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Chapter 1 : Atmospheric Waves Awareness: An Explainer | The Planetary Society

The largest amplitude atmospheric tides are generated by the periodic heating of the atmosphere by the Sun - the atmosphere is heated during the day and not heated at night. This regular diurnal (daily) cycle in heating generates tides that have periods related to the solar day.

The increasing vigor of this phenomenon is revealed in the accompanying figure, where the yearly differences between the high and low points of the seasonal CO2 cycle are plotted as a function of time. As can be seen from these data, over the period the "breath" of the biosphere has been considerably enhanced. A slight temperature increase reported in some Northern Hemisphere land areas over this time period may also be a contributing factor Keeling et al. Together, these phenomena combine to produce the results shown in the graph above, which stands as a strong testament to the reality of the ubiquitous "greening of the earth" Idso, that is currently in progress. To access a file of the data from which the graph was constructed, click here. Journal of Geophysical Research The seasonal component of atmospheric CO2: Information from new approaches to the decomposition of seasonal time-series. The interannual variation of carbon dioxide concentration at Mauna Loa. Anthropogenic enhancement -- environmental response. Global Biogeochemical Cycles 9: Modeling the global carbon cycle: Nitrogen fertilization of the terrestrial biosphere and the "missing" CO2 sink. Global Biogeochemical Cycles 8: Industrial age leading to the greening of the Earth? CO2 and the Biosphere: The Incredible Legacy of the Industrial Revolution. Increased activity of northern hemispheric vegetation inferred from atmospheric CO2 measurements. Modeling the seasonal contribution of a CO2-fertilization effect of the terrestrial vegetation to the amplitude increase in atmospheric CO2 at Mauna Loa Observatory. Tellus Series B Increased plant growth in the northern high latitudes from to The annual variation of atmospheric CO2 concentration observed in the northern hemisphere. The biosphere as an increasing sink for atmospheric carbon: Estimates from increased nitrogen deposition. Global Biogeochemical Cycles 7:

Chapter 2 : Atmospheric pressure - Wikipedia

The ï¬‚uctuations of the relative temperature measurements in Eq. (1) can be analyzed as a function of the time scale. The atmospheric-dominated ï¬‚uctuations are expected to aï¬€ect the received signal.

