XXII международная конференция
"СОВРЕМЕННЫЕ ПРОБЛЕМЫ ДИСТАНЦИОННОГО ЗОНДИРОВАНИЯ ЗЕМЛИ ИЗ КОСМОСА“
Институт космических исследований РАН, 11-14 ноября 2024 г., Москва

Изменения арктических морских льдов в XX веке: неопределённость и новые реконструкции

В.А. Семенов

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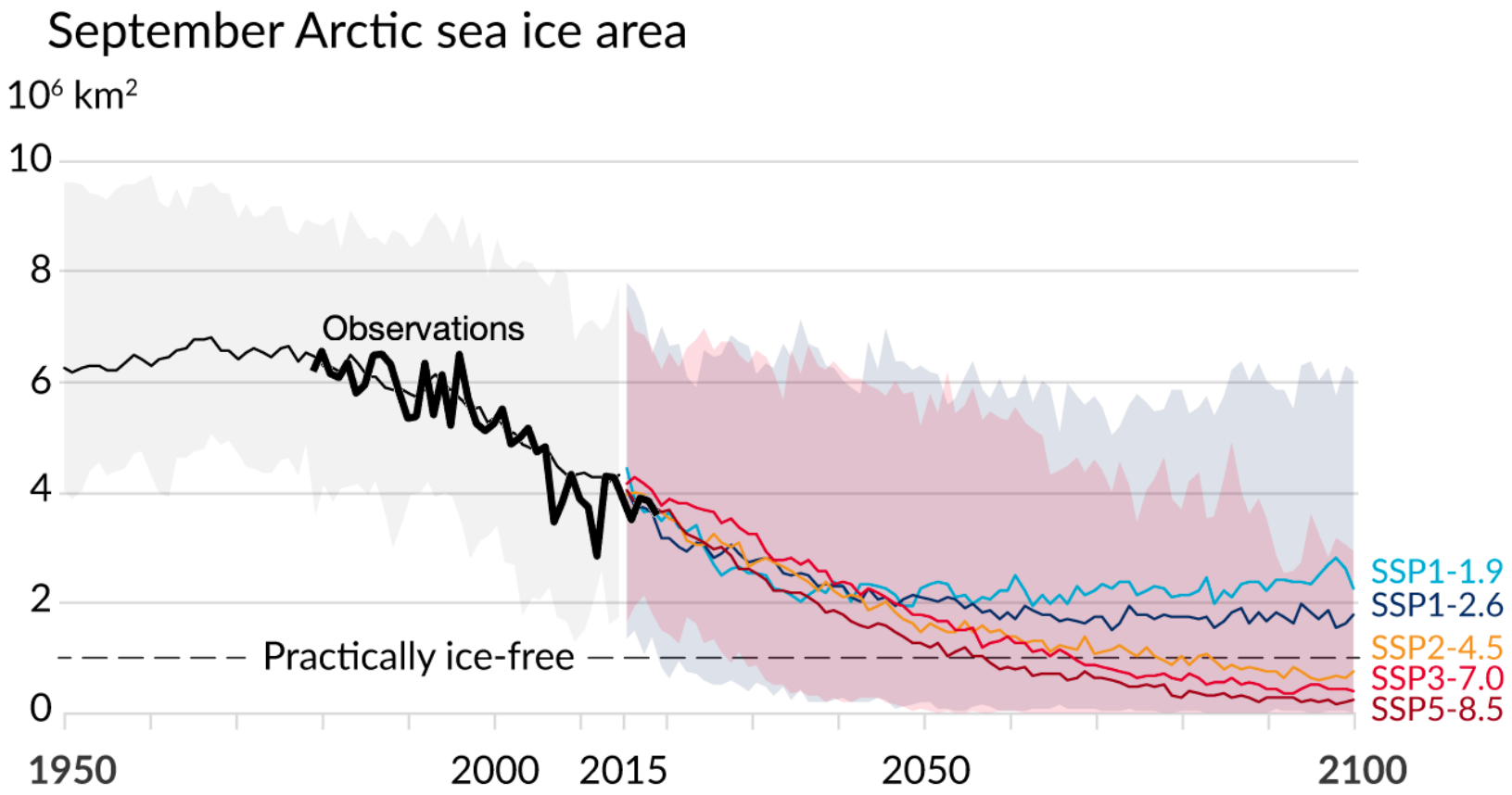
Оценки будущих изменений арктических морских льдов в XXI веке по данным ансамбля моделей CMIP6 для различных сценариев антропогенного воздействия (IPCC AR6)



Актуальные вопросы, связанные с изменением площади арктических морских льдов

Что будет с арктическими морскими льдами в будущем?

Что мы знаем об изменениях морских льдов в Арктике в XX веке?

Насколько надежны используемые данные по сплоченности льдов?

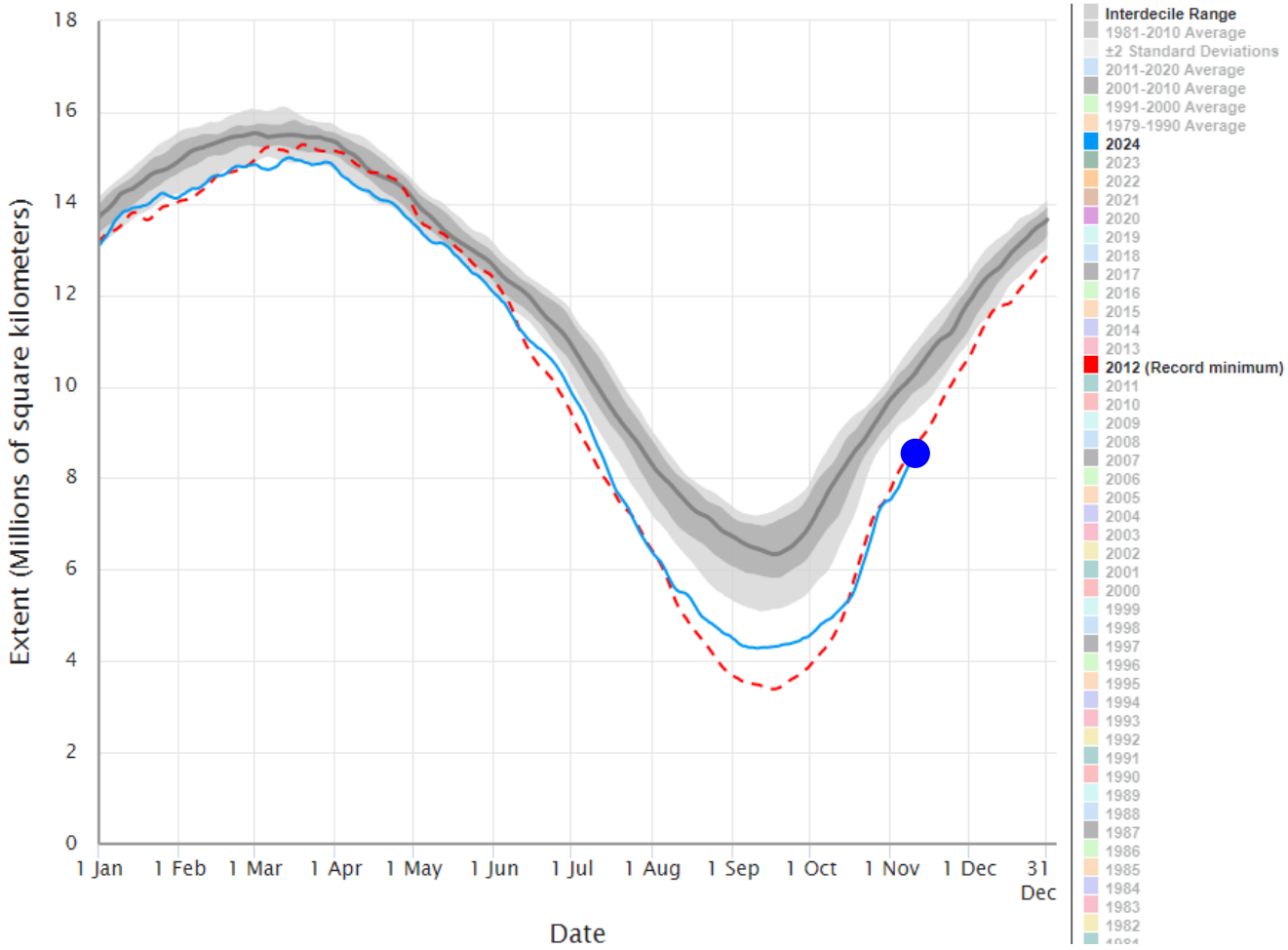
Наблюдались ли циклические долгопериодные колебания площади льда?

Если характерные черты естественных и антропогенных изменений площади льда (fingeprint)?

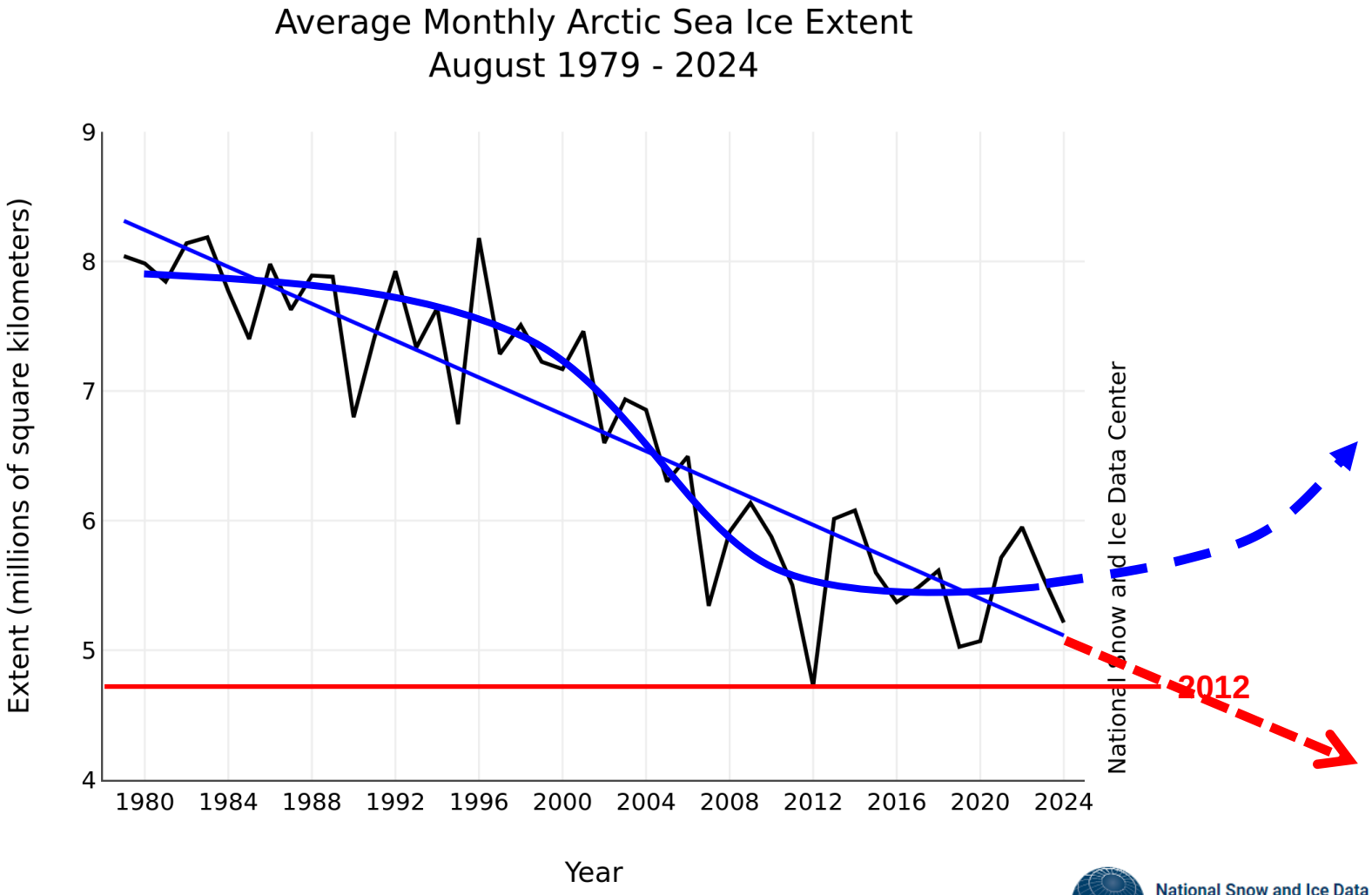
Есть ли в динамике морских льдов пороги неустойчивости?

Можем ли мы реконструировать поля сплоченности в период отсутствия данных наблюдений?

