Nudging observed winds in the Arctic to quantify associated sea ice loss in the past decades and 2020

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Most models show a lower sensitivity to anthropogenic forcing

(2016).

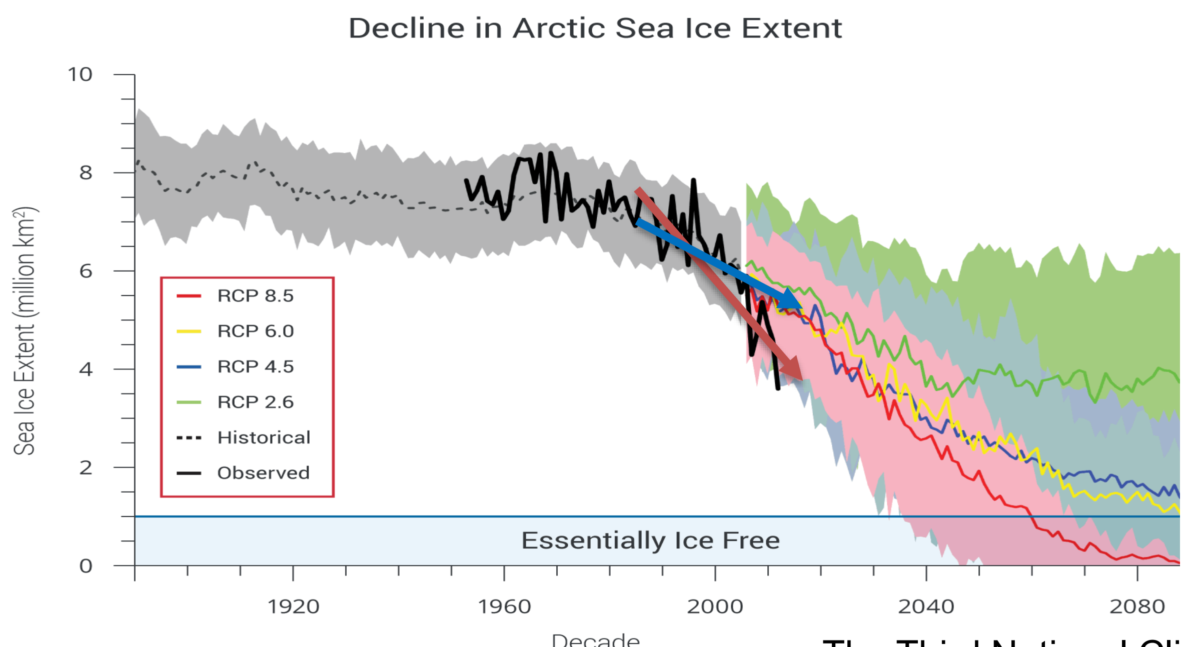
Observed Arctic sea-ice loss directly follows anthropogenic CO_2 emission

Science

Dirk Notz[1*] and Julienne Stroeve[2,3]

Abstract

Most models show a lower sensitivity, which is possibly linked to an underestimation of the modeled increase in incoming longwave radiation and of the modeled Transient Climate Response.



The Third National Climate Assessment
Walsh and Wuebbles 2014

Two ideas to explain the discrepancy (lower sensitivity) between the simulations and observations

1. The trends are due to anthropogenic forcing but models are less sensitive (Solution: recalibration)
2. Internal variability plays an important role (Solution: understand the internal source)

