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

• Studies by Bracken and Bosart (2000) and Davis and Bosart (2003, 2004) undoubtedly show that many subtropical TC genesis events are caused by upper-level disturbances through forced ascent.

Here we will focus on development in the “deep” tropics.
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• Studies by Bracken and Bosart (2000) and Davis and Bosart (2003, 2004) undoubtedly show that many subtropical TC genesis events are caused by upper-level disturbances through forced ascent.

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

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)

Easterly shear seems to be strongly preferred for genesis.
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:

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

- **Moist Tropical Sounding**
  - Temperature (°C)
  - Pressure (hPa)

- **Zonal Wind Profiles**
  - Zonal wind (m/s)
  - Height (km)

- **U (m/s⁻¹), 01–00:00 max=8.97e+00 min=−8.96e+00 int=1.00e+00**

- **5 m/s easterly flow plus zonal shear**

- **Initial “disturbance”**
  - RMW = 126 km
  - \( V_{\text{max}} = 9 \text{ m/s} \text{ at } z = 3.7 \text{ km} \)
  - \( = 4.5 \text{ m/s} \text{ at } z = 0 \text{ km} \)
Results: Control Sounding, Easterly Flow, Increasing Westerly Shear

Smoothed Minimum Surface Pressure

- sh=0
- sh=+2.5
- sh=+5
- sh=+7.5

pressure (hPa)
time (h)

+7.5 m/s
0 m/s
2.5 m/s
5 m/s
Results: Control Sounding, Easterly Flow, Increasing Westerly Shear

- Low shear: Delayed Genesis, Faster Development
- Moderate shear: Earlier Genesis, Limited Development

Max smoothed 10 m wind speed, total (thick), westerly (thin)
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

24 hr

36 hr

48 hr

60 hr
Results: Easterly Shear versus Westerly Shear

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

- 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...

Minimum Surface Pressure

- easterly shear
- westerly shear
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.

\[ V_{\text{POT}} \text{ (m/s)} \]

\[ \text{zonal shear (m/s)} \]

- = genesis values
- = random locations
**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.
• Was there something wrong with Tuleya and Kurihara (1981)?

Cyclone Track, 6-hr locations

-6.4 m/s

-3.7 m/s

Shear -15 m/s
-10.7 m/s

Shear +15 m/s
-4.9 m/s