Nocturnal Low Level Jets (NLLJ) in West Africa

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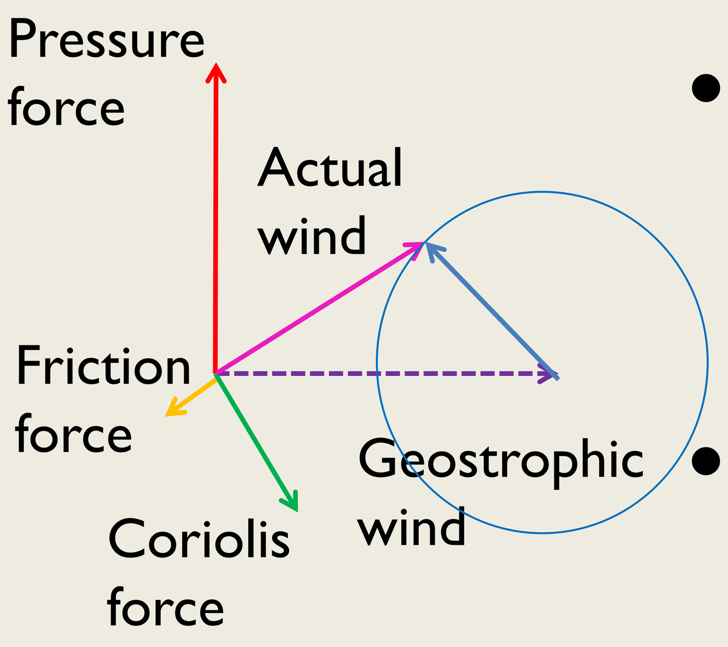
Summary

- 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, baroclinc 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"



