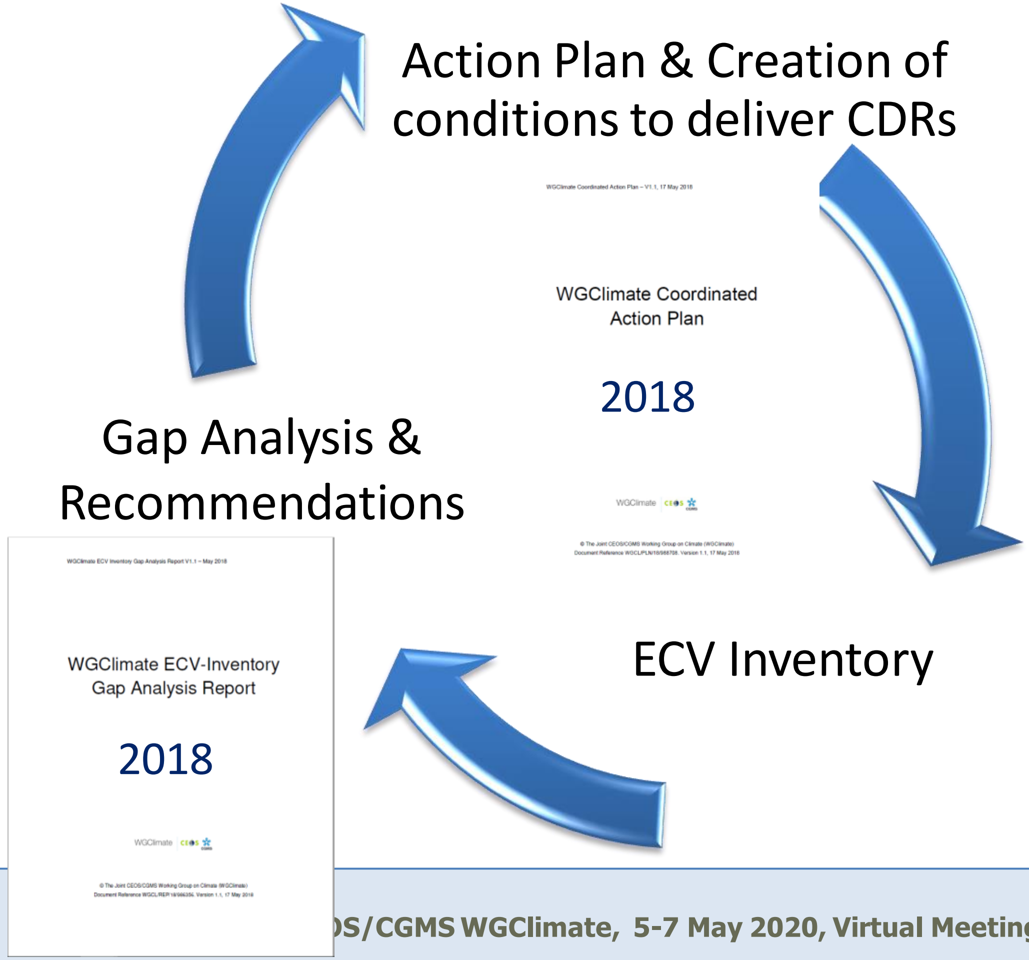
Results from the Gap Analysis on ECV Inventory #3

12th Session

Item 1.2

GCOS ECV CDR Inventory – Set up and Benefits

Recurrent actions CMRS-17, 20, and 21



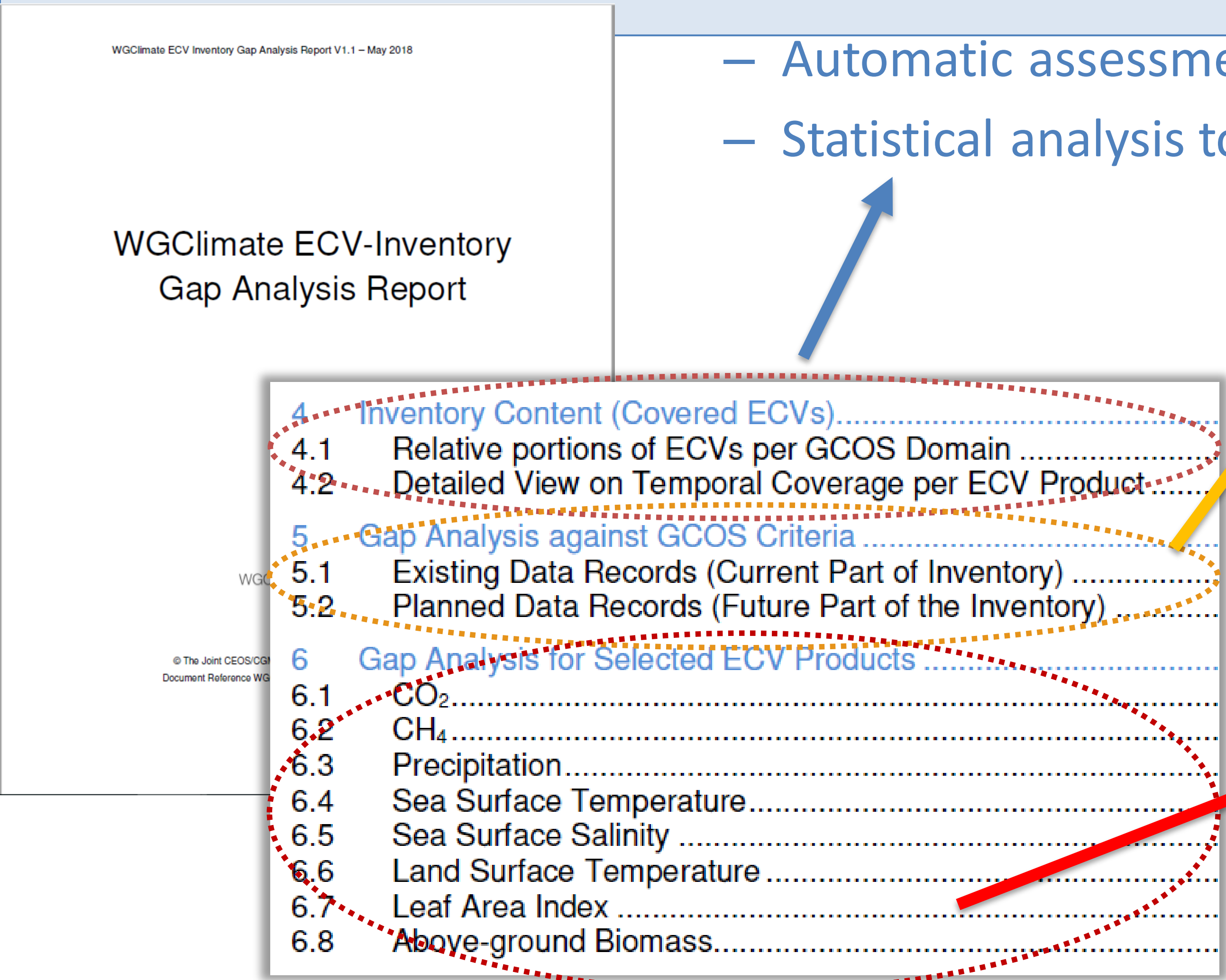
- ECV Inventory fully describes current and planned implementation arrangements (ECV-by-ECV) within the Architecture
- Content fully verified and updated annually with approval from CEOS and CGMS
- Informs space agency planning, improves availability and interoperability of climate data records
- Feeds material for all future responses of the space agencies to the GCOS status report and IP
- Is used by Climate Services to chose CDRs, e.g. Copernicus Climate Change Service
- Users can download the ECV Inventory content for own analysis, find direct access points to CDRs in the Inventory, get access to WGClimate gap analysis results and planned actions.

Gap Analysis Topics

Related to the objectives of the WG Climate the gap analysis addresses three topics:

1. Existence of Climate Data Records
2. Analysis of Inventory Entries against GCOS Criteria
3. Analysis for specific ECVs
   - An analysis as to whether the ECV inventory misses a known existing or planned climate data record;
   - An analysis of missing measurements in the future that would be required to continue existing and planned data records or to establish new ones with enhanced quality;
   - An analysis of the missed opportunities for creating a climate data record from existing past and planned future measurements from space.

ECV CDR Inventory and Gap Analysis


WGClimate ECV Inventory Gap Analysis Report V1.1 – May 2018

WGClimate ECV-Inventory
Gap Analysis Report

4 Inventory Content (Covered ECVs)
4.1 Relative portions of ECVs per GCOS Domain
4.2 Detailed View on Temporal Coverage per ECV Product
5 Gap Analysis against GCOS Criteria
5.1 Existing Data Records (Current Part of Inventory)
5.2 Planned Data Records (Future Part of the Inventory)
6 Gap Analysis for Selected ECV Products
6.1 CO_2
6.2 CH_4
6.3 Precipitation
6.4 Sea Surface Temperature
6.5 Sea Surface Salinity
6.6 Land Surface Temperature
6.7 Leaf Area Index
6.8 Above-ground Biomass

- Automatic assessment
- Statistical analysis tools and graphical display
  - Statistical analysis tools and graphical display on the web interface
  - Analysis of delta to version #2

