• Grand Challenge science problems have often been addressed by creating and using international observatories
• Climate variability and change is a Grand Challenge that requires very broad collaboration
• Space Agencies are wrestling with how to collaborate effectively across a range of activities
• Metrics are needed to assess where we are and what progress need to be made
• Tension remains between the traditional Principal Investigator approach and Observatory needs
Adopting Systems Engineering Approach Demands Metrics to Assess Progress

Systems Engineering Approach

- Questions (scientists)
- Grant (scientists)
- Analyses (scientists)
- Exp Design (scientists)
- Data Collection (Engineering)
- Construction (Engineering, Permitting)

- Formalized hierarchical requirements
- Asks ‘what must be done?’
- Measurements are considered baseline
- Steps are parsed out (see diagram)

<table>
<thead>
<tr>
<th>Pro</th>
<th>Con</th>
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<tbody>
<tr>
<td>✓</td>
<td>New roles for scientists, both internally and externally</td>
</tr>
<tr>
<td>✓</td>
<td>Clearly defines scope, budget, schedule, risks</td>
</tr>
<tr>
<td>✓</td>
<td>Complexity is inherently planned for</td>
</tr>
<tr>
<td>✓</td>
<td>Develops planning horizons for Program Officers/Sponsors</td>
</tr>
<tr>
<td>✓</td>
<td>Fosters long term sustainability</td>
</tr>
<tr>
<td>✓</td>
<td>Requirement approach does not necessarily impose a single unique solution</td>
</tr>
</tbody>
</table>
Concept of Maturity

- The concept of measuring maturity of technical and software processes has arisen in several different industries
  - NASA technical readiness levels
  - Software Capability Maturity Model Integration
- The rapid advances in climate observations by Space Agencies over the last several decades has been accompanied by a recognition of the need to capture best practices
- The Maturity Matrix attempts to capture these best practices from scientists, software engineers and the information preservation communities
Evolution of a Climate Data Record (CDR) Maturity Index

• A Maturity index was first proposed for satellite CDRs in 2006 by Bates and Barkstrom
• Informal feedback was obtained from several space agencies
• WOAP Workshop in Frascatti 2011 led to a more rigorous assessment and feedback (published as GCOS-153) as well as specific recommendations
• Recommendations and feedback were included in a version-controlled Maturity Matrix V4 by NOAA’s Climate Data Records Program
• This version was published by Bates and Privette in EOS Transactions AGU in the Fall of 2012 (DOI: 10.1029/2012EO440006)
The Maturity Index Addresses These Questions

Climate Preservation Description Information

- Reference Information
  - Where can products easily be found?
- Provenance Information
  - What original observations were used in the product?
- Context Information
  - What methods were used to create the product?
- Fixity Information
  - Digital signature is needed to prove authenticity of product
- Access Rights Information
  - Are the Data Publicly Available?
Several Agencies/Programs are currently conducting self evaluations of their ECVs/CDRs using the Maturity Index.

This is an important process as:
- The index is still new and terminology needs to be refined.
- Application of the index will always be (somewhat) subjective.
- Goals of different Programs varies and the Index may need slight modifications to ensure those goals are met.

Being applied or in discussion at NOAA CDR Program, Eumetsat CDRs, and ESA CCI.
Application of the Maturity Index – Independent Validation

• Eventually there must be an independent evaluation of ECVs/CDRs using the Maturity Index

• I have started some validation exercises and found the following:
  💧 We need to define a validation status proposed as: 1) Green – can be validated using publicly accessible information, 2) Yellow – contact with a subject matter expert is required to validate, or 3) Red – Insufficient information available to validate

• For future assessments, data sets should be required to be validated and above a minimum maturity to be included in the Summary for Policymakers
Conclusions

• The Maturity Index responds to the 2012 Joint WCRP/GCOS Letter
  • (to develop a...) systematic international approach to ensure transparency, traceability and sound scientific judgment in the generation of climate data records across all fields of climate science and related Earth observations...

• Community feedback has led to refinements and improvements in the Maturity Index

• I recommend that we not let ‘...the perfect be the enemy of the good...’ and adopt the Maturity Index as an interim standard