Automatic Segmentation of Geophysical Trackline Data Applied to Pacific-Rivera Motion

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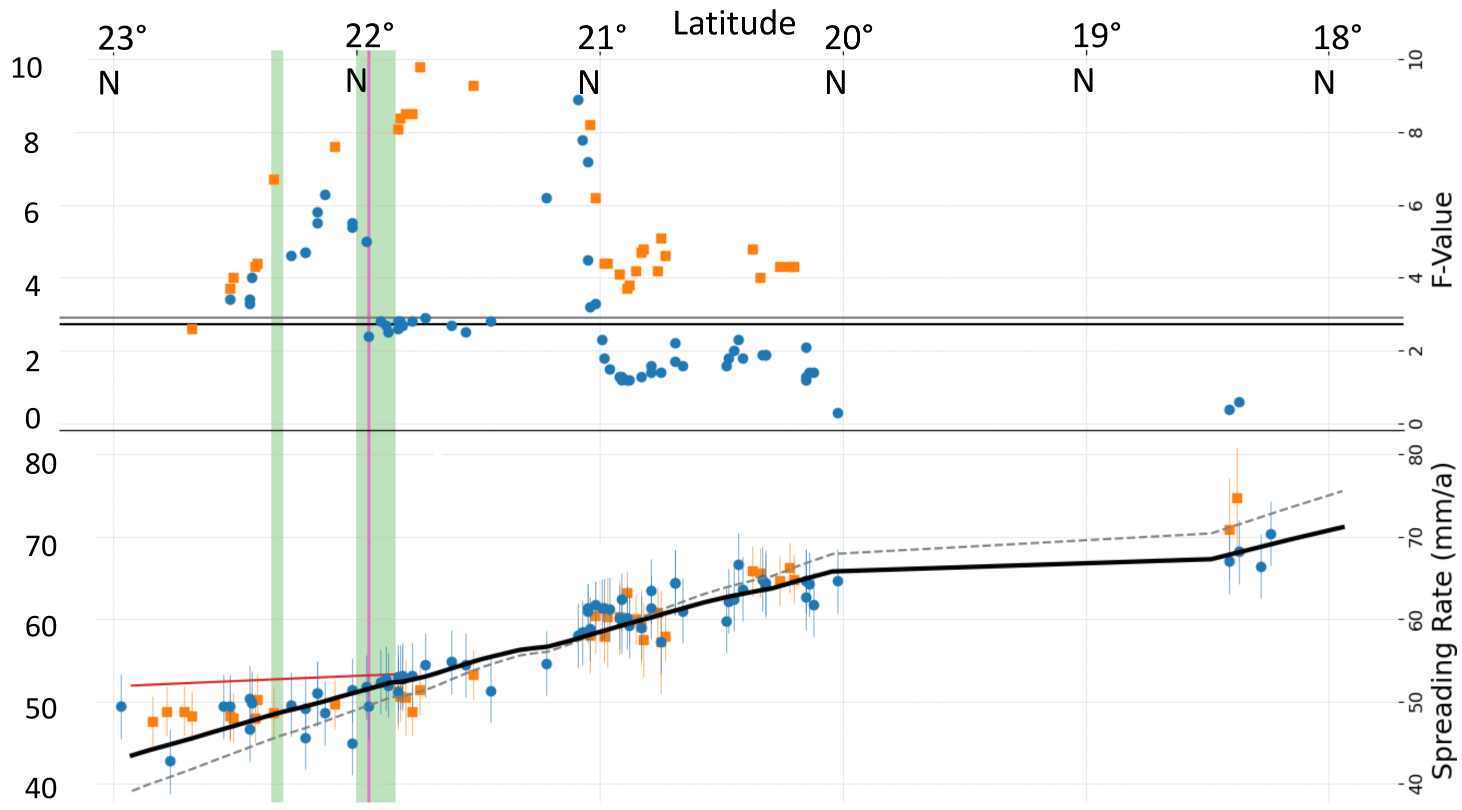
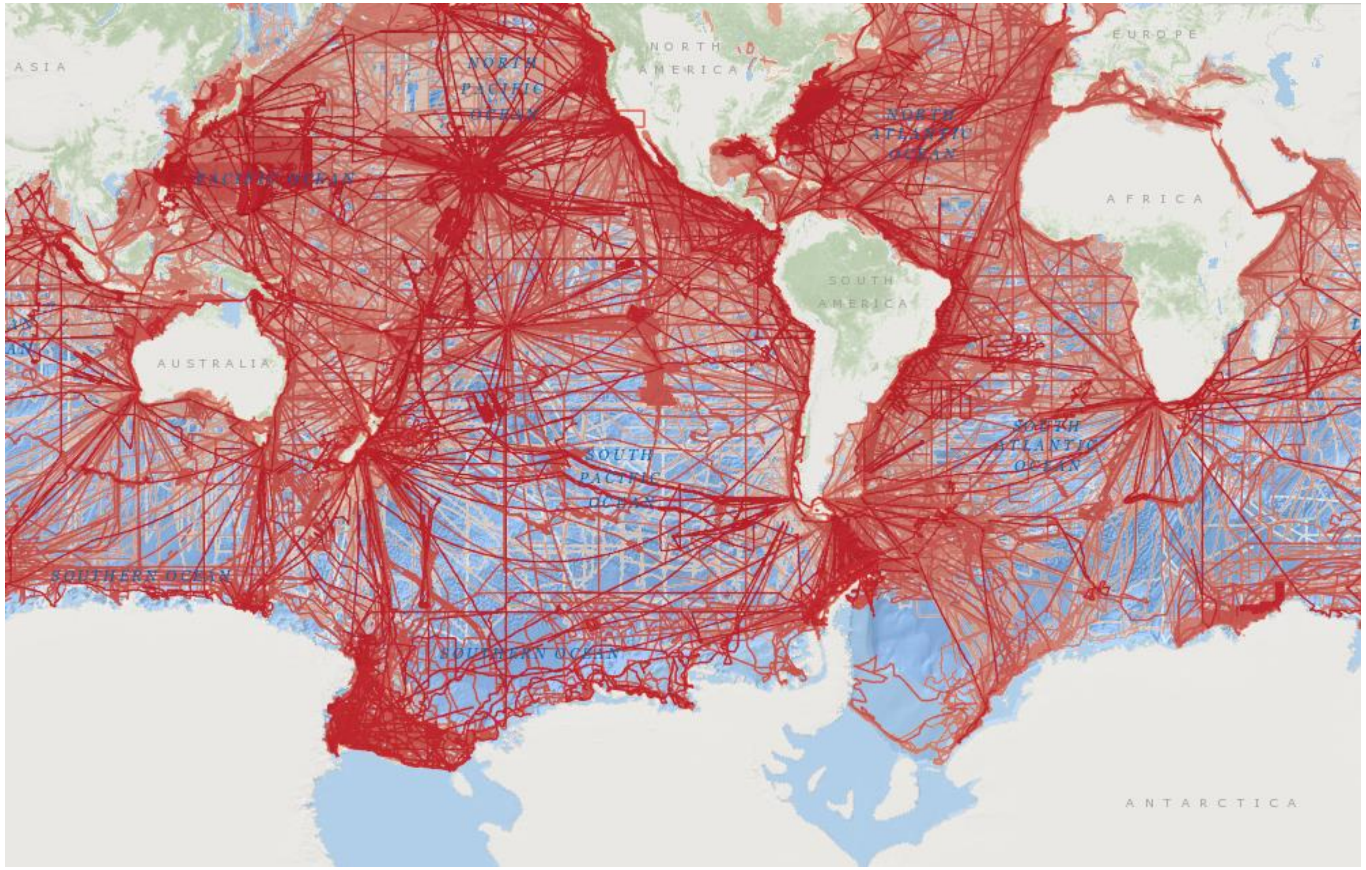


