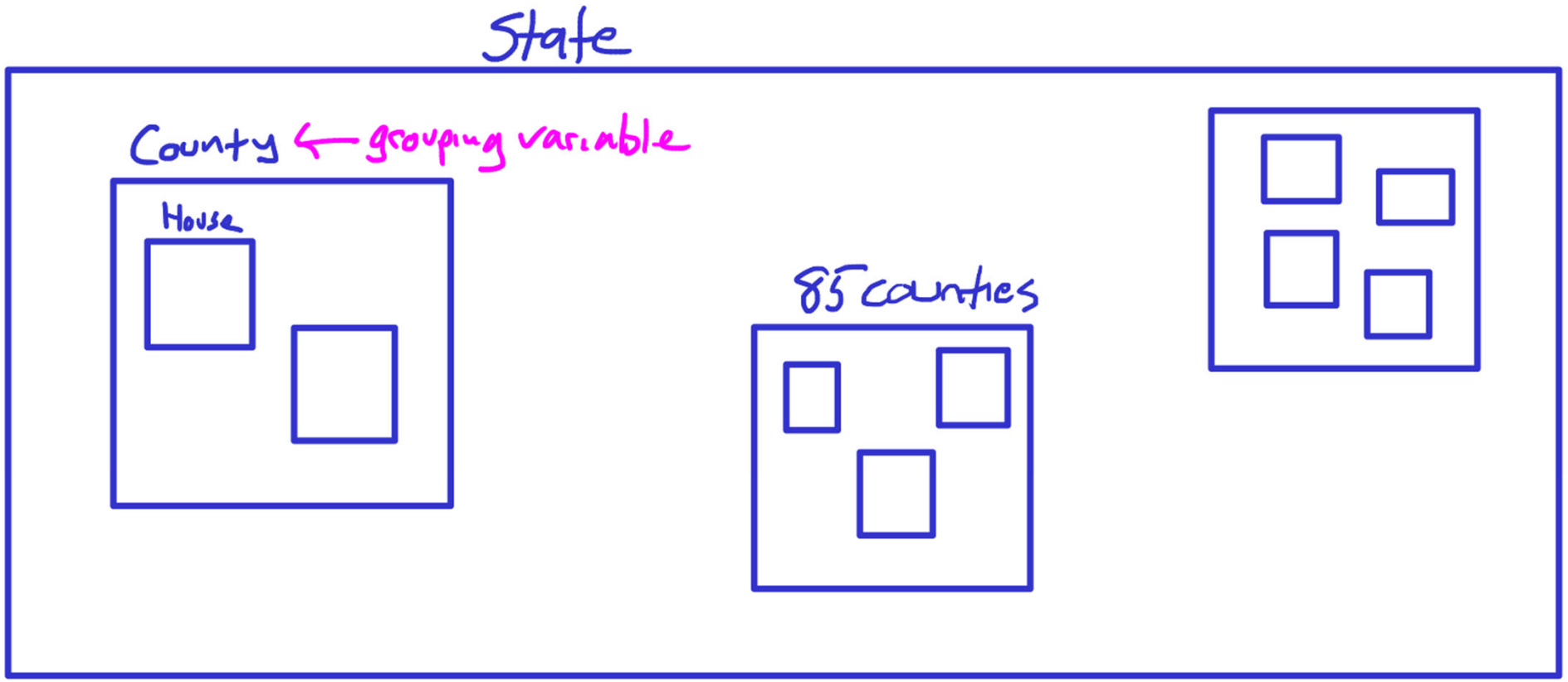
For each analysis problem

- Sketch data design
- Math equations
- Linear model syntax

Model 1: random effects

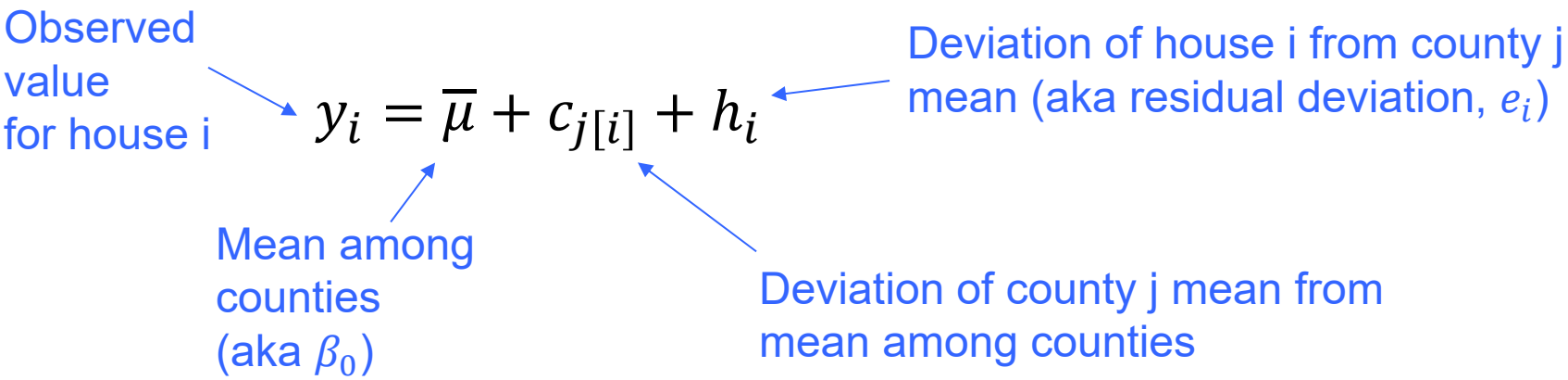


$$y_i \sim \text{Normal}\left(\mu_{j[i]}, \sigma_h^2\right) \quad \text{House scale}$$

$$\mu_j \sim \text{Normal}\left(\overline{\mu}, \sigma_c^2\right) \quad \text{County scale}$$

