The Challenges of Fog Forecasting in the Ross Island Region of Antarctica

Matthew A. Lazzara [1,2] and Jeffrey D. Fournier [3,4]

[1]Antarctic Meteorological Research and Data Center, Space Science and Engineering Center, University of Wisconsin-Madison, Madison, WI

[2]Department of Physical Sciences, School of Engineering, Science, and Mathematics, Madison Area Technical College, Madison, WI

[3]Naval Information Warfare Center (NIWC), Atlantic - Polar Programs (NPP)

[4]DIGITALiBiz LLC, North Charleston, SC

Peak fog season at the U.S. Antarctic Program's airfields is late November through early February, the busiest portion of this program's operational season. The town of McMurdo is where 00 UTC & 12 UTC radiosonde observation (RAOBS) are launched, 13 miles NW of Phoenix Airfield. Fog at the airfields rarely reaches McMurdo, leaving the critical near-surface layer of the fog-supporting airmass unsampled.

Fig. 1 is representative of a typical fog event. Phoenix Airfield is near the western edge of a shallow fog bank developing during the early local morning hours. The McMurdo RAOB, taken prior to the onset of fog, is very dry above the surface layer.

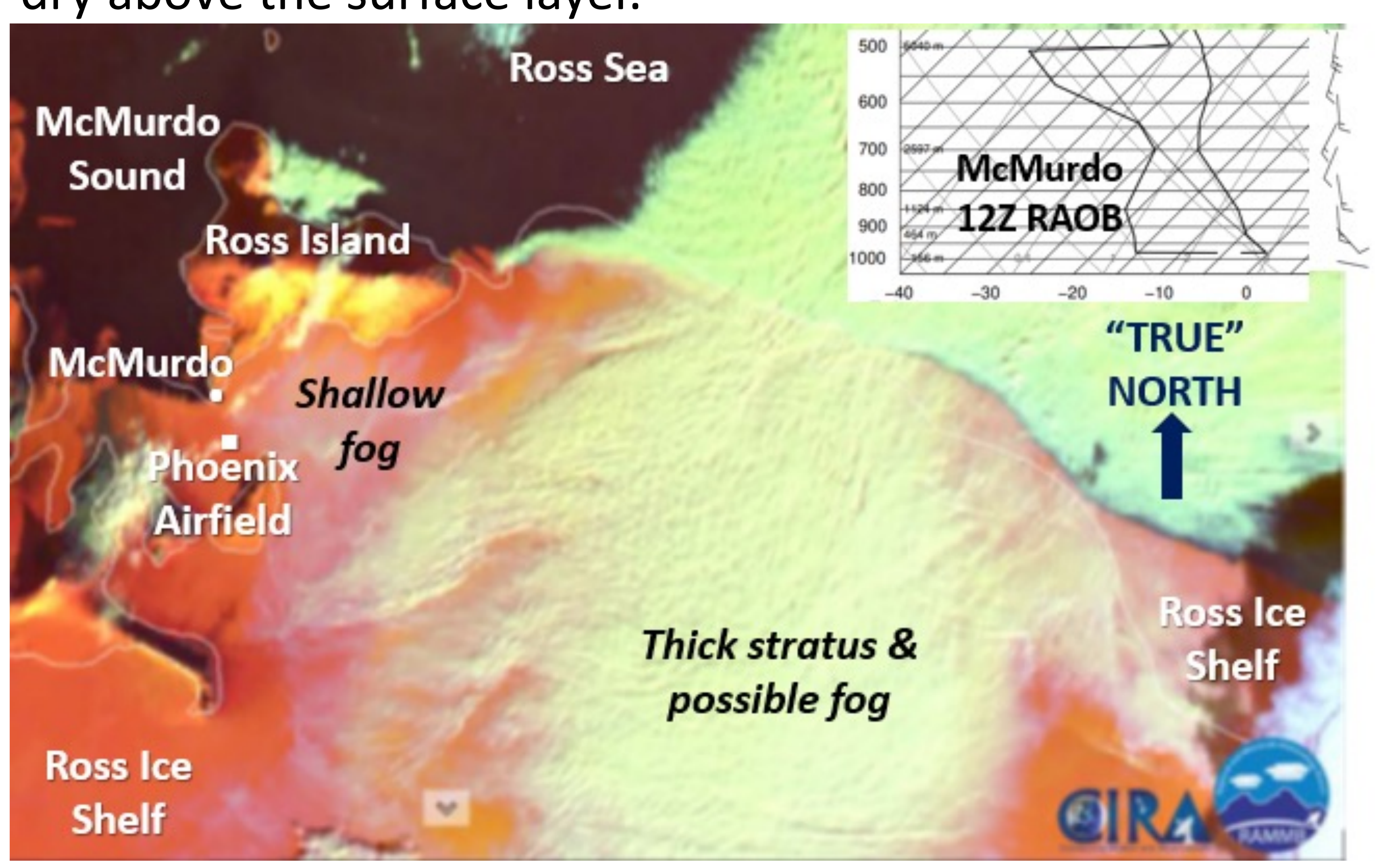

Fig. 1. 1525 UTC 1 FEB 2021 NOAA-20 VIIRS Day/Snow Fog Product (RAMMB-SLIDER website). Fog is first reported in the distance NE-E of Phoenix at 1655 UTC, in agreement with this image. Fog is intermittently observed at Phoenix from 2037 through 2236 UTC, with a lowest visibility of 1000 meters.

Austral summer fog near Ross Island is often less than 200 meters deep and offers poor contrast to the cold, snowy surface (Fig. 2a). Algorithms can be used to help mitigate this problem. The Day/Snow Fog product (Fig. 1) uses multispectral red, green, blue (RGB) composites that enhance the appearance of fog against a background of snow during the daytime. Lazzara (2008) uses a similar method, along with an additional analysis to enhance fog via creating Fog Principal Component Imagery (PCI) RGB composites (Fig. 2b).

