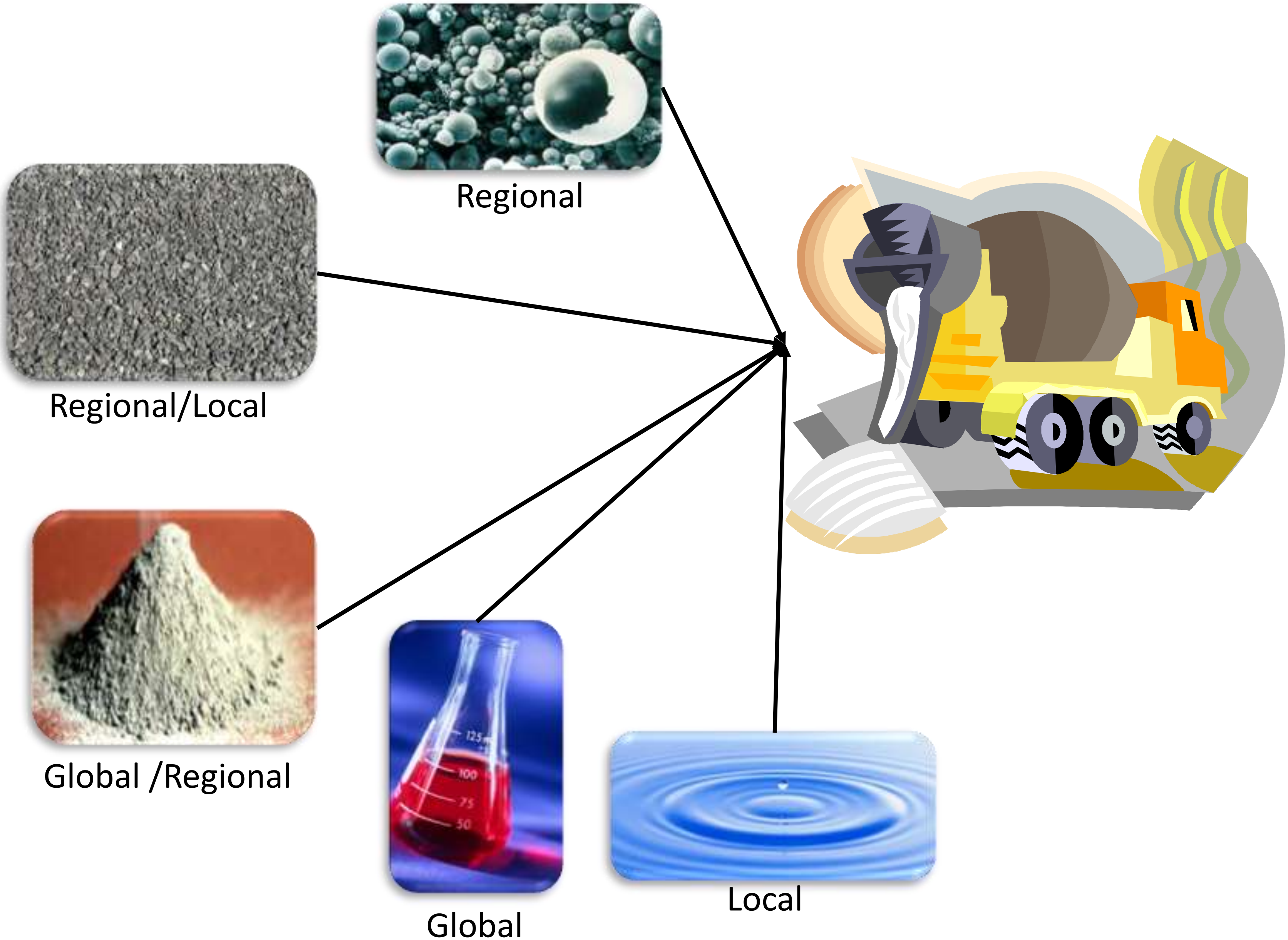
Materials: Data Selection

Tom Van Dam, Ph.D., P.E.
Program Director
Applied Pavement Technology

Alissa Kendall, Ph.D.
Assistant Professor
Dept. of Civil & Environmental Engineering
UC Davis

