Research Experiences for Teachers

# Longwave Radiation Impacts Winter Arctic Sea Ice Cover


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## 1. Abstract

The relationships between outgoing longwave radiation (OLR), surface downward longwave radiation (SDLR), and sea ice cover (SIC) in the Barents and Kara seas are being investigated using satellite and surface data from NASA CERES and ECMWF. Long-term trends and seasonal cycles were removed from the data to focus on these relationships only. The strong negative correlations between monthly sea ice cover and winter OLR/SDLR in the Barents and Kara seas show that longwave radiation can still cause sea ice to melt even without sunlight during Arctic winters. A comparison between the monthly longwave radiations to monthly SIC in the Barents Sea suggests that an increase in SIC results in less moisture in the atmosphere, causing more radiation to escape as OLR and trapping less as SDLR in the summer. In the Kara Sea, September OLR and SDLR could be one of the strongest predictors of fall and winter SIC. From the negative correlation, more September OLR predicts less fall/winter SIC. An increase in OLR is positively correlated with absorbed shortwave radiation (ASR) in preceding summer months. As more radiation is absorbed, temperatures increase, causing sea ice to melt and evaporate. The increase in moisture in the atmosphere allows more heat to be trapped as SDLR.


## 2. Data Description

Solar and terrestrial radiation data obtained from NASA's CERES (Clouds and the Earth's Radiant Energy System) instruments on the Terra, Aqua, and Suomi NPP satellites. Sea ice cover data was obtained from ECMWF's ERA-Interim climate reanalysis, which is produced by combining models and observations. Data ranges from 2000-2016.

## 3. Monthly SIC vs Winter OLR/SDRL

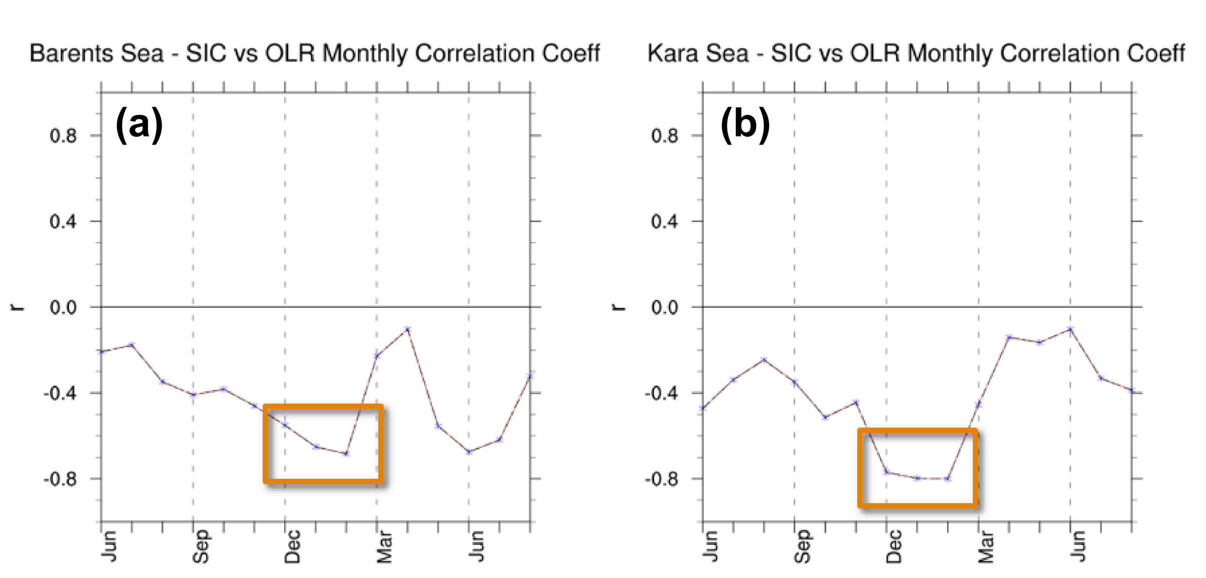



**Figure 1:** Correlation coefficient of monthly SIC vs winter OLR plotted as a function of time in (a) Barents and (b) Kara seas. Boxed region shows strong negative correlation between the variables in winter months.