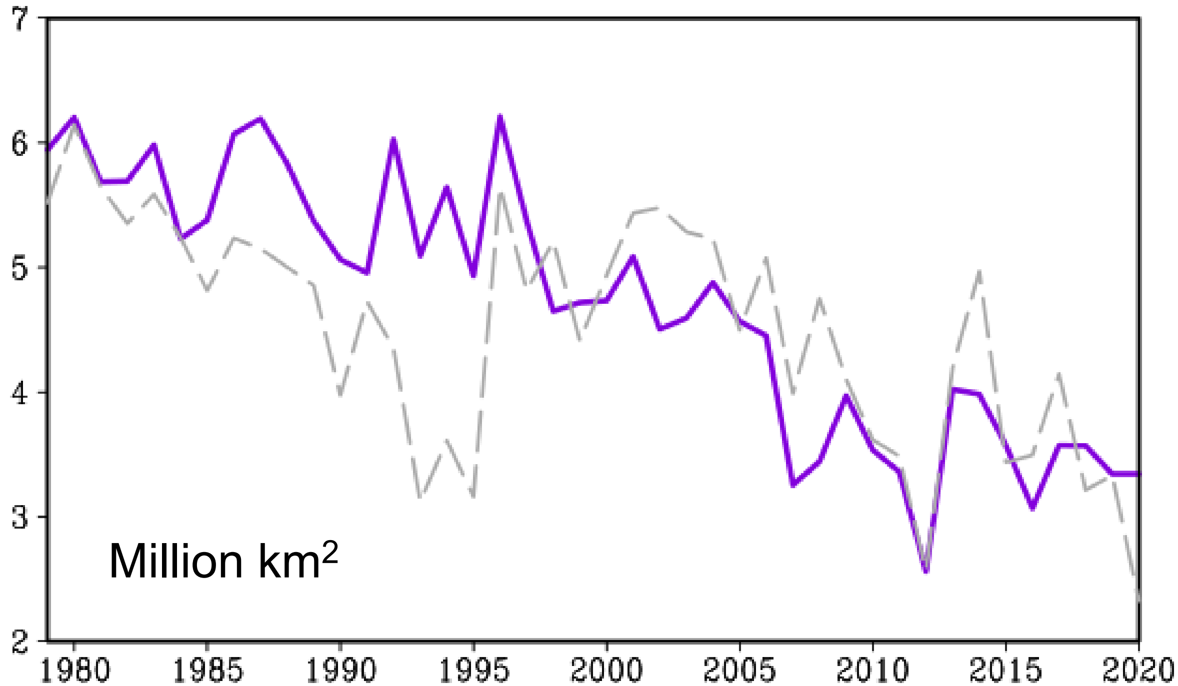
Anthropogenic thermal warming

Arctic amplification

Internal atmospheric dynamical warming

- Sea ice loss
- Albedo feedback
- Cloud cover and water vapor
- Black carbon aerosol
- Local thermal inversion/Lapse rate feedback
- Vegetation feedback
- Poleward heat and moisture transport by atmosphere and ocean

September Arctic sea ice total area from 1979 to 2020

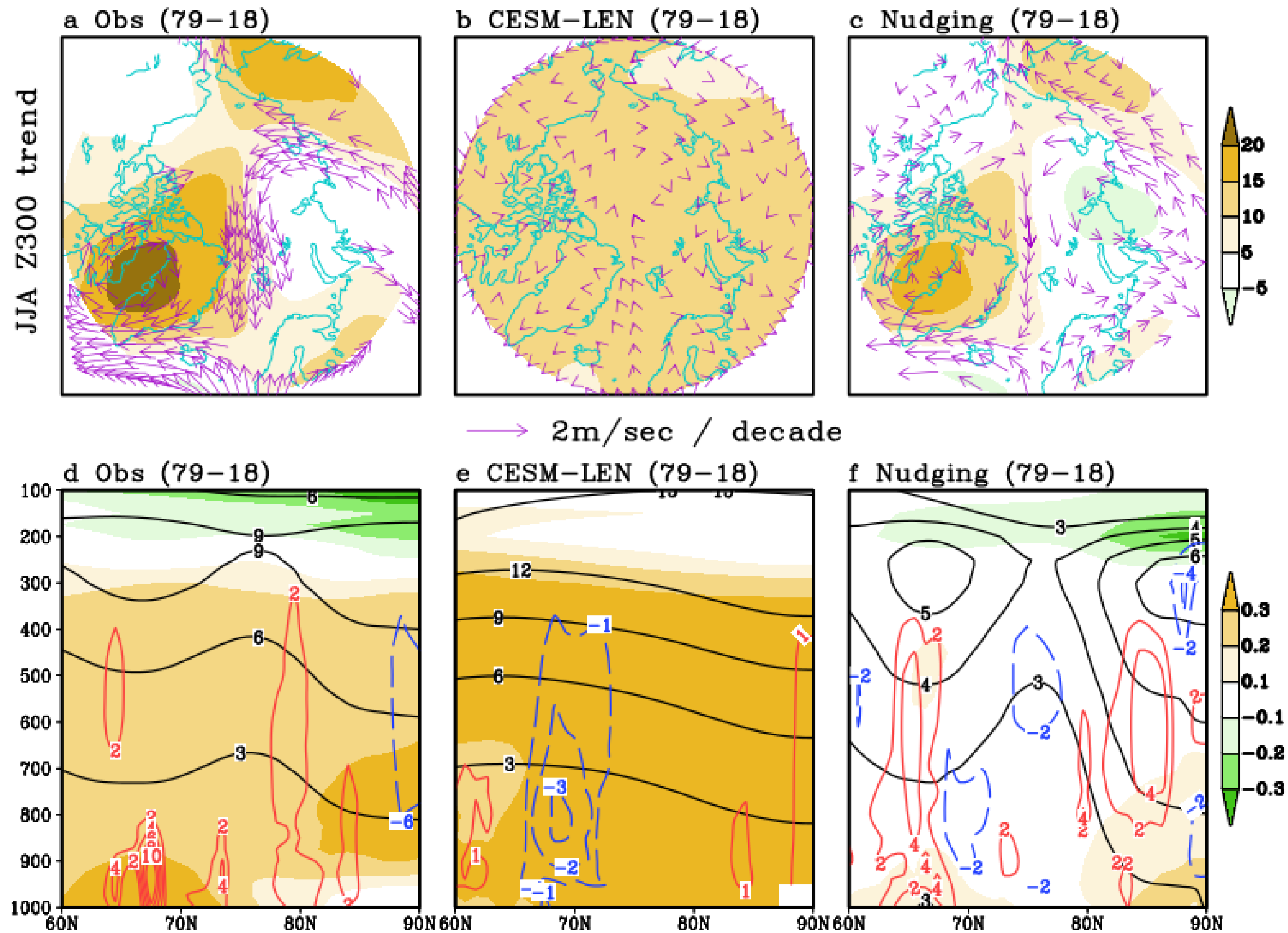


Goal: Quantify the contribution of internal and anthropogenic forcing in the recent sea ice decline (2000-2012)

