Climatology in Global/Regional Integrated Model system (GRIMs)

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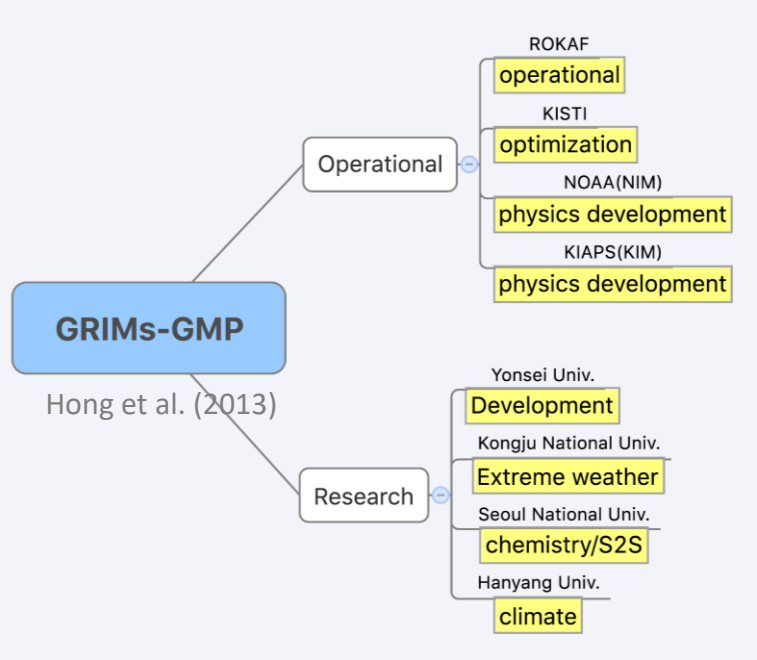
GRIMs update

GRIMs-GMP V3.1 → Major update! → GRIMs-GMP V4.0



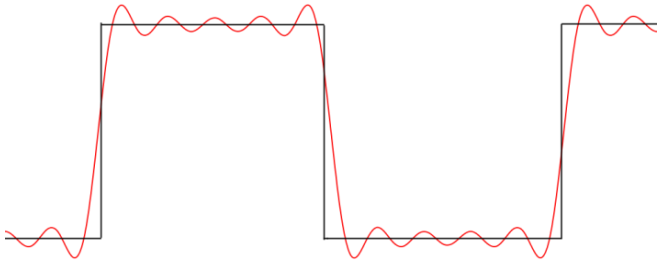
Hong et al. (2013)

- **Dynamics**
  - Semi-Lagrangian moisture advection
- **Physics**
  - New physics schemes based on WRF v4.0
- **Ancillary dataset**
  - High-quality and –resolution climatology dataset
- **Others**
  - I/O system and minor update for user convenience

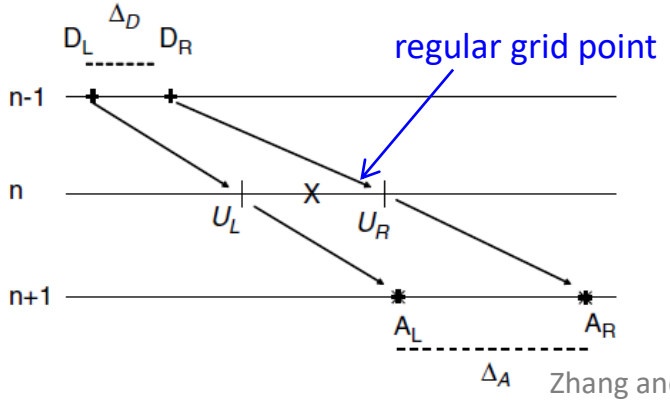
GRIMs update: Dynamics

- Dynamics

Spectral method (V3.1)