Seasonal cycle of the Arctic sea ice extent



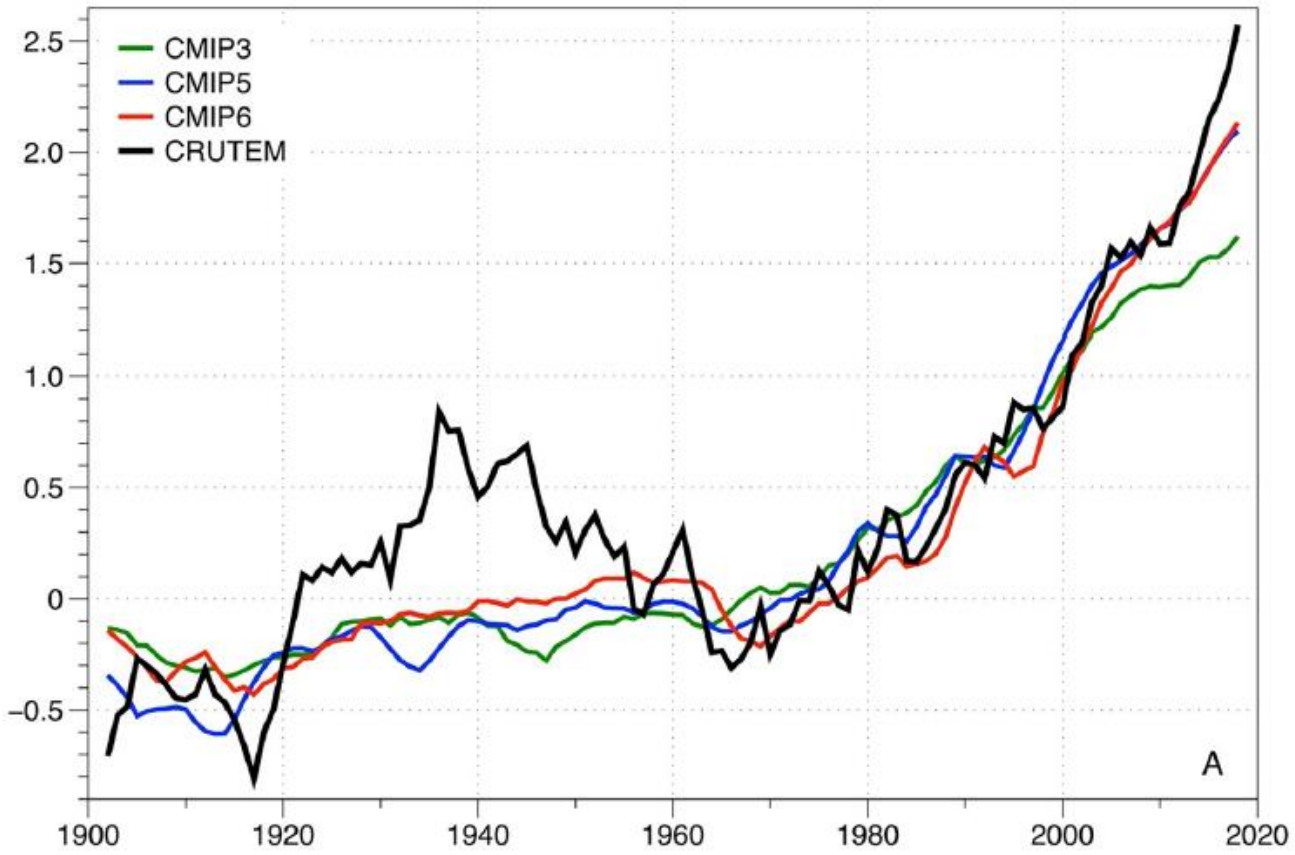
National Snow and Ice Data Center
a part of CIRES at the University of Colorado Boulder



National Snow and Ice Data Center
a part of CIRES at the University of Colorado Boulder

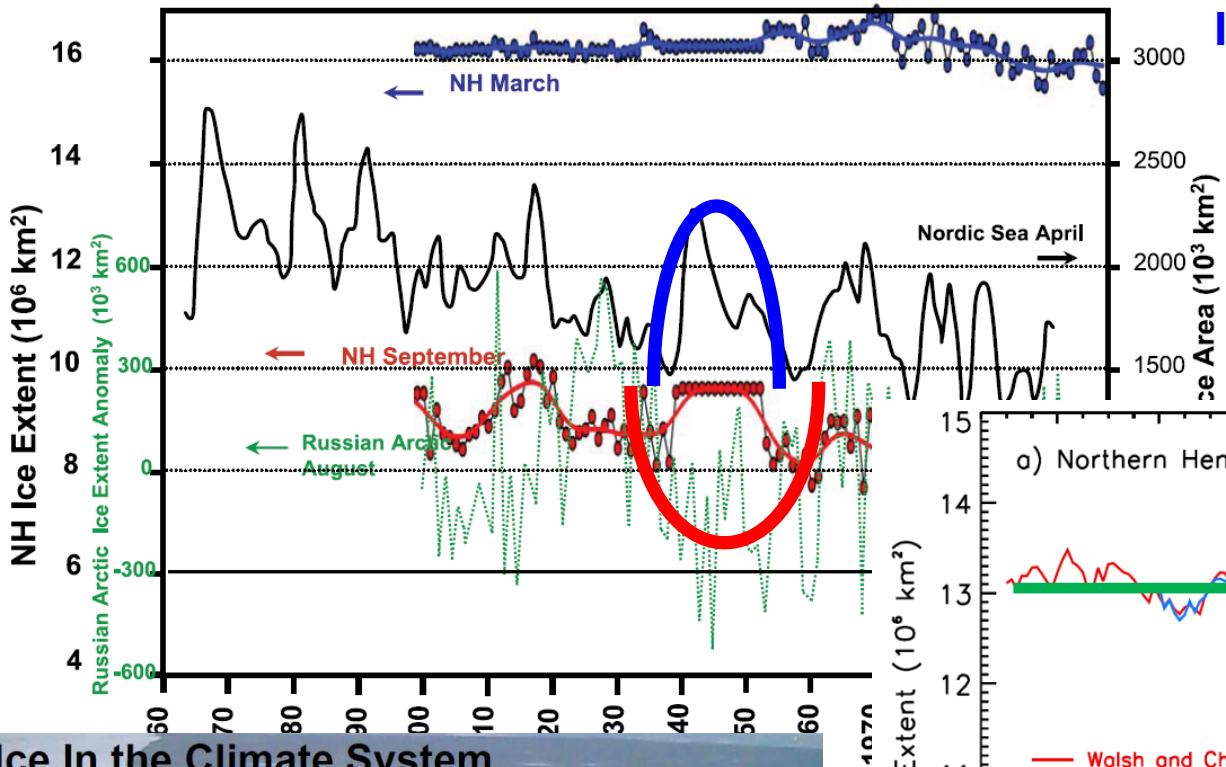
Early Twentieth Century Warming in the Arctic

Annual Arctic surface air temperature anomalies

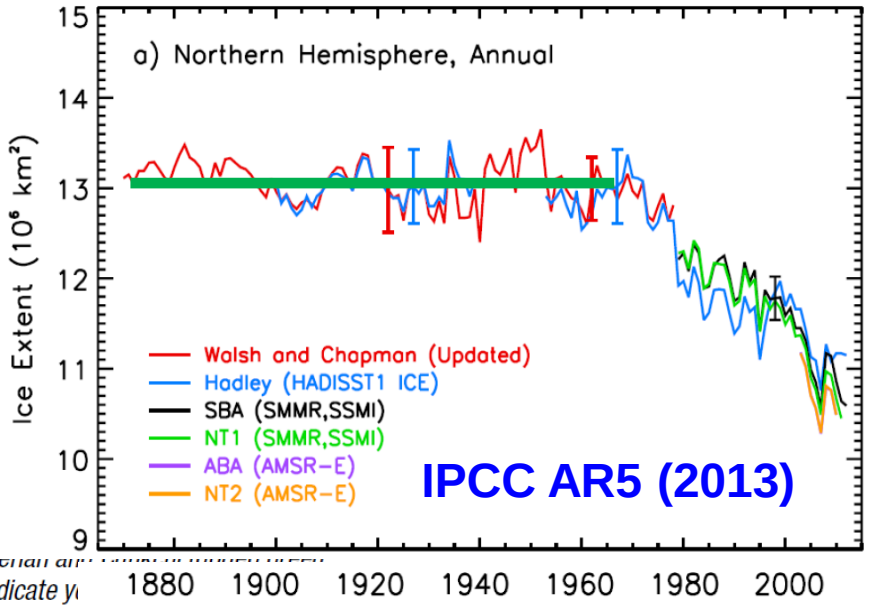


Bokuchava and Semenov , 2021, Earth Sci. Rev.

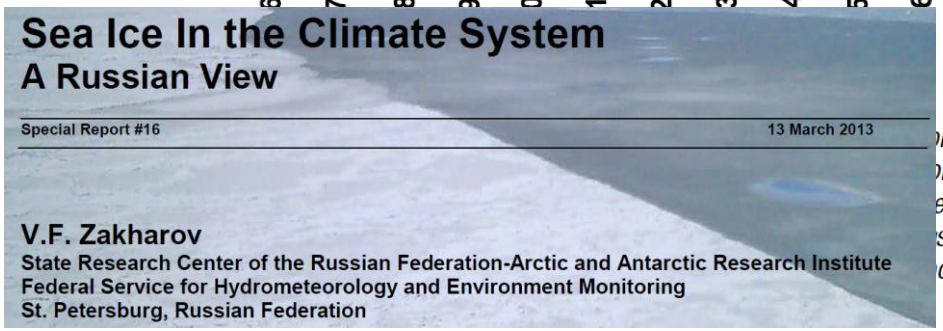
Arctic sea ice area during the Early Twentieth Century Warming



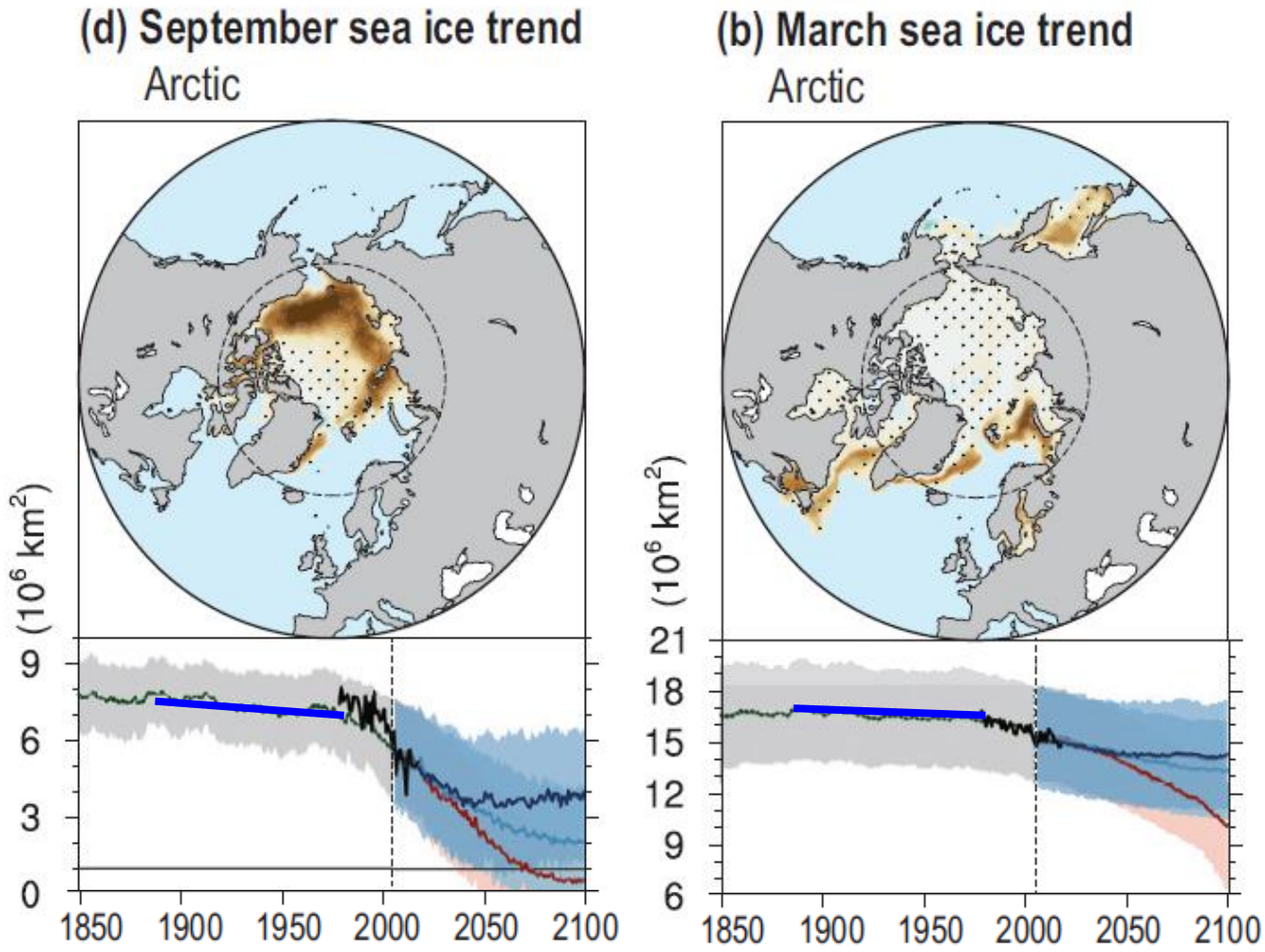
IPCC AR4 (2007)