Trackline Data

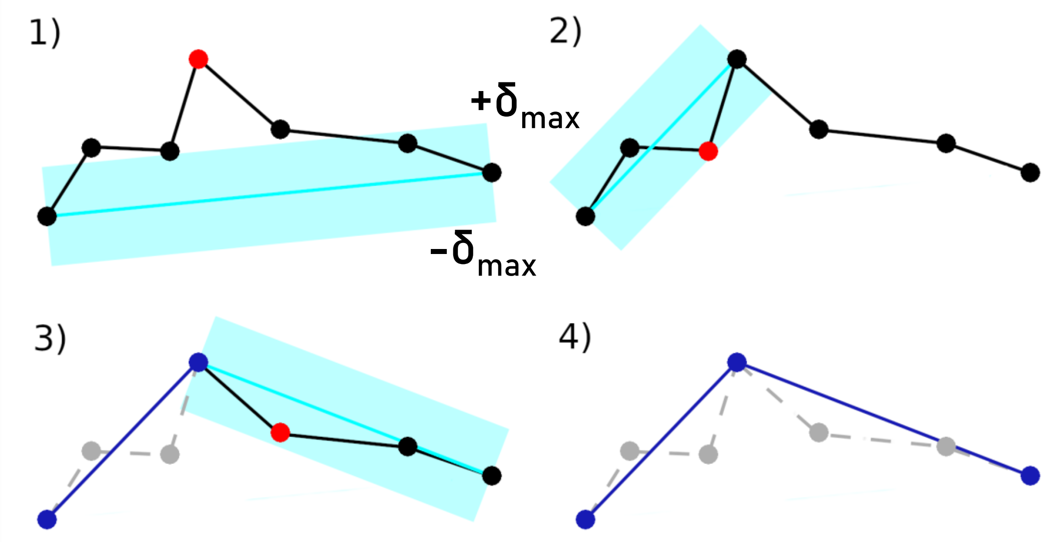
- Geophysical trackline data is widely available and used extensively
  - Skewness analysis of marine magnetic anomalies
  - Tectonic reconstructions
  - Crust and mantle structure



- Processing methods for trackline data are applicable across fields

Ramer-Douglas-Peucker Algorithm

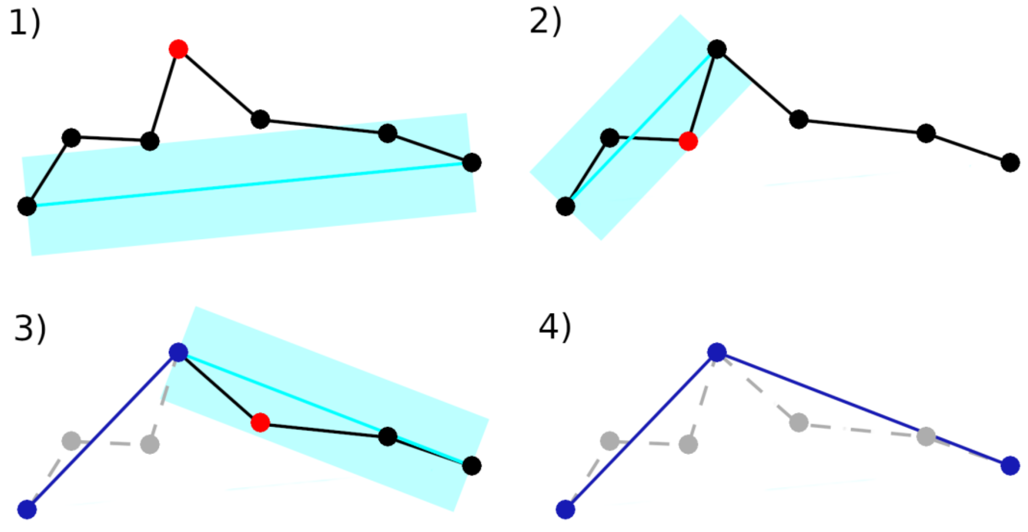
- ➢ Decimates curves to identify approximately straight segments.
- ➢ The furthest point beyond a distance threshold Δ_{max} from the chord connecting the first and last points of a segment defines a new segment endpoint.
- ➢ The same process is applied iteratively to all segments until now points lie beyond δ_{max} from the chord connecting the first and last points of any segment



