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


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WCRP World Climate Research Programme

HYDROMETEOROLOGICAL CENTRE OF RUSSIA

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Environment and Climate Change Canada
Environnement et Changement climatique Canada

気象庁 Japan Meteorological Agency

# Introduction

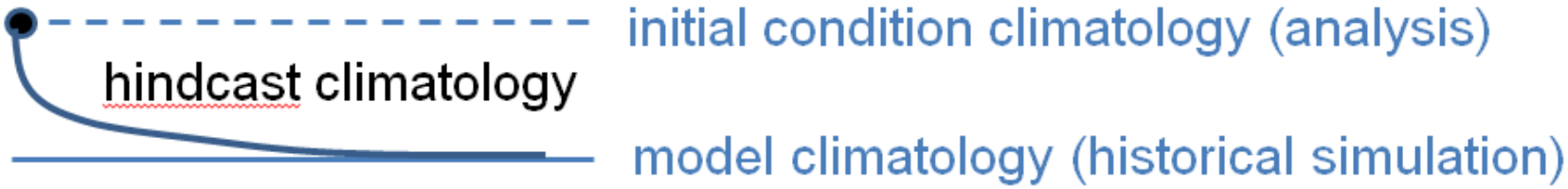
- LRFTIP is an initiative of WCRP's Working Group on Subseasonal to Interdecadal Prediction (WGSIP)
- Purpose is to enable **multi-model inter-comparison studies** of the transient behavior of coupled long-range forecast models evolving from observation-based initial conditions. (*WMO defines long-range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

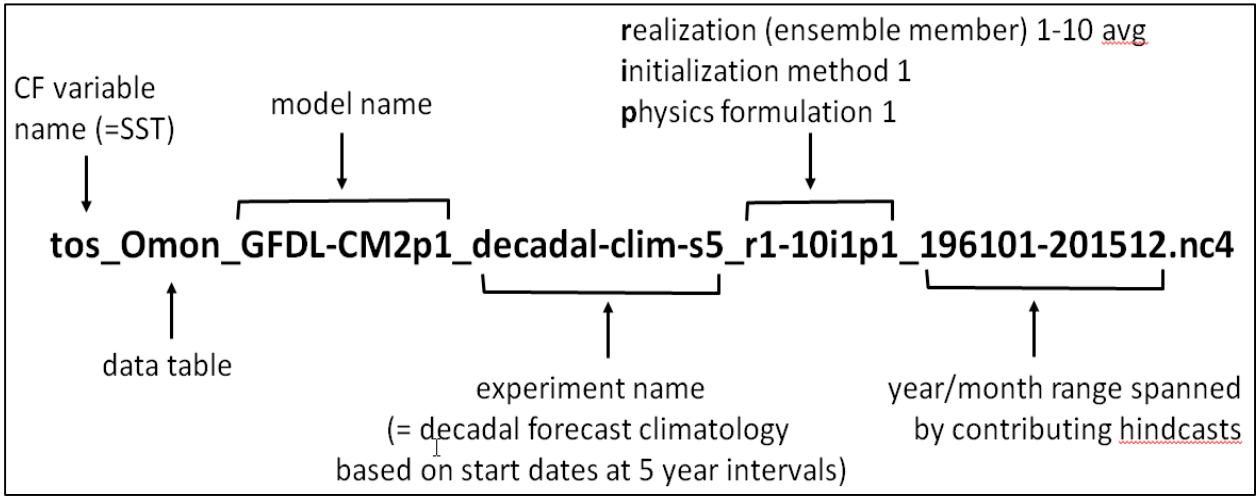
# Data Archive

**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 | |
|---|---|---|---|---|
| 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, DePreSys, HadGEM2 | 16 | 20 | 20 | 20 | | | 1 | | |

