# A Dynamical Systems Characterisation of Atmospheric Jet Regimes

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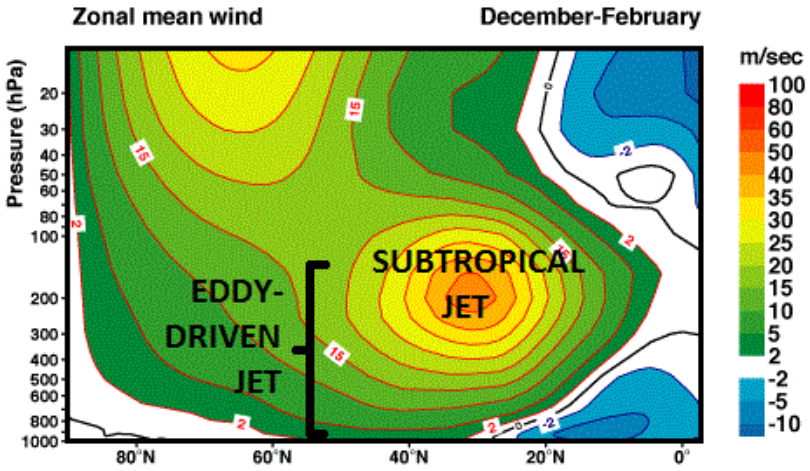
# Background

**Atmospheric jet streams** can be primarily:

- Eddy-driven/polar-front jets.
- Thermally-driven/subtropical jets.
- Merged jets, where the above mechanisms are co-located.

These result in very different jet locations and characteristics.

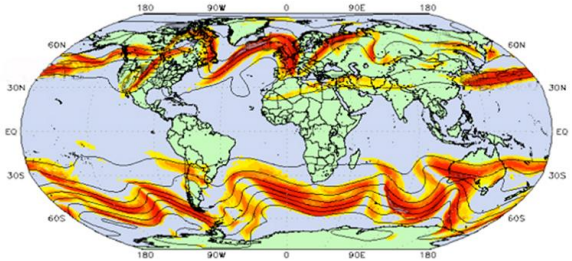



Zonal-mean wind, showing the eddy-driven and subtropical jets. Adapted from a figure by L. Novak.

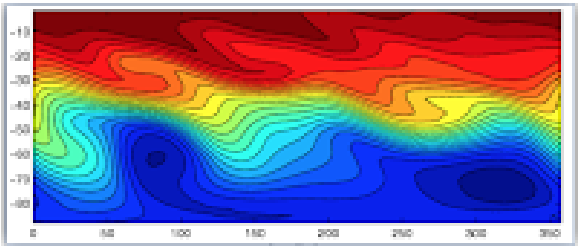
# Scientific Question

## How can we distinguish between these jets?

Relating the perfect «eddy-driven», «thermally-driven» and «merged» jets seen in idealised atmospheric models to «reality» (e.g. reanalysis data) is a challenge.




Observed upper-level jets. Source: NetWeather



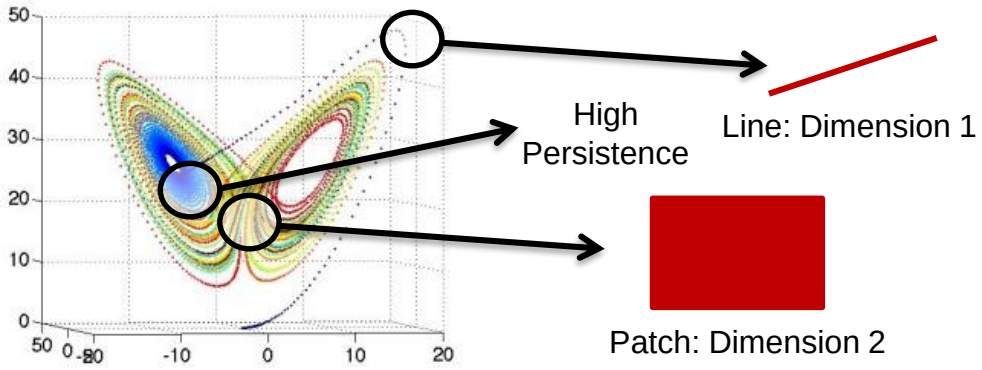
Eddy-driven jet in an idealised model. Source: O. Lachmy

We propose **a unitary analysis framework** to diagnose jet characteristics, which may be applied to both idealised model and reanalysis data, and allow for direct intercomparison.

