

Tropical Cyclone Formation in Wind Shear: Climatological Relationships and Physical Processes

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Some Questions...

- I. Is “some wind shear” more or less favorable for TC formation than no wind shear at all?

- II. Is easterly shear more or less favorable than westerly shear?

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Here we will focus on development in the “deep” tropics.

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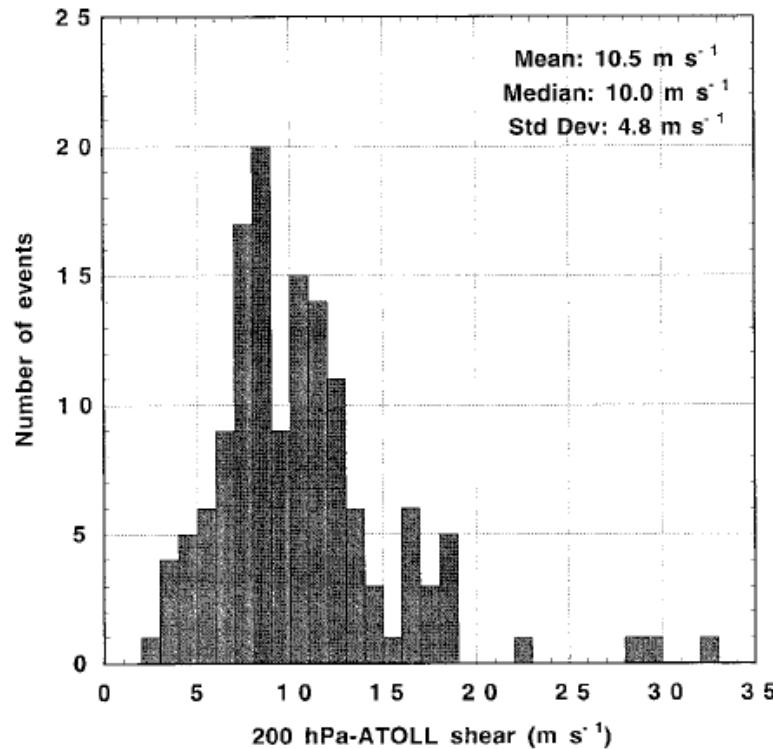
II. Is easterly shear more or less favorable than westerly shear?

- Idealized simulations of Tuleya and Kurihara (1981) showed easterly shear to be much more favorable.

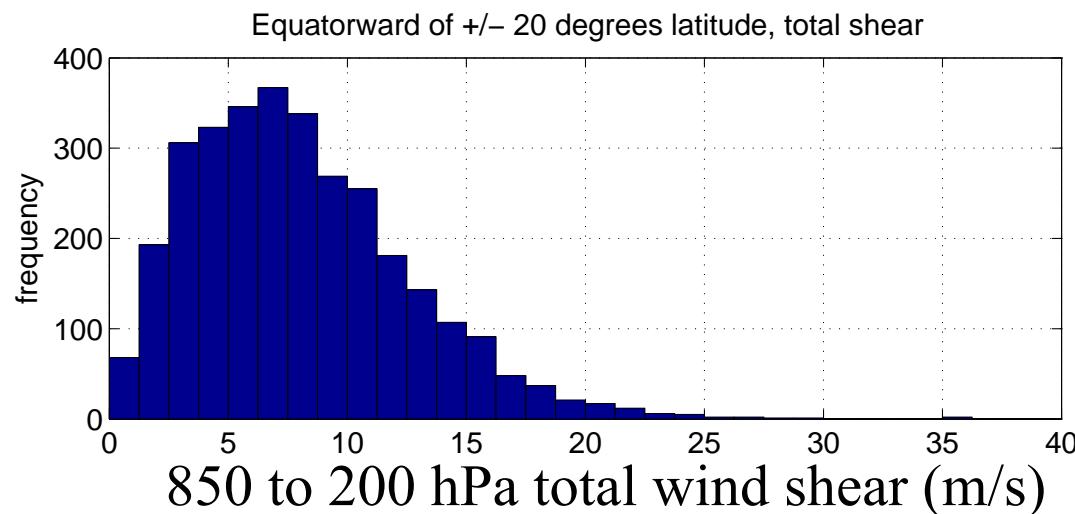
This is consistent with the high frequency of TC genesis in the East Atlantic and much of the Pacific where shear is often easterly.

Analyzed Wind Shear Around Individual TC Genesis Events

Bracken and
Bosart (2000),
Atlantic depressions
1975-1993

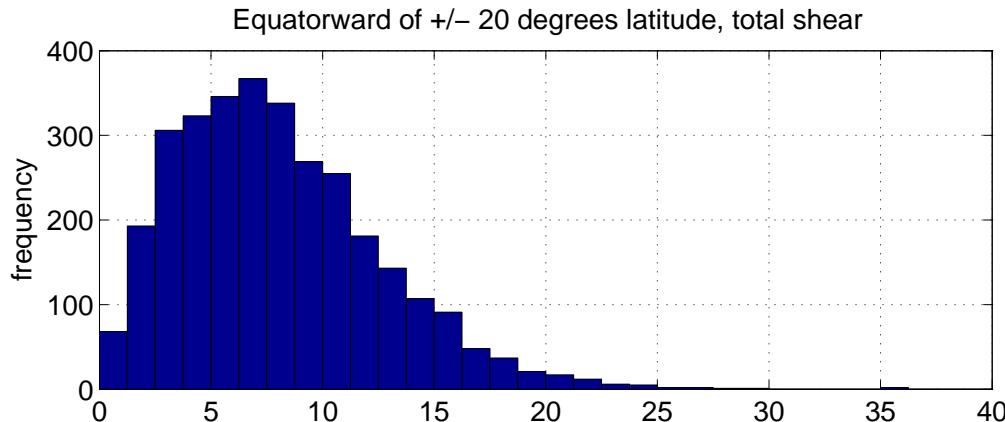


IBTRaCS
plus
NCEP/NCAR
Reanalyses
1969-2008,
Lat < 20

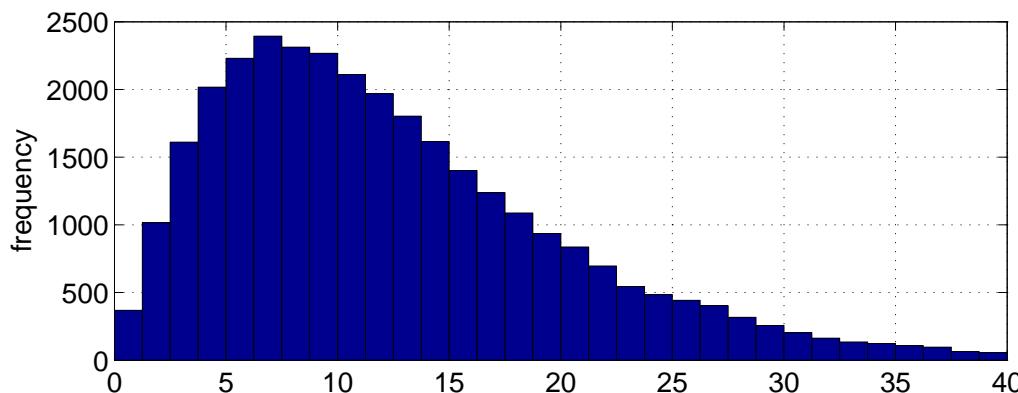


Is 7-8 m/s of shear really the most favorable for TC genesis?

