BioEarth Milestones, November 2013
Note: Year 2 = April 1 2012 to Mar 30 2013
Year 3 = April 1 2013 to Mar 30 2014

PROJECT INTEGRATION: full project period

1. Model Full Integration Timeline
    a. Years 1-3:
        i. Offline model simulations - Offline couplings of WRF-VIC-MEGAN, VIC-CropSyst, and VIC-CropSyst-NEWS have been conducted over the Pacific Northwest to investigate how climate change in next 70-years could affect regional hydrological and biogeochemical cycles over the Pacific Northwest and how bias corrections on climate data could affect these impact assessments.
        ii. Consistent land cover datasets – different resolutions: 1) A primary data sets with 3-level classification system of land-use and land-cover has been generated from a combination of 30-meter NLCD2006, USDA CDL2011, MODIS land cover map, and other data sets (e.g. MODIS-derived irrigation map of the US, global wetland map, etc.). They have a spatial resolution of 1-km and 12-km and can be aggregated to any resolution larger than 1-km and each land use/land cover type in each grid cell are represented as area fraction. This dataset is being tested with WRF-VIC simulations over the Pacific Northwest and the WRF-VIC-EPIC runs over the North America. 2) 90-meter resolution vegetation map that was used in driving MEGAN simulations over the North America will be improved for BioEarth project. The reclassified and improved finest resolution (90-meter) data will be used for driving RHESSys model and consistent coarse resolution (12-km or 1/16th degree) fractional land use/land cover data will be used for other individual and coupled models.
    b. Year 3-5:
        i. Terrestrial:
            1. Inclusion of crops into RHESSys
            2. VIC-RHESSys-MEGAN (i.e., incorporation of newest version MEGAN (version 3.0) for biogenic emissions, as is currently being done for CLM)
            3. For solving the up-scaling issues in macro-scale models (e.g. VIC-CropSyst) and representing aspatial patch structures in RHESSys, distributions of land-use/land-cover bands along the topography and/or meteorological zones will be produced from the highest spatial resolution land use/land cover and DEM data sets.
        ii. Offline coupling: Offline coupling between CMAQ and VIC-CropSyst to study how fire-caused air pollutions can affect crop yield and regional carbon and water cycles through changing the aerosols and hence the solar radiation reached to the land surface.
        iii. Atmospheric: (WRF-CMAQ)/VIC
        iv. All WG I: (WRF-CMAQ)/(VIC-RHESSys-MEGAN)

v. Incorporate interactions with land-atmosphere tightly-coupled framework to economics and nutrient export through looser coupling

ATMOSPHERIC WORKING GROUP: Years 3-4

1. New Timeline: November 2013 through December, 2014

   Because of delays in setting up WRF-VIC and memory issues with the original version of coupled WRF-VIC in which VIC was not parallelized, this part has been delayed since the milestones was updated in February 2013:

   a. WRF-VIC historical runs
      i. VIC params (plan to use NLDAS2 soil and veg prior to integrating with MEGAN and RHESSys)

         <u>Status Update from June 2012</u>: Testing of WRF-VIC on a western US domain started in March 2012. To generate initial conditions for VIC, input data (meteorological forcing, VIC surface input data and VIC parameter files) were prepared and offline VIC simulations were run using NLDAS2 forcing for 10 years. Testing of the coupled WRF-VIC then proceed, but we encountered memory issues because the western US domain has many grid cells (due to the high resolution) and VIC was not parallelized. More recently we obtained a parallelized version of WRF-VIC and have started testing the new version. Also, WRF-VIC resulted in large positive biases in temperature in Arctic areas; the source of the problem has been identified.
         <u>Status as of February, 2013</u>: PNNL has been able to run WRF-VIC (4.0 racm tag32?) for a short period without memory errors. Initial check of result seems reasonable. More tests are being performed.

      ii. Evaluation of simulations over historical period
         1. Short-Simulation Tests

            <u>Status Update from June 2012</u>: This timeline has been pushed back depending on when WRF-VIC results will be verified. We have already done offline VIC simulations needed for initialization of coupled WRF-VIC simulations for Ruby's WRF-CLM western US grid. We plan on running coupled WRF-VIC on this domain for a relatively short period (1-2 years?) to verify the performance of coupled WRF-VIC for the western US, which has never been done before. Once Ruby is satisfied with the WRF-VIC results, she will switch to a new grid because her WRF-CLM grid is incompatible with CMAQ (see below).
            <u>Status as of February, 2013</u>: PNNL is in the process of running and evaluating results of 1-month simulation to see if things are ok before carrying out longer simulations.

