Phenological Monitoring:
A key approach to assessing the impact of spring starting earlier

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Research Contributions

- Collaborators: R. Ahas, A. Aasa, L. Liang
- Phenology data from J. Caprio, X. Chen, DWD, and A. Menzel
- Climate data from Chinese Academy of Meteorological Sciences, Environment Canada, German Weather Service (DWD), European Climate Assessment, Instytut Meteorologii i Gospodarki Wodnej (Poland), USA Carbon Dioxide Information and Analysis Center, USA National Climatic Data Center
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- Estonian Science Foundation Grant 5836 (Ahas)
- Base maps from ESRI data

Definition of Phenology

- **Phenology** which is derived from the Greek word *phaino* meaning to show or to appear, is the study of plant and animal life cycle events, which are triggered by environmental changes, especially temperature and precipitation. Thus, timings of phenological events are ideal indicators of global change impacts.
- **Seasonality** is a related term, referring to similar non-biological events, such as timing of the fall formation and spring break-up of ice on fresh water lakes.

Phenological Research

- Traditional approach: agriculture-centered, and local-scale events
- Recent approach: Earth systems interactions, and global-scale events

Integrated Approach

- Satellite Observations (MODIS-NDVI/EVI)
- Indicator Species Phenology
- Native Species Phenology

Cloned Species Phenology

- **Advantages:**
  1) Ideal for model development;
  2) Standardized response to environment;
  3) Broad range
- **Limitations:**
  1) Lack of network geographical coverage;
  2) Not adapted to local environment

Lilac First Leaf

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Lilac First Bloom

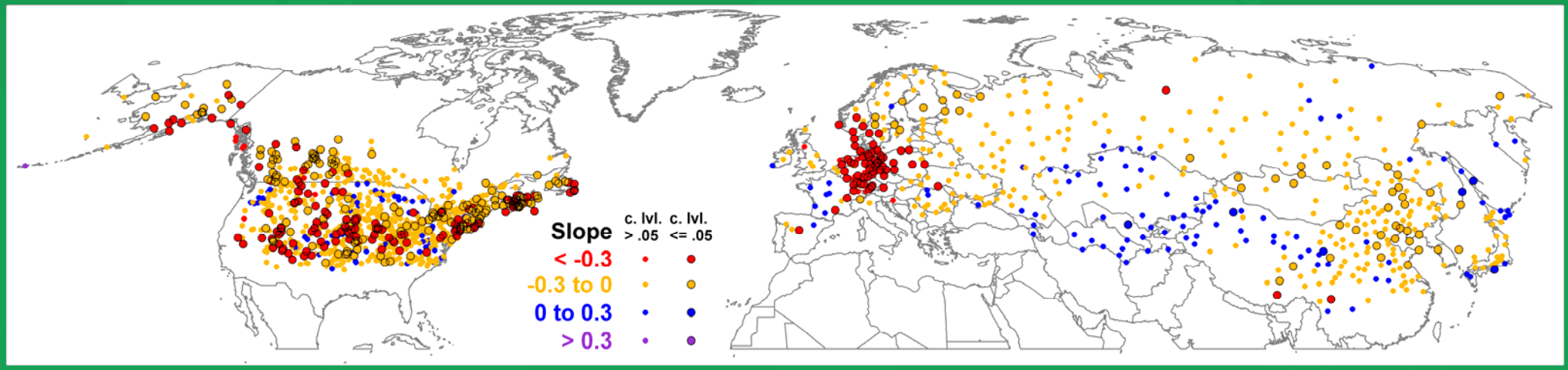
Simulated Phenology

- **Advantages:**
  1) Broad coverage if using simple input;
  2) Standardized response
- **Limitations:**
  1) Model inadequacies;
  2) Small set of events and plants

