



# Changes in Tropical Cyclone Tracks near Landfall

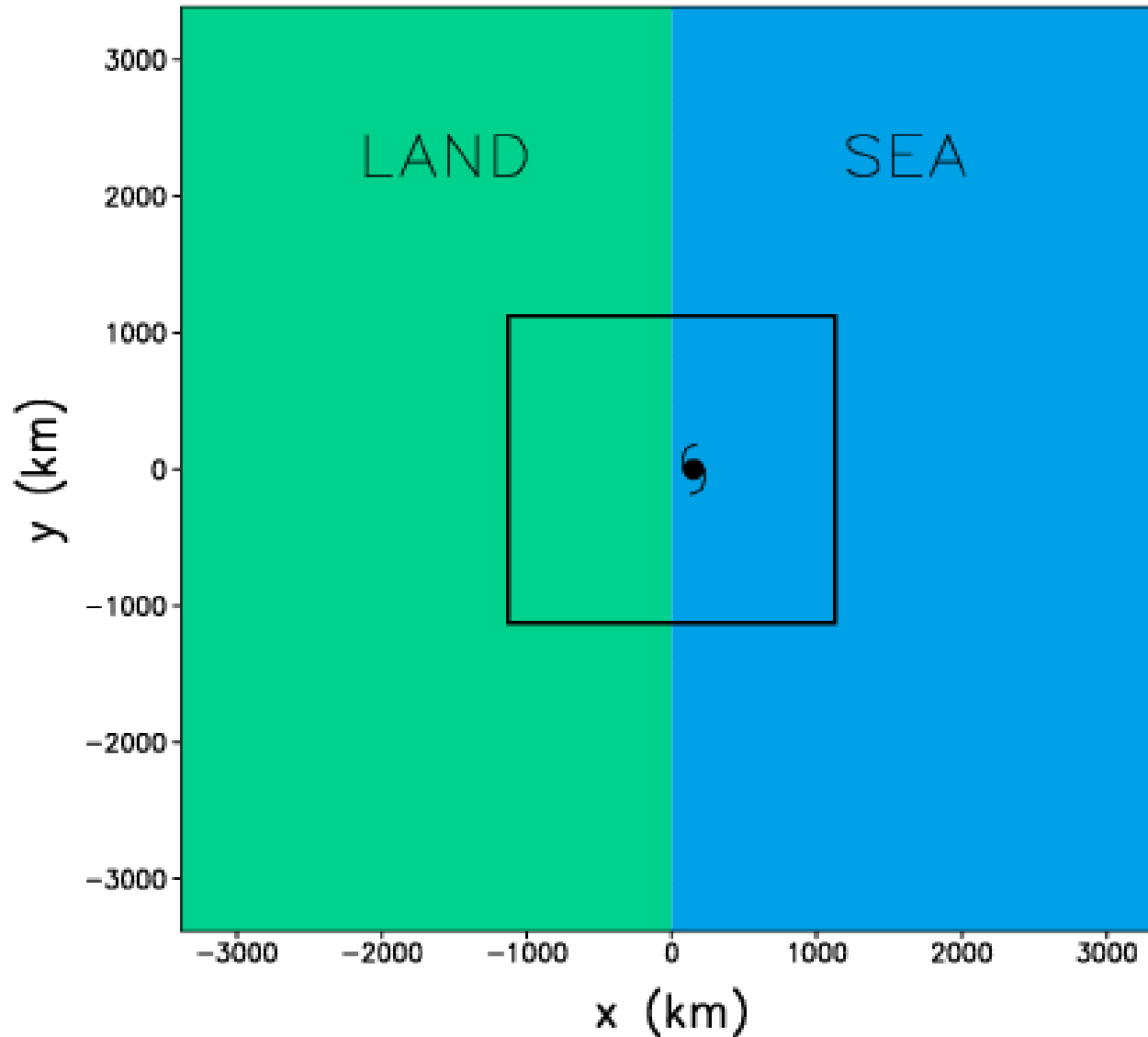
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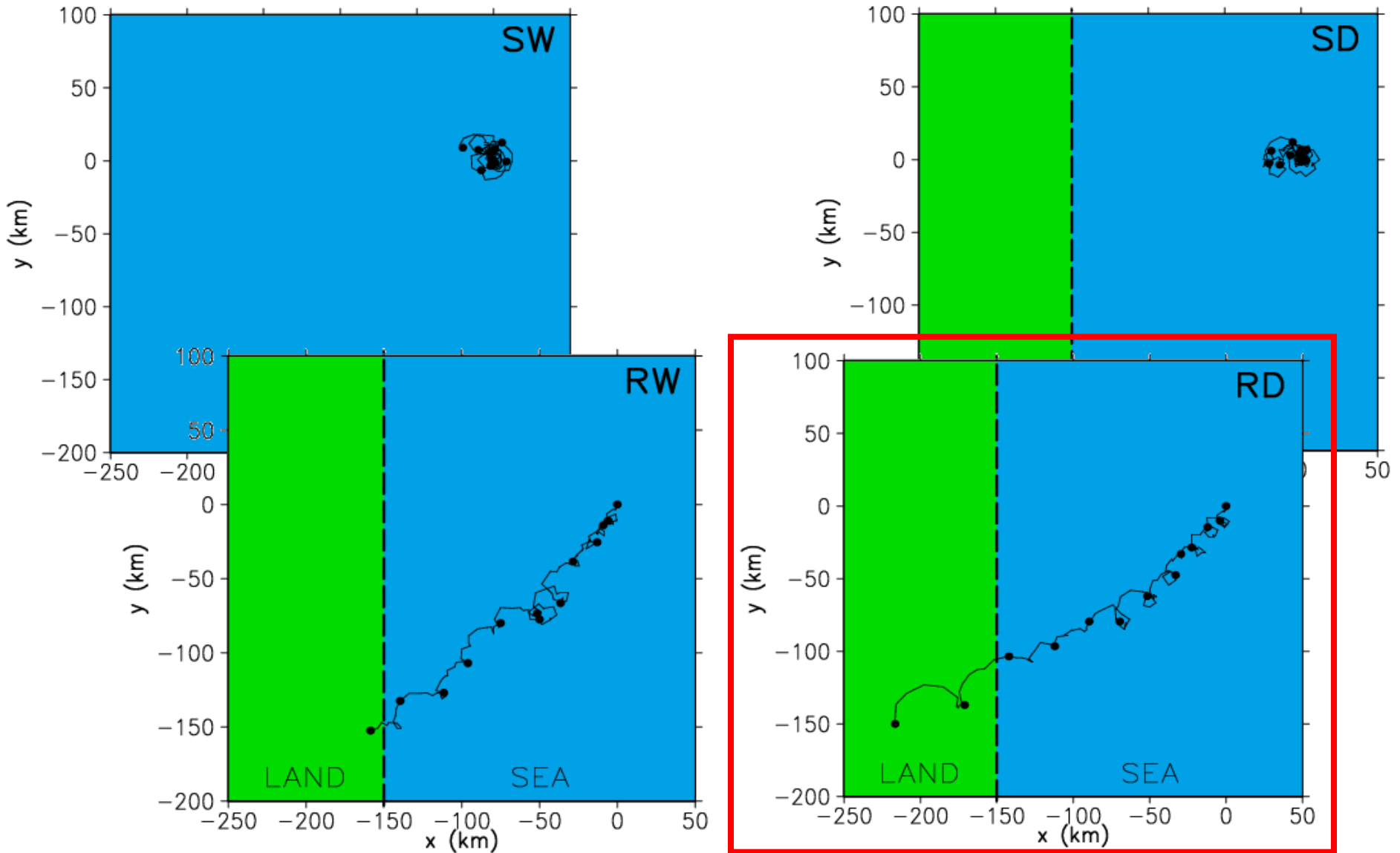
# Outline

