Kriging Ordinario: Comparación utilizando distancias euclidianas y no euclidianas aplicadas a la salmonicultura

Francisco Vega

Tabla de contenidos I

Principales desafíos

Caligidosis

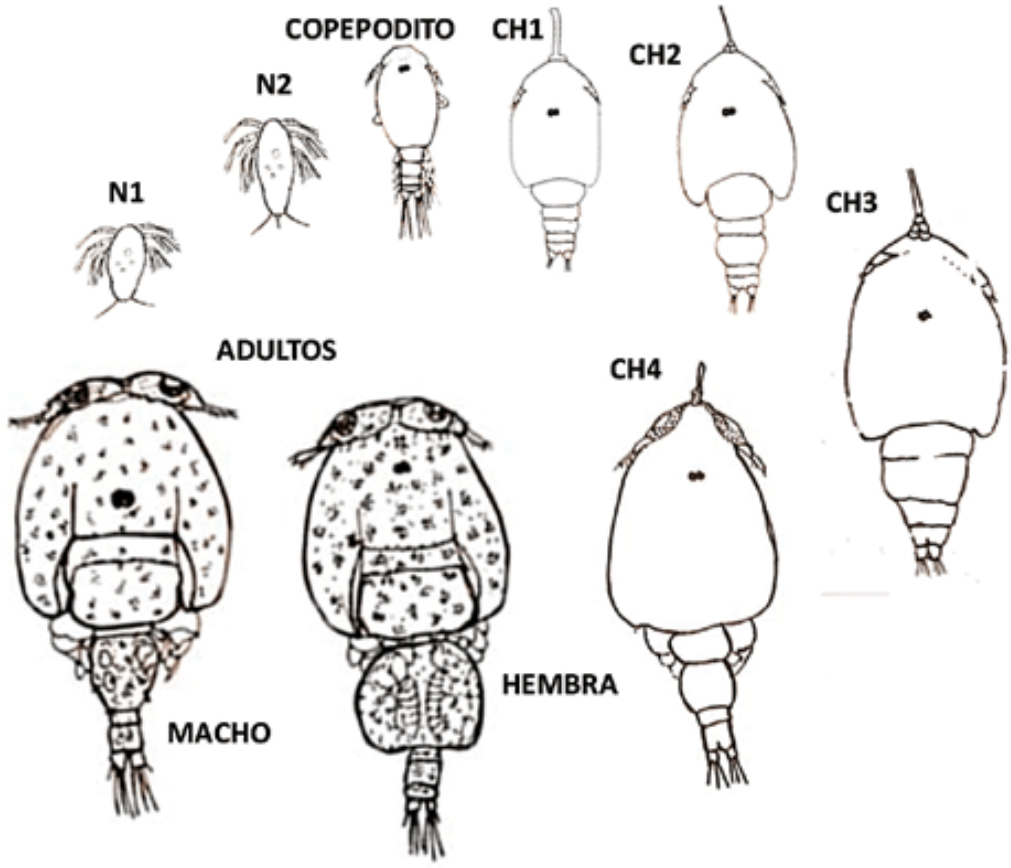


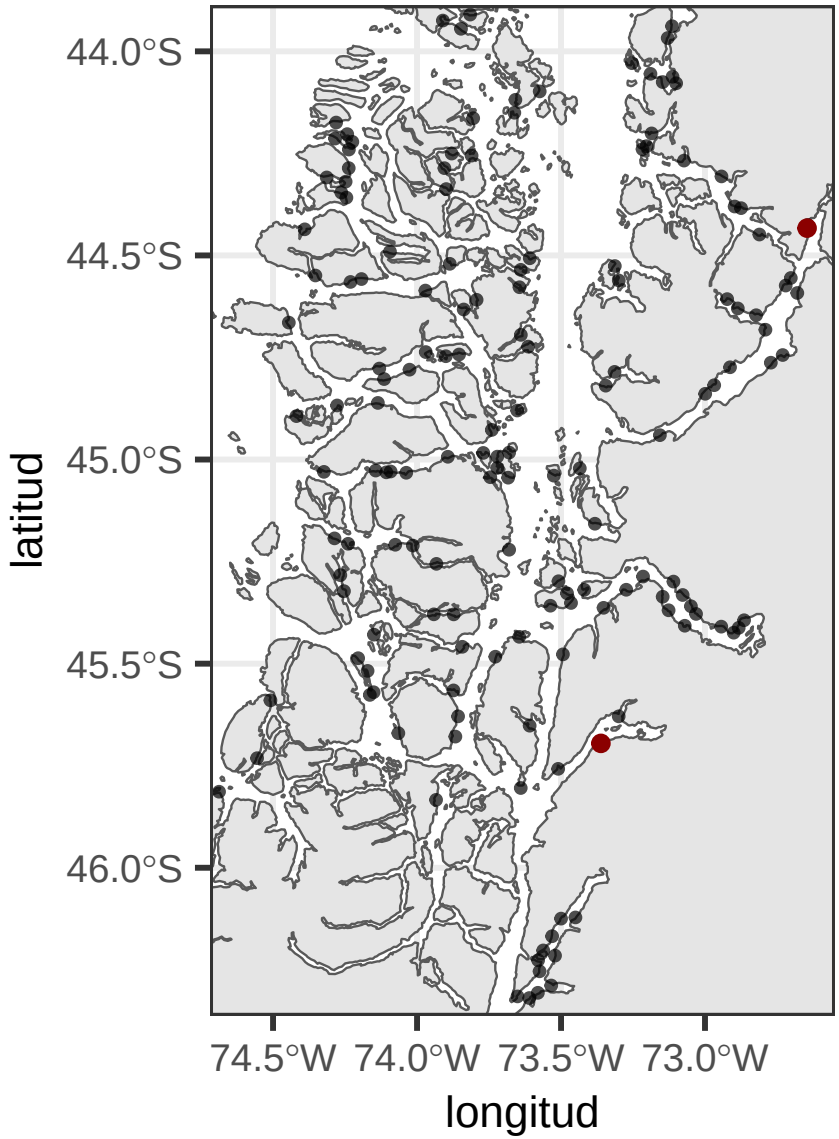
Figura 1: Ciclo de Caligus Carvajal, González Poblete, y George-Nascimento (1998)

Costos y pérdidas

- Directos
  - Tratamientos en alimento
  - Tratamientos en jaula
  - Pérdida de calidad
- Indirectos
  - Aumento en FCR (Lepe-López et al. 2021)
  - Susceptibilidad a otros patógenos

