SAC-C CLOUD ATLAS

Velasco, I.; Vidal, L. and Flores, A. L.

Universidad de Buenos Aires
Buenos Aires – Argentina

ABSTRACT
In this work we present the current stage of development of the SAC-C Cloud Atlas. This Atlas will include several examples of types of clouds and cloud systems observed with the argentine satellite SAC-C. It will also include a discussion of the spectral behavior analyzed through the data obtained from different bands and their combinations. In some cases, the examples provided are accompanied by sketches of air circulation alongside pictures taken from the ground, information and meteorological maps. All these will allow the user/reader to associate the cloud patterns in the images with weather conditions and be able to document the different scale circulations involved in their formation. Up to date, several examples of different scale cloud systems over southern South America and the near oceans have been put together. These illustrate synoptic and mesoscale vortices, shallow convection cloud fields, fog and convective clouds in different states of development. The publication of this Atlas is expected to fill the gap of a much needed reference guide for students of meteorology and other related sciences, elementary to intermediate and upper level teachers and the public in general.

INTRODUCTION

Historically, clouds were classified according to their general aspect observed from the ground. They were identified only at individual shape and altitude. The recognition of a cloud belonging to a certain class is a useful indication of the nature of the cloud and the atmospheric movements and processes which are present. Clouds were classified as low, middle or high level according to their base heights.

Formal definitions could be found in the World Meteorological Organization's International Cloud Atlas (1956). With the beginning of the Earth observation from space, it was possible to identify cloud patterns associated with circulation patterns observed in the meteorological charts. Other patterns were observed not yet identified in the charts, i.e. hurricanes (Kidder and Vonder Harr 1995). The scale of these last ones was smaller than the information provided by the regular meteorological networks.

Clouds formed under similar atmospheric conditions could be classified in individual categories based on their shape when they are observed from the ground. Every cloud type will exhibit a unique pattern on the satellite image. Once those patterns are recognized, it will be possible to identify the cloud type presented on a satellite image (Conway, 1997).

In this work we present only some examples developed to include in the SAC-C Cloud Atlas. The SAC-C is the first argentine satellite devoted to Earth observation. It was designed to study terrestrial and marine ecosystems and temperature and water vapor monitoring of the atmosphere, terrestrial magnetic field among other tasks. More details could be obtained from the CONAE web page. In the Atlas most of the images used were obtained by SAC-C satellite.

This publication is expected to be a useful reference to meteorological and related sciences students, also to elementary and middle level teachers and general public.

ATLAS DEVELOPMENT

The Atlas content will have the basic knowledge about structure, composition and circulations that lead to different clouds and cloud systems formation. The explanation of physical principles of remote sensing and a minimum knowledge about image correction and the needed transformations to improve their interpretation will be explained. All these subjects are organized according to a previous content list that could be modified during the atlas development, according to new environments or circumstances.

An antecedent of this work could be the METEOSAT CLOUD ATLAS (Atlas de Nubes METEOSAT in Spanish) (Brimacombe, 1991), however, the examples in this Atlas are almost exclusively for the Northern Hemisphere.

The SAC-C main instrument is the Multispectral Medium Resolution Scanner (MMRS), with five bands (Table 1) and is operating since November 2000

.

Table 1. SAC-C Bands
Band #1: 480 - 500 nm blue green Band #2: 540 - 560 nm green Band #3: 630 - 690 nm red Band #4: 795 - 835 nm IR near (NIR) Band #5:1550 - 1700 nm IR short wave medium (SWIR)

The difference between clouds identification and classification from the ground to space observation should answer the following questions, among others:

- How could be distinguished on images high, medium and low level clouds?.
- How could be distinguished stratus, cumulus and cirrus?.

The scheme of work to develop the Atlas is approximately as follows:

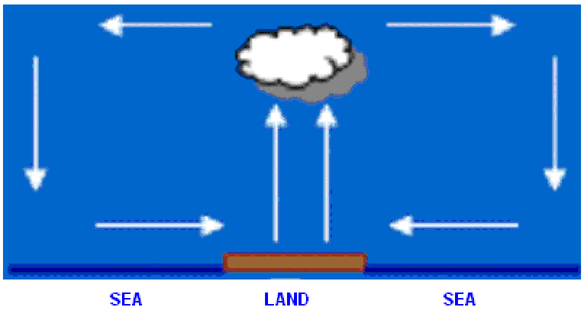
- SAC-C catalog exploration
- Examples selection based on “quick look” image view analysis
- Get the overpass and sectorize the regions of interests
- Image collection for different cases of clouds and cloud systems
- Image visual analysis for every band and bands combinations
- Calibration and reflectance’s computation
- Cloud types description by band and bands combination.
- Spectral analysis
- Georeferentiation, if it is considered necessary
- SAC-C cloud images compared with other satellite cloud images

- Cloud types and cloud systems explanation according to their dynamic formation, when it is possible.

