The Surface Storm Track (Northern Hemisphere)

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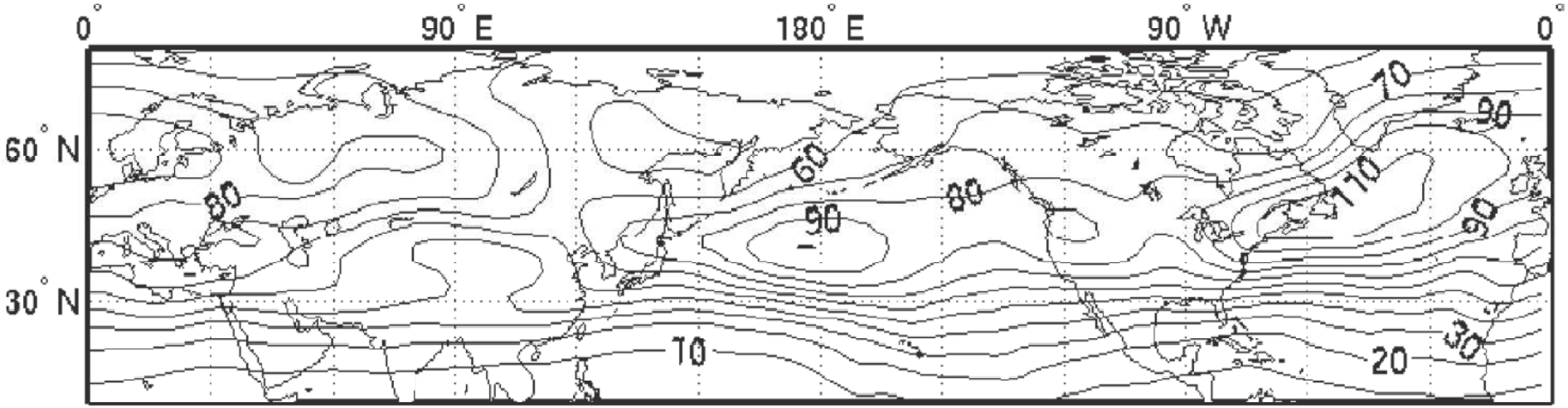
Introduction and Motivation

Northern Hemisphere Storm Tracks
(calculated for geopotential height at 250mb)

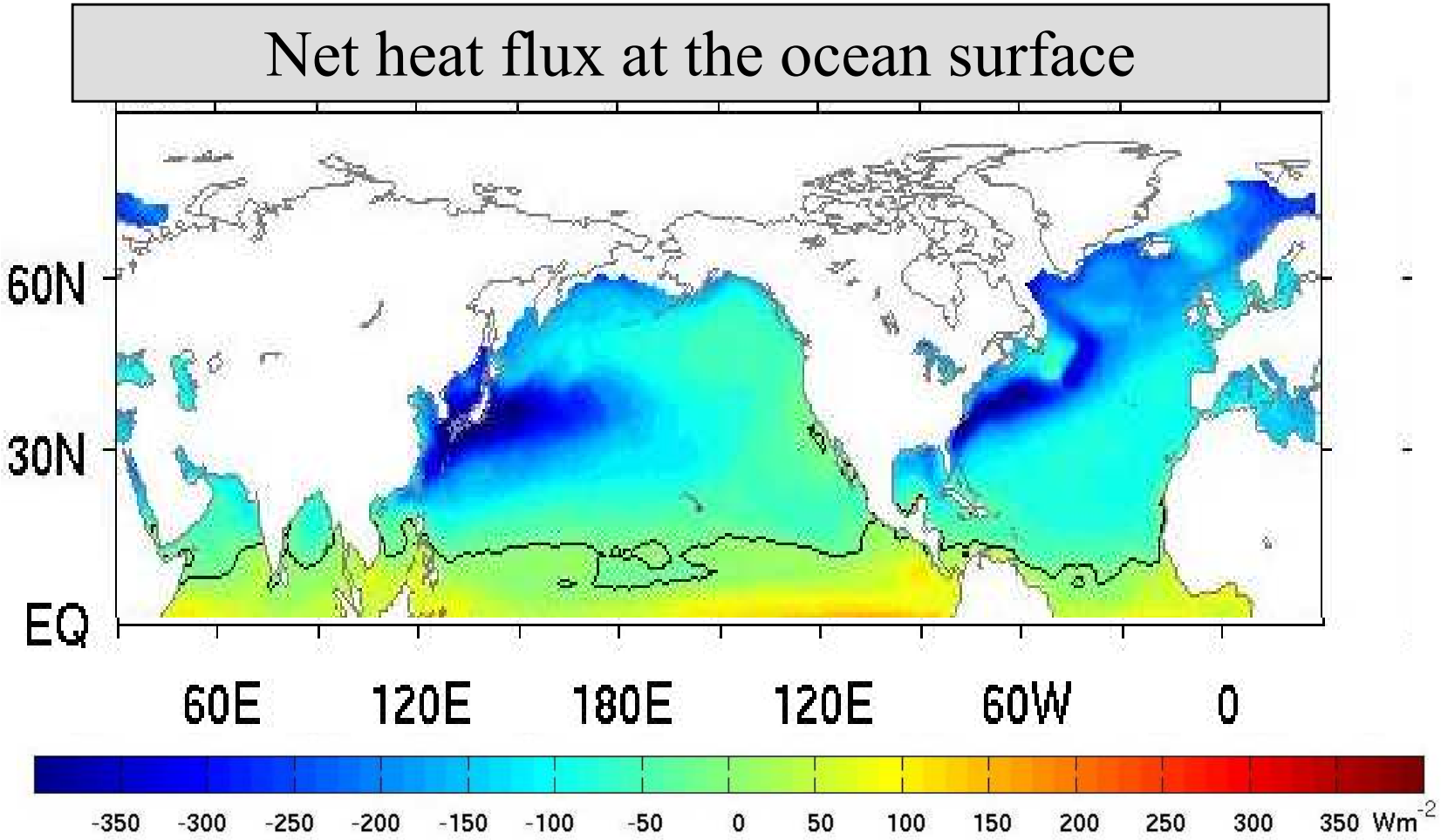


from Swanson, 2006

"Storm Track Anchoring Theory"

Hoskins and Valdez [1990] and Nakamura et al [2004 and 2008] : the strong western boundary currents of the ocean feed the cyclogenesis at the atmospheric storm track entrance region.

