# Understanding connections of Tropics-Arctic is necessary to explain ENSO diversity

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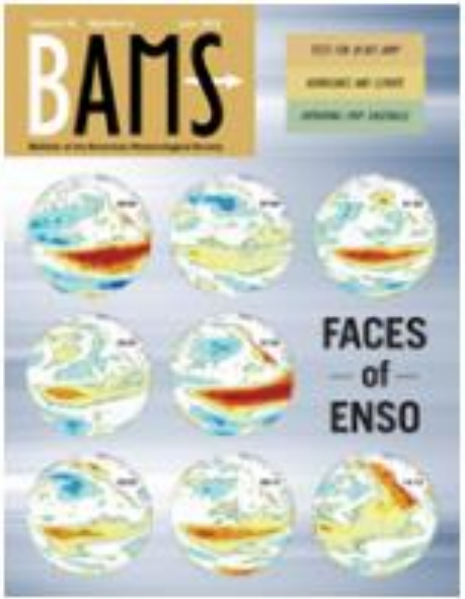
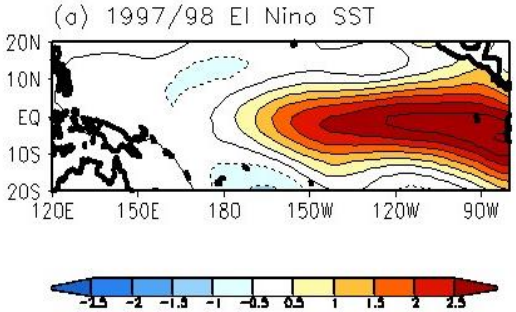
# • ENSO diversity

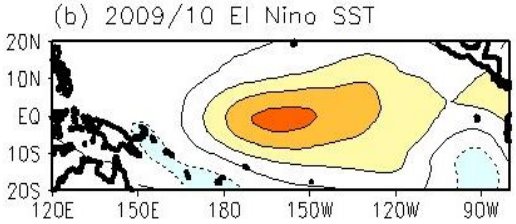



Capotondi et al., (2015)

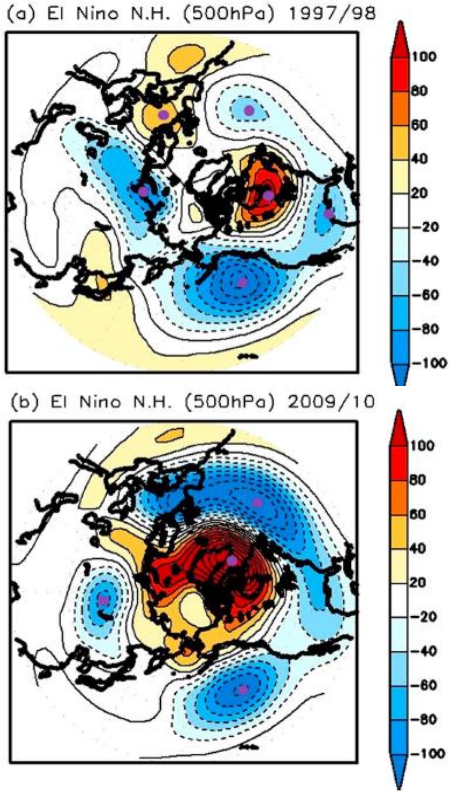
1997/98 El Nino (Eastern Pacific (EP) El Nino)



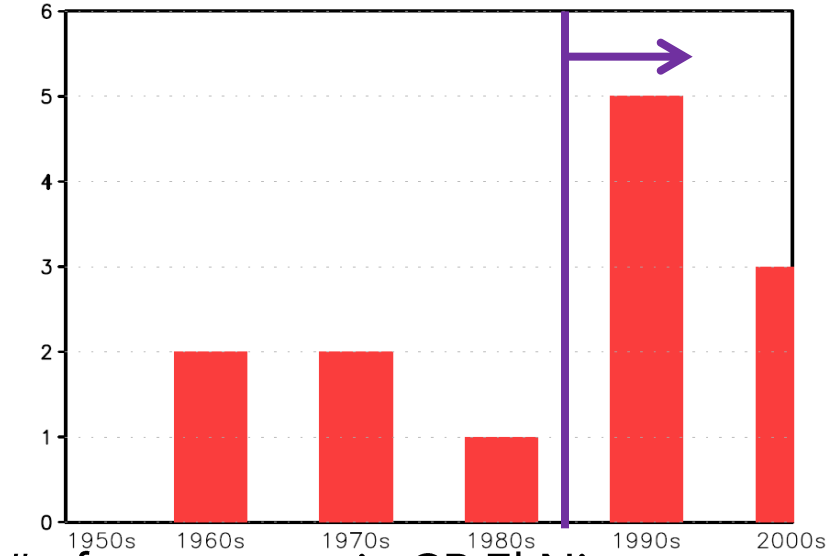

2009/10 El Nino [Central Pacific (CP) El Nino]




Yeh et al. (2018)