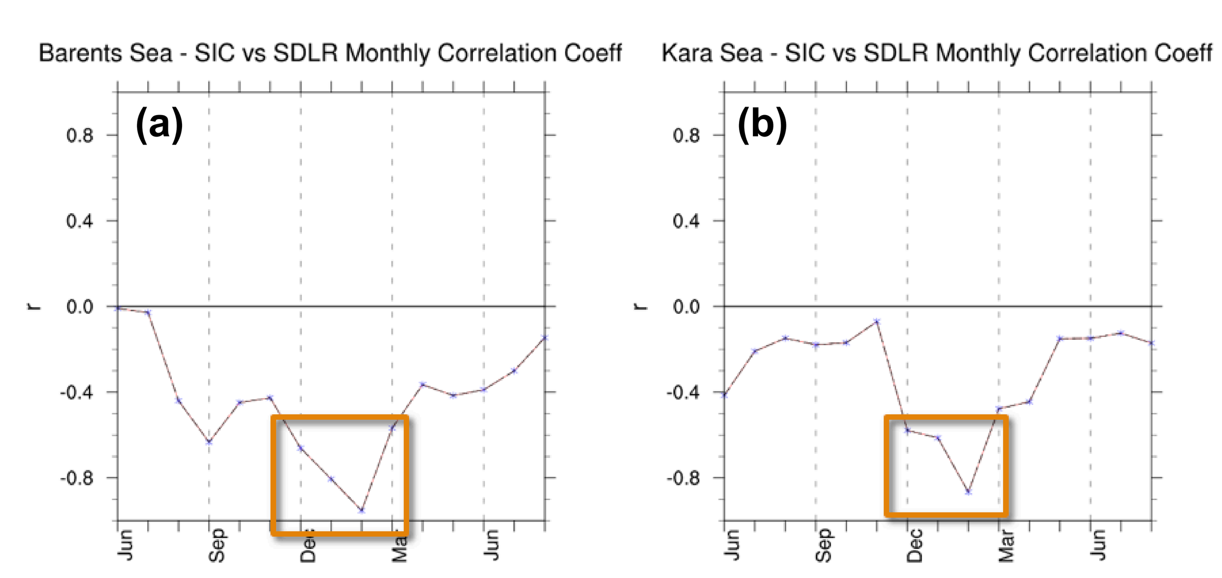



**Figure 2:** Correlation coefficient of monthly SIC vs winter SDLR plotted as a function of time in Barents and Kara seas. Boxed region shows strong negative correlation between the variables in winter months.

These figures show that as winter OLR and SDLR increase, winter SIC decreases.

## 4. SIC vs OLR/SDLR vs Correlation Coefficient – Barents Sea

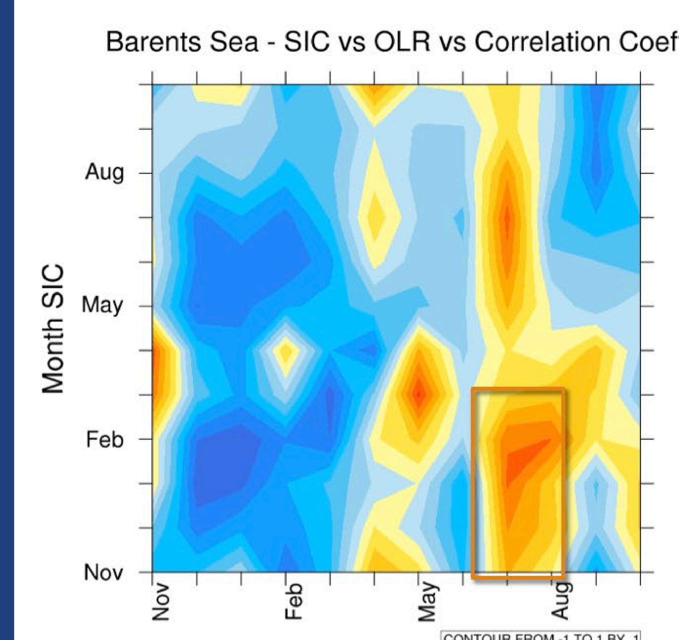



Fig 3.

