



북미 겨울 한파에 대한  
북극-북태평양 상호작용의 영향  
- 초겨울 한파에 대하여 -

극지연구소

성미경

# 최근 북미 겨울 한파 개황

<http://www.weather.com>



2015년 2월 19일  
Washington Post



"In Chicago, possibly a new nickname?"

“추운 겨울”은 우리나라 뿐만 아니라 북미에서도 공통의 이슈

# 왜? 추울까? 기존 연구들에서는.

**PHYS.ORG**

## Climate scientist proposes extremely cold 2014 winter link to global warming

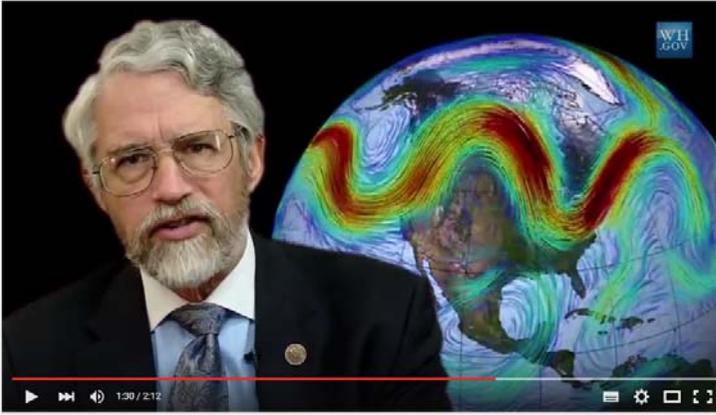
23 May 2014, by Bob Yirka



Credit: Larisa Koshkina/public domain

continues, caused ripples to form in the jet stream, and it was those ripples that caused the cold weather in the northern U.S.

Meteorologists generally agree that the cold weather wasn't due to it just being colder, it was because parts of the jet stream plunged south carrying arctic temperatures with it—areas north of the jet stream are typically very cold, while those below it are warm. It was those same conditions that led to a very wet Europe as the jet stream wobbled back and forth, generating storms in the Atlantic, dropping massive amounts of water as the sea gave way to land.



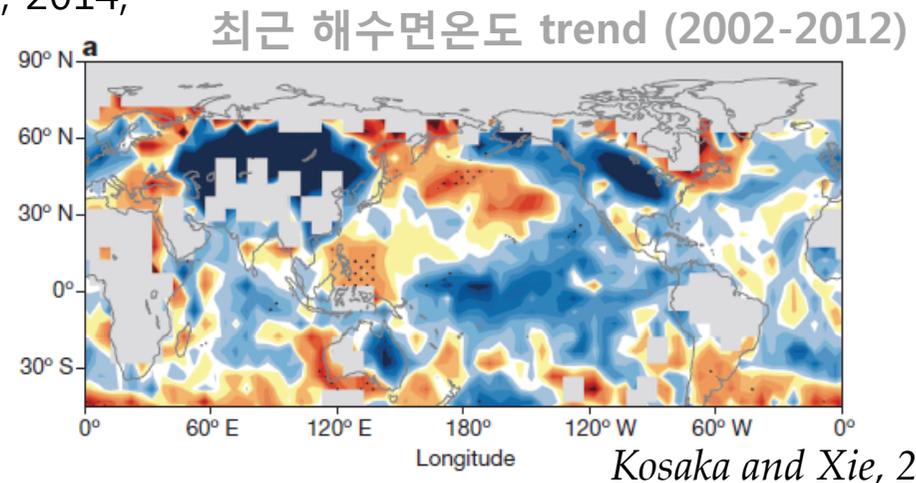
The Polar Vortex Explained in 2 Minutes

The White House

982,216

257,811

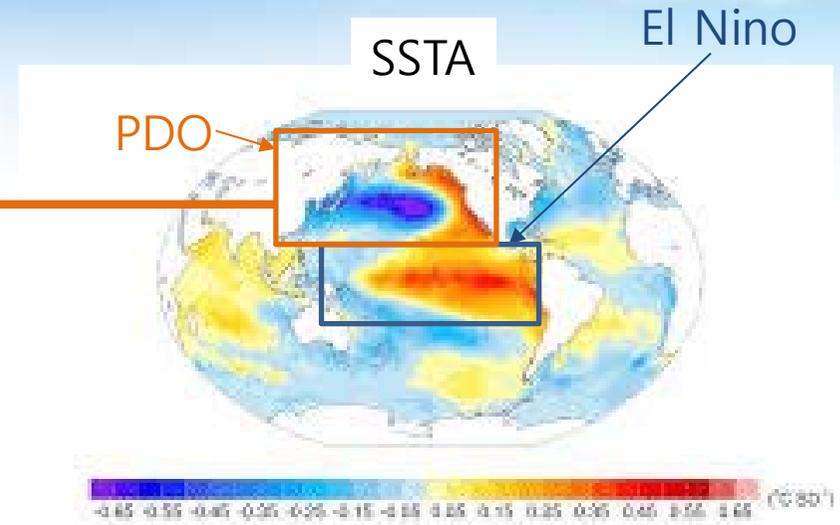
- 북극 온난화/해빙 감소  
⇒ 극 소용돌이(polar vortex) 약화  
⇒ 제트 사행과 동반되는 대기 파동  
(Cohen et al., 2014; Screen and Simmonds, 2014; Tang et al. 2014; )
- 서태평양 warming  
=> 적도에서 전파된 대규모 대기파동열  
(Palmer, 2014, Hartmann, 2014)



