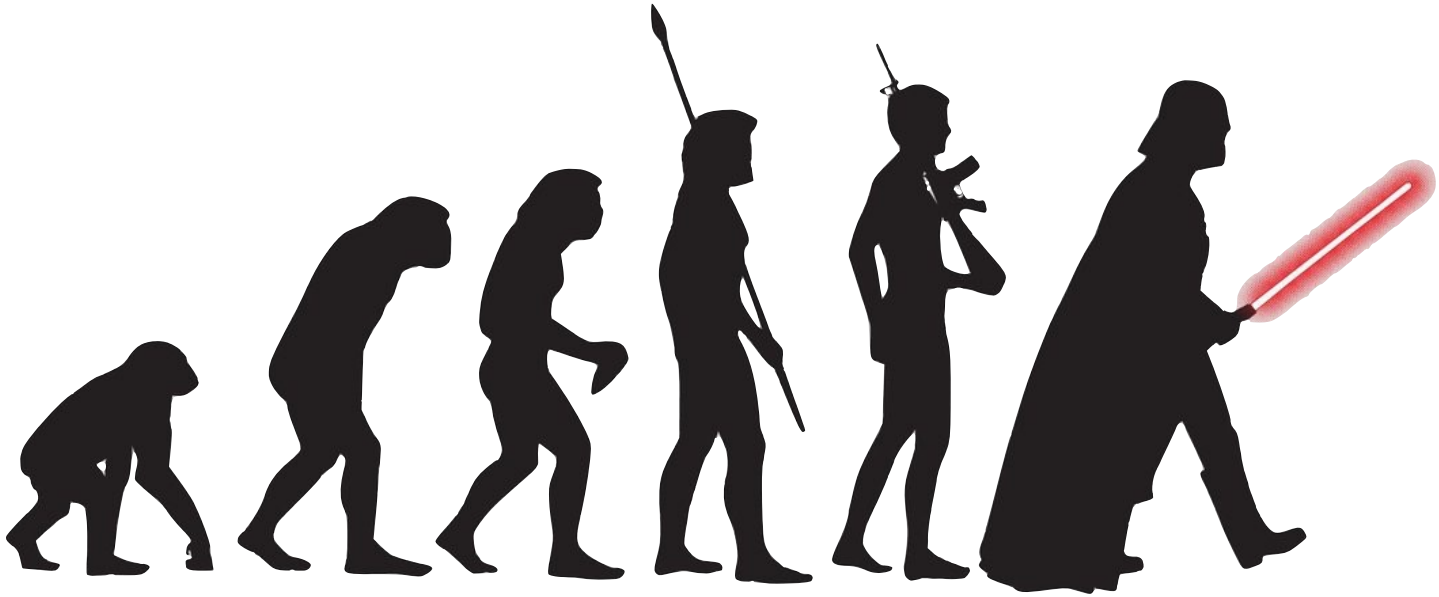
# An Overview of the Simplified CESM2 Model Configurations

Picture from B.Madeiros's Google search




**Simpler models team (in alphabetical order):**

**J. Benedict (Univ. Miami), A. Clement (Univ. Miami), B. Eaton (NCAR), C. Jablonowski (UMICH), A. Gettelman (NCAR), P. Lauritzen (NCAR), S. Goldhaber (NCAR), B. Madeiros (NCAR), L. Polvani (Columbia U.), K. Reed (Stony Brook), I. Simpson (NCAR), C. Zarzycki (NCAR), …**

