GEO Task US-09-01a: Earth Observations Priorities Common to Many Societal Benefit Areas

Results of Task

US-09-01a Task Lead:
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User Interface Committee Member

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GEO Task US-09-01a

Objective:
Establish and conduct a process for identifying critical Earth observation priorities common to many GEO societal benefit areas, involving scientific and technical experts, taking account of socio-economic factors, and building on the results of existing systems’ requirements development processes.

GEO Societal Benefit Areas:
- Agriculture
- Disasters
- Health
- Biodiversity
- Ecosystems
- Water
- Climate
- Energy
- Weather
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SBA Analyses:
The Cross-SBA analysis produced an overall ranking of 146 Earth observations that were identified as priority needs across the SBAs.

The Task Team obtained the overall rankings by using an ensemble of 4 prioritization methods to integrate and prioritize the set of observations.
This chart presents the 30 highest-ranked Earth observations, shown according to score in the Cross-SBA analysis. The range in ranks is also shown.

Ranks are ‘inverted’ so highest score is 146.
## Highest Ranked Earth Observations (#1-15) and Associated SBAs

* Biodiversity SBA Team did not produce a set of Earth observations priorities.
Group on Earth Observations

Task US-09-01a

**Highest Ranked Earth Observations (#16-25) and Associated SBAs**

<table>
<thead>
<tr>
<th>Earth Observation Parameter</th>
<th>Agriculture</th>
<th>Climate</th>
<th>Disaster</th>
<th>Ecosystems</th>
<th>Energy</th>
<th>Health</th>
<th>Water</th>
<th>Weather</th>
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<tbody>
<tr>
<td>Glacier/Ice Sheet Extent</td>
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<td>Elevation</td>
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<td>River Flow Observations</td>
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<td>Upper Level Winds</td>
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<td>Land Use</td>
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<td>Upper Level Temperature</td>
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<tr>
<td>Net Primary Productivity</td>
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<tr>
<td>Sea Level</td>
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<tr>
<td>Snow Cover Extent</td>
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</tr>
</tbody>
</table>

Continuation – Priorities 16-25

* Biodiversity SBA Team did not produce a set of Earth observations priorities.
Method 1: Distribution of Observations by Number of SBAs

The figure shows the distribution of the 146 Earth observations by the number of SBAs that specified an observation as a priority (Method 1). 29 observations (20%) are priorities to 4 or more SBAs.
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Results (Based on Method 1):

8 observations (5% of the 146 total) are common to 6 or more SBAs

29 observations (20%) are common to 4 or more SBAs

100 observations (68%) are common to 2 or more SBAs

All of the 30 Highest-Ranked observations are common to 3 or more SBAs
Findings & Recommendations
Findings

• Precipitation Reigns the Cross-SBA Analysis
• Methods Showed Agreement at Highest-Rankings
• Priorities of a Single SBA May Not Be on the Cross-SBA List
• Task’s Approach Produced Users’ Needs in Users’ Terminology
• Articulation of Observation Needs in Documents Varied
• Regional Needs Incorporated but Not Featured
• Availability of Documents by Region Varied
• Insufficient Information across Documents on Parameter Characteristics
Lessons Learned

• Task Approach Achieved Desired Diversity in Prioritization Methods
• Variety in Analysts’ Approaches Introduced Complexities
• Approach to Sponsorship of Analysts Impacted Process
• Approach to Selection of SBA Sub-Areas Introduced Challenges
• Advisory Groups Played Valuable Yet Variable Roles
Recommendations

• Gather information and engage users on specific characteristics of the priority Earth observations, especially Precipitation.
• Conduct an assessment of the current and planned availability of the priority Earth observations.
• GEO and/or Regional Caucuses could consider pursuing similar assessments at regional levels.
• Consider additional analytic methods to gathering users’ needs and pursue an ensemble of approaches.
• Prescribe the prioritization methods, SBA sub-areas, and other aspects of the SBA analyses.
• Pursue broader incorporation of documents in many languages.
• Continue the use of ad hoc Advisory Groups, with refinements.
• Strongly consider a single organization to manage the individual SBA analyses.
• Articulate an SBA’s community of users to support systematic collection of users’ needs.
Future Activities
Task Lead’s Comments

Task’s efforts and results represent significant contributions and first steps within GEO to articulate Earth observation priorities. GEO has documented in a transparent way how Earth observation needs have been identified, involving numerous organizations and experts.

