

Initial Drifts/Shocks: WGSIP's Long-Range Forecast Transient Intercomparison Project

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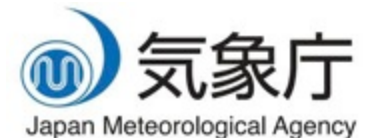
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Introduction

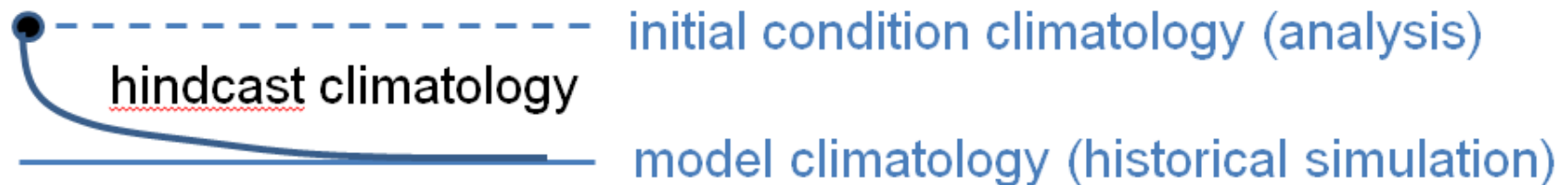
- LRFTIP is an initiative of WCRP's Working Group on Subseasonal to Interdecadal Prediction (WGSIP)
- Purpose is to enable **multi-model inter-comparison studies** of the transient behavior of coupled long-range forecast models evolving from observation-based initial conditions. (*WMO defines long-range forecasting as from 30 days up to years.*)

Objectives

- 1) Develop a **multi-model online archive** of hindcast climatologies and related diagnostics including systems contributing to S2S, CHFP, DCPP
- 2) Develop **standard diagnostics** characterizing forecast shock/drift
- 3) Address **science questions**, including
 - influence of different initialization methods on transient behavior of climate model components
 - identification of any impacts (likely negative) on climate forecast quality

Approach

- For a particular model and start date, hindcasts are averaged over available years and ensemble members to form a *hindcast climatology*
- When available, climatologies are also constructed for
 - Freely running model (e.g. CMIP **historical** simulations, averaging over multiple ensemble members)
 - Hindcast initial conditions = assimilating model run or **analysis** used for initialization, alternatively use observational **reference** dataset
- These represent “endpoints” of hindcast drifts, with differences from hindcast climatology indicating evolution away from initial conditions, toward model’s own climate:



- Community input is invited and indeed sought, including
 - Suggestions for shock/drift diagnostics
 - Data contributions for models and/or initialization methods not in archive

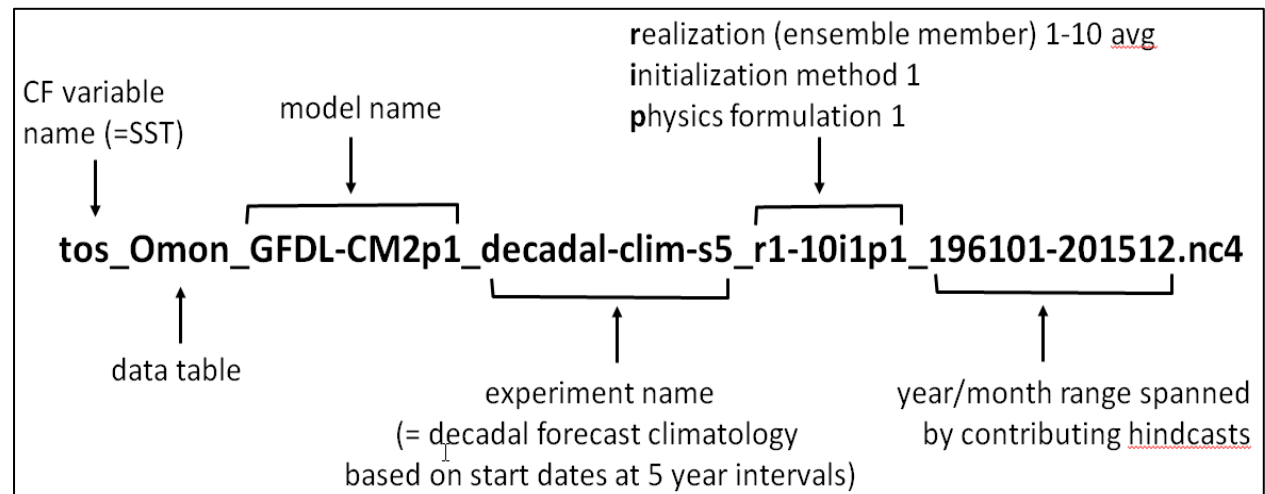
Data Archive

Time scales represented for different forecast types

- **Subseasonal:** daily to 30/60 days
- **Seasonal:** daily to 30/60 days + monthly through forecast range
- **Decadal:** daily to 30/60 days + monthly/annual through forecast range

Data format

- CF-compliant **NetCDF4**
- Time variable=**leadtime**
- File names, directory tree guided by **CMIP/ESGF conventions** →



Data location: <ftp://dapp2p.cccma.ec.gc.ca/pub/goapp/LRFTIP/>



- Can be accessed from <https://www.wcrp-climate.org/wgsip-projects/lrftip> (web search “LRFTIP”), includes data specification document

Current Status

Models: The LRFTIP archive currently includes

- **4 subseasonal forecast models (S2S)**
- **19 seasonal forecast models (CHFP, ENSEMBLES)**
- **15 decadal forecast models (CMIP5, ENSEMBLES)**

Variables: Number of variables for each model, climate system component, and averaging interval are shown in tables

 Reference  Forecasts

Subseasonal Model	Atmosphere Daily		Ocean Daily	
	Reference	Forecasts	Reference	Forecasts
ECMWF-S2S	7	7	1	1
JMA-S2S	2	2	1	1
NCEP-S2S	7	7	1	1
UKMO-S2S	1	1	1	1

S2S data processed by Mikhail Tolstykh and Tatiana Krasjuk, INM-RAS

Current Status - Seasonal

Reference
 Forecasts

Seasonal Model	Atmosphere Daily		Atmosphere Monthly		Ocean Monthly		Land Monthly	Sea Ice Monthly	
CanCM3	18	22	22	22	12	12	4	1	2
CanCM4	18	22	22	22	12	12	4	1	2
ECMWF-S4			18	20			1		
JMAMRI-CGCM1	12	16	20	20	6	7			
JMAMRI-CGCM2			19	21	6	6	13		13
MIROC5_v1.0	12	18	16	18	6	7			
MPI-ESM-LR			20	22					
POAMA p24a/b/c			12	13					
ARPEGE			7	7					
CFS_SHFP	3	3	8	7					
CMAM	3	5	7	7			10		10
GloSea4		1	7	7					
GloSea5		1	7	7					
ENSEMBLES (CMCC-INGV, ECMWF-S3, IFM-GEOMAR, MF, <u>DePreSys</u> , HadGEM2)	16	20	20	20			1		

