SWOT - Surface Water and Ocean Topography Mission

SWOT Applications Working Group
SAWG meeting
7 July 2015, 5:45pm

M. Srinivasan (JPL), C. Peterson (Stennis)
A. Andral (CNES), M. Dejus (CNES),
Applications Leads
Add UKSA logo?
ANDRA; 11/04/2014
# SWOT Applications Working Group (SAWG)

<table>
<thead>
<tr>
<th><strong>Leads</strong></th>
<th><strong>Team</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>5. <strong>Ocean Lead, NASA</strong> – Yi Chao, RSS</td>
<td>2. Sylvain Biancamaria, LEGOS</td>
</tr>
<tr>
<td></td>
<td>6. Laurence Houptert, CNES</td>
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<td></td>
<td>7. Gregg Jacobs, NRL</td>
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<td>8. Alexander Kurapov, U. Oregon</td>
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<td></td>
<td>11. Dennis Lettenmaier, U. Washington</td>
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<td>12. Delwyn Moller, RSS</td>
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<td>13. Steve Nerem, U. Colorado</td>
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<td>14. Tamlin Pavelsky, U. North Carolina</td>
</tr>
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<td></td>
<td>15. Robert Saint-Jean, CSA</td>
</tr>
<tr>
<td></td>
<td>16. Guy Schumann, UCLA</td>
</tr>
</tbody>
</table>

This document has been reviewed and determined not to contain export controlled technical data.
SWOT Applications Products

SWOT mission is implementing an applications approach at the project level, supported by NASA HQ, by CNES and by the science leads.

• SWOT Applications Plan
• SWOT Early Adopter Program Guide
• “SWOT 101” presentation
• 1st User Workshop report online
• SWOT User Survey (in review)
• Applications Traceability Matrix (in development)
• Hydrology & ocean data latency graphics

Applications web pages;
  NASA/JPL  http://swot.jpl.nasa.gov/applications,
  AVISO  http://www.aviso.altimetry.fr/swot
SAWG Meeting Discussion Topics

• **User database** – SAWG & SDT inputs needed
• **User survey** – Finalize for online posting & distribution, format (Google doc? Survey Monkey? Other?)
• **Traceability Matrix**; comments, discussion, refinement
• **Early Adopter implementation**: proposed process, options/discussion, user database inputs
• **Data latency graphics**: hydrology, floods, ocean
• **NRT data products** – assessing user needs, useful feedback to Project
  • Pre-summing & OBP considerations (issues summary from SAWG-SDT members?)
  • Contributions from SAWG?
## SWOT User Database