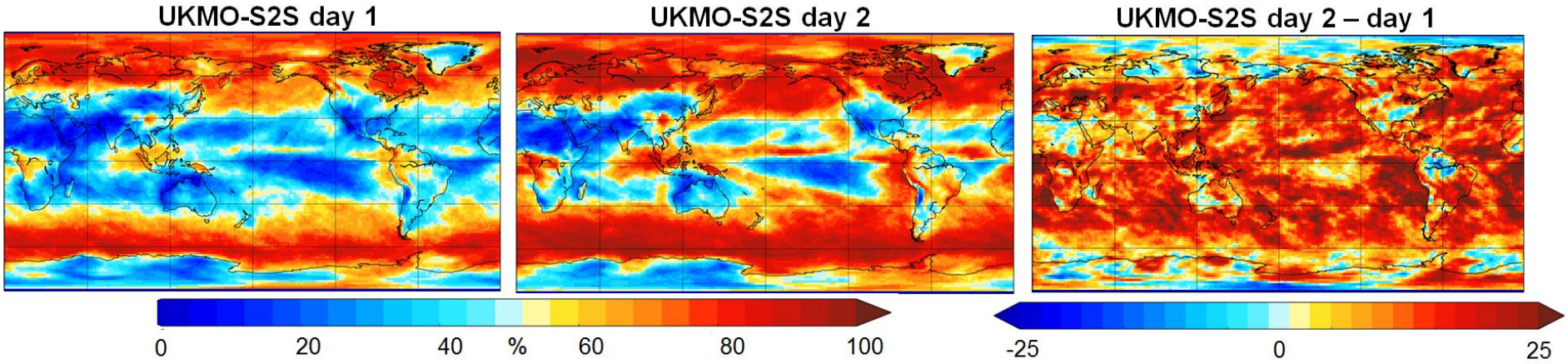
# Current Status - Decadal

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 |

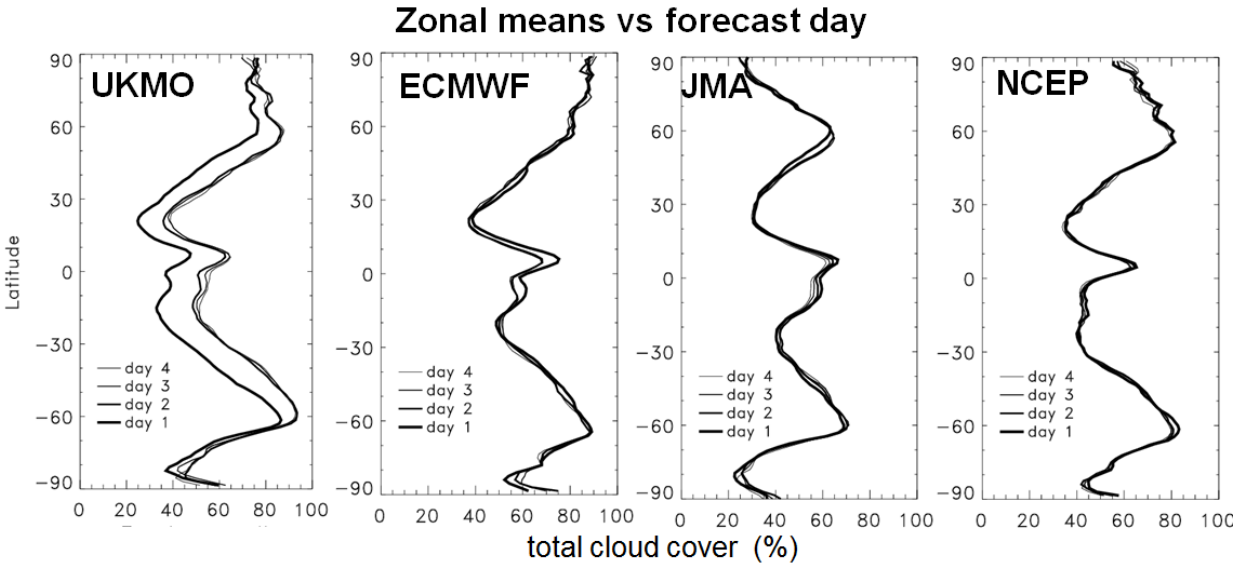
# Sample Diagnostics - Subseasonal

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




- UKMO model shows large transient relative to other models ↓

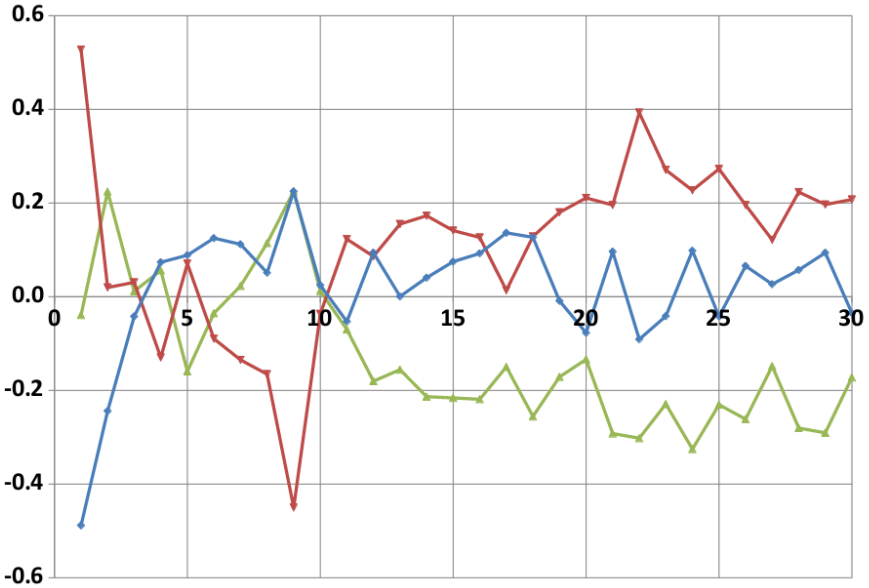
- Low initial cloud cover is a result of initializing UKMO model with ERA-Interim fields



