

# Use of GRACE Satellites to Assess Impacts of Agriculture on Water Storage<sup>2</sup>

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# Basic Issues

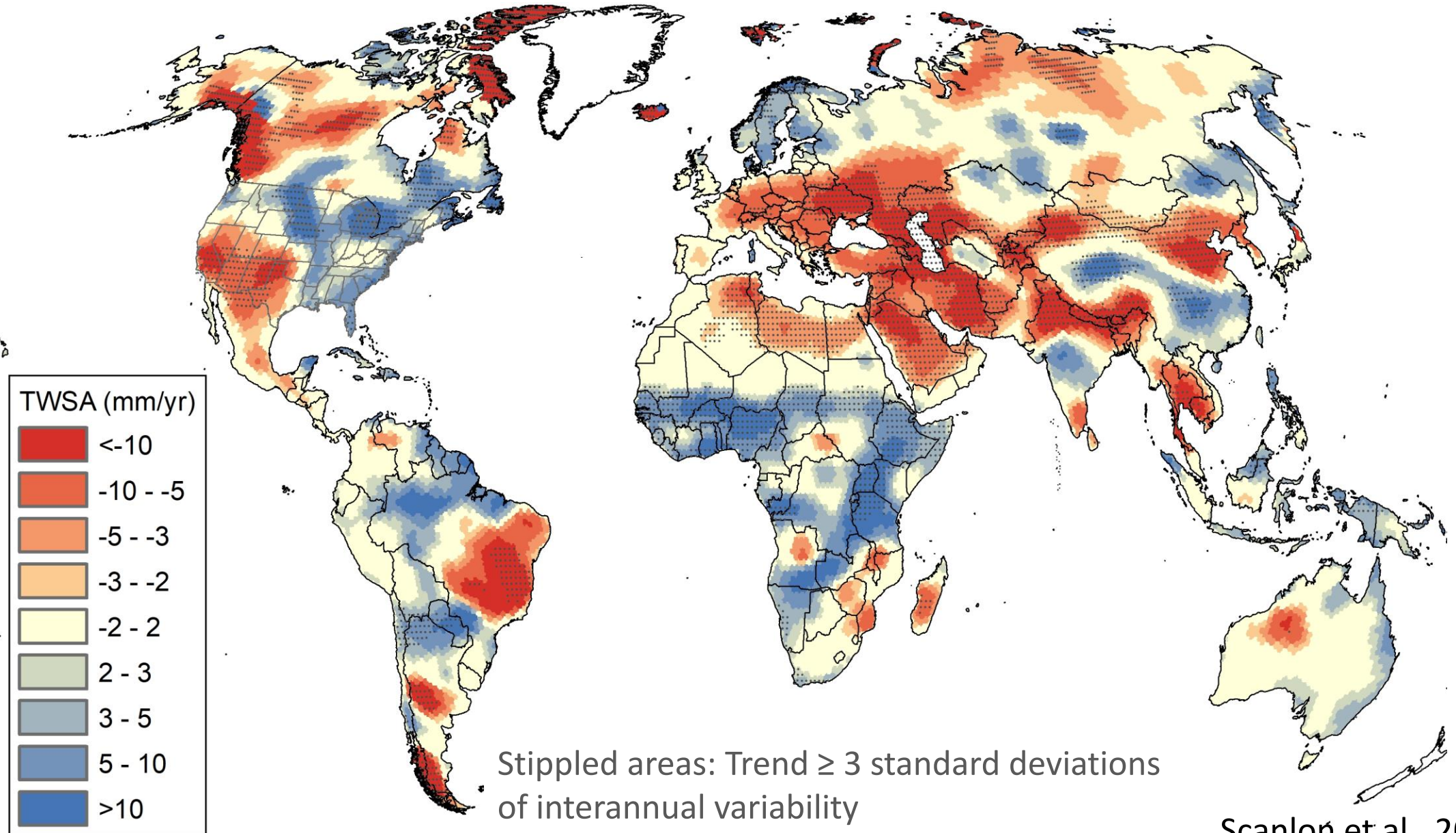
- How can we monitor changes in water storage globally?
- What is controlling changes in water storage?
- How can we manage water resources more sustainably?

