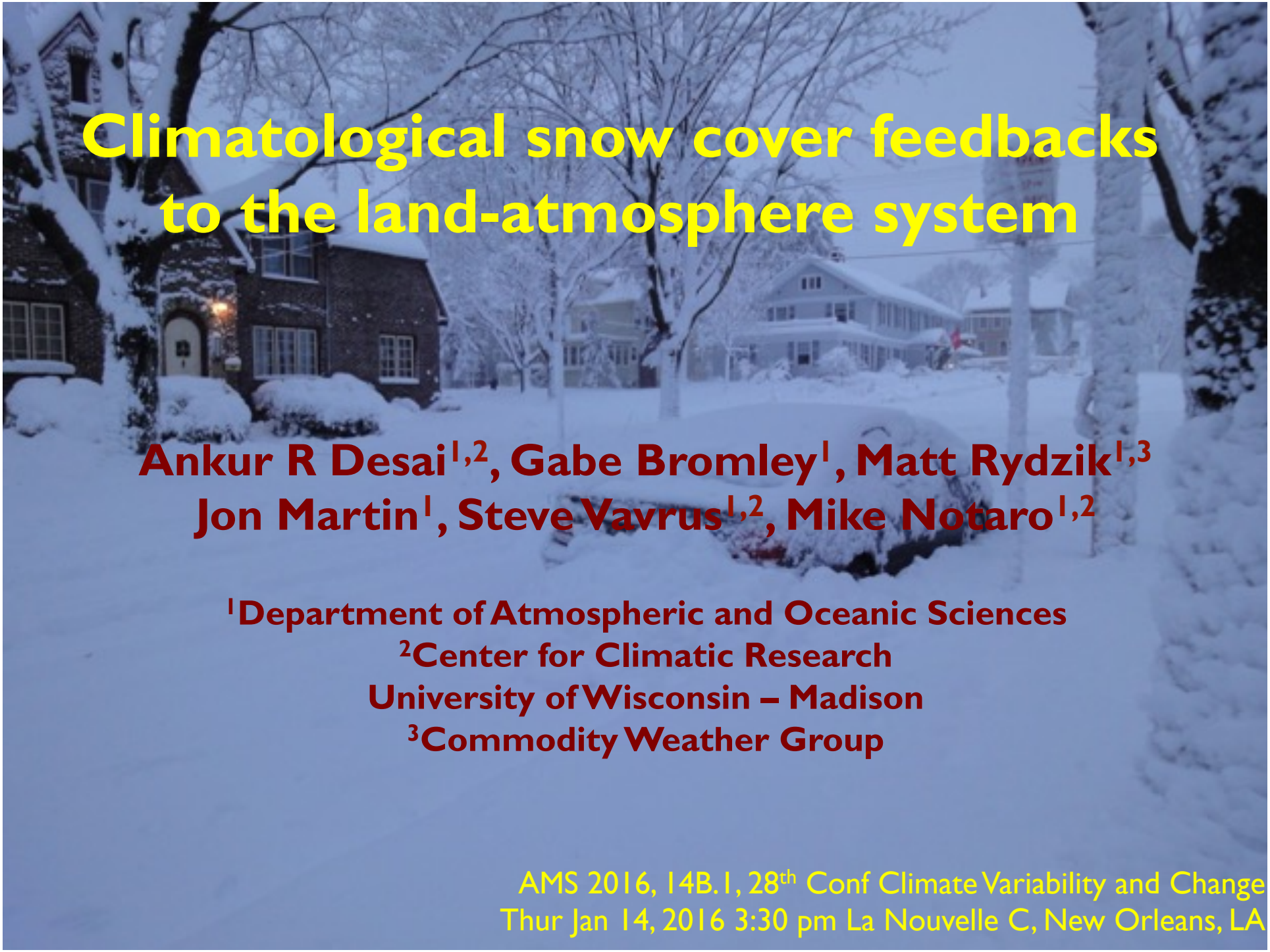
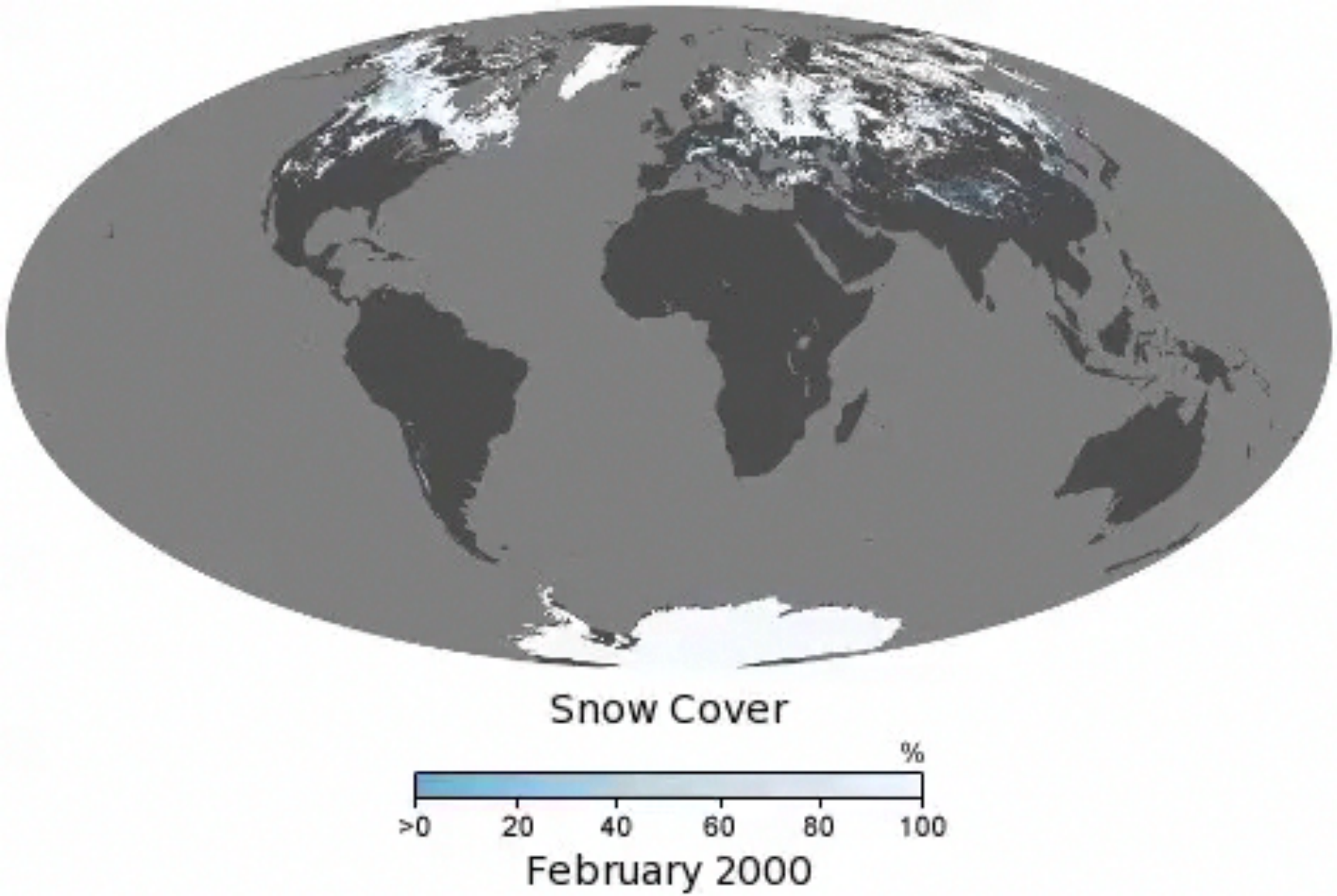


Climatological snow cover feedbacks to the land-atmosphere system

Ankur R Desai[1,2], Gabe Bromley[1], Matt Rydzik[1,3]
Jon Martin[1], Steve Vavrus[1,2], Mike Notaro[1,2]

[1]Department of Atmospheric and Oceanic Sciences
[2]Center for Climatic Research
University of Wisconsin – Madison
[3]Commodity Weather Group

AMS 2016, 14B.1, 28th Conf Climate Variability and Change
Thur Jan 14, 2016 3:30 pm La Nouvelle C, New Orleans, LA



