A Description of the Ross Ice Shelf Air Stream (RAS) Through the Use of Self-Organizing Maps

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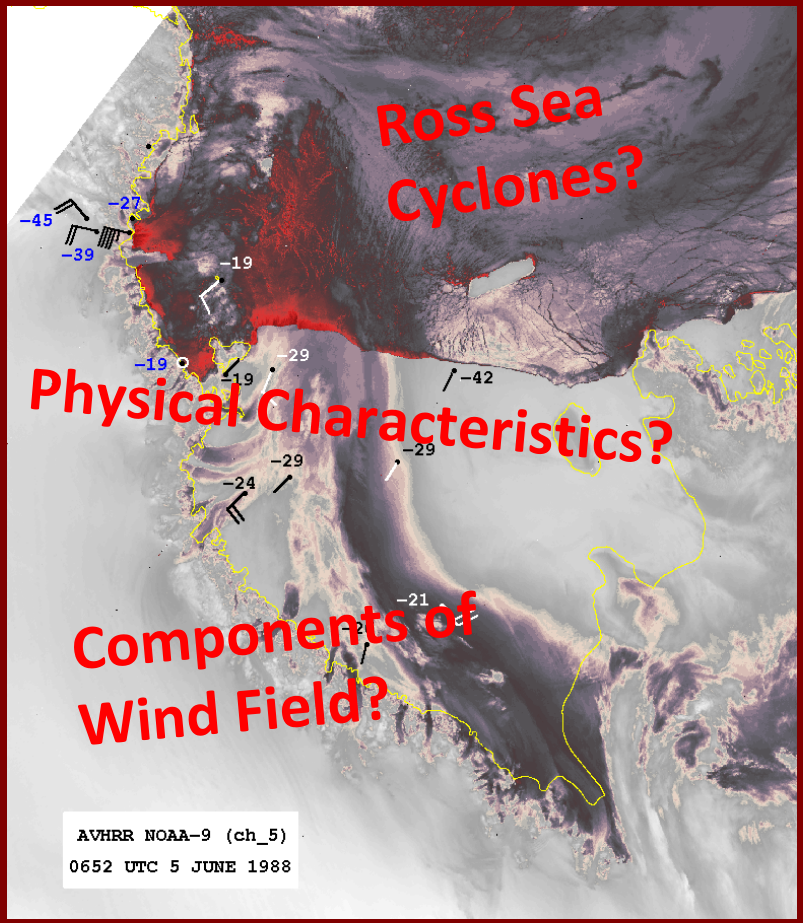
Outline

- Background information: RAS, surface winds, AMPS
- Horizontal wind at ~ 150 m
- Introduction to the SOM methodology
- SOM of 5th sigma-level horizontal wind field
  - Seasonality
  - Corresponding sea-level pressure
- Four distinct patterns in the SOM
  - Corresponding wind rose patterns
- Frequent node transitions

Ross Ice Shelf Air Stream (RAS)

- A northward moving air stream in the lower atmosphere over the western Ross Ice Shelf

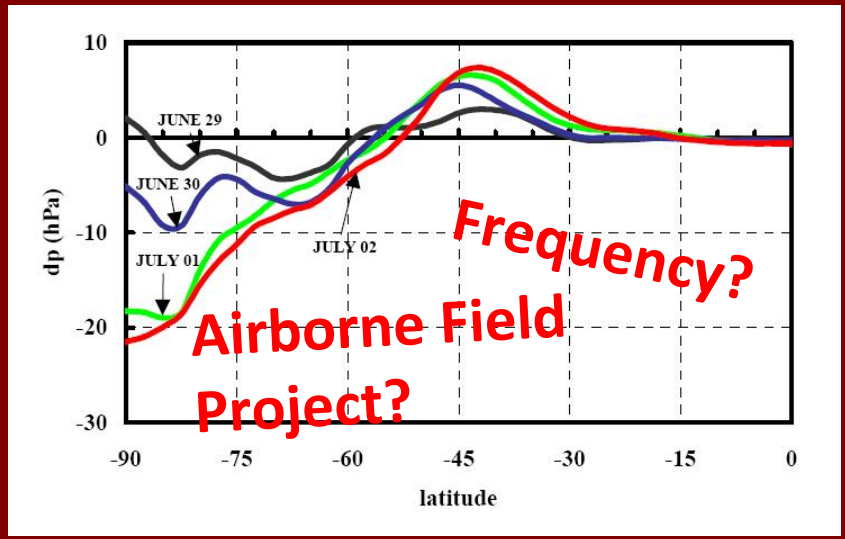


June 5, 1988
(Carrasco and Bromwich, 1993)

Seasonal Dependence?

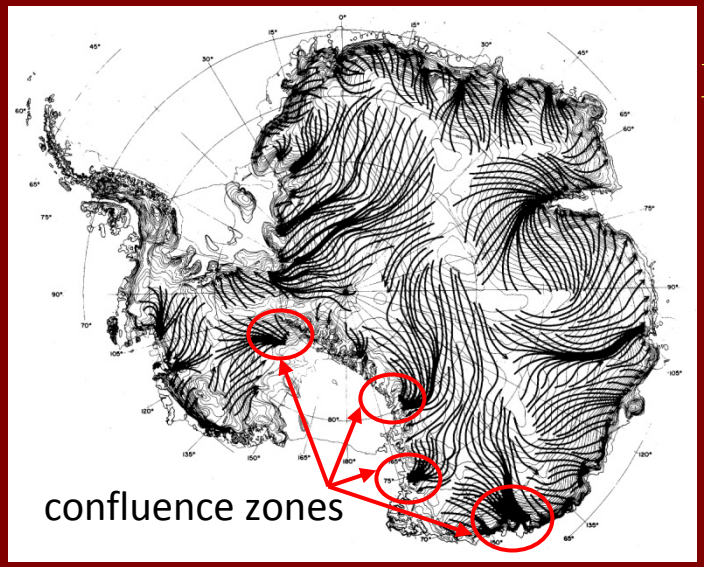
AWS Observations?

- The RAS results in a significant atmospheric mass transport away from the Antarctic continent

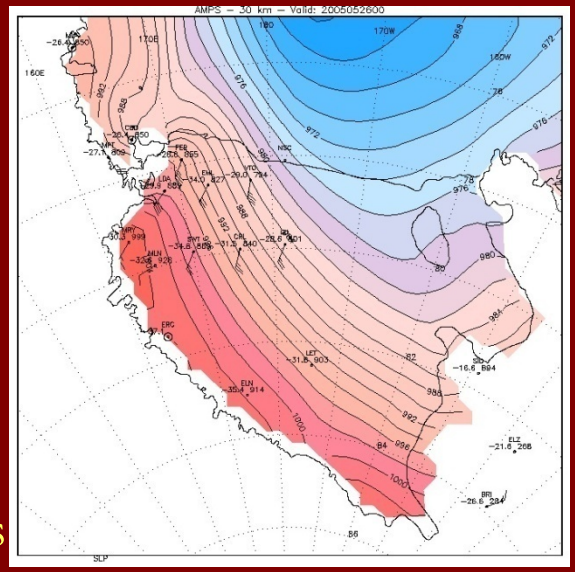


Zonally-averaged changes in surface pressure from 00 UTC 28 June 1988, based on ECMWF analyses. (Parish and Bromwich 1998)