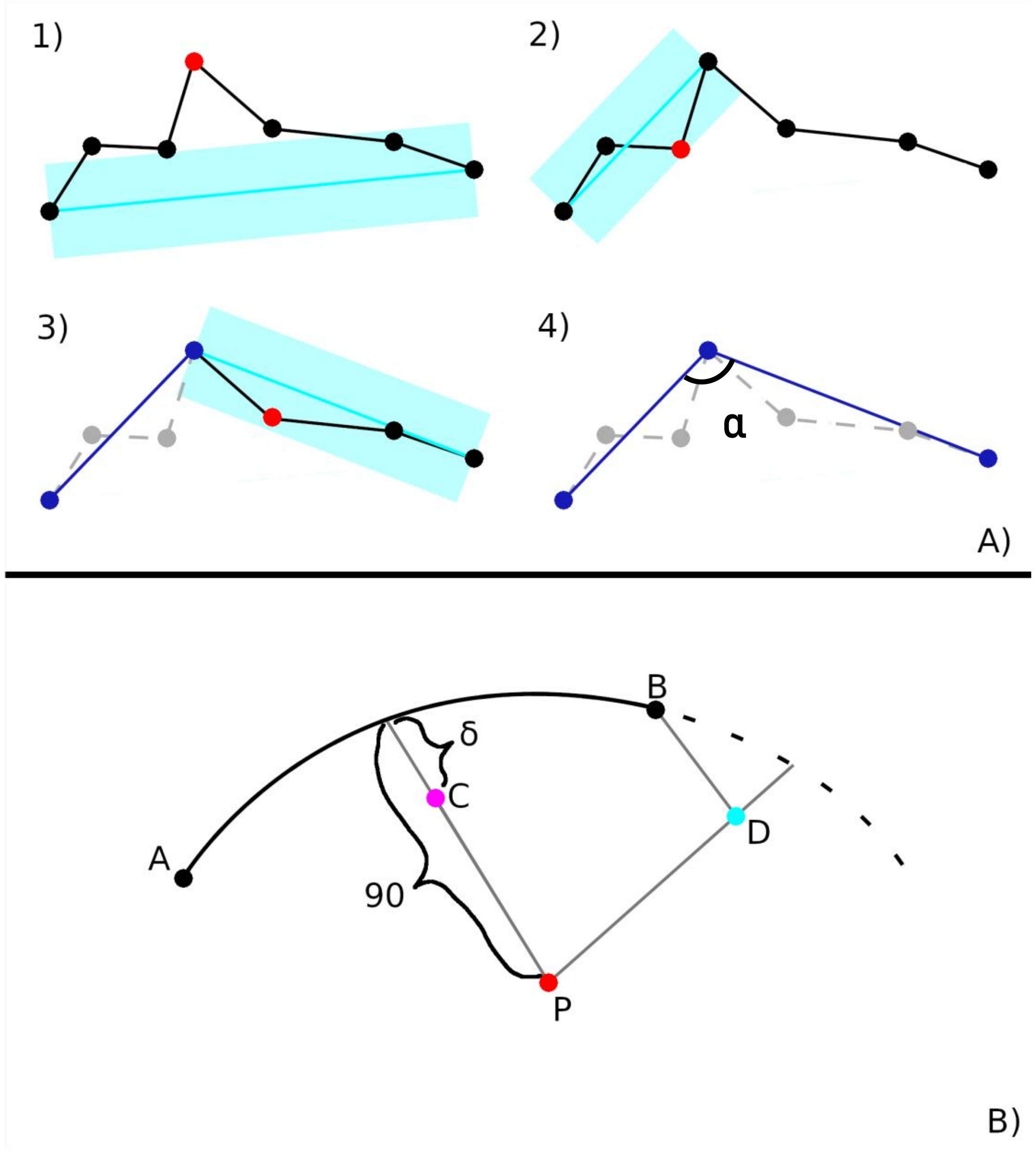
Ramer-Douglas-Peucker Algorithm

- Widely used in vector graphics and map generalization.

- Limitations for geophysical use:
  - Predominantly optimized for data compression.
  - Conventionally adapted to constant-bearing projections, without full spherical adaption.



RDP Spherical Adaptation



- Adapted for spherical coordinates and optimized for segmentation

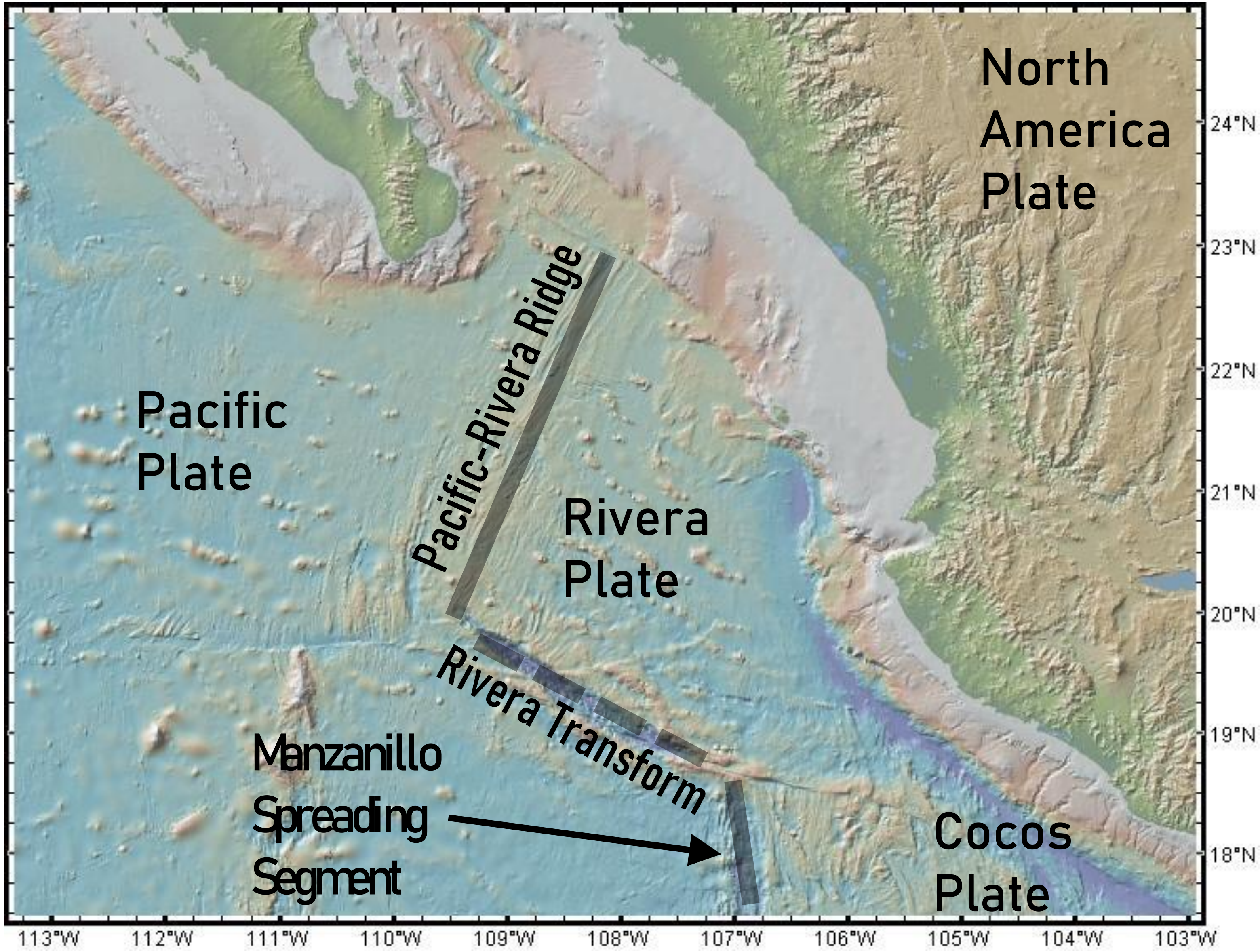
- Cartesian distance is replaced by spherical distance
  $\delta = 90 - gc\_dis(\lambda_C, \phi_C, \lambda_C, \phi_P)$

  - Where:
    λ_C is the latitude of the point in question,
    ϕ_C is the longitude of the point in question,
    λ_P is the latitude of the pole to the great circle connecting the endpoints,
    ϕ_P is the longitude of the pole to the great circle connecting the endpoints.