Figura 2: Daño en el pez

Problema distancia euclidiana

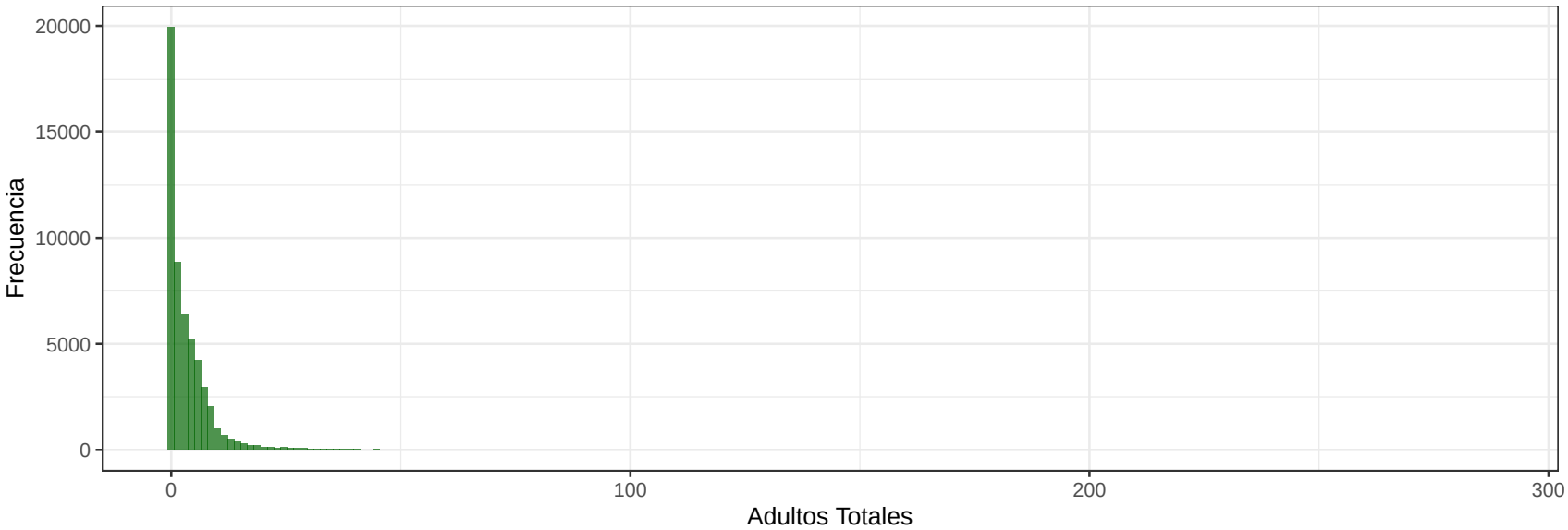


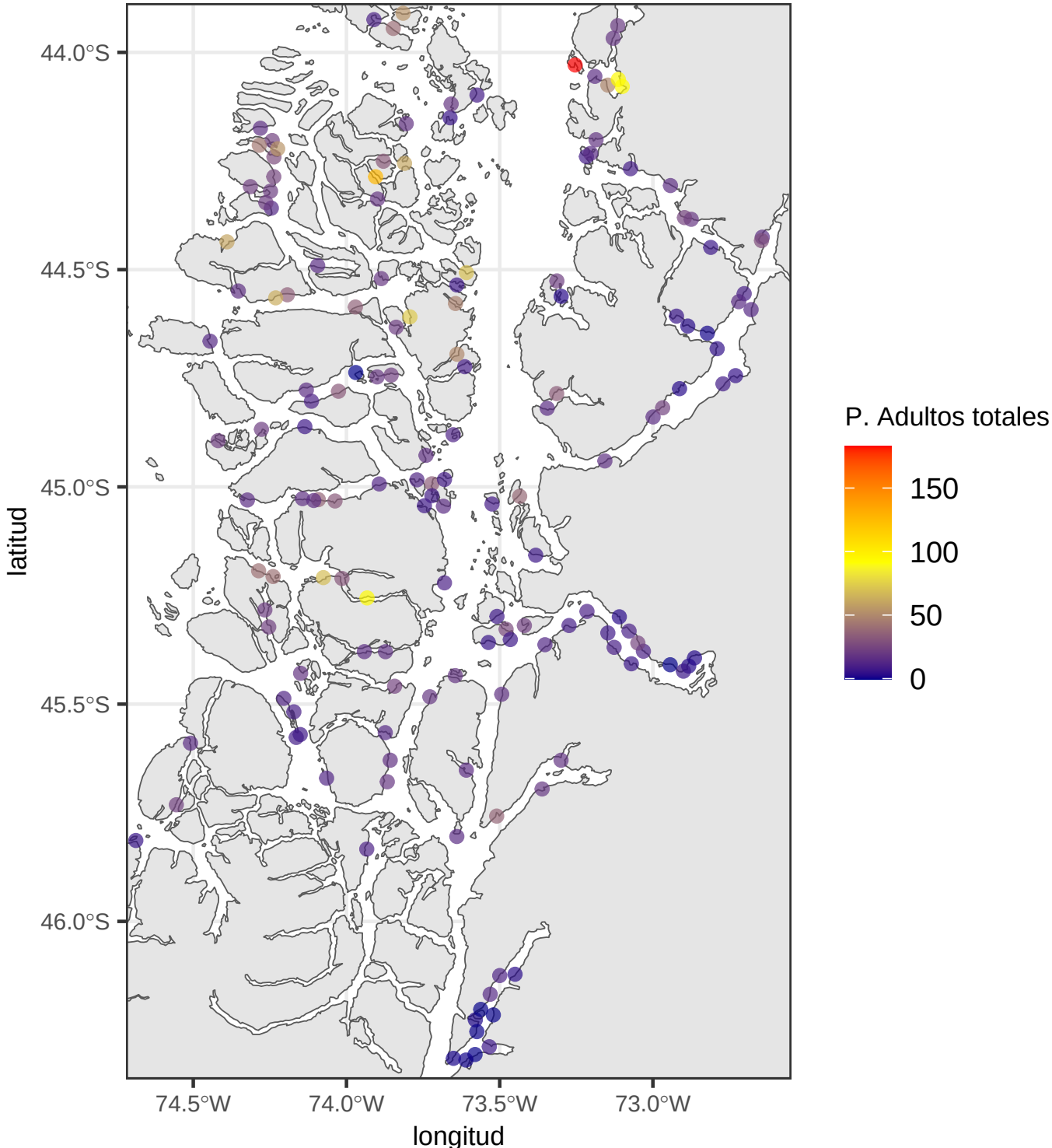
Datos

Resumen

- Fuente: SERNAPESCA
- Período: 2015 - 2022.
- Ubicación: Región de Aysén.
- Especies consideradas: *Salmo salar* y *Oncorhynchus mykiss*.

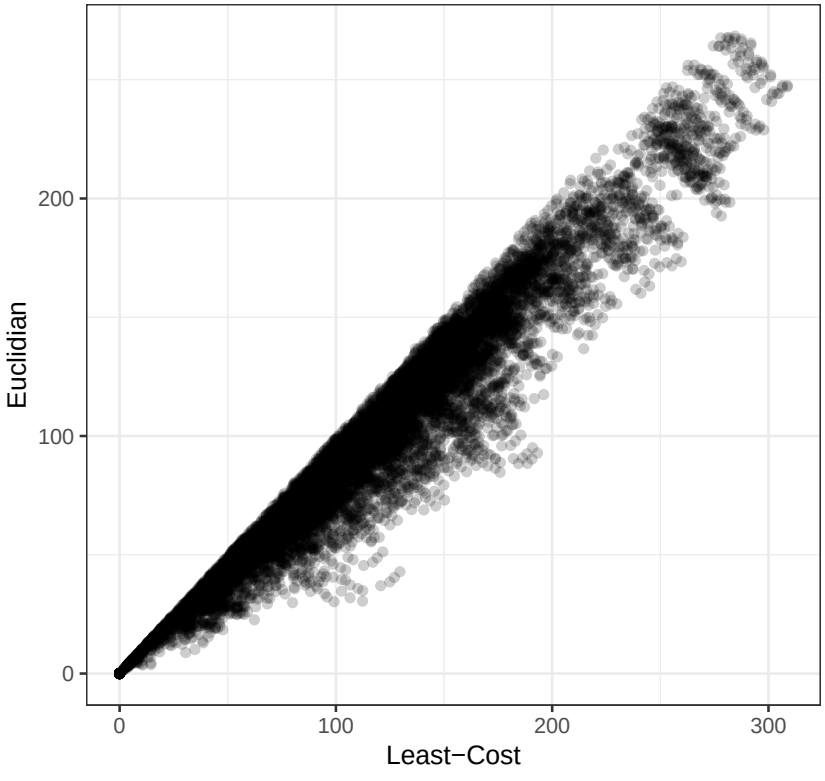
Para resumir a un problema solo espacial, se resumieron las observaciones a través de el promedio de los máximos por cada ciclo.

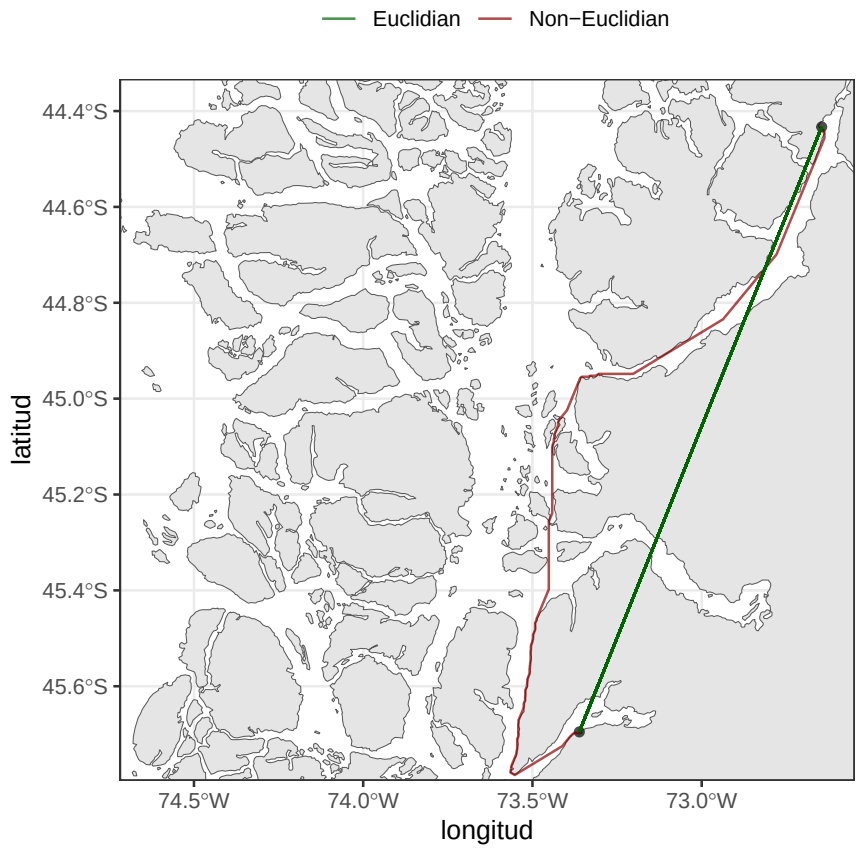



44.0°S
44.5°S
45.0°S
45.5°S
46.0°S
latitud
74.5°W
74.0°W
73.5°W
73.0°W
longitud
P. Adultos totales
150
100
50
0

Cálculo de distancia

- Paquete gdistance (van Etten 2017).
  - "Camino más corto" o Least-Cost.
  - Rasters.
  - Matrices de transición.





