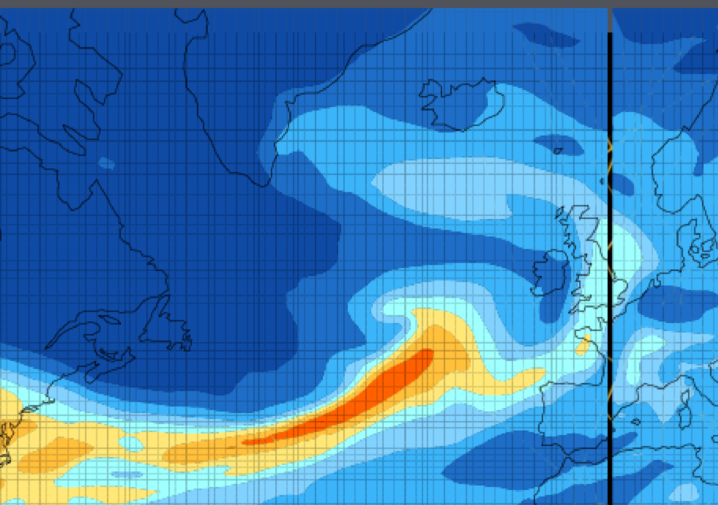
LINKING ATMOSPHERIC RIVERS AND WARM CONVEYOR BELT AIRFLOWS



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1. University of Reading, 2. University of Oxford

WHAT ARE ATMOSPHERIC RIVERS?

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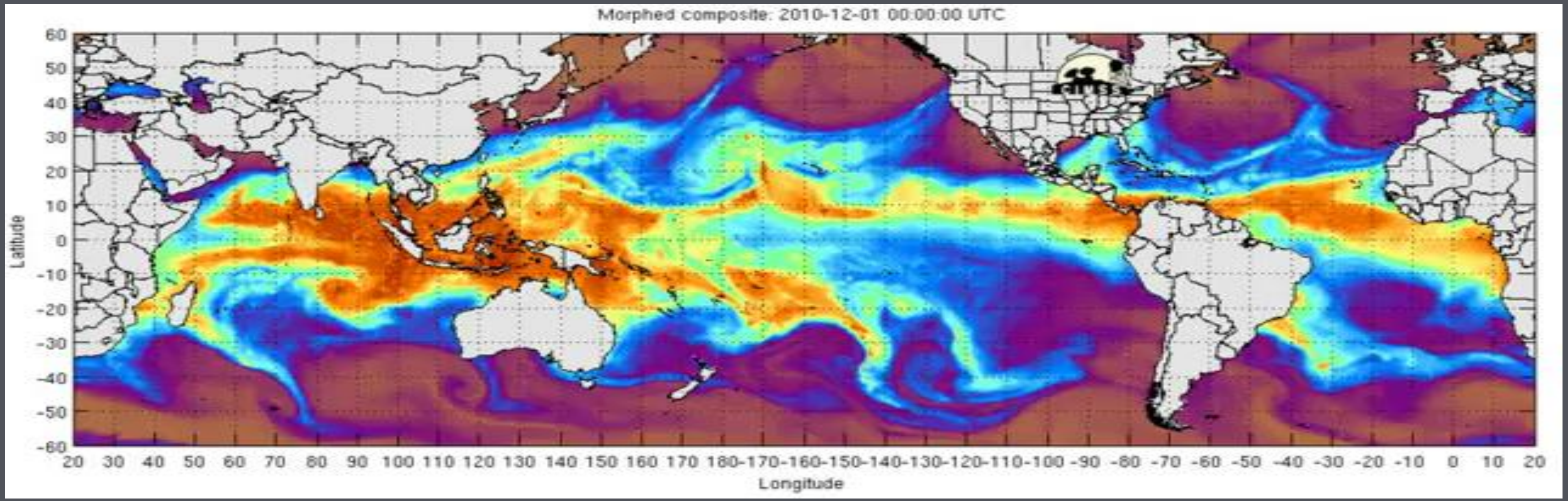
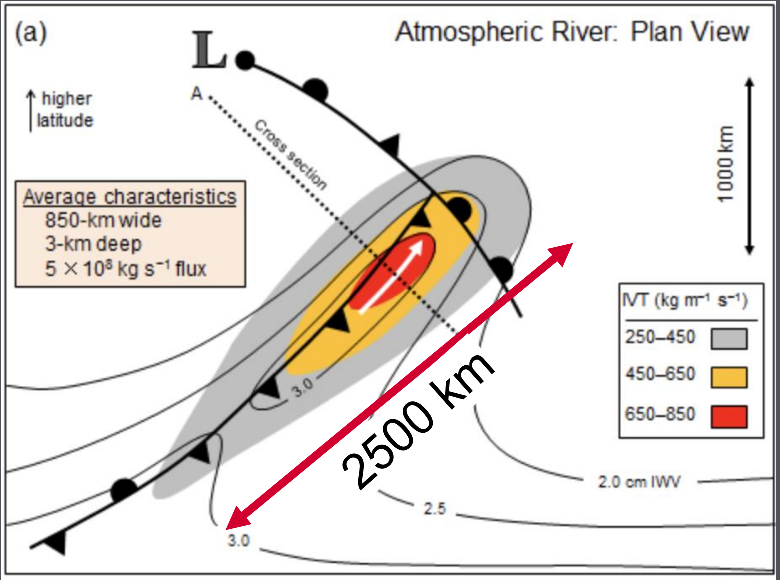
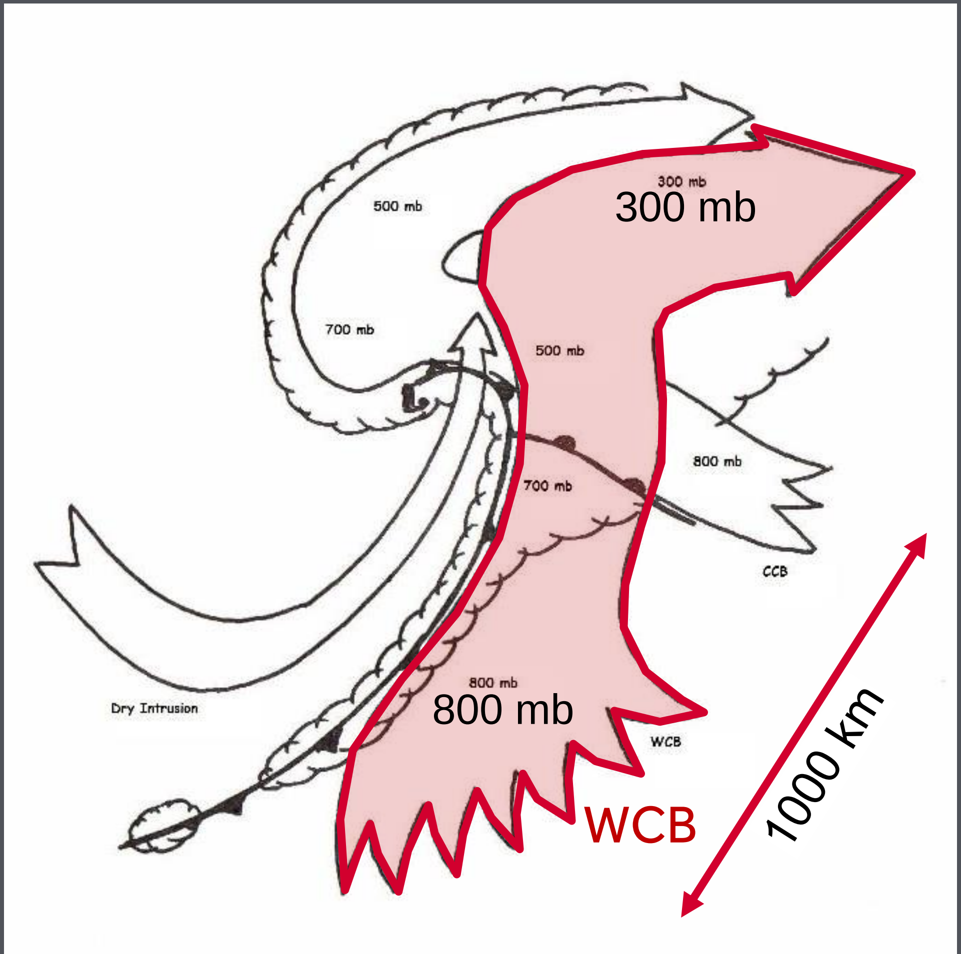


