Treasure Valley
METRIC Application
Status and Review

University of Idaho
Wenguang Zhao, Clarence Robison and Rick Allen

March 7, 2019

Assistance by Qiuyan Huang and Ricardo Trezza
Quantifying Evapotranspiration for Treasure Valley

- ET$_{\text{Idaho}}$ based estimation for intervening years adjusted by METRIC processed years and spatial (county) crop distributions.

METRIC processing of Landsat Path 42, Rows 29 and 30
Operational ET “mapping” using energy balance

**Mapping EvapoTranspiration with high Resolution and Internalized Calibration (METRIC)**

University of Idaho, *Kimberly*

– *development began in 2000*
  – *rooted in SEBAL*\(^{2000}\)

METRIC uses thermal and reflected data

It can be used with Landsat, MODIS, VIIRS, Aster
Energy balance gives us “actual” ET

Surface Energy Balance:

ET is calculated as a “residual” of the energy balance

\[ ET = R_n - G - H \]

- \( R_n \) (radiation from sun and sky)
- \( G \) (heat to ground)
- \( H \) (heat to air)

**Basic Truth:**

Evaporation consumes Energy

The energy balance includes all major sources (\( R_n \)) and consumers (ET, G, H) of energy
METRIC uses a two step process:

• Production of fraction of reference ET ($ET_r F$) from energy balance

• Time integration between Landsat dates to produce daily and monthly ET:

\[ ET = ET_r F \times ET_r \]
Accuracy of ET by Satellite Energy Balance

What can we expect?

- **METRIC** is an “engineer’s tool”
- Focus is on a ‘small’ region of interest (100 miles x 100 miles) (i.e., not the world, not 17 western states all at once)

**METRIC combines** the strengths of energy balance from satellite and accuracy of ground-based reference ET calculation:

- satellite-based energy balance provides the spatial information and distribution for a large area (and does most of the “heavy lifting”)
- reference ET calculation “anchors” the energy balance surface and provides “reality” to the product.
Accuracy of ET by Satellite Energy Balance

What can we expect?

Because **METRIC** uses $ET_r$ to tie to and by which to integrate ET over time, ET from METRIC incorporates any errors and bias of the $ET_r$ calculation.

Extrapolation over an area is similar to $K_c$ $ET_r$ approach:

- Use $ET_r$ surface to represent climatic demand
- **Whereas**: Satellite energy balance incorporates effects of vegetation density, water availability (via $T_s$) etc. in the calculation of **specific ET by field** ($K_c$ curve usually does not)

Accuracy of ET by **METRIC** is probably:

- +/- 10 to 20% for a specific field on a specific day
- +/- 10 to 15% for many fields on a specific day
- +/- 10 to 15% for a specific field over a season *(if done well)*
Current status of the TV images processing

• 1987 – Reprocessing with updated models and revised landuse, will be ready for review within a week.
• 1994 – Reprocessed with updated models, in review.
• 1997 – Images ready for processing.
• 2000 – Complete -- have submitted, minor refinement will be submitted within 1 week.
• 2004 – Images ready for processing.
• 2007 – Completed with updated models -- products submitted to IDWR.
• 2010 – Currently processing with updated models.
• 2015 – Complete -- reprocessed with updated models and landuse. Monthly products under refinement should be completed with a month.

Updated models reflect changes in soil heat flux, aerodynamic roughness, adjustments for afternoon water stress.
# TV METRIC processing order

<table>
<thead>
<tr>
<th>Proposed processing order:</th>
<th>Actual processing order:</th>
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<tbody>
<tr>
<td>• 1 -- 2015</td>
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<td>• 2 -- 1987</td>
<td>• 2 -- 2007</td>
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<td>• 3 -- 2000</td>
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<td>• 7 -- 1997</td>
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<tr>
<td>• 8 -- 2004</td>
<td>• 8 -- 2004</td>
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</table>
Cloud filling has been difficult.
(5/25/2015)
Non METRIC Year ET Estimates

• $ET_{Idaho}$ based estimation for intervening years adjusted by METRIC processed years, spatial crop/vegetation distributions.

• Non METRIC year ET will only be performed for the Treasure Valley aquifer model area.

• METRIC adjustment factors for $ET_{Idaho}$ will require completed monthly METRIC products.

• Factors for $ET_{Idaho}$ monthly data for non METRIC years may need to be interpolated between METRIC years.

