

# **Snow-Cover Monitoring using NOAA-AVHRR images for Water Resource Management**

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Ministry of Energy**

# **Snow cover monitoring importance**

**Water resource management**

**Soil moisture**

**Surface temperature**

**Air temperature**

**Surface albedo**

**Radiation balance**

**Hydrologic budget**

**Heat budget**

**Earth atmosphere system**

# **Snow observation alternatives**

## **Weather stations**

**Limited number of stations**

**Point surface measurement**

**Distribution problem**

## **Snow cover survey**

**Limited**

**High cost**

## **Satellite imagery**

**Large coverage**

**Continues day and night**

**multi-spectral**

**Low cost**

# **Spectral signature of snow**

**Very high reflectance in visible band**

**Reflectance drops off quickly in near IR**

**Reflectance varies as snow ages**

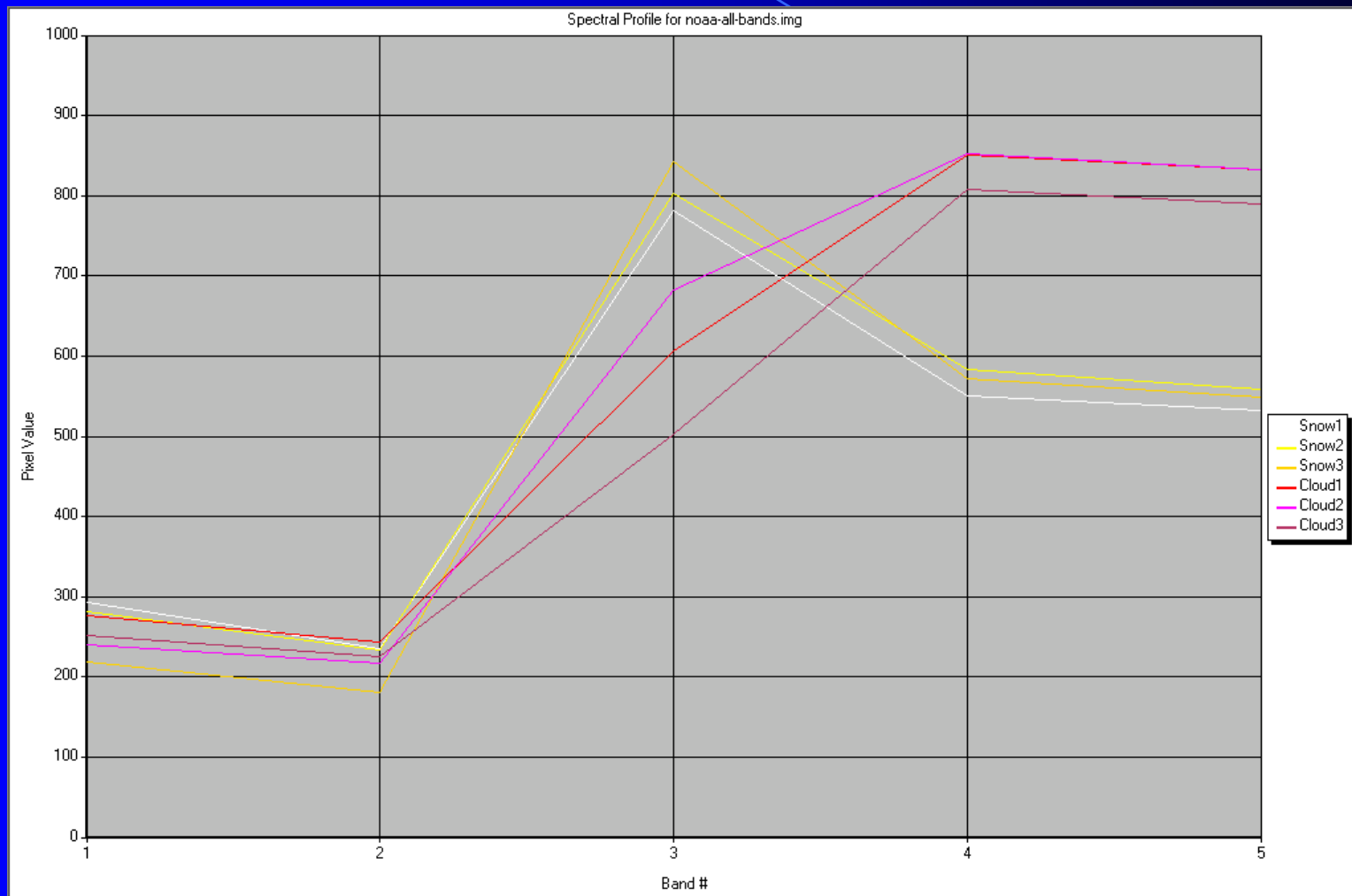
**Changes in snow crystal size affects scattering**

