# Towards an improved climate event attribution framework

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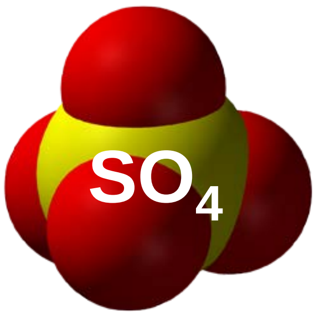
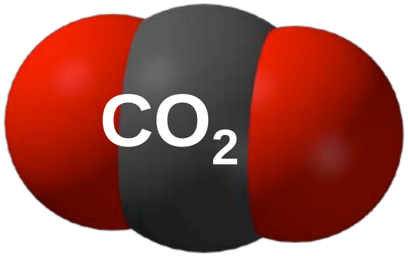
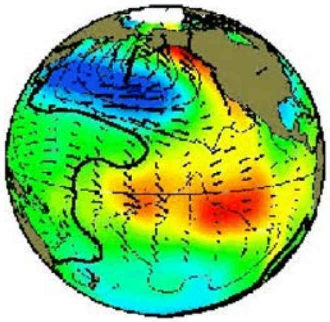
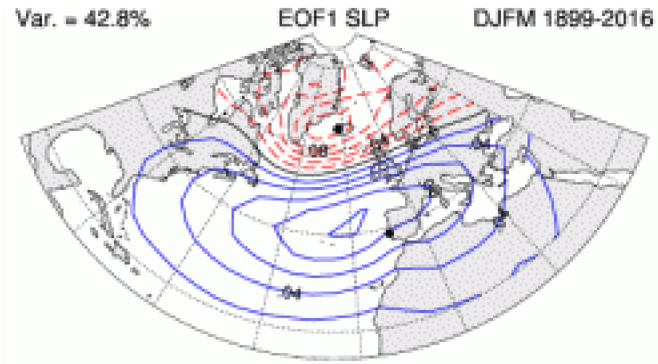




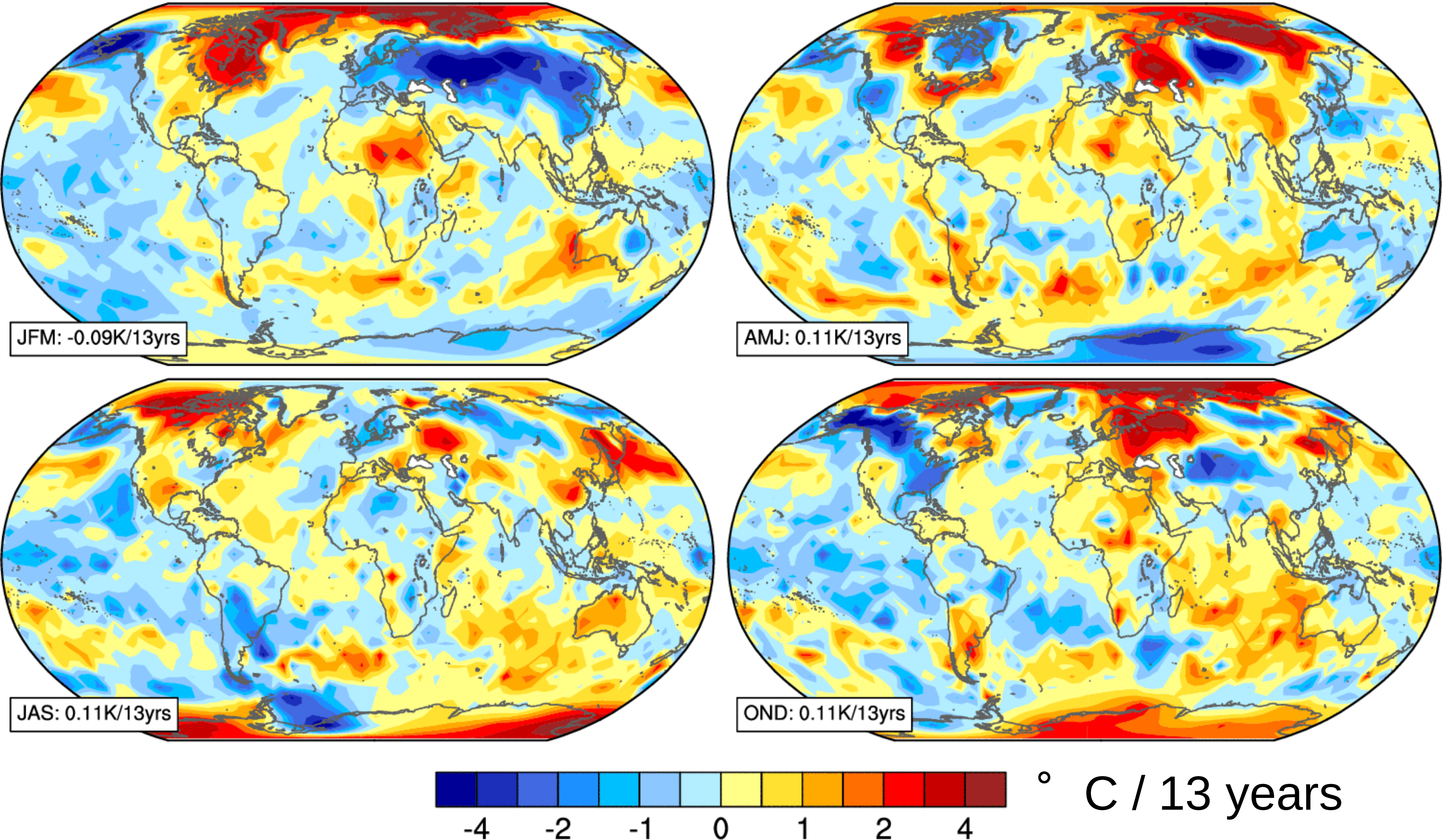

**PDV/IPV** **NAO/AO**

## The early 2000s Eurasian Winter Cooling

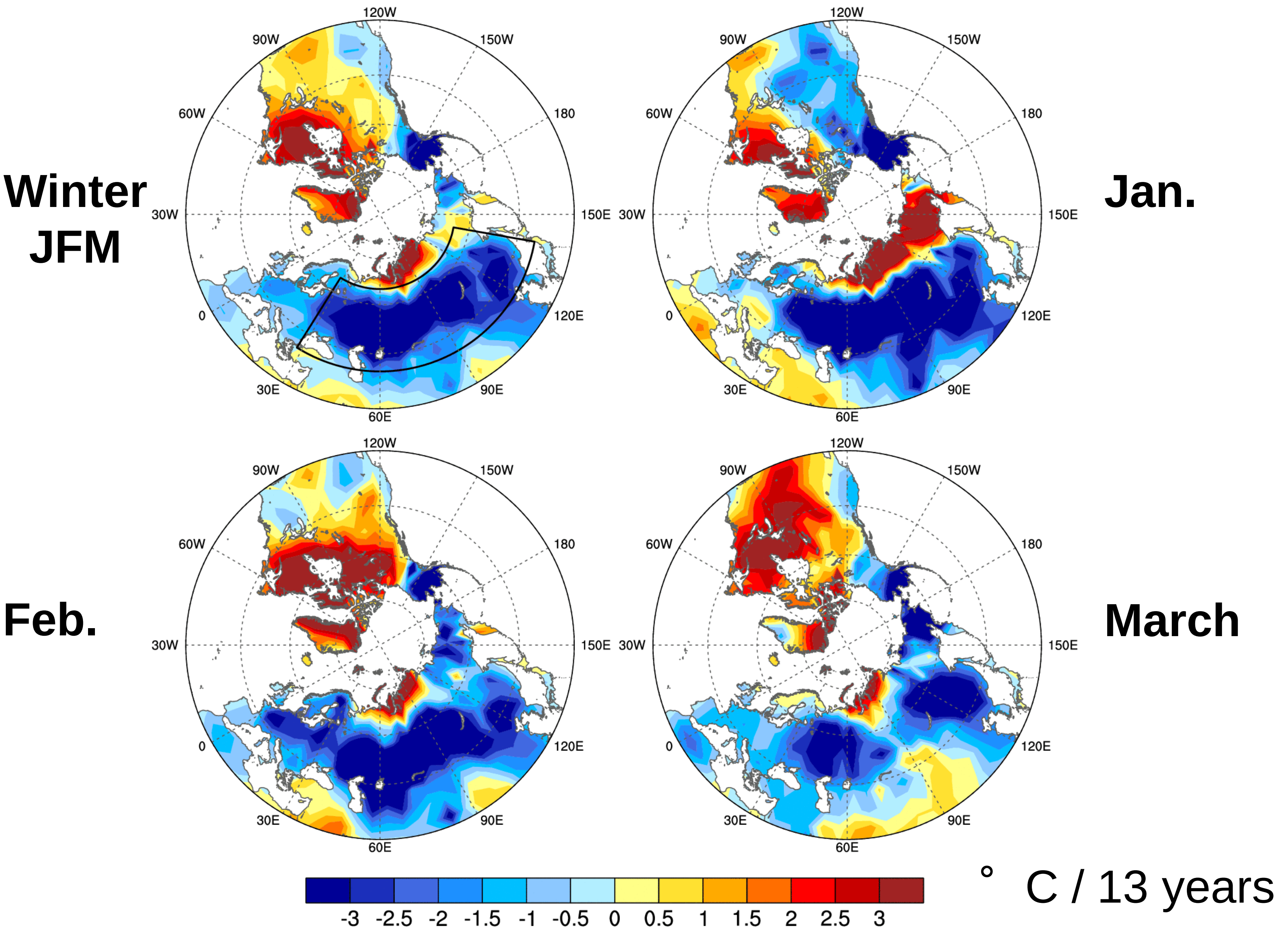
Thanks to all CAS members and to T. Sheperd