Modelos en la literatura

- Modelo espacio-temporal estocástico:
  $\mu_{it} = S_{it} \cdot \kappa_{it}^{susc} \cdot (\lambda_{it}^{w} + \lambda_{it}^{d} + \lambda_{it}^{o})$ (Aldrin et al. 2013)
- Modelos autoregresivos de estado-espacio (Elghafghuf et al. 2020)
- Modelos de dos partes con efectos aleatorios (Rees et al. 2015)

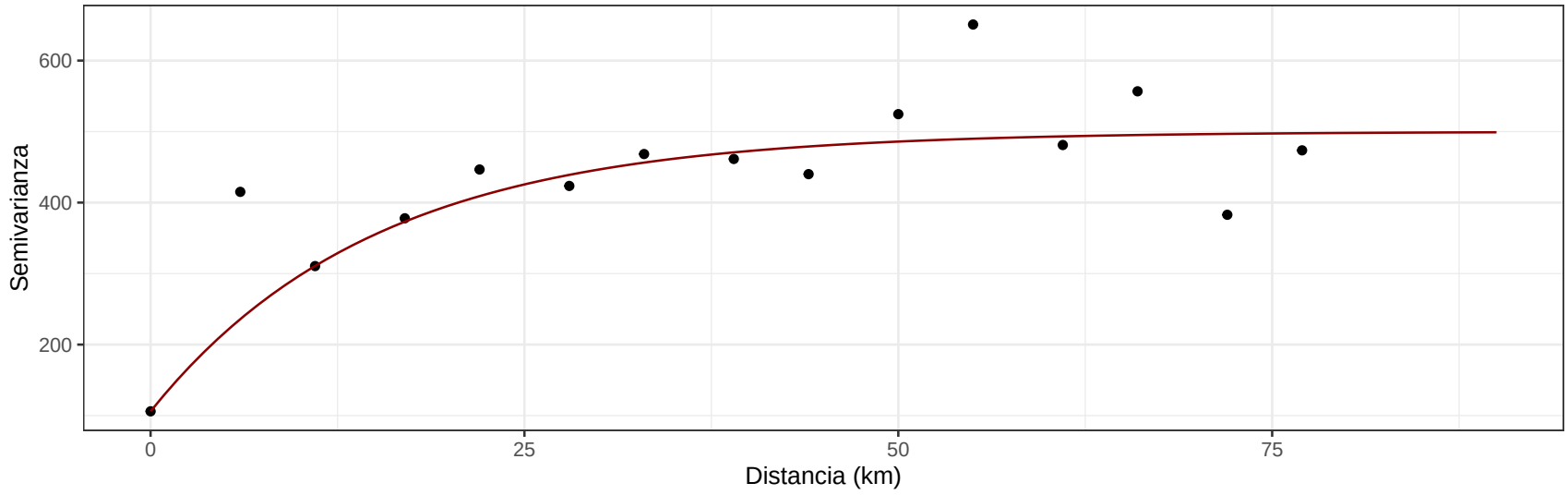
Kriging Ordinario:

$\mathbf{Z}^*(\mathbf{x_0}) := \lambda^\top \mathbf{Z}$, donde:

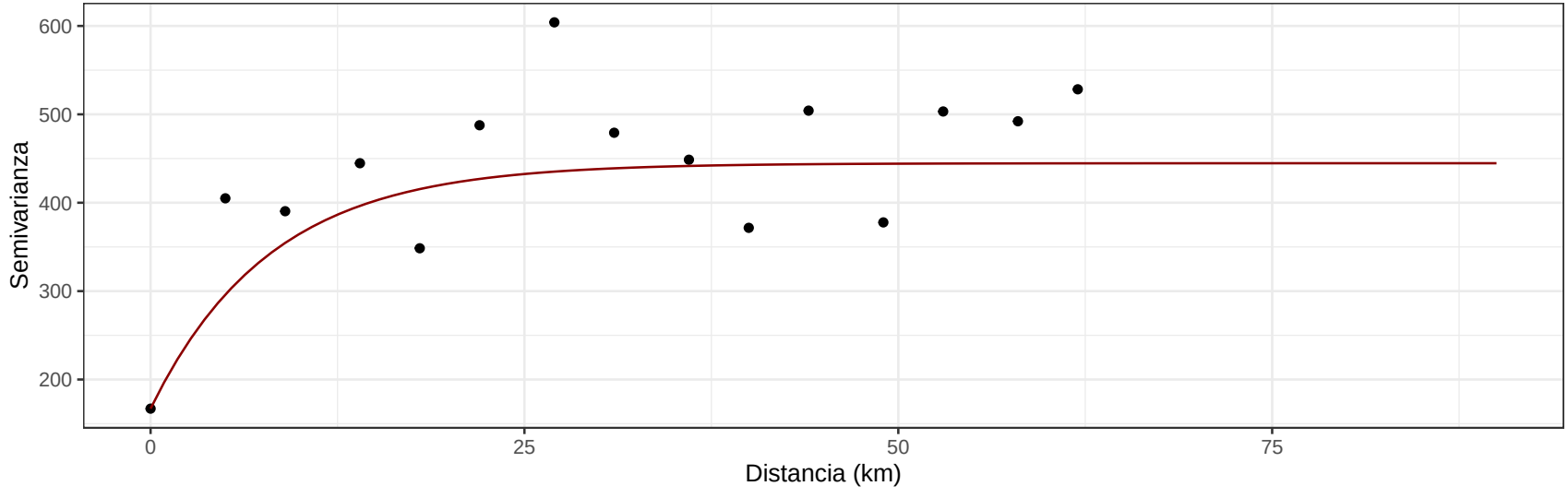
$$\lambda = \Sigma^{-1}\left[\mathbf{c_0} + \mathbf{1}(\mathbf{1}^\top\Sigma^{-1}\mathbf{1})^{-1}(1 - \mathbf{1}^\top\Sigma^{-1}\mathbf{c_0})\right] \ , \ \lambda^\top\mathbf{1} = 1$$

$$\sigma_{ok}^2 = \sigma_0^2 - \mathbf{c_0}^\top\Sigma^{-1}\mathbf{c_0} + (1 - \mathbf{1}^\top\Sigma^{-1}\mathbf{c_0})^\top(\mathbf{1}^\top\Sigma^{-1}\mathbf{1})^{-1}(1 - \mathbf{1}^\top\Sigma^{-1}\mathbf{c_0})$$

