Quantifying, Predicting, and Exploiting Uncertainty Modeling Pilot Study Results

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1. **Seven pairs of daily forecasts were issued for the period 6-12 September 2008. Each pair contrasted different initial transports through the strait of Taiwan.**
2. **For each forecast, sound and transmission loss forecasts were issued along the five acoustic propagation paths.**
3. **Volume averaged bias and RMS errors were calculated for the period 2-5 September 2008.**
4. **CTD casts processed and analyzed for three cruises and two SeaSoar surveys**
5. **All nowcast and forecast products and dynamical descriptions of ocean and acoustic conditions were provided in real-time via the web site http://mseas.mit.edu/Sea_exercises/QPE/index.html.**

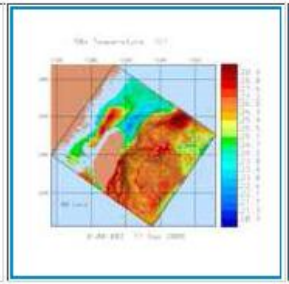
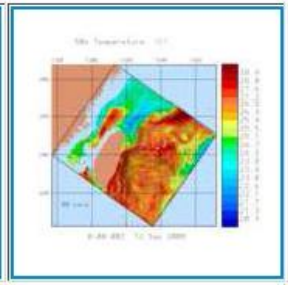
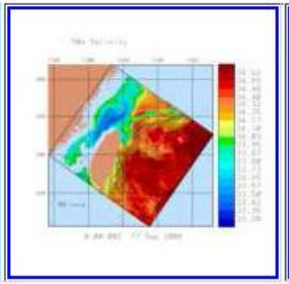
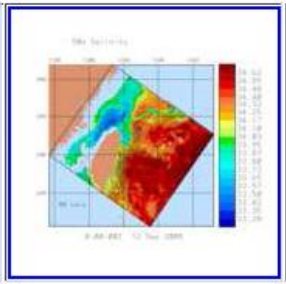
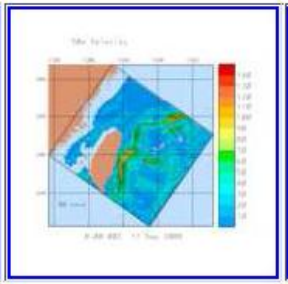
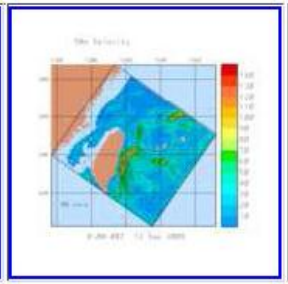
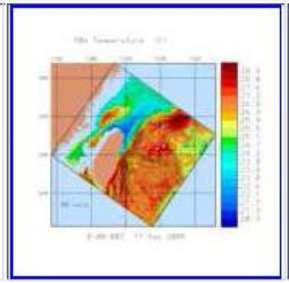
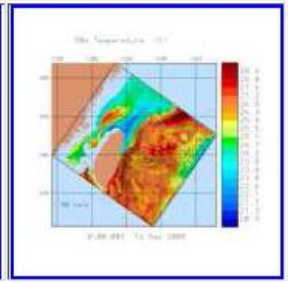
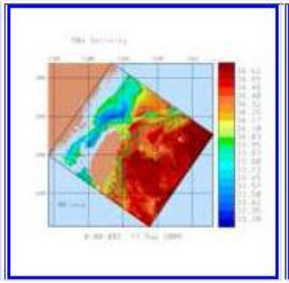
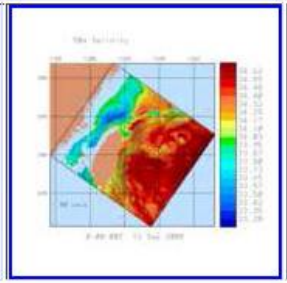
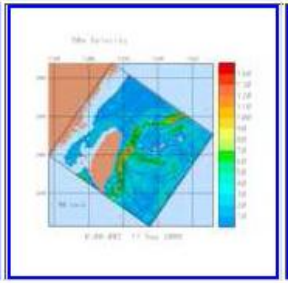
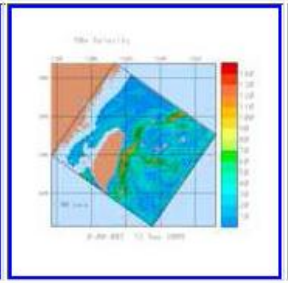
Modeling System Results

