

# TASK TEAM FOR THE INTERCOMPARISON OF REANALYSES (TIRA)

Michael Bosilovich

(drawing on input from the TIRA  
telecons)

# Main Objectives of TIRA

- ▣ The primary charge to the TIRA is to develop a reanalysis intercomparison project plan that will attain the following objectives.
  - 1) To foster understanding and estimation of **uncertainties in reanalysis** data by intercomparison and other means
  - 2) To **communicate** new developments and best practices among the **reanalyses producing centers**
  - 3) To enhance the **understanding of data and assimilation** issues and their impact on uncertainties, leading to improved reanalyses for climate assessment
  - 4) To communicate the **strengths and weaknesses of reanalyses**, their fitness for purpose, and best practices in the use of reanalysis datasets by the scientific community

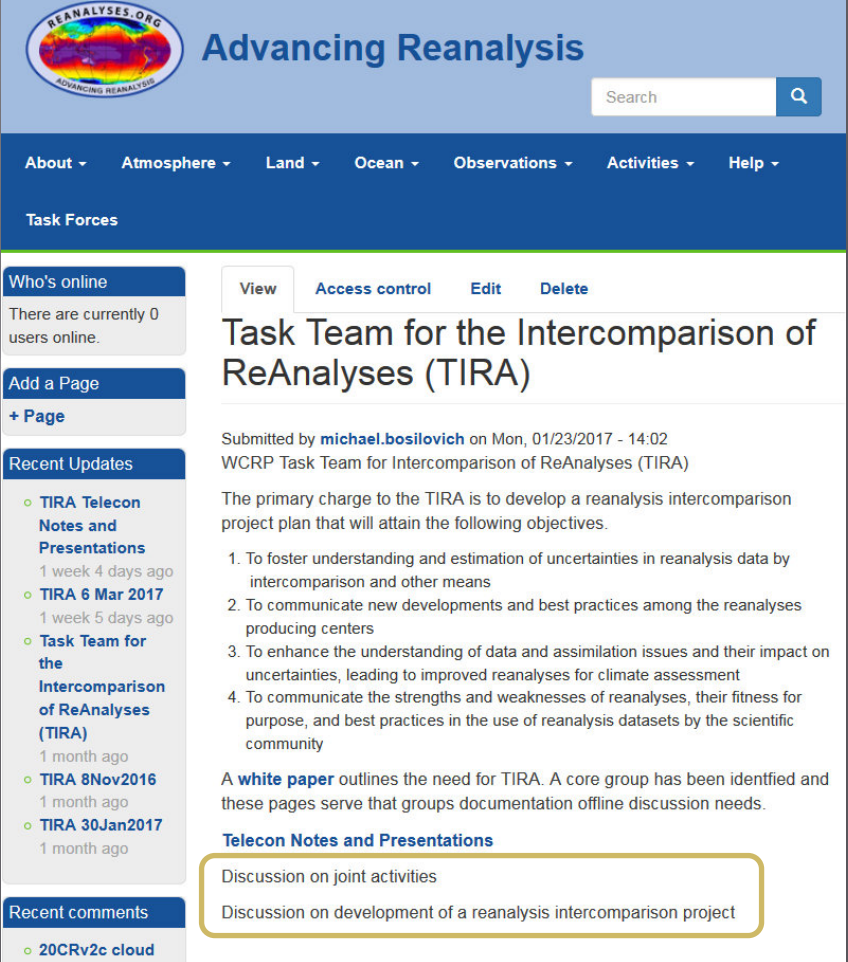
# Task Team Members

- ▣ Magdalena Balmaseda (ECMWF/CLIVAR)
- ▣ Michael Bosilovich (NASA/GMAO/USA Co-Chair\*)
- ▣ Gil Compo (CIRES/WRIT/USA)
- ▣ Chris Derksen (ECCC/CliC/Canada)
- ▣ Masatomo Fujiwara (JMA/SPARC/Japan/S-RIP)
- ▣ Hans Hersbach (ECMWF)
- ▣ Shinya Kobayashi (JMA)
- ▣ Chenghu Sun (CMA/NMIC)
- ▣ Suranjana Saha (NOAA/EMC/USA)
- ▣ Gerald Potter (NASA/CREATE/USA)
- ▣ Otis Brown (NCSU/USA/WDAC)
- ▣ Michel Rixen (WCRP)

\*Looking for a co-chair

# Telecons

- ▣ 8 Nov 16
  - Introductions/Status
  - Mission
- ▣ 21 Dec 2017
  - Intro cont.
  - AGU and ICR5
- ▣ 30 Jan 2017
  - Intercomparison Tools (WRIT/CREATE)
  - Reanalysis.org
- ▣ 6 Mar 2017
  - S-RIP and Ocean Reanalysis Workshop Reviews