- 2D filaments of high TCWV flux extending from the subtropics - termed atmospheric-rivers (Newell et al. 1992)
- ARs structure (WMO):
  - shallow (3 km deep)
  - narrow (850 km wide)
  - elongated (> 2000 km in length)
  - water vapour flux (> 250 kg/m/s)



WHAT ARE WARM CONVEYOR BELTS?

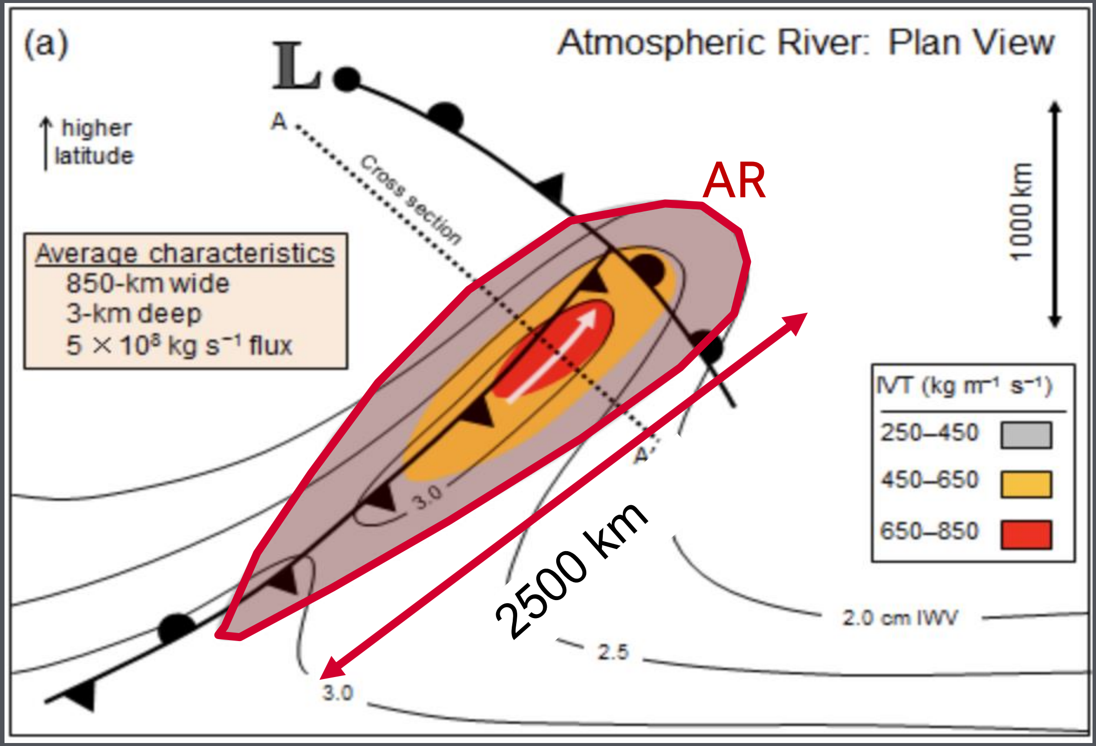
- Cyclone airstream analysed in a cyclone-relative framework
- Subtract vectorially cyclone propagation velocity from absolute wind velocity
- Cyclone-relative winds are represented on surfaces of constant θ or θ_w
- WCB is a cyclone-relative airstream on a warm θ_w surface ascending by ~ 600hPa from the top of boundary layer to upper-troposphere



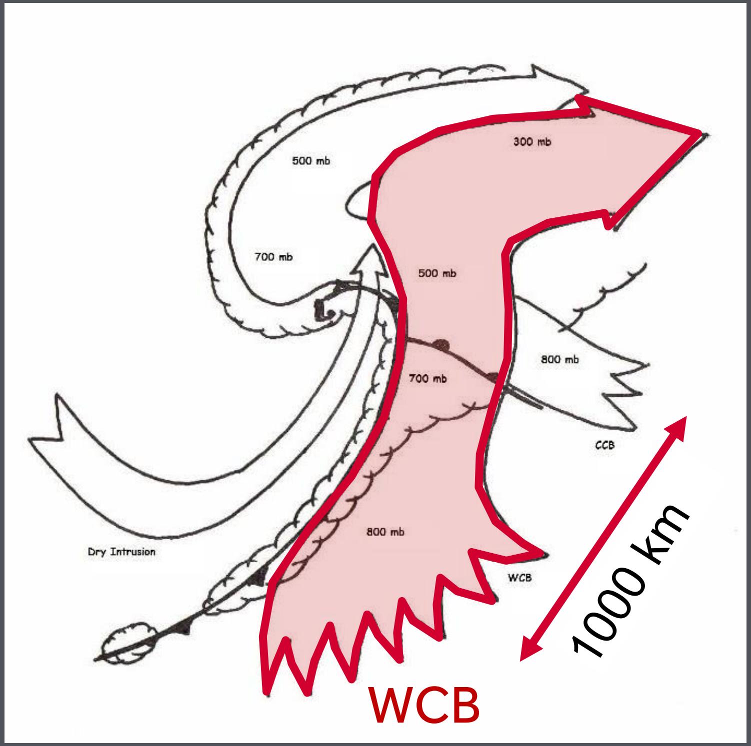
Adapted from Carlson (1980)

How are warm conveyor belts and atmospheric rivers linked?

