

Synoptic influence on the atmosphere over Greenland and observations at Summit Station

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Self Organizing Maps (SOMs)

Kohonen, T. (2001); Hewitson, B. C., and R. G. Crane (2002)

- statistical learning neural network algorithm
- groups similar vectors into generalized patterns (“nodes”)
- classifies nonlinear data well
- removes human element
- generalized, non-discrete, and robust
- nodes closer are similar, distant are dissimilar
- used to classify and group atmospheric circulation
- typically height and pressure fields
- often compared to k-mean and PCA

Greenland SOM

- **Methods:**

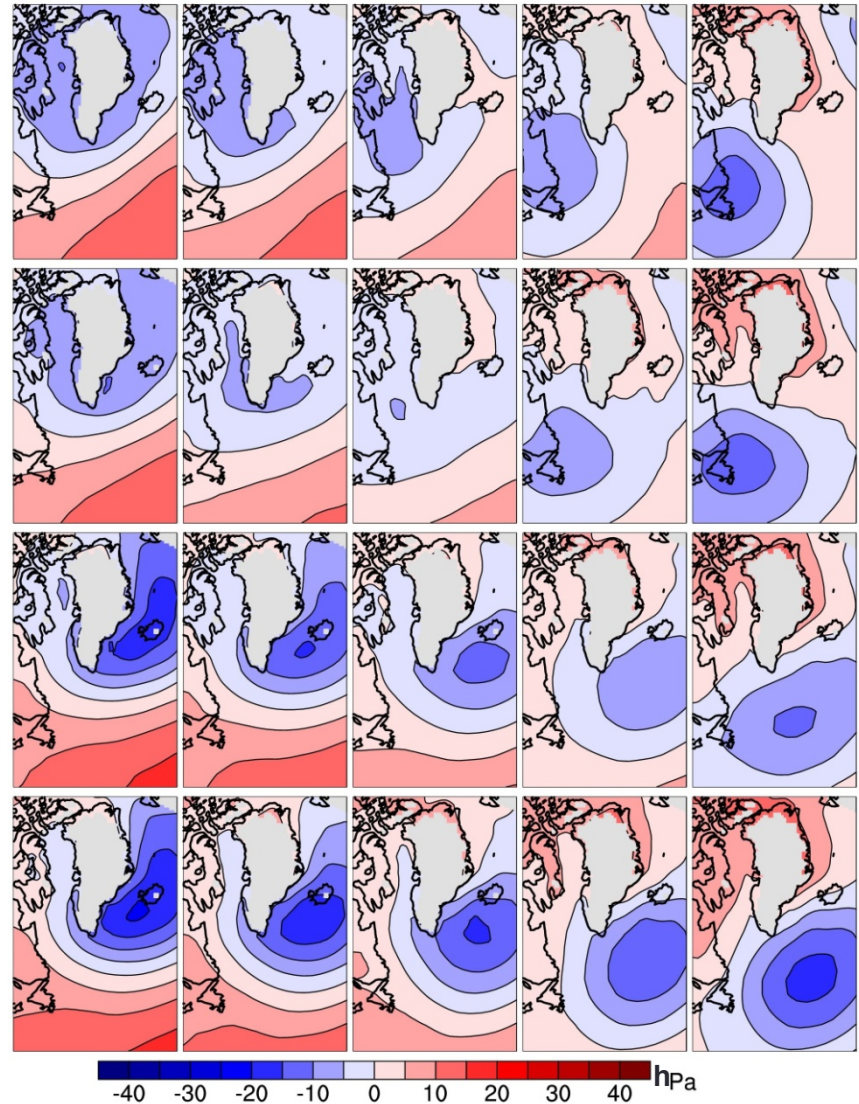
- train and create SOM using 500mb heights from NCEP/NCAR
- map 'entire' data range (Jan 1st 1948 – Oct 13th 2015)
- organized map of synoptic regime
- days associated with specific synoptic patterns
- let someone else take data for 5 years

- **Motivators:**

- characterize in situ observations
- statistically quantify synoptic influence
- understand large scale context of gridpoint values

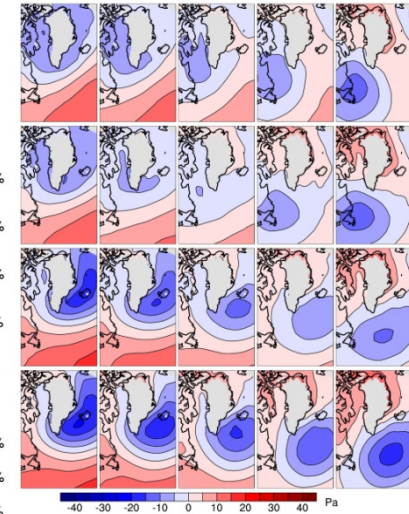
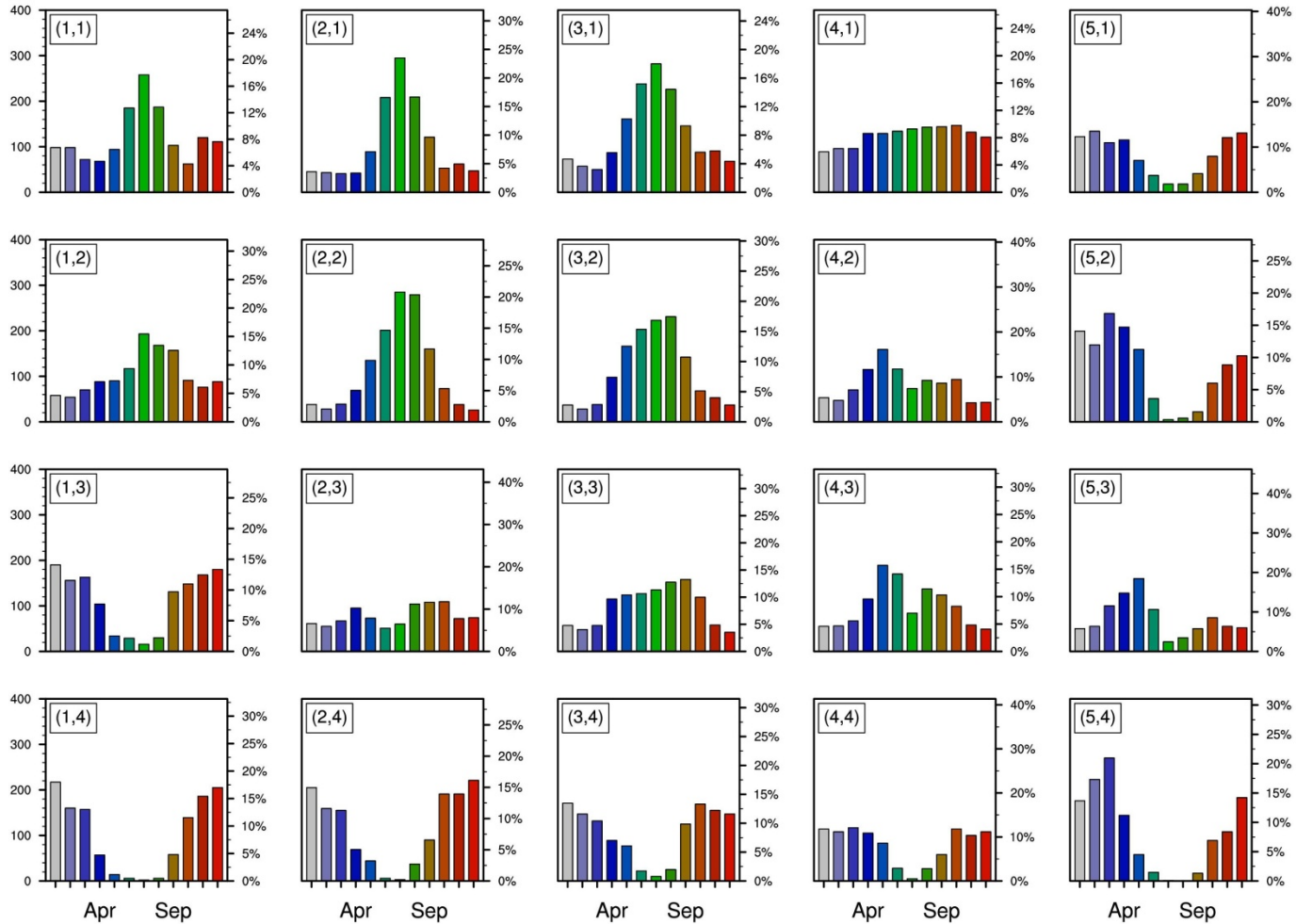
Greenland SOM

- sea level pressure anomaly
- lower dimensionality
 - better statistics
 - tradeoff
 - more generalized