<u>Status Update from November 2013</u>: This timeline has been pushed back depending on when WRF-VIC results will be verified. We have already done offline VIC simulations needed for initialization of coupled WRF-VIC simulations for Ruby's WRF-CLM western US grid. We have run coupled WRF-VIC on this domain for a relatively short period (1 year) to verify the performance of coupled WRF-VIC for the western US and evaluated its performance against NLDAS. We are updating the land use data (to use the data compiled by Mingliang) and will do simulation for a longer period (5 – 10 years).

2. 30-year WRF-VIC simulations to be completed by end of Spring of 2014 –
   - be sure to give at least 4 hours WRF-VIC output to Serena to make sure that WRF-VIC provides all the output needed CMAQ (may require adding more variables to WRF output by changing the Registry)

b. CMAQ setup

i. Soon – get domain/terrain info to Ruby and Jin-Ho

<u>Status Update from June 2012</u>: Ruby provided the grid/domain info of her WRF-CLM simulations to WSU. Unfortunately, this grid is incompatible with CMAQ. The WRF-CLM grid uses Lambert conformal conic with one standard parallel. CMAQ requires that the projection have two standard parallels. We have now decided on a different grid that is compatible with CMAQ. The new grid still covers the western US using 12-km x 12-km grid cells, but the domain is slightly smaller than Ruby's WRF-CLM domain.
<u>Status as of February 2013</u>: The domains has been constantly involving to leverage other work and has not been officially finalized. The the domain will be finalized very soon, in parallel with discusion on integration strategy, so that 30-year WRF-VIC simualation can be carried in a CMAQ-compatible domain.
<u>Status as of November 2013</u>: After several discussions, we decided that Ruby and Jinho should stay with the same domain they are using. Changing the WRF-VIC would require asking Tony Craig of NCAR to create a new mapping file (required by the flux coupler), as well as modification to VIC input files. We will re-visit the domain issue when we want to run WRF-VIC-CMAQ in fully coupled mode.

ii. Get anthropogenic emissions and fire emissions processing using SMOKE scripts–new time line: April-June, 2013

<u>Status Update from June 2012</u>: This has been delayed for reasons mentioned above. We plan on doing short WRF-Noah simulations using the "finalized" grid to get SMOKE scripting setup instead of waiting on

final WRF-VIC simulations. The new expected timeline for this is July - October 2012. We will use 2002 National Emissions Inventory (NEI 2002) for anthropogenic emissions. For fire emissions, we already have historical fire emissions output processed by BlueSky for 1995-2004. Tsengel will do the SMOKE setup with Rodrigo's help.
<u>Status Update as of February 2013</u>: This has been delayed as Tsengel has been focusing on correlation of climate indices with wet deposition rate of nitrogen using NAPD and writing the MEGAN section of the overview paper. There had been discussions with Rodrigo about how to set up SMOKE. Because we will be using the same projection as EPA's emission and spatial surrogate files, configuration of SMOKE should follow directly that of Rodrigo's simulations and airpact-4 and thus not so difficult. Tsengel will be going to the SMOKE training at EPA in April. The timeline for this has been pushed back form Jan-Mar, 2013 to April-Jun, 2013.
<u>Status Update as of November 2013</u>: This has been delayed again as Tsengel is still focusing on the paper on correlation of climate indices with wet deposition rate of nitrogen using NAPD data. Tsengel took training classes for CMAQ and SMOKE in March and for WRF and WRF-Chem in July. She will start working on CMAQ simulations as soon as the NADP-ENSO paper is completed, which is expected in early 2014. Because only some science questions will require coupled the WRF-VIC-CMAQ model, we will first focus on offline CMAQ simulations to address science questions that do not require CMAQ to be coupled to other models.

iii. Setup offline MEGANv2.1 simulations (this was not explicitly written out in the original milestone document).

