LINKING ATMOSPHERIC RIVERS AND WARM CONVEYOR BELT AIRFLOWS

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WHAT ARE ATMOSPHERIC RIVERS?

• 2D filaments of high TCWV flux extending from the subtropics - termed atmospheric-rivers (Newell et al. 1992)

• ARs structure (WMO):
  • shallow (3 km deep)
  • narrow (850 km wide)
  • elongated (> 2000 km in length)
  • water vapour flux (> 250 kg/m/s)
WHAT ARE WARM CONVEYOR BELTS?

Cyclone airstream analysed in a cyclone-relative

Adapted from Carlson (1980)
WHAT ARE WARM CONVEYOR BELTS?

Cyclone airstream analysed in a cyclone-relative surface ascending by ~ 600hPa from the top of boundary layer to upper-troposphere

- WCB is a cyclone-relative airstream on a warm \(\theta_w\) surface ascending by ~ 600hPa from the top of boundary layer to upper-troposphere

Adapted from Carlson (1980)
How are warm conveyor belts and atmospheric rivers linked?

Schematic of an atmospheric river airstream

Schematic of a warm conveyor belt airstream
BAND OF HIGH TCWV EXTENDING FROM SUBTROPICS TO THE UK

ERA-Interim Total Column Water Vapour (TCWV)
18UTC 31 Jan 2002
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HIGH TCWV FOUND AHEAD OF COLD FRONT IN THE WARM SECTOR

Total column water vapour

Synoptic analysis

IR satellite

www.met.rdg.ac.uk/~storms
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The low-level cyclone-airflow splits into 2 branches at the cold front.
CYCLONE AIRFLOW ON 285K $\theta$ SURFACE

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The low-level cyclone-airflow splits into 2 branches at the cold front.
- The cold front sweeps up water vapour in the warm sector leading to moisture accumulation.
- Moist air ahead of the cold front is exported from the cyclone leaving a footprint of high TCWV.
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Moist air ahead of the cold front is exported from the cyclone leaving a footprint of high TCWV.
CYCLONE COMPOSITING IS USED TO EXAMINE CYCLONE CHARACTERISTICS

1. Extract fields from ERA-I along cyclone tracks within 1500km radius surrounding the identified cyclone position
2. Rotate cyclone centred fields so direction of travel is left to right
3. Composite 200 most intense cyclones at times relative to max intensity

Catto et al. (2010)
A BAND OF HIGH TCWV IS LOCATED AHEAD OF THE COLD FRONT

Composite cyclone-centred fields 24 hours prior to time of maximum intensity

TCWV (filled contours, kg m\(^{-2}\)), 6-hr Precipitation (blue, mm), 6-hr Evaporation (orange, mm), 925 hPa \(\theta_e\) (black dashed)
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Cyclone propagation

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3000km

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3D CYCLONE RELATIVE AIRFLOWS ARE IDENTIFIED ON ISENTROPIC SURFACES

Composite cyclone-centred fields 24 hours prior to time of maximum intensity

Pressure in hPa (contours) and cyclone-relative winds on 285 K $\theta$ surface
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Pressure in hPa (contours) and cyclone-relative winds on 300 K $\theta$ surface
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Composite cyclone-centred fields 24 hours prior to time of maximum intensity

(c) Pressure in hPa (contours) and cyclone-relative winds on 285 K \( \theta \) surface

(d) Pressure in hPa (contours) and cyclone-relative winds on 300 K \( \theta \) surface
Composite cyclone-centred fields 24 hours prior to time of maximum intensity

(c) Pressure in hPa (contours) and cyclone-relative winds on 285 K θ surface

(d) Pressure in hPa (contours) and cyclone-relative winds on 300 K θ surface
THE FEEDER AIRSTREAM TRANSPORTS AIR TOWARDS THE COLD FRONT

Schematic of cyclone-relative airflows overlaid on surface features

Precipitation (dark blue), high TCWV (light blue), Warm conveyor belt (red), Dry intrusion (yellow), Feeder airstream (green)
CYCLONE PRECIPITATION IS RELATED TO DOWNSTREAM TCWV 24HRS EARLIER

Lagged linear regression between precipitation and TCWV 24 hours earlier

Composite 10-day filtered TCWV at T-24 (contours) and sensitivity of precipitation (kg m\(^{-2}\)) at max intensity to TCWV 24 hrs earlier
CYCLONE PRECIPITATION IS RELATED TO DOWNSTREAM TCWV 24HRS EARLIER

Lagged linear regression between precipitation and TCWV 24 hours earlier

(b) Composite 10-day filtered TCWV at T-24 (contours) and sensitivity of precipitation (kg m\(^{-2}\)) at max intensity to TCWV 24 hrs earlier

(c) Pressure in hPa (contours) and cyclone-relative winds (vectors) on 285 K \(\theta\) surface at T-24
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CYCLONE IVT IS RELATED TO DOWNSTREAM TCWV 24HRS EARLIER

Lagged linear regression between integrated vapour transport (IVT) and TCWV 24 hours earlier

Composite 10-day filtered TCWV at T-48 (contours) and sensitivity of IVT (kg m$^{-1}$ s$^{-1}$) at T-24 to TCWV 24 hours earlier
CYCLONE IVT IS RELATED TO DOWNSTREAM TCWV 24HRS EARLIER

Lagged linear regression between integrated vapour transport (IVT) and TCWV 24 hours earlier

Composite 10-day filtered TCWV at T-48 (contours) and sensitivity of IVT (kg m\(^{-1}\) s\(^{-1}\)) at T-24 to TCWV 24 hours earlier

Pressure in hPa (contours) and cyclone-relative winds (vectors) on 285 K \(\theta\) surface at T-48
SUMMARY
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Q. How is moisture re-distributed by cyclone airflows at low-levels?
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• Feeder airstream exports moisture from the cyclone creating a long filament of high TCWV marking the track of the cyclone
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Q. How is the moisture in atmospheric rivers and warm conveyor belts linked?
- Not through direct transport from the AR to the WCB
- Moisture at the entrance to the feeder airstream controls both
  - strength of IVT in the atmospheric river
  - precipitation due to ascent in the warm conveyor belt