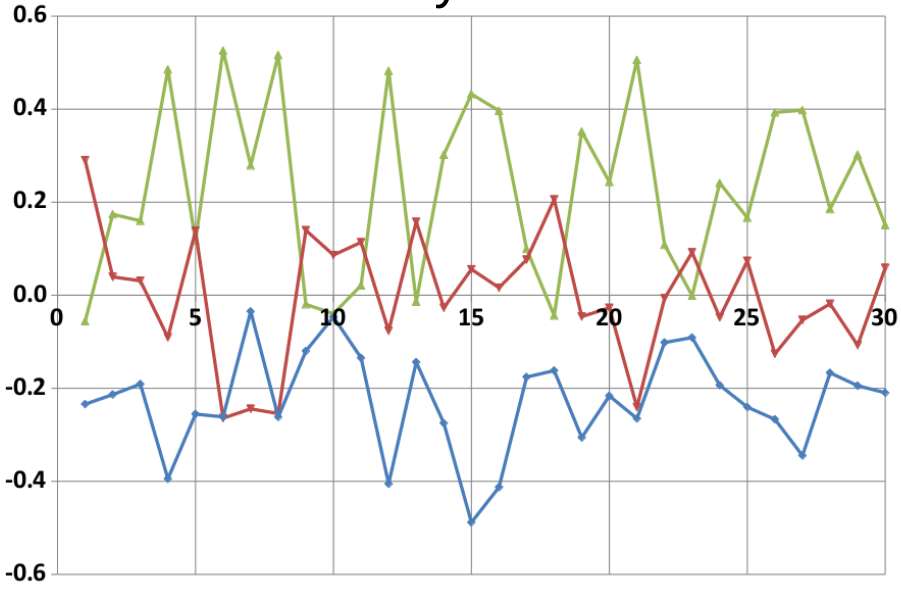
# Sample Diagnostics - Subseasonal

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

from 1 Nov 1999-2010




from 1 May 1999-2010

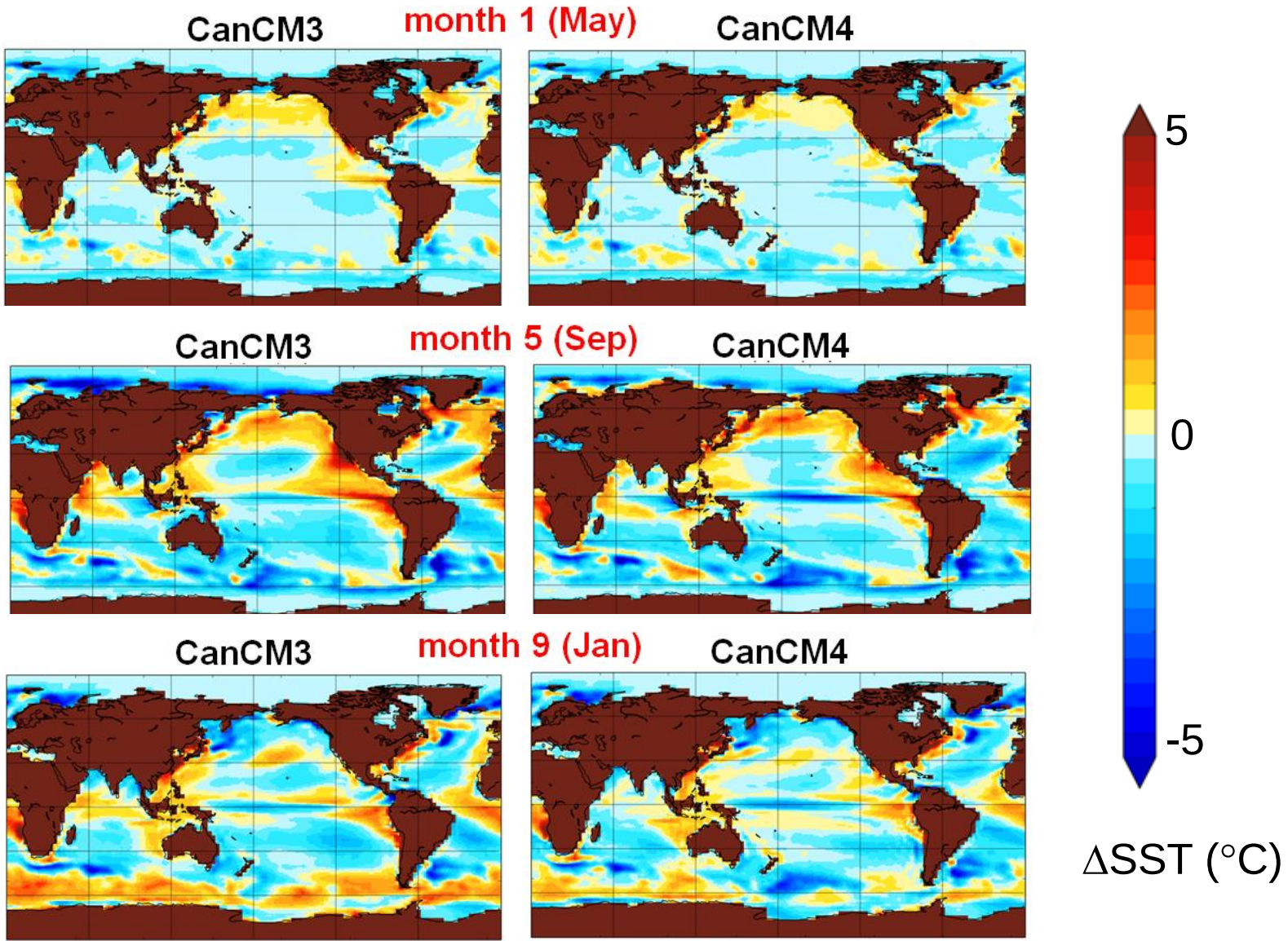



ECMWF UKMO NCEP

*Plots courtesy of Mikhail Tolstykh*

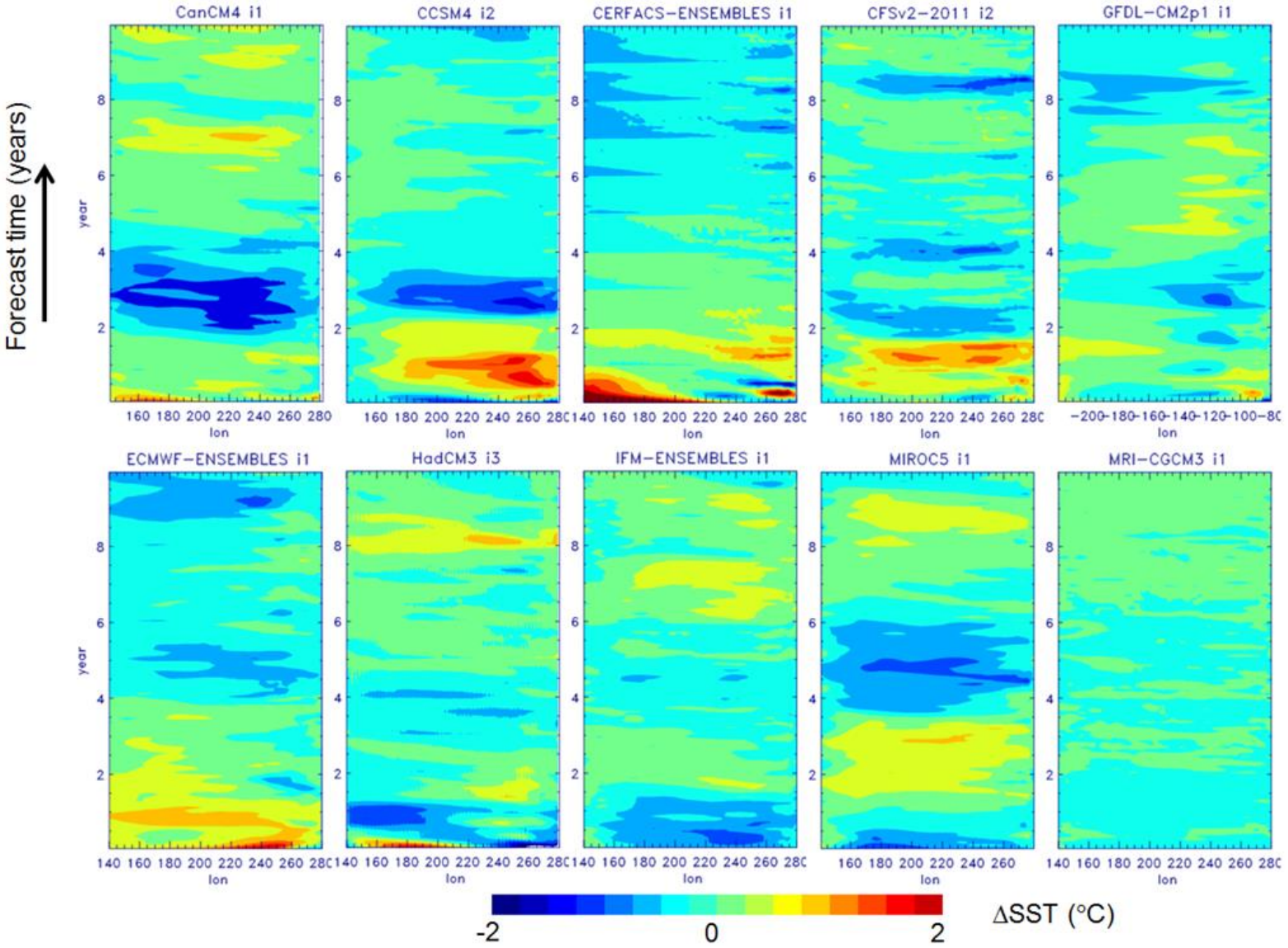