<u>Status Update from June 2012:</u> MEGANv2.1 uses the most recent land cover data set (see section 3b of project integration), estimates emissions of ~150 compounds, and includes CO_2 effects. It can be run in offline mode or online mode coupled to CLM4. A paper on MEGANv2.1 is in review in Geophysical Model Development Discussions (Guenther et al., 2012; http://www.geosci-model-dev-discuss.net/5/1503/2012/). Tsengel will setup offline MEGANv2.1 run with help from Alex and Xiaoyan. The timeline is November 2012.

<u>Status Update as of February 2013</u>:

- *MEGANv2.1 paper has been published in GMD online at:*

  http://www.geosci-model-dev.net/5/1471/2012/gmd-5-1471-2012.html; the full citation is

  Guenther, A. B., X. Jiang, C. L. Heald, T. Sakulyanontvittaya, T. Duhl, L. K. Emmons, and X. Wang (2012), The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an extended and updated framework for

modeling biogenic emissions, Geoscientific Model Development, 5(6), 1471–1492, doi:10.5194/gmd-5-1471-2012.

- *Alex and Xiaoyan are working on new landcover data set and the next version of MEGAN (3.0) and will make an effort to ensure that it is compatible with BioEarth.*
- *Tsengel has learned to run a test case using MEGANv2.1. She will still need help from Xiaoyan in creating or learning to create input files for MEGAN once the simulation domain has been finalized.*

Status Update as of February 2013:

- *Alex has moved to PNNL and will continue to work on the MEGAN component of BIOEARTH. Xiaoyan has a new position and is no longer working on this project. Alex is identifying a replacement for Xiaoyan and will continue to work on the new landcover data and next version of MEGAN.*

iv. ENSO variability analysis over historical period.

Status Update from June 2012: Tsengel has been applying the wavelet analysis to measured wet nitrogen deposition rates from NADP/NTN. Preliminary results indicate that there is no 2-7 year cycle in wet N deposition for the 32 NADP sites in the western US for which there are continuous wet N deposition data, suggesting that wet N deposition is not modulated by ENSO. On the other hand, cross wavelet transform and coherent wavelet transform show some significance in common variance, particularly during the 1997/1998 El Nino event for some sites. We plan to look at correlations with other climate indices, e.g., AO, and extending the analysis to include dry deposition data from CASTNET.
Status Update as of February 2013: Tsengel has extended the analysis to include the whole US and other climate indices, including AO, NAO, PNA, and WP. She presented a poster at AGU in December. Currently, she is refining the analysis by de-trending the NADP data and writing the manuscript. The plan is to have the manuscript finished by August 2013.
Status Update as of November 2013: The analysis was carried out at 151 sites across the US against five different climate indices (NINO3.4, AO, NAO, PNA, and WP). De-trended N wet deposition rates (as NO_3-N and NH_4-N) were prepared and analyzed with each climate index. The first draft of the manuscript is near completion. The draft paper discusses cyclic components of precipitation and N wet depositions; spatial and seasonal variability of the correlations between 2- to 6-year band-pass filtered series of precipitation, N wet depositions and NINO3.4 index; agreement of zero lagged correlations with anomalies in precipitation (or total N wet deposition) during ENSO events using PRISM and NADP data; and potential future work.

v. Determine what chemical boundary conditions to use for CMAQ runs and get them

<u>Status Update from June 2012:</u> We have 2007 MOZART-4 output from Louisa Emmons of NCAR and plan on using this for chemical boundary conditions. This means that we will not be able to look at inter-annual variability of long-range transport impact, which we suspect to have relatively small for N deposition in the western US during the historical period. If of interest, we can uses MOZART-4 results for 2008 and 2009 in the future to see how N deposition may vary between 2007-2009 due to different long-range transport patterns during those three years.
<u>Status Update as of February 2013: The plan remains the same. MOZART-4 files have been obtained.</u>

