Surface turbulent heat fluxes response to the variability of the Arctic sea ice

The major input by Selivanova Julia (2nd year of PhD)
Verezemskaya Polina (PhD competed this year)

Presenting author:
Natalia Tilinina

Shirshov Institute of Oceanology, Moscow, Russia

Project leaders:

Sergey Gulev
Shirshov Institute of Oceanology, Moscow, Russia

Thomas Jung
Alfred Wegener Institute for Polar and Marine Research

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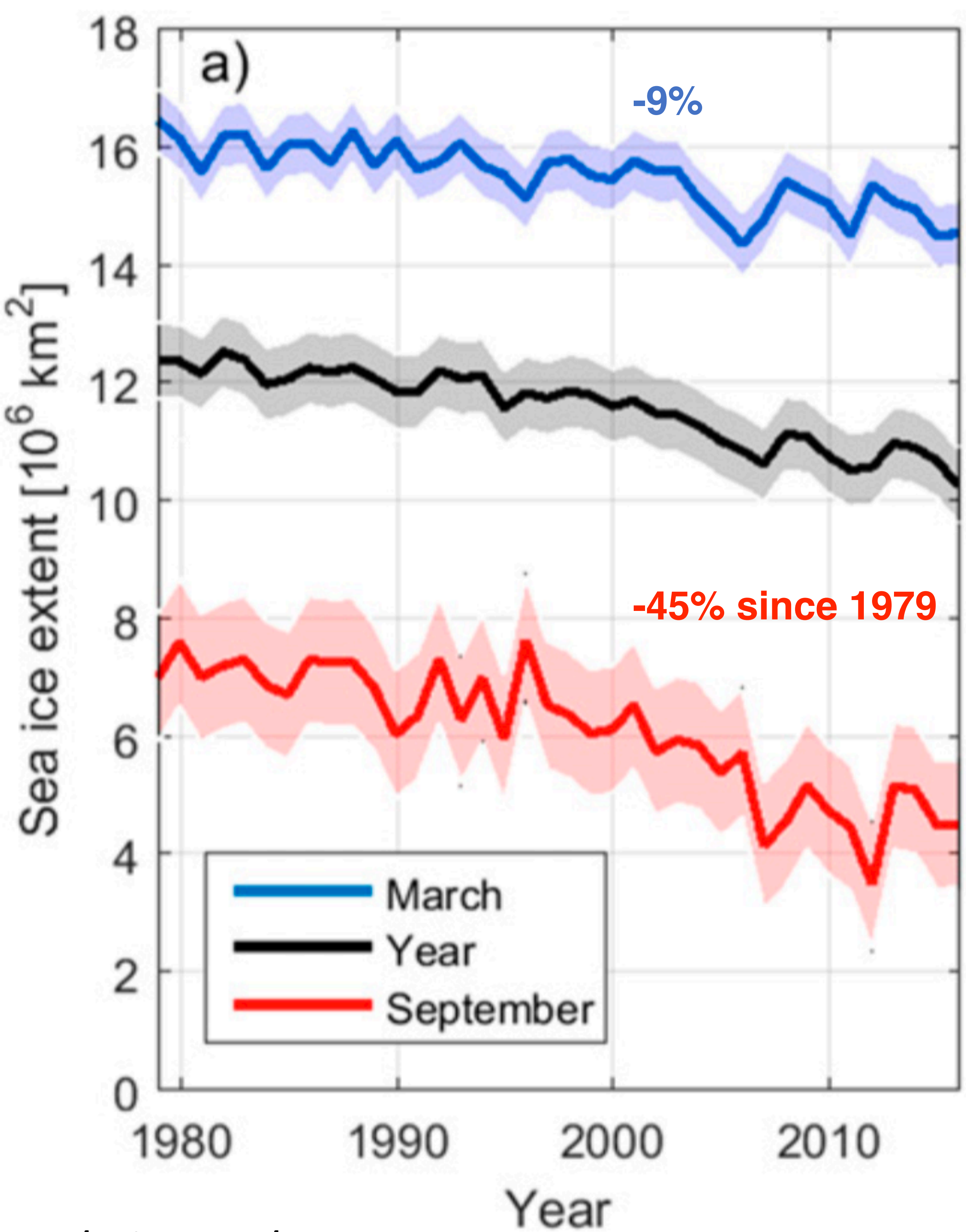
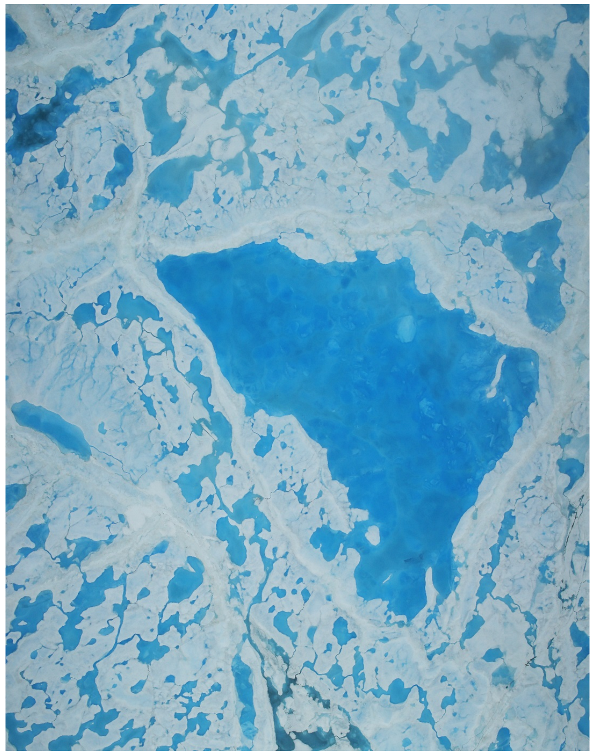
Ice is thermally isolating ocean from the atmosphere

major feedback →

Sea ice decline will lead to the activation of the sea-air interaction processes and increase of the surface turbulent heat fluxes



