Eyes Over Puget Sound: Producing Validated Satellite Products to Support Rapid Water Quality Assessments in Puget Sound

Brandon S. Sackmann  
Integral Consulting Inc., bsackmann@integral-corp.com

Christopher Krembs  
Washington (State). Department of Ecology

Suzan Pool

Julia Bos

Tarang Khangaonkar  
Pacific Northwest Pollution Prevention Resource Center

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Eyes Over Puget Sound

Producing Validated Satellite Products to Support Rapid Water Quality Assessments in Puget Sound

Brandon Sackmann (bsackmann@integral-corp.com)
Christopher Krembs, Suzan Pool, Julia Bos, and Tarang Khangaonkar

2 May 2014
Salish Sea Conference 2014

MODIS-Aqua 500-m Chlorophyll a product developed for Puget Sound, WA.
What is Eyes Over Puget Sound (EOPS)

- Communication/outreach product developed by WA Ecology with a focus on near-surface conditions
- Merges aerial photographs, satellite data, ferry observations, in situ CTD measurements, mooring data, and regional weather

2013 Review

- 3+ yrs ... 640+ subscribers ... 1M+ downloads ... 2-day turn-around !!!
Ferries provide a novel source of ground truth information

- Satellite observations are most useful when they can be reconciled with ground truth observations.
- Ferries provide a unique dataset that lets us do this in a scientifically-rigorous and cost-effective way.
Ferries for Science

- **Turner Designs C3 optical sensor** (May 2010-present)
  - Phytoplankton (chl a fluor.)
  - Turbidity
  - River water (CDOM fluor.)
  - Sea Surface Temperature

- **RDI Citadel Thermosalinograph** (2012-present)
  - Sea Surface Temperature
  - Sea Surface Salinity

- **RDI Workhorse Mariner ADCP 300 kHz** (May 2014)
  - Depth-resolved currents
  - Acoustic backscatter
Ferries for Science

- Cost-effective data collection
  - 100 m spatial resolution (5 sec.)
  - 4-hr temporal resolution
- Regular schedules/Reliable
  - 80 mile long transect (30 knots)
  - 1-2 time daily (year-round)
  - 300 m spatial resolution
  - ~1-hr temporal resolution
  - 5 mile long transect (8-10 knots)
  - 10-17 time daily (year-round)
- Daily data pickup (WSF data available via web)
What can be measured from space?
Hi-res products for coastal and offshore applications

- Time period: 2000 - Present (1-8 day revisit)
- Resolution: 30 - 500 m, hi-res; >1 km, standard-res
  (nearshore) (coastal/offshore)

- Water Quality Indicators
  - Water Color (True Color/RGB)
  - Algal Biomass (Chlorophyll \textit{a}, FLH, MCI)
  - Water Clarity (Turbidity)
  - Freshwater Influence (CDOM)
  - Sea Surface Temperature

- Combined approach using traditional ocean color sensors and terrestrial platforms
What can be measured from space?
Hi-res products for coastal and offshore applications

- Multiple parameters from a single image
- MERIS (ESA) provided global, hi-res (300 m) ocean color products for coastal and offshore applications (2002-2012)
- Follow-on missions (OLCI) planned for 2015/2017; we need to be able to take advantage of these datasets...
Phytoplankton Bloom Off Bainbridge Island
22 August - 12 September 2011

- Ferry data corroborated satellite images.
- Merged dataset remotely defined temporal and spatial extent of the bloom!
Hi-res satellite products can be challenging to produce due to optical complexity, lack of standard algorithms, and insufficient ground truth spanning large optical gradients.
Partial Least Squares Regression

- Widely used in chemometrics, bioinformatics, sensometrics, neuroscience and anthropology
- Well suited when predictors are many and highly collinear
- Emphasis is on predicting the responses; not necessarily on understanding the relationship between variables
- Leverages information from all spectral channels (visible -> near IR)
- Can be used with a variety of ocean color sensors
- Requires no atmospheric correction (TOA radiances adjusted for Rayleigh scattering only)

>75% of variance explained using 5 PLS components
Partial Least Squares Regression
Partial Least Squares Regression

23 April 2011

Integral Turb PLSR (Puget Sound)

NASA Kd490 (SeaWiFS - Global Open Ocean)
Partial Least Squares Regression
Uses for validated satellite information products
Retrospective Analyses <-> Real-time Monitoring <-> Forecasting/Risk Assessment

• Habitat characterization, ecological impact assessments, and permitting (e.g., aquaculture facilities)
• Seasonal anomalies <-> climate change (e.g., develop a comprehensive ocean color baseline for Puget Sound)
• Red tides and harmful algal blooms
• Eutrophication/shifting food webs
• Optimize field operations/sampling in dynamic areas
• Spill assessment and management
• Initial conditions and cal/val data for WQ modeling
Recommendations/Future Efforts

- Blend data from multiple sources to create value-added information products
- PLSR method refinements
- QA procedures for in situ data (including mid-day F quenching)
- Operational workflow for creating validated products
- Move beyond static maps of individual WQ indicators
  - Characterize spatial variability/gradients
  - Feature/anomaly detection