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)

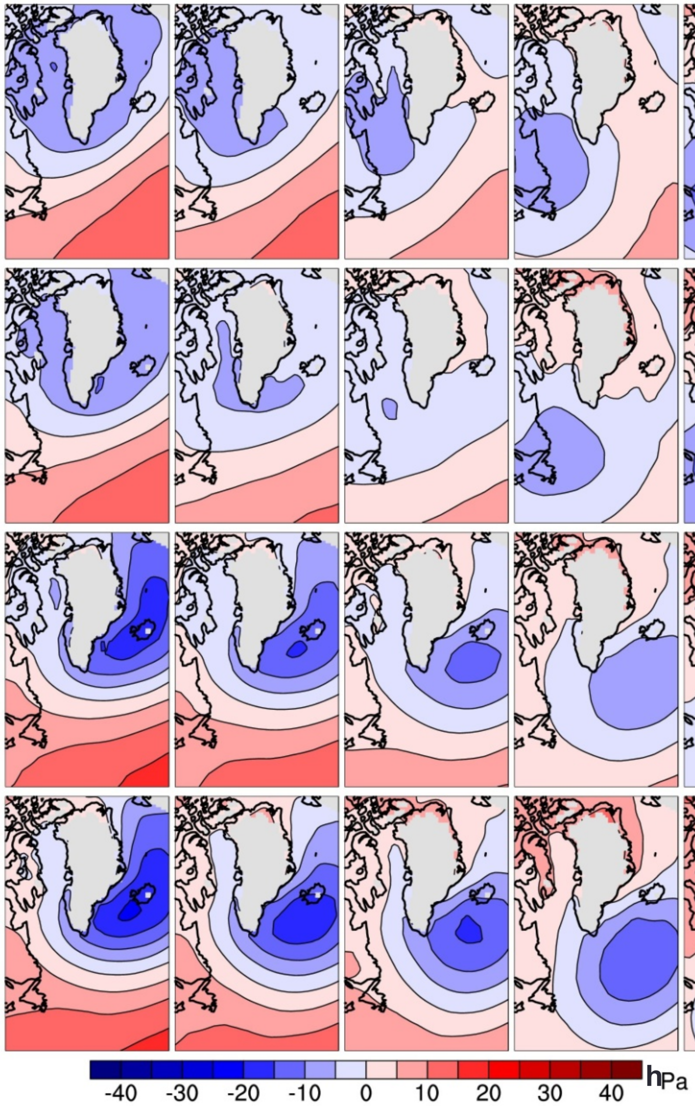
- statistical learning neural network algorithm
- groups similar vectors into generalized patterns (“nodes”)
- classifies nonlinear data well
- removes human element
- generalized, non-discrete, and robust
- nodes closer are similar, distant are dissimilar
- used to classify and group atmospheric circulation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

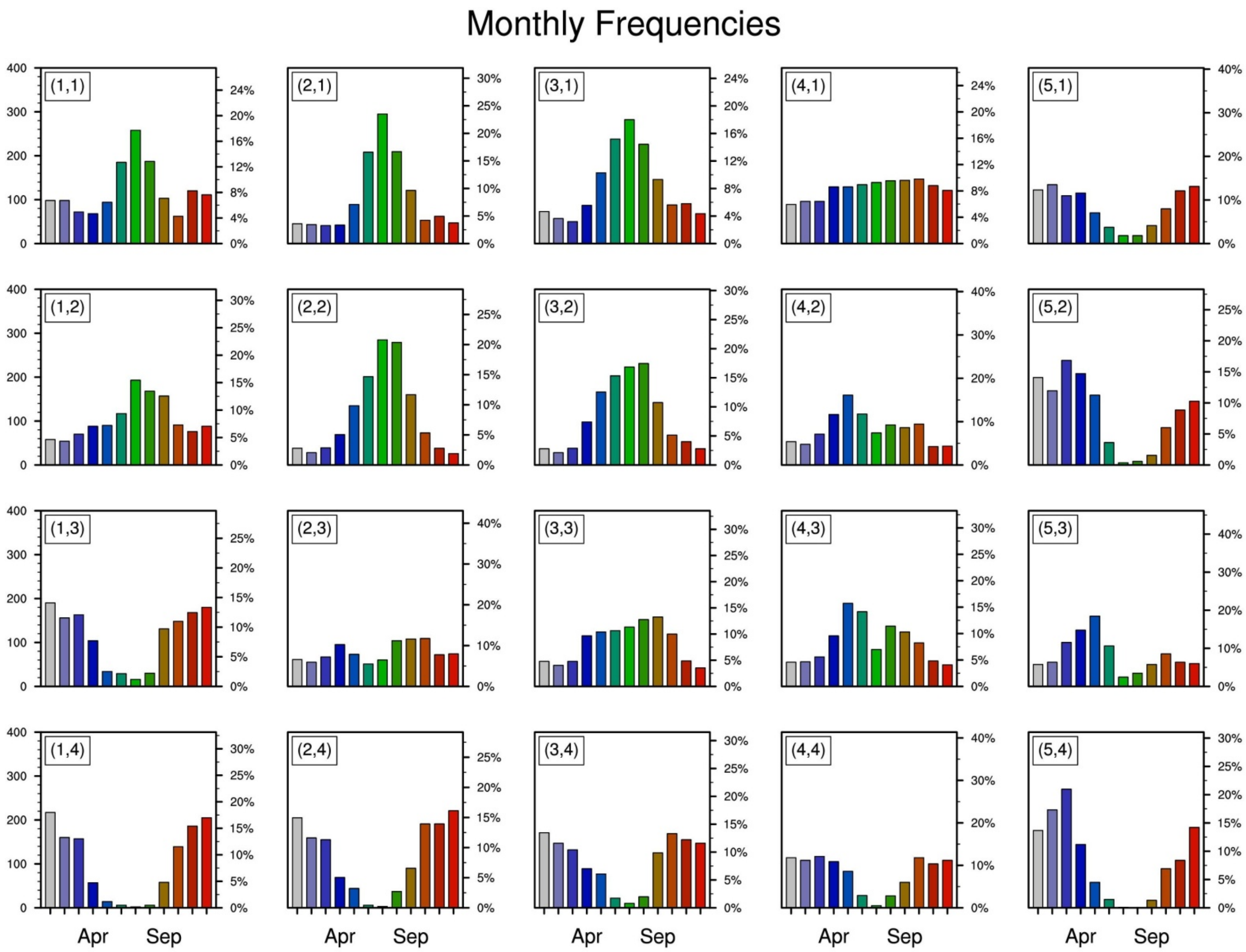
Greenland SOM

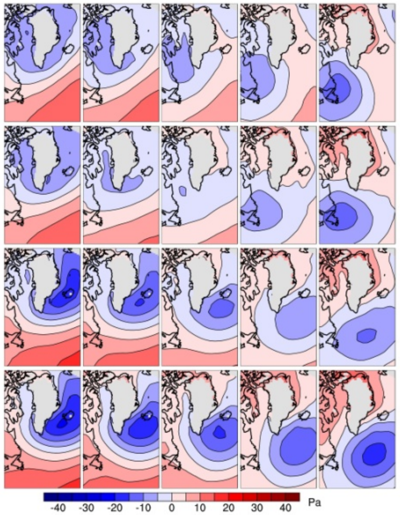
- sea level pressure anomaly
- lower dimensionality
  - better statistics
  - tradeoff
  - more generalized



