GEWEX Process Evaluation Studies (PROES): A proposed framework and a preliminary example

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Motivation

- GEWEX GDAP is producing and evaluating long term, globally complete water and energy budget products at increasingly higher time resolution.

- Vast majority of model evaluation studies (and many climate process studies) use only the monthly mean version of the datasets.

- *The use of monthly means implies that for a 3-hourly dataset 0.4% of the data are utilized while for a daily dataset 3.3% of the data.*

- *Monthly mean fields do not resolve most processes and are of little use in placing regional studies and field campaigns (which do resolve high time and space resolution processes but cover limited domain) in the global context.*

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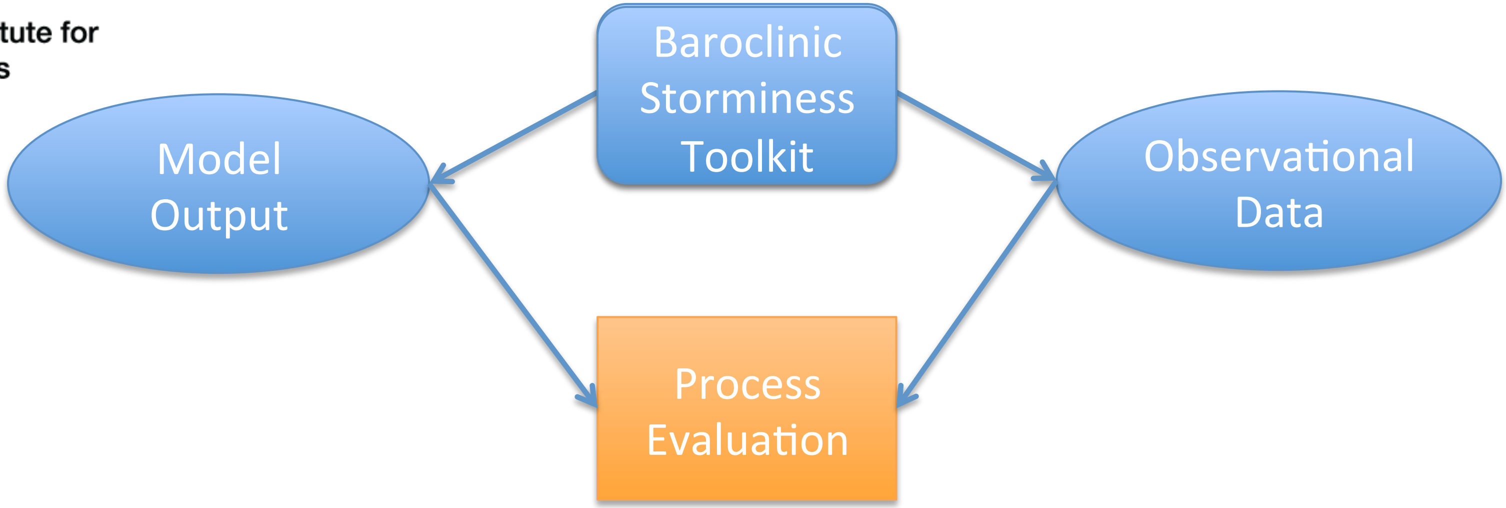
Formalizing PROcess Evaluation Studies: The GEWEX PROES framework



Objectives: Optimize the use of high resolution satellite observations with emphasis on the GEWEX datasets – Facilitate development and application of data mining and compositing techniques – Create a framework for process evaluation studies that enhance process understanding and evaluates model process performance at different space and time scales.

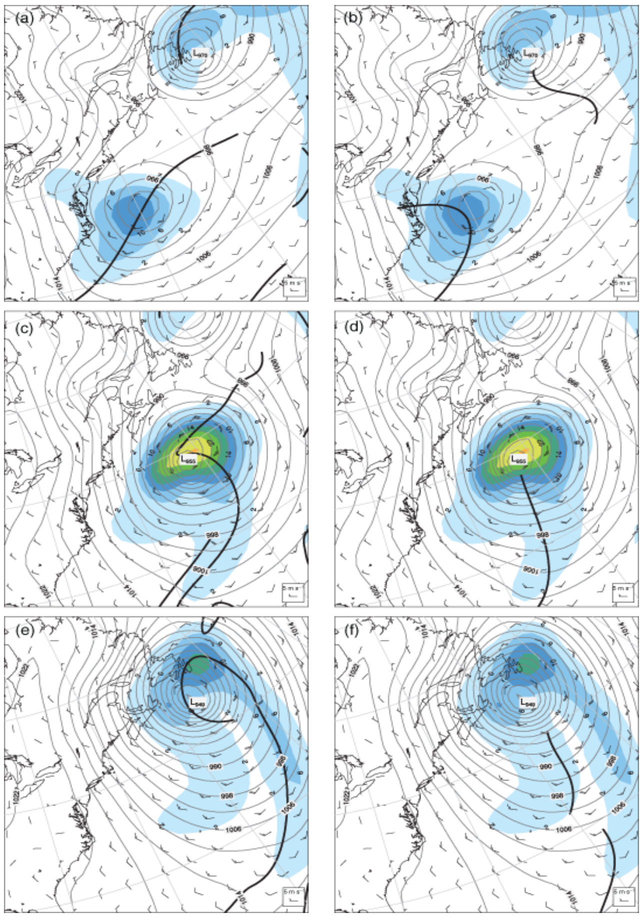
Synergies: *Obs.* - GDAP, GHP, Obs4MIPS *Diags. Models* – CMIP, GASS, GLASS, CFMIP

Initial Steps: Pilot studies, including Midlatitude Storm study led by GISS in collaboration with Monash U.