Schematic of an atmospheric river airstream

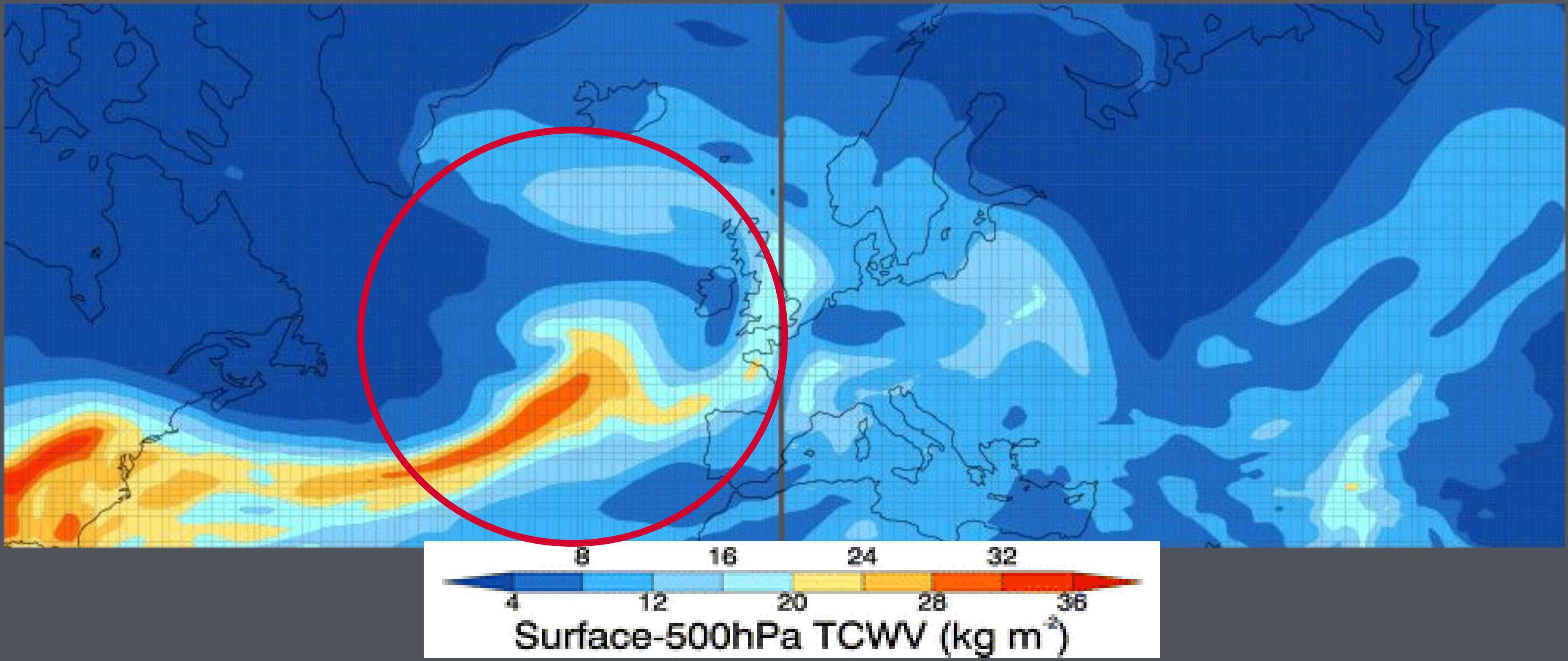


Schematic of a warm conveyor belt airstream



BAND OF HIGH TCWV EXTENDING FROM SUBTROPICS TO THE UK

ERA-Interim Total Column Water Vapour (TCWV)
18UTC 31 Jan 2002



HIGH TCWV FOUND AHEAD OF COLD FRONT IN THE WARM SECTOR

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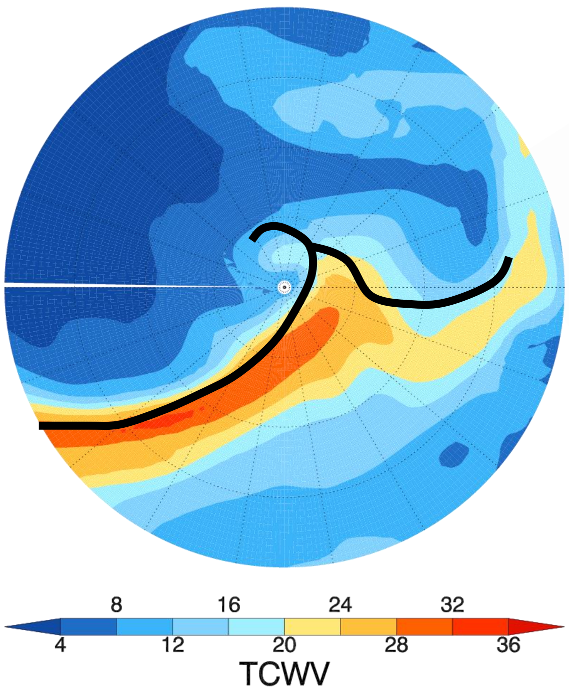
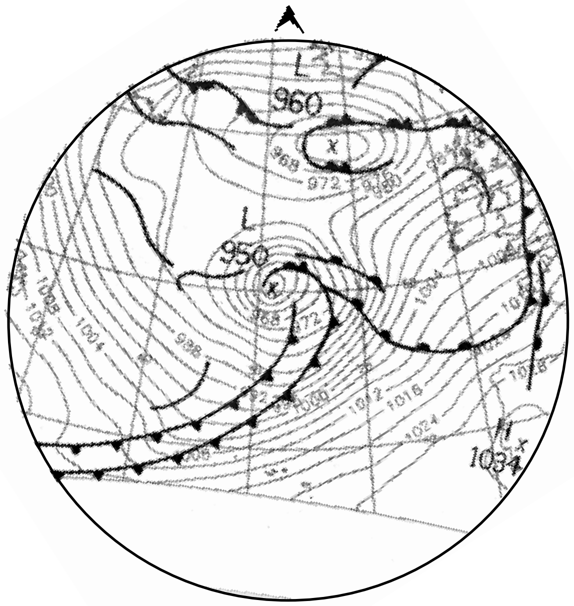
Total column water vapour