Alt parameterization

Additive decomposition



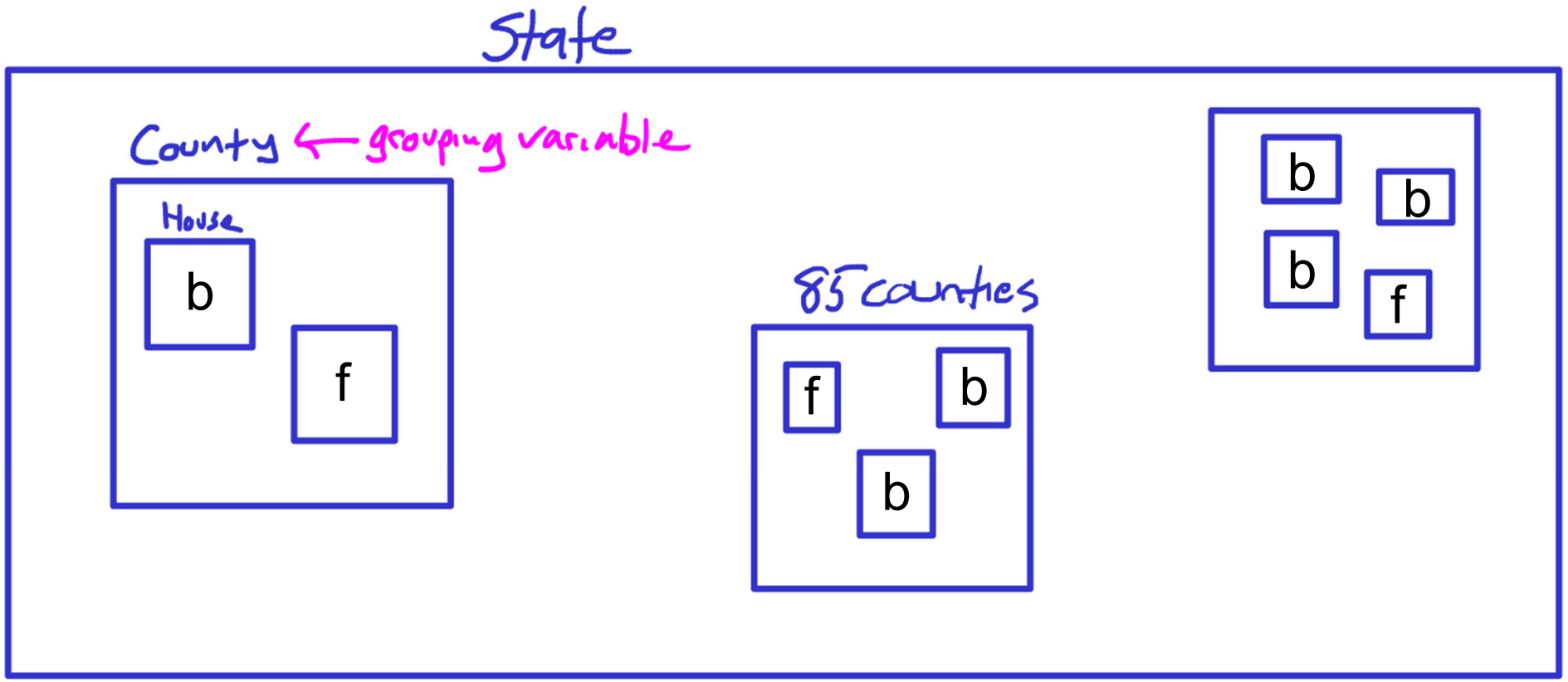
$c_j \sim \text{Normal}(0, \sigma_c^2)$ — Variance among counties within state — County-scale stochastic model

$h_i \sim \text{Normal}(0, \sigma_h^2)$ — Variance among houses within counties — House-scale stochastic model