Semivariograma



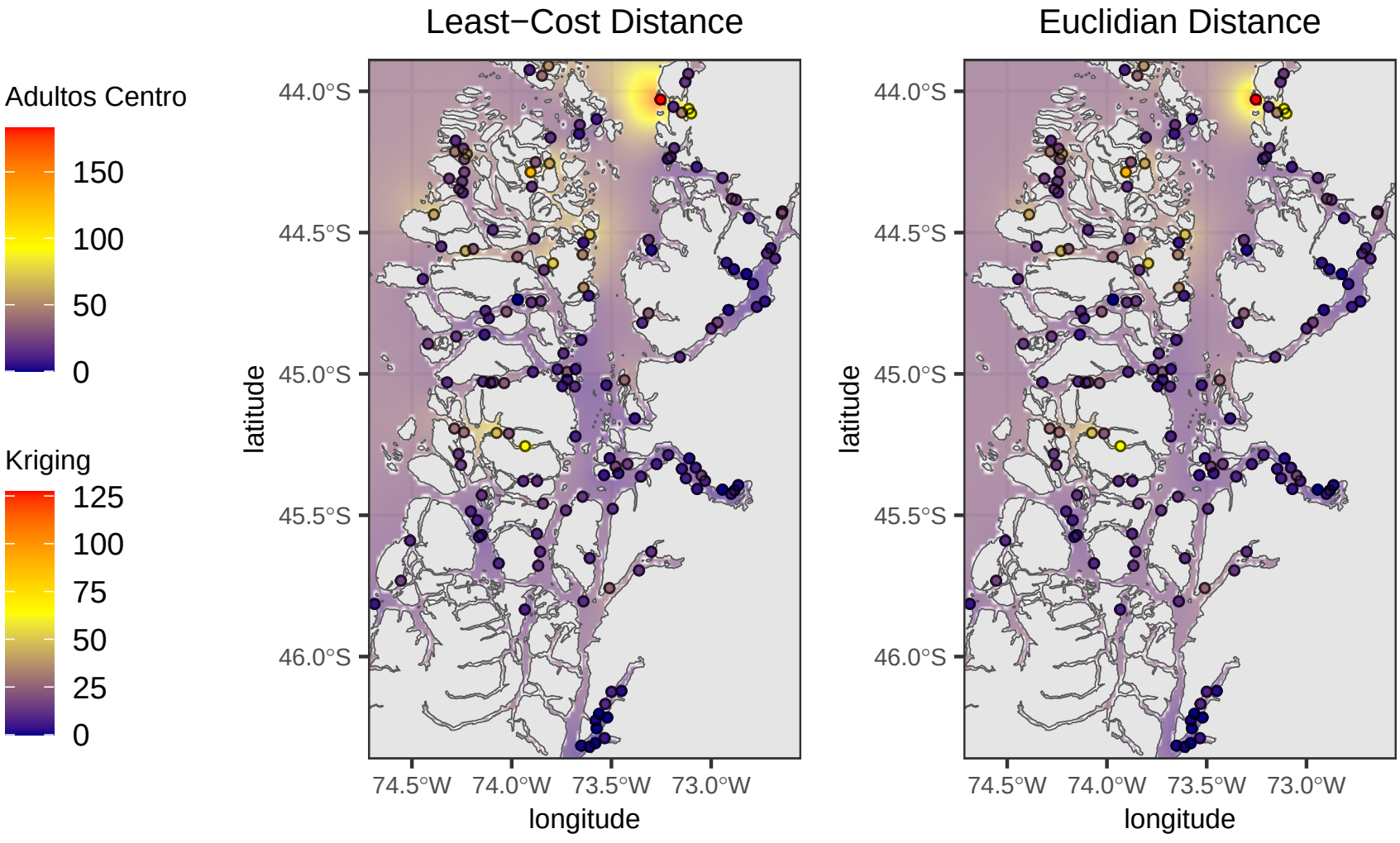
Modelo Matérn Least−Cost: σ^2=394, Φ=20, nugget=106, $\kappa = 0.5$



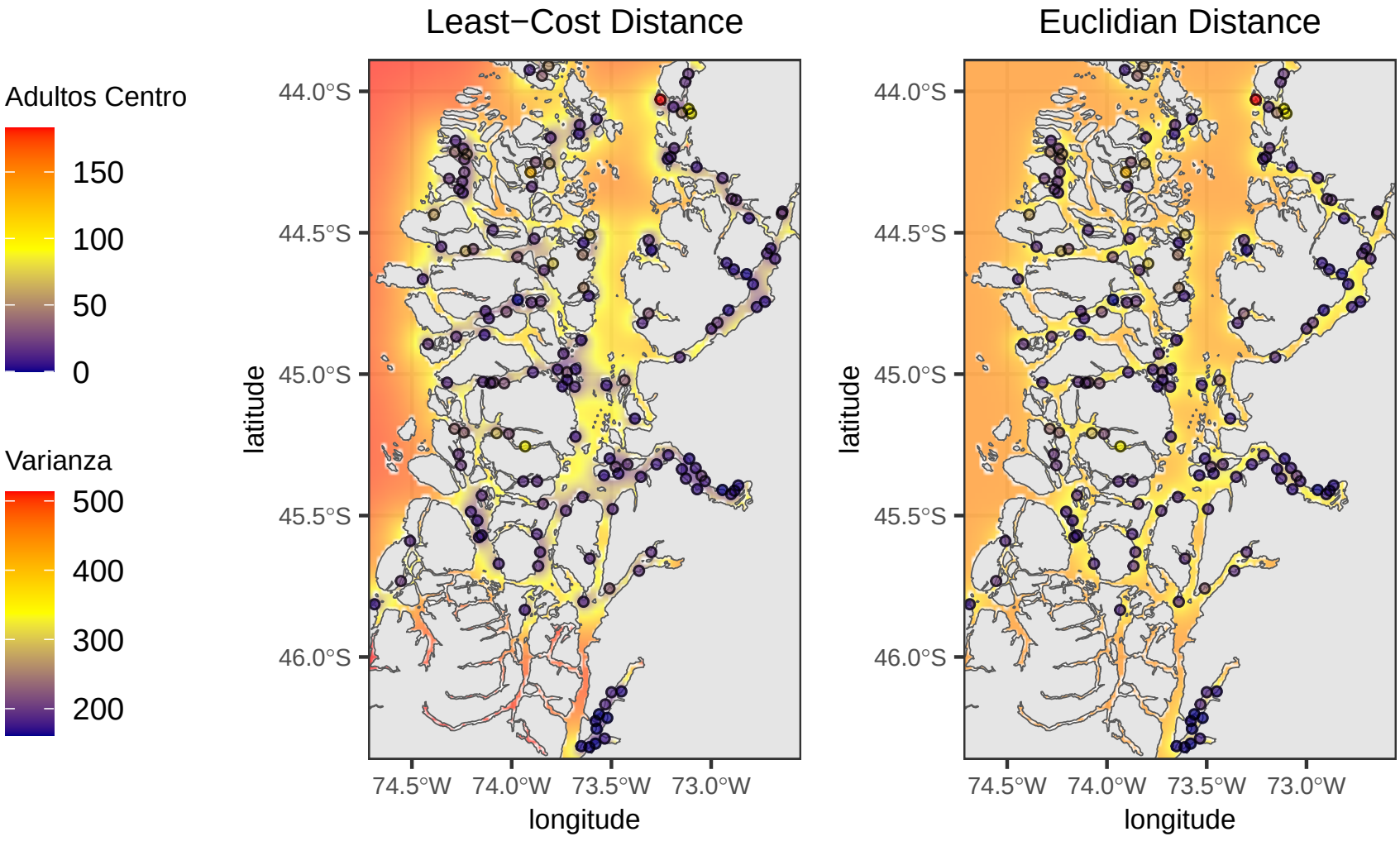
Modelo Matérn Euclidiano: σ^2=278, Φ=8, nugget=167, $\kappa = 0.5$