**Changes in amount of liquid water in snowpack**

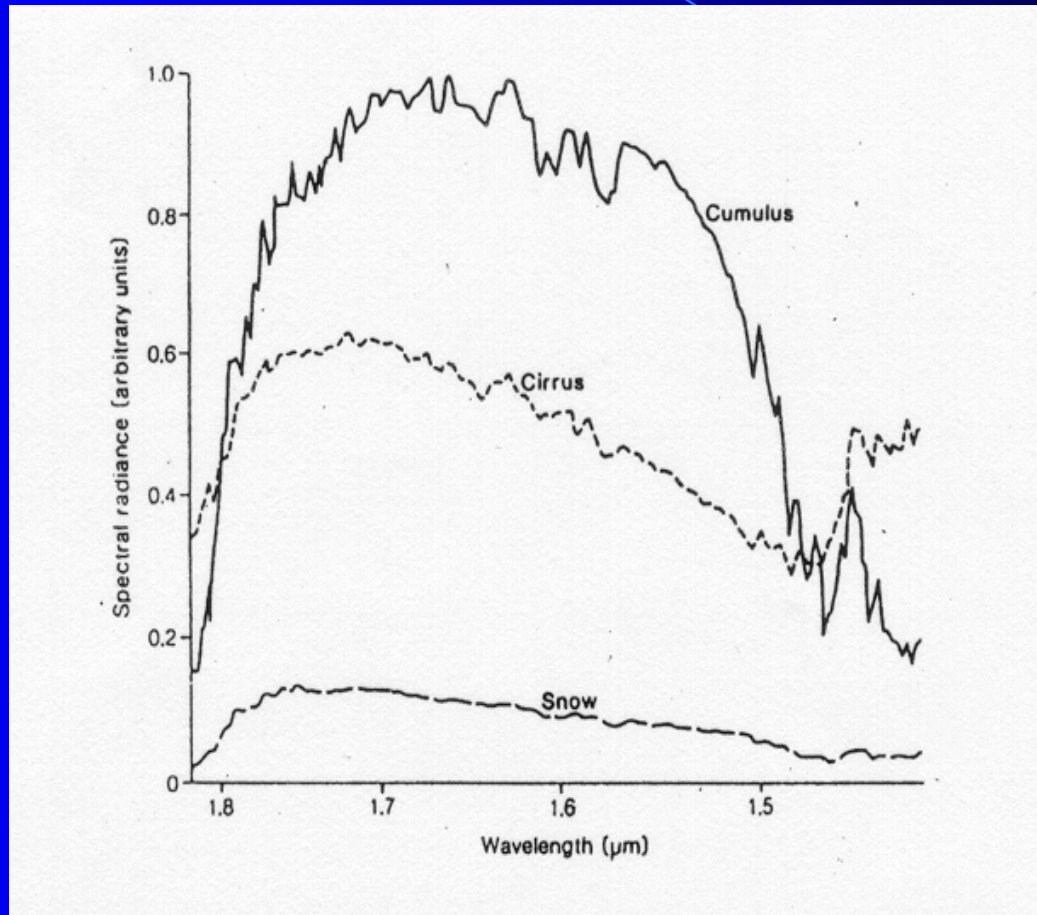
**Mid-IR band useful for separation of snow and clouds**

**Confusion with clouds**

# Spectral signature of snow and cloud

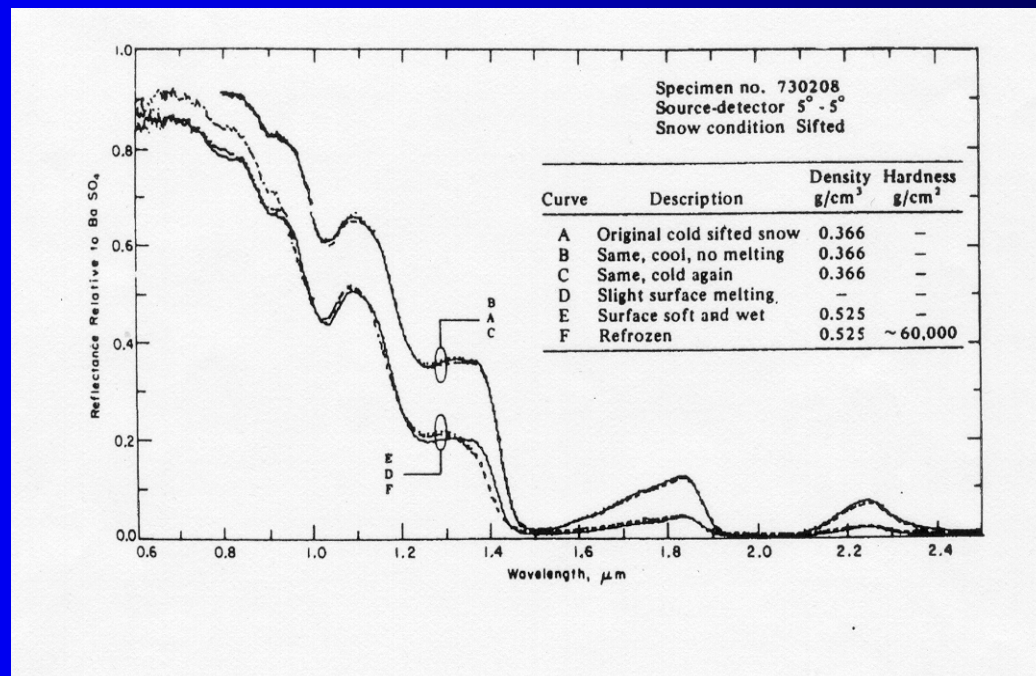


# Spectral signature of snow and cloud



# Fresh snow has higher reflectance than old snow

Surface Type	Albedo
Cumulonimbus	0.9
Fresh snow	0.8-0.9
Stratocumulus	0.6
Melting snow	0.4-0.6
Cirrus	0.4-0.5



# Comparison of sensors for snow cover monitoring

<b>AVHRR</b>	<b>Advantages</b>	<b>Five bands in AVHRR/2 Six bands in AVHRR/3 A 1.6 micrometer band for snow/cloud discrimination Two times visit per day Low cost</b>
	<b>Disadvantages</b>	<b>Low spatial resolution Cloud problem</b>
<b>VISSR</b>	<b>Advantages</b>	<b>Three bands 1 hour revisit cycle 1.25 km spatial resolution for visible band 5 km spatial resolution for IR and WV bands Low cost</b>
	<b>Disadvantages</b>	<b>Very low spatial resolution Cloud problem No 1.6 micrometer band</b>
<b>ETM</b>	<b>Advantages</b>	<b>Eight bands 30 m spatial resolution A 1.6 micrometer band</b>
	<b>Disadvantages</b>	<b>16 days revisit cycle High cost</b>