- **Review of *f*-plane results**
- **Results on a beta plane**
- **Effects of Inhomogeneous land surface**
- **Summary**

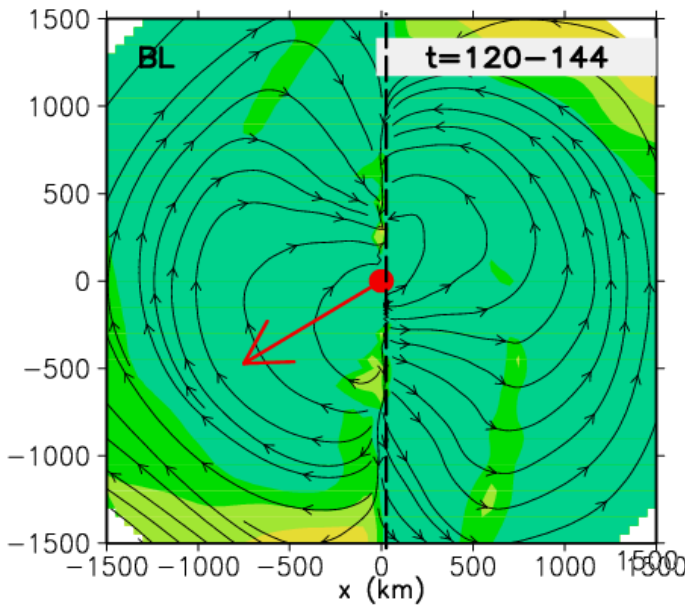
# Track – $f$ plane experiments



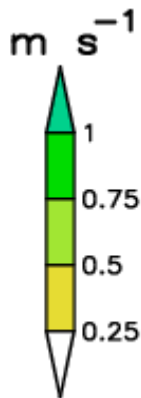
