Using "Replay" to Data Assimilation for AGCM Model Development

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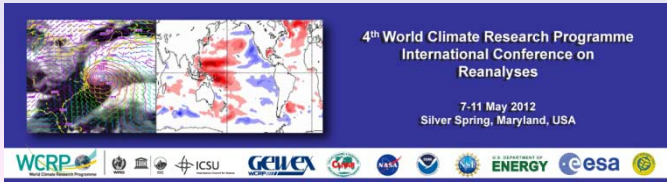


Outline

- Example where data assimilation experiments at 0.25° exhibited undesired behavior in response to an AGCM change which improved simulated climate

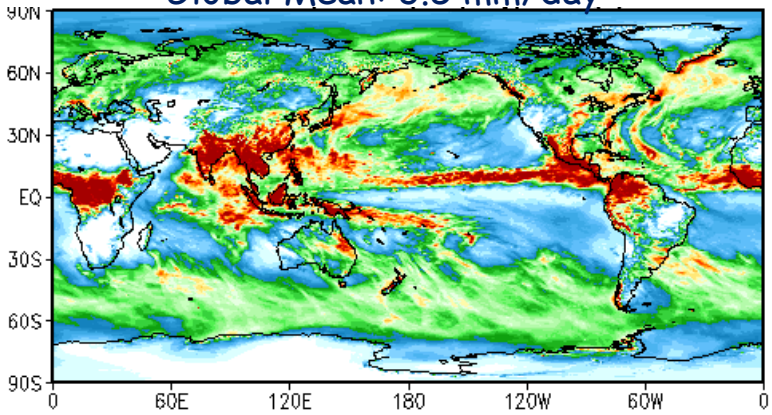
- "Replay" experiments at 1° used as a proxy for running data assimilation experiments to explore parameter sensitivity with new model

- Confirmation of "replay" results with data assimilation experiments

Issue: Impact of AGCM Change in Moist Processes

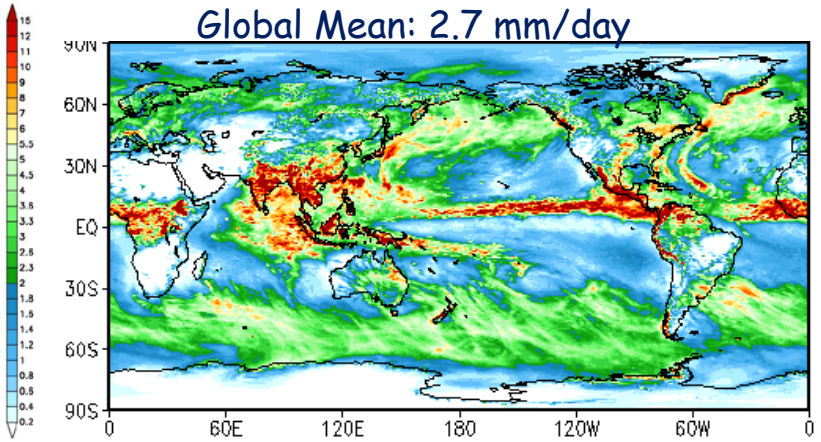
Data Assimilation at 0.25° -> Precipitation changes with model change

Global Mean: 3.5 mm/day

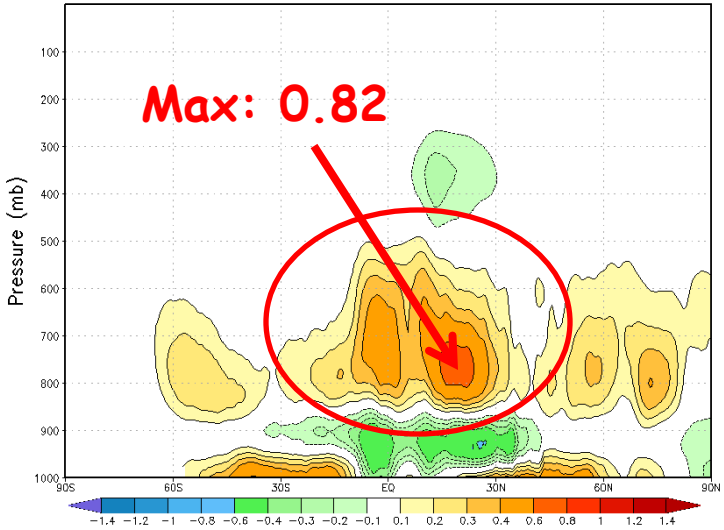


Modified AGCM

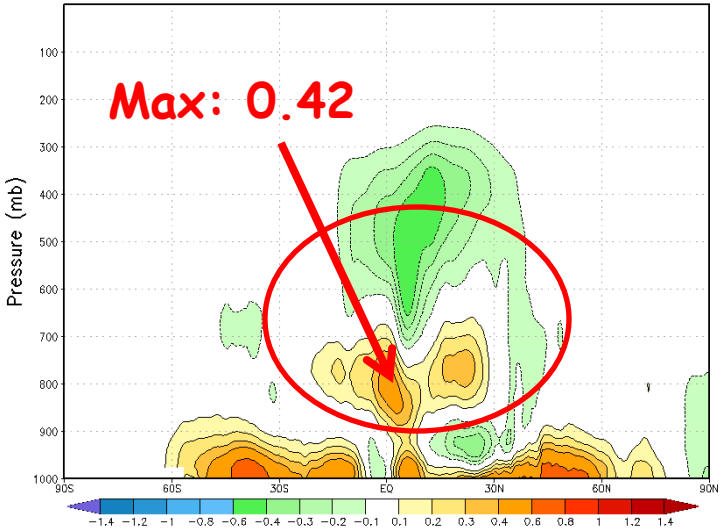
Global Mean: 2.7 mm/day



"Original AGCM"



