

# Near Earth Objects

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# Outline

- **Near Earth Objects**
  - What are Near Earth Objects?
  - What are the hazards?
  - Is the Earth at risk?
  - What are the issues?

**What are Near Earth Objects?**



**COMET**

**or**

**ASTEROID**

**with orbit within 0.3 AU of Earth**

**1 AU = 150,000,000 km**

**Potentially Hazardous if within 0.05 AU (7,500,000 km) and size > 150m**

# Short and Long Period Comets originate from Outer Solar System

KUIPER BELT

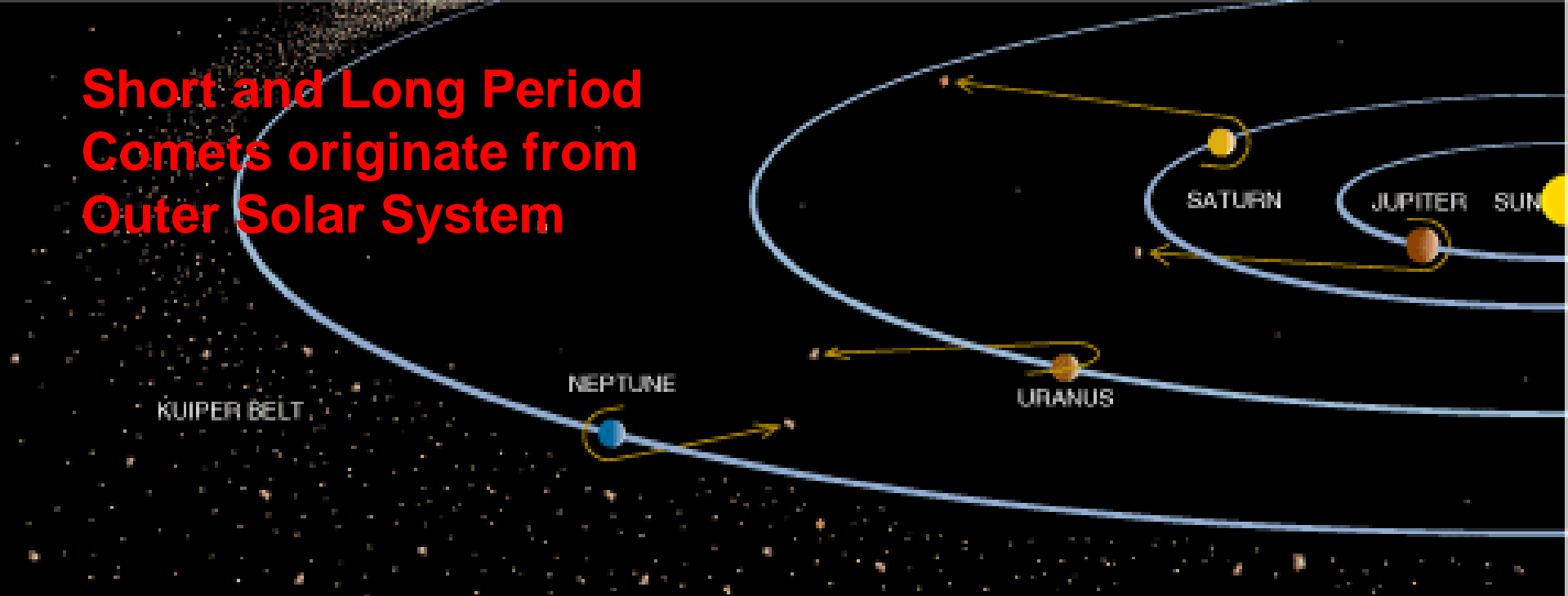
NEPTUNE

URANUS

SATURN

JUPITER

SUN



**Near Earth Asteroids are  
believed to originate from  