# "Non-Hacked" Simplified CESM2 Model Configurations

# Overview

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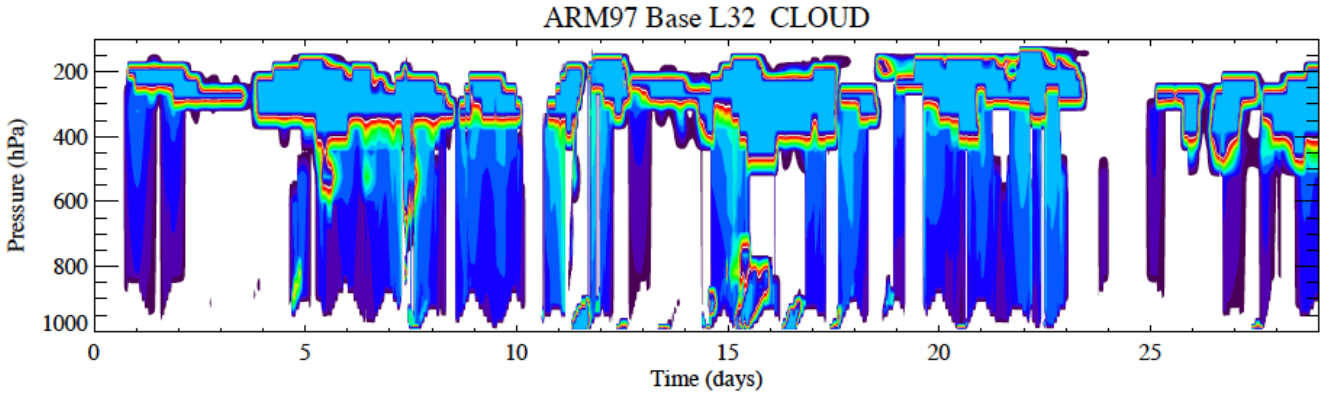
## "Out-of-the-box" support for:

- **Single column setup** (Gettelman and Truesdale)
- **Idealized dry baroclinic wave** (Polvani et. al., 2004)
  - initial condition created as initial condition file
- **Idealized dry baroclinic wave** (Jablonowski & Williamson, 2006)
  - initial condition analytically computed in code
- **Idealized moist baroclinic wave** (Ullrich et al., 2014)
  - initial condition analytically computed in code
- **Kessler Microphysics** (Kessler, 1969)
- **Toy terminator chemistry** (Lauritzen et al., 2015)
- **Held-Suarez forcing** (Held and Suarez, 1994)
  - initial condition analytically computed in code or initial condition file
- **Moist Held-Suarez forcing** (Thatcher and Jablonowski, 2016)
- **Aquaplanet configurations** (Medeiros et al., 2016; ...)

# The Single Column Atmosphere Model (SCAM6)




SAMPLE: SCAM6 ARM97 Case, Cloud Fraction

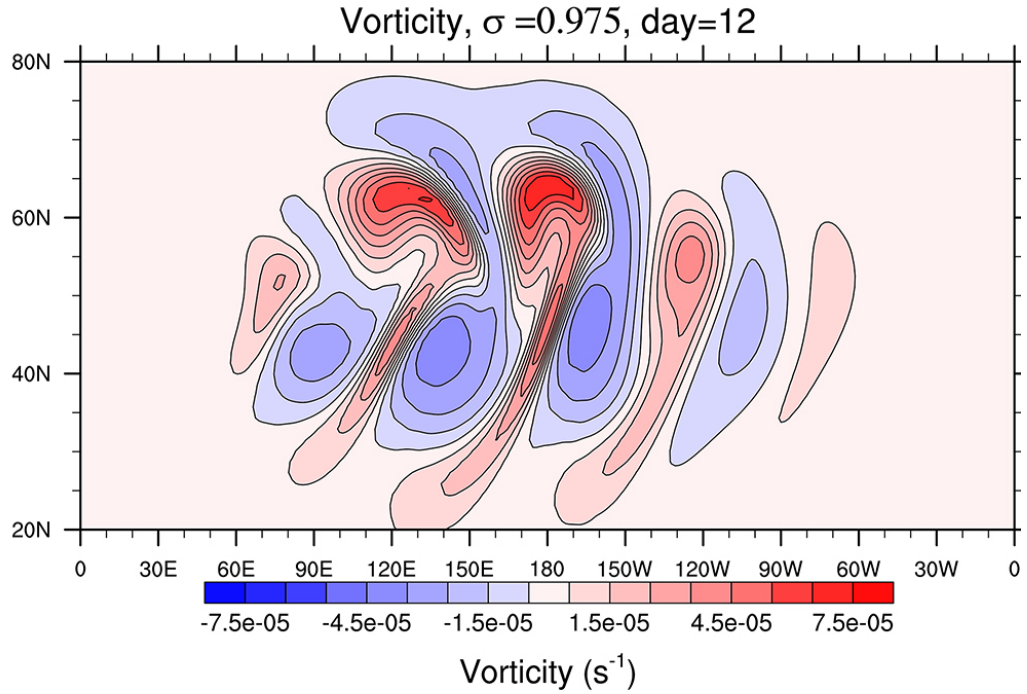
- Continues Single Column Version: exact CAM6 physics
  - Useful for process studies, development/debugging physics
- SCAM6 Features
  - Sample Script for running (single script)
  - Larger number of IOP Cases (use cases)
  - Easy method to add cases
- New Feature: make your own IOP
  - Run CAM nudged & flag for SCAM outputs at a single point
  - Generates a file that can be used as a SCAM IOP file