The screenshot shows the ReAnalyses.org website. The header features the logo and the text 'Advancing Reanalysis'. A navigation bar includes links for About, Atmosphere, Land, Ocean, Observations, Activities, and Help. Below this is a 'Task Forces' section. The main content area displays the 'Task Team for the Intercomparison of ReAnalyses (TIRA)' page, which includes a submission by Michael Bosilovich, a description of the project's objectives, and a list of four goals. A sidebar on the left contains sections for 'Who's online', 'Add a Page', 'Recent Updates' (listing TIRA Telecon Notes and Presentations, TIRA 6 Mar 2017, Task Team for the Intercomparison of ReAnalyses (TIRA), TIRA 8 Nov 2016, and TIRA 30 Jan 2017), and 'Recent comments' (listing 20CRv2c cloud). A search bar is located in the top right corner.

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1 week 4 days ago
- TIRA 6 Mar 2017  
1 week 5 days ago
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1 month ago
- TIRA 8 Nov 2016  
1 month ago
- TIRA 30 Jan 2017  
1 month ago

Recent comments

- 20CRv2c cloud

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## Task Team for the Intercomparison of ReAnalyses (TIRA)

Submitted by [michael.bosilovich](#) on Mon, 01/23/2017 - 14:02  
WCRP Task Team for Intercomparison of ReAnalyses (TIRA)

The primary charge to the TIRA is to develop a reanalysis intercomparison project plan that will attain the following objectives.

1. To foster understanding and estimation of uncertainties in reanalysis data by intercomparison and other means
2. To communicate new developments and best practices among the reanalyses producing centers
3. To enhance the understanding of data and assimilation issues and their impact on uncertainties, leading to improved reanalyses for climate assessment
4. To communicate the strengths and weaknesses of reanalyses, their fitness for purpose, and best practices in the use of reanalysis datasets by the scientific community

A [white paper](#) outlines the need for TIRA. A core group has been identified and these pages serve that groups documentation offline discussion needs.

**Telecon Notes and Presentations**

Discussion on joint activities

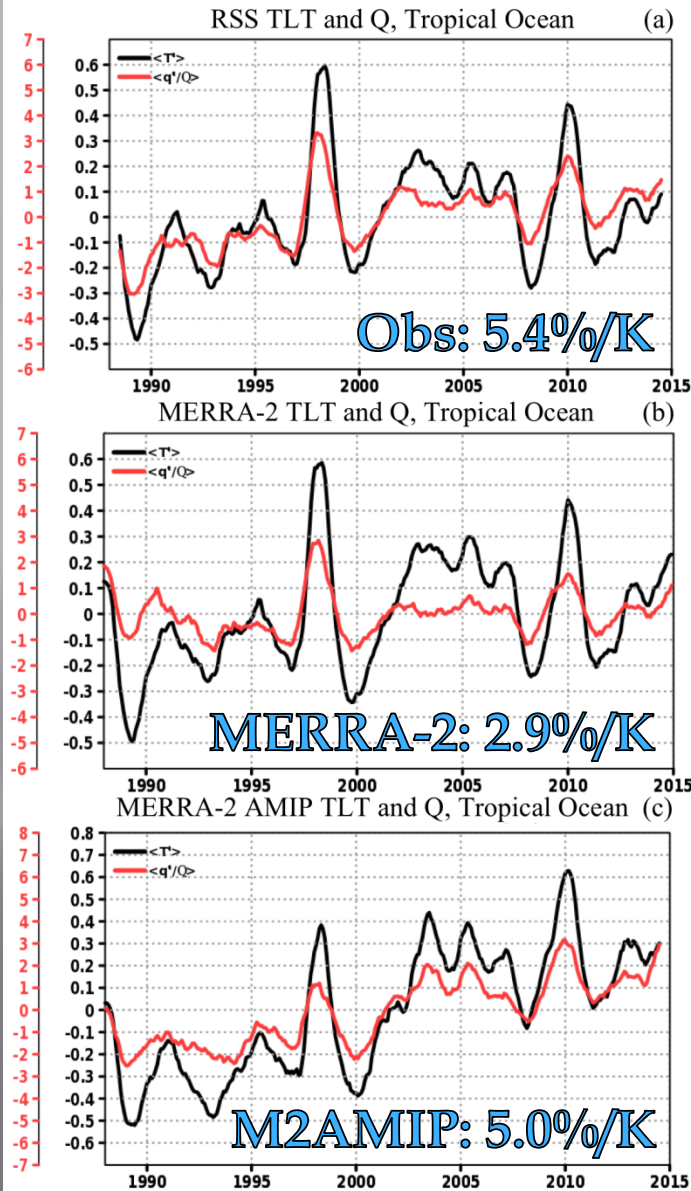
Discussion on development of a reanalysis intercomparison project