Approach: Use a nudging method available to the CESM to quantify the role of observed winds in driving sea ice changes and compare it with that due to CO2 forcing in the same model

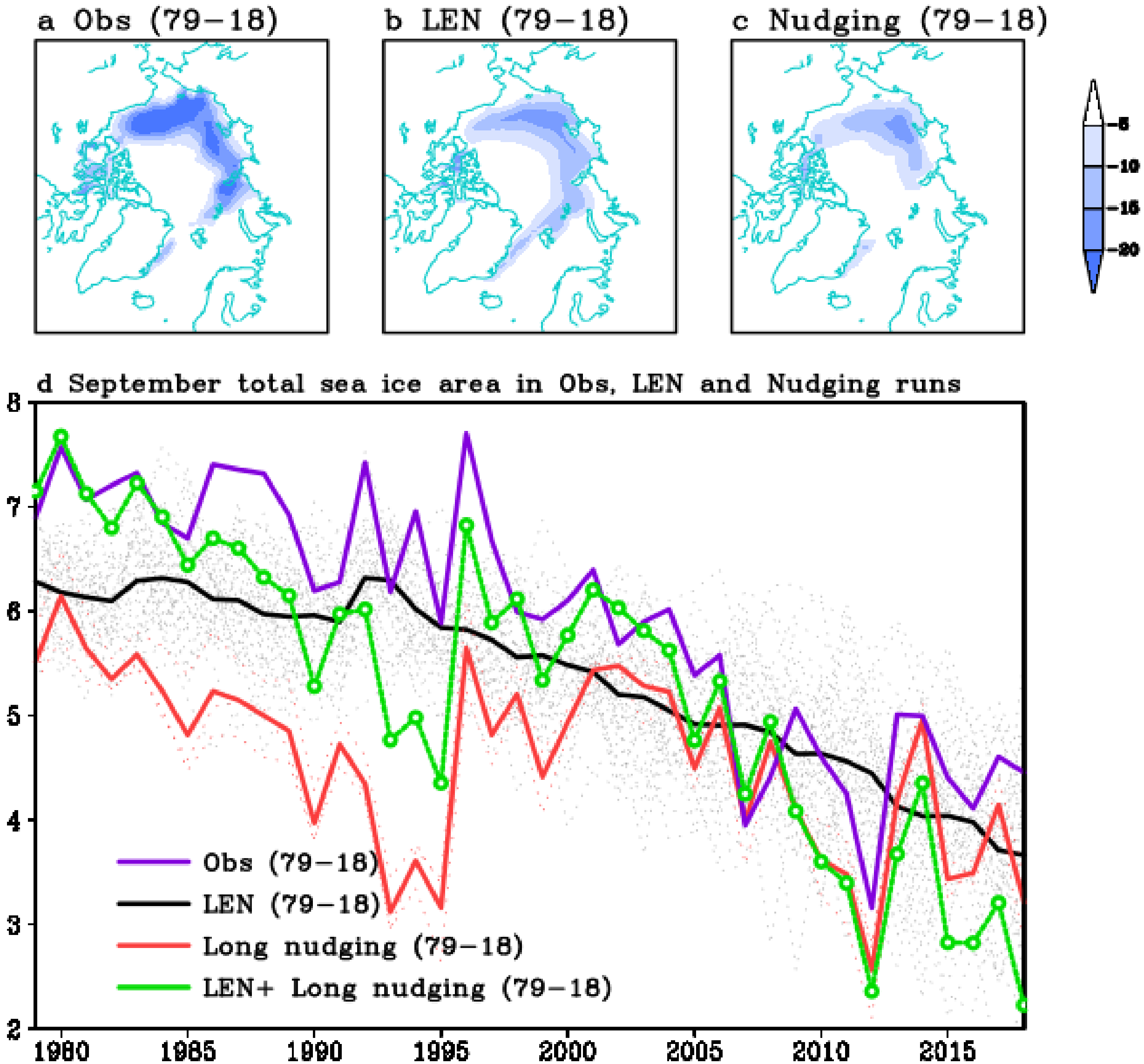
Linear trends of JJA atmospheric variables from 1979 to 2018