# Track – $f$ plane experiments



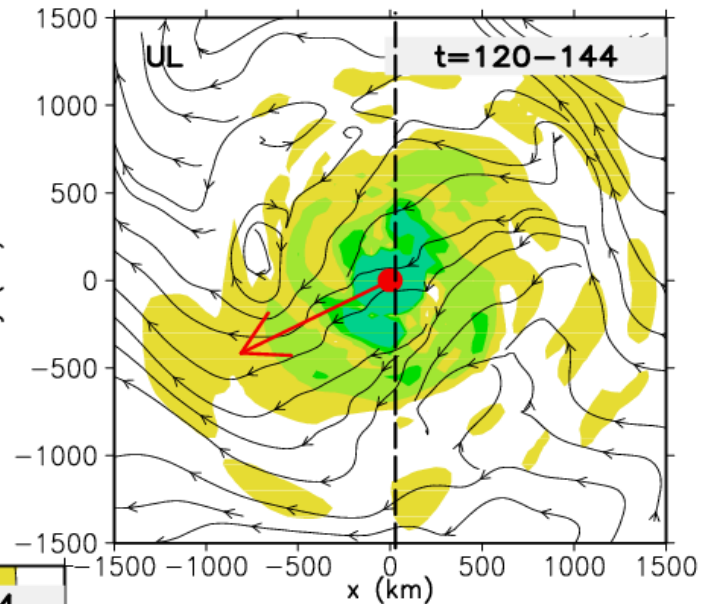
# Asymmetric flow RD experiment Day 6



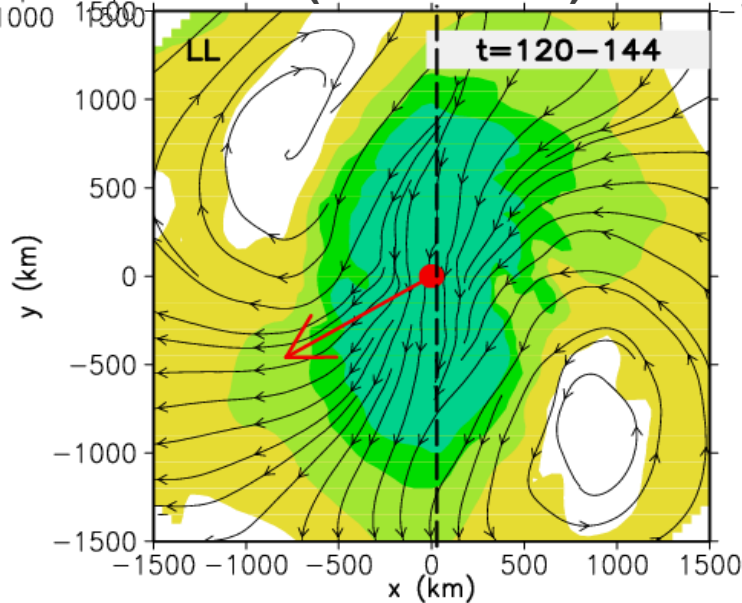
**boundary layer**  
( $0.9 < \sigma < 1.0$ )



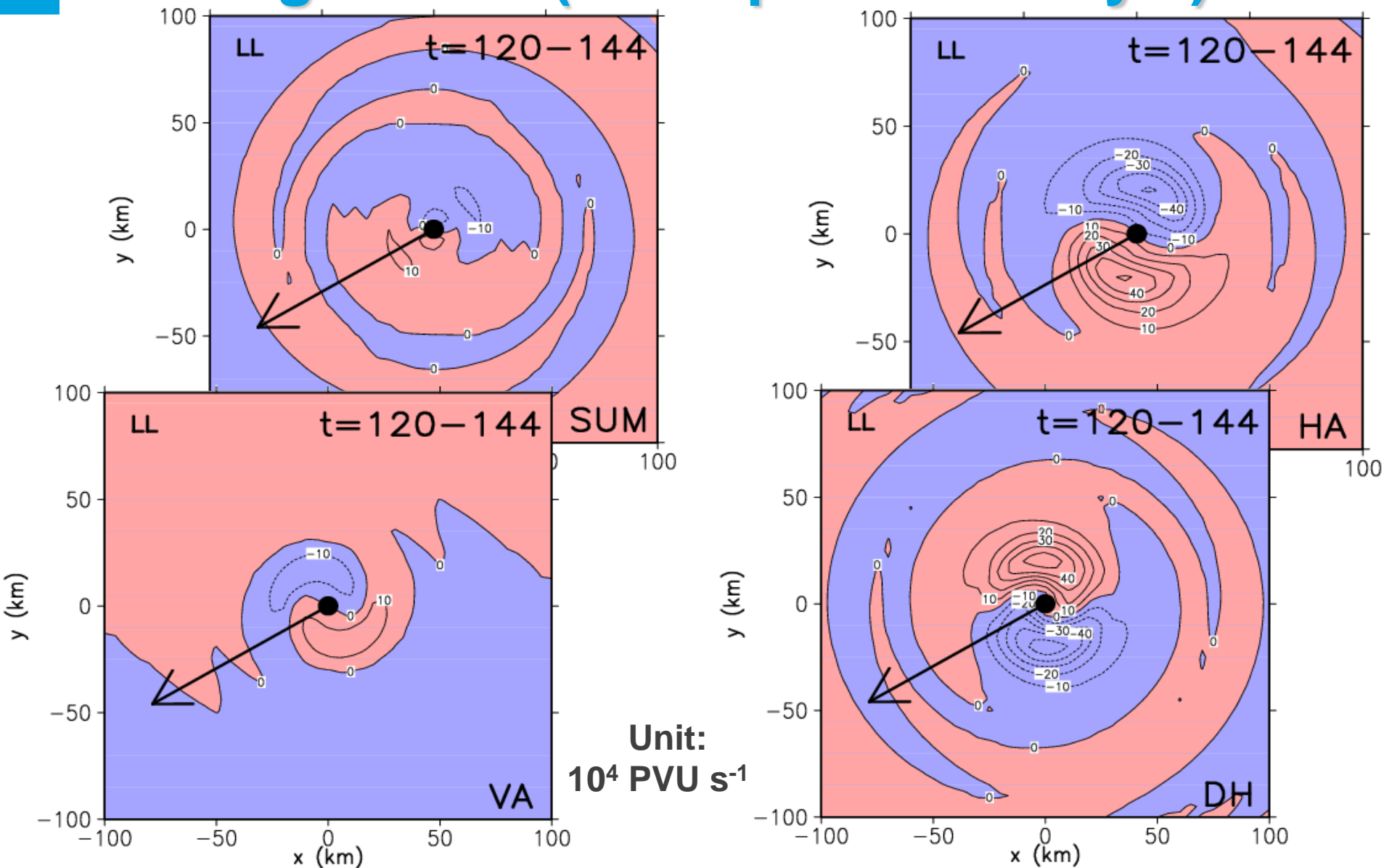
**lower layer**  
( $0.55 < \sigma < 0.9$ )