# The early 2000s « Hiatus »

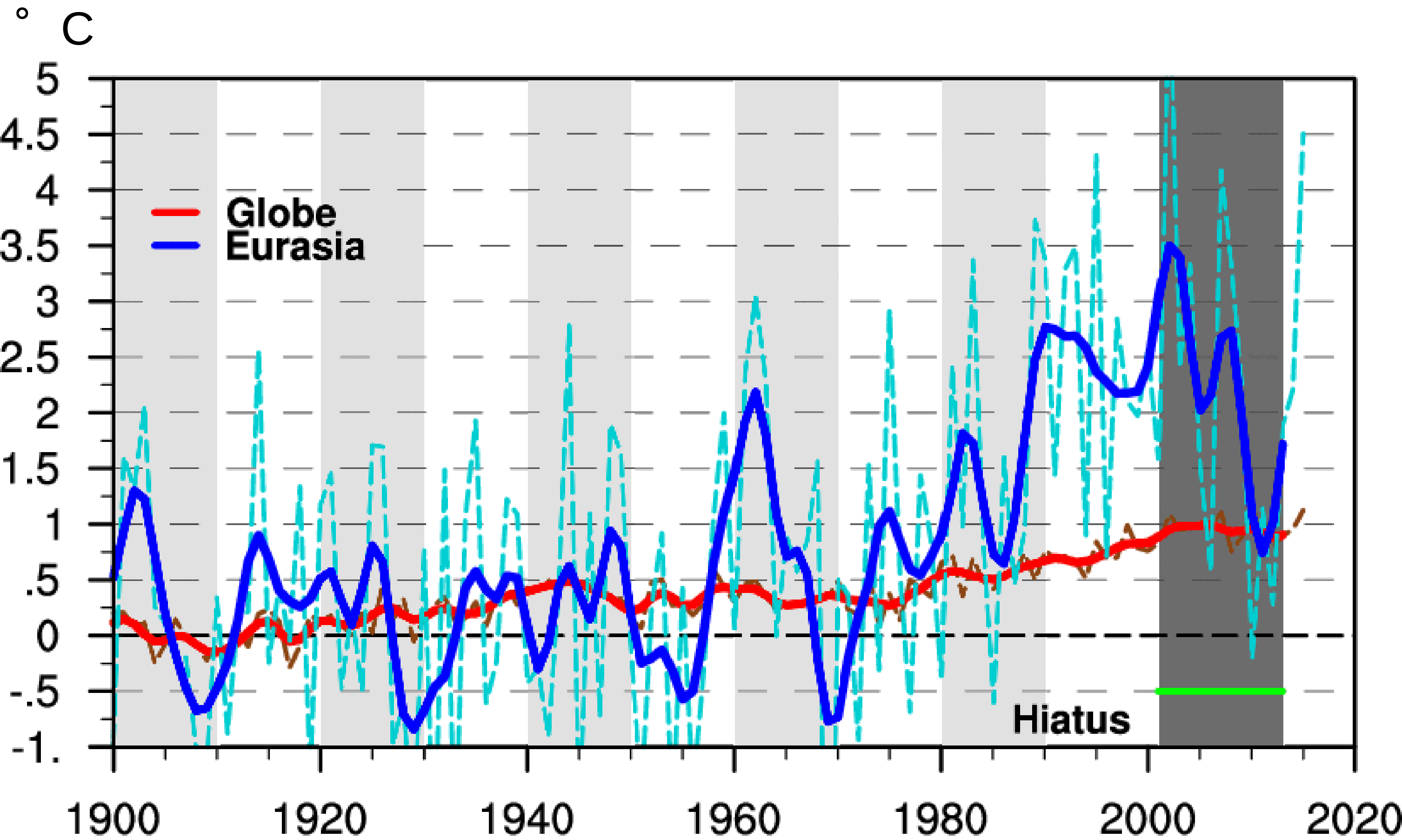
## Cowtan&Way 2001-2013 linear trend



# Observed Winter T2m trend 2001-2013



# Observed T2m in winter (JFM)



# Science current status ?

- (2014): « **tropical Pacific forcing** of the atmosphere such as that associated with a negative phase of the PDO produces **many of the pronounced atmospheric circulation anomalies** observed globally during the hiatus »
- (2014): « Here we use a 100-member ensemble of simulations ... **to show that as a result of sea-ice reduction in the Barents–Kara Sea, the probability of severe winters has more than doubled in central Eurasia**. »
- (2015): « Our experimental results suggest that the **Arctic sea ice loss does not drive systematic changes in the Northern Hemisphere large-scale circulation in the past decades.**
- (2016): « In our atmospheric-only simulations, **we find no evidence of Barents and Kara seas sea-ice loss having impacted Eurasian surface temperature** »
- (2016): « The findings confirm that **sea-ice concentrations in Autumn in the Barents and Kara seas are an important driver of winter circulation in the midlatitudes**. »
- External forcing (volcanic & solar), atmospheric internal variability ...

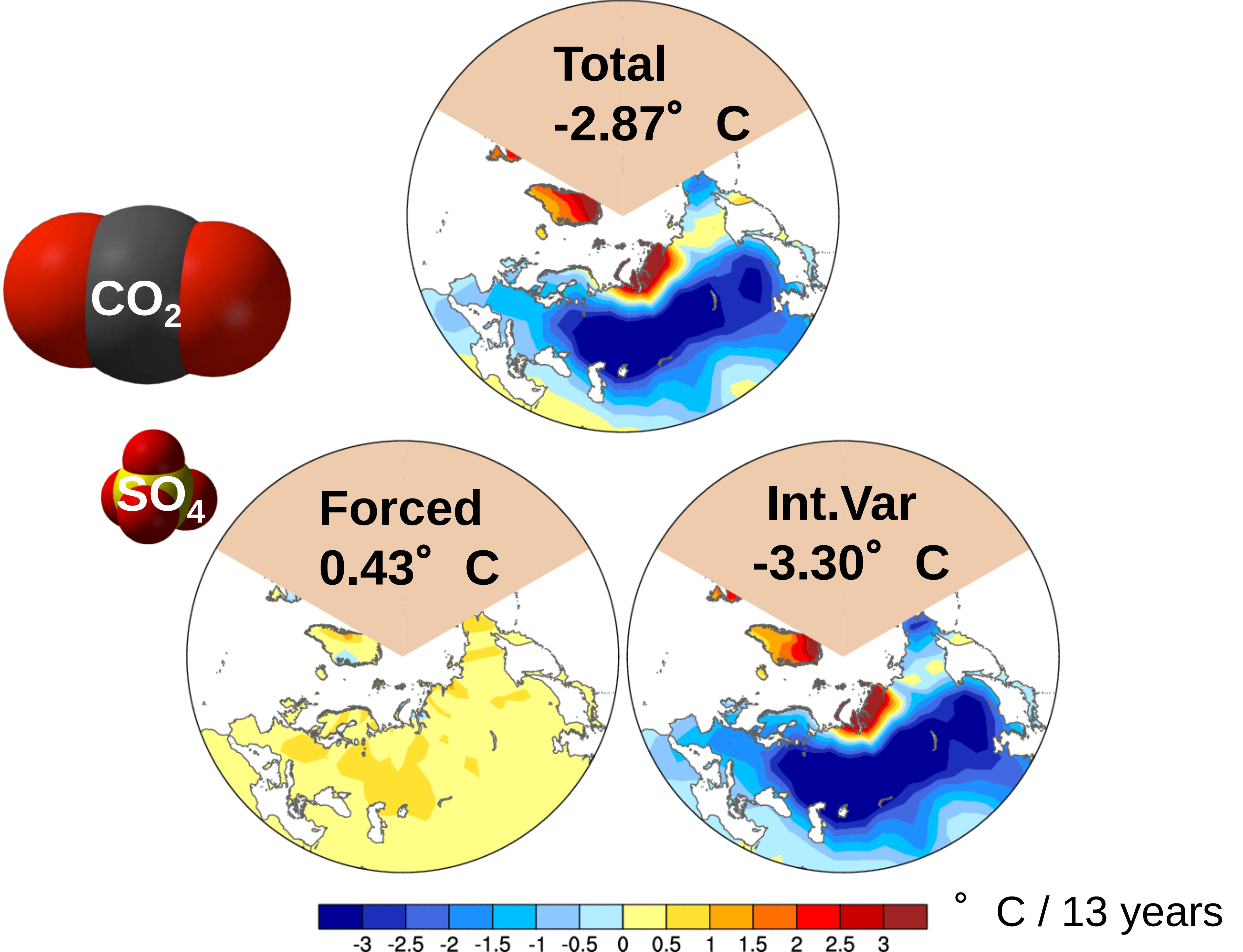
# 2001-2013 Eurasian cooling: -2.87° C/13 years

| **Processes/ Causes** | **Thermodynamical** | **Dynamical** |
| --- | --- | --- |
| **Forced** | ??? ° C | ??? ° C |
| **Free** | ??? ° C | ??? ° C |

