Cloudy Windows: What GCM Ensembles, Reanalyses and Observations Tell Us About Uncertainty in Greenland's Future Climate and Surface Melting

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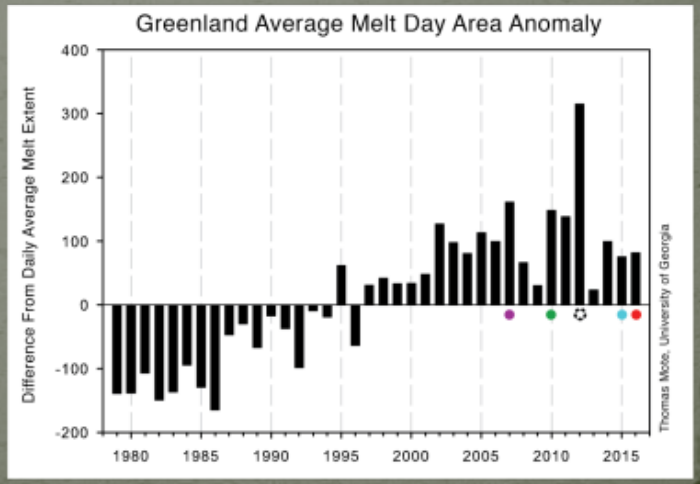
Motivation

- Greenland ice sheet surface is melting, climate is warming, where is this going long-term?
- Regional models provide better resolution, etc., need GCMs to look at the future
- Predictions need to have uncertainty estimates
- Model ensembles help with this



http://nsidc.org/greenland-today/files/2016/10/GrnToday_18Oct2016_Fig4_adj.png

Outline: Exploring Uncertainty

- Skill: GCM vs AWS observations
- Basic ensemble variability (mean, std dev)
- Generalized ensemble variability (SOMs)
- Regional modeling (Polar WRF)

CESM Large Ensemble

- Uses coupled climate model CESM1(CAM5)*
- Examining internal (unforced) climate variability via small perturbations of the initial atmospheric state
- Originally 30 ensemble members, 1920-2100

* Fine print:

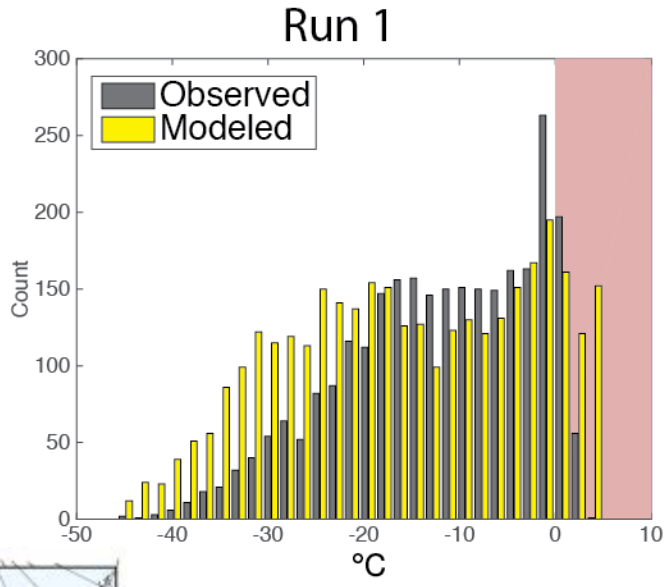
- Coupled model components: CAM5, CICE4, POP2, CLM4
- CESM1(CAM5) Large Ensemble Community Project and supercomputing resources provided by NSF/CISL/Yellowstone
- Kay, J. E., et al, The Community Earth System Model (CESM) Large Ensemble Project: A Community Resource for Studying Climate Change in the Presence of Internal Climate Variability, Bulletin of the American Meteorological Society, doi: 10.1175/BAMS-D-13-00255.1, 2014.