Frequencies

Monthly Frequencies

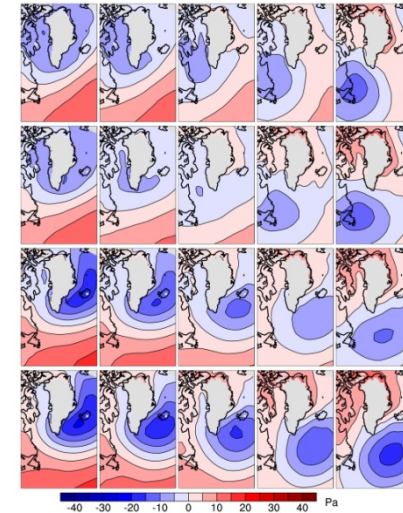


Frequencies

SOM frequencies

Frequency of occurrence

1	<p>7.65%</p> <p>5.86%</p> <p>4.11%</p>	<p>6.03%</p> <p>5.05%</p> <p>3.84%</p>	<p>7.40%</p> <p>6.31%</p> <p>4.93%</p>	<p>7.65%</p> <p>6.04%</p> <p>4.92%</p>	<p>4.92%</p> <p>4.00%</p> <p>2.74%</p>
2	<p>6.30%</p> <p>5.03%</p> <p>3.55%</p>	<p>6.58%</p> <p>5.52%</p> <p>4.38%</p>	<p>6.58%</p> <p>5.33%</p> <p>3.84%</p>	<p>4.93%</p> <p>3.97%</p> <p>3.01%</p>	<p>7.38%</p> <p>5.69%</p> <p>3.84%</p>
3	<p>7.38%</p> <p>5.43%</p> <p>4.10%</p>	<p>4.64%</p> <p>3.74%</p> <p>2.74%</p>	<p>5.75%</p> <p>4.80%</p> <p>3.84%</p>	<p>6.28%</p> <p>4.84%</p> <p>3.56%</p>	<p>4.38%</p> <p>3.49%</p> <p>2.74%</p>
4	<p>6.28%</p> <p>4.86%</p> <p>3.28%</p>	<p>6.83%</p> <p>5.52%</p> <p>4.10%</p>	<p>6.28%</p> <p>5.11%</p> <p>4.10%</p>	<p>4.93%</p> <p>3.89%</p> <p>3.01%</p>	<p>6.85%</p> <p>5.19%</p> <p>3.01%</p>
	1	2	3	4	5



Frequencies

SOM frequencies

frequency Dec-Feb

1	5.03%	2.21%	3.24%	5.01%	6.32%
2	3.28%	1.51%	1.67%	2.34%	8.40%
3	8.61%	3.11%	2.41%	2.62%	2.57%
4	9.53%	9.58%	7.62%	5.40%	9.53%
	1	2	3	4	5

frequency Mar-May

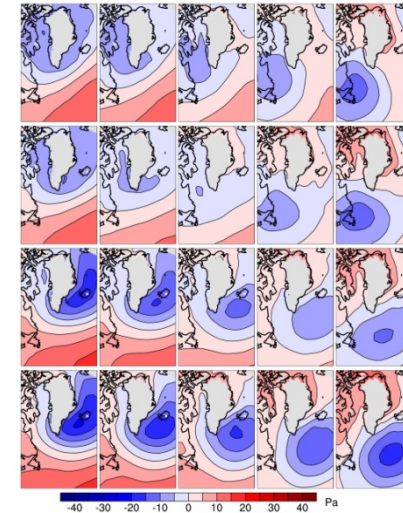
1	3.74%	2.75%	4.76%	5.66%	4.70%
2	3.96%	3.88%	4.83%	5.50%	9.67%
3	4.81%	3.76%	4.73%	5.93%	6.20%
4	3.64%	4.28%	4.76%	4.88%	7.54%
	1	2	3	4	5

frequency Jun-Aug

1	10.07%	11.38%	11.92%	6.65%	1.17%
2	7.64%	12.23%	10.50%	4.48%	1.02%
3	1.20%	3.44%	6.62%	6.25%	2.29%
4	0.22%	0.74%	0.91%	0.96%	0.32%
	1	2	3	4	5

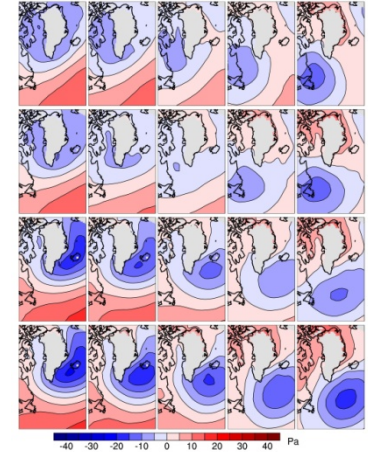
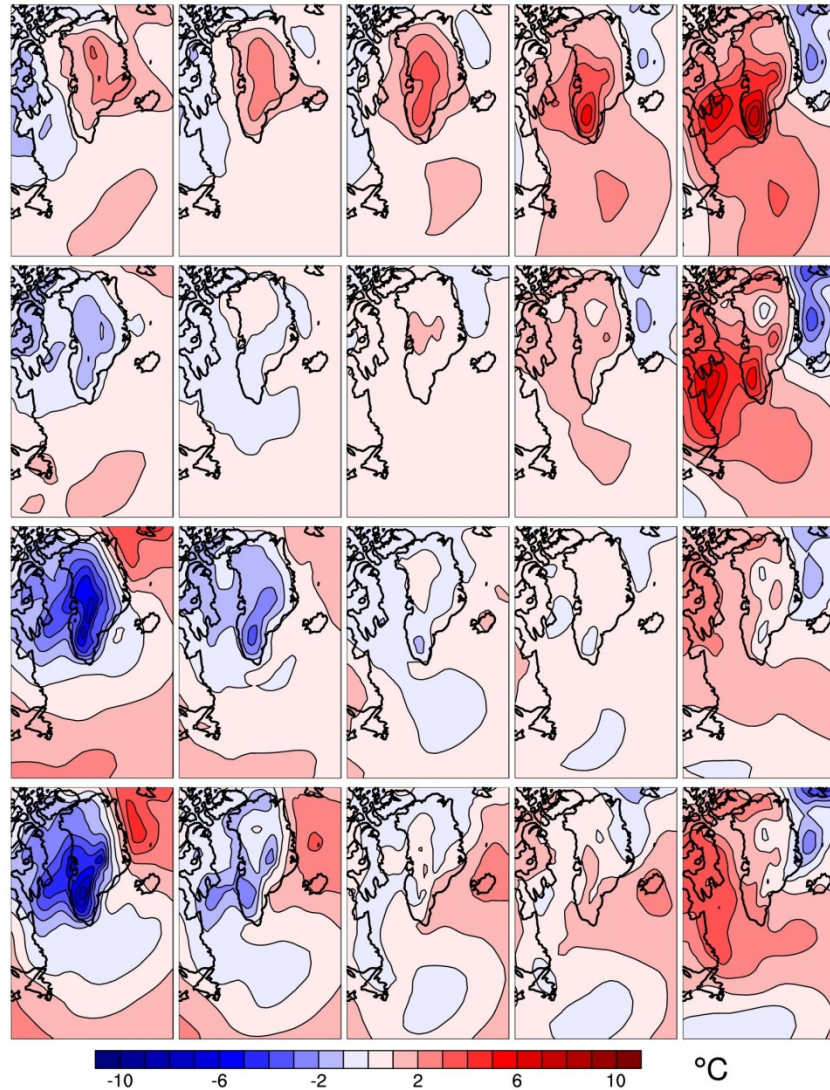
frequency Sep-Nov

1	4.64%	3.84%	5.29%	6.89%	3.91%
2	5.28%	4.41%	4.28%	3.58%	3.78%
3	7.28%	4.71%	5.46%	4.58%	2.92%
4	6.24%	7.69%	7.31%	4.43%	3.49%
	1	2	3	4	5



