



Re-analysis

for Climate Change Assessment & Adaptation



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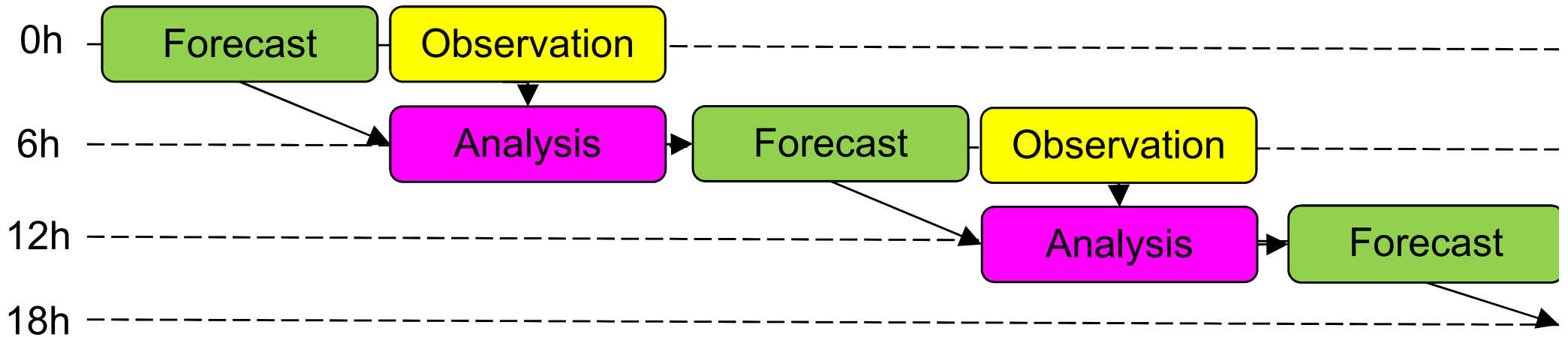
Outline

- Introduction
 - What is Reanalysis?
 - How is Reanalysis dataset useful?
- Status of JMA Reanalyses
 - JRA-25/JCDAS
 - JRA-55
- Application for Climate Change Assessment & Adaptation
 - Example of down scaling



What is Re-analysis ?

Operational forecast-analysis cycle for weather forecast

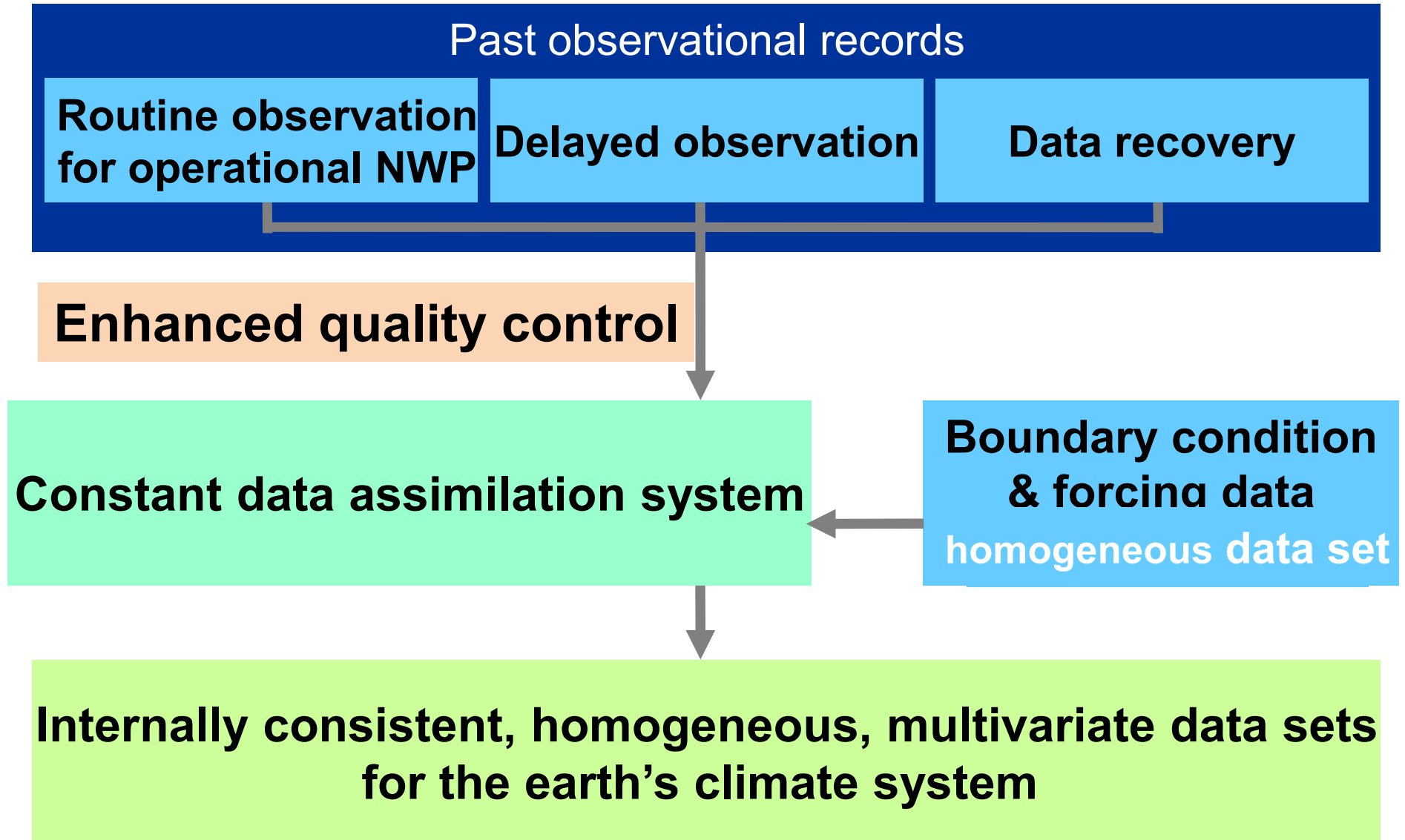


**Apply this procedure to the past observational records
with the fixed (latest) system**

homogeneous reanalyzed dataset for a long period



What is Re-analysis?





