What geologic processes could influence vertical land motions in the Chesapeake Bay?

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Background

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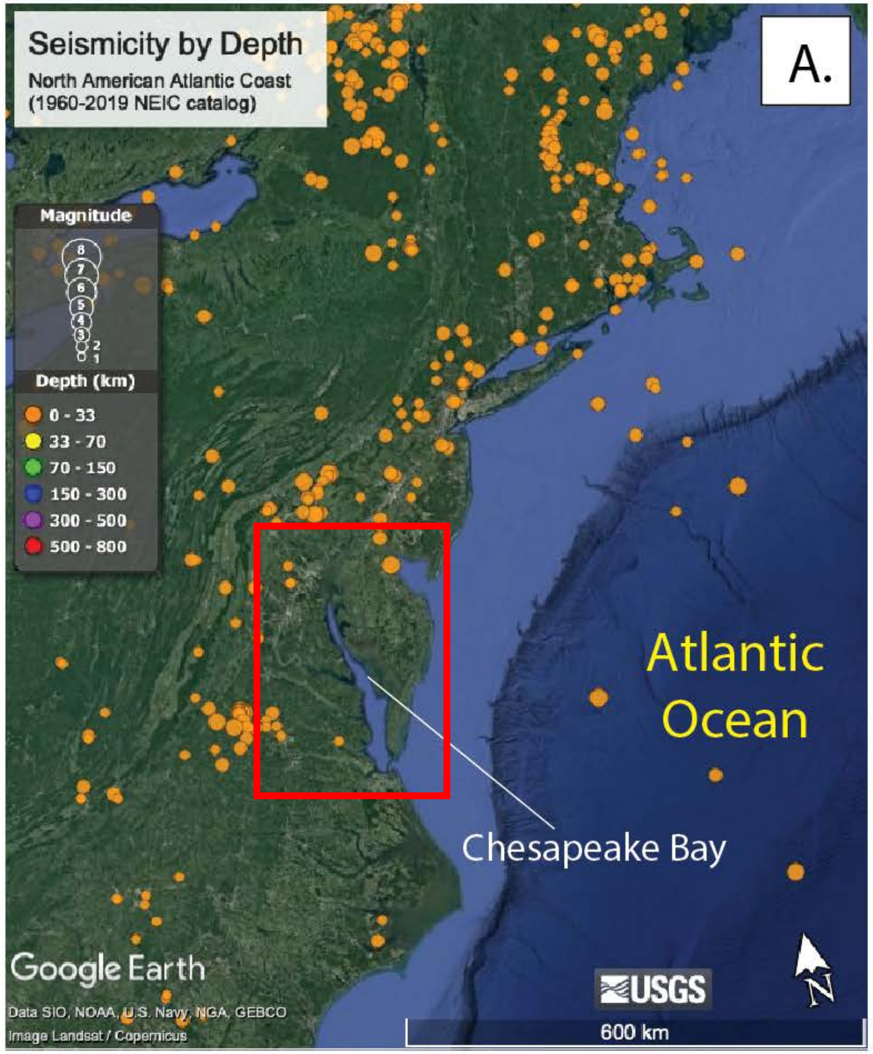
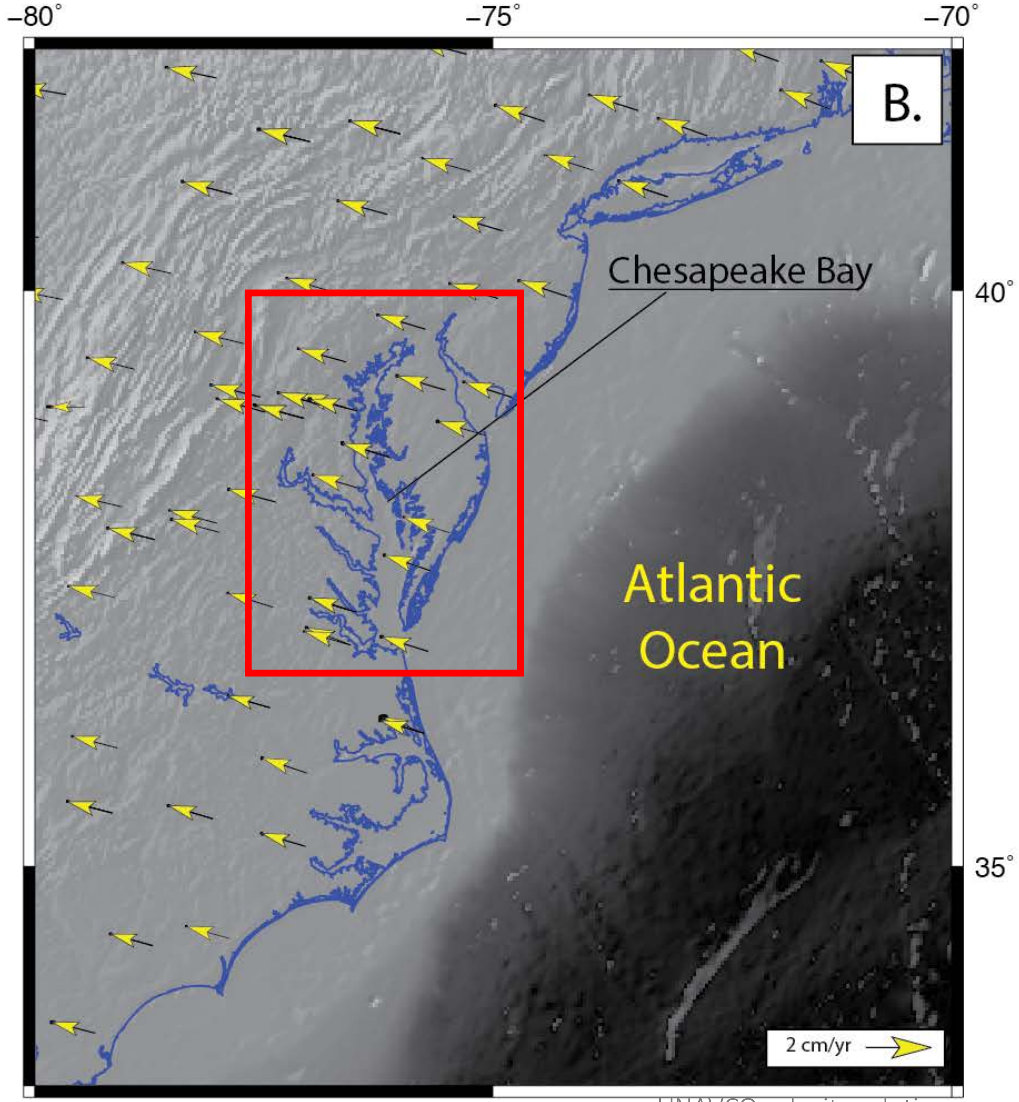
Tectonic Setting of the Chesapeake Bay