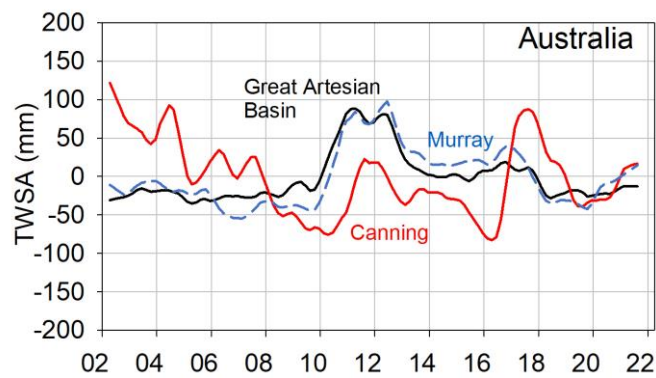
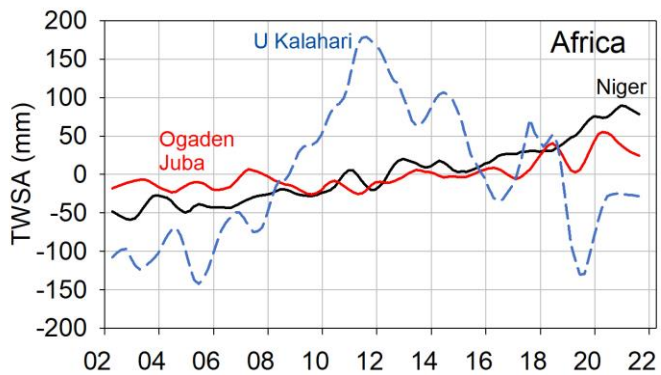
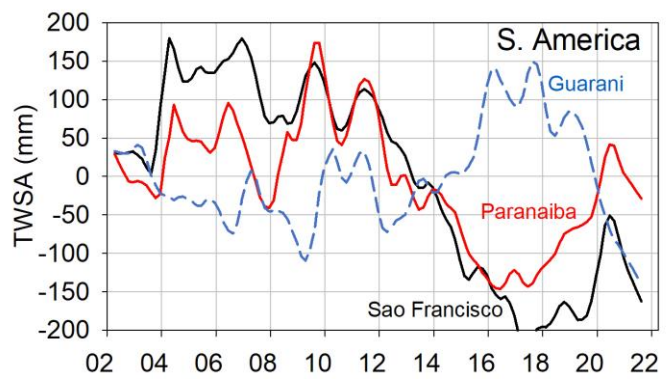
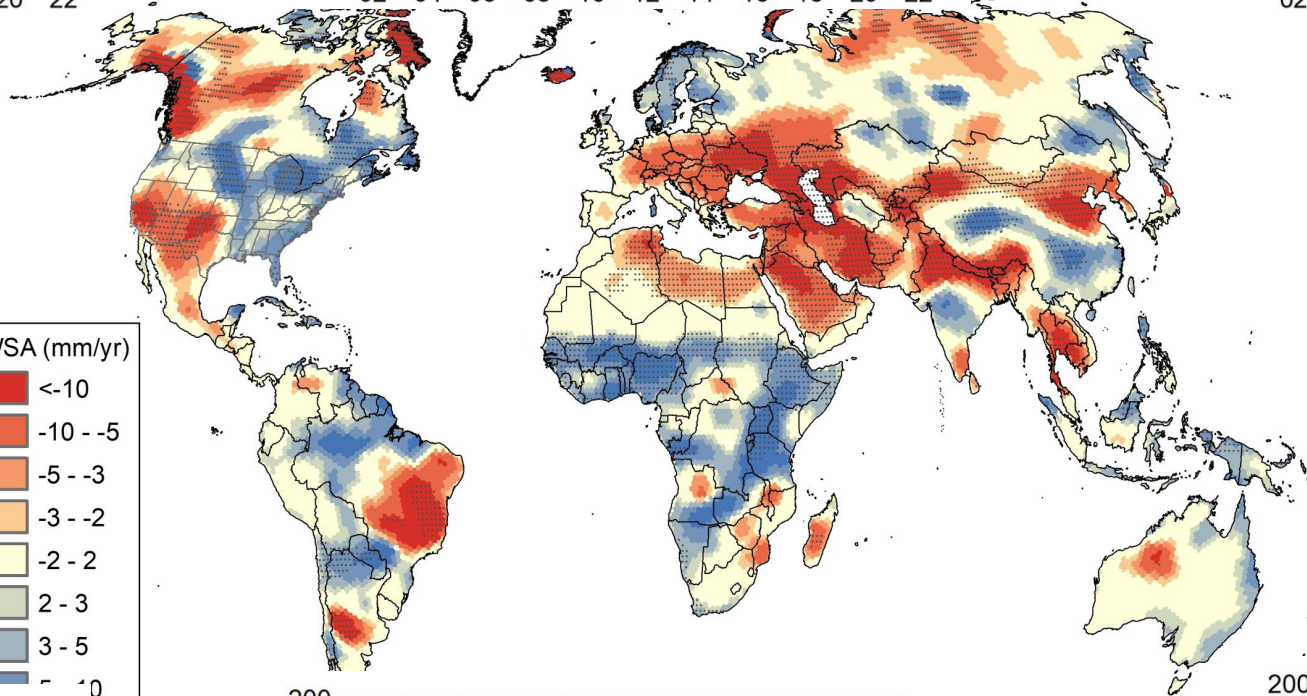
