

## Comparisons of CyberShake models

- **CyberShake 1.0 uses CVM-SCEC as the velocity model and rupture generator described in Graves and Pitarka (2007)**
  - Rupture propagates more coherently
- **CyberShake 1.1 uses CVM-SCEC as the velocity model and rupture generator described in Graves and Pitarka (2010)**
  - Rupture propagates less coherently
- **We can compare CyberShake models using “averaging-based factorization” scheme (Wang and Jordan, 2013)**
  - Expected shaking intensities are constructed from a hierarchy of averaging operations over slip variations ( $s$ ), hypocenters ( $x$ ), sources ( $k$ ), and sites ( $r$ )

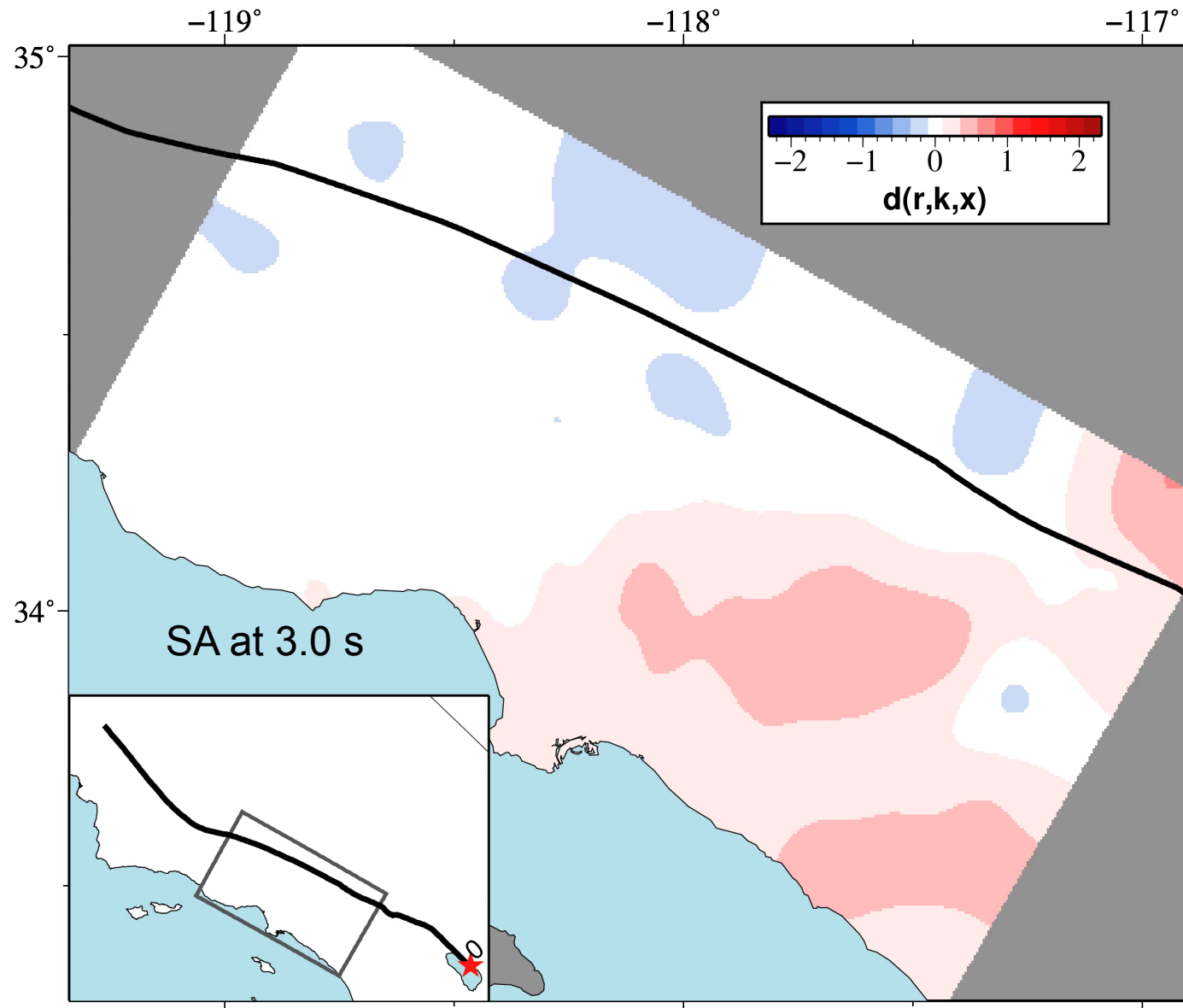
$$\begin{array}{ccccccc}
 \text{In (intensity, e.g. SA)} & & \text{site} & & \text{directivity} & & \\
 & & \text{effect} & & \text{effect} & & \\
 & & \downarrow & & \downarrow & & \\
 & & & & & & \\
 \downarrow & & & & & & \\
 G(r, k, x, s) = & A + & B(r) + & C(r, k) + & D(r, k, x) + & E(r, k, x, s) & \\
 & & \uparrow & & \uparrow & & \uparrow \\
 & & \text{level} & & \text{path effect} & & \text{slip variability} \\
 & & & & & & \text{effect}
 \end{array}$$