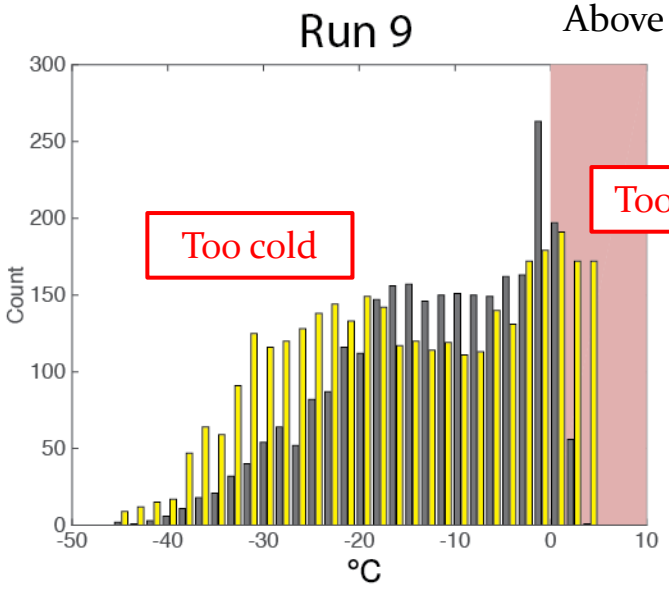
Skill: GCM versus AWS

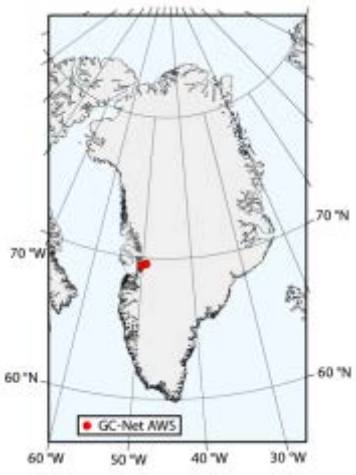
CESM LE versus GC-Net Swiss Camp AWS (1996-2005)

