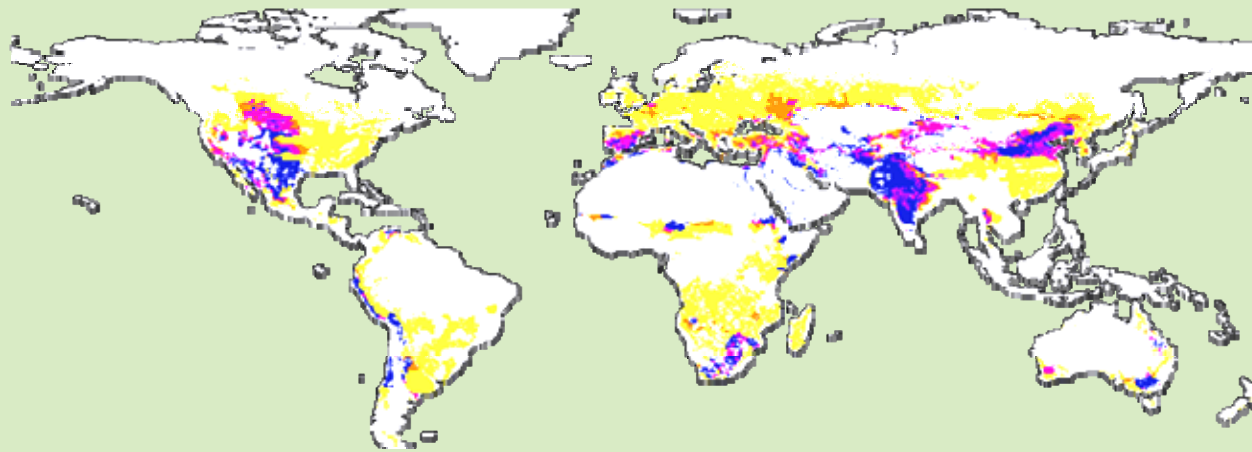


# IMPACTS OF WATER CONSUMPTION: UNCERTAINTIES AND THE QUESTION OF SCALE



**Stephan Pfister**

Institute of Environmental Engineering, ETH Zurich

[pfister@ifu.baug.ethz.ch](mailto:pfister@ifu.baug.ethz.ch)

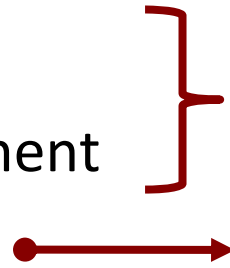
# Question of scale

- **No water scarcity** on global average
- Different impacts:
  - Ecosystems
  - Humans
  - Stock/fund resources
- Especially relevant in **agricultural LCA**
  - Highly variable inventories

# Uncertainties

- Uncertainty

- Inventory
- Impact assessment
- Spatial



Any LCA

RegionalisedLCA

- Variability

- Technology
- Climate
  - Regional
  - Temporal

If  $LCA\text{-value} = f(\text{location})$

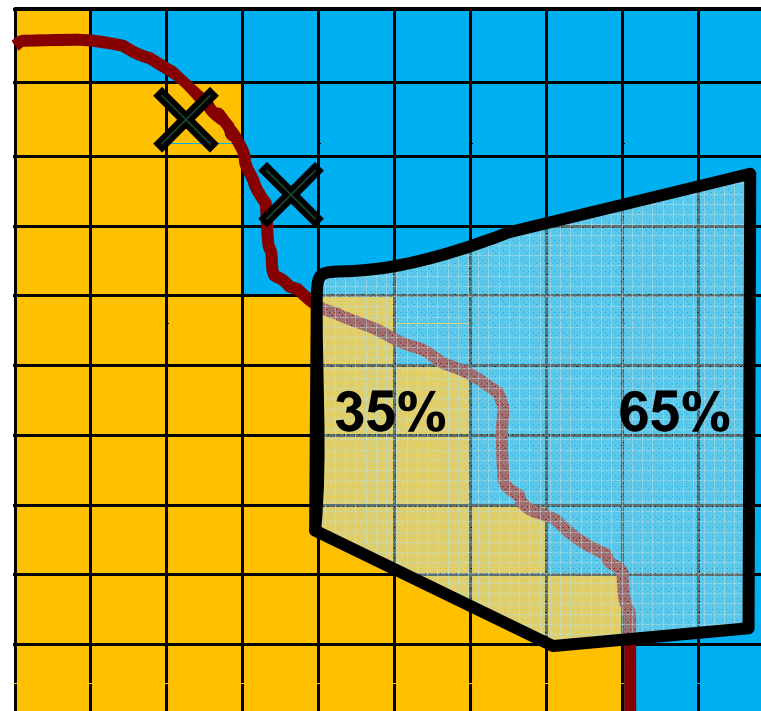
➡ Spatial uncertainty reflects variability

