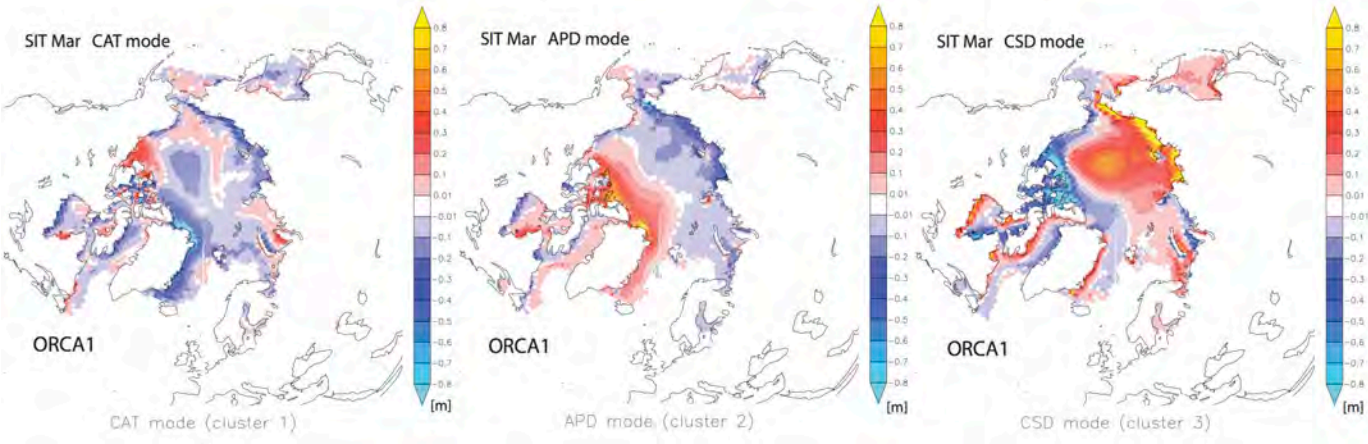
- ***K*-means method** is non-hierarchical clustering analysis that allows reassignment of members between different clusters (not possible in hierarchical clustering):
  - → **optimal number of clusters K** (typically determined via hierarchical approach) **has to be specified in advance**
  - → **produces** representation of the spatial and temporal variability with **K patterns of cluster centers and time series of cluster occurrences**



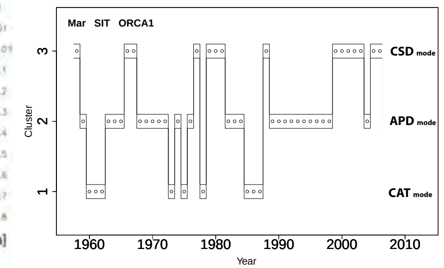
● Fučkar, N.S., V. Guemas, N.C. Johnson, F. Massonnet, and F.J. Doblas-Reyes. (2016) Clusters of inter-annual sea ice variability in the northern hemisphere. Clim Dyn 47: 1527. doi:10.1007/s00382-015-2917-2

ORCA1/ORCA025 - March (1958-2006)