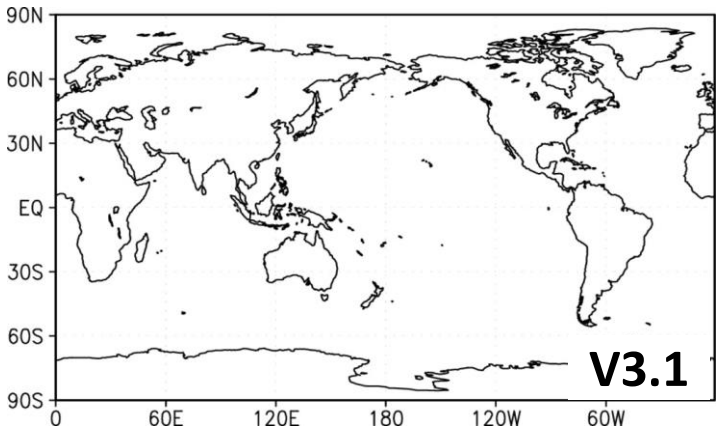


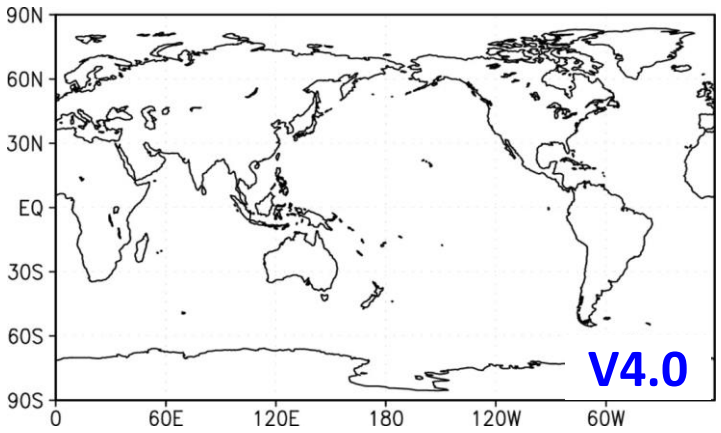
Non-iteration Dimension-split Semi-Lagrangian (NDSL; V4.0)



Zhang and Juang (2012)

Hydrometeors (Q_{ci}+Q_{rs})





Koo et al. (2021 in preparation)

GRIMs update: Physics

- Physics

Physics	H2013	K2021
Radiation	Chou et al. (1999); Chou and Suarez (1999); Chou and Lee (2005)	RRTMG_WRF4 (Iacono et al., 2008)
Surface layer	MO (Long, 1984;1986)	MO + revision (Koo et al., 2018; Zeng et al., 2012)
Land	Noah V2.7 (Ek et al., 2003; Mitchell et al., 2005)	Noah V3.4.1_WRF4
Ocean	Charnock (1955); Briegleb et al. (1986); Kim and Hong (2010)	Charnock (1955); Taylor et al. (1996)
Vertical diffusion	YSU (Hong, 2010; Hong et al., 2006)	YSU_WRF4
Gravity wave drag by orography	KA (Hong et al., 2008; Kim and Arakawa, 1995)	KA_WRF4 (w/ FBD) (Choi and Hong, 2015)
Gravity wave drag by non-orography	CB (Chun and Baik, 1998; Jeon et al., 2010)	-
Deep convection	SAS (Byun and Hong, 2007; Park and Hong, 2007)	KSAS_WRF4 (w/ scale-aware) (Han et al., 2020)
Shallow convection	GRIMSCV (Hong and Jang, 2018)	NSCV_WRF4
Cloud microphysics	WSM1 (Hong et al., 1998)	WSM3_WRF4 (Hong et al., 2004)
Cloudiness	Diagnostic (Xu and Randall, 1996)	Diagnostic_WRF4

GRIMs update: Ancillary dataset and others

- Ancillary dataset

	H2013	K2021
Vegetation fraction	16-km monthly climatology_NCEP (Gutman and Ignatov, 1998)	1-km monthly climatology_WRFV4
Maximum snow albedo	Constant	Barlage et al. (2005)
Land use	100-km NCEP	1-km modified MODIS-IGBF_WRF4
Soil texture	100-km NCEP	1-km hybrid STATSGO/FAO_WRF4
CO2	Table	400 ppmv
Aerosol	Table	Monthly climatology by MACC
Ozone	Prognostic (climatological prod/loss)	Monthly climatology by CAMS

- Others
  - Updated I/O system (from GRIB to NetCDF)
  - Minor update for user convenience

Model configuration

	Description	Note
Resolution	T126L64 (~1°x1°; 0.3 hPa)	High-top version
Integration period	1989-2018 (30 years)	
Boundary condition	SST and SIC	OISSTv2.1
Ozone	Monthly climatology	CAMS
Aerosol	Monthly climatology	MACC
Other gas species	Fixed CH4, CO2, N2O, CFC12, CFC12, and CCL4	2005 values from IPCC (2007), but CO2=400 ppmv

- Updated version of GRIMs is used for AMIP-type experiments.
- Model setting is mostly same to seasonal evaluation one.

Data

- GRIMs dataset
  - Variables: Daily U, V, Z, T, SAT, and prcp (precipitation)
  - Linear interpolation to 1.5°x1.5°
  - Selected vertical levels: 37 pressure levels

- Reference dataset

  ERA5
  - Variables: Daily U, V, Z, T, and SAT
  - Time period: 1989-2018 (30 yrs)
  - Resolution: 1.5°x1.5° and 37 pressure levels

  CMAP (CPC Merged Analysis of Precipitation)
  - Variables: Monthly prcp
  - Time period: 1989-2018 (30 yrs)
  - Resolution: 2.5°x2.5°