Questions: Gettelman, Truesdale

# Polvani et al. (2004) baroclinic wave

http://www.cesm.ucar.edu/models/simpler-models/adiabatic.html

I.Simpson & L.Polvani

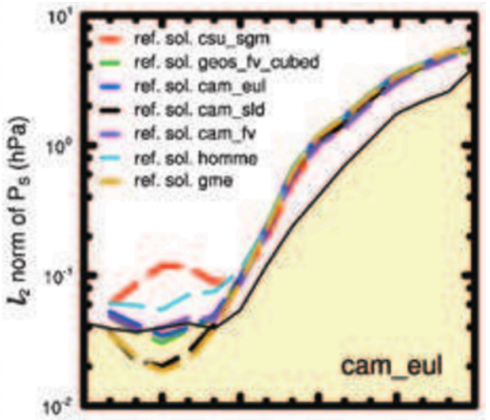



```
./create_newcase -compset FDABIP04 -res T42_T42 -case $CASEDIR -mach
$MACH
./case.setup
./case.build
./case.submit
```

# Jablonowski & Williamson baroclinic wave

Implementation in progress - led by C.Jablonowski

**Test case extensively used in the literature to debug, evaluate & compare dynamical cores**



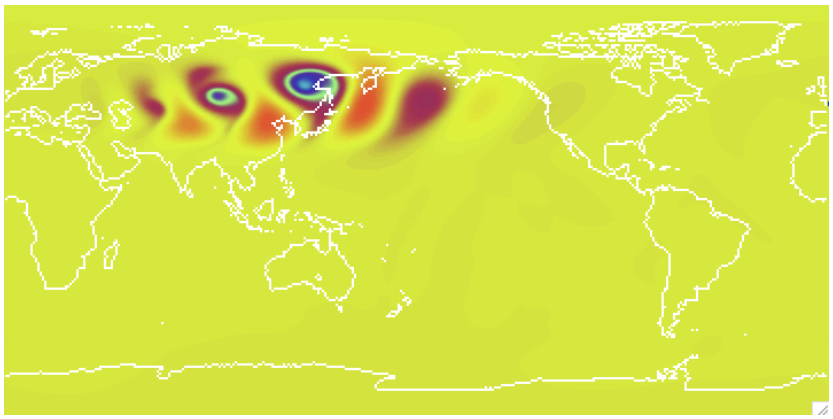

Jablonowski & Williamson (2006)