An overly studious person, an intellectual, a nerd with a keen interest in policies, strategy, and technical details. Objective Truth Exists, and is Accessible to Everyone. A global system of monitoring stations shows the dispersion of these emissions from the Northern Hemisphere to the Southern Hemisphere. The amplitude of the seasonal cycle is increasing due to human agriculture. The Southern Hemisphere has a seasonal cycle that is the opposite polarity of the Northern Hemisphere, but is very weak due to a smaller land mass and less agriculture. About half of human carbon emissions are being absorbed by carbon reservoirs oceans, soils and biomass. Carbon isotopes show that large volumes of atmospheric carbon are freely exchanged with carbon in carbon reservoirs. The size of the carbon reservoirs exchanging carbon with the atmosphere can be estimated through the dilution of human-derived carbon isotopes in the atmosphere. The calculation indicates that these carbon reservoirs contain about 7 times the quantity of carbon in the atmosphere. Human carbon emissions will continue. After filtering the seasonal cycle from the carbon isotope data, a multi-year cycle remains. The multi-year cycle can be correlated with the El Nino climate cycle. The El Nino cycle changes the rate at which atmospheric carbon is absorbed by the Pacific Ocean, and changes isotopic composition of the atmosphere. The curve shows seasonal cycles and a steady rise in the concentration of CO2, beginning about ppm and currently approaching ppm. Long-term CO2 records are also available from a number of other observatories, located from the Arctic Ocean to the South Pole. Atmospheric CO2 concentrations and CO2 carbon isotopes show seasonal and long term trends which vary by latitude. This progressive change is seen in bulk concentration of CO2, in carbon isotopes of CO2, and the amplitude of the seasonal cycle. Long-term changes in global CO2 are consistent with known volumes of fossil fuel emissions. A simple model can be constructed based solely on human carbon emissions and agricultural biomass, that matches the observed seasonal cycle and long-term trends in bulk CO2,. This model shows that it is reasonable to conclude that human activities are influencing carbon dioxide in the atmosphere. The Energy Information Agency EIA predicts rising carbon emissions for the foreseeable future, from about 35 gigatonnes CO2 annually to nearly 50 gigatonnes CO2 by the year , in the base-case forecast. Carbon dioxide from fossil fuels and deforestation carries a distinctive isotopic signature, which marks the movement of man-made CO2 through the atmosphere and carbon reservoirs soils, biomass, and oceans. This movement of carbon, as seen in both carbon isotope data and bulk CO2 data, reveals complexity in the carbon cycle. Discrepancies between the datasets imply the active exchange of carbon between the atmosphere and carbon reservoirs. The size of carbon reservoirs is estimated at more than 7 times the volume of carbon present in the atmosphere, based on a dilution calculation of anthropogenic carbon isotopes in the atmosphere. Understanding the patterns of atmospheric CO2 may provide a tool for recognizing and measuring changes in global climate. C12 is the more abundant isotope; the natural ratio of C12 to C13 is about 99 to 1. The standard is a uniform Cretaceous limestone with a d 13 value defined as zero. Positive values indicate a heavier composition, i. Negative values indicate a lighter composition, i. Plants fractionate carbon, favoring the lighter isotope C The distinctive isotopic signature of CO2 from fossil fuels and deforestation is useful in tracking the movement of carbon through the atmosphere and oceans. Those estimates were used in this work. A network of observatories, mostly operated by Scripps Oceanographic Institute, monitors global atmospheric CO2 concentrations and CO2 carbon isotopes. Bulk CO2 has been monitored since , and CO2 carbon isotopes since In all figures, data from the Northern Hemisphere is indicated in cool colors, and data from the Southern Hemisphere is indicated with warm colors. Global CO2 observations show a seasonal cycle and a steady rise in the concentration of CO2. The amplitude of the CO2 seasonal cycle is largest in the high latitudes of the Northern Hemisphere, and diminishes southward. The polarity of the Northern Hemisphere cycle persists to about 30 degrees South Latitude. From that point southward, the polarity of the cycle is reversed, but with low amplitude. The seasonal cycle in bulk CO2 was removed by taking a one-year rolling average at each observatory. The concentration of CO2 is highest in the Arctic, and is progressively lower by latitude to the South Pole. The progression marks the dispersion of fossil fuel emissions from the Northern Hemisphere to the Southern Hemisphere. The seasonal cycle in the CO_2 carbon isotope ratio was removed by taking a one-year rolling average at each observatory. The isotopic composition of CO_2 is lightest near the North Pole, and becomes progressively heavier to Antarctica. A simple model was constructed to investigate the plausibility of the idea that human activity causes changes in atmospheric CO_2. The model begins at the global baseline CO_2 concentration in Global agricultural biomass was scaled by year to human population, and allocated to the Northern and Southern Hemispheres by population. Volumes of carbon were converted to CO_2 concentration by hemisphere, and defined the concentration at the poles. Concentrations at intermediate latitudes were created by mixing concentrations from each hemisphere, with weighting by latitude. The ease with which the model was created suggests that human activity is plausibly responsible for much of the change in atmospheric CO_2. The Keeling Curve is characterized by a strong seasonal cycle, dominated by the Northern Hemisphere. The concentration of atmospheric CO_2 falls during the Northern Hemisphere growing season, when land plants remove carbon from the air through photosynthesis. The concentration of CO_2 rises in the fall, winter and spring as decay returns carbon to the atmosphere as CO_2. Land plants in the Northern Hemisphere strongly fractionate carbon isotopes. Amplitude of the seasonal cycle is relatively small in the Southern Hemisphere, reflecting a smaller land mass and sparse population. Seasonal cycles in low latitudes of the Southern Hemisphere follow the polarity of the Northern Hemisphere, but with a phase shift. Seasonal cycles in high latitudes of the Southern Hemisphere carry the opposite polarity to the Northern Hemisphere. Amplitude of the seasonal cycle is increasing over the past 40 years, particularly at high northern latitudes. The increase in amplitude correlates well to the increase in human population over the past 40 years. By inference, the increase in seasonal amplitude also correlates to a proportional increase in human agriculture. The correlation implies that agriculture accounts for about one-third of the amplitude of the seasonal CO_2 cycle. The polarity reversal of the seasonal cycle occurs at about 30 degrees South Latitude, near the southern boundary of the Hadley convection cell. The atmosphere north of degrees latitude contains air which is mixed with air from the Northern Hemisphere; CO_2 concentrations and carbon isotopes follow the seasonal cycle of the Northern Hemisphere. The atmosphere south of degrees latitude carries the seasonal cycle of the Southern Hemisphere. This finding suggests that additional CO_2 observatories between degrees and degrees south latitude could monitor climate-change induced expansion of Hadley circulation, by detecting air from the Northern Hemisphere, according to the Northern Hemisphere seasonal CO_2 cycle. The rate of human CO_2 emissions is increasing. Anthropogenic CO_2 emissions, including deforestation, have grown from about 5 gigatonnes annually in to about 38 gigatonnes in The greatest part of that increase occurred in the last 50 years. Net annual fossil fuel emissions in the Northern Hemisphere, converted to CO_2 concentration, neatly match the difference in CO_2 concentration between the hemispheres. Deforestation, which is more prevalent in the Southern Hemisphere was not included in the emissions numbers, which might account for the growing discrepancy in recent years. Despite international efforts to reduce carbon emissions, global industrial CO_2 emissions are rising sharply. Emissions including deforestation bring the total in to 53 gigatonnes, assuming a constant rate of deforestation from to The Carbonsphere The Carbonsphere consists of atmospheric carbon and all reservoirs ocean, biomass, and soils freely exchanging carbon with the atmosphere. A 2-year lag is required for the concentration of bulk CO_2 to equilibrate from sources in the Northern Hemisphere to the Antarctic. Differences in the behavior of bulk CO_2 and CO_2 carbon isotopes indicate the active role of carbon reservoirs in the ocean, plants, and soil in exchanging carbon with the atmosphere. Bulk carbon requires about a 2-year lag for CO_2 concentration to equilibrate from the Arctic to the Antarctic. In contrast, CO_2 carbon isotopes require an 8-year lag for equilibration. The difference indicates that the specific molecules released by fossil fuels are cycled through carbon reservoirs and replaced in the atmosphere by other molecules from those reservoirs. The difference in equilibration lag of bulk carbon and carbon isotopes indicates residency time in those reservoirs. If all human carbon emissions remained in the atmosphere, the concentration of atmospheric CO_2 would be much higher. Carbonsphere reservoirs are assumed to be in equilibrium with the atmosphere, which is demonstrated by the relatively good fit to the solution for 30 years. The model assumes a balance of fractionation between the carbonsphere reservoirs and the atmosphere. The solution calls for a gigatonne carbonsphere in including the atmosphere. Lower amplitude but correlative waves also exist in the bulk CO2 chart. The amplitude of the waves interrupts and sometimes reverses the secular trend, indicating that the volumes of carbon exchanged sometimes exceed the volume of human carbon emissions. A series of mathematical operations can reduce the global CO2 isotope record to a single trace which indicates the rate at which atmospheric carbon is exchanged with the Carbonsphere. Assuming no fractionation in the exchange process, positive values indicate a faster rate of absorption of C12 by the Carbonsphere. Negative values indicate a slower rate of C12 absorption by the Carbonsphere. The quality and quantity of oceanic carbon data is weak in comparison to atmospheric CO2 data. Oceanic carbon data is limited by a lack of continuous readings or fixed observation sites, and is strongly influenced by local biological activity. Nevertheless, at the broadest scale, oceanic dissolved inorganic carbon is isotopically lighter in the Northern Hemisphere, reflecting the influence of fossil fuels in the Northern Hemisphere. Department of Energy, Oak Ridge, Tenn. Global Stable Carbon Isotopic Signature.

