

# Mantle structures beneath the northern Reelfoot Rift and southern Illinois Basin

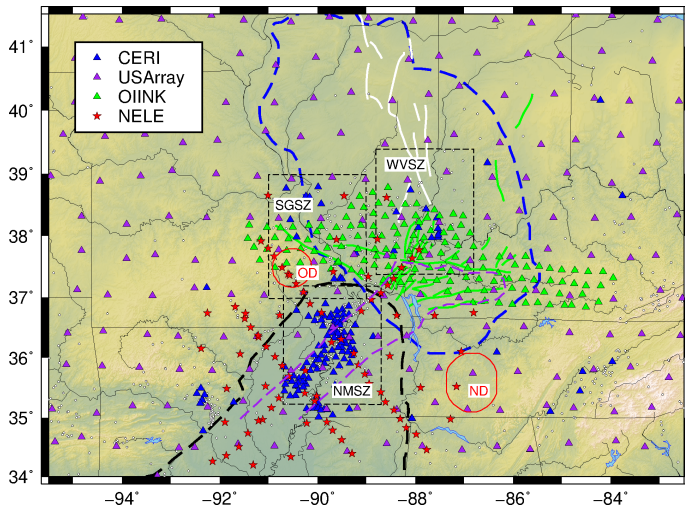
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# Overview

- ▶ Previous studies
  - ▶ Low-velocity zone beneath the RR [Pollitz and Mooney, 2014]
  - ▶ Structural variations in the upper mantle [Biryol et al., 2016]
  - ▶ High crustal  $v_s$  [Chen et al., 2016]
- ▶ Unanswered questions
  - ▶ Relation between the RR and the IB
  - ▶ Relation between mantle structures and seismic zones
  - ▶ Does the LVZ beneath ME extend to the transition zone?
- ▶ Research target
  - ▶  $v_p$ ,  $v_s$ , and  $v_p/v_s$  structures to transition zone depths beneath the upper RR and lower IB

