Testing Recent and Future GCM Expressions of Antarctic Surface Melting Conditions

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National Science Foundation

NEW MEXICO TECH
EARTH AND ENVIRONMENTAL SCIENCE

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

NSF

Project Overview

- Three project goals
  - Relate observed surface melt to modeled meteorology
  - Evaluate CMIP5 GCM skill against modern
  - Predict future surface melt with CMIP5 projections
- Polar WRF 3.3.1* on 45/15 km continental grids

WRF(Reanalysis)
1989 - 2008

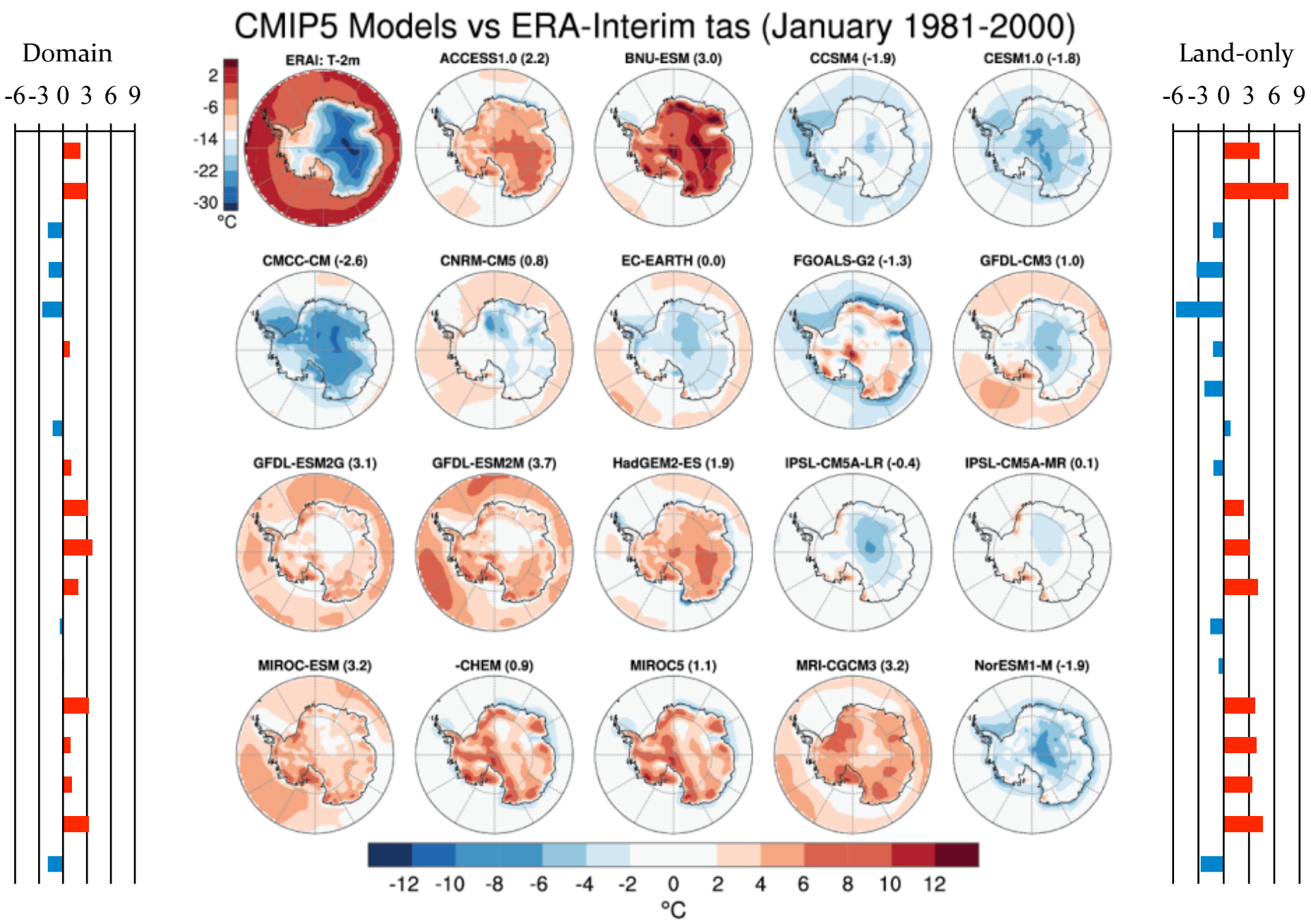
WRF(modern GCM)
1990 - 1999

WRF(future GCM)
2090 - 2099

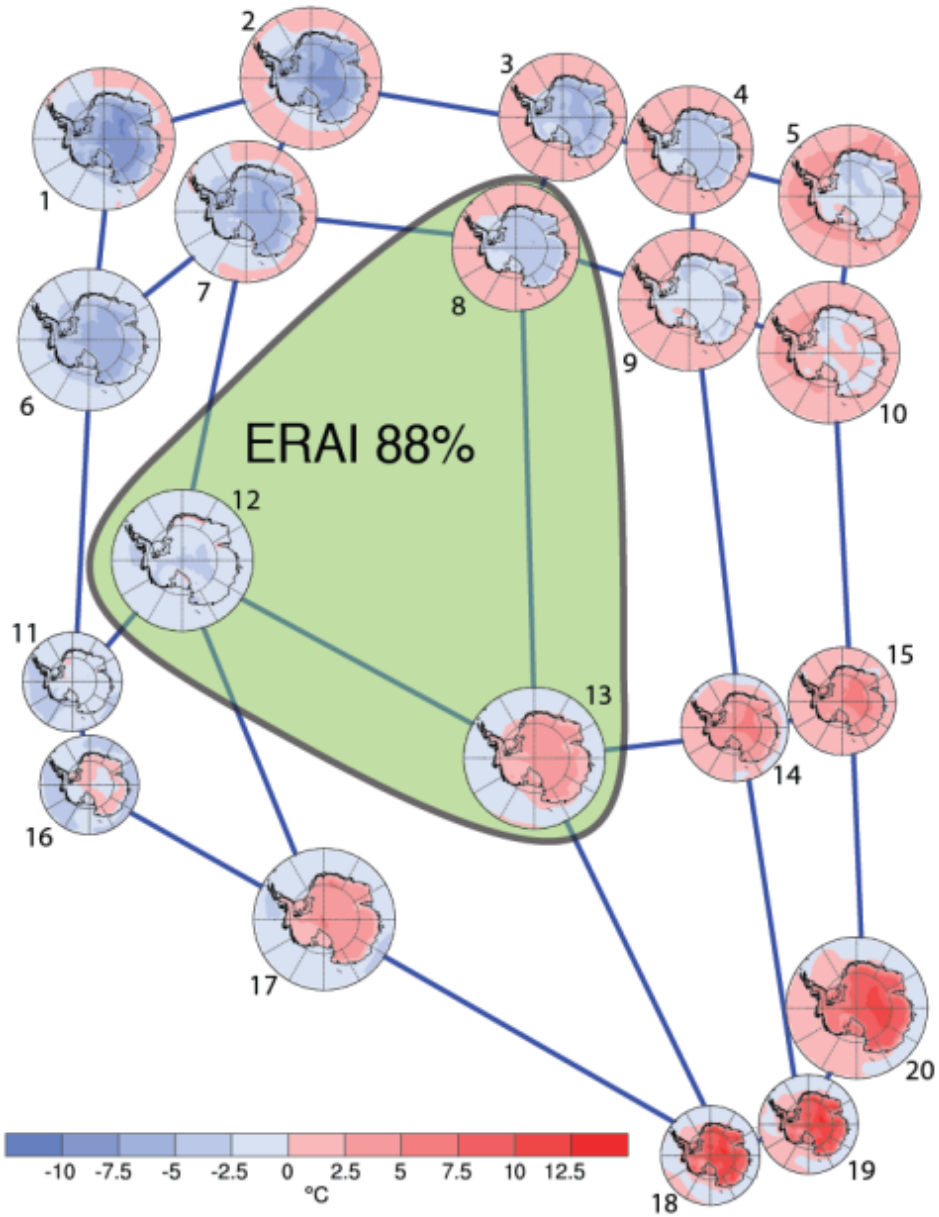
* WRF with modifications for polar conditions
Polar Meteorology Group, Byrd Polar Research Center, Ohio State

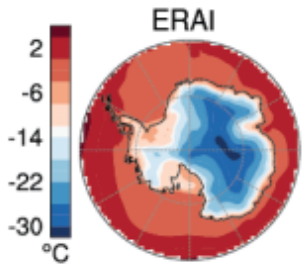
Talk Overview

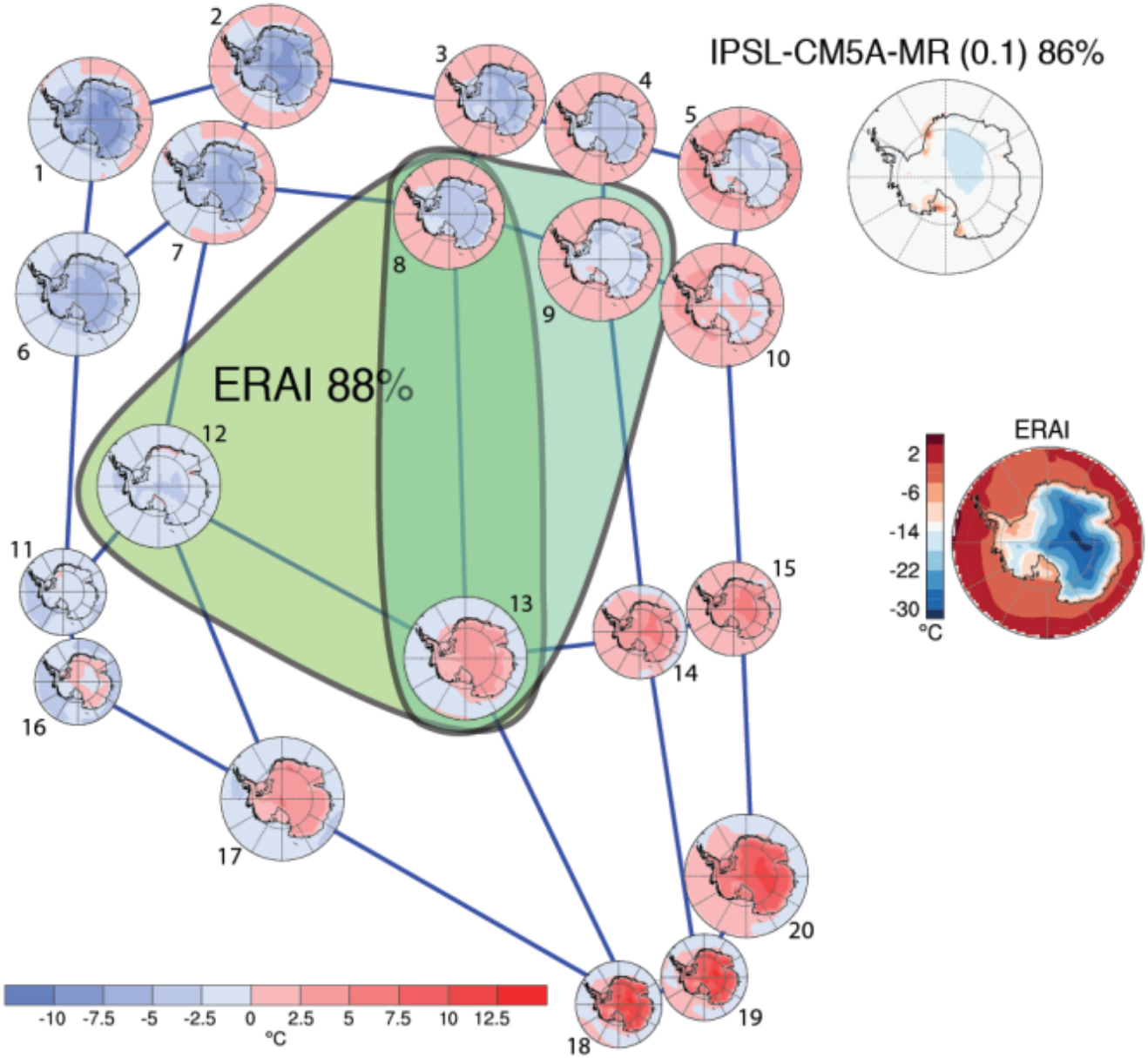
- Intermodel Uncertainty: CMIP5
- Melt Events & Meteorology
- Intramodel Uncertainty: CESM Large Ensemble