Analysis Moisture Increment (g/kg/day)



GOAL: Use new model in Data Assimilation mode with better parameter choices

Issue: Impact of AGCM Change in Moist Processes

* Issue traced to change in model parameters to describe the sub-grid scale probability distribution of total water. Width of PDF ~ AGCM "Critical Relative Humidity" (RHcrit).

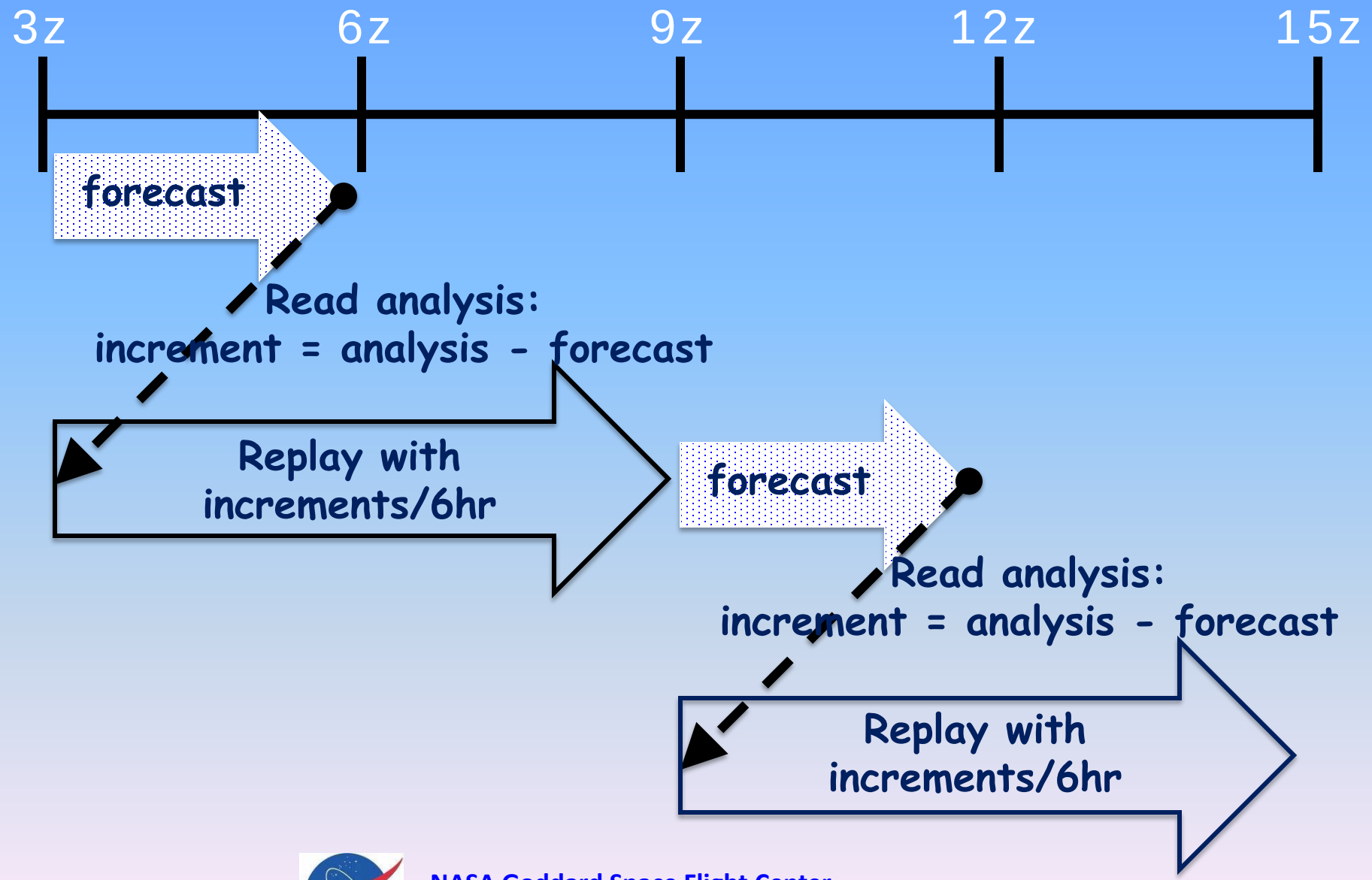
* Smaller RHcrit in new AGCM results in:

More precipitation and larger analysis increment (Humidity is constrained)

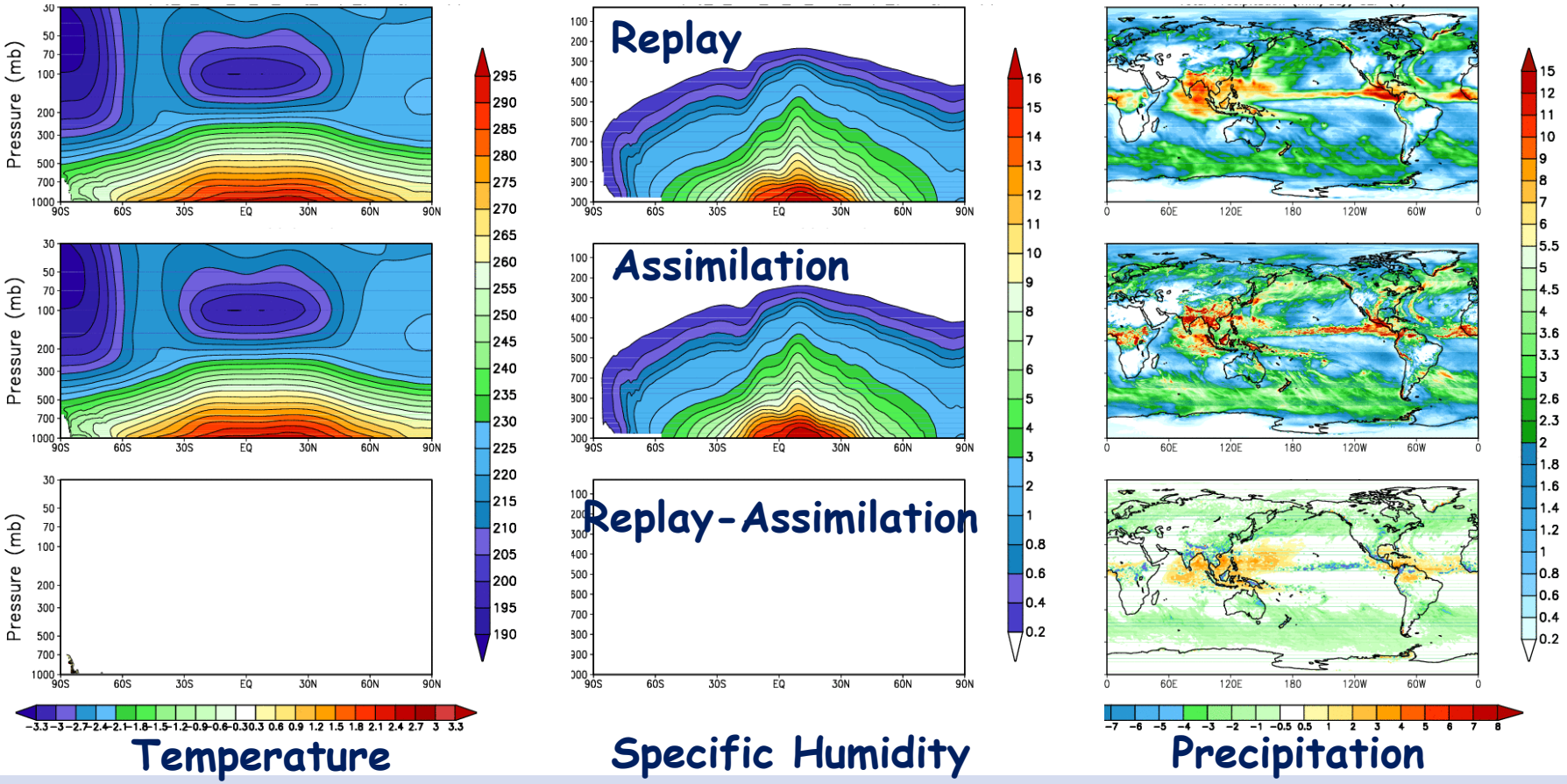
Strategy --> Explore parameter space for data assimilation mode. Seek out smaller analysis increment and correct total precipitation

Approach --> Run "Replay" experiments at 1°

"Replay" at GMAO: Flow Diagram



Comparison of 1° Replay to 0.25° Assimilation



Replay reproduces assimilation analyzed fields, approximates assimilation derived fields

