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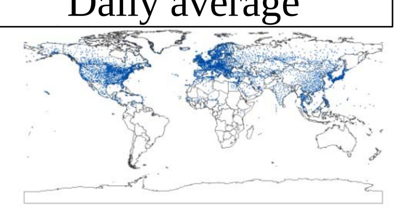
Introduction:

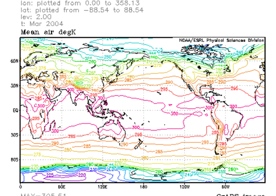
Approximately 50 million km^2 of the terrestrial Northern Hemisphere undergoes seasonal freeze-thaw (F/T) transitions each year. The timing and duration of landscape F/T processes are closely linked to surface energy budget and hydrological activity, vegetation phenology, terrestrial carbon budgets and land-atmosphere trace gas exchange. Satellite microwave remote sensing is relatively insensitive to signal degradation by atmospheric contamination and solar illumination effects and is uniquely capable of detecting and monitoring a range of biophysical processes associated with the F/T signal, especially at high latitudes.

Datasets:

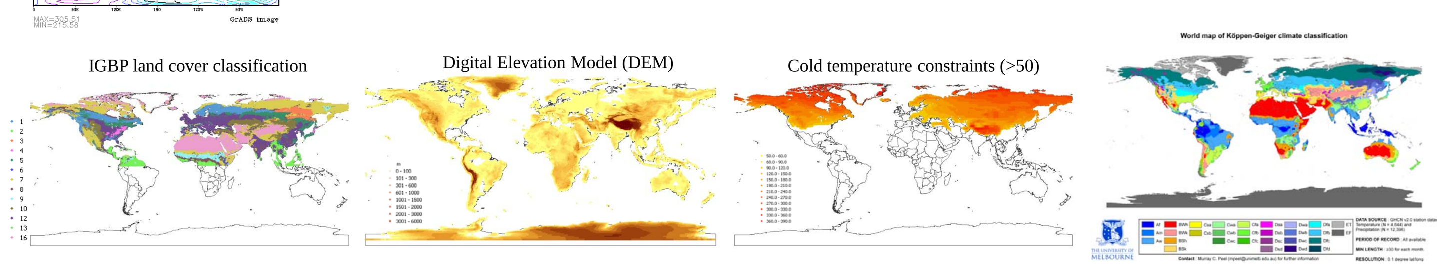
	Passive		Active
Sensor	SSM/I	AMSR-E	SeaWinds
Platform	DMSP	Aqua	QuikSCAT
Frequency	37GHz	36GHz	13.4GHz
Polarization	H-pol	H-pol	H-pol
Resolution	25x25km	25x25km	15x25km
Overpass	6pm	1:30pm	Daily average

Surface air temperature data
(1)National Climate Data Center (NCDC, 1988-2007): daily summary of the day from in situ weather stations





(2) NCEP/NCAR (NNR, 1988-2007) : 6-hour reanalysis with 1.875 x 2 degree resolution



Long-term global record of F/T dynamics for all vegetated regions where low temperatures are a major constraint to ecosystem processes are constructed

F/T Algorithms:

(1) Seasonal Threshold Approach (STA)