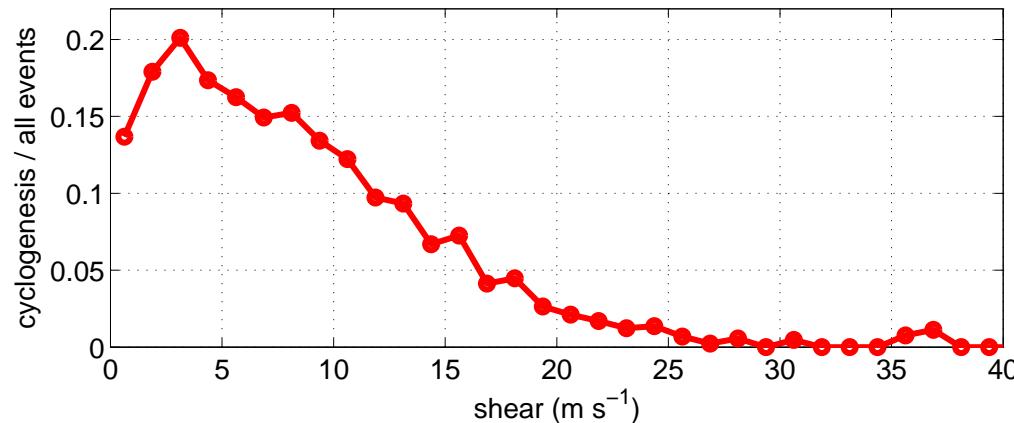
Shear for
TC genesis events,
Lat < 20



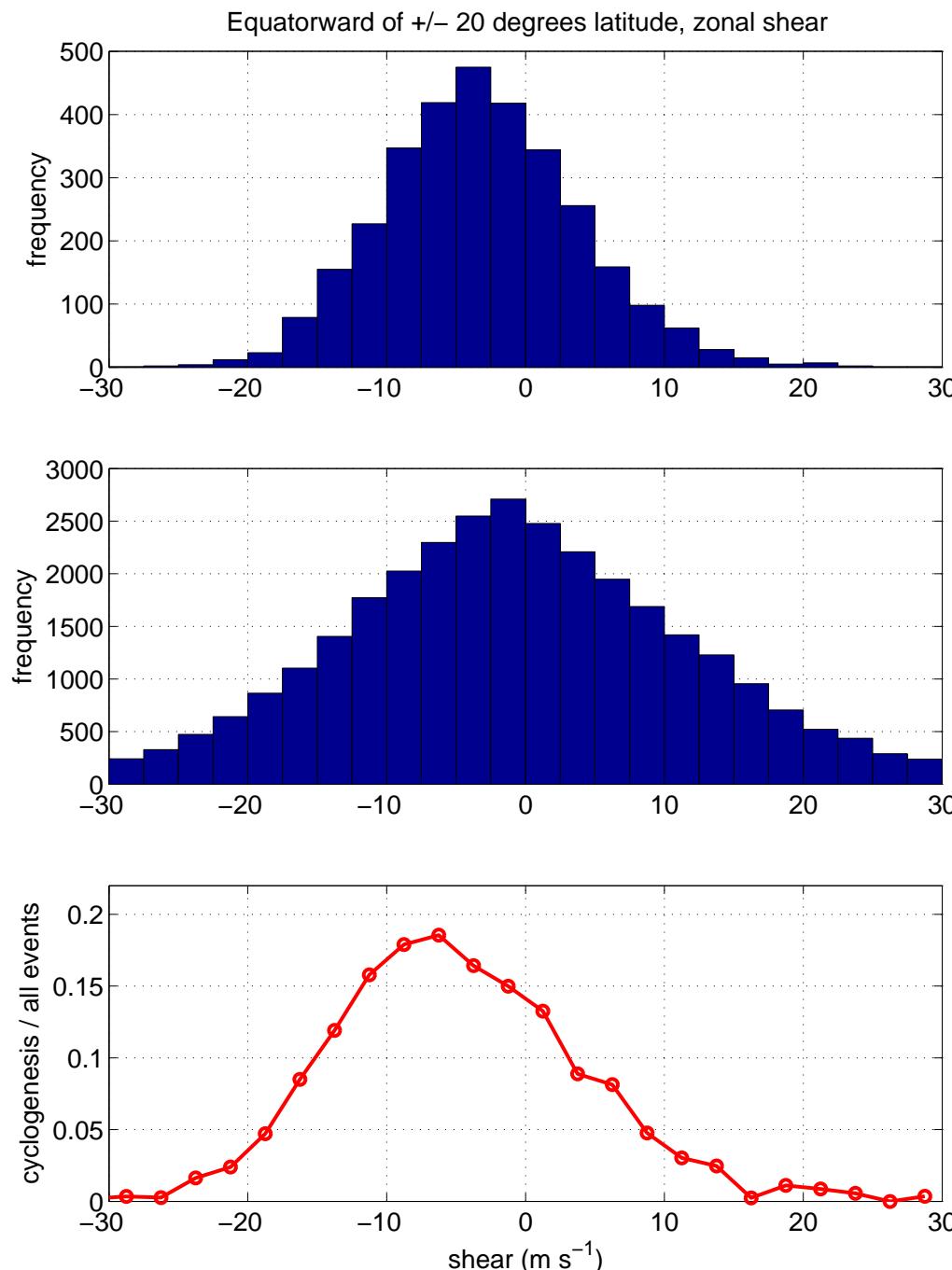
A random sampling
of wind shear weighted
to TC genesis regions
and seasons



Divide the frequencies
for “relative”
favorableness



- What about easterly versus westerly shear? (Lat < 20)

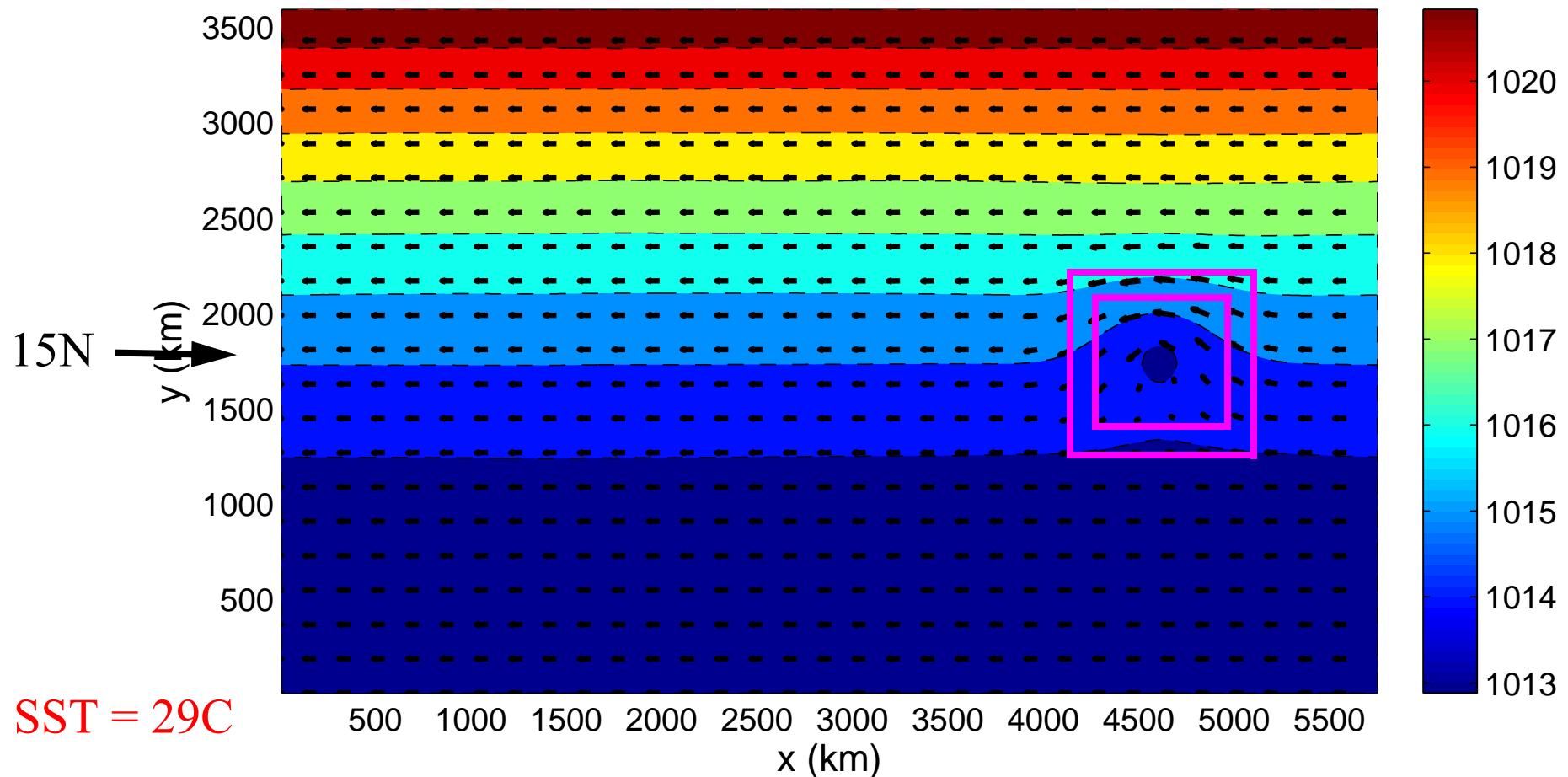


Idealized Simulations of Tropical Cyclone Formation in Shear

- We use “tropical channel” domains with mean flow and wind shear.

