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Workshop on Continuity and Architecture Requirements for Climate Monitoring

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

Geneva, 13-14 January 2011

Technical Breakout Group

"Sustaining Space-based Climate Observations"

Considerations

- **Scientific Rationale**
  - Justification for ECV selection/consideration (gaps, potential gaps)
  - Opinion on relative priorities among all ECVs – why?
  - Criterion for assignment of priorities
- **Implementation Approach**
  - Consideration of contingency issues related to the selected ECVs
  - What contingency planning steps are needed to ensure continuity?
  - What would a failure-response look like?
- **Architecture Implications**
  - Implications for an overall architecture and component functions
- **Sustainability – R2O transitions have been a risk for continuity**
  - How could a new R&O paradigm mitigate these risks and ensure sustainability?

Approach

- Identify 'at risk' climate only observation for which there is little or no other way to make the observation
  - ERB, limb sounding in UT/LS & stratosphere, rain radar and microwave constellation, …
- Identify synergistic Weather-climate observations?
  - How to ensure climate calibration transfer standard among 'weather' sensors?

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ERB (1/4)

- **Scientific Rationale**
  - Justification for ECV selection/consideration (gaps, potential gaps)
    - Next generation ERB (in U.S.) – last ERB on JPSS-J1; follow-on ERB needs to be developed; insufficient funds exist to develop follow-on ERB in time for JPSS-J2
    - When is gap – 2020-2030 – development needs to take place when?
    - What alternatives exist? – China –ERB planned for FY-3 on am orbit : FY-3C (2013), FY-3E (2017), FY-3G (2021) but only 3 years life time
  - Opinion on relative priorities among all ECVs – why?
    - Relative to others – fundamental for Earth climate balance and validation of climate models
  - Criterion for assignment of priorities
    - Can only be measured from space – no in situ

ERB (2/4)

- **Implementation Approach**
  - **Consideration of contingency issues related to the selected ECVs**
    - **Use existing narrow band instruments (imagers) – narrow band do not observe major areas of the spectrum (i.e., longwave IR nor entire SW) so errors are much larger then acceptable**
  - **What contingency planning steps are needed to ensure continuity?**
    - **Long term plans for next generation ERB – when next 'block' of sensors is required there are always large initial costs – mitigate these costs by sharing with many agencies? – must have help of research agencies episodically; or pro-rating costs over multiple instruments (must have resource commitment to allow this**
  - **What would a failure-response look like? –**
    - **No recovery; the record would have to be started over**

ERB (3/4)

- **Architecture Implications**
  - **Implications for an overall architecture and component functions**
    - **Even with only 1 ERB polar, we must sample diurnal cycle with well characterized Geo imagers**
    - **Need regularly updated input on status of acquisition of climate sensors as status can change yearly and long lead times are required**
    - **Need more robust planning approach for climate sensors as current system is not robust**
    - **Why? Visibility to decision makers for weather observations; the impact for not having the climate observations is seen as lower issue**
    - **How can we make the climate observing system more robust? How to achieve this?**
    - **For those climate satellite unique measurements, should these observations be de-coupled from weather?**
    - **Non-sun synchronous may be advantageous**
    - **Data processing issues and implications?**

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ERB (4/4)

- **Sustainability – R2O transitions have been a risk for continuity**
  - **How could a new R&O paradigm mitigate these risks and ensure sustainability?**
    - **Recognition that acquisition of each new block of sensors, or jump in observing capability, require insertion of research agencies each**
    - **Greater long term planning among all agencies for climate unique sensors – need a 30 year planning horizon –**
    - **need to agree to a baseline set of missions among international partners**

Precipitation ECV (1/6)

- **Scientific Rationale**
  - **Justification for ECV selection/consideration (gaps, potential gaps)**

  - The greatest gap threat is the continuity of imagers.
  - There are many questions on the Defense Meteorological Satellite Program (DMSP) follow on (called Defense Weather Satellite System (DWSS)). There is discussion that DWSS does have imagers available, but there is concern that this could cuts in instruments and there is still the issue of civilian/military interaction on operations and data characteristics.
  - Imagers have been the target for budget cuts in the NOAA follow-on from day: There is a concern for US operational capability/gaps due to demise of National Polar-orbiting Operational Environmental Satellite System (NPOESS) and then a scaled a back Joint Polar Satellite System (JPSS) capability much like current POES with AMSU.