Kriging ordinario

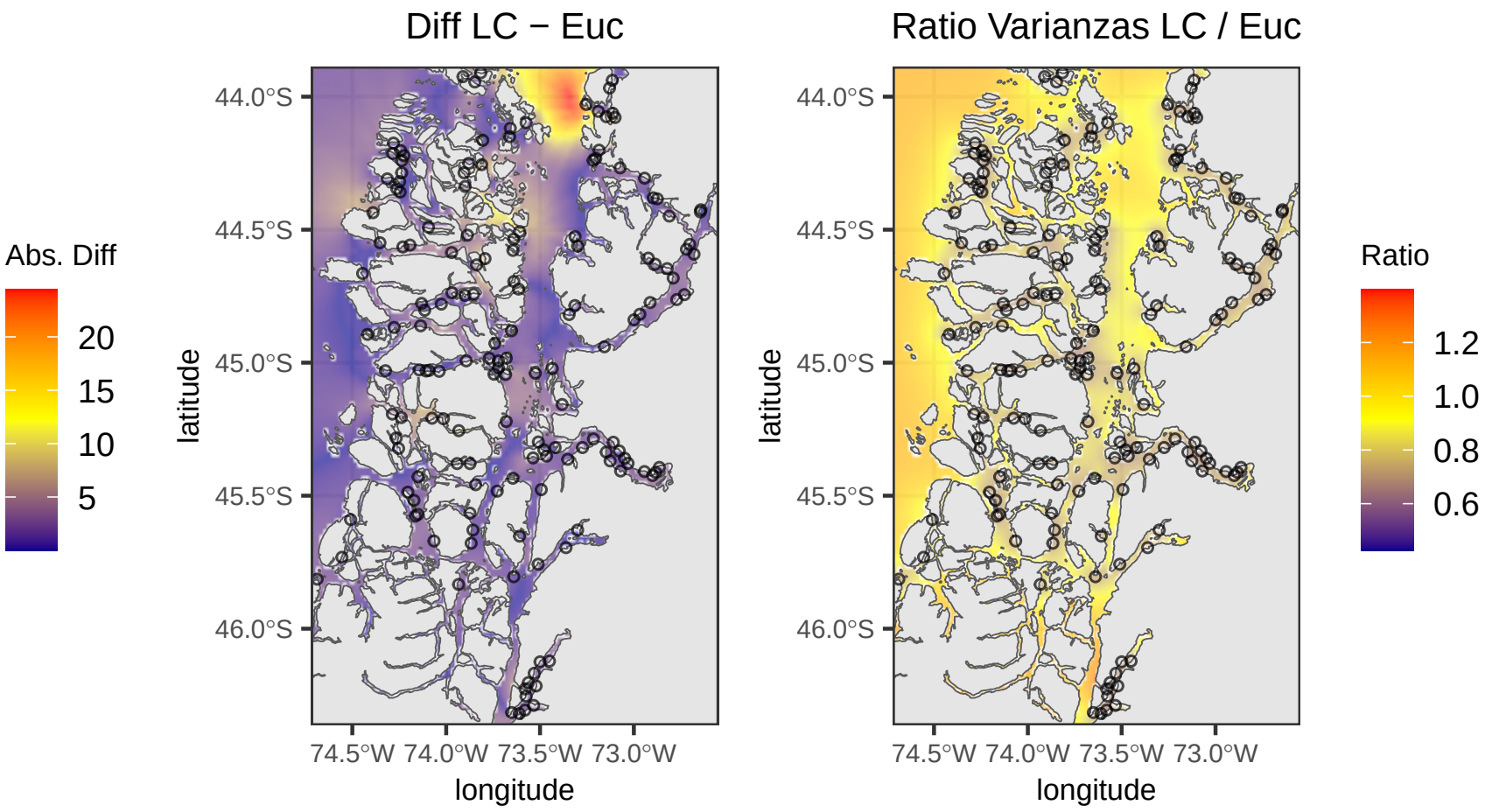
Media

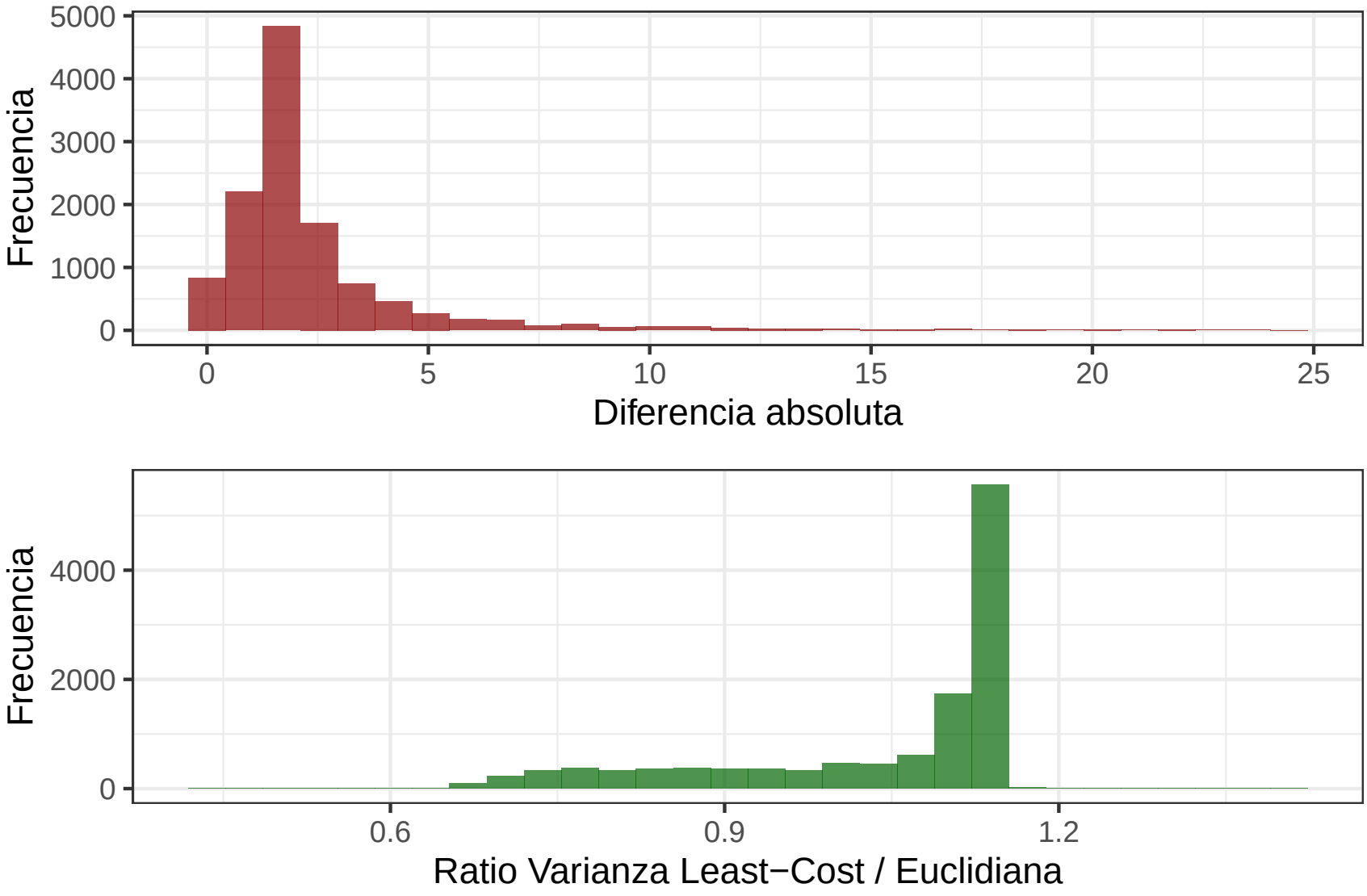

Adultos Centro
150
100
50
0
Kriging
125
100
75
50
25
0
Least−Cost Distance
Euclidian Distance
latitude
44.0°S
44.5°S
45.0°S
45.5°S
46.0°S
74.5°W
74.0°W
73.5°W
73.0°W
longitude

Varianza


Adultos Centro
150
100
50
0
Varianza
500
400
300
200
Least−Cost Distance
Euclidian Distance
latitude
longitude
44.0°S
44.5°S
45.0°S
45.5°S
46.0°S
74.5°W
74.0°W
73.5°W
73.0°W

