GRACE Education Curriculum Intro – Background Information	
Teachers	Grades K-12

GRAVITY RECOVERY AND CLIMATE EXPERIMENT
Get ready to launch with GRACE in 2002!

Mission Objectives:

- A new model of the Earth's gravity field with unprecedented accuracy every 30 days for 5 years.
- Changes due to surface and deep currents in the ocean.
- Runoff and ground water storage on land mass.
- Exchanges between ice sheets or glaciers and the oceans.
- Variations of mass within the Earth.
- Creating a better profile of the Earth's atmosphere.

The results from GRACE will make a huge contribution to the goals of NASA's Earth Science Enterprise, Earth Observation System (EOS) and global climate change studies.

GRACE Unravels Global Climatic Issues By:

- Enabling a better understanding of ocean surface currents and ocean heat transport
- Measuring changes in sea-floor pressure
- Watching the mass of oceans change
- Measuring the mass balance of ice sheets and glaciers
- Monitoring changes in the storage of water and snow on the continents

Mission Characteristics:

- Launch into polar orbit from Plesetsk, Russia near the next solar maximum.
- Two satellites in tandem formation loosely controlled, 170 to 270 km apart.
- Initial orbit altitude is approximately 480 km, decays to re-entry near the solar minimum.
- The dual launch of the twin GRACE - Gravity Recovery And Climate Experiment satellites on ROCKOT launched March 17, 2002 from Eurockot's dedicated launch facilities at Plesetsk in Northern Russia. Mission life is approximately 5 years.

- The mission lifetime is divided into five phases. These are the Pre-Launch Phase, Launch and Early Operations Phase (LEOP), the Commissioning Phase, the Validation Phase and the Observational Phase.
- The re-ignitable third stage BREEZE will be used to place both satellites in the same nominal orbit. The GRACE mission will be launched just past the solar flux maximum of Cycle 23.
- The altitudes of the two satellites will decay in tandem, from near 500 km at the beginning of the mission, to 300 km and lower at the end of mission.

The Instrument for the mission will be the Twin GRACE Satellites:

- Variations in the gravity field cause the range between the two satellites to vary.
- The relative range is measured by a high-accuracy p-wave link, which is integrated with a GPS receiver.
- The measured range variations are corrected for non-gravitational effects by an electrostatic accelerometer.

Mission Management provided by: International United States/German Team.

The Primary Goal of the GRACE Mission is to provide, with unprecedented accuracy:

- Estimates of the global high-resolution models of the Earth's gravity field for a period of up to 5 years.
- A temporal sequence of approximately monthly estimates to provide the mean (or static) gravity field, as well as a time history of its temporal variability.
- Several hundred globally distributed profiles each day of the excess delay, or bending angle of the GPS measurements due to ionosphere and the atmosphere, using GPS limb sounding. Just as light is refracted as it passes through water, the GPS signals are refracted as they pass through the atmosphere. The GPS receiver tracks refracted signals from the GPS satellites as they rise or set through the Earth's atmosphere. This measurement is known as ***occultation***. Each occultation lasts about one minute. Electron density studies will be conducted using GPS signals from all GPS satellites. The GRACE occultation measurements will be made throughout the mission life to assist in predicting global weather.

Applications of GRACE

Earth System Science and Gravity

- Several areas of scientific concern in the Earth System Sciences would benefit from accurate measurements of the Earth's gravity field.
- Gravity field measurements serve as integral constraints on mass distribution and variations in the combined solid Earth, oceans and atmosphere system.
- Mapping of the Earth's gravity field from space offers global, continuous and homogeneous high quality monitoring of the static and time variable components of the Earth's gravity field.
- Potential areas of impact include Oceanography, Hydrology, Glaciology, the Solid Earth Sciences and Geodesy.

Earth Gravity from Space

The need for high accuracy, global measurements of the static and time variable components of the Earth's gravity field has been articulated consistently over the last decades by:

- Williamstown Report (1969)
- US National Research Council (1971, 1978, 1979, 1985, 1986, 1987, 1988, 1991, 1995, 1997)
- NASA (1986, 1991)
- ESA (1978, 1991, 1996)
- Erice Report (1988)

Dedicated spaceflight missions provide the best opportunity for obtaining highly accurate measurements of the Earth's gravity field variations with a homogeneous quality, and with global and continuous coverage.

Advantages of Dedicated Space-Based Geopotential Missions:

- Global coverage
- Homogeneity of data quality
- Clean space environment enables high accuracy
- Cost-effective long term monitoring

Gravity and Earth System Science:

Measurements of the Earth's gravity field from space provide integral constraints (necessary restrictions) on global mass variations in the Solid Earth-Oceans-Atmosphere System

- Oceanography: (Gravity + Radar Altimetry)
  - Absolute Surface Currents
  - Upper Ocean Heat Content and Heat Flux
  - Deep Ocean Currents and Mass Transport
  - Long Term Sea-Level Change

- Hydrology: (Gravity + in-situ data)
  - Evapo-transpiration and Soil Moisture Changes
  - Aquifer depletion

- Glaciology: (Gravity + Ice-Sheet Altimetry + in-situ data)
  - Polar Ice Sheet Mass Variations (Global Sea Level Change)
  - Post-Glacial Rebound

- Solid Earth Sciences: (Gravity + in-situ data)

- Mantle & Lithospheric Density Variations

- Geodesy:
  - Precise Positioning and Orbit Determination

Additional background information is available from the GRACE Brochure which can be accessed from the publications section of the GRACE homepage: http://www.csr.utexas.edu/grace