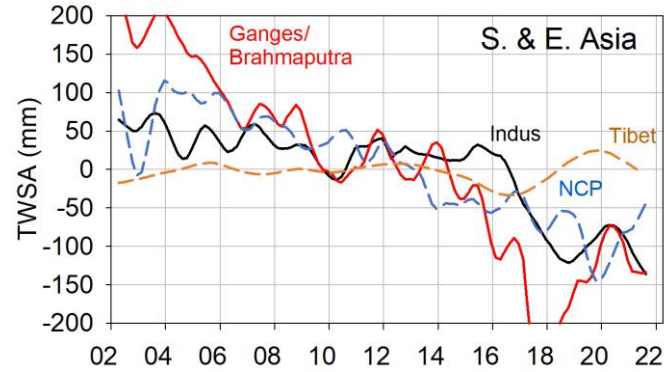
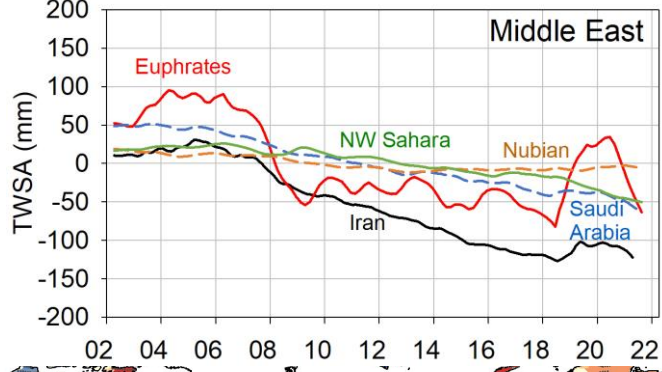
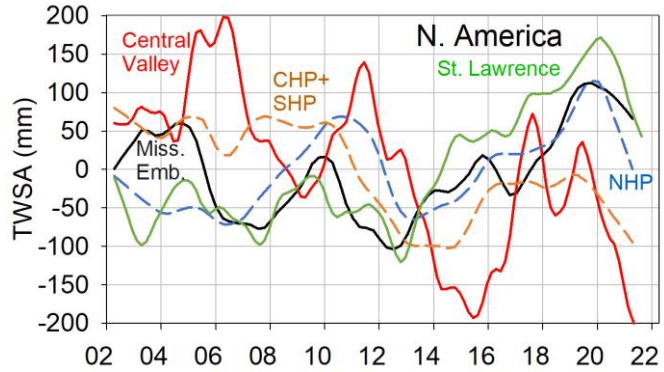