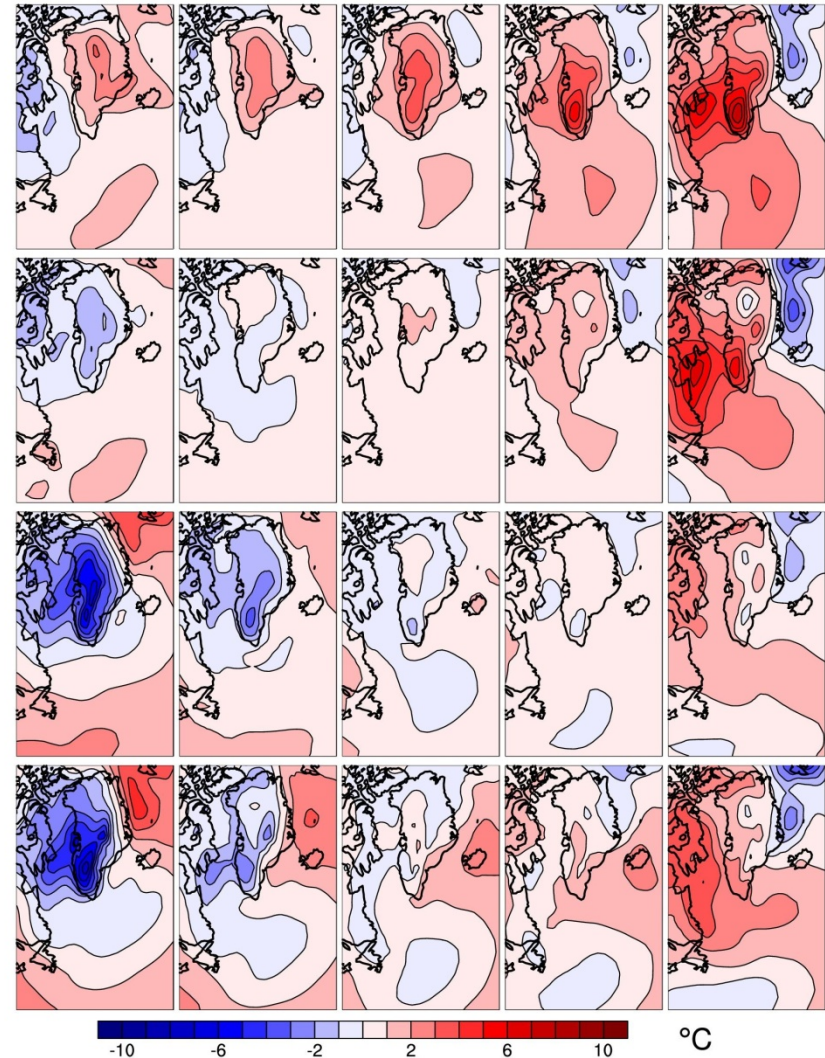
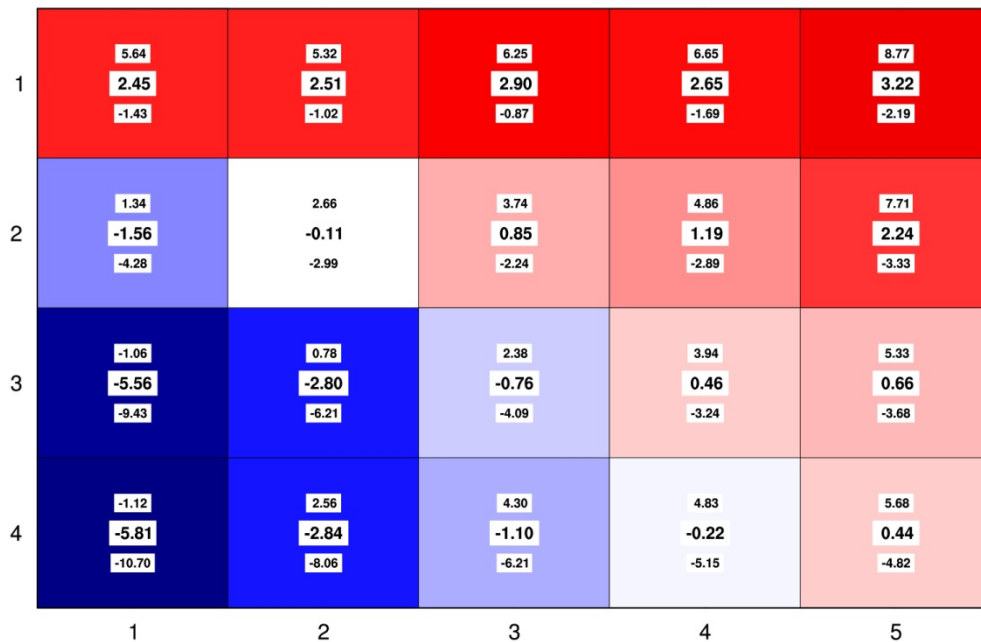
Softball

- temperature anomalies
- seasonally subtracted
- mapped to SOM
- averaged for each node



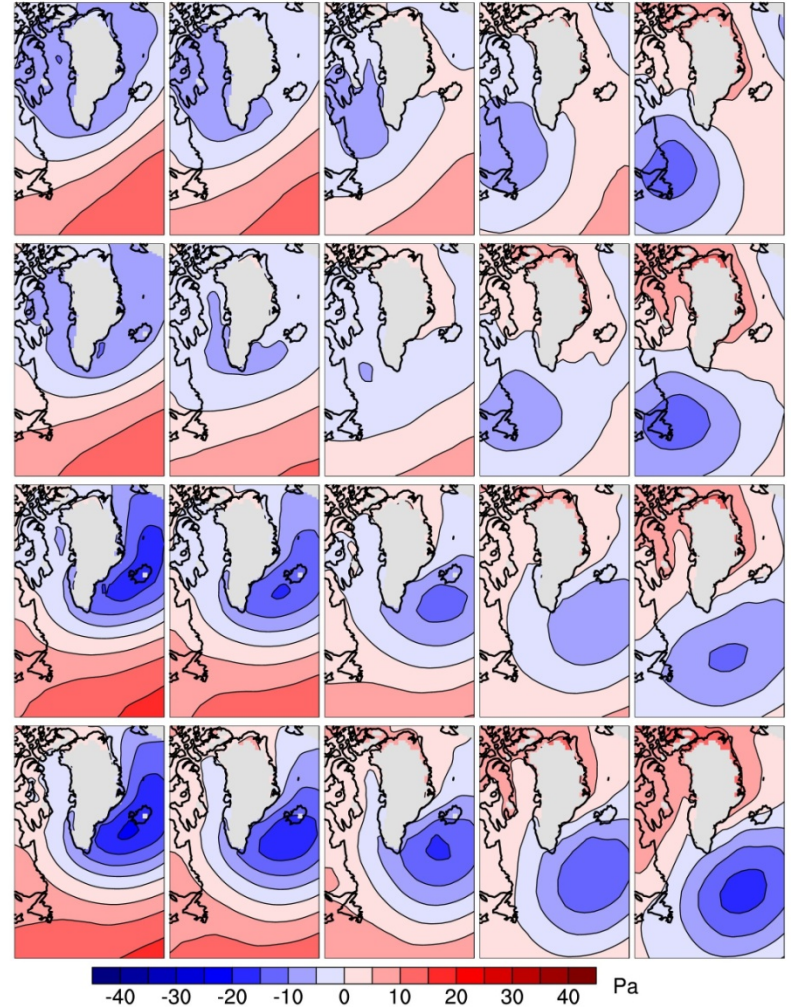
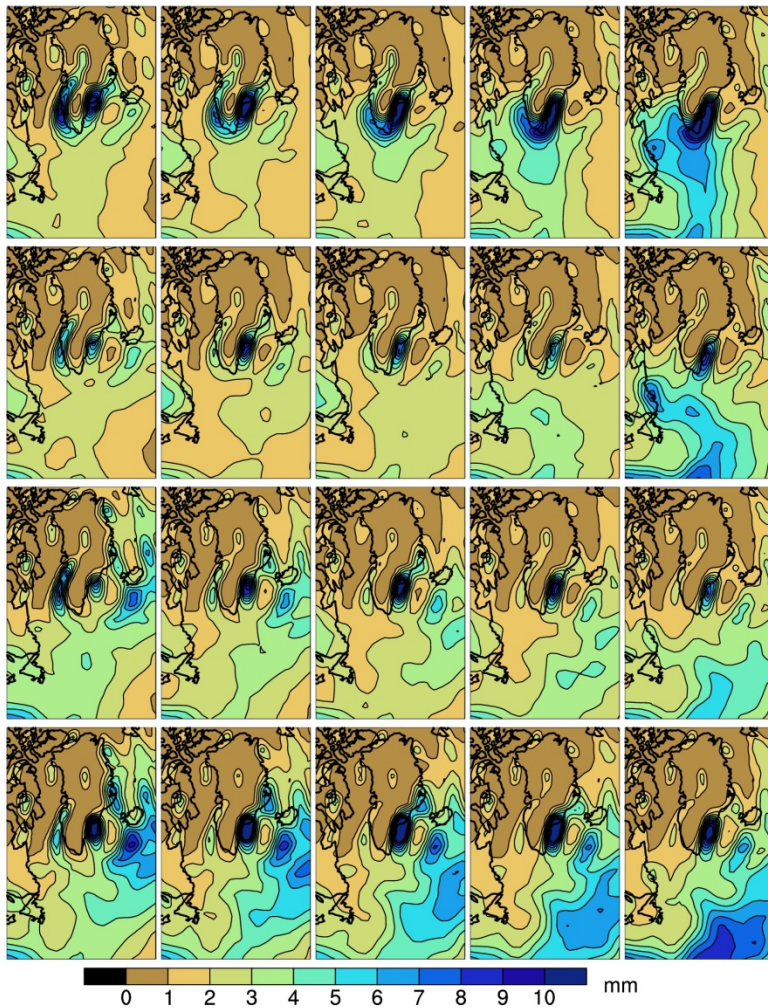
What about Summit?