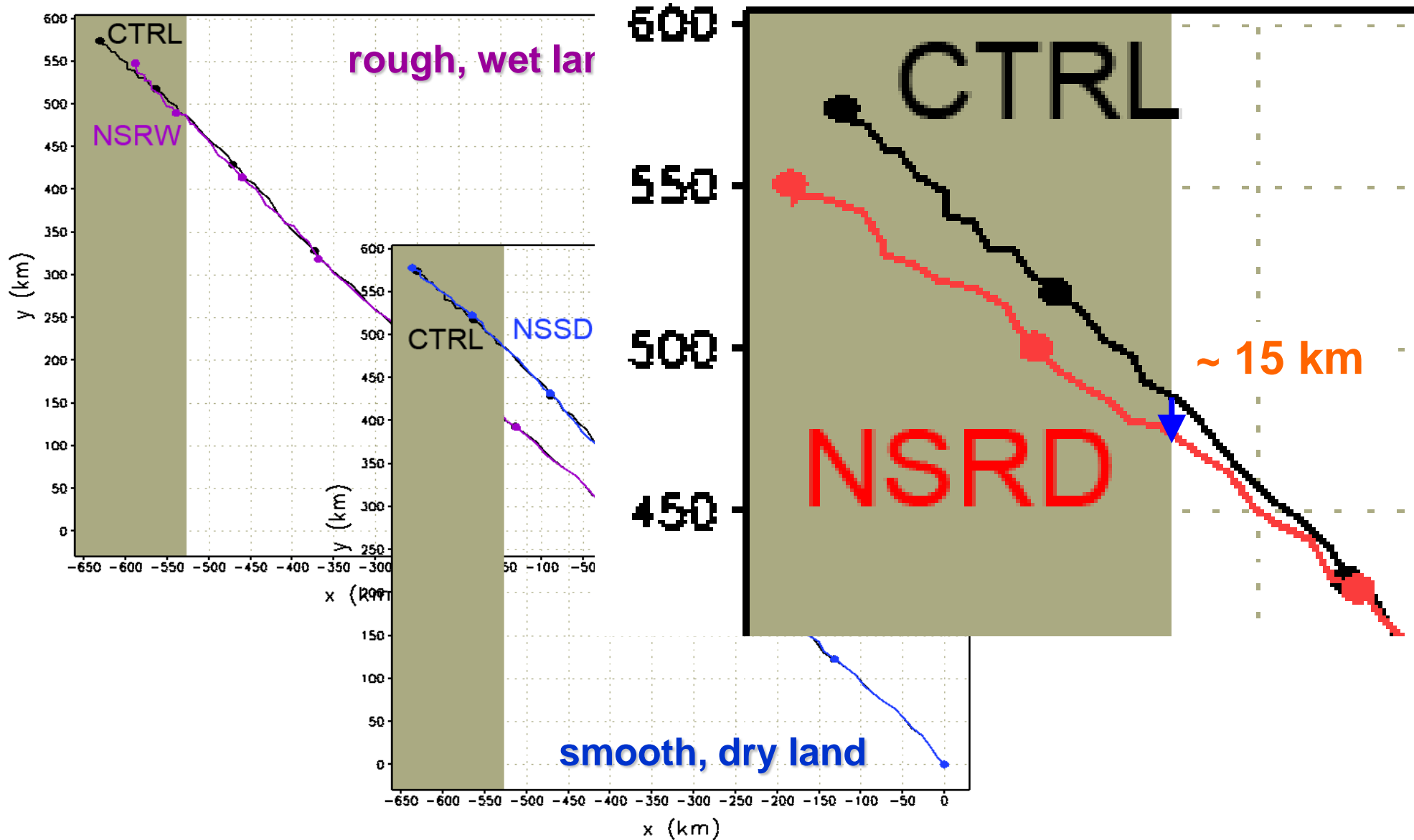
**upper layer**  
( $0.25 < \sigma < 0.55$ )



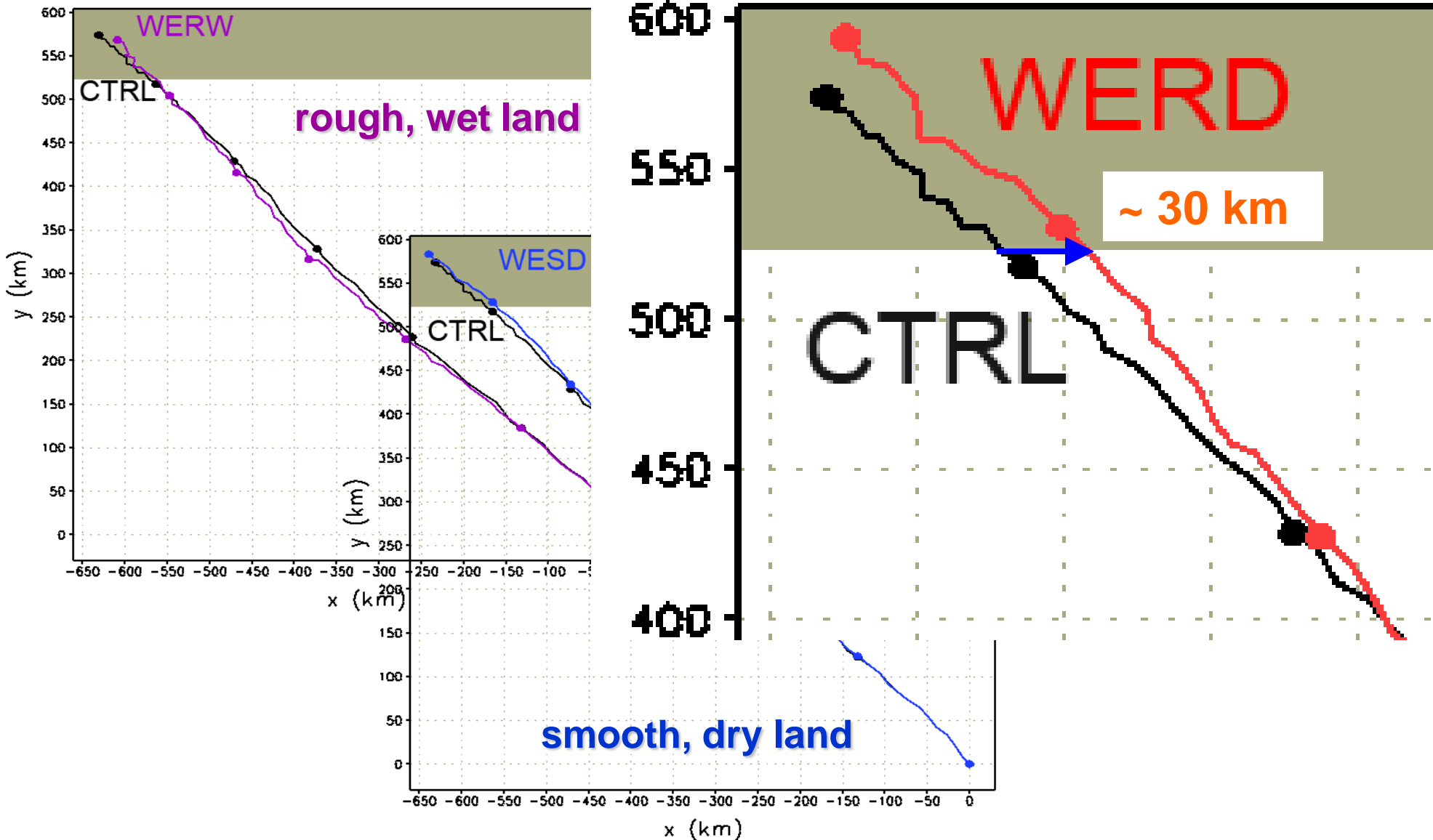
# PV budget at LL (RD experiment Day 6)



