WGNE Systematic Error Survey Results Summary

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Outline

1. **Working Group on Numerical Experimentation**
2. **WGNE Systematic Error Workshop**
3. **Survey Results**
4. **Summary and Future Work**

5th WGNE workshop on systematic errors in weather and climate models

June 19-23, 2017, Montréal, Québec, Canada

Recommendations Include:

- **Use hierarchy of modeling techniques and fully coupled systems to improve understanding of poorly represented processes**
- **Evaluation and benchmarking tools using long time series with high temporal resolution, should be employed.**
- **Optimal uses of observations, LES and theoretical studies recommended to address errors related to clouds and precipitation.**
- **Enhanced interaction among model developers, verification groups, and forecasters/users is essential.**

Zadra et al, 2017, Systematic Errors in Weather and Climate Models: Nature, Origins, and Way Forward, BAMS Meeting Summaries, https://journals.ametsoc.org/doi/full/10.1175/BAMS-D-17-0287.1

Survey Motivation:

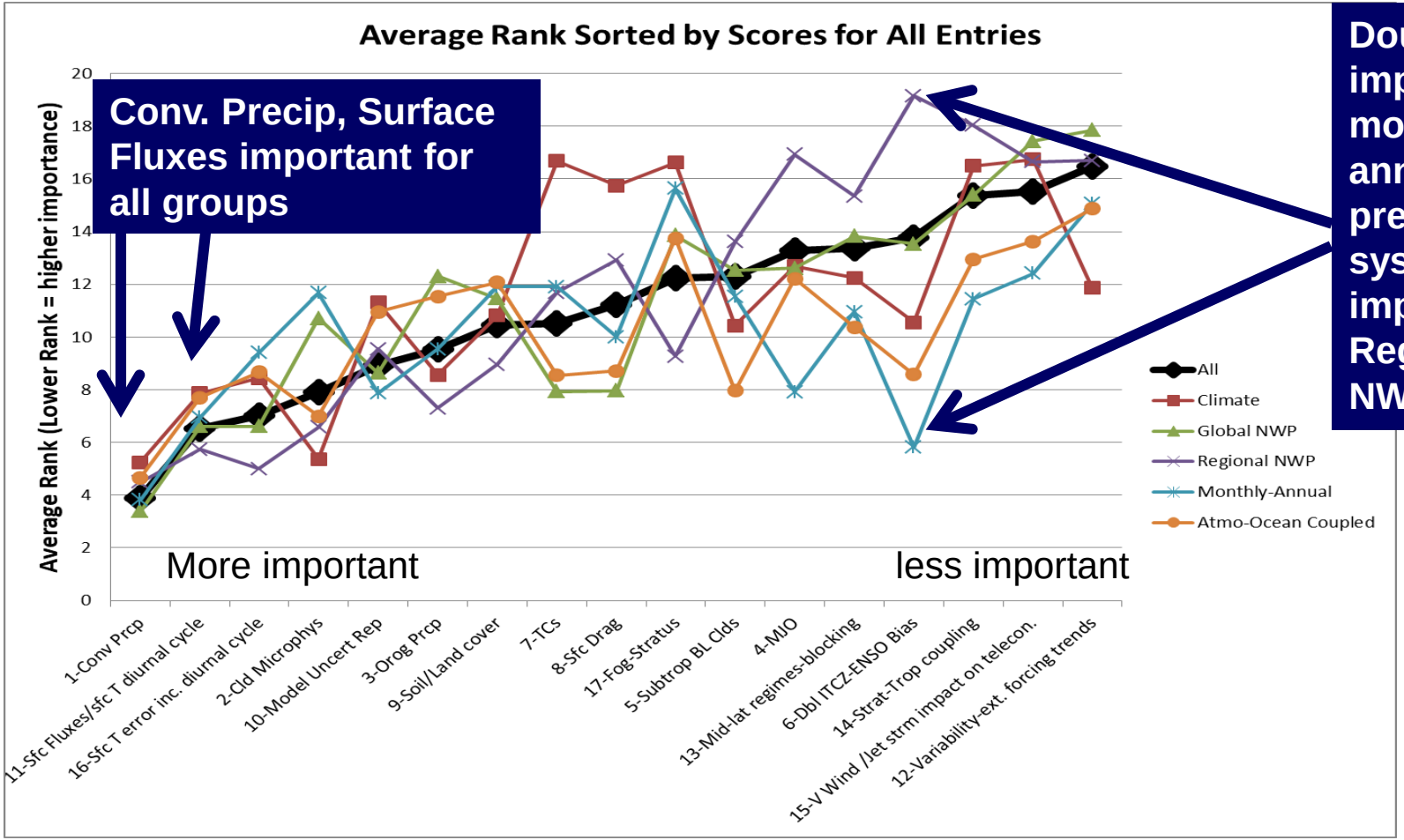
- WGNE Systematic Errors workshop identified several systematic errors of major concern to multiple modeling centers (weather and climate)