# Sample Diagnostics - Seasonal

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



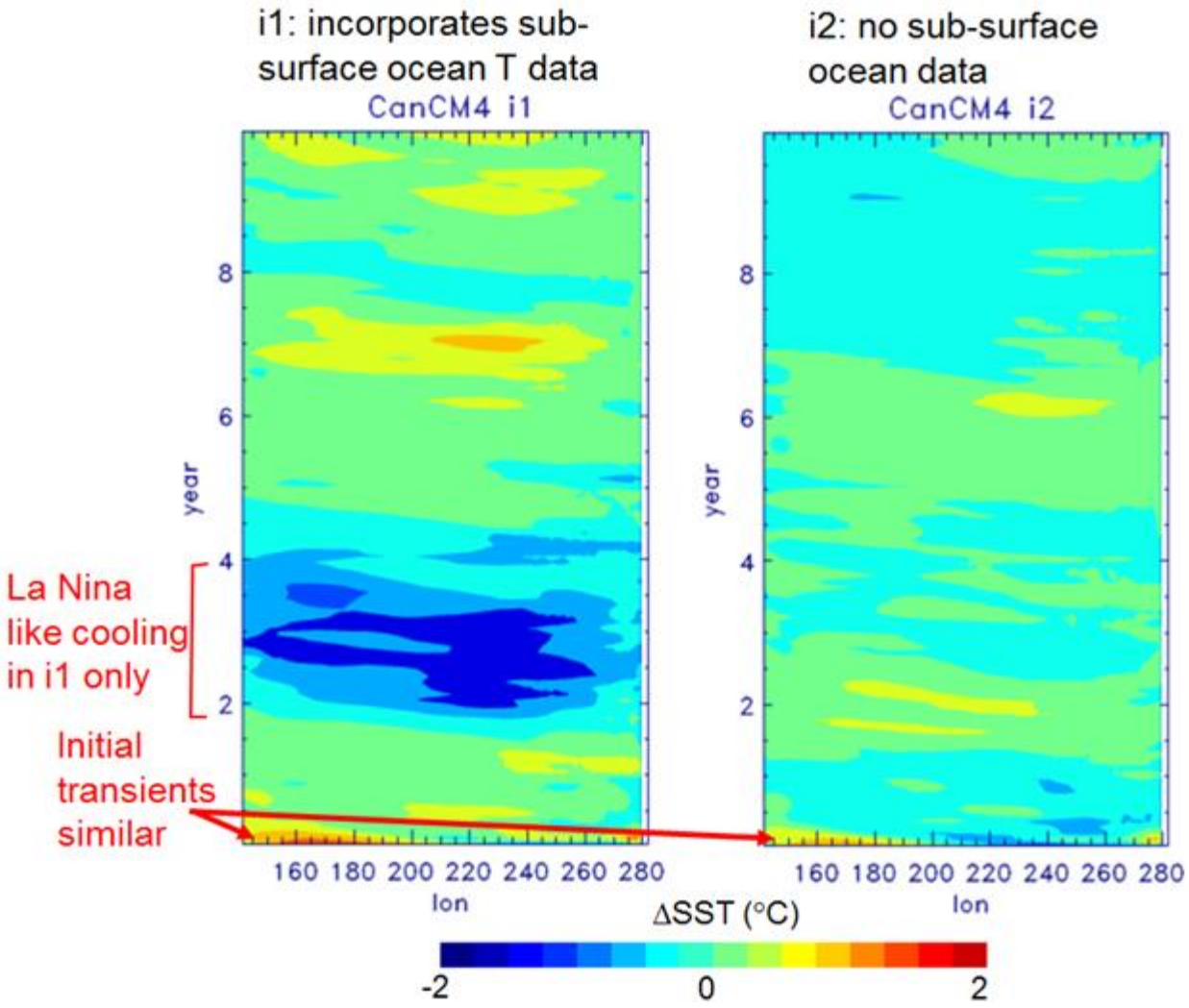
# Sample Diagnostics - Decadal

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



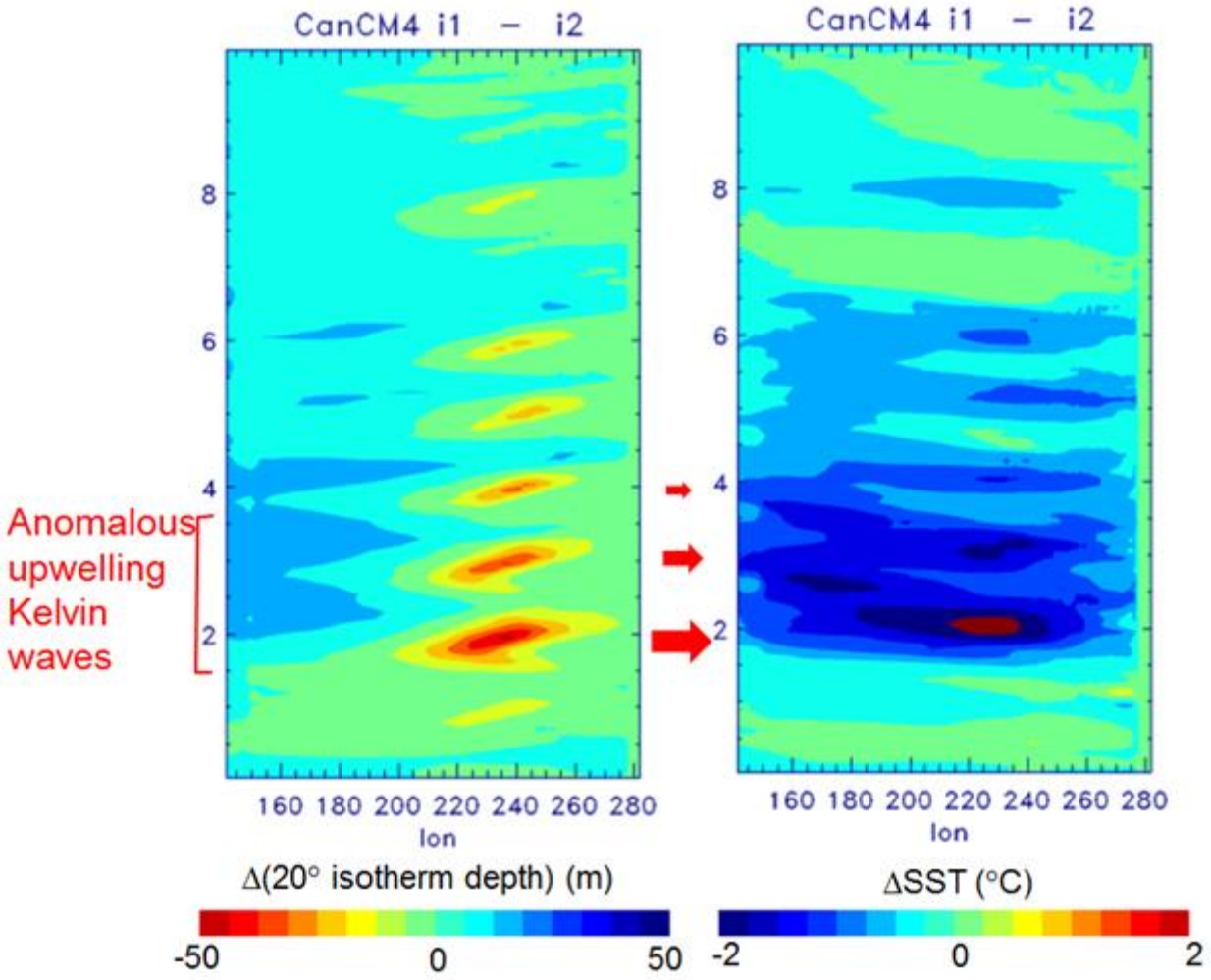
# Sample Diagnostics - Decadal

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