Introduction and Motivation



Negative = flux from ocean to atmosphere. Yu and Weller, 2008

Introduction and Motivation

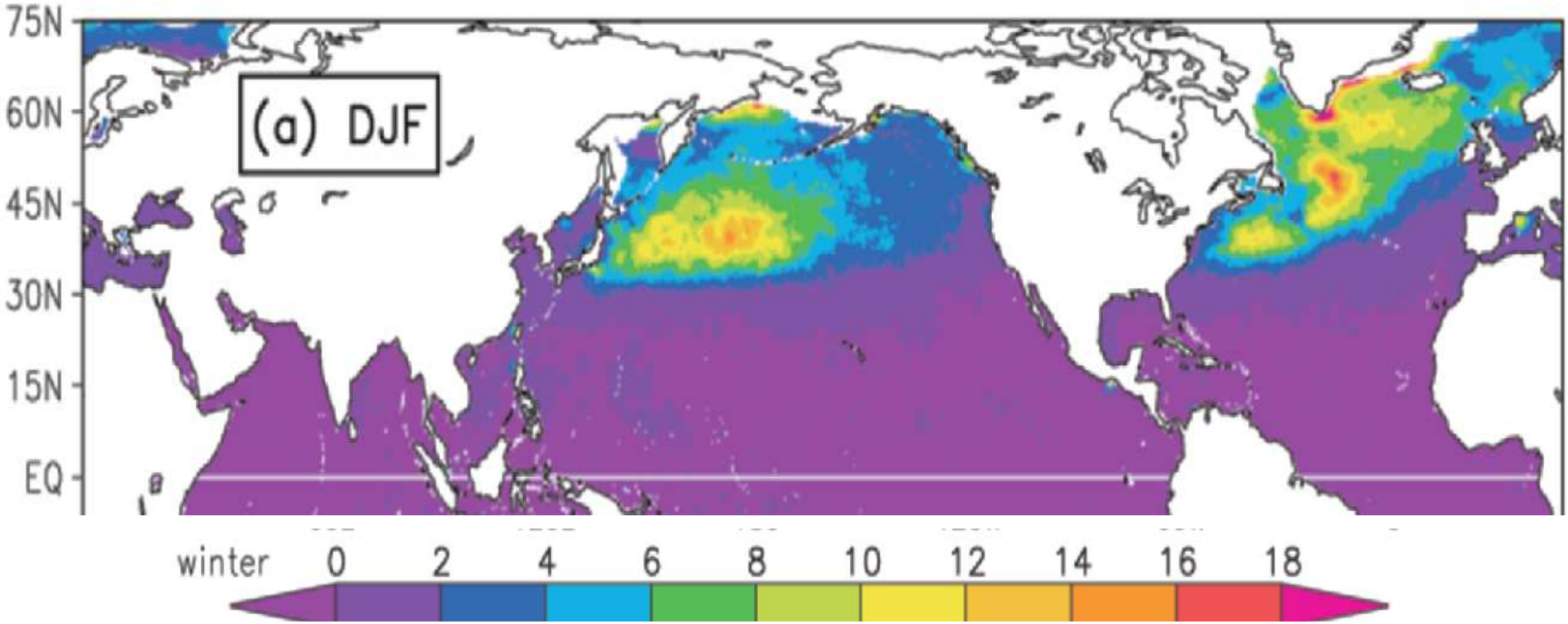
- We would like to understand the connections between the sensible and latent heat fluxes from the ocean boundary currents and midlatitude storminess.

But first, we need to have a good metric for storminess near the air-sea boundary.

Introduction and Motivation

Sampe and Xie (2007) : **high-wind frequency**

Occurrence of high winds (> 20m/s) at the surface



Units: percentage of days in winter

Sampe and Xie, 2007

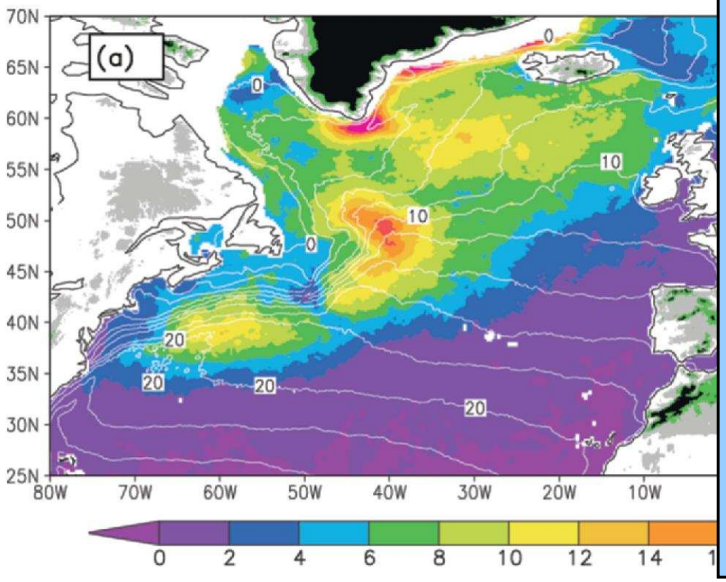
Introduction and Motivation

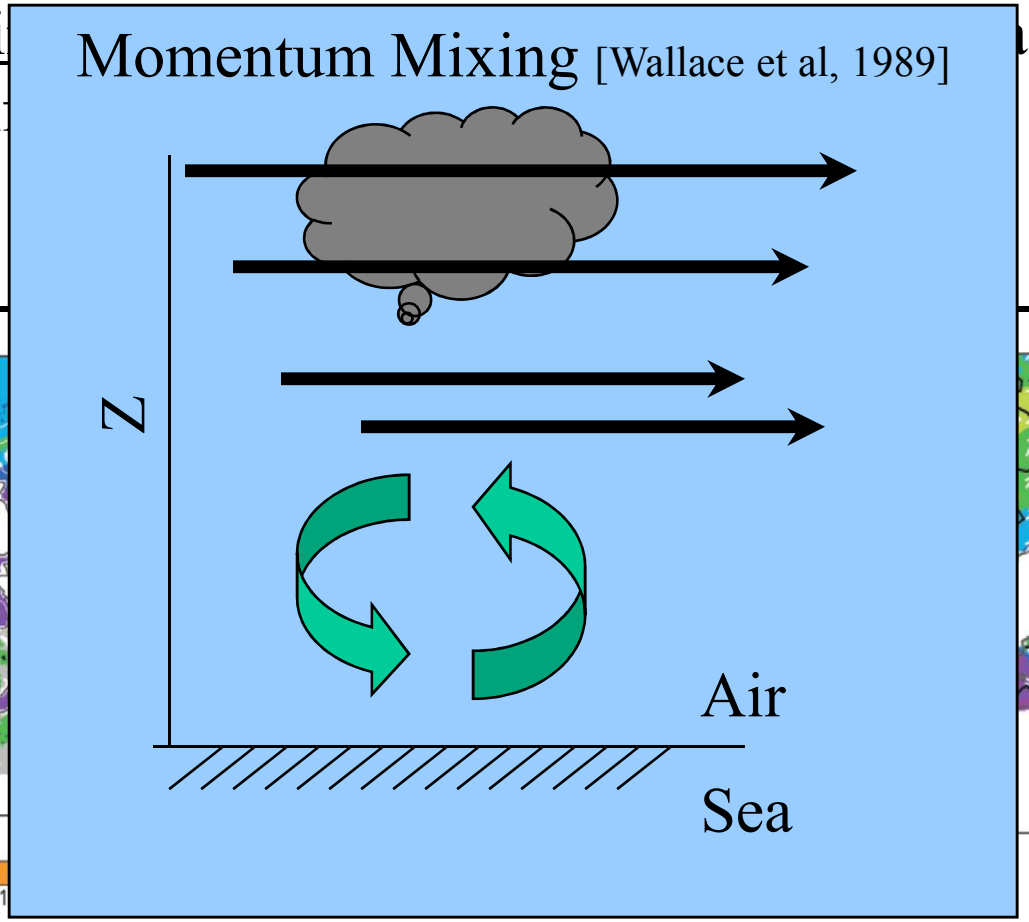
Sampe and Xie (2007): **high-wind frequency**

