POS Panel Breakout Reports

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POS Panel Breakout Report

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Machine Learning Action Items

- POS member **(Aneesh, Chris, Sergey, Michelle)** stay engaged with the Machine Learning Working Group (e.g., report-outs)
- POS members stay engaged with webinars and activities (e.g. trainings, sessions at conferences)
- Identify where Machine Learning can be useful for POS-related activities/foci

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East Coast Sea Level Rise

- East Coast sea level in the context of the climate system
  - Long time-scale drivers of Sea level rise
- High tide flooding along the U.S. East Coast : William Sweet (NOAA)
  - NOAA flood prediction product for US coastal cities

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East Coast Sea Level Rise Action Items

- Task team on identifying gaps using the feedback spreadsheet from IAG (+other community input/reports) and produce a synthesis report

Uncertainty Quantification

- Quantifying uncertainty in coupled forecasts - Sergey Frolov
  - Navy NRL model UQ strategy
- ESIP community whitepaper on uncertainty quantification - David Moroni
  - White paper on UQ strategies
- JPL "Validation, Verification, Uncertainty Quantification" effort: Kerry Cawse-Nicholson (JPL)

UQ action items

- OceanObs'19 breakout session and poster on UQ (Aneesh, Shane, Kyla)
- Whitepaper defining common terminology, general best practices

Arctic Ocean Observing Action items

- Submit an Arctic Ocean Circulation Workshop proposal
  - Should US CLIVAR should have a Science Team?

- Add a polar/high-latitude member to POS Panel.

Observing systems

- US GO-SHIP Review Report: Fred Bingham
  - US CLIVAR and OCB jointly reviewed the US GO-SHIP program, generated a report
- Southern Ocean / SOCCOM: Lynne Talley
  - Currently in the 6th year, planning for the next 4-year phase
  - Many publications & exciting results on the biogeochemistry of the Southern Ocean
- Coupled ocean-atmosphere boundary layer measurements : Carol Anne Clayson (WHOI)
  - This is still an underappreciated and important topic in the community

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Observing Systems
Action Items

- Start a connection with UNOLS to help inform discussions about future of the research fleet (relevant to GO-SHIP and other programs) (with PSMI?)
- Stay informed on current efforts to eliminate harassment in the field (with PSMI?)
- Air-sea flux observations
  - US CLIVAR Surface currents workshop
  - Continue facilitating interaction of this community, e.g., through side meetings at AGU/AMS conferences
  - Flux measurements (Direct vs bulk) – work with PSMI
  - Organize webinars
  - Engage with Coupled DA community

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West Coast Ecological Forecasting Action Items

- Pacific Research Board RCN activity proposed.
- Panel will follow-up if this is encouraged and engage with the wider community

Biogeochemistry

- Integration of biology into observing systems: why, how, and when - Frank Muller-Karger
  - More biological observations are needed
  - Synthesis with ocean physical observations
- Observation of Biogeochemical Cycles: current state, recent advances and remaining challenges - Michelle Gierach
  - Many new and exciting satellites coming!
- Modeling of Biogeochemical Cycles: current state, recent advances and remaining challenges - Cecile Rousseaux
  - BGC modeling efforts are expanding.

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BGC Action Items

- Be engaged with Frank and report back to the panel
  - Biological/BGC data management strategy
- Integrate Biological observations into ocean observing (Ships, mooring, buoys, gliders, animals)
  - Promote community reanalyses with a workshop of DA and observation

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Other Action Items

- Continue POS Webinar series with a focus on POS Priorities
- Teleconnection from low- to high-latitudes
  - Organize webinars,
  - Connect with Ecosystem predictions
  - Connect with PPAI on S2S

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PSMI Panel Breakout Reports

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Air-Sea Interaction

- Significant progress in last two decades in understanding the physics of air-sea interaction at mesoscales
- Need to develop common, multiple-scale diagnostic metric to evaluate the high-res. models. Construct a common modeling and diagnostic framework; a goal of the new WG.
- Quantification needed of the downstream influence of the WBC fronts.
- Call for a super-site array to construct a budget analysis using multiple platforms. Useful approach for model development and assessment
- Data accessibility: maintain quality-controlled field campaign data for community
- Invest in innovative and emerging technologies (UAVs, autonomous platforms)
- Progress in understanding gas exchanges and the impact of bubbles - connections to OCB WG
- Biological and chemical impacts of air-sea gas exchange, e.g. ice melt