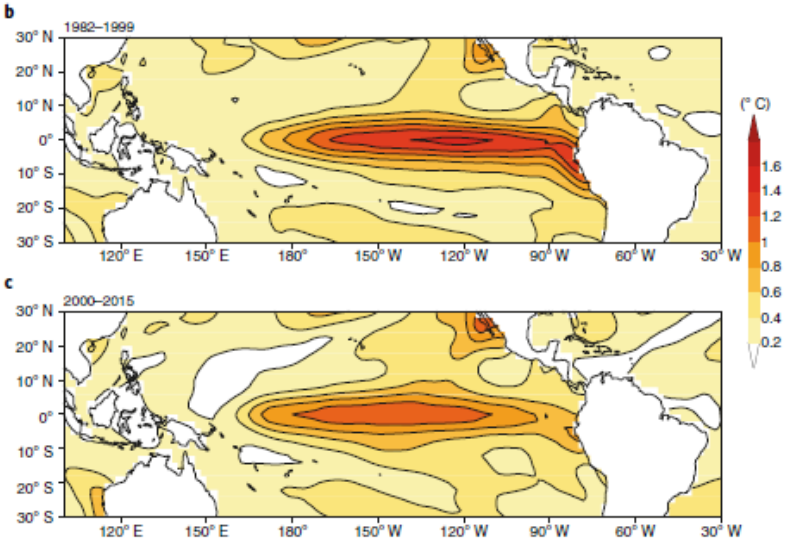
# • ENSO diversity




# of occurrence in CP El Nino

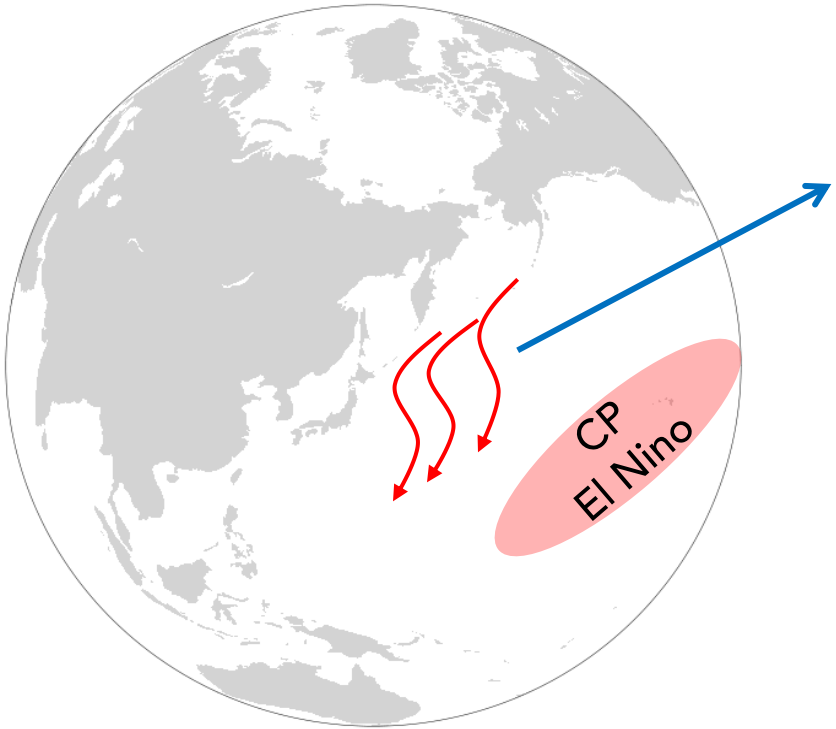
Kao and Yu (2009)

SSTA standard deviation




Yeh (2018)

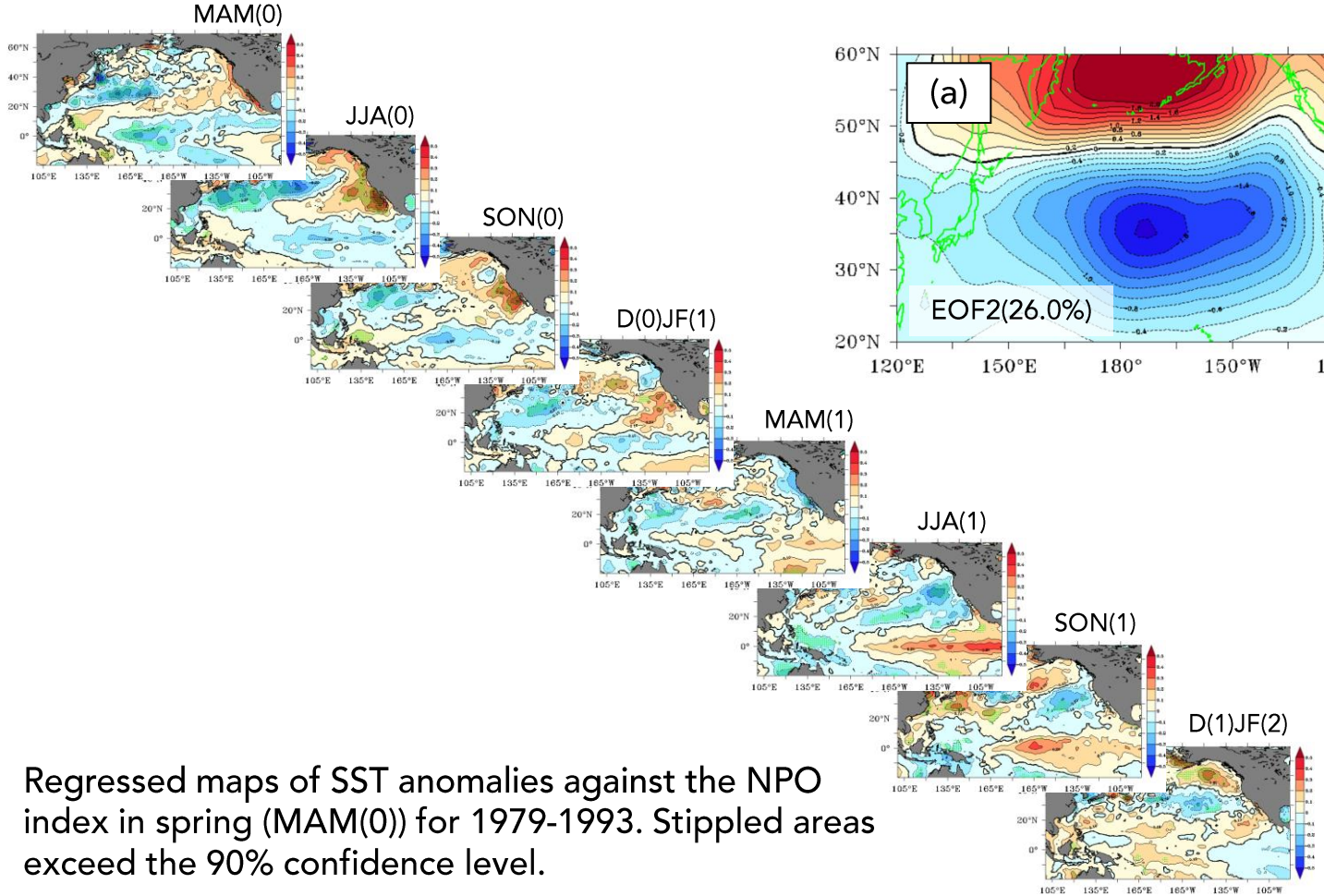
# • Mechanism




Variability of atmospheric circulation (North Pacific Oscillation, NPO) in the North Pacific