Methods

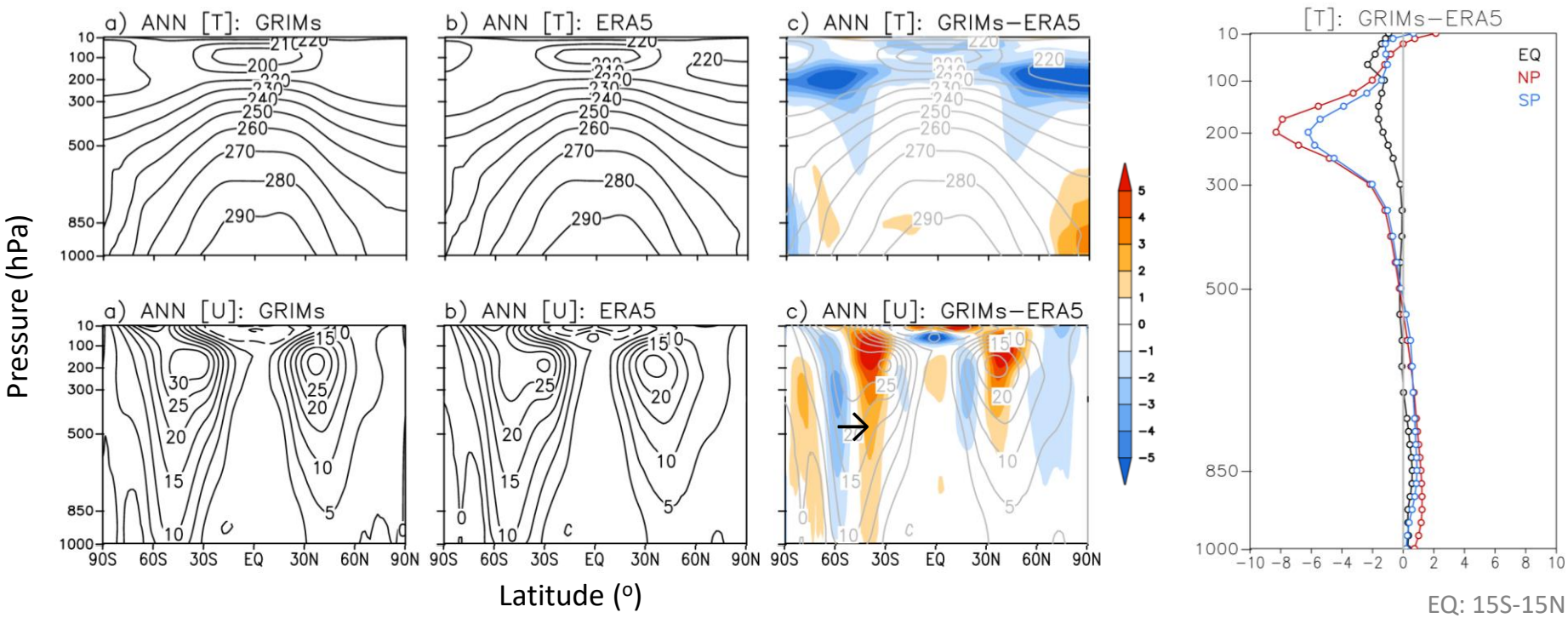
Θ: Latitude
Ψ: Mass stream function
Z: Geopotential height anomaly at 500 hPa
V: Meridional wind
*: Deviation from zonal mean

- Indices
  - Hadley cell edge: θ where $[\Psi]_{500\ hPa} = 0$
  - Eddy-driven jet location: θ where $[U]_{850\ hPa}$ is maximized
  - Transient eddy (storm track activity): V^{*2}
  - PNA index: 1/4[Z(20N,160W)-Z(45N,165W)+Z(55N,115W)-Z(30N,85W)]
    (Wallace and Gutzler 1981)
  - Time-filtered QBO index: $[U]_{10S\text{-}10N}$ with 24-30 months bandpass filter

- Detection
  - SSW: Wind reversal of $[U]_{60N}$ at 10 hPa (Charlton and Polvani 2007)
  - ENSO: SST during five consecutive overlapping seasons ≥ |0.5 K|, but DJF SST must be larger than |0.5 K| (NCEP/CPC convention)

Zonal-mean features: [T] and [U]