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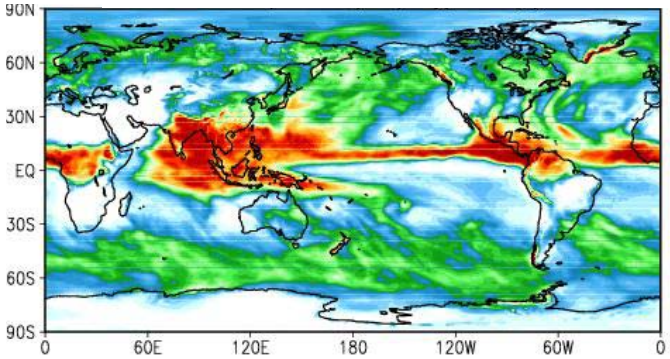
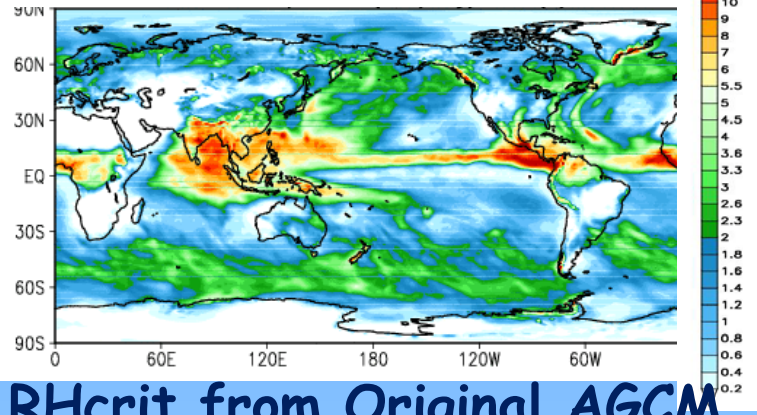
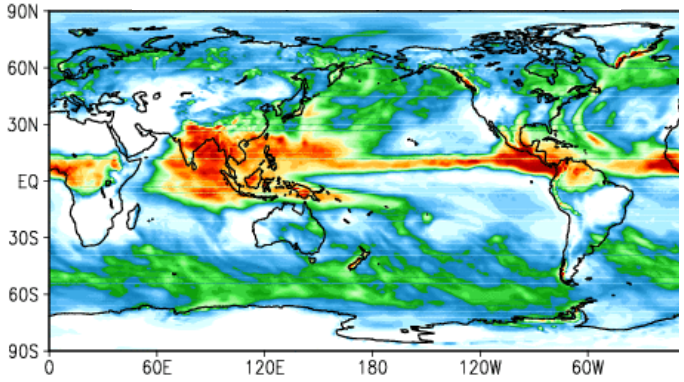
Replay with different RHcrit – Total Precipitation



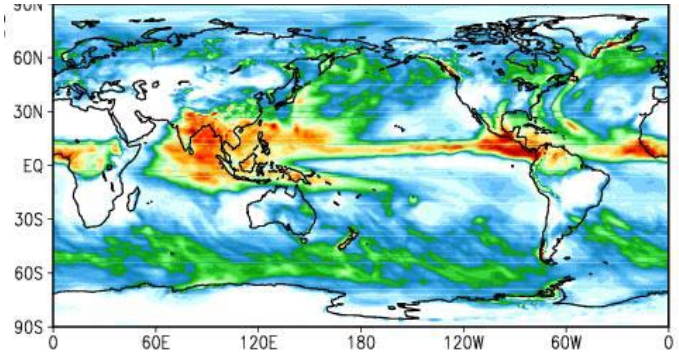
RHcrit: 0.80



RHcrit from Original *AGCM*



RHcrit: 0.90



RHcrit: 0.95

Replay experiments were performed with RHcrit ranging from 0.8 to 0.98. Precipitation similar to original *AGCM* result when RHcrit=0.95