$$\Delta(t) = \frac{\sigma(t) - \sigma_{fr}}{\sigma_{th} - \sigma_{fr}}$$

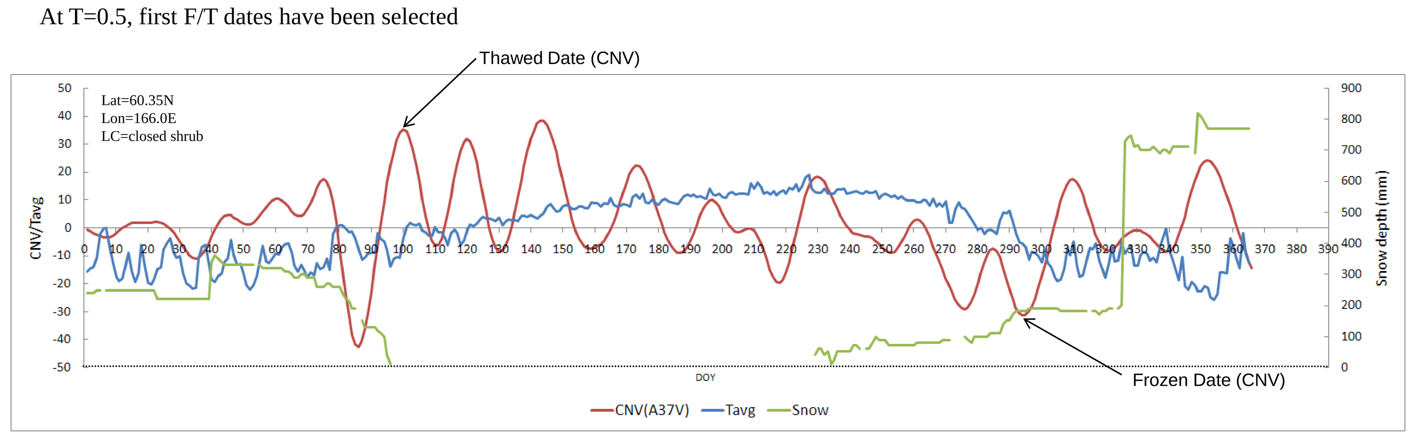
σ_{fr} = mean in Jan, σ_{th} = mean in Jul; $\Delta(t) > T$ Thawed; $\Delta(t) \le T$ Frozen

At T=0.5, first F/T dates have been selected

(2) Temporal Edge Detection Approach (CNV)

$$CNV(t) = \int_{-\infty}^{\infty} f'(x)\sigma(t-x)dx$$

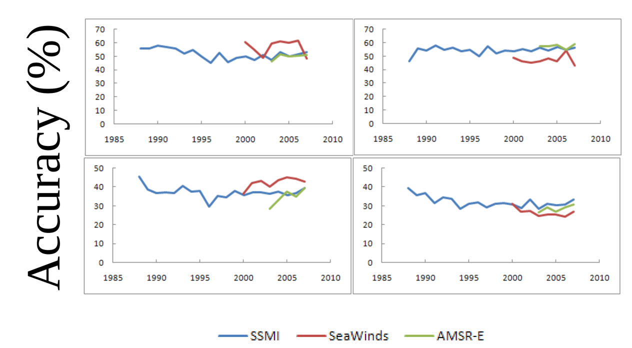
Passive sensor: Max(CNV): primary thawed; Min(CNV): primary frozen



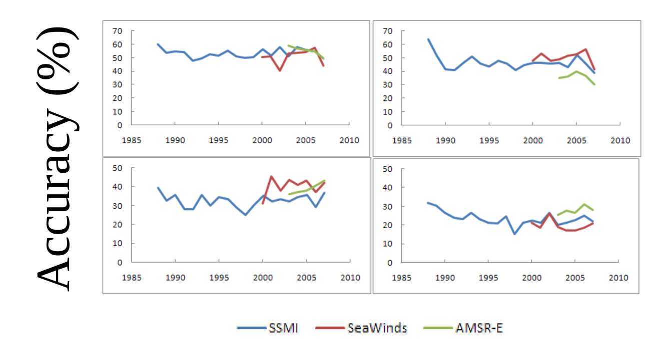
- Microwave sensors are able to observe freezing and thawing of landscape has its origin in the distinct changes in landscape dielectric properties that occur during transitions between solid and liquid phases of water.