# Moist baroclinic wave

**Ullrich et al. (2014): Q≠0; supports deep atmosphere approximation**

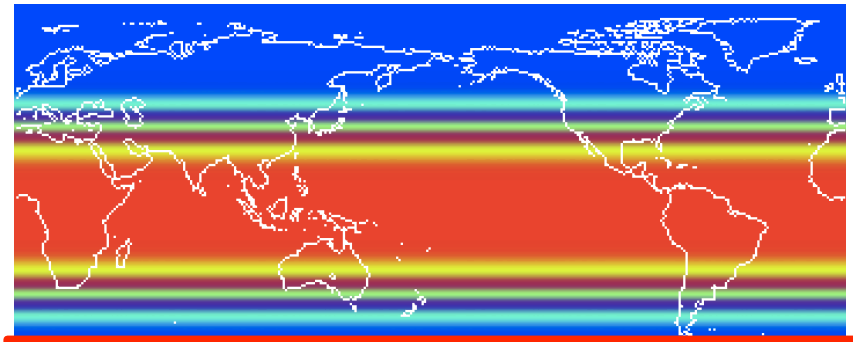
P.H.Lauritzen & S.Goldhaber

PS, day 10

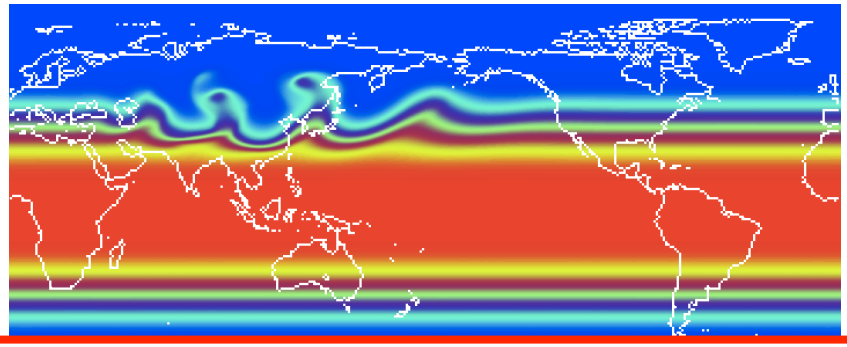


**Baroclinic wave used for DCMIP 2016**


Q, level 976hPa, Day 0



Q, level 976hPa, Day 10



```
./create_newcase -compset FADIAB -res ne30_ne30
./xmlchange –append CAM_CONFIG_OPTS=”-analytic_ic”
echo "analytic_ic_type    = 'baroclinic_wave'"">> user_nl_cam
```

# Moist baroclinic wave with Kessler Micro Physics

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## Ullrich et al. (2014) baroclinic with 3 tracers (cloud ice, rain water, water vapor)+Kessler (1969) physics

P.H.Lauritzen, C.Zarzycki & S.Goldhaber

**A. KESSLER PHYSICS**

The cloud microphysics update according to the following equation set:

$$\frac{\Delta\theta}{\Delta t} = -\frac{L}{c_p \pi}\left(\frac{\Delta q_{vs}}{\Delta t} + E_r\right) \quad (78)$$

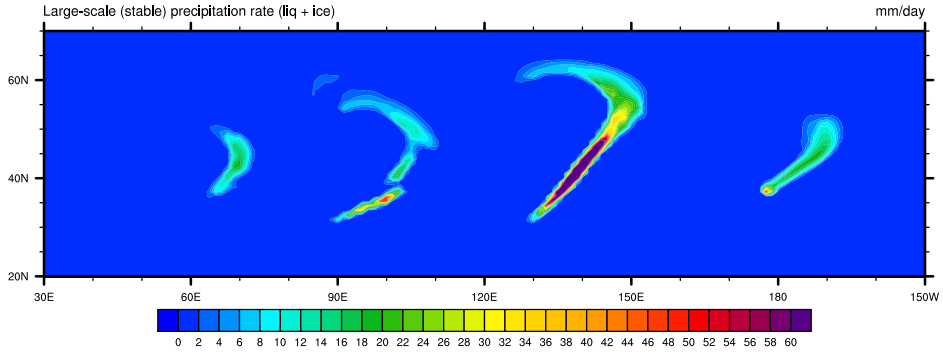
$$\frac{\Delta q_v}{\Delta t} = \frac{\Delta q_{vs}}{\Delta t} + E_r \quad (79)$$

$$\frac{\Delta q_c}{\Delta t} = -\frac{\Delta q_{vs}}{\Delta t} - A_r - C_r \quad (80)$$

