

Vermont Climate Change Indicators

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“Communicating Earth Science Information”

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Climate Change

- **One of the great challenges for 21st C**
- *Global issue & local issue;
societal & personal issue*
- **Clash of Earth science & social values**
- *How do we deepen public understanding?*
[NOT: how do we communicate to public!]

Strategy

Public Issues:

- *Global changes are beyond direct experience*
- *Complex models for future - limited credibility*
- *Scientific literature is unintelligible jargon*

Instead

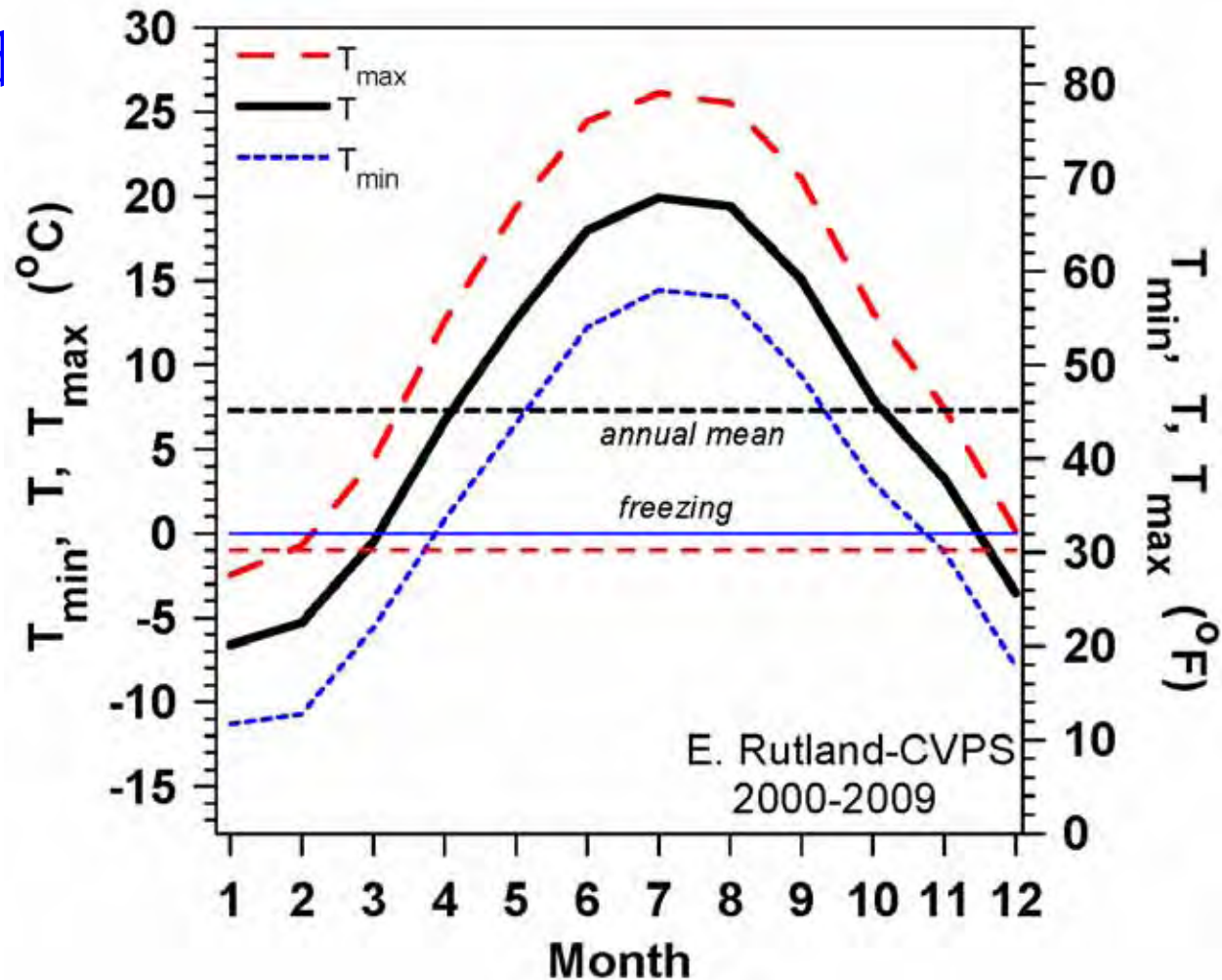
- **Identify and describe what is happening locally, to link direct perception & collective experience of local communities with global picture**
- **Deepens community understanding and acceptance of the reality of climate change**
- **Provides conceptual basis for adaptation planning**