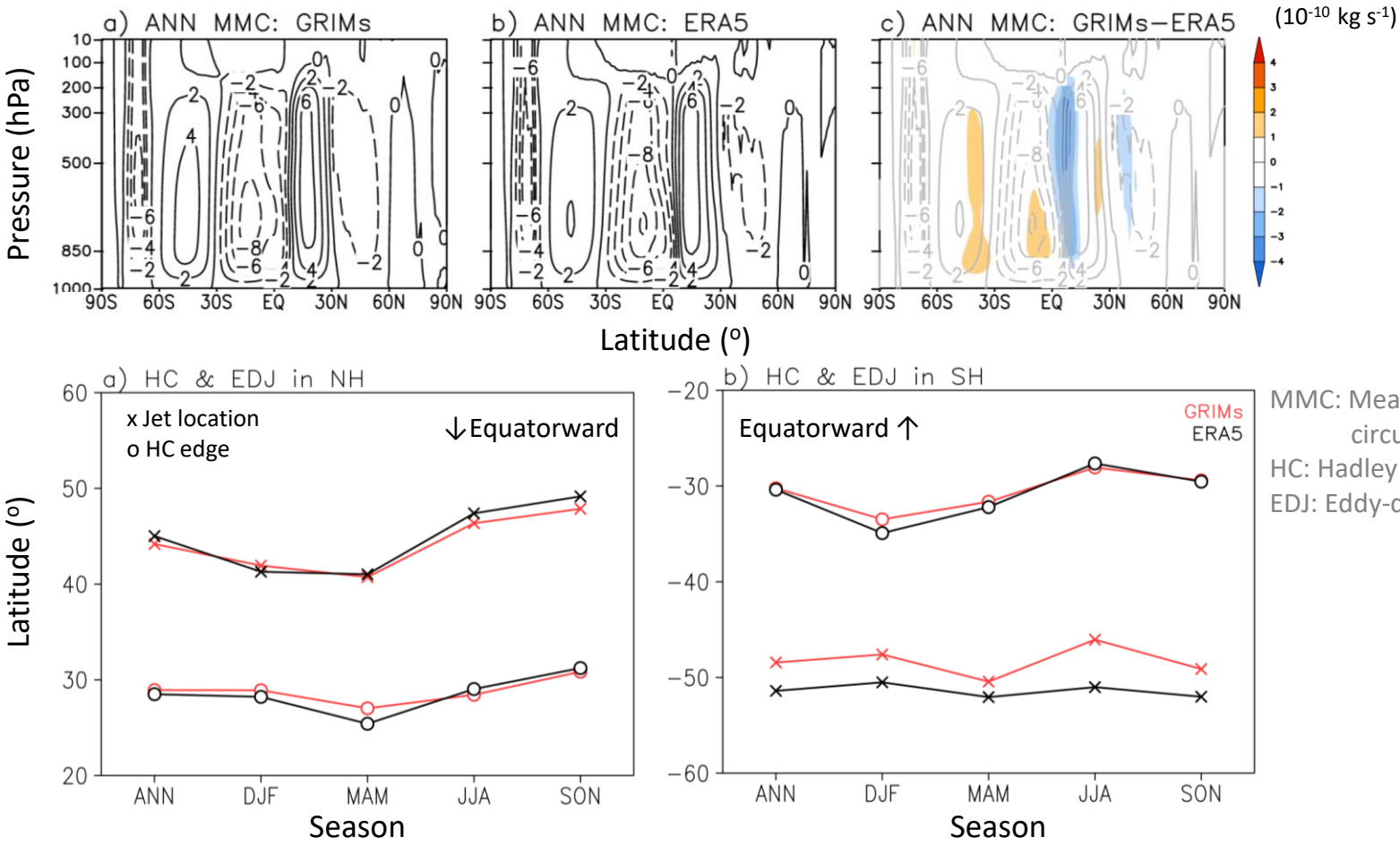
GRIMs ERA5 Diff. Diff.



EQ: 15S-15N
NP: 60-90N
SP: 60-90S

- Cold bias is found at the upper tropospheric and lower stratospheric (UTLS) region and at the extratropical UTLS (ExUTLS) region.
- Qualitatively, equatorward shift of eddy-driven jet. It is presumably related to the cold bias at ExUTLS.

