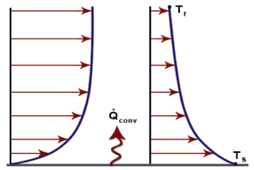
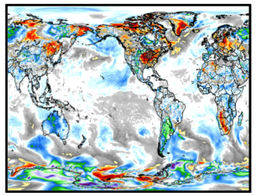
CCPP Single Column Model Overview

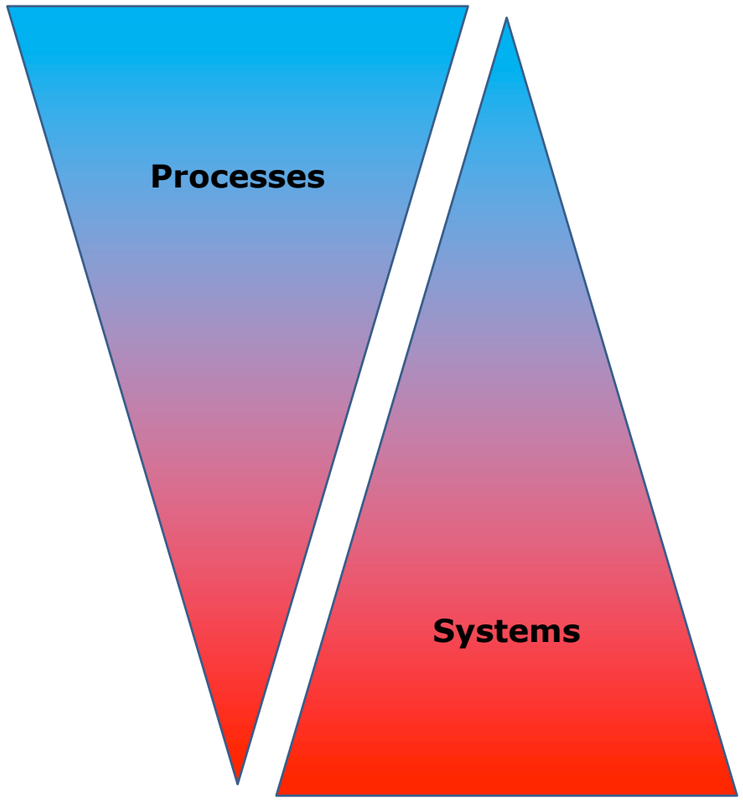
Motivation



"Simple" Processes

Complex Systems





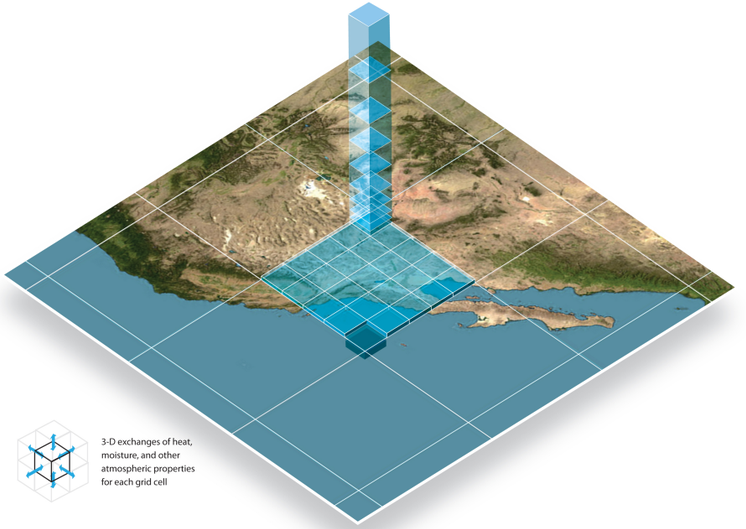
HSD Testing "Harness"

- Parameterization Simulator
- Single Column Model ◆
- 2-D Model
- Limited-Area Domain
- Regional Model
- Global Model
- Fully-Coupled Model

- ◆ Simplest framework for intra-suite physics interaction
- ◆ Necessary-but-not-sufficient for physics development

Single Column Model Overview

- Initial state (T, q, u, v) from observations, idealization, or model
- Forcing applied to mimic changes in column state from surrounding environment (replaces dycore)
  - 3 typical methods
    1. "total" advective forcing
    2. horizontal advection + prescribed vertical velocity
    3. 2 + nudging to observed profiles
- Physics responds to these changes and further modifies the column state
- End state is combination of forcing + physics