## AVHRR sensor

<b>Band</b>	<b>AVHRR/1</b>	<b>AVHRR/2</b>	<b>AVHRR/3</b>
<b>1</b>	<b>0.58-0.68</b>	<b>0.58-0.68</b>	<b>0.58-0.68</b>
<b>2</b>	<b>0.725-1.10</b>	<b>0.725-1.10</b>	<b>0.725-1.10</b>
<b>3</b>	<b>3.55-3.93</b>	<b>3.55-3.93</b>	<b>3.55-3.93</b>
<b>3a</b>	<b>-</b>	<b>-</b>	<b>1.58-1.64</b>
<b>4</b>	<b>10.50-11.50</b>	<b>10.30-11.30</b>	<b>10.30-11.30</b>
<b>5</b>	<b>Ch4 repeated</b>	<b>11.50-12.50</b>	<b>11.50-12.50</b>

# **Snow detection methodology**

## **Thresholding technique**

**Reflectance characteristics in bands 1 and 2**

**Brightness temp characteristics in bands 3, 4 and 5**

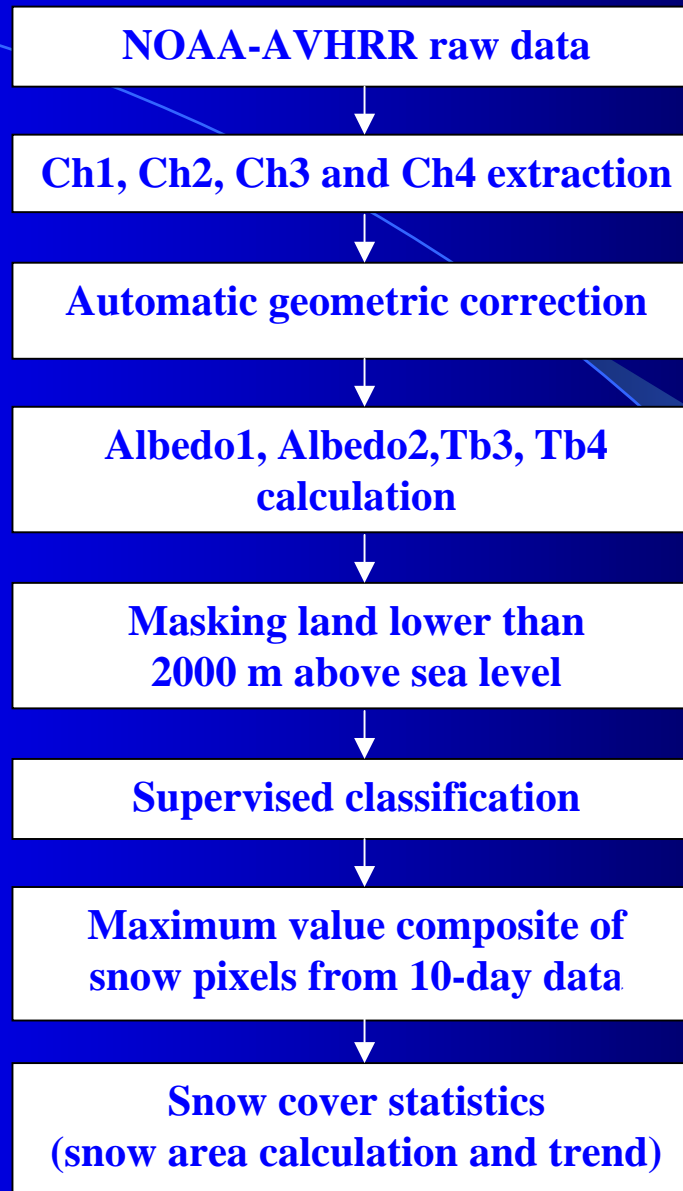
**Difference between bands 3 and 4**

**ch2/ch1**

**NDSI= (ch2-ch1)/(ch2+ch1)**

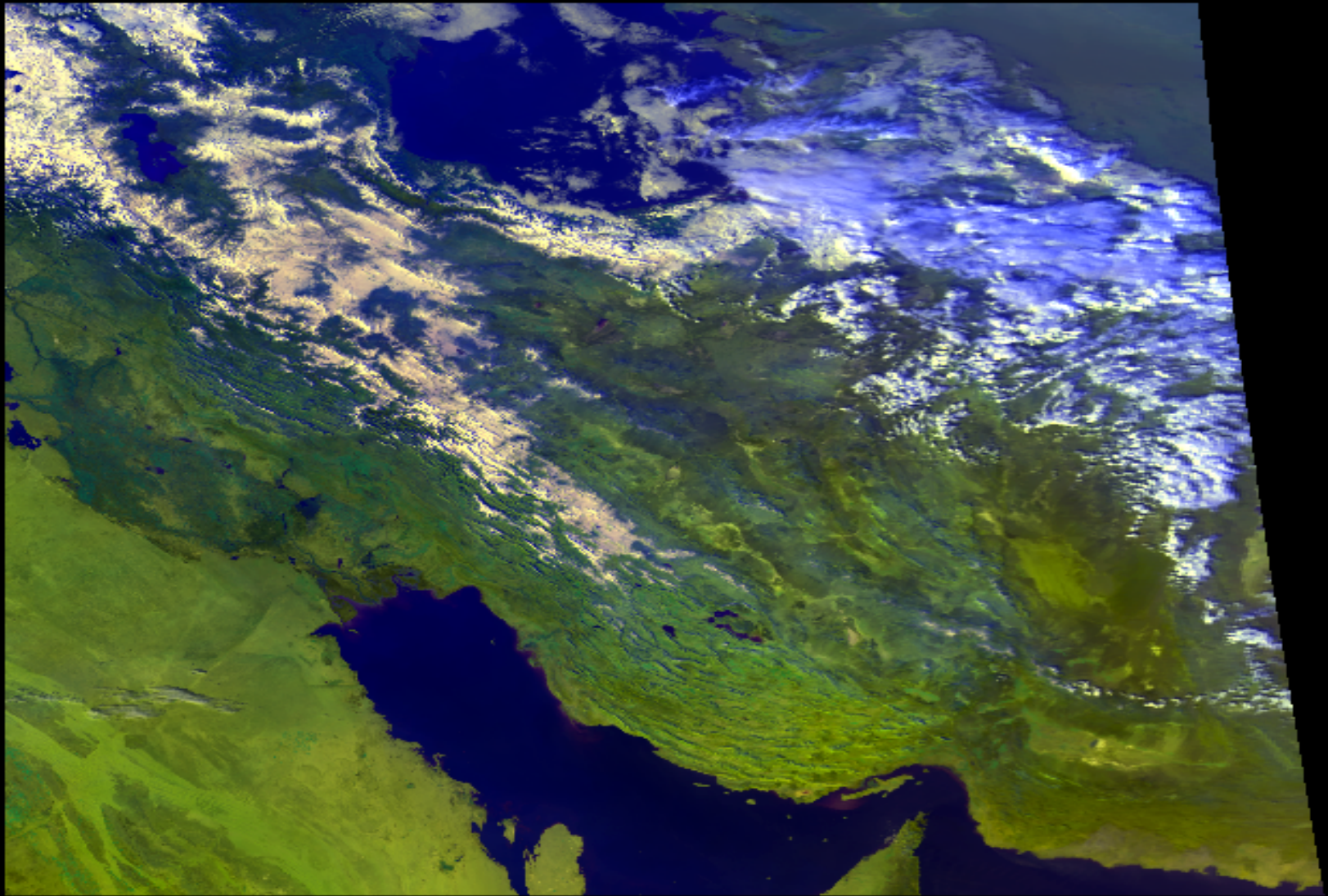
## **Classification technique**

**Maximum Likelihood Classification  
on bands 1, 2, 3, and 4**

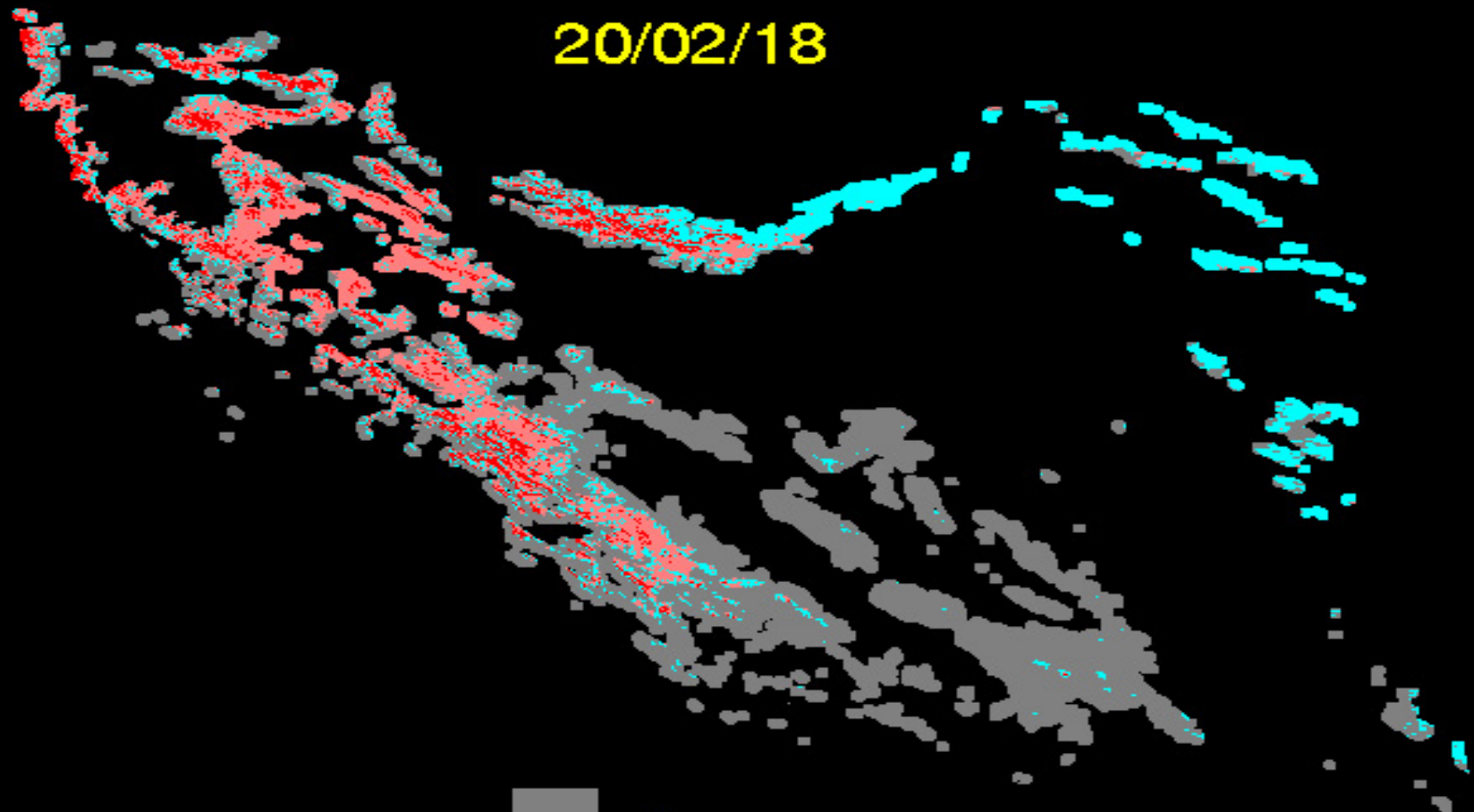


**The flowchart of snow monitoring system**

20/02/18



20/02/18



Classification Key