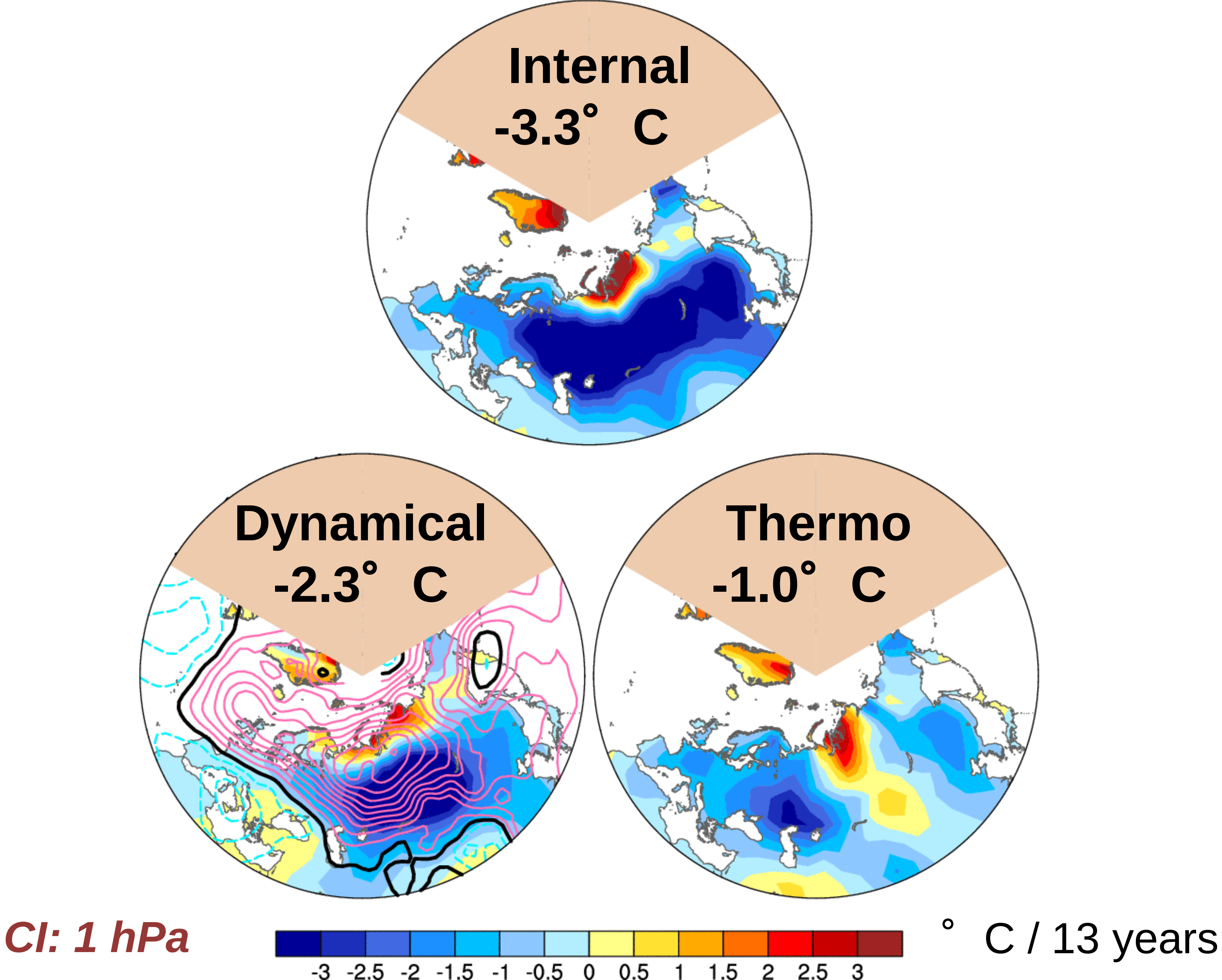
1. **Quantify** the different factors with their mechanisms
2. Give **uncertainty** estimates !

# Methods

- External forcing: use Ensemble Empirical Mode Decomposition (EEMD) to derive the forced response
- Dynamical adjustment: use a non-linear regression method (gradient boosting regression trees) to predict temperature from sea level pressure (20CR)
- Use leave-one-out method to derive circulation-related temperature for each month



CO2
SO4
Total
-2.87° C
Forced
0.43° C
Int.Var
-3.30° C
° C / 13 years
-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3


Internal
-3.3° C
Dynamical
-2.3° C
Thermo
-1.0° C
CI: 1 hPa
-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3
° C / 13 years

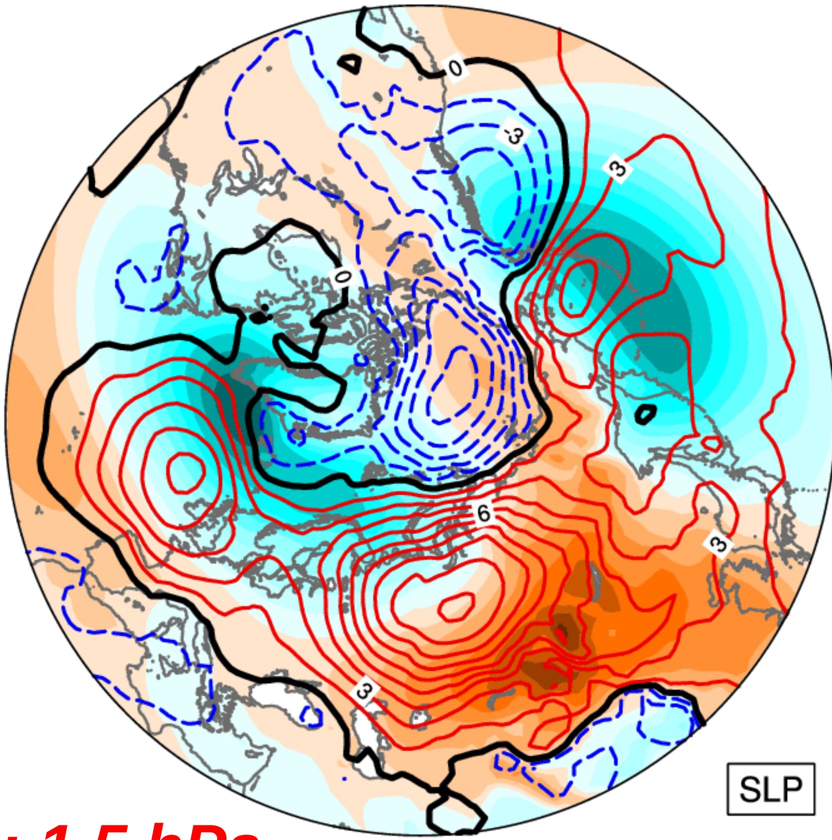
# 2001-2013 Eurasian cooling: -2.87° C/13 years

| Processes/ Causes | Thermodynamical | Dynamical |
|---|---|---|
| **Forced** | [0.29, 0.43] ° C | ~ 0. ° C |
| **Free** | [-1., -0.75] ° C | [-2.41; -2.3] ° C |

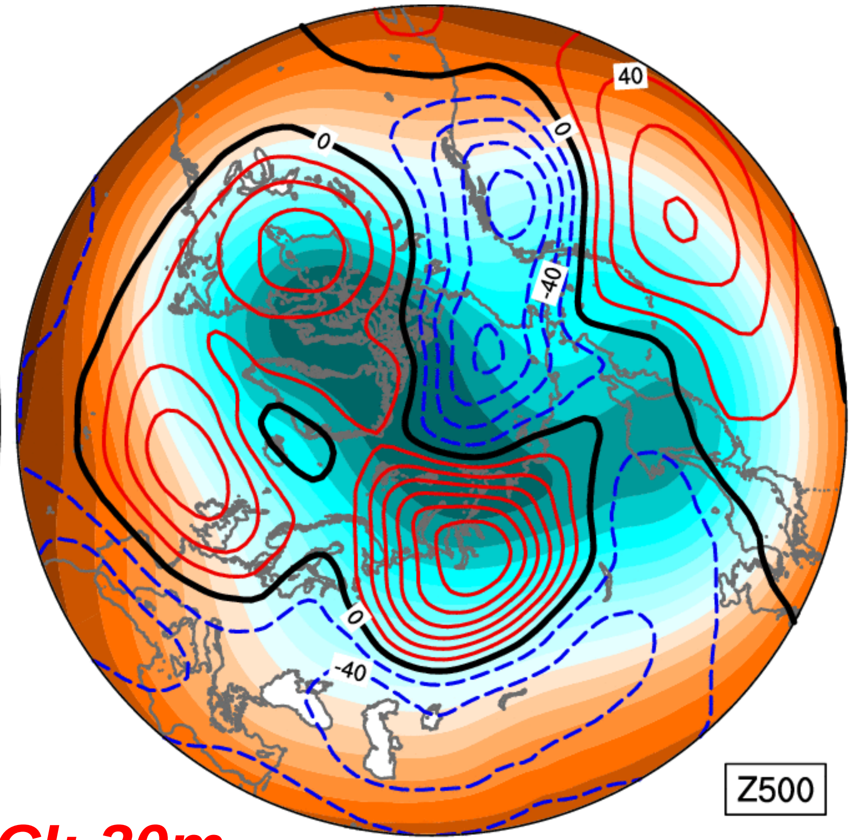
1. Origin of the anomalous circulation pattern ?
2. Mechanisms of the thermodynamical part ?