Onarheim et al., 2018



- Dramatic decrease of the Arctic sea ice during the past decades is associated with changes in the diabatic signals in high latitude oceans and has potential impact on the weather and climate

- Lengthening of the melt-season from 1979 to 2013 at a rate of 5 days per decade

Most of works diagnosing of the impacts of declining sea ice in the Arctic onto different climate phenomena and analyzing associated mechanisms are based on the assumption the

reduction in the sea ice cover is closely linked to increasing heat flux from the ocean to the atmosphere

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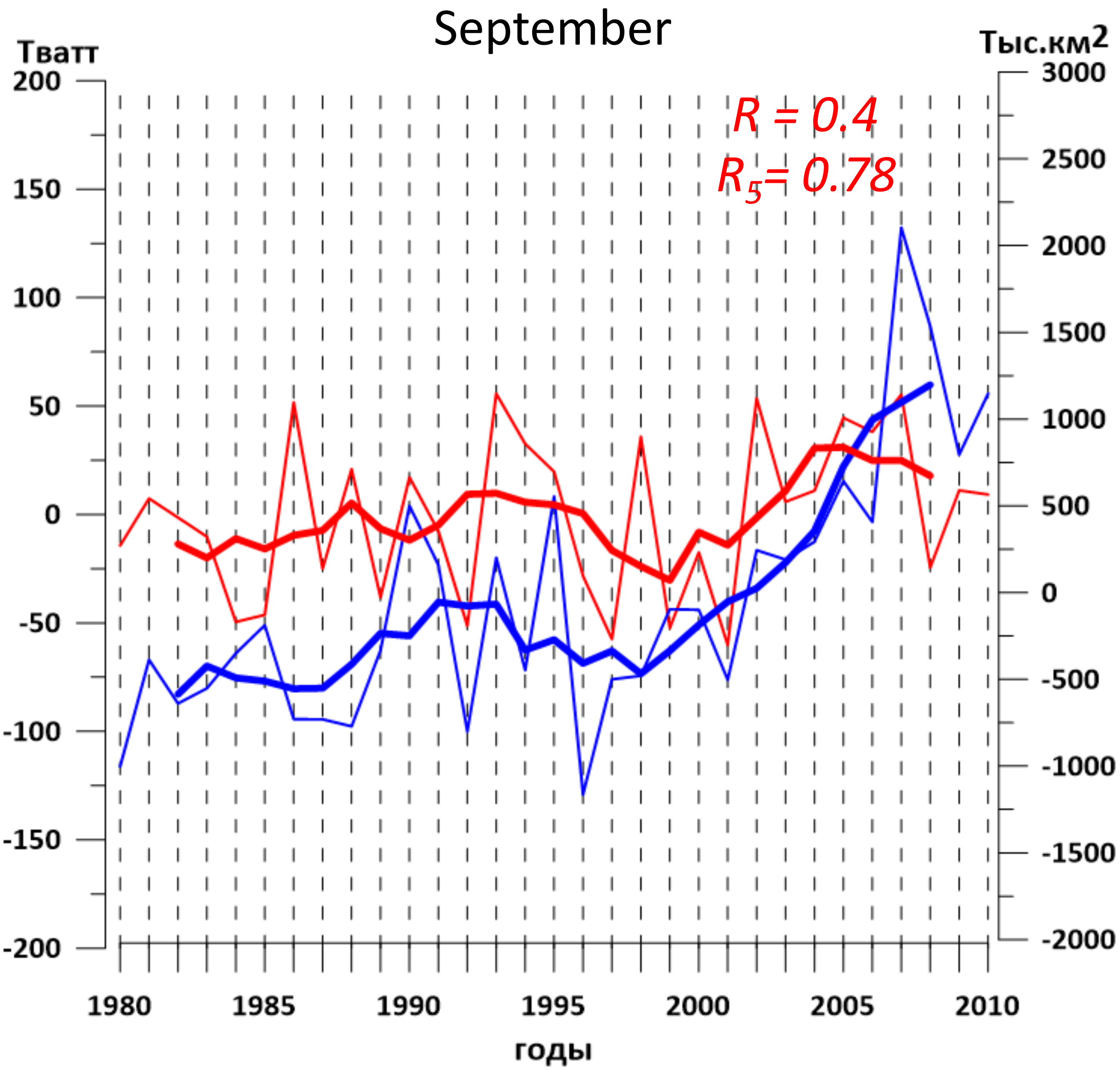