Tool 1: Frontal Identification

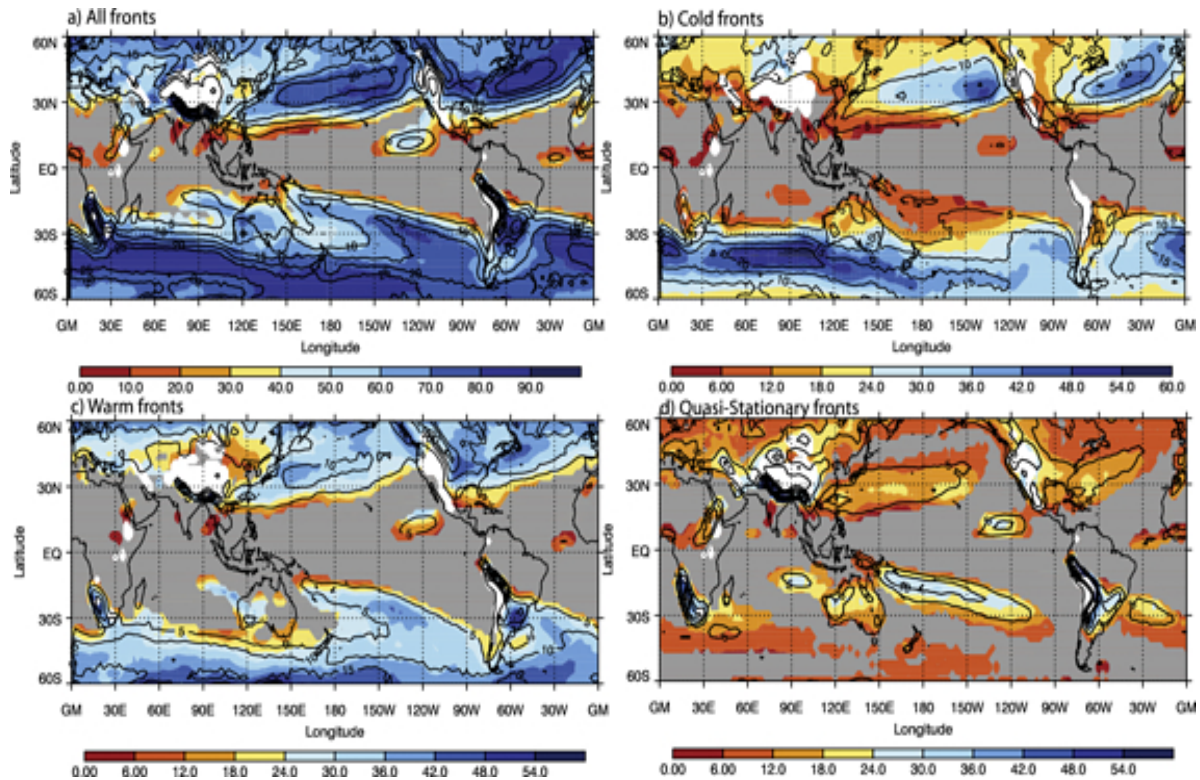
Thermal method

Wind method



Schemm et al. 2014

GPCP Precipitation Frontal distribution



Catto et al. 2012

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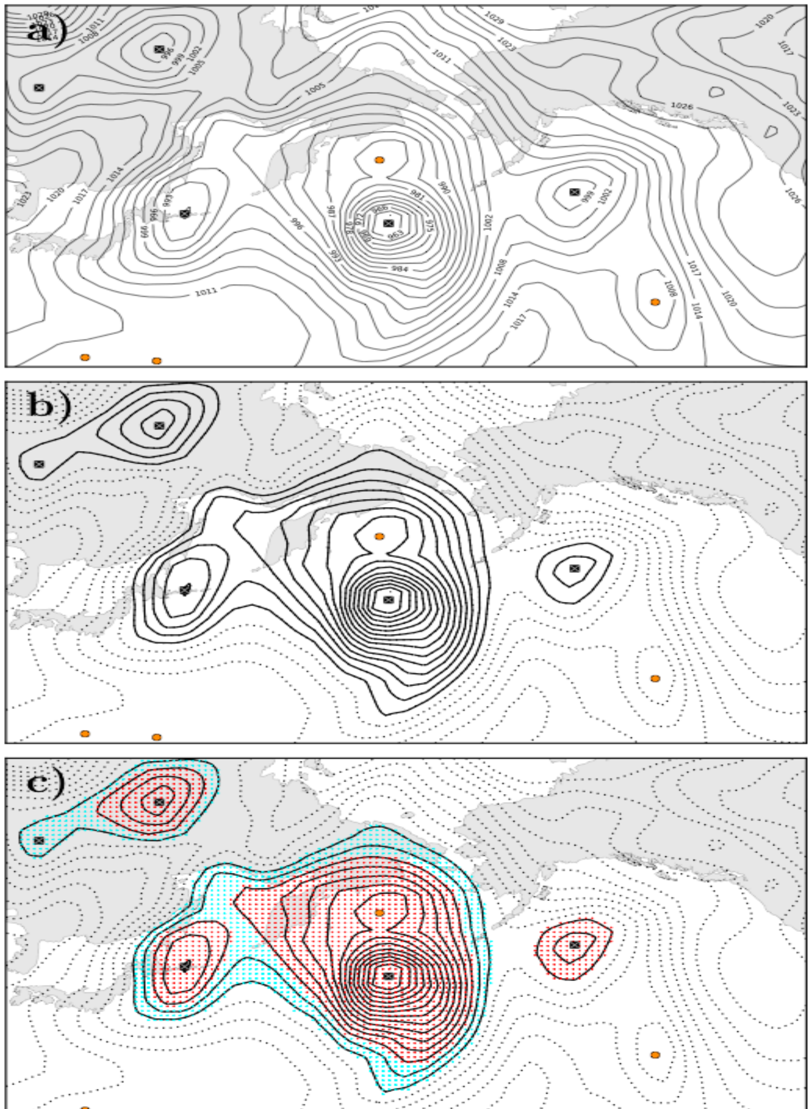
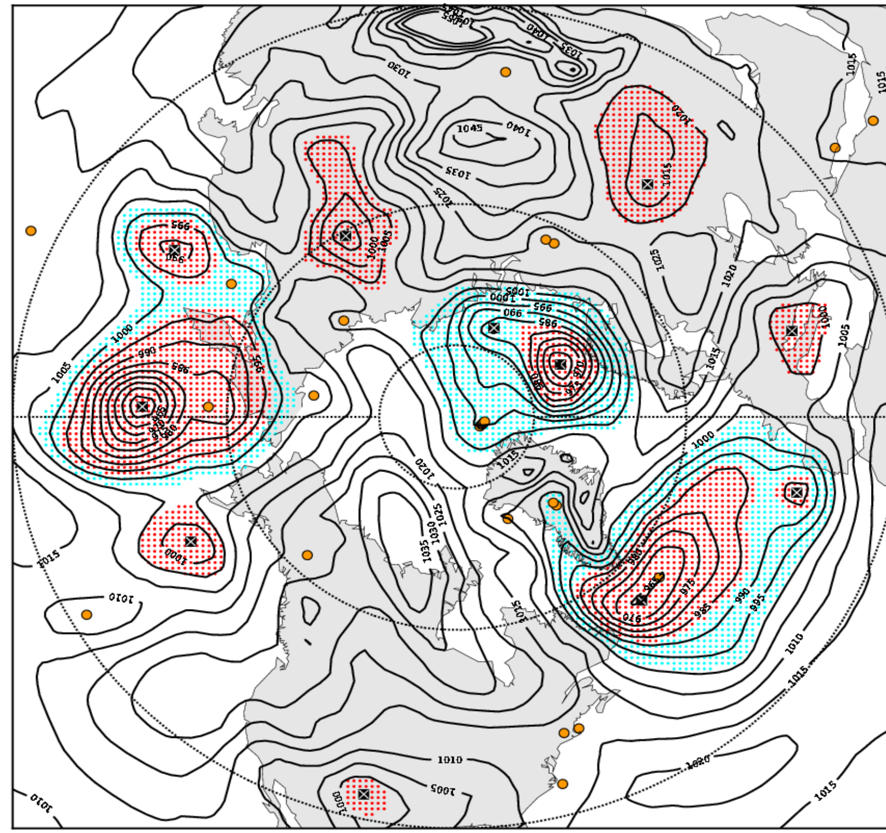
Tool 2: MAP Climatology of Midlatitude Storminess (MCMS)