What is happening to New England? –*Vermont!*

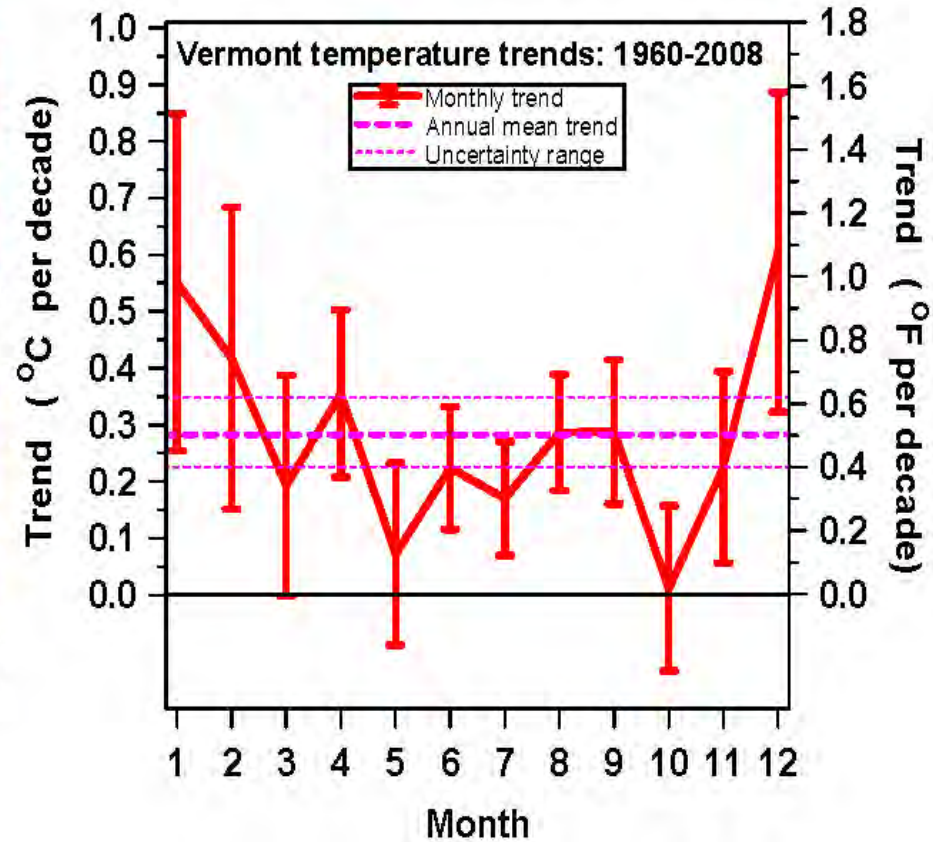
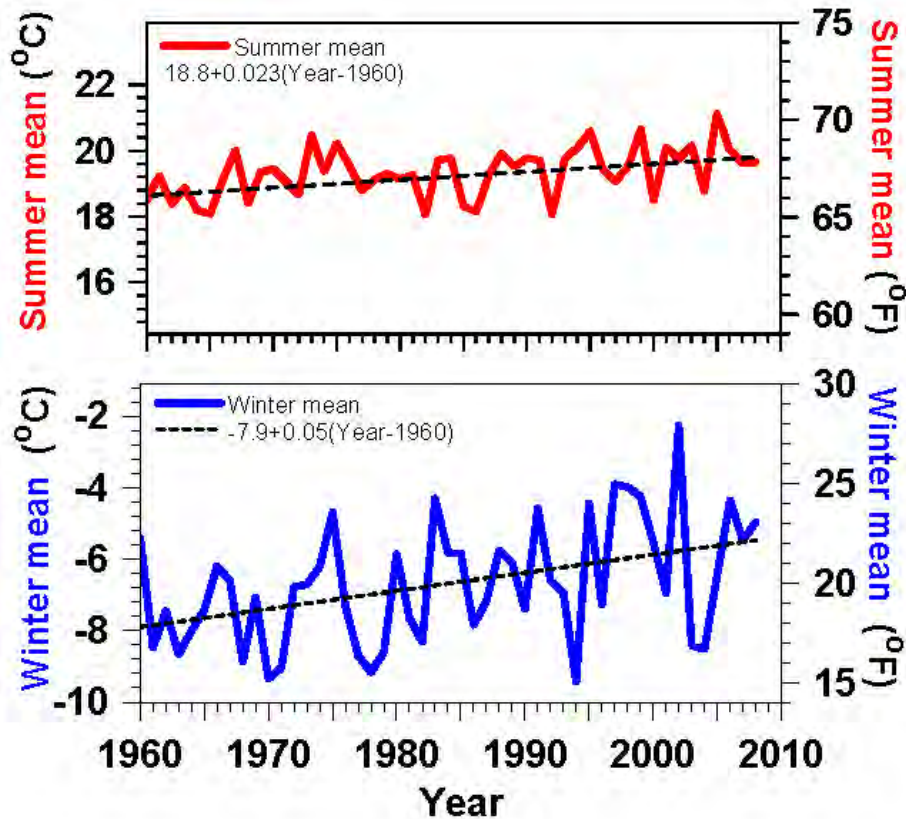
- Local climate change indicators
- Easier to grasp than global view
- *Warming twice as fast in winter than summer*
- *Winter severity decreasing*
- *Lakes frozen less by 7 days/decade*
- *Growing season longer 3.7 days/decade*
- *Spring earlier by 2-3 days per decade*

Annual Cycle of Temperature

- Warm and cold seasons (frost) comparable in length
- Shift of $+1^{\circ}\text{C}$ relative to freezing is significant