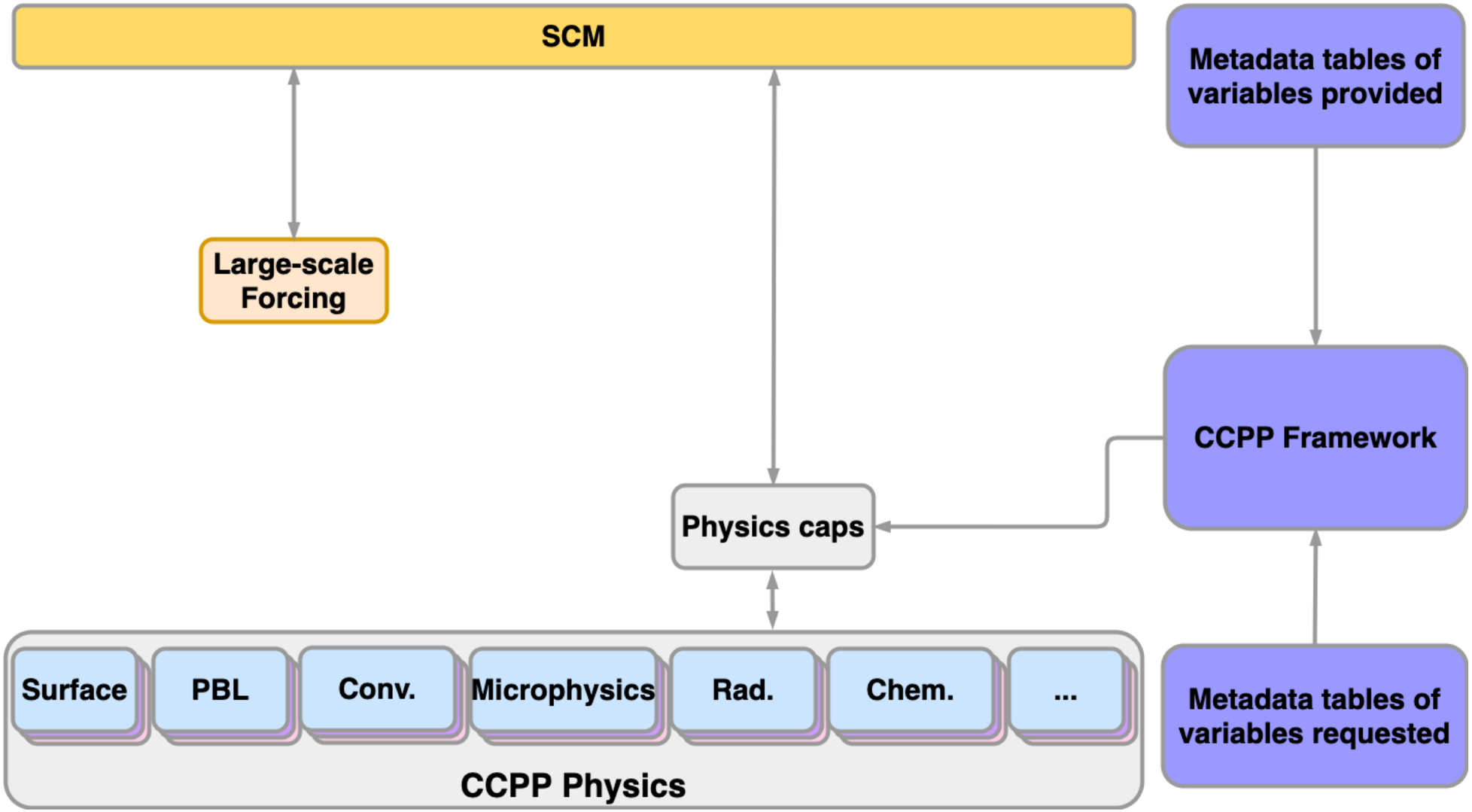
Pros

- Simple and cheap
- Interpretability
- Approachable

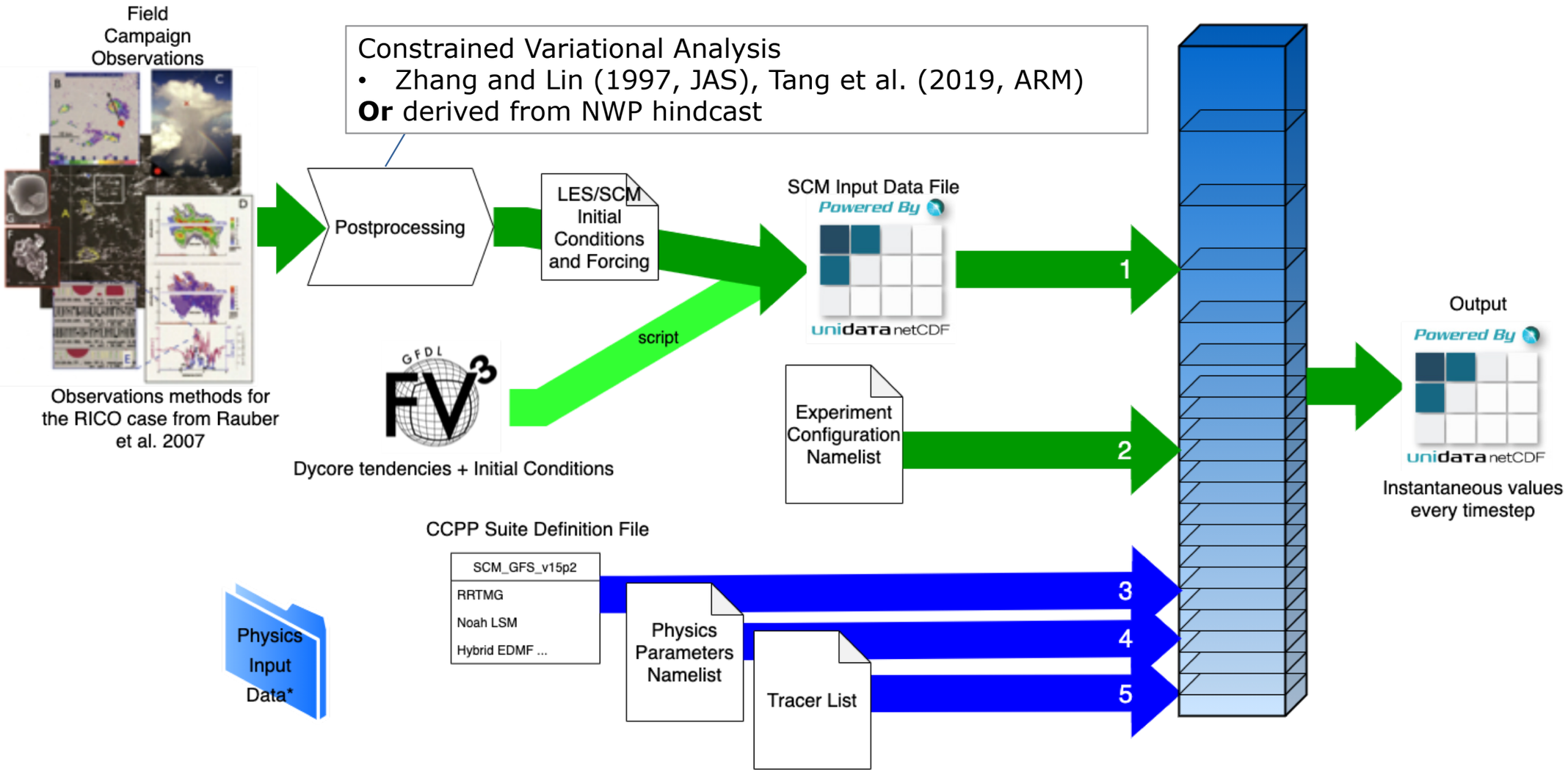
Cons

- Necessary, but not sufficient
- Forcing sensitivity

The CCPP within the SCM



SCM Inputs and Outputs



CCPP Public Releases

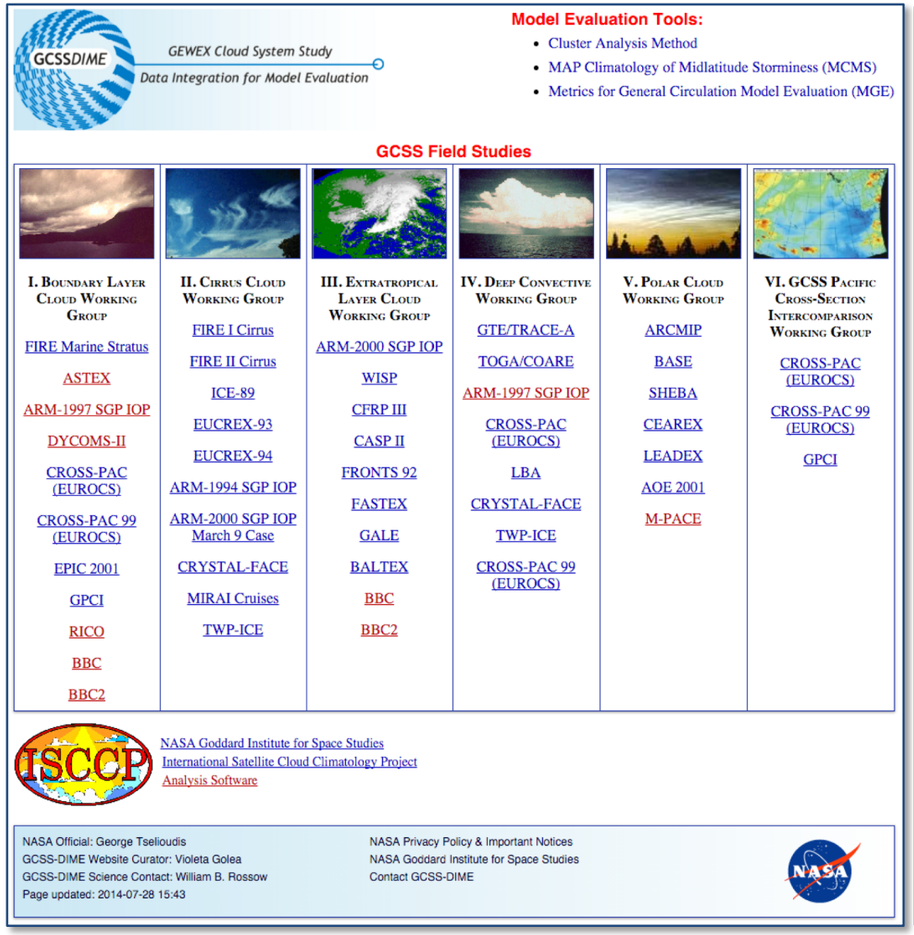
V	Date	Physics	Host
1.0	2018 Apr	GFS v14 operational	SCM
2.0	2018 Aug	GFS v14 operational updated GFDL microphysics	SCM UFS WM for developers
3.0	2019 Jul	GFS v15 operational Developmental schemes/suites	SCM UFS WM for developers
4.0	2020 Mar	GFS v15 operational Developmental schemes/suites	SCM UFS WM / UFS MRW App v1.0
4.1	2020 Oct	GFS v15 operational Developmental schemes/suites	SCM UFS WM / UFS MRW App v1.1
5.0	2021 Mar	GFS v15 operational Developmental schemes/suites	SCM UFS WM / UFS SRW App v1.0
6.0	2022 Jun	GFS v16 operational Developmental schemes/suites	SCM UFS WM / UFS SRW App v2.0

https://github.com/NCAR/ccpp-scm

CCPP SCM Version 6.0

- Up-to-date with NOAA operational GFS v16 physics through the CCPP (and also works with developmental suites)
- Available to public on GitHub
- Bundled with CCPP v6
- Simple host model for calling physics through CCPP
  - Contains CCPP software framework and physics as Git submodules
  - Contains example of using CCPP framework to:
    - Reconcile model-provided data with that needed by all schemes in physics suite
    - Initialize a CCPP-compliant physics suite
    - Call physics suite (one-liner!)
- Run script to execute permutations of supported physics suites and cases
- Script to generate cases with UFS initial conditions (only!)
- Choice of prescribed surface fluxes, LSM, or simple ocean surface
- DEPHY international case data file format support