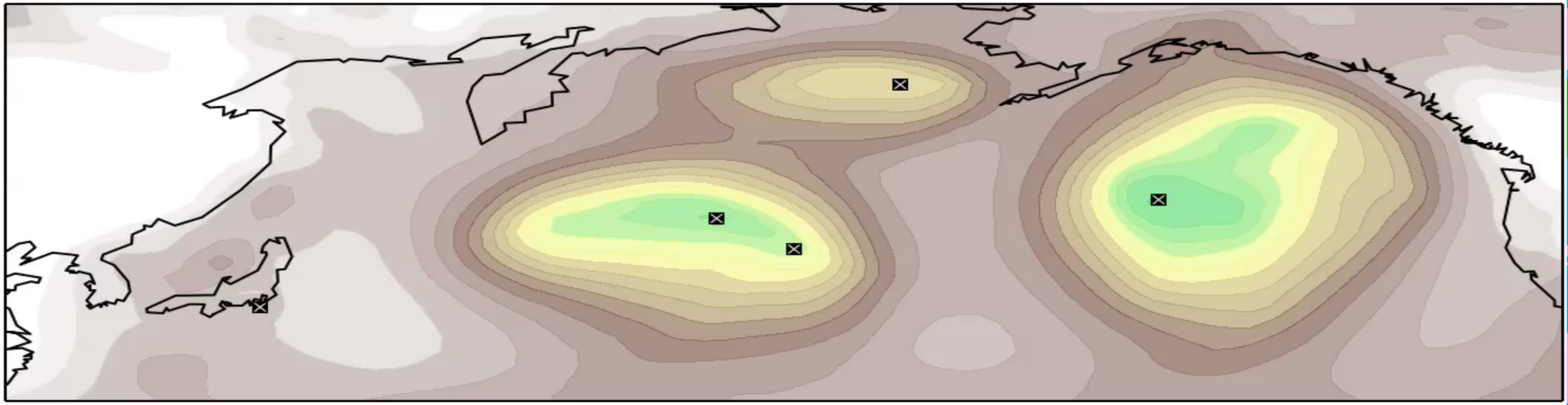


•Definition of a storm area of influence that makes it possible to attribute cloud, radiation, and precipitation properties to the dynamical system that is creating the

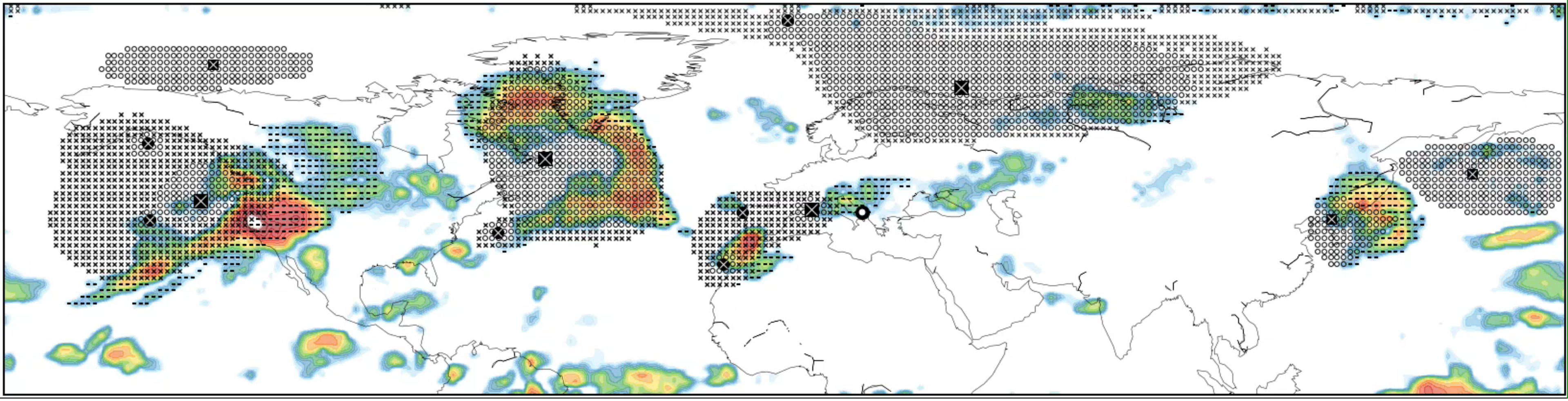
Bauer et al. 2014

MAP Climatology of Midlatitude Storminess (MCMS) demonstration

Method steps: Center id – Storm tracking – Storminess attribution

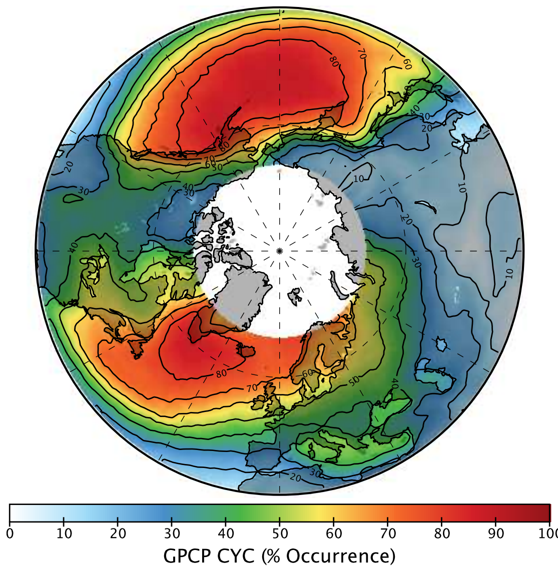


GPCP Precipitation – MCMS Storminess

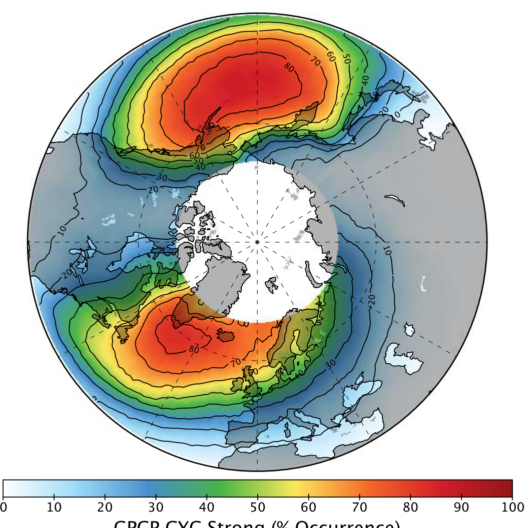


GPCP Precipitation Storminess distribution

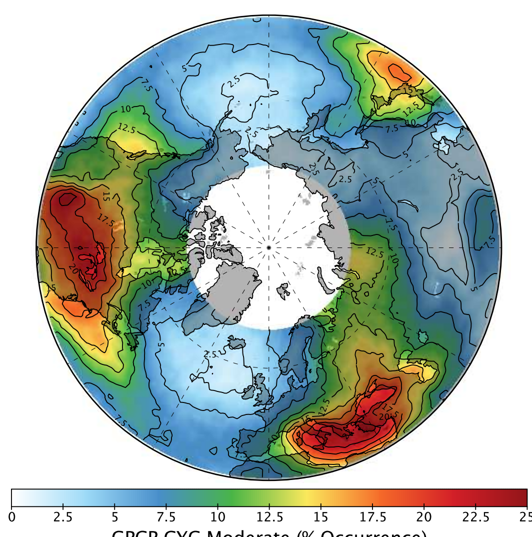
Precip % from all storms
(NH-DJF)