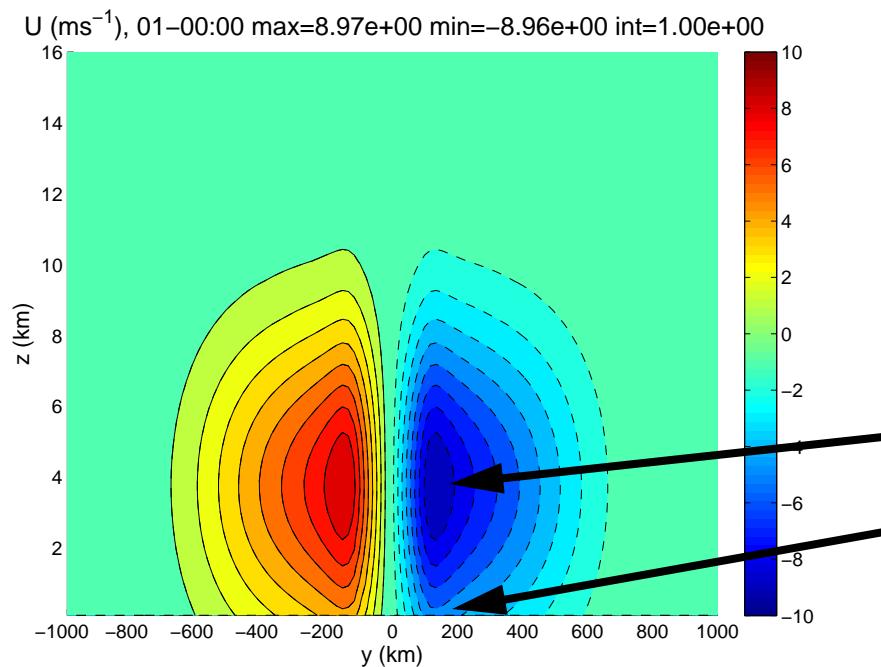
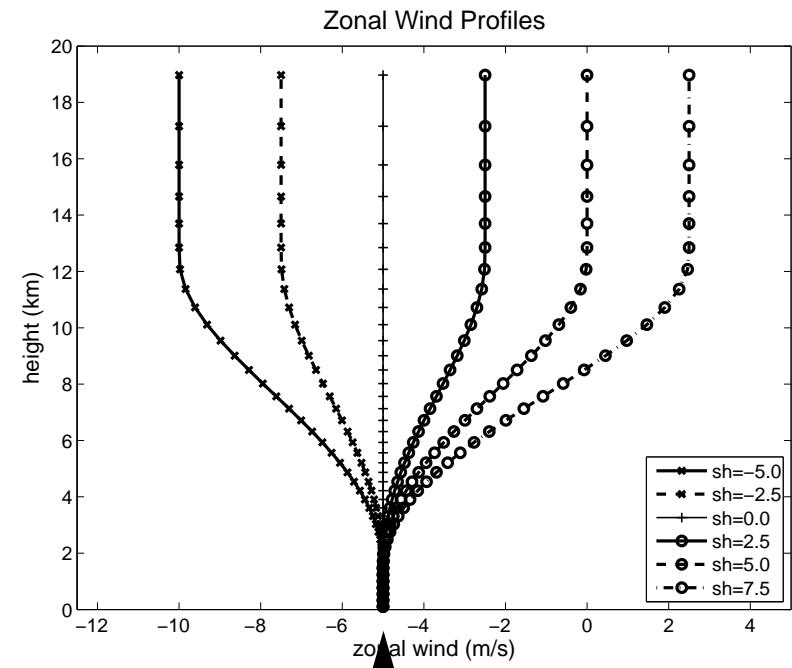
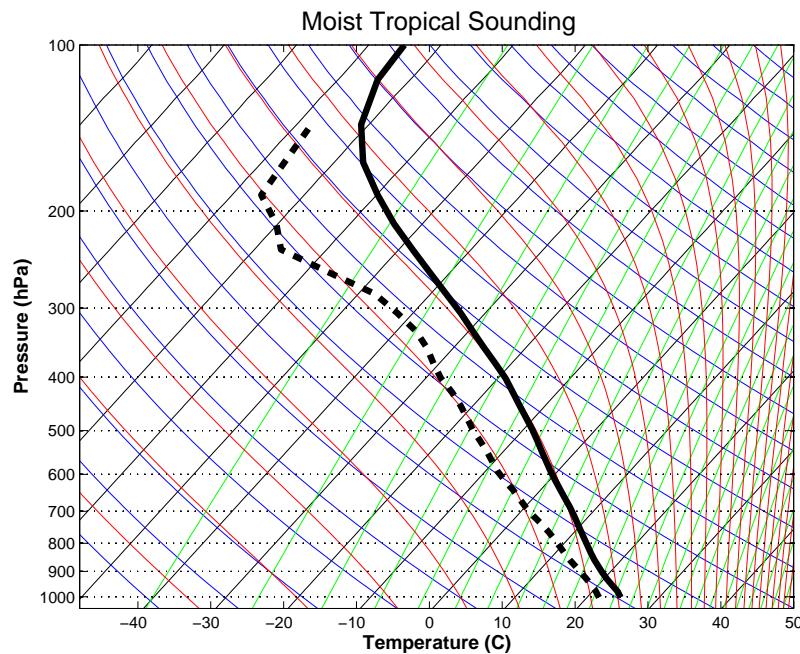
WRF 3.1.1, 18km/6km/2km resolution, on the beta-plane:

PSFC (hPa), 01–01–03 z=5.45e+02 max=1.02e+03 min=1.01e+03 int=8.84e–01



Free-slip walls; zonally periodic; mean flow balanced by temperature gradient.

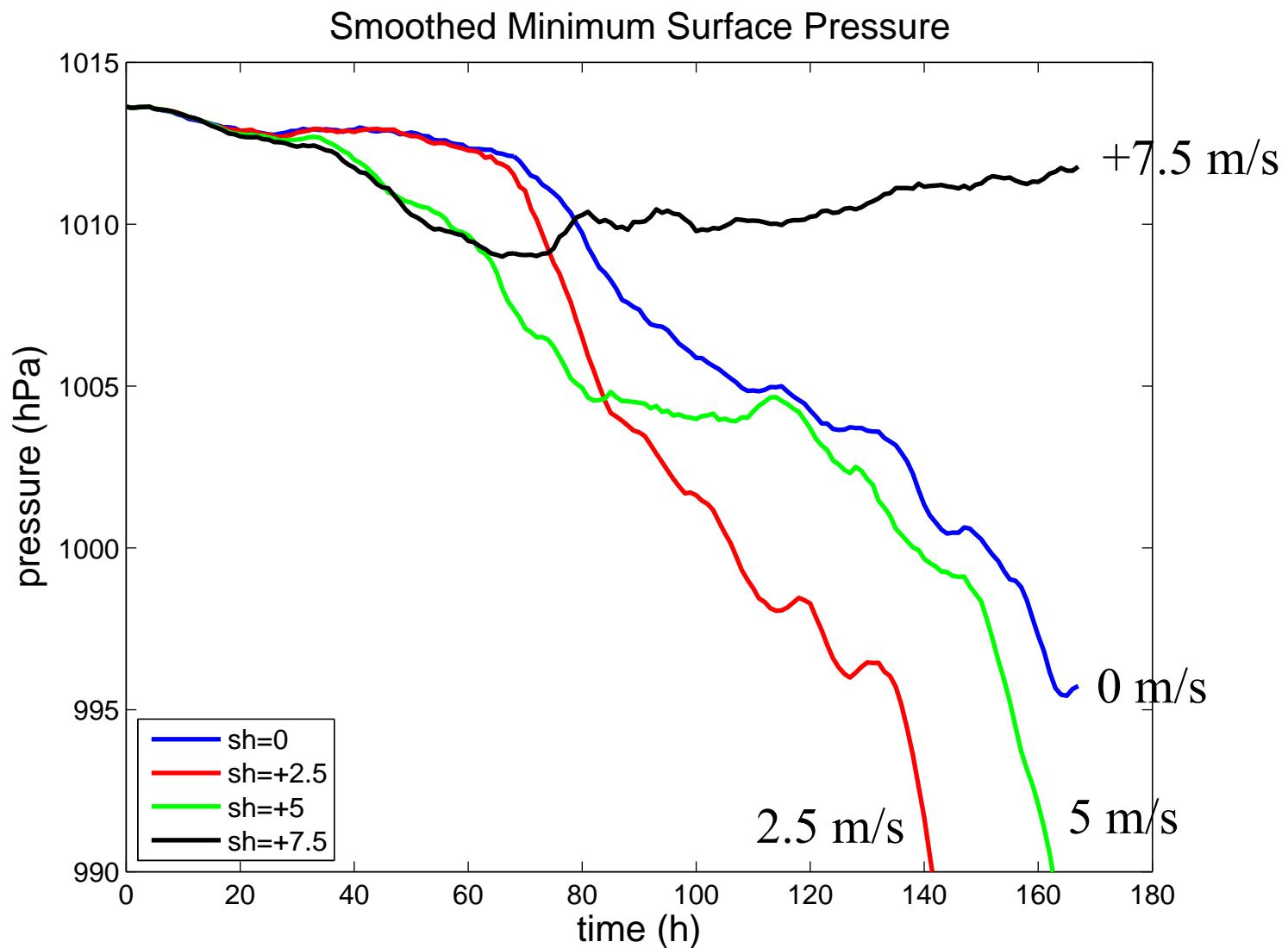
Initial Conditions:



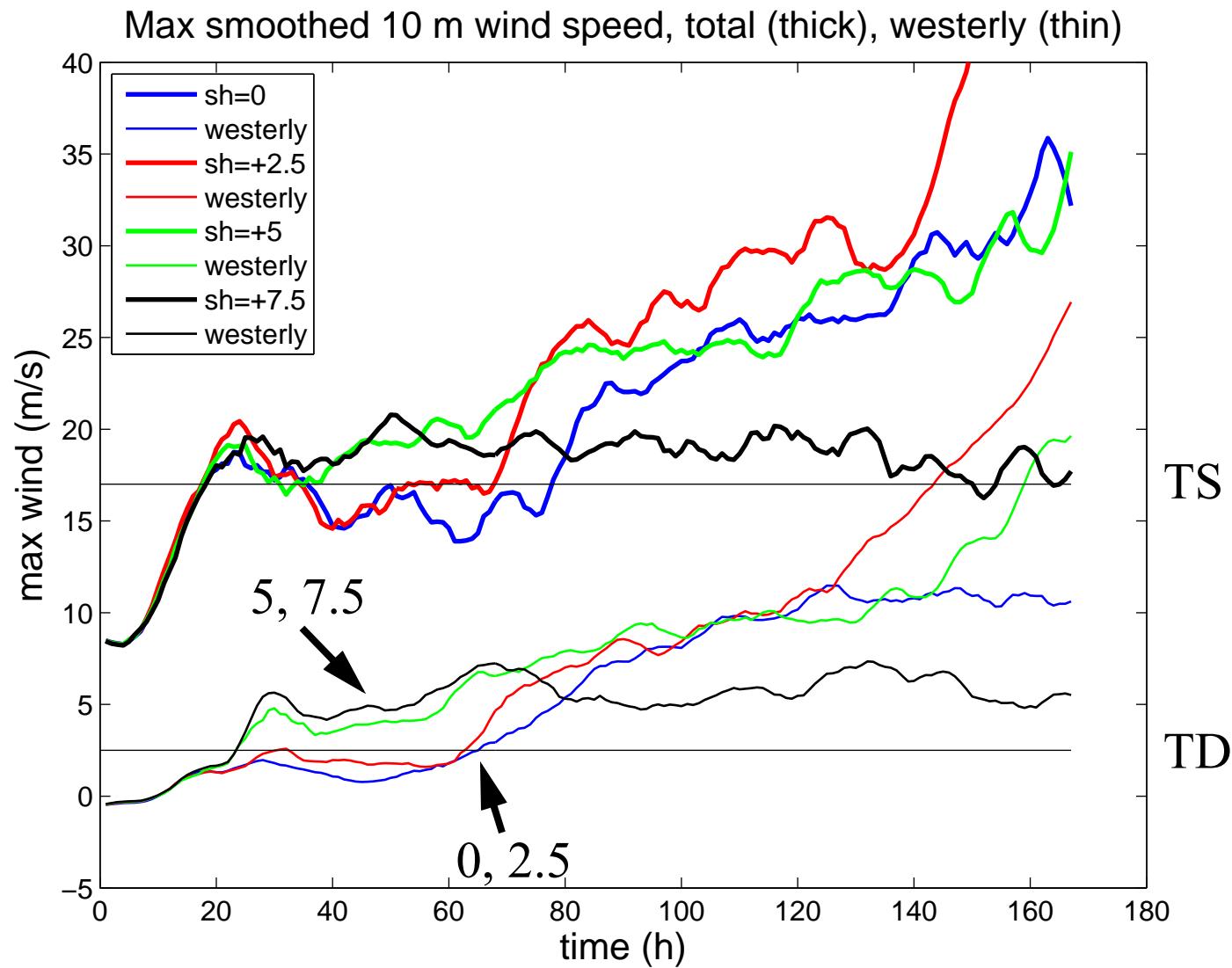
5 m/s easterly flow
plus zonal shear

Initial “disturbance”
RMW = 126 km
 $V_{\max} = 9 \text{ m/s}$ at $z = 3.7 \text{ km}$
 $= 4.5 \text{ m/s}$ at $z = 0 \text{ km}$

Results: Control Sounding, Easterly Flow, Increasing Westerly Shear



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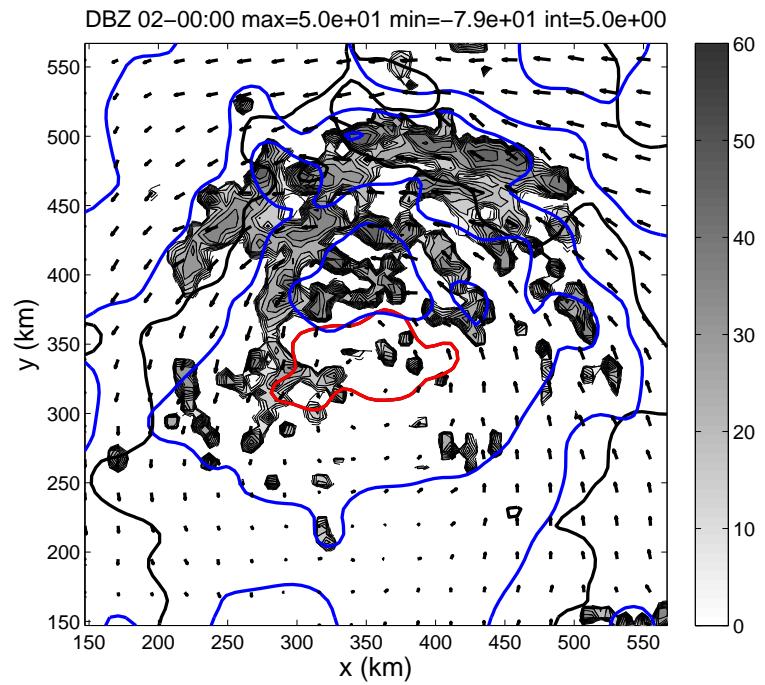