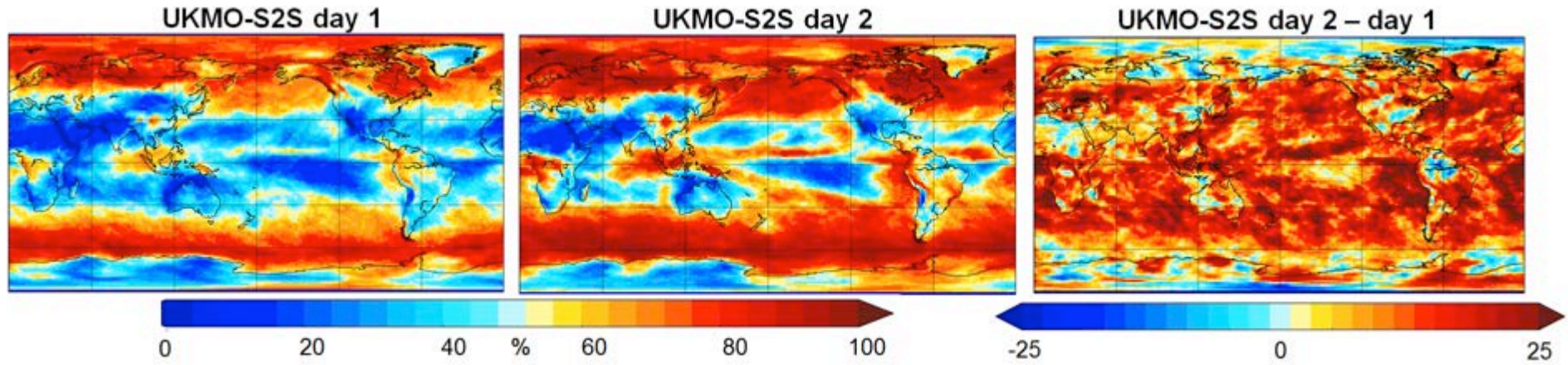
Current Status - Decadal

■ Analysis / Initial Conditions
 ■ Forecasts
 ■ Historical Simulations

Decadal Model	Atmosphere Daily	Atmosphere Monthly	Atmosphere Yearly	Ocean Monthly	Ocean Yearly	Land Month/yearly	Sealce Month/Yearly
CCSM4 (i1,i2)		24 24	24 24	8 9	8 9	3 3	2 2
MF-ENSEMBLES		20	20	11	11	1	
CFSv2(i1,i2)		26	26	7	7	1	2
CanCM4 (i1,i2)	25 16 6	25 26 17	25 26 17	13 13 13	13 13 13	4 3 2	2 2 2
CNRM-CM5	6 6	26 26	26 26	10 10	10 10	3 3	2 2
ECMWF-ENSEMBLES		20	20	11	11	1	
GFDL-CM2p1		18 18	18 18	11 11	11 11	2 2	2 2
HadCM3	9 9	25 25	25 25	6 6	6 6	3 3	2 2
IFM-ENSEMBLES		20	20	11	11	1	
MIROC5	20 20	26 26	26 26	7	7	3 3	2 2
MRI-CGCM3	6	26	26	10	10	3	2
UKMO-DePreSys-ENS		20	20			1	
UKMO-HadGEM2-ENS		20	20			1	
EC-EARTH		19 17	19 17	7 3	7 3		2 2
BCC-CSM1.1	6 6	26 26	26 26	7 7	7 7		2 2
CNRM-CM5	6 6	26 26	26 26	10 10	7 7	3 3	2 2

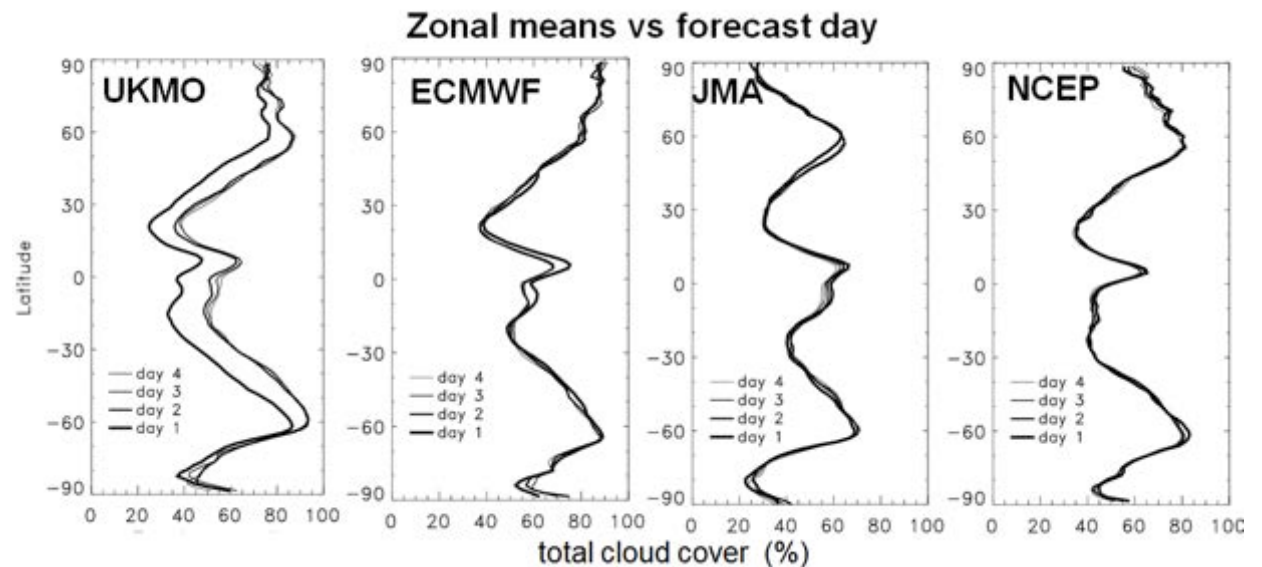
Sample Diagnostics - Subseasonal

- **Total cloud cover** in first days of hindcasts initialized near **1 Nov**



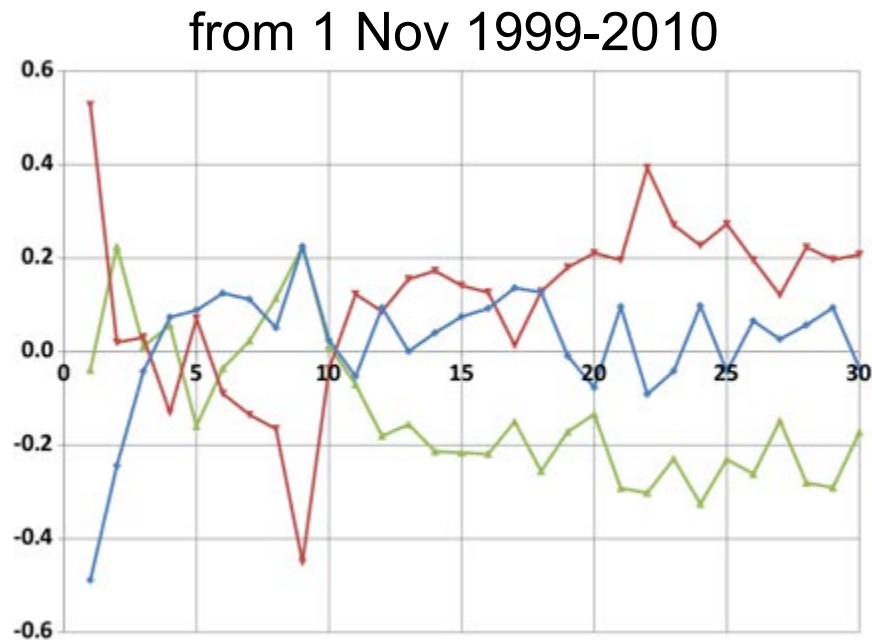
- UKMO model shows large transient relative to other models ↓

