C3S Climate Data Store workshop

ECMWF, Reading, UK
3-6 March 2015

Existing Solutions:

EUMETSAT Satellite Application Facility on Climate Monitoring

Martin Werscheck
Deutscher Wetterdienst
CM SAF: Content

- Mandate
- EUMETSAT Satellite Application Facility (SAF) network
- Products
- Users
- Downstream application (examples)
- CM SAF & Copernicus Climate Change Service
- Planning 2017 - 2022

www.cmsaf.eu
CM SAF: Mission Statement

The Satellite Application Facility on Climate Monitoring

develops

generates

archives

disseminates

high quality satellite data derived products of the

energy and water cycle

and related

sustained services

in support to understand our climate
Climate Data Records

Climate trends, variability and processes

Validation and satellite simulators

Mitigating

Adapting

Observing

Predicting

Understanding

Modelling

CM SAF
CM SAF: The EUMETSAT SAF Network

- **CM SAF**: Climate Monitoring
  - EUMETSAT Member States
  - EUMETSAT Cooperating States

- **H SAF**: Support to Operational Hydrology and Water Management
  - EUMETSAT Member States

- **O3M SAF**: Ozone and Atmospheric Chemistry Monitoring
  - EUMETSAT Member States

- **LSA SAF**: Land Surface Analysis
  - EUMETSAT Member States

- **NWC SAF**: Support to Nowcasting and Very Short Range Forecasting
  - EUMETSAT Member States

- **OSI SAF**: Ocean and Sea Ice
  - EUMETSAT Member States

- **NWP SAF**: Numerical Weather Prediction
  - EUMETSAT Member States

- **ROM SAF**: Radio Occultation Meteorology SAF
  - EUMETSAT Member States
CM SAF: Partners

- **EUMETSAT Member States**
- **EUMETSAT Cooperating States**
- **CM SAF Member States**
- **Location of Partner NMHSs**

- **Swedish Meteorological and Hydrological Institute**
- **Koninklijk Nederlands Meteorologisch Instituut**
  *Ministerie van Infrastructuur en Milieu*
- **Royal Meteorological Institute of Belgium**
- **Schweizerische Eidgenossenschaft**
  *Confédération suisse*
  *Confederazione Svizzera*
  *Confederaziun svizra*
- **Finnish Meteorological Institute**
- **Met Office, United Kingdom**

3-6 March 2015
<table>
<thead>
<tr>
<th>Year of release</th>
<th>Temporal coverage of CDR</th>
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<tbody>
<tr>
<td>2017</td>
<td>TCDR SSM/I Ed. 2</td>
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<td>TCDR MVIR/SEVIRI Ed. 3</td>
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<td>ICDD SEVIRI Ed. 2</td>
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<td>ICDD GERB/SEVIRI Ed. 2</td>
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<td></td>
<td>ToA fluxes</td>
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<tr>
<td>2014</td>
<td>ICDD SEVIRI Ed. 1</td>
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<td>2013</td>
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<td></td>
<td>FTH</td>
</tr>
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<td>2012</td>
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<td>ToA Rad</td>
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<td>2008</td>
<td>EDR ATOVS</td>
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<td></td>
<td>global</td>
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<tr>
<td>2007</td>
<td>EDR SEVIRI</td>
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<tr>
<td></td>
<td>Africa &amp; Europe</td>
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<tr>
<td>2006</td>
<td>EDR SEVIRI</td>
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<tr>
<td>2005</td>
<td>EDR AVHRR LAC</td>
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<td></td>
<td>Europe</td>
</tr>
<tr>
<td>2004</td>
<td>EDR GERB/SEVIRI</td>
</tr>
<tr>
<td></td>
<td>Africa &amp; Europe</td>
</tr>
</tbody>
</table>

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Copernicus CDS; M. Werscheck
CM SAF: TCDRs of ECVs

Essential Climate Variable (ECV) Inventory

- CNES
- EC
- ESA
- Eumetsat (90% from CM SAF)
- Jaxa
- JMA
- NASA
- NOAA
- USGS
- Multiple or not selected