History of Re-analyses

Reanalysis	Producer	Period	Resolution	Assimilation
NASA/DAO	NASA/DAO	1980-1995	2x2.5L20	3D-OI +IAU
ERA-15	ECMWF	1979-1993	T106L31	3D-OI
NCEP-NCAR	NCEP-NCAR	1948-present	T62L28	3D-Var SSI
NCEP-DOE	NCEP-DOE	1979-present	T62L28	3D-Var SSI
ERA-40	ECMWF	1957.9-2002.8	T _L 159L60	3D-Var
JRA-25/JCDAS	JMA-CRIEPI	1979-present	T106L40	3D-Var
ERA-Interim	ECMWF	1989-present	T _L 255L60	4D-Var
CFSR	NCEP	1979-present	T382L64	3D-Var GSI
MERRA	NASA	1979-2010	1/2x1/2deg	3D-Var GSI
20th Century Reanalysis	NOAA-CIRES	1871-2008	T62L28	EnKF
JRA-55 (ongoing)	JMA	1957.12-2012	T _L 319L60	4D-Var
ERA-20C (planned)	ECMWF	Extending back to just after 1900	T _L 511	Weak-constraint 4D-Var

7th CG, Tokyo

Longer Higher Sophisticated



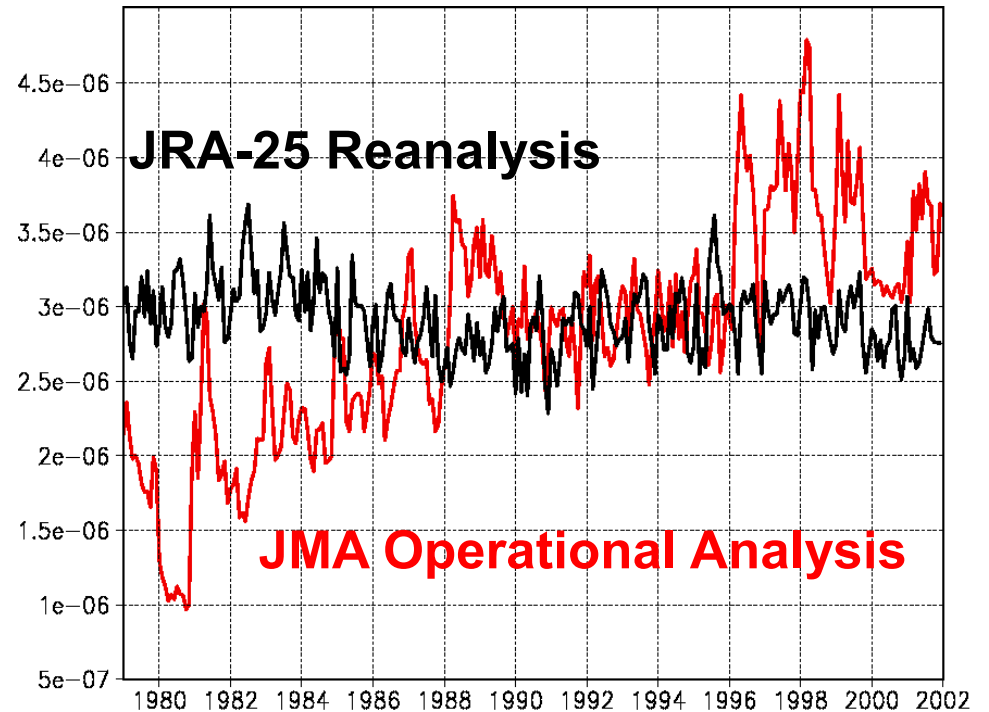
How is Reanalysis useful?

Merit of re-analysis from a point of view of climate monitoring

- Temporal Consistency (homogeneity of records)
- Global Coverage
- Comprehensive Archive

Before JRA-25, it was impossible to diagnose velocity potential (or vertical velocity) in tropics due to temporal inconsistency of atmospheric analysis.

Standard deviation of 200hPa divergence over Tropics

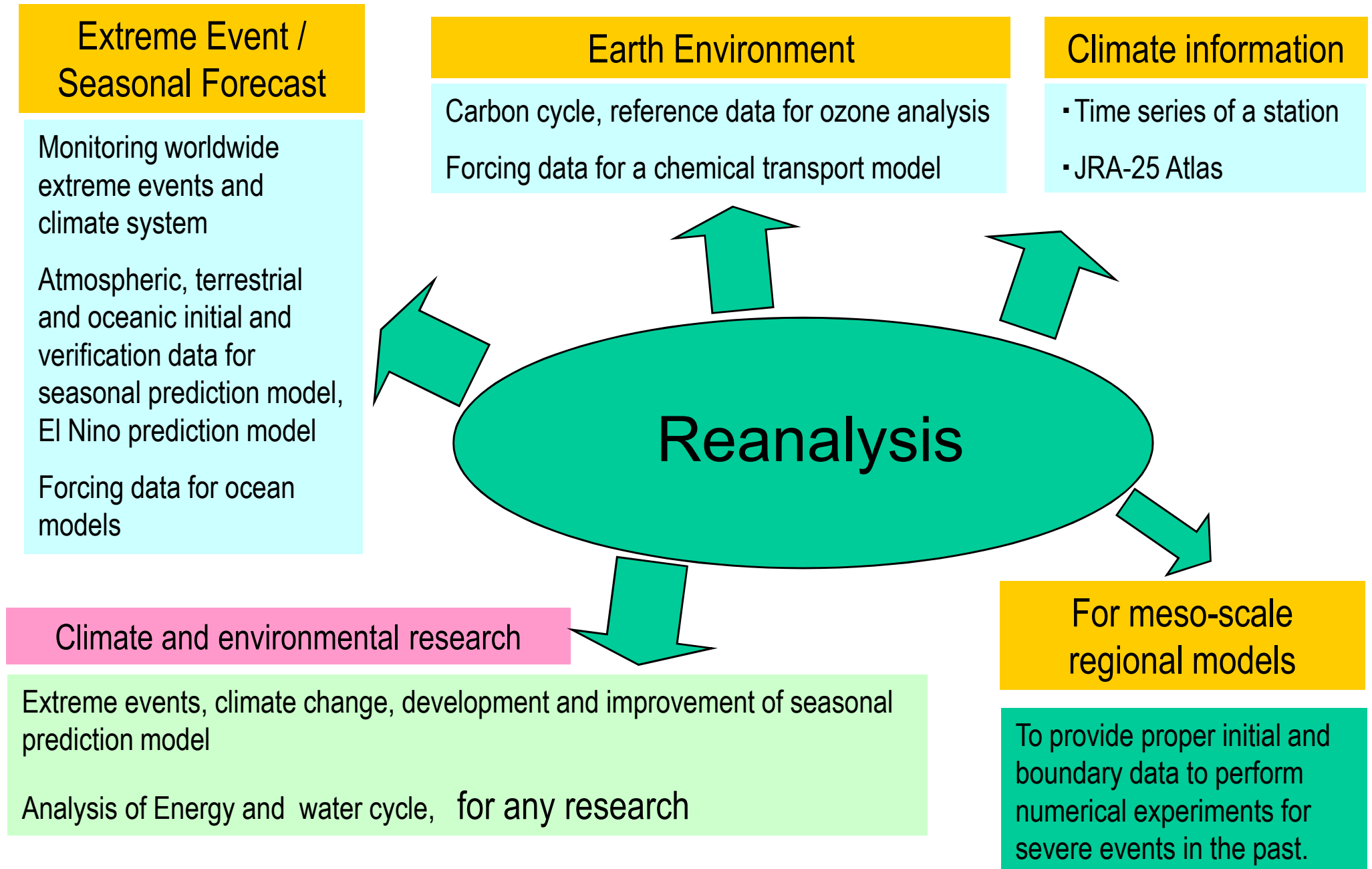


/users/gpu/rimst14/ana_mark/ana_0-200/stddev

Reanalysis provides us homogenous data.