- Low initial cloud cover is a result of initializing UKMO model with ERA-Interim fields



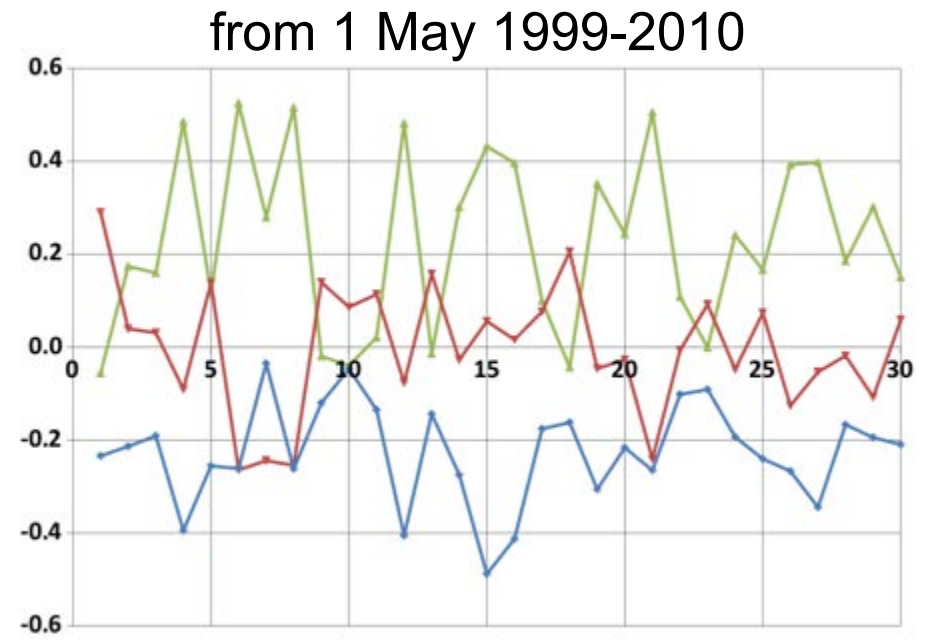
Sample Diagnostics - Subseasonal

- Daily precipitation minus GPCP reference climatology
- Averages over North Atlantic region