SOME EXAMPLES

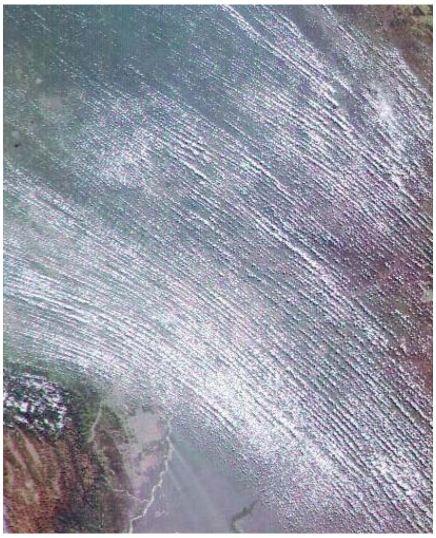
The following figures present some examples included in the Atlas.

SAC-C Image MMRS RGB 321

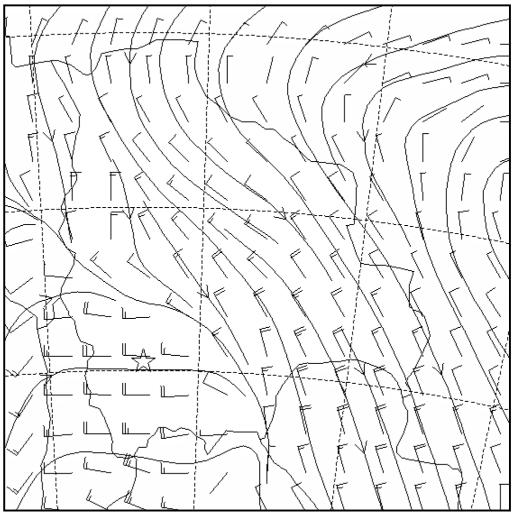


The circulation is established because land warms faster than water during sunlight. The air over land will warm up faster, becomes less dense and will raise forming stratocumulus clouds (if the air water vapor content is enough). This air rising generates a convergence zone at surface with divergence in altitude and descending movement over the sea are established and the cloud formation is inhibited. Atkinson, (1981).

Figure 1. A particular example of cloud formation due to land-sea breeze in the particular geographical formation located in Argentina (Peninsula Valdes).

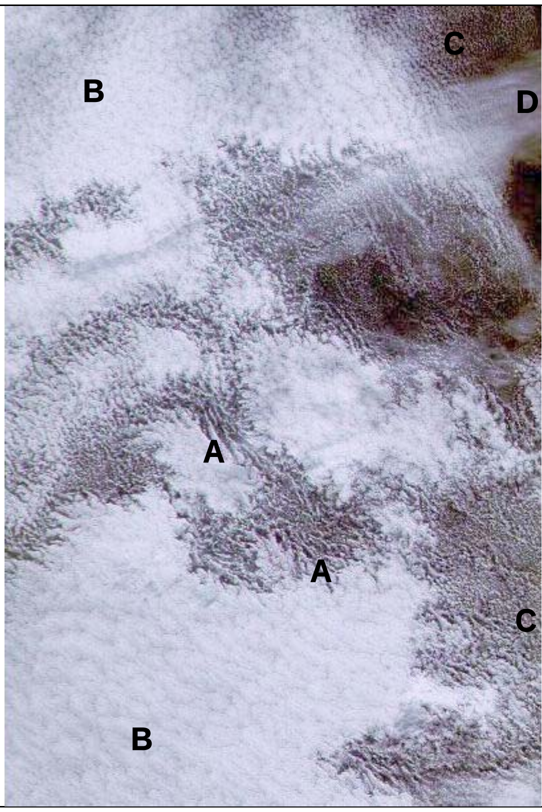


SAC-C MMRS image RGB 321



Analysis of 850 hPa (wind vectors and streamlines)

Figure 2. Street Cumulus Clouds over Bolivia associated to a low level jet.