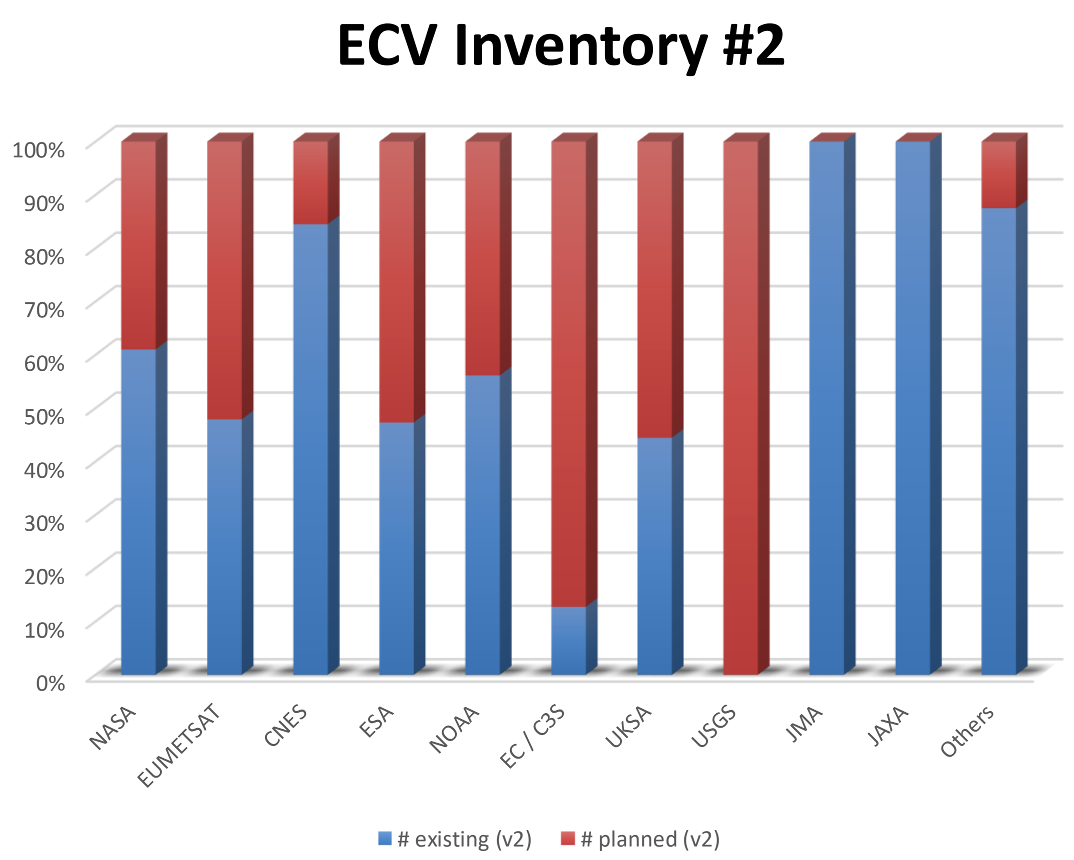
Detailed analysis per ECV / ECV Product:

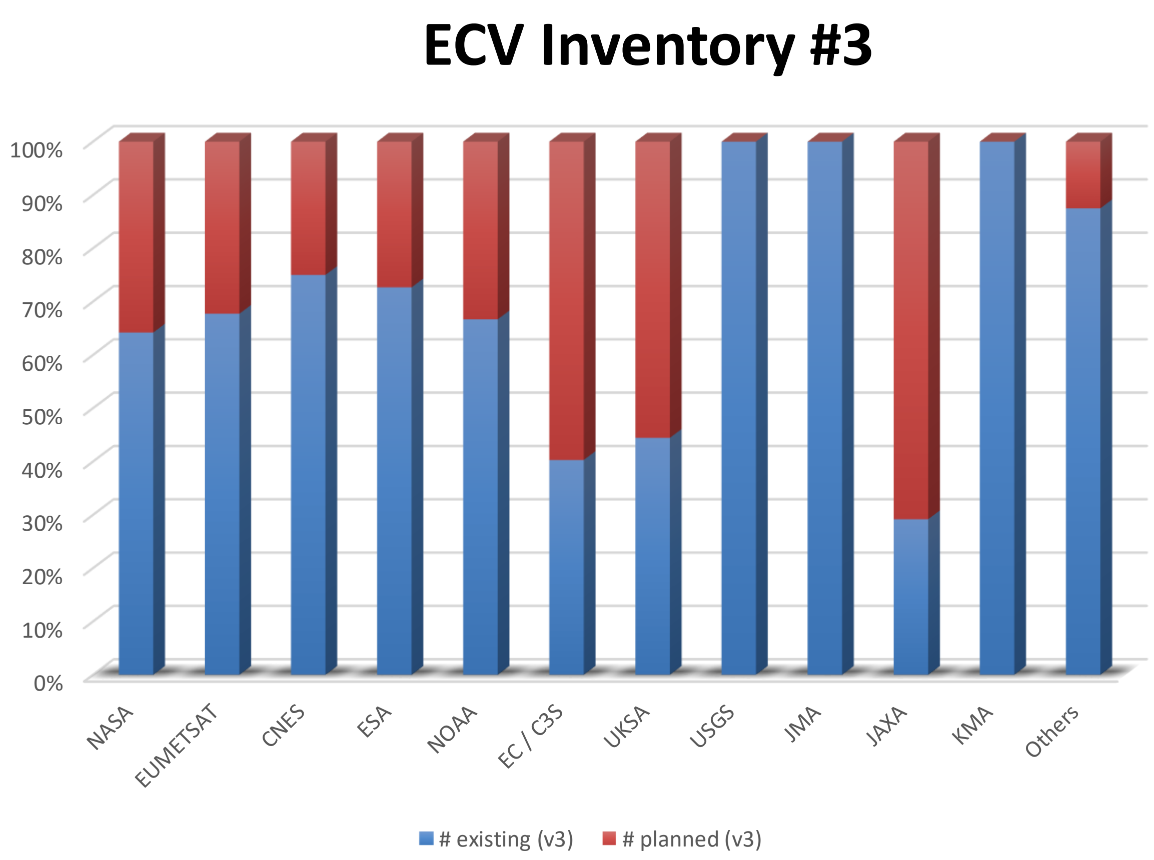
- Assesses progress for 8 ECVs addressed last year
- Selected 13 additional ECVs (5 atmosphere, 5 land, 3 ocean) not addressed before that are specifically part of 2016 GCOS-IP actions
- Postponed 2 land (FAPAR, Glaciers) and 1 atmosphere (lightning) due to missing support

General Status

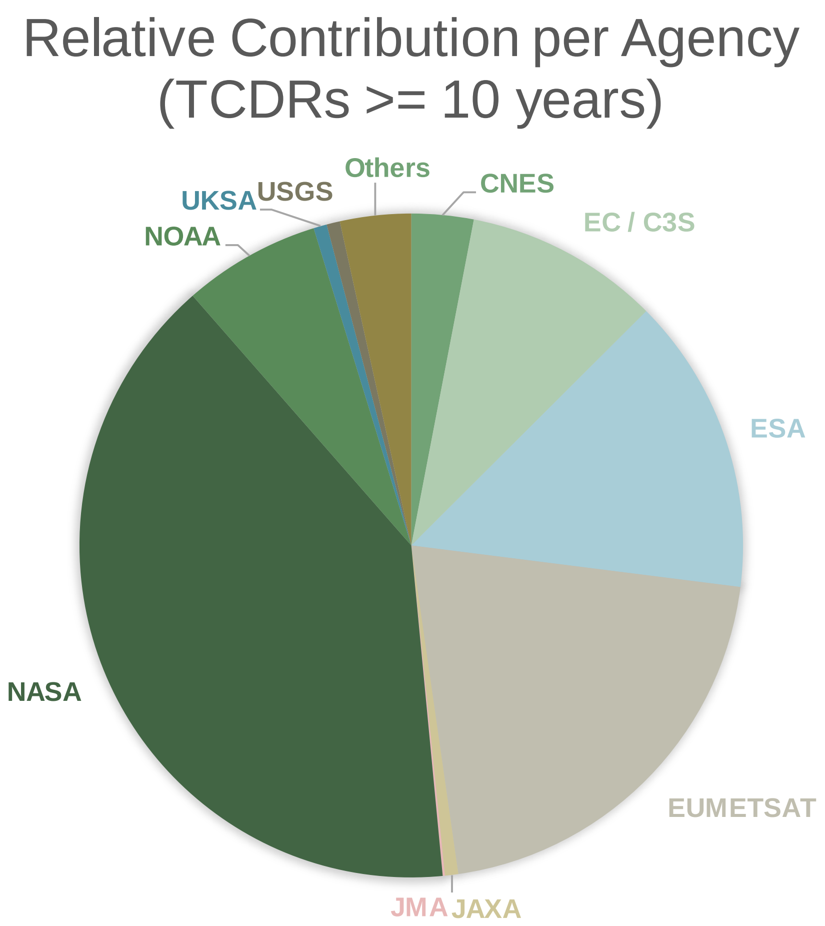
- Existence of Climate Data Records – done
- GCOS criteria analysis – significant amount of data sets not assessed but statistics very stable
- Progress on already assessed ECVs – TBD, but progress on some coordinated actions
- Individual ECVs – New ECVs assessed with various degree of information

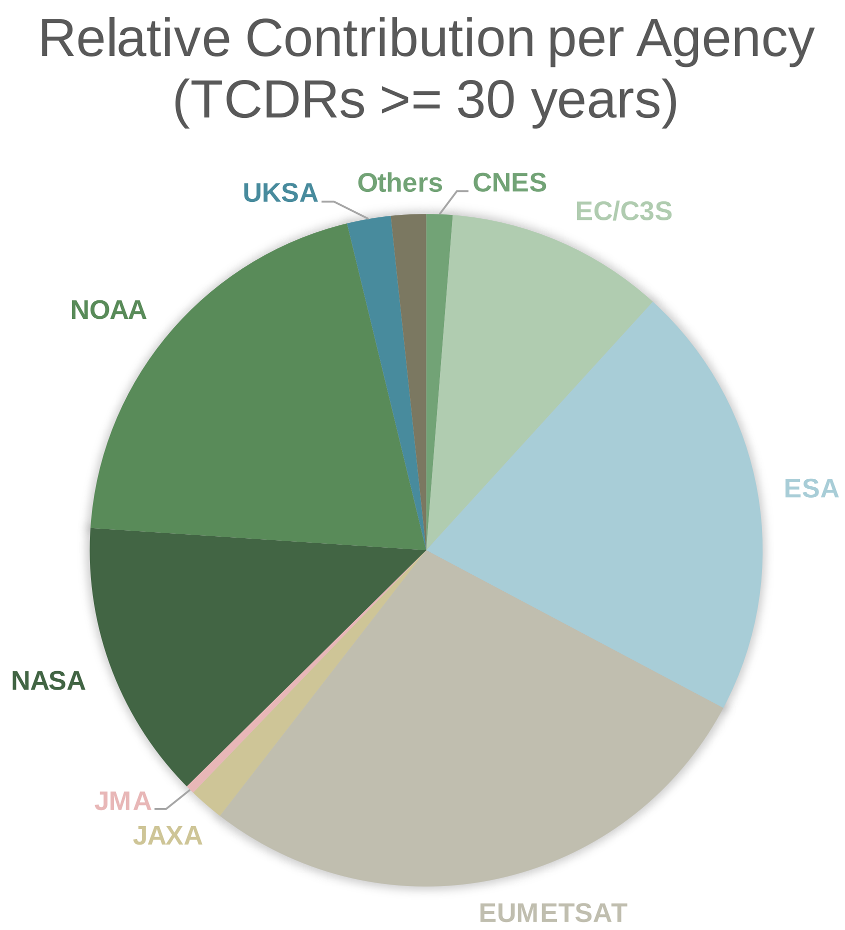
Relative number of existing and planned data records per agency