ECMWF

UKMO

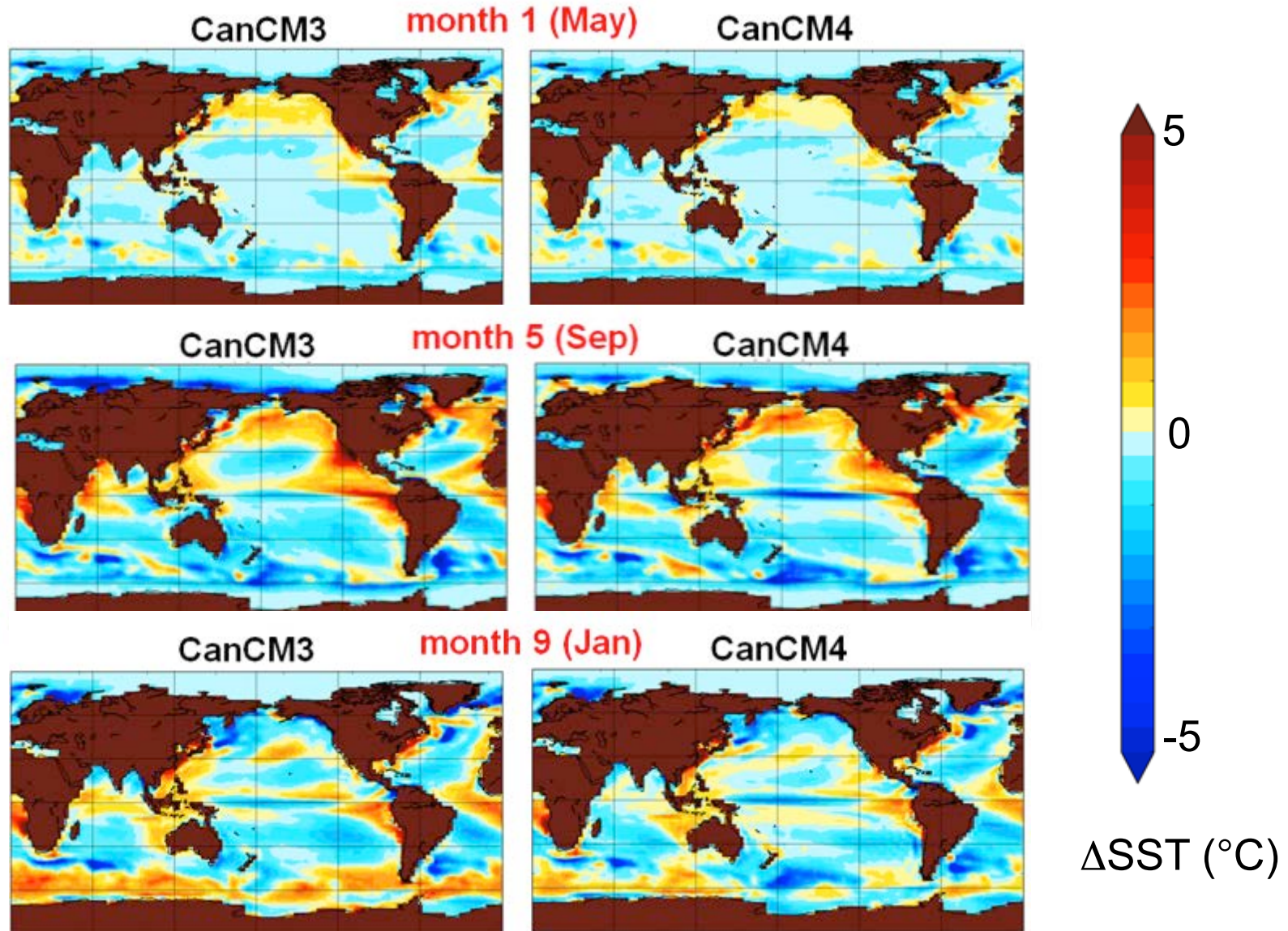


NCEP

Plots courtesy of Mikhail Tolstykh

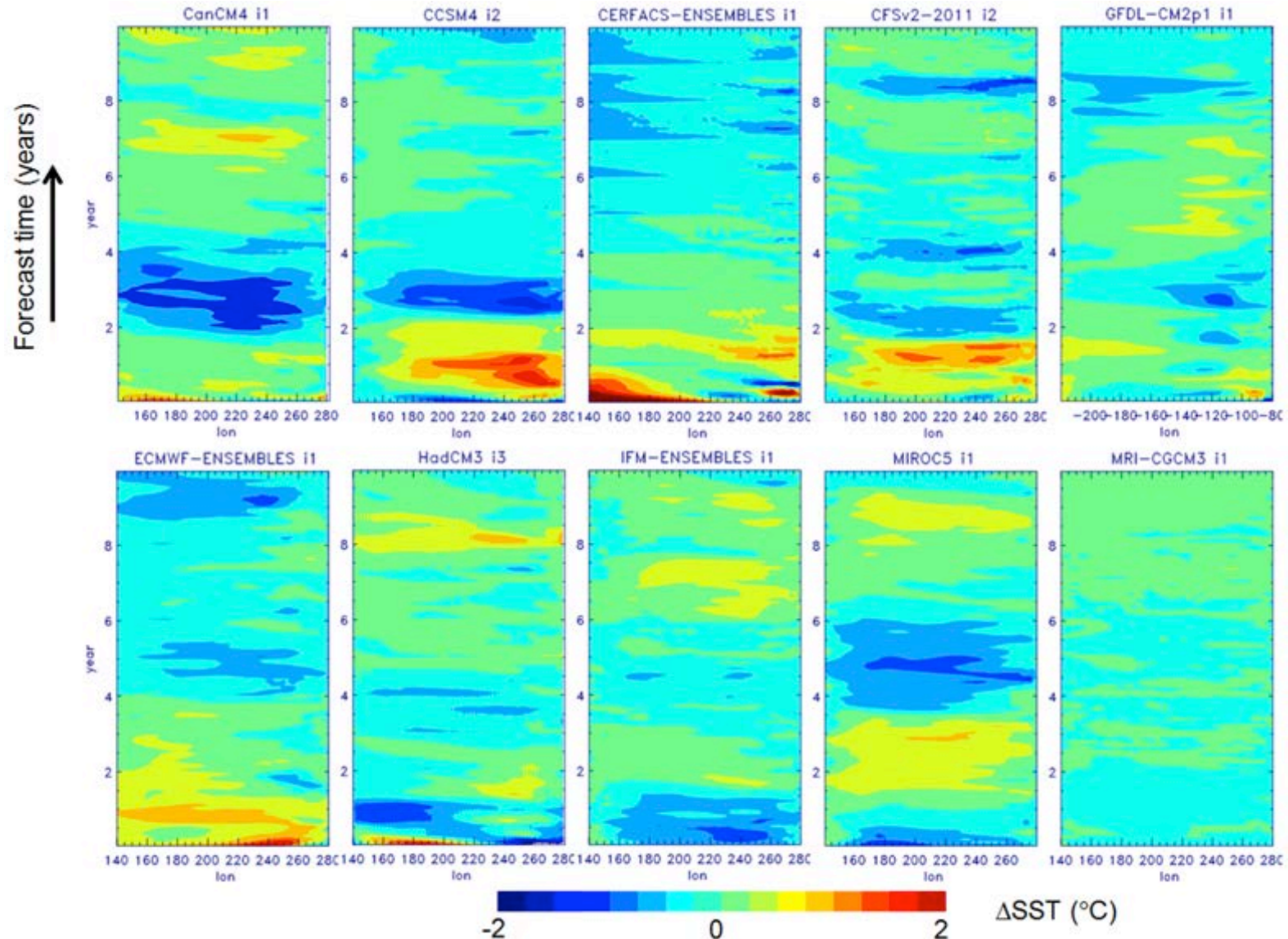
Sample Diagnostics - Seasonal

- **SST biases** developing in hindcasts initialized **1 May** in two models having same ocean, different atmospheric components (vs OISST reference)



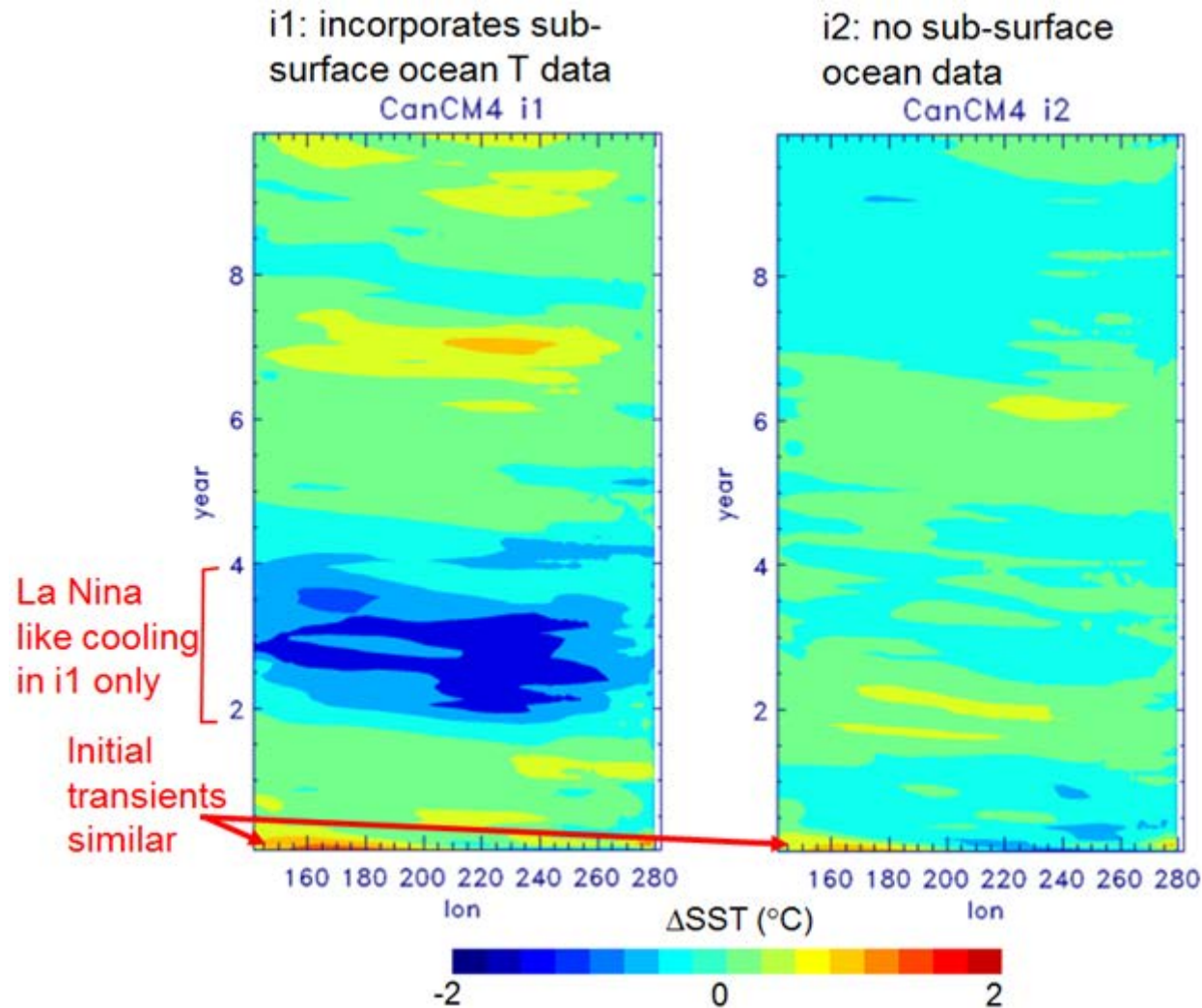
Sample Diagnostics - Decadal

- Drift evolution of SST across equatorial Pacific in 10 decadal prediction models, showing El Niño and La Niña-like transients