Spring Indices
Suite of Measures

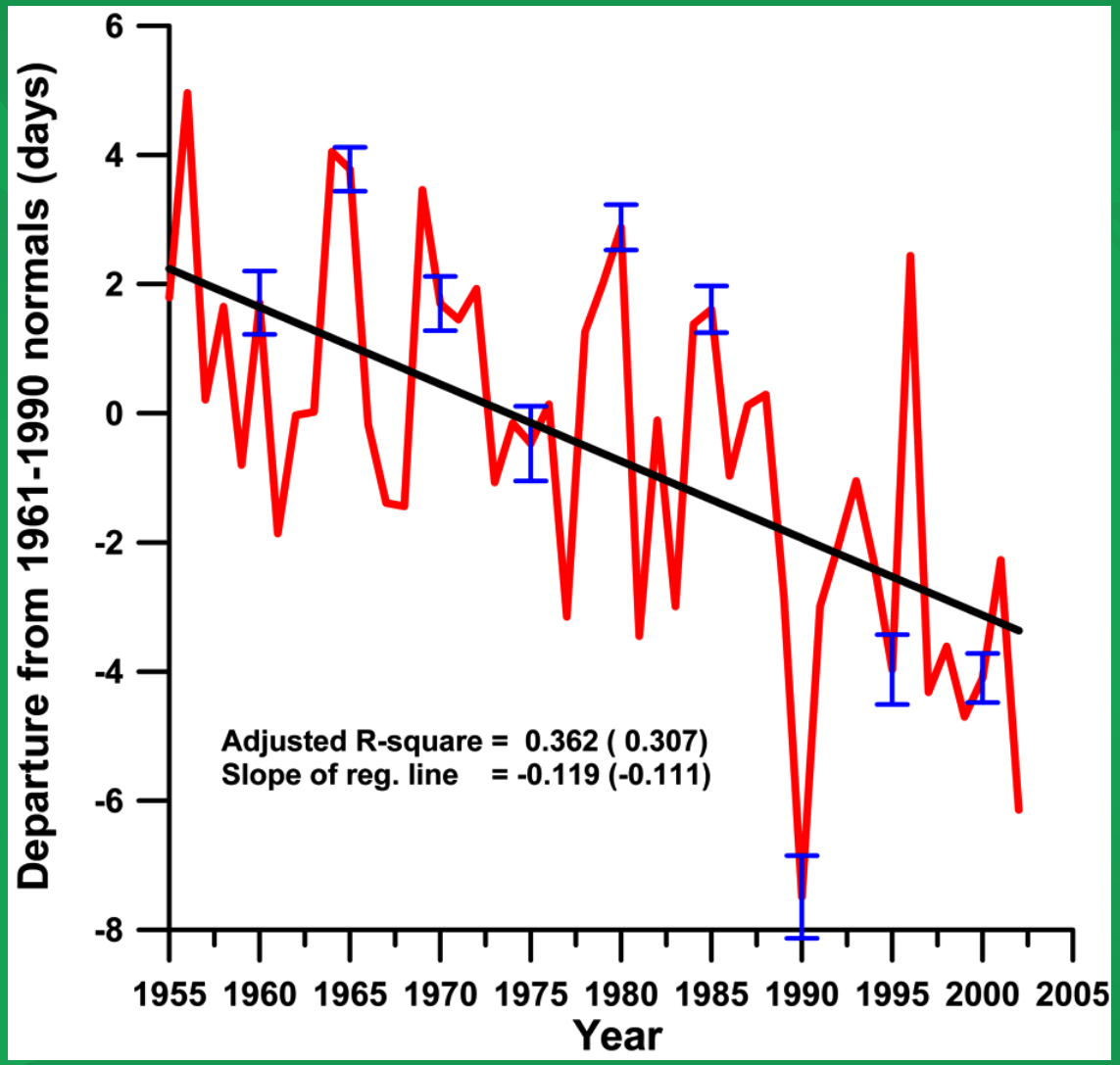
- First -2.2ºC freeze date in autumn
- Composite chill date (SI models)
- First leaf date, “early spring” (SI models)
- First bloom date, “late spring” (SI models)
- Last -2.2ºC freeze date in spring
- -2.2ºC Freeze period
- Damage index value (first leaf date – last frost date)
- Average annual, average seasonal, and twelve average monthly temperatures