- value extracted from NCEP mapped spatial temperature anomaly



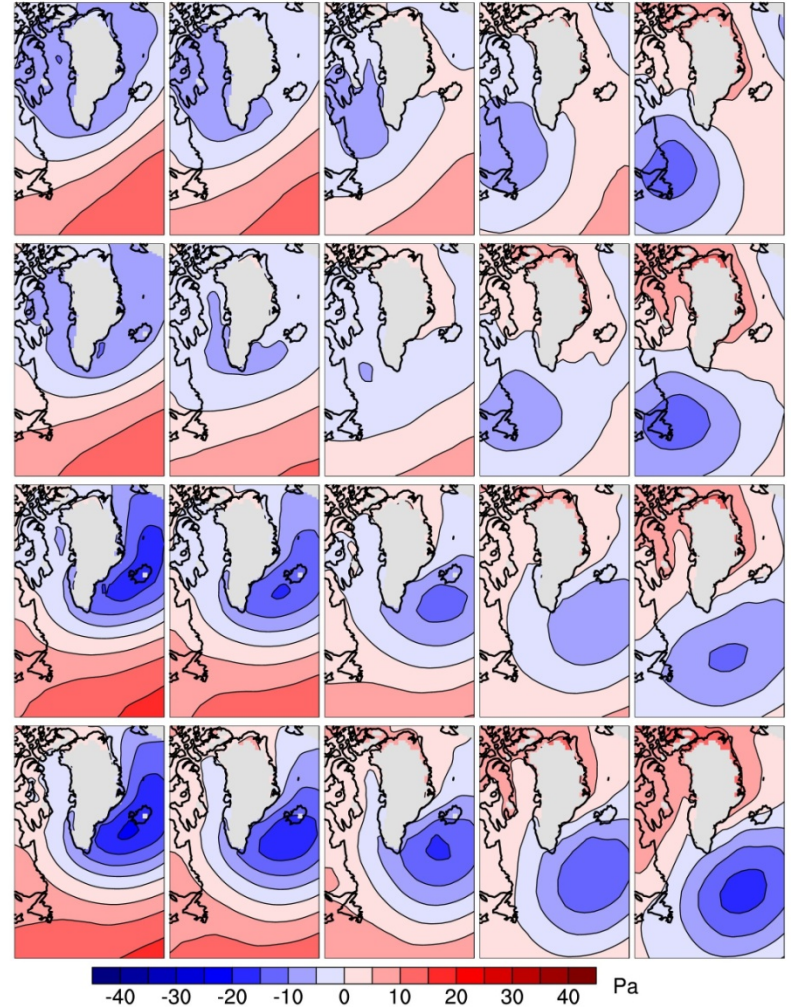
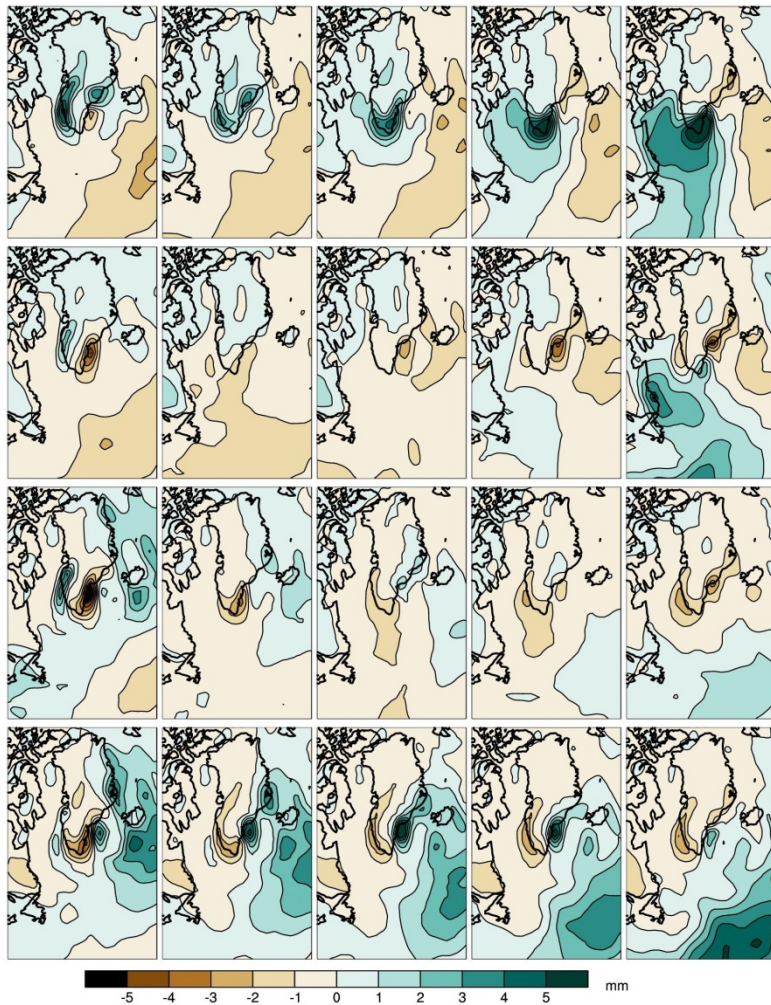
What about the bigger picture?

Precipitation



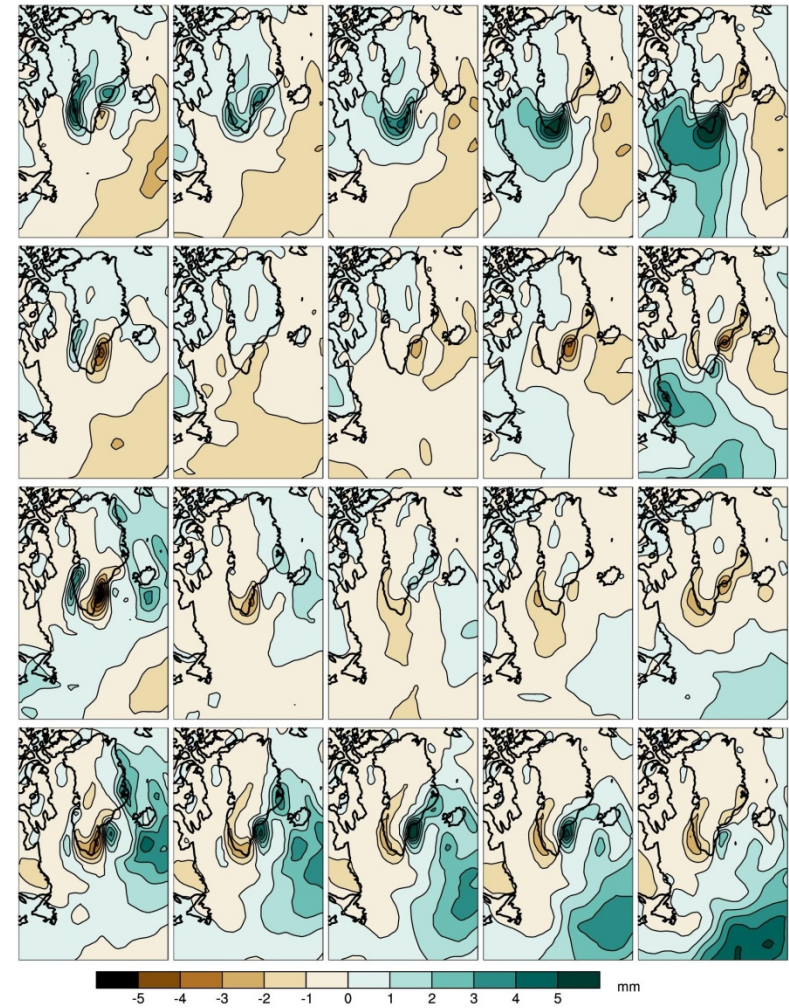
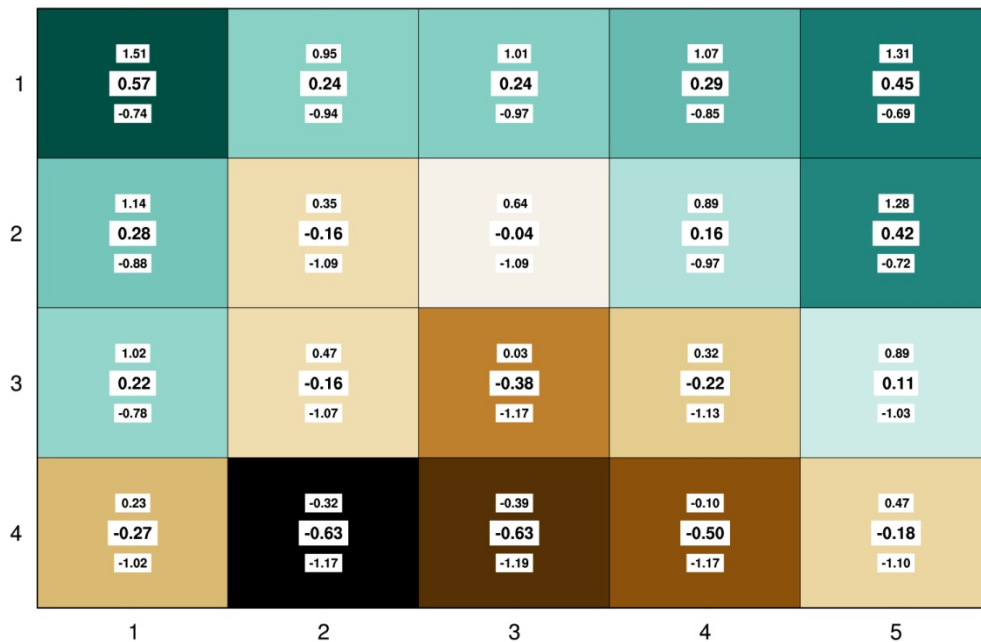
What about the bigger picture?