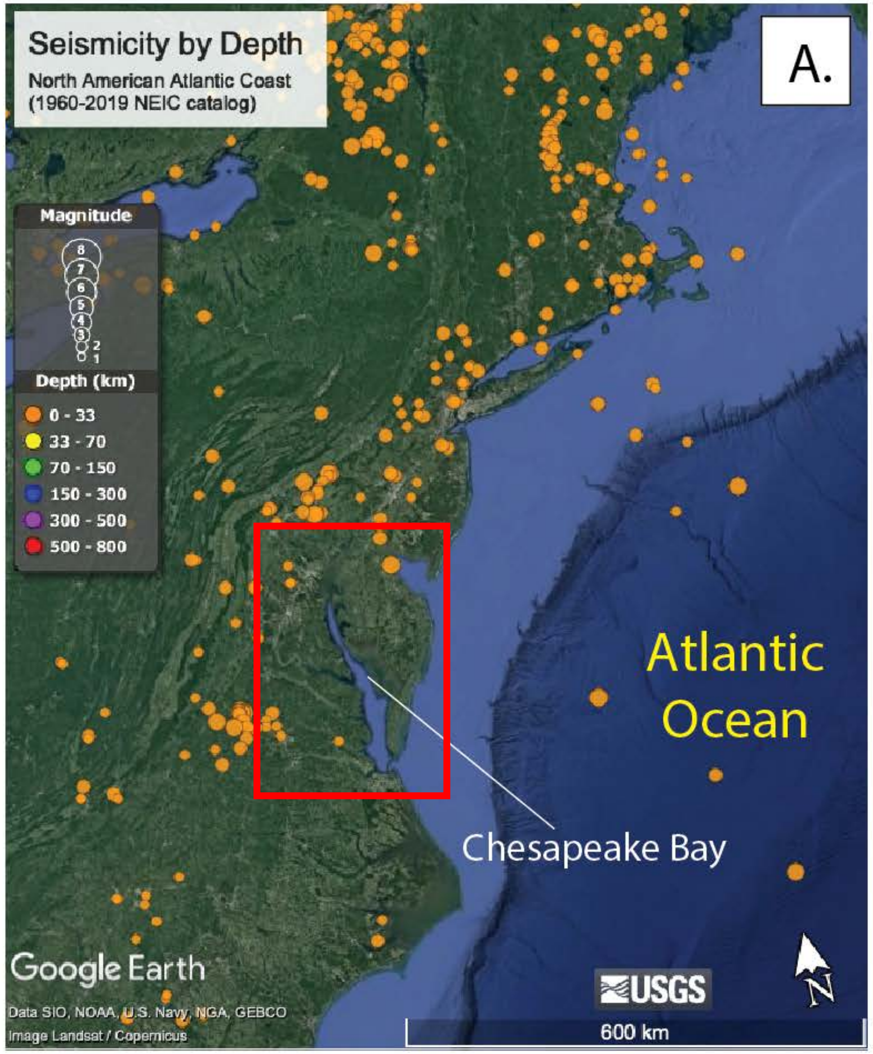




UNAVCO velocity solution

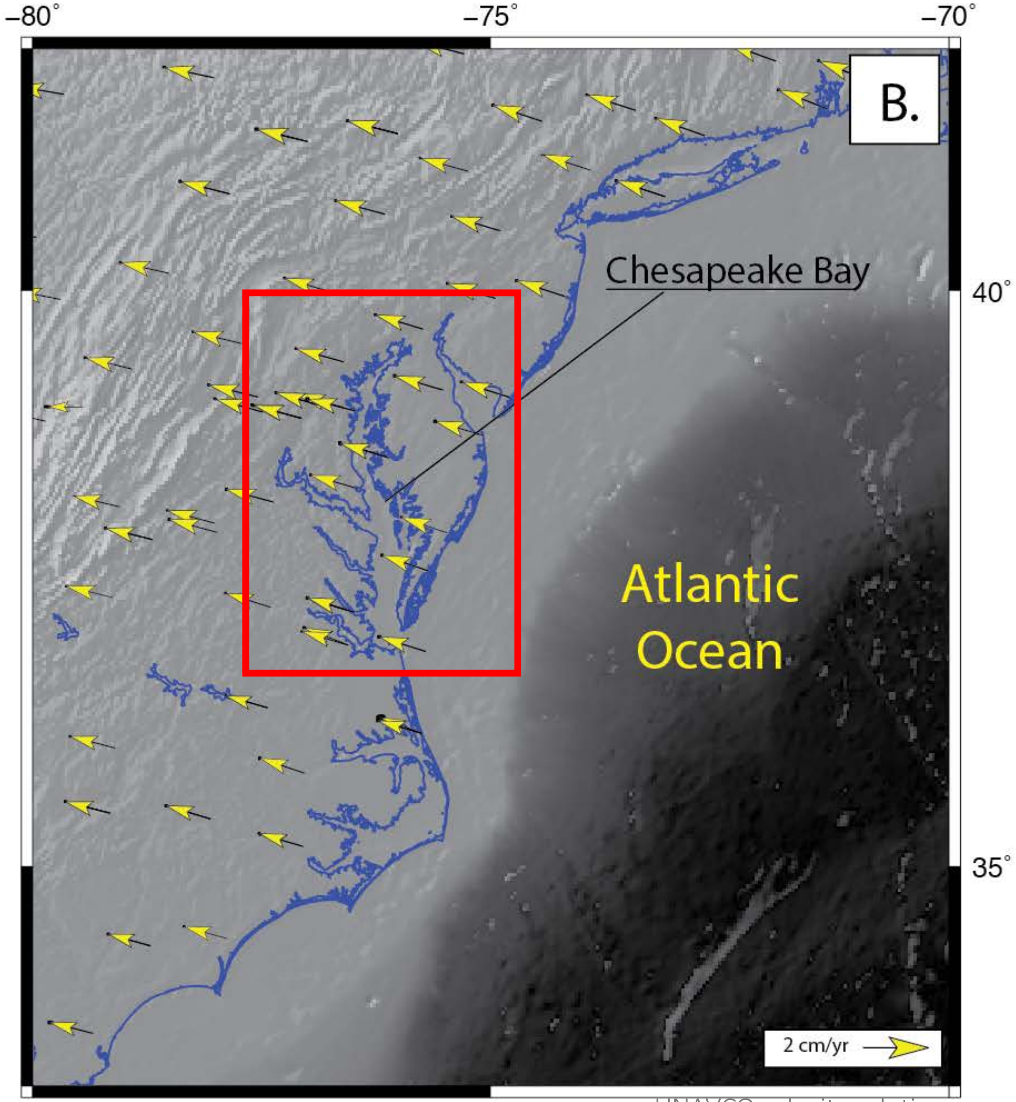
Minimal Seismic Activity

0-33 km depth



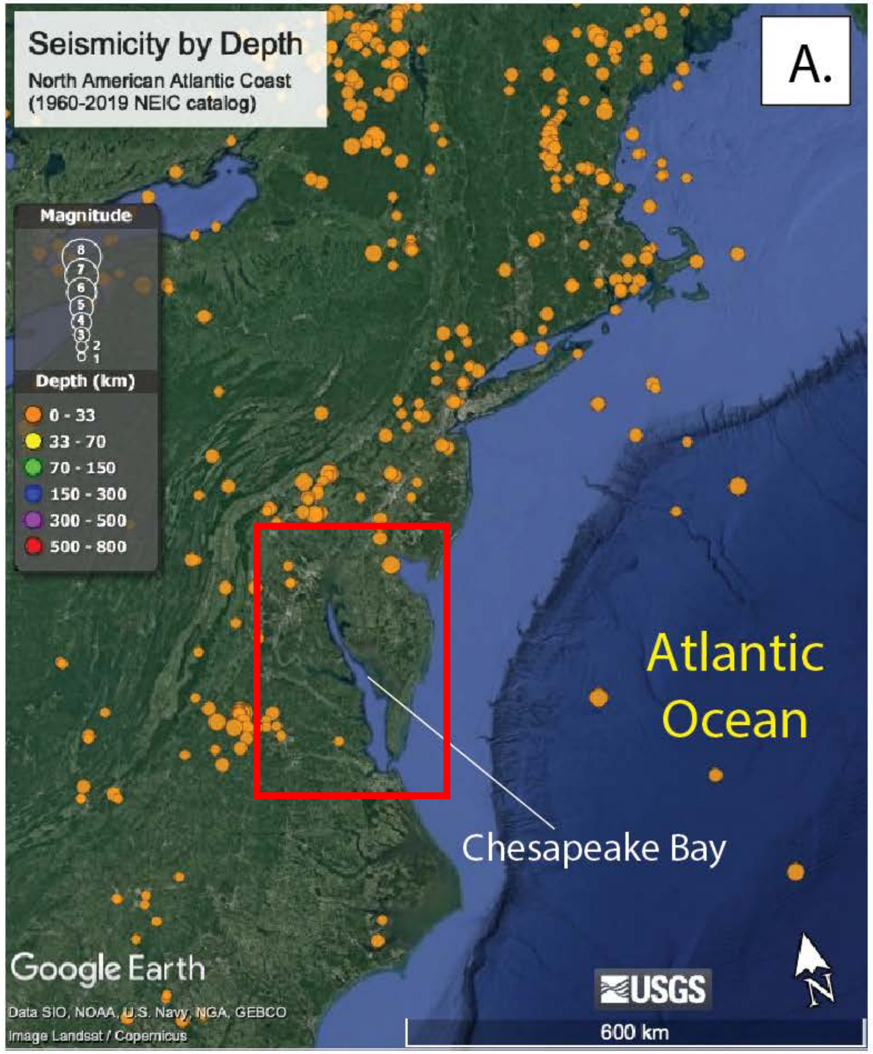
Rigid Plate Rotation

Not on a tectonic plate boundary

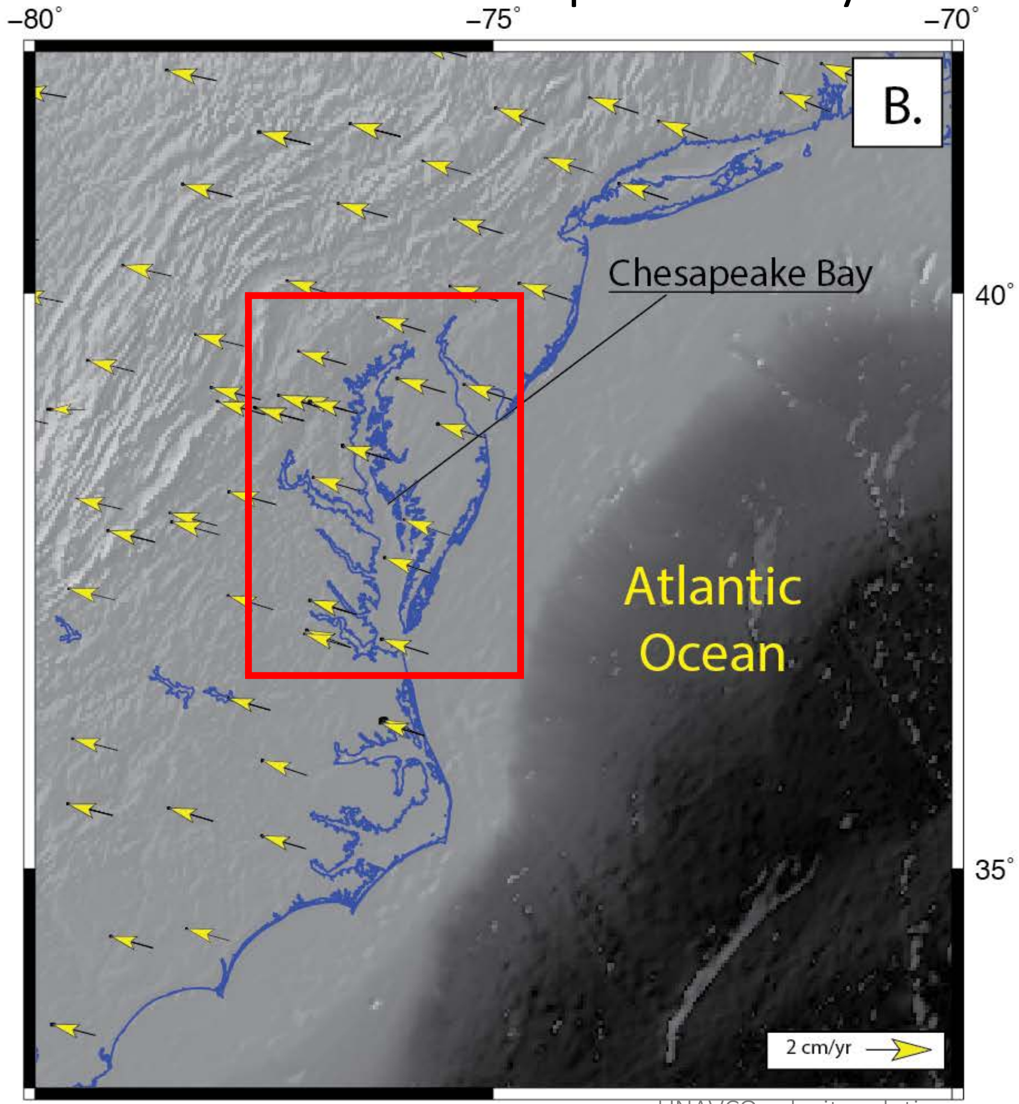


UNAVCO velocity solution

No active volcanism

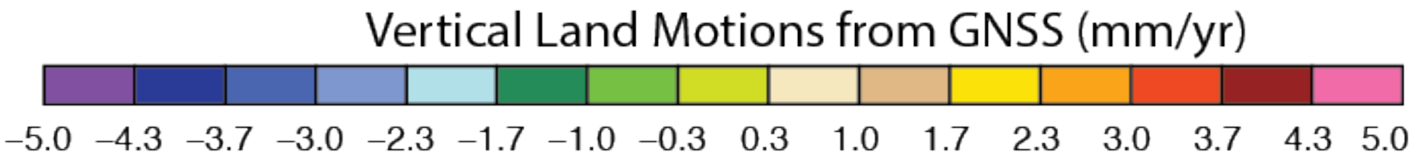


No expected tectonic influence on the Chesapeake Bay

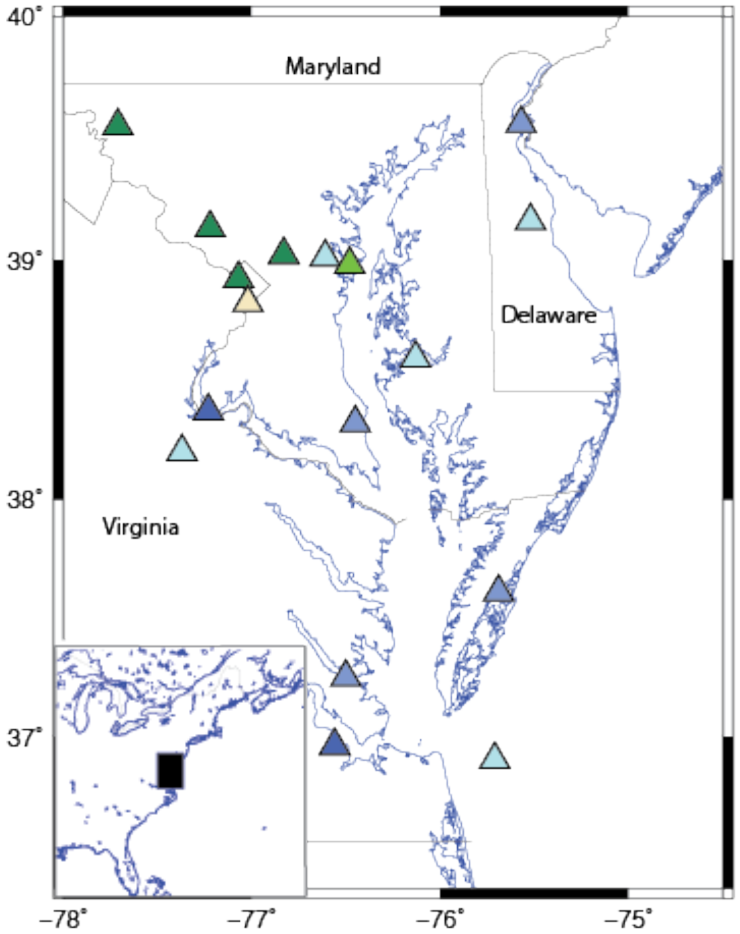


UNAVCO velocity solution

Existing Estimates of Vertical Land Motions from GPS

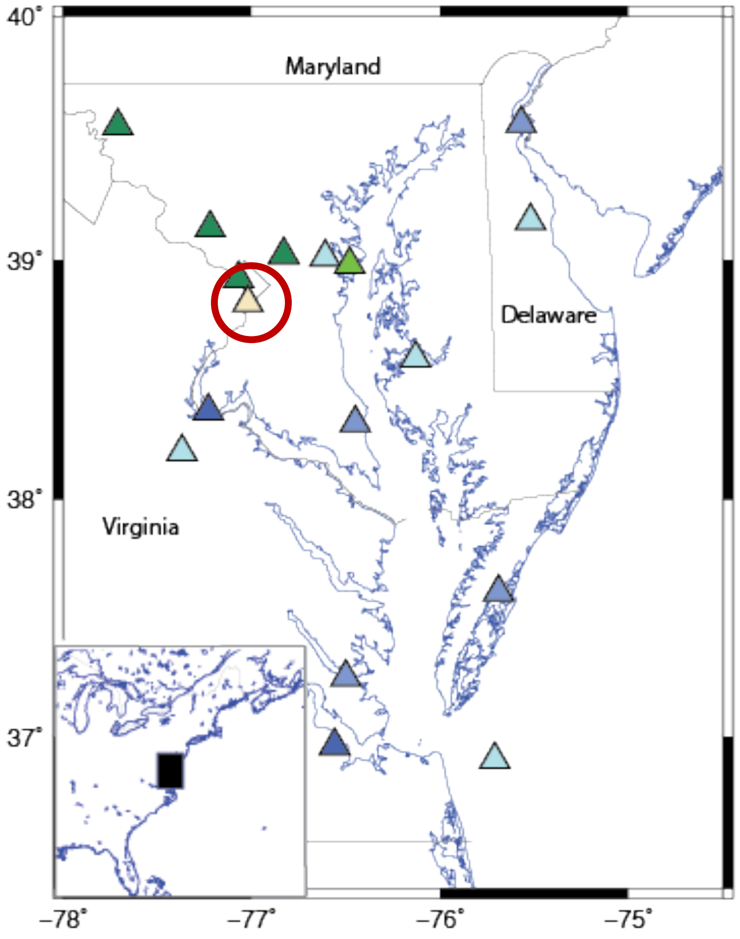


Peltier et al. (2015)