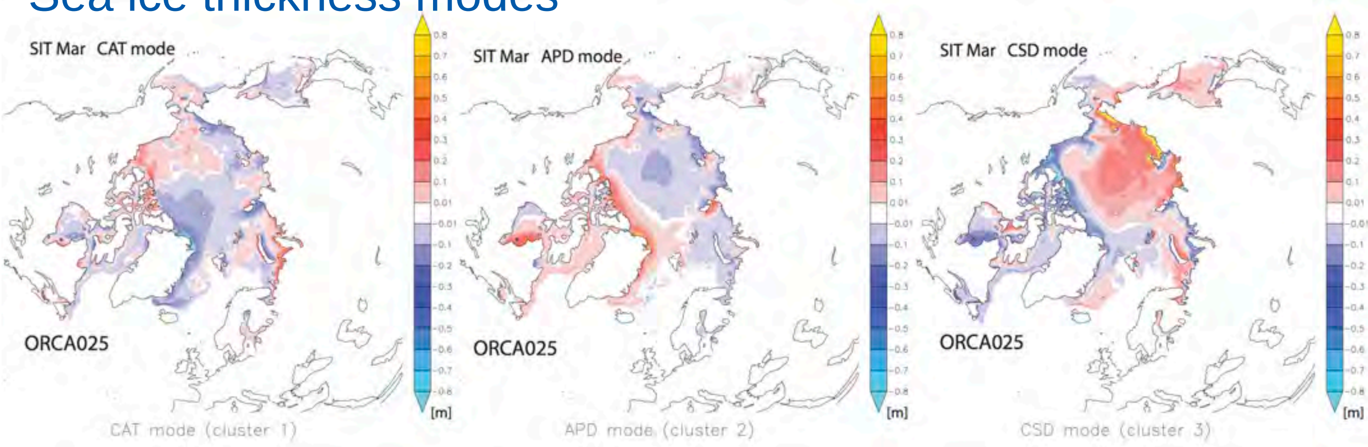
Sea ice thickness modes



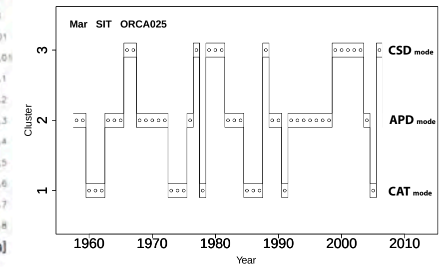
ORCA1
March



Sea ice thickness modes

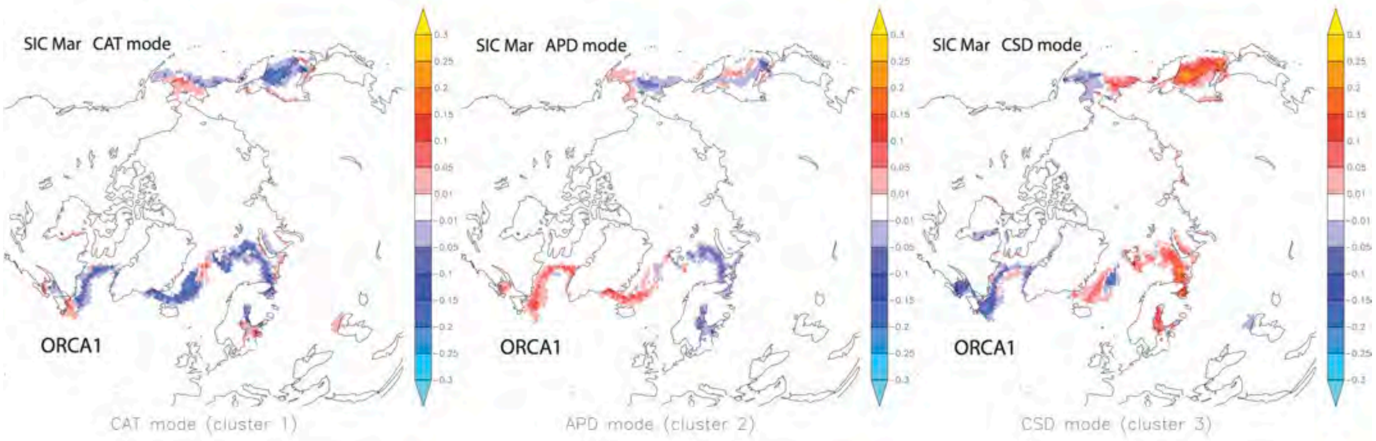


ORCA025
March

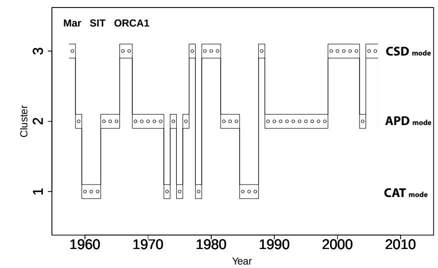


ORCA1/ORCA025 - March (1958-2006)

