

# Date, Lunar Phase and Time of Giant Earthquakes might be Specified for Each Subduction Zone

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## Background and objectives

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- \* Background
  - \* Earthquakes tend to occur around daily tidal stress peaks (Cochran et al., 2004, Tanaka, 2010, etc.).
- \* Ultimate goal
  - \* To predict dangerous seasons, lunar phase and time of giant earthquake occurrences without complex calculations on tidal stress or statistical analysis
  - \* so that ordinary people can greatly reduce damages by giant earthquakes by well preparing a few dangerous hours of a few dangerous lunar phases in dangerous seasons in a year.
- \* What we present here
  - \* Effects of season, lunar phase and time on solid tidal stress
  - \* Feature of mainly M<sub>w</sub>8+ earthquake occurrences during 1900-2011 for each subduction zone.

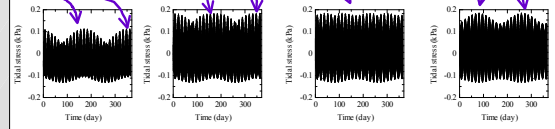
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## Theoretical increment of P-axis stress of a reverse fault by solid earth tide

- \* Stress increment shows peaks (peak seasons)
  - \* around the solstices (June and Dec.) for N60 and N30.
  - \* around the equinoxes (Mar. and Sept.) for the equator.
- \* No significant seasonal difference for N15.



For N0S30°E fault at 10 km deep assuming a uniform 3000 kg/m<sup>3</sup> density and for 2012. Circular orbits for the sun and the moon for simplicity.

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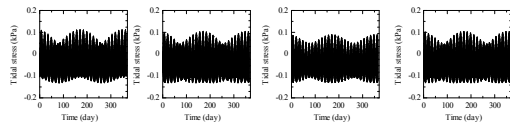
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## Influences of season, lunar phase and time on tidal stress

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### Effect of fault strike

- \* Not significant
  - \* Nor dip, friction angle as long as for reverse faulting



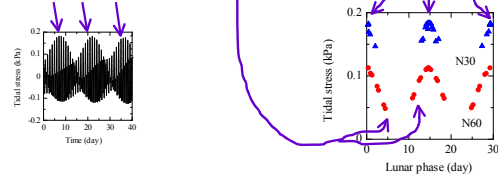
NS30E N45E30SE EW30S N45W30SW  
N60 examples

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## Local (monthly) peak positions by lunar phase

- \* They appear
  - \* around spring tides for the peak seasons.
  - \* at middle tides for non-peak seasons.

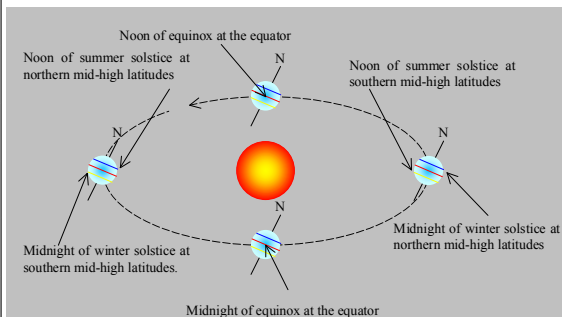
Local peaks



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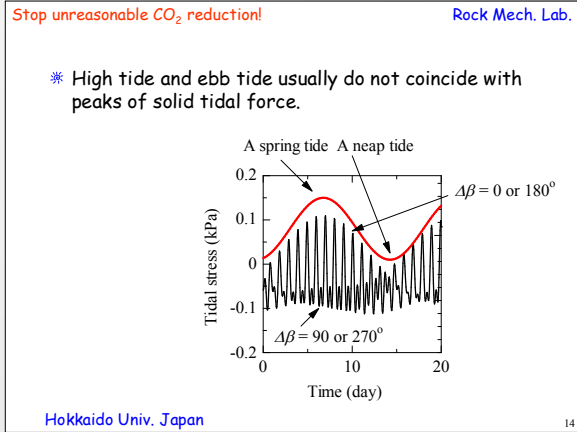
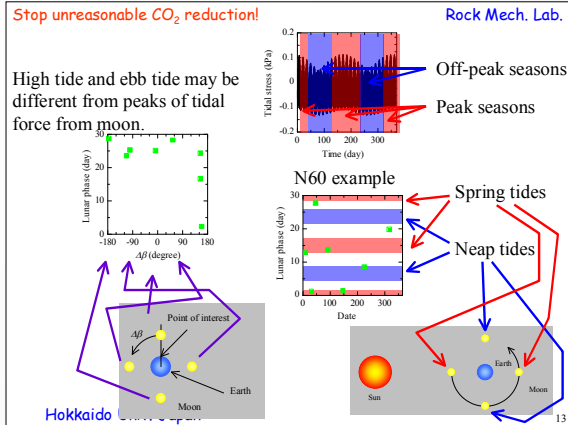
## If giant earthquakes occur under the largest tidal stress increment...

