This substorm onset matrix shows relevance of various observations/modelings to various substorm-onset physical models. Comments and suggestions are very welcome.	excuse, other explanations, criticism, comments	merit	near-earth reconnection	flow braking	current disturptio n	ballooning/ interchange	convection reduction	Nishimura/ Lyons model	Alfven wave model	M-I coupling model	Catapult slingshot model
Below are from GEM Substorm FG presentations on June 19-20, 2013.											
session 1 (June 19, 10:30-12:15), joint with mapping FG											
Eric Donovan: Identifying magnetic conjugacy between satellites and the ground during onset. He showed 630nm keograms obtained by highly-sensitive camera at Rankin Inlet to show various auroral/airglow structures, which was invisible by panchromatic THEMIS camera. He is planning to make a chain of such high-sensitive camera from polar cap to subauroral latitudes. GO-IRIS is a chain of 3x3 pixel imaging riometer at auroral latitudes to see injection structures mapped on the ground.		giving a new imaging tool to monitor plasma sheet structures and their boundaries on the ionosphere.									
Matina Gkioulidou: RBSP observations of injections. She showed one RBSP injection event at ~06 UT on Feb.2, 2013 during a small substorm with AE~500nT at good conjunction with BARREL balloons. RBSPICE observed dispersionless injection (25-800keV) at 00MLT and 02MLT with dipolarization/fluctuation of B-field and E-field. BARREL balloon observed X-ray enhancement simultaneously with the RBSP injection. However, the peak of BARREL X-ray is ~1 hour delayed from the dispersionless injection. Why? RBSPICE also observe similar features in He, Oxygen, while Hydrogen enhancement seems to be delayed.											
Phil Erickson (given by Robyn Millan): Ground-based measurements during BARREL substorms and connection to in situ electric fields. He/She showed March 17, 2013 event during the main phase of storm, using DMSP-F18 and RBSP-A/B, using OP77Q and T89Q, and TS04D magnetic field model. They compared E-field velocity obtained by two satellites. The location SAID peak is ~1 degree different between DMSP and RBSP.		SAID is a good locator for mapping									
Xiangning Chu: Magnetic perturbation of substorm current wedge. Thye showed an inversion technique for substorm current wedge using a wedge current model. They compared the model results with IMAGE auroral images in ewogram (east-west keogram). The model follows the observed east-west development of aurora. They also compared the model results with electrojet intensity obtained by the IMAGE magnetometer chain. The peak electrojet intensity fits well, while they are different at developing phase of substorm. This may be because of limited location of the IMAGE chain which missed the main part of electrojet at the developing phase.	This model consider only the substorm unloading part. Directly-driven part is not included. Region 2 sense currents is difficult to be included.										
Tetsuo Motoba: Conjugate observations of onset auroral dynamics. He showed auroral beads structures at the onset of auroral breakup with propagates azimuthally with a speed of several km/s. The auroral beads show good conjugacy between northern and southern hemispheres (Motoba et al., GRL, 2012). The ground magnetometer data also show good conjugacy. When the auroral beads appeared, any magnetic pulsation acitivity (Pi2, PiB) was not observed. The pulsation was observed a few minutes after the auroral beads. The auroral beads at Syowa developed along the peak of proton aurora. It is still a question what physical mechanism creates the beads?	This observation may suggest that the beads (tail plasma instabilities) seems to occur before Pi2 (flow burst). The beads may be caused by drift-ballooning instability or flow shear in the magnetosphere.							Item 3 is consistent with the idea of FB causes near-earth instability			
Suggestion was made by Robyn to accumulate more data that are useful to make more reliable mapping. AGO magnetic field data together with BARREL. High-sensitive camera, GPS-TEC. Estimation of field-aligned current is important and DMSP/AMPERE would contribute to the estimation. It would be intersting to determine one event for GEM challenge for mapping, to accumulate all available data for mapping. November 14, 2012 event is one of the candidates.											Explains the generation of catapult slingshot before the X-reconnection.
session 2 (June 19, 13:30-15:00)											
Larry Lyons showed expansion phase surge evolution associated with slider arcs. He started from the question, "How does westward traveling surge fit into substorm onset picture? Not all substorms have WTS. How often?". When the poleward-arc (PBI) moving equatorward touch the brightening arc, a surge develops in the brightening arc and it moved westward. Surge slides westward following a poleward boundary slider. SuperDARN radar data show eastward/equatorward flow poleward of the slider just before the surge, suggesting that earthward flow drives wesward surge development.											
Toshi Nishimura showed PFISR radar observation of densit and flow of pre-onset sequence. The altitudes of growth phase arc at 150-350km and initial brightening at ~130-170km. Equatorward plasma flow penetrating across the PBI arc, reaching the growth phase arc, suggesting flow across the open-close boundary. Detailed look of pre-existing arc shows quasi-periodic activity propagating westward with a speed of ~1 km/s and a period of ~2 min. This wave may be a seed of onset instability. Similar wave tends to be observed even during non-substorm time quiet arc.											
Beatriz Gallardo shows highly-structured ionospheric flow confined in the brightening arc with auroral beads, using SuperDARN radar data with THEMIS mode, suggesting clockwise flow shear corresponds to the brightened part of auroral beads.											