Inner Solar System**

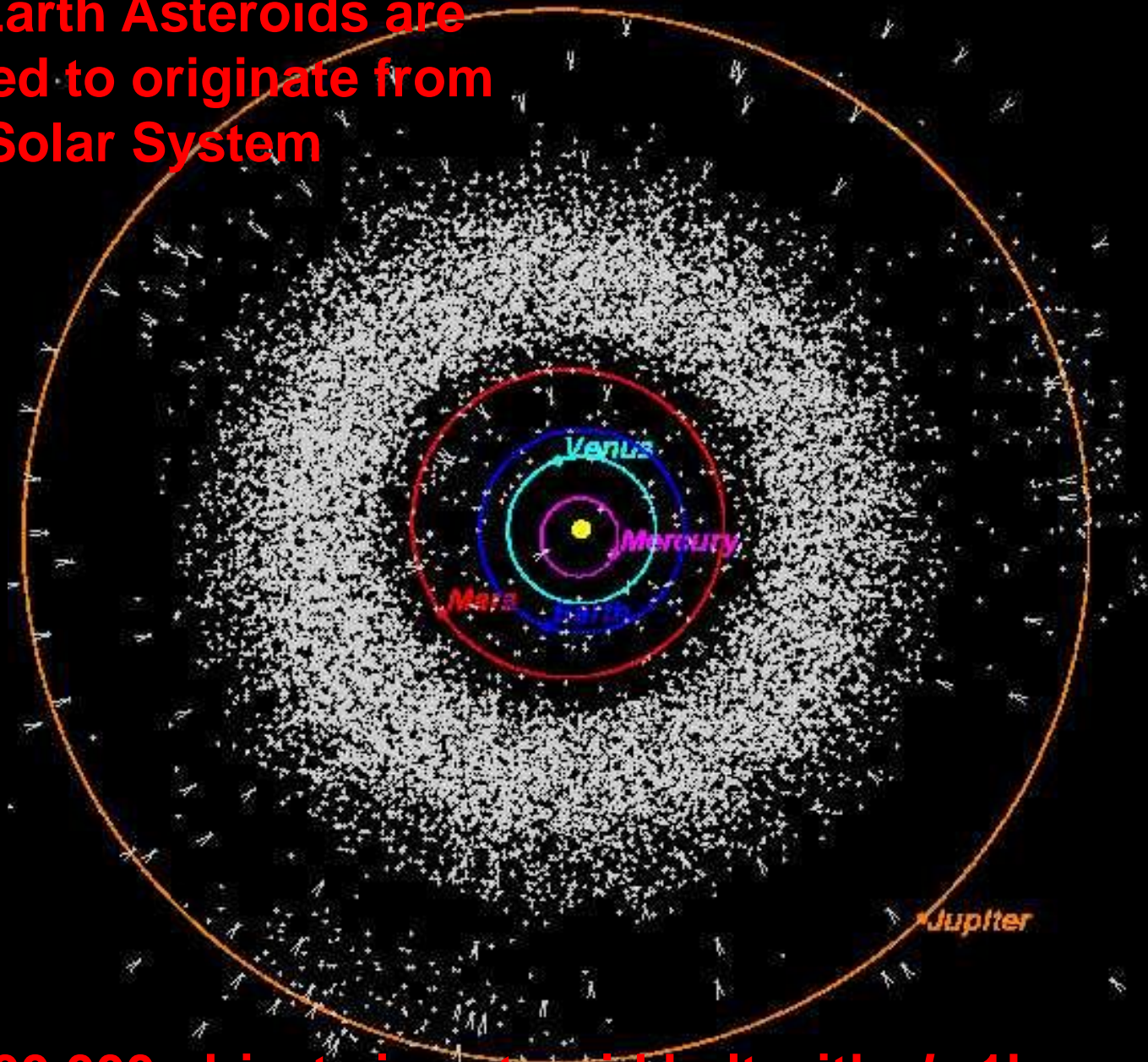
*Mercury*

*Venus*

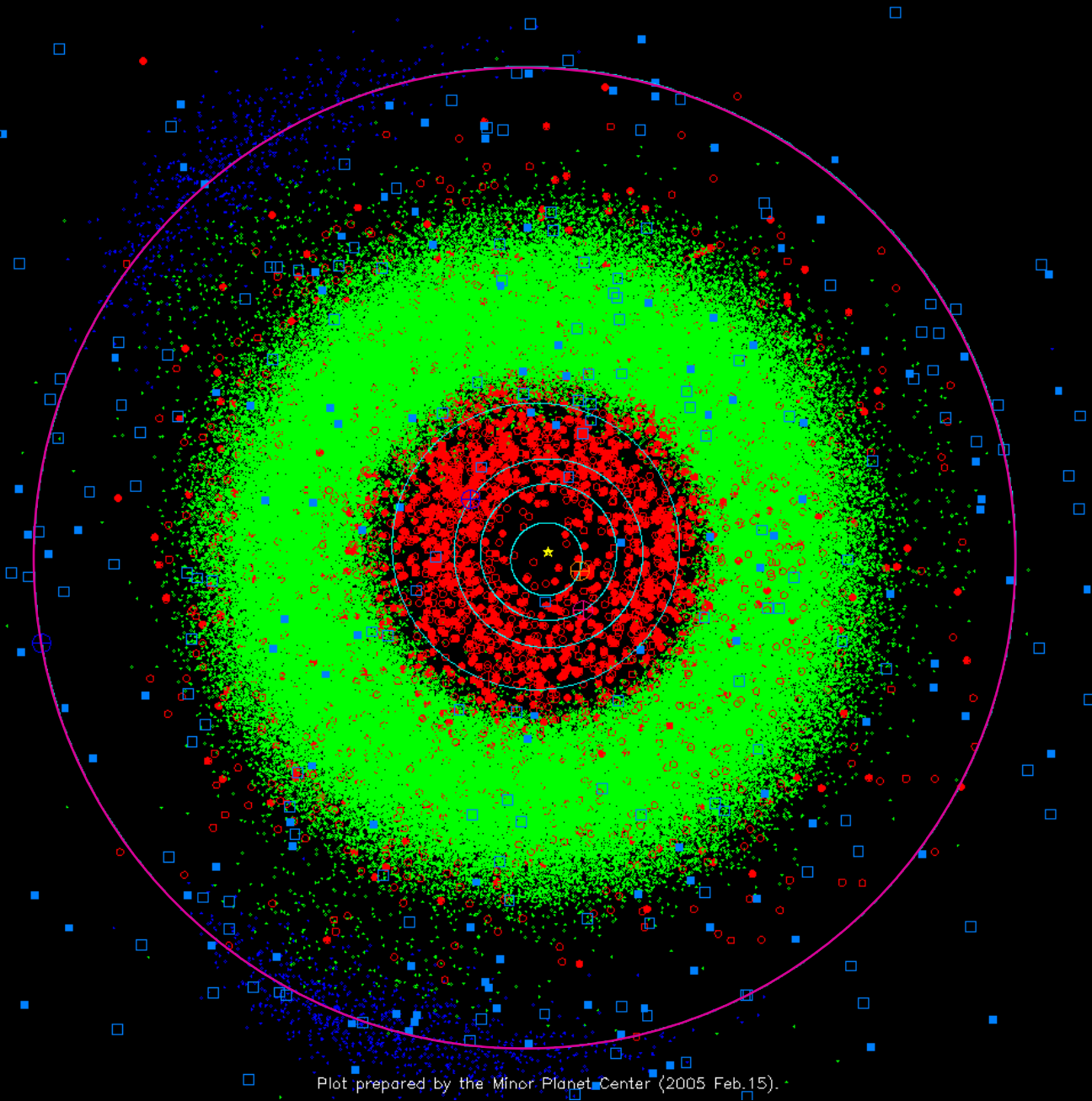
*Earth*

*Mars*

*Jupiter*



**1,000,000 objects in asteroid belt with  $d > 1\text{km}$**



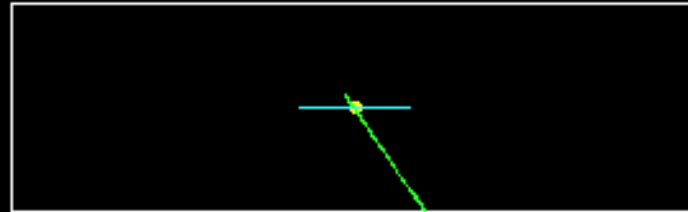
**Only a small percentage of comets and asteroids are NEOs**

Plot prepared by the Minor Planet Center (2005 Feb.15).

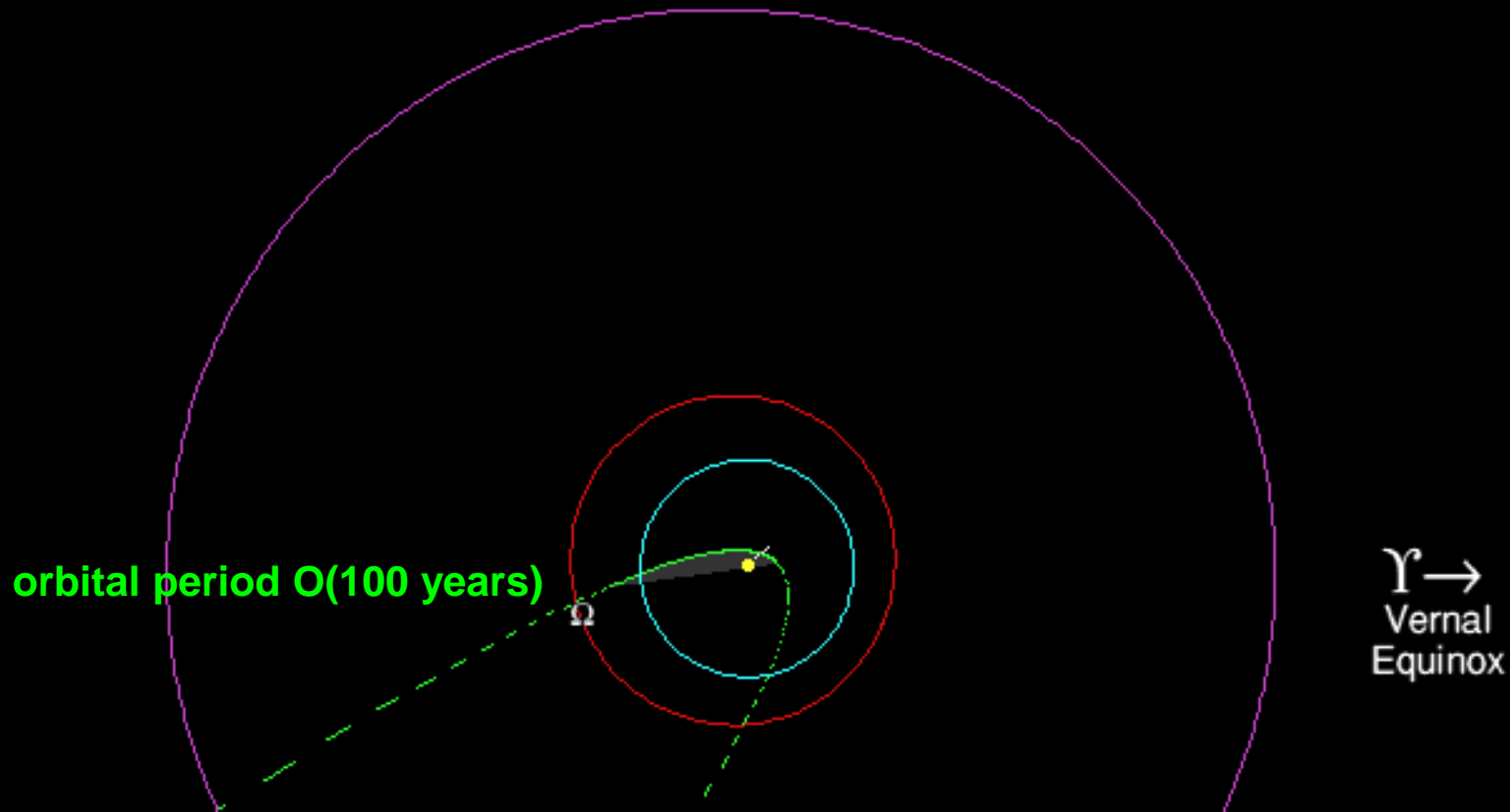
# LONG PERIOD COMETS

## C/1996 B2 (Hyakutake)

Ecliptic View Along The Asc.-Desc. Nodal Line



North Ecliptic Polar View



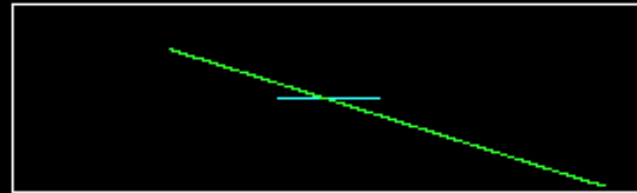
orbital period O(100 years)