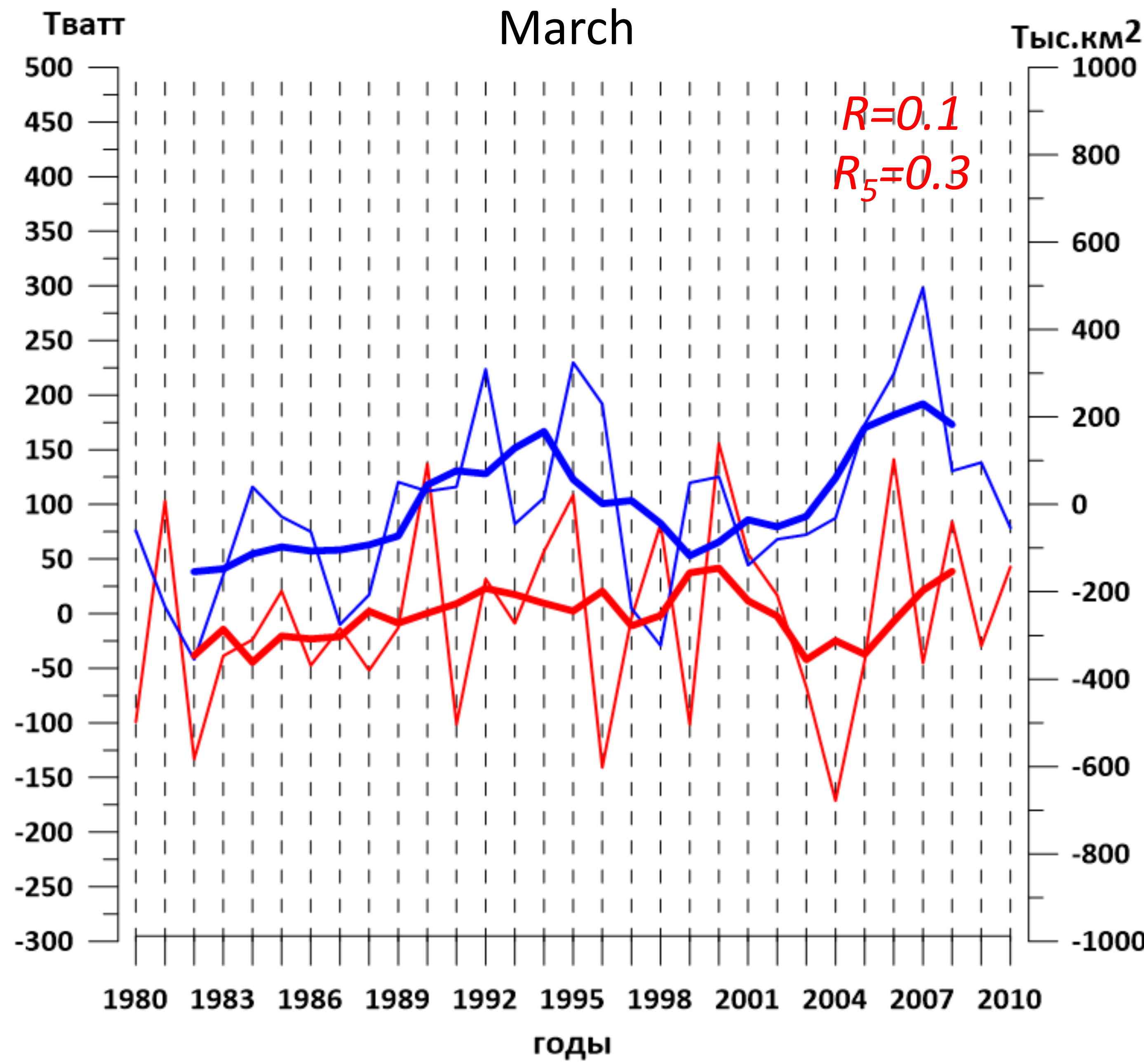
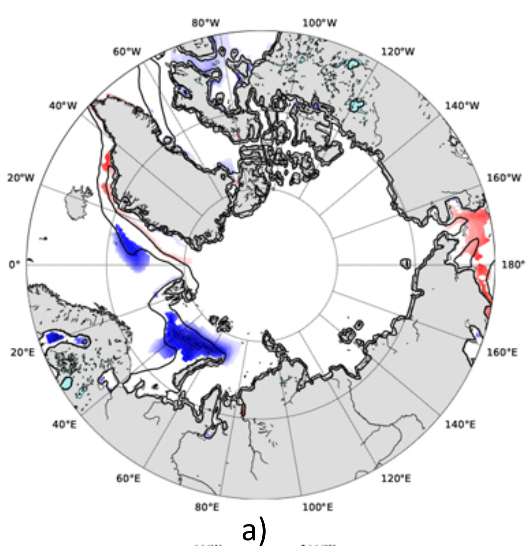
We test here the concept that STHF, integrated over the Arctic should be dependent on the area of the ice free ocean

Time series of the ice-free area (blue) and integrated over the ice free area turbulent heat fluxes (red)







Selivanova et al., 2019, submitted on the basis of NCEP CFSR data

In this study we provide detailed analysis of STHF (latent+sensible heat fluxes) response to the Arctic sea ice loss over the last decades using surface fluxes, sea ice concentration and sea ice thickness from modern era reanalysis NCEP-CFSR and satellite data