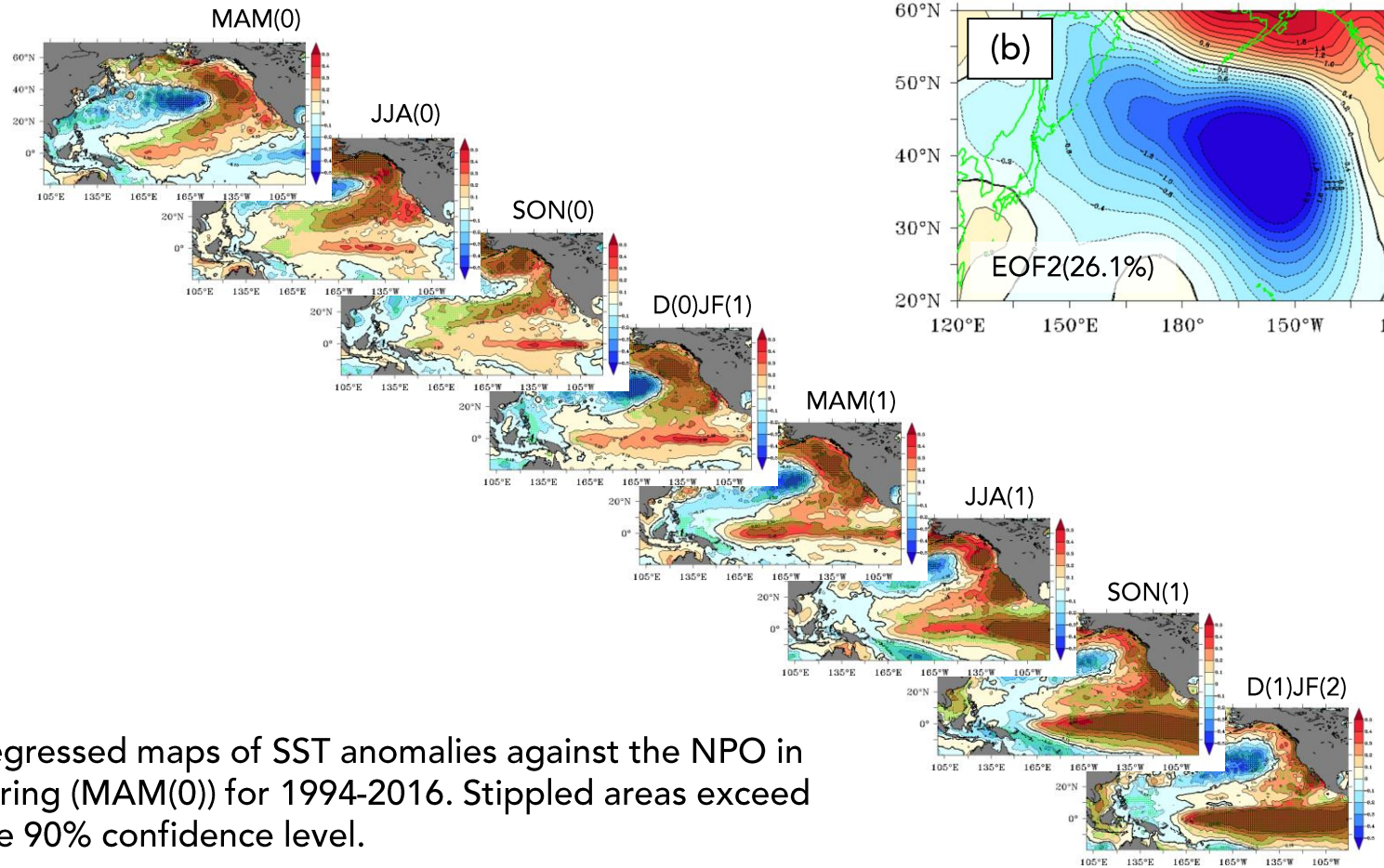
(Yeh et al., 2018, Paek et al., 2016, Yu et al., 2012, Kim et al., 2012)

# • NPO before the mid-1990s & SST




Regressed maps of SST anomalies against the NPO index in spring (MAM(0)) for 1979-1993. Stippled areas exceed the 90% confidence level.