-The strong winds are caused by storms.

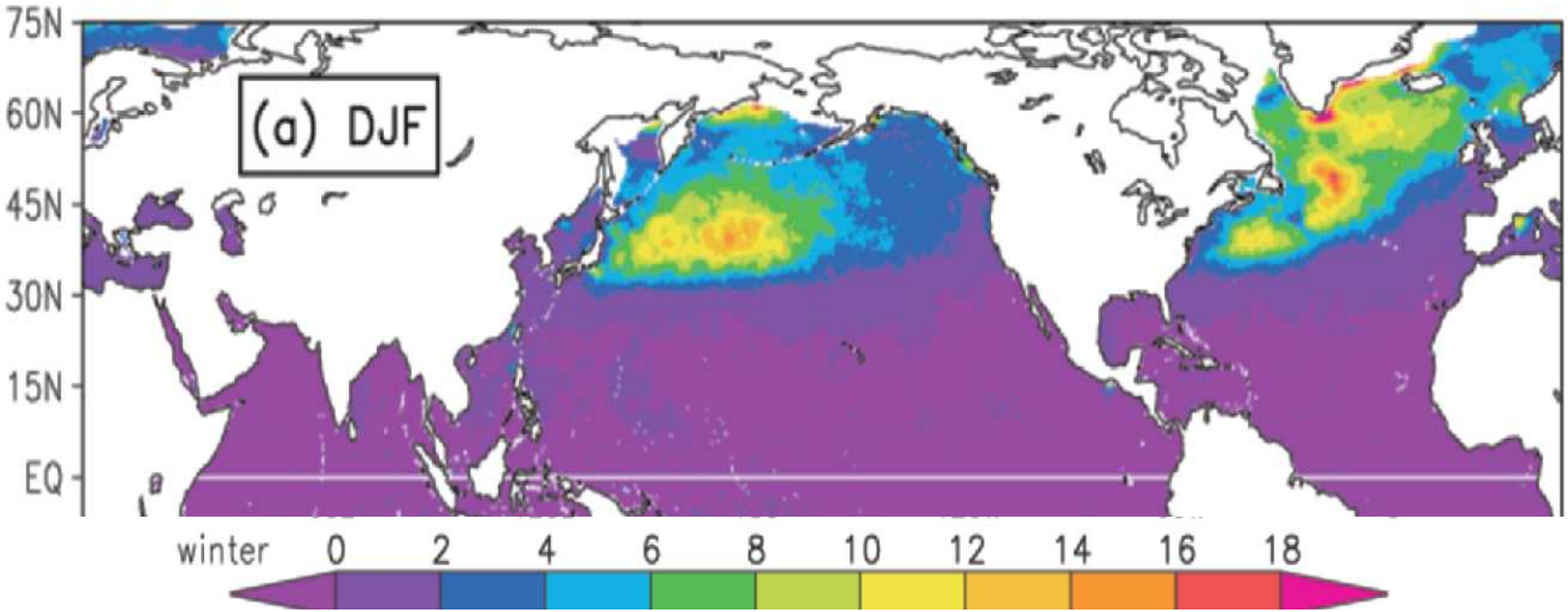
-Momentum-mixi

temperature difference in





Introduction and Motivation



The **high-wind frequency** captures a signature of storms in the surface winds.

But: When (during a storm's life cycle) do the strongest winds occur? Why isn't the momentum-mixing mechanism more evident in the Pacific?

We wish to supplement the Sampe and Xie study with another metric of the storm's signature in the surface winds.

Question

- What patterns emerge when storm track analysis is applied to the surface winds.

- Does the analysis capture the same storm activity as when it is applied aloft?

Methods

- All results are for Winter season for the years 1999-2006.
- For continuity, all results shown use ECMWF winds, which incorporate QuikSCAT winds starting in 2002.

  (I have verified the surface wind results using QuikSCAT winds.)
- Atmospheric boundary layer **(A.B.L.)** instability = positive values for SST minus SAT.
- Gulf Stream and Kuroshio Extension based on altimetry data [provided by Kelly]

Storm track analysis:

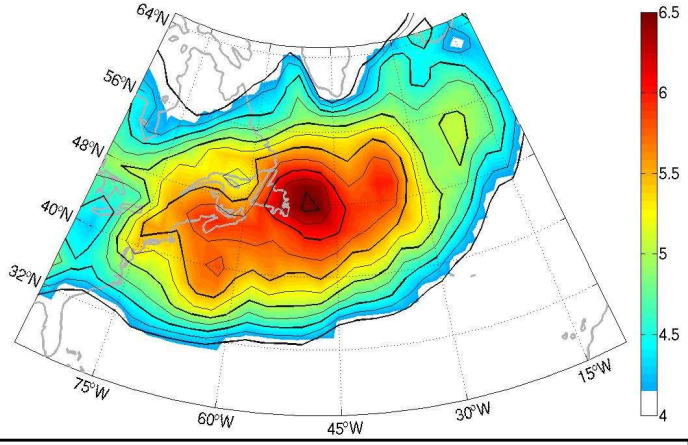
Time filter at each spatial grid point to isolate synoptic variability (2-8 day band pass).

Calculate the standard deviation for the filtered data.