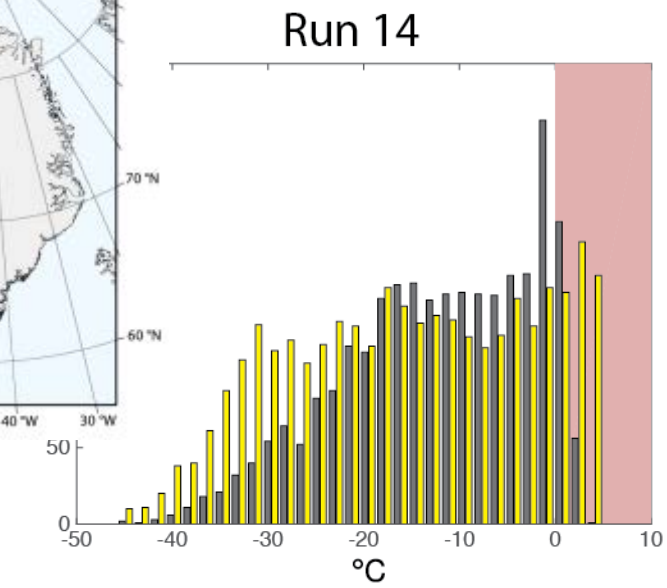
Daily Average Near-surface Temperature

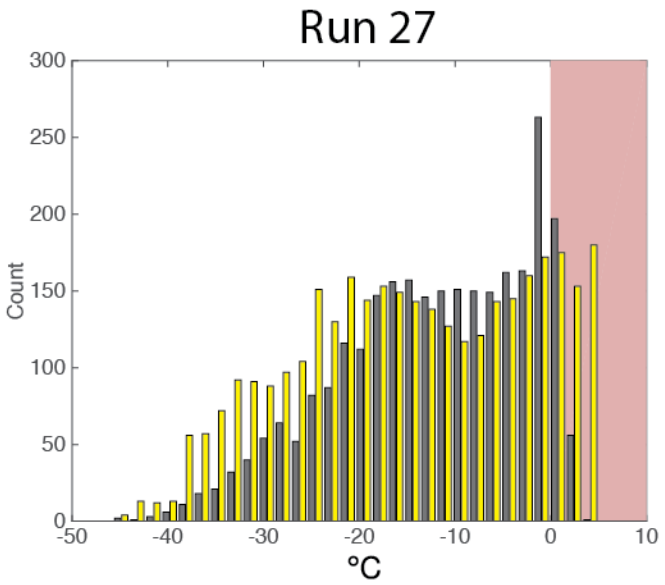
Above freezing







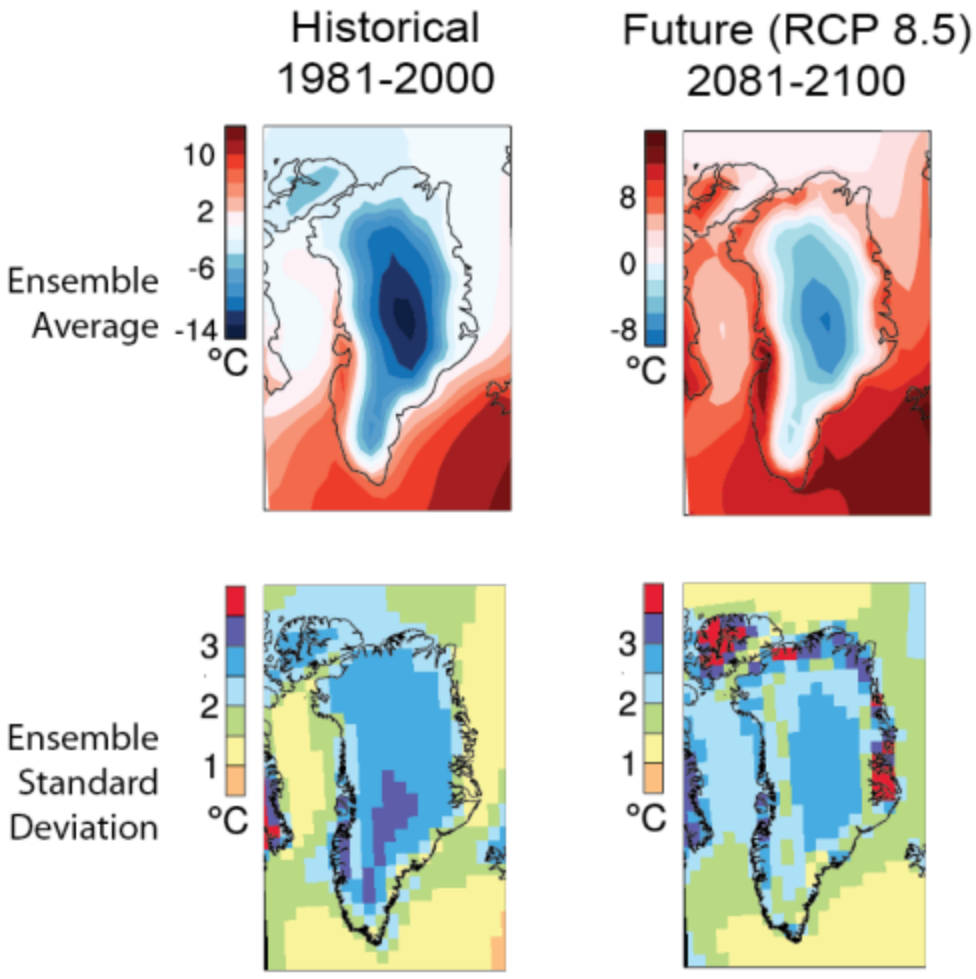