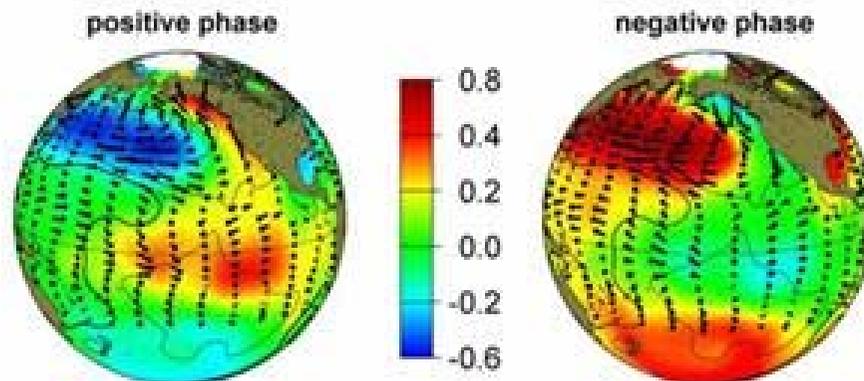
왜? 추울까? 혹은 다른 원인?

⇒ PDO & Arctic warming

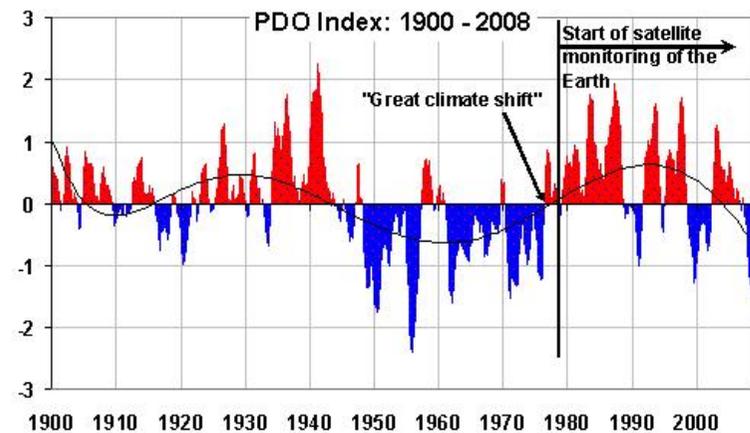
EOF  
1<sup>st</sup> leading mode



### Pacific Decadal Oscillation

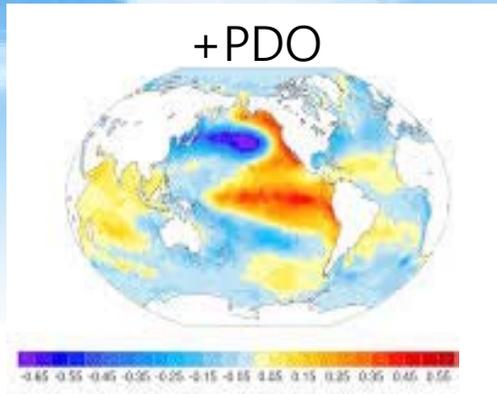


<http://research.jisao.washington.edu/pdo/>



- ✓ Decadal variability
- ✓ Interannual variability

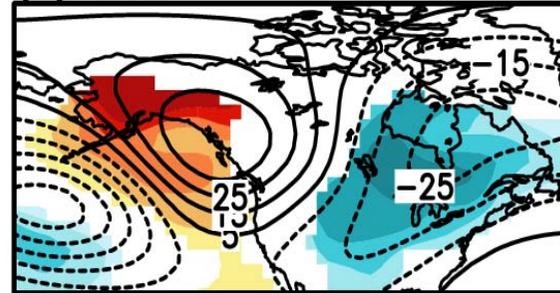
# 왜? 추울까? 혹은 다른 원인?