The value of the Task’s results and cross-SBA report is at least twofold:

- Provide a baseline and entry point for further engagement with end users on their needs.
- Confirm any expected priority observations as backed up by an analysis of the literature.
Next Steps: US-09-01a Gap Analysis

Gap analysis of observation priorities relative to current and future availability.

Current & Future States of Critical Earth Observation Priorities

Results of Gap Analysis can be shown in such a diagram.
Finding #13: GEO has not conducted a comprehensive gap analysis of either their implementation approach (structural) or observation needs (observational).

Recommendation #7: GEO should conduct comprehensive observational and structural gap analyses as anticipated in the 10-Year Implementation Plan and Strategic Targets document.

Executive Committee Response: EC Action 19.11 calls for process to conduct the gap analysis (though UIC is not listed as a explicit participant)
Final Report and Individual SBA Reports

Task Website: http://sbageotask.larc.nasa.gov/
### 20 Highest Ranked Observations and Method 1-4 Rankings

<table>
<thead>
<tr>
<th>Rank</th>
<th>Observation Parameter</th>
<th>Rank From Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Precipitation</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>2</td>
<td>Soil Moisture</td>
<td>1 2 3 2</td>
</tr>
<tr>
<td>3 (tie)</td>
<td>Surface Air Temperature</td>
<td>1 2 5 2</td>
</tr>
<tr>
<td>3 (tie)</td>
<td>Surface Wind Speed</td>
<td>4 2 2 2</td>
</tr>
<tr>
<td>5</td>
<td>Land Cover</td>
<td>6 5 3 2</td>
</tr>
<tr>
<td>6</td>
<td>Surface Humidity</td>
<td>4 6 7 2</td>
</tr>
<tr>
<td>7</td>
<td>Vegetation Cover</td>
<td>9 7 6 8</td>
</tr>
<tr>
<td>8</td>
<td>Surface Wind Direction</td>
<td>6 8 11 7</td>
</tr>
<tr>
<td>9 (tie)</td>
<td>NDVI</td>
<td>9 8 8 8</td>
</tr>
<tr>
<td>9 (tie)</td>
<td>Sea Surface Temperature</td>
<td>9 8 8 8</td>
</tr>
<tr>
<td>11</td>
<td>Urbanization</td>
<td>9 8 8 15</td>
</tr>
<tr>
<td>12</td>
<td>Vegetation Type</td>
<td>9 12 12 8</td>
</tr>
<tr>
<td>13</td>
<td>Land Surface Temperature</td>
<td>9 13 13 8</td>
</tr>
<tr>
<td>14</td>
<td>Surface Atmospheric Pressure</td>
<td>6 15 21 15</td>
</tr>
<tr>
<td>15 (tie)</td>
<td>Glacier/Ice Sheet Extent</td>
<td>19 17 17 8</td>
</tr>
<tr>
<td>15 (tie)</td>
<td>Leaf Area Index</td>
<td>9 13 13 26</td>
</tr>
<tr>
<td>17</td>
<td>Upper Level Humidity</td>
<td>9 17 24 15</td>
</tr>
<tr>
<td>18</td>
<td>Elevation</td>
<td>9 24 25 8</td>
</tr>
<tr>
<td>19 (tie)</td>
<td>Stream/River/Flow</td>
<td>19 17 17 15</td>
</tr>
<tr>
<td>19 (tie)</td>
<td>Upper Level Winds</td>
<td>19 17 17 15</td>
</tr>
</tbody>
</table>
Back-up Materials
US-09-01a Process: Nine Steps

The process lists the steps serially, yet some are done in parallel.