$\Upsilon \rightarrow$   
Vernal  
Equinox

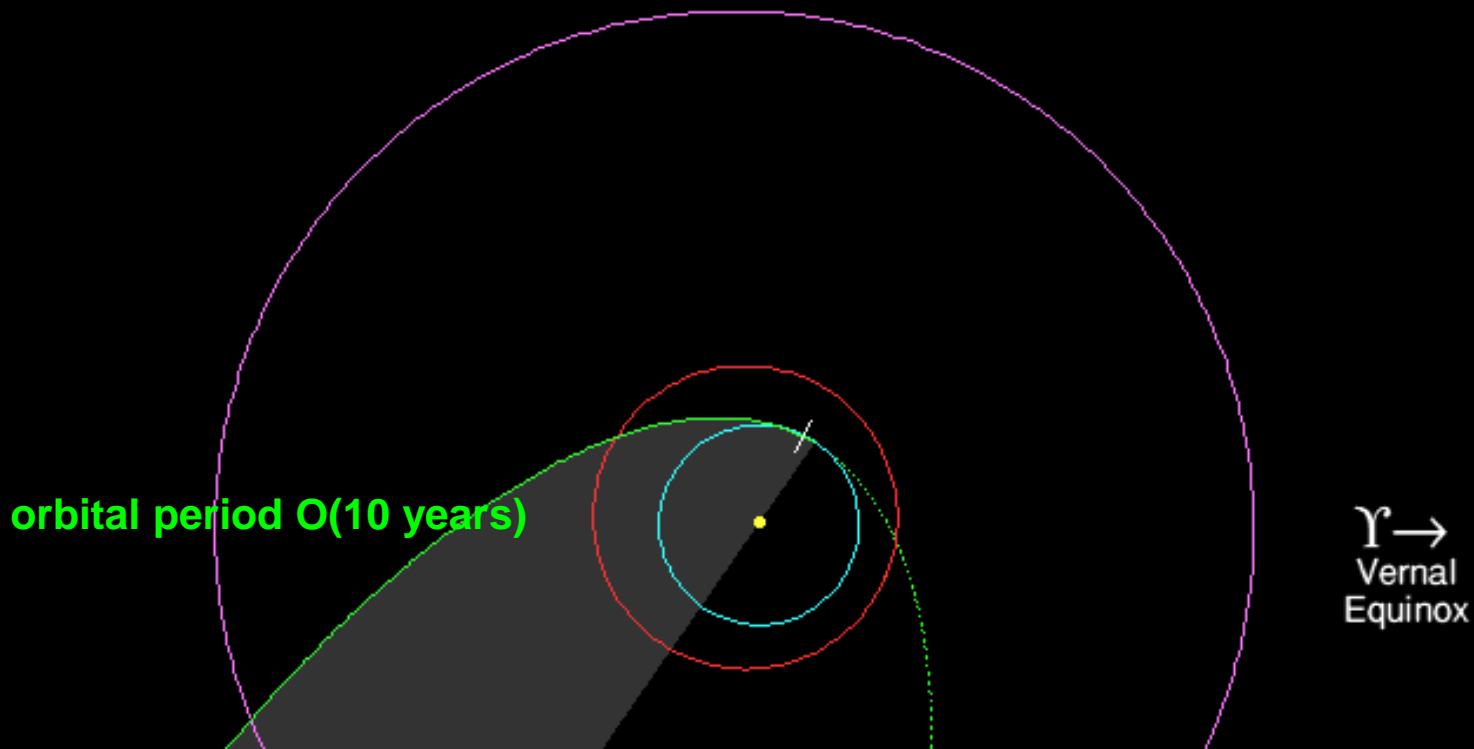
# SHORT PERIOD COMETS

## 55P/Tempel-Tuttle

Ecliptic View Along The Asc.-Desc. Nodal Line



North Ecliptic Polar View



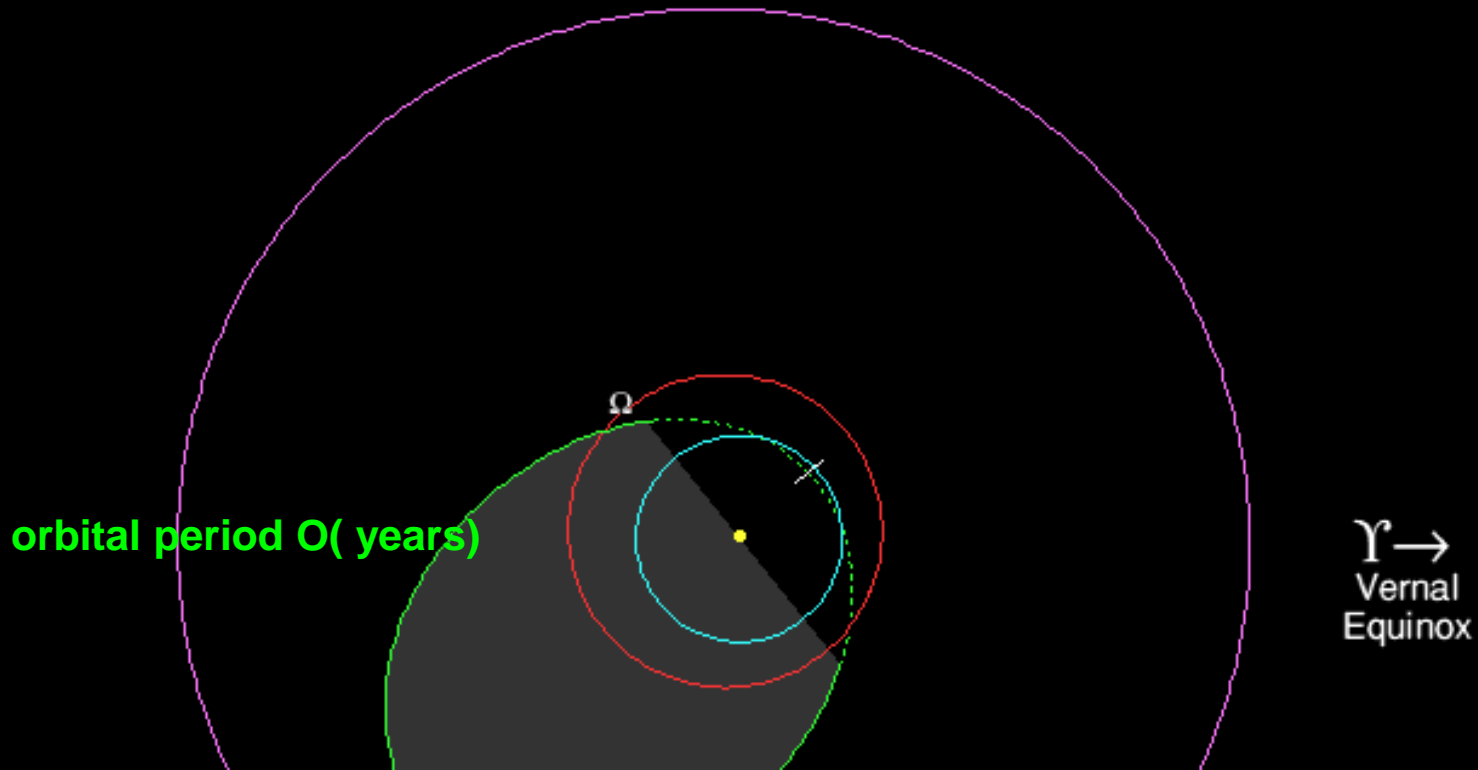
# NEAR EARTH ASTEROIDS

## (4179) Toutatis

Ecliptic View Along The Asc.-Desc. Nodal Line



North Ecliptic Polar View



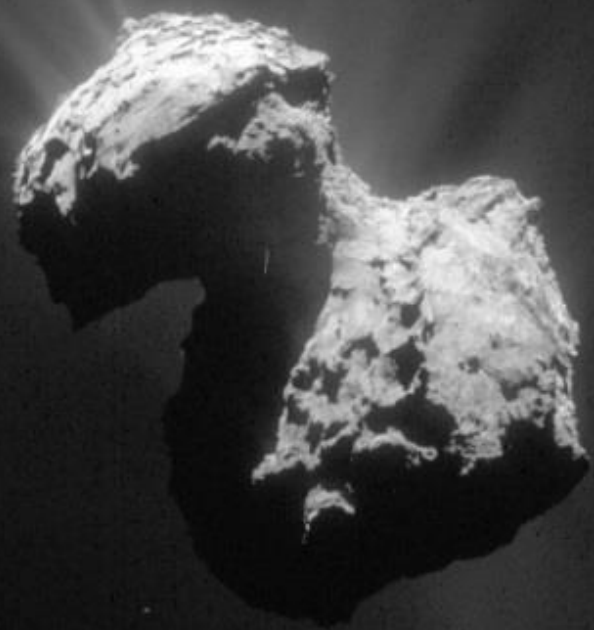


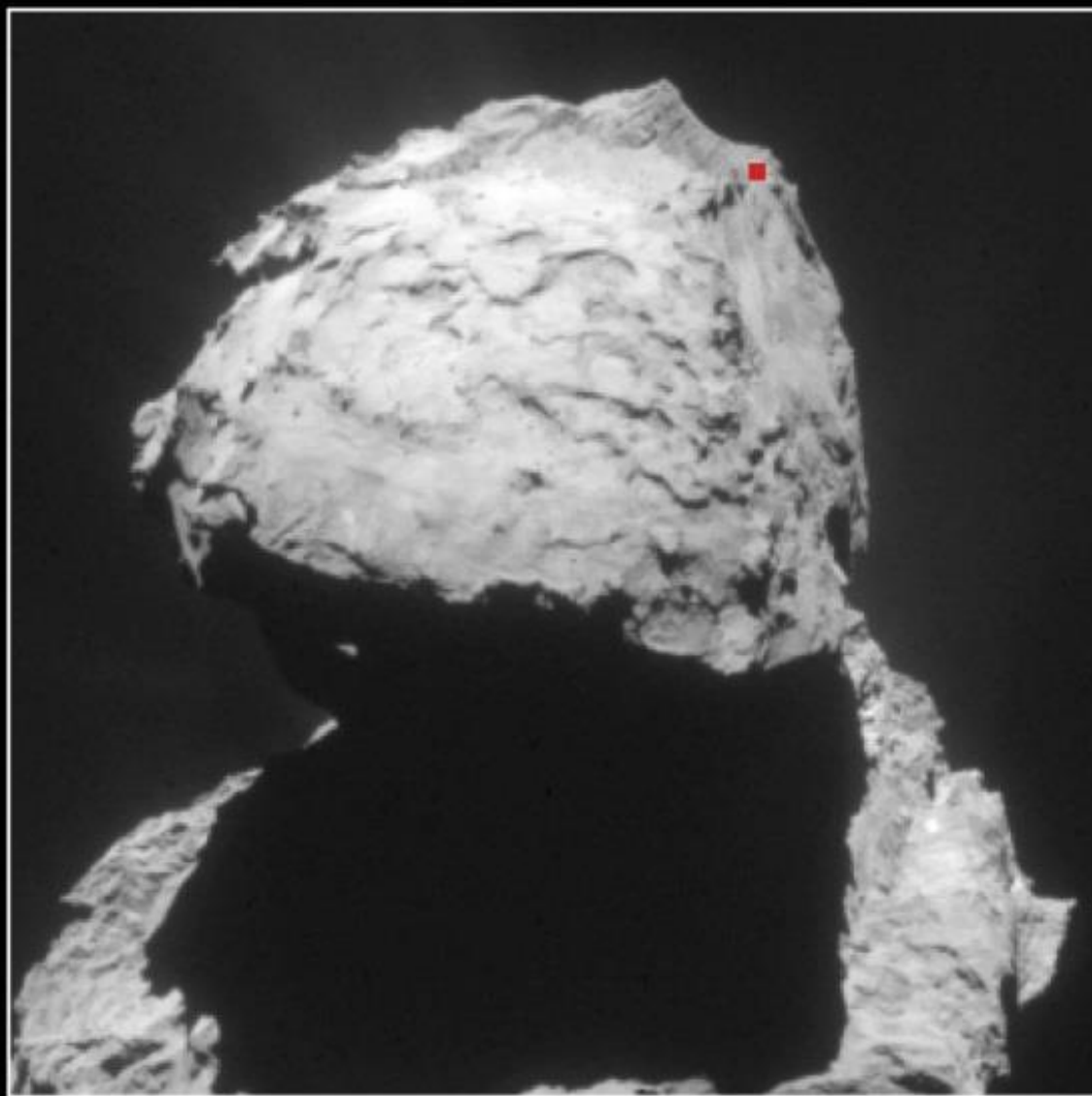
**Comets and asteroids are detected from ground by their motion relative to star background**