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Action Items for PSMI

- Need to address the biases and errors of the air-sea fluxes in the climate models.
- An intercomparison study of CMIP6 and reanalysis datasets with focus on air-sea interaction including PBL, mixed layer, air-sea fluxes (perhaps through WGs):
  - survey what parameterizations are being used in climate models (CMIP, HighResMIP, etc).
  - determine what data sets are available for comparison
  - compare the state variables, re-compute the fluxes using the latest COARE algorithm, and compare to the inherent model fluxes
- Recommend joint session of Boundary Layer WG and OCB Gas Exchange WG

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Machine Learning for Model Improvement

There is significant potential of these tools for the US CLIVAR community:

- Reducing computational costs through emulation of expensive calculations (allowing for ensembles, high-resolution, etc.).
- Testing for producing realistic (or unrealistic) parameters for conceptual models thereby test the validity of models - or improving models or satellite retrievals.
- Hypothesis generation to aid physical understanding (e.g., signal-to-noise or teleconnections).
- Quantifying uncertainty to make more informed climate change projections and models.
- Building on existing techniques for event and pattern classification.

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Machine Learning for Model Improvement

New avenues to explore based on discussions:

- Could the ML approaches to emulators in model include/capture stochasticity (i.e., is relevant for convection).
- Training datasets remain a challenge: instability arise in emulators, some are hard to train, always a need for extensive amount of ***quality controlled*** data.
- High quality data of multiple variables are needed (e.g., labeled supervised learning).
- It is important that ML applications be constrained by physical laws such as conservation requirements.

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Action Items for PSMI

- Coordinate closely with new US CLIVAR WG on Emerging Data Science Tools (e.g., participation in webinars, workshop, reports)
- An assessment by the community of the value of ML in comparison to traditional statistical methods is needed.
- Propose a summer school on ML application to climate research:
  - Involve early and mid-career researchers, experienced ML users in the climate sciences community and professional statistical/computational scientists.
  - Instructors need to be able to communicate beyond their own research interests.
  - Trainees could come prepared with their research problems.
  - The release of CMIP6 model output provides a good opportunity for identifying training and research problems.

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Action Items for PSMI

(further down the road...)

- Coordinate the development of broader ML for climate science tutorials (potentially coordinate with community such as UCAR).
- Coordinate ML for climate science toolkits.

Subseasonal-to-Seasonal Prediction

- Identify common model biases and uncertainties in S2S prediction systems that, if improved, could best improve predictive skill.
  - Examples included: SST biases (importance of a coupled ocean), ENSO westward extension, low clouds, resolving coastal topography, small-scale wave parameterizations, precipitation diurnal cycle etc.
- To better address model biases we need to improve the connection between model developers and those who use the model output
  - CPTs are one avenue, but more built-in structures for collaboration would be useful.

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Subseasonal-to-Seasonal Prediction

- Need a systematic way to understand why some models have higher predictive skill.
  - Are there model experiments that could isolate processes and their influence on skill?
  - Are there ways to isolate which observations being assimilated into initial conditions improve forecast skill, and/or to reduce observational uncertainty in the initial conditions?

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Subseasonal-to-Seasonal Prediction

- Provide a mechanism for interactions between the model developers and those conducting process studies and model analysts.
  - Coordinate regional and global modeling experiments for process understanding with modelling centers.
  - Encourage modeling centers to have liaison to communicate model parameterizations.
- Possible survey/report of current modelling and observational S2S projects on lessons learned, challenges faced, remaining gaps, data output needed to address certain processes, broader impacts, key biases that impact predictability specifically of S2S.

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Seasonal-to-Decadal Prediction

- Tropical Pacific decadal predictions are challenging because interannual ENSO variations act as a source of noise.
- Southern Ocean exhibits skill at decadal scales associated with deep water formation. Unclear how this is related to model mean state (stratification) and so how model dependent this might be.
- Methods for initializing decadal predictions need to be enhanced to reduce model biases/shocks
- Workshop in multi-year predictability - stakeholder engagement.

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Action Items for PSMI

- Contribute to the planning of the US CLIVAR multi-year prediction workshop.
- Facilitate coordinated paper/whitepaper for community on:
  - Promote enhanced understanding of mechanisms of tropical Pacific decadal variability that are independent of ENSO.
  - Evaluate the sources of predictability in the Southern Ocean across models.
  - Explore different approaches for initializing decadal predictions.
- Establish a dialogue (e.g., through webinars, workshops) with the operational and applications communities to identify how multi-year predictions could be useful.