Courtesy: Alain Ratier, EUMETSAT
## CM SAF: Radiative Product

<table>
<thead>
<tr>
<th>Radiation</th>
<th>Acronym</th>
<th>Europe &amp; Africa Coverage</th>
<th>global Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Radiation Budget</td>
<td>SRB</td>
<td>◊</td>
<td>●</td>
</tr>
<tr>
<td>Surface Incoming Shortwave</td>
<td>SIS</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Surface Net Shortwave</td>
<td>SNS</td>
<td>◊</td>
<td>●</td>
</tr>
<tr>
<td>Direct Irradiance at Surface</td>
<td>SID</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Direct Normalized Irradiance at Surface</td>
<td>DNI</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>Spectrally Resolved Irradiance at Surface</td>
<td>SRI</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>Daylight</td>
<td>DAL</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>Surface Albedo</td>
<td>SAL</td>
<td>◊1</td>
<td>●, ○, ●1</td>
</tr>
<tr>
<td>Cloud Albedo</td>
<td>CAL</td>
<td>-</td>
<td>●</td>
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<tr>
<td>Cloud Radiative Effect SW &amp; LW</td>
<td>CFS/L</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>Surface Net Longwave</td>
<td>SNL</td>
<td>◊</td>
<td>●</td>
</tr>
<tr>
<td>Surface Downward Longwave</td>
<td>SDL</td>
<td>◊</td>
<td>●</td>
</tr>
<tr>
<td>Surface Outgoing Longwave</td>
<td>SOL</td>
<td>◊</td>
<td>●</td>
</tr>
<tr>
<td>Top of Atmosphere Reflected Solar Radiative Flux</td>
<td>TRS</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Top of Atmosphere Emitted Thermal Radiative Flux</td>
<td>TET</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Top of Atmosphere Incoming Solar Radiation</td>
<td>TIS</td>
<td>◊</td>
<td>-</td>
</tr>
</tbody>
</table>

- Available
- not available
◊ data are only available until March 2012
1 including Arctic
○ planned
## CM SAF: Cloud & Aerosol Products

**Water Vapour + Temperature, radiances**

<table>
<thead>
<tr>
<th>Cloud &amp; Aerosol</th>
<th>Coverage</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acronym</td>
<td>Europe &amp; Africa</td>
<td>global</td>
<td></td>
</tr>
<tr>
<td>Cloud Fractional Cover</td>
<td>CFC</td>
<td>●1</td>
<td>○</td>
</tr>
<tr>
<td>Cloud Optical Thickness</td>
<td>COT</td>
<td>●</td>
<td>-</td>
</tr>
<tr>
<td>Cloud Phase</td>
<td>CPH</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Cloud Top Temperature/Height/Pressure</td>
<td>CTO</td>
<td>●1</td>
<td>○</td>
</tr>
<tr>
<td>Cloud Water Path (ice &amp; liquid)</td>
<td>CWP</td>
<td>●</td>
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<tr>
<td>Liquid Water Path</td>
<td>LWP</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Ice Water Path</td>
<td>IWP</td>
<td>-</td>
<td>●</td>
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<tr>
<td>High Cirrus Cloud Amount</td>
<td>CA</td>
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<td>●</td>
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<tr>
<td>Joint Cloud property Histograms</td>
<td>JCH</td>
<td>◊</td>
<td>-</td>
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<tr>
<td>Cloud Type</td>
<td>CTY</td>
<td>◊</td>
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<tr>
<td>Cloud Mask</td>
<td>CFC</td>
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<td>●</td>
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</table>

<table>
<thead>
<tr>
<th>Water Vapour + Temperature, radiances</th>
<th>Coverage</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Vertically Integrated Water Vapour</td>
<td>HTW</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Layered Water Vapour and Temperature</td>
<td>HLW</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Specific Humidity and Temperature at pressure levels</td>
<td>HSH</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Free Tropospheric Humidity</td>
<td>FTH</td>
<td>-</td>
<td>●</td>
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<tr>
<td>Land Surface Temperature</td>
<td>LST</td>
<td>-</td>
<td>o</td>
</tr>
<tr>
<td>Microwave Radiances</td>
<td>FCDR-SSMI</td>
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</table>

- Available
- not available
1 including Arctic
○ planned

◊ data are only available until March 2012

3-6 March 2015

Copernicus CDS; M. Werscheck
## CM SAF: HOAPS Product

<table>
<thead>
<tr>
<th>HOAPS</th>
<th>Acronym</th>
<th>Europe &amp; Africa</th>
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<tbody>
<tr>
<td>Latent Heat Flux</td>
<td>LHF</td>
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<td>●</td>
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<tr>
<td>Precipitation</td>
<td>PRE</td>
<td>-</td>
<td>●</td>
</tr>
<tr>
<td>Evaporation</td>
<td>EVA</td>
<td>-</td>
<td>●</td>
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<td>Freshwater Flux</td>
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<td>Near Surface Specific Humidity</td>
<td>NSH</td>
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<tr>
<td>Vertically Integrated Water Vapour</td>
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<td>-</td>
<td>●</td>
</tr>
</tbody>
</table>

- Available
- not available
- including Arctic
- planned

- data are only available until March 2012

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[Image]
CM SAF cCloud, Albedo & Radiation dataset, AVHRR-based, Edition 1