<table>
<thead>
<tr>
<th>Country</th>
<th>Organization</th>
<th>Applications Area</th>
<th>Potential users</th>
<th>Early Adopter PI</th>
<th>SWOT Contact</th>
<th>Applied Research Topic</th>
<th>Relevant URL</th>
<th>E-Mail Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>LEGOS</td>
<td>Lakes, rivers, wetland water levels, basin management</td>
<td></td>
<td></td>
<td>E. Charvet</td>
<td></td>
<td><a href="http://esr.legos.obs-mip.fr/hydrologie/hybreu">http://esr.legos.obs-mip.fr/hydrologie/hybreu</a></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>FMGlobal</td>
<td>Flooding, disasters</td>
<td></td>
<td></td>
<td>E. Baughn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>USGS</td>
<td>agencies with interest in large river basins</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>UNA</td>
<td>Agência Nacional de Águas e Saneamento</td>
<td></td>
<td></td>
<td>Joelito Santos da Silva</td>
<td></td>
<td><a href="http://www.safenasa.gov.br">http://www.safenasa.gov.br</a></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>NOAA/NOAA</td>
<td>MMS and NOAA National Marine Fisheries Service conducted studies on Storm Warming and ocean water sound in the Gulf of Mexico; NMFS; tracks Stellar sea lions in the Gulf of Alaska</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><a href="http://www.ngdc.noaa.gov/mgg/announcements/announcements">http://www.ngdc.noaa.gov/mgg/announcements/announcements</a></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>Navy/NRL</td>
<td>coastal, estuarin, ocean conditions, polar</td>
<td></td>
<td></td>
<td>Gregg Jacobs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>MDEI/Environmental</td>
<td>SeaTurtle.org researchers use NITL ultraflex to study migratory routes of hawksbill turtles in relation to surface eddies off.</td>
<td>Project Monterey Bay Aquarium (also MMBIR?)</td>
<td></td>
<td>SeaTurtle.org, Monterey Bay Aquarium</td>
<td></td>
<td><a href="http://seaTurtle.org/">http://seaTurtle.org/</a></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>Gulf of Mexico Coastal Ocean Observing System (GCOOS)</td>
<td>environmental activities and conducting studies associated with mineral extraction carried out in the GOM OCS</td>
<td>GOM Region's Office of Environment</td>
<td></td>
<td>B. Lubben</td>
<td></td>
<td><a href="http://www.gcoos.org">http://www.gcoos.org</a></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>BOEM</td>
<td>Research on needs/applications developing countries</td>
<td>local water, agriculture, community support agencies</td>
<td></td>
<td></td>
<td></td>
<td><a href="http://www.boem.gov/Lagueran-Study/">http://www.boem.gov/Lagueran-Study/</a></td>
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</tr>
</tbody>
</table>

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### WEATHER, CLIMATE: drought

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# SWOT User Database

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<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>irrigation, flooding, river/reservoir</td>
</tr>
<tr>
<td>Meteo-France</td>
<td>Pierre-Olivier Malaterre</td>
</tr>
<tr>
<td>Themes</td>
<td>Coastal ocean, estuaries, agriculture, forest</td>
</tr>
<tr>
<td>IMRA</td>
<td>Eric Martin</td>
</tr>
<tr>
<td>Other Ind. agencies</td>
<td>New Zealand Ministry of Fishing &amp; Fluke Tuna</td>
</tr>
<tr>
<td>Universities</td>
<td>Industry partners, commercial operators, Forest Service, DWR</td>
</tr>
<tr>
<td>Federal agencies</td>
<td>GLOBE Program hydrology</td>
</tr>
<tr>
<td>State agencies</td>
<td>NOAA, NWS</td>
</tr>
<tr>
<td>Local org agencies</td>
<td>Climate Variability &amp; Change, NOAA</td>
</tr>
<tr>
<td></td>
<td>Environment Canada</td>
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<tr>
<td></td>
<td>EPA</td>
</tr>
<tr>
<td></td>
<td>US Forest Service</td>
</tr>
<tr>
<td></td>
<td>CISBIO, Carbon &amp; water, drought and floods, water &amp; agriculture, hazards and risk assessment, Ahmad Al Bitar</td>
</tr>
<tr>
<td></td>
<td>ECOMAR, weather and risk prediction, NWP centers, Patricia de Rooy</td>
</tr>
<tr>
<td></td>
<td>SCHAAR, flash floods</td>
</tr>
<tr>
<td></td>
<td>AER?</td>
</tr>
<tr>
<td>OCEAN STATE</td>
<td>petroleum production operations in the Gulf of Mexico, Indian Ocean, Arabian Sea, Brazil, and Trinidad.</td>
</tr>
<tr>
<td>Edison Chevenet Offshore</td>
<td>validation of claims for lost cargo due to storms at sea</td>
</tr>
<tr>
<td>Insurance</td>
<td>insurer Canada's Drought Insurance, recreational boaters</td>
</tr>
<tr>
<td>Other: human health, national security</td>
<td>military, world bank, usaid, uswit, naacoc, sea ice extent, nasa serirr hirwal ong hub, seasonal forecasts, eric anderson, nasa marshall spc, nasa.gov</td>
</tr>
</tbody>
</table>
SAWG User Survey

SWOT Applications Survey to Determine User Needs

The purpose of this survey is to identify the ways in which the SWOT mission data and information products may be useful to operational, private, institutional, and other individuals and organizations. The SWOT Applications team is launching an Early Adopters program and are interested in identifying a broad community of users who will participate in pre-launch applications activities including studies, meetings, briefings, and workshops. For more information on the SWOT mission, please visit http://swot.jpl.nasa.gov.