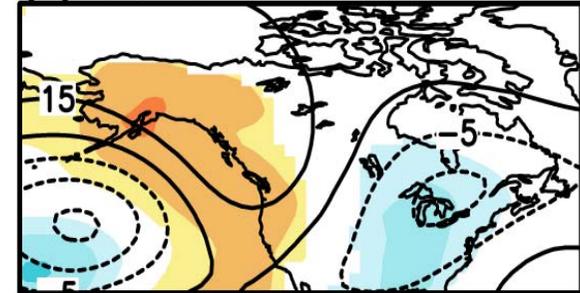
10-11월

Shading : REG(T1000,PDO)  
Contour : REG(Z300,PDO)

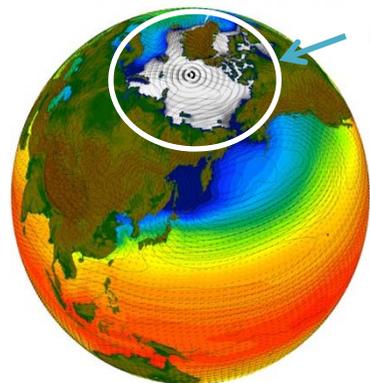
(a) OBS



(b) CM2.1

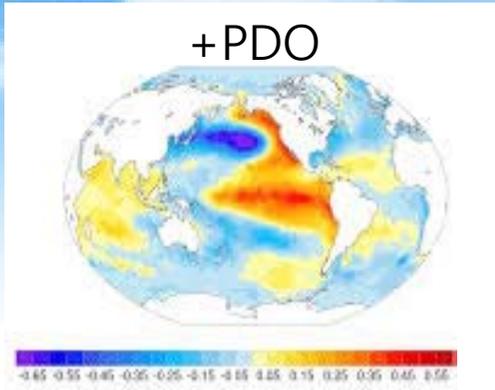


Arctic SST  
restoring experiment  
(GFDL CM2.1)



Observed SST

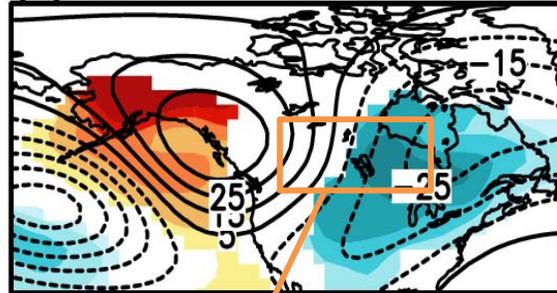
# 왜? 추울까? 혹은 다른 원인?



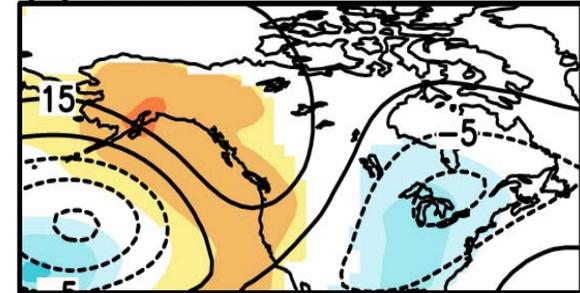
10-11월

Shading : REG(T1000,PDO)  
Contour : REG(Z300,PDO)