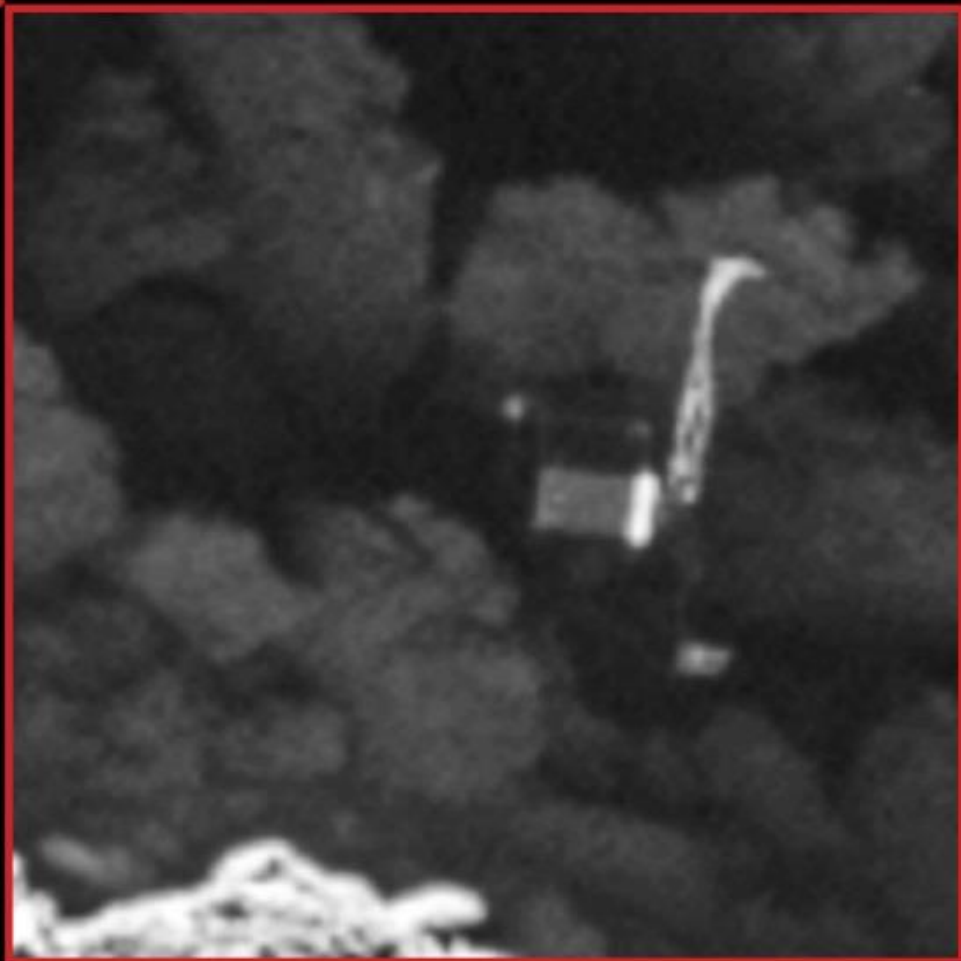
NEAR - 433 Eros

March 07 2000 03:10:00 -27 -158



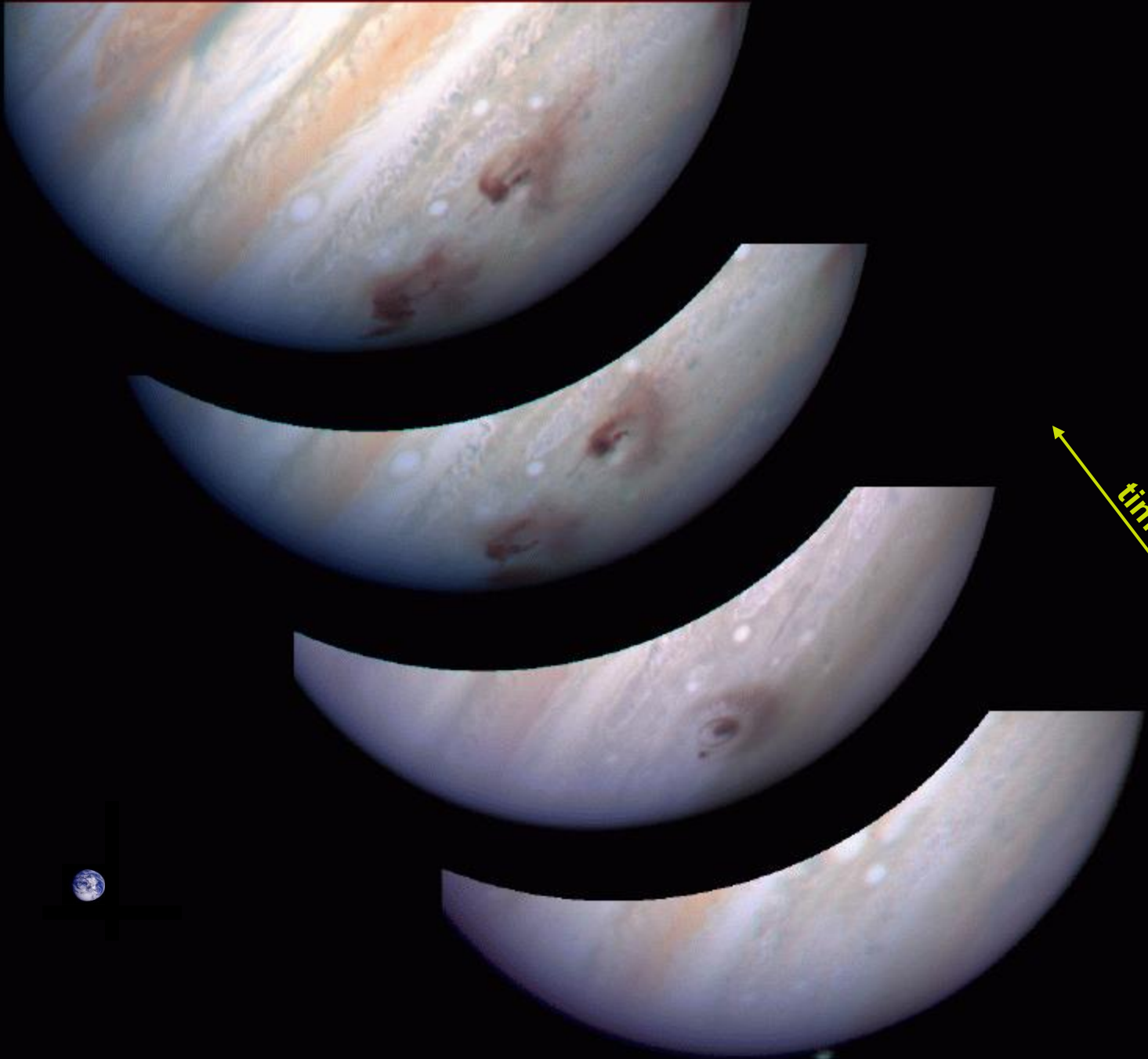






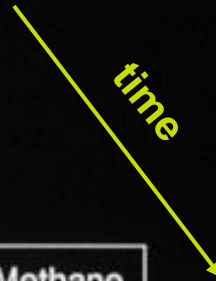
**What are the hazards?**



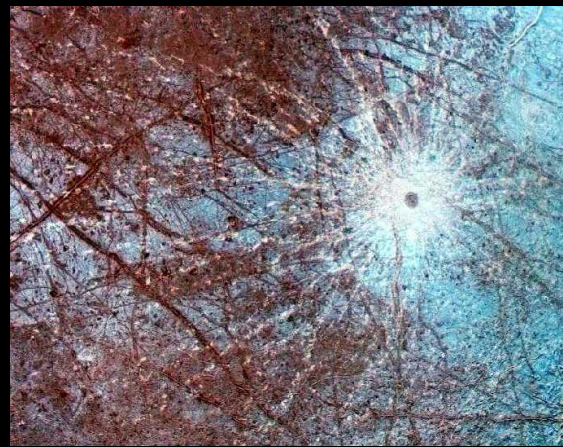
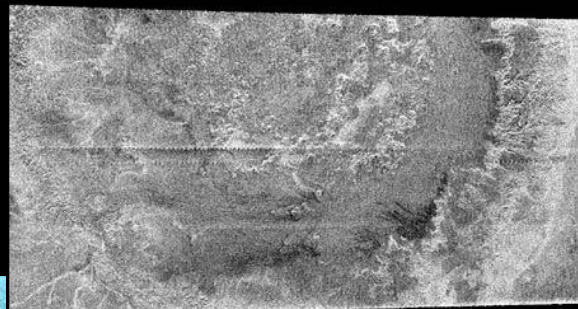
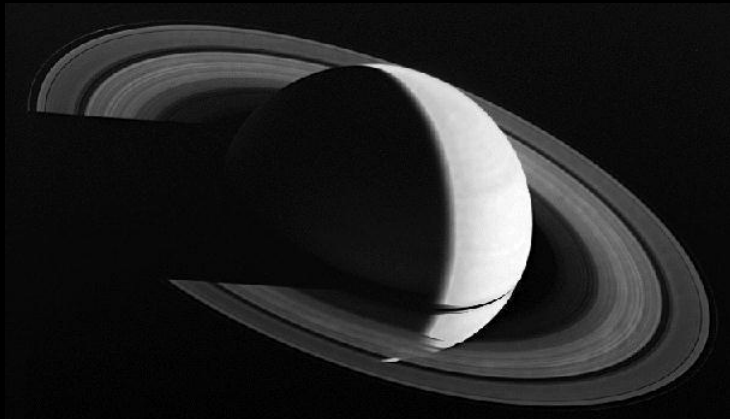