In order to clearly measure effective means of communicating with our future user community, and optimal ways to disseminate information, we have compiled a series of questions that we hope will help us understand how the future SWOT data will support your decisions and processes. This survey will be used as an important benchmarking component of SWOT's Applications program.

As a professional in hydrology or oceanography, you have been recommended as someone with insight into how SWOT data may be used after launch. The information you provide will help NASA, CNES and our partners at CSA and UKSA to better support your activities in the future.

The SWOT satellite is currently scheduled to launch in late 2020, so the data products we suggest in this survey are for discussion purposes only. The final list of data products, as well as the attributes of those products, will be determined by the SWOT Project Team prior to launch.

If you would like further information about this survey, please contact Margaret Srinivasan at margaret.srinivasan@nasa.gov, or Alice Andral at alice.andral@cnes.fr.

* Required

LEVEL OF PRODUCTS: For ocean products: What level of products are you interested in: *

- Raw data?
- Level 1 products (interferograms)?
- Level 2 products (SSH, SSH slopes, SHM, SHG, ...)?
- Value-added products (multi-mission maps, temporal series, ...)?
- Not applicable to my work/interests
- Other: _____

LEVEL OF PRODUCTS: For hydrology products: What level of products are you interested in: *

- Level 1 products (complex images, interferograms)?
- Level 2 products (water mask, elevation, slopes, global river discharge, ...)?
- Value-added products (refined river discharge, multi-mission maps, temporal series, change detection, other)?
- Other: _____
## SWOT Traceability Matrix

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>How does the concept of surface water availability affect downstream water flow?</td>
<td>River basins are increasingly regulated and located in hydrological networks where information on storage change and flow dynamics is fundamentally unavailable (but shared in research).</td>
<td>Storage change of reservoirs, discharge estimates, location and movement of reservoirs</td>
<td>Urban, Agriculture, Energy, Environment</td>
<td>Water Resources and Planning (WFP)</td>
<td>Water Management (WMS)</td>
<td>Some evidence indicates that infrastructural changes need to be made to reduce water stress.</td>
<td>7 for WMS (Bangladesh) &amp; 8 for WFP</td>
<td>Additional observations from Hydrorisk,十多水等. Observations (JAMA and MRRS) can provide a superset to address potential SWOT gaps in latency and accuracy.</td>
</tr>
</tbody>
</table>

## Disaster Mitigation, Ecological Forecasting, Water Management, Agriculture, Energy Management, Resource Management

**Categories:** Climate, Energy, Oceans, and Weather

| How will SWOT help in coastal area forecasts be constructed using SWOT? | Integrate river flow data with coastal models to predict stratification, ventilation and oxygenation. | Observed river levels and hydrological model, dynamic, existing water level forecasts, surface height for ocean forecasts. | Ecological Forecasting (NOAA) | 0.5mm higher resolution sea surface height with less than 24 hour latency. | Emergency response will be more efficient and effective due to more detailed information and search areas. | 7 for NOAA, 8 for MRRS | This document has been reviewed and determined not to contain export controlled technical data. |
### SWOT Traceability Matrix

