Long-range weather prediction using coupled model

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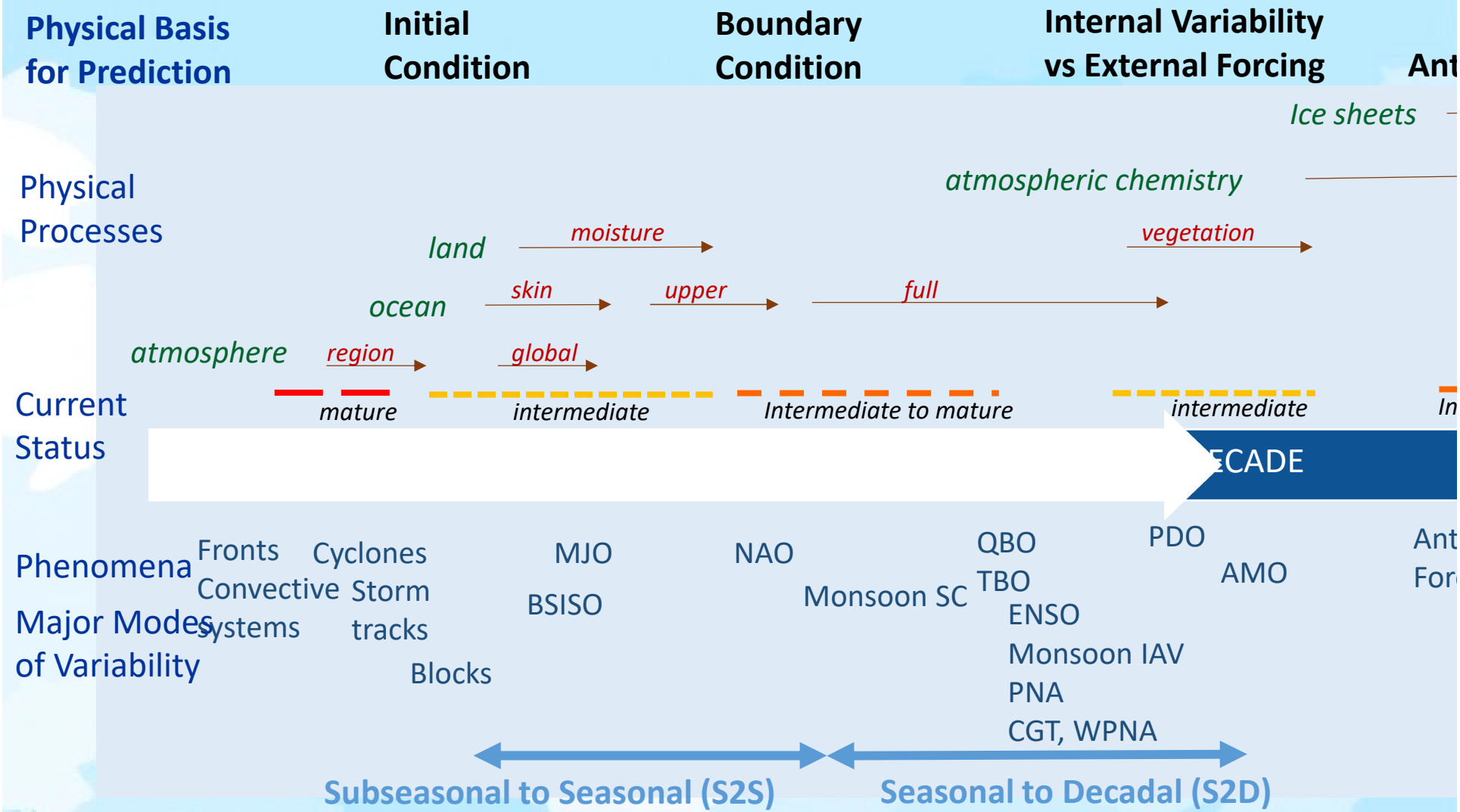
The Seamless Weather-Climate Prediction Problem



Slide from June-Yi Lee presentation at CITES-2019 School

Operational long-range models

Таблица 1: Operational coupled models for the seasonal prediction.

Center	Model	Atmosphere model, resolution	Ocean model, resolution	Ice model, resolution	Other components
UK MetOffice	GloSea5	Unified model, 0.83°x0.85° (50 km), 85 levels to 85 km.	NEMO, ORCA025, 75 levels	CICE, 0.25°, zero-layer	OASIS3, JULES
ECMWF	SEAS5	IFS, Tco399 (25km), 91 levels	NEMO, ORCA025, 75 levels	LIM2, 0.25°, 3 layers	OASIS3 HTESSEL WAM, SPPT
Meteo-France	SYSTEM5	Arpege Climate, TL359 (about 0.5°), 91 levels to 0.01 hPa	NEMO, ORCA1, 42 levels	Gelato, 1°, 10 layers	OASIS3 Surfex TRIP
NCEP	CFSv2	GFS, T126 (about 100 km), 64 levels	MOM, 0.5°, 40 levels	SIS, 0.5°, 3 layers	NOAH
Canada	CanSIPS	CanAM4, T63 (2.8°), 35 levels up to 1 hPa	CamOM4, 1.41°x0.94°, 40 levels	Built-in CanAM	CLASS

From SLAV to SLAV-INMIO-CICE coupled model

SLAV “seamless prediction” version – 2014.

SLAV-INMIO coupled model – 2015.

SLAV-INMIO-CICE 0.5^{o} first run on Sep 2018.

- Simulations up to 10 years.
- 4-month hindcasts (1992-2010).

SLAV-INMIO-CICE 0.25^{o} – first run on Apr 2019.

Coupled SLAV-INMIO-CICE model configuration:

SLAV– combines atmosphere, land and soil models

- 0.9^ox0.72^o (400x250), Δt = 1440 s.
- 96 levels up to 0.03 hPa,
- Regular lat-lon grid, 1D MPI-decomposition.
- 10 level multilayer soil model INM RAS.

