Environmental Influence Analysis of Global Gravity Anomaly Gradient Basing on Neighbourhood Satistics in GIS

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Abstract. A series of abnormal environmental phenomena were found related with local earth gravity field anomaly through statistics and calculation analysis. Gravity anomaly gradient was used to describe gravity anomaly change in local extent. Total of 79% in earth surface gravity anomaly gradient express stable (<30 mGal/ Degree), 7.37% area express major gravity anomaly gradient (> 50 mGal/ Degree), of 3.43% area gravity anomaly gradient is very high (>70 mGal/ Degree). While gravity anomaly is over 30 mGal/ Degree, there will may more easily appear sandstorm, tornadoes and haze we ather, if thermodynamic conditions and material conditions are proper. Many natural disasters start from these areas, where gravity anomaly gradient is very high.

Keywords: Hurricane; Mesoscale vortex; Aerosol sedimentation; Sandstorm; Gravity anomaly.

1. Introduction
Gravity anomaly can indicate the change of rock density. The gravity anomaly amplitude is proportional to the density contrast and thickness of the anomaly body. Kane and Godson (1989) pointed out that long wavelength high gravity is related to high mantle seismic velocity, and low gravity is related to low mantle velocity. Kaban et al. (2003) showed that the variation of upper mantle density resulted in long wavelength gravity anomalies from −250 mGal to +150 mGal. Mantle seismic tomography using ray paths along the section connecting Tonga and Hawaii identified seismic velocity anomalies at intervals of about 1500 km, which are associated with variations in gravity and bathymetry (Katzman et al., 1998). Synthetic calculations show that the gravity anomaly signature of a thickened crust is negative and larger in absolute value, relative to a case where thickening affects the entire lithosphere. Also, Hydrosphere and atmosphere can be affected by abnormal distribution of gravity field. But until now no study focuses on the relation between environmental fluid and the gravity anomaly. Gravity anomaly value was normally regarded as very low, which not enough to lead atmosphere and hydrosphere condition change. Indeed, Long time and giant mass of air mass or ocean flow caused gravity anomaly take important effect in some environmental phenomena. These anomaly phenomena include sandstorm, aerosol, hurricane and wind shear.

2. Methods and Materials

2.1. Gravity Anomaly Gradient
In some areas, the level of gravity anomaly rises rapidly, which leads to the rapid decline of air mass in motion. Therefore, the gravity anomaly gradient is defined to describe the variation of gravity anomaly in local scale.

$\text{Gravity Anomaly Gradient} = \frac{\text{Gravity Anomaly}}{\text{Distance}} \quad \text{(Unit: mGal/ Degree)}$
2.2. Neighbourhood Statistics and Mapping
Neighborhood statistical function is a focus function for calculating the output cell, where the value of each position is a function of the input unit in the specified neighborhood. For each cell in the input cell, the neighborhood statistical function calculates the statistical information according to the value of the processing unit and the value of the cell in the specified neighborhood, and then sends the value to the corresponding cell position on the output cell. Statistical data indicate that major gravity anomaly changes always were found in 1 degree. According to this result, we analysis the gravity anomaly gradient by neighbourhood statistics using GIS (Geography Information System), the change of gravity anomaly in 1 degree was calculated and mapped by AcrGIS 9.3.

2.3. Gravity Anomaly Data
The GRACE (Gravity Recovery And Climate Experiment) satellites were launched to make detailed measurements of Earth's gravity field anomalies since 2002. Because gravity is determined by mass, Grace can indicate the mass distribution around the planet and its change with time by measuring gravity anomalies. In this study, The GRACE Gravity Model 02 (GGM02) data was used, which was based on the analysis of 363 days of GRACE in-flight data. Inner mass distribution also influences gravity sedimentation of particulate matter and air mass in atmosphere by tiny gravity anomaly change. Grace satellite provide accurate gravity anomaly data, higher value and low value was clearly discriminated.

3. Results and Discussions
Globle gravity anomaly gradient was mapped to discover environmental anomaly and important environmental anomaly area were found. These are important sources of global hurricanes and sandstorms. The fall process play a key role, which influenced by gravity change and form wind with high velocity. The ocean also was influenced by gravity change. Ocean flow will form downwelling and lead to mesoscale eddies in higher gravity anomaly gradient.