## Comparisons of CyberShake models

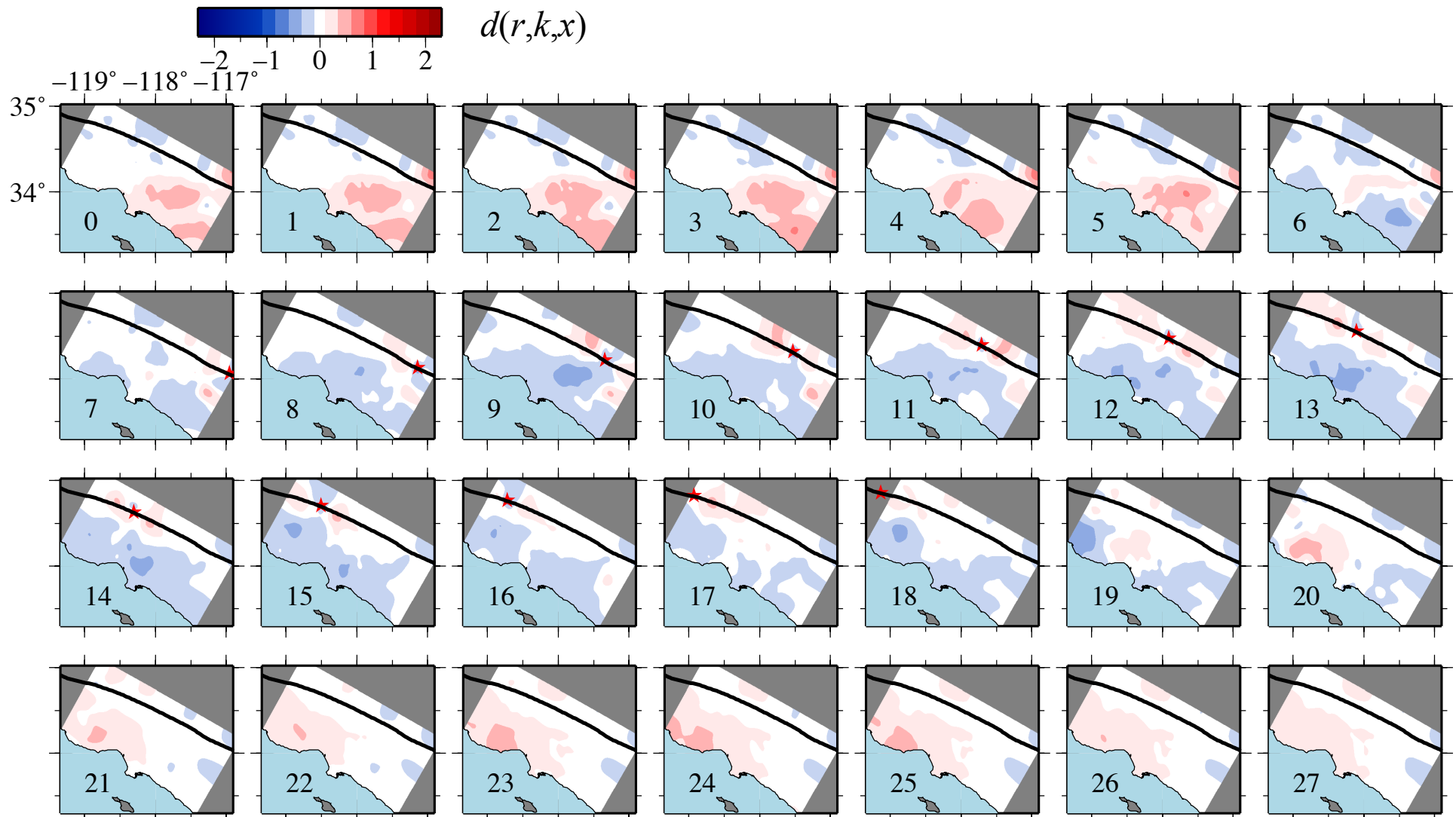
- **CyberShake 1.0 uses CVM-SCEC as the velocity model and rupture generator described in Graves and Pitarka (2007)**
  - Rupture propagates more coherently
- **CyberShake 1.1 uses CVM-SCEC as the velocity model and rupture generator described in Graves and Pitarka (2010)**
  - Rupture propagates less coherently
- **We can compare CyberShake models using “averaging-based factorization” scheme (Wang and Jordan, 2013)**

$$\begin{aligned} & G^{(1.0)}(r, k, x, s) - G^{(1.1)}(r, k, x, s) \\ & = a + b(r) + c(r, k) + d(r, k, x) + e(r, k, x, s) \end{aligned}$$