# Methods:

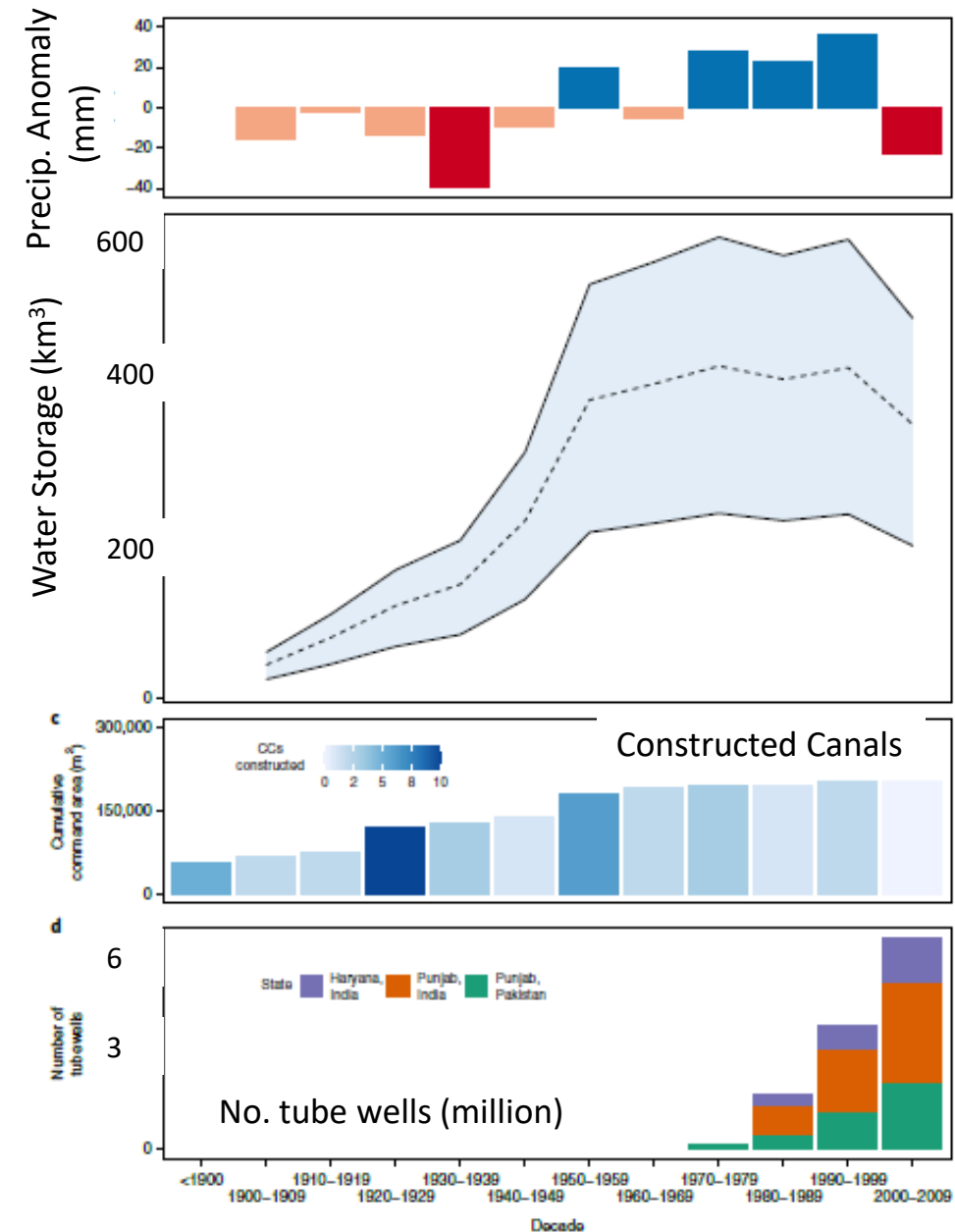
- Satellites (GRACE satellites, total water storage)
- Global and regional models
- Ground-based monitoring
- Water use, land use change

