JAMSTEC

218805, 11:45-12:00, Tuesday, 11 September 2018@CRAYA Amphitheatre (Grenoble INP ENSE<sup>3</sup> – Site Bergès) The seismic cycle: from transient and precursory deformation to seismic ruptures **19<sup>th</sup> General Assembly of WEGENER** 

#### Periodic change in the interplate locking state off Kyushu Island, Southwest Japan, inferred from spatial gradient of displacement rate field and small repeating earthquakes

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- Periodic (2~6 years) occurrence of slow slip events (= change in the degree of locking) [Uchida et al., 2016]
  - In northeast Japan subduction zone
    - Pacific plate is subducting beneath the continental plate
    - Many M7 class earthquakes
    - The 2011 Tohoku earthquake (M9.0)
  - Based on small repeating earthquakes and GNSS observations



Uchida et al. [2016]

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    - The cumulative slip of repeaters that are averaged for several repeater sequences



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### Interplate locking & velocity gradient



 Velocity field estimated from GNSS observations

- **<u>Strong</u>** interplate locking
  - → Large negative spatial gradient of the horizontal velocities along the trench normal direction
- <u>Weak</u> interplate locking
  - → Small negative or positive spatial gradient of the horizontal velocities along the trench normal direction

### Interplate locking & velocity gradient



### Interplate locking & velocity gradient



#### Spatio-temporal variation 37° + 2009/01/03-2011/01/03 in the velocity gradient Goka ±20km 36° 2002 2004 2006 2008 2012 2014 2000 2 year 160 1 σ 🔶 Obs. 20 mm/yr ±20 km 150 35° Horizontal displacement rate gradient [mm/yr/100km] 140 130 120 34 110 100 90 33° 80 70 60 32° 50 40 31 30 20 10 30° 129° 130° 133° 134° 2008 2012 131 132° 135° 1998 2000 2002 2004 2006 2010 2014 Year







### Interplate activities off Kyushu Island



# Spatio-temporal variation 37° -







# Summary

- Periodic slow slip events occur off Kyushu Island as well as northeast Japan subduction zone
  - Indicated by the small repeating earthquakes and
  - Spatial gradient of the surface displacement rate field
- Postseismic slip after Hyuga-nada earthquakes in 1996 might shorten the recurrence periods of the slow slip events
- Combined analysis of the seismological and geodetic data should be applicable to other subduction zones

# Time series analysis

- F3 solution of GEONET (Daily site coordinate time series)
- Picking 5 or 6 years' time series with shifting the time windows by one week
  - The final dates of the time windows are every Monday during 24 March 1997 to 22 July 2013
- Least square estimation to fit the components,
  - Linear long-term trend (=velocity) for 0.5, 1, 2, 3 or 5 years
  - Annual and biannual variations
  - Steps due to the antenna replacements and earthquakes



# Spatial gradients of velocity field

- Calculating the velocity gradient for the horizontal and vertical components in the band-like regions along the plate convergence direction with...
  - Shifting the latitude of the band-like region by 0.1 degree
  - Changing the width of the band, as 20, 30 and 40 km
  - Directions of the band and horizontal component
    - Tohoku: N105°E
    - Hokkaido : N120°E
  - Spatial gradients of the velocity field with respect to the distance along the band





# Detectability of the change in the interplate coupling on the shallow plate interface



- Northeast Japan subduction zone
  - Pacific plate is subducting beneath the continental plate
  - Many M7 class earthquakes



#### linuma et al. [2012]

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- Northeast Japan subduction zone
  - Pacific plate is subducting beneath the continental plate
  - Many M7 class earthquakes
  - The 2011 Tohoku earthquake (M9.0)
- Before the Tohoku earthquake
  - Weakening of the degree of interplate coupling in the decadal-scale [Ozawa et al., 2012; Mavrommatis et al., 2014; Yokota & Koketsu, 2015]



Mavrommatis et al. [2014]

# Spatio-temporal variation in the velocity gradient







#### **Spatio-temporal variation in**<sup>46°</sup> the velocity gradient ±30km 45° 1998 2002 2010 44 2000 2004 2006 2008 5 year 160 39.0 ±20 km 43° 150 38.8 140 42° 130 Displacement rate gradient [mm/yr/100km] 120 41° 110 38.0 100 37.8 40° 39.0 90 37.6 39° 80 37.4 38.0 70 38° 60 37.0 50 37° 40

36.1

30

20

10

0

1998

2000

2002

2004

Year

2006

2008

2010



### Spatio-temporal variation in <sup>46°</sup> the velocity gradient <sup>45°</sup>





#### Spatio-temporal variation in <sup>46</sup> the velocity gradient <sup>45</sup>





#### Spatio-temporal variation in <sup>46</sup> the velocity gradient <sup>45</sup>



