Nocturnal Low Level Jets (NLLJ) in West Africa

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Summary

➢ There is a strong diurnal cycle within the West African Monsoon flow, with a nocturnal low-level jet (NLLJ)
➢ We compare radiosonde data from Niamey in the Sahel with reanalyses and two conceptual models of the NLLJ
➢ Inclusion of night-time friction in the Van de Wiel et al. (2010) model improves it relative to the Blackadar (1957) model
➢ Sunset stability transition period leads to errors in Van de Wiel.
➢ ERA-I under-estimates LLJ strength leading to an underestimate in moisture flux.

Background

➢ Main mechanisms: Inertial oscillation, terrain effects, baroclinic effects and cold pools outflows above a stable layer.
➢ Inertial oscillation is the main explanation for NLLJ over flat terrain:
  • Equilibrium between pressure, friction and Coriolis forces
  • Nocturnal wind accelerates clockwise around the circle from the "actual daytime wind"

Models

➢ Humidity and pollutant transport
  • During the monsoon, the NLLJ advects cold humid air and aerosols from the ocean (Parker et al, 2005, QJRMS, 131, 2839-2860)
➢ Low level clouds formation
  • NLLJ driven cool air advection and turbulent vertical mixing leads to low level clouds formation in southern West Africa (Schuster et al, 2013, J Atm Sci, 70, 2337-2355).

Results

a. Vertical wind profile

➢ For days without mesoscale convective systems AMMA radiosonde observations are compared with ERA-I and 2 inertial oscillation conceptual models:
  • Van de Wiel: Constant Friction at night (Van de Wiel et al., 2010, J Atm Sci, 67, 2679-2689)
  • Blackadar: No Friction at night (Blackadar, 1957, BAMS, 38, 283-290)
➢ NLLJ at Niamey is consistent with an inertial oscillation
➢ Van de Wiel model gives the most accurate representation
➢ Lack of friction in Blackadar gives too strong winds near surface
➢ ERA-I under-estimates LLJ core wind-speeds and over-estimates near-surface wind-speed at night, suggesting errors in mixing

b. Wind hodograph

➢ Time independence in Van de Wiel leads to errors relative to the initialization time

[Wind hodograph comparing radiosonde observations (dashed line), Van de Wiel result with initialisation at sunset (full line) and Van de Wiel result with initialisation 2 hours after sunset (dots), equilibrium wind at each altitude are represented by the cross]

Further work

➢ Does NLLJ influence cloud formation in Sahel as well as southern West Africa?
➢ What NLLJ mechanisms are most important in southern West Africa in the DACCIWA field campaign region?

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Motivations

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