Precipitation Anomaly



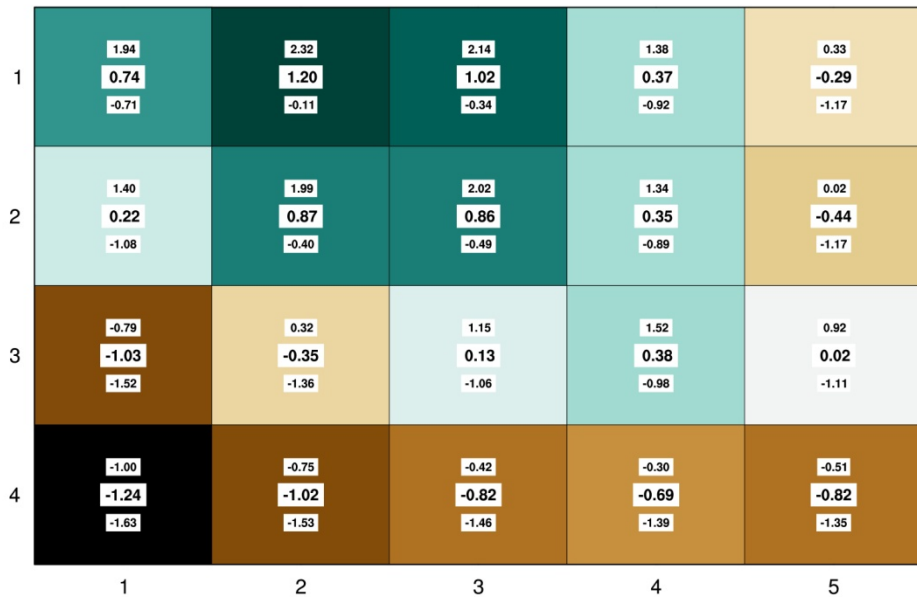
What about Summit?(again)

- precipitation anomalies (mm)

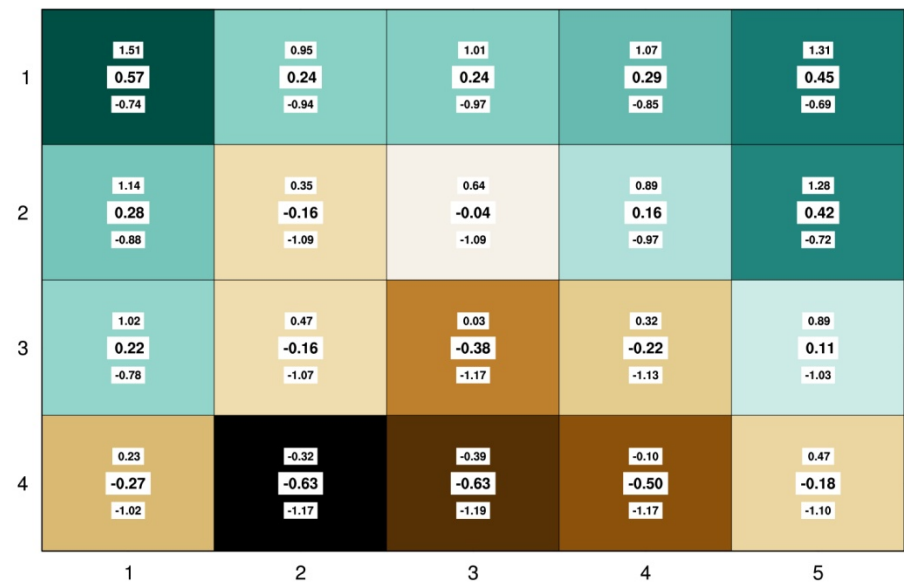


PWV vs Daily Precipitation (mm)

PWV Anomaly

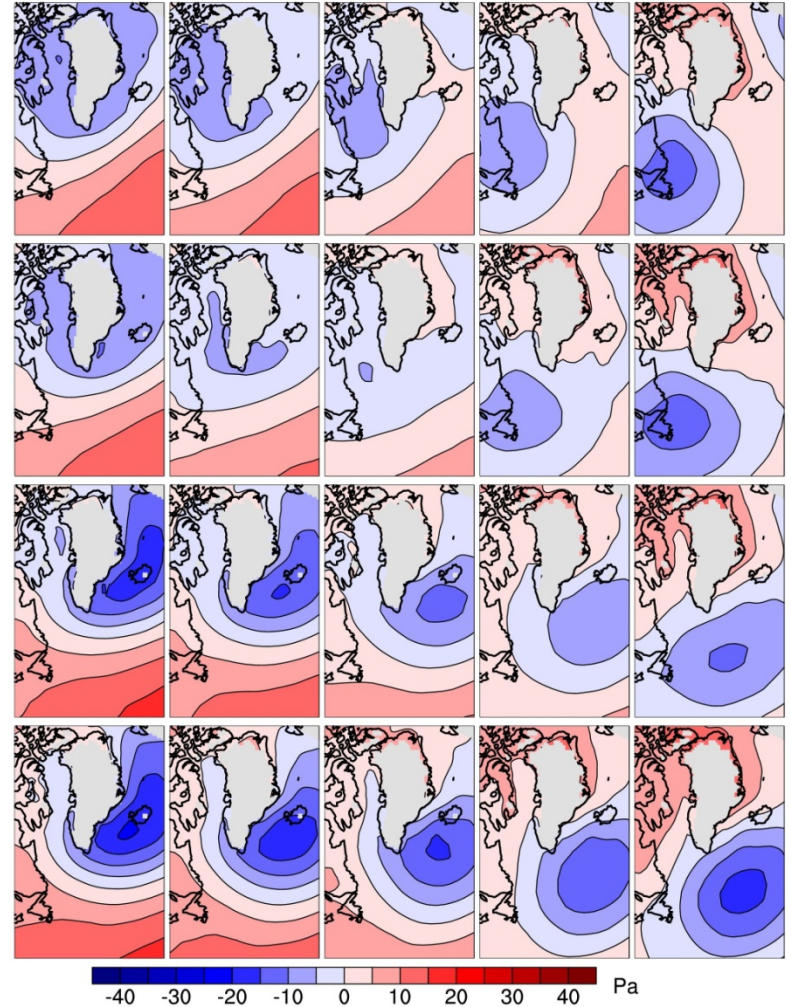
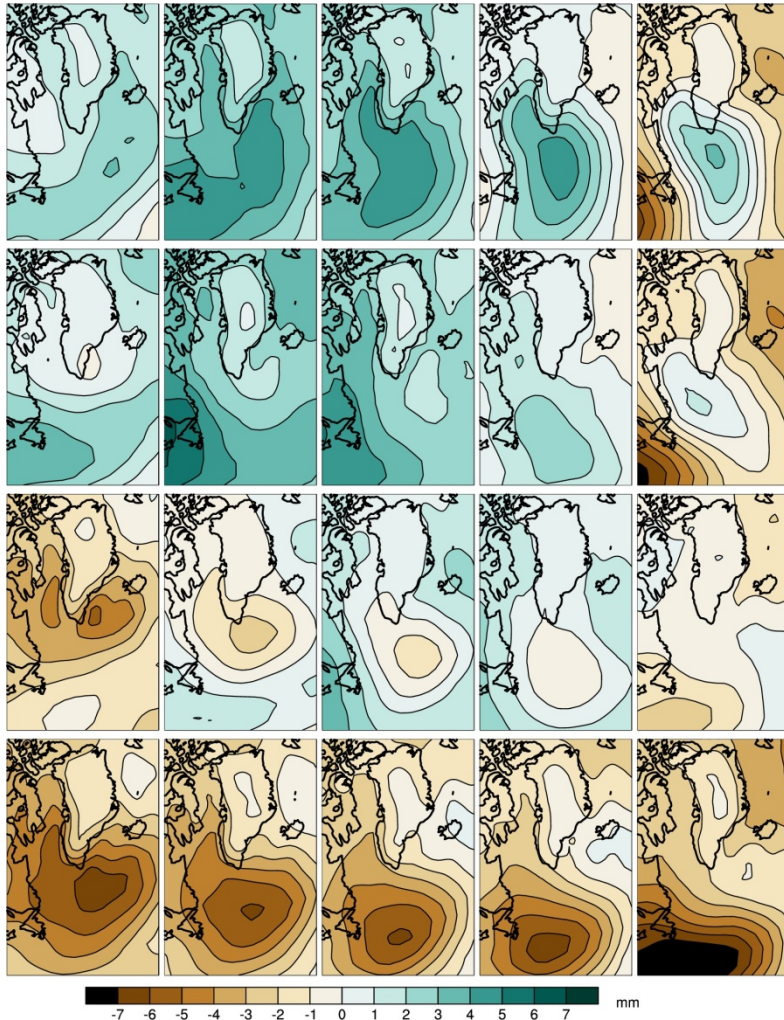


