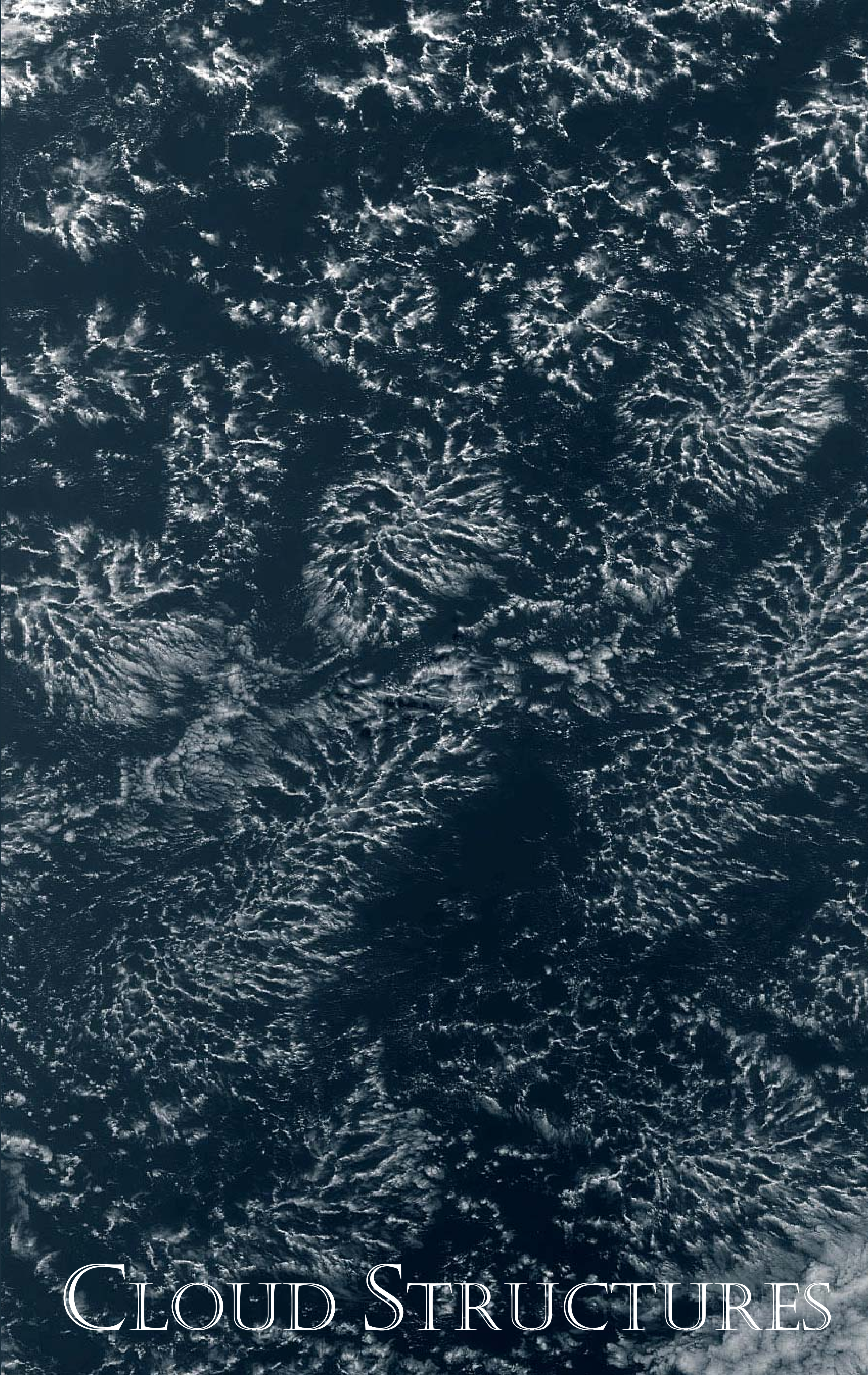
Michael Paperin



Cloud Structures

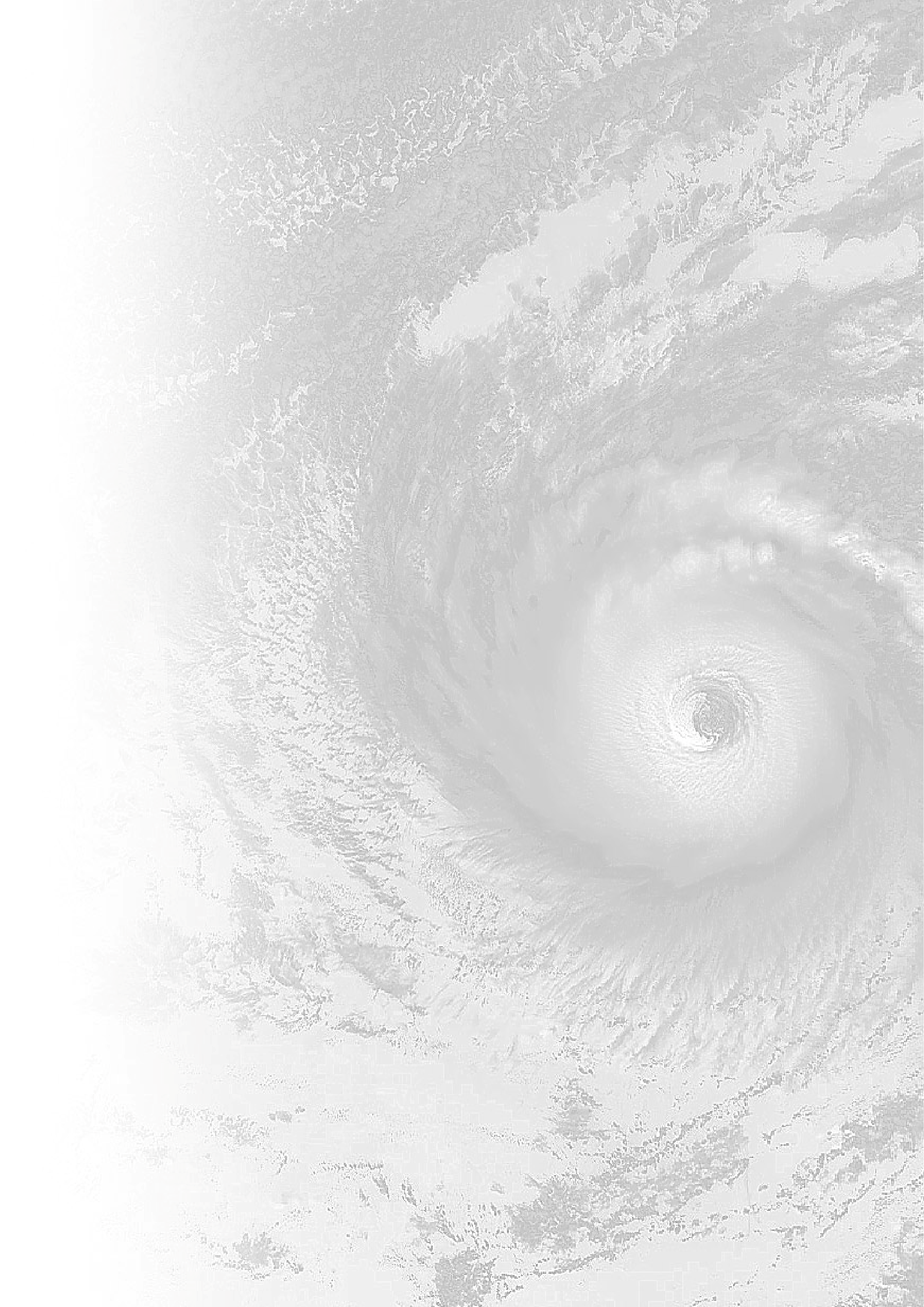
Michael Paperin

Brockmann Consult

Cloud Structures

2010

Since the beginning of the XIX century basic cloud structures observed from the earth surfaces have been classified by the Englishman Luke Howard.
In this book an attempt is made to classify clouds seen from above using ENVISAT MERIS Level 1 RGB images.
The work is concentrating on clouds above the ocean, and the clouds have been structured according to its visual characteristic features. The commonalities in their physical characteristics could be established, and also their occurrence can be linked to certain specific geographical regions and seasons in many cases. Co-existence as well as metamorphoses of cloud structures was observed.



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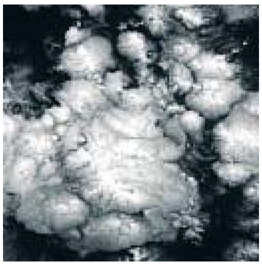
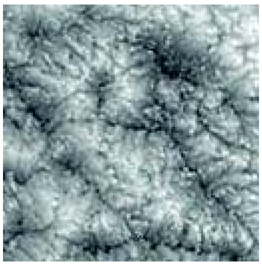
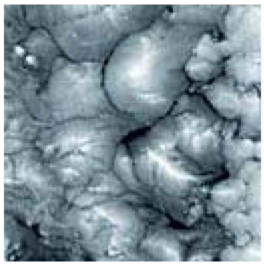
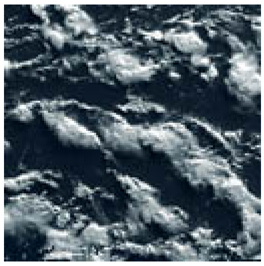
CLOUD STRUCTURES

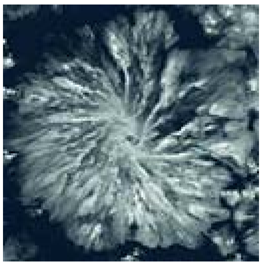
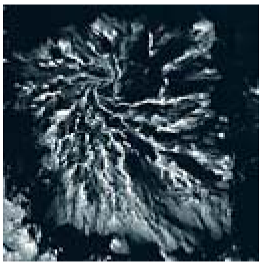
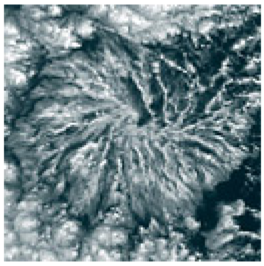
So full of frost, of storm, and cloudiness?

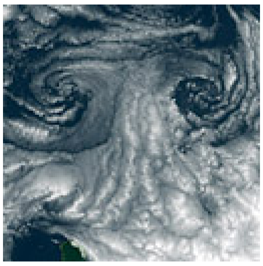
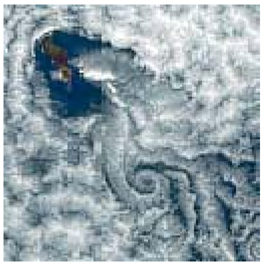
William Shakespeare, "Much Ado About Nothing", Act V, Scene IV

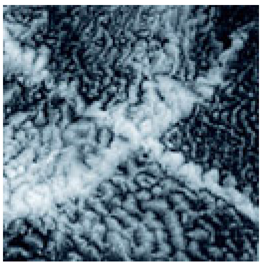




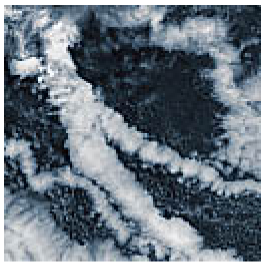


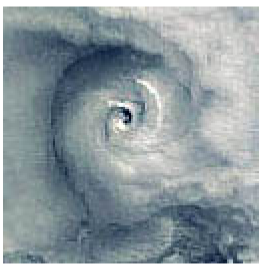
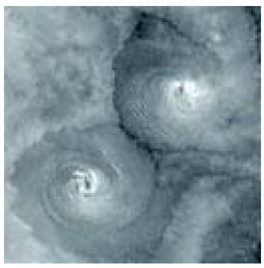


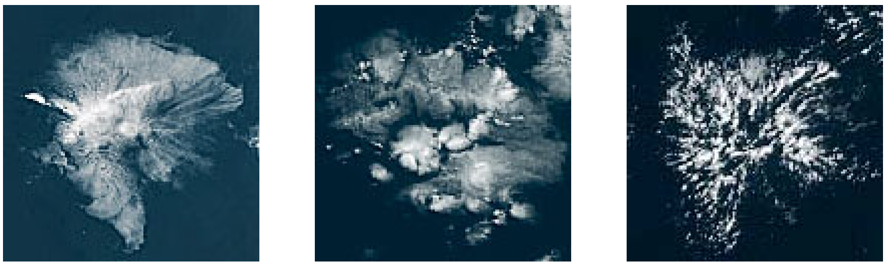




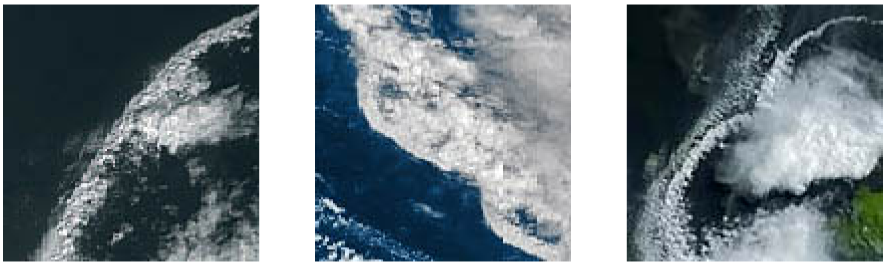





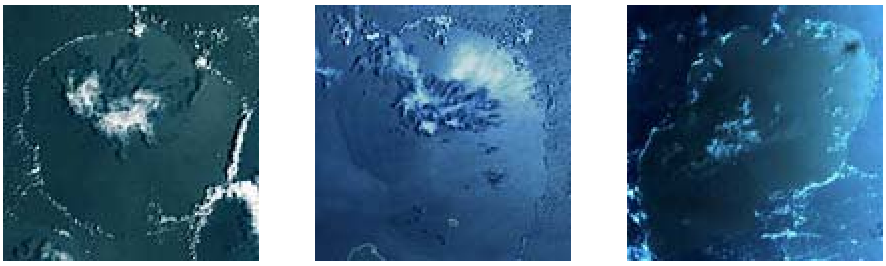






- "Outflow Boundary" Structure (OBS), A Shelf Cloud

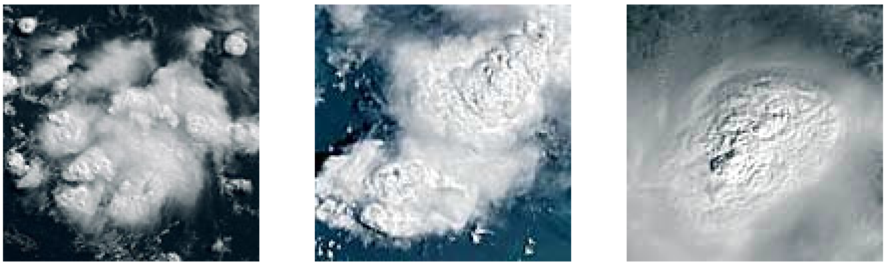


- "Cloud Arc" Structure (CAS)



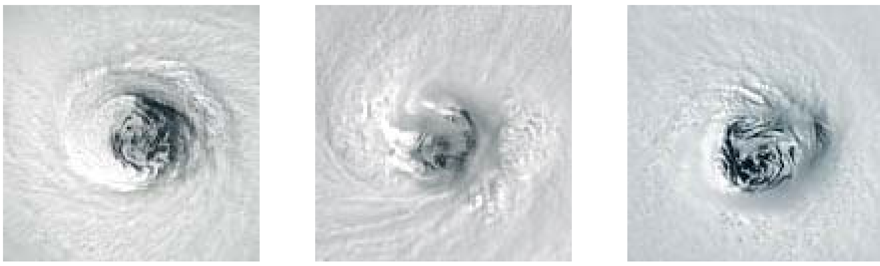
- "Cloud Arc Chain" Structure (CAS)

- "Mesoscale Convective" System (MCS)



- "Cloud Torch" Structure (CTS)

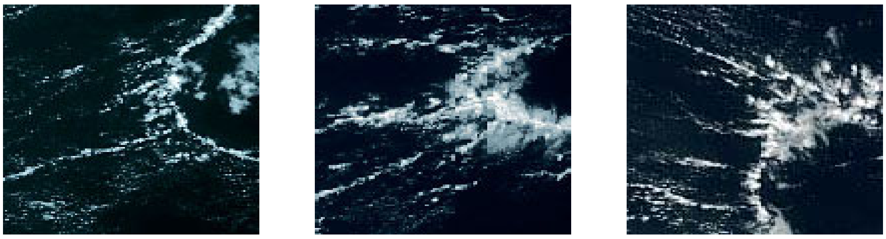
- "Tropical Cyclone" (TCS)



- "Extratropical Cyclone" Structure (ETCS)

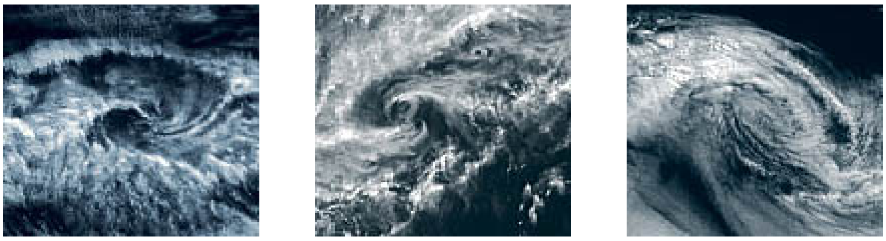
- "Convection Streets" Structure (CSS)

- "Peacock Feather Looking" Structure (CLS)

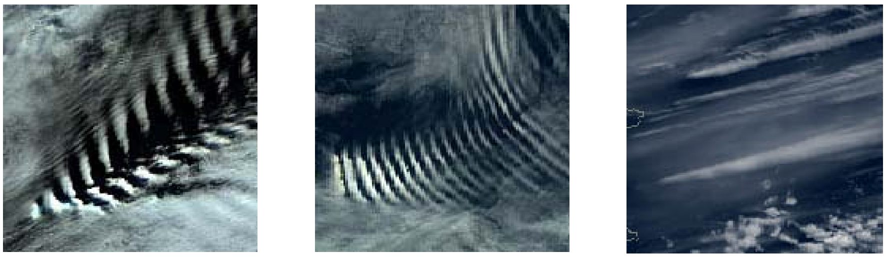


- "Gravity Waves Cloud" (GWCS)

- "Kelvin Helmholtz Instability" Cloud Structure (KHICS)

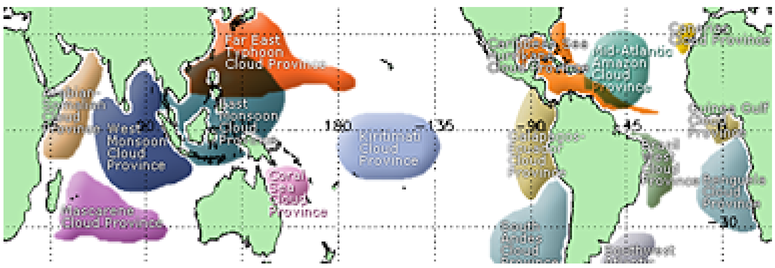


- "Orographic Clouds" (OC)



- Other Interesting Cloud Forms

- Cloud Provinces



Literature

In 2002 ESA launched the ENVISAT satellite equipped with many devices including MERIS (medium-spectral resolution, imaging spectrometer).
While making visual archive fort this sensor I have happened to witness tens of thousands of circuits since then. I make 14-15 full turns around the Earth daily and see the land, seas and oceans as well as the sky with its clouds.

Observing the cloudy cover regularly I noticed that in large areas clouds form structures, of which appearance and properties may depend on geographic and seasonal elements.

That was how the idea occurred to me to try to somehow systemize what I'd seen, especially because I did not manage to find comprehensive papers containing description of large-scale cloudy structures.

The project "Cloud Structures" was started in 2006 during the preparation period for the ENVISAT Symposium in Montreux. Using the huge amount of accumulated information it became possible to single out some over-the-ocean cloud structures and bring together the available data in a web-page, which saw the light in May, 2007. The said web-page contains description, a version of origin and a lot a examples for each cloud structure.

The Cloud Structures project is a dynamic one, meaning that there appear additional examples of the structures that have already been revealed as well as even new structures and phenomena.
The picture of the cloudy cover is changeable and never repeats itself. Practically every circuit allows to discover either some remarkable examples or some new formations. It is hard to refrain from including such images in the existing collection!

Because cloud structures correlate with atmospheric processes they help to study the latter, whether already known or new. Thus the efforts to compile a catalogue of cloud structures are also aimed at arousing scientists' interest in still incomprehensible phenomena and providing researchers with examples to facilitate finding explanations.

I am convinced that the picture of the cloudy cover along with a set of cloud structures defines the Earth to the same extent as the planet is defined by its size, atmospheric parameters (thickness and chemical composition) and underlying surface. It is even possible that it defines the current state of the planet's climate, the 3-cell structure of the atmosphere (*the Hadley cell, the Ferrel cell and the Polar cell*), the Earth's rotating velocity, slope of axis, etc.

And undoubtedly, to study cloud structures may be important not only for scientific purposes but also from the point of view of esthetics.

This book (in the PDF format) is based on the existing web-page. Each cloud structure is illustrated with only several (no more than a dozen) images selected from many tens. In some cases there are commentaries.

To conclude, I'd like to express my gratitude to my chief Dr. Carsten Brockmann, who made it possible for me to be engaged in this project.

Michael Paperin, Hamburg, Germany
May 2007-August 2009

Introduction

Hamlet
Do you see yonder cloud that's almost in shape of a camel?

Polonius
By the mass, and 'tis like a camel indeed.

Hamlet
Methinks it is like a weasel.

Polonius
It is backed like a weasel.

Hamlet
Or like a whale.

Polonius
Very like a whale.

William Shakespeare: Hamlet, Prince of Denmark: ACT III. Scene II

Clouds are the most mobile and changeable structure in the aspect of our live planet. Approaching the Earth it is impossible to look over their deversity, complexity and striking beauty.
The following work is to describe some cloud formations over the ocean as well as present examples of some of the most frequently found cloud structures.
The work includes the analysis of the notion "a cloud structure" (also known as "a cloud pattern"), the description of these structures, some of inherent physical parameters thereof, the statistics on allocation and a wide range of images.
The data that was received during many years from the MERIS - a programmable, medium-spectral resolution, imaging spectrometer installed on the ESA's satellite ENVISAT served as the source material; the Software BEAM VISAT developed by the Brockmann Consult, Germany, was used as the basic tool.
The work was conducted at the Brockmann Consult, Germany, within the framework of the "Image of the Day" project.

The Cloud Structures (CS)

While observing the Earth from the height of 500-5000 km it is possible to notice that the cloudy envelope of the planet is a ranked rather than a chaotic accumulation of clouds as far as it concerns their forms. These forms either repeat themselves or differ but in any event they reflect definite process taking place in the atmosphere. The outward appearance of CS remains invariable within a year and on the whole does not depend on their geographical location.
All this allows to try to unify them on the base of appropriate criteria and thus to speak about the cloud structures and systemize them.
In this work a "cloud structure" means a compact cloud formation of a distinct spatial form with the dimensions of more than 10-20 km and reflecting a definite state of the atmosphere and the underlying surface.
Very often some CSs may be associated to these or that geographic realities. Formation and expansion of CSs also depend on the season. Some CSs consolidate in large mega structures (MCS). Most of CSs are so large, that to observe them from the surface of the Earth or from one side, for example from the board of an airplane, means to obtain an incomplete picture.

Observation from above, namely from a satellite, may give the information only about the top layer of the structure, but at the same time to cover the whole object. To see CSs from all sides would be, of course, the perfect choice.

The Distinction between Cloud Structures and Clouds

A Cloud Structure usually differs from the clouds that constitute it.
This difference concerns:

the dimensions (a CS is much larger)

the way of interacting with the environment (the CSs effect on the processes in the atmosphere and the ocean is much more profound than the one of the clouds)

Besides:

CSs may transform in other CSs

the processes taking place within a SC may change its looks in different spots whereas it still keeps its integrity and houses various kinds of clouds

different CSs may include identical types of clouds.

The clouds constituting CS may serve as markers (an indicator) of the air mass movement. Being structurally unified they themselves influence the atmospheric phenomena.

Methods

The Brockmann Consult is one of the receivers of the ESA satellite ENVISAT information.
Since 2002 the MERIS data has been transmitted to the firm and then distributed to the ESA consumers world-wide. The software developed by Brockmann Consult processes and collects all arriving fresh data and visualizes it in real resolution (1120 pixels width, pixel Size 1040m x 1200m), so that the data could be studied just after it had arrived.
In 2003 an Internet project "Image of the Day" was launched.
According to the said project the whole body of MERIS level 1 data (covering already more than 27000 orbits) is examined in order to discover interesting nature phenomena, and is then represented as RGB colour pictures. These colours have near resemblance to natural ones.
Thus certain weather events and cloud structures arrested special attention and were stored as RGB pictures.
In 2006 the systematization of the new as well as of the already existing cloud data started.
As the result the data was stored as JPG pictures and grouped pursuant to its types.
The BEAM VISAT software developed on the Brockmann Consult allows visualizing and processing both the MERIS level 1 satellite data and supplementary information.
Fragments of interest will be cut out from whole orbit and visualized e.g. from the TOA radiance band 1 MERIS channel (wavelength: 412.691nm, range 9.937nm) (where the clouds are easily recognized). They are first possibly contrasted and geographically referenced and then stored, possibly along with the additional information. The name of the stored file contains the date and the orbit number of the fragment.
The BEAM VISAT software allows to observe the MERIS level 2 data as well.
The values of Cloud top pressure, Cloud albedo and Cloud type index, contained in the MERIS level 2 data, are important as cloud characteristics.

The Cloud top height can be calculated by the formula

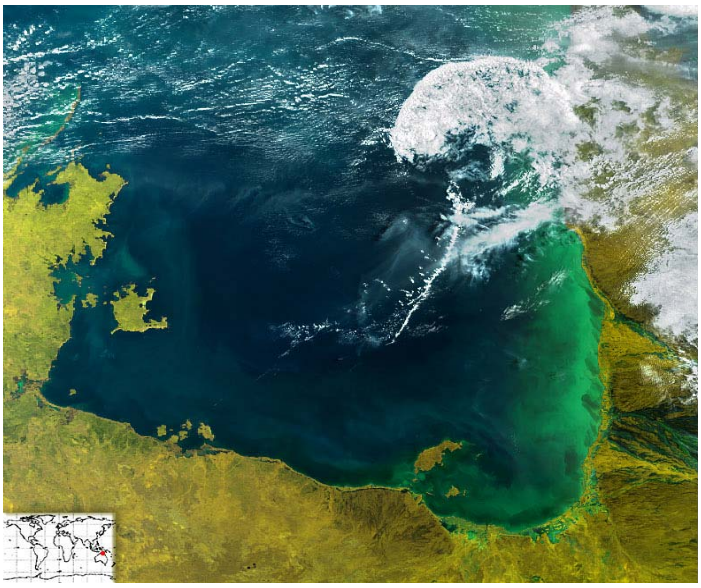
h [km] = -8 * LOGS (cloud_top_press [hPa]/1013).

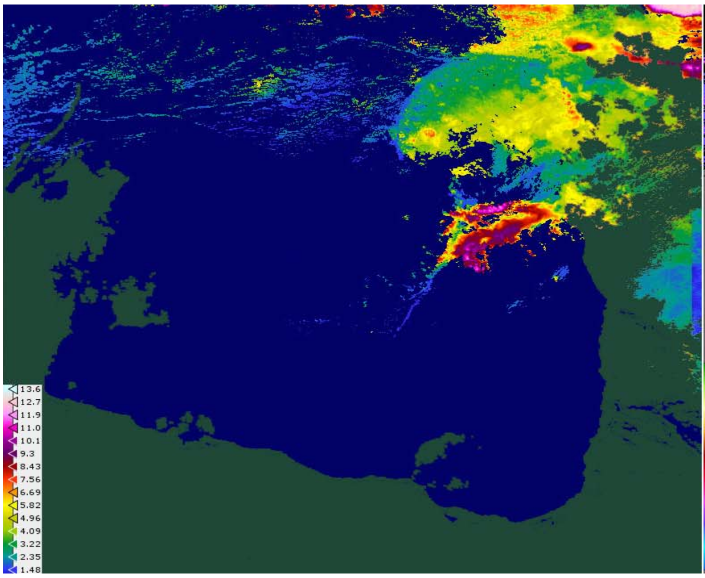
The type of the clouds contained in a cloud structure is indicated in the ESA Cloud type index table.

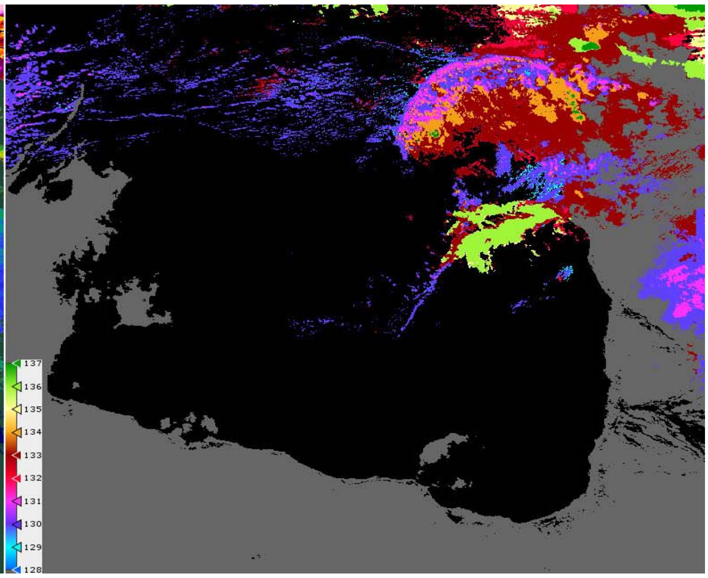
Optical thickness Pressure (hPa)	0 - 3.6	3.6 - 23	23 - 379
50 - 440	135 (Cirrus) Ci	136 (Cirrostratus) Cs	137 (Deep convection) Cb
440 - 680	132 (Altocumulus) Ac	133 (Altostratus) As	134 (Nimbostratus) Ns
680 - 1000	129 (Cumulus) Cu	130 (Stratocumulus) Cs	131 (Stratus) St

An example of the "of the Morning Glory" Cloud Structure of 2007.02.08, orbit 25836:

- RGB image in the visual 412,691 Nm channel,
- Cloud top height with the Scale in [km],
- Cloud type index with the Scale.

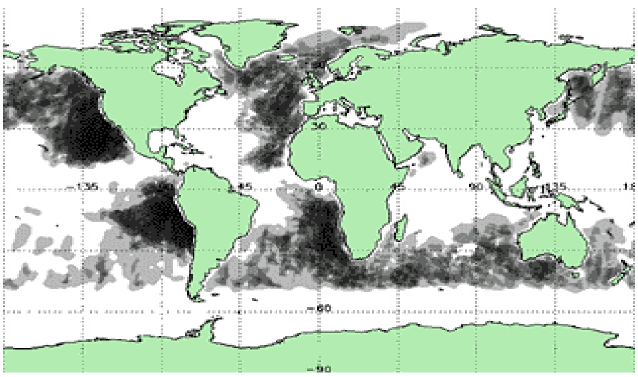




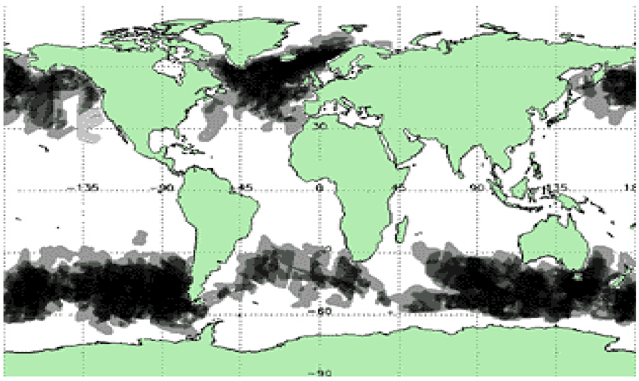


The BEAM VISAT software allows the whole orbit to be projected on the world map (in the case in question the geographical projection is used). Therefore each cloud structure revealed can be interactively superposed on the map of the world and geographically referenced. Using the daily MERIS data (14 orbits per day) it is possible to make up the picture of the global occurrence, season changes and theobservation frequencies of different cloud structures. This does not only help to describe the cloud structure, but also enables to better understand the Earth's climate processes.

Examples of observation frequency diagrams (the statistic work is carried on the period of 04.2006-10.06 and 02.07). The darker the point is, the more often observations were made.



"Close Cells" observation diagram for 06.06



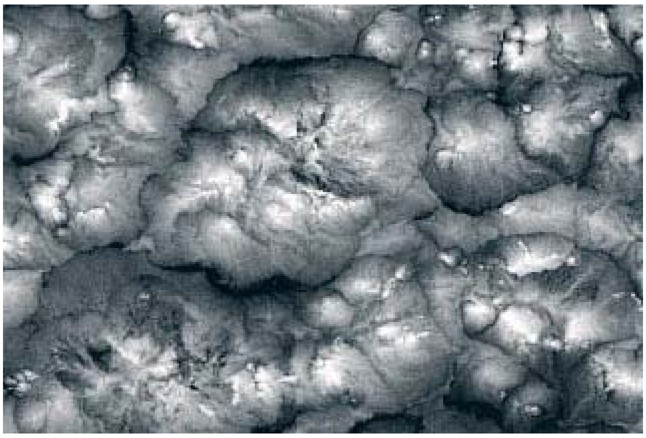
"Enhanced Cumulus" observation diagram for 10.06

Data Presentation

To present the most of structures the following data will be offered:

- The MERIS level 2 data
    - Cloud top height [km]
    - Cloud albedo
    - Cloud type (the clouds, which are contained in structure)
- Statistic data
    - Global Occurrence
    - Diagram Observation Diagrams (for some structures)
- The physical explanation for a structure emergent
    - Because the origin and developing of structures is sometimes unclear, the explanation of the physical nature of a structure emergent is offered only as basis for a discussion.
- Pictures of corresponding structure for the time period (mostly) 2006-2009
    - MERIS level 1 RGB or black-and-white with or without geographical references
    - The MERIS level 2 can be attached:
        - cloud top height false colour images
        - albedo false colour images
        - cloud type index false colour images
        - cloud optical thickness false colour images
    - Cloud anaglyph image (in some cases)

'Close Cell' Cloud Structure



I tell the day, to please him thou art bright,

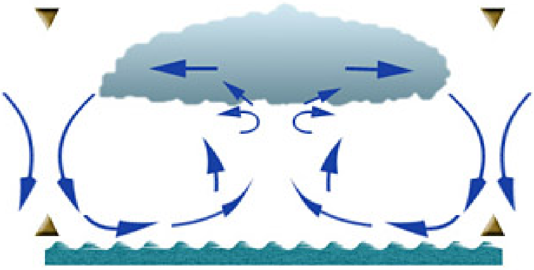
And dost him grace when clouds do blot the heaven...

William Shakespeare, Sonnet XXVIII

Convective Cells

'Close Cell' Structure (CCS)

Some of the CCS are polygonal, round or oval, the others are often stay close to each other and form large fields up to more than a million square kilometers in size. Occasionally single cells may be discovered. The larger the cell is, the clearer its borders are (seen as thin lines). Through these lines the sea surface can be watched. The area extent of an individual cell unit is from several kilometers to one hundred or even more kilometers. The Cloud top heigh is normally from several hundred meters up to 2÷2.5 km., sometimes 1÷2 km., rarely up to 3÷3.5 km. Albedo is 0.7÷0.8 (up to 0.9).



The 'Close Cell' Cloud Structure may shape:

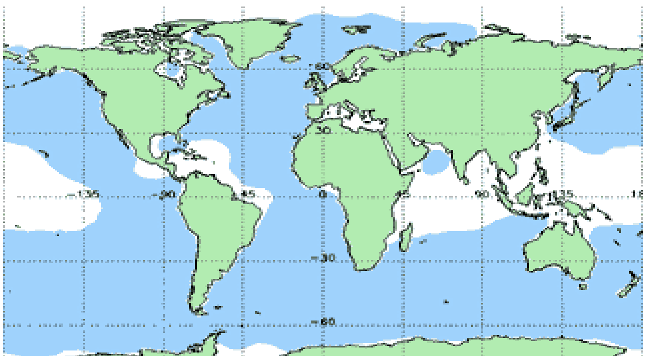
- above areas situated in middle latitudes where the temperature difference between the sea surface and the troposphere is little,
- at the edge of cyclones vortices in middle latitudes,
- above polar seas

The latter structure is the prevailing type. .

It is found (depending on the season) in the latitude of > 30° and <-20°. It also occurs in the Northern Hemisphere above the Eastern part of the Atlantic and Pacific oceans, as well as above the Arabian Sea in the Indian Ocean, above the equator on the western coast of Africa and above South Americas Waters. In the Southern Hemisphere it extends up to the equator. Above Australian waters it stretches up to the latitude of 15°. Above the polar seas the clouds are semitransparent and consist of a quantity of small deep flowing cells. This type of CS can be also found above the land, mostly the plains.

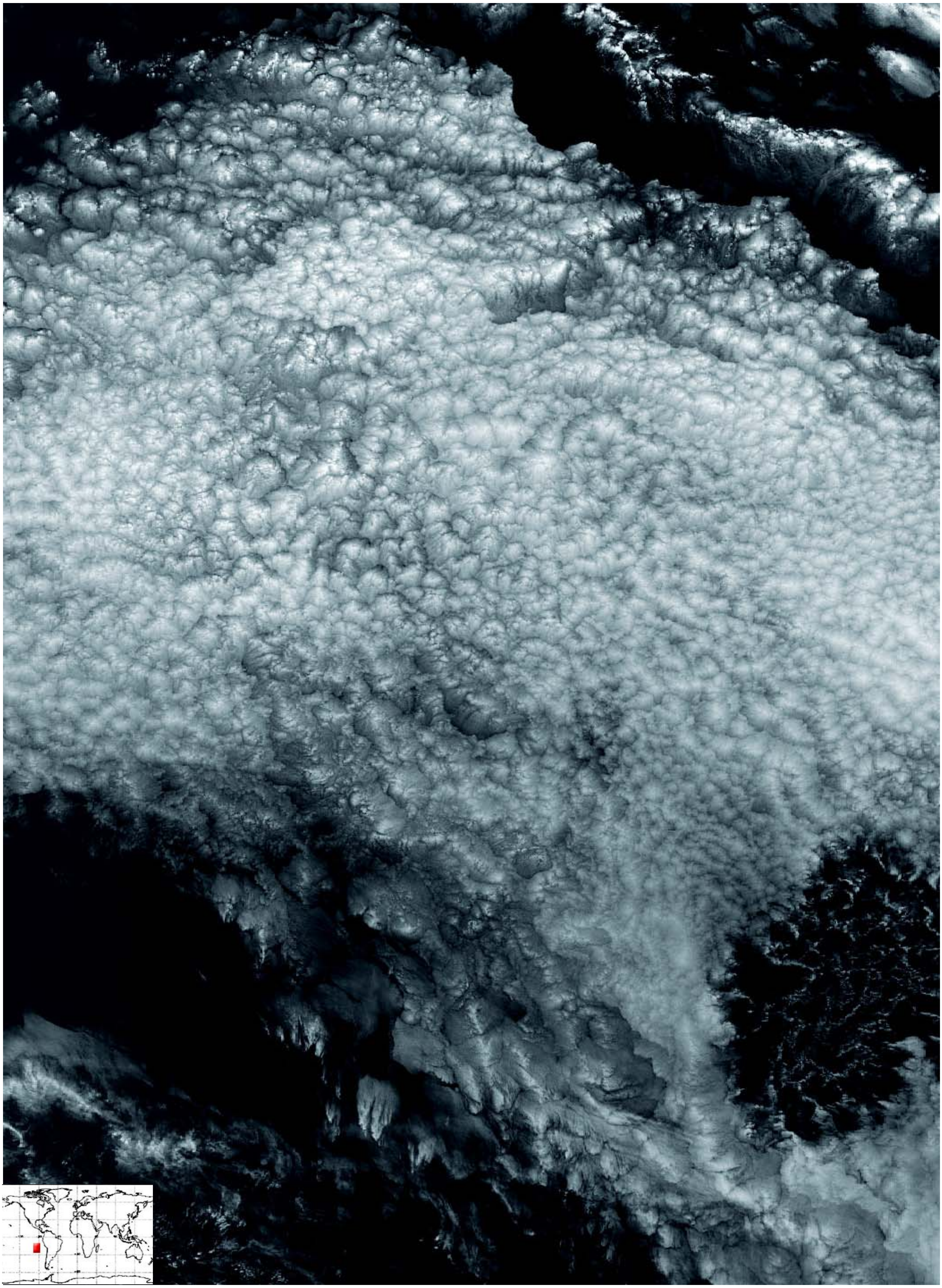
Various physical phenomena can emerge and be seen on the cloudiness of this structure type, besides other types of structures may use the said structure as the foundation for their evolution.

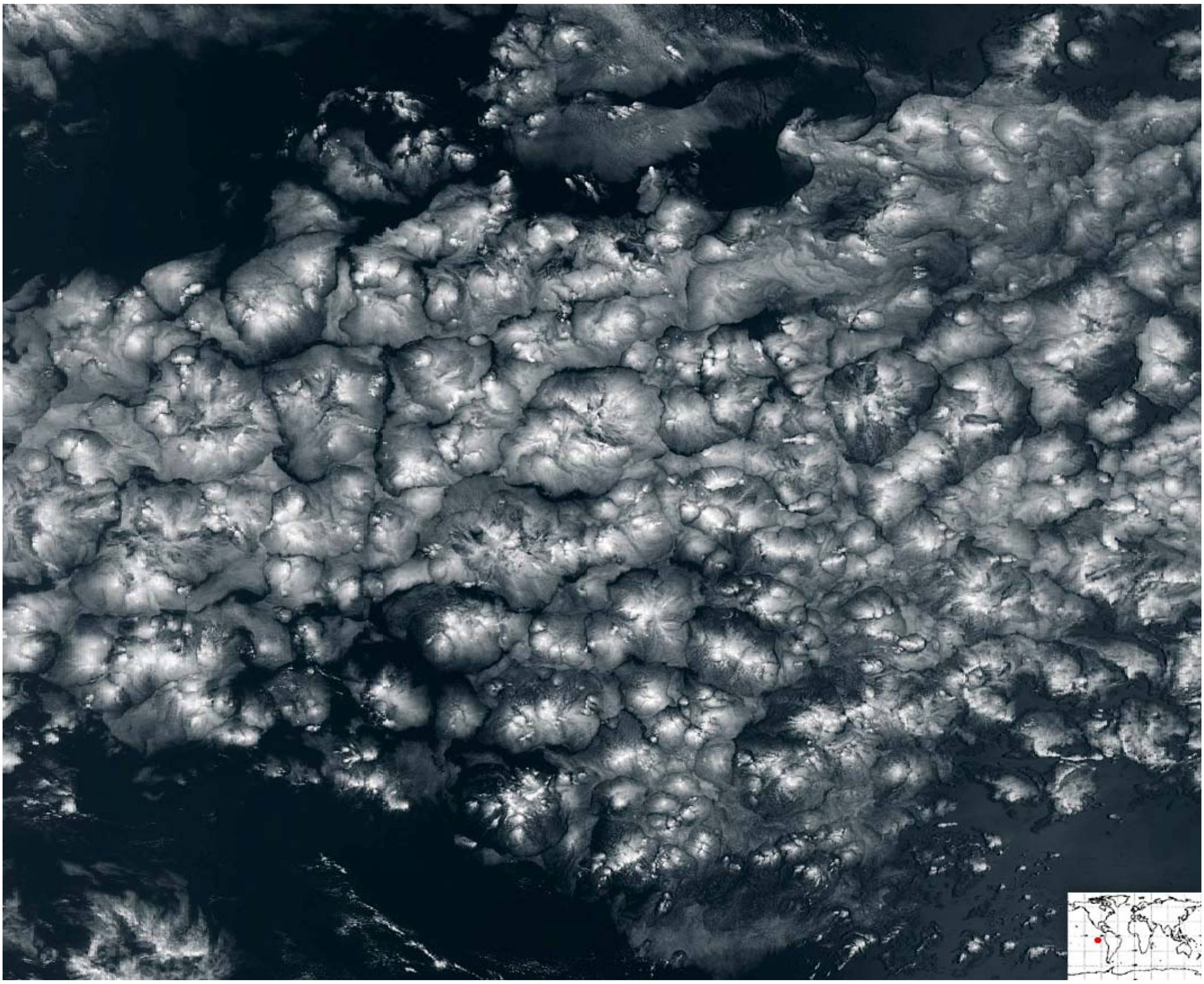
The Closed cells consist of convective clouds and their circulation is vertical. These cells appear frequently in the atmospheric layer in rough hexagonal rows, and consist of Stratocumulus and Stratus clouds. The sides of the cloud tops are kept down by the inversion layer. Closed cells appear when the temperature difference between the sea surface and the troposphere is minor. They may shape when the inflow of cool air is weak. Besides, they can convert from Opened cells in the event that the flowing cool air subsides. In this case the future form of cells (opened or closed) depends on the intensity of the inflow of the cool air. However this process is very chaotic and it is very difficult to predict the result of convention. Sometimes the conditions of the atmosphere change, which gives rise to curious forms of clouds.

