2012-05-10

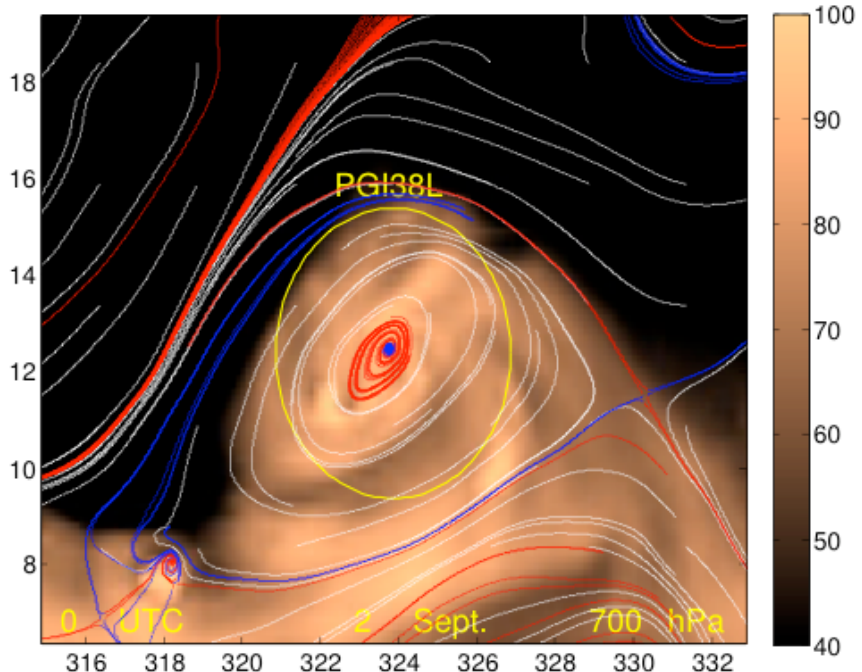
Lagrangian boundaries in non-developing and developing disturbances

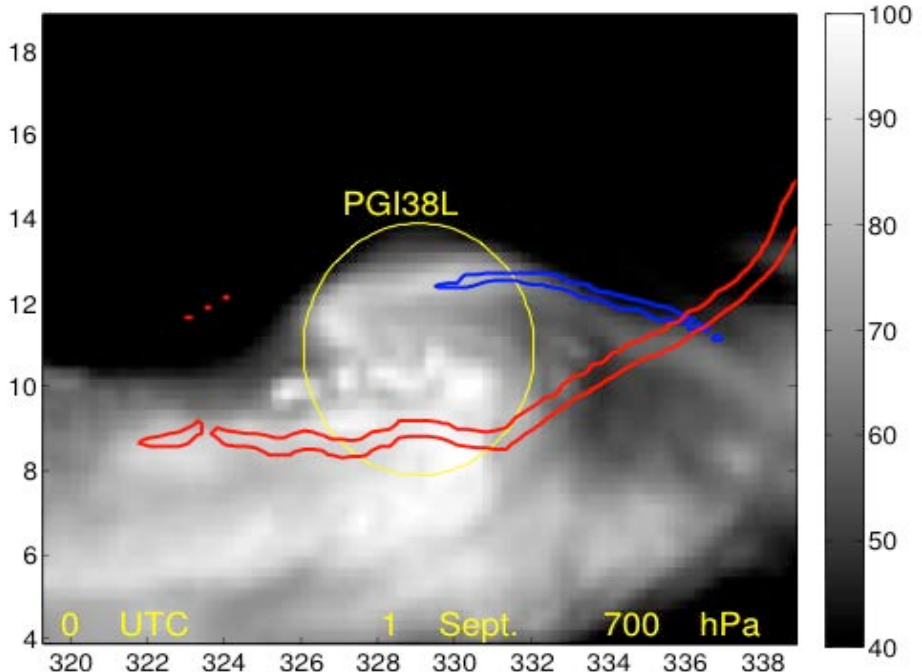
Rutherford, Blake; Montgomery, Michael

Monterey, California: Naval Postgraduate School

Lagrangian boundaries in non-developing and developing disturbances

Blake Rutherford and Michael Montgomery
Naval Postgraduate School, Monterey, CA





Boundaries in time-dependent flows

In a steady flow, flow boundaries are the streamlines emanating from a hyperbolic fixed point.

Boundaries in time-dependent flows are determined by the existence of a hyperbolic trajectory, which is the time-dependent analog of a hyperbolic fixed point.