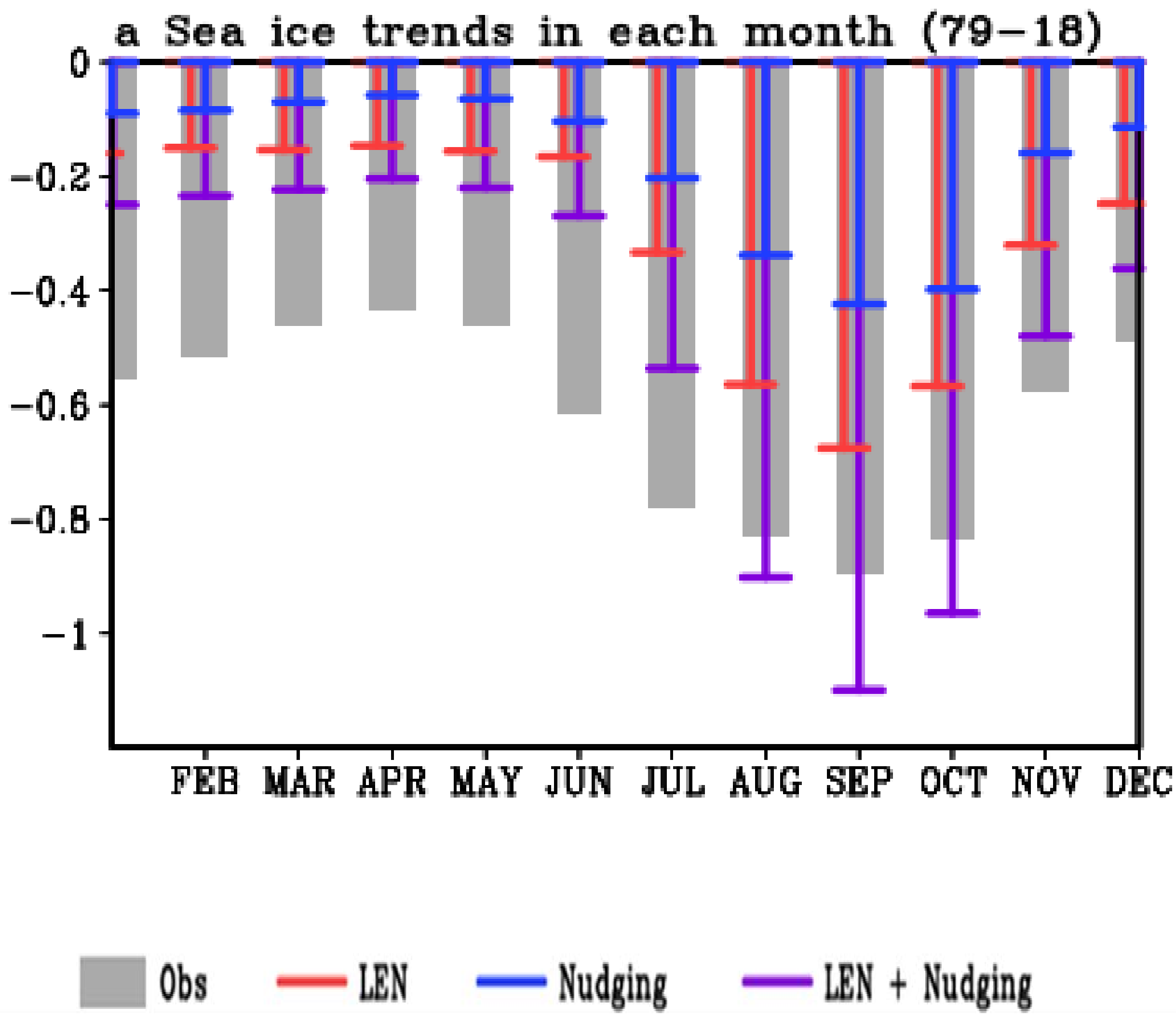
Obs | Forced | Wind-driven



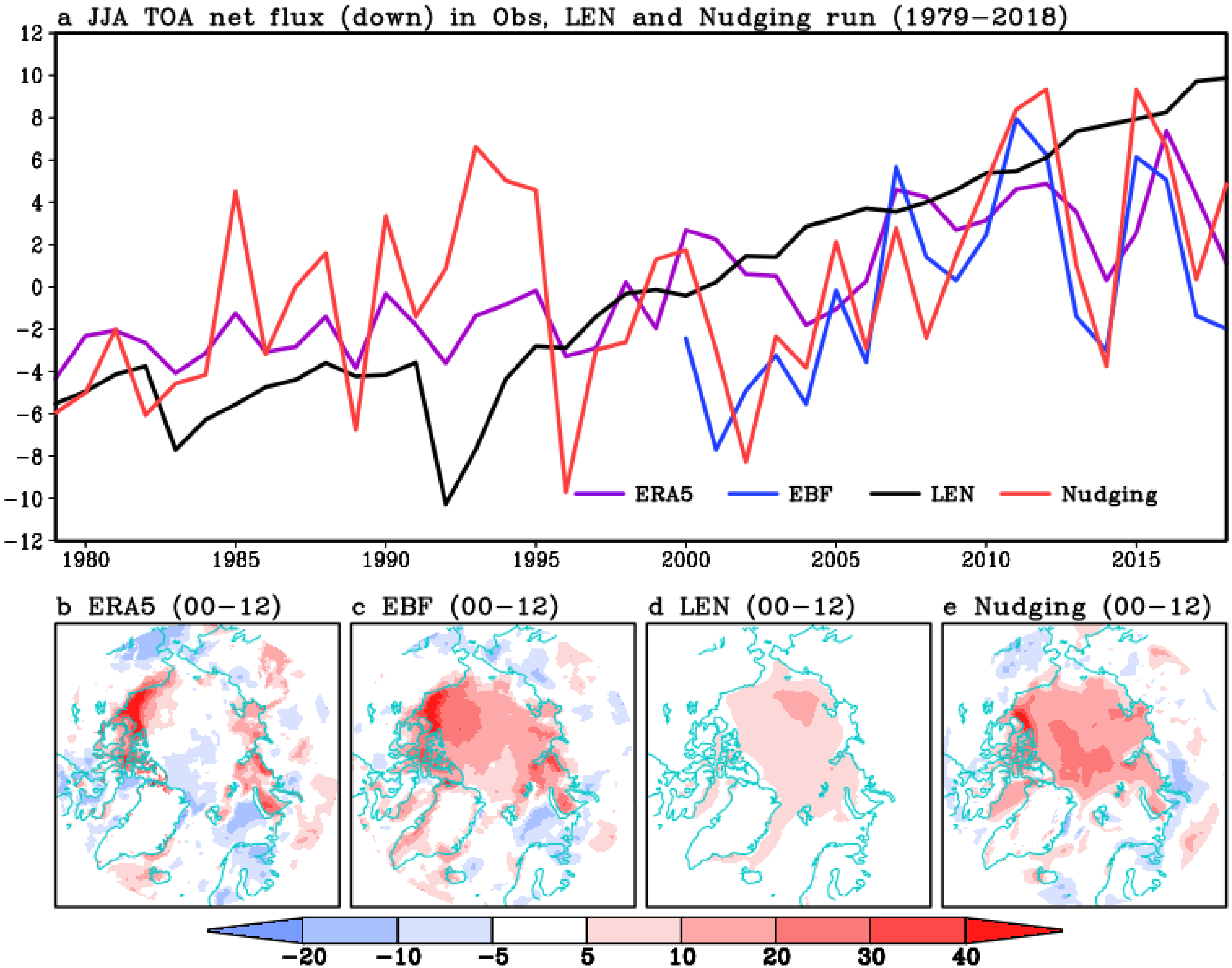
Shading: temp
black contour: height
Red contour : omega

