GRAPE

Global Retrieval of ATSR Cloud Parameters and Evaluation

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Abstract and Introduction: The aim of the GRAPE project is to produce a global cloud dataset using a state-of-the-art physical retrieval of the entire duration of the ATSR-2 mission (aboard ERS-2). This dataset will be compared and contrasted with existing climatologies (based on different instruments and very different retrieval algorithms). The cloud parameters produced will allow a direct comparison with model simulations from climate models. In addition GRAPE will also retrieve an aerosol optical depth from clear pixels.

A new cloud climatology based on ATSR-2

The GRAPE project is using ATSR-2 data to produce a new cloud database which includes the following parameters:

- Cloud Optical Depth
- Cloud Phase
- Cloud Particle Size
- Cloud Top Pressure
- Cloud Fraction
- Cloud Water Path

along with associated error measurements. The database will be based on retrievals carried out using ATSR-2 data from 1995 to at least 2001, and will be produced using a method developed for Meteosat Second Generation SEVIRI measurements and tested on ATSR-2 data (hereafter, the RAL algorithm). The RAL algorithm is an application of Optimal Estimation (OE) to the cloud retrieval problem: all available measurements and all available a priori information are combined using fast radiative transfer and known error characteristics to find the most probable values of all cloud parameters simultaneously.

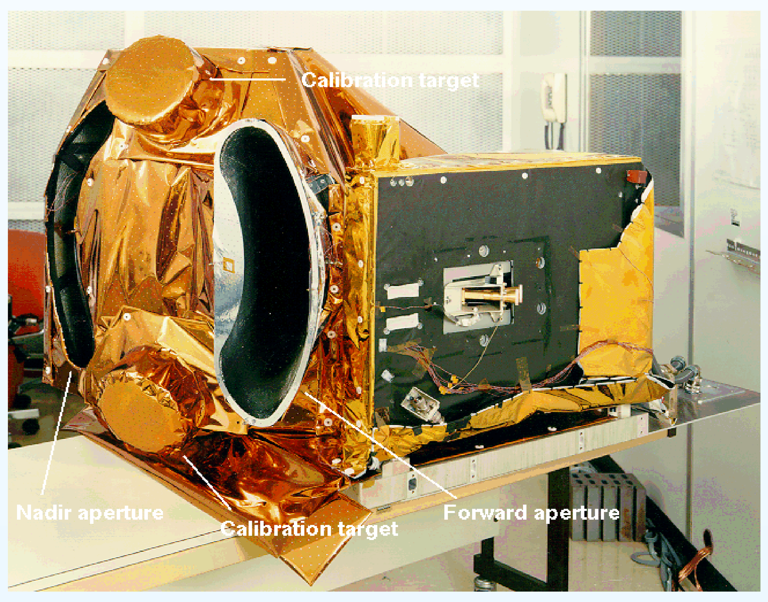
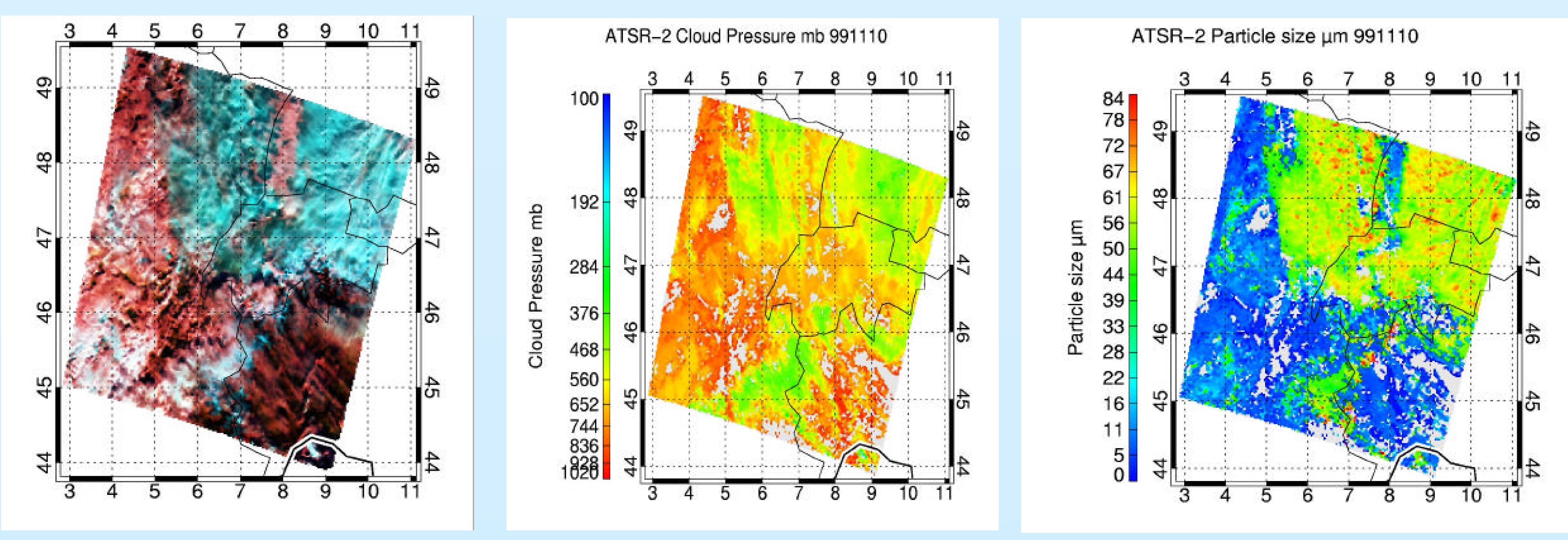