Zonal-mean features: MMC and jet



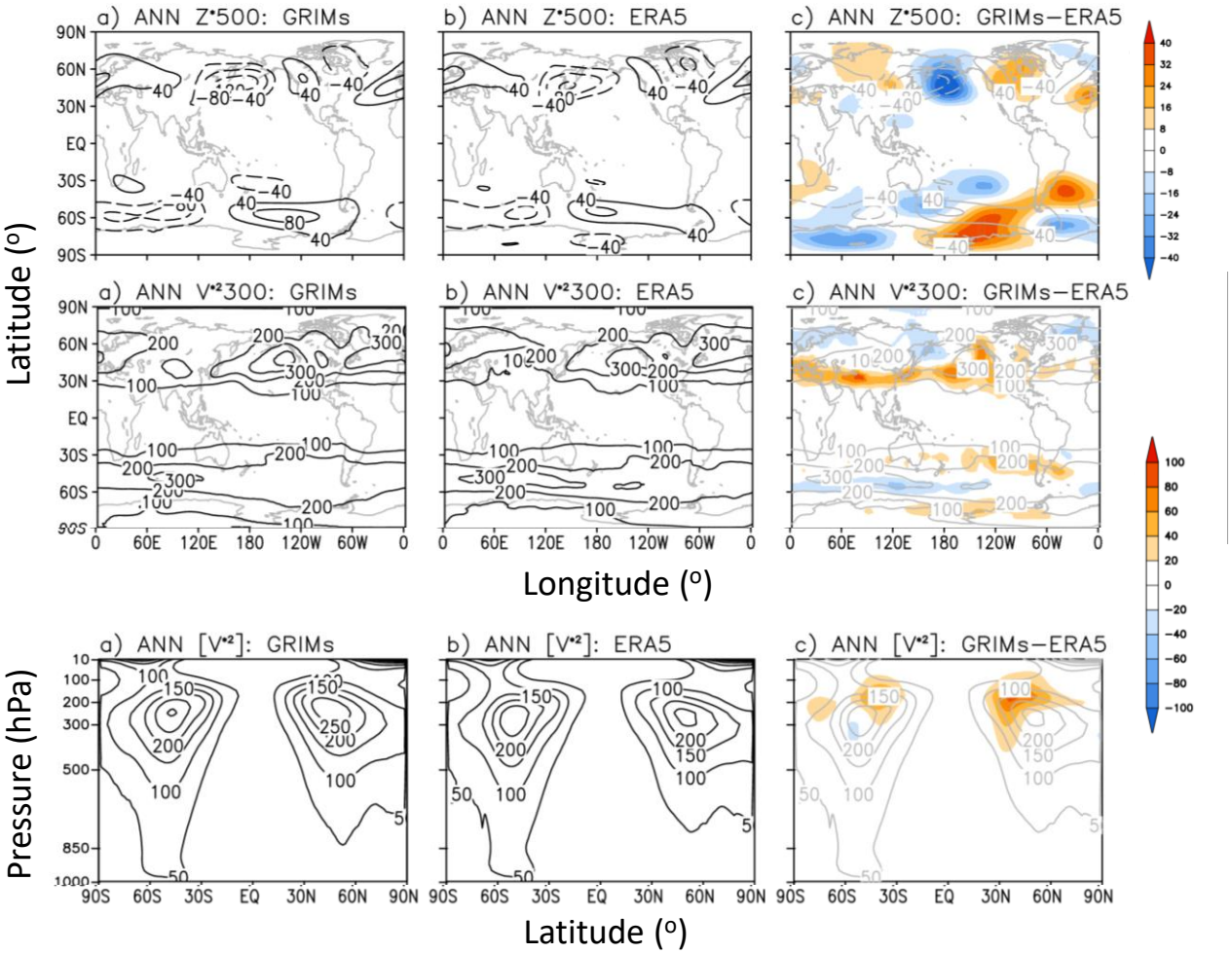
MMC: Mean-meridional circulation
HC: Hadley cell
EDJ: Eddy-driven jet

- The location of Hadley cell edge in GRIMs is not much different from ERA5.
- However, eddy-driven jet is shifted toward the equator.

