Investigating and Predicting West Antarctic Surface Melting with Reanalysis- and GCM-driven Polar WRF

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Project Goals

1. Identify relationships between observed surface melt and modeled meteorology
2. Examine CMIP5 GCM skill against modern
3. Say something sensible about future surface melt using (1) and CMIP5 projections

The Model

- Polar WRF 3.3.1*
- "Best practices" parameters from polar community
- 45/15 km outer/nested continental grids (analyses use 15-km, 3-hourly data)
- Melt season: main (Dec/Jan), extended (Nov & Feb)

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

Modeling Modes

- Modern Reanalysis-based (ERA-Interim)
  - Diagnose drivers/dynamics of observed melt
  - 3-day "forecast mode"
  - Twenty Dec/Jan: 1988/89 to 2007/08
- CMIP5 GCM-based (CCSM4 etc)
  - Compare to reanalysis-based results & observations
  - Project the future
  - 32-day "climate mode"
  - Ten+ Januarys: 1989-99 & 2050-59

Surface melt from satellite

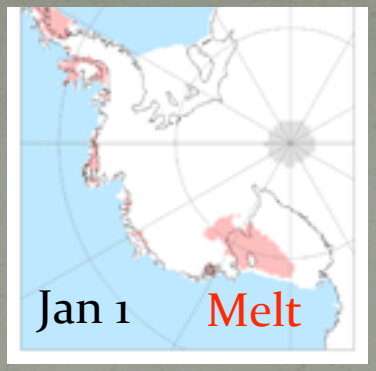
- XPGR algorithm (Abdalati and Steffen, 1995) uses passive microwave data to detect changes in emissivity associated with melt
- Detects melt *occurrence*, not magnitude
- Processing at Penn State for Dec-Jan, 1987-2008
- 25 km pixels, daily

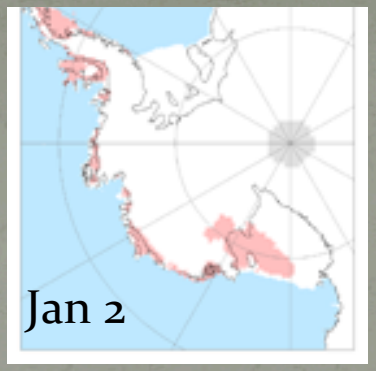
$$\mathrm{XPGR} = \frac{T_b(19\mathrm{H}) - T_b(37\mathrm{V})}{T_b(19\mathrm{H}) + T_b(37\mathrm{V})}.$$