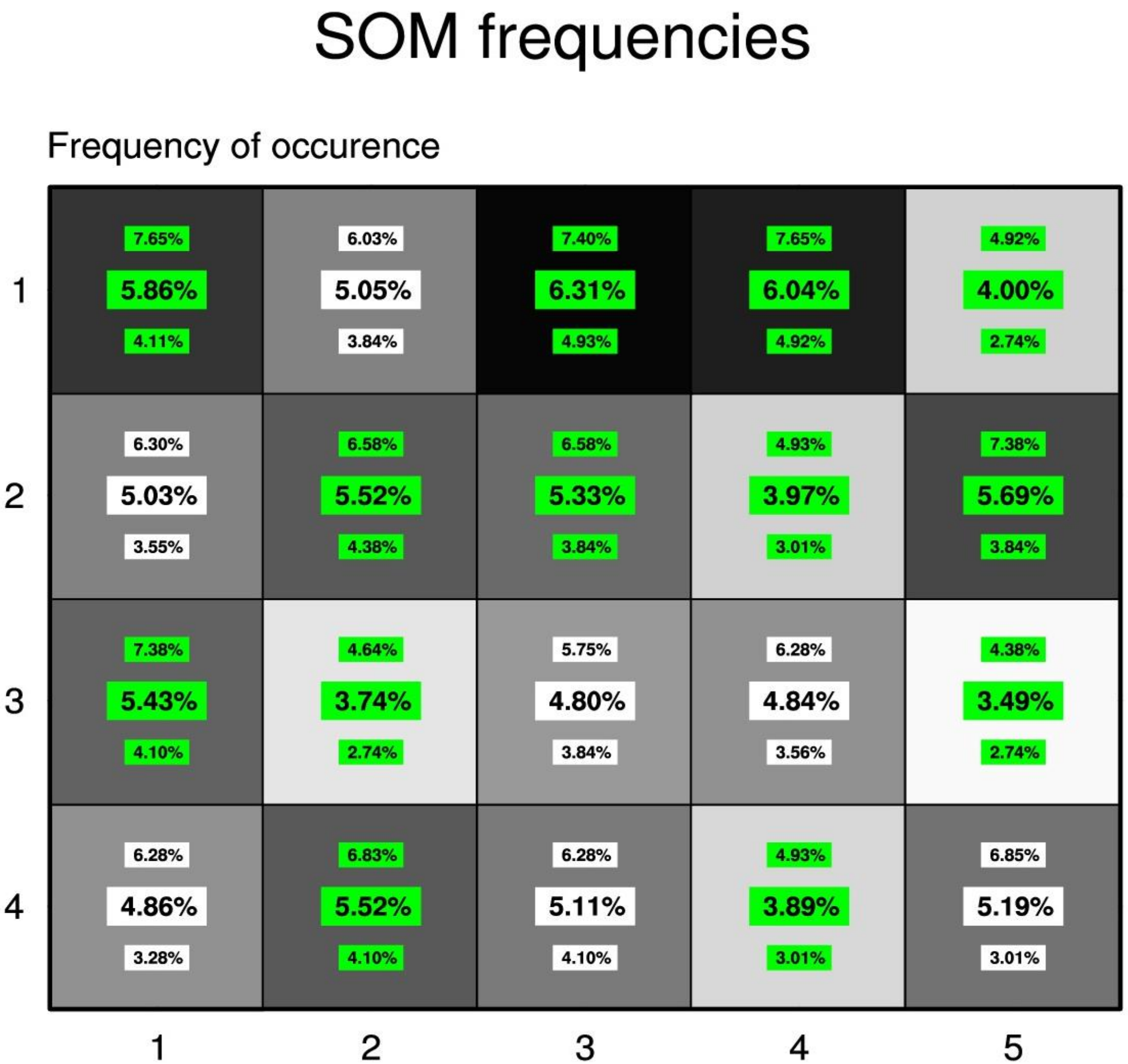
Schuenemann, K. C., and J. J. Cassano (2010)

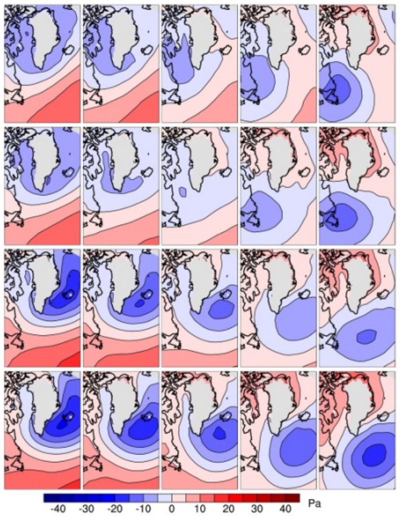
Frequencies



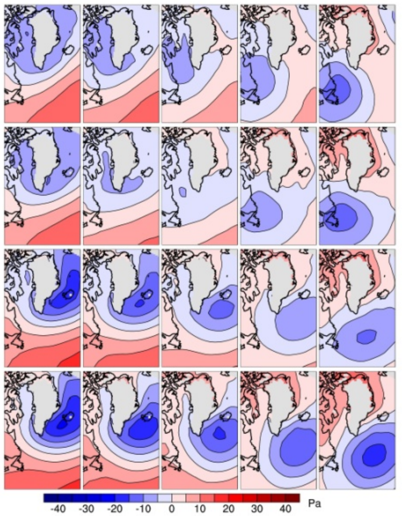


Frequencies



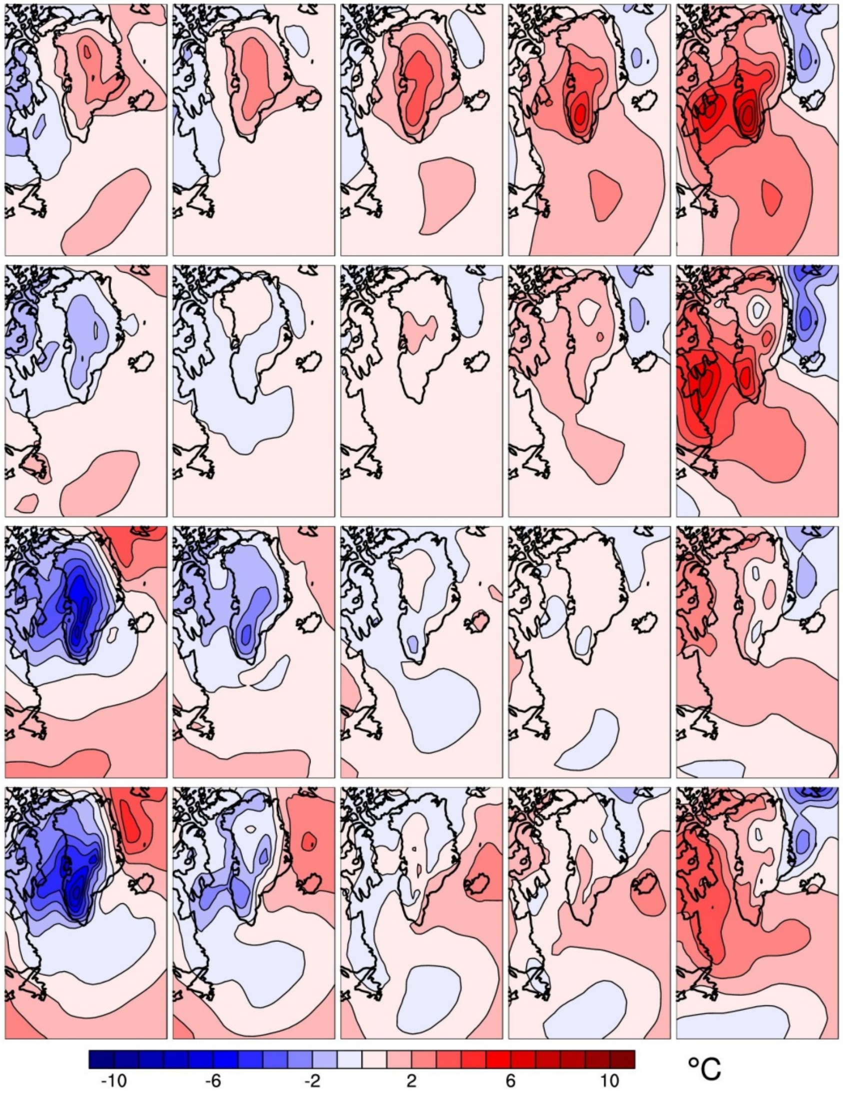


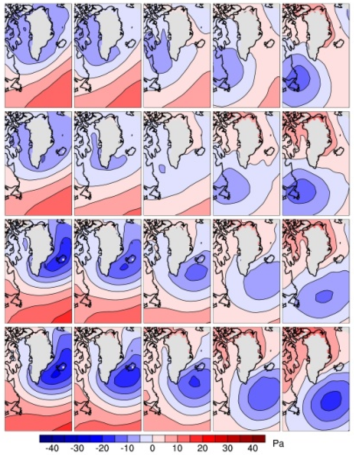
Frequencies



Softball

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

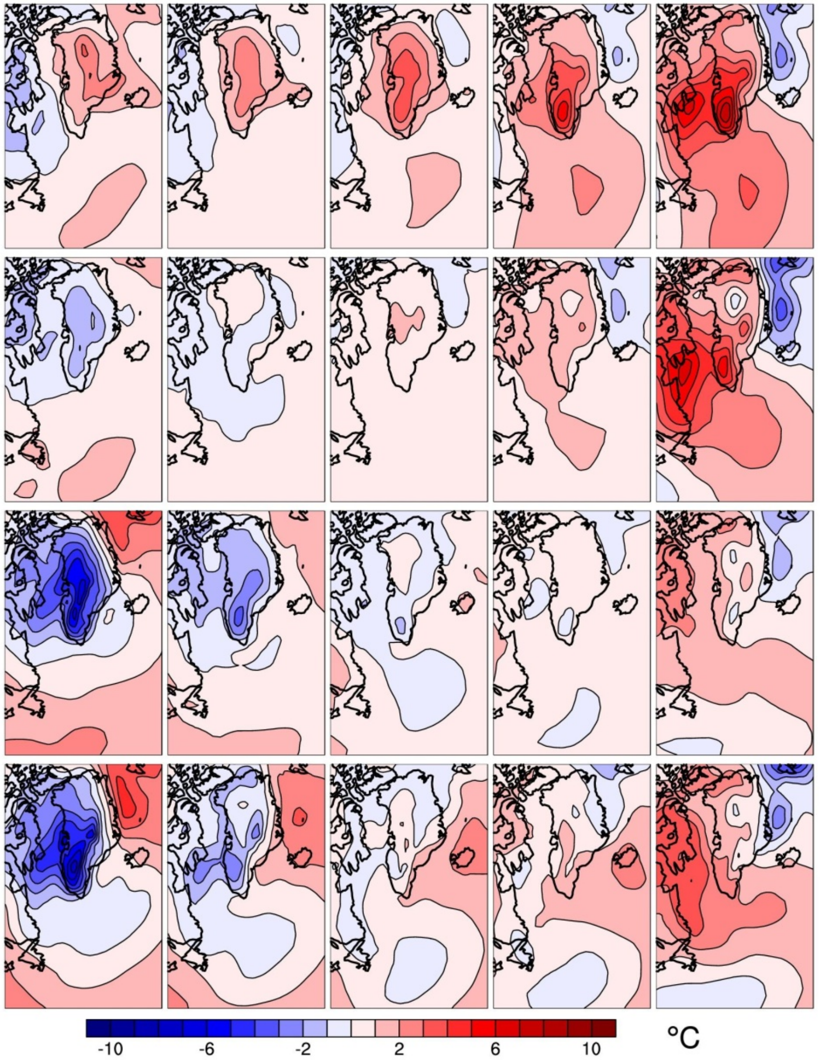




What about Summit?

