# Impacts of LCLUC on Carbon Cycling in South and South East Asia

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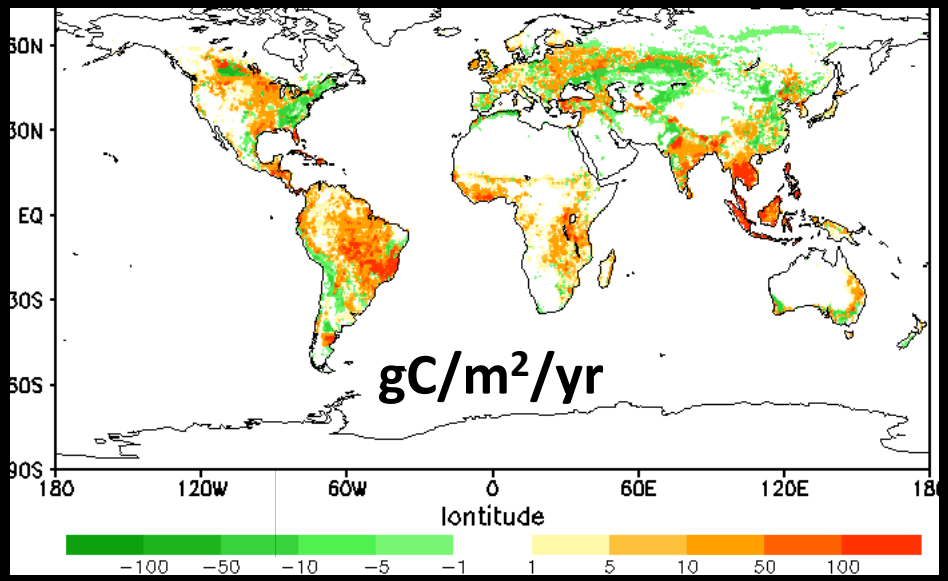
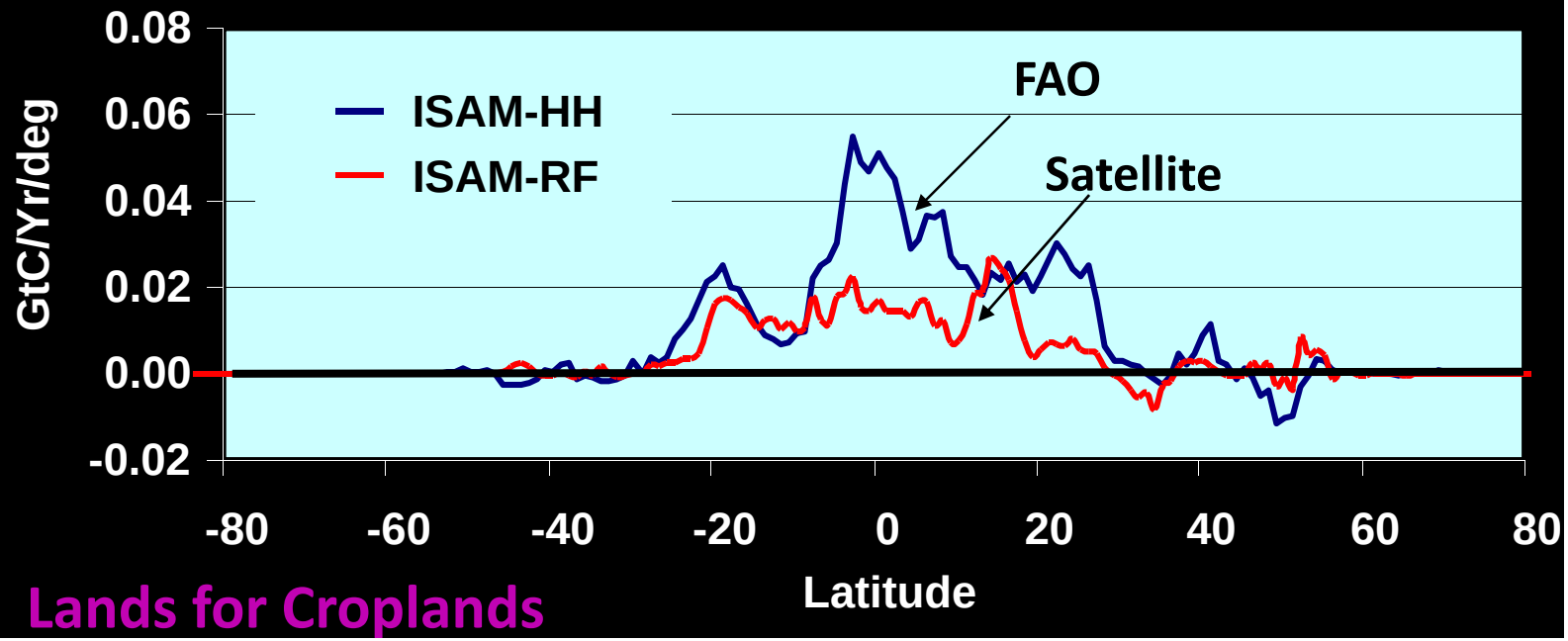
# Overall Objective

- Improve our understanding of the historical effects of LCLUC dynamics on the quantities and pathways of terrestrial carbon fluxes
  - *achieve by systematically synthesizing existing terrestrial ecosystem model results for LCLUC $CO_2$ emissions.*

# ISAM Estimated Land Use Emissions (1990s*)

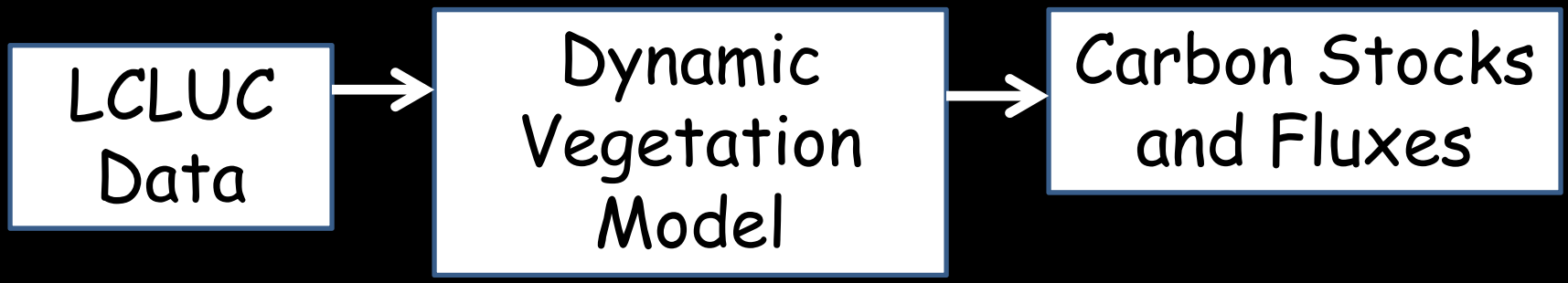



Jain and Yang (2005)



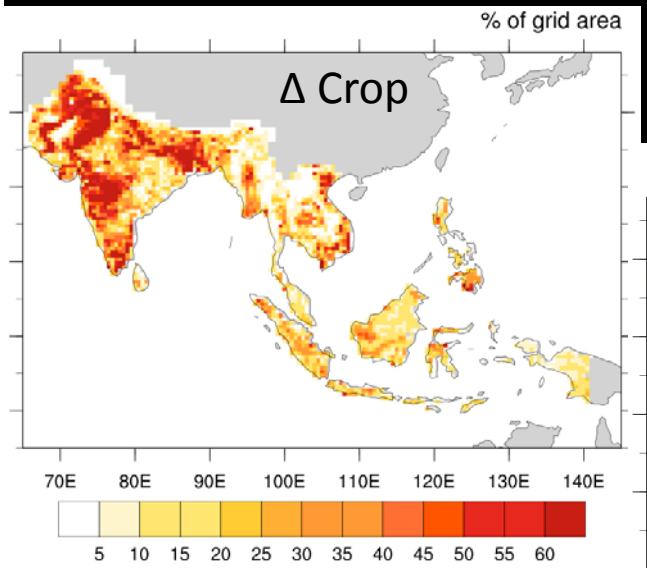

*Clearing of Lands for Croplands

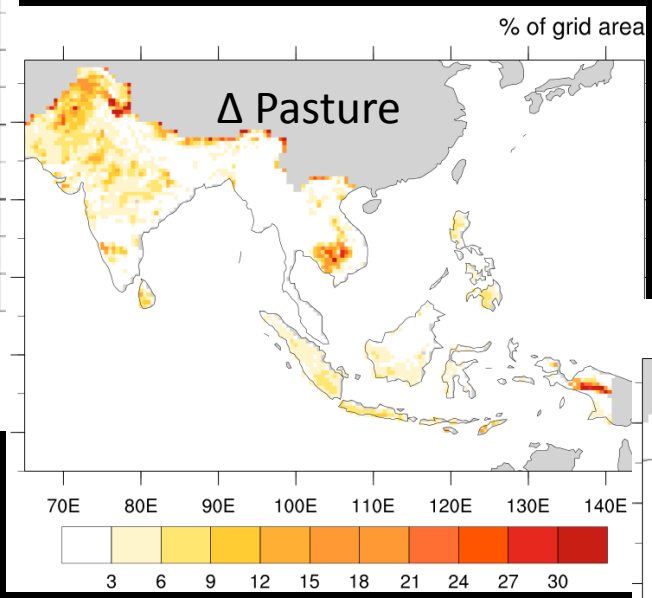
# Estimating the Impact of LCLUC on Carbon Stocks and Fluxes