- During WGNE32 at the Met Office, UK in October 2017, conducting a survey among modelling centers to determine the priorities of the errors noted in the workshop was recommended

Survey Participation:

- 14 centers contributed 35 surveys (most centers contributed multiple responses). Modeling system characteristics (e.g., global, regional, NWP, monthly-annual, climate etc.) were collected to stratify results by type and purpose of system.
- Results available on the WGNE web page (wgne.meteoinfo.ru)

WGNE Systematic Error Survey Results



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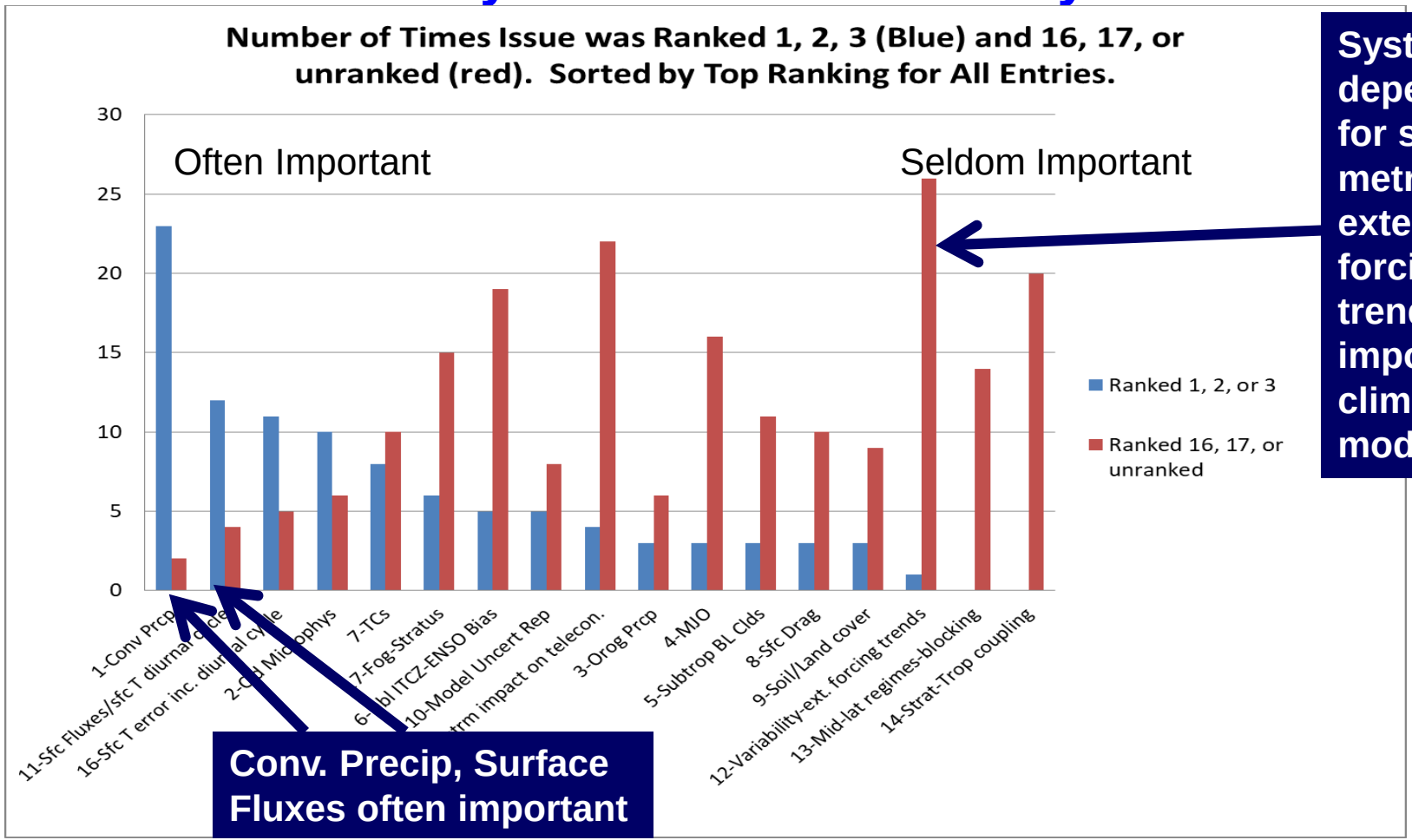