Vermont temperature trends

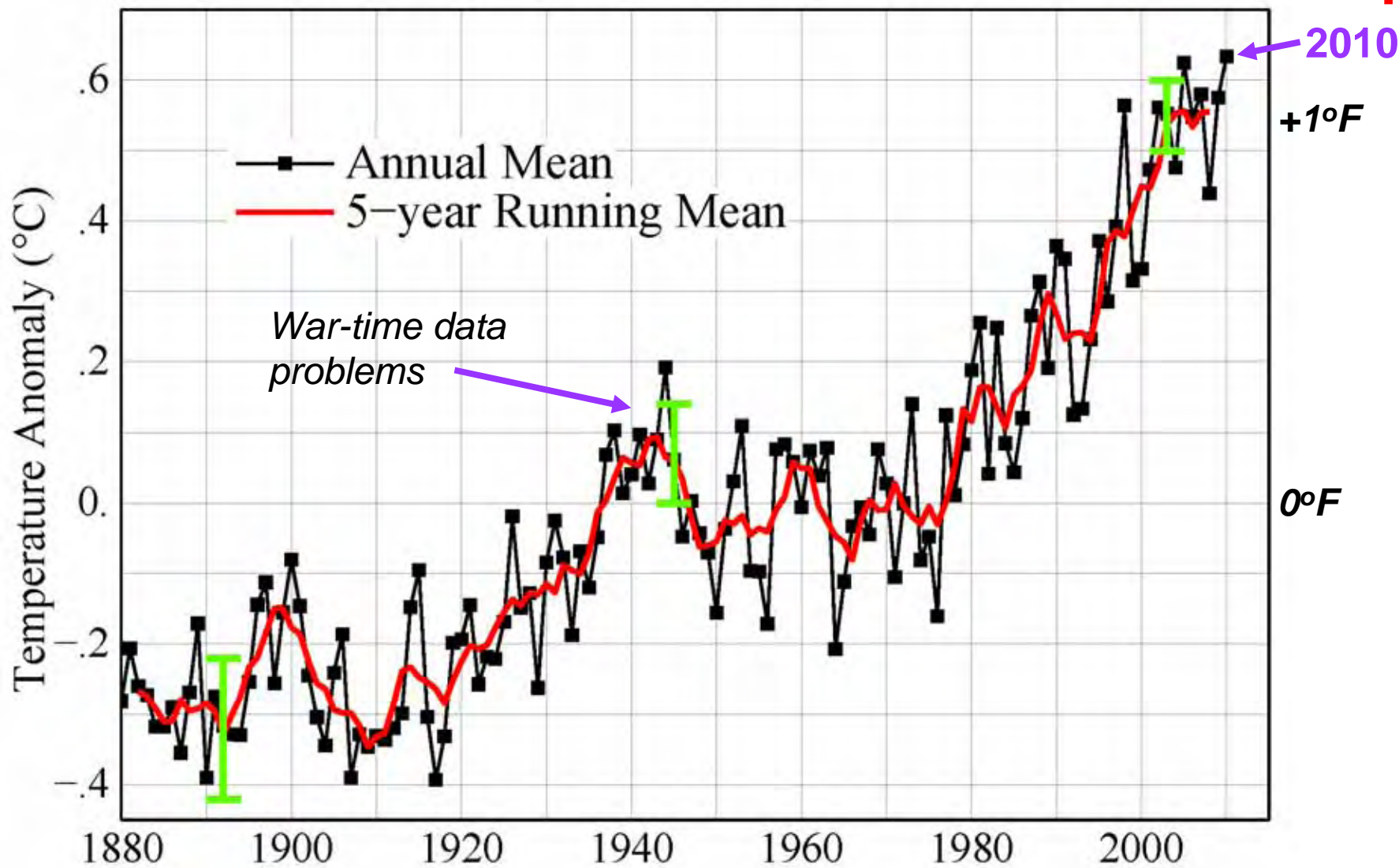


- *Warming twice as fast in winter than summer*
- summer $+0.23^{\circ}\text{C}$ (0.4°F)/decade
- winter $+0.5^{\circ}\text{C}$ (0.9°F)/decade

Global temperature rise 1880-present

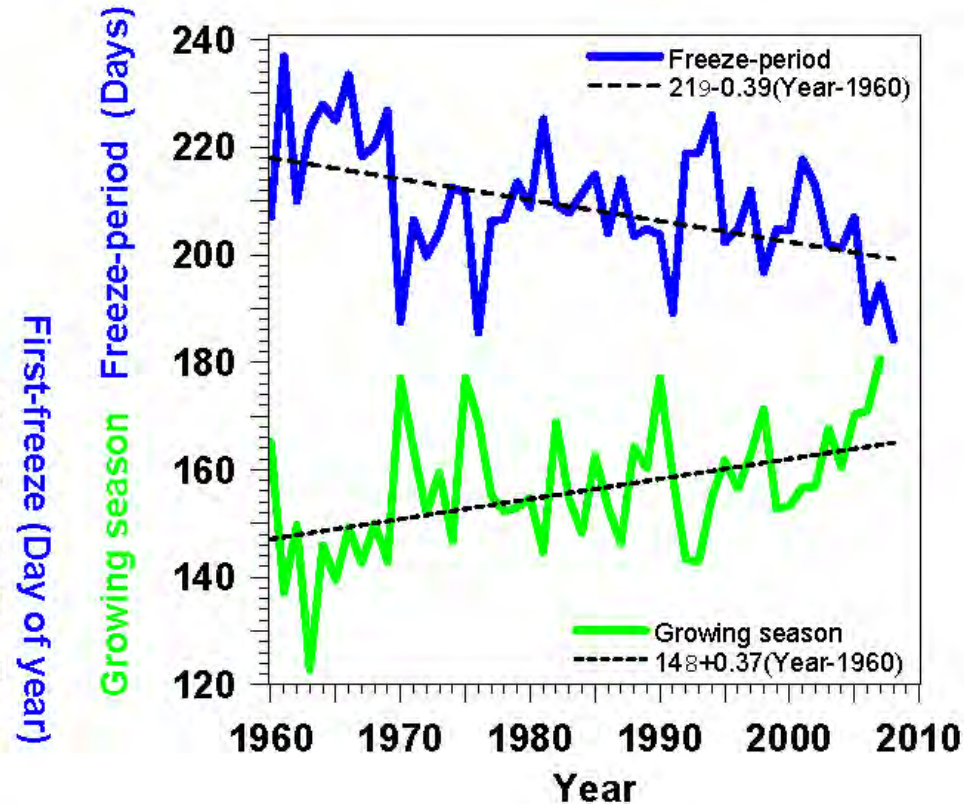
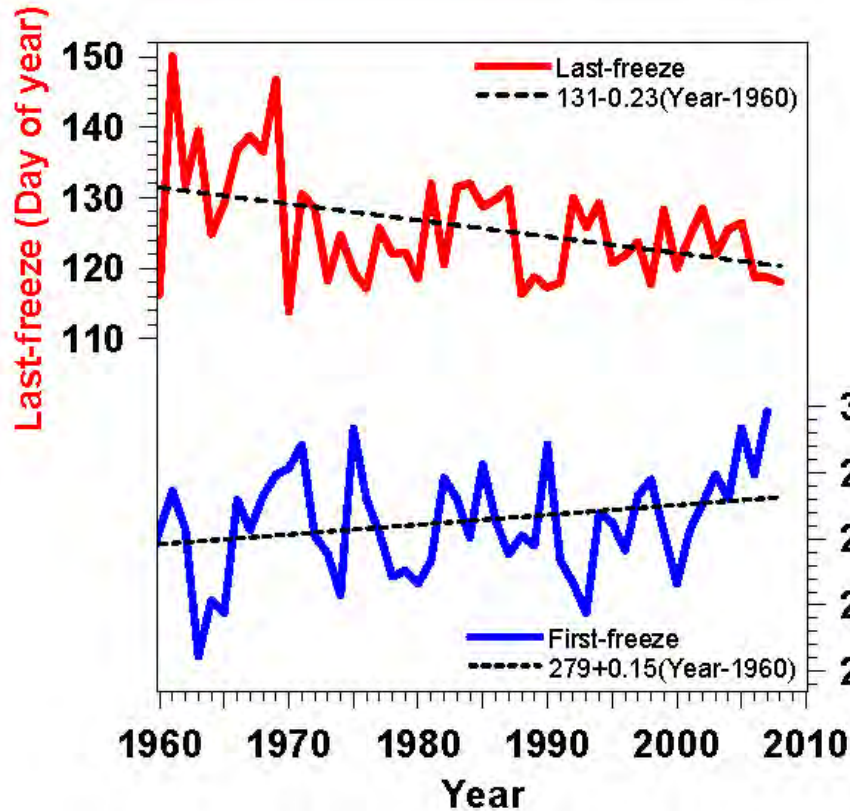
2100: +5°F