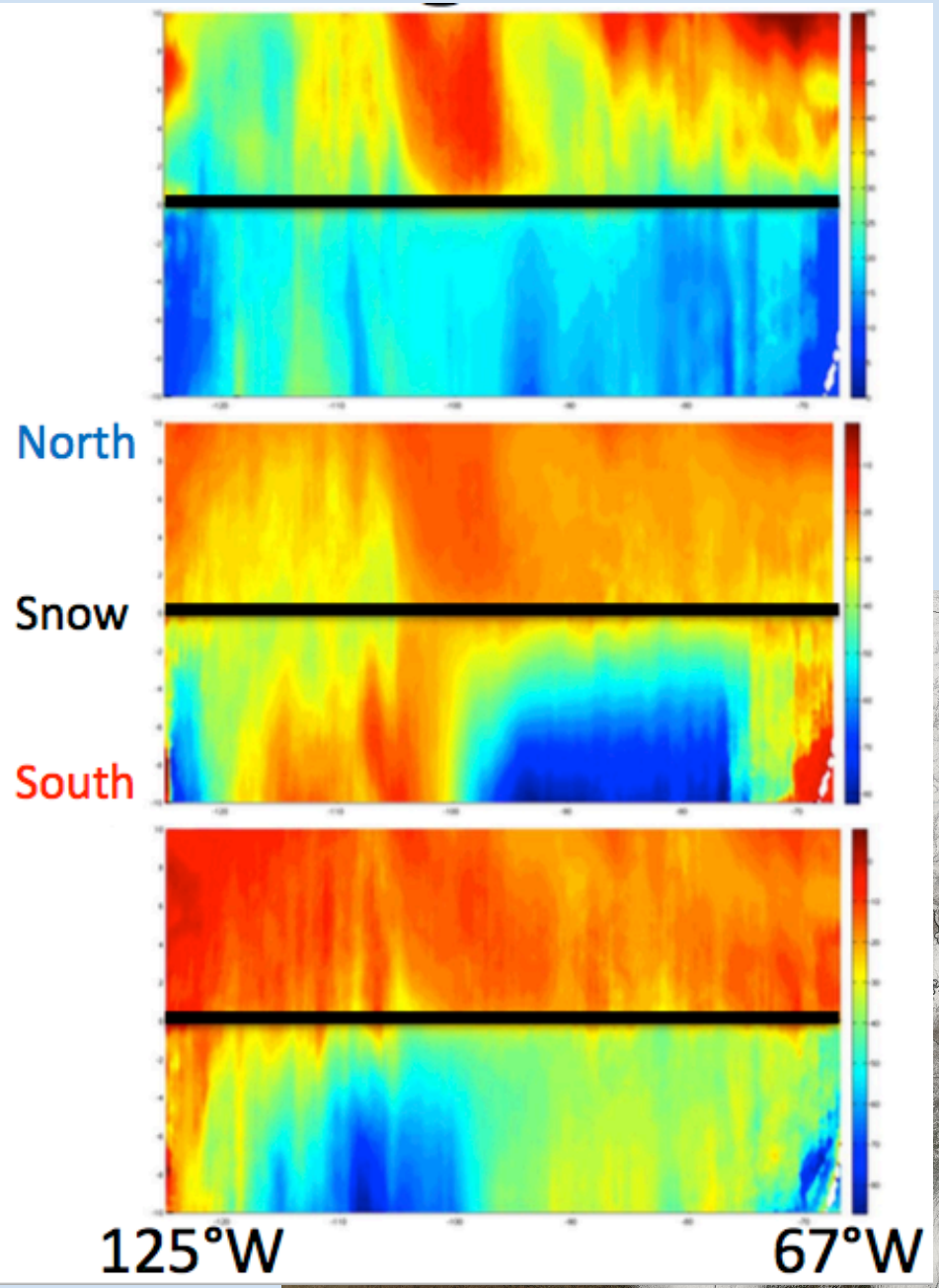
NASA MODIS

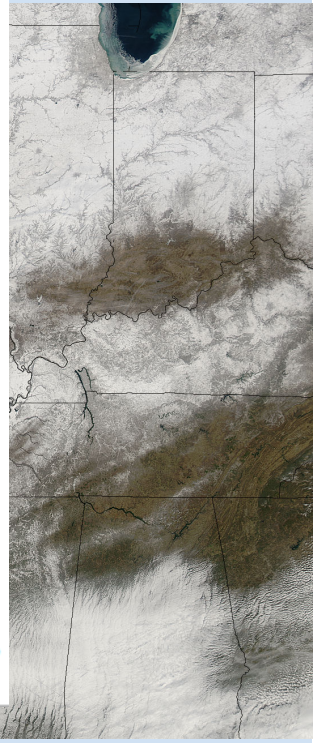
NARR 1979-2010

Albedo

Latent Heat Flux

Sensible Heat Flux



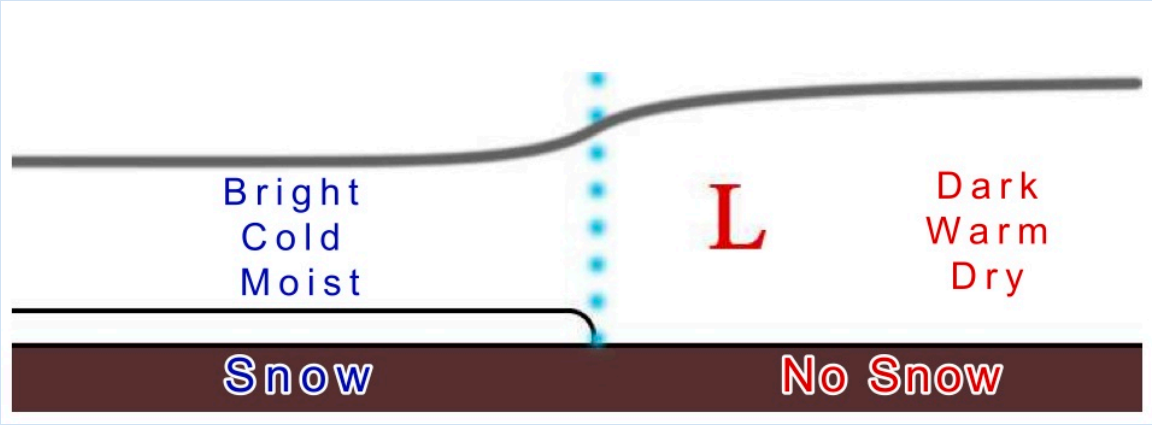


Let it snow

- Snow is a dynamic boundary, deposited by mid and high latitude disturbances
- The presence or absence of snow influences both the atmosphere and ecosystems
- What is the role of synoptic to interannual variation in snow cover?
  - 1. Atmosphere: Rydzik and Desai, 2014 *J Clim* and ongoing work by Gabe Bromley
  - 2. Ecosystem: Desai et al., 2016 ERL

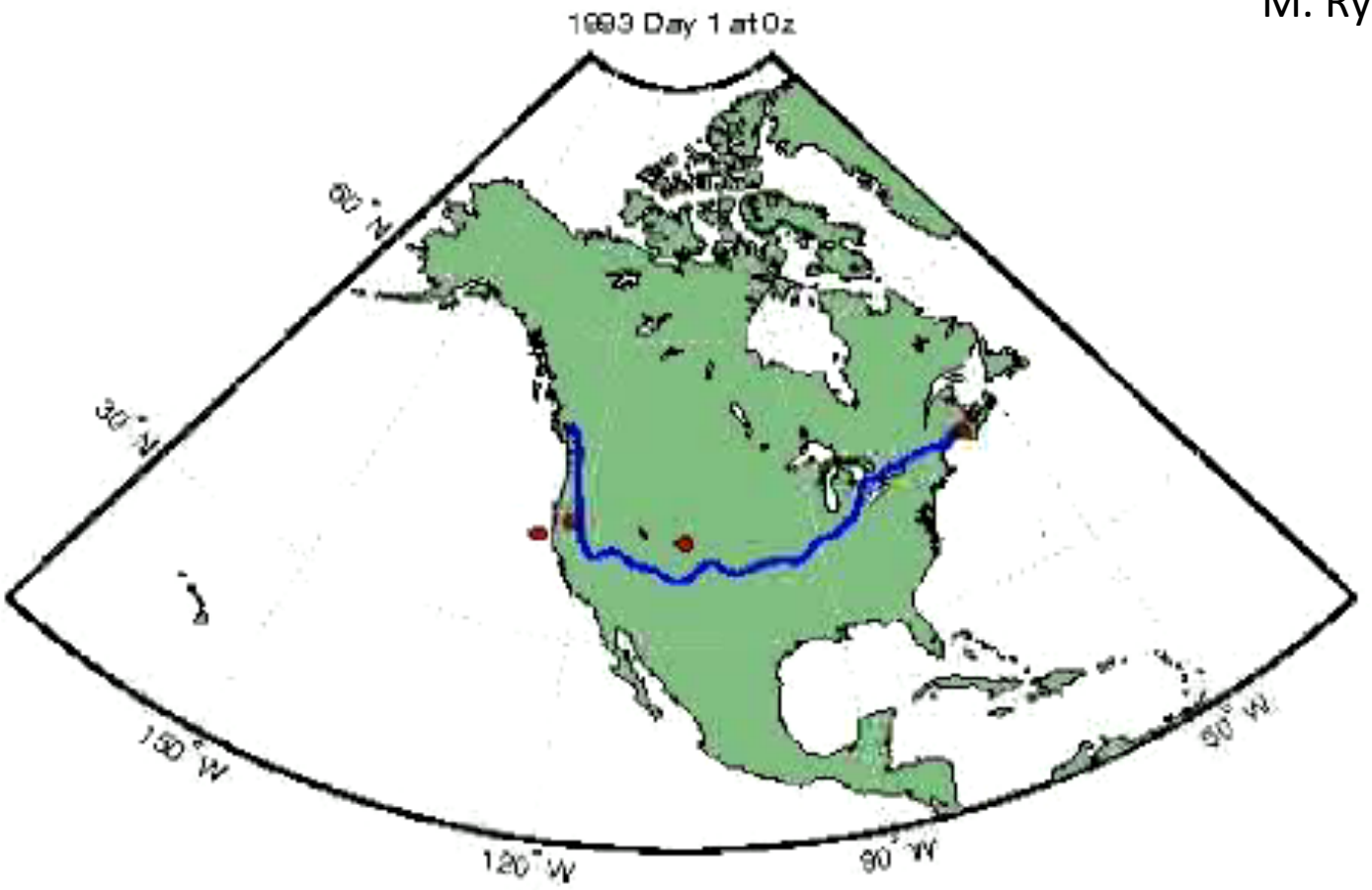
This not necessarily news, but it matters

- "The baroclinic zone is a lot of times the place where storms will track. Repeated storm tracks will continue to move the snow cover slightly southward." - Eric Sorensen – WREX
- "General features include a **poleward shift** in storm track location, increased storm intensity, but a decrease in total storm numbers" - IPCC (2007)



1993 NARR daily snow extent (**BLUE**)

Animation by
M. Rydzik



Mid-latitude low pressure centers (NARR) –(**RED DOTS**)

Snow Cover Influence on Mid-latitude Disturbances/Cyclones (MLC)

- Namias (1962) postulated feedback cycle

1. General circulation favored southern snow extent
2. Air masses cooled by anomalous snow cover
3. Increased low-level temperature contrast
4. MLCs feed off of enhanced low-level baroclinicity
5. MLCs aided in injecting future air masses further southward