- Reduced track cut if segment heading differs by more than a threshold angle α_{min}

Application to Pacific-Rivera Spreading Rates

- Spreading rates along the Pacific-Rivera boundary make an ideal test case for the method
- Current Pacific-Rivera spreading rates have been estimated using by multiple studies (e.g. Lonsdale, 1995; DeMets & Wilson, 1997; DeMets et al. 2010)
- Magnetic tracklines are densely packed due to nearby ports



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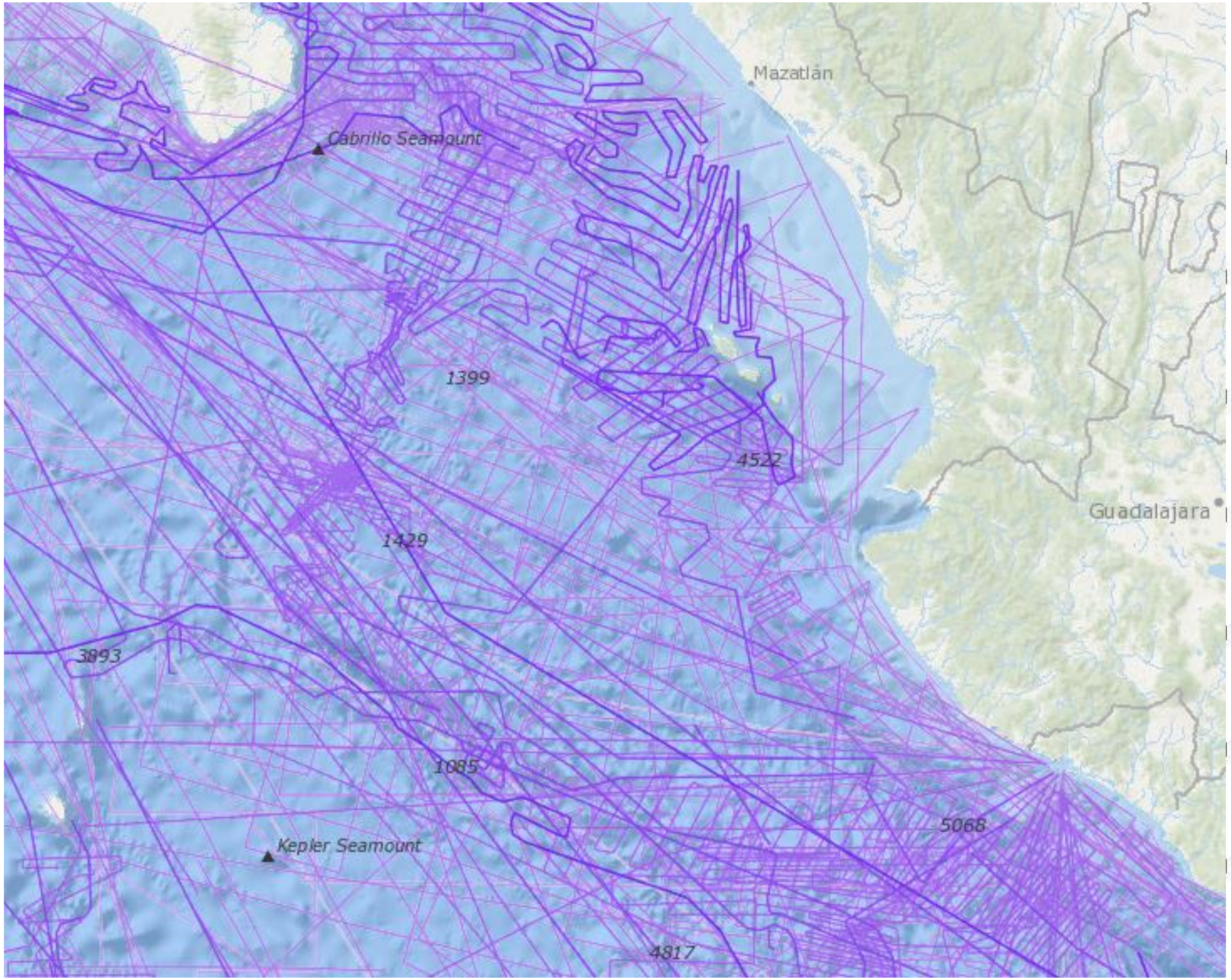
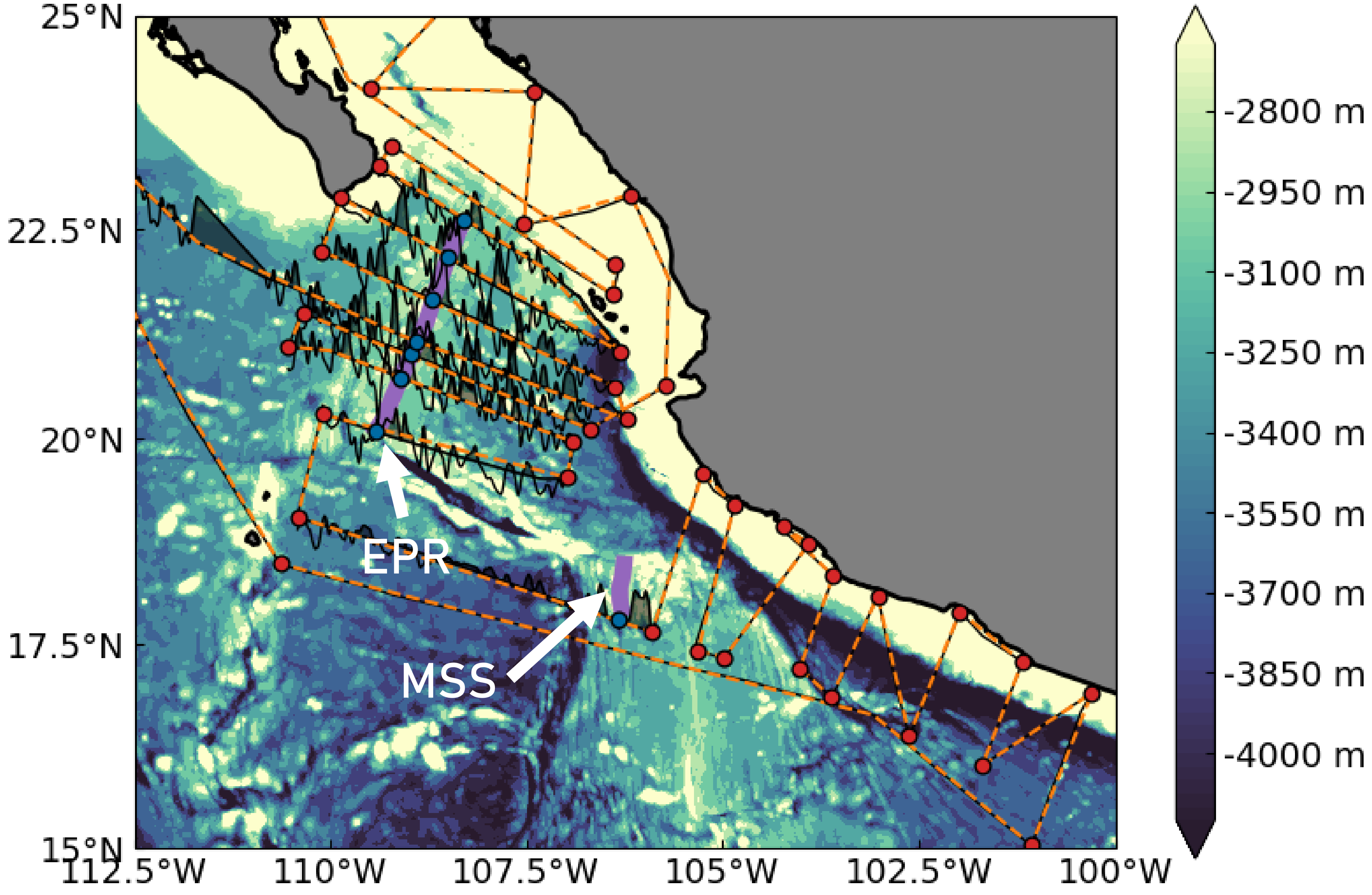
- Magnetic tracklines are densely packed due to ridge and nearby ports