Detrended anomalies

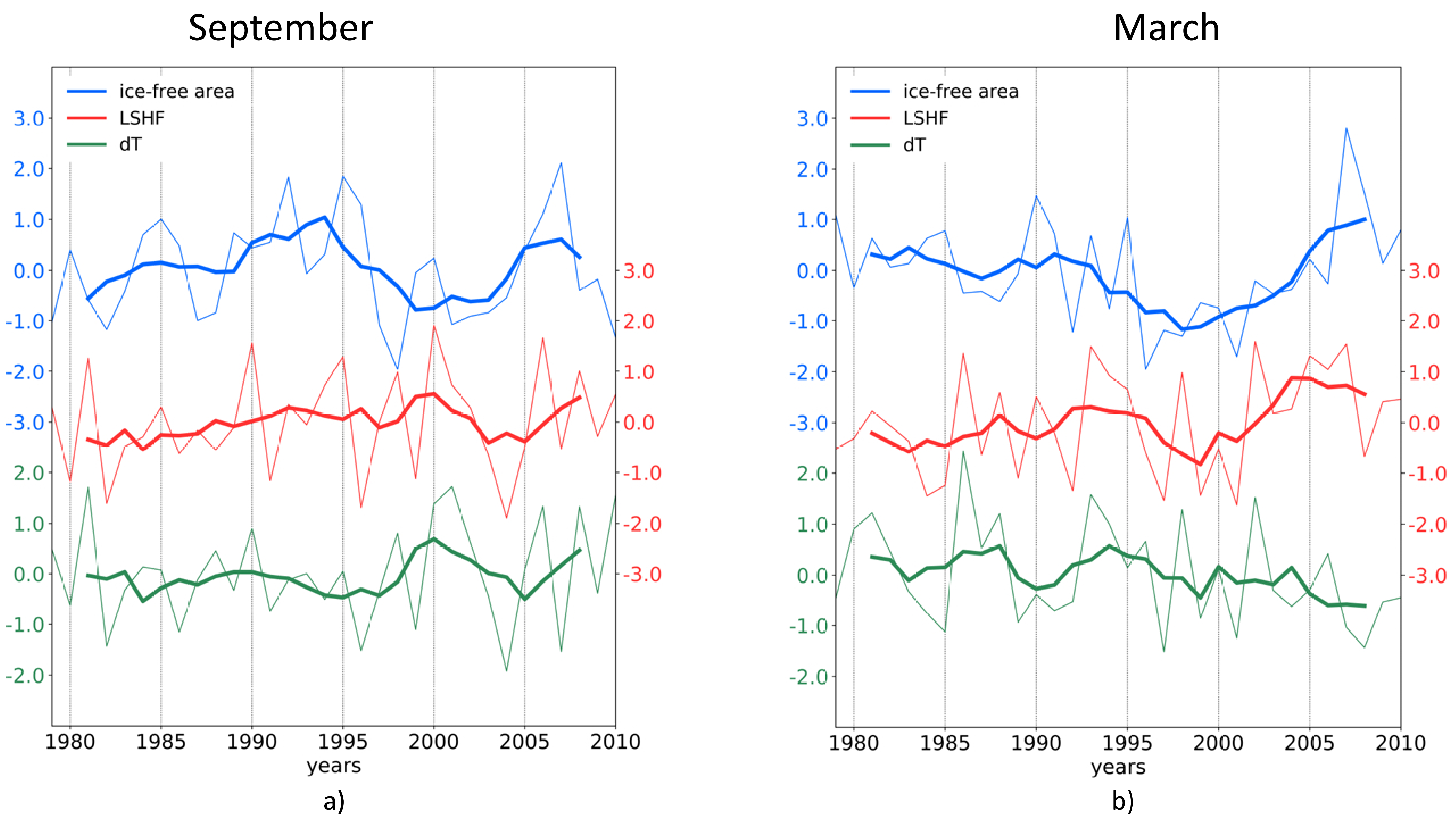
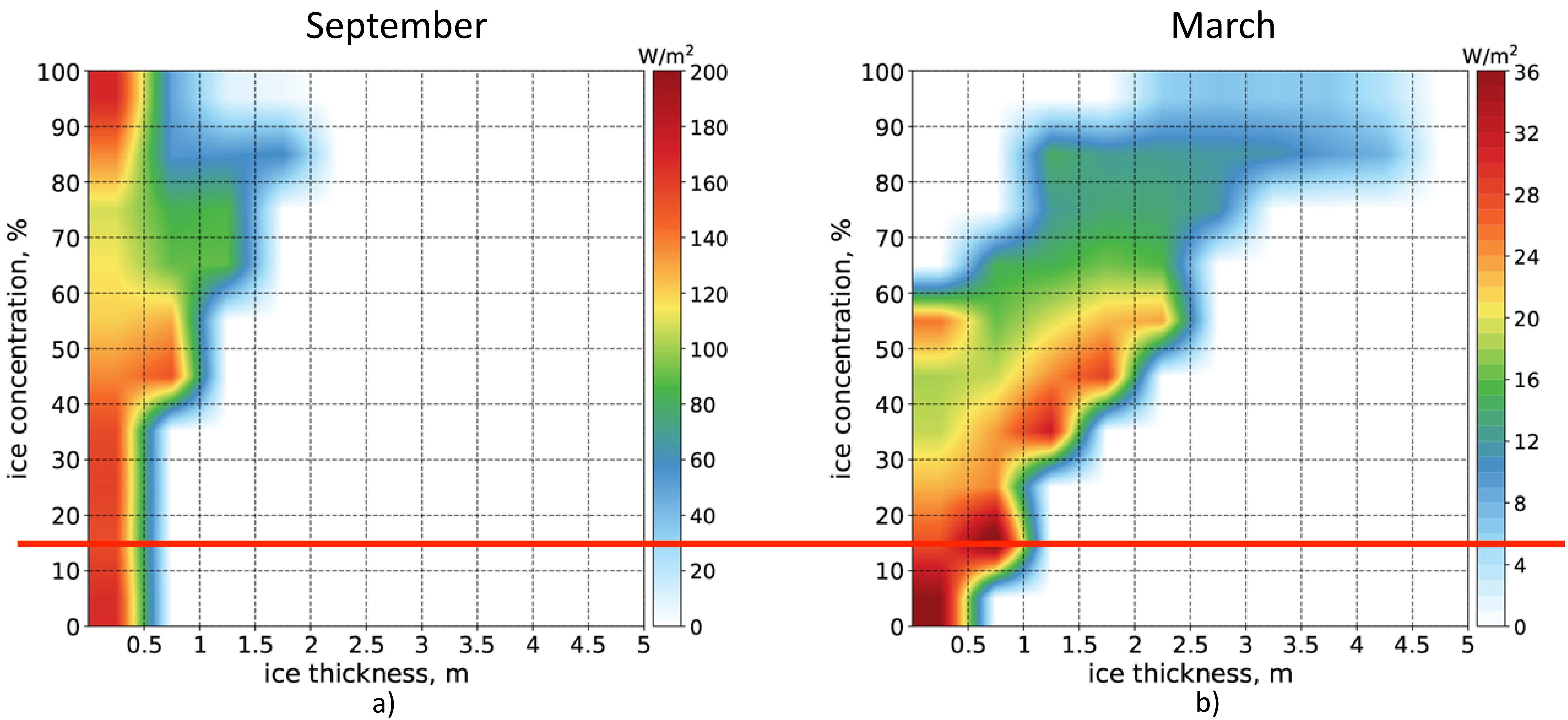
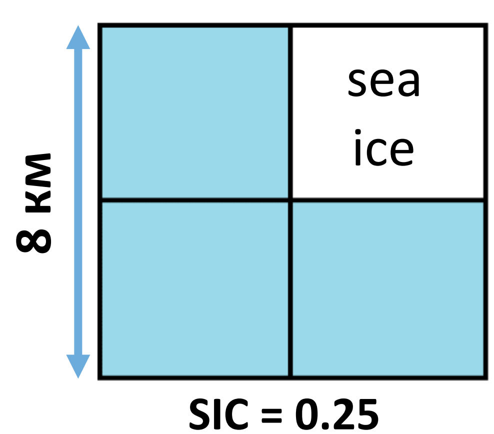


