



SCWS2017  
Creative Informatics for the Earth



# Visualization of Geoscientific Simulation Data in Academic Research

**Daisuke Matsuoka, Ph.D.**

**Japan Agency for Marine-Earth Science and Technology (JAMSTEC)**

# Research facilities/target in JAMSTEC

Drilling vessel "CHIKYU"



Manned submersible "SHINKAI 6500"



## Facilities/instruments

- Drilling vessel
- AUV/ROV
- Manned submersible
- Super computer

etc.

## Scientific target

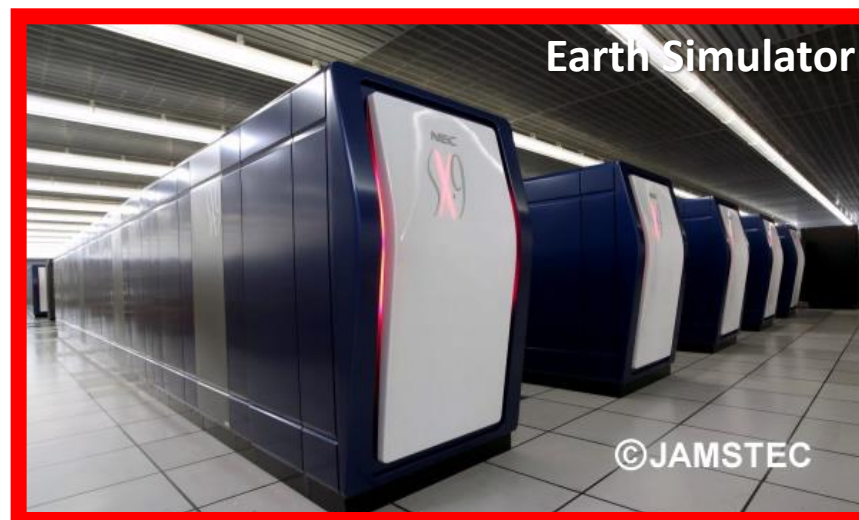
- Ocean
- Atmosphere
- Earth's interior
- Submarine creature

etc.

Argo float



Earth Simulator



# Advanced Visualization and Computation Research Group, Center for Earth Information Science and Technology

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- Research
- Publication
- Environment
- Gallery

Home » Research

- Research
- EXTRAWING
- Volume Data Visualizer for Google Earth
- Data mining
- Large-scale Parallel Visualization
- VFIVE



## Advanced Visualization and Perception Research Group/Research

Last update : 2012.10.01

Data visualization is an indispensable step in the simulation researches. We can extract hidden information behind massive numerical data only through the visualization. When the output data to be visualized are small enough, simple graphs or charts are sufficient to understand what happened, or simulated, in the computer. However, when the data size becomes large, more sophisticated methods or tools than simple graphs are required for the data visualization.



One of the focused technologies in our research and development is the virtual reality (VR). Our VR system is described in other page. We investigate the application of advanced VR technology to

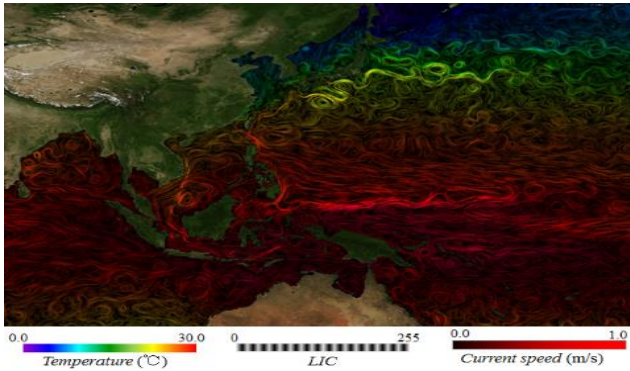
# Study on scientific data visualization

- Visualization for **analytics**
- Visualization for **machine learning**
- Visualization for **scientific arts and artistic science**
- Visualization for **virtual reality (VR) System**
- Visualization for **general public**

# Visualization for Analytics

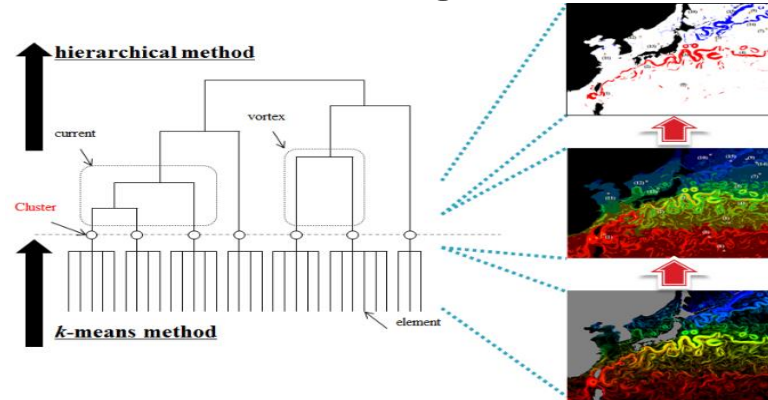
# Visualization for analytics

## 1. Visual representation



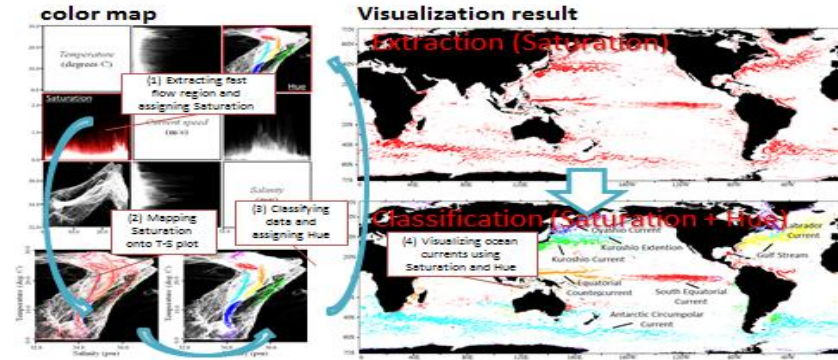
Matsuoka et al., 2012

## 2. Visual data mining



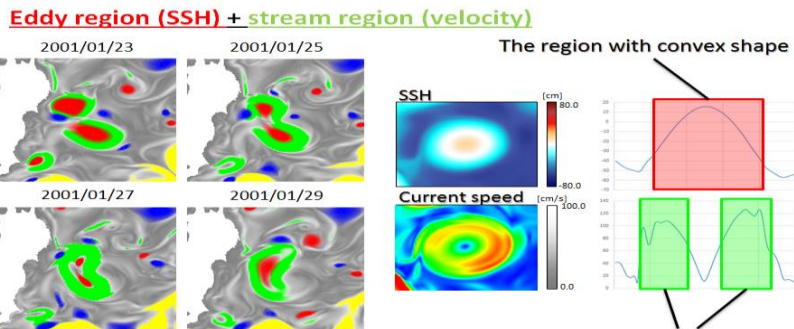
Matsuoka et al., 2012

## 3. Visual analytics



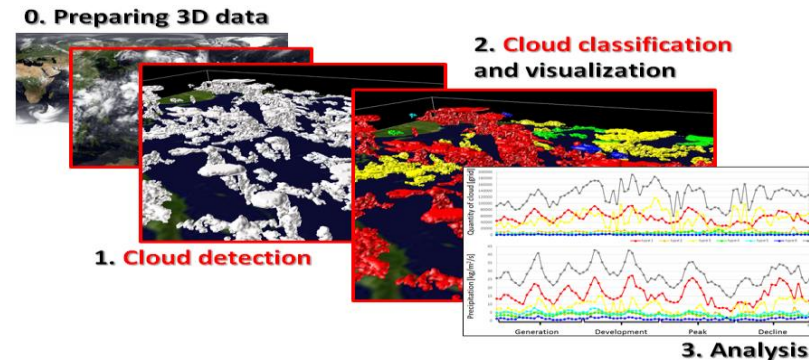
Matsuoka et al., 2015

## 4. Feature tracking



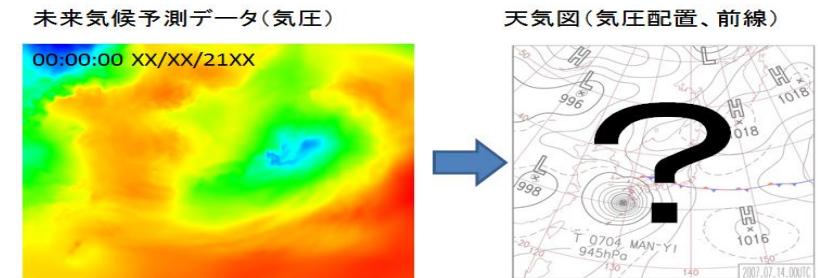
Matsuoka et al., 2016

## 5. Feature classification

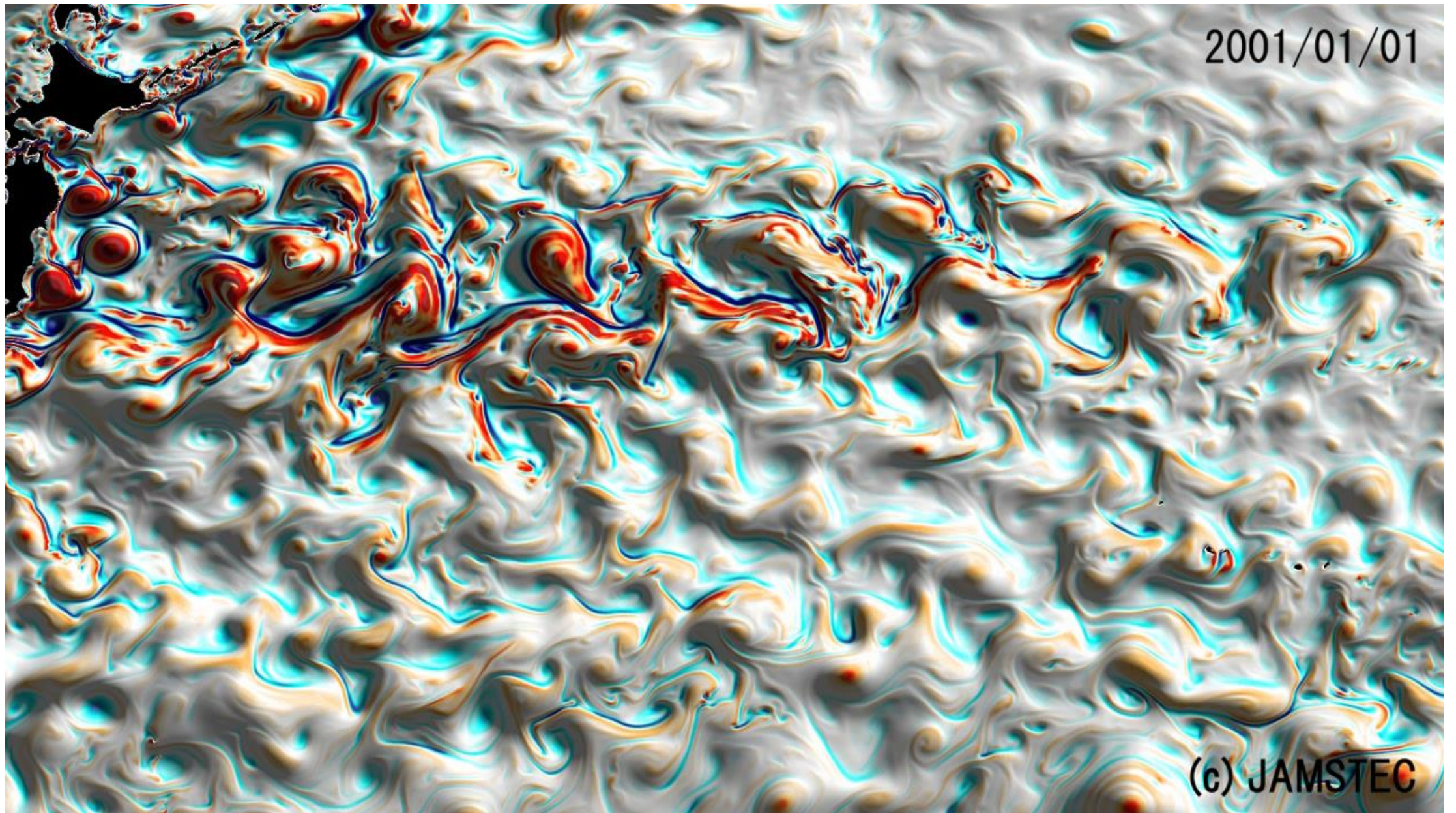


Matsuoka et al., 2016

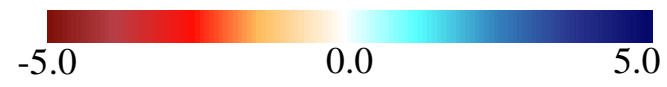
## 6. Machine learning



2001/01/01



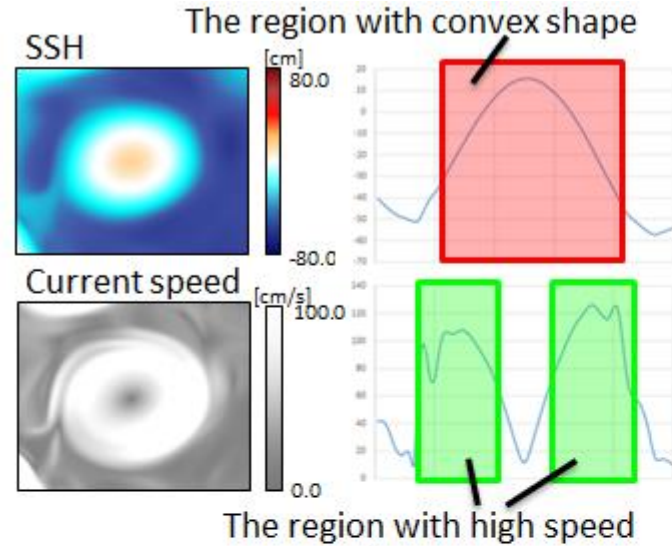
(c) JAMSTEC



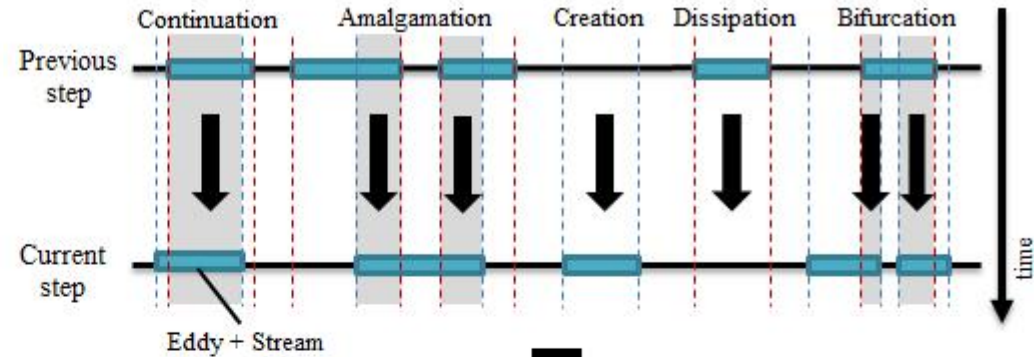
Relative vorticity ( $10^{-5} \text{ s}^{-1}$ )