Basic Variability

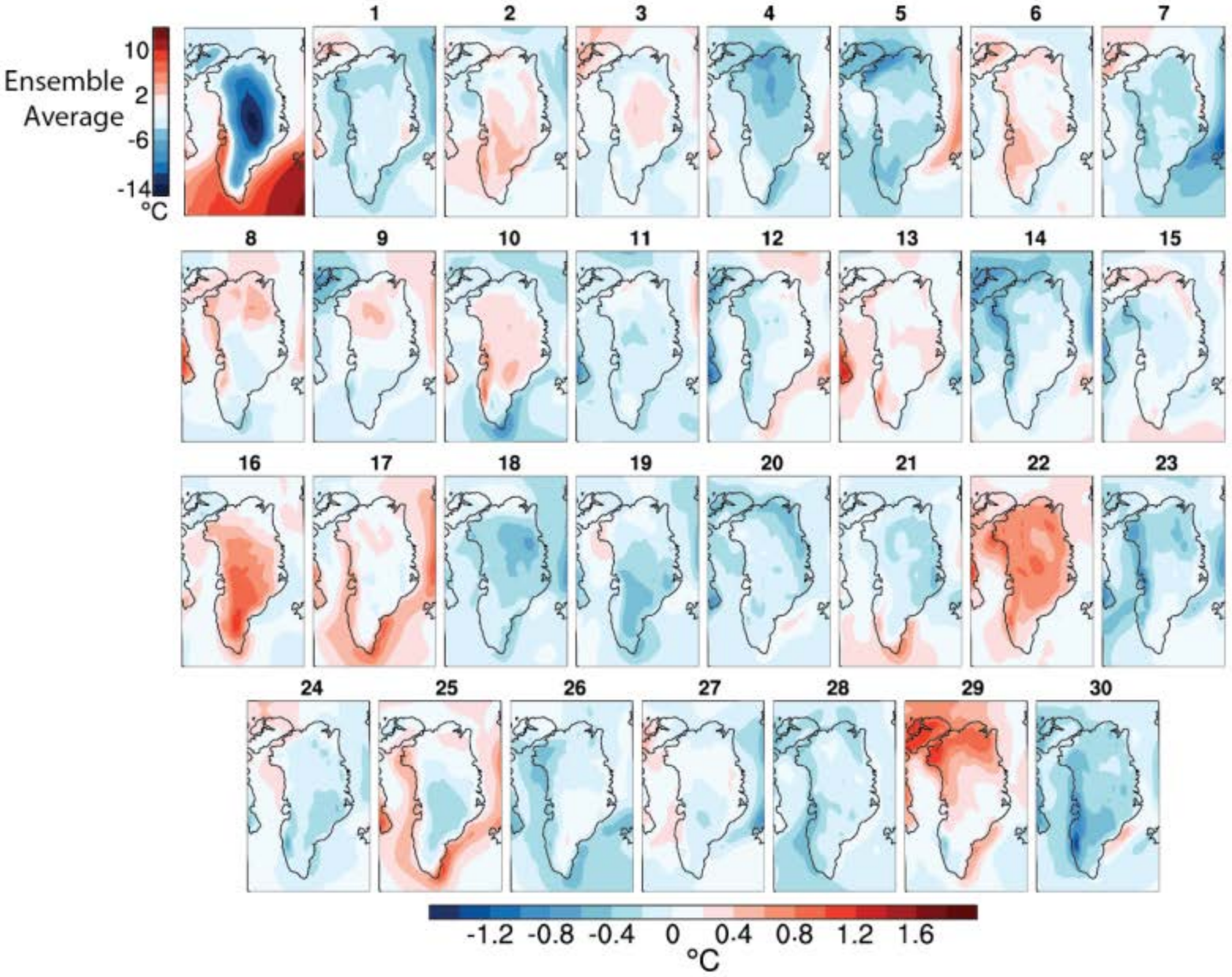
CESM Large Ensemble, July

Daily Average Near-surface Temperature (Gridpoint difference)