1991/1992 Melt Event

Largest area and longest duration: 12/25/91 to 1/14/92

Peak area



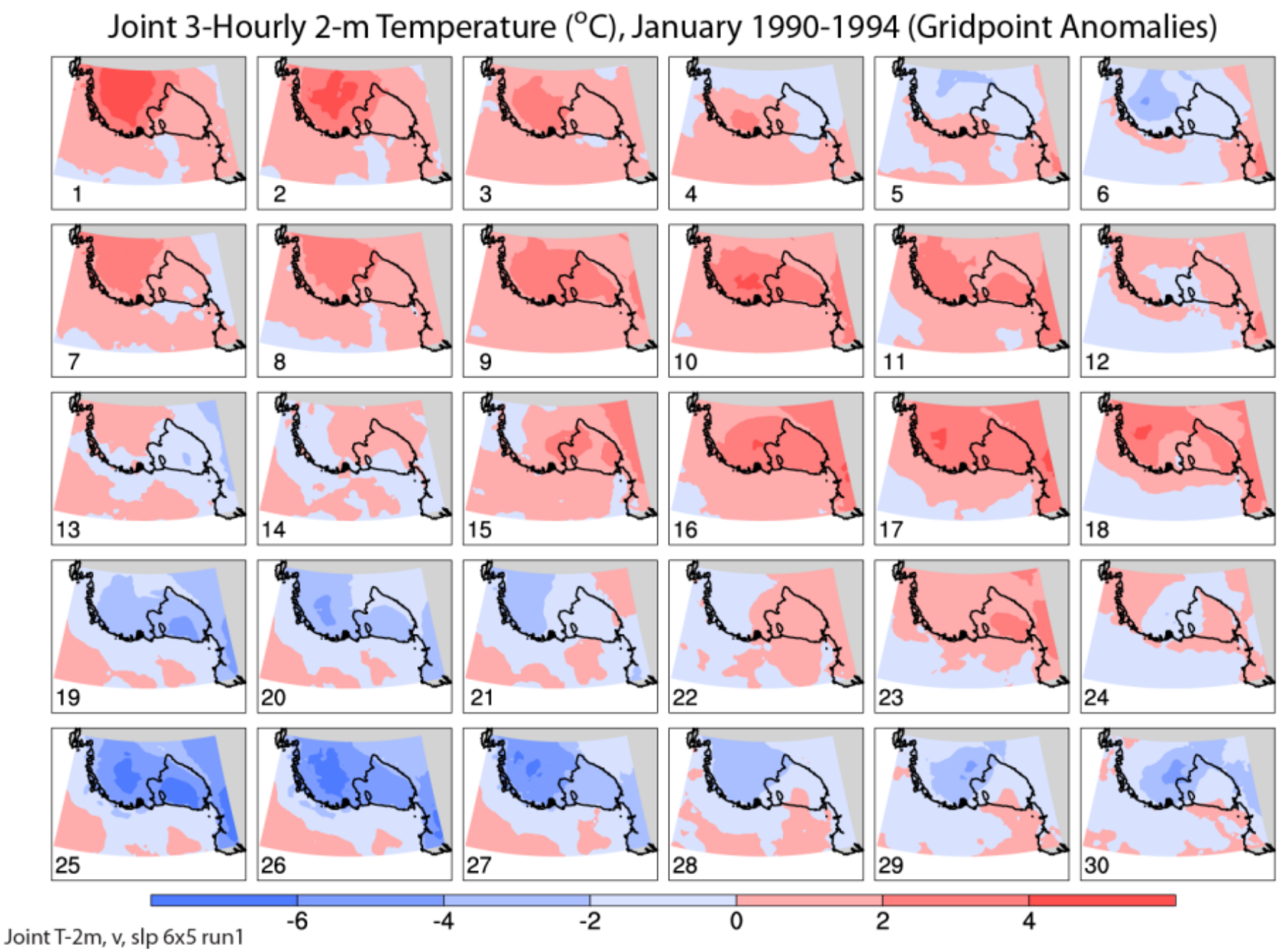


Decline

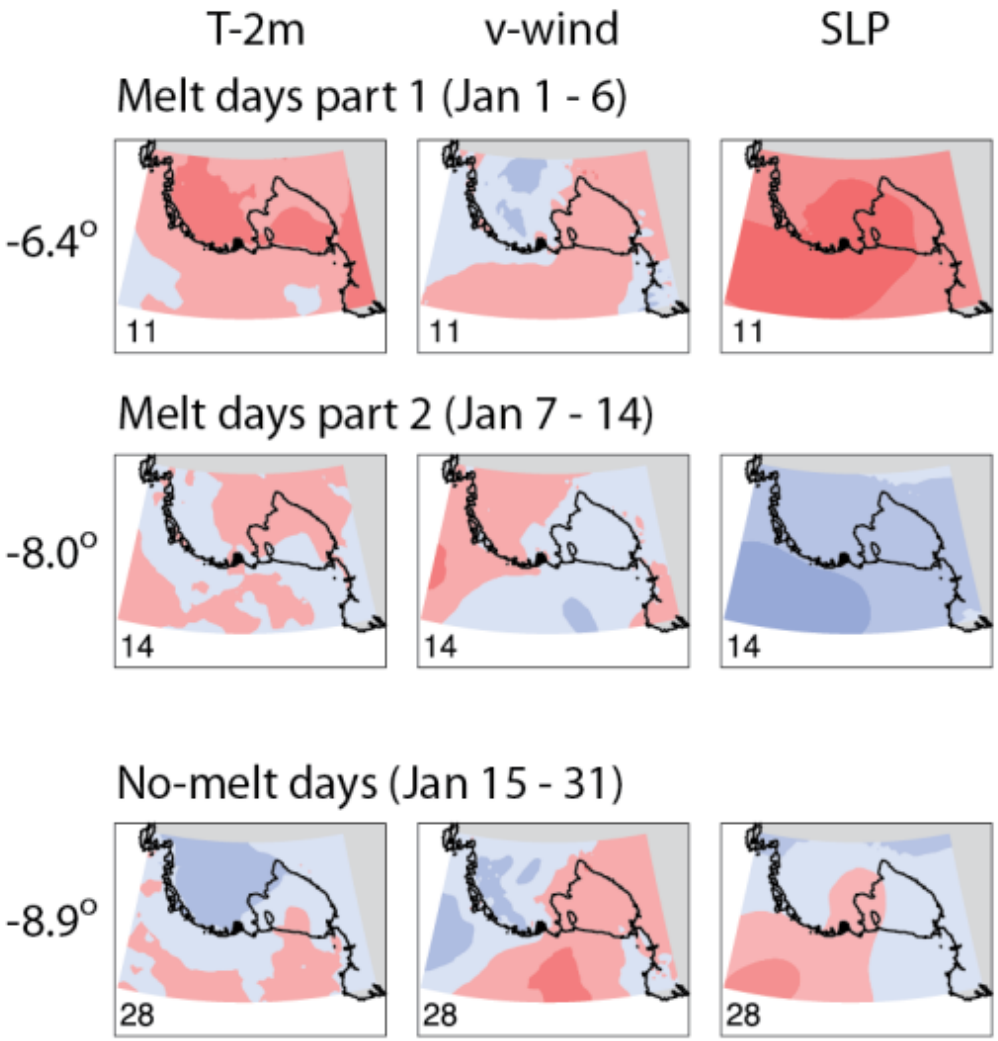
The end

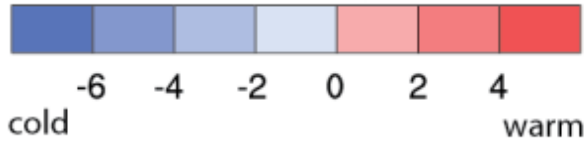
1991/92 Melt Event Case Study

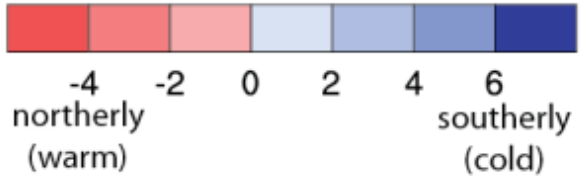
- Five year reference period: January 1990-1994
- Which variables
  - Temperature (T-2m)
  - Meridional wind (v-wind)
  - Sea-level pressure (slp)
- Self-organizing maps (SOMs)
  - Summarize complex datasets as generalized patterns
  - Pattern frequency: Melt vs no-melt period