# Preliminary results and analysis

## **Year 1:**

**Autumn 1998 and winter 1999 have relatively good snow cover**

## **Year 2:**

**Autumn 1999 and winter 2000 have low snow cover  
and spring 2000 have very low snow cover**

## **Year 3:**

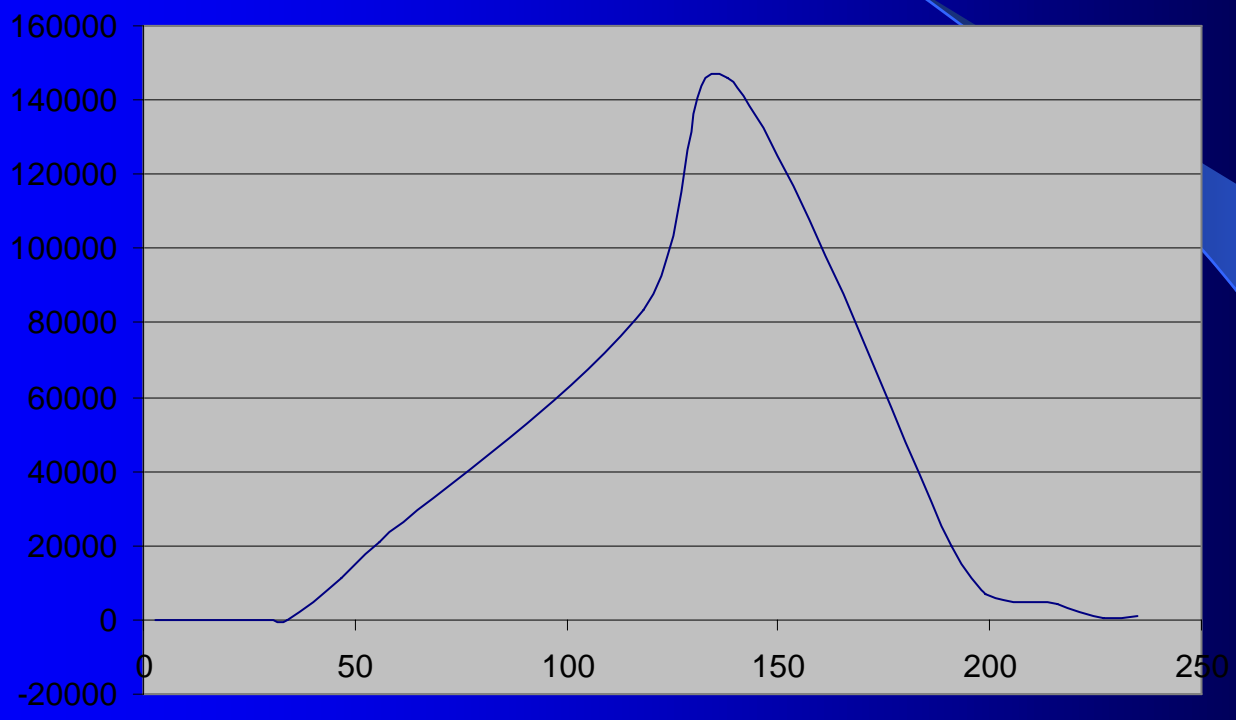
**Autumn 2000 and winter 2001 have very low snow cover  
and spring 2001 have no snow cover**

## **Year 4:**

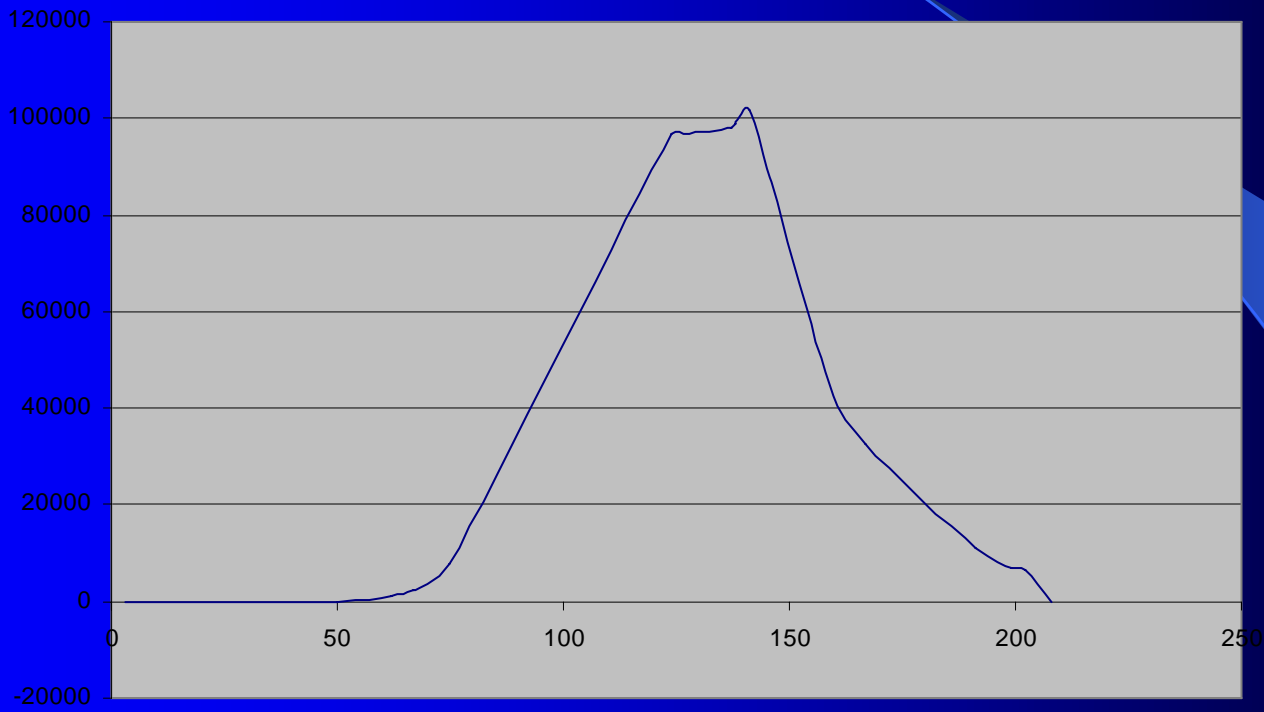
**Autumn 2001 and winter 2002 have very good snow cover  
and spring 2002 have average snow cover**