- Low shear: Delayed Genesis, Faster Development

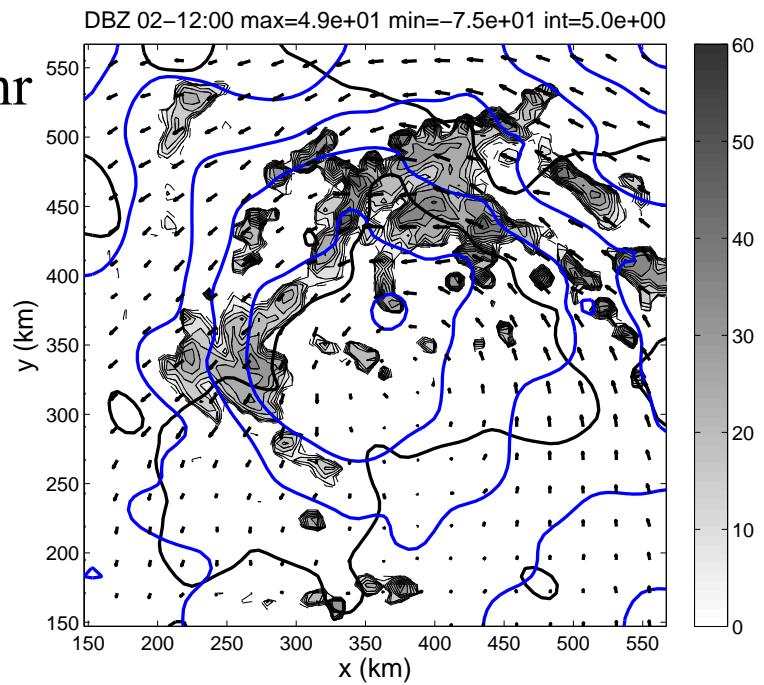
Moderate shear: Earlier Genesis, Limited Development