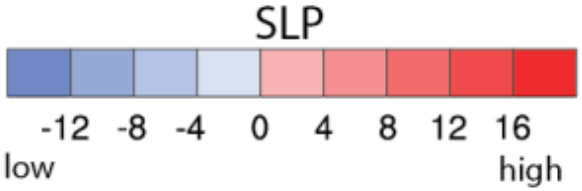

Joint 3-Hourly 2-m Temperature (°C), January 1990-1994 (Gridpoint Anomalies)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
-6
-4
-2
0
2
4
Joint T-2m, v, slp 6x5 run1

January 1992: melt versus no-melt







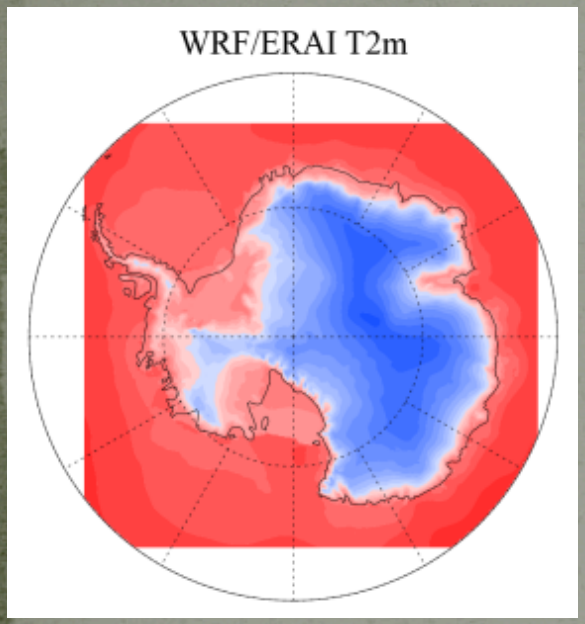


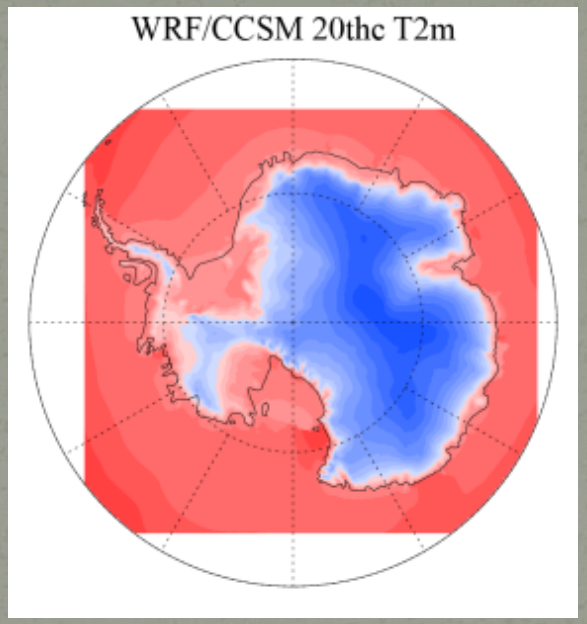
Joint T-2m, v, slp 6x5 run1

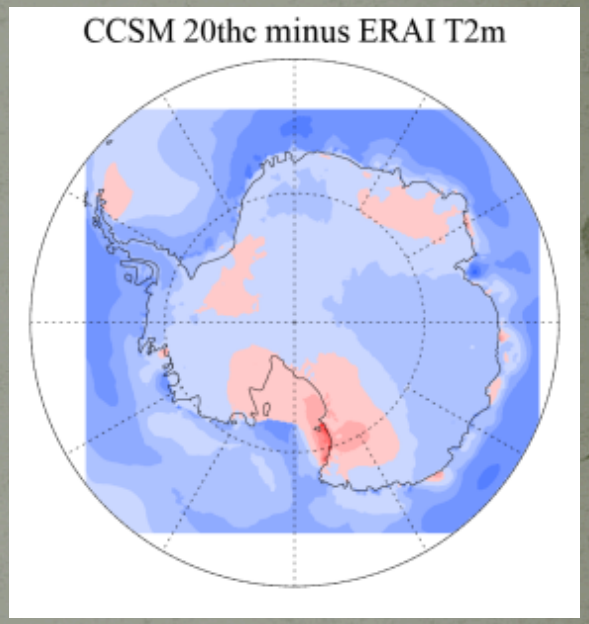
Evaluating Modern GCMs

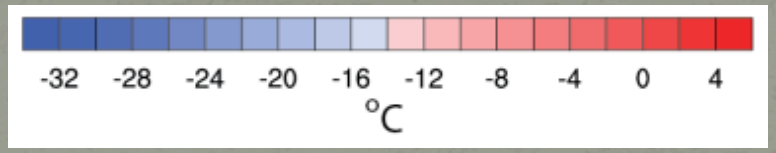
- Need to test GCMs against modern before using them for future predictions
- Compare to observations (Schneider work)
- Compare to ERAI-driven WRF

