The nocturnal low-level jet in the West African Sahel

Contact email: eegb@leeds.ac.uk

Geoffrey Bessardon[1], Barbara Brooks[1,2], John Marsham[1,2], Andrew Ross[1]

[1]Institute for Climate and Atmospheric Science (ICAS), School of Earth and Environment, University of Leeds, UK, [2] National Centre for Atmospheric Science (NCAS), UK

UNIVERSITY OF LEEDS

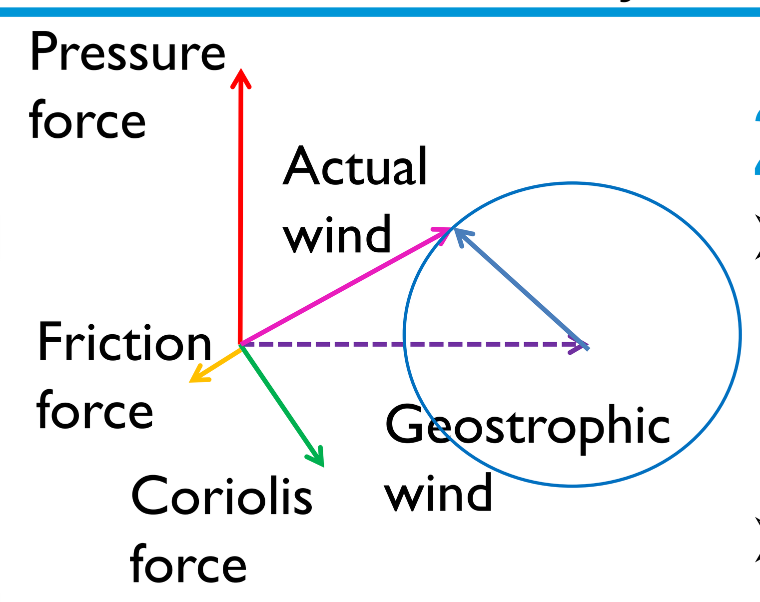
Summary

- There is a strong diurnal cycle within the West African Monsoon flow, with a nocturnal low-level jet (NLLJ)
- We have compared 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
- Equilibrium wind changes due to geostrophic wind changes leads to errors in Van de Wiel
- Reanalyses under-estimates NLLJ strength leading to an underestimate in moisture flux.

1. 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

2. 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)

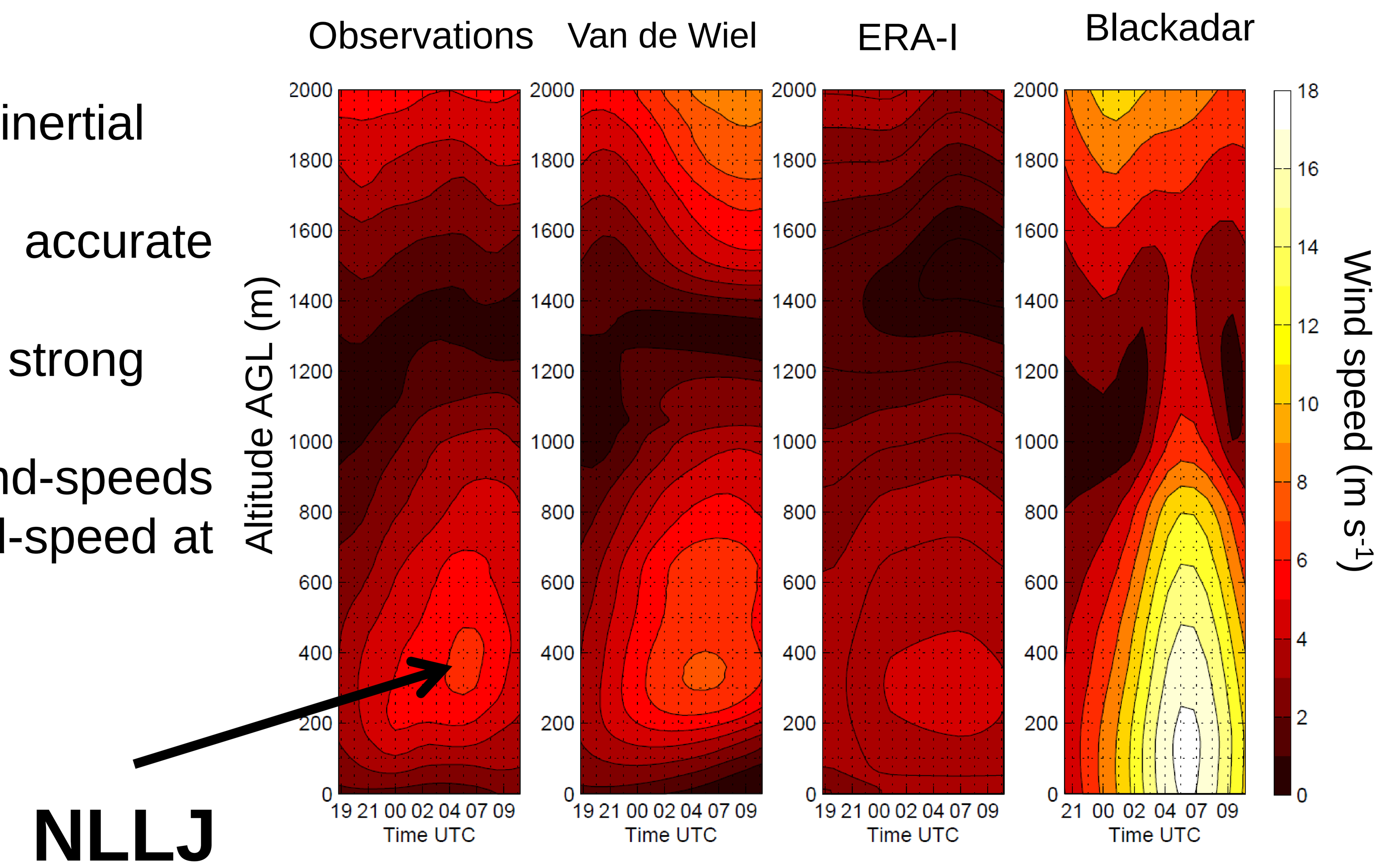
- **Low level clouds formation:** NLLJ driven cool air advection and turbulent vertical mixing leads to low level clouds formation in southern West Africa (Schuster et al, 2013, J Atm Sci,**70**, 2337–2355).

