National Climate Observing System (GCOS Switzerland)

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Vorlesung ‘Grundlagen Fernerkundung’, Universität Zürich, 28. April 2015
Outline

• Global Climate Observing System (GCOS)
• GCOS & Satellites
• GCOS Switzerland
• Use of satellite-based products within GCOS Switzerland
  → Cloud cover
  → Glaciers
• Conclusions and Outlook
• Established in 1992; co-sponsored by WMO, UNEP, IOC-UNESCO and ICSU

• 3 Scientific Panels: 'Atmosphere', 'Ocean' and 'Terrestrial'

• 'Systematic observation' in UN Framework Convention on Climate Change (UNFCCC)

• Objective: ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users

Global Climate Observing System → GCOS Secretariat at WMO = International Coordination

Swiss GCOS Office at MeteoSwiss = National Coordination
Global Climate Observing System

  → GCOS Essential Climate Variables (ECVs)

  → GCOS Monitoring Principles (10 +10 satellite)
  → Importance of national and regional actions
  → Need for a major, sustained, satellite component
Action C10: Earth Observation Satellites:
“… A detailed global climate record for the future critically depends upon a major satellite component. …”
GCOS & Satellites

GCOS
“Satellite Supplement”

2006
Conclusions COP12, Nairobi:

"The SBSTA invited the Parties that support space agencies to enable these agencies to implement, to the extent possible, the actions identified in the CEOS report and to continue responding in a coordinated manner through CEOS to the efforts to meet these needs."

2009: Guideline for the Generation of Satellite-based Datasets and Products meeting GCOS Requirements (GCOS-128)

2006: Support to the Committee on Earth Observation Satellites (CEOS) Response to the GCOS Implementation Plan – September 2006
GCOS & Satellites

- ESA Climate Change Initiative (CCI)
- EUMETSAT Climate Monitoring IP

CEOS Progress Report
COP14 Poznan 2008

GCOS Switzerland | Vorlesung Universität Zürich, 28. April 2015
Dr. Gabriela Seiz
GCOS & Satellites

→ Decision ‚Systematic climate observations‘
→ Decision REDD (National monitoring systems)
→ Important role of satellite data (‘global view‘)

COP15 Copenhagen 2009
# GCOS Essential Climate Variables (ECVs)

<table>
<thead>
<tr>
<th>Domain</th>
<th>Essential Climate Variables</th>
</tr>
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</table>
| Atmospheric       | **Surface:** Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour.  
                   | **Upper-air:** Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties.  
                   | **Composition:** Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties. |
| Oceanic           | **Surface:** Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure.  
                   | **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton. |
| Terrestrial       | River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Biomass, Fire disturbance. |

ECVs largely dependent upon satellite observations  

**Source:** GCOS Implementation Plan 2004, GCOS Satellite Supplement 2006
Global products: cloud cover

- MODIS (onboard Aqua)
- Monthly Mean Cloud Fraction product (Daytime), April 2005 (Collection 5)

(M. D. King, S. Platnick et al., 2006 – NASA GSFC)
Global products: cloud cover

Terra: ~ 10.30 am
Aqua: ~ 13.30 pm

July 2002 – July 2004

(M. D. King, S. Platnick et al., 2006 – NASA GSFC)
GCOS Switzerland

• Ratification of Kyoto Protocol by Swiss Parliament in 2003
  → National Focal Point for GCOS at Federal Office of Meteorology and Climatology MeteoSwiss
  → since 1 February 2006: Swiss GCOS Office

• Swiss GCOS Office = National GCOS Coordination

• Annual National GCOS Round Table: Federal Offices, Research Institutions and Universities

→ Ensure the continuation of important long-term measurement series and international data centers as well as foster new measurement techniques and data series
GCOS Switzerland

Report “National Climate Observing System (GCOS Switzerland)” (Seiz and Foppa, 2007)