# Joint Activities

- ▣ **Concept:** Common issues can be present in more than one reanalysis, or new methods make help produce improved analysis
- ▣ **Action:** Determine which centers can participate. Develop an experimental plan including case studies and/or additional diagnostic output
- ▣ **Cost:** Developing centers incur computing and time to evaluate the experiments
- ▣ **Benefit:** Should provide more understanding of the reanalysis method than could be accomplished alone

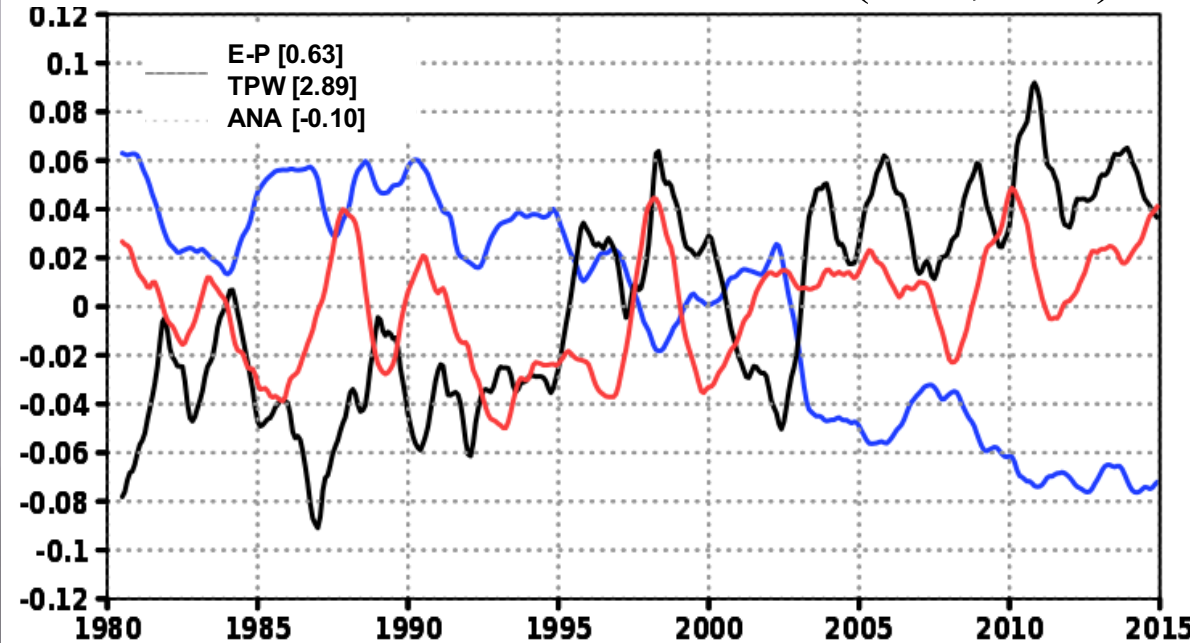
# Example: Clausius-Clapyeron



- Using TLT and TPW, MERRA-2 shows a weaker C-C relationship compared to RSS obs and AMIP simulation
- Analysis increment counters some local evaporative increases
- Other reanalyses also show a weak C-C relationship
- Bosilovich et al. (2016, JClm); Schröder et al. (2016, JAMC)

# Ocean Anomalies: TPW, Evaporation and Analysis Increment

MERRA-2 Ocean Anomalies (60S,60N)



- TPW does respond to SST (e.g. apparent ENSO signal)
- E-P is increasing over the period, generally in response to SST, but also varies according to wind.
- Increment is always negative, and decreases in time – countering a model wet bias
- In MERRA-2, it appears the Analysis is damping C-C