INMIO – ocean model

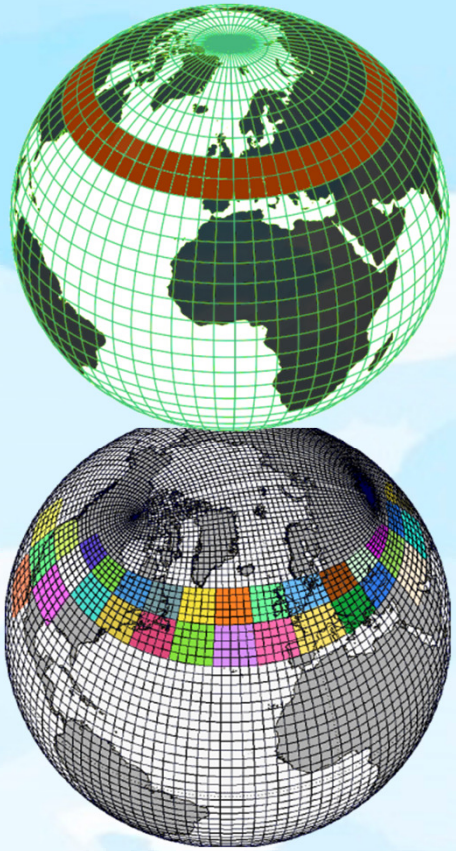
- 0.5^ox0.5^o (720x360) / 0.25^ox0.25^o (1440x720)
- 49 levels,
- Δt = 720 s. / 600 s. (inner step – 30 s.)
- Tripolar grid 0.5^o, 2D MPI-decomposition.

CICE-5.1 – sea ice models

- Tripolar grid 0.5^o/ 0.25^o (same as in INMIO),
- 5 thickness cat., 1 snow category.

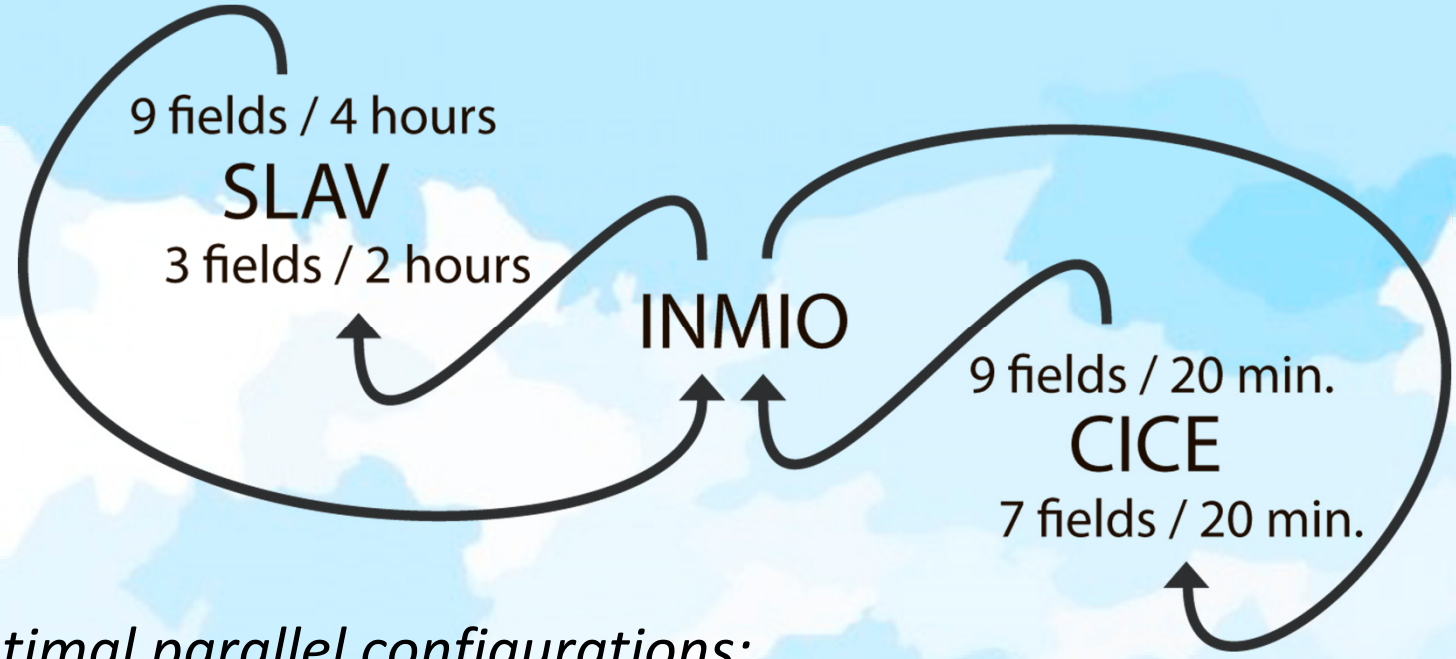
CMF – own developed coupler

- See (Kalmykov, et al., GMD, 2018) for details.



Tolstykh et al, GMD, 2017;
Ibrayev et al, Izv AOP, 2012;
Fadeev et al, RJNAMM, 2016, 2018

Coupled model structure



Optimal parallel configurations:

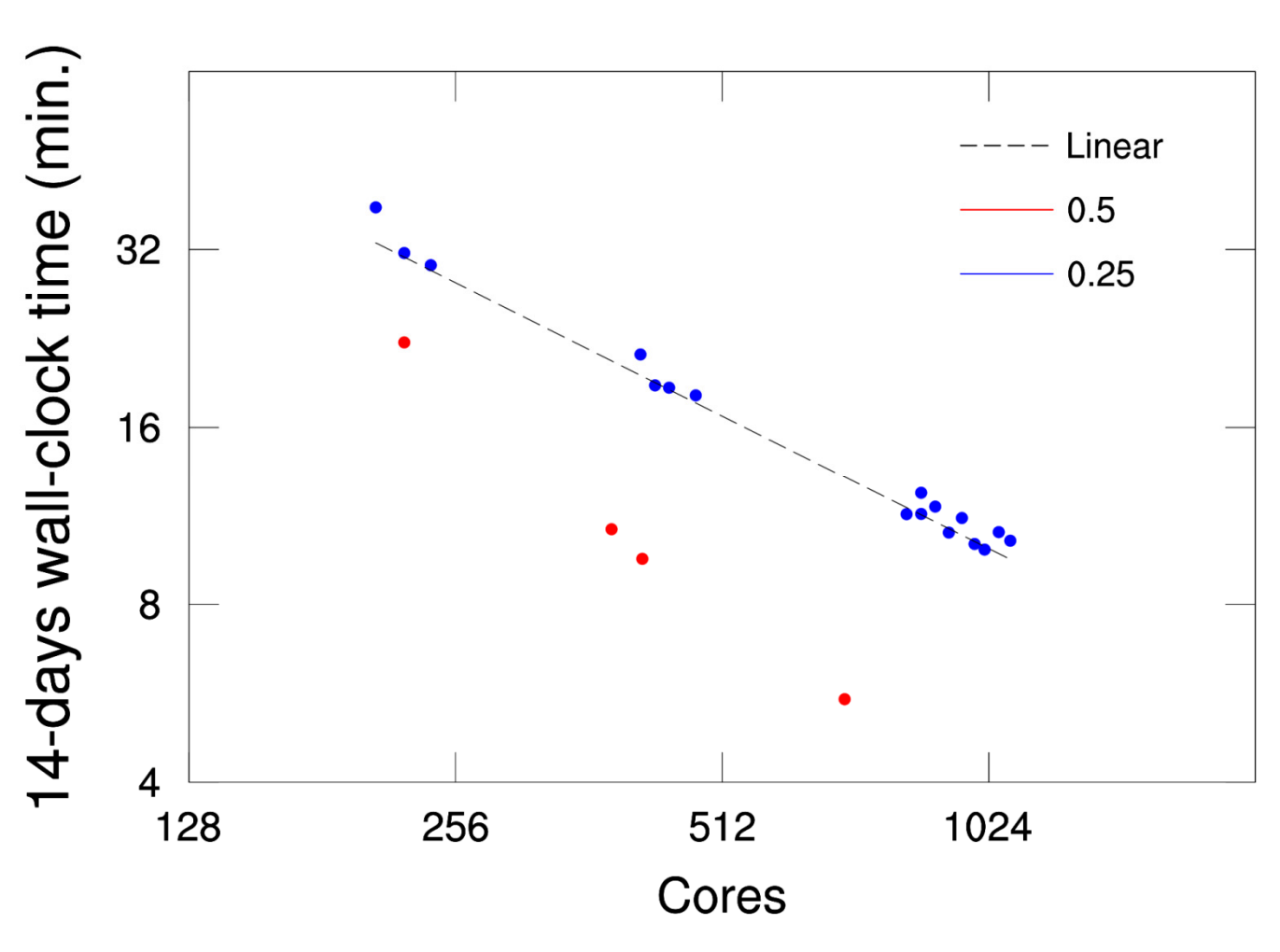
SLAV 0.9°x0.72° - 500 cores,
INMIO **0.5°** – 128 cores,
CICE **0.5° –** 32 cores,
661 cores total,
9.4 years/day.

SLAV 0.9°x0.72° - 250 cores,
INMIO **0.25°** – 640 cores,
CICE **0.25° –** 160 cores,
1051 cores total,
4.2 years/day at CrayXC40.

Coupled model scaling

***Red**: SLAV 0.9ºx0.72º, INMIO & CICE – 0.5º*

***Blue**: SLAV 0.9ºx0.72º, INMIO & CICE – 0.25º*



Verification of SLAV model climate: why?

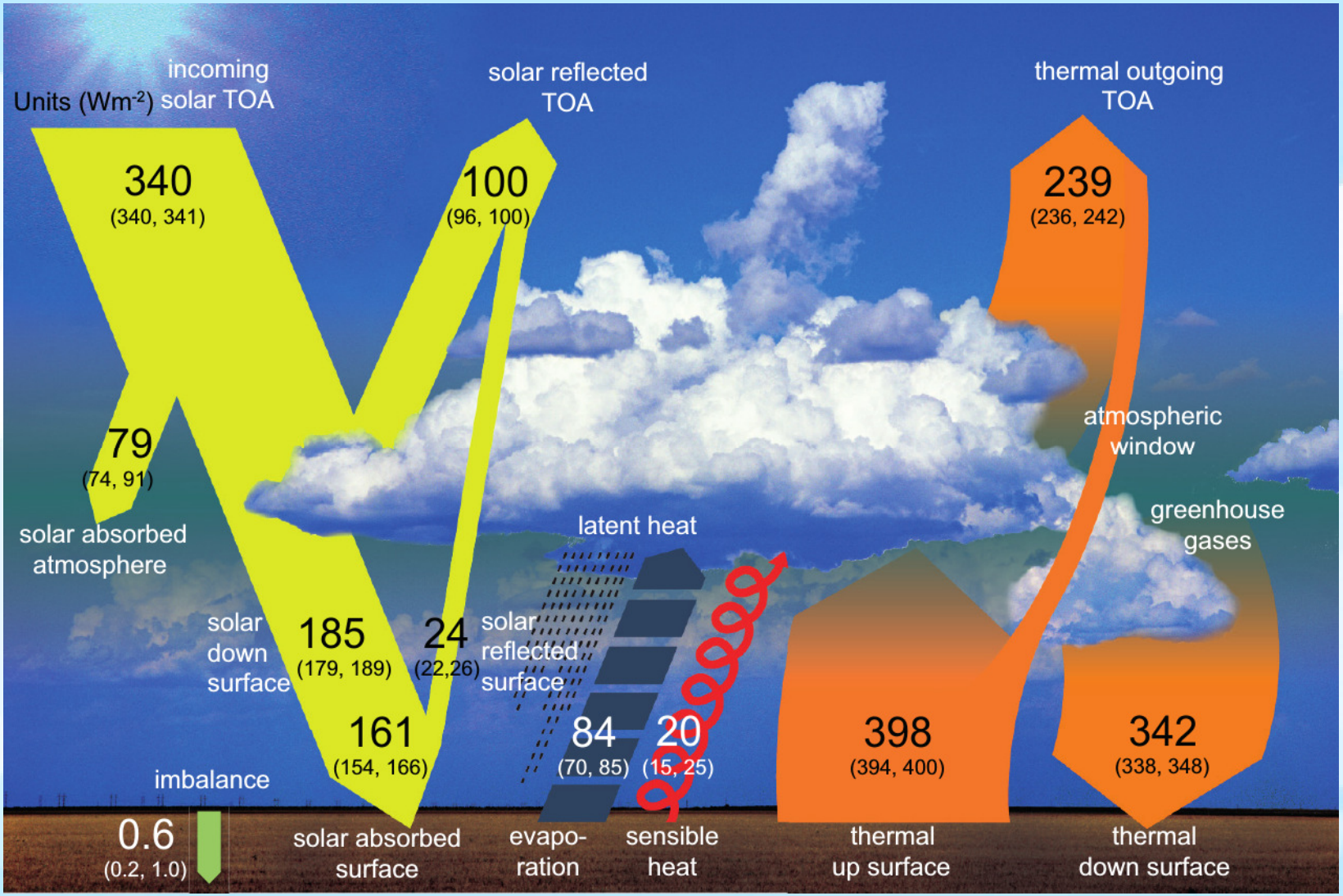


Image: IPCC Fifth Assessment Report (AR5). Climate Change 2013: The Physical Science Basis // http://www.ipcc.ch/report/ar5/wg1.