Evolution: 5 m/s easterly flow, zero shear

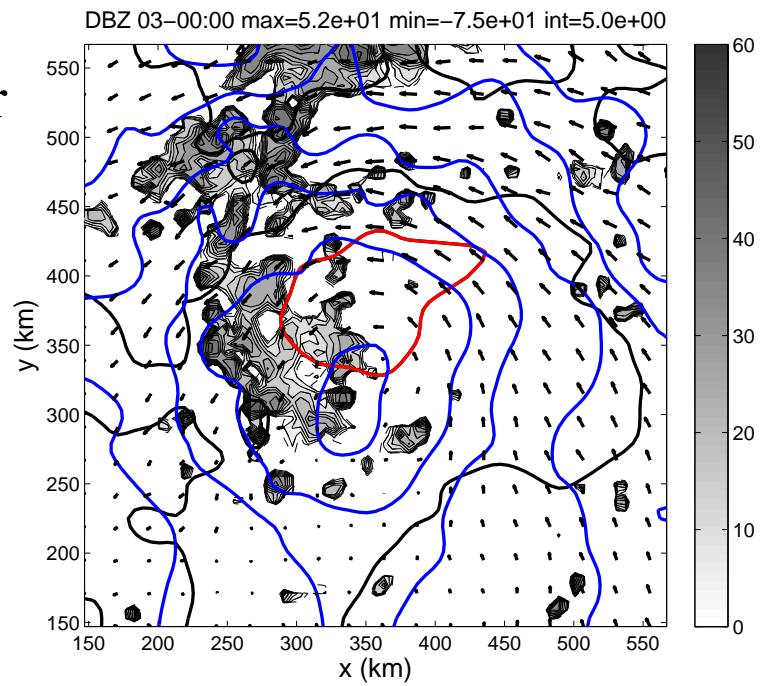
24 hr



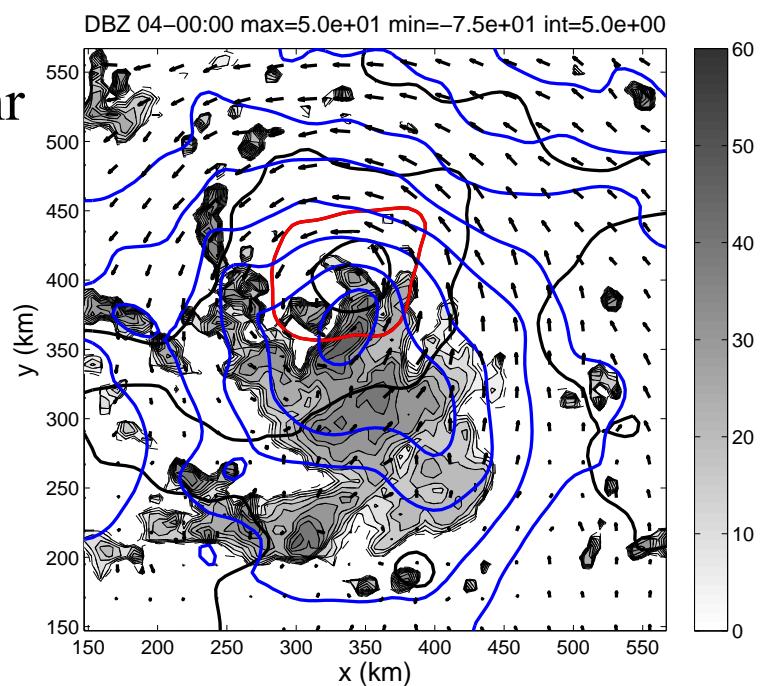
36 hr



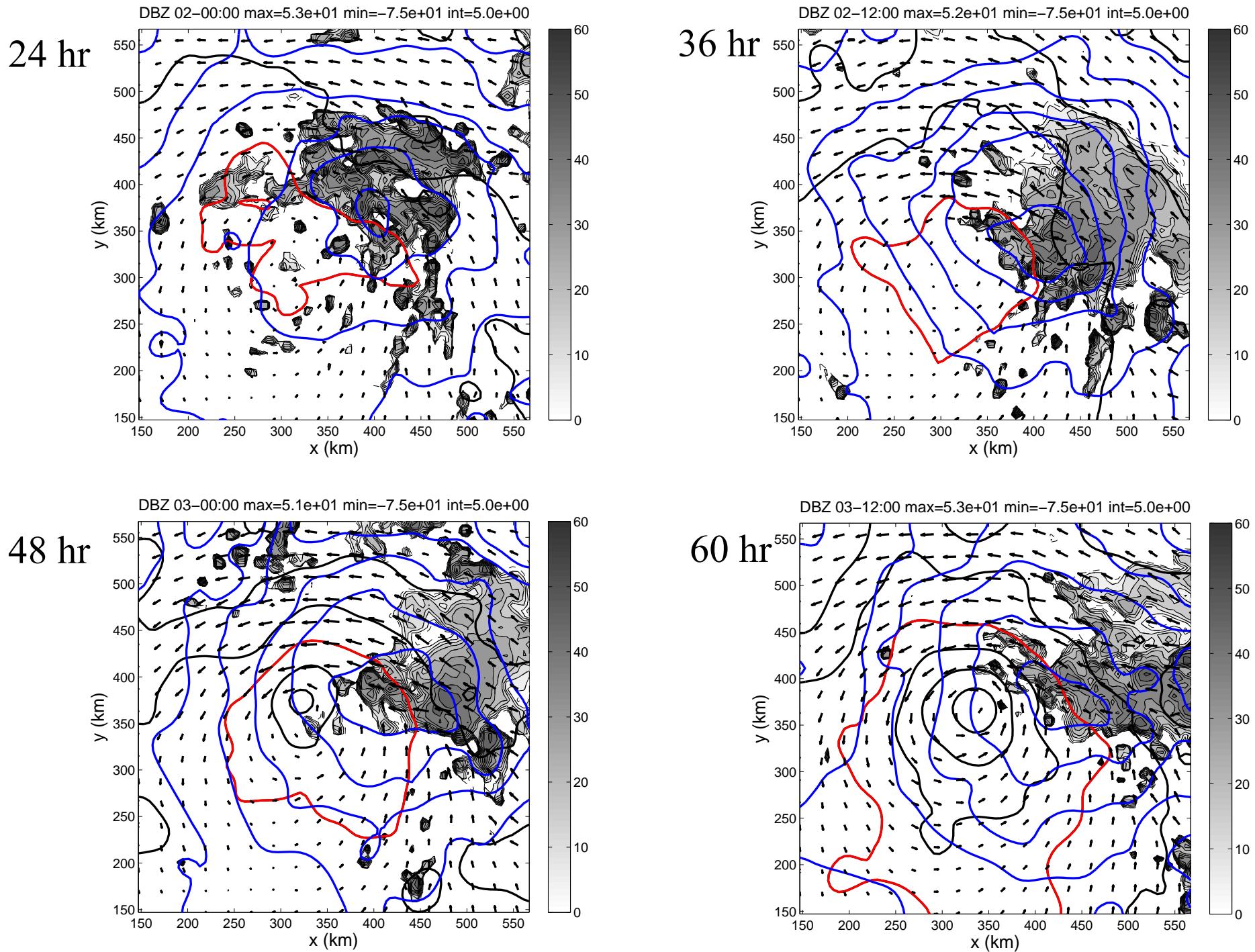
48 hr



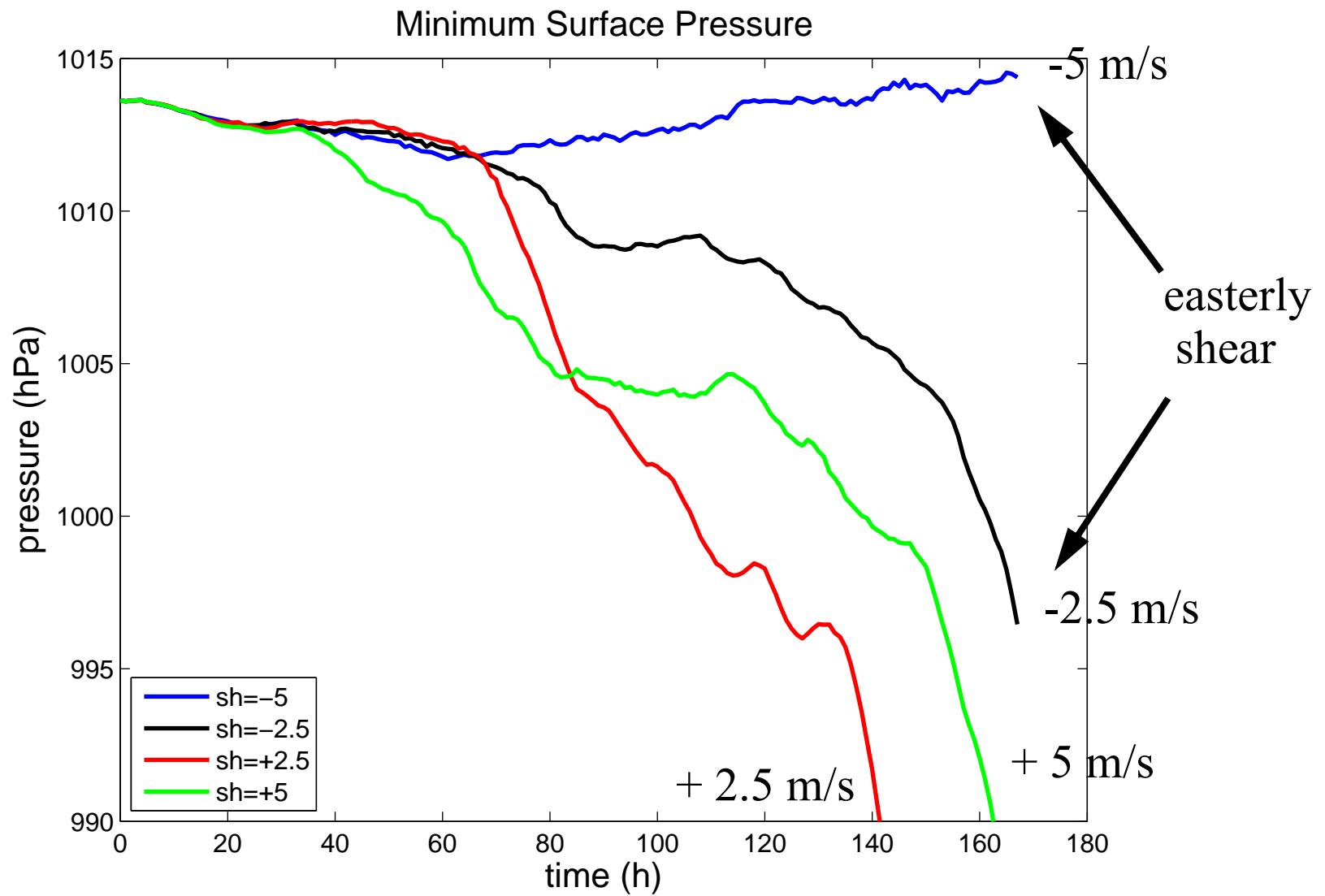
72 hr



Evolution: 5 m/s easterly flow, 5 m/s westerly shear



Results: Easterly Shear versus Westerly Shear

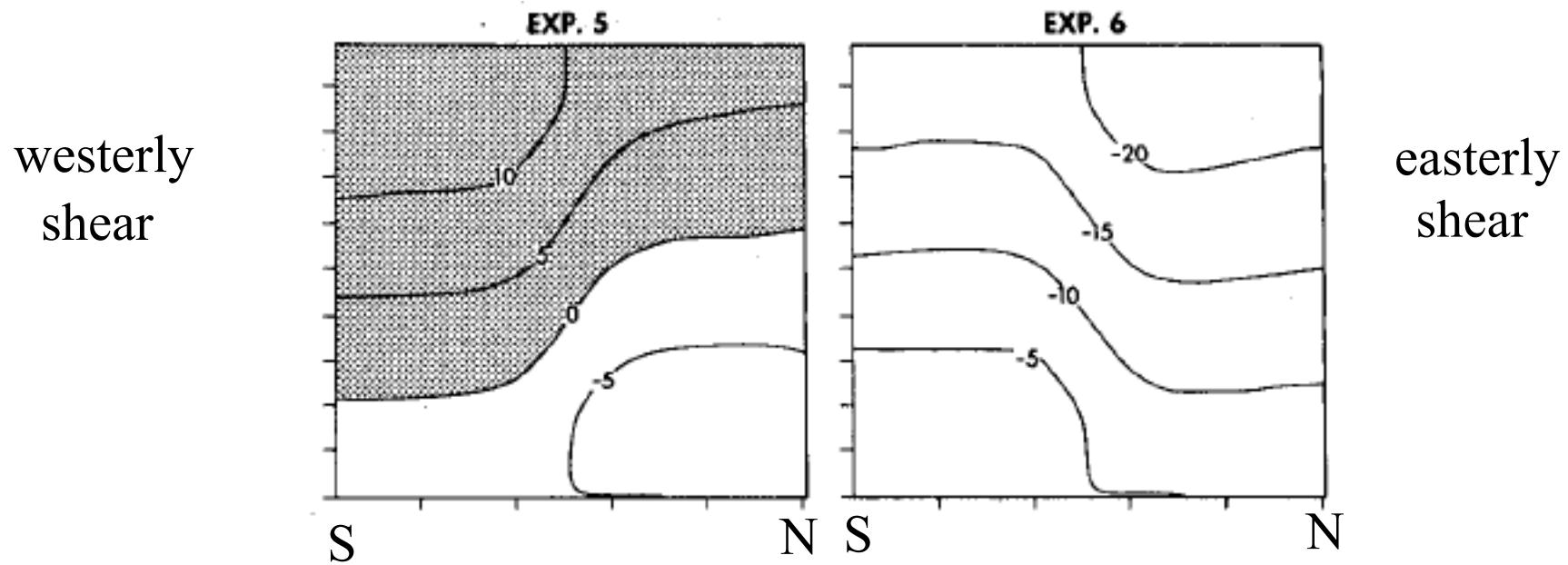


- In our simulations, easterly shear is considerably *less* favorable for genesis.