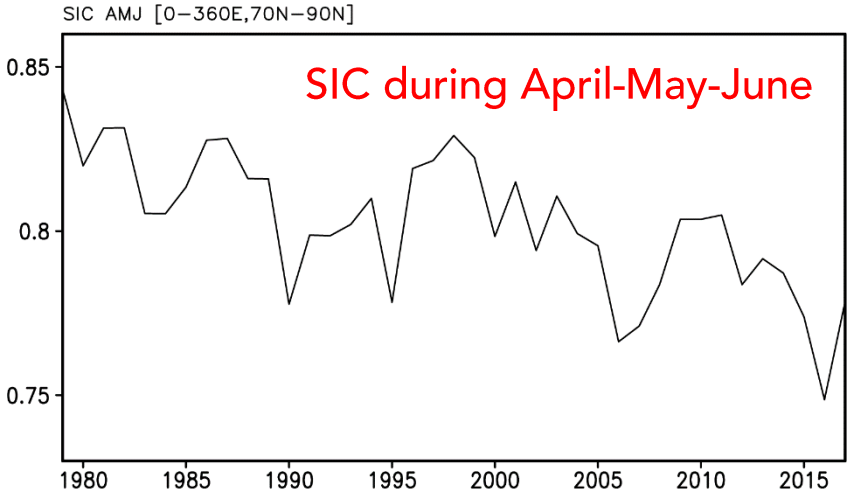
# • NPO after the mid-1990s & SST

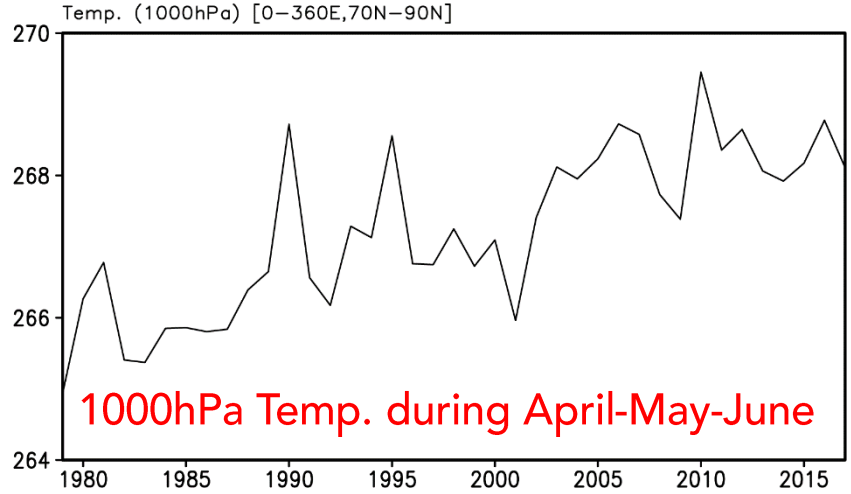



Regressed maps of SST anomalies against the NPO in spring (MAM(0)) for 1994-2016. Stippled areas exceed the 90% confidence level.

These results indicate that atmospheric circulation in the North Pacific characterized by the NPO becomes more influential in the tropical Pacific SST variability after the mid-1990s

Q] What causes the changes in NPO's characteristics in the recent past?



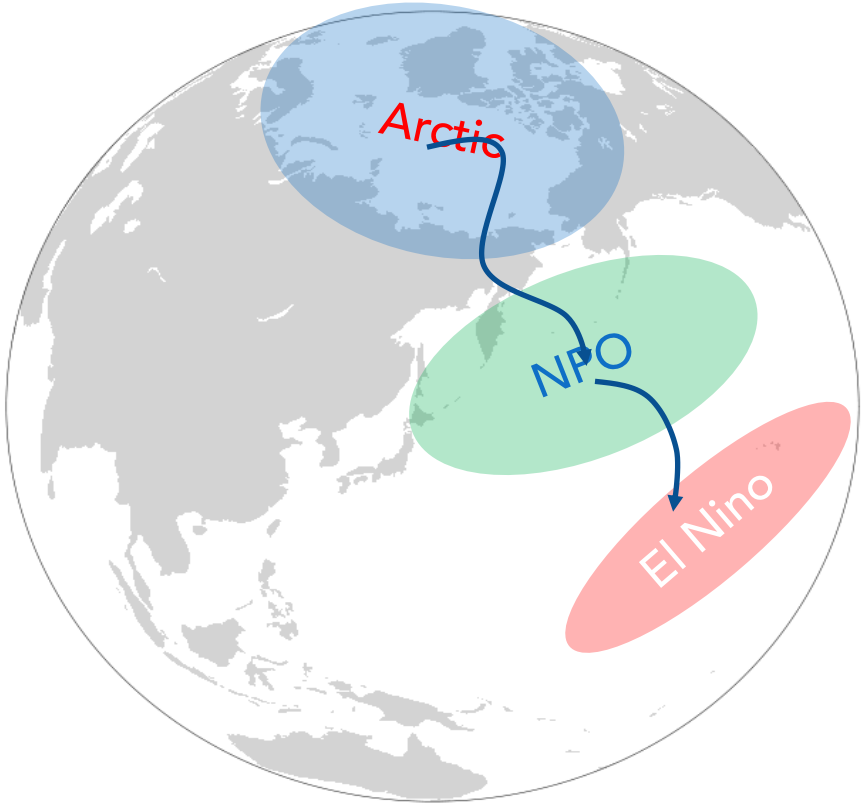

PERSPECTIVE
PUBLISHED ONLINE: 26 OCTOBER 2016 | DOI: 10.1038/NCLIMATE3121
nature climate change

# Nonlinear response of mid-latitude weather to the changing Arctic

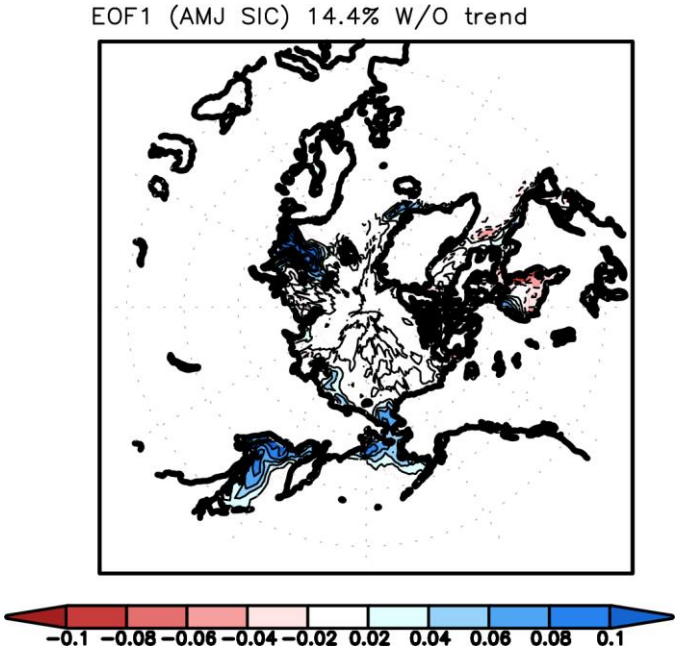
James E. Overland[1*], Klaus Dethloff[2], Jennifer A. Francis[3], Richard J. Hall[4], Edward Hanna[4], Seong-Joong Kim[5], James A. Screen[6], Theodore G. Shepherd[7] and Timo Vihma[8]

