The influence of Föhn on the boundary layer over the Larsen Ice Shelf, Antarctica: A comparison of observations and model simulations

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Why study Föhn events in Antarctica?

With a trend towards a more positive Southern Annular Mode (SAM), circumpolar Westerlies around the Antarctic continent have strengthened. While for weak westerly winds, the mountains of the Antarctic Peninsula (AP) form a barrier, strengthened westerlies are more likely to flow across the AP and can lead to Föhn events over the Larsen Ice Shelf. Such warm, dry Föhn events are thought to have contributed to the break-up of the Larsen A and B ice shelves. Here we present an analysis of measurement data from an Automatic Weather Station (AWS) on Cole Peninsula and model data from the Antarctic Mesoscale Prediction System (AMPS). For AMPS, the Weather Research and Forecasting model (WRF) is run at 5km resolution, initialized daily at 00UTC and 12UTC, for a domain that covers the AP (Fig. 1).

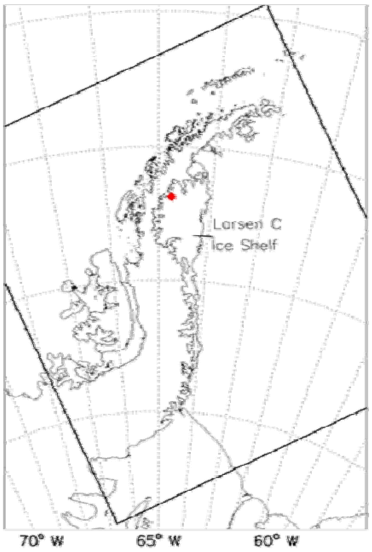

Fig. 1: Map of the Antarctic Peninsula, with location of the AWS at Cole Peninsula (red diamond) and the AMPS domain (black rectangle).

How do we identify Föhn events:

Due to local effects the wind direction measured at the AWS cannot be used reliably as an indicator for Föhn. Therefore Föhn events in the AWS data are identified through a decrease in Relative Humidity (RH), coinciding with an increase in temperature (T) (See Fig. 2 top left). RH has been chosen as the primary criterion as during summer the temperature increases during Föhn events tend to be not significant. Empirical thresholds were chosen at RH <=65%, or RH<=70% when ΔT over the previous/following 12 hours was 3K or more. To determine Föhn events in the AMPS data set, the potential temperature is utilised. For illustration see Figure 3 top right. These two methods of Föhn event detection agree very well. Out of 352 days both identify the same 107/165 days as showing/not showing Föhn events.

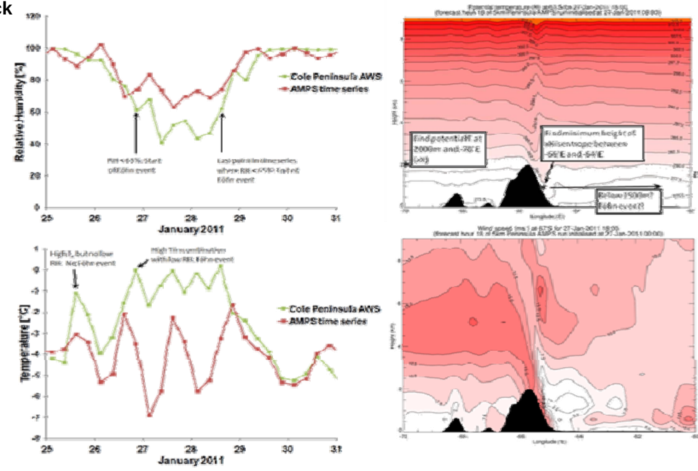

Fig2 : Föhn event in January 2011. Left: Time series of AWS data (green) and AMPS data (red) of T (top) and RH (bottom). Right: AMPS cross sections at 67°S of potential temperature (top) and wind speed (bottom) on Jan 27th 18UTC.

How do model and measurements compare?

For 2011 table 1 shows a comparison of AWS measurements and AMPS data when classified into "Föhn" and "no Föhn" conditions. Only those data have been used where both sets fall into the same category.

During non-Föhn conditions AMPS and AWS agree very well, though AMPS tends to be slightly warmer and drier than measurements. During Föhn conditions though, the bias changes sign, and AMPS underestimates T and overestimates RH. The agreement between model and measurements is less good, indicated by larger biases and lower correlation coefficients. This can also be seen in the time series in Fig. 3.

	No Föhn (n=855)			Föhn (n=227)		
	Mean bias	Std dev.	Correlation	Mean bias	Std dev.	Correlation
T	**1.60K**	3.36K	0.93	**-2.61K**	2.63K	0.86
p	-0.31hPa	1.40hPa	0.99	-0.70hPa	2.04hPa	0.97
RH	**-6.95%**	9.35%	0.35	**6.96%**	15.33%	0.33

Table 1: Comparison of AWS measurements and AMPS model output for temperature, pressure and relative humidity. Based on data points where both data sets agree on „no Föhn" or „Föhn".

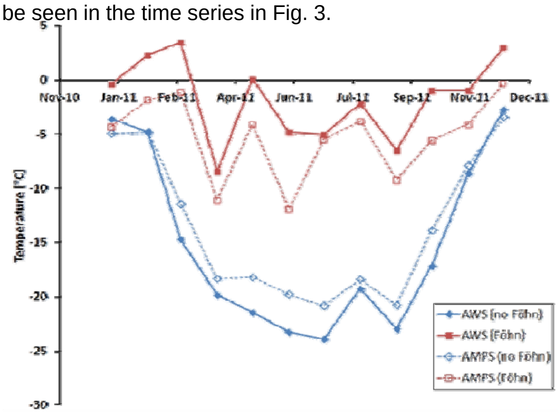

Fig 3: Monthly mean values of T for „Föhn" conditions (red) and „non-Föhn" conditions (blue) from AWS data (filled symbols) and AMPS output (open symbols).

	SW net	LW net	H	L	EAV
All	29.4	-6.2	25.0	-11.9	36.3
no Föhn	26.4	-6.5	-6.1	-2.3	11.5
Föhn	31.0	-5.9	84.2	-48.6	60.7

Table 2: AMPS output of surface energy balance components in W/m2 for 2011.

What does this mean for the atmospheric boundary layer?

- **Analysis of one year of AWS measurements and AMPS output with regard to "Föhn" and "no Föhn" conditions shows that during "no Föhn" conditions, measurements and model agree well, though the model tends to be warmer and drier.**
- **In contrast, during "Föhn" conditions the model underestimates T and overestimates RH (Table 1, Fig. 3)**
- **The model especially underestimates the maximum temperature observed during Föhn conditions.**
- **Preliminary analyses indicate that Föhn events provide eight times more energy for melt than is available under "no Föhn" conditions (table 2).**
- **Misrepresentation of clouds plus underestimation of Föhn conditions in model meansurface melt potential of Föhn events is underestimated in the model.**

! See also posters 1 by J. King and 4 by A. Elvidge !