## **Year 5:**

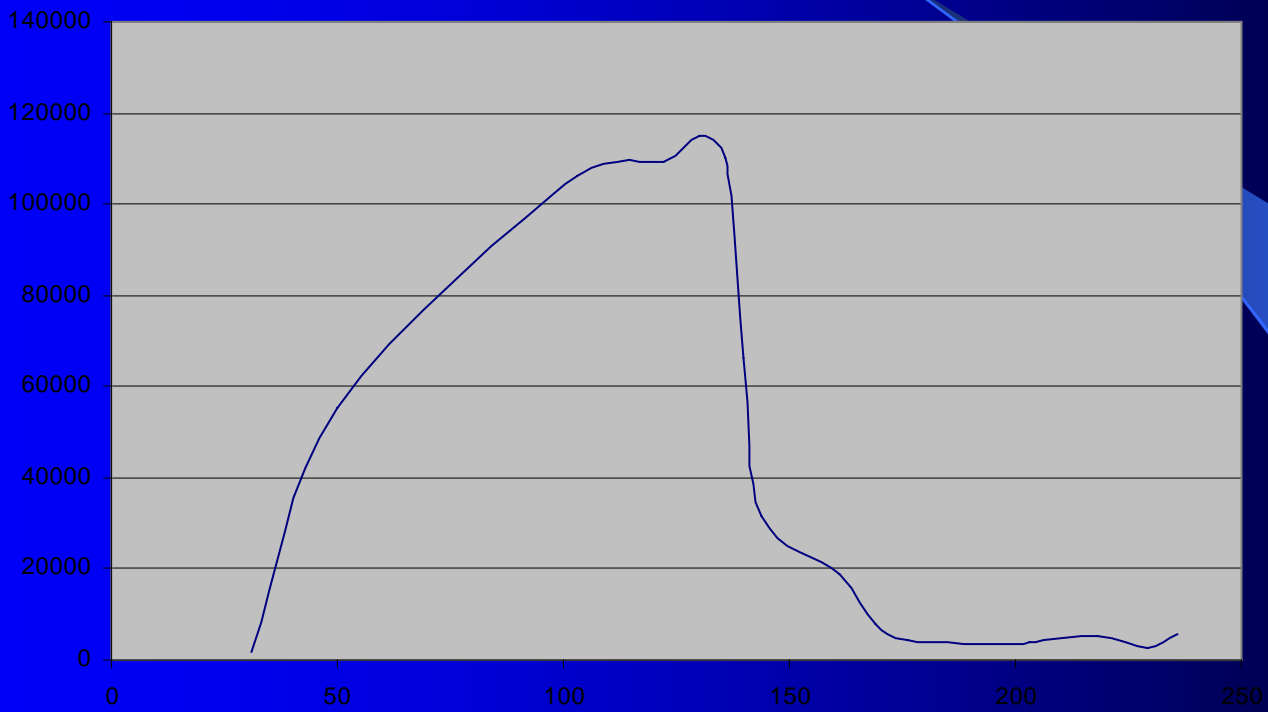
**Autumn 2002 have average snow cover,  
winter 2003 have good snow cover  
and spring 2003 have very good snow cover**



