The Development of Hydrostatic Seasonal Forecast System within the Unified Forecast System

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Background

- All current UFS-based applications have been non-hydrostatic
- Why hydrostatics for SFS
  - Suitable for the SFS time scale
  - Proven Performance and Reliability
    - Long history of application with hydrostatic FV3 in GFDL climate models
  - Reduced Computational Costs
    - reduce ~12% computing cost for C192 with same settings
  - Potential for Longer Time Step

dt_atmos	**Acoustic time step**	**NH**	**HYD**	-C192L127 -atmos-only -8x8 layout -2 threads
600s	75	4.5 mins/day	4 mins/day	
900s	75	unstable	2.4mins/day	

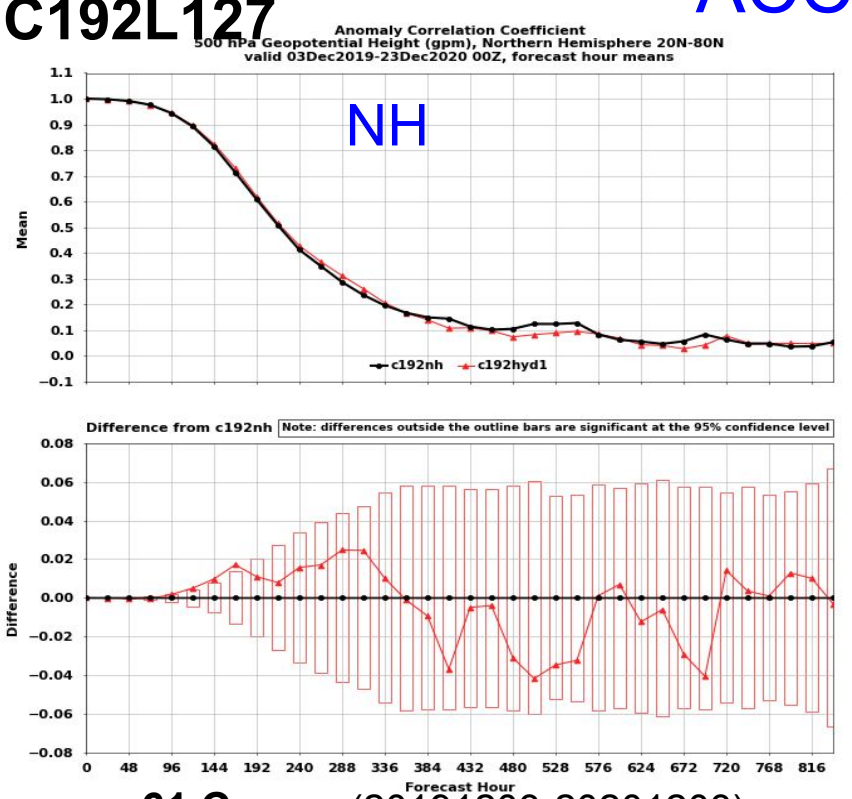
FV3 dycore parameters: NH .vs. HYD

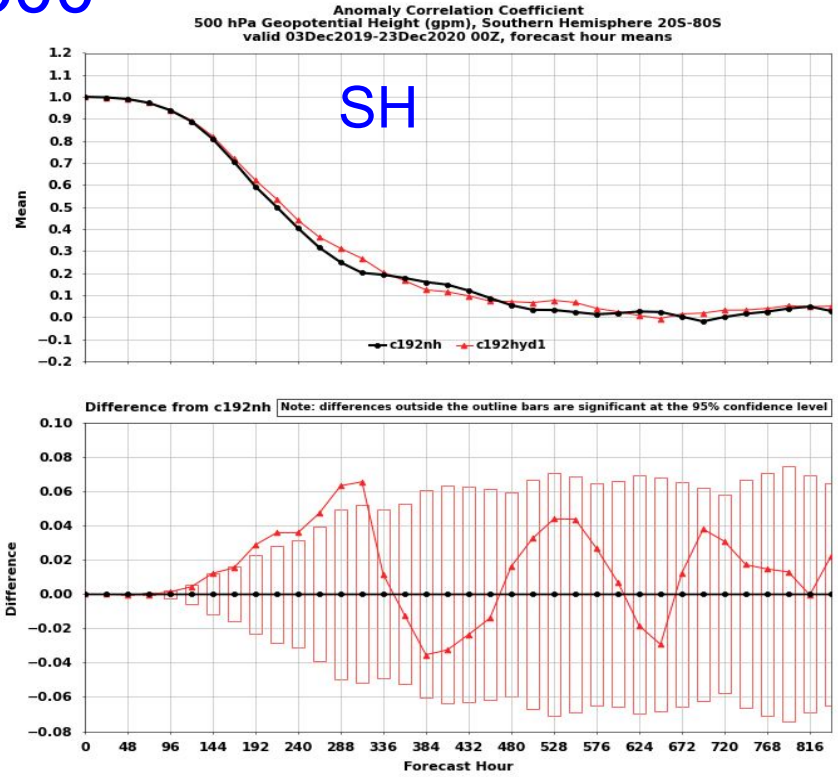
		UFS(NH)	UFS(HYD)
Remapping scheme	**kord**	9/-9	10/-10 (AM4 version)
Advection scheme	**hord(other/dp/tr)**	5/-5/8	10/10/8
2nd-order Smagorinsky-type divergence damping	**dddmp**	0.1	0
Logic for flux damping	**do_vort_damp**	true	false
Coeff for div. damping	**d4_bg**	0.12	0.15
Damping coeff. for other variables except div.	**vtdm4**	0.02	0
Fraction of KE lost to heat	**d_con**	1	0