Application of Reanalysis





Status of JMA Reanalyses



- **JRA-25 (1979-2004)**

- completed in 2006
- jointly conducted by JMA and Central Research Institute of Electric Power Industry (CRIEPI)
- based on JMA forecast system as of 2004
- **freely available for research purposes**
 - http://jra.kishou.go.jp/JRA-25/index_en.html
- A full copy of the JRA-25 data also available from the NCAR data archive: <http://dss.ucar.edu/datasets/ds625.0/>
- **Over 1,700 registered users and 100 cited references** as of Aug 2010
 - The JRA-25 description paper (**Onogi *et al.*, 2007, JMSJ**)

- **JCDAS (2005-present)**

- Near real-time operational climate analysis with the JRA-25 system.

- **JRA-55 (1958-2012)**

- **New JMA reanalysis project is on-going (2008-2012).**



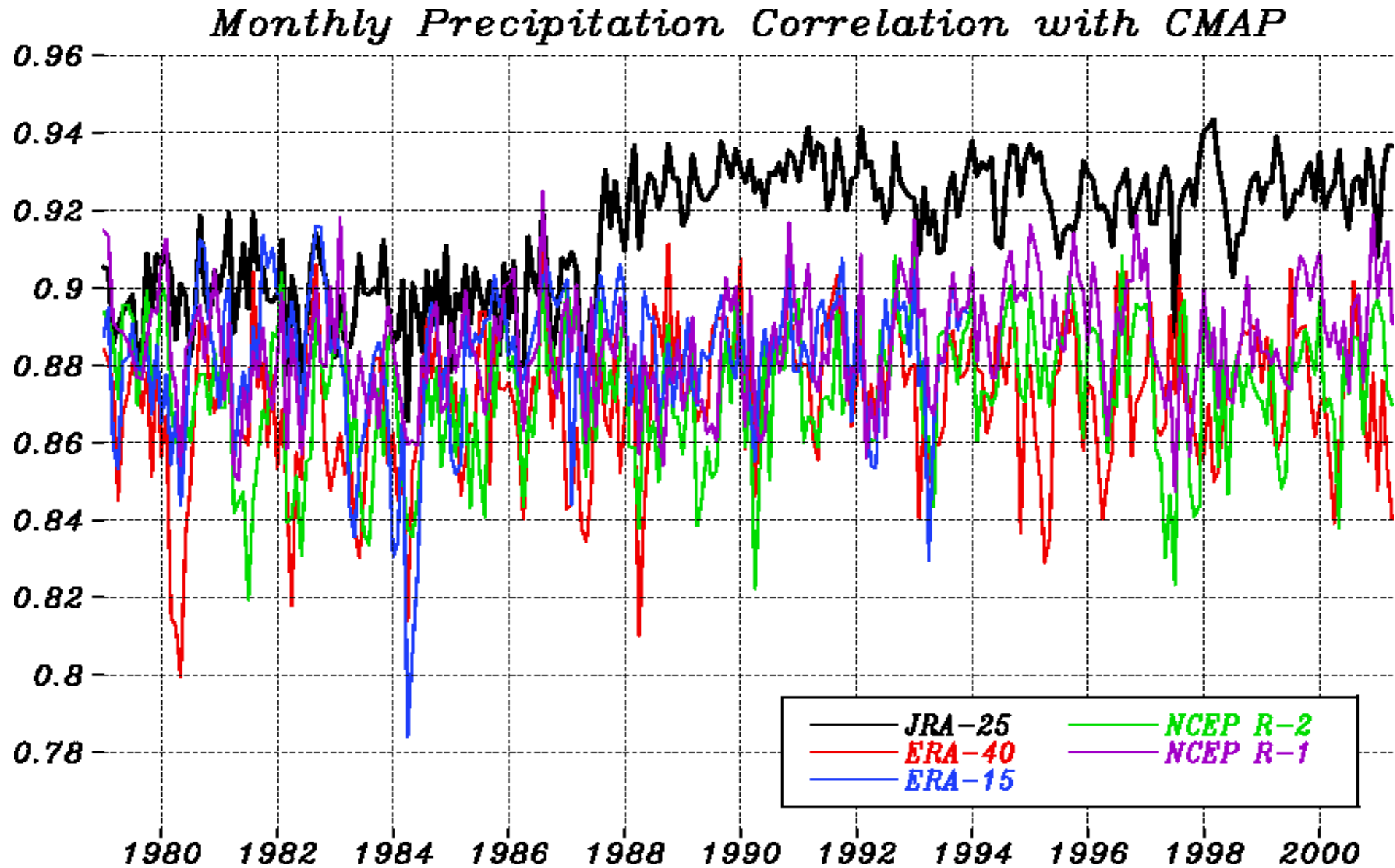
JRA-25 overview



- Assimilation system : **JMA operational system as of April 2004**
- Global model resolution : **T106L40** (120km,model top: 0.4hPa)
- Data assimilation : **3D-Var**
- Assimilated satellite data:
 - ✓SSM/I precipitable water retrievals
 - ✓TOVS/ATOVS radiances (level 1d: HIRS/MSU, level 1c: SSU/AMSU-A/AMSU-B)
- JRA-25 original boundary/forcing data:
 - ✓Daily COBE SST and sea ice (Ishii et al. 2005, *Int. J. Clim.*)
 - ✓Daily 3D-ozone profile
- JRA-25 was the first reanalysis using the observational data outlined below.
 - ✓ Wind profile retrievals surrounding tropical cyclones
 - ✓ SSM/I snow coverage
 - ✓ digitized Chinese snow depth data
 - ✓ reprocessed GMS-AMV

