

New Methods for Modeling International Trade in GCAM

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(and acknowledgements to the GCAM
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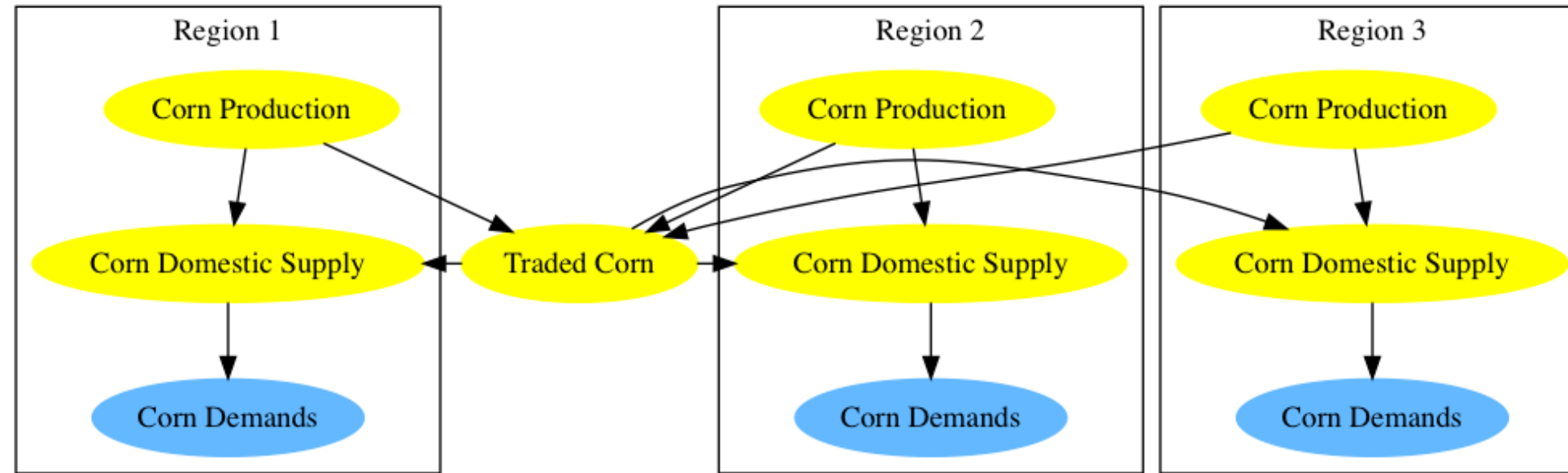
New Trade Approaches and Methods in GCAM

- For decades, the modeling approach of pure Global Markets (Hecksher-Ohlin) has served our needs well for long-term analysis.
- Several research questions arose that benefit from consideration of regional prices, inter-regional markets, and trading relationships and costs.
 - In general, many near-term analyses where trade is a potential factor.
 - Other trade scenario assumptions, such as the impact of changing shipping costs.
- We have begun implementing other trade approaches opportunistically.
 - Dynamic electricity trade in GCAM-USA (which has been in core GCAM).
 - Regional self-sufficiency constraints.
 - Targeted bilateral trade relationships between regions.
 - Secondary products that previously had been confined to regional markets in GCAM.
- This presentation focuses on the Regionally-Differentiated Crop Markets with Global Trade approach, which is newly implemented in GCAM 5.2.