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Precipitation ECV (2/6)

- **Scientific Rationale (Cont'd)**
  - **Justification for ECV selection/consideration (gaps, potential gaps)**

    - European post-EPS idea - the microwave (imaging) radiometer is on the borderline of whether it is flown or not
    - There possible funding issues with the Japanese Global Change Observation Mission (GCOM: e.g., GCOM W2)
    - Currently, there is no commitment to a follow on to GPM after 2018
    - Europe is planning for EarthCARE radar - but that is not ideal for global precipitation (wavelength/coverage), no current follow on after 2017
    - Bottom line is we could suffer gaps in our microwave imagers and precipitation radars.

Precipitation ECV (3/6)

- **Scientific Rationale (Cont'd)**
  - **Opinion on relative priorities among all ECVs – why?**
    - In relation to other ECV's, the distribution of precipitation is one of the fundamentals variables for Earth Climate. Accurate observations are necessary for validation of climate models
  - **Criterion for assignment of priorities**
    - Over oceans, precipitation can only be measured from space – very limited in situ; Over land – very few observations in remote areas (e.g., polar regions)

Precipitation ECV (4/6)

- **Implementation Approach**
  - **Consideration of contingency issues related to the selected ECVs**
  - There is a need for continuity beyond GPM. Two aspects need to be addressed: 1) The need for GPM microwave imager (GMI) capability for anchoring the radiometer constellation and for the continuity for a low inclination orbit and/or precessing orbit. There need more overlaps with the sun synchronous orbits for this calibration. 2) The need for an operational space-borne radar capability: Dual Frequency Precipitation Radar (DPR) + CloudSat type radar to cover full range of precipitation (DPR alone does not have the sensitivity to capture all snow types).

  - **What contingency planning steps are needed to ensure continuity?**
  - Develop long term plans for the next microwave imager and precipitation radar missions beyond GPM. Try to mitigate high R2O costs by sharing the continuation of imager and precipitation instrumentation.

  - **What would a failure-response look like?**
  - Failure response will look like the early years of the microwave era - a few microwave swaths embedded in lower-quality VIS/IR estimates. Studies have shown that microwave overpasses are needed every 3 h to avoid seriously degrading quality.

Precipitation ECV (5/6)

- **Architecture Implications**
  - **Implications for an overall architecture and component functions**
  - Precipitation-capable radars, preferably with CloudSat type low-end sensitivity and DPR high-end sensitivity. Critical for on-going calibration/validation and research.
  - Microwave imagers, multi-channel dual-polarization conically scanning have proved their worth, for fine-scale retrievals. This isn't just a "weather" issue if we want fine-scale things like extreme precipitation events to be accessible to climate statistics. Need to include "high-frequency" channels to enable retrievals in Polar Regions.
  - Microwave sounders, which are also useful for general precipitation retrieval, but currently lack the fine spatial resolution of imagers.
  - Geosynchronous multi-channel imager/sounders in VIS and IR. Provide a monitoring capability between microwave overpasses.

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Precipitation ECV (6/6)

- **Sustainability – R2O transitions have been a risk for continuity**
  - **How could a new R&O paradigm mitigate these risks and ensure sustainability?**
  - Precipitation radars have been entirely research; Move to have operational support from various agencies.
  - Microwave Imagers are a valuable instrumentation, but the near-term launch manifest is increasingly weighted to research; Move to have more operational support?
  - Sounders are largely operational and seem stable due to demands by other users; GEO instruments are similarly operational and appear well-supported.
  - The next "obvious" advance - GEO microwave. It currently has little support in research or operational sectors.
  - Precipitation and All-weather Temperature and Humidity (PATH) mission is listed as a Decadal Survey mission for NASA, the biggest obstacle for it is finding the support (justification and cost/benefit), the technology has recently become available

Limb sounding

- **Scientific Rationale**
  - Limb sounding provides good vertical resolution useful for improved understanding of atmospheric composition. Critical for ozone monitoring, AQ, and other processes.
  - Looming gaps in limb-profiling instruments for ozone, aerosols, H_2O in future agency space mission plans
  - Scientific rationale & gaps considered in detail at CEOS ACC workshop in October 2008. Report issued (see http://www.ceos.org/images/ACC/ACC-3%20Report%20vsfinalA.pdf) which details priorities and gaps relating to climate modeling, validation, and forecasting.
  - Criterion for assignment of priorities: workshop discussion on scientific issues, needed measurements, required observations -> gap analysis, recommendations.