Chapter 3 : Jamie Bollenbach â€“ The Amplitude of Time

Atmospheric pressure shows a diurnal or semidiurnal (twice-daily) cycle caused by global atmospheric tides. This effect is strongest in tropical zones, with an amplitude of a few millibars, and almost zero in polar areas.

General characteristics[edit] The largest-amplitude atmospheric tides are mostly generated in the troposphere and stratosphere when the atmosphere is periodically heated, as water vapor and ozone absorb solar radiation during the day. These tides propagate away from the source regions and ascend into the mesosphere and thermosphere. Atmospheric tides can be measured as regular fluctuations in wind , temperature , density and pressure. Although atmospheric tides share much in common with ocean tides they have two key distinguishing features: This means that most atmospheric tides have periods of oscillation related to the hour length of the solar day whereas ocean tides have periods of oscillation related both to the solar day as well as to the longer lunar day time between successive lunar transits of about 24 hours 51 minutes. Atmospheric tides propagate in an atmosphere where density varies significantly with height. A consequence of this is that their amplitudes naturally increase exponentially as the tide ascends into progressively more rarefied regions of the atmosphere for an explanation of this phenomenon, see below. In contrast, the density of the oceans varies only slightly with depth and so there the tides do not necessarily vary in amplitude with depth. At ground level, atmospheric tides can be detected as regular but small oscillations in surface pressure with periods of 24 and 12 hours. However, at greater heights, the amplitudes of the tides can become very large. The reason for this dramatic growth in amplitude from tiny fluctuations near the ground to oscillations that dominate the motion of the mesosphere lies in the fact that the density of the atmosphere decreases with increasing height. As tides or waves propagate upwards, they move into regions of lower and lower density. If the tide or wave is not dissipating, then its kinetic energy density must be conserved. Since the density is decreasing, the amplitude of the tide or wave increases correspondingly so that energy is conserved. Following this growth with height atmospheric tides have much larger amplitudes in the middle and upper atmosphere than they do at ground level. Solar atmospheric tides[edit] The largest amplitude atmospheric tides are generated by the periodic heating of the atmosphere by the Sun â€” the atmosphere is heated during the day and not heated at night. This regular diurnal daily cycle in heating generates tides that have periods related to the solar day. However, observations reveal that large amplitude tides are generated with periods of 24 and 12 hours. Tides have also been observed with periods of 8 and 6 hours, although these latter tides generally have smaller amplitudes. This set of periods occurs because the solar heating of the atmosphere occurs in an approximate square wave profile and so is rich in harmonics. When this pattern is decomposed into separate frequency components using a Fourier transform , as well as the mean and daily hr variation, significant oscillations with periods of 12, 8 and 6 hrs are produced. Tides generated by the gravitational effect of the sun are very much smaller than those generated by solar heating. Solar tides will refer to only thermal solar tides from this point. Variations in the global distribution and density of these species result in changes in the amplitude of the solar tides. The tides are also affected by the environment through which they travel. Solar tides can be separated into two components: Migrating solar tides[edit] Figure 1. Tidal temperature and wind perturbations at km altitude for September as a function of universal time. Migrating tides are sun synchronous â€” from the point of view of a stationary observer on the ground they propagate westwards with the apparent motion of the sun. As the migrating tides stay fixed relative to the sun a pattern of excitation is formed that is also fixed relative to the Sun. Seasonal variations of the tides also occur as the Earth tilts relative to the Sun and so relative to the pattern of excitation. However, non-migrating tides do not follow the apparent motion of the sun. Either they do not propagate horizontally, they propagate eastwards or they propagate westwards at a different speed to the sun. These non-migrating tides may be generated by differences in topography with longitude, land-sea contrast, and surface interactions. An important source is latent heat release due to deep convection in the tropics. The primary source for the hr tide is in the lower atmosphere where surface effects are important. This is reflected in a relatively large non-migrating component seen in longitudinal differences in tidal amplitudes. Largest amplitudes have been observed over South America , Africa and Australia. Classical tidal theory[edit