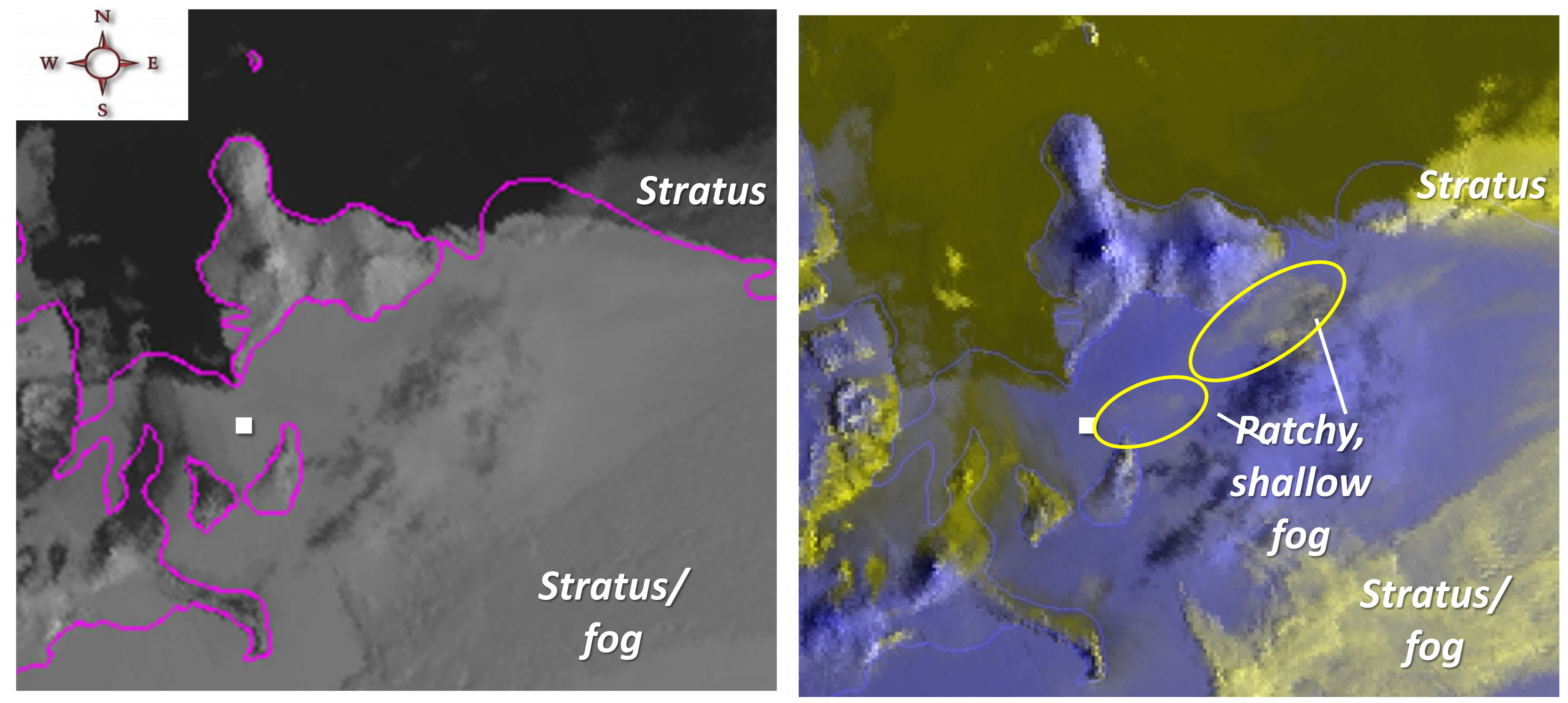

Figure 2a (left). 1845 UTC 1 FEB 2021 Aqua MODIS visible focused on Phoenix Airfield. Figure 2b (right). As in Figure 2a, except PCI RGB fog product. Fog is too shallow to be seen in visible channel but is faintly visible in PCI RGB. At this time, fog is being observed NE-E of Phoenix.

NPP forecasters routinely use a WRF model (part of the Antarctic Mesoscale Prediction System) with horizontal resolutions as fine as 0.89 km. The available output includes an explicit cloud base forecast down to 200 ft AGL. However, it struggles to reliably forecast cloud layers (Figs. 3a vs. 3b). (An explicit visibility forecast was added to the AMPS product suite in the spring of 2022).