3. Results

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)

a. Vertical wind profile

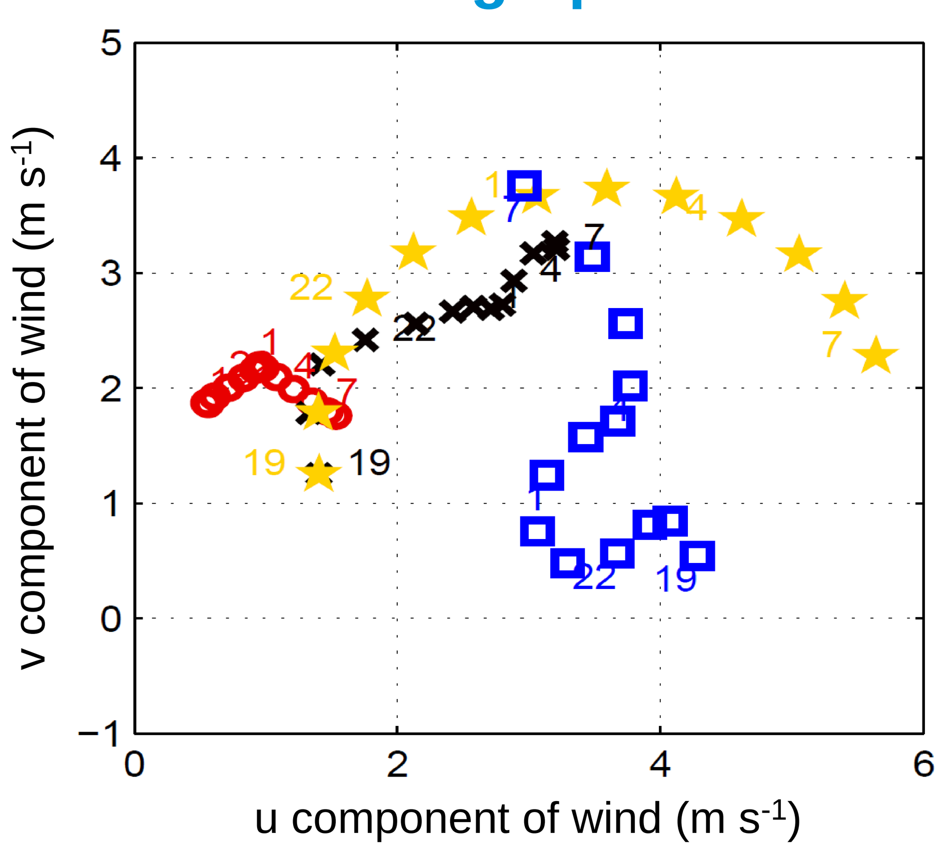
- NLLJ at Niamey is consistent with an inertial oscillation
- Van de Wiel model gives the most accurate representation
- Lack of friction in Blackadar gives too strong winds near surface
- ERA-I under-estimates LLJ core wind-speeds and over-estimates near-surface wind-speed at night, suggesting errors in mixing