IPCC AR5 (2013)



Arctic sea ice area during the Early Twentieth Century Warming

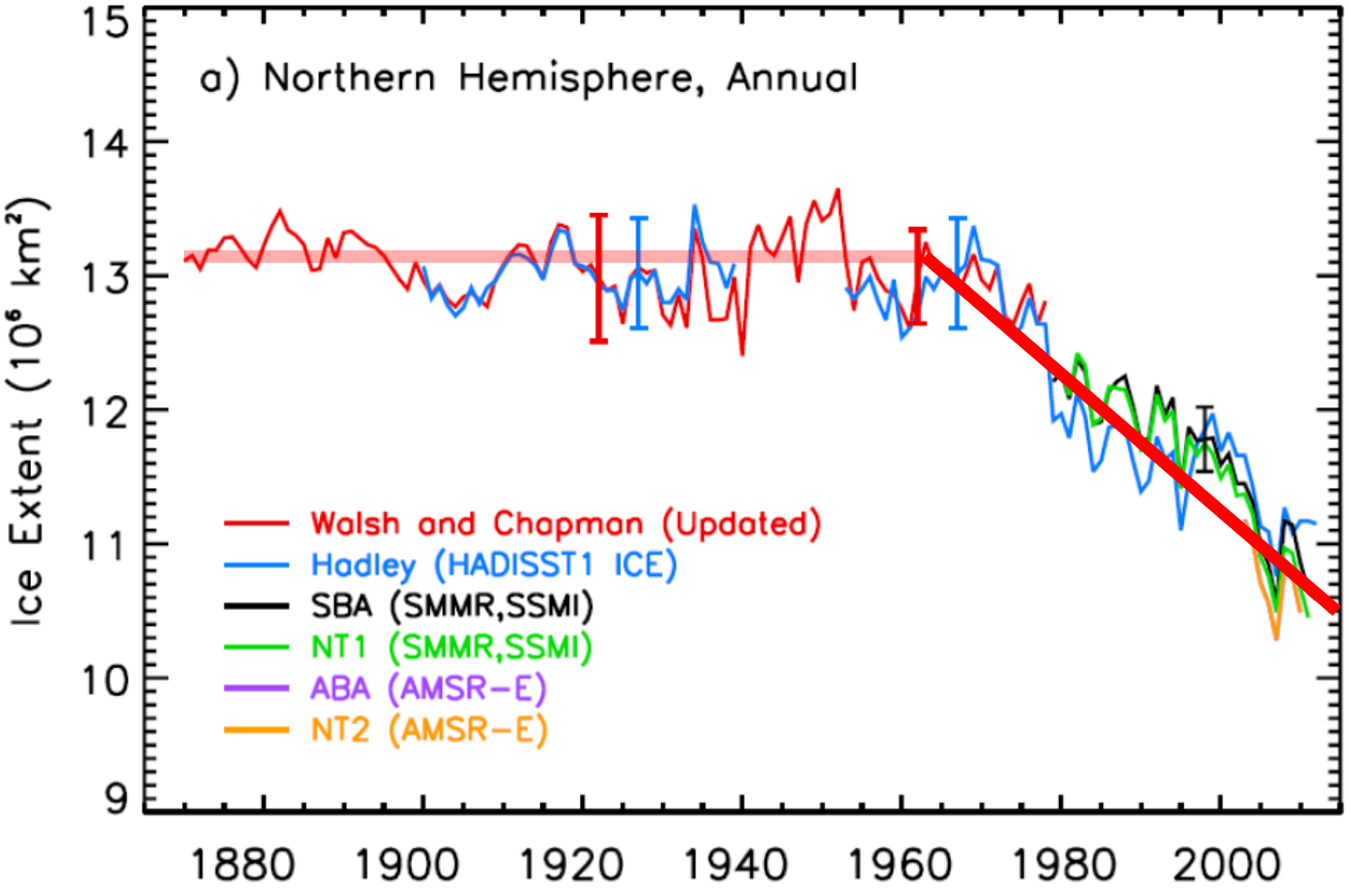


IPCC SROCC,

AR6 (2021)

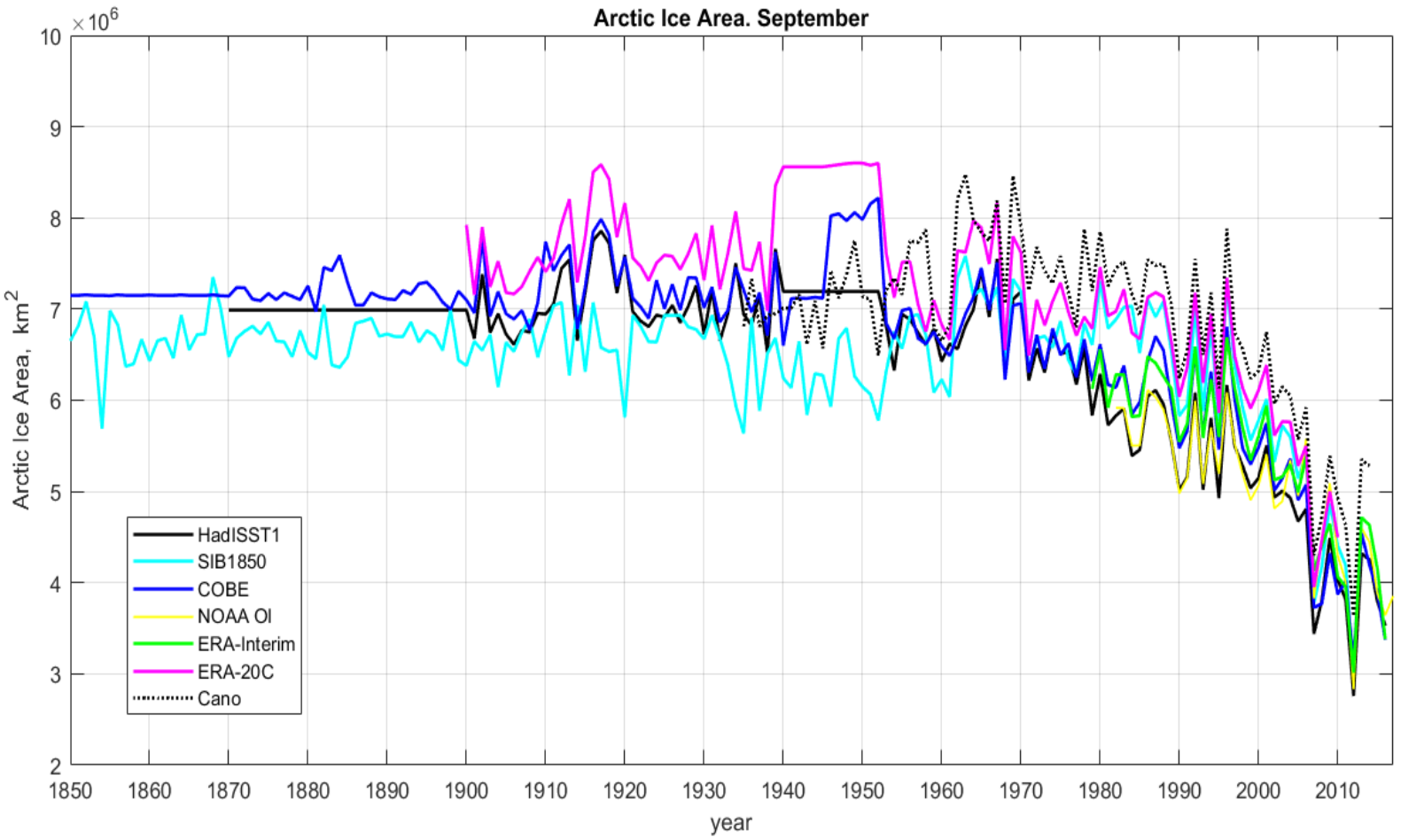
Changes of the Arctic sea ice extent

Annual mean Northern Hemisphere sea ice extent, mln.km^2 according to different gridded datasets (**IPCC AR5, 2013**)



How uncertain are modern historical sea ice data?

Northern Hemisphere sea ice area (in mln.km^2) in September according to different datasets

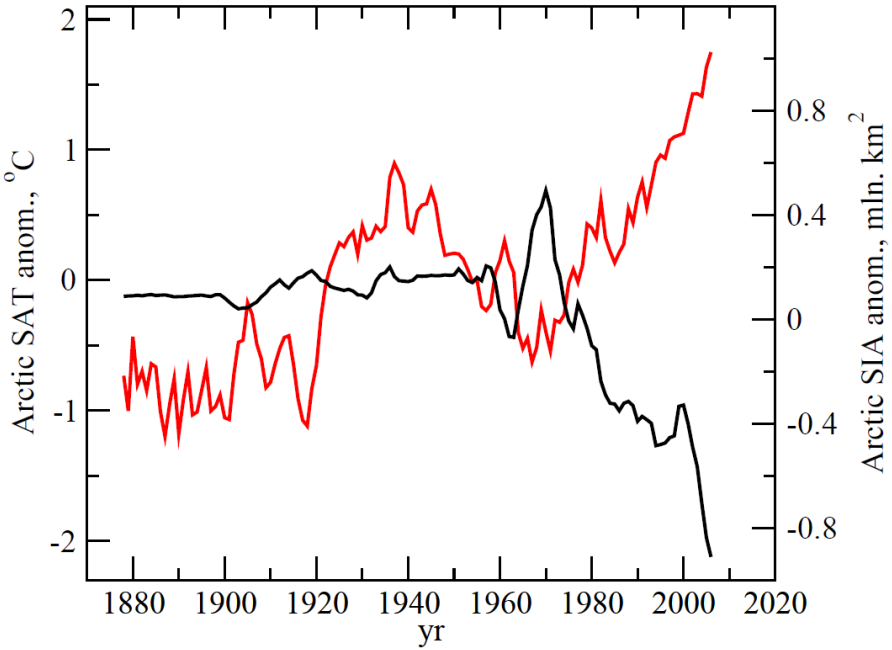


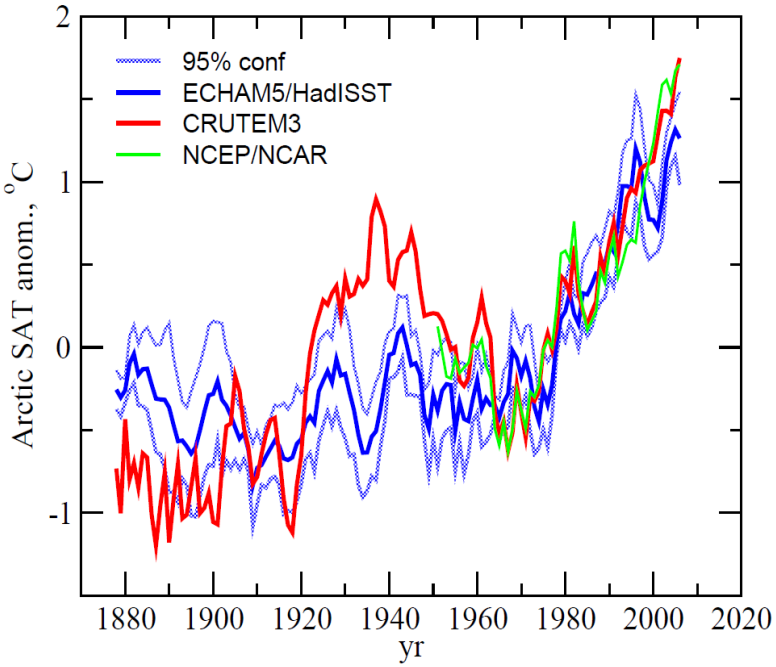
Can we reproduce ETCW in climate models with HadISST1 data used as boundary conditions?