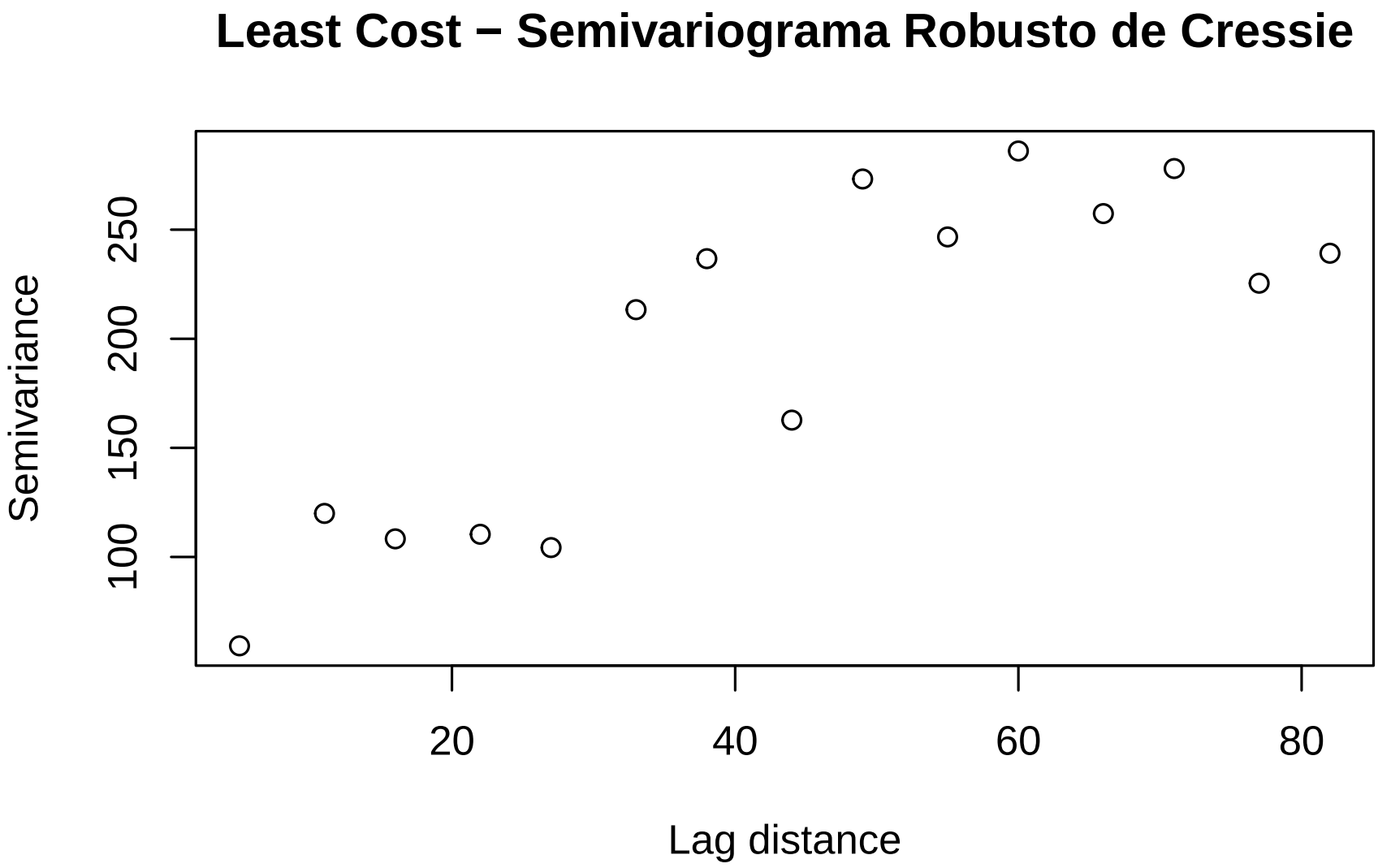
Comparaciones

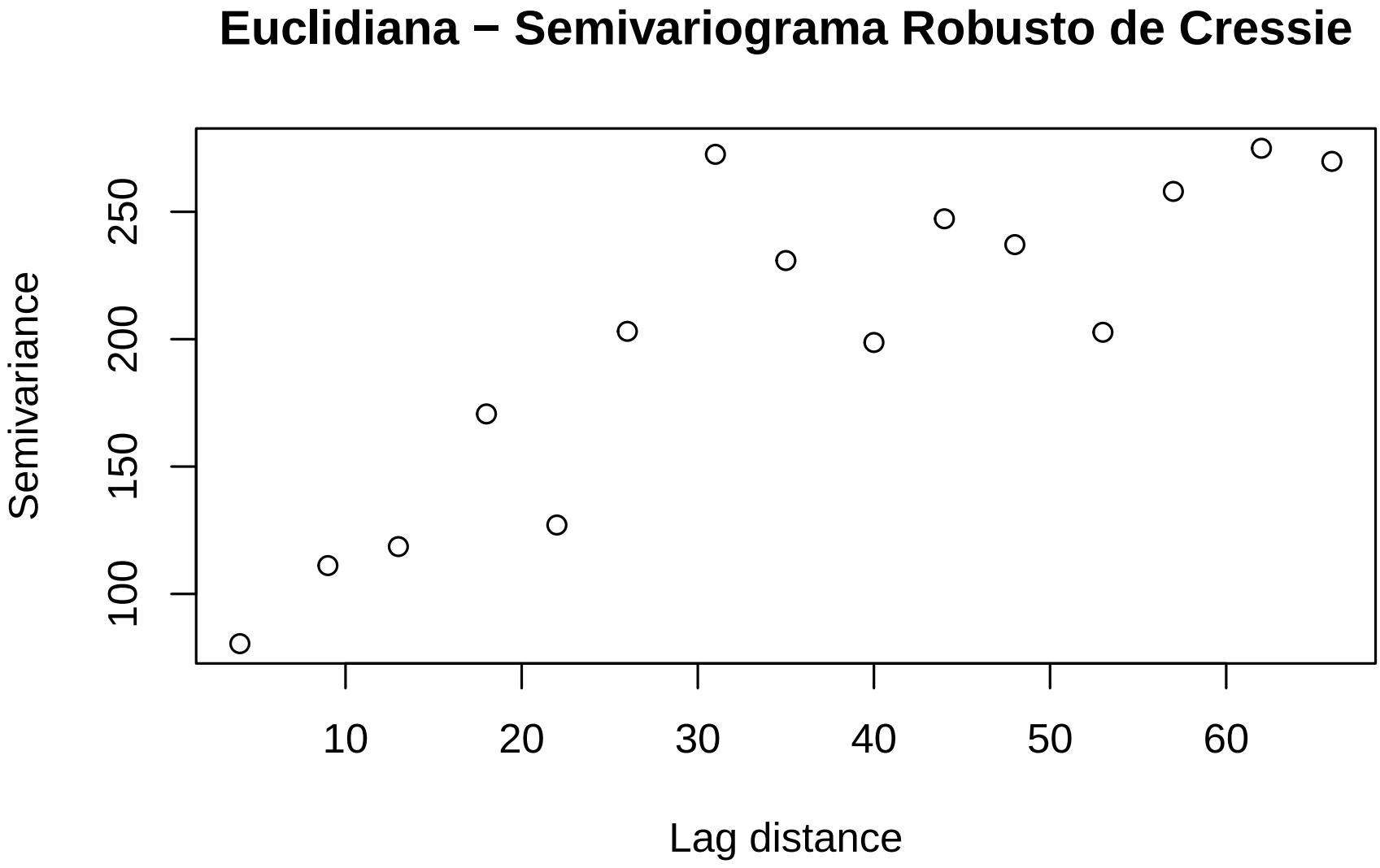



Frecuencia
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
Diferencia absoluta
Frecuencia
4000
2000
0
0.6
0.9
1.2
Ratio Varianza Least−Cost / Euclidiana

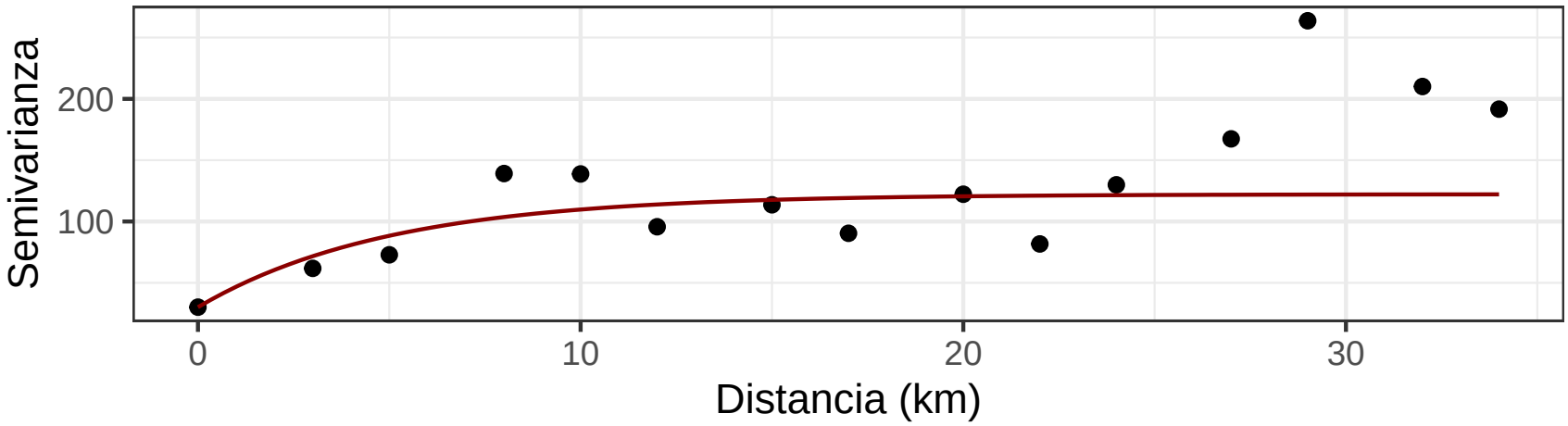
Efecto Outlier?