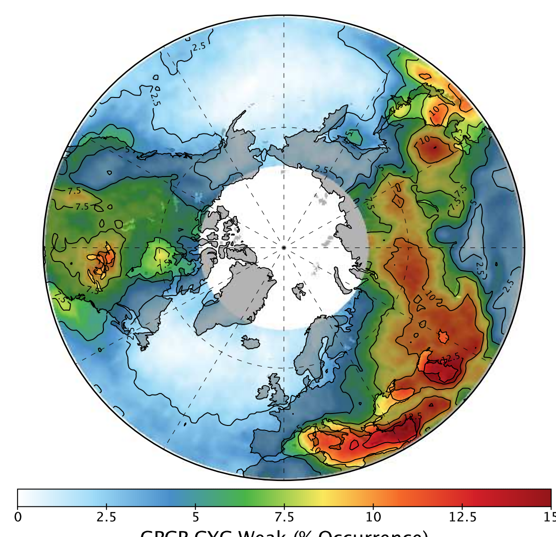
Strong storms



Moderate storms



Weak storms



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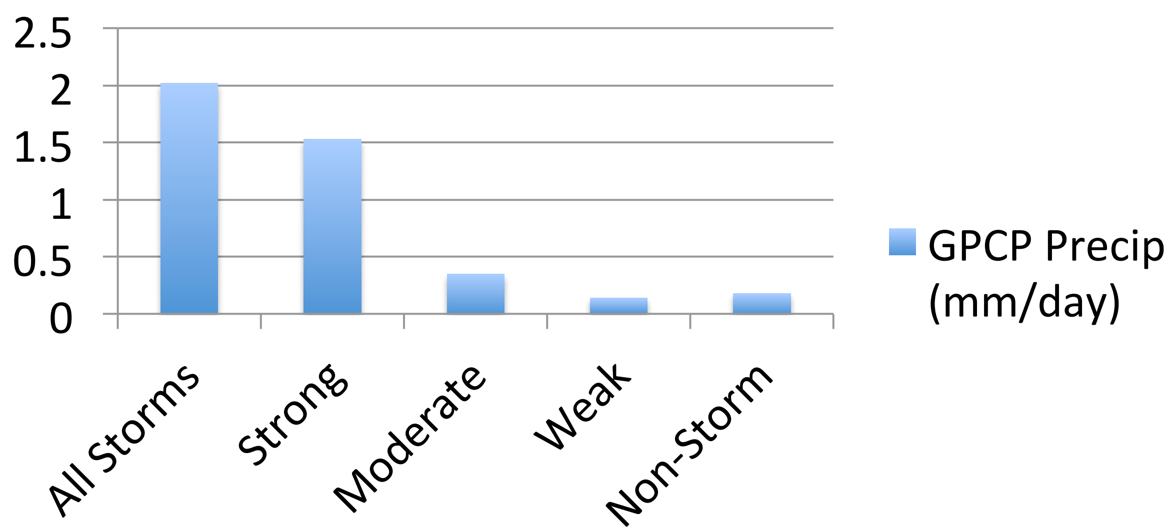
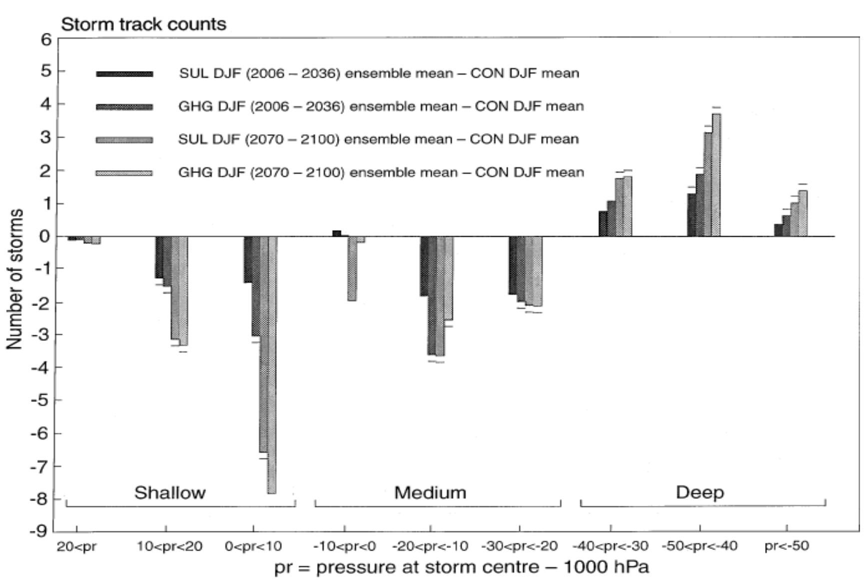
GPCP Precipitation Storminess distribution

(N.H. – DJF)



UKMO prediction for 2XCO2 storm changes (Carnell and Senior 1998)



7% storm decrease due to 7% weak and 5% moderate storm decreases and 5% strong storm increase.

From observational distribution, this implies:
Storm Frequency decrease: -0.02 mm/day
Storm Strength increase: + 0.8 mm/day
Overall: +0.06 mm/day (3% increase)

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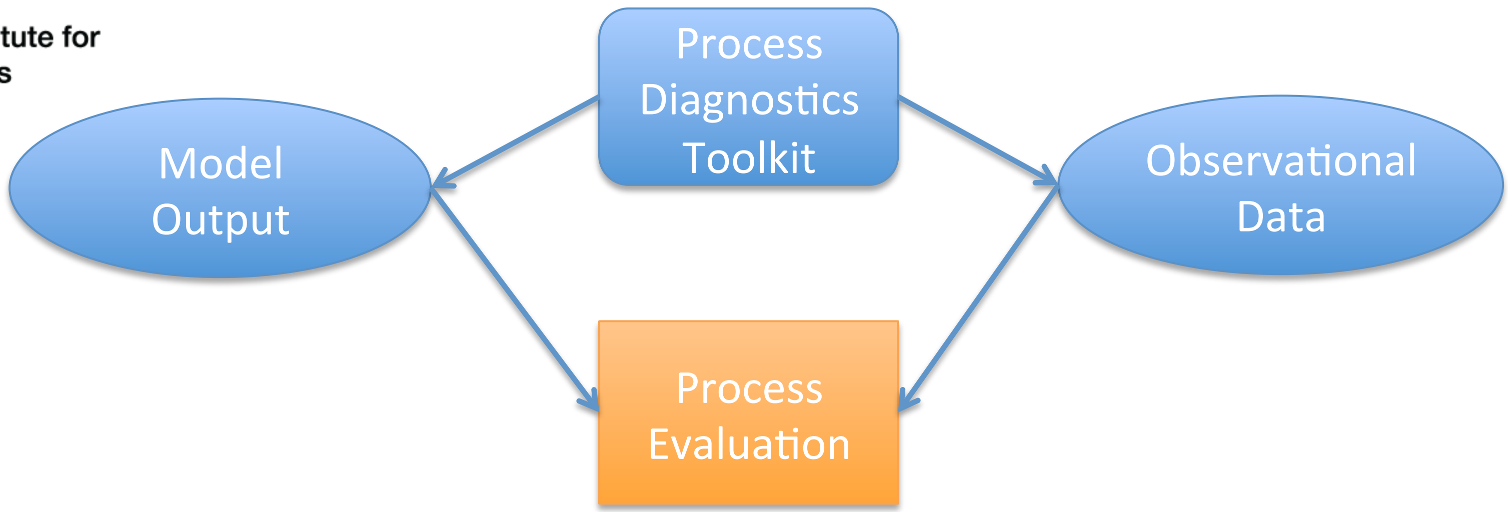