SI First Leaf Date 1961-2000 Slope



Source: Schwartz et al. 2006, Figure 1

North. Hem. SI First Leaf Date Departures



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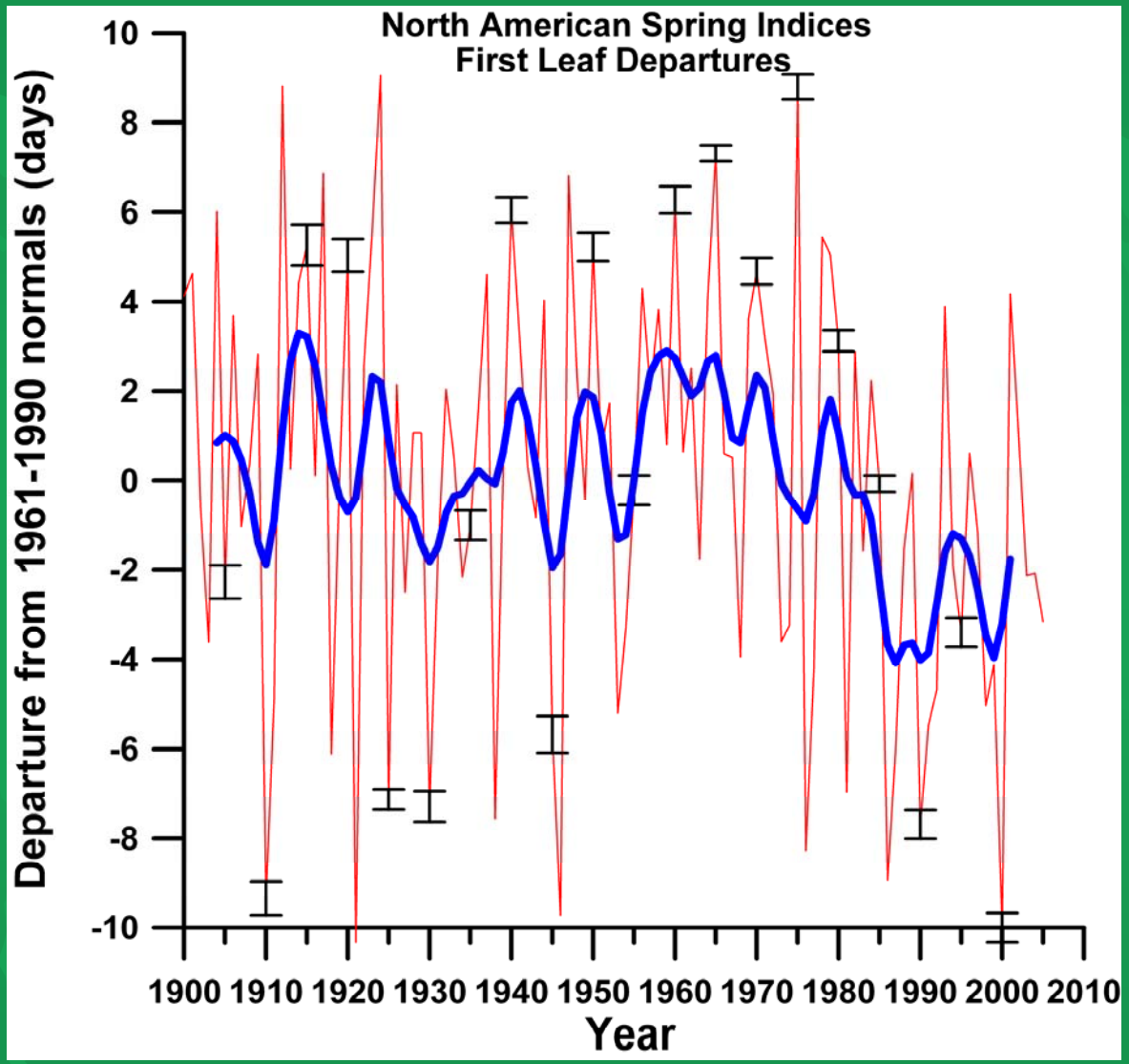
Source: Schwartz et al. 2006, Figure 2 (modified)