• Spatial distribution of crop/vegetation will be categorized by USDA county data and Crop-Scape information. Irrigation entity and aquifer model grid cells may also be used to distribute crop/vegetation patterns.

• This component is waiting for more METRIC years to be completed.
METRIC ET Products
(using year 2015 as an example)
ET (mm)

- High: 350
- Low: 0

ETrF

- High: 1.25
- Low: 0

July
Daily Reference ET Surfaces

• Derived from weather data using the ASCE Penman-Monteith alfalfa reference method
• Primarily AgriMet stations are used with supplement from NWS Coop stations
• Stringent QA/QC is applied to the weather data
• Stations are screened to eliminate those impacted by substantial local aridity
Challenge: Consistency in station network among years for consistency in assessing changes in ET

• To assess change in ET between years, the ET<sub>r</sub> station network should use a consistent set of stations to generate ET<sub>r</sub> surfaces.

• Basic Approach in METRIC:

\[ ET = ET_r F \ast ET_r \]
Daily Reference ET<sub>r</sub> Surfaces

- Because ET<sub>Idaho</sub> will be used in the non-METRIC years, only ET<sub>Idaho</sub> stations were evaluated.
- Of those 197 stations, only 45 had at least 240 days of data in the March through October. No AgriMet stations qualified.
- When discounting 1987 and 1994, the station count increased to 78 with 6 AgriMet stations qualifying.
- Review of the various possible networks by looking at seasonal (March through October) reference ET.
Results from filtered ET<sub>r</sub> station network that used the same stations over time

- A few recent stations were dropped for consistency
- Others were dropped to reduce local extremes (by aridity?)

Growing Season (March through October) reference ET
After review of $\text{ET}_r$ surfaces, the two networks were reevaluated with the following modifications:

- The Homedale (NOAA Coop) station was discarded.
- The Parma AgriMet record was extended back to 1986. The station data did not have dew point temperature in the record until the summer of 1989.
- The Prairie City, OR, AgriMet daily $\text{ET}_r$ was brought in.
- A combination of stations were used to create a “mirror” station in the southwest corner for interpolation purposes.
- Review included looking at GridMET seasonal $\text{ET}_r$ surfaces for comparison of trends.
Impact of consistency range and Comparison with GridMET

Based on stations having complete data 1994 thru 2015

2010 Mar-Oct ETr (mm)

Based on stations having complete data 1997 thru 2015

GridMET (EarthEngine)
<table>
<thead>
<tr>
<th>Name</th>
<th>Network</th>
<th>Station Characteristics</th>
<th>Seasonal ET&lt;sub&gt;r&lt;/sub&gt; (mm), March through October</th>
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<tbody>
<tr>
<td>Arrowrock Dam, ID</td>
<td>COOP</td>
<td>-115.916 Degrees, 43.600 Degrees, 968 m</td>
<td>1569, 1546, 1428, 1430, 1417, 1488, 1345, 1509, 1467</td>
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<td>Baker City, OR</td>
<td>NWS</td>
<td>-117.809 Degrees, 44.843 Degrees, 1024</td>
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<td>Mirrored SW Station</td>
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</table>
Land Use Modifications for 2015 and 1987.

• Purpose: Adjust the 2011 and 1992 NLCD land use maps to better reflect land use conditions (ag. vs. city) for 2015 and 1987.

• Determination of LU was based on mid-June through mid-July maximum spectral indices, including NDVI, using averages for irrigation polygons.

• Control based on irrigation status coverage supplied by IDWR.

• For 2015, the base land use was the NLCD 2011 dataset
• Focus was limited to the Treasure Valley Aquifer area.

• 2015 was the test year where the 2015 NAIP could be examined.
• For 1987, the base land use was the 1992 NLCD supplemented with NLCD.
• Modification rule set was based on 2011 indices and land use.
Evaluation of vegetation and other indices to identify residential/city etc. based on the average seasonal maximum index during 2011

- NDVI = Normalized difference vegetation index
- NDBI = Normalized difference built-up index
- MDWI = Modified normalized difference water index
- BAEM = Built-up area extraction method

Non-NDVI results were inconclusive
Some of the general rules for separating agriculture from residential/city:

• If the polygon was classified as irrigated, it was assigned agricultural land use.
• If the polygon was classified as semi-irrigated, preference went to development.
  • Except for very high NDVI with agricultural pixels present in 2011.
  • If “native” land use was the majority in 2011, a “native” land use was assigned.
• If the polygon was classified as non-irrigated, preference was to “native” land use.
  • If “developed” land use was the majority for 2011, developed use was assigned.
Area-wide ET$_r$F before and after Land Use Revision - 2015

![Graph showing ET$_r$F Change for 2015 Revision](chart.png)
Water Consumption Patterns by Land Use Type
2000 Seasonal ET for different national land cover types

Samples are from the entire Landsat domain with heavier weighting for Treasure Valley.
2007 Seasonal ET for different national land cover types

ET (mm/year)

Developed/High Intensity
Barren (Rock/Sand, etc)
Developed/Medium Intensity
Herbaceous Upland
Developed/Low Intensity
Evergreen Forest
Emergent Herbaceous Wetlands
Developed/Open Space
Agricultural Fields
Open Water
Woody Wetlands

Number of Observations
2007 Seasonal ET for different crop land use types

- ET
- # of Observ.

- Developed/High Intensity
- Developed/Low Intensity
- Shrubland
- Barren
- Evergreen Forest
- Grassland/Open Space
- Developed/Idle Cropland
- Fallow/Idle Cropland
- Onions
- Dry Beans
- Sweet Corn
- Herbs
- Winter Wheat
- Peas
- Barley
- Corn
- Triticale
- Alfalfa
- Sugarbeets
- Potatoes
- Spring Wheat
- Oats
- Open Water
- Apples

2007 Treasure Valley – March-October
2015 Seasonal ET for different crop land use types

- Barren
- Developed/High Intensity
- Developed/Med Intensity
- Shrubland
- Fallow/Idle Cropland
- Developed/Low Intensity
- Developed/Open Space
- Grassland/Pasture
- Onions
- Peas
- Oats
- Carrots
- Dry Beans
- Bayley
- Evergreen Forest
- Sweet Corn
- Spring
- Wheat
- Triticale
- Winter Wheat
- Potatoes
- Other Hay/Non Alfalfa
- Herbs
- Sugarbeets
- Alfalfa
- Apples
- Open Water

ET (mm/year) vs Number of Observations
Distribution of Growing Season ET by Field, year 2000

Agricultural Fields

Shrubland

Developed/Open Space

Developed/Low Intensity

Developed/Medium Intensity

Developed/High Intensity
Distribution of Growing Season ET by Field, year 2007

- Treasure Valley – March-October

- Developed/Open Space
- Shrubland
- Agricultural Fields
- Developed/High Intensity
- Developed/Medium Intensity
- Developed/Low Intensity
Comparison of ET to Precipitation

For areas of native vegetation, the ET should be close to Precipitation

- Spatially distributed precipitation obtained from GridMET.
- Monthly ET comparisons to monthly precipitation.
- Seasonal ET comparisons to January through October precipitation.

- Evaluation of several areas within or close to the Treasure Valley aquifer study area:
  - North of Murphy
  - Southwest of Marsing
  - North of Swan Falls
  - West of I-84 Rest Area
  - Between Middleton and Emmett
  - East of New Plymouth
  - Northwest of Sand Hollow
  - Southwest of Adrian, OR
  - West of Homedale
<table>
<thead>
<tr>
<th>2007 Adjustments were needed</th>
<th>Area (ac)</th>
<th>ET(\text{F}) Growing Season</th>
<th>ET Growing Season</th>
<th>(P) (Mar-Oct)</th>
<th>(\text{ET} - P) (Mar-Oct)</th>
<th>(P) (Jan-Oct)</th>
<th>(\text{ET} - P) (Mar-Oct)-(Jan-Oct)</th>
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<td>591</td>
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<td>474</td>
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<td>98</td>
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<td>B: Southwest of Marsing</td>
<td>199</td>
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<td>240</td>
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<td>After Adjustment</td>
<td>Area (ac)</td>
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<td>ET Growing Season</td>
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<td>46</td>
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Daily Spline Interpolation Issues.

• The spline interpolation procedure captures vegetation growth provided that there are sufficient images throughout the season.

• Seasons with a large time period between images can be an issue.
  • Or if images are closely spaced in time and have large differences in ET_r,F.

• Looking at ways to incorporated linear interpolation based monthly product with splined based monthly products.
Thank you!
Questions?