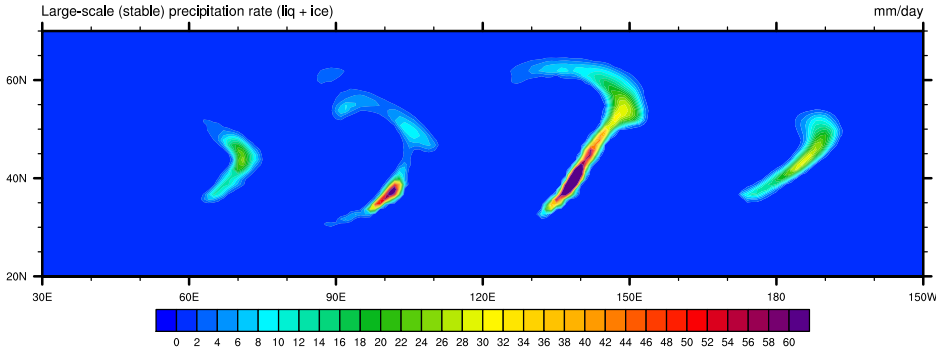
$$\frac{\Delta q_r}{\Delta t} = -E_r + A_r + C_r - V_r \frac{\partial q_r}{\partial z}, \quad (81)$$

where $L$ is the latent heat of condensation, $A_r$ is the autoconversion rate of cloud water to rain water, $C_r$ is the collection rate of rain water, $E_r$ is the rain water evaporation rate, and $V_r$ is the rain water terminal velocity.

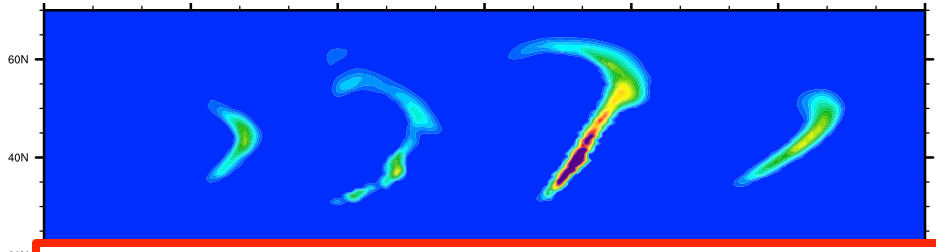
**CAM-FV, day 10**



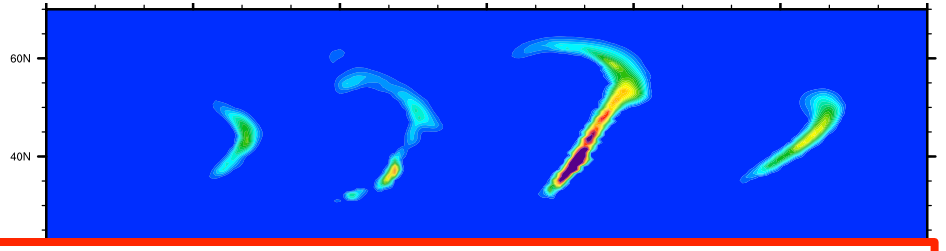

**CAM-SE-CSLAM, day 10**




**CAM-SE, day 10**




**CAM-SE (dtime = 900s), day 10**




```
./create_newcase -compset FKESSLER -res ne30_ne30
```

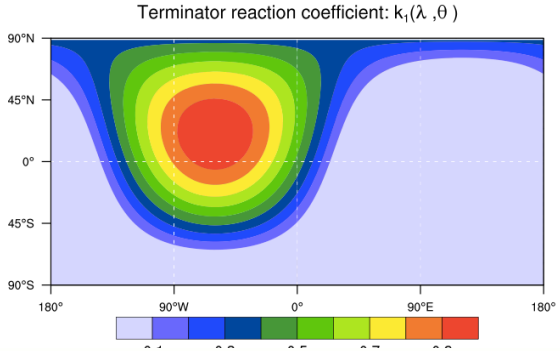
## Moist baroclinic wave + Kessler physics + terminator chemistry

