Beyond Crop Production Estimates: Integrated climate, biophysical and remote sensing approaches

"If you can look into the seeds of time, and say which grain will grow and which will not, speak then unto me. “

William Shakespeare

A Potgieter et. al.
The right answer to the wrong question therefore…

Asking the right questions before starting to collect DATA
Global food supply and demand (food security)

- Challenge – production nearly DOUBLE by 2050,
- Yield growth of most crops is declining,
- Demand for maize, rice and wheat is increasing and
- Population increased by 40% by 2050
- International markets fail the poor.
- Thus, knowledge of How Much, Where and When is produced will become
Predicting Plant Growth

Utility of crop predictions is a function of timing and accuracy.

Crop life cycle duration is closely associated with temperature.

(Slafer, 1999)
Example 1: USA maize yields

David Lobell,
Stanford University, USA
A scalable satellite-based crop yield mapper

David B. Lobell a,*, David Thau b, Christopher Seifert a, Eric Engle b, Bertis Little c

A scalable crop yield mapper (SCYM)

APSIM crop simulations of leaf area index (LAI) and yield

Convert LAI to satellite measure

Train regressions, which relate yield to vegetation index and weather, for various image timings

Apply regressions to Landsat in Google Earth Engine
Maize yields in Iowa, 2008-2013
Estimates from "SCYM"
Example 2: GEOGLAM

Inbal Rashef Becker, Maryland University, USA

Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) & Agricultural Market Information System (AMIS)
Model enhanced using Growing Degree Days (GDD) to improve timeliness. Extended to China and all of US.

**China Example:** Forecast within 6% of final yields 2-3 months prior to harvest.

\[
GDD = \frac{T_{\text{max}} + T_{\text{min}}}{2} - T_{\text{base}}
\]

\[
T_{\text{base}} = 0 \degree C
\]

\[
GDD_{\text{accum}}(\text{day}) = \sum_{i=\text{biofix date}}^{\text{day}} GDD_i
\]

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Example 3: Canada
Nathaniel Newlands,
Agriculture and Agri-Food
Canada (AAFC)
The Integrated Canadian Crop Yield Forecaster (ICCYF) tool

The ICCYF integrates climate, satellite remote sensing derived vegetation indices, soil and crop information through a physical process-based soil water budget model and statistical algorithms

References:
- Kouadio et al., 2014. Remote Sens. 6:10193-10214
Example 4: Production estimates for major crops in Australia

A Potgieter,

University of Queensland Australia
Regional scale commodity forecasting framework

Near-real time Integrated Crop & Agricultural Monitoring System (iCAMS)

- Economic Survey Approach
- Actual Data ABS/ABARES
- Biophysical Model
- Satellite Data
- Data Crowd Sourcing from producers/industry

Potgieter et. al. 2003, 2005, 2006

Regional Shire scale

Climate

Pixel/Field scale Area & Crop Discrimination

Crop Stress Yield Area Crop type Phenology Crop Intensity Land Use
Spatial within season forecast

Predicted percentile median yield relative to all years
1st July 2015
Area Estimates: Reconstructing of time series

Harmonic analysis of time series

Barley from satellite

Wheat from satellite

Ground truthing - Crowd sourcing

Paddock Watch

Google Earth environment

http://www.paddockwatch.com.au
Specific & Total Crop Area & Production

### Summer 2014/15

<table>
<thead>
<tr>
<th>Region</th>
<th>Cotton (Ha)</th>
<th>Sorghum (Ha)</th>
<th>Sorghum Tonnes</th>
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<tbody>
<tr>
<td>CQ</td>
<td>215,862</td>
<td>16,675</td>
<td>460,135</td>
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<tr>
<td>NNSW</td>
<td>249,366</td>
<td>58,753</td>
<td>675,554</td>
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<td>SEQ</td>
<td>265,695</td>
<td>148,986</td>
<td>728,080</td>
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<td>SWQ</td>
<td>117,883</td>
<td>28,392</td>
<td>113,177</td>
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<tr>
<td>Total</td>
<td>848,806</td>
<td>252,806</td>
<td>1,976,946</td>
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### Winter 2014

#### NEAUS

<table>
<thead>
<tr>
<th>Region</th>
<th>Totals</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Barley (Ha)</td>
<td>247,222</td>
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<tr>
<td>Chickpea (Ha)</td>
<td>413,591</td>
<td></td>
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<tr>
<td>Oats (Ha)</td>
<td>61,685</td>
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<tr>
<td>Wheat (Ha)</td>
<td>937,845</td>
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<tr>
<td>Wheat Prod (T)</td>
<td>1,324,758</td>
<td></td>
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</tbody>
</table>
Where to from here

- Framework high efficacy in predicting point and regional crop yield, through integration of satellite imagery and crop simulation models
- Aligns with UN SDG 2 (food security) & SDG 13 (climate change & impacts)
- Issues for further discussion:
  - Scalability (State, Nation Continental, Global)?
  - Automation to enable implementation?
  - Increase Lead time further (linking with Global General circulation models)