Global Land–Ocean Temperature Index



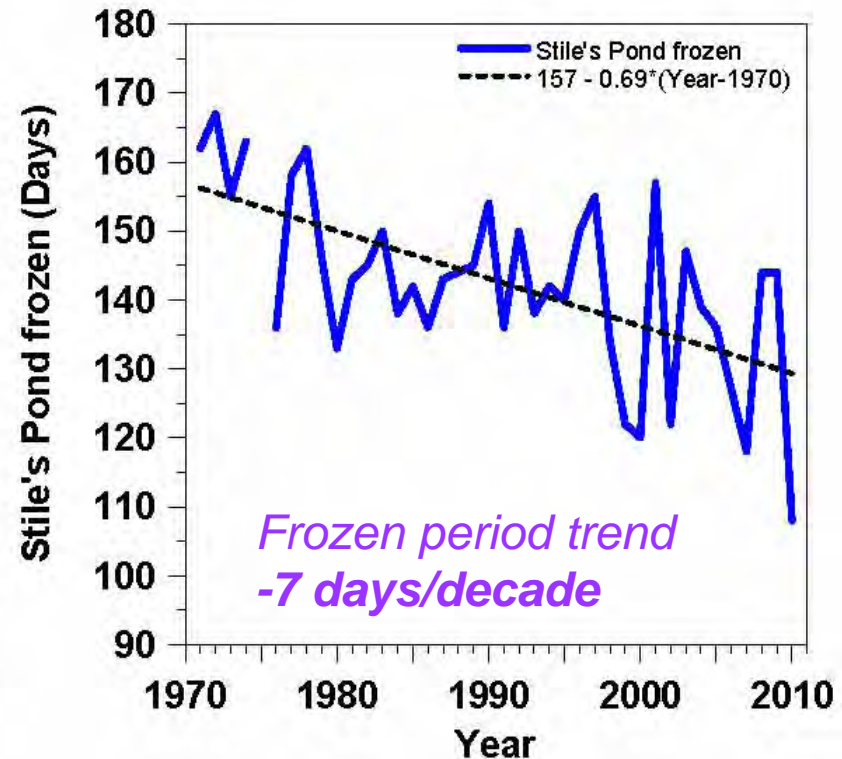
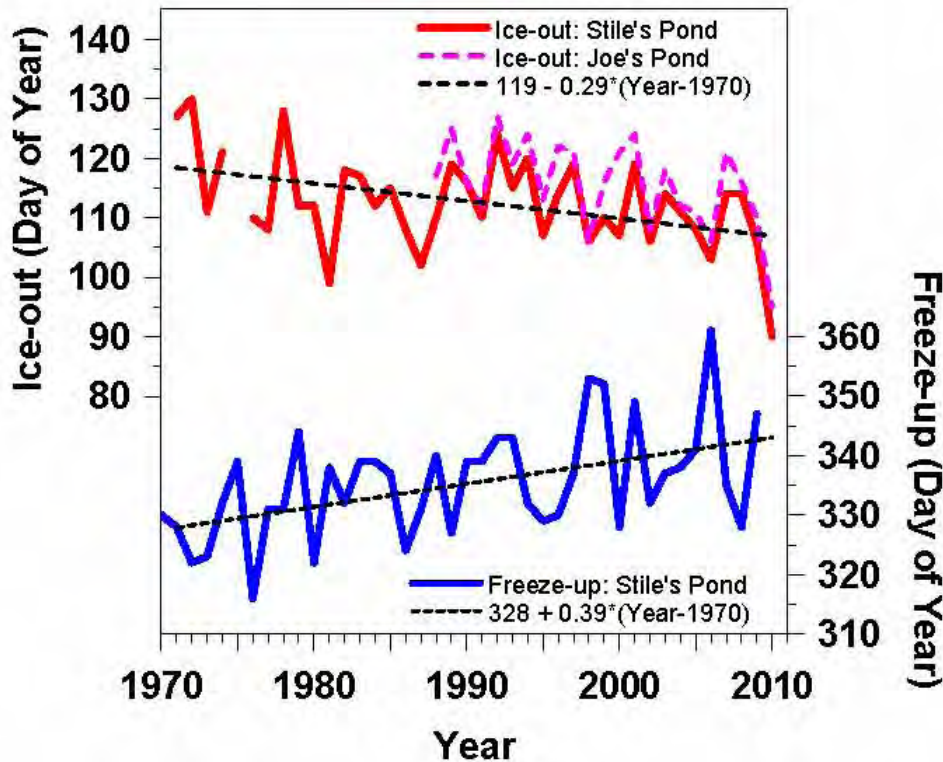
NASA-GISS, 2011

First & last frosts changing



- *Growing season for frost-sensitive plants increasing 3.7 days/decade*
- *Large interannual variability*

