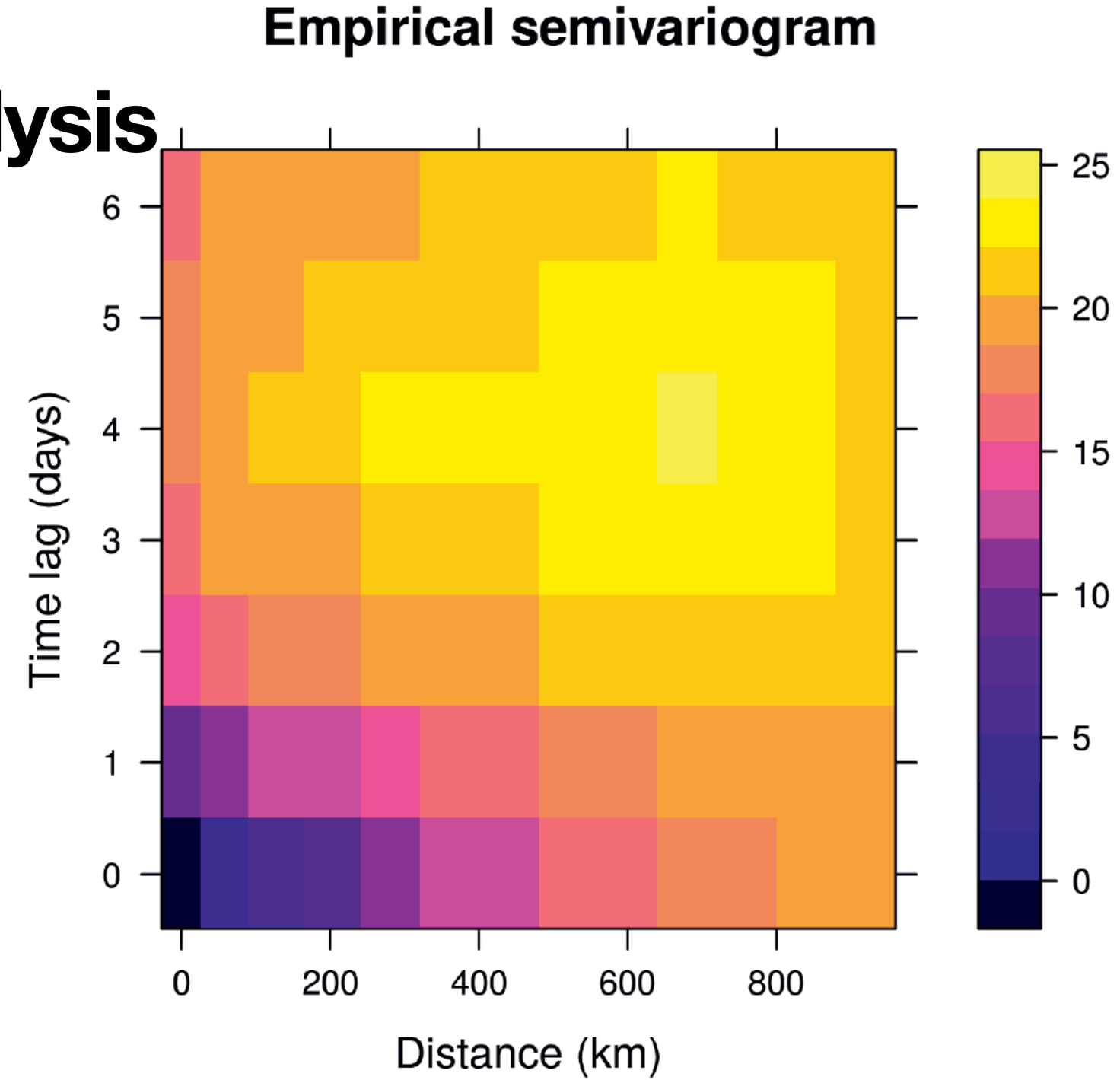
Spatio-temporal statistics

Exploratory analysis

- Everything covered for space and time (+ facets)
- Animation
- EOFs (`eigen, prcomp`)
- ST variograms (`gstat::variogram`)