SI First Leaf Date in North America



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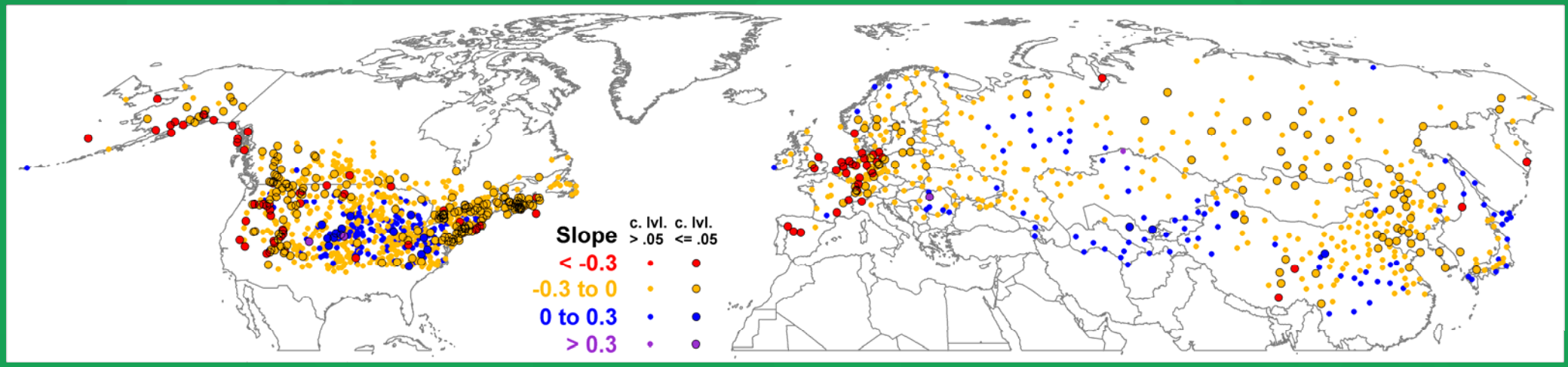
Source: Schwartz and Reiter 2000, Plate 4 (updated)