# Jupiter • W Impact

July 22, 1994



Hubble Space Telescope  
Wide Field Planetary Camera 2



**Is the Earth at risk from NEOs?**







**AIR-BURST**



**Tunguska, Siberia**  
**1908, stone asteroid**  
**2000 sq km of forest flattened**



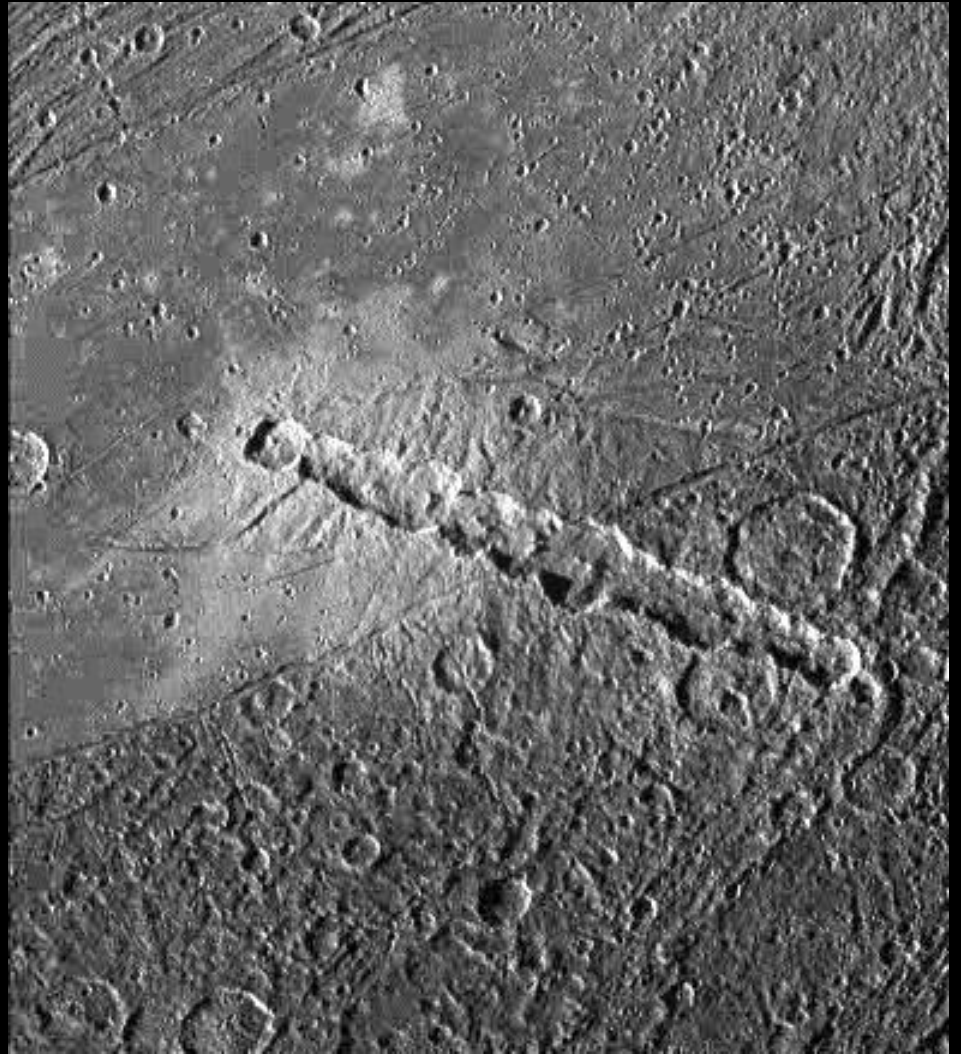
**Barringer Crater, Arizona**  
**49,000 years ago**  
**nickel-iron asteroid**