ECV CDR Inventory and Gap Analysis





ECV Inventory contains:

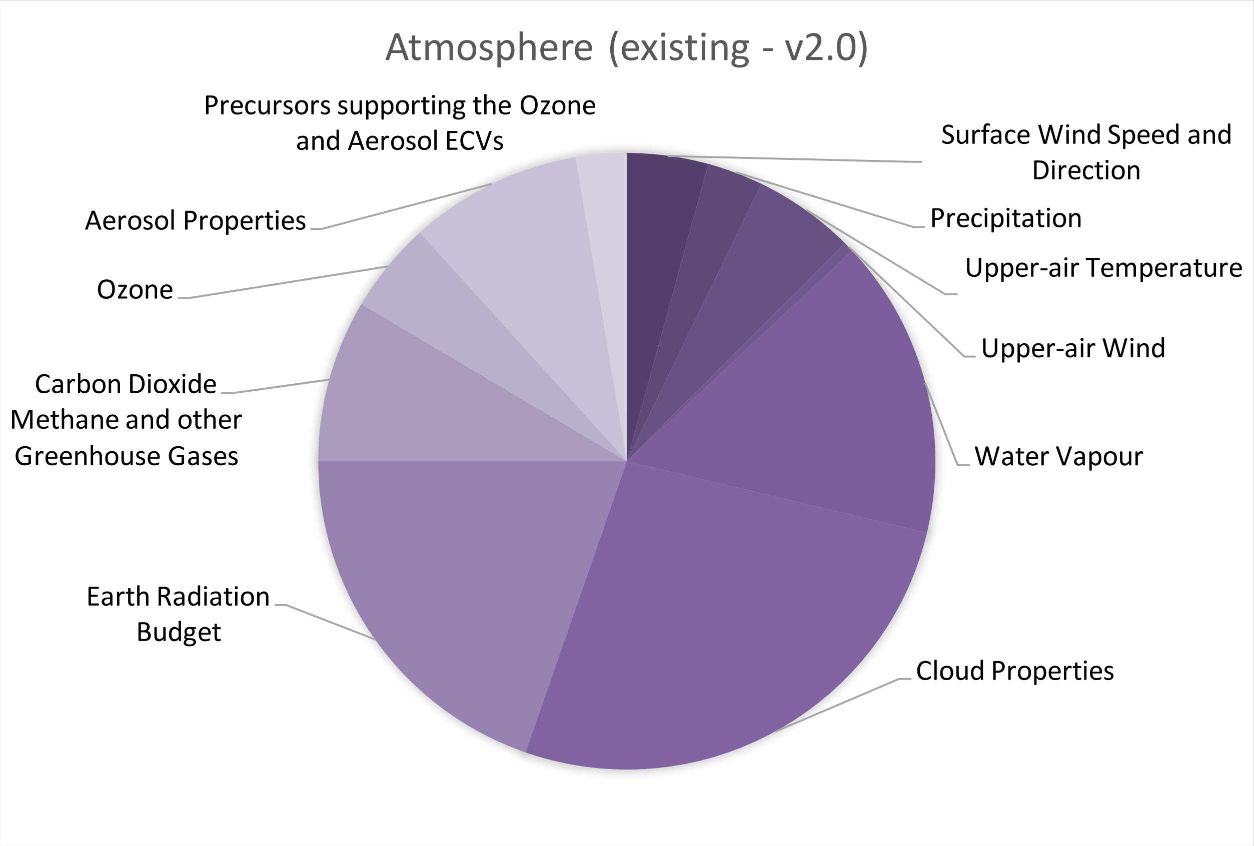
- 72% CDRs
- 28% ICDRs

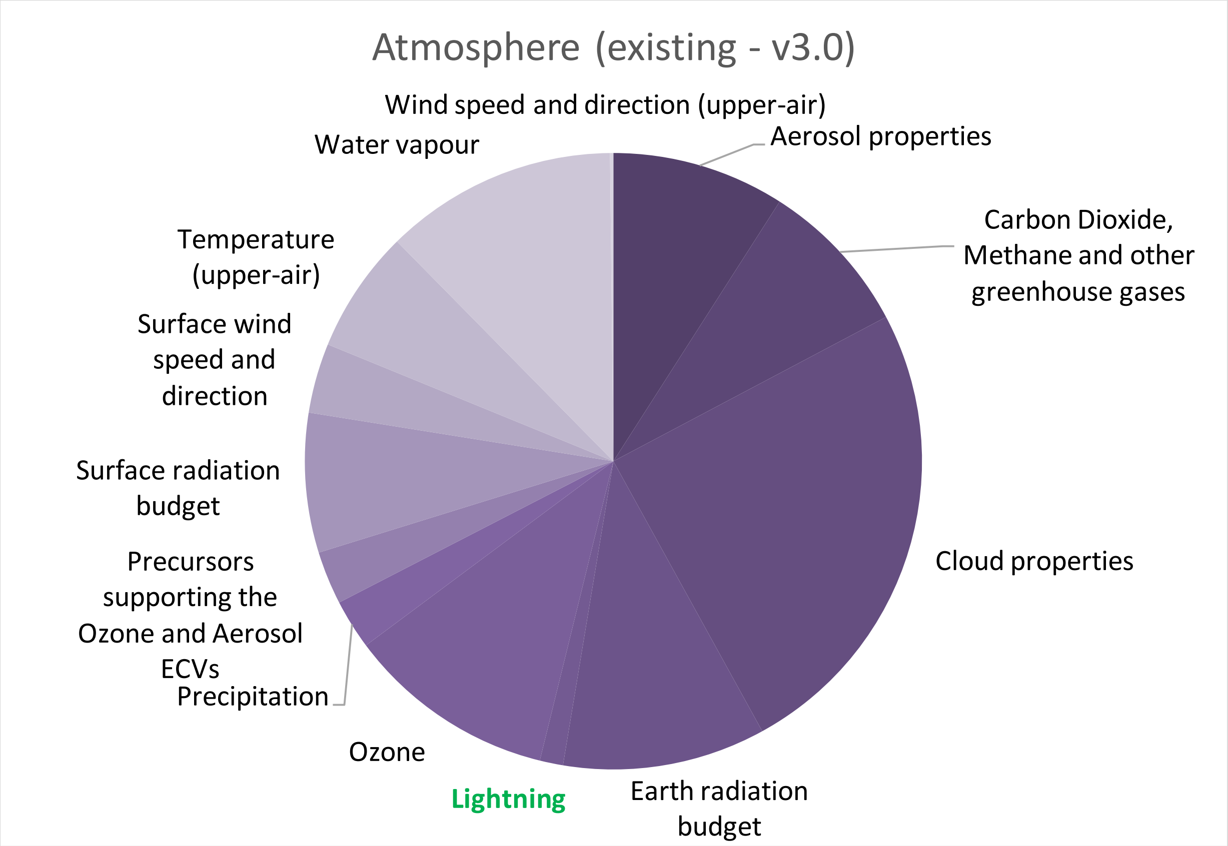
CDR length:

- 27% < 10 years
- 73% >= 10 years
- 33% >= 20 years
- 18% >= 30 years

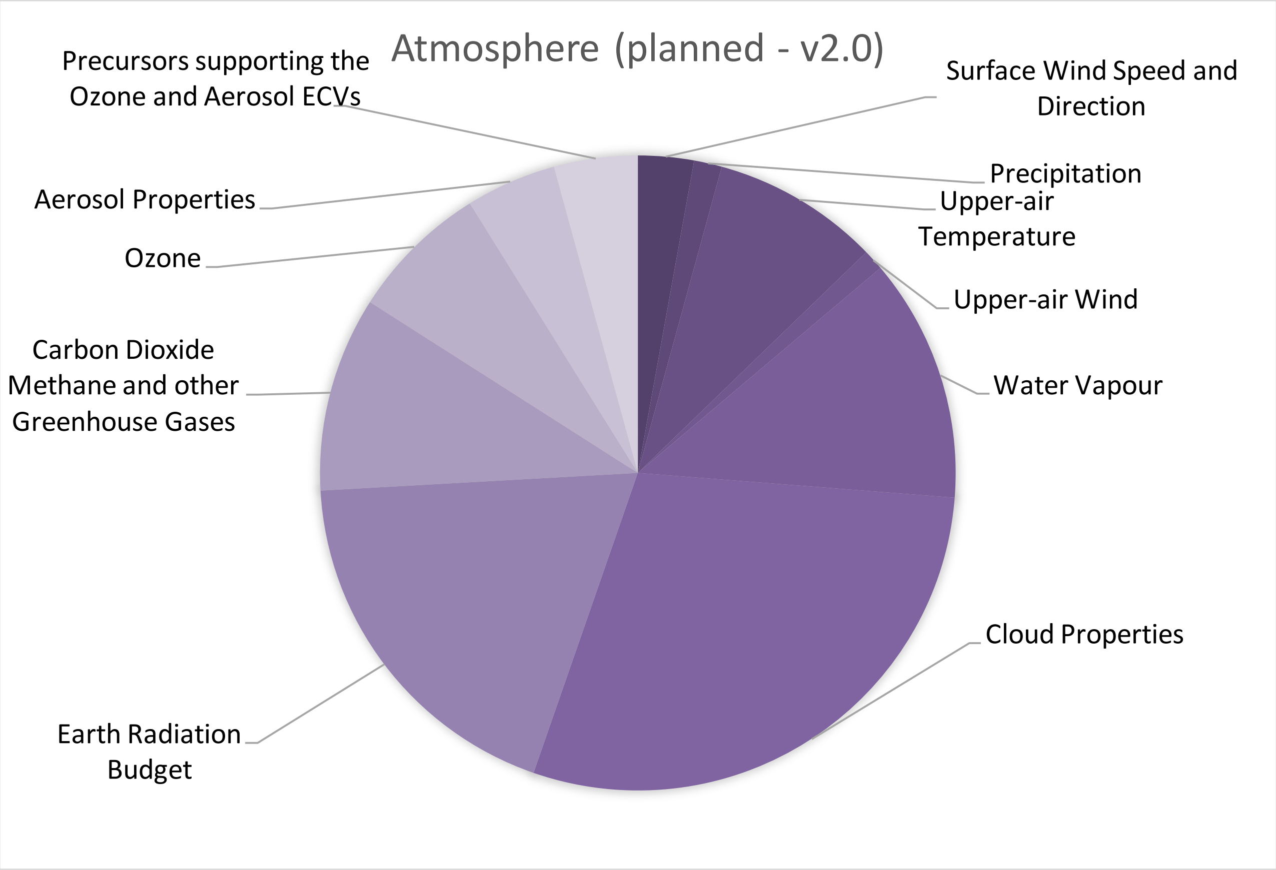
Maximum length possible: ~50 years.