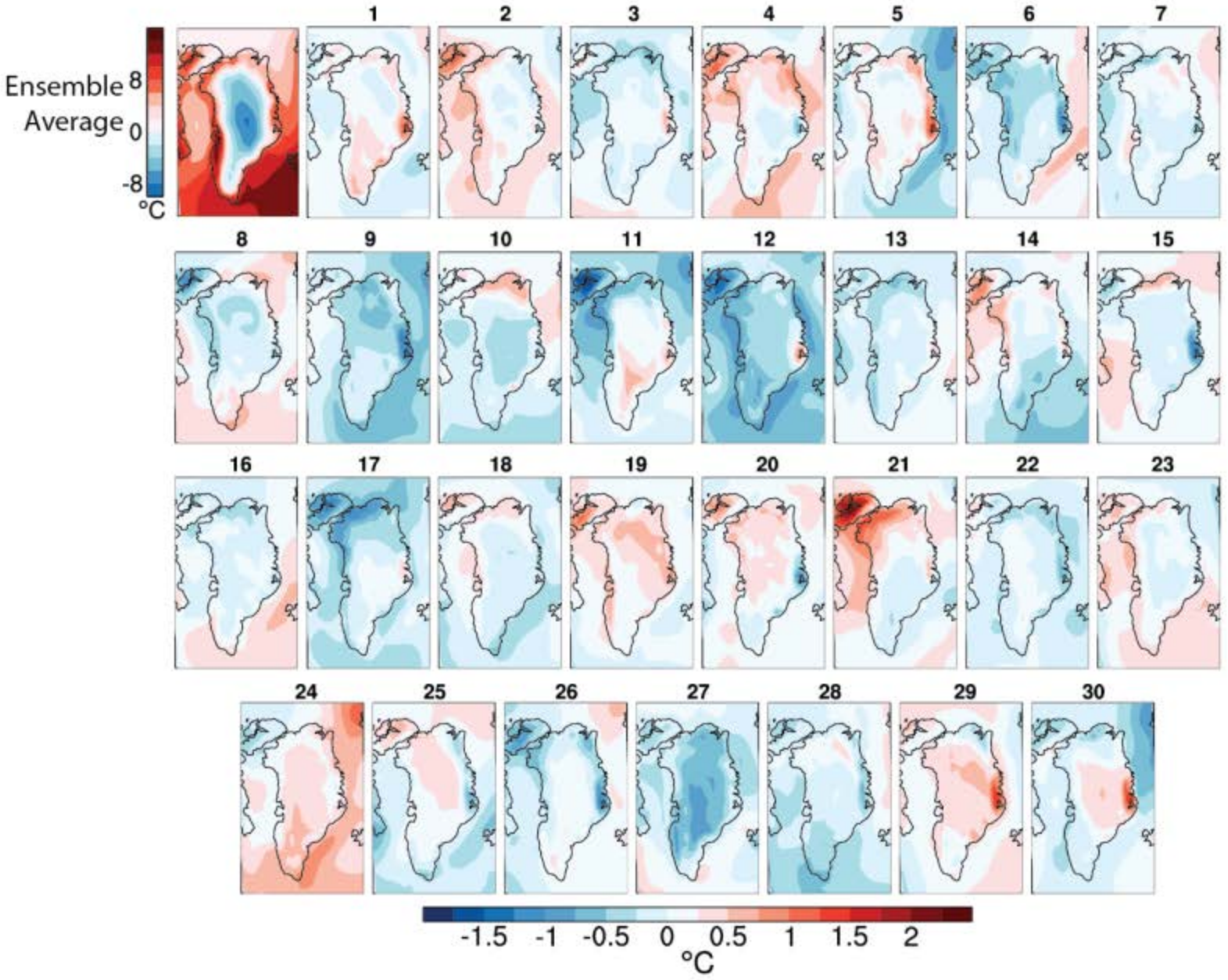
CESM LE Historical: July 1981-2000

Daily Average Near-surface Temperature (Gridpoint difference)



CESM LE RCP8.5: July 2081-2100

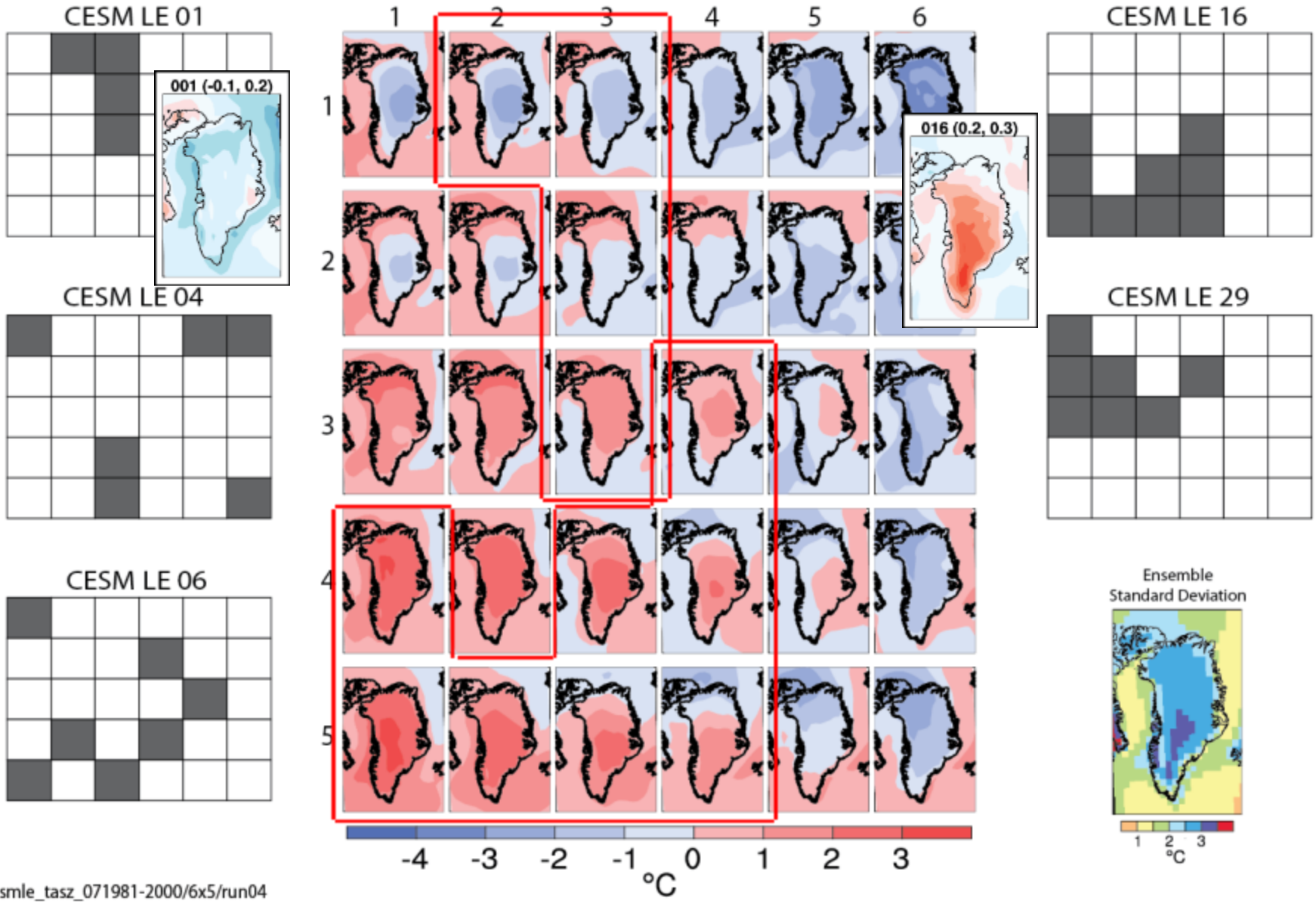
Daily Average Near-surface Temperature (Gridpoint difference)