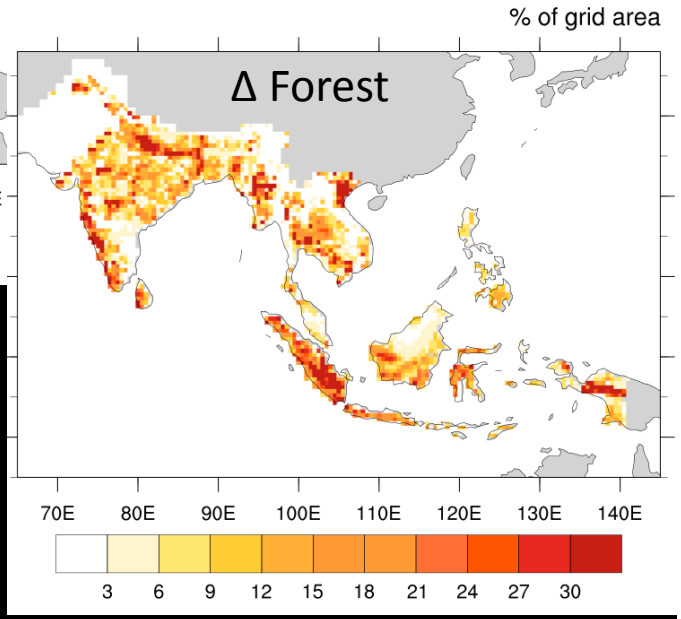



- Uncertainty in Carbon Stocks and Fluxes could be due to
  - Uncertainty in LCLUC Data
  - Uncertainty in process level understanding of parameterization of different biogeochemical (BGC) and biophysical (BGP) processes

# Maximum grid-level differences using Various Realizations of LCLUC (Average for the period 2001-2013)



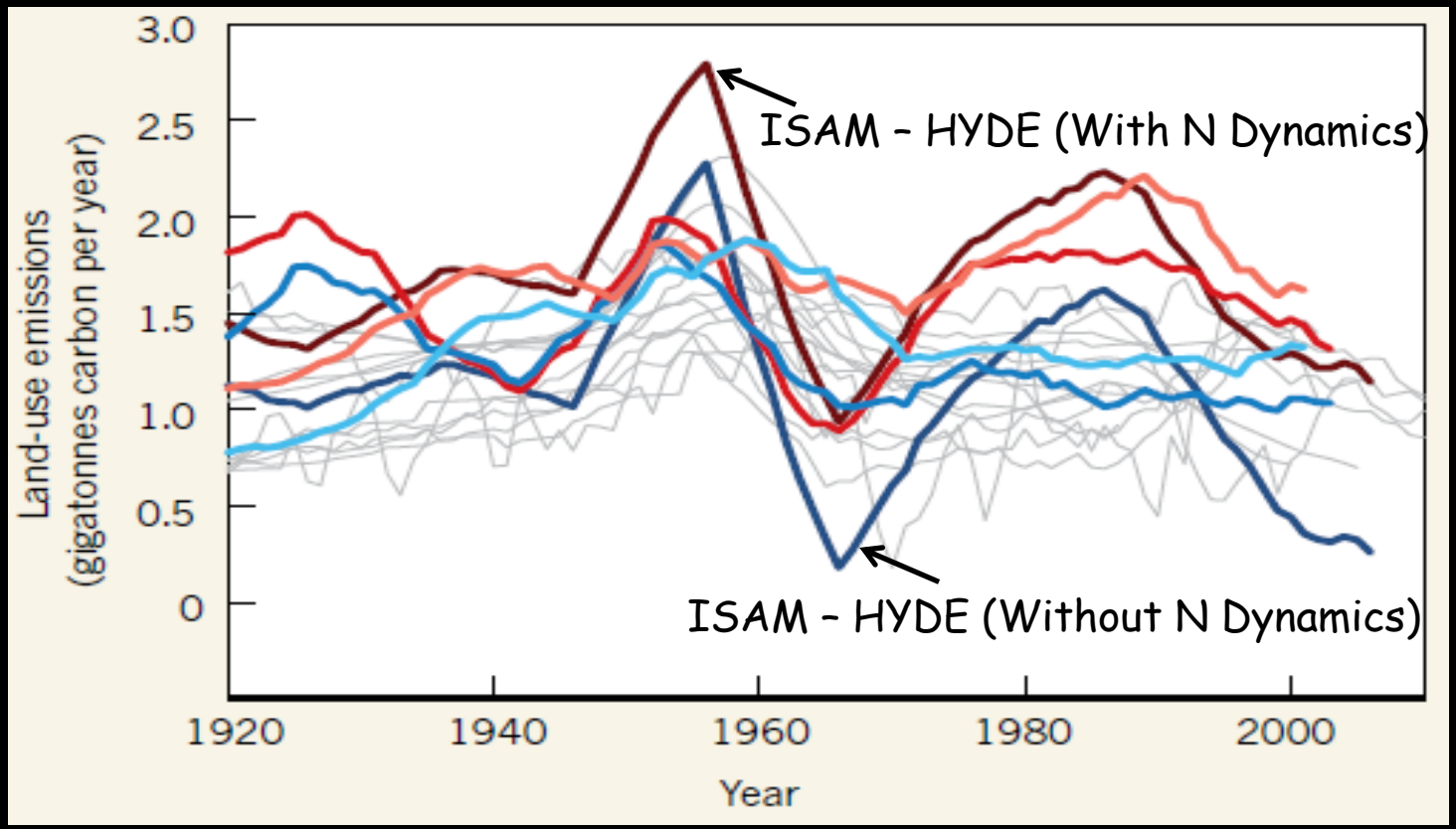




Various Realizations:

- HYDE
- SAGE (RF)
- Houghton (HH)
- Satellite data sets

# Estimates of Land Use Emissions for $CO_2$ Calculated based on Various Dynamic Vegetation Models




Pongratz (2013, Nature)

# Quantify Magnitude and Uncertainty in Carbon Stocks and Fluxes

1) Used ISAM dynamic vegetation model results, which are calculated based on three sets of LCLUC data for SSEA (1 DGVM and 3 LCLUC Date Sets)