# Extension to Other Systems using T850 as a Proxy

| System  | T    | Q   | dT/dt | dQ/dt | %/K<br>Detrend | %/K<br>Trend | %/K<br>S(Q)/S(T) | Corr(T,Q) |
|---------|------|-----|-------|-------|----------------|--------------|------------------|-----------|
| OBS     | TLT  | TPW | 0.10  | 1.03  | 4.6            | 5.4          | 6.2              | 0.90      |
| MERRA2  | TLT  | TPW | 0.11  | 0.15  | 3.2            | 2.9          | 3.7              | 0.78      |
| M2AMIP  | TLT  | TPW | 0.28  | 1.53  | 4.5            | 5.0          | 7.1              | 0.97      |
| MERRA2  | T850 | TPW | 0.20  | 0.15  | 4.0            | 2.3          | 5.3              | 0.63      |
| M2AMIP  | T850 | TPW | 0.24  | 1.53  | 6.0            | 6.2          | 3.7              | 0.97      |
| ERA1    | T850 | TPW | 0.05  | 0.23  | 4.3            | 4.3          | 10.9             | 0.58      |
| JRA55   | T850 | TPW | 0.12  | 0.30  | 4.7            | 4.0          | 6.4              | 0.71      |
| 20CR    | T850 | TPW | 0.13  | 0.84  | 6.8            | 6.7          | 6.4              | 0.95      |
| ERA20C  | T850 | TPW | 0.27  | 1.42  | 7.1            | 5.9          | 7.2              | 0.94      |
| ERA20CM | T850 | TPW | 0.22  | 1.38  | 7.0            | 6.5          | 5.7              | 0.98      |

▣ Trends are K/dec and %/decade; MERRA and CFSR withheld



# Next Steps

- ▣ Need further variables to test reanalyses (TLT, ANA) more completely
  - If not a result of analysis increment in other reanalyses, then what holds back the C-C relationship?
- ▣ Test satellite reanalyses removing water vapor assimilation (likely too expensive for most or all centers to consider)

# Developing a Reanalysis Intercomparison Project


- ▣ Perhaps more of a coordinating body, than an actual project
- ▣ Could have membership that includes the disciplinary projects as well as developing centers
- ▣ Maintain and promote best practices and promotes communication of results
- ▣ Still needs discussion

# Atmospheric Reanalysis Plans

- ▣ NASA GMAO
- ▣ JMA
- ▣ ERA
- ▣ NCEP

# NASA Reanalyses

- ❑ MERRA was discontinued in Feb 2016, but is still the most cited J. Clim paper over the last 3 years
- ❑ MERRA-2 Special Collection is being developed. The overview paper is reviewed and should be accepted soon
- ❑ Thinking is going into the next reanalysis. More coupling to land and ocean. No firm timetable set



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These are the most cited articles over the past 3 years. This list is organized with the articles in descending order with the most cited article at the top.

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1. MERRA: NASA's Modern-Era Retrospective Analysis for Research and Applications (890 times)

*Michele M. Rienecker, Max J. Suarez, Ronald Gelaro, Ricardo Todling, Julio Bacmeister, Emily Liu, Michael G. Bosilovich, Siegfried D. Schubert, Lawrence Takacs, Gi-Kong Kim, Stephen Bloom, Junye Chen, Douglas Collins, Austin Conaty, Arlindo da Silva, Wei Gu, Joanna Joiner, Randal D. Koster, Robert Lucchesi, Andrea Molod, Tommy Owens, Steven Pawson, Philip Pegion, Christopher R. Redder, Rolf Reichle, Franklin R. Robertson, Albert G. Ruddick, Meta Sienkiewicz, and Jack Woollen*

*Journal of Climate*  
July 2011, Vol. 24, No. 14  
Published online on July 01, 2011

[Abstract](#)  | [Full-text](#)  | [PDF](#) 



## MERRA-2 Current and Near-Future Products

Data available from the NASA Goddard Earth Sciences (GES) Data Information Services Center (DISC)