→ Inventory of
  a) Long-term measurements in Switzerland
  b) International Data and Calibration Centers
  c) Support of measurements in other countries

• Available in German, French and English
• Regular update of the inventory online at www.gcos.ch
Role of satellite data within GCOS Switzerland

- Goal: foster use of new measurement techniques within GCOS Switzerland

- Atmospheric Domain: Radiation, Clouds

- Terrestrial Domain: Snow cover, Glaciers, Fire Disturbance, Vegetation

→ Important: focus on specific issues of mountainous areas

Foppa et al. (2008), Seiz et al. (2009, 2011)
ECV Cloud Properties

Objective:
Comparison of satellite-based cloud cover from MODIS with other satellite-based products and ground-based measurements and observations

Products/Data:
Cloud Fraction from MODIS MOD 08 (Terra), monthly level 3 product, 1°x 1° spatial resolution, period 2000-present
ECV Cloud Properties

Monthly Mean Cloud Fraction (MODIS Terra) 01/01/2007

MODIS MOD 08, Monthly Mean Cloud Cover, January-December 2007
ECV Cloud Properties

MODIS MOD 08, Monthly Mean Cloud Cover, January-December 2007
ECV Cloud Properties

Monthly Mean Cloud Fraction (MODIS Terra) 01/01/2007

MODIS MOD 08, Monthly Mean Cloud Cover, January 2007

GRUAN Station Payerne
ECV Cloud Properties

- MODIS MOD08 Monthly Mean Cloud Fraction, 2000-2009,
  Courtesy: NASA LAADS
ECV Cloud Properties

- MODIS MOD08 Monthly Mean Cloud Fraction, 2000-2009, Courtesy: NASA LAADS
- CM-SAF Monthly Mean Cloud Fraction (from MSG SEVIRI), 2005-2009, Courtesy: CM-SAF, DWD
ECV Cloud Properties

- MODIS MOD08 Monthly Mean Cloud Fraction, 2000-2009, Courtesy: NASA LAADS
- CM-SAF Monthly Mean Cloud Fraction (from MSG SEVIRI), 2005-2009, Courtesy: CM-SAF, DWD
- Ground-based synop observations, monthly mean, 2000-2009
ECV Glaciers

- **Swiss Glacier Inventory**
  - 1850 (red), reconstructed from surveys and maps
    ~ 1,600 km²
  - 1973 (blue), aerial photographs
    1,340 km²
  - 2000, satellite-based
    1,050 km²
  - 2010, satellite-based
    945 km²

→ Paul (2007), Paul et al. (2008)
→ Fischer et al. (2010)

Courtesy: Frank Paul, University of Zurich
ECV Glaciers

- **Glacier Inventory worldwide**
  - World Glacier Monitoring Service (WGMS), University of Zurich
  - GLIMS (Global Land Ice Measurements from Space), NSIDC, Boulder, USA

→ ESA Project GlobGlacier
→ ESA CCI 'Glaciers'

Courtesy: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team
Conclusions and Outlook

- Potential of satellite-based products for climatological analysis over Switzerland

- Limits of current products and sensors, in particular in mountainous terrain and for regional and local scale

- Further analysis of satellite-based products
  - Clouds, Radiation, Ozone, Aerosols, CO2/CH4,
  - Lakes, Snow cover, Glaciers, Fire disturbance, Vegetation
  → ESA Climate Change Initiative
  → EUMETSAT SAF CDOP-2

- Use of satellite data for climate services (adaptation, mitigation)
«New Earth Observation satellites will complement the established observing systems to provide a more comprehensive integrated Global Climate Observing System for the future.»

John Zillman
Chairman World Climate Conference 3 (WCC-3)
Former Chairman GCOS Steering Committee
Thank you for your attention!