Efecto Outlier?

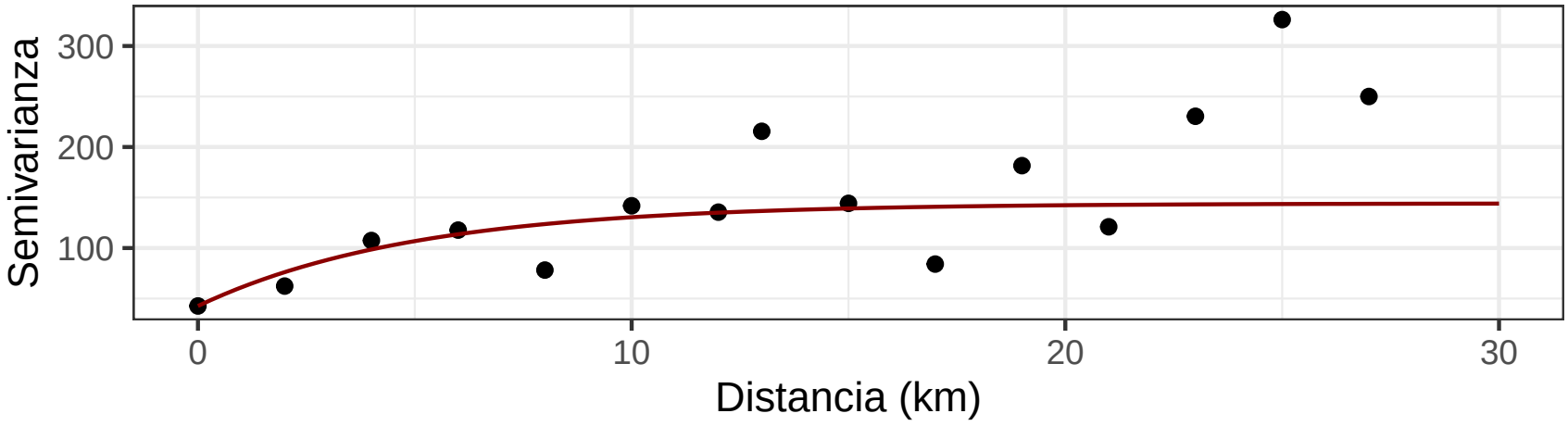



Euclidiana − Semivariograma Robusto de Cressie
Semivariance
100
150
200
250
10
20
30
40
50
60
Lag distance