2. Isotopic Analyzes of N Deposition (this section is substantially expanded from the Jun 2012 version)
    a. February 2013- early 2014—Nitrogen and oxygen isotopic analysis of historic NADP Samples
        i. One objective of Sarah's research is to measure the nitrogen and oxygen isotope composition of historic NADP samples. Initial samples have been analyzed for isotope composition. The goal was to finish sample analysis by the end of April 2013, but due to instrument difficulties, this goal has been pushed back to early 2014.
        ii. Analyze isotopic results with CMAQ and HYSPLIT to separate geographic emission locations and emission sources for the Pacific Northwest. Sarah has taken Brian's atmospheric modeling class, and the goal is to continue learning how to use CMAQ and CMAQ output to integrate modeling and isotopic data.
        iii. Goals for the upcoming year are to expand the temporal and spatial scale of samples and to integrate isotopic results with CMAQ, HYSPLIT, and synoptic weather analysis. Back-trajectories have been ran for all NADP precipitation samples, and currently, a source contribution function (in R) is being used to identify the dominant synoptic pattern along with a cluster analysis (from HYSPLIT).
    b. A second objective is to use biological indicators (mosses, lichens) to extend the temporal scale from years to decades. Preliminary experiments to address this objective will begin this year.
        i. Carry out a growth experiment with biological indicators (specifically lichens and mosses) to understand how long biological indicators integrate deposition
        ii. Analyze historic (herbaria) samples to develop a timeline of indicator (and deposition) isotopic composition overtime. Currently, preliminary samples have been collected from the Smithsonian and the WSU Marion Ownbey Herbaria; they are awaiting analysis.
        iii.
3. January 2014 - December 2014

    Due to delay in finishing up Tsengel's NAPD work and getting WRF-VIC to run, this timeline has been pushed back.

    a. CMAQ runs
    b. Analysis on deposition results from CMAQ output
    c. ENSO analysis on WRF-VIC simulations
    d. papers out on ENSO and land/atm interactions as modulated by ENSO cycles
4. Post December 2013: climate change experiments – e.g., CMIP5 data being prepared from CCSM4 – creating of WRF input files from this

TERRESTRIAL AND AQUTIC WORKING GROUPS: Years 2-3

1. RHESSys focus study sites (i.e., improvements of RHESSys on N processes and evaluations over small watersheds)
    a. Site selection: Wet – McKenzie (Willamette); - *DONE*
    b. Data collection for sites: *complete for wet site DONE*
    c. wet *site simulations and analysis – DONE see Zhu et al poster*
    d. Results from sensitivity analysis. Research question: How do increases in temperature (and associated shifts from snow to rain) impact local/patch-scale N retention and export for a range of local settings, including: 1) elevation, 2) vegetation type and biomass, and 3) N-loading. This analysis focuses on local processes only and does not include the impact of hillslope-watershed redistribution. – *Presentation at Fall 2013 AGU*
    e. Draft of paper on sensitivity analysis of N, C and hydro sensitivity to climate (Jun Zhu, by Dec 2013)
    f. submission of second paper. Research question: How does watershed redistribution of moisture and N impact the sensitivity of watershed N-retention and export to warming temperatures? (This analysis is on the hillslope/watershed-scale) – *draft manuscript by end of year 2*
    a. reporting scaling strategy based on focus site analysis for upscaling RHESSys: trade-off between resolution and processing time – *approach identified, scaling relationships determined during year 2 to be completed by Garcia May 2013*
    b. *estimation of impact of carbon allocation strategy selection on estimates of long-term post-disturbance forest – sequestration (completed by April 2013, Garcia)*
    c. *Testing of RHESSYs standalone work flows DONE*
2. Regional-Scale VIC/RHESSys work *completed* during Year 1
    a. Finished an analysis on the effects of historical climate change on regional evapotranspiration and runoff by using an offline VIC simulations with 6-km resolution driving forces data; submitted for publication
    b. Finished an offline VIC simulations over the North America with NLDAS-2 forcing data and parameters and parallelized VIC code through OpenMP;
    c. Added a NetCDF format climate data reader for RHESSys;
    d. Processed historical LAI data sets (1981-2011) for running VIC in order to study how changes in phenology can affect regional water cycles;
    e. Identified strategies to combine VIC components into RHESSys.
3. Regional-Scale VIC/RHESSys work to be completed during Year 2