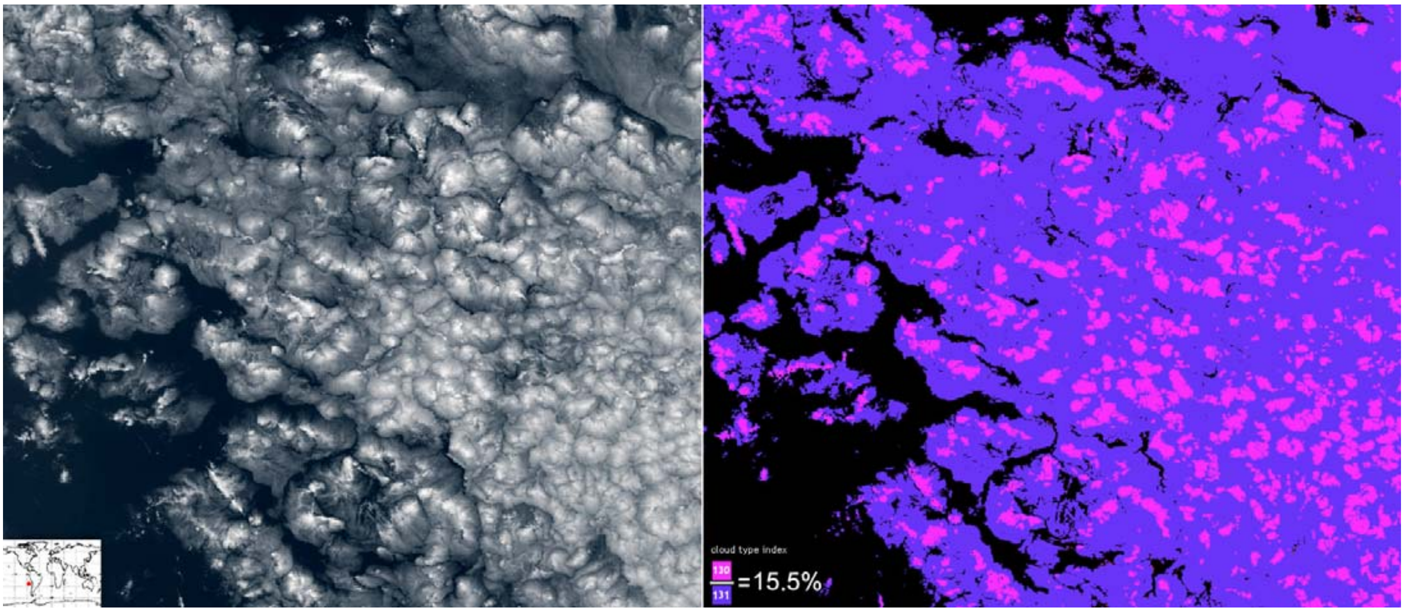


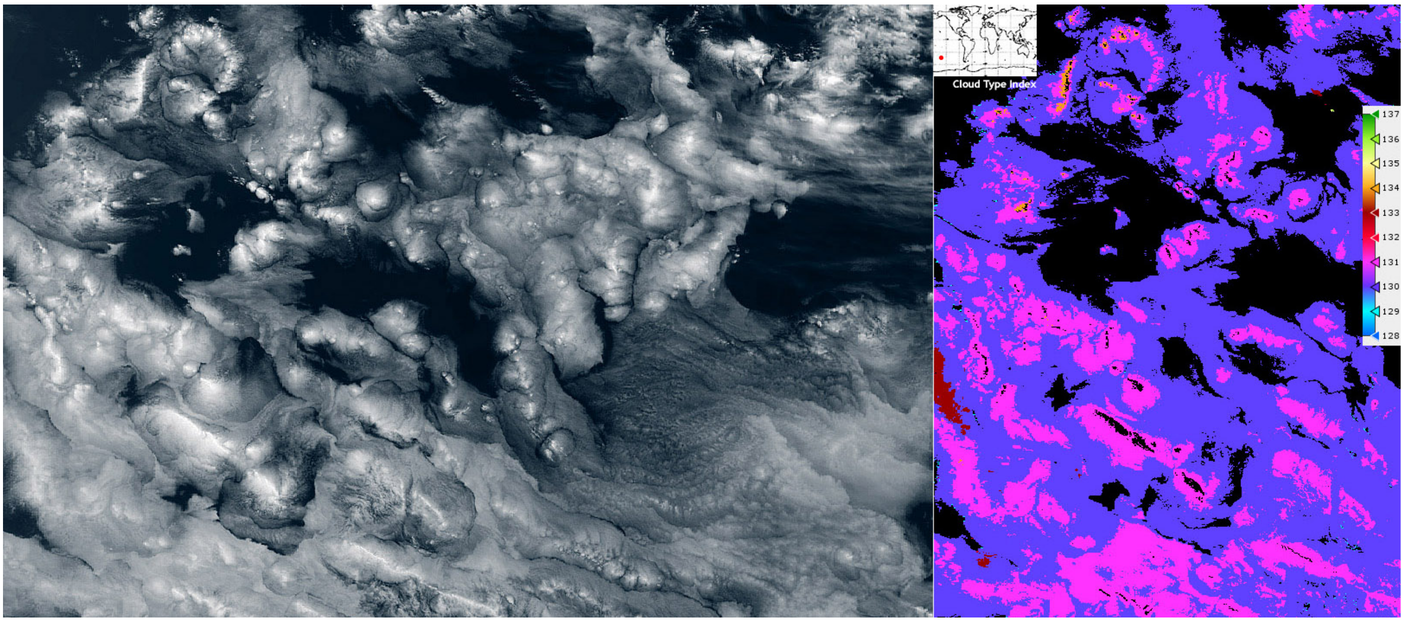
Global Occurrence Diagram

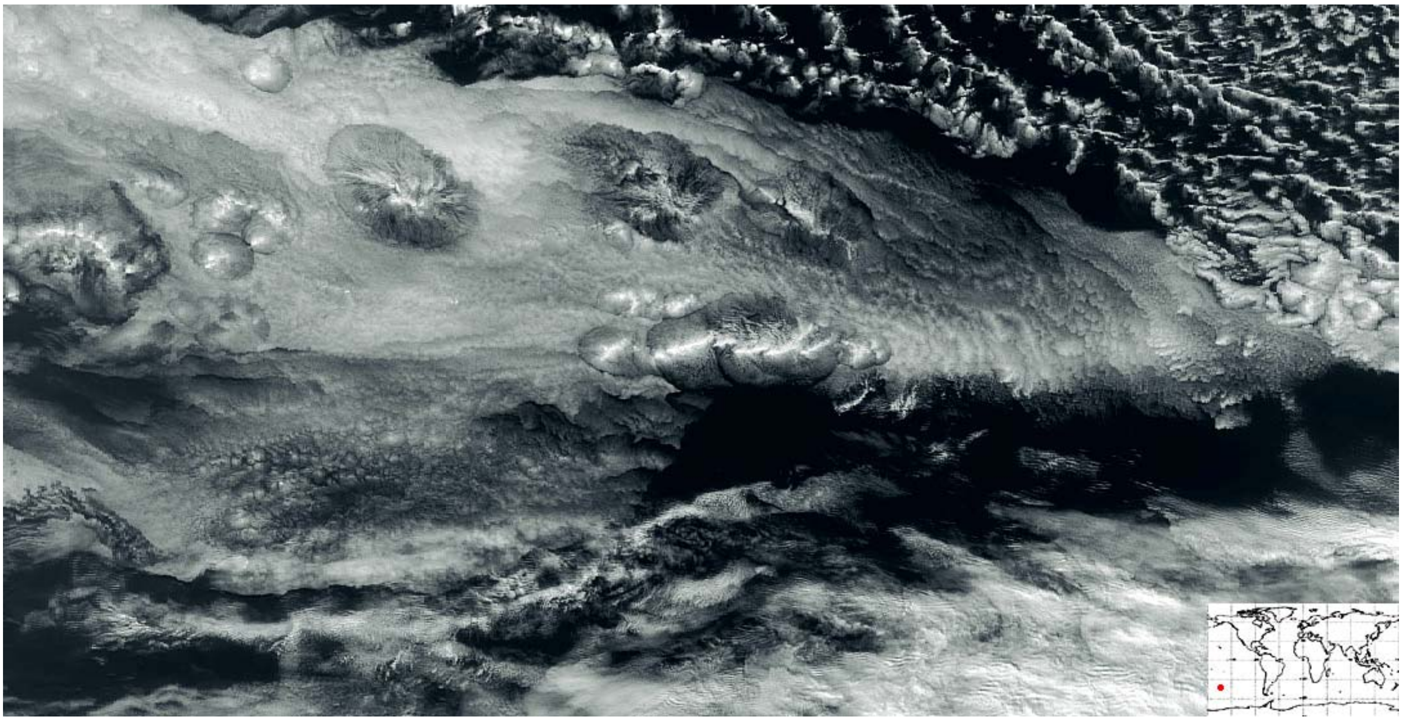
Examples.

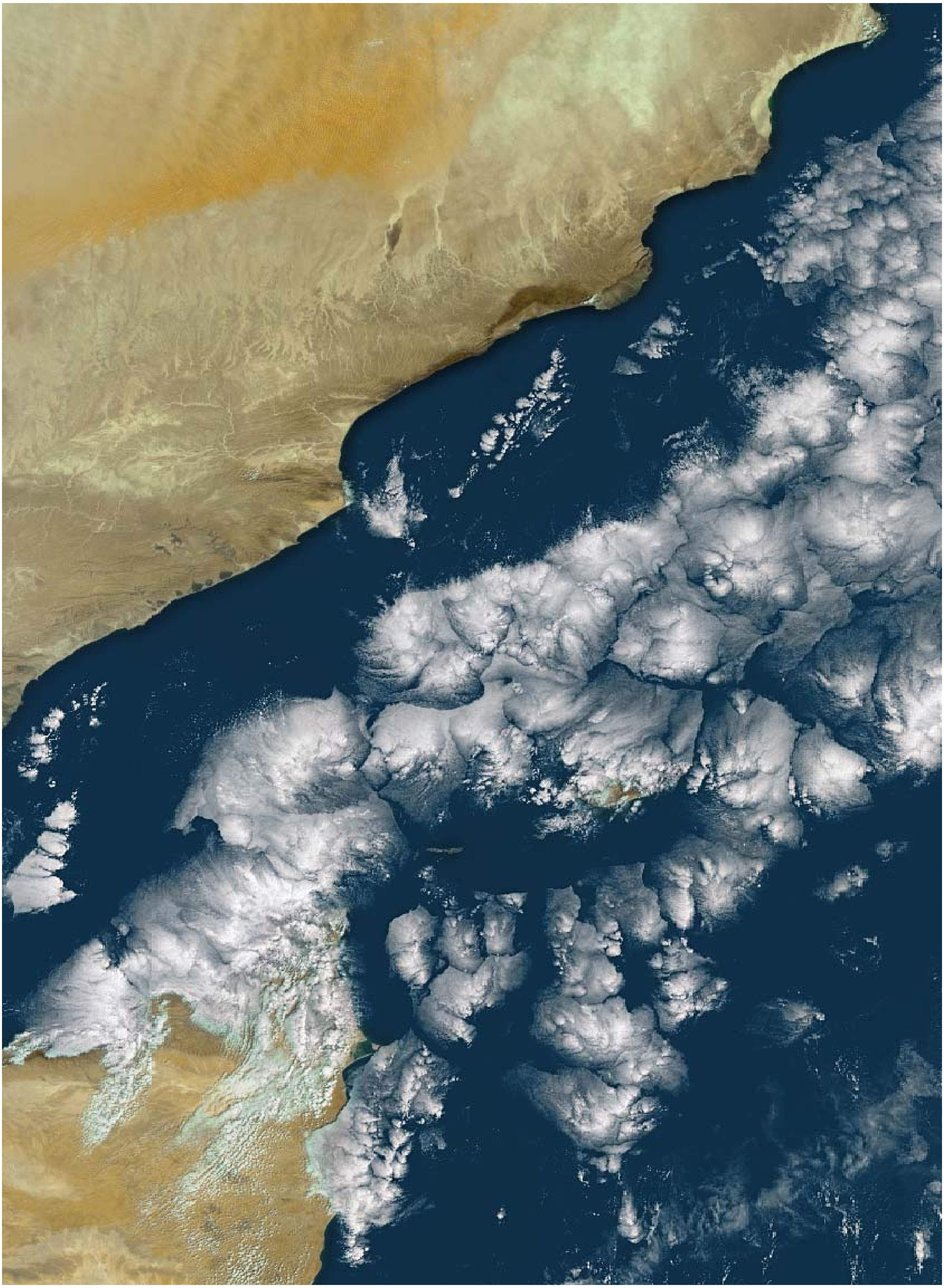


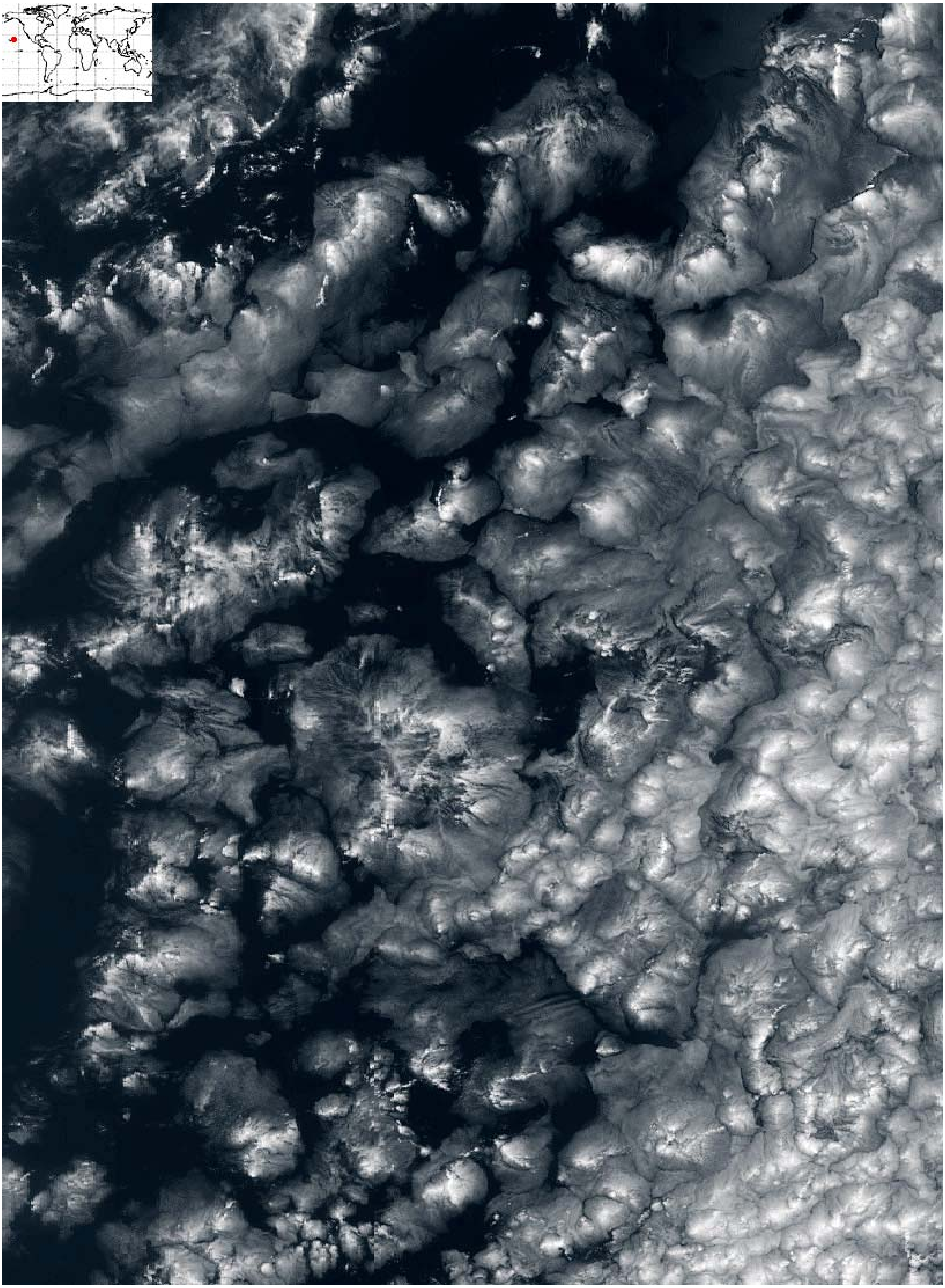


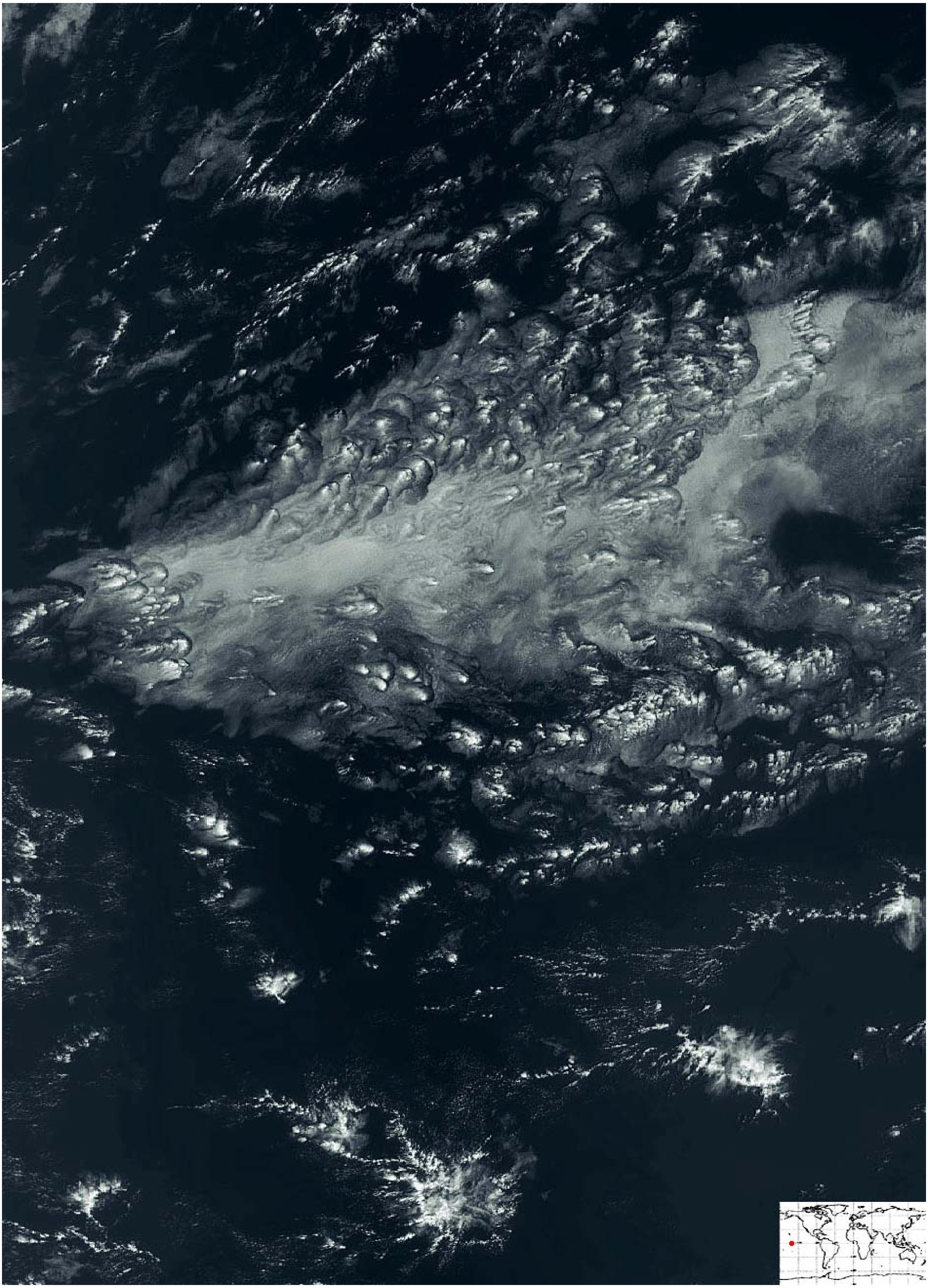

cloud type index
130
131
=15.5%

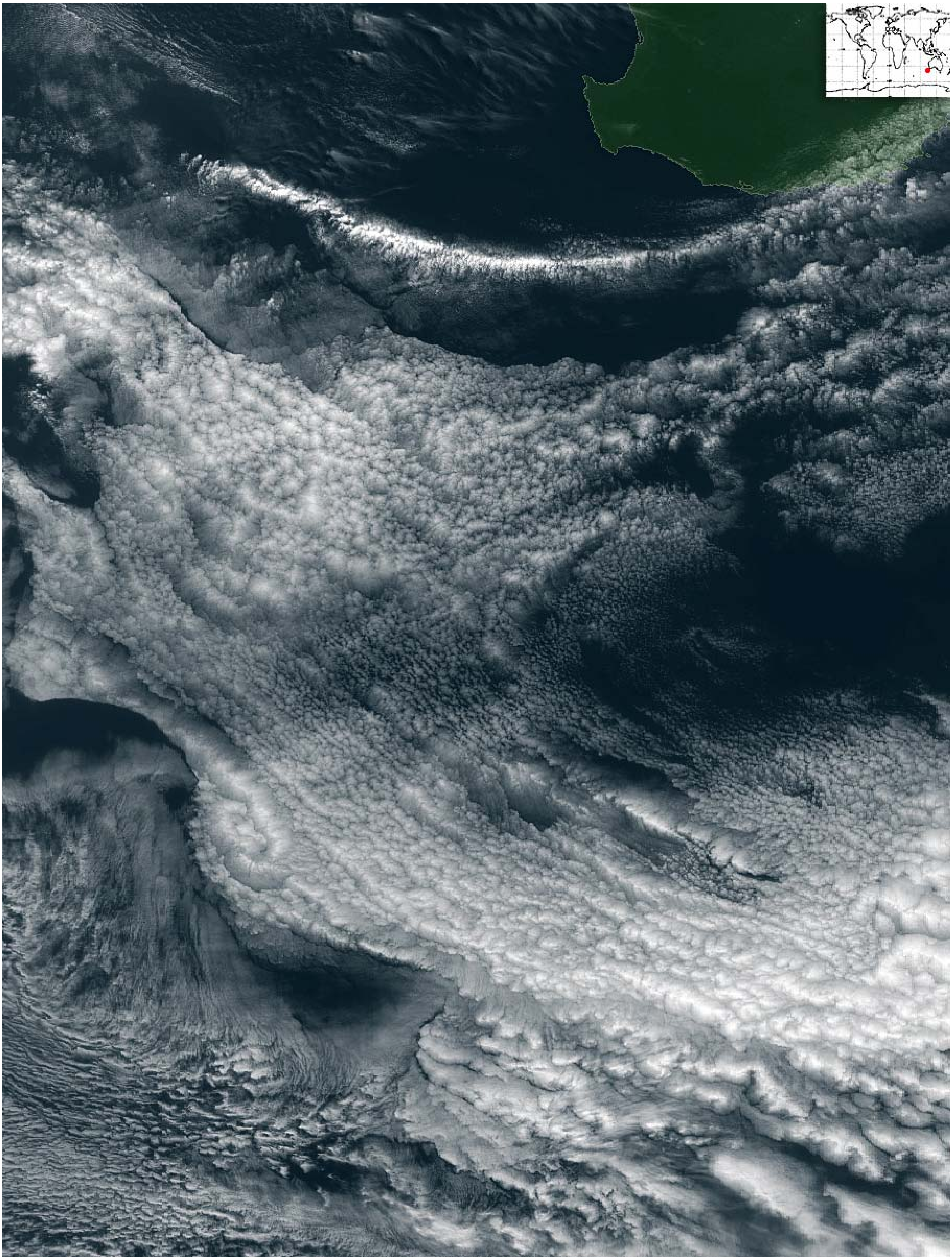

Cloud Type Index
137
136
135
134
133
132
131
130
129
128

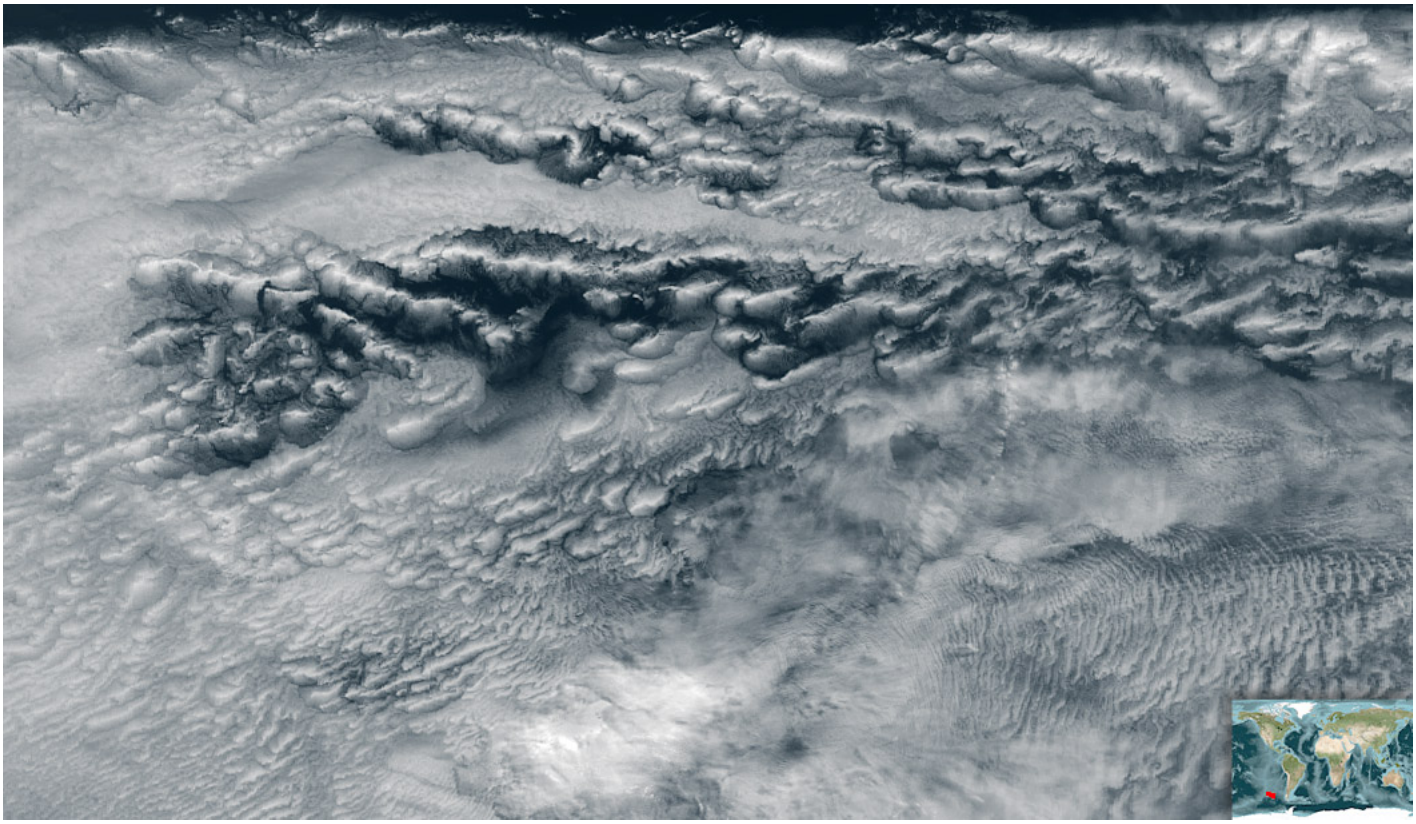


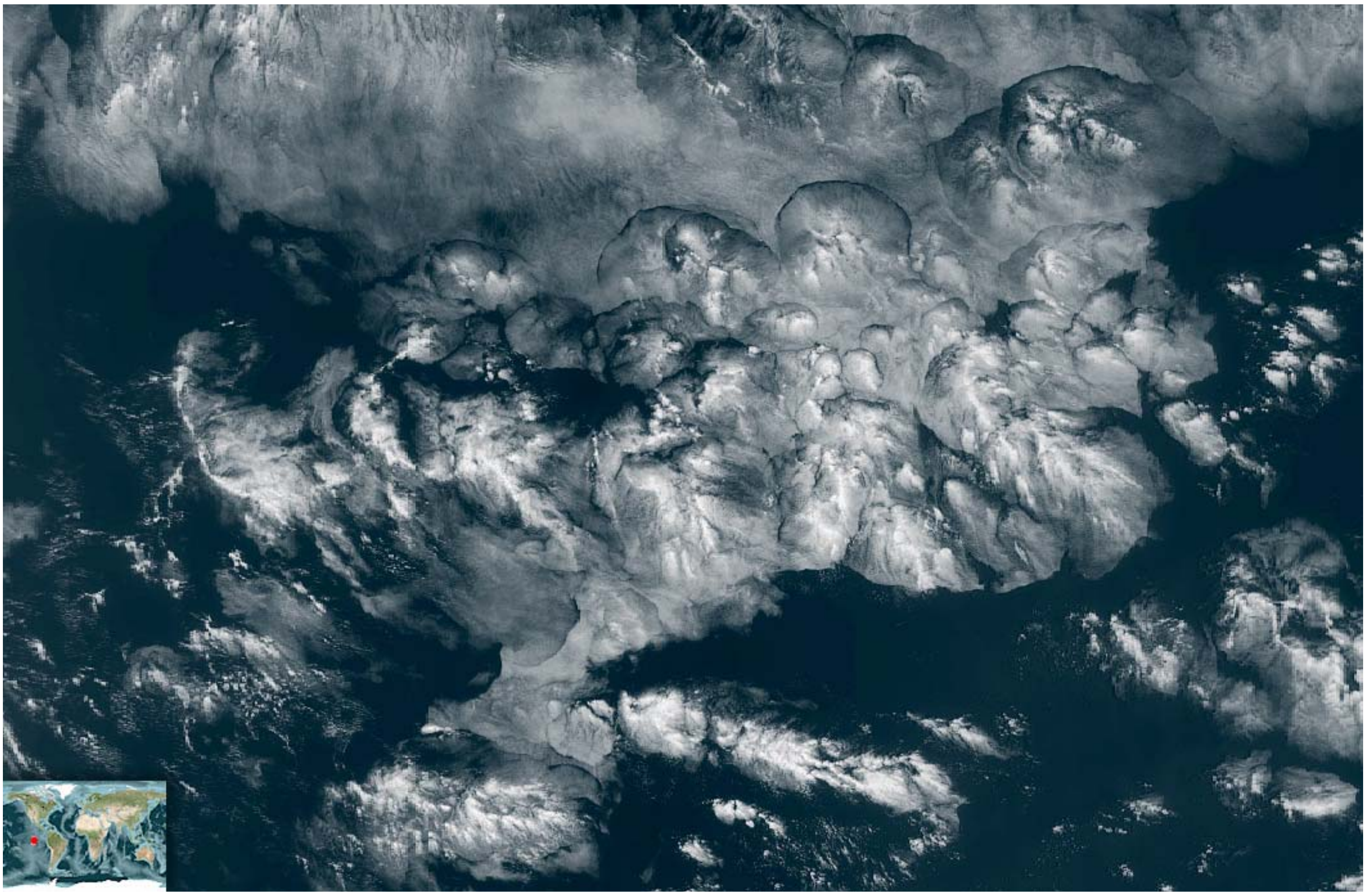


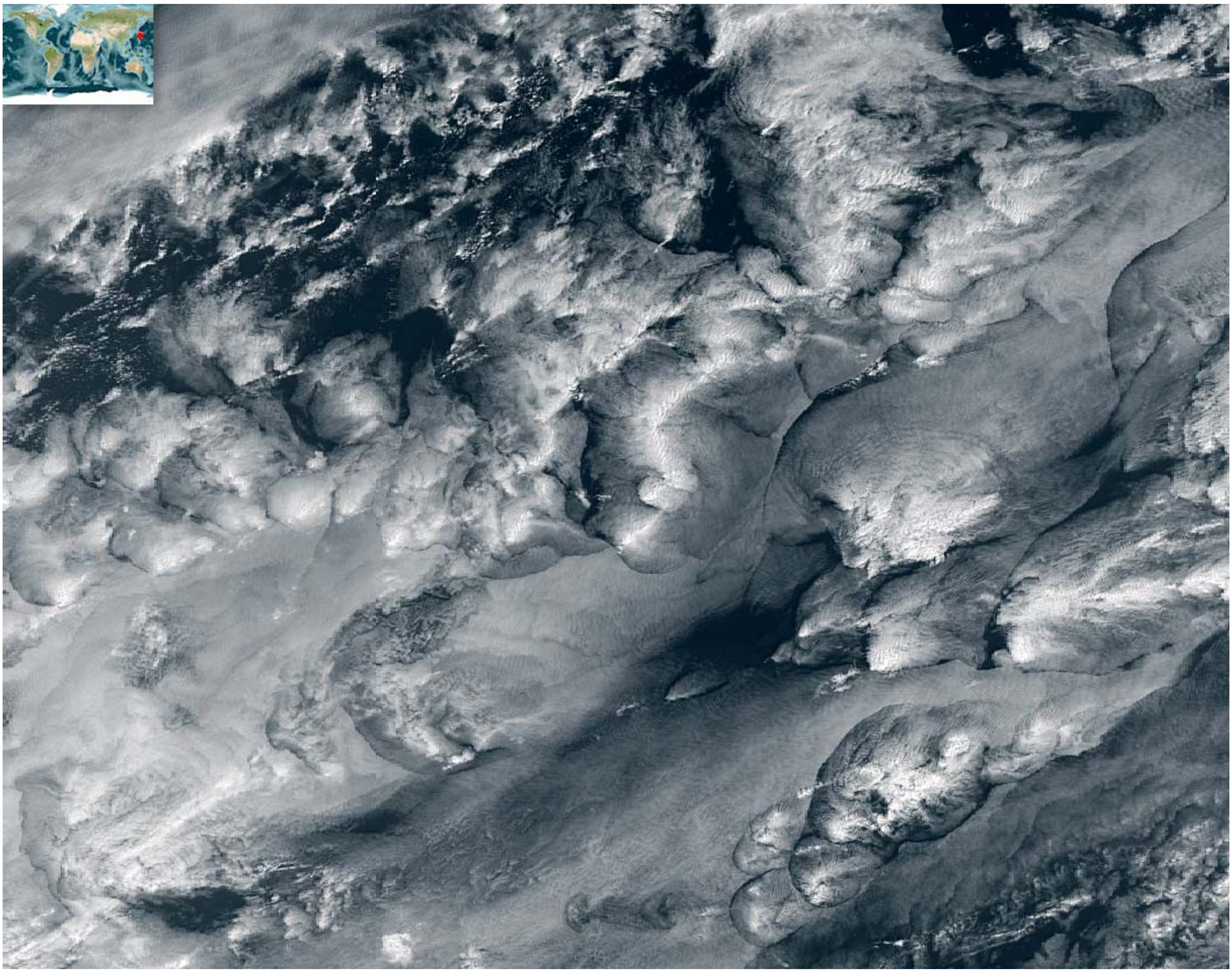


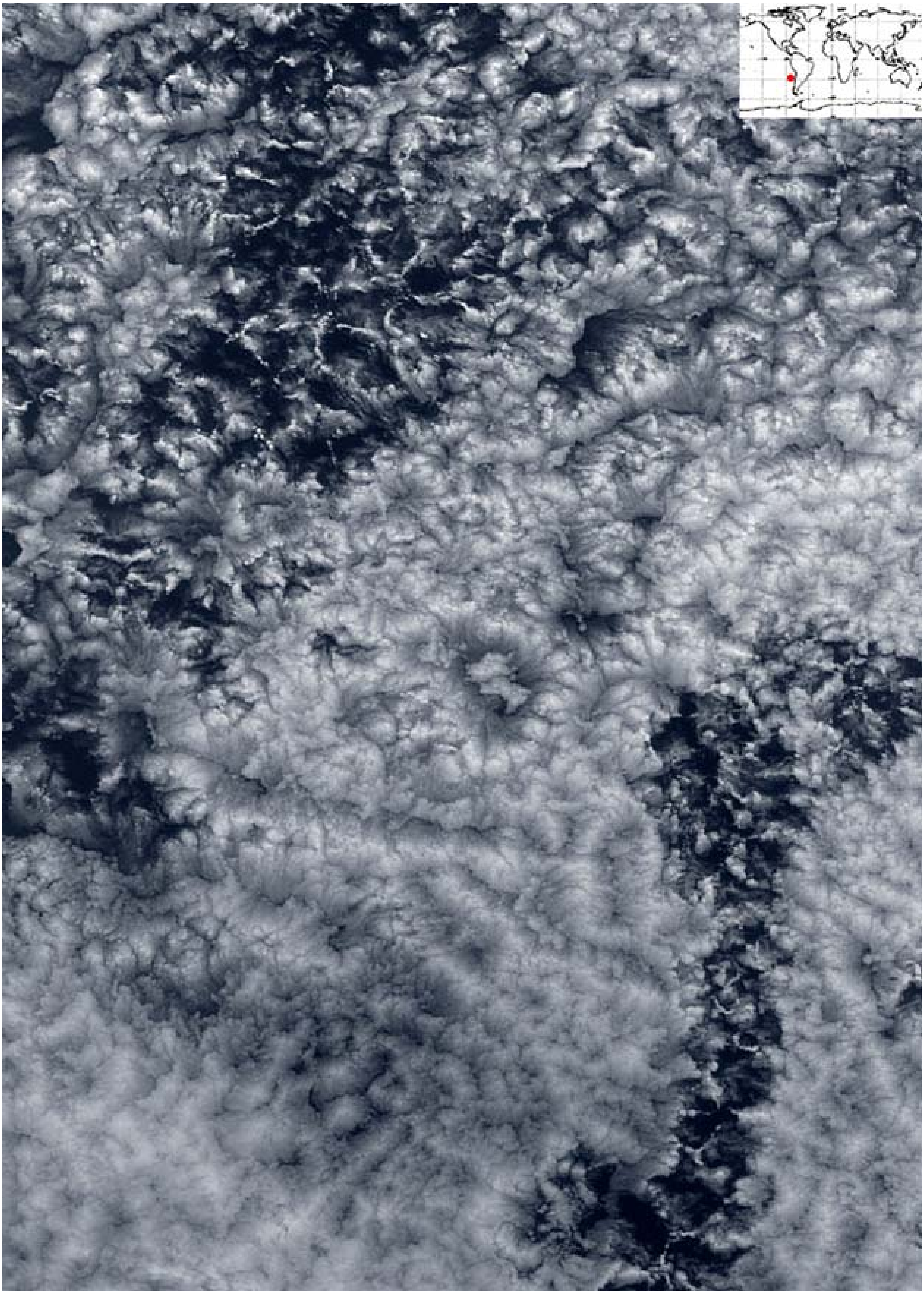


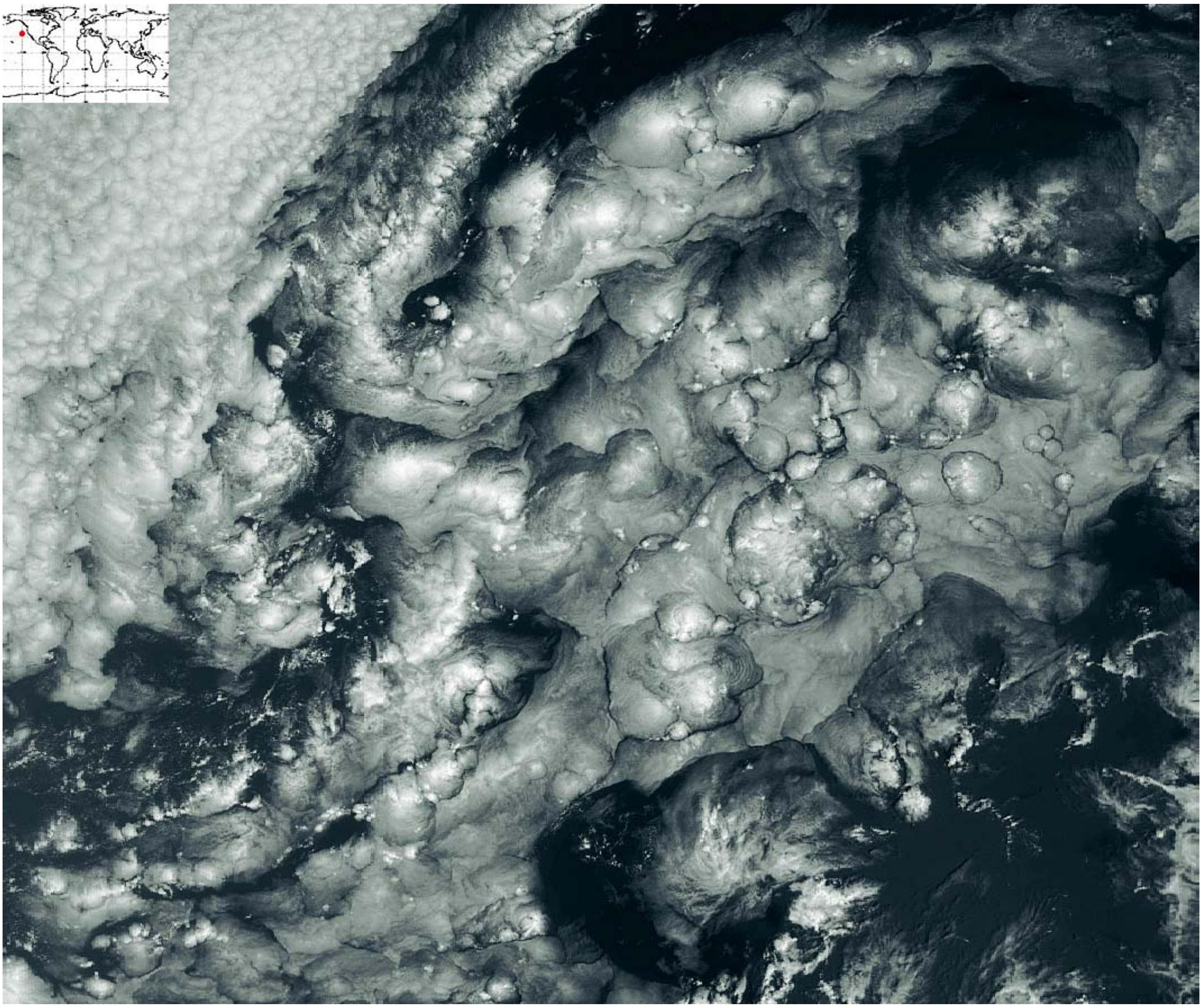


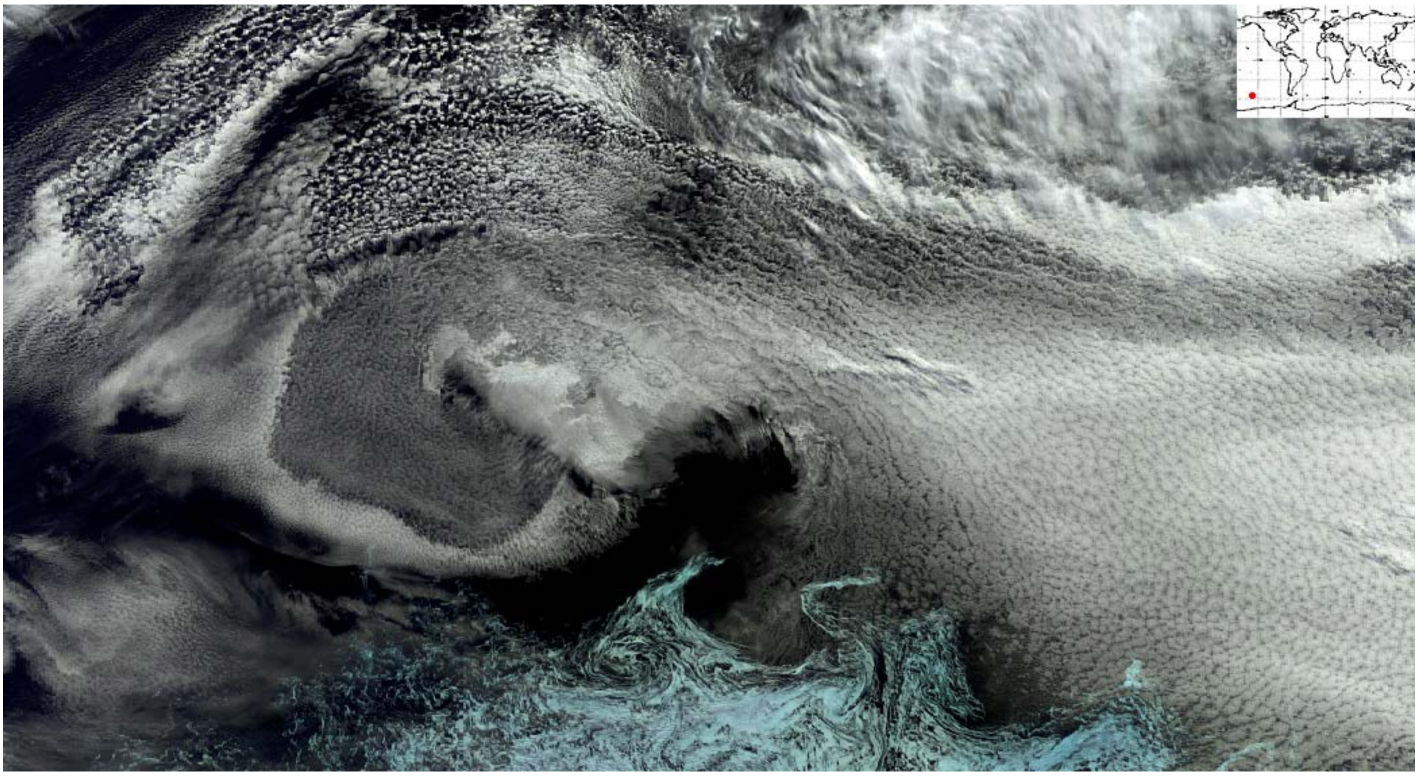


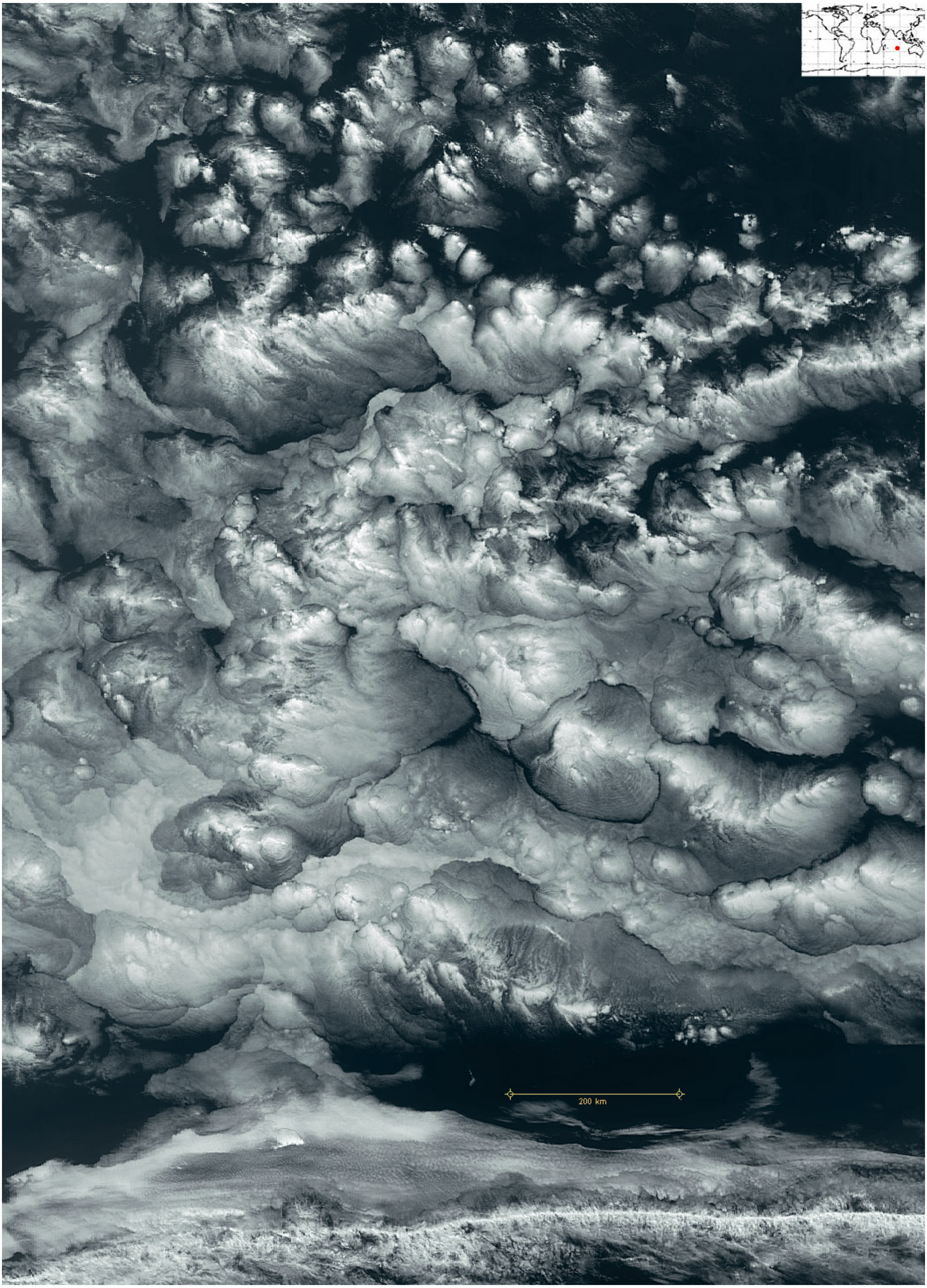






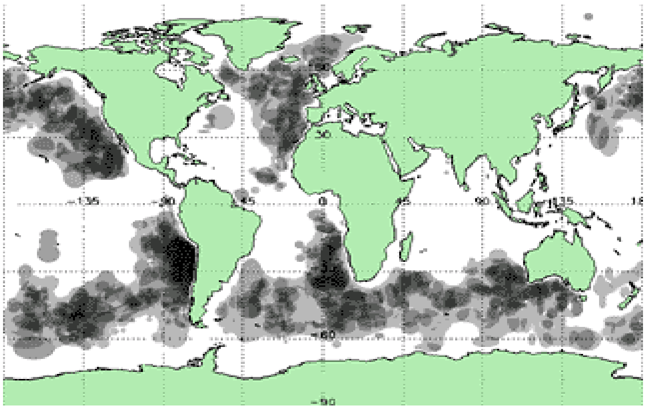




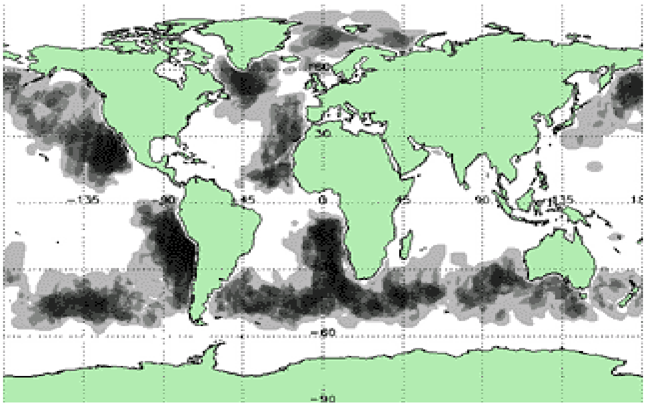

200 km

Observation diagrams

(the darker the point is, the more often observations were made)