Sea ice and temperature: atmosphere GCM as a diagnostics tool

Arctic sea ice anomalies and high latitude temperature data in the first half of the 20th century do not match

AGCM simulations provide estimates of temperature response to sea ice anomalies and help to verify reliability of the sea ice datasets

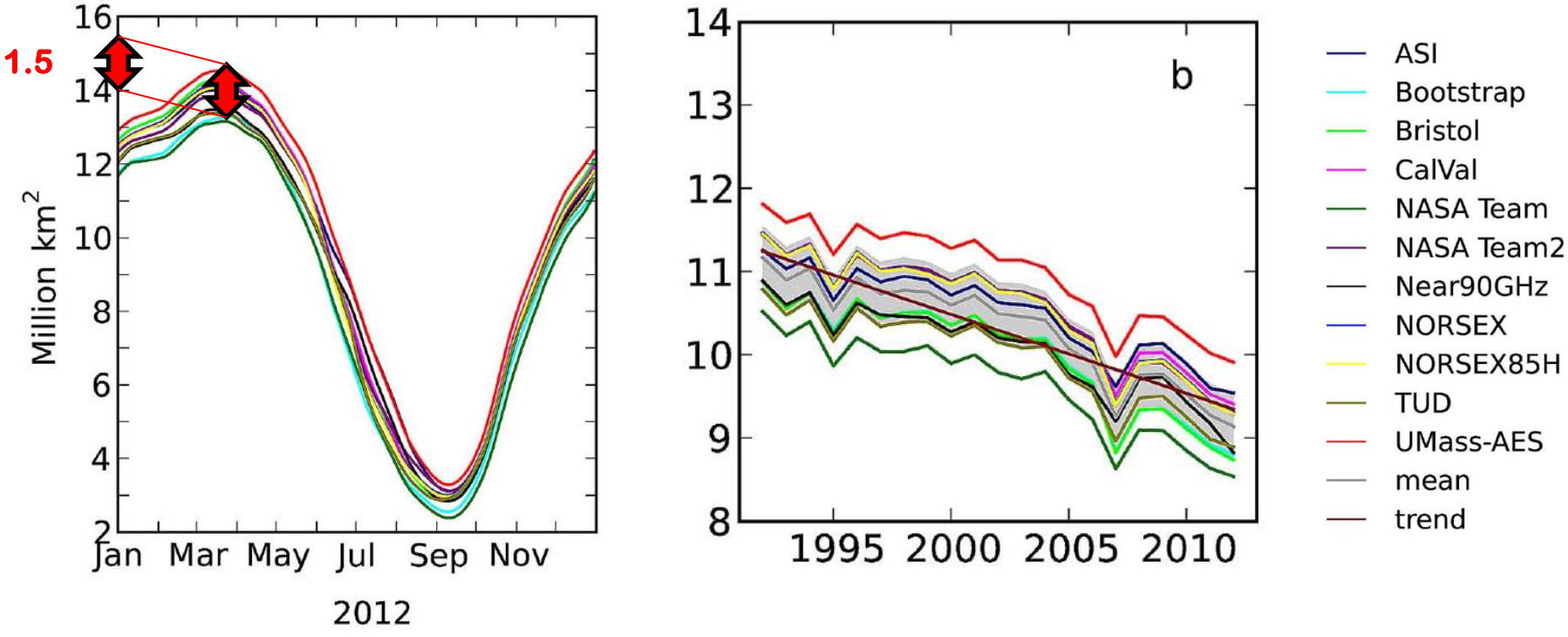




Semenov and Latif, 2012; Semenov, 2016

How uncertain are modern sea ice satellite retrieval algorithms?

Northern Hemisphere September sea ice area (in mln.km^2) obtained using the same satellite brightness temperature data (SMMR, SSM/I, SSMIS), but using different sea ice retrieval algorithms



Ivanova et al., 2012

Sea ice area in climate models: How is it turned?

GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L10501, doi:10.1029/2007GL029914, 2007

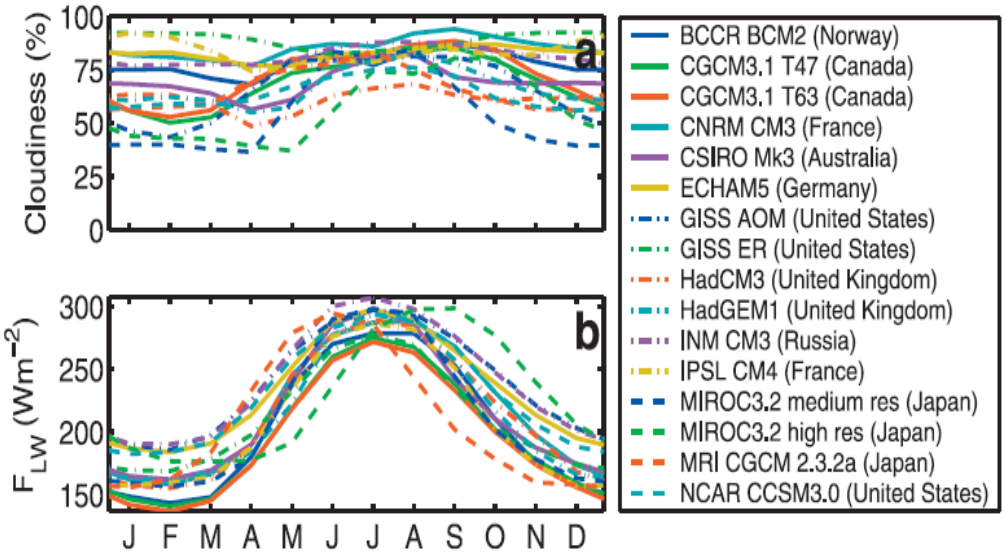
Click Here for Full Article

On the reliability of simulated Arctic sea ice in global climate models

I. Eisenman,[1] N. Untersteiner,[2] and J. S. Wettlaufer[3]

Received 8 March 2007; accepted 17 April 2007; published 18 May 2007.

Annual cycle of cloudiness and downward longwave radiation DLWR in CMIP3 models



Albedo of fresh ice with snow 0.9, melting ice 0.4

Dependence of annual sea ice thickness on DLWR and albedo

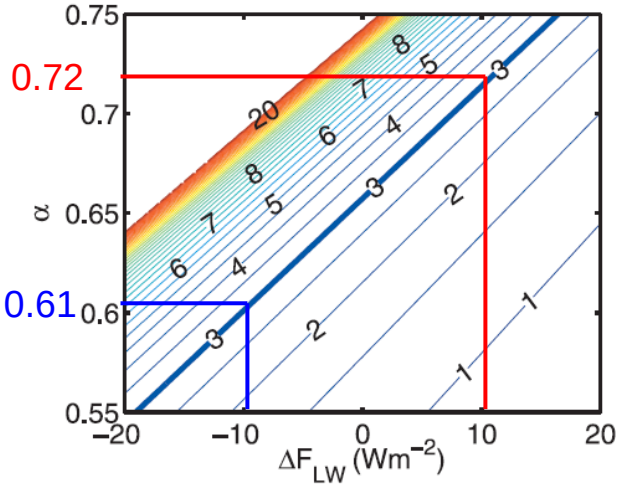


Figure 3. Equilibrium ice thickness in the idealized analytical model (equation 3) as a function of absorbed radiation for the range of downwelling longwave radiative fluxes predicted by GCMs (ΔF_{LW}) and varying ice albedo (α).

Short Communication

On assessment of the relationship between changes of sea ice extent and climate in the Arctic

Genrikh Alekseev,* Natalia Glok and Alexander Smirnov

Ocean–Air Interaction Department, Arctic and Antarctic Research Institute, St. Petersburg, Russia

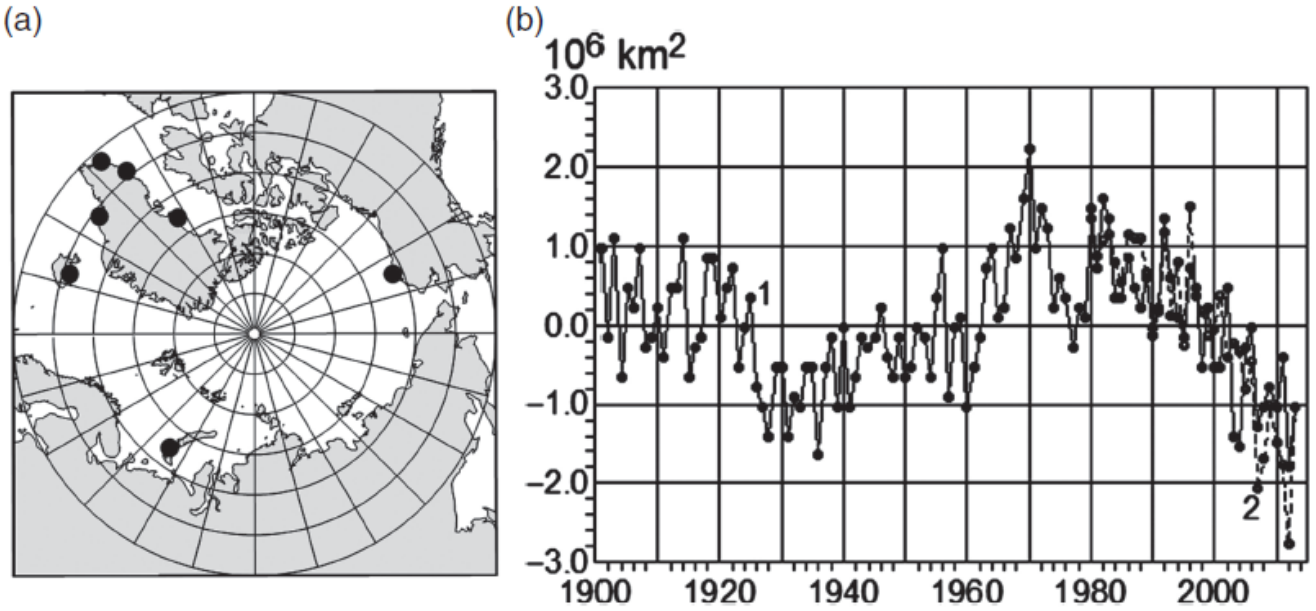


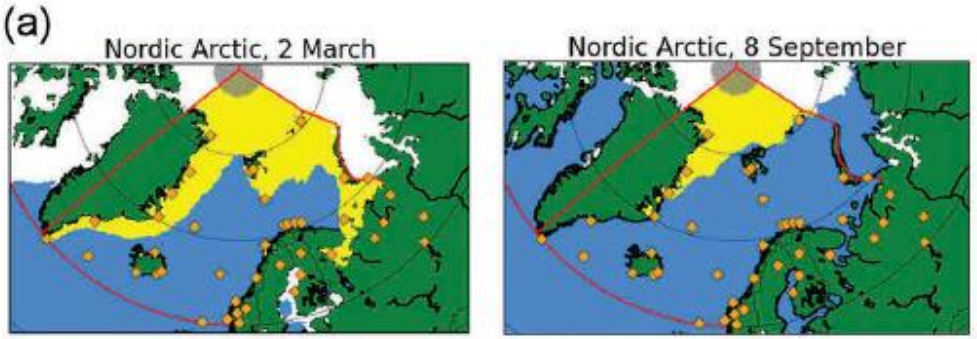
Figure 3. (a) Positions of seven meteorological stations in the marine Arctic with collected observations since 1900; (b) (1) reconstructed September SIE in the Arctic from 1900 to 2013 and (2) observed SIE for 1980–2013.

Alekseev et al., 2015

Re-calibration of Arctic sea ice extent datasets using Arctic surface air temperature records

Ronan Connolly, Michael Connolly & Willie Soon

To cite this article: Ronan Connolly, Michael Connolly & Willie Soon (2017) Re-calibration of Arctic sea ice extent datasets using Arctic surface air temperature records, Hydrological Sciences Journal, 62:8, 1317-1340, DOI: 10.1080/02626667.2017.1324974



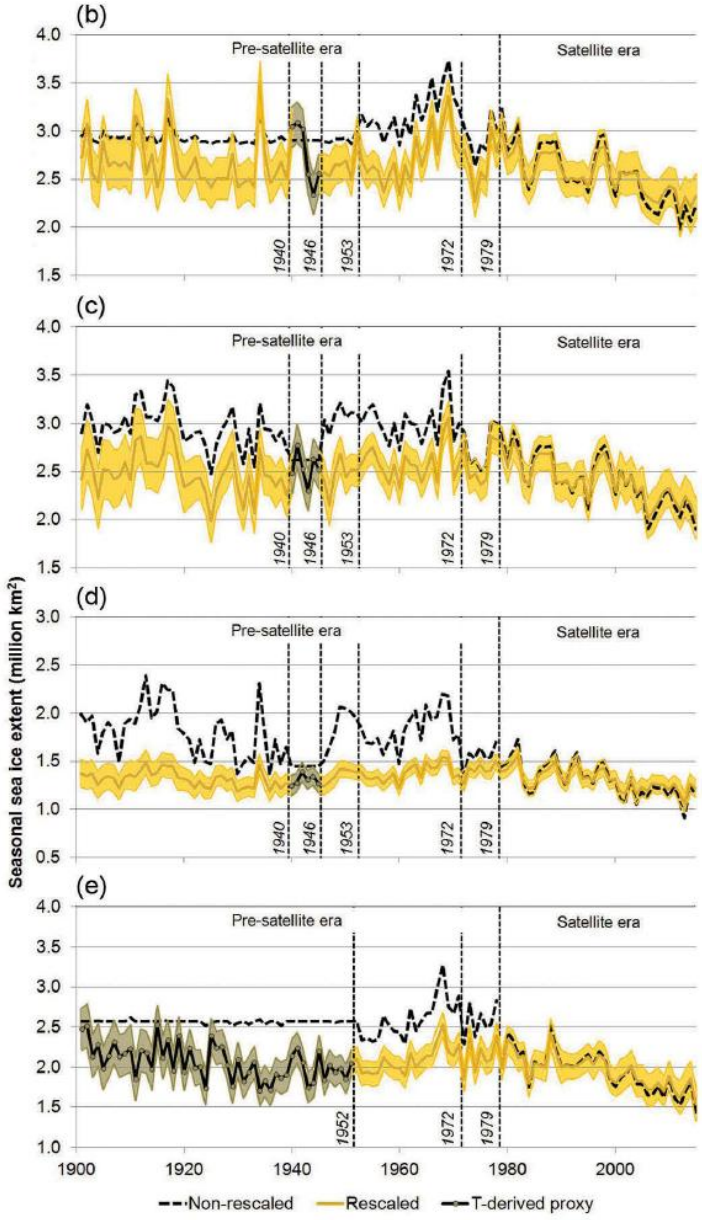


Figure 8. (a) The mean sea ice extents, and station locations for the Nordic Arctic region. (b)–(e) Nordic Arctic sea ice extent trends before and after rescaling for each season: (b) winter, (c) spring, (d) summer, (e) autumn. Note that the *y*-axes are different for each season.