# Sample Diagnostics - Decadal

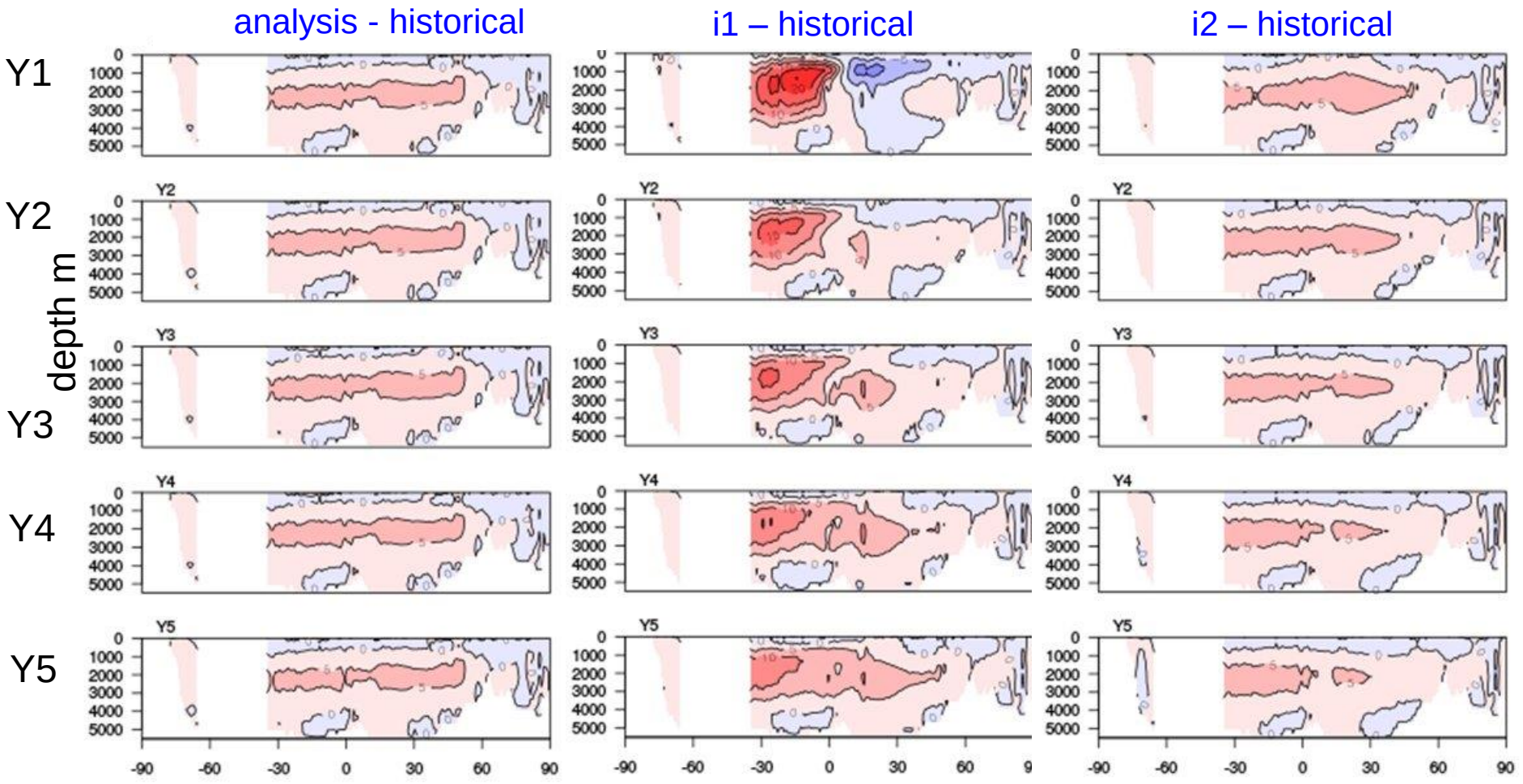
- *differences* (i1–i2) in 20°C isotherm depth (left) and SST (right), showing La Niña-like transient excitation by anomalous upwelling Kelvin waves in years 2-6



# 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

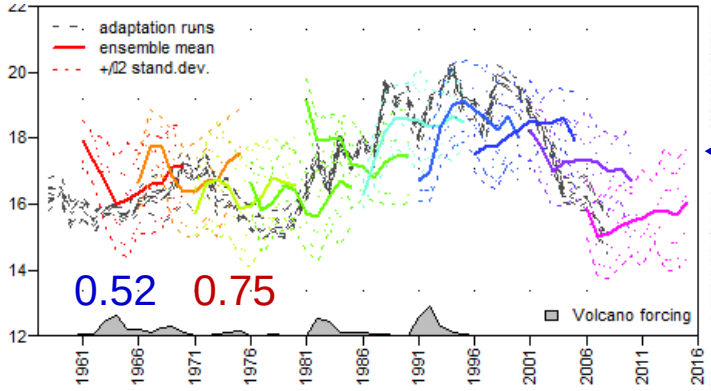