Figure 1. The ATSR-2 Instrument before deployment. ATSR-2 is a very well calibrated radiometer with 3 visible and 4 infrared channels (0.55, 0.67, 0.87, 1.6, 3.7, 10.8, 12.0 μm). ATSR's field of view comprises two 500 km-wide curved swaths, with 555 pixels across the nadir swath and 371 pixels across the forward swath. The nominal resolution is 1km.

The radiative transfer includes cloud, atmosphere and surface effects and (currently) assumes a plane-parallel single layer cloud (the 'model cloud').

The OE method presents several advantages:

- It is theoretically sound, based on radiative transfer calculations and modelled errors in the input information.
- It enables simultaneous use of all measurements, so that maximum information is extracted from the data set. (E.g. optical depth is normally best estimated from VIS channels as IR channels saturate very quickly, but in the extreme case of thin cloud over land the IR information becomes more useful than the VIS information which is compromised by the reflectance effects of the underlying surface. The OE method “knows” this and weights measurements appropriately.)
- It can use a priori information easily and accounts correctly for errors in this information.



(a) (b) (c)

Figure 2. (a) Is a false colour image of a 512x512 pixel ATSR-2 scene constructed from the three visible channels. The almost fully cloudy scene centred over Switzerland shows low, warm cloud in red and higher cold cloud in blue. (b) is the retrieved cloud top height. Grey areas indicate a failed retrieval. (c) is the retrieved effective particle radius. It is apparent that the retrieval is detecting large ice particles in the high cloud while the low cloud consists of much smaller water droplets.

Why produce a new cloud climatology?

Existing information about cloud properties is often limited to frequency information and optical thickness along with environmental data (e.g. cloud top temperature and pressure). The 7+ years of GRAPE data will provide a comparable length dataset to existing climatologies, and in conjunction with future data from the AATSR a very long duration dataset is possible. However, GRAPE will have the advantage of including additional parameters which are important for the development and validation of cloud parameterizations in climate models.

One microphysical parameter of great interest is the effective radius, r_e, of the droplets in clouds. This can be derived from the cloud liquid water, itself a prognostic variable in modern parameterizations. Our retrieval method provides an estimate of r_e (primarily based on the sensitivity of the 1.6 and 3.7 μm reflection to the size of the particles in the cloud), and this will be available wherever the retrieval is successful (i.e. near global coverage for the mission duration).