➡ Improve by increasing precision



# Resolution issues

- Connect to inventory



- Maximize resolution
- Use weighted results for features

# Water Impact Assessment (WIA)

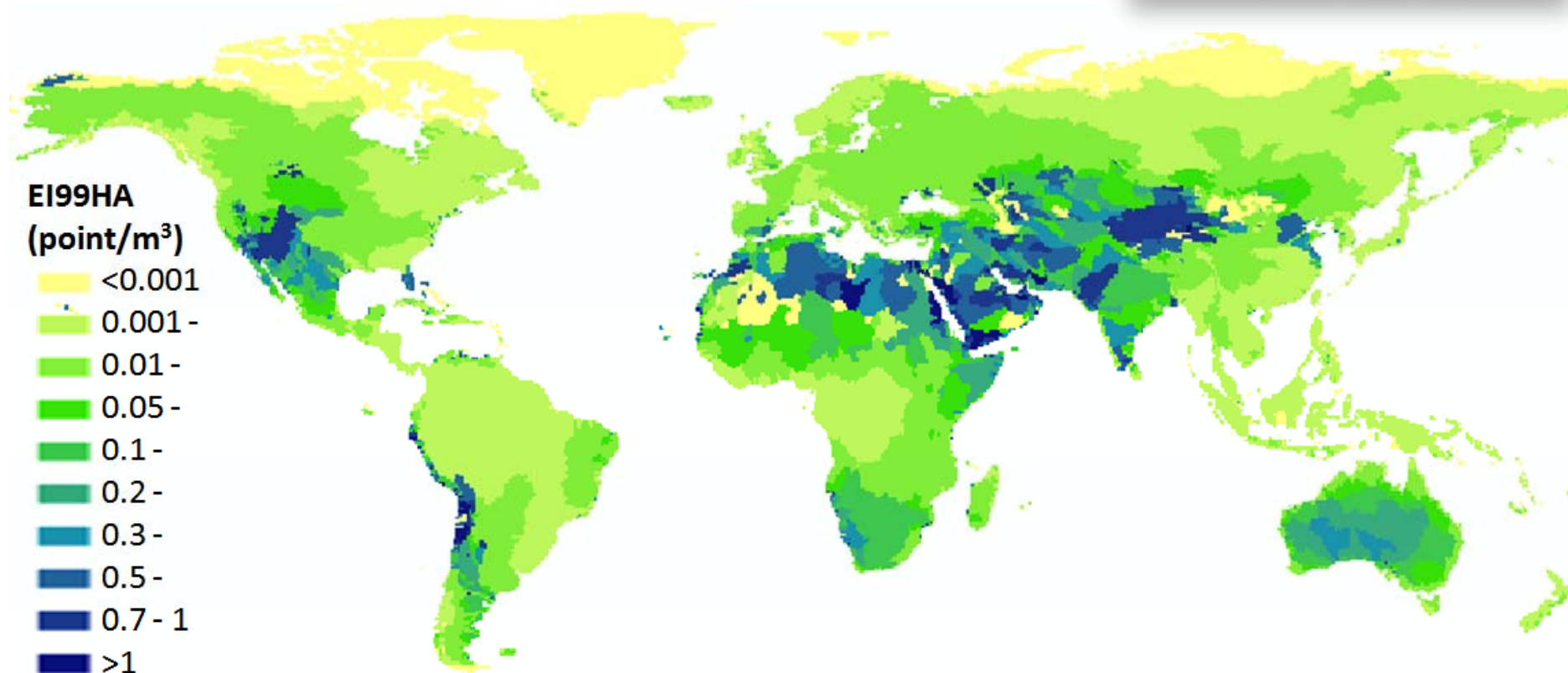
- Midpoint and endpoint factors
  - compatible with Eco-indicator 99 (EI99)
- More than 11'000 watersheds characterized (global coverage)
- Publicly available:

- Google Earth layer:  
[http://www.ifu.ethz.ch/staff/stpfiste/Impact factors LCA pfister et al.kmz](http://www.ifu.ethz.ch/staff/stpfiste/Impact%20factors%20LCA%20pfister%20et%20al.kmz)
- Reference:  
Pfister, S.; Koehler, A.; Hellweg, S. **Assessing the environmental impacts of freshwater consumption in LCA.** *Environ. Sci. Technol.* 2009, 43 (11), 4098–4104.

