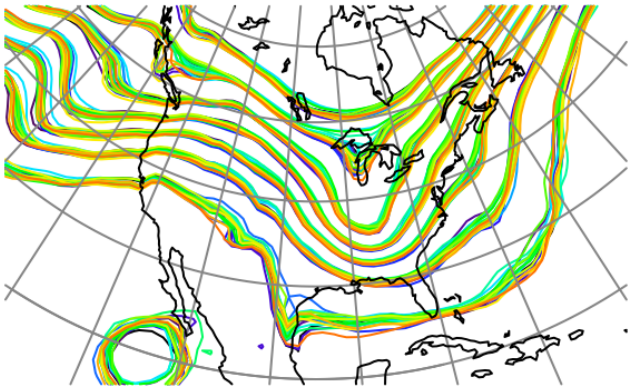
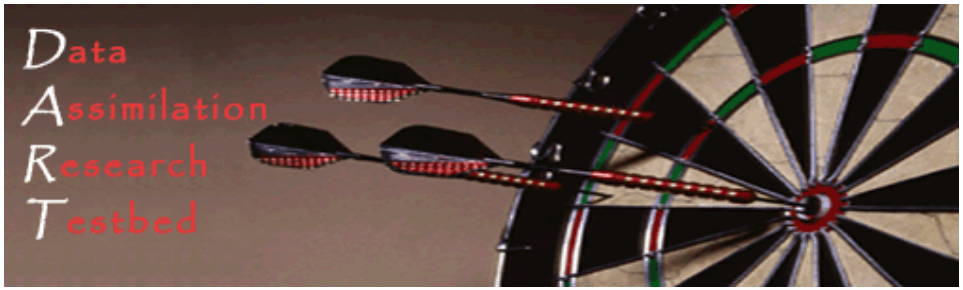


The Data Assimilation Research Testbed:
A Community Facility for Ensemble Data Assimilation

Jeff Anderson, Tim Hoar, Nancy Collins, Kevin Raeder, Hui Liu, Glen Romine



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Overview of Data Assimilation