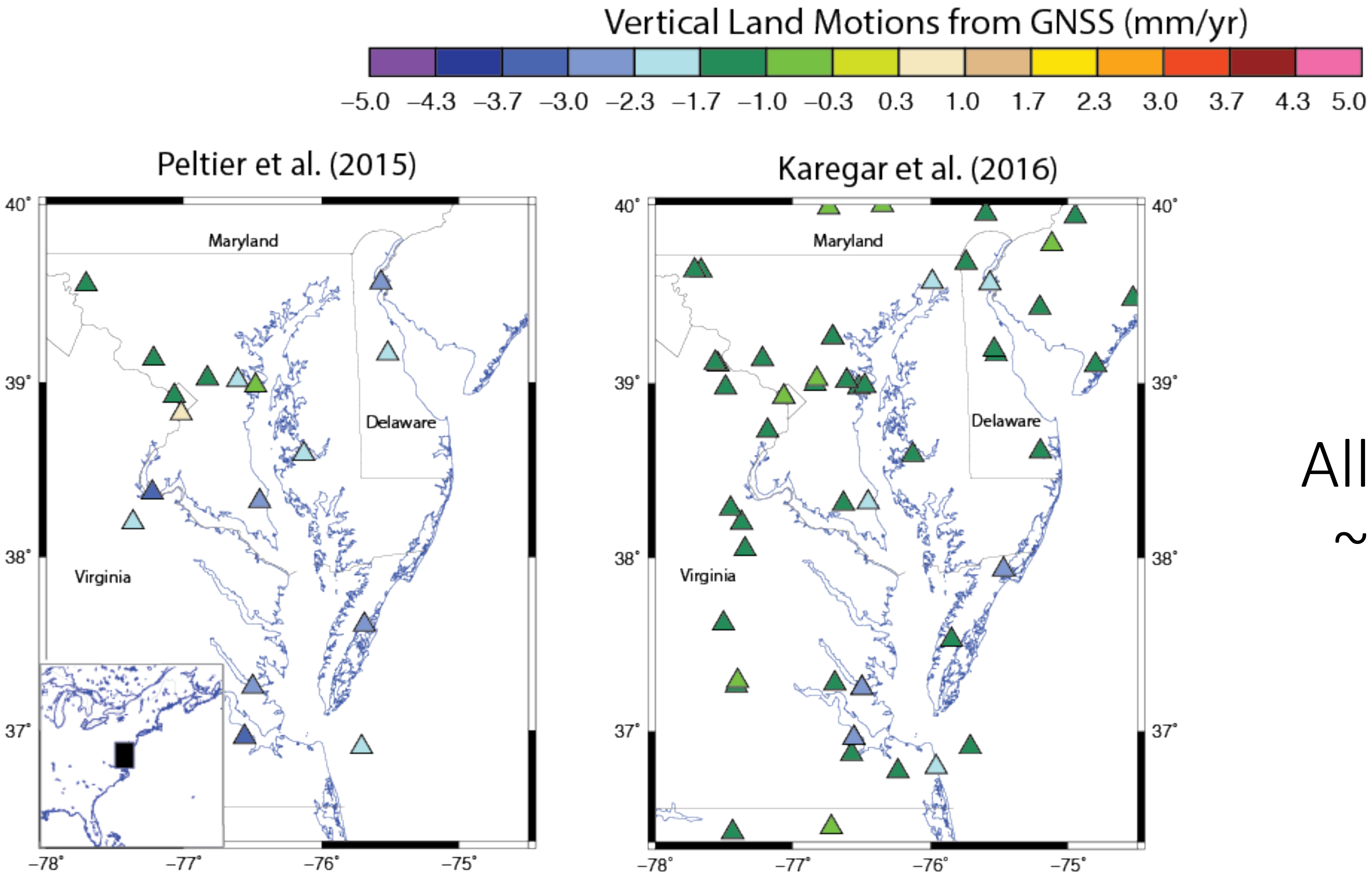
Existing Estimates of Vertical Land Motions from GPS

Peltier et al. (2015)



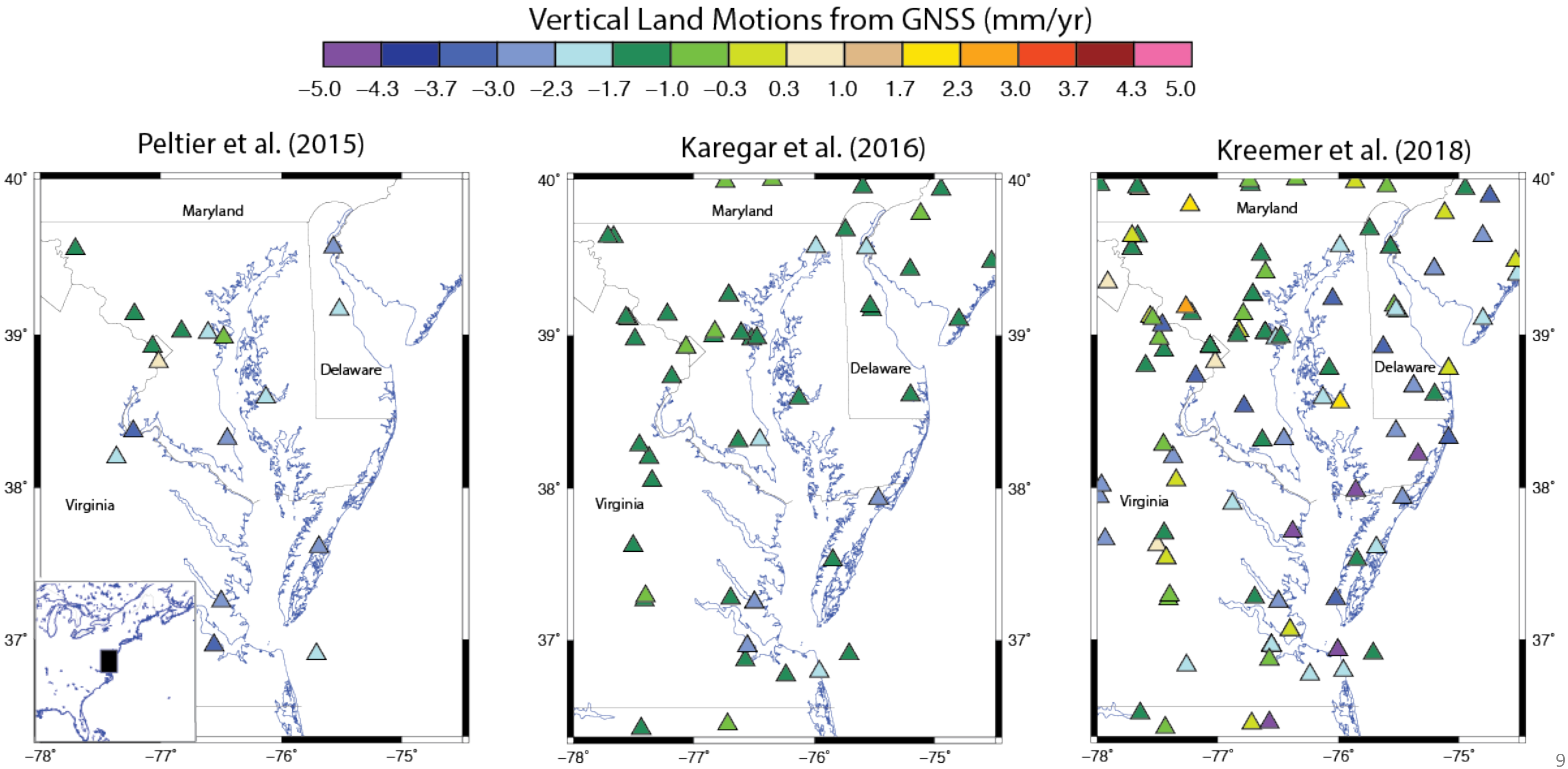
Uplifting site ~2 mm/yr
Subsidence ~0.5-4 mm/yr

Existing Estimates of Vertical Land Motions from GPS

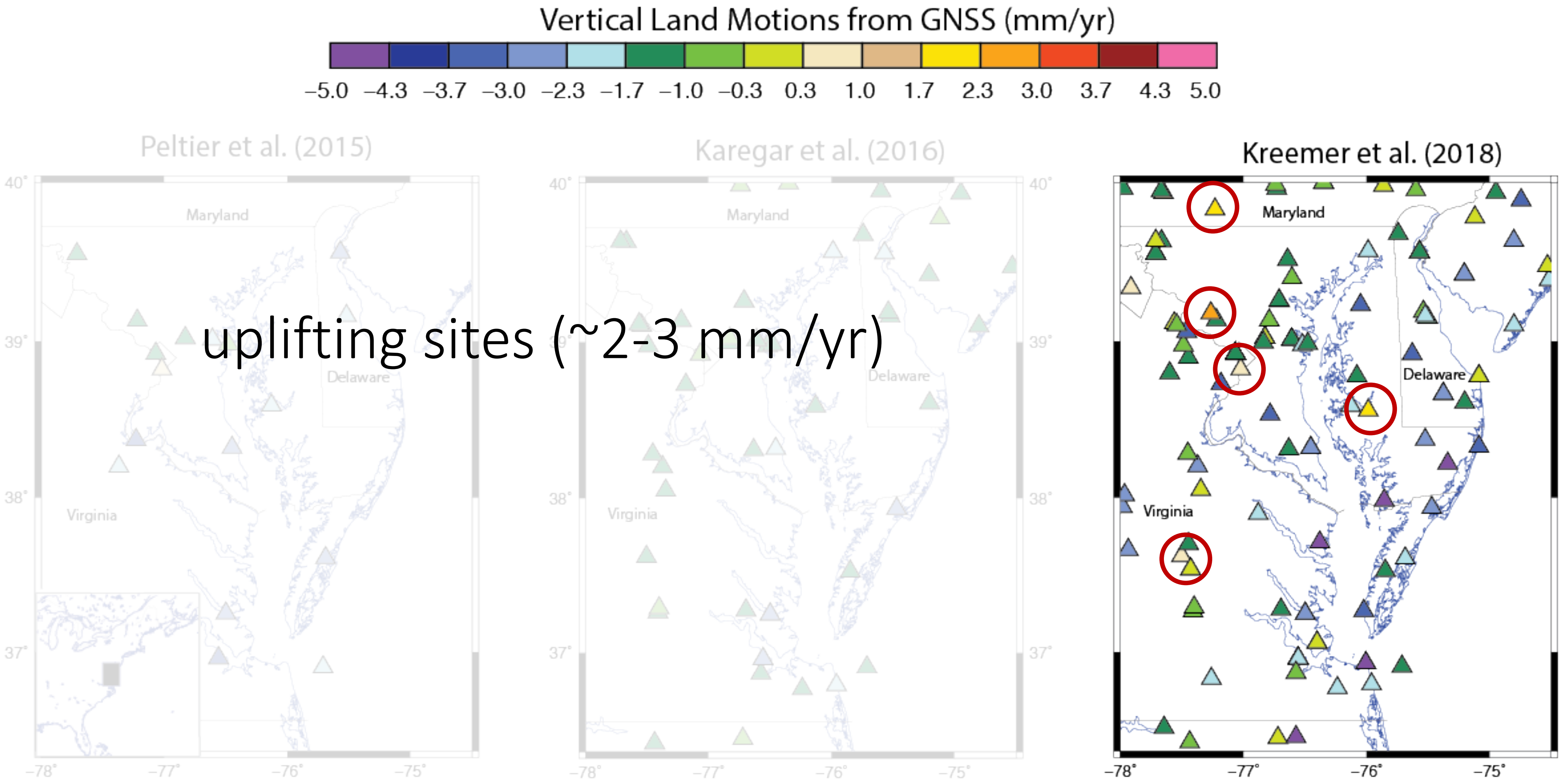


All subsidence ~1-2 mm/yr

Existing Estimates of Vertical Land Motions from GPS

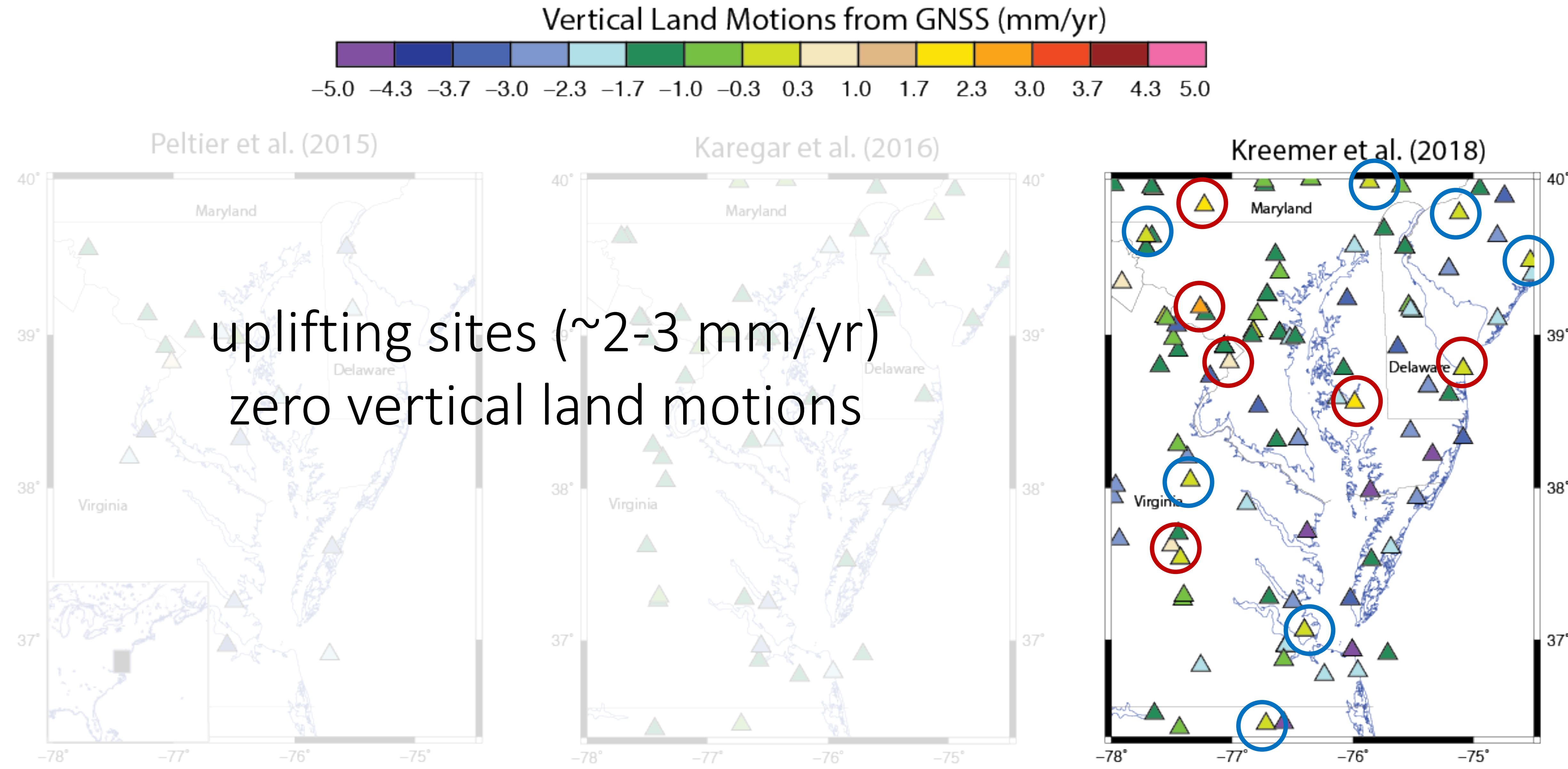


New VLM Estimates Inconsistent with Prior Work



uplifting sites (~2-3 mm/yr)