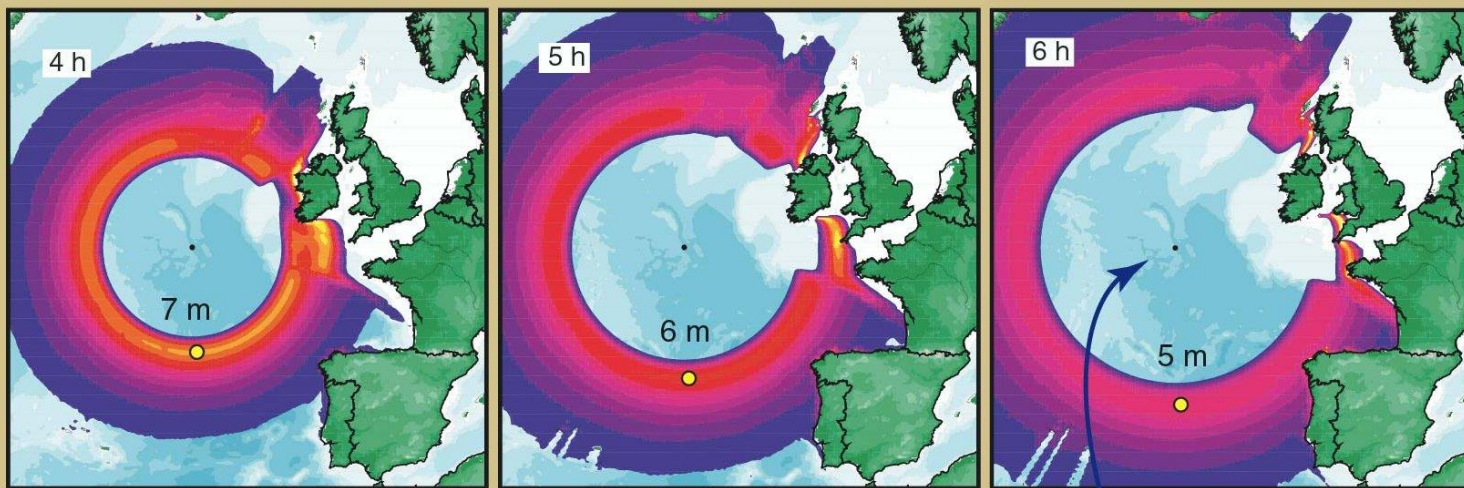
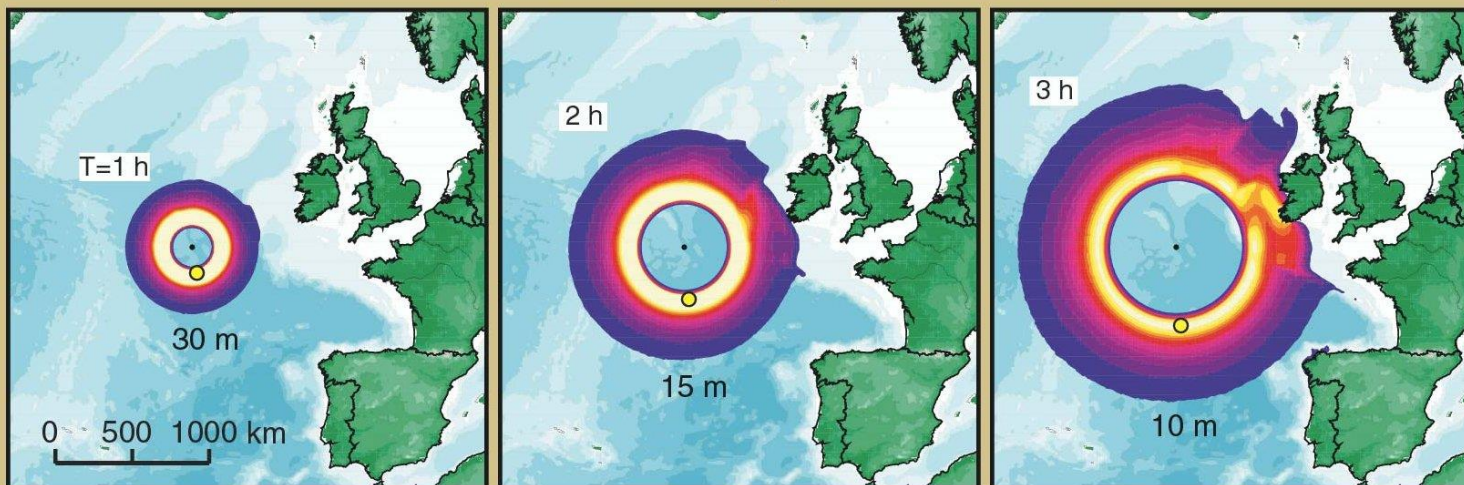


**Multiple impacts are common (e.g. Moon and Gannymede)**





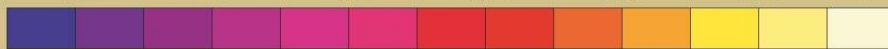
# North Atlantic Impact Tsunami



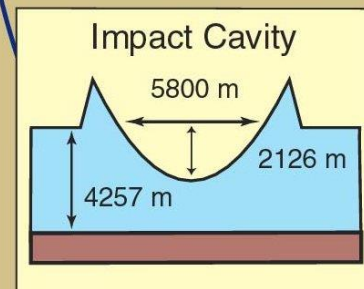
Impactor Diameter= 200 m    Water Depth at Impact= 4257 m

Tsunami Energy=  $2.8 \times 10^{17}$  J     $T_{\min} = 50$ s

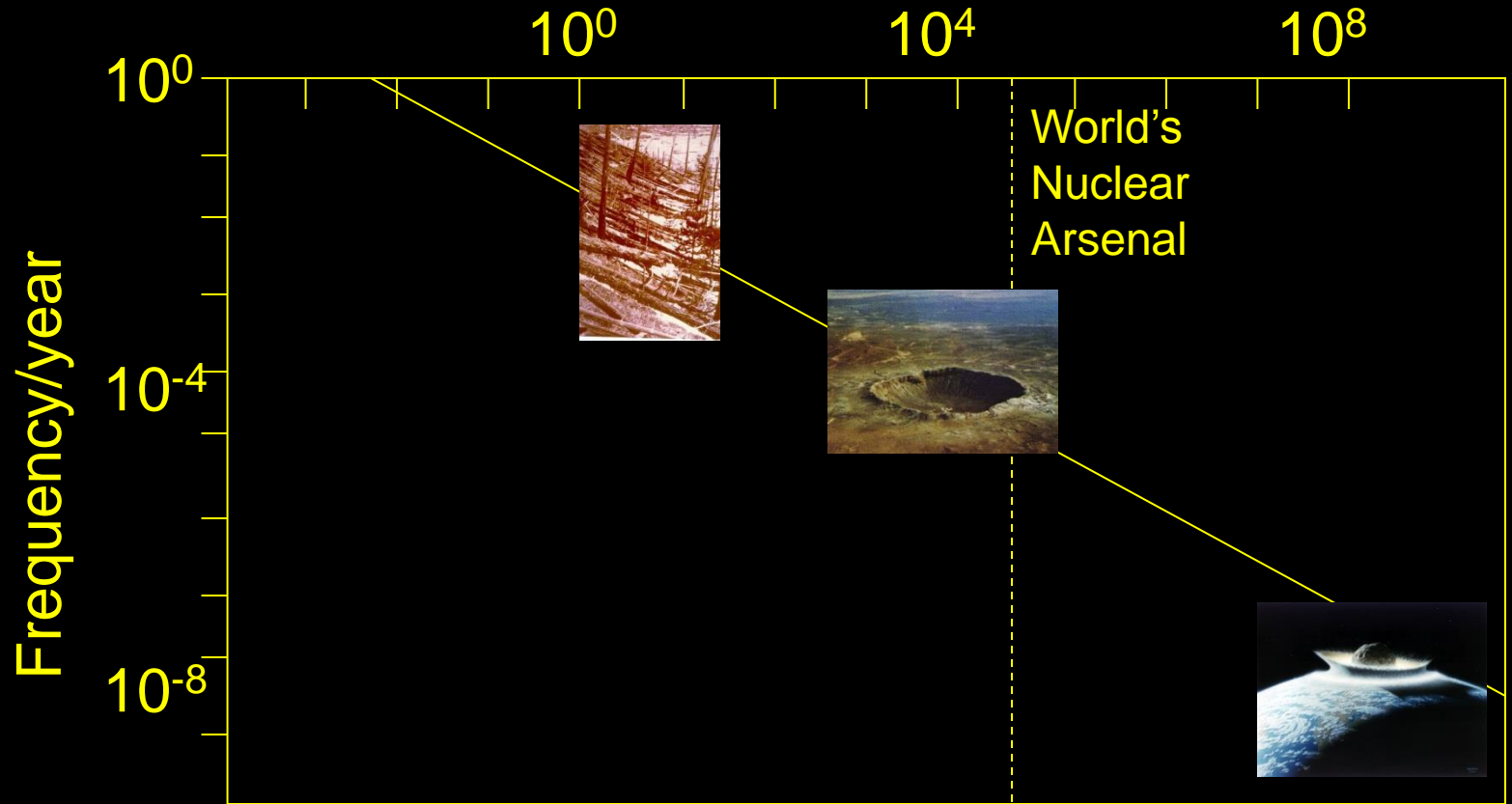
1.5    3.0    4.5    6.0    7.5    9.0    >9.75