System dependence for some metrics (e.g., external forcing trends only important for climate modelers)

Conv. Precip, Surface Fluxes often important

WGNE Systematic Error Survey Results

- Additional Systematic Errors/Issues brought up by survey respondents
  - Climate modelers and land surface modelers brought up important issues related to other components of the earth system
    - Climate modelers brought up issues such as incorrect separation of the Gulf Stream, shallow mixed layer depths in the southern ocean, and biases in the sea ice over
    - Land-surface modelers were concerned about evapotranspiration modeling and related impacts
  - Several Centers mentioned issues related to snow and winter weather

WGNE Systematic Error Survey Results

- Top priorities across modeling system types:
  - Convective precipitation—including diurnal cycle (timing and intensity); the organization of convective systems; precipitation intensity and distribution; and the relationship with column-integrated water vapor, SST, and vertical velocity
  - Outstanding errors in the modeling of surface fluxes, errors in the representation of the diurnal cycle of surface temperature
  - Surface temperature errors (land and sea) including errors in the diurnal cycle of surface temperature
  - Cloud microphysics—including errors linked to mixed-phase, supercooled liquid cloud, and warm rain

- WGNE will use this information to guide community efforts
  - WGNE Surface Flux intercomparison identifying first order differences in surface fluxes among modeling centers
  - MJO task force examining model ability to capture organized convection
- Other groups tackling other priorities
  - GLASS LIAISE water valance over semi-arid areas (surface temperature over land)
  - SOCRATES Southern Ocean Clouds, Radiation, Aerosol Transport (microphysics)

Next Steps: Input from the ECMWF Workshop on Observational Campaigns for Better Weather Forecasts, June 2019

See summary in the ECMWF newsletter, autumn edition.

- Recommendations from the workshop
  - ECMWF and other centers should produce report on key processes and systematic errors for which the model development process would benefit from observation programs.
    - Follow-on to WGNE survey which does not focus on processes or how to gain insight from observation programs (could expand to include intercomparison projects).
  - Other recommendations relating to observations/field campaigns
    - Develop and share flight campaign and data analysis tools
    - Define best practices catalogue for field campaigns to facilitate data access/exchange
    - Publish field campaign datasets in data journals
    - Access to data assimilation monitoring statistics

Next Steps: Input from the ECMWF Workshop on Observational Campaigns for Better Weather Forecasts, June 2019

- ECMWF priorities for observations and process studies to improve the IFS
  - Coupling of lower atmosphere with underlying surface (land, snow, ice, ocean)
    - Need co-located obs through atmo-surface interface
    - Observation transections across various surfaces
  - Low-level clouds (maritime stratocumulus and low-level mixed-phase clouds)
    - Need observational constraints for high resolution microphysical processes
  - Momentum transport and wind profiles in the BL
    - Need better representation of BL winds for renewable energy, large scale circulation which is a function of surface drag
  - Temp, moisture and trace gases (ozone) in the stratosphere (currently very few obs).
  - Temporal and spatial variability
    - Need obs at high temporal and spatial frequencies to verify high-res atmo and ocean models, particularly over boundary currents.

- Should there be a follow-on survey (focused on processes, need for observations, need for intercomparisons), perhaps in conjunction with GASS? Or should other centers produce a similar summary as ECMWF?

Emerging Issues for WGNE

- Weather and climate science has seen rapid change since WGNE started over 30 years ago.
- Many traditional differences between weather and climate models no longer exist.
  - Coupled atmosphere-ocean-ice models now used for operational NWP.
  - Earth system components such as interactive aerosols and chemistry are used for climate change projections, air quality forecasting and subseasonal to seasonal predictions alike.
  - Convective permitting models are increasingly being used to downscale climate projections for specific regions.
- The earth system model development community needs to share best practice and work together on common systematic errors.
- WGNE is unique in reporting to both WCRP-JSC and CAS – both undergoing change
- WGNE's purpose and seamless methodologies can allow it to evolve into an earth system model development focal point

Evolved purpose of WGNE:

fostering the **development of ~~atmospheric circulation~~ earth system models** for use in weather prediction and climate studies on **all time scales**, and **diagnosing and resolving shortcomings**.