Evaluation of SLAV model climate

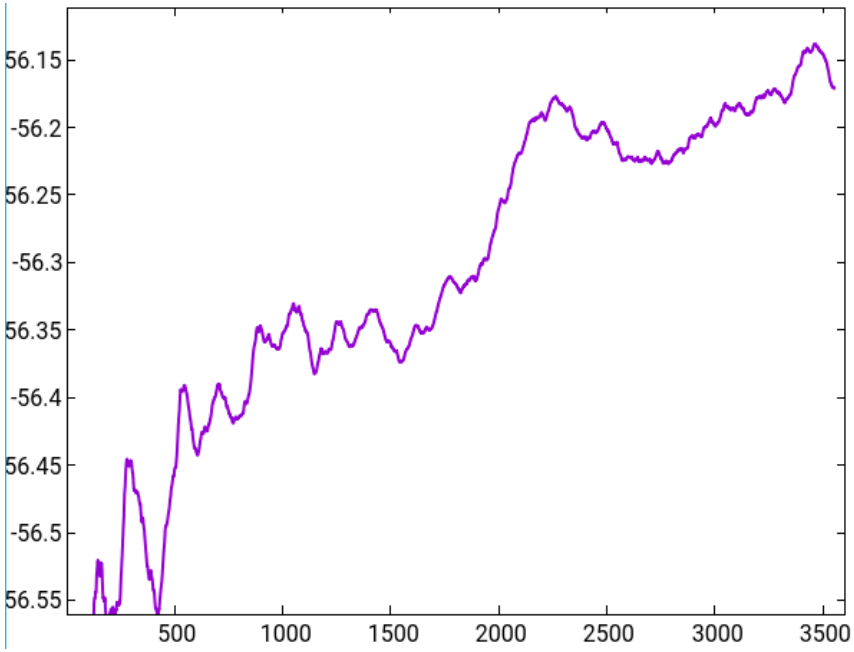
Prescribed ocean and sea ice evolution.

Annual mean surface fluxes:

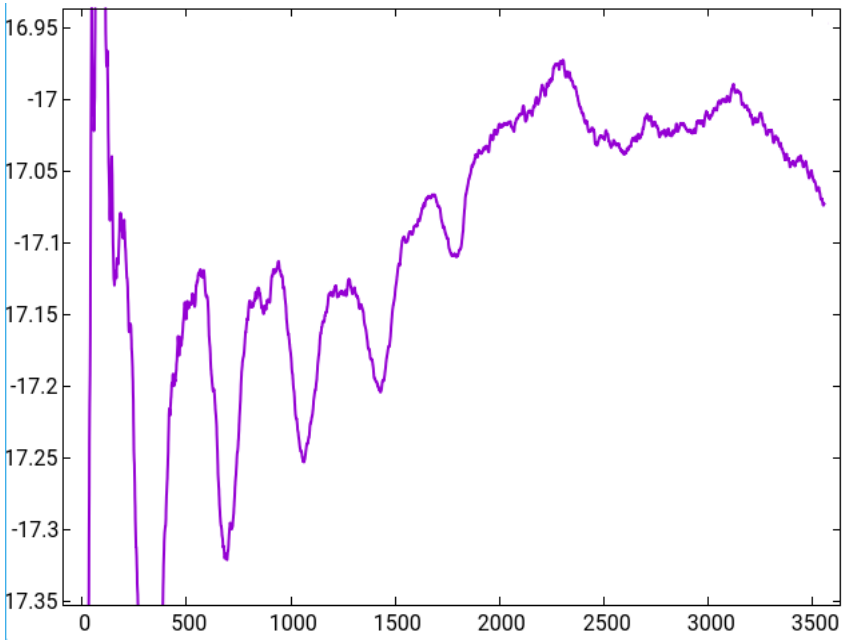
SR 159.3, TR -56.2, SH -17., LH -86.4 Wt/m^2

Total surface flux -0.3 Wt/m^2 (land: +0.028 Wt/m^2)