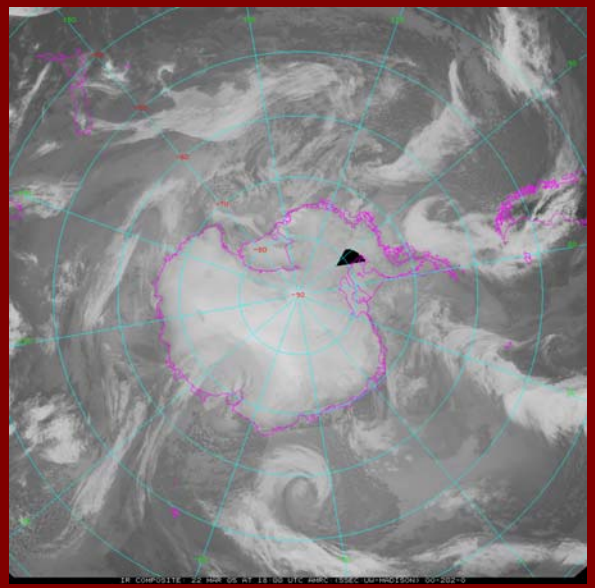
Ross Ice Shelf - Surface Wind Features



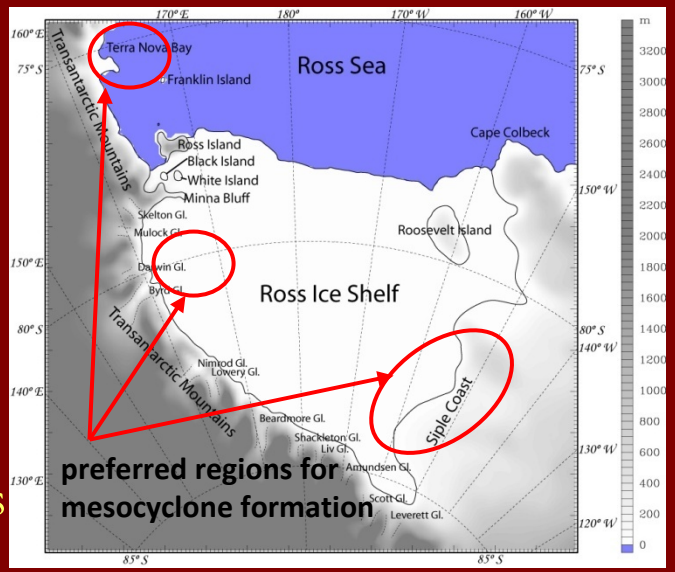
Katabatic Winds



Barrier Winds



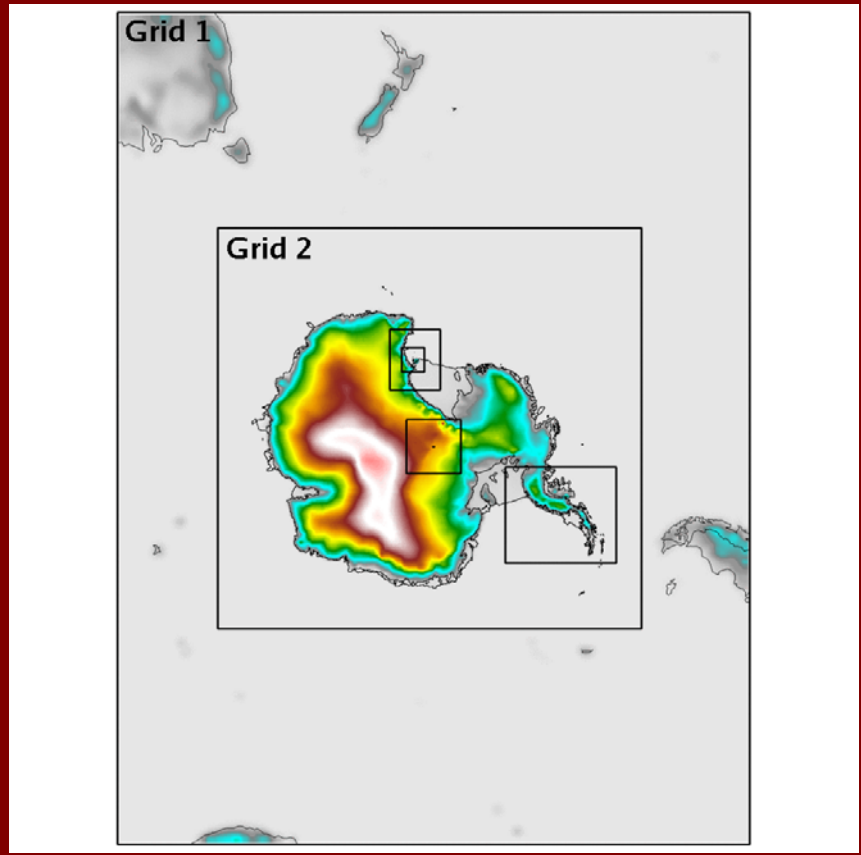
Cyclones



Mesocyclones

Antarctic Mesoscale Prediction System (AMPS)

- Real-time numerical weather prediction for Antarctica
- Run twice daily at 00 and 12 UTC
- The 12h, 15h, 18h, and 21h valid forecast hours are used to make a continuous time series
- The time series consists of 14,273 time slices from 2001 – 2005 using the Polar MM5 30-km domain

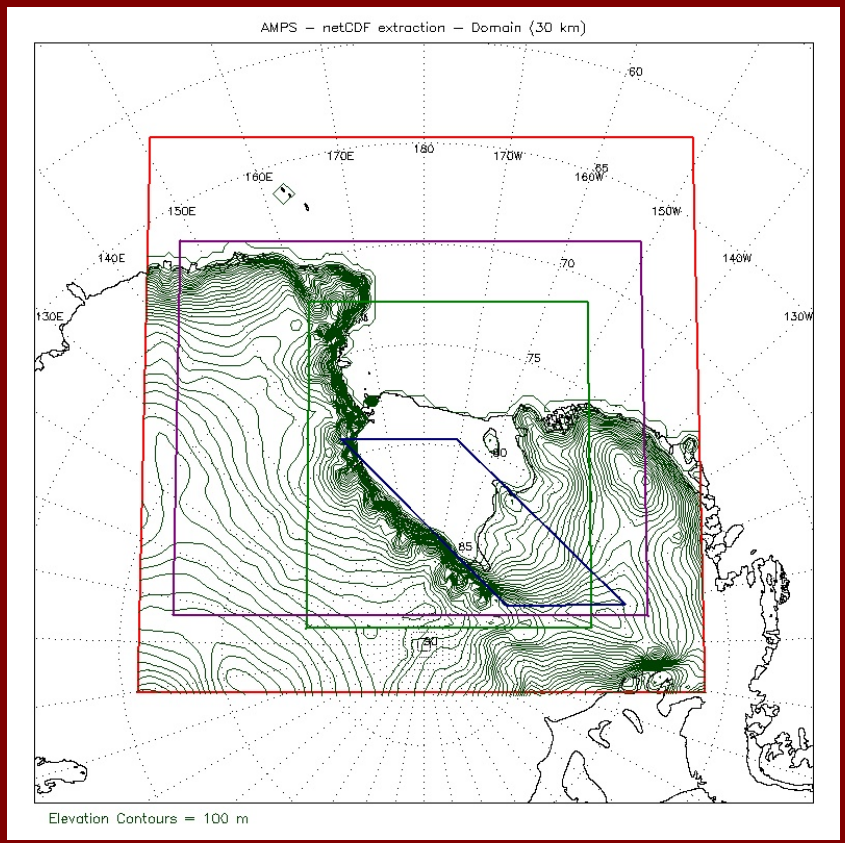


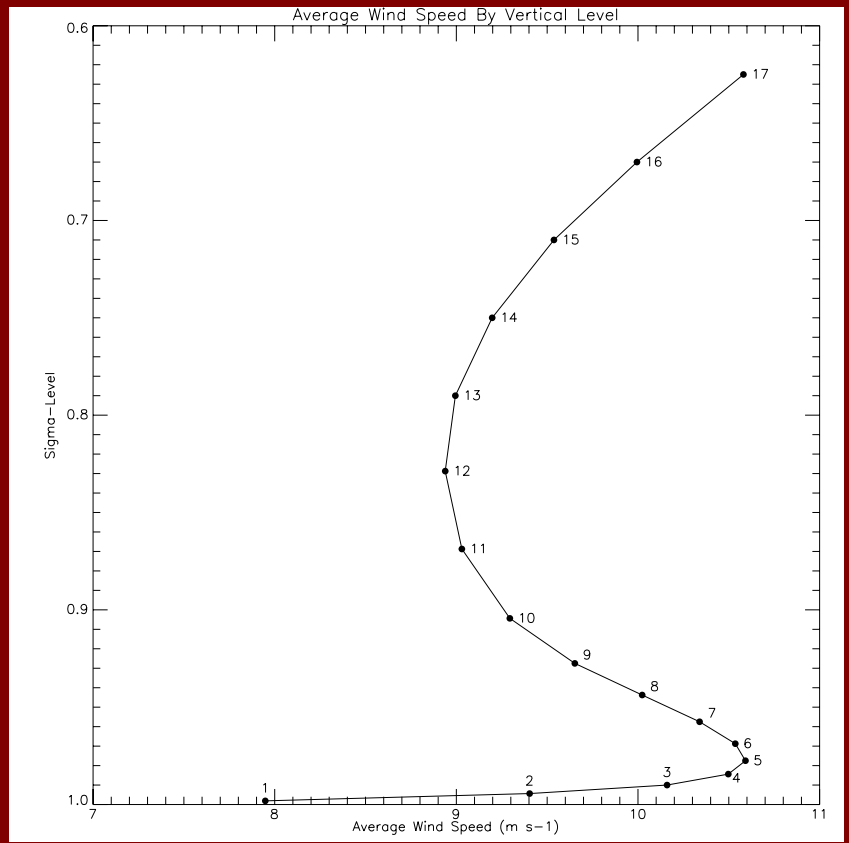
Powers et al. (2003)

Bromwich et al. (2005)

Vertical Profile of Wind Speed

- The maximum average wind speed in the lower atmosphere occurs at the 5th sigma-level





