EFFECTS OF COLD FRONT PASSAGE AND ATMOSPHERIC BOUNDARY LAYER STABILITY IN THE ESTIMATES OF SPATIALLY DISTRIBUTED HEAT FLUXES IN A TROPICAL RESERVOIR

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Heat budget is one of the most fundamental component of physical limnology;

Modulated by seasonal cycle of incoming shortwave solar radiation;

At short time scale variations occurs in response to atmospheric disturbance, such as cold fronts passage;

Cold fronts incursions are one of the most recurrent synoptic pattern over South America;

Some of these cold fronts can reach the Southeastern part of Brazil where are located many hydroelectric reservoirs;

**Objective:**

**INVESTIGATE THE EFFECTS OF COLD FRONT PASSAGE AND ABL STABILITY IN THE SPATIALLY DISTRIBUTED ESTIMATES OF SENSIBLE AND LATENT HEAT FLUXES OF ITUMBIARA RESERVOIR, CENTRAL BRAZIL.**

Source: http://sigel.aneel.gov.br/
Study Area:

Itumbiara Hydroelectric Reservoir → Central Brazil

Reservoir characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooded area</td>
<td>778 km²</td>
</tr>
<tr>
<td>Volume</td>
<td>17 bi m³</td>
</tr>
<tr>
<td>Generation capacity</td>
<td>2082 MW</td>
</tr>
</tbody>
</table>

Source: http://www.furnas.com.br
Study period:

- From 27/04/2010 to 16/06/2010;
- 5 cold fronts incursions detected by CPTEC/INPE;
- Different intensities.

<table>
<thead>
<tr>
<th>Cold Front</th>
<th>( \Delta T_a ) (°C)</th>
<th>( U_{10} ) (m s(^{-1}))</th>
<th>( \Delta R_h ) (%)</th>
<th>( P ) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>5.2</td>
<td>7.1</td>
<td>30.9</td>
<td>0</td>
</tr>
<tr>
<td>F2</td>
<td>3.8</td>
<td>6.5</td>
<td>55.7</td>
<td>0</td>
</tr>
<tr>
<td>F3</td>
<td>3.4</td>
<td>8.6</td>
<td>54.1</td>
<td>4.4</td>
</tr>
<tr>
<td>F4</td>
<td>3.1</td>
<td>8.8</td>
<td>63.9</td>
<td>73.2</td>
</tr>
<tr>
<td>F5</td>
<td>4.3</td>
<td>7.2</td>
<td>57.6</td>
<td>16.7</td>
</tr>
</tbody>
</table>
Meteorological data:

SIMA ¹ (Integrated System for Environmental Monitoring):

- Wind speed and direction, air temperature, humidity and pressure;
- Data measured at 1 hour interval;

Water Surface Temperature (WST):

<table>
<thead>
<tr>
<th>MOD11A L3 and MYD11A1 L3 product</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal coverage</td>
<td>03/2000 - nowadays</td>
</tr>
<tr>
<td>Image dimension</td>
<td>1200 x 1200 (lines/rows)</td>
</tr>
<tr>
<td>Projection</td>
<td>Sinusoidal</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>~1000 m</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>Up to 4 images per day</td>
</tr>
</tbody>
</table>


¹ For more details about SIMA see http://www.dsr.inpe.br/hidrosfera/sima/
**Methodology:**

MODIS WST → Preprocessing → Visual inspection

100% Cloud Free?

- yes → Sub-Pixel Temperature Retrieving
- no → Rejected

MODIS Reprojection Tool:

- Reprojection to UTM zone 22 South;
- Resampled to 100 meters resolution

\[
\Phi_{le} = \rho_a L v C_E U_{10} (e_a - e_w) 0.622 p^{-1}
\]

\[
\Phi_{se} = \rho_a C_a C_H U_{10} (T_a - T_w)
\]
Images available after preprocessing and visual inspection:

- 196 images pre processed;
- 47 images 100% cloud free;
- 6 images obtained during cold fronts events.

<table>
<thead>
<tr>
<th>MODIS/Terra</th>
<th>MODIS/Aqua</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>Night</td>
</tr>
<tr>
<td>22</td>
<td>8</td>
</tr>
</tbody>
</table>
Transfers coefficients adjust:

- Atmosphere boundary layer unstable;
- Transfers coefficients well correlated with stability parameter;
- \( C_{H,E} = 1.6 \times 10^{-3} \rightarrow 45\% \) higher than estimated for neutral ABL conditions;
- \( C_D = 1.4 \times 10^{-3} \rightarrow 27\% \) higher than estimated for neutral ABL conditions.

ABL highly unstable during cold front passage before and after cold front passage
MODIS-derived sensible heat flux maps:

- Ranged from 10 to -75 W m\(^{-2}\);
- Tends to increase during cold front passage;
- Decrease after cold front passage;
- Higher values → Littoral zone;

* All MODI WST images obtained at 10:30 (MODIS/Terra day image)
MODIS-derived latent heat flux maps:

- Ranged from -50 to -450 W m\(^{-2}\);
- Tends to decrease during cold front passage;
- Increase after cold front passage;
- Higher values → Littoral zone;

* All MODI WST images obtained at 10:30 (MODIS/Terra day image)
• Sensible heat flux can be up to 5 times greater during the cold fronts days if compared with flux 1-3 days before and after the passage;

• Latent heat flux tends to be 50% lower during the cold front passage if compared with flux 1-3 days before and after the passage;

• The drop in air temperature and increase of wind speed were the main responsible for the changes observed in heat fluxes during the cold front passage;

• Bowen ratio was always <1 → Latent heat flux dominates the exchanges with atmosphere;

• Despite of the higher fluxes values were observed in littoral zone, the main source of heat to atmosphere is the pelagic zone, due it major extension and depth of mixed layer;

• The correction of transfer coefficients of momentum, sensible and latent heats are important procedure to do accurate estimates in tropical reservoirs often subject to cold fronts passage and ABL unstable conditions, such as, Brazilian reservoirs.
Acknowledgements
THANKS!

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