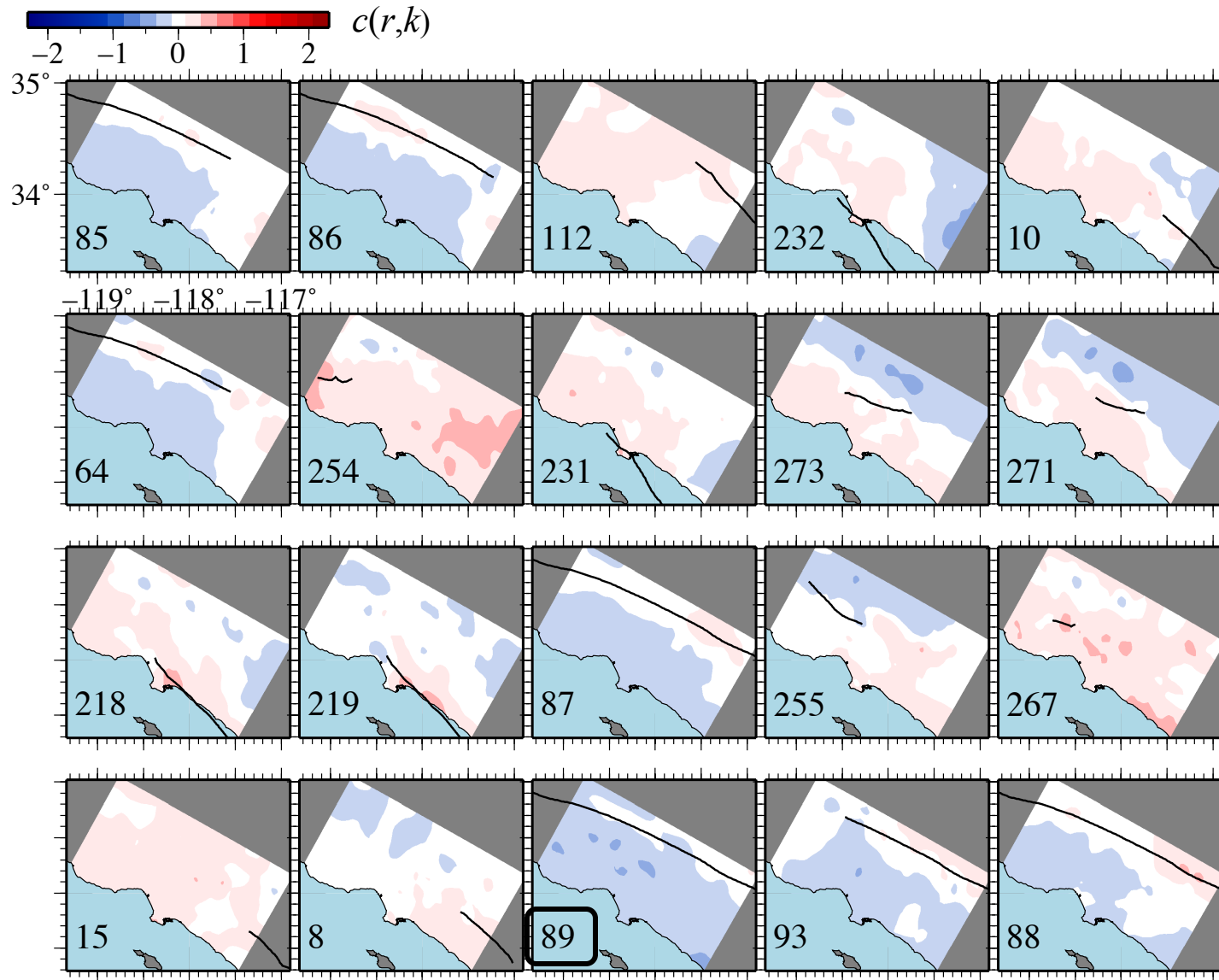
## Directivity effects are smaller in CyberShake 1.1 than CyberShake 1.0