Using Observations to Drive SCM



GCSSDIME
GEWEX Cloud System Study
Data Integration for Model Evaluation

Model Evaluation Tools:

- Cluster Analysis Method
- MAP Climatology of Midlatitude Storminess (MCMS)
- Metrics for General Circulation Model Evaluation (MGE)

GCSS Field Studies

I. Boundary Layer Cloud Working Group	II. Cirrus Cloud Working Group	III. Extratropical Layer Cloud Working Group	IV. Deep Convective Working Group	V. Polar Cloud Working Group	VI. GCSS Pacific Cross-Section Intercomparison Working Group
FIRE Marine Stratus	FIRE I Cirrus	ARM-2000 SGP IOP	GTE/TRACE-A	ARCMIP	CROSS-PAC (EUROCS)
ASTEX	FIRE II Cirrus	WISP	TOGA/COARE	BASE	CROSS-PAC 99 (EUROCS)
ARM-1997 SGP IOP	ICE-89	CFRP III	ARM-1997 SGP IOP	SHEBA	GPCI
DYCOMS-II	EUCREX-93	CASP II	CROSS-PAC (EUROCS)	CEAREX	
CROSS-PAC (EUROCS)	EUCREX-94	FRONTS 92	LBA	LEADEX	
CROSS-PAC 99 (EUROCS)	ARM-1994 SGP IOP	FASTEX	CRYSTAL-FACE	AOE 2001	
EPIC 2001	ARM-2000 SGP IOP March 9 Case	GALE	TWP-ICE	M-PACE	
GPCI	CRYSTAL-FACE	BALTEX	CROSS-PAC 99 (EUROCS)		
RICO	MIRAI Cruises	BBC			
BBC	TWP-ICE	BBC2			
BBC2					

ISCCP
NASA Goddard Institute for Space Studies
International Satellite Cloud Climatology Project
Analysis Software

NASA Official: George Tselioudis
GCSS-DIME Website Curator: Violeta Golea
GCSS-DIME Science Contact: William B. Rossow
Page updated: 2014-07-28 15:43

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NASA

Available Today

- GASS/TWP-ICE (maritime convection; near Australia, Jan-Feb 2006)
- ARM Great Plains (continental convective, Jun-Jul 1997)
- EUCLIPSE/ASTEX field campaign (stratocumulus, June 1992)
- LASSO (continental shallow cu, May 18, 2016)
- BOMEX (maritime shallow cu, June 1969)
- DEPHY repository cases