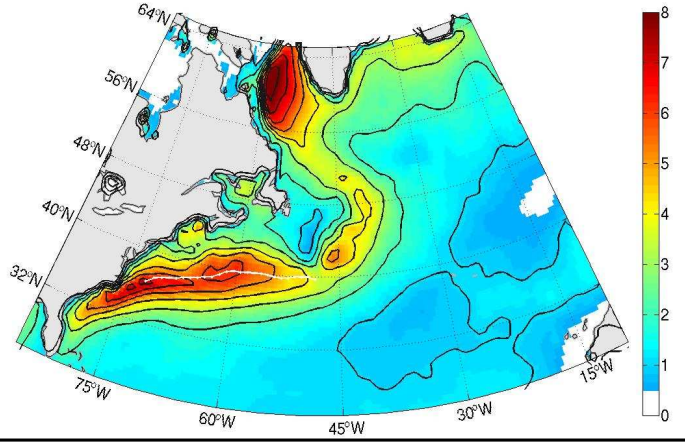
υ = standard deviation of bandpass filtered meridional winds.

Results: Atlantic Basin

υ_{850mb}



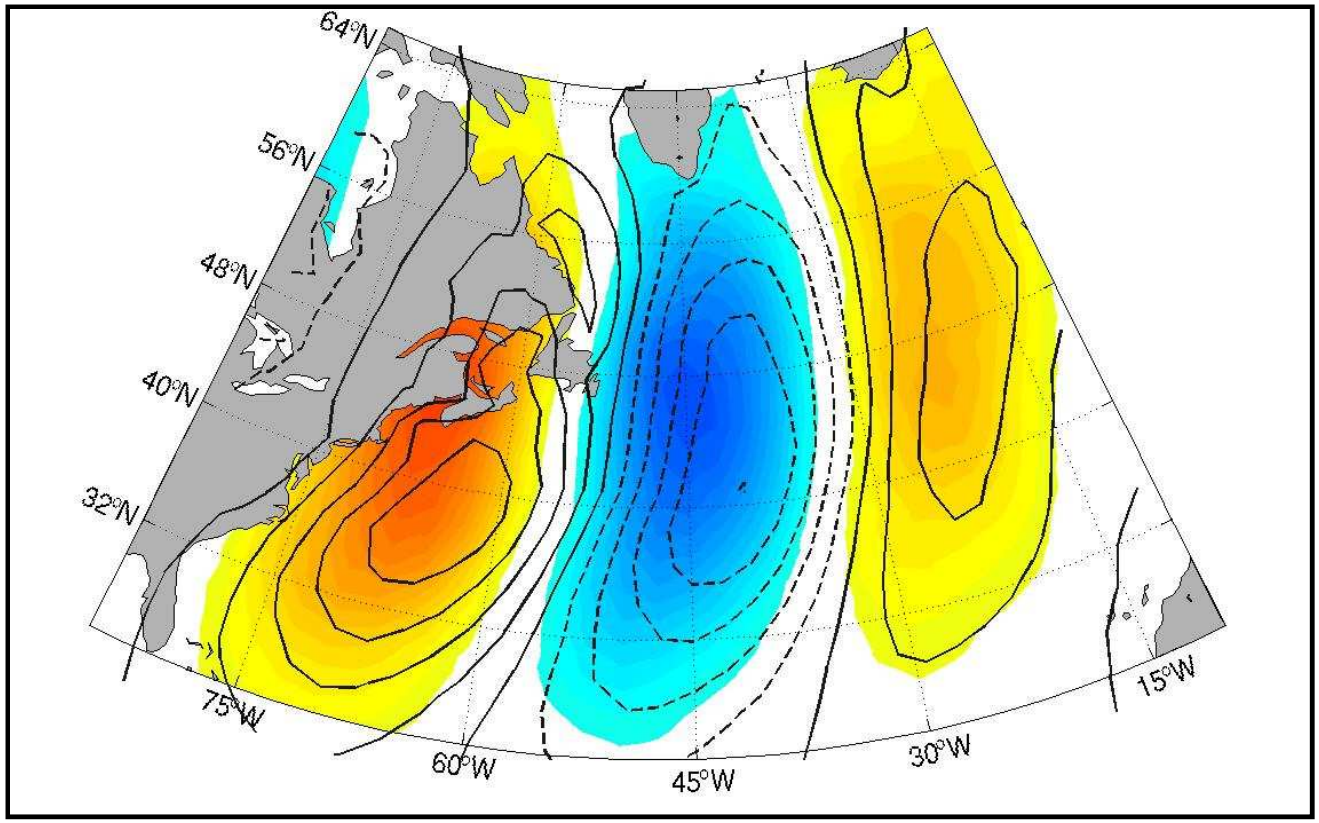
A.B.L. Stability



Results: Atlantic Basin

EOFs

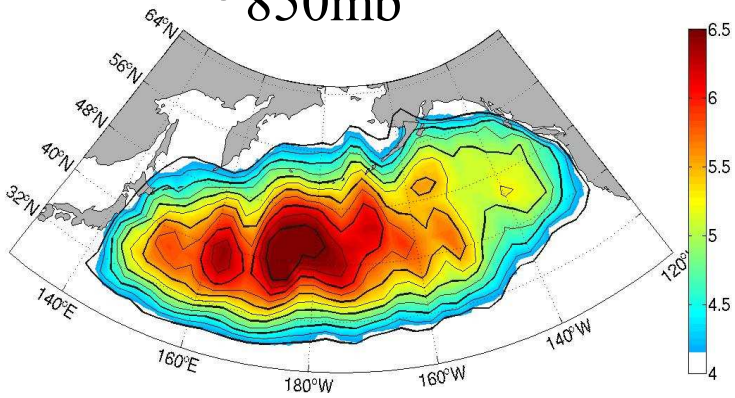
υ_{850mb} (color) and υ_{10m} (contour) show the same wave structure.



Principal components are highly correlated: $r^2 = .89$.