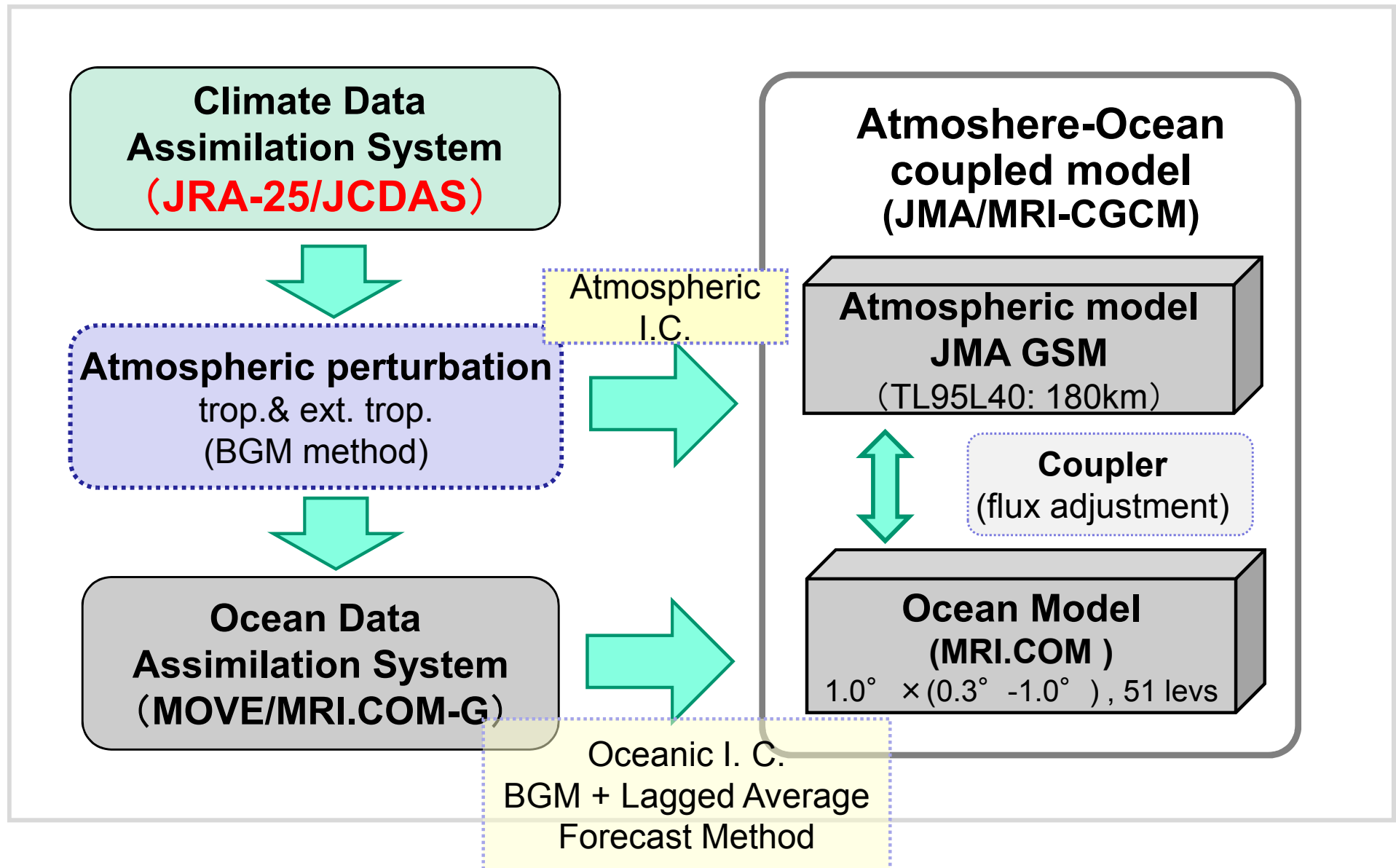


Spatial correlation of monthly precipitation with CMAP





JMA Seasonal Forecast System with JRA-25/JCDAS





Status of JRA-55 (1)

Global analysis

Compared with JRA-25

- Longer Period (1958-2012)
- Higher resolution
- Latest assimilation system with the latest model
- Enhanced QC
- More conventional data
- Adjustment of background error for a gap between satellite and no-satellite eras.

providing a fundamental data set for

- **researches** on climate change and decadal variability in the last half century
--- *Global Warming*
- real-time climate **monitoring**
- **verification** of seasonal forecast and climate models
- atmospheric **forcing fields** for ocean data assimilation
- chemical transport simulations
- carbon cycle simulations
- water resource management
- estimation of renewable energy resources
- severe weather risk assessment

and much more



Status of JRA-55(2)

	JRA-25 (1979-2004)	JRA-55 (1958-2012)
Resolution	T106L40 (~120km) (top layer at 0.4 hPa)	TL319L60 (~60km) (top layer at 0.1 hPa)
Time integration	Eularian	Semi-Lagrangian
Assimilation scheme	3D-Var	4D-Var (with T106 inner model)
B matrix	Constant	Different B matrices for pre-satellite and satellite eras
Bias correction (radiosonde)	Radiation bias only (Andrae <i>et al.</i> , 2004)	RAOBCORE v1.4 (Haimberger, 2007, <i>J. Climate</i>)
Bias correction (radiances) For satellite	Offline	Variational Bias Correction
Long-wave radiation	<i>Line absorption</i> Statistical band model <i>Water vapor continuum</i> e-type	<i>Line absorption</i> Table lookup + K-distribution <i>Water vapor continuum</i> e-type + p-type