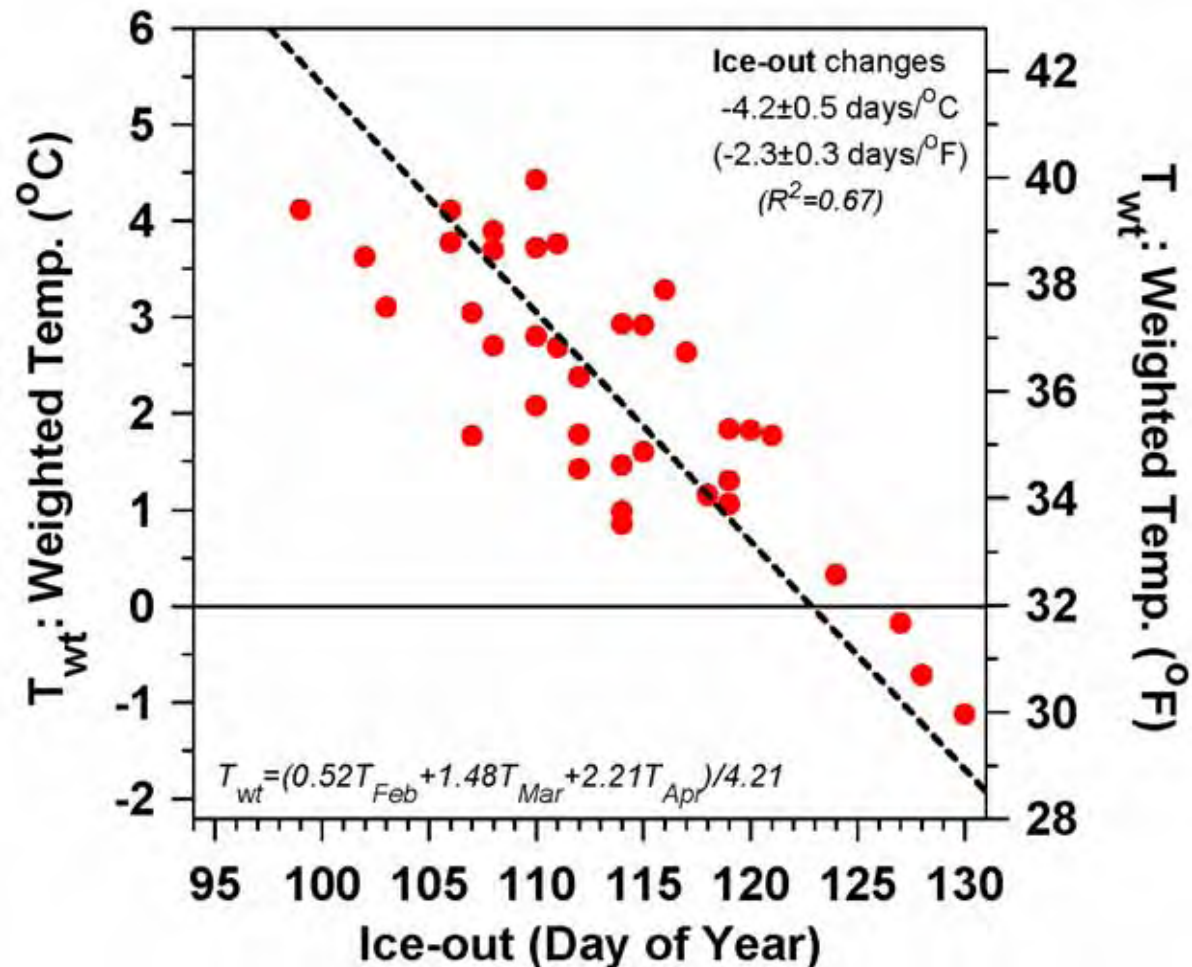
Lake freeze-up & Ice-out changing – *frozen period shrinking fast*



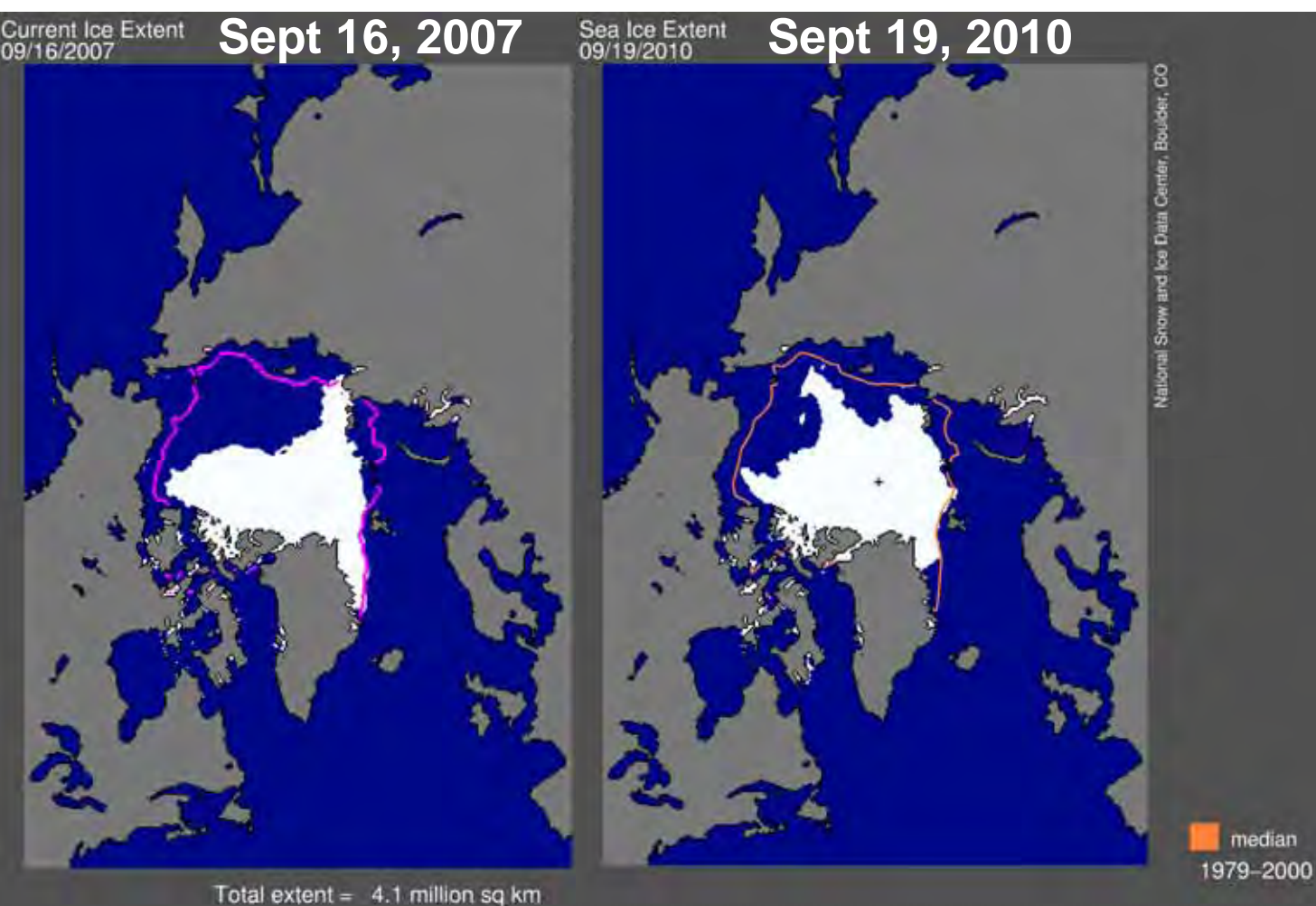
- *Ice-out earlier 3 days/decade*
- *Freeze-up later 4 days/decade*

Interannual variability of Ice-out related to Feb-Mar-Apr temperatures

- Ice-out changes by -4.2 ± 0.5 days/ $^{\circ}\text{C}$
- T_{wt} is weighted Feb-Mar-Apr temperature derived from multiple linear regression