Results: Pacific Basin

υ_{850mb}



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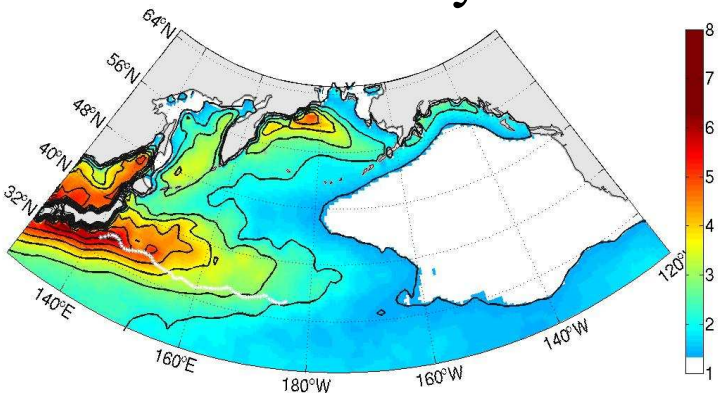
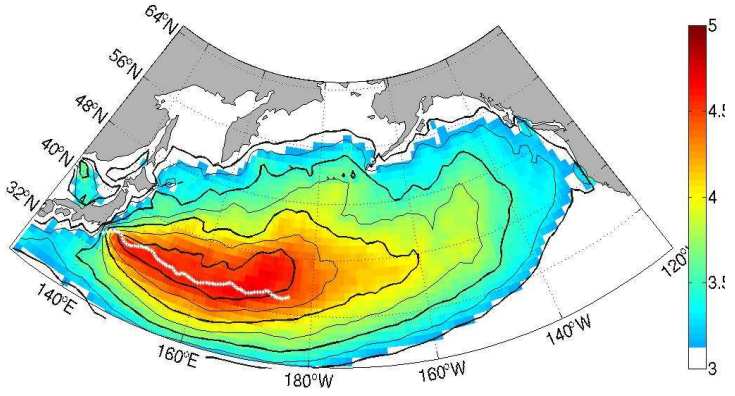
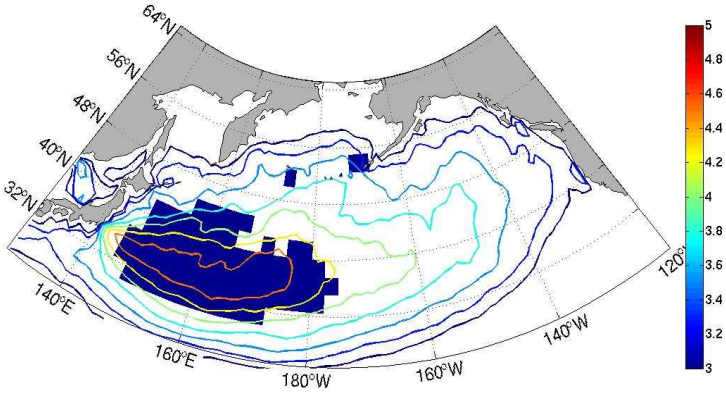


υ_{10m}

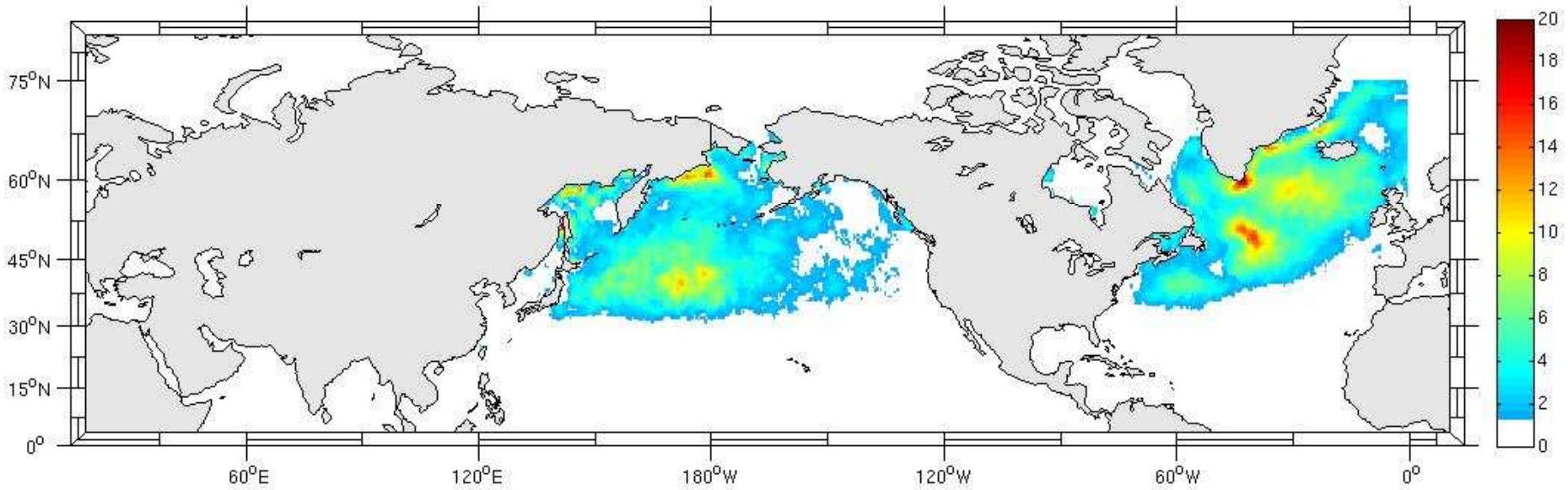


Predicted and actual surface storm track



Surface Storm Track Metrics

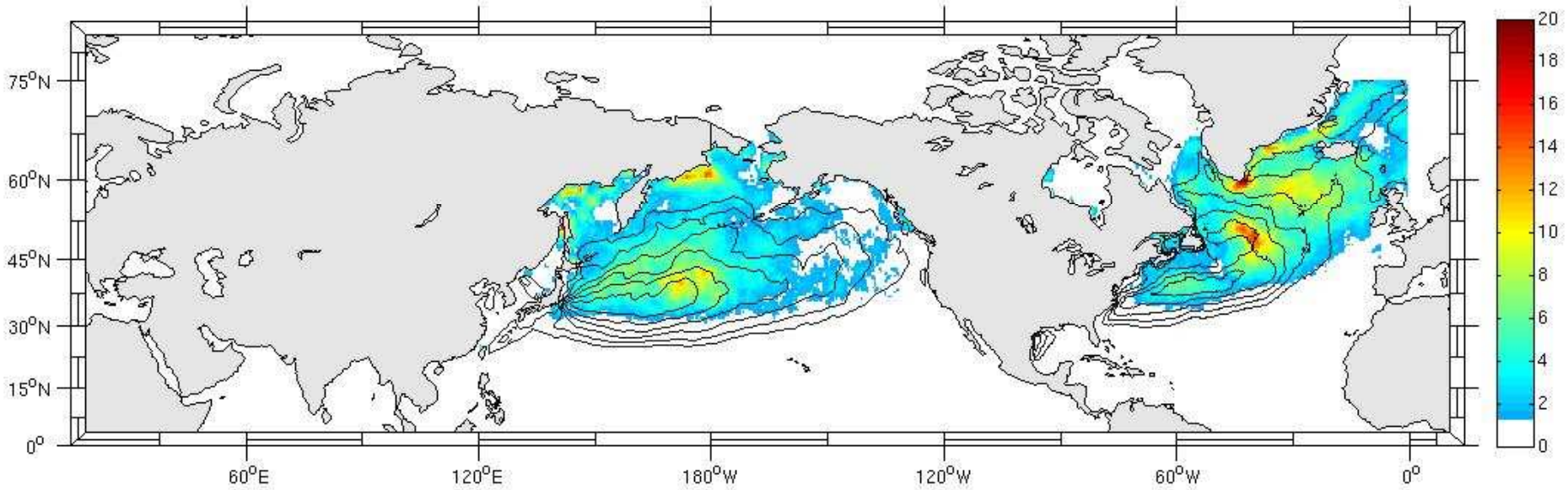
Color: Sampe and Xie method of counting strong winds



Surface Storm Track Metrics

Color: Sampe and Xie method of counting strong winds

Contour: Surface storm track.