- Seven sets of daily forecasts were issued for the period 6-12 September 2008.
- For each day's forecast, O(10) simulations were run with different parameters for both sensitivities and redundancy.
- Each of these forecasts was from a free surface simulation forced with COAMPS (wind stress) and NOGAPS (heat-flux, E-P) atmospheric forcing, initialized with the Taiwanese OR2 and OR3 CTD data and a summer climatology created using June-August profiles and the HydroBase2 software.
- The NCOR bathymetry was used for all simulations (even though it is likely too smooth)
- The OR1 CTD and the SeaSoar data were assimilated into each simulation as available.

Dynamics and Uncertainty Results

Example Dynamical Analysis: September 12, 2008

- Approaching typhoon appears to impose southward transport in the Strait.
- Major uncertainties on that day: effect of tides, transport in Strait
- Kuroshio water upwelled in QPE area with filaments being advected northeastward

Nowcasts and Forecasts of Environmental Conditions							
Initial Transport	50m Temperature		50m Salinity		50m Velocity		Complete set of Plots
	Nowcast - 11 September	Forecast - 12 September	Nowcast - 11 September	Forecast - 12 September	Nowcast - 11 September	Forecast - 12 September	
0 Sv							X
1.0Sv S							X

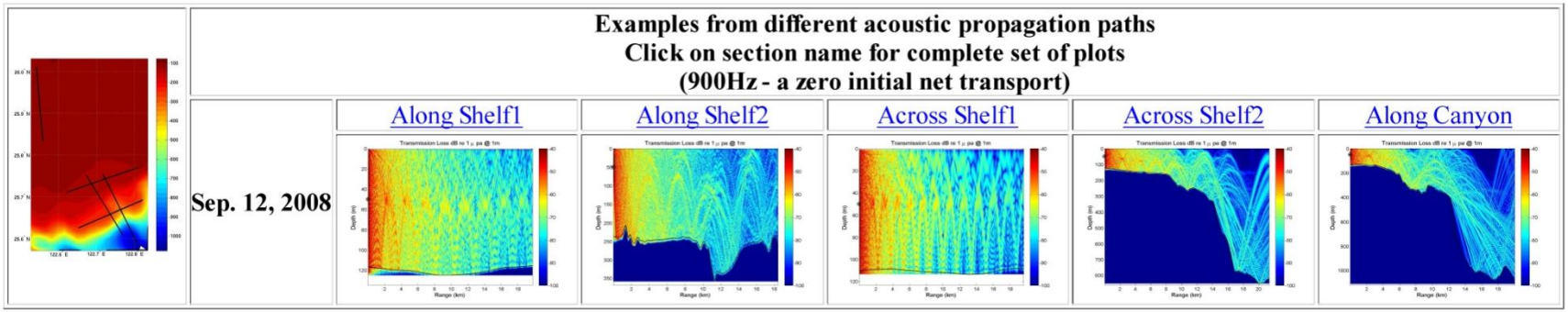
Acoustic Modeling Results

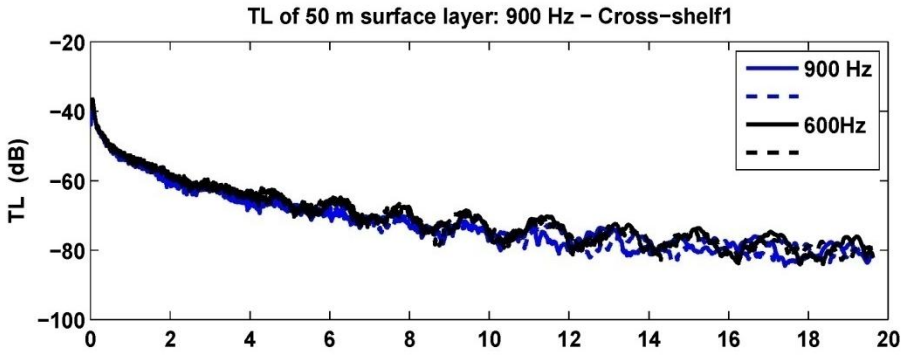
- Seven sets of daily forecasts of sound speed and transmission loss were issued for 6-12 September 2008.
- Forecasts were along the five 20 km-long acoustic propagation paths which were identified during a planning meeting at MIT.
- Acoustic simulations were run in both along-section directions for each frequency and for the two contrasting different initial transports through the strait of Taiwan.
- The frequencies chosen were 300, 600, and 900 Hz; which are in the range of OMAS sources. The source depth was set at 50m.
- Acoustic simulations are performed with the Coupled SACLANTCEN normal mode propagation loss model (C-SNAP). It is a range-dependent one-way coupled modes model with impedance matching to account for energy conservation.
- The sea bottom model was chosen to be range independent.