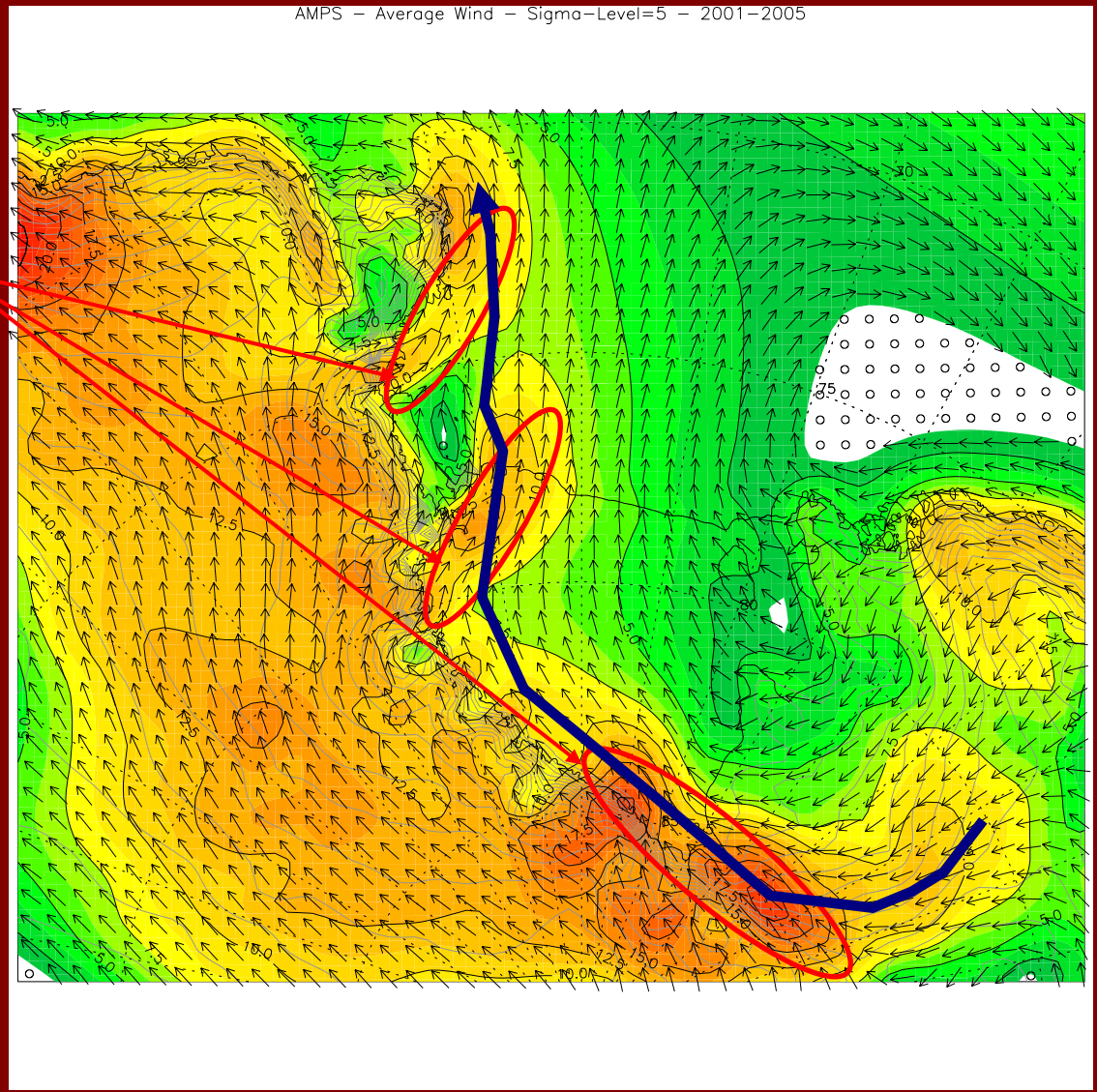
Mean Wind Speed for the 5th Lowest Sigma-Level

- The low-level wind field is pronounced at the 5th lowest sigma-level (~ 150 m AGL).

- There are three distinct low-level jets across the Ross Ice Shelf / Sea

Seefeldt and Cassano (in press)

- The RAS is visible across the western Ross Ice Shelf / Sea



Method of Self-Organizing Maps (SOMs)

- A method to objectively stratify large volumes of data into a smaller number of recurring patterns on a physically meaningful basis
- The end product is the clustering of the data into a user selected number of nodes (patterns) which span the range of the data space
- Projects high-dimensional data onto a low-dimension (2D) surface
- During the training process the algorithms modify the node with the closest match as well as the neighboring
- Similar nodes are placed next to each other and very different nodes are placed in the corners and along the edges
  - node-by-node analysis as well as area-by-area analysis

Kohonen (2001)

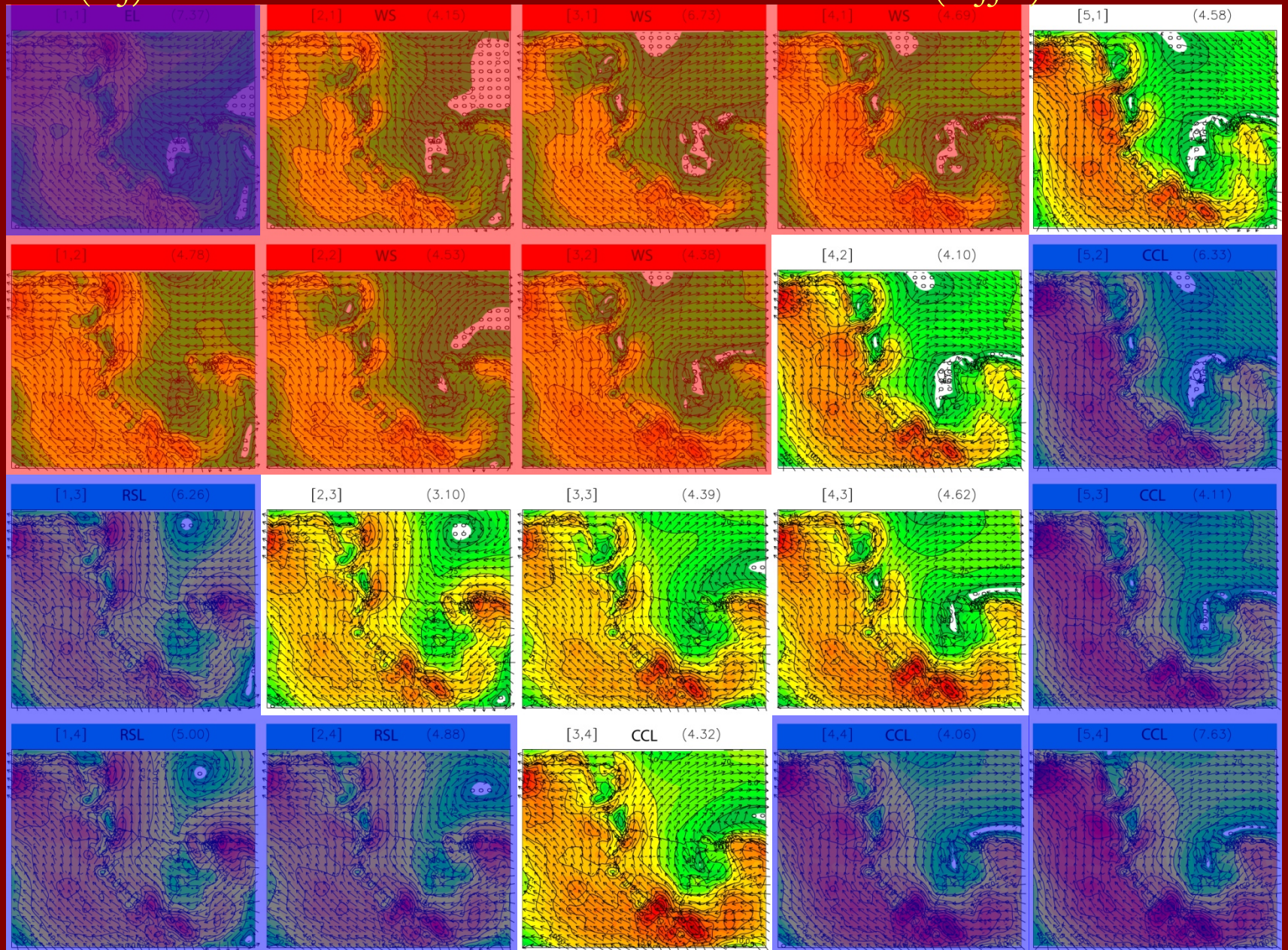
Hewitson and Crane (2002)

Cassano et al. (2006)