# Aggregated damage factors

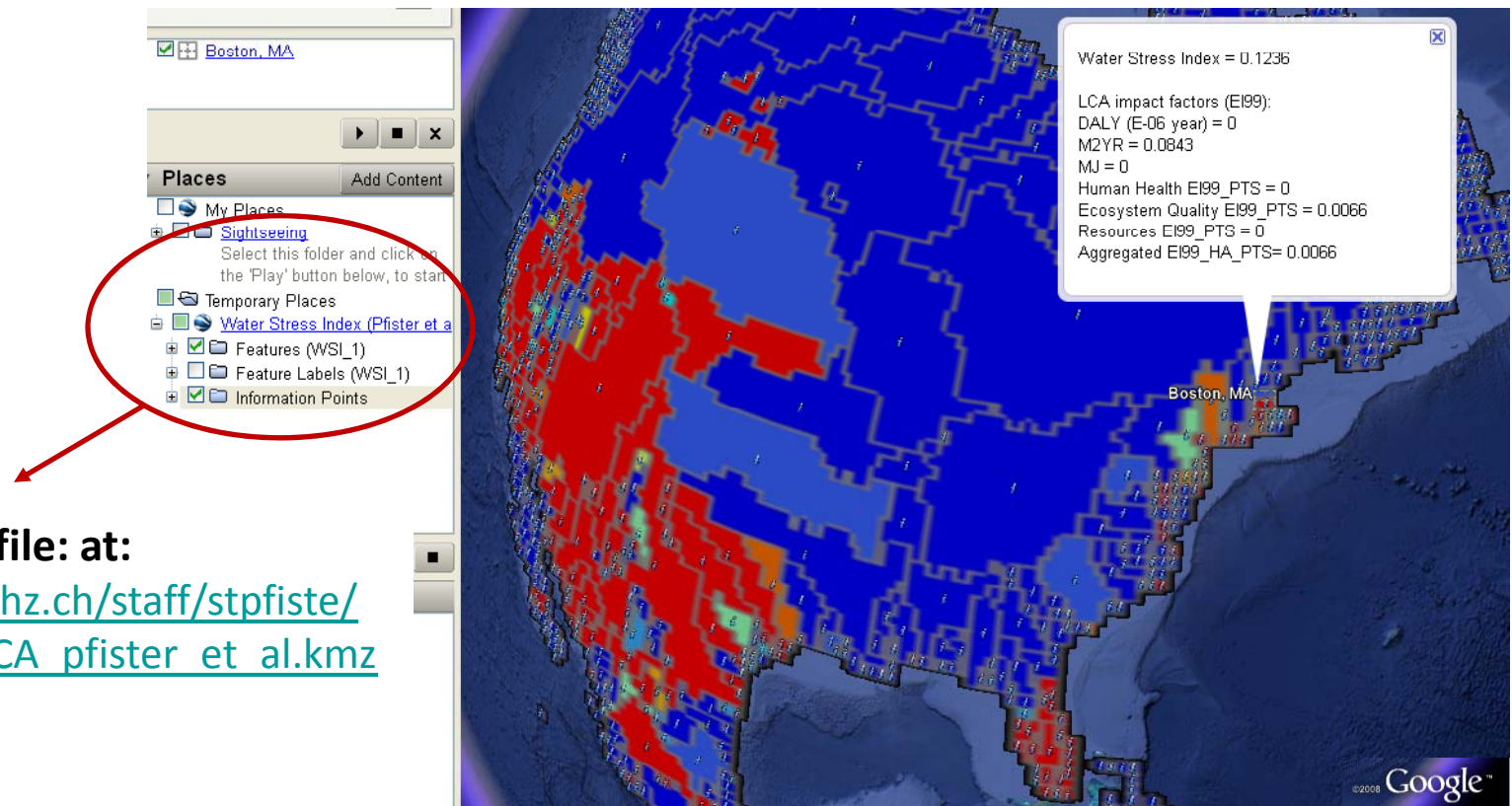
(based on EI99 average weighting)