Common:
dt_atmos=600s
k_split=2
n_split=4
tau=6
n_sponge=42
fv_sg_adj=1800

Atmos-Only 35-day fcst C192L127

ACC Z500

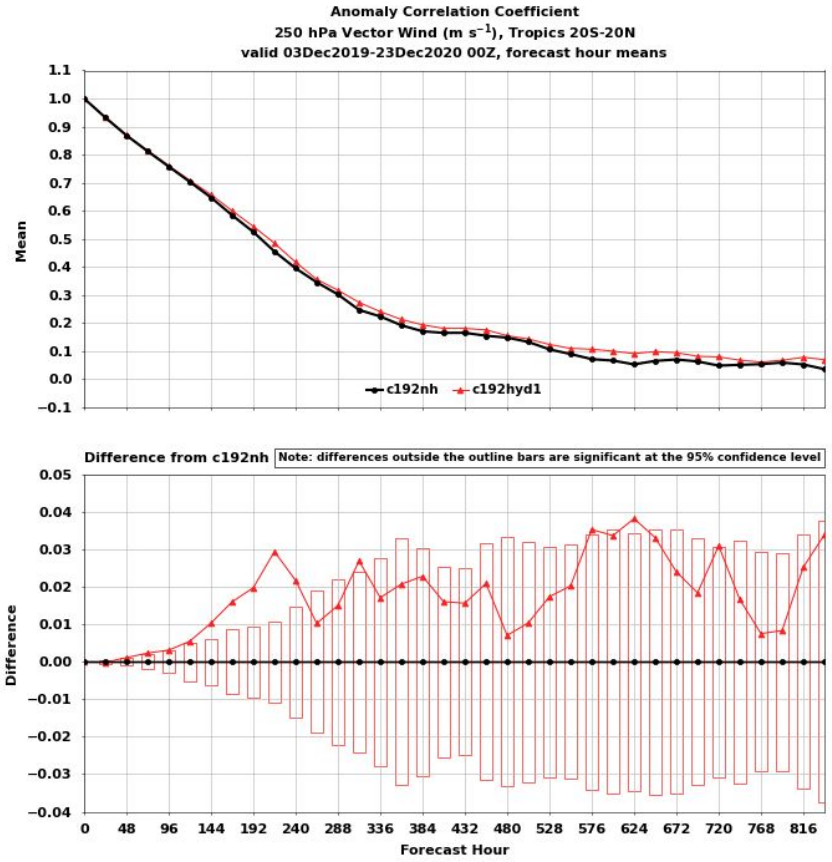




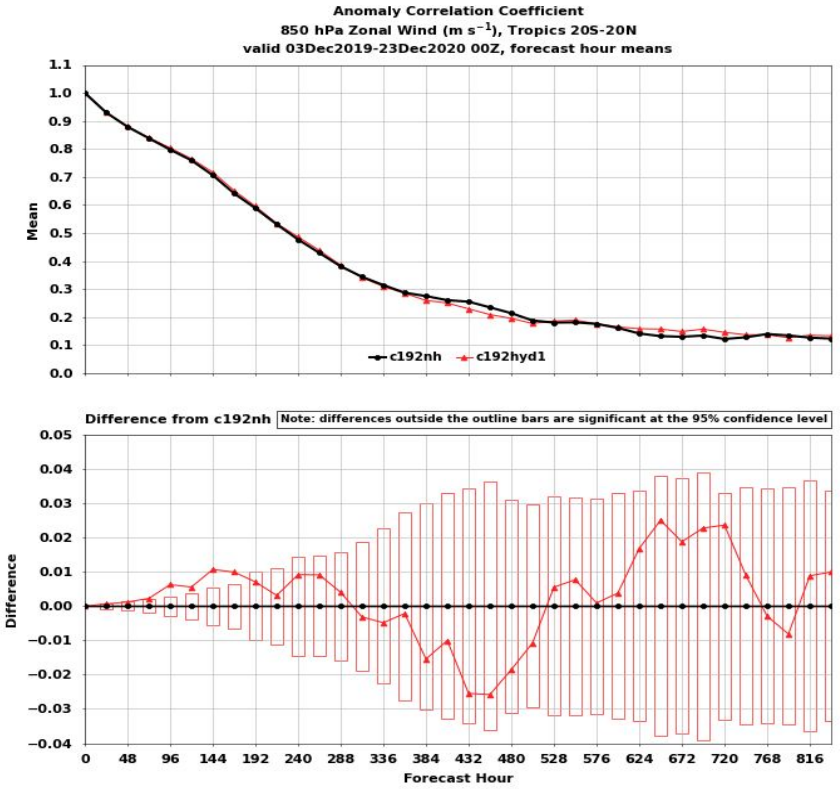
- **61 Cases**: (20191203-20201203) every 6 days
- 35-days forecasts
- Cold start from GFSv16 analysis
- **Metplus Verification**: [GFS Experiment Verification (noaa.gov)]

ATMOS-Only C192L127

Tropical 250-hPa wind ACC



Tropical 850-hPa wind ACC

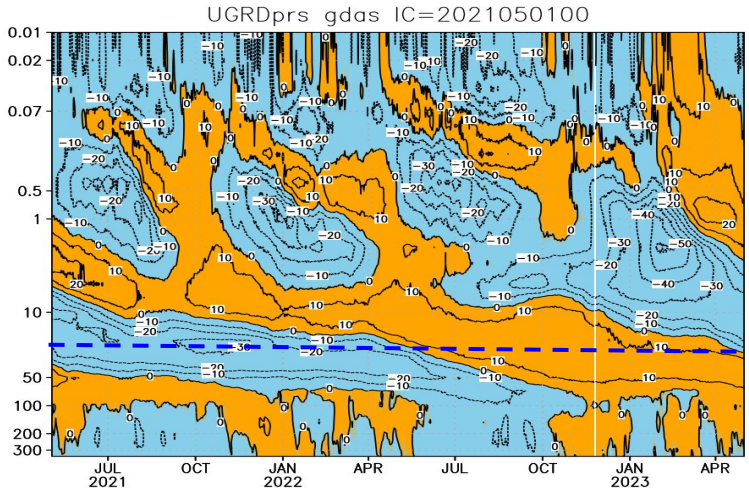


Coupled and atmos-only seasonal forecasts

- **C192L127**
- **Initialized from 1st May (1999-2023)**
- **Forecast length: 1-2 year**
- **IC: IFS replayed ICs**
- **Coupled fcsts have ocean and ice, no wave and aerosol**
- **Atmos-only fcst uses RTG SST as a forcing**
- **UFS model version (21st Feb 2024, 698866272846e8c)**
- **Experiments:**
  - **nh_cpl:** coupled non-hydrostatic,
  - **hyd_cpl:**coupled hydrostatic with dyn setting similar with AM4
  - **nh_atm:** ATM only non-hydrostatic,
  - **hyd_atm:**ATM only hydrostatic dyn setting similar with AM4