] The basic characteristics of the atmospheric tides are described by the classical tidal theory. The two major results of the classical theory are atmospheric tides are eigenmodes of the atmosphere described by Hough functions amplitudes grow exponentially with height. Basic equations[edit] The primitive equations lead to the linearized equations for perturbations primed variables in a spherical isothermal atmosphere:

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Chapter 4 : Research on Time-Space Fractional Model for Gravity Waves in Baroclinic Atmosphere

F. Zhao and N. Zeng: Continued increase in atmospheric CO2 seasonal amplitude in the 21st century Table 1. List of Models used and their characteristics. Land Resolution.

Introduction to Computer Music: Volume One Chapter One: An Acoustics Primer 6. Below, we will see how these three phenomena correspond. A perplexing element in many discussions of amplitude is the confusion between mechanical or electronic measurements of amplitude, and amplitude expressed as an acoustic measure of sound pressure. The amplitude of sound pressure is frequently measured in pascals Pa. For reference, sea-level air pressure 1 atmosphere is approximately kPa, close to 15 pounds per square inch. Causing air molecules to move in a direction and with a velocity other than their normal state of motion to create a sound pressure wave requires force. The benchmark threshold of hearing, the smallest perceptible amplitude, is approximately 0. Discussions of amplitude depend largely on measurements of the oscillations in barometric pressure or electrical energy from one extreme or peak to equilibrium and not normally measured peak to peak PP. The degree of change above OR below an imaginary center value is referred to as the peak amplitude, or peak deviation, of that waveform. If we tried to calculate the average amplitude over time of a sine wave, it would unfortunately equal zero, since it rises and falls symmetrically above and below the zero reference. This would not tell us very much about its amplitude, since low-amplitude and high-amplitude sine waves would appear equivalent. A more meaningful reference has been developed to measure the average amplitude of a wave over time: You may also see the rms measurement applied to the power output of an amplifier. The rms value of a waveform represents a squaring of the instantaneous amplitude for each point in time or a sufficient number of equally spaced points of a waveform, calculating the average arithmetic mean of those values, and finally taking the square root of this average. This is extremely useful information for those using averaging level meters with audio equipment or software. How does this work? If we took 4 equally-spaced samples of a sine wave with an amplitude of 1, we would get 0, 1, 0, We then take the arithmetic average to get. We then take the square root of. If we took the rms of a sine wave with an amplitude of 3 with 4 sample values, we would get 0,3,0, When using audio gear or software, it is important to know whether your meter is a peak-reading meter or averaging meter or neither. Wind turbine efficiency is determined using a root-mean-cubed method as the cube of wind speed is proportional to the energy produced over time.

Chapter 5 : Wonky Thoughts: The Keeling Curve and Global CO2

Gundolf H. Kohlmaier, Ernstâ€•Olof SirÃ©, Alex Janecek, Charles D. Keeling, Stephen C. Piper and Roger Revelle, Modelling the seasonal contribution of a CO2 fertilization effect of the terrestrial vegetation to the amplitude increase in atmospheric CO2 at Mauna Loa Observatory, Tellus B, 41B, 5, (), ().