Method

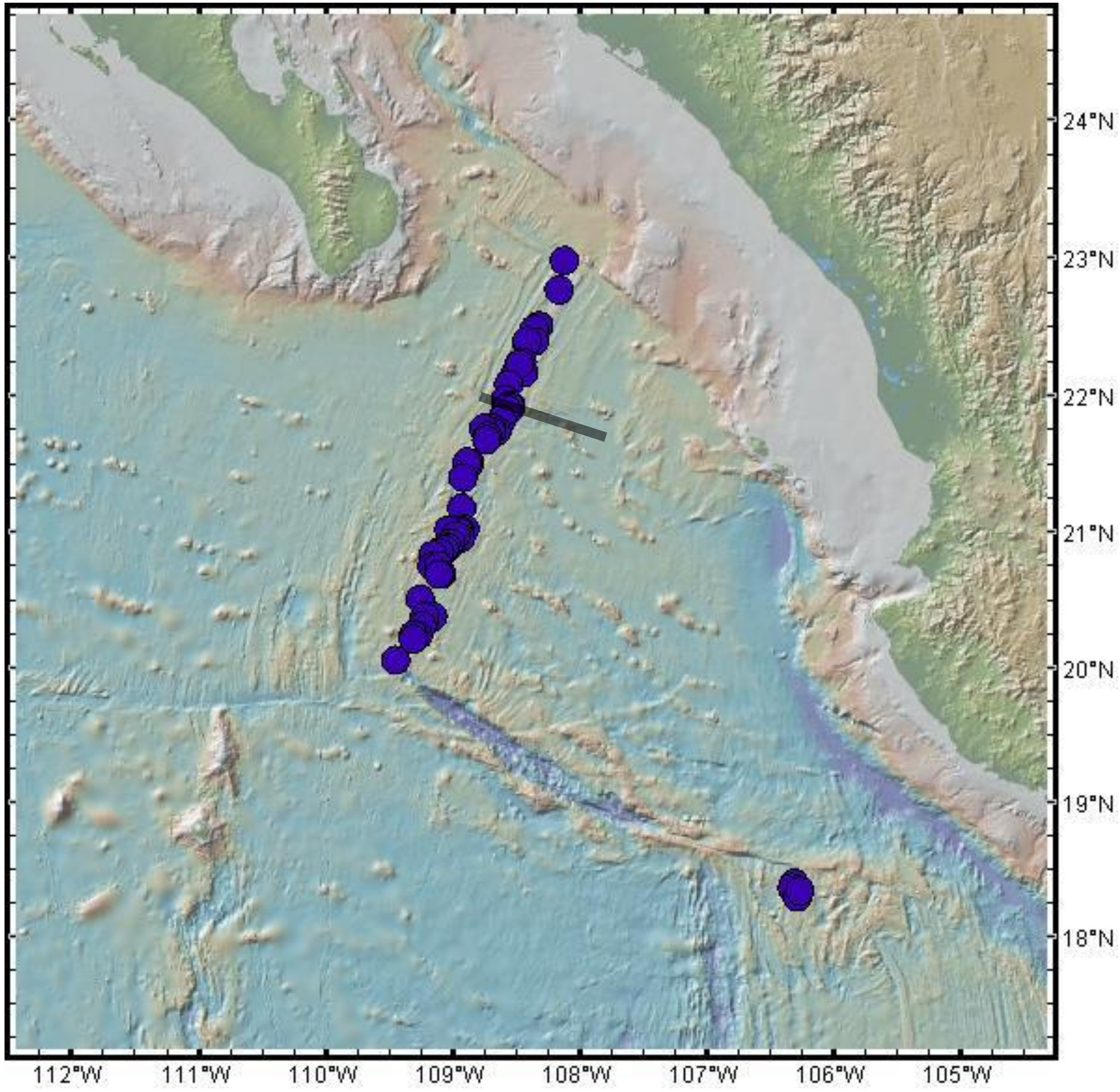
- Tracklines in the area of interest are selected from the NOAA NCEI geophysical trackline database.
- Tracklines are compared to digitized C1n isochron to check for crossings
- All tracklines with at least one crossing are processed using spherical RDP algorithm to identify ~straight segments.
- Each segment is checked for C1n crossings