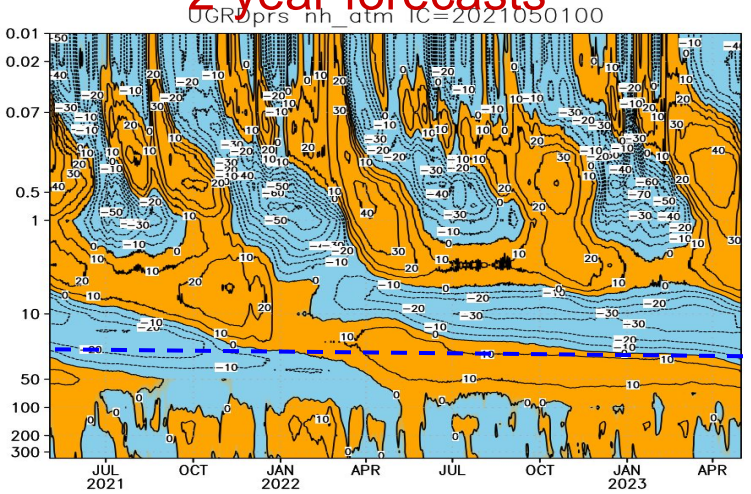
Zonal mean U-Comp (5S-5N)

GDAS

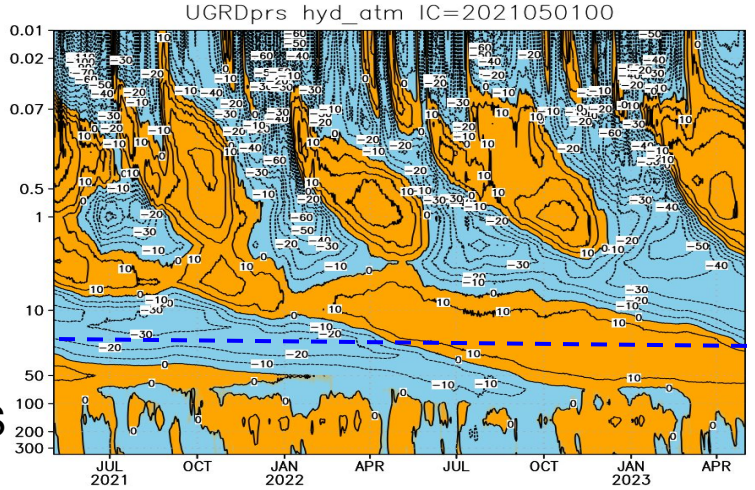


*The oscillation in NH faster than HYD and GDAS

2-year forecasts



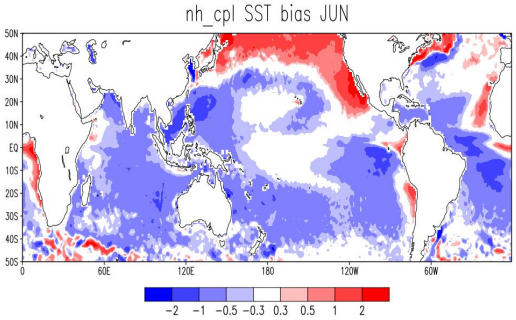
NH_atm



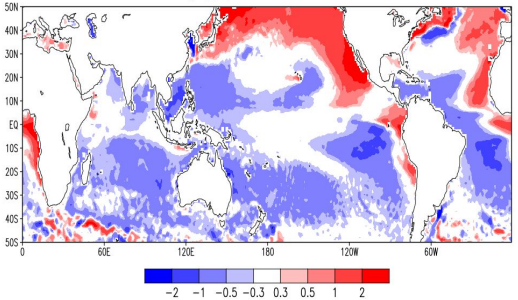
HYD_atm

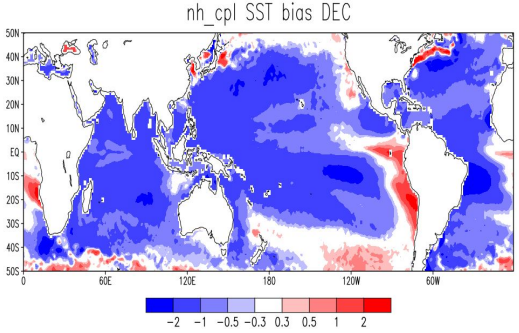
- 1999-2022
- large cold SST biad

NH

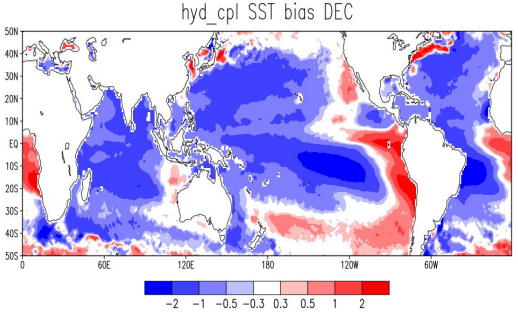


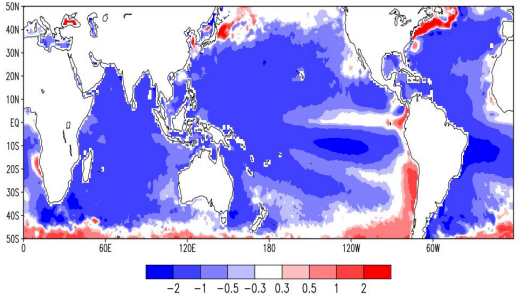
Lmon1



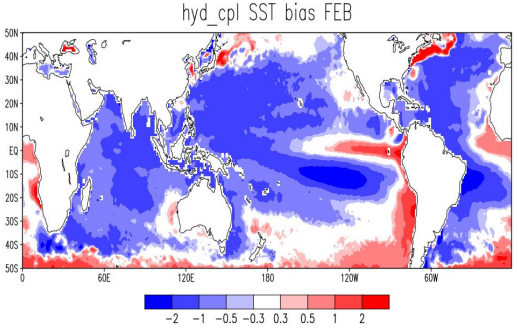