J. NAMIAS

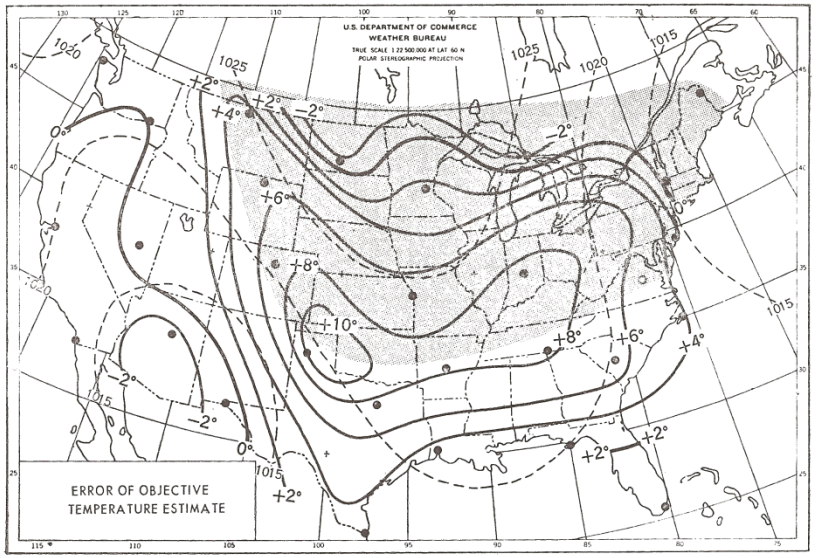
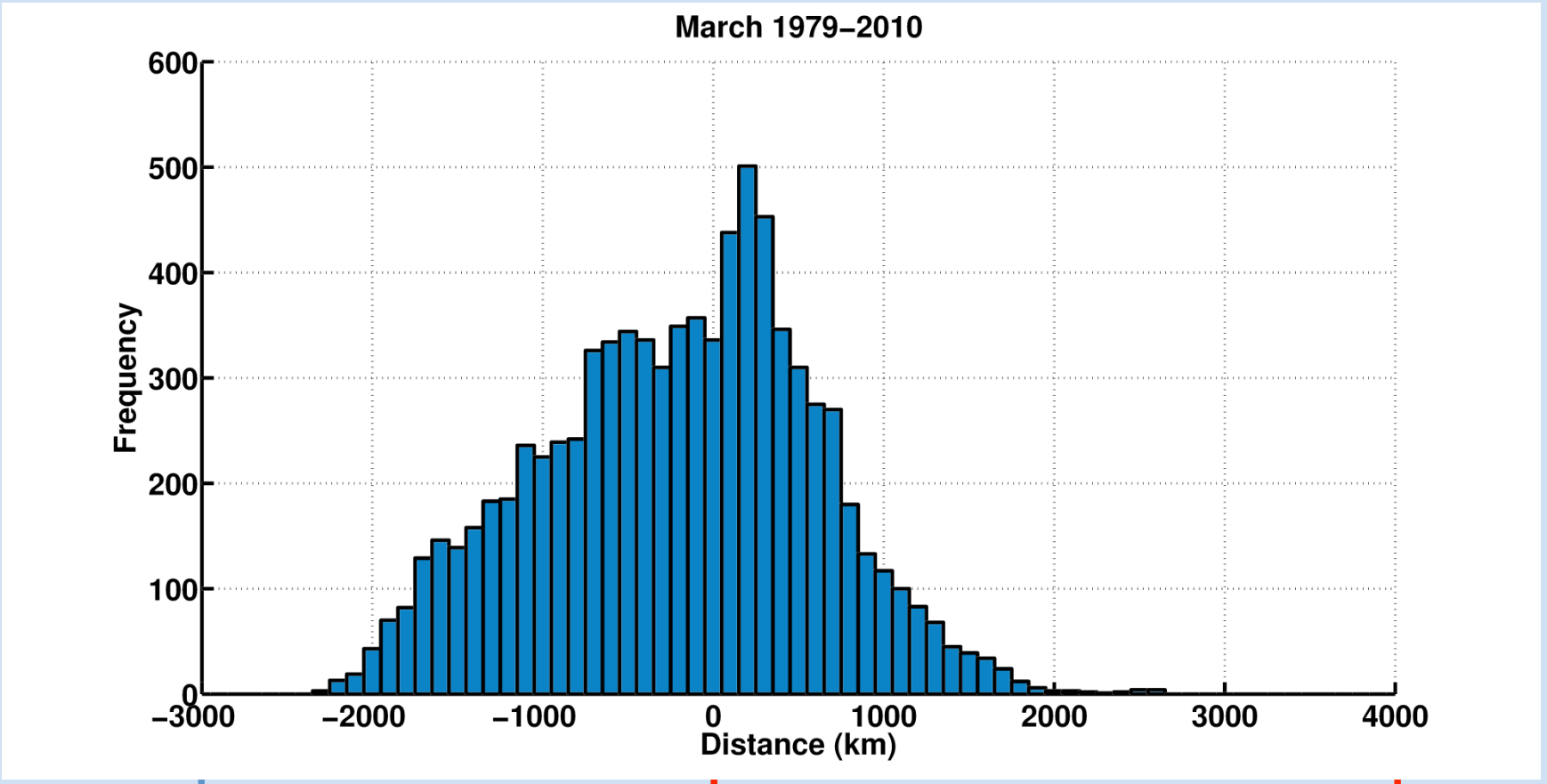


Fig. 10. Isopleths of error in °F of temperature estimates (solid), and isobars of mean sea level pressure (broken), for the period mid-February to mid-March 1960. Shading indicates prevailing snow cover.

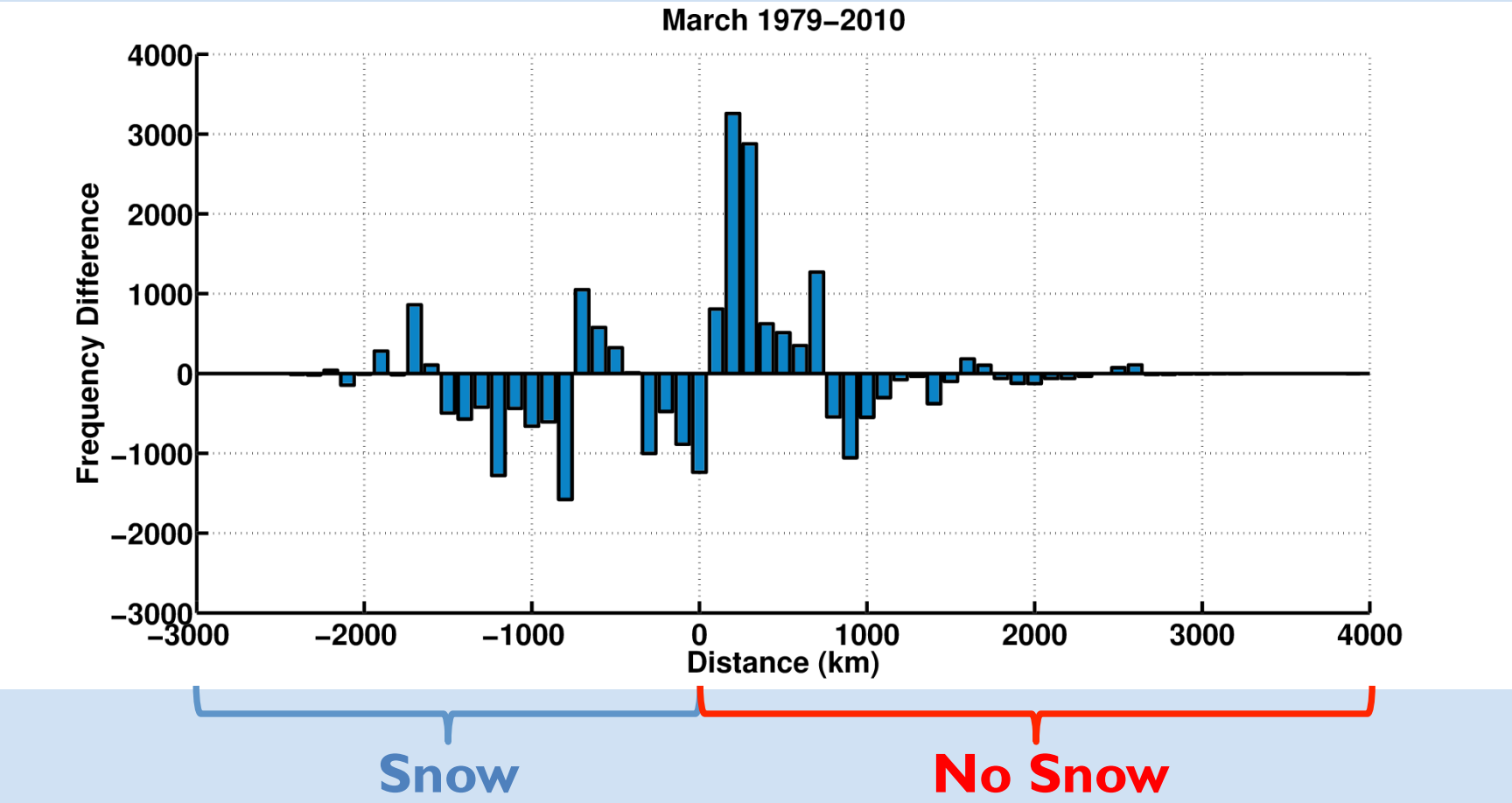
Rydzik and Desai, 2014, J Clim

MLC Distance from Snow Extent

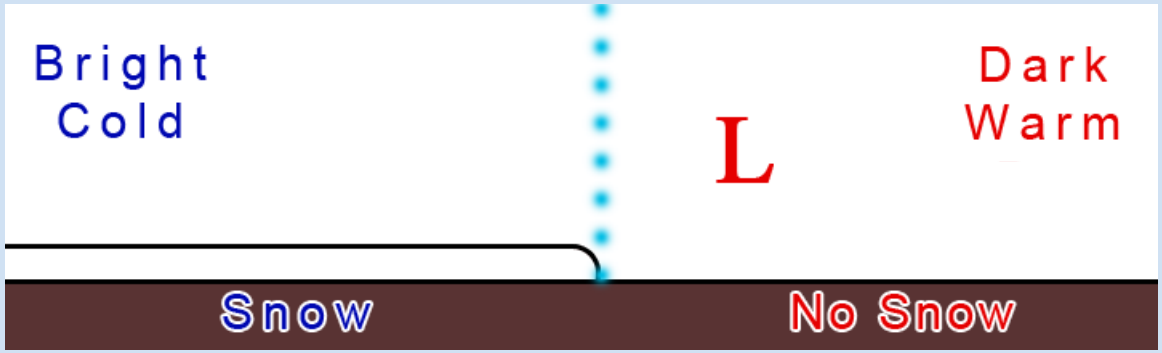
MLC tracking based on NARR surface low pressure location tracking algorithm