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

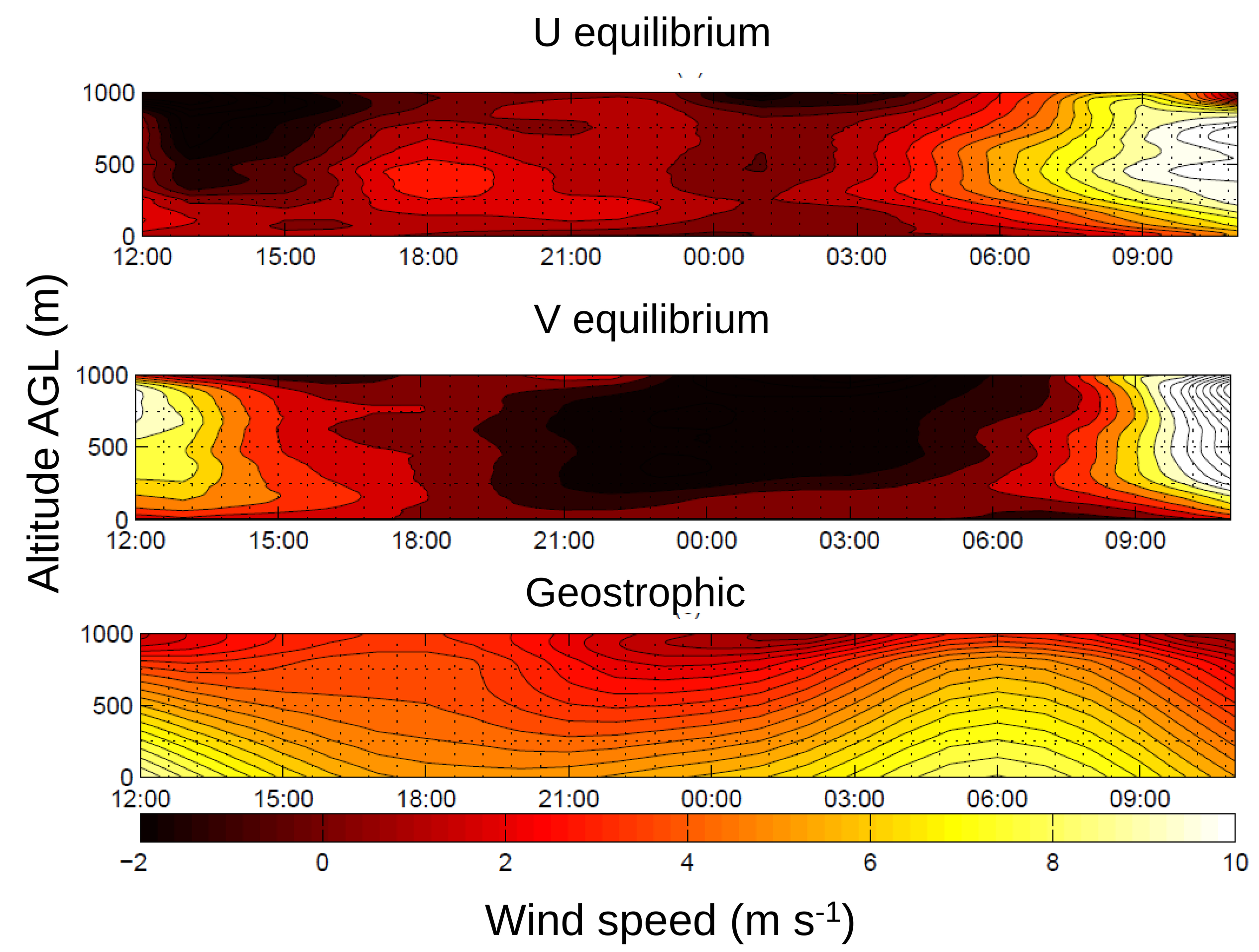
- Both Van de Wiel and ERA-I do not represent well the direction changes of the observed wind
- Van de Wiel error increases when the equilibrium wind increases