Linear trends of Sep sea ice from 1979-2018

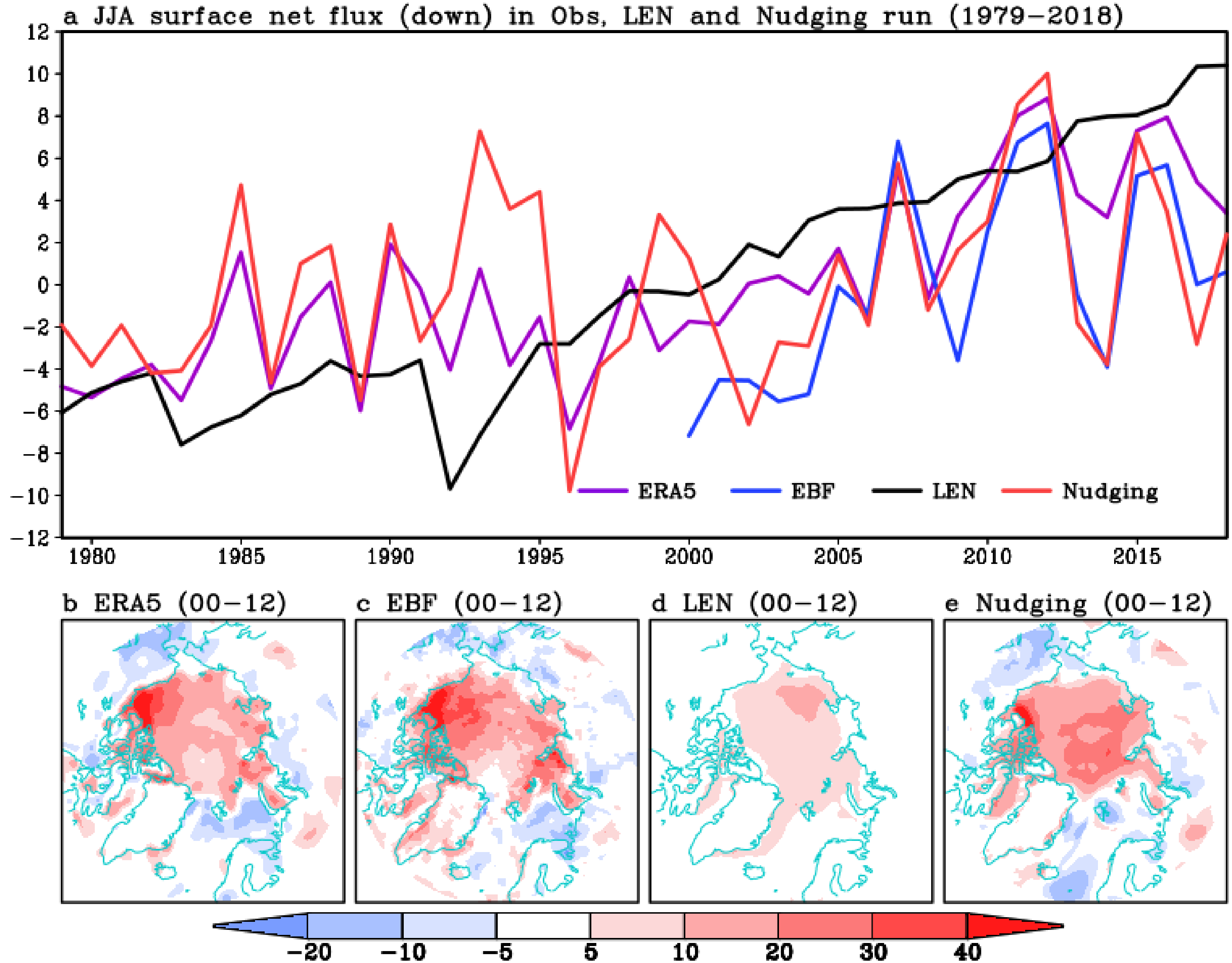




a Sea ice trends in each month (79-18)
0
-0.2
-0.4
-0.6
-0.8
-1
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Obs
LEN
Nudging
LEN + Nudging