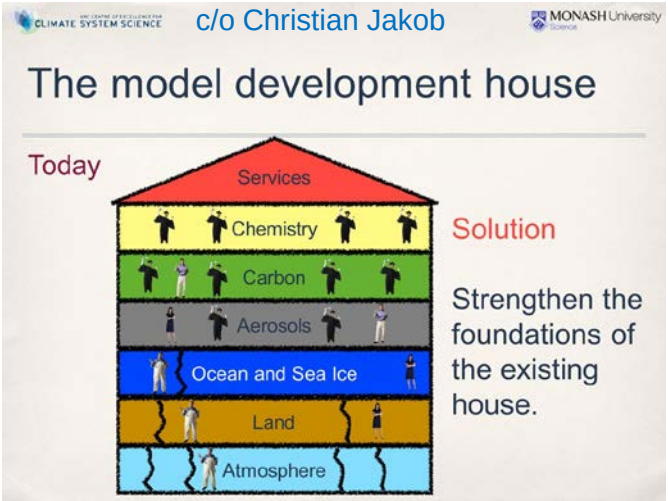
Links to the WCRP Strategic and Implementation Plans

WCRP strategic plan:

1. **Fundamental understanding of the climate system**
2. **Prediction of the near-term evolution of the climate system**
3. **Future evolution of the climate system**
4. **Bridging climate science and society**

The need for accurate physical models fundamentally underpins at least the first 3

The climate information we give and services we provide require robust foundations in terms of minimising systematic errors in core modelling components



Links to the WWRP Implementation Plan Action Areas

- AA1 Address Limitations: Increase knowledge of physical … factors limiting capability to predict …. impacts of high-impact weather events, identify how limitations can be overcome
  SE Survey, Surface Flux Intercomparison, COORDE (w/GASS), MJO TF, Gray Zone II (w/GASS)
- AA2 Uncertainty: Identify, characterize and quantify analysis and forecast uncertainty using advanced probabilistic methods …..
  Coarse-graining Experiment (w/PDEF), Gray Zone II, Stochastic Forcing on S2S (w/PDEF, S2S)
- AA3 Full Coupled: Work with different science communities to develop modelling systems that fully integrate the most relevant components of the earth system ….
  Sharing knowledge (Blue book, SE Survey, Meeting presentations), Aerosol Phase II (w GAW/S2S)
- AA5 Verification: Develop methods to verify forecasts and warnings of high-impact weather, demonstrate benefit, focus on probabilistic and impact-based methods, …. emphasis on what is of value to the user.
  JWGFVR White paper, possible joint meeting in 2020, TC intercomparison paper in BAMS
- AA14 Advanced Methods: Conduct research to ensure that scientific enhancements can be implemented in future forecasting systems, provide timely services; AA16 Tools: Share methods and tools enabling wider community to run complex models
  Exascale awareness assessment of trends and scalability

Extra Slides

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Verification methods	Fraction of surveys that included method
Compare to observations	0.70
Compare to independent analysis or reanalysis	0.38
Forecaster feedback	0.30
Short climate runs (assess model climate)	0.27
Data Assimilation statistics	0.24
Intercomparision projects	0.19
Tropical cyclone verification	0.11
Object-oriented verification/radar verification	0.08
Process studies	0.08
Conditional biases	0.05
Field project observations	0.05
Power spectra/pdfs	0.03

Center	Model	Global	Regional	NWP	Monthly-Annual	Climate	Atm-Ocean Coupled
CMC-IPSL	IPSL-CM Climate	x			x	x	
CPTEC	BRAMS		x	x			
CPTEC	BESM-OA	x		x	x	x	x
CRC Singapore	SINGV		x	x		x	
DWD	ICON Global	x		x			
DWD	ICON Regional		x	x			
ECMWF	IFS-ECWAM-NEOM3.4-LIM2	x		x	x		x
Envir. Canada	Global Coupled	x		x			x
Envir. Canada	Regional (det./ens)		x	x			
Envir. Canada	High-Res Regional		x	x			
Envir. Canada	Land Surface System	x	x	x			
Hydromet Russia	SLAV	x		x	x		
JMA	GEPS	x			x		
JMA	JMA/MRI-CPS2	x			x		x
JMA	GSM	x		x			
JMA	MSM/LFM		x	x			
JMA	GEPS	x		x	x		
Météo-France	Arpege	x		x			
Météo-France	Arome		x	x			
MO	Conv. Scale Climate		x			x	
MO	Global climate	x				x	x
MO	UK NWP		x	x			
MO	Global NWP	x		x			
MO	GloSea5	x			x		x
NCAR	CESM	x			x	x	x
NCEP	NAM		x	x			
NCEP	HWRF/HMON		x	x			x
NCEP	GFS	x		x			
NRL	Navy ESPC Weather	x		x			x
NRL	NAVGEM	x		x			
NRL	Navy ESPC S2S	x		x	x		x
NRL	COAMPS/COAMPS-TC		x	x			x
SMHI	HCLIM	x				x	