- Toolkit depends on the targeted process and can include a suite of already developed or new tools
- Model and observational data depend on the process and on the space and time scales examined
- Process based analysis bridges model scales from LES to GCM and observational scales from satellite to in-situ and facilitates the use of global GEWEX data in regional and field study analyses

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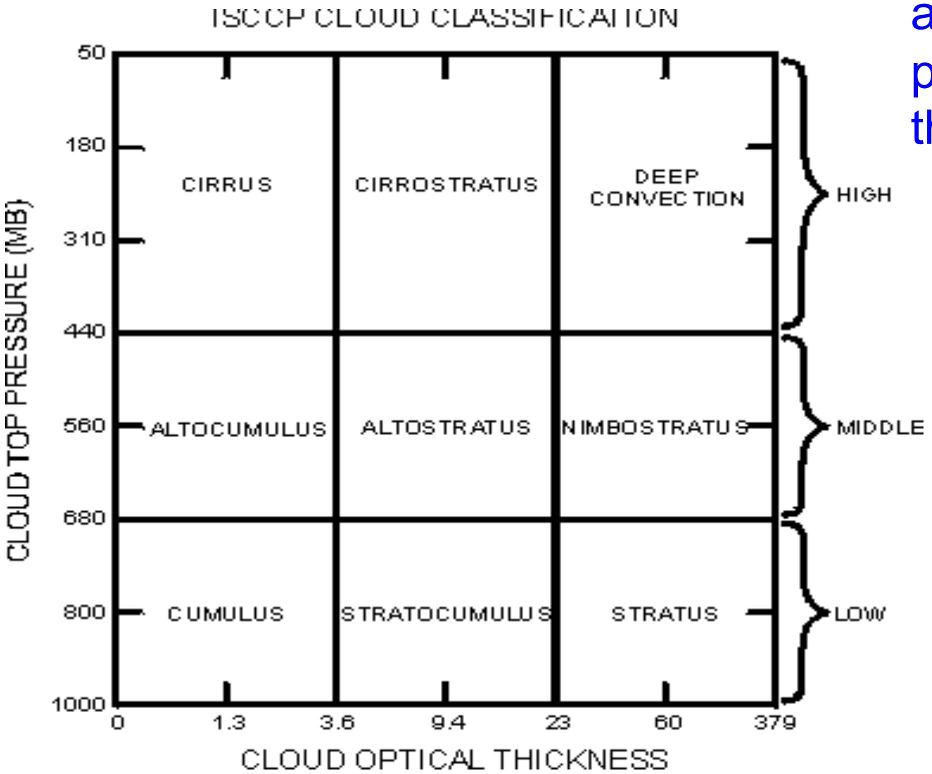
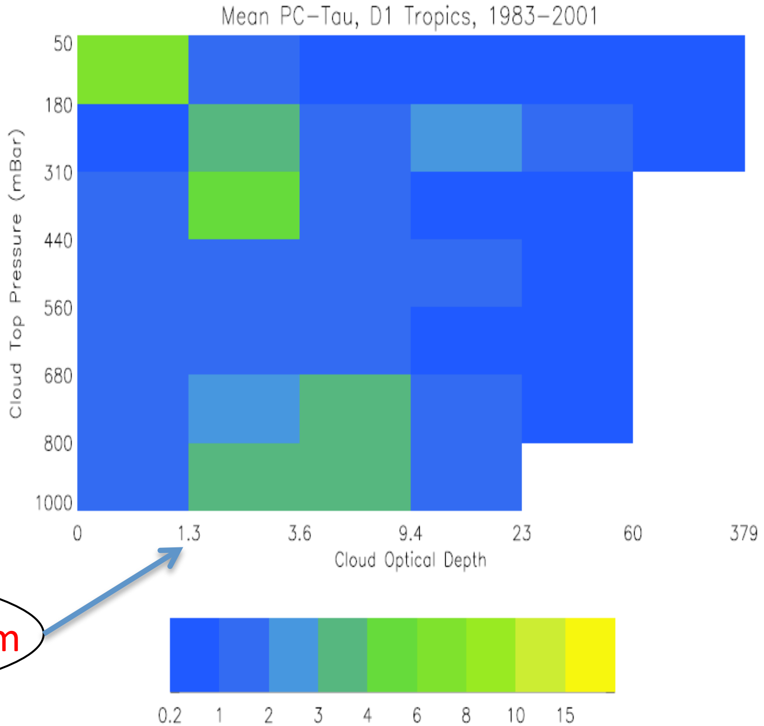
Cloud types according to ISCCP

Every 3 hours for each 2.5 degree grid box around the globe the ISCCP-D1dataset provides cloud frequencies at 42 cloud optical thickness – cloud top pressure categories





We apply a clustering algorithm to the histogram

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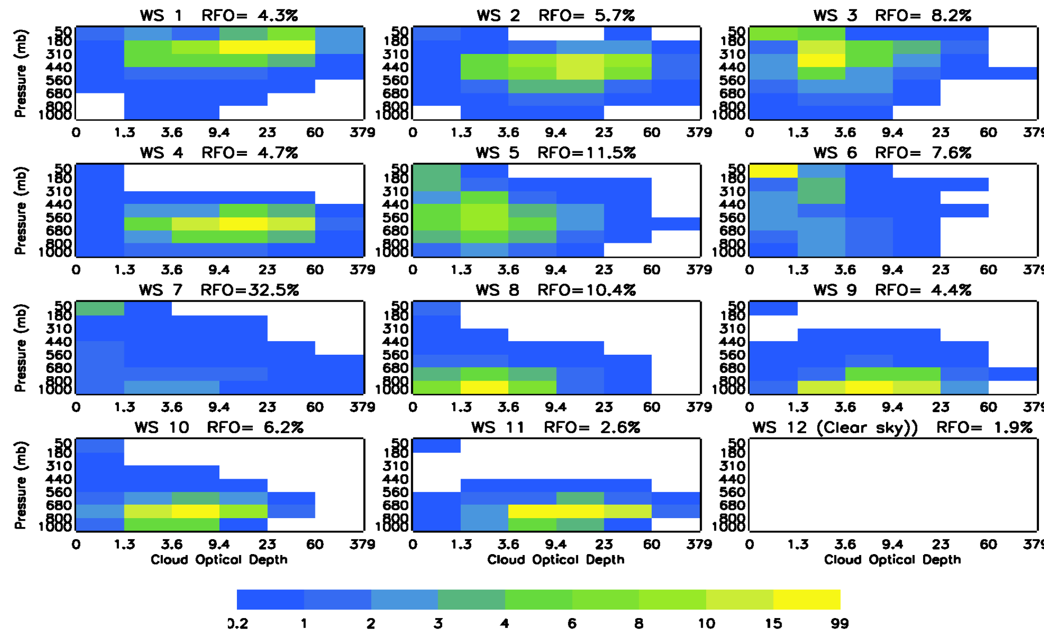
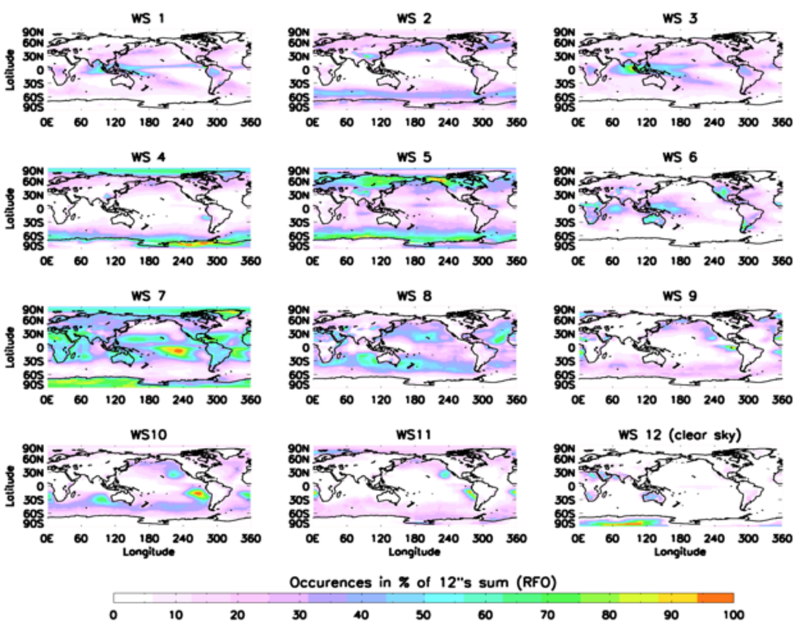