Tsunami Envelope Height in Meters

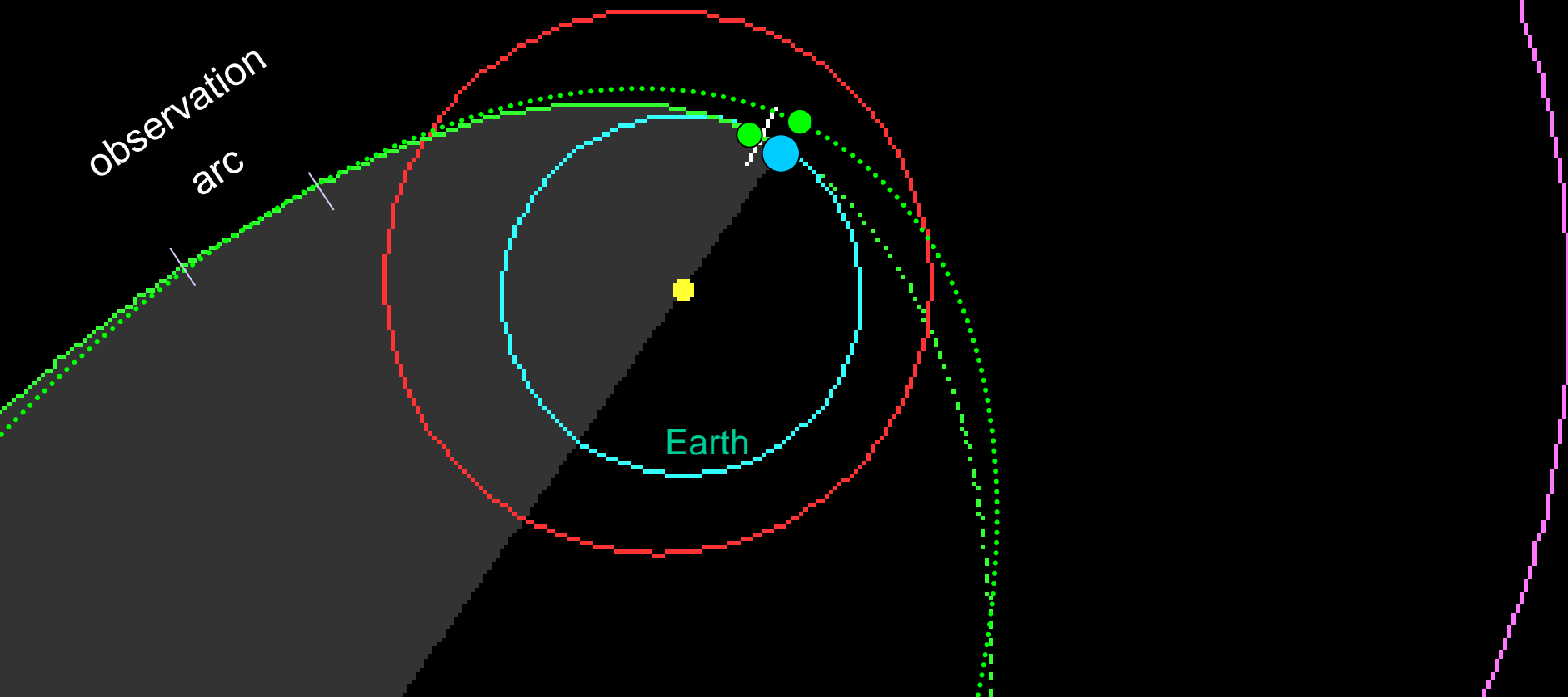


# Megatons TNT Equivalent



Major uncertainty is frequency, small data set

# Accurate impact probability requires extensive observational data

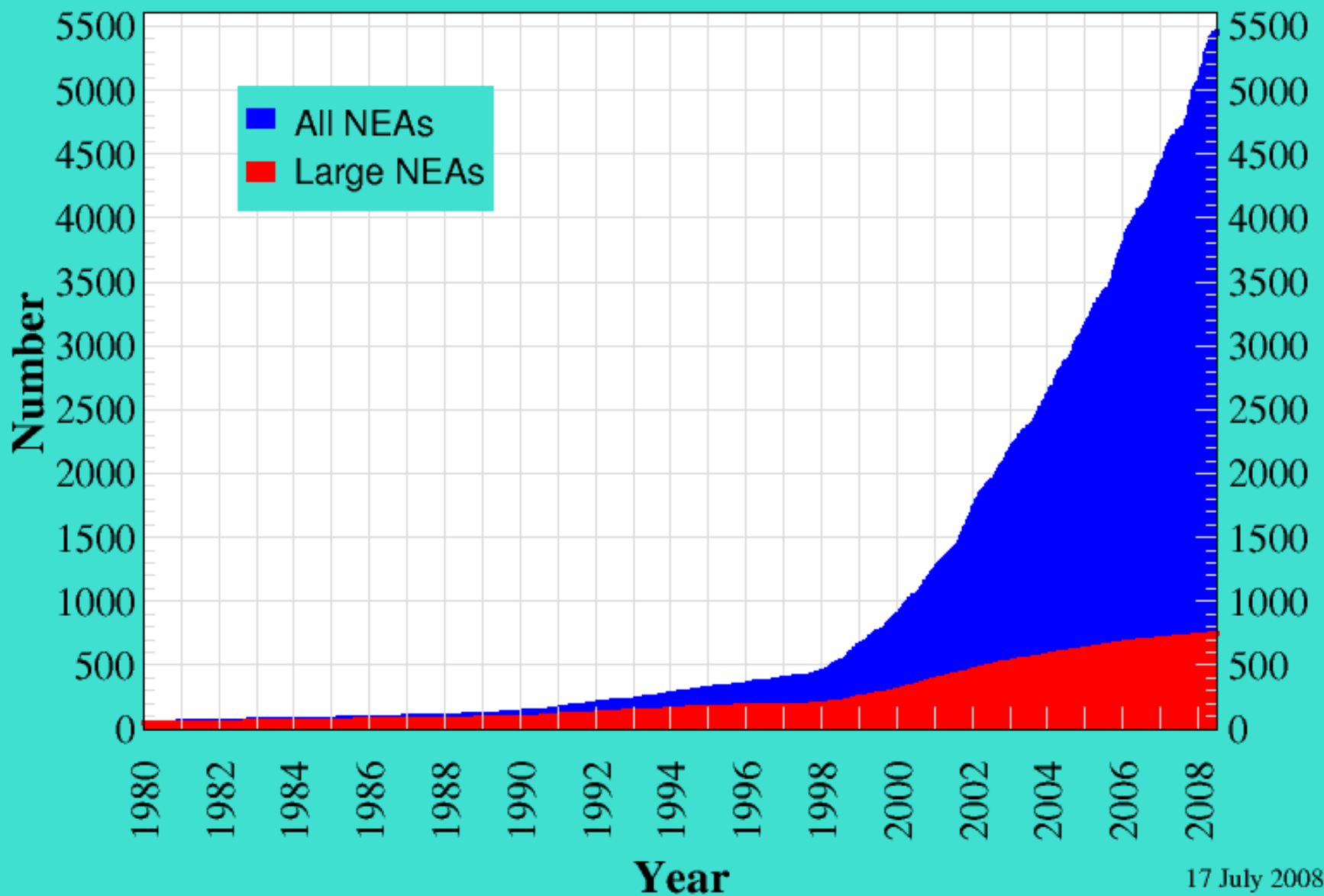


**Carancas, Peru  
2007 impact crater**



# Known Near-Earth Asteroids

1980-Jan through 2008-Jun



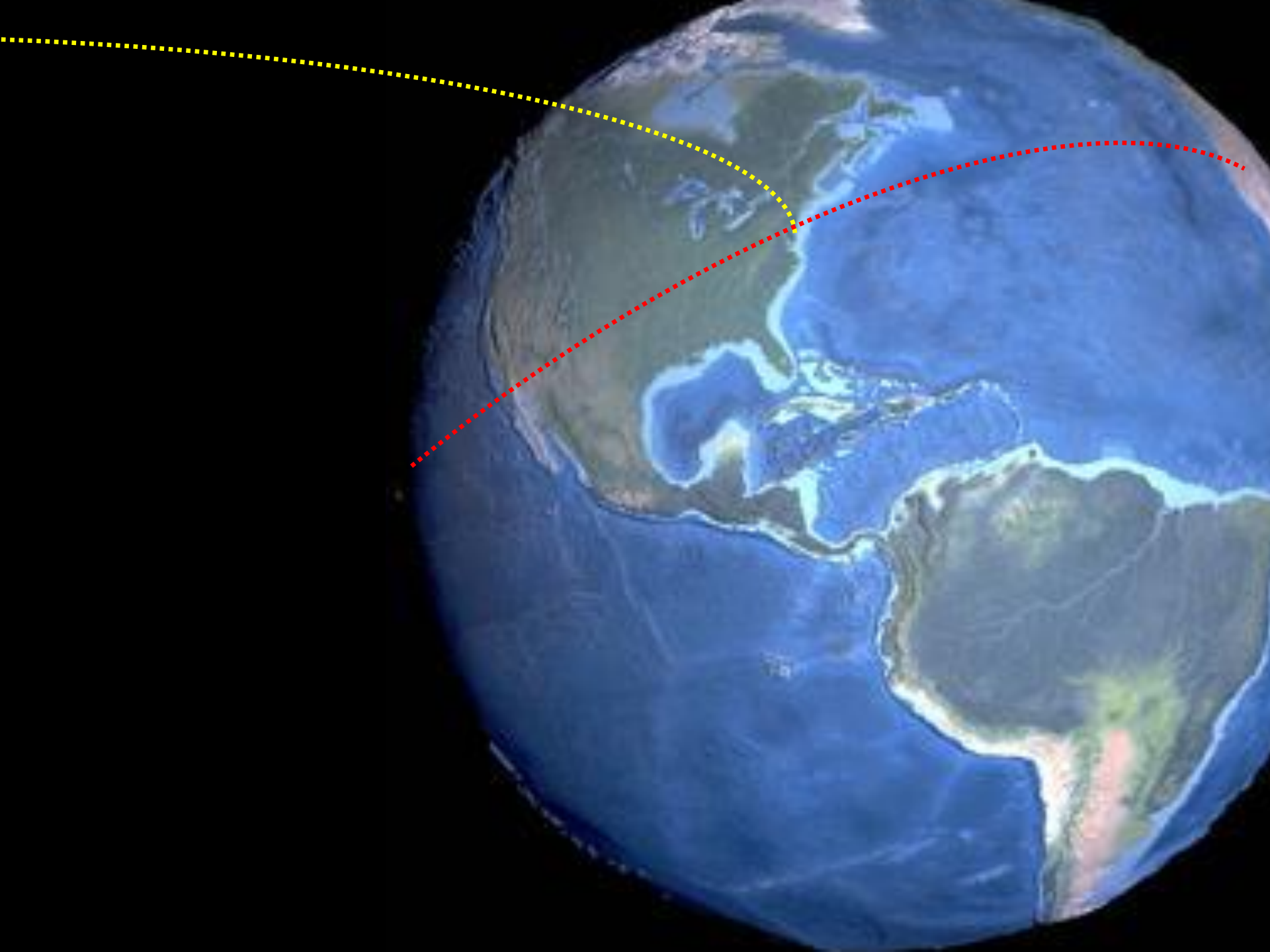
# NEO risk management issues to be addressed

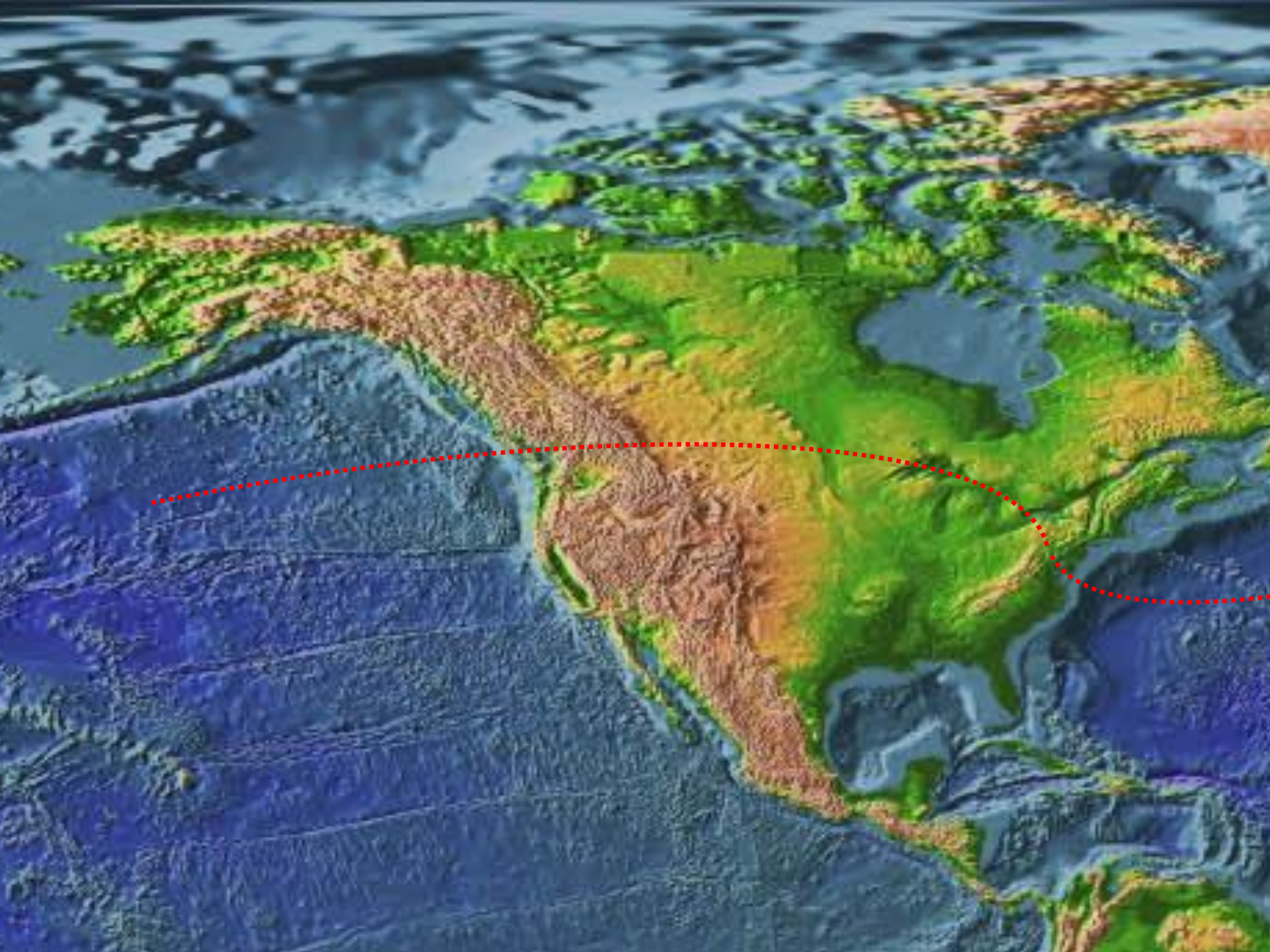


<b>OBJECT IDENTIFICATION</b>	<b>ORBIT DETERMINATION</b>	<b>CONSEQUENCE DETERMINATION</b>	<b>IN-SITU CHARACTERISATION</b>	<b>MITIGATION</b>	<b>EVALUATION</b>
<b>POLICY</b>					
