SAR remote sensing of open mesoscale cellular convection

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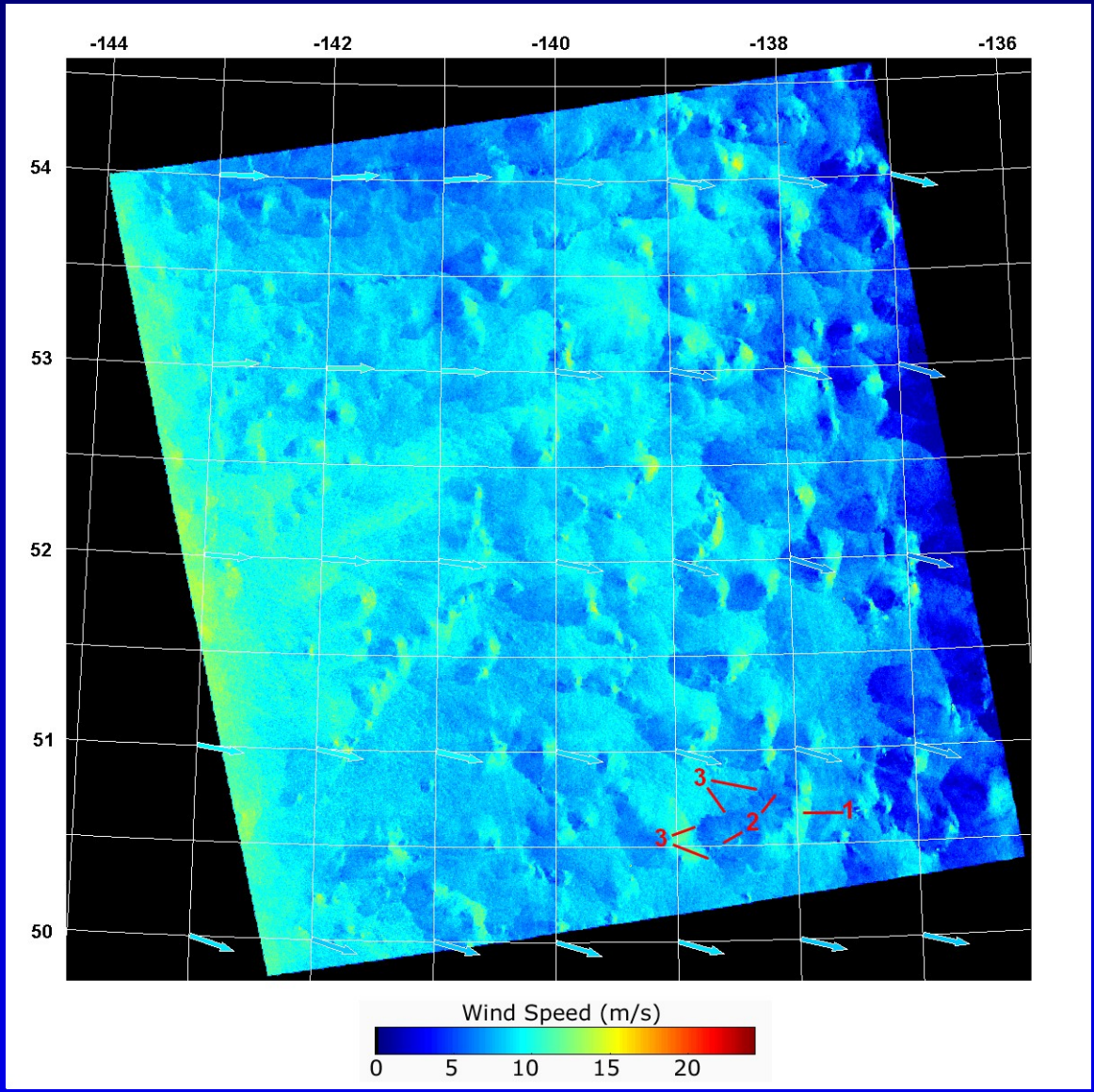
Introduction

- **Young et al. (2007) investigated cold-air outbreak open mesoscale cellular convection via a case study for the Gulf of Alaska**