CMIP5 Models vs ERA-Interim tas (January 1981-2000)
Domain
-6 -3 0 3 6 9
Land-only
-6 -3 0 3 6 9
ERAI: T-2m
2
-6
-14
-22
-30
°C
ACCESS1.0 (2.2)
BNU-ESM (3.0)
CCSM4 (-1.9)
CESM1.0 (-1.8)
CMCC-CM (-2.6)
CNRM-CM5 (0.8)
EC-EARTH (0.0)
FGOALS-G2 (-1.3)
GFDL-CM3 (1.0)
GFDL-ESM2G (3.1)
GFDL-ESM2M (3.7)
HadGEM2-ES (1.9)
IPSL-CM5A-LR (-0.4)
IPSL-CM5A-MR (0.1)
MIROC-ESM (3.2)
-CHEM (0.9)
MIROC5 (1.1)
MRI-CGCM3 (3.2)
NorESM1-M (-1.9)
-12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12
°C

20 years x 31 days
x 20 datasets:
12,400 days






IPSL-CM5A-MR (0.1) 86%
ERAI 88%
ERAI
2
-6
-14
-22
-30
°C
-10 -7.5 -5 -2.5 0 2.5 5 7.5 10 12.5
°C
1
2
3
4
5
6
7
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10
11
12
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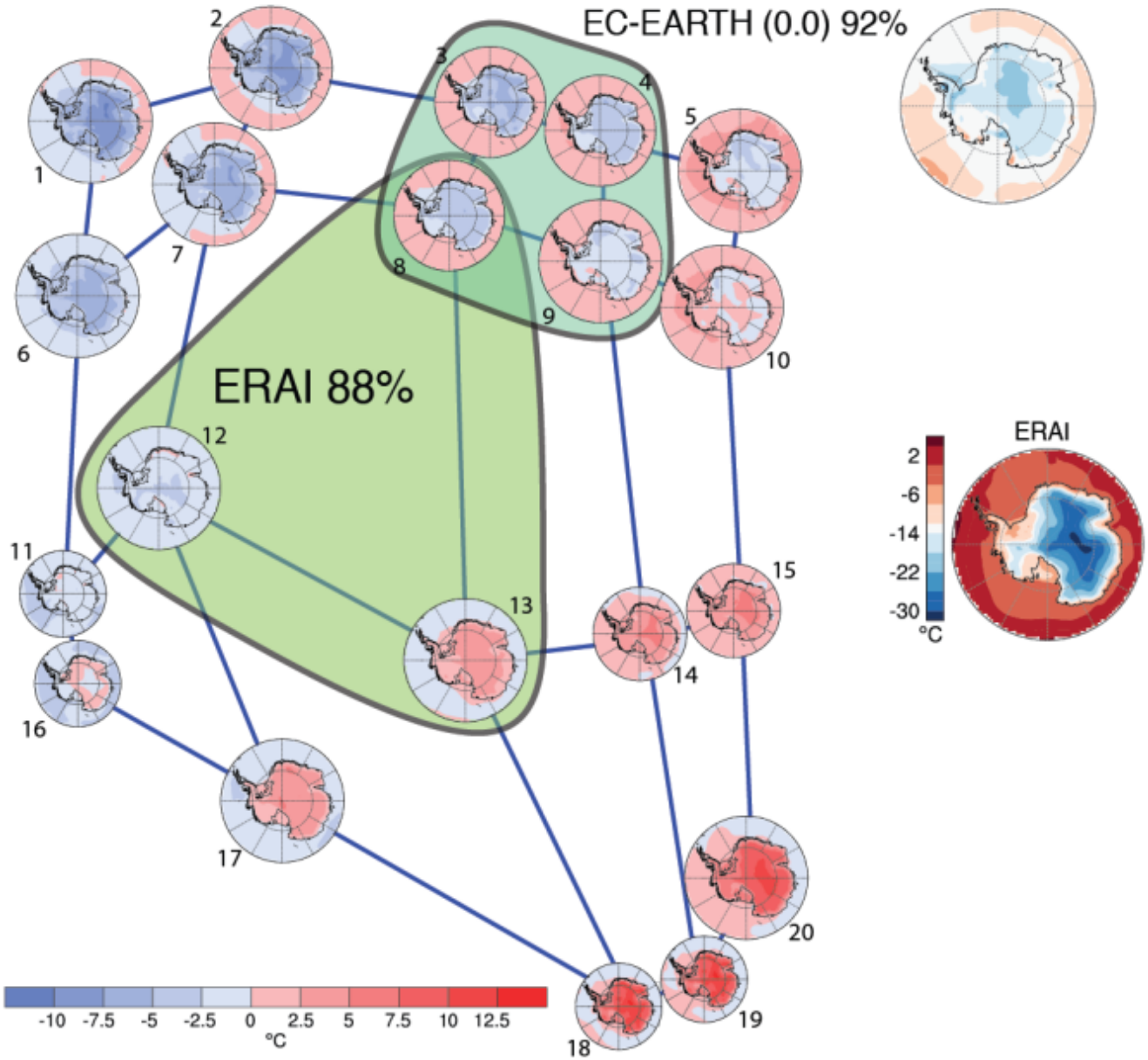
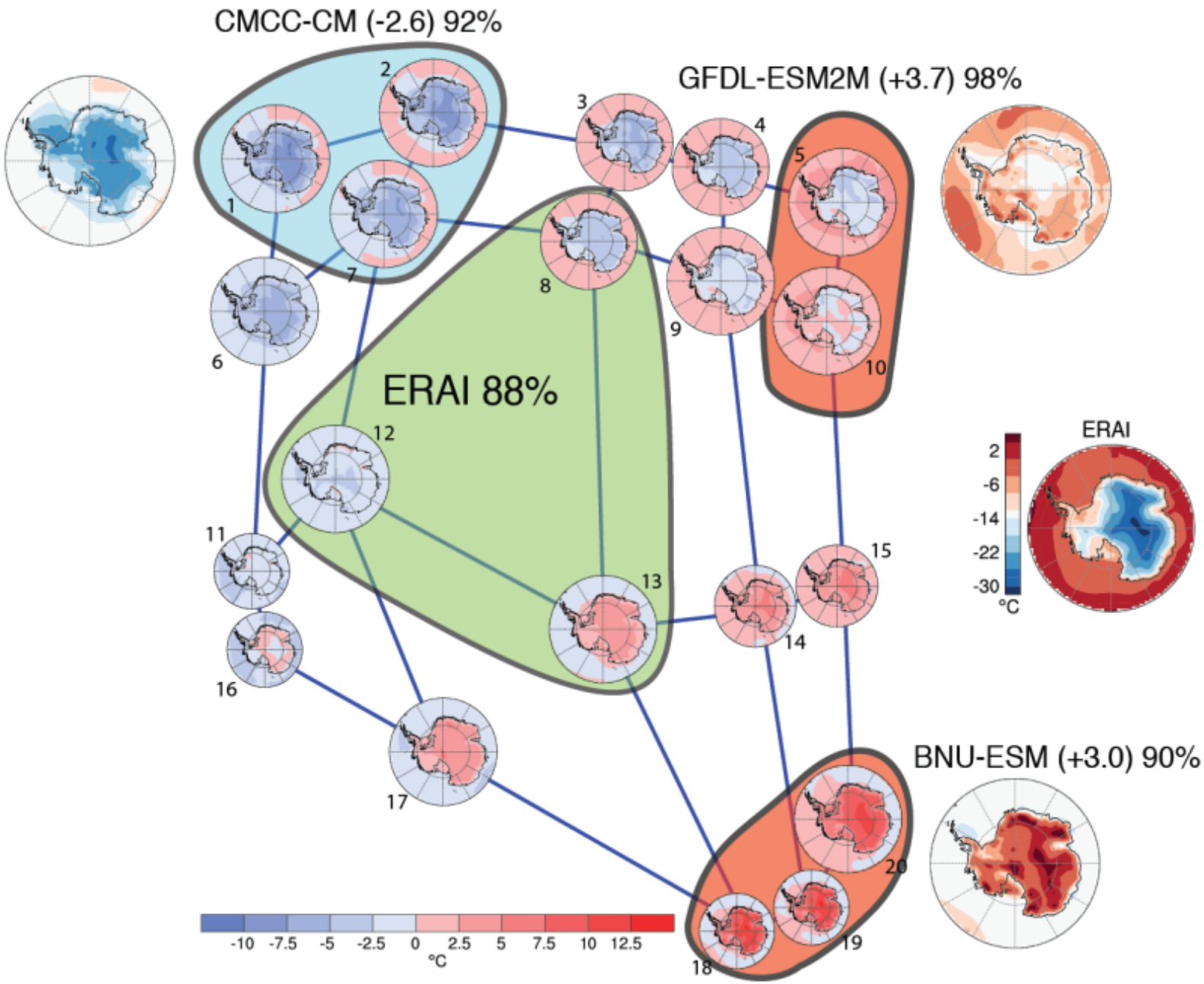
17
18
19
20


EC-EARTH (0.0) 92%
ERAI 88%
ERAI
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
-10 -7.5 -5 -2.5 0 2.5 5 7.5 10 12.5
°C
2
-6
-14
-22
-30
°C