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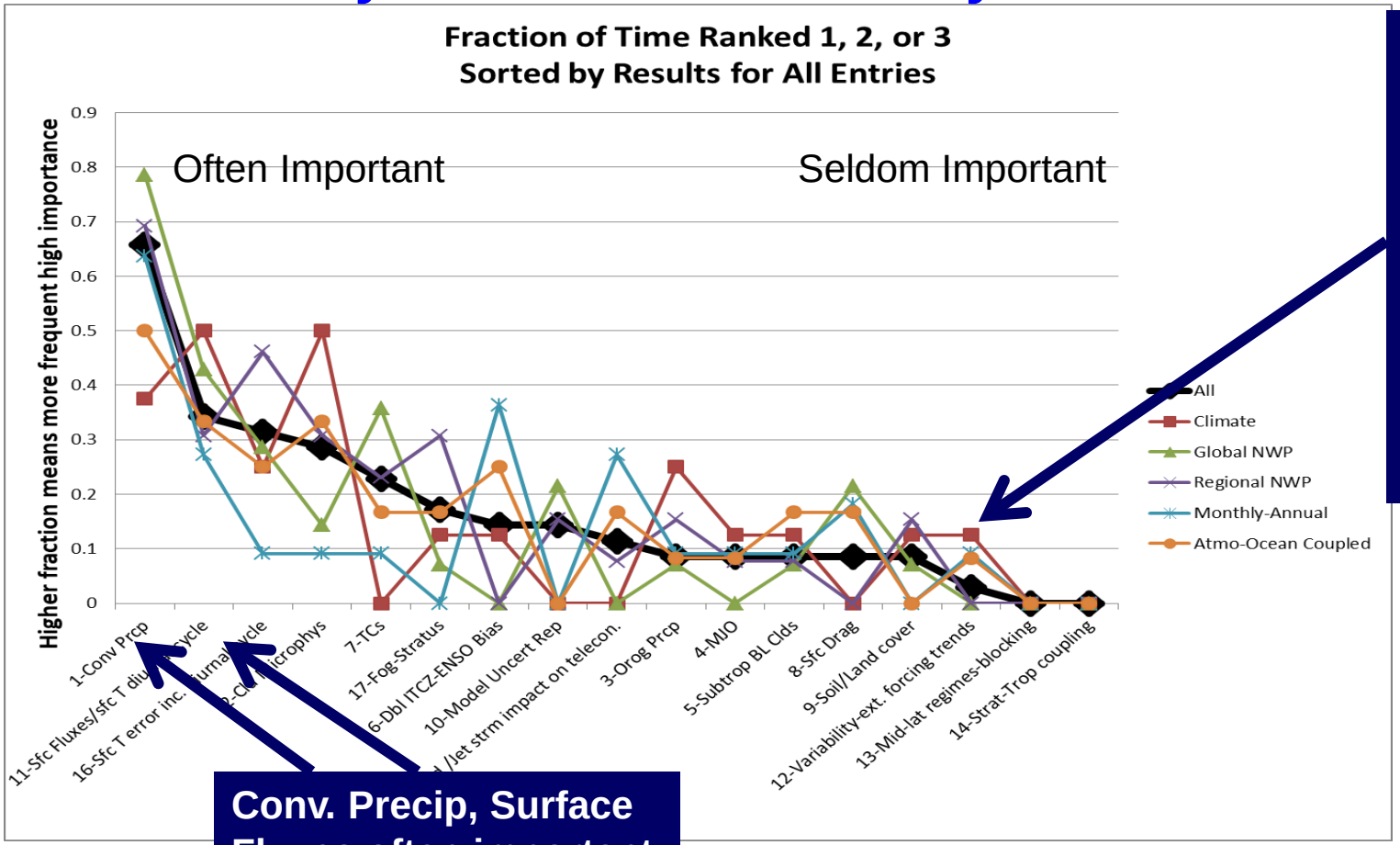

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