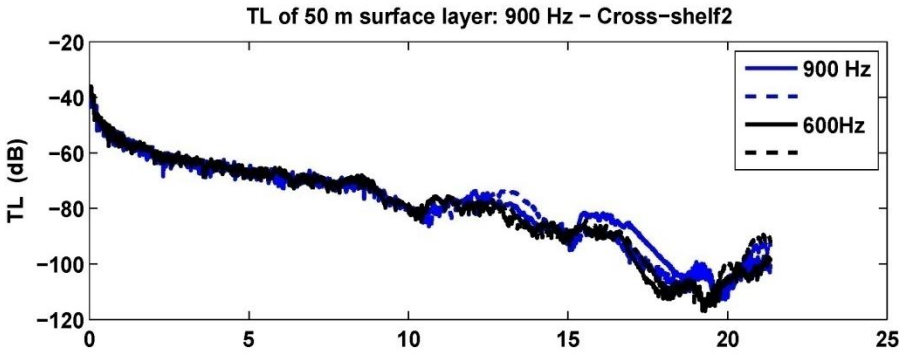
Acoustic Modeling Results

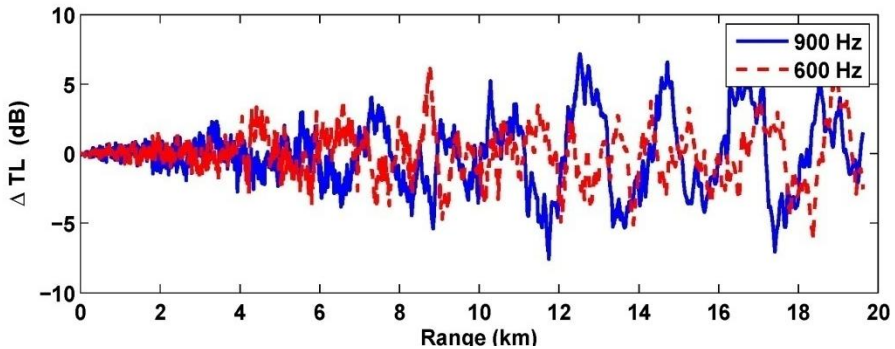
Example Acoustic Products

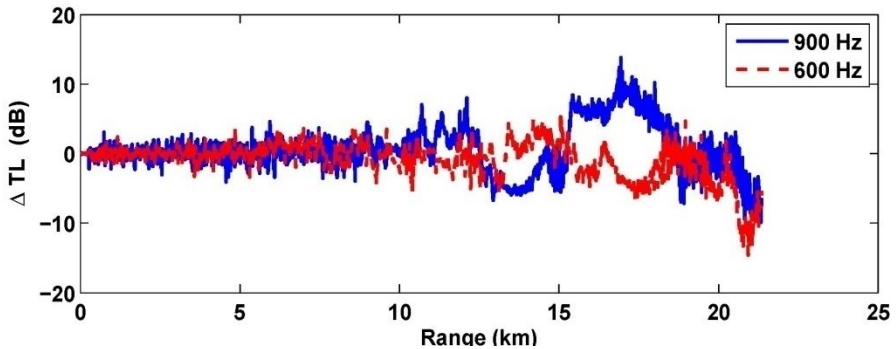
September 12, 2008





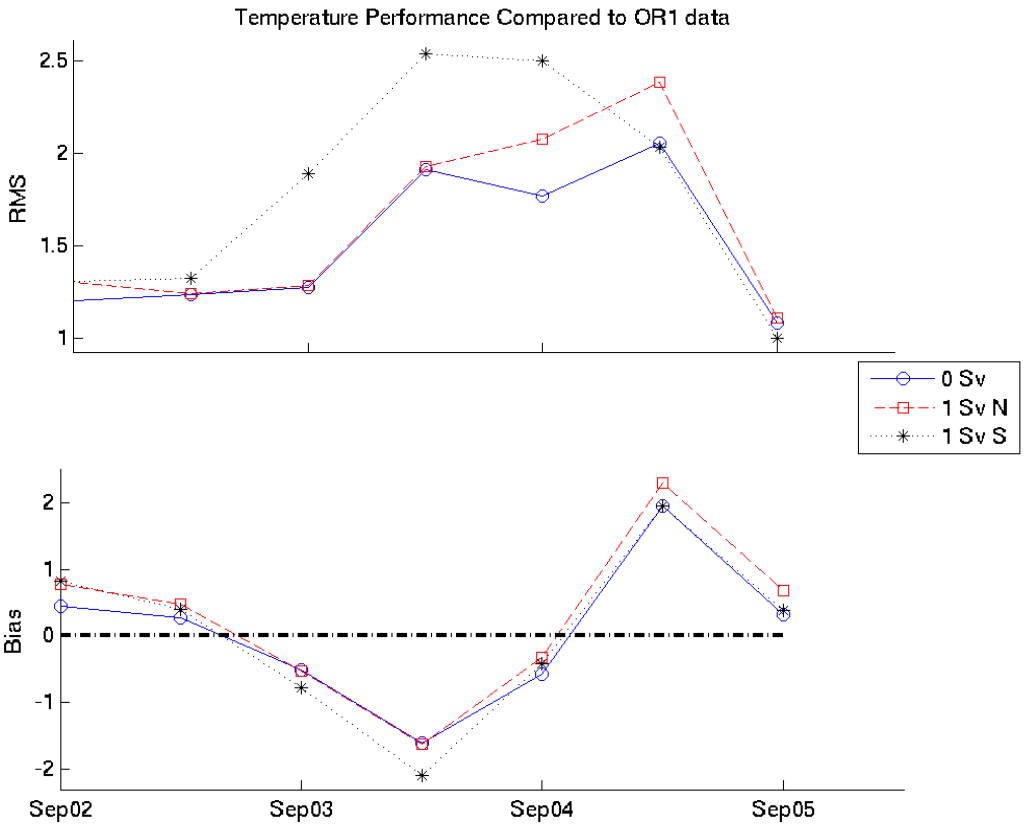






Forecast Skill Metrics

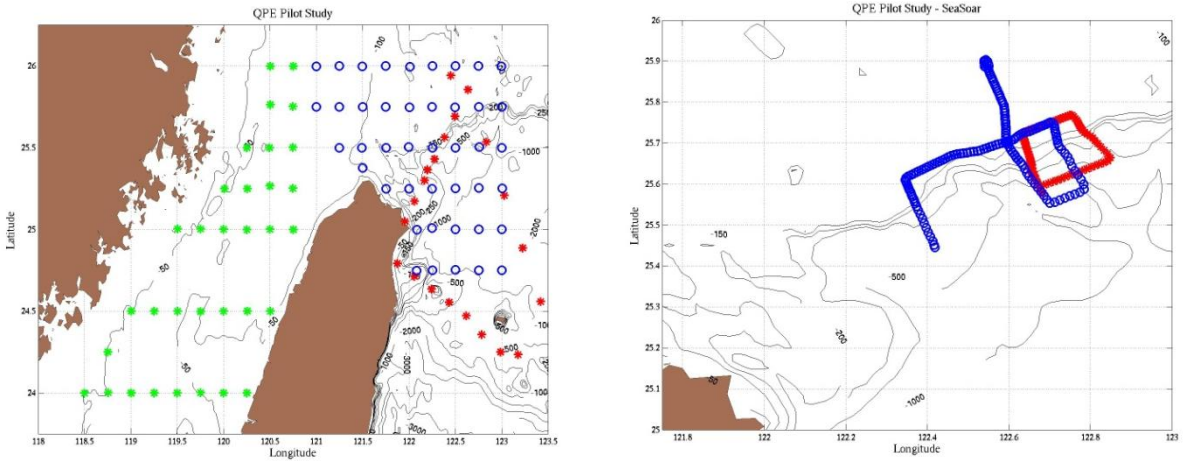
- Bias and RMS skill metrics were calculated for 3 different 9 day forecasts, each starting on 31 Aug 2008. The forecasts differ in the initial transport imposed between Taiwan and mainland China.
- Seven snapshot realizations of the OR1 initialization survey are created by objectively analyzing the data every 12 hours during 2-5 Sep 2008. From these realizations, volume averaged bias and RMS errors are computed for each forecast, using the misfits between these forecasts and the OA'd data where the error estimates of the OA'd data are small enough.
- Based on these metrics it appears that during 3-5 Sep. 2008, the net transport between Taiwan and mainland China was either zero or 1Sv northward.