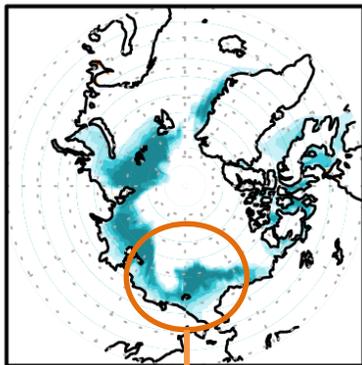
(a) OBS



(b) CM2.1



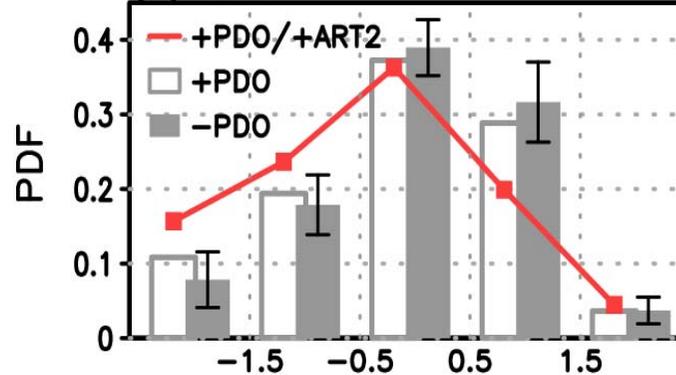
일최저기온 분포



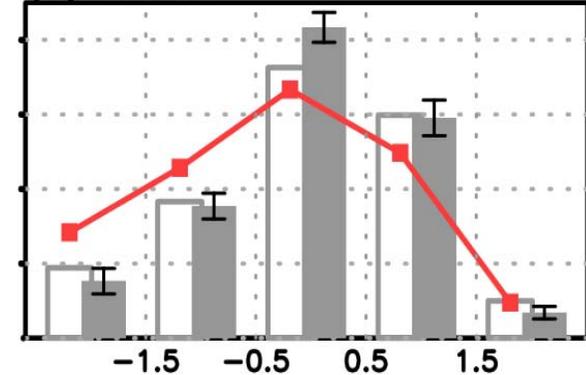
Arctic Temperature Index  
(160°E~160°W, 65-80°N)  
≡ ART2

(Kug et al., 2015)

(c) OBS



(d) CM2.1



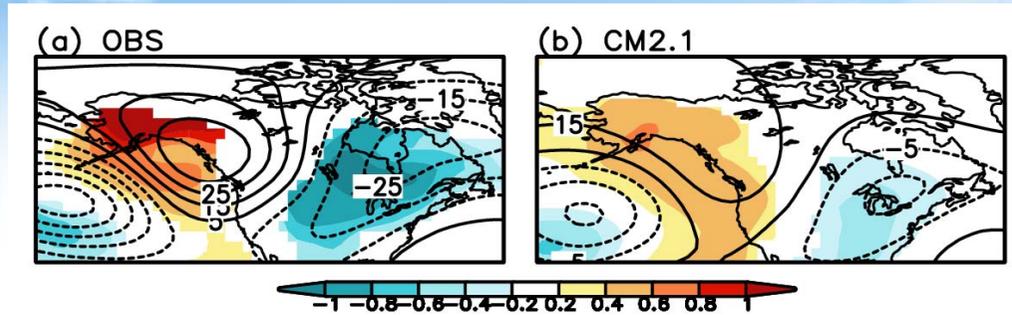
⇒ +PDO & Warm arctic 일 때 더 춥다?

# Warm arctic vs. Cold arctic

10-11월

Shading : REG(T1000,PDO)

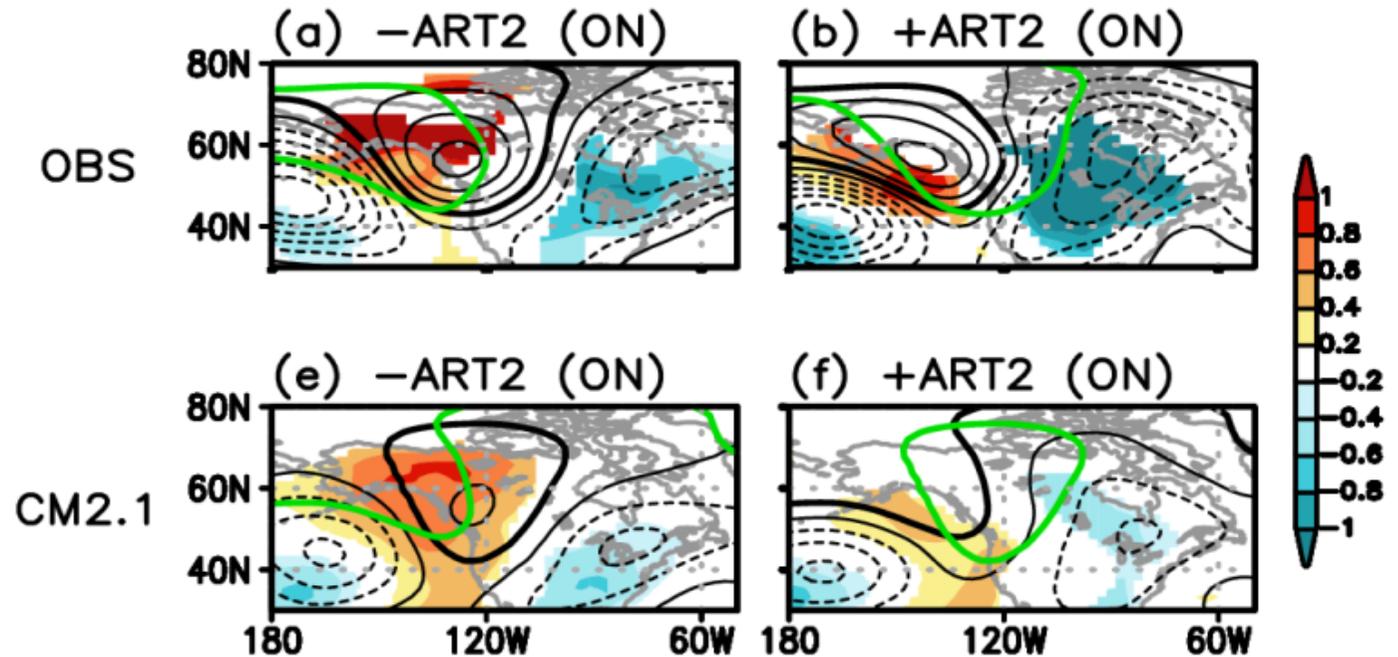
Contour : REG(Z300,PDO)