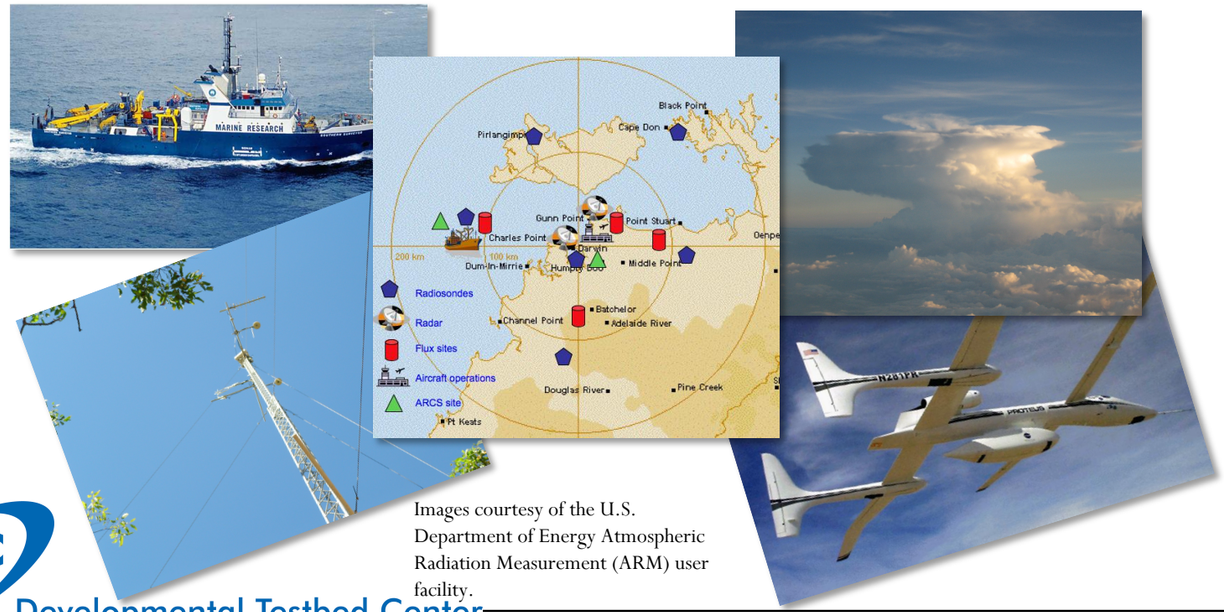
Planned

- Expand the variety of meteorological regimes

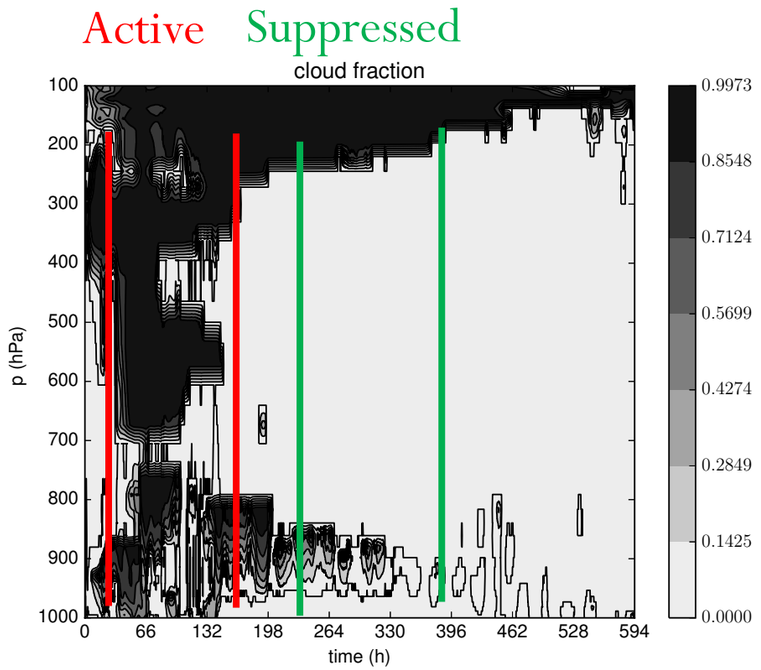
Note: A detailed SCM User's Guide explains how community users can add their own cases/data.

TWP-ICE case

- Tropical Warm Pool – International Cloud Experiment
  - DOE ARM field campaign near Darwin, Australia in Jan-Feb 2006
  - Features active and suppressed convective states related to monsoon
  - Model intercomparison studies using this case:
    - For CRMs: Fridland et al. (2012, JGR)
    - For SCMs: Davies et al. (2013, JGR)

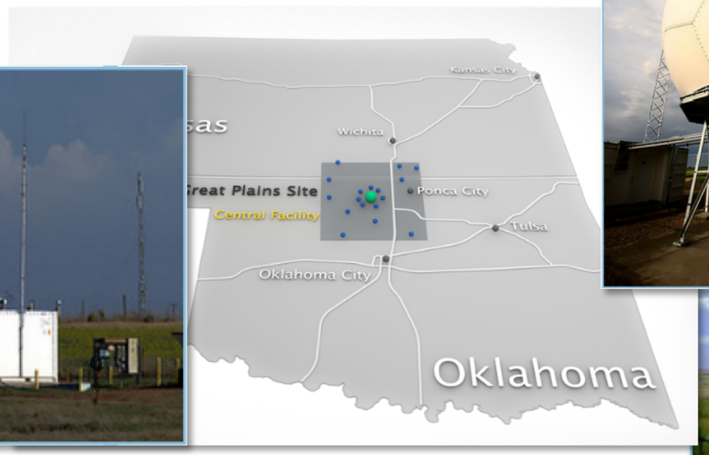


Images courtesy of the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility.

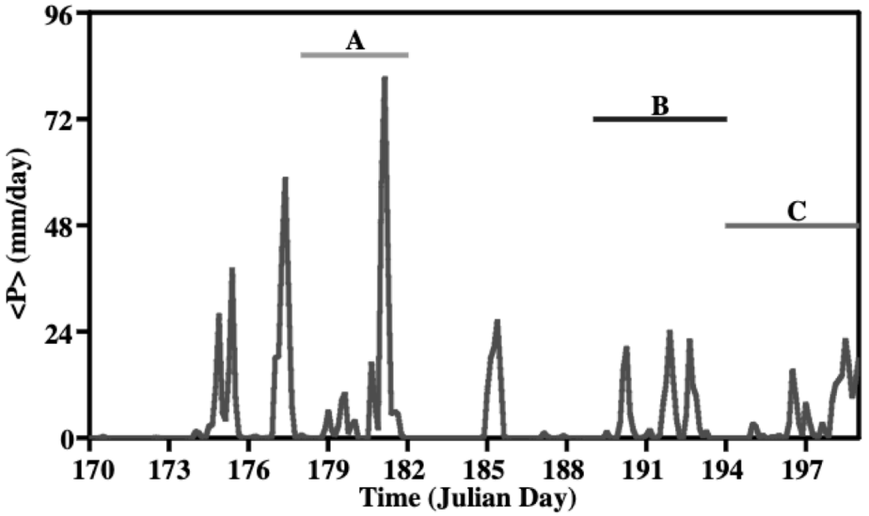


ARM SGP Summer 1997 case

- Atmosphere Radiation Measurement Southern Great Plains site
  - DOE ARM "Laboratory Without Walls"
  - Features 3 different summertime weather regimes over 30 days
    - Disorganized convection, clear/hot, passing MCS
    - Case is divided into time periods by phenomenon
  - Model intercomparison studies using this case:
    - Xu et al. (2002)

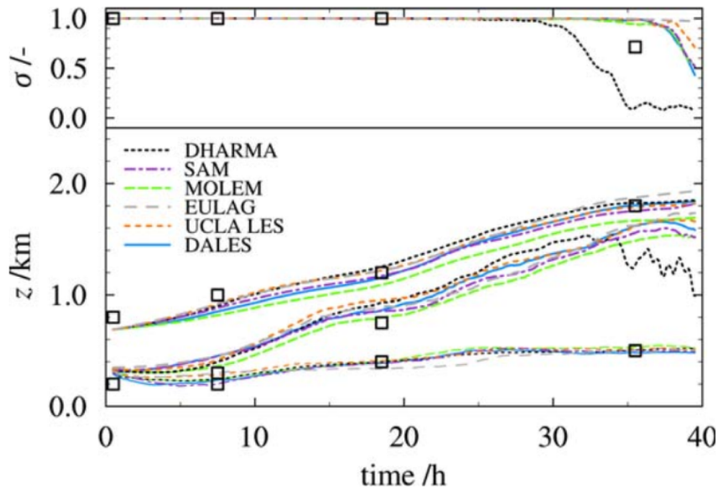


Images courtesy of the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility.