SI First Bloom Date 1961-2000 Slope



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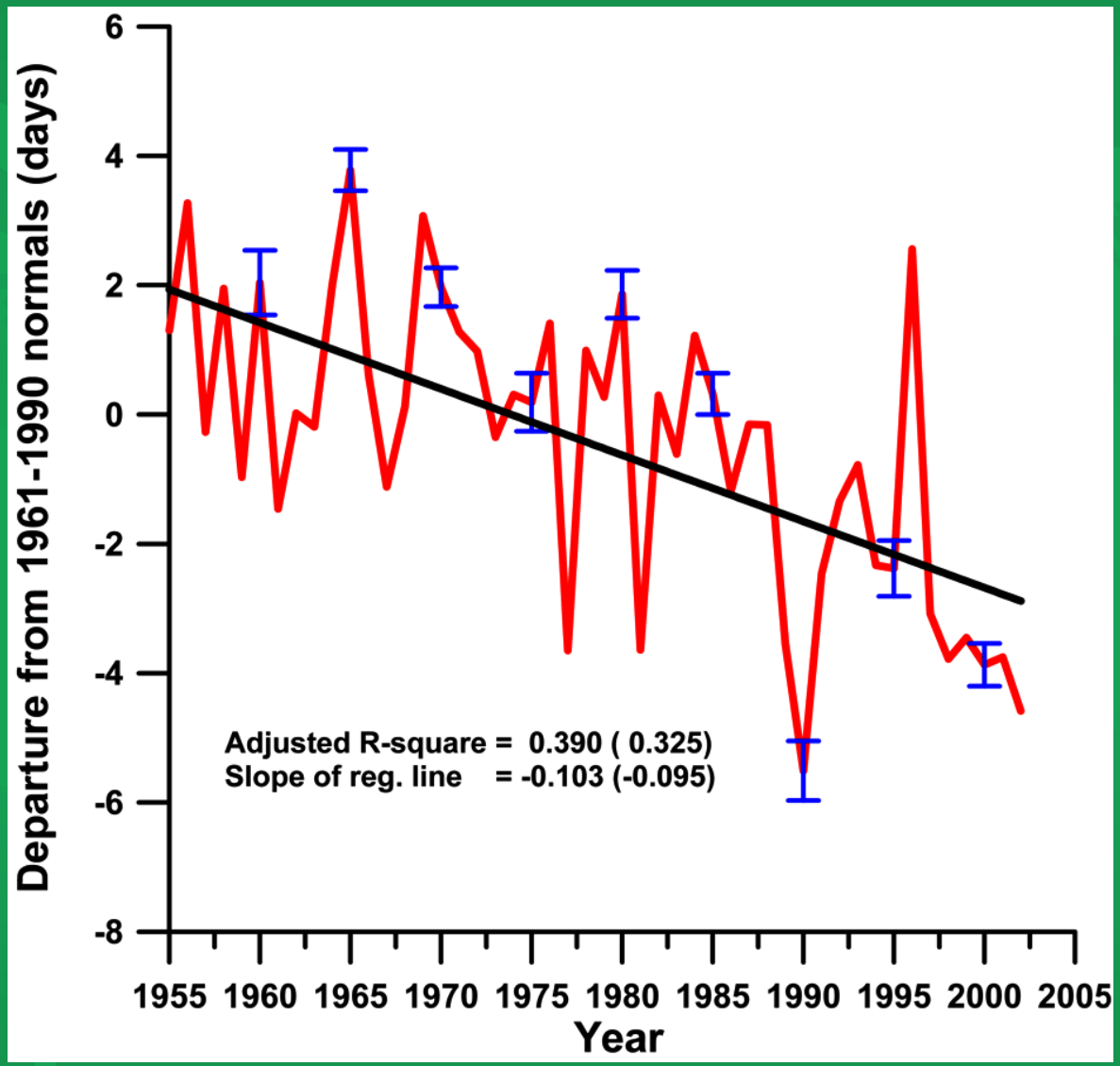
North Hem. SI First Bloom Date Departures