Thermal radiation, Wt/m^2



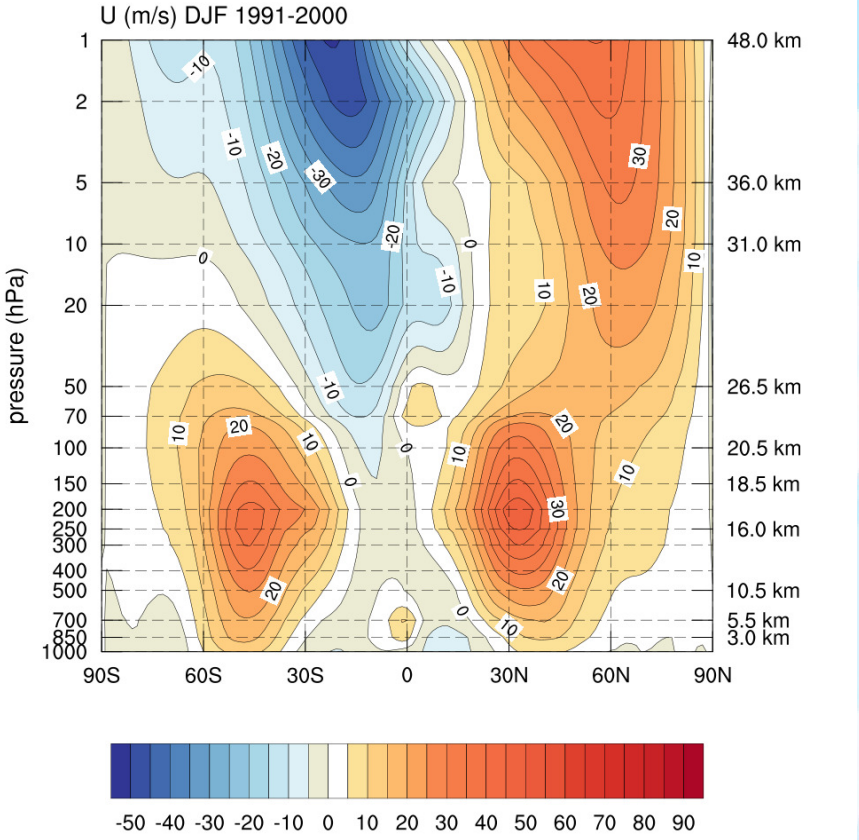
Sensible heat, Wt/m^2



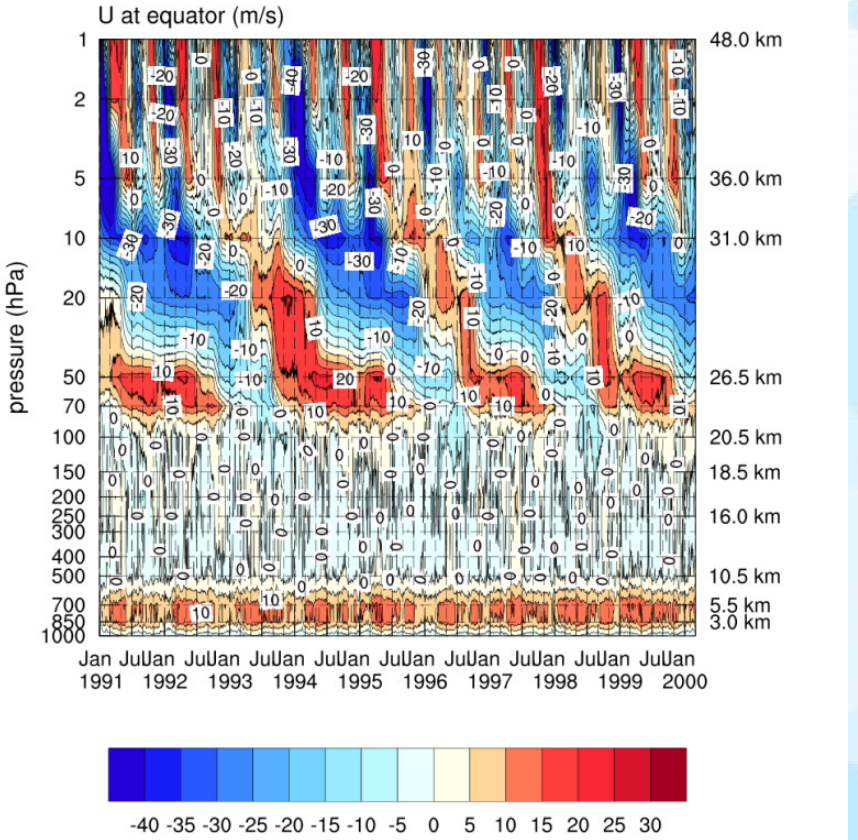
Model days

Evaluation of SLAV model climate: **wind**

Winter (DJF) zonal U-wind (1991-2010)

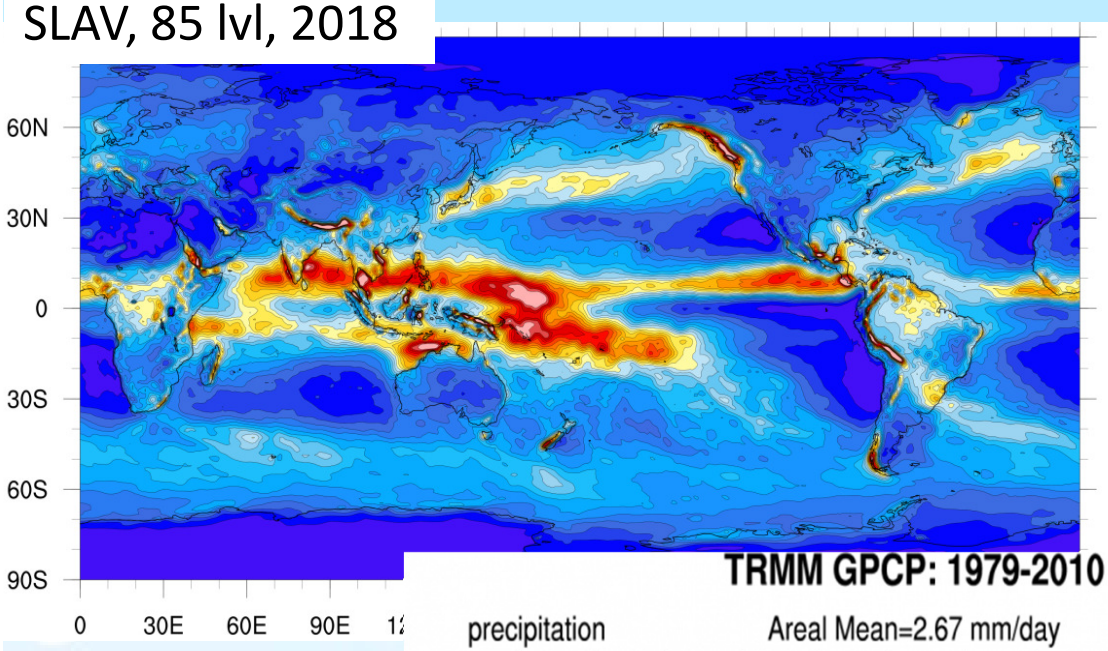


U-wind at equator (1992-2010)