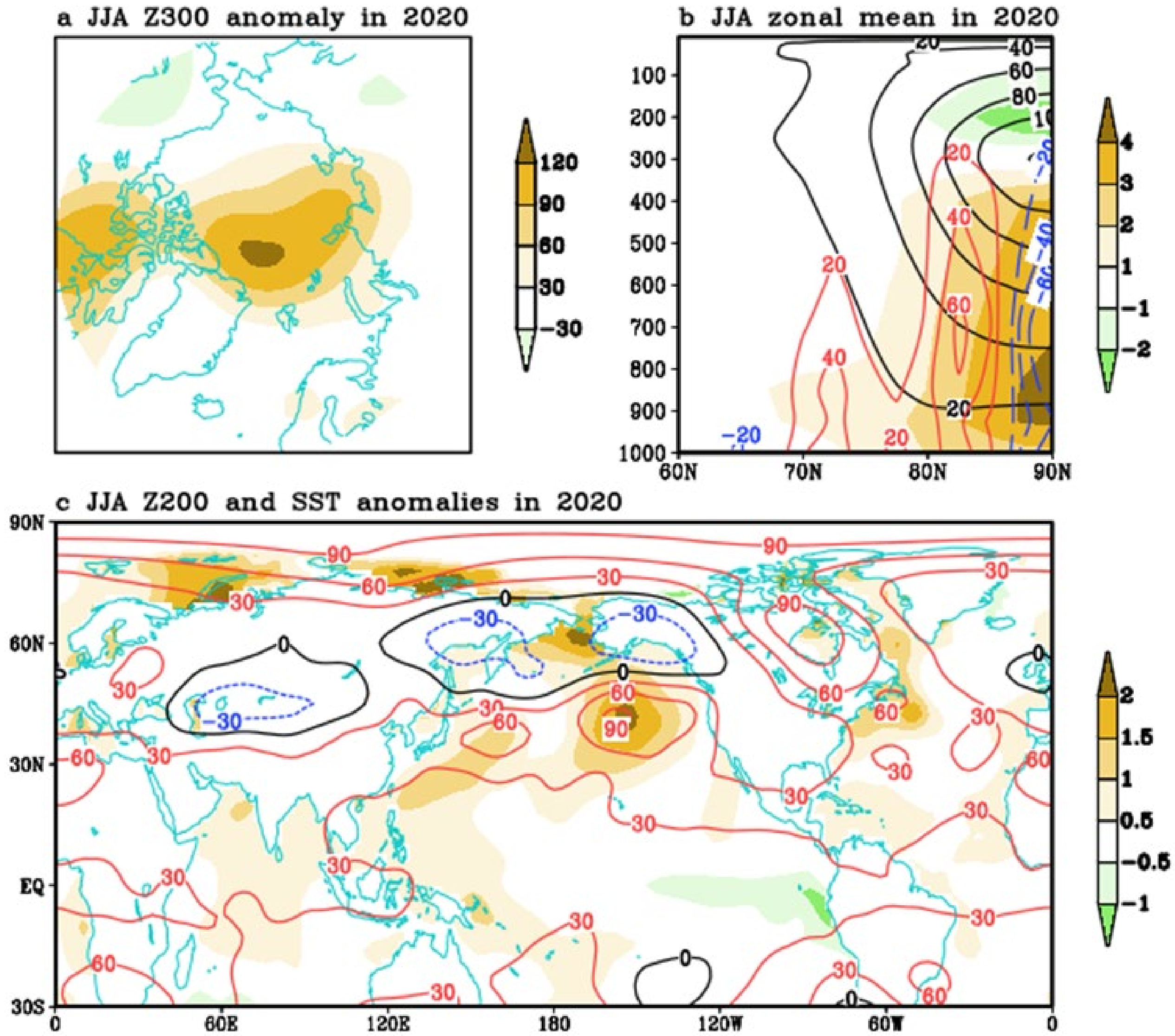


a JJA TOA net flux (down) in Obs, LEN and Nudging run (1979–2018)
12
10
8
6
4
2
0
−2
−4
−6
−8
−10
−12
1980
1985
1990
1995
2000
2005
2010
2015
ERA5
EBF
LEN
Nudging
b ERA5 (00–12)
c EBF (00–12)
d LEN (00–12)
e Nudging (00–12)
−20
−10
−5
5
10
20
30
40