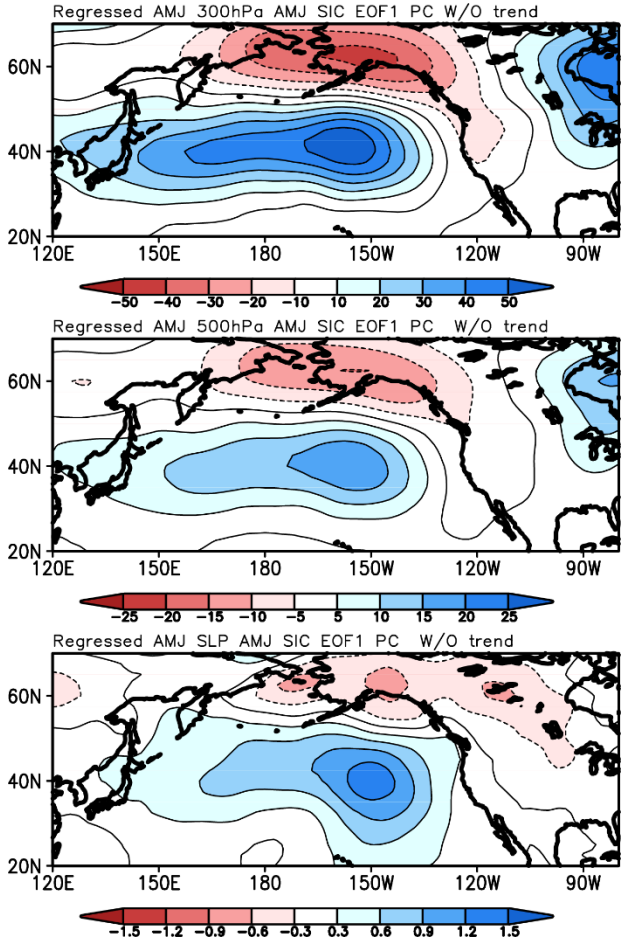
**Are continuing changes in the Arctic influencing wind patterns and the occurrence of extreme weather events in northern mid-latitudes? The chaotic nature of atmospheric circulation precludes easy answers. The topic is a major science challenge, as continued Arctic temperature increases are an inevitable aspect of anthropogenic climate change. We propose a perspective that rejects simple cause-and-effect pathways and notes diagnostic challenges in interpreting atmospheric dynamics. We present a way forward based on understanding multiple processes that lead to uncertainties in Arctic and mid-latitude weather and climate linkages. We emphasize community coordination for both scientific progress and communication to a broader public.**

# • Hypothesis



# • EOF1 SIC (AMJ) & Regressed SLP (W/O Trend)




300hPa

500hPa

SLP

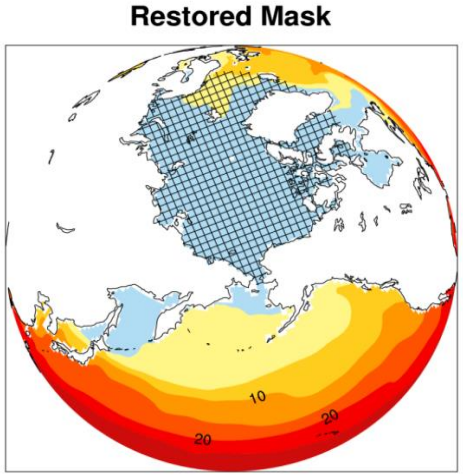
HadISIC & NCEP2 reanalysis for 1979-2017