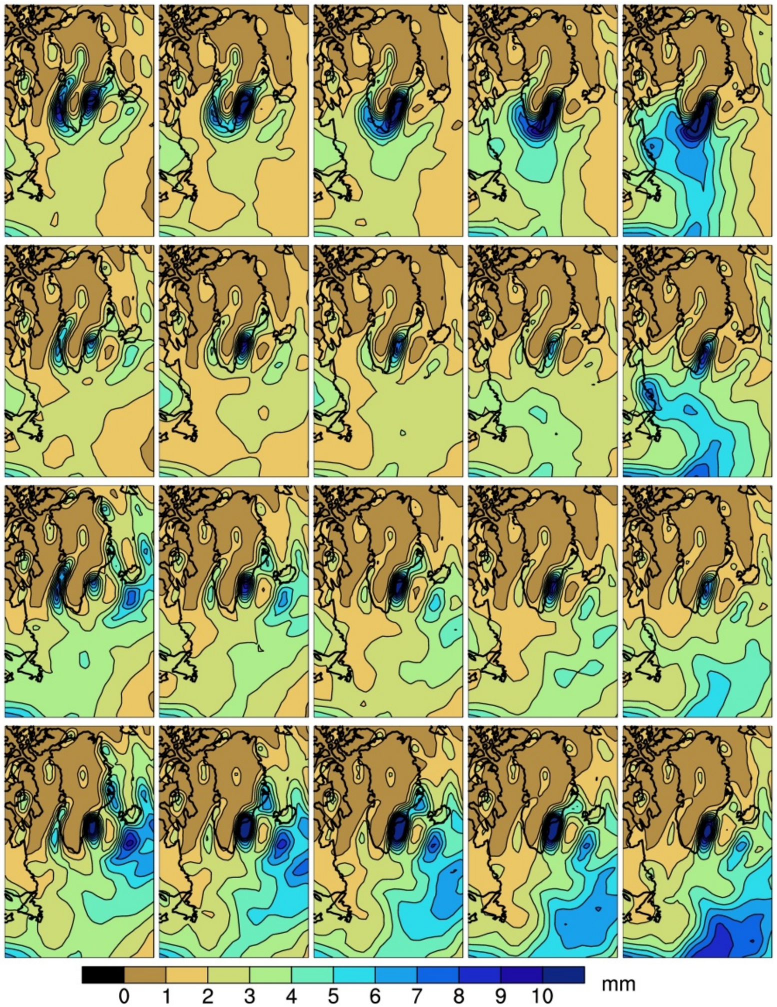
- value extracted from NCEP mapped spatial temperature anomaly

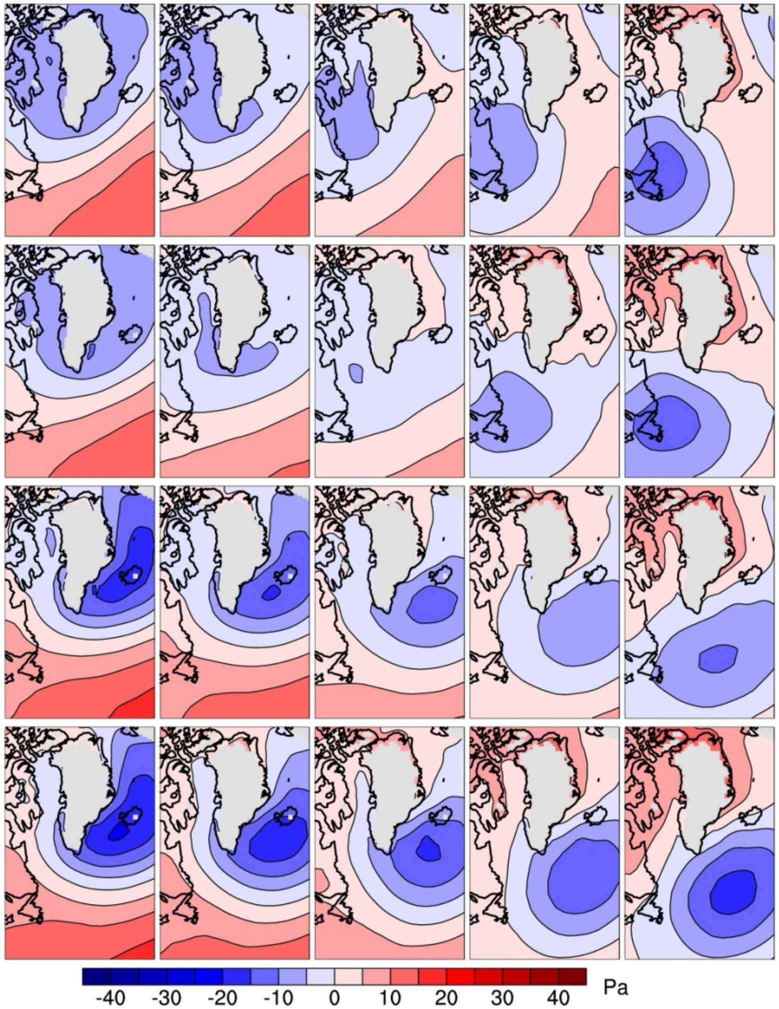
	1	2	3	4	5
1	5.64 2.45 -1.43	5.32 2.51 -1.02	6.25 2.90 -0.87	6.65 2.65 -1.69	8.77 3.22 -2.19
2	1.34 -1.56 -4.28	2.66 -0.11 -2.99	3.74 0.85 -2.24	4.86 1.19 -2.89	7.71 2.24 -3.33
3	-1.06 -5.56 -9.43	0.78 -2.80 -6.21	2.38 -0.76 -4.09	3.94 0.46 -3.24	5.33 0.66 -3.68
4	-1.12 -5.81 -10.70	2.56 -2.84 -8.06	4.30 -1.10 -6.21	4.83 -0.22 -5.15	5.68 0.44 -4.82



What about the bigger picture?

