May 2014

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

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Sackmann, Brandon; Krembs, Christopher; Pool, Suzan; Bos, Julia; and Khangaonkar, Tarang, "Eyes Over Puget Sound: Producing Validated Satellite Products to Support Rapid Water Quality Assessments in Puget Sound" (2014). *Salish Sea Ecosystem Conference*. 82.  

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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
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
  – 300 m spatial resolution
  – ~1-hr temporal resolution

• Regular schedules/Reliable
  – 80 mile long transect (30 knots)
  – 1-2 time daily (year-round)
  – 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 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!

MERIS Chl 27 Aug
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

$n = 3495$
Partial Least Squares Regression

![Graph showing Partial Least Squares Regression](image)

- **Turb Fitted** vs. **Turb Observed**
- **PLSR with 5 components**
- Color scale represents **Hour** from 8 to 20
Partial Least Squares Regression

Integral Turb PLSR (Puget Sound)

23 April 2011

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