A hyperbolic trajectory may be inferred from a hyperbolic stagnation point when the stagnation points

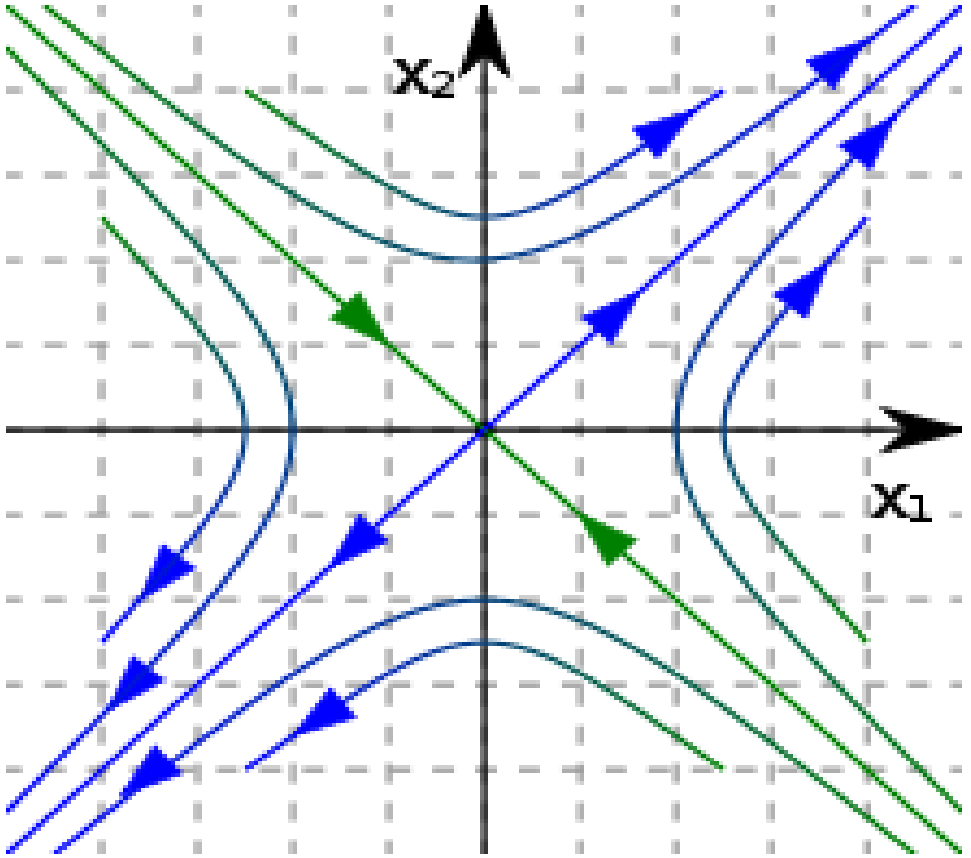
1. Are persistent through time
2. Remain hyperbolic
3. Have small translation relative to the Lagrangian speed.

A hyperbolic trajectory has local manifold segments.

The time-evolution of the local manifold segments produces the time-dependent manifolds.

The stable manifold is repelling while the unstable manifold is attracting to trajectories.

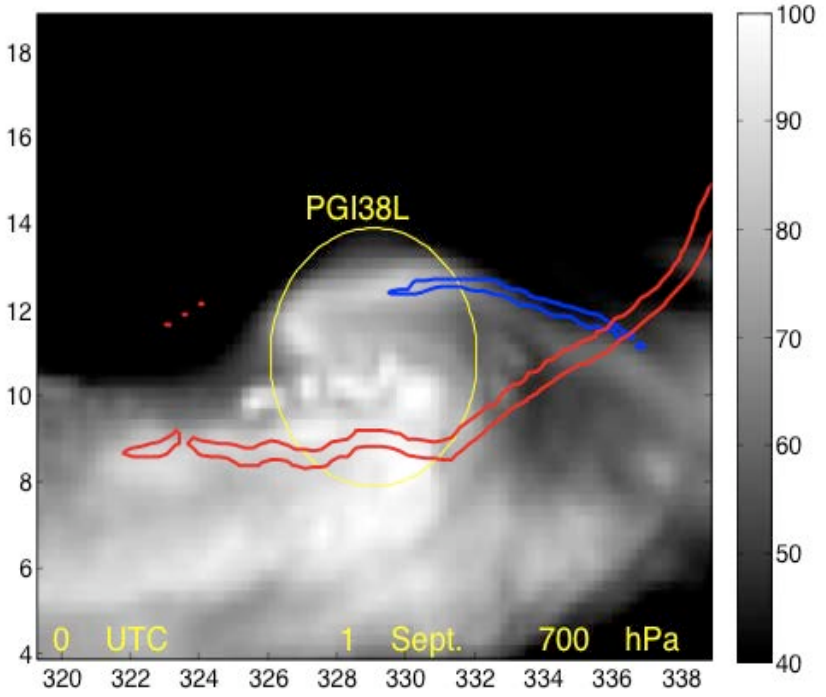
Ide et al. (2002), Malhotra and Wiggins (1998), Haller (2000)