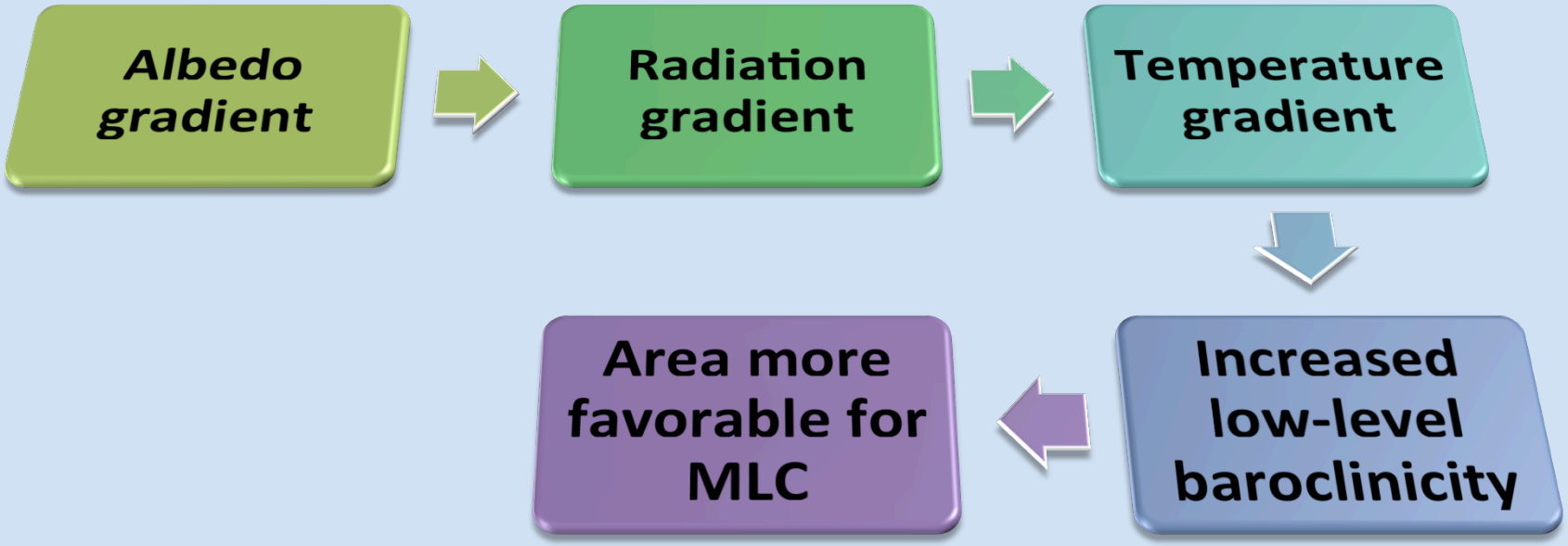


It appears to be robust since we see loss of coherence when shuffling data and redoing analysis

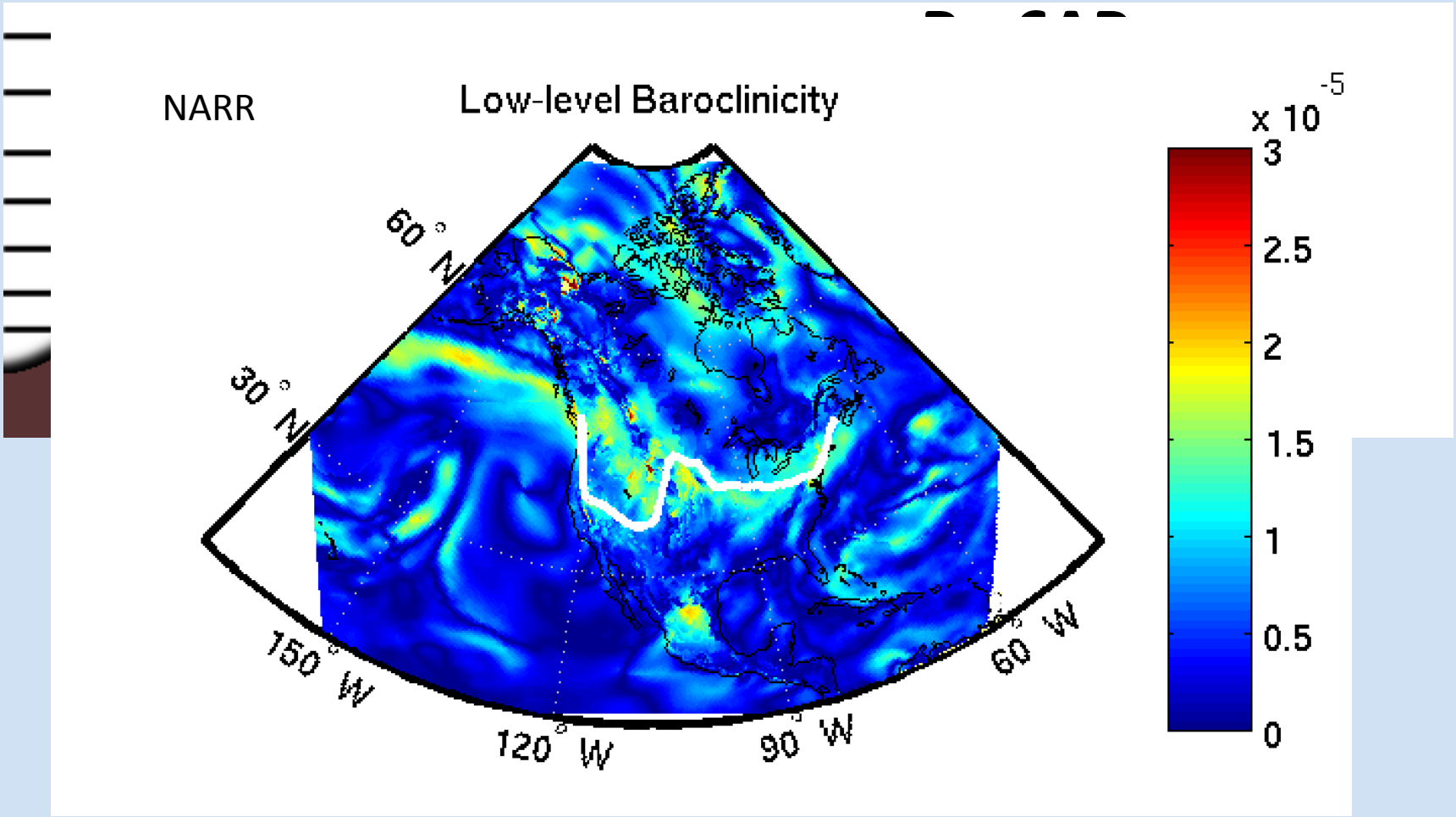


Why is there a relationship?