Global Weather States (WS) derived through cluster analysis of ISCCP TAU-PC histograms:

11 WS going from deep convective to stratocumulus clouds

Fair-weather WS7 most frequent one



Separation of tropical and midlatitude convective clouds

Tropical-subtropical region shows a stratocumulus-shallow cumulus-fair weather transition

Tselioudis et al. 2013

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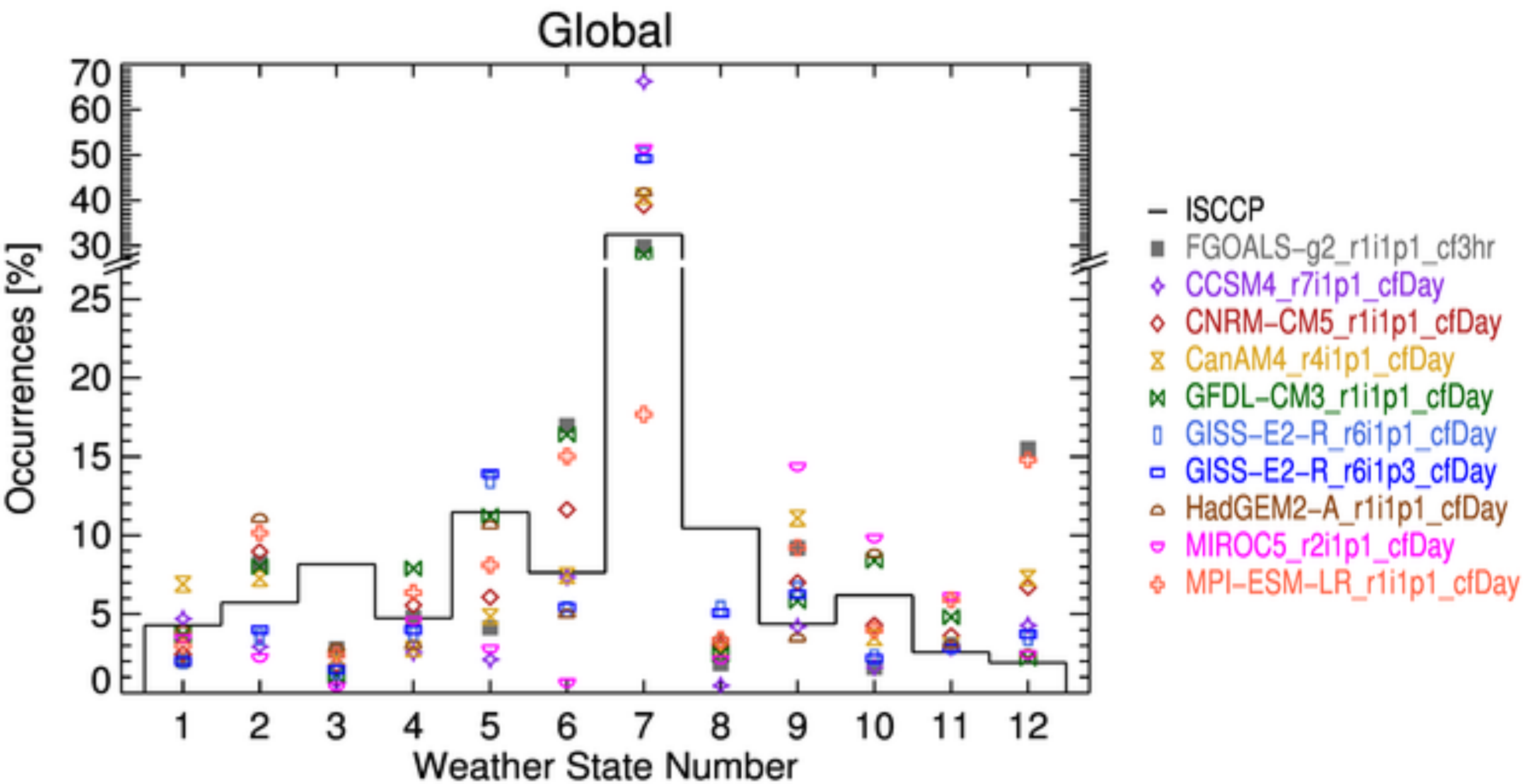
CMIP5 Evaluation of Global WS RFO



GCMs overestimate fair-weather WS7 and underestimate shallow cumulus WS8, making it hard to simulate climate transitions of tropical-subtropical low clouds

Tselioudis et al. 2014

Cloud Vertical Structure (CVS) of the ISCCP WS derived from CloudSat-CALIPSO retrievals

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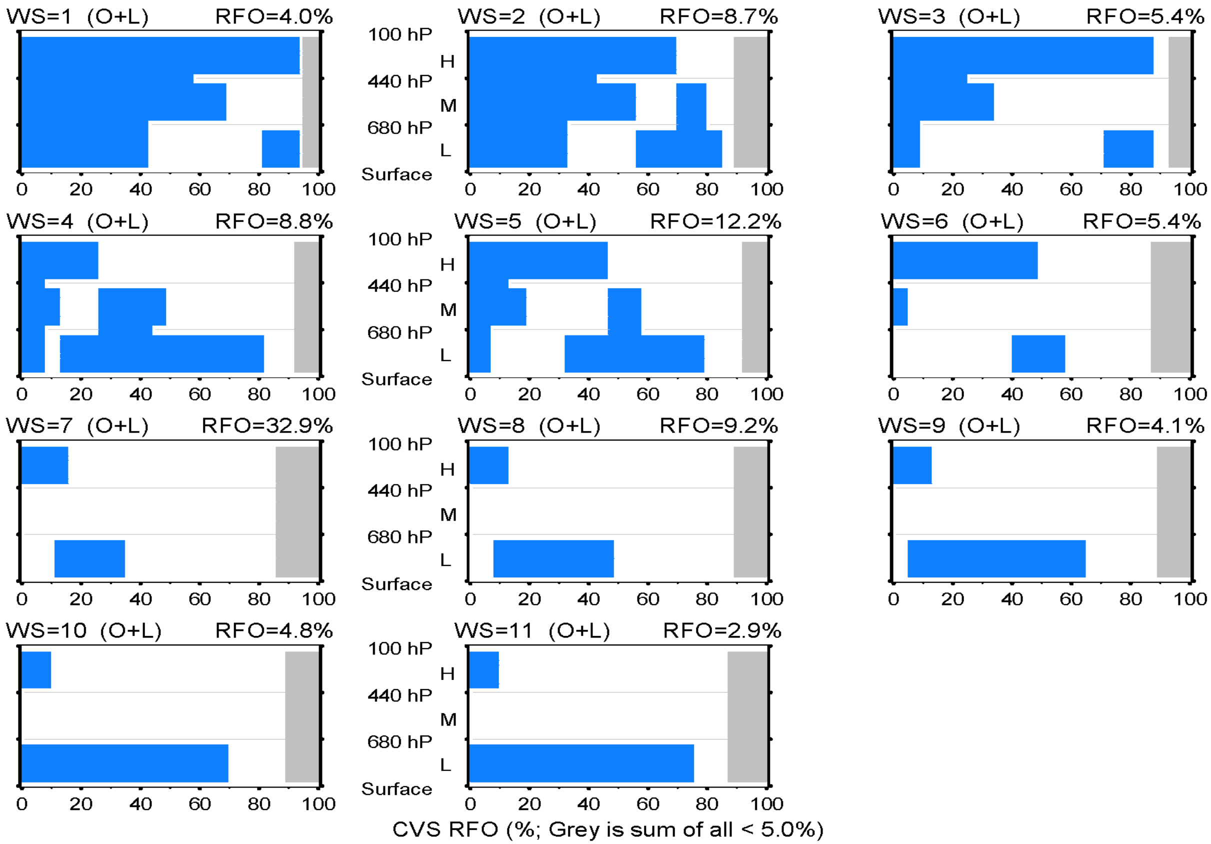