WATERSHED LEVEL



# How to use the regionalized “add-on”

- Impact factors in Google Earth

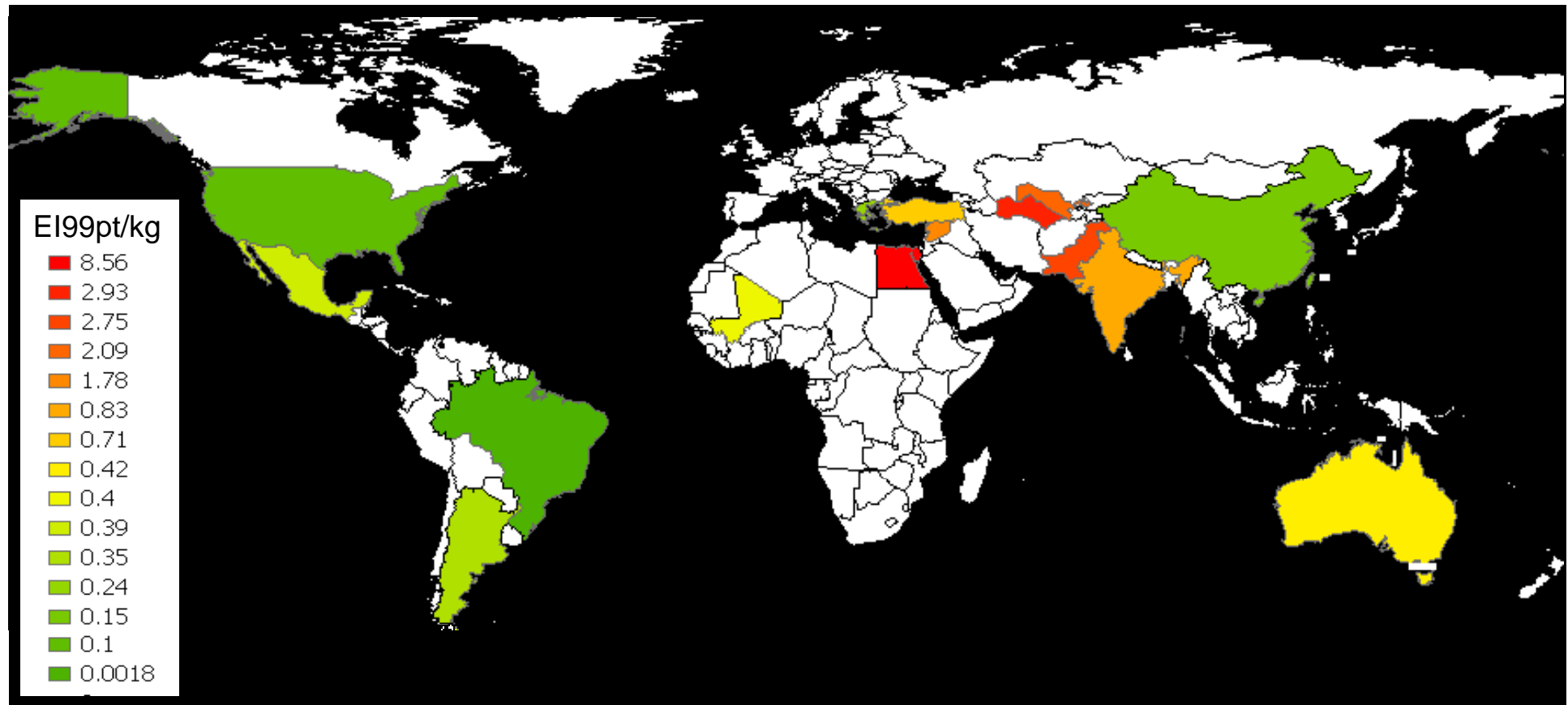




# Application

# Cotton example

- Analysis based on country level  
(inventory and impact factors)