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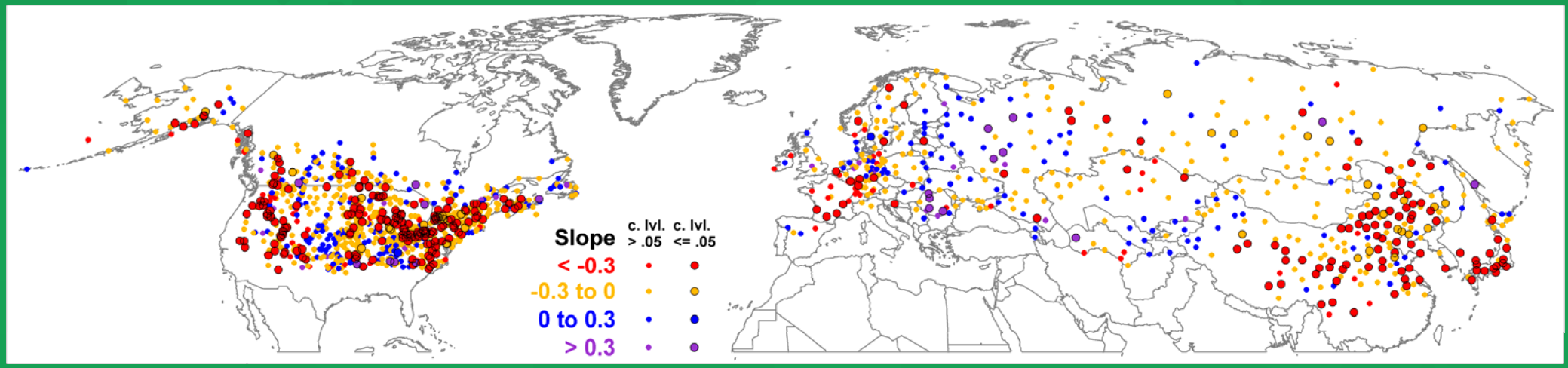
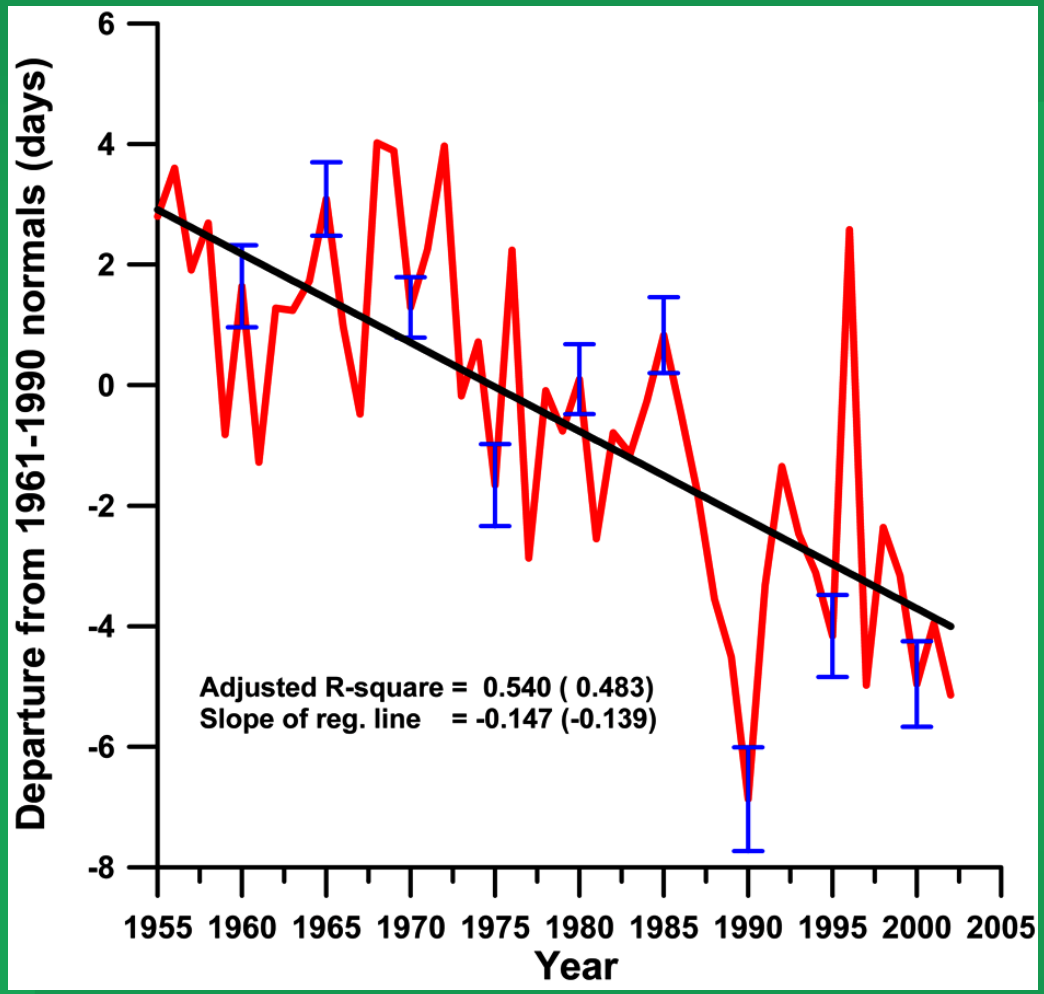
Last Spring –2.2ºC Freeze Date 1961-2000 Slope