# Sample Diagnostics - Decadal

## Another comparison between CanCM4 i1 vs i2 intializations

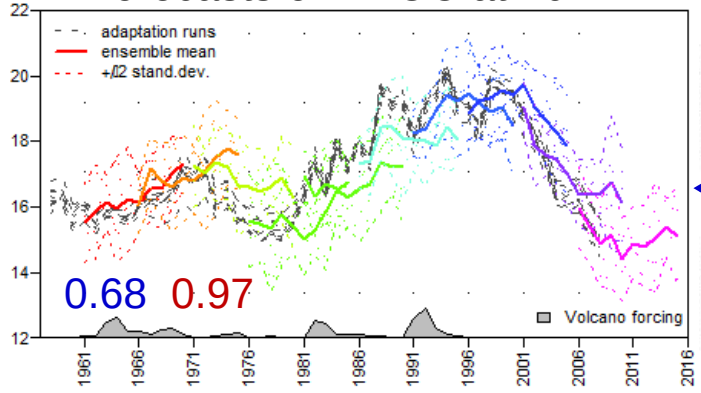
- Evolution of Atlantic meridional overturning: differences from historical in years 1-5
- CanCM4 assimilating analysis (used for initialization of seasonal/decadal forecasts), i1 and i2-initialized hindcasts