# Variability of regional impacts

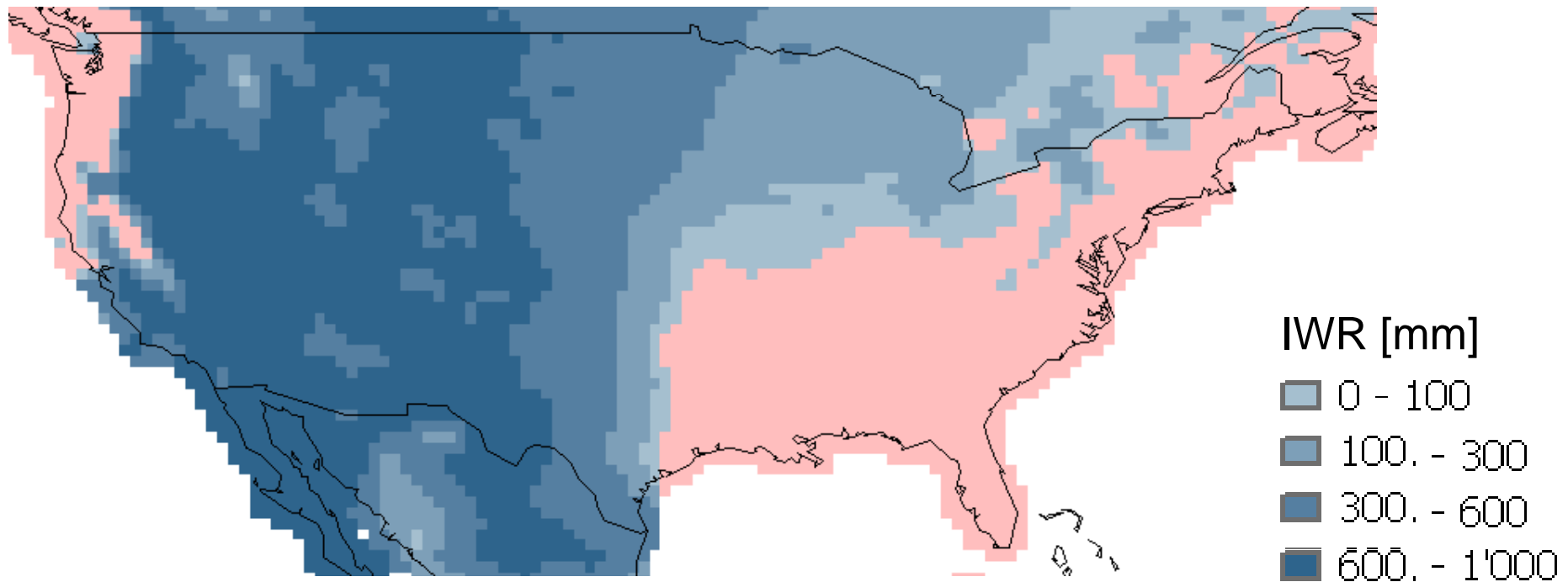
- Water impacts and inventors highly climate-dependant
  - Big countries -> high variations
- Example **United States:**
  - Impact: 0.001 – 0.987 EI99pt/m<sup>3</sup>  
(~ factor of 1000; average: **0.069**)
  - Inventory: infinite factor

Resolution is not enough:  
→ Use highest possible resolution

# Simulated irrigation water consumption

- Neglected:

Yield = f(irrigation, temperature, fertilization, machinery, etc.)