Synoptic analysis



IR satellite

CYCLONE AIRFLOW ON 285K θ SURFACE

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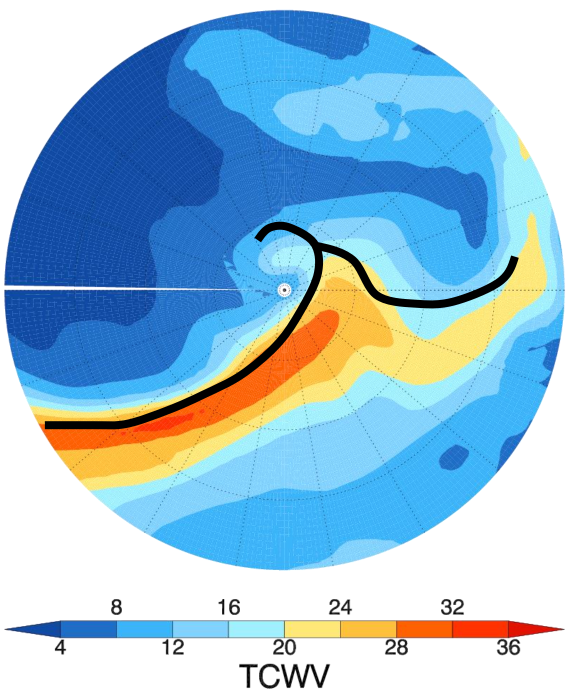
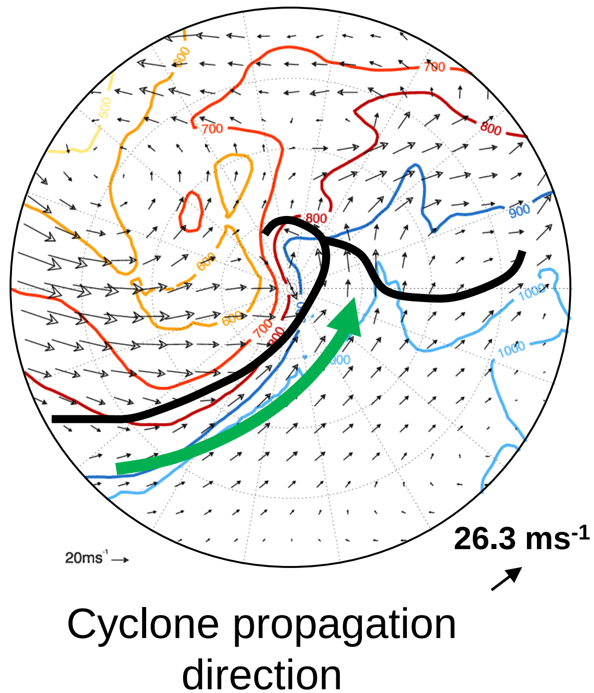
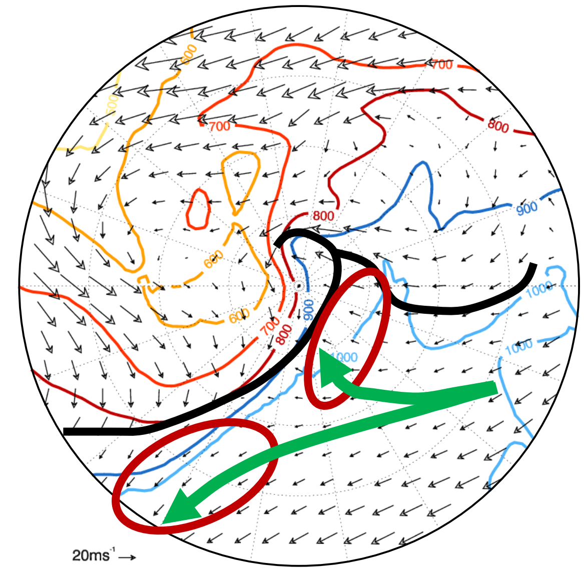
Total column water vapour



Earth-relative winds and pressure on 285K θ surface



Cyclone-relative winds and pressure on 285K θ surface



- Air is transported rearwards from the pre-cyclone environment towards the cold front
- The low-level cyclone-airflow splits into 2 branches at the cold front

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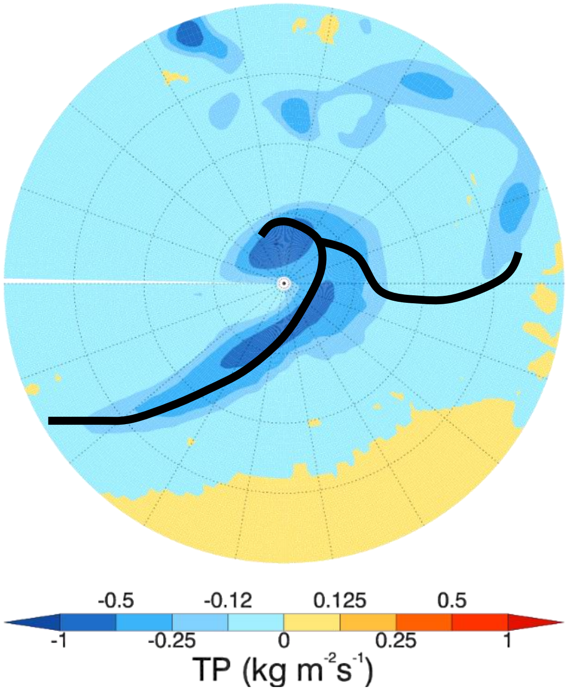
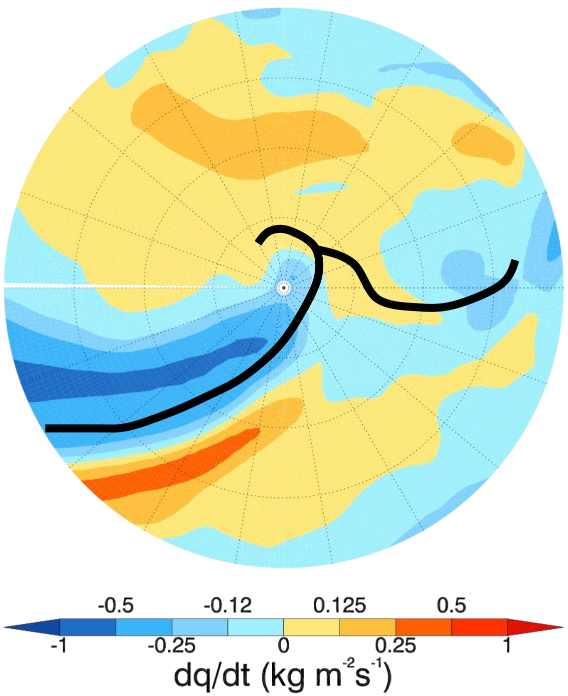
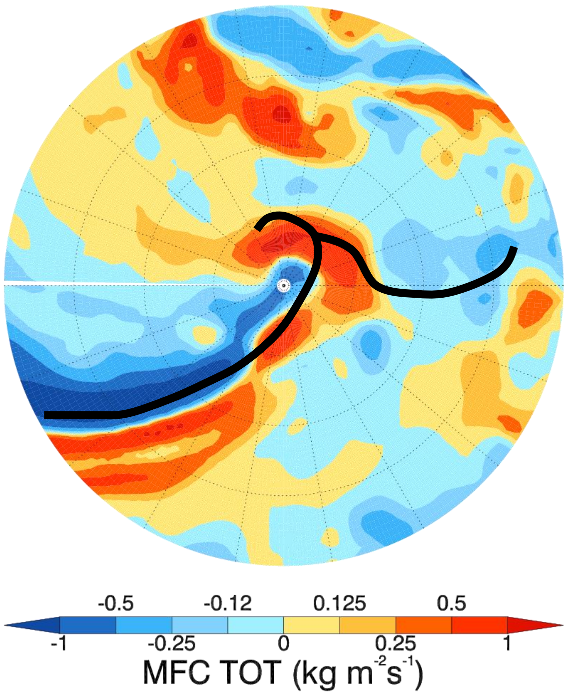
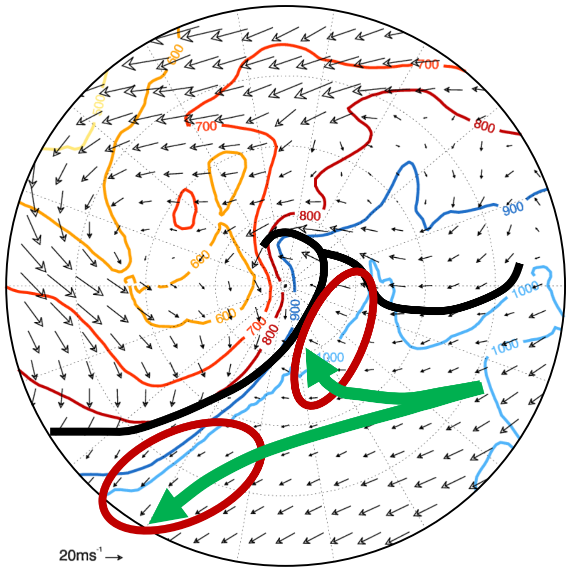