West Coast Ecological Forecasting (PSMI)

Observational needs:

- Finescale coastal measurements such as Chl-a, O_2, pCO_2, and physically relevant measurements (e.g. temperature, ssh, salinity) are needed for model assimilation and validation.
- Providing a stable, robust BGC climatology/reanalysis would much improve initialization efforts for model forecasting and data assimilation efforts

Modeling Challenges:

- Very high resolution modelling is critical to capturing submesoscale variability which has a large impact on ecological measures such as export or net primary productivity and is essential for producing management relevant quantities (e.g., anthropogenic nutrient point sources).
- Model potential for ~18 month predictability in some regions/seasons for chlorophyll, also for bulk fisheries catch (!). Species-level information needed to improve forecasts to be useful for fisheries managers.
- Dynamical and empirical ecological and coastal forecasting may be useful approaches.
- Need for more submesoscale process studies to understand biophysical interactions; in general, must reconcile scales of variability between observations and models.
- Need for coordinated efforts across other US Coastal regions.

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Action Items

- Develop a venue for forming collaborations among modelers and observing systems across the large marine ecosystems of the US Coasts (e.g., EPOC Eastern Pacific Ocean Conference).
- Advocate for maintenance and further development of altimeter, scatterometer HF Radar currents etc. in coastal regions.
- Facilitate process studies to improve understanding of biophysical interactions in coastal interactions. Possible OCB session on mechanisms of predictions and predictability (e.g. ENSO, Heat waves, Hydrology).

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CMIP6 Progress

- Too early to evaluate CMIP6 progress
  - individual models show improvement (e.g., CESM2 large-scale circulations, MJO).
- Persistent biases in:
  - rainfall rate frequency, intensity
    - too frequent light rainfall in subtropics
  - ENSO, including event diversity
    - suspect cold tongue bias

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Action Items for PSMI

- WG to study sources and mechanisms and missing processes behind persistent phenomenological biases in CMIP6 member models (multi-model)
  - e.g., Double ITCZ, cold tongue, WBC, Marine low clouds, signal-to-noise paradox, Atlantic SE Tropics, Arctic surface energy budget.
  - Hierarchy of models may be one path forward
- Relate phenomenological biases to process biases
- Utilize established and emerging model metrics to characterize biases, improvements

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Action Items for PSMI

- Write position/white commentary advocating a longer period between CMIP events to better understand the processes underlying model biases and model changes. Evaluate differences between models and between model versions which will facilitate closer interactions between researchers and model developers.

PPAI Panel Breakout Reports

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PPAI Panel Breakout Summary

Sessions

1. Big Data / AI / ML
2. Arctic
3. S2S prediction (joint PSMI / split)
4. S2D prediction (joint with PSMI)
5. West Coast Ecosystems (joint all panels)
6. Climate and Health

Cross-cutting discussion about the 'Interface'

- how and to what extent to engage applications
- PPAI webinar series theme inviting stakeholders
- invited long-term participation of Fellows from different groups
- will continue discussion

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Big Data / AI / ML

Discussion Points

- Use cases and contexts for ML technique application are important
  - conventional uses such as in data fusion (eg PERSIANN precip) and short/medium range prediction (eg Barnes AR prediction)
  - newer applications in parameter estimation, parameterization development, and UQ for climate models (Pierre Gentine, Tapio Schneider)
  - model benchmarking
  - Strong interest in the climate community -- but comfort levels and performance increase with 'interpretability' and 'physical constraints'
  - The distinction and utility over traditional statistical techniques has to be better articulated/understood.
  - Insufficient connection between CS/AI/ML/AM discipline and geosciences

Recommendations / Panel Interests

- ASP-type Colloquium or Summer School for students to apply ML/DL methods in geoscience problems
- Promote longer term interactions (eg a PACE-type program, eg 'Postdocs Applying Deep Learning in Geoscience')
- White Paper on optimal uses in different contexts (from WG?)

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S2S Prediction

Discussion Points

- The role of the stratosphere for subseasonal-to-seasonal (S2S) prediction,
- Seamless prediction system development activities at the NOAA GFDL, and
- An overview of WMO S2S prediction project phase 2.
- But NOT: land surface role … 

Recommendations / Panel Interests

- Need to promote investigation and discussion of sources of predictability beyond the oceans, and in particular from the land surface
  - Stronger CLIVAR connection with GEWEX programs?
  - CLIVAR led review paper?
  - Next calls for all the panels to include more land process calls
  - Theme for PPAI webinar series
- Need for greater coordination in S2S initiatives and between modeling groups
  - Despite a plethora of activities and databases, consensus about value of multi-model efforts is lacking; some missed opportunities (eg w/ SubX)
  - Real-world value proposition needs refinement in many sectors
    - use of forecasts of opportunity