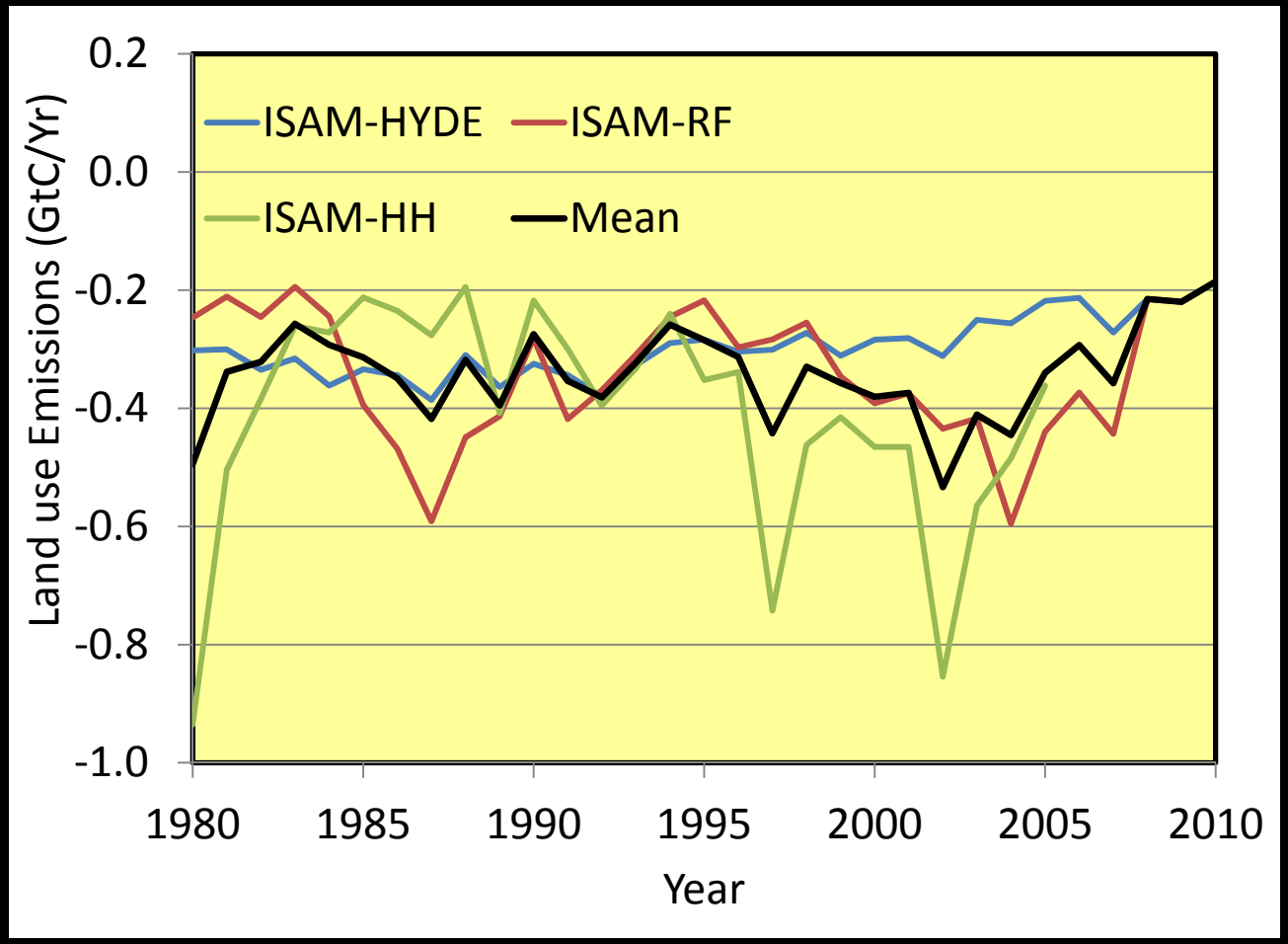
2) Used nine different dynamic vegetation model results, which are calculated based on one set of LCLUC data for SSEA (9 DGVM and 1 LCLUC Date Set)

ISAM dynamic vegetation model results, which are calculated based on three sets of LCLUC data for SSEA region

# Various Land Use Change History

- Richard Houghton (HH)
  - *Cropland, Pastureland*
- HYDE
  - *Cropland, Pastureland, Urban land*
- SAGE (RF)
  - *Cropland, Pastureland*
- Hurtt et al. (GLM)
  - *Wood Harvest*

# ISAM Estimated Land use Emissions based on three different data sets (GtC/yr)




Negative values represent net C release to the atmosphere

Jain et al. (GCB, 2013)

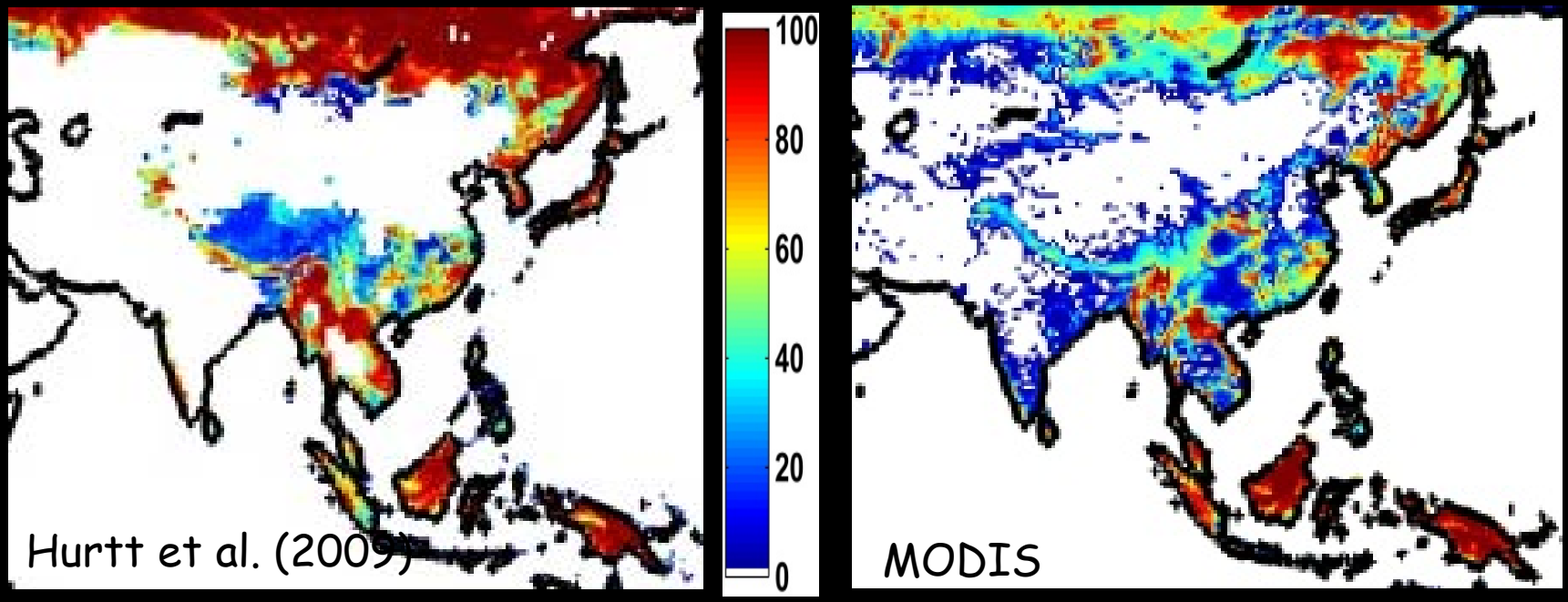
Front. Earth Sci. , 6(2): 122–139
DOI 10.1007/s11707-012-0314-2

RESEARCH ARTICLE

# Three distinct global estimates of historical land-cover change and land-use conversions for over 200 years

Prasanth MEIYAPPAN, Atul K. JAIN (✉)

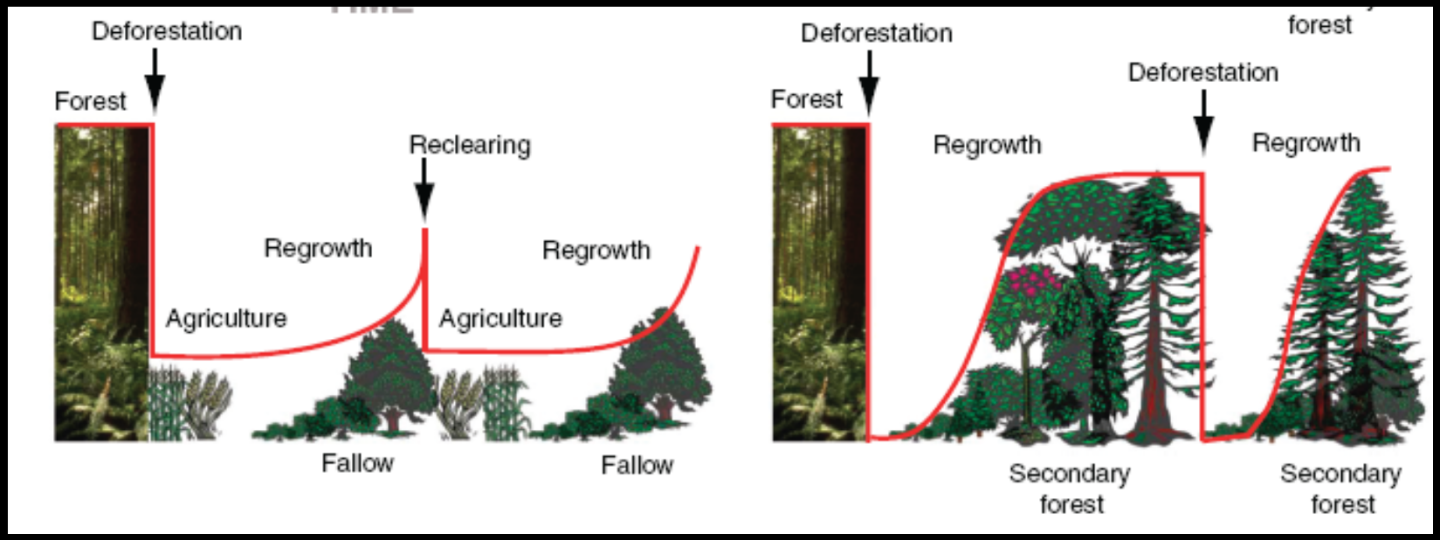
# Estimates of Forests Unit % of Grid Cell




Data sets do not account of changes in land cover, which are resulting from both indirect anthropogenic and natural causes.