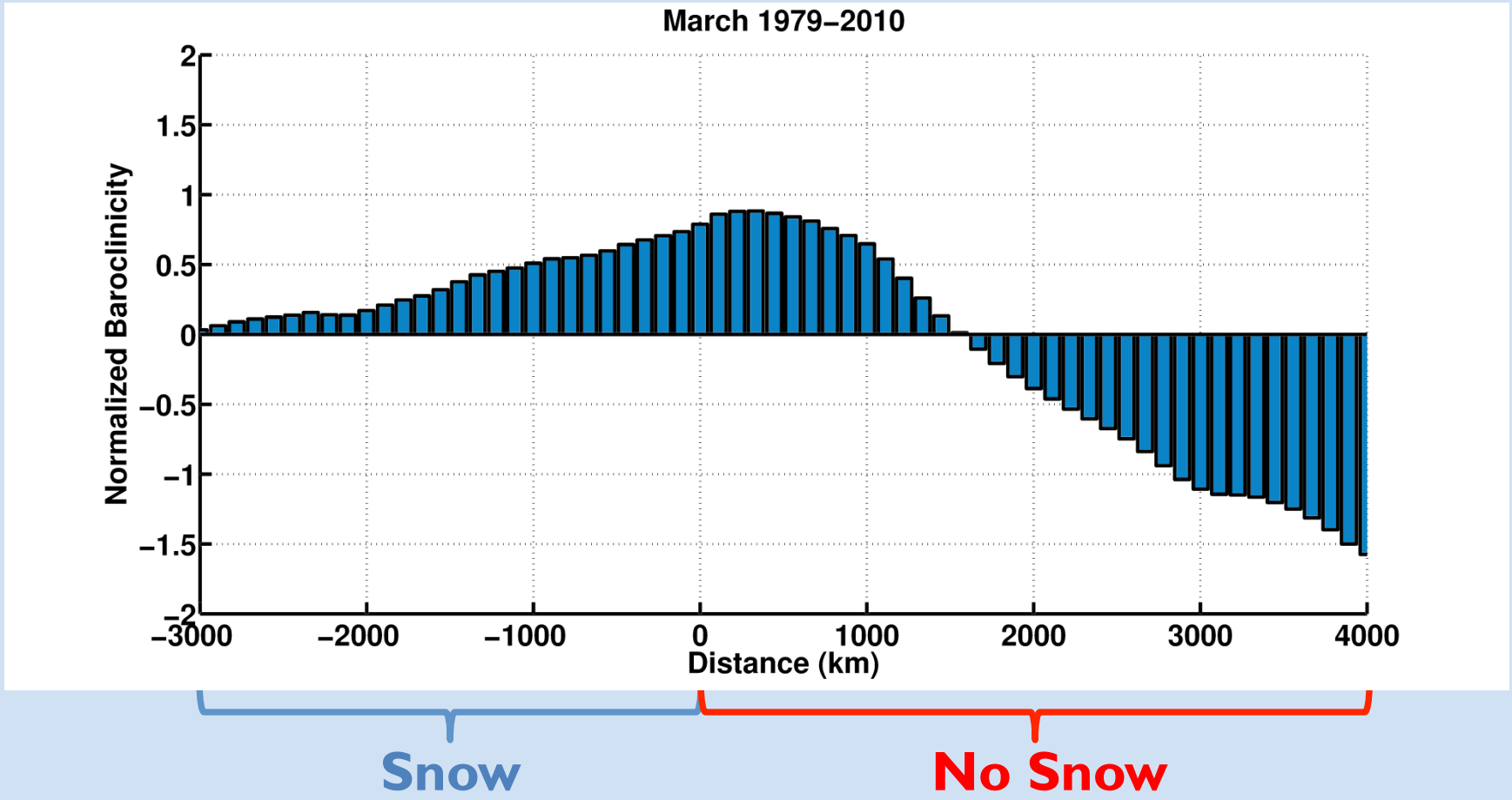
Low-level Baroclinicity



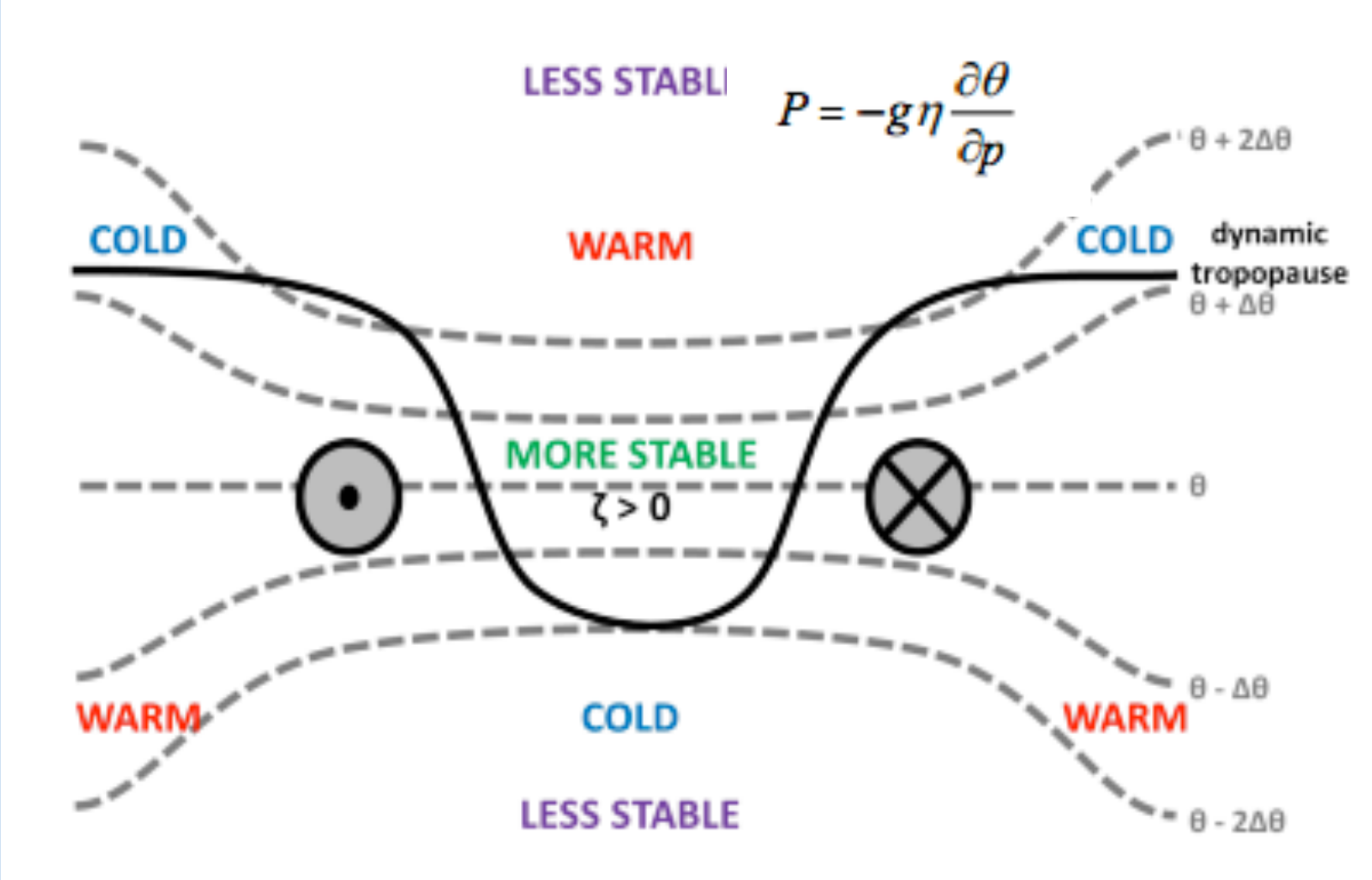
(based off of Lindzen and Farrell, 1980)

Low-level Baroclinicity

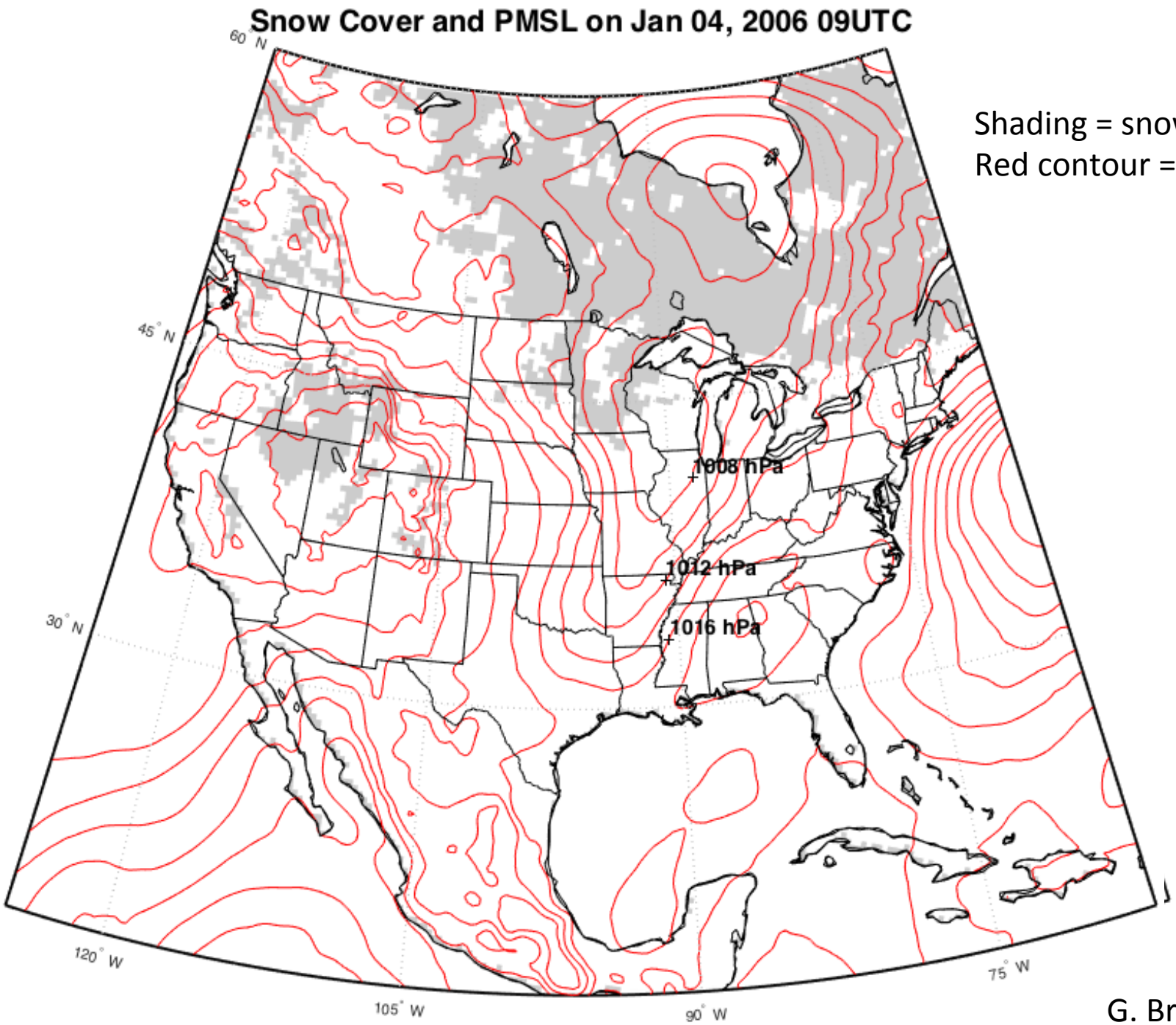
NARR based low-level baroclinicity that enhances total baroclinicity



Could we do piecewise PV inversion to identify mechanism in a numerical model?



Clark Evans, UW-Milwaukee lecture notes



Shading = snow
Red contour = SLP

G. Bromley

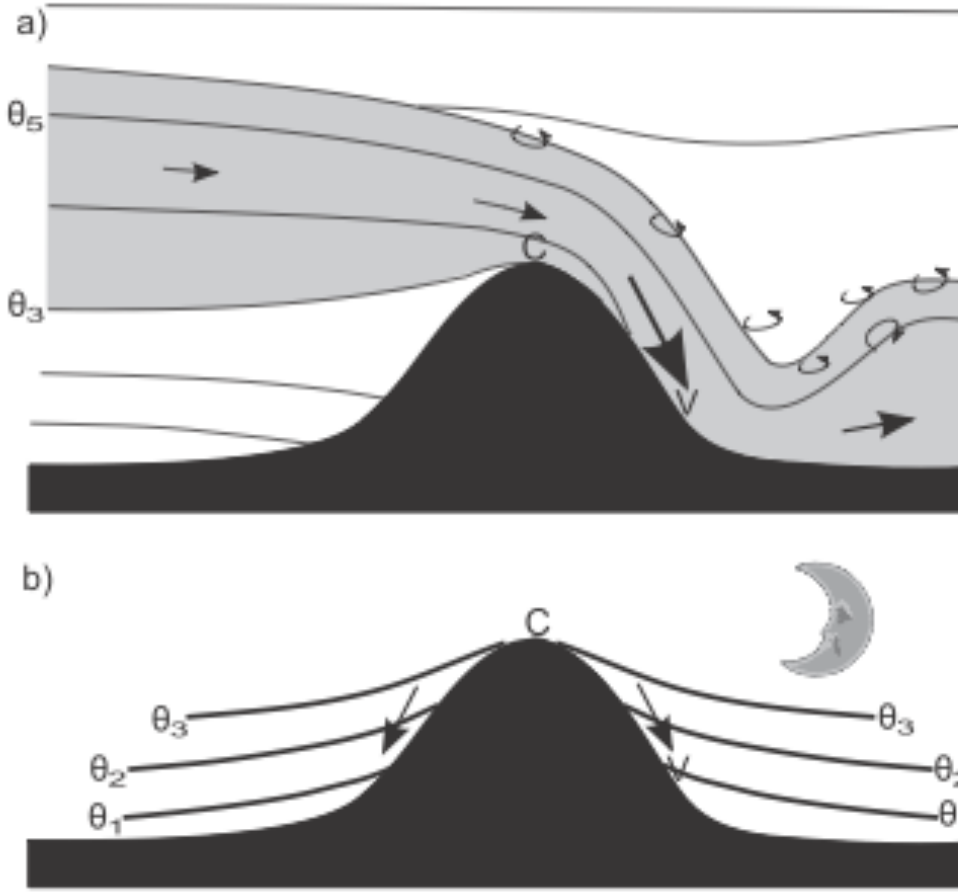

What’s happening under the snow?