Dr. Gabriela Seiz

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Federal Office of Meteorology and Climatology MeteoSwiss

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Satellitenmeteorologie

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Vorlesung ‘Grundlagen Fernerkundung’, Universität Zürich, 28. April 2015
Inhaltsverzeichnis

• Geschichte
• Typen von meteorologischen Satelliten
• Von Meteosat First Generation zu Second Generation
• Anwendungen MeteoSchweiz
• Ausblick
Geschichte

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First meteorological satellite (MetSat) | TIROS-I (USA) | ESSA-1 (USA) | | | | | | | 
First operational MetSat | | | ATS-1 (USA) | | | | | | 
First geostationary MetSat | | | | | | | | | 
First Soviet MetSat | | | | | | | | | 
Introduction of Automatic Picture Transmission (APT) | | | Meteor-1m (USSR) | | | | | | 
First atmospheric sounder | | | | | | | | | 
Coordination Group for Meteorological Satellites (CGMS) | | | | | TIROS-1 (USA) | | | | 
First operational geostationary MetSat | | | | | | | | | 
First Japanese geostationary MetSat | | | | | | | | | 
First European geostationary MetSat | | | | | | | | | 
First water vapour imager | | | | | | | | | 
First operational atmospheric sounder | | | | | | | | | 
Global coverage achieved, for the First Global GARP Experiment (FGGE) | | | | | | | | | 
Start of continuous operational coverage | | | | | | | | | 
First regional consortium for operational MetSats | | | | | | | | | 
New generation of geostationary satellites | | | | | | | | | 
First Russian geostationary MetSat | | | | | | | | | 
European commitment to Joint Polar System | | | | | | | | | 
New generation of atmospheric sounders | | | | | | | | | 
New multi-functional satellite concept | | | | | | | | | 

First meeting of the CGMS
Satellites from the USA, USSR, Japan and Europe (ESA)
Geostationary satellites from Europe, Japan, USA,
Data gap over Indian Ocean
Establishment of EUMETSAT

GOES-8 (USA)
GOMS-1/Elektro (Russia)
NOAA-K (USA)
MTSAT (Japan)
Polar satellites from USA, USSR
Intergovernmental agreement on EUMESAT Polar System (EPS)
Geschichte

Launch TIROS-I: 1 April 1960

Courtesy: NASA
Geschichte

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<td>Start of continuous operational coverage</td>
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<td>First Russian geostationary MetSat</td>
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<td>European commitment to Joint Polar System</td>
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<td>New generation of atmospheric sounders</td>
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- TIROS-I (USA)
- ESSA-1 (USA)
- ATS-1 (USA)
- Meteor-I-m (USSR)
- ITOS-1 (USA)
- NOAA-2 (USA)
- First meeting of the CGMS
- SMS-1 (USA)
- GMS-1 (Japan)
- Meteosat-1 (ESA)
- Meteosat-1 (ESA)
- TIROS-N (USA)
- Satellites from the USA, USSR, Japan and Europe (ESA)
- Polar satellites from USA, USSR
- Data gap over Indian Ocean
- Establishment of EUMETSAT
- GOES-8 (USA)
- GOMS-1/Elektro (Russia)
- Intergovernmental agreement on EUMESAT Polar System (EPS)
- NOAA-K (USA)
- MTSAT (Japan)
Launch **Meteosat-1**: 23 Nov 1977

→ European Organisation for the Exploitation of Meteorological Satellites (**EUMETSAT**): since 19 Jun 1986 (1 Jan 1987)
Geschichte

1961

1978

1990

2009

Satellitenmeteorologie | Vorlesung Universität Zürich, 28. April 2015
Dr. Gabriela Seiz

Courtesy: WMO Space Programme
Typen von meteorologischen Satelliten

geostationär:
- 36‘000 km Höhe
- hohe zeitliche Auflösung
- Erdhemisphäre

polar-orbiting:
- ca. 800 km Höhe
- hohe räumliche Auflösung
- Streifen
- Abdeckung ganze Erde, inkl. Polarregionen
Geostationäre meteorologische Satelliten