CloudSat-CALIPSO retrievals map the distinct vertical structures of the ISCCP WS

Tselioudis et al. 2013

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The process space as the solution to the

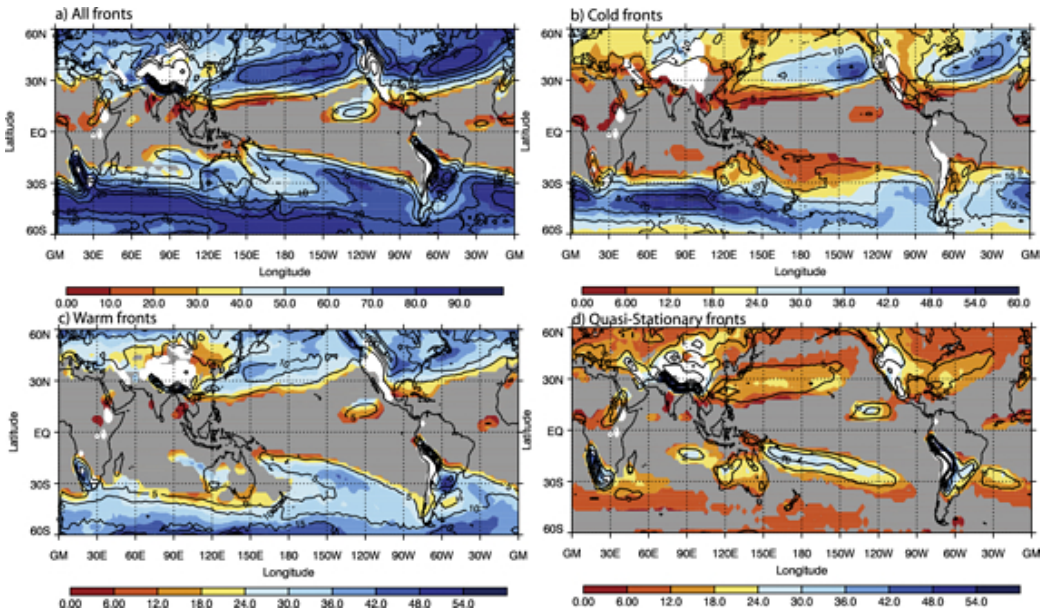
Problem:

- Satellite top-down view vs model layer output
- Volume of high resolution data and complexity of high resolution model-data comparisons
- Inability of satellite data alone to resolve process variability issues

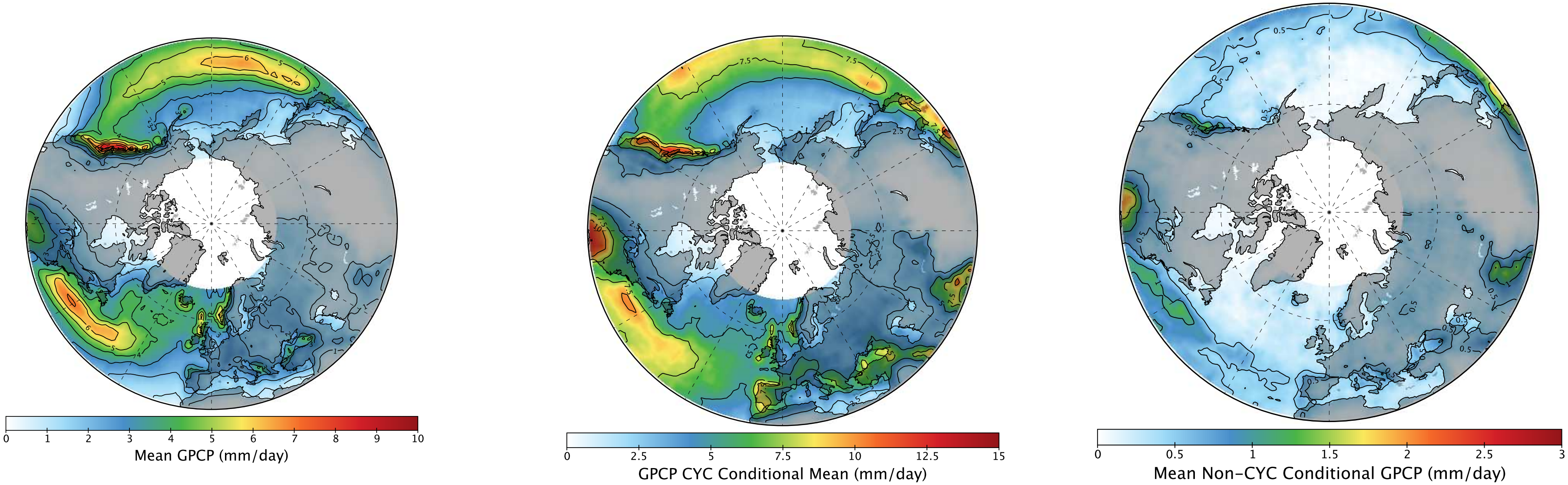
Solution:

- Instrument simulators – e.g. the ISCCP simulator or the COSP (ISCCP, MODIS, MISR, CloudSat, CALIPSO) simulator package
- Data mining techniques – e.g. clustering, to derive physically meaningful subsets of satellite data and model output
- Compositing techniques – e.g. midlatitude cyclone composites, to place data in the context of the dominant atmospheric processes