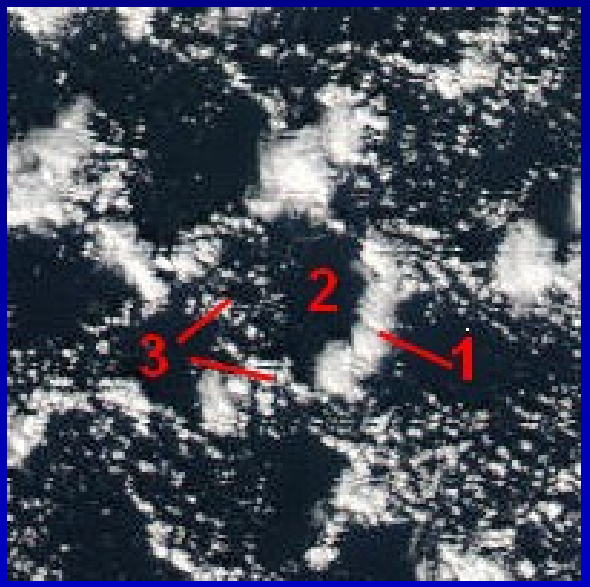
- **Employed nearly coincident MODIS and SAR-derived wind speed (SDWS)**

Previous findings

- **Young et al. (2007)**
  - **Demonstrated spatial and temporal correspondence between MODIS and SDWS signatures of open cell convection**



SDWS image from 0301 UTC on 8 November 2006. Pixel size is 600 m by 600 m. Pale blue arrows indicate the NOGAPS wind vectors. The squall appears as an area of stronger wind (1), with a sharp gradient along its leading edge. The trailing lull appears as an area of weaker wind upwind of the squall (2), with the cell's sides and upwind edge also marked by a sharp gradient of wind speed (3).



MODIS true color image from the Aqua satellite at 2310 UTC on 7 November 2006. The pixel size is 500 m by 500 m. The image is 100 km by 100 km. The arc clouds are found along the downwind edge (1) of the nearly cloud-free center (2) while ring clouds are found along the cell's sides and rear (3).

Previous findings

- **Young et al. (2007)**
  - **Arc clouds reached to ~ 500 hPa**
    - **Deeper than for previously reported results of open cell convection at middle- to high-latitude (see Atkinson and Zhang [1996] and Brümmer [1997,1999])**
  - **Arc clouds were glaciated**

Motivation

- Young et al. (2007) suggested the need for a comprehensive remote sensing-based study of middle- to-high latitude open cell convection

Objective

- **The present research satisfies that need via eight-year (1999-2006) Northeast Pacific Ocean climatology of:**
  - **Frequency of open cell convection**
- **Thermodynamic and kinematic environment of its formation**

Data

- SDWS from JHUAPL comprehensive on-line archive
- http://fermi.jhuapl.edu/sar/stormwatch/web_wind/
- Mostly R1 ScanSAR Wide B
- Some other R1 products and satellite SARs