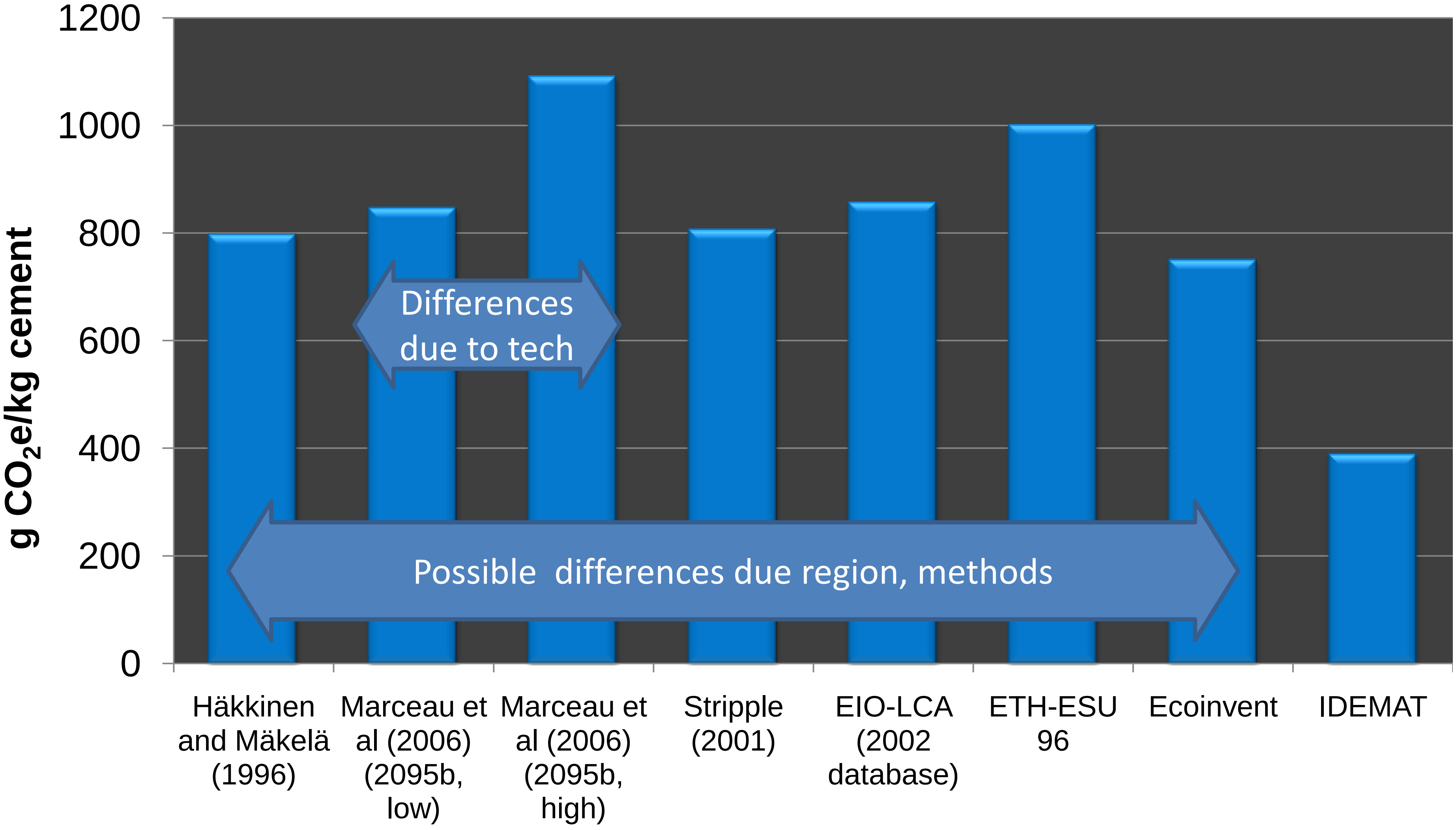
Spatial Scales for Materials



Cement and Concrete LCIs

- Production process for cement and concrete is well understood
- Doesn’t require an allocation process like bitumen
- Yet there is variability across datasets characterizing cement production

GHG emissions per kg cement



Sources of Variability

- Production technology
- How cement is defined
- Fuel source
- Raw material source
- These are *real* and *reasonable* sources of variability that should be captured in an LCI of cement

Cement Production Technologies

- "Wet" versus "dry" process plants
- Older versus newer plants
  - Preheaters/precalciners
- Data that is a decade old may not reflect modern cement
- How important is this?