CMCC-CM (-2.6) 92%
GFDL-ESM2M (+3.7) 98%
ERAI 88%
BNU-ESM (+3.0) 90%
ERAI
2
-6
-14
-22
-30
°C
-10 -7.5 -5 -2.5 0 2.5 5 7.5 10 12.5
°C
1
2
3
4
5
6
7
8
9
10
11
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13
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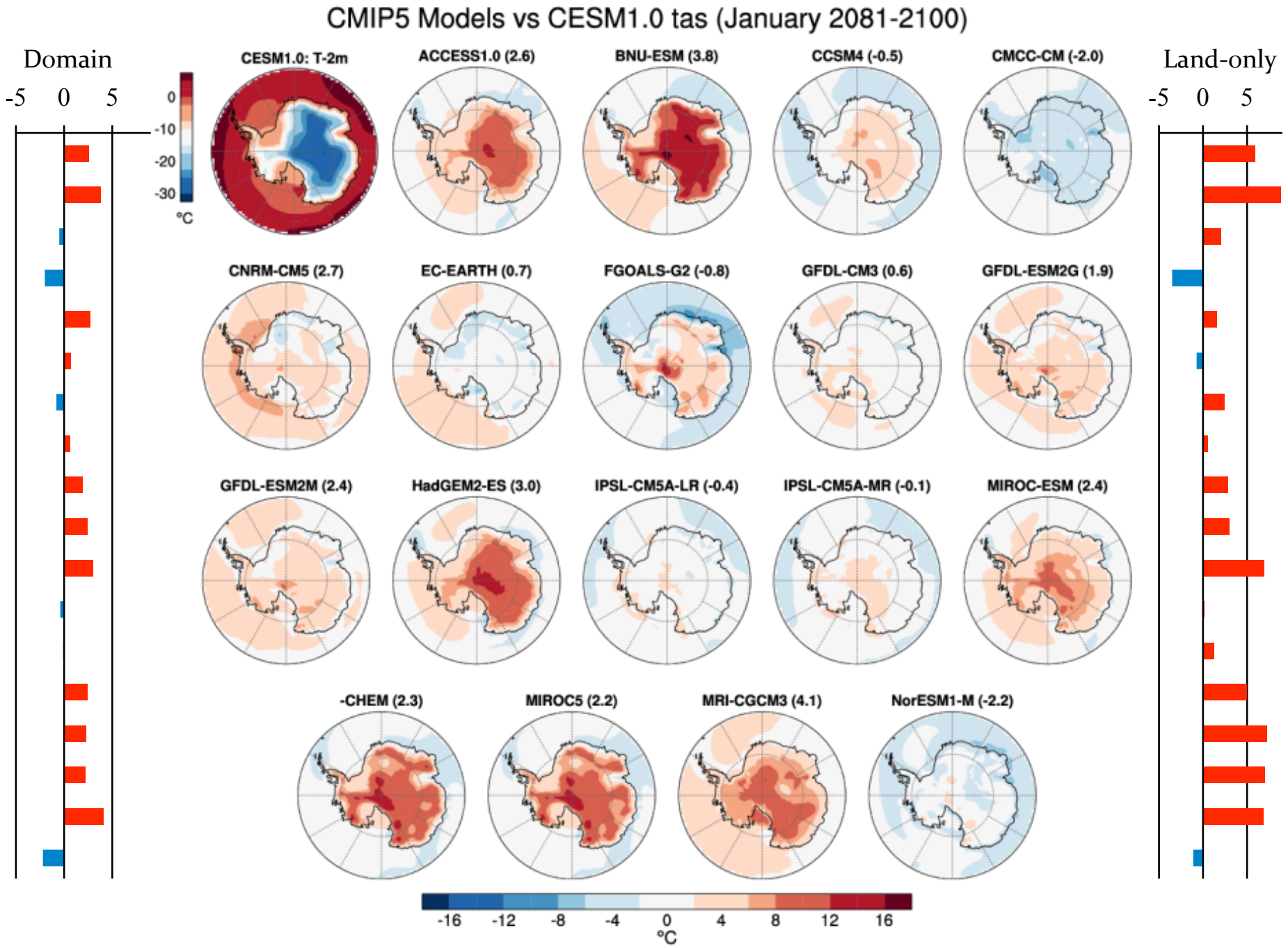
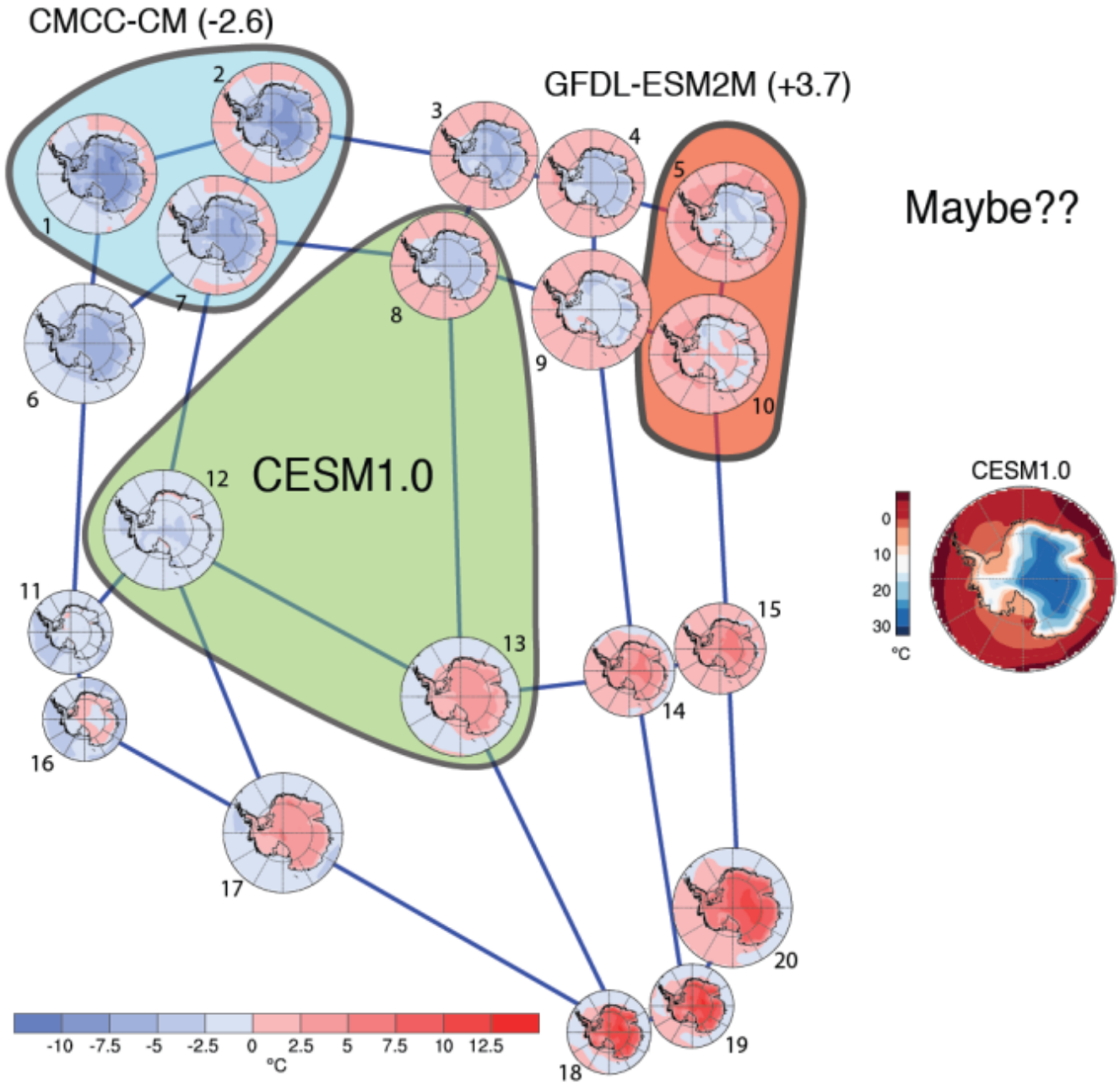
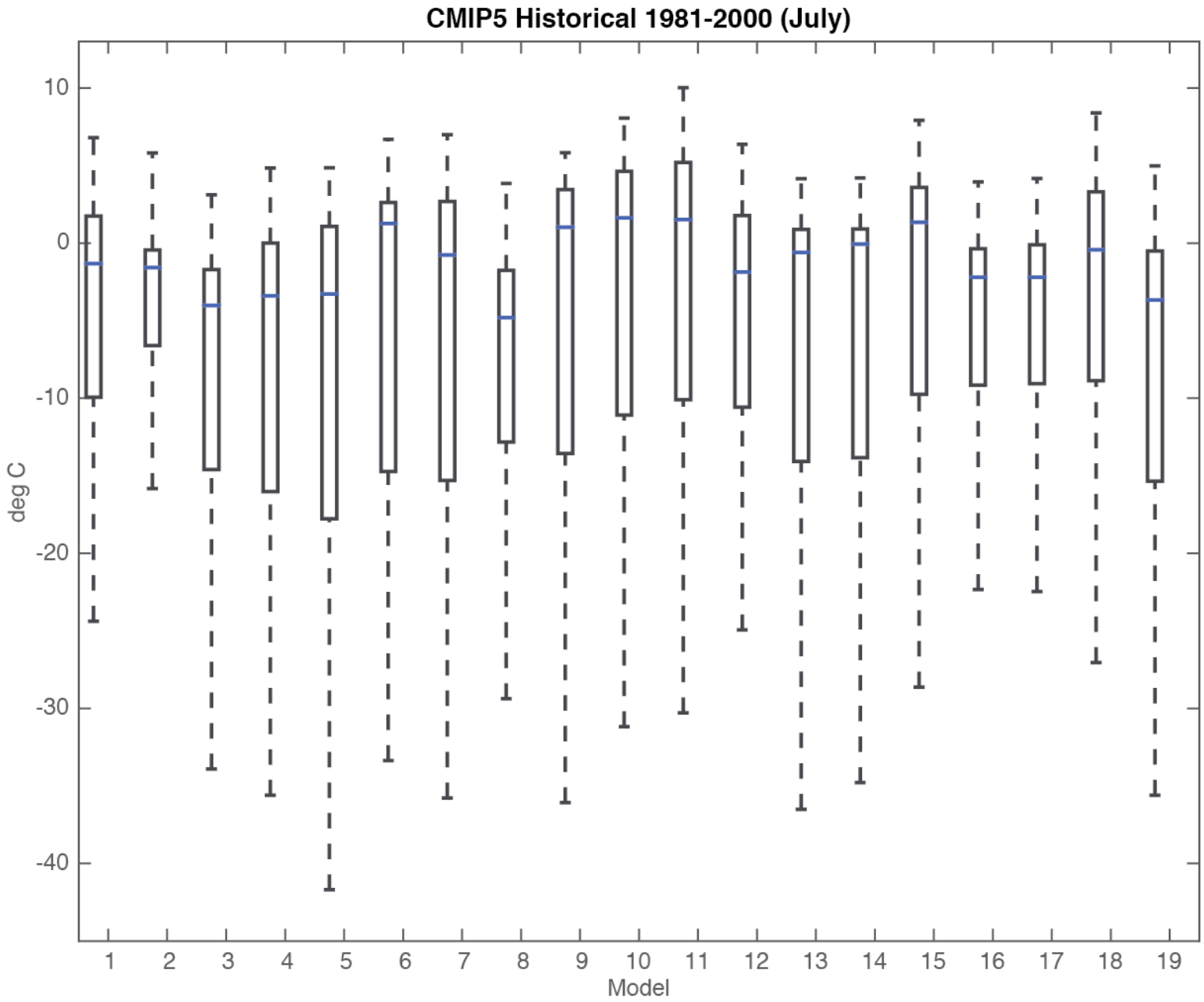
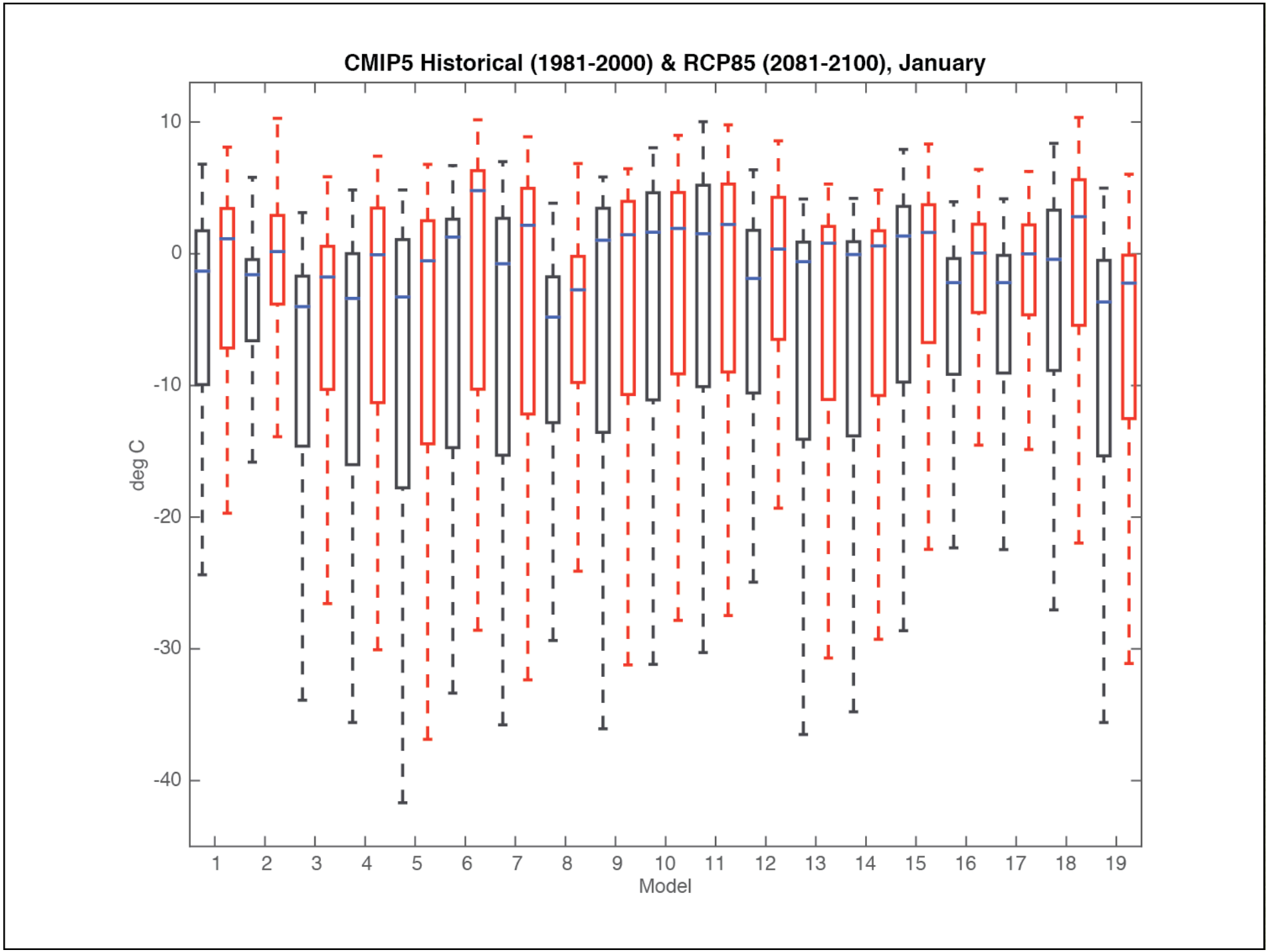
16
17
18
19
20