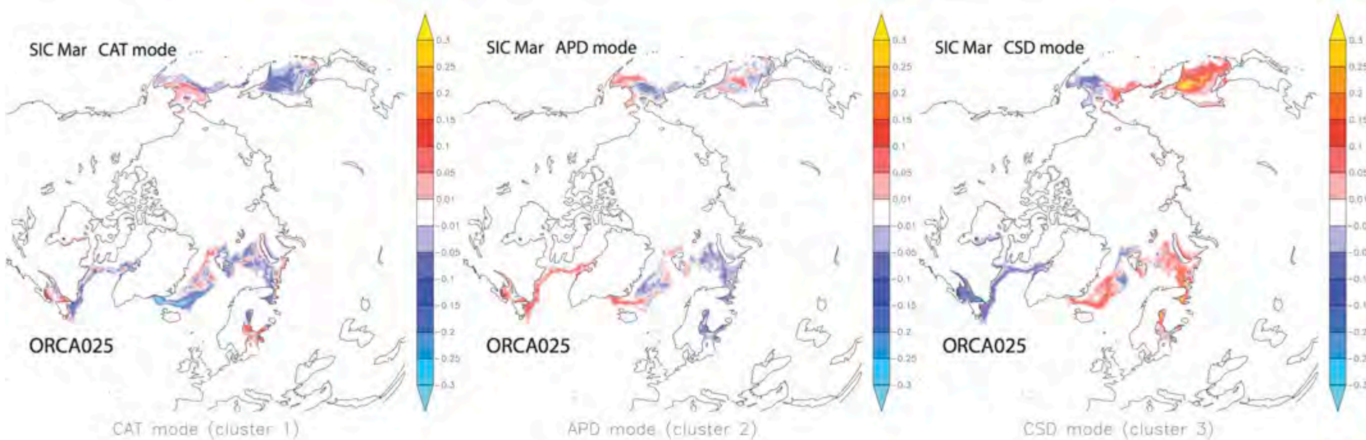
The associated sea ice concentration modes



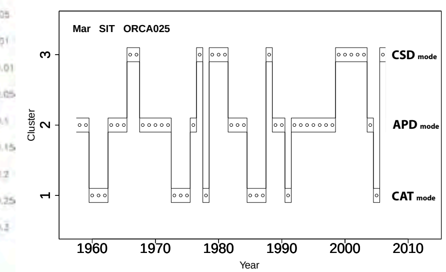
ORCA1
March



The associated sea ice concentration modes

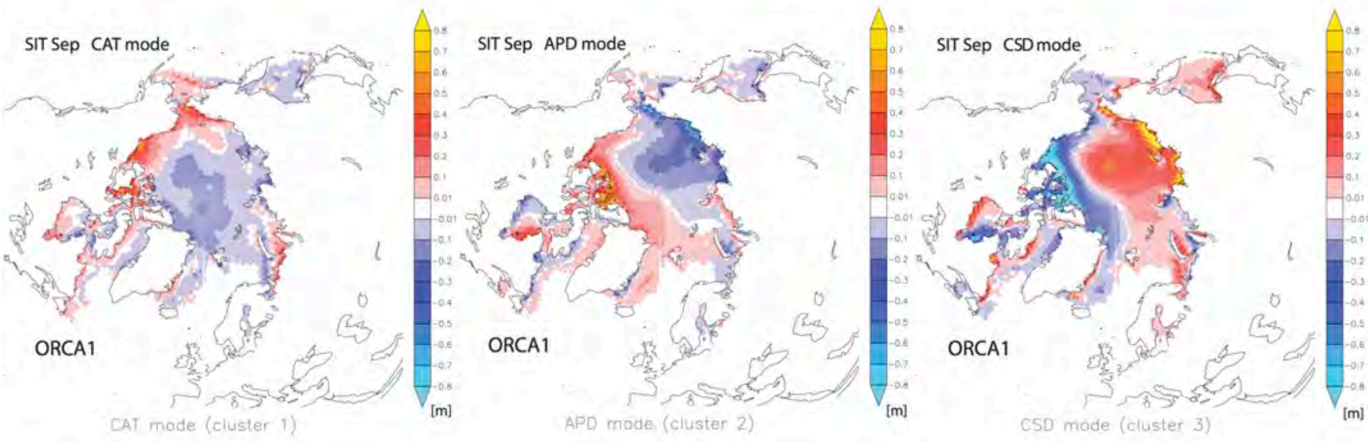


ORCA025
March

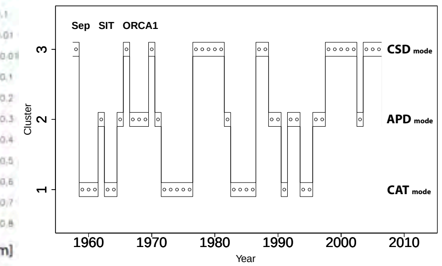


ORCA1/ORCA025 - September (1958-2006)