**+PDO & Warm arctic 일 때 더 추울까?**

Cold arctic

Warm arctic

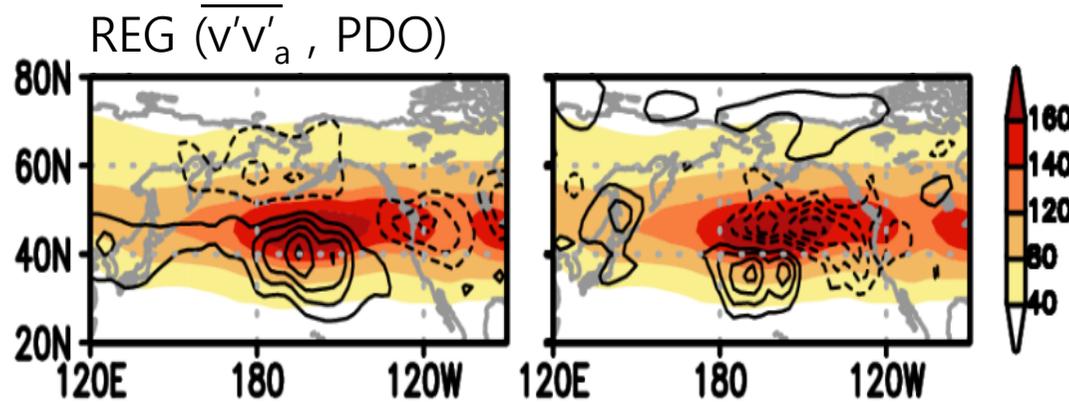


# Warm arctic vs. cold arctic

## 대기파동열 경로 차이의 원인은?

Cold arctic

Warm arctic



Sung et al. 2014

: PDO 위상에 따른 oceanic baroclinicity의 차이는 중위도 스톰트랙의 남북방향 변동을 유도.

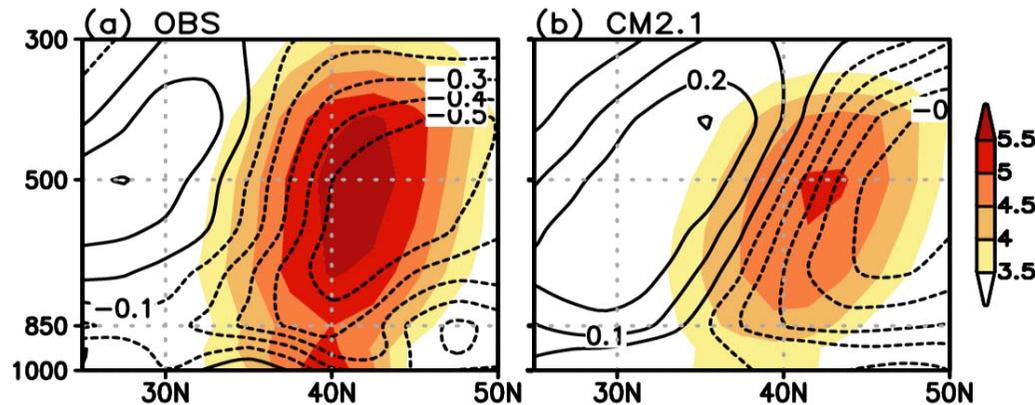
⇒ +PDO일 때 스톰트랙이 남하

## 왜? 대기경압성의 차이

$-dT/dy$  (북태평양 영역에서)