   a. Close the surface energy budget and development of initial code to improve the soil thermal dynamics in RHESSys by combining with VIC – this needs to be completed in year 3;
   b. Parallelize RHESSys code to handle large number of patches for large-scale regional simulations;
   c. Add stream routing processes in RHESSys; (DONE)
4. Regional-Scale VIC/RHESSys work to be completed during Year 3
   a. Impact studies on how vegetation dynamics, climate change, and atmospheric CO2 concentrations affect regional hydrological processes (with VIC model) over the conterminous US has been finished. Regional model-data comparisons against remote sensing data have been conducted in this study.
   b. Add management processes for agricultural ecosystems in RHESSys by introducing methods from VIC/CropSyst coupled model;
   c. Calibrate RHESSys with field observations over the CRB and make offline simulations with air quality data (i.e. nitrogen deposition and surface ozone concentration) from CMAQ/WRF coupled simulations;
   d. Start coupling RHESSys with WRF by implementing a coupler (CPL7) to map watershed and patch scale simulated results of RHESSys to grid cells of WRF;
   e. Provide preliminary offline simulation results and spatial data sets to aquatic ecosystem model (NEWS) and social economic model trying to study material and energy exchange between the interfaces of terrestrial system, aquatic ecosystems, and social economics.
   f. Preliminary offline VICCropSyst results provided to the Economics team to create crop production functions. This process is ongoing and is being refined. Preliminary VIC and VIC Offline results provided to NEWs at the sub basin level. This process is also currently ongoing.
   g. The biogeochemical processes (C & N cycling) of the CropSyst will be implemented in the coupled VIC-CropSyst for both agricultural and natural ecosystems. Model calibration and validations will be conducted in the study domain. A close linkage between new VIC-CropSyst (V3) and NEWS will be conducted through transferring daily simulated C & N leaching information (as well as routed stream flow) into NEWS.
   h. Routing and reservoirs online with VIC. *In progress.*
      Bart Nijssen's group at UW (Student: Joe Hammen) have a coupled VIC - routing version available for us to try. We have a plan for the reservoir component which we will refine and implement Spring/Summer 2014. It is a two pronged approach – a) an offline reservoir model based off of Colsim that is more detailed and b) a simple store and release function in the online coupled version that is based off of offline results or a generic reservoir model like the one developed by Nathalie Voisin.
5. VIC-CropSyst development for focus study site, Yakima River Basin
   a. Calibration and validation (Jan 2014)
   b. Switching to Hourly time step (March 2014)
   c. Coupling with a boundary layer model
   d. Inclusion of Nitrogen model in VIC_CropSyst

    e. Manuscript preparation: 2 paper will be prepared: 1- impact of irrigation management 2- impact of climate change
6. RHESSys rapid implementation – work with CI group to run RHESSys in Kepler workflow for rapid implementation of stand-alone RHESSys – test over the new Idaho CZO (Reynolds Creek). Also, we will implement the automation and workflow managements on handling multi-format (ascii, binary gridded climate data, netCDF etc.) and multi-source (e.g. WRF simulated results, MACA downscaled, and station-based gridded data) meteorological input data for RHESSYs;
7. Rangeland-specific work with RHESSys: Primary objective of Julian Reyes' dissertation work is to examine forage quality and quantity in rangelands with respect to changing climate conditions and management schemes/decisions.
    a. Year 3 progress: Develop and compare impact of different carbon allocation strategies . Develop capability to represent Grazing as an input time series of potential carbon loss. Currently testing 'combined' allocation scheme at point scale at a variety of grass and rangeland sites where data are plentiful for calibration (leafC and frootC) and evaluation (leafC, frootC, leafN, frootN, LAI, NPP, NEE). Sites to be evaluated by December are Konza Prairie and LTER (Kansas) and Shortgrass Steppe (SGS) LTER in Colorado.
    b. Future work: Develop a strategy to capture variable C:N ratios for leaves (completed by Feb 2013). Test phenology model (leaf on/ leaf off) for grasses and adapted if needed (completed by March 2013). (1) select additional sites representing diverse biomes (i.e. Sevilleta LTER (desert grasslands), (2) select more complex sites to test competition (i.e. shrubs vs. grasses), such as Curlew Valley, Utah, (3) develop an upscaling scheme, (4) develop working plan for integrating National Climate Assessment Indicators into simulation work, and (5) create a list of management schemes to be tested.
8. Sub-Alpine work with RHESSYs and field research: The objective of Justin's research is to determine community-specific biogeochemical responses to atmospheric nitrogen (N) deposition in subalpine ecosystems.
    a. Baseline field measurements of N deposition partitioning at ambient deposition rates completed in 2013 at Mount Rainier National Park.
        i. Preliminary modeling of N partitioning under ambient and elevated N deposition using DayCent biogeochemical model
        ii. Concentrations of N deposition stored in snowpack
        iii. Soil nitrous oxide (N_2O) emissions
        iv. Soil NH_4^+ and NO_3^- leaching
        v. Microbial N immobilization
        vi. Plant N uptake
    b. Future objectives
        i. Complete parameterization of research site in RHESSys using field measurements and simulate N partitioning under ambient N deposition
        ii. Compare RHESSys model output to field measurements of N partitioning to determine model sensitivity to N deposition
        iii. Evaluate N partitioning at elevated N deposition rates through field N manipulation experiment
9. NEWS nutrient export completed past year