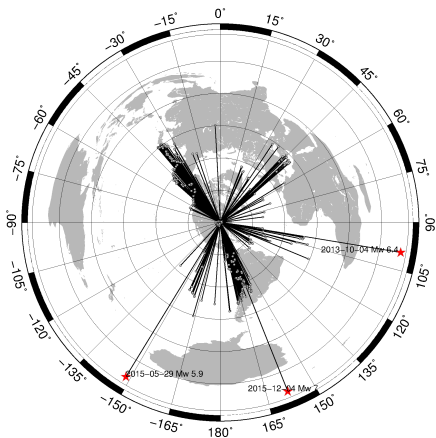
# Data and method

## Stations (2011-2015)

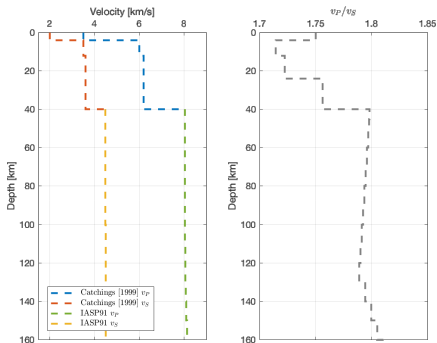


# Data and method

## Azimuth coverage

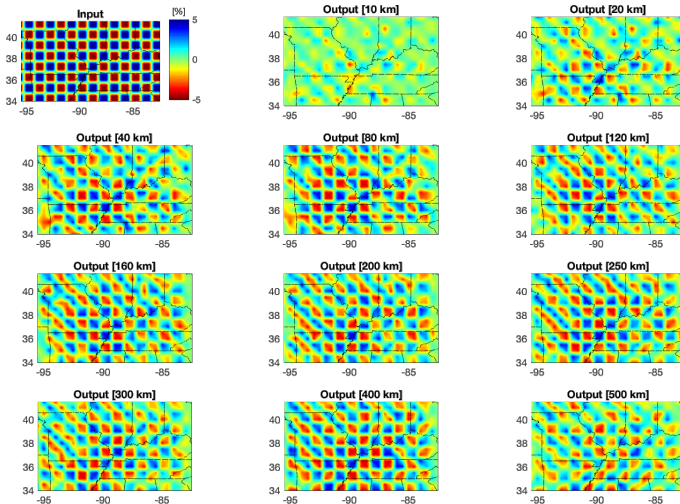


## Starting models



# Synthetic test

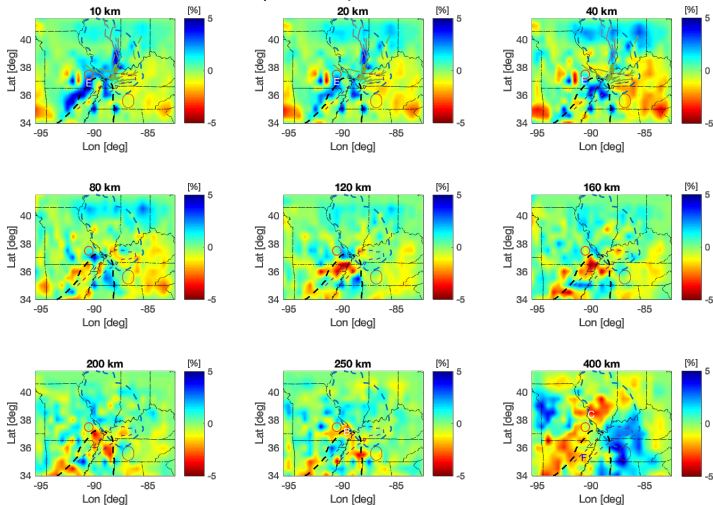
## P-wave checkerboard models



# Results (map view)

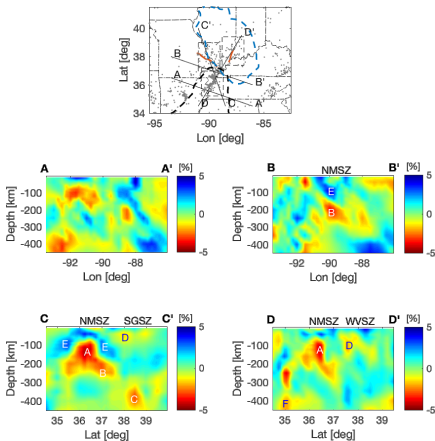
$v_p$  model

(The  $v_s$  model is similar to the  $v_p$  model)

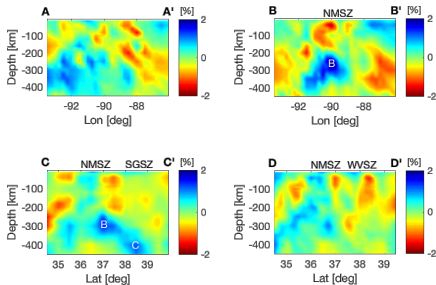


# Cross-section views

$v_p$  model

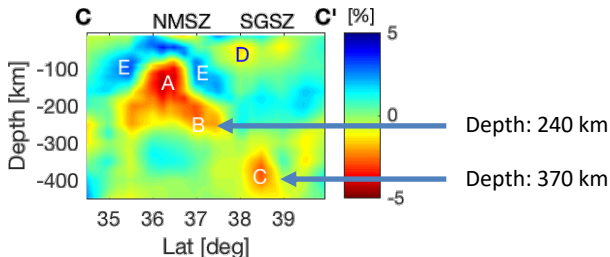


$v_p/v_s$  ratio



## Interpretation

- ▶ LVZ below the NMSZ (labeled A)
  - ▶ Bermuda hotspot [Pollitz and Mooney, 2014]
  - ▶ Counter flow [Biryol et al., 2016]
  - ▶ Rifting origin [Chen et al., 2016]
- ▶ LVZ below the IB (labeled B and C)
  - ▶  $v_s$  anomalies are larger than  $v_p$  anomalies (in %)