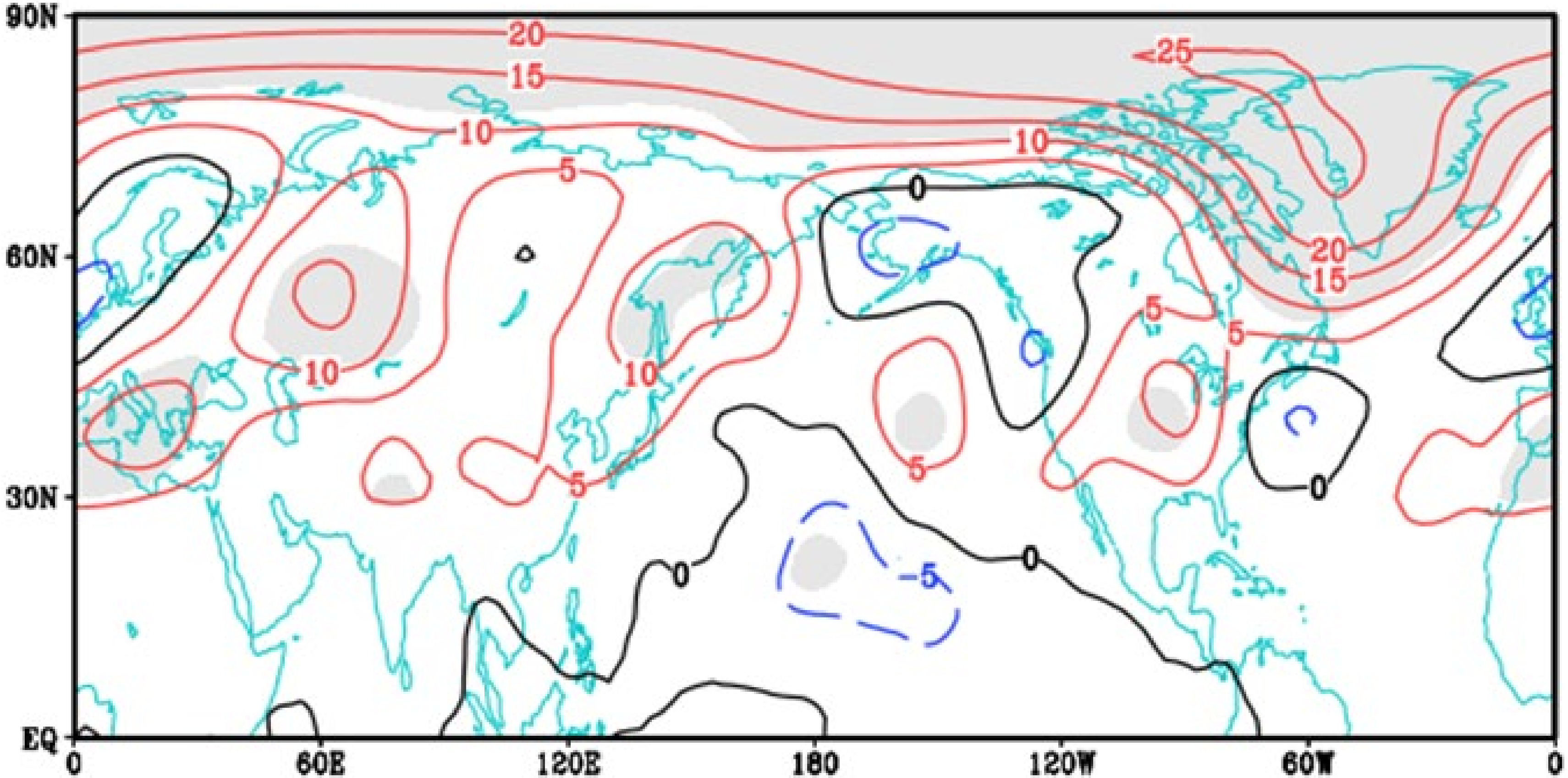


a JJA surface net flux (down) in Obs, LEN and Nudging run (1979–2018)
12
10
8
6
4
2
0
−2
−4
−6
−8
−10
−12
1980
1985
1990
1995
2000
2005
2010
2015
ERA5
EBF
LEN
Nudging
b ERA5 (00–12)
c EBF (00–12)
d LEN (00–12)
e Nudging (00–12)
−20
−10
−5
5
10
20
30
40