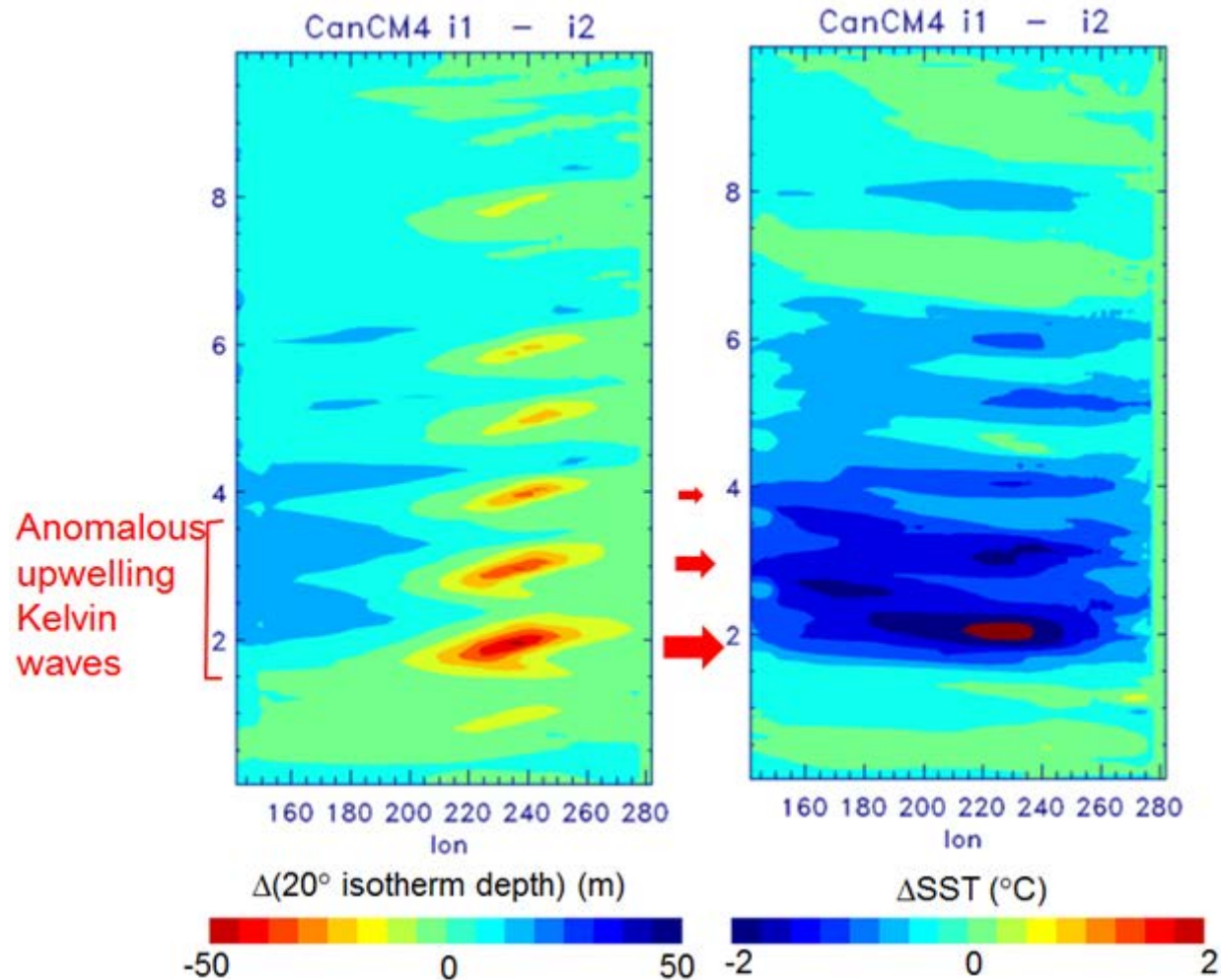
Sample Diagnostics - Decadal

- Same except for CanCM4 using two different ocean initialization methods:
i1 includes subsurface data, i2 = surface initialization only



Sample Diagnostics - Decadal

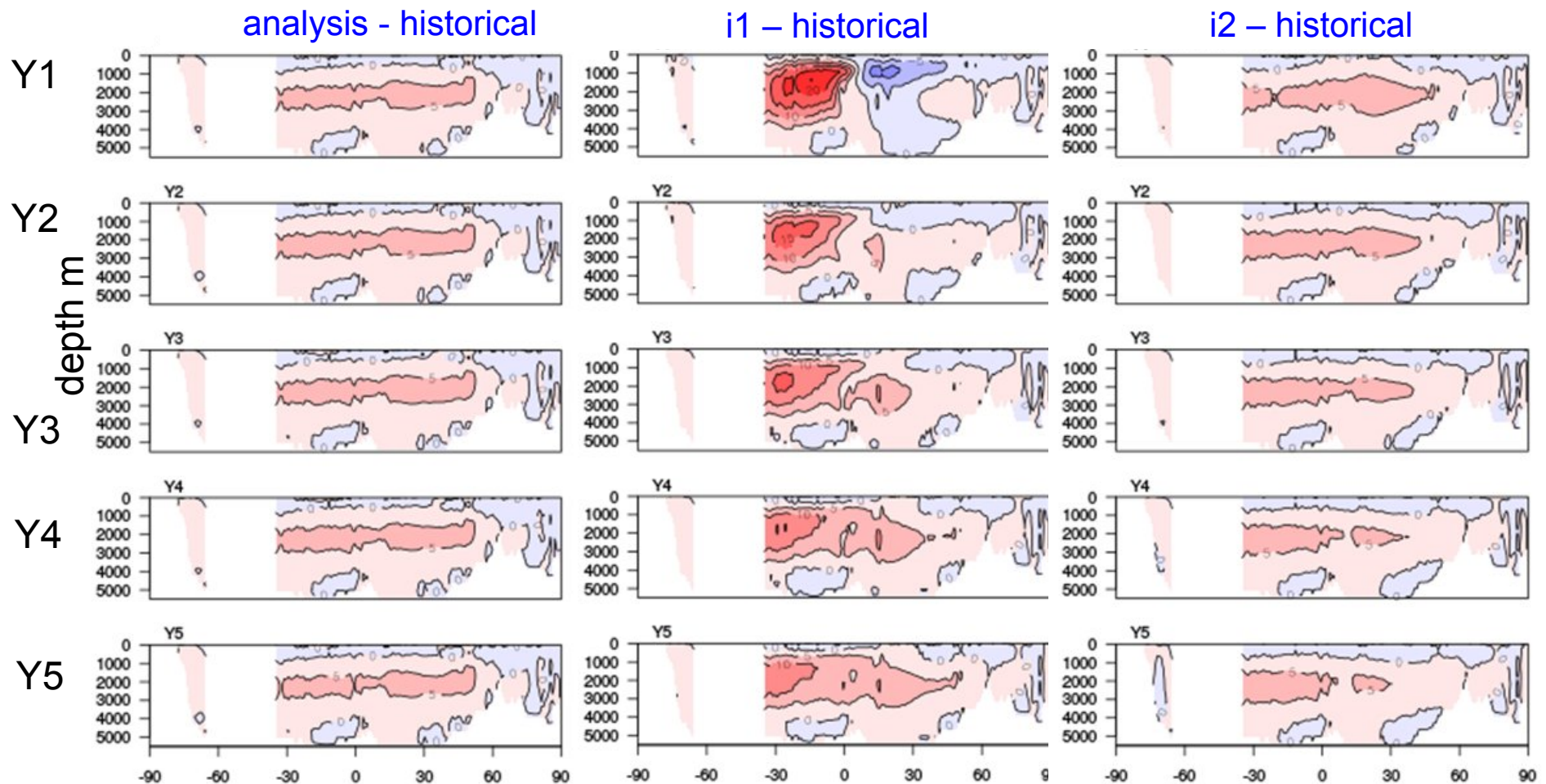
- *differences* (i1–i2) in 20°C isotherm depth (left) and SST (right), showing La Niña-like transient excitation by anomalous upwelling Kelvin waves in years 2-6