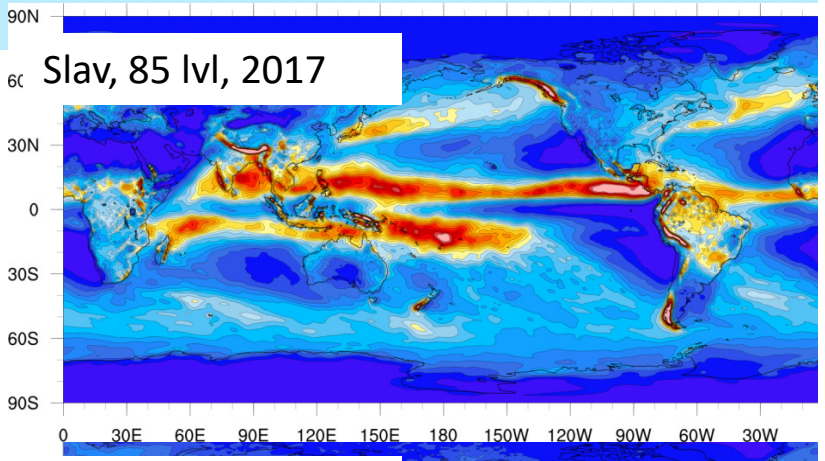


Evaluation of SLAV model climate: **precipitations**

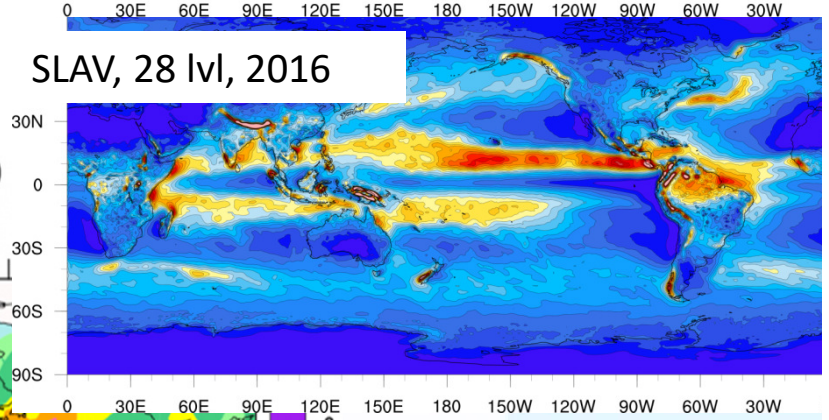
SLAV, 85 lvl, 2018



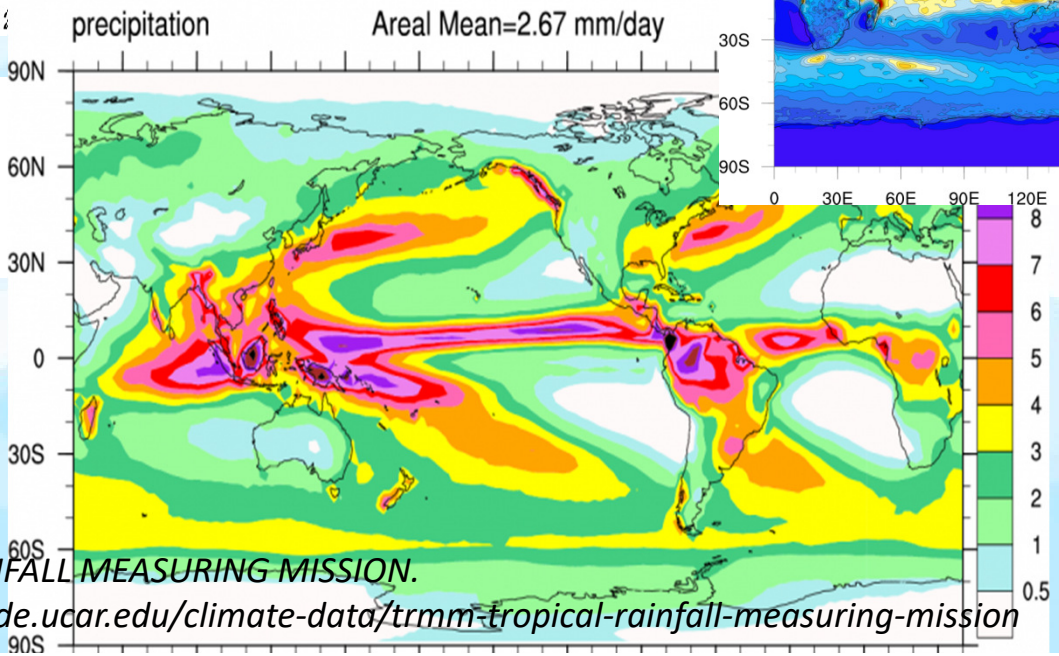
Slav, 85 lvl, 2017



SLAV, 28 lvl, 2016



Obs GPCP
TRMM
(1979-2010)



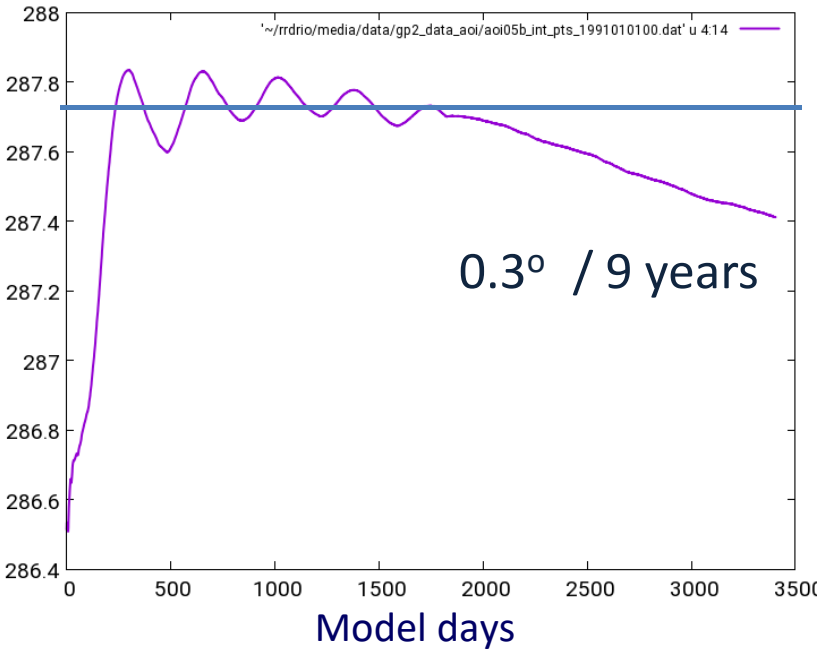
TRMM: TROPICAL RAINFALL MEASURING MISSION.
https://climatedataguide.ucar.edu/climate-data/trmm-tropical-rainfall-measuring-mission