Data

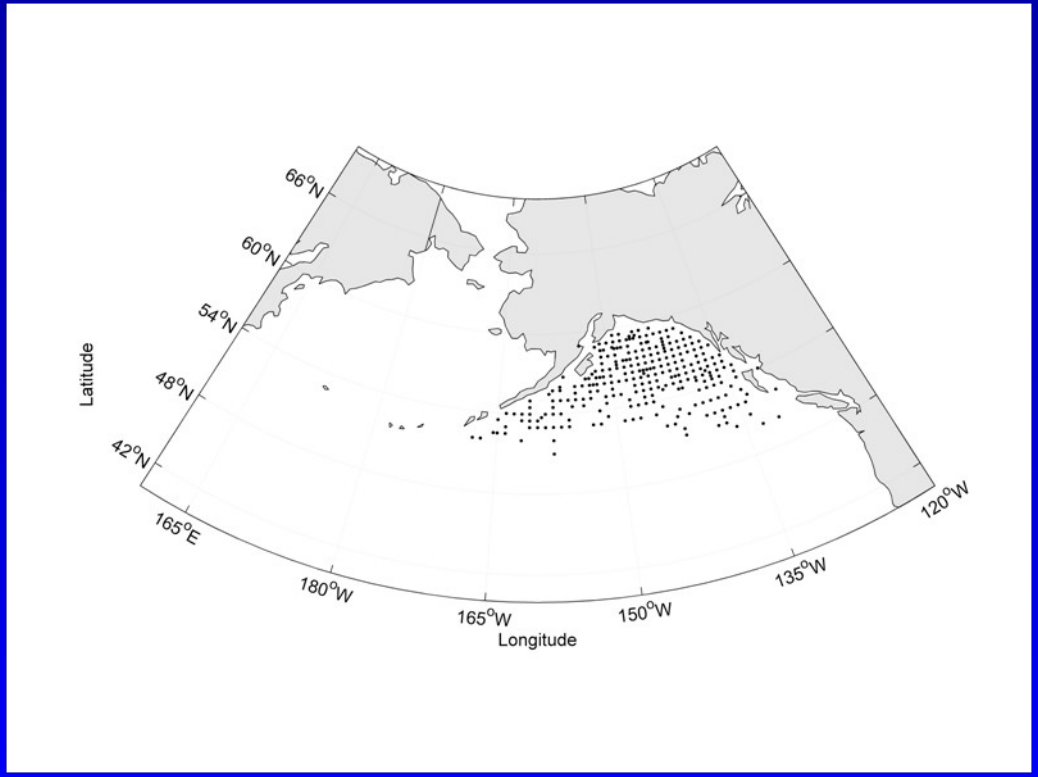
- **Reanalyses from NCEP/NCAR Reanalysis Project**

- **http://www.cdc.noaa.gov/cdc/reanalysis/reanalysis.shtml**

- **Surface sensible and latent heat flux, sea surface temperature, and air temperature and wind vector at the near-surface and at 925 hPa, 850 hPa, 700 hPa, and 500 hPa**

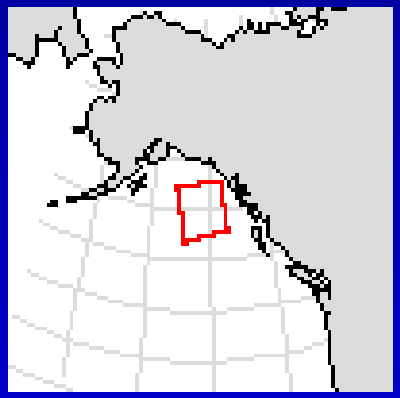
Procedures

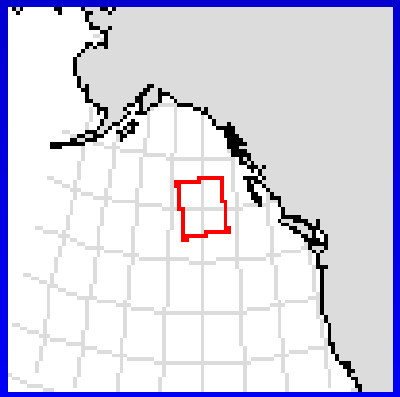
- **From 1999 to 2006, 616 events of open cell convection were observed via SDWS**