3.1. Globle Gravity Anomaly Gradient
Statistical data indicate that major gravity anomaly changes always were found in 1 degree. According to this result, we analysis the gravity anomaly gradient by neighbourhood statistics using GIS, the change of gravity anomaly in 1 degree was calculated and mapped (Figure 1). From Figure 1, the area was selected, where gravity anomaly gradient changes fast and even change from 50 mGal/ Degree to 250 mGal/ degree. For example, gravity anomaly gradient of central Asia, western Pacific, South America, the gulf of Mexico, Siberia and equatorial guinea is significant higher than that of other area in the world. Total of 79% in earth surface gravity anomaly gradient express stable (< 30 mGal/ Degree), 7.37% area express major gravity anomaly gradient (> 50 mGal/Degree), of 3.43% area Gravity Anomaly gradient is very high (> 70 mGal/ Degree).
3.2. Fall Process Analysis
The fall process was influenced by gravity anomaly gradient through acceleration change. Based on D'Alembert principle, gravity anomaly change can be equal to increase an inertia force. We calculated the ideal conditions, air resistance keep stable, still equal to early gravity. This force can make particles similar to free fall, but acceleration is only about 1/100000 of g(9.8 m/s\(^2\)). Although force is very little, continuous acceleration for long time can bring great change of particulate matter velocity. More importantly, this effect will be enhanced by downdrafts, caused air extremely thin and presents less drag force. Air resistance even can disappear, in part of fall process, form real free fall. The force can increase or decrease the terminal velocity of falling objects. With continuous process of gravity change and acceleration. For assessing the effect of gravity anomaly gradient changing, we simulate the time of sedimentation from 10000, 5000, 3000 meters to the ocean surface, we hypothesis the air drag force keep stable. In these ideal conditions, with the gravity increasing 100 mGal, the fall process only need less than 1 hour from a height of 5000 meters. If we consider the sustained air sedimentation, caused drag force is very low, free fall from the top of the troposphere will reach high terminal velocity about 50 m/s. This process will provide energy for air mass system such as hurricane and wind shear.

3.3. Environmental Influence
Verticle wind shear, cyclone and hurricane were also caused by change of gravity. By statistical analysis, over 70% hurricane was formed in high gravity anomaly gradient (>50 mGal/ degree) area in the world. The vertical movement will start, while air mass flow for a horizontal movement through gravity changed space of significant differences. If gravity anomaly gradient over 50 mGal, the vertical movement will become strong and fast. In fluid mechanics, the increase of fluid velocity occurs simultaneously with the decrease of pressure or the decrease of fluid potential energy. The air pressure decreasing is a basic condition for formation of hurricane. And sedimentation of air mass can provide energy for the disturbance. Without external air disturbance, high gravity anomaly areas will lead to low density and low pressure. If external air flow through, begin vertical movement and form vertical airflow. Continued weak acceleration reduce fluid density so that vertical wind flow down form vertical wind shear. Gravity anomaly gradient can change the fluid direction and velocity of motion.
Gravity anomaly gradient theory also can explain the formation of mesoscale eddies in ocean. Mesoscale eddies can form sea level gradients, which produce a jet stream or ocean current, such as
the Antarctic circumpolar current. This is part of a barometric instability system where the current winds and produces vortices. These types of mesoscale eddies have been observed in many major ocean currents, including the Gulf current, the Aulas current, the Kuroshio Current and the Antarctic circumpolar current.

When ocean flow pass along higher gravity anomaly gradient from lower gravity to higher gravity. Ocean flow will form downwelling by continuous gravity anomaly acceleration. Adversely, upwelling will appear where gravity anomaly is lower in deep ocean. This is a circle of vertical ocean flow moving, can be found in local area of ocean, where gravity anomaly gradient is over 50 mGal/Degree. If a cyclic gravity anomaly gradient area is exist, also influenced by coriolis force, heat and other ocean flow, there will be a mesoscale eddies form. That is why Gulf of Mexican and Caribbean sea always more easily appear mesoscale eddies. There are more complex cyclic gravity anomaly compared to others area in ocean.

4. Conclusion
Total of 79% in earth surface gravity anomaly gradient express stable (<30 mGal/ Degree), 7.37% area express major gravity anomaly gradient (> 50 mGal/ Degree), of 3.43% area gravity anomaly gradient is very high (> 70 mGal/ Degree). While gravity anomaly is over 30 mGal/ Degree, there will may more easily appear sand duststorm, tornadoes and haze weather, if thermodynamic conditions and material conditions are proper. Many natural disasters start from these areas, where gravity anomaly gradient is very high. Downwelling ocean flow can lead to wreck of ship and submarine, and wind shear increase more air crash. So it’s important to avoid these areas in global transportation. Hurricane and mesoscale eddies may be controlled by increasing the fluid density before it form. So management such as meteorological engineering could be taken to reduce disasters in 7.37% areas in world.

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