One of the major advantages of the ATSR-2 retrieval will be an accurate assessment of cloud phase. A rigorous comparison with numerical simulations will eventually be carried out in the context of trying to understand particular experiments, or to understand the climate behaviour of some specific model versions.

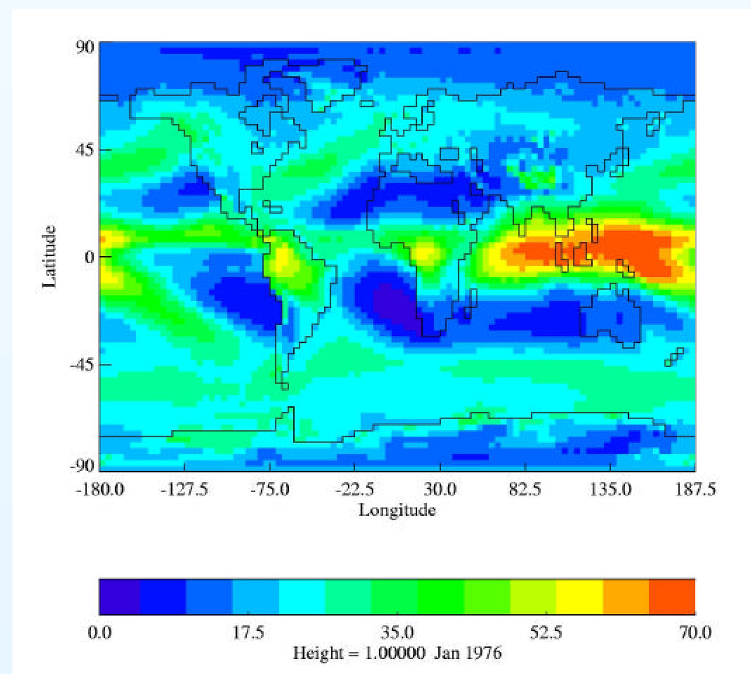
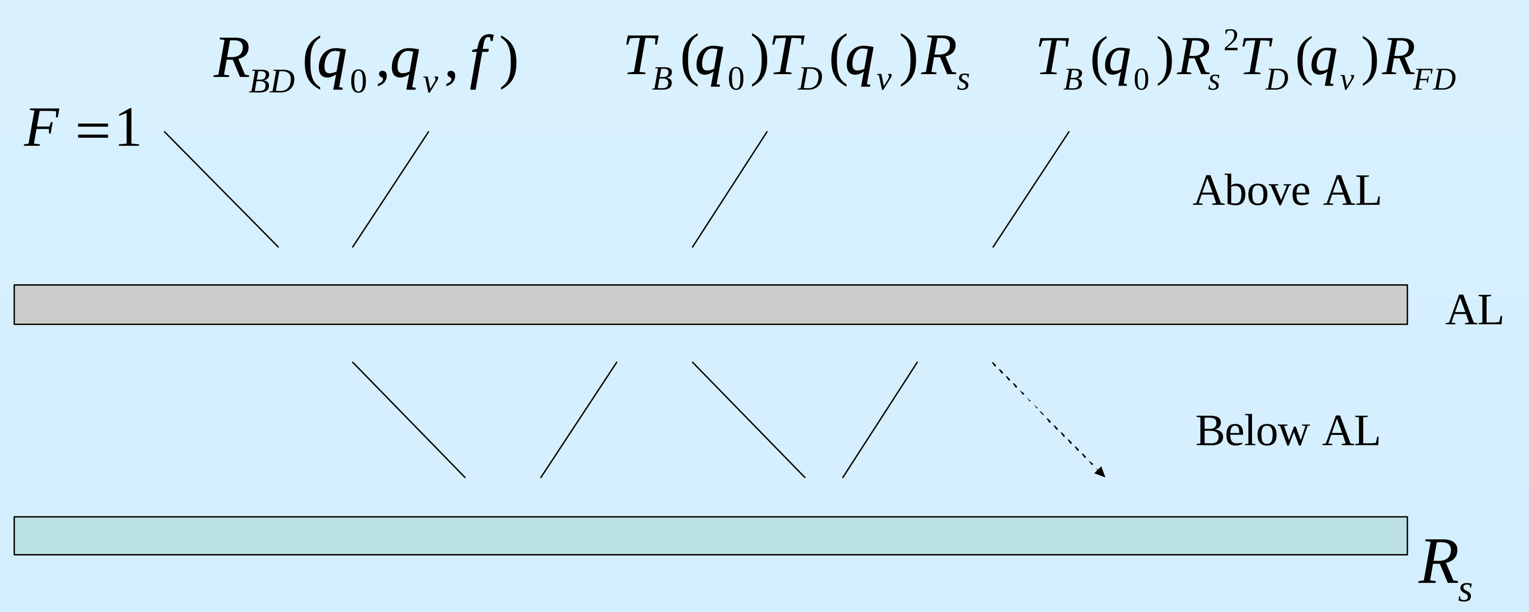