Inertial oscillation schematic

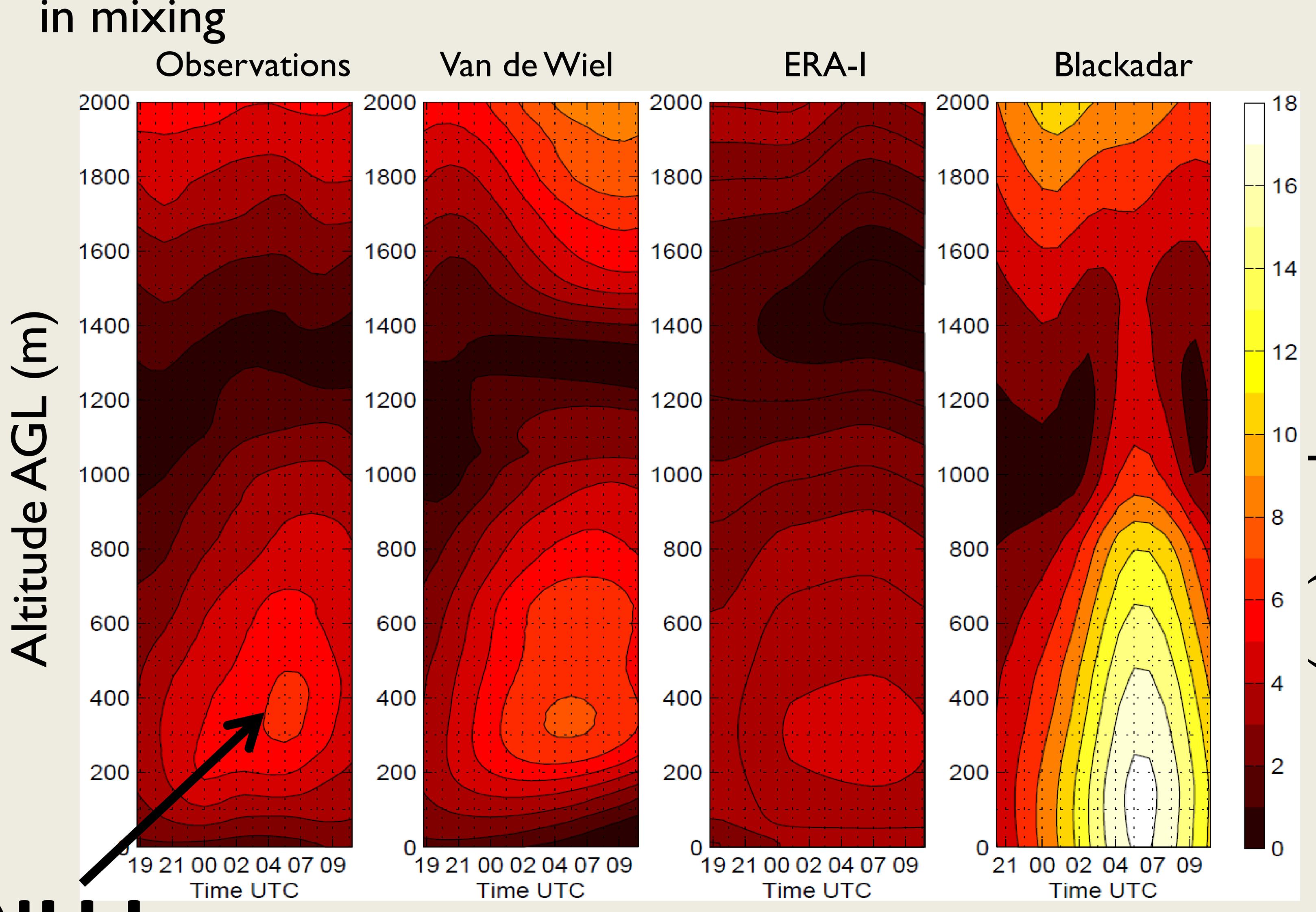
Motivations

- 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

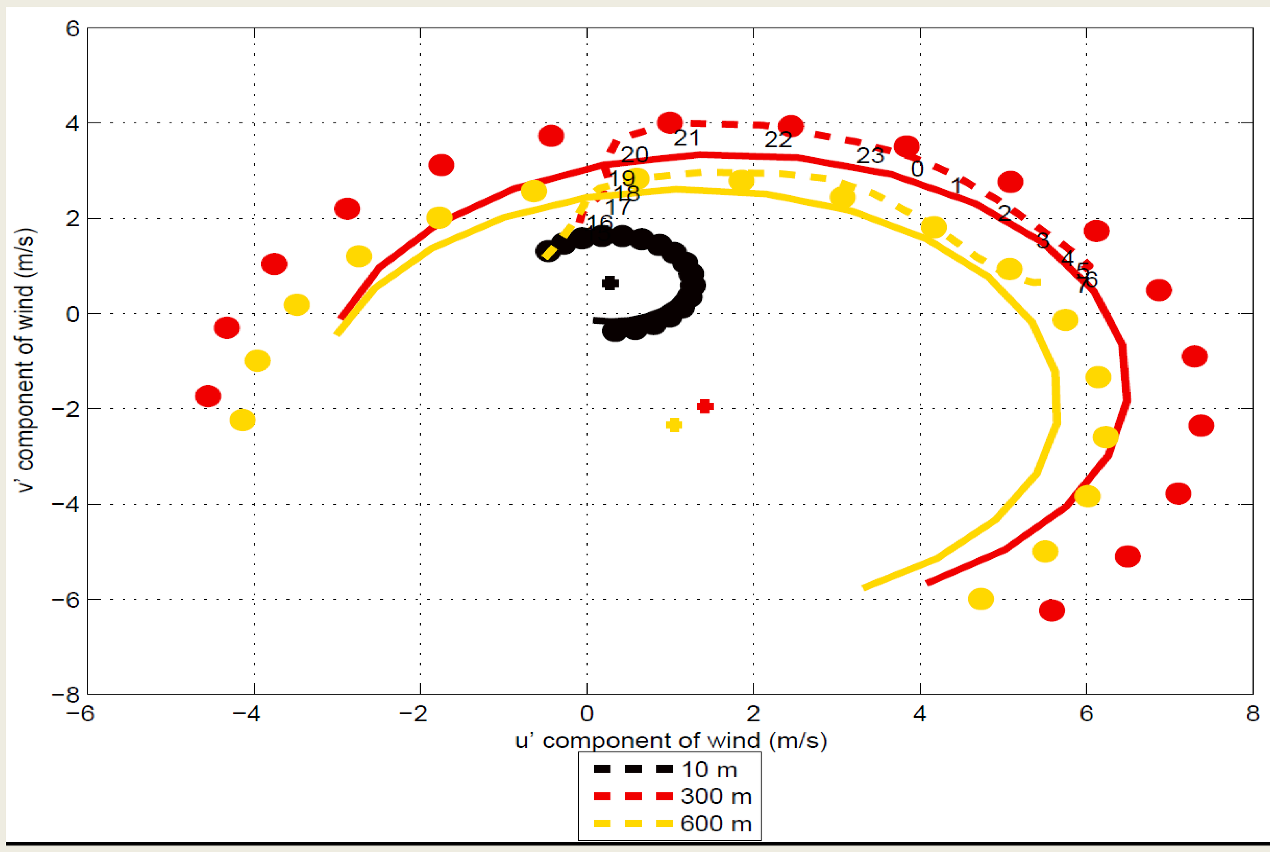
- For days without mesoscale convective systems AMMA radiosonde observations are compared with ERA-I and **2 inertial oscillation conceptual models:**
  - Van de Wiel : **Constant Friction** at night (Van deWiel et al., 2010, J Atm Sci, **67,** 2679-2689)
  - Blackadar: **No Friction** at night (Blackadar ,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