# Siberian High: westward shift and intensification

**Sea level pressure**

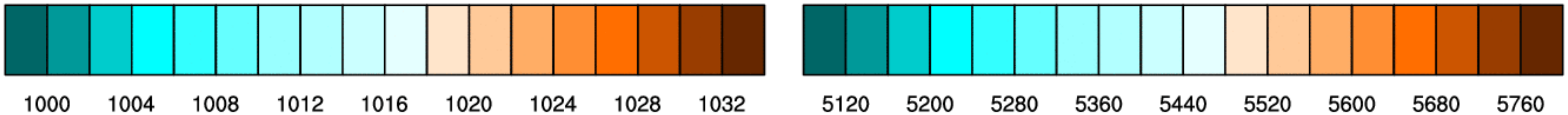



**500 hPa Geopotential Height**

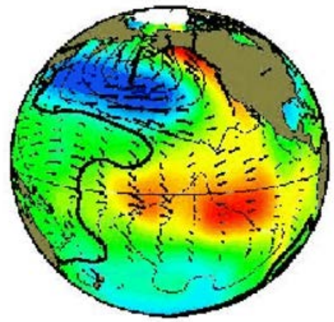



***CI: 1.5 hPa***

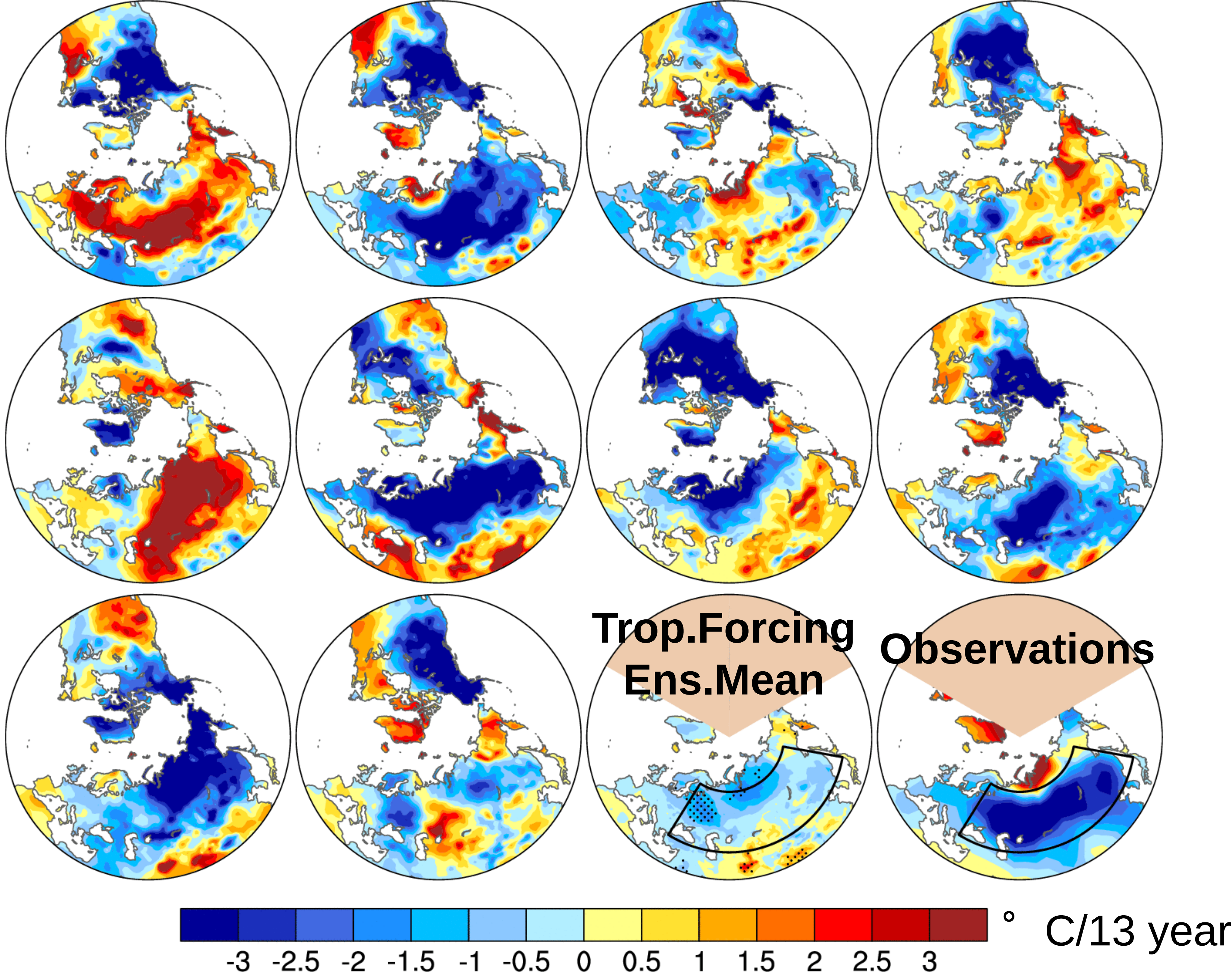
***CI: 20m***

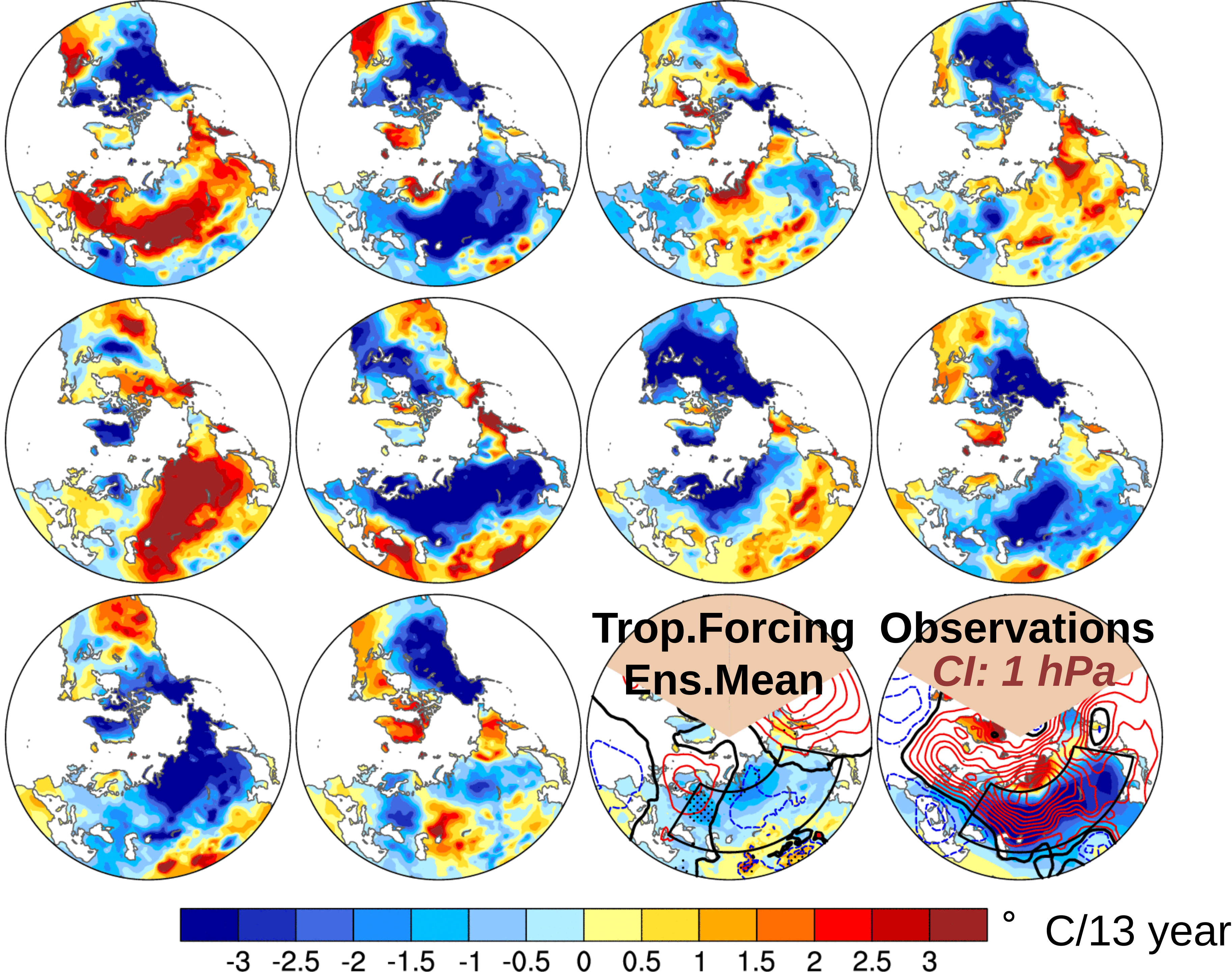


# The Tropical forcing hypothesis



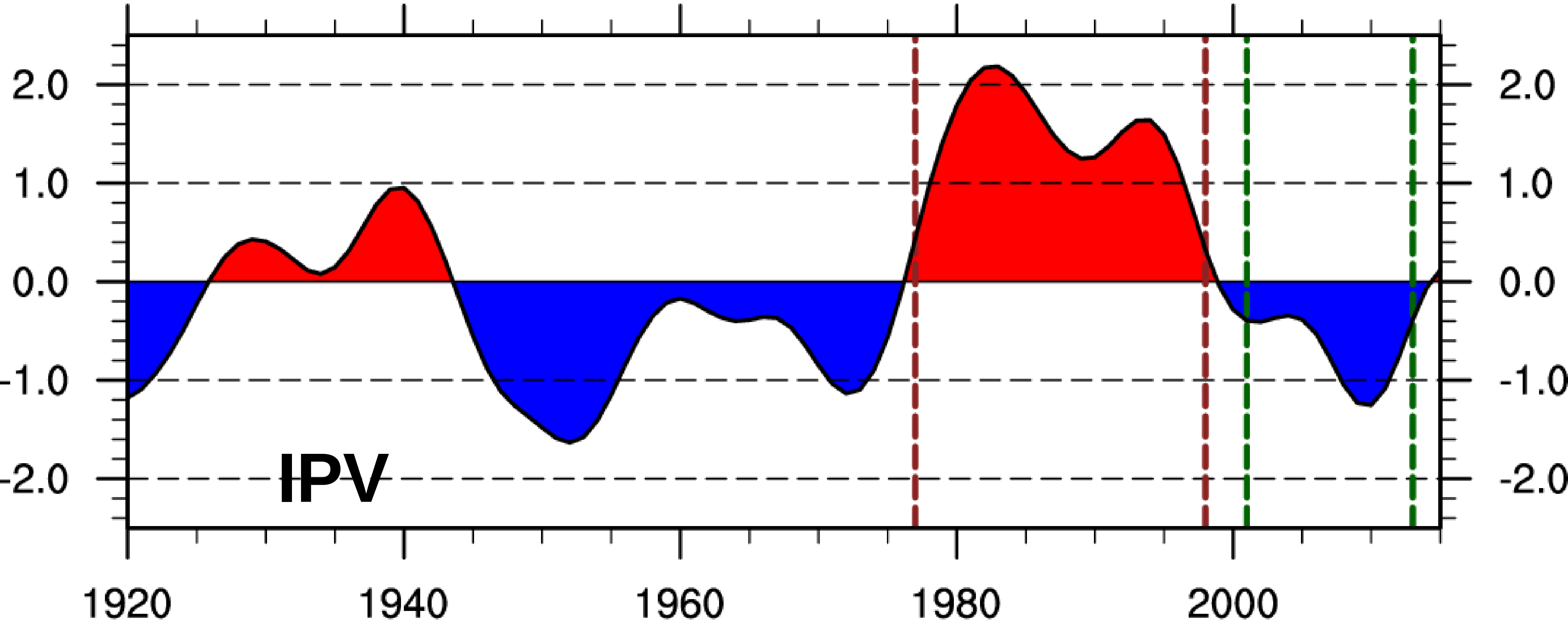
- Can be tested with the CESM LENS and Pacemaker (PCMK) ensembles
- Tropical forcing ~ Emean(PCMK) – Emean(LENS)
- Observations and role of IPV


