Discussion to the Stein *IMS* Invited Lecture

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- **Models and models**
- **What is the process?**
- **YAOZE**
- **Genton's space-time example**

Geophysical model evaluation

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- **improve the models**
- **combine deterministic models with stochastic components.**

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Space-time modeling of the discrepency between model output and observations is a very useful step!

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Temporal structure may not be useful **For filling in missing data, the current spatial field may have most of the information about missing locations.**

$$[Y_t|X_t, X_{t-1}] \approx [Y_t|X_t]$$

(e.g. locating someone's spouse)

Beyond second moments **Often sophisticated applications use a nonlinear, "physical" model for forecasting.**

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- **Steadiness for power generation**
- **Frequency and duration of severe wind events**
- **Understanding of transport in the atmosphere**

What is the process?

To complement

$$COV(Z(\boldsymbol{x},t), Z(\boldsymbol{x}',t'))$$

For linear processes also consider:

$$\boldsymbol{Z}_t = A\boldsymbol{Z}_{t-1} + \boldsymbol{e}_t$$

or

$$\boldsymbol{Z}_t = \sum_k A_k \boldsymbol{Z}_{t-k} + \boldsymbol{e}_t$$

But A_k can be huge!

Argues for parametric forms for the autoregressive matrices.

Yet another ozone example

The model

Deseasonalization/standardization:

$y(\boldsymbol{x}, t)$ = **8-hour surface ozone at location $\boldsymbol{x}$ and time t.**

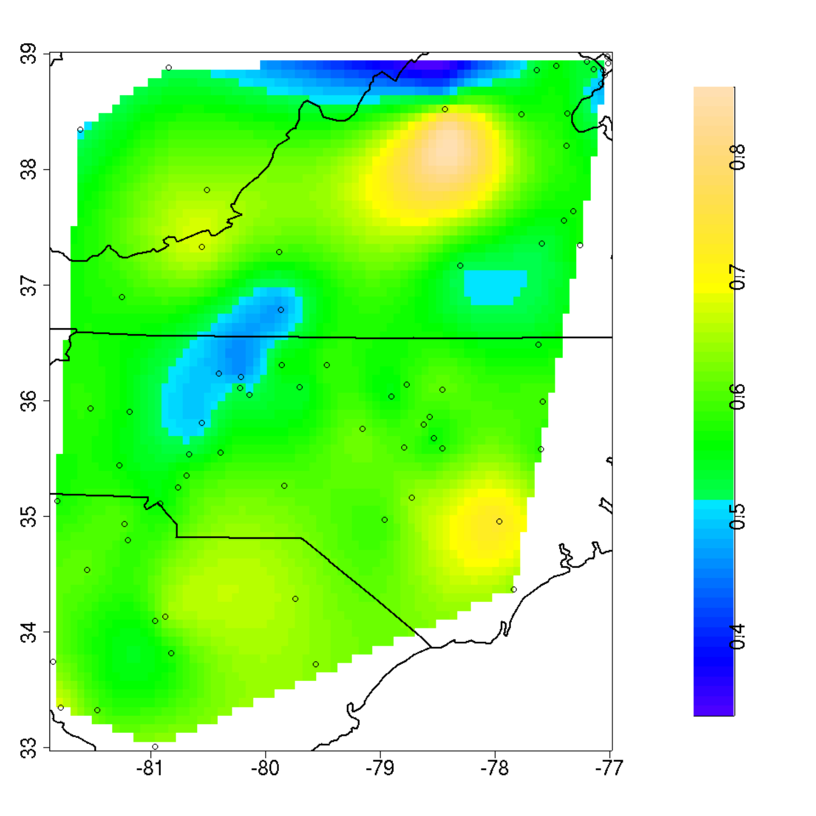
$$u(\boldsymbol{x}, t) = \frac{y(\boldsymbol{x}, t) - \mu(\boldsymbol{x}, t)}{\sigma(\boldsymbol{x})}$$

Autoregression: $u(\boldsymbol{x}, t) = A(\boldsymbol{x})u(\boldsymbol{x}, t-1) + e(\boldsymbol{x}, t-1)$