# Feature extraction and tracking

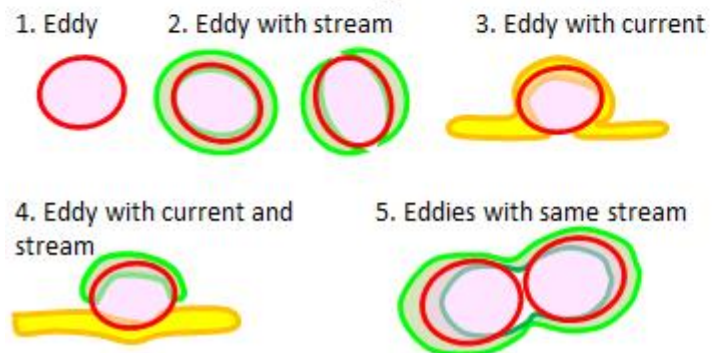
## Eddy detection



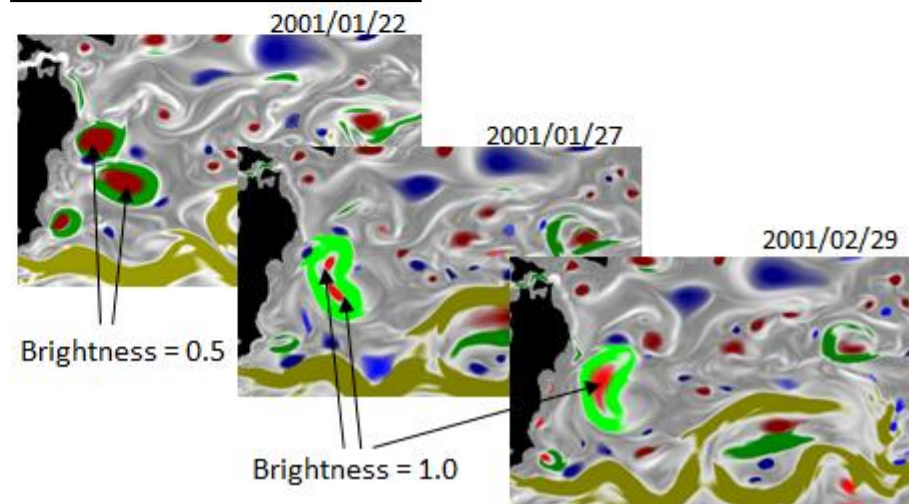
## Eddy tracking



## Classification

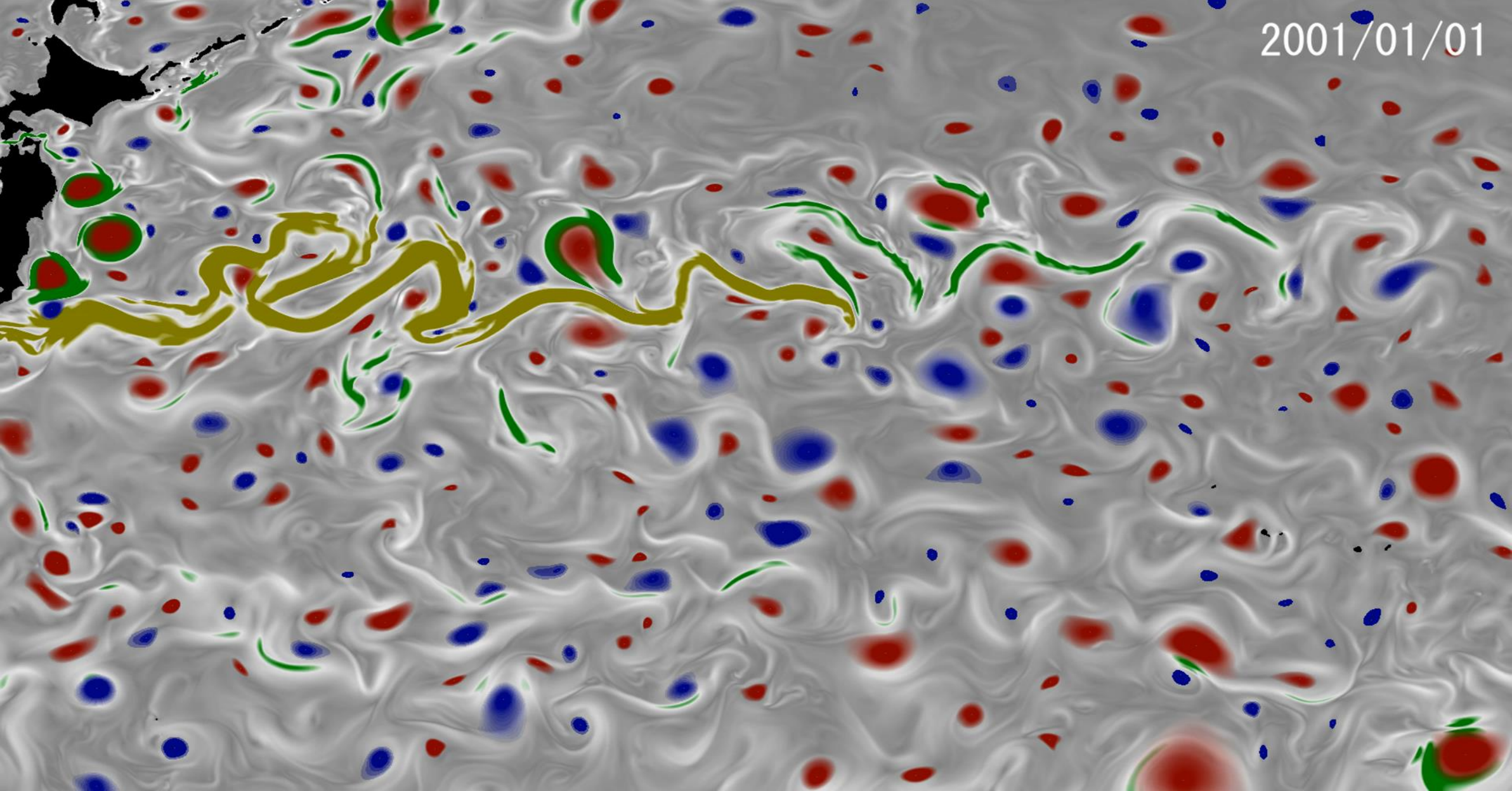


## Event visualization





2001/01/01



● Warm eddies

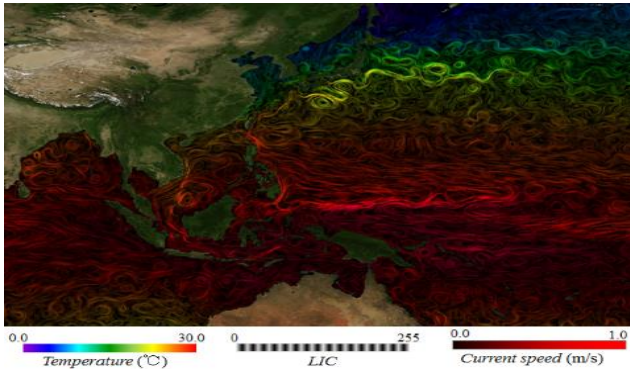
● Cold eddies

● Currents

● Streams

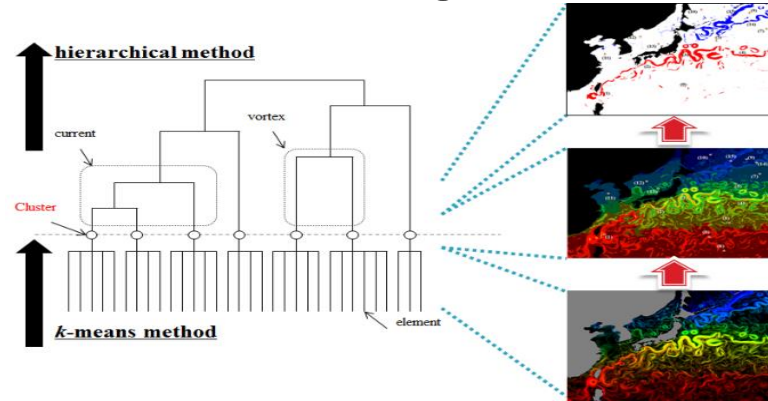
# Visualization for analytics

## 1. Visual representation



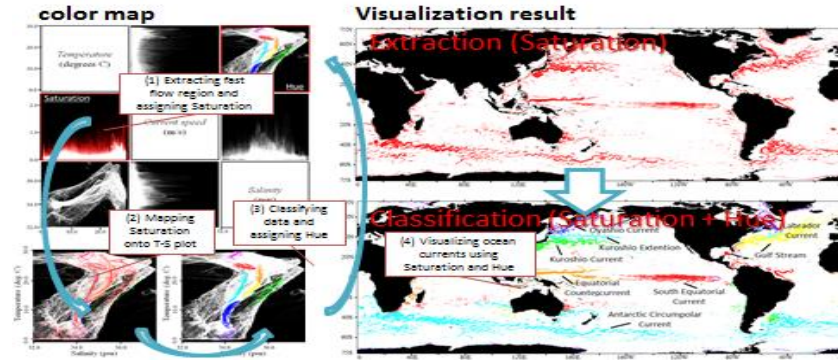
Matsuoka et al., 2012

## 2. Visual data mining



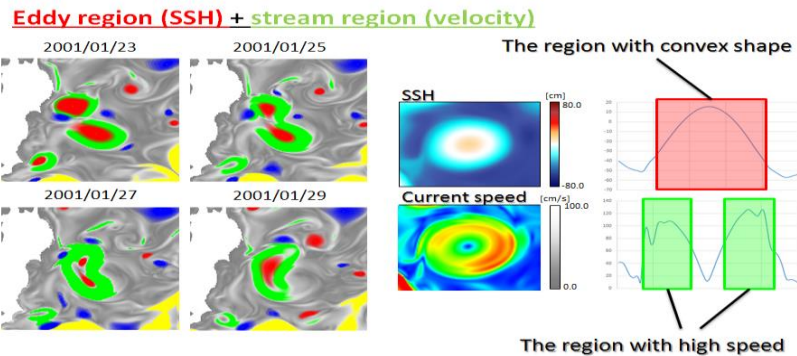
Matsuoka et al., 2012

## 3. Visual analytics



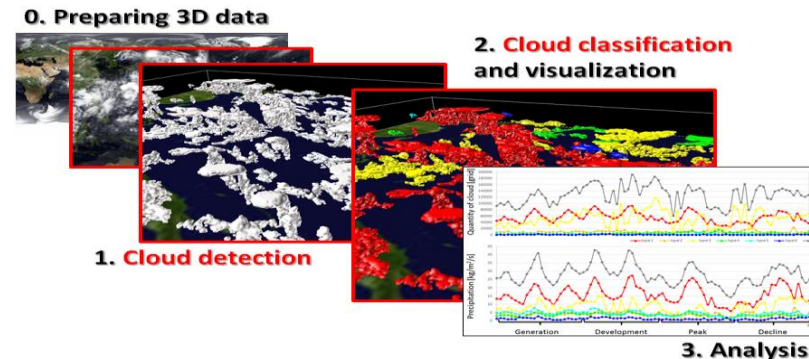
Matsuoka et al., 2015

## 4. Feature tracking



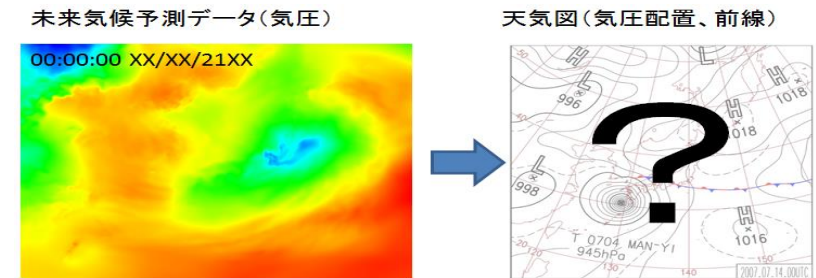
Matsuoka et al., 2016