# GRACE Trends in Total Water Storage (2002 – 2022)

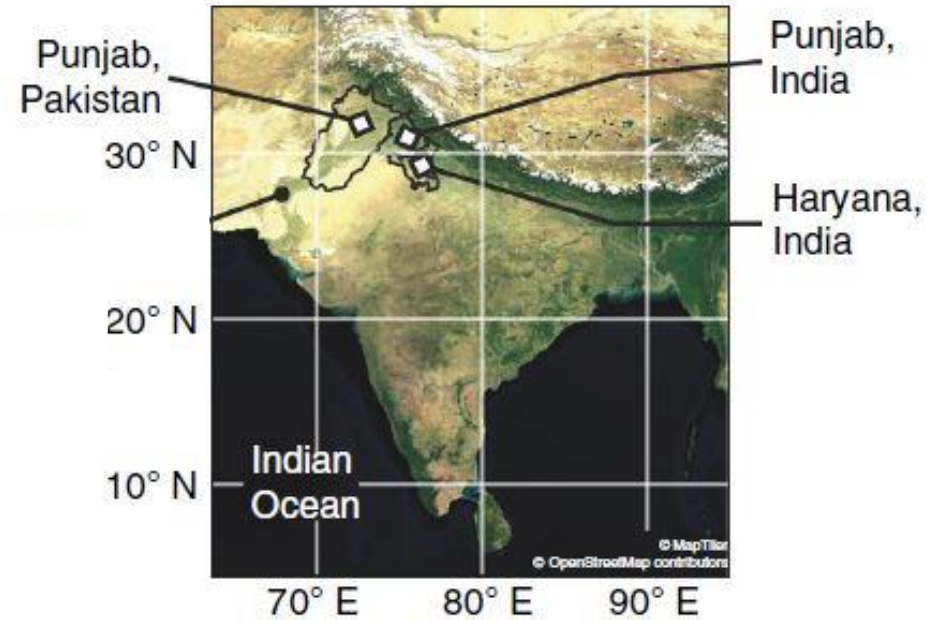




# Long-term Changes in Water Storage in NW India

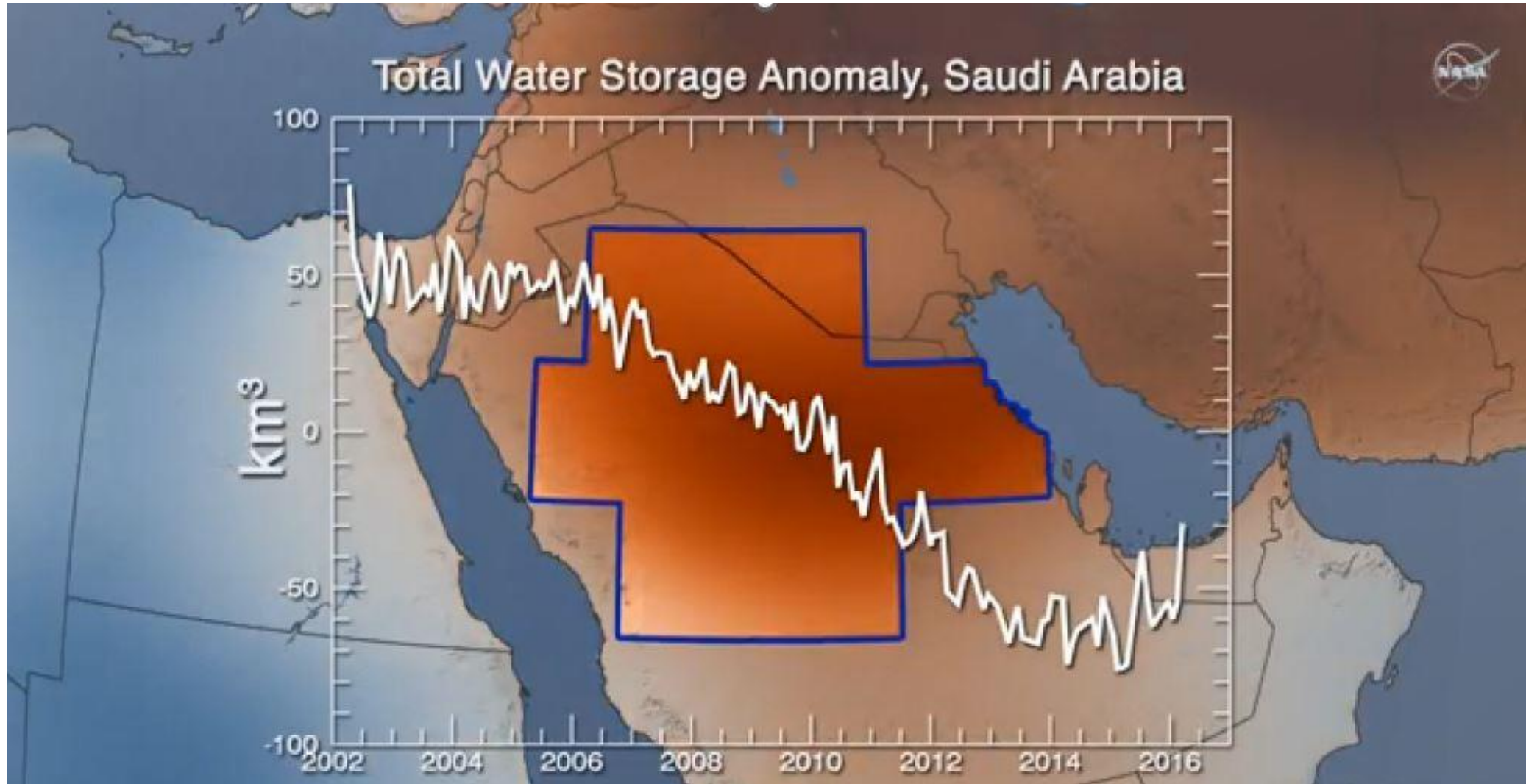


Punjab Pakistan and India and Haryana,



Net increase in water storage of 350 km<sup>3</sup> (1900 – 2010)  
 Decline of ~ 100 km<sup>3</sup> (2000 – 2010)  
 Surface water irrigation recharging groundwater