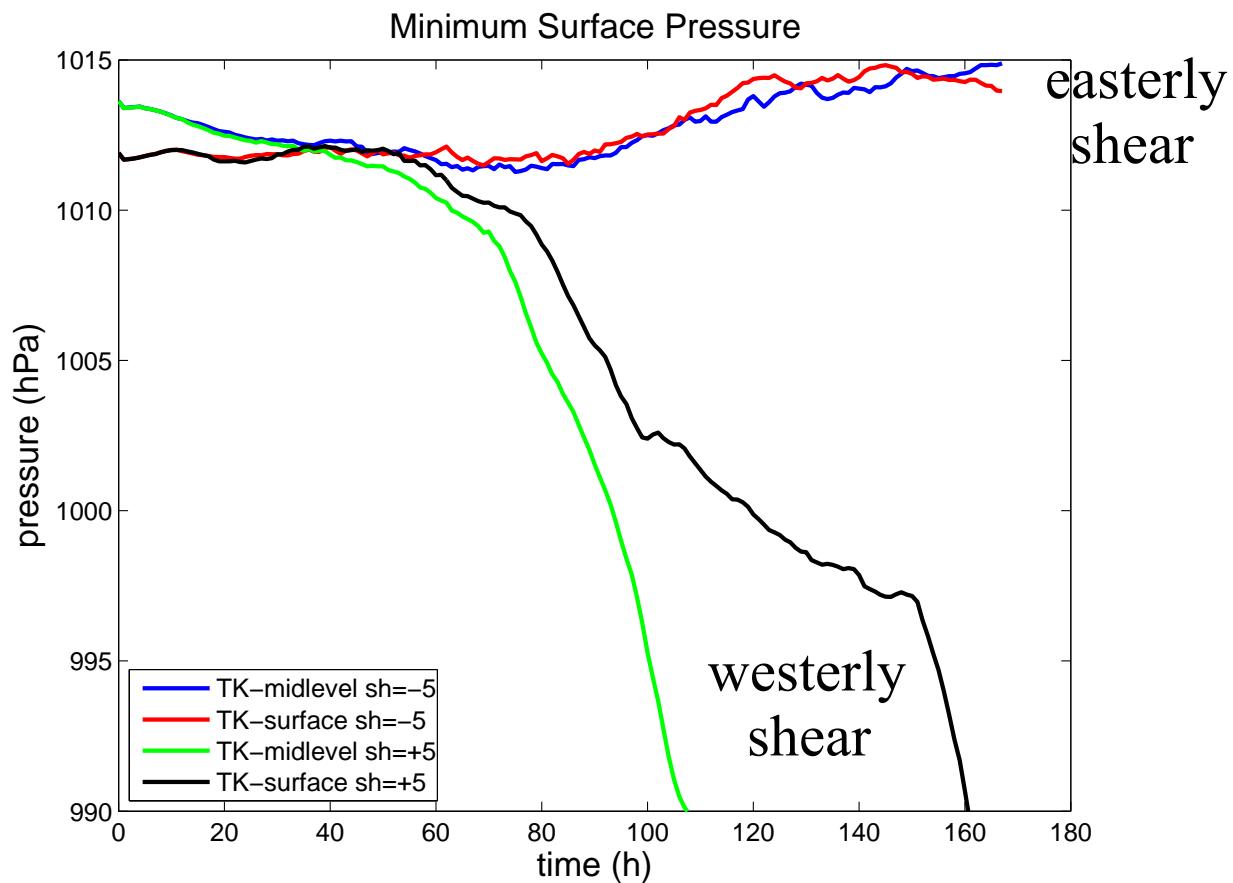
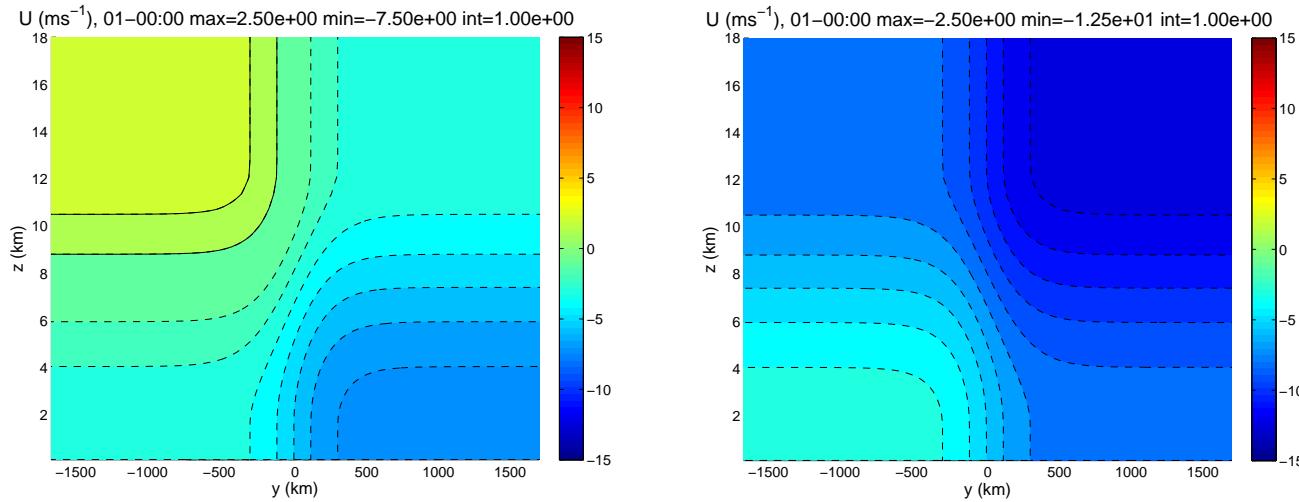
- Didn't Tuleya and Kurihara (1981) show that easterly shear is more favorable?

Yes, but...

- * They used 70 km resolution and 11 vertical levels.
- * Their initial vortex had maximum winds at the surface.
- * Their easterly shear was embedded in a deep cyclonic horizontal shear:

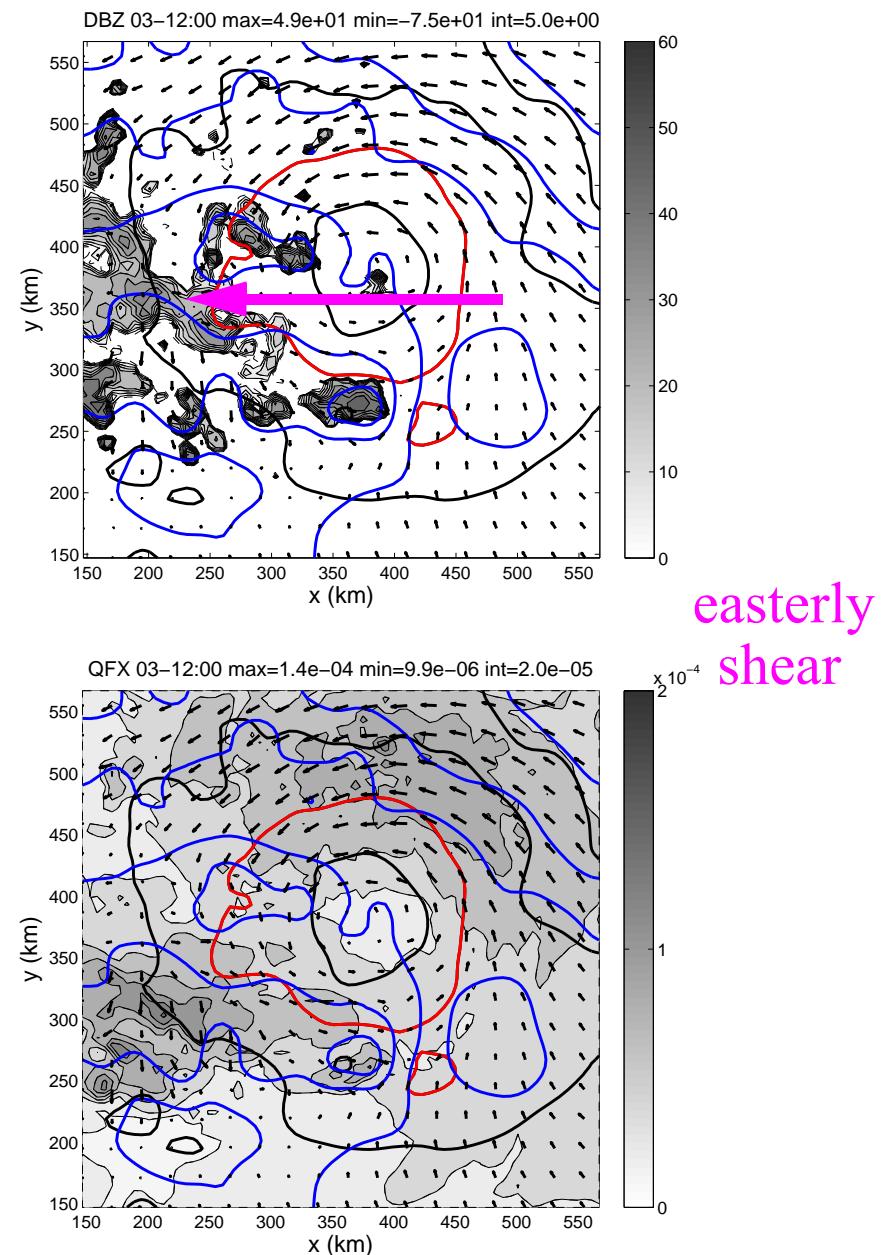
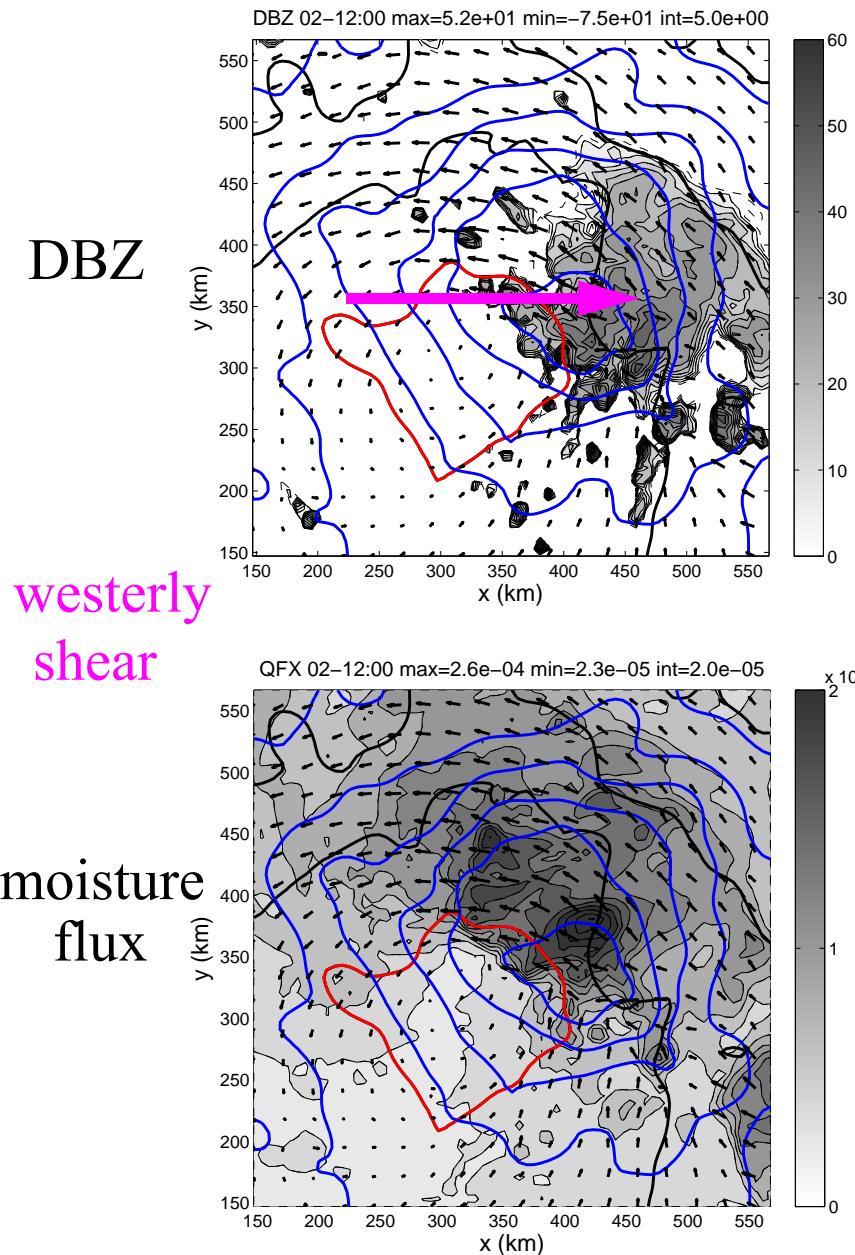