Meiyappan and Jain (2012)

# Land Use Change Data is Available at Decadal or Longer Time Scale




Over the decadal and longer time scales different pathways of carbon dynamics after deforestation

Ramankutty et al.

# Causes of Differences in Crop Lands

- These data sets adopted different methods to estimate agricultural inventory.
  - HYDE inventory data was based on FAO (2008)
  - RF estimates relied more on national-level census statistics, along with FAO estimates for recent years.
  - HH data includes only cropland that were created or abandoned on land originally covered by forest.

Nine different dynamic vegetation model results, which are calculated based on one set of LCLUC data for SSEA (Global Carbon Project -TRENDY)

Earth Syst. Sci. Data, 7, 47–85, 2015
www.earth-syst-sci-data.net/7/47/2015/
doi:10.5194/essd-7-47-2015


Open Access Earth System Science Data

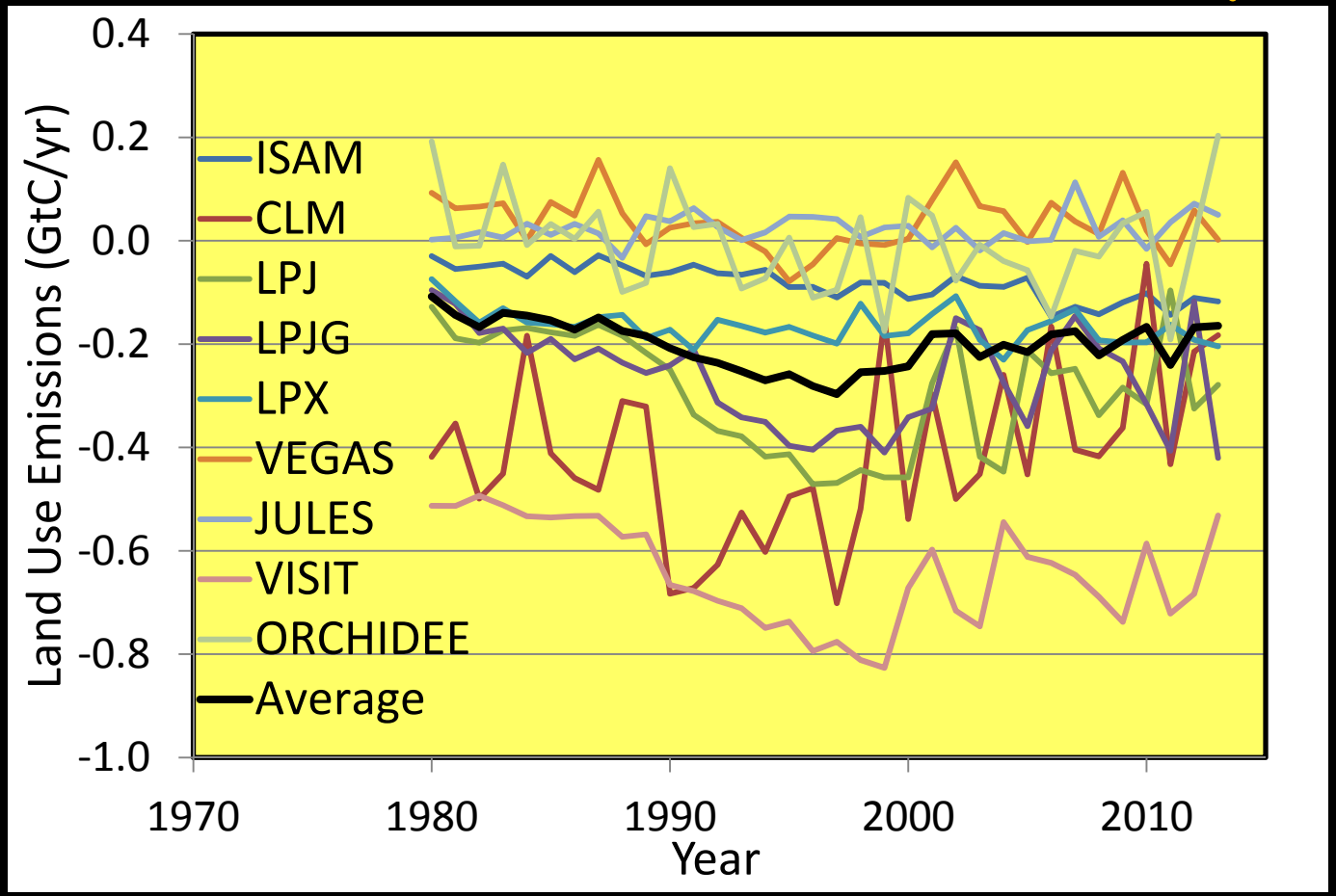
# Global carbon budget 2014

C. Le Quéré[1], R. Moriarty[1], R. M. Andrew[2], G. P. Peters[2], P. Ciais[3], P. Friedlingstein[4], S. D. Jones[1], S. Sitch[5], P. Tans[6], A. Arneth[7], T. A. Boden[8], L. Bopp[3], Y. Bozec[9,10], J. G. Canadell[11], L. P. Chini[12], F. Chevallier[3], C. E. Cosca[13], I. Harris[14], M. Hoppema[15], R. A. Houghton[16], J. I. House[17], A. K. Jain[18], T. Johannessen[19,20], E. Kato[21,22], R. F. Keeling[23], V. Kitidis[24], K. Klein Goldewijk[25], C. Koven[26], C. S. Landa[19,20], P. Landschützer[27], A. Lenton[28], I. D. Lima[29], G. Marland[30], J. T. Mathis[13], N. Metzl[31], Y. Nojiri[21], A. Olsen[19,20], T. Ono[32], S. Peng[3], W. Peters[33], B. Pfeil[19,20], B. Poulter[34], M. R. Raupach[35,†], P. Regnier[36], C. Rödenbeck[37], S. Saito[38], J. E. Salisbury[39], U. Schuster[5], J. Schwinger[19,20], R. Séférian[40], J. Segschneider[41], T. Steinhoff[42], B. D. Stocker[43,44], A. J. Sutton[45,13], T. Takahashi[46], B. Tilbrook[47], G. R. van der Werf[48], N. Viovy[3], Y.-P. Wang[49], R. Wanninkhof[50], A. Wiltshire[51], and N. Zeng[52]

# 9 DGVMs and One Land Use Data Set

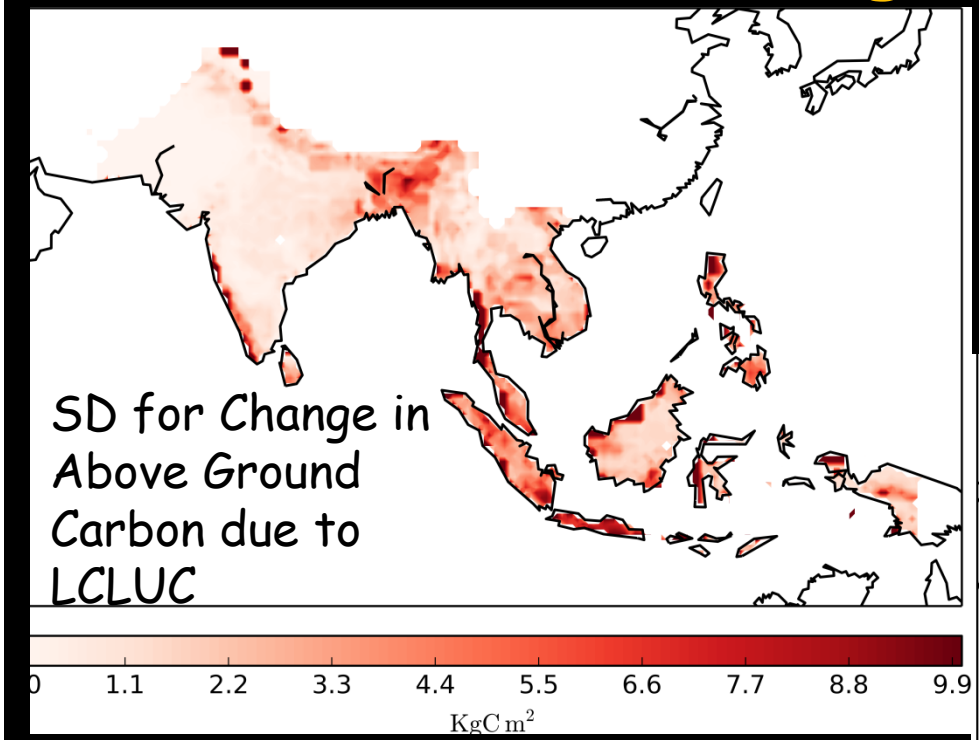
- Nine dynamic vegetation models
  - CLM (NCAR, USA)
  - ISAM (University of Illinois, USA)
  - JULES (Met Office, UK)
  - LPJ (University of Exeter, UK)
  - LPJ GUESS (Lund University, Sweden)
  - LPX (University of Bristol, UK)
  - ORCHIDEE (IPSL, France)
  - VEGAS (University of Maryland, USA)
  - VISIT (IAE, Japan)
- One set of LCLUC data set
  - HYDE Data set