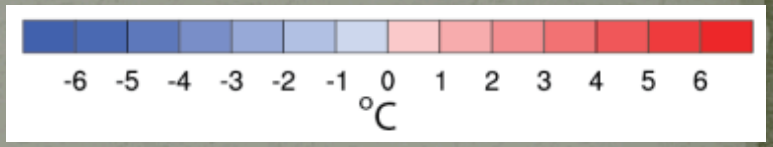
Decadal* Average T-2m





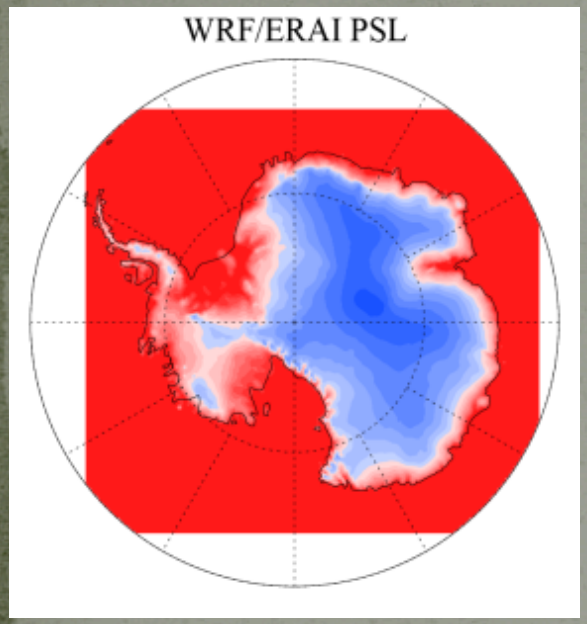


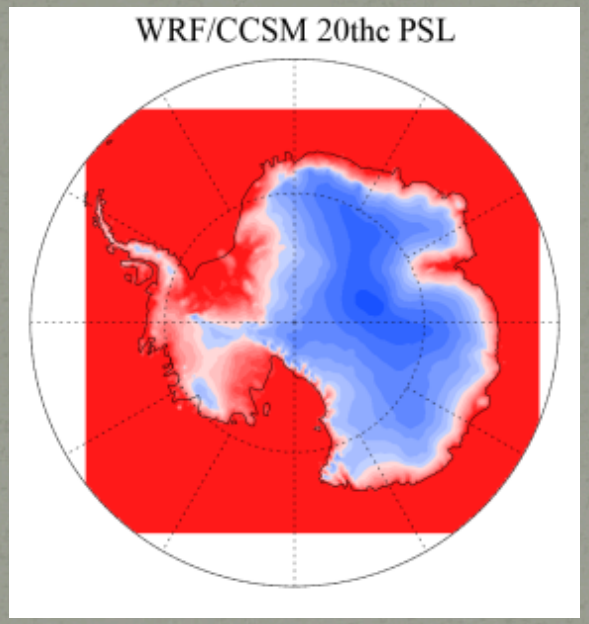


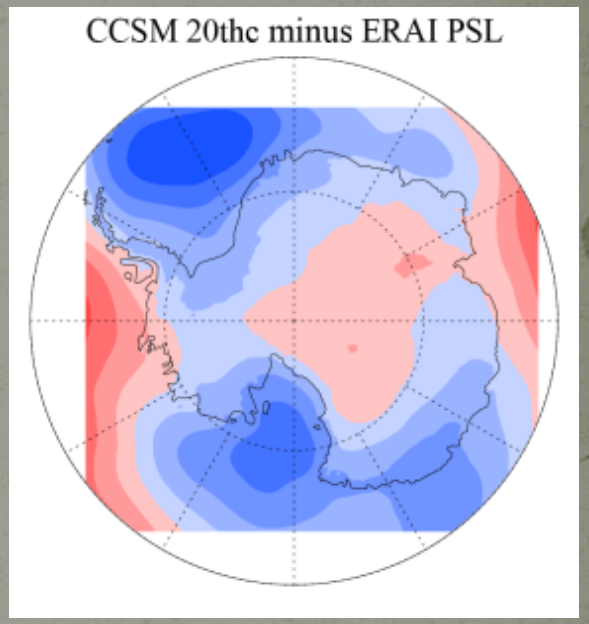


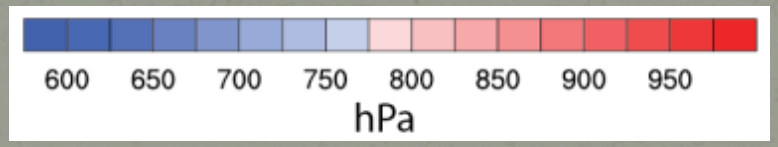