CMIP5 Models vs CESM1.0 tas (January 2081-2100)
Domain
-5 0 5
Land-only
-5 0 5
CESM1.0: T-2m
0
-10
-20
-30
°C
ACCESS1.0 (2.6)
BNU-ESM (3.8)
CCSM4 (-0.5)
CMCC-CM (-2.0)
CNRM-CM5 (2.7)
EC-EARTH (0.7)
FGOALS-G2 (-0.8)
GFDL-CM3 (0.6)
GFDL-ESM2G (1.9)
GFDL-ESM2M (2.4)
HadGEM2-ES (3.0)
IPSL-CM5A-LR (-0.4)
IPSL-CM5A-MR (-0.1)
MIROC-ESM (2.4)
-CHEM (2.3)
MIROC5 (2.2)
MRI-CGCM3 (4.1)
NorESM1-M (-2.2)
-16 -12 -8 -4 0 4 8 12 16
°C


CMCC-CM (-2.6)
GFDL-ESM2M (+3.7)
CESM1.0
Maybe??
CESM1.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
-10 -7.5 -5 -2.5 0 2.5 5 7.5 10 12.5
°C
0
10
20
30
°C

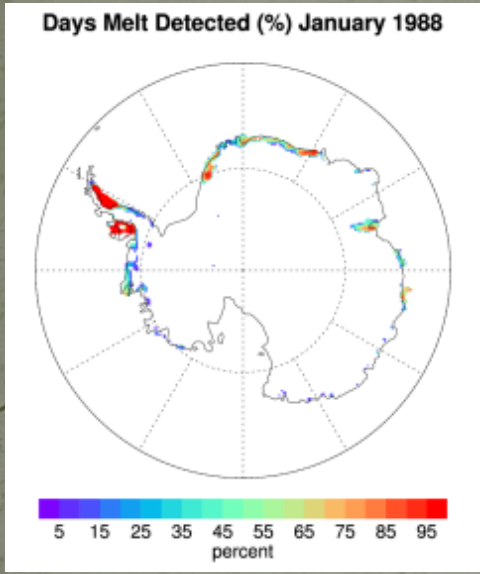

CMIP5 Historical 1981-2000 (July)
10
0
-10
-20
-30
-40
deg C
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Model

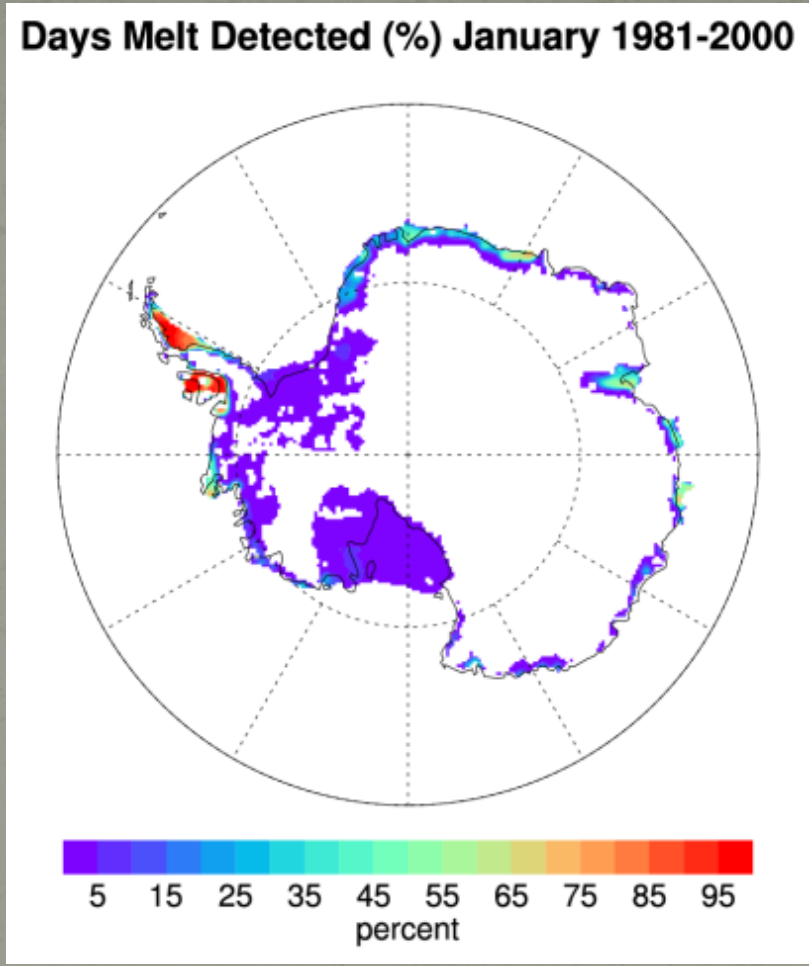

CMIP5 Historical (1981-2000) & RCP85 (2081-2100), January
10
0
-10
-20
-30
-40
deg C
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Model

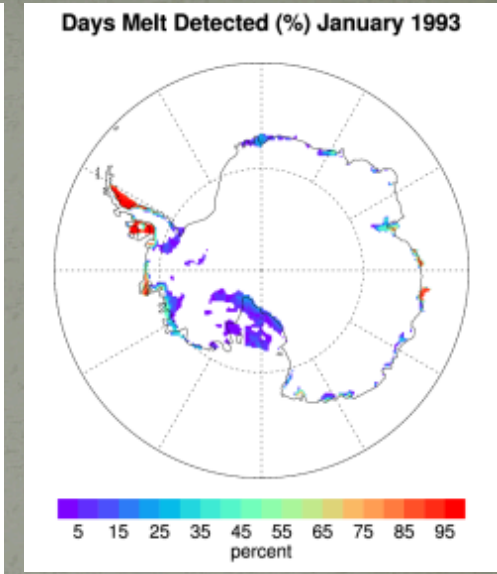
Talk Overview

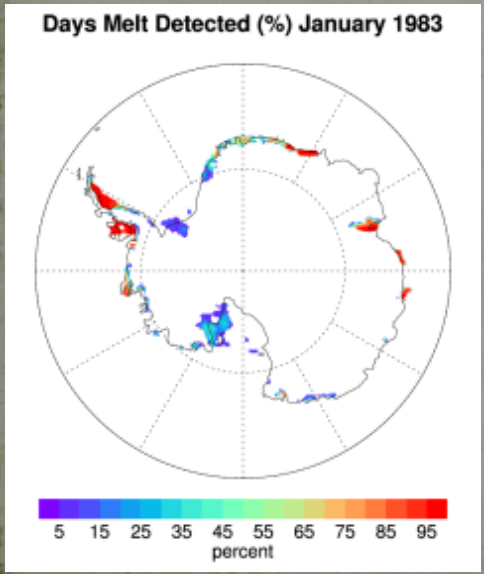
- Intermodel Uncertainty: CMIP5
- Melt Events & Meteorology
- Intramodel Uncertainty: CESM Large Ensemble