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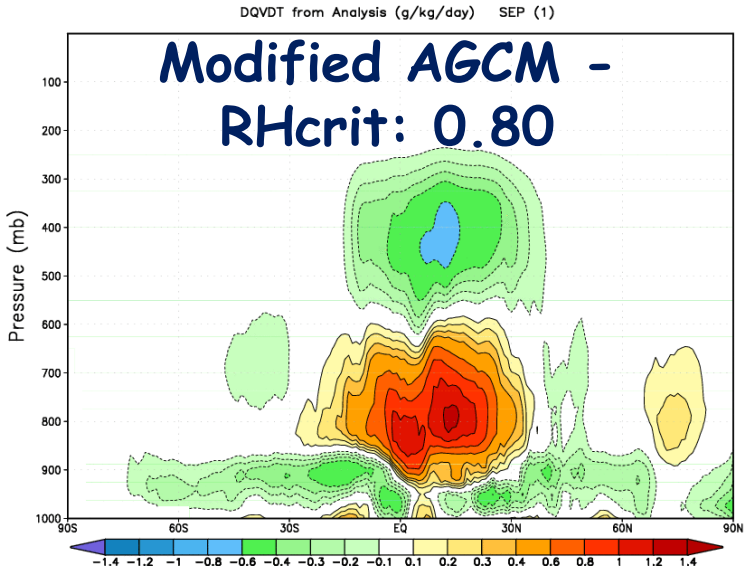
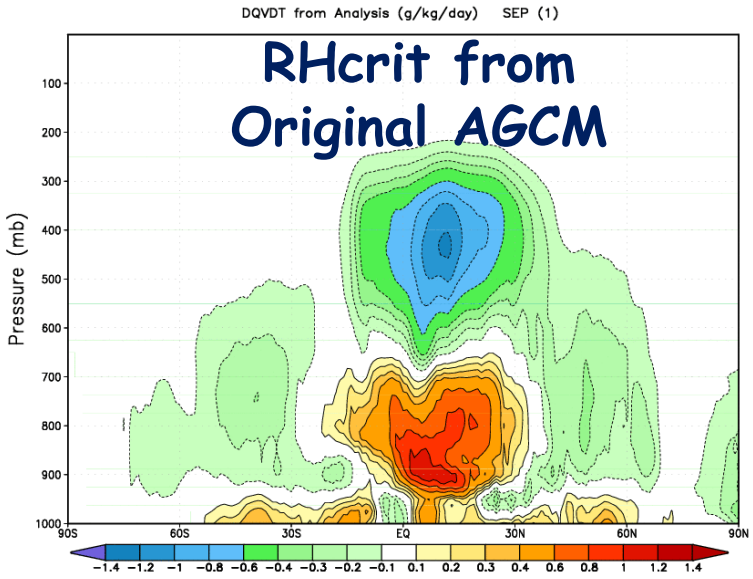
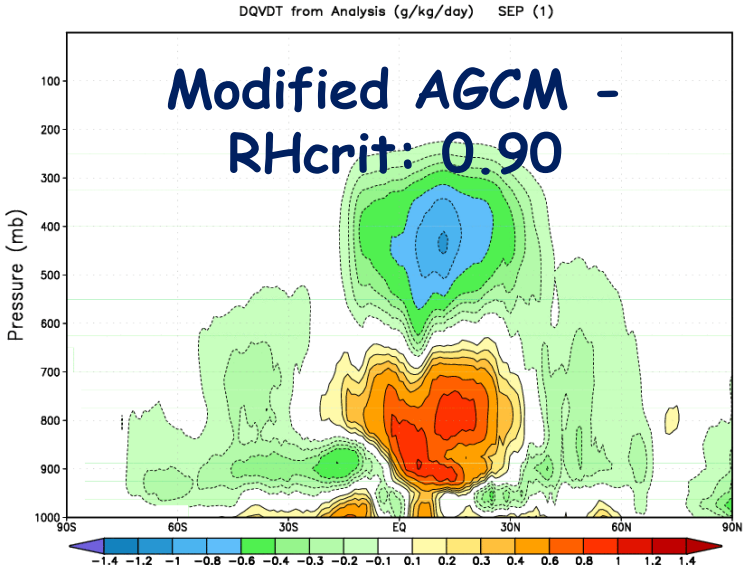
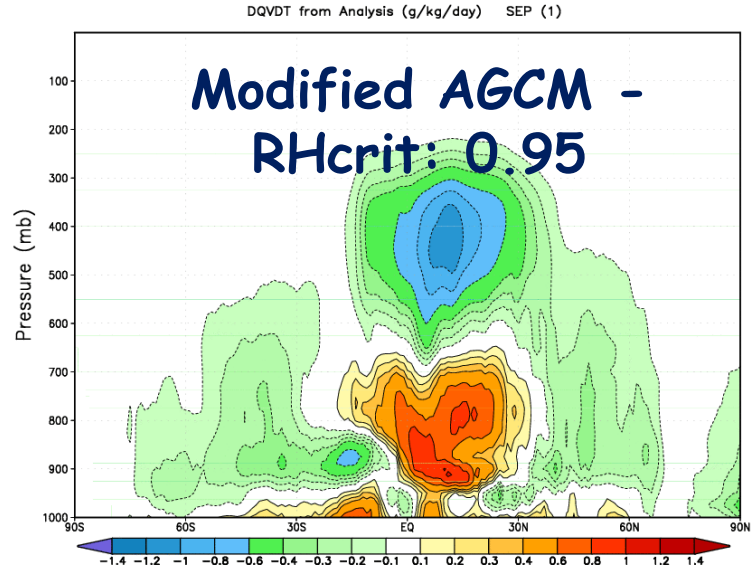
Replay with different RHcrit Values





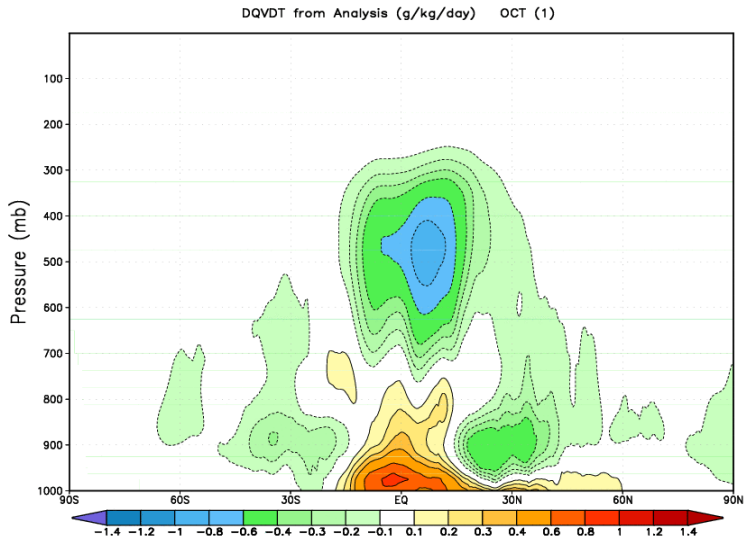
Replay data increment of moisture in g/kg/day