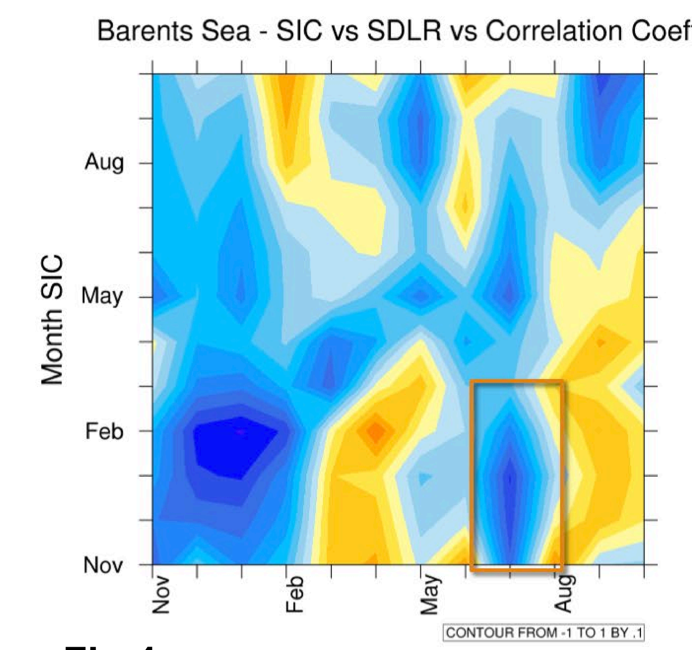



Fig 4.

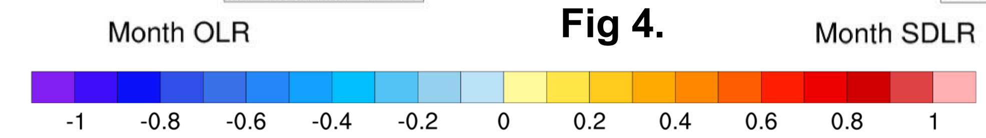



**Figure 3:** Contour Plot shows correlation coefficients of SIC and OLR at corresponding months for the Barents Sea. Boxed region shows that winter SIC is positively correlated with summer OLR.
**Figure 4:** Contour Plot shows correlation coefficients of SIC and SDLR at corresponding months for the Barents Sea. Boxed region shows that winter SIC is negatively correlated with summer SDLR.

These figures show that the more SIC in the Barents Sea during winter, the more OLR and less SDLR should be expected in the following summer. This is likely due to decreased moisture in the atmosphere, allowing more heat to escape and less to be trapped.

## 5. SIC vs OLR/SDLR vs Correlation Coefficient – Kara Sea

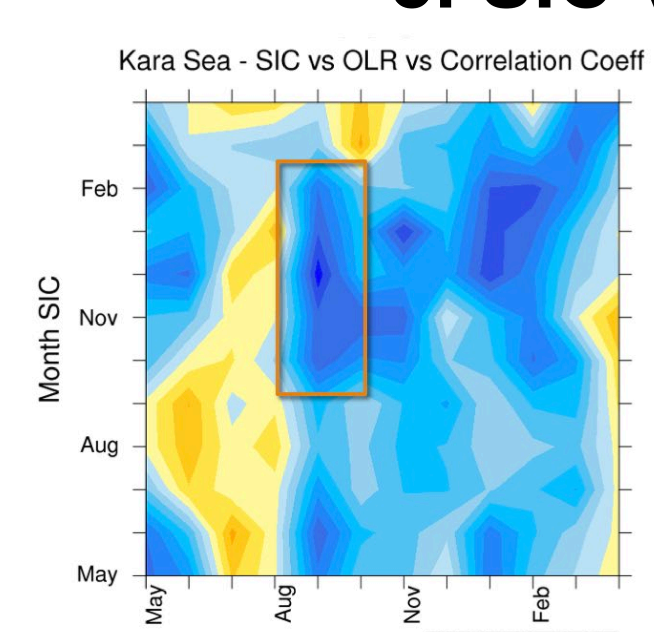



Fig 5.