Lmon6





Lmon8



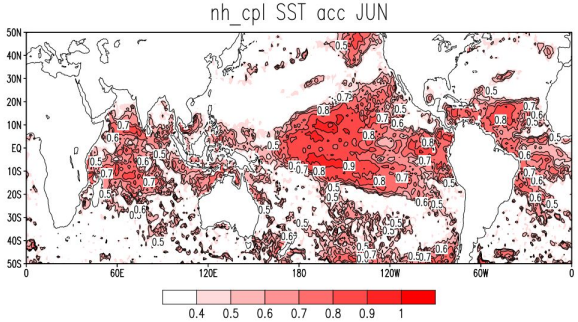
HYD

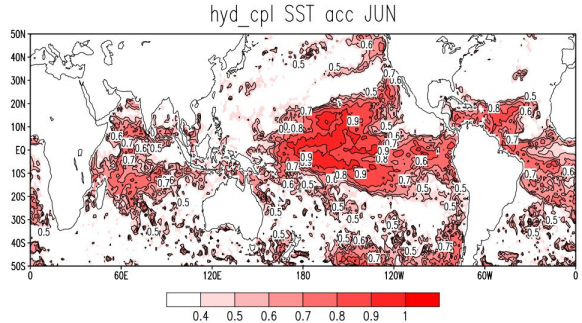
SST anomaly correlation

NH

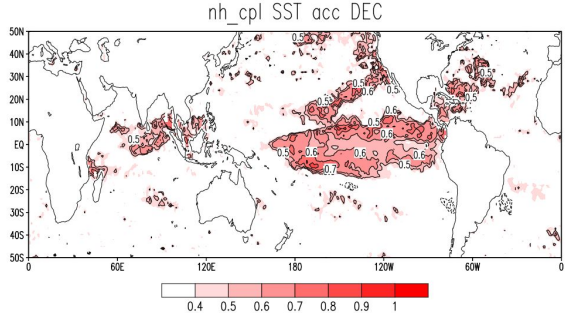
HYD

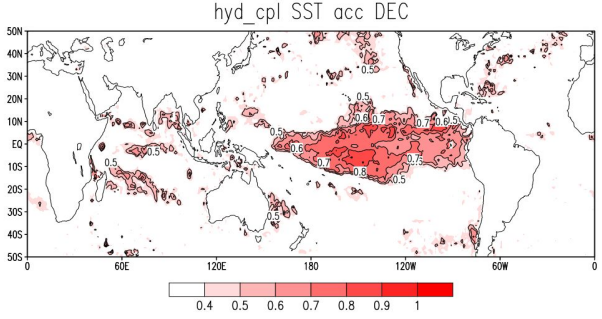
Lead mon1

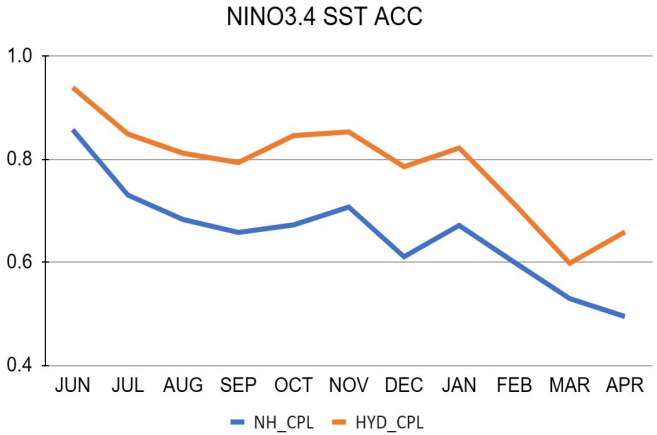




Lead mon6



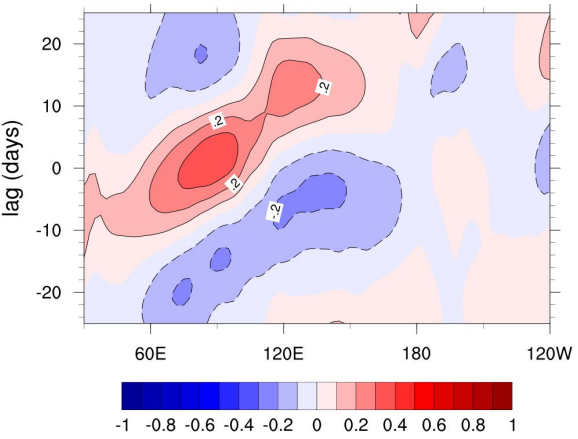




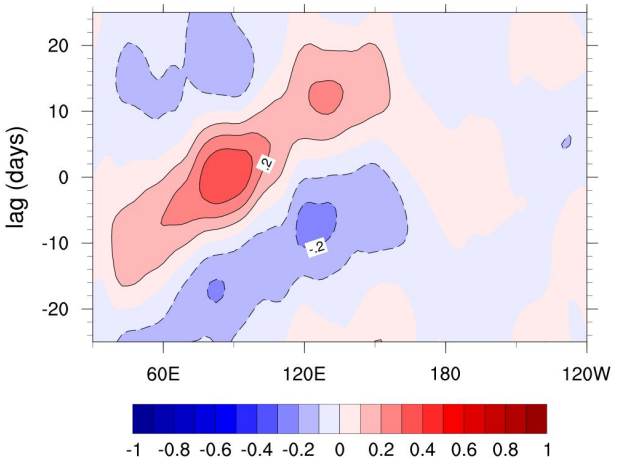
20-100 day filtered OLR lag correlation from IO

23 seasons averaged (Nov-Feb, 1999-2022) eastward propagation