The surface storm track picks out the storm track entrance regions.

The high-wind frequency captures the storm track region where storms are developed.

The differences reflect differences between the development characteristics for storms in the Atlantic and Pacific.

Conclusions

- Momentum-mixing due to boundary layer instability influences the spatial structure of the surface storm track.

- Storm track analysis of the surface winds captures the same baroclinic wave activity as the storm track aloft.

- Momentum-mixing can induce feedbacks:
  - (A) Negative feedback on the strength of surface winds [Nonaka and Xie, 2003]
  - (B) Positive feedback for storm genesis:

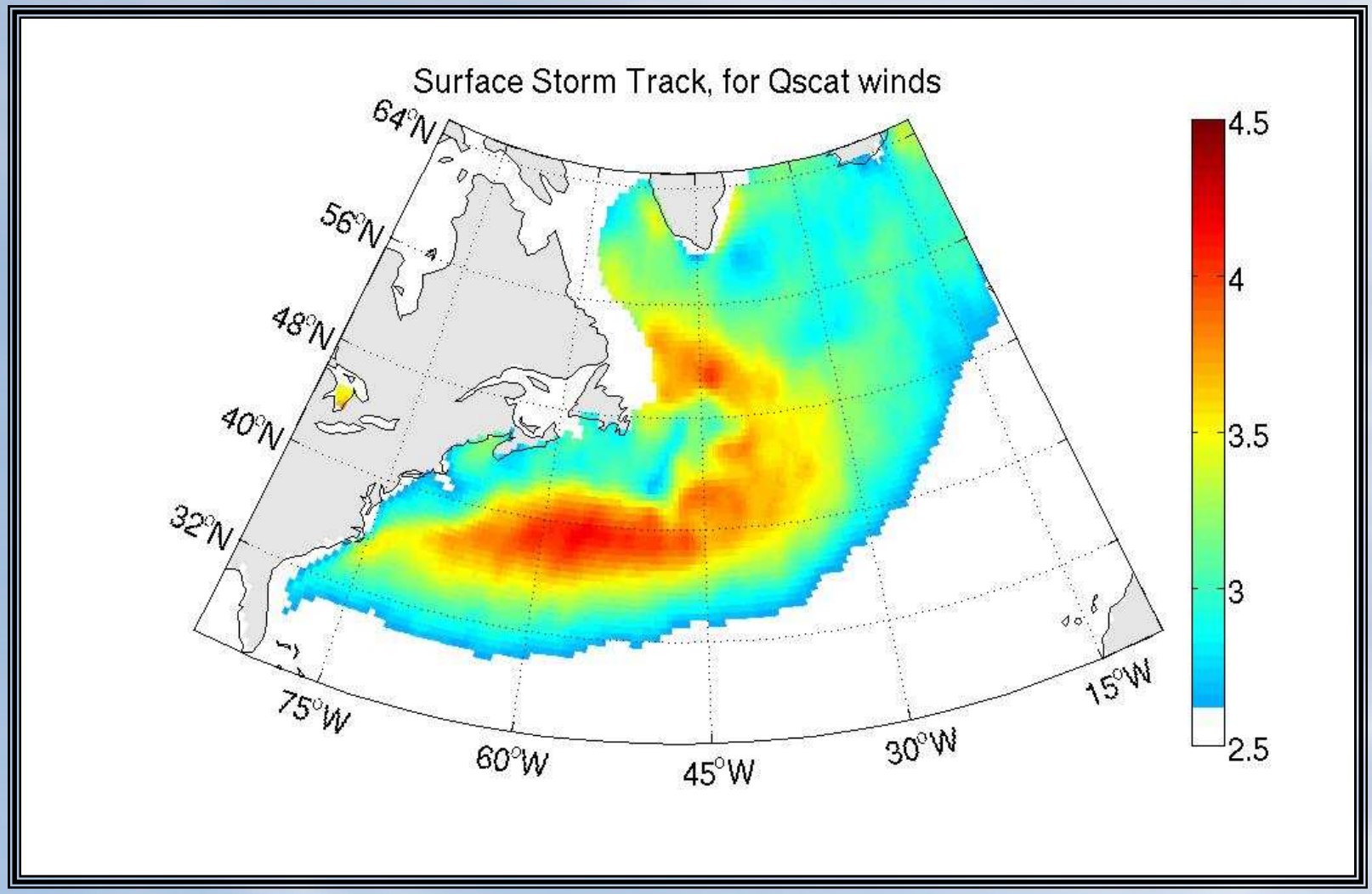
(1) Fluxes destabilize the boundary layer

(2) Momentum-mixing down of stronger winds

(3) Stronger winds create more fluxes

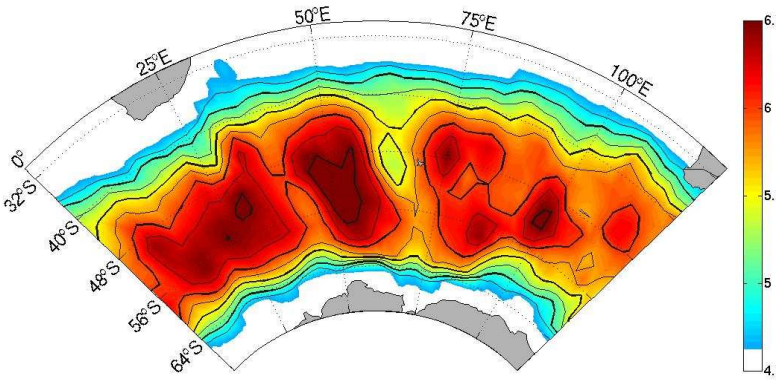
(4) Fluxes feed heat and moisture into the lower troposphere, which makes the air more conducive to storm formation.

