INFLUENCE OF METEOROLOGICAL REGIMES ON CLOUD PROPERTIES OVER ROSS ISLAND, ANTARCTICA: A USERS GUIDE TO AWARE DATA

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BACKGROUND

- The US Department of Energy Atmospheric Radiation Measurement (ARM) program, in collaboration with the National Science Foundation Division of Polar Programs (PLR), deployed the Second ARM Mobile Facility (AMF-2) to Ross Island, Antarctica, comprising the most advanced suite of atmospheric science yet fielded in Antarctica.
- The AMF-2 operated between 01 December 2015 and 31 December 2016, comprising the “central facility” of the ARM West Antarctic Radiation Experiment (AWARE). Cloud radar data were obtained throughout the campaign by at least one instrument.
- Mixed-phase Antarctic clouds show strong contrasts with the Arctic, and observations of these clouds can provide unique and rigorous tests of climate model parameterizations.
- Interpretation of AWARE measurements may be daunting to a researcher unfamiliar with Antarctic meteorology. We have therefore developed a “Users Guide” to illustrate how the passage of Southern Ocean storm tracks influences the meteorology and cloud formation. The goal is to help researchers select case studies for model analysis.

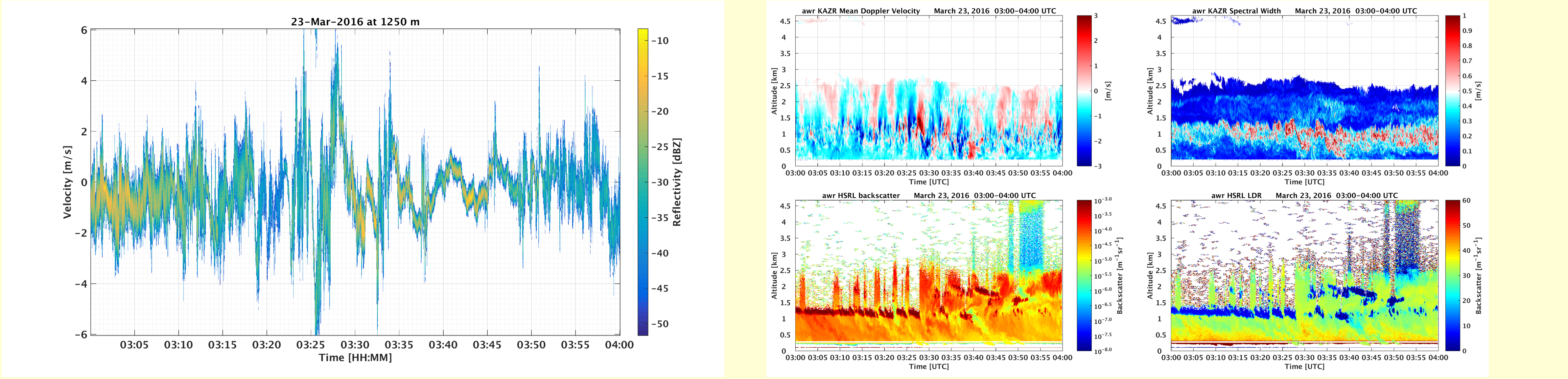


Figure 1. Example of radar data from AMF-2 at Ross Island showing extremes in vertical velocities that are an order of magnitude larger than normally observed in Arctic clouds. Also structural complexity in mixed-phase clouds seen in High Spectral Resolution Lidar (HSRL) data.