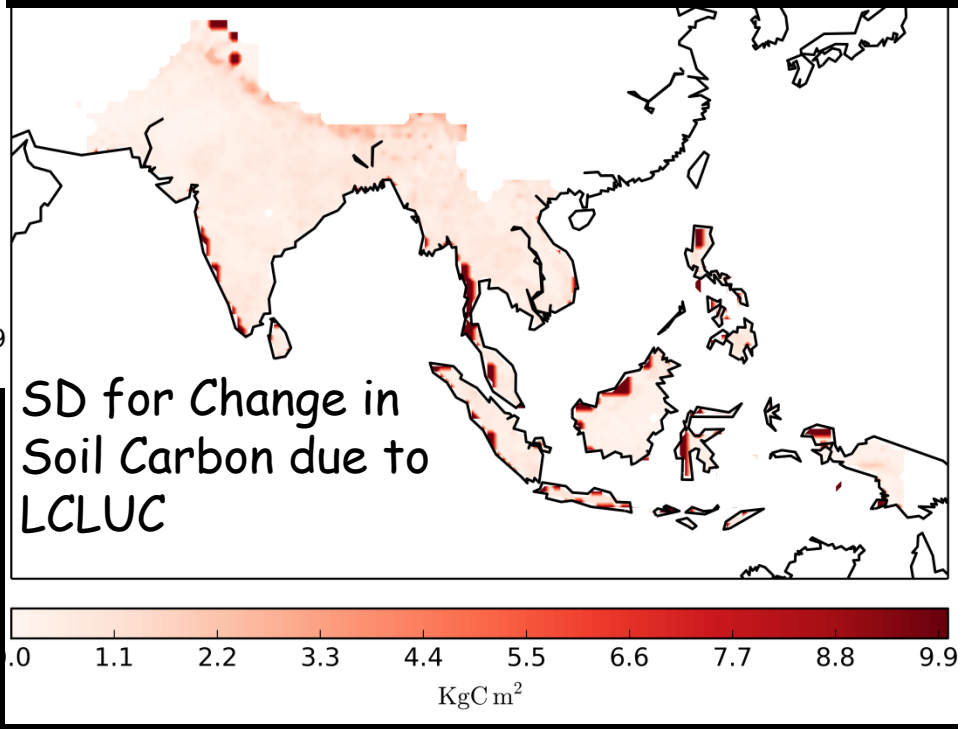
# Land Use Emissions Estimated Based on 9 DGVMs (GtC/yr)



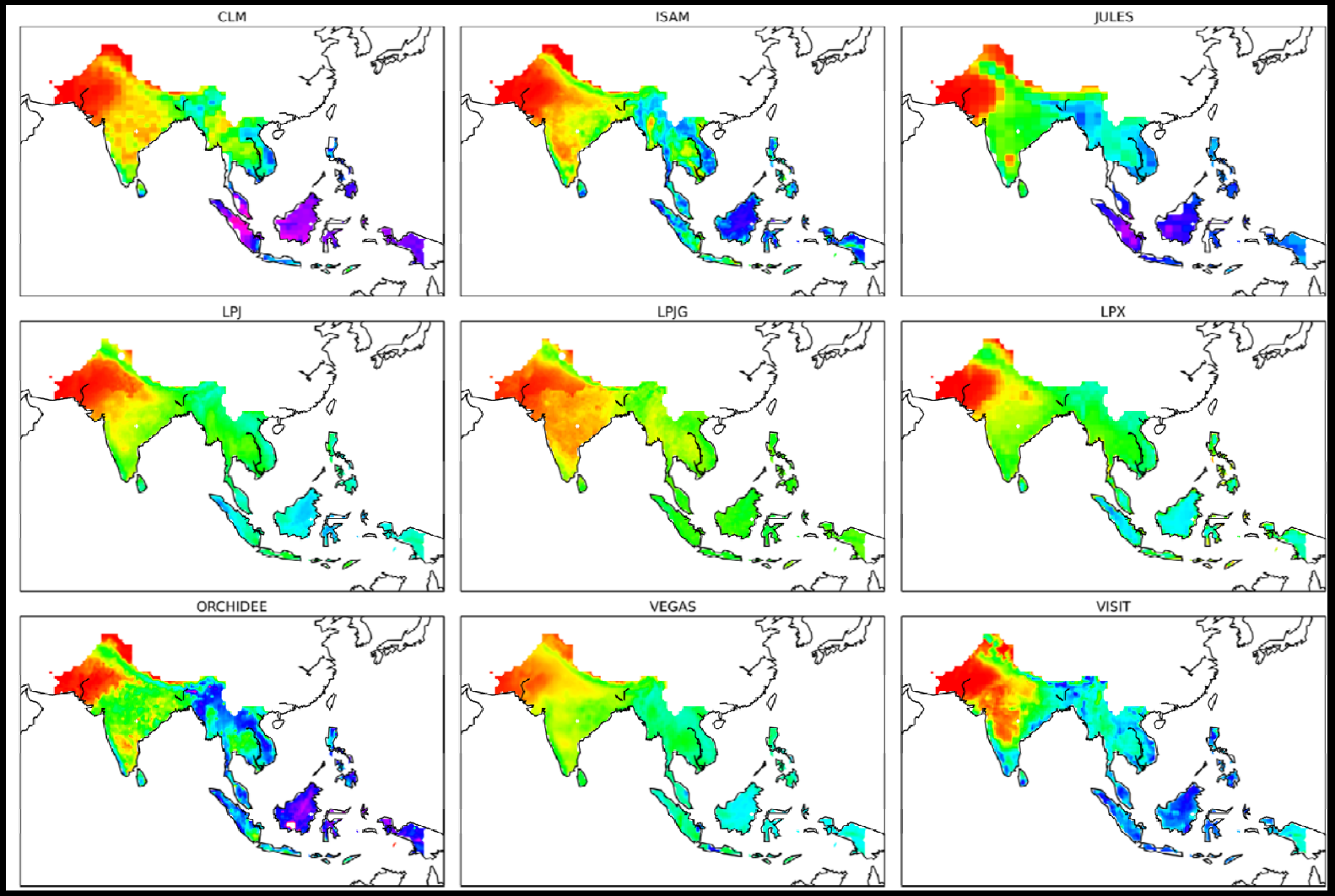

Negative values represent net C release to the atmosphere and positive values net C storage in terrestrial biosphere