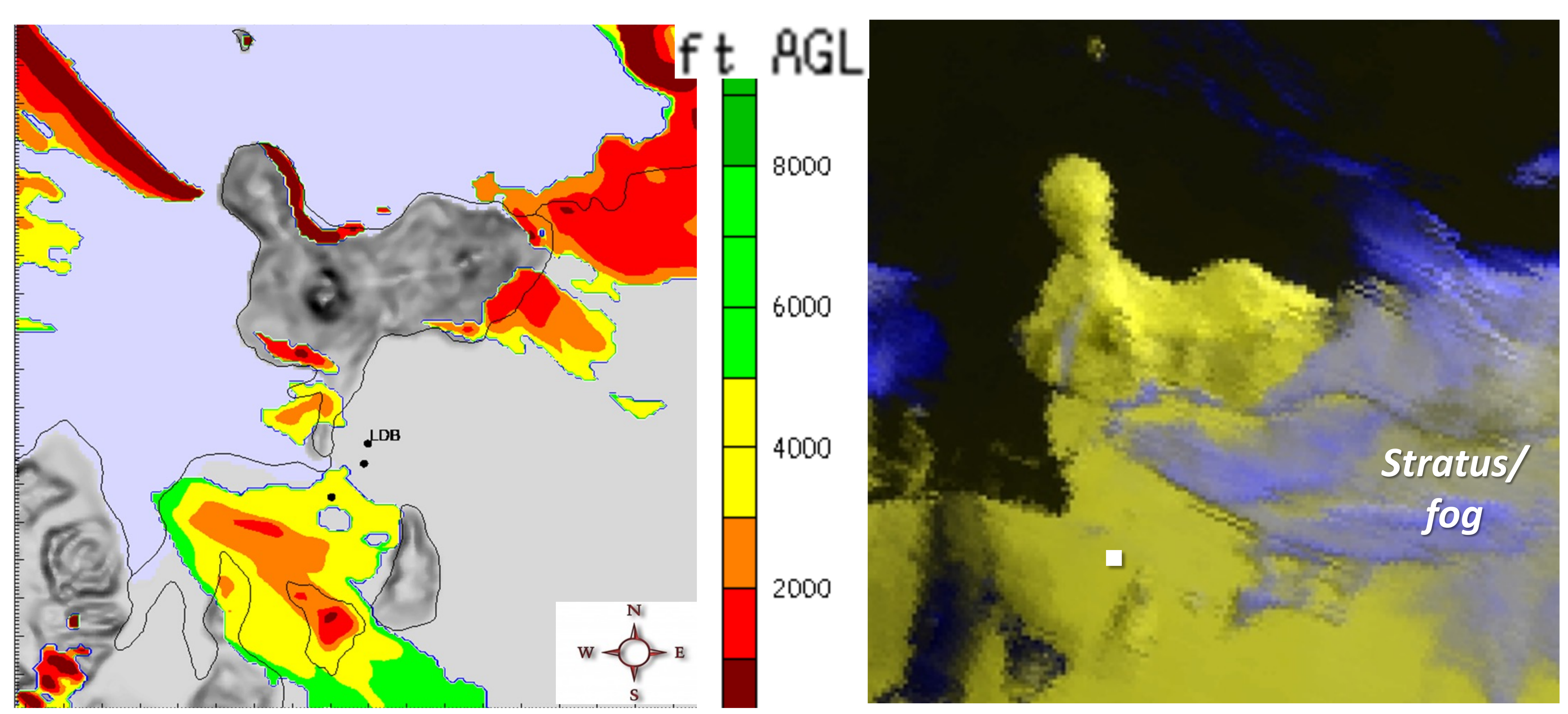

Fig. 3a (left). 00 UTC 1 FEB 2021 AMPS 0.89 km cloud base forecast, valid 22 UTC. Fig. 3b (right). As in Fig. 2b, except valid 22 UTC. Note the qualitatively poor simulation of low cloud bases SE of Ross Island.

Forecasters are left to use the more "traditional" parameters of PBL relative