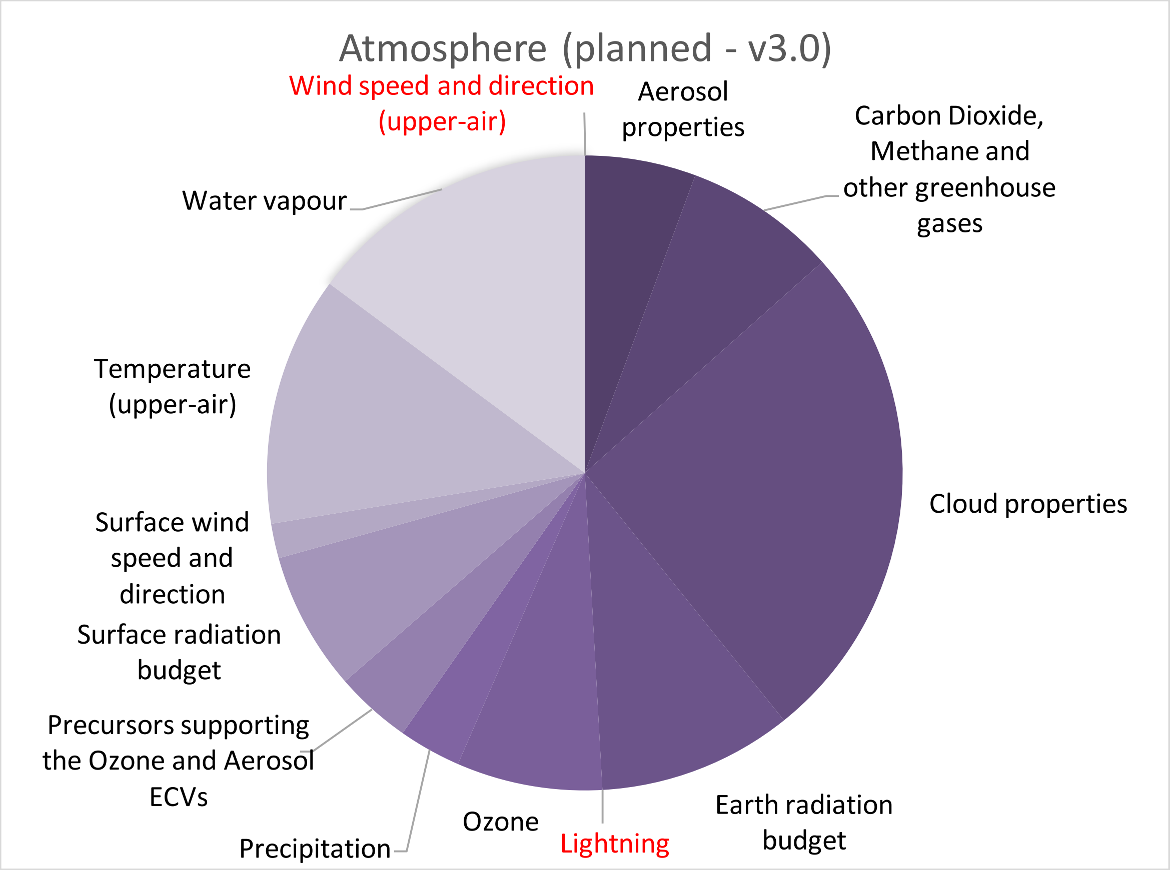
Existing Atmospheric Records



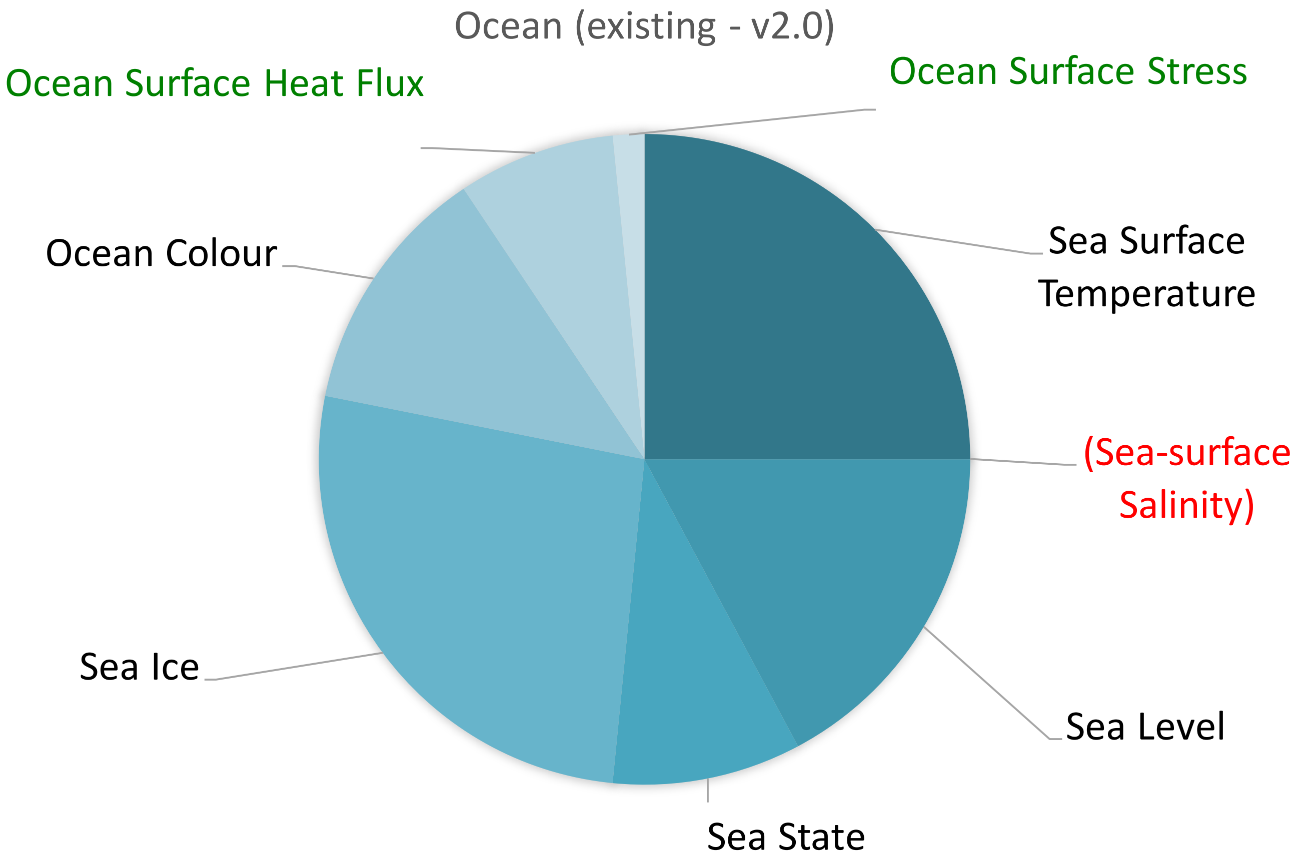


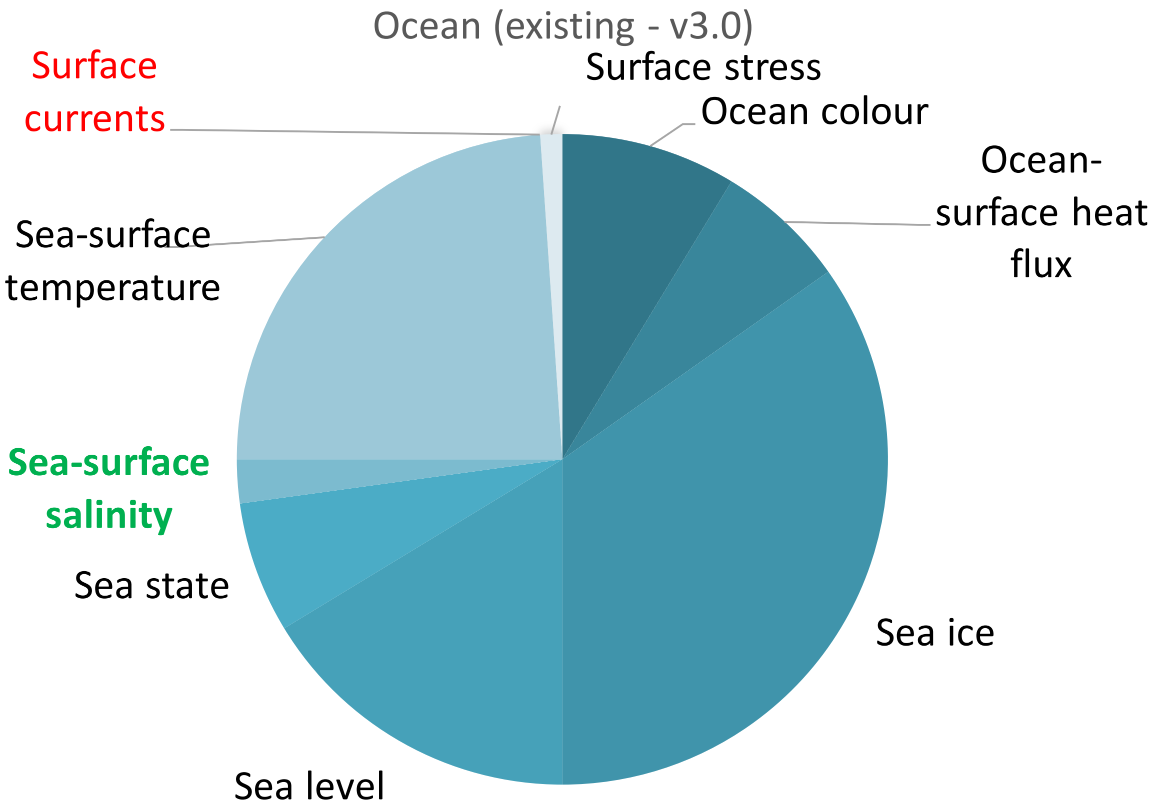
Planned Atmospheric Records



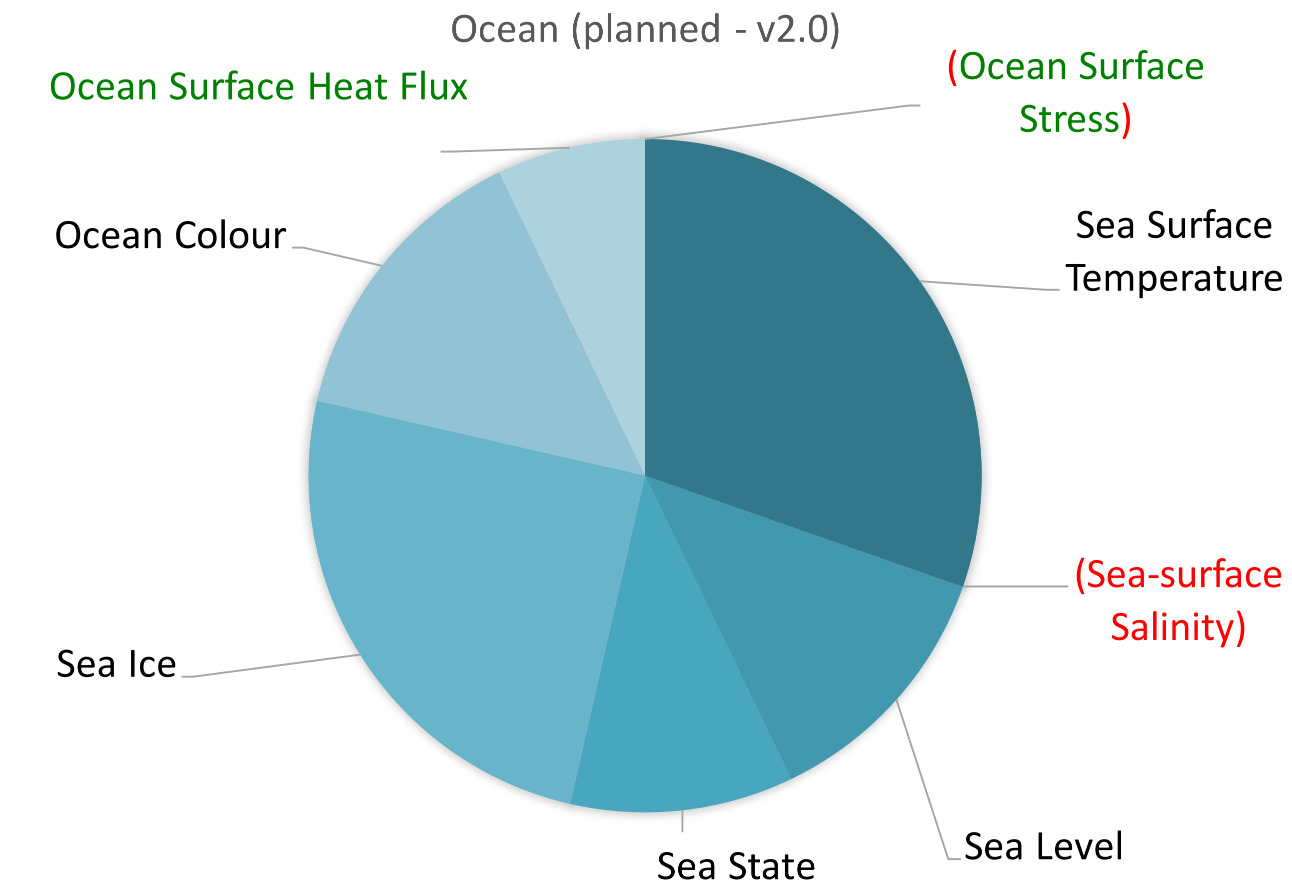


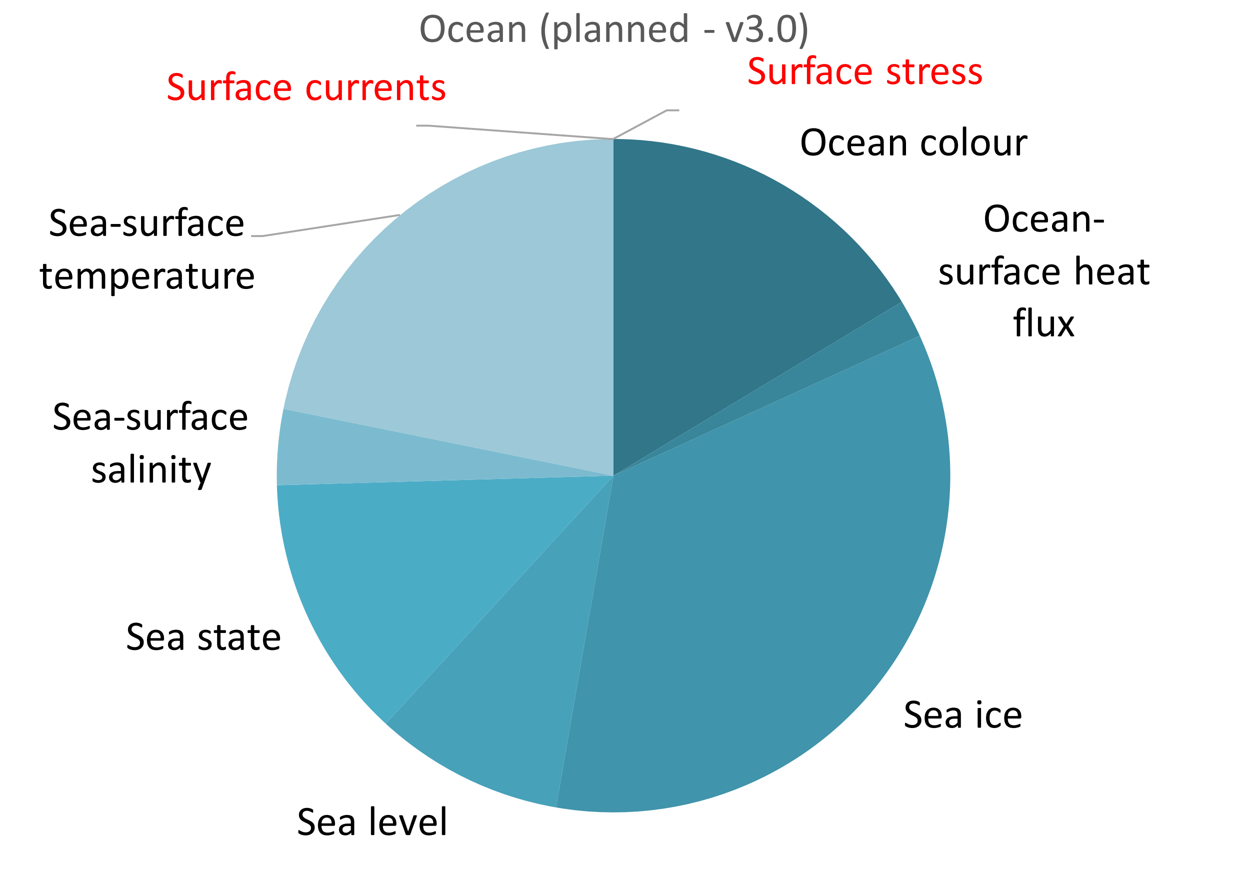
Existing Ocean Records



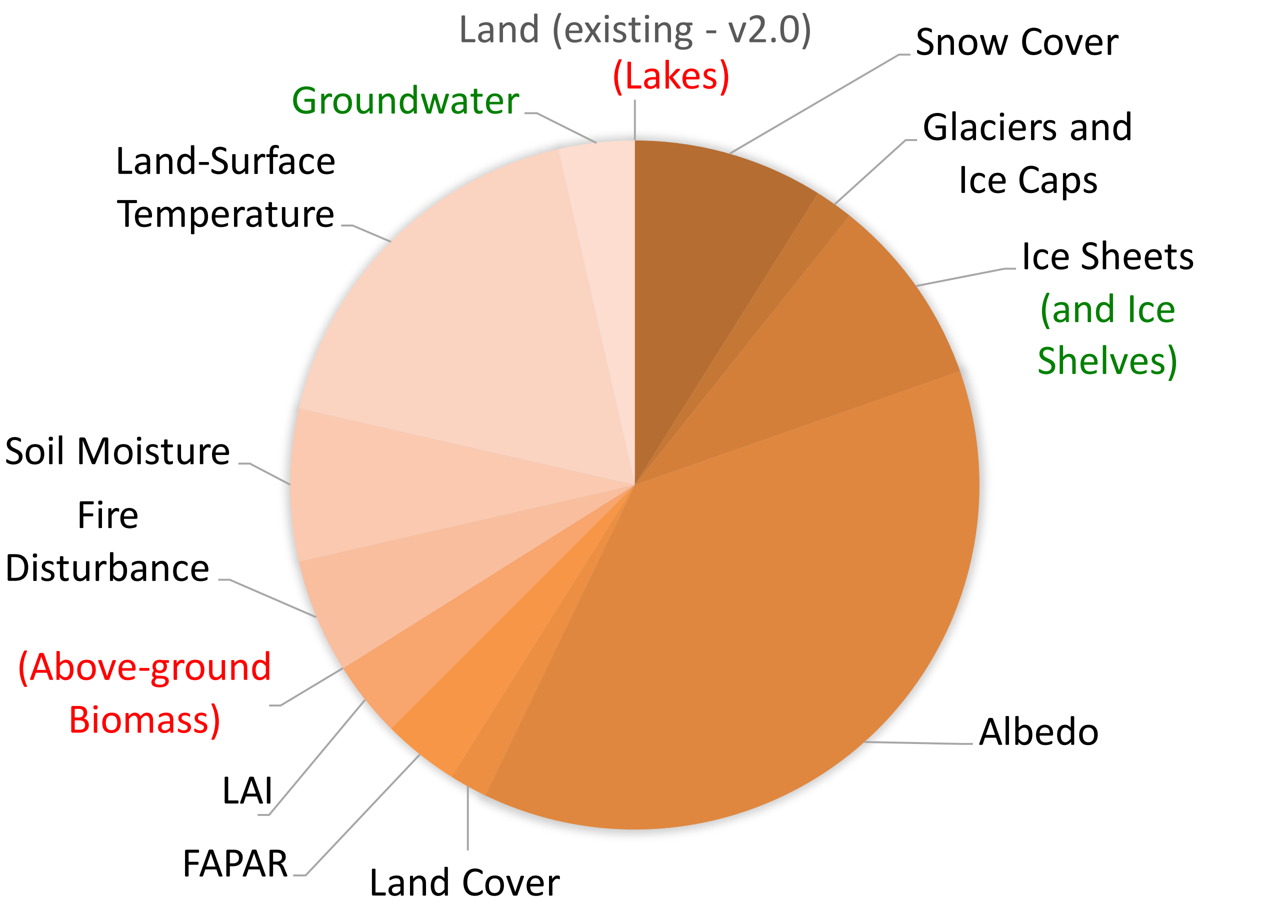


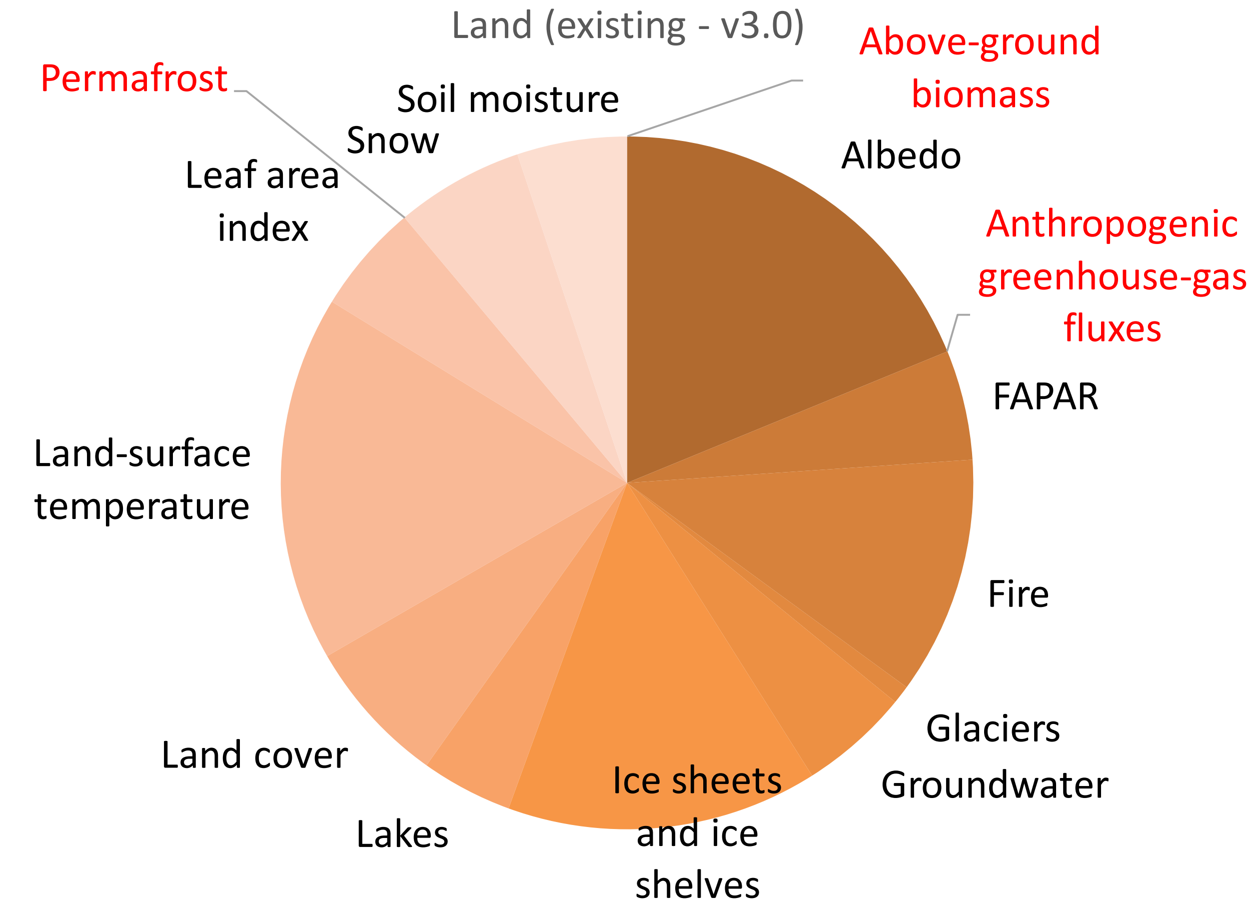
Planned Ocean Records



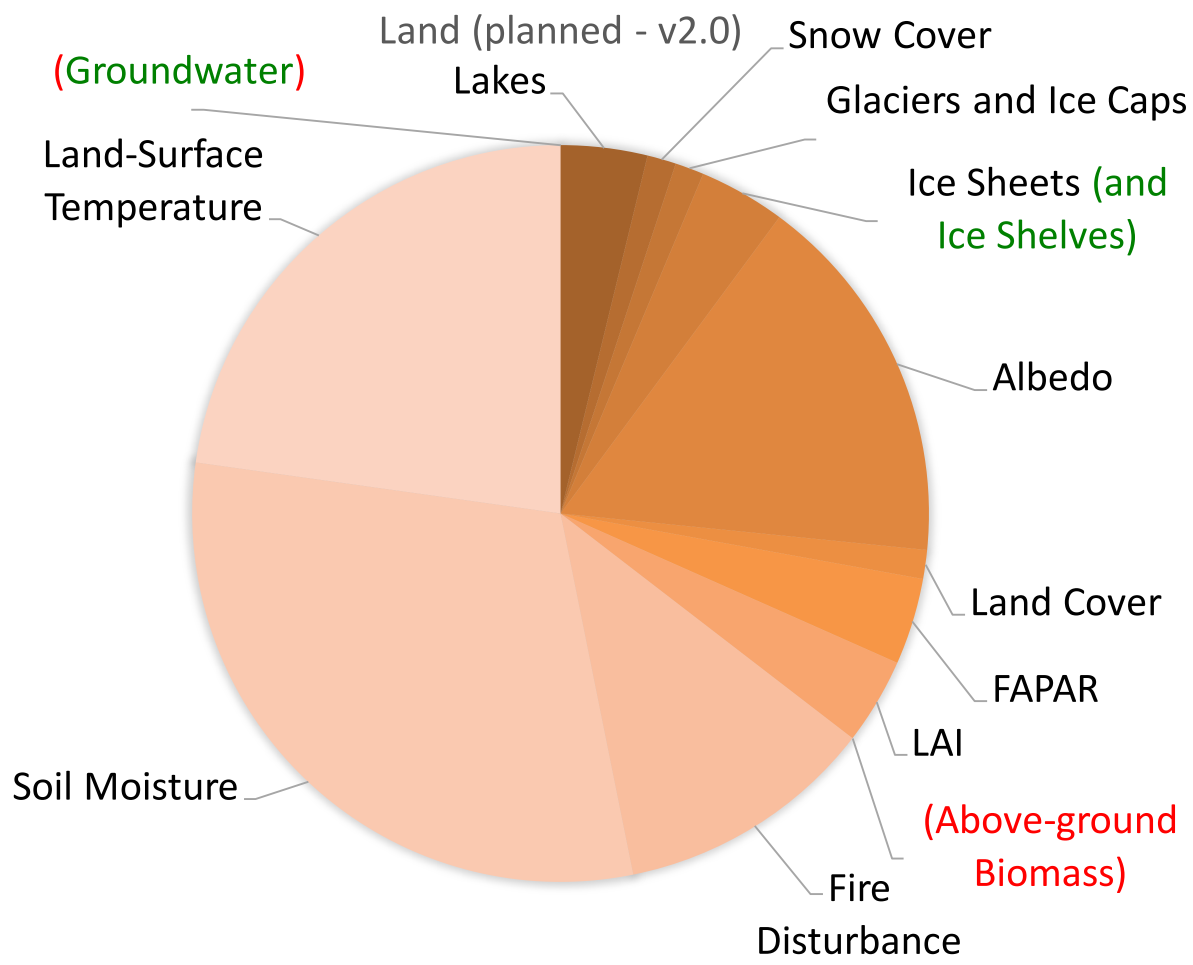


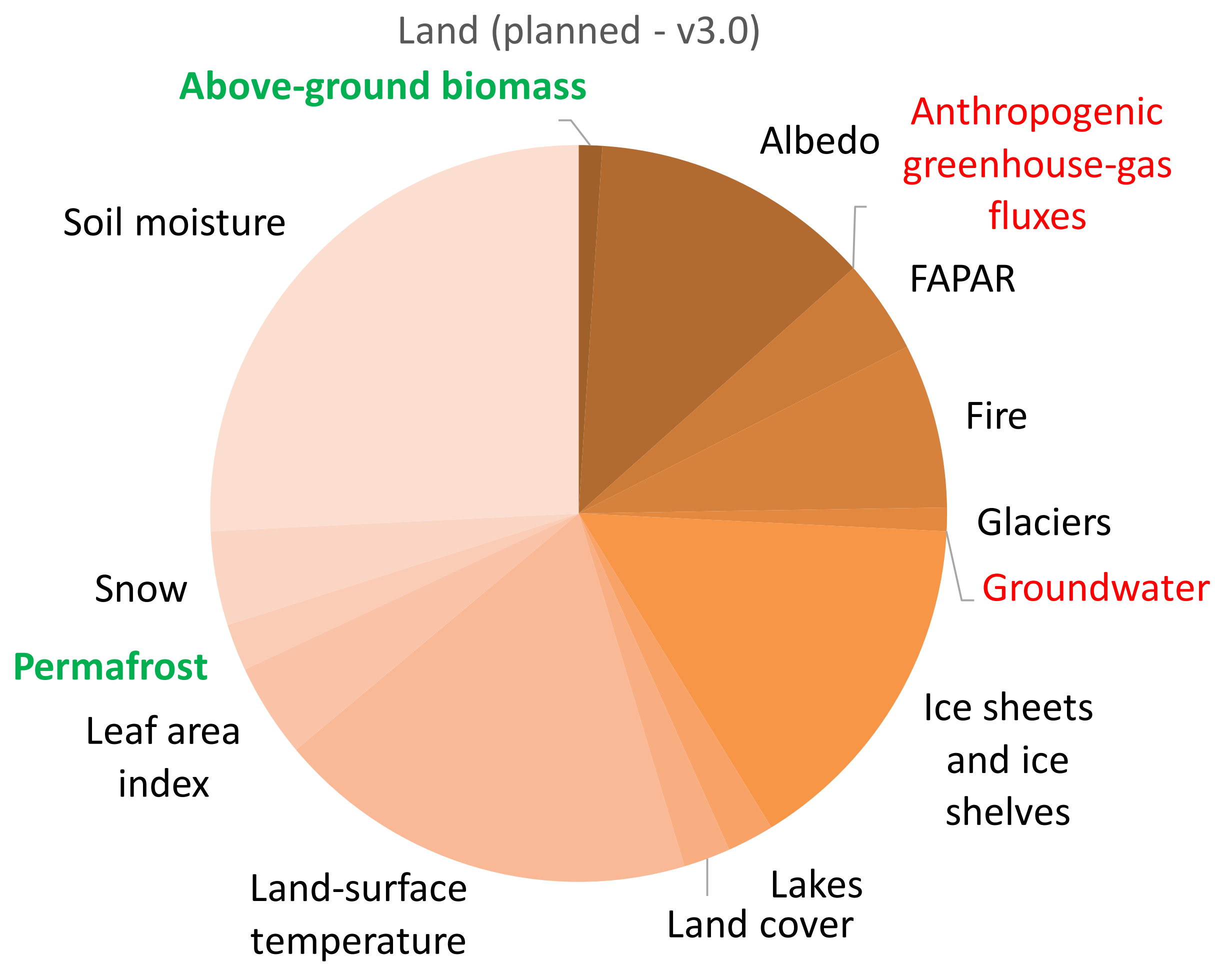
Existing Land Records



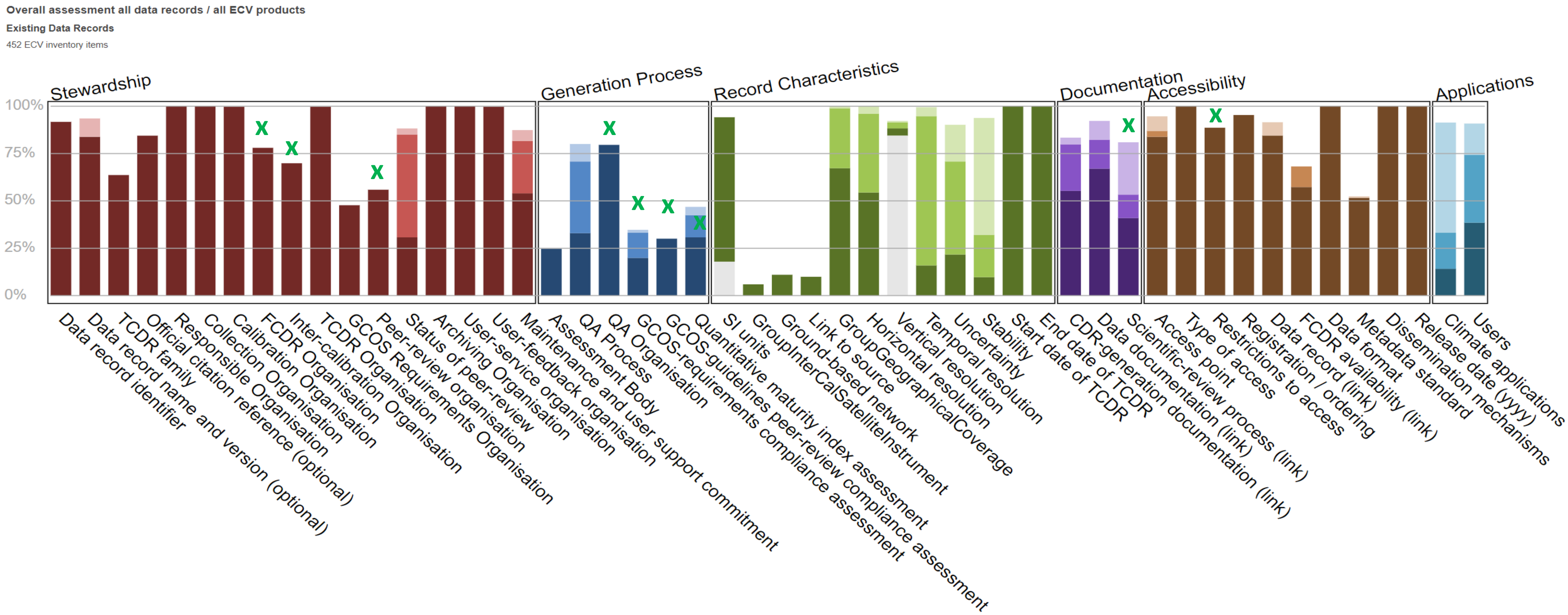


Planned Land Records

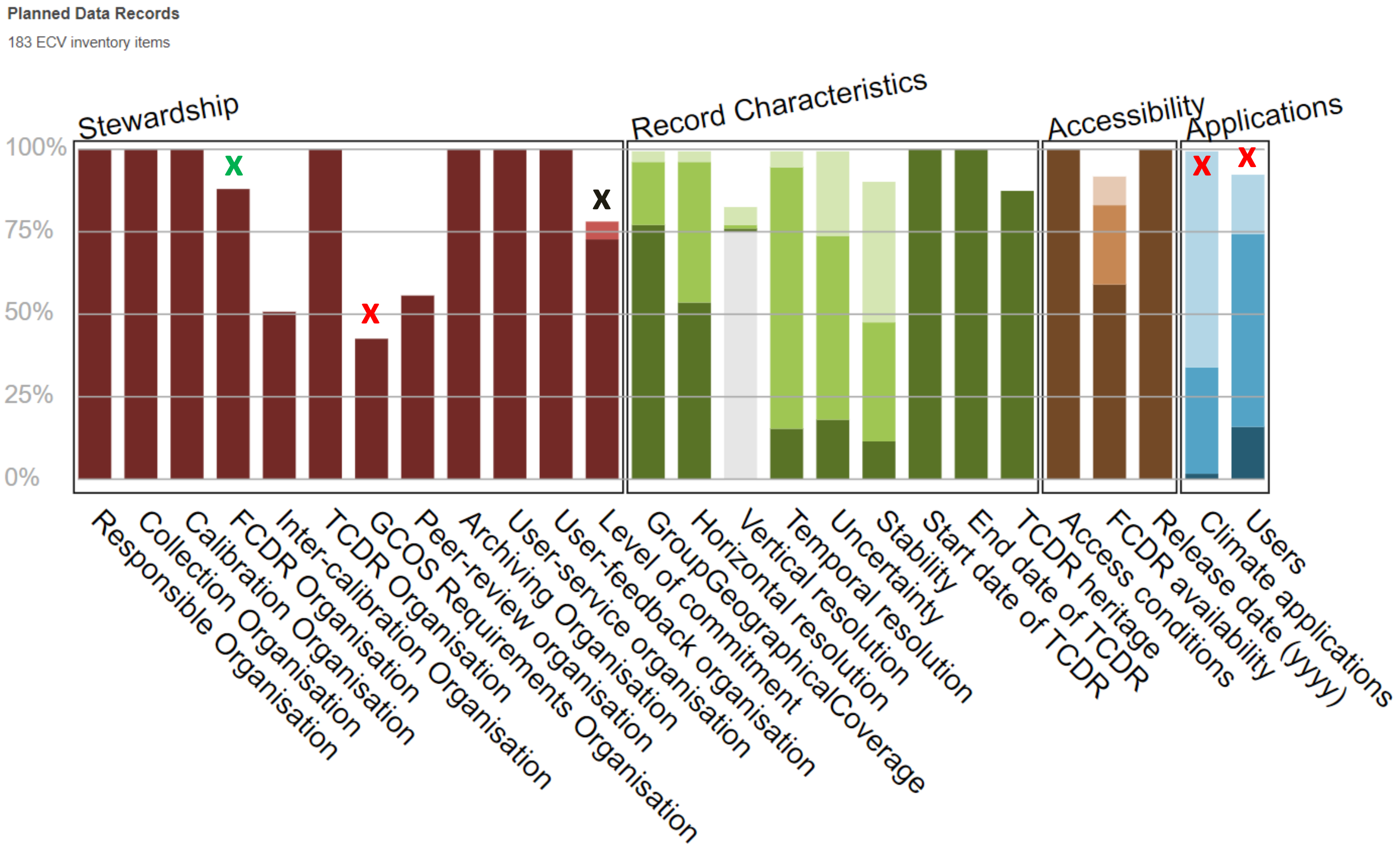




Assessment of GCOS Criteria for existing data records