Generalized Variability

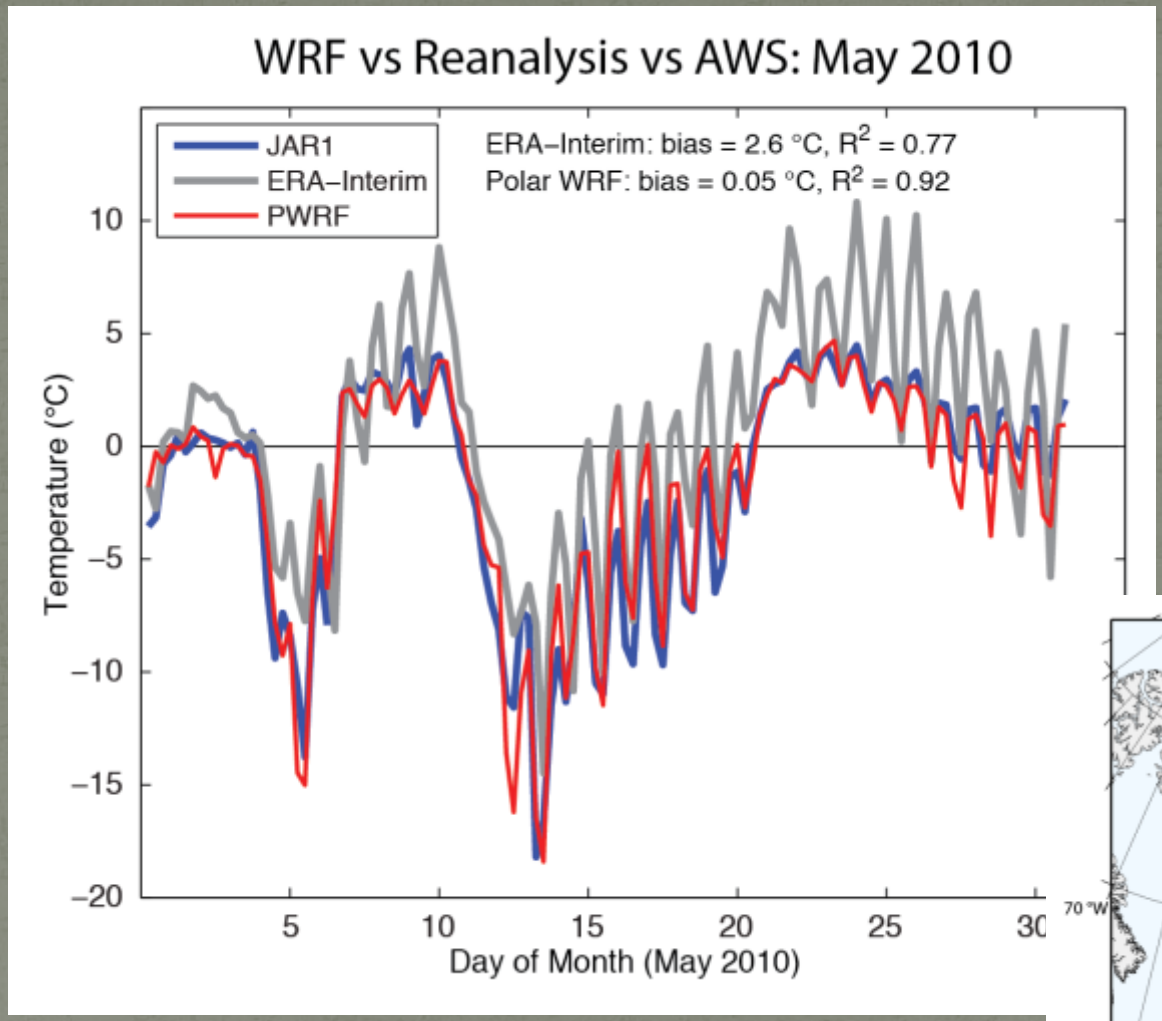
CESM LE Historical: July 1981-2000

Daily Average Near-surface Temperature (Gridpoint difference)