Time altitude Hovmüller plots of wind speed averaged over the period (25/07/2006 – 31/08/2006) in Niamey

b. Wind hodograph

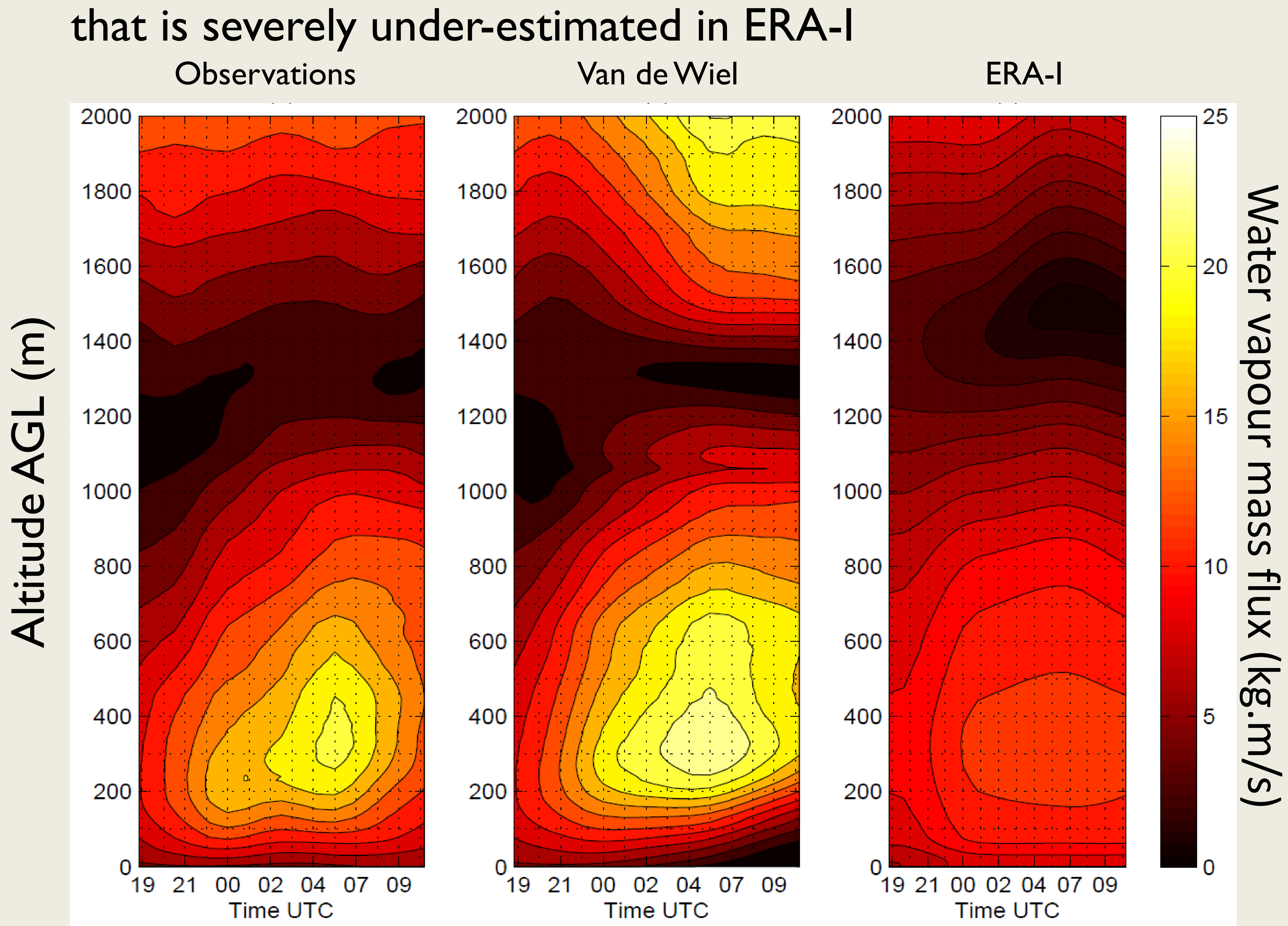
- Time independence in Van de Wiel leads to errors relative to the initialization time



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

c. Water vapour mass flux

- NLLJ makes a major contribution to water vapour mass flux that is severely under-estimated in ERA-I



Time altitude Hovmüller plots of water vapour mass flux averaged over the period (25/07/2006 – 31/08/2006) in Niamey

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?

Acknowledgements:

This work has been performed as part of the DACCIWA project .The DACCIWA project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 603502. The AMMA radiosonde campaign was funded by the EU FP6 AMMA project (Grant 004089) and radiosonde data were obtained from the AMMA database at http://database.amma-international. We acknowledge the UK Principal Investigator Doug Parker.

National Centre for Atmospheric Science
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Dynamics-aerosol-chemistry-cloud interactions in West Africa

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