Xiaoyan Xing (presented by Larry Lyons) showed a possibility of tail ballooning instability preceding a small substorm in the transition region, using THEMIS-Rankin conjugate observation. The auroral beads were observed in 630nm images of NASCAM at RANK. Using several pairs of THEMIS satellites at X=-10--13 Re they investigate criteria of ballooning instability according to Pu et al. (1997) criteria with B curvature by Wolf et al. (2006). They suggested that the ballooning instability initiated at ~11 Re may lead to the formation of auroral wave structure.	There is always a difficulty of estimating ballooning stability using tail satellite data.										
Christine Gabrielse showed superposed epoch analysis of electron injections observed by THEMIS. The events were categorized by flow velocity (<100km/s, 100-300km/s, and >300km/s). X-Y maps of injection rate per day was made.											
session 3 (June 19, 15:30-17:00)											
Jian Yang showed RCM-E simulation of field-aligned currents in the tail-dipole transition region. How does the large-scale convection in the growth pahse lead to an upward thin FAC? In the model, the thin current exists at the boundary of region 1 and 2 current at 65 deg latitude in the premidnight sector. This thin current is fromed at 7.5-10 Re (centered at 9 Re) due to pressure distribution in the plasma sheet (using Vasyliunas [1970]' equation). This region corresponds to the location where curvature of B field becomes comparale to ion gyro radii. This region also corresponds where the convection flow is balanced with the tailward stretching of magnetic field.											
Jiang Liu showed small-scale field aligned current generation around dipolarizing flux bundle at the dipolarization front (DF), using superposed epoch analysis of pressure distribution at the evening and morning side of 506 dipolarization front events. Azimuthal gradient exists towards the DF center within 1 Re from the center. The pressure gradient also toward the DF outside 1 Re and outward from DF inside 1 Re. This gives Region 2 sense FACs ahead of the DF (outside 1 Re), and Region 1 sense FACs inside the DF layer (inside 1 Re).											
Xiangning Chu showed simulated evolution of ground magnetic perturbation using substorm current wedge model, which uses midlatitude multi-point magnetic field. Magnetic perturbation caused by wedgelets. Simple model consideration shows taht as the longitudinal width of current wedge becomes smaller from 4 MLT to 1 MLT, the amplitude of midlatitude H and D variations becomes smaller. As the observation latitude becomes smaller from 60 deg to 20 deg, the amplitude becomes smaller. Then he also showed one event of THEMIS-ground data analysis of current wedge estimation.											
Shanshan Li (presented by Vassilis) showed statistical study of azimuthal scale size of mid-tail plasmoids using two ARTEMIS satellites. The plasmoid occurrence is higher in the premidnight sector. Typical size in Y-direction is 6 Re. Some plasmoids extends 9-15 Re during AE>500 nT. Small-scale plasmoids may be the tailward counterpart of small-scale earthward bursty flow.											
session 4 (June 20, 10:30-12:15) joint with magnetotail reconnection FG											
Joachim Birn and M. Hesse showed PIC and MHD simulations of near-tail reonnection onset in 2-D magnetotail configuration. Both show bifarcated current sheets before the reconnection. In the PIC simulation the bifarcated current is the electron current. The thin current sheet may provide driver of auroral signatures at growth phase. Both PIC and MHD simulation gave nearly same reconnection rate and time. The entropy S for the field line at the PS boundary kept constant up to the onset time. They S decreases on the reconnected flux tube. Perpendicular particle anisotropy develops on the closed field line near the reconnection point, and field-aligned anisotropy develops away from the reconnection point.											
Joachim Birn and M. Hesse showed near-tail reonnection energy conversion using PIC and MHD simulation. The integrated energy outflow from the reconnection points are enthalpy flux. Energy conversion J dot E occurs in the reconnection point and in the outgoing flow region. Energy conversion is dominated by incoming Poyting flux to outgoing enthalpy flux in both PIC and MHD. DF and associated current is generated in the earthward part of reconnection point.											
Stefan Kiehas showed reconnection observations with two ARTEMIS spacecrafts at X=-57.9 Re separated ~1 Re in Z direction. They show difference of ion beam structures depending on Z-distance from the current sheet, suggesting reconnection tailward of ARTEMIS and X-line earthward of ARTEMIS.											
Yaosong Ge showed global MHD simulation of large-scale plasmoid features using OpenGGCM model. The 3-D model result was analysed for bipolar Bz variation at X=-40, -50, and -60 Re at different latitudes. He also showed a tilted small-scale flux rope on X-Y plane showing bipolar Bz signature.											
Jim Drake simulated structure of reconnection exhausts and dipolarization fronts. Firehorse instability was seen in the exhausts. Slow mode ahead of intermediate mode boundary in the exhausts. An explanation of the negative dip in Bz at the dipolarization front was proposed as the Hall magnetic field due to two current looks in the x-y plane. 2-D PIC simulation can reproduce this Hall field and negative Bz dip.	There are other explanations of Bz negative, e.g., pileup of B at DF.										
session 4 continued (June 20, 13:30-14:00) joint with magnetotail reconnection FG											

Mikhail Sitnov showed detailed structures of magnetotail reconnection and dipolarization fronts using 3D PIC simulation. It includes interchange instability and flapping motion.											
Mikhail Sitnov and S. Merkin showed difference between MHD and full-particle simulations for magnetotail reconnection onset. The comparison shows that the spontaneous formation of DF and reconnection is fully non-MHD processes. Kinetic simulations are consistent with the tearing stability theory. Non-MHD process is the sling shot, while MHD is the unloading by cutting the tail.											

Major topics of 5-year Substorm FG.
onset timing: inside-out / outside-in
Harang relation to onset arc
PBI-streamer-onset, story by Nishimura
bubble - PV^gamma analysis
detailed structure of dipolarization front
detailed structures of onset arc including auroral beads

future direction - three FGs
mapping
connection to the inner magnetosphere
reconnection