<b>CATEGORISING, CATALOGUING, NOTIFICATION</b>	<b>SENSOR TASKING</b>	<b>NOTIFICATION, RISK CRITERIA</b>	<b>ROLES, RESPONSIBILITIES</b>	<b>TREATY COMPLIANCE, AUTHORITY, RESPONSIBILITY</b>	<b>OUTCOME NOTIFICATION</b>
<b>INFRASTRUCTURE</b>					
<b>SENSOR AVAILABILITY, LOCATION</b>	<b>SENSOR COORDINATION, PRIORITISATION</b>	<b>TOOLS, VULNERABILITY</b>	<b>PAYLOAD DELIVERY, DATA COMMUNICATION</b>	<b>PAYLOAD DELIVERY, COMMAND &amp; CONTROL</b>	<b>SENSOR TASKING</b>
<b>SCIENCE</b>					
<b>SENSOR LOCATION, DETECTION THRESHOLD</b>	<b>FOLLOW -UP STRATEGY</b>	<b>MULTI-DISCIPLINARY STUDIES</b>	<b>SENSOR DEVELOPMENT, DATA EXPLOITATION</b>	<b>NEGATION PHYSICS</b>	<b>SHORT TERM TRAJECTORY PREDICTION</b>









# International Asteroid Warning Network



# **International Asteroid Warning Network**



**Space Mission Planning Advisory Group**