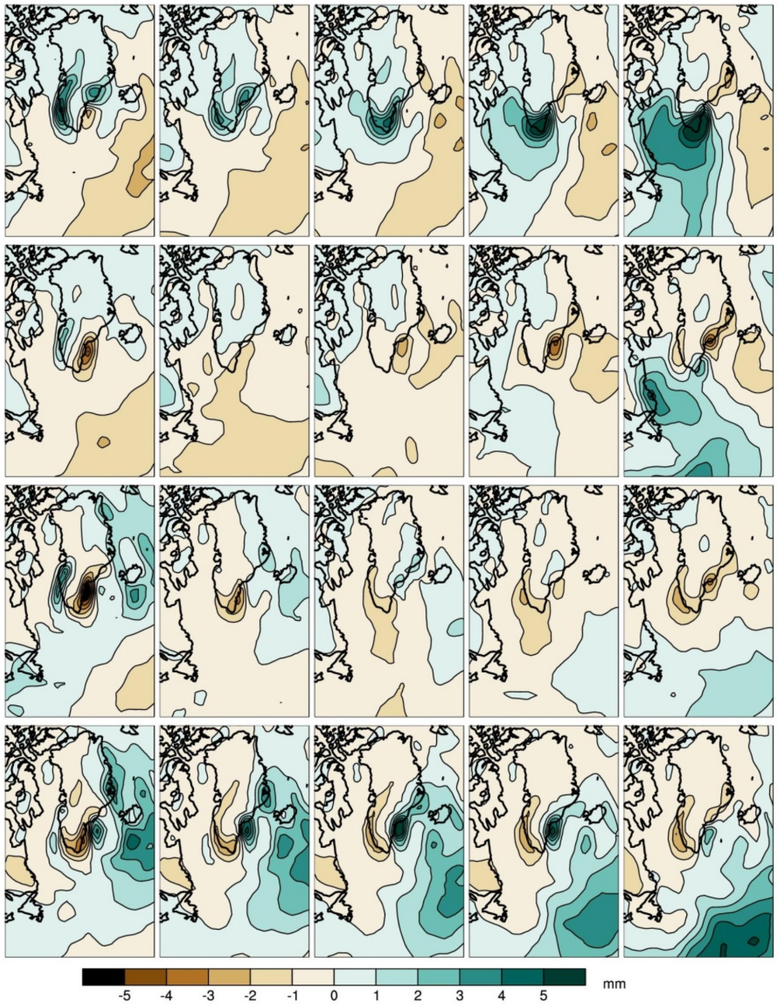
Precipitation

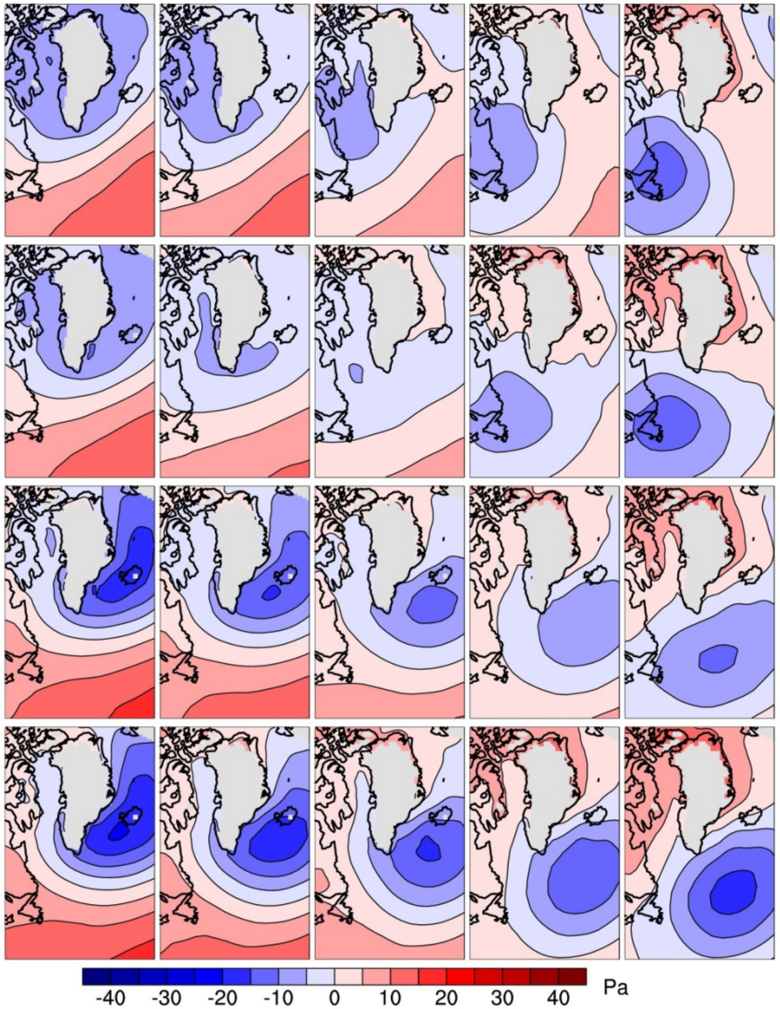




What about the bigger picture?

Precipitation Anomaly

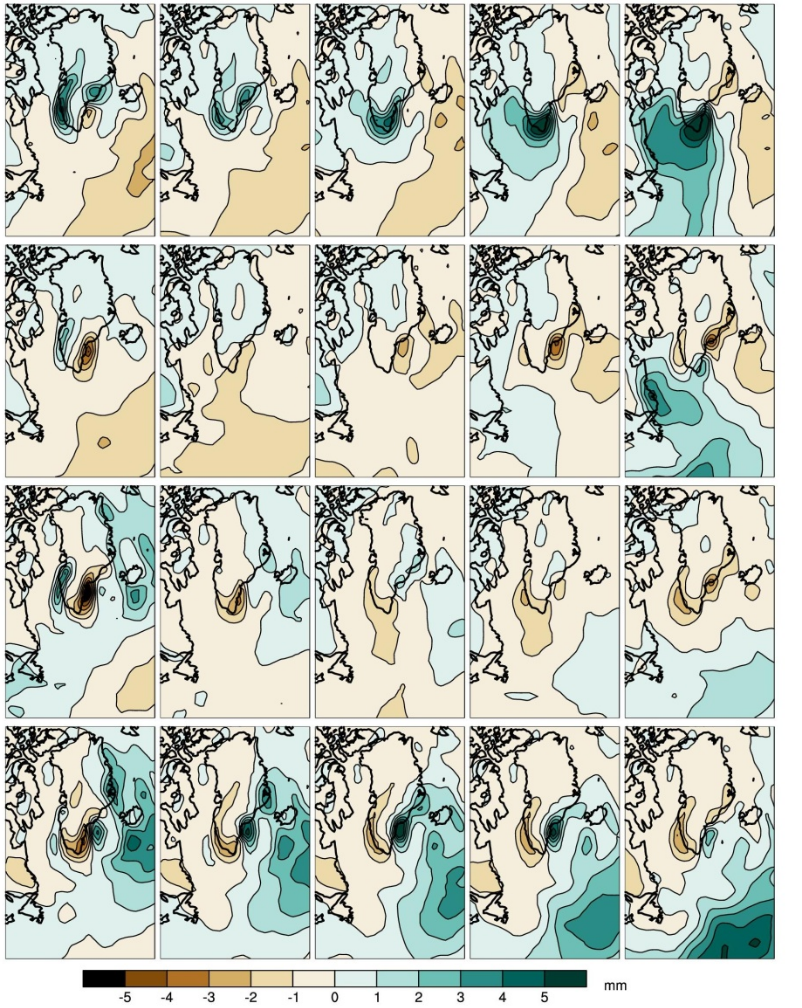




What about Summit?(again)

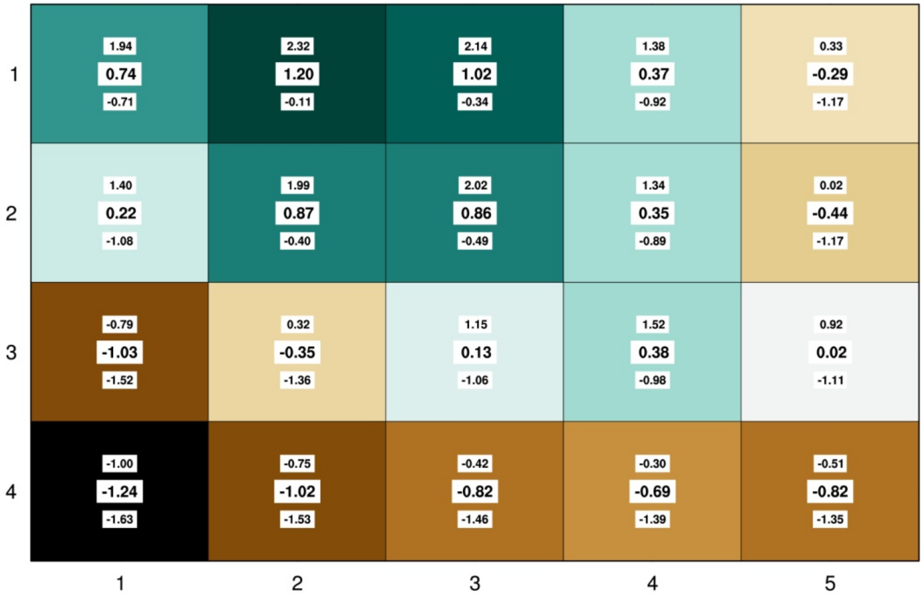
- precipitation anomalies (mm)

	1	2	3	4	5
1	1.51 0.57 -0.74	0.95 0.24 -0.94	1.01 0.24 -0.97	1.07 0.29 -0.85	1.31 0.45 -0.69
2	1.14 0.28 -0.88	0.35 -0.16 -1.09	0.64 -0.04 -1.09	0.89 0.16 -0.97	1.28 0.42 -0.72
3	1.02 0.22 -0.78	0.47 -0.16 -1.07	0.03 -0.38 -1.17	0.32 -0.22 -1.13	0.89 0.11 -1.03
4	0.23 -0.27 -1.02	-0.32 -0.63 -1.17	-0.39 -0.63 -1.19	-0.10 -0.50 -1.17	0.47 -0.18 -1.10

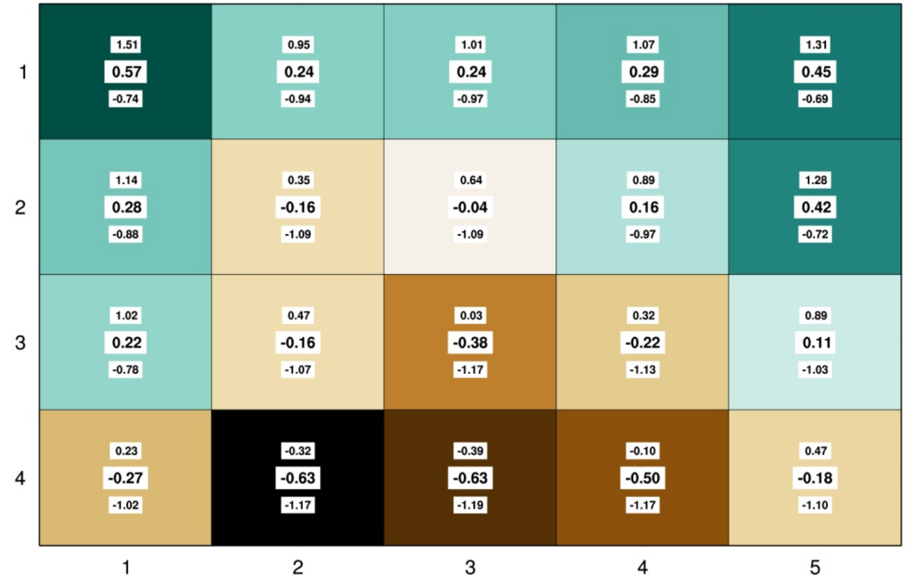


PWV vs Daily Precipitation (mm)