New VLM Estimates Inconsistent with Prior Work



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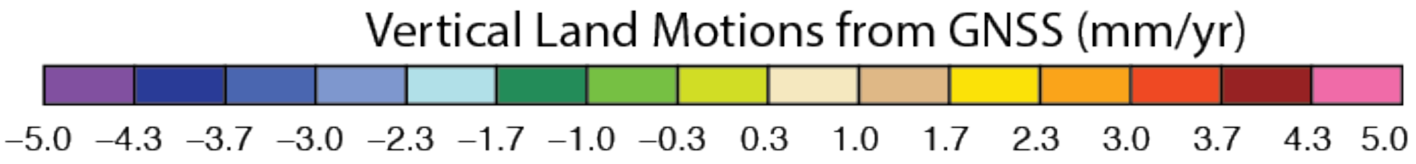
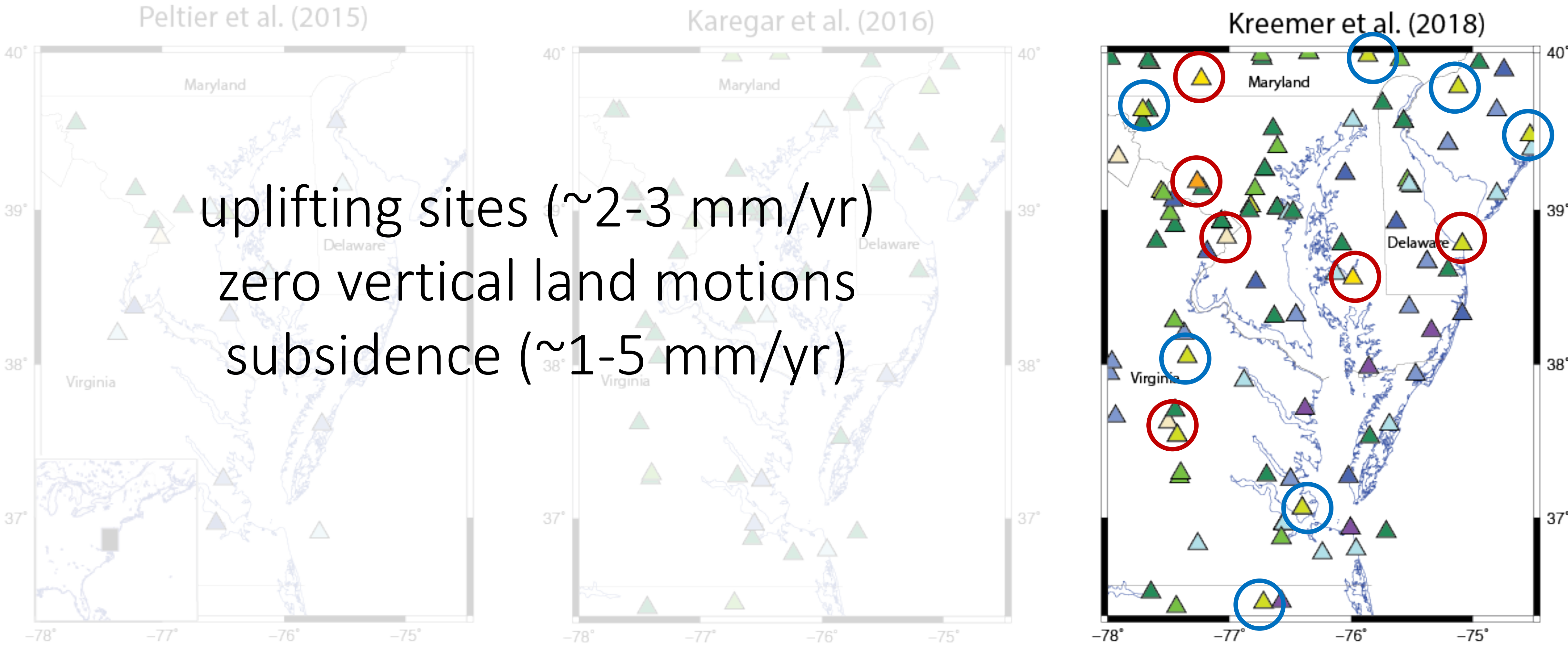


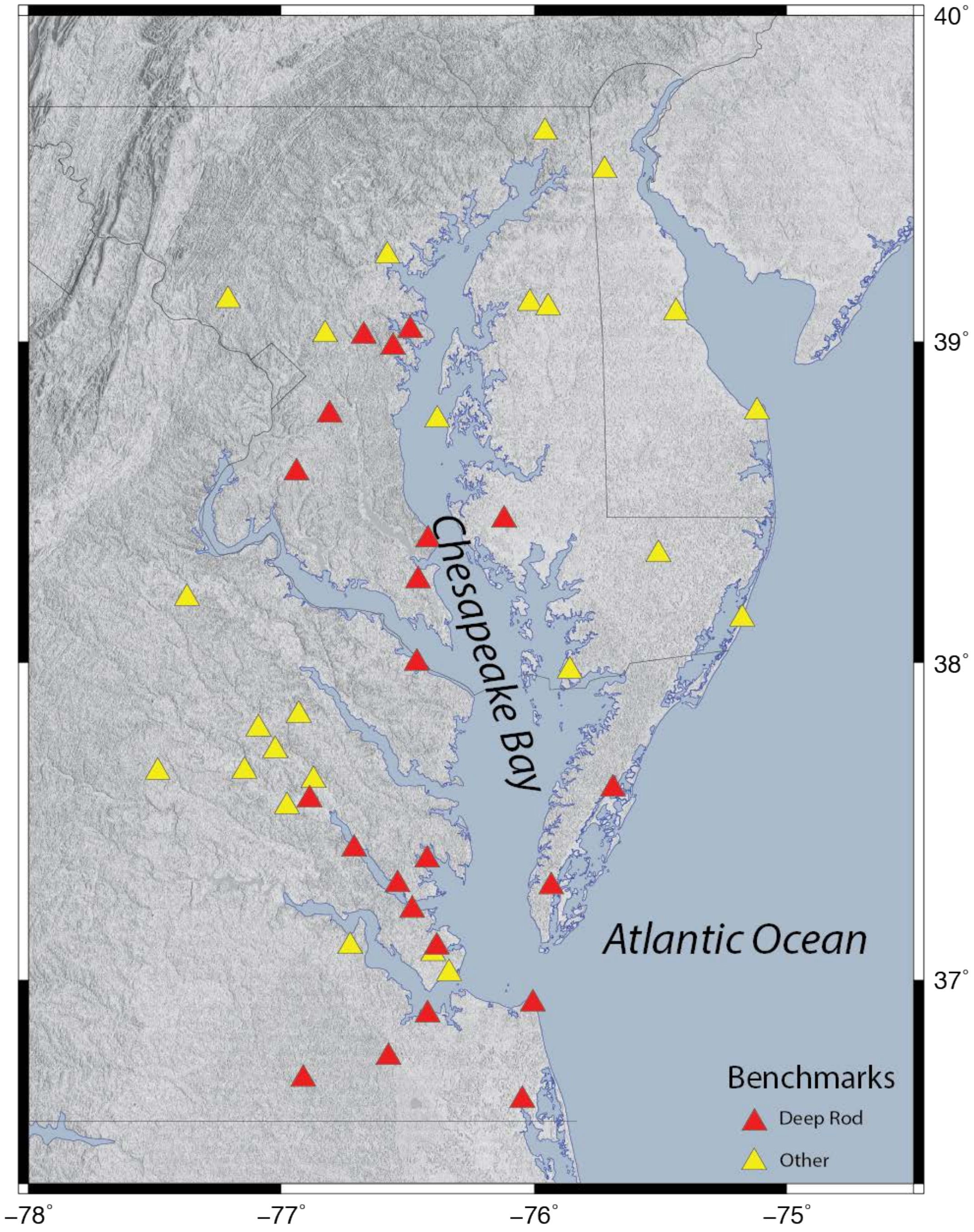


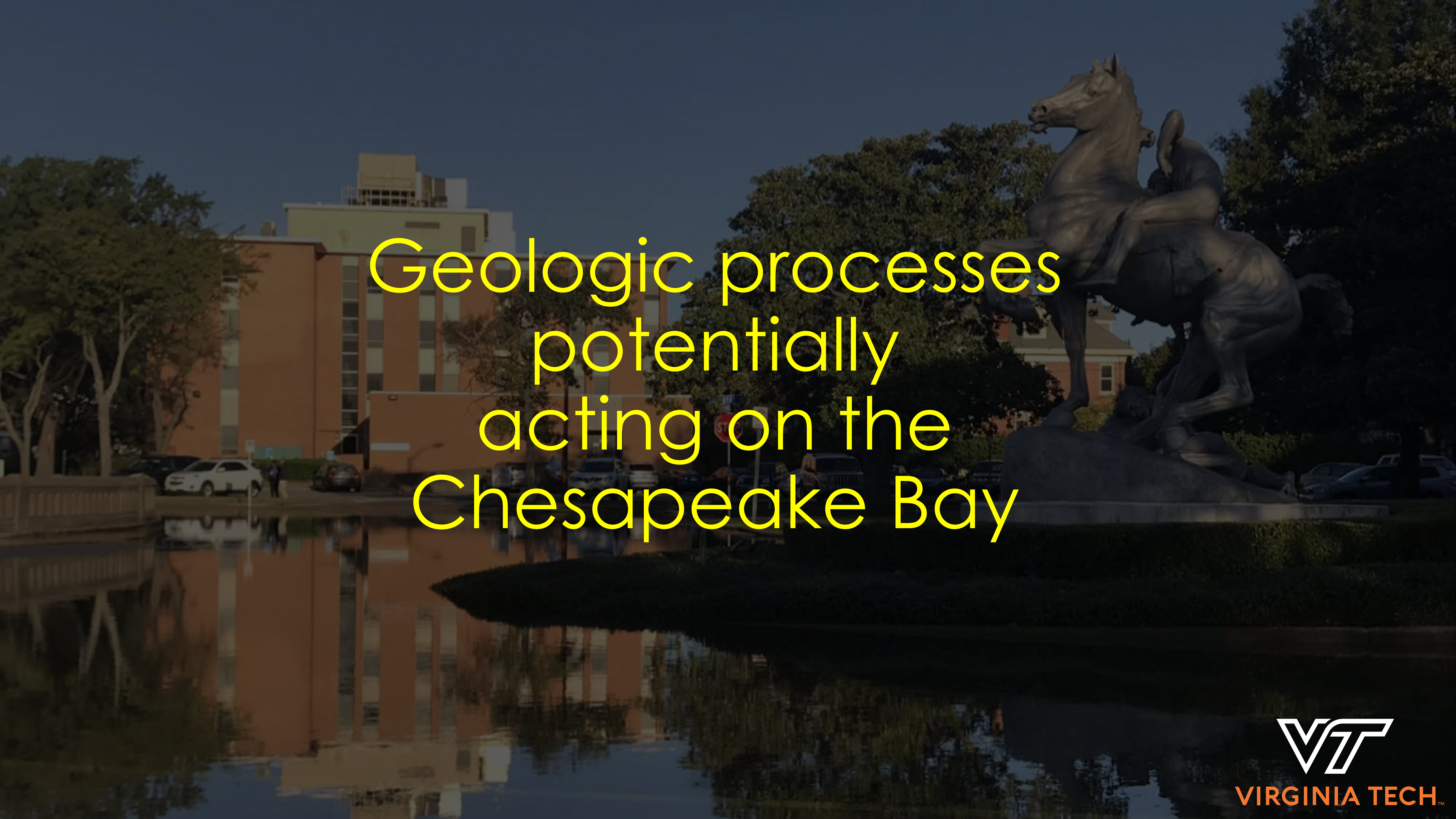
uplifting sites (~2-3 mm/yr)
zero vertical land motions
subsidence (~1-5 mm/yr)