Observation diagram for April 2006



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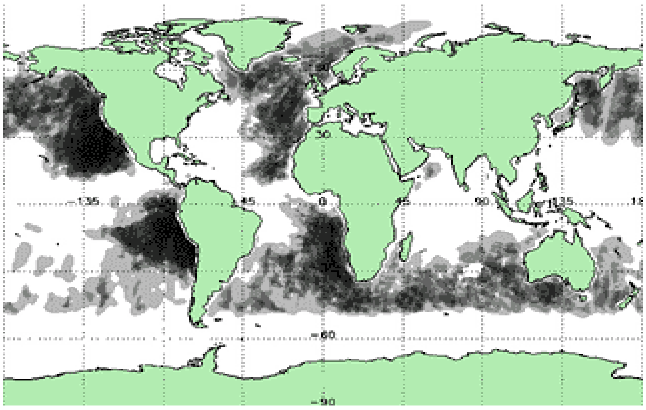

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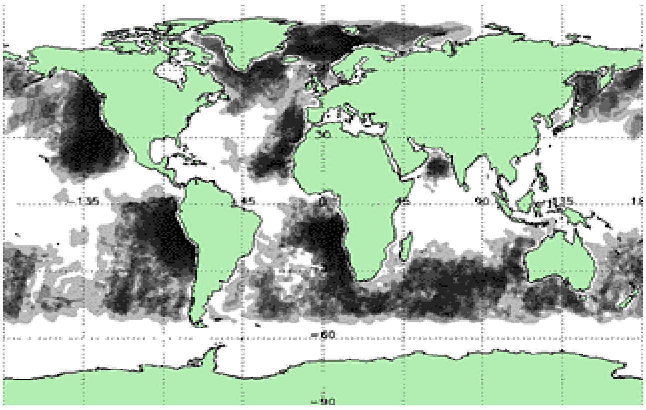

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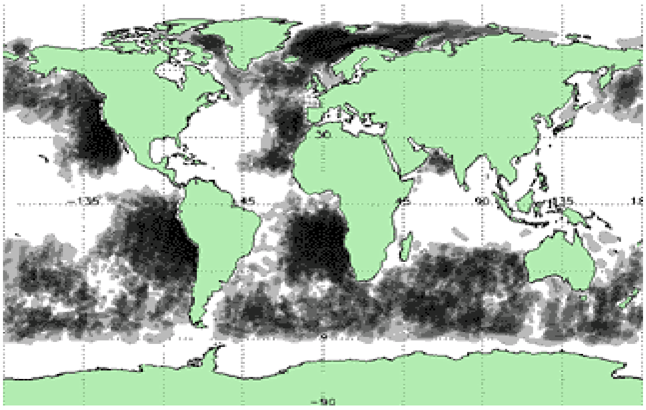

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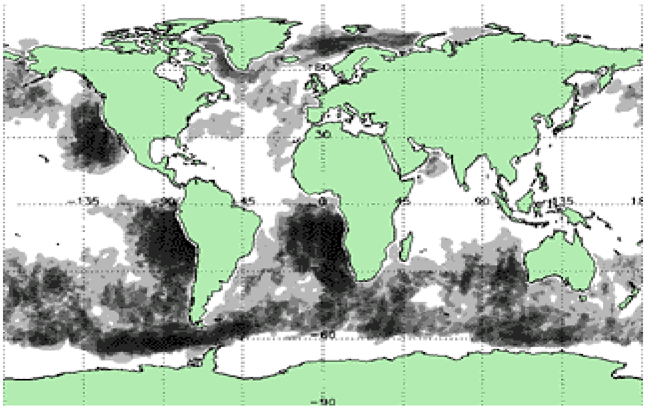
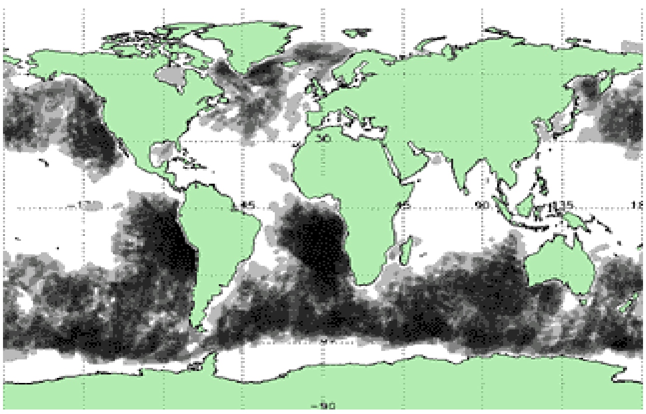
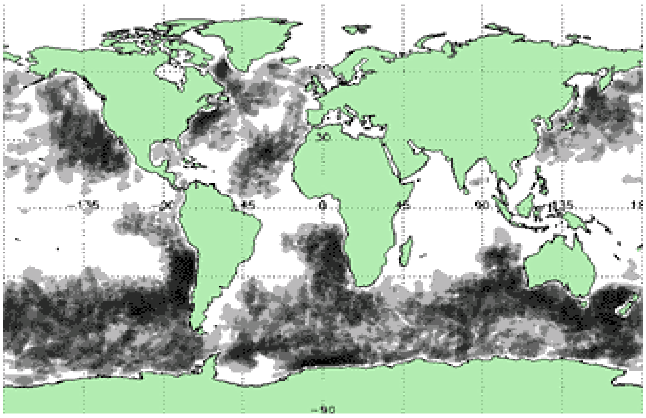


Observation diagram for September 2007



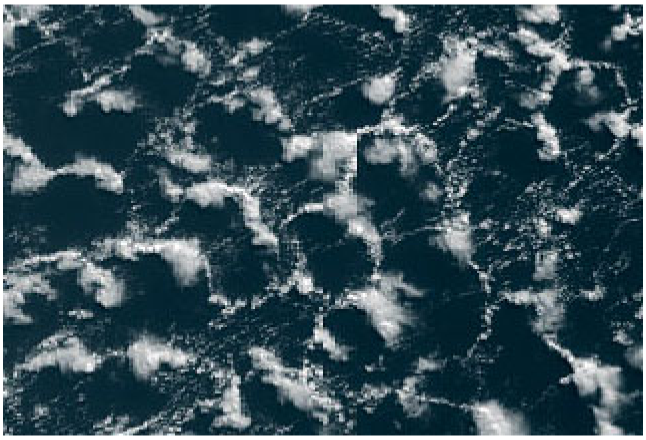
Observation diagram for October 2006



Observation diagram for February 2007

'Open Cell' Cloud Structure

CLOUD STRUCTURES



The clouds methought would open and show riches

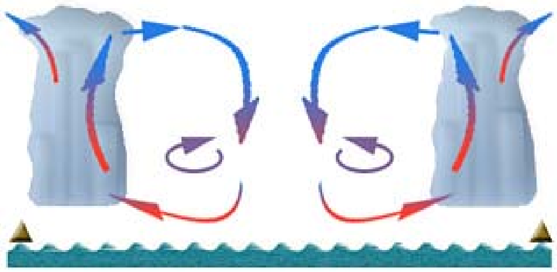
Ready to drop upon me; that, when I wak'd ...

William Shakespeare, "The Tempest", Act III, Scene II

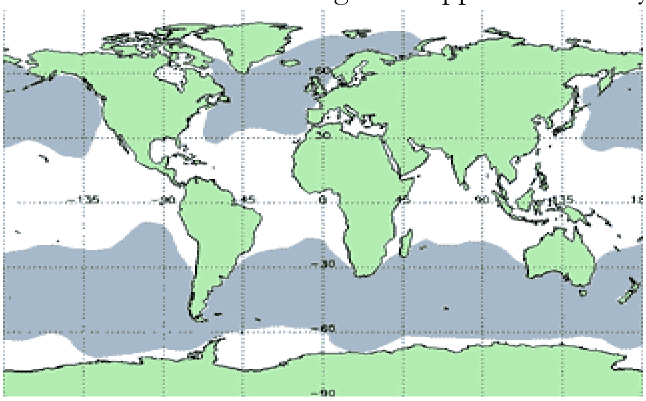
Convective Cells

'Open Cell' Structure (OCS)

An open cell consists of convective clouds, which top reaches only the lower layers of the troposphere. Within the cell vertical circulation takes place: the streams of the air go up in the zone close to its vertical borders (the cell sides) and then go down in an "empty place" (in the middle of the cell where there are almost no clouds).
Seen from above, an open cell ideally looks like a hexagon with the sides formed by rising clouds. However, a separate cell can be found quite seldom; they usually make up fields that ideally look (from above) like honeycomb and in reality resemble chain amour.
The size of a cell is up to 70 km (not rarely up to 100 km).
The cloud top height of a cell is 1.5-2.5 km, (sometimes up to 3 km).
The cloud top height of Enhanced Cumulus Clouds is up to 4-6 km, (rather often up to 7 km).
Accordingly albedo increases from ~0.5 to ~0.8 (and even to 0.85).
Space pictures often enable to see open and close cells sharing one and the same cloud field.

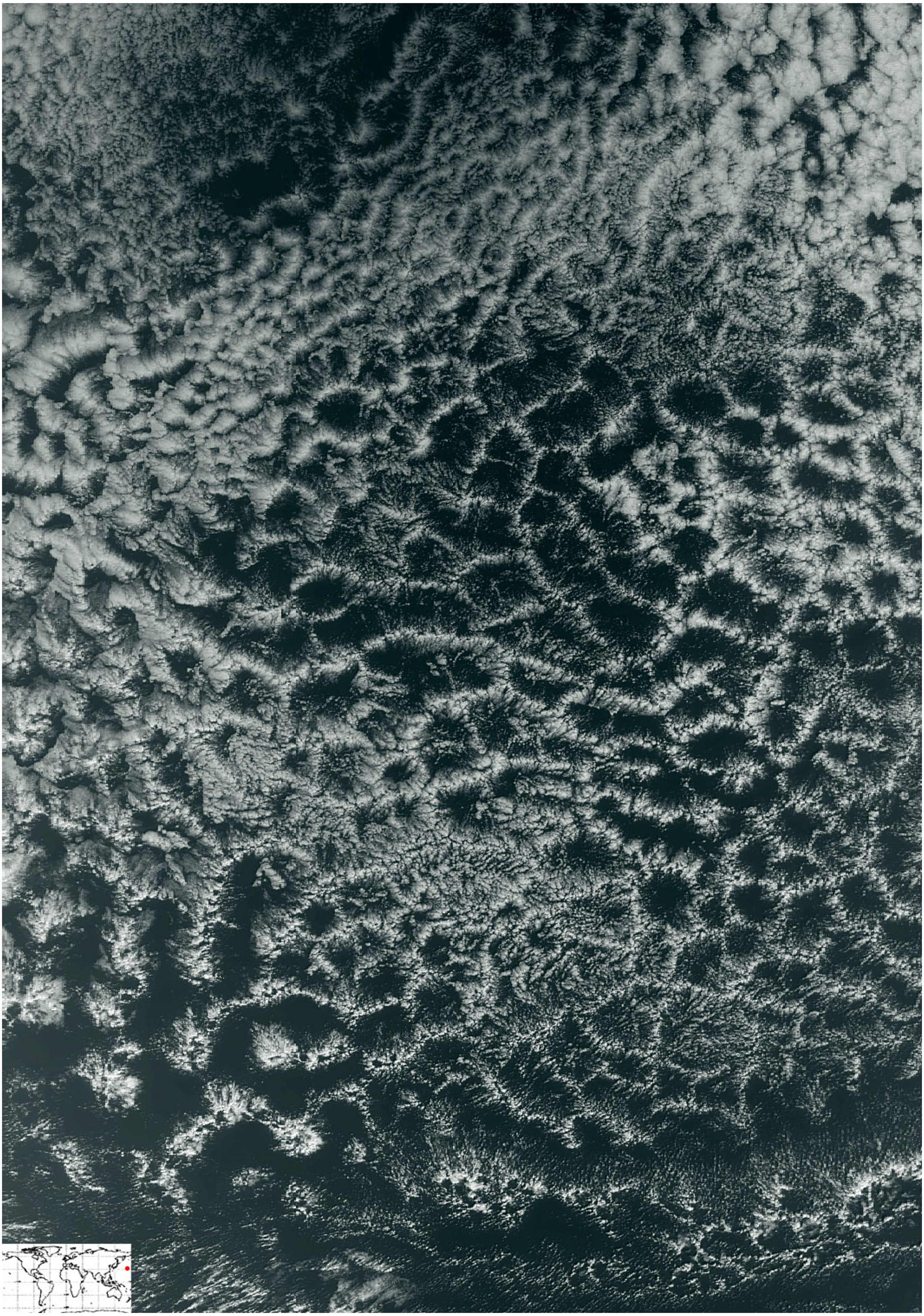


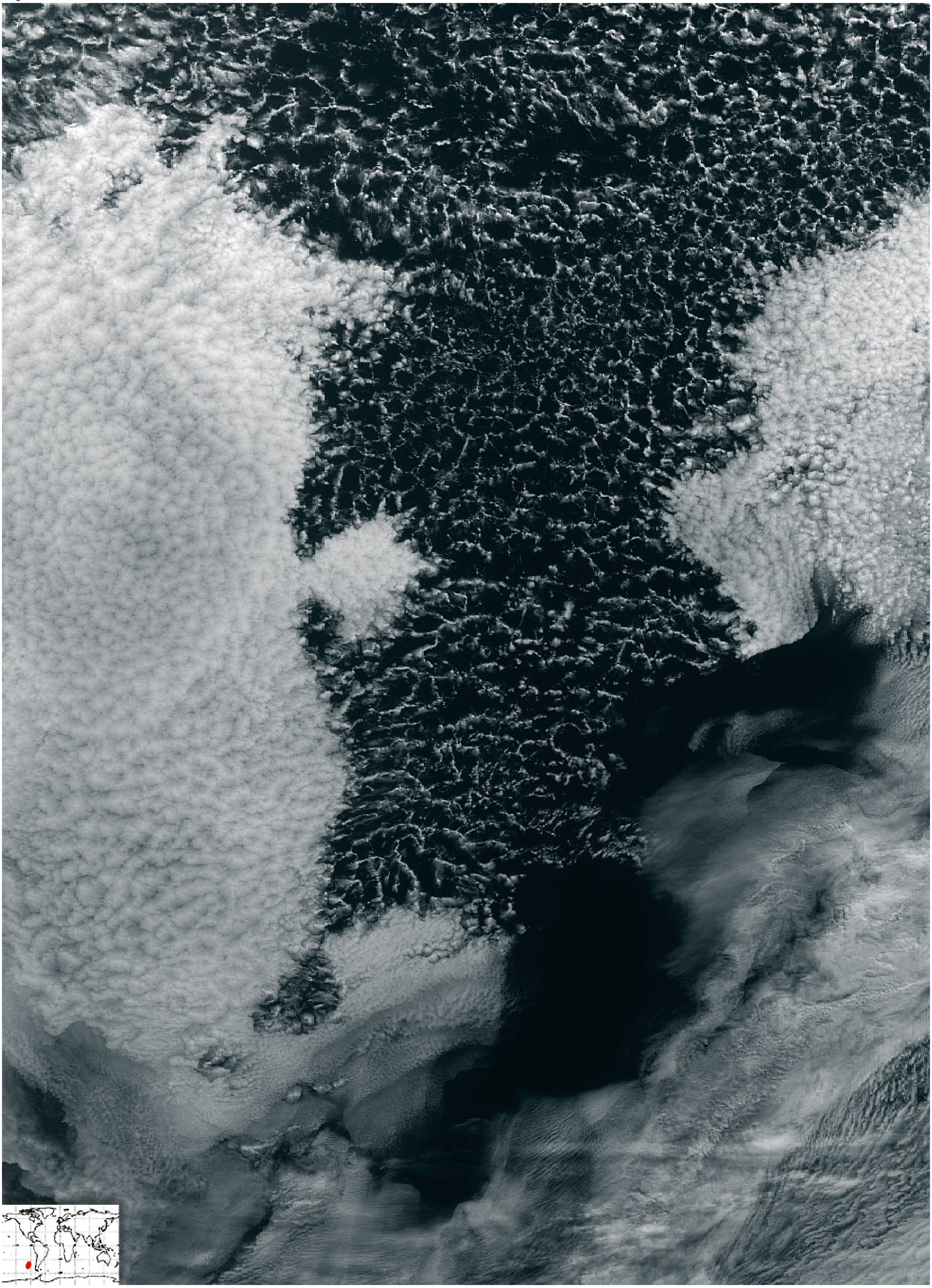
Open cells are present in convection cells cloud streets that in most cases emerge as the result of strong cold wind blowing over polar seas.
The Enhanced Cumulus Clouds represent a particular kind of the open sells.
They form above polar seas and seas in the middle latitudes as the season may be.
The cold air moving over the sea surface heats from below as its temperature is lower than that one of the water.
As the result of this heating there appears instability in the surrounding atmosphere and the warm masses of the air go up, cooling.

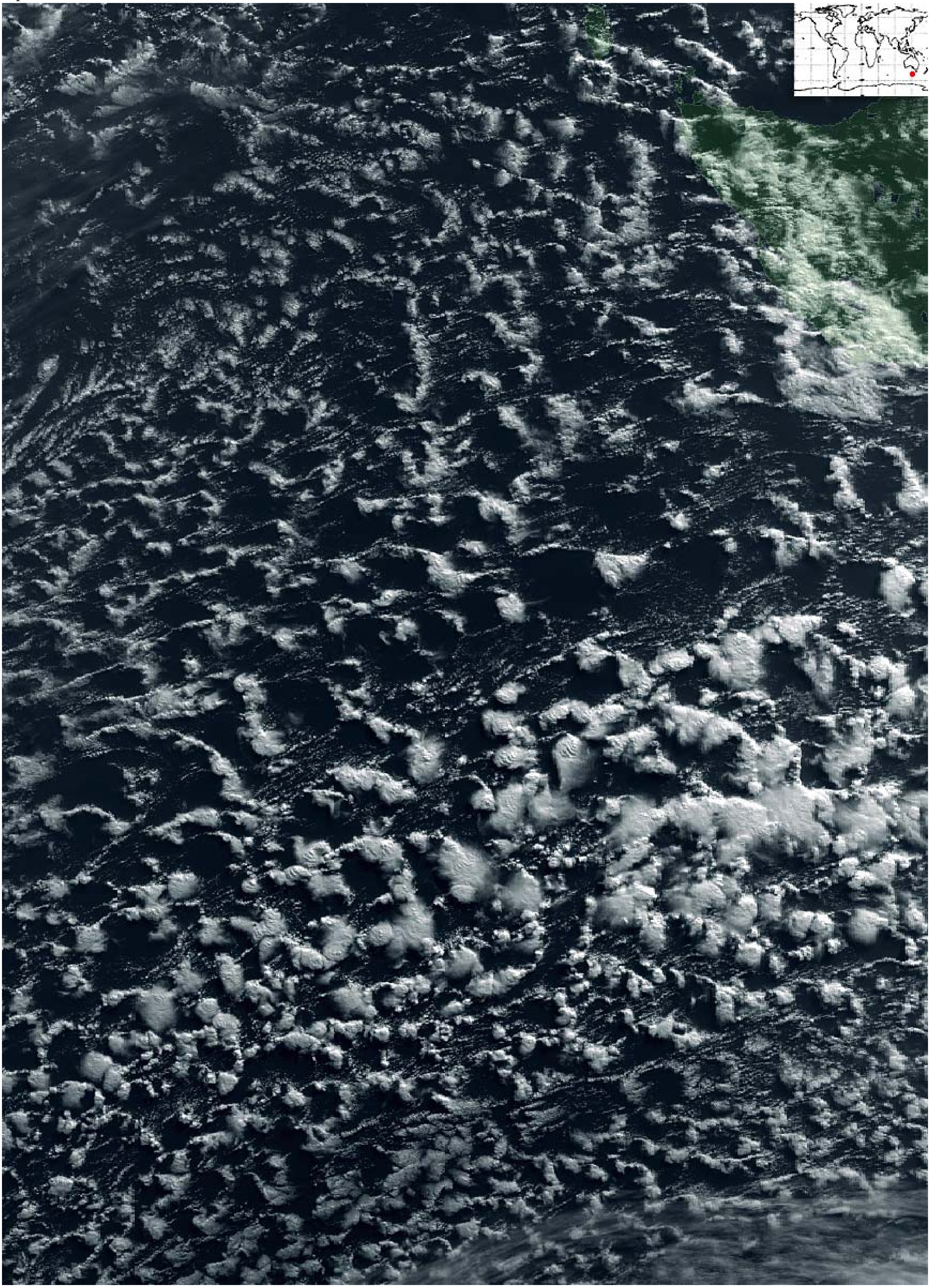


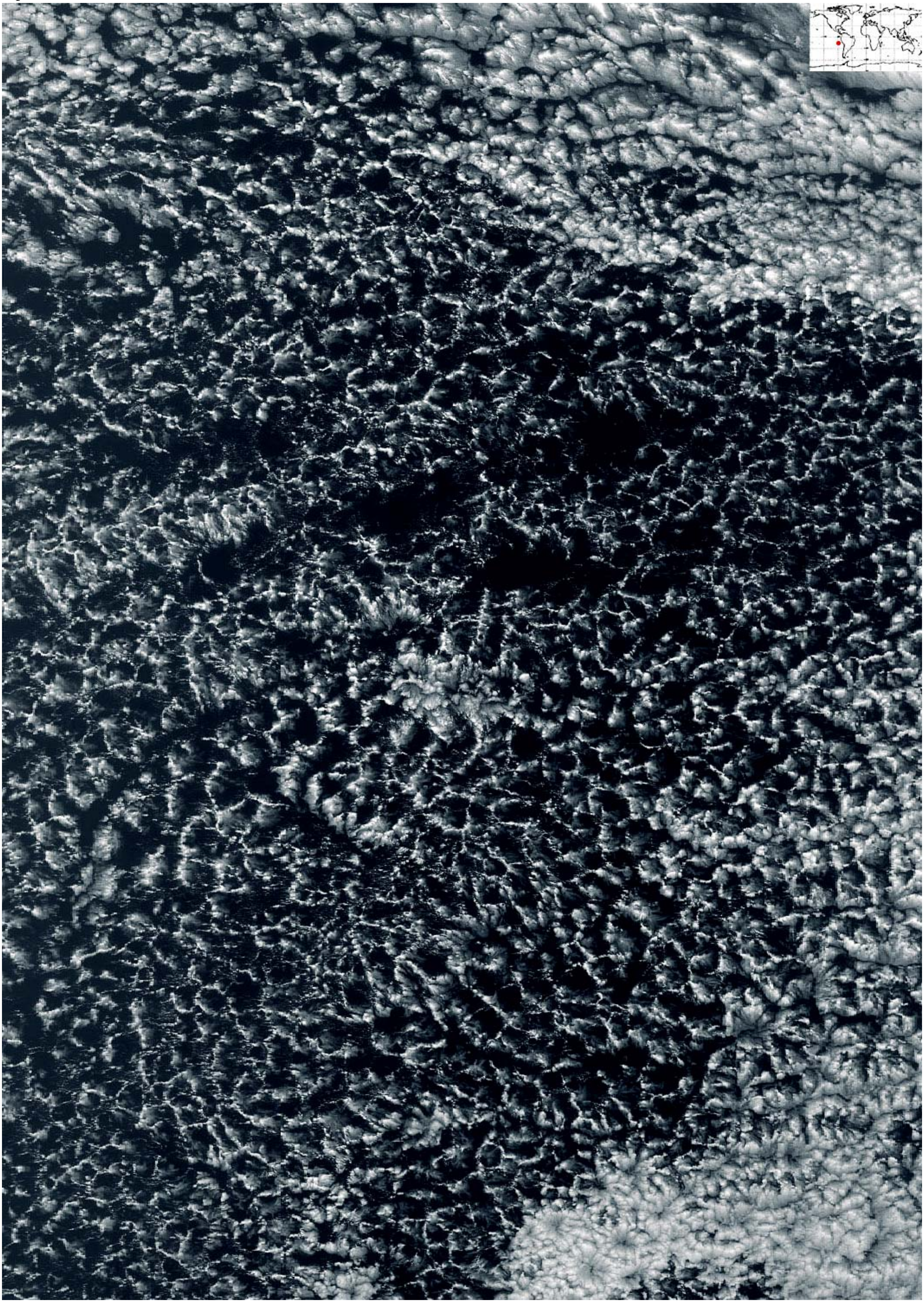
The condensation goes with the release of latent heat that holds the vertical streams. Owing to the cooling of the air that is being raised this support is accompanied with the enhancement of condensation. From the upper layers of the atmosphere the cold dry air is going down towards the rising stream. That is why the movement upward is limited in the convective cells and in some time there appears the balance between the rising and descending streams of the air. As the result large fields of cold cells emerge often causing a great amount of precipitation.
In the upper level of outlet channel inside cold air masses following the cold front under strong wind caused by the instability in the atmosphere the sides of the cell perpendicular to the direction of the wind become higher and (when seen from above) thicker. Not seldom such an effect occurs in the cold areas on the backside of large cyclone swirls.

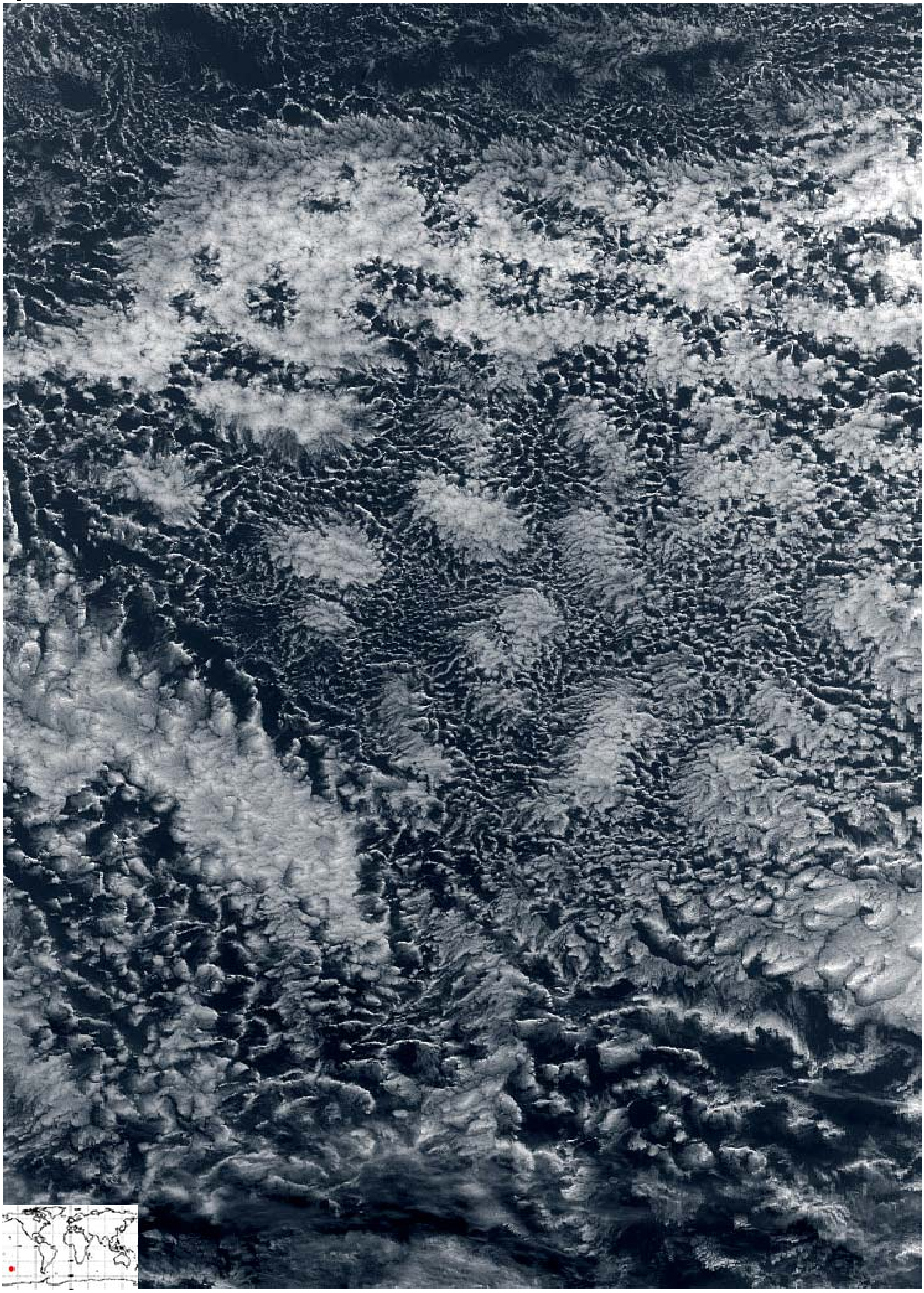
Examples.

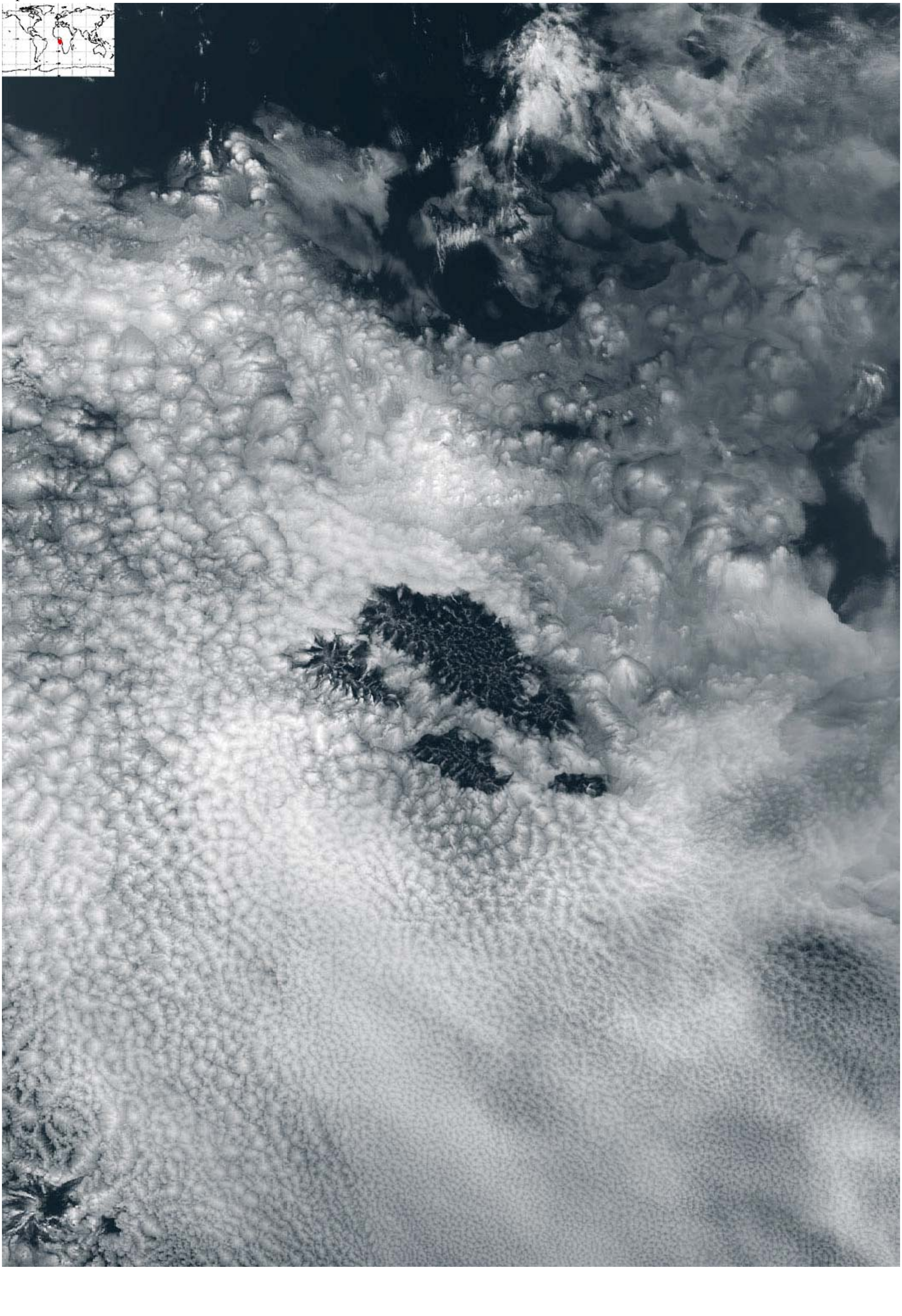


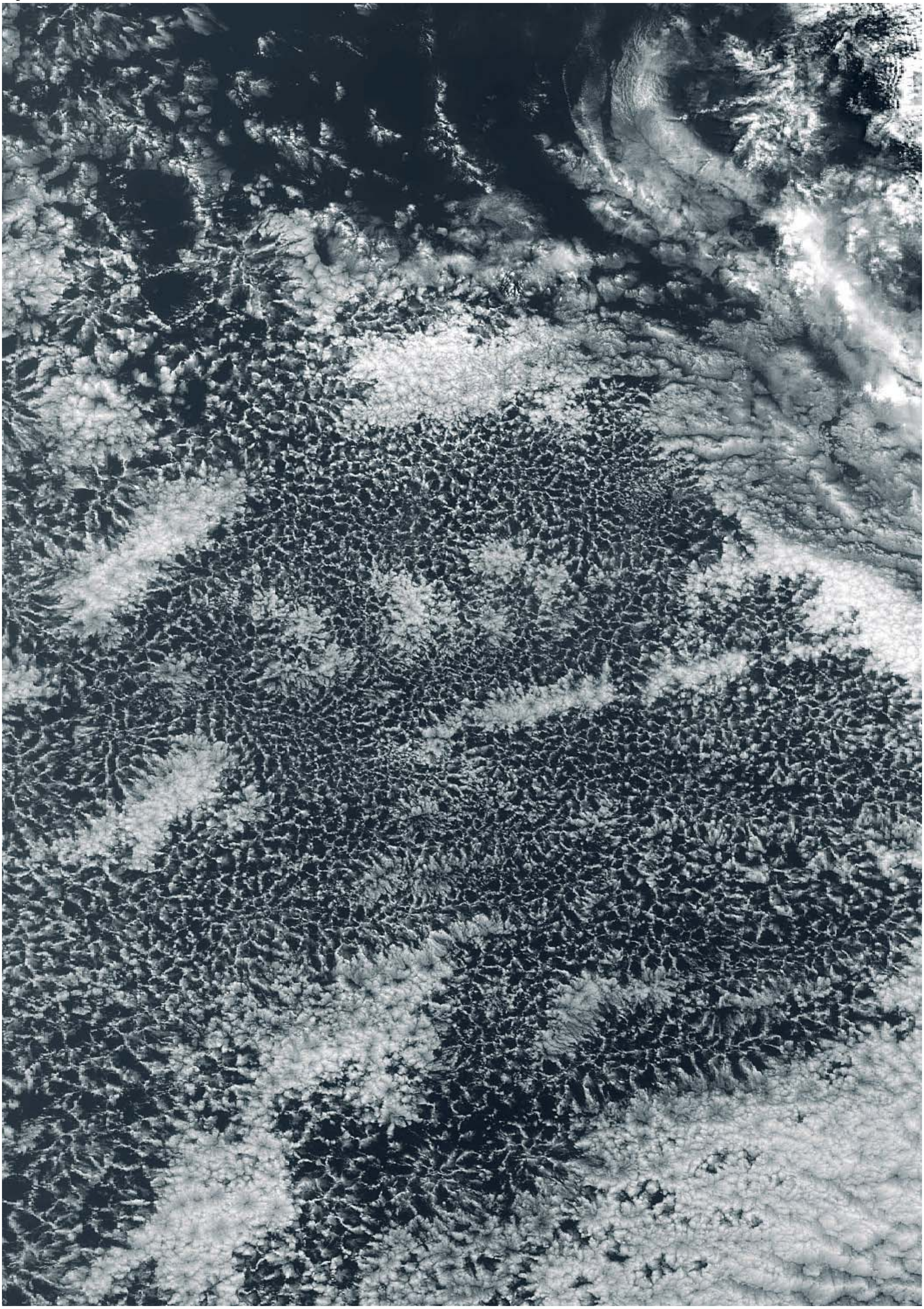


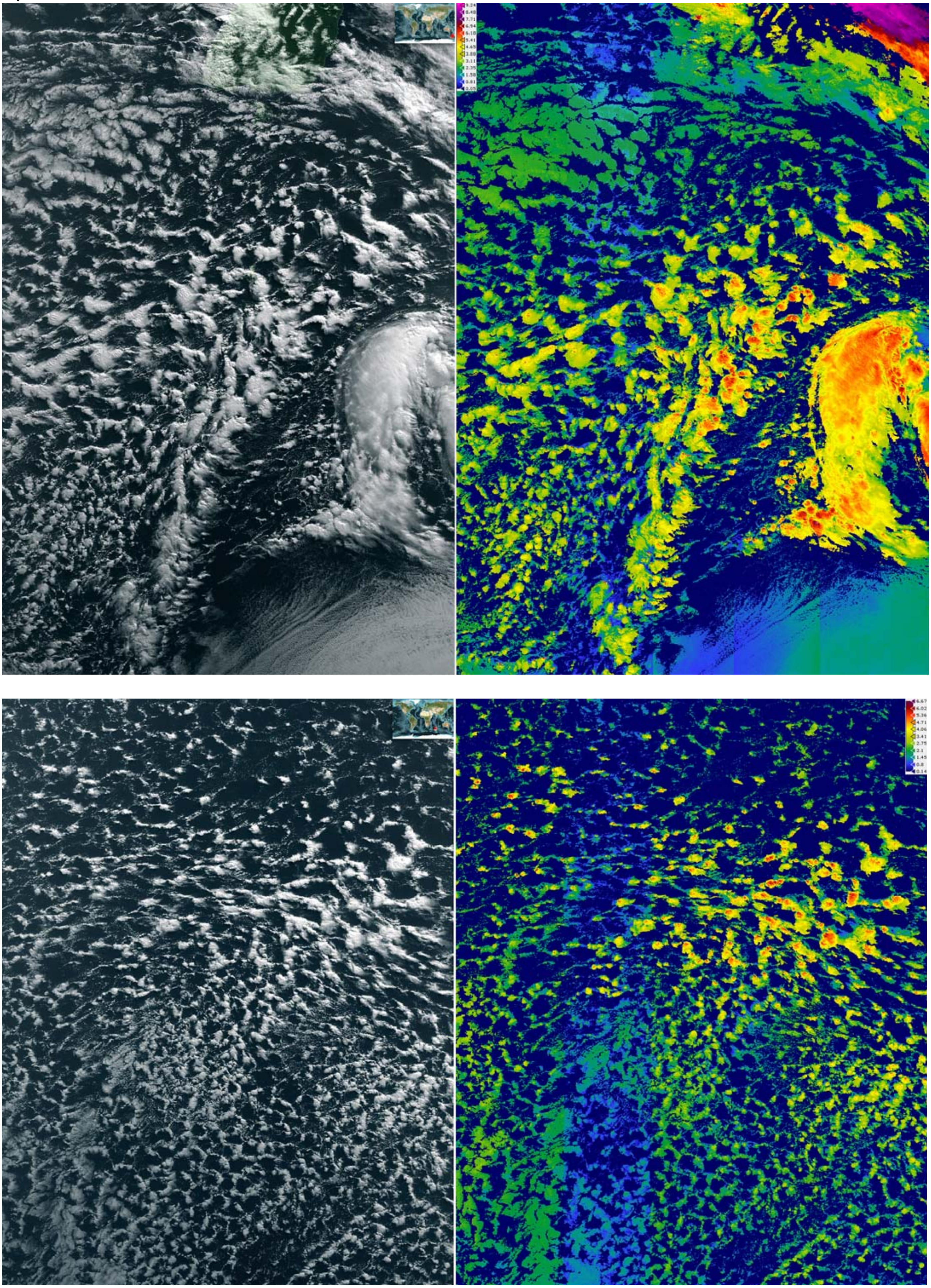


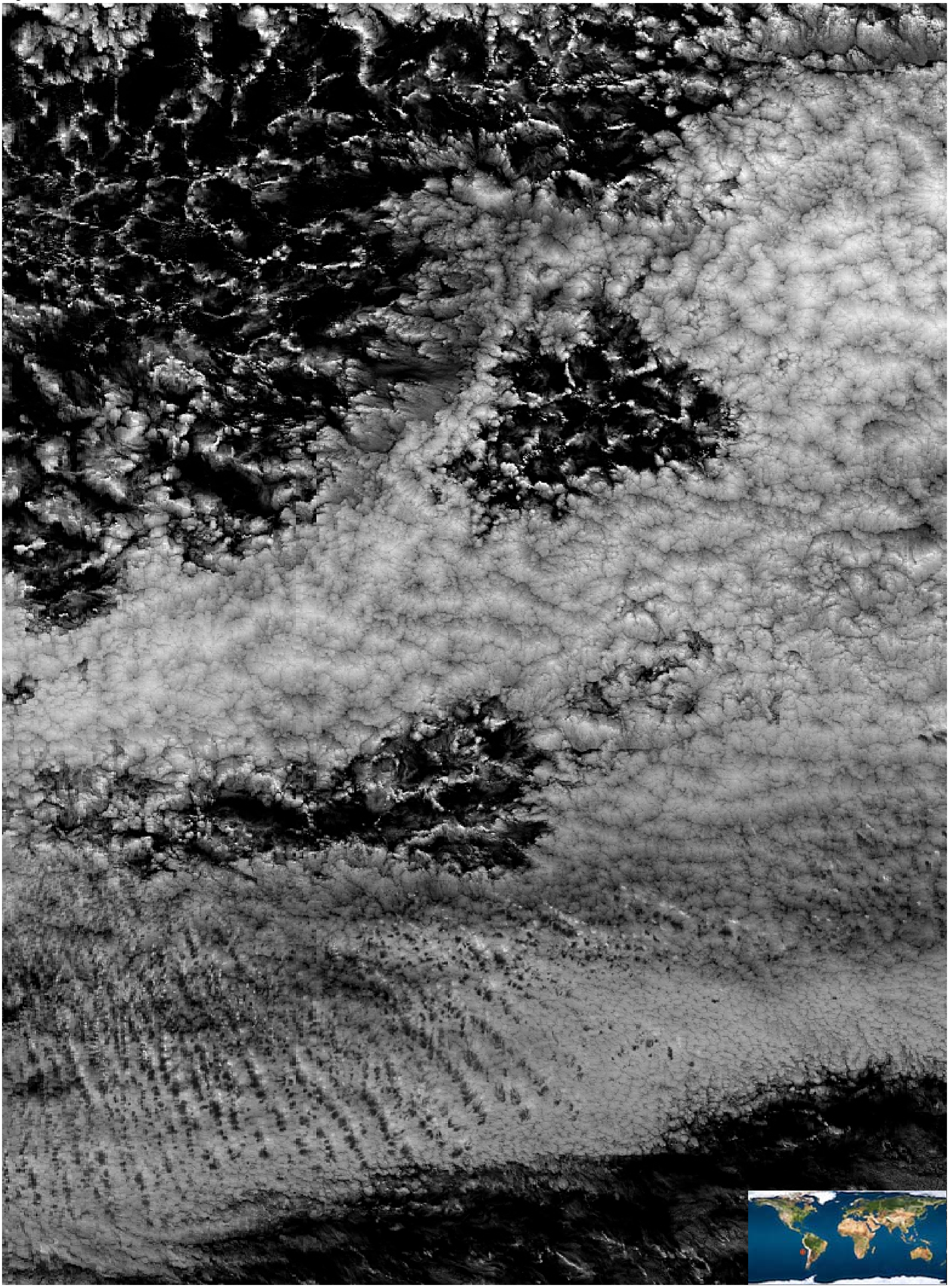






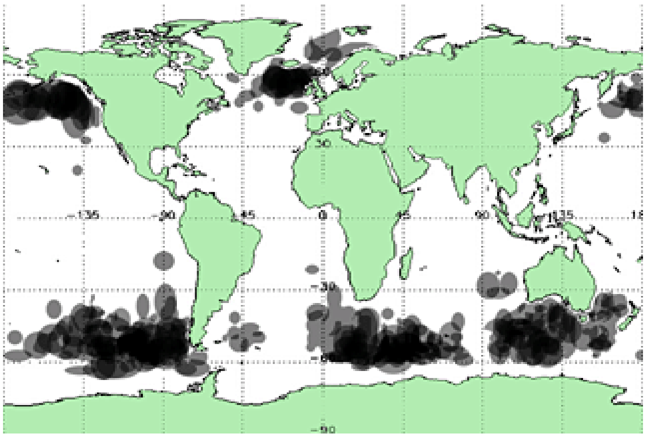




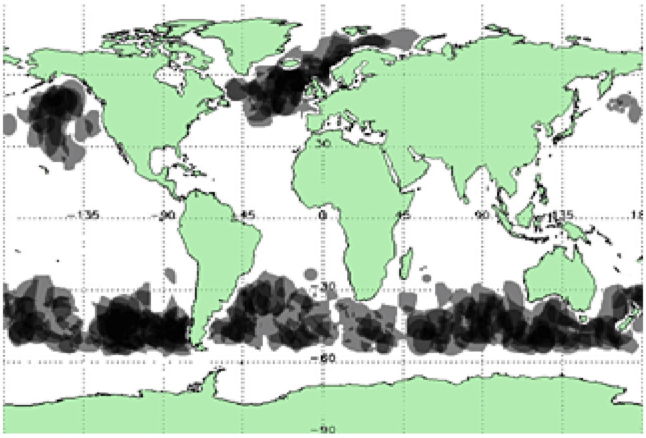


Observation diagrams

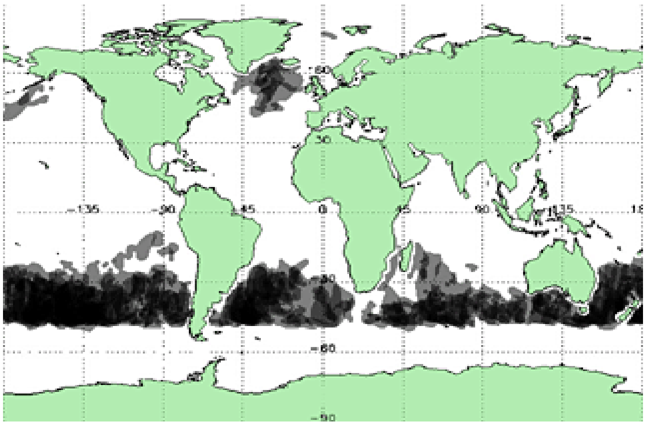
(the darker the point is, the more often observations were made)



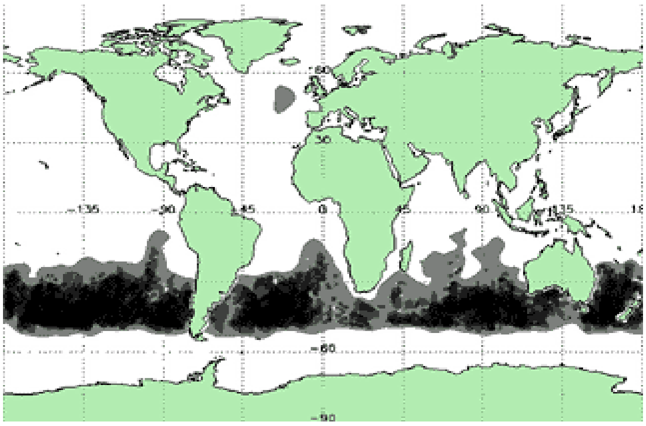
Observation diagram for April 2006



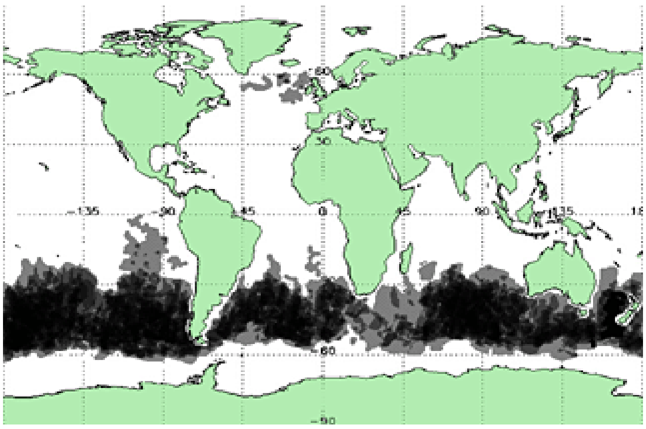
Observation diagram for May 2006



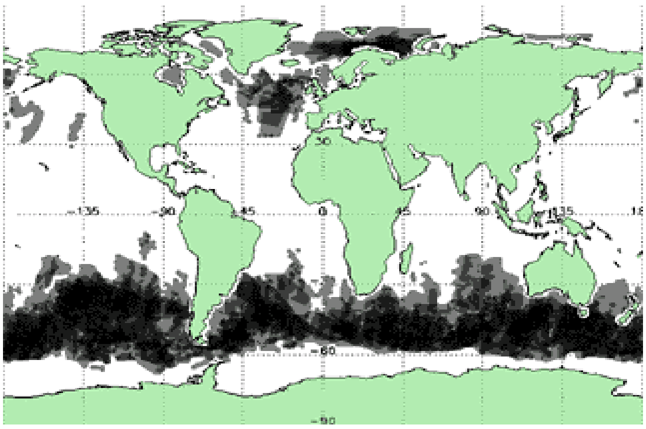
Observation diagram for June 2006



Observation diagram for July 2007



Observation diagram for August 2006



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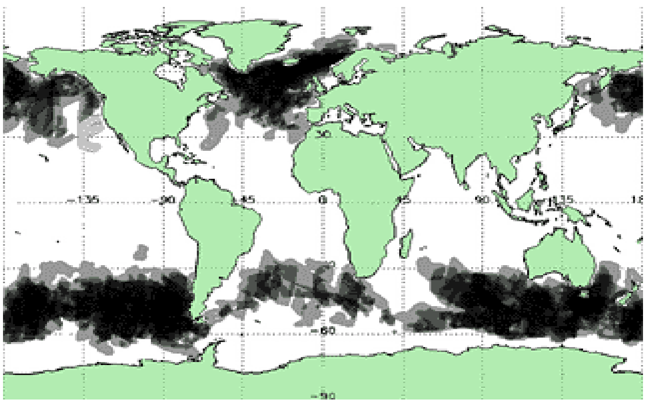
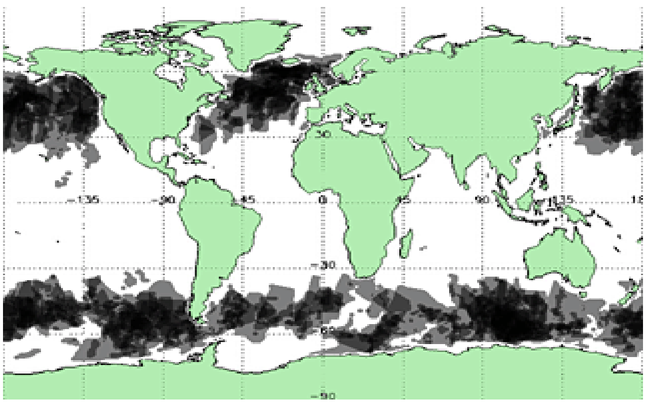
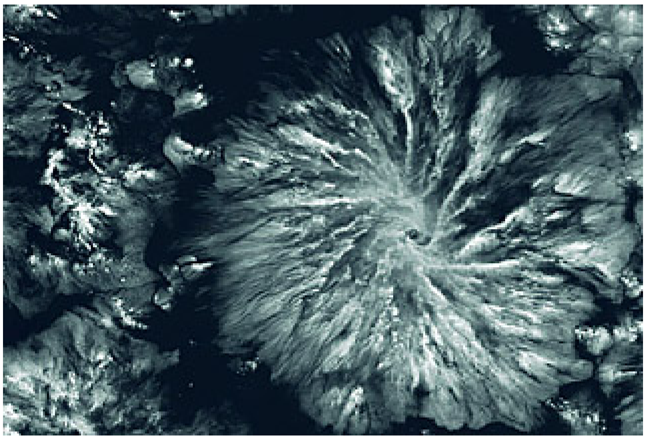


Observation diagram for October 2006



Observation diagram for February 2007

'Actinoform' Cloud Structure



Clouds and eclipses stain both moon and sun,

And loathsome canker lives in sweetest bud.