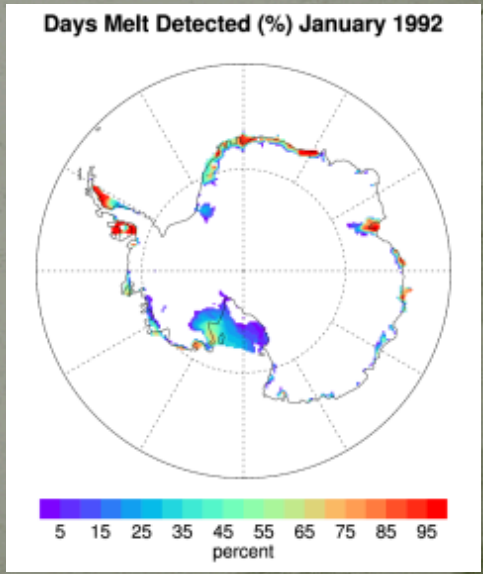
Observed Melt Occurrence



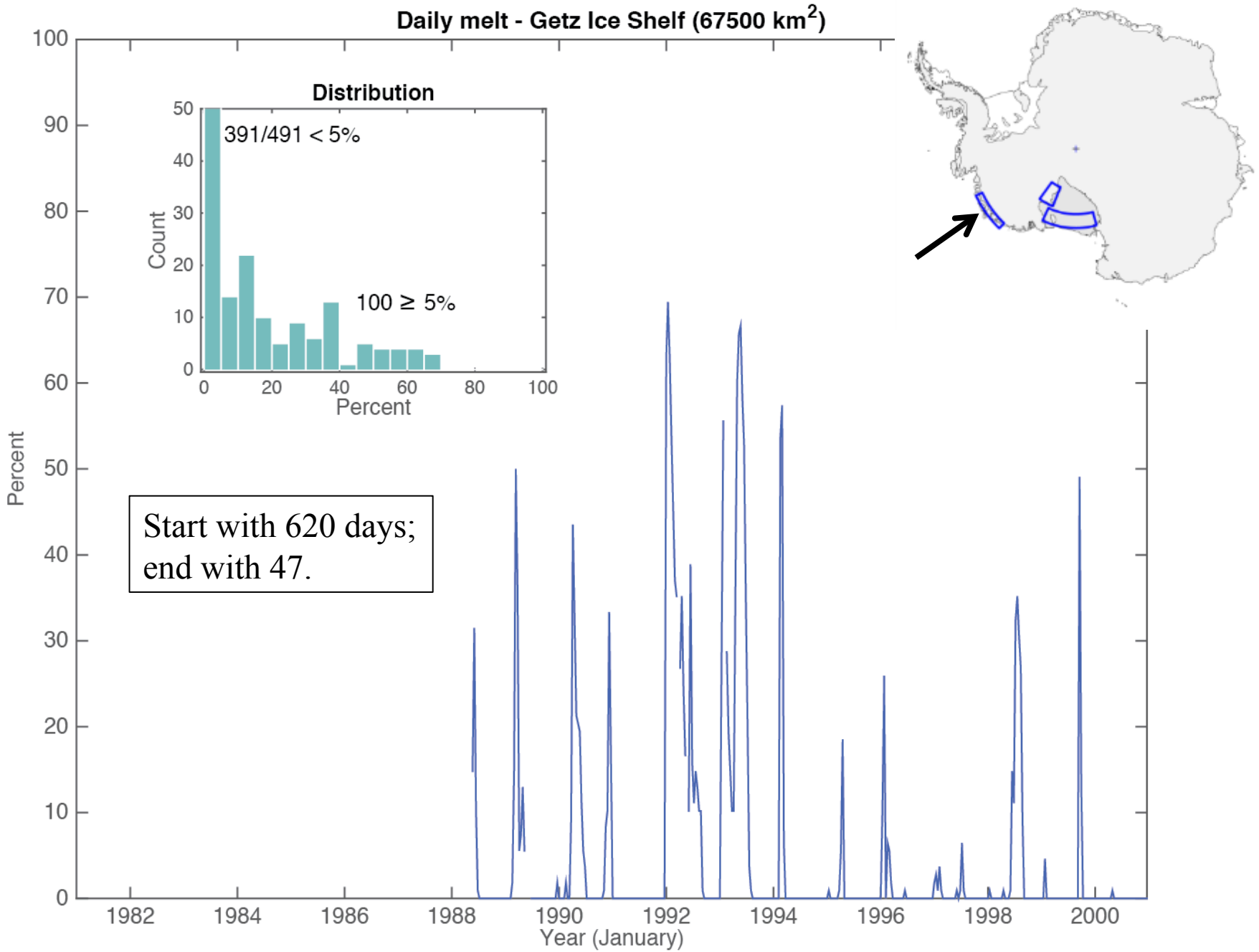


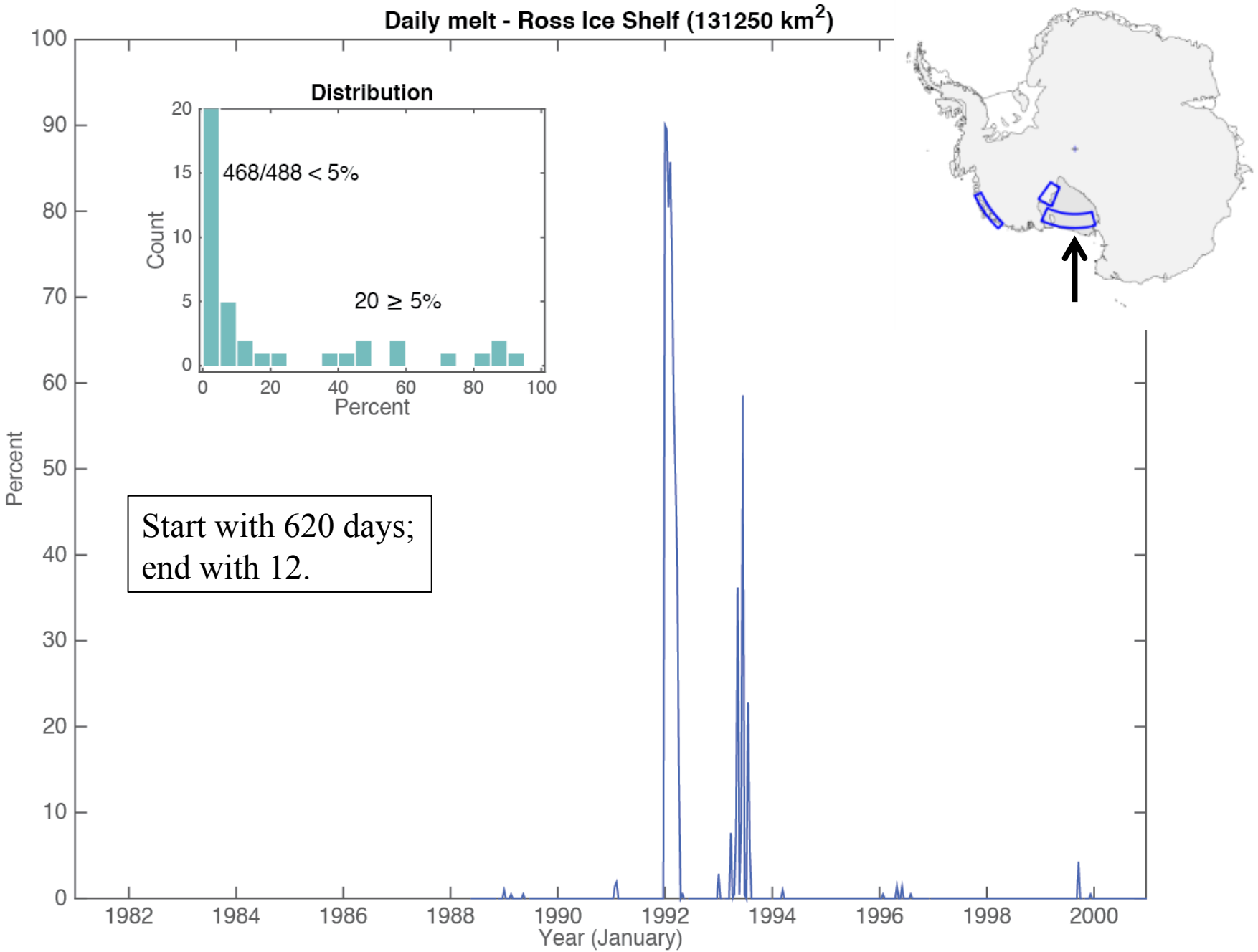




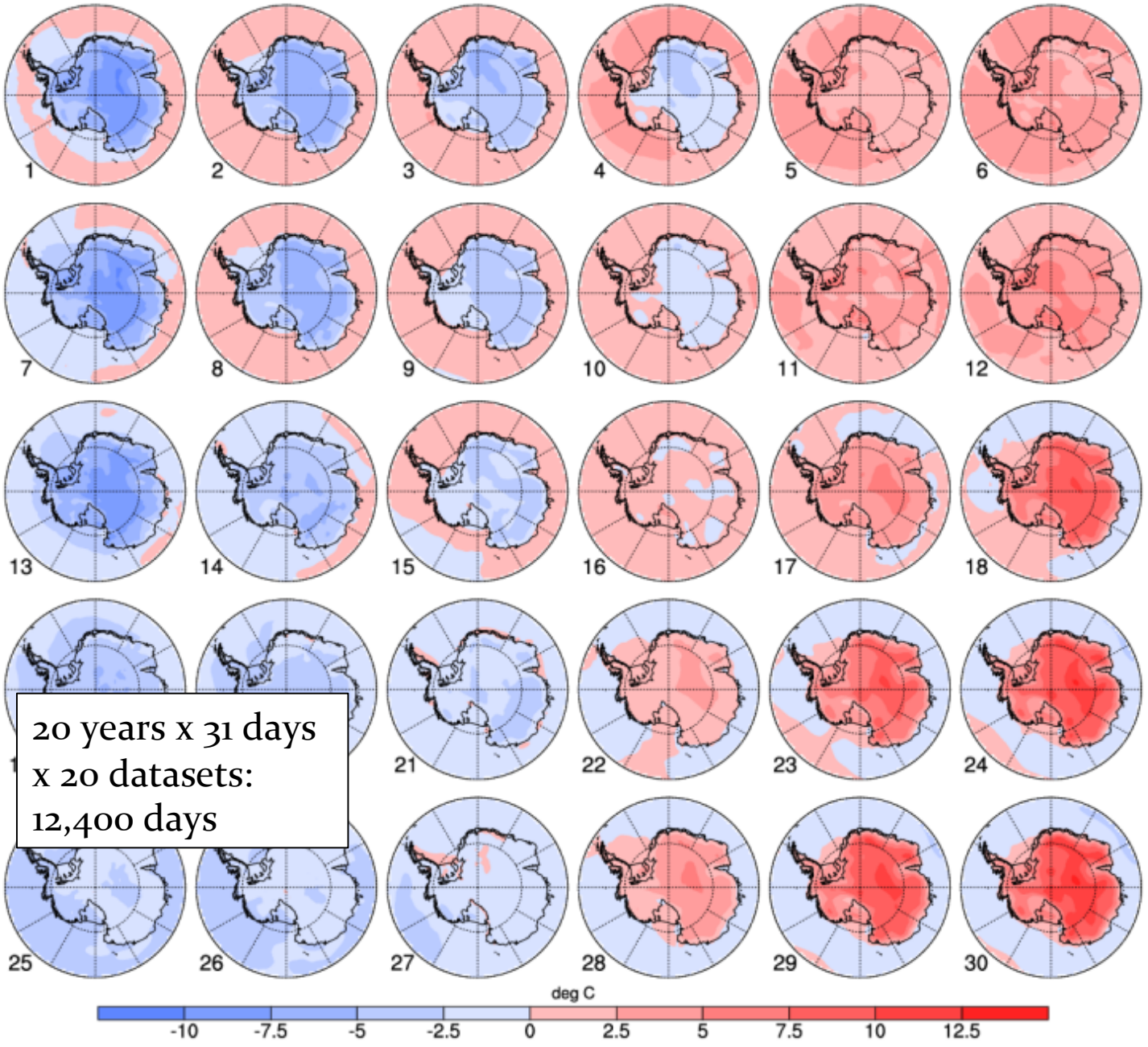


G. Picard, M.Fily, 2006, Surface melting observations in Antarctica by microwave radiometers: correcting 26 year-long timeseries from changes in acquisition hours. Remote Sensing of Environment.
http://lgge.osug.fr/~picard/melting/