Towards a new baseline of present-day Chesapeake Bay vertical land motions

USGS, NGS, Virginia Tech, Hampton University

Will use new constraints to test influences of geologic processes





Geologic processes potentially acting on the Chesapeake Bay

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Glacial Isostatic Adjustment

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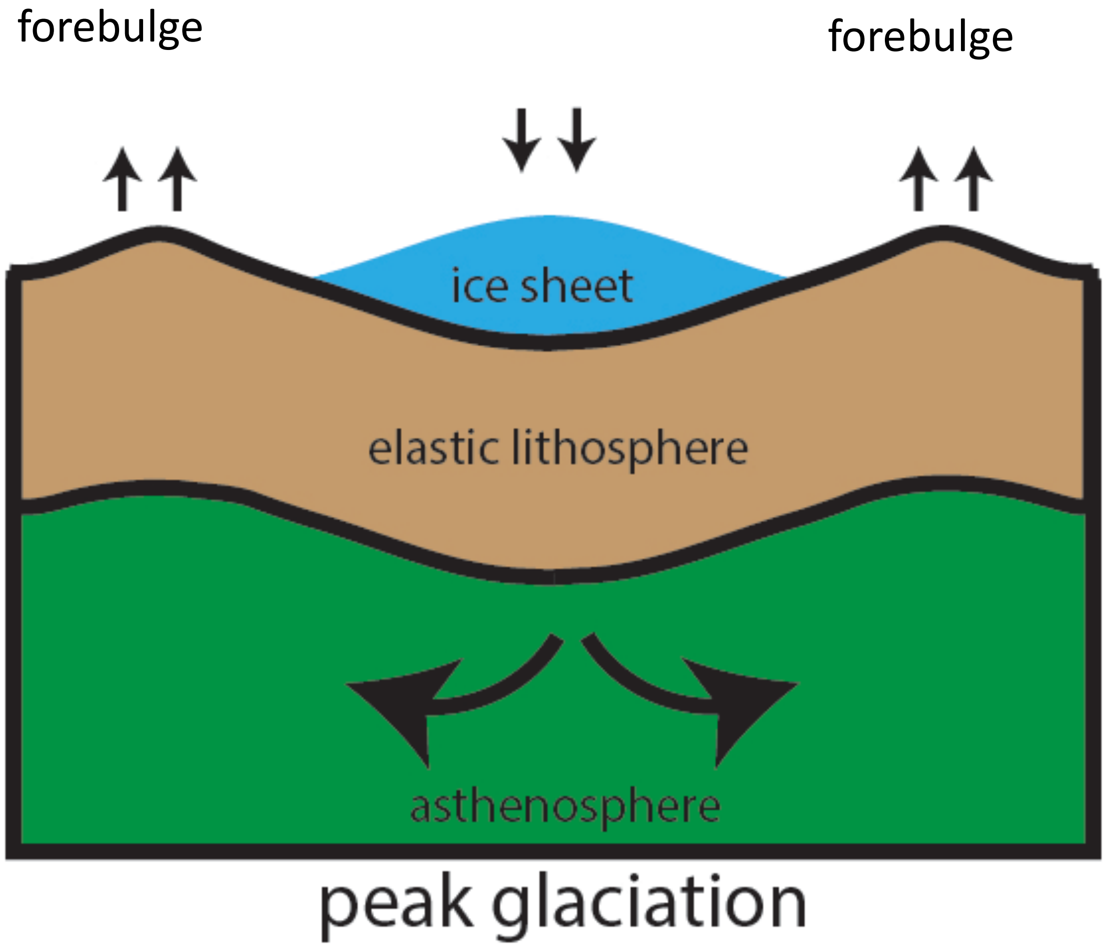
Glacial Isostatic Adjustment



Ice sheet depresses lithosphere beneath center of ice sheet mass

Upper mantle is displaced

Forebulges uplift

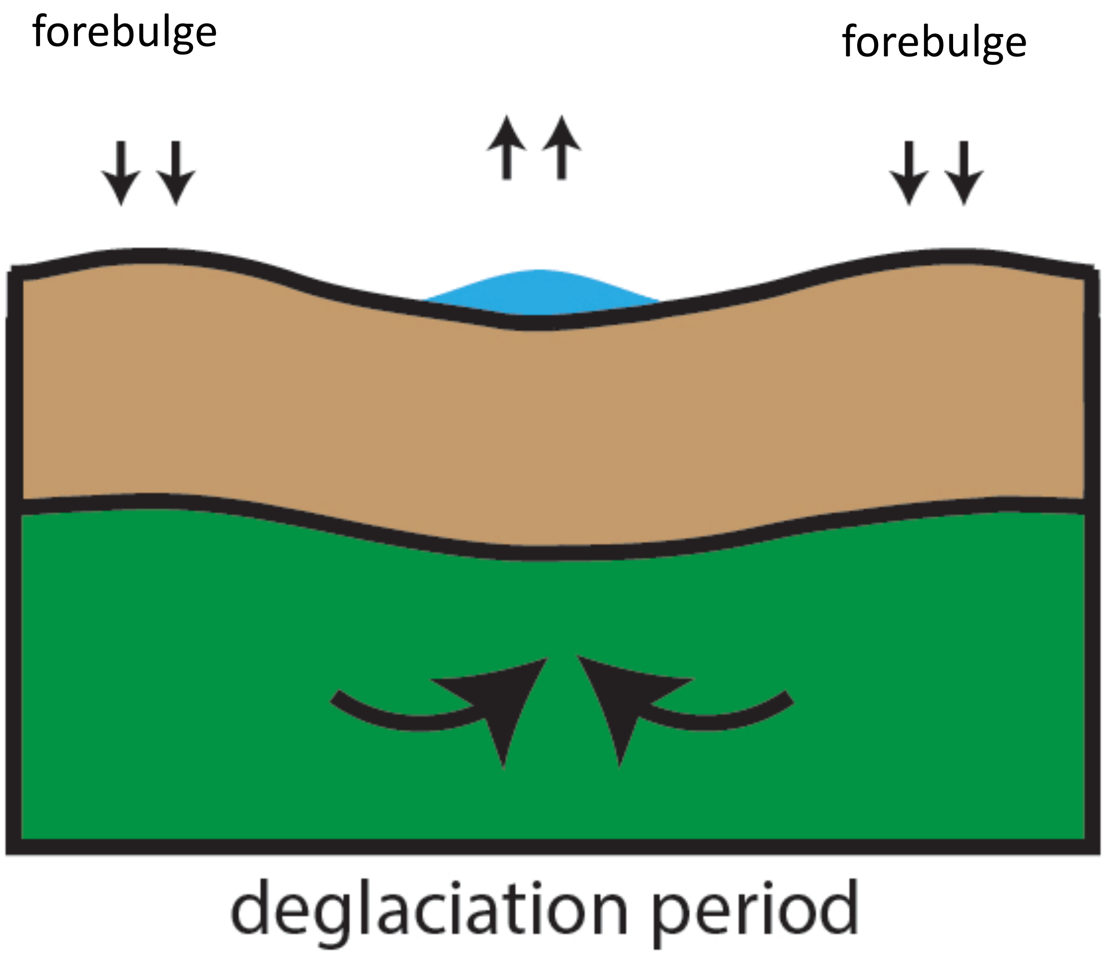
Farrand, 1962; Walcott, 1972; James and Bent, 1994; Davis and Mitrovica, 1996; Peltier, 1996; Larson and Van Dam, 2000; Calais et al., 2006; Sella et al., 2007; Eggleston and Pope, 2013; Karegar et al., 2017

Glacial Isostatic Adjustment

Lithosphere rebounds

Upper mantle flows back to it's original location

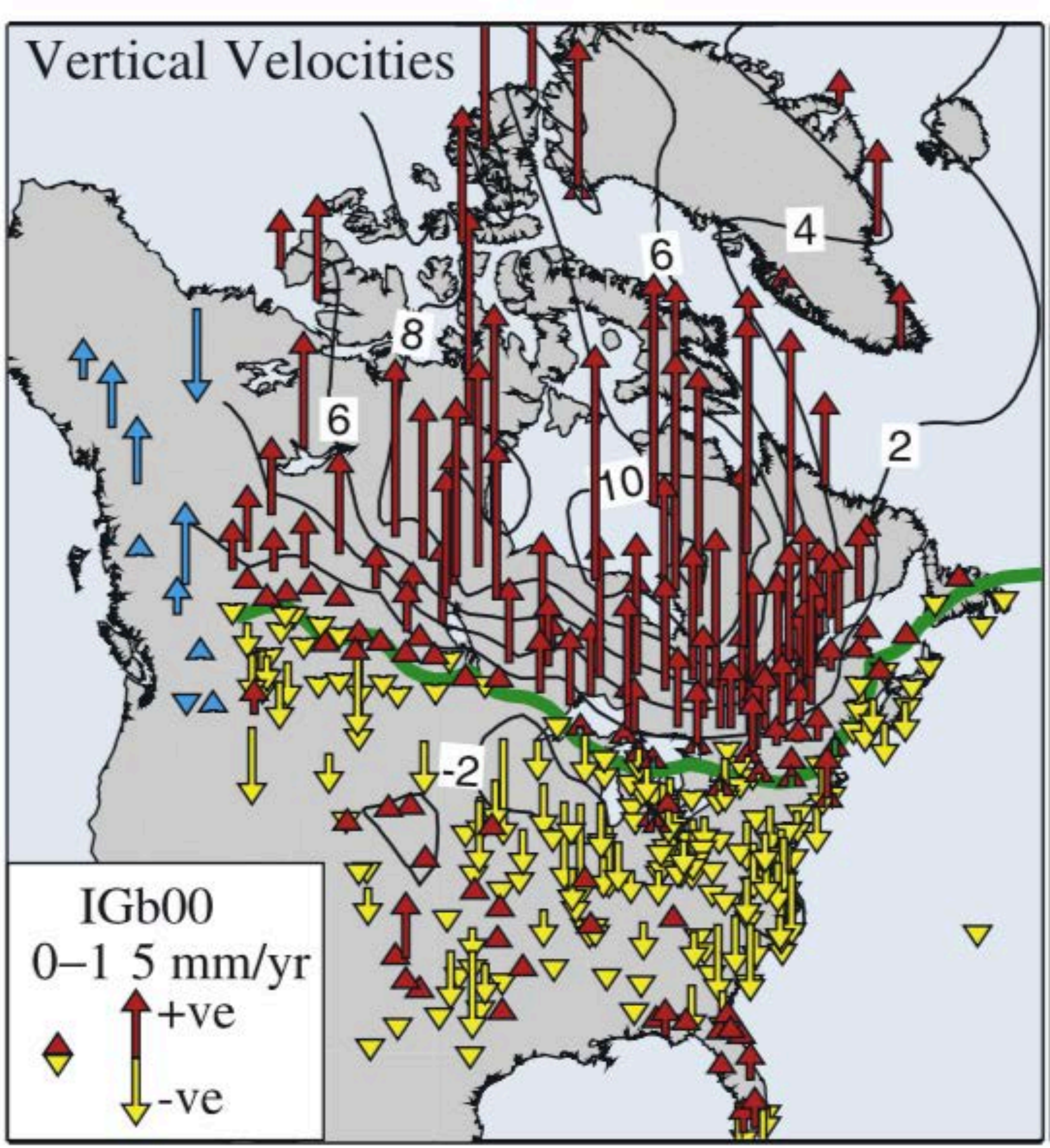
Forebulges subside



Farrand, 1962; Walcott, 1972; James and Bent, 1994; Davis and Mitrovica, 1996; Peltier, 1996; Larson and Van Dam, 2000; Calais et al., 2006; Sella et al., 2007; Eggleston and Pope, 2013; Karegar et al., 2017