METHODS AND RESULTS: *k*-MEANS CLUSTERING

	DATES	SYNOPTIC CONDITIONS	LOCAL METEORLOGY AT ROSS ISLAND
CLUSTER 1	2015 DECEMBER: 9, 10, 11, 12, 13, 20, 21, 22, 23, 25, 25, 26, 27 2016 JANUARY: 1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 2016 FEBRUARY: No occurrence 2016 DECEMBER: 6, 10, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31	A prominent blocking high over the Amundsen Sea drives marine air advection and foehn wind-induced warming of Marie Byrd Land and the Ross Ice Shelf. Similar forcing triggered the January 2016 melt event sampled by AWARE (Nicolas et al. 2017).	Northerly-northeasterly flow brings warm temperatures and liquid-bearing clouds to Ross Island. The most likely airmass source region is the Ross and Western Amundsen Seas and the eastern Ross Ice Shelf.
CLUSTER 2	2015 DECEMBER: 1, 2, 3, 8, 18, 19, 28, 29 2016 JANUARY: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30 2016 FEBRUARY: 8, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 2016 DECEMBER: No occurrence	A low pressure system over the Bellingshausen Sea draws continental polar air northward, promoting cooling of West Antarctica (cf. Nicolas & Bromwich 2011). At the same time, foehn warming occurs on the eastern Antarctic Peninsula.	This regime, associated with a positive SAM index, favors the coldest average summertime conditions at Ross Island. When present, clouds likely contain significant ice water. This is the most frequent pattern in the long-term and during AWARE.
CLUSTER 3	2015 DECEMBER: 14, 15, 16, 17 2016 JANUARY: No occurrence 2016 FEBRUARY: No occurrence 2016 DECEMBER: 1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 21,	A strong negative phase of the Southern Annular Mode (SAM) and a weak Amundsen Sea Low. Two ridging centers over the Ross Sea and the Antarctic Peninsula favor warming along their western flanks. Moderate foehn warming in Ellsworth Land.	Anticyclonic flow over the Ross Sea advects marine air from the western Ross Sea directly toward Ross Island, similar to the 2nd case study presented by Scott & Lubin (2014). This is the least frequent pattern during AWARE.
CLUSTER 4	2015 DECEMBER: 4, 5, 6, 7, 30, 31 2016 JANUARY: 3, 4, 5, 16, 17, 18, 19, 31 2016 FEBRUARY: 1, 2, 3, 4, 5, 6, 7, 9, 10, 22, 23, 24, 25, 26, 27, 28, 29 2016 DECEMBER: No occurrence	A deep Ross Sea cyclone injects warm, moist air over Marie Byrd Land, which subsequently descends onto the southern Ross Ice Shelf (RIS). Especially warm T2m is observed on the southern RIS, downwind of the Prince Olav Mountains.	Cyclonic intrusions of marine air support a well-developed marine cloud band over West Antarctica. At McMurdo, strong southerly-southeasterly winds prevail, bringing ice and mixed-phase cloud systems influenced by local and remote orographic forcing, e.g., from the Transantarctic Mountains (Scott et al. 2017). This is the second most frequent pattern during AWARE.

Table 1. Using *k*-means clustering previously applied to Arctic data (Mülmenstädt et al. 2012) we have successfully identified each day of the AWARE campaign with a particular meteorological regime. In each season, four distinct clusters emerged, each associated with a particular synoptic condition and its consistently occurring effect on Ross Island meteorology. Here we present results from the summer months (DJF). Our forthcoming paper will discuss all seasons (Scott et al. 2018), and will also identify the most representative days for each cluster based on distances to cluster centroids.