cesmle_tasz_071981-2000/6x5/run04

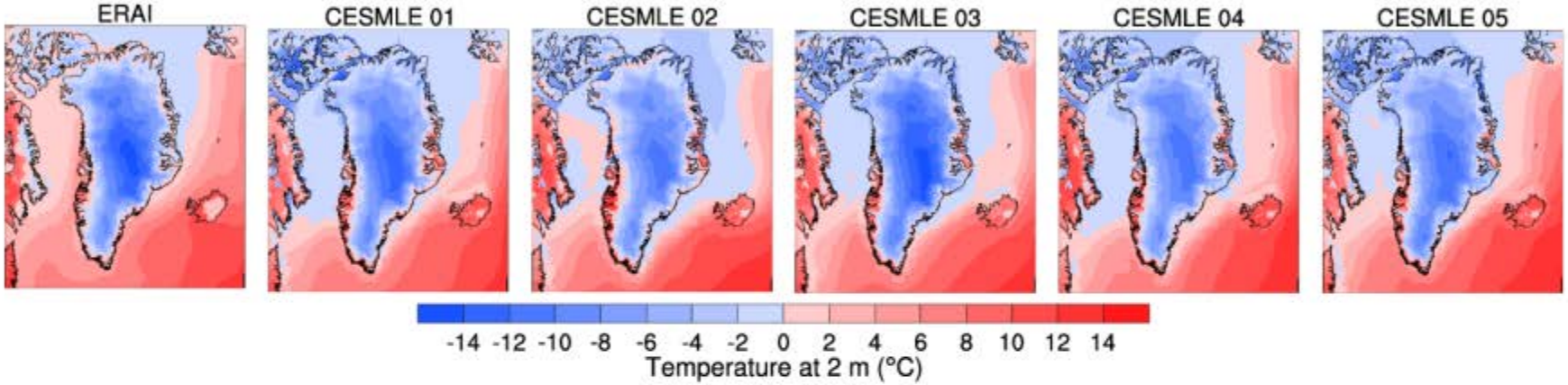
Regional Modeling


WRF vs Reanalysis vs AWS: May 2010
JAR1
ERA–Interim
PWRF
ERA–Interim: bias = 2.6 °C, R2 = 0.77
Polar WRF: bias = 0.05 °C, R2 = 0.92
Temperature (°C)
10
5
0
−5
−10
−15
−20
5
10
15
20
25
30
Day of Month (May 2010)