# GRACE Total Water Storage Changes in NW Saudi Arabia



# Irrigation Expansion in Saudi Arabia to Support Agriculture





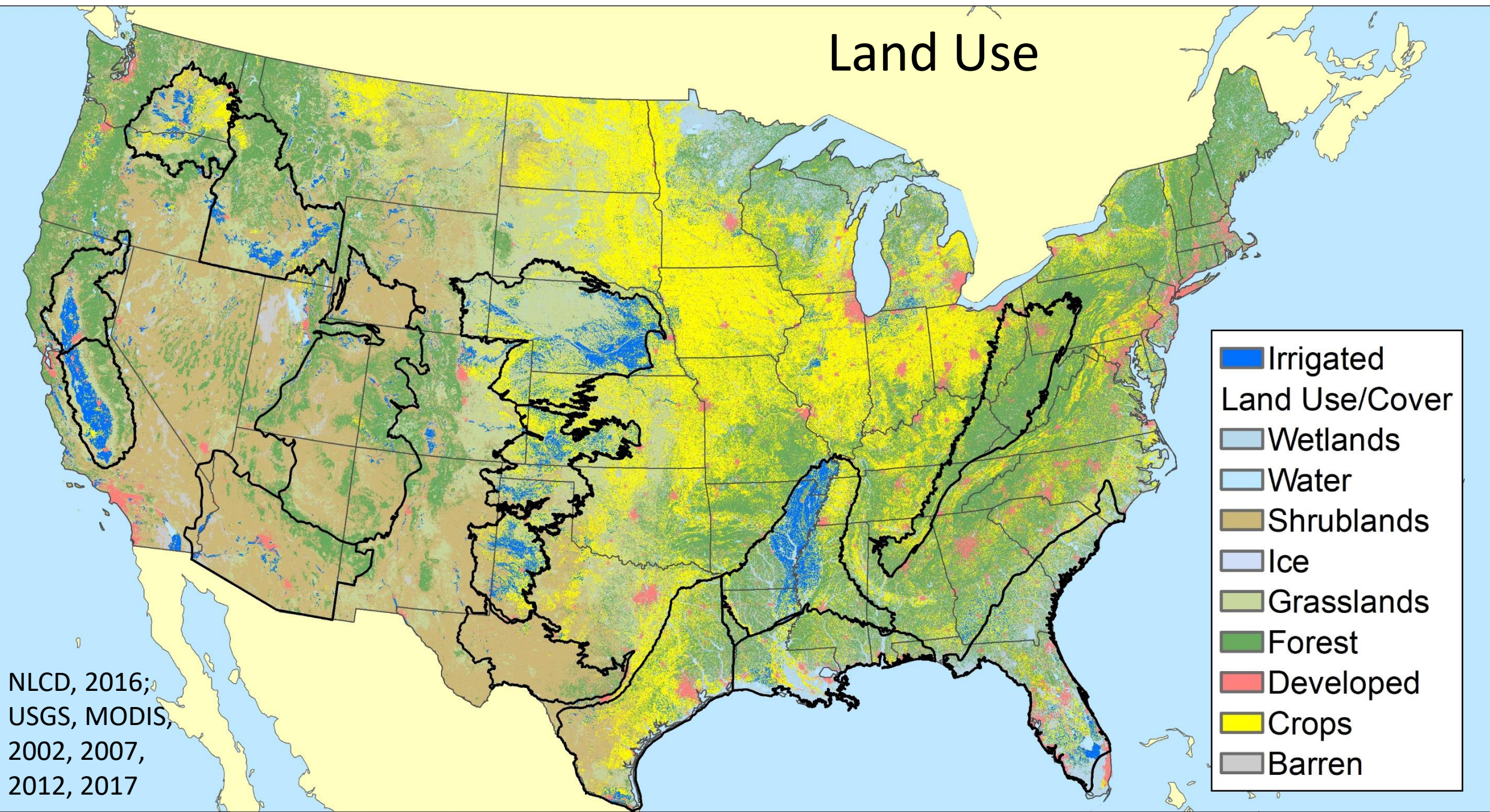
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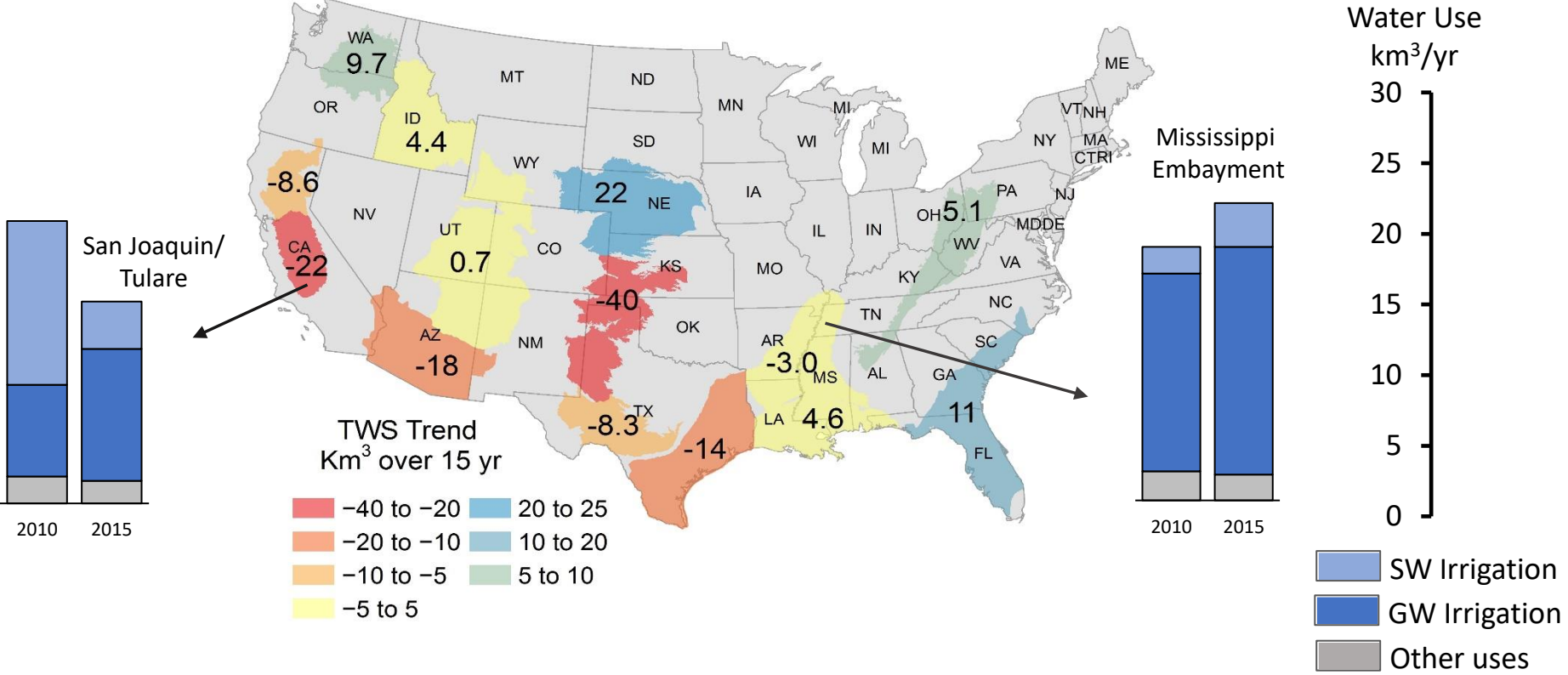