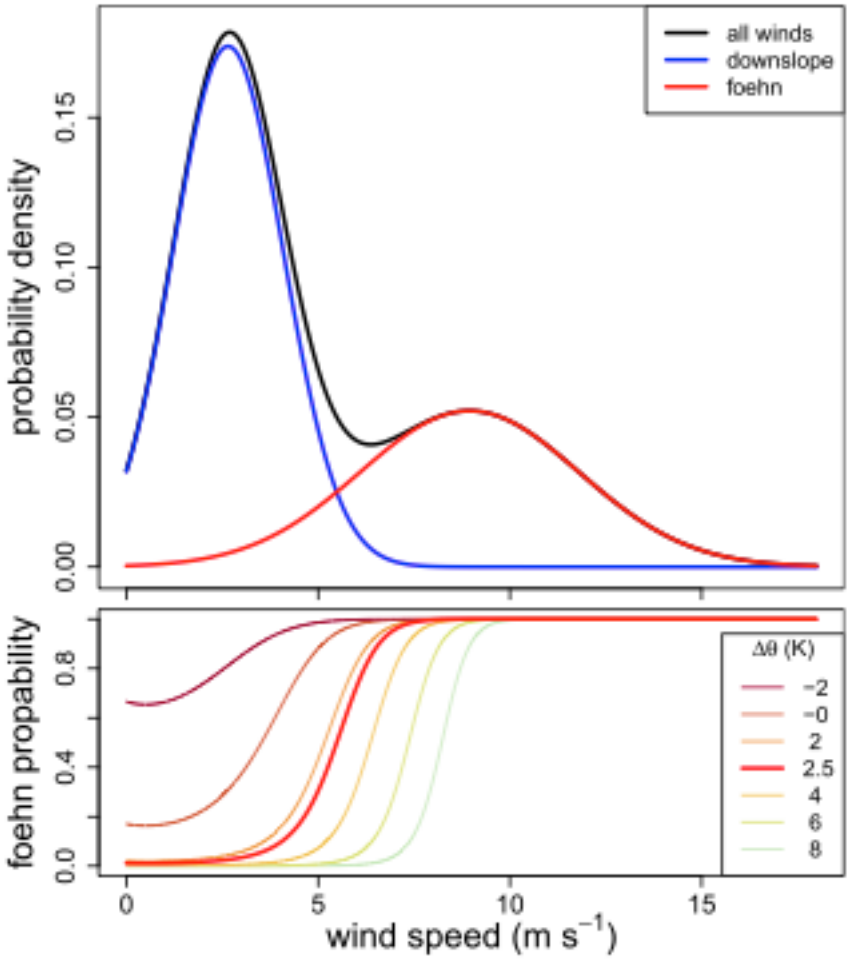

Lots of snow moisture dependent ecosystem productivity!

The Föhn eats snow!

Automatic and Probabilistic Foehn Diagnosis with a Statistical Mixture Model

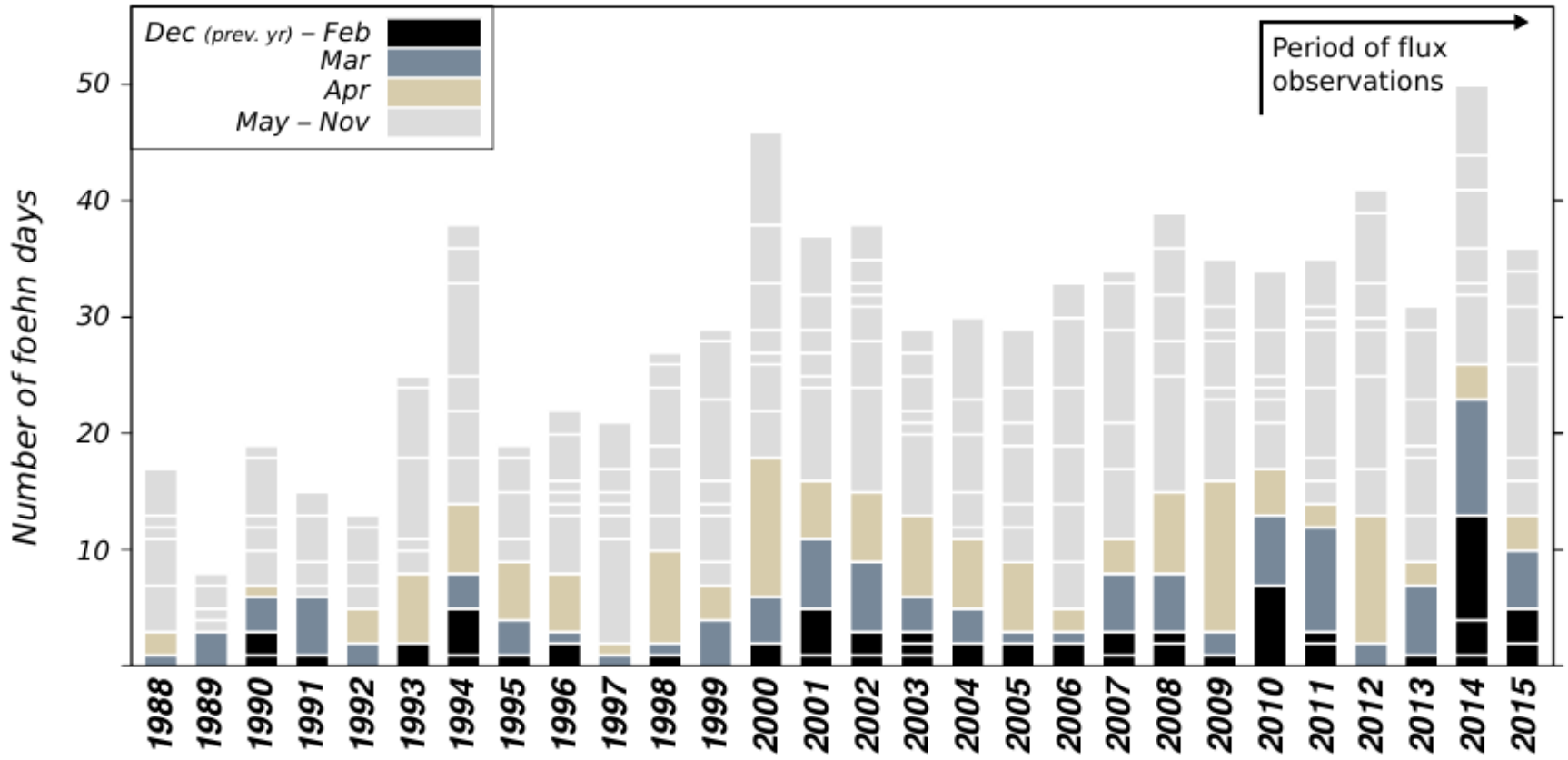
DAVID PLAVCAN AND GEORG J. MAYR
Institute of Meteorology and Geophysics, University of Innsbruck, Innsbruck, Austria
ACHIM ZEILEIS
Department of Statistics, Faculty of Economics and Statistics, University of Innsbruck, Innsbruck, Austria





High interannual variability in Föhn flows

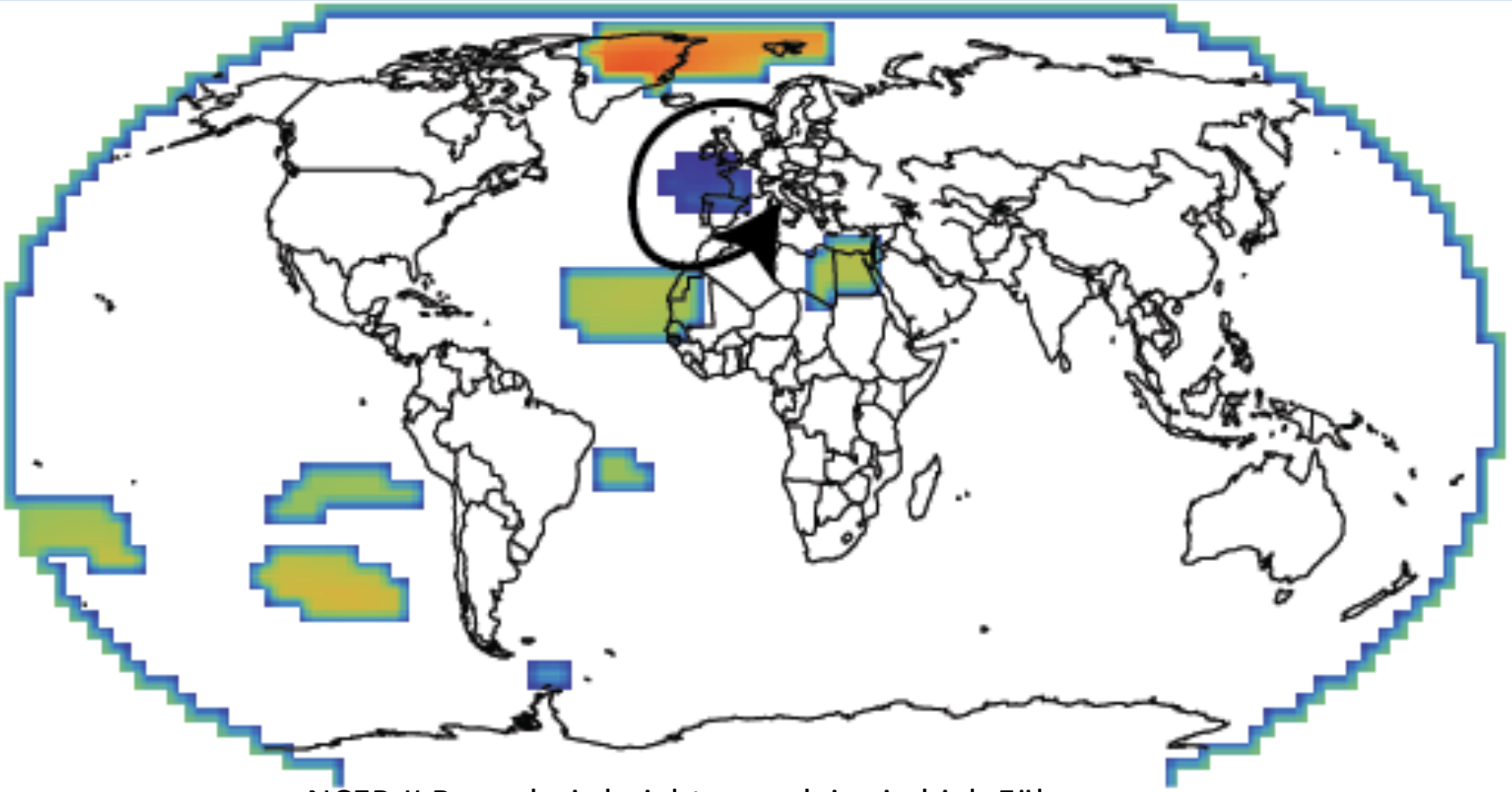
Based on wind and temperature gradients at Zugspitze and Garmisch-Partenkirchen, Germany



Zeeman et al., in prep, Ag. For. Met.

