A Remote Sensing-based Framework for Forecasting Forest Fire Danger Conditions

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Outline

1. Introduction

2. Objectives

3. Study area and data used

4. Methodology

5. Results & discussion

6. Concluding remarks

7. Acknowledgements

8. Q & A

Introduction (1)

- ✓ **Forest fire is one of the most important natural hazards in Alberta and rest of Canada.**
- ✓ **In Alberta, on an average 1500 of forest fire occurred and burned approximately 220 thousand ha during the period 2002-2011.**
- ✓ **In 2011, several catastrophic fires were observed in Alberta:**
  - **Slave Lake fire burned 22,000 ha including the town with an estimated economic loss of $700 million; and**
  - **Fort McMurrary regional fires burned 595,000 ha of muskeg and bush.**
- ✓ **Thus, it would be worthwhile to study fire danger as part of forest fire management.**

Introduction (2)

- ✓ The operational "Fire Weather Index" system forecasts danger condition as a function of weather variables acquired at point locations.
- ✓ Once the point source data is interpolated to generate the spatial dynamics, then the outcome would potentially be vary depending on the type of GIS interpolation technique.
- ✓ In this context, remote sensing data might be useful as it provides continuous surfaces.

Introduction (3)

- ✓ In the recent time, we have developed a remote sensing-based forest fire danger forecasting system (FFDFS).

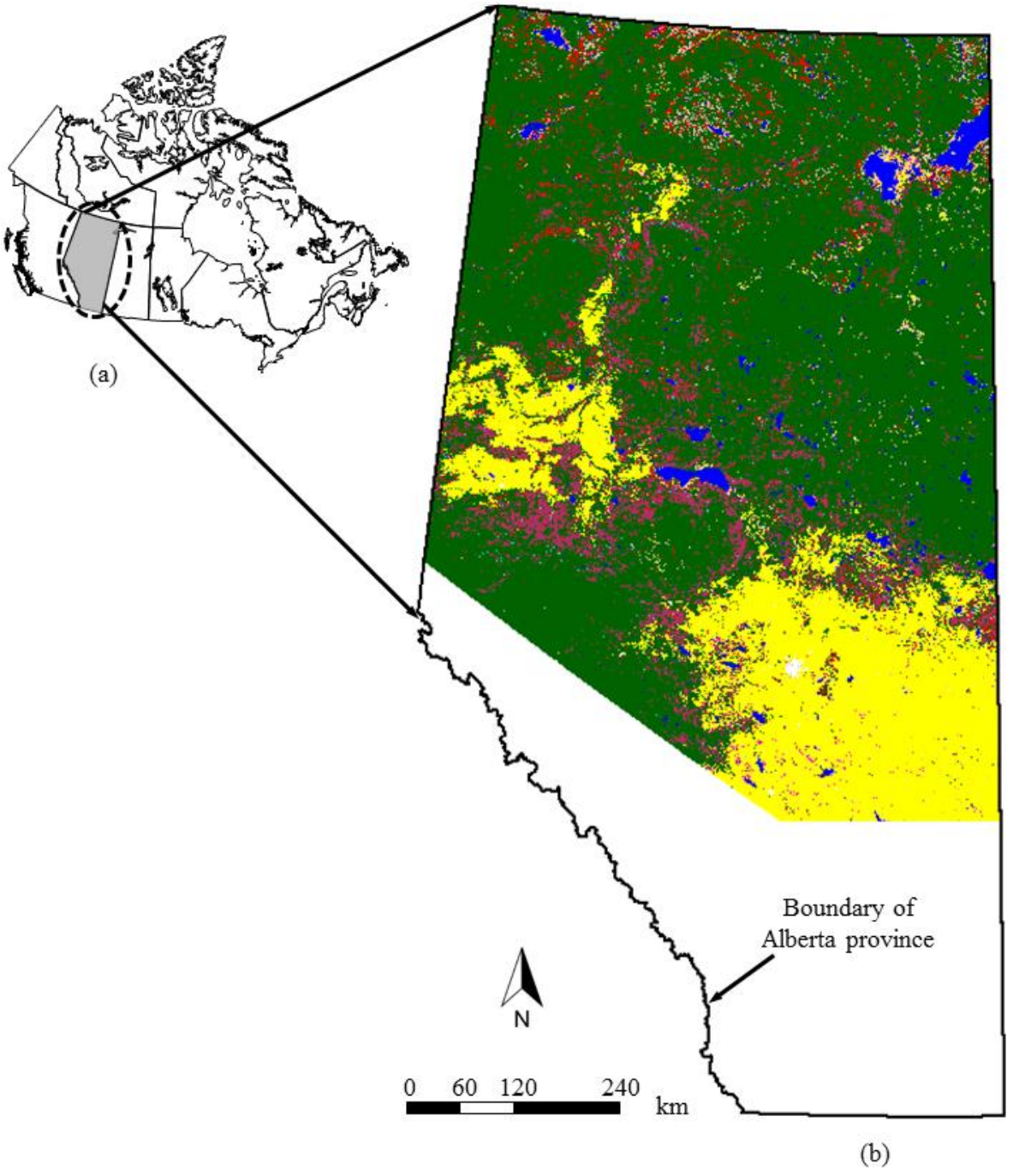
- ✓ The FFDFS uses three MODIS-derived variables/indices at 8-day temporal resolution, e.g.,
  - Surface temperature (T_S);
  - Temperature-vegetation wetness index (TVWI: an indirect way of estimating soil moisture contents); and
  - Normalized multi-band drought index (NMDI: a measure of vegetation moisture conditions).