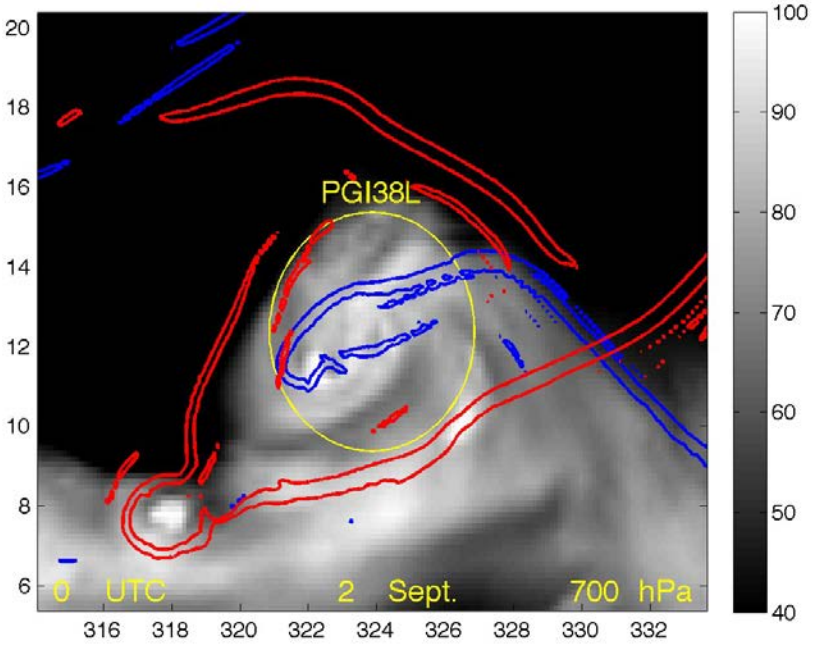


Local flow geometry around a hyperbolic fixed point

Lagrangian boundaries for Gaston on Sept. 1 and 2 at 700 hPa

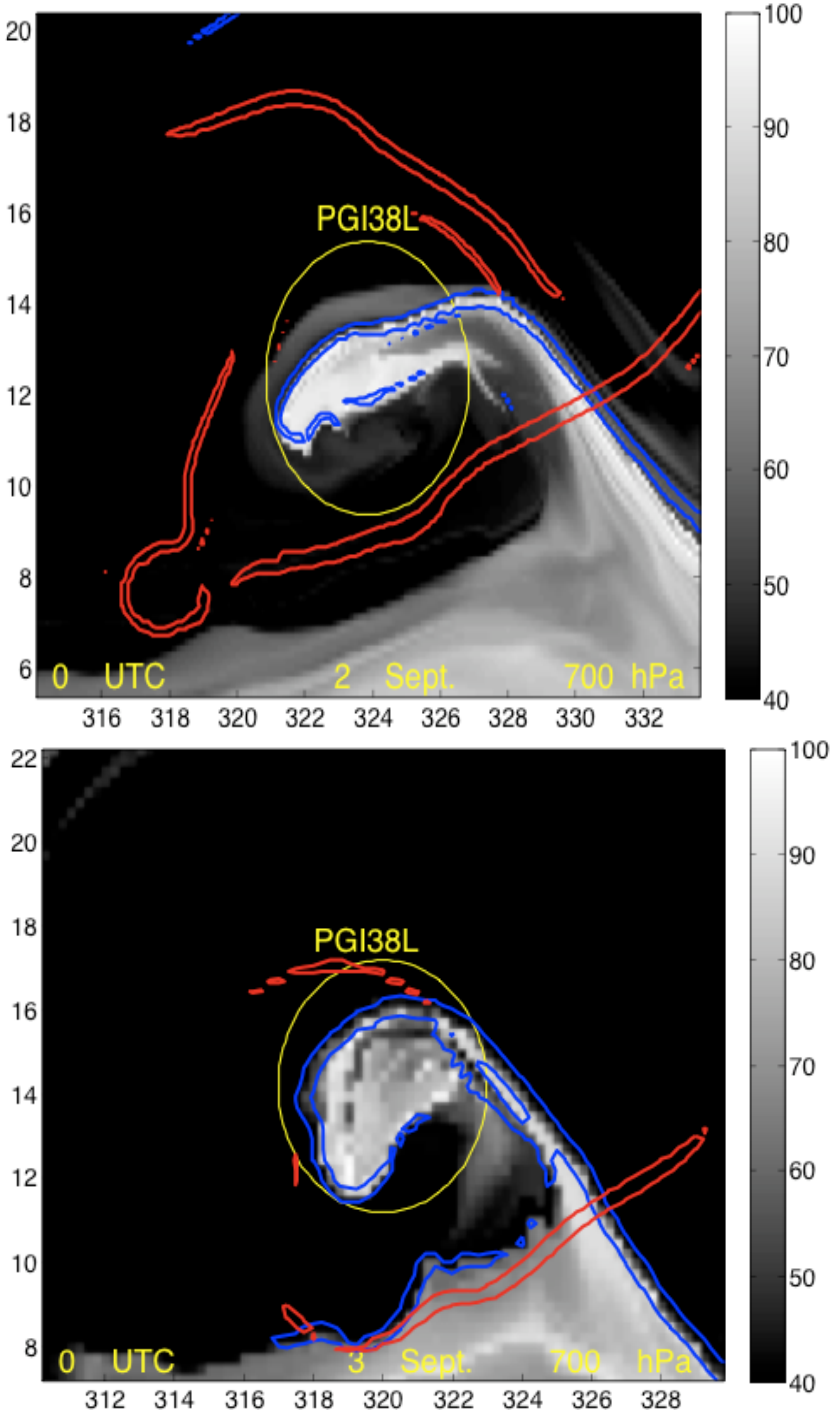
- The Eastern hyperbolic fixed point is present for a six day period, and is associated with a Lagrangian hyperbolic trajectory.
- The stable and unstable manifolds do not intersect.
- The Western stagnation point is not associated with a hyperbolic trajectory and manifolds.
- Particles have an open pathway to enter the center of the circulation.