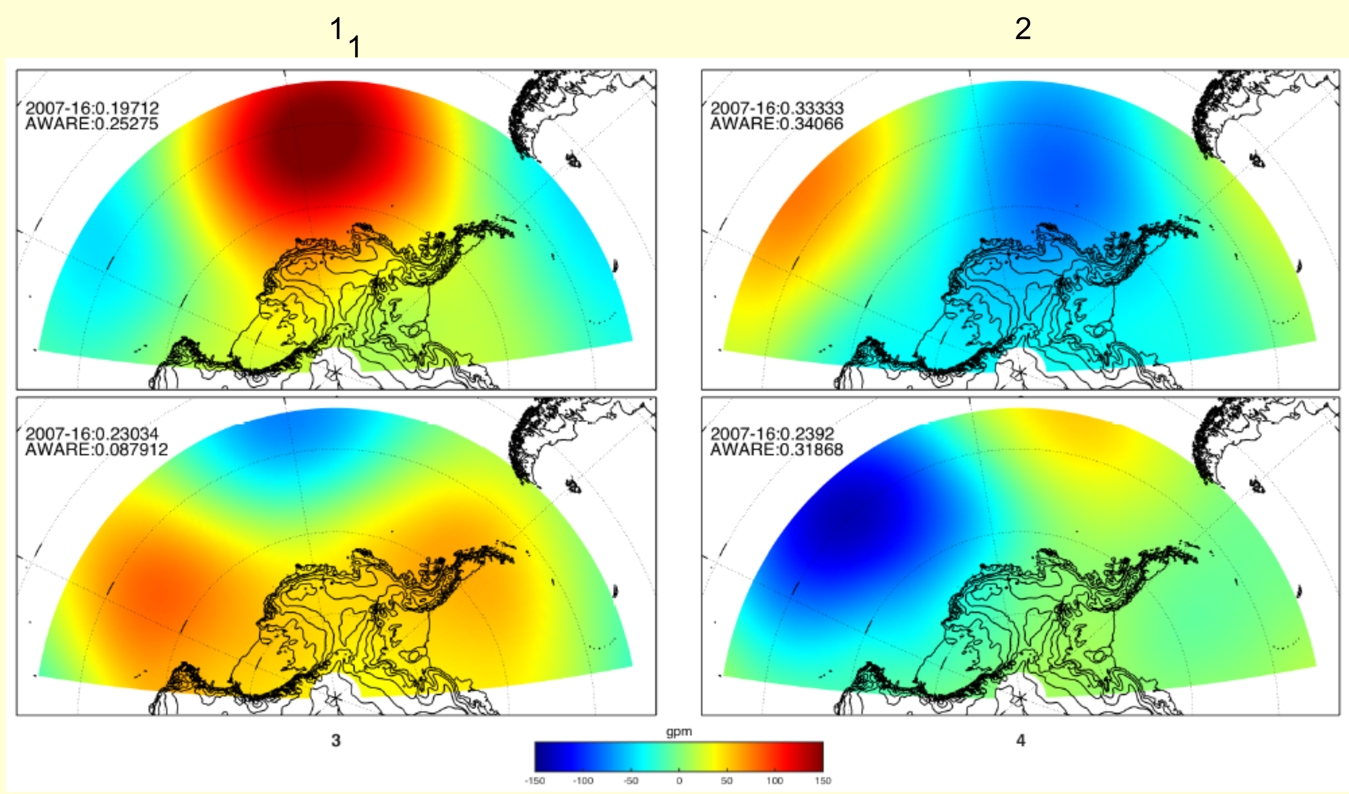


Figure 2. Distinct meteorological regimes emerged from *k*-means clustering on 700 hPa geopotential height anomalies from the most recent ten years of ERA-Interim reanalysis data .

EXAMPLES

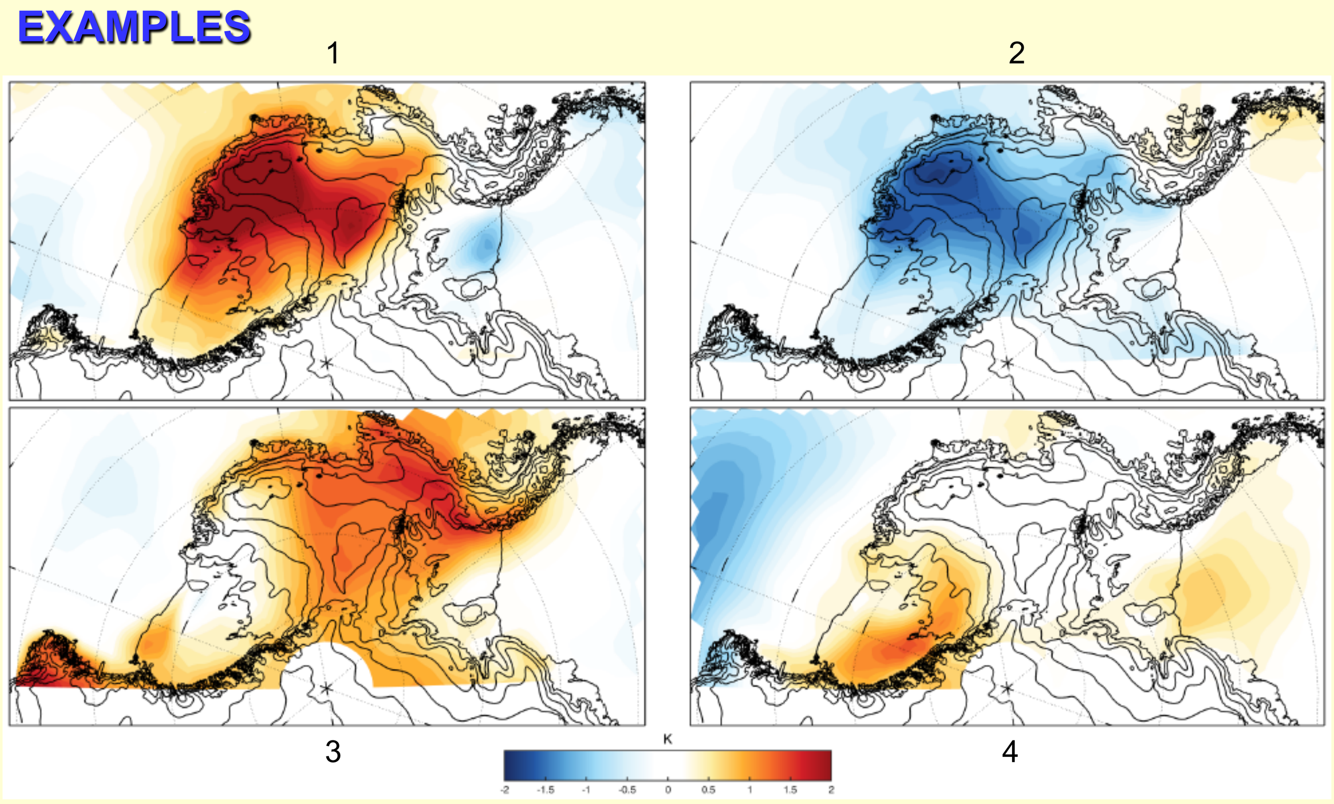


Figure 3. ERA-Interim T2m anomalies for each of the four DJF clusters.