Accuracy assessment of Terrestrial F/T products:

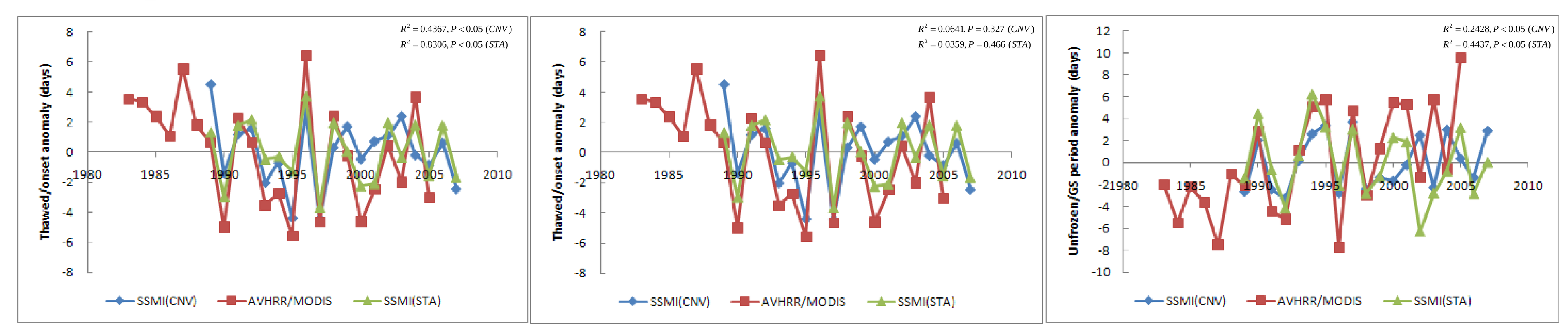
(1) Pixel-to-point comparison with NCDC air temperatures



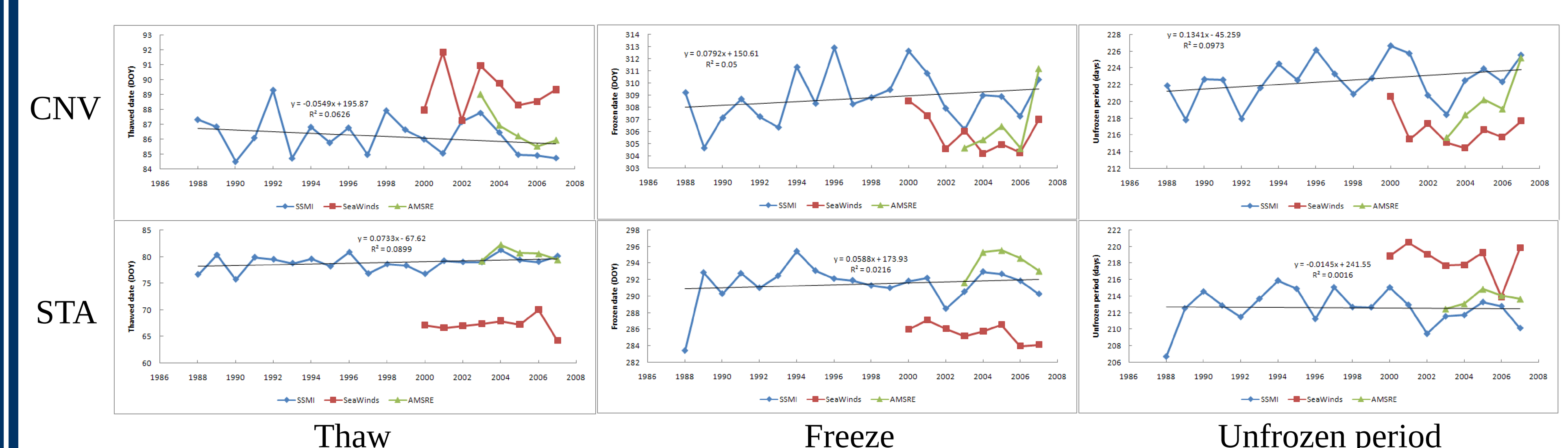
(2) Pixel-to-pixel comparison with NNR air temperatures