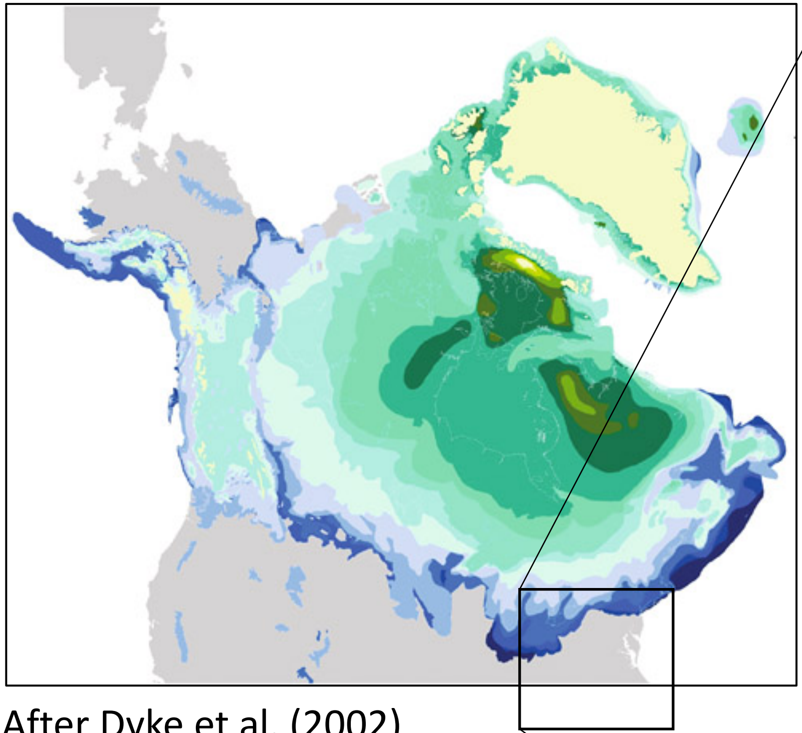
Glacial Isostatic Adjust has been assumed to be the primary factor in explaining North American vertical land motions

(i.e. Sella et al., 2007)

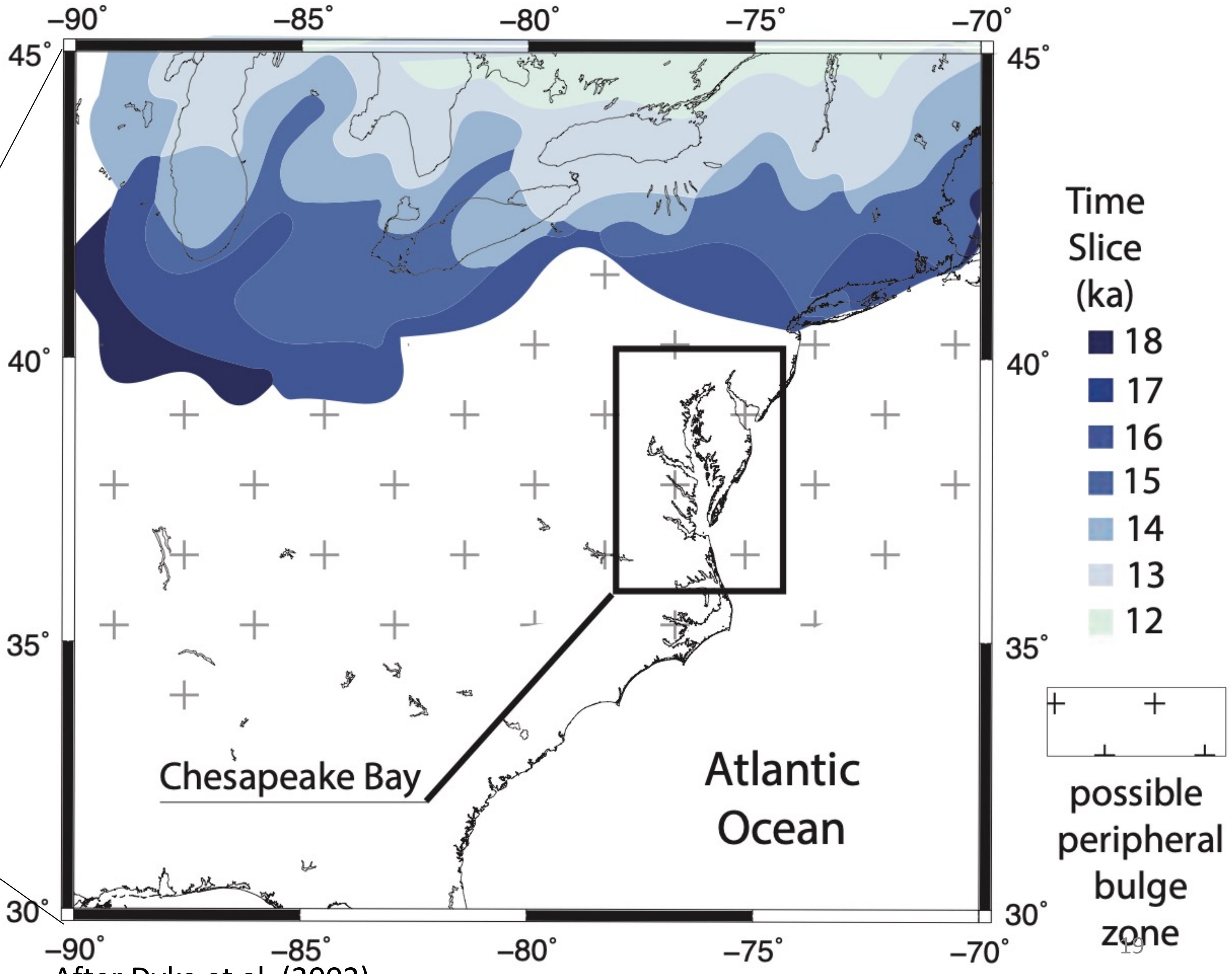


Sella et al., 2007

Laurentide Ice Sheet

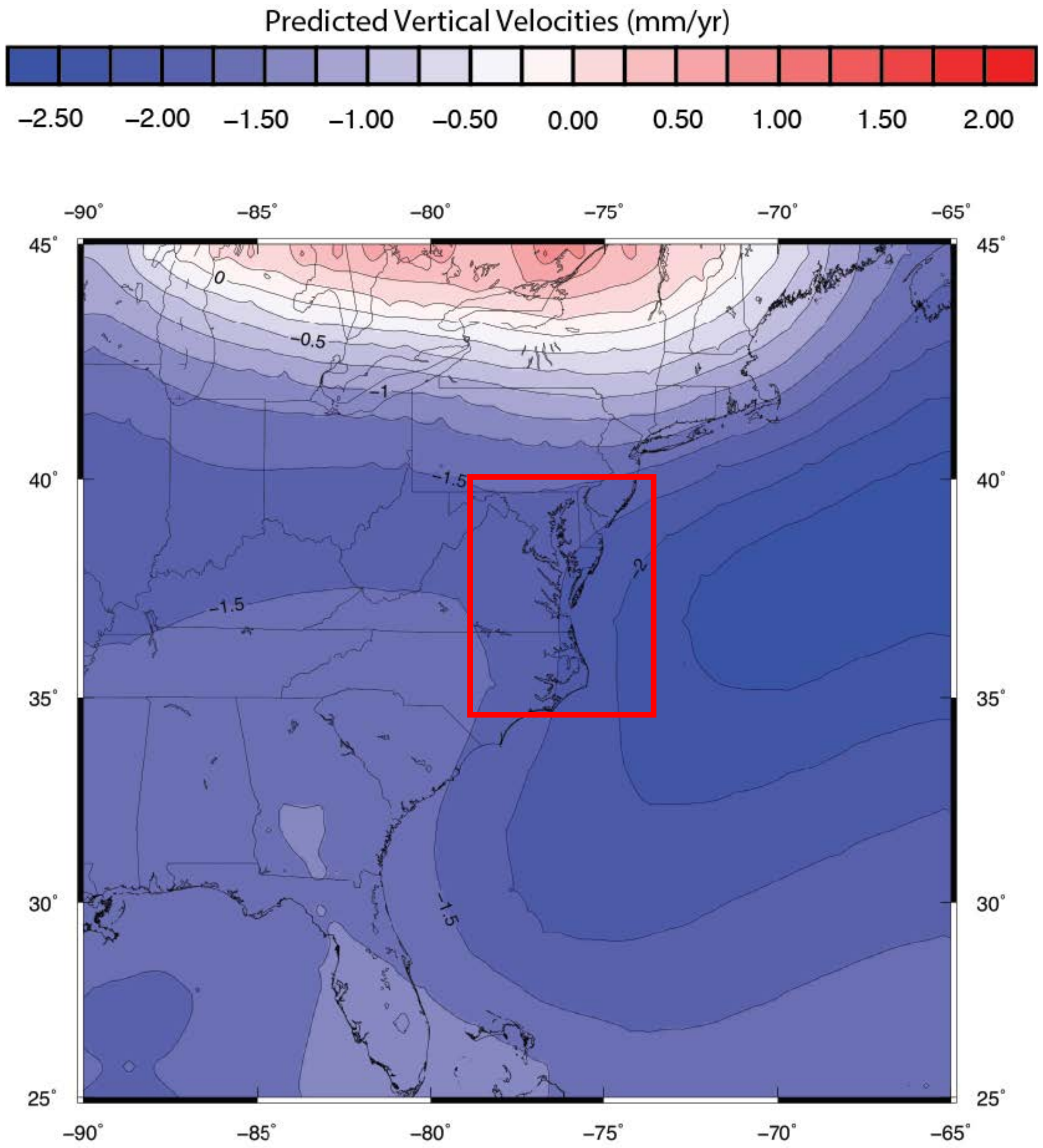


After Dyke et al. (2002)



After Dyke et al. (2002)

Glacial Isostatic Adjust predicted to produce 1.5-2 mm/yr of subsidence in the Chesapeake Bay region



Derived from ICE-6G model using SELEN4.0

Dynamic Uplift/Subsidence from Mantle Flow

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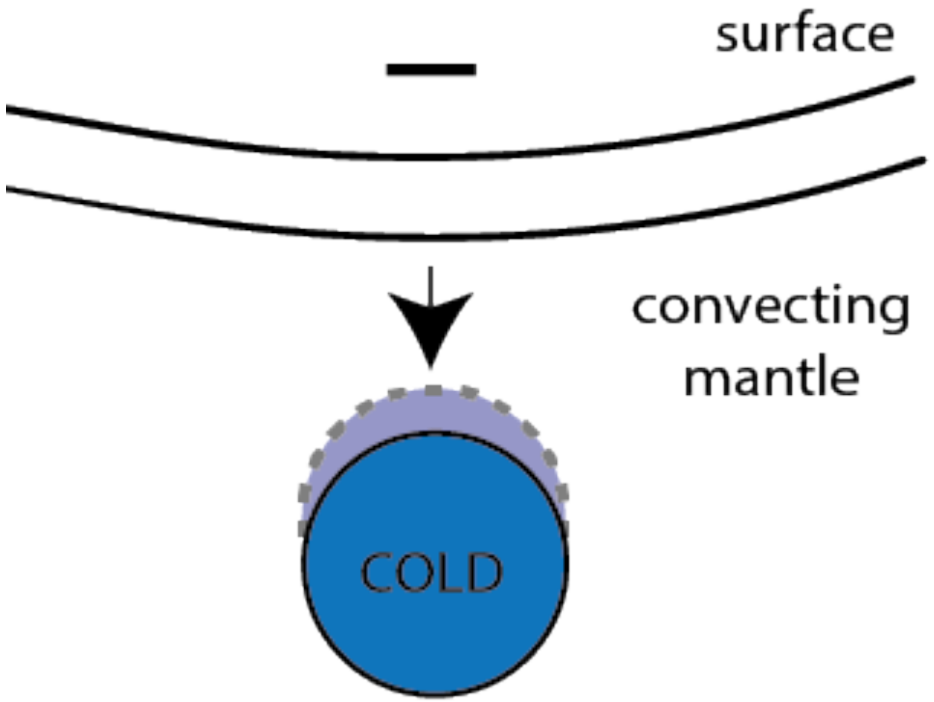
Dynamic Uplift/Subsidence from Mantle Flow

Convecting mantle is coupled to the lithosphere

Mantle tractions influence tectonic plate motions

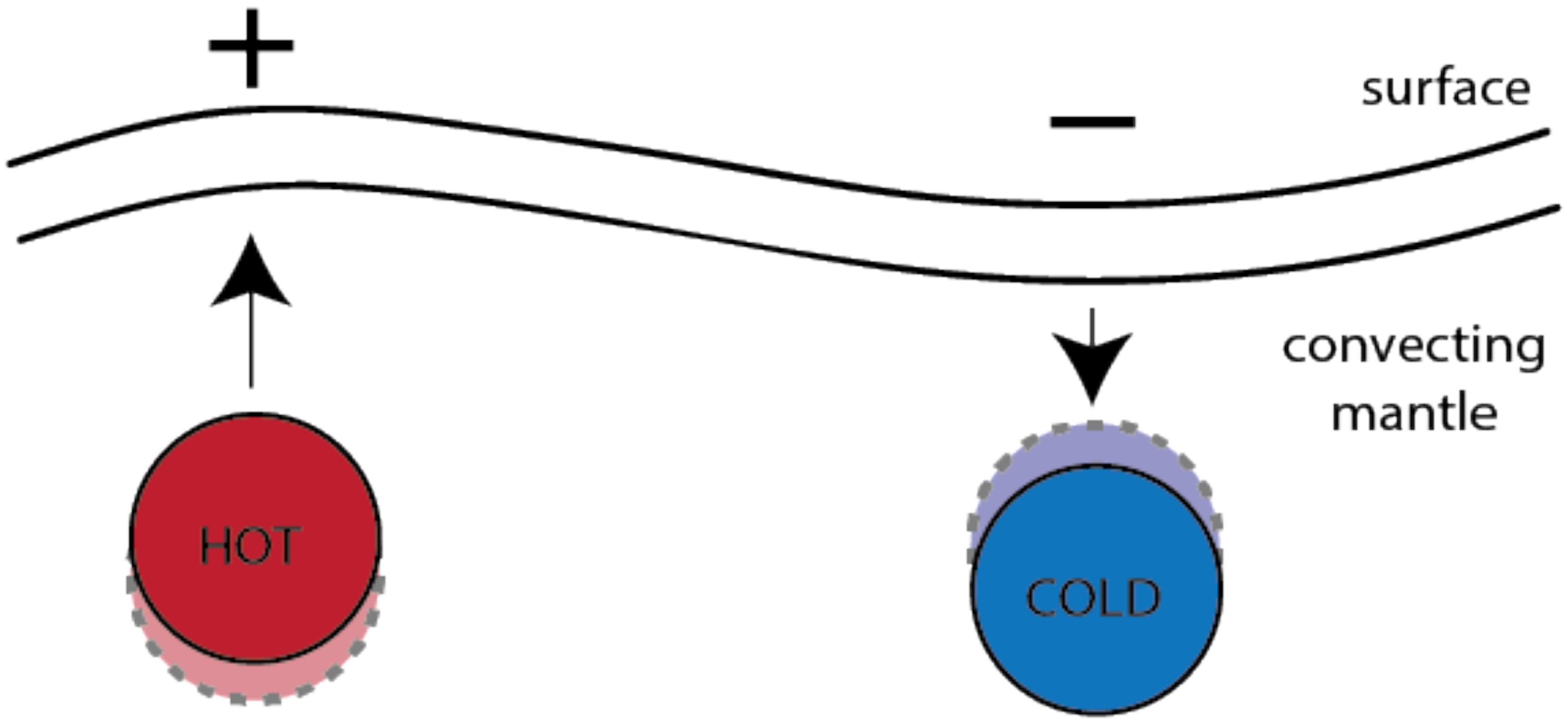
Downwelling mantle flow pulls surface downwards