METEOSAT: http://www.eumetsat.int/

GOES: http://rsd.gsfc.nasa.gov/goes/
Geostationäre meteorologische Satelliten

Meteosat satellites

- Meteosat-5 → not in operation since 2007
- Meteosat-6 → 57.5°E, Indian Ocean Data Coverage (IODC) (Backup)
- Meteosat-7 → 57.5°E, IODC
- Meteosat-8 → 3.5°E, Operational Meteosat satellite (Backup)
- Meteosat-9 → 9.5°E, Rapid Scan Service (RSS; 5min)
- Meteosat-10 → 0°, Operational Meteosat satellite
- Meteosat-11 (MSG-4)
Von Meteosat First Generation (MFG; bis Meteosat-7) zu Meteosat Second Generation (MSG; ab Meteosat-8)

<table>
<thead>
<tr>
<th>Canaux Channels</th>
<th>MFG (bis Meteosat-7)</th>
<th>MSG (Meteosat-8, etc.)</th>
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<tbody>
<tr>
<td>Visible</td>
<td>0.5 - 0.9</td>
<td>HRV</td>
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<tr>
<td></td>
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<td>VIS 0.6</td>
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<td>VIS 0.8</td>
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<td></td>
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<td>IR 1.6</td>
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<td>Vapeur d’eau</td>
<td>WV 6.4</td>
<td>WV 6.2</td>
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<td>Water Vapour</td>
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<td>WV 7.3</td>
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<tr>
<td>Infrarouge</td>
<td>IR 11.5</td>
<td>IR 3.8</td>
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<td>IR window</td>
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<td>IR 8.7</td>
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<td>IR 10.8</td>
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<td>IR 12.0</td>
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<td>Pseudo sondage</td>
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<td>IR 9.7</td>
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<tr>
<td>Pseudo sounding</td>
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<td>IR 13.4</td>
</tr>
<tr>
<td>Distance d'échantillonage</td>
<td>2.25 km (Visible)</td>
<td>1 KM (HRV)</td>
</tr>
<tr>
<td>Sampling distance</td>
<td>4.5 km (IR + WV)</td>
<td>3 KM (others)</td>
</tr>
</tbody>
</table>

Frequency

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<thead>
<tr>
<th>MFG (bis Meteosat-7)</th>
<th>MSG (Meteosat-8, etc.)</th>
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<tbody>
<tr>
<td>30 min</td>
<td>15 min</td>
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</table>
Von MFG zu MSG

V I S

IR

Meteosat-8 composite
Von MFG zu MSG

MSG: IMPROVED SPATIAL SAMPLING
(Example: 4 December 2002, 12:30 UTC)

 Courtesy: EUMETSAT
Von MFG zu MSG

MSG: IMPROVED TIME SAMPLING (Example: 8 June 2003)
Polar-orbiting meteorologische Satelliten

- NOAA
  http://www.oso.noaa.gov/poes/

- Envisat
  http://envisat.esa.int/

- Metop/EPS: Initial Joint Polar System (IJPS)
  http://www.eumetsat.int/Home/Main/Satellites/Metop
  Metop-A launched on 19 October 2006

- EOS-Terra

- EOS-Aqua
Polar-orbiting meteorologische Satelliten

- NOAA
  http://www.oso.noaa.gov/poes/

- Envisat
  http://envisat.esa.int/

Metop/EPS: Initial Joint Polar System (IJPS)
http://www.eumetsat.int/Home/Main/Satellites/Metop

ESA Earth Explorer satellites

- **SMOS** (Soil Moisture and Ocean Salinity)
  launched on **2 Nov 2009**

Metop-A
launched on
19 October 2006

Courtesy: ESA – AOES Medialab
Sensoren

- NOAA: AVHRR, AMSU
- Envisat (ERS-2): MERIS, AATSR (ATSR2), GOMOS (GOME), SCIAMACHY

Metop: AVHRR, IASI, GOME-2, AMSU
Anwendungsbeispiel: Schnee

• **Eumetsat Fellowship Projekt**, 2004-2007
  ETHZ - Institut für Geodäsie und Photogrammetrie
  MeteoSchweiz