Moisture flux convergence

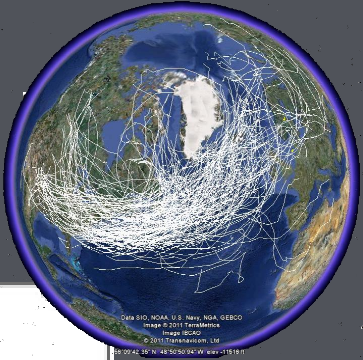


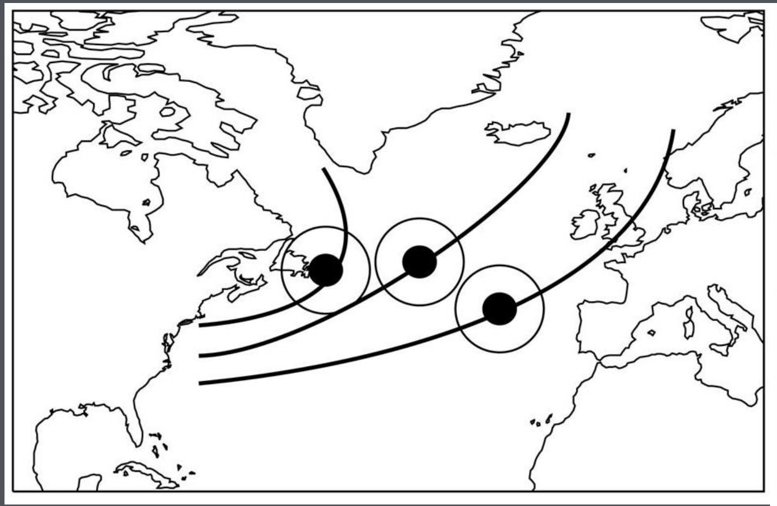
Cyclone-relative winds and pressure on 285K θ surface



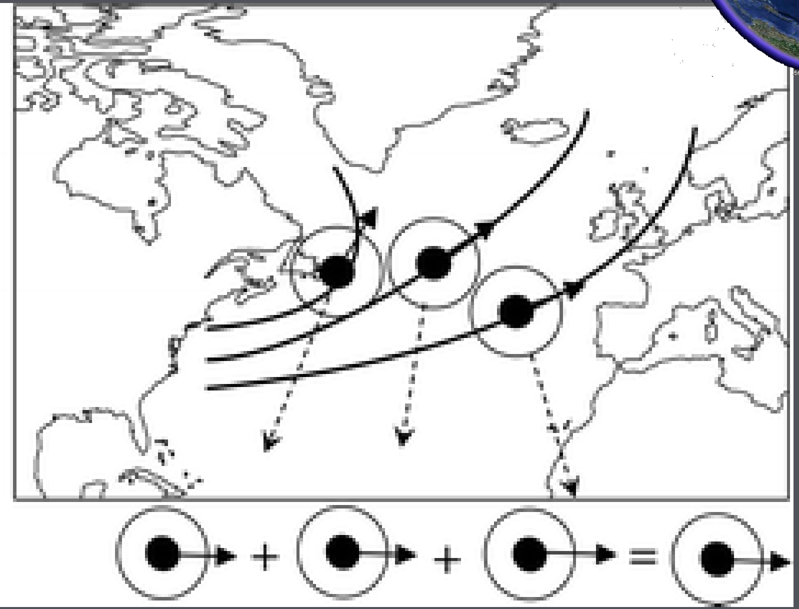
- The cold front sweeps up water vapour in the warm sector leading to moisture accumulation
- Moist air ahead of the cold front is exported from the cyclone leaving a footprint of high TCWV

CYCLONE COMPOSITING IS USED TO EXAMINE CYCLONE CHARACTERISTICS





Catto et al. (2010)