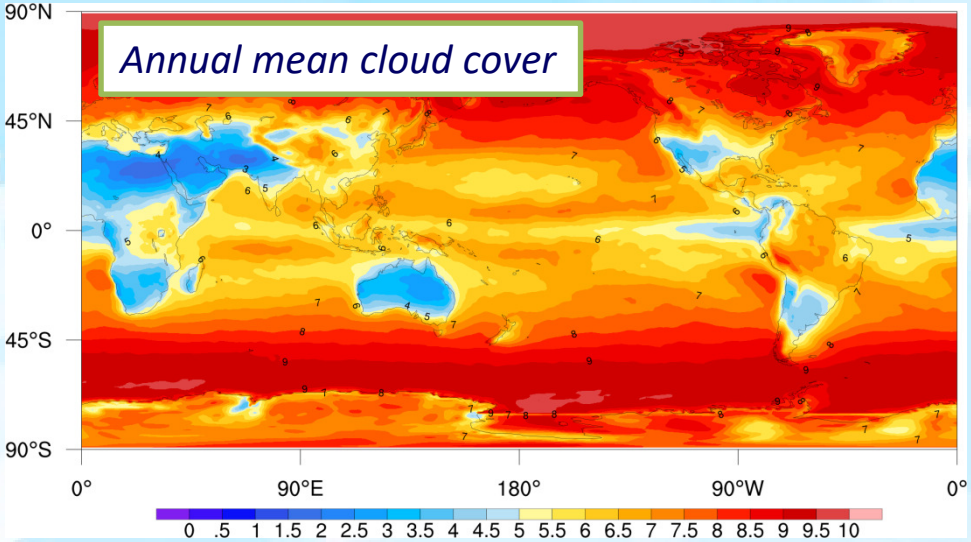
SLAV-INMIO-CICE: integration up to 10 years

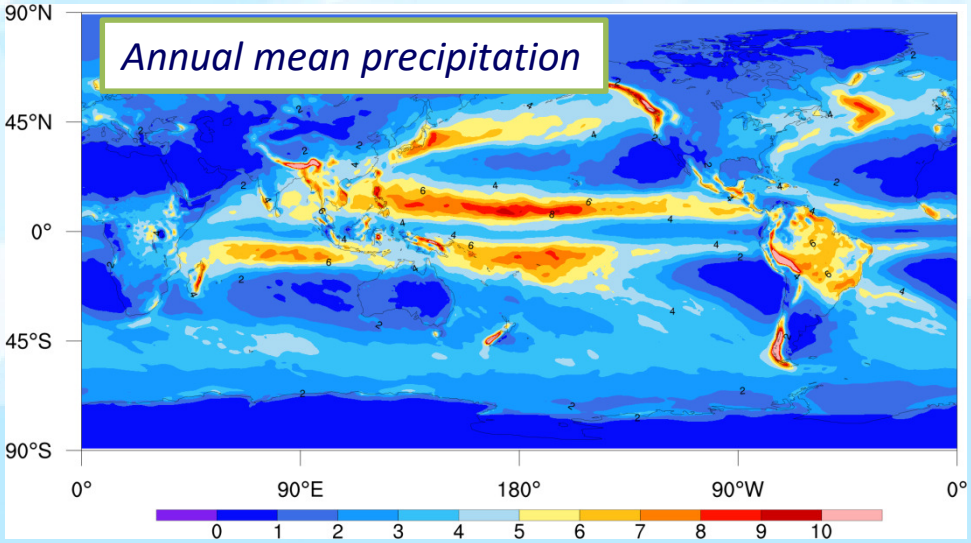
SR 163.8, TR -58.6, SH -15.8, LH -88.3 Wt/m^2

Total surface flux +1.1 Wt/m^2 (land: +0.031 Wt/m^2)

Global annual mean SST (K^o)







4-month hindcasts analysis

	H200			H500			T850		
	RMS	BIAS	Correlation	RMS	BIAS	CORR	RMS	BIAS	CORR
SLAV-INMIO-CICE, 1991-2010	81.41	41.44	99.42	48.02	27.26	99.13	2.13	1.10	99.00
SLAV-INMIO-CICE, 1992	88.01	50.08	99.27	51.67	30.05	98.98	2.28	1.23	98.90
SLAV, 1992	94.10	57.68	99.35	49.26	28.48	99.20	1.78	1.05	99.37
SLAV-INMIO-CICE, 1995	89.14	54.28	99.35	51.24	30.44	99.12	2.37	1.26	98.82
SLAV, 1995	107.43	73.13	99.40	53.73	32.57	99.28	2.08	1.21	99.13

Initialization *(for experimental runs)*

SLAV:

operational analysis (3D-var)

the state of deep soil is pre-calculated within 10-years run.

INMIO+CICE:

30-60 years CORE2 forcing

2-years of ERA-Interim forcing

Ensemble generation

Perturbation of deep convection intensity parameter.

(stochastic physics in plans)

Ways forward

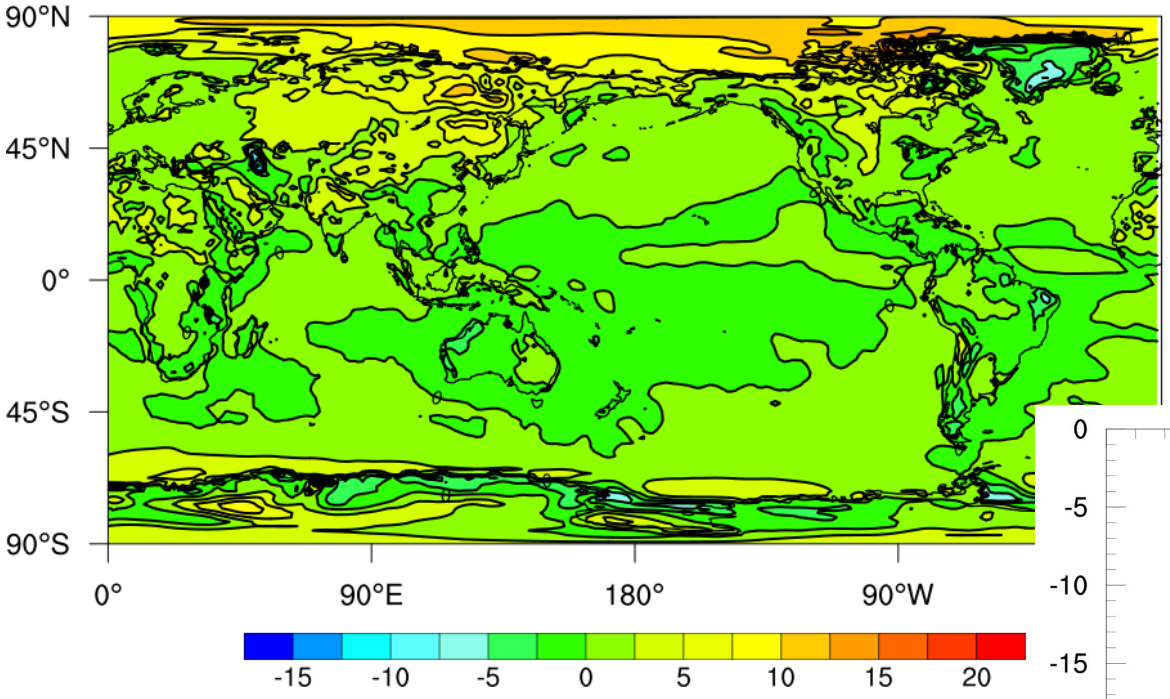
- Tuning and evaluation of the SLAV and SLAV-INMIO-CICE coupled model.
- Upgrading initialization technology & ensemble generation.