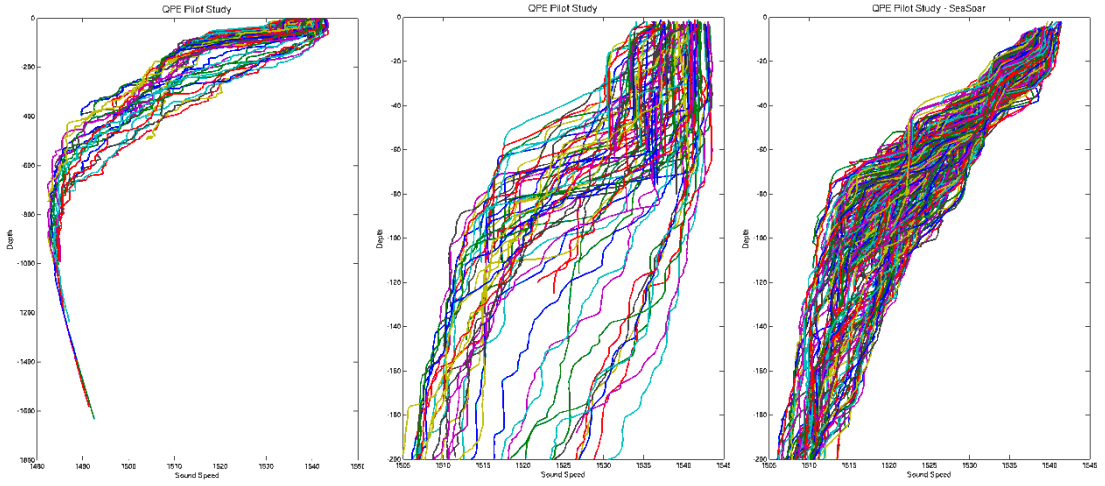
Data Processing and Analysis

- CTD casts have been collected and processed for three individual cruises during the Pilot Study. This data comes from the Ocean Researcher 3 (37 casts, 23-25 August 2008), Ocean Researcher 2 (43 casts, 23-27 August 2008) and the Ocean Researcher 1 (28 casts, 2-5 September 2008).
- In addition to the CTD casts there are CTD-like profiles collected by the SeaSoar operated from the Ocean Researcher 1. There are 115 profiles from the first survey pattern (6 September) and 157 profiles from the second survey pattern (6-7 September).
- The five sets of synoptic data have been found to be in excellent agreement. The mixed layer depth is found to vary greatly from location to location and also with tidal-related frequencies; ranging from a depth of a few meters to over 50m.
- The complete water column plots for the CTD show a deep (~800m) sound speed minimum. Plots of the CTD and SeaSoar over the range of 0-200m (full depth for the SeaSoar) illustrate the wide range of sound speed (15-30m/s) which can be found at any particular depth, even in the limited geographical extent covered by the SeaSoar.

Data Processing and Analysis



Location of CTD and SeaSoar casts, 23 Aug. – 5 Sep., 2008;
(left) OR1 [red], OR2 [blue] and OR3 [green]; (right) SeaSoar pattern 1 (red), pattern 2(blue).



Vertical profiles of sound speed from CTD and SeaSoar casts;
(left) CTD [0-1800m]; (center) CTD [0-200m]; (right) SeaSoar [0-200m].