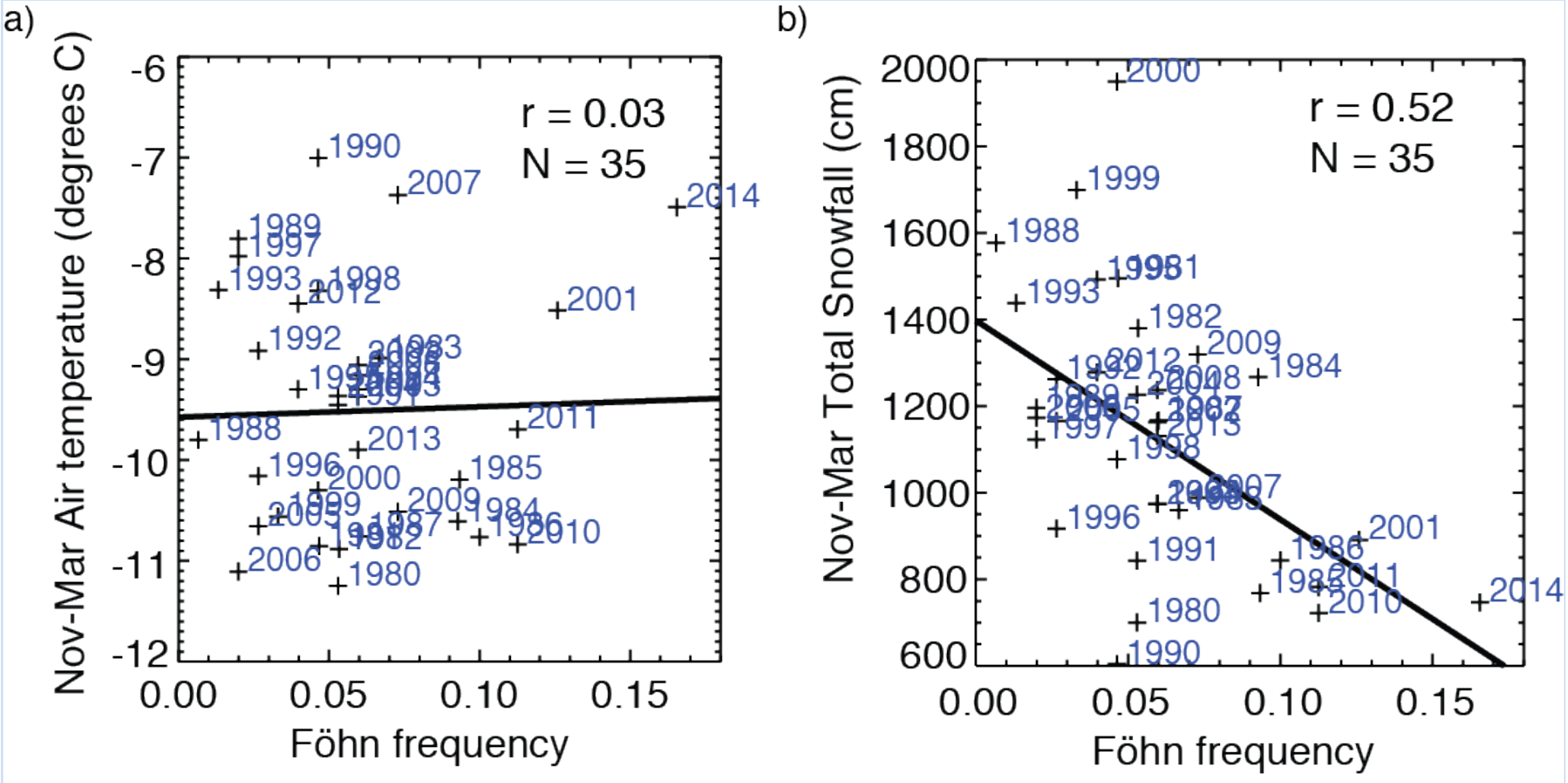
Figure A.11: Number of days with foehn per month for the period 1988 to 2014.

Circulation that promotes Föhn



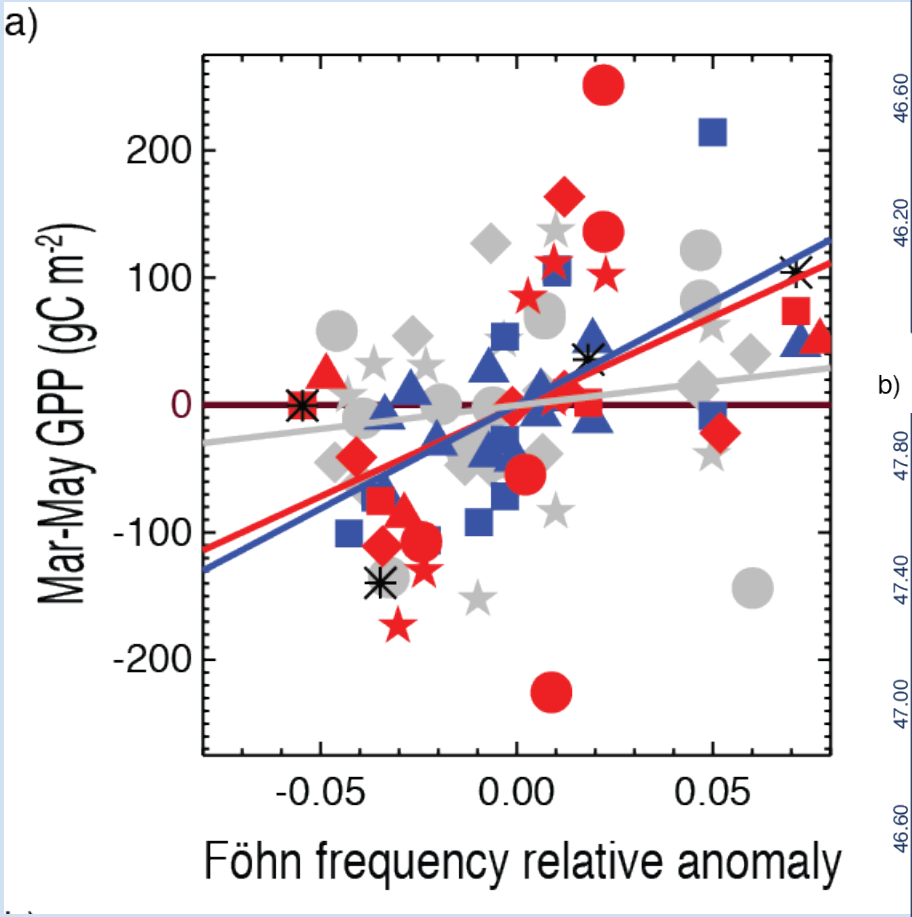
NCEP-II Reanalysis height anomlaies in high Föhn years

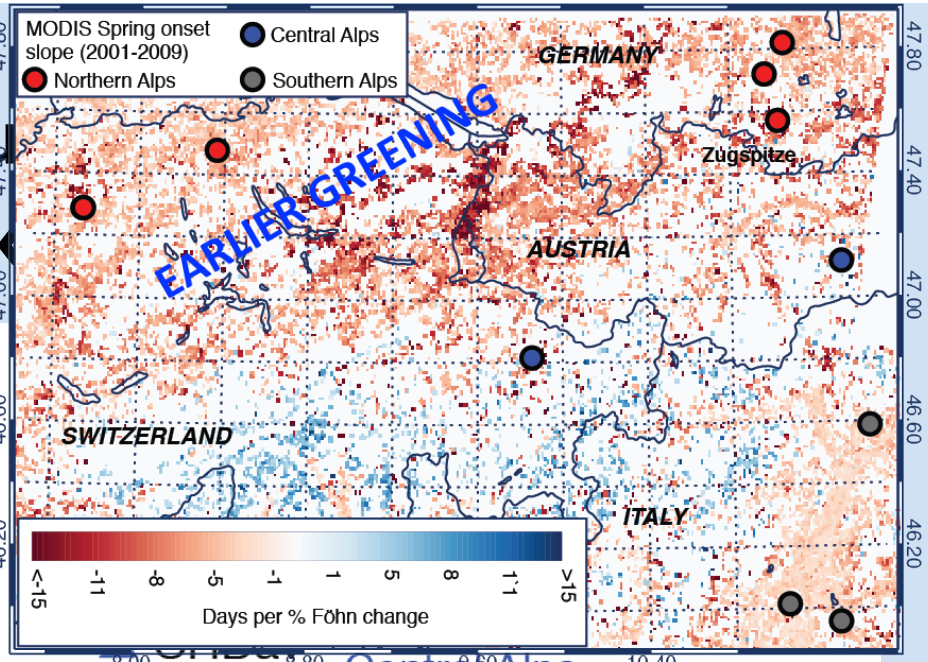
Föhn is linked to snowfall and snowmelt but not temperature