Feedbacks are accelerating Arctic sea-ice loss



*Feedbacks -
speed melting*

*-less ice, less
sunlight reflected*

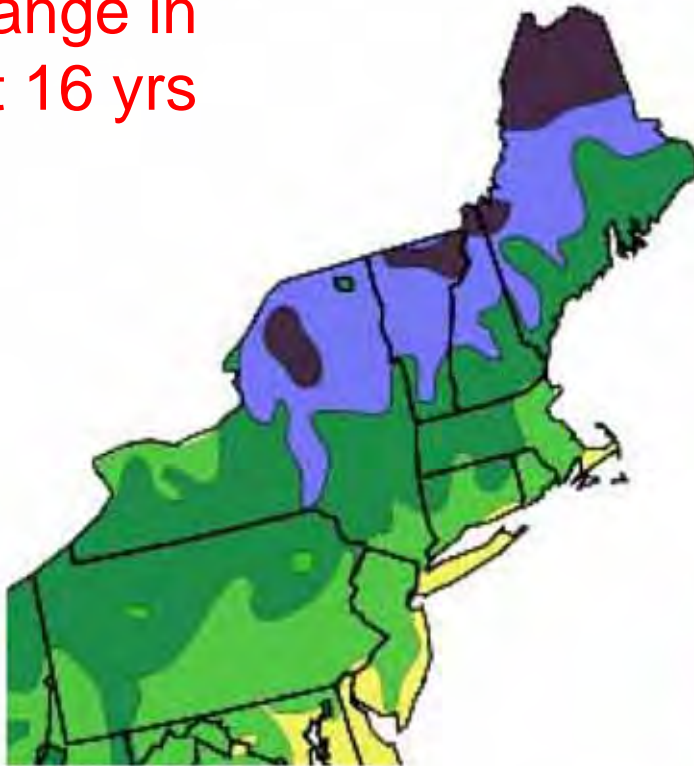
*-more evaporation,
larger water vapor
greenhouse*

(www.nsidc.org)

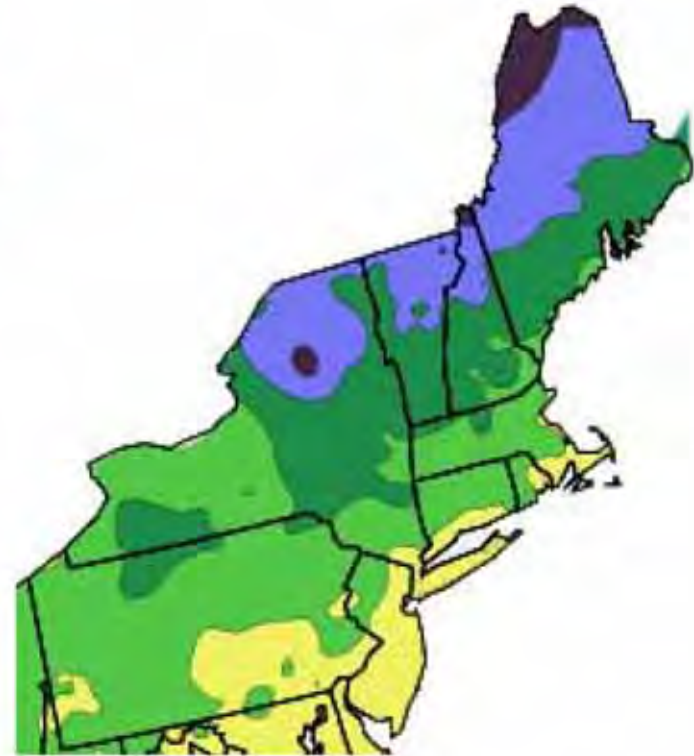
- *Open water in October contributes to warmer Fall in New England*

USDA Hardiness Zones - Northeast

Change in
last 16 yrs



1990



2006



USDA Hardiness Zones

Gardening in Pittsford, VT in January



Jan 7, 2007

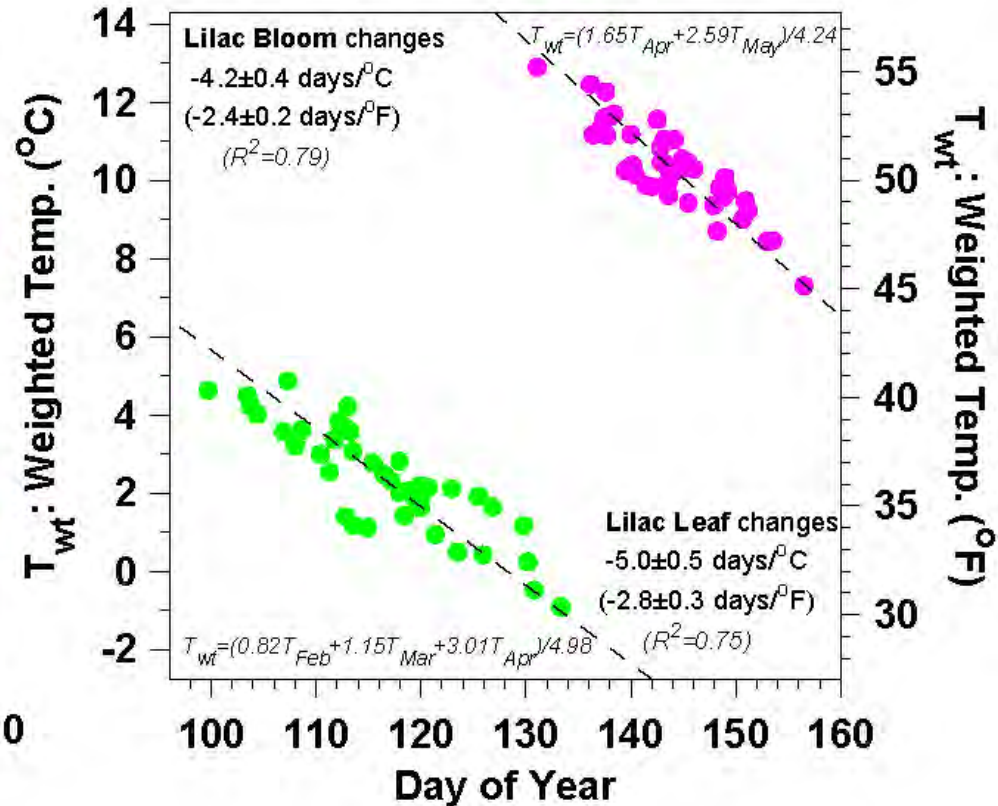
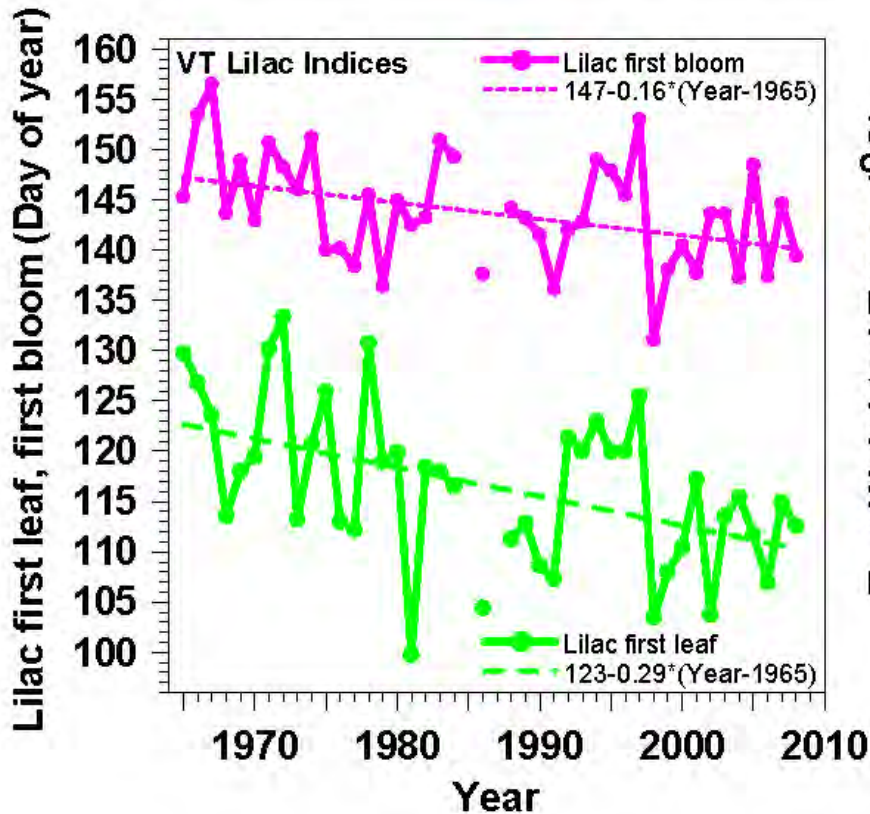
December, 2006, *warmest on record*
[since 1894]