Assessment of GCOS Criteria for planned data records



CEOS
Committee on Earth Observation Satellites

Water Vapour

CGMS

Total Column Water Vapour:

- Conically scanning, multi-channel passive microwave radiometers are the backbone of various TCWV CDRs;
- Maintenance of existing and non delayed launch of new sensors (AMSR-3, MWI, Weather Satellite Follow-on – Microwave (WSF-M)) is needed to avoid gaps. The issue is that an earliest launch is in 2022;
- 5G issue may hamper TCWV retrieval;
- There are still some unexplored microwave imagers for water vapour;
- New combinations of instruments shall be used in future, e.g., Sentinel-3 OLCI, SLSTR and EPS-MetImage, together with microwave observations over ocean;
- A follow up to GPM would also be useful for TCWV CDRs. Its decent temporal sampling, in combination with the U.S. DoD, EUMETSAT and JAXA missions in separate orbits, can be of interest for cross-ECV extreme analysis and associated process studies.

Water Vapour

- Profiles:
  - Different set of instruments needed below and above the tropopause
  - Below tropopause situation isn't bad with the availability of radio occultation, hyperspectral infrared and microwave sounding instruments
  - Above tropopause largely satellite limb sounders (e.g., from solar occultation, limb scattering, or limb emission) are used. There is an impending gap in water vapour measurements from stratospheric limb sounders
  - Climate data record quality of past limb measurements still remains to be assessed (currently underway in the ESA CCI WV and SPARC WAVAS), several currently proposed missions would promise highly improved measurement capabilities (EPS MACCS, ATMOSAT).

- Reviewer suggests to guarantee an unambiguous assessment of past and future data availability and to avoid the risk of missing to flag a substantial gap in data availability in UTLS profile measurements, the separation of the current ECV into a tropospheric profile ECV and a UTLS and S stratospheric profile ECV separately, should be considered to split ECV into two to highlight the difference.