Spasojević et al., 2008; Forte et al., 2010; Karlstrom et al., 2012; Husson et al., 2014; Dávila and Lithgow-Bertelloni, 2015

Dynamic Uplift/Subsidence from Mantle Flow

Upwelling mantle flow uplifts tectonic plates



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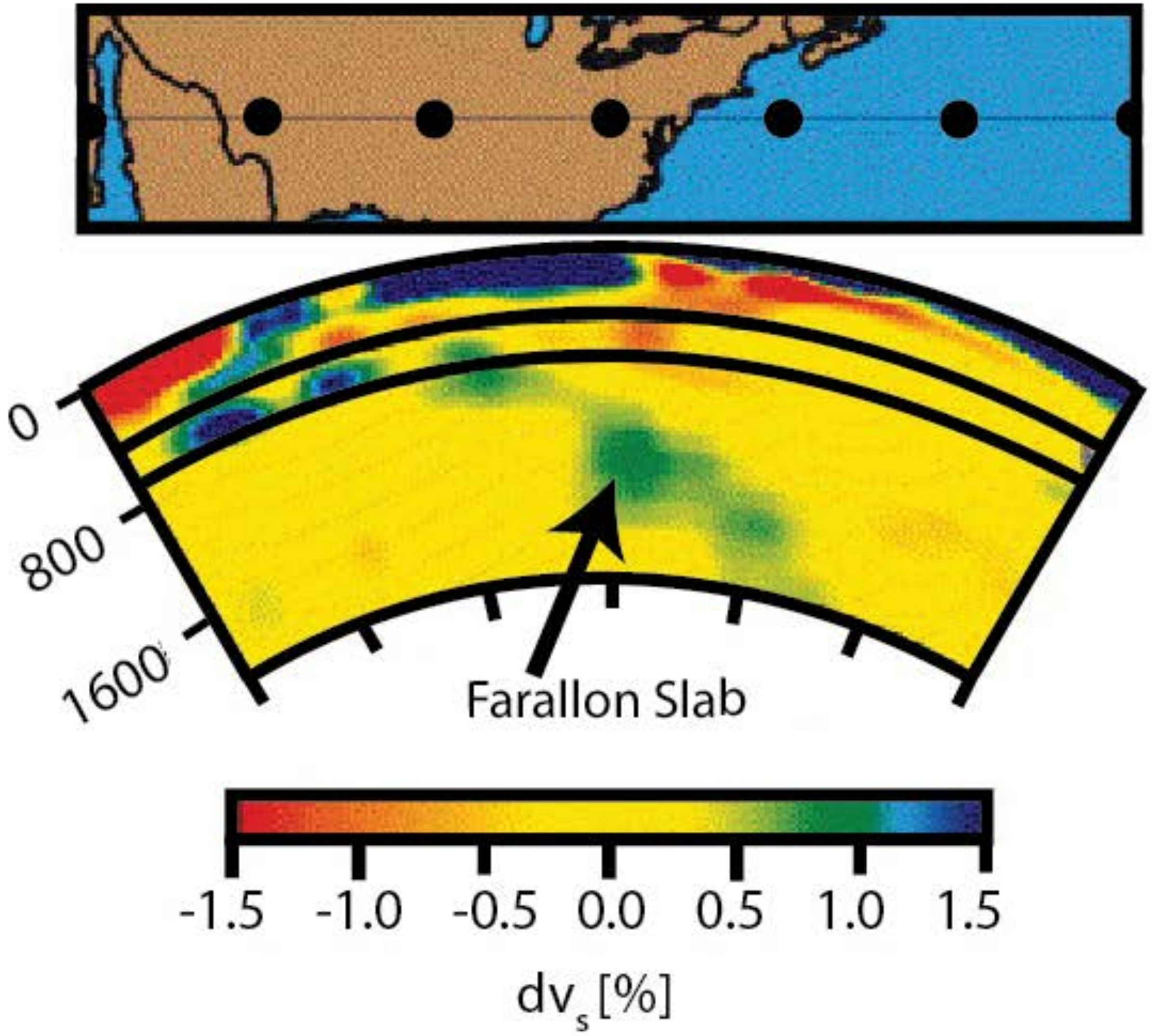
Dynamic Uplift/Subsidence from Mantle Flow

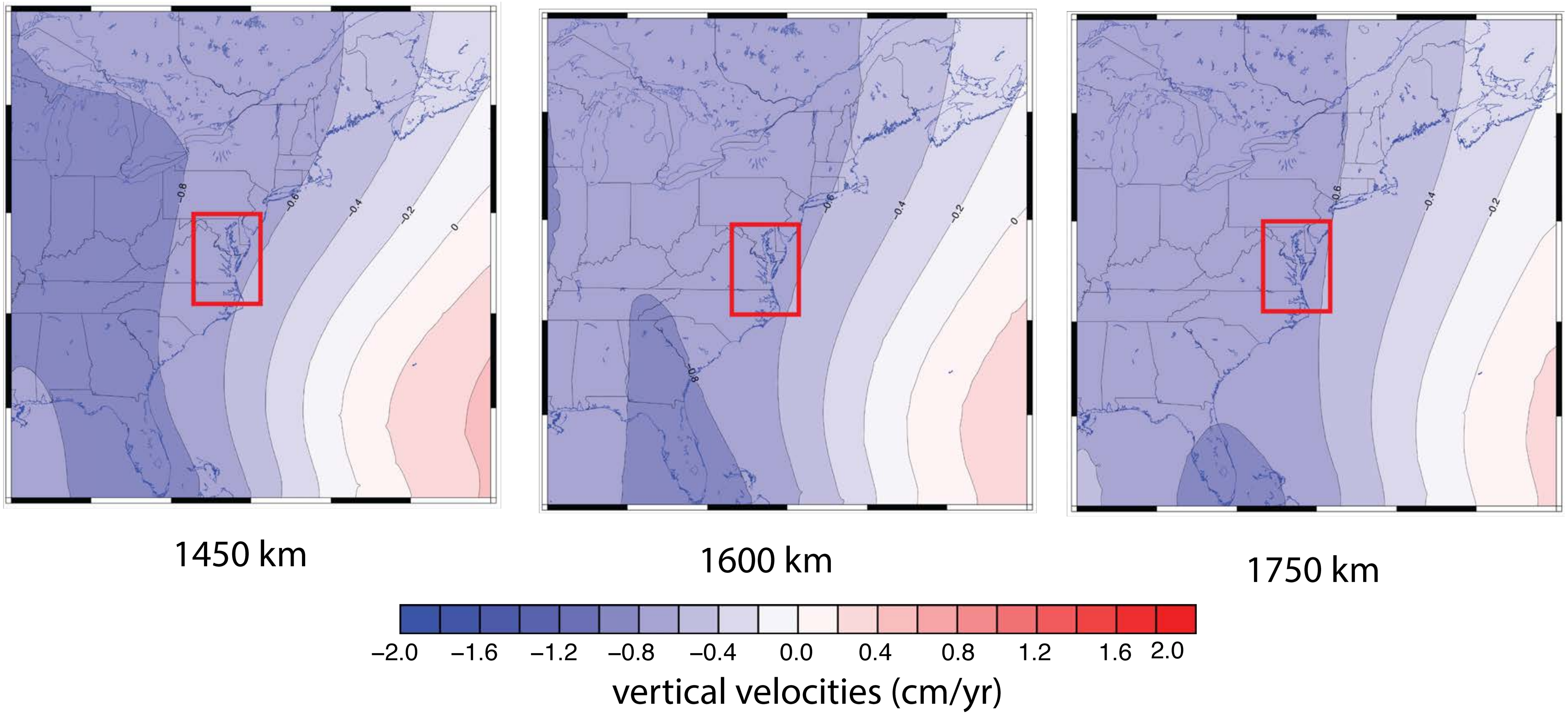


Subducting Farallon slab beneath the eastern coast of North America detected with seismic tomography

Can create downwelling mantle flow that is suggested to influence vertical land motions in the eastern US (Forte et al., 2010)

After Schmid et al., (2002)

Deep downwelling flow from Farallon Slab subduction

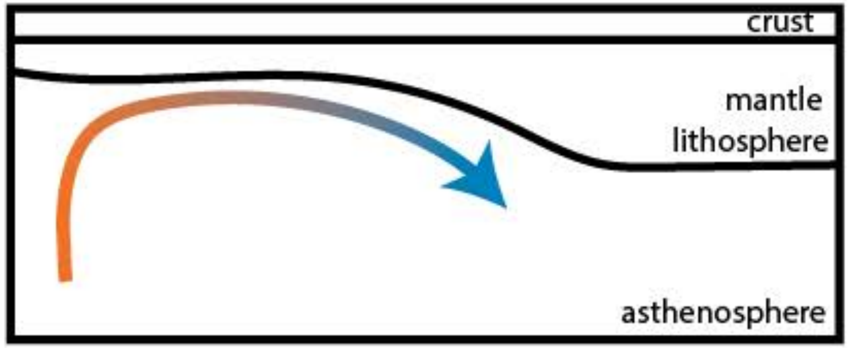


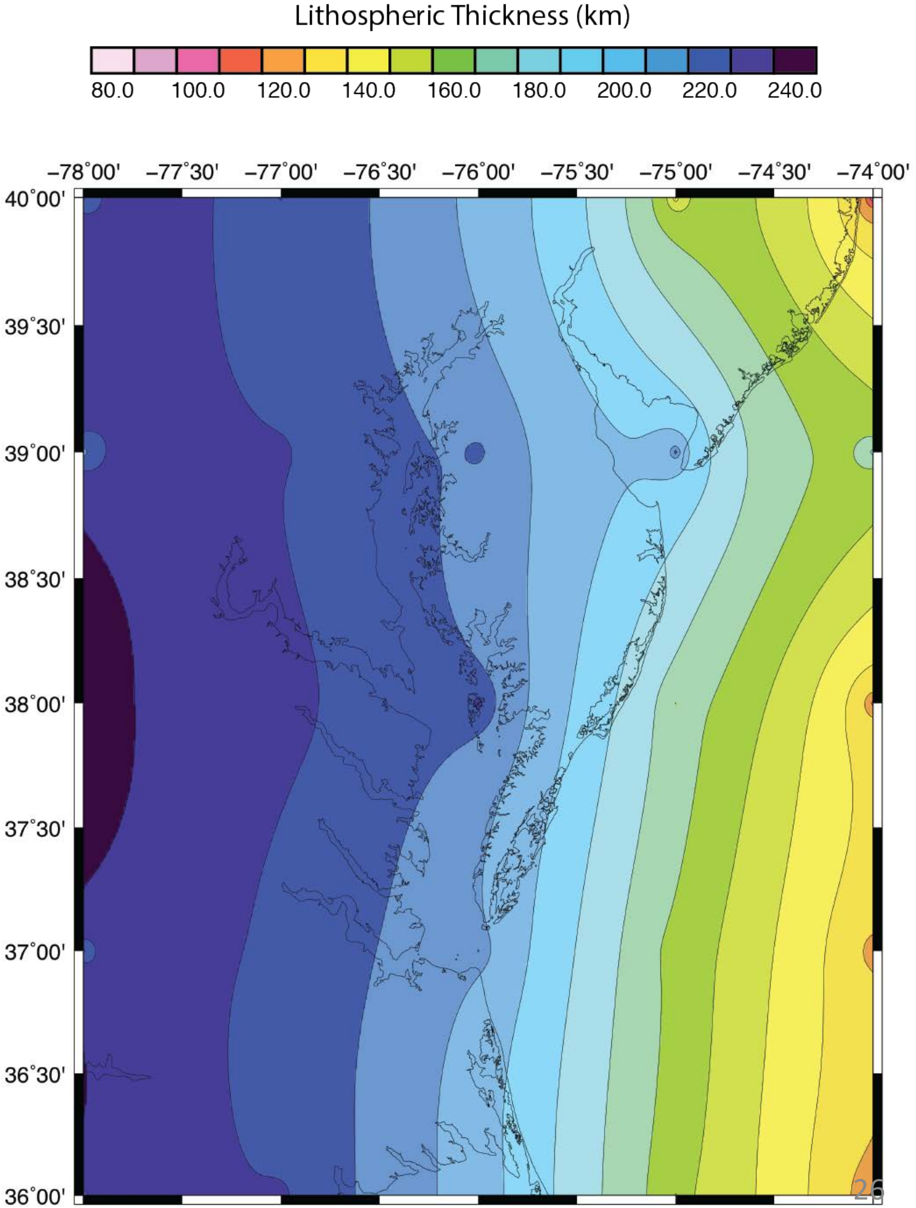
Conrad and Behn (2010) mantle flow model