Step 1: UIC Members identify Advisory Groups and Analysts for each SBA
Step 2: Determine scope of topics for the current priority-setting activity
Step 3: Identify existing documents regarding observation priorities for the SBA
Step 4: Develop analytic methods and priority-setting criteria
Step 5: Review and analyze documents for priority Earth observations needs
Step 6: Combine the information and develop a preliminary report on the priorities
Step 7: Gather feedback on the preliminary report
Step 8: Perform any additional analysis
Step 9: Complete the final report on Earth observations for the SBA

Based on the SBA reports, the Team Team performed a meta-analysis on the individual SBA reports. The team combined and prioritized parameters from the SBA lists and prepared an over-arching report to identify “Earth observation priorities common to many SBAs.” The report includes findings, lessons learned, and recommendations.
General structure:
An “Advisory Group” and an “Analyst” work together to identify documents, analyze them, and prioritize observations within each SBA.

<table>
<thead>
<tr>
<th>Advisory Group (1 per SBA)</th>
<th>Analyst (1 per SBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functions:</td>
<td>Functions:</td>
</tr>
<tr>
<td>- Will help to identify documents</td>
<td>- Will read and analyze the documents</td>
</tr>
<tr>
<td>- Comment on analytic methods and priority-setting criteria</td>
<td>- Develop an analytic method and priority-setting criteria</td>
</tr>
<tr>
<td>- Review the analysts’ findings, priorities, and reports.</td>
<td>- Conduct the meta-analysis to identify common priorities within a SBA.</td>
</tr>
</tbody>
</table>

Involved 6-23 people from developed and developing countries that represent experts in an SBA.

Involved Communities of Practice, former IGOS Themes, GEO Countries and Participating Organizations.

The Analyst was the primary coordinator and organizer of the activity to meet the schedules and deadlines.

Interacted with and utilized the Advisory Group to vet prioritization methods and review results and reports.
Advisory Groups

Sought broad international and regional representatives.

Involved GEO CoPs, former IGOS Themes, GEO Countries and Participating Organizations.

CEOS Participants:
Disasters: Guy SÉGUIN
Health: Murielle LAFAYE
Water: Osamu OCHIAI
Weather: Paul COUNET and Robert HUSBAND

<table>
<thead>
<tr>
<th>Geographic Distributions of Advisory Group Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
</tr>
<tr>
<td>Asia &amp; Middle East</td>
</tr>
<tr>
<td>East Asia</td>
</tr>
<tr>
<td>Europe</td>
</tr>
<tr>
<td>North America</td>
</tr>
<tr>
<td>Oceania/Australia</td>
</tr>
<tr>
<td>South/Central America</td>
</tr>
<tr>
<td>International</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
Notice

Cross-SBA Report – Notice on Biodiversity

Biodiversity report is referenced in the Final Report. However, Biodiversity did not produce a set of Earth observations priorities. Thus, Cross-SBA team had no Biodiversity-specific observations to include in the Cross-SBA meta-analysis. It was assumed that the Ecosystems observations were likely similar, so Biodiversity is partly indirectly included.
Cross-SBA Analysis

Prioritization Methods
Cross-SBA Analytic Methodologies

Method 1: Tally of All Priorities
Frequency analysis is a simple tally of the SBAs that require a given observation. (Total of 146 observations were included in this prioritization.)

Methods 2&3: Weighted Sums of All Priorities
Weighted frequency analysis is a weighted sum of the number of SBAs that require a given observation, taking into account the high/medium/low importance assigned by SBA Analysts. Different weighting schemes in the two methods (Same 146 parameters as Method 1.)

Method 4: Top 15 Priorities by SBA
This key parameters method is based on each SBA Analyst preparing a list of the “top 15” for that SBA. (Total of 99 observations were included.)

