Use of Remote Sensing/Geographical Information Systems (RS/GIS) to identify Environmental Limits of Soil Transmitted Helminthes (STHs) Infection in Boaco, Nicaragua

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Presentation Overview

• **Background of the Diseases**
  ✷ Helmithiasis (Neglected Diseases)
  ✷ Sanitation
  ✷ Health Impact

• **Study Area**
  ✷ Boaco, Nicaragua

• **In situ data from AMOS**

• **Remote Sensing**
  ✷ MODIS Land Surface Temperature (LST)
  ✷ MODIS Normalized Difference Vegetation Index (NDVI)
  ✷ MODIS Land Cover Land Use Type (LCLU)

• **Results**

• **Conclusions**

• **Recommendations**
Background

• Environment is a major factor for health, both directly or indirectly
  - Sanitation, poverty, neglected diseases
  - Natural environment

• A number of agents of diseases are carried by vectors and reservoirs whose viability depends on given environmental conditions

• Such conditions describe not only the characteristics of the natural environment but also of sanitation

• Such conditions can be inferred with satellite data

- Temperature
- Presences of water bodies
- Soil moisture
- Vegetation
- Elevation
- Precipitation

Background cont.

- Soil transmitted helminthes infection, Helminthiasis, Neglected Diseases

- Impact
  - Reduced physical growth
  - Weak physical fitness
  - Impaired cognitive functions
  - Increase with intensity of infections

Photo courtesy Dr. Ligia Cruz Espinoza

1. UNICEF, 2006. Progress for Children
• *Ascaris lumbricoides*

• Life cycle

• 2 to 3 months after ingestion of the eggs, the mature worms commence egg laying in the intestine

• 2 or 3 weeks outside the host to develop to the infective stage
Background cont.

• Microscopic Evaluation

*Ascaris suum* zygotes inactivated  
*Ascaris suum* developed larva

Photos Courtesy of Dr. Ligia Cruz Espinoza
Background cont.

[Image of Ascaris lumbricoides showing female and male worms.]

http://curezone.com/image_gallery/parasites/ascaris/
In situ data

- *Ascaris lumbricoides*
- *Trichuris trichiura*
- *Ancilostoma duodenale*

- AMOS Health & Hope
- [http://www.amoshealthandhope.org/Health_for_all/Home.html](http://www.amoshealthandhope.org/Health_for_all/Home.html)
Study area

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- ≤ 26.62
- 27.55
- 28.01
- 28.95
- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

630 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily

Nicaragua

Study Site (Boaco)
Study area

<table>
<thead>
<tr>
<th>Mean Land Surface Temperature (Celsius)</th>
<th>Aug 21, 2009 – Aug 15, 2010</th>
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<tbody>
<tr>
<td>≤ 26.62</td>
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<tr>
<td>31.28</td>
<td></td>
</tr>
<tr>
<td>≥ 32.21</td>
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</table>

200 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily
Study area

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- ≤ 26.62
- 27.55
- 28.01
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- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

125 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily
**Study area**

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily

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**Mean Land Surface Temperature (Celsius)**

Aug 21, 2009 – Aug 15, 2010

- ≤ 26.62
- 27.55
- 28.01
- 28.95
- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

10 Kilometers
Remotely sensed data

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- ≤ 26.62
- 27.55
- 28.01
- 28.95
- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

2 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily
Remotely sensed data

- MODIS Land Cover Land Use (LCLU)
- MCD12Q1 Combined
- 500 m Yearly
Remotely sensed data

- MODIS Land Cover Land Use (LCLU)
- MCD12Q1 Combined
- 500 m Yearly
Remotely sensed data

NDVI
Aug 5 – Aug 25, 2010

-2000  –  -483
-483   –  915
1915  –  1928
1928  –  2942
2942  –  3865
3865  –  4699
4699  –  5443
5443  –  6100
6105  –  6694
6694  –  7217
7217  –  7689
7689  –  8123
8123  –  8539
8539  –  8988
8988  –  9996

2 Kilometers

- MODIS Normalized Difference Vegetation Index (NDVI) 16 days
- MYD13Q1  250 m
Remotely sensed data

- MODIS Normalized Difference Vegetation Index (NDVI) 16 days
- MYD13Q1 250 m
LST & *Thrichuris trichuria*

- Wilcoxon Two-Sample Test:
  - Normal Approximation
    - Pr > |z| 0.0157
  - t Approximation
    - Pr > |z| 0.0161
- Kruskal-Wallis Test
  - Pr > Chi-Square 0.0156
- Positive: n=152 mean=26.27
- Negative: n=244 mean=26.47
LST & *Ascaris lumbricoides*

- Wilcoxon Two-Sample Test:
- Normal Approximation
- $Pr > |z| < 0.0001$
- t Approximation
- $Pr > |z| < 0.0001$
- Kruskal-Wallis Test
- $Pr > \text{Chi-Square} < 0.0001$
- Positive: $n=111$, mean=26.13
- Negative: $n=285$, mean=26.49
LST & Ancilostoma duodenale

- Wilcoxon Two-Sample Test:
  - Normal Approximation
  - $\text{Pr} > |z| = 0.7824$
  - $t$ Approximation
  - $\text{Pr} > |z| = 0.7825$
- Kruskal-Wallis Test
  - $\text{Pr} > \text{Chi-Square} = 0.7813$
- Positive: $n=10$ mean=26.61
- Negative: $n=386$ mean=26.39
## Land Cover

Prevalence considering all three parasites together

- Evergreen broad leaf forest
- Woody savannas
- Croplands
- Croplands/natural vegetation mosaic

<table>
<thead>
<tr>
<th>Land Class</th>
<th>Posit.</th>
<th>Negat.</th>
<th>Odd ratio</th>
<th>n</th>
<th>Prevalence</th>
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<td>8</td>
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<td>6</td>
<td>10</td>
<td>0.6</td>
<td>16</td>
<td>0.37</td>
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<td>14</td>
<td>91</td>
<td>74</td>
<td>1.23</td>
<td>165</td>
<td>0.55</td>
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</table>
Preliminary Conclusions

• Although not clear limits could be suggested for any of the species of soil transmitted helminthes considered, a mean LST greater than 30.8 Celsius at 1:30 PM seems to be more favorable for prevalence of *Trichuris trichuria*.

• As expected, the prevalence of infection for all three species seems to increase with the increase of LST.

• MODIS LST shows potential as a tool to identify areas at risk of Helminthiasis however studies covering larger range in temperature are needed to more clearly show such applicability.

• Due probably to the small area of the study site, it was not possible to suggest the applicability of MODIS Normalized Difference Vegetation Index (NDVI) and Land Cover under the study conditions.