# A Unitary Analysis Framework

We use **two indicators** from dynamical systems theory, which describe instantaneous jet states:

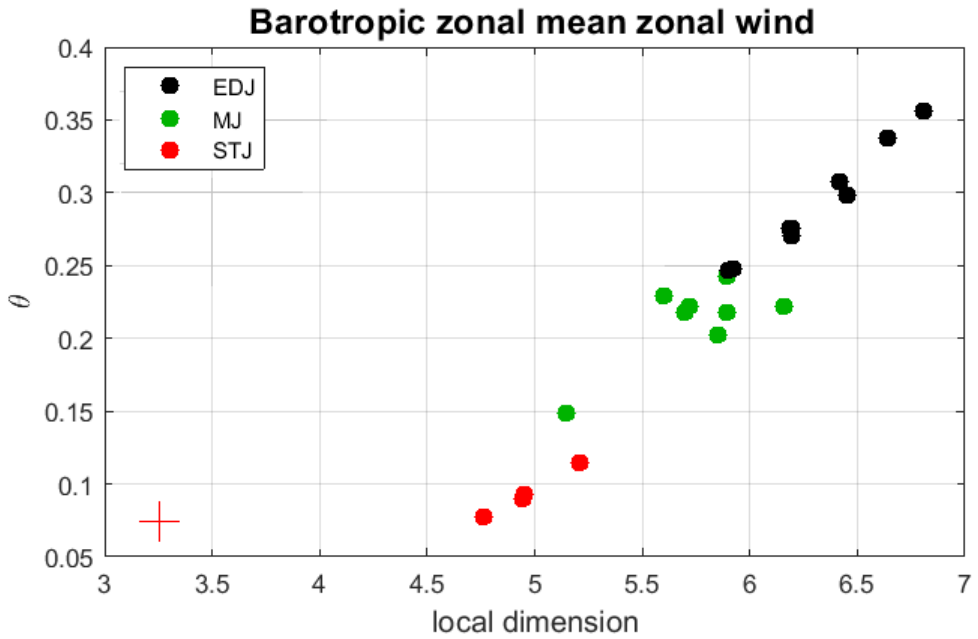
- **Local Dimension (d):** A proxy for the number of active degrees of freedom, which can be related to atmospheric predictability.
- **Persistence ($\theta^{-1}$):** Measures the persistence of jet states.




Examples of the dynamical systems metrics applied to the Lorenz Butterfly.

# A Unitary Analysis Framework

The three jet regimes from an idealised model are **well-separated in d–θ space.**




EDJ: Eddy-driven jet; MJ: Merged jet; STJ: Subtropical jet

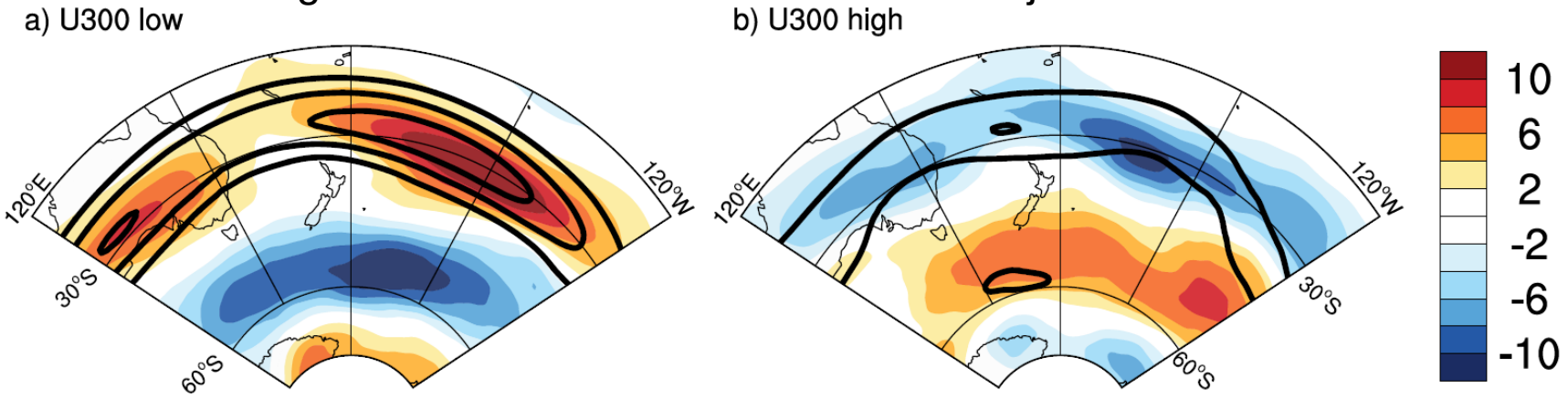
Adapted from Messori *et al.*, *Earth Sys. Dyn.*, in review

# A Unitary Analysis Framework

The same holds for **reanalysis data:**

Subtropical or Merged Jet

Polar Front (South) and Subtropical (North) jets




Zonal wind composites for (a) days with low values of d and θ; and (b) high values of d and θ. Colours: anomalies; contours: absolute values.

Adapted from Messori *et al.*, *Earth Sys. Dyn.*, in review

# Conclusions

Two dynamical systems metrics, **local dimension and persistence,** reflect the degree of nonlinearity of the jet dynamics, and thus provide an effective way of distinguishing between different jet regimes in both idealised models and reanalysis data.

For more information and methodological details see our paper in review for Earth System Dynamics:

A Dynamical Systems Characterisation of Atmospheric Jet Regimes