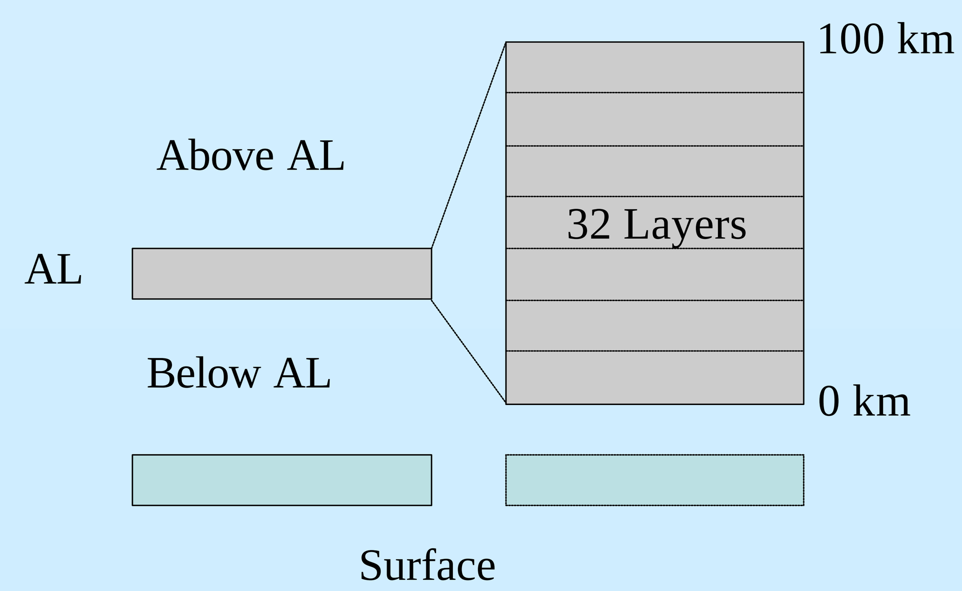
Figure 3. Climatological global high cloud (cloud top pressure < 400 hPa) from a ten year simulation of the Unfied Model. The cloud is sampled from the model in a similar way to the way in which ATSR observes the Earth's clouds.

Aerosols

A scheme to retrieve aerosol optical depth and effective radius from cloud free pixels is currently being implemented into the RAL algorithm. For efficiency the aerosol retrieval will utilise as much of the cloud forward model as possible. As such the effective TOA radiance is calculated for the following three layer scheme (above the aerosol layer (AL), the AL and below the AL)



Aerosol are distributed at appropriate height levels within the AL and a DISORT based 32 layer model predicts the effect on TOA radiance due to particle scattering, Rayleigh scattering and molecular absorption.



Conclusion: The first complete processing of the ATSR-2 dataset is expected to be finished by October 2003. A second production run is scheduled after further development and validation of the retrieval algorithm. The cloud and aerosol products will then be available through the British Atmospheric Data Centre.