Dynamic Uplift/Subsidence from Mantle Flow

Lithospheric modulated convection (Njinju et al., 2019; Rajaonarison et al., 2020)

Lithospheric variations generate lateral temperature variations that drive downwelling

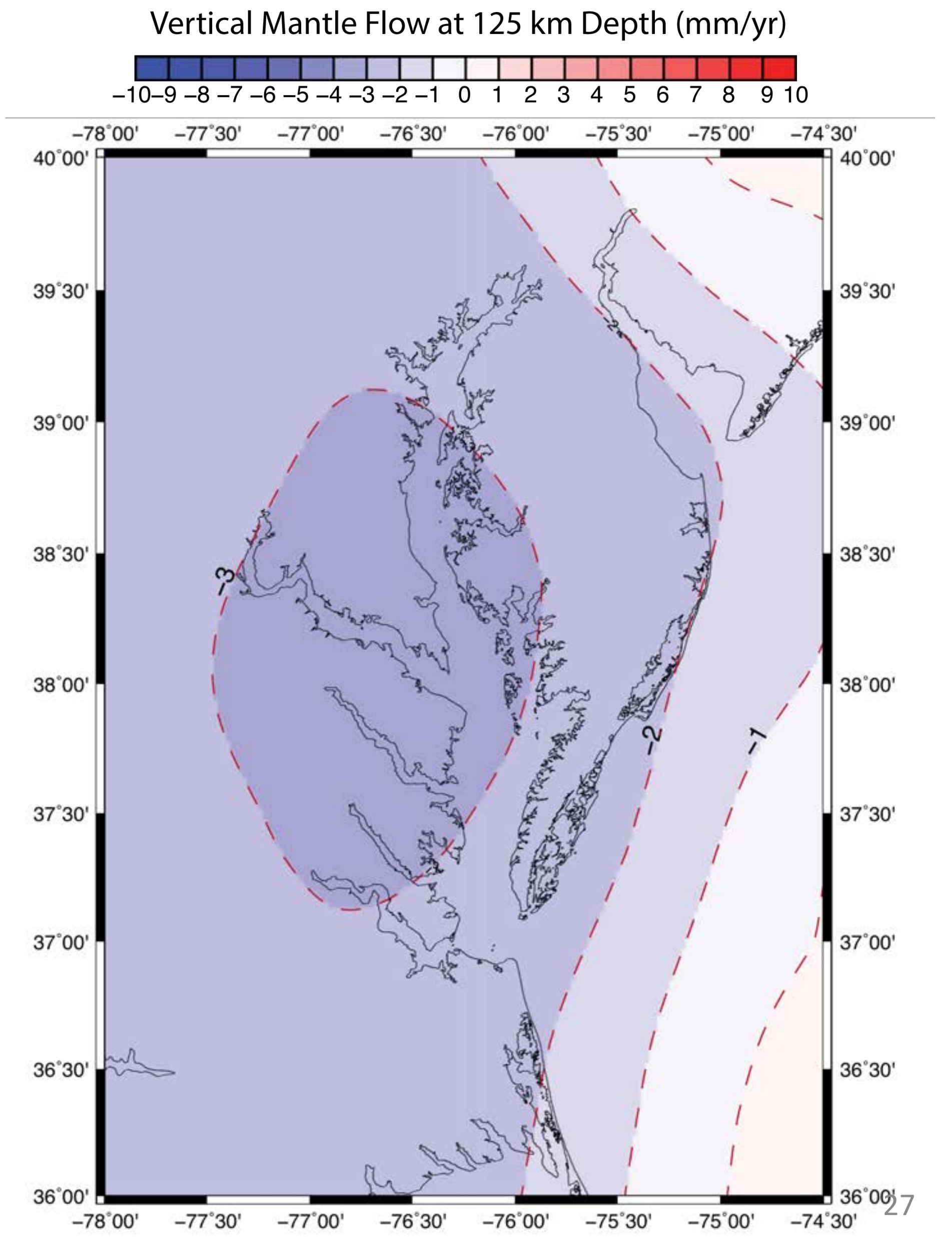




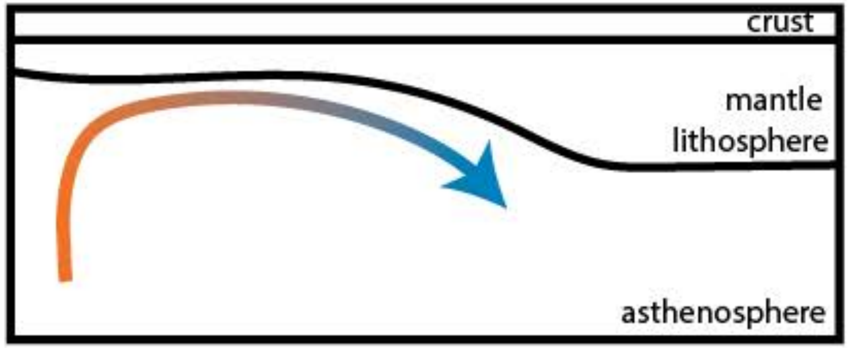
LITHO1.0 (Pasanyos et al., 2013)

Shallow downwelling from lithospheric modulated convection

Lithospheric modulated convection (Njinju et al., 2019; Rajaonarison et al., 2020)



Lithospheric variations generate lateral temperature variations that drive downwelling



Sediment compaction

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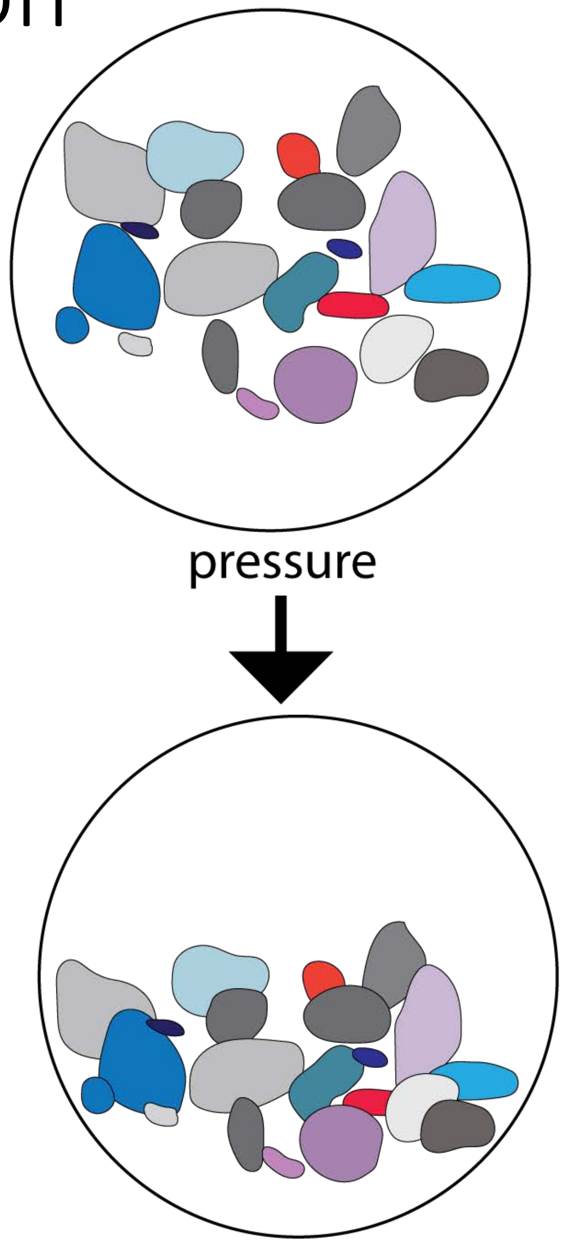
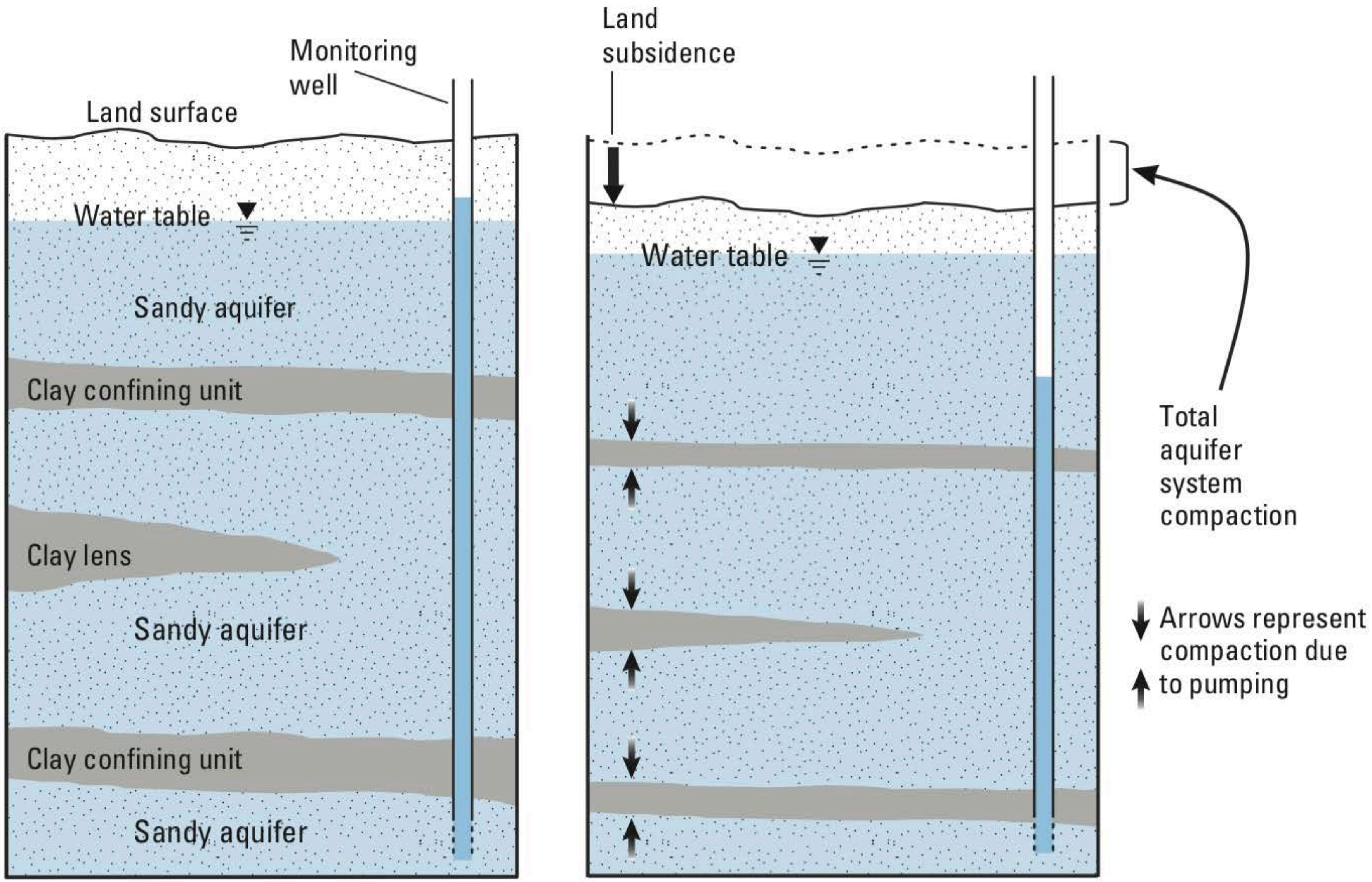
Sediment Compaction

Compaction of clastic sediments, mainly sand in the Chesapeake Bay



Sediment Compaction

Compaction of clay layers from groundwater extraction



Eggleston and Pope, 2013

Summary of Geologic Processes Potentially Affecting the Chesapeake Bay

Glacial Isostatic Adjustment
Dynamic Uplift/Subsidence
Sediment Compaction

No evidence for these geologic effects:

- Impact crater (35 Mya)
- Bedrock dissolution (bedrock is crystalline)
- Settling of fill and disturbed soils on a regional scale

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