# Interpretation

## ► Factors that reduce mantle velocities

- Water (reduces  $v_s$  more than  $v_p$ )
- Mg# (reduces  $v_s$ )
- Temperature (reduces  $v_s$  more than  $v_p$ )
- Orthopyroxene (reduces  $v_p$  more than  $v_s$ )

$$Mg\# = 100 \times \frac{Mg}{Mg + Fe}$$

## ► Calculations

### Anomaly B at 240 km

- Reduced Mg# (94 → 86)
- Solubility of water: 900 ppm
- Temperature elevation:  $170 \pm 10^\circ\text{C}$
- Opx volume fraction: ~60%

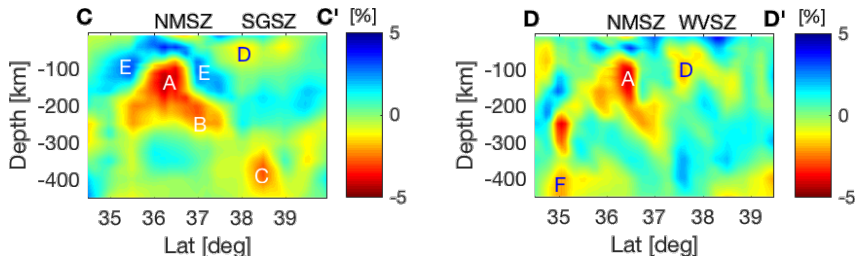
### Anomaly C at 370 km

- Reduced Mg# (94 → 86)
- Solubility of water: 1500 ppm
- Temperature elevation:  $100 \pm 10^\circ\text{C}$
- Opx volume fraction: ~50%

## Implications for flat slab subduction

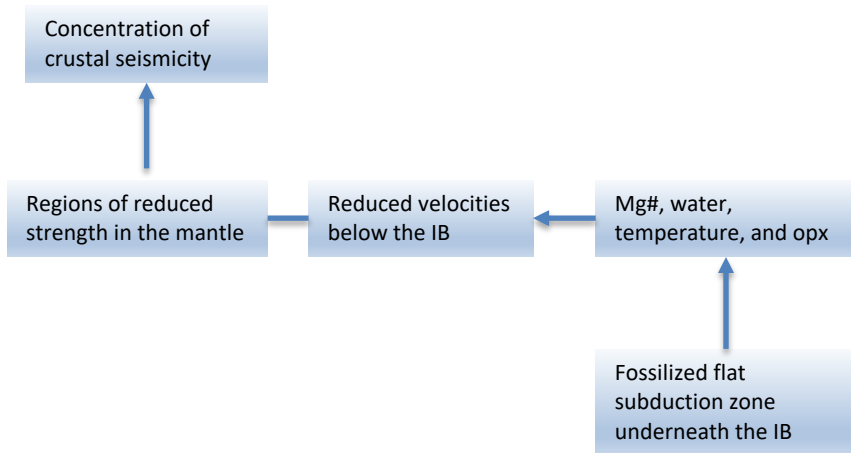
- ▶ Flab slab underneath the ME [e.g., Liu et al., 2008; 2010]
  - ▶ Does not exert a pull force
  - ▶ Incapable of further penetration
- ▶ Processes that may weaken SCLM [Kusky et al., 2014]
  - ▶ Hydration
    - ▶ May help explain the saturation of water at 240 km and 370 km
  - ▶ Influx of fertile mantle
    - ▶ May help explain temperature, Mg#, opx content

## Implications for intraplate seismicity



- ▶ Common factors that weaken mantle materials
  - ▶ Increased iron [Zhao et al., 2009]
  - ▶ The incorporation of water [e.g. Demouchy et al., 2012]
- ▶ Numerical modeling
  - ▶ Stress transfer to the upper crust [Kenner and Segall, 2000]

# Conclusions



# Acknowledgement

- ▶ Dataset, Moho depth, etc.
  - ▶ Cecilia Nyamwandha
  - ▶ Hersh Gilbert (Purdue University)
  - ▶ ...
- ▶ Software package
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  - ▶ Dapeng Zhao (Tohoku University)
  - ▶ ...
- ▶ Grants to access NELE and OIINK
  - ▶ Charles Langston
  - ▶ Christine Powell