## 5. Feature classification

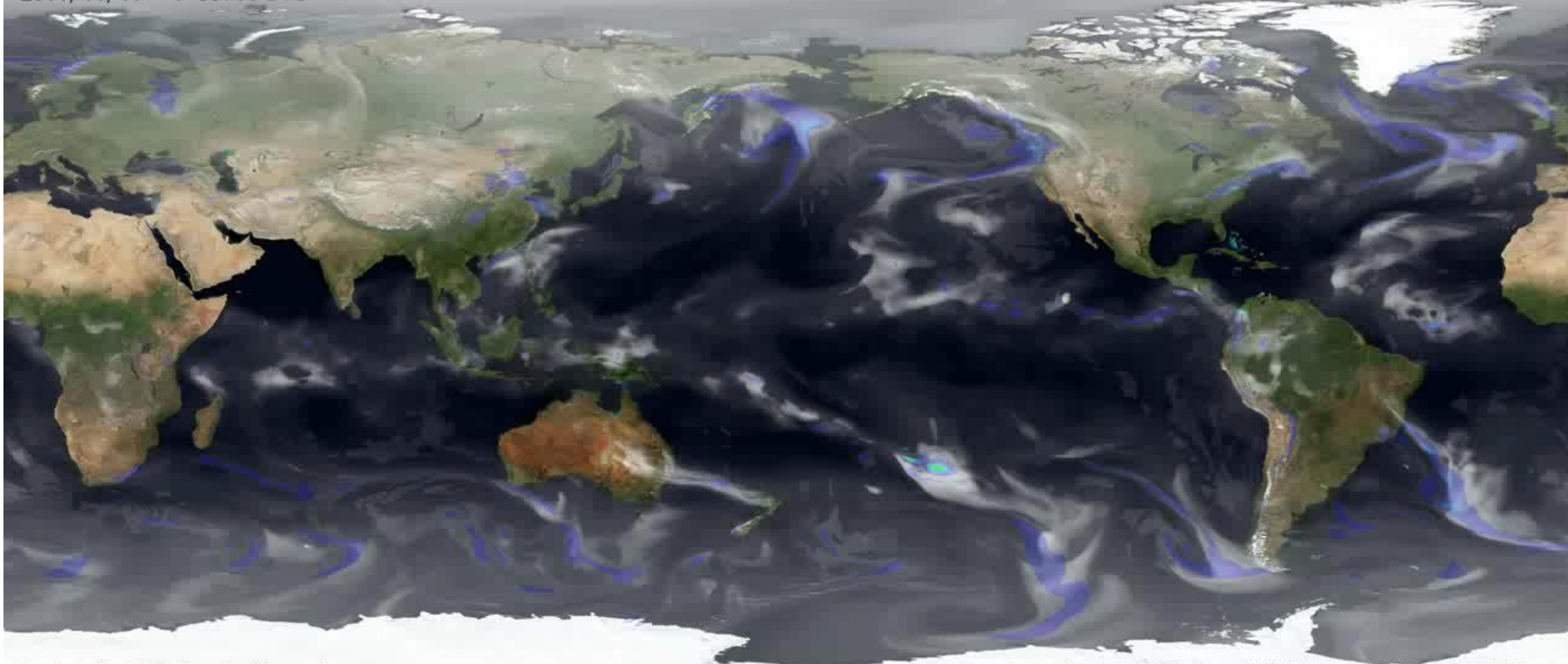


Matsuoka et al., 2016

## 6. Machine learning

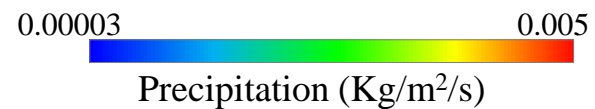


2011/11/17 1:00:00 UTC



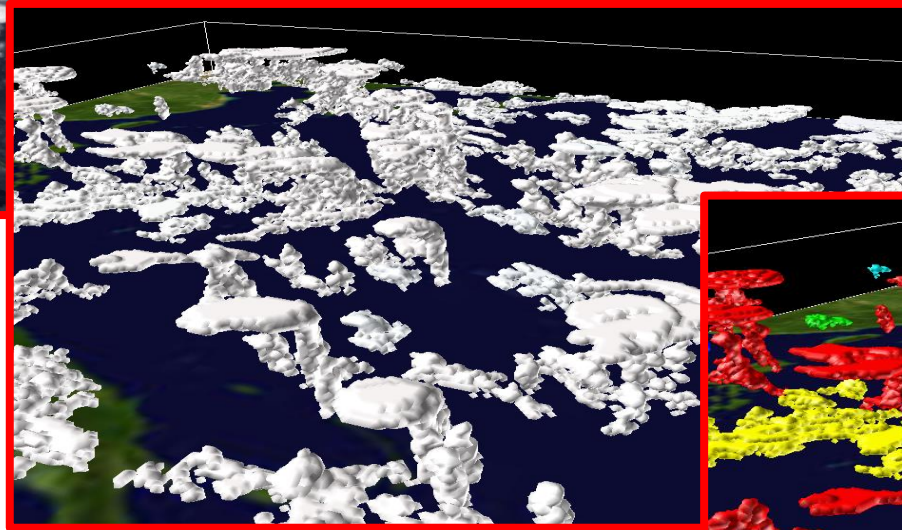
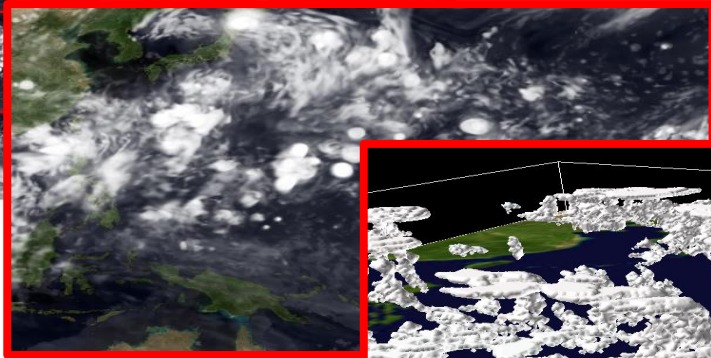
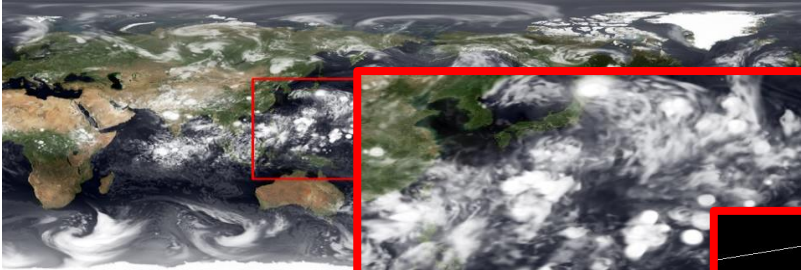
Simulated by NICAM on the K computer  
SPIRE Field 3 (hp120313)

Operated by Dr. Tomoki Miyakawa (DCOP, JAMSTEC) and NICAM Team  
Visualized by Dr. Daisuke Matsuoka (CEIST, JAMSTEC)

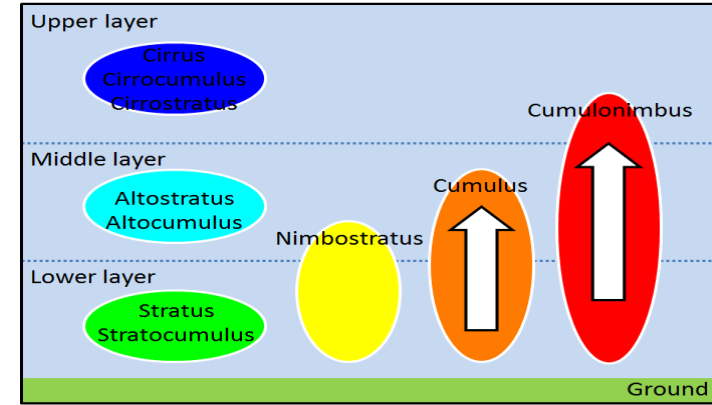


# 3D cloud classification and visualization

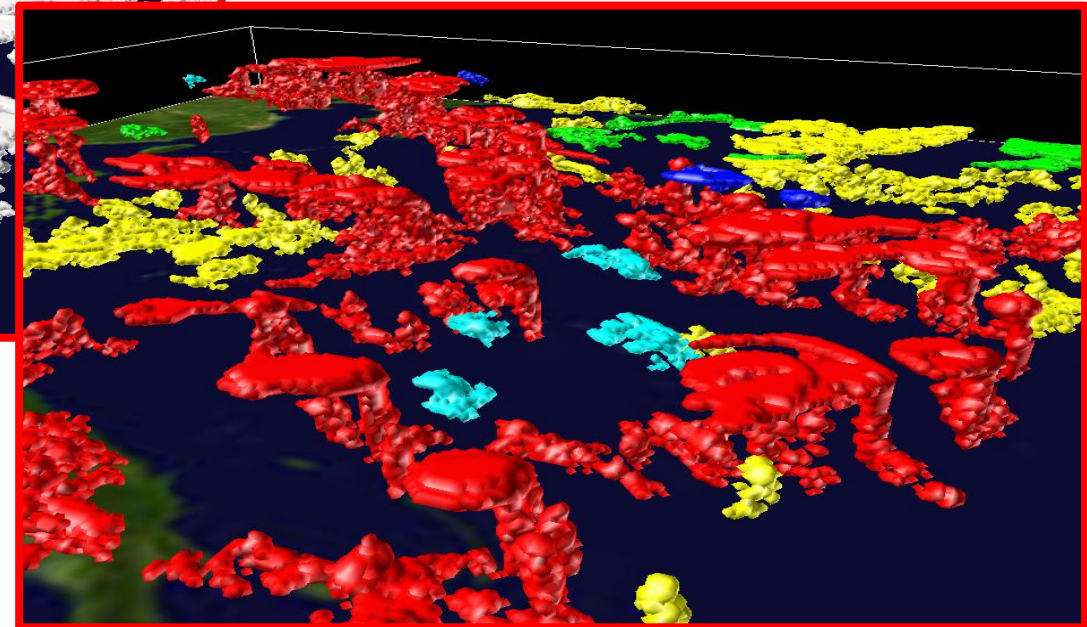
## 1. Preparing data



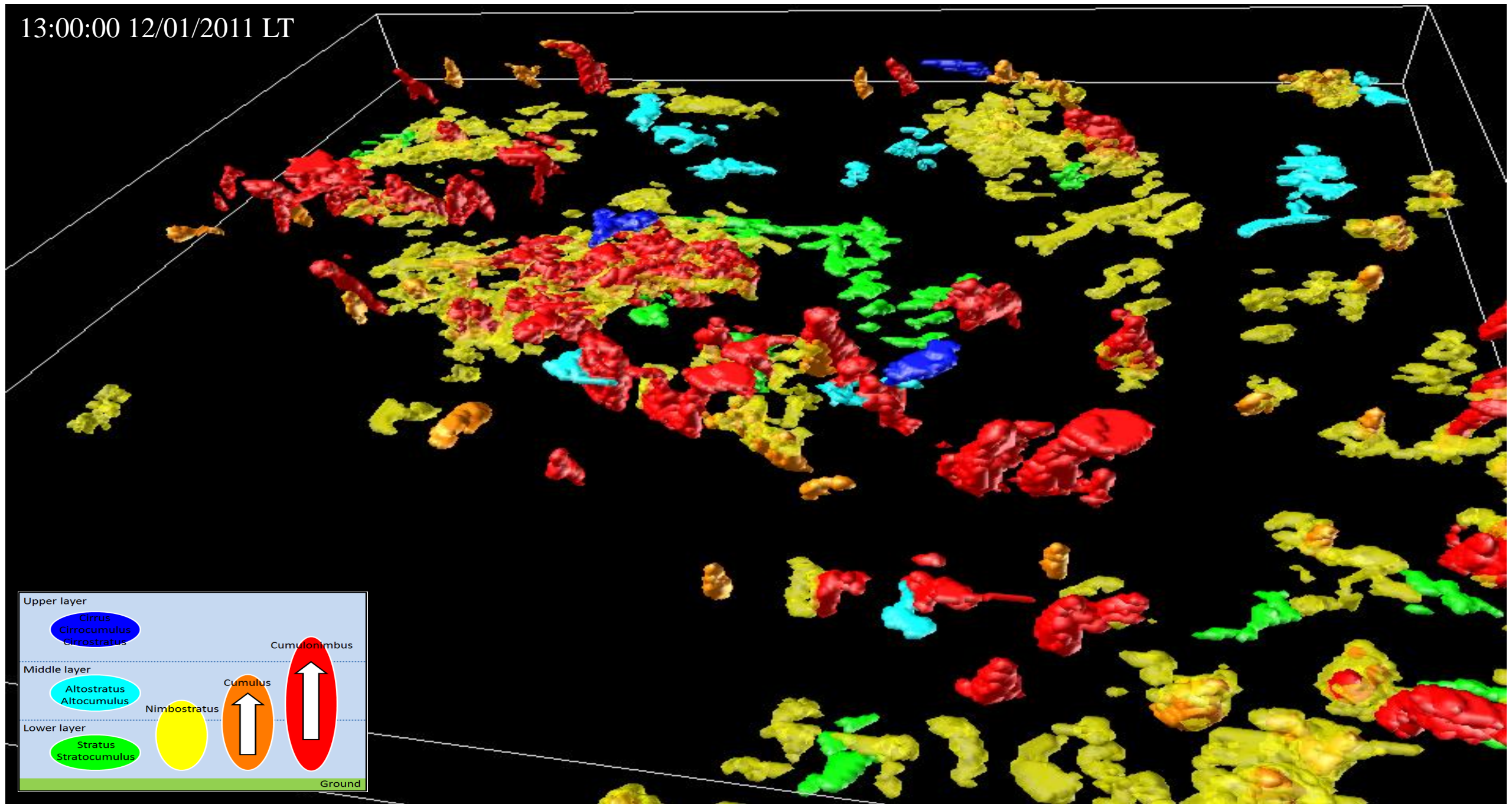
## 2. Cloud detection



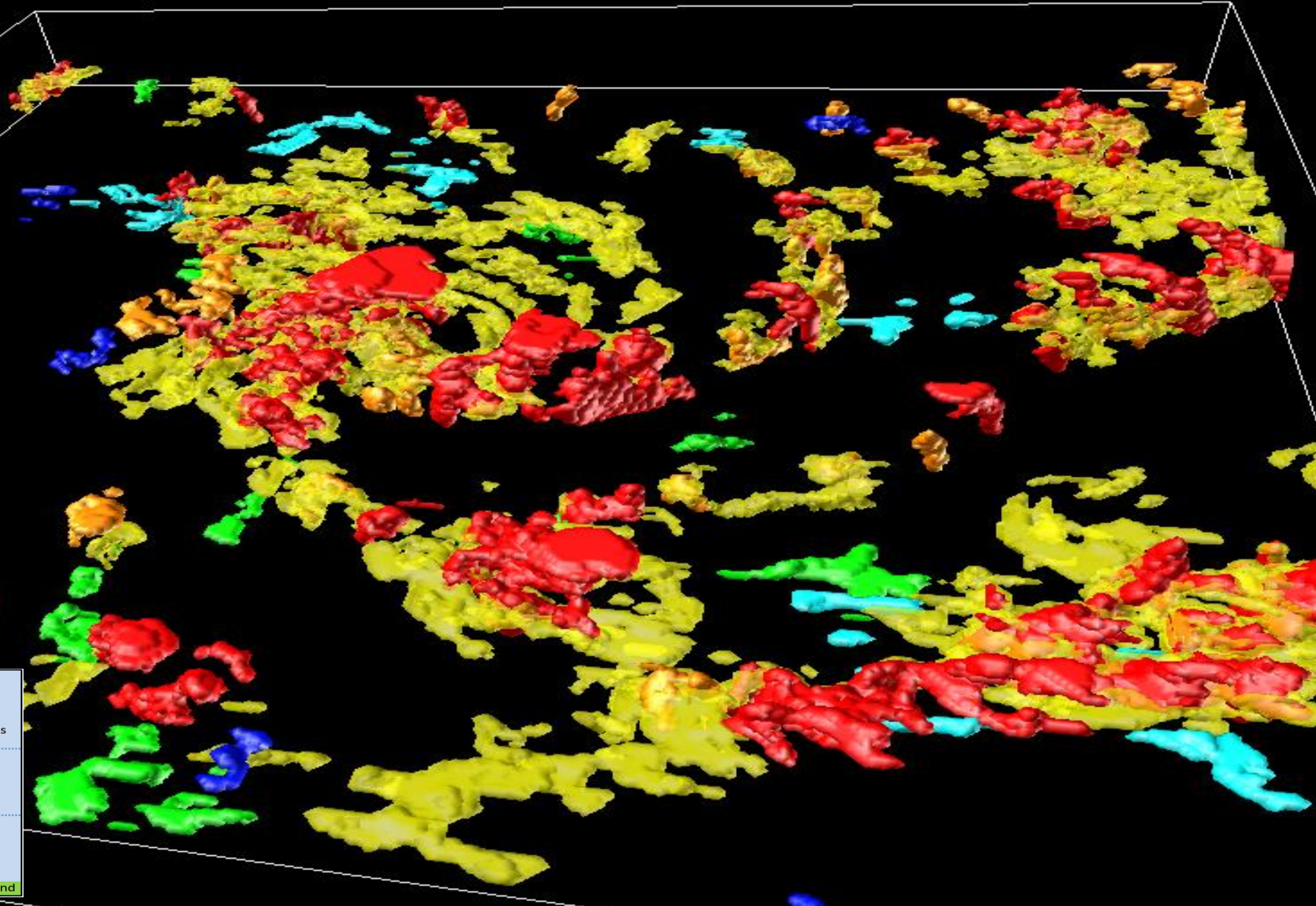
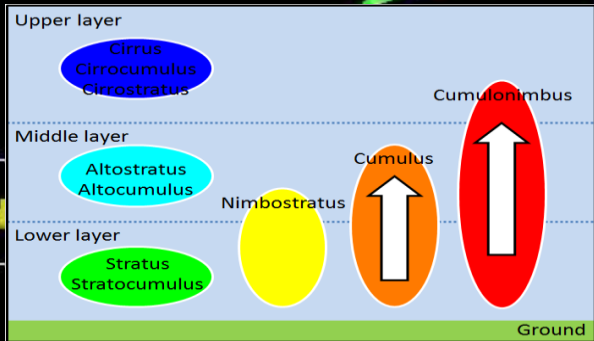
## 3. Classification and visualization