# Track – $\beta$ plane experiments NS-oriented coastline



# Track – $\beta$ plane experiments EW-oriented coastline





# Land-induced flow

Hypothesis :

TC circulation = Symmetric flow + Asymmetric flow

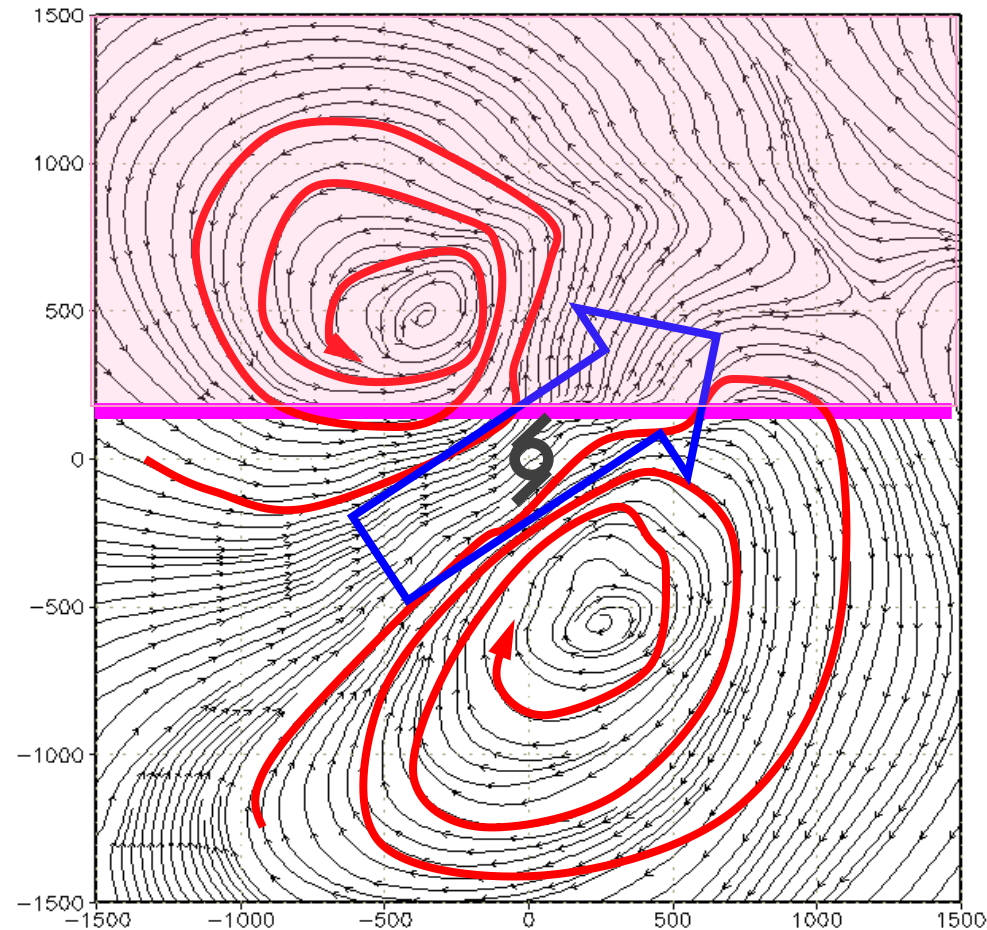
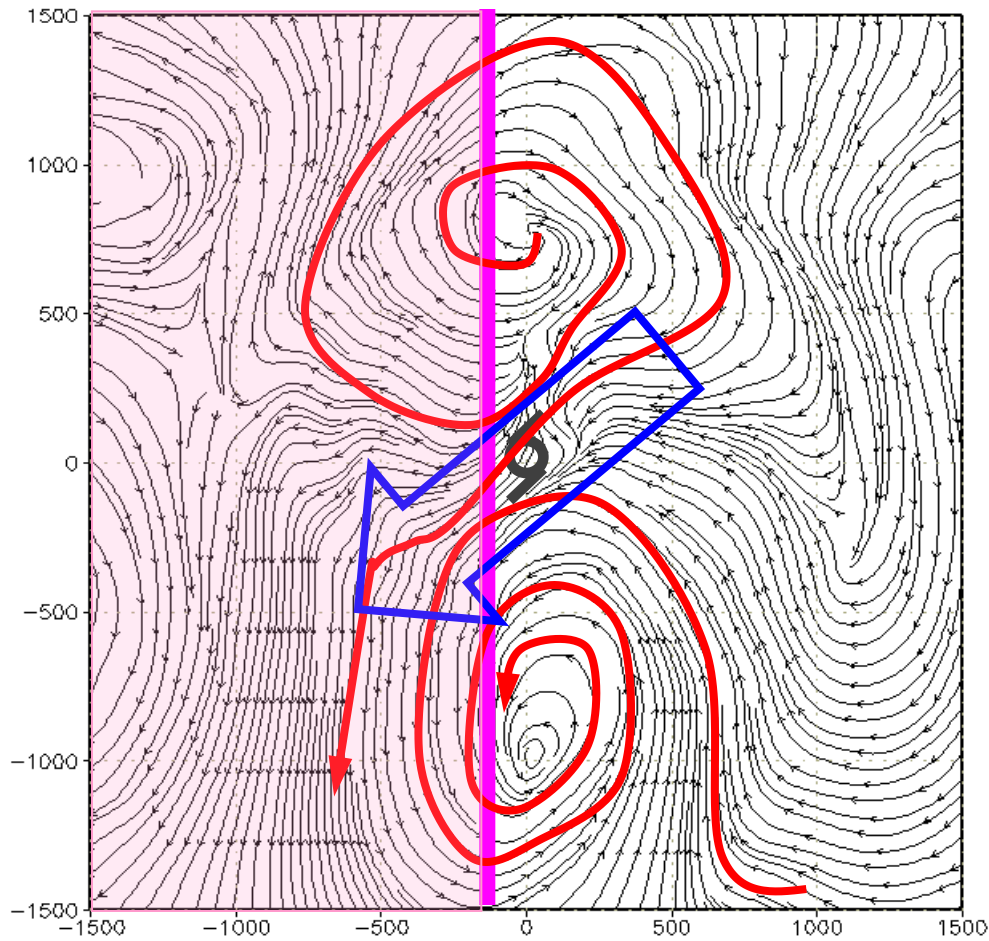
Asymmetric flow = Beta gyres + Land-Induced Flow