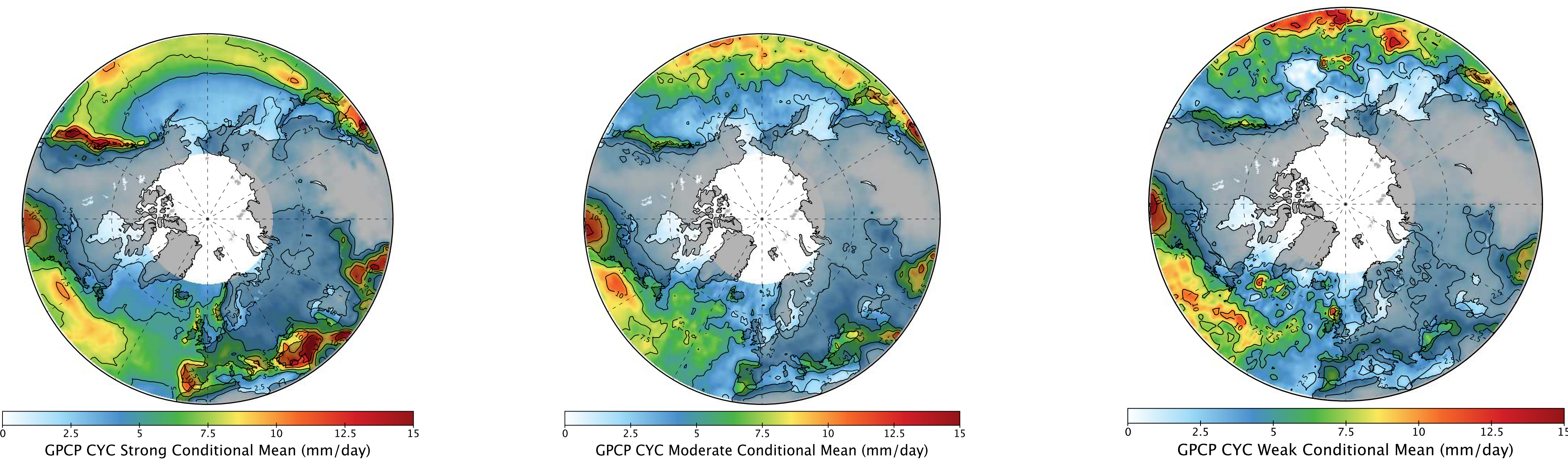
Relating global precipitation to atmospheric fronts



Geophysical Research Letters
Volume 39, Issue 10, L10805, 18 MAY 2012 DOI: 10.1029/2012GL051736
http://onlinelibrary.wiley.com/doi/10.1029/2012GL051736/full#grl29209-fig-0001



0 1 2 3 4 5 6 7 8 9 10
Mean GPCP (mm/day)
0 2.5 5 7.5 10 12.5 15
GPCP CYC Conditional Mean (mm/day)
0 0.5 1 1.5 2 2.5 3
Mean Non-CYC Conditional GPCP (mm/day)


0 2.5 5 7.5 10 12.5 15
GPCP CYC Strong Conditional Mean (mm/day)
0 2.5 5 7.5 10 12.5 15
GPCP CYC Moderate Conditional Mean (mm/day)
0 2.5 5 7.5 10 12.5 15
GPCP CYC Weak Conditional Mean (mm/day)

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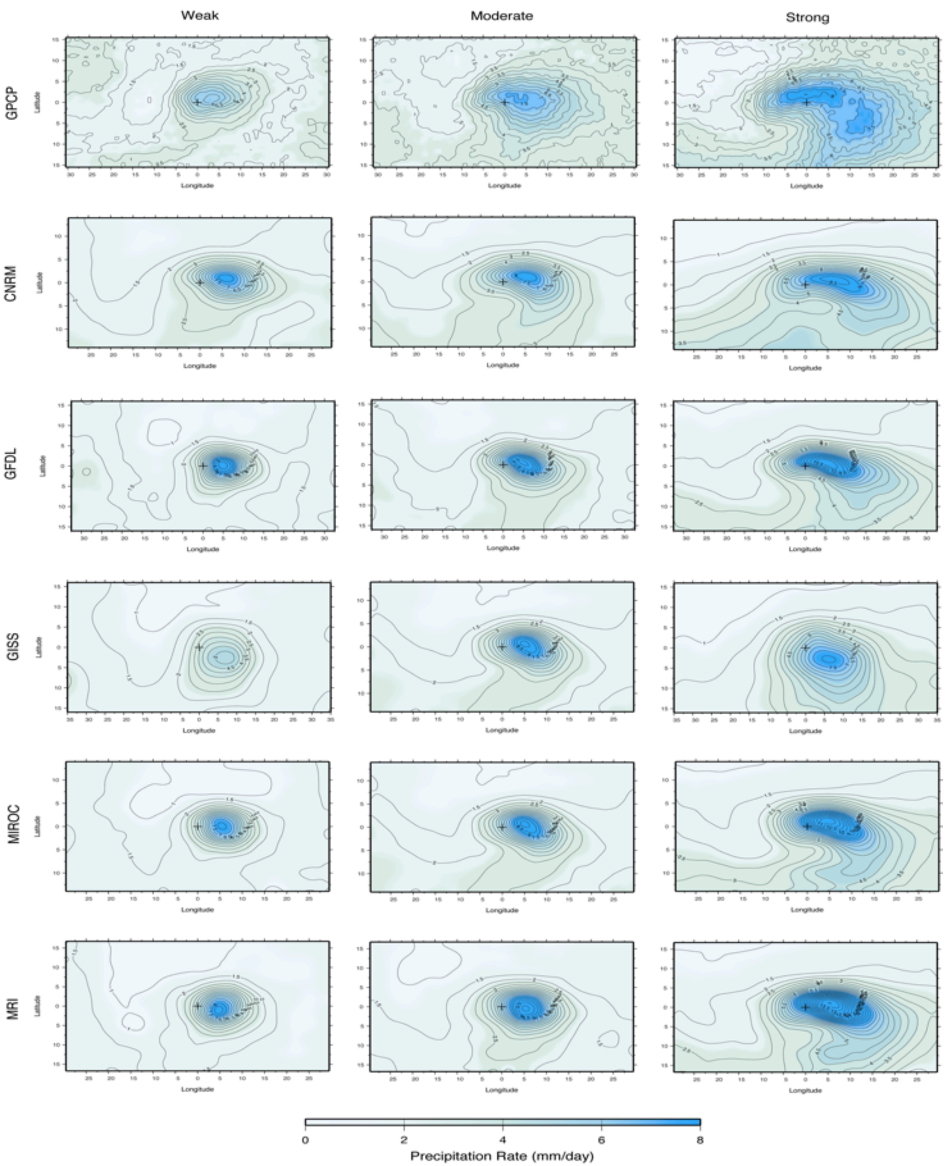
Using storm composites for process-based model evaluation

Calculation of midlatitude precipitation changes with climate assuming UKMO-predicted Fewer-but-Stronger storms



	Storm Strength	Storm Frequency	Total
GPCP	+0.1 (mm/day)	-0.02 (mm/day)	+0.08 (mm/day)
CNRM	+0.08	-0.14	-0.06
GFDL	+0.08	-0.11	-0.03
GISS	+0.05	-0.10	-0.05
MIROC	+0.08	-0.11	-0.03
MRI	+0.10	-0.11	-0.01

•Models estimate correctly the increase in precipitation with storm strength but overestimate the decrease in precipitation with storm frequency.

•This is because all models produce very little midlatitude precipitation outside storm events.

•As a result, models produce a negative rather than a positive precipitation feedback when the Fewer-but-Stronger storm changes are applied together

Tselioudis et al. 2014