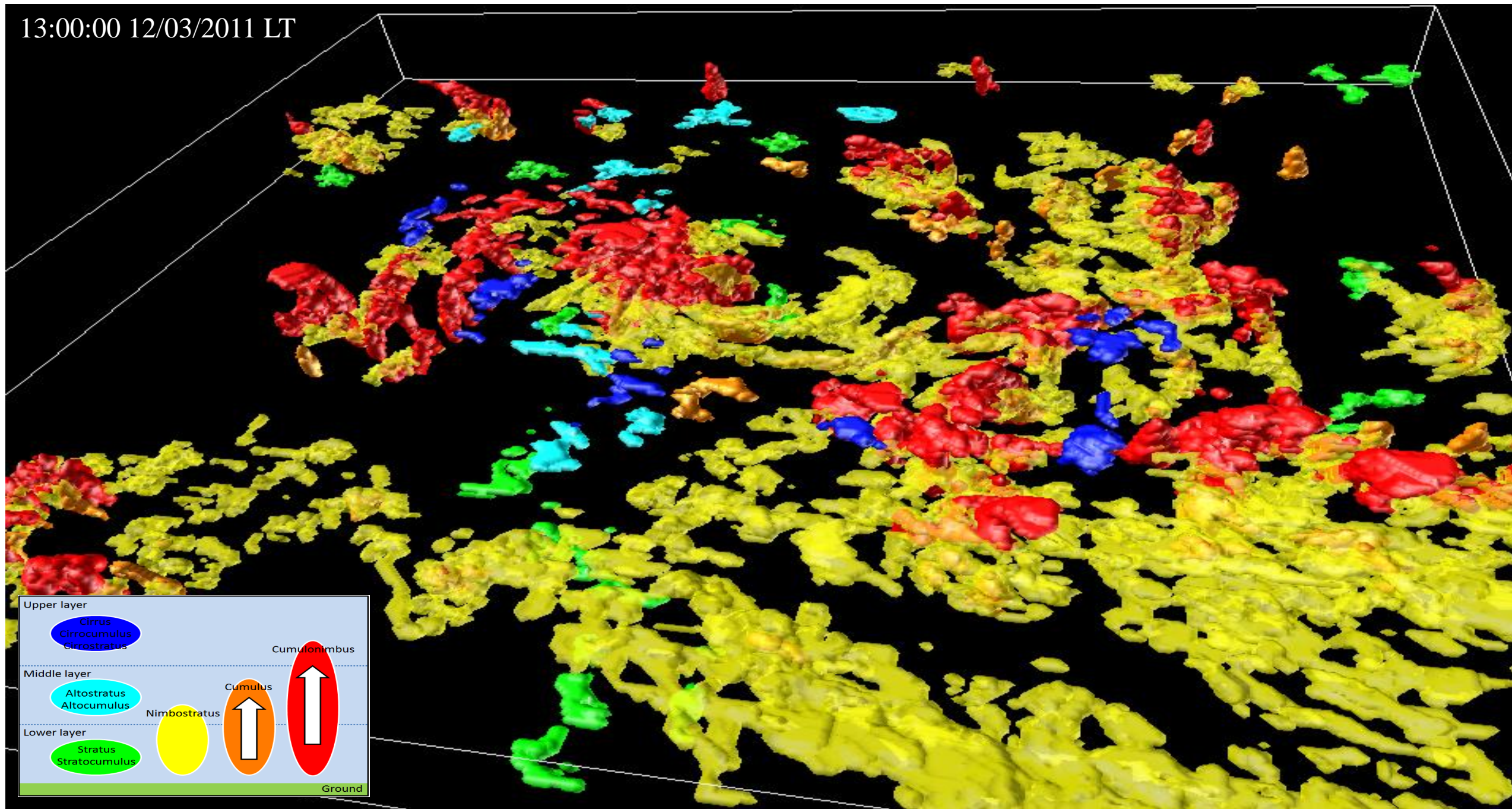
13:00:00 12/01/2011 LT



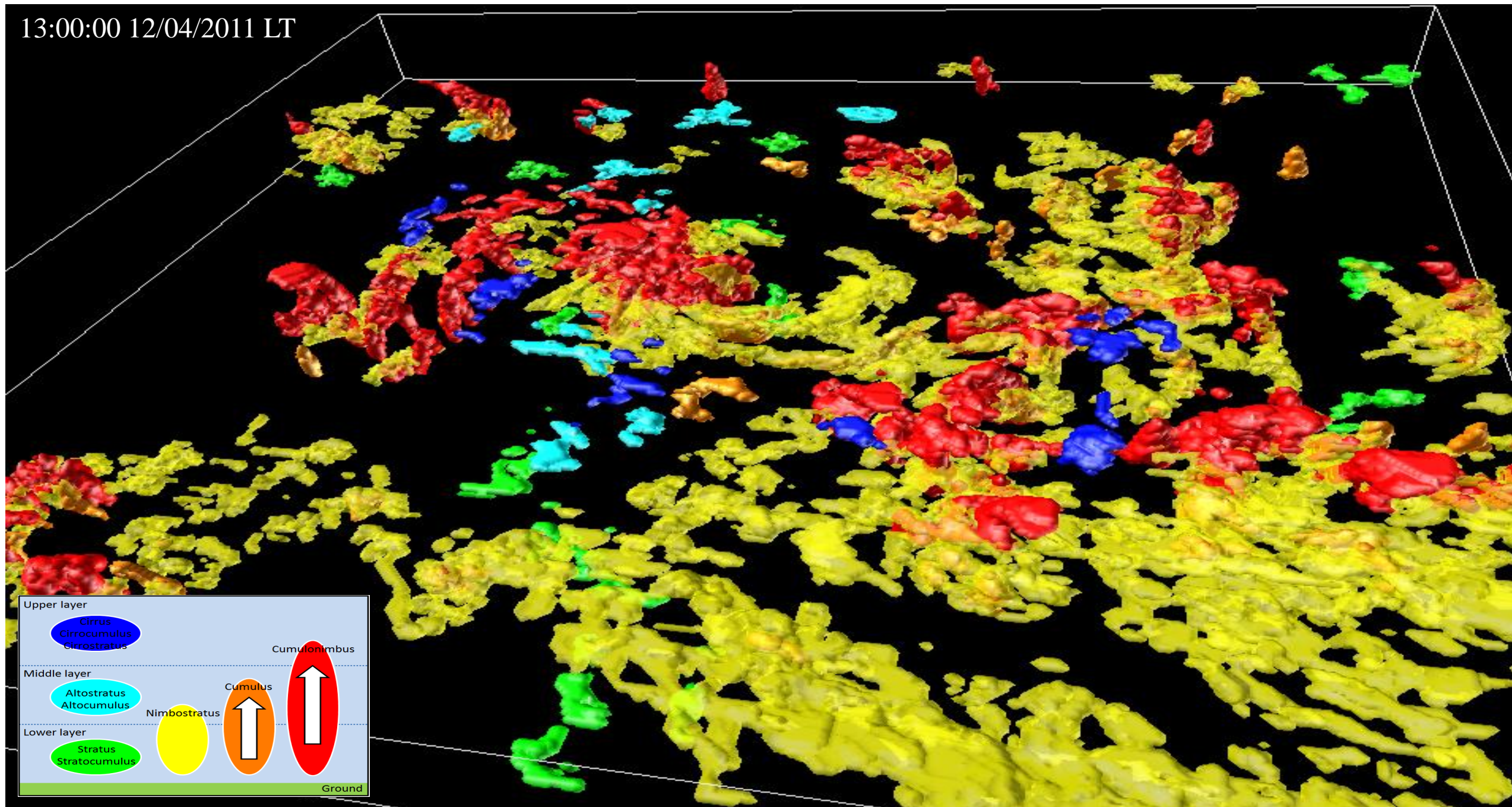
13:00:00 12/02/2011 LT



13:00:00 12/03/2011 LT

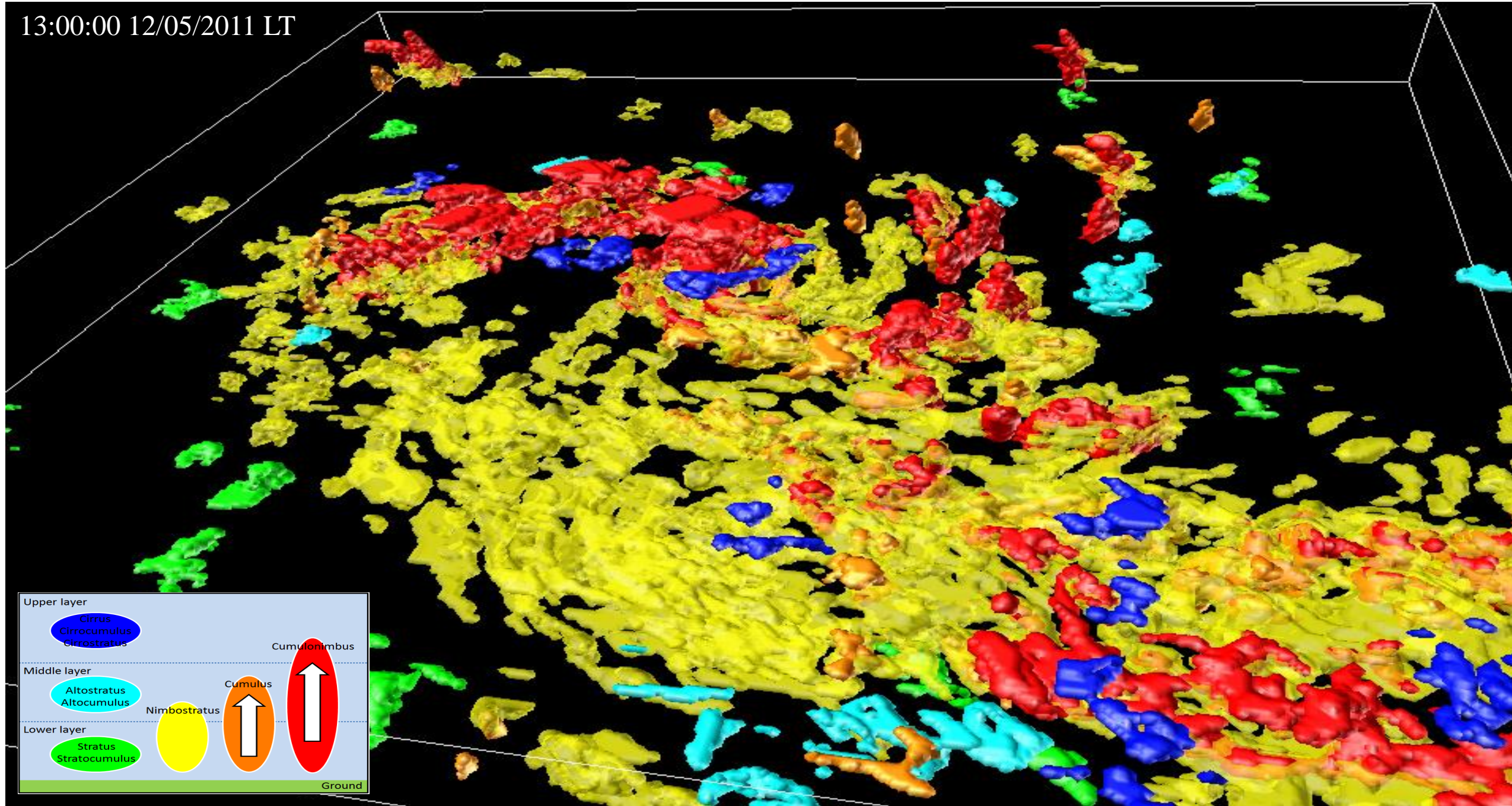


13:00:00 12/04/2011 LT

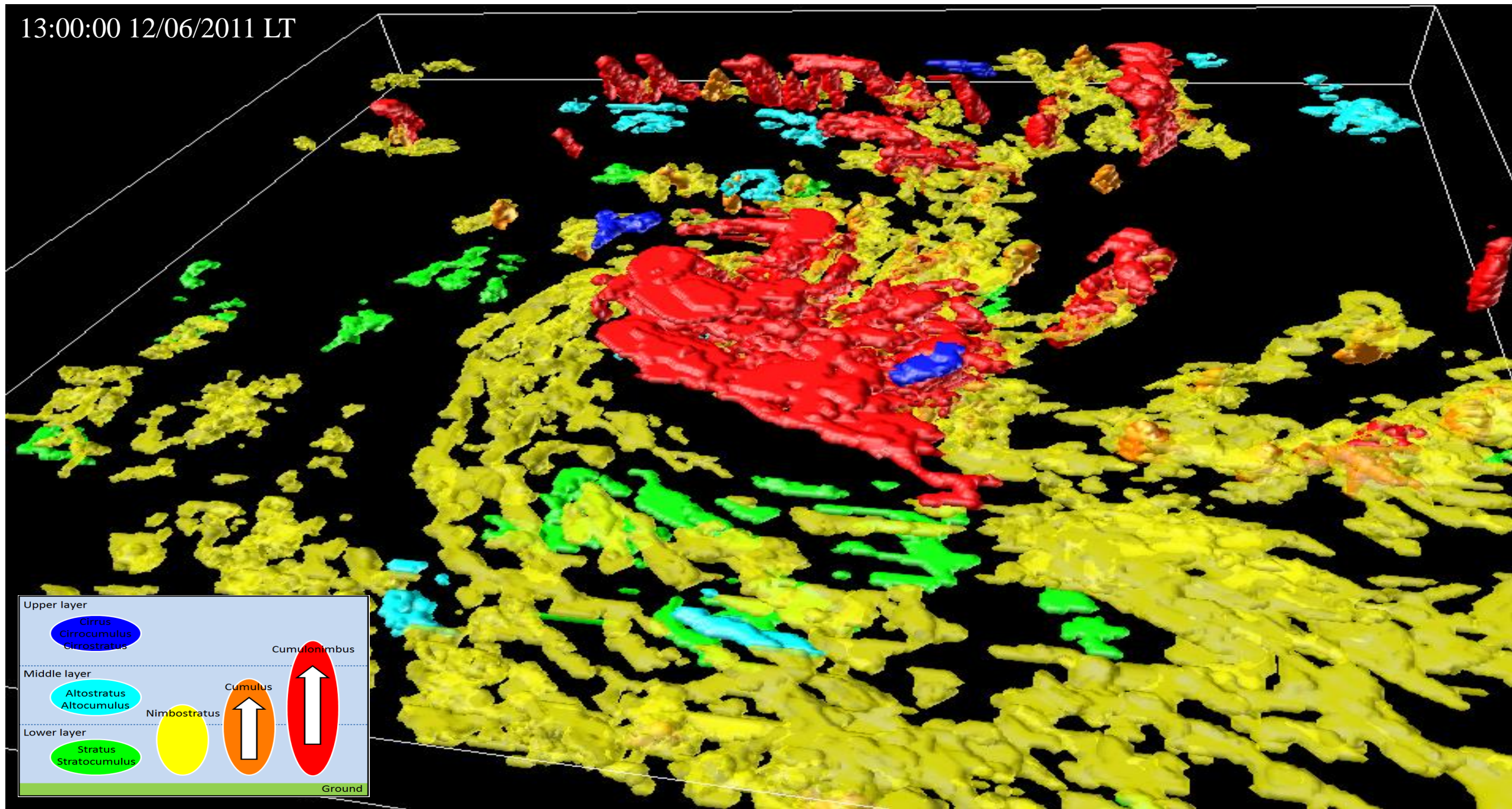




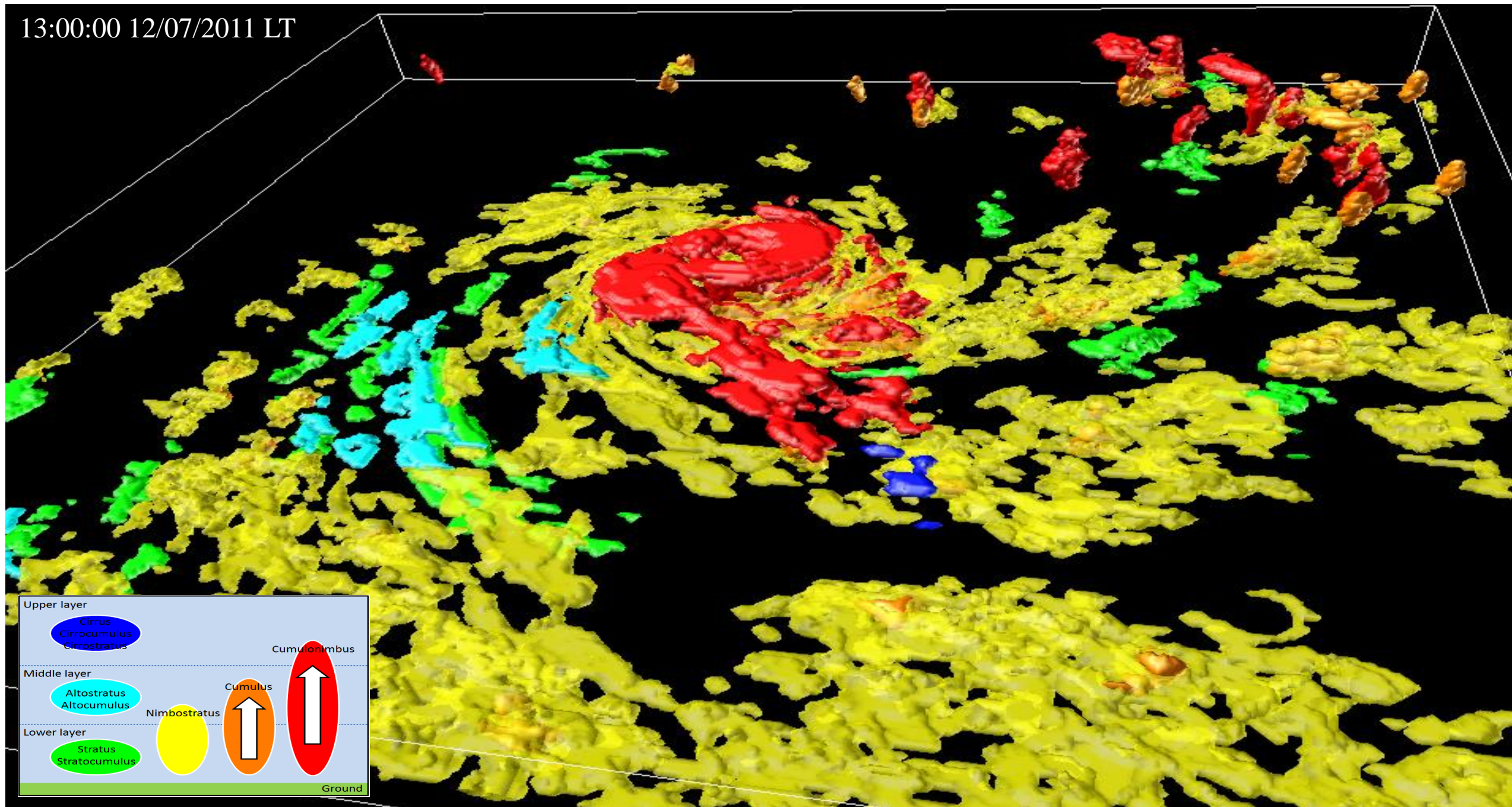
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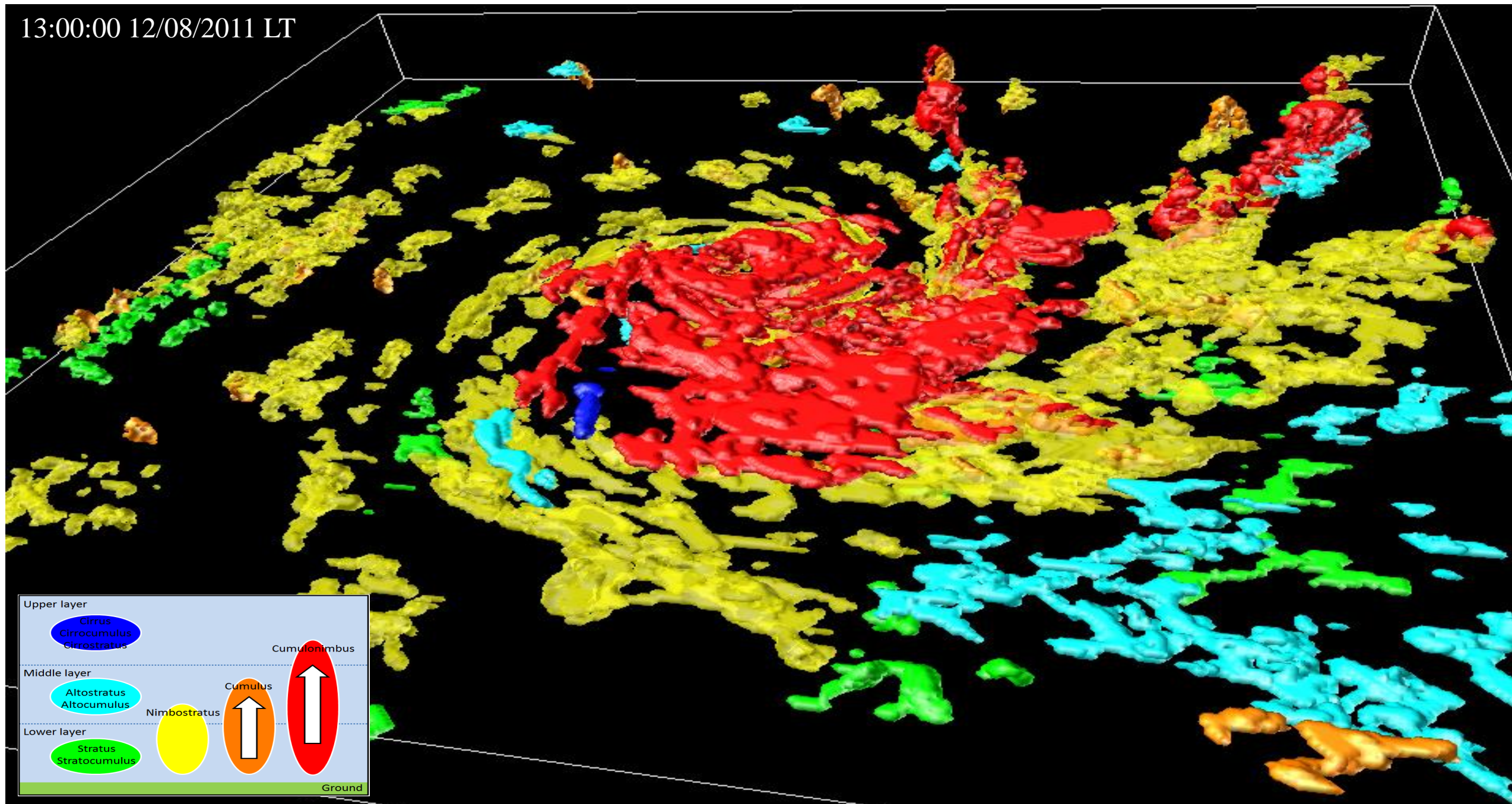