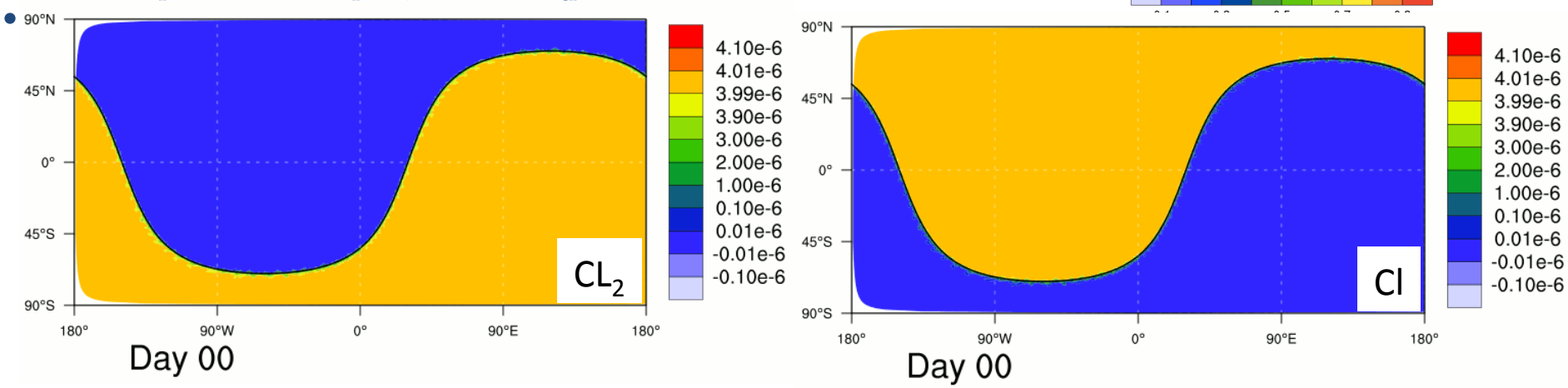
**(Lauritzen et al., 2015)**

P.H.Lauritzen, F.Vitt, A.Conley, J.-F.Lamarque & S.Goldhaber


- Consider 2 reactive chemical species, Cl and $Cl_2$ :