Atmospheric Upper Air Wind

- This ECV is approached by Atmospheric Motion Vectors derived from VIS and IR imaging and more recently Doppler wind lidar observations (Aeolus)
- Some data records are missing from CIMSS and more general all from CMA
- GCOS requirements may only be in reach for AMVs combining instruments, vertical resolution only with Aeolus type of instrumentation
- There is a big amount of potential instruments to be used that haven’t been used including Russian and Indian imagers
- 3D AMVs are developed for IR sounders, data records could start in 2000, maybe earlier if HIRS and predecessors could be used
- After demonstration of positive impact on NWP Aeolus type missions should be operationalised to build long term records
- GCOS Action 19 is partly addressed by space agency planning of AMV reprocessing

Aerosol

- Detected strong issues in WMO OSCAR concerning the relevance category of missions for aerosol retrieval;
- On missions concluded:
  - Good coverage of AOD from 1995 (over ocean 1981) until now; with currently operating and scheduled sensors also assured into the future
  - Single Scattering Albedo good coverage only for 2005-2013; future perspectives only from ~2021 (3MI sensor – but no such planned product is contained in the ECV inventory)
  - Coverage of Aerosol Extinction Coefficient Profile 1984 – 2012, future perspectives with CALIOP and ATLID
  - Coverage of Aerosol Layer Height 2002-2018, future perspectives with IASI, CALIOP, ATLID

Aerosol

Missing data records:

- The ECV inventory contains only one set of datasets from geostationary platforms (MSG-SEVIRI AOD records covering 2004 - 2016);
- There is no single Asian dataset (from Chinese, Korean or Indian instruments) except planned datasets from JAXA (GOSAT, HIMAWARI), but they could provide valuable additional observations.
- A few well established AOD records are missing: MISR product (this is one of three Obs4MIPs aerosol datasets); a further MODIS record (MAIAC algorithm).
- One well established aerosol extinction profile dataset is missing: OSIRIS.
- The ECV inventory covers only the GCOS variables, but not further aerosol composition variables requested by the AEROCOM modelling community such as Fine-Mode AOD (can be inverted with SDA algorithm from AOD at 4 wavelengths), Dust AOD (can be measured at 10 micron from IASI, but needs uncertain conversion to 50nm).

Aerosols

- Future missions:
  - Some of the records listed in the ECV inventory exhibit gaps (e.g. between AATSR and SLTR there is a gap 2012 – 2016; between POLDER and 3MI there will be a gap 2014 - 2021)
  - Some show inconsistencies of their used instruments (e.g. AATSR forward view, / SLSTR rearward view; channel differences between MODIS and VIIRS) between similar instruments on different missions
  - Lacking cross-sensor consistency / long-term multi-sensor CDRs is a principal issue which is due to responsibilities at space agencies being assigned on single mission level (e.g. ATSR-2 / AATSR / SLSTR or MODIS / VIIRS); here cross-mission responsibilities for series of similar instruments are needed.
  - There exist limitations in validation reference data needed to comprehensively assess data quality (e.g. coverage in remote areas or coastal zones with case 2 waters, accuracy of inverted aerosol properties such as SSA for low AOD, coverage of vertical profile measurements); to overcome this limitation, long-term systematic flight campaigns in different zones of the globe are needed.
  - There are limitations of historic coverage with aerosol-specific sensors (in particular over land) before 1995. To overcome those, more research is needed in exploiting combined capabilities of older weak sensors.
- Also missing long term planning was identified for SSA with 3MI and MISR stereometric products for aerosol layer height.

Sea level

- A large majority of CDRs already listed in the inventory have missing information related to the stewardship, the documentation and above all, the quality assessment process. This missing information is of major importance for the users to better understand the difference between the different products of each ECV, produced by different entities.
- Three additional existing global mean sea level CDRs are produced and distributed by different international groups and have not been listed in the inventory. These existing CDRs are produced by the Colorado university (http://sealevel.colorado.edu/), the CSIRO (http://www.cmar.csiro.au/sealevel/sl_data_cmar.html) and NOAA (https://www.climate.gov/maps-data/dataset/global-mean-sea-level-graph).
- Regional sea level ECV products dedicated to high latitudes already exist (ESA SL_cci) but have not been listed in the ECV inventory: one regional sea level CDR in the Arctic Ocean (based on the Envisat and SARAL/AltiKa missions) and a second regional sea level CDR in the Arctic Ocean and the Antarctic Ocean (based on ERS-1 & 2, Envisat and CryoSat-2 missions).

Sea Level

- On global and regional scale, continuity of the altimetry missions and of the sea level processing are required in the future to ensure the continuity and homogeneity of the different sea level ECV products;
- FCDR quality is affected by the change of measurement approach, it will be essential to ensure the production of the Sentinel-6/Jason-CS FCDR based on the historical Low Resolution Mode measurements to support climate applications;
- Continuity of the global mean sea level after 2030 requires the continuity of the current measurements.

Sea Level

Missing opportunities:

- Sea ice extent and snow thickness could be derived from altimetry data which should be encouraged for cross comparions and reduction of uncertainty in all products

GCOS requirements:

- It is thus essential to go beyond the individual assessment of single ECVs and to have a global approach to check the homogeneity of the different variables to ensure their combined use.

Soil Moisture

Missing Existing Data records:

- SMAP 9 km LPRM soil moisture (NASA, VdS)
- SMAP 9 km L2 Soil Moisture SCA (NASA)
- SMAP 9 km IC soil moisture (NASA, CESBIO, INRA) – launched 2015!
- AMSR-E/2 25 km IC soil moisture (NASA/JAXA, CESBIO, INRA)
- AMSR -E/2 25 km L2 Soil Moisture SCA (NASA)
- GPM GMI 25 km LPRM soil moisture (NASA/JAXA, VdS)
- SMOS 25 km IC soil moisture (ESA, CESBIO, INRA)
- Sentinel 1 1 km Soil moisture (Copernicus Land Service)
- Metop C Level 1b VV Polarization (Eumetsat)

In addition, 3 future data records were identified that should be included in the inventory:

- Metop SG (Eumetsat)
- CIMR multifrequency passive microwave mission (ESA)
- ROSE L-band SAR Mission (ESA)

-> For none of these instruments a committed or best-effort plan is in place.

Soil Moisture

Recommendation 1: Agencies to support L-band passive microwave missions and to plan for the generation of L-band based ECV soil moisture data records based on the data collected by instruments on missions such as SMOS, SMAP, and in the future CIMR.

Recommendation 2: To develop an ensemble of different soil moisture retrieval algorithms which could form the base for a further improved continuity of the soil moisture CDR.

Recommendation 3: Agencies to support L-band SAR missions and algorithm development for ECV soil moisture data records based on the data collected by SAR-L band instruments such as Aquarius and the future mission ROSE-L.

A few more headlines for ECVs

- Burnt area: Several NASA records seem to be missing in the inventory;
- Land Cover: 2 global (MODIS and VIIRS) and several regional data records seem missing, e.g., USGS LCMAP;
- Sea State: Properly resolving wave spectra is key to providing the necessary reference data for the calibration and validation of numerical wave models. CFOSAT is a first step towards resolving the shorter waves. The Sea surface KInematics Multiscale monitoring (SKIM) mission may resolve longer waves (> 10m);
- Ocean Surface Heat Flux: No specific analysis on instruments is needed as this is covered by individual ECV analysis for SST and wind speed or by analogues for water vapour and precipitation;

Issues observed in the process

- Observed decline in support to population, verification and gap analysis for ECV Inventory #3 within CEOS/CGMS agencies and bodies
- Gap analysis Topic 2 on GCOS criteria was hardly to finish, committed contributions were not realised in some cases;
- Gap analysis Topic 3:
  - Quality of expert contributions varies strongly
  - WMO and CEOS relevance estimates of missions seems not useful in many cases
  - Some experts seem not to understand the questions asked (others do very well)
  - There is a danger of biased assessment, seemingly trying to generate funding for specific activities of the experts

Needed support for ECV CDR Inventory and Gap Analysis

- It is of high importance that the inventory only contains verified information on which we base recommendations and actions
- Estimated support to the ECV Inventory work is ~ 6.5 PY per annum assuming 220 working days:
  - ~2.0 PY, (1.5 PY funded by EC) EUMETSAT support
  - ~0.5 PY, WGClimate members coordinating individual agency contributions
  - ~3.5 PY, ~150 responders in agencies populating and verifying the ECV Inventory (5 working days is assumed for each responder)
  - ~0.7 PY, ~30 individuals supporting the gap analysis (two stages (i) closeness of processes to GCOS guidelines, ii) analysis of individual GCOS ECVs including future need for measurements and missed opportunities) (5 working days is assumed for each person)
- Agencies were asked at CEOS TW and CEOS Plenary to continue/enhance their support to the ECV Inventory related work and to award full appreciation to engaged contributors within their agencies

Proposal for Discussion

- Reduce number of data records in ECV Inventory by:
  - Resolving the multiple spatial and temporal resolution issue where this is the only difference (keep the highest and mention others);
  - Keep only latest version of an existing data record in the inventory;
  - Ask GCOS to reduce the number of ECV Products to the products that are retrieved from measurements and not modelled from a set of ECV Products (or reduce the ECV Inventory to those);
  - Apply the definitions for CDRs (when widely accepted) and restrict the ECV Inventory to those, .i.e., all short data records will not be accepted. Has the risk that content does not serve some applications, in particular for research, or keep data records but concentrate analysis only on CDRs;
  - Review the questionnaire with the aim to reduce the number of questions, maybe based on new accepted guidelines published by WGClimate to produce a CDR from satellite data;
  - Assess the automatic harvesting option with respect to updated guidelines;
  - Etc.

Proposal for Discussion

- Decouple in time ECV Inventory update from gap analysis, i.e., ECV Inventory #x in year 1 is analysed in year 2.
- Reformat the gap analysis work into one workshop event per year collating experts on ECVs to perform the gap analysis. First was planned for 31/08-04/09/2020@EUMETSAT but will most likely not go ahead;
- Schedule 2020:
  - For 2020 concentrate on finishing ECV Inventory #3 report;
  - Concentrate on chasing the identified missing data records for ECV Inventory #4;
  - Perform analysis of ECV Inventory #4 in 2021 with a gap analysis workshop.