Shading : cold arctic & +PDO일 때

Contour : warm arctic & +PDO일 때의 차이

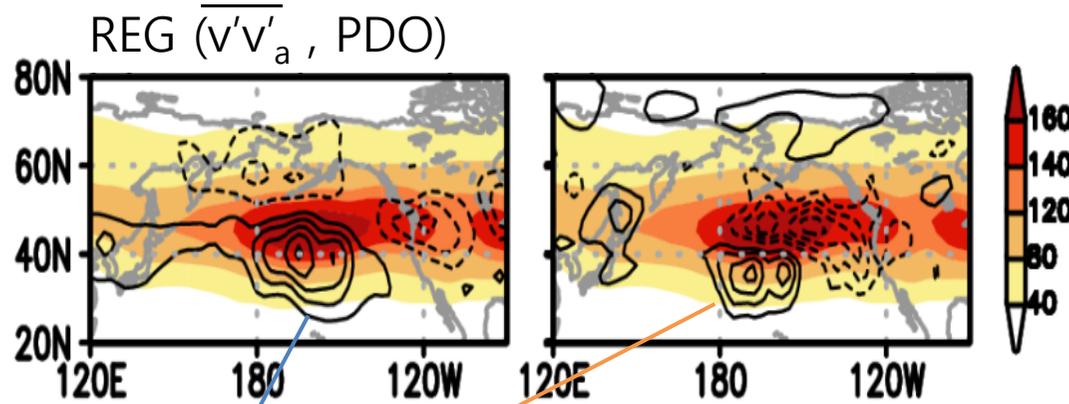


# Warm arctic vs. Cold arctic

대기파동열 경로 차이의 원인은?

Cold arctic

Warm arctic



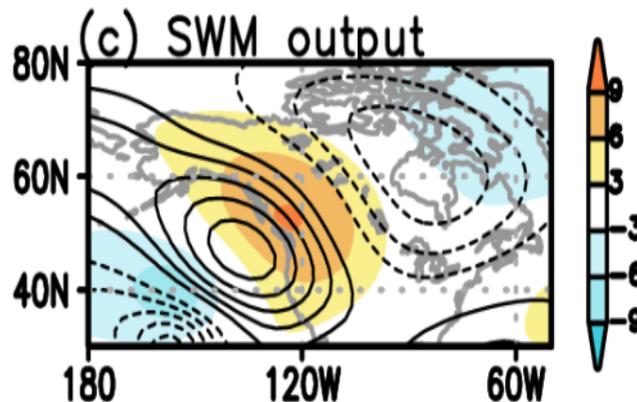
160W, 40N  
forcing

160W, 30N  
Transient vorticity forcing

Stationary wave model

contour

shading

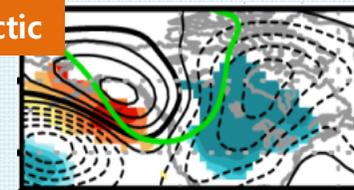


Sung et al. 2014

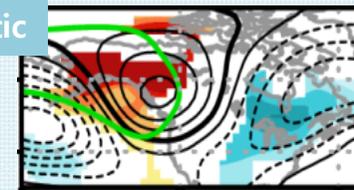
: PDO 위상에 따른 oceanic baroclinicity의 차이는 중위도 스톰트랙의 남북방향 변동을 유도.

⇒ +PDO일 때 스톰트랙이 남하

Warm arctic



Cold arctic



# Warm arctic vs. Cold arctic

여름철  
해빙 감소



초겨울  
**Warm arctic**



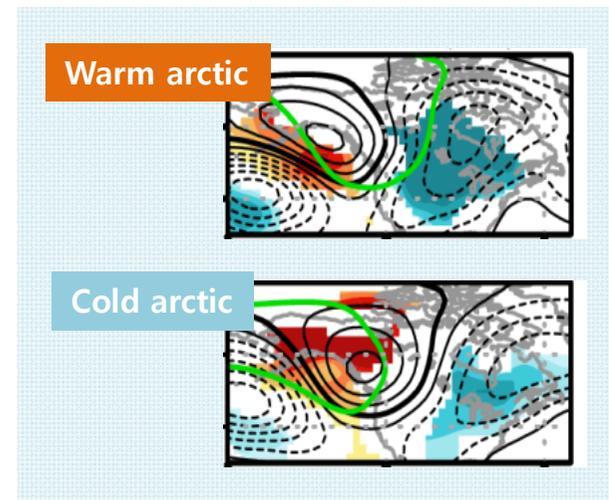
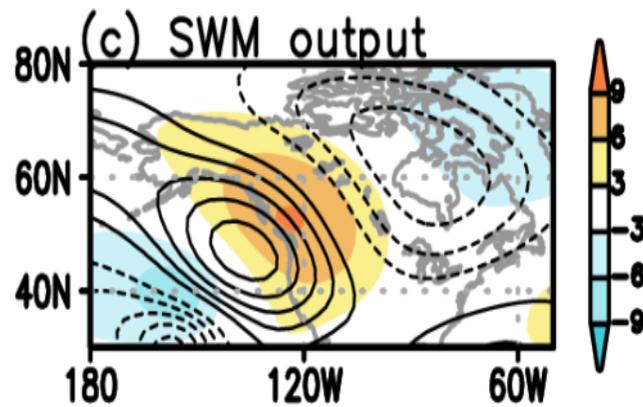
한겨울?