Precip Anomaly

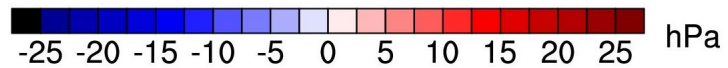
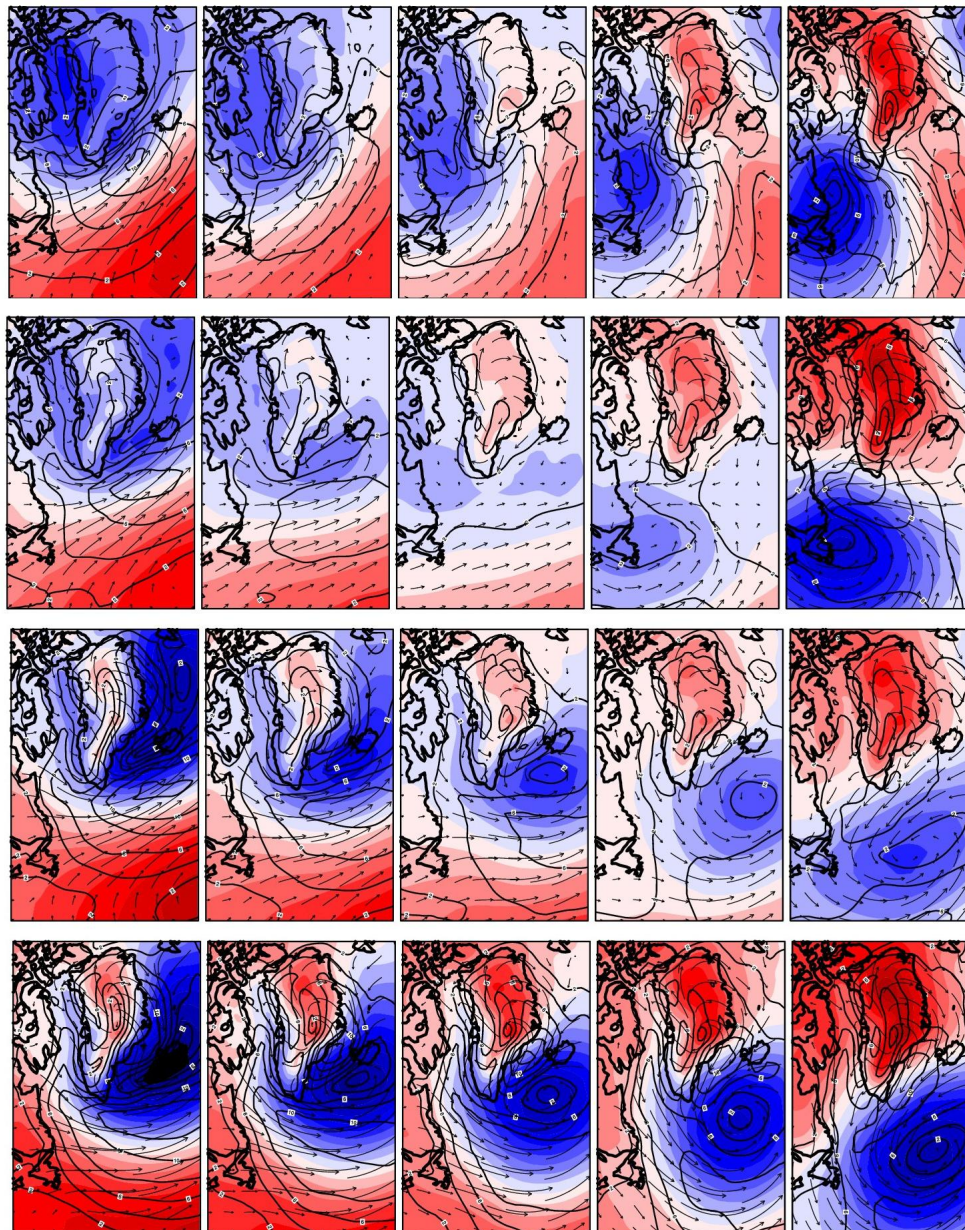


More bigger picture?

PWV Anomaly

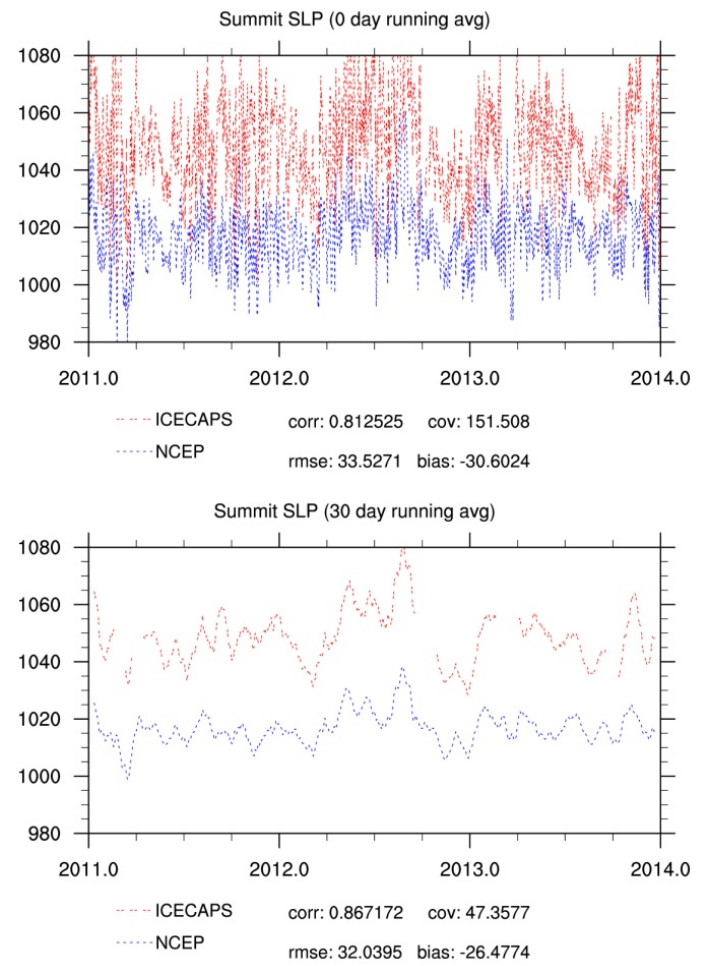
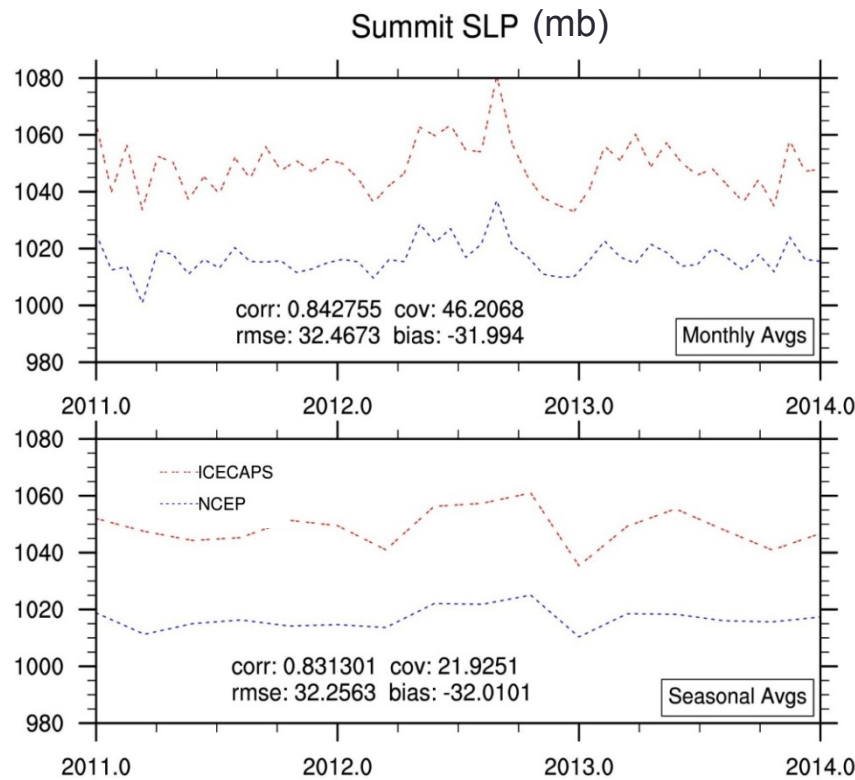


Pretty plot:



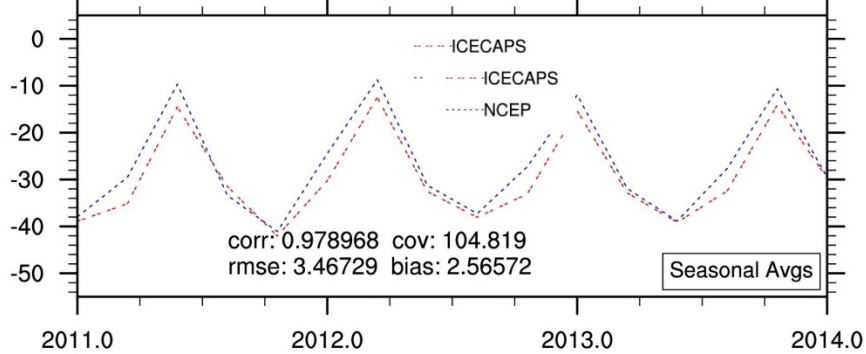
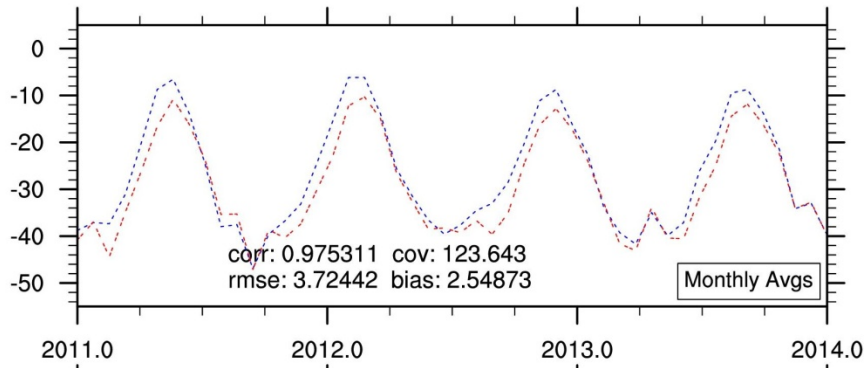
NCEP/ICECAPS SLP