Segmentation Example



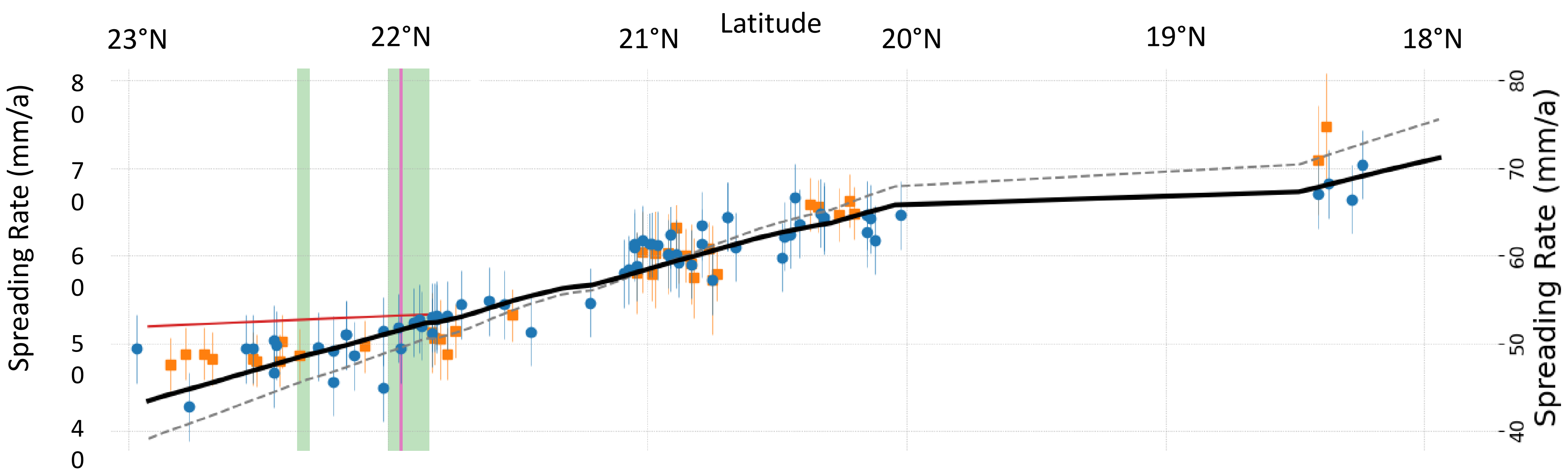
- MARSUR78
  δ_{max}=0.1°
  α_{min}=30°
- Algorithm identifies >30 segments in the area of interest
- Eight crossings identified in the region of interest
- Entire process complete in ~minutes

PA-RI Data



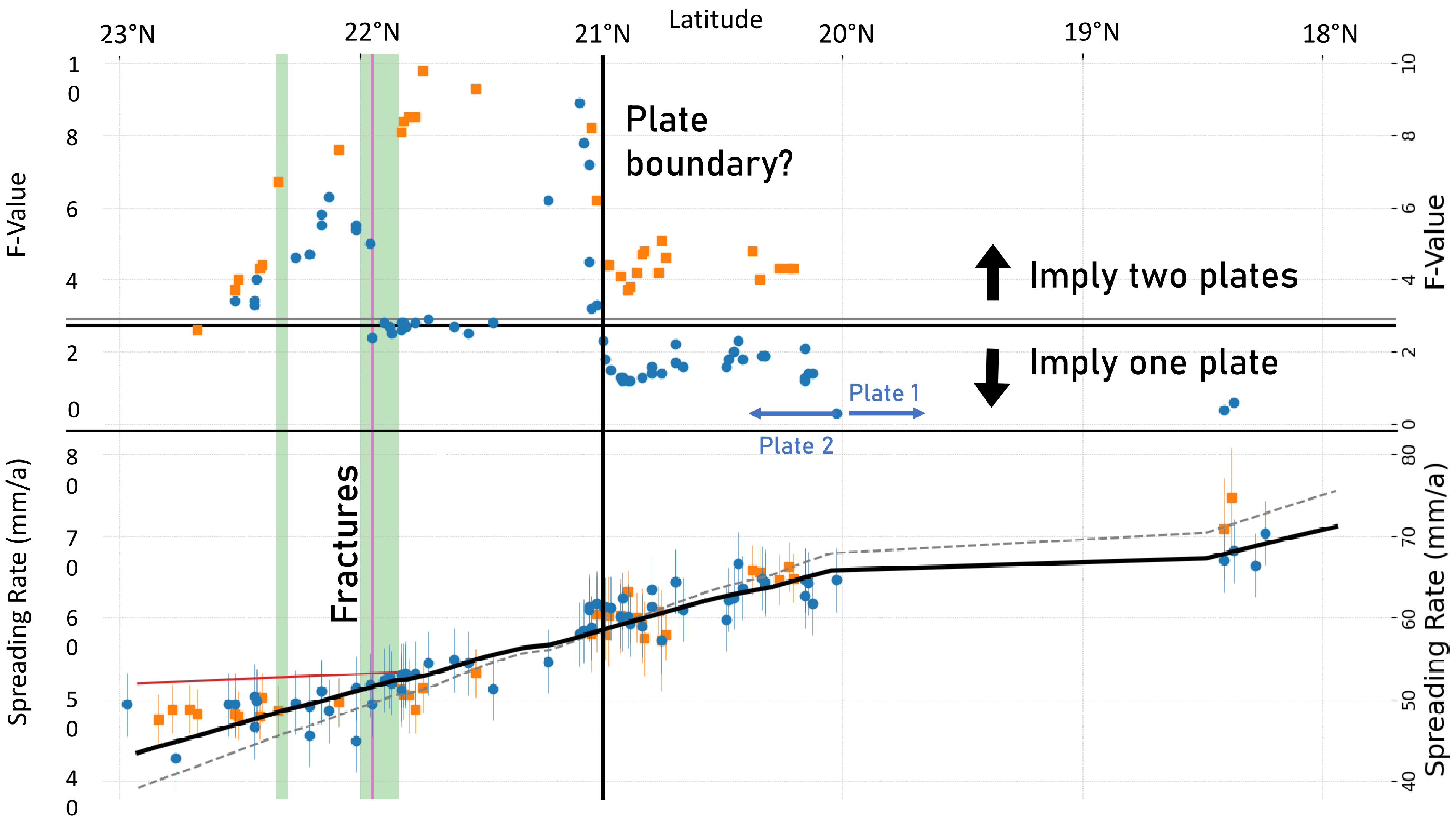
- We identify 465 interesting segments.
- After removing crossings potentially biased by topography, track characteristics, or incomplete data, we used 70 spreading rates in our analysis.
- This expands the MORVEL dataset by a factor of ~2, including in the geometrically important Manzanillo Spreading Segment.
- We invert these spreading rates together with MORVEL transform azimuths to find angular velocity.