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

A BAND OF HIGH TCWV IS LOCATED AHEAD OF THE COLD FRONT

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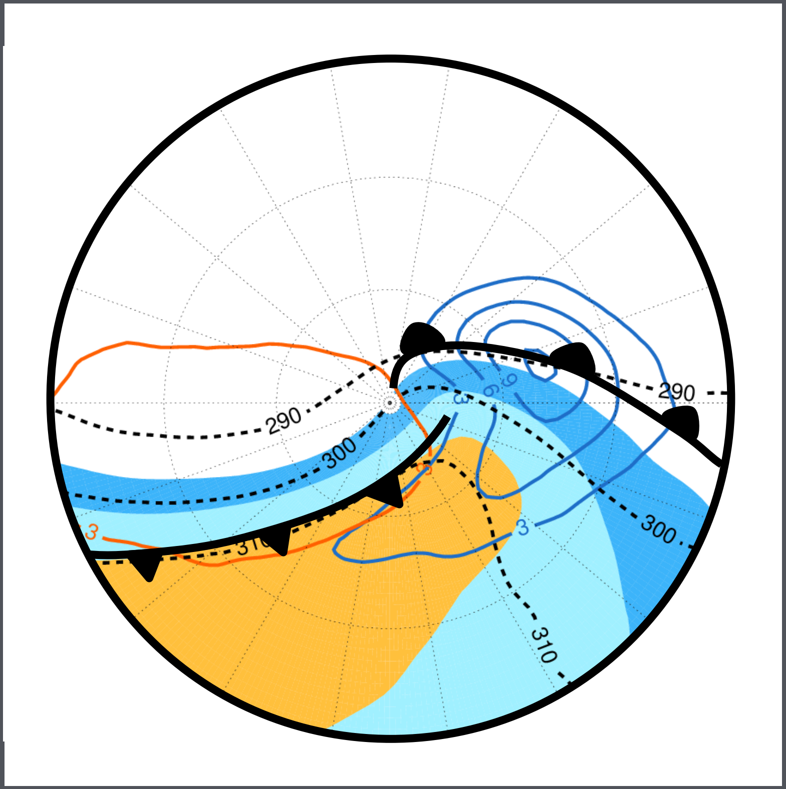
Composite cyclone-centred fields 24 hours prior to time of maximum intensity

3000km

Cyclone propagation



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

3D CYCLONE RELATIVE AIRFLOWS ARE IDENTIFIED ON ISENTROPIC SURFACES

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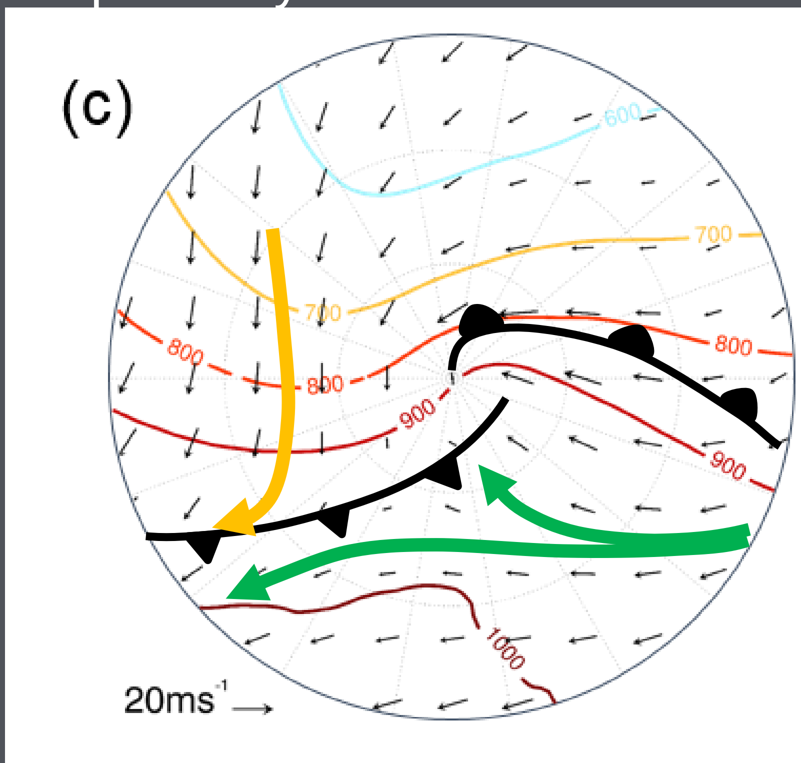
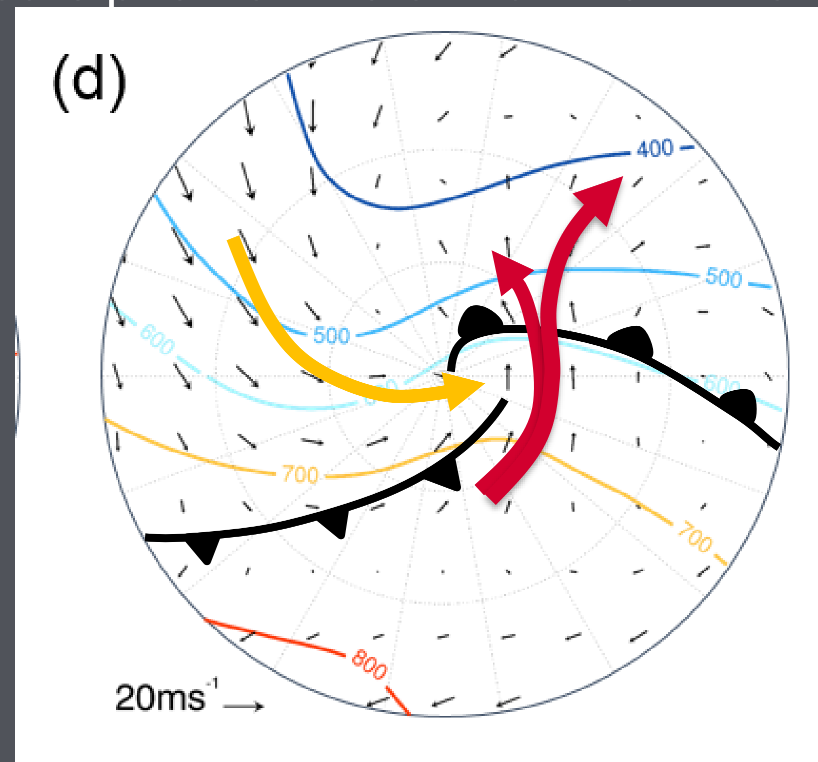
Composite cyclone-centred fields 24 hours prior to time of maximum intensity