Thank you


Surface Storm Track, for Qscat winds
64°N
56°N
48°N
40°N
32°N
75°W
60°W
45°W
30°W
15°W
4.5
4
3.5
3
2.5

Extra Results

υ_{850mb}



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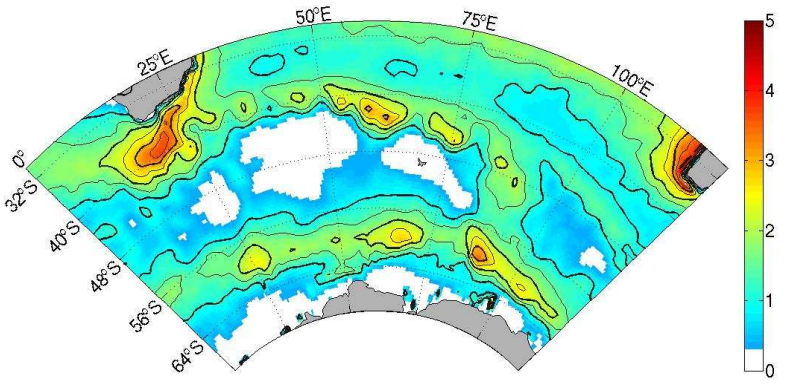
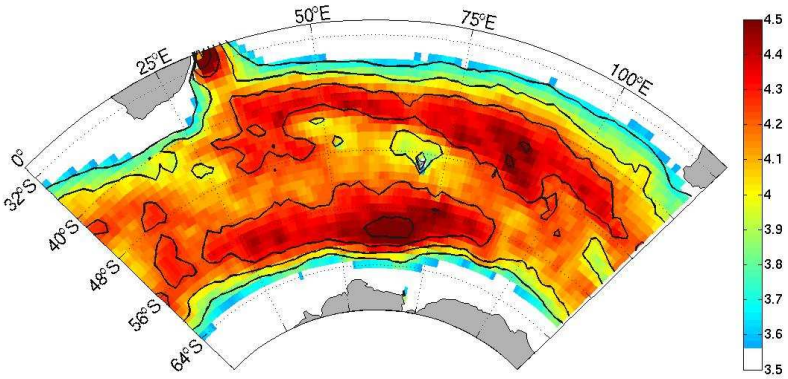
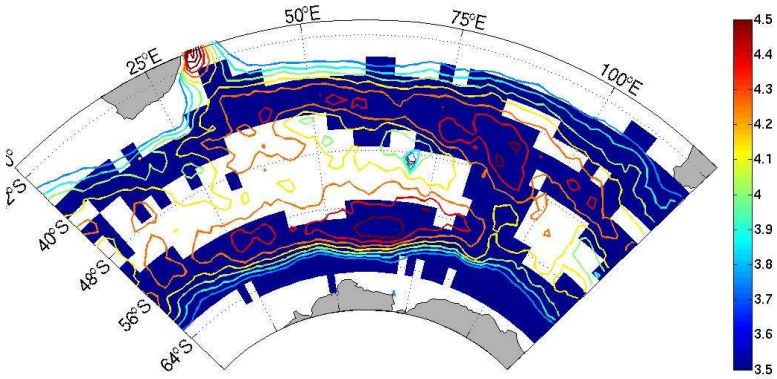