* January 1990-1999

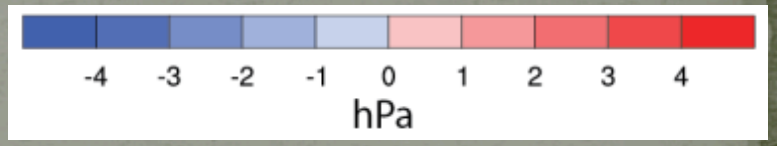
Decadal Average Surface Pressure



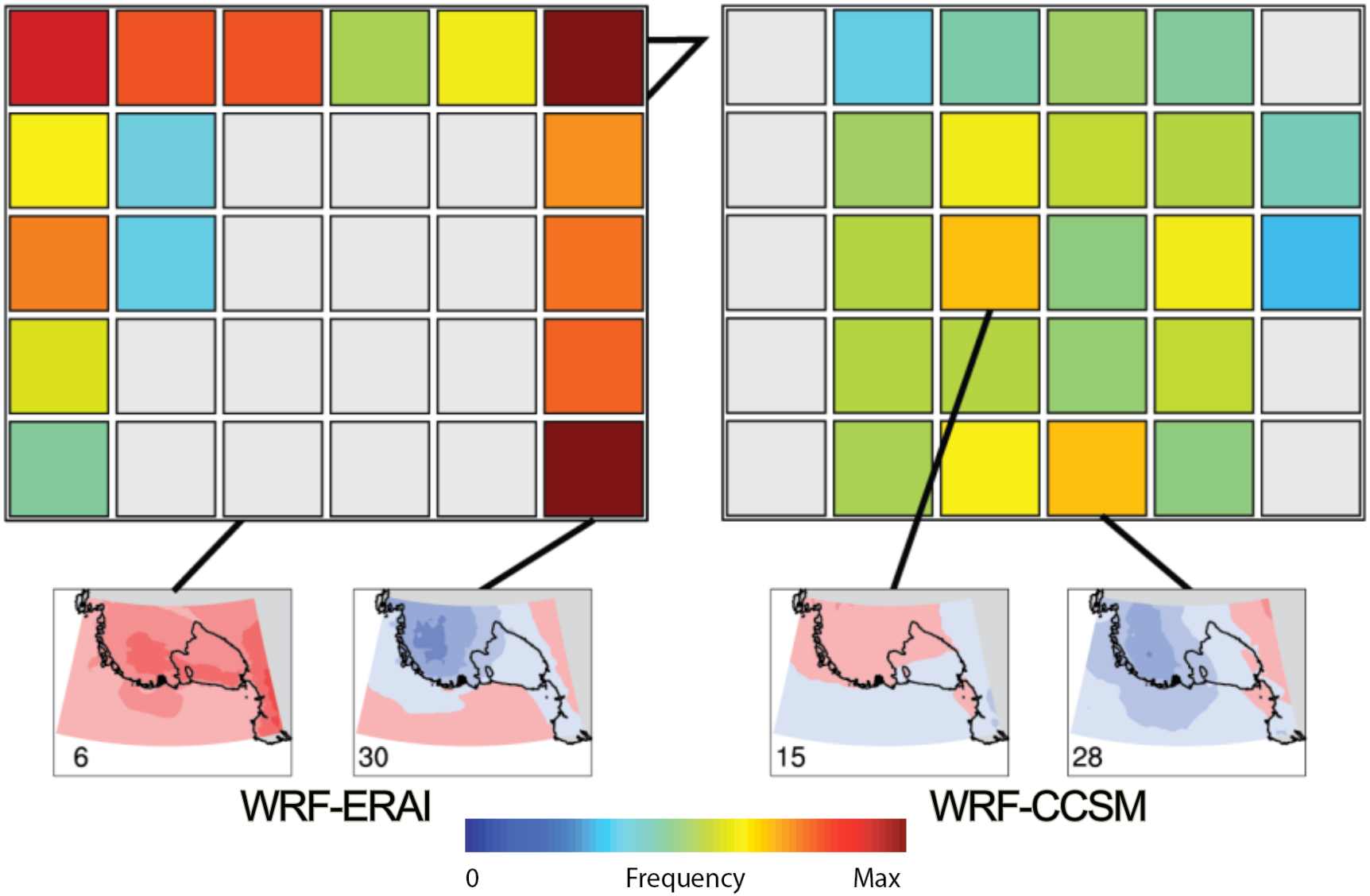




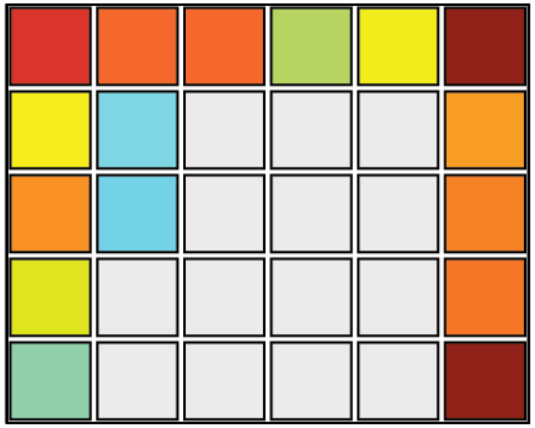




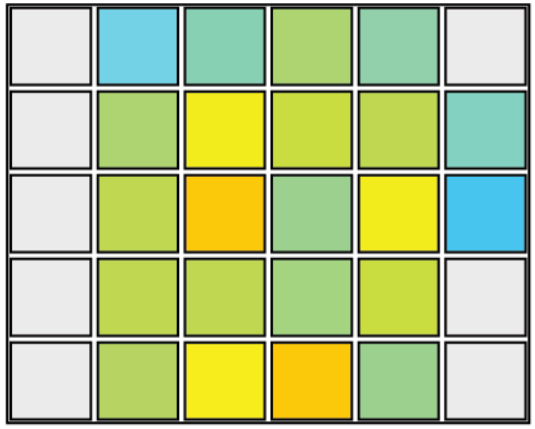