Procedures

- **Not all events are independent**

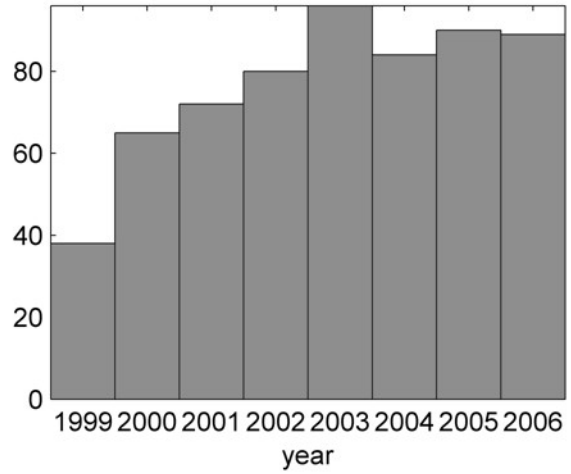


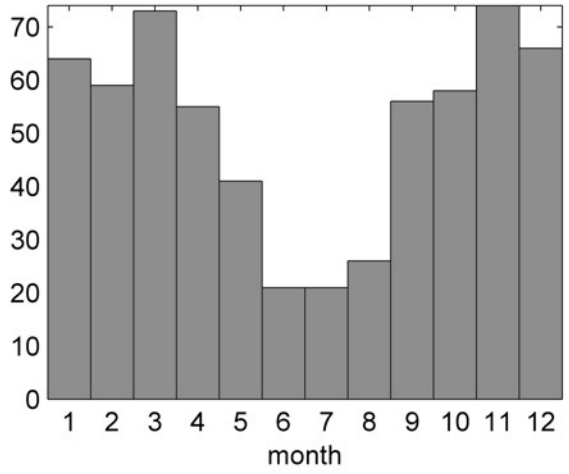


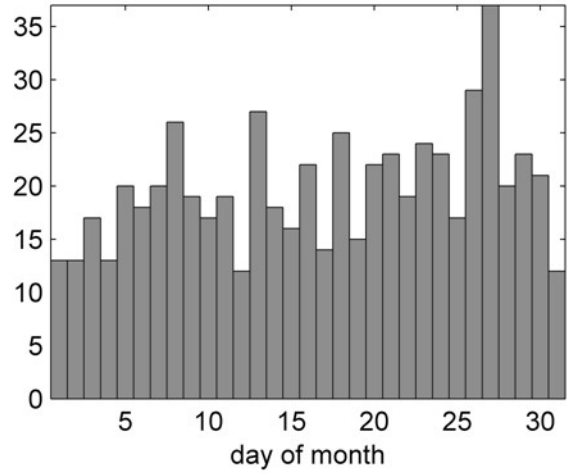
Procedures

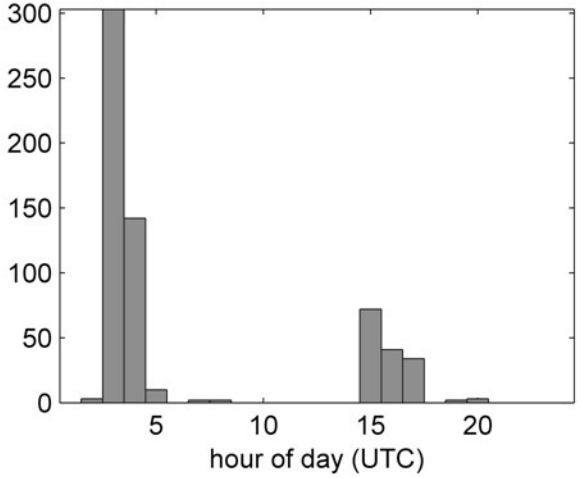
- For each event center location, nearest reanalysis data was retrieved

Frequency results









Thermodynamic and kinematic results

	First Quartile	Median	Third Quartile
H ($W\ m^{-2}$)	4.0	15	35
H_L ($W\ m^{-2}$)	29	52	85
ΔT (K)	-1.8	-0.9	-0.3
$\Gamma_{925\text{-}SFC}$ ($K\ km^{-1}$)	7.2	8.9	11
$\Gamma_{850\text{-}925}$ ($K\ km^{-1}$)	5.7	7.0	8.1
$\Gamma_{700\text{-}850}$ ($K\ km^{-1}$)	4.8	5.7	6.6
$\Gamma_{500\text{-}700}$ ($K\ km^{-1}$)	5.7	6.5	7.4
$\Delta V_{925\text{-}SFC}$ ($m\ s^{-1}$)	2.7	4.2	6.3
$\Delta V_{850\text{-}925}$ ($m\ s^{-1}$)	1.0	1.7	2.5
$\Delta V_{700\text{-}850}$ ($m\ s^{-1}$)	1.6	2.7	4.3
$\Delta V_{500\text{-}700}$ ($m\ s^{-1}$)	2.7	4.7	8.4

Thermodynamic results

- **Fluxes**
- **Values in keeping with previously reported results**
  - **Supportive of surface based convection**
- **Thermodynamic profiles**
- **Values for cloud layer and below in keeping with previously reported results**
- **Upper-layer value implies rather deep (~500 hPa) open cell convection was possible**
- **Similar to Young et al. (2007)**