The vibrations are then transferred though the environment from neighbour to neighbour. This energy transfer is called wave motion. Waves move energy through a medium without moving the whole medium. Leonardo di Vinci "waves made in a field of grain by the wind, In the simulation below from Dr. Russell you can see energy move to the right while individual particles vibrate to the left and right about fixed points. The places when the particles cluster together are volumes of high pressure so these waves are also called pressure waves. Sound waves are an example of pressure waves and they can move through gases, liquids and solids. For sound waves, the denser the medium the faster the speed. In the simulation below also from Dr. Russell you can see energy move to the right while individual particles vibrate up and down about fixed points. They all move at the same speed of , km. They slow down when they travel through a medium this is an average speed between interactions. Mechanically twisting or pulling a medium sideways is called shearing so waves formed this way are also called shear waves. Longitudinal and Transverse waves together Sometimes longitudinal and transverse waves occur together. Ocean waves are a combination of longitudinal and transverse waves because the surface of the water can be pulled sideways as well as pushed longitudinally. Russell you can see energy move to the right while individual particles move clockwise in circles or ellipses. When ocean waves get to a shelving beach the speed of the waves changes relative to each other and circles go to ellipses and then the wave breaks. This may happen anywhere between several km and several s km down from the surface. The wave motions that occur through the crust have The -1 The -1 When they reach the surface an Earthquake occurs, and the timing between the arrivals of the The Note: Basic Wave Parameters The amplitude A, is half the height difference between a peak and a trough. The period T, is the time between successive peaks or troughs. The wave speed c, is the speed at which peaks or troughs move. Note that "c" from the Latin word "celeritas" meaning swiftness is used for wave speed, not "v". One reason is so that it is not confused with frequency. Example W1 Seismic Shear waves travel at m. Find the wavelength of these waves. Answer W1 Representing Moving Shapes The station below has a frame of reference with axes labelled x and y. The engine and carriage below have a frame of reference at the end of the first carriage. It has axes labelled X and Y. The engine and carriage are moving at a constant speed c to the right positive x axis. At time t s later: Vertical distance references do not change, i. The horizontal distance between the Y and y axes increases uniformly with time, i. The distance X from the carriage origin to a point P on the side of the carriage will not change in time. The distance x from the station origin to the point P will increase with time, i. In the station frame of reference: Representing Transverse Sinusoidal Waves You can only have the sine of an angle. To represent a sine shape in space, the x distance has to be converted to get an angle. The relationship between phase angle and distance is given by: It is measured in radians per metre rad. The wave speed is: It is measured in metres per second m. It is measured in radians per second rad. It is measured in Hertz s A sine shape in space is given by: A sine wave moving to the right positive x direction at speed c will be written: A sine wave moving to the left negative x direction at speed c will be written: The time part of the wave can be written: A sine wave moving to the right is: In concentrating on the particles, it is seen that neighbouring particles have slightly different x values which appear as slightly different initial phases in a Simple Harmonic Motion. The transverse displacements of particles are governed by: The transverse particle speeds are given by: When the particle is at its largest displacement, there is zero particle velocity. Maximum transverse particle velocity occurs as the particle crosses the axis. Example W2 A sinusoidal wave has a wavelength of 1. Find the phase difference between a point 0. Answer W2 The equation of a transverse sinusoidal wave is given by: Answer W3 Amplitude, A is 2 mm. The Intensity of waves called Irradiance in Optics is defined as the power delivered per unit area. The unit of Intensity will be W. The wave energy comes from the simple harmonic motion of its particles. The total energy will equal the maximum kinetic energy. Combining these two results: The Impedance of the medium called the Specific Acoustic Impedance in Acoustics is defined by the product of density and wave speed. P0 is called the pressure amplitude, because when the unit for Impedance Pa. It is useful when dealing with pressure waves. Example W4 A wave of frequency Hz travels in air of density 1. It is an objective measurement and has the unit of W. Loudness is a subjective perception. For a long time it was thought that the ear responded logarithmically to sound intensity, i. The Intensity Level was defined to represent loudness. It was accordingly based on a logarithmic scale and has the unit of Bel after Alexander Graham Bell, not the Babylonian deity. The frequency response will be looked at later.

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Chapter 6 : Atmospheric tide - Wikipedia

Amplitude is the objective measurement of the degree of change (positive or negative) in atmospheric pressure (the compression and rarefaction of air molecules) caused by sound waves. Sounds with greater amplitude will produce greater changes in atmospheric pressure from high pressure to low pressure to the ambient pressure present before sound was produced (equilibrium).