Figure 2. Linearly detrended anomalies over 1979-2010 of ice-free area (15% SIC), integral surface turbulent heat flux and temperature gradient (SST-T2m) normalized by the standard deviation of 1979-2010 period in a) March and b) September. The thinnest lines depict monthly means, thick lines are for 5-year running means.

Mean turbulent heat flux distribution over the different sea ice concentrations and thicknesses



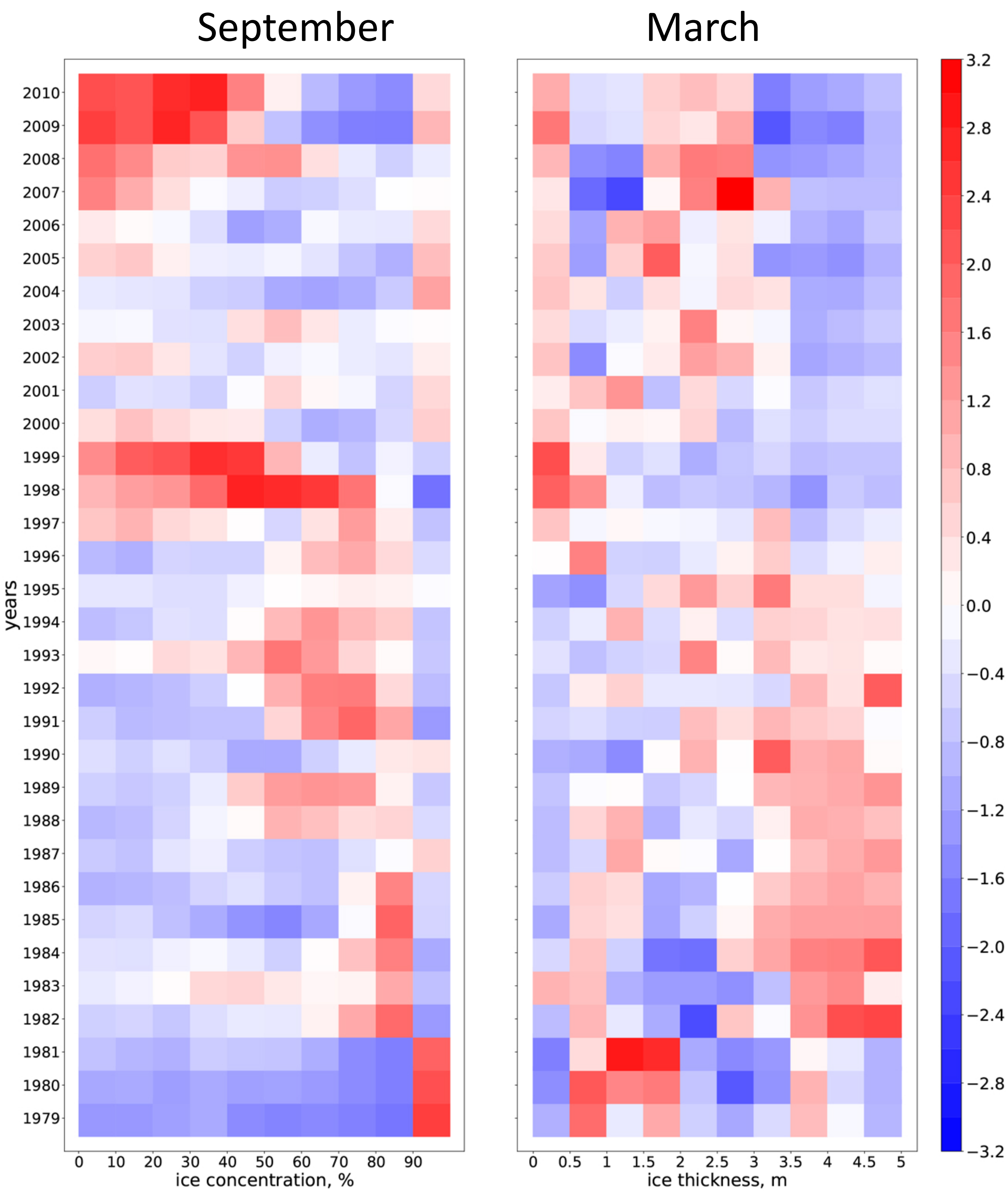


$$S^j = \sum_{i=1}^{N} S_i * (1 - SIC_i) \quad Q_{int}^j = \sum_{i=1}^{N} Q_i^j * S_i$$

0.82 - September

0.76 - March

Evolution of the sea ice characteristics over Arctic

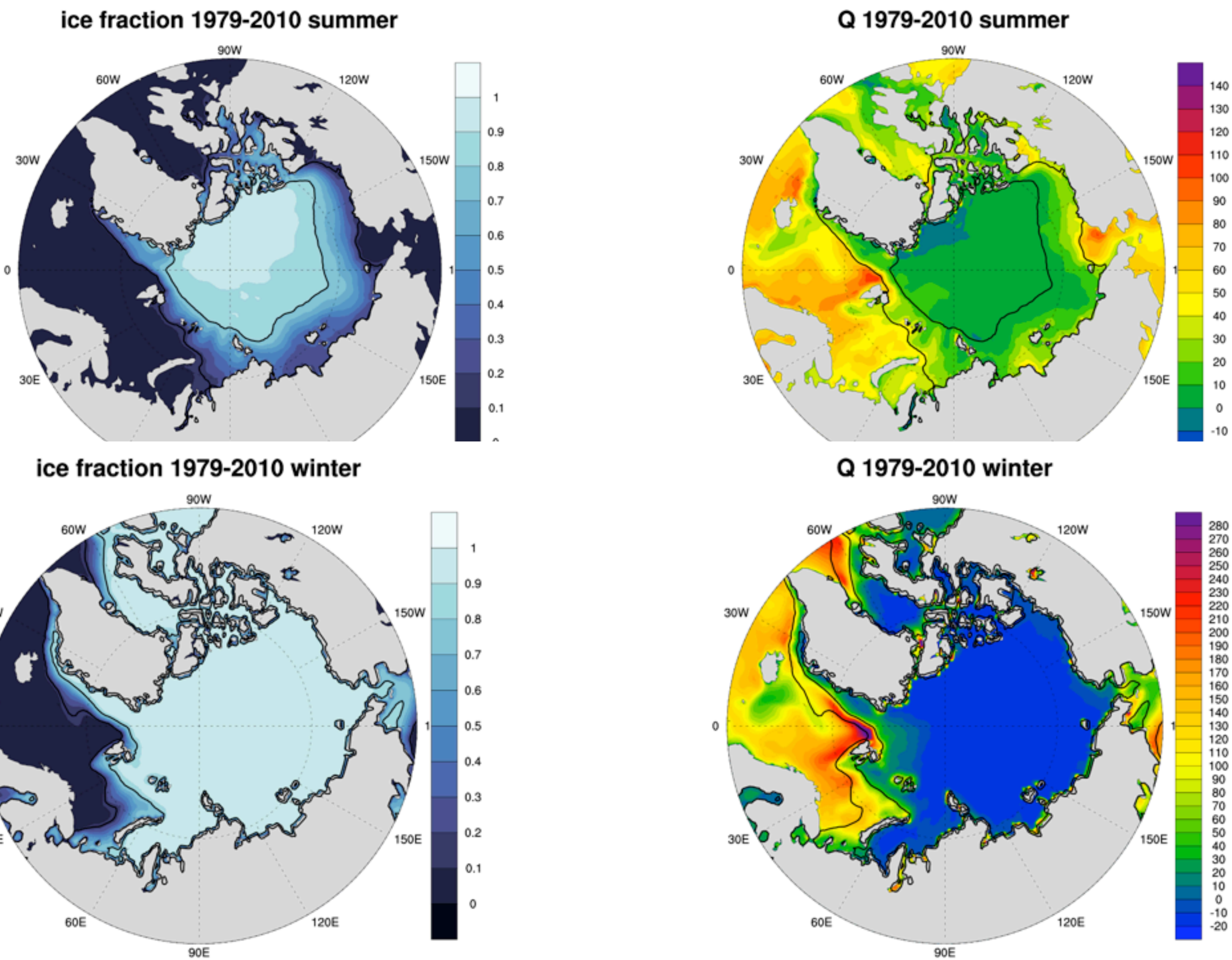


In summer the area of the ice with concentrations 0-50% increased twice, while 50-90% ice decreased during 32 years