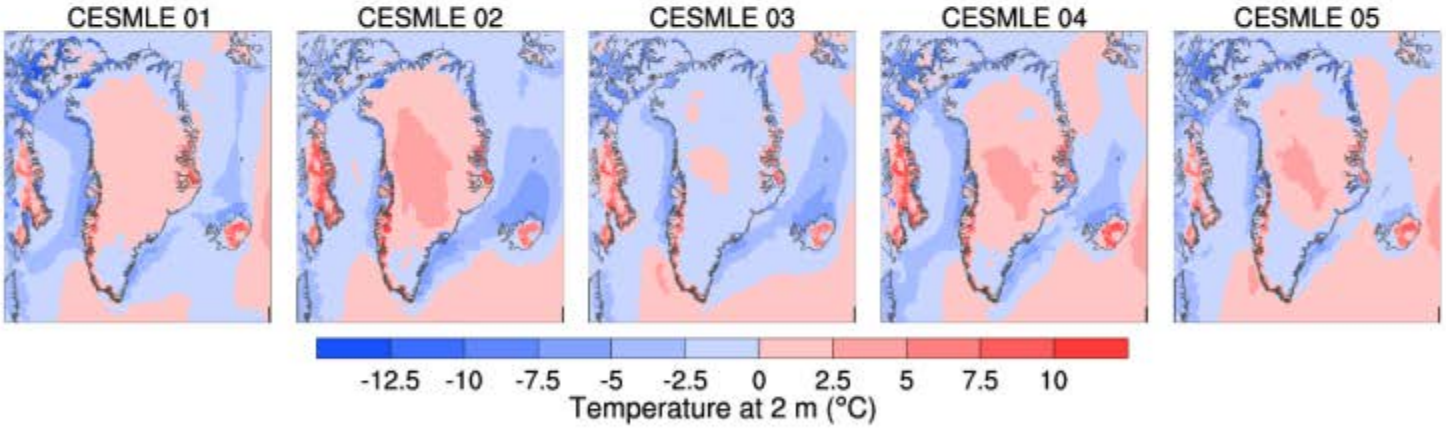

70 °W
70 °N
60 °N
60 °N
GC-Net AWS
60 °W
50 °W
40 °W
30 °W

Polar WRF(ERAI, CESM LE) July 2000

Average Near-surface Temperature

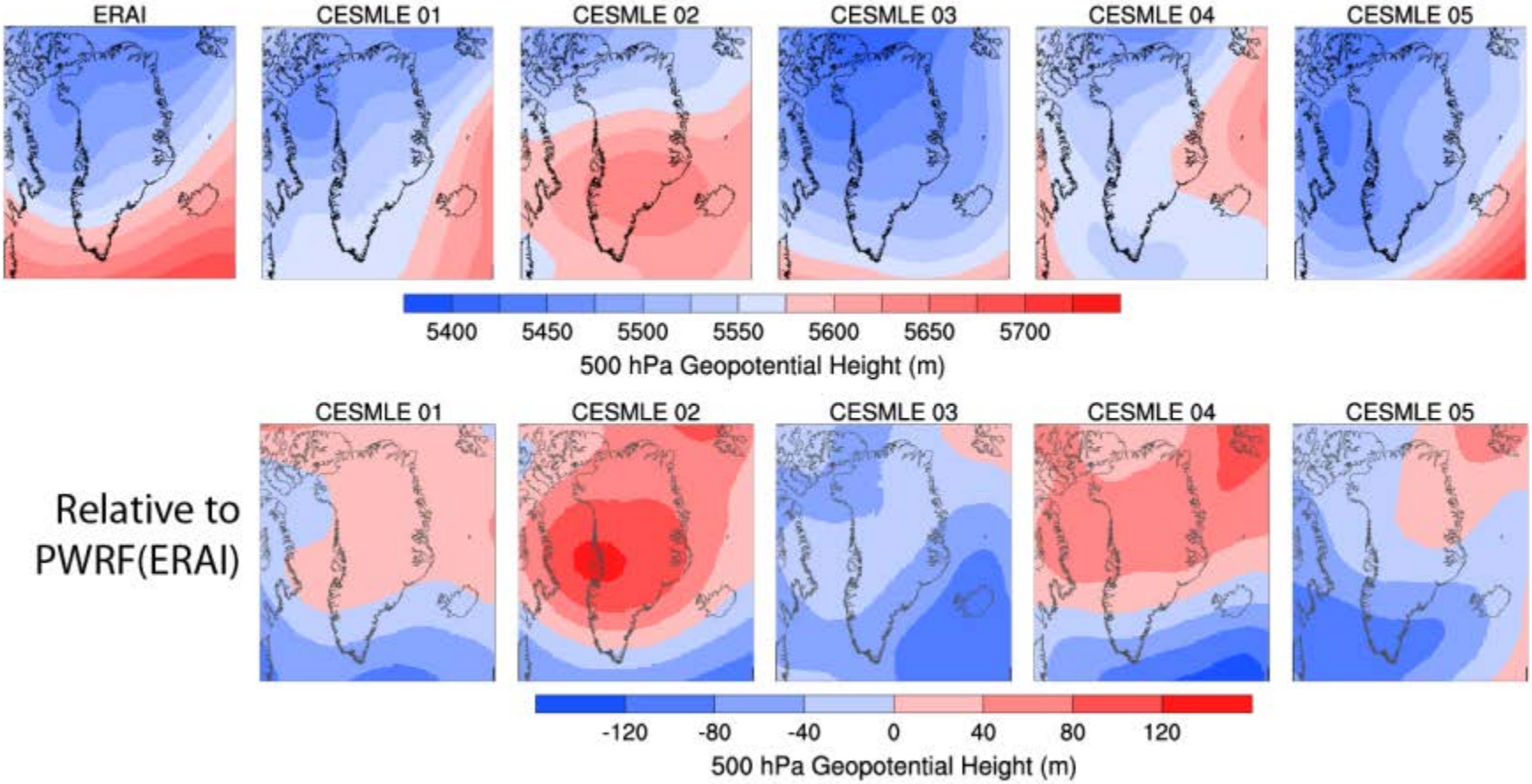


Relative to PWRF(ERAI)



Polar WRF(ERAI, CESM LE) July 2000

Average 500 hPa Geopotential Height



Summary

- CESM LE definitely helpful for intramodel uncertainty
  - Small initialization differences -> useful variability
  - Multiple climate scenarios -> uncertainty estimates
- CESM LE overpredicts both low and high temperatures with the latter of more significance for melting
- SOMs can help identify ensemble members with specific variability characteristics (all warm, regionally cold…)

- “Uncertainty” remains a complex target