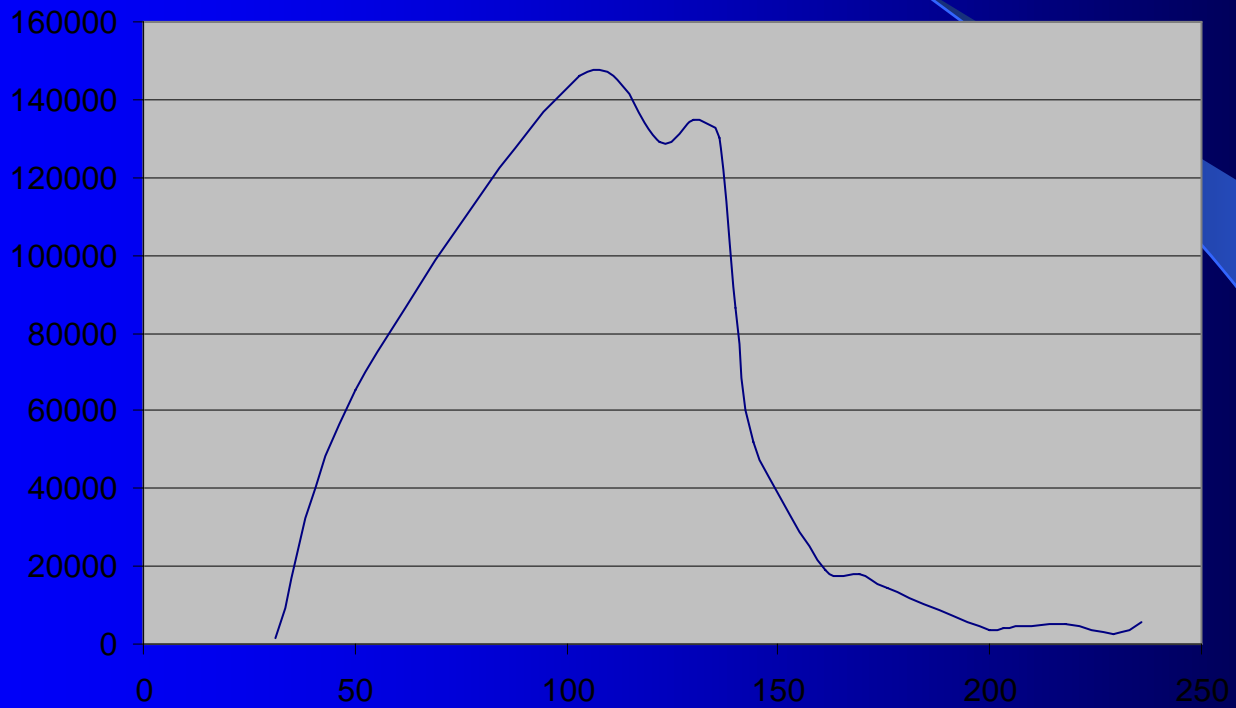
— Series1



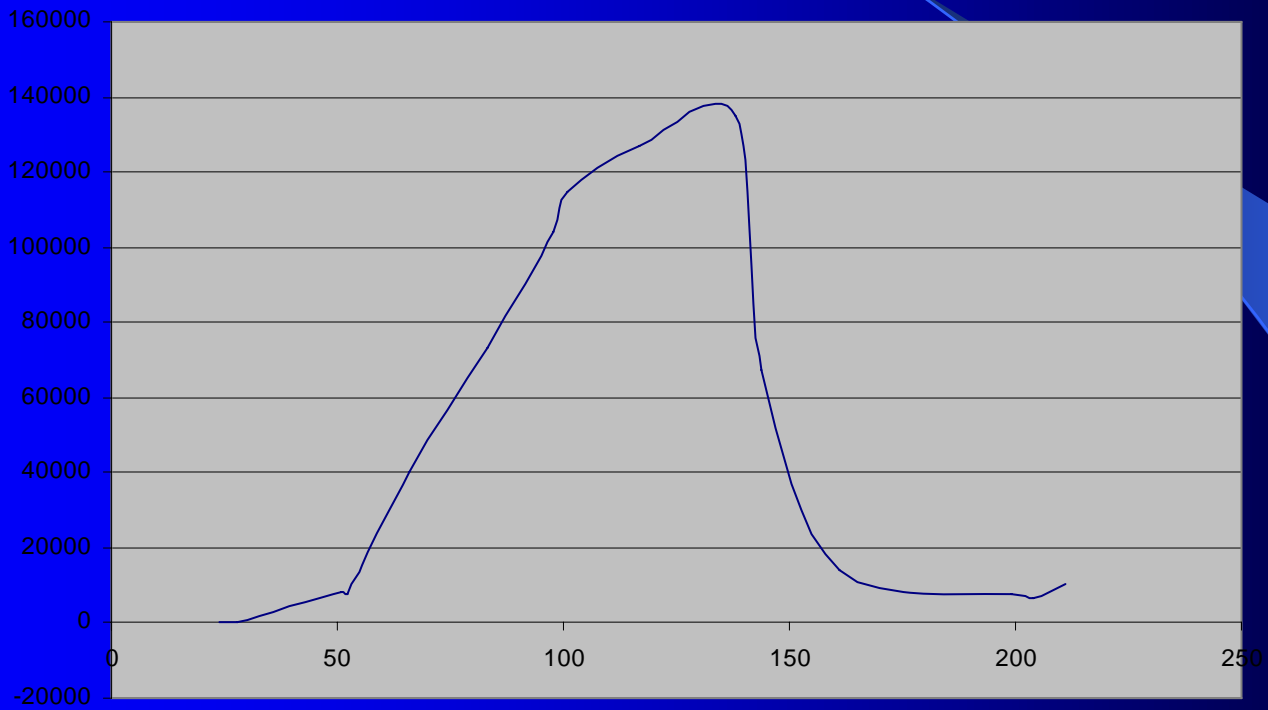
Series1



Series1



Series1



Series1

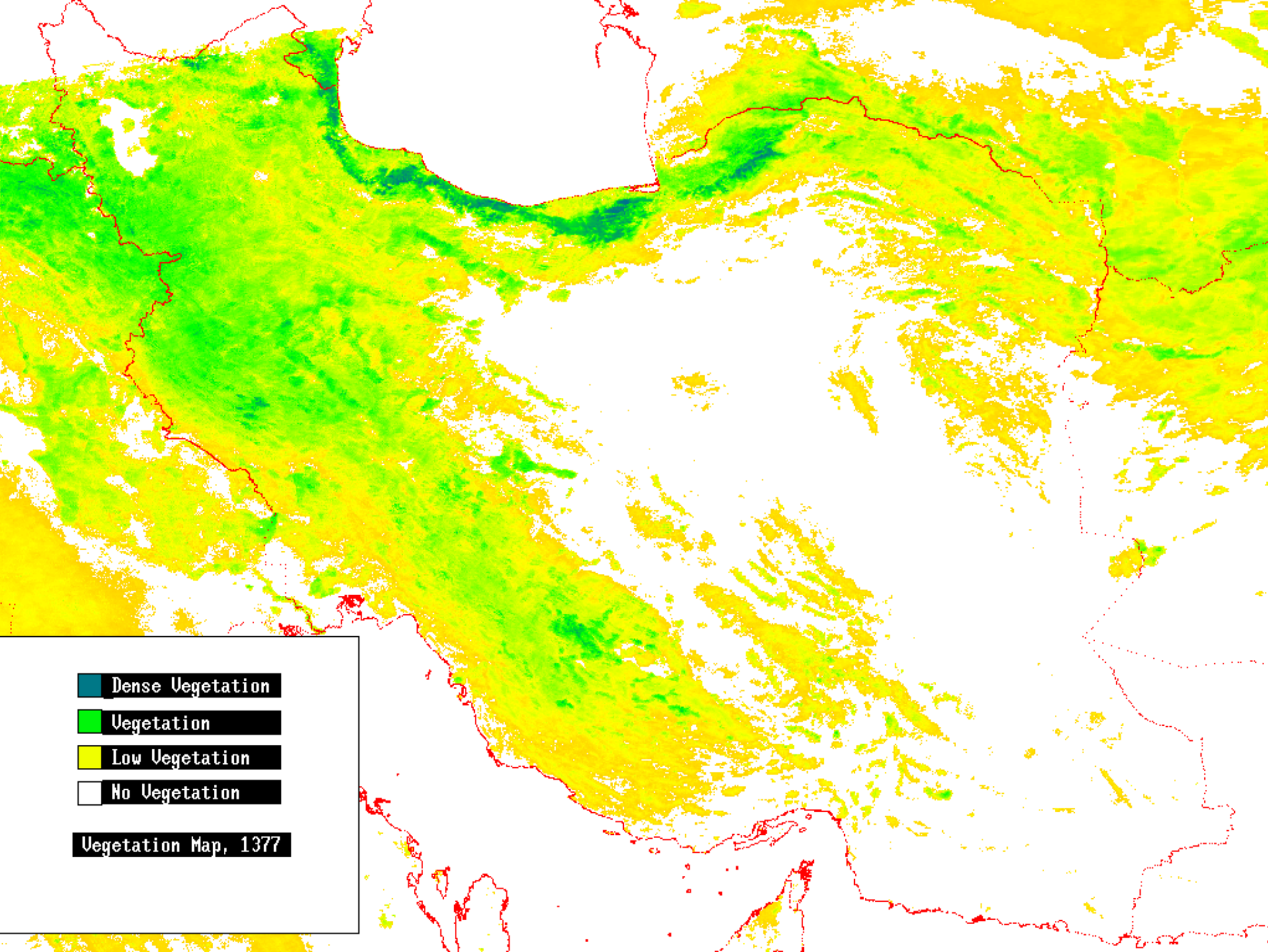
# Conclusions

**Snow cover is an effective index in estimating the amount of potential water resource**

**Snow cover monitoring is possible using AVHRR images**

**By masking land lower than 2000 m above sea level the accuracy