SOM of 5th Sigma-Level Horizontal Wind

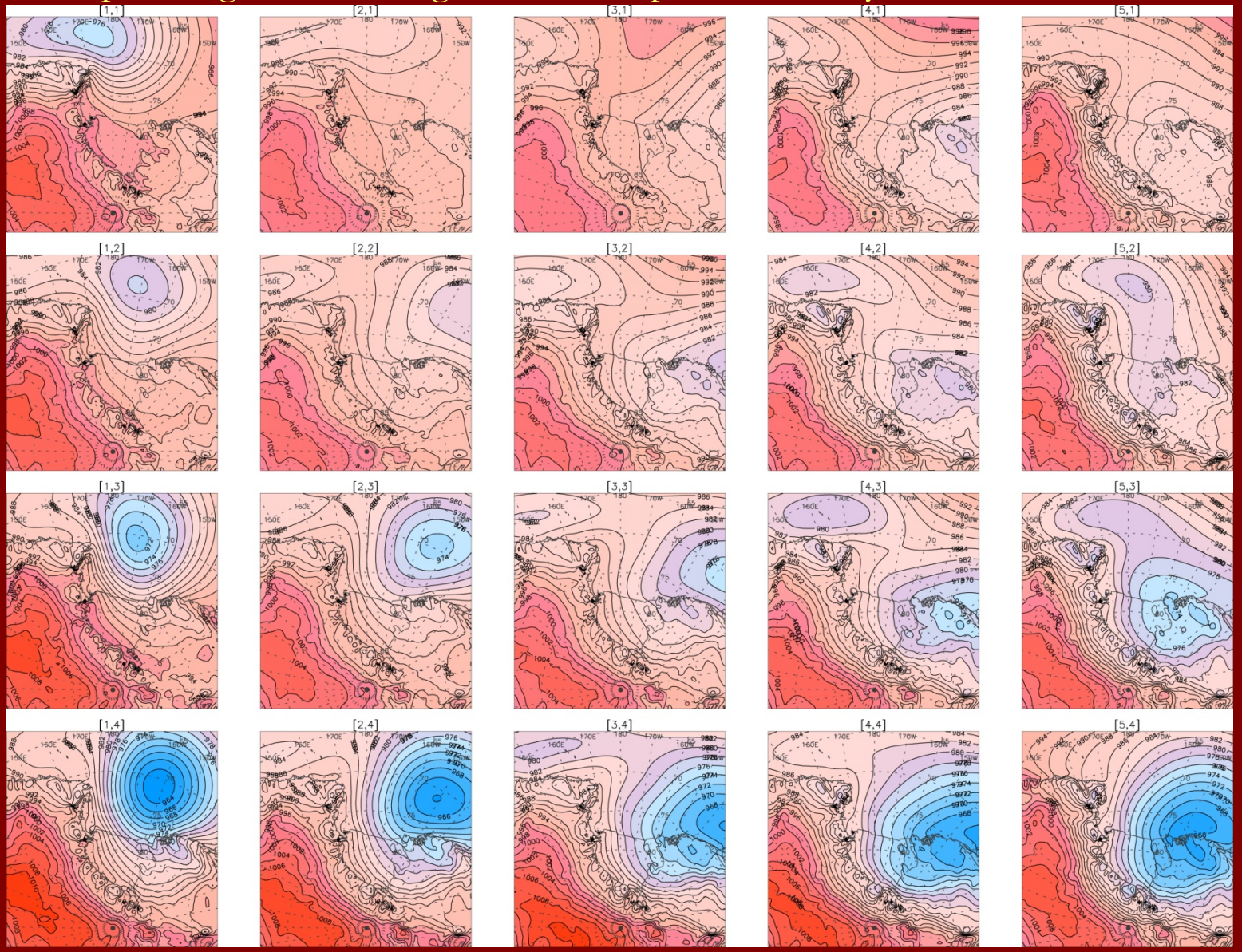
Summer (DJ) – 7 nodes – 82%

Winter (MJJA) – 8 nodes – 67%



SOM of 5th Sigma-Level Horizontal Wind

- Corresponding node-averaged sea-level pressure analyses.