Trop.Forcing
Ens.Mean
Observations
-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3
° C/13 year



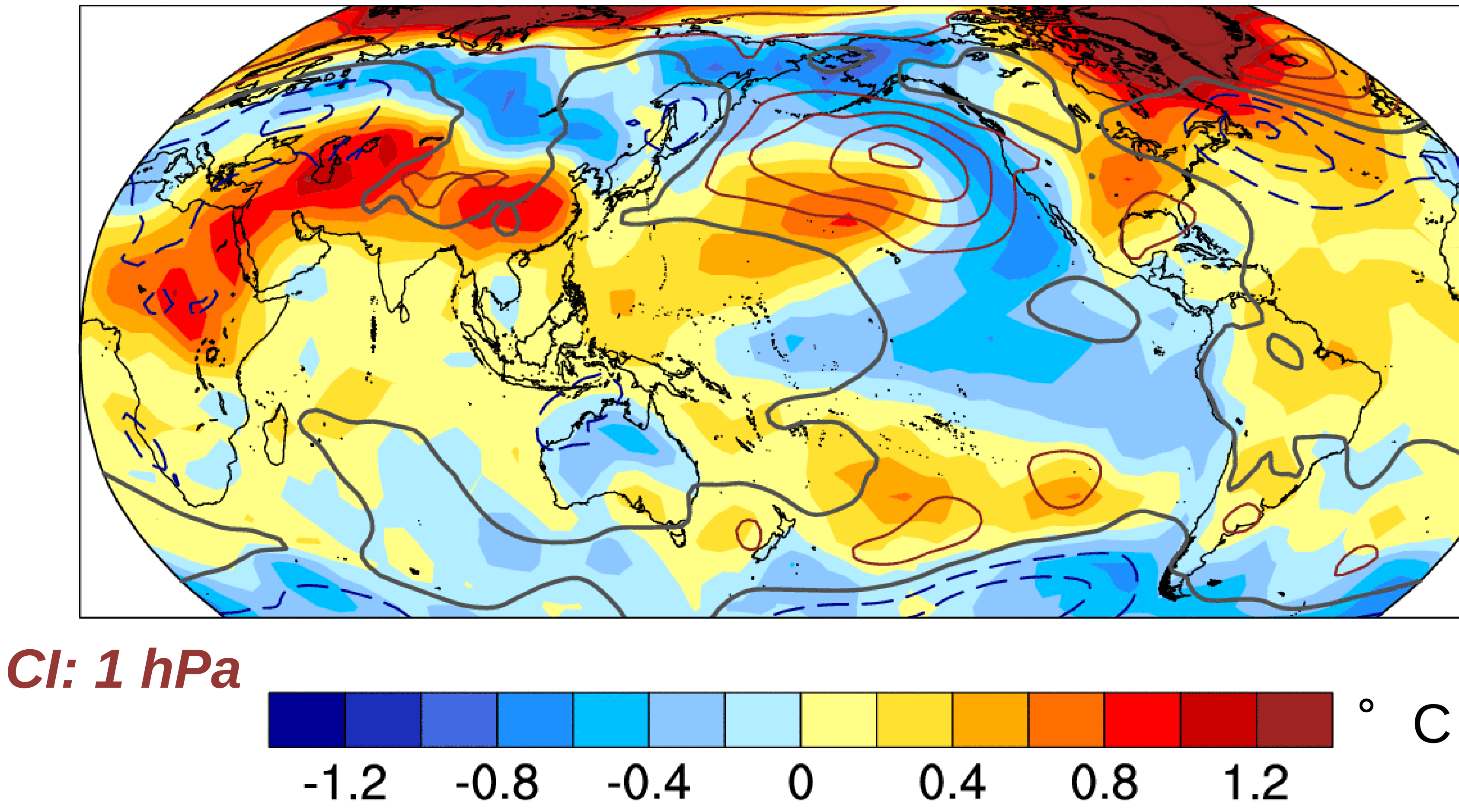
Trop.Forcing
Ens.Mean
Observations
CI: 1 hPa
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3
° C/13 year

# Observed IPV: contrast negative and positive phase composites

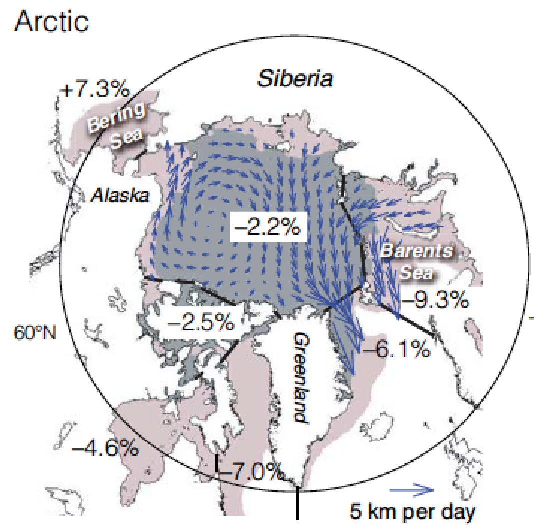



IPV influence: Cold(2001-2013) – Warm(1977-1998)