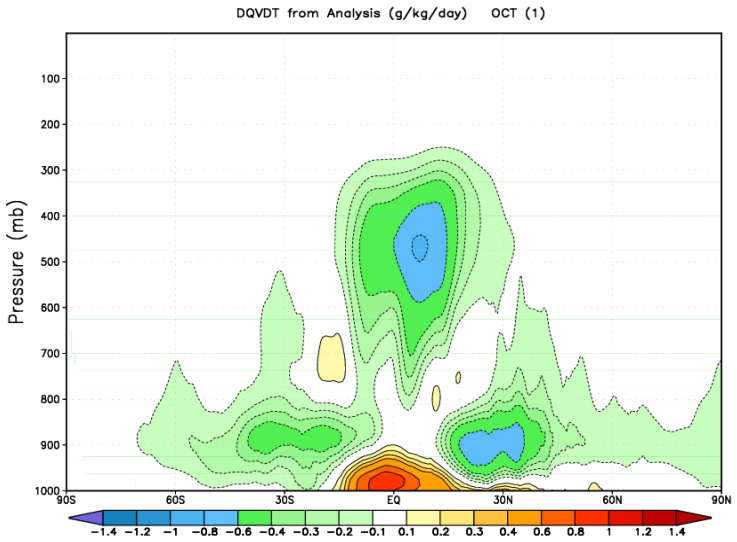




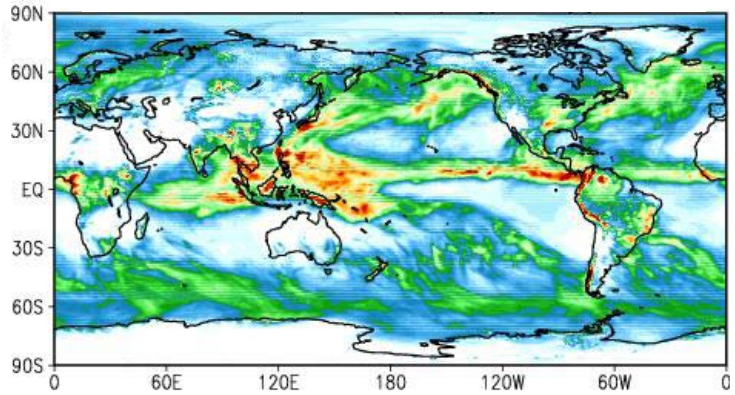
Data increment similar to original AGCM results when RHcrit=0.95

Confirmation of "Replay" result: Data Assimilation Experiments at 0.5°

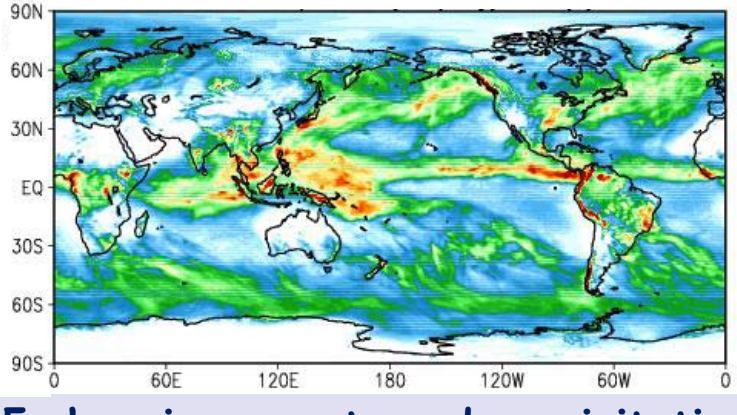




RHcrit: 0.95



"Original AGCM"



Full data assimilation experiment with RHcrit=0.95 show increments and precipitation resembling the result using the original model formulation. Replay result is borne out.

