River ice monitoring (AQUA) via screening-in thin cloud data and its validation

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Outline

I. Introduction
II. Detecting opt. thick clouds and river ice
III. Algorithm
IV. Results and validation (daily)
V. Results and validation (entire winter)
I. River ice and ice jams

Purpose
- Using satellites to obtain frequent river ice observations over a larger region

Stakeholders
- National Weather Service
- National ice center
- River forecasting centers
- Sus. River Basin Commission
- ....
I. Susquehanna River Basin
I. Discharge at Harrisburg, PA

Discharge for the 171 days monitored

Blue: Median Q
Yellow: Estimated Q
Black: Observed Q
Bars: 25th to 75th percentile Q

Most variable, least predictable flows coincide with winter-spring transition
I. Problem statement

- Nov 1 to Apr 20 (171 days)
- Clouds cover the river (CM)
  - Especially when it bears ice, $90 \text{ d}^*$
  - $>50\%$ of river CF in only $2/90 \text{ d}^*$
  - But clouds often are opt. thin!*

- Approach:
  - Develop automated algorithm to extract data when/where clouds are opt. thin first, then check results

*shown later on
II. Relevant VIS/NIR bands

*note: 70% of band 6 detectors are broken on AQUA, instead band 7 is used
II. Band decomposition (Jan 9, 2014)
II. Determining where the river is

- River masks (AQUA, 500m)
  - Max. Likelihood for bands 1-4,7
  - Based on 3 images (Summer 2009)
    - Keep only those that were classified as river in every scene
II. Statistical contrast of band 7, river (7r)
II. Statistical contrast of band 7, scene (7s)

Aqua (547), 11/1/13.

<table>
<thead>
<tr>
<th>Scene, (7)</th>
<th>Mean</th>
<th>Sdev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.118</td>
<td>0.066</td>
</tr>
</tbody>
</table>

Count

Reflectance
II. Statistical contrast of band 7, river (7r)
II. Statistical contrast of band 7, scene (7s)

Aqua (547), 12/22/13.
II. Histogram of data that includes ice, snow

River, (4)

Scene, (4)
III. Algorithm

Test 1: Informed by time series

<table>
<thead>
<tr>
<th>Case</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (No snow)</td>
<td>$\tilde{r}/\tilde{T} &lt; 0.58$ and $\tilde{T} &lt; 0.21$</td>
</tr>
<tr>
<td>2 (Snow)</td>
<td>$\tilde{r}/\tilde{T} &lt; 0.83$ and $\tilde{T} &lt; 0.11$</td>
</tr>
</tbody>
</table>

Test 2: Informed by spatial contrast

<table>
<thead>
<tr>
<th>Band/Class</th>
<th>R ('low')</th>
<th>B ('mod')</th>
<th>G ('high')</th>
<th>'thick cld'</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>B4</td>
<td>$&gt; \bar{r} + \sigma$</td>
<td>$&gt; \bar{r} + 2\sigma$</td>
<td>$&gt; \bar{r} + 3\sigma$</td>
<td>NA</td>
<td>$\leq \bar{r} + \sigma$</td>
</tr>
<tr>
<td></td>
<td>$&gt; 0.103$</td>
<td>$&gt; 0.143$</td>
<td>$&gt; 0.183$</td>
<td>NA</td>
<td>$\leq 0.103$</td>
</tr>
<tr>
<td>B7</td>
<td>$\leq 7 + 3\sigma$</td>
<td>$\leq 7 + 2\sigma$</td>
<td>$\leq 7 + \sigma$</td>
<td>$&gt; 7 + 3\sigma$</td>
<td>$\leq 7 + 3\sigma$</td>
</tr>
<tr>
<td></td>
<td>$\leq 0.195$</td>
<td>$\leq 0.152$</td>
<td>$\leq 0.110$</td>
<td>$&gt; 0.195$</td>
<td>$\leq 0.195$</td>
</tr>
</tbody>
</table>
IV. Results (daily)

- **3/9/14**
  - Test 1 failed

- **3/10/14**

- **3/11/14**
  - Reflectance change

- **3/11 ice likelihood**

- **3/11 ice composite**

- **3/11 ice age (days)**
IV. Validation (daily)
IV. Results (winter)

Data: 1.0 represents 402 pixels, Obs: number of days in which at least one pixel was observed, Rev: effective revisit time (days)
IV. Validation (winter)

\[ AFDD_j = \sum_{i=1}^{j} (32 - \bar{T}_{air})_i \]

- **AFDD**
  - Low
  - Mod
  - High
  - Q_est

- River ice extent
- River ice amount

- Ice end: day 133 (USGS)
- Ice start: day 43 (USGS)

- Daily mean discharge (cfs)

- Day 124
- Day 126
- Day 129
- Day 131
- Day 133
- Day 135
Acknowledgements

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- IDL Coyote
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- Recent presentations (2015)
  - AMS, NOAA EPP, NOAA Advisory board meeting