Not present in the CTRL

**Land-induced Flow** = Asymmetric flow – Beta gyres  
= (Asymmetric flow)<sub>Landfall</sub> –  
(Asymmetric flow)<sub>CTRL</sub>

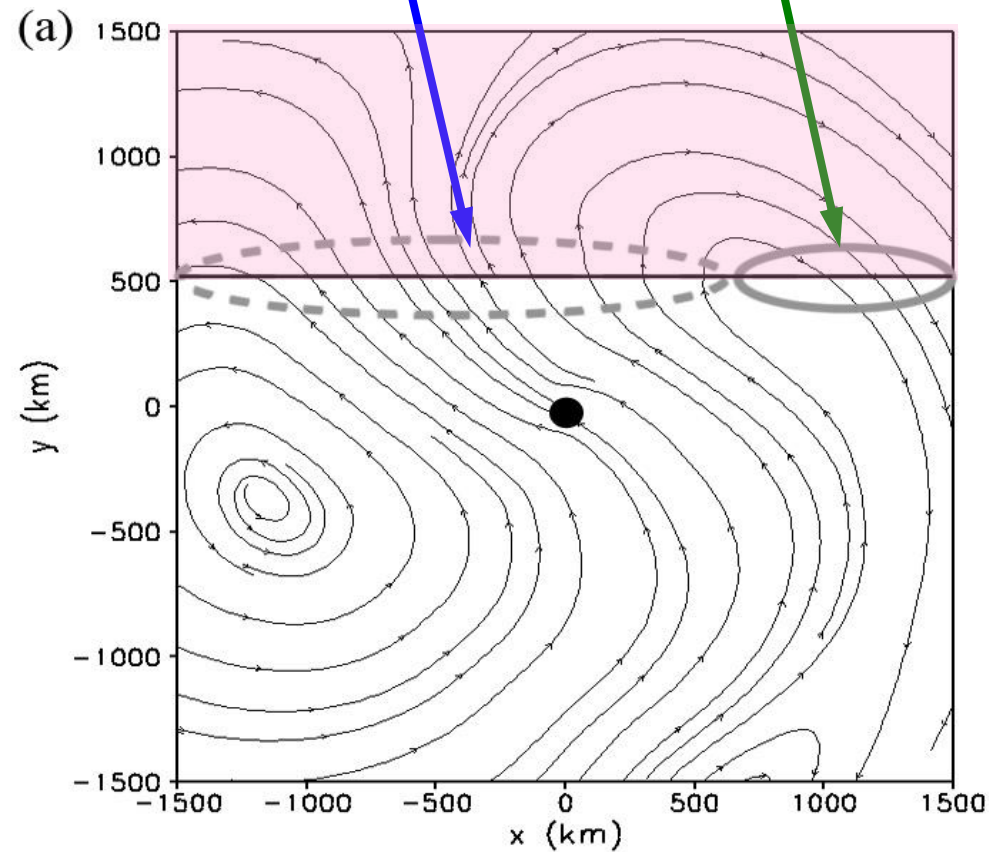
# LL Asymmetric flow ( $0.9 \geq \eta \geq 0.55$ ) $t = 36 - 48$ h