# SD for 9 Model Results for Above Ground Carbon and Soil Carbon ($KgC/m^2$)

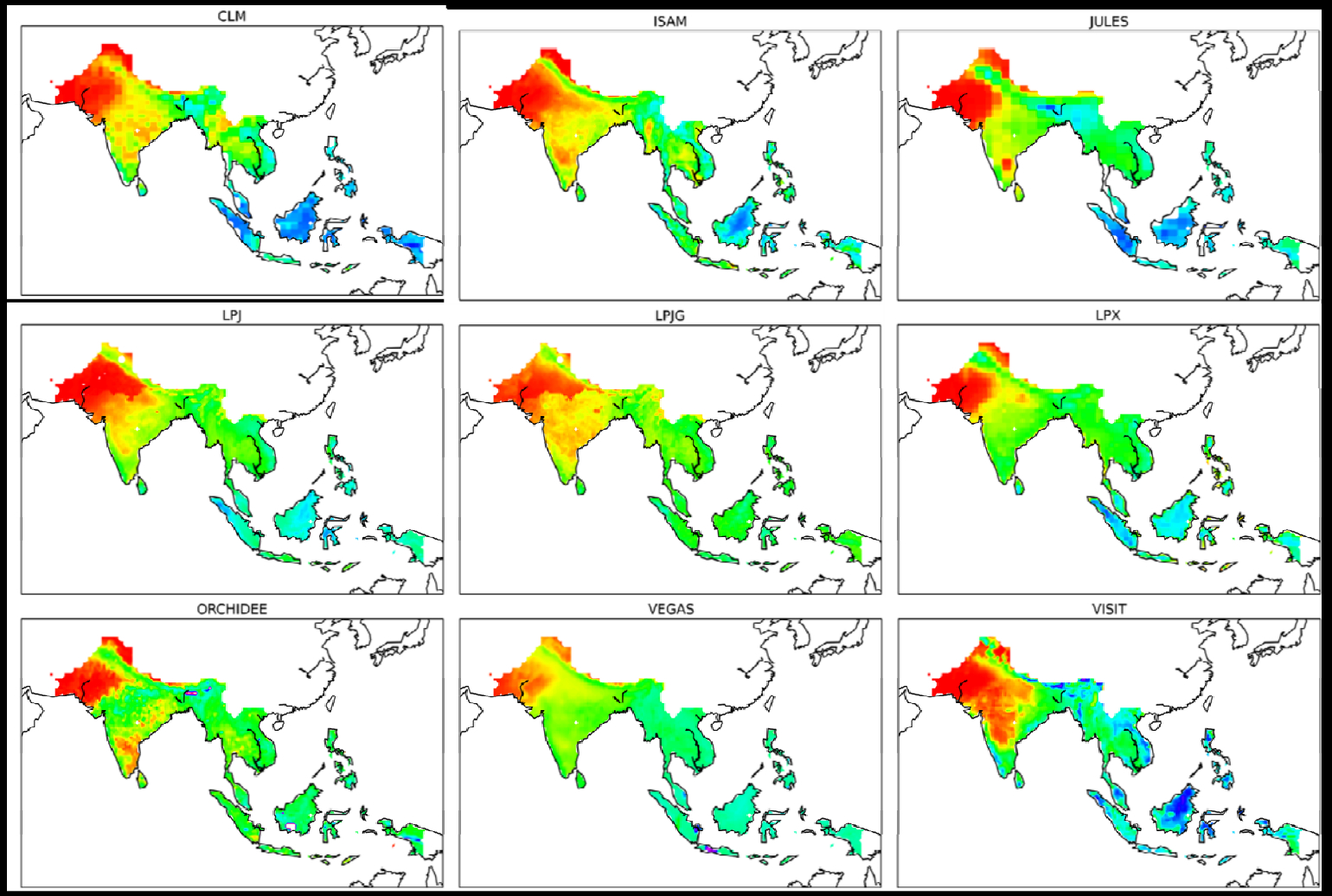


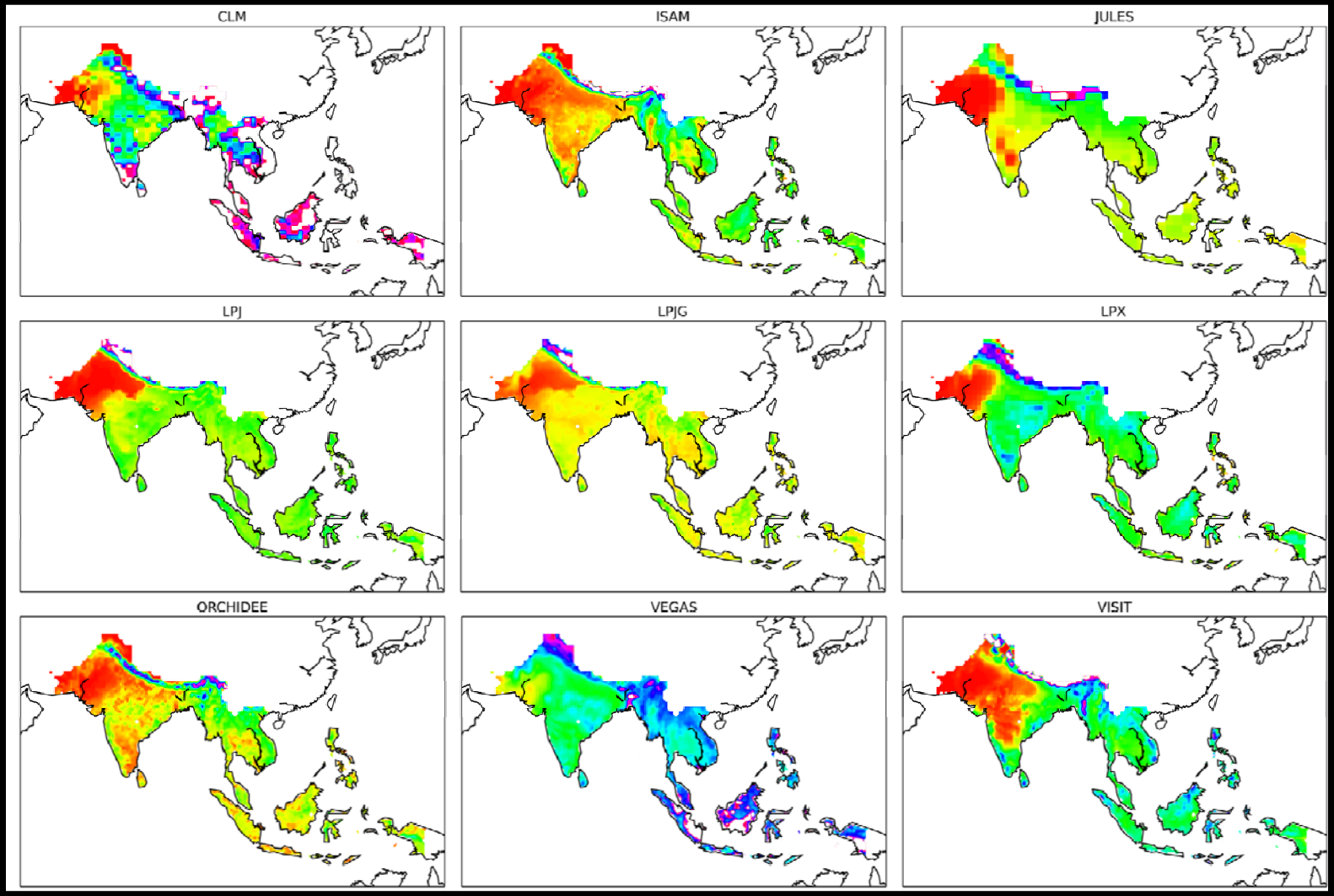
# Annual Average Gross Primary Productivity (GPP) for the Period 2000s



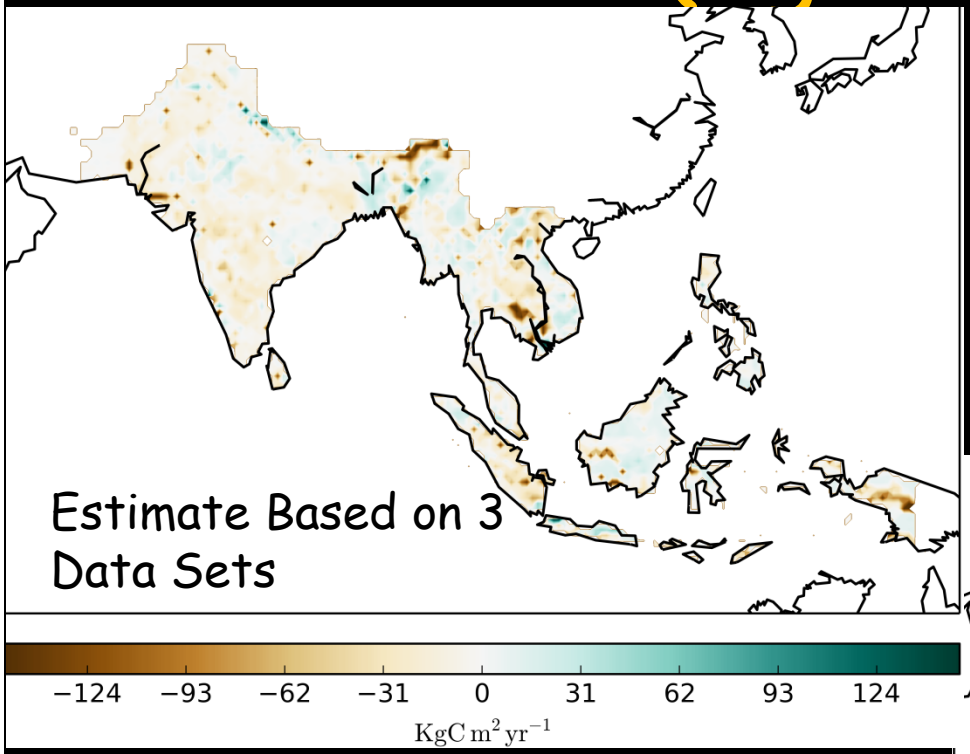
# Annual Average Net Primary Productivity (NPP) for the Period 2000s