Jan 10, 2008

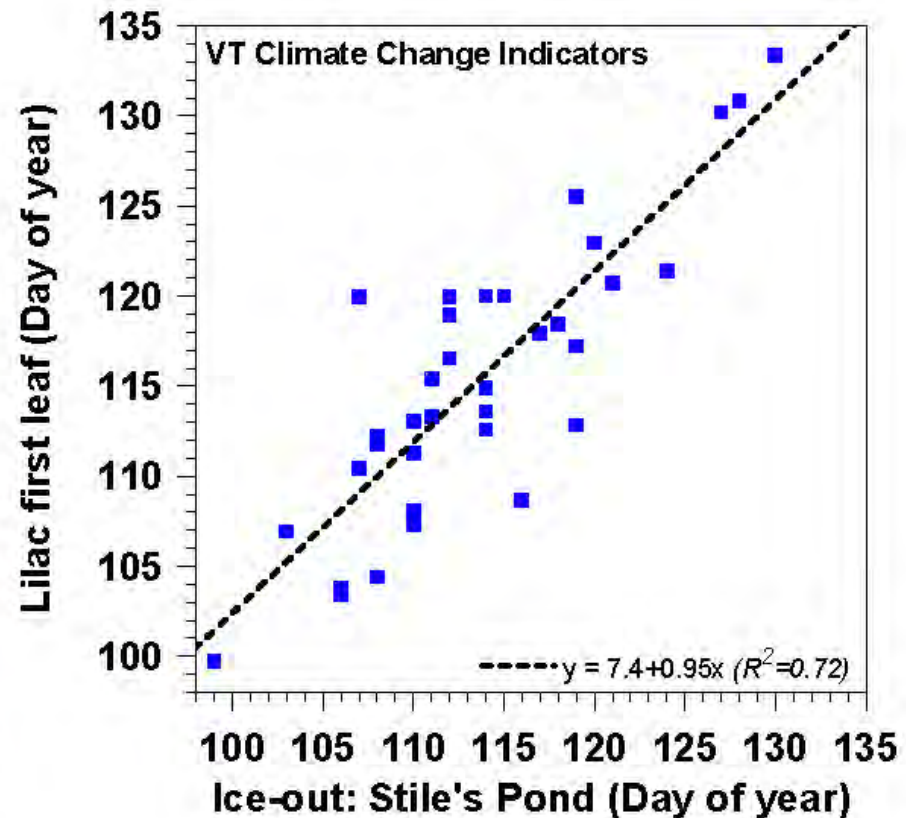
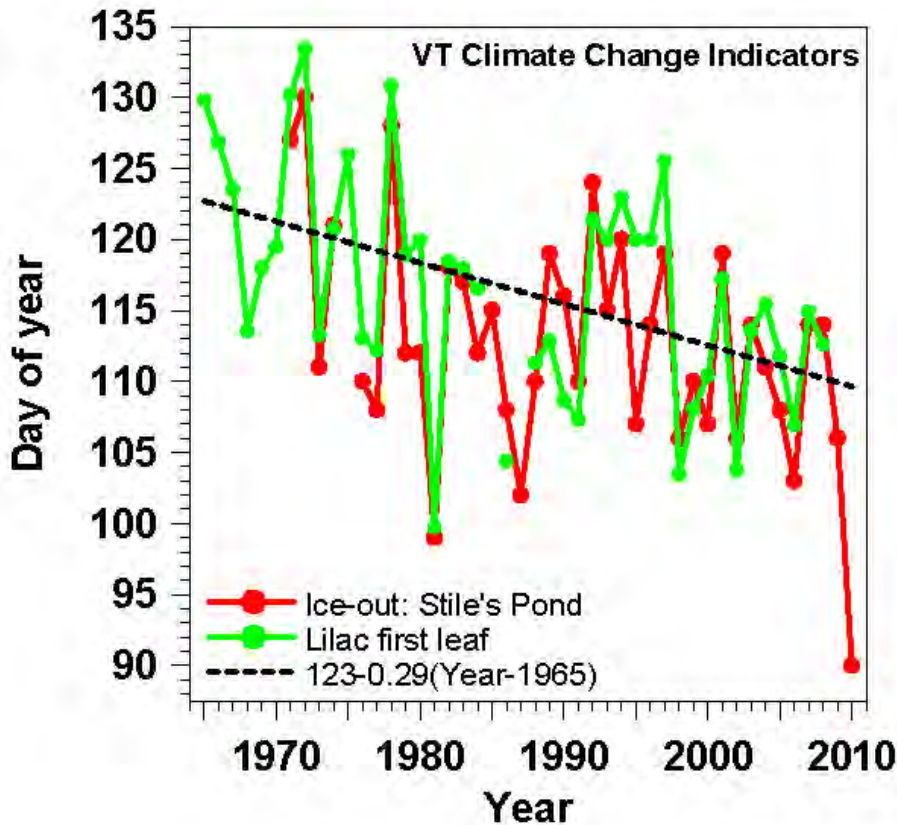
Warm Fall, *record Arctic sea-ice melt*
Snow cover in December, ground unfrozen