# IPV influence: Cold(2001-2013) – Warm(1977-1998)
## Temp. (Cowtan&Way) SLP (20CR)

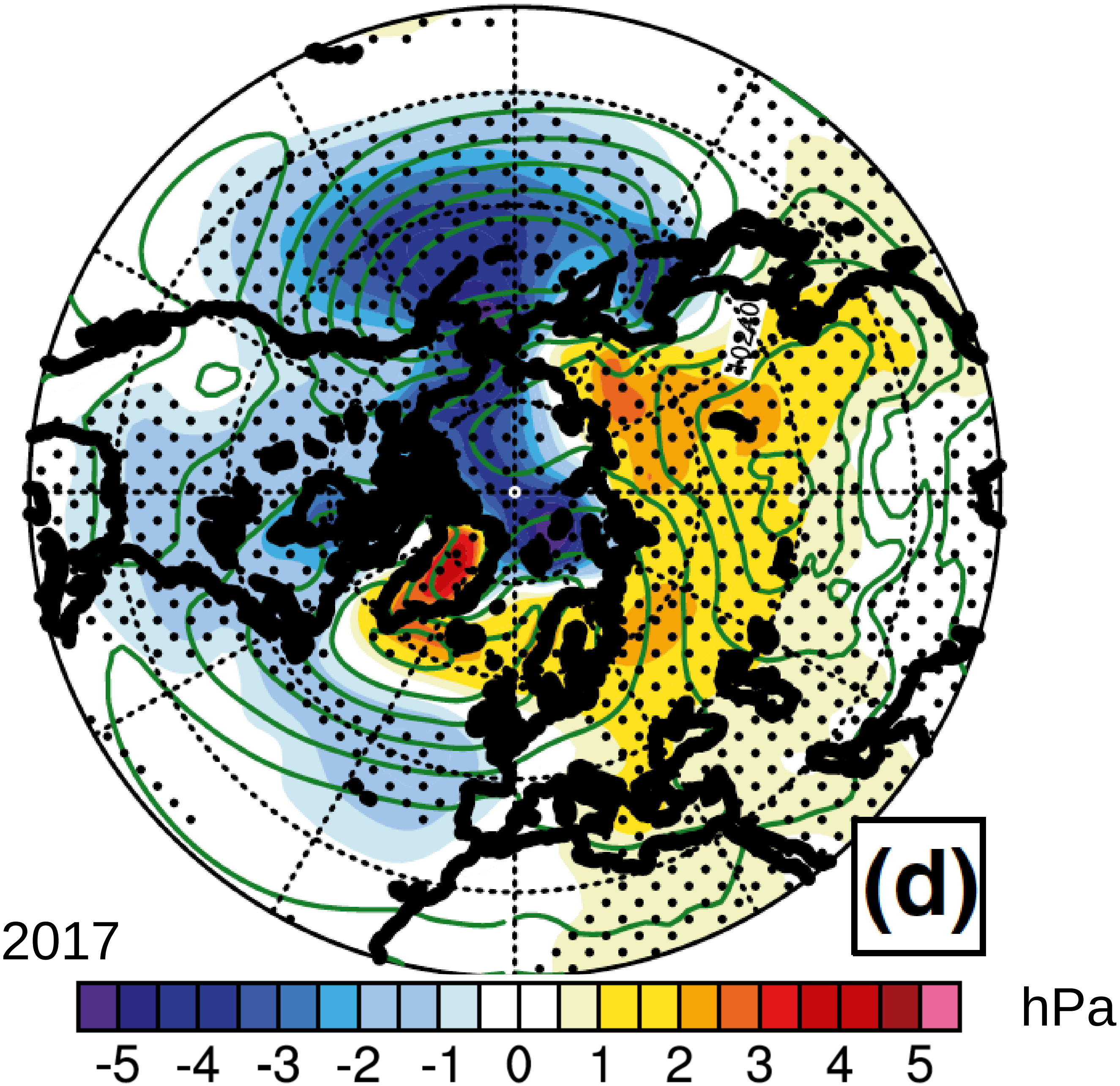


# The Barents-Kara sea-ice hypothesis

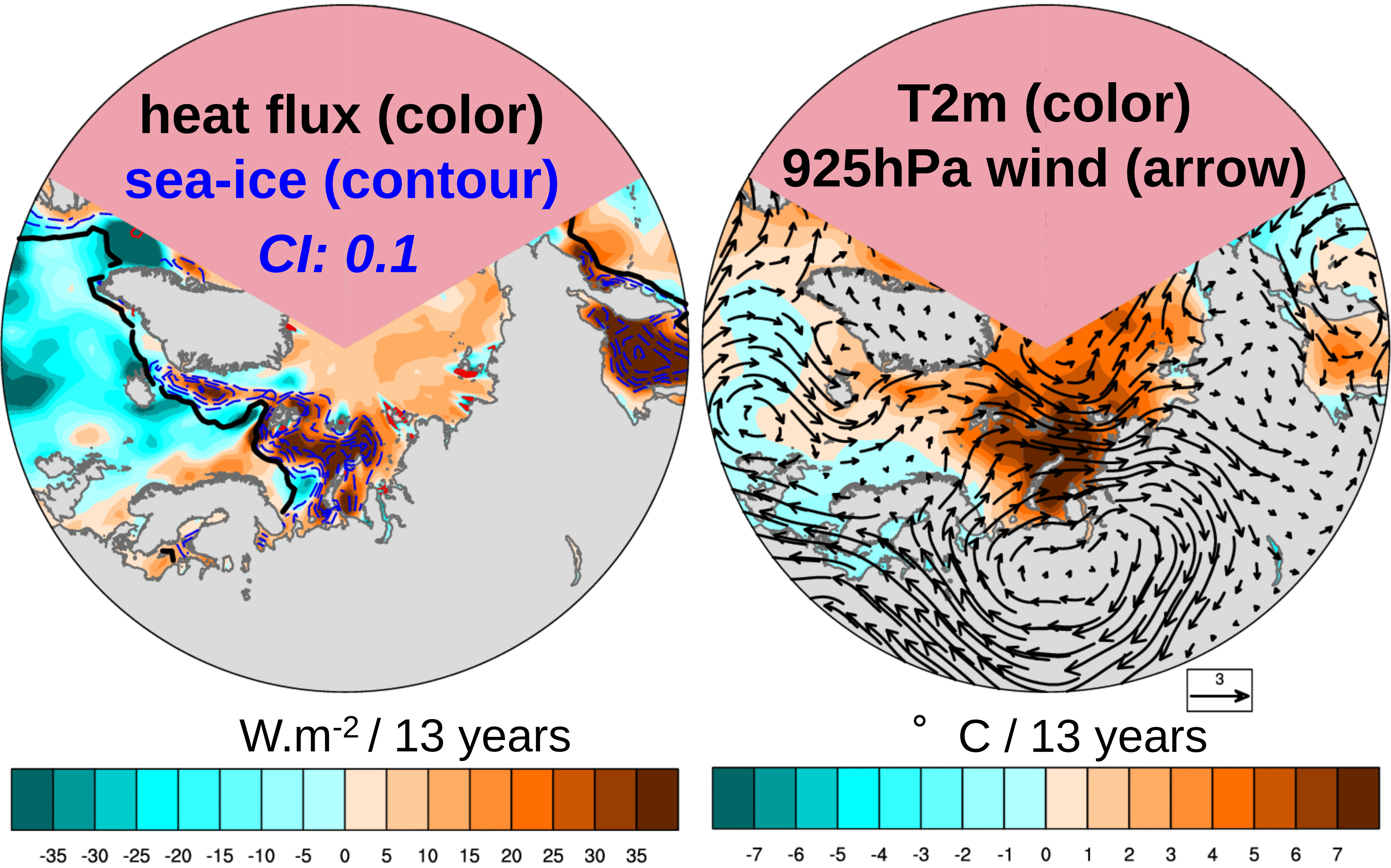


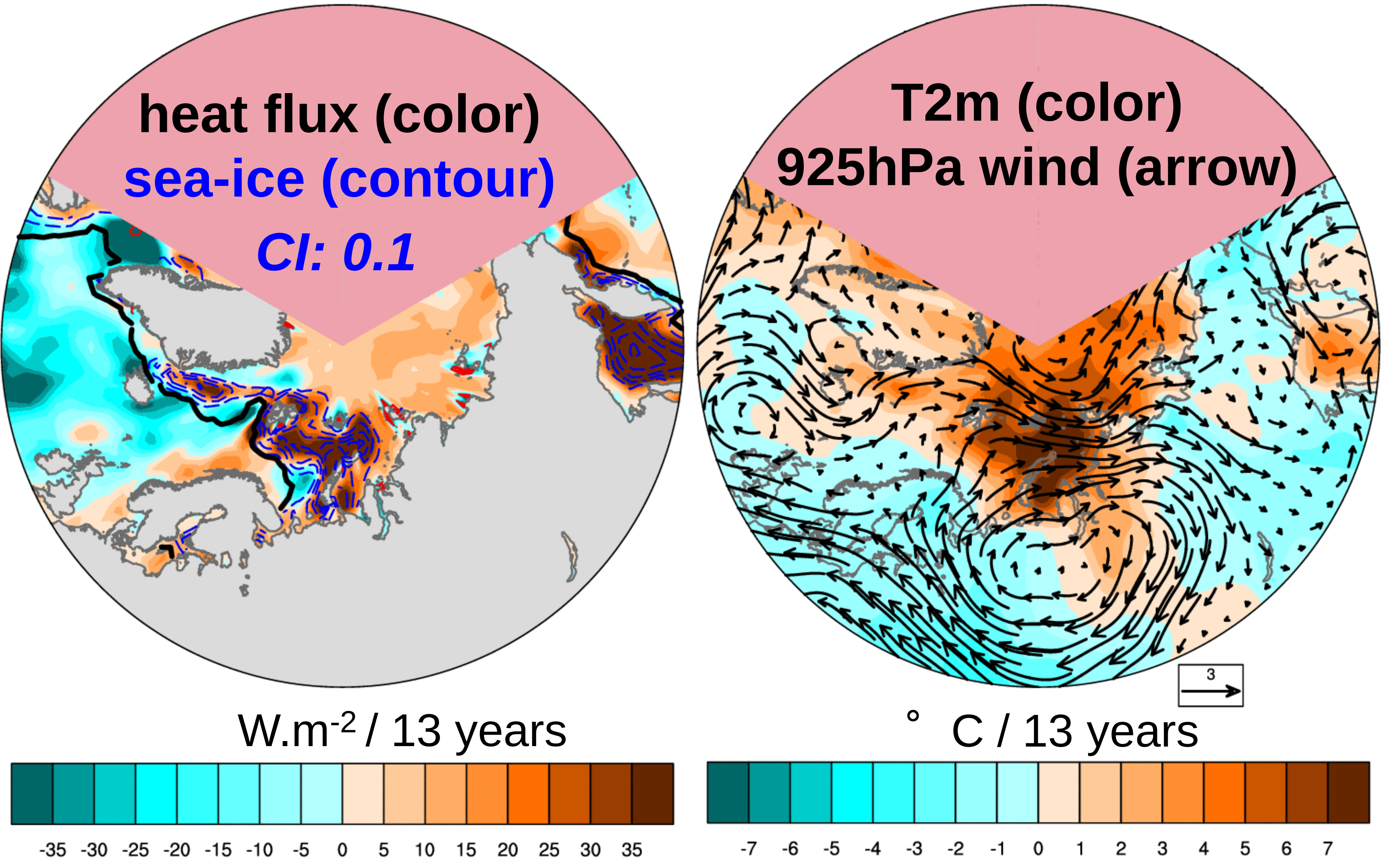

- Anomalous circulation pattern related to sea-ice decline ?
- Contribution of Barents-Kara seas sea-ice decline to thermodynamic component ?