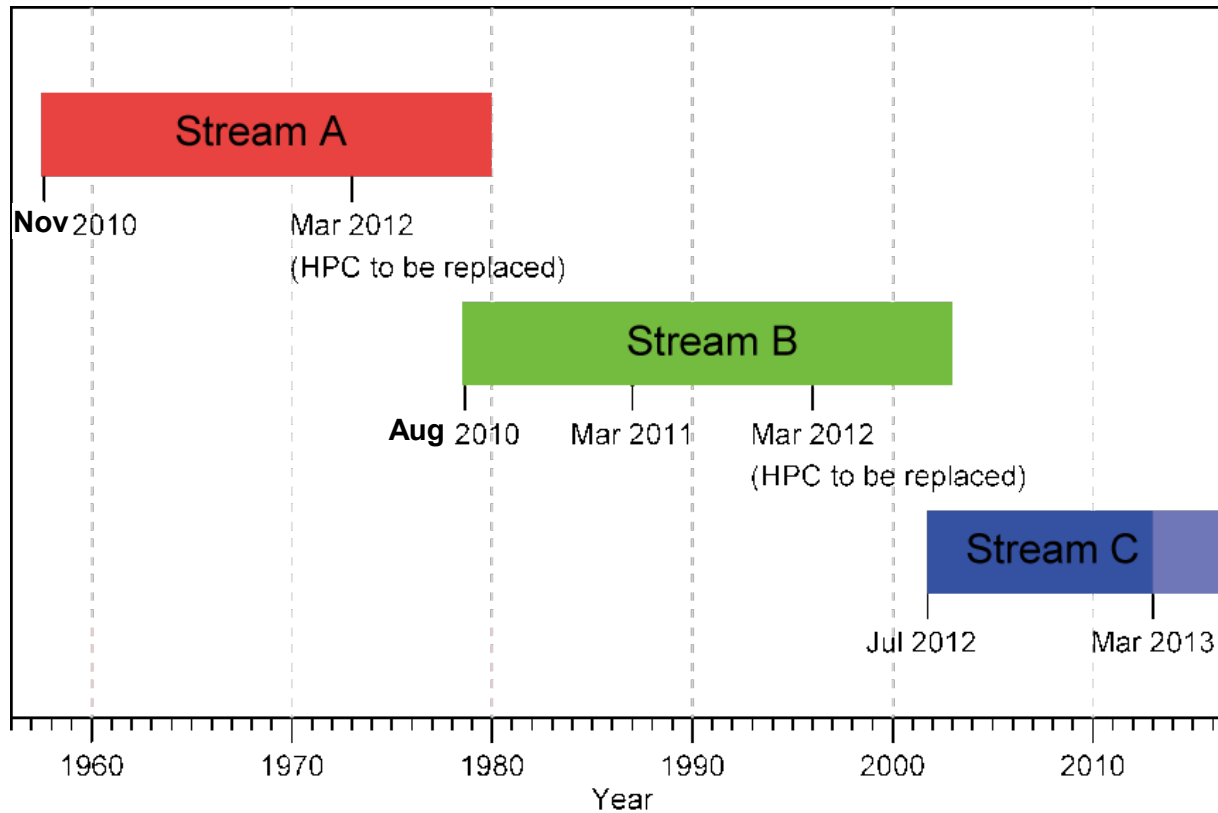


Status of JRA-55 (3)

	JRA-25 (1979~2004)	JRA-55 (1958~2012)
Radiatively active gases	H ₂ O, CO ₂ , O ₃	H ₂ O, CO ₂ , O ₃ , CH ₄ , N ₂ O, CFC-11, CFC-12, HCFC-22
GHG concentrations	Constant at 375 ppmv (CO ₂)	vary over time
Ozone	Daily 3-D ozone <i>(produced by AED/JMA)</i>	(-1978) Monthly climatology (1979-) New daily 3-D ozone <i>(produced using a revised CTM)</i>
Aerosols	Annual climatology for continental and maritime aerosols	Monthly climatology for continental and maritime aerosols
SST Sea ice	COBE SST <i>(Ishii et al., 2005, I.J.Clim.)</i>	COBE SST <i>(Same as JRA-25)</i>



JRA-55 project schedule



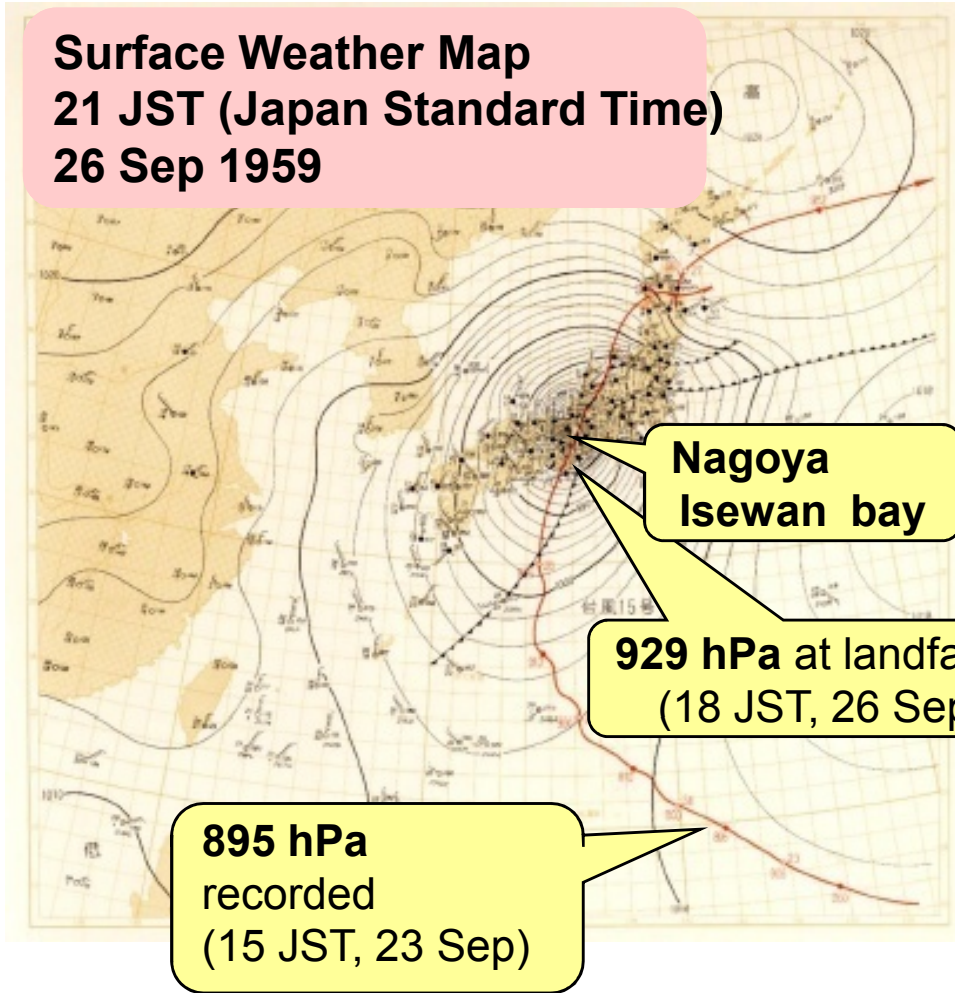
- Aug 2010 start of Stream B
- Nov 2010 start of Stream A
- Early 2013 completion of production
- **Mid 2013 product release**
 - Production will be continued as a new JCDAS



Application for Climate Change Adaptation

Re-examination of extreme event:

Typhoon Vera (Isewan typhoon) (1959) forecasts

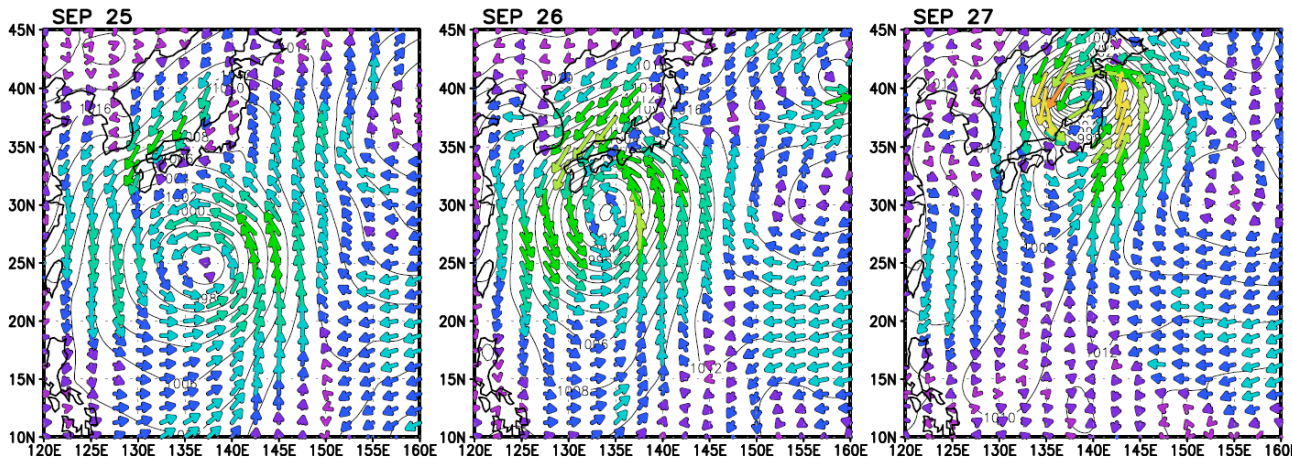


Case studies of past devastating events with reanalysis would be of great help for planning of disaster prevention, decision making in case of disasters as adaptation strategy.

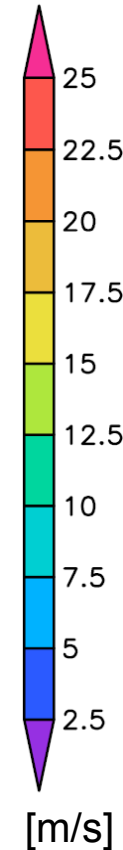
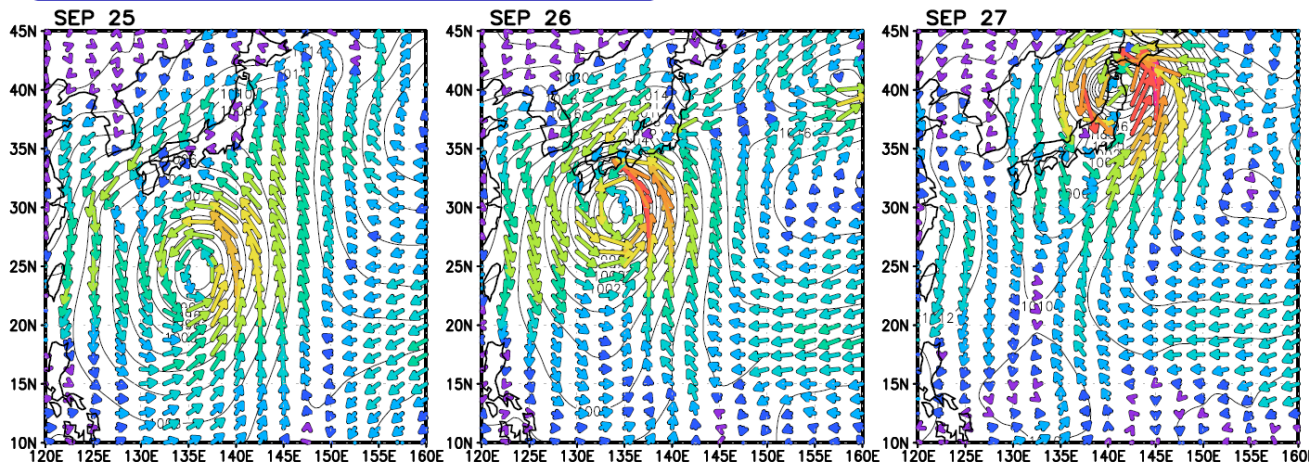


Re-analysis of Typhoon Vera 1959

ERA40 Ps, Us



JRA-55 Test Ps, Us



JRA-55 high resolution would improve representations (intensity) of typhoons in reanalysis products.

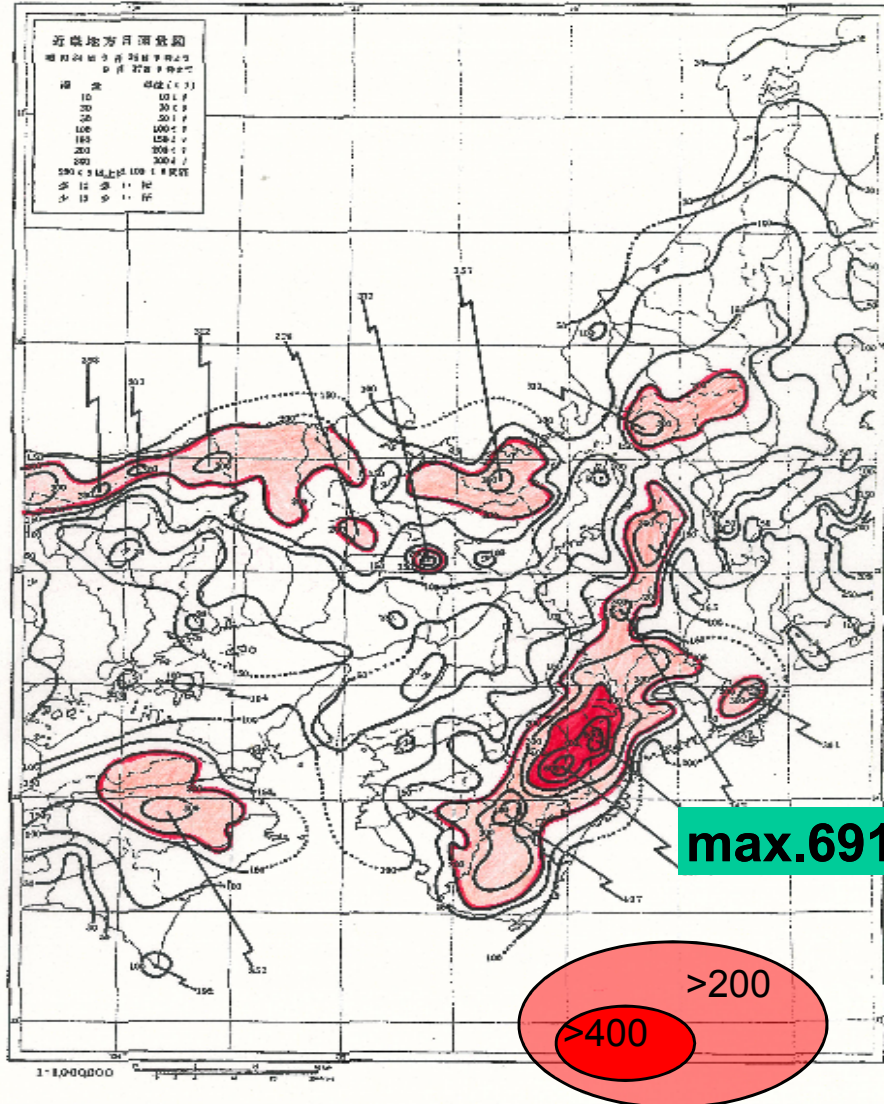
Surface pressure and wind fields in (upper) ERA-40 and (lower) JRA-55 test experiment with JRA-55 resolution. 1.25 deg data are plotted in both figures.