William Shakespeare, Sonnet XXXV

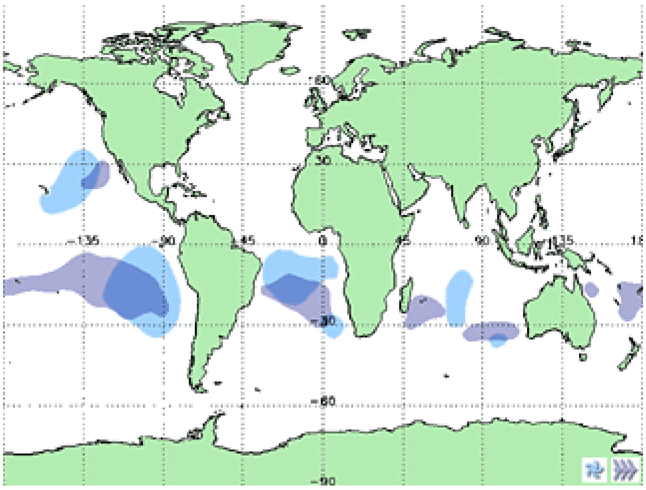
"Convective Cells"

"Actinoform" Structure (AFS)

The Actinoform Structure (named after the Greece *actinos*, a beam) may have two forms:

- round or oval cloud formation where there appear to be radial symmetry and sometimes even helical motion. These formations, when seen from high above, resemble veins of a leaf. In this case the dimension of the structure is from 80 to 400 km (seldom more).
- long (up to thousands of kilometres) bands that consist of "accrete" cells.

When seen from above this structure looks like a huge centipede with well-marked spine and multiple ribs.
In this event the width of the band is 70-120 km, and the length is from several hundreds to 1-1.5 thousand (or even more) km.
The cloud top height is from 0.6 - to 2 km, seldom to 2.5.
It is interesting to note that according to the new MERIS Level 2 data the cloud top height in the centre of round structures (as well as the "spine" of the band structures) is always 300-700 m lower than the cloud top height of the clouds located in the periphery of the structures.
The Actinoform Structure emerges at the border of the fields of the open and close convective cells using the open convective cells as the substrate.



Large (from ~200 km) round/oval structures may attract neighbouring closed convective cells. Segregating they may later on form isolated (located outside the fields that have created them) vast elements in which the general circulation seems to be similar to that one that takes place in open convective cells. Such structures often separate from the convective cells that have created them and exist on its own, sometimes revolving around its own centre, even forming an "eye".
On their part the band structures also demonstrate sufficient stability and segregate along the low-level streams of the air most often in parallel with the equator.
The Actinoform Structure mainly consists of stratocumulus clouds; quite often there are stratus clouds along the ridge of the "ribs" and small cumulus - in their periphery.

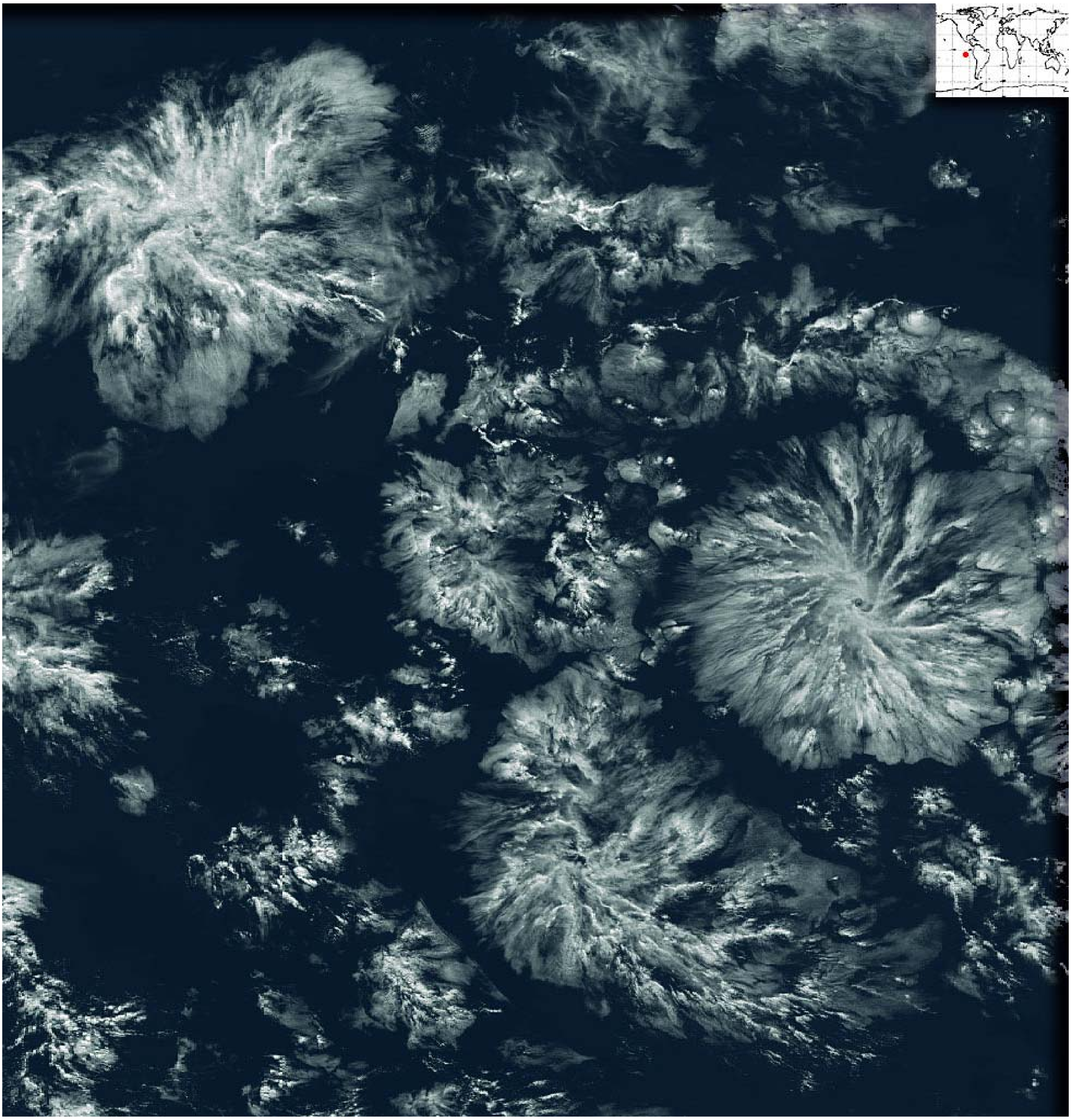
Actinoform Structures are not seen frequently, though they can be seen quite often.

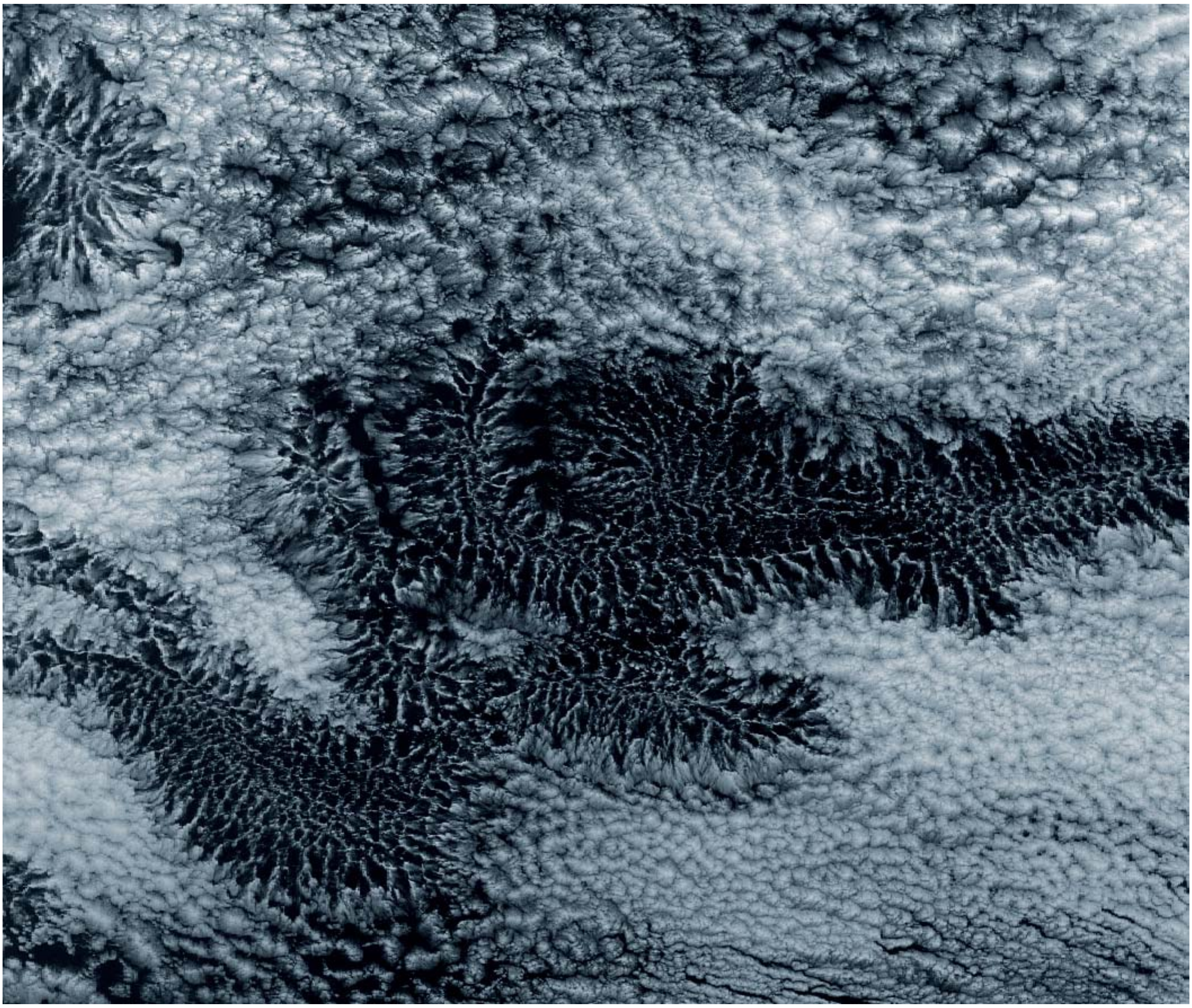
They can be observed where there are large fields of open and close convective cells: mostly over East Pacific not far from the Peruvian cost, as well as not far from the Atlantic coast of Brazil and above the Indian Ocean close to the coast of Western Australia.

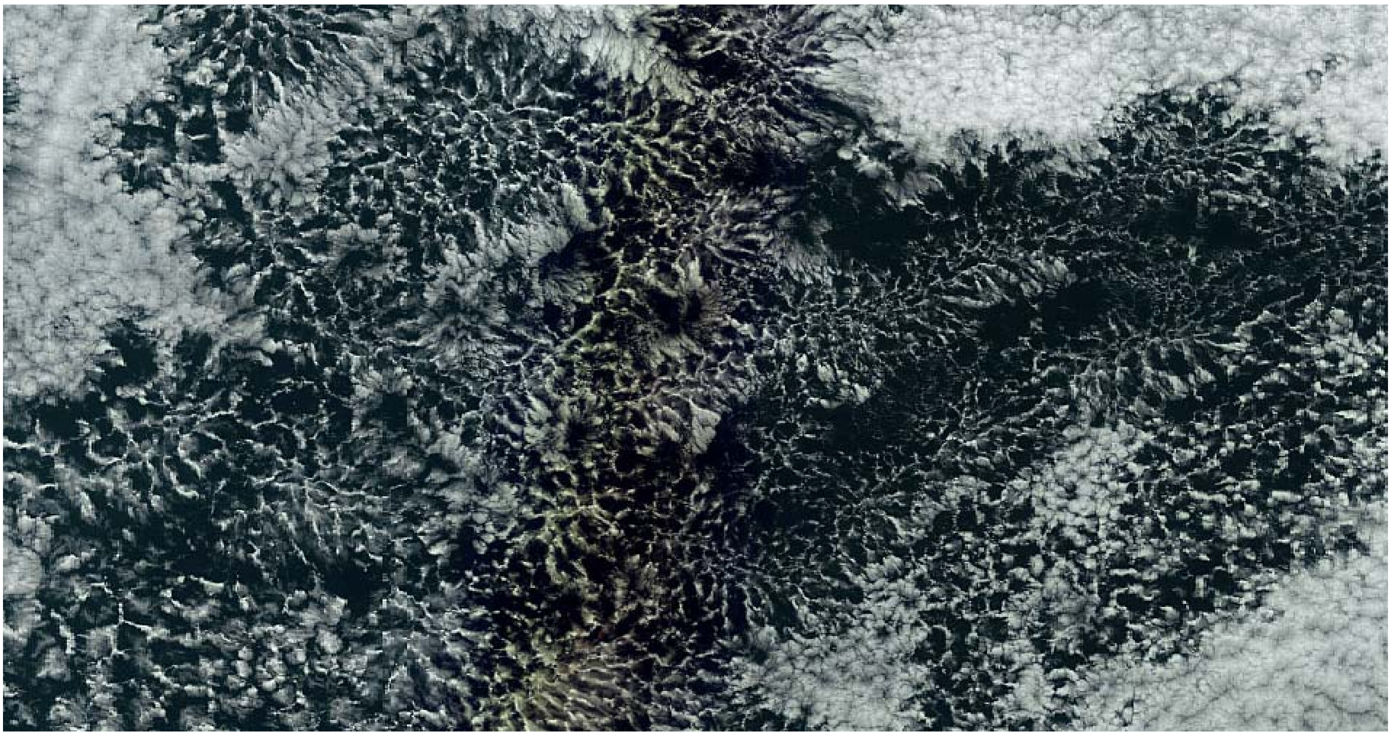
According to some weather reports the clouds of these structures are the source of drizzle.

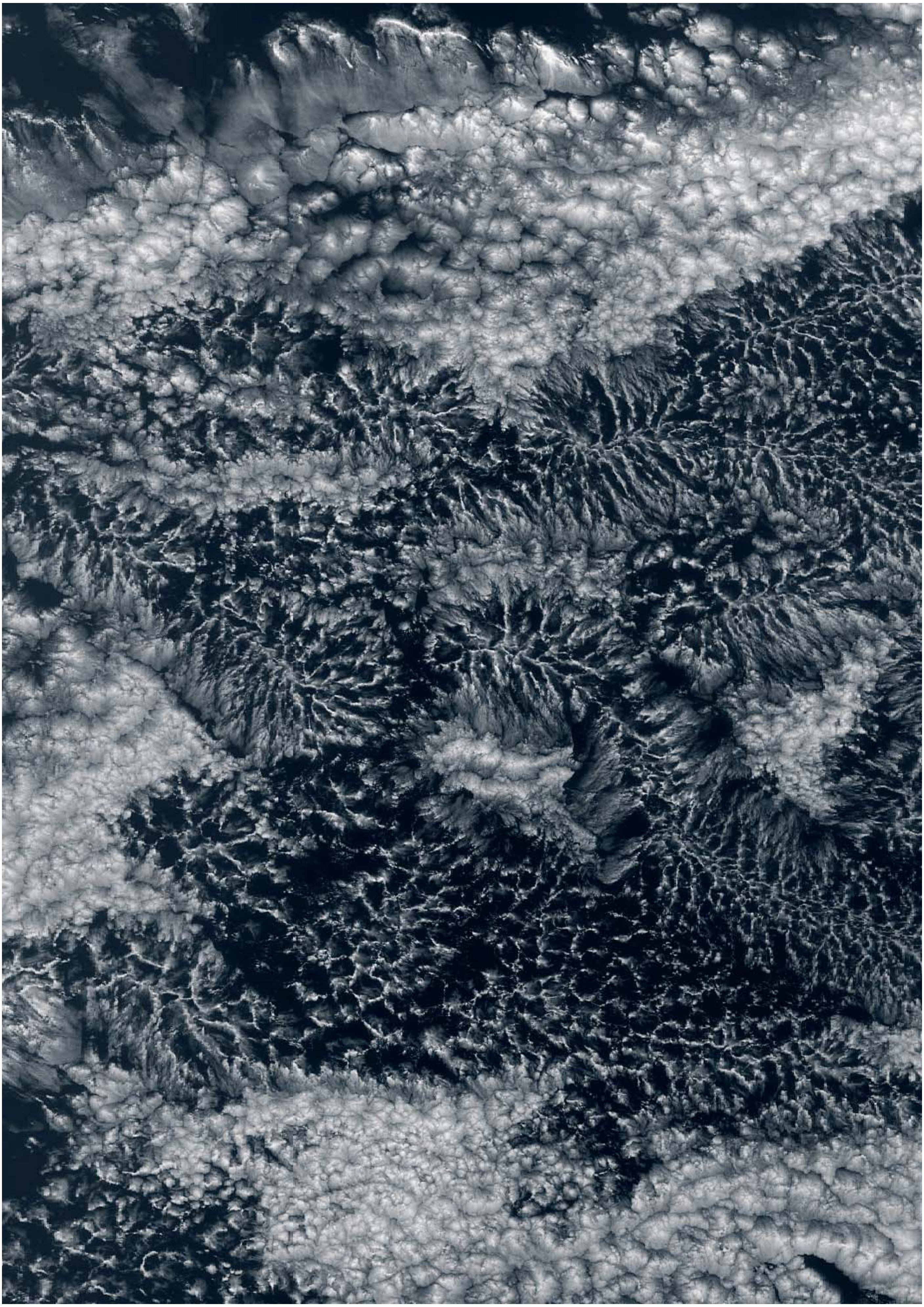
Not often it is possible to watch large (up to 600 - 700 km) cloud structures bearing some similarities to the Actinoform structure and undergoing dissociation (possibly the increase of the dimension causes the structural instability). It is hard to say exactly if such enormous formations belong to the Actinoform structure, because there is no valid physical description of this structure yet.

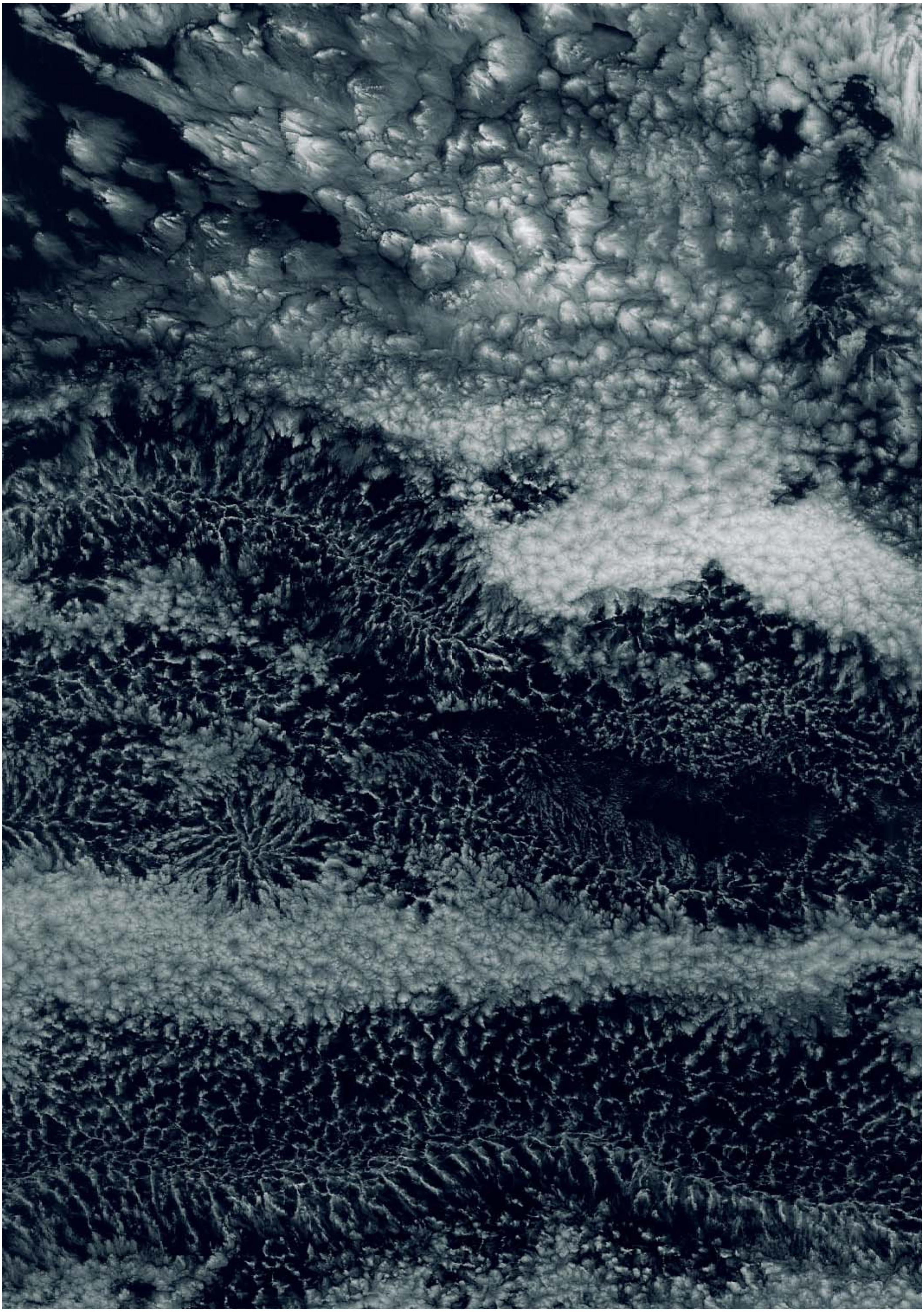
Examples.

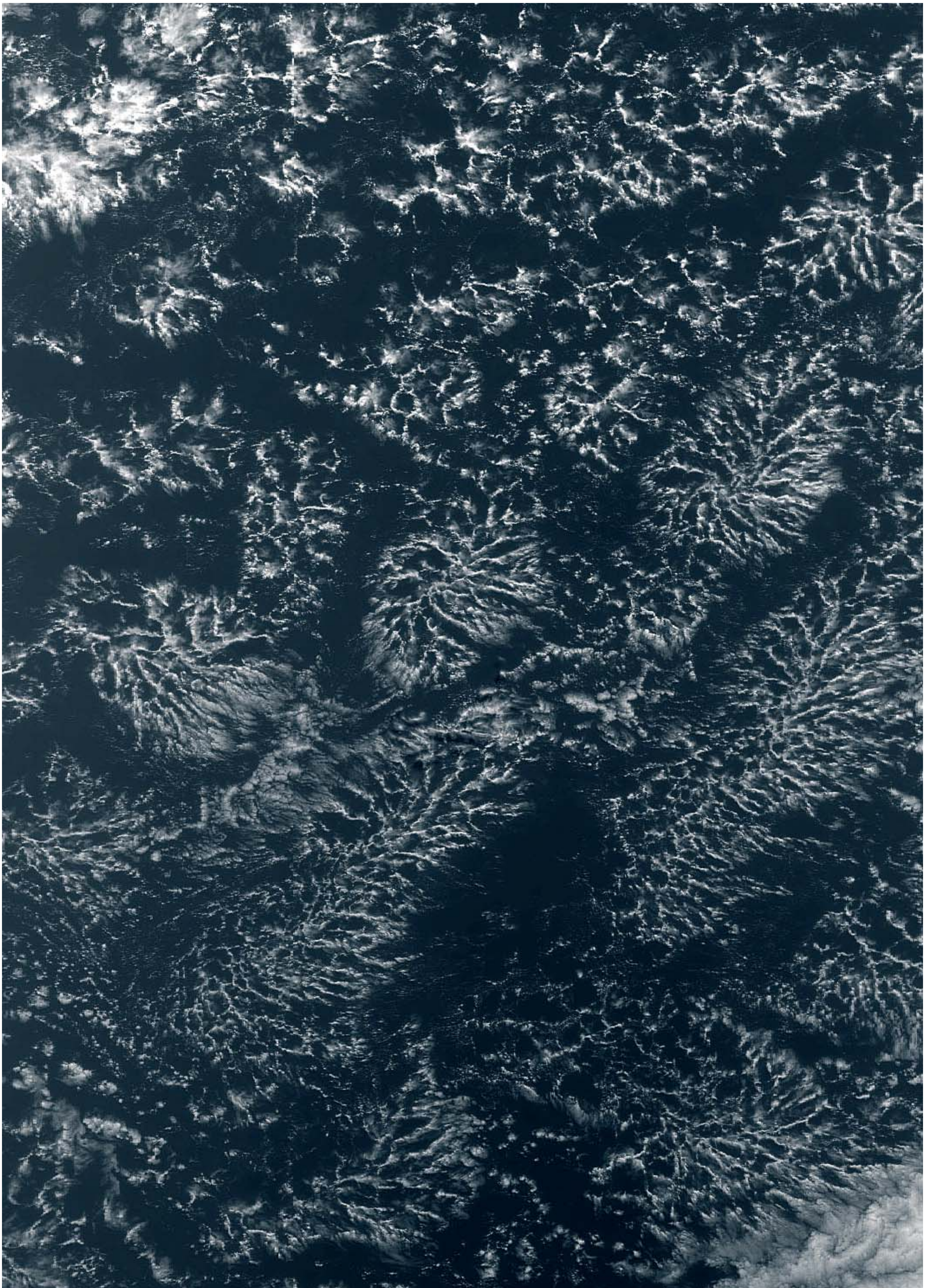


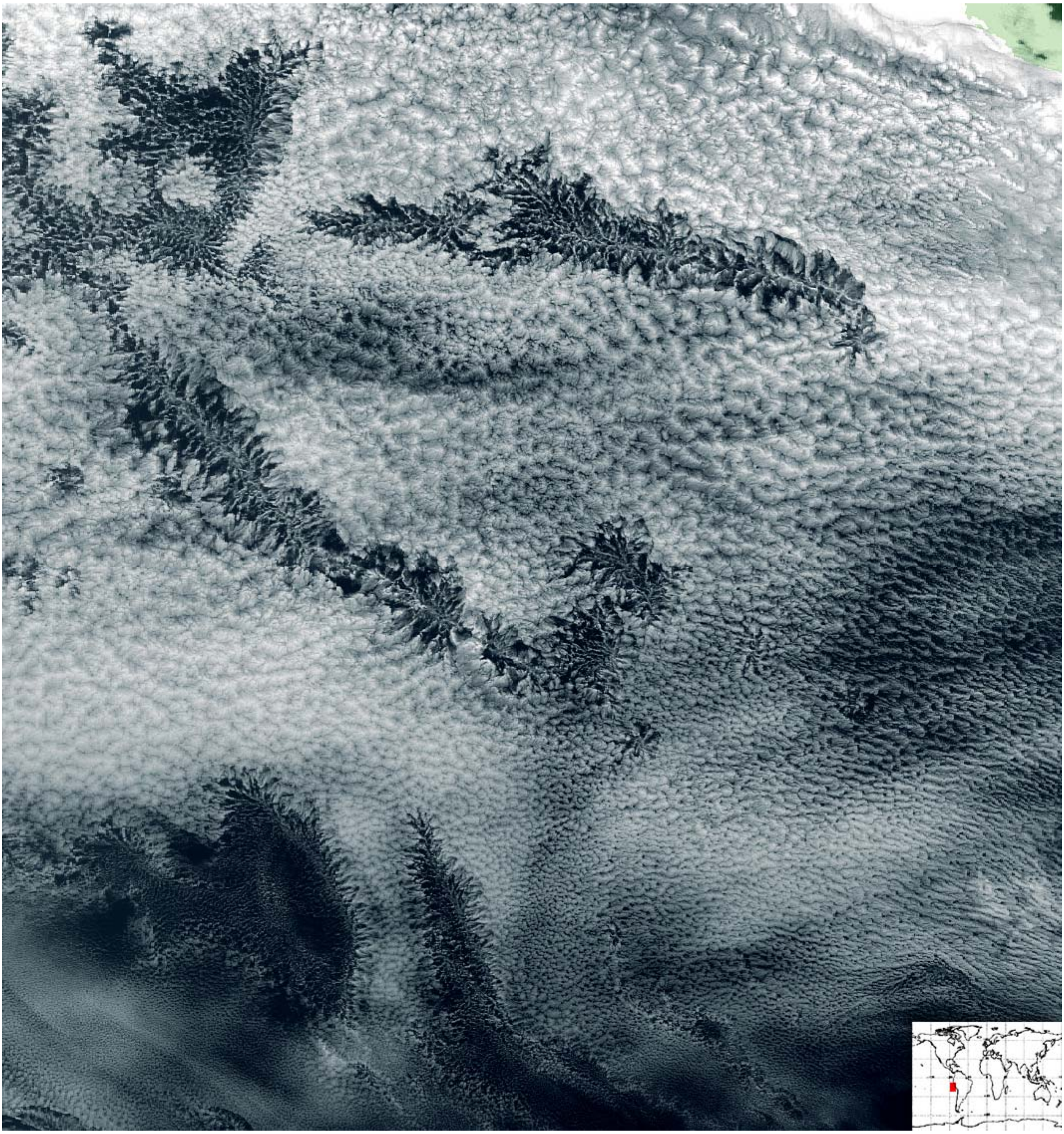


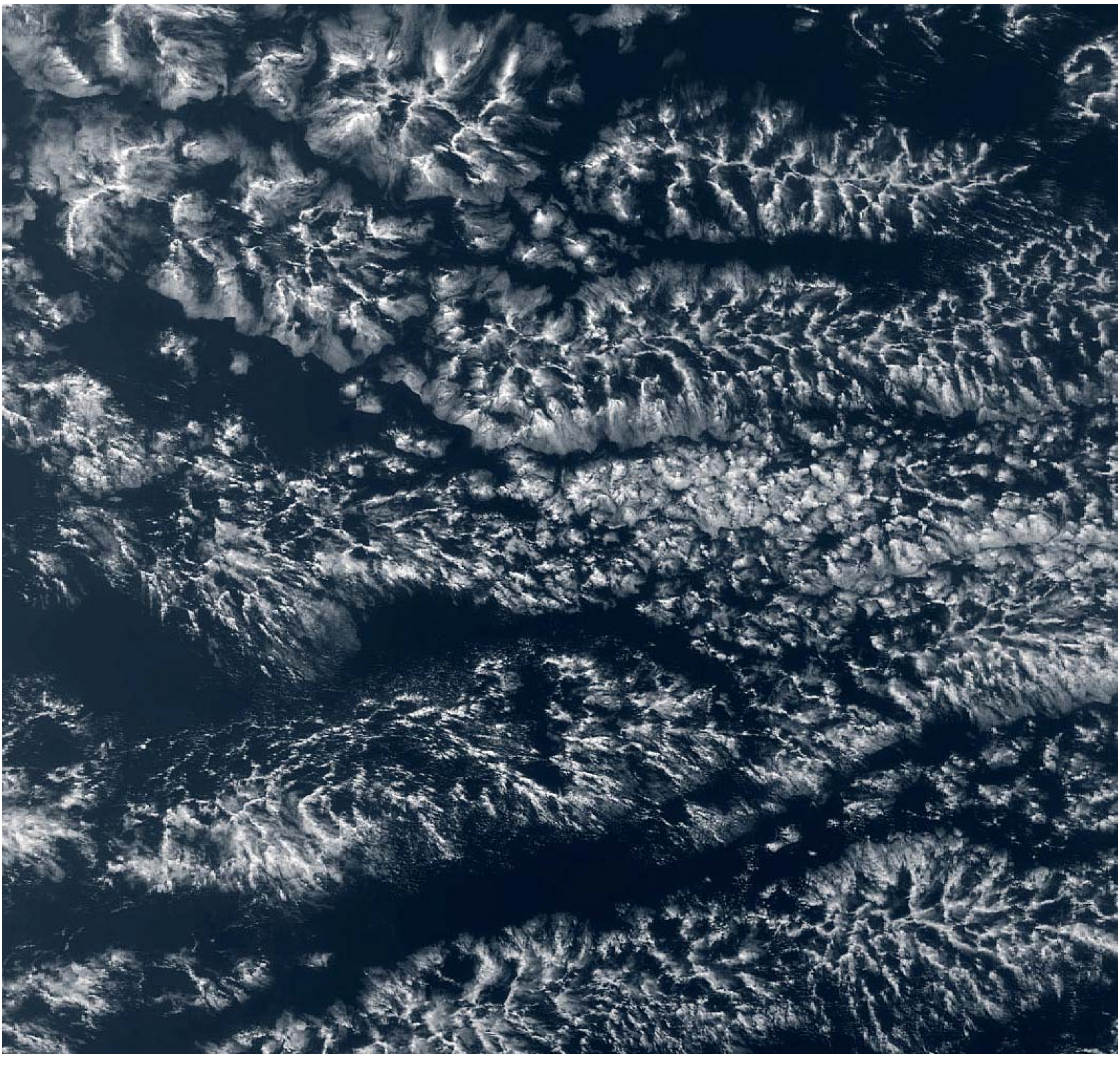


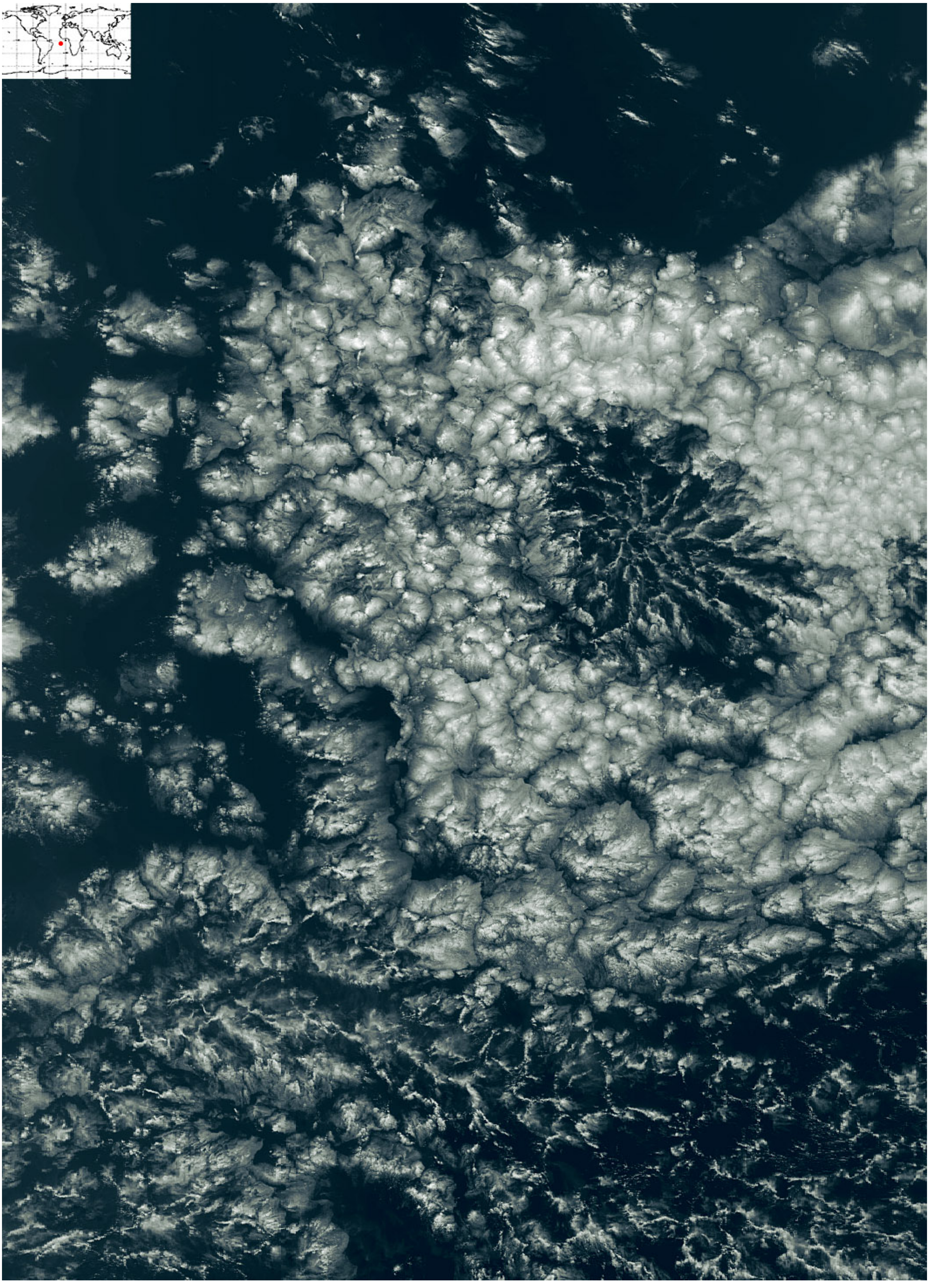


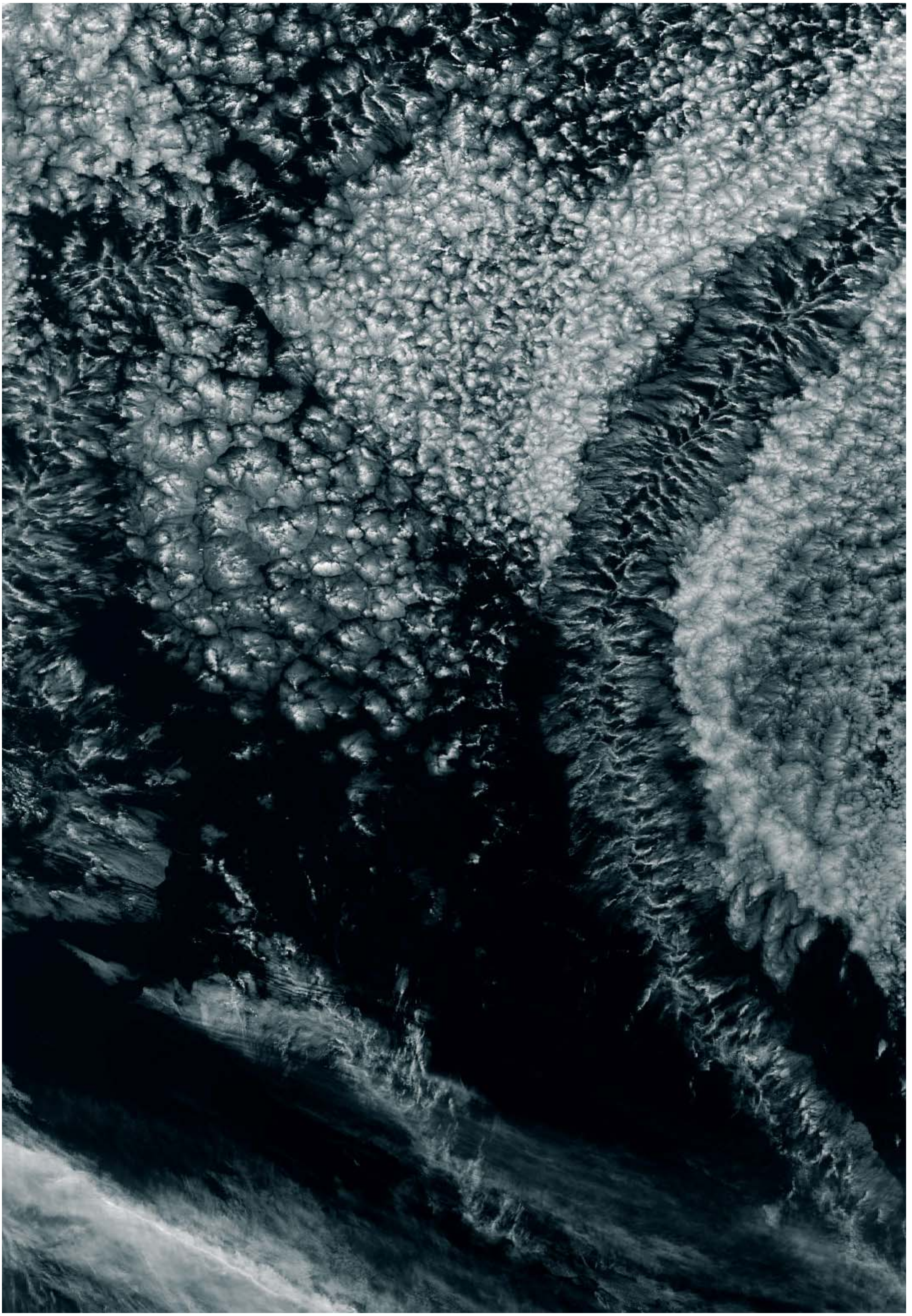












'Karman Vortex' Cloud Structure

But out, alack, he was but one hour mine,

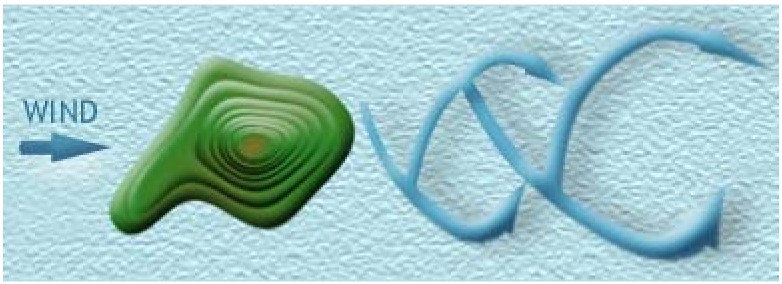
The region cloud hath mask'd him from me now.