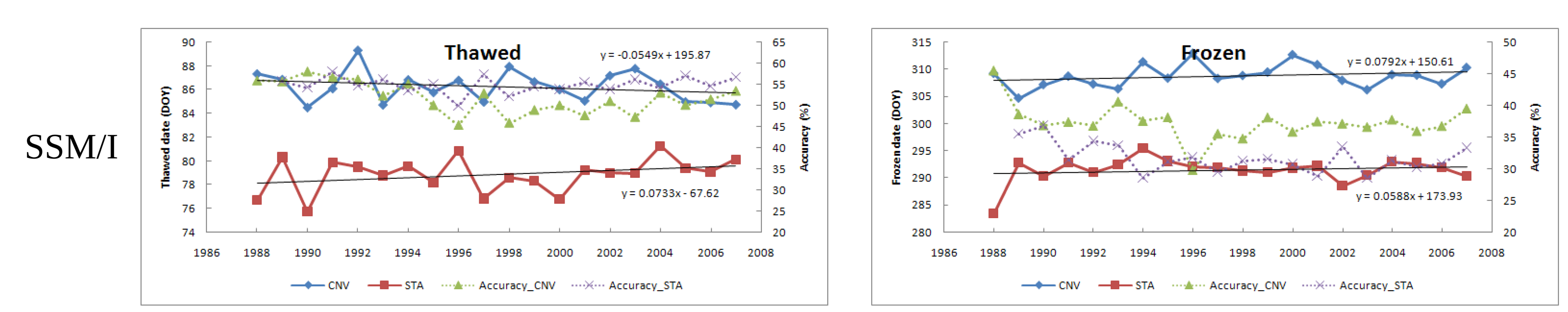


(3) Comparison between SSM/I F/T and AVHRR/MODIS NPP onset/offset

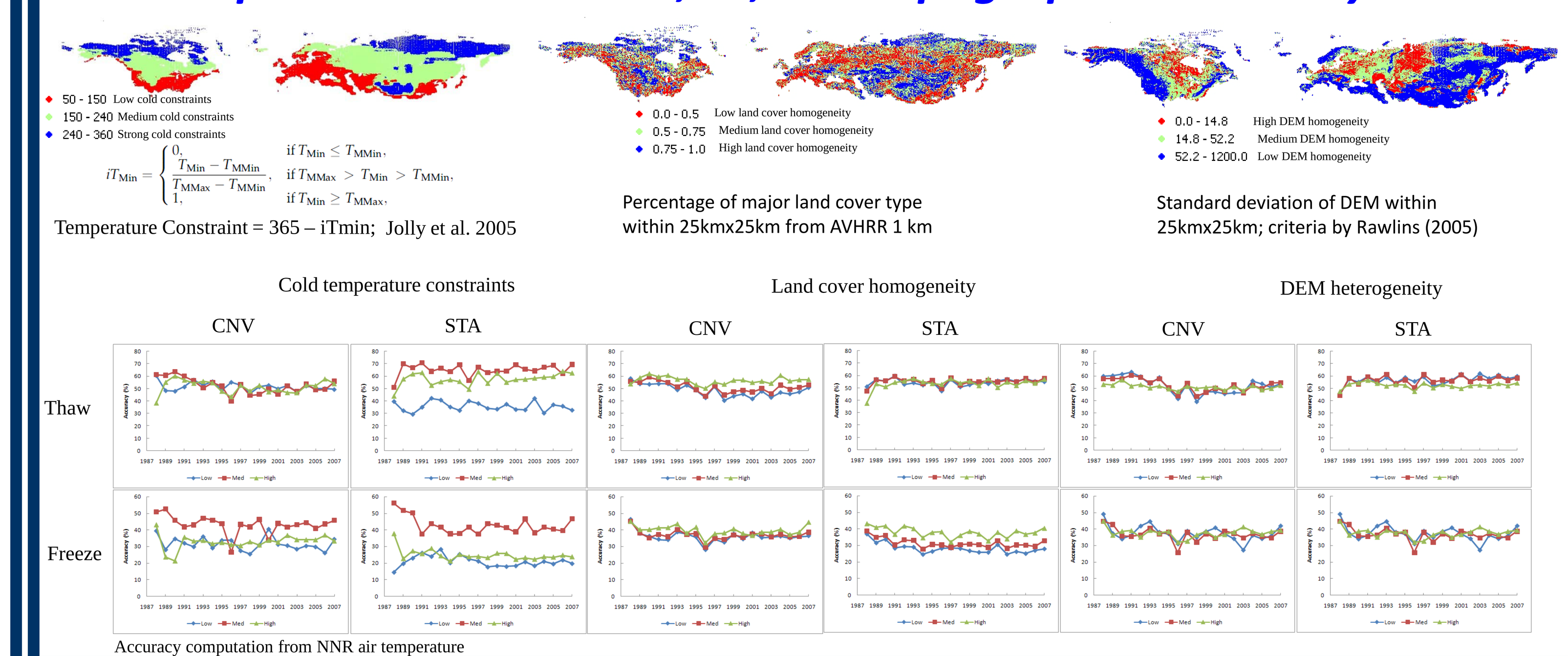


(4) Multi-sensor F/T classification comparison





Cold temperature constraints, LC, and topographic variability:



Conclusions:

- Satellite F/T classification accuracy ranges from ~40-60% and is higher and lower during respective thaw and freeze transitions; classification accuracy is similar for different sensors and from year-to-year;
- Thaw transition generally coincide with growing season timing and length defined by independent satellite (MOD17) derived NPP time series;
- Annual mean F/T dates from SSMI and AMSR-E shows similar F/T patterns, while those from SeaWinds displays earlier thaw timing in STA (later in CNV) and earlier freeze timing in both algorithms;