# Land Use



NLCD, 2016;  
USGS, MODIS,  
2002, 2007,  
2012, 2017

# Human Intervention Irrigation



# Move Agriculture from Semi-arid to more Humid Regions

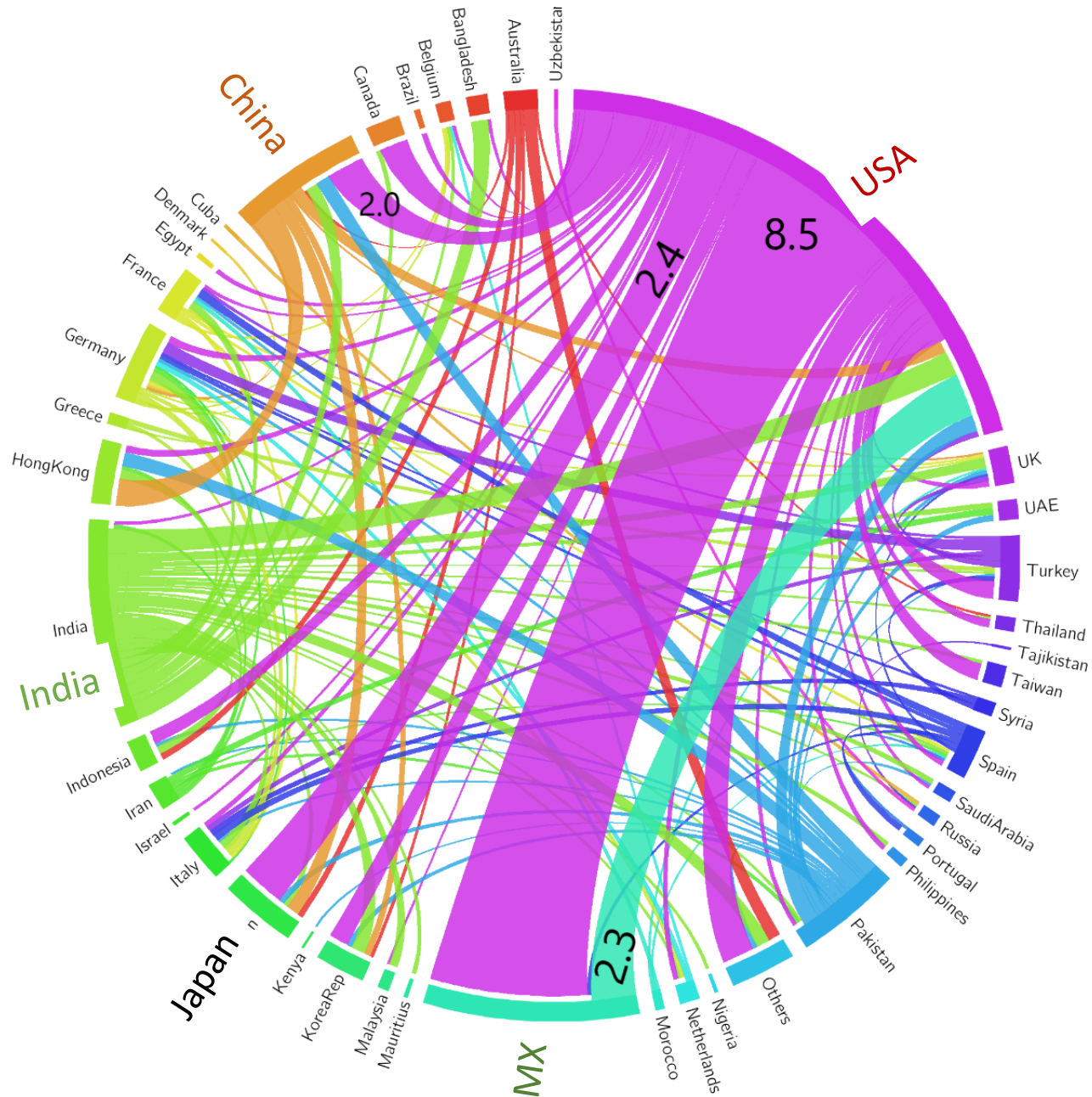


## **The Next California**

Phase 1: Investigating Potential in the mid-Mississippi Delta River region

Julia Kurnik, WWF Director, Innovation Startups - Markets

# Virtual Water Transfers



Blue virtual water flows totaled 301 km<sup>3</sup>/yr from 1996 – 2005

Major virtual groundwater exporters include the USA (31% of global total), India (15%) Pakistan (13%)

# Summary

- Satellite data allow us to track water storage variability and irrigated agriculture globally over past two decades
- GRACE data show declines in water storage in semiarid regions globally related to irrigation and climate
- Long-term trends in NW India and Pakistan: rises in storage related to canal irrigation followed by declines linked to groundwater pumpage
- US: Groundwater pumpage impacts on storage in humid region much less than in arid region because capturing surface water in humid region
- Virtual water transfer in food trade



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