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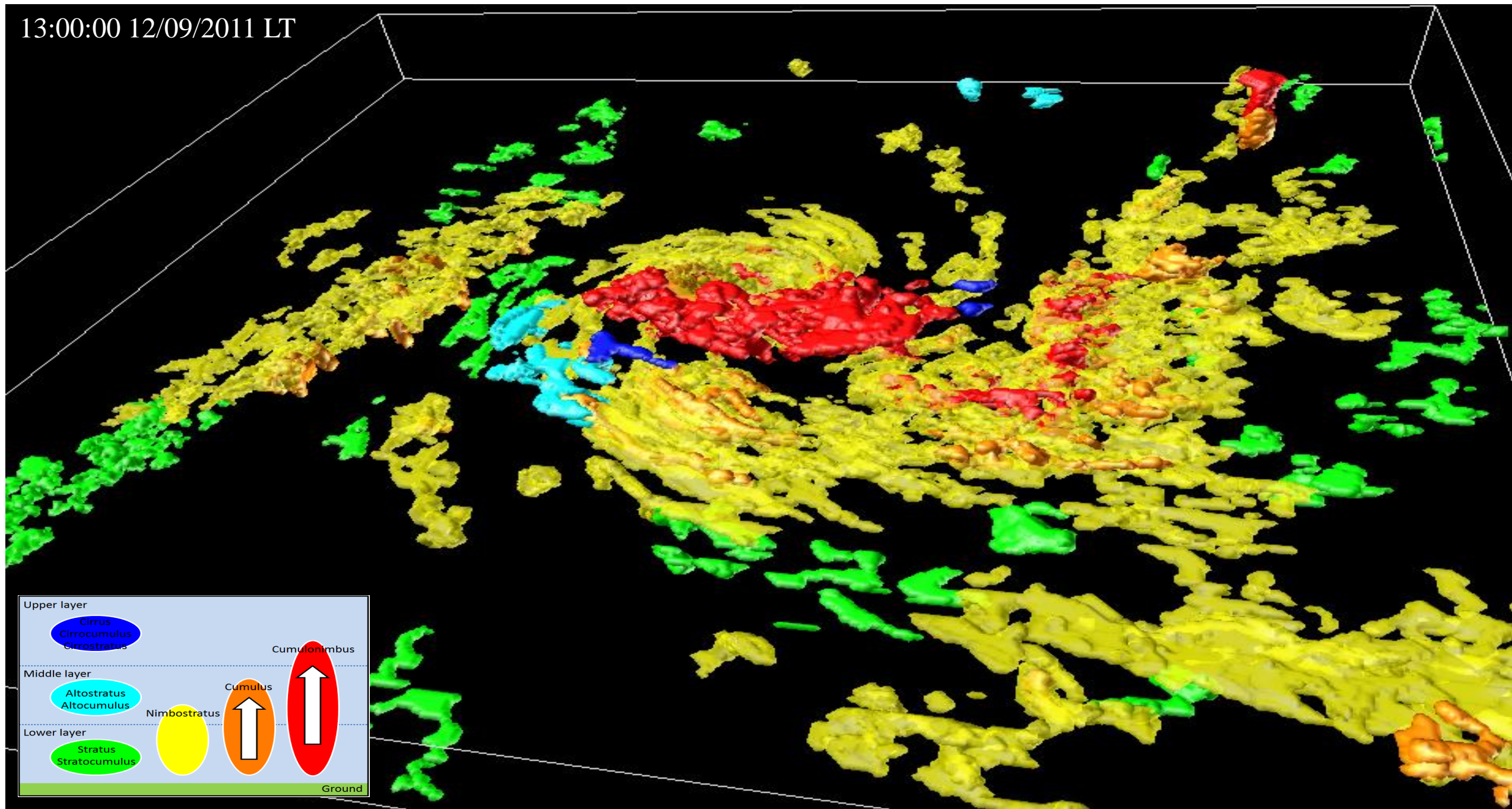
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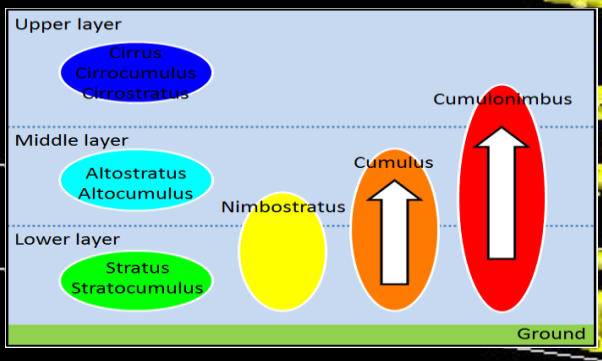
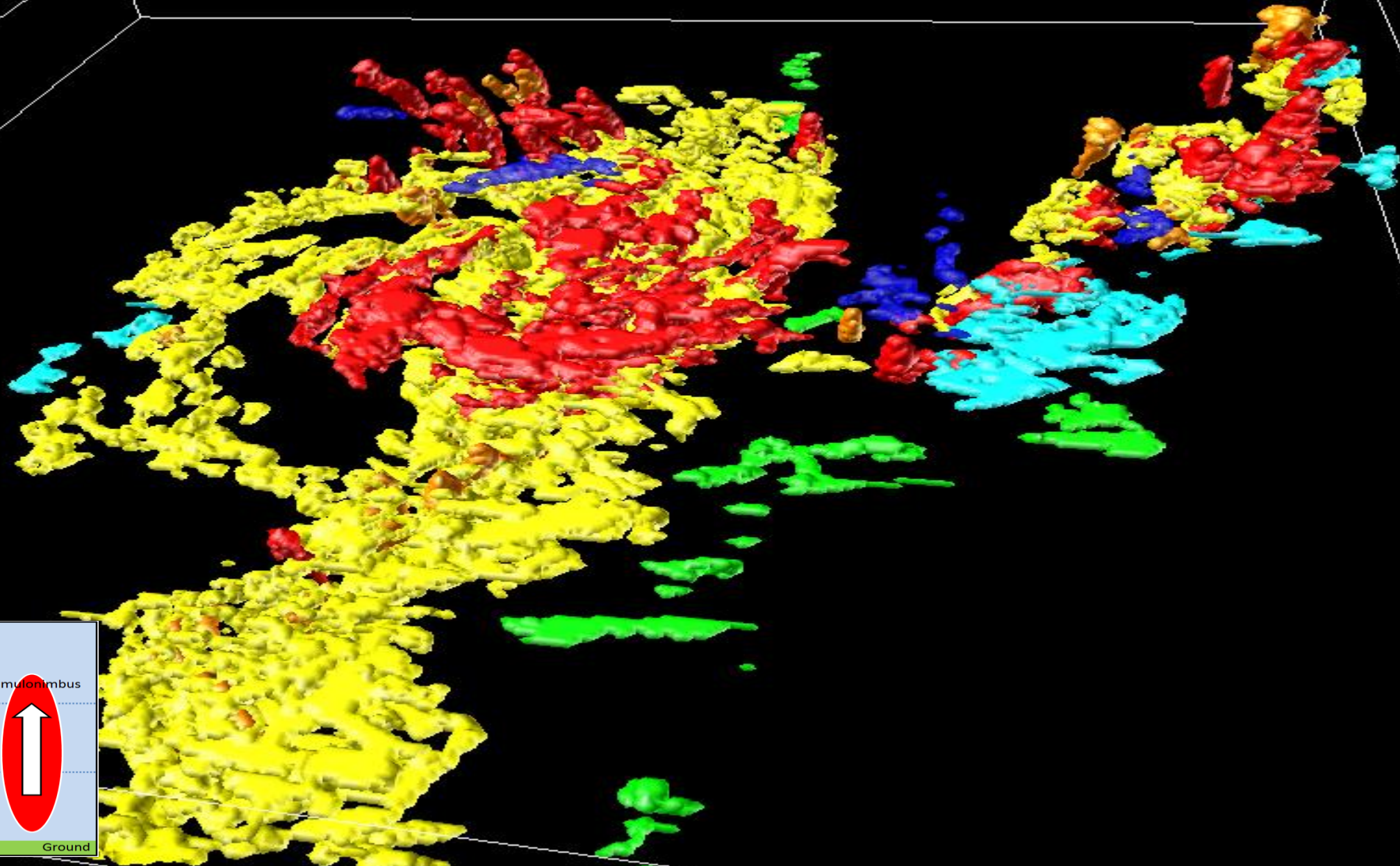
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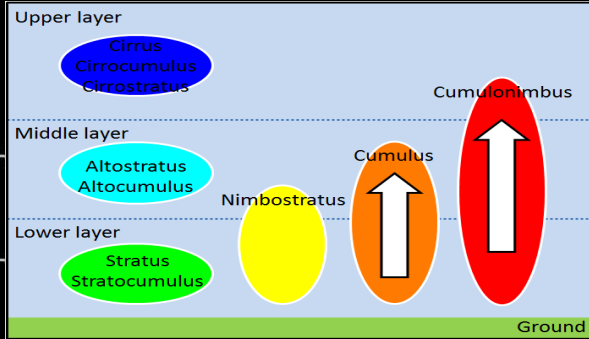
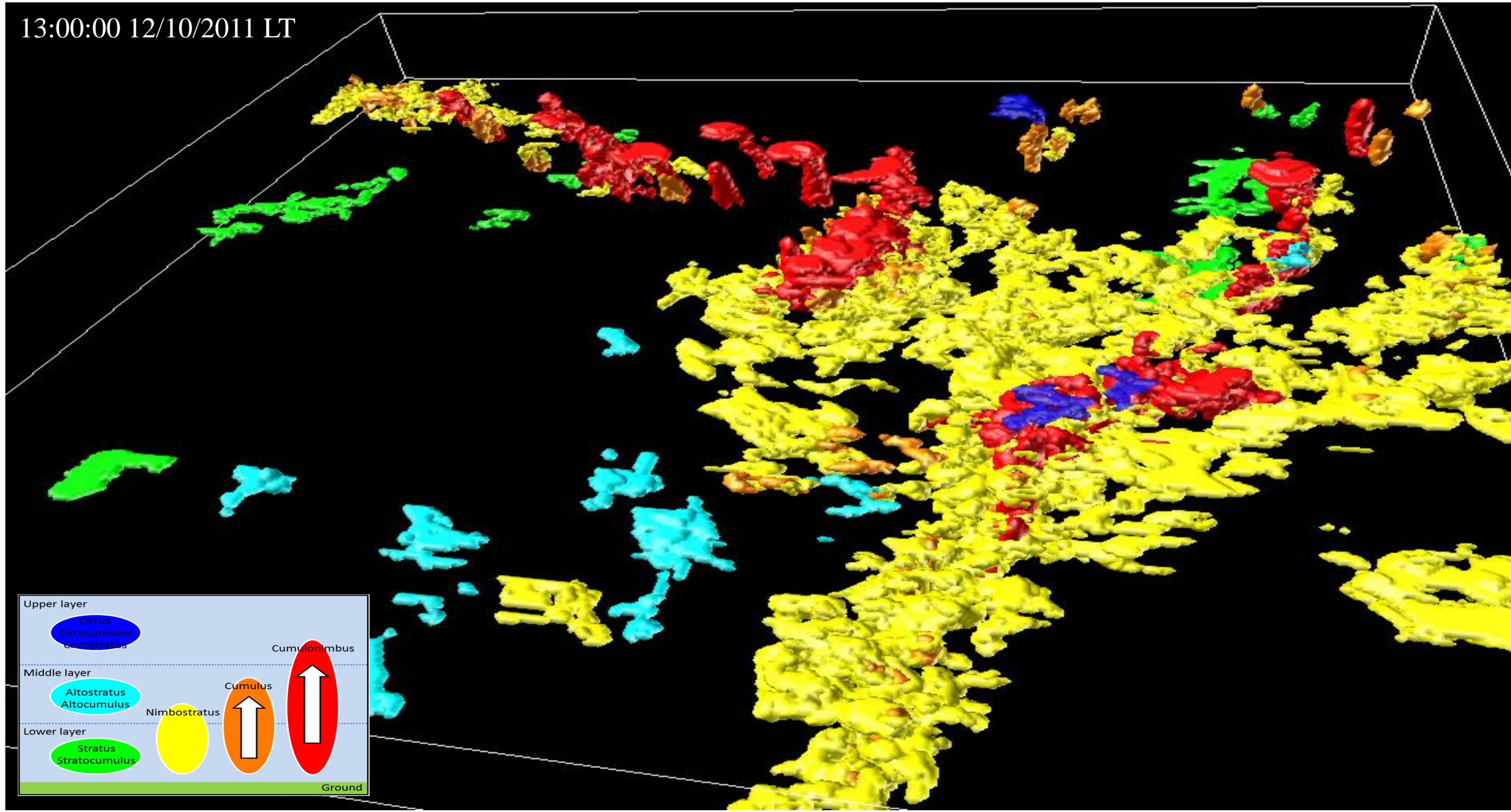
13:00:00 12/09/2011 LT