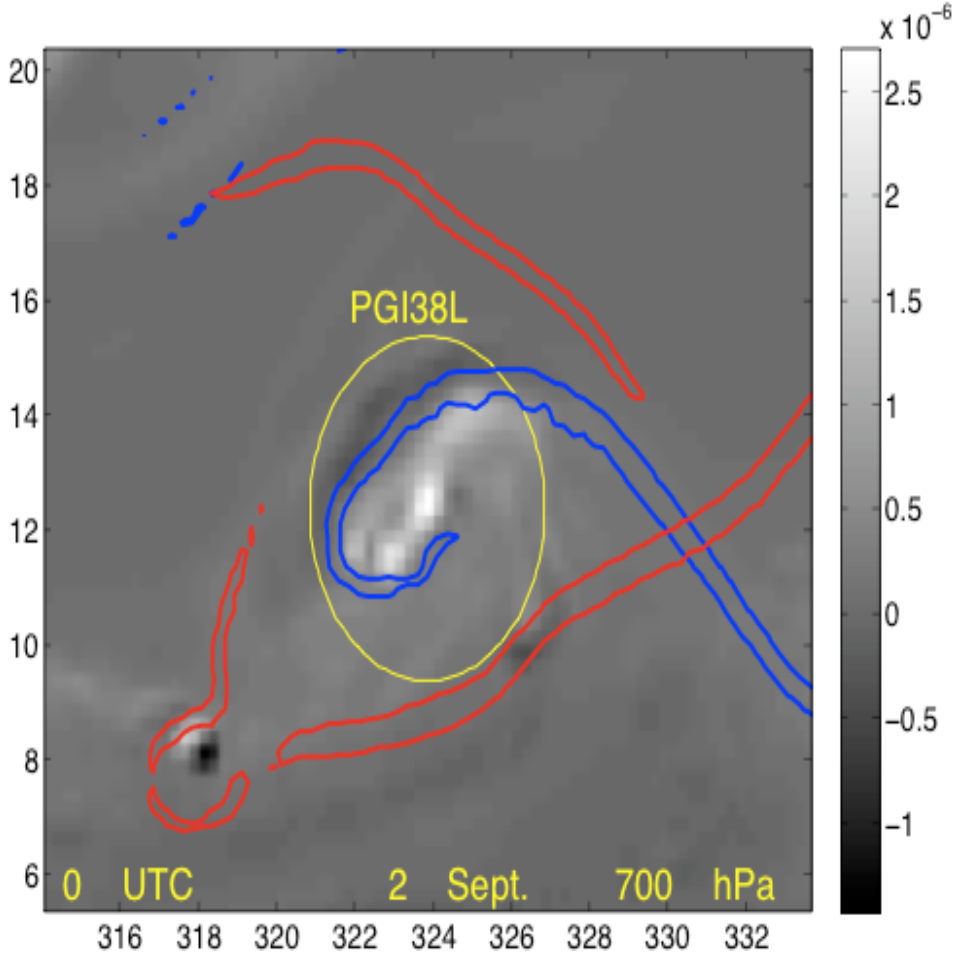


Tracer field (relative humidity) and manifolds on Sept. 2-3

- Moisture is attracted to the unstable manifold (blue)
- Dry air is entrained into the circulation center through an open pathway.
- The stable manifold (red) blocks transport of moisture from the South
- A similar profile is present above 700 hPa while the environment remains favorable below 700 hPa.



- The interior of the manifolds also mark the focal point of vorticity aggregation.
- Air parcels are attracted to the unstable manifold (blue).



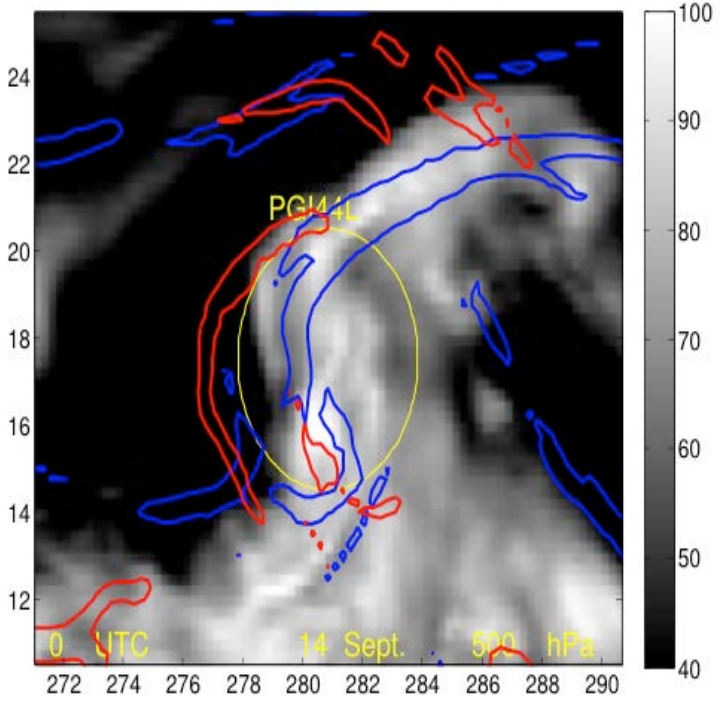