Following is an explainer on planetary waves, gravity waves, and atmospheric tides. Atmospheres are full of waves. Some, like sound waves, are abundantly clear to our ears especially near a college dormitory on a Saturday night. Some of the most powerful waves propagating through atmospheres, however, are silent and invisible. Even worse is the fact that these poor waves are under-appreciated by everyone from Google to that one engineering colleague who thought that I made them up. These atmospheric waves are big, having wavelengths ranging from meters and kilometers gravity waves to thousands of kilometers planetary waves. Their effects on the climate system and energy budget of a planet are both tremendous and varied: Please accept marketing-cookies to watch this video. A time lapse of gravity waves in Iowa passing through an atmosphere. These are most likely caused by the instabilities from warm land air flowing over cool lake air. Note that the gravity waves are perpendicular to the flow. WeatherFlow Gravity wave clouds Gravity waves may produce clouds that are visible from the ground by expanding and then compressing air, which we see as clouds. These clouds are perpendicular to the flow. Unlike gravitational waves, gravity waves are compressional waves in an atmosphere. They occur when a parcel of air gets bumped to aregion of different density, and the force of gravity pushes it back. This results in a propagating oscillation which we perceive as a wave. Compressed air looks the same to human eyes as decompressed air, so a better analogy might be an invisible slinky. This is the same mechanism as sound wave propagation in the air. Sometimes we get lucky, and the compression of air results in cloud formation, because compressing air that is relatively humid results in condensation. But more often, especially in dry areas, the process of wave propagation is invisible. Clear-air turbulence, the bumps we feel on planes, is often the result of gravity waves breaking. Planetary waves are different from gravity waves. Planetary waves are propagated by the rotational forces of the Earth, rather than gravity. Planetary waves occur when a parcel of air gets bumped to a region with a different rotational speed and the Coriolis force pushes it back. As such, gravity waves can propagate vertically and horizontally, whereas planetary waves only propagate along meridians of longitude. Rather, they push air molecules together and then apart. So what do these things do? Planetary waves are responsible for most weather on Earth. At mid-latitudes between the subtropics and polar regions , a Rossby wave manifests itself as meanders in the jet stream, which then spin off to form the high and low pressure systems that we experience as weather. In the tropics, equatorial waves control precipitation by interacting with the convection cells over the oceans known as the Walker Circulation. This produces something known as the Madden Julien Oscillation, which can either bring bountiful rains or wreak havoc on East Africa and Indonesia. In either a cruel twist of fate or an argument for international agriculture markets, the result is reversed for each region so that bountiful conditions in East Africa mean ruinous conditions for Indonesia, and vice versa. Upwards moving gravity waves have fewer direct consequences on humans, but grow more important in the upper atmosphere. As they move away from the surface, the amplitude of the waves must grow to conserve energy in the thinning air. These waves grow in amplitude with increasing altitude above the surface until they "break", just like waves at the beach. This wave breaking releases large amounts of energy into the atmosphere. In particular, it drives the circulation of the stratosphere. This controls everything from where ozone is located -- while it is produced in the tropics, it ends up at the poles -- to whether or not the polar vortex stays together. In a sense, gravity waves allow the bottom of the atmosphere to communicate with the top, by transmitting momentum and energy from the surface without moving air masses. Other types of atmospheric waves exist, and any world with a dense atmosphere such as Jupiter or Titan is home to waves sorry asteroids, no fun for you. Atmospheres have tides, too. Atmospheric tides are a type of wave caused by either gravitational forces or solar heating which, like ocean tides, have a signal that occurs daily as well as possibly twice or four times daily. On Earth, atmospheric tides are seen far away from the surface in what we call the middle and upper atmosphere, defined as the mesosphere and above, above an altitude of 50 kilometers. We observe atmospheric tides as diurnal disturbances in pressure fields, caused by thermal forcing rather than gravitational pull from celestial bodies. Thermal atmospheric tides are well theorized, studied, modeled, and measured on other planets and moons. These waves can cause large variations in atmospheric density in regions where engineers would typically rely on atmospheric braking to slow down vehicles. Understanding the range and frequency of these perturbations is then critically important to preventing your spacecraft from crashing into the ground. One last type of wave that normally remains the domain of action movies: Shock waves only occur naturally on Earth when comets or airplanes break the sound barrier, and rarely during explosions , but we may be seeing them on exoplanet HDb. Though physical confirmation is limited to using climate models, extreme heat swings are theorized to result from a shock wave traveling around the planet. Langton UC Santa Cruz The atmosphere of HD b Atmospheric simulation of the exoplanet HD b suggests a shock wave of storms is responsible for temperatures that vary hundreds of degrees within a few hours. An animated version can be viewed here. Oh, and those examples from the beginning of the article?

Chapter 7 : Acoustics Chapter One: What is Amplitude? | page 2

Troposphere scintillation is the rapid fluctuations in the refractive index of owing to turbulence and produces random fades and enhancements of the received signal amplitude. This phenomenon can seriously affect satellite-earth links at frequencies above 10 GHz and at very low elevation angles (=5 degrees).