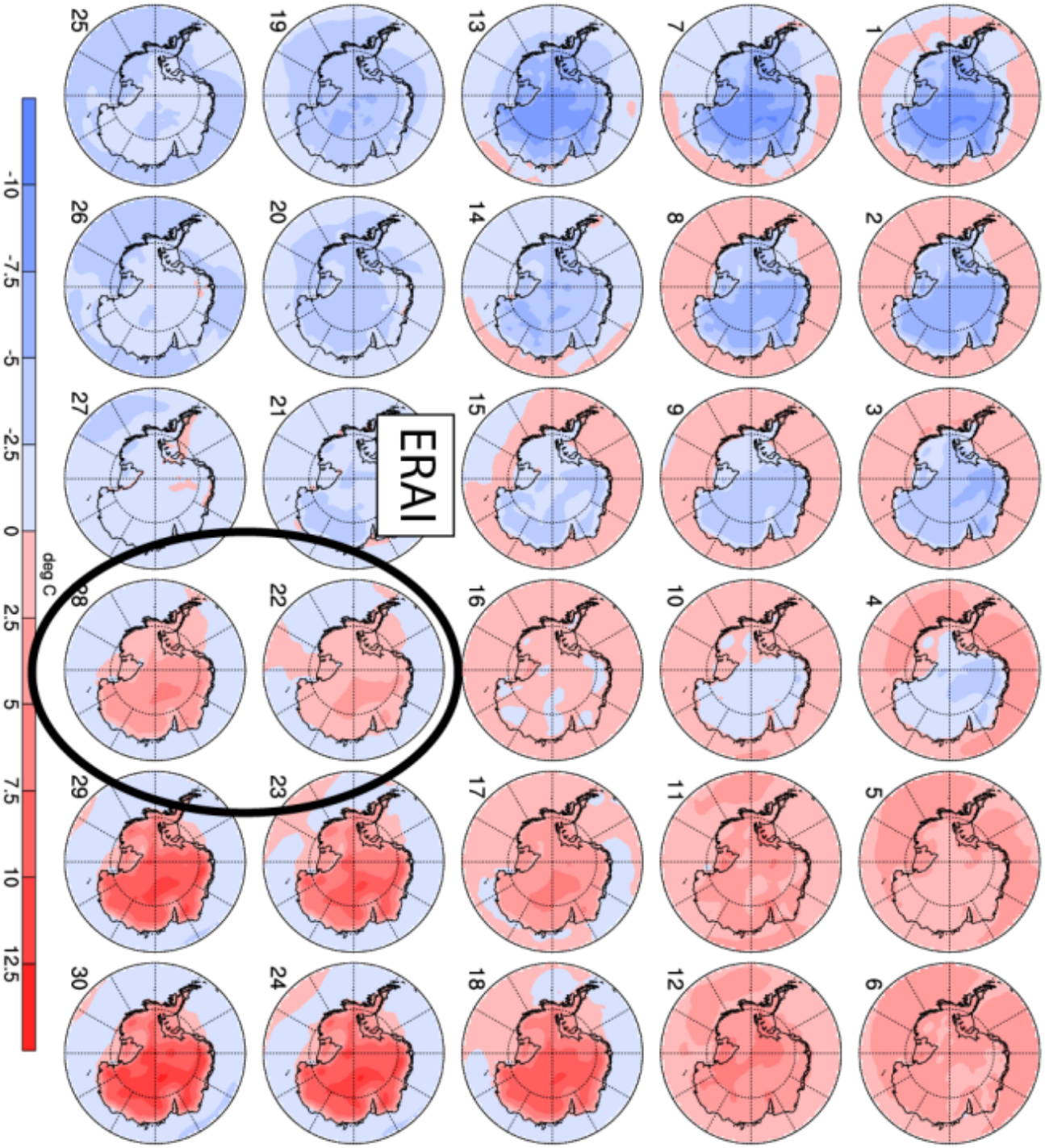

Daily melt - Getz Ice Shelf (67500 km^2)
Distribution
391/491 < 5%
100 ≥ 5%
Count
Percent
Percent
Year (January)
Start with 620 days;
end with 47.

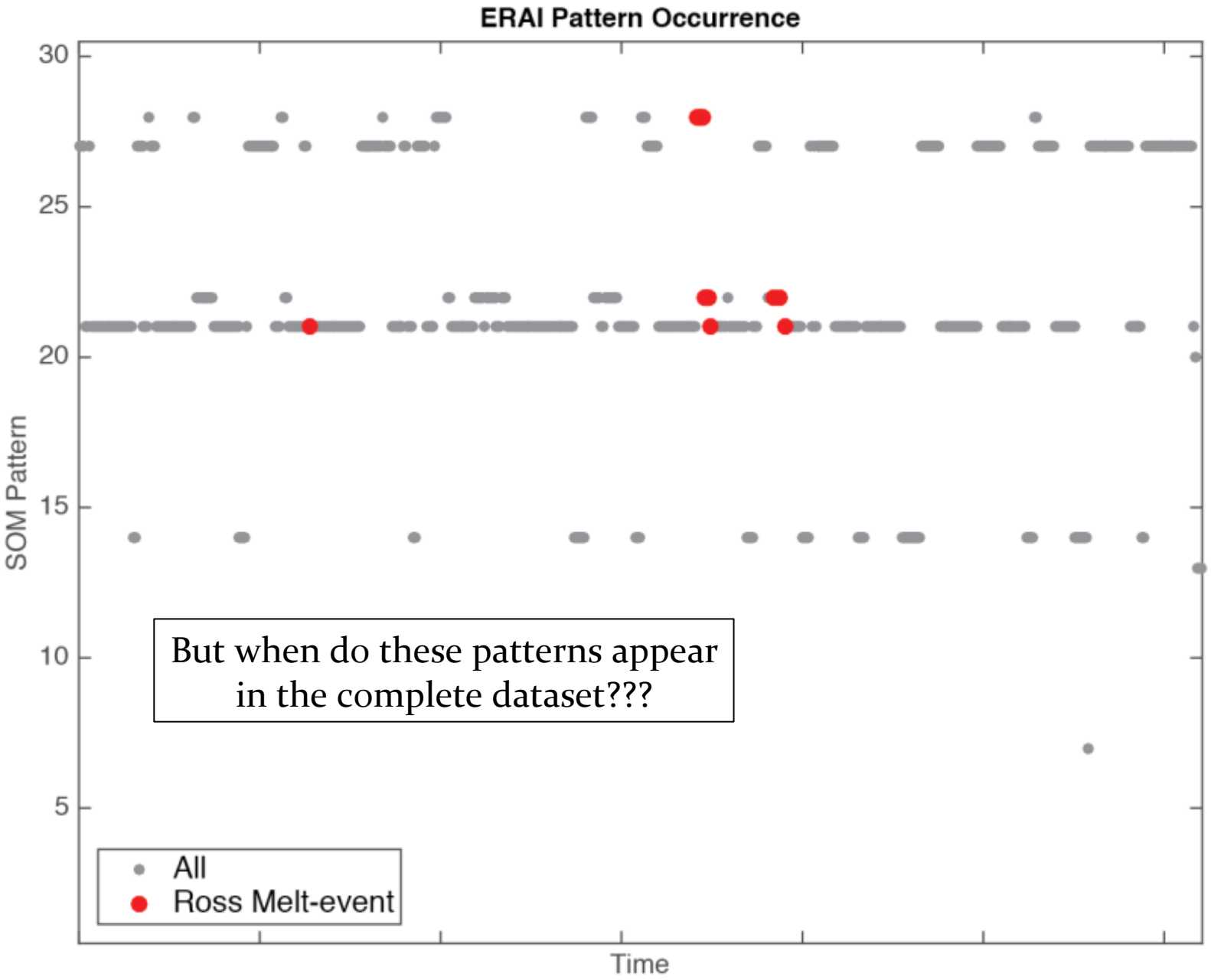

Daily melt - Ross Ice Shelf (131250 km^2)
Distribution
468/488 < 5%
20 ≥ 5%
Count
Percent
Start with 620 days;
end with 12.
Percent
Year (January)
0
10
20
30
40
50
60
70
80
90
100
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000

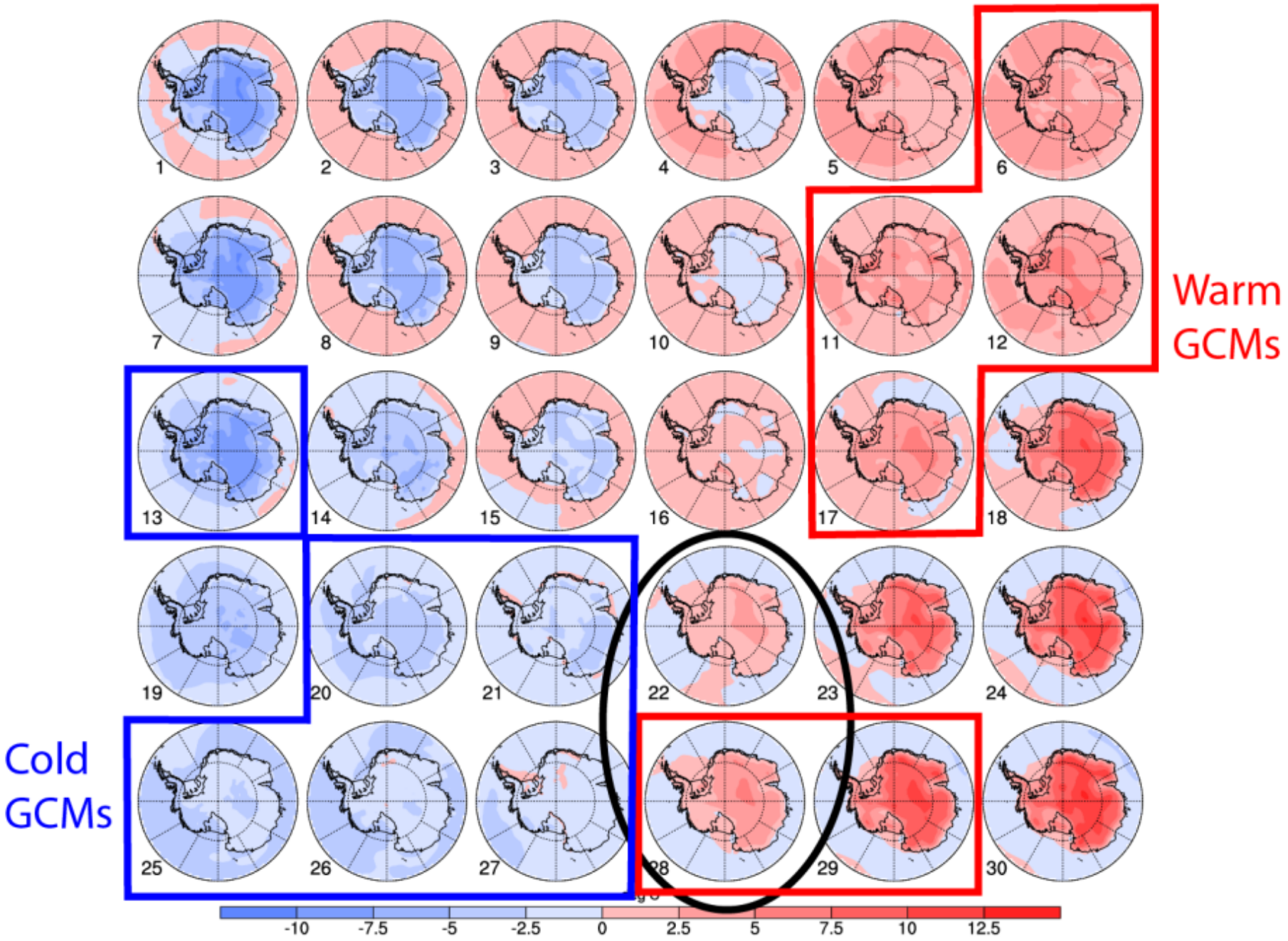
Universal SOM (ERAI with 19 GCMs)



Ross Ice Shelf Events




ERAI Pattern Occurrence
30
25
20
15
10
5
SOM Pattern
Time
All
Ross Melt-event
But when do these patterns appear in the complete dataset???