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



Pressure in hPa (contours) and cyclone-relative winds on 300 K θ surface

THE FEEDER AIRSTREAM TRANSPORTS AIR TOWARDS THE COLD FRONT

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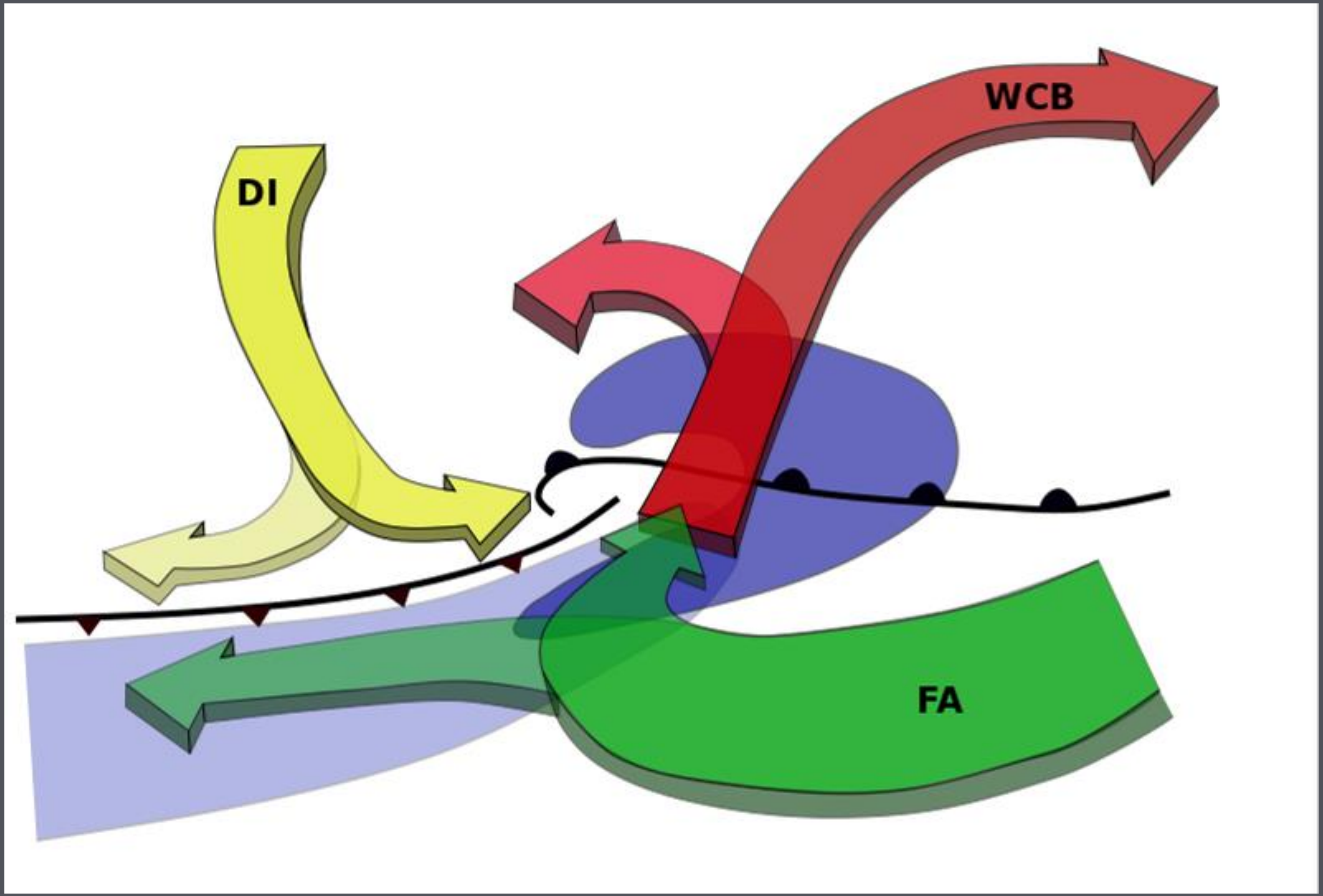
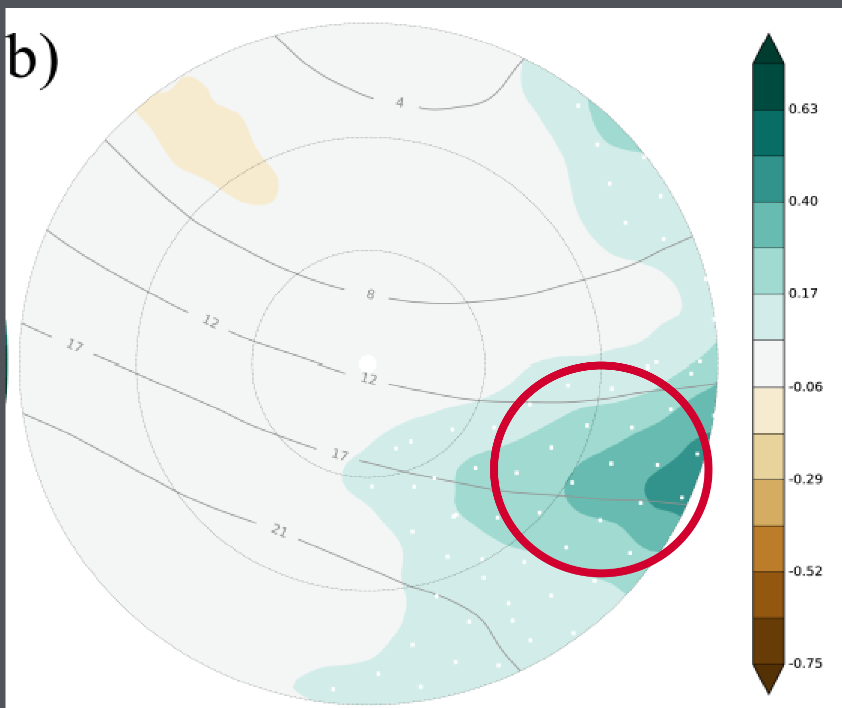
Schematic of cyclone-relative airflows overlaid on surface features



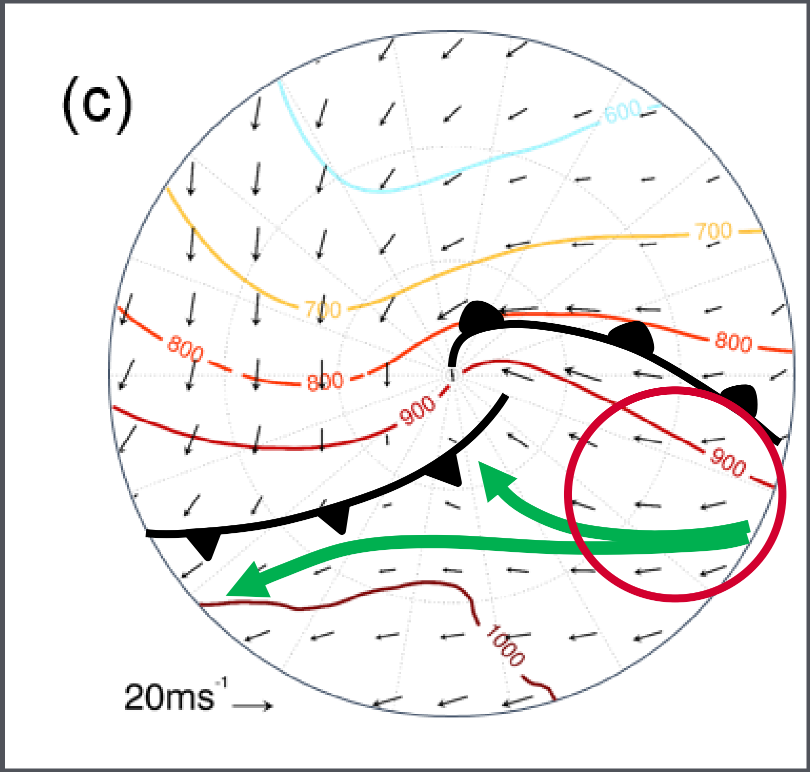
Precipitation (dark blue), high TCWV (light blue), Warm conveyor belt (red), Dry intrusion (yellow), Feeder airstream (green)