 Abstract The research of gravity solitary waves movement is of great significance to the study of ocean and atmosphere. Baroclinic atmosphere is a complex atmosphere, and it is closer to the real atmosphere. Thus, the study of gravity waves in complex atmosphere motion is becoming increasingly essential. Deriving fractional partial differential equation models to describe various waves in the atmosphere and ocean can open up a new window for us to understand the fluid movement more deeply. Generally, the time fractional equations are obtained to reflect the nonlinear waves and few space-time fractional equations are involved. In this paper, using multiscale analysis and perturbation method, from the basic dynamic multivariable equations under the baroclinic atmosphere, the integer order mKdV equation is derived to describe the gravity solitary waves which occur in the baroclinic atmosphere. Next, employing the semi-inverse and variational method, we get a new model under the Riemann-Liouville derivative definition, i. Furthermore, the symmetry analysis and the nonlinear self-adjointness of STFmKdV equation are carried out and the conservation laws are analyzed. Finally, adopting the method, we obtain five different solutions of STFmKdV equation by considering the different cases of the parameters. Particularly, we study the formation and evolution of gravity solitary waves by considering the fractional derivatives of nonlinear terms. Introduction With the intercross and penetration of different knowledge, Rossby solitary waves have been applied to many fields successfully, such as physical oceanography, atmospheric science, hydraulic engineering, and communication engineering. Particularly, Rossby solitary waves have important theoretical significance and research value in marine atmospheric science. They have largely determined the impact of the oceans on the atmosphere and other climate change. On the time scale, the energy of Rossby waves determines the ocean energy spectrum, which makes the energy spread from east to west to form and maintain a strong ocean boundary flow, such as Kuroshio, Gulfstream, and East Australian flow. Great achievements have been made in this regard. As we know, Rossby solitary waves in the westerly shear flow were first found by Long [1]. He found that the amplitude of the Rossby waves satisfied KdV equation by the -plane approximation With the development of Rossby waves theory, Wadati [2] derived the modified KdV equation In view of the barotropic fluid and stratified fluid model, the KdV model and the mKdV model are also generated to describe the generation and evolution of Rossby solitary waves by Redekopp [3]. Apart from the KdV model and the mKdV model, for other initial disturbance, employing a different time and space stretching transform, Boussinesq equation was derived by Meng and Lv [4]. Afterwards, the Rossby parameters along with the changes of latitude were discussed by Luo [5] and generalized -plane approximation was obtained. In recent years, in the theoretical study of Rossby waves, many new wave equations were obtained to describe the generation and evolution of various types of fluctuations in the ocean [6 , 7], such as NLS equation, ILW-Burgers equation, and ZK-Burgers equation. In the past, predecessors studied wave equations in the barotropic atmospheric environment by using the -plane approximation. But we know that the basic dynamic equations for describing the baroclinic atmospheric movement are more in line with the actual situation and are very complicated. And the baroclinic problem in real atmosphere is inevitable [8]. In this paper, starting with the basic equations adopting the Bousinesq approximation [9] and under the baroclinic atmospheric environment, using multiscale analysis and turbulence method, we get a new model mKdV to describe the Rossby solitary waves. The advantages of basic equations are as follows: The equations are multivariate, and the physical meaning of each variable is clear; The baroclinic atmosphere problem is considered to help us understand the generation and evolution of isolated waves in the ocean. In recent years, the study of integer partial differential equations has yielded many brilliant achievements [10 â€” 15]. Simultaneously, it has been found that fractional order partial differential equations also play an important role in many fields [16 â€" 22]. The fractional differentiation calculus [23 , 24] was first developed by Liouville primary. Liouville expands the function into an exponential form and defines the -order derivatives of this expanded form term by term. Afterwards, Riemann proposed a different definition that can be implemented to a power series with a negative power term. Finally, Ross and Oldham [25 , 26] unified the two definitions, so that the application of fractional differential was further developed. Subsequently, a version of the Euler-Lagrange equations for problems of calculus of variation with fractional derivatives was formulated by Riewe in s [27 , 28]. Recently, Agrawal [29 , 30] studied the fractional Euler-Lagrange equation deeper and a series of new methods have been put forward in his research, which provide a new idea for us to study fractional partial differential equations [31 , 32]. The fact has shown that the new fractional equation is more suitable than the integer order equation due to the precise description of the nonlinear phenomena[33 , 34]. At the same time, in the field of oceanography, the fractional partial differential equation can better describe the generation and evolution of solitary waves, which is more favorable for us to study the theory of fluctuation. Similar to the study of integer order differential equation, the conservation laws of the fractional differential equation are an important branch. Lie symmetry analysis was proposed by Sophus Lie. The main idea of this method is that the infinitesimal transformation keeps the solution set of the partial differential equation unchanged. The Lie symmetry analysis offers an efficient and powerful tool for the study of conservation laws of fractional partial differential equation [38 â€" 42]. For this reason, the researchers are very interested in studying the symmetry analysis of fractional differential equations. As far as we know, in the past, the symmetric method was only used for time fraction partial differential equations TFPDE , but has not been used to analyze space and time fraction partial differential equations STFPDE [43 , 44]. By studying the work of predecessors, we can find that several methods have been used to solve nonlinear partial differential equations, such as the trial equation method [47 , 48], Hirota bilinear method [49], binary nonlinearization method [50], Darboux transformation method [51], Jacobi iteration method [52], -expansion method [53 â€" 55], -function method [48], sub-equation method [56], and others [57 , 58]. Therefore, it is an important task to find an accurate and effective method to solve the fractional differential equation. This paper is organized as follows: In Section 2 , using multiscale analysis and turbulence method, from the basic dynamic multivariable equations under the baroclinic atmosphere [59 , 60], the integer order mKdV equation is derived. In Section 3 , we use the semi-inverse method to derive the Lagrangian form of the mKdV equation [61 , 62] firstly. Then the Lagrangian space and time operator of the mKdV equation have been transformed into the fractional domain of the left Riemann-Liouville fractional differential operator. In Section 4 , we first study the symmetry analysis of the fractional equation to obtain the corresponding infinitesimal generator of the equation. Then we discuss the nonlinear self-adjointness of the STFmKdV equation and finally get the conservation vectors of the equation. In Section 5 , based on the STFmKdV equation, employing the method, and considering the different cases of the parameters , we obtain five different solutions of the equation. Derivation of the mKdV Equation Using the sum of disturbance pressure gradient force and buoyancy force expressing the vertical pressure gradient force and gravity force, and adopting the Bousinesq approximation [60], the dimensionless basic dynamic equations of atmospheric motion are as follows [59]: Because the second term of the fourth formula in the left side is lesser, we get the following approximation:

Chapter 8 : Lecture 14 (Waves, Wave Equation and Intensity)

The amplitude-probability distribut ion function of atmospheric radio noise can be predicted with reasonable accuracy for a give n bandwidt h using only the first two moments of the noise measured at t hat bandwidth.

Now the range of that cycle is growing as more CO2 is emitted from the burning of fossil fuels and other human activities, according to a study led by Scripps Institution of Oceanography, UC San Diego. Observations of atmospheric CO2 made by aircraft at altitudes between 3 and 6 kilometers 10,, feet show that seasonal CO2 variations have substantially increased in amplitude over the last 50 years. This means that more carbon is accumulating in forests and other vegetation and soils in the Northern Hemisphere during the summer, and more carbon is being released in the fall and winter, said study lead author Heather Graven, a postdoctoral researcher in the Scripps CO2 Program led by geochemist Ralph Keeling. It is not yet understood why the increase in seasonal amplitude of CO2 concentration is so large, but it is a clear signal of widespread changes in northern ecosystems. The researchers compared recent aircraft data with older aircraft data gathered from to using U. These aircraft measurements were done at the same time C. Carbon dioxide concentrations in the atmosphere varied between and parts per million over the past , years. By the time C. Keeling began collecting data at Mauna Loa in , the concentration had risen to about parts per million. In May , daily CO2 measurements at Mauna Loa exceeded parts per million for the first time in human history. The aircraft repeatedly ascended and descended from a few hundred meters to roughly 12 kilometers 40, feet between the North Pole and the coast of Antarctica to construct a unique snapshot of the chemical composition of the atmosphere. Additional recent data comes from regular flights conducted at a network of locations by NOAA. Increasing CO2 amplitude since had already been observed at two ground-based stations: Mauna Loa and Barrow, Alaska. The aircraft-based observations uniquely show the large area in the northern high latitudes where CO2 amplitude increased strongly since The reasons for the wider seasonal swings in CO2 concentration remain to be determined, said researchers. Even though plant activity can increase with warmer temperatures and higher CO2 concentrations, the change in CO2 amplitude over the last 50 years is larger than expected from these effects, the researchers said. Additional factors may involve changes in the amount of carbon allocated to leaves, wood, or roots, changes in the extent or species composition of the ecosystems, or changes in the timing of photosynthesis and respiration. Simulating complex processes in terrestrial ecosystems with models is recognized to be a challenge, and the observed change in CO2 amplitude is larger than simulated by models used by the Intergovernmental Panel on Climate Change IPCC. While this underestimate does not call into question the response of climate to CO2 concentration in the IPCC models, it does suggest that a better understanding of what happened over the last 50 years could improve projections of future ecosystem changes. The bottom line is that northern ecosystems appear to be behaving differently than they did 50 years ago, said study authors. Note to broadcast and cable producers: University of California San Diego provides an on-campus satellite uplink facility for live or pre-recorded television interviews. Please phone or email the media contact listed above to arrange an interview. About Scripps Oceanography Scripps Institution of Oceanography at the University of California San Diego, is one of the oldest, largest, and most important centers for global science research and education in the world. Now in its second century of discovery, the scientific scope of the institution has grown to include biological, physical, chemical, geological, geophysical, and atmospheric studies of the earth as a system. Hundreds of research programs covering a wide range of scientific areas are under way today on every continent and in every ocean. Scripps operates oceanographic research vessels recognized worldwide for their outstanding capabilities. Equipped with innovative instruments for ocean exploration, these ships constitute mobile laboratories and observatories that serve students and researchers from institutions throughout the world. Birch Aquarium at Scripps serves as the interpretive center of the institution and showcases Scripps research and a diverse array of marine life through exhibits and programming for more than , visitors each year. Learn more at scripps. Today, as one of the top 15 research universities in the world, we are driving innovation and change to advance society, propel economic growth, and make our world a better place. Learn more at www.

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Chapter 9 : Acoustics Chapter One: What is Amplitude?

atmospheric tideswill have to serve as a surrogate for all the omittedhistories of other topics we have covered. As such it is a relatively good choice.