13:00:00 12/10/2011 LT



13:00:00 12/10/2011 LT

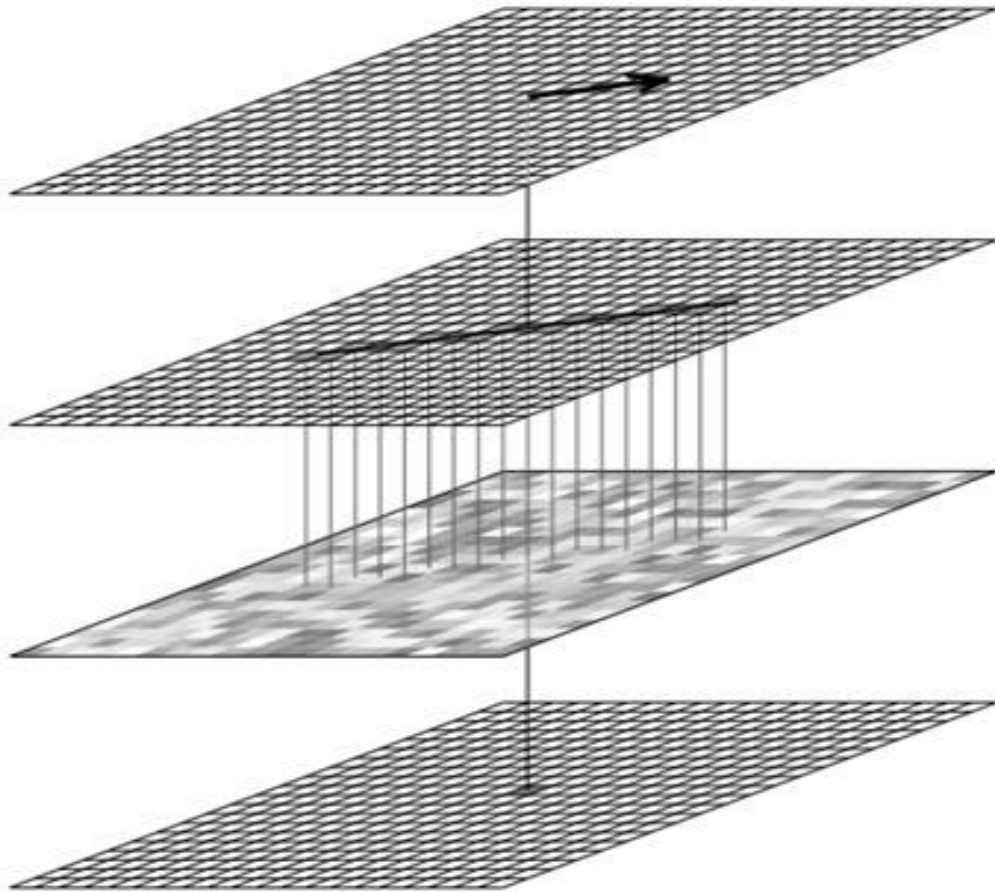


# Visualization for Scientific arts and artistic science

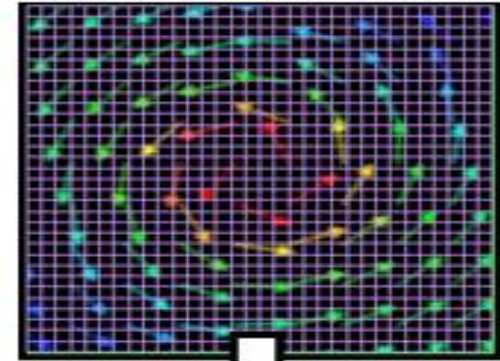


# Application of LIC

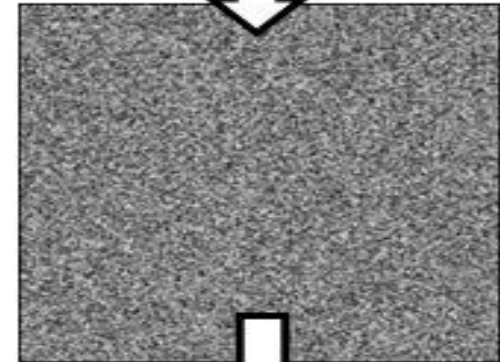
Line Integral Convolution (Cabral, 1993)