Zonally-asymmetric features: Stationary and transient eddies

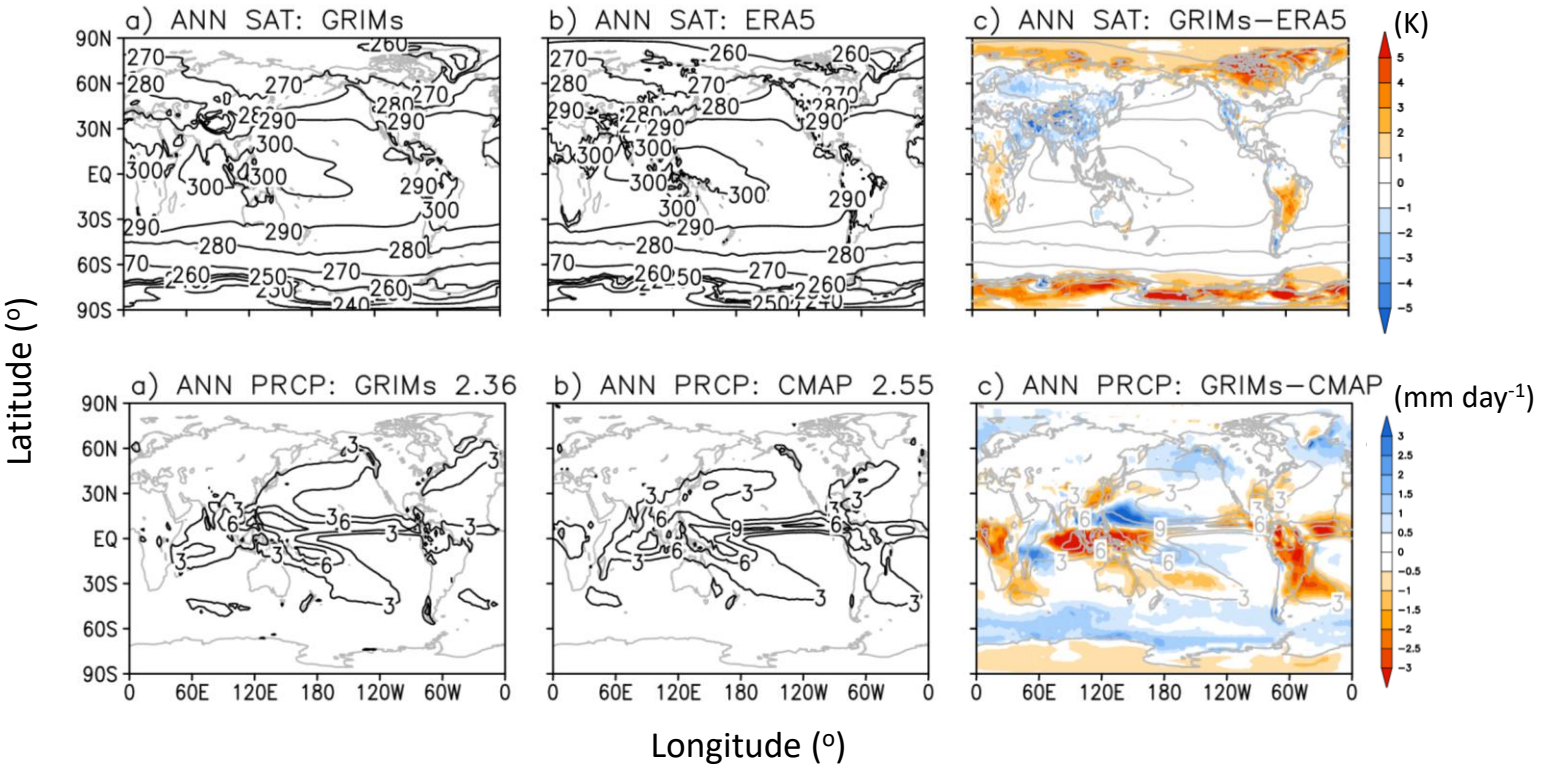
Stationary eddy
500-hPa Z*

Transient eddy
300-hPa V*^{2}



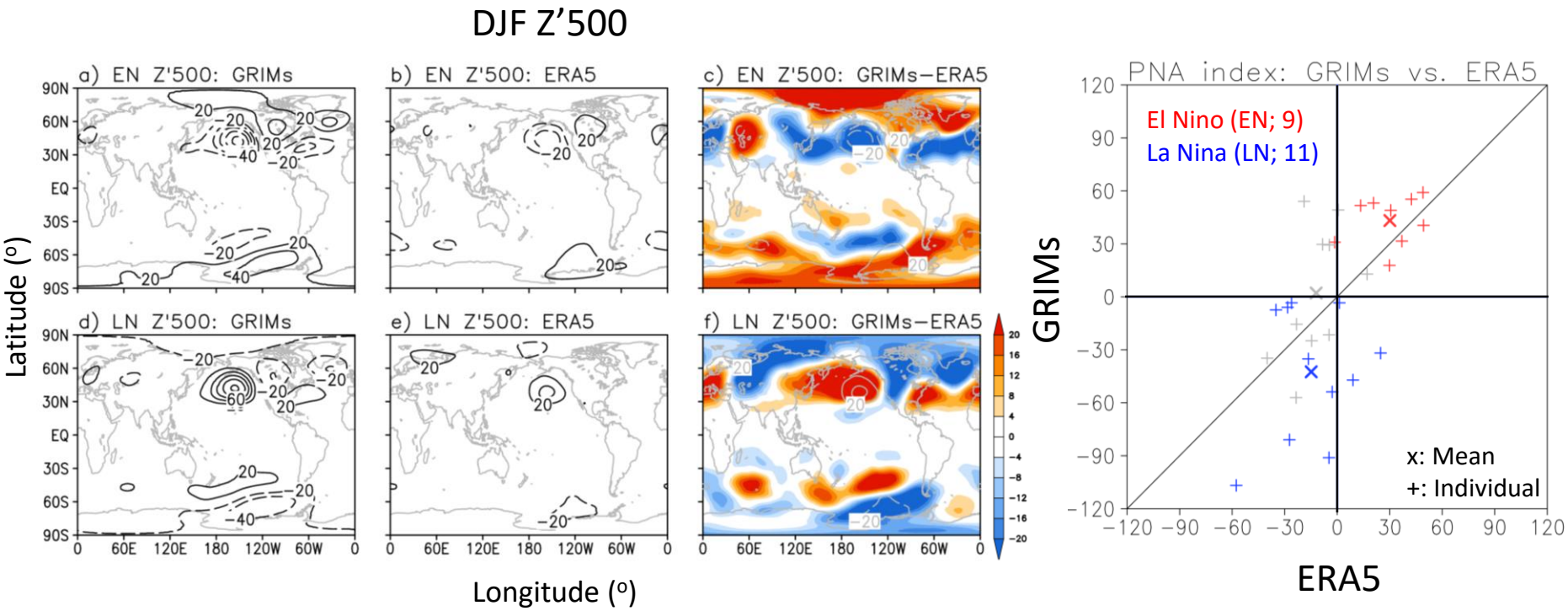
- Overall pattern of stationary eddy is similar to the ERA5, but its amplitude is large (possibly due to strong ENSO teleconnection).
- Equatorward shift of transient eddy is detected in GRIMs, like eddy-driven jet.

Surface conditions: SAT and PRCP



- SAT bias is large over snow cover and sea ice regions.
- Poleward shift of tropical precipitation in the Pacific is found in GRIMs.