# • Model Exp.: Arctic_Exp

## Experiment design

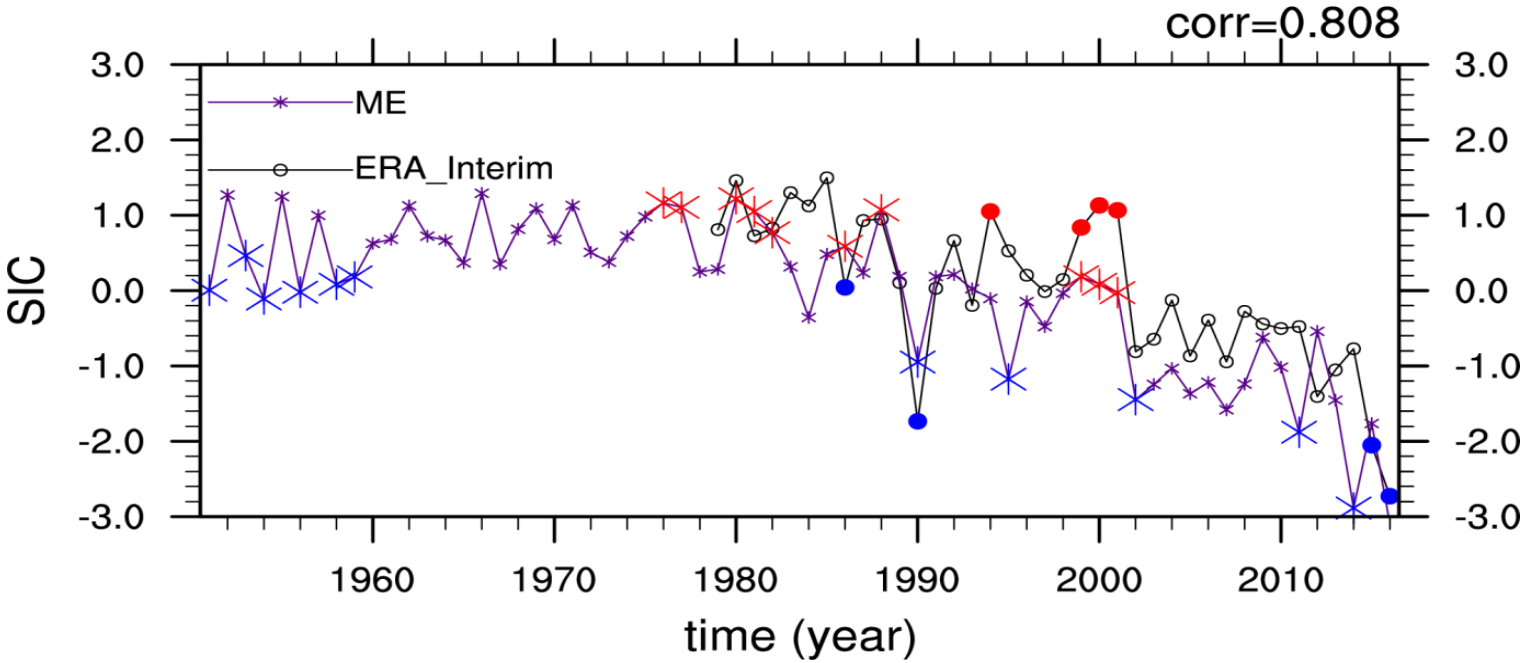
GFDL CM2.1 Model Descriptions
Resolution
-Atmos.: 144x91
-Ocean and ice: 360x200 (tripolar)

Description
Restored SST generates SIC thermodynamically




| Experiment (Ensemble Member, 15) | CO2 level | Region SST restored | Restoring SST | Simulation time |
|---|---|---|---|---|
| Arctic_Exp | Historical | Over Arctic only [>65N] | Historical (1951-2016) | 66 years |

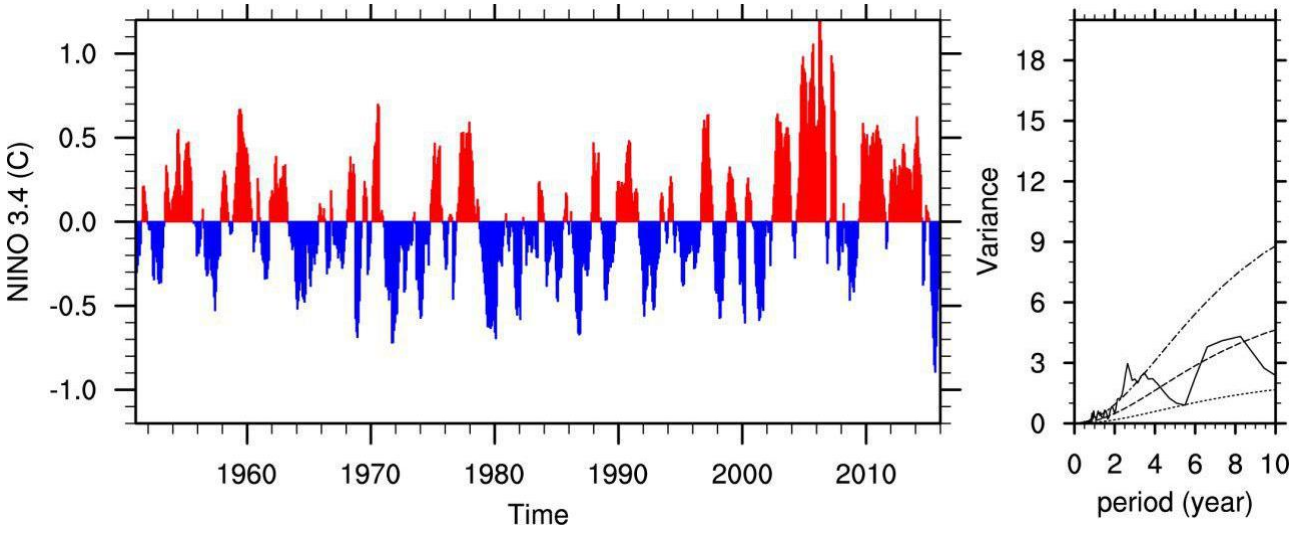
# • SIC time series




Time series of averaged sea ice concentration over the Pacific Arctic sector in AMJ of reanalysis data( black line) and 15 ensemble averaged (ME) of Arctic_Exp experiments. Units are standardized.