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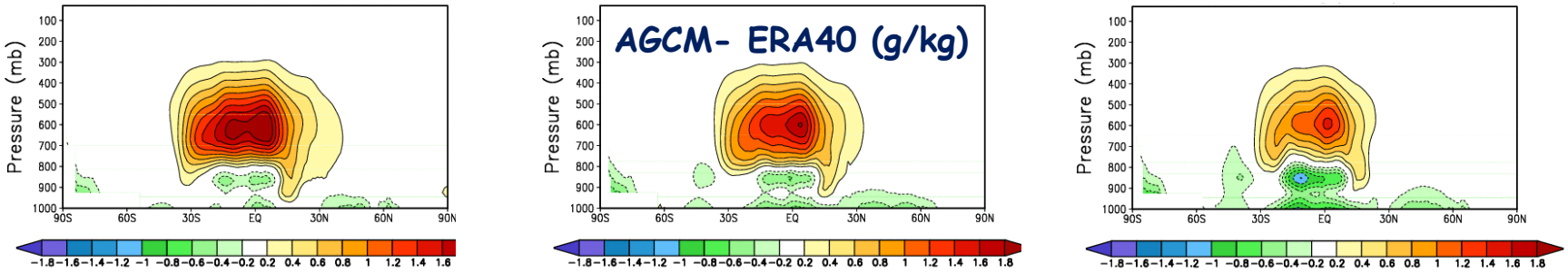
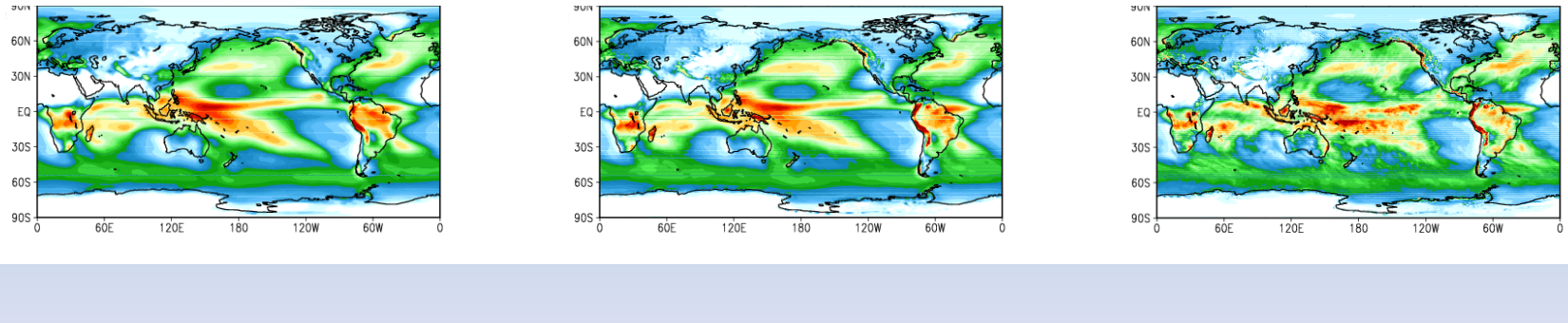
Lessons learned for AGCM Development: Dependance on Horizontal Resolution

Before: GEOS-5 AGCM Specific Humidity is sensitive to resolution



GEOS-5 AGCM Total Precipitation is insensitive to resolution



Initial parameter choice based on coarse resolution AGCM -> DAS precipitation sensitivity and resulting parameter choice revealed resolution dependance

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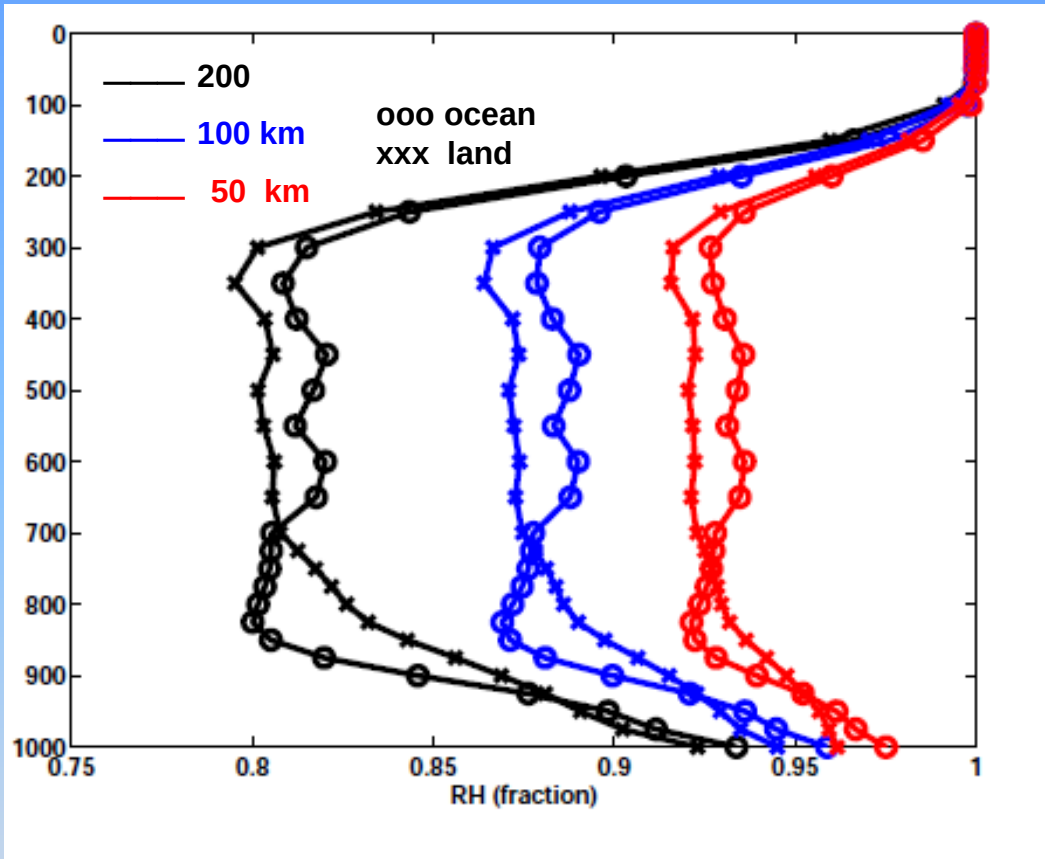
RHcrit Dependance on Horizontal Resolution

Total water field from a GEOS-5 simulation at ~10 km resolution on the cubed sphere was regridded to coarser resolution, and sub-grid variance was computed.