- calculated with station pressure and temp at Summit
- 23.117 km apart (as the crow flies)

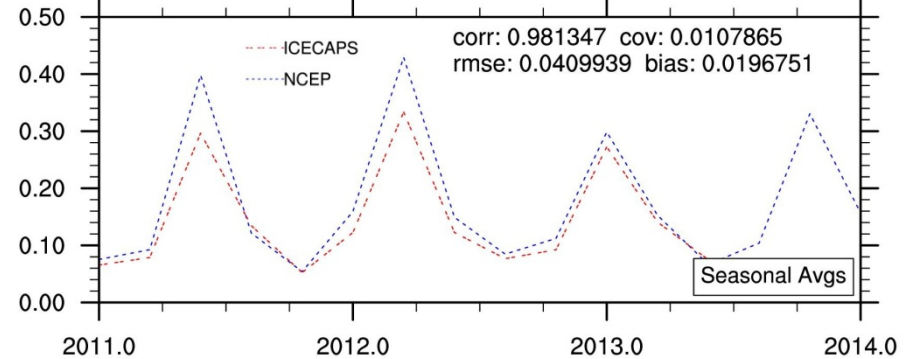
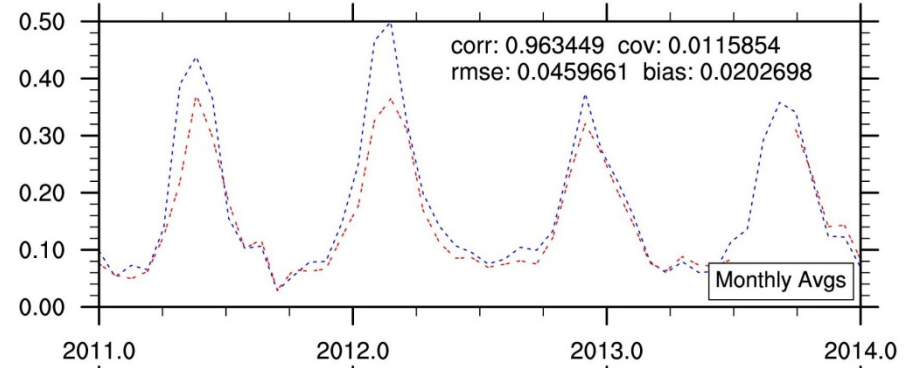


More comparisons

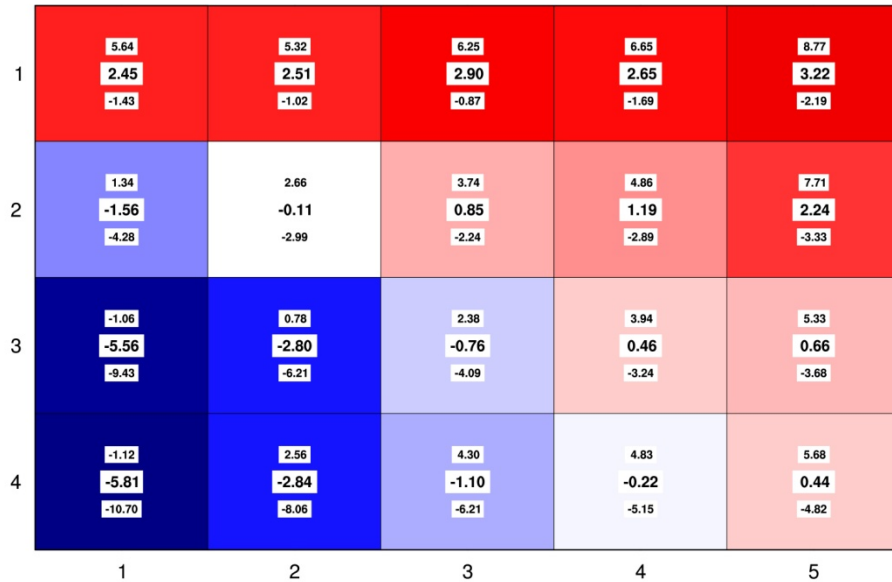
Summit Temperatures (C)



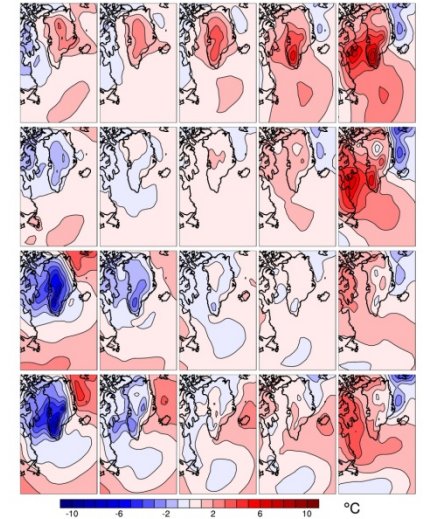
Summit PWV (cm)



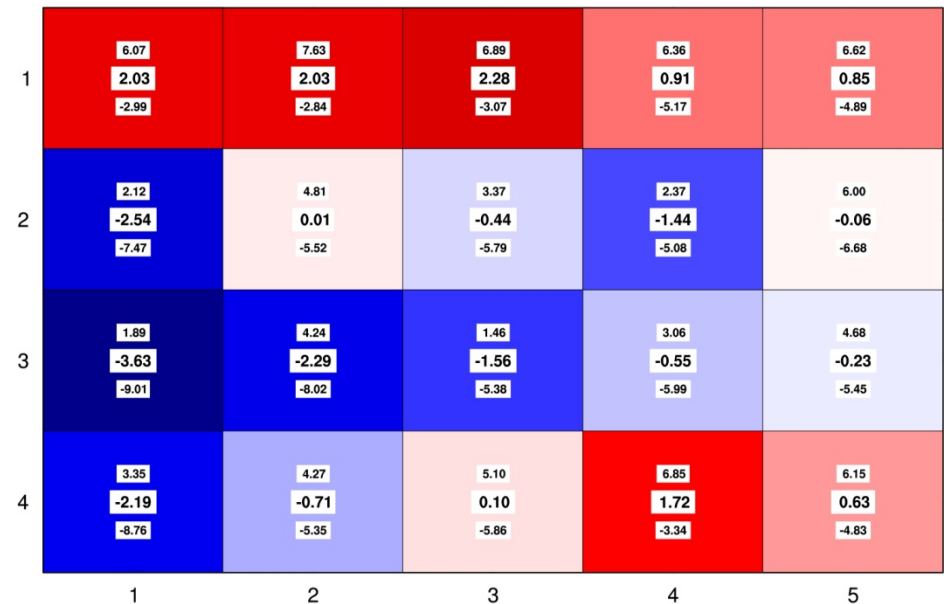
Temperature anomaly at Summit (°C)



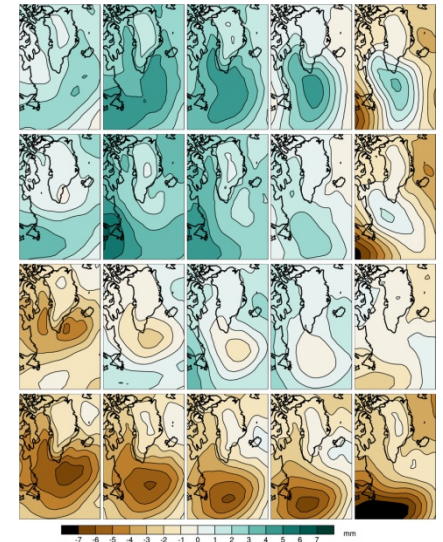
NCEP values



ICECAPS values



PWV at Summit (mm)



NCEP values

1	1.94 0.74 -0.71	2.32 1.20 -0.11	2.14 1.02 -0.34	1.38 0.37 -0.92	0.33 -0.29 -1.17
2	1.40 0.22 -1.08	1.99 0.87 -0.40	2.02 0.86 -0.49	1.34 0.35 -0.89	0.02 -0.44 -1.17
3	-0.79 -1.03 -1.52	0.32 -0.35 -1.36	1.15 0.13 -1.06	1.52 0.38 -0.98	0.92 0.02 -1.11
4	-1.00 -1.24 -1.63	-0.75 -1.02 -1.53	-0.42 -0.82 -1.46	-0.30 -0.69 -1.39	-0.51 -0.82 -1.35
	1	2	3	4	5

