The ESA Cloud_cci dataset simulator
description and a demonstration assessing EC Earth Arctic cloud response to
the changing sea-ice cover

Salomon Eliasson¹, Karl–Göran Karlsson¹
Jan Fokke Meirink², Martin Stengel³

¹Swedish Meteorological and Hydrological Institute
² Royal Netherlands Meteorological Institute
³Deutscher Wetterdienst

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Introduction

Why satellite simulators?

- Model quantities, such as clouds should not be compared directly to satellite observations, because the following needs to accounted for:
  - Instrument-dependent sensitivities
  - Horizontal and vertical resolution
  - Microphysical assumptions in retrievals (and models)
- Product simulators simulate the cloud products that would been made from satellite measurements if the underlying atmosphere was that of the model.

Satellite simulators bridge the gap between models and observations
Introduction

Novelty of the ESA Cloud cci product simulator

- Is based on AVHRR data from meteorological satellites (35+ years)
- Is for comparing models to the optimal estimation-retrieved ESA Cloud cci products
- It provides output of daily maps of sampled model data so that it has the same local time as the satellite measurements (called level 2B).

- Takes orbital drift and would-be solar zenith angle into account.

http://www.remss.com/support/crossing-times

Salomon.Eliasson@smhi.se
Introduction

Development of the simulator

- In collaboration with EC Earth

- Plan to be installed in the Cloud Feedback Model Intercomparison Project (CFMIP) Observation Simulator Package (COSP)
- COSP allows models to output simulated observational datasets on the fly
- It is recognised as necessary tool for model–observation inter-comparisons such as in the IPCC reports
- Currently, this simulator can only be run “offline”, i.e. not in COSP
- Keeping around an “offline” version will useful for models that have not integrated COSP into their framework.
- Running the simulator in COSP in the model is preferable, since:
  - More efficient use of data resources, which allows for better temporal sampling
  - Will reach a larger user community
Method

ESA Cloud_cci product simulator

- Cloud properties are derived using the same retrieval method used to derive Cloud_cci products wherever possible.
- The structure of the simulator is as follows:
  1. Samples only the climate model input so that it has a local time corresponding to the satellite overpass times, taking orbital drift into account
  2. Calculates the “would-be” solar zenith angle
  3. Horizontally sub-divide the model grid into smaller “atmospheric columns” using scops.f
  4. Maps model fields to these “atmospheric columns” (emulating the measurement geometry)
  5. Estimate the cloud sensitivity by treating columns with $\tau < 0.2$ as cloud free
  6. Simulates spectral radiances and convert them to $T_b$
  7. Simulates cloud properties and make CTP-$\tau$ histograms
  8. Saves monthly statistics, effectively emulating the Cloud_cci level 3 (monthly) dataset

Salomon.Eliasson@smhi.se
Sample the model data to match the satellite equator crossing times based on the satellite ID and epoch.

Linearly interpolate all fields so that all grid boxes have the same local time = satellite overpass time.
The simulator reproduces the lack of sensitivity to thin clouds as expected in Cloud_cci cloud products.
Previous studies using AIRS liquid cloud fraction indicate a correlation between the sea ice extent and liquid cloud cover (Devasthale et. al. BAMS, under revision). This aspect is investigated as a test case of simulator usefulness.

Using CLARA-A2 observation data from 1982–1990 and 2006–2008 (AVHRR-based and similar to cloud_cci, and since cloud_cci observational data was not available)

Only illuminated months (here JJA)

The simulated observations are based on the EC Earth model atmosphere for the same period. It is a decoupled run using prescribed sea surface temperatures.
Clouds and Sea-ice

Correlation coefficient liquid cloud vs. sea ice

CLARA cloud fraction

EC Earth cloud fraction

CLARA cloud fraction

EC Earth cloud fraction

-0.6 -0.4 -0.2 0.0 0.2 0.4 0.6

NaN

Salomon.Eliasson@smhi.se
The occurrence of liquid clouds increases where the sea ice is detracting according to CLARA-A2 data (same with AIRS data).

It appears that EC Earth shows the opposite relation, a decreasing cloudiness where the ice is detracting.

More to follow…
Outlook

- Make a full scale study in the Arctic using Cloud_cci data from 1982–2015.
- Further improvements to the simulator
  - Include into COSP-v2
  - Take the satellite viewing geometry into account (artificially increase cloudiness due to parallax-like situations)
  - Make the optical depth limit more stochastical (e.g. hitrates of 0% at $\tau_c = 0.1$, 50% at 0.2, 100% at 0.3 or something like that)
  - Make the simulator faster
  - etc.