A **is diagonal !**

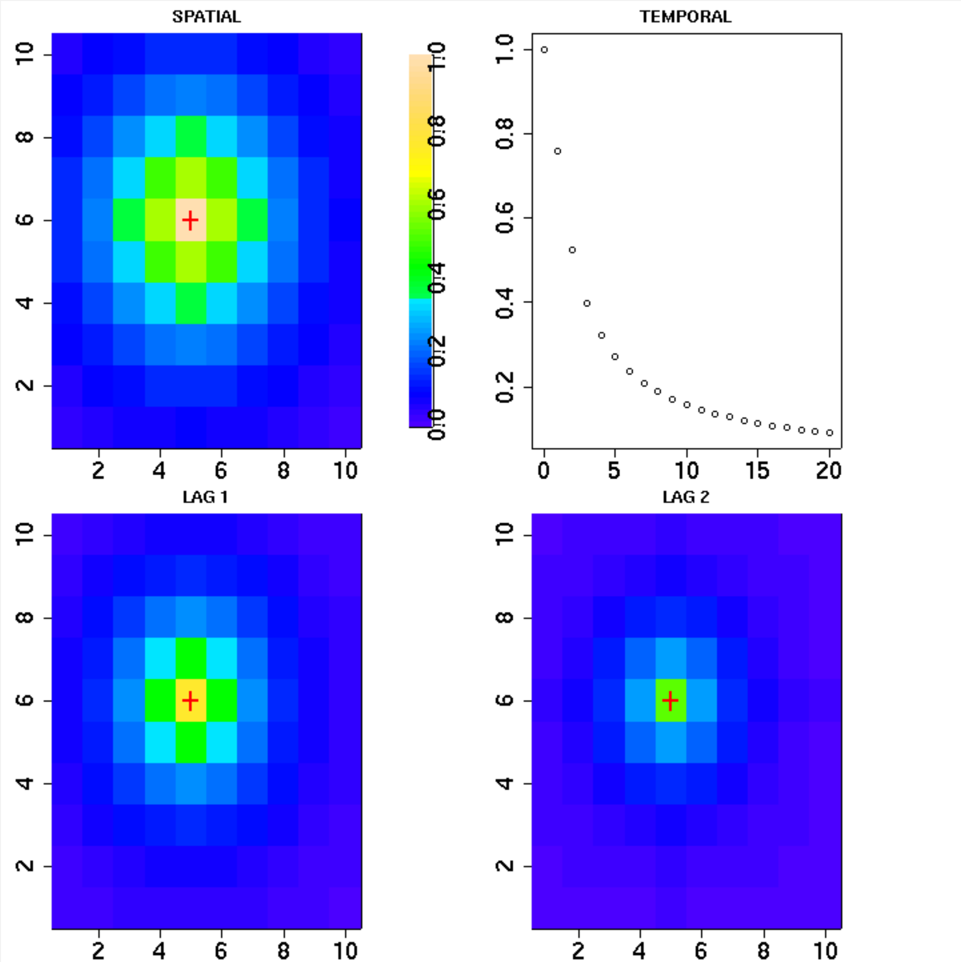
Spatial dependence: $e(\boldsymbol{x}, t)$ **uncorrelated over time and stationary over time covariance is a mixture of exponential covariance functions.**

Autoregressive surface $A(\boldsymbol{x})$



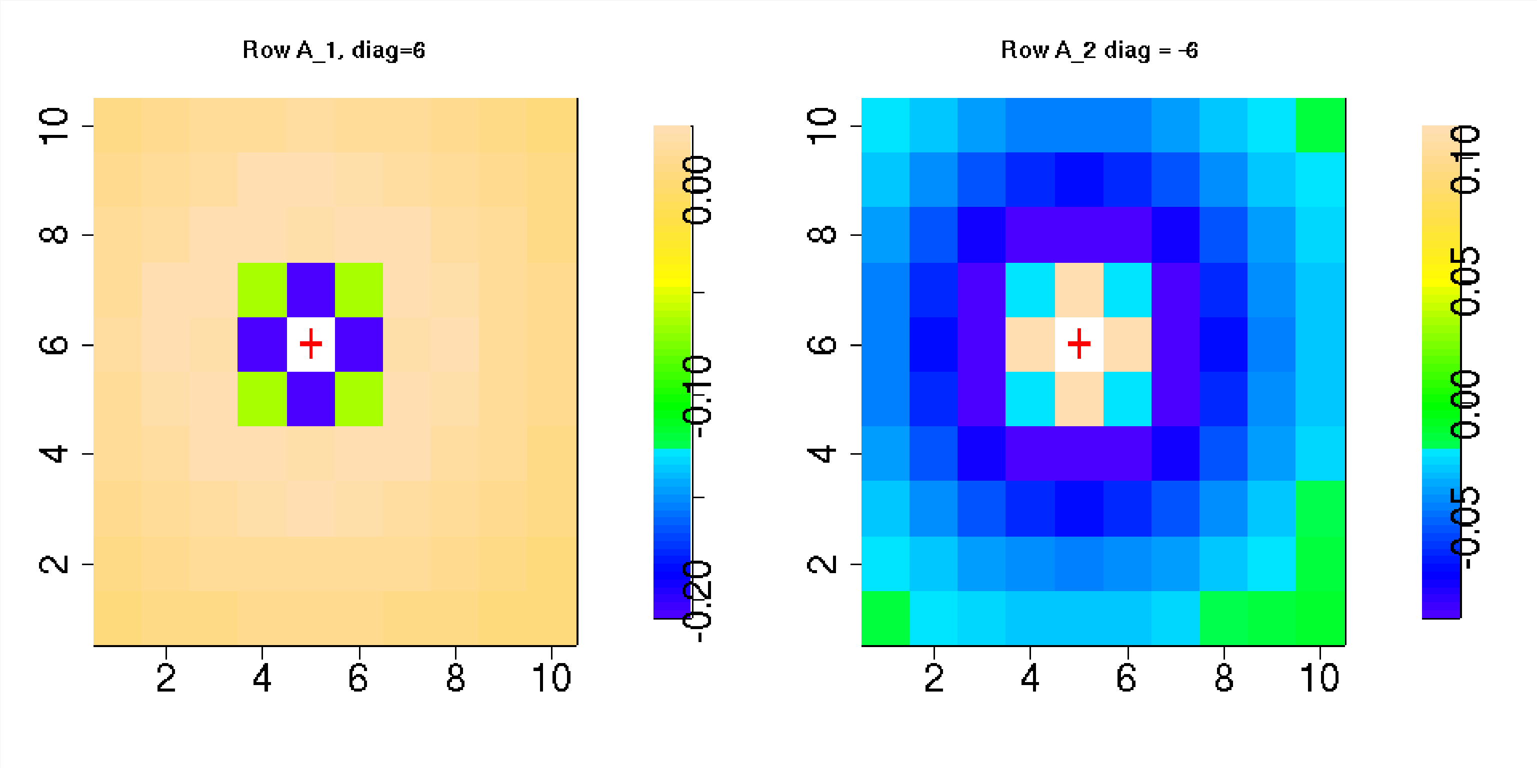
$$E(u(\boldsymbol{x},t),u(\boldsymbol{x}',t-\tau)) = \frac{A(\boldsymbol{x})A(\boldsymbol{x}')^{\tau}k(\boldsymbol{x},\boldsymbol{x}')}{1-A(\boldsymbol{x})A(\boldsymbol{x}')}, \quad \tau \geq 0$$