Vector field

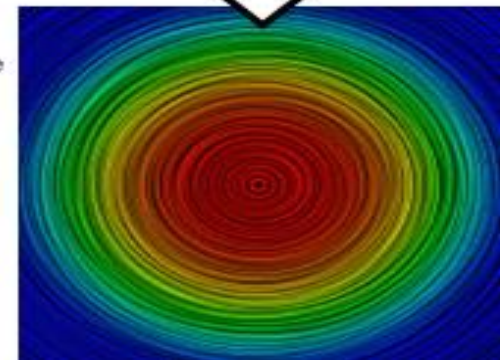


DDA line

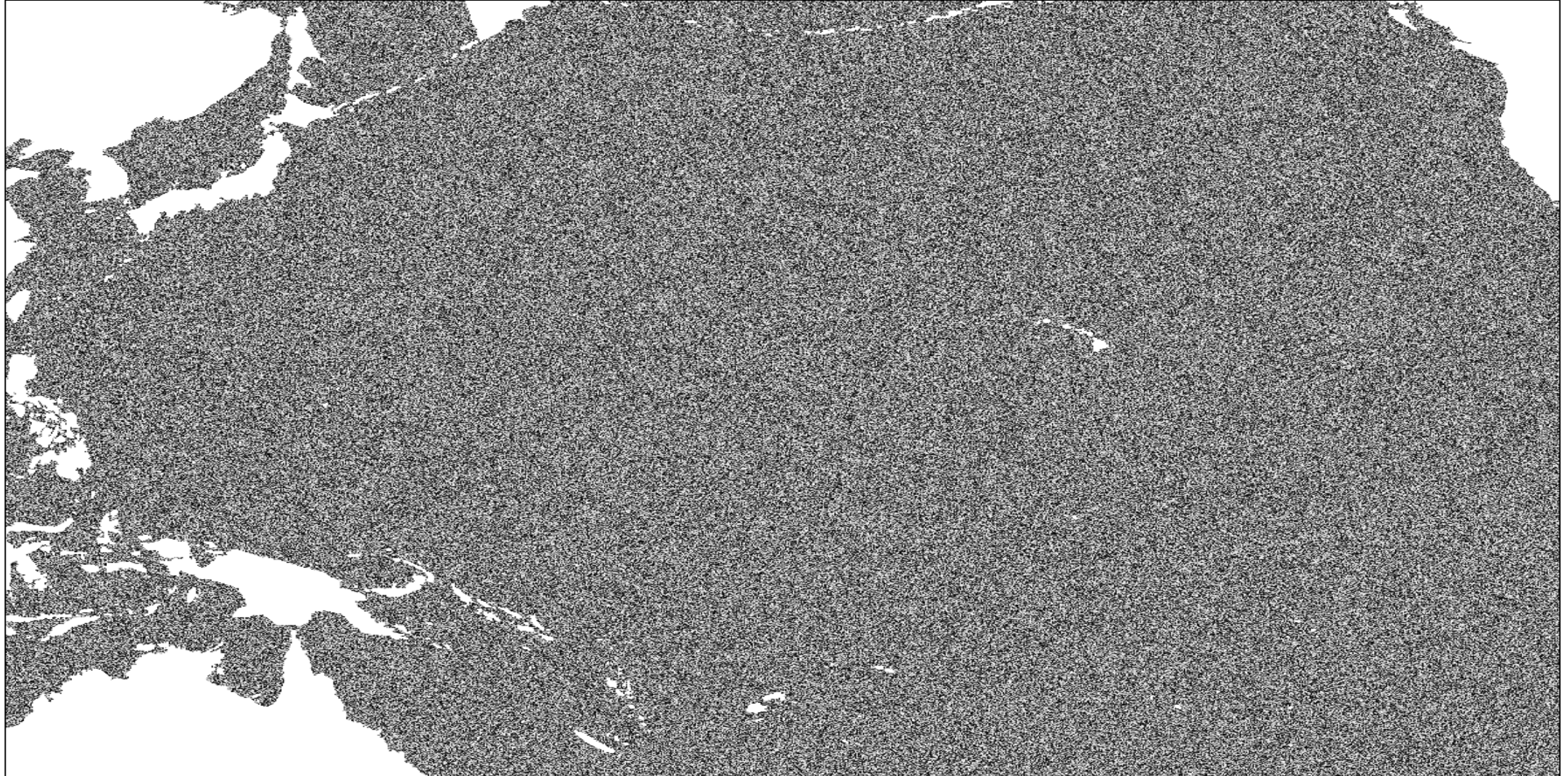


Input texture

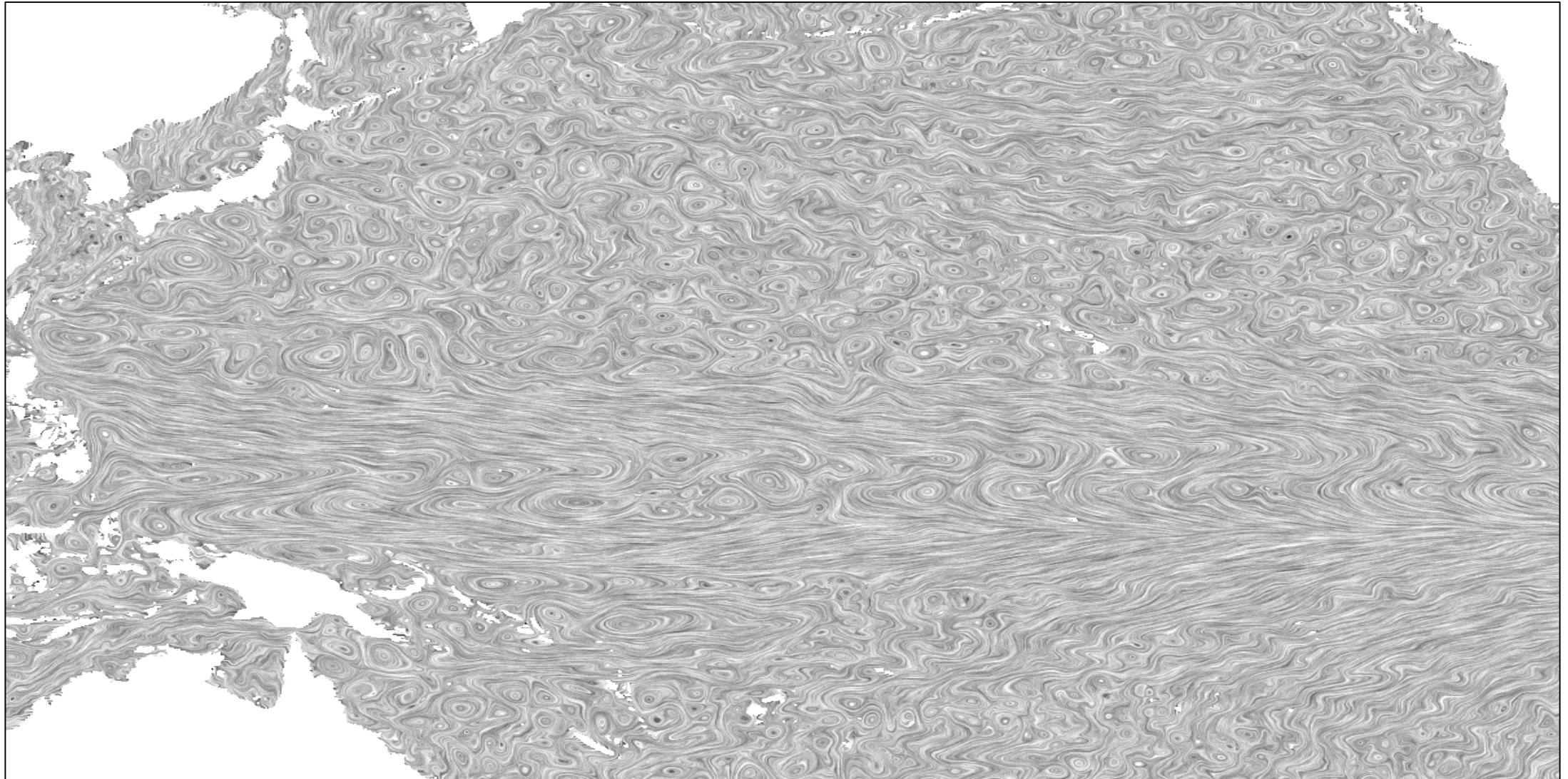
Output image



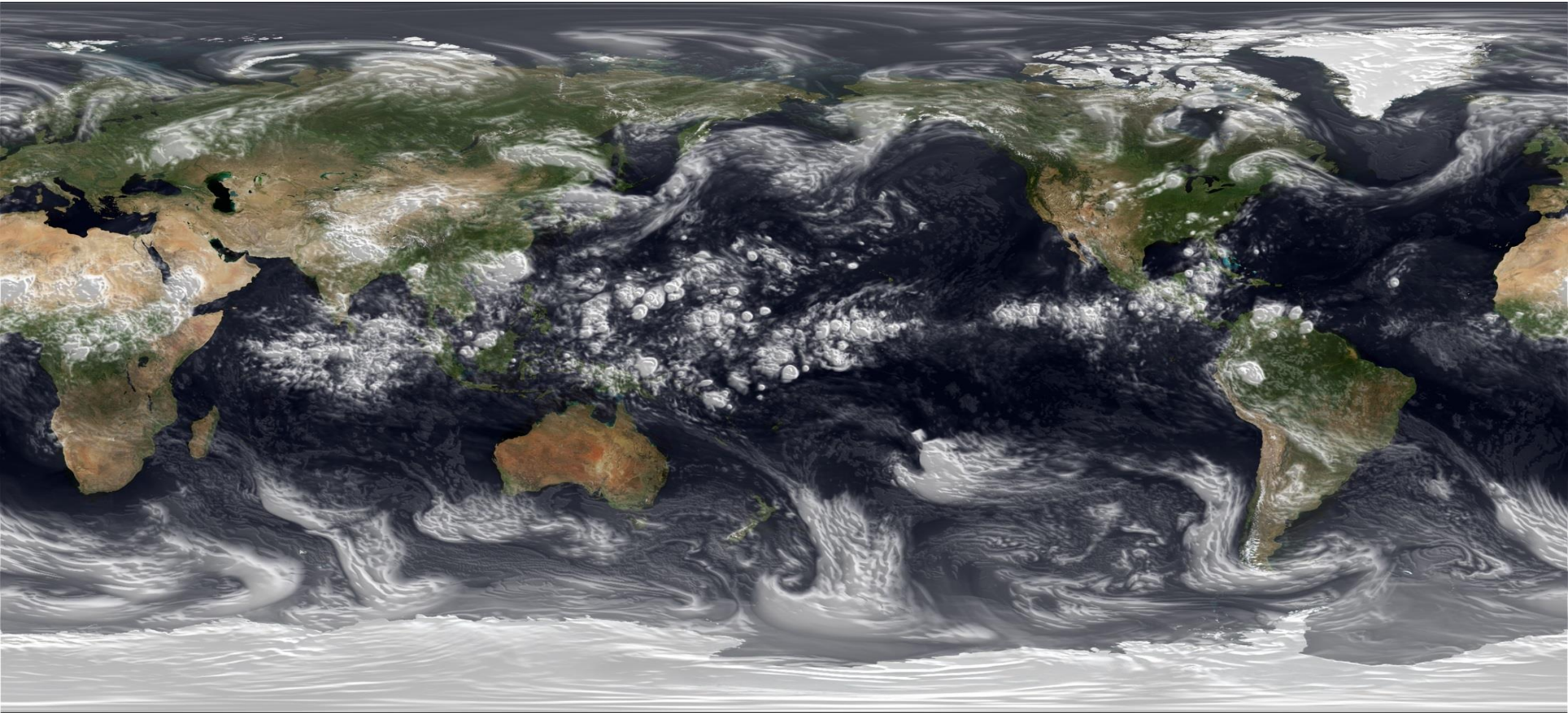
# Application of LIC



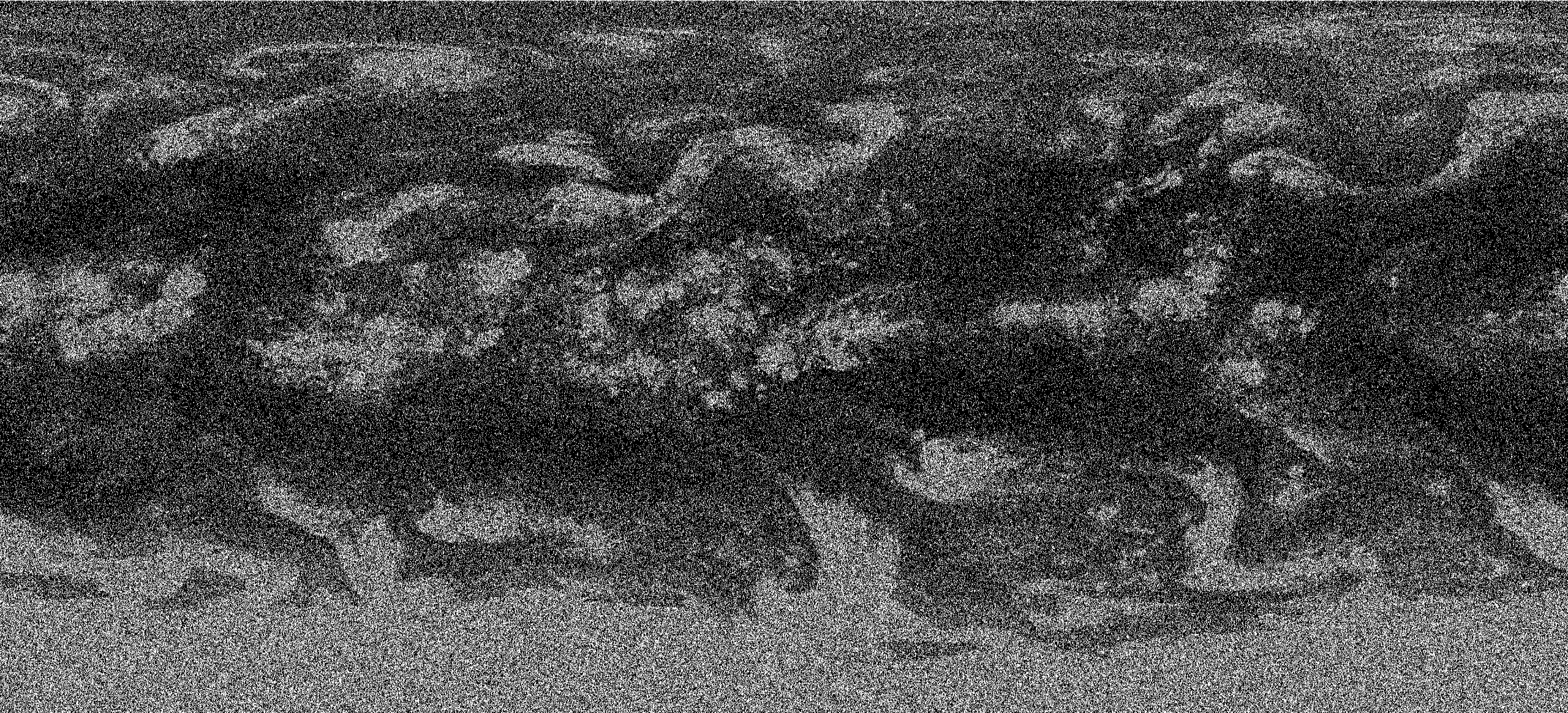
# Application of LIC

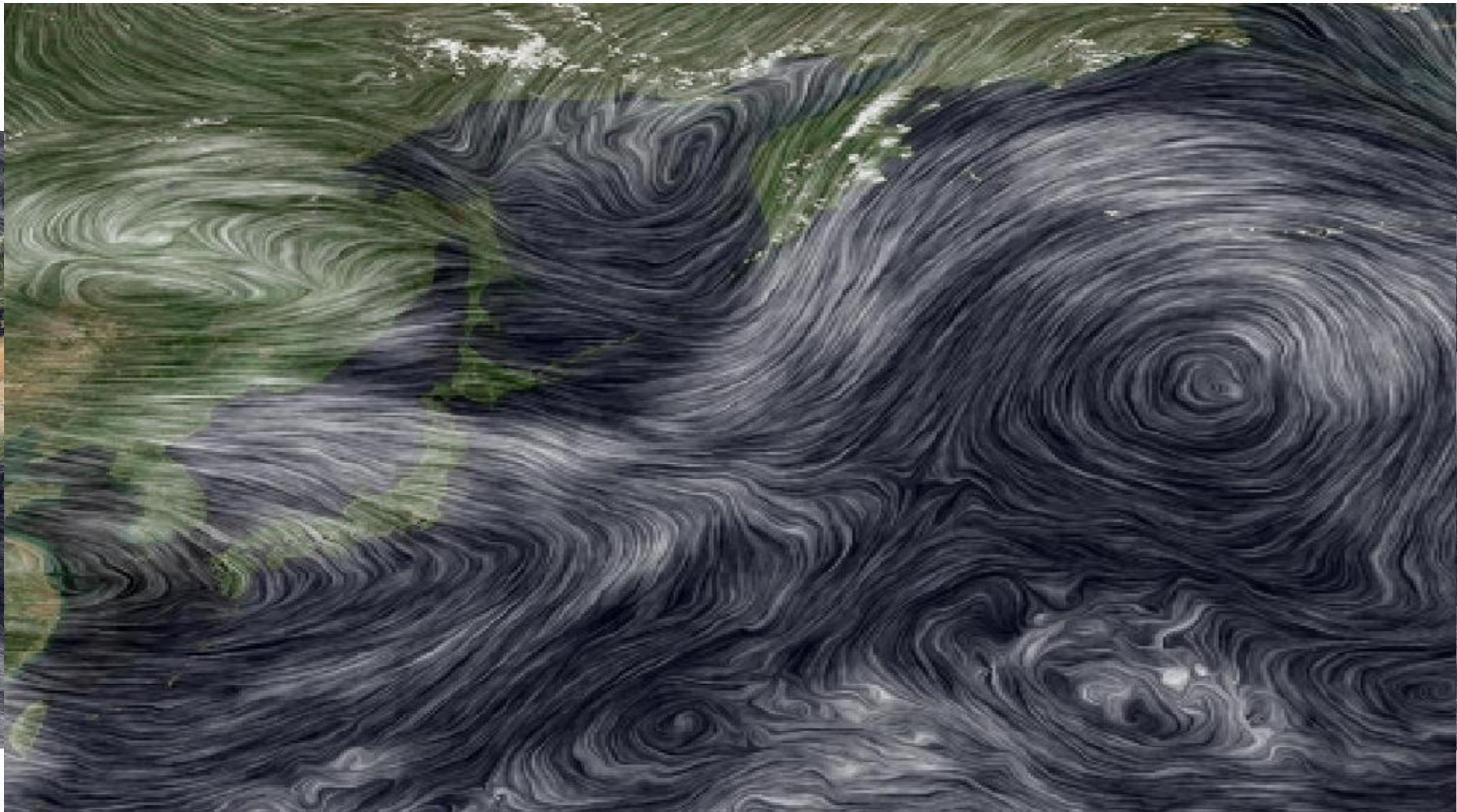


# Multivariate LIC



# Multivariate LIC





The painting 'The Starry Night' by Vincent van Gogh, depicting a night scene with a turbulent, swirling blue sky filled with bright yellow stars and a large, glowing moon. In the foreground, a dark, jagged cypress tree stands on the left, and a small village with a prominent white church spire is visible in the distance. The overall style is characterized by visible, expressive brushstrokes and a rich, textured color palette.

La nuit étoilée  
(The starry night, 星月夜)

Vincent Willem van Gogh, 1889

# Visualization in Virtual Reality System



# Visualization in CAVE

BRAVE: Booth for Research Virtual Environment



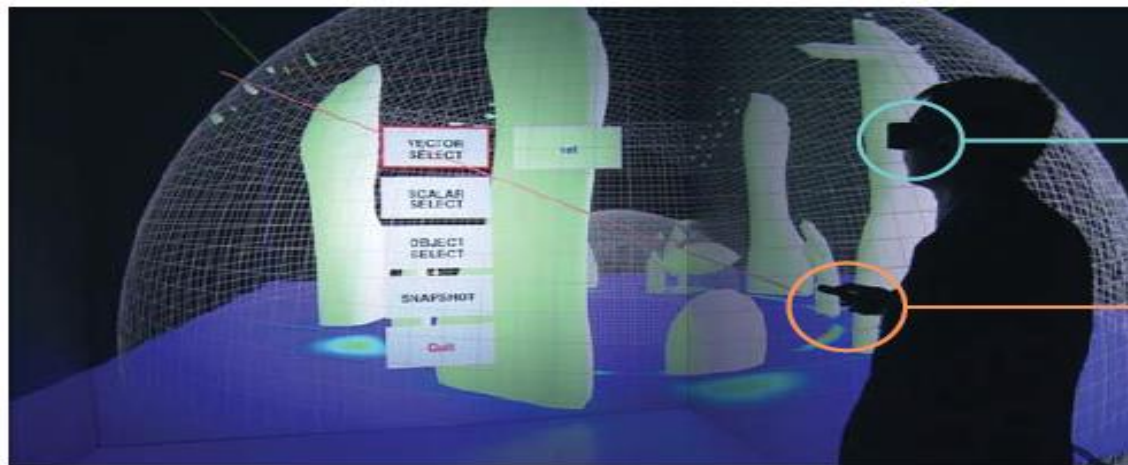
Overview



4 Screen (3x3m)



Asterism Ultra Model  
CPU: AMD Opteron 8224SE x8  
Memory 256GB, HDD: 8 TB  
NVIDIA Quadro PLEX 1000x2



Controller



Shuttering glass

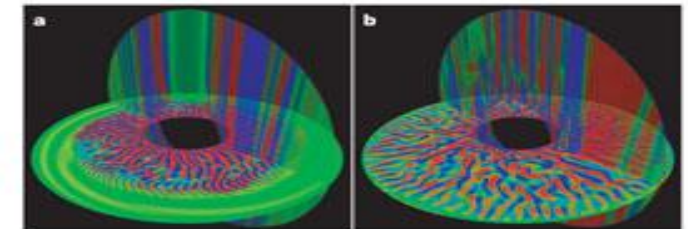
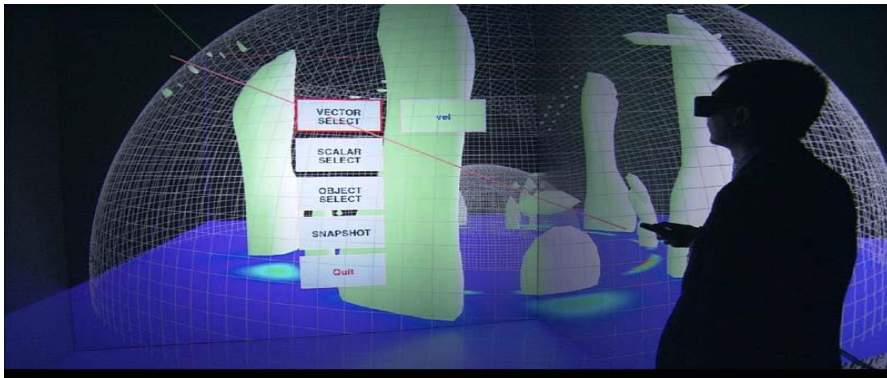
# Visualization in CAVE

VFIVE: Virtual Reality Visualization Software for CAVE Systems

- Streamlines, particle tracer, arrow glyph, isosurface, volume rendering, etc.
- OpenGL, VTK, CAVELib

Kageyama et al., 2000; Ohno et al., 2006

Application to geo-dynamo simulation data



**Figure 1 |** Equatorial and meridional cross-sections of the axial component of the vorticity,  $\omega_y$ . The Ekman number,  $E$ , is  $2.3 \times 10^{-7}$  in **a** and  $2.6 \times 10^{-6}$  in **b**. Convection plumes are evident in the equatorial cross-sections. The meridional cross-sections show that the flow is nearly two-dimensional. The convection in these low-Ekman-number regimes is organized as a set of thin plume sheets, rather than columnar cells. It can be seen that the larger Ekman number in **b** leads to thicker plume sheets.