**How will marine operators use SWOT data to improve their operations?**

<table>
<thead>
<tr>
<th>SWOT Traceability Matrix</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>See Surface Height in coastal and open oceans.</td>
<td><strong>Maritime operations</strong></td>
<td>Transport Canada, Canadian Coast Guard, Canadian Forces, Maritime Shipping Industry</td>
</tr>
<tr>
<td>See Surface Height in coastal and open oceans.</td>
<td></td>
<td><strong>10 km or higher resolution sea surface height with less than 72 hour latency.</strong></td>
</tr>
<tr>
<td><strong>Physical ocean conditions, an integrated part of the marine ecosystem, can influence nutrient and plankton transport, survival and mortality of species, and fisheries.</strong></td>
<td><strong>Ecosystems and fisheries</strong></td>
<td>Environment Canada, Department of Fisheries and Oceans</td>
</tr>
<tr>
<td><strong>10 km or higher resolution sea surface height with less than 72 hour latency.</strong></td>
<td></td>
<td><strong>Data latency of up to several weeks/months is acceptable.</strong></td>
</tr>
</tbody>
</table>

**How will SWOT data improve weather and marine forecasts?**

<table>
<thead>
<tr>
<th>SWOT Traceability Matrix</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>See Surface Height in coastal and open oceans.</td>
<td><strong>Climate Change Adaptation</strong></td>
<td>Environment Canada</td>
</tr>
<tr>
<td>See Surface Height in coastal and open oceans.</td>
<td></td>
<td><strong>10 km or higher resolution sea surface height with less than 72 hour latency.</strong></td>
</tr>
<tr>
<td><strong>The SWOT data can be assimilated into ocean models to improve weather and marine forecasts in coastal zones for better emergency preparedness (storm surge, flooding, tsunamis) and responses (e.g., search and rescue, response to oil spills).</strong></td>
<td><strong>Weather and Marine forecasts</strong></td>
<td>Environment Canada, Department of Fisheries and Oceans</td>
</tr>
<tr>
<td>See Surface Height in coastal and open oceans.</td>
<td></td>
<td><strong>10 km or higher resolution sea surface height with less than 72 hour latency.</strong></td>
</tr>
</tbody>
</table>

**How do we measure water elevation of large lakes and reservoirs or extent and volume estimation in small lakes, dams and ponds?**

<table>
<thead>
<tr>
<th>SWOT Traceability Matrix</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada's Great Lakes and large Northern lakes are so large that they can be considered &quot;Internal Oceans.&quot; Monitoring these lakes presents a challenge due to their very large size.</td>
<td><strong>Hydrology</strong></td>
<td>Environment Canada, Agriculture and Agri-Food Canada, Agricultural Insurance Companies</td>
</tr>
<tr>
<td></td>
<td><strong>Water Elevation:</strong></td>
<td>Water elevation, Water Management (field sense)</td>
</tr>
<tr>
<td></td>
<td><strong>Discharge:</strong></td>
<td>Discharge, Discharge from SWOT, River width and height for river mouths.</td>
</tr>
<tr>
<td>Using 45-day latency is tolerable for large lakes. Up to 22-day repeat over a reservoir is acceptable.</td>
<td><strong>Statistical: ± 50cm</strong></td>
<td>Key requirement is the ability to &quot;zero&quot; shift (include a large number of reservoirs and required systems which SWOT would be able to do with its wide reach capability).</td>
</tr>
</tbody>
</table>

**How do we estimate flow change in elevation and flow?**

<table>
<thead>
<tr>
<th>SWOT Traceability Matrix</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Many Canadian rivers are characterized by complex braided channels, flow from the South to the North. This is a big problem for monitoring.</td>
<td><strong>Hydrology</strong></td>
<td>Environment Canada, Public Safety Canada</td>
</tr>
<tr>
<td></td>
<td><strong>River discharge:</strong></td>
<td>River discharge, River discharge from SWOT, River width and height for river mouths.</td>
</tr>
<tr>
<td></td>
<td><strong>River flow:</strong></td>
<td>River flow, River flow from SWOT, River width and height for river mouths.</td>
</tr>
<tr>
<td>For pre- and post-flood season updating and extraction of flood models, latency is not an issue. However, for assimilation on the flow of changing river dynamics and SWOT must characterize and for flood damage repair/preparation. A latency of 2 days or less is required at a 3km spatial scale.</td>
<td></td>
<td><strong>AR: 27</strong></td>
</tr>
</tbody>
</table>