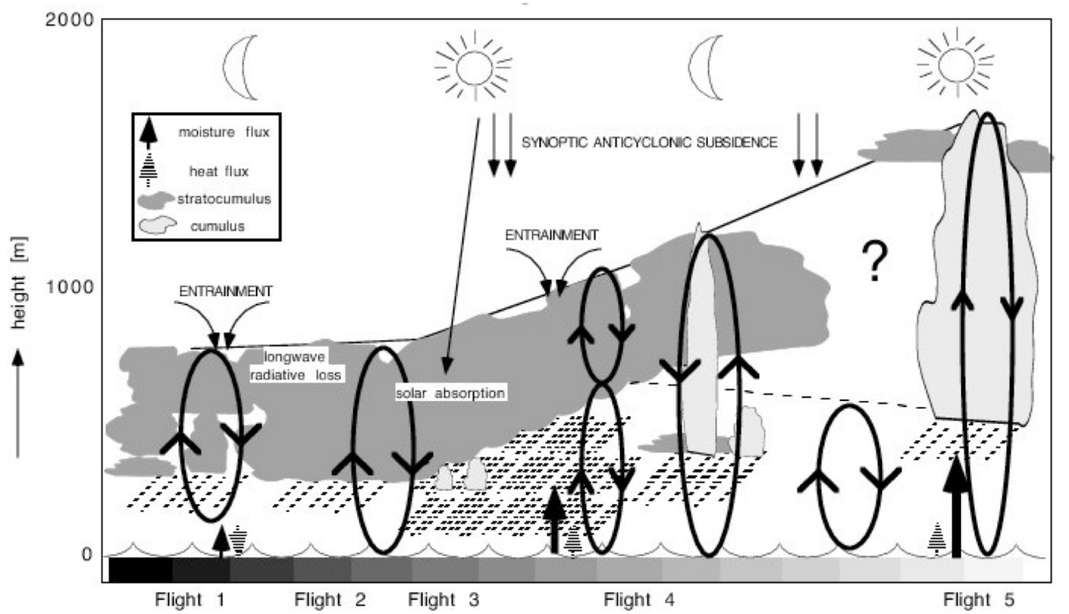


ASTEX (Lagrangian) case

- Atlantic Stratocumulus to Cumulus Transition Experiment
  - EUCLIPSE
  - Features stratocumulus-to-cumulus transition over 2 day period in June 1992 near the Azores via following a column in a Lagrangian sense
  - Model intercomparison studies using this case:
    - Bretherton et al. (1999)
    - van der Dussen et al. (2013)



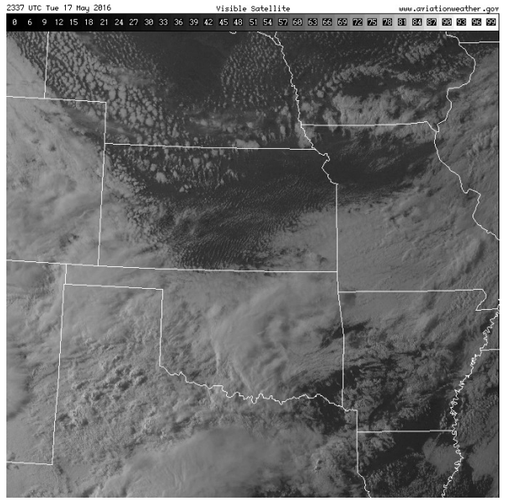
Cloud base/top from van der Dussen et al. (2013)



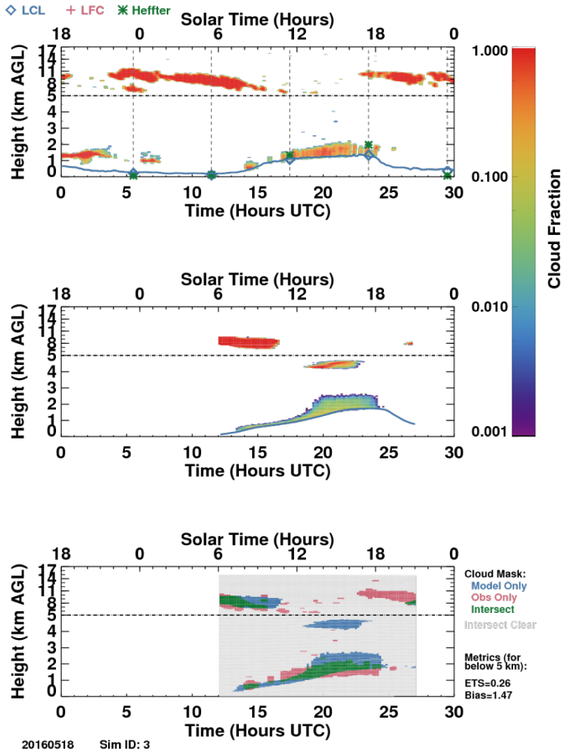
Obtained from http://www.euclipse.nl/wp3/ASTEX_Lagrangian/Introduction.shtml

LASSO case(s)

- LES ARM Symbiotic Simulation and Observation
  - DOE ARM Southern Great Plains site
  - Focuses on shallow cumulus; example case from May 18, 2016
  - Includes observations, SCM forcing data, and LES simulations for MANY days from 2015-2019
  - Gustafson et al. 2020