b. Wind hodograph



Wind hodograph comparing radiosonde (cross) with ERA-I (circles), VdW10 (pentagrams), and equilibrium wind (squares)

c. Equilibrium wind changes

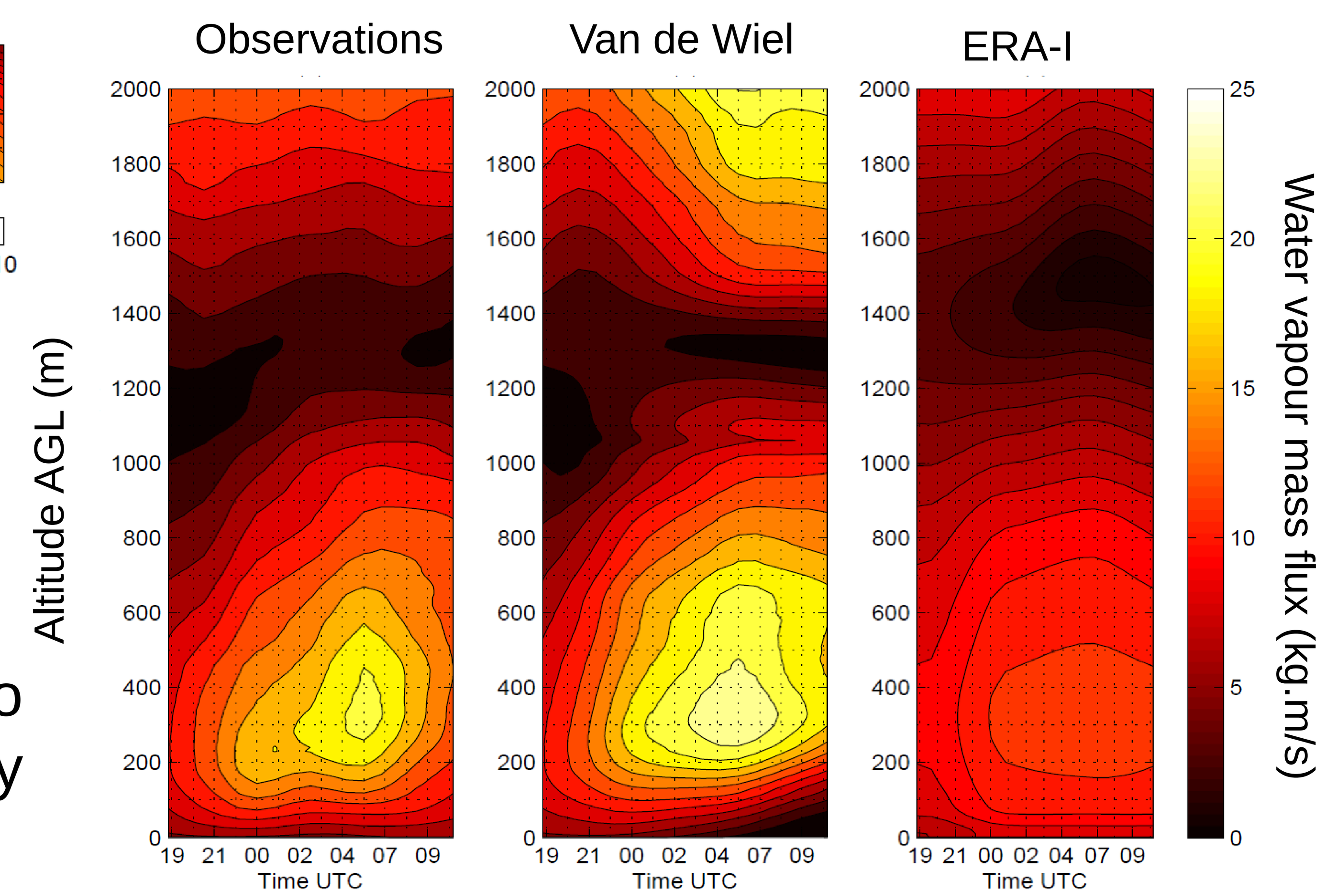


Time altitude Hovmüller plots of equilibrium wind component and geostrophic wind

- Component of the equilibrium winds have been computed every hour
- The variations of the geostrophic wind correspond to the change of the equilibrium wind
- Change of the geostrophic winds are likely to explain the errors in Van de Wiel

d. 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

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.