Regionally-Differentiated Crop Markets with Global Trade: Objectives

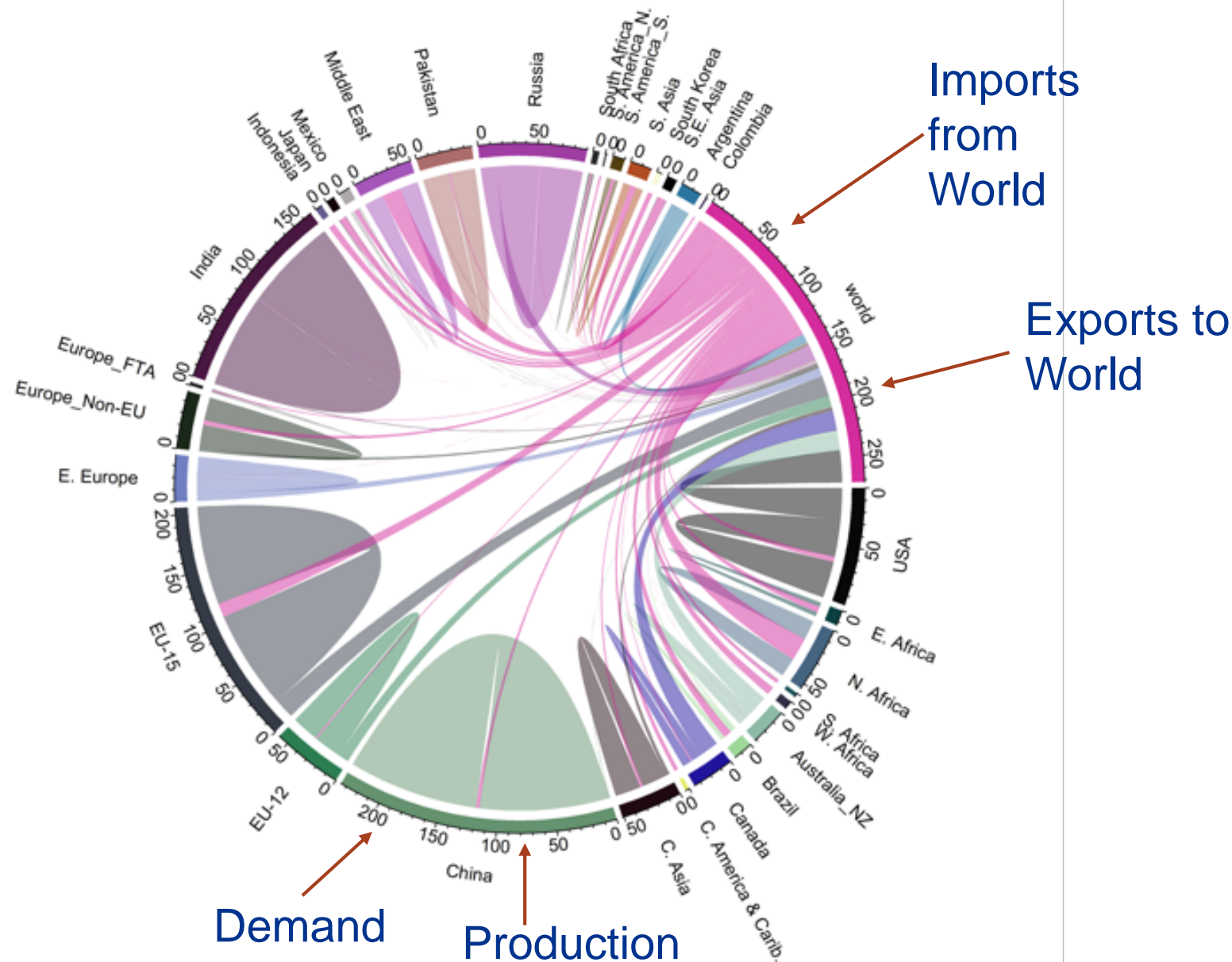
- Address research questions where the global market approach is limiting.
 - Direct impact of regional food demand growth on regional production.
 - Direct and indirect impacts of regional crop demand changes on regional land use change and emissions.
 - Impacts of regional supply disruptions on food demand and costs, and the impact of the ease of or difficulty of trade.
- Design considerations: maintaining flexibility and feasibility
 - Parametrically span the space between pure Global and Regional Markets.
 - We did not want to lock in bilateral relationships.
 - Model equations still need to solve in a timely manner.
- Thanks to the support of and collaboration with the EPA Office of Transportation and Air Quality (OTAQ) in implementing this approach into GCAM 5.2.

Regionally-Differentiated Crop Markets with Global Trade: Simple Schematic (corn as example)



- Regional corn production is split between providing domestic supply and being sent to a global traded corn market.
- Correspondingly, regional demand is supplied by both own-regional production and imports from the global traded market.
 - An Armington-style distinction between domestic and imported goods.
- Gross trade is tracked as regions both import and export.

Regionally-Differentiated Crop Markets with Global Trade: Chord Diagram for Wheat in 2010