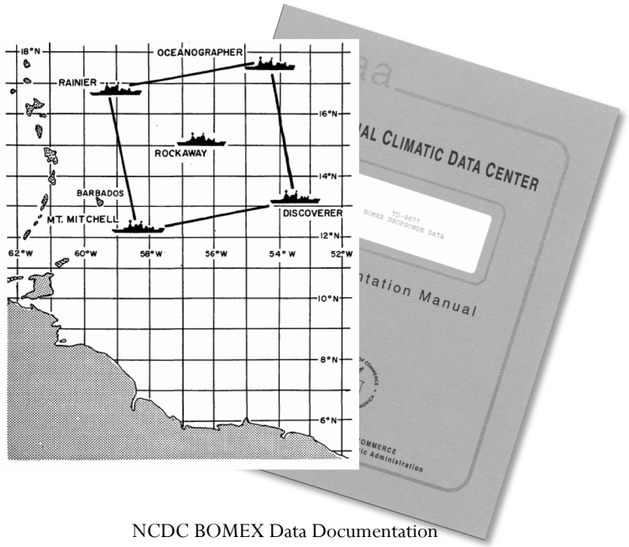


Images obtained from the LASSO Bundle Browser:
https://adc.arm.gov/lassobrowser

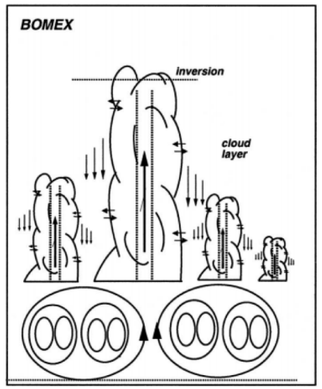


BOMEX case

- Barbados Oceanographic and Meteorological EXperiment
  - Near Barbados; joint project among 7 US agencies
  - Focuses on maritime shallow cumulus from June 22, 1969(!)
  - Model intercomparison studies using this case:
    - Siebesma et al. (2003)



NCDC BOMEX Data Documentation



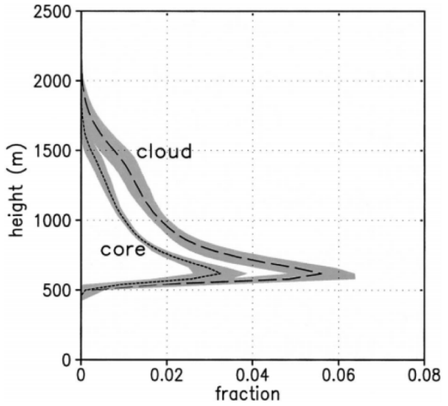
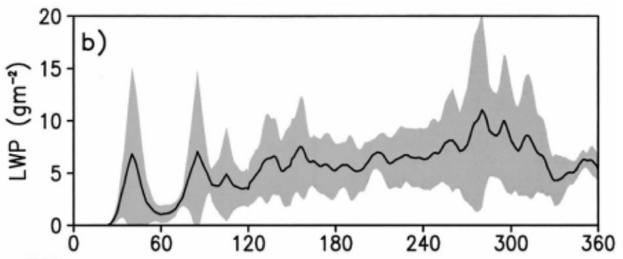


FIG. 6. Cloud cover and core cover profiles.

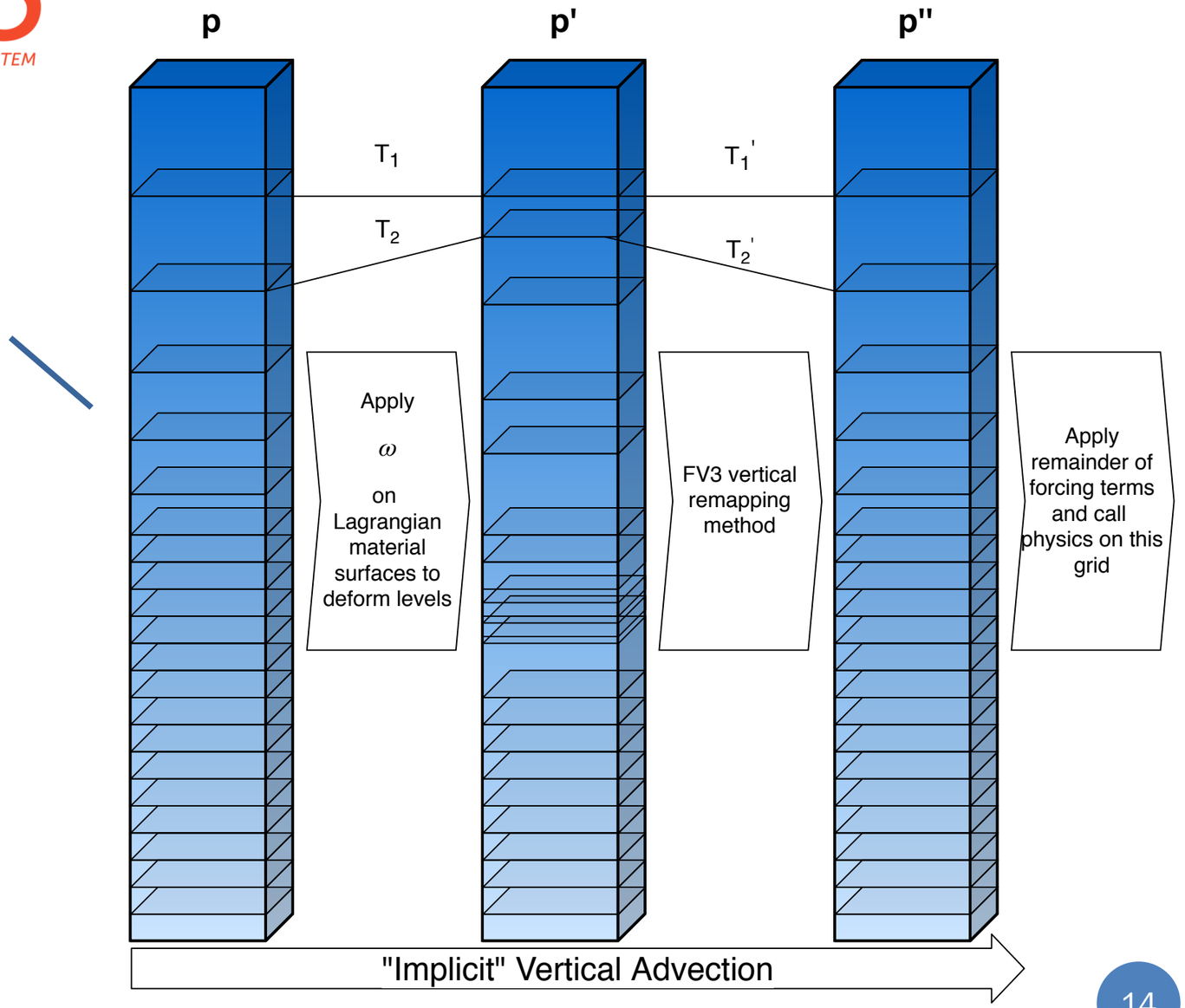
Plots from Siebesma et al. (2003)