# Winter coupled response to Arctic sea ice loss




Oudar et al. 2017
ClimDyn

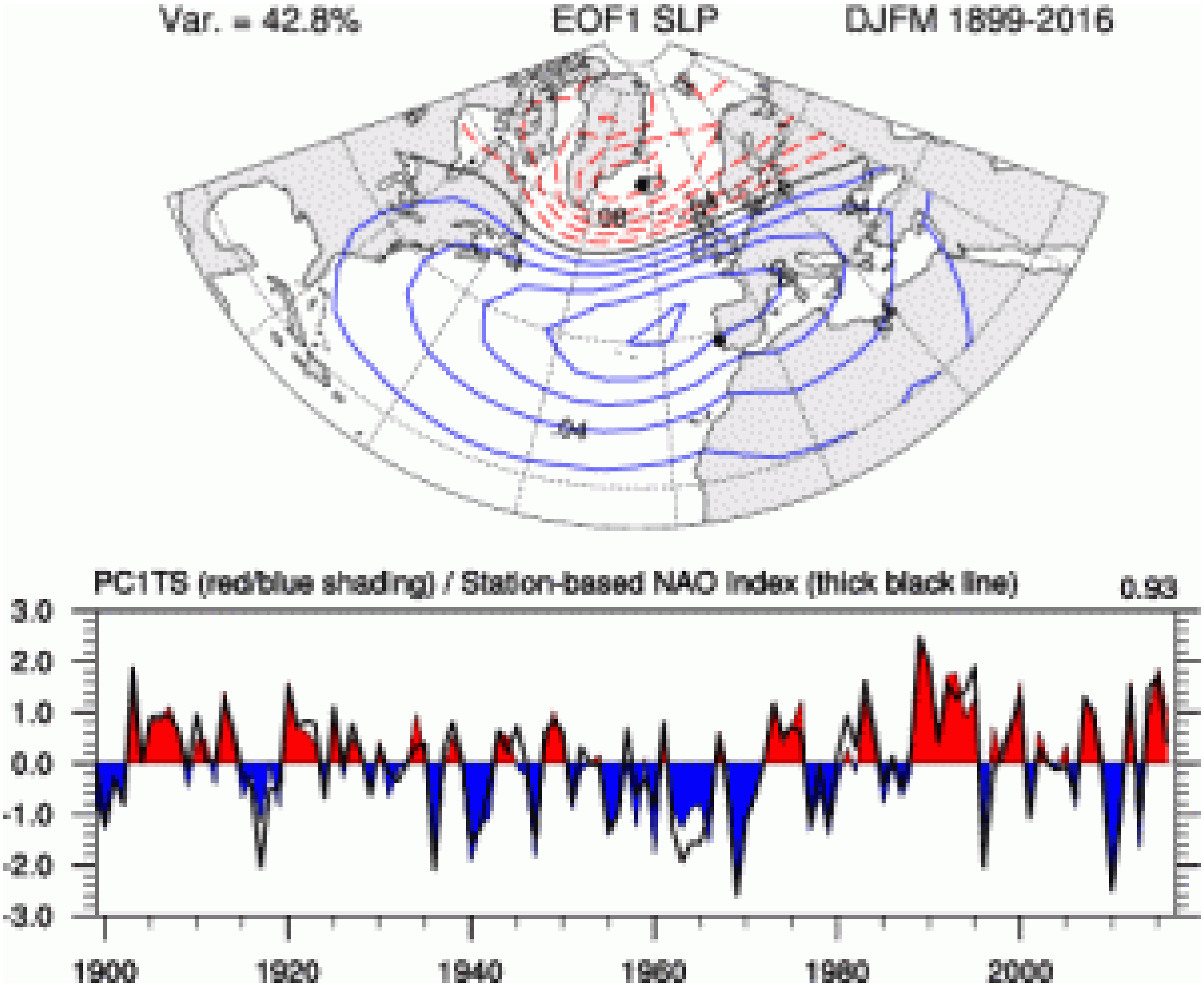

heat flux (color)
sea-ice (contour)
CI: 0.1
W.m-2 / 13 years
-35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35
T2m (color)
925hPa wind (arrow)
3
° C / 13 years
-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7


heat flux (color)
sea-ice (contour)
CI: 0.1
W.m-2 / 13 years
-35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35
T2m (color)
925hPa wind (arrow)
3
° C / 13 years
-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7

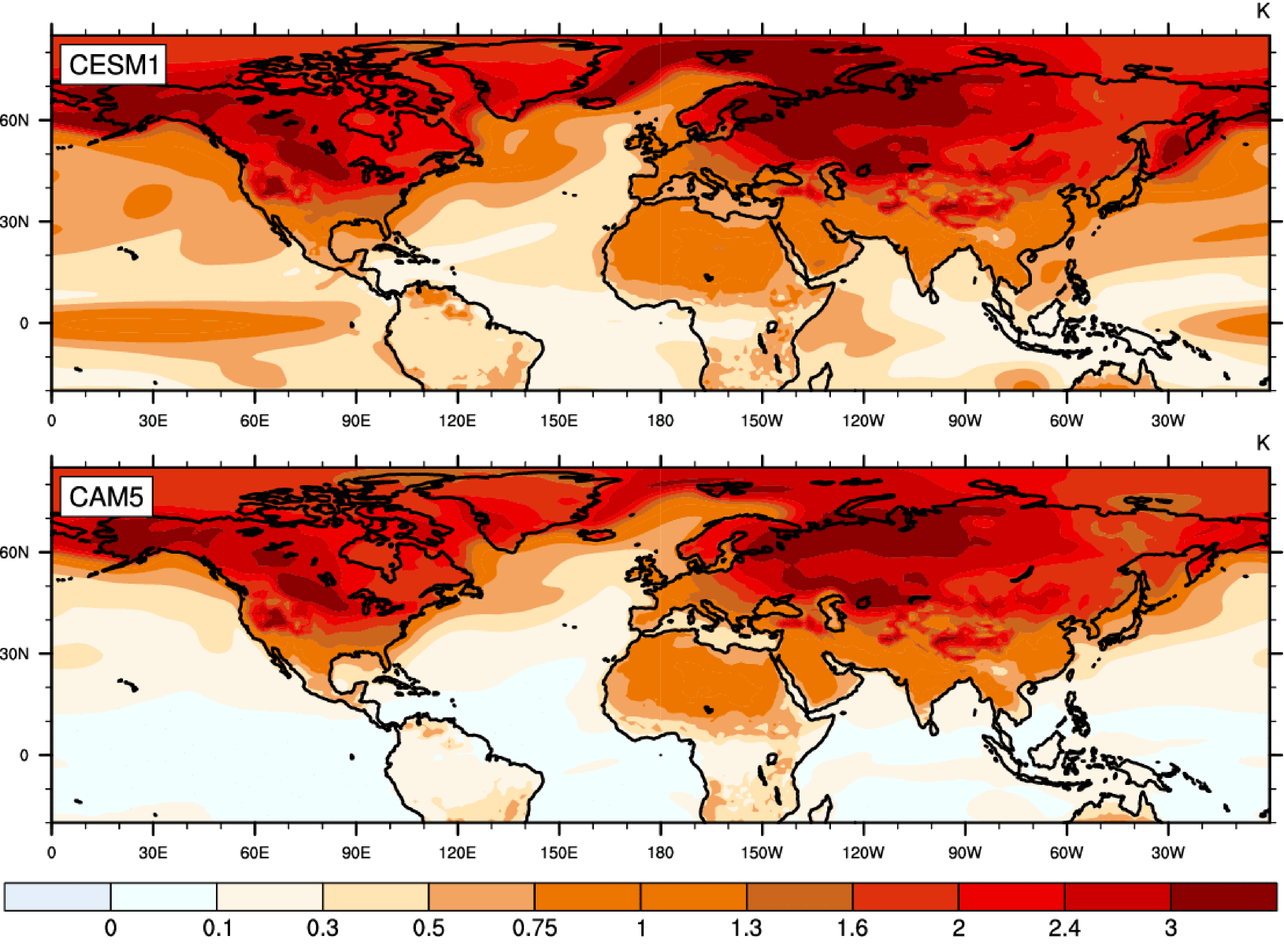
# Summary

- Causes of a climate event: need to quantify contributing factors and uncertainties (as in D&A studies)
- Combine a purely data-driven approach with well-designed (multi-)model experiments
- Dynamical adjustment can be used to separate large-scale circulation effects from land/ocean surface forcing contributions
- Neither tropical forcing nor Barents-sea ice retreat seem to have significantly contributed to the anomalous Siberian High
- The early 2000s Eurasian Cooling is mostly due to a chaotic, non predictable atmospheric fluctuation

Thanks,
Questions ?



Var. = 42.8%
EOF1 SLP
DJFM 1899-2016
PC1TS (red/blue shading) / Station-based NAO Index (thick black line)
0.93
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
1900
1920
1940
1960
1980
2000


K
CESM1
60N
30N
0
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
K
CAM5
60N
30N
0
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
0.1
0.3
0.5
0.75
1
1.3
1.6
2
2.4
3

# The External Forcing contribution

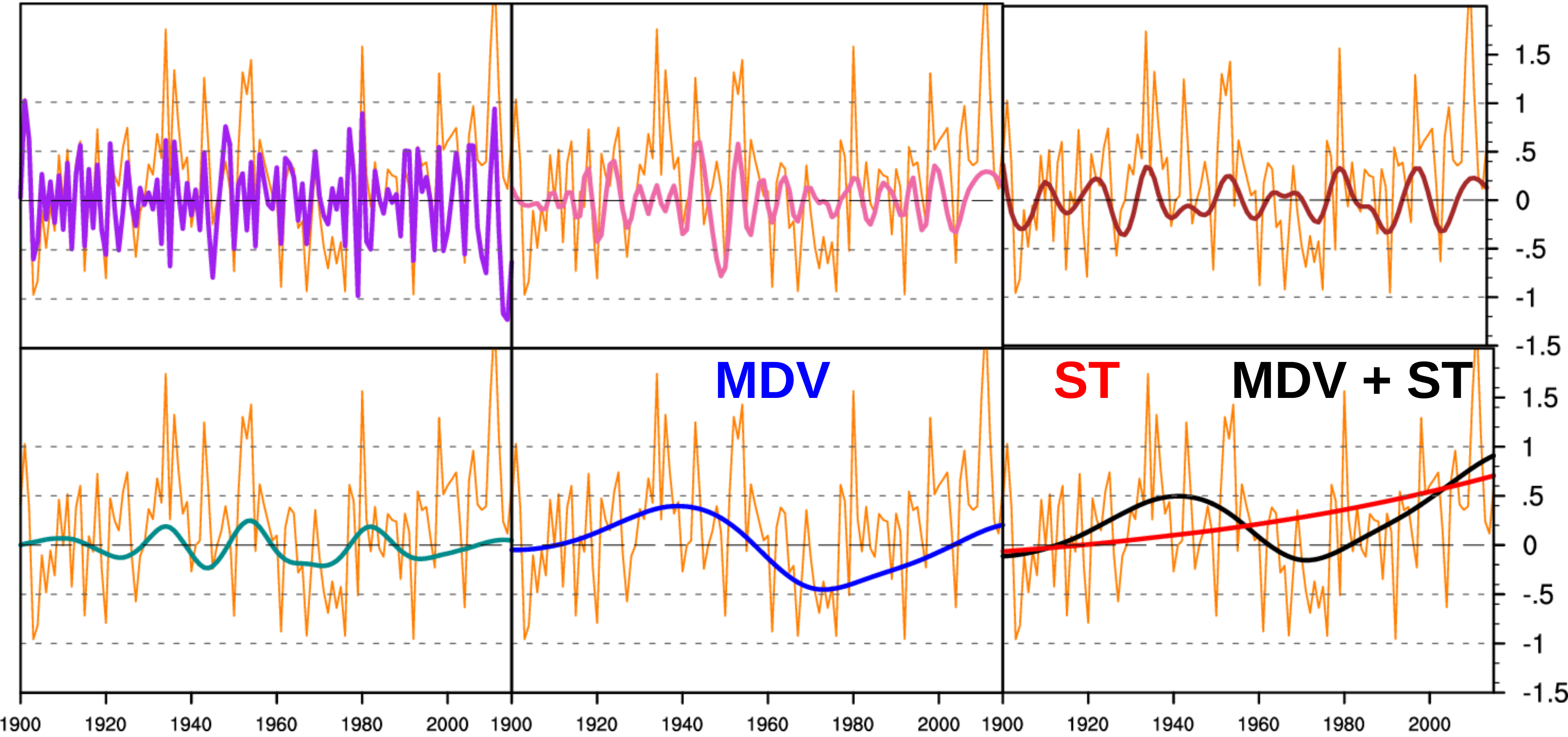
- Can be estimated with models or observations