A DATABASE FOR DEPICTING ARCTIC SEA ICE VARIATIONS BACK TO 1850

JOHN E. WALSH, FLORENCE FETTERER, J. SCOTT STEWART, and WILLIAM L. CHAPMAN

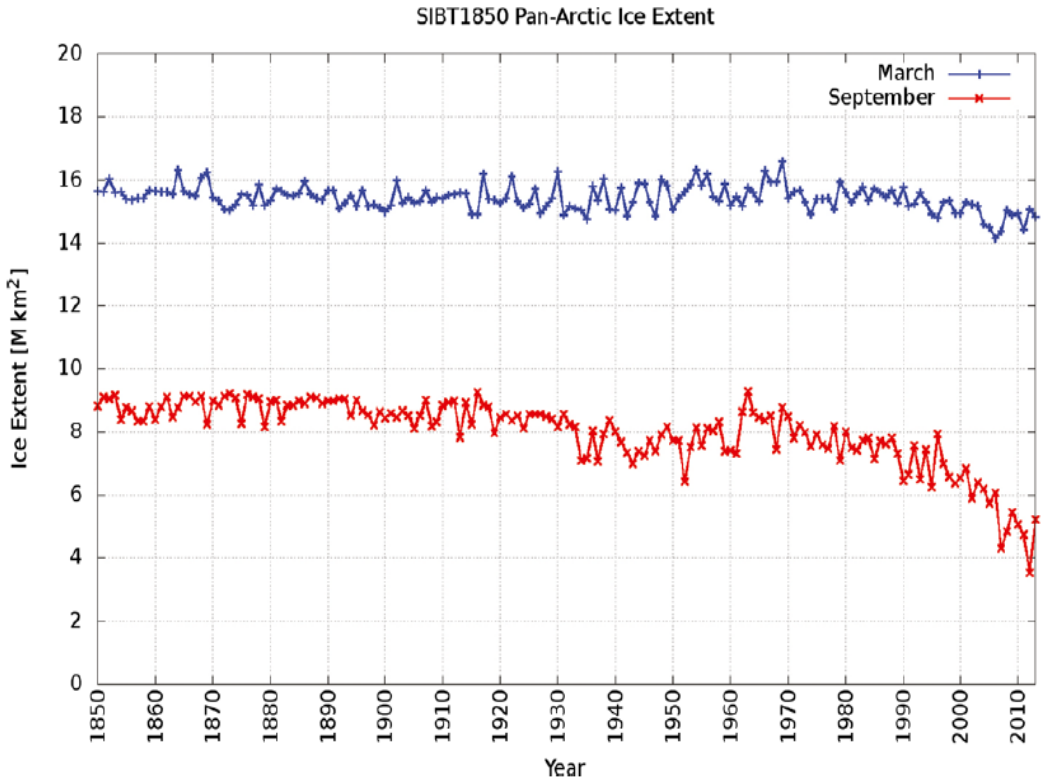


FIG. 8—Time series of pan-Arctic ice extent, 1850-2013, for March (blue line) and September (red line).

Walsh et al., 2017

Geophysical Research Letters

RESEARCH LETTER
10.1029/2019GL086843

Arctic Sea-Ice Variability During the Instrumental Era

M. Kathleen Brennan[1], Gregory J. Hakim[1], and Edward Blanchard-Wrigglesworth[1]

[1]Department of Atmospheric Sciences, University of Washington, Seattle, WA, USA

Key Points:

- Data assimilation is a skillful technique for reconstructing

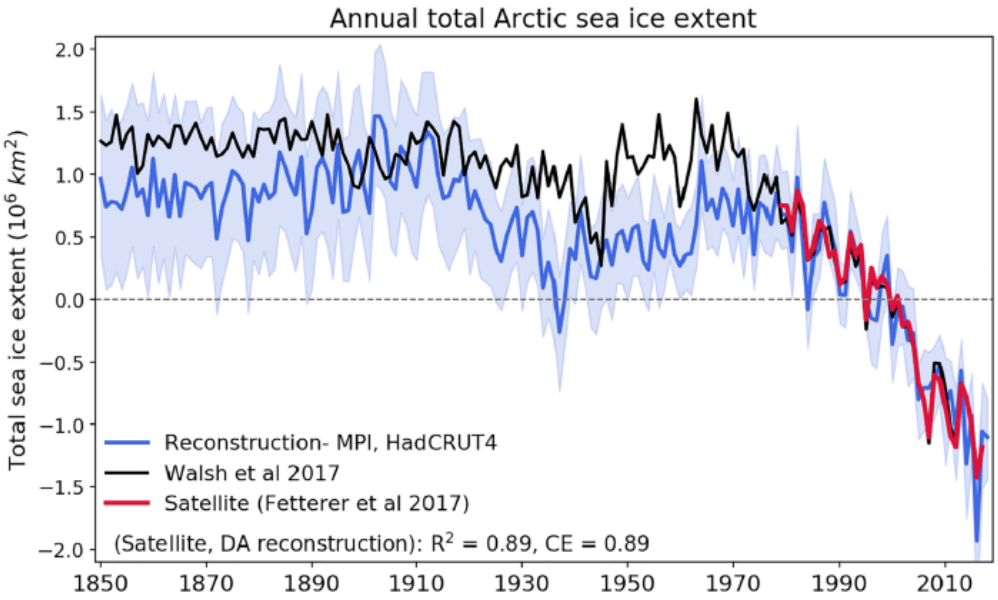
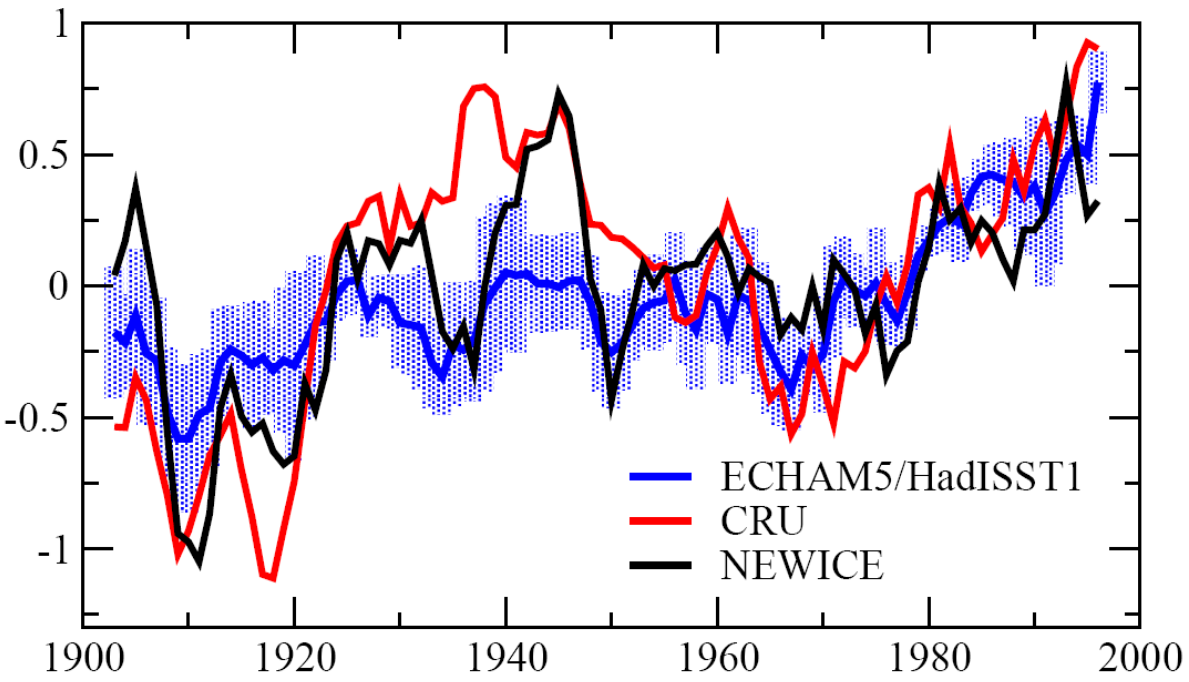


Figure 3. Reconstructed Arctic SIE from DA (blue), Walsh et al. (2017) (black), and satellite observations (red). For our reconstructions, annually averaged HadCRUT temperature data were assimilated with a prior ensemble drawn from the MPI Last Millennium simulation. The blue shaded region indicates the 2.5-97.5th percentile range of reconstructed ensemble members. Anomalies are centered about 1979–2013.

Brennan et al., 2020

Sea ice reconstruction based on AARI data



$$Ice(t_i) = (STDDEV_{1960\text{-}98}(Ice)/STDDEV_{1960\text{-}98}(T)) * (T(t_i) - MEAN_{1960\text{-}98}(T)) + MEAN_{1960\text{-}98}(Ice) \quad (2.1),$$

где $T(t_i)$ – среднемесячные аномалии температуры по данным ААНИИ.

Semenov, 2010, Dr.Sci. Thesis

ADVANCES IN ATMOSPHERIC SCIENCES, VOL. 41, AUGUST 2024, 1483–1495

• Original Paper •

Arctic Sea Ice Variations in the First Half of the 20th Century: A New Reconstruction Based on Hydrometeorological Data※

Vladimir A. SEMENOV*[1,2], Tatiana A. ALDONINA[1,2], Fei LI[3], Noel Sebastian KEENLYSIDE*[3,4], and Lin WANG[5]

[1]*A.M. Obukhov Institute of Atmospheric Physics RAS, Moscow* 119017, *Russia*

[2]*Institute of Geography RAS, Moscow* 119017, *Russia*

[3]*Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Bergen* 5007, *Norway*

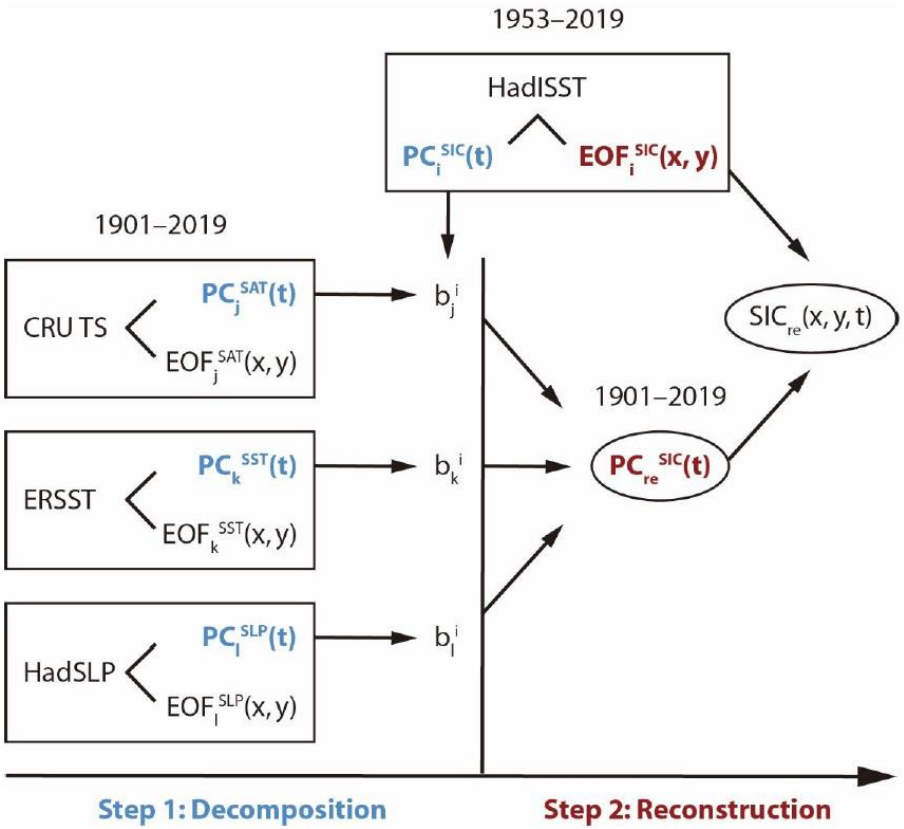
[4]*Nansen Environmental and Remote Sensing Center, Bergen* 5007, *Norway*