Ties to the UFS

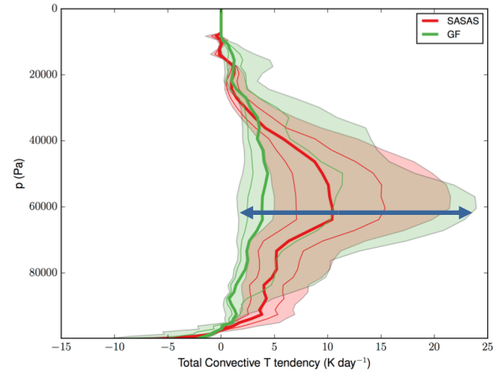
UNIFIED FORECAST SYSTEM

- Same vertical coordinate
  - σ-p hybrid
  - Today: Eulerian
  - Soon: semi-Lagrangian (allows for changing p_s)
- Physics namelist
- Physics data structure
  - GFS_typedefs.F90 with minor differences
- Soon: ICs/Forcing from configurable, selected columns
  - AKA "Column Replay"



Past/Current Uses

- DTC testing of the Grell-Freitas convection scheme
- Exploration of a forcing ensemble approach



T tendency due to convection

- Lisa Bengtsson et al. (2019, MWR: https://doi.org/10.1175/MWR-D-19-0195.1)

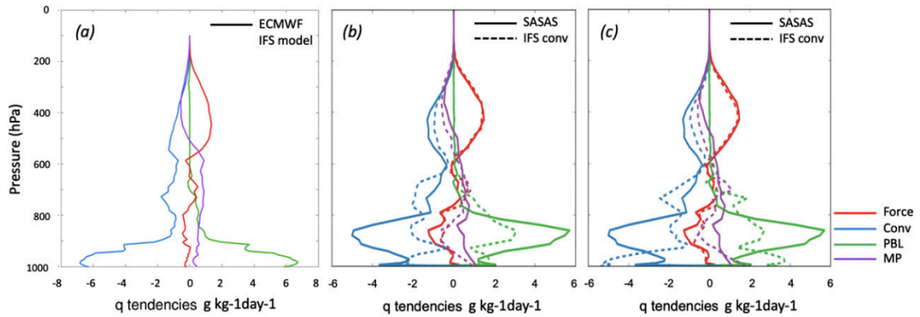
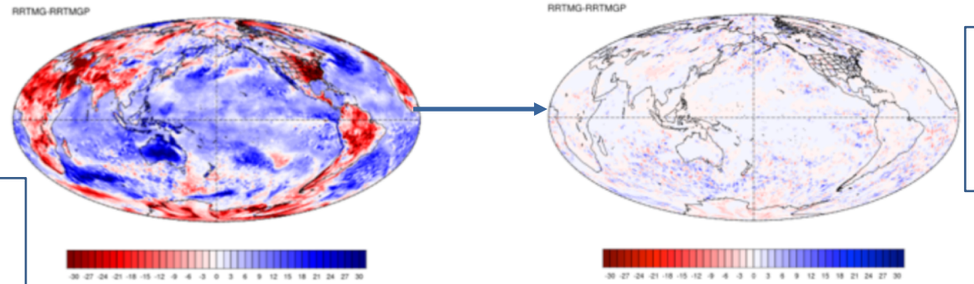


FIG. 2. Specific humidity tendency output for convection (blue), PBL (green), cloud microphysics (purple), and model forcing (red) for 1D simulations of the TWP-ICE campaign. Tendencies are averaged over the period 19 Jan–12 Feb 2016. (a) ECMWF IFS model output tendencies, (b) GFSIC-SASAS (solid) and "un-tuned" GFSIC-IFSconv (dashed) runs are shown. (c) GFSIC-SASAS (solid) and tuned GFSIC-IFSconv (dashed) runs are shown.

- 2020 AMS Short Course on CCPP/SCM
- RRTMGP development/debugging



Buggy result: large, systematic differences between RRTMG/RRTMGP

Expected result: small, random differences between RRTMG/RRTMGP

Courtesy: Robert Pincus and Dustin Swales

Summary

- One of simplest components of hierarchical physics testing framework
- Closely developed with CCPP
- Several supported suites with many unsupported developmental schemes
- Ties to UFS
- Used for scientific studies, physics sensitivity tests, teaching, physics development/debugging
- Actively developed with several planned usability improvements