a. Compile observed data sources for evaluation of regional-scale model along major tributaries of the CRB (and for select smaller tributaries): solute concentration, discharge, etc…
b. Create and incorporate nitrogen datasets for incorporation into the regional scale NEWS model for the Columbia River Basin. These include fertilizer application, manure application, sewage, agricultural N deposition and fixation, non-agricultural N deposition and fixation, and N removed from crop harvest and grazing.
c. Update hydrologic inputs for the regional NEWS model. Runoff and Consumptive water use produced from VIC output.

10. NEWS nutrient export next year milestones
    a. Incorporate updated reservoir retention factor in regional NEWS based on runoff/discharge calculated using VIC and both GRanD and NID dam databases.
    b. Calibrate and validate regional NEWS model
    c. Complete sensitivity analyses for model
    d. Use model to predict changes in N export occurring with potential climate change scenarios.
    e. Finish Thesis Project

CYBERINFRASTRUCTURE WORKING GROUP: Years 2-3

1. Support for BioEarth communications:
    a. ***Forum was been dropped for lack of use. We are using email and using the BioEarth Web site for calendar support.***
    b. Support for tele-web-conferencing of the group. ***Using Adobe Connect successfully, courtesy of Chad Kruger***
2. Support for BioEarth codes:
    a. Code acquisition – Background: earlier request for people to communicate/covey codes and data for archive has resulted in no codes being archived. ***See next***
    b. Code storage -- ***We are evaluating whether to use GitHub to archive BioEarth codes generally, and indeed some codes are already being archived via GitHub. For example, Julian Reyes has been utilizing GitHub for archiving RHESSys. GitHub usage has apparently surpassed other archival sites/solutions, and seems to be the most recent and most obvious choice for code archival, especialy for an open source project such as BioEarth. No BioEarth-wide archival of codes has yet been undertaken. We plan to begin this much-delayed task in 2014 through v***ersion controls for BioEarth models (VIC-CropSyst, VIC, RHESSys, etc.) and spatial data sharing and distributing system.
    c. Work-flow -- we've identified Kepler as a promising tool to create script-like control codes. ***Instead of making a Kepler Workflow demonstration of running a sequence of different models, as was anticipated, the decision was made to focus on Kepler and the requirement to accomplish a plethora of RHESSys runs for calibration over the project domain in the Pacific Northwest. During summer 2013 Tristan Mullis began demonstrating a Kepler Workflow that he is***

developing for running the RHESSys hydrologic model. Tristan has also made substantial progress in wrapping that workflow in a calibration workflow that exercises RHESSys over a large number of watersheds, varying control parameters, as is necessary to calibrate RHESSys to our domain.