Sample Diagnostics - Decadal

Another comparison between CanCM4 i1 vs i2 intializations

- Evolution of Atlantic meridional overturning: differences from historical
- CanCM4 assimilating analysis (used for initialization of seasonal/decadal forecasts), i1 and i2-initialized hindcasts

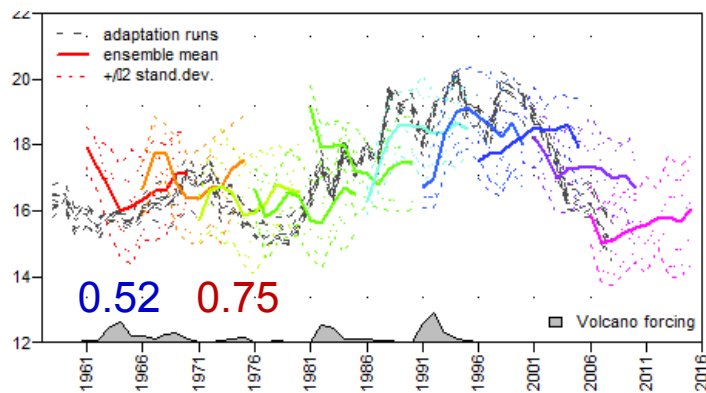


Sample Diagnostics - Decadal

Another comparison between CanCM4 i1 vs i2 intializations

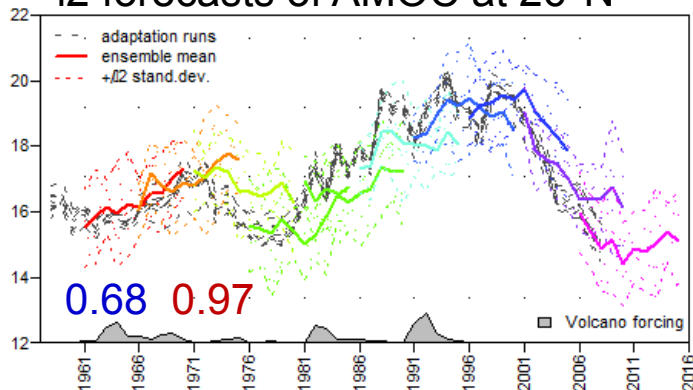
- Evolution of Atlantic meridional overturning: differences from historical in years 1-5
- CanCM4 assimilating analysis (used for initialization of seasonal/decadal forecasts), i1 and i2-initialized hindcasts