Final Set: Ensemble approach across the methods.
Calculated mean rank and the range of ranks for all 146 parameters across methods. Natural breaks at top 19 and top 36 parameters.
The figure shows the distribution of the 146 Earth observations by the number of SBAs that specified an observation as a priority (Method 1). 29 observations (20%) are priorities to 4 or more SBAs.
Method 2: Distribution of Observations by Method 2 Weighting

The figure shows the distribution of the 146 Earth observations by the scores of the Method 2 weighting scheme. Scores range from 1 to 24. 81 observations (55%) received scores of 4 or above.

One observation (Precipitation) received the highest possible score of 24.

Twenty-eight observations received a score of 3.
Method 3: Distribution of Observations by Method 3 Weighting

The figure shows the distribution of the 146 Earth observations by the scores of the Method 3 weighting scheme. Scores range from 1 to 48. 109 observations (75%) received scores of 4 or above.
Method 4: Distribution of “15 Most Critical” Observations by Number of SBAs

The figure shows the distribution of the 97 observations on the “15 Most Critical” lists, according to the number of SBAs that specified an observation as a priority (Method 4). 58 observations (60%) are priorities to 2 or more SBAs.

Total number of observations included in Method 4 is 97.

8 observations are on the “15 Most Critical” list for 4 SBAs.
GEO Societal Benefit Areas
15 Most Critical: Agriculture

<table>
<thead>
<tr>
<th>Report Sub-Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Famine Early Warning</td>
</tr>
<tr>
<td>• Agriculture Production</td>
</tr>
<tr>
<td>• Seasonal/Annual Agriculture Forecasting and Risk Reduction</td>
</tr>
<tr>
<td>• Aquaculture Production</td>
</tr>
</tbody>
</table>

Number of Documents: 54

<table>
<thead>
<tr>
<th>15 Most Critical Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vegetation Indices</td>
</tr>
<tr>
<td>2. Crop Area</td>
</tr>
<tr>
<td>3. Disturbances</td>
</tr>
<tr>
<td>4. Precipitation</td>
</tr>
<tr>
<td>5. Evapotranspiration</td>
</tr>
<tr>
<td>6. Temperature</td>
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<tr>
<td>7. Solar radiation</td>
</tr>
<tr>
<td>8. Wind Characteristics</td>
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<tr>
<td>9. Weather</td>
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<tr>
<td>10. Soil Chemistry</td>
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<tr>
<td>11. Crop Residue</td>
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<tr>
<td>12. Hydrology</td>
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<tr>
<td>13. Bathymetry</td>
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<tr>
<td>14. Land Cover</td>
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<tr>
<td>15. Crop Yield</td>
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</tbody>
</table>
15 Most Critical: Biodiversity

The Biodiversity SBA report did not include Earth observation priorities per se. The Biodiversity SBA Analyst did not provide the Task Team with Earth observations priorities for Method 1-3 nor a list of “15 Most Critical” observations.

Report Sub-Areas

- Species
- Ecosystem

Number of Documents: 60
15 Most Critical:
Climate

Report Sub-Areas
- Atmosphere
- Oceans
- Lands
Number of Documents: 40

15 Most Critical Observations (unordered)
- Reservoir/Lake Level and Surface Temperature
- River Discharge
- Precipitation
- Aerosol Properties
- Sea Surface Temperature
- Land Cover Type
- Soil Moisture
- Sea Level
- Sea Ice
- Snow Cover Area
- Glacier/ice Cap Area Maps
- Glacier/ice Cap Elevation
- Water Use
- Groundwater
- Surface Radiation Budget
**15 Most Critical: Disasters**

**Report Sub-Areas**
- Earthquakes
- Landslides
- Floods
- Tropical Cyclones
- Wildfires
- Volcanic Eruptions

**Number of Documents:** 40

**15 Most Critical Observations**

1. Elevation/Topography
2. Precipitation
3. Surface Deformation
4. Wind Properties
5. Soil Properties
6. Seismicity
7. Atmospheric Properties
8. Flood Monitoring Properties
9. Wave Properties
10. Stream/River Properties
11. Gravity Field
12. Water Properties
13. Ice/Snow Properties
14. Magnetic Field
15. Thermal Properties
15 Most Critical: Ecosystems