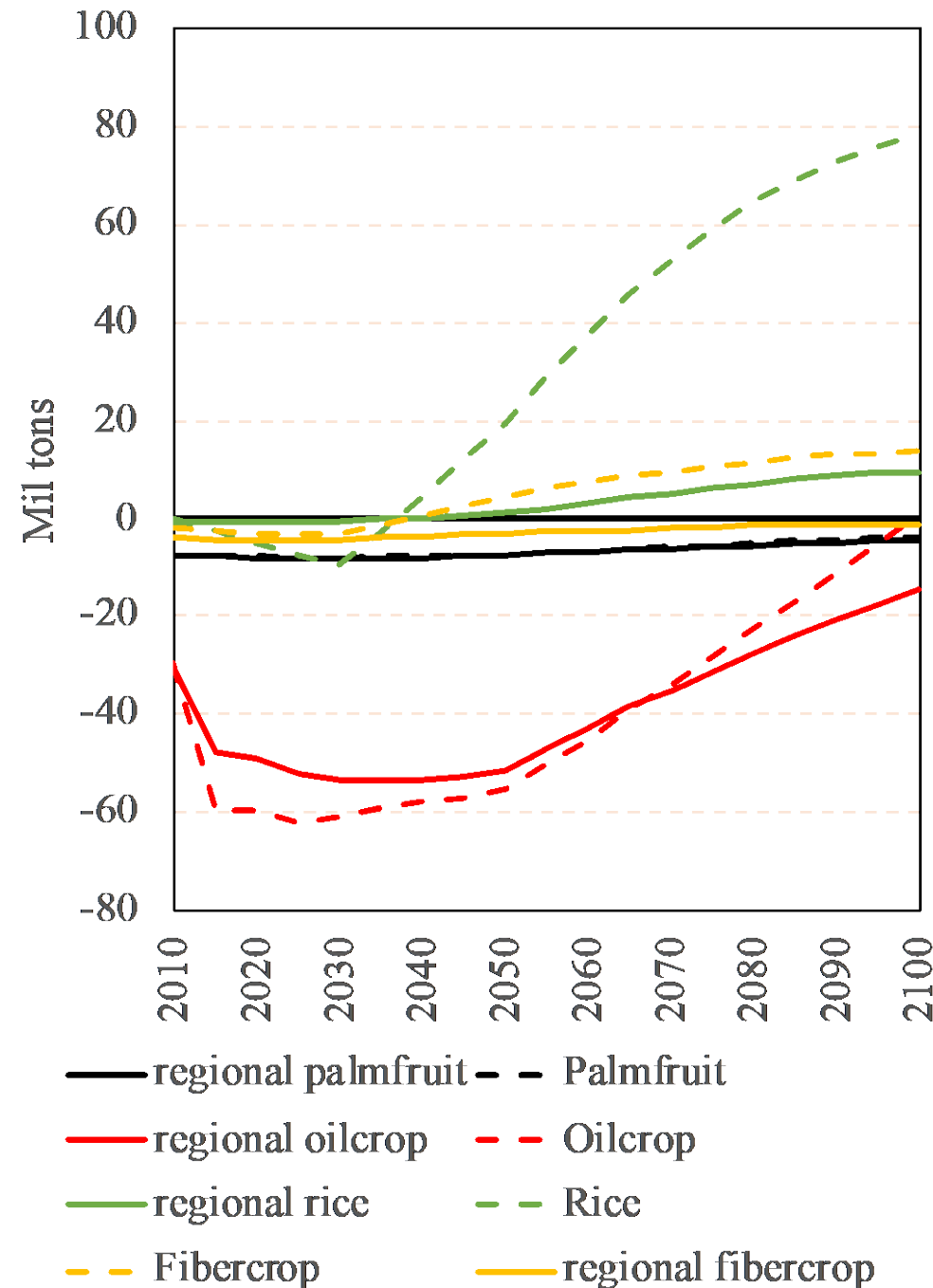
- GCAM 2010 Wheat production, demand, and gross trade.
 - Matches historical data.
- Color-coded chords show regional exports to world and imports from world.
- Also shows relative size of regional production and demand.
- Many regions, e.g. EU-15, have both imports and exports.

GCAM Global vs Regional Markets Comparison

| Approach | Trade | Market Prices | Market Equations | Calibration | Use in GCAM 5.2 Core |
|------------------------------------|---------------------|---------------|----------------------------|--|--|
| Global (Hecksher-Ohlin) | Dynamic Net Trade | Global | 1 per Commodity | Regional Production & Demand | Fossil Fuels, Forest Products |
| Regional Markets with Global Trade | Dynamic Gross Trade | Regional | 1 per Region per Commodity | Regional Production, Demand, Gross Imports and Gross Exports | Most Crops (<i>New for GCAM 5.2</i>) |

- In calibrating Gross Imports and Gross Exports:
 - Regional preferences for domestic production vs imports for each crop are calibrated.
 - Regional export propensities to the global market are also calibrated.
- In GCAM, calibration is important, but it is not destiny.
 - Future regional production and trade will change in response to physical and economic changes.