# • ENSO simulated in Arctic_Exp

15 Ensemble mean NINO3.4 SST index in Arctic_Exp




S.D.(NINO3.4 SST index during DJF) 0.32°C

# • SST, 850hPa wind & SLP composite

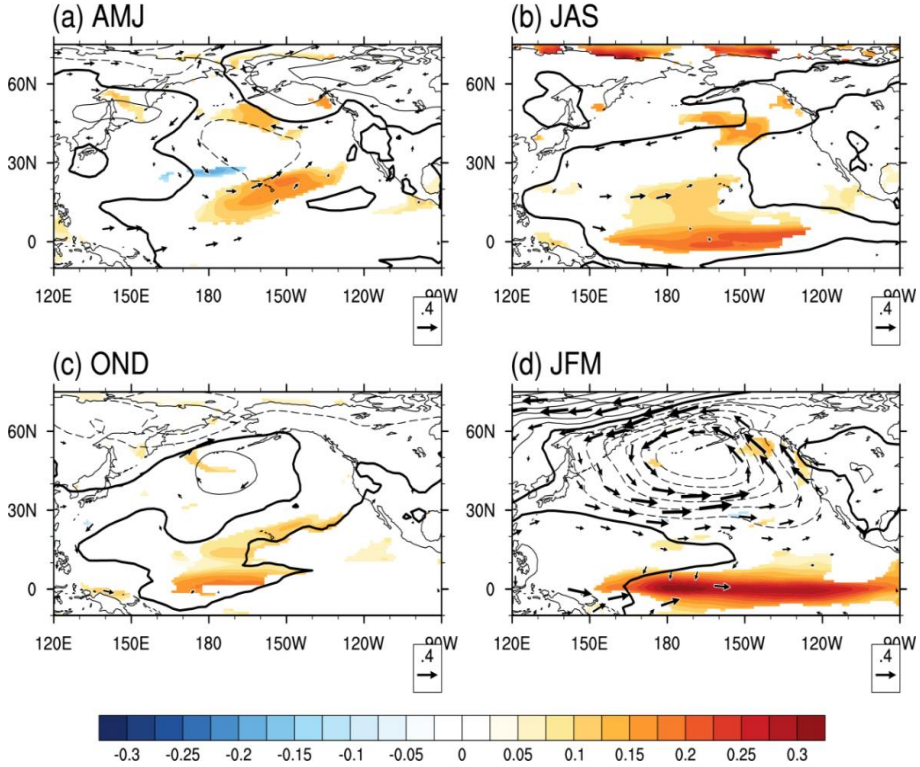
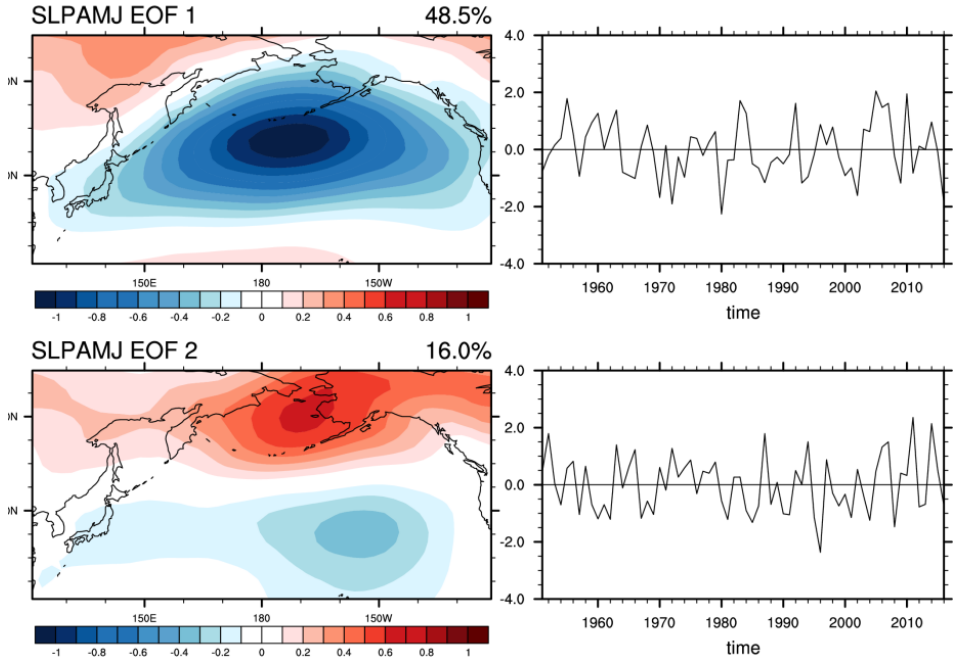


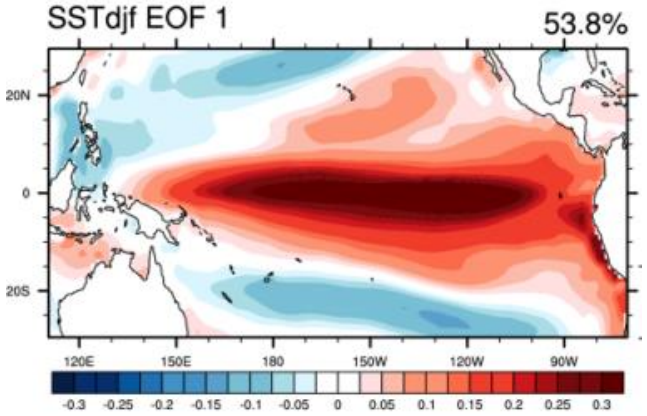

Fig. 3 Composite maps in SST (shading), SLP (contours) and zonal and meridional winds at 850 hPa. Composite years are selected when CS AMJ is lower (higher) than its -1 (+1) standard deviation. SST is exhibited only where the statistical significance exceeds 90% level from the t-test. (a) Concurrent season with CS AMJ. (b) July August September averaged (JAS). (c) OND and (d) JFM+1