# Annual Average Soil Carbon for the Period 2000s



# Mean Land Use Emissions ($KgC/m^2/yr$)

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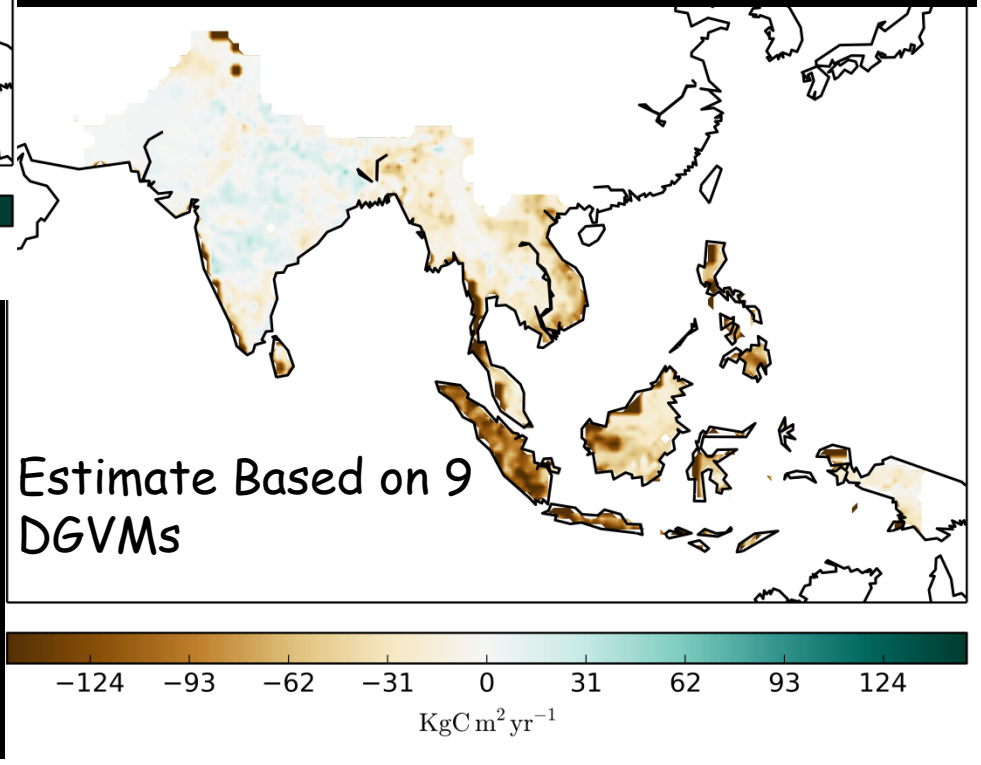
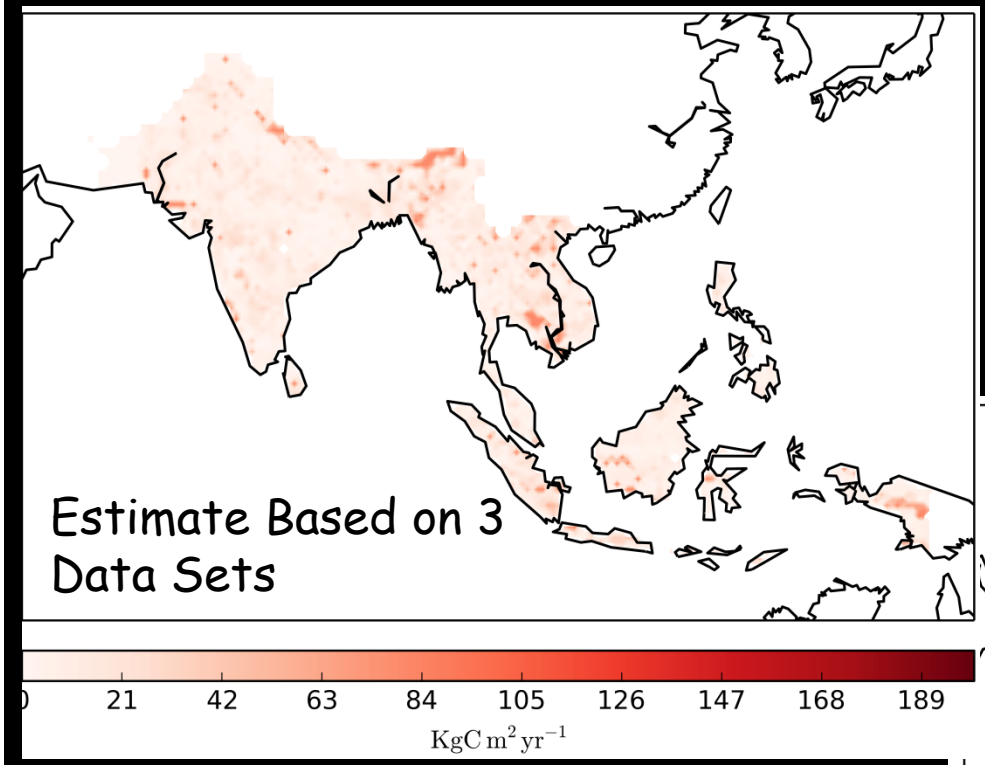
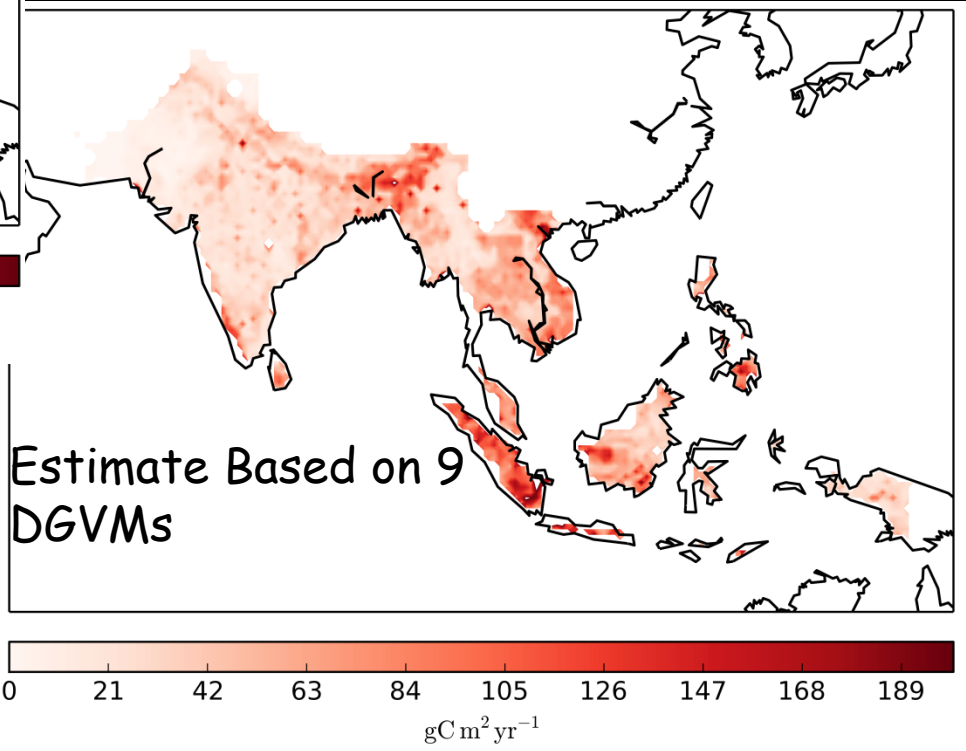
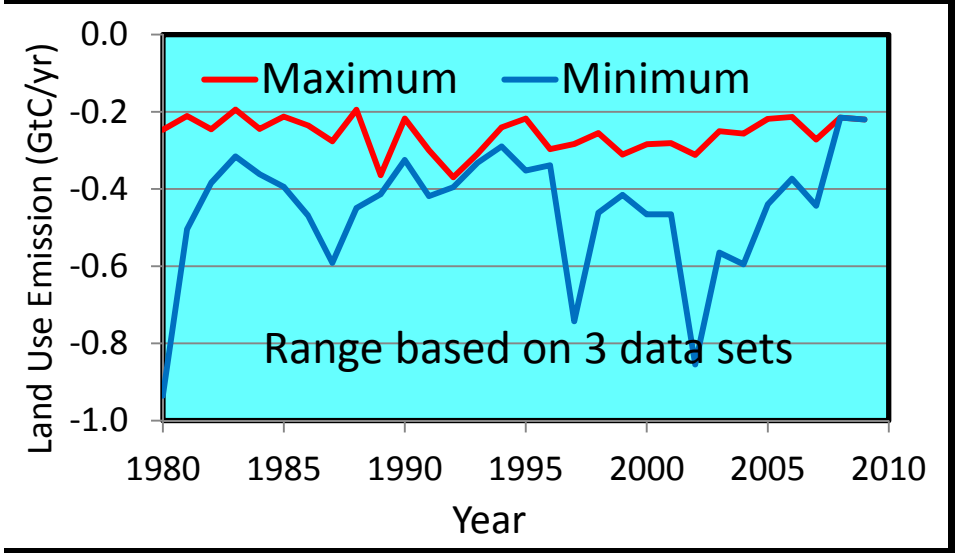