1. Vegetation Cover, Changes
2. Permafrost Condition and Dynamics (degradation, reduction)
3. Disturbance (including fire, drought, and land clearing)
4. Extent, Location, and Fragmentation of Ecosystem and Habitat Types
5. Soil Carbon
6. Biomass (including spatial distribution, biomass moisture content)
7. Forest Fragmentation
8. Water Salinity
9. Vegetation indices
10. Forest Cover
11. Land Use, Land Cover
12. Mangrove Extent
13. Carbon (including dissolved in/organic carbon, particulate organic carbon)
14. Glacier Extent, Mass Balance
15. Ocean Circulation Patterns

Report Sub-Areas
- Forests
- Coastal and Near-Shore Marine Systems
- Inland Waters
- Tundra
- Islands and Archipelagos
- Water Salinity
- Vegetation indices
- Number of Documents: 115
15 Most Critical: Energy

Report Sub-Areas
- Solar Energy
- Wind Energy (land-based)
- Wind Energy (offshore)
- Hydropower
- Bioenergy
- Geothermal Energy

Number of Documents: 54

15 Most Critical Observations
1. Water Run-off
2. Wind Speed
3. Land Cover
4. Normalized Difference Vegetation Index (NDVI)
5. Net Primary Productivity (NPP)
6. Global Horizontal Irradiation (GHI)
7. Direct Normal Irradiation (DNI)
8. Elevation/Topography
9. Air Temperature
10. Surface Temperature
11. Relative Humidity
12. Cloud Cover (cloud index)
13. Temperature of Geothermal Fluid at Depth
14. Surface Deformation
15. Groundwater Chemistry (e.g., presence of borates)
15 Most Critical:
Health

15 Most Critical Observations (unordered)

- Population Density
- Precipitation
- Air temperature
- Humidity
- Land Use/Land Cover
- Vegetation
- Water Bodies
- Sea Surface Temperature
- Wind
- Sea Surface Height
- Topography
- Vector population
- Atmospheric Particulates
- Biodiversity
- Atmospheric Trace Gases

Report Sub-Areas

- Aeroallergens
- Air Quality
- Infectious Diseases

Number of Documents: 1093
15 Most Critical: Water

15 Most Critical Observations* (unordered)

- Precipitation (liquid, solid and mixed phase)
- Soil Moisture: Surface/Sub-Surface
- Soil Temperature: Surface/Sub-Surface
- Evaporation-Lakes and Wetlands
- Evapotranspiration - From Land Surface
- Runoff/Stream Flow
- River Discharge (To Ocean Coastal Zones/Estuaries)
- Glaciers & Ice Sheets (Extent/Depth)
- Aquifer Volumetric, & Change
- Land Cover – Vegetation Cover/Type
- Elevation/Topography
- Water Quality – Large Water Bodies, Major Rivers, Estuaries
- Lakes/Reservoirs Levels (Including Other Surface Storages)
- Snow: Cover/Depth/Type, Snow Water Equivalent
- Ground Water Recharge/Discharge Rates

Report Sub-Areas

- Surface Waters
- Ground Waters
- Forcings
- Water Quality & Water Use

Number of Documents: 200
15 Most Critical:
Weather

Report Sub Areas
- Global Numerical Weather Prediction
- Regional Numerical Weather Prediction
- Synoptic Meteorology
- Nowcasting and Very Short Range Forecasting
- Seasonal and Inter-annual Forecasts
- Aeronautical Meteorology
- Atmospheric Chemistry
- Ocean Applications
- Agricultural Meteorology
- Hydrology
Number of Documents: 25

15 Most Critical Observations (unordered)
- 3D Humidity Field
- 3D temperature field
- Cloud Cover
- Cloud Water/Ice Amounts (3D distribution)
- Land Surface (skin) Temperature
- Ozone
- Precipitation
- Sea Surface Temperature
- Soil Moisture
- Surface Air Humidity
- Surface Air Temperature
- Surface Pressure (over land)
- Surface Wind
- Vegetation Cover
- Wind (3D) - vertical and horizontal components