$$Cl_2 \rightarrow Cl + Cl : k_1$$
$$Cl + Cl \rightarrow Cl_2 : k_2$$



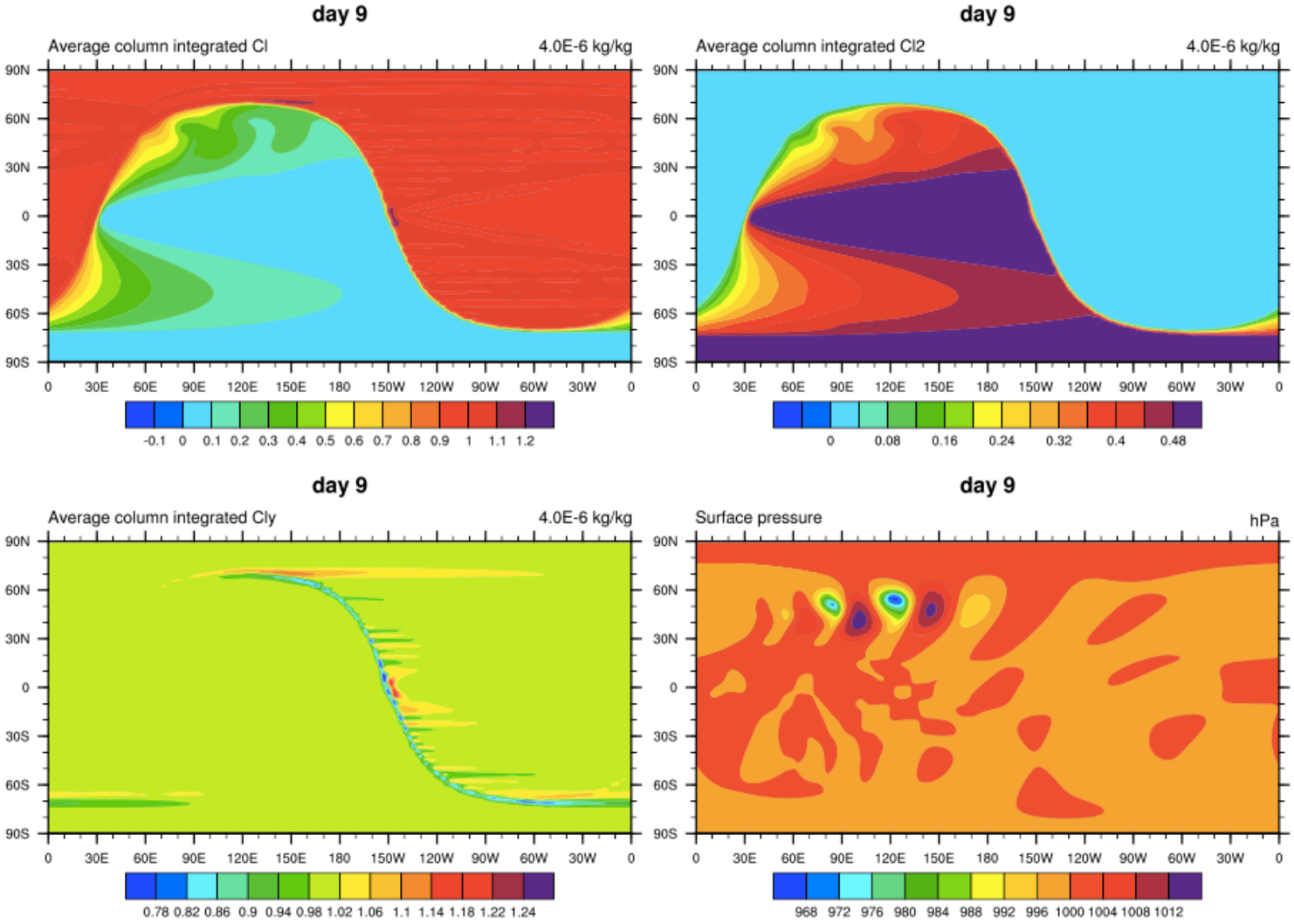




- In any flow-field $Cl_y = Cl + 2*Cl_2$ should be constant at all times (correlation preservation).

```
./create_newcase -compset FKESSLER -res ne30_ne30
./xmlchange --append CAM_CONFIG_OPTS=" -chem terminator"
```

# Ullrich et al. (2014) baroclinic with 5 tracers (cloud ice, rain water, water vapor, Cl and $Cl_2$)+Kessler (1969) physics+'toy' terminator chemistry


P.H.Lauritzen, F.Vitt, A.Conley, J.-F.Lamarque & S.Goldhaber



# Held-Suarez forcing

http://www.cesm.ucar.edu/models/simpler-models/held-suarez.html

I.Simpson & L.Polvani

Held and Suarez (1994):

$$\frac{\partial v}{\partial t} = \cdots - k_v(\sigma) v$$

$$\frac{\partial T}{\partial t} = \cdots - k_T(\phi, \sigma)\left[T - T_{eq}(\phi, p)\right]$$

```
./create_newcase -compset FHS94 -res T42_T42
```

# Moist Held-Suarez

Slide C.Jabonowski (implementation in progress – led by C.Jablonowski)

Large-scale condensation

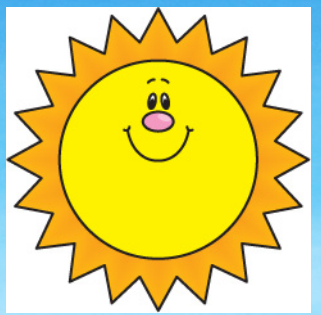
PBL Mixing of pot. T, q, ~~u, v~~

Merge & Adjust

Surface fluxes of sensible & latent heat, ~~and momentum~~

Simple-Physics (Reed and Jablonowski 2012)

Radiation: Newtonian Temperature relaxation



Surface momentum fluxes and PBL mixing of momentum: Rayleigh Friction between the surface and 700 hPa