humidity and wind to infer the probability of fog. One major problem with this approach is that these parameters are frequently supportive of fog, at least from a synoptic scale viewpoint.

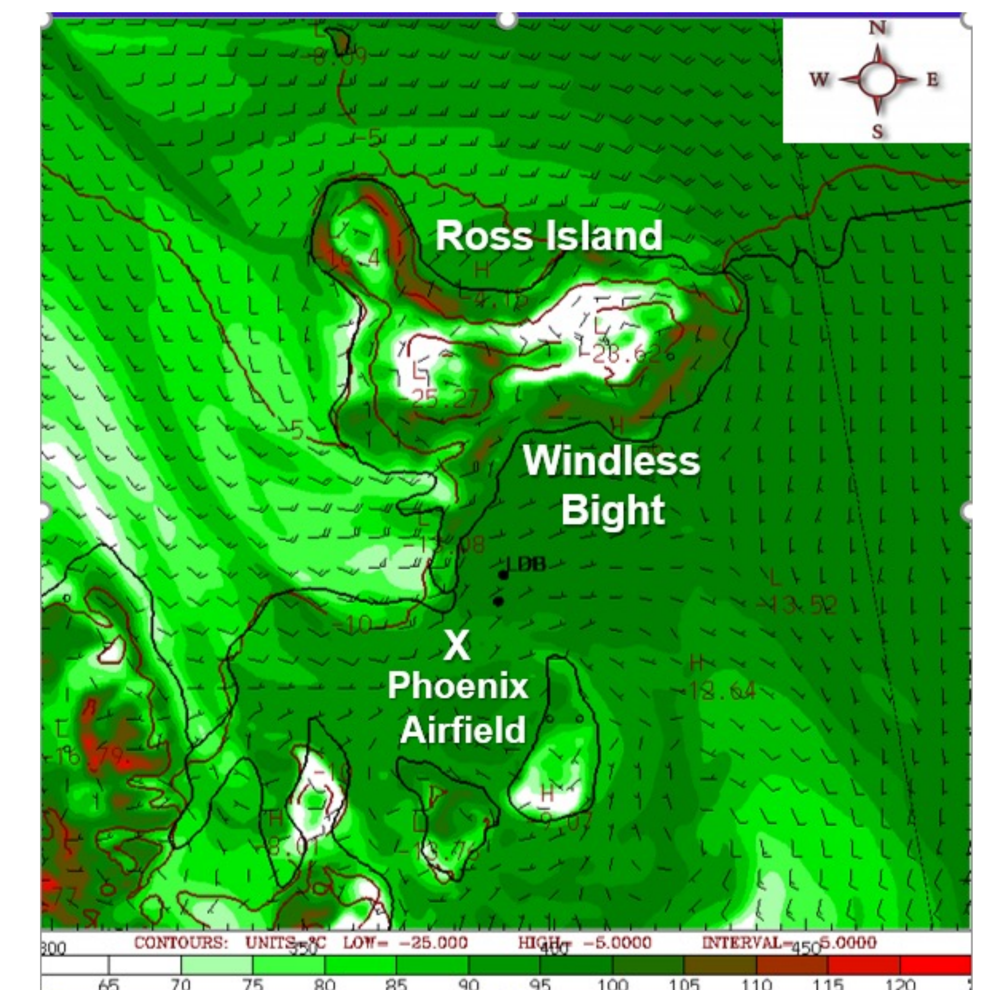

Fig. 4a (top). As in Fig. 3a, except 2-meter RH wrt ice (image) and 10-meter wind barbs (knots).