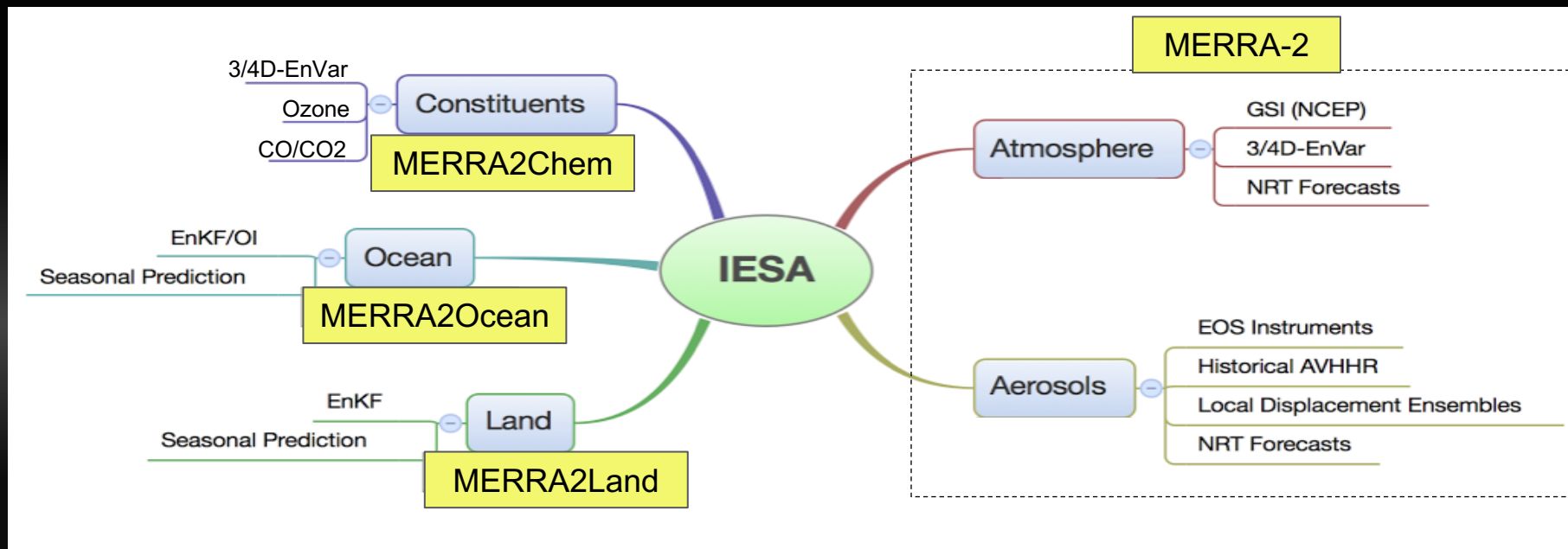
- 1-hourly surface/2D fields (**COSP MODIS/ISCCP**), 3- and 6-hourly 3D fields
- Daily Products ~25 GB/day (9.1 TB/yr)
- Monthly Products ~34 GB/mo (408 GB/yr)

Gridded Innovations and Observations (6 hourly conventional - monthly radiances O-F, O-A and BC, still under a QC review and documentation)

Ensemble of 10 AMIP integrations using MERRA-2 model configuration

MERRA-2-driven analyses of ocean state (physics and biogeochemistry), atmospheric chemistry (EOS period), and carbon cycle (~Summer 2017)

# Toward NASA's Integrated Earth System Analysis



**Coupled and MERRA2-driven component  
reanalyses**

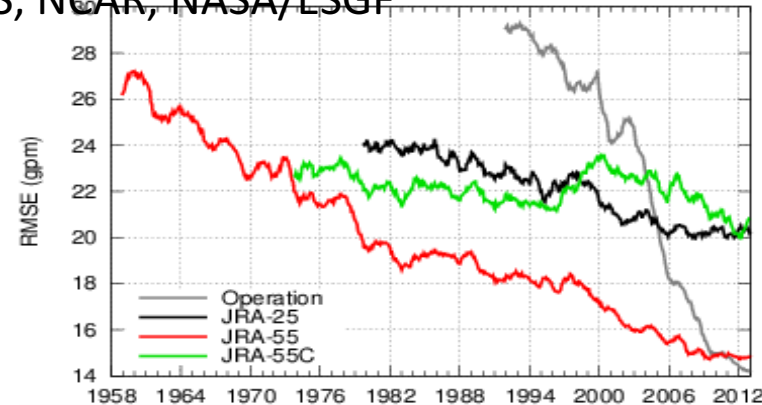




# JRA-55 family



- To facilitate investigations on the credibility of trends and low-frequency variability represented in JRA-55, different types of product have been produced with the common NWP system.
- **JRA-55 (JMA)**
  - Full observing system reanalysis
  - Available from JMA (<http://jra.kishou.go.jp>), DIAS, NCAR, NASA/ESGF
  - [S. Kobayashi et al. \(2015\)](#), [Harada et al. \(2016\)](#)
- **JRA-55C (MRI/JMA)**
  - Using conventional observations only
  - Available from DIAS, NCAR
  - [C. Kobayashi et al. \(2014\)](#)
- **JRA-55AMIP (MRI/JMA)**
  - AMIP type run
  - Available from DIAS, NCAR



*RMS errors of 2-day forecasts of geopotential height (gpm) at 500hPa averaged over the northern hemisphere*

[Adapted and updated from C. Kobayashi \(2014\)](#)