**How do we measure the changing topographic features like sea level rise due to large regions of Canada (particularly relevant in rapidly vegetated areas and over marine and freshwater basins)? Changes in glacier height and Arctic ice monitoring?**

<table>
<thead>
<tr>
<th>SWOT Traceability Matrix</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SWOT will provide ways to obtain slope measurements of large areas. Yet, validation of these measurements with data collected at a point (estimation of flow)?</td>
<td><strong>Hydrology</strong></td>
<td>Environment Canada, Public Safety Canada, Hydro Power Industry, Arctic region oil engineering</td>
</tr>
<tr>
<td>Discharge estimates upstream and downstream of reservoirs, Stage evaluation, Flow measurement, Maybe more science than applications.</td>
<td></td>
<td><strong>River discharge:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>River flow:</strong></td>
<td>River flow, River flow from SWOT, River width and height for river mouths.</td>
</tr>
<tr>
<td>Latency is not an issue</td>
<td><strong>AR: 27</strong></td>
<td><strong>RAJASAKAT, Sarath, MODIS, LANDSAT</strong></td>
</tr>
</tbody>
</table>

This document has been reviewed and determined not to contain export controlled technical data.
Can SWOT meet these latency requirements (several hours to a few days) in order to maximize SWOT applications?

NB: 2 day difference (e.g. 3 day vs 5 day latency) is significant, esp. for floods in medium-sized catchments such as many rivers in Europe!
SWOT Hydrology Applications

Data Latency →
- Seasonal to Annual
- Week to Month
- Hours to days

Transformative
- Agriculture
- Hydropower Scheduling
- National Security
- River Navigation

Incremental
- Water Supply
- Flood Hazard/Risk Mapping
- Ecosystem Functions
- Flood Hazard/Risk Mitigation

Societal Benefits
- Human Health
- Wetland/Estuary Conservation
- Freshwater Fisheries
- National Security
- Wetland/Estuary Conservation

Accuracy/Skill (SWOT water surface elevation)
- LOW (>1 m)
- HIGH (<10 cm)

E. Beighley, F. Hossain
Present altimeter capability allows us to forecast mesoscale eddies to a limited extent.

SWOT will enable forecasts of submesoscale eddies.

Forecasting mesoscale and submesoscale eddies will enable forecasting frontal effects.

G. Jacobs
NRT Products Roadmap

Objectives:
• Connect user needs with Project objectives and mission capabilities
• *Optimize opportunities to consider mission design impacts, architecture, software systems to support applied uses of data, where possible and feasible*
• Develop and/or support tools (within mission objectives) that will
  - promote awareness of SWOT mission capabilities to the appropriate user communities
  - provide access to the information products resulting from SWOT mission data
  - feed back information to the Project from users for feasibility analysis

Considerations:
• Project: What are the mission system constraints & flexibilities (flight architecture, mission system design) that affect/support the development of NRT data products?
• What are the user constraints?
  - Latency = access to data + computing power
    o What processing schemes will support this?
    o What applications are is enabled with what latency (i.e., 72-hr vs 24-hr, etc).
  - Data extraction & manipulation – what are the system constraints & flexibilities?
  - What tools are required to achieve these objectives?
• What are the archiving options (PODAAC?)

*Timing may not support October timeframe*
NRT Products Roadmap

Methodology:
• Identify users:
  • Who are they?
  • What is their application?
  • What is their current data source & system?
  • What are latency requirements (desires)?
• Create graphics to illuminate: lists of applications vs latency requirements
• Identify potential processing schemes that will support this.
• Identify 1 or 2 feasible pathways to achieve NRT SWOT data for a given (or few) users
• What’s useful for the applications community (taking the constraints on flight & mission systems into account)?