William Shakespeare, Sonnet XXXIII

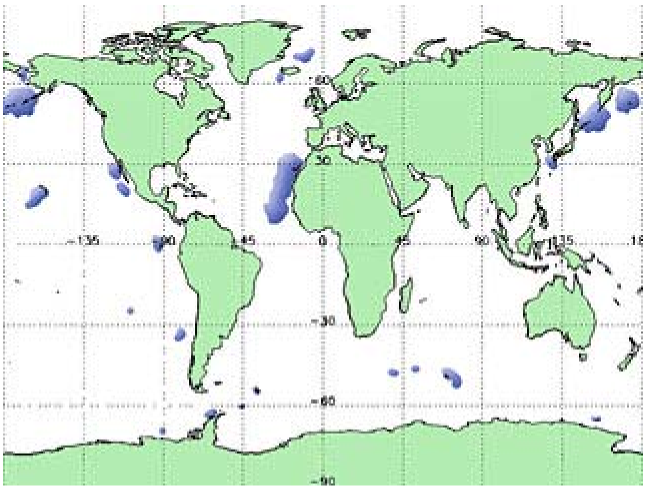
"Convective Cells"

"Karman Vortex" Cloud Structure (KVS)

The clouds of this structure look like a set of organized turbulences within the layer of "Close Cells" structure that normally consist of Stratocumulus and Stratus clouds.



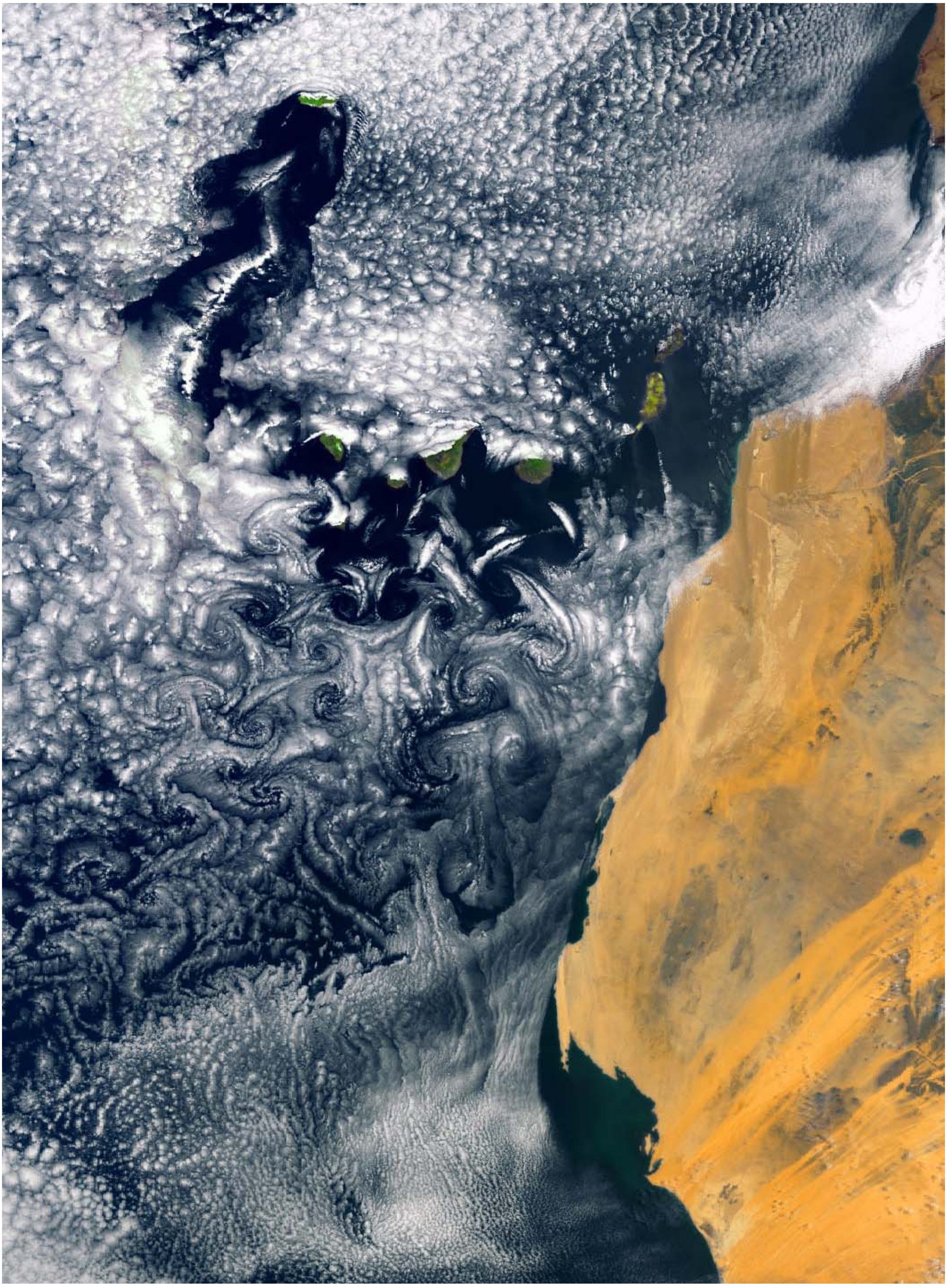
Each swirl turns (seen from above) in the clockwise direction on the left side of the thereby formed cloud street and against the clockwise direction on the right side.
This structure emerges usually above the sea surface if the temperature of the cold air gradually rises.
This leads to the strong flowing constant wind, which blows on the lower level.
If the wind has a significant barrier in the wind direction (normally a hilly island with the summit that raises some of meter more highly than the cloud top height of the surrounding cloud layer), can a turbulence street form.

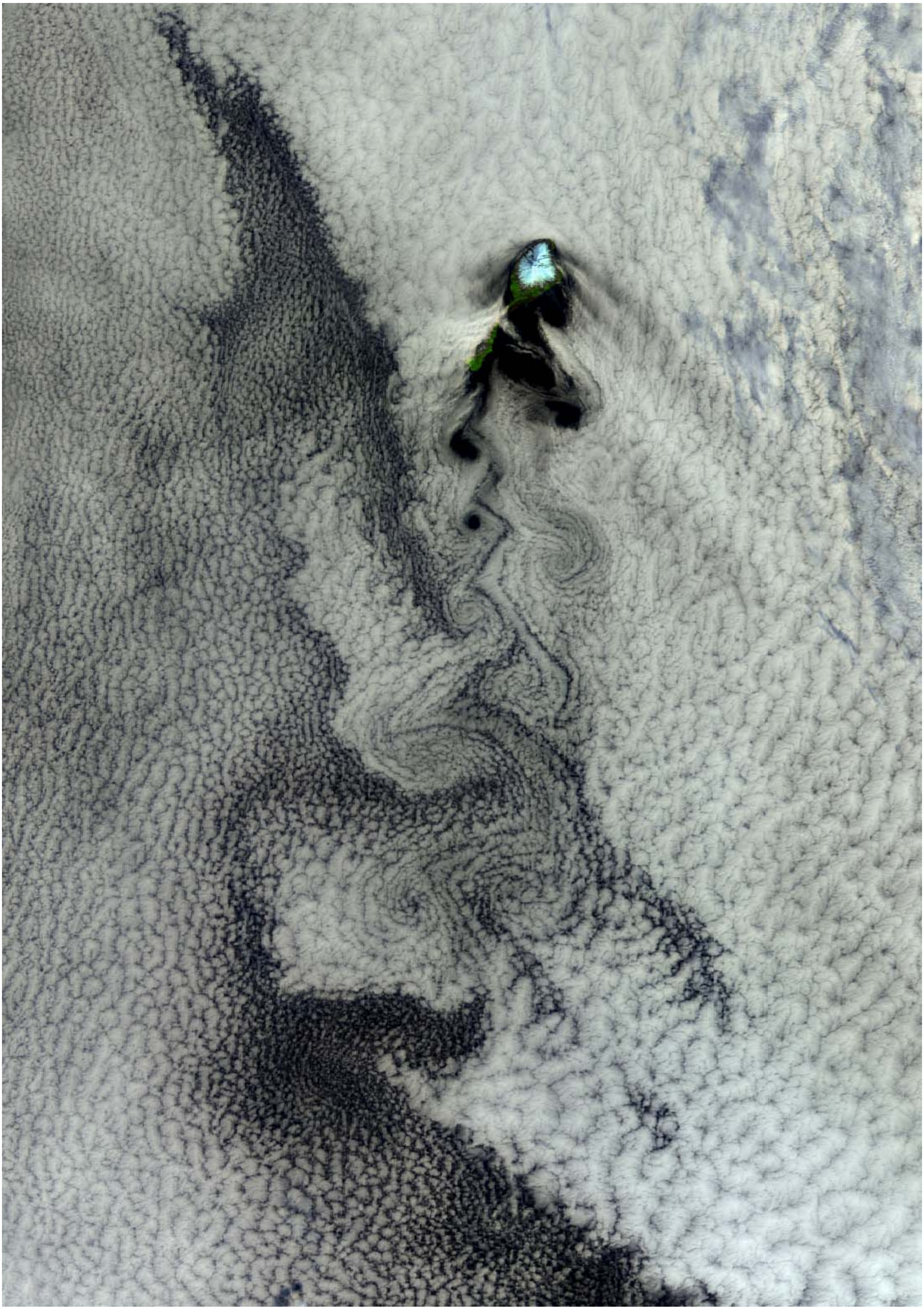


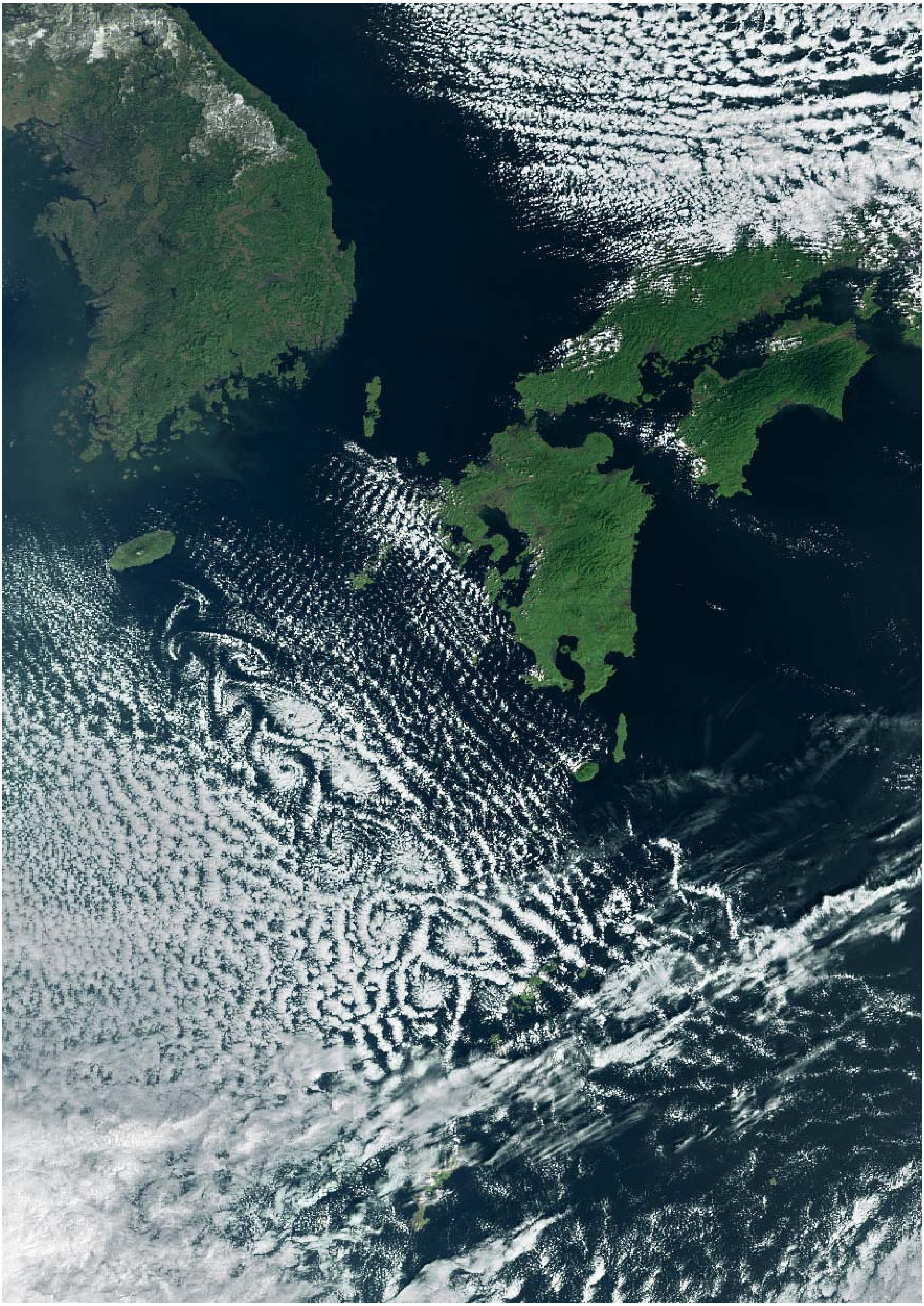
The further away the barrier the turbulences spread, the bigger they appear.
Cloud top height and the other parameters do not differ from parameters of the surrounding convective cloud structure.

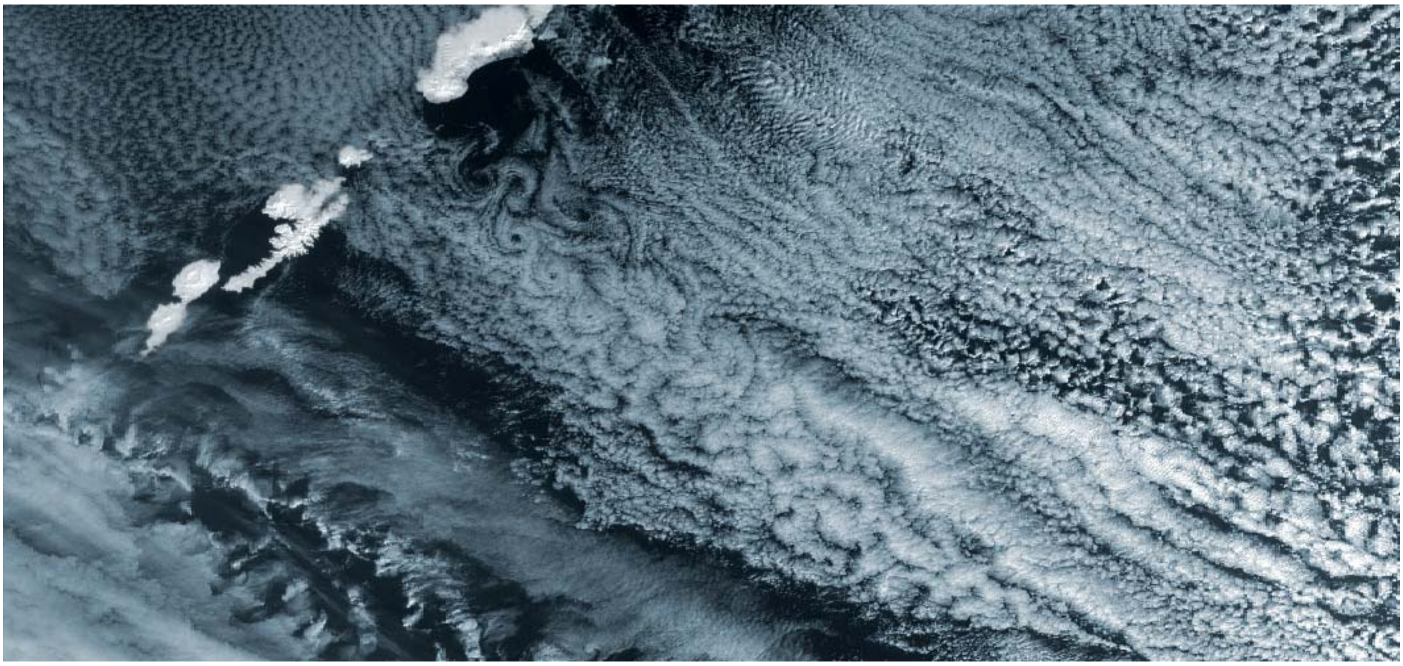
This phenomenon is well-known as Karman vortex or Karman turbulences. (*Theodore von Kármán* [1881-1963] was a Hungarian engineer. He is considered as a pioneer of the modern aerodynamics and the aviation research.)
During the observation period this structure was seen only in few places: at most above Canarias, Cabo Verde islands and over Aleutian and Kuril islands, in addition, above Cheju, Guadalupe, January Mayen, Alexander Selkirk, Heard and some other islands.

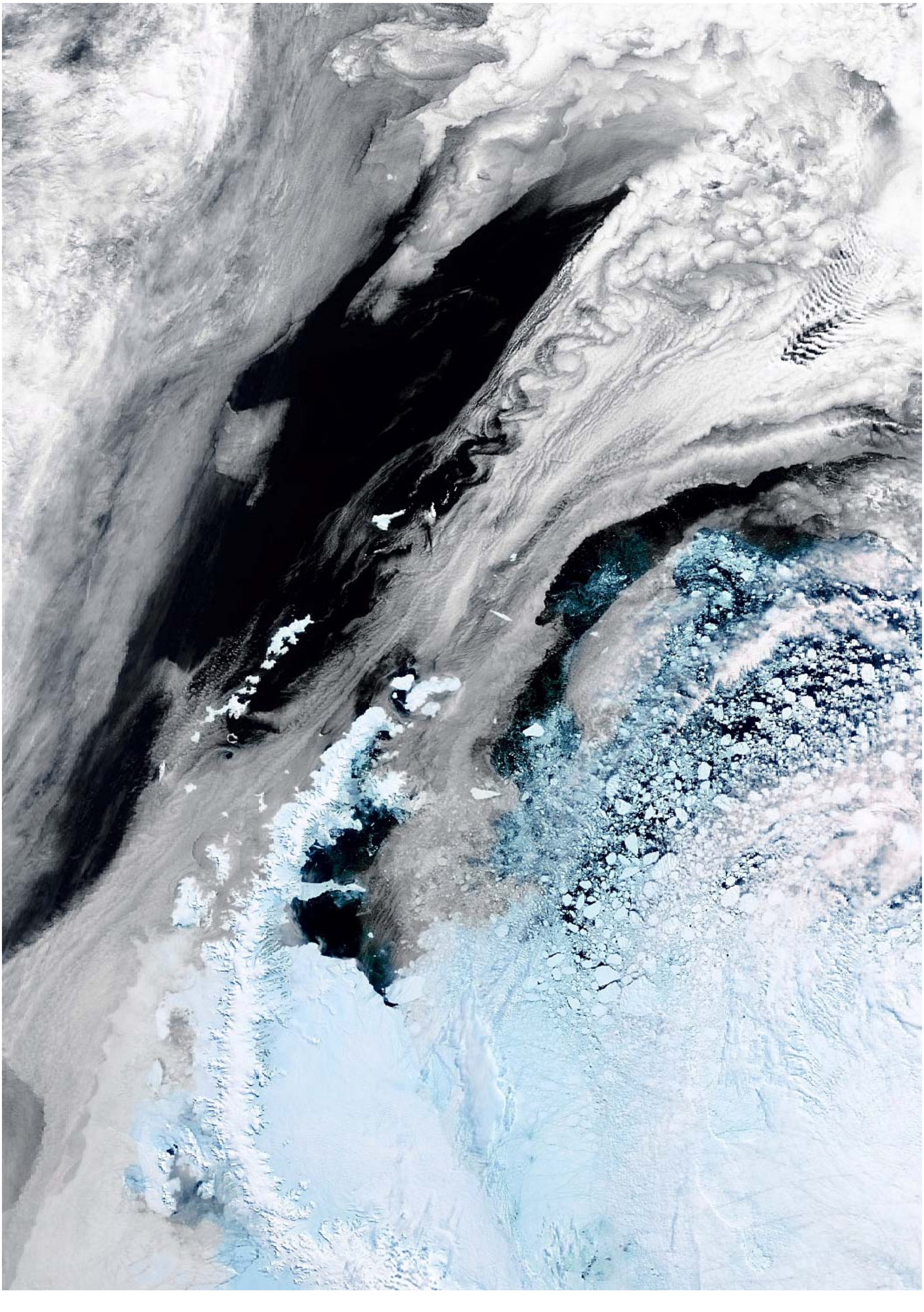
Examples.

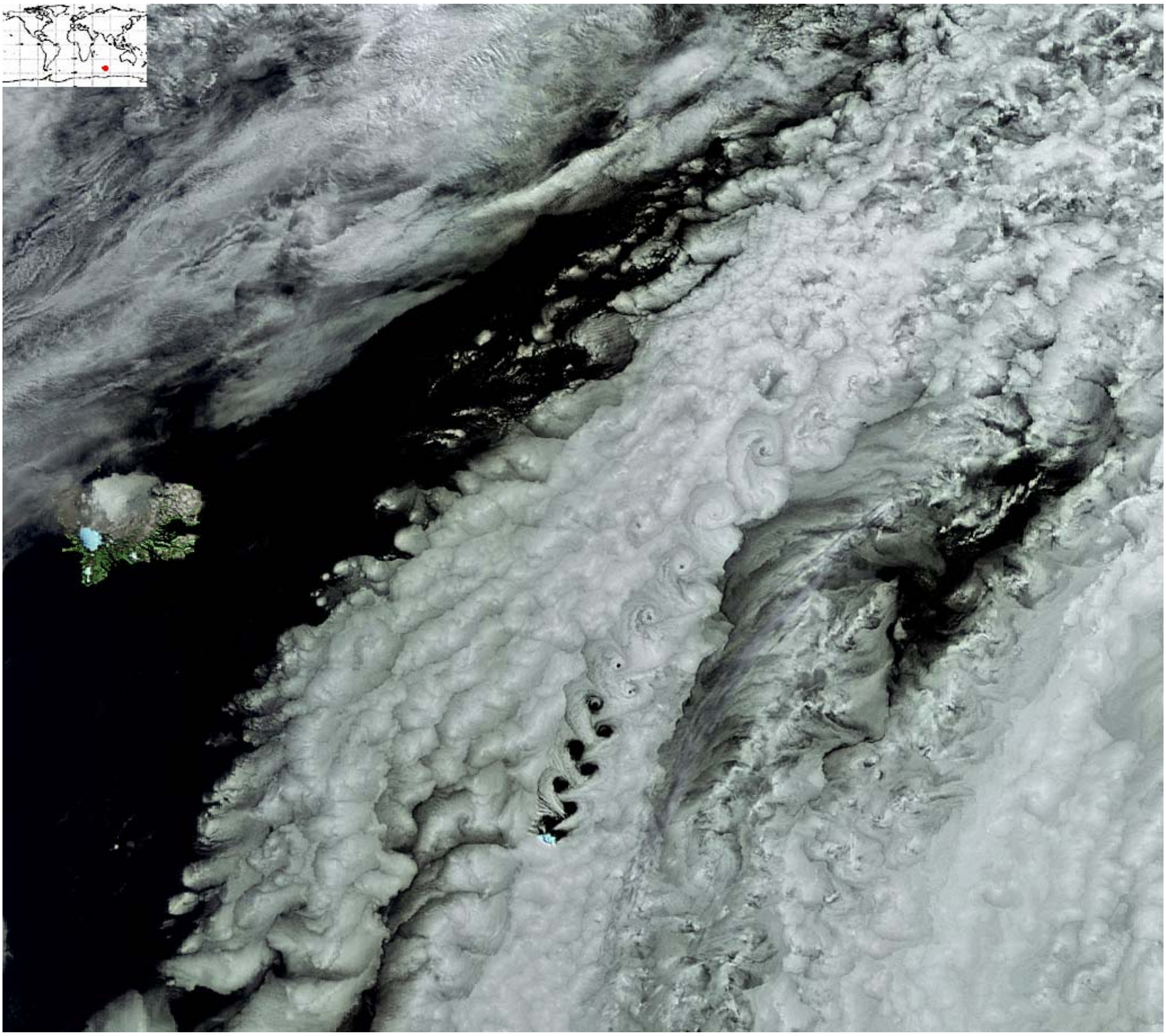


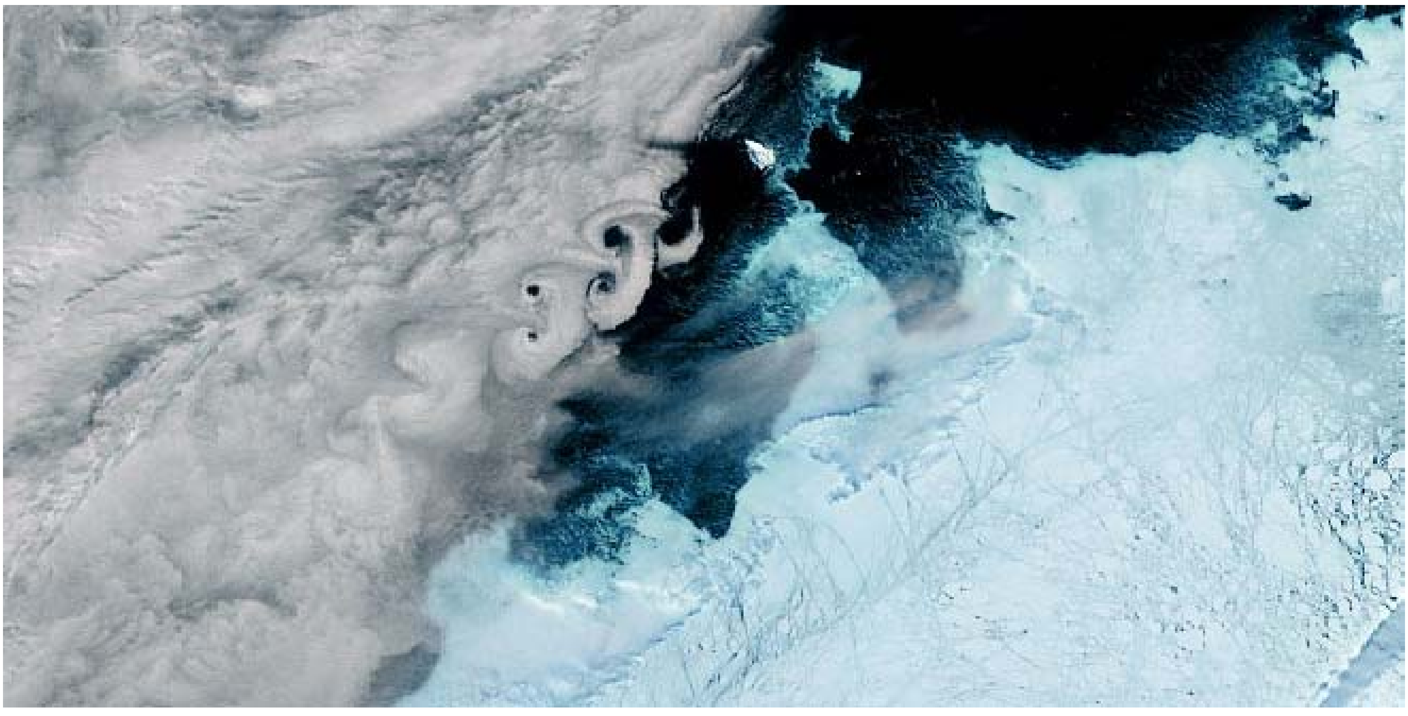




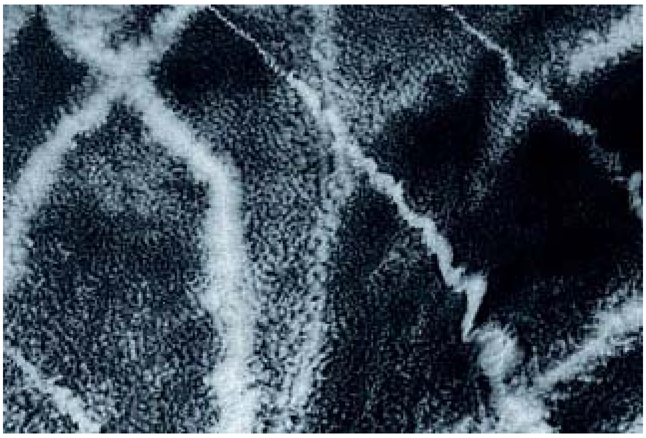








'Ship Trails' Cloud Structure



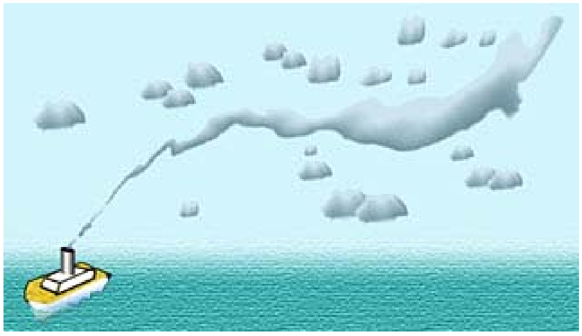
But to the brightest beams

Distracted clouds give way...

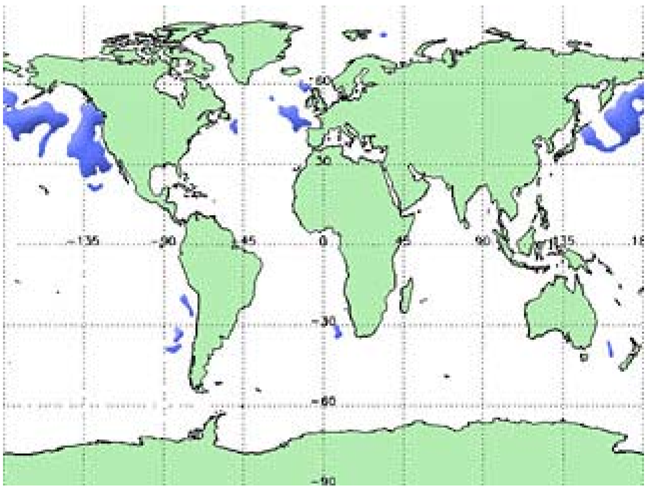
William Shakespeare, Alls Well That Ends Well, Act V, Scene III

"Convective Cells"

"Ship Trails" Structure (STS)

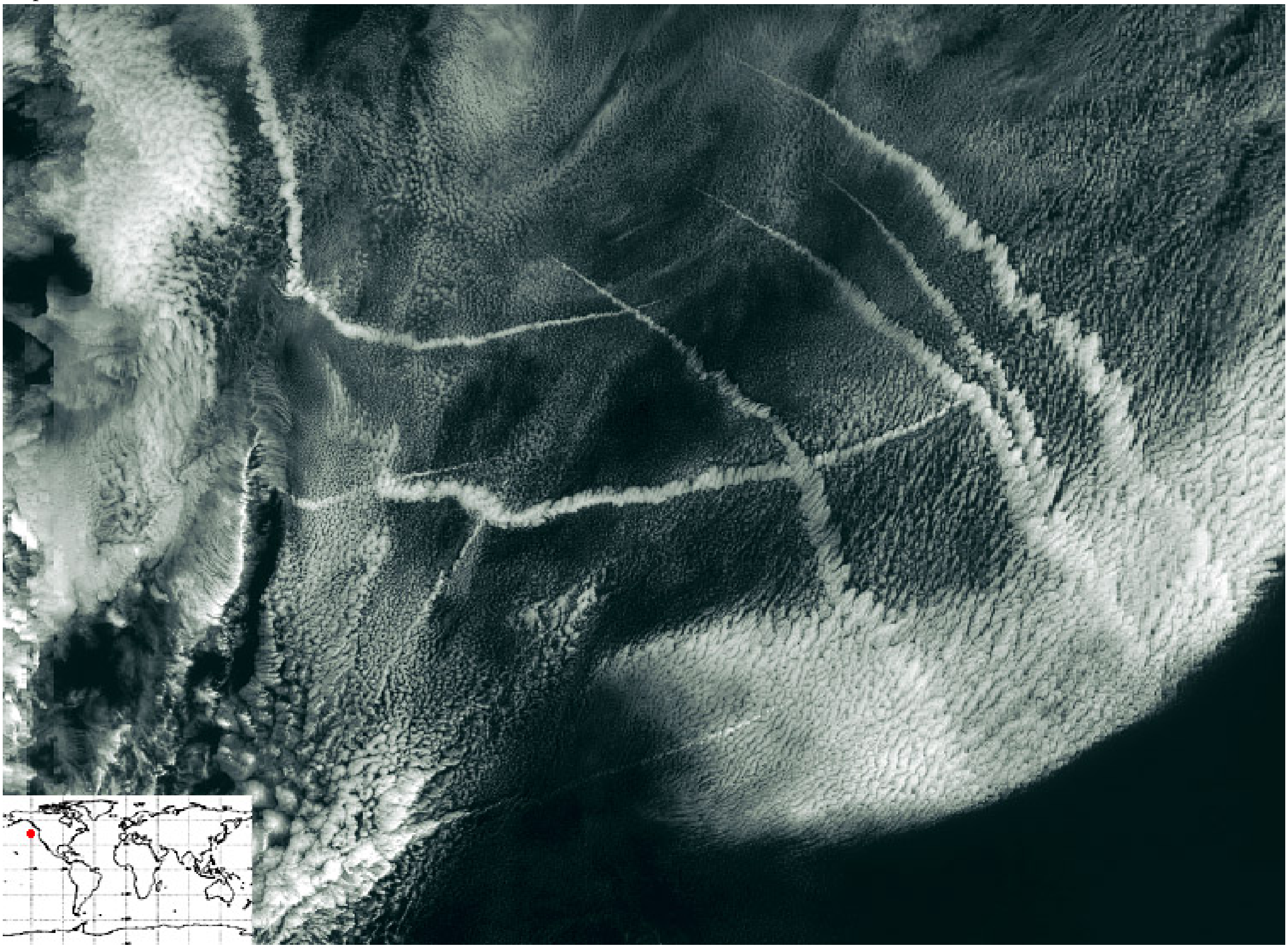


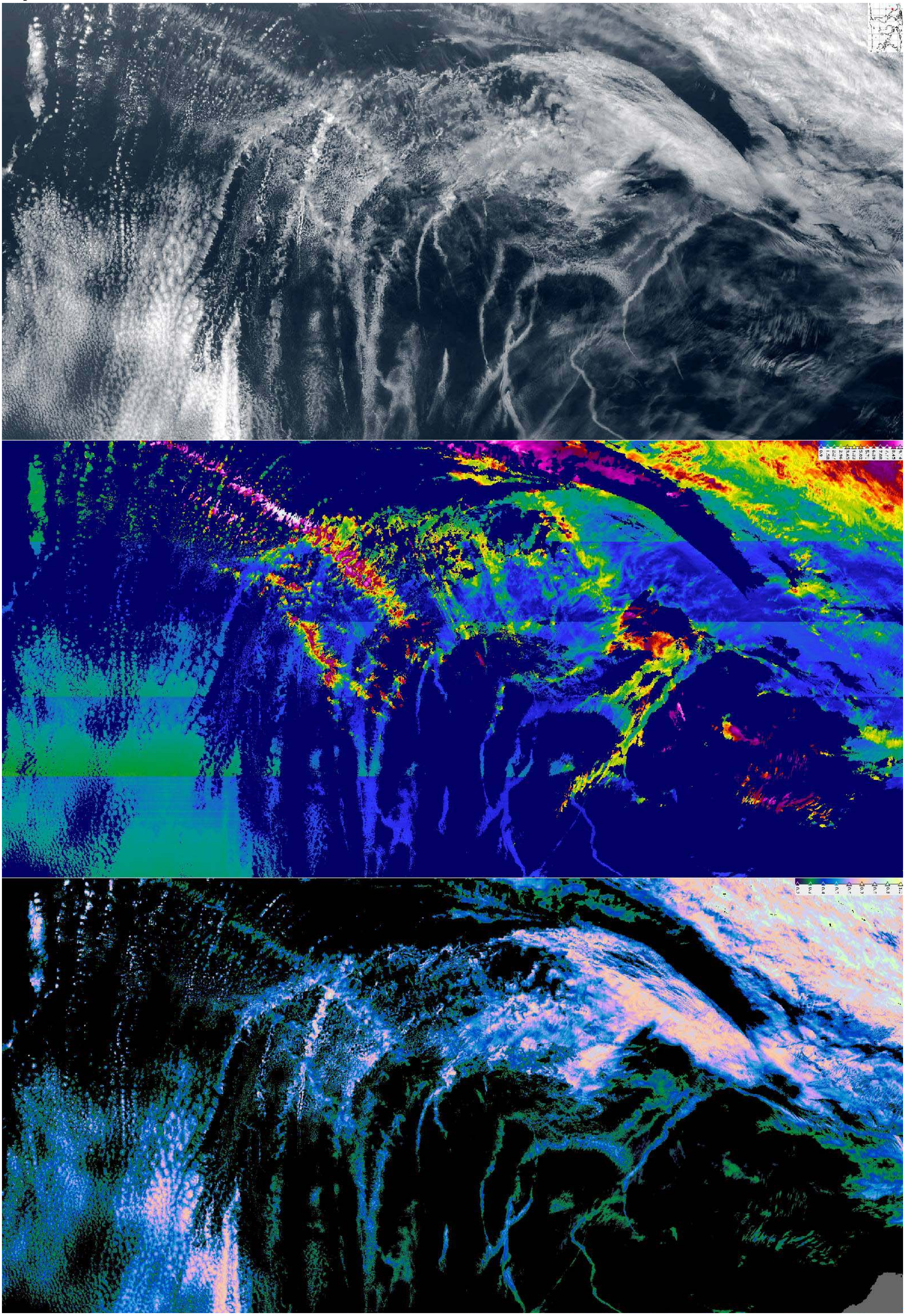
"Ship trails" cloud structure consists of stratocumulus (and at its edge of low cumulus) cloud lines.
Clouds of this structure, embedded in a layer of small and low stratus and stratocumulus clouds (which build a convective cells structure), can be observed above a sea areas.
The dimension of such cloud lines reaches as much as 30 km width (sometimes up to 50 km) and up to 1000 km (and more) length.
Cloud top height does not exceed the height of 1-2km, and the albedo is in the range 0.3-0.6.
It is supposed that this structure has an artificial origin, because it is connected with the navigation of vessels. In the image of visible range it has the higher brightness than the surrounding low clouds, however it can not be recognized in the infrared picture, because the cloud top height are low.
The moving ships give off the fine particles (also called aerosols) and warm exhaust steam.
In a cool and humid atmospheric layer, which is connected with a high-pressure system, these particles become a condensation nucleus of clouds, absorb the humidity and produce the bright clouds. Those consist of the small droplets.

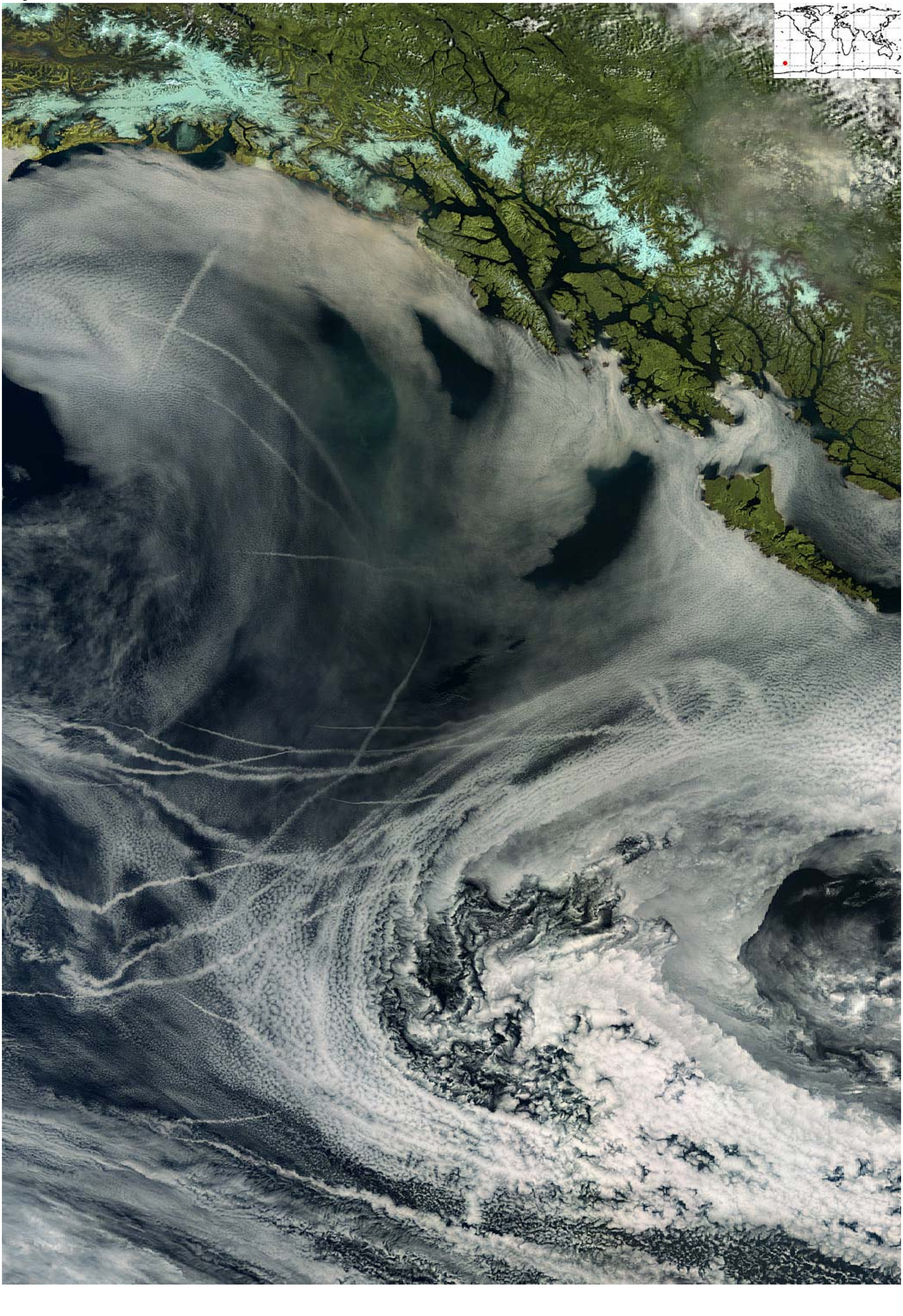


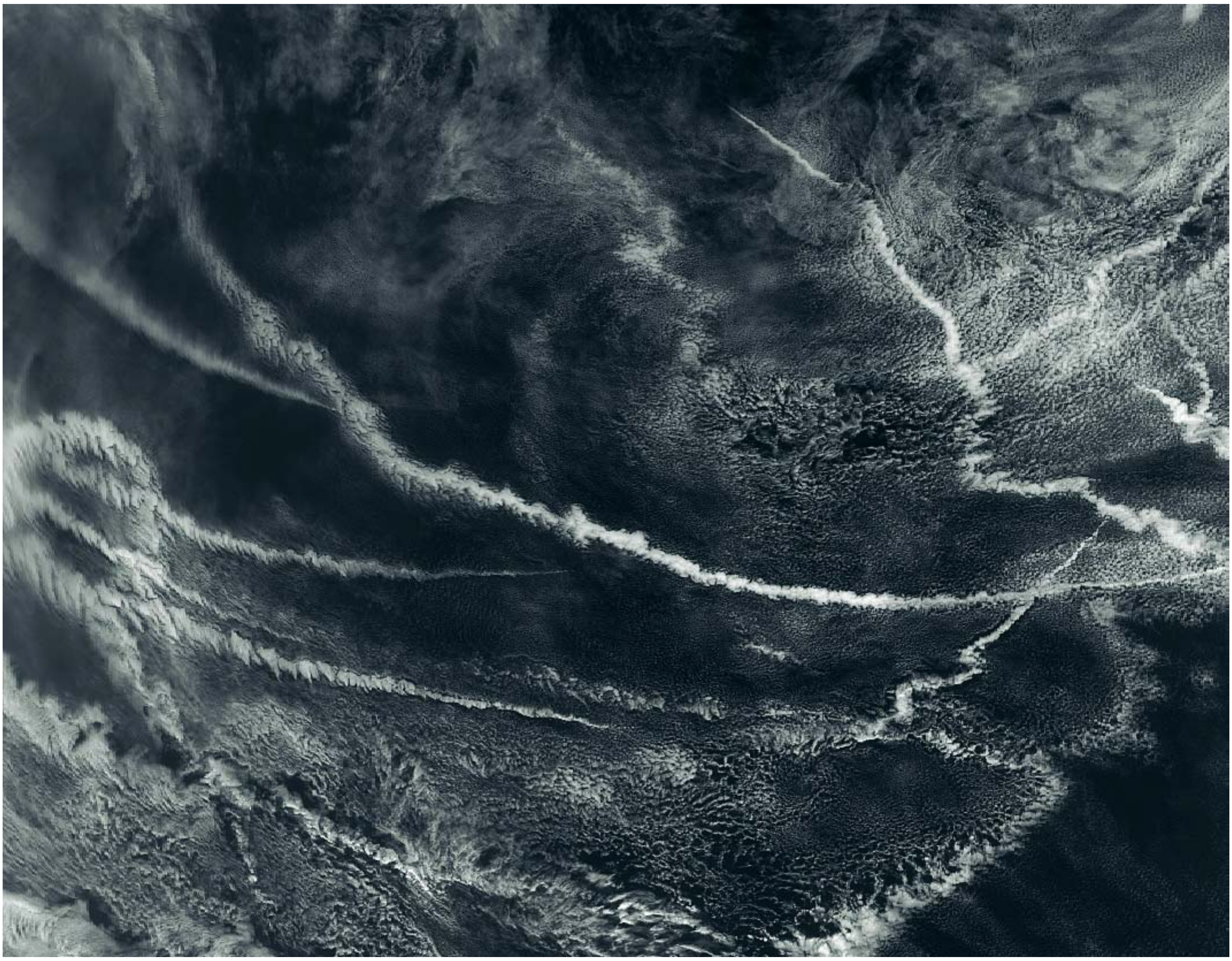
The small droplets reflect more lights (within the visible range) than large droplets, therefore the clouds of "Ship trails" structure have the higher brightness than the surrounding convective cells clouds.
However within the infrared range they can be only badly recognized, because the cloud top height is low and accordingly warm.
The "Ship trails" cloud structure can be observed mostly over North Pacific (close to the west coast of the USA, Aleuts, Kamchatka and northeast coast of Japan) as well as over North Atlantic (west coast of Europe, east coast of Newfoundland), rarely - not far from the Peruvian and Chile coast, coast of Namibia, Tasman Sea.