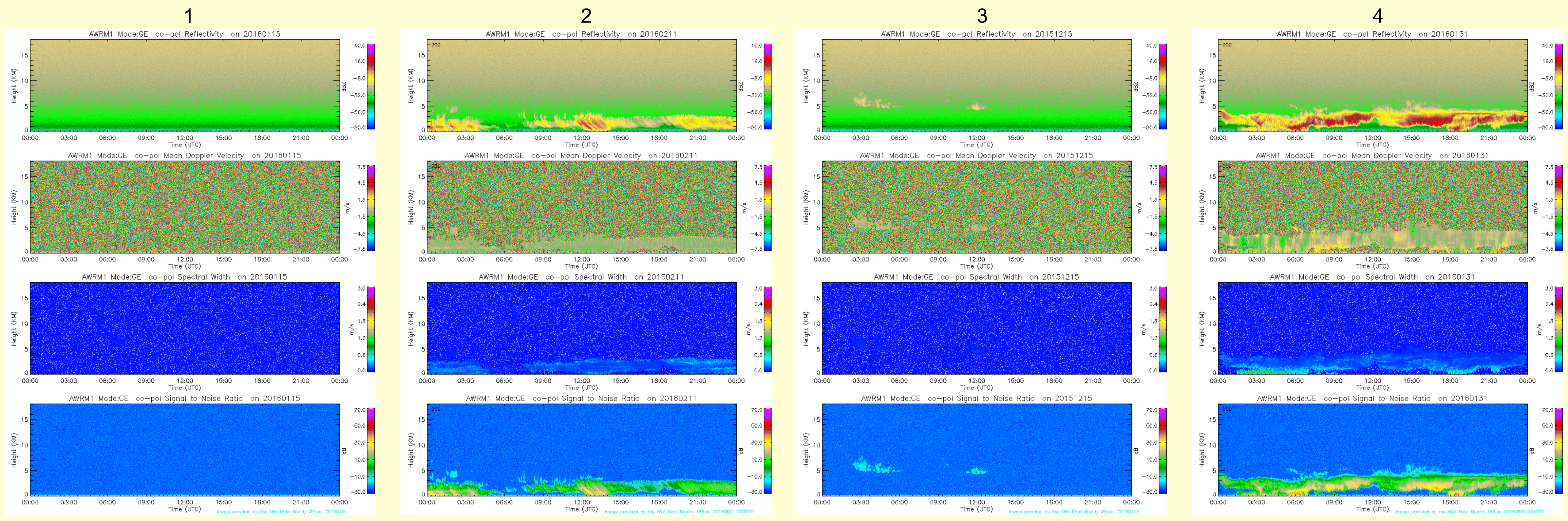
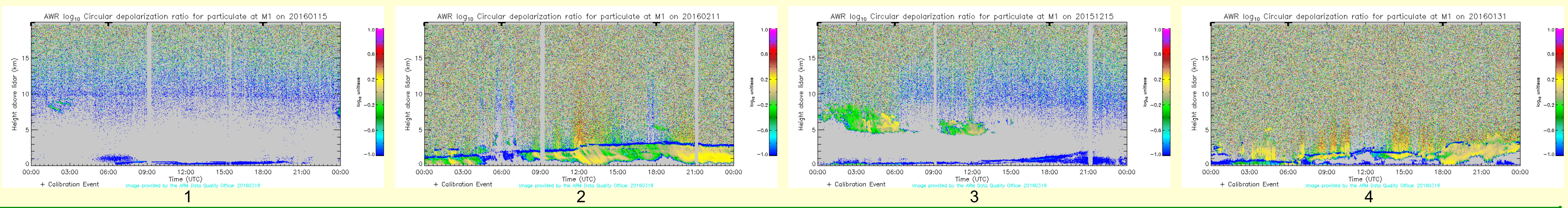


Figure 4. Daily examples of Ka-band Zenith Radar (KAZR) data for each of the four *k*-means clusters. Note the Doppler velocity contrasts between the orographically-forced regime (cluster 4) and the other cold regime (cluster 2).

Figure 5. Daily examples of HSRL depolarization ratio cloud signatures from each of the DJF clusters. Note mainly low liquid water cloud for clusters 1 & 3, and mixed-phase cloud layers with greater vertical extent for clusters 2 & 4, which have high ice water content (e.g., Scott & Lubin 2016).



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DATA MANAGEMENT

AWARE data are now fully accessible in the ARM archive. There is no proprietary period for any researcher, and we encourage broadest possible use of data from this campaign.

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