Ajuste a corta distancia

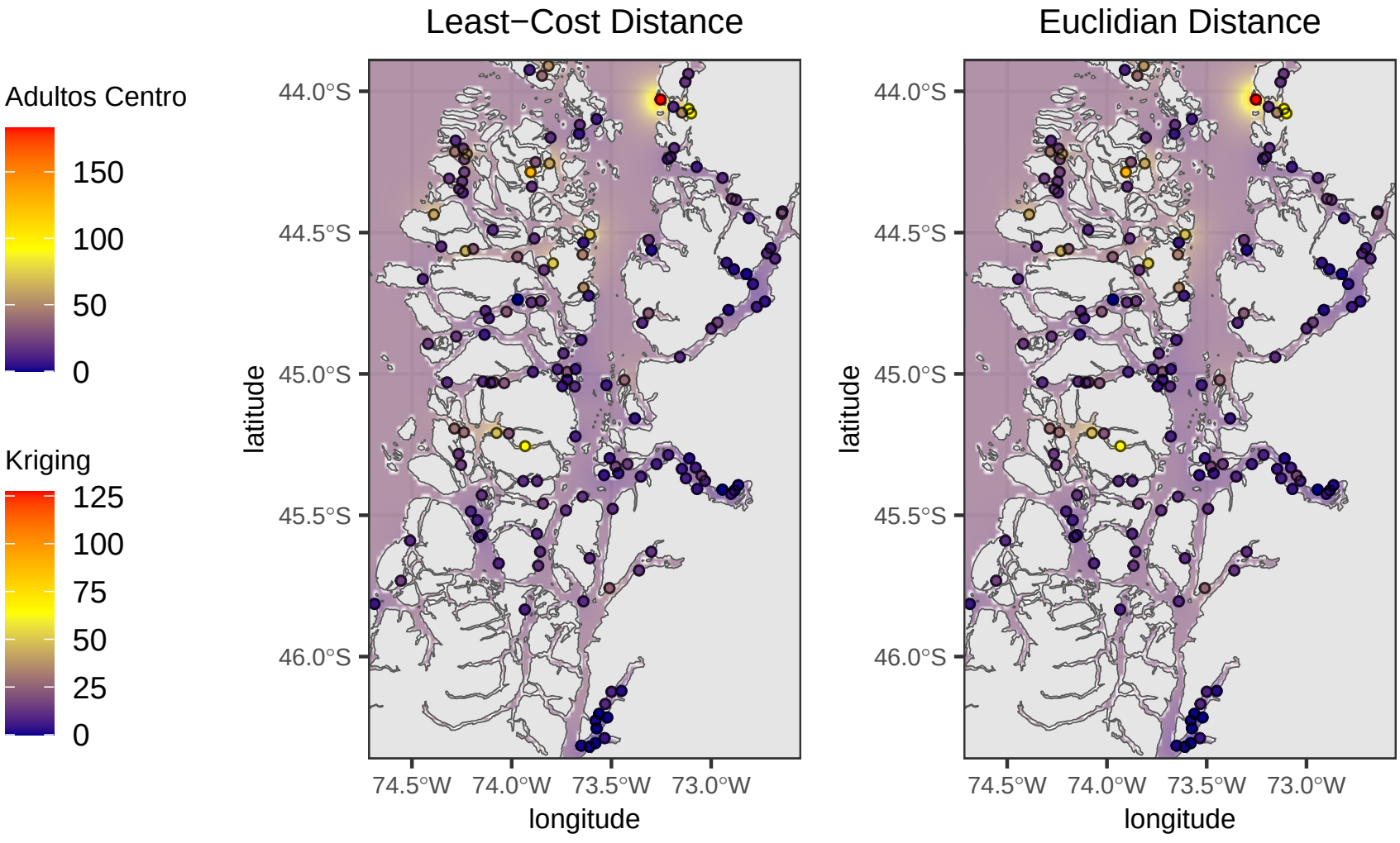


Modelo Matérn Least−Cost: σ^2=92, Φ=5, nugget=30, $\kappa = 0.5$

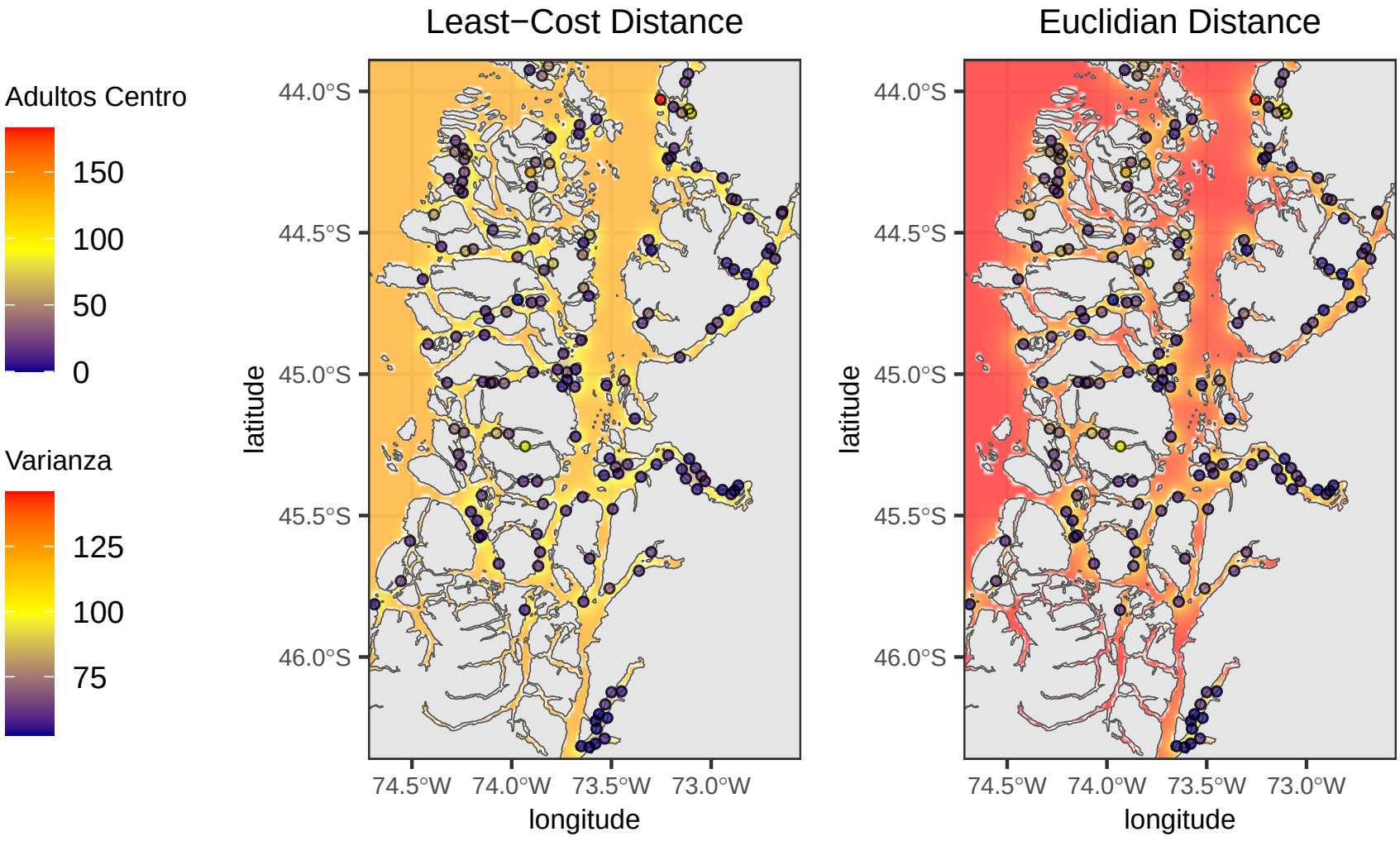


Modelo Matérn Euclidiano: σ^2=101, Φ=5, nugget=43, $\kappa = 0.5$

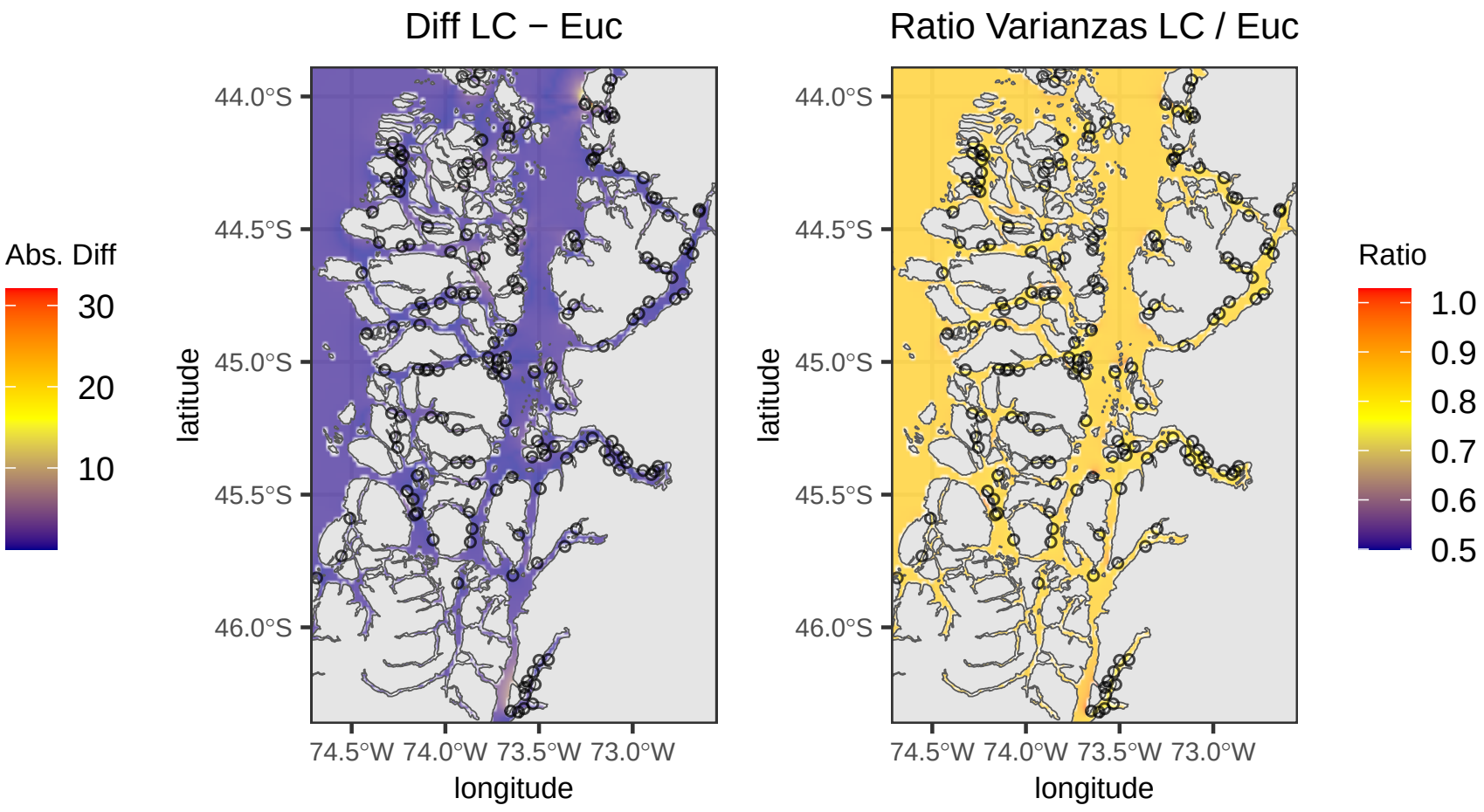
Media


Adultos Centro
150
100
50
0
Kriging
125
100
75
50
25
0
Least−Cost Distance
Euclidian Distance
latitude
longitude
44.0°S
44.5°S
45.0°S
45.5°S
46.0°S
74.5°W
74.0°W
73.5°W
73.0°W

Varianza


Adultos Centro
150
100
50
0
Varianza
125
100
75
Least−Cost Distance
Euclidian Distance
44.0°S
44.5°S
45.0°S
45.5°S
46.0°S
latitude
74.5°W
74.0°W
73.5°W
73.0°W
longitude

Comparaciones



Futuros trabajos

Futuros trabajos

- Extensión:
  - Cokriging
  - Extensión a modelos geoestadísticos espacio-temporales
  - Considerar modelos cero-inflados

Referencias

Referencias I

Aldrin, Magne, B. Storvik, Anja Bråthen Kristoffersen, y P. A. Jansen. 2013. «Space-Time Modelling of the Spread of Salmon Lice between and within Norwegian Marine Salmon Farms». *PLoS ONE* 8 (5). https://doi.org/10.1371/journal.pone.0064039.

Carvajal, Juan, Laura González Poblete, y Mario George-Nascimento. 1998. «Native sea lice (Copepoda: Caligidae) infestation of salmonids reared in netpen systems in southern Chile». *Aquaculture* 166 (julio): 241-46. https://doi.org/10.1016/S0044-8486(98)00301-9.

Elghafghuf, Adel, Raphael Vanderstichel, Larry Hammell, y Henrik Stryhn. 2020. «Estimating sea lice infestation pressure on salmon farms: Comparing different methods using multivariate state-space models». *Epidemics* 31 (junio): 100394. https://doi.org/10.1016/j.epidem.2020.100394.

Referencias II

Lepe-López, Manuel, Joaquín Escobar-Dodero, Daniel Rubio, Julio Alvarez, Natalia Zimin-Veselkoff, y Fernando O. Mardones. 2021. «Epidemiological Factors Associated With Caligus rogercresseyi Infection, Abundance, and Spatial Distribution in Southern Chile». *Frontiers in Veterinary Science* 8 (agosto): 595024. https://doi.org/10.3389/fvets.2021.595024.

Rees, E. E., S. St-Hilaire, S. R. M. Jones, M. Krkošek, S. DeDominicis, M. G. G. Foreman, T. Patanasatienkul, y C. W. Revie. 2015. «Spatial patterns of sea lice infection among wild and captive salmon in western Canada». *Landscape Ecology* 30 (6): 989-1004. https://doi.org/10.1007/s10980-015-0188-2.

van Etten, Jacob. 2017. «R Package gdistance: Distances and Routes on Geographical Grids». *Journal of Statistical Software* 76 (13): 1-21. https://doi.org/10.18637/jss.v076.i13.