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



Pressure in hPa (contours) and cyclone-relative winds (vectors) on 285 K θ surface at T-24

CYCLONE IVT IS RELATED TO DOWNSTREAM TCWV 24HRS EARLIER

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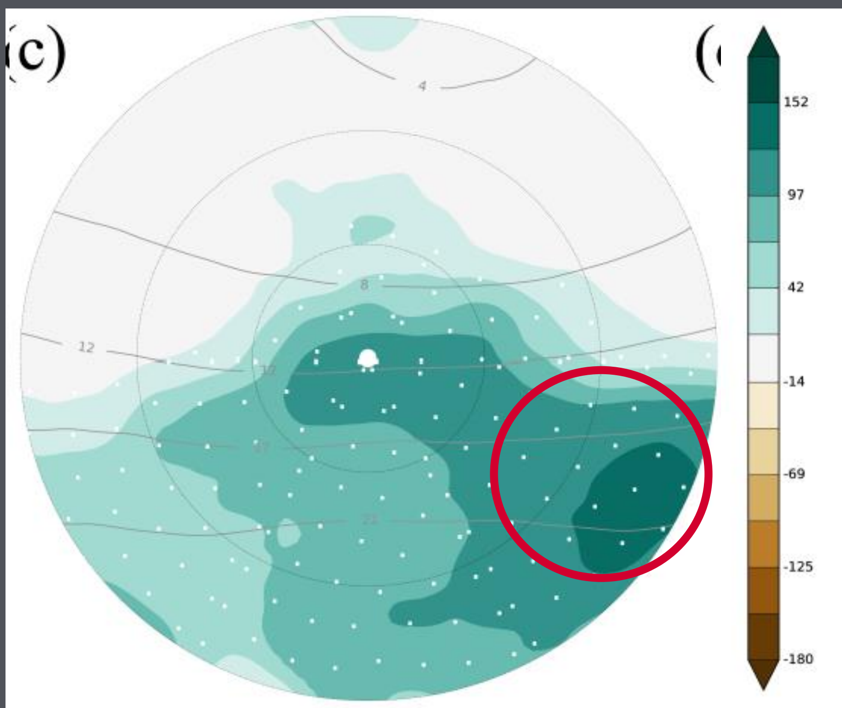
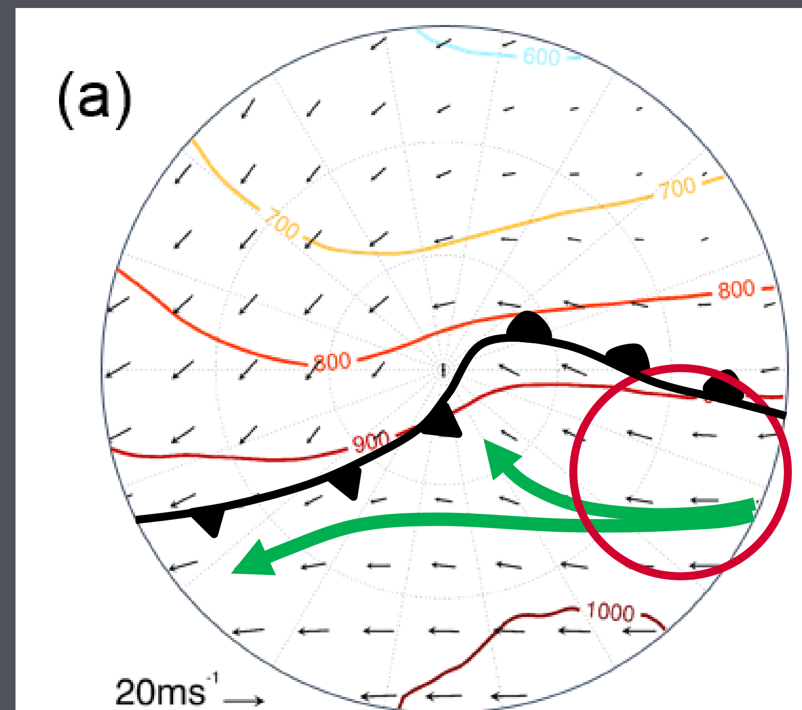
Lagged linear regression between integrated vapour transport (IVT) and TCWV 24 hours earlier



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

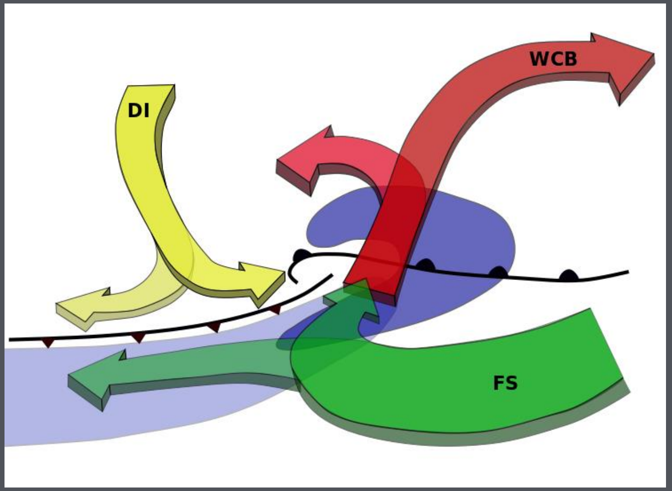


Pressure in hPa (contours) and cyclone-relative winds (vectors) on 285 K θ surface at T-48

SUMMARY

Q. How are atmospheric rivers formed?

- Cyclone sweeps up water vapour in the atmosphere causing a band of high TCWV to form ahead of the cold front



Q. How is moisture re-distributed by cyclone airflows at low-levels?

- Feeder airstream transports moisture to the base of the WCB from the pre-cyclone environment where it then ascends
- Feeder airstream exports moisture from the cyclone creating a long filament of high TCWV marking the track of the cyclone

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