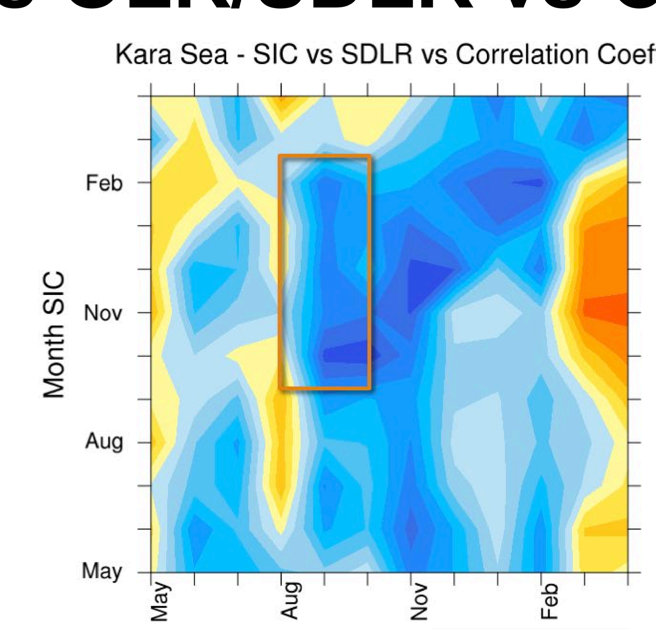



Fig 6.

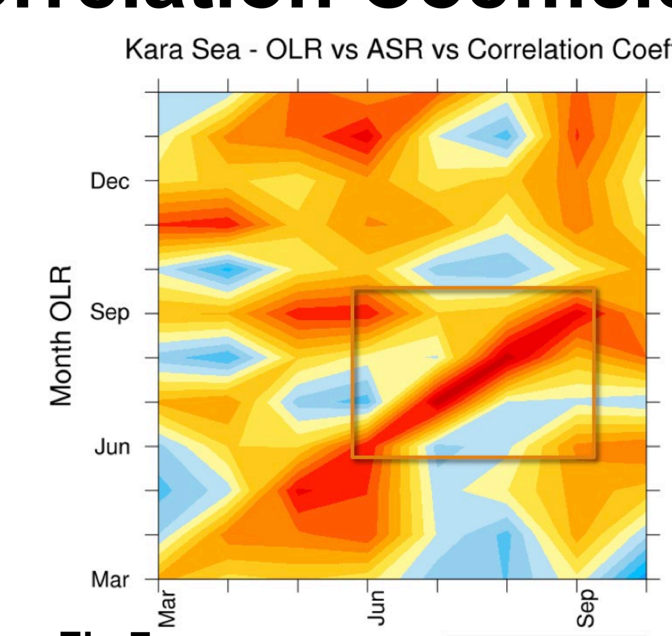



Fig 7.