- The STA and CNV algorithms produce similar F/T patterns and time series, through STA shows earlier thaw timing than CNV;
-F/T classification accuracy is generally improved over regions with medium cold temperature constraints, while F/T accuracy is mostly consistent with respect to LC and terrain heterogeneity.

Acknowledgements

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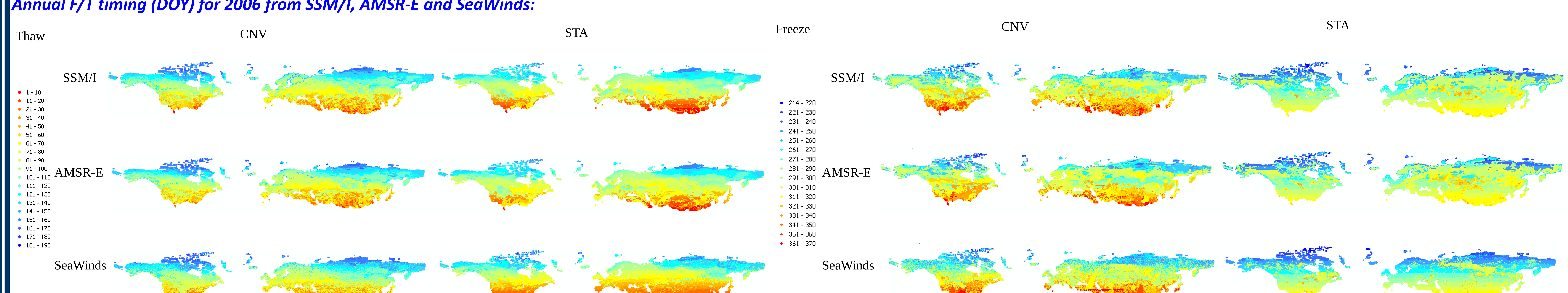
Annual F/T timing (DOY) for 2006 from SSM/I, AMSR-E and SeaWinds:



F/T timing from three sensors are distributed similarly. Most differences between two algorithms occur in the lower latitude, resulting in earlier F/T timing in STA.