i1 forecasts of AMOC at 26°N



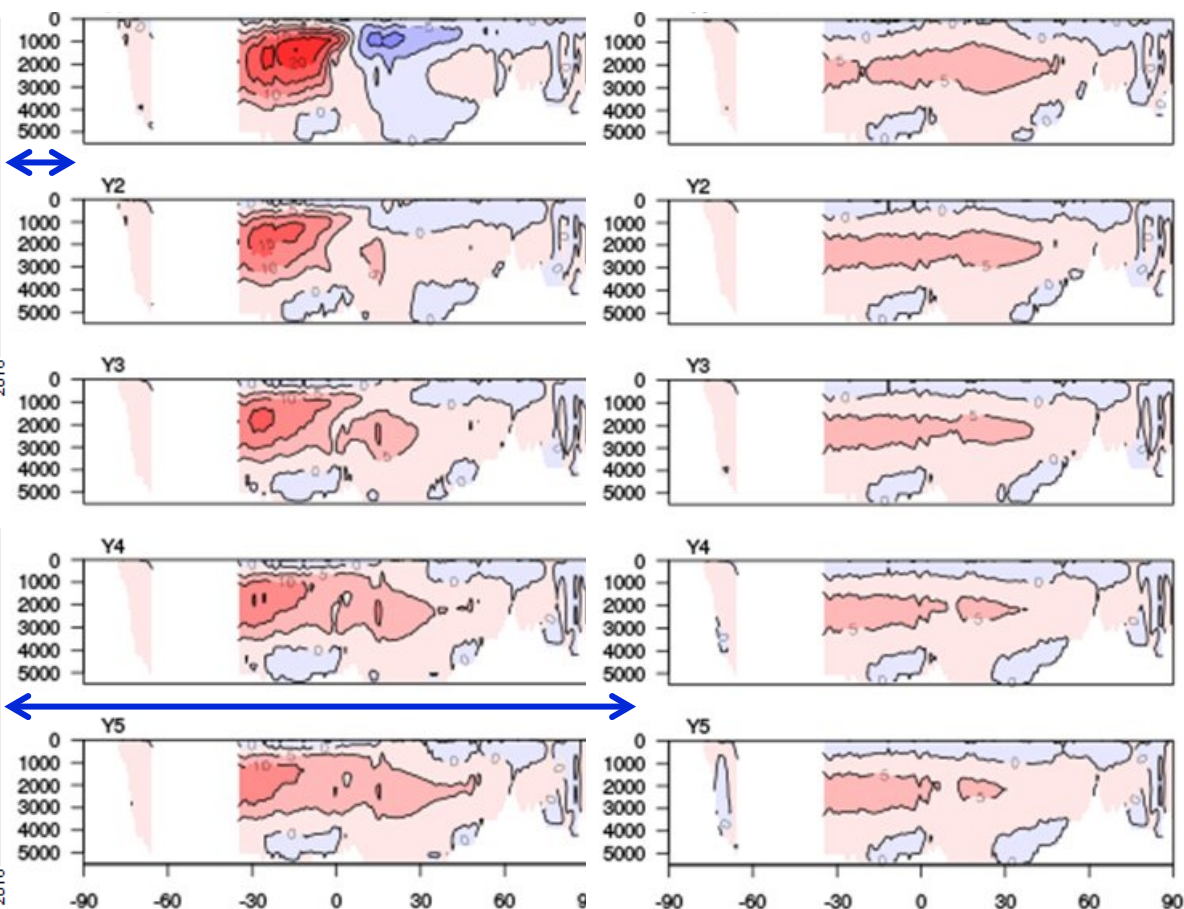
mean ACC in Y1-10 ACC of Y1-10 mean

i2 forecasts of AMOC at 26°N



i1 – historical

i2 – historical

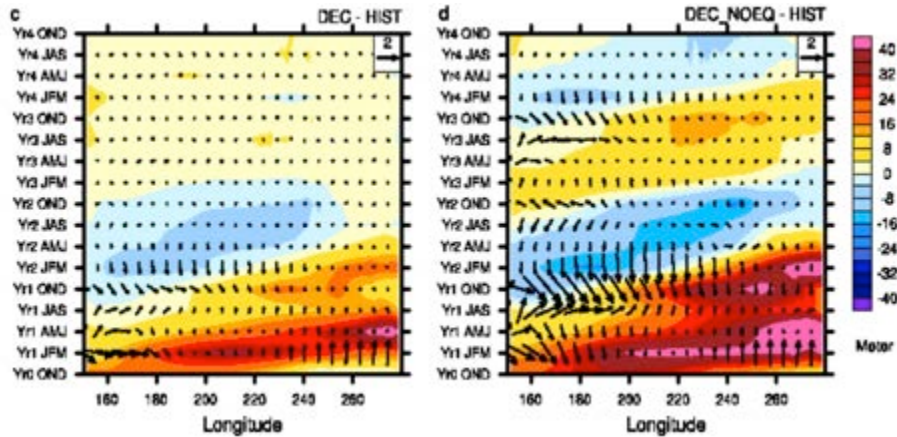


Summary

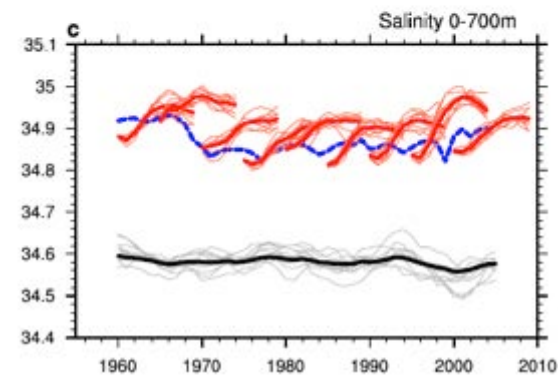
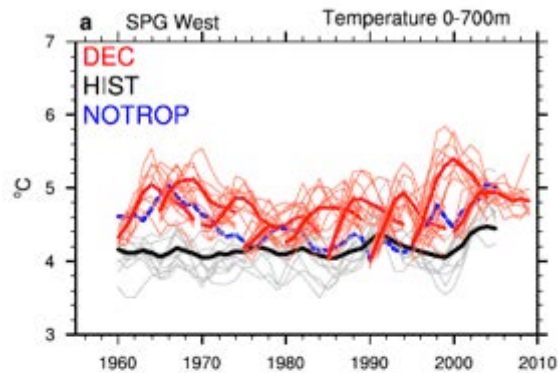
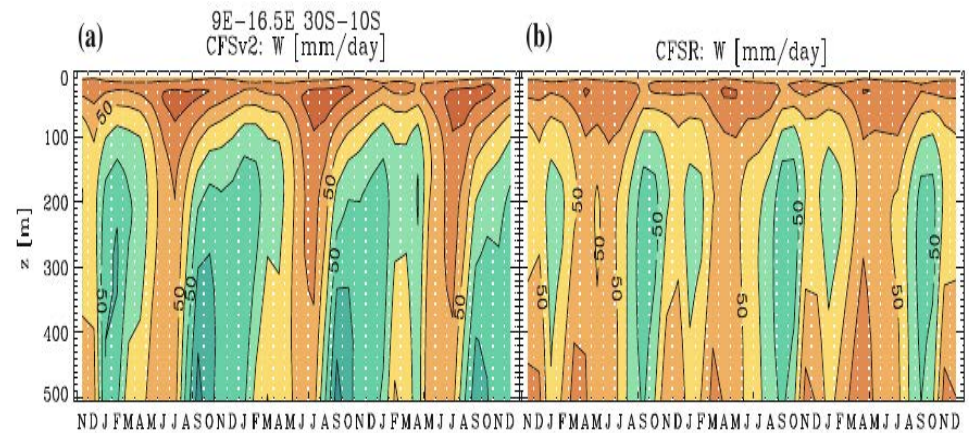
- Large **multi-model archive** of hindcast climatologies has been developed
- Ancillary climatologies (reference/obs, initial condition, historical simulation) aid in identifying and characterizing transient behavior
- Data structure guided by CMIP/ESGF conventions
- Sample diagnostics point to **diversity of model transient behavior**
- Site to include library of diagnostic plots
- **Resource for community investigations** of shock/drift phenomena in initialized climate predictions
- **Community input welcome**, including
 - Suggestions for shock/drift diagnostics
 - Data contributions for models and/or initialization methods not in archive
- Data & documents can be accessed through WCRP project web page (search “LRFTIP”)

Some of the many hindcast climatology diagnostics examined in recent studies

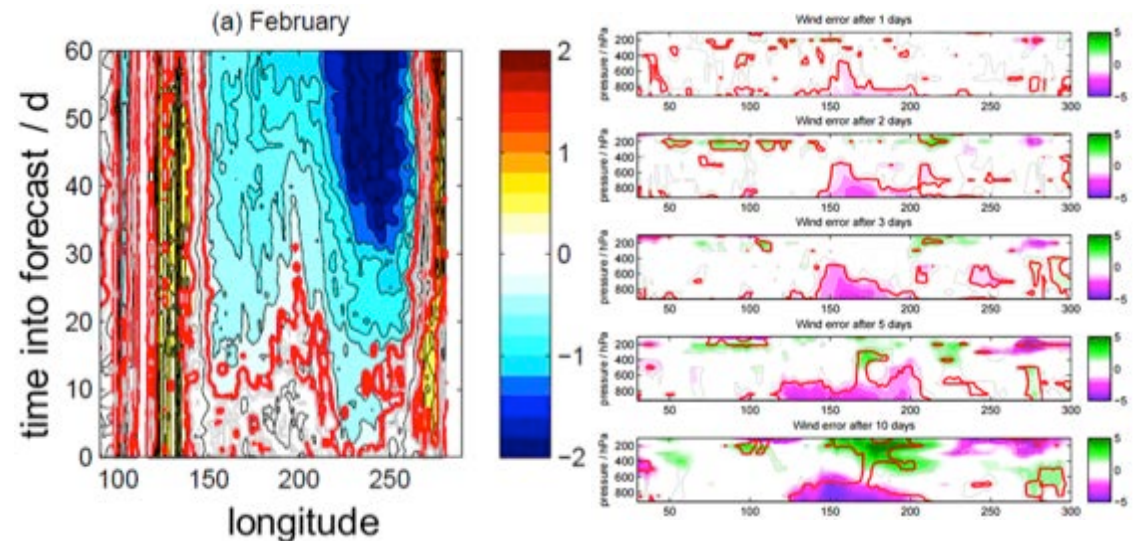
Sanchez-Gomez et al., *Clim. Dyn.*, 2015