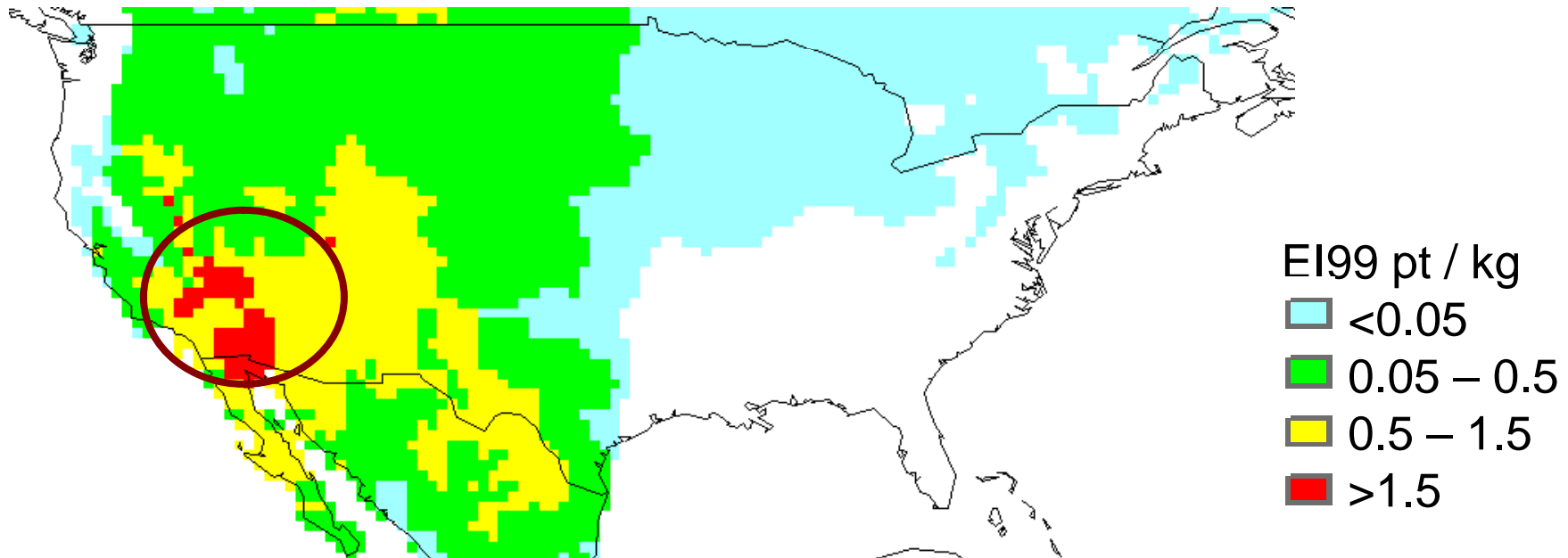


# Impact assessment

Damage per m<sup>3</sup>  
water consumed



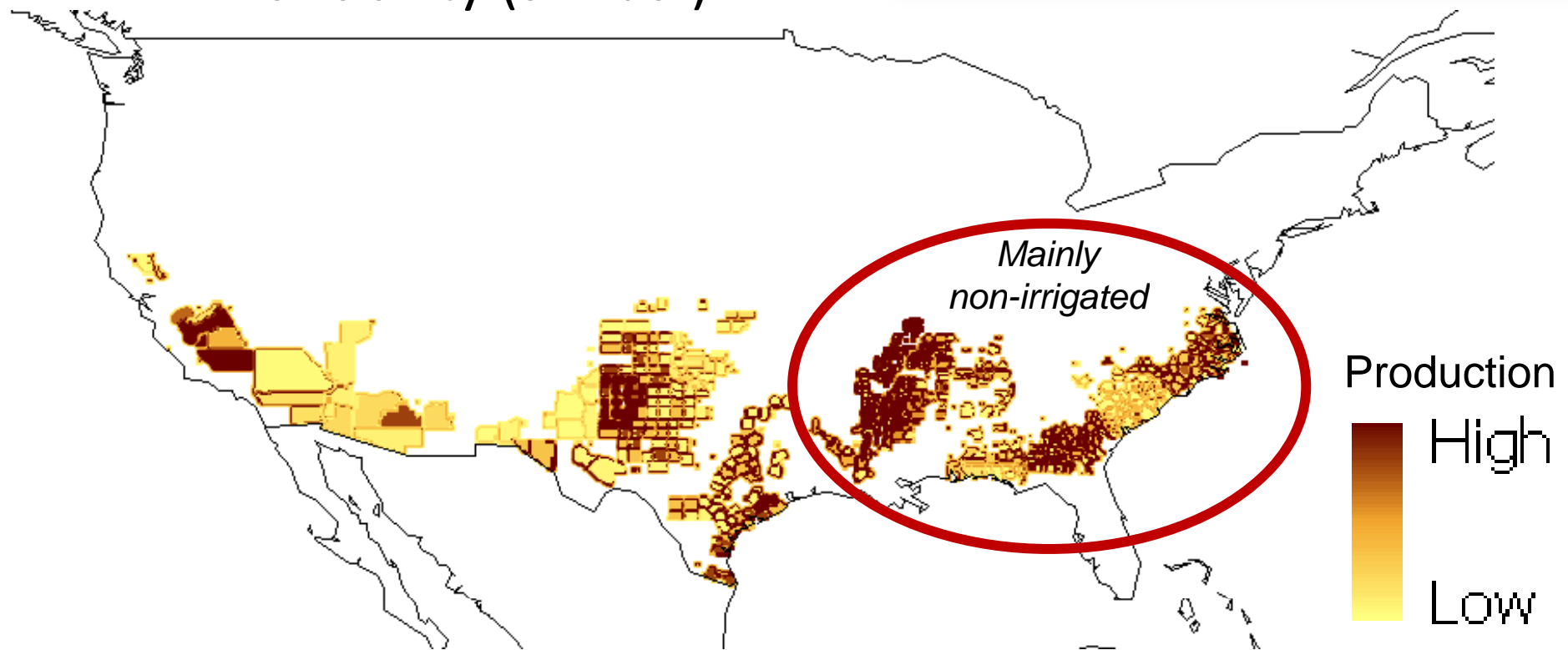
Damage per kg cotton



# Production

- Statistical data
  - Uncertainty
  - Variability (annual)

Calculate production-weighted country average



# Difference in results

- Cotton lint production:
  - global & national average based on country data
  - national average based on local analysis

	Water consumption [m <sup>3</sup> ]	Ecosystem Quality [PDF•m <sup>2</sup> •yr]	Human Health [E-06 DALY]	Resources [MJ]	Share of total Eco-indicator damage
<b>Global Average</b>	<b>7.89</b>	<b>3.67</b>	<b>5.40</b>	<b>12.1</b>	<b>37%</b>
US average data	1.34	0.42	0.003	2.51	7%
US local assessment	2.92	3.28	0.022	12.1	31%