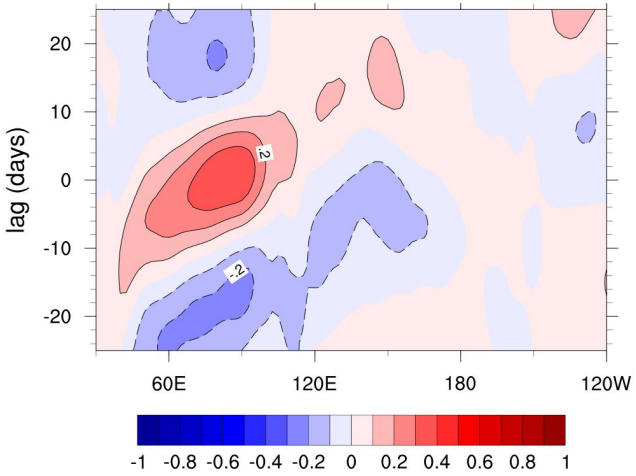
OBS



NH



HYD



Summary and Limitations

Preliminary results:

- HYD and NH have similar performance in terms of atmos-only 35-day forecasts
- HYD captures the QBO oscillation time period better
- HYD shows promising SST ACC score but both HYD and NH options have a persistent cold bias
- NH presents clearer eastward MJO propagation compared with HYD

Limitations:

- Very preliminary verification
- Control run only
- Strong cold SST bias