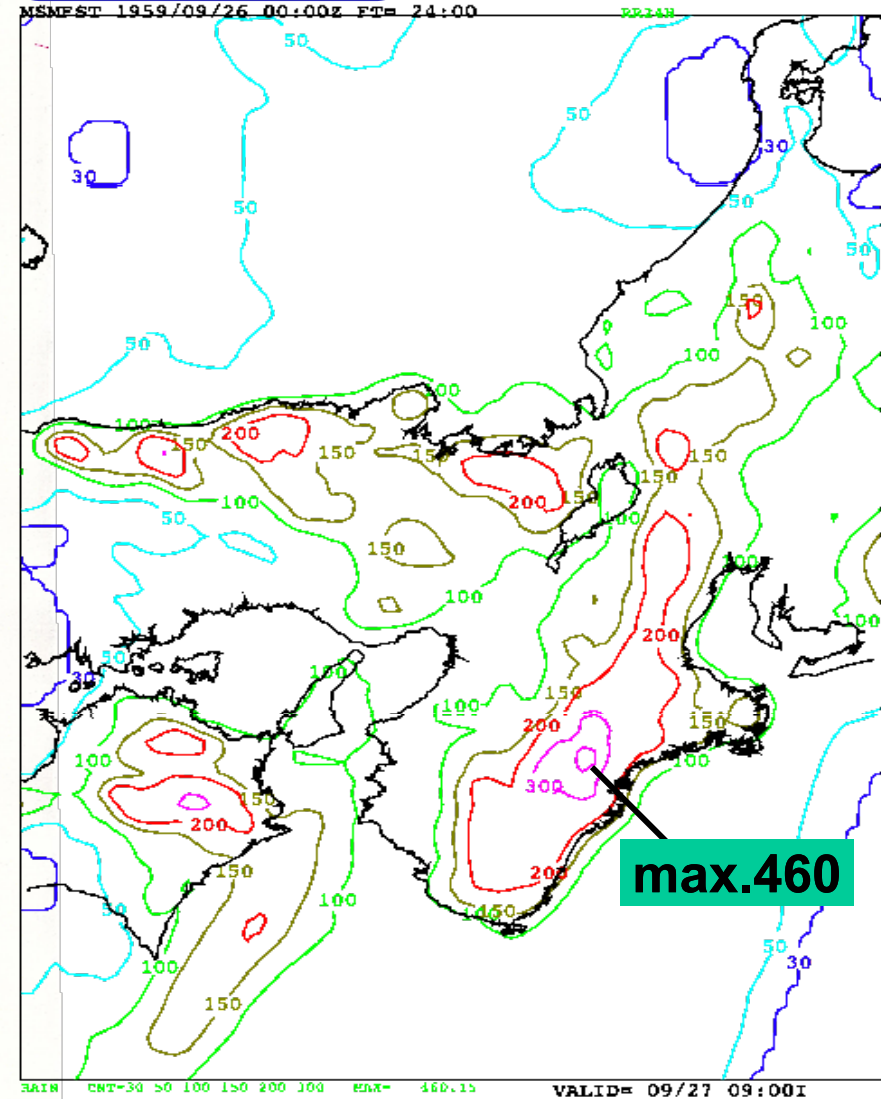
Typhoon Vera 1959 forecast with JMA non-hydrostatic model

Accumulated 24-hr Rainfall (1959.09.26,00UTC-1959.09.27,00UTC)