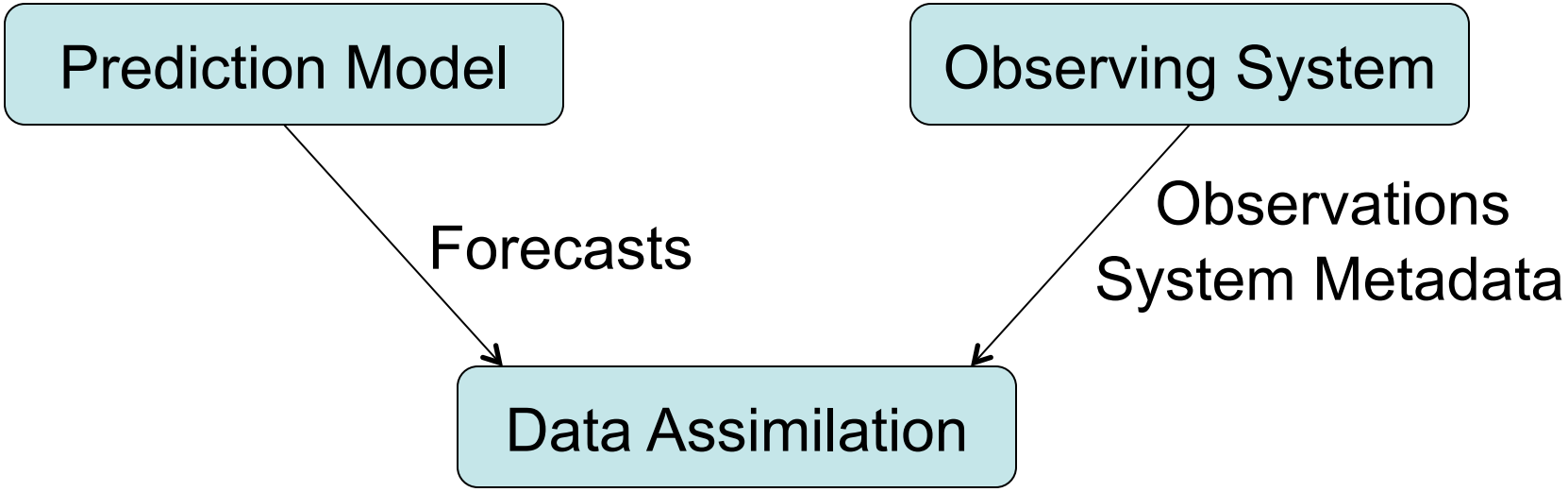
Prediction Model

Overview of Data Assimilation

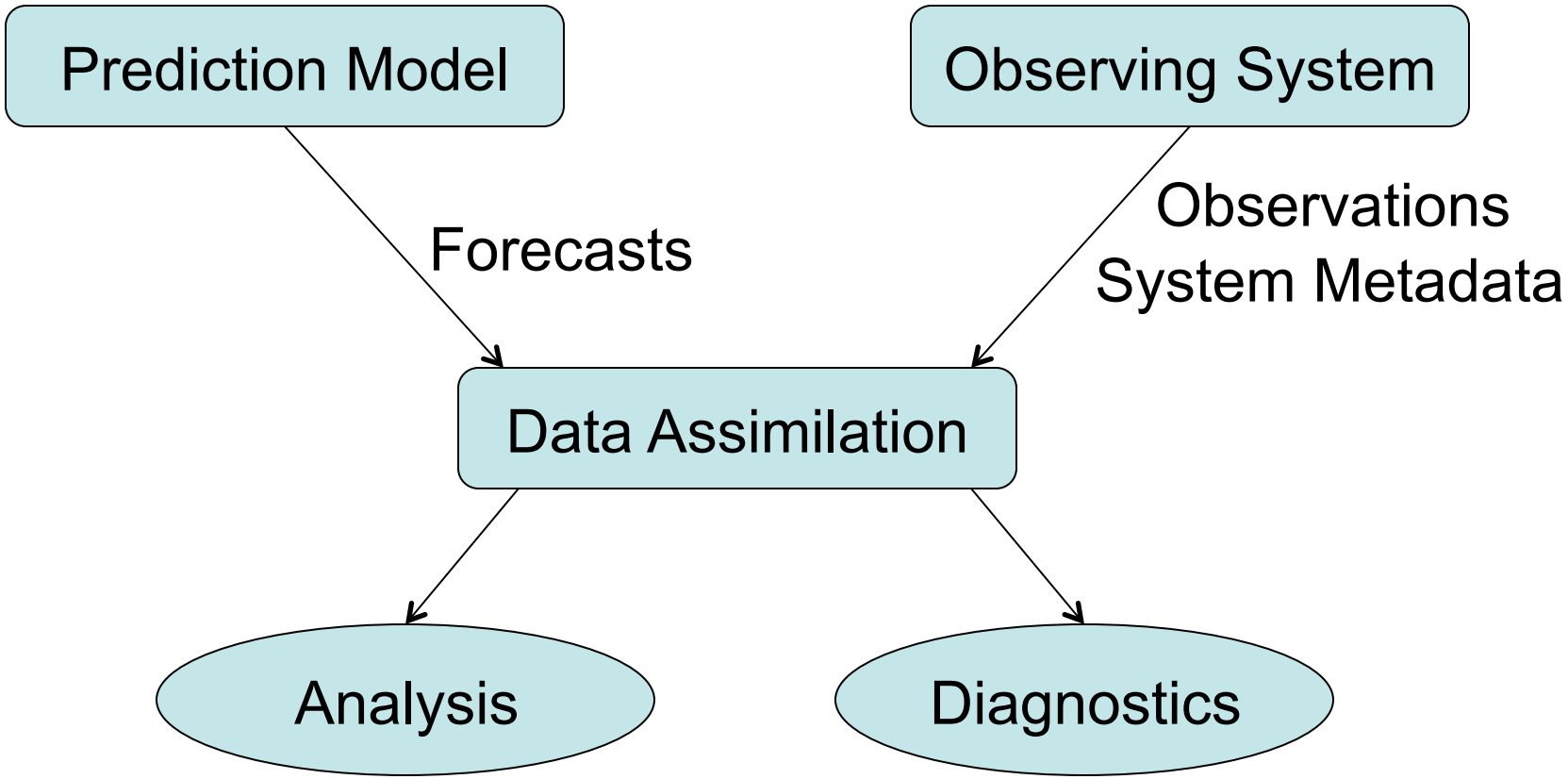
Prediction Model

Observing System

Overview of Data Assimilation