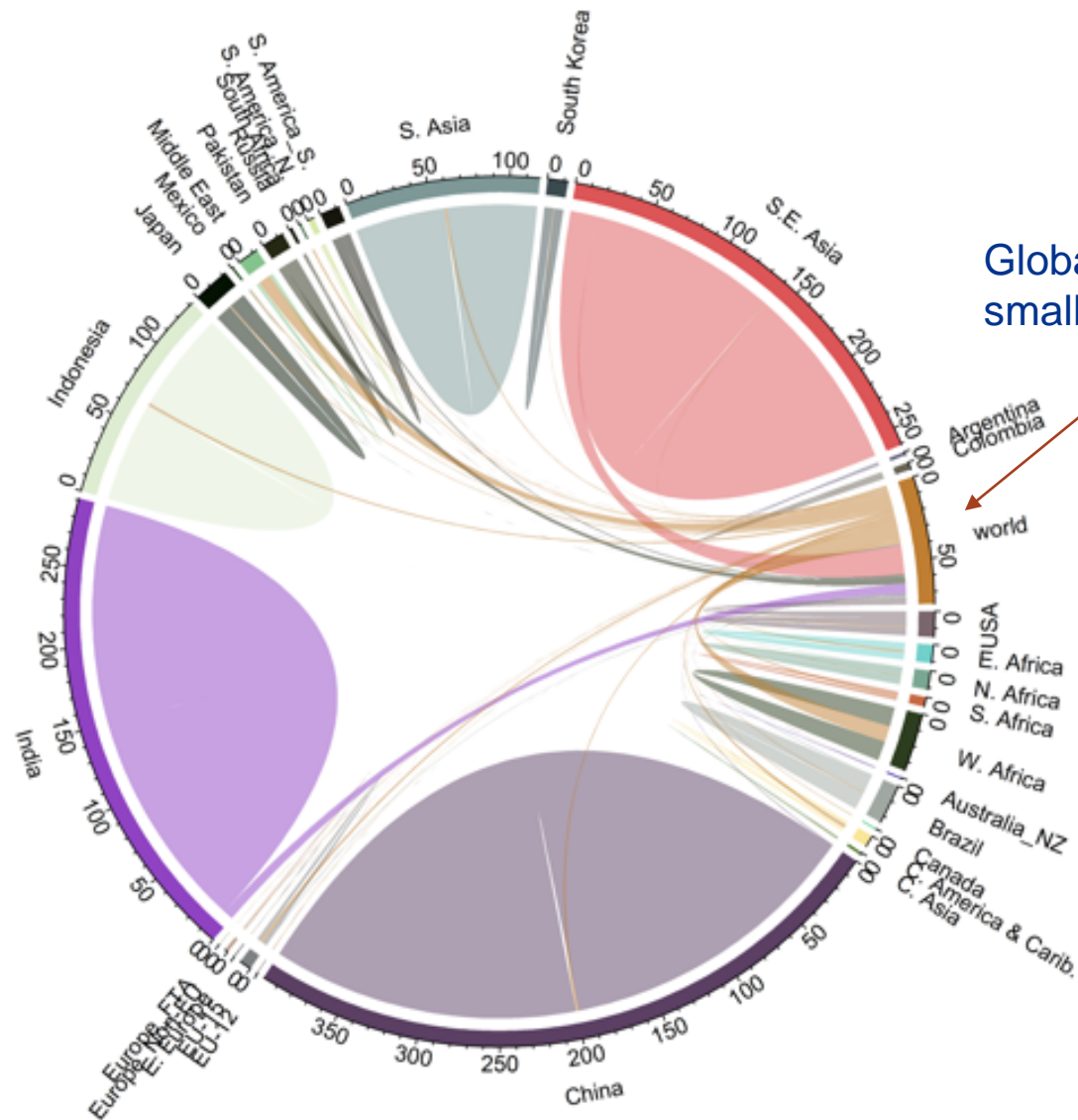
China Net Exports: Comparing the Global vs Regional Market Approaches in GCAM



- Dashed Lines show Global Market approach
- Solid Lines show Regional Market approach
- With population peaking and declining by end of century, China's demand for crops such as Rice also peaks and declines.
- Using Global Market approach – China continues to increase Rice production levels – resulting in growing exports.
- Using Regional Market approach – China's Rice production is influenced by its own demand, as well as its low historical exports, and export growth is reduced.