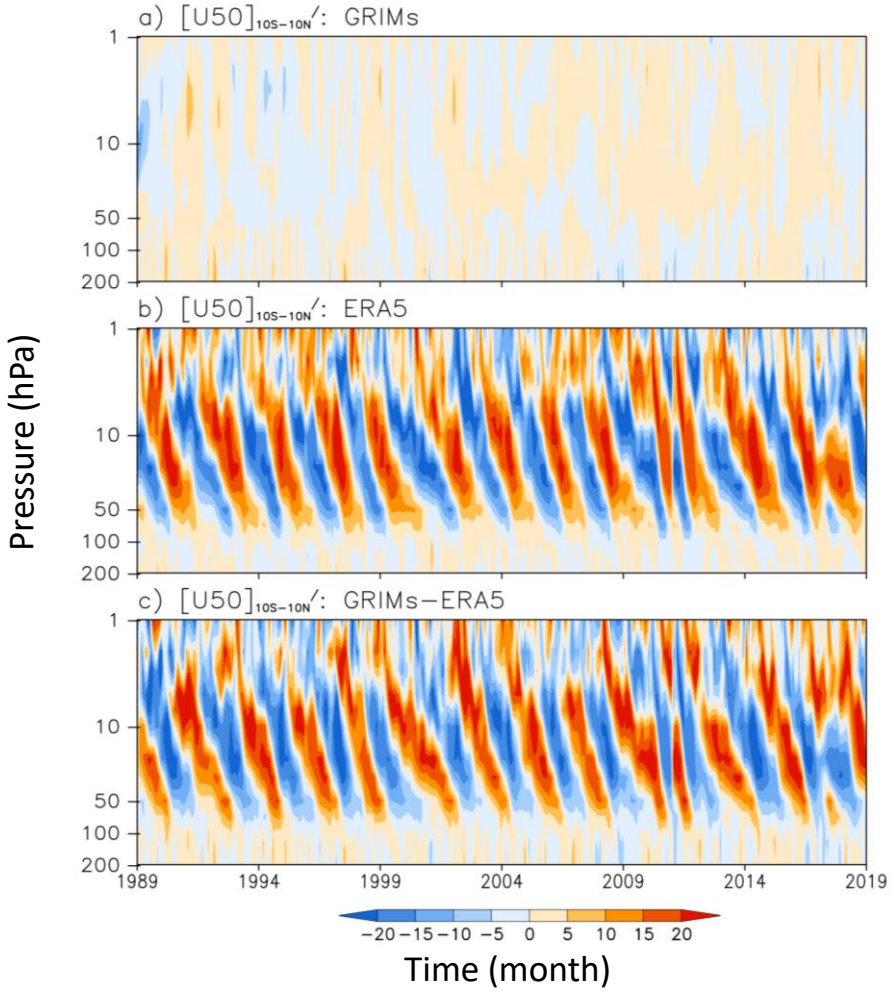
ENSO teleconnection



- ENSO teleconnection in GRIMs is stronger than ERA5. It means that GRIMs sensitively respond to the tropical forcing.
- GRIMs also shows the diversity of La Nina teleconnection.

Tropical stratosphere

QBO*

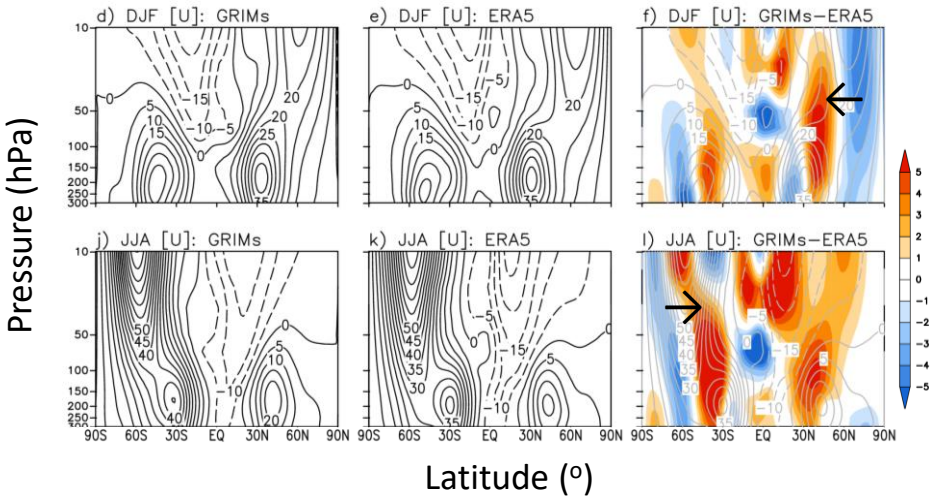


- QBO is not reproduced by GRIMs.
- Although not shown, tropical [U] is biased to the easterly phase.