# Aggregate as late as possible!

- High spatial resolution:
  - Increased precision
  - Decreased accuracy
  
- Combine on country level:
  - Increased precision
  - Increased accuracy



# Conclusions

- Calculate impact factors on highest resolution
- Define inventory flows as locally as possible
  - Provide link to inventories (e.g. country/global average)
- Aggregate factors as late as possible
  - Generic, process-specific data (supply chain modeling)
- Need for consistent uncertainty assessment
  - Impact factors and inventories
  - Trade off accuracy / precision
  - Overall decreased uncertainties

# THANKS FOR YOUR ATTENTION!



[pfister@ifu.baug.ethz.ch](mailto:pfister@ifu.baug.ethz.ch)

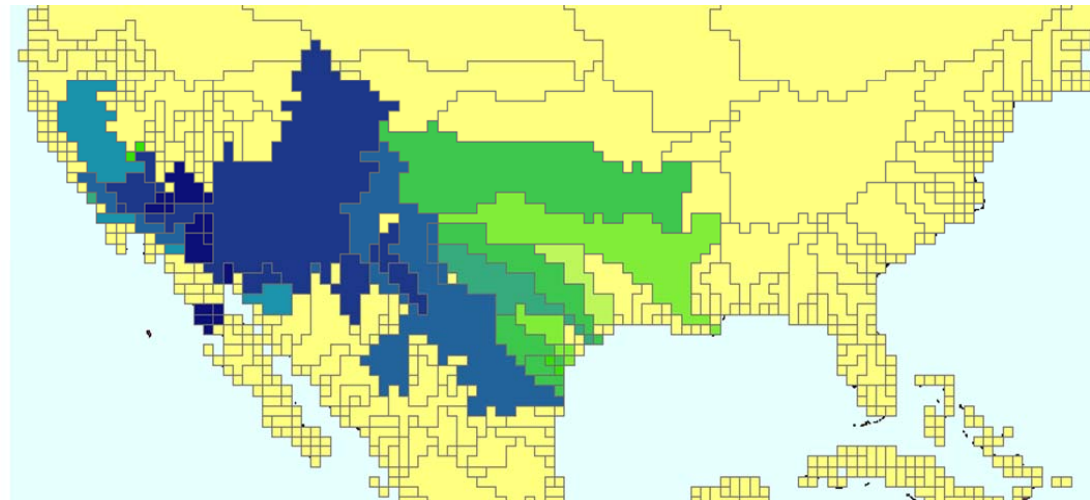
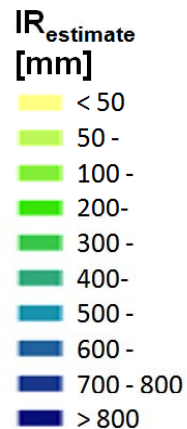
# APPENDIX



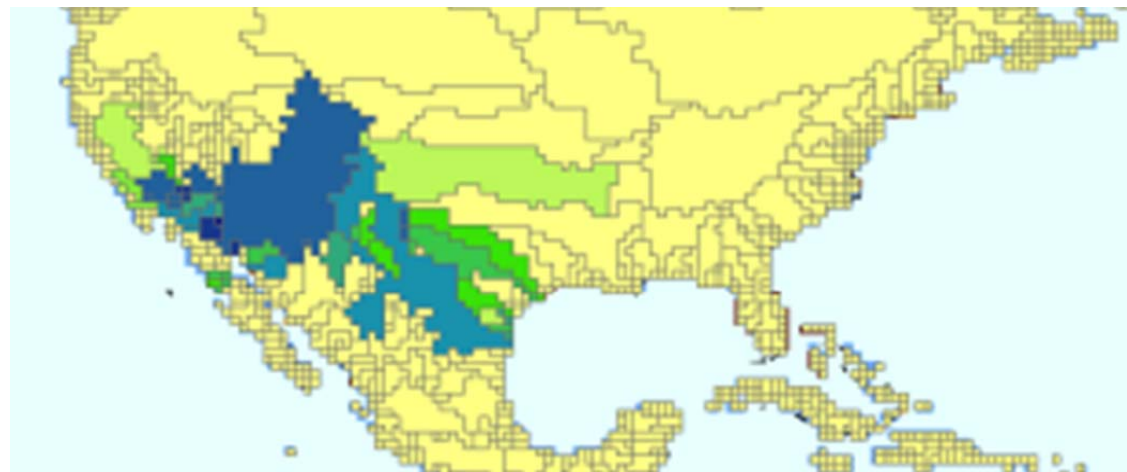
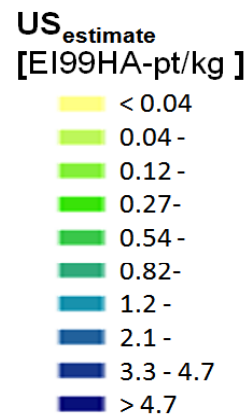
[pfister@ifu.baug.ethz.ch](mailto:pfister@ifu.baug.ethz.ch)