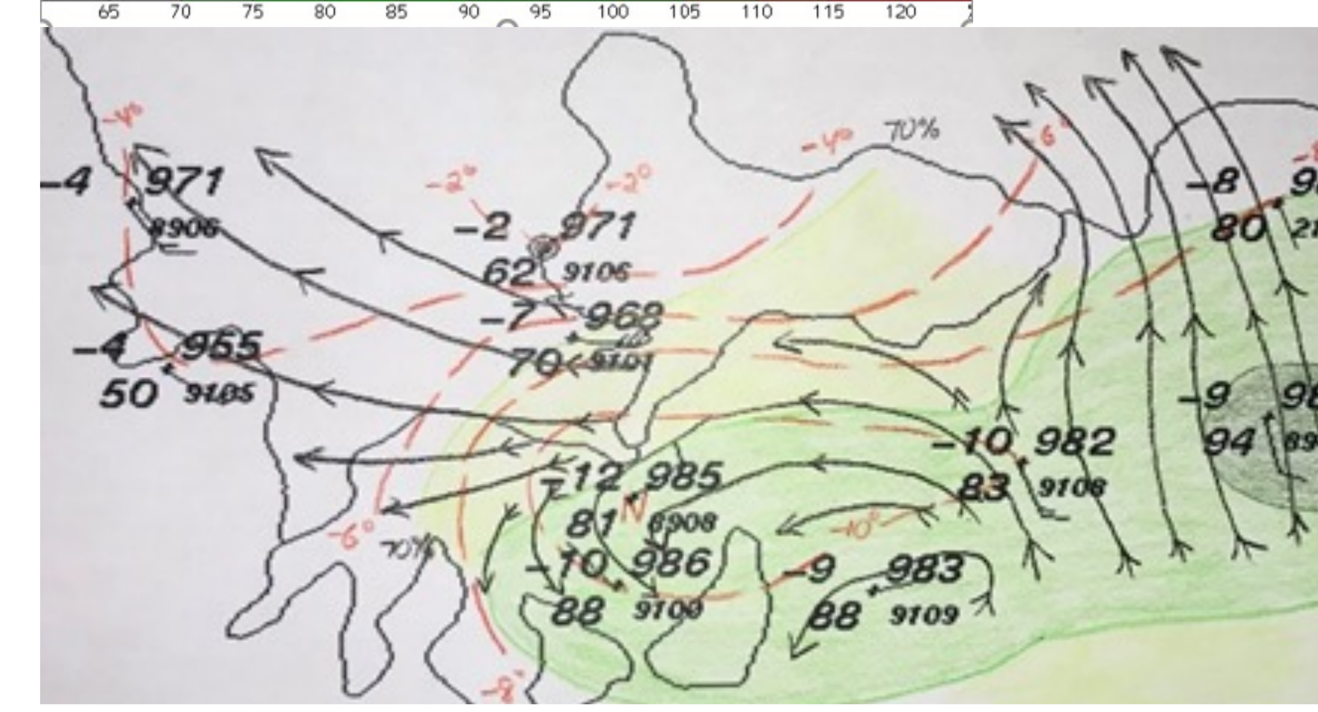

Fig. 4b (bottom). Subjective analysis of 22 UTC automated surface observation plots. Green shading highlights high RH values wrt water.

It is not uncommon for 2-meter relative humidity to be above 80% and 10-meter wind to be NE to E 5-12 KT during the local morning hours (the diurnal peak of summer fog). Fog that develops near or SE-S of Windless Bight can advect into the nearby airfields quickly.

Fig. 4a is an example of such a surface weather pattern. While the AMPS forecast cloud bases did not verify well on 1 FEB 2021, the AMPS simulated surface weather forecast for 22 UTC verified quite well (Figs. 4a and 4b). Although fog did occur at Phoenix in this case, similar patterns often do not produce fog.

A forecaster could (somewhat) justifiably forecast fog for half the days during the peak fog season. However, this would result in an unacceptably high false alarm rate. For now, forecasters must rely on innovative satellite strategies like PCI RGB and VIIRS Day/Snow Fog products to detect nearby fog. This approach reduces false alarms at the cost of reduced lead time.

Acknowledgements

The authors wish to acknowledge the support of the National Science Foundation, Office of Polar Programs, grant #1924730, 1951720, and 1951603.