Warm
GCMs
Cold
GCMs
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5

Talk Overview

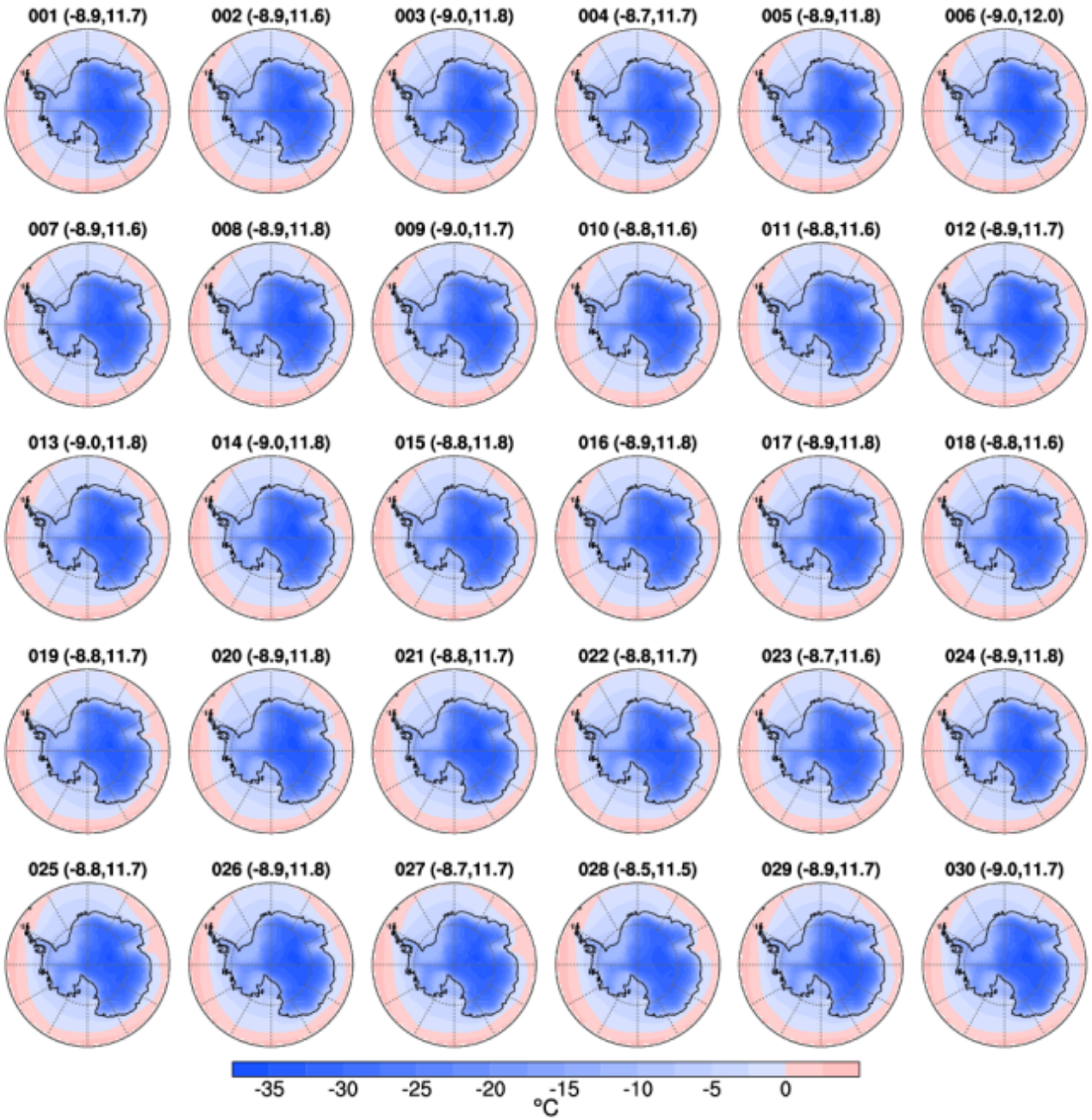
- Intermodel Uncertainty: CMIP5
- Melt Events & Meteorology
- Intramodel Uncertainty: CESM Large Ensemble

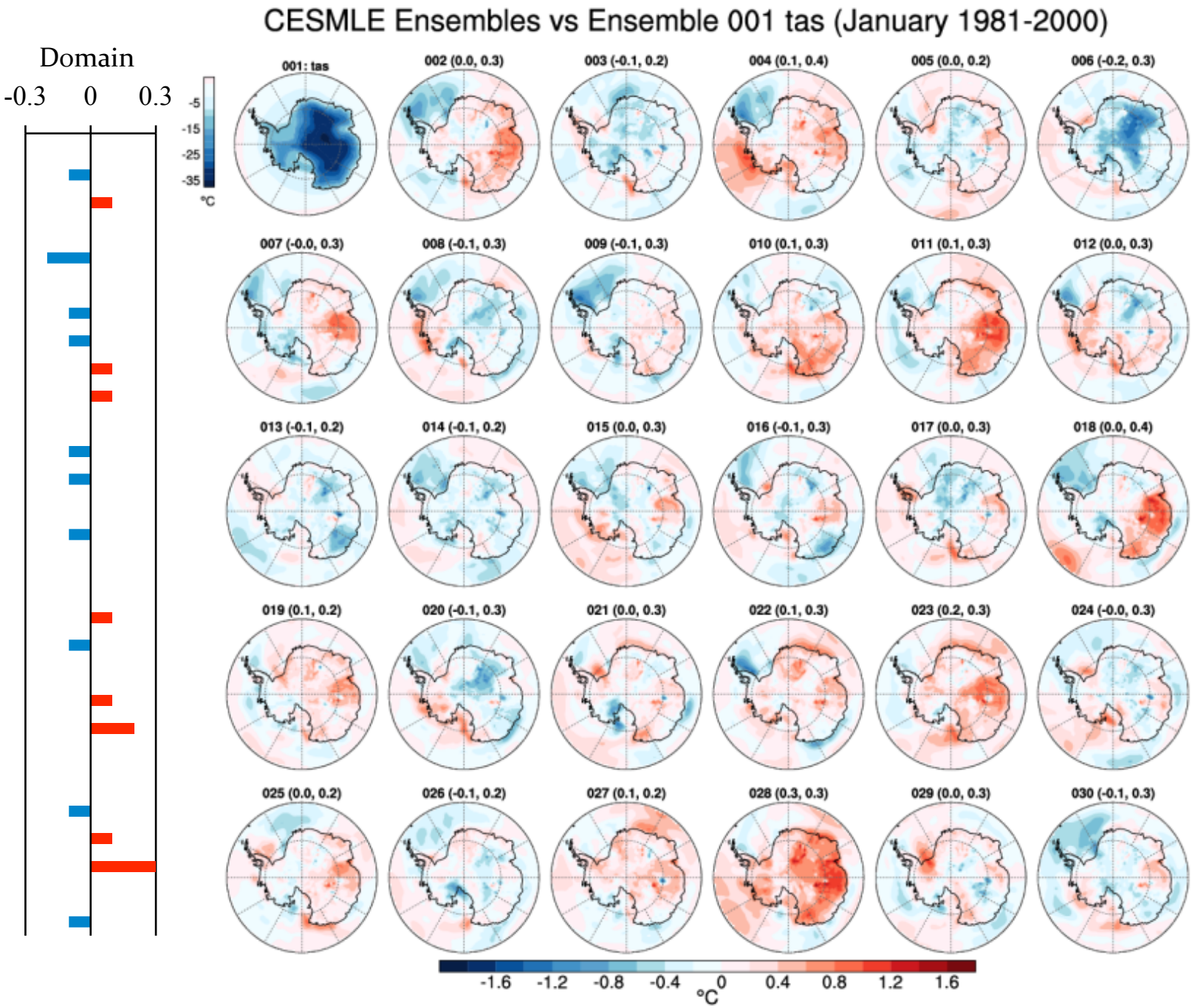
CESM1(CAM5) Large Ensemble

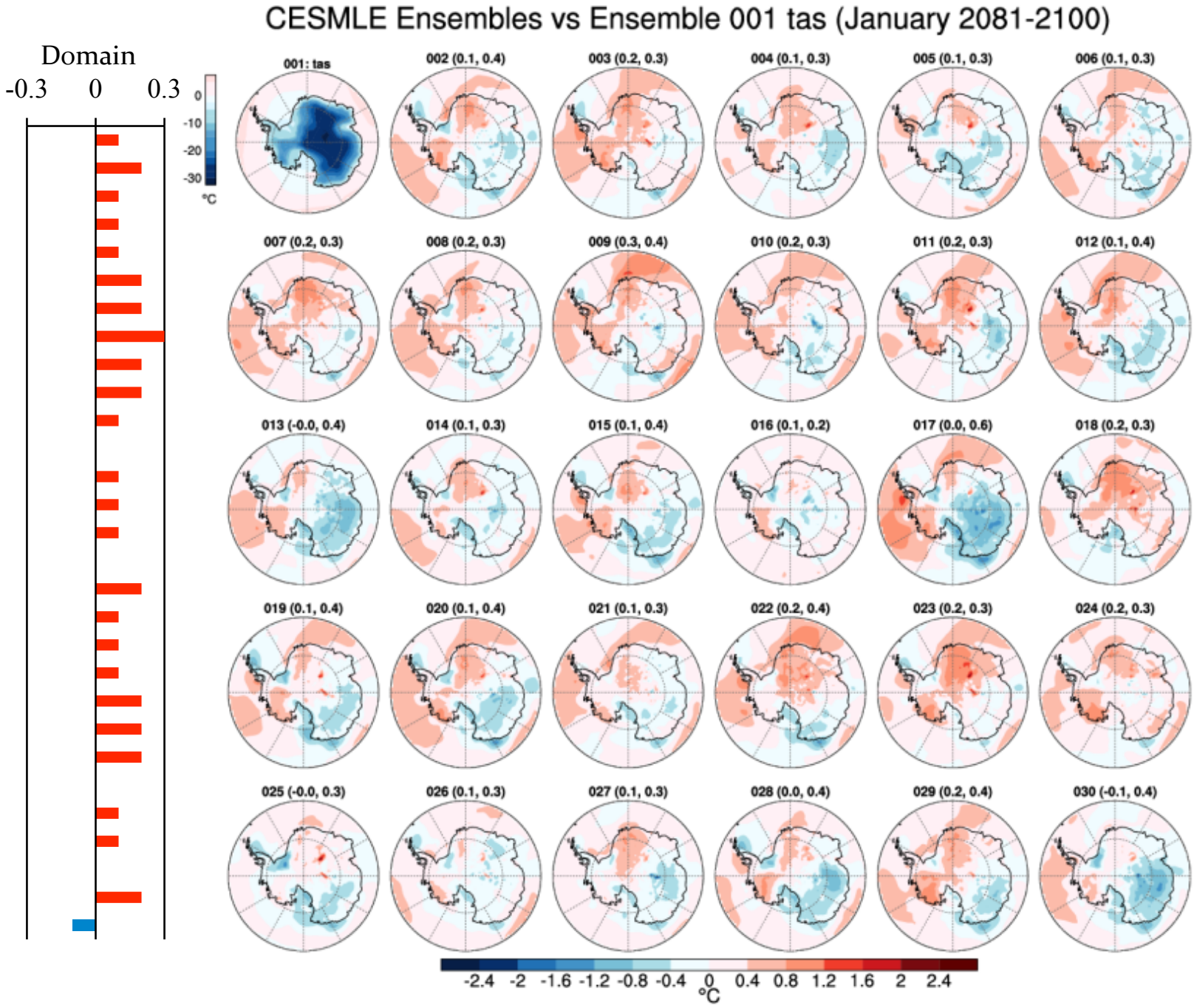
- Same GCM (CESM 1.0-CAM5-BGC), multiple runs
- 30-plus ensemble members, 1850-2100
- Ensemble spread is generated using round-off differences in the initial atmospheric state
- Looks at internal model uncertainty