i1 forecasts of AMOC at 26°N



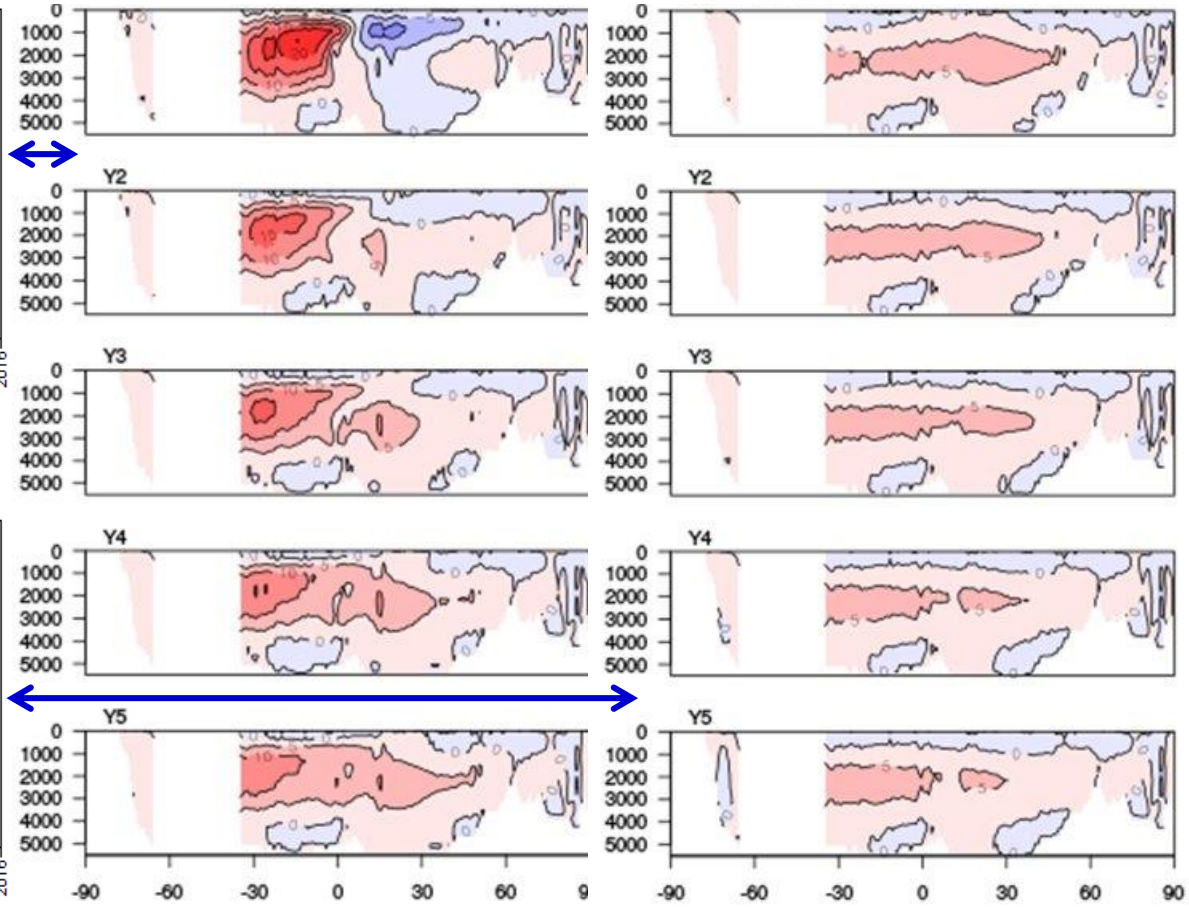

**mean ACC in Y1-10** **ACC of Y1-10 mean**

i2 forecasts of AMOC at 26°N




i1 – historical

i2 – historical

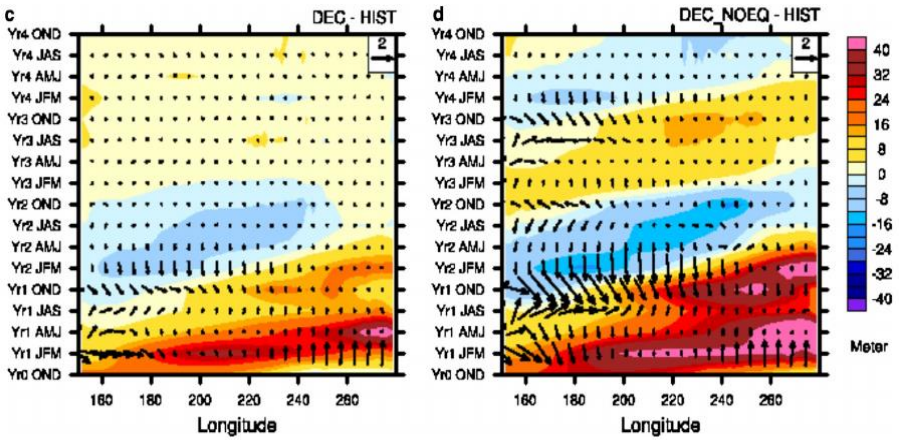


# Summary

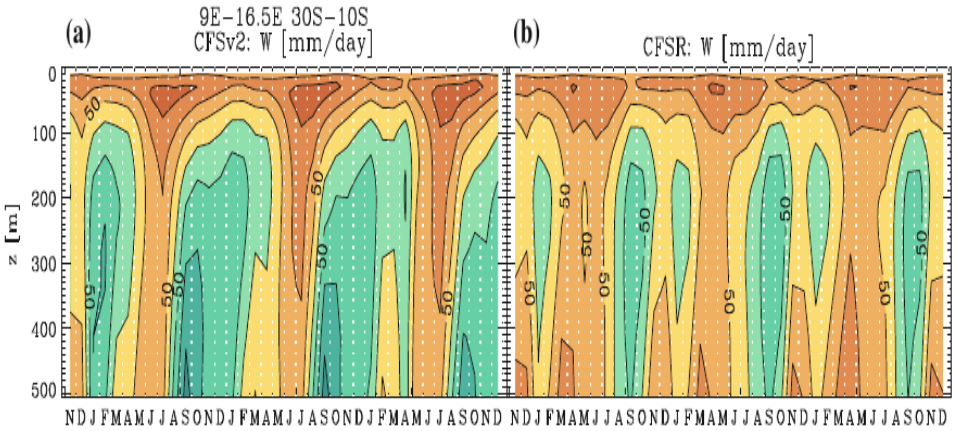
- Large **multi-model archive** of hindcast climatologies has been developed
- Ancillary climatologies (reference/obs, initial condition, historical simulation) aid in identifying and characterizing transient behavior
- Data structure guided by CMIP/ESGF conventions
- Sample diagnostics point to **diversity 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”)