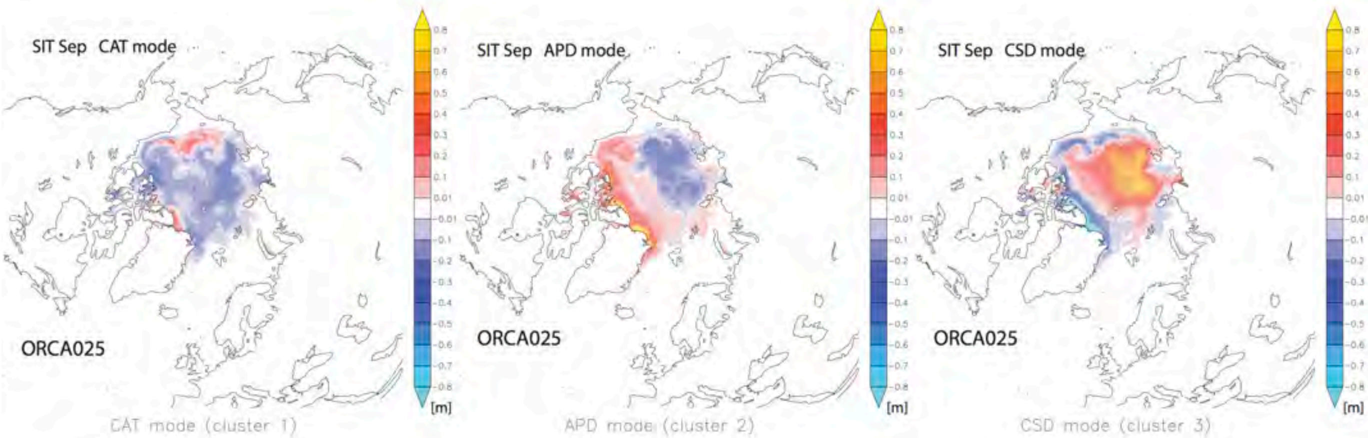
Sea ice thickness modes



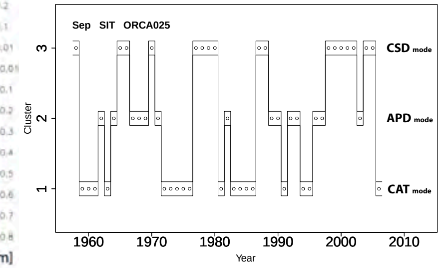
ORCA1
September



Sea ice thickness modes

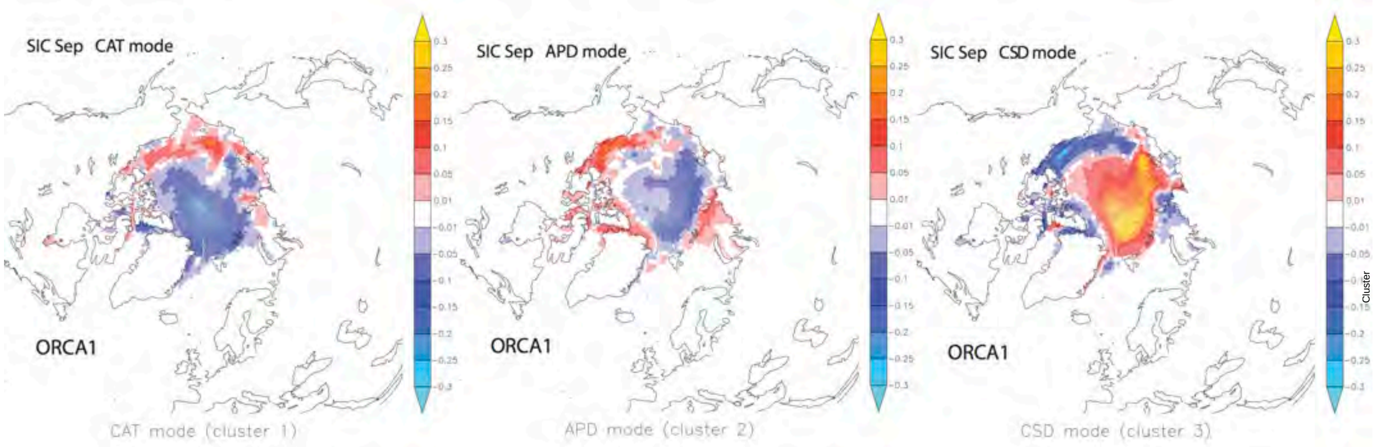


ORCA025
September

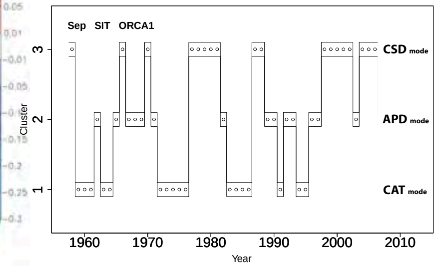


ORCA1/ORCA025 - September (1958-2006)

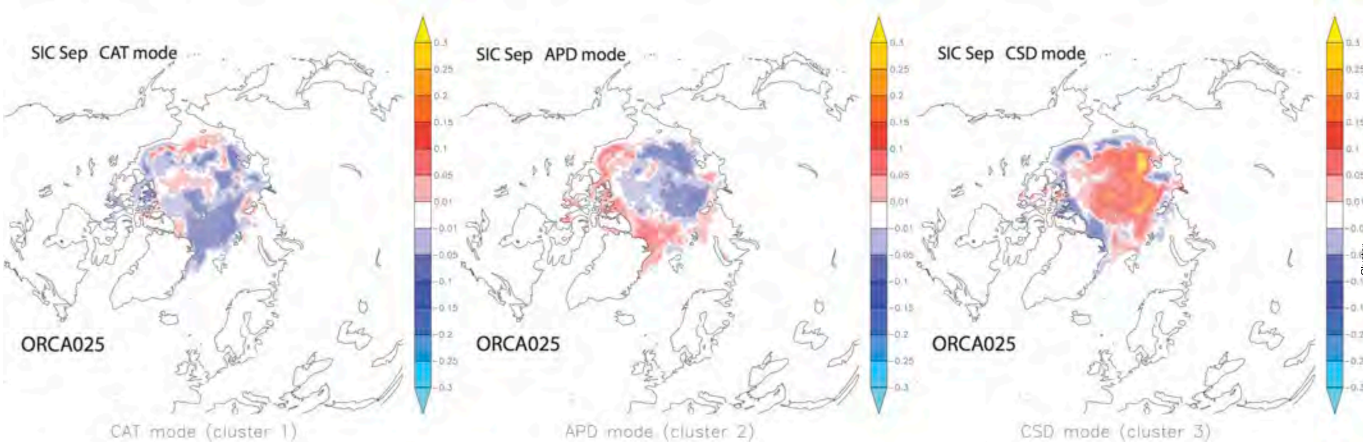
The associated sea ice concentration modes



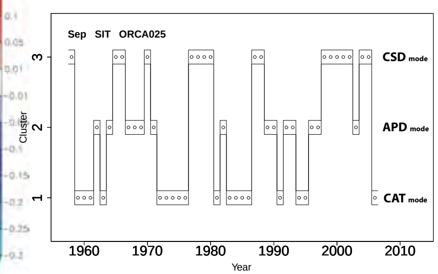
ORCA1
September



The associated sea ice concentration modes



ORCA025
September



Summary and conclusions

- We have confirmed the three NH SIT modes: Central Arctic Thinning (CAT) mode (cluster 1), Atlantic-Pacific Dipole (APD) mode (cluster 2), and Canadian-Siberian Dipole (SCD) mode (cluster 3)
- Monthly time series of NH SIT mode occurrences in simulations with different horizontal resolutions show some differences, but overall their persistence values are compatible and reach to inter-annual timescales
- The pattern of CAT mode exhibits the highest level of inter-seasonal and inter-resolution variability (i.e., APD and CSD modes are more consistent among different model's resolutions and different months)
- Both resolutions appears to have too much SIC variability in central Arctic in summer
- ORCA1 (ORCA025) often has a stronger amplitude of mode anomaly patterns in winter (summer) than ORCA025 (ORCA1)