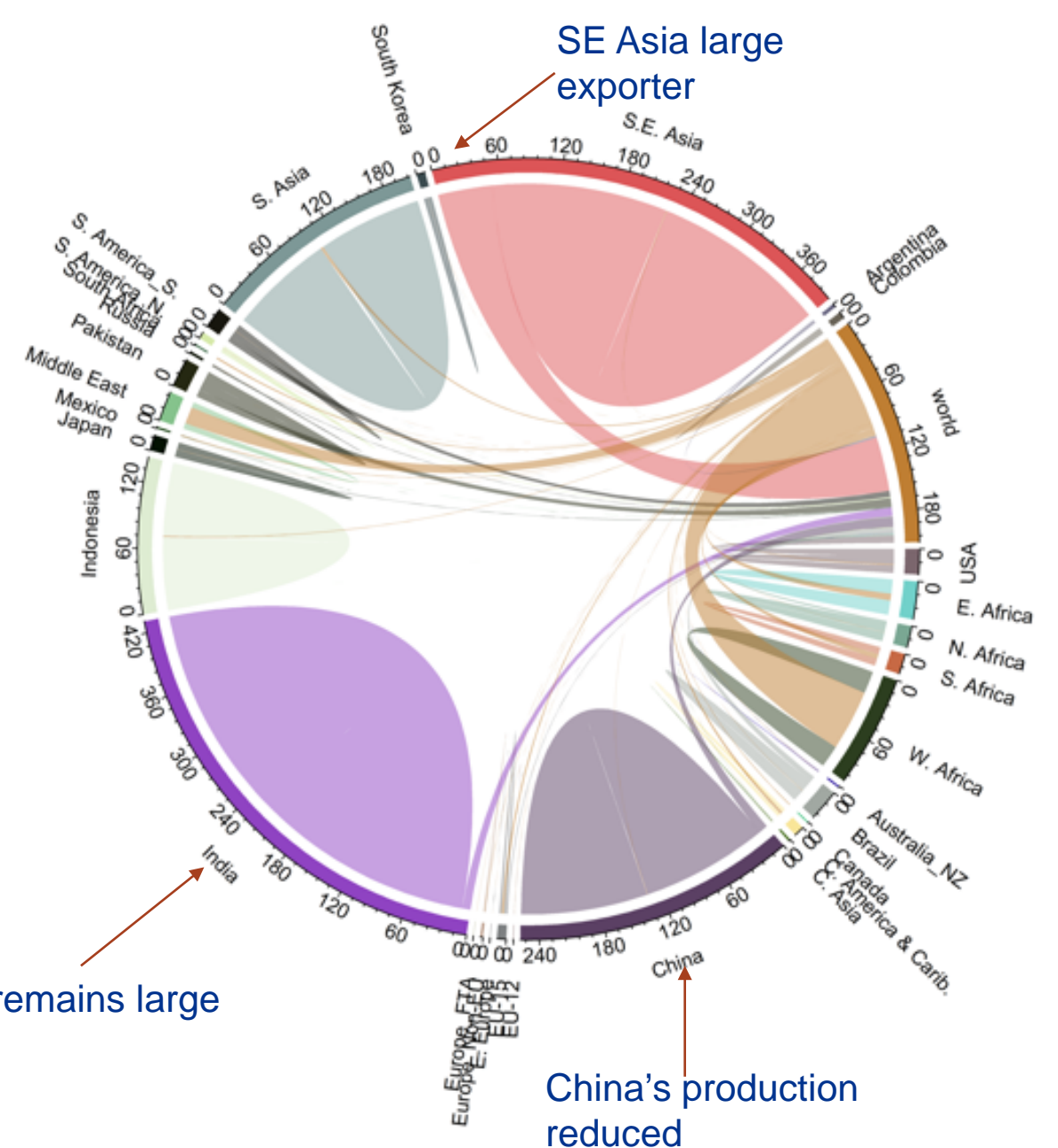
Rice Production and Trade under Regional Crop Markets: GCAM Results for Year 2100 vs 2010

Rice 2010



Global Trade much smaller than Wheat

Rice 2100



SE Asia large exporter

India remains large

China's production reduced

Summary

- We believe that these new market and trade approaches provide us with greater ability to analyze a broader spectrum of near term and long-term future scenarios and impacts.
 - General goal of flexibility in modeling: To the extent possible, we do not want the model to be locked into one approach for international trade.
- We have improved our ability to span a larger approach space within our modeling to explore the implications of different market and trade approaches.
 - Help identify which assumptions are important to future projections,
 - But also which assumptions are important to the responses to future changes in technology, socioeconomics, and other factors of change.



Thank You



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