PROcess Based Diagnostics – PROBE
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Introduction
Some of the most interesting properties of the climate system are emergent (e.g., sensitivity to external forcing, predictability at the regional scale). By emergent we mean a property that arises from complex interactions between, for instance, dynamics, radiation, cloud formation, and surface fluxes, rather than being a function of a single physical process. Most of the traditional global-scale diagnostics used for climate model evaluation are therefore emergent. Emergence therefore complicates our ability to attribute a systematic model-observation discrepancy to a specific piece of code or model assumption. Indeed, model developers are often left to their experience and trial-and-error when addressing these discrepancies. Unsurprisingly, some notable discrepancies have persisted across multiple generations of climate model development (e.g., the double ITCZ problem). Even with the availability of large archives of coupled GCM output (e.g., CMIP5) and complementary observations to go with them (e.g., Obs4MIP) our ability to address certain questions is limited.

Often these approaches can take the form of a Lagrangian conditional average, which when done correctly, merges a case-by-case perspective of single events with the statistical approach required by climatologists. In this way process-based diagnostics (PBDs) broaden the pool of traditional climate model validation methods.

Use Case – Extratropical Cyclones

Extra-tropical cyclones make excellent candidates for PBDs because: 1) Cyclones are specific, identifiable and well understood phenomena; 2) Cyclone activity shapes the distribution many quantities on both climatic and weather scales (e.g., cloud, temperature, wind). 3) Cyclones have interesting internal and external variability. 4) While today’s climate models can in principle resolve basic cyclogenesis features, they are less able to represent smaller key features (e.g., fronts). and questions remain about their ability to capture more subtle changes in cyclone behavior and structure (e.g., variations between seasons, hemispheres). Indeed, mid-latitude cyclone clouds are a key source of inter-model difference in climate sensitivity (Williams and Tselioudis 2007).

An ongoing project led by one of us, “The MAP Climatology of Mid-latitude Storminess” or MCMS, is designed to address just these sorts of questions (see Fig. 2, http://gcss-dime.gsfc.nasa.gov/mcms/mcms.html).

Process Based Diagnostics (PBDs) can be seen directly in the time mean of the field (e.g., convective storms and cyclones). As a result, this suggests the need for a more effective approach to diagnostic-based model development.

Workflow Automation
Aside from implementing various custom analysis procedures such as CCL, PROBE will primarily extend AES by incorporating workflow technology to automate the process of creating PBDs. Such automation will:

• Re-apply PBD analysis to auxiliary datasets
• Automatically ingest new model output to SciDB
• Rerun previous PBDs as new data arrives
• Notify user when new results are available

References
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MERRA - http://gmao.gsfc.nasa.gov/research/merra/mbh/