- **Implementation Approach**
  - Recommendations generated based on science community discussion and agreement; for example, restore OMPS limb sounding on NPOESS/JPSS. Fly limb sounders on Sentinel 5, which with NASA GACM would result in covering both morning and afternoon orbits.

Weather-Climate Synergy

- Identify synergistic Weather-climate observations? (How to ensure climate calibration transfer standard among ‘weather’ sensors?)

➢ **Need Calibration Standard to use Operational Weather Satellites for Climate Trend Analysis of ECVs**

Calibration Standard to use Operational Weather Satellites for Climate Trend Analysis (1/5)

- **Scientific Rationale**
  - Key long-term climate data records of temperature, water vapor, precipitation, clouds, snow, vegetation, SST, etc are based on operational satellites.
  - Most operational weather sensors do not meet climate accuracy requirements.
  - Climate requirements call for low uncertainties in trends
  - Issues with ECV products/trends are mostly traceable to quality of the fundamental sensor calibration of the observations - we strive to produce the most accurate FCDR.
  - Need a few reference instruments (calibration standards preferably SI traceable) for all spectral regions (IR, MW, UV, etc) to increase the confidence/accuracy of climate trends from satellites and/or use overlap between successive accurate weather/climate sensors such as AIRS and IASI, MODIS and MERIS, etc….

Calibration Standard to use Operational Weather Satellites for Climate Trend Analysis (2/5)

- **Implementation Approach**
  - **Requirements call for different constellation and contingency planning.**
  - **What contingency planning steps are needed to ensure continuity?**

  – Have two or more long-lived climate quality highly stable/accurate sensors “free flyers”, which provides great overlap with operational satellites to ensure continuity of high quality FCDRs (infrared, microwave, UV, etc) needed to derive the ECVs.
  – Or need a few climate quality instruments for both weather and climate applications (e.g. IASI and AIRS)
  – Routine intercomparison of these instruments to assess accuracy and stability.
  – Prefer three such instruments to determine which instrument is an outlier (if any)
  – Reliance of calibration sites for some spectral regions

Calibration Standard to use Operational Weather Satellites for Climate Trend Analysis (3/5)

- **What would a failure-response look like?**
  - If there is a gap, the reference sensor would allow the correct offset to be computed to allow the replacement operational sensor to continue the time record. A gap may exist, but the long-term trend will remain accurate and stable

Calibration Standard to use Operational Weather Satellites for Climate Trend Analysis (4/5)

- **Implications for an overall architecture and component functions**
  - Launch planning of reference sensors to minimize risk of gap.
  - Reference sensors become key components of the constellations. Do not need as many as operational sensors.
  - Cost effective : allows use of more but less accurate/stable sensors for climate trends.

- **Sustainability – R2O transitions have been a risk for continuity**
  - **How could a new R&O paradigm mitigate these risks and ensure sustainability?**
  - Some agencies commit to providing sustained reference 'Calibration Standard » sensors - preferably in orbit SI traceable.
  - Or improve accuracy of weather sensors for cross calibration.

Constellation Planning

- Operational satellites

- Reference "calibration standards" Satellites

Cross-cutting Findings and Recommendations of the Technical Break-out Session (1/2)

- The Gap Analysis submitted to the workshop shows need for additional long-term planning for several ECVs, or specific ECV-related products. **As matters of example**, the working group highlighted that Earth Radiation Budget (incl. solar irradiance), global precipitation, atmospheric composition (as measured by limb sounding instruments) were areas of anticipated gaps.

  With respect to these examples, agencies are encouraged:
  - to urgently consider planning for continuous availability of at least one broad-band radiometer and one Total Solar Irradiance instrument as of 2020; it encouraged scientific cooperation to support such missions
  - to consider a follow-on to the planned GPM DPR mission of NASA/JAXA noting its expected benefit for climate, weather and hydrology applications
  - to give more consideration to climate instruments such as limb sounders which could fly aboard operational missions.

Cross-cutting Findings and Recommendations of the Technical Break-out Session (2/2)

- A process to identify needs and priorities based on a systematic Gap Analysis is a critical step in the definition of an architecture
- Communication and coordination should be increased among the CGMS-sponsored international scientific working groups (IPWG, IROWG, ITWG, IWWG) and the CEOS Virtual Constellations
- Ensuring continuity of high-accuracy and stable reference instruments providing anchor measurements would increase the value of operational instruments for climate purpose. GSICS in consultation with WGCV should to explore mechanisms to implement this approach.