Latitudinal Variation in Spreading Rate



- ➢ Our observed spreading rates (blue) are similar to MORVEL (orange)
- ➢ Our predicted rates from the angular velocity inverstion (black line) differ from MORVEL for the southern RI

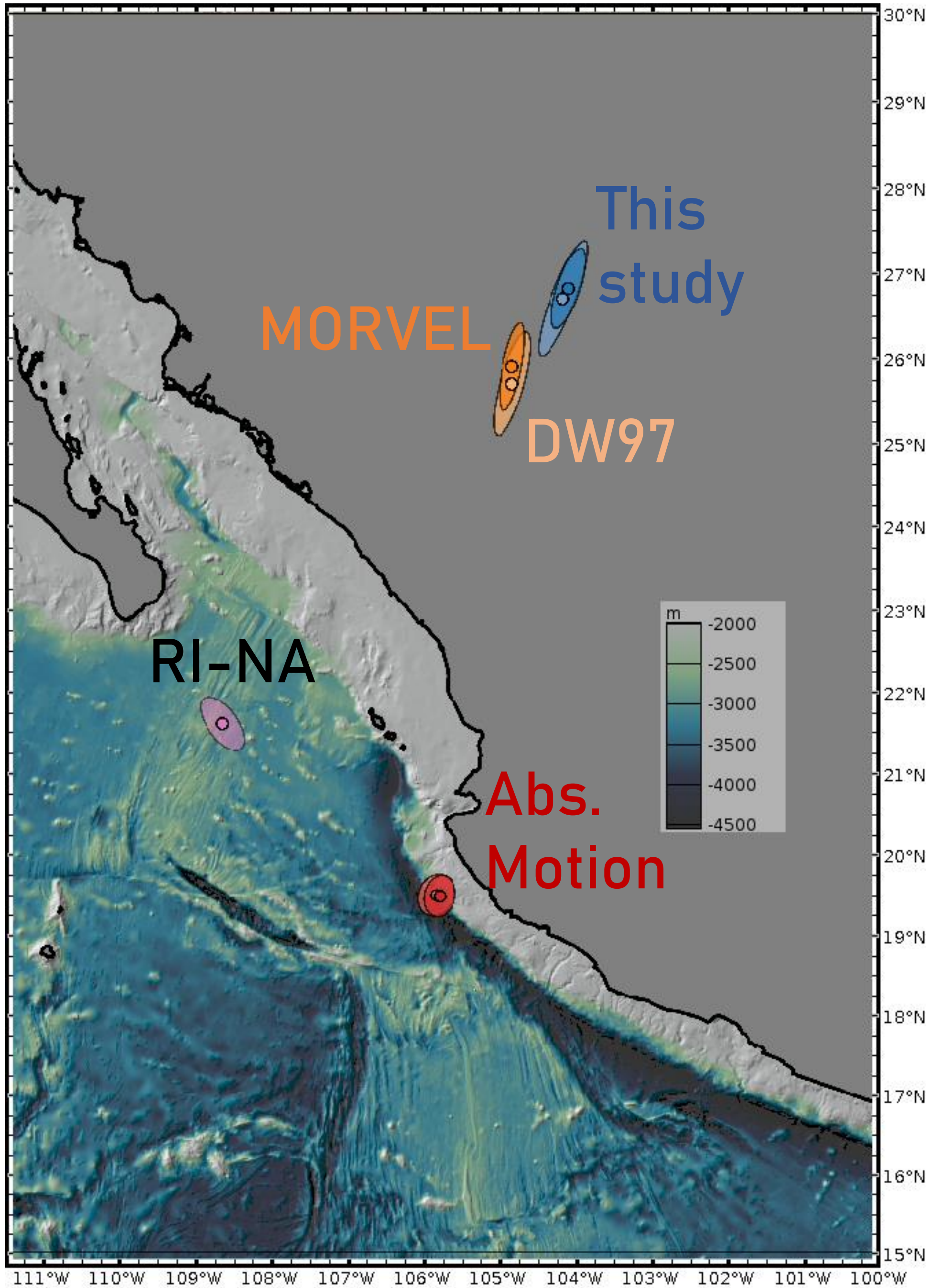
Latitudinal Variation in Spreading Rate



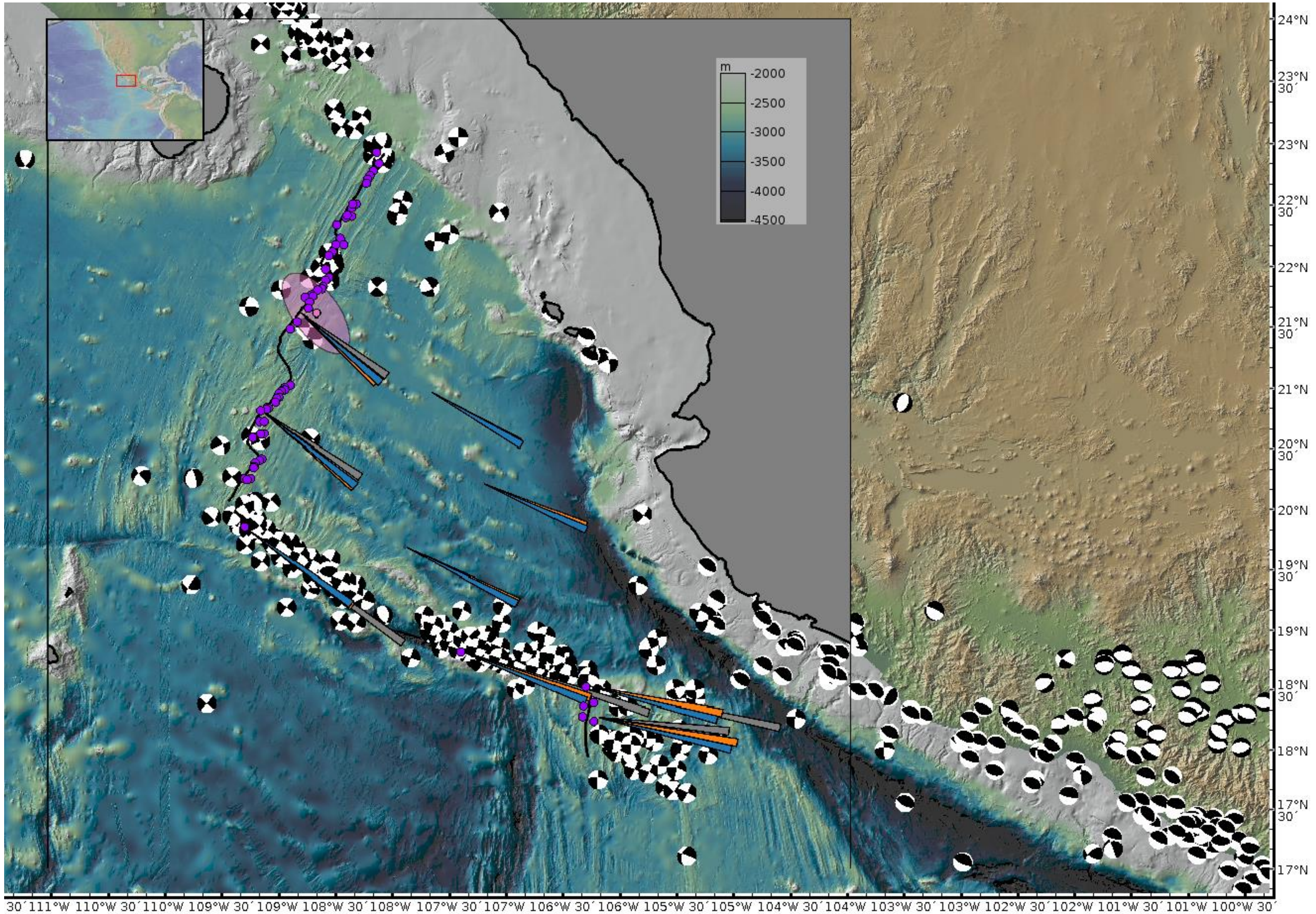
- At each crossing we use an F-test to determine whether the data are fit significantly better with a plate boundary at that latitude
- Critical F-values for our result (black) and MORVEL (gray)
- F-values rise near 21°N overlapping spreading,
- Consistent with northern boundary at 22°N fractures