Full text access provided to Japan Agency for Marine-Earth Science and Technology by Advanced Research and Technology Promotion

**nature** International weekly journal of science

Journal home > Archive > Letter > Full Text

Letter

Nature 454, 1106-1109 (28 August 2008) | doi:10.1038/nature07227; Received 2 May 2008; Accepted 27 June 2008

Formation of current coils in geodynamo simulations

Akira Kageyama<sup>1</sup>, Takehiro Miyagoshi<sup>2</sup> & Tetsuya Sato<sup>1</sup>

1. Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology, Yokohama, 236-0001, Japan

Correspondence to: Akira Kageyama<sup>1</sup> Correspondence and requests for materials should be addressed to A.K. (Email: kage@jamstec.go.jp).

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FULL TEXT

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Kageyama et al., 2008

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**nature** International weekly journal of science

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Letter

Nature 463, 793-796 (11 February 2010) | doi:10.1038/nature08754; Received 5 October 2009; Accepted 4 December 2009

Zonal flow formation in the Earth's core

Takehiro Miyagoshi<sup>1</sup>, Akira Kageyama<sup>2</sup> & Tetsuya Sato<sup>3</sup>

1. Japan Agency for Marine-Earth Science and Technology, Yokohama, 236-0001, Japan  
2. Graduate School of Engineering, Kobe University, Kobe 657-8501, Japan  
3. University of Hyogo, Kobe 650-0044, Japan

Correspondence to: Akira Kageyama<sup>2</sup> Correspondence and requests for materials should be addressed to A.K. (Email: kage@ce.kobe-u.ac.jp).

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FULL TEXT

• Readers' Comments

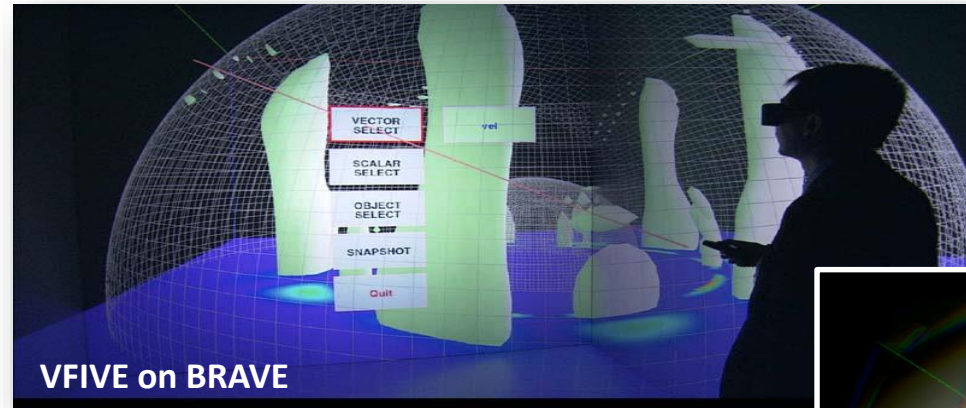
• Subscribe to comments (RSS)

• What is RSS?

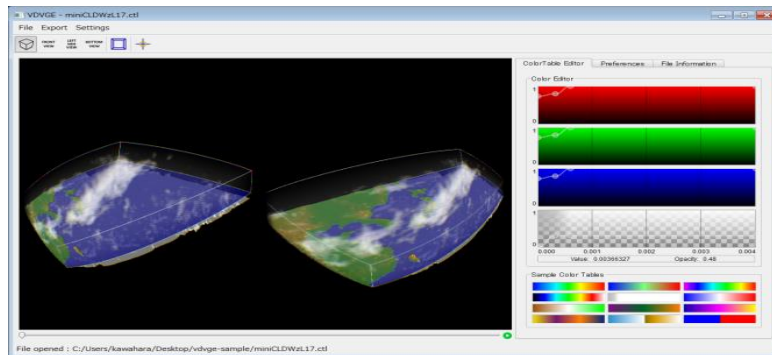
Miyagoshi et al., 2010

# Visualization in HMD system

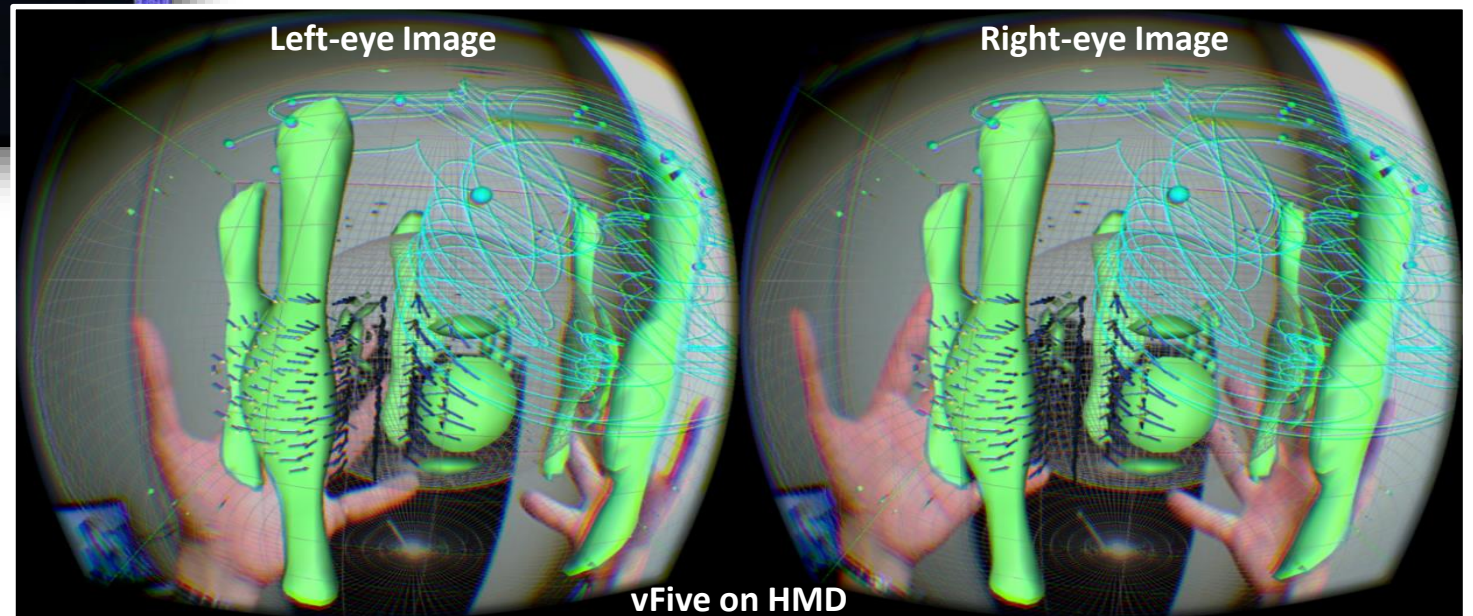
HMD: Head Mounted Display



Oculus Rift + OVRVision



Visualization software for HMD

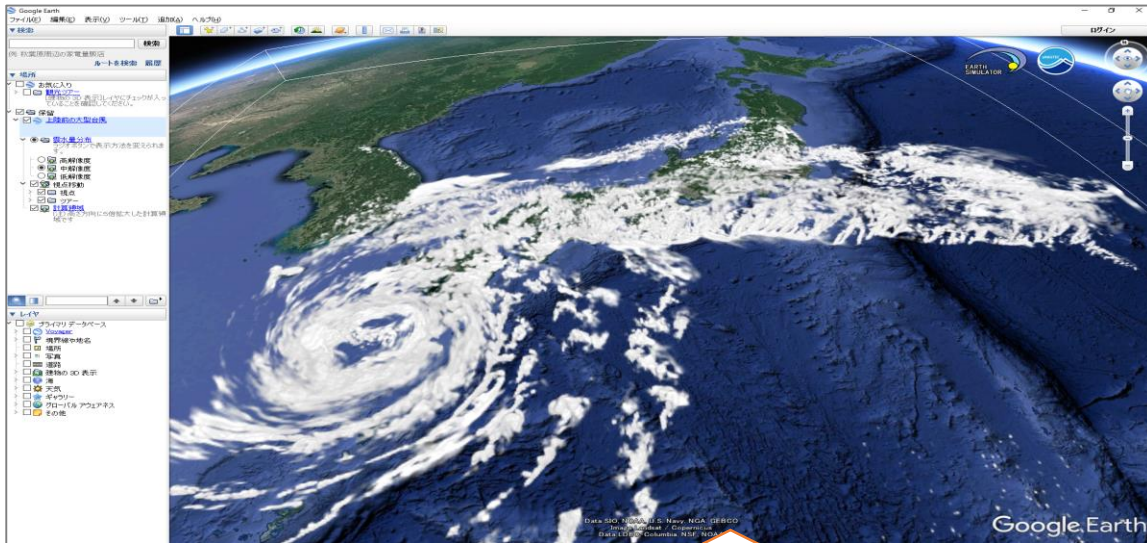


# Visualization for General Public

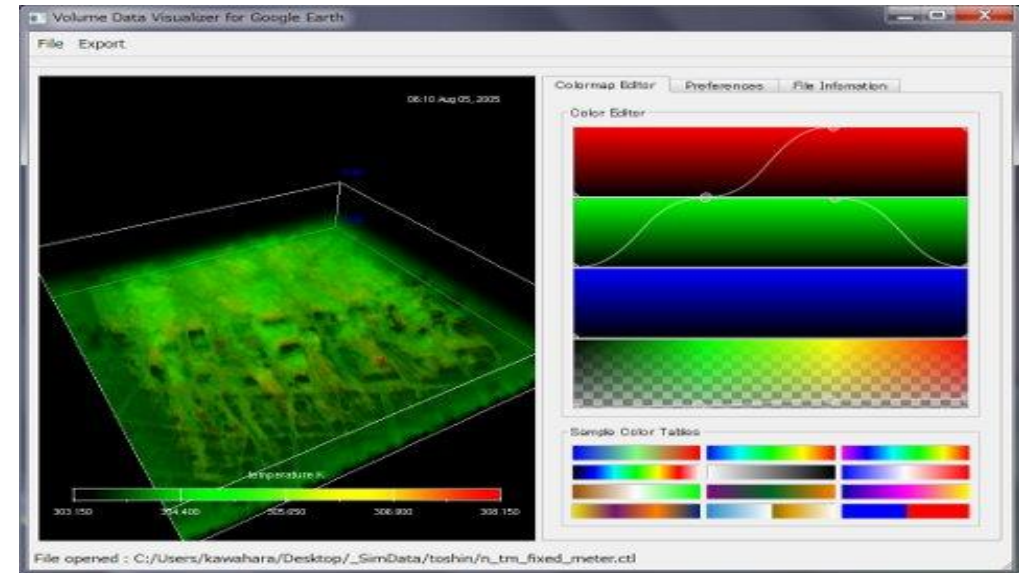
(Children, stakeholder and other non-specialist)

# Visualization in Google Earth

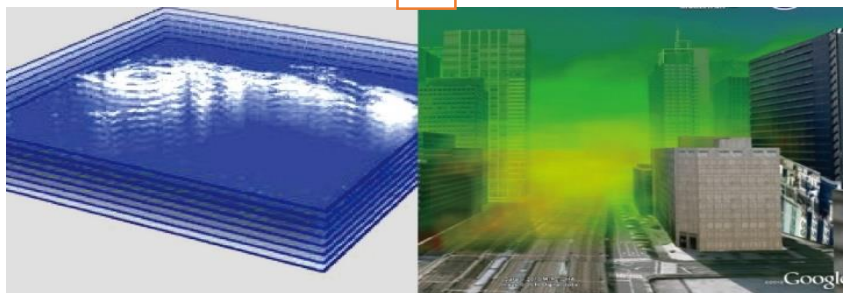
EXTRAWING:  
EXploring and TRAvelling the World INSIDE Geoscientific data



VDVGE:  
Volume Data Visualizer for Google Earth



Texture-based volume rendering using layered PNG image



Kawahara et al., 2014



# 高層ビルに囲まれたオアシス緑地の 低温化現象と樹木の効果

## Cooling Effect of Urban Green Oasis

丸の内パークビル周辺の熱環境

**Thermal environment at Marunouchi Park Building**

独立行政法人海洋研究開発機構 (JAMSTEC)

株式会社 三菱地所設計 (Mitsubishi Jisho Sekkei Inc.)

株式会社 竹中工務店 (Takenaka Corporation)

Visualization by Shintaro Kawahara and Fumiaki Araki (JAMSTEC)

# JAMSTEC Open Day Events

**5/21** **JAMSTEC** 国立研究開発法人 海洋研究開発機構

## 施設一般公開

入場無料 追浜駅下車 (無料送迎バスあり)

平成28年5月21日(土) 9:30~16:00 (16:30入場受付終了、雨天実施)

初公開 海底広域研究船「かいめい」

公開セミナー

10:30	海洋調査船「しんかい16500」
11:50	深海サメの体のなかをのぞいてみよう!
13:10	「かいよう」体験乗船
14:00	「YOKOSUKA軍港めぐり」の船舶によるミニクルーズ

★実験・実演コーナー他イベント多数開催!

お問い合わせ 国立研究開発法人海洋研究開発機構 横須賀本部 〒237-0061 横須賀市東町2-15 TEL: 046-867-9059 (平日9:00~17:00) E-mail: openhouse@jamstec.go.jp

**11.11** **JAMSTEC** 国立研究開発法人 海洋研究開発機構

## 横浜研究所 施設一般公開

入場無料

平成29年11月11日(土) 10:00~16:30 (16:00受付終了・雨天実施)

研究者と話そう! いろいろ聞いてみよう!!

特別公開! 地球シミュレータ  
スパコン地球シミュレータを間近で見学頂けます。

地震・津波観測監視システム(DONET)  
横浜バックアップサイト見学ツアー(当日受付)

気軽に聞こう 立ち寄りセミナー (受付不要)  
楽しい実験などイベント盛りだくさん!!

詳しくは **JAMSTEC** **検索** で検索!!

お問い合わせ 国立研究開発法人海洋研究開発機構 横浜研究所 〒236-0001 横浜市金沢区昭和町3173-25 ☎ 046-778-5407

JR根岸線「新杉田」から徒歩約13分、京急線「杉田」から徒歩約15分、京急バス「杉田」バス停から徒歩約5分

イベントは集合日より開始となります。  
※観覧人数が多くなる見学会となりますので、安全のためピークは入り口にてお控ください。  
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協力: 新江ノ島水族館、横浜・八景園シーパラダイス

**10/1** **JAMSTEC** 国立研究開発法人 海洋研究開発機構 (JAMSTEC) 横須賀本部

## 施設一般公開

入場無料 追浜駅下車 (無料送迎バスあり)

平成23年10月1日(土) 9:30~16:00 (15時30分入場受付終了、雨天実施)

大人気企画!! 有人潜水調査船「しんかい2000」コックピット見学

当日受付・抽選 10:00~15:00 毎時12名 (合計72名)

海洋調査船「かいよう」体験乗船

YOKOSUKA 軍港めぐり

「YOKOSUKA軍港めぐり」の船舶によるミニクルーズ

※定員190名 当日受付・抽選 乗船時間14:00~15:00 抽選受付9:30~12:00 9:30~12:00までは船内公開 (事前申込不要 最終入場11:45)

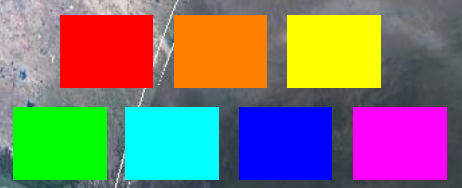
お問い合わせ 国立研究開発法人海洋研究開発機構 横須賀本部 〒237-0061 横須賀市東町2-15 TEL: 046-867-9059 E-mail: openhouse@jamstec.go.jp





# Call for help by balloon with letter

**1. Choose the color of the balloon!**



**2. Choose the start point!**

**Hint: wind velocity and cloud**

**3. Start!**

**Winner can get a present!**

**Desert island**



Thank you for  
your attention!

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