Lilac leaf and bloom in spring



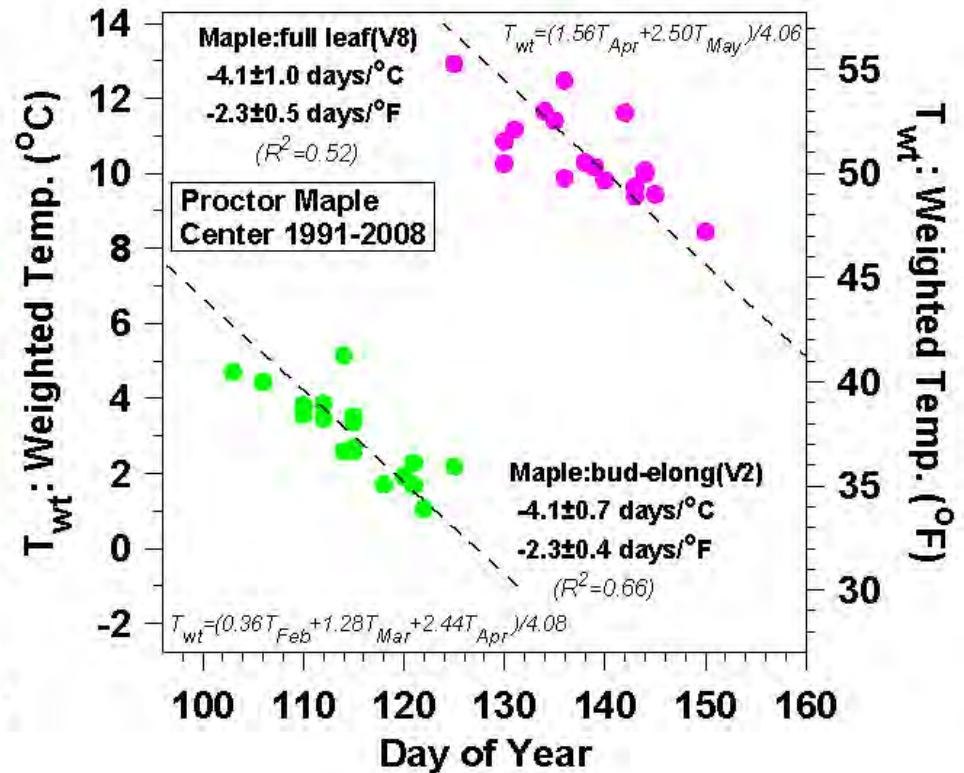
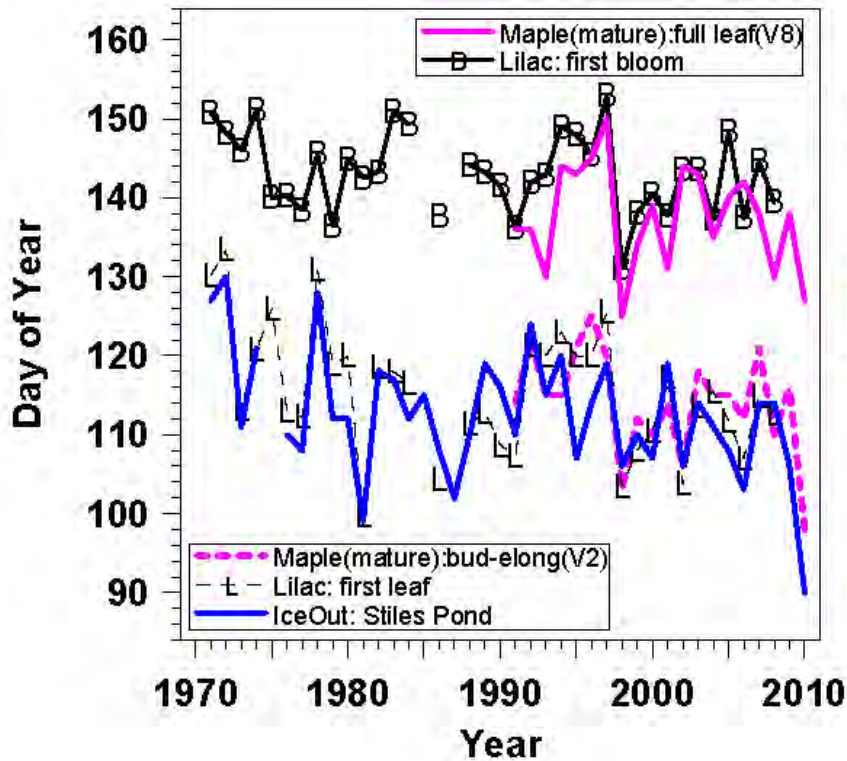
- Leaf-out trend: -3 days/decade
- Bloom trend: -1.5 days/decade
- Leaf & bloom dates change by 4 to 5 days/ $^\circ\text{C}$

Lilac leaf-out and Ice-out coupled



- *Lilac leaf and lake ice-out depend on Feb-Mar-Apr temperatures*
- *Both indicate trend to earlier spring*

Maples and Lilacs in spring



- *Maple bud elongation mirrors lilac leaf-out*
- *Maple leaf-out mirrors lilac bloom*

Conclusions

- **Coherent picture of shrinking of winter ‘frozen’ season by 7 days/decade and lengthening of growing season**
- **Ice-out and spring phenology linked**
- *Observables familiar to VT communities deepen understanding and acceptance of the reality of climate change*
- **Provide a basis for community discussion and adaptation planning – [with hydrologic indices]**