ST Covariance

$$c_*(\mathbf{s}, \mathbf{s}'; t, t') \equiv \mathrm{cov}(Y(\mathbf{s}; t), Y(\mathbf{s}'; t')),$$

$$c_*(\mathbf{s}, \mathbf{s}'; t, t') = c(\mathbf{s}' - \mathbf{s}; t' - t) = c(\mathbf{h}; \tau),$$

second-order stationarity

$$c(\mathbf{h}; \tau) \equiv c^{(s)}(\mathbf{h}) \cdot c^{(t)}(\tau)$$

“separable” assumption guarantees validity

May be invalid if ST variogram suggests an interaction, more advanced corr fcn possible

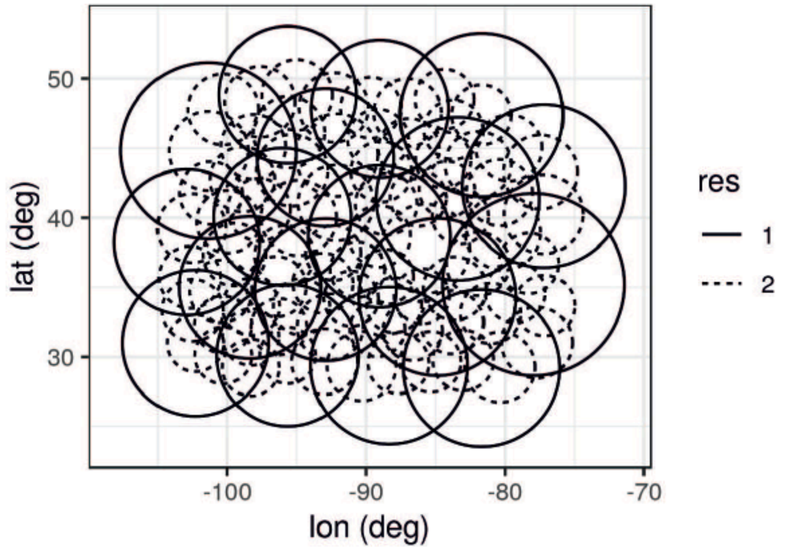
Random-effects parameterization

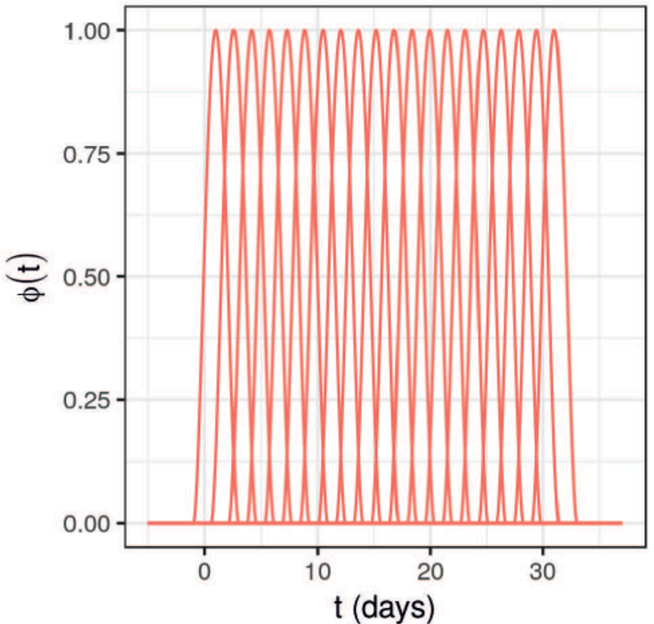
$$Z(s) = \underbrace{\mu(s|\beta)}_{\textit{trend}} + \underbrace{w(s|\phi)}_{\textit{spatial error}} + \underbrace{\epsilon(s)}_{\textit{residual error}}$$

$$\mathbf{Z}_i = \mathbf{X}_i\beta + \Phi\alpha_i + \varepsilon_i$$

Basis functions

Random effects





- example gam function specification

```
f <- cnt ~ te(lon, lat, t,          # inputs over which to smooth
              bs = c("tp", "cr"),   # types of bases
              k = c(50, 10),        # knot count in each dimension
              d = c(2, 1))          # (s,t) basis dimension
```

- remember to check residuals for autocorrelation, may still need (short-range) spatial error

Resources

- Text and code available at https://spacetimewithr.org/
- Also covers dynamic ST models