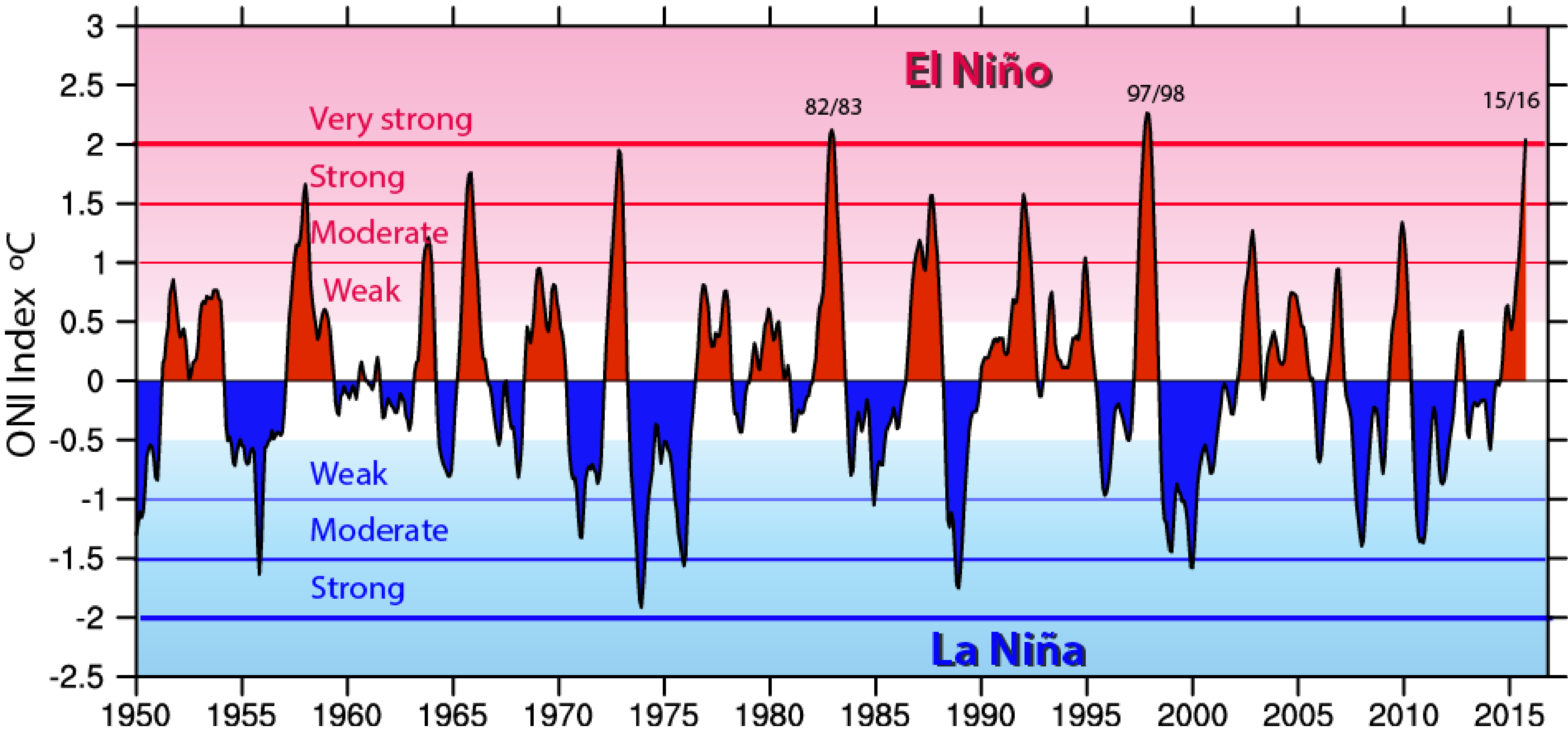
- **Observations**: use a purely data-driven and non parametric approach, the *Ensemble Empirical Mode Decomposition* (EEMD) technique

- EEMD decomposes any time series in a suite of amplitude-frequency modulated oscillatory components and a secular (non linear) trend

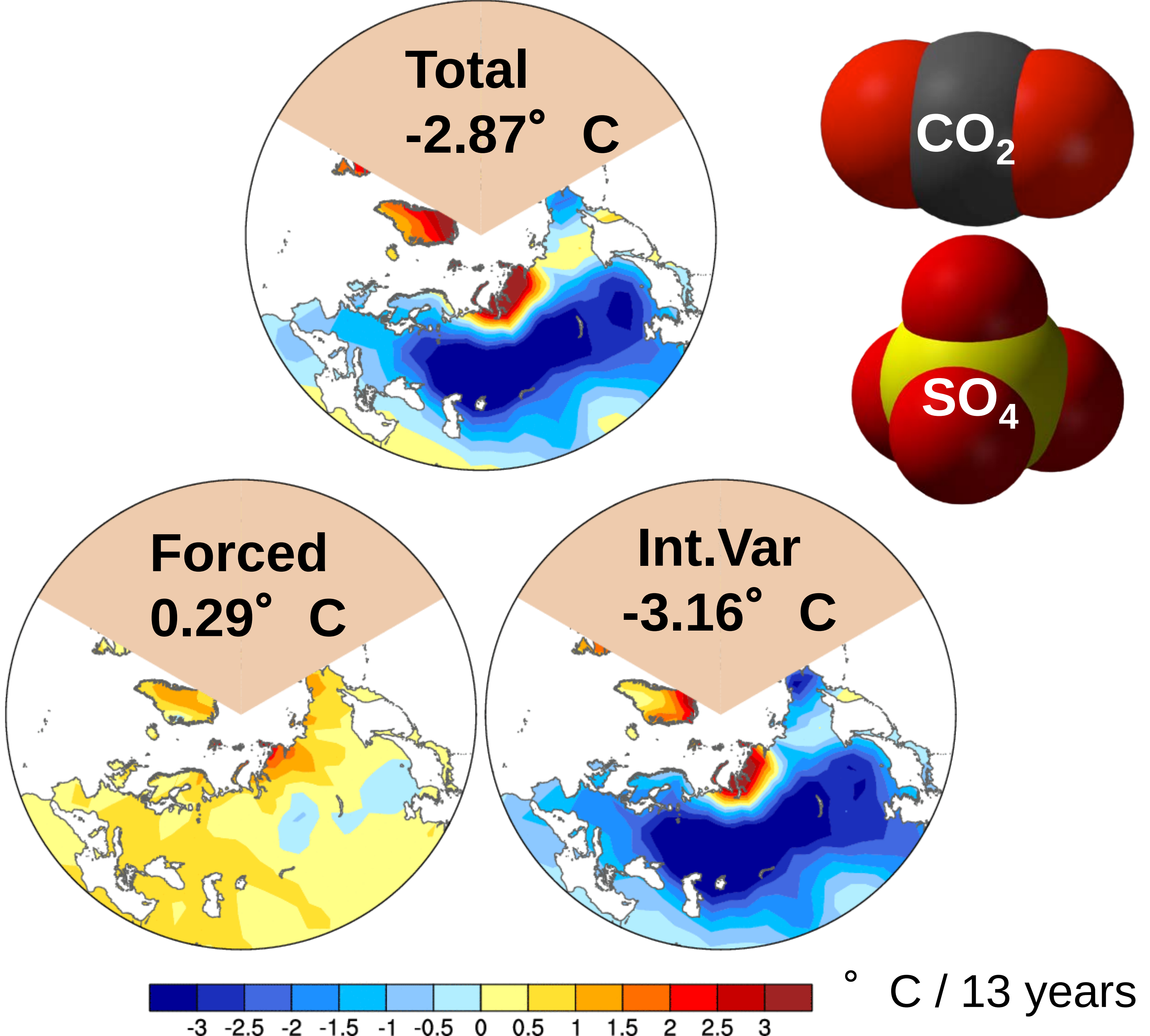
- Apply EEMD to the Cowtan&Way data set

# EEMD decomposition of temperature





El Niño
Very strong
Strong
Moderate
Weak
82/83
97/98
15/16
Weak
Moderate
Strong
La Niña
ONI Index °C
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015


Total
-2.87° C
CO2
SO4
Forced
0.29° C
Int.Var
-3.16° C
° C / 13 years
-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3