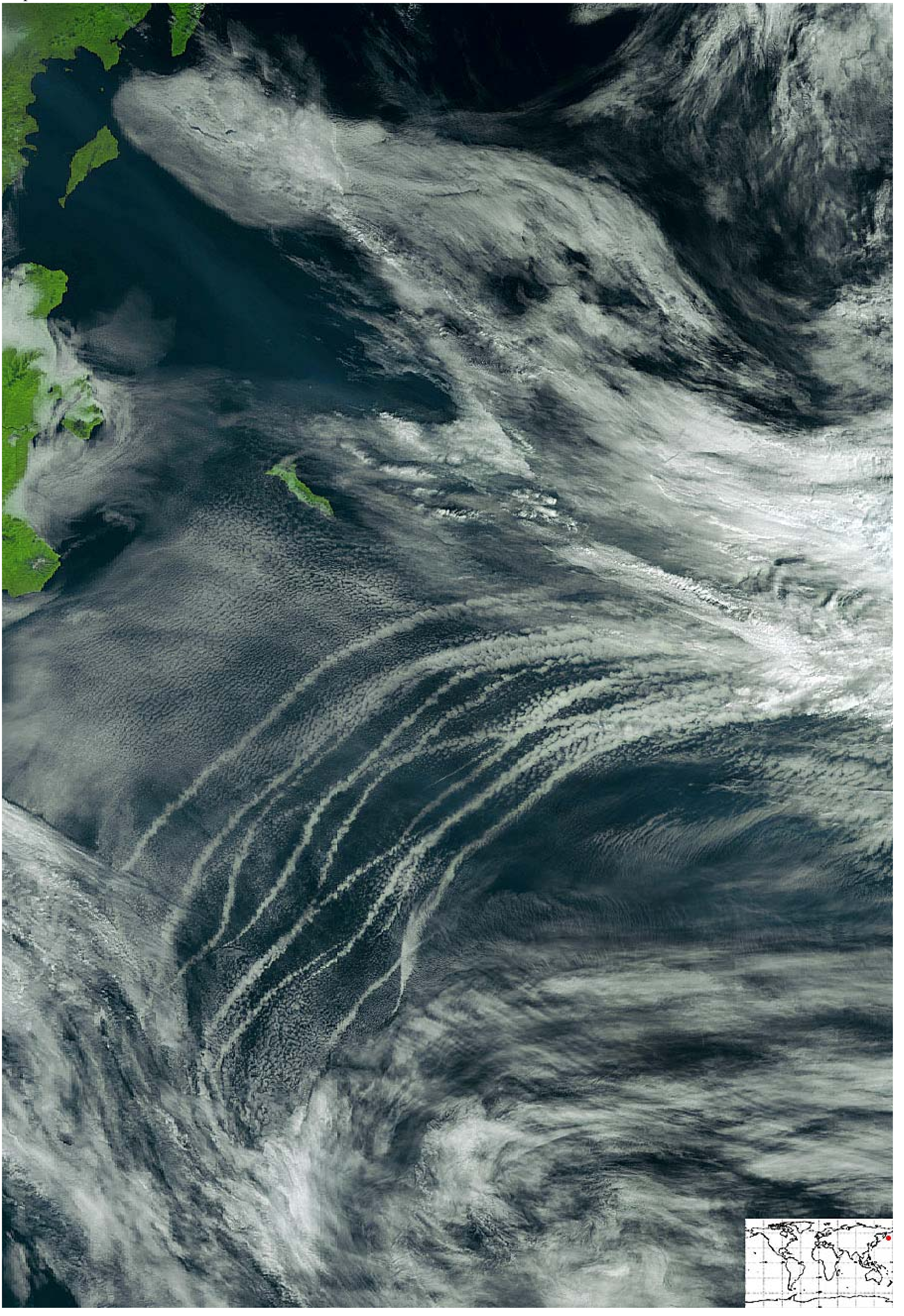
Examples.

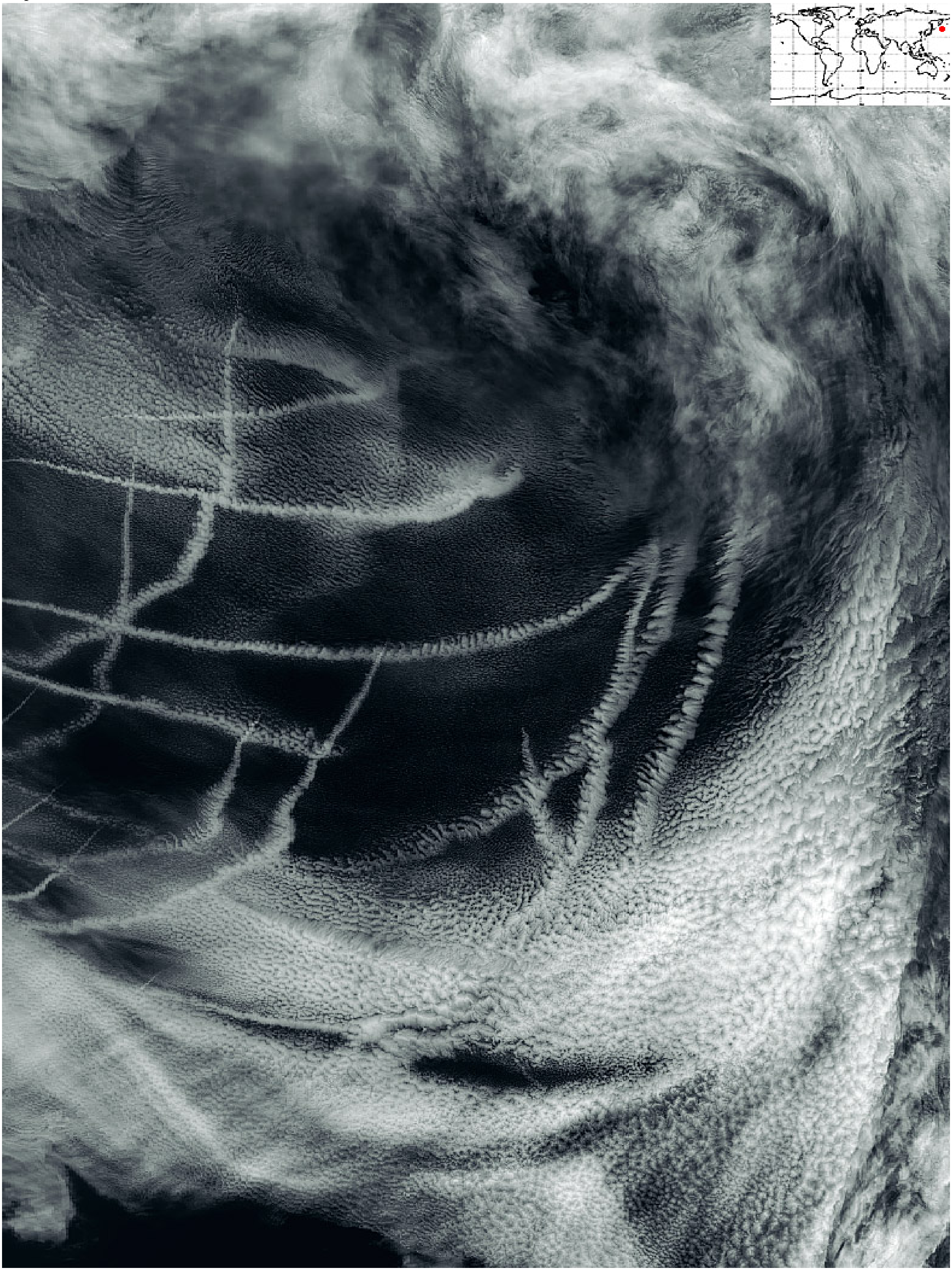












'Cloud Curls' Cloud Structure

Agrippa

He has a cloud in's face

William Shakespeare,
The Tragedy of Antony and Cleopatra, Act III, Scene II

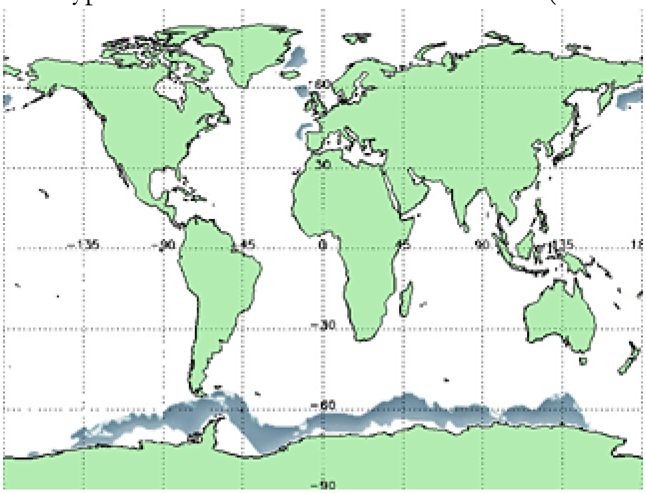
"Convective Cells"

"Cloud Curls" Structure (CUS)

Cloud Structures tentatively called Cloud Curls occur rather seldom and mainly above circumpolar waters, most often above the waters situated close to the Antarctic.

Cloud Curls emerge within cloud fields from Stratus and/or Stratocumulus clouds. They usually appear in groups. The size of each curl varies from 40 to 80 km, rarely from 20-30 km to 120-140 km. Quite often the Cloud Curls top is a little bit lower than the surrounding cloud field top, and the curls themselves have an outer border which is well marked and clearly seen. An interesting peculiarity of this structure is that the top of the curls' center is often lower than the top of their bulk (forming some kind of a funnel-like relief) and has a greater albedo.

The types of cloudiness within cloud curls (according to the values resulted from the processed MERIS level 2 data) are usually Stratocumulus (on the rims) and Stratus (toward the centre of the structure).



The nature of the rise of such a structure is not clear.

It is possible to assume that the discrepancy in the temperature of the sea surface beneath the cloud cover may stipulate for the initiation of local winds. These winds interacting with the prevailing mesoscale wind and experiencing the Coriolis effect (the cloud curls twist in one and the same direction depending on the hemisphere, and there are no swirls less than 15-20 km in size), which becomes stronger as the cloud approaches the Poles, may form swirls.

The cold air is drawn out from upper atmosphere layers into these swirls, cooling them.

As the result the swirls go down compared with the surrounding cloud field. Cold heavy air that amasses in the center of the funnel cools the remaining clouds, besides the reduction of pressure leads to the rise of the ice-point, so that ice crystals appear (which is accompanied by the increase of their albedo), and pushes them more downward.

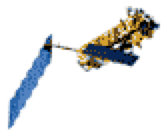
'Dragon-looking Cloud' Structure CLOUD STRUCTURES

Puck

For night's swift dragons cut the clouds full fast...

William Shakespeare,
A Midsummer Night's Dream , Act III, Scene II

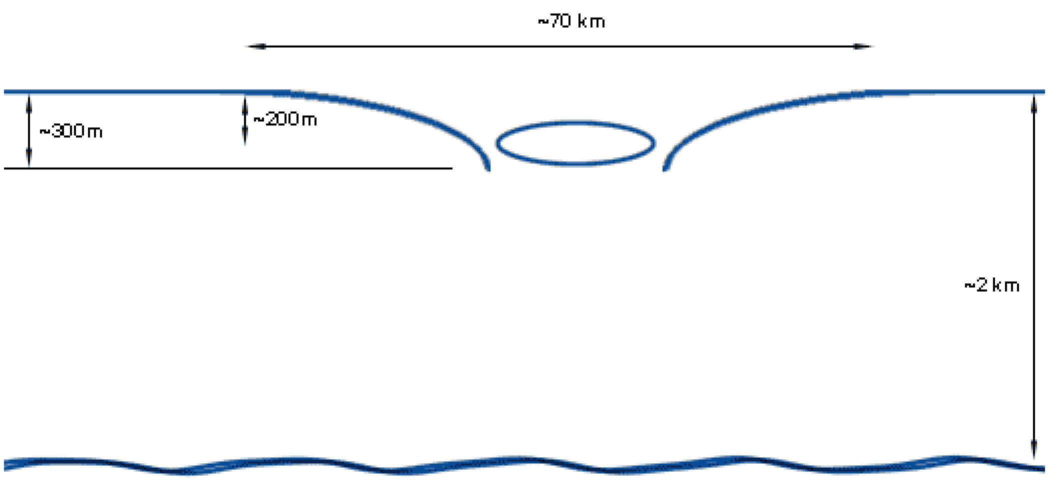
"Dragon-Looking Cloud" Structure (DLCS)
The "Dragon Eye" structure was so called because I discovered this name on the NASA Visible Earth web page. It would be natural to suppose that the warm streams of air go upward, "breaching" a layer of stratocumulus clouds, where ice crystals fluffy cloud with great albedo further (increasing in the height) appear. At the same time the cold dry air moves downward, surrounding the warm "column" along its perimeter and breaching the layer of stratocumulus clouds from above, driving away clouds.
However the MERIS Level 2 data show that the upper board of the clouds (the so called 'eye"), is not located over the upper boarder of the surrounding cloud field.
It has been tried to solve this problem studying the shadows as the Sun in polar latitudes is not too high in the sky and objects cast long shadows. Unfortunately it did not bring good results, though no long shadows was seen.
While exploring the structures tentatively called "Cloud Curls" (and later "Dragon Eye") by means of the processed MERIS Level 2 data I paid my attention to the unusual configuration of the upper board of the curls.



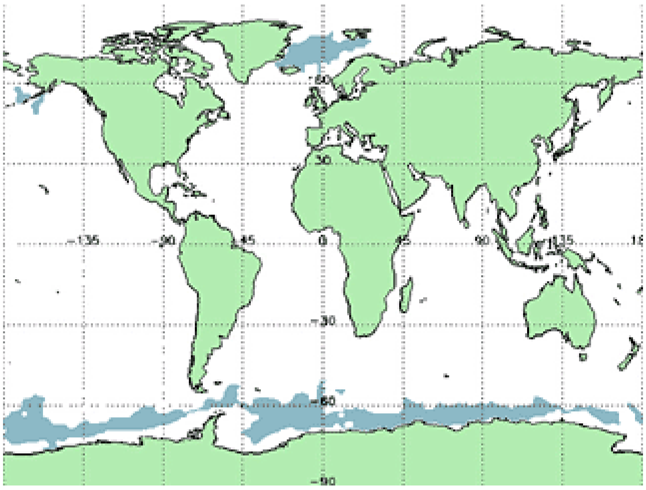
As the MERIS Level 2 shows, the structures are down-directed funnels and the clouds located in center and underneath have great albedo.

The examples are as follows:

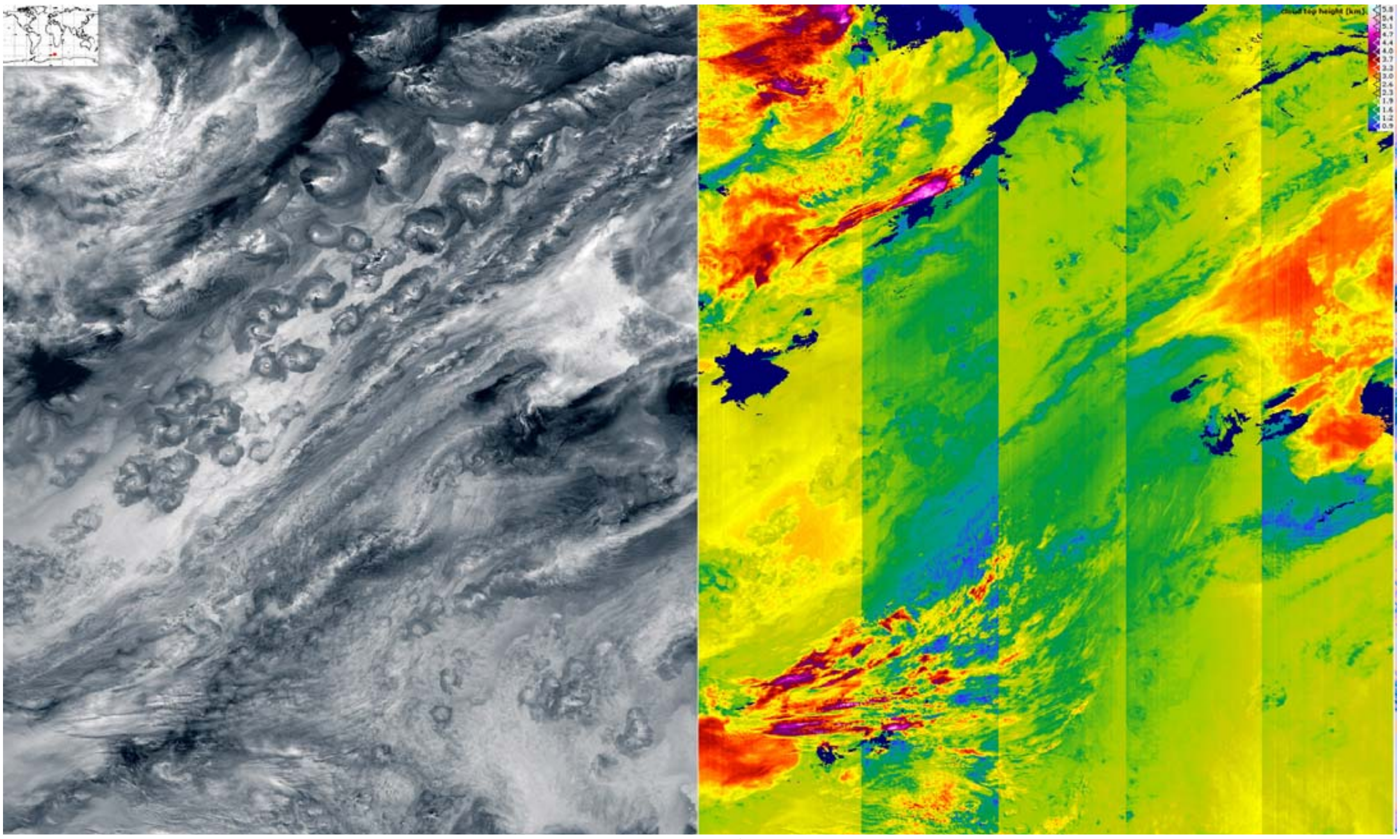
Part "Cloud Curls"
20061224_25182.jpg
20060201_20514.jpg
So it may be assumed that the situation is not always covered with the model used to develop Level 2 data in which case the data do not reflect the reality.
On the other hand, if it works in the right way, it is hard to explain the phenomena I told you about. And I myself am not completely satisfied



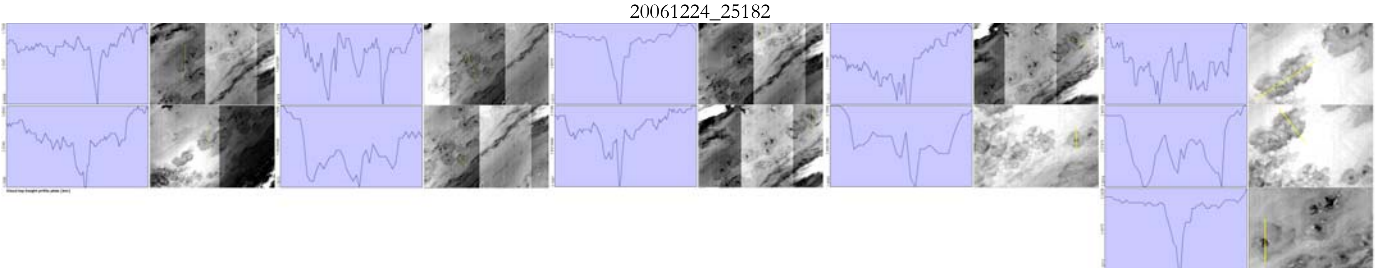
with these reasons of my own explanations.
Studying the "Dragon-Looking Cloud - Dragon Eye" structures I discovered the same situation.
Here are the examples:
Part "Dragon-Looking Cloud"
20050105_14904.jpg
20070205_25798.jpg
The structure could be rare observed above sea surface in Polar Regions.
The "Dragon Looking Cloud" Structures tentatively was called like this, because they are often the neighbours of "Dragon Eye" structures. In addition this kind of cloud with its chaotic, turbulent, irregular shape can remind of dragon. Of course it is a very free definition, which does not base on certain physical phenomenon.

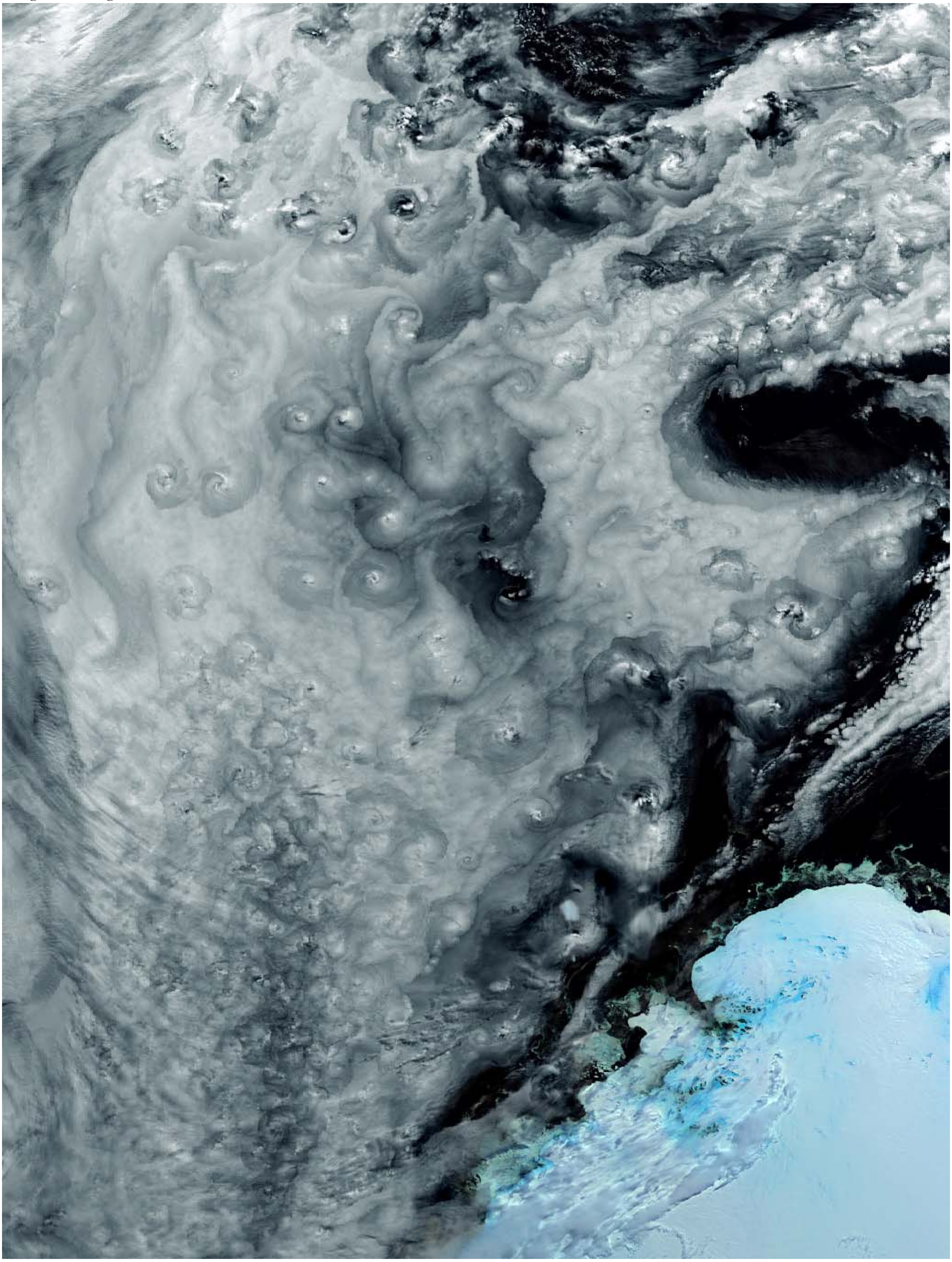


The structure could be observed above cold water in Polar Regions.
The Coriolis Effect works relatively strongly in these widths. Vertical air flows can be formed above the warm sea areas. In cooperation with local winds many small vortices from small convective cloud cells can develop there.
The neighbours of "Dragon Looking Cloud" Structures are quite often spacious layers of stratocumulus clouds and "Cloud Curls" Structures.
"Dragon Looking Cloud" Structures are not seen frequently, though they can be seen quite often.

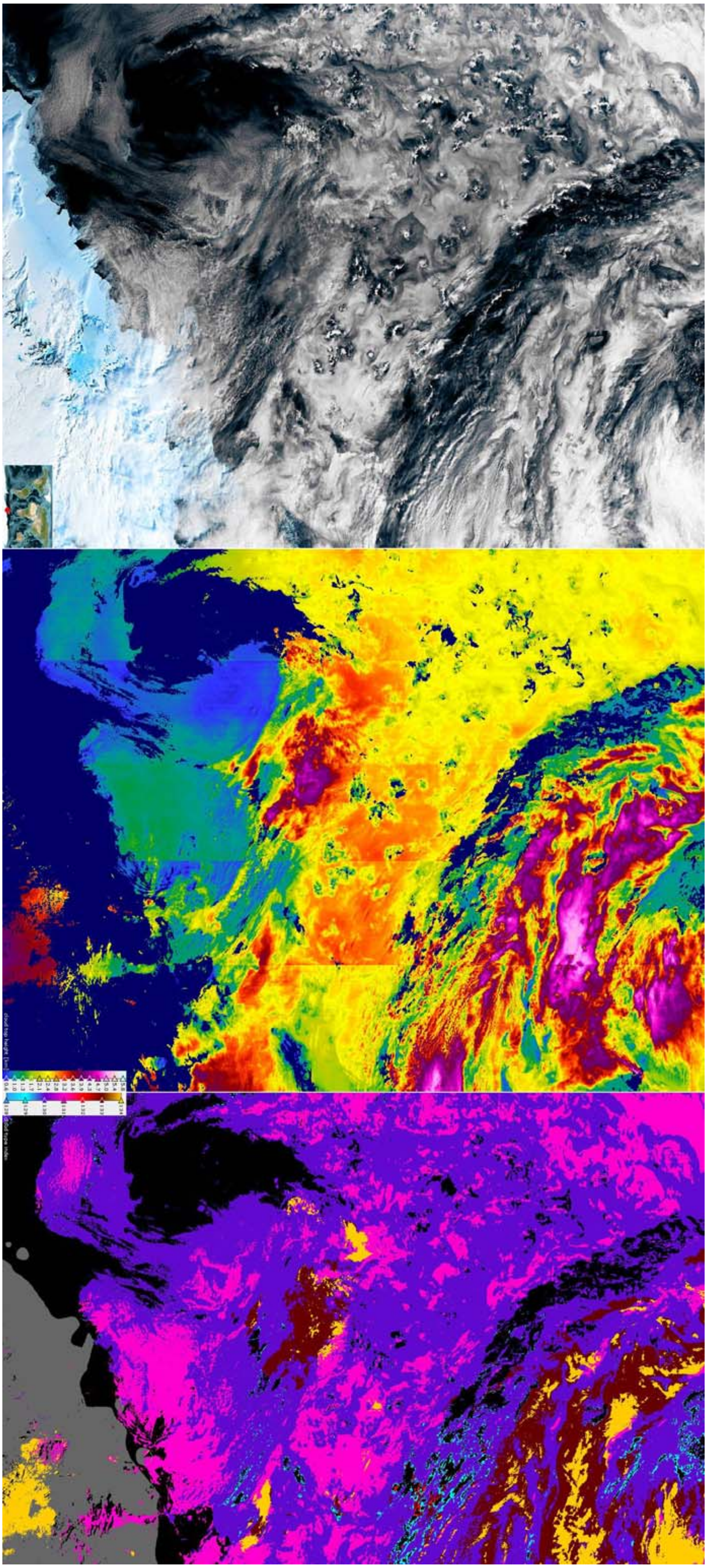


20061224_25182

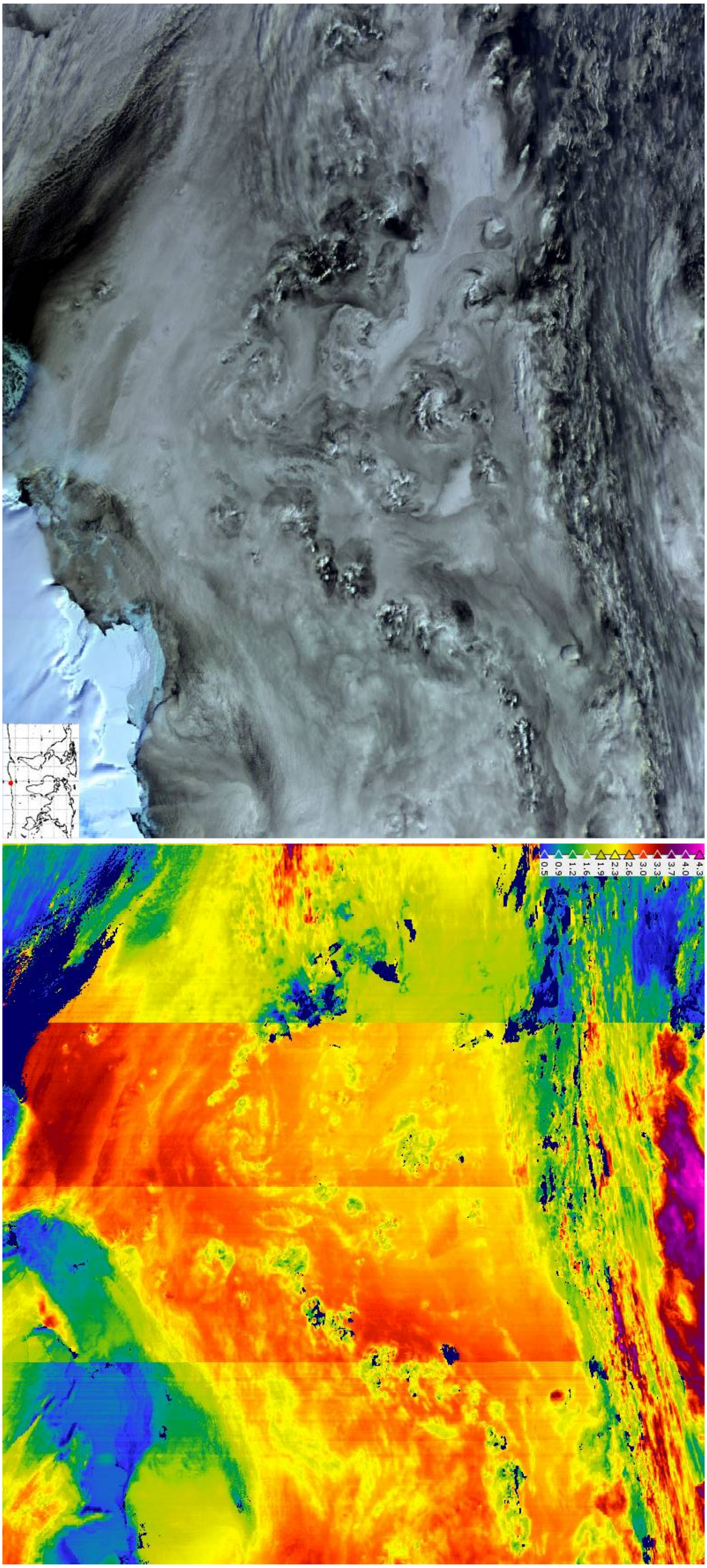




20060201_20514



20050105_14904



20070205_25798

'Hokusai' Phenomenon

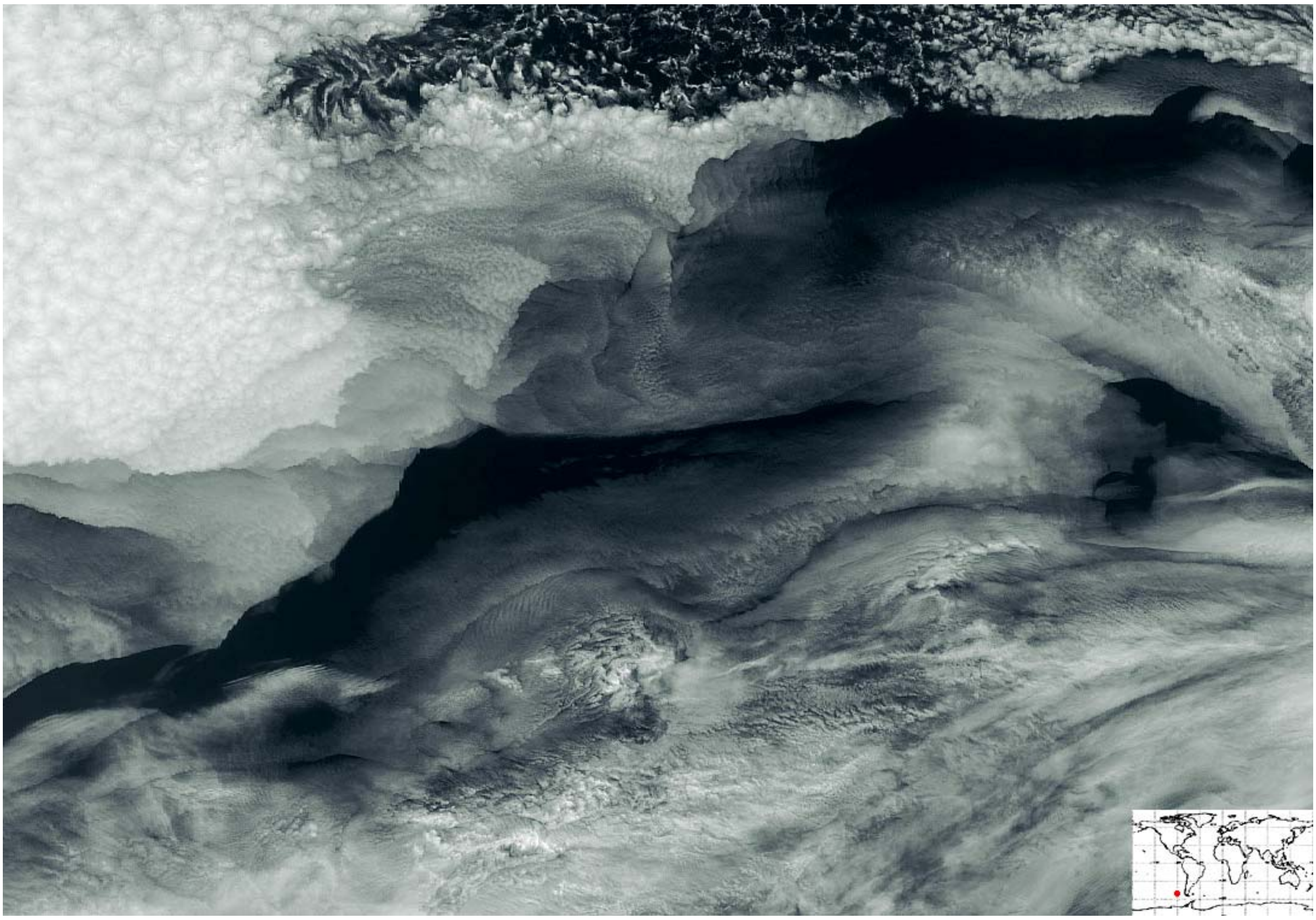
Someone passes,
And while I wonder
if it is he,
The midnight moon
is covered with clouds.

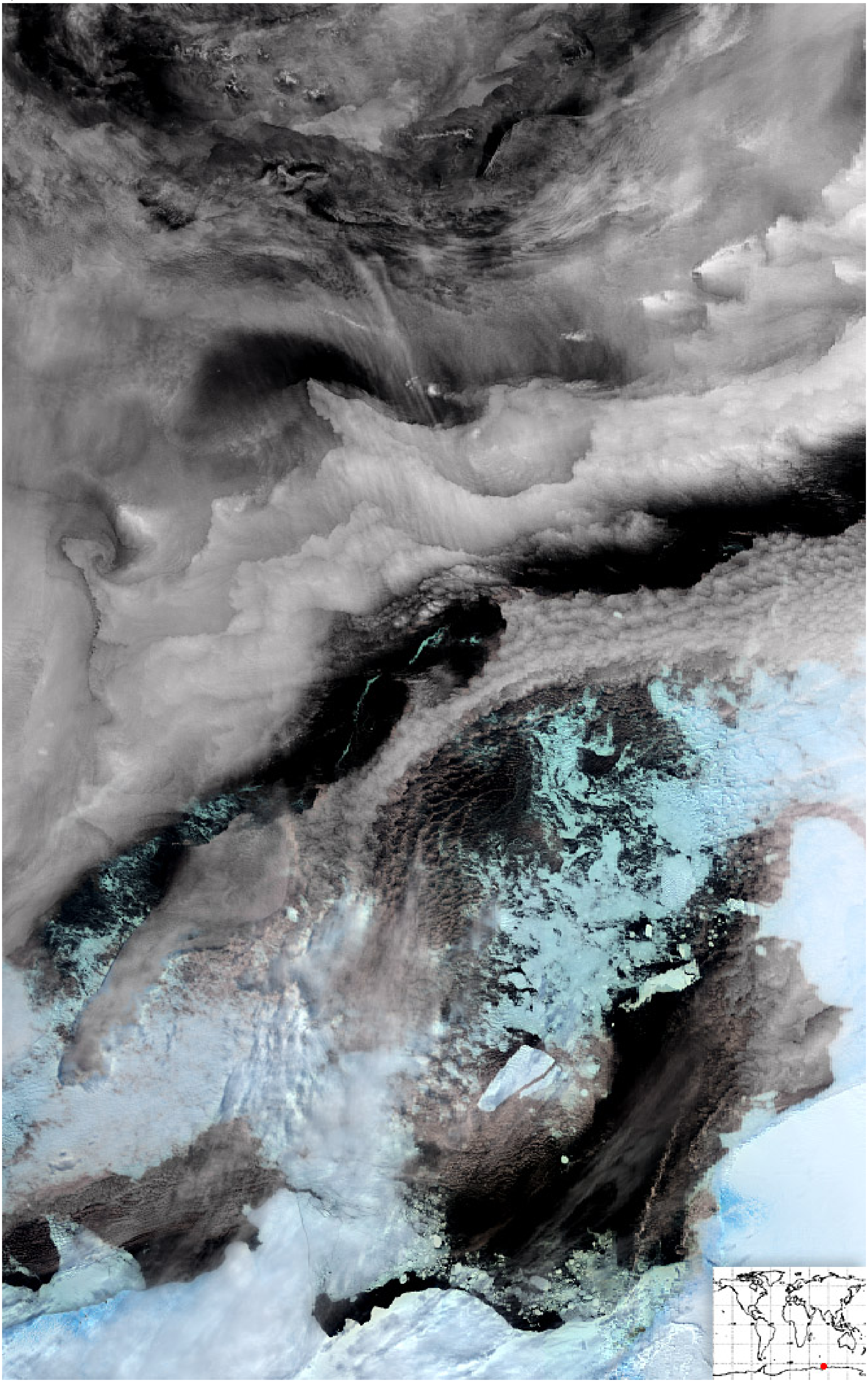
Murasaki Shikibu (974-1031), translation by D. Russell

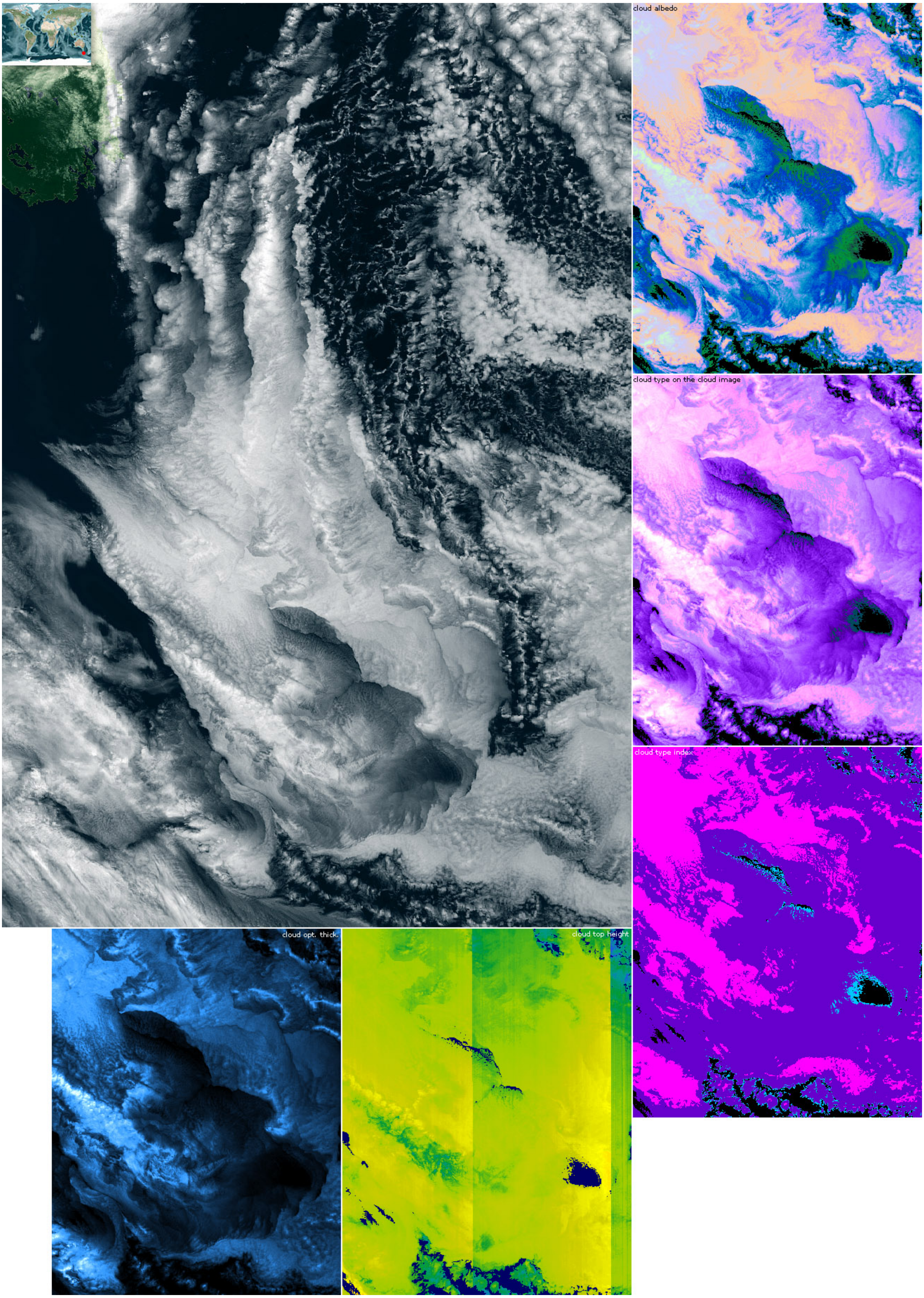
"Convective Cells"

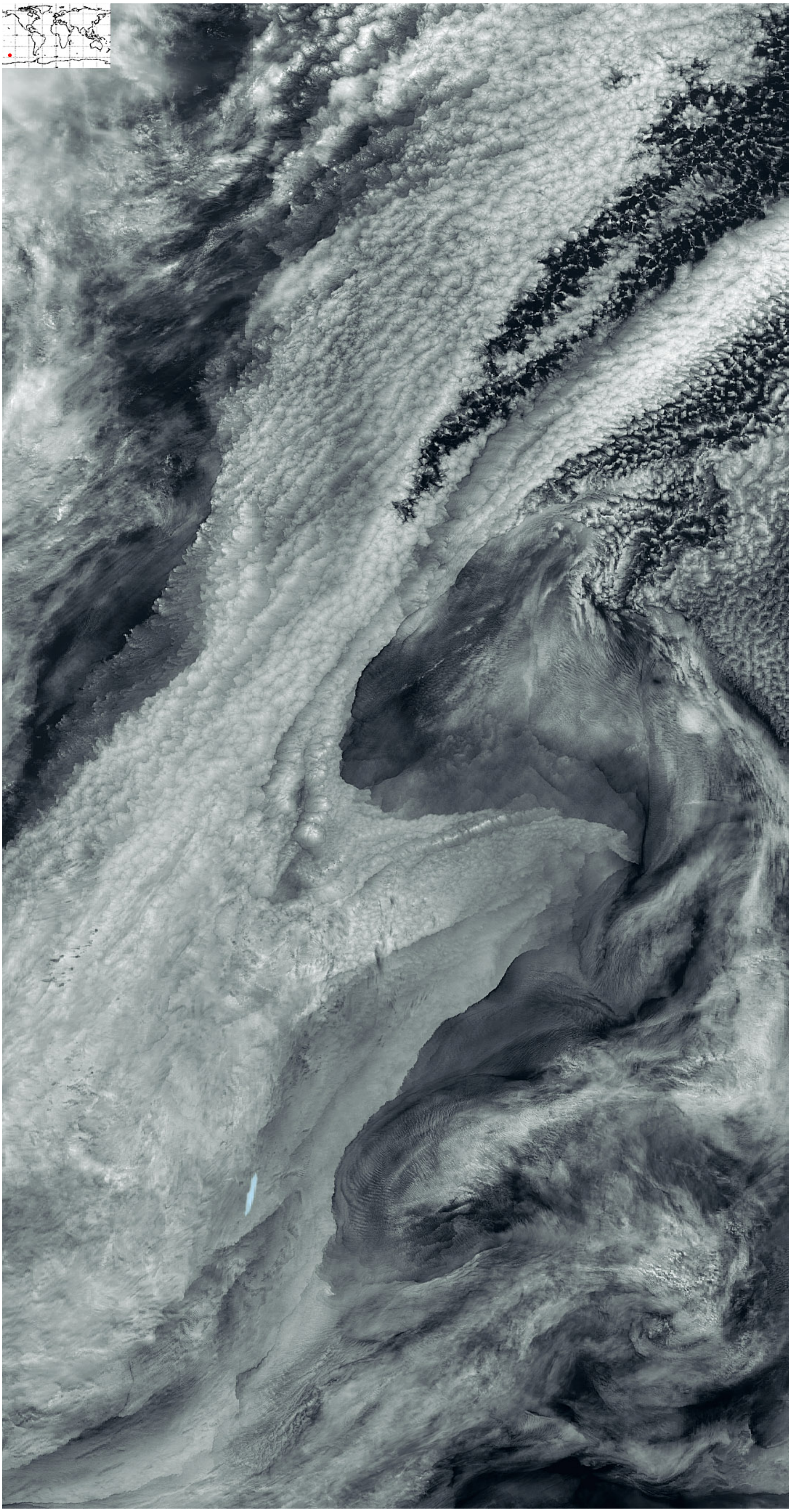
"Hokusai" Phenomenon (HP)

The pictures, where the phenomenon can be observed, remind me of some works of famous Japanese painter K.Hokusai (Katsushika Hokusai (1760-1849)). Therefore the phenomenon was tentatively called after his name. The vertical layers with irregular arc-like edges are characteristic for this phenomenon.
It can be assumed that the phenomenon is connected with cold air currents sinking downward.
Above maritime stratokumulus clouds a cold inversion layer lies. The cold air sinks from this layer downward through the underlying borders between convective close cells and produces sharp picturesque "Hokusai" edges. Although the vertical coexisted layers have often different albedo, its cloud top height (within the given methods accuracy and device resolution) remains the same. This phenomenon can be rarely observed over polar seas.






cloud albedo
cloud type on the cloud image
cloud type index
cloud opt. thick.
cloud top height



'Cutting' Phenomenon

夏の夜は	In the summer night
まだ宵ながら	The evening still seems present,
明けぬるを	But the dawn is here.
雲のいづくに	To what region of the clouds
月やどるらむ	Has the wandering moon come home?
清原深養父	Kiyohara no Fukayabu

"Convective Cells"

"Cutting" Phenomenon (CP)

This phenomenon looks (seen from above) like a sharp border between the field of convective close cells and usually cloudless sky.

The border is more often a straight line, sometimes a bend-like one.