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S2D Prediction

Discussion Points

- Decadal prediction efforts at NCAR and GFDL were reported.
  - eg NCAR DPLE has carried out a 40-member large ensemble decadal prediction with CESM1, which is being submitted to CMIP6 DCPP MIP.
  - GFDL has tried different initialization methods (DA, nudging of SLP).
- Significant scientific challenges remain
  - Lack of process understanding of the low-frequency modes, especially the tropical Pacific decadal variability.
  - Model drift/initialization shock
  - Lack of experience to initialize the land; lack of DA experience to initialize a coupled earth system model (with atmosphere, ocean, land and ice)
  - Relatively low predictability in the surface climate over land
  - Sparse ocean observations and changing observation system
- A need to learn more about decadal prediction applications across sectors

Recommendations / Panel Interests

- Proposed Workshop will explore some of these questions
  - *Prospects for Multi-year Climate Predictability and Societally-relevant Climate Predictions*
- Follow on review paper

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Climate and Health

Discussion Points

- Climate change impacts human health in many and complex ways
  - Challenges of climate predictability are compounded by also defining vector/transmission pathways and societal vulnerability
  - Observations and their availability are a severe deficit for research and application
- A lot of activities are underway and there are notable achievements
  - CDC has the "Building Resilience Against Climate Effects (BRACE)" framework that allows health officials to help communities address long-term climate-health risk
  - The fourth National Climate Assessment report has an entire chapter on human health
  - USGCRP produced a special report on the impacts of extreme events on human health

Recommendations / Panel Interests

- CLIVAR could promote collaborations among meteorologists, climatologists and health professionals to better understand opportunities for using climate variability and change information to manage near and long-term health impacts.
- PPAI is developing a Workshop proposal

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West Coast Ecological Forecasting

Observational needs

- Fine-scale coastal measurements such as Chl-a, O_2, pCO_2, and physically relevant measurements are needed for model assimilation and validation.
- SSH is especially valuable for predictability: maintaining altimeter record, improving estimated SSH in coastal regions are both crucial
- Providing a stable, robust BGC climatology would much improve initialization efforts for model forecasting and data assimilation efforts
- Need for more systematic observation of biological activity: next-generation imaging techniques provide less biased estimates of plankton populations

Modeling Challenges

- Very high resolution modelling is critical to capturing sub-mesoscale variability which has a large impact on ecological measures such as export or net primary productivity and is essential for producing management relevant quantities.
- At high resolution, processes such as anthropogenic nutrient point sources become relevant.
- Models show ~18month predictability in some regions and seasons for chlorophyll, also for bulk fisheries catch (!). Species-level information needed to improve forecasts to be useful for fisheries managers.
- Both dynamical and empirical ecological and coastal forecasting may be useful approaches.
- Need for more submesoscale process studies to understand biophysical interactions; in general, must reconcile scales of variability between observations and models.

Applications Challenges

- Climate model predictions often need further processing for utility for managers e.g. high beach sand area from SLR or BGC to fisheries requiring species specific analysis.
- Stakeholder involvement from the outset is key: co-production of knowledge makes results more useful in the end
- Major events (storms, fires, hurricanes) can be a catalyst for management; though opportunities can be provided, science advanced is very dependent on specific stakeholder needs.

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West Coast Ecosystem Action Items

- CLIVAR to strengthen interactions with programs such as Sea Grant that can be information brokers to science and stakeholders.
- Develop a venue for forming collaborations among modelers and observing systems across the large marine ecosystems of the East and Gulf Coasts.
- Advocate for maintenance of altimeter record, improving coastal observations of SSH and other relevant quantities
- Facilitate process studies to improve understanding of BGC, biophysical interactions.

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Arctic

Discussion Points

- Presentations on interactions between sea ice and local and remote atmospheric drivers
- Discussed current status and limitations of S2S *prediction* of Arctic sea ice
- Summer season sea ice and atmosphere coupling dynamics remain unclear. Basic feedback processes, such as cloud-radiation feedback, sea ice albedo feedback and lapse rate feedback, need to be better understood.
- Arctic-lower latitudes connection theories remain controversial
- Balance of Internal vs forced variability not well understood
- Prediction skill limited by gaps in process understanding and of observations to quantify variability and predictability

Recommendations / Panel Interests

- A new WG under US CLIVAR to bring together researchers with complementary backgrounds to tackle the fundamental scientific issues regarding the Arctic climate system and advance the capability of sea ice prediction.
  - Complementary efforts: YOPP, Arctic research as NSF big issue
  - Would large new observational campaigns (ie MOSAIC)

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