Held and Suarez (BAMS, 1994) physics

# Aqua-planet

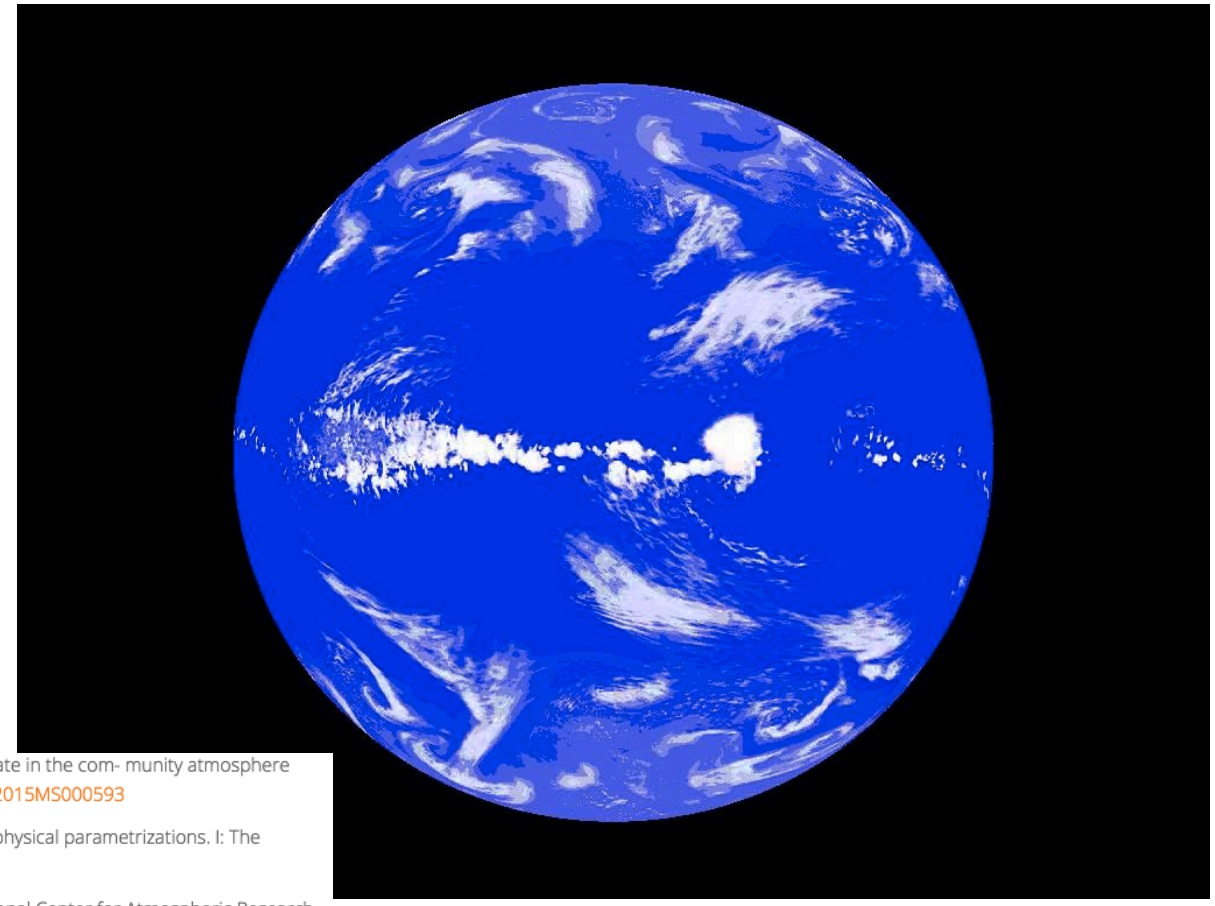
http://www.cesm.ucar.edu/models/simpler-models/aquaplanet.html

J.Benedict & B.Medeiros

**CESM Compsets:**

Prescribed/analytic SST:
FC4AQUAP, FC5AQUAP, FC6AQUAP

Slab-ocean:
EC4AQUAP, EC5AQUAP, EC6AQUAP



Medeiros, B., D. L. Williamson, and J. G. Olson, 2016: Reference aquaplanet climate in the com- munity atmosphere model, version 5. Journal of Advances in Modeling Earth Systems, doi: 10.1002/2015MS000593

Neale, R. B. and B. J. Hoskins, 2000a: A standard test for AGCMs including their physical parametrizations. I: The proposal. *Atmos. Sci. Lett.*, **1,** 101-107.

David L. Williamson and Co-Authors, 2012: The APE Atlas. Technical report, National Center for Atmospheric Research. URL http://nldr.library.ucar.edu/repository/collections/TECH-NOTE-000-000-000-865.