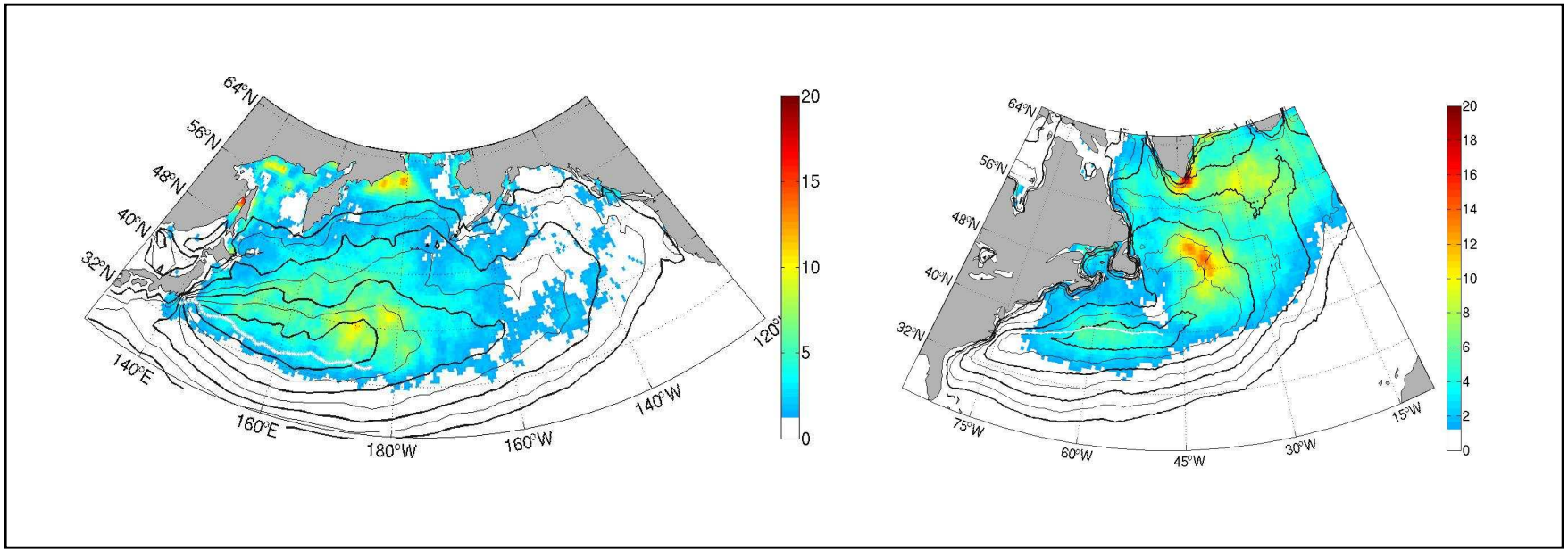
υ_{10m}

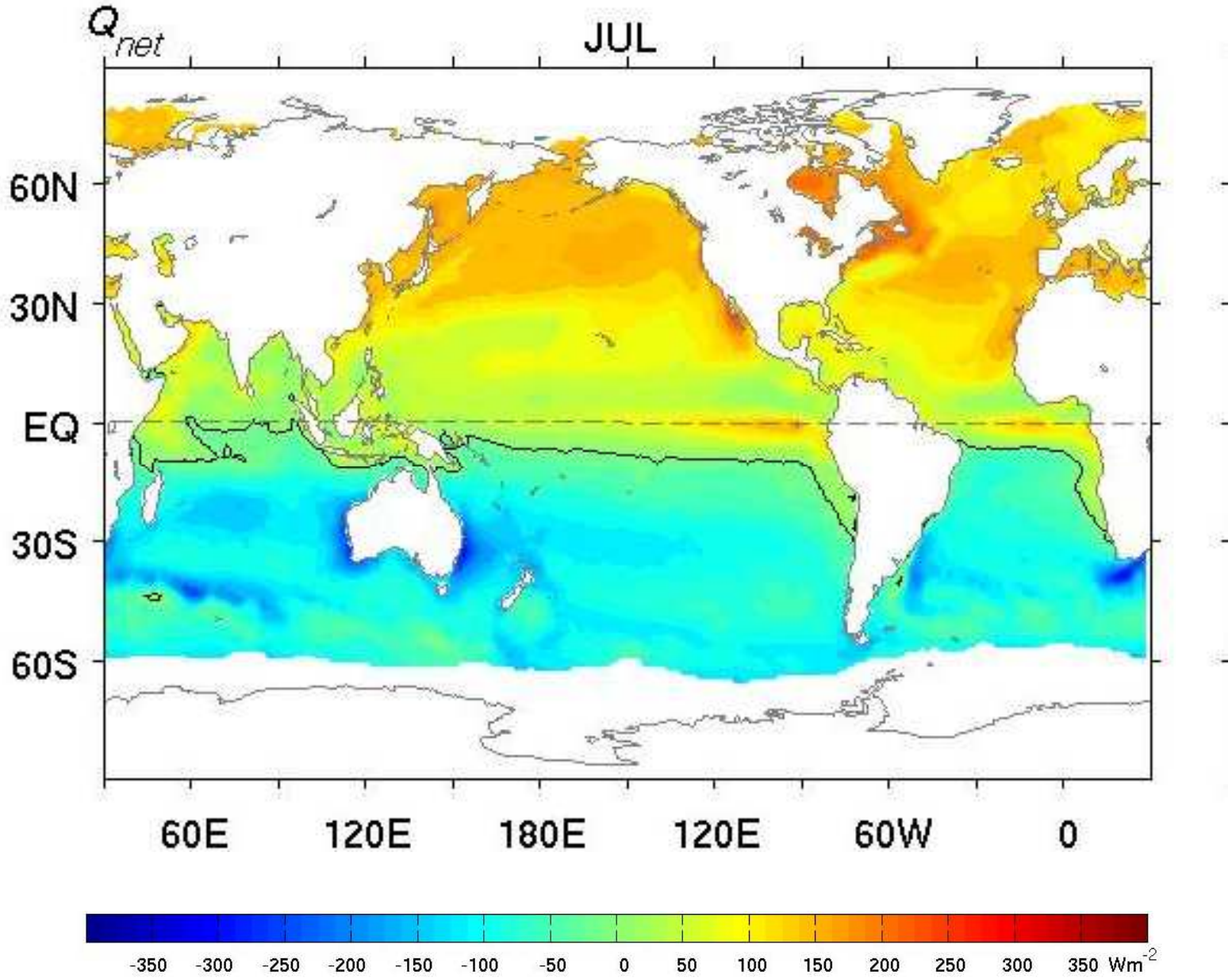


Predicted and actual surface storm track

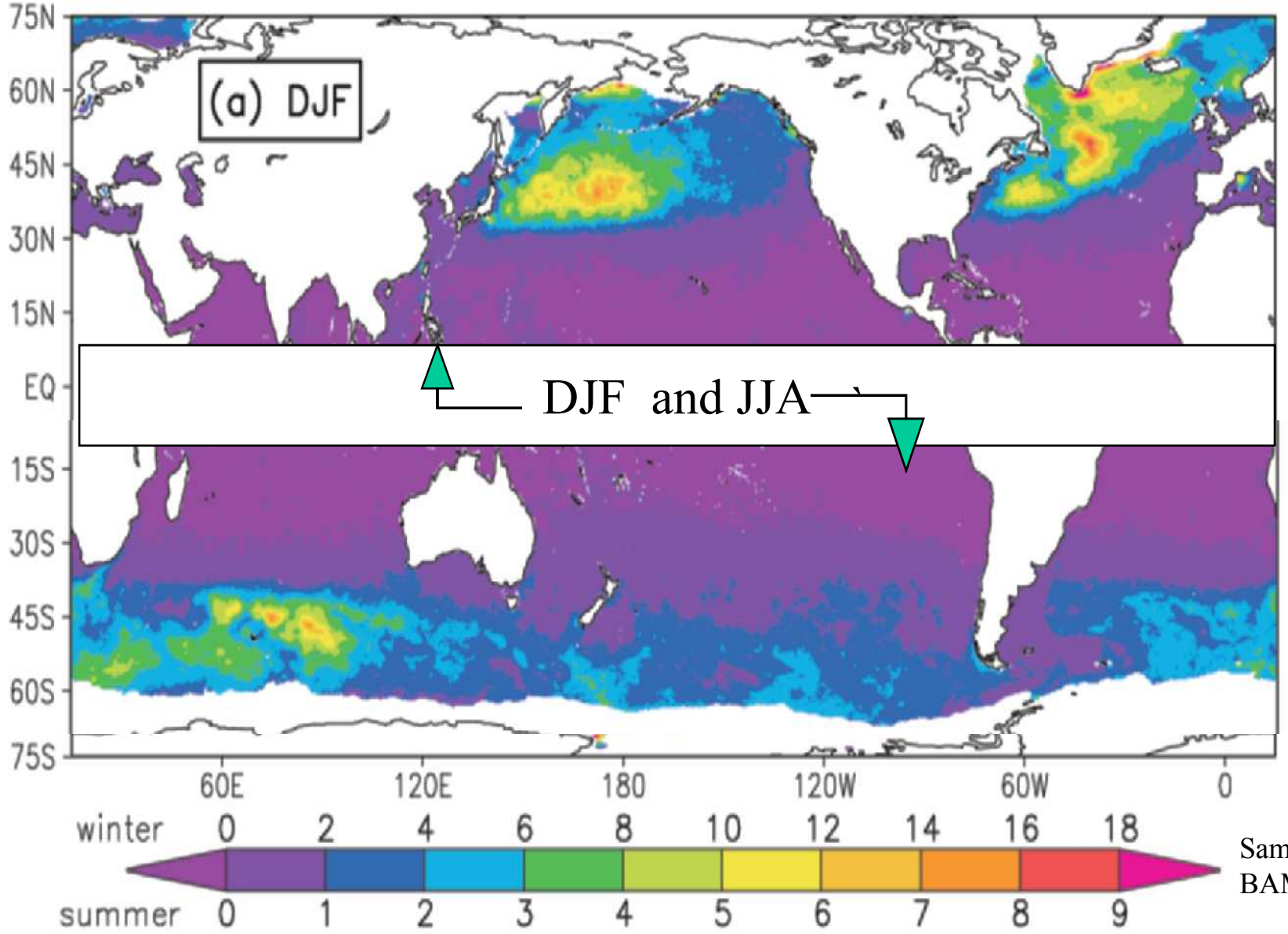


Extras


64°N
56°N
48°N
40°N
32°N
140°E
160°E
180°W
160°W
140°W
120°W
20
15
10
5
0
64°N
56°N
48°N
40°N
32°N
75°W
60°W
45°W
30°W
15°W
20
18
16
14
12
10
8
6
4
2
0


Q_{net}
JUL
60N
30N
EQ
30S
60S
60E
120E
180E
120E
60W
0
-350 -300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350 Wm^{-2}

Introduction and Motivation



Sampe and Xie, BAMS 2007

Storm track based on SLP