of classification has been increased due to the fewer classes under process**

**The results obtained through snow cover monitoring is compatible with vegetation monitoring results**



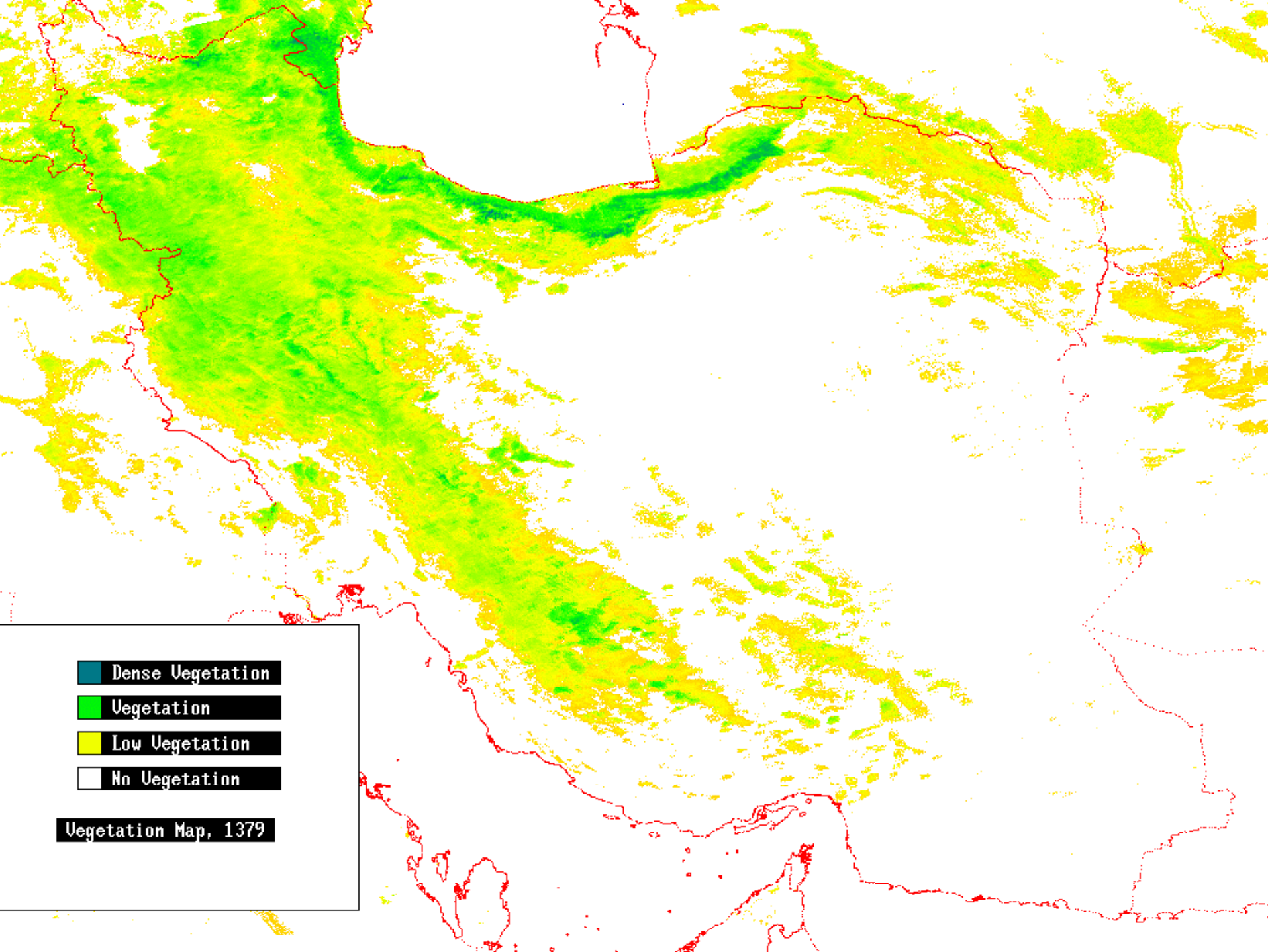
Dense Vegetation

Vegetation

Low Vegetation

No Vegetation

Vegetation Map, 1377



 Dense Vegetation

 Vegetation

 Low Vegetation

 No Vegetation

**Vegetation Map, 1379**