Angular Velocity

- Our preferred angular velocity (dark blue blue) is broadly similar to MORVEL (dark orange) and DeMets & Wilson (1997; light orange)
- However, our uncertainty ellipsoid is reduced by a factor of 0.5 compared to MORVEL due to our larger dataset and the use of both shipboard and aeromagnetic data.
- Our result differs significantly from previous results, largely due to newly identified crossings at the southern end of the Pacific-Rivera Ridge and in the MSS



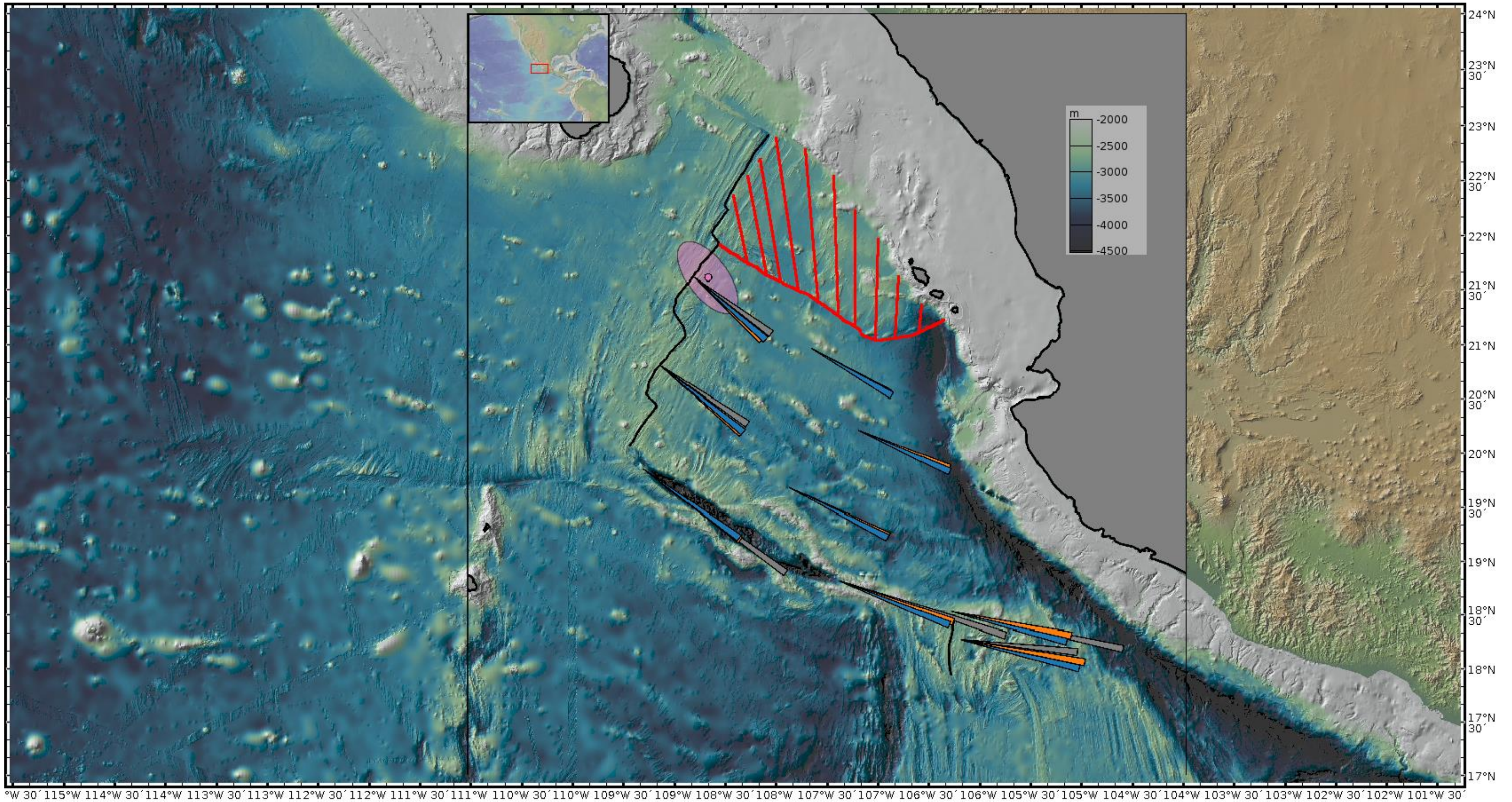
Geological Interpretation



- Crossings plotted with earthquake focal mechanisms
- Cones indicate:
  1) Our predicted RI motion relative to the fixed Pacific (blue)
  2) MORVEL (orange)
  3) Observed (gray)
- Location of RI-NA pole between 21°N and 22°N suggests spreading rates should be consistent with RI-PA and NA-PA motion.

Geological Interpretation

- Our result confirms the presence of a northern RI fragment attached to NA.
- With additional data we provide additional support for placing this boundary along the ~22°N fractures.
- Our angular velocity better fits the PA-RI ridge and the MSS than MORVEL, but misfits the Rivera Transform more.



Summary and Future Applications

- We adapt the widely used RDP algorithm to be fully compatible with spherical geometry and optimized for segmenting geophysical trackline data.
- Applying this spherical RDP algorithm to crossings of the Pacific-Rivera Ridge, we identify 70 spreading rates, greatly expanding the available data with a minimum of effort.
- Our method allows a better constrained Pacific-Rivera relative motion angular velocity to be defined and a more detailed consideration of Rivera plate geometry.
- Future analysis of our Pacific-Rivera angular velocity may provide additional insight into plate geometry, particularly of the southern boundary of the Rivera plate.
- The spherical RDP algorithm we define will allow rapid segmentation of geophysical trackline data