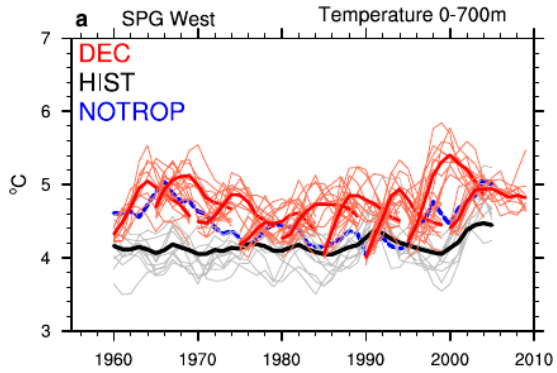
# Some of the many hindcast climatology diagnostics examined in recent studies

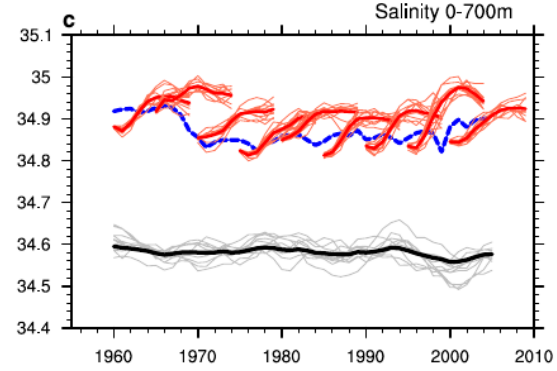
Sanchez-Gomez et al., *Clim. Dyn.,* 2015



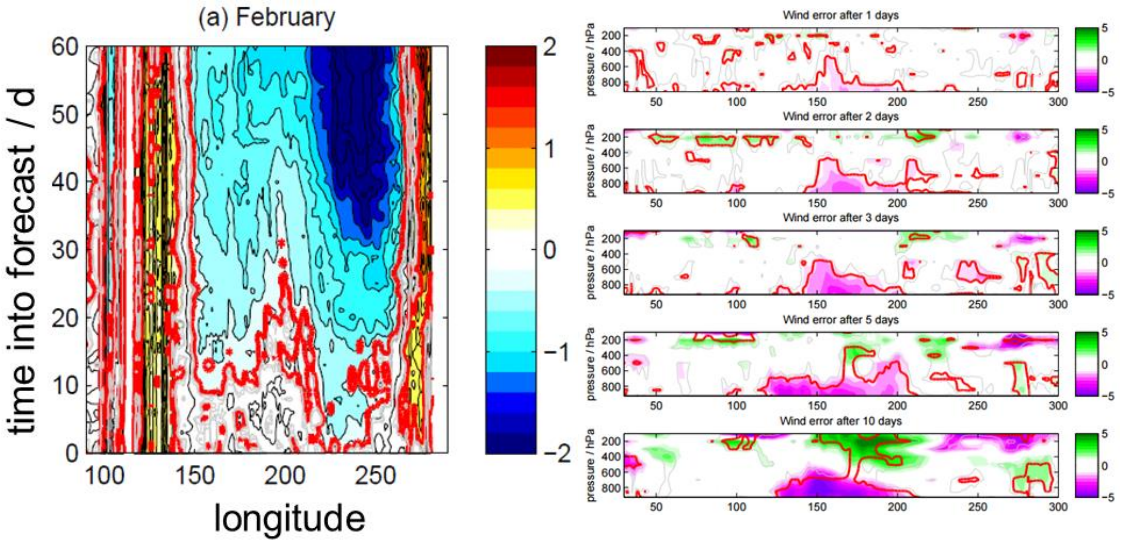

Toniazzo & Woolnough, *Clim. Dyn.,* 2014




Shonk, *Presentation at WGSIP 17,* 2015



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

| Variable name | Description | CF Standard Name | unit | realm | freq | pri- ority |
|---|---|---|---|---|---|---|
| **clt** | Total Cloud Fraction | cloud_area_fraction | % | atmos | d,m,y | 1 |
| **evspsbl** | 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 | pri-ority |
|---|---|---|---|---|---|---|
| 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 | pri-ority |
|---|---|---|---|---|---|---|
| **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 | m3 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 | pri-ority |
|---|---|---|---|---|---|---|
| **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 | pri-ority |
|---|---|---|---|---|---|---|
| **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 OImon)

| Variable name | Description | CF Standard Name | unit | realm | freq | pri-ority |
|---|---|---|---|---|---|---|
| **sic** | Sea Ice Area Fraction | sea_ice_area_fraction | % | sealce | m,y | 1 |
| **sit** | Sea Ice Thickness | sea_ice_thickness | m | sealce | m,y | 1 |

# **Time-Invariant Fields** (CMOR Table fx)

| Variable name | Description | CF Standard Name | unit | realm | dimensionality | pri-ority |
|---|---|---|---|---|---|---|
| **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