## Rough and dry land

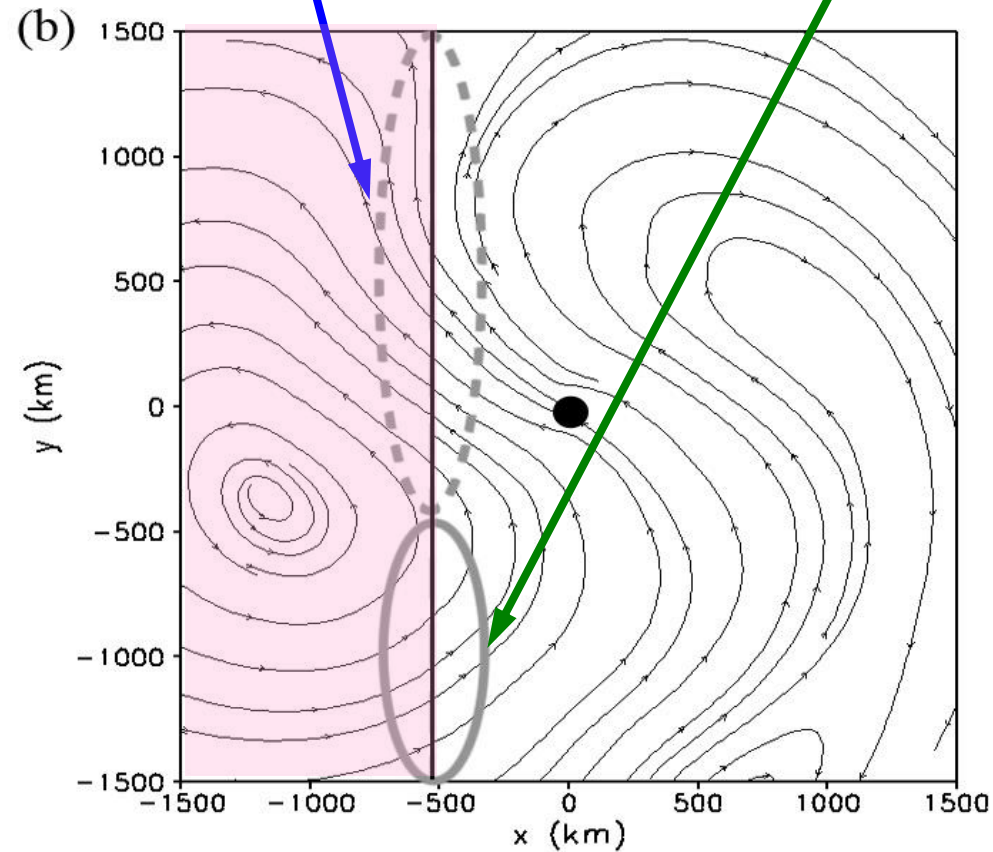


# Changes in the location of onshore vs. offshore flow

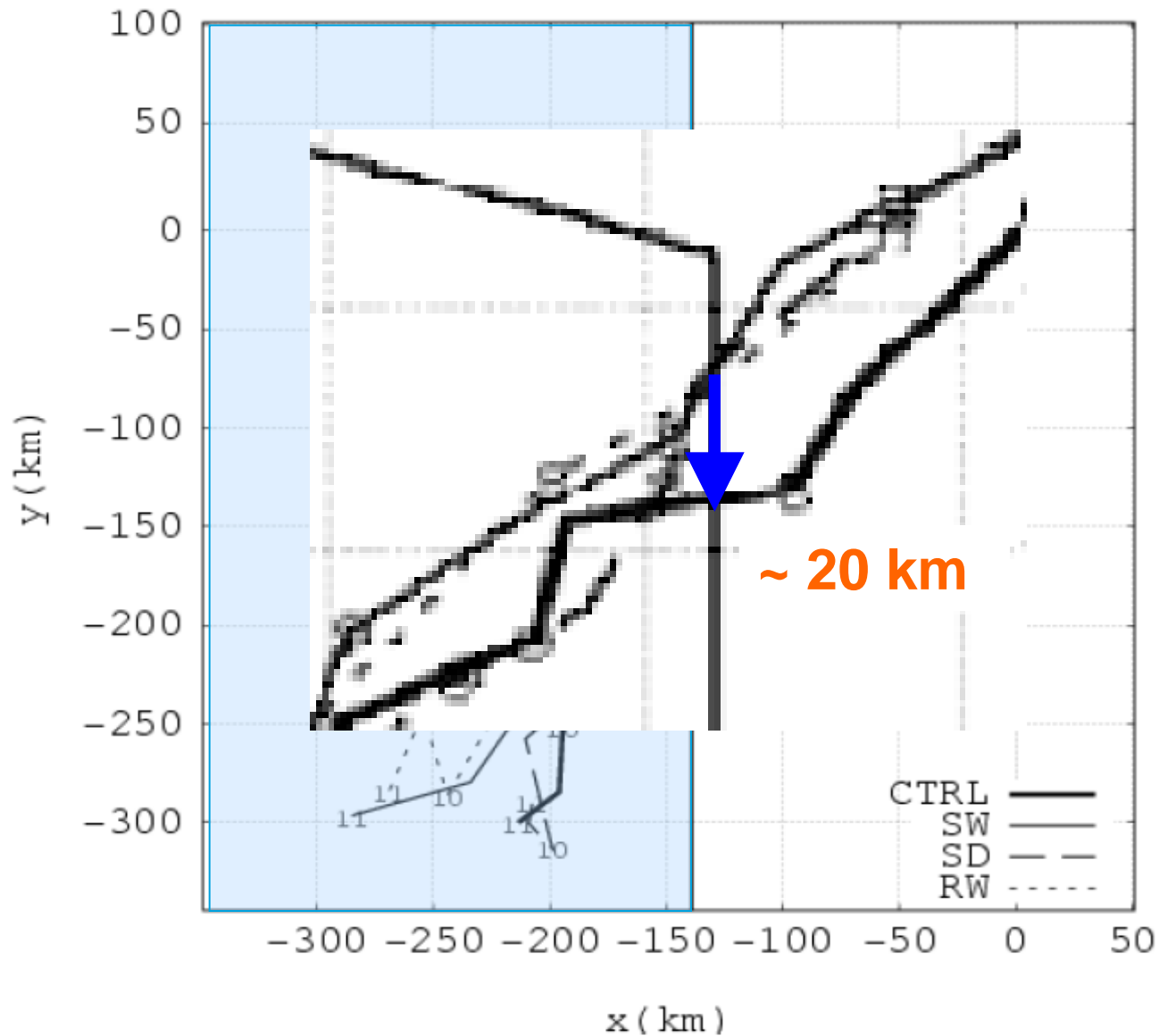
**onshore flow**      **offshore flow**



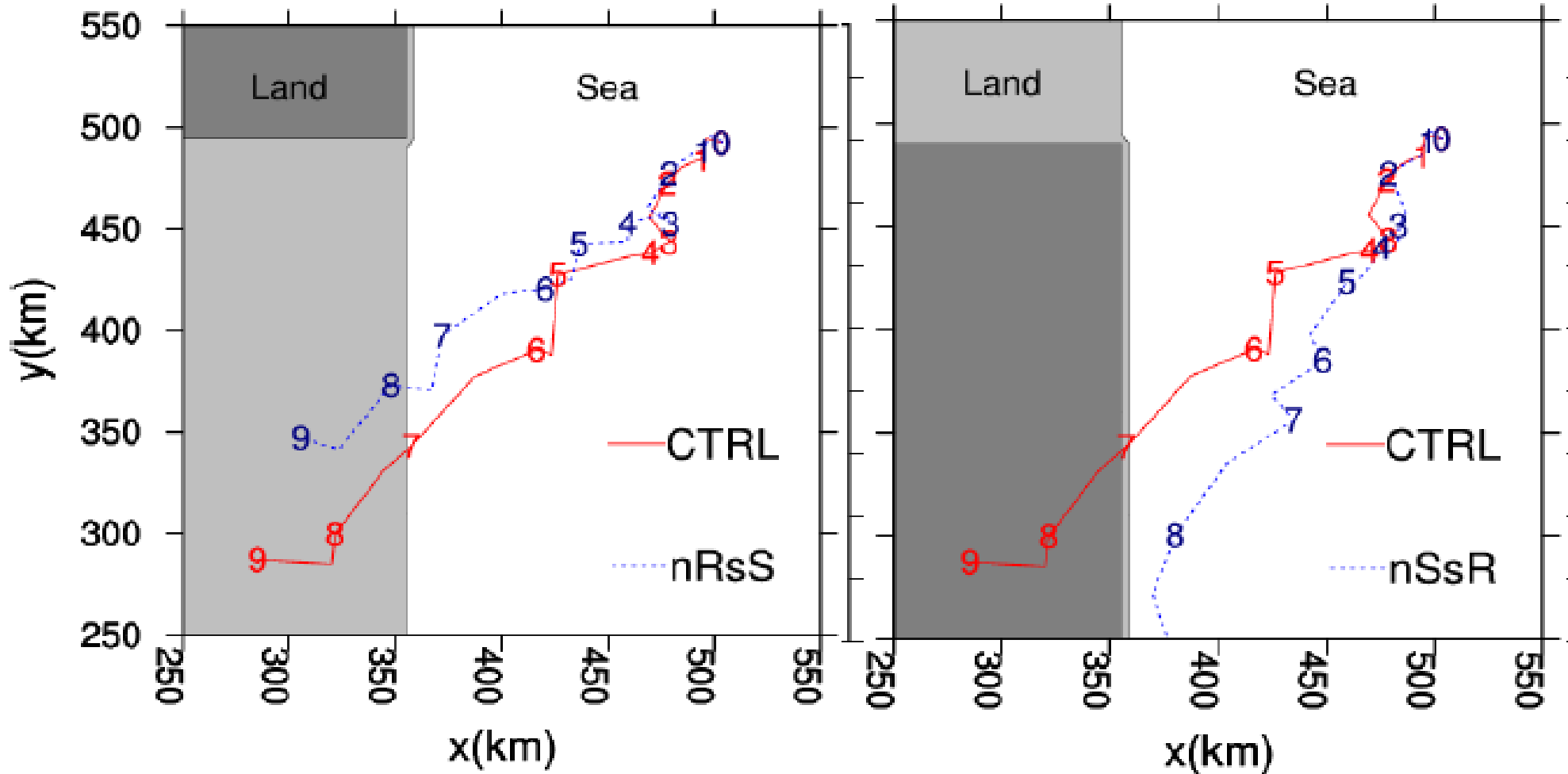
**onshore flow**      **offshore flow**



# Track – $f$ plane experiments River Delta



# Track – $f$ plane experiments Differential roughness



north Rough south Smooth

north Smooth south Rough

# Summary

- **An inherent vortex motion in the presence of a discontinuity in surface friction.**
- **Such motion is caused by two main processes:**
  - **the development of a “ventilation flow” associated with a vortex pair through the generation of relative vorticity from the divergent term in the vorticity equation**
  - **diabatic heating due to differential convergence**

# Summary

- **Such an inherent motion modifies the beta effect so that different coastline orientation will cause the TC track to deviate differently.**
- **Differential friction over land will also cause track deviations towards rougher land**