초겨울  
북미 한파 강화

Stationary wave model

contour  
shading



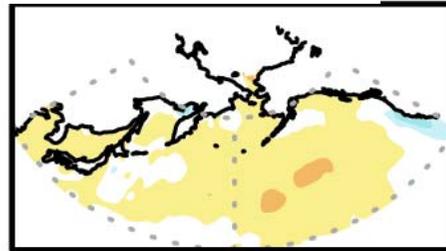
# 한겨울 추위는 왜?

2013/14

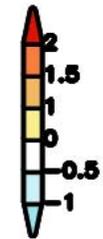
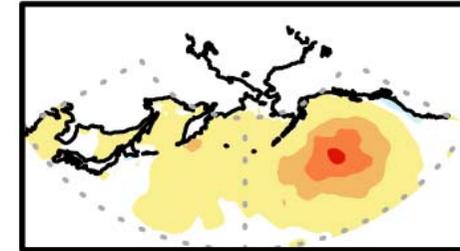


SST

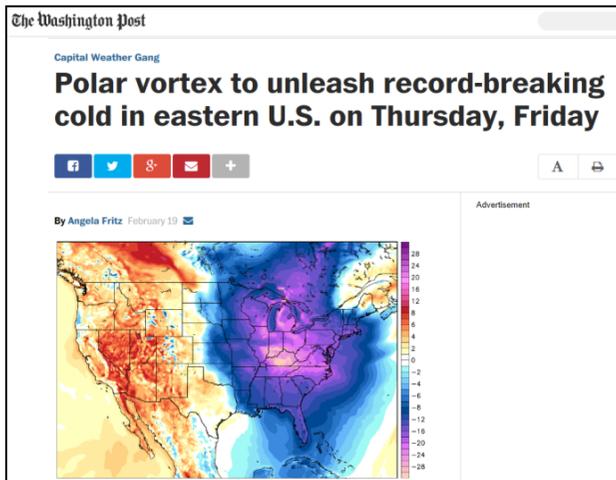
Oct-Nov 2013



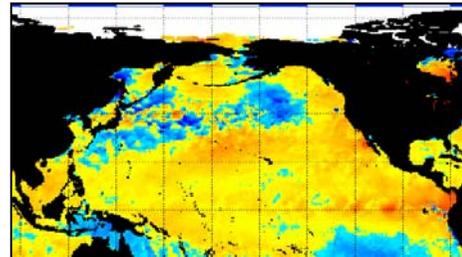
Dec 2013-Jan 2014



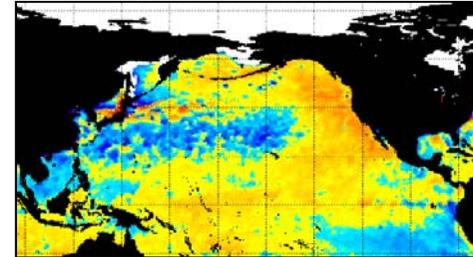
2015. 2



Oct 2014



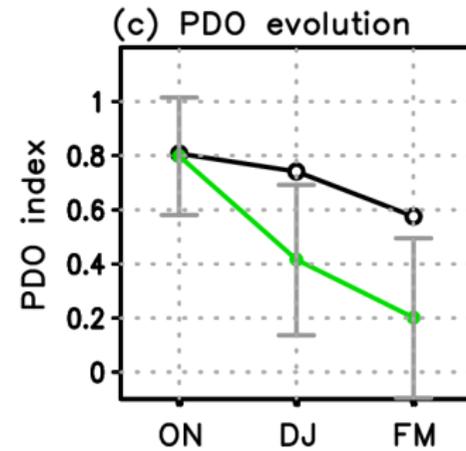
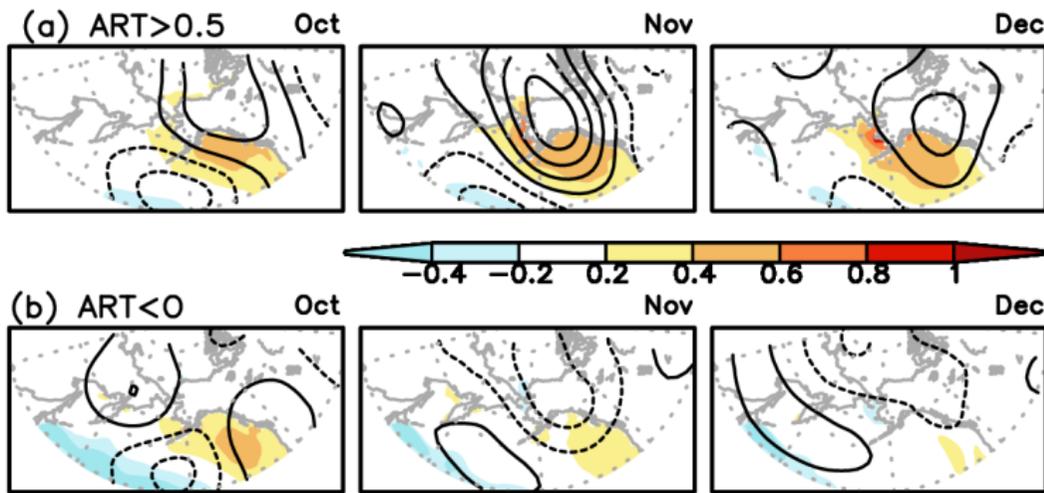
Feb 2015