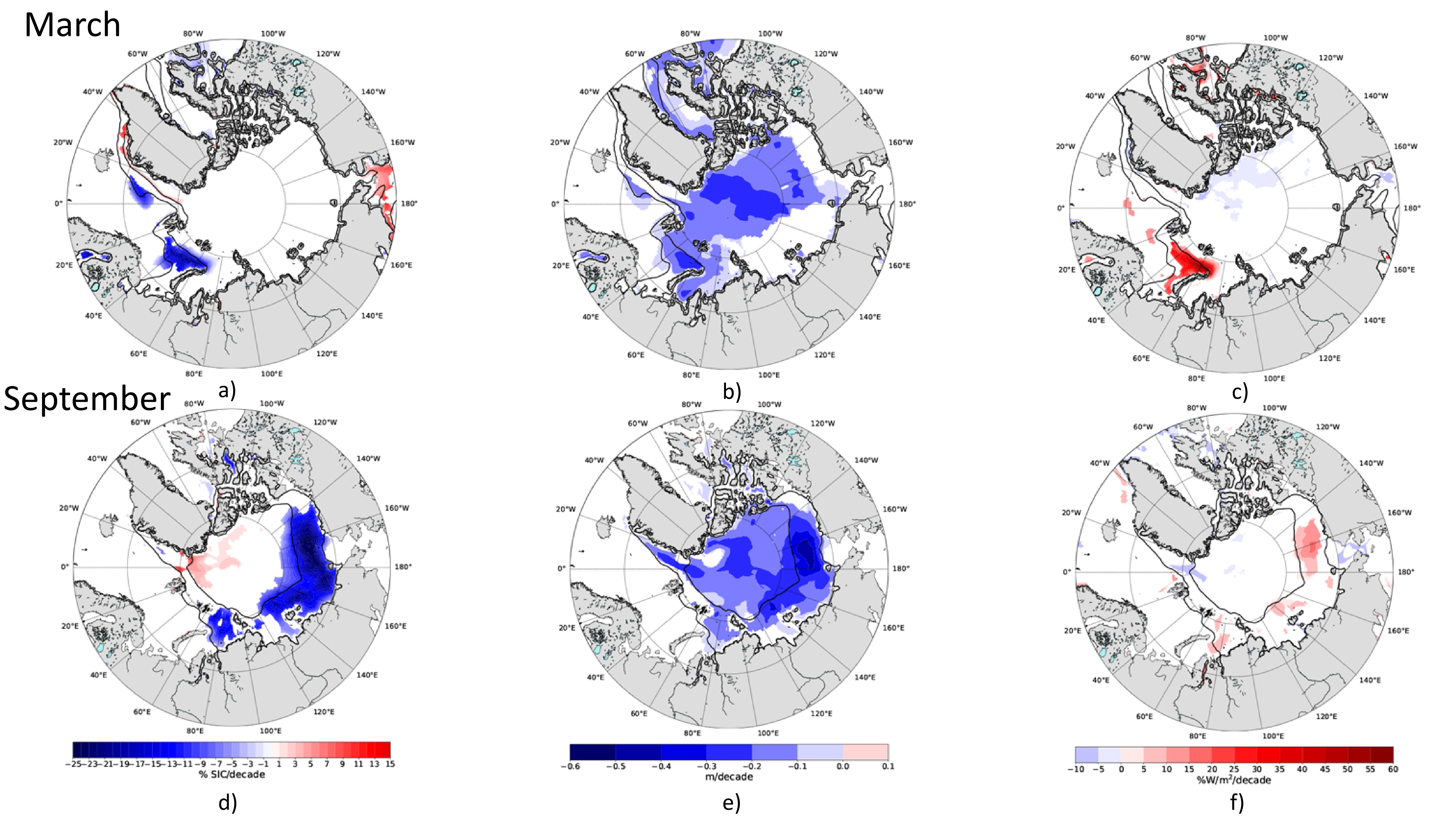
The area of the thick sea ice decreased by

3,4 times in summer
2,6 times in winter

Importance of the marginal zone



Spatial patterns



Linear trends of SIC (%/decade) and SIT (m/decade) and surface heat flux (W/m2/decade)
for cold (FMA) and warm (ASO) seasons: a) SIC, FMA; b) SIT, FMA; c) heat flux, FMA; d) SIC, ASO; e) SIT, ASO; f) heat flux, ASO;
trends significant at the 95% level (Student criterion).

