model with a mantle viscosity of about 10^{19} Pa s. Contemporary crustal deformation of the Cascadia forearc, 300 years after a great earthquake, can be explained by the viscoelastic model. The observation that GPS sites 300-400 km landward of the rupture region of the 1960 great Chile earthquake are presently moving seaward, opposite to the motion of the coastal sites, can be explained by stress relaxation. Elastic models can also fit most of the observations by assuming that all deformation is due to fault motion. The fault motion thus determined effectively includes contribution from stress relaxation.

G22E-03 1630h

Long-term Postseismic Deformation Following the 1964 Alaska Earthquake

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Geodetic data provide a rich data set describing the postseismic deformation that followed the 1964 Alaska earthquake (Mw 9.2). This is particularly true for vertical deformation, since tide gauges and leveling surveys provide extensive spatial coverage. Leveling was carried out over all of the major roads of Alaska in 1964-65, and over the last several years we have resurveyed an extensive data set using GPS. Along Turnagain Arm of Cook Inlet, south of Anchorage, a trench-normal profile was surveyed repeatedly over the first decade after the earthquake, and many of these sites have been surveyed with GPS. After using a geoid model to correct for the difference between geometric and orthometric heights, the leveling+GPS surveys reveal up to 1.25 meters of uplift since 1964. The largest uplifts are concentrated in the northern part of the Kenai Peninsula, SW of Turnagain Arm. In some places, steep gradients in the cumulative uplift measurements point to a very shallow source for the deformation. The average 1964-late 1990s uplift rates were substantially higher than the present-day uplift rates, which rarely exceed 10 mm/yr. Both leveling and tide gauge data document a decay in uplift rate over time as the postseismic signal decreases. However, even today the postseismic deformation represents a substantial portion of the total observe deformation signal, illustrating that very long-lived postseismic deformation is an important element of the subduction zone earthquake cycle for the very largest earthquakes. This is in contrast to much smaller events, such as M 8 earthquakes, for which postseismic deformation in many cases decays within a few years. This suggests that the very largest earthquakes may excite different processes than smaller events.

G22E-04 1645h INVITED

Relative land/sea-level movements and great Holocene earthquakes, Alaska

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The “earthquake deformation cycle” (EDC) model describes relative sea-level (RSL) movements associated with large plate boundary earthquakes. On March 27, 1964, an earthquake of magnitude 9.2 occurred along the south coast of Alaska, USA. By applying quantitative transfer functions to microfossil data collected from contemporary tidal flats, marshes and wetlands together with observational data from 1964 we can calibrate models of Holocene environmental change represented by fossil assemblages in sediment sequences. We use the transfer function models to quantify relative sea-level changes through multiple Holocene EDCs in Alaska and separate co-seismic from non-seismic events. Geological evidence from four sites around the Cook Inlet - Girdwood, Ocean View (Anchorage), Kenai and Kasilof, support a four phase EDC model that in the zone of co-seismic submergence comprises: (1) Relatively rapid land uplift and sedimentation immediately after an earthquake, i.e. the postseismic period; (2) Centuries-long inter-seismic period of slower relative land uplift caused by strain accumulation along the locked portion of the Alaska-Aleutian subduction zone; (3) A pre-seismic period of relative sea-level rise (relative land subsidence) lasting approximately a decade; (4) Rapid co-seismic land subsidence during a great (Mw > 8) earthquake. The four sites record evidence of Holocene co-seismic submergence in the form of multiple peat-mud couplets. Not all events are recorded at each site, the interval between events is variable and the magnitude of submergence varies from less than 0.5 m to greater than 2.0 m. A unique finding is the identification and quantification of pre-seismic RSL rise prior to each co-seismic event. Biostratigraphic changes that reveal a pre-seismic RSL rise typically occur over 1 to 5 cm of sediment, are dated at Kenai and Girdwood (for the 1964 earthquake) to start approximately 10 years before the event and indicate pre-seismic RSL rise up to 0.2 m. This is strong evidence to suggest that pre-seismic movements may represent a precursor to a great earthquake. Independent work based on twentieth century observations and limited to only parts of an EDC describe possible mechanisms for this phenomenon. This has potential implications for other subduction zone locations including Chile, Japan and the Pacific Northwest of the USA and Canada.

G22F MCC: 2010 Tuesday 1710h

Bowie Lecture

Presiding: **V Dehant,** Royal Observatory of Belgium**; J T Freymueller,** University of Alaska, Fairbanks