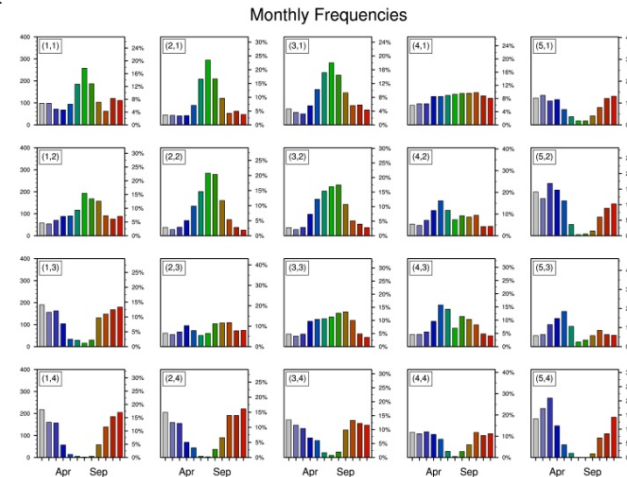
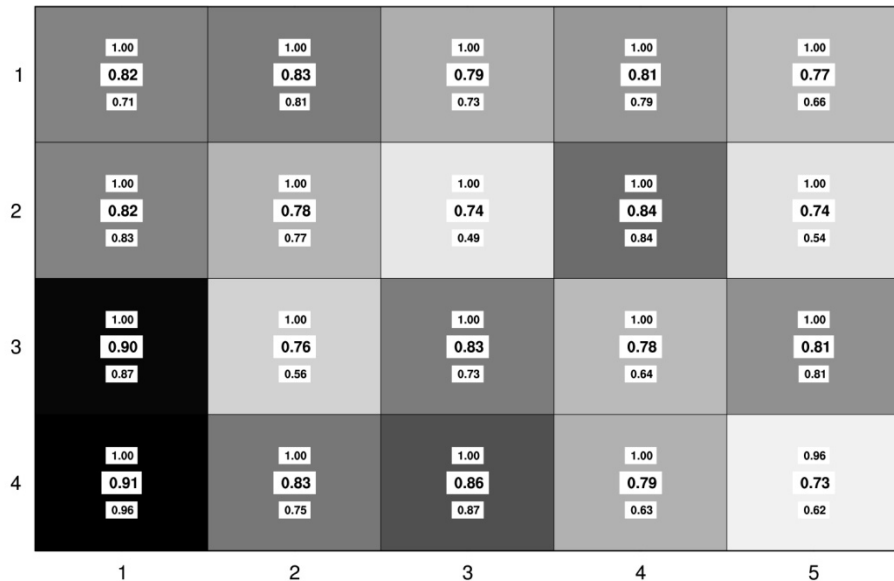


ICECAPS values

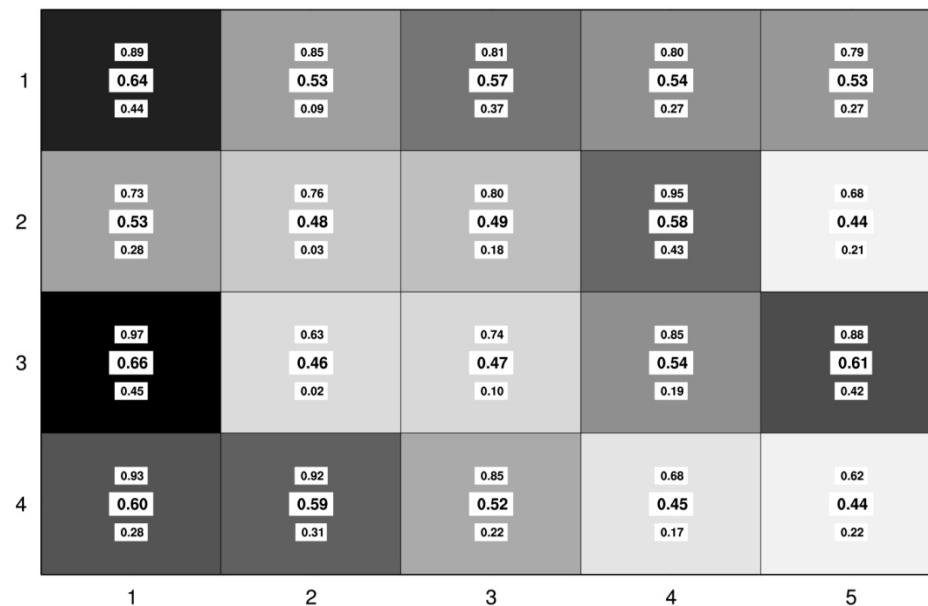
1	1.11 0.31 -0.79	1.89 0.91 -0.62	2.40 1.14 -0.06	1.22 0.40 -0.62	0.06 -0.50 -1.13
2	0.34 -0.26 -1.11	1.38 0.68 -0.33	1.44 0.67 -0.43	1.53 0.56 -0.85	-0.21 -0.55 -1.18
3	-0.70 -0.88 -1.33	0.41 -0.14 -0.96	0.79 0.02 -0.76	1.84 0.76 -0.68	1.16 0.37 -0.71
4	-0.63 -0.86 -1.25	-0.52 -0.76 -1.10	-0.22 -0.61 -1.06	0.34 -0.26 -0.84	-0.43 -0.63 -1.11
	1	2	3	4	5

Cloud fraction

low clouds (<1km)



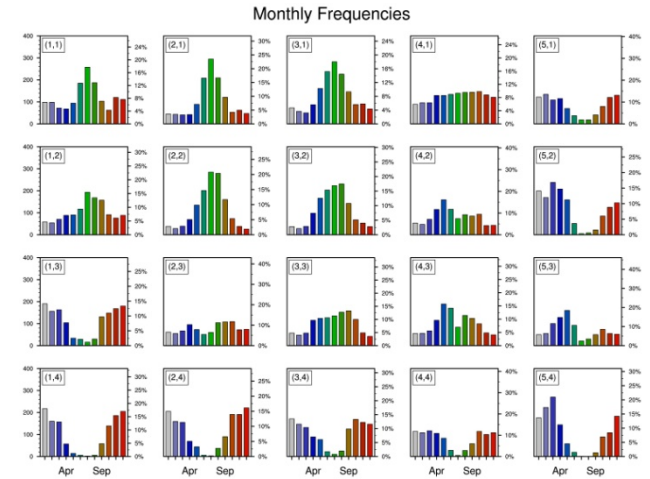
high clouds (>2km)



Radiation

LWD (W/m²)

1	209.63 182.53 157.85	240.27 200.05 159.45	245.10 208.33 176.67	234.21 191.36 156.58	195.18 157.19 123.44
2	189.61 159.16 128.00	216.62 192.48 165.04	235.02 195.07 162.51	196.36 169.30 131.84	178.81 145.41 113.38
3	152.79 129.66 100.54	193.72 163.37 142.77	205.64 175.34 140.53	227.36 186.06 149.28	204.04 179.39 155.44
4	154.27 134.07 102.41	165.75 140.99 117.47	177.07 147.03 123.11	180.73 159.05 126.69	164.76 141.91 117.64
	1	2	3	4	5



SWD (W/m²)

1	258.95 153.20 3.88	345.25 207.88 38.87	339.05 233.33 144.50	323.34 183.03 24.88	107.44 58.52 -1.00
2	273.61 163.55 43.88	357.93 242.12 119.74	348.91 244.05 180.80	358.25 197.75 19.01	93.28 52.62 -0.28
3	145.50 79.09 0.24	333.57 173.94 5.47	295.13 179.86 45.16	311.81 202.84 100.66	349.96 179.12 29.14
4	58.60 39.99 -0.17	49.60 40.98 -1.17	59.44 54.84 -1.45	201.50 106.72 6.42	118.47 73.82 -0.11
	1	2	3	4	5

Conclusions

- Basic:
 - Radiation is highest in summer
 - Precipitation happens in summer
 - Summit measurements fit in fairly well with NCEP reanalysis data
- Advanced:
 - Synoptic conditions cause “dry days” at summit but do not as clearly influence precipitation events
 - Precipitation and PWV are not driven by the same conditions
 - Winter nodes with negative and positive anomalies
- Hitches:
 - Dependence on domain selection and SOM dimensions. Optimize!
 - Results could be more robust with improvement

Remaining questions/ideas:

- Do changes in node frequency impact annual values?
- Is there relationships between nodes transitions and local phenomena?
- Quantify the impact that changes in frequencies have on yearly averages.
- Statistics! Correlation maps. A node is a time series!
- SOM other fields? 700mb? 500mb?

Similar work and citations

- Like all good scientists I stand on the shoulders of others:
 - Hewitson, B. C., and R. G. Crane. "Self-organizing maps: applications to synoptic climatology." *Climate Research* 22.1 (2002): 13-26.
 - David B. Reusch, Richard B. Alley, Bruce C. Hewitson. "Relative Performance of Self-Organizing Maps and Principal Component Analysis in Pattern Extraction." *Synthetic Climatological Data Polar Geography* Vol. 29, Iss. 3, (2005)
 - Keah C. Schuenemann, John J. Cassano, and Joel Finnis. "Synoptic forcing of precipitation over greenland: climatology for 1961–99." *J. Hydrometeor*, 10, 60–78. (2009) doi: <http://dx.doi.org/10.1175/2008JHM1014.1>
 - Schuenemann, K. C., and J. J. Cassano. Changes in synoptic weather patterns and Greenland precipitation in the 20th and 21st centuries, *J. Geophys. Res.*, 115, (2010), D05108, doi:10.1029/2009JD011706.
 - Scott C. Sheridan and Cameron C. Lee. "The self-organizing map in synoptic climatological research." *Progress in Physical Geography* (2011) 35: 109-119, doi: 10.1177/0309133310397582