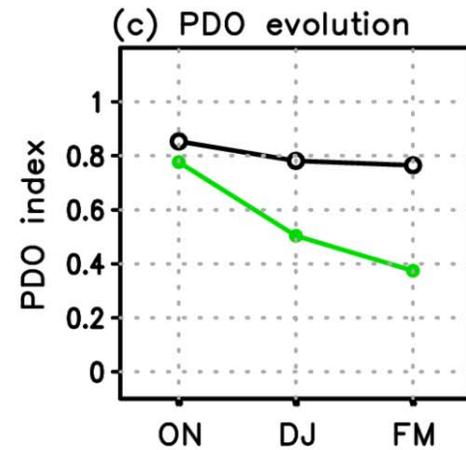
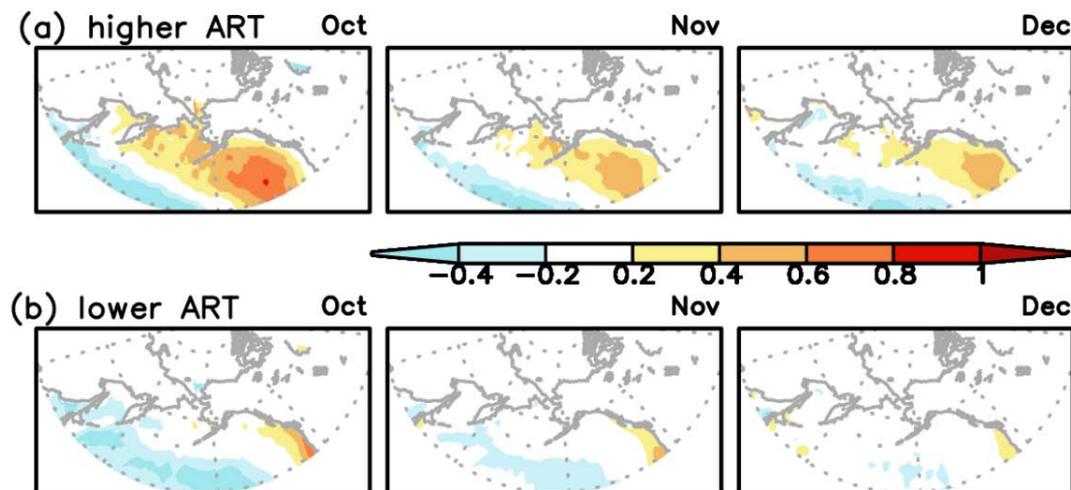
# PDO persistence

Shading : SSTa

**CM2.1** Contour : Z300a



## OBS



# Summary

- ✓ 초겨울 북미 한파 강화 기작에 대해서 분석하였음.
- ✓ +PDO 위상을 나타낼 때 북미 지역은 추운 초겨울을 나타내는 경향이 있음
- ✓ 이러한 초겨울 추위는 베링해 지역 해빙 감소에 따라 더욱 강화될 수 있음
- ✓ 이는 PDO 및 북극 온난화에 따른 대기경압성의 변동이 스톰 트랙과 대기 파동열의 전파 경로 변동을 유도하기 때문임.
- ✓ Warm arctic 조건일 때 PDO와 관련된 대기 순환장의 차이는 warm subarctic SST anomaly를 지속시킬 수 있음. 이는 해빙 감소의 영향이 한겨울까지 연장될 수 있는 근거가 됨.



**monthly values for the PDO index: 1900-2013**