# Example: US cotton production

Inventory  
(water  
consumption)



Impact  
factors

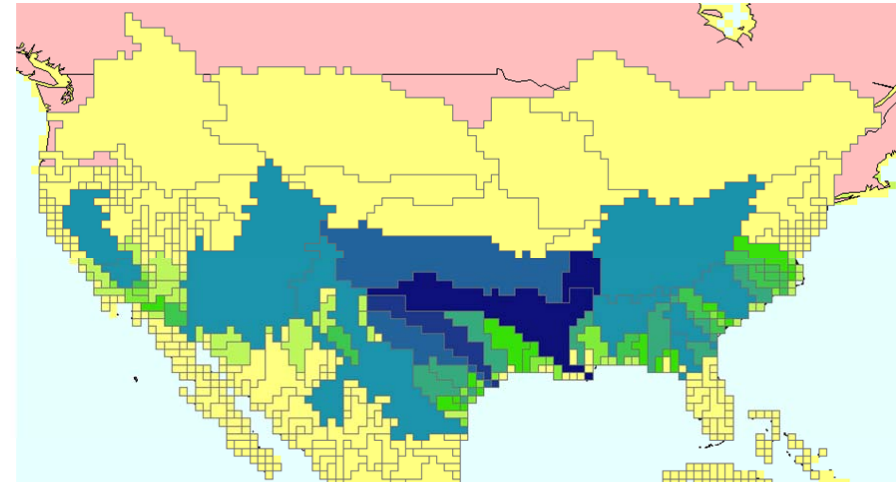
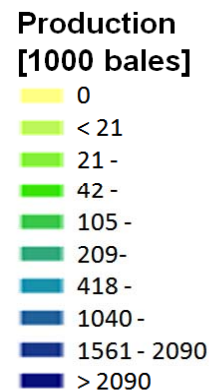


Reference:

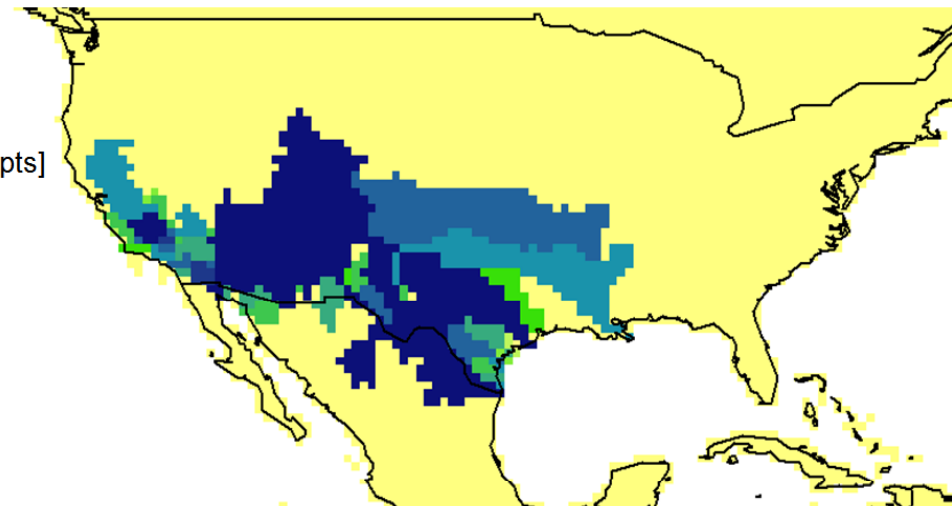
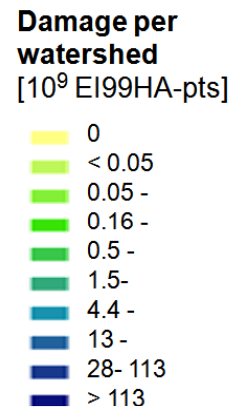
Pfister, S.; Koehler, A.; Hellweg, S. **Assessing the environmental impacts of freshwater consumption in LCA.** *Environ. Sci. Technol.* 2009, 43 (11), 4098–4104. -> SUPP INFO

# Example: US cotton production

production  
per watershed



total water impact  
per watershed



Reference:

Pfister, S.; Koehler, A.; Hellweg, S. **Assessing the environmental impacts of freshwater consumption in LCA.** *Environ. Sci. Technol.* 2009, 43 (11), 4098–4104. -> SUPP INFO

# How to use our “add-on”

Click on Information Points “i” in relevant watershed