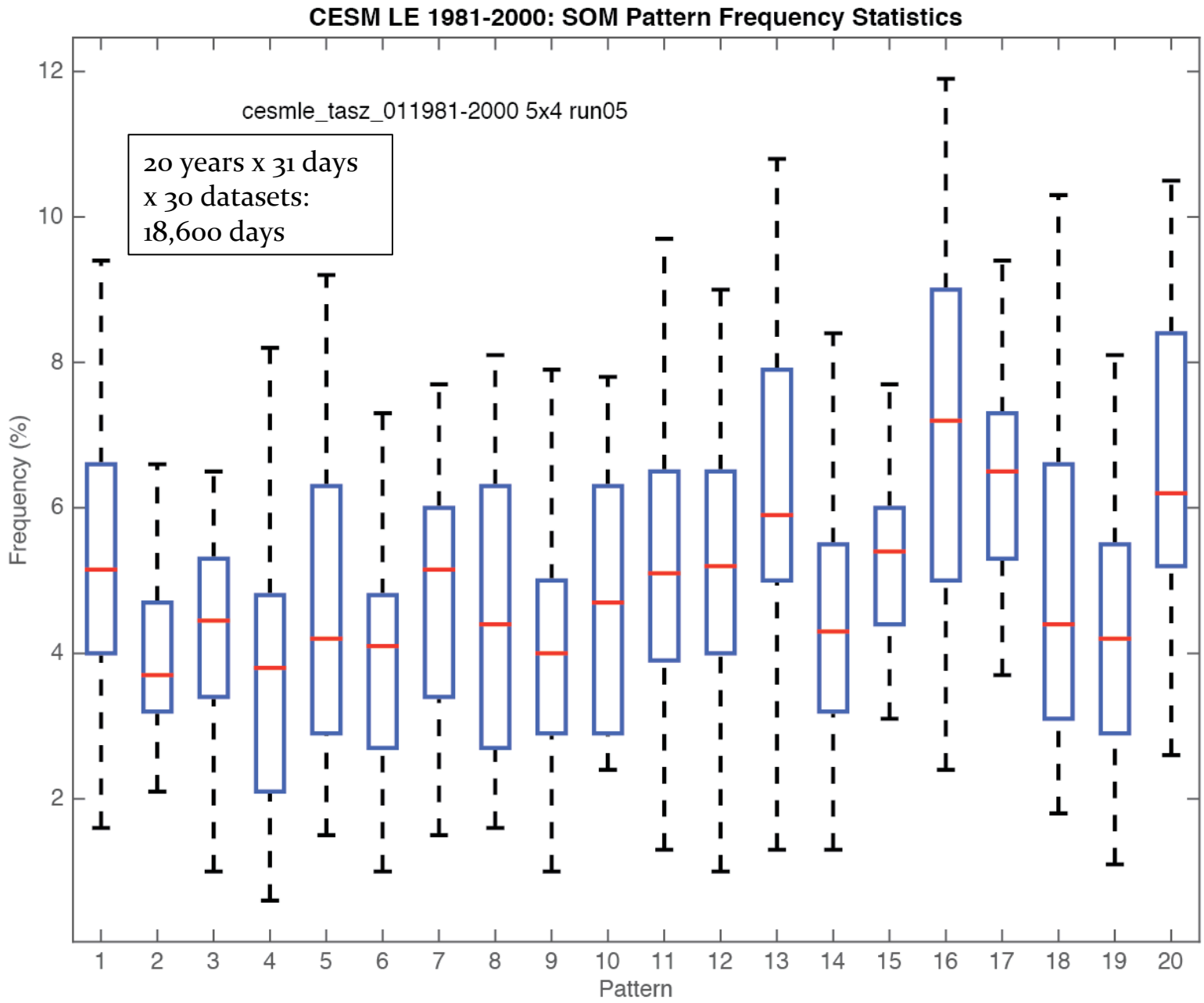
Acknowledgements:

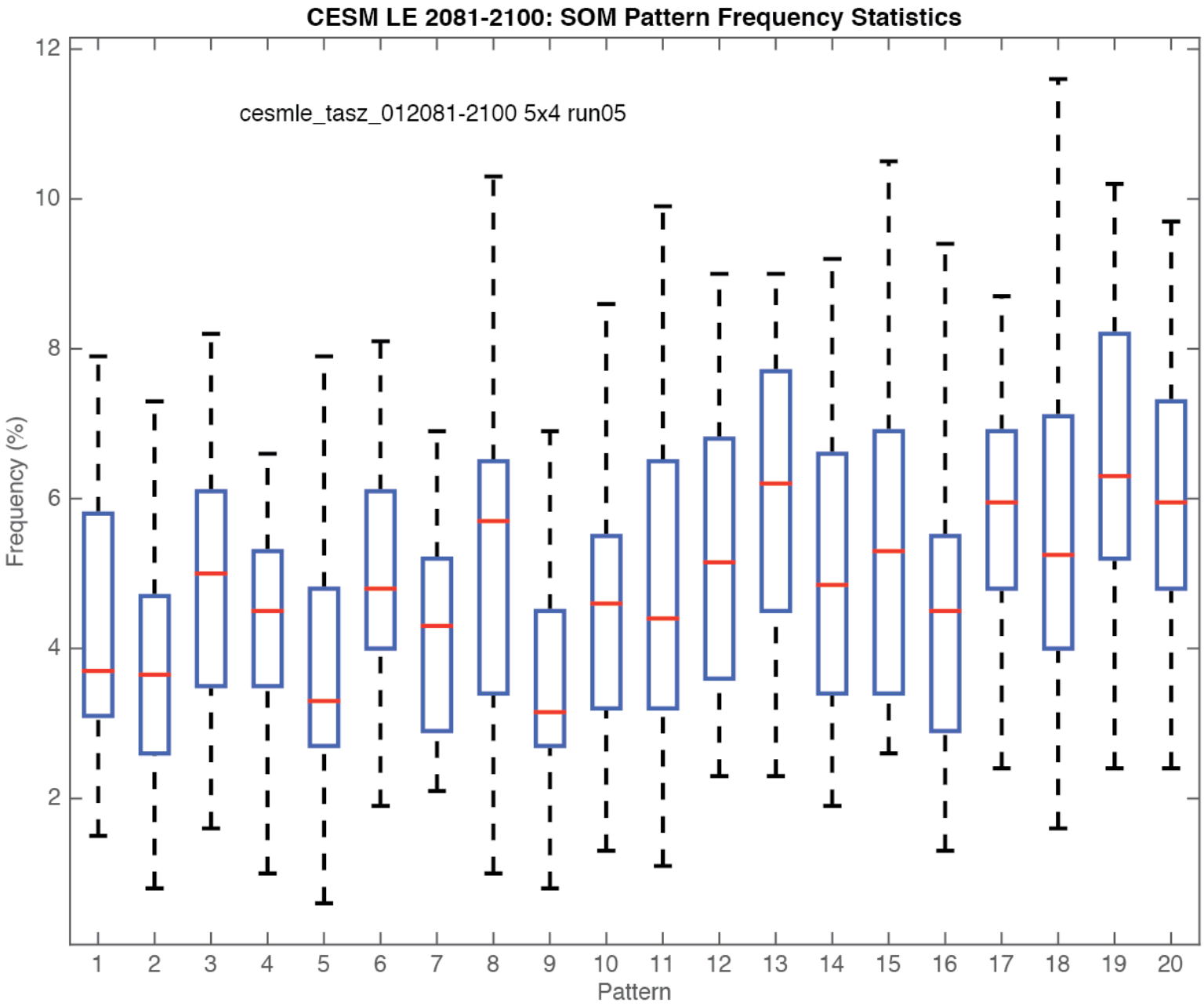
- CESM1(CAM5) Large Ensemble Community Project and supercomputing resources provided by NSF/CISL/Yellowstone
- Kay, J. E., et al, The Community Earth System Model (CESM) Large Ensemble Project: A Community Resource for Studying Climate Change in the Presence of Internal Climate Variability, Bulletin of the American Meteorological Society, doi: 10.1175/BAMS-D-13-00255.1, 2015, in press.


CESM LE January 1981-2000 Average tas
001 (-8.9,11.7)
002 (-8.9,11.6)
003 (-9.0,11.8)
004 (-8.7,11.7)
005 (-8.9,11.8)
006 (-9.0,12.0)
007 (-8.9,11.6)
008 (-8.9,11.8)
009 (-9.0,11.7)
010 (-8.8,11.6)
011 (-8.8,11.6)
012 (-8.9,11.7)
013 (-9.0,11.8)
014 (-9.0,11.8)
015 (-8.8,11.8)
016 (-8.9,11.8)
017 (-8.9,11.8)
018 (-8.8,11.6)
019 (-8.8,11.7)
020 (-8.9,11.8)
021 (-8.8,11.7)
022 (-8.8,11.7)
023 (-8.7,11.6)
024 (-8.9,11.8)
025 (-8.8,11.7)
026 (-8.9,11.8)
027 (-8.7,11.7)
028 (-8.5,11.5)
029 (-8.9,11.7)
030 (-9.0,11.7)
-35 -30 -25 -20 -15 -10 -5 0
°C


CESMLE Ensembles vs Ensemble 001 tas (January 1981-2000)
Domain
-0.3
0
0.3
-5
-15
-25
-35
°C
001: tas
002 (0.0, 0.3)
003 (-0.1, 0.2)
004 (0.1, 0.4)
005 (0.0, 0.2)
006 (-0.2, 0.3)
007 (-0.0, 0.3)
008 (-0.1, 0.3)
009 (-0.1, 0.3)
010 (0.1, 0.3)
011 (0.1, 0.3)
012 (0.0, 0.3)
013 (-0.1, 0.2)
014 (-0.1, 0.2)
015 (0.0, 0.3)
016 (-0.1, 0.3)
017 (0.0, 0.3)
018 (0.0, 0.4)
019 (0.1, 0.2)
020 (-0.1, 0.3)
021 (0.0, 0.3)
022 (0.1, 0.3)
023 (0.2, 0.3)
024 (-0.0, 0.3)
025 (0.0, 0.2)
026 (-0.1, 0.2)
027 (0.1, 0.2)
028 (0.3, 0.3)
029 (0.0, 0.3)
030 (-0.1, 0.3)
-1.6
-1.2
-0.8
-0.4
0
0.4
0.8
1.2
1.6
°C


CESMLE Ensembles vs Ensemble 001 tas (January 2081-2100)
Domain
-0.3
0
0.3
0
-10
-20
-30
°C
001: tas
002 (0.1, 0.4)
003 (0.2, 0.3)
004 (0.1, 0.3)
005 (0.1, 0.3)
006 (0.1, 0.3)
007 (0.2, 0.3)
008 (0.2, 0.3)
009 (0.3, 0.4)
010 (0.2, 0.3)
011 (0.2, 0.3)
012 (0.1, 0.4)
013 (-0.0, 0.4)
014 (0.1, 0.3)
015 (0.1, 0.4)
016 (0.1, 0.2)
017 (0.0, 0.6)
018 (0.2, 0.3)
019 (0.1, 0.4)
020 (0.1, 0.4)
021 (0.1, 0.3)
022 (0.2, 0.4)
023 (0.2, 0.3)
024 (0.2, 0.3)
025 (-0.0, 0.3)
026 (0.1, 0.3)
027 (0.1, 0.3)
028 (0.0, 0.4)
029 (0.2, 0.4)
030 (-0.1, 0.4)
-2.4 -2 -1.6 -1.2 -0.8 -0.4 0 0.4 0.8 1.2 1.6 2 2.4
°C


CESM LE 1981-2000: SOM Pattern Frequency Statistics
cesmle_tasz_011981-2000 5x4 run05
20 years x 31 days
x 30 datasets:
18,600 days
Frequency (%)
Pattern
12
10
8
6
4
2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20


CESM LE 2081-2100: SOM Pattern Frequency Statistics
cesmle_tasz_012081-2100 5x4 run05
Frequency (%)
Pattern
12
10
8
6
4
2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Conclusions

- SOMs help evaluate intermodel uncertainty through analyses of daily data, not just 20-year averages
- CESM LE is a valuable resource for estimating intramodel uncertainty, SOMs can help make that manageable
- These analyses can help us understand why models are wrong *and* why they are right (or at least close…)
- SOMs *should be* a useful tool (among many) for decoding melt event complexity but not there quite yet


Walgreens
DRIVE-THRU PHARMACY
5:17
-196°F


United States
Provo
Denver
Grand Junction
Aspen
COLORADO
UTAH
Colorado Springs
Pueblo
Santa Fe
Albuquerque
Amarillo
New Mexico Institute of Mining and Technology
ARIZONA
Tonto National Forest
Phoenix
Mesa
Lubbock
Tucson
Las Cruces
Abilene
Midland
El Paso
Odessa
Google