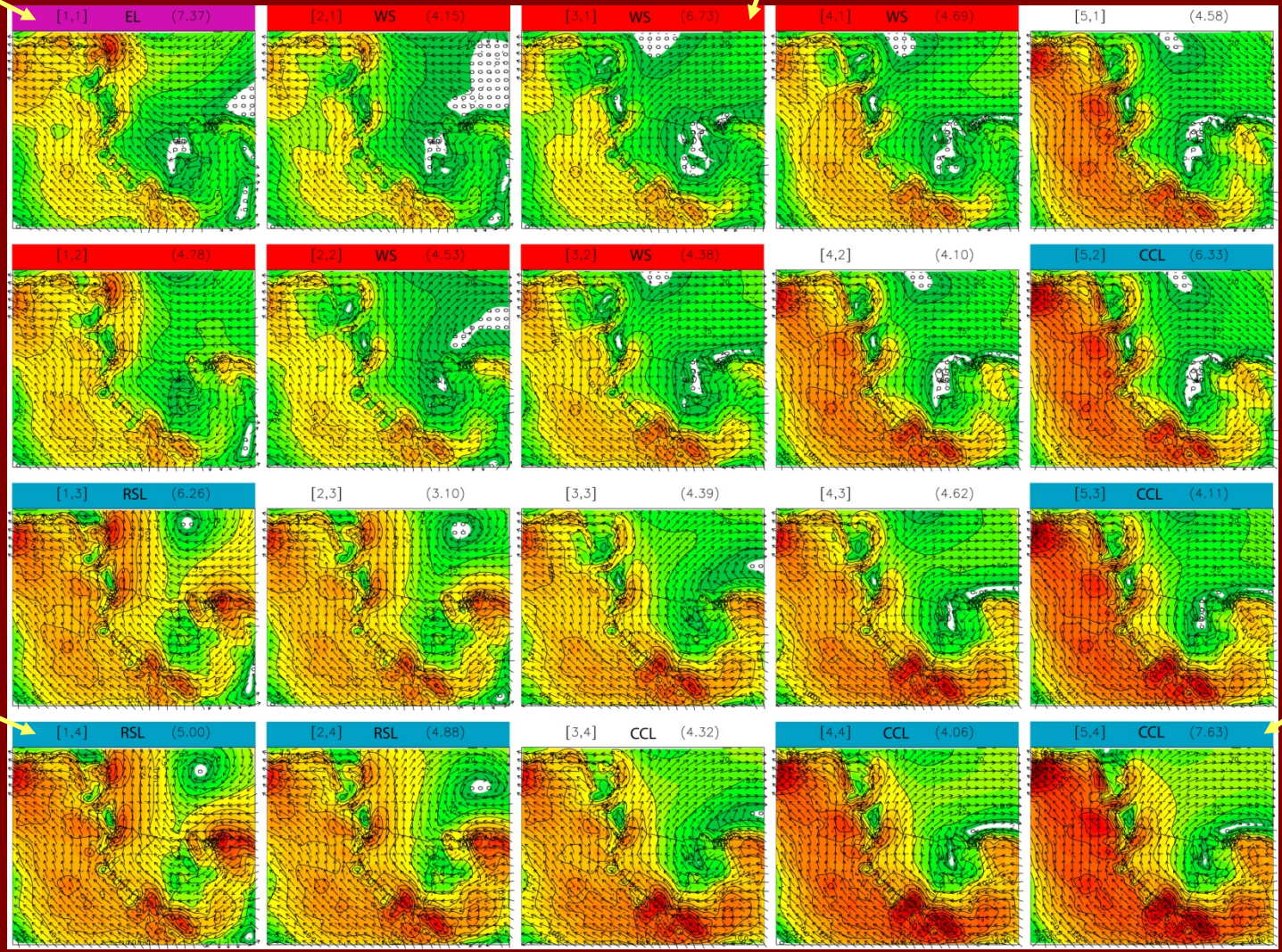


SOM of 5th Sigma-Level Horizontal Wind

- There are four distinct patterns across the SOM

Elongated Low

Weak Synoptic



Ross Sea Low

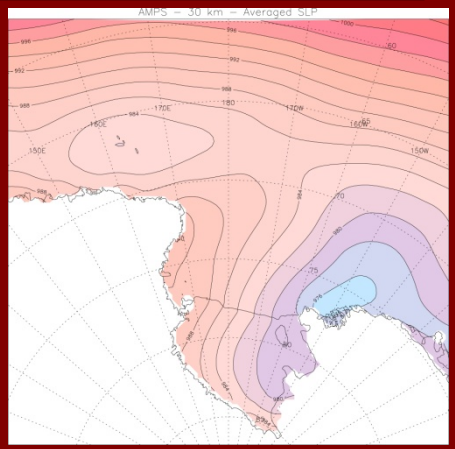
Cape Colbeck Low

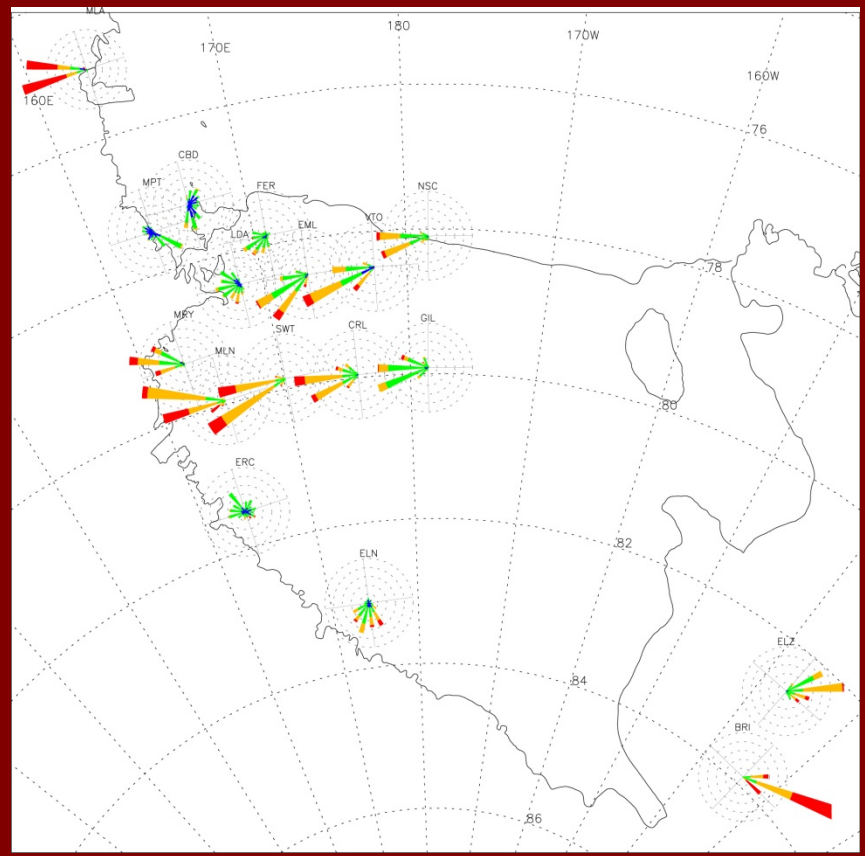
Dominant Wind Regimes

- Dominant wind regimes are defined to separate the AWS observations into common patterns
  - barrier wind, strong katabatic wind, weak katabatic wind, light wind
- Observations are selected by matching AWS observations to a set criteria (wind speed and wind direction)

Ex: Strong Katabatic Regime

AWS Site	Wind Dir.	Wind Speed
Marilyn	236º - 304º	>= 5.0 m s^{-1}
Schwerdtfeger	214º - 304º	>= 5.0 m s^{-1}

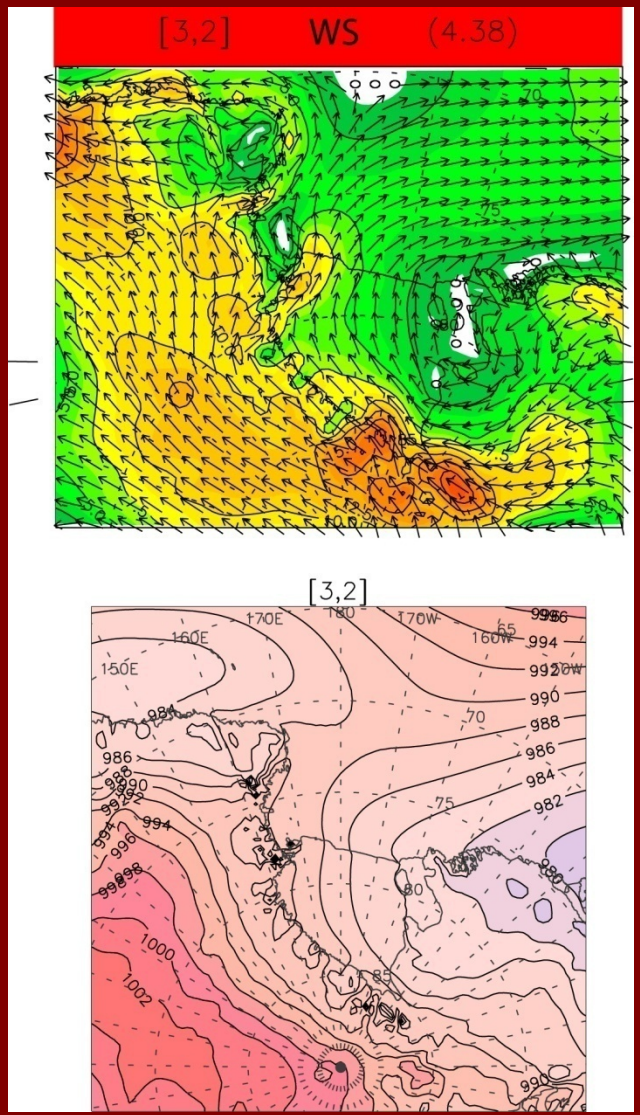


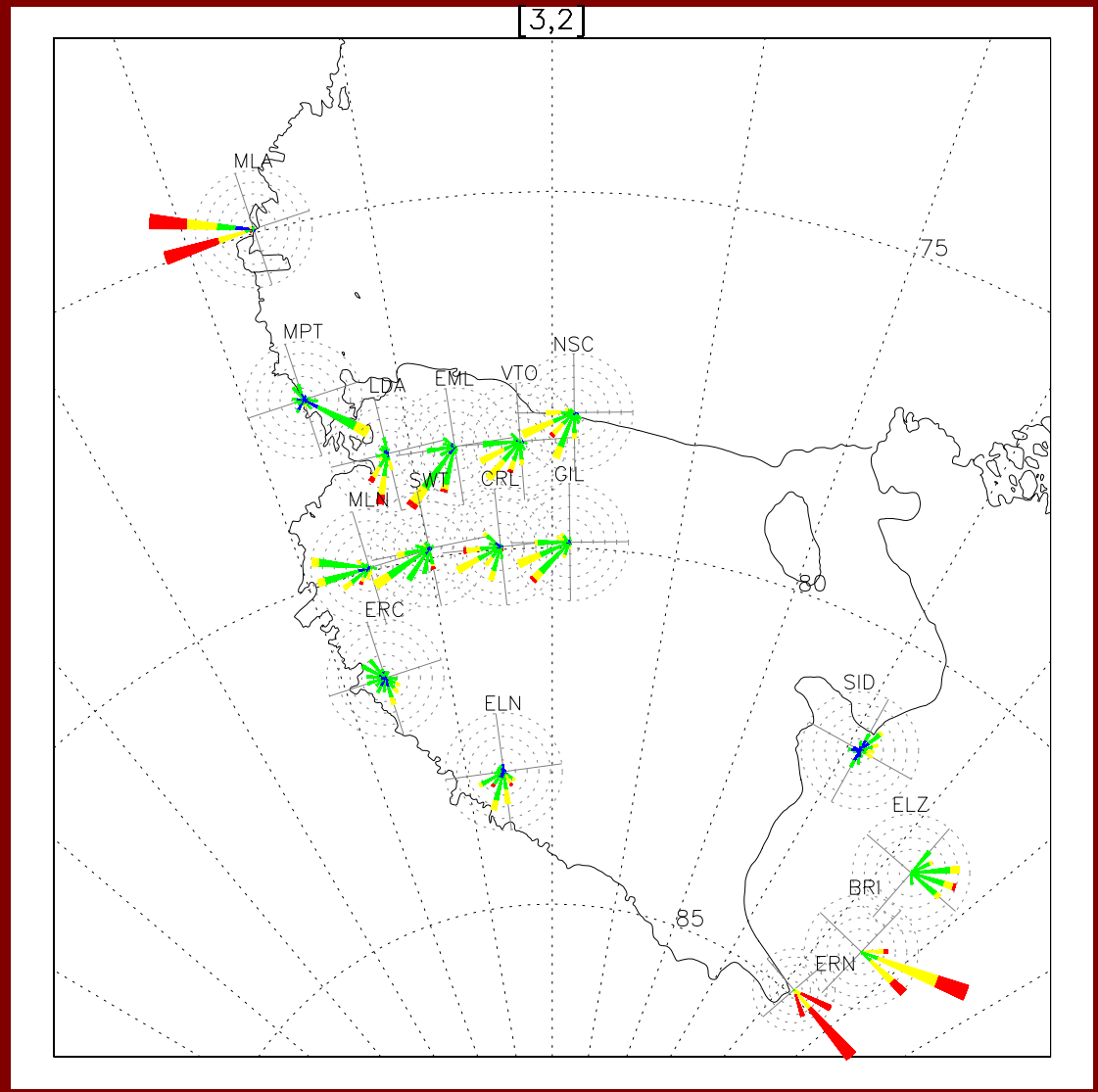


Seefeldt et al. (2007)

SOM Pattern Analysis / AWS Wind Rose

Weak Synoptic – Node [3,2]