[5]*Center for Monsoon System Research, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing* 100029, *China*

(Received 4 November 2023; revised 15 June 2024; accepted 21 June 2024)

Semenov et al., 2024

Method: EOF decomposition, regression models for PCs



$$\mathrm{SIC}(x,y,t) = \sum_{i=1}^{N=K} \mathrm{PC}_i^{\mathrm{SIC}}(t)\,\mathrm{EOF}_i^{\mathrm{SIC}}(x,y)\,,$$

$$\mathrm{SAT}(x,y,t) = \sum_{j=1}^{N=M1} \mathrm{PC}_j^{\mathrm{SAT}}(t)\,\mathrm{EOF}_j^{\mathrm{SAT}}(x,y)\,,$$

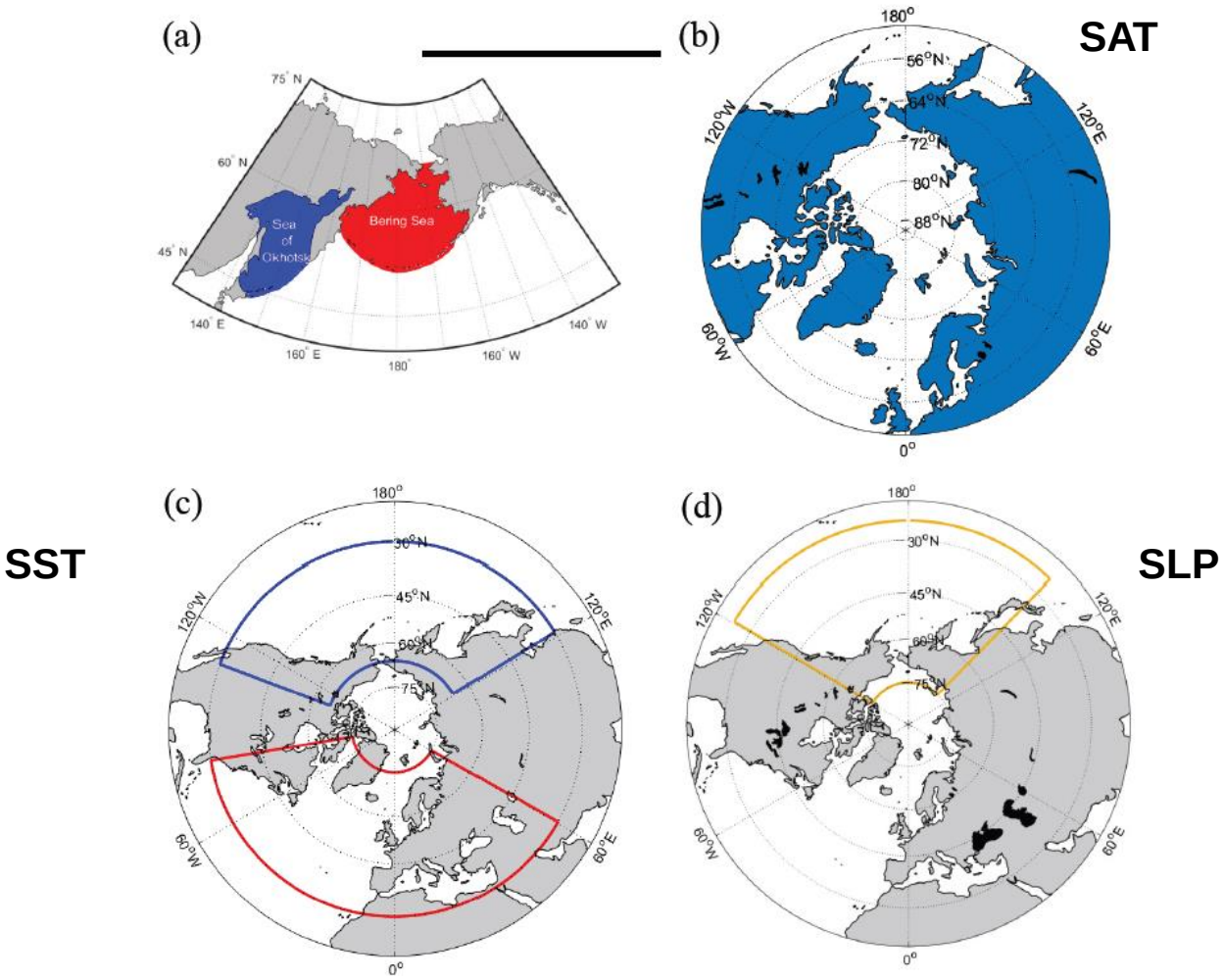
$$\mathrm{SST}(x,y,t) = \sum_{k=1}^{N=M2} \mathrm{PC}_k^{\mathrm{SST}}(t)\,\mathrm{EOF}_k^{\mathrm{SST}}(x,y)\,,$$

$$\mathrm{SLP}(x,y,t) = \sum_{l=1}^{N=M3} \mathrm{PC}_l^{\mathrm{SLP}}(t)\,\mathrm{EOF}_l^{\mathrm{SLP}}(x,y)\,,$$

$$\mathrm{PC}_{\mathrm{re}}^{\mathrm{SIC}}(i,t) = \sum_{j=1}^{N=M1} \mathrm{PC}_j^{\mathrm{SAT}} b_j^i + \sum_{k=1}^{N=M2} \mathrm{PC}_k^{\mathrm{SST}} b_k^i + \sum_{l=1}^{N=M3} \mathrm{PC}_l^{\mathrm{SLP}} b_l^i\,,$$

$$\mathrm{SIC}_{\mathrm{re}}(x,y,t) = \sum_{i=1}^{N=K} \mathrm{PC}_{\mathrm{re}}^{\mathrm{SIC}}(t)\,\mathrm{EOF}_i^{\mathrm{SIC}}(x,y)\,.$$

Regression model's predictors: SAT, SST, SLP



Arctic sea ice area as reconstructed, in HadISST1 and Walsh SIBT1850 data

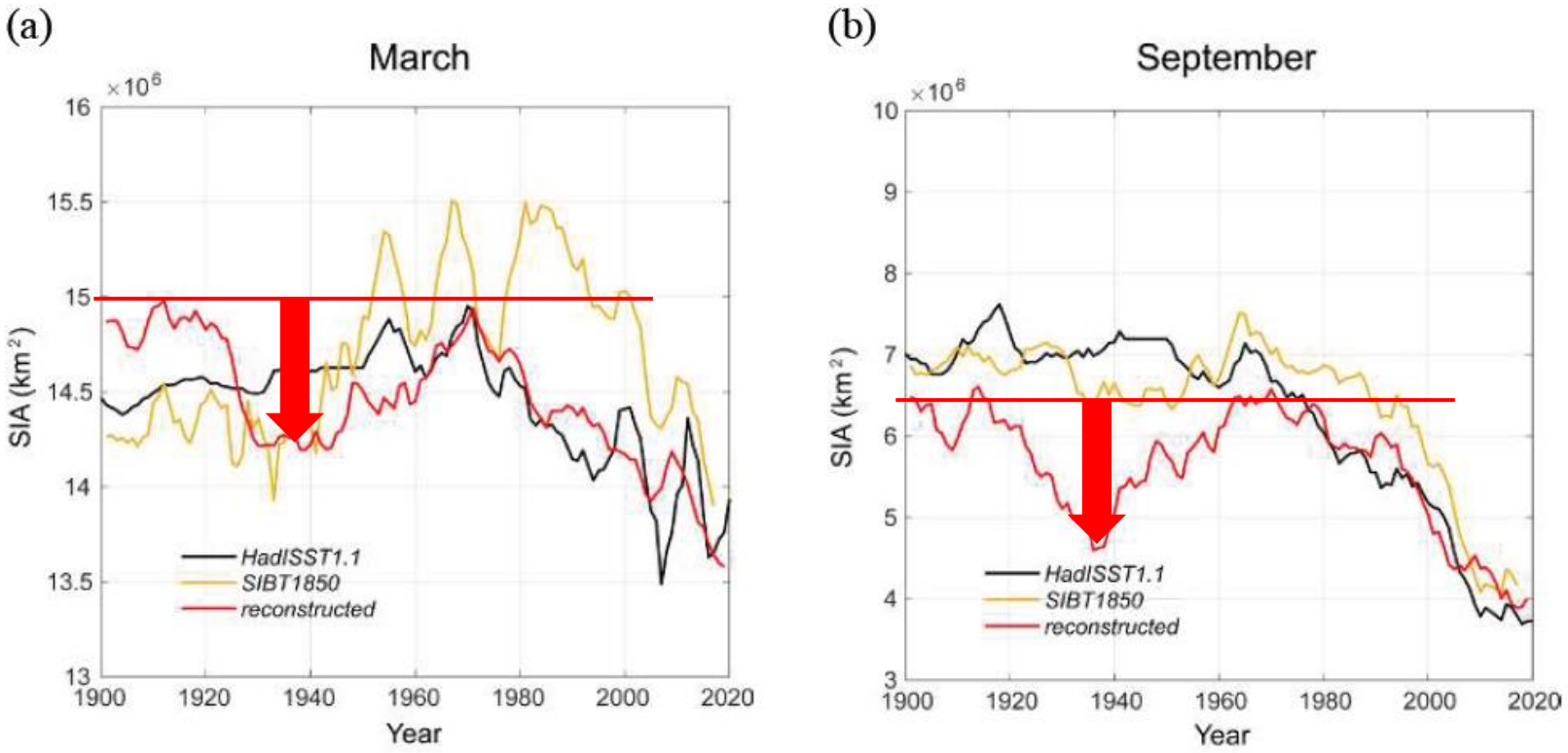


Fig. 1. Arctic SIA (units: km^2) in (a) March and (b) September according to HadISST1.1, SIBT1850, and the reconstructed data (IAPICE1). Data are smoothed with 5-yr running means.

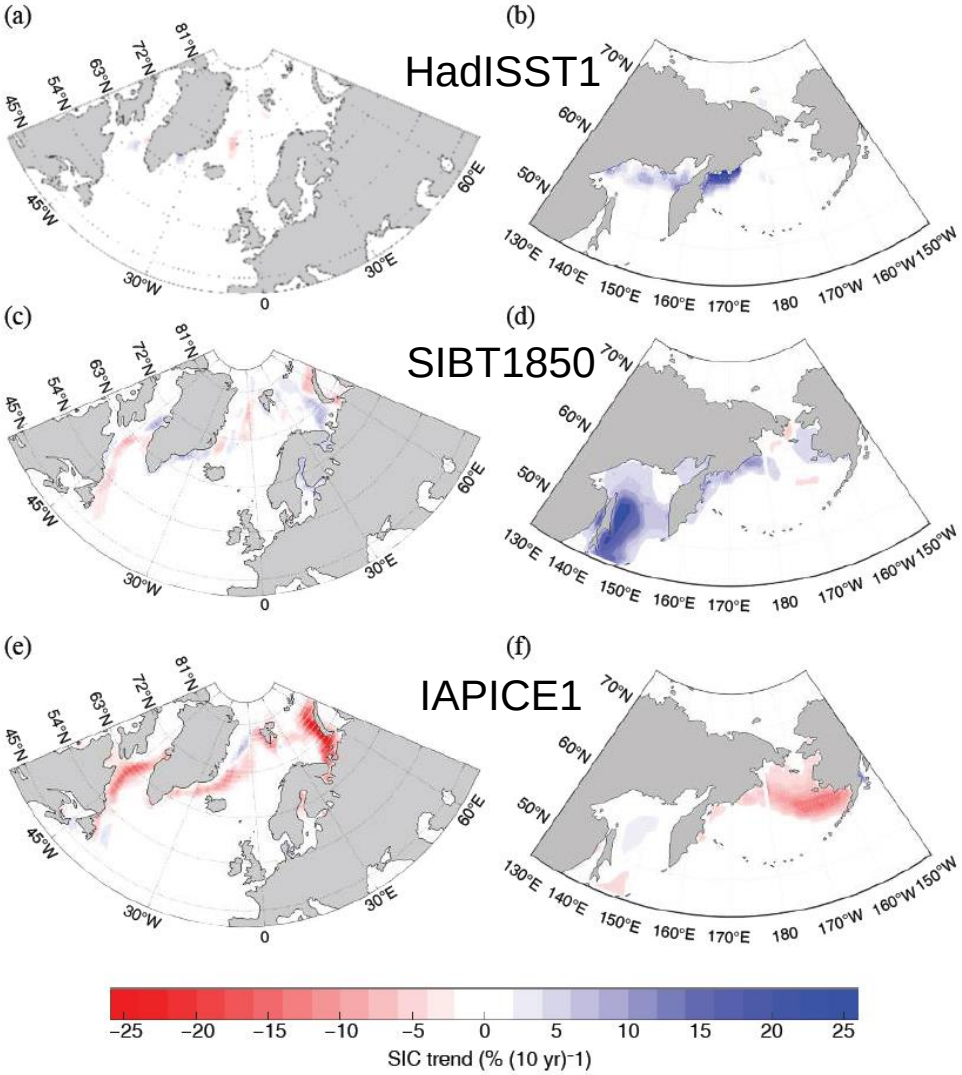


Fig. 3. March SIC trends [units: % (10 yr)$^{-1}$] in the (a, c, e) Atlantic and (b, d, f) Pacific sectors for the period 1915–45 according to (a, b) HadISST1.1, (c, d) SIBT1850, and (e, f) IAPICE1 data. White dots indicate trends significant at the 90% confidence level.