PWV Anomaly

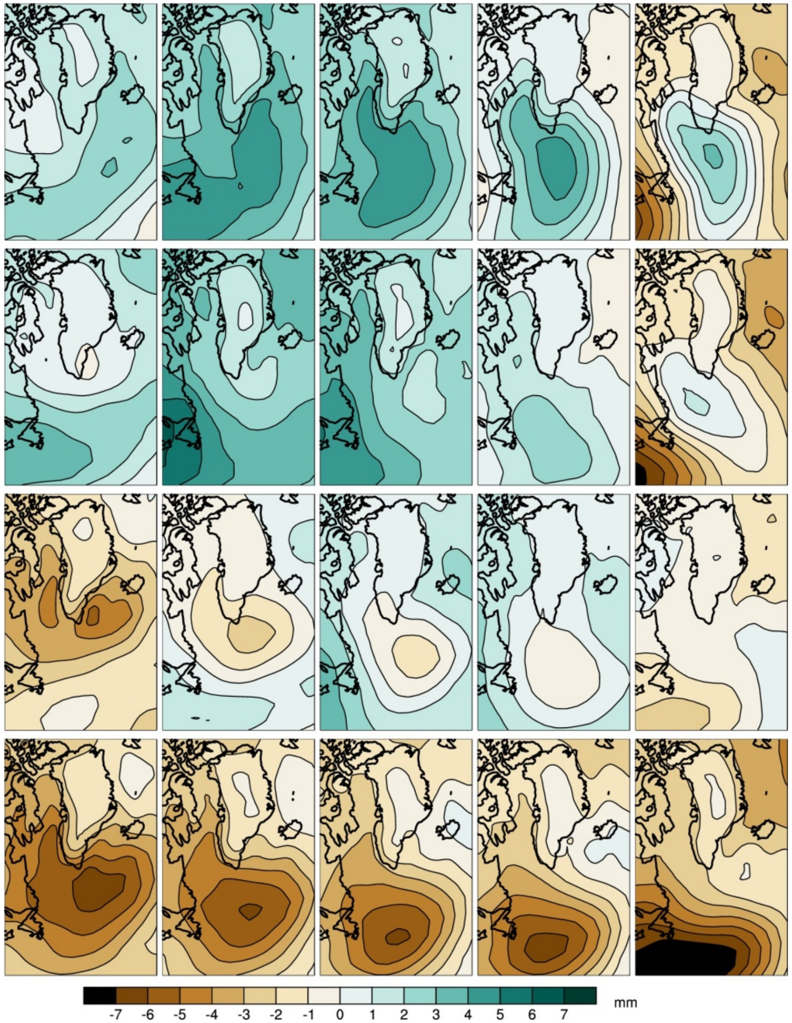


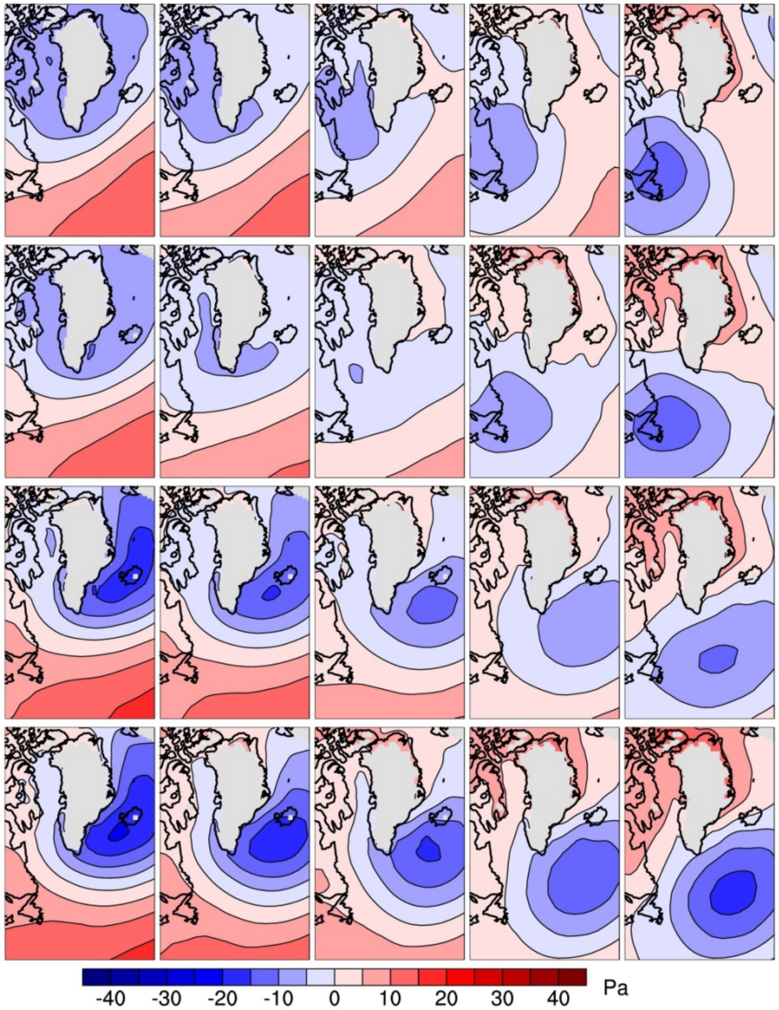
Precip Anomaly



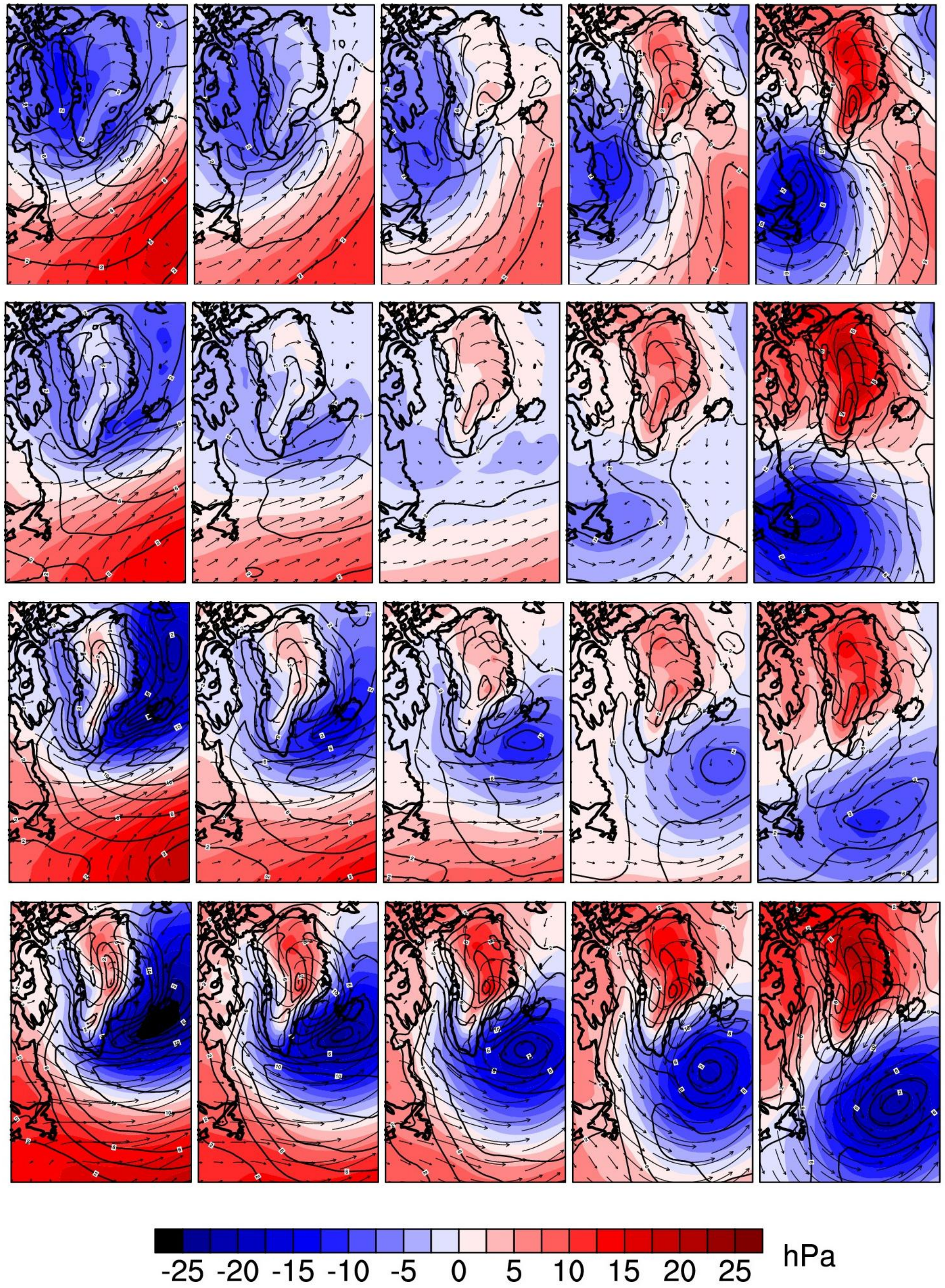
More bigger picture?