*QBO: Quasi-biennial oscillation

Polar stratosphere

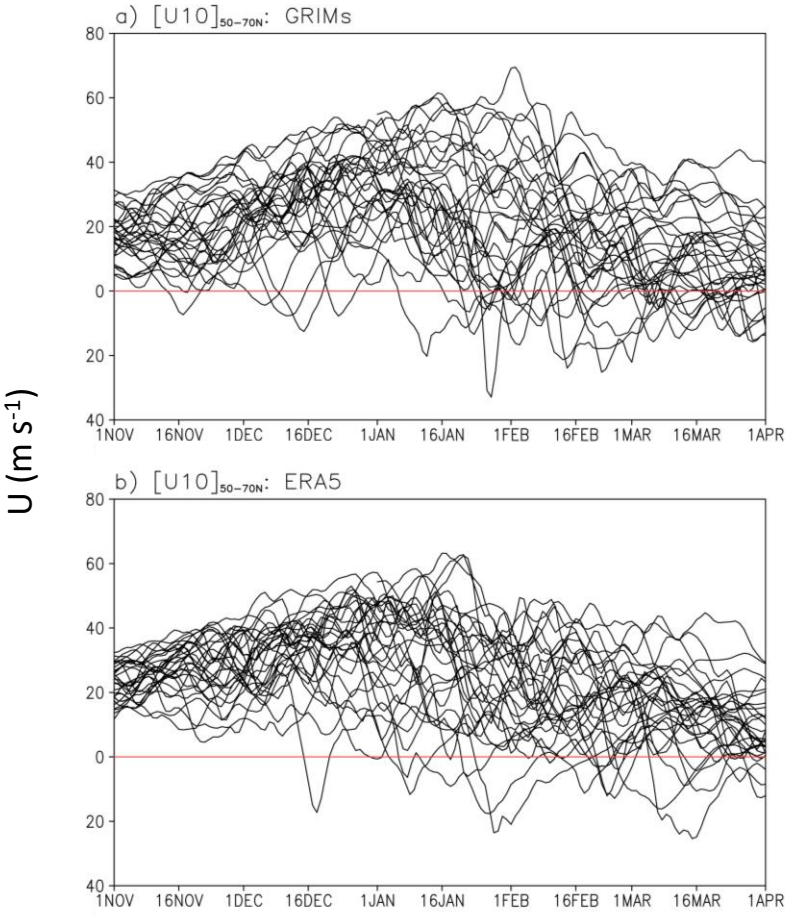
Polar vortex on the winter hemisphere



- GRIMs tends to show the equatorward shift of polar vortex.
- The SSW* events are well detected in GRIMs experiment.

*SSW: Stratospheric sudden warming

SSW event in the NH



GRIMs: 24 events
ERA5: 16 events
(25 event for U65 definition)

Conclusions

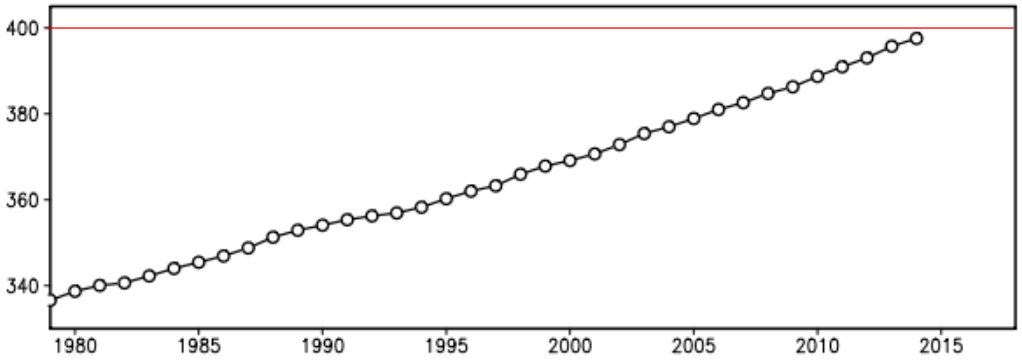
- GRIMs has strong cold biases at ExUTLS and represents strong ENSO teleconnection.
- The strong cold biases are possibly related to other biases, such as stratospheric and tropospheric jet shift.
- However, overall characteristics in GRIMs AMIP are not much different from reanalysis dataset.
- As other models, QBO generation is one of the big issue in GRIMs.

Further study

	Recent study	Future study
Resolution	T126L64 (~1°x1°; 0.3 hPa)	
Integration period	1989-2018	1979-2014
Boundary condition	OISSTv2.1 SST and SIC	CMIP6 standard
Ozone	Monthly climatology from CAMs	Monthly-varying data provided by CMIP6
Aerosol	Monthly climatology from MACC	
Other gas species	Fixed CH4, CO2, N2O, CFC12, CFC12, and CCL4	Yearly-varying data provided by CMIP6
Solar irradiance	Fixed	Monthly-varying data provided by CMIP6

- Long-term trend analysis!
- Expecting more reasonable Interannual variability
- Physics parameter analysis?

CO2 gas concentration (ppmv)



GRIMs

Questions and Comments