March SIC trends for 1915-1945 period

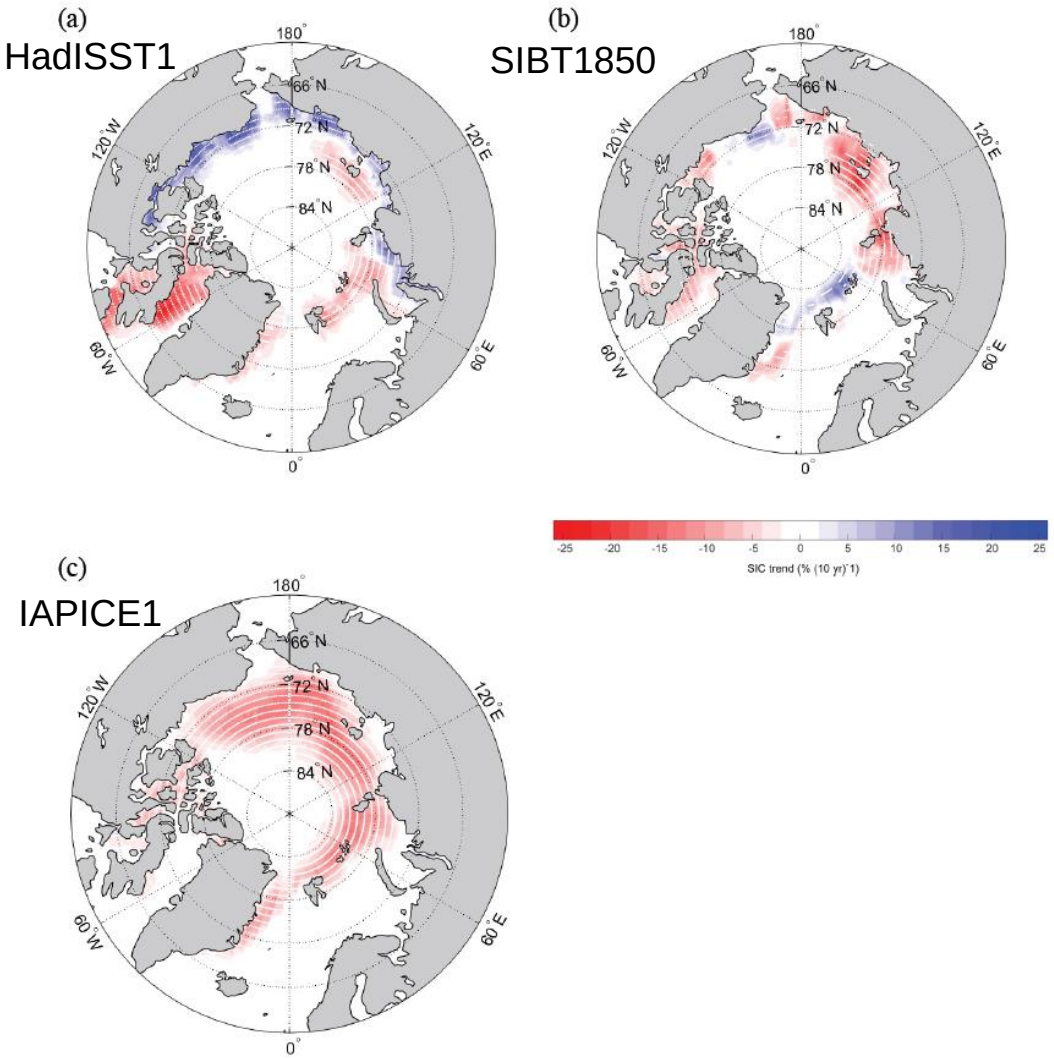


Fig. 4. September SIC trends [units: % (10 yr)$^{-1}$] for the period 1915–45 according to (a) HadISST1.1, (b) SIBT1850, and (c) IAPICE1 data. White dots indicate trends significant at the 90% confidence level.

September SIC trends for 1915-1945 period

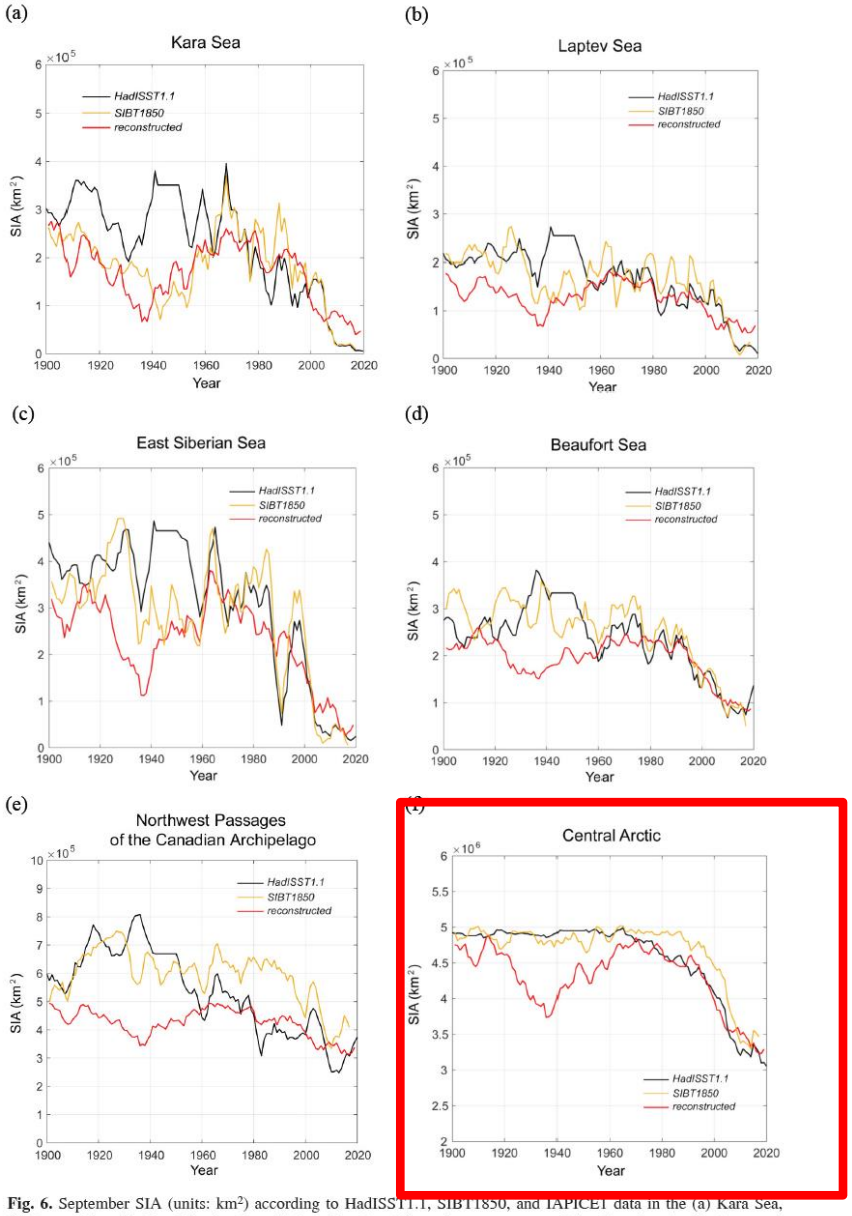


Fig. 6. September SIA (units: km^2) according to HadISST1.1, SIBT1850, and IAPICE1 data in the (a) Kara Sea, (b) Laptev Sea, (c) East Siberian Sea, (d) Beaufort Sea, (e) northwest passages of the Canadian Archipelago, and (f) central Arctic. Data are smoothed with 5-yr running means.

September sea ice area in different Arctic seas

Data availability. The IAPICE1 dataset is available at http://www.ifaran.ru/DATA/IAPICE1/, https://doi.org/10.11582/2024.00112, and https://doi.org/10.57760/sciencedb.iap.00005.

Data availability. The IAPICE1 dataset is available at http://www.ifaran.ru/DATA/IAPICE1/, https://doi.org/10.11582/2024.00112, and https://doi.org/10.57760/sciencedb.iap.00005.

Спасибо за внимание!

Arctic Sea Ice in the First Half of the 20th Century: Temperature-Based Spatiotemporal Reconstruction

V. A. Semenov[a, b, *] and T. A. Matveeva[b]

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[b] *Institute of Geography, Russian Academy of Sciences, Moscow, 119017 Russia*

**e-mail: vasemenov@ifaran.ru*

Received May 7, 2020; revised May 14, 2020; accepted June 3, 2020

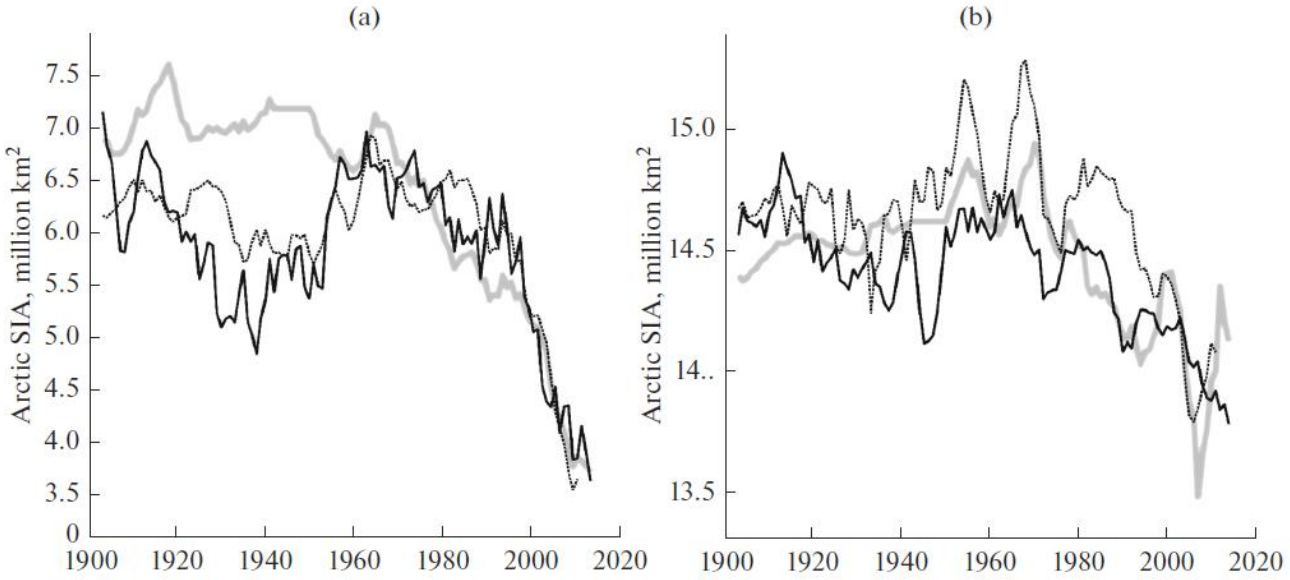
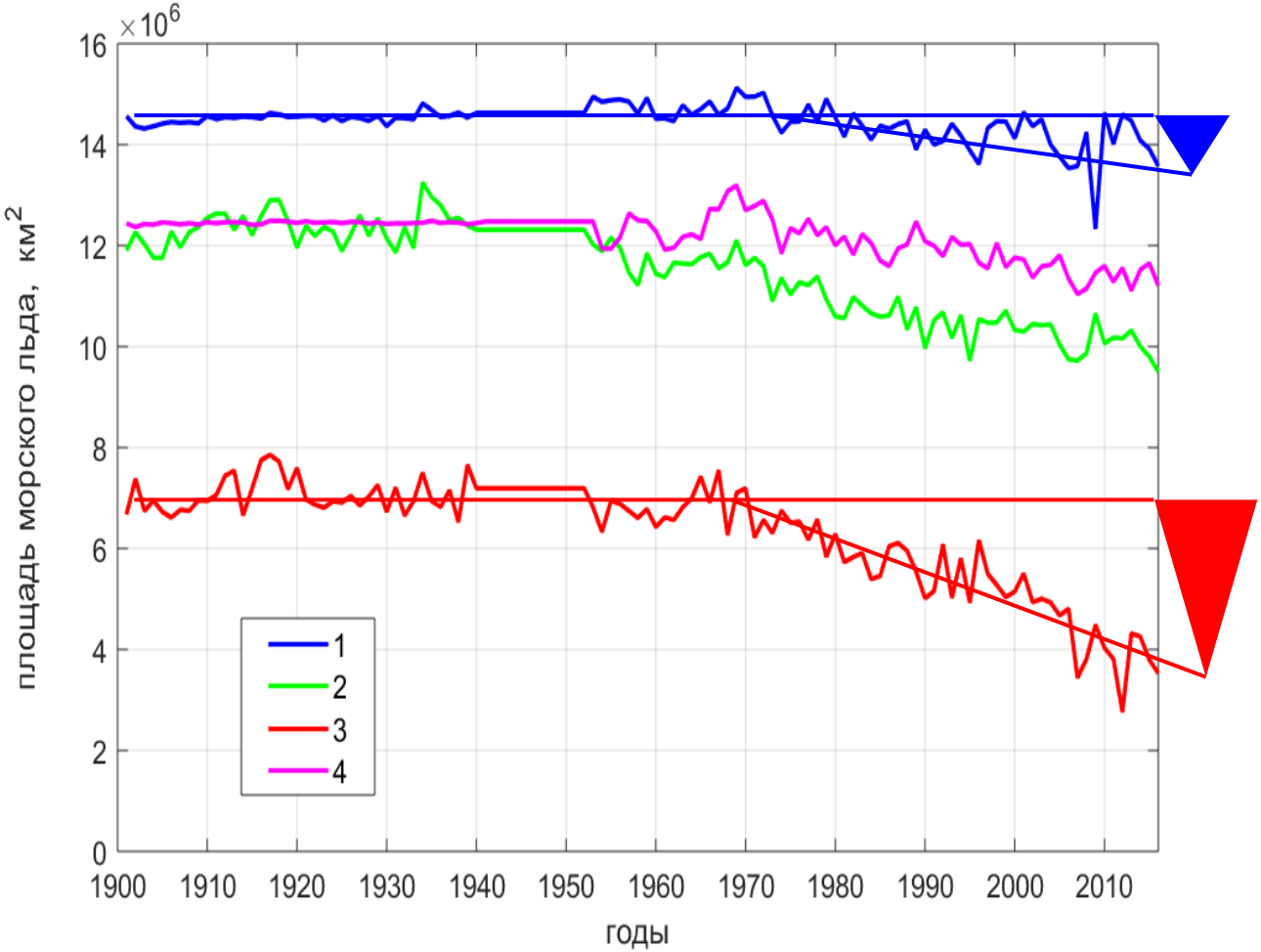


