Evaluate, Enhance, and Apply Aura Products in Public Health Tracking – Year 2 Report

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In the US, skin cancer costs an estimated $1.7 billion to treat and results in $3.8 billion in lost productivity. The most severe type of skin cancer, melanoma, causes over 75% of skin cancer deaths (~9,500/yr).

The lifetime risk of an American developing invasive melanoma is 1 in 59 (1 in 39 for white men and 1 in 58 in white women) (Rigel et al. 2010)
UV radiation derived from sun exposure is well-known to be the most important cause of skin cancer.

UV exposure data used in large-scale melanoma epidemiologic research has in general been estimated from weather parameters and are poorly validated.

- UV index published by NWS
- TOMS UV measurements
- National Solar Radiation Database (NSRDB) by the National Renewable Energy Laboratory (NREL)
Research Team

- Emory: Yang Liu (PI), Futu Chen, Jesse Belle, Xia Meng
- U. Nebraska (now at U. Iowa): Jun Wang
- CDC EPHT: Judy Qualters, Fuyuen Yip, and Ying Zhou
- CDC Division of Cancer Prevention and Control (DCPC): Blythe Ryerson and Tom Richards, Jane Henley
Yr 2 Study Objectives

- Develop a county-level, solar radiation and UV exposure dataset for the National Environmental Public Health Tracking (EPHT) network at CDC to distribute through their national portal.

- Provide annual solar radiation and UV exposure estimates to the Division of Cancer Prevention and Control (DCPC) at CDC on their melanoma epidemiological modeling effort.
<table>
<thead>
<tr>
<th>Milestones</th>
<th>Deadline</th>
<th>Team</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation of OMI UV data</td>
<td>04/2016</td>
<td>UNL</td>
<td>Complete</td>
</tr>
<tr>
<td>Generation of UV exposures for DCPC</td>
<td>04/2016</td>
<td>Emory / CDC</td>
<td>Complete</td>
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<tr>
<td>Health and exposure data integration in GIS for Tracking</td>
<td>04/2016</td>
<td>Emory / CDC</td>
<td>Complete</td>
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<tr>
<td>Epidemiological study</td>
<td>04/2017</td>
<td>Emory / CDC</td>
<td>Ongoing</td>
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<td>Data Transition to CDC</td>
<td>11/2016</td>
<td>Emory</td>
<td>Ongoing</td>
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<tr>
<td>Documentation &amp; metadata preparation</td>
<td>04/2017</td>
<td>Emory</td>
<td>Ongoing</td>
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<tr>
<td>Training and outreach</td>
<td>04/2017</td>
<td>Emory</td>
<td>Ongoing</td>
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</table>
Exposure Datasets

- SolarAnywhere
  - Proprietary, widely used by energy industry
  - Relies on GOES imagery and Aqua MODIS AOD, modeled with GOCART
  - Global Horizontal Irradiance (measure of insolation, unit: Wh/m²) at 0.1° resolution for 1998 – 2012
  - Permission obtained to distribute aggregated data on Tracking portal

- NSRDB version 2
  - Hourly ground-measured and modeled GHI values at 1,300 sites for the years 1991-2010
Solar radiation exposure is better estimated for individual patients instead of using long-term averages.
Correlations between SolarAnywhere and NSRDB were high, with site-specific correlations ranging from 0.84 to 0.98 with an average of 0.94.

First spatially interpolate NSRDB data to counties, then merge with SolarAnywhere to extend the overall solar radiation time series.

Universal Kriging with elevation as the fixed effect was applied to the NSRDB data to calculated county-level GHI estimates.

Data merging is underway.
Level 2 OMUVB products (spatial resolution 13 x 24 km) between October 1, 2004 and May 31, 2014 were processed.

More recent data are currently being processed.

First parameter to extract: Erythemally weighted daily dose (EDD) (Unit: J/m$^2$)

Spatially joined to counties
Annual mean erythemally weighted daily dose (EDD) of UV radiation has been gradually increasing by ~1% per year over the past decade.
Epidemiological Study

- Our DCPC partners developed generalized linear mixed models (GLMM) to analyze the association between melanoma incidence rates and UV exposure.
- Expected counts of melanoma in each county stratified by sex and by age group were calculated and used as dependent variables (state treated as a random effect).

\[
\log(Y_{ij}) = (\gamma_0 + \mu_{0j}) + (\gamma_1 + \mu_{1j})UV + \sum (\gamma_k + \mu_{kj}) \text{Covariates} + \varepsilon_{ij}
\]

- Covariates may include education, poverty, household income, health insurance, indoor tanning, rural-urban status, etc.
### Preliminary Results Based on GHI

<table>
<thead>
<tr>
<th>Sex / Global Horizontal Irradiance</th>
<th>All Stages Rate Ratio</th>
<th>Early-stage Rate Ratio</th>
<th>Late-stage Rate Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (3149-3913)</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
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<tr>
<td>Medium (3914-4502)</td>
<td>1.13</td>
<td>1.14</td>
<td>1.11</td>
</tr>
<tr>
<td>High (4503-5873)</td>
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<td>1.27</td>
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<td><strong>Females</strong></td>
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<td></td>
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<tr>
<td>Low (3149-3913)</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
</tr>
<tr>
<td>Medium (3914-4502)</td>
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<td>1.02</td>
</tr>
<tr>
<td>High (4503-5873)</td>
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<td>1.06</td>
<td>1.14</td>
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<tr>
<td><strong>Combined</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Low (3149-3913)</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
</tr>
<tr>
<td>Medium (3914-4502)</td>
<td>1.09</td>
<td>1.10</td>
<td>1.08</td>
</tr>
<tr>
<td>High (4503-5873)</td>
<td>1.16</td>
<td>1.18</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Men tend to have higher risks of developing melanoma than women when exposed to high-level of solar radiation.
Start of project ARL = 3

Current ARL = 6

Milestone 1: County-average SolarAnywhere data have been delivered to DCPC in February. County-average NSRDB data are being processed for Tracking. OMI UV data are being processed for Tracking.

Milestone 2: Written approval has been obtained from the vendor of SolarAnywhere for portal publication. We have met with Tracking in June and the final format for data delivery has been decided. Code development for data production is in progress.
Emory yr 2 budget has been fully allocated.

A positive balance was carried over from yr 2 because Dr. Jun Wang has been transitioning from UNL to UI the past year and it took some time to establish a new subaward with UI (executed in September)
Risks and Issues

- Technical Challenges
  - It took over two years to get approval to access the indoor tanning data from the Census RDC
  - We are in the final stage to complete all the required security clearance
  - Actual data extraction will take place in Yr 3 but full implementation of this dataset in DCPC’s epidemiological study may be pushed to the NCE period
Plan for Year 3

- Complete SolarAnywhere, NSRDB, and OMI data production and delivery
- Complete metadata preparation for Tracking portal dissemination
- Participate in Tracking outreach efforts to advertise our data products
- Access and extract Census indoor tanning data
- Deliver indoor tanning data to DCPC
- Work with DCPC and Tracking on manuscript preparation