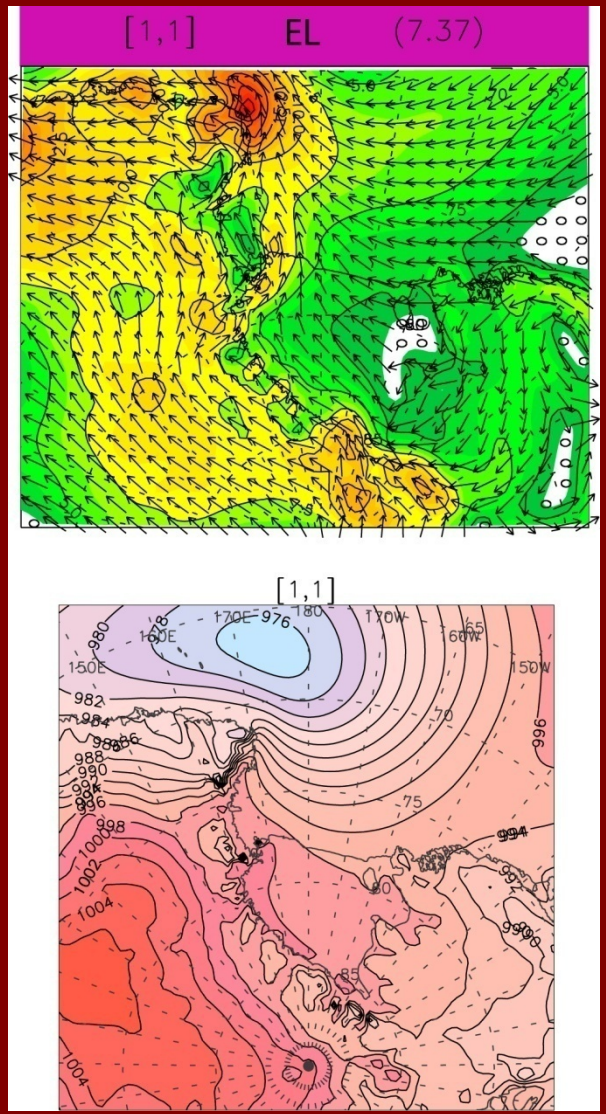


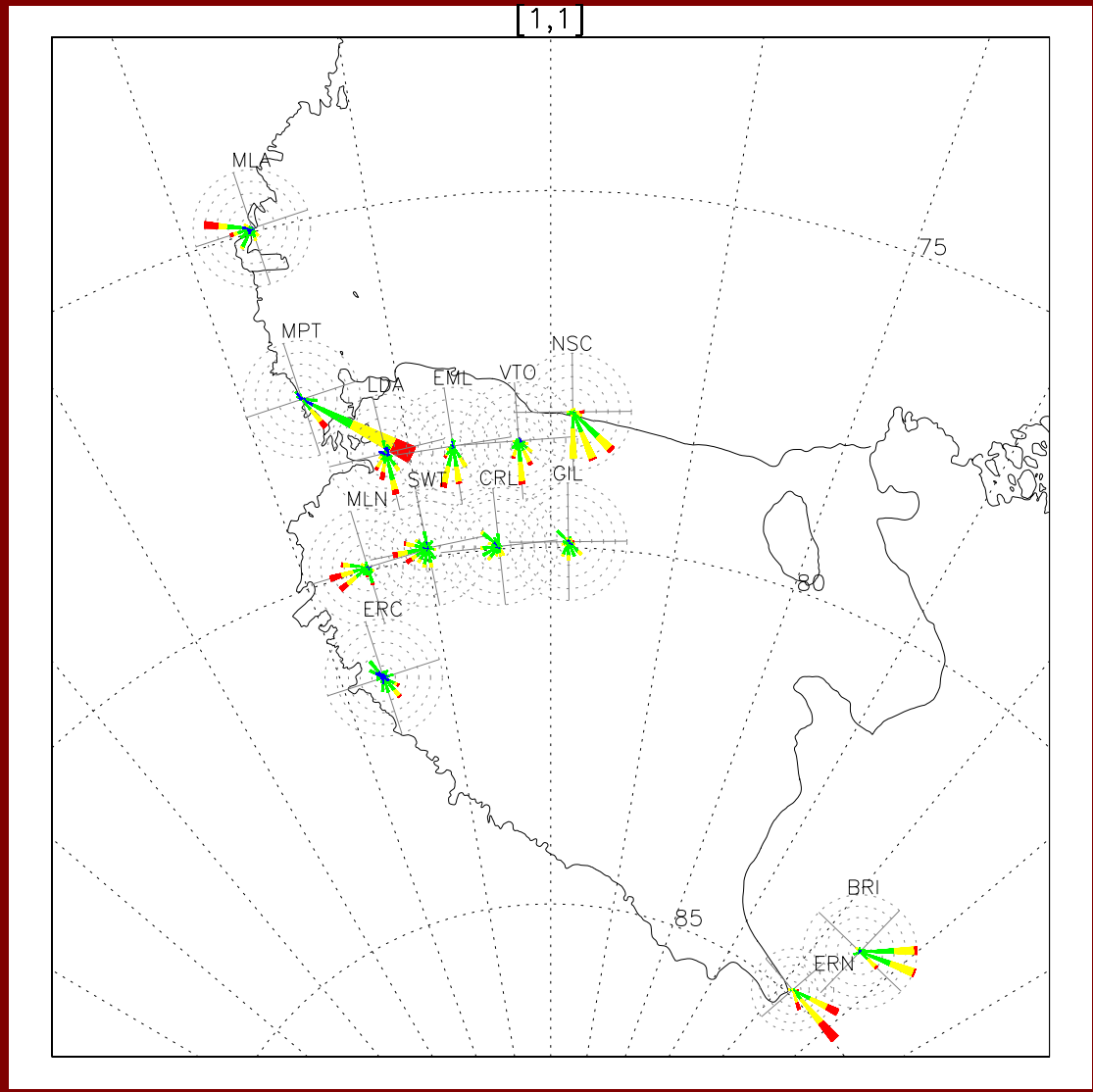


Dominant regime: weak katabatic

SOM Pattern Analysis / AWS Wind Rose

Elongated Low – Node [1,1]