PWV Anomaly



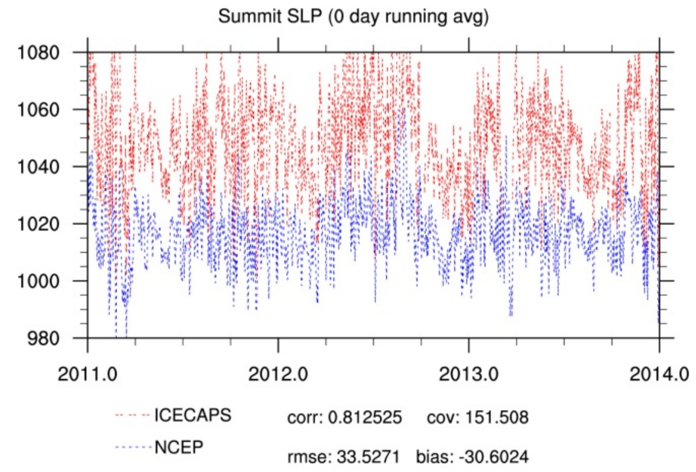


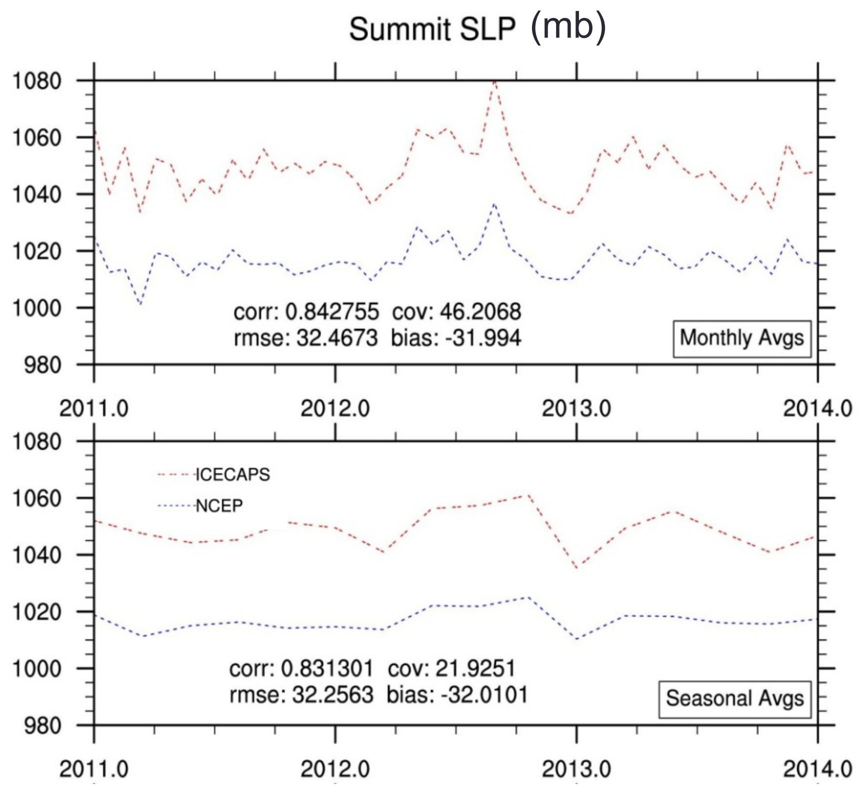
Pretty plot:

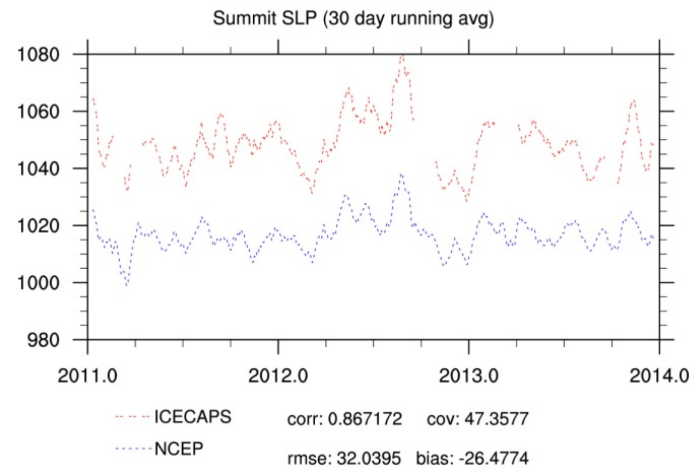


NCEP/ICECAPS SLP

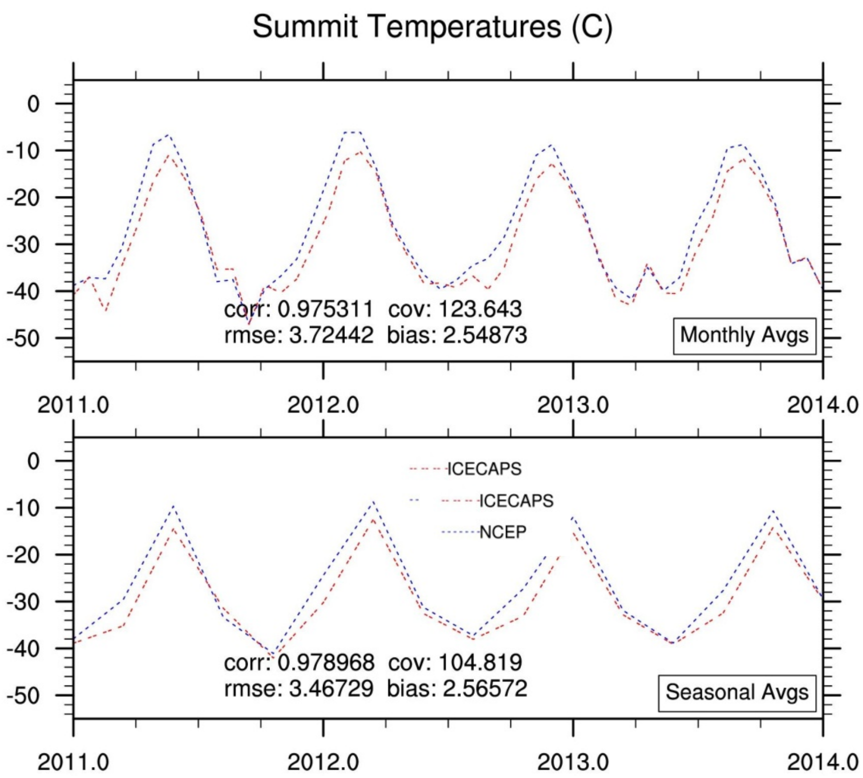
- calculated with station pressure and temp at Summit
- 23.117 km apart (as the crow flies)