Extras

Real-time Web Support and Product Dissemination

- The web site http://mseas.mit.edu/Sea_exercises/QPE/index.html was utilized for operational support and real-time product dissemination for the period 6-12 September 2008.
- Nowcast and forecast products with dynamics and uncertainty descriptions were provided for physical (T, S, velocity) and acoustical (sound speed and transmission loss) variables.
- An analysis of the regional dynamics and a description of the conceptual basis for the simulations were part of each product set.
- Forecast skill metrics were included on 12 September to compare the results utilizing differing initial transport imposed between Taiwan and mainland China (0, ±1 Sv).
- In addition to the complete web page, a smaller specialized page was created for at-sea participants in order to reduce network bandwidth needs.

Real-time Web Support and Product Dissemination

MSEAS QPE Pilot Study Real-Time Results

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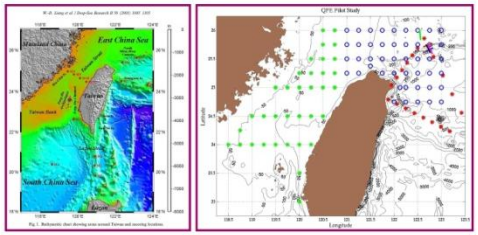

Collaborators: G. Gawarkiewicz, P. Abbot, C.-S. Chiu, K. Heaney, J. Sen, B. Cornuelle, J. Lynch, L. Mayer, B. Calder, P. Niiler

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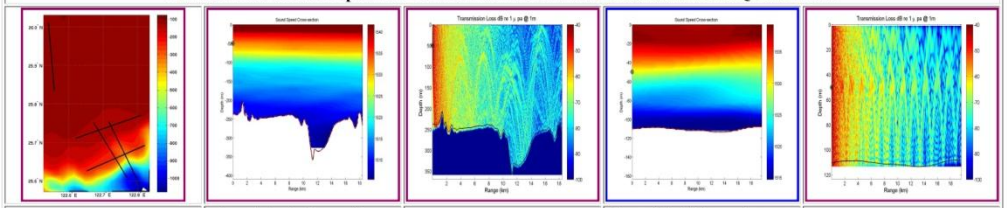
Real-Time Analyses and Forecasts
Background information
Preparation and Plans
Additional Pilot Study Links

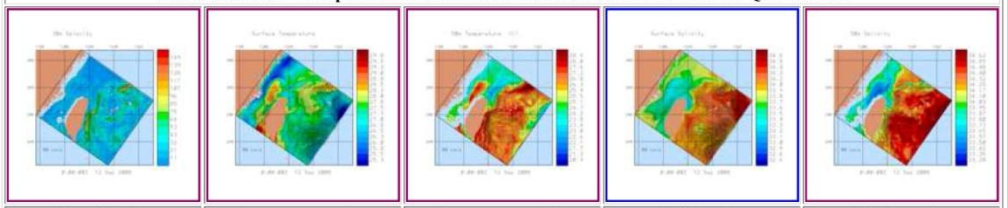
QPE Pilot Study - September 2008

Estimates of 000Z 12 September Environmental-Acoustic Conditions in the QPE Domain



Section Locations	Sound Spd. Sec. - Along shelf	Trans. Loss - Along shelf	Sound Spd. Sec. - Across shelf	Trans. Loss - Across shelf

Estimates of 000Z 12 September Environmental Conditions in and around the QPE Domain



30m Velocity	Temperature - 0m	Temperature - 50m	Salinity - 0m	Salinity - 50m

Nowcast and Forecast Products with dynamics and uncertainty descriptions	Forecast For						
	6 Sep. 2008	7 Sep. 2008	8 Sep. 2008	9 Sep. 2008	10 Sep. 2008	11 Sep. 2008	12 Sep. 2008
Ocean Physics	X	X	X	X	X	X	X
Acoustics	X	X	X	X	X	X	X
Model Output	X	X	X	X	X	X	X
Skill Metrics							X

- Data collected by SeaSoar on OR1 during Pilot Study
- Data collected by OR1 during Pilot Study
- Data collected by OR2 and OR3 for Initialization