SAC-C image MMRS RGB 321

Mesoscale cellular convection and Cirrus

A. Actinoform clouds
B. Closed cells
C. Open cells
D. Cirrus

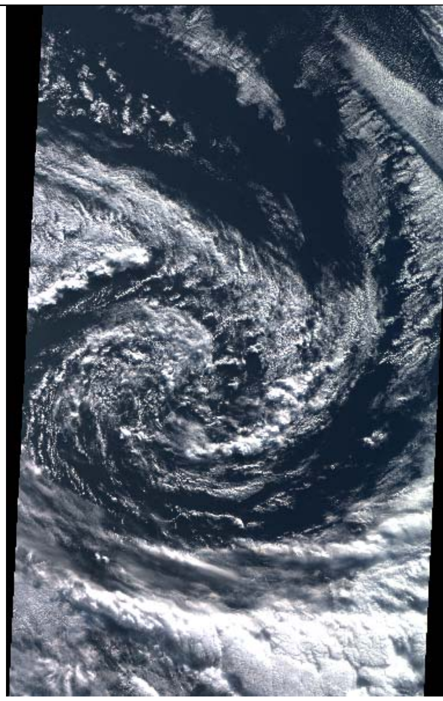
This image is an example of Mesoscale Cellular Convection over the South Pacific Ocean close to the Chile coast. A superposed veil of Cirrus could be observed in the upper right corner.

The cellular convection is observed at the top of the boundary layer, especially over the oceans This formation is frequently observed in the regions of cold oceanic currents with atmospheric stability conditions associated to subtropical anticyclones.

The development of actinoform clouds is being object of recent research as scientists use satellite data to better understand their complexity. However, its identification in satellite imagery started in 1961 (Krueger and Fritz., 1961).

Figure 3. Example of cellular convection

Two vortices observed over the Pacific Ocean close to Chilean coast



Synoptic scale cyclonic circulation over the South Atlantic Ocean

Figure 4. Mesoscale and synoptic cyclonic circulations examples.

CONCLUSIONS

In this paper we present the approximately scheme followed in the development of a Cloud Atlas and some examples that already have been prepared for the southern South American region and neighboring oceans, using Argentina's satellite SAC-C data, obtained from CONAE.

Initially some selected images from the "quick view" of CONAE´s web page were used. The first visual analysis of each SAC-C band allowed to distinguish differences among bands 3, 4 and 5 which, in turn, allowed to distinguish differences in cloud types and to discriminate, in an approximate form, the cloud formation level, based on band 5 reflectance. The exact determination is difficult because there is not a thermal sensor in the SAC-C.

As it was pointed out by Vidal et al, (2005) and Velasco et al. (2005), the use of SAC-C images, does not offer operational possibilities for a meteorological point of view, but it will allow making an inventory of cloud types and systems that appear frequently in the South American region. The satellite coverage makes it possible to prepare an inventory covering Argentina, neighboring countries and oceans. Moreover, there are certain details, associated with small scale movement that could be detected due to the fact that the SAC-C spatial resolution is better than the usual with the meteorological satellites. This work will contribute to improve the atmospheric system knowledge, because in vast regions of the Earth, clouds are almost the only elements permitting the visualization of certain atmospheric movement pattern.

Acknowledgments

This research was supported by UBA grant UBACYT X239.
CONAE provided the satellite images.

REFERENCES

ATKINSON B. W., (1981). **Meso-scale atmospheric circulations**. Academic Press, NY, 466 pp.

BRIMACOMBE C. A. (1991). **Atlas de imágenes de METEOSAT.** Publicación INM Serie 32 Número 32. España. Edición original ESA.

CONWAY E. D. THE MARYLAND SPACE GRANT CONSORTIUM, (1997). **Identifying Cloud Types in Satellite Imagery**. *An Introduction to Satellite Image Interpretation. Chapter 6, 66-83.*

CONAE: http:// www.conae.gov.ar

KIDDER S. Q., VONDER HARR T. H (1995). **Satellite Meteorology. An introduction.** Academic Press, NY, 495 pp.

KRUEGER, A. F., AND S. FRITZ (1961). **Cellular Cloud Patterns Revealed by TIROS I**, Tellus, 13, 1-7

VELASCO I., VIDAL L. y FLORES A. L. (2005). **Identificación de Nubes y Sistemas nubosos con Imágenes SAC-C en la Región Sur de Sudamérica y Áreas Oceánicas adyacentes.** Anales del IX Congreso Argentino de Meteorología. Buenos Aires, Argentina.

VIDAL, L., FLORES, A. L. y VELASCO (2005). **Clasificación Visual de Nubes a Partir de Imágenes SAC-C sobre la Provincia de Buenos Aires y Sur del Litoral.** Anales del Congreso Argentino de Tecnología Espacial CATE 2005, Córdoba, Argentina.

WORLD METEOROLOGICAL ORGANIZATION, 1956: *International Cloud Atlas*, Volumes I and II