Latitude	Examples	Season	Moon phase	Time
Northern mid-high lat.	Alaska, Kuril, Japan	Late June	New or full	Noon
Northern low lat.		Late Dec.	New or full	Midnight
Equator	New Guinea, Indonesia	Any season	New or full	Noon or midnight
Southern low lat.		Late Mar. and Sep.	New or full	Noon or midnight
Southern mid-high latitude	Peru, Tonga, Chile	Any season	New or full	Noon or midnight
		Late June	New or full	Midnight
		Late Dec.	New or full	Noon

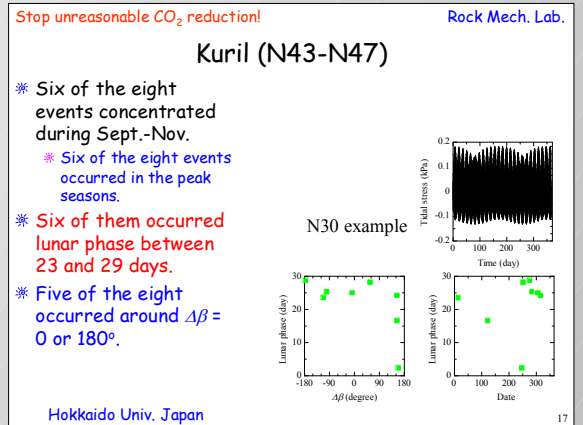
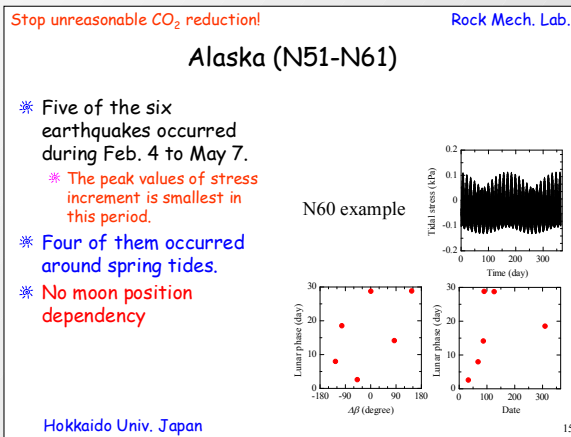
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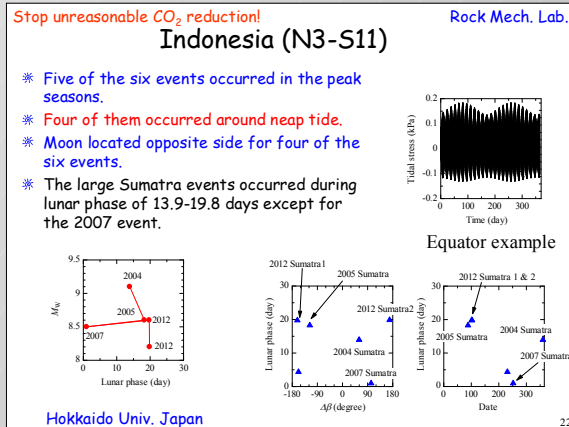
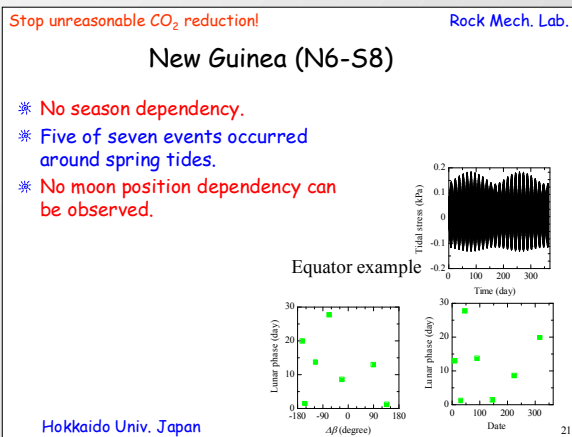
# Basic explanations on tidal force with the layout of Sun, Moon and Earth