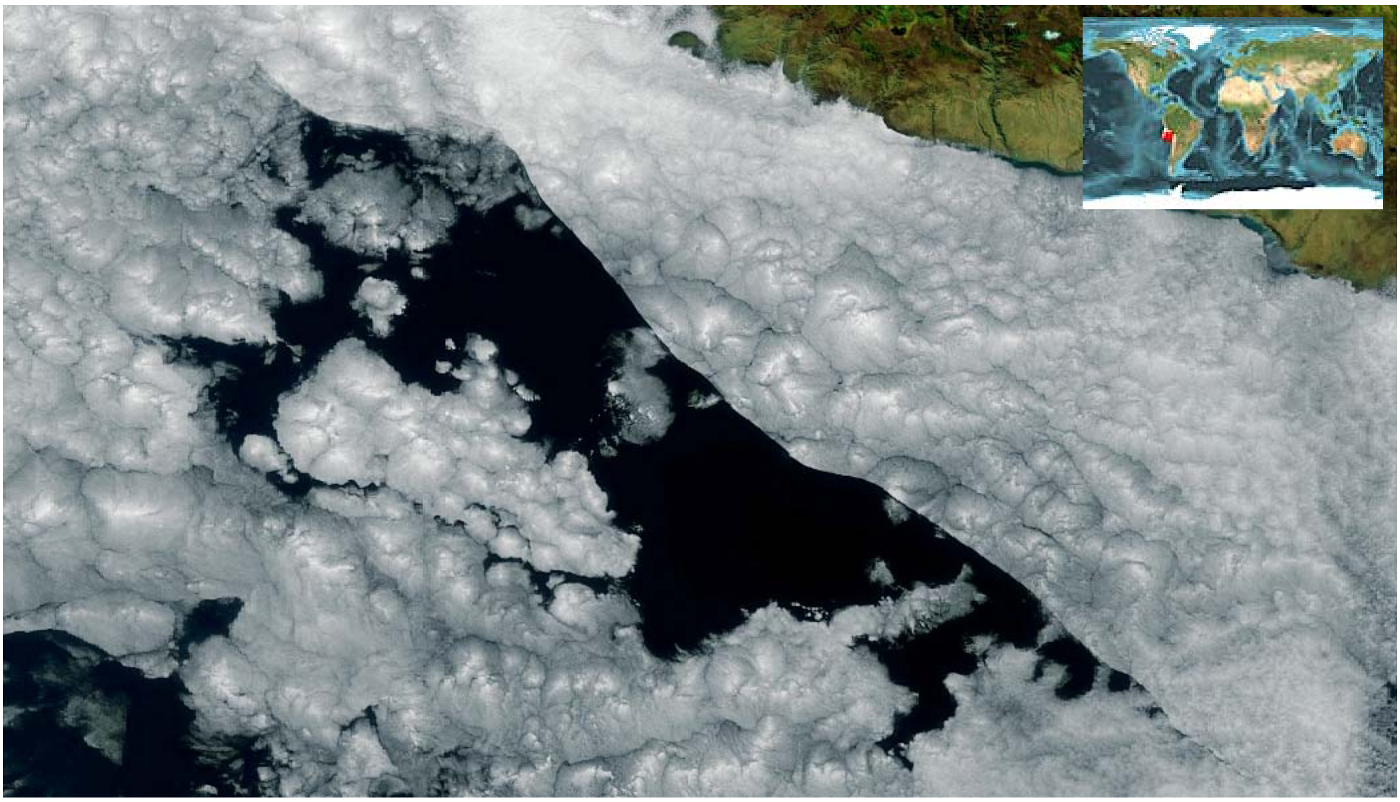
As a result large close cells are often cut off like a solid substance in the middle.

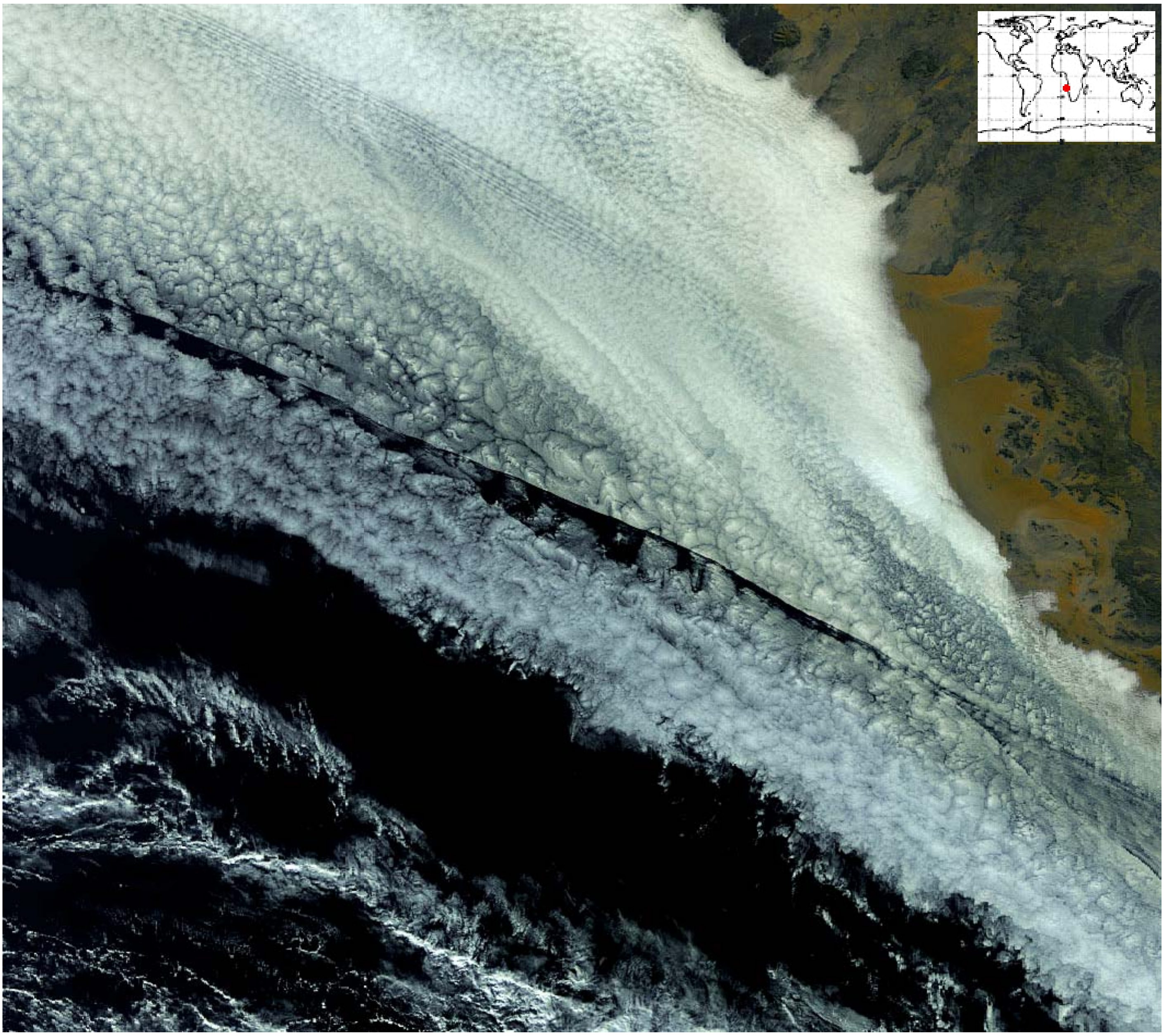
It can be supposed that the phenomenon is caused by the movement of the inversion layer. The straight-line or curved front of cold inversion layers will be printed downward and prevents the existence of the cloud cells. Cold air flows downward.

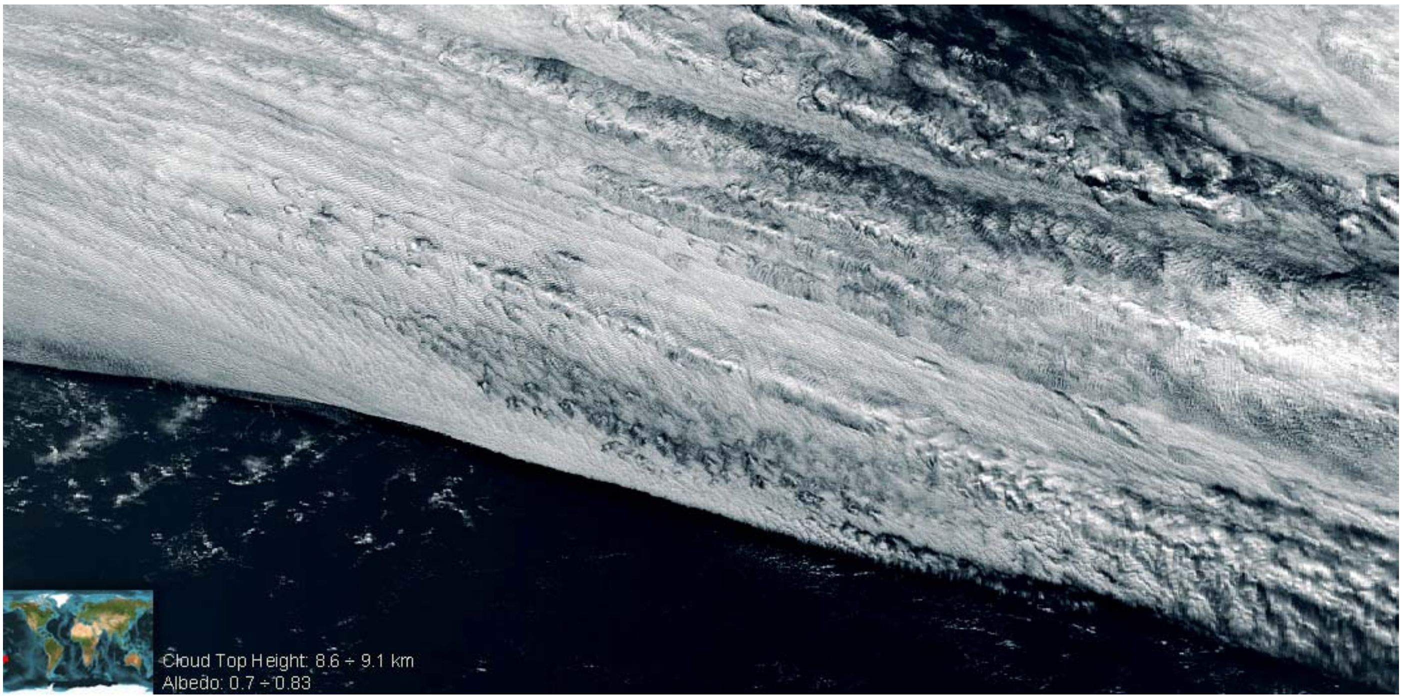
The mentioned downward pressure can be affected by a high-pressure area or by a low frequencies oscillation in inversion layer.

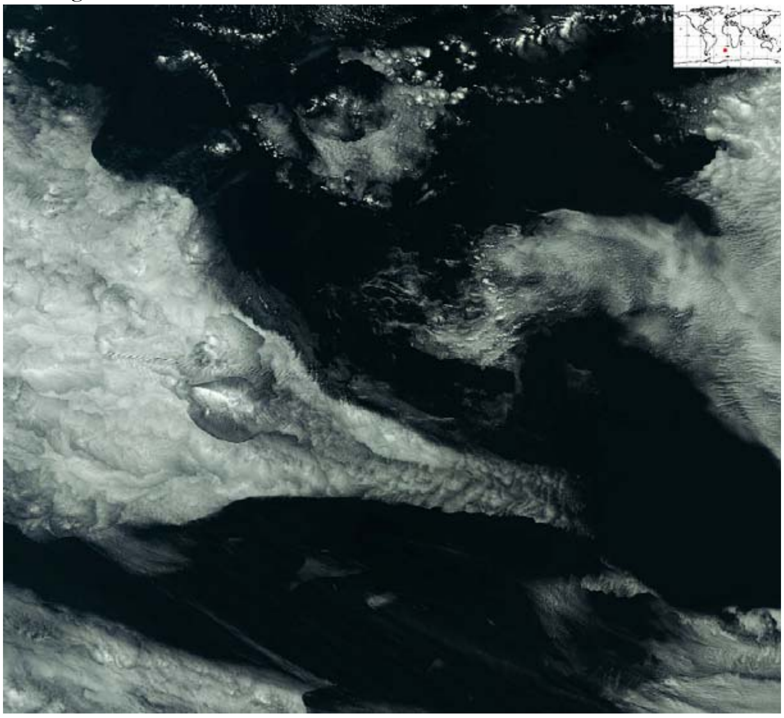
The phenomenon could be usually observed above cold waters of south and west Pacific and south Atlantic where there are close cells fields, but not often.

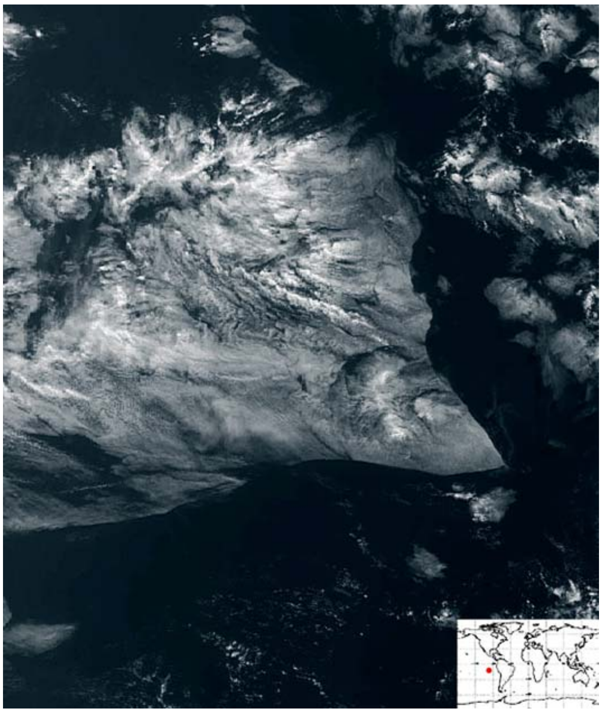
It could be observed also over the land.

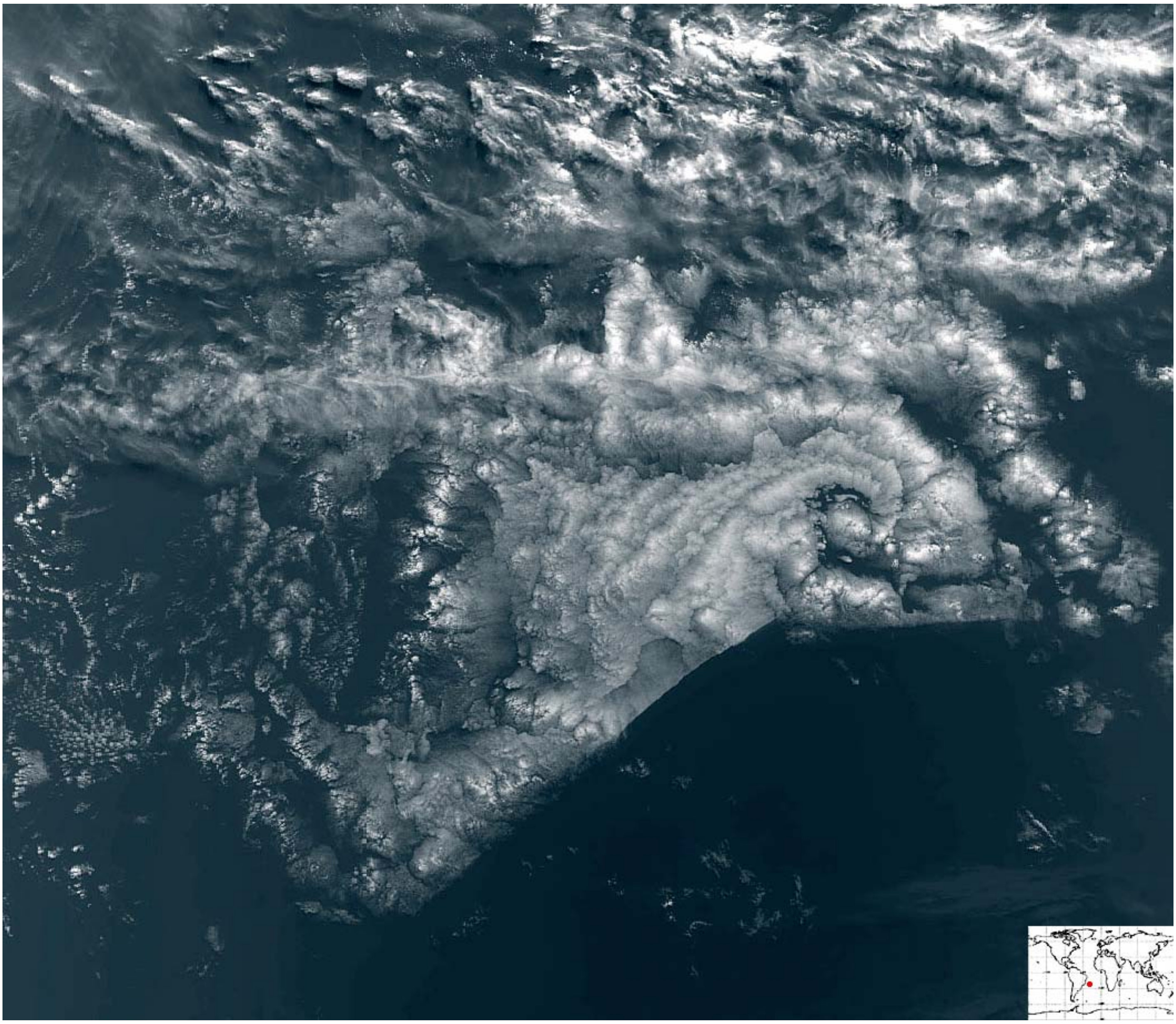




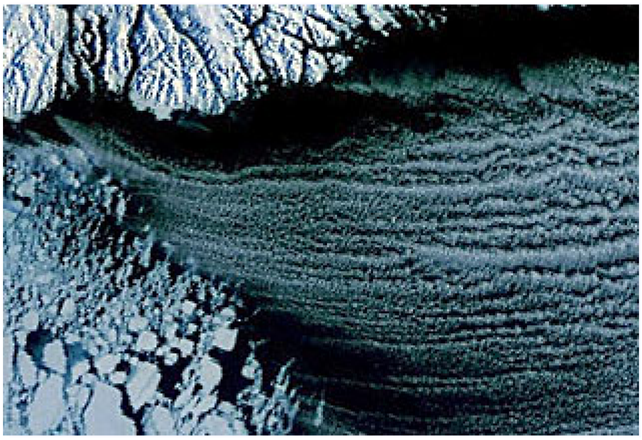

Cloud Top Height: 8.6 ÷ 9.1 km
Albedo: 0.7 ÷ 0.83







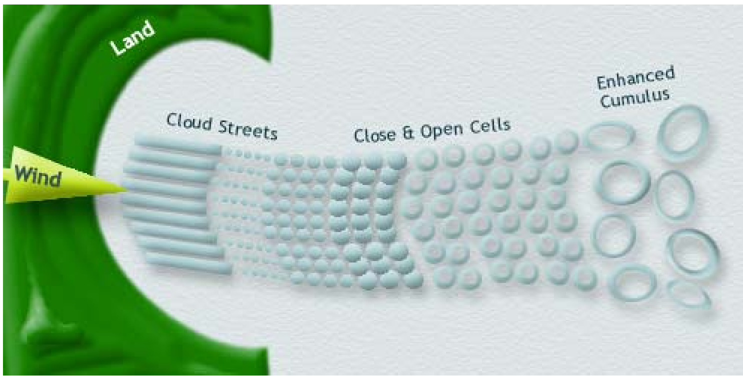
'Convection Cells Streets' Phenomenon CLOUD STRUCTURES



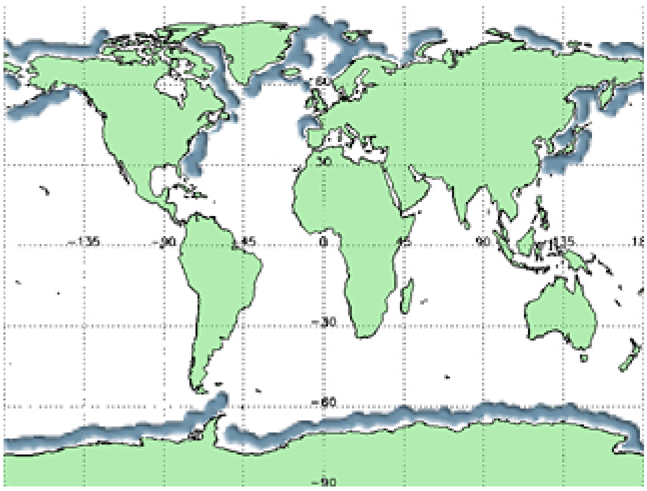
秋風に	See how clear and bright
たなびく雲の	Is the moonlight finding ways
たえまより	Through the riven clouds
もれ出づる月の	That, with drifting autumn wind,
かげのさやけさ	Gracefully float in the sky.
左京大夫顕輔	Sakyo no Daibu Akisuke

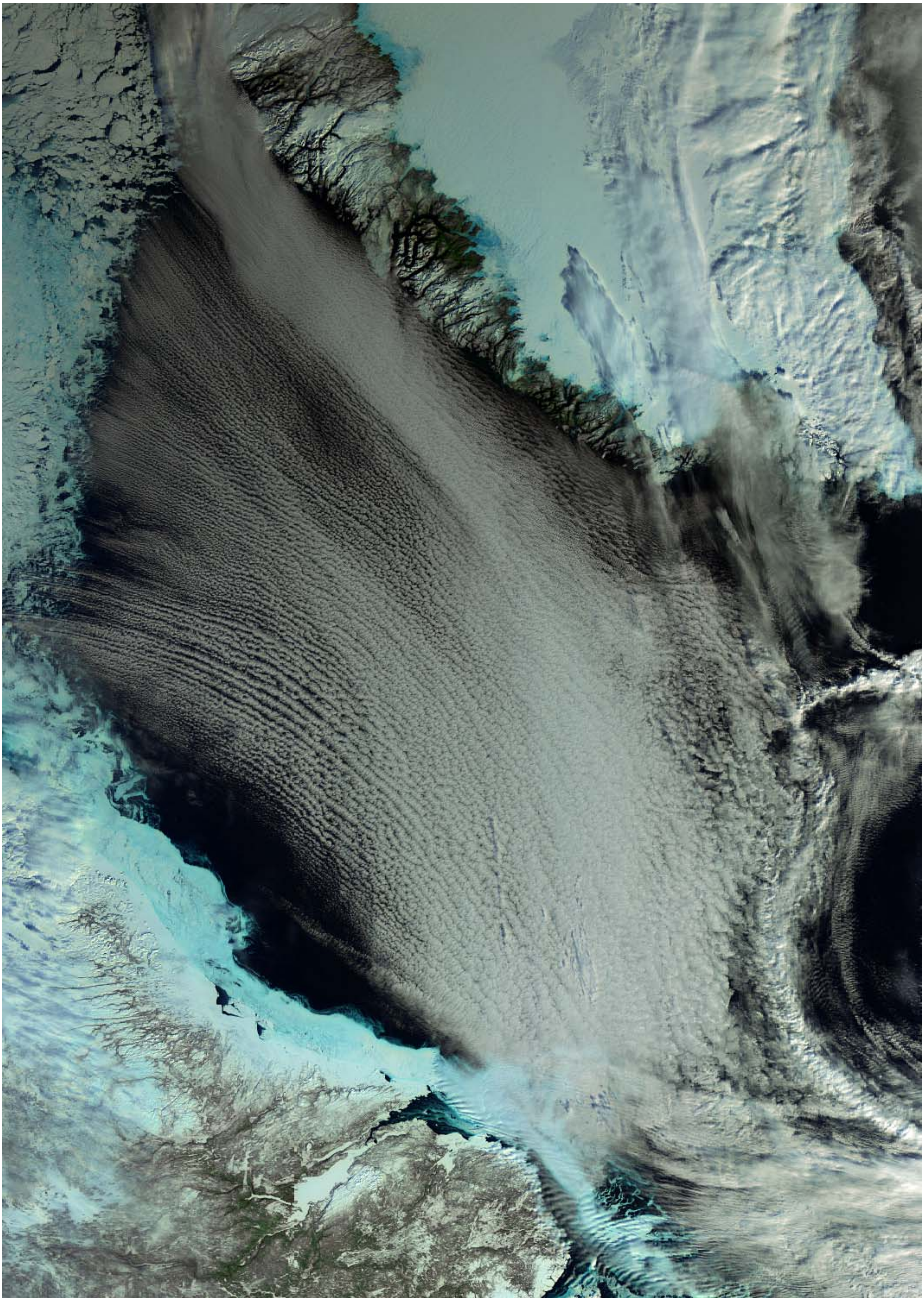
"Convective Cells"

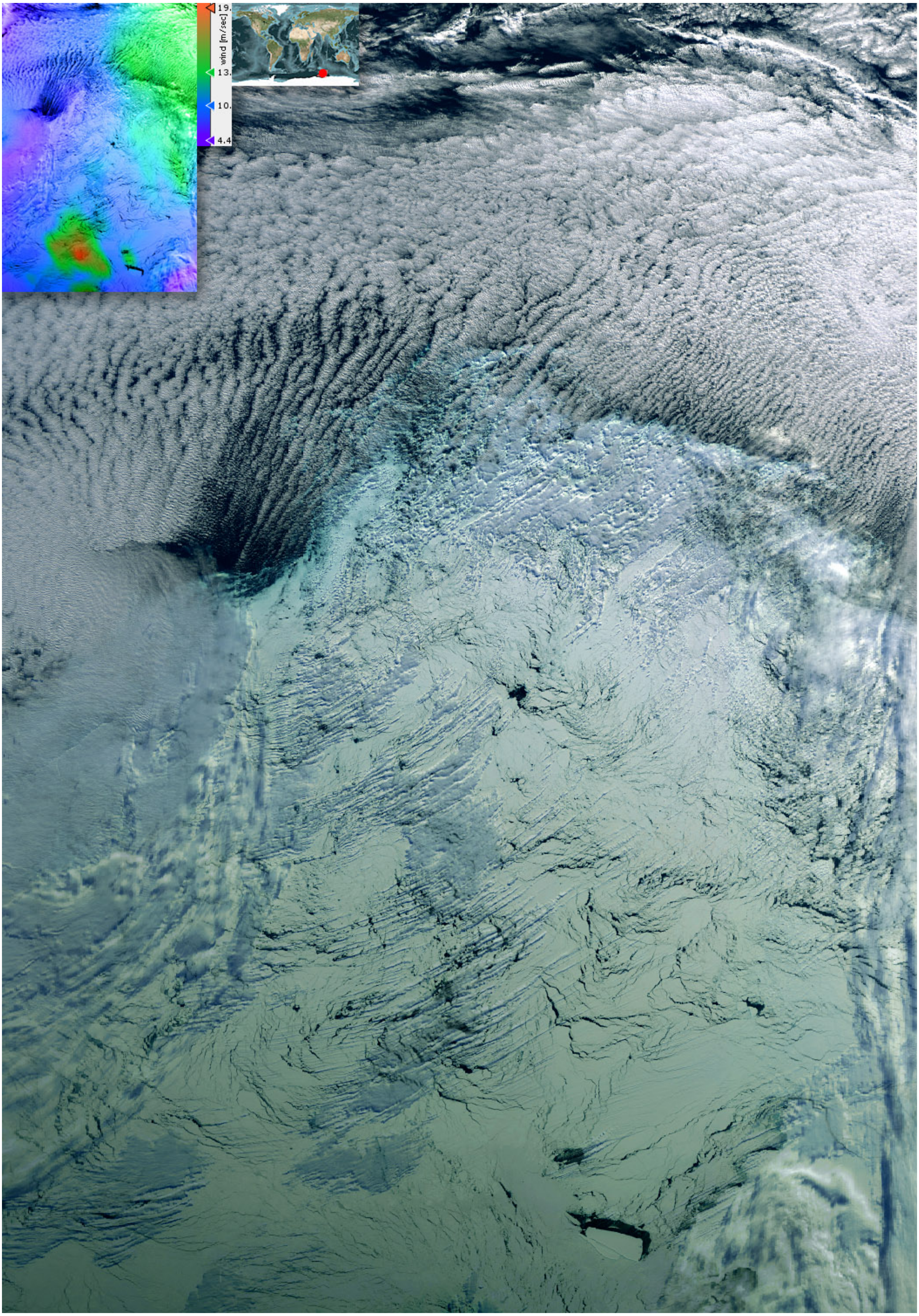
"Convection Cells Streets" Cloud Phenomenon (CCSP)

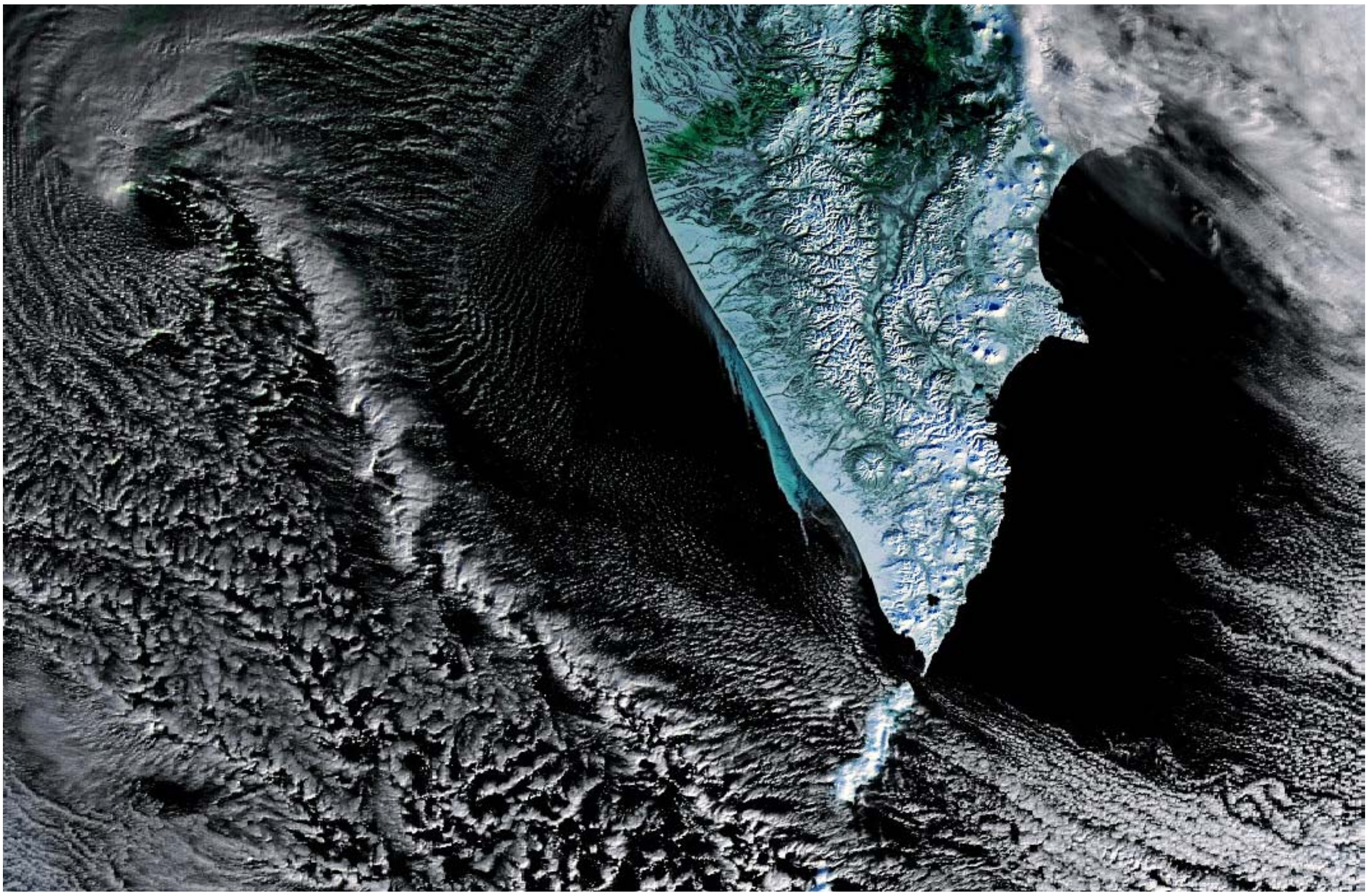


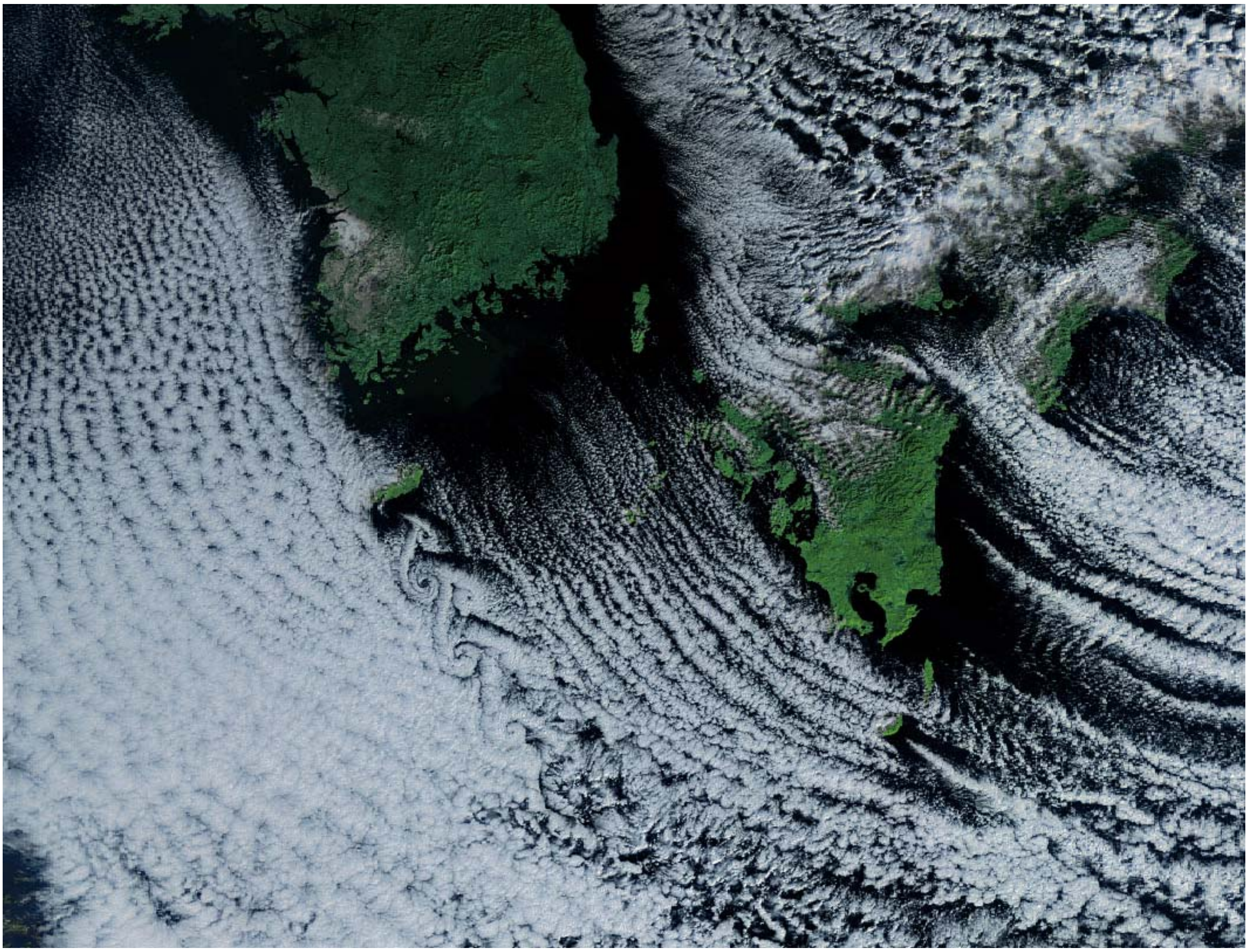
The organization of the clouds in "streets" can be explained by the existence of the horizontal role turbulences in the boundary layer.
The clouds are formed in the upper layer of this roll system.
If outbreaks of the continental cold dry air spread above a neighbouring relatively warm ocean, the cloud streets can be seen.
This takes place frequently behind a cold front. If the cool air leaves the land or ice surface, its properties changes by vertical transfer of the heat and humidity of the underlying water surface.
An inversion layer is formed and its basis rises with the distance from the coast.
The transformation of air mass leads finally to the formation of the clouds, that, under certain circumstances, the shape of the cloud streets assumes, and develops approximately parallel to the wind direction.
Further the streets develop to the three-dimensional opened cells.
Near the upper-trough the convection is enhanced and Enhanced Cumulus becomes to form.
These structures can be often observed in spring and winter above polar waters, in addition, above cold water of middle latitudes (s. illustration below).

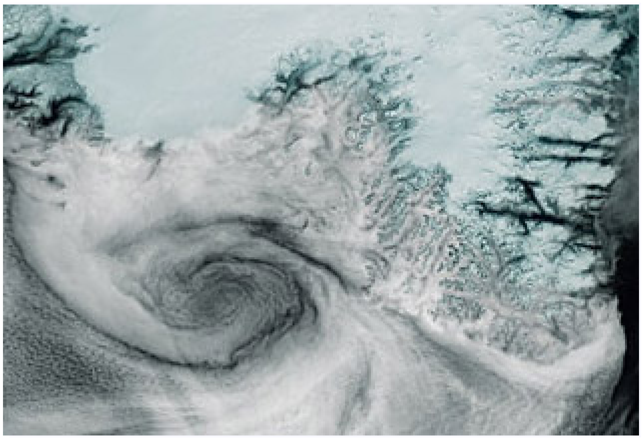





wind [m/sec]





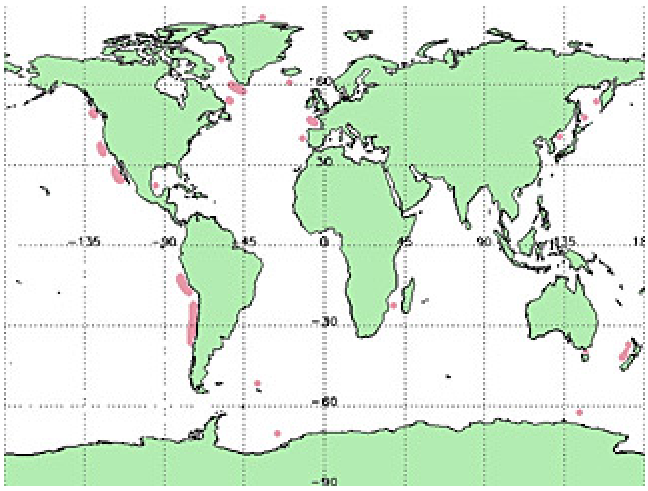


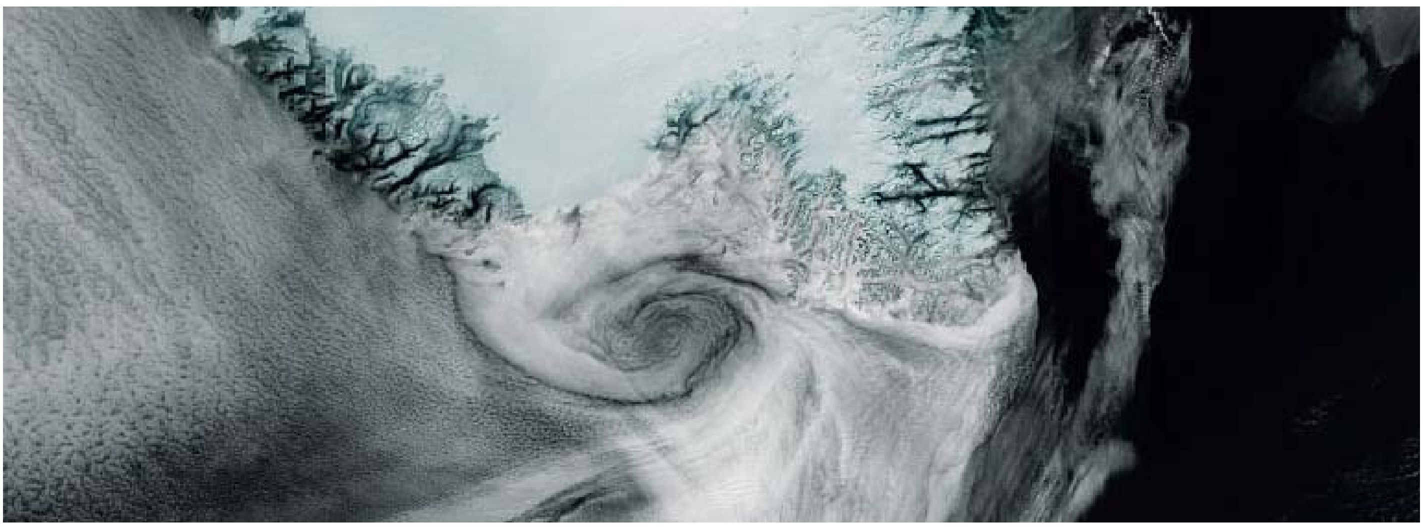
As banked clouds
are swept apart by the wind,
at dawn the sudden cry
of the first wild geese
winging across the mountains.
Saigyo (1118-1190), translated by S. Hiroaki

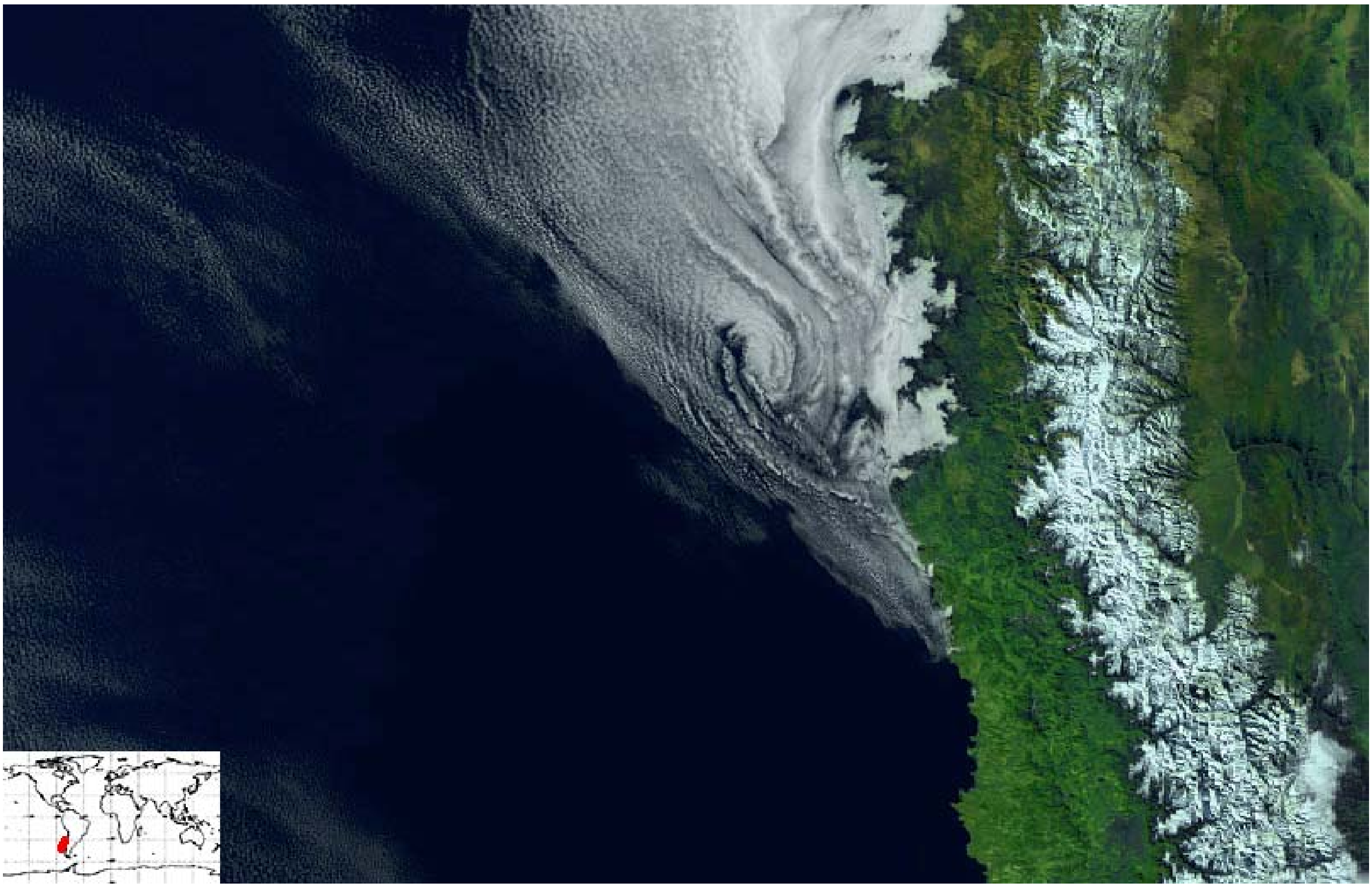
"Convective Cells"

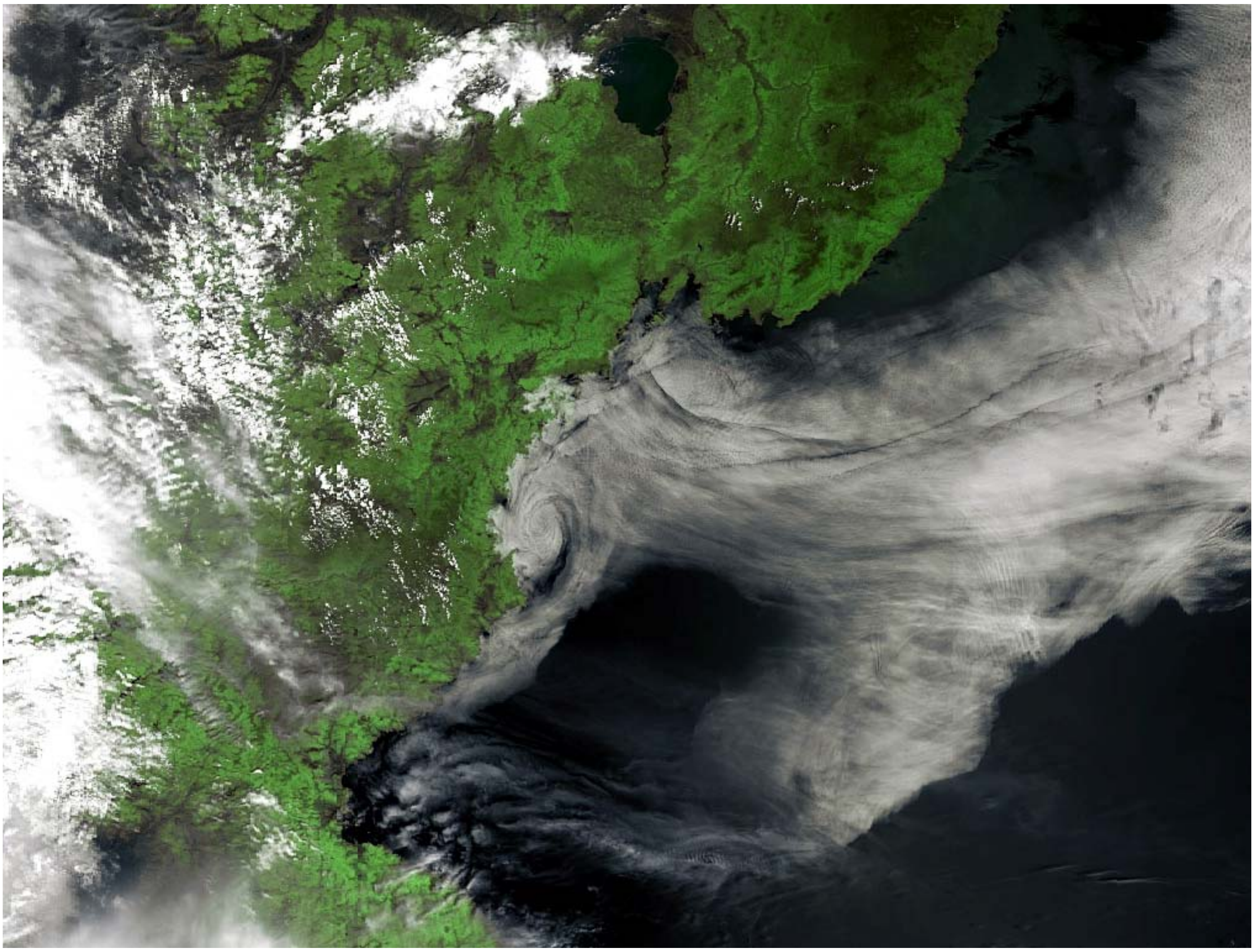
"Coast Vortex" Phenomenon (CVP)

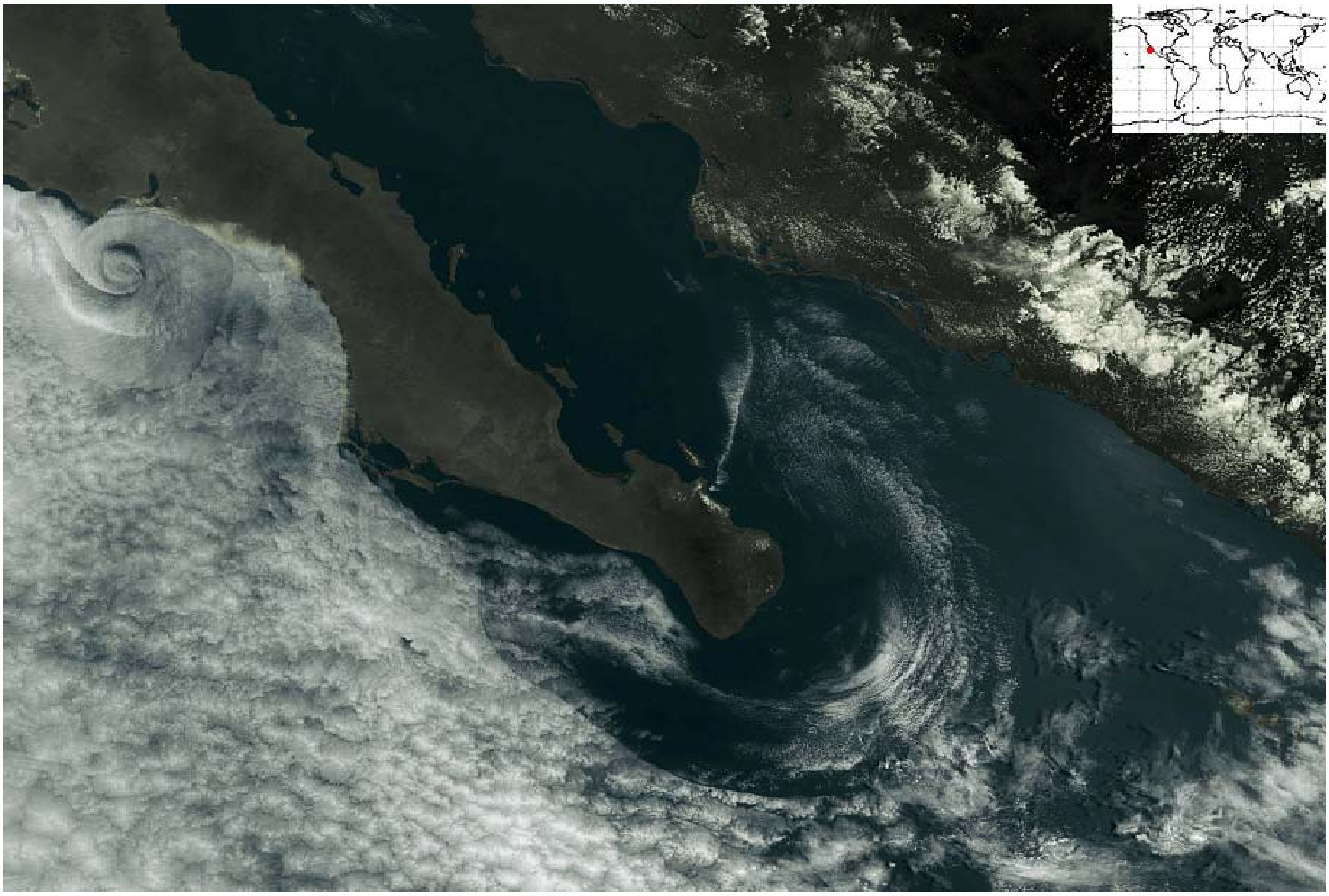
The phenomenon, which was tentatively called "coast vortex", can be observed in the form of medium sized (20-150km) low cloud eddies over the water in the frontier "sea-country".
During the observations of "coast vortex" phenomena it was noticed that over the neighbouring country is nearly always clear. This could refer to high pressure area.
It is (in cases of "coast vortex") not rare that the neighbouring country has rather mountainous coast area.
The cause of the emergence "coast vortex" phenomena could be the following.
In a high pressure area above a land (not rare - above a high land) the mass of dry air sinks toward the earth's surface and flow finally apart.
There are hardly large convective cloud cells above the neighbouring sea area.
If in this area the winds in the land direction occur, they force to move the clouds in same direction.
However it is obstructed by conditions dominant over the country. The eddy can appear by air friction.
It could be the other reason: cold land air masses heat up over the water and rise.
The wind over the water affects the upward rise. The Coriolis Effect veers the clouds into appropriate direction.
The phenomenon is to be observed rarely and only in certain places with mostly more highly coastal area. Sometimes it occurs above large bays, where developing eddies flows the coastal line around.