Toniazzo & Woolnough, *Clim. Dyn.*, 2014



Shonk, *Presentation at WGSIP 17, 2015*



Atmosphere 2D (CMOR Tables day, Amon) - 1

Variable name	Description	CF Standard Name	unit	realm	freq	priority
clt	Total Cloud Fraction	cloud_area_fraction	%	atmos	d,m,y	1
evpsbl	Evaporation	water_evaporation_flux	kg m-2 s-1	atmos	d,m,y	2
hfss	Surface Upward Sensible Heat Flux	surface_upward_sensible_heat_flux	W m-2	atmos	d,m,y	1
hfls	Surface Upward Latent Heat Flux	surface_upward_latent_heat_flux	W m-2	atmos	d,m,y	1
huss	Near-Surface Specific Humidity	specific_humidity	1	atmos	d,m,y	2
pr	Precipitation	precipitation_flux	kg m-2 s-1	atmos	d,m,y	1
psl	Sea Level Pressure	air_pressure_at_sea_level	Pa	atmos	d,m,y	1
rlds	Surface Downwelling Longwave Radiation	surface_downwelling_longwave_flux_in_air	W m-2	atmos	d,m,y	1*
rlus	Surface Upwelling Longwave Radiation	surface_upwelling_longwave_flux_in_air	W m-2	atmos	d,m,y	1*
rlut	TOA Outgoing Longwave Radiation	toa_outgoing_longwave_flux	W m-2	atmos	d,m,y	1**
rsds	Surface Downwelling Shortwave Radiation	surface_downwelling_shortwave_flux_in_air	W m-2	atmos	d,m,y	1*
rsdt	TOA Incident Shortwave Radiation	toa_incoming_shortwave_flux	W m-2	atmos	d,m,y	1**
rsut	TOA Outgoing Shortwave Radiation	toa_outgoing_shortwave_flux	W m-2	atmos	d,m,y	1**

Atmosphere 2D (CMOR Tables day, Amon) - 2

rsus	Surface Upwelling Shortwave Radiation	surface_upwelling_shortwave_flux_in_air	W m ⁻²	atmos	d,m,y	1*
tas	Near-Surface Air Temperature	air_temperature	K	atmos	d,m,y	1
tasmax	Daily Maximum Near-Surface Air Temperature	air_temperature	K	atmos	d,m,y	2
tasmin	Daily Minimum Near-Surface Air Temperature	air_temperature	K	atmos	d,m,y	2
tauu	Surface Downward Eastward Wind Stress	surface_downward_eastward_stress	Pa	atmos	d,m,y	1
tauv	Surface Downward Northward Wind Stress	surface_downward_northward_stress	Pa	atmos	d,m,y	1
ts	Surface Temperature	surface_temperature	K	atmos	d,m,y	1
uas	Eastward Near-Surface Wind	eastward_wind	m s ⁻¹	atmos	d,m,y	2
vas	Northward Near-Surface Wind	northward_wind	m s ⁻¹	atmos	d,m,y	2

Atmosphere 3D (CMOR Tables day, Amon)

Variable name	Description	CF Standard Name	unit	realm	freq	priority
hus	Specific Humidity	specific_humidity	1	atmos	d,m,y	1
ta	Air Temperature	air_temperature	K	atmos	d,m,y	1
ua	Eastward Wind	eastward_wind	m s ⁻¹	atmos	d,m,y	1
va	Northward Wind	northward_wind	m s ⁻¹	atmos	d,m,y	1

Ocean 2D (CMOR Tables day, Omon)

Variable name	Description	CF Standard Name	unit	realm	freq	priority
hc300*	upper 300m heat content	heat_content_to_300m_depth	K	ocean	d, m,y	2
mlotst	Ocean Mixed Layer Thickness Defined by Sigma T	ocean_mixed_layer_thickness_defined_by_sigma_t	m	ocean	m,y	1
msftbarot	Ocean Barotropic Mass Streamfunction	ocean_barotropic_mass_streamfunction	kg s-1	ocean	m,y	1
msftmyzv***	Ocean Meridional Overturning Volume Streamfunction	ocean_meridional_overturning_volume_streamfunction	m ³ s-1	ocean	m,y	2
sos	Sea Surface Salinity	sea_surface_salinity	psu	ocean	m,y	1
t20d*	20 degree isotherm depth	ocean_20_degree_isotherm_depth	m	ocean	d, m,y	2
thetaoeq**	Equatorial cross section of sea water potential temperature	equatorial_sea_water_potential_temperature	K	ocean	d,m,y	2
tos	Sea Surface Temperature	sea_surface_temperature	K	ocean	d,m,y	1
zos	Sea Surface Height Above Geoid	sea_surface_height_above_geoid	m	ocean	m,y	1

Ocean 3D (CMOR Table Omon)

Variable name	Description	CF Standard Name	unit	realm	freq	priority
so	Sea Water Salinity	sea_water_salinity	psu	ocean	m,y	1
thetao	Sea Water Potential Temperature	sea_water_potential_temperature	K	ocean	m,y	1
uo	Sea Water X Velocity	sea_water_x_velocity	m s-1	ocean	m,y	1
vo	Sea Water Y Velocity	sea_water_y_velocity	m s-1	ocean	m,y	1
wo	Upward Ocean Velocity	upward_ocean_velocity	m s-1	ocean	m,y	1

Land (CMOR Tables Lmon, LImon)

Variable name	Description	CF Standard Name	unit	realm	freq	priority
mofso	Soil Frozen Water Content	soil_frozen_water_content	kg m-2	land	m,y	2
mrso	Total Soil Moisture Content	soil_moisture_content	kg m-2	land	m,y	1*
mrsov	Total Volumetric Soil Moisture (Liquid and Solid) Content	volume_fraction_of_water_in_soil	1	land	m,y	1*
snw	Surface Snow Amount	surface_snow_amount	kg m-2	land	m,y	1

Sea Ice (CMOR Table Olmon)

Variable name	Description	CF Standard Name	unit	realm	freq	priority
sic	Sea Ice Area Fraction	sea_ice_area_fraction	%	seaIce	m,y	1
sit	Sea Ice Thickness	sea_ice_thickness	m	seaIce	m,y	1

Time-Invariant Fields (CMOR Table fx)

Variable name	Description	CF Standard Name	unit	realm	dimensionality	priority
areacella	Atmosphere Grid-Cell Area	cell_area	m2	atmos	xy	1
sftlf	Land Area Fraction	land_area_fraction	%	atmos	xy	1
mrsofc	Capacity of Soil to Store Water	soil_moisture_content_at_field_capacity	kg m-2	land	xy	2
areacello	Ocean Grid-Cell Area	cell_area	m2	ocean	xy	1
basin	Region Selection Index*	region	1	ocean	xy	1
deptho	Sea Floor Depth	sea_floor_depth_below_geoid	m	ocean	xy	1
thkcello	Ocean Model Cell Thickness	cell_thickness	m	ocean	z	2

Subseasonal part of the Long-Range Forecast Transient Intercomparison Project

Mikhail Tolstykh, William Merryfield, Tatiana Krasjuk

- Creating an archive of daily hindcast climatologies produced by coupled models from the WMO S2S project database.
- Inform on transient behavior of initialized coupled prediction during 1st forecast month
- Starting dates 1st of May and 1st of November (+/-1day).
- Sample plots: averaged over 1996-2010 (1999-2010 for NCEP) daily anomalies w.r.t. reanalysis. Tropical Pacific precip (left) and North Atlantic total cloud cover (right) anomalies