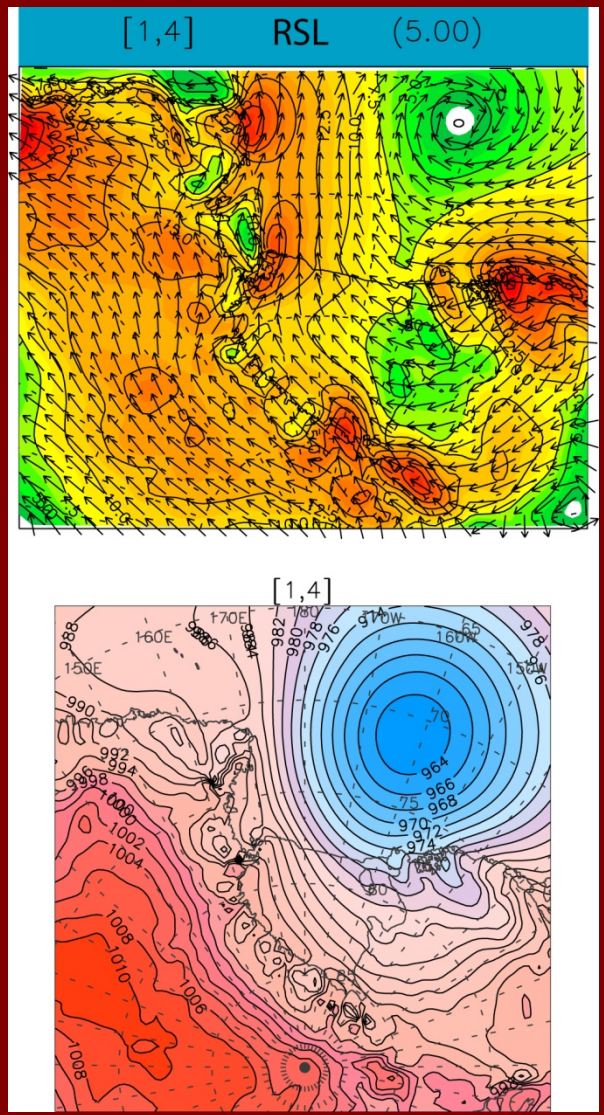


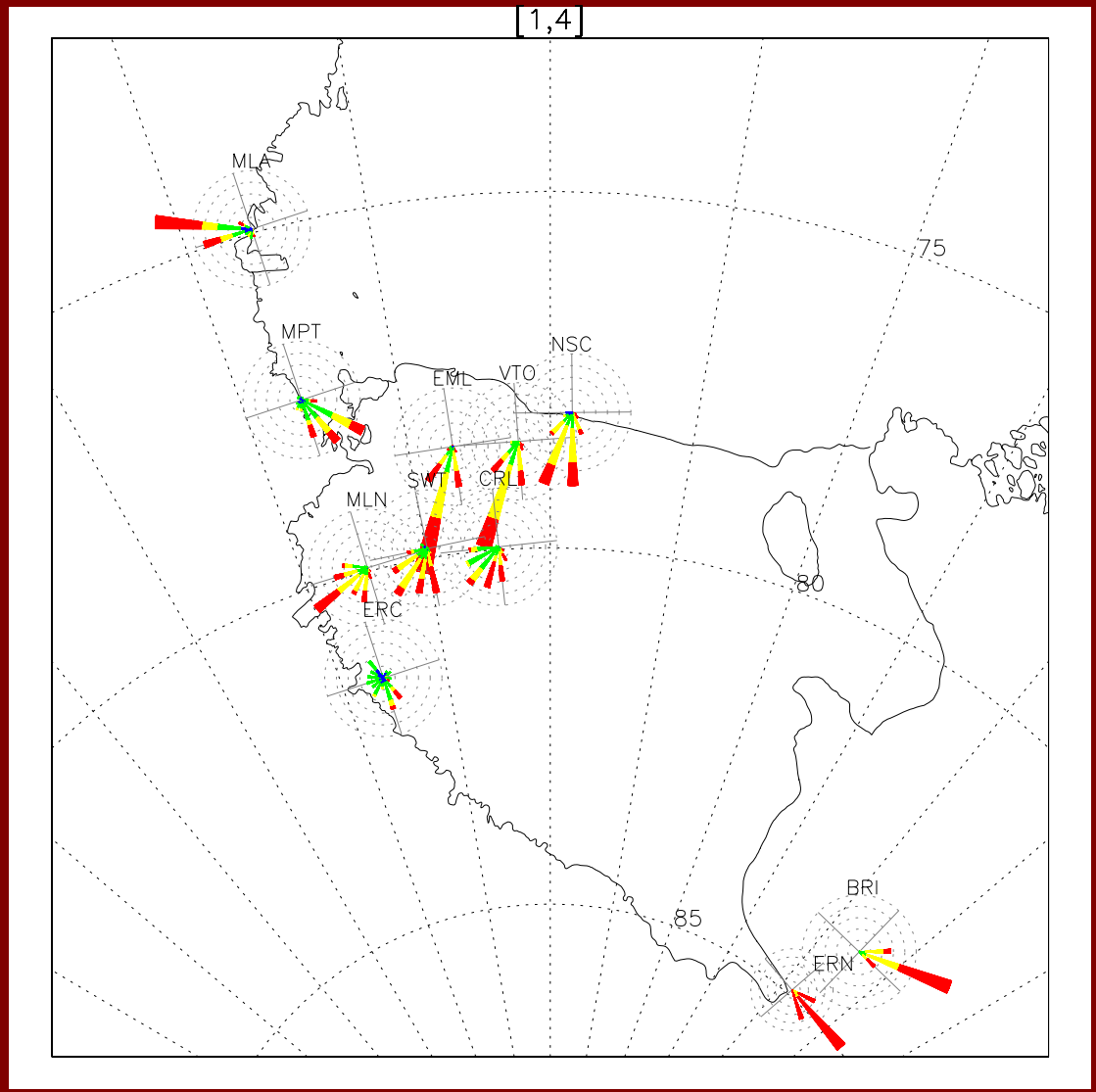


Dominant regime: light wind

SOM Pattern Analysis / AWS Wind Rose

Ross Sea Low – Node [1,4]

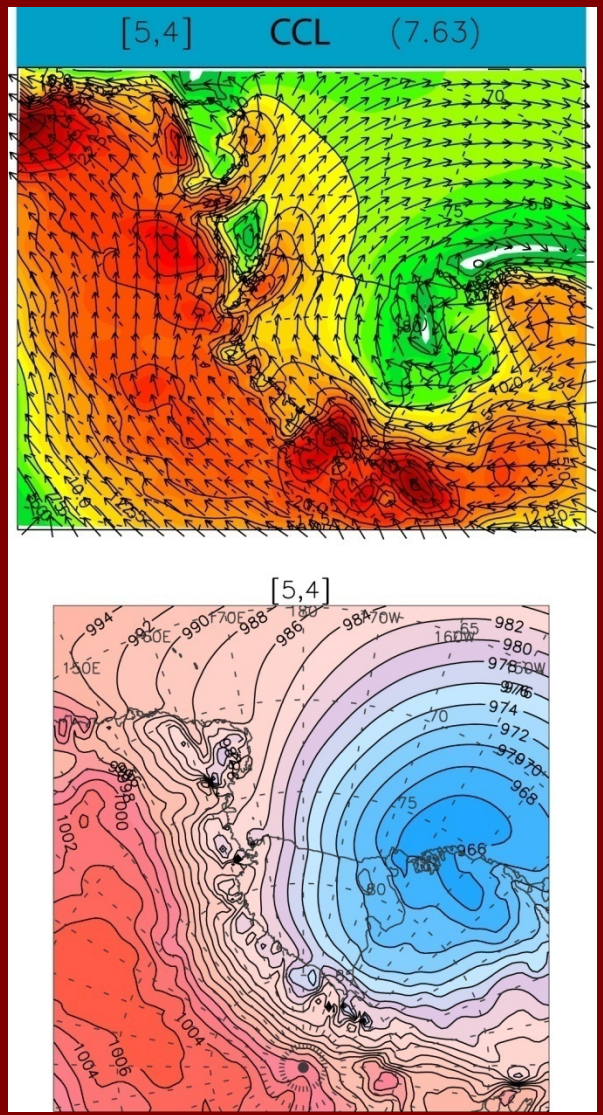


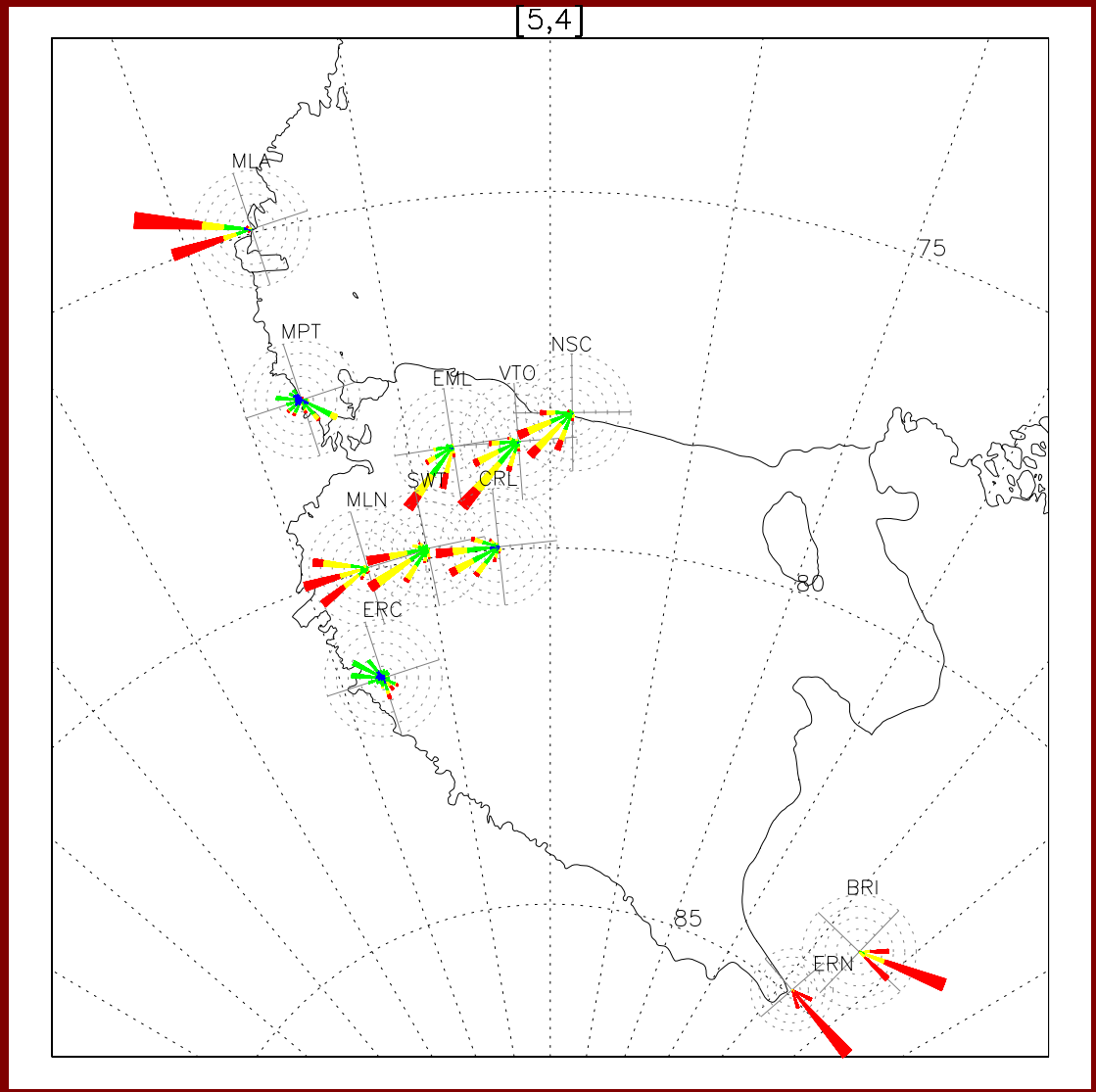


Dominant regime: barrier wind

SOM Pattern Analysis / AWS Wind Rose

Cape Colbeck Low – Node [5,4]