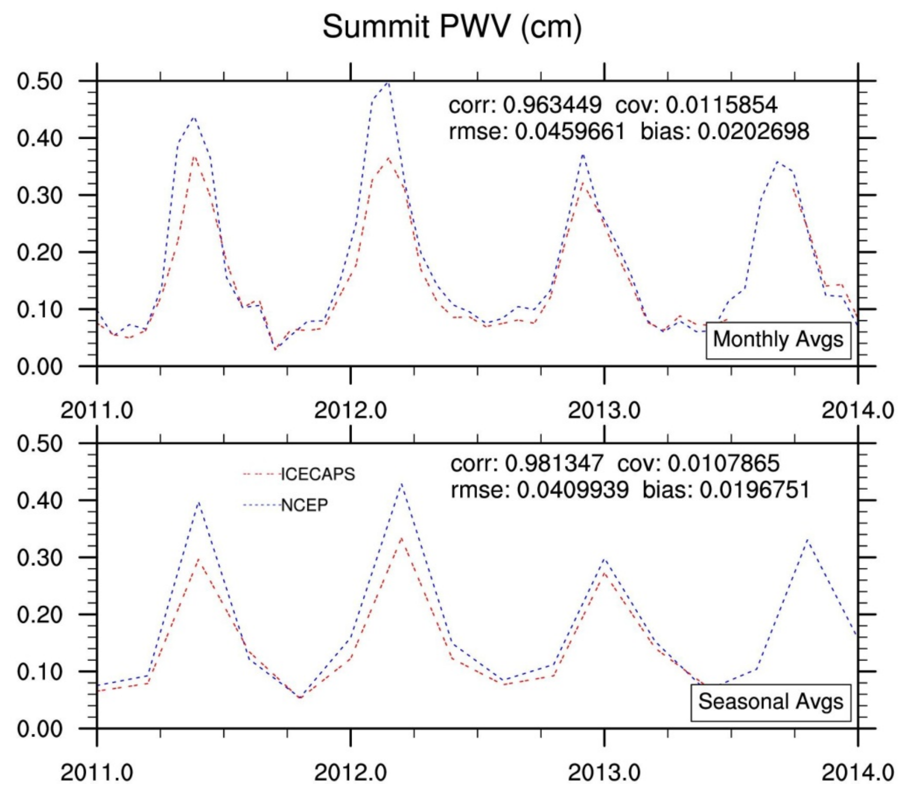




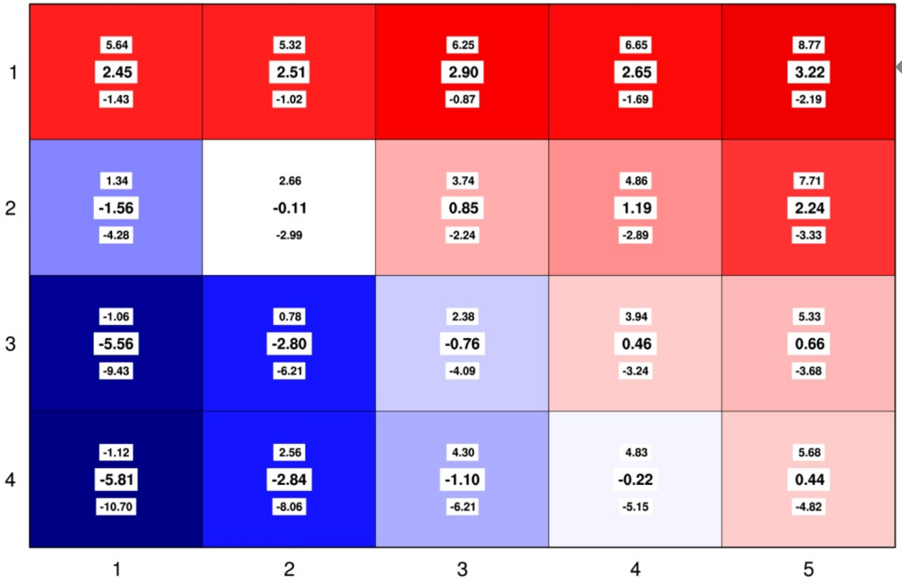


More comparisons

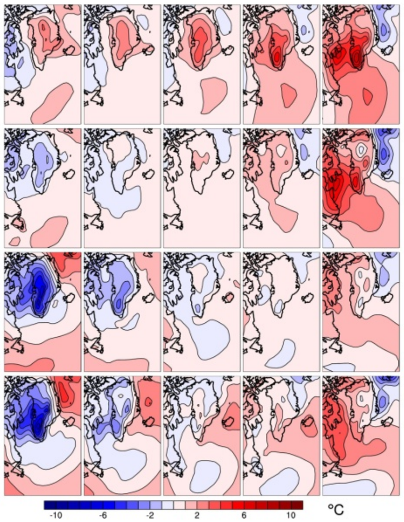




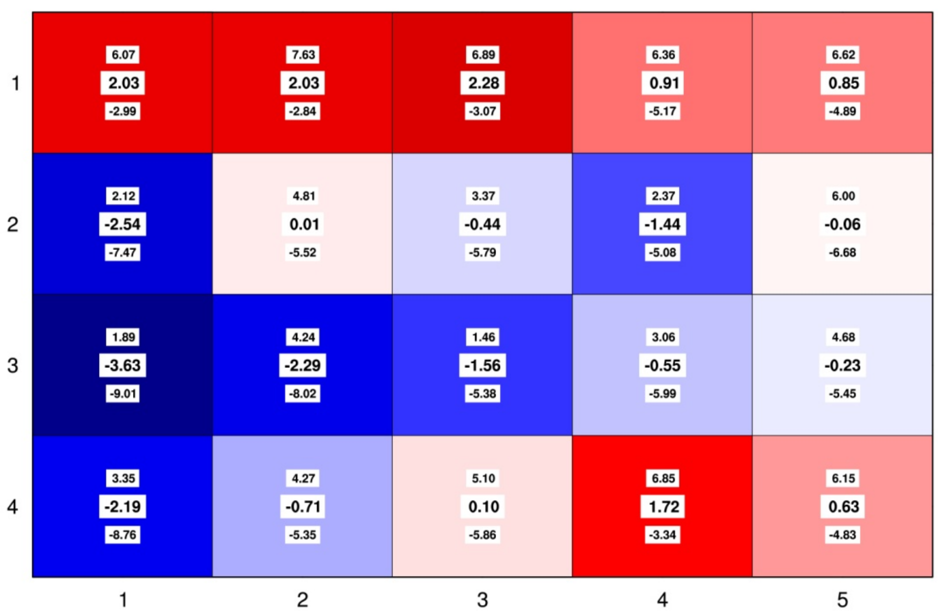
Temperature anomaly at Summit (°C)



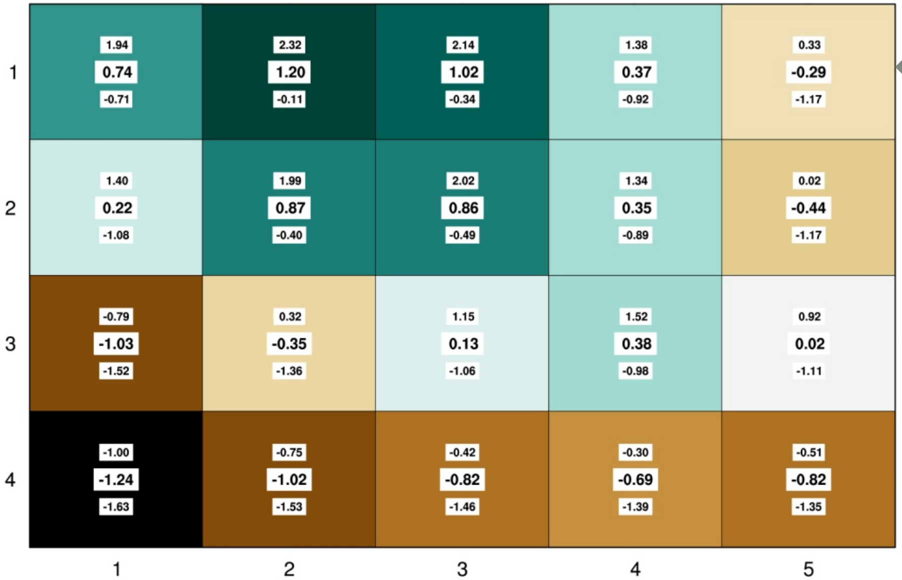
NCEP values



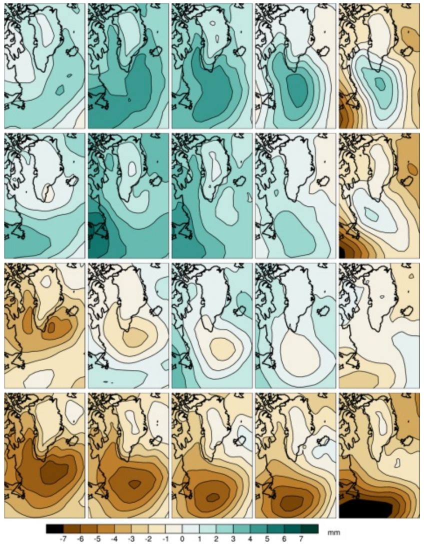
ICECAPS values

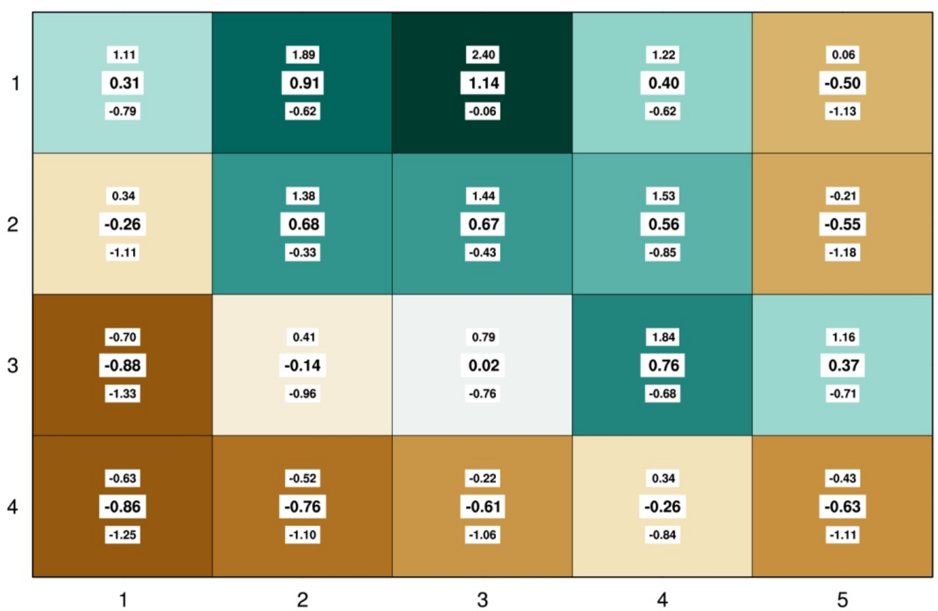


PWV at Summit (mm)