Pattern frequency: ERAI vs CCSM



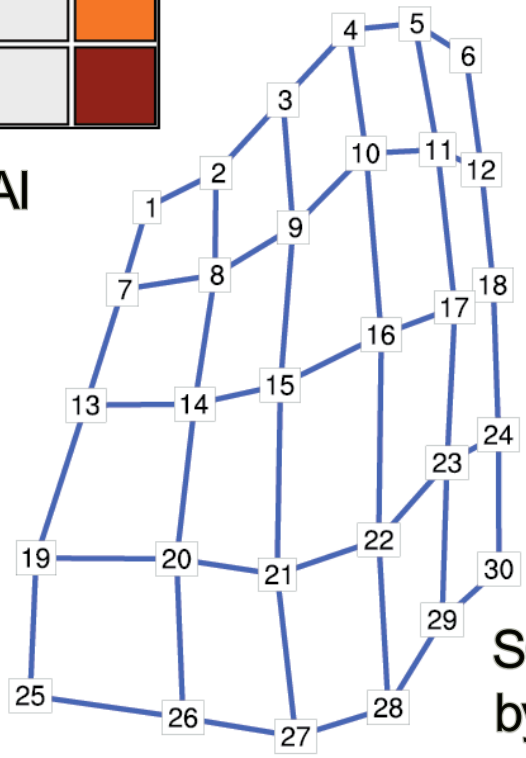
Patterns in “SOM Space”



WRF-ERAI



WRF-CCSM

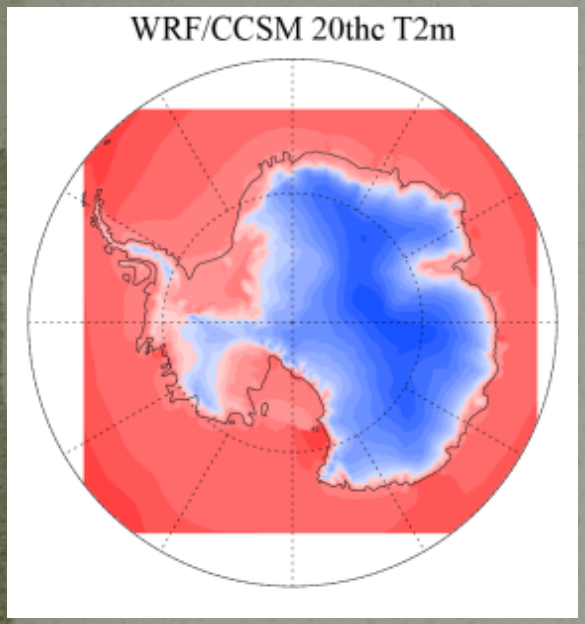


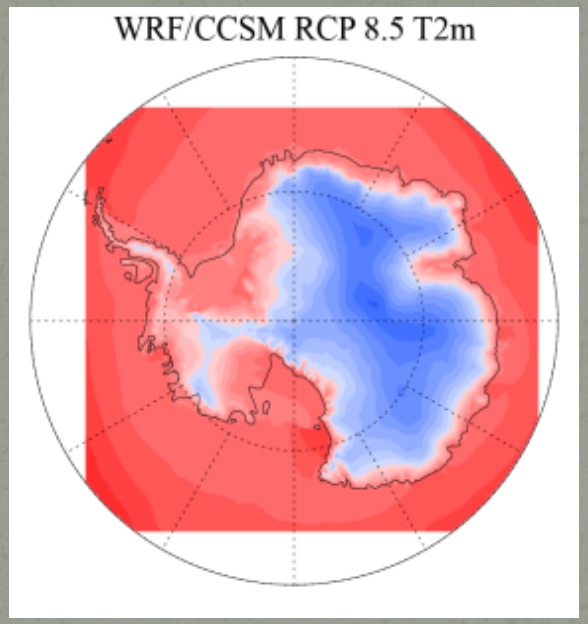
SOM nodes plotted
by relative similarity