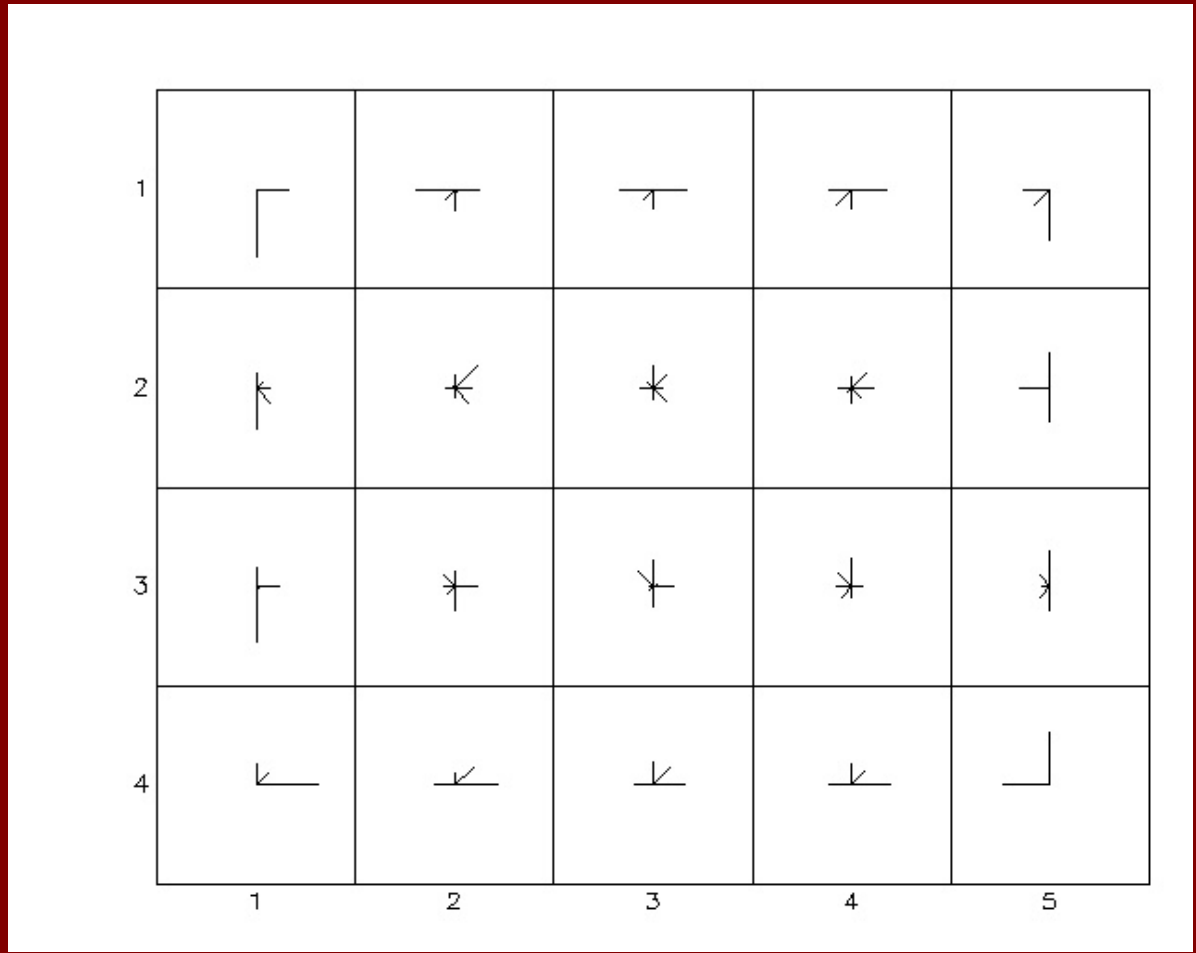




Dominant regime: strong katabatic

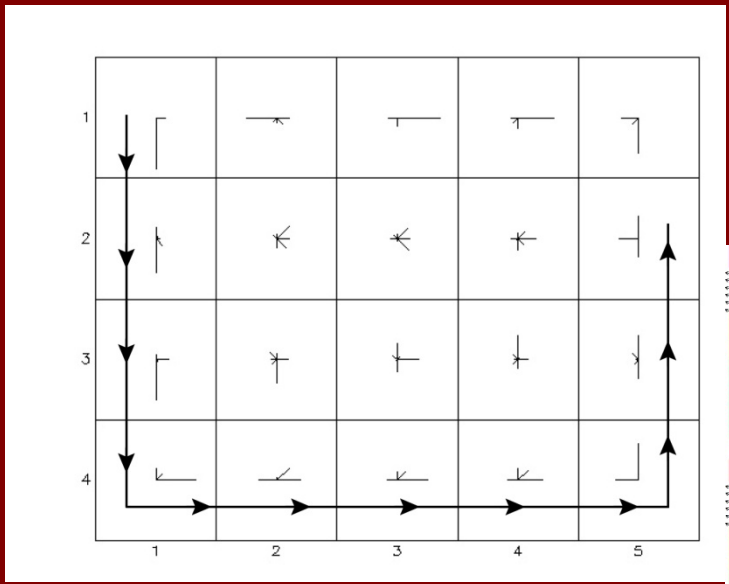
SOM Node Transitions

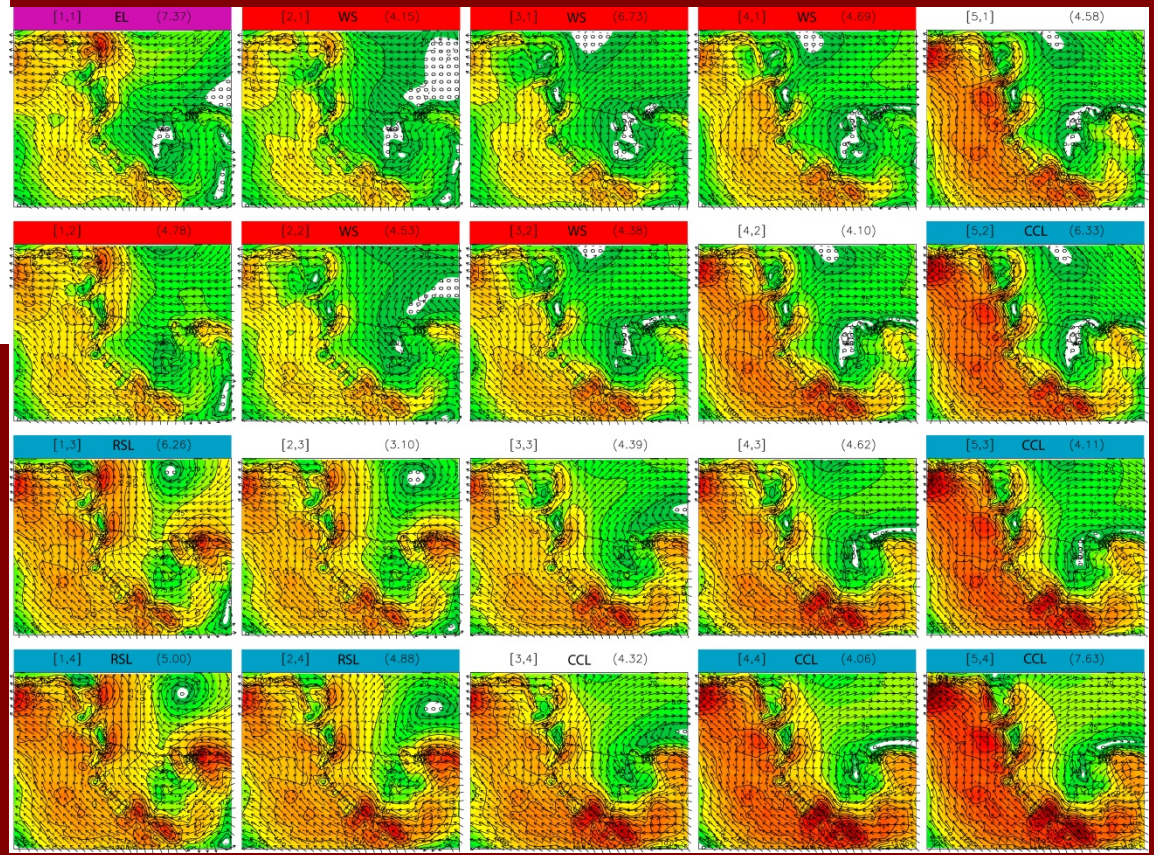
- The length of the line corresponds to the frequency of the next time slice transitioning to the neighboring node.
- The nodes along the edge often remain along the edges.



SOM Node Transitions - MJJA

- During the winter months the transitions along the edges establishes a likely sequence in the wind field patterns.





Conclusions

- There are patterns in the AWS observations which correspond to the low-level wind field associated with the RAS.
- The RAS is located along the western Ross Ice Shelf and it is made up of three dominant LLJs (Siple LLJ, Byrd LLJ, Reeves LLJ).
- There is a strong seasonality in the low-level wind field across the Ross Ice Shelf region with the most pronounced events during the winter and spring months.
- The primary origins of the RAS include:
  - circulation across West Antarctica
  - katabatic winds through the glacier valleys of the Transantarctic Mountains
- The Ross Sea Cyclone plays a significant role in the forcing and modulation of the RAS.
- There is a typical sequence in the low-level wind field, especially during the winter months.