- ➢ These input variables could be computed during the *i* period and integrated to forecast the fire danger conditions into four categories (i.e., very high, high, moderate, and low) during *i+1* period.

Objective

Evaluate the ability of FFDFS in forecasting the forest fire danger conditions associated with the devastating fire events of 2011 fire season in Alberta

Study Area and Data Used (1)



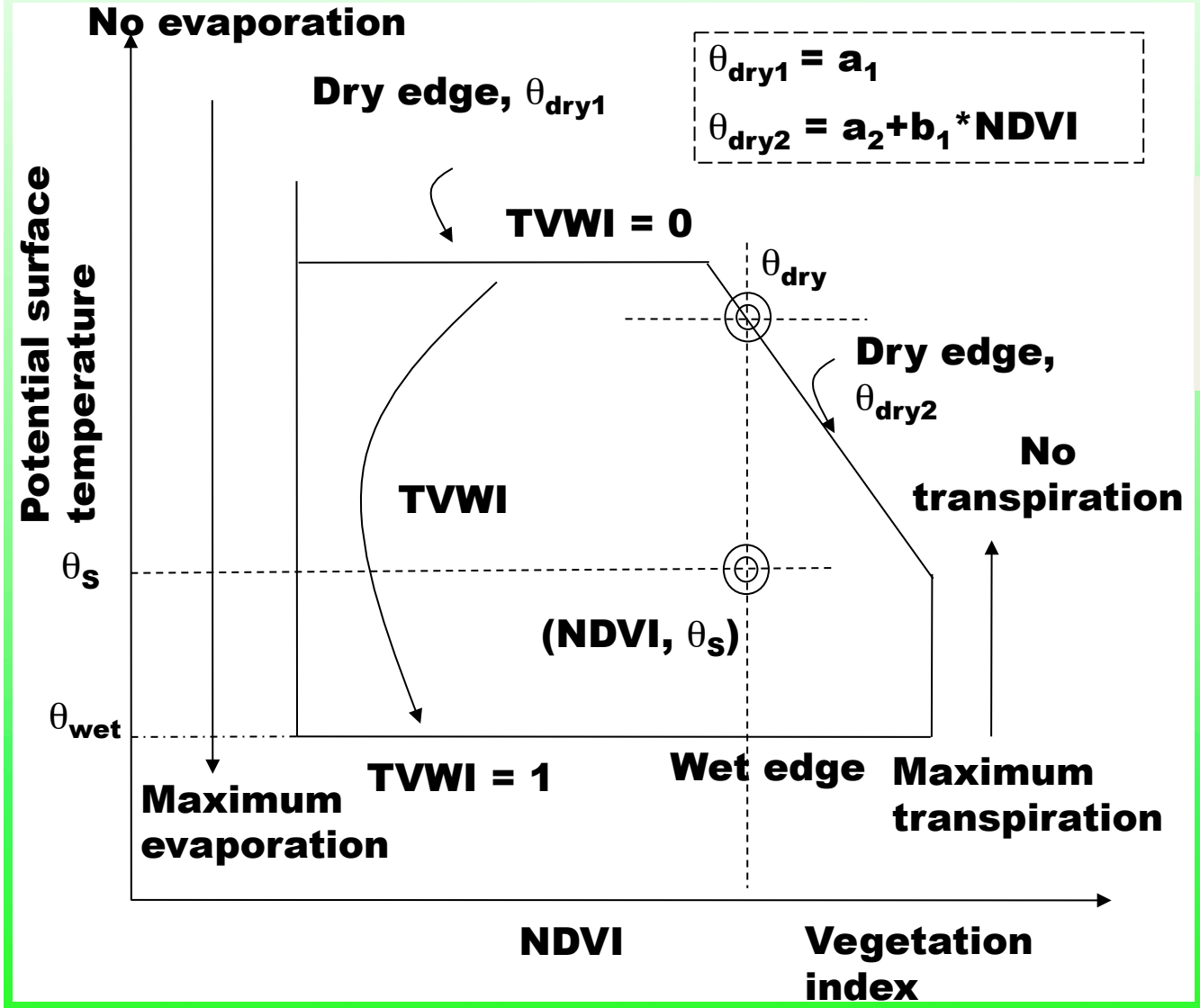
Land Cover Types

- Water (2.39%)
- Grasses/Cereal crops (20.4%)
- Shrubs (0.76%)
- Broadleaf crops (0.17%)
- Savanna (1.26%)
- Evergreen Broadleaf forest (0.08%)
- Deciduous Broadleaf forest (6.78%)
- Evergreen Needleleaf forest (64.8%)
- Deciduous Needleleaf forest (2.98%)
- Non-vegetated (0.03%)
- Urban (0.11%)

Study Area and Data Used (2)

- ✓ During the period April-September 2011, MODIS-based 8-day composites of:
  - ✓ Surface temperature (T_S) at 1 km spatial resolution
  - ✓ Surface reflectance at 500 m spatial resolution
  - ✓ Fire spot data at 1 km spatial resolution
- ✓ NASA Shuttle Radar Topography Mission (SRTM)-derived digital elevation model (DEM) at 500 m resolution.

Data Pre-processing (1)