d. Provenance feature will be enabled for the above workflow demonstrations. ***Provenance will be a near-tern focus in Kepler development, initially building upon the RHESSys workflow accomplishments. The logic of this is that as workflows are developed for running other model components besides RHESSy, having the Provenance feature functioning will support those workflows becoming used in production more meaningfully. With Provenance functioning, a model run will not only generate output files (data) but information on the input file and output file identifiers, hence producing metadata in addition to data. This supports an important Quality Assurance aspect of the overall project.***

e. Kepler training will be necessary for model users to be able to test the Kepler workflows developed for their models. ***A Kepler user training module still needs to be developed. Based on the above, development of this module will be deferred until we are able to demonstrate the Provenance function.***

f. BioEarth workflow development for RHESSys is in some sense paralleled by a project at UNC-CH, seen at https://pypi.python.org/pypi/rhessysworkflows/1.0. This UNC-CH workflow uses Python scripts for preparing RHESSys data. Source code is found at https://github.com/selimnairb/RHESSysWorkflows. ***A new BioEarth task is to become familiar with the UNC-CH workflow capabilities and learn how to productively exploit, accommodate and/or support that effort.***

3. System support and maintenance:

a. BioEarth has sought for the past year to have the aeolus cluster disk array connected to the WSU central cluster via an upgraded, high capacity access path and method. This remains an unmet need for the support of BioEarth and discussions appear to be reaching a point of resolving this request one way or another. In either event, the cluster resources available to BioEarth should be better defined soon. ***The much discussed and long awaited 10GB switch that could enable more efficient use of the WSU center HPC cluster is still under consideration but unaccomplished.***

b. The aeolus cluster on which BioEarth largely depends for computation was due an upgrade for several aspects. A storage upgrade was been given the highest priority, with upgrades and replacements of compute nodes running a close second. ***In the spring and summer of 2013 the data storage disk array capacity was increased from 90 TB to 190 TB. The number of 8-core Dell compute nodes was decreased from 20 to 16, to accommodate an increase from 4 to 9 64-core Silicon Mechanics nodes. These compute node changes resulted in an increase from 416 cpu to 704 cpu, with the SM nodes having 128 GB each, as compared with the Dell nodes with 8 GB each. The much discussed and long awaited 10GB switch that cold enable more efficient use of the WSU center HPC cluster is still under consideration but unaccomplished. Also, BioEarth's high level of commitment to high-performance computing has involved us in***

discussions about development of a larger HPC capability at WSU, for which a NSF MRI proposal is being developed with our participation.

ECONOMICS WORKING GROUP: Year 3

1. For the economics modeling component the third year of the grant has focused on integration of with the hydrology modeling component via the parameterization of crop water yield curves. This process involves generating crop yield production in VIC-CropSyst at varying levels of water availability. This model output is then used as data to estimate parameters of curves that can map water intensity to yield at all levels. This forms the basis of the production function embedded within the economics partial equilibrium model. A number of aspects of this effort have needed to be addressed. In particular, developing methods for measuring solar radiation and water presented some obstacles but have been addressed. A remaining issue is spatial aggregation since each subregion in the economic model is watershed scale. This process is expected to be completed in early 2014 and is the last significant step in completion of the regional economic model and the integration of this with the land surface hydrology model.
2. The development of the second economic model, the spatially explicit agent based model, was also initiated this year during Dr. Yong Chen's visit to the WSU campus in Pullman. An approach was developed using look-up tables that will allow for full coupled with the land surface hydrology model. The agent based model will undergo substantial development in the second half of 2014.

COMMUNICATIONS WORKING GROUP: Years 1-3

Milestones from Year 1 (Spring 2011-Spring 2012):

1. Conduct interviews with all PIs about stakeholder engagement **(Done)**
2. Complete a written report of researchers' perceptions **(Done)**

Milestones from Year 2 (Spring 2012-Spring 2013):

1. Host 2 stakeholder workshops during year 2 **(Done)**
2. Initiate analysis of interactive communication between scientists and stakeholders **(Ongoing; we will compile information about which suggestions from stakeholders are being acted on and report back to stakeholders, and conduct further surveys)**
3. Submit manuscript on scientists' perceptions of stakeholder engagement **(Done, published in Journal of Environmental Studies and Sciences)**

Milestones for Year 3 (Spring 2013-Spring 2014):

1. Host 2 stakeholder workshops during year 3 **(Planning is underway, will be held in February 2014)**
2. Conduct a second round of interviews with all project PIs **(Happening now)**
3. Begin comparative assessment of approaches to stakeholder engagement in other regional environmental modeling projects (WISDM and REACCH) **(In planning phase)**
4. Launch AgClimate.net **(In pre-launch phase)**