# The next Japanese reanalysis

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- **JRA-3Q** (pronounced as “Thank you!” in Japanese)
  - Japanese Reanalysis for Three Quarters of a Century
- **Provisional specifications**
  - **Higher resolution:**  $T_L319L60 \rightarrow T_L479L100$ 
    - 40 km in horizontal, 100 layers up to 0.01 hPa in vertical
  - **Extending the reanalysis period back in time**
    - Atmospheric reanalysis from 1948 (planned) to present
  - **New boundary conditions and forcing fields**
    - COBE-SST2 (from the beginning to 1981)
    - MGD SST (satellite-based SST from 1982 onward)
  - **New observations**
    - Observations newly rescued and digitised by ERA-CLIM et al.
    - Improved satellite observations through reprocessing
    - JMA’s own tropical cyclone bogus



# Data assimilation system

|  | JRA-55                                       | JRA-3Q  |
|--|--|---|
| Base system                                      | JMA's operational system as of December 2009 | JMA's operational system as of 2018 (planned)   |
| Horizontal resolution                            | T <sub>L</sub> 319 (~55 km)                  | T <sub>L</sub> 479 (~40 km)   |
| Vertical levels                                  | 60 levels up to 0.1 hPa                      | 100 levels up to 0.01 hPa   |
| Analysis scheme                                  | 4D-Var<br>(with the T106 inner resolution)   | 4D-Var<br>(with the T <sub>L</sub> 319 inner resolution)  |
| Radiative transfer model for satellite radiances | RTTOV-9.3                                    | RTTOV-10.2 (used in the current system) <ul style="list-style-type: none"><li>• Improved accuracy</li><li>• Inclusion of the Zeeman effect</li><li>• Inclusion of GHGs variations</li></ul> |
| GNSS-RO  | Refractivity (up to 30 km)                   | Bending angle (up to 60 km)   |

## Status of the CFSR and current CFSv2 operational suite

- The CFS version 2 was developed at the Environmental Modeling Center at NCEP. It is a fully coupled model representing the interaction between the Earth's atmosphere, oceans, land and seaice. It became operational at NCEP in March 2011.
- It also includes a real time weakly coupled data assimilation component which became an extension of the CFS Reanalysis at a higher atmospheric resolution of 28 Km (T574) and a real time coupled forecast model component that generates forecasts that are an extension of the retrospective forecasts generated by the same model.
- There are a total of 16 CFSv2 forecasts every day in real time, of which 4 runs go out to 9 months (required to calibrate the operational Climate Prediction Center (CPC) longer-term seasonal predictions of ENSO, etc.), 3 runs go out to 1 season (required to calibrate the operational CPC first season predictions for hydrological forecasts of precipitation, evaporation, runoff, streamflow, etc.) and 9 runs go out to 45 days (required for the operational CPC week3-week6 predictions of tropical circulations, such as MJO, PNA, etc.).
- All these forecasts are initiated from the CFSv2 real-time data assimilation system (CFSR-extension).
- The CFSv2 is primarily used to produce operational intra-seasonal to interannual forecasts of SST, surface temperature, and precipitation. These forecasts inform the operational prediction products at CPC.
- The skill of CFSv2 monthly and seasonal forecasts is competitive with similar models from other forecast centers and there is continuing development of its participation in real-time Multi-Model Ensemble (MME) forecast systems such as the North American MME (NMME) and the International MME (IMME) in order to inform seasonal prediction efforts at the CPC.