Kinematic results

- **Vertical wind shear**
- **Lower-layer value in keeping with previously reported results**
- **Vertical distribution**
- **Large lower-layer value and small mid-layer value**
- **Reminiscent of that associated with radar-detected arcs of tropical deep moist convection (see LeMone et al. [1998] and Johnson et al. [2005])**

Discussion

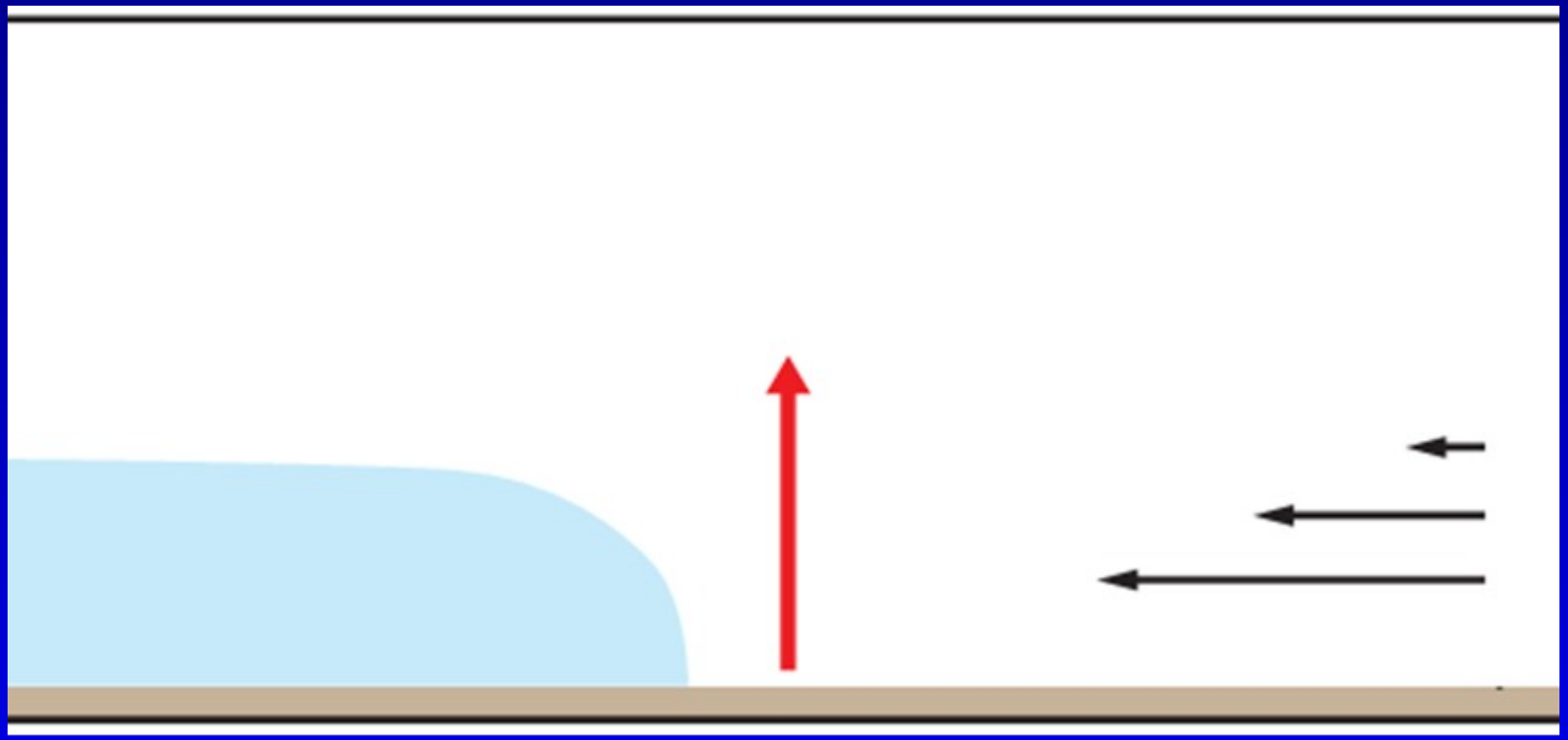
- **Young et al. (2007)**

- **Suggested similarity between middle- to high-latitude open cell convection and tropical deep moist convection**