Fig. 1. SIA (mln km^2) (smoothed with a 5-year running mean) for (a) September and (b) March from HadISST 1.1 (thick grey line), SIBT1850 (Walsh) (black dotted line), and reconstruction based on linear regression of SIC onto SAT (black line).

Semenov, Matveeva, 2020

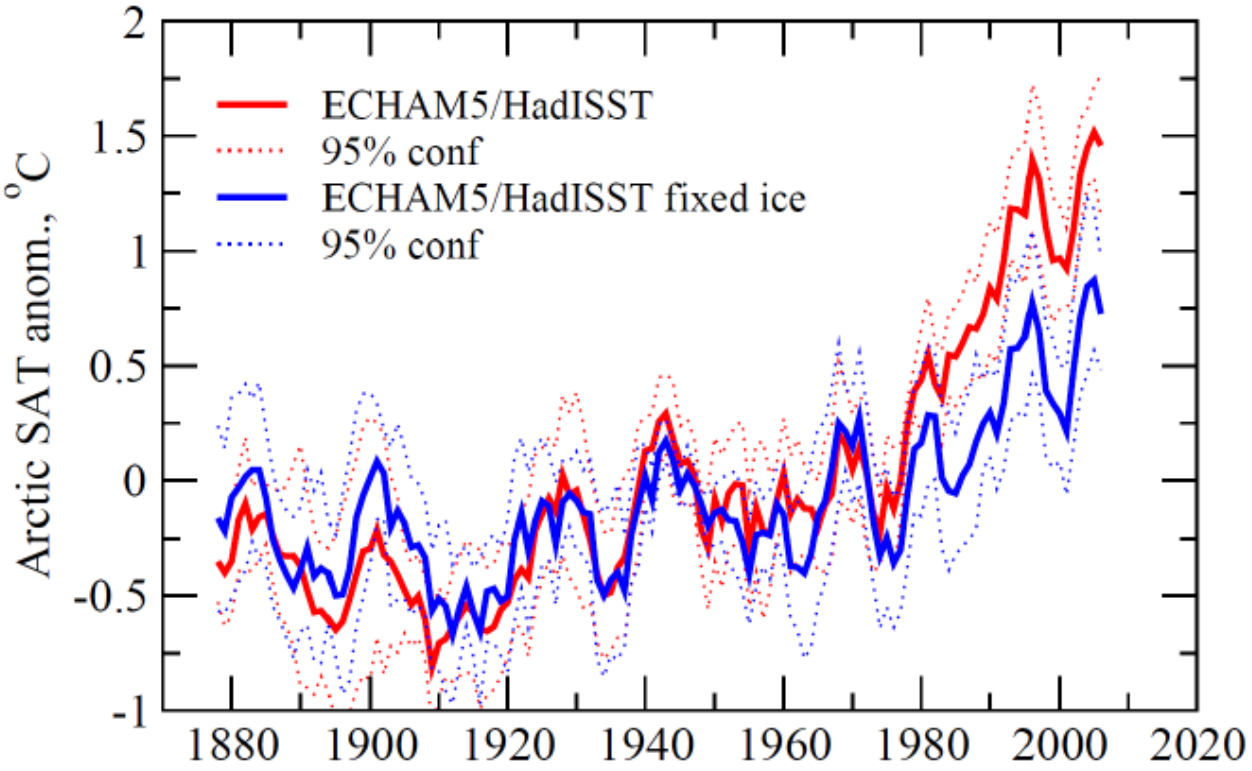
Changes of the Arctic sea ice extent: seasonality

Northern Hemisphere sea ice area, mln.km^2 data of Hadley Centre (HadISST1)
in **March**, **June**, **September** and **December**



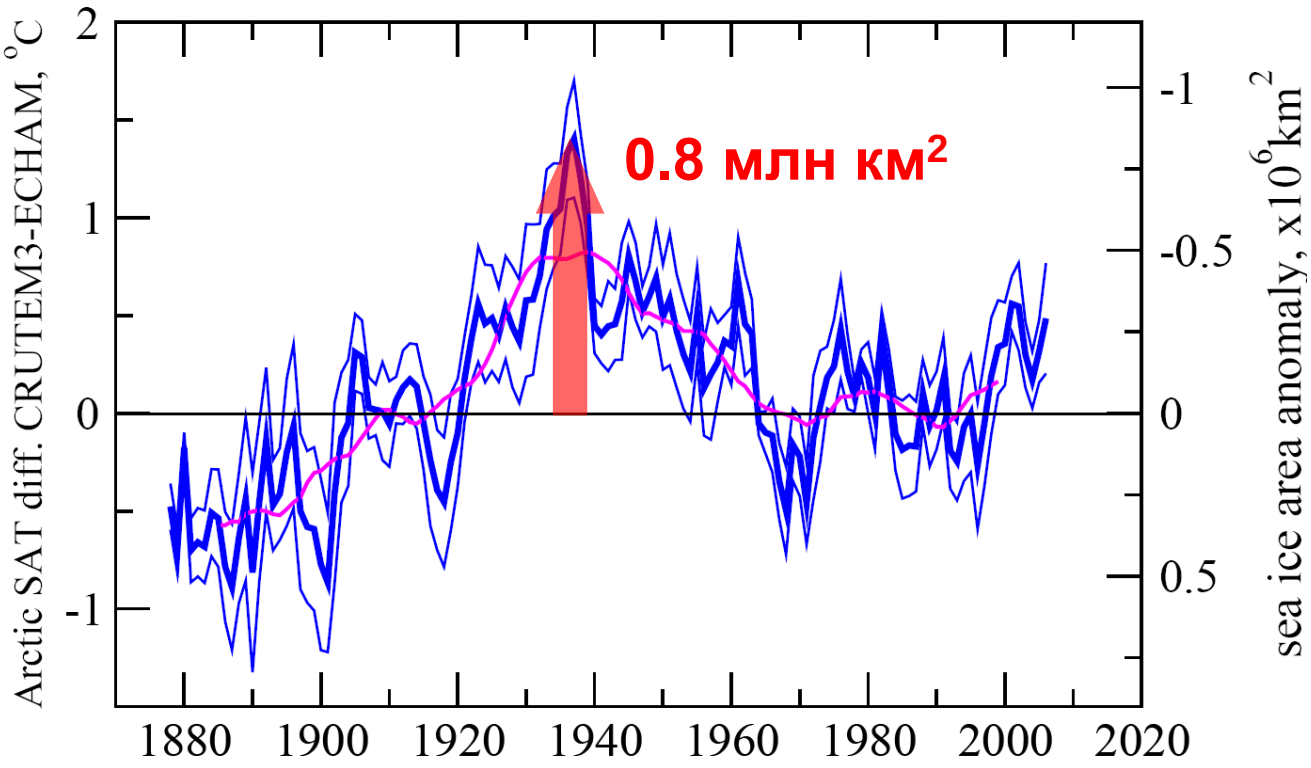
Использование модели общей циркуляции атмосферы для исследования влияния морских льдов на климат и валидации данных

Изменения зимней т-ры в Арктике в эксперименте с данными по концентрации морских льдов (КМЛ) HadISST1 и в эксперименте с замороженными данными по КМЛ



Сравнение этих экспериментов позволяет оценить чувствительность т-ры к изменениям площади льда (и наоборот)

Использование модели общей циркуляции атмосферы для исследования влияния морских льдов на климат и валидации данных



Разница приповерхностной температуры над сушей по данным наблюдений и результатам модельных экспериментов с использованием данных HadISST1 как граничных условий и оценка аномалии площади морских льдов в зимний период (ноя-апр)

Отрицательная аномалия площади морских льдов зимой в Арктике во время потепления середины XX века сравнима с современными изменениями

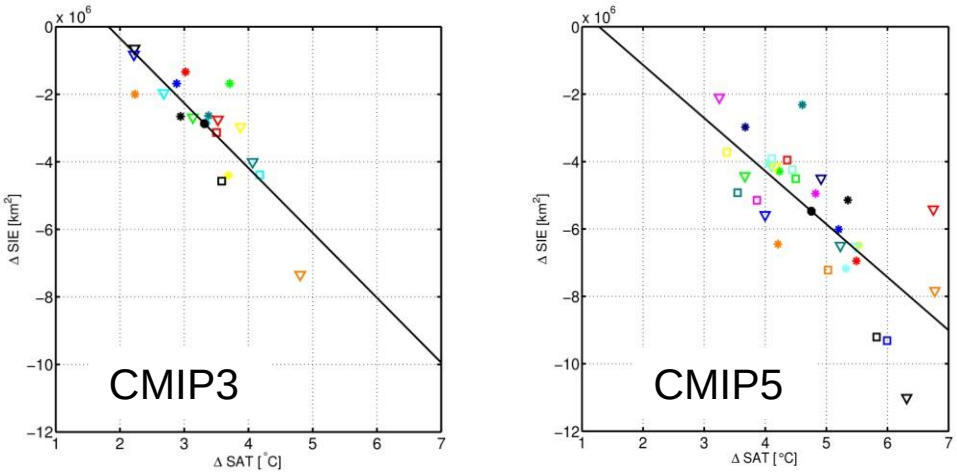
Sea ice area in climate models: problems and progress

New climate models' generations (CMIP5) better reproduces summer sea ice characteristics (area, variability), but does it worse in winter

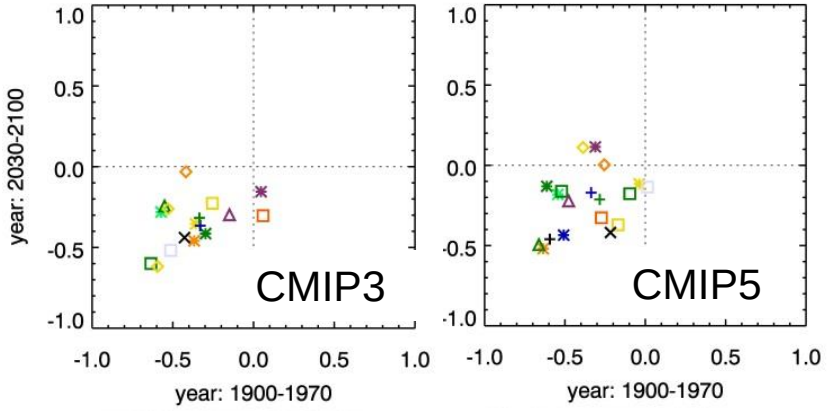
Regional biases are too large

Models are not that bad!

A link between sea ice area and NH temperature



A link (correlation) between sea ice area in the Barents Sea and Spitzbergen-Nordcap pressure difference (a measure of oceanic inflow strength)



Model uncertainties of the Arctic sea ice changes are related to the uncertainty in models' temperature sensitivity to GHG forcing

Models can reproduce regional sea ice dynamics