Overview of Data Assimilation



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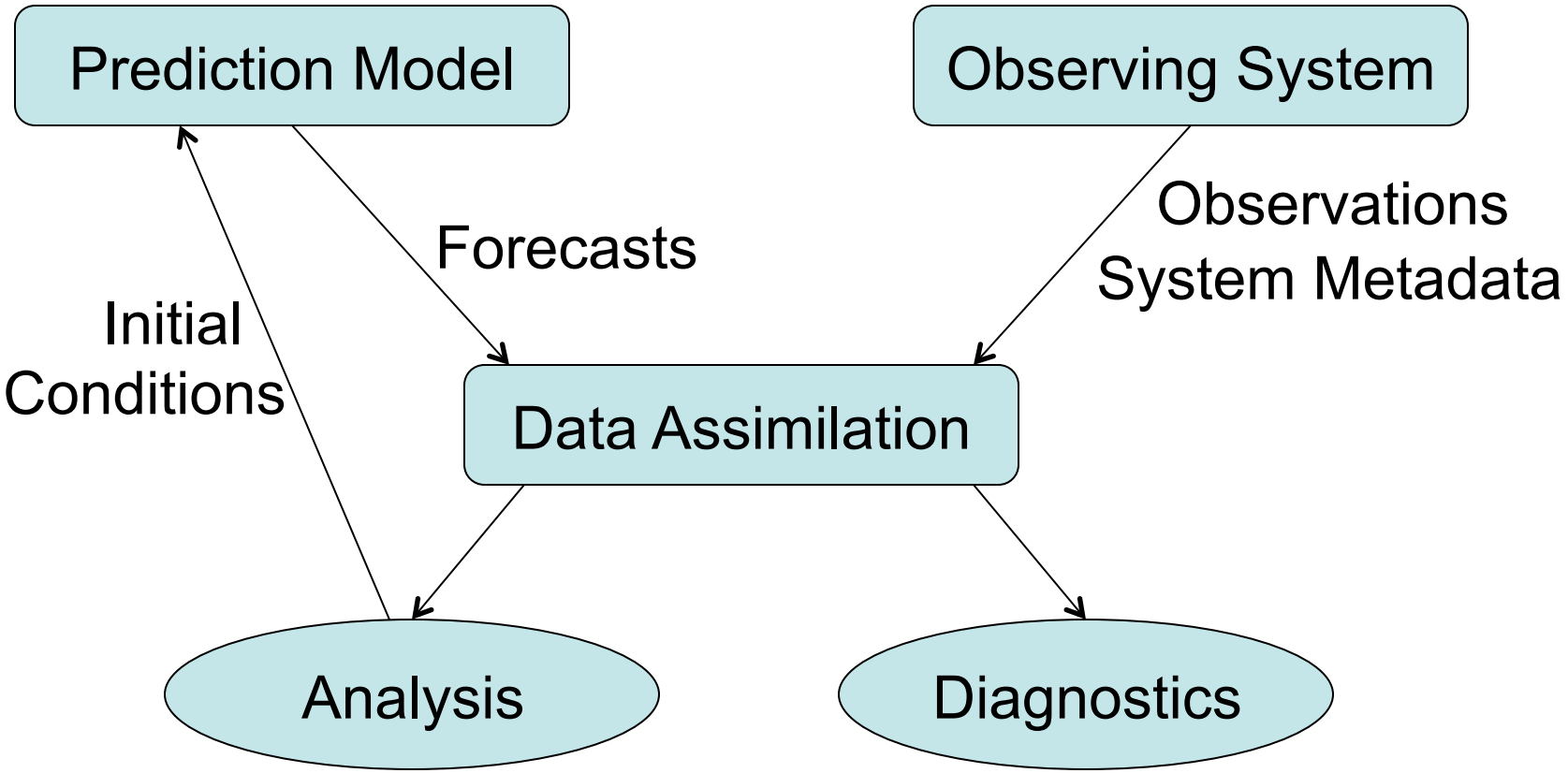

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