NCEP values

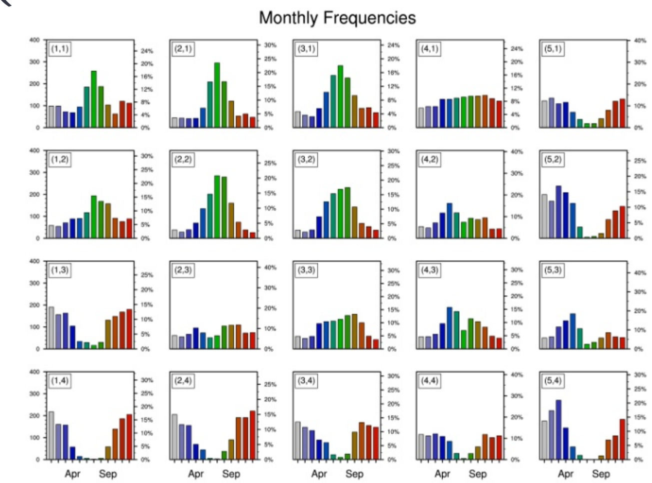


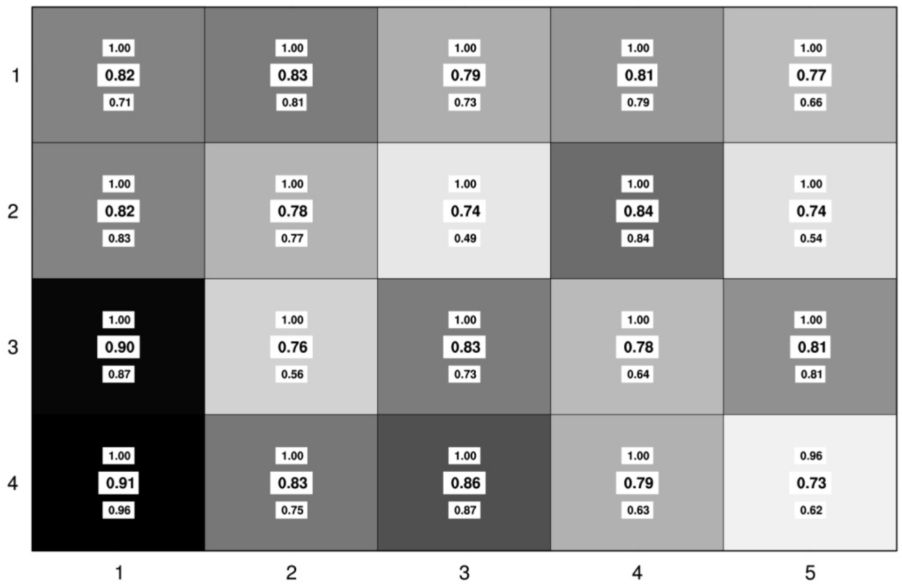


ICECAPS values

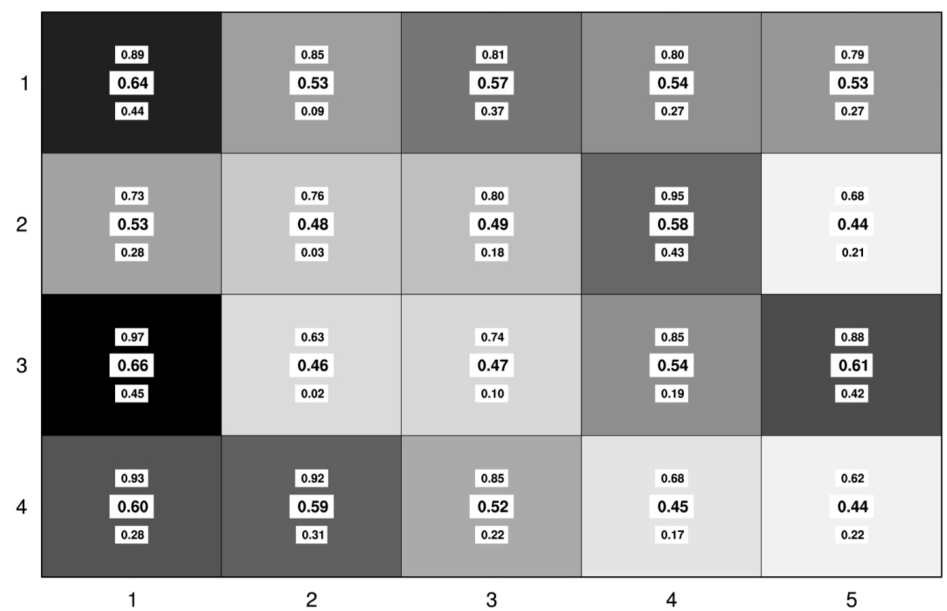
Cloud fraction

low clouds (<1km)



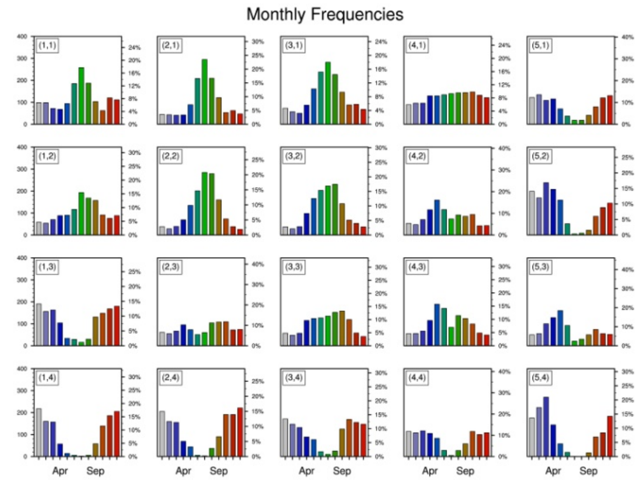


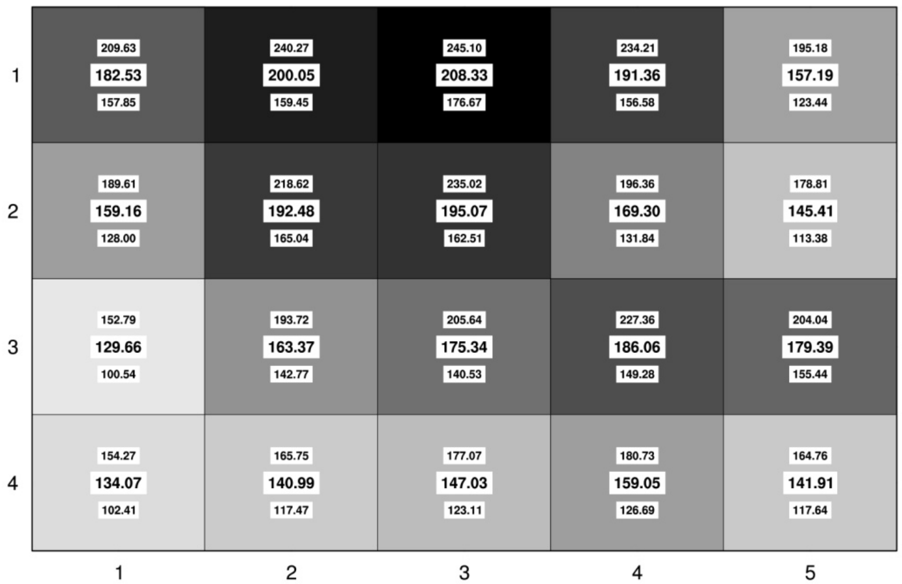
high clouds (>2km)



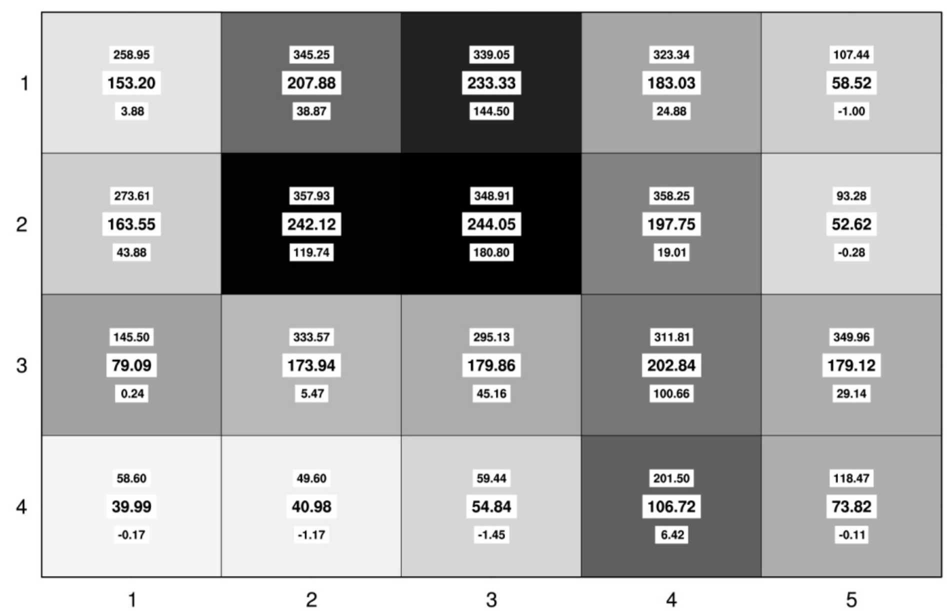
Radiation

LWD (W/m2)





SWD (W/m2)



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