# NCEP Unified Global Coupled System (UGCS) for Weather and Climate Prediction

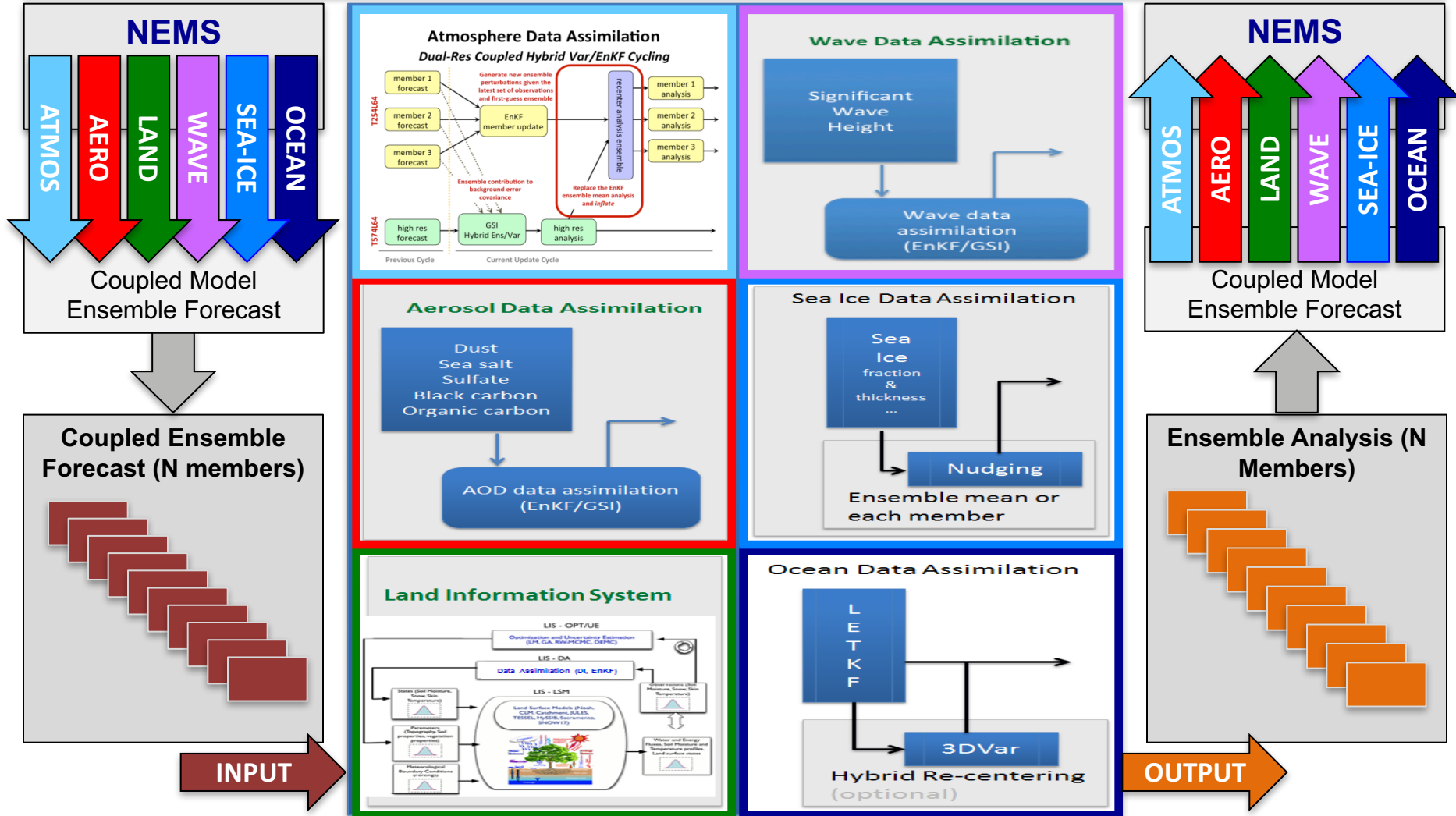


- UGCS will include fully coupled components of the Earth system, namely Atmosphere, Land, Ocean, Sea-Ice, Waves and Aerosol, both for data assimilation and model forecasts.
- Use NEMS/ESMF software
- **Atmosphere** will comprise of a new FV3 dynamic core from GFDL, new physics, higher resolution in the horizontal and vertical, accompanied by an advanced 4D EnVAR data assimilation system
- **Ocean** component will be MOM6 and HYCOM model systems with updated physics and biogeochemistry and an ensemble based coupled data assimilation system
- **Land** component will be the Noah Land model with upgrades to land surface physics and an upgraded ensemble based Land Information System that assimilates new data sources
- **Sea-Ice** component will be CICE5 and SIS2 model systems with an ensemble based coupled sea-ice data assimilation system for seaice cover and thickness
- **Wave** component will be Wavewatch III which will be fully coupled to the atmosphere and ocean, with a new ensemble based coupled data assimilation for assimilating significant wave height observations, etc.
- **Aerosol** component will be GOCART and will also have a ensemble based coupled data assimilation to incorporate AOD and other sources of data.
- Will unify the GFS, GEFS and CFS models under a single unified modeling system for:
  - Weather (GFS):** ~10 days, 10 km, 128 levels, previous 3 year Reanalysis & hindcasts, implement every year
  - Sub-seasonal (GEFS):** ~45 days, 30km, 128 levels, 20+ year Reanalysis & hindcasts (1999-present), implement every 2 years
  - Seasonal (CFS):** ~12 months, 50km, 128 levels, 40+ year Reanalysis & hindcasts (1979-present), implement every 4years.