An example of the Genton space-time covariance



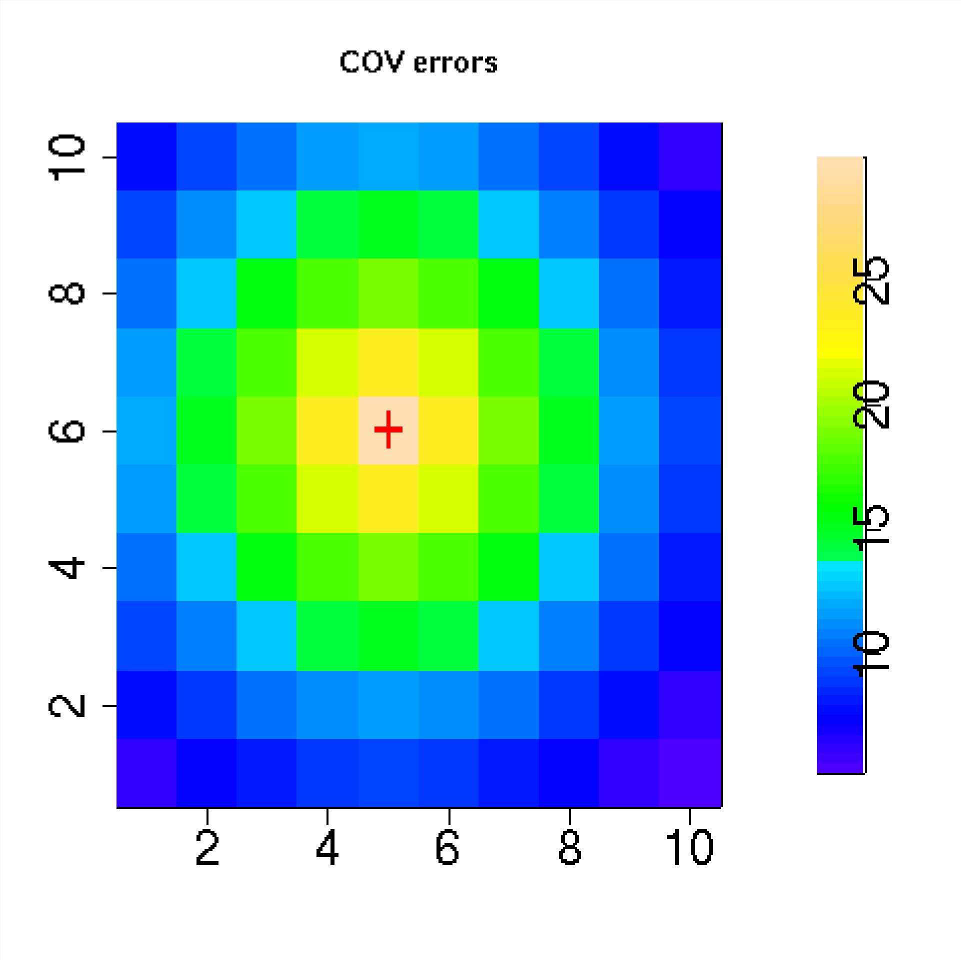
$$\alpha = .4, \gamma = .5, a = 1, C = .5$$

The Autoregressive matrices



(**Diagonal elements** ≈ 6 **for** A_1 **and** ≈ -6 **for** A_2**.**)

Spatial innovations (shocks)



Conclusions

It is very useful to explore new covariance families.

But it is important to think of process representations too.