What Constituents Cement?

- ASTM C150 (AASHTO M 85) portland cement
  - Now allows up to 5% limestone addition plus processing additions
- ASTM C595 (AASHTO M 240) blended cements
  - Portland cement blended with pozzolan, slag cement, or combination of two
  - May include limestone in future
- ASTM C1157 performance cements
  - Typically portland-limestone cements

Fuel Sources

- Main fossil fuel source is coal
- Waste fuels
  - Tires
  - Waste solvents and oils (major fuel source)
- Biofuels
- How is this currently modeled, how important is this?

What is the “Correct” LCI for cement?

- Cement is a global commodity
- Example: US reliance on foreign cement

Year	2004	2005	2006	2007	2008
Net import reliance as a % of apparent consumption	21%	25%	26%	19%	12%
Production (portland and masonry cement - includes imported clinker)	97,434	99,319	98,167	95,464	87,700

*97% of imports to the port of LA are from China and Thailand – but we don’t have good data on what fuels or production technology are being used in these places, nor do we have a good idea of the transportation burdens

* So for California, what is the “right dataset”?

Source: van Oss, H. G. (2009) “Cement” in *Mineral Commodity Summaries*. USGS

Supplementary Cementitious Materials

- Hydraulic cement specifications allow for various additions of SCMs
  - ASTM C150 (AASHTO M 85), ASTM C595 (AASHTO M 240), ASTM C1157
- In U.S., SCMs are commonly added at concrete plant
  - Outside of control of cement company
- In an LCA, the impact of SCMs can be easily assessed

What About Emerging Cements?

- Alkali-activated fly ash and slag cement
  - Requires alkali solution (NaOH)
- Geopolymers
  - Requires alkali solution (NaOH)
  - Many are based on fly ash or metakaolin
- Magnesium silicates
- Carbon sequestering
  - Added as SCM and/or carbon negative cement
- <u>How will this be reflected in an LCA?</u>

Aggregate Transport

- 0.05 MJ / kg aggregate (for extraction and processing)
- 0.001 MJ/kg-km (truck)

  - **100 miles of truck travel is twice as much energy as producing the aggregate**

  - So is using national average data appropriate for aggregate (e.g. the commodity flow survey)

Cement versus Concrete

- Concrete is what matters, not cement
- Approach must account for SCM additions at both cement plant and concrete mix plant
  - Limestone additions of 3% to 12%
  - 15% to 40% replacement of portland cement with SCMs
- Concrete mixture design must be considered
- And of course, it is the life-cycle that ultimately must dictate
  - Design, longevity, and so on

Concrete Mixtures for the I-35W Bridge (CI, February 2009)

Component	Specified Strength (psi)	Cementitious Materials					Est. CO_2 (lb/yd³)
		Total (lb/yd³)	Portland Cement (%)	Fly Ash (%)	Slag (%)	Silica Fume (%)	
Superstructure	**6500**	**700**	**71**	**25**	**-**	**4**	**467**
Piers	**4000**	**575**	**15**	**18**	**67**	**-**	**85**
Footings	**5250**	**< 600**	**40**	**18**	**42**	**-**	**235**
Drilled Shafts	**5000**	**< 600**	**40**	**18**	**42**	**-**	**235**

Observations/Questions

- LCIs are well developed for cement/concrete
- Datasets may not accurately reflect modern cements and U.S./regional practices
- Local cement production variations are not usually considered
- Aggregate transportation dominates their impact thus is average data useful?
- How are the impacts of emerging technologies validated and included in datasets?