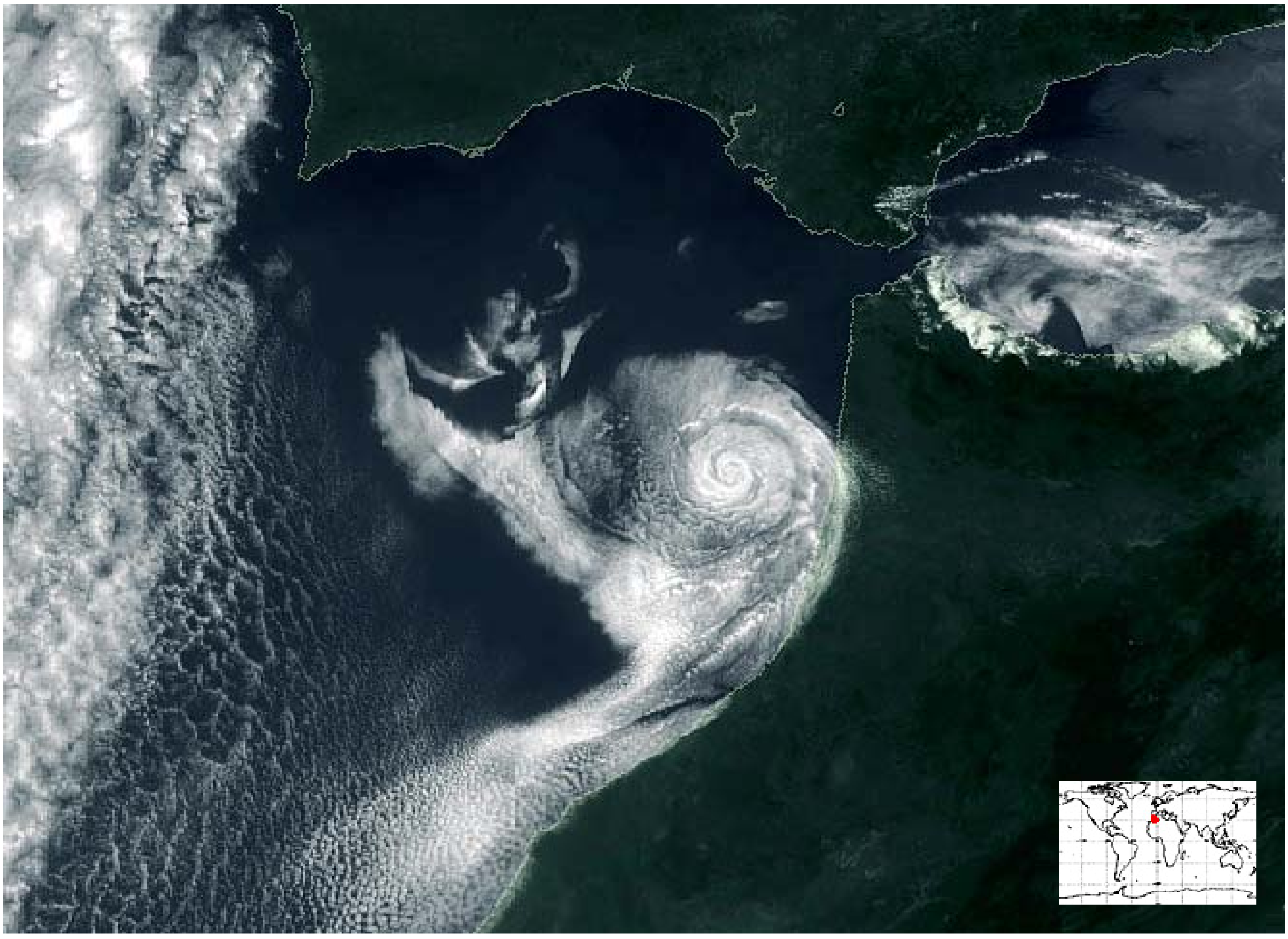












'Wave over' Phenomenon

天つ風	Let the winds of heaven
雲のかよひ路	Blow through the paths among the clouds
吹きとぢよ	And close their gates.
乙女のすがた	Then for a while I could detain
しばしとどめむ	These messengers in maiden form.
僧正遍昭	*Sojo Henjo*

"Convective Cells"

"Wave over" Phenomenon (WOP)

The wavelike convective close cells structures were tentatively defined as "Wave over" structures.

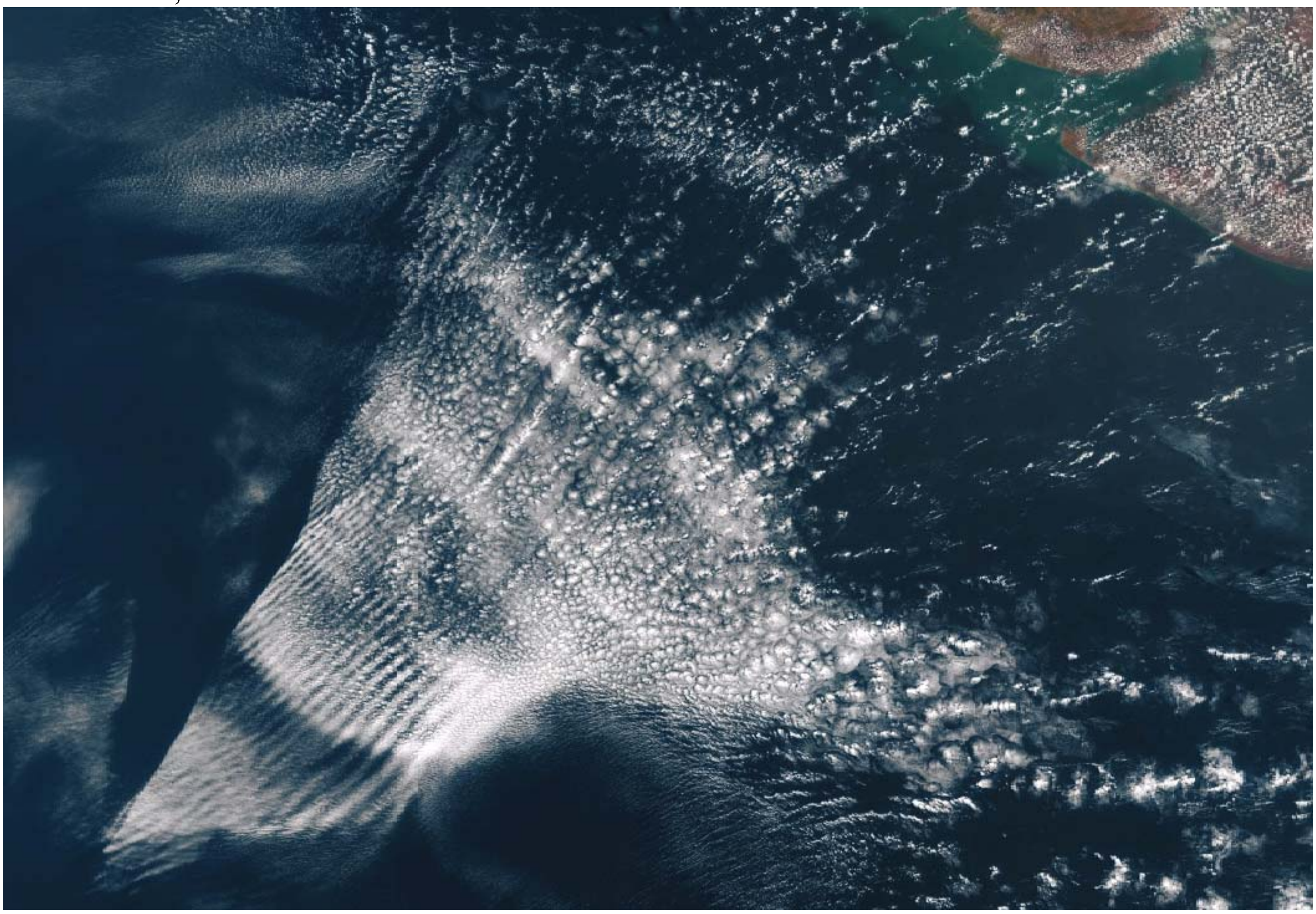
The "gravity waves" can appear when the relatively stable and stratified air masses are disturbed by a vertical trigger from the overlying (or underlying) environment.

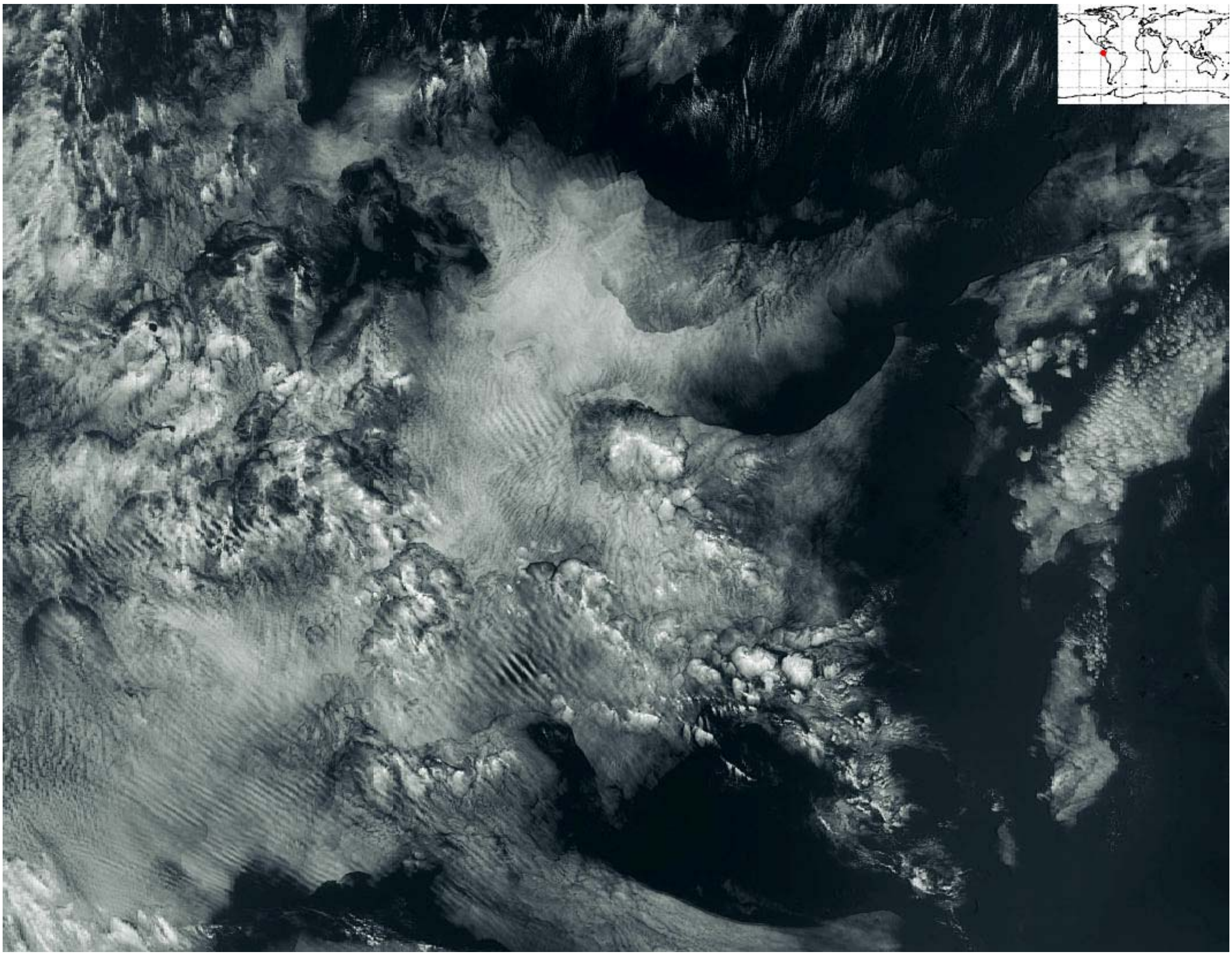
The inversion layer (sudden increase of the temperature with the height), which lies a little bit higher than convective close cells field, and is affected by gravity waves, has an effect on the underlying calm layer of convective clouds in such a way that those reflect the wave picture.

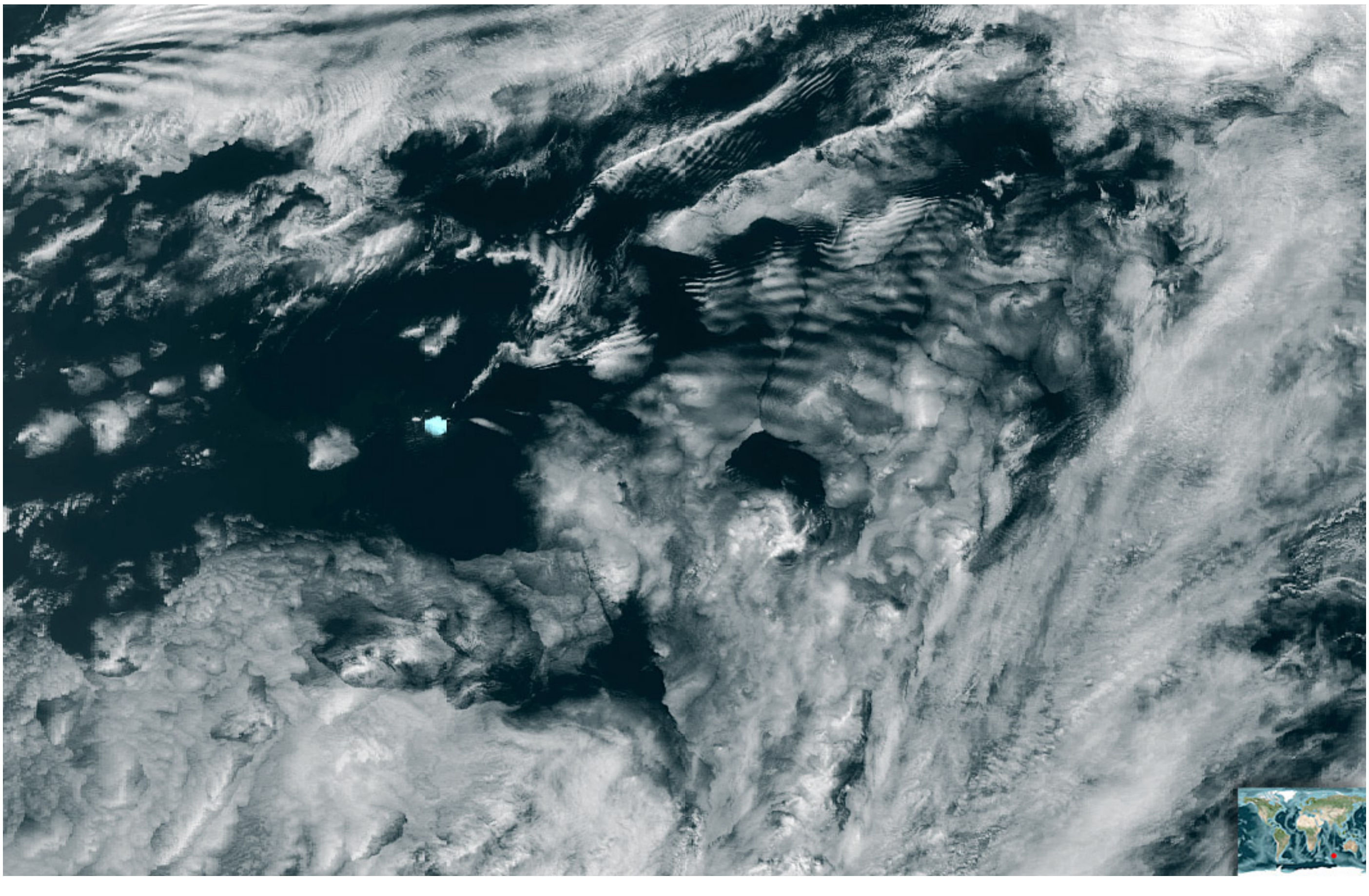
The wave front shows often arc-like or nearly straight-line structures.

The "Wave over" structures are not seen frequently.

They can be observed mostly over Southeast Atlantic close to the West Africa coast, around the sound coast of South America, over North Atlantic and Northwest of Indian Ocean.







Travelling Convective Cells

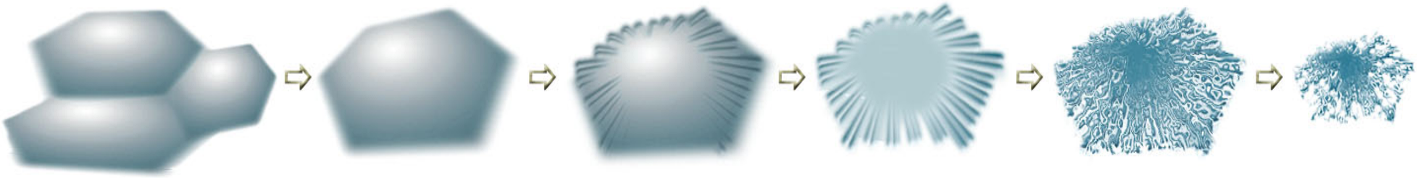
CLOUD STRUCTURES

The "Cloud-Bird"
Maya Emblem Glyph

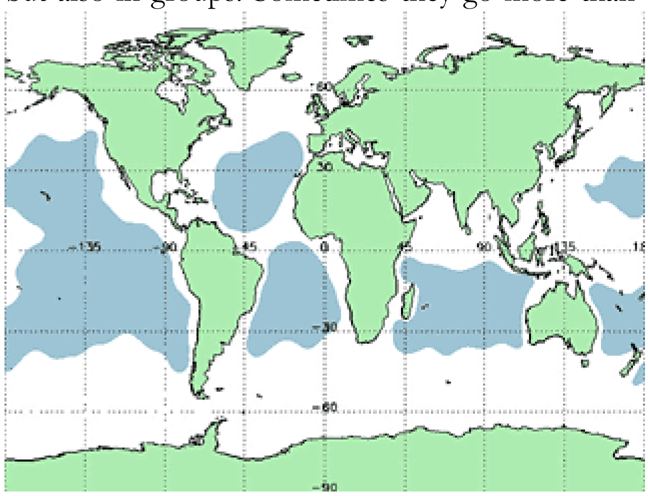
http://decipherment.wordpress.com/page/2/

"Convective Cells"

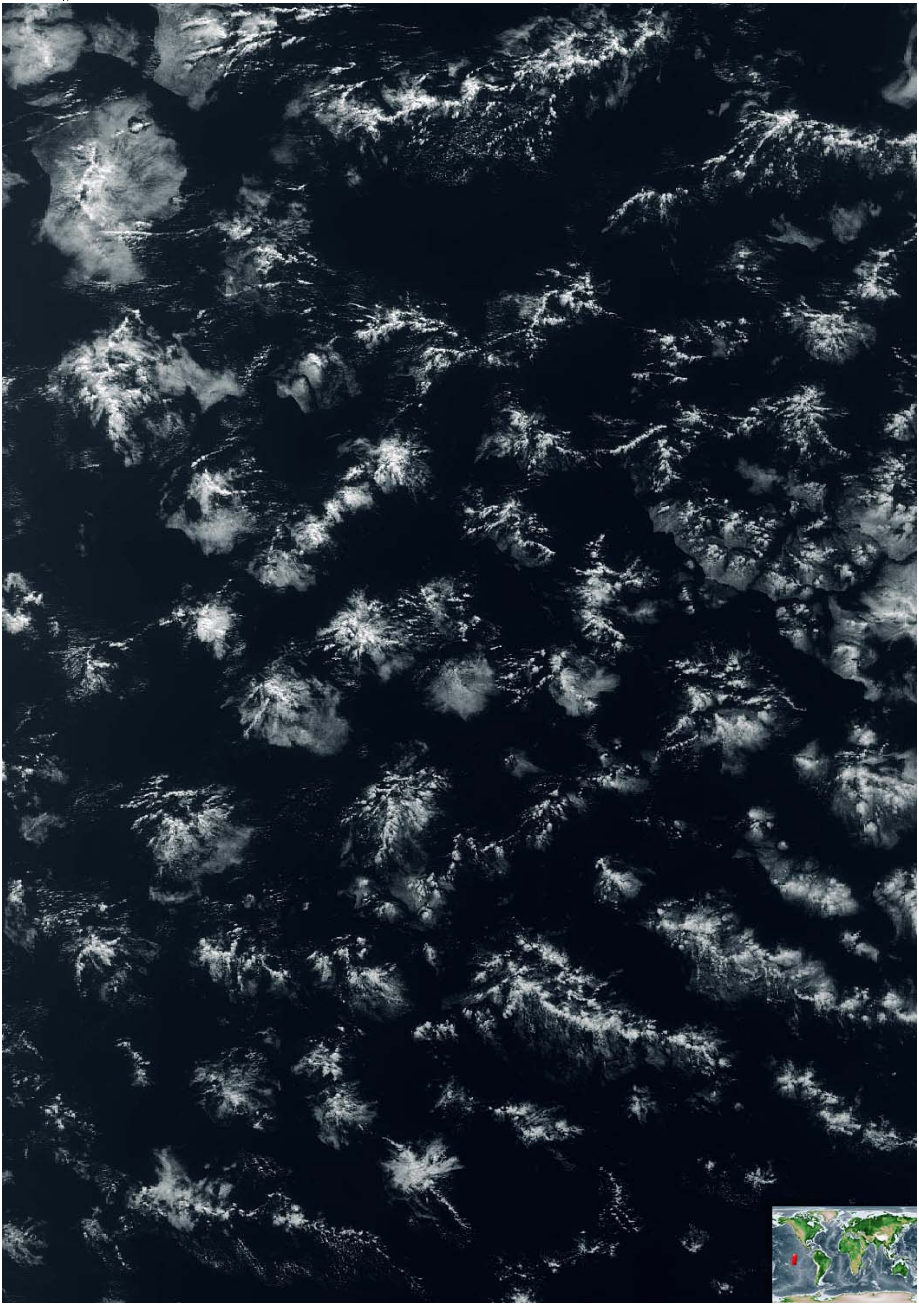
"Travelling Convective Cells" (TCC)
The clouds of this structure emerge probably from "Close Cell" cloud structure.
If the assumption is correct, these cloud form demonstrate certain stability, while they depart from with the wind Close Cells field.
It is not clear, whether there are only the clouds back of convective cells, or the whole convective cells travels also. In any case some metamorphoses, which happen with clouds, are to be observed.
The large (up to 300 km) separate (if they are emerged from the CCS) cells, which are outlasted the dissolution process, are usually covered with the ravines.

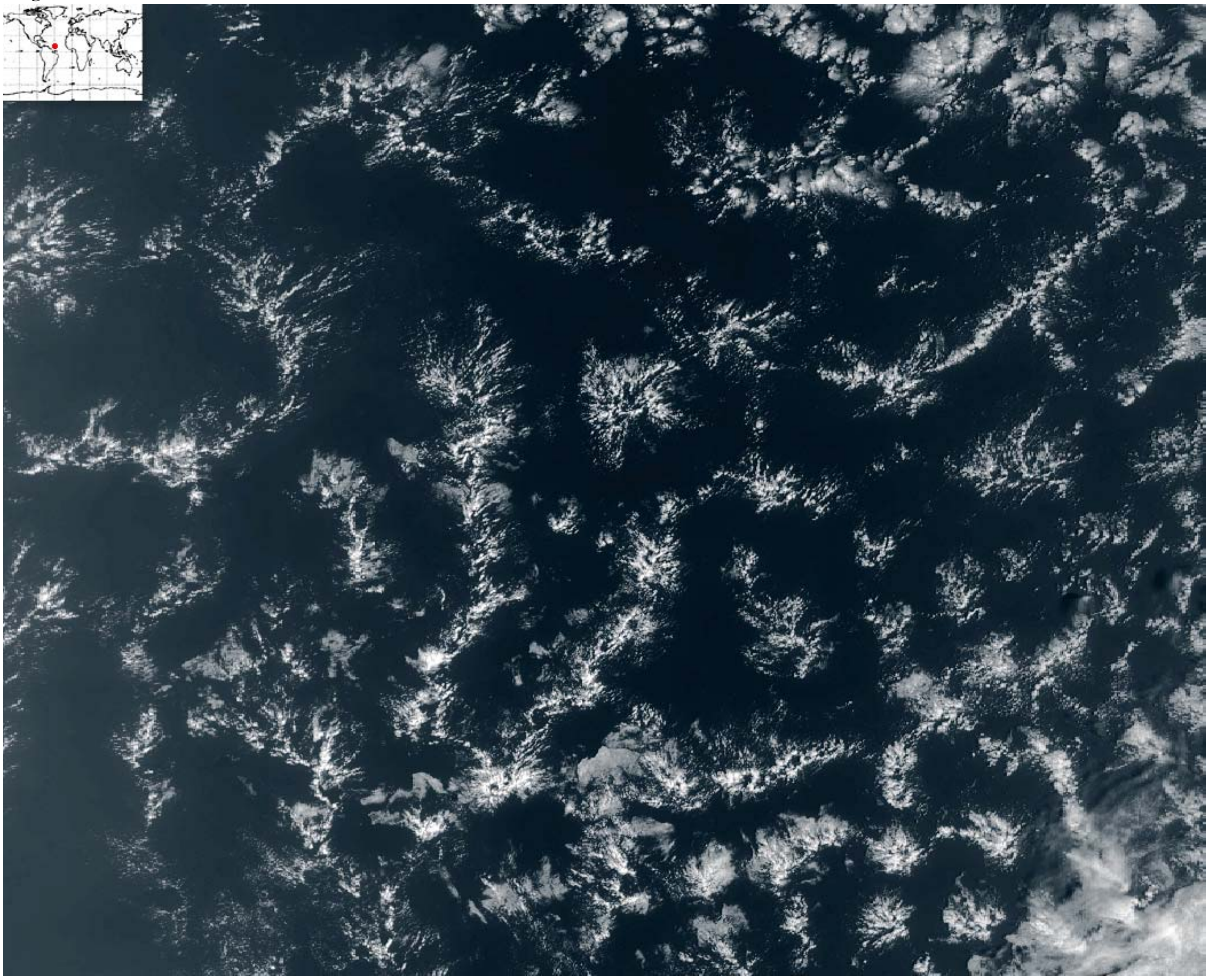


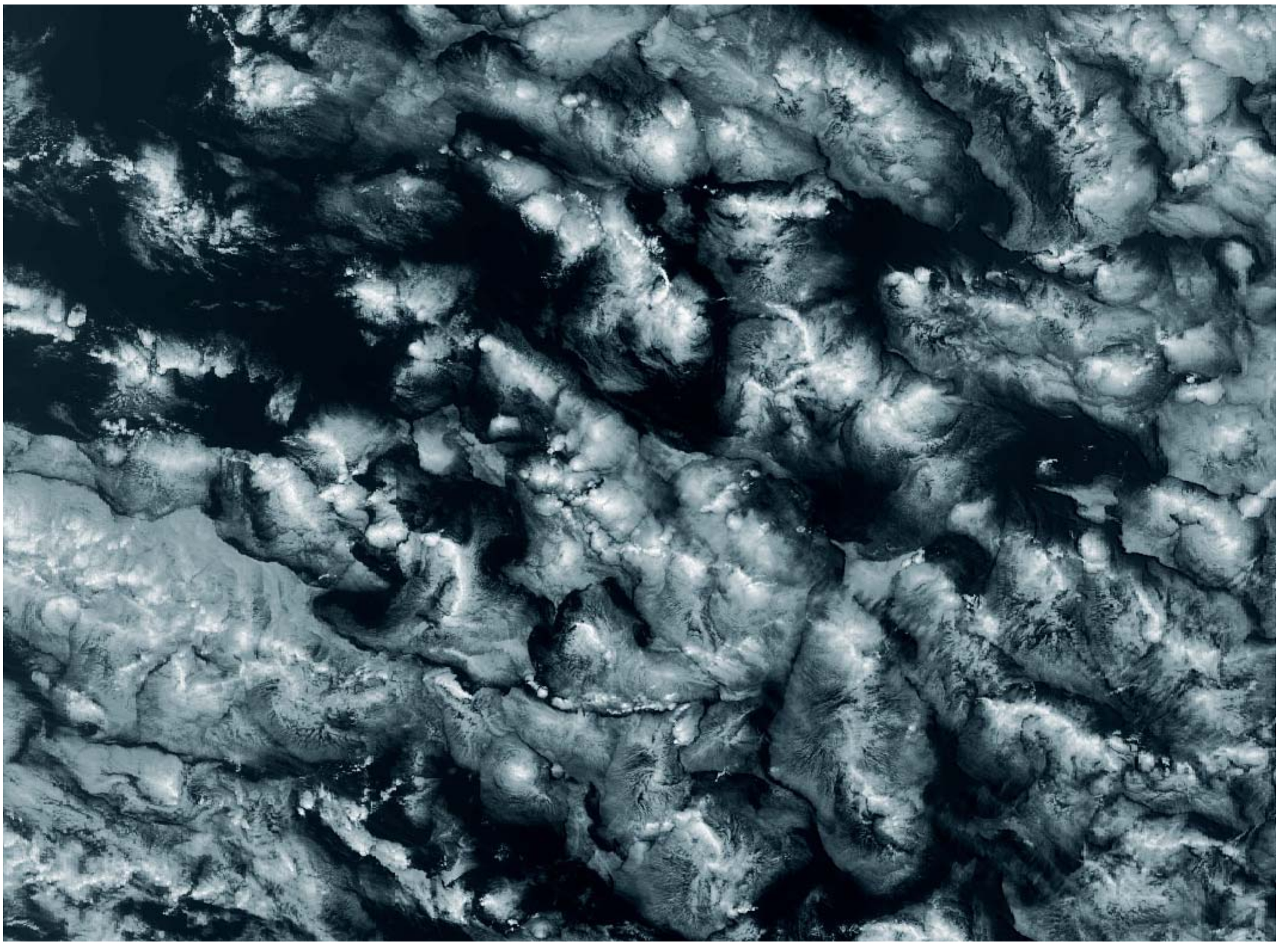
It could be accepted that they developed from the cold air flows, which flow downward from the summit of the cloud form.
Cold dry air drives the water vapour out to lower warmer layers, so that the ravines become finally deep enough and the clouds among them disappear completely.
The remnants in form of mountain combs "live" still longer, after that they will smaller and finally dissolve.
Elements of this structure are seasonally observed as single, but also in groups. Sometimes they go more than thousands of kilometres away from their sources.
They are observed over the warm latitudes.
In east Pacific in a strip of ±40° above equator,
In west Pacific above [+15°, +40°] and [- 15°, - 40°],
In Atlantic above [+5°, +40°] and [+2°, -40°],
In Indian ocean above [- 2°, -40°].
Sometimes it is nevertheless very difficult to say, where they came from, which field of "Close Cell" cloud could be the source for it.
This refers to the fact that some travel cells can have another origin than "Close Cell" cloud structure.
In this sense the "Mid-Atlantic Amazon Cloud Province" [in a rectangle with coordinates top-left (+30°, -55°) ÷ down-right (+5°, -40°)] is particularly interesting.

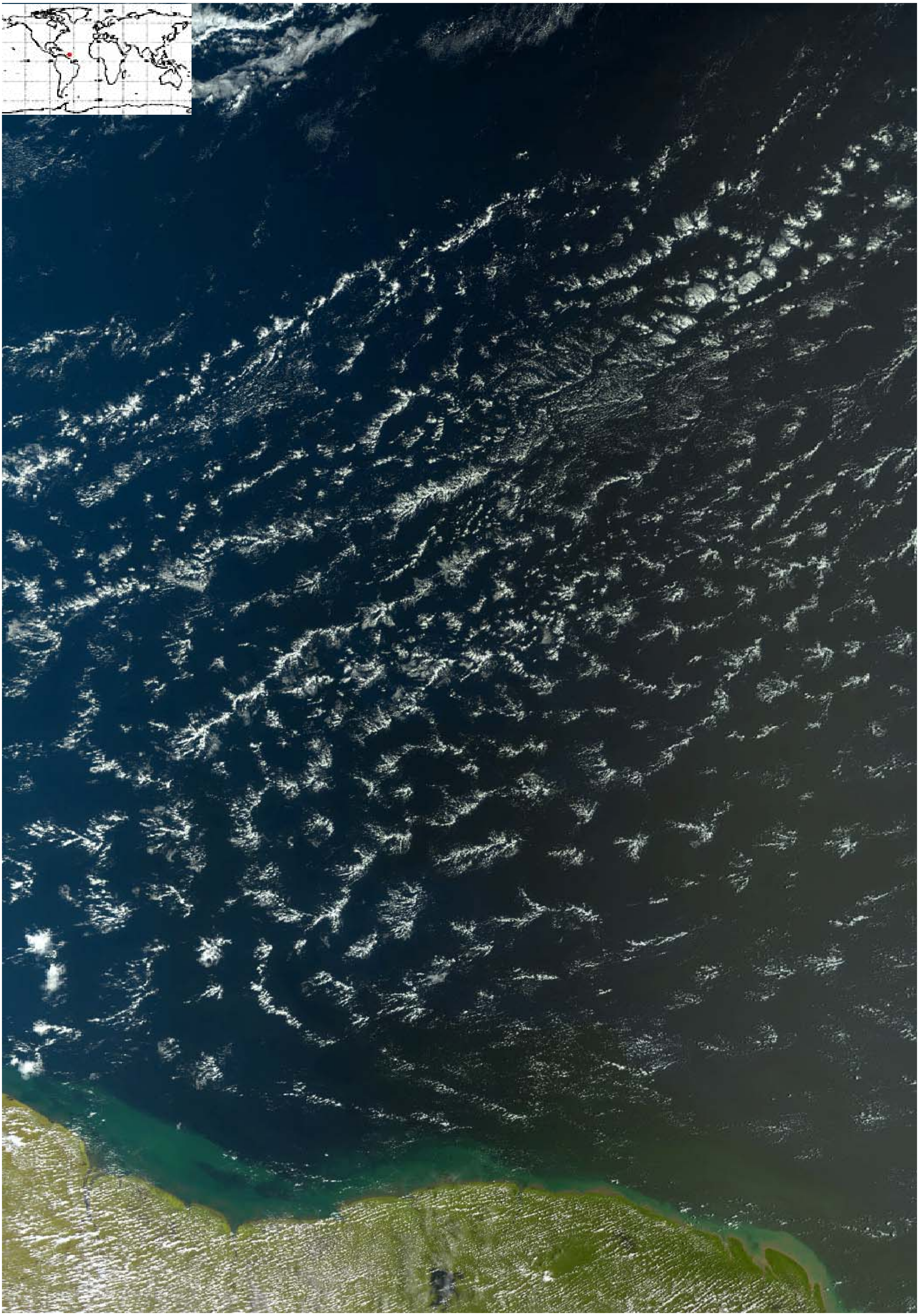


There the "travel cells" are seasonally observed as the knots of a regular net. They are relatively small (starting from 30 km), have a star-like shape and dissolve fast. It is not clear, where they are come from.
The "travel convective cells" form also the season-conditioned "Coral Sea Cloud Province".

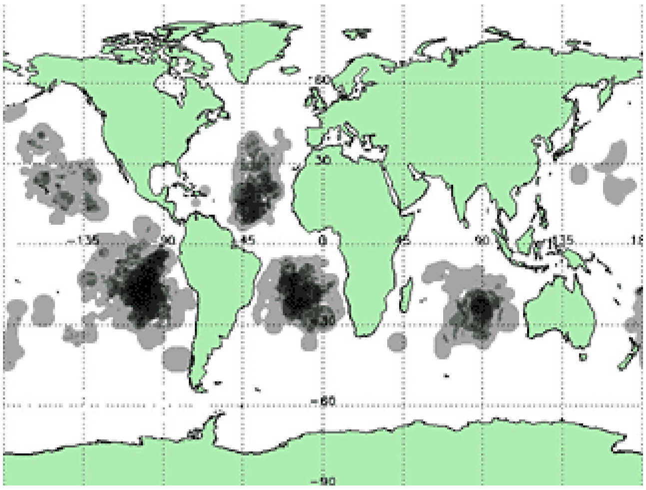




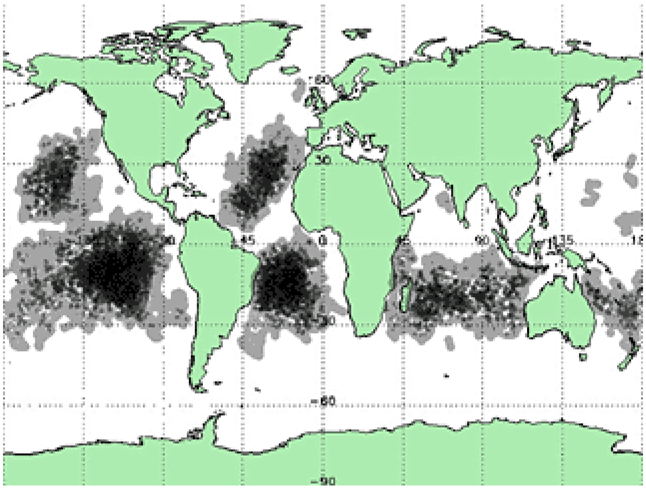




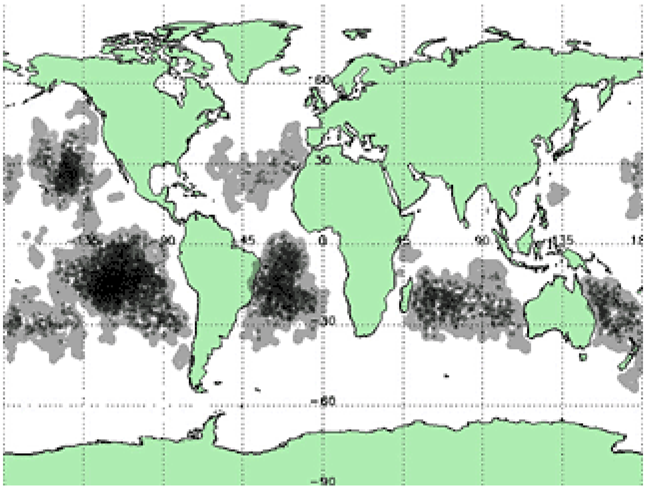
Observation diagrams



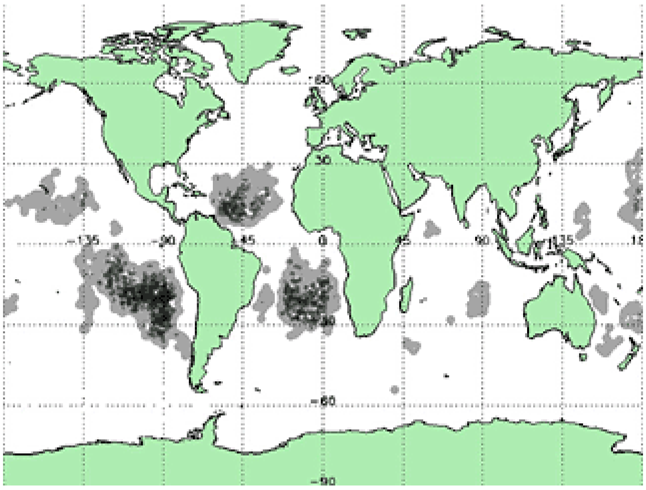
Observation diagram for April-May 2006



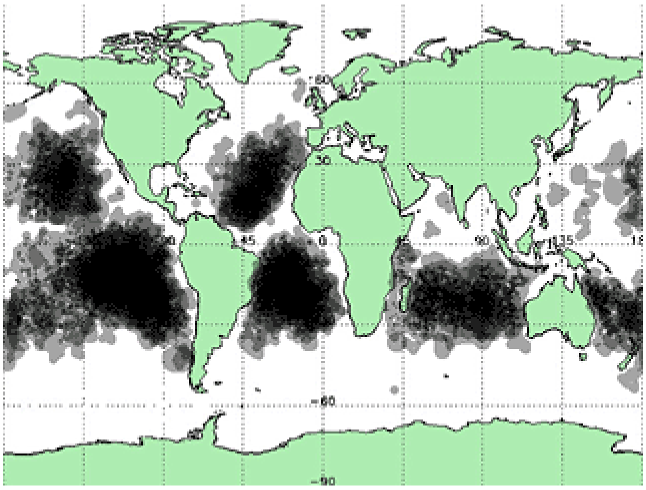
Observation diagram for June-August 2006



Observation diagram for September-October 2006

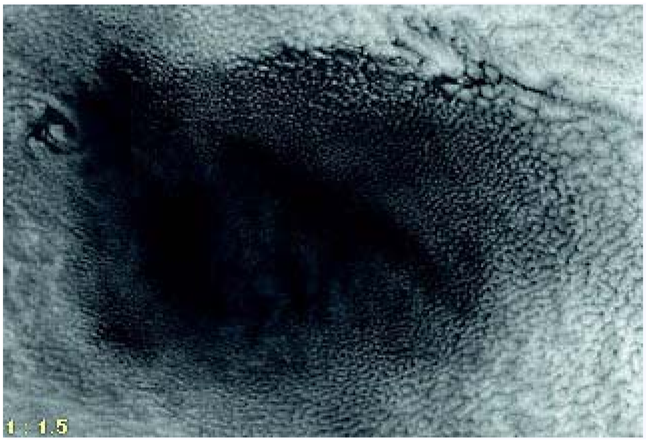


Observation diagram for February 2007



Observation diagram for all mentioned months

'Black Hole' Phenomenon



Miranda
The sky, it seems, would pour down stinking pitch,
But that the sea, mounting to th' welkin's cheek,
Dashes the fire out.

William Shakespeare, The Tempest, Act I, Scene II

"Convective Cells"

"Black Holel" Phenomenon (BHP)

The absence of cloudiness within Convective Close Cells structures was tentatively defined as a "Cloud Black Hole" phenomenon.
Such cloudlessness may be explained by anticyclone developments (which is proved by the near surface wind direction around the "black hole").
Such phenomenon may occur in the area above masses of cold water where cold dry air rushes out from the upper layers of the atmosphere, driving away the cloud cells in its way.
The holes are usually round or oval, but their shape is often irregular, "lacerated".
This phenomenon mainly emerges within low small-cells convective cells structures in the circumpolar regions above water surface, mostly above the waters situated close to the Antarctic.
The edges of black holes usually make up small closed convective cells, nearly dissolved in the air.
The holes may be several dozens of kilometres in size or much larger - up to several hundreds of km.
Cloud black holes do not emerge often in the atmosphere.