Observation



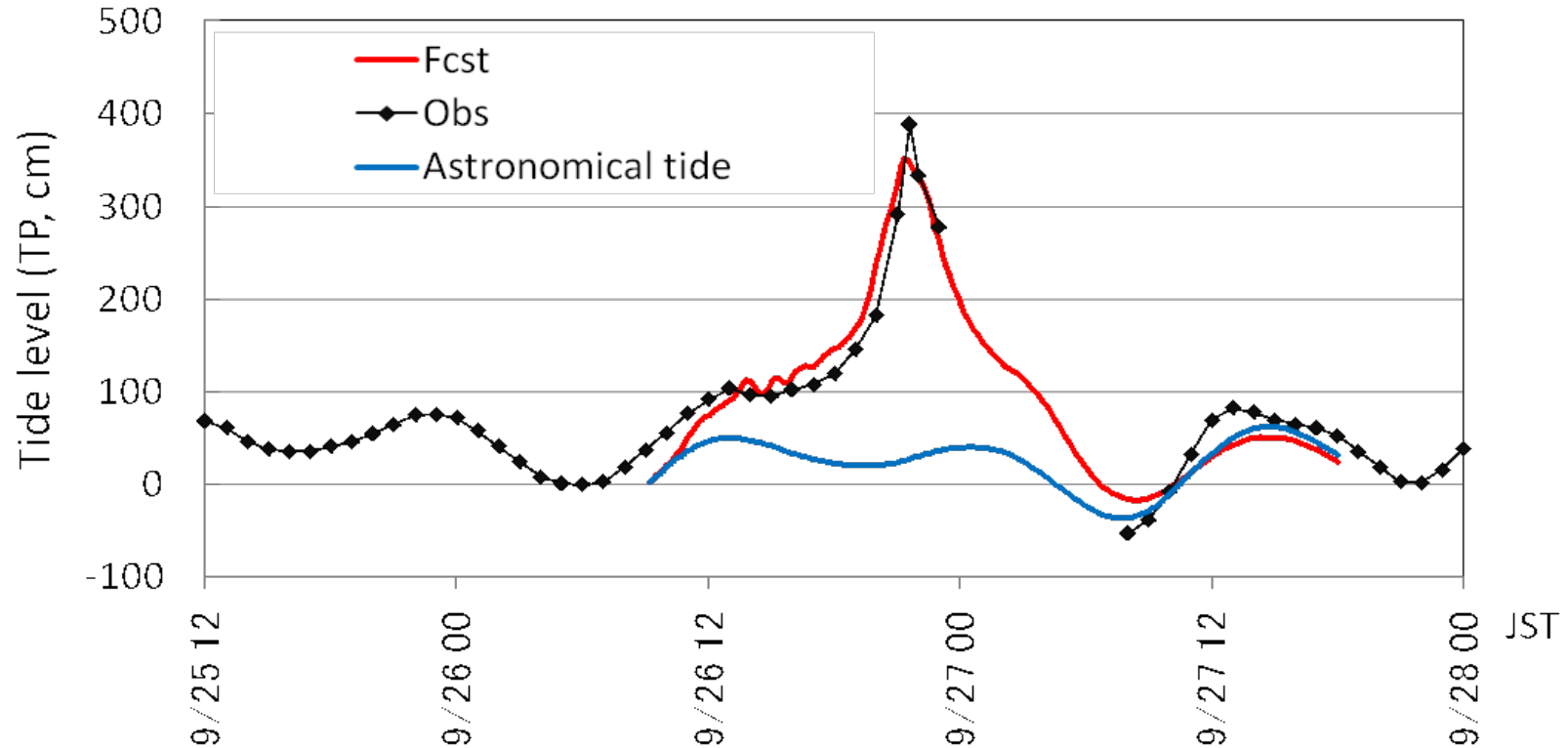
Forecast





Comparison between Forecast and Observation Storm Surge in Isewan Bay

Sea level at Nagoya Port



	Max anomaly (time)	Max tide level (time)
Observation	3.45 m (12:35)	3.89 m (12:35)
Forecast	3.26 m (12:20)	3.52 m (12:20)



Summary

- **Reanalysis**

- based on maximally available observation data with enhanced QC
- continuously produced analysis data for a long period with the latest analysis system
- **Best estimates or proxies of the truth** with homogenous constant quality

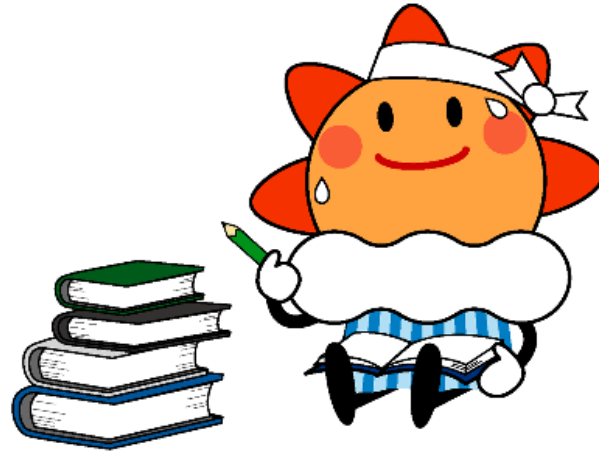
- **JRA-55 will be released in 2013.**

- **Applications of reanalysis**

- Reanalysis is widely used for various purposes.
 - Operational long-range forecasting system
 - Initials for predictions and for hindcasts
 - Forcing data in ocean data assimilation
 - Verification in forecasts predictability
 - Research activities
 - Climate monitoring
 - Extreme events
 - Decadal variations and global warming
- Assessment and adaptation for climate change
 - Reproducing extreme events in the past



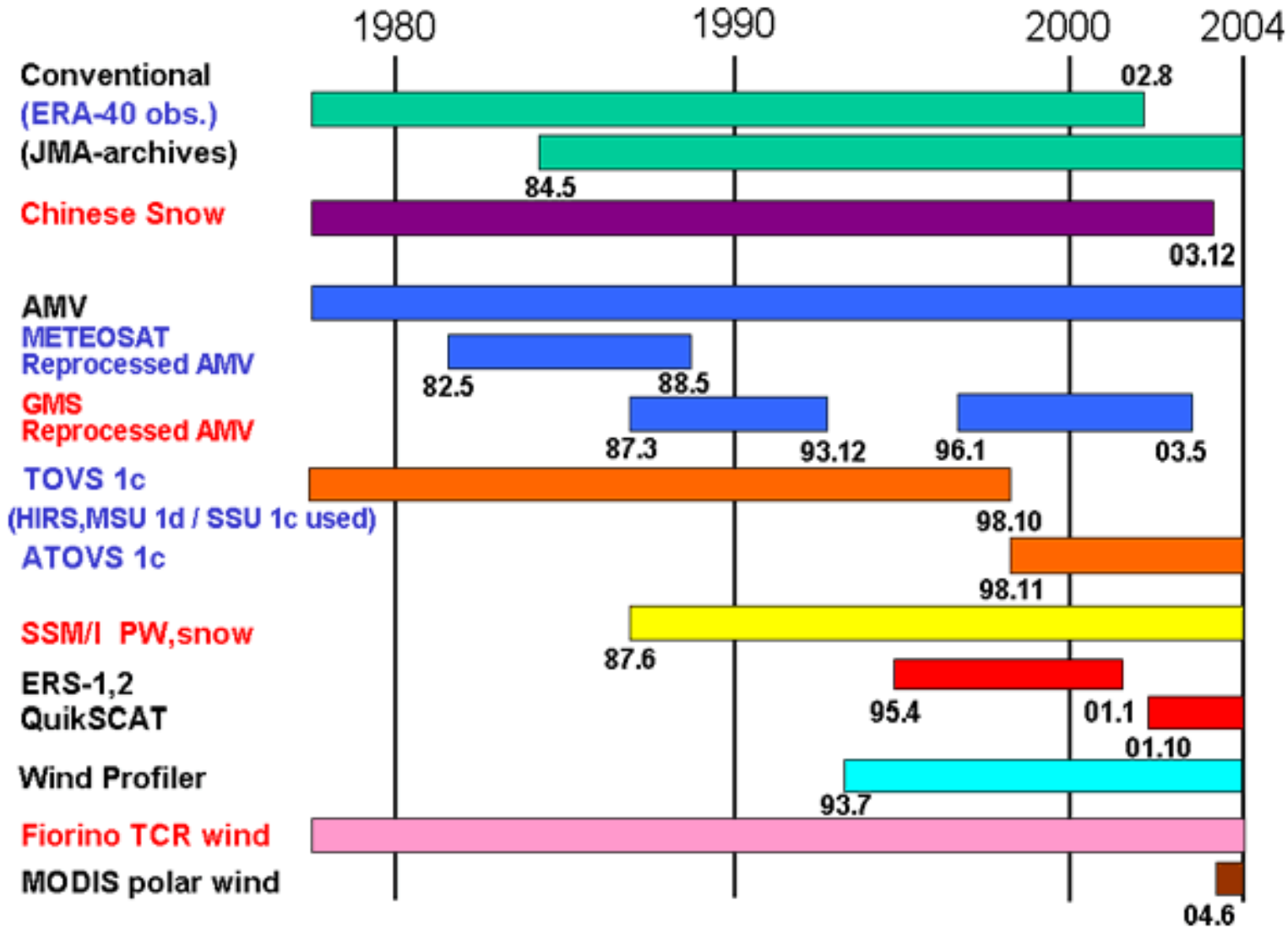
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Thank you for your attention



Observation data used for JRA-25



Datasets written in **red** are used for the first time in reanalyses.