Linear model syntax

```
log_radon ~ 1 + (1|county)
```

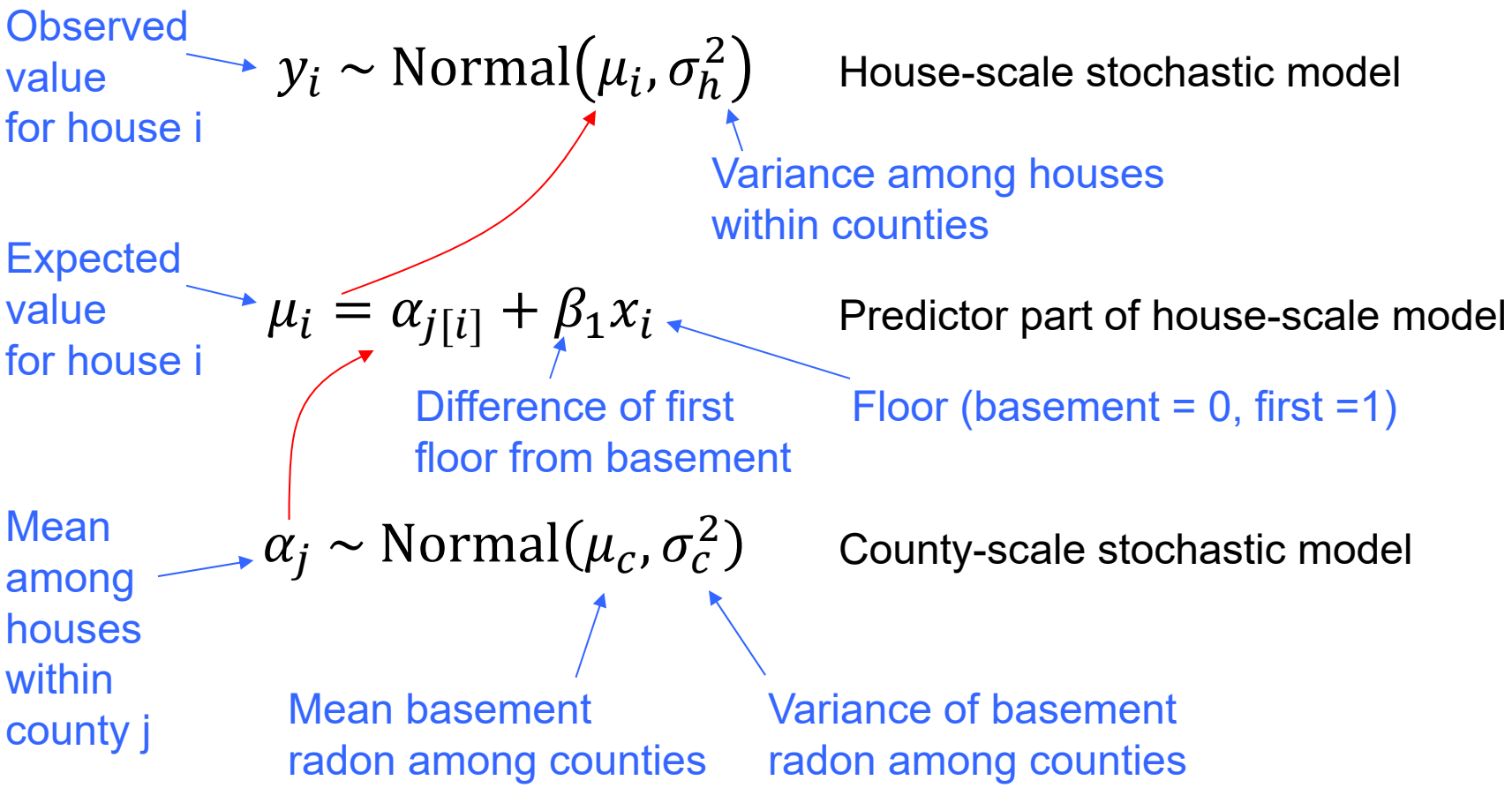
Model 2: 1 predictor



Predictor (fixed effect) is at house scale

Writing model 2

Multilevel model, with 1 predictor at house scale



Model 2: Alt parameterization

Multilevel model, with 1 predictor at house scale

Difference of first floor from basement

Floor (basement = 0, first =1)

$$y_i = \beta_0 + \beta_1 x_1 + c_{j[i]} + e_i$$

Deviation of house i from county j mean

Mean basement radon among counties

Deviation of county j mean from mean among counties

$$c_j \sim \text{Normal}(0, \sigma_c^2)$$

Variance among counties within state

County-scale stochastic model

$$e_i \sim \text{Normal}(0, \sigma_e^2)$$

Variance among houses within counties

House-scale stochastic model

Linear model syntax

```
log_radon ~ floor + (1|county)
```

Equivalent:

```
log_radon ~ 1 + floor + (1|county)
```

Model with one house-scale predictor

See 11_2_radon_multilevel_2.R
11_2_radon_multilevel_2.md