Monthly averages for sea ice concentrations (blue), vertical t2m gradient (green), turbulent fluxes (red) over the marginal zone

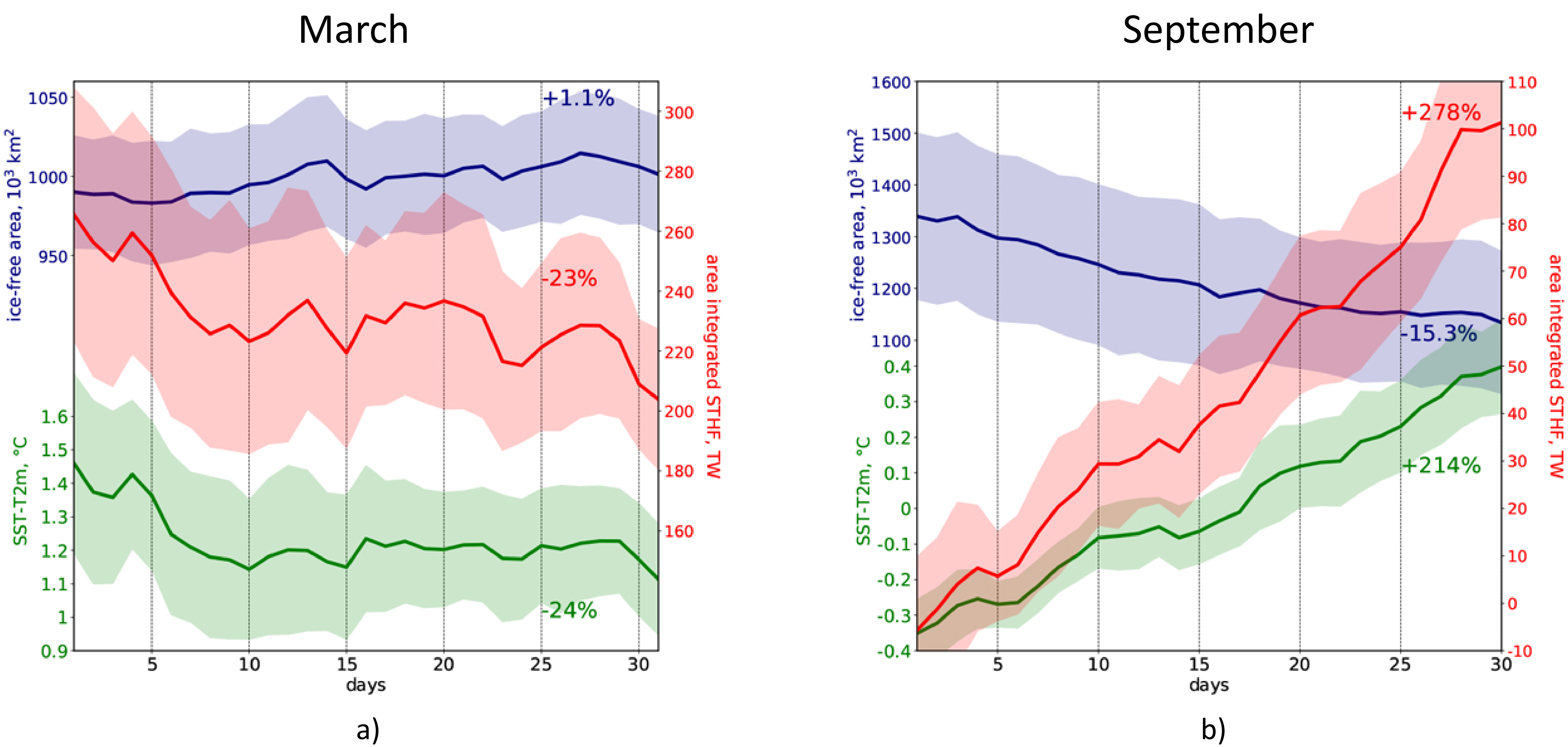


Figure 9. Mean distribution of ice-free area, integral surface heat flux and temperature gradient (SST-T2m) anomalies from mean 1979-2010 period in a) March and b) September for MIZ (SIC 15-80%). Half sigma range is shaded.

Conclusions

(i) There are two principally different approaches for the assessment of the integral heat flux response to the sea ice variability in the Arctic. The first one based on the sea ice extent criterion (15%) did not discover the link between open-water area and the surface heat flux variations, reporting maximum correlation between corresponding monthly mean values as 0.45 in September. This result is seemed to be expected as this methodology implies midlatitude atmosphere forced processes over the open ocean and eliminates heat flux over MIZ

(ii) A warm season (August-September) pack-to-sparse and thick-to-thin ice area transition has been revealed. Since 1979 the pack ice (80-100%) area decreases by 34%, while the ice area with SIC of 0-30% enlarges by 190% and the thick ice (3-5 m) area declines significantly since 1982

(iii) The spatial analysis of linear trends detected regional heat flux response on the sea ice concentration and thickness change. Positive response follows the sea ice retreat in the Barents Sea (up to -20%/decade). In summer heat flux feedback exists in the Chukchi and Beaufort Seas

(iv) The link between sea-ice extent and intensity of the air-sea interaction processes (surface turbulent heat fluxes) is strongly non-linear and has to be accounted in climate models (currently not resolved process with linear response)

(v) Accounting for the marginal zone (sea ice concentrations 0-90%) is critically important when studying various atmospheric responses to the sea ice decline in Arctic