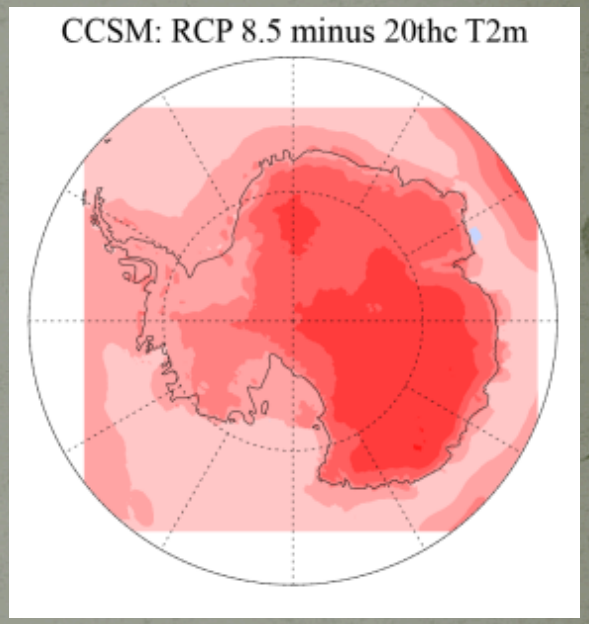
Looking into the future with CCSM4

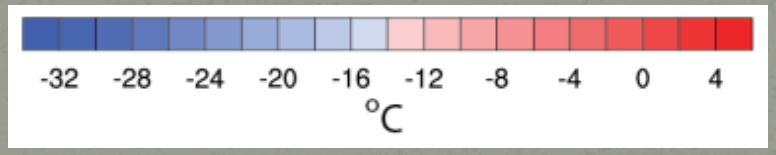
- Predicting future surface melting is a major goal
- RCP: Representative Concentration Pathway
  - GHG concentration trajectories that replaced emissions scenarios used up to IPCC AR4
  - Named by expected radiative forcing value in 2100
  - RCP 8.5 => adds 8.5 W/m^2
- Looking at a decade (2050-59) under RCP 8.5