# NCEP Coupled Hybrid Data Assimilation and Forecast System

## Saha et al.

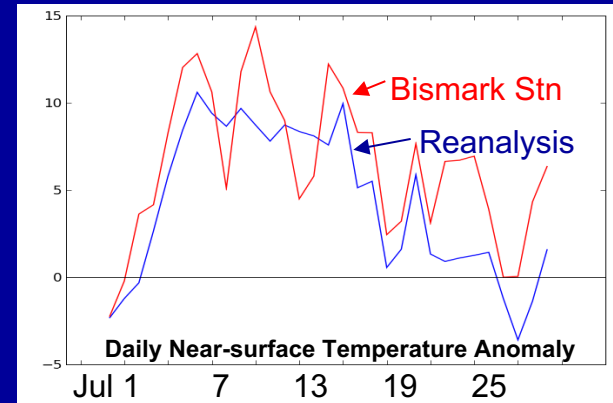
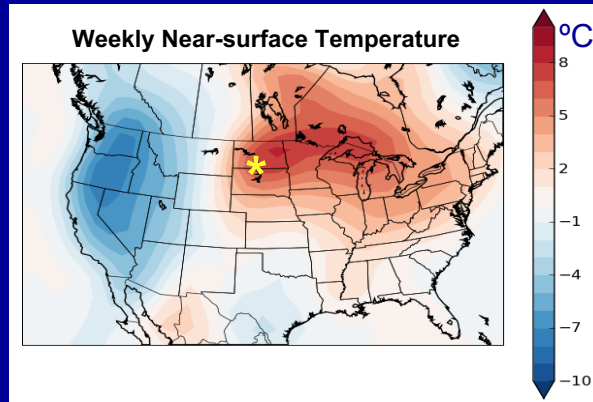


# The 20th Century Reanalysis Project (1851-Present)

**Summary:** An international project led by NOAA and CIRES to produce *4-dimensional* reanalysis datasets for climate applications extending back to the 19th century using an Ensemble Kalman Filter and *only surface pressure observations*.

Weekly-averaged anomaly during  
**July 1936** North American Heat Wave (> 2,000 dead during 10-day span)

Daily variations compare well with in-situ data.



The reanalyses provide:

- First-ever estimates of near-surface to tropopause 6-hourly fields extending to the beginning of the 20<sup>th</sup> century;
- Estimates of uncertainties in the basic reanalyses and derived quantities (e.g., storm tracks).

Examples of uses:

- Validating climate models.
- Determining storminess and storm track variations over the last 150 years.
- Understanding historical climate variations (e.g., 1930s Dust Bowl, 1920-1940s Arctic warming).
- Estimating risks of extreme events

# Historical Reanalysis Status and Plans

## 20th Century Reanalysis Project <http://go.usa.gov/XTd>

- **Fall 2014:** 1871-2012 (includes time-varying CO2, volcanic aerosols, GFS from NCEP). **Ensemble mean and spread and individual member variables online now.**
  - [http://www.esrl.noaa.gov/psd/data/gridded/data.20thC\\_ReanV2.html](http://www.esrl.noaa.gov/psd/data/gridded/data.20thC_ReanV2.html) (NOAA ESRL)
  - <http://dss.ucar.edu/datasets/ds131.1> (NCAR)
  - [http://portal.neresc.gov/20C\\_Reanalysis](http://portal.neresc.gov/20C_Reanalysis) **Every member** (US Dept of Energy, NERSC)
  - NERSC High Performance Storage System Tape Gateway **Every member**
  - Earth System Grid Federation ana4MIPS distribution and validation for IPCC AR5
  - British Atmospheric Data Center (BADC)

## 20CR v2c <http://go.usa.gov/XTd> **Ensemble mean and spread and 3D individual member variables online now.**

**Spring 2016:** 1851-2012, 2013-2014 extension

Very similar system to 20CRv2. Fixed Sea ice using COBE-SST2 sea ice.

More observations, ensemble of SODAsi.2 SST (1851-2012), Reynolds et al. SST (2013-2014).

- distribution via: ESRL, NCAR, NERSC **Every member**

## 20CR version 3

**Winter 2017:** 1851-2015, additional tests for 1815-1850

Higher resolution, improved algorithm and observational quality control

Coordinate with ERA-CLIM2, SOUSEI, GFDL - Test possible BCs: HadISST2.1, COBE-SST2, SODAsi.3

# Development of Suite of NOAA Climate Reanalyses

Joint NOAA NCEP, ESRL, NCDC, Univ. of Colorado CIRES

- Tiered assimilation approach
  - *0. Boundary forced* (equivalent to AMIP); 1850-present
  - *1. Historical using only surface pressure*; 1850-present [20CRv3]
  - *2. Modern using surface and conventional data*; 1946-present
  - *3. Satellite using conventional and satellite data*; 1973-present
- Assimilation System
  - Hybrid Global Statistical Interpolation [3D-Var]/Ensemble Kalman Filter (GSI/EnKF)
  - Possibly T254L64 (~50 km resolution) for 0-2
    - Higher resolution for 3. Satellite