Other factors...
• Begin with Jason-type ocean products initially (for actual production)
• Flight & mission system architectures, and system designs that will impact NRT development.
• Identify a process/outline
• ‘Solid pathway’ by January 2016 PDR
• What do we know?
• Where are the gaps in our knowledge?

Tools:
• User database
• User survey
• Traceability matrix

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NRT Products Roadmap

Outline:
• Ocean—
  - Ocean circulation: factors =
  - Coastal region/impacts: factors =
• Hydrology—link science to developing world water problems
  - Drought factors: Regional? Format for GIS (to stack w other data)?
  - Groundwater factors:
  - Reservoir management factors:
  - River discharge factors:
• Identify who is doing what: user database
• Identify the need (application): traceability matrix
• Identify required data products that will address: what are modeling & prediction paradigms?
• What are the project infrastructure elements (flight, design) that can be enhanced or manipulated to achieve this?*
• How do we get there and what is the Project role?
• Early Adopter role?

*Timing may not support October timeframe
Additional information
**SWOT User Survey**

Identify the ways the proposed SWOT mission may be useful to operational, private, institutional, and other individuals and organizations.

- **PRODUCTS**
  1. For ocean products: What level of products are you interested in?
  2. For hydrology products: What level of products are you interested in?

- **Temporal frequency**
  How often does the data need to be updated

- **Data latency**
  How timely must information be from data collection

- **Data format**
  What is the best data format for your application?
SWOT User Survey (Continued)

- **DATA VOLUME**

- **DATA ACCESS**
  How would you prefer to get SWOT products?

- **DOMAIN of INTEREST**
  What is your main domain of interest?
  Geographically, what is your region of interest?

- **USER INFORMATION**
  What your professional training expertise or experience

- **Miscellaneous**
  What are your priorities
  What information do you need to understand /use data?

Username/password (case sensitive): SWOT/SWOTUser15
SWOT Applications – Focus

→ International components and cooperation
→ Applications life cycle in step with mission phases
→ Early Adopter Program; user database, survey
→ Focus pillars;
  - **Hydrology**: developing world water problems, food security (flooding & drought)
  - **Oceanography**: coastal applications (circulation, impacts), marine operations support/open ocean issues
  - **Climate**: regional capabilities, coastal and agricultural impacts
Key Messages

- SWOT is a research mission, not an applications mission
- The SWOT Project will not develop applications, it will develop the right data products that enable the use of SWOT observations/information (by users)
- Data availability and access are critical to success
Objectives

Outreach:
• Inform the stakeholders about SWOT capabilities (website, workshops, publications, meetings), develop communication strategies to target and support requirements of the user community

Improve existing applications
• Sea transport, shipping, fisheries, seasonal meteorology (i.e., ENSO), forecast extreme events (cyclones, storms), monitoring of climatic parameters

Coastal applications
• In particular for coastal management and offshore resource exploitation, mining, continental shelves

Create new environmental services
• Hydrology of inland waters (lakes, reservoirs, major rivers), offer opportunities for water resources management, estuaries, flood risk prevention/mitigation, propagation of disease, health impacts

Open data policy
• Strengthen services with added value in oceanography and create new services for water resources
This document is being reviewed to determine if it contains export-controlled technical data.

SWOT (*Generic*) Applications

Data Latency →

- Seasonal to Annual
- Week to Month
- Hours to days

Societal Benefits →

- Incremental
- Transformative

Accuracy/Skill (SWOT water surface elevation):

- Low (>1 m)
- High (<10 cm)

Note to respondents:
Please position your applications on the graph you think is appropriate. Choose also the latency shape you want (ellipse, rectangle, trapezoid?).

Lastly – you may suggest the minimum time series length you think is required for the application to happen (e.g., for flood insurance or floodplain zoning one needs longer time series).

See next slide for an example.