• **Ziel:** verbesserte Schneeanalyse als Input für das
  operationelle Wettervorhersagemodell aLMo (= alpines
  Lokalmodell) der MeteoSchweiz
  → Nutzen der neuen Spektralkanäle (vs. Meteosat-7) und
    der hohen zeitlichen Auflösung (vs. NOAA AVHRR) von
    MSG
  → Assimilation der Schneedaten ins operationelle aLMo:
    a) 7 km, b) 2.2 km

• Operational processing chain: seit Okt 2005
  Operational use in NWP model COSMO: seit Nov 2006

Ruijter, Seiz and Gruen (RSE, 2007)
Spectral classification

\[(r_{0.64} > 0.25 \text{ AND } r_{1.6} > 0.30) \text{ OR } BT_{3.9} - BT_{10.8} > 10 \cos \theta_{\text{sun}} \text{ OR } BT_{10.8} < 253 \text{ K} \text{ OR } BT_{10.8} - BT_{12.0} > 1.5\]

no

\[
\text{NDSI} > 0.20 \text{ AND } r_{0.64} > 0.1 \text{ AND } r_{0.84} > 0.30 \text{ AND } BT_{10.8} < 288.15 \text{ K}\]

no

bare land

ty

cloud

no

snow

classification result:

UTC: 200403101057

white : snow
dark gray : clouds
light gray : snow-free land
black : sea
Meteosat-8 (SEVIRI) vs. andere Sensoren

Ruijter et al., 2007
Temporal classification?
Temporal classification?

Use of high temporal resolution

a) Temporal classification (image ± 2 images; 8 surrounding pixels)
b) Reduction of cloud coverage by composite maps
Anwendungsbeispiel: Schnee

Composite snow maps:
⇒ reduces area that is obscured by clouds

1 image:
10-3-2004, 10:57 UTC

24-hour period:
9-3-2004 12:00 UTC - 10-3-2004 12:00 UTC

white : snow
dark gray : clouds
light gray : snow-free land
black : sea
Anwendungen MeteoSchweiz

- Eumetsat Satellite Application Facilities (SAF)
  - Erweiterung der operationellen Eumetsat-Produkte
  - 8 thematische SAFs
  - dezentral
  - MeteoSchweiz:
    - Climate-SAF (CM-SAF)
Ausblick

- Aktive Satellitensensoren: Calipso (Lidar), Cloudsat (Wolkenradar)

*gestartet am 28. April 2006*

Courtesy: NASA
Cloudsat (Wolkenradar)

23 Aug 2006  GOES-11  21:00 UTC

Hurricane Ileana

Brightness Temperature (°C)

-70 -50 -30 -10 0 20 40

Courtesy: NASA/JPL/The Cooperative Institute for Research in the Atmosphere (CIRES), Colorado State University/NOAA
Cloudsat (Wolkenradar)

23 Aug 2006 GOES-11 21:00 UTC

[Brightness Temperature (°C)]

Hurricane Ileana

Eye

Courtesy: NASA/JPL/The Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University/NOAA
Ausblick

• Aktive Satellitensensoren: Calipso (Lidar), Cloudsat (Wolkenradar)

• Meteosat Third Generation (MTG)
  -> 2 platforms, MTG-I (imager) and MTG-S (sounder)
  -> 3-axis-stabilised
  -> 10min (+ rapid scanning 2.5min)
    500m+ resolution
    additional spectral channels
  -> launch in 2017 and 2019

• Post-EPS (launch ~2020)

• ESA Earth Explorers (eg. ADM-Aeolus, EarthCare) and GMES Sentinels (in particular Sentinel-3, -4 and -5)

• „Satellitenklimatologie“ -> Global Climate Observing System

gestartet am 28. April 2006