# Standard Deviation for Land Use Emissions for the 2000s ($gC/m^2/yr$)



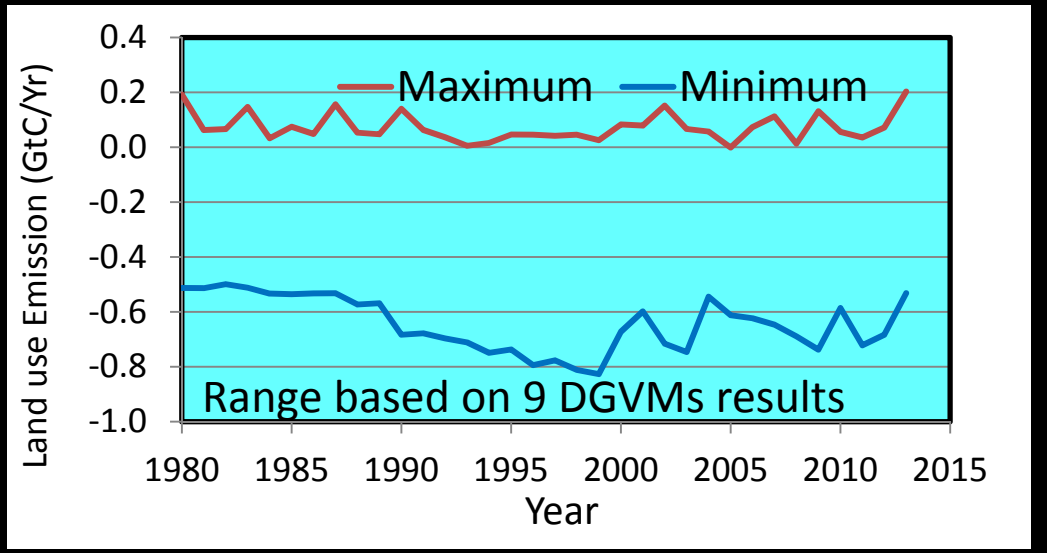



# Overall Uncertainty




Uncertainty range for recent decade
-0.43 – (-0.24) GtC/yr

Uncertainty range for recent decade
-0.65 – 0.07 GtC/yr



# Conclusion

- The discrepancy in the magnitudes of the modeled and the data based estimates for LCLCU emission in SSEA region is large due to
  - Uncertainty in LCLUC data sets
  - Limitations of the terrestrial ecosystem models

# Importance of satellite and ground-based measurement Data

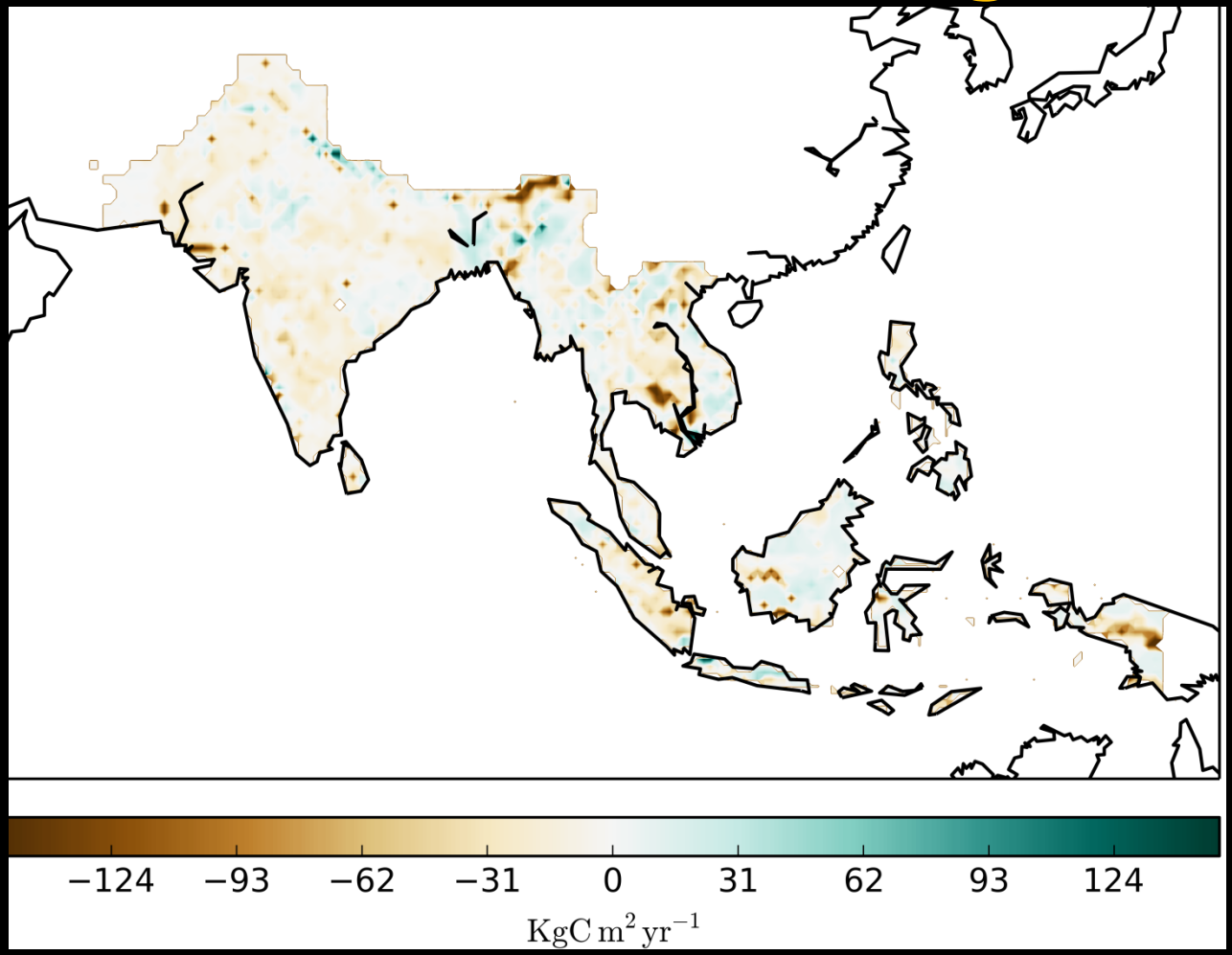
- Satellite data provides important information to study the impacts of historical LCLUC on carbon
  - But the focus so far is on mapping land cover and land Use
  - More emphasis should be give on improving the rates and spatial patterns of LUC
  - Ground based measurement data is also needed to further improve our estimates

# Improving Model Based Estimates

- Model based estimates for carbon emissions due to LCLUCs needs to more focus on
  - improving the estimates for biomass for different vegetation and soil pools by evaluating the model results using both ground based and satellite based measurements.
  - Evaluating the models for various regional case studies
  - Emphasis should be given to improve quantitative estimates of LCLUCs

Thank You

# Mean land Use Emissions based on three data sets (KgC/m$^2$/yr)

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