Problem

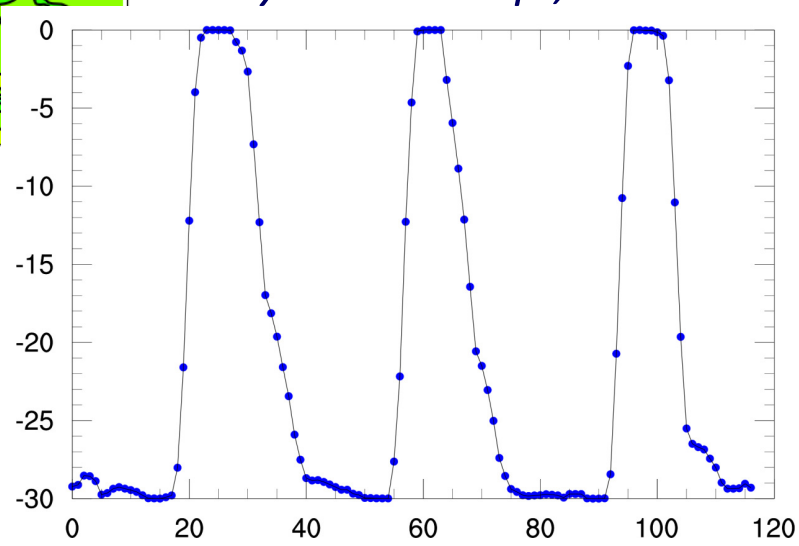
- Evolution of coupled model components.

4-month hindcasts analysis

Temperature error at 2-meters (spring).



Daily mean temp., C°



Model days

Thank you for attention!

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Ocean-atmosphere interaction

The experiments indicate **that short-lived heating produces responses** in midlatitudes at locations **far removed from the source** and these responses persist much longer than the pulses themselves.

Image:

Meridional wind at 300hPa response on 2-day temperature pulse (5°).

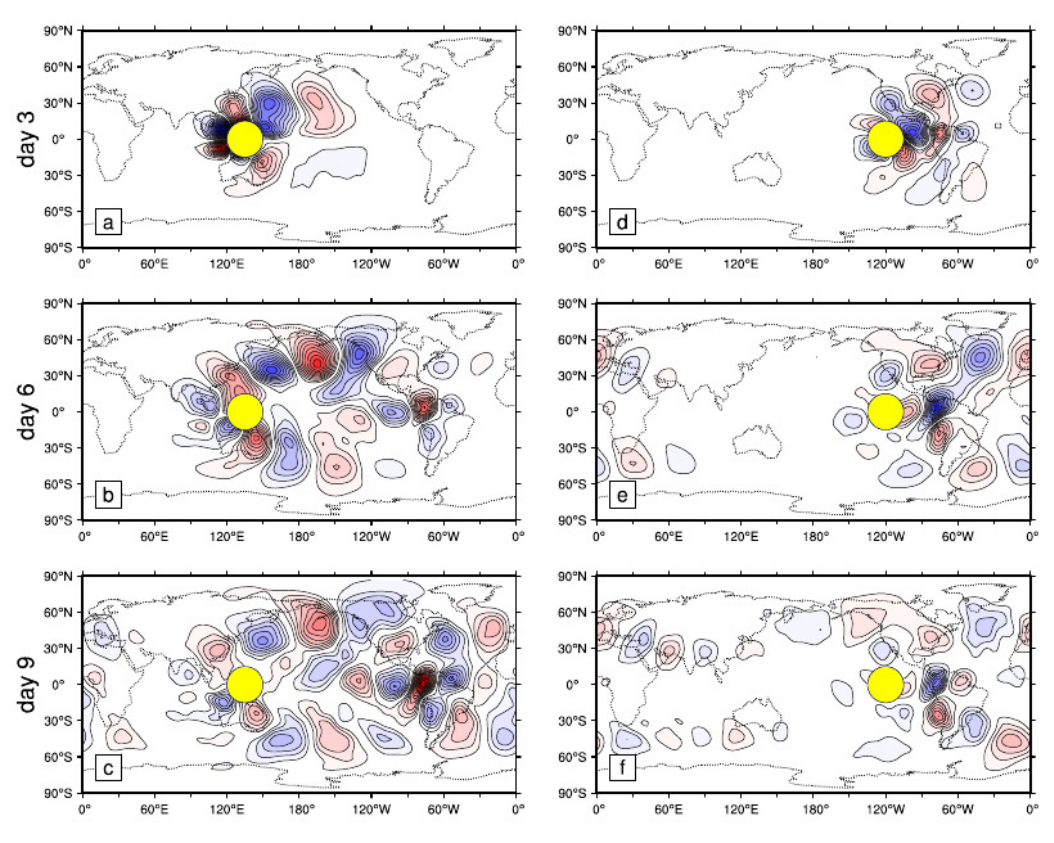

FIG. 3. Ensemble mean v300 response in CAM3 to a 2-day pulse of heat at 0°N, 135°E (a) 3, (b) 6, and (c) 9 days after the pulse begins. (d)–(f) As in (a)–(c), but for a pulse at 0°N, 120°W.

Branstator, J. Climate, 2014;

Sardeshmukh, Hoskins, JAS, 1988.