- We can do some of those things too...



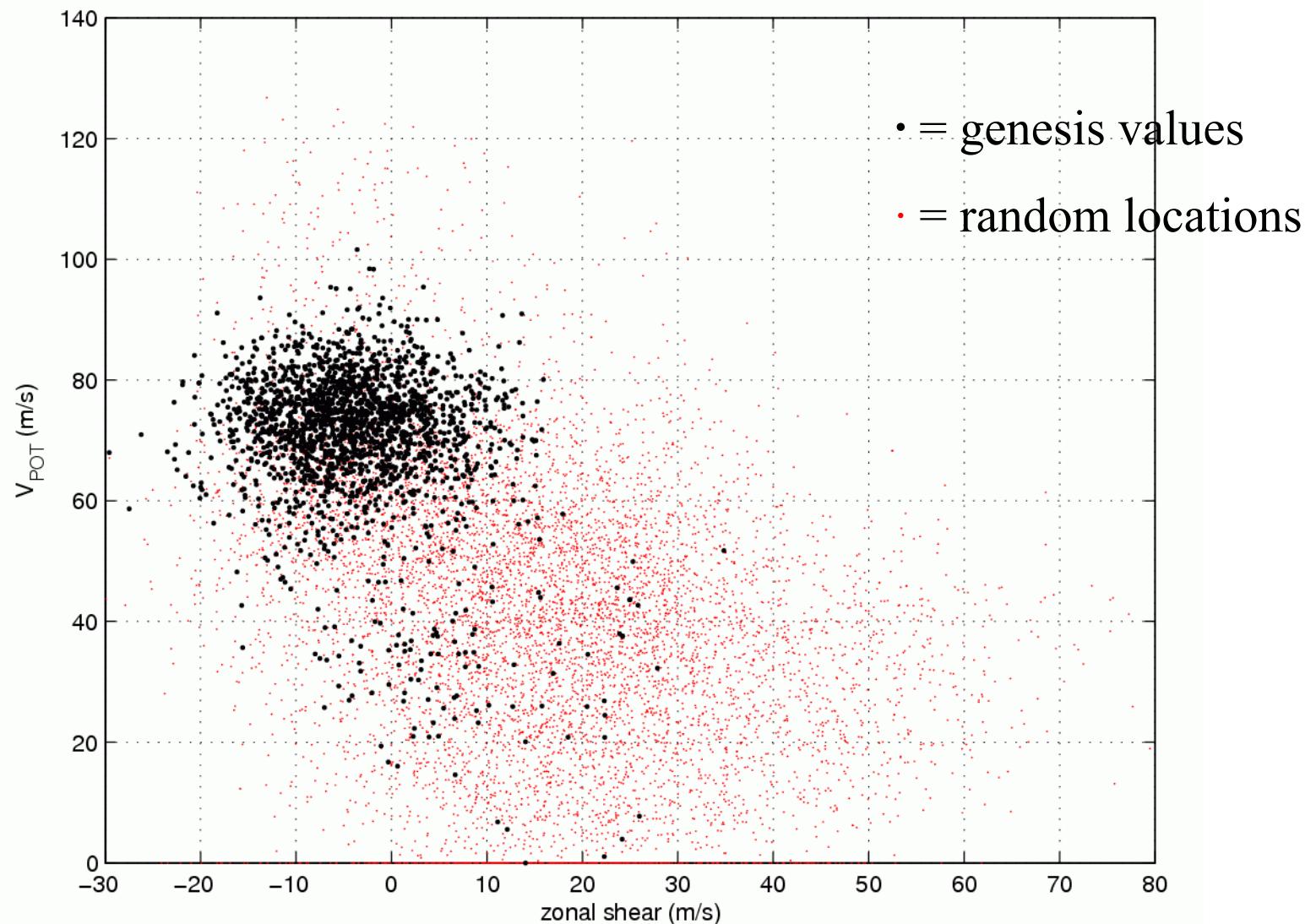
- In our simulations...why is westerly shear more favorable?

As discussed in Rappin and Nolan (2012), wind shear directed opposite to the low-level surface flow is more favorable than shear aligned with the surface flow.



- Is easterly shear really more favorable, or is it because of other correlated factors?

Easterly shear happens more often at low latitudes, and in the Pacific, which are both thermodynamically more favorable.



Some Answers

I. Is “some wind shear” more or less favorable for TC formation than no wind shear at all?

- Statistical analyses of TC genesis events and numerical simulations show that light wind shear (2.5-5 m/s) is indeed the most favorable condition for genesis.

Near-zero wind shear is not unfavorable - just very rare.

II. Is easterly shear more or less favorable than westerly shear?

- Numerical simulations suggest that, all other factors being equal, easterly shear is *less* favorable than westerly shear.

Statistically, genesis is strongly correlated with easterly shear, but this may be due to correlation between easterly shear and more favorable thermodynamics.

The complete article will be published in:



- Was there something wrong with Tuleya and Kurihara (1981)?