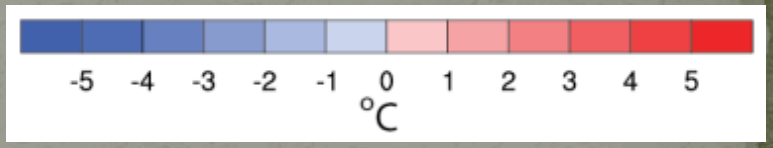
Future* vs Recent: T-2m





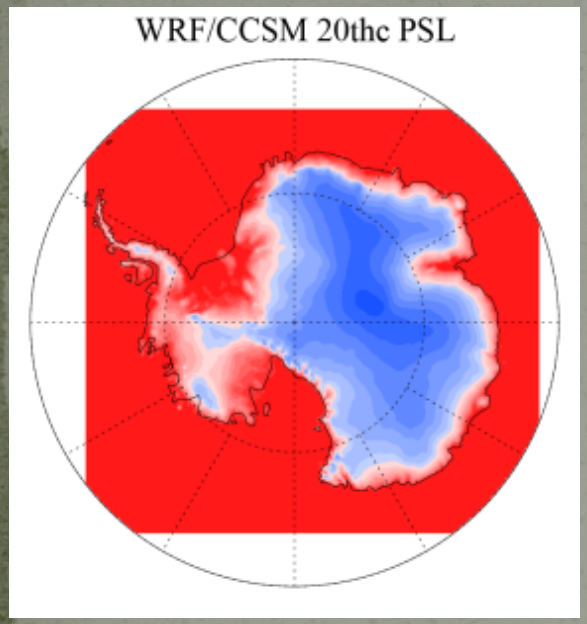


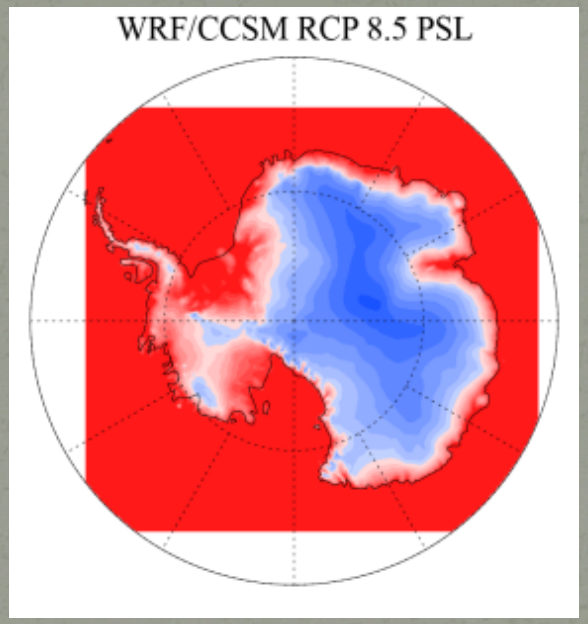


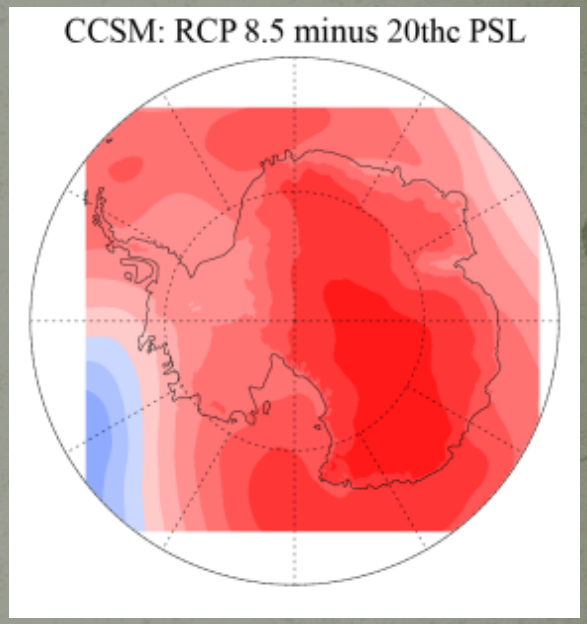


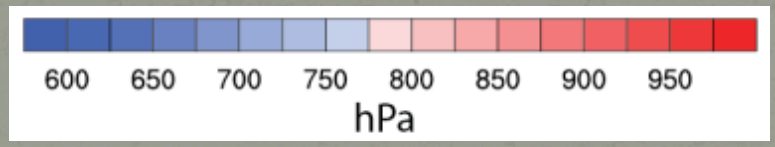
* January 2050-2059

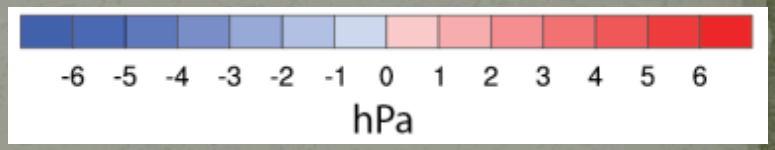
Future vs Recent: Surface Pressure



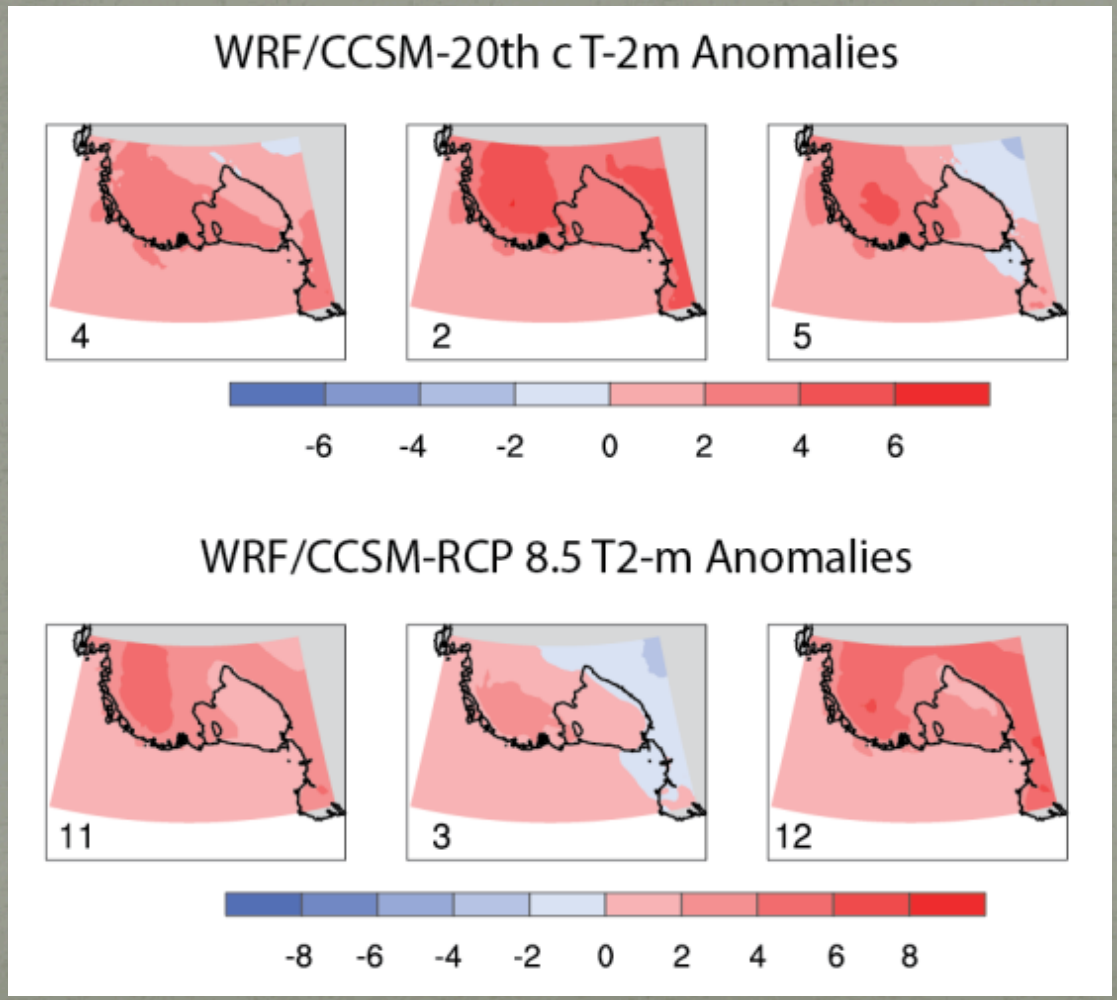








Most frequent patterns at oo UTC



Coming attractions…

- Working with more melt events to characterize potential synoptic drivers
- Add surface energy-balance components
- Additional skill evaluations of modern GCMs (incorporate Schneider's work)
- Additional GCMs, modern and future

Ross/Siple Coast Melt Events 1988-2008