G22F-01 1715h INVITED

Episodic Tremor and Slip in the Cascadia Subduction Zone: A Story of Discovery

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For more than two decades, seismologists at the Pacific Geoscience Centre puzzled over the episodic appearance of simultaneous ”noise” on seismographs from stations located over the Cascadia subduction zone in southwestern British Columbia. With the 1992 initiation of continuous GPS monitoring in Victoria, B.C., another puzzle presented itself in an inexplicable 5-mm westward displacement of the then solitary regional continuous GPS monument over a period of about a week in October 1994. These observations remained unexplained (and unrelated) until recently. Beginning in 1996, as a result of improvements in GPS orbits and regional densification of continuous GPS networks, transient aseismic crustal motions lasting from periods of a few days to over a year were starting to be recognized. For the Pacific Northwest, detailed analyses of continuous GPS data successfully resolved a spatially coherent, transient signal that occurred in August 1999. Unrelated to after-slip that can follow great thrust earthquakes or to shallow slow-slip ”tsunami” earthquakes, this signal, detected at 7 contiguous GPS sites, was characterized by a change in site positions ranging from 2 to 5 mm over a period of 6 to 15 days in a direction opposite to long-term deformation motions. This brief reversal was modeled by $\sim$2 cm of slip on the plate interface, providing the first evidence for discrete ”silent” slip events occurring on the deeper Cascadia subduction zone. In early 2002, researchers at Central Washington University established the surprising regularity of Cascadia slip events on the plate interface underlying southern Vancouver Is. and northwestern Washington State. Eight slip events were identified between 1992 and 2002, with a recurrence interval of 14.5 ±2 months. Next, Japanese scientists discovered the episodic occurrence of unique, non-volcanic tremors at average depths of about 30 km along the Nankai Subduction Zone. The similarity of the average depth of slip and the migration velocity of slip for the GPS-determined Cascadia slip events, to the depth and migration velocity of the Japanese tremors triggered the search for seismic signatures for the Cascadia slip events. An examination of seismic records from 1996 to 2002 for sites on Vancouver Is. revealed that what had previously been deemed surface noise was signal from seismic tremors that accompanied slip events. The Cascadia tremors were found to be similar in character to the Japanese deep tremors. In addition, their source region was found to coincide with, or directly overlie, the region of the subducting slab interface where transient slip occurs. The close correlation of tremors with slip coined the naming of the phenomenon as Episodic Tremor and Slip (ETS). The physical processes which give rise to this dynamic behavior on the deeper plate interface are not yet well understood. To date, only the Nankai and Cascadia subduction zones have been observed to share aspects of this behavior, suggesting that this phenomenon may be restricted to young subduction zones. The release of fluids, contact with a hydrated mantle wedge, and episodic changes in shear strength or mechanical coupling may all play a part in governing this behavior. Possible connections of ETS with the development of ”E-zone” reflector bands, basal erosion, and pulsating metamorphism await further research. In the context of seismic hazard, the ETS zone may mark the down-dip limit of coseismic rupture of the next megathrust earthquake. Also, since it is conceivable for a slip event to trigger a large subduction thrust earthquake, the onset of ETS activity could identify times of higher probability for the occurrence of megathrust earthquakes.

G31A MCC: 2010 Wednesday 0800h

Satellite Measurements of Temporal Gravity Variations I

Presiding: **M M Watkins,** Jet Propulsion Laboratory, California Institute of Technology**; R S Nerem,** University of Colorado

G31A-01 0800h

GRACE Gravity Field Analysis Results from JPL

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The Jet Propulsion Laboratory serves as the GRACE gravity field analysis verification center, generating independent gravity solutions for assessing the error characteristics of the fields through comparison with the other centers (UTCSR and GFZ), and performing studies to develop optimal parameterizations which may improve the field quality. In addition, we provide a quick gravity solution turnaround capability to assess the utility of alternate Level-1 algorithm implementations. In this presentation, we will present the most recent gravity field results from GRACE, with special attention to summarizing our best understanding of the Level-1 data quality and influence on the field characteristics, and the effects on the fields of varying parameterizations (orbital arc lengths, nuisance parameterization and sub-arc lengths, etc) in the Level-2 analysis.

G31A-02 0815h INVITED

Low-degree temporal gravity field variations using CHAMP data

Christoph Reigber[1] (49-331-288-1100; reigber@gfz-potsdam.de); Horst Jochmann[1]; Johann Wünsch[1]; Svetozar Petrovic[1]; Peter Schwintzer[1]; Franz Barthelmes[1]; Christoph Forste[1]; Karl-Hans Neumayer[1]

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The ability to recover with CHAMP the Earth’s gravity field homogeneously and precisely from only a few weeks’ worth of GPS satellite-to-satellite tracking data stimulates the investigation of temporal gravity field variations as seen by CHAMP. From a multi-annual exploitation of CHAMP data, time series of low degree spherical harmonic gravitational coefficients are derived and evaluated in the spatial and spectral domain by comparison with geophysical data and models covering atmospheric, oceanic and hydrologic mass redistributions. The space/time resolution and stability obtainable with a mission like CHAMP in recovering short-term environmentally induced gravity field variations were estimated. From experience gained up to now with the CHAMP data processing, the investigations are restricted to spherical harmonics up to degree/order 4, i.e. spatial wavelengths not shorter than 10000 km. The coefficients’ time series are simultaneously derived in a comprehensive global gravity field solution with the higher-degree terms kept time-invariant. Results from both CHAMP-only and CHAMP combined with selected Laser satellite solutions are studied.

G31A-03 0830h

GRACE Gravity Field Product Description and Mission Profile

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