Manifolds overlaid on potential vorticity

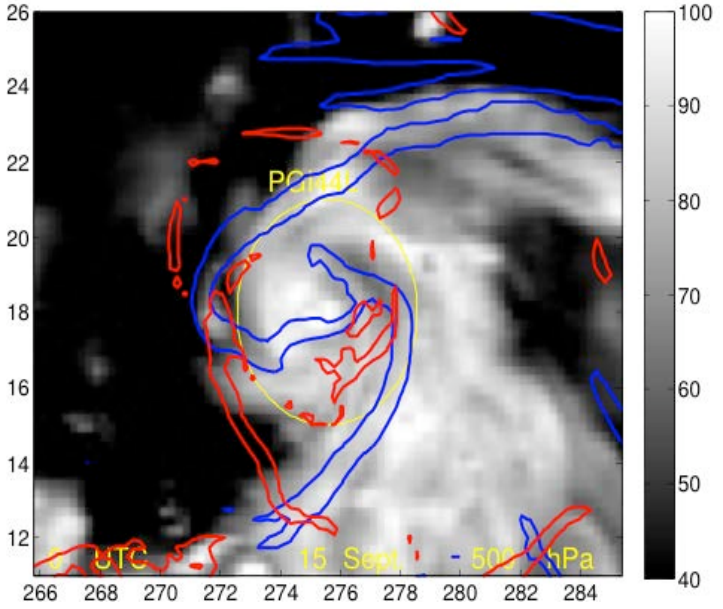
Lagrangian boundaries for Karl on Sept. 14-15 at 500 hPa

A more complete boundary is formed between the pouch and dry air to the North and West.

Entrainment of dry air into the pouch occurs through lobe transport after Karl had developed.

The Lagrangian boundaries showed vertical alignment from 500 hPa to the sea-surface.





Conclusions

- Lagrangian boundaries better reflect particle transport in time-dependent flows.
- These products will be available this summer as part of the pouch products.
- These methods can be extended to 3D flows.