Source: Schwartz et al. 2006, Figure 3

North. Hem. Last –2.2ºC Freeze Date Departures



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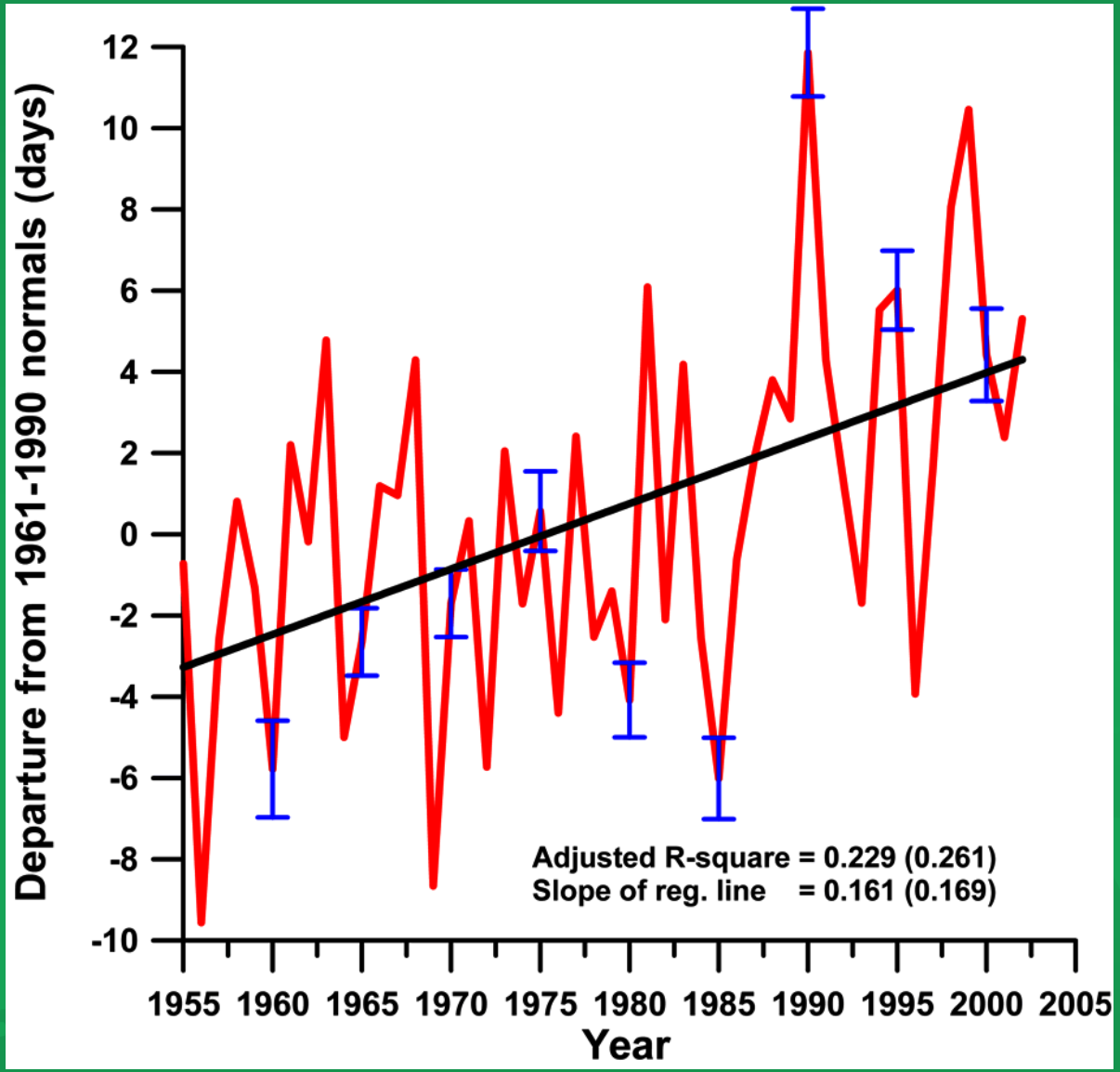
Source: Schwartz et al. 2006, Figure 4 (modified)