Sub-grid scale variance of total humidity is related to "Critical relative humidity" used for moist processes.



General vertical profile of the critical relative humidity is unchanged as the grid resolution changes, for all regions and underlying surfaces, and shifts to higher values with smaller grid size.

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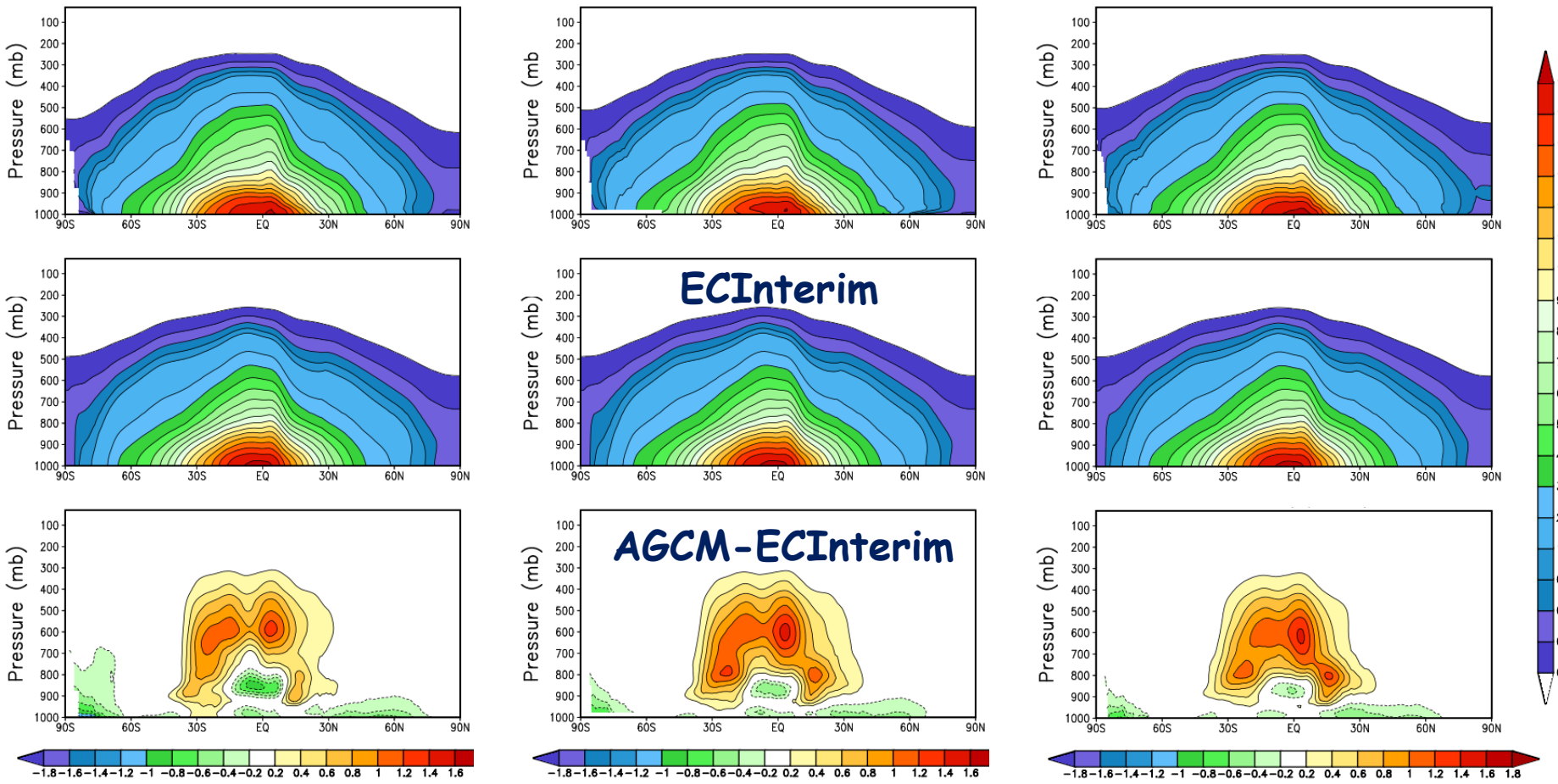
Dependance on Horizontal Resolution

After: GEOS-5 AGCM with resolution dependant RHcrit



2° x 2.5°

1° x 1°

0.5° x 0.67°

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Summary

- "Replay" experiments exhibit DAS behavior *at the resolution of the constraining assimilation.* That is, replay experiments at 1° reflect the behavior of the 0.25° analysis.

- Data assimilation experiments at 0.5° confirmed the results of replay experiments --> Replay can be used to assess behavior in DAS mode

- Results from examining DAS sensitivity used to improve AGCM at high resolution