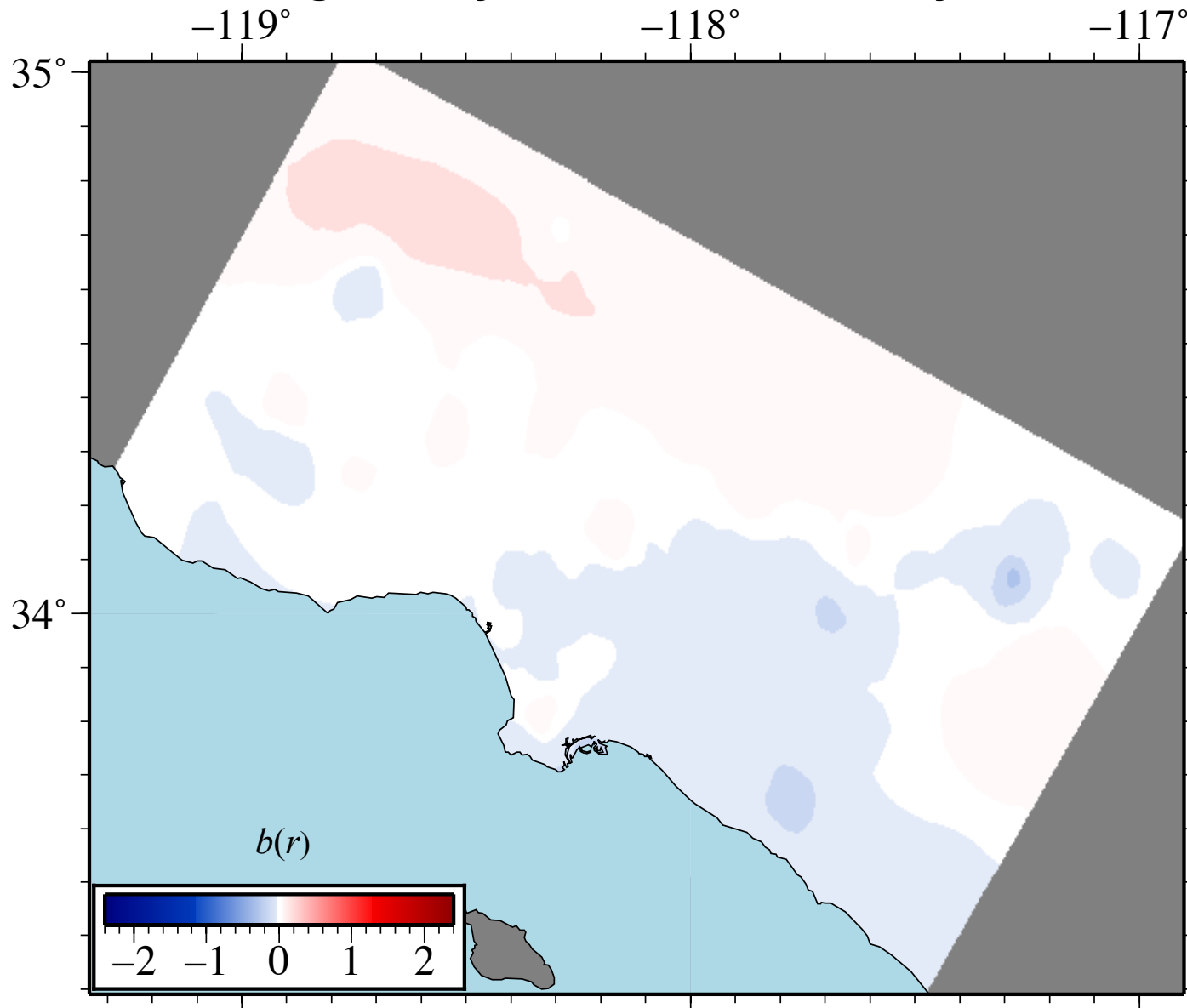
# Directivity effects are smaller in CyberShake 1.1 than CyberShake 1.0



# Path effects are larger in CyberShake 1.1 than CyberShake 1.0



## Basin effects are larger in CyberShake 1.1 than CyberShake 1.0



## Discussion

- **CyberShake 1.1**
  - **More randomness and heterogeneities in slip and rupture propagations -> more seismic wave energy radiated from a source**
- **Comparison of CyberShake 1.0 and 1.1 (for SA at 3.0 s)**
  - **CyberShake 1.1 shows smaller directivity and directivity-basin coupling effects, but larger basin effects due to basin-guide wave excitations**