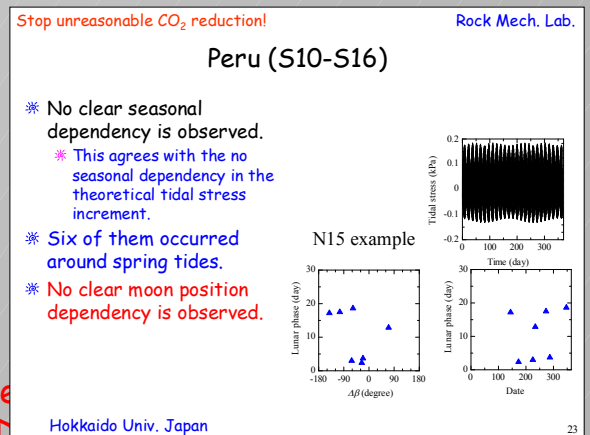
## Observations in northern mid-high lat.



## Observations around the Equator



## Observations in southern low lat.



Observations in southern mid lat.

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**Tonga (S15-S23)**

- \* Four of the five events concentrated during Apr. to June.
  - \* Four of the five earthquakes occurred in the peak season.
- \* Four of them occurred at neap tide.
- \* Three of them occurred around  $\Delta\beta = 0$  (beneath the moon) or  $180^\circ$ .

N30 example

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**Chile (S23-S38)**

- \* Seasonal dependency is not clear.
- \* Six of the seven events occurred around spring tides.
- \* No clear moon position dependency.

N30 example

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Observations in Japan

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**Japan (N28-N43)**

- \* Four of the six earthquakes occurred during Mar. 2 to June 15.
  - \* Four events occurred in the peak seasons.
- \* They occurred lunar phase between 4.9-6.3 and 17.9-21.2 days.
  - \* Middle to neap tide!
- \* Only three of them occurred around  $\Delta\beta = 0$  or  $180^\circ$ .

N30 example

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- \* 2011 Tohoku (5:46, N38E142) occurred
  - \* at middle-neap tide (lunar phase: 6.8 day)
    - \* why not spring tide?
  - \* around the peak of solid tidal stress
  - \* 84 min after the estimated ebb tide peak based on the ebb tide at the nearest tidal station (Ayukawa, N38E141) at 4:22.

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- \* 9 of the 18  $M_{JMA}7+$  earthquakes between 2002-2011 in Japan occurred 1-3 hours after ebb tides.
  - \* Half of the events in just 2 hours!

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- \* Findings
  - \* Theoretical seasonal dependency of tidal stress increment
    - \* significant varies with latitude.
    - \* doesn't show significant influences by strike, dip or friction angle.
  - \* Occurrences of giant earthquakes shows different characteristics for each subduction zone.
    - \* Some of them can be explained by solid tidal stress.
    - \* Some of them can't be explained.
  - \* Most Japanese  $M_w8+$  events occurred under middle to neap tide.
    - \* Half of Japanese  $M_{JMA}7+$  events during 2002-2011 occurred 1-3 hours after ebb tides.

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Concluding remarks

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- \* Future studies
  - \* Not only solid tidal force but also actual sea level should be of course considered although it will not change timings of spring and neap tides.
    - \* Minimum detailed analyses on slip direction will be required.
  - \* Integration of forces acting to the tectonic plates across the source fault rather than using tidal stress at hypocenter
  - \* Or, the balance of the whole tectonic plates on the earth?

Example of earthquakes at Aleutian trench, based on an image from Wikipedia

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