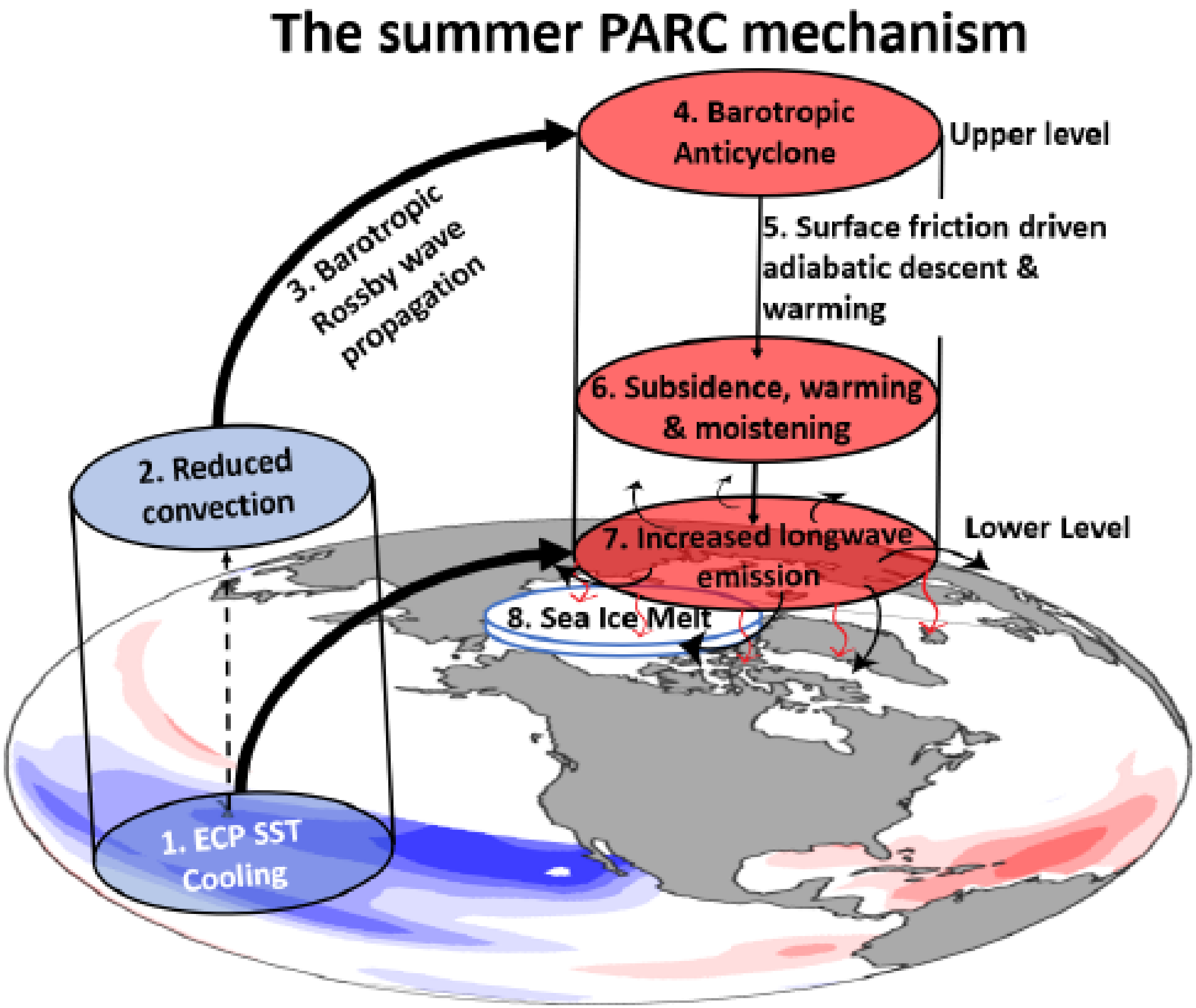
Anomalous circulation and SST in JJA of 2020



Observed correlation of detrended JJA Z200 with September SIA index for 1979-2019.



Pacific-Arctic teleconnection (PARC)



Baxter et al. 2019

Take-home message

- Wind related internal variability contributes to 30-40% of September sea ice loss from 1979 to 2018 (60% for 2000-2012) though its adiabatic warming in summer and associated dynamical drifting effects only play a minor role.
- A similar internal process may also play a role to cause strong sea ice melt in the summer of 2020
- The model constrained by observed winds in the Arctic can simulate a similar local energy budget as observations at the TOA and surface.
- Large scale wind changes is important in shaping Arctic climate in the past decades and its future changes is a critical factor to determine Arctic climate projections.