Overview

The CLARA-A1 dataset is a global dataset of cloud, surface albedo and surface radiation products derived from measurements of the Advanced Very High Resolution Radiometers (AVHRR) onboard the polar orbiting NOAA and Metop satellites. Monthly and daily mean products have been compiled over a time period of 28 years starting in 1982 and ending in 2009. Results are available for individual satellites as well as aggregated for all satellites. The data are provided on two types of grids: one global regular latitude-longitude grid with 0.25 degrees resolution and two equal-area grids covering the polar regions with 25 km resolution (products on the polar grids are resampled to cloud amount and surface albedo). Further extensions, e.g. single- and multi-parameter histograms, and subsets, e.g. daytime-only and night-time only results, are also available.

Available documentation

- Product User Manual
- Algorithm Theoretical Basis Document
- Validation Report


Satellite Input Data

Temporal coverage of used AVHRR instruments aboard NOAA and Metop satellites.

Products

<table>
<thead>
<tr>
<th>Fractional Cloud Cover</th>
<th>CPC</th>
<th>Surface Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint Cloud property Histogram</td>
<td>JCH</td>
<td>Surface Net Shortwave Radiation</td>
</tr>
<tr>
<td>Cloud Top Height, Temperature, Pressure</td>
<td>CTC</td>
<td>Surface Outgoing Longwave Rad.</td>
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<td>Cloud Optical Thickness</td>
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<tr>
<td>Cloud Phase</td>
<td>CPH</td>
<td>Surface Net Longwave Rad.</td>
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<td>Liquid Water Path</td>
<td>LWP</td>
<td>Radiation Budget</td>
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<td>Ice Water Path</td>
<td>IWP</td>
<td>Cloud Radiative Effect short wave</td>
</tr>
<tr>
<td>Surface Incoming Shortwave Radiation</td>
<td>SIS</td>
<td>Cloud Radiative Effect long wave</td>
</tr>
</tbody>
</table>

Technical Specifications

- Temporal resolution: daily mean, pentad mean, monthly mean, monthly histograms (depending on product)
- Spatial coverage: global on a regular latitude/longitude grid (polar areas: equal area)
- Spatial resolution: 0.25° x 0.25° [JCH: 1° x 1°; polar areas: 25x25 km²]
- Data Format: NetCDF 3, Climate and Forecast (CF), Metadata Convention v1.5
  Note: On request, data are also available reformatted using the CMOR (http://www2-permi.lnl.gov/CMOR/library compliant with Obs4MIPS (https://www.earthsystemgrid.org/projects/obs4mips/) file format standard.

Free Data Access & Contact

www.cmsaf.eu/wui
User help desk: contact.cmsaf@dwd.de
The definition, generation and the release of a CM SAF Climate Data Record undergoes a three-step, rigorous peer review process:

**Requirement Review (RR)**
- Assess the adequatness and feasibility of the product requirements

**Product Consolidation Review (PCR)**
- Assess the maturity of the algorithm selected / developed for product generation
- Assess the infrastructure capability to generate the data set

**Delivery Readiness Review (DRR)**
- Assess the validation results agains the defined product requirements
- Assess the readiness to deliver the data record

**Operations Review (OR) (annual review)**
- Assess the level of compliance of the delivered products & services against the Service Specifications
CM SAF: Processing Centres

Satellite Data Reception/Procurement

DWD, Offenbach
- Local Archive
- Product generation at DWD
- Product generation at ECMWF

Product generation at RMIB

RMIB, Brussels
- Local Archive
- Scientific development and validation at RMIB

Scientific development and validation at DWD, KNMI, SMHI, MeleoSwiss, FMI, UKMO

Interdependency

CM-SAF Database, DWD

Central Archive

USER
- WUI, CM SAF
- EO Portal, EUMETSAT
- FTP-SERVER DVD etc.

EDR generation at CAF (planned)
CM SAF: Data Access

Free and easy access via

https://wui.cmsaf.eu/

WUI allows:

• Easy selection and online ordering of Data Records
• Standing orders
• Postprocessing, i.a.
  • Reformating of data
  • Area selection (also CORDEX areas)
  • On request some data are available compliant with Ops4MIPs

Offline tools:

• Graphical User Interface (cloud & radiation products)
• Climate Data Operators (CDO)
• R tools
CM SAF: Users