North. Hem. 5ºC Growing Season Length Departures



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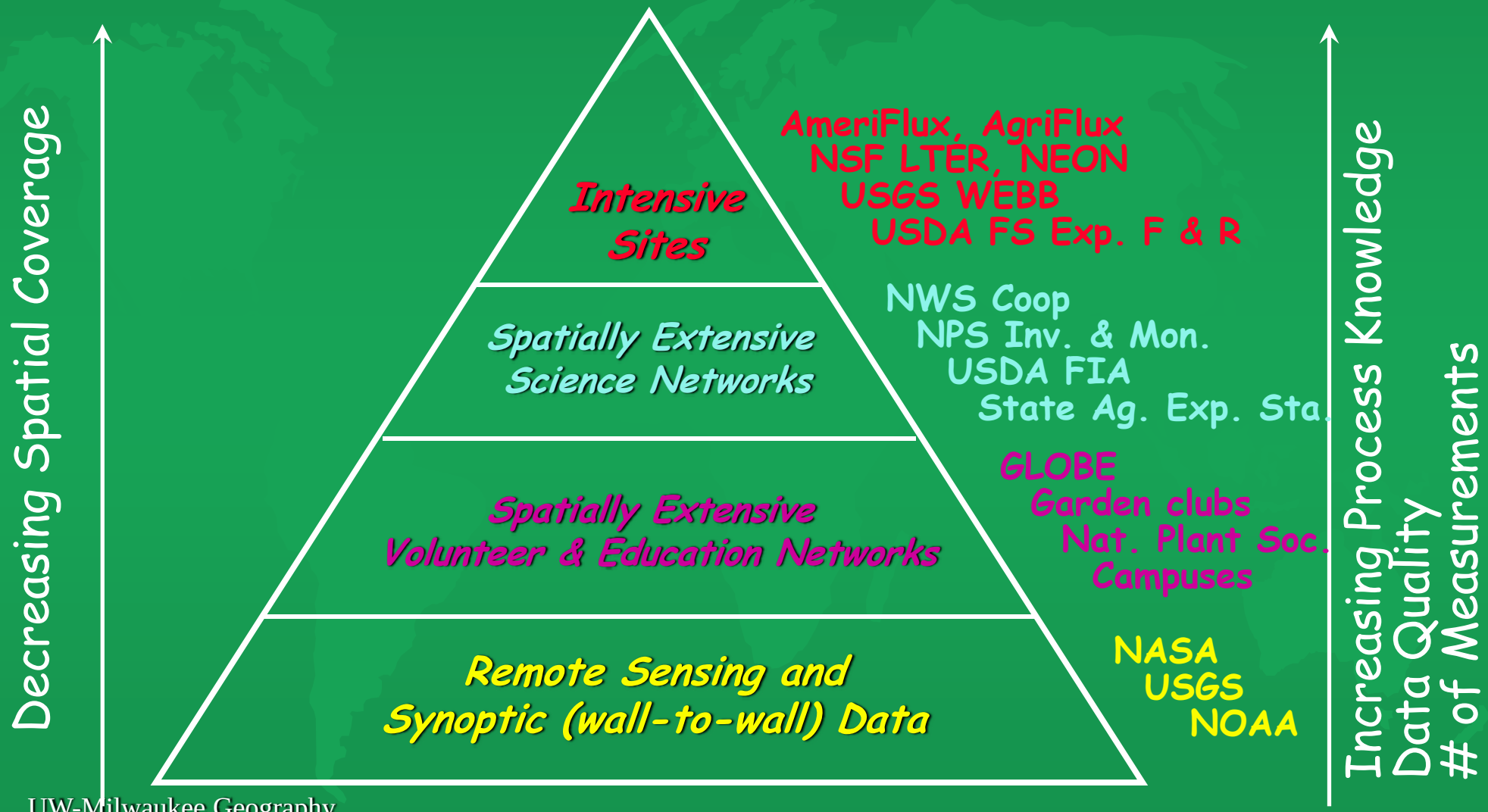
Conclusions

- The onset of spring has become significantly earlier across most temperate land areas of the Northern Hemisphere from 1955-2002.
- Important regional differences exist among the indices.
- These results provide a consistent and conventional framework for comparison to past and future studies, and a first approximation of likely impacts.
- These results reinforce the results from previous regional-scale phenological and climatological studies.
- National and global scale phenological networks, like the developing USA-NPN are needed to enhance understanding of these important changes, see http://www.npn.uwm.edu

Plan for a USA National Phenology Network (USA-NPN) http://www.npn.uwm.edu

- a continental-scale network observing regionally appropriate native plant species, cloned indicator plants (lilac + others), and selected agricultural crops
- designed to complement remote sensing observations
- data collected will be freely available to the research community and general public

USA-NPN Monitoring Framework



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USA-NPN Plant Observation Strategy

- Cloned plants (lilac, dogwood, ocotillo)
- "Calibration" species (about 20 with 1-4 each from allergans, coniferous, crops, coniferous, deciduous, herbaceous, and "showy")
- Additional species of interest to the observer or local/regional networks