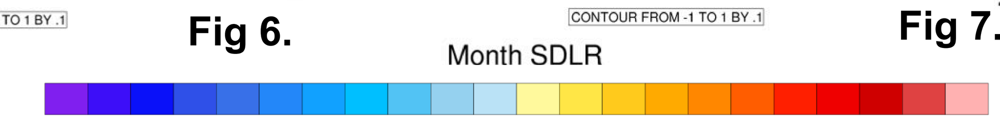
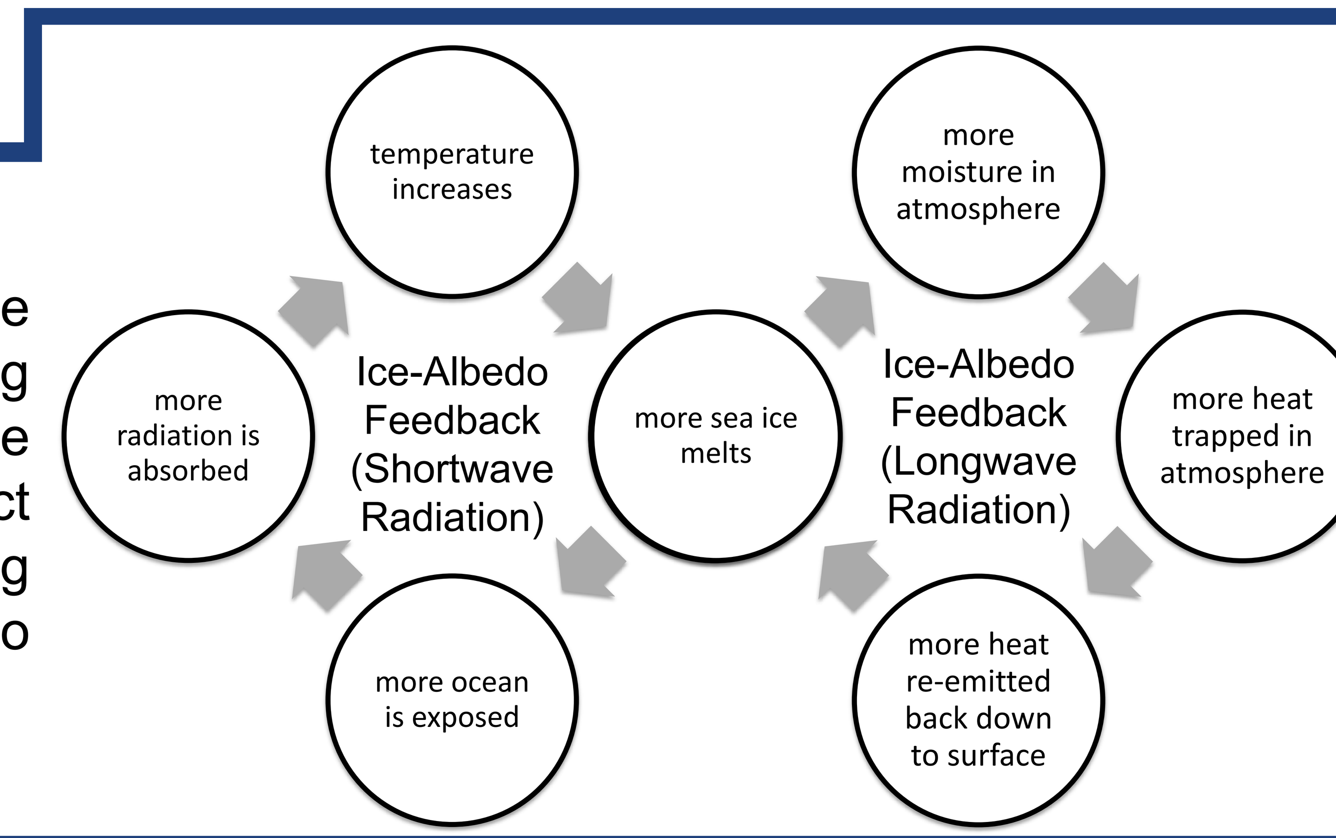



**Figure 5:** Contour Plot shows correlation coefficients of SIC and OLR at corresponding months for the Kara Sea. Boxed region shows that September OLR is negatively correlated with fall and winter SIC.
**Figure 6:** Contour Plot shows correlation coefficients of SIC and SDLR at corresponding months for the Kara Sea. Boxed region shows that September SDLR is negatively correlated with fall and winter SIC.
**Figure 7:** Contour Plot shows correlation coefficients of OLR and ASR at corresponding months for the Kara Sea. Boxed region shows that an increase in ASR during the months of June through September is strongly correlated with an increase in OLR during the same period of time.

These figures show that the more OLR and SDLR in the Kara Sea during September, the less fall and winter SIC should be expected because more ASR results in more OLR and puts more moisture in the atmosphere, trapping more heat.

## 6. Conclusion

Solar radiation is thought to be the most important factor influencing sea ice melting, but longwave radiation also has a strong impact on the melting of sea ice during Arctic winters when there is no sunlight present.





## 7. Acknowledgments

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## 8. References


Park, D.-S., S. Lee, and S. B. Feldstein 2015: Attribution of the recent winter sea-ice decline over the Atlantic sector of the Arctic Ocean. J. Climate, 28, 4027-4033.
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Lee, S., Gong, T., Feldstein, S. B., Screen, J. A., & Simmonds, I., 2017: Revisiting the cause of the 1989–2009 Arctic surface warming using the surface energy budget: Downward infrared radiation dominates the surface fluxes. Geophysical Research Letters, 44, 10,654–10,661.



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