CM SAF Users by Reporting Period

<table>
<thead>
<tr>
<th>Reporting Period</th>
<th>Number of Registered Users</th>
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<tr>
<td>1/2007</td>
<td>94</td>
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<tr>
<td>2/2007</td>
<td>120</td>
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<tr>
<td>1/2008</td>
<td>137</td>
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<tr>
<td>2/2008</td>
<td>176</td>
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<tr>
<td>1/2009</td>
<td>195</td>
</tr>
<tr>
<td>2/2009</td>
<td>221</td>
</tr>
<tr>
<td>1/2010</td>
<td>254</td>
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<td>1115</td>
</tr>
<tr>
<td>1/2014</td>
<td>1301</td>
</tr>
<tr>
<td>2/2014</td>
<td>1501</td>
</tr>
</tbody>
</table>
CM SAF: Users

- Research Institute: 46%
- Meteorological Service: 34%
- Private Company: 12%
- Government Service: 8%
- Others: 0%

Bar chart showing the number of registered users from 1/2007 to 2/2014.

- 1/2007: 94
- 2/2007: 120
- 1/2008: 137
- 2/2008: 176
- 1/2009: 195
- 2/2009: 221
- 1/2010: 254
- 2/2010: 319
- 1/2011: 382
- 2/2011: 477
- 1/2012: 568
- 2/2012: 687
- 1/2013: 860
- 2/2013: 1115
- 1/2014: 1301
- 2/2014: 1501

World map showing countries with up to 10 users, up to 100 users, and more than 100 users, with new users in 2014 marked.
CM SAF: User support

- **User (requirements) workshops**
- **User training workshops**
- CM SAF community site (http://training.eumetsat.int/enrol/index.php?id=147)
- User help desk
- User information & documentation, including i.a.
  - Newsletter
  - Service Messages
  - Change logs
  - FAQs
  - Product User Manuals (PUM)
  - Algorithm Theoretical Baseline Documents (ATBD)
  - Validation Reports (ValReps & Annual Quality Assessment; AQA)
  - Operations Reports

**Upcomming**

- Commentary Metadata
- Maturity Matrix (System & Application)

**Web Mapping Services (WxS)**
New: PVGIS expanded to cover Asia. Click here to read about it.

## CM SAF: FCDR -> TCDR -> ICDR

<table>
<thead>
<tr>
<th></th>
<th>FCDR</th>
<th>TCDR</th>
<th>ICDR</th>
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</thead>
<tbody>
<tr>
<td><strong>CDR type</strong></td>
<td>Fundamental Climate Data Record</td>
<td>Thematic Climate Data Record</td>
<td>Intermediate Climate Data Record</td>
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<tr>
<td><strong>CDR description</strong></td>
<td>Calibrated / Intercalibrated Sensor data</td>
<td>Long time series of Essential Climate Variables</td>
<td>Regular &amp; consistent updates of TCDRs</td>
</tr>
<tr>
<td><strong>Provider</strong></td>
<td>Satellite operators</td>
<td>e.g. CM SAF</td>
<td>GCFS?, RCC?, C3S?</td>
</tr>
</tbody>
</table>

### Climate Monitoring & Services

- FCDR
- TCDR
- ICDR

3-6 March 2015

Copernicus CDS; M. Werscheck
CM SAF: Downstream Application; Example 2 WMO Regional Climate Centre RA VI

Thematic Climate Data Record  Long time series of Essential Climate Variables  Intermediate Climate Data Record  Regular & consistent updates of TCDRs

http://www.dwd.de/rcc-cm
CM SAF: FCDR -> TCDR -> ICDR

CM SAF

- Peer-reviewed dataset and method
- Continuous development and scientific updates of algorithms
- Clear traceability of user requirements
- High quality
- Well documented
- User support & training

??

- Consistent with TCDR datasets
- Based on TCDR expertise & team
- Regular updates
- Esp. for climate monitoring and services
- Capitalize on TCDR production & service environment
CM SAF: From data to information

CDS → CIS → O&D

Climatological
Background
Information:
Thematic Climate
Data Records
TCDR

Climatological
Up-to-date
Information:
Intermediate Climate
Data Records
ICDR

• Maps & films
• Statistics
• Indices &
• Indicators
• ....

• Interactive
• User-taylored
• Post-processing
• Web-Mapping
services
• others
Currently drafting the proposal for 2017 – 2022:

- Continue with successful product & service portfolio

- Extend to
  - ("Real") Global ("All") Precipitation Climate Data Record
  - Include Global Evapotranspiration Climata Data Record

- Focus on Thematic Climate Data Records (long time series of ECVs) (at the cost of other activities, e.g. ICDRs?)
CM SAF: Summary

Products & services related to the global energy & water cycle

Thorough quality assurance & control mechanisms

Comprehensive user interaction and support

Ready to contribute to C3S

Ready to consider adjustments / tayloring / adding to C3S on request (remember proposal writing now!)

www.cmsaf.eu