# • NPO & ENSO in Arctic_Exp

## SLP: EOF1, EOF2 during AMJ

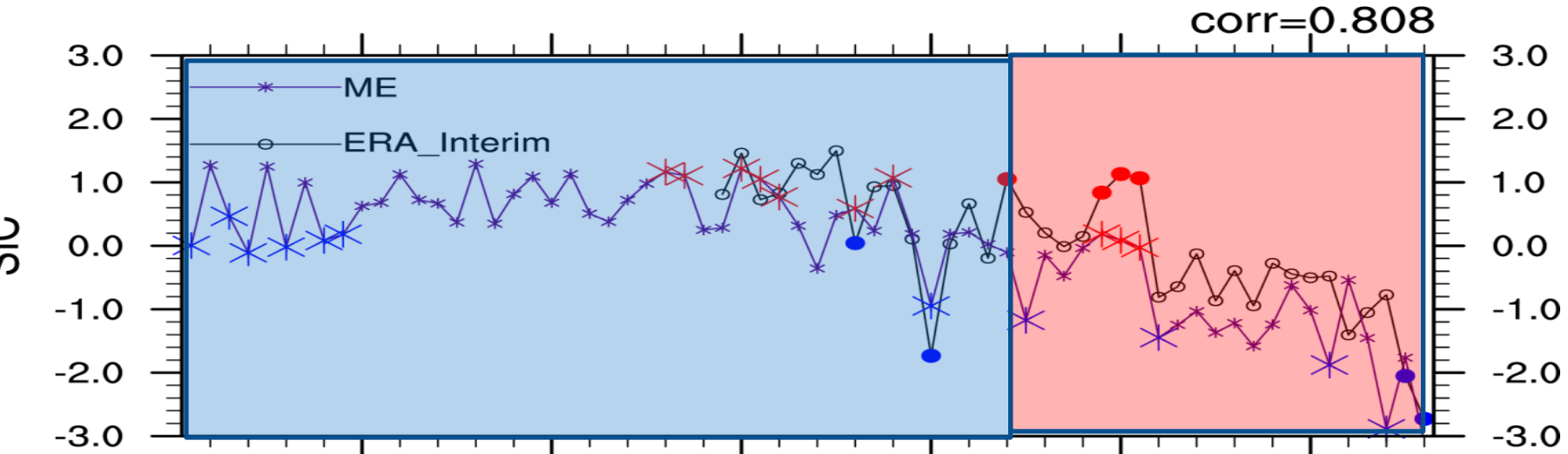



## SST EOF1 during DJF: ENSO

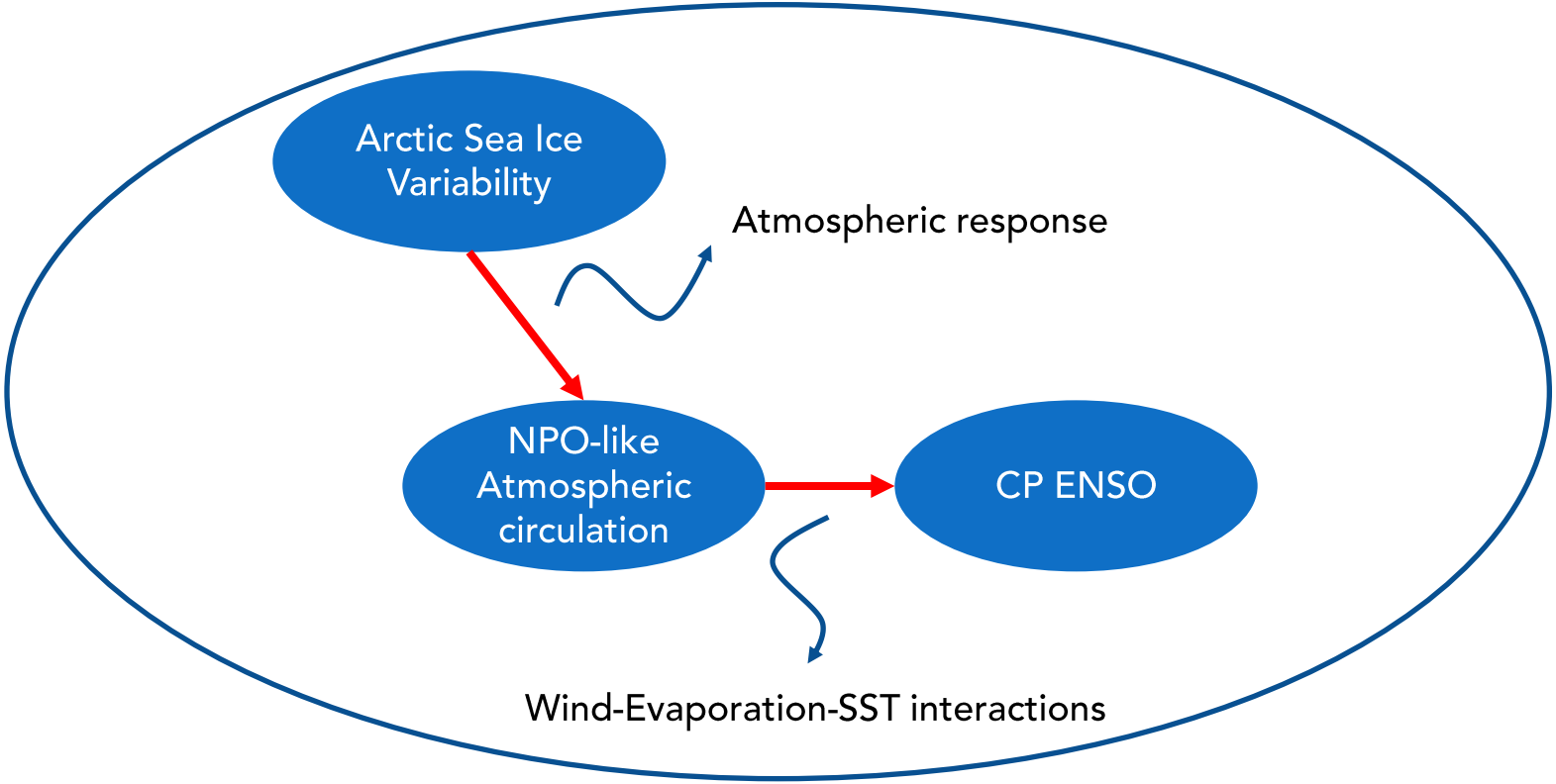


# • NPO & ENSO in Arctic_Exp

| | Correlation<br>[SLP EOF2 during AMJ(0)] &<br>[SST EOF1 during D(0)JF(+1)] |
|---|---|
| 1951-1993 | -0.27 |
| 1994-2016 | 0.51* |



# • Conclusion




More effective after the mid-1990s when the SIC is reduced and Its variability becomes large

# Thank you