Modelling the effects of land-sea contrast on tropical cyclone precipitation under environmental vertical wind shear

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Publications on TC Landfall Processes


strongest frictional convergence

TC George (2007) in Li et al. (2012)

MOTIVATION

Proposed processes during TC landfall

- Roughness and moisture differences
  - Friction
  - Convergence/divergence within B.L.
  - Asymmetric convection
    - Asymmetric diabatic heating
    - Asymmetric flow (lower-level)
    - Asymmetric flow (upper-level)
  - Vertical wind shear
    - PV tendency distribution
    - Land-induced motion
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Roughness</th>
<th>Moisture Availability</th>
<th>Environmental Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW</td>
<td>No land</td>
<td>No land</td>
<td>1 m s(^{-1}) easterly mean flow</td>
</tr>
<tr>
<td>RW</td>
<td>0.5 m</td>
<td>100%</td>
<td>1 m s(^{-1}) easterly mean flow</td>
</tr>
<tr>
<td>SD</td>
<td>As water surface</td>
<td>5%</td>
<td>1 m s(^{-1}) easterly mean flow</td>
</tr>
<tr>
<td>RD</td>
<td>0.5 m</td>
<td>5%</td>
<td>1 m s(^{-1}) easterly mean flow</td>
</tr>
<tr>
<td>SW-C1</td>
<td>No land</td>
<td>No land</td>
<td>4 m s(^{-1}) easterly shear</td>
</tr>
<tr>
<td>SW-C2</td>
<td>No land</td>
<td>No land</td>
<td>4 m s(^{-1}) northerly shear plus 1.5 m s(^{-1}) easterly mean flow</td>
</tr>
<tr>
<td>SW-C3</td>
<td>No land</td>
<td>No land</td>
<td>4 m s(^{-1}) southerly shear plus 0.5 m s(^{-1}) easterly mean flow</td>
</tr>
<tr>
<td>RD-C1</td>
<td>0.5 m</td>
<td>5%</td>
<td>4 m s(^{-1}) easterly shear</td>
</tr>
<tr>
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No environmental flow (and shear)

With environmental shear

WRF idealized experiments

Vertical wind speed profile for environmental VWS
Internally generated VWS is identified (no environmental VWS here) in the rough-land experiments. This VWS is nearly parallel to the coast during landfall.
Factors affecting TC rainfall during landfall

• Change in vertical stability due to advection of dry air from land by the TC circulation
• Land-sea contrast in surface friction
• Internally generated VWS and environmental VWS
• Have to consider cloud types with these factors!
Rainwater mixing ratio at $\sigma=0.4$ to 0.9 during landfall

Inner-core convective rain develops from $\sigma=0.4$

Outer-band stratiform rain develops at much lower levels, and thus more affected by the land-sea contrast in surface friction
Rainwater mixing ratio at $\sigma=1.0$ and vertical stability at $\sigma=0.88$

SW and SD experiments shown here

Note the difference in rain development on the offshore side, and increase in vertical stability.
Inner-core (<100 km) rain in RW and RD experiment

Azimuthal distribution, 0° is due east, 90° is due north, etc.

More axisymmetric due to strong cyclonic advection and higher-level rain development
Outer-band rain in RW and RD experiment

Rain concentrates on the onshore side during landfall due to increased frictionally induced convergence

Correlated with surface to PBL-top convergence pattern

In RD, rain on the offshore side (270° degree) is also intense due to cyclonic advection and adjustment of radial wind (Li et al. 2013b)
How about when there is environmental VWS? (inner core)

In the inner core, environmental VWS dominates.

Rain concentrates on the downshear-left side.
How about when there is environmental VWS? (outer-band impacts)

Although the downshear to downshear-left relationship with convection is still valid, note the transition from control by the internal VWS to the external (environmental) after landfall.
Proposed processes during TC landfall

- roughness and moisture differences
- friction
- modification to vertical stability
- asymmetric convection
- asymmetric diabatic heating
- asymmetric flow (lower-level)
- asymmetric flow (upper-level)
- vertical wind shear
- Environmental VWS
- PV tendency distribution
- land-induced motion

Convergence/divergence within B.L.