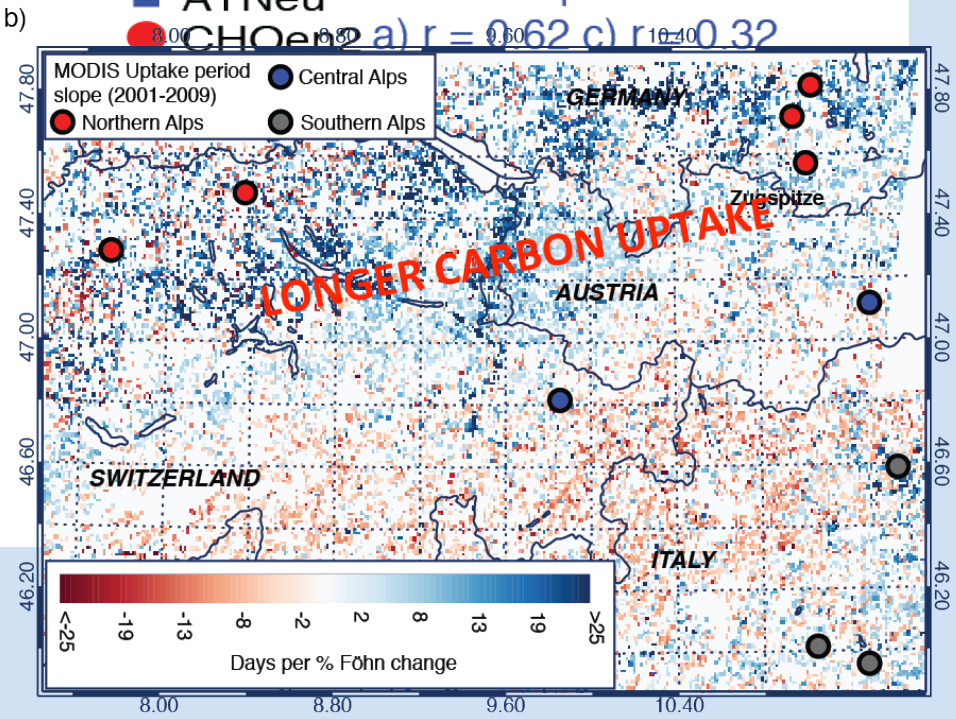


Zugspitze, Germany (9718 m) weather station observations Nov-Apr 1980-2014

Föhn drives produ
snowmelt feedback

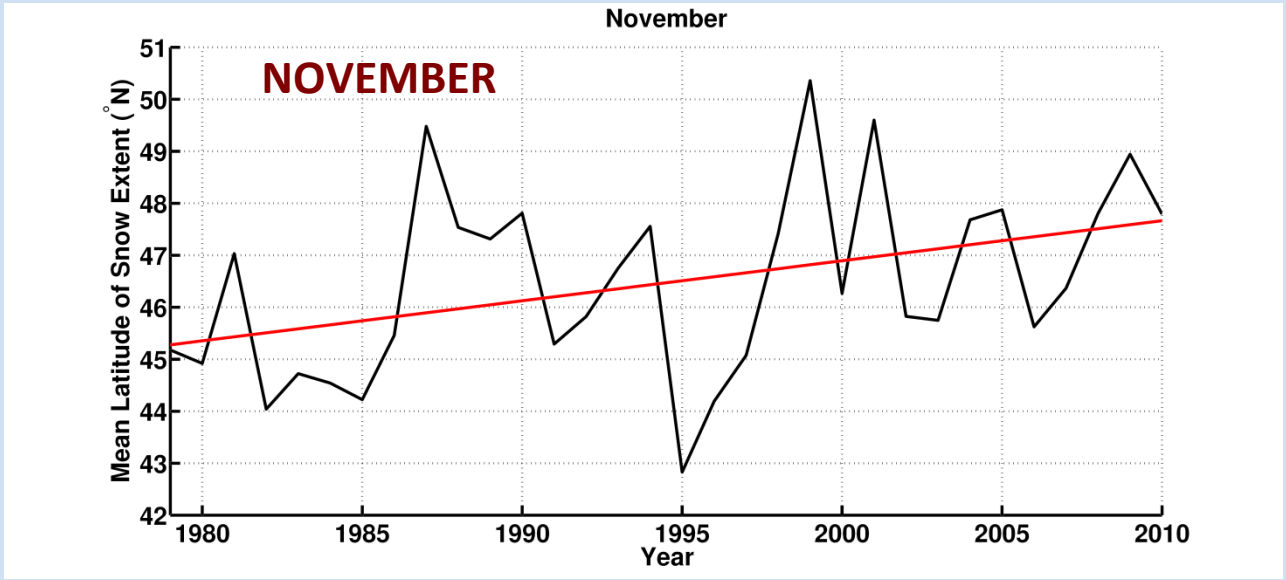




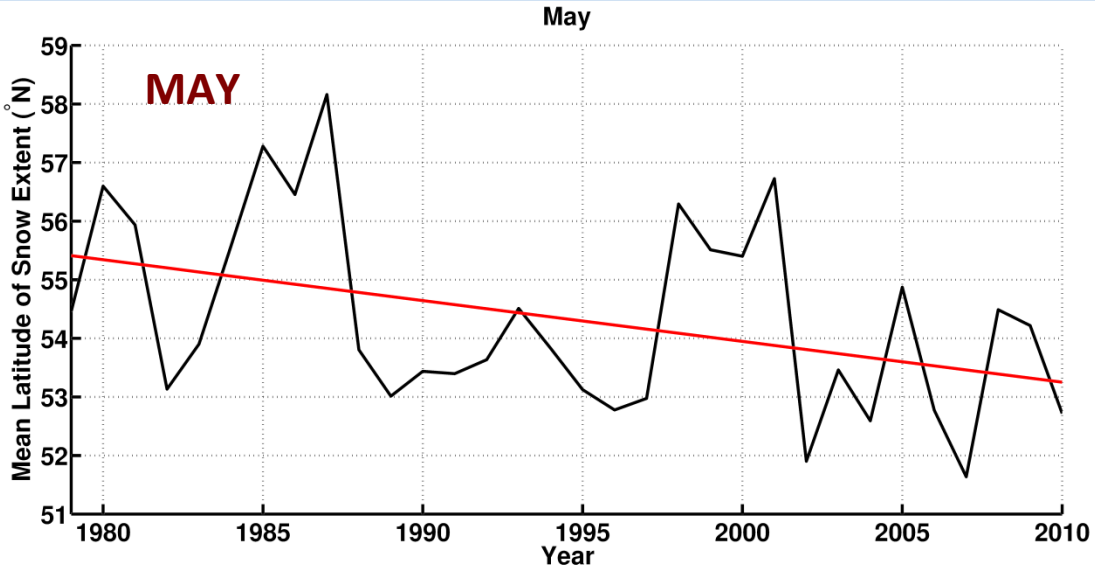


ATNeu
Central Alps
a) r = 0.62 c) r 0.32

Implications of snow extent in a changing climate are significant



Data: NARR
North America



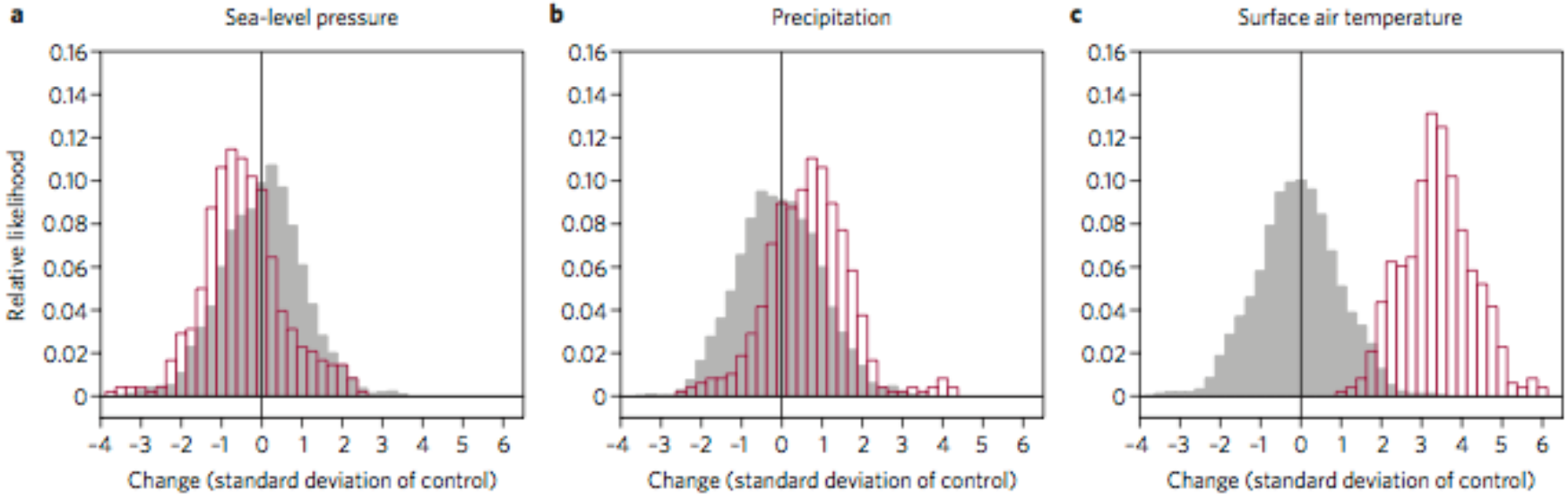
nature geoscience

PERSPECTIVE

PUBLISHED ONLINE: 21 SEPTEMBER 2014 | DOI: 10.1038/NGEO2253

Atmospheric circulation as a source of uncertainty in climate change projections

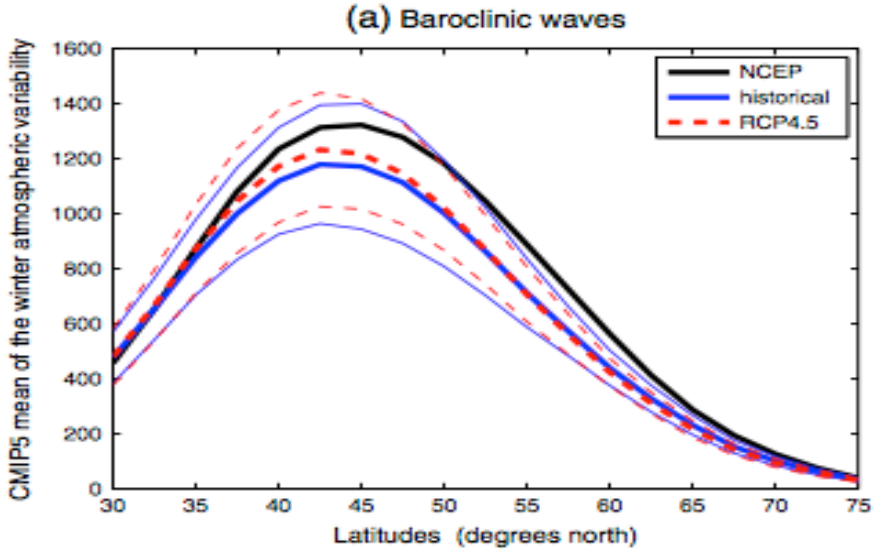
Theodore G. Shepherd



Northern Hemisphere winter midlatitude atmospheric variability in CMIP5 models

Valeria Di Biagio[1], Sandro Calmanti[2], Alessandro Dell'Aquila[2], and Paolo M. Ruti[2]

GRL, 2014



THANKS!

desai@aos.wisc.edu

Rydzik, M. and **Desai, A.R.**, 2014. Relationship between snow extent and midlatitude disturbance centers. J. Climate, 27, 2971–2982, doi:10.1175/JCLI-D-12-00841.1.

Desai, A.R., Wohlfahrt, G., Zeeman, M.J., Katata, G., Eugster, W., Montagnani, L., Gianelle, D., Mauder, M., and Schmid., H.-P., 2015. Montane ecosystem productivity responds more to global circulation patterns than climatic trends. Environ. Res. Lett. #ERL-101637, revision in review.

Funding: Center for Climatic Research Reid Bryson Climate People Environment Program Exploratory Research Grant, Dept of Energy Wind by 2030, UW Sabbatical Research Program, KIT IMK-IFU Helmholtz/MICMOR Visiting Scholar Program

It's not an artifact of disturbances depositing snow