- **Related to precipitation-driven cold pools and resulting arcs of deeper convection**

$$\alpha_o \nabla^2 p' = -\left[\left(\frac{\partial u'}{\partial x}\right)^2 + \left(\frac{\partial v'}{\partial y}\right)^2 + \left(\frac{\partial w'}{\partial z}\right)^2\right] - \frac{1}{2}\left\|\left[\left(\frac{\partial w'}{\partial y} + \frac{\partial v'}{\partial z}\right)\hat{i} + \left(\frac{\partial u'}{\partial z} + \frac{\partial w'}{\partial x}\right)\hat{j} + \left(\frac{\partial v'}{\partial x} + \frac{\partial u'}{\partial y}\right)\hat{k}\right]\right\|^2$$

$$+ \frac{1}{2}\left\|\left[\left(\frac{\partial w'}{\partial y} - \frac{\partial v'}{\partial z}\right)\hat{i} + \left(\frac{\partial u'}{\partial z} - \frac{\partial w'}{\partial x}\right)\hat{j} + \left(\frac{\partial v'}{\partial x} - \frac{\partial u'}{\partial y}\right)\hat{k}\right]\right\|^2 - 2\vec{S} \bullet \nabla_h w' + \frac{\partial B}{\partial z}$$

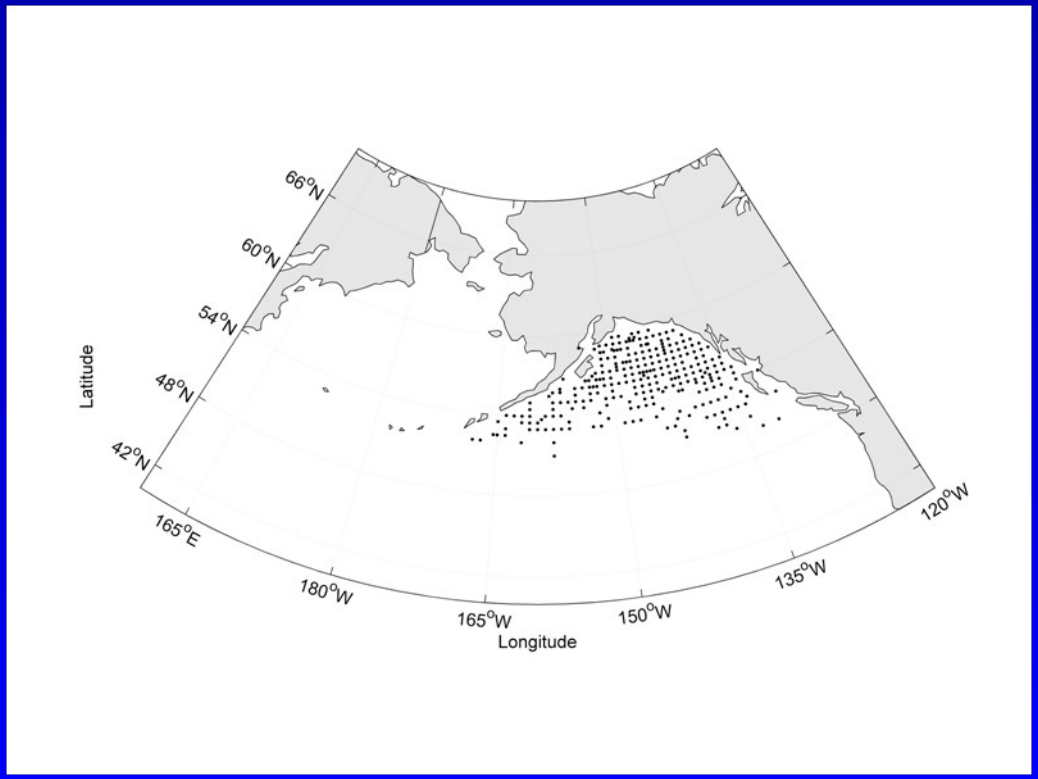


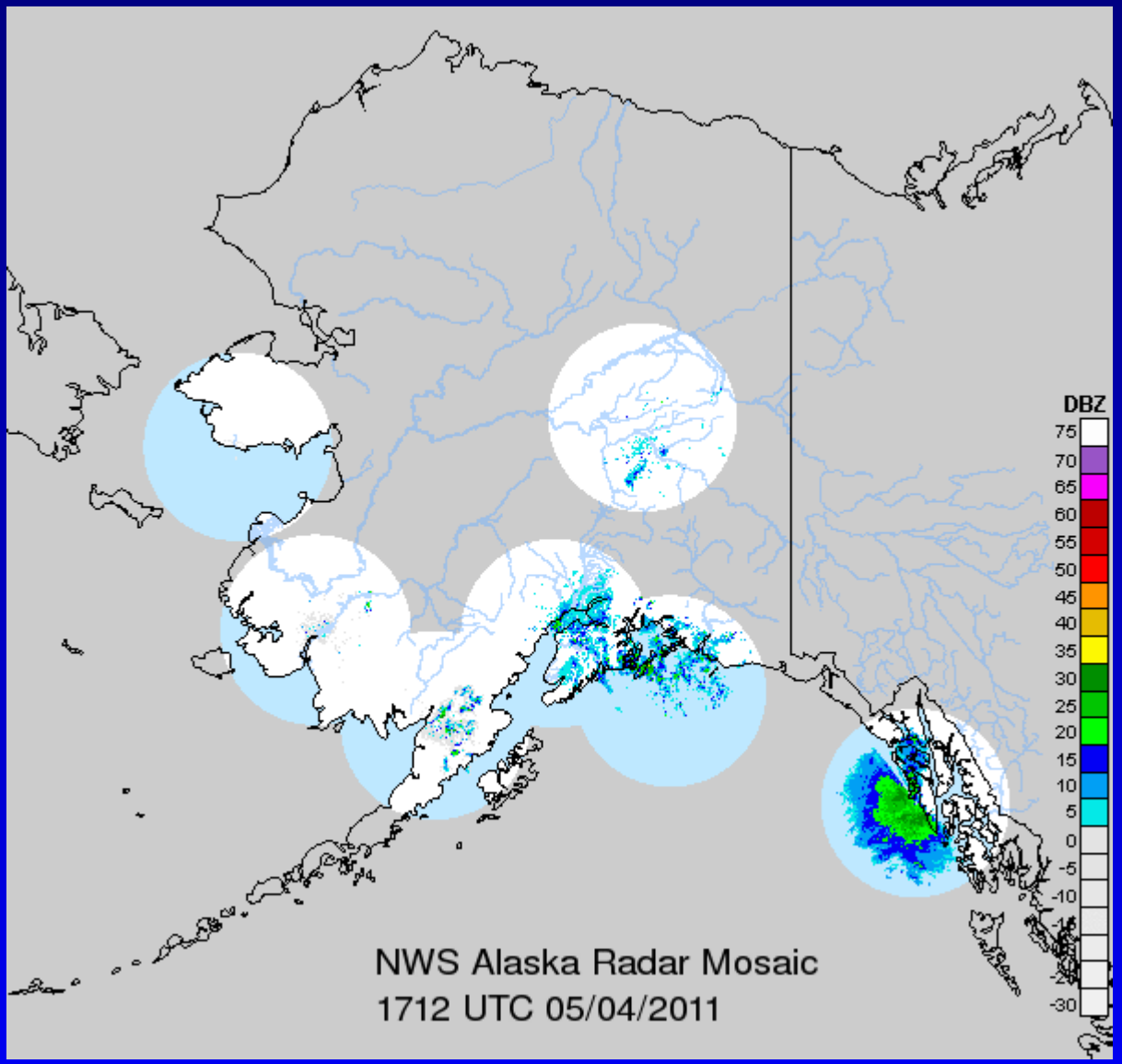
Discussion

- **The present research supports Young et al.’s suspicions**
- **However, we have no precipitation data**

Future work

- **Precipitation verification**
  - **Employ NWS weather radar from Alaska Region**




DBZ
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25
20
15
10
5
0
-5
-10
-30
NWS Alaska Radar Mosaic
1712 UTC 05/04/2011

Reference

•Sikora, T. D., G. S. Young, C. M. Fisher, and M. D. Stepp, 2011: A synthetic aperture radar-based climatology of open cell convection over the northeast Pacific Ocean. *J. Appl. Meteor. Climatol.*, **50**, 594-603.