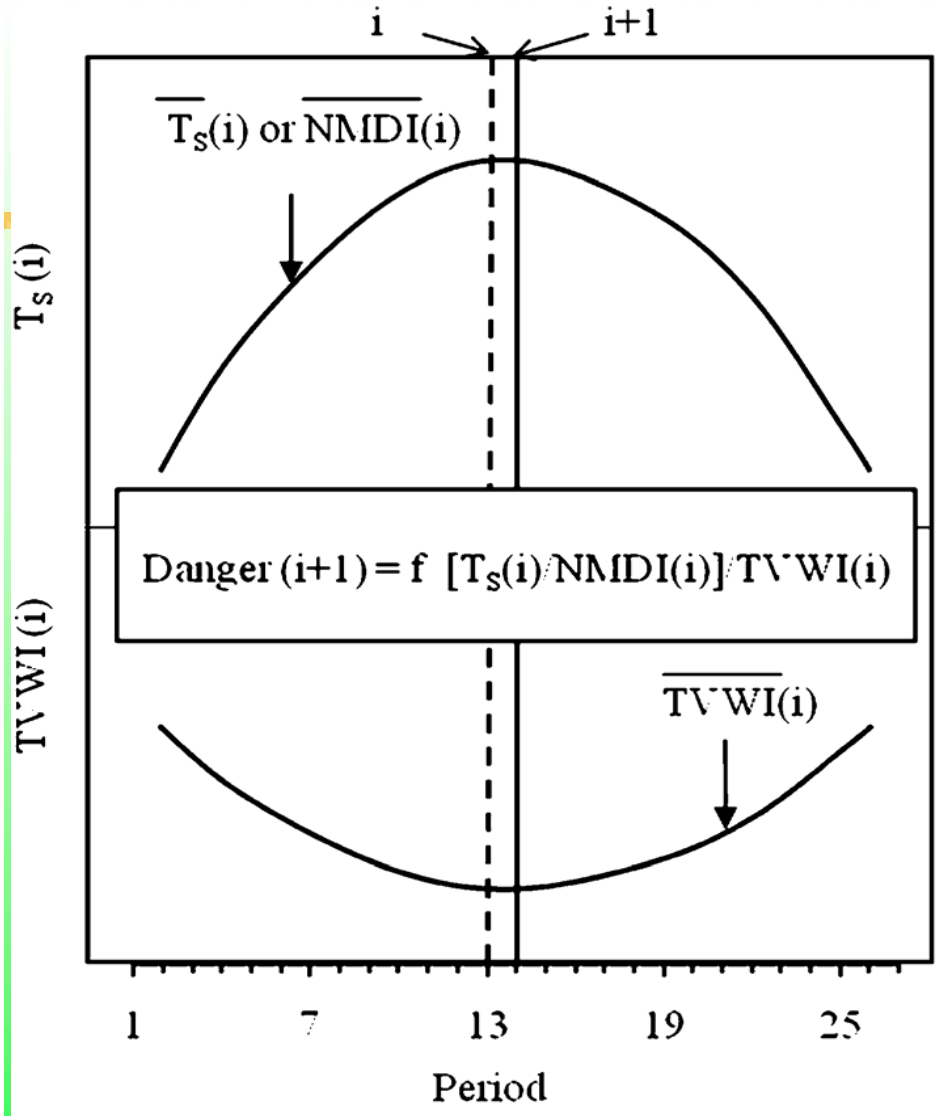
$$NDVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red}}$$

$$TVWI = \frac{\theta_{dry} - \theta_s}{\theta_{dry} - \theta_{wet}}$$

Data Pre-processing (2)

$$NMDI = \frac{\rho_{NIR} - \left[\rho_{1.64\mu m} - \rho_{2.13\mu m}\right]}{\rho_{NIR} + \left[\rho_{1.64\mu m} - \rho_{2.13\mu m}\right]}$$

Methodology

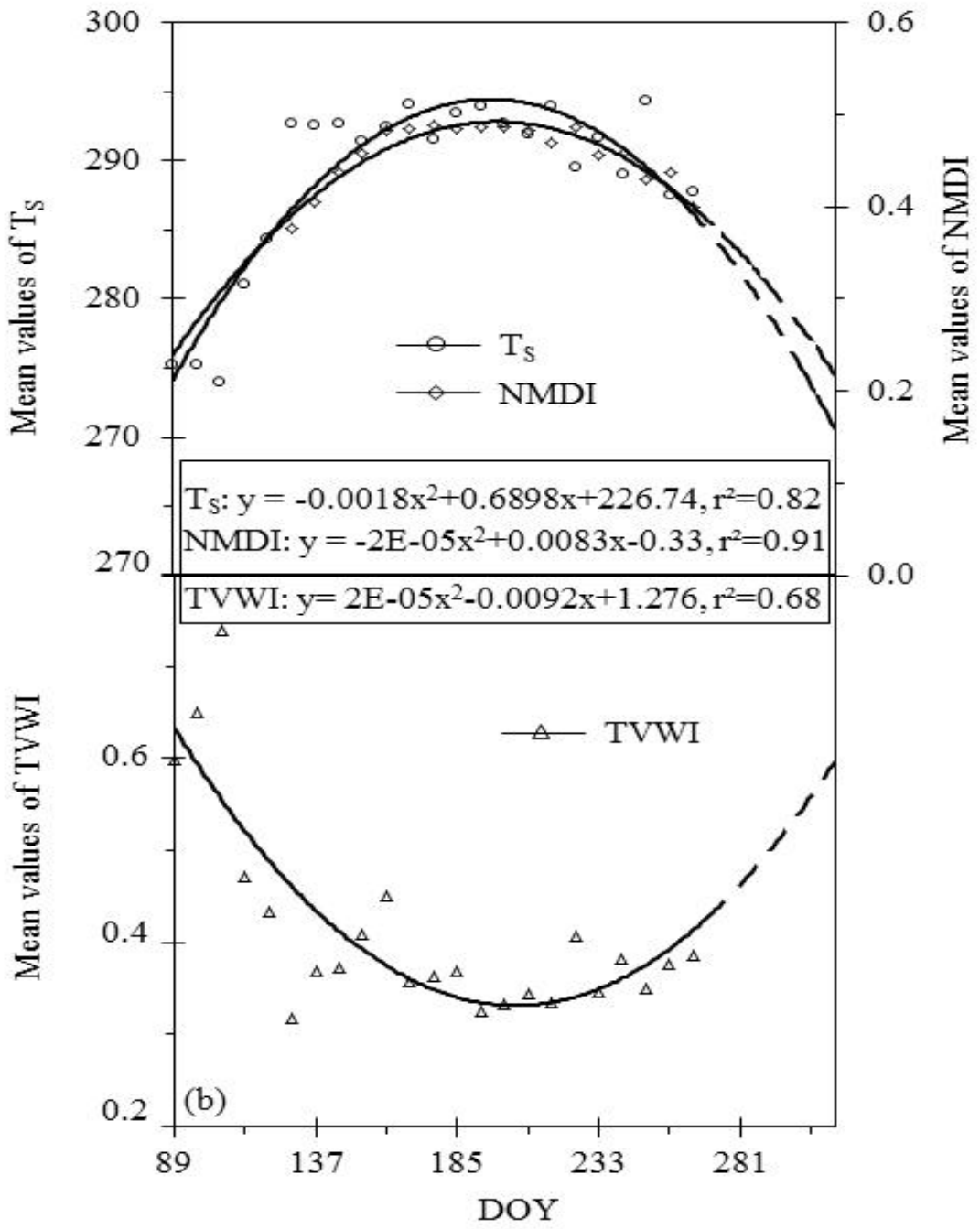


Variable	Danger (i+1)	
	High	Low
$T_S(i)$	$\geq \overline{T_S(i)}$	$< \overline{T_S(i)}$
NMDI(i)	$\leq \overline{NMDI(i)}$	$> \overline{NMDI(i)}$
TVWI(i)	$\leq \overline{TVWI(i)}$	$> \overline{TVWI(i)}$

$T_S(i)$/ NMDI(i)/TVWI(i) are the value of the respective variable for each of the pixels during i^{th} period

$\overline{T_S(i)}$/ $\overline{NMDI(i)}$/$\overline{TVWI(i)}$ are the average of the respective variable for all of the pixels during i^{th} period

Results & Discussion (1)

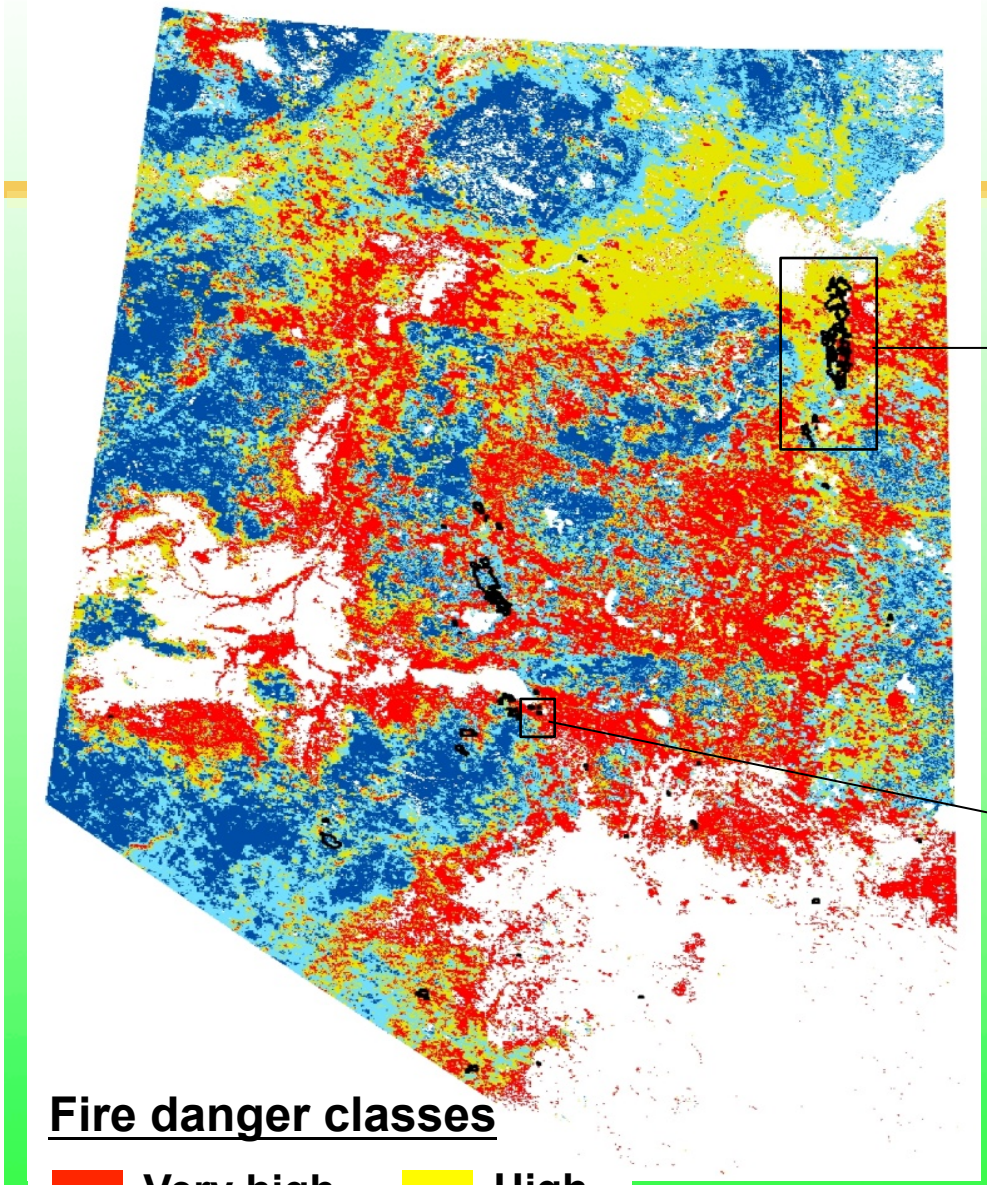


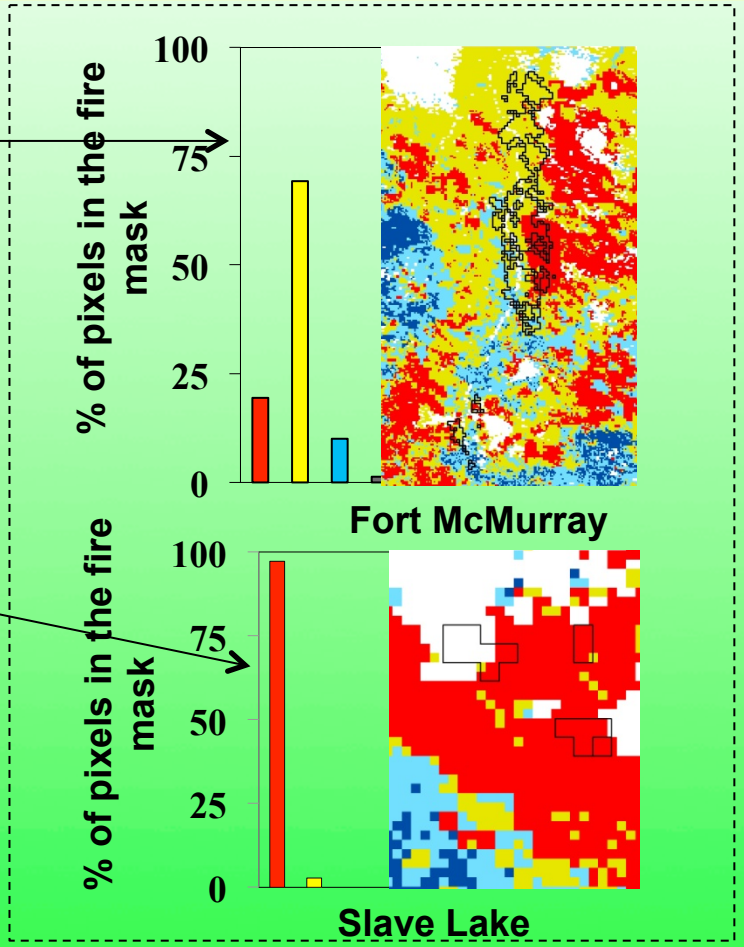
Results & Discussion (2)

Period	No. of input variables satisfying the fire danger conditions	Fire danger classes	% of data	Cumulative % of data
2011	All	Very high	33.58	33.58
	At least 2	High	47.62	81.21
	At least 1	Moderate	15.29	96.50
	None	Low	3.50	100.00
2006-2008	All	Very high	32.51	32.51
	At least 2	High	33.00	65.51
	At least 1	Moderate	26.11	91.62
	None	Low	8.38	100.00

Results & Discussion (3)

Fire danger map for the period 9-16 May 2011 using the input variables from 1-8 May 2011





Fire danger classes

- Very high
- High
- Moderate
- Low
- Fire mask

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Concluding Remarks

- ✓ **Here we evaluated the potential of three MODIS-based indices/ variables (*i.e.*, T_S, NMDI, and TVWI) for forecasting the forest fire danger conditions in the boreal forested region of Alberta.**

- ✓ **Thus, it could potentially be incorporated in the framework of forest fire management.**

Recommendation & Further Research

- ✓ Despite the reasonable performance of the FFDFS, there are two major drawbacks in the present study, such as:
  - the exclusion of the pixels having null values (that were contributed due to cloud contamination, missing input, data faulty and corrections out of bounds pixel etc.), and
  - the complexity of computing TVWI.
- ✓ In addition, temporal resolution should also be high.
- ✓ Improvement on these limitations would be important in enhancing the robustness of the FFDFS.

Acknowledgements

NSERC CRSNG

NASA

Alberta Environment and Sustainable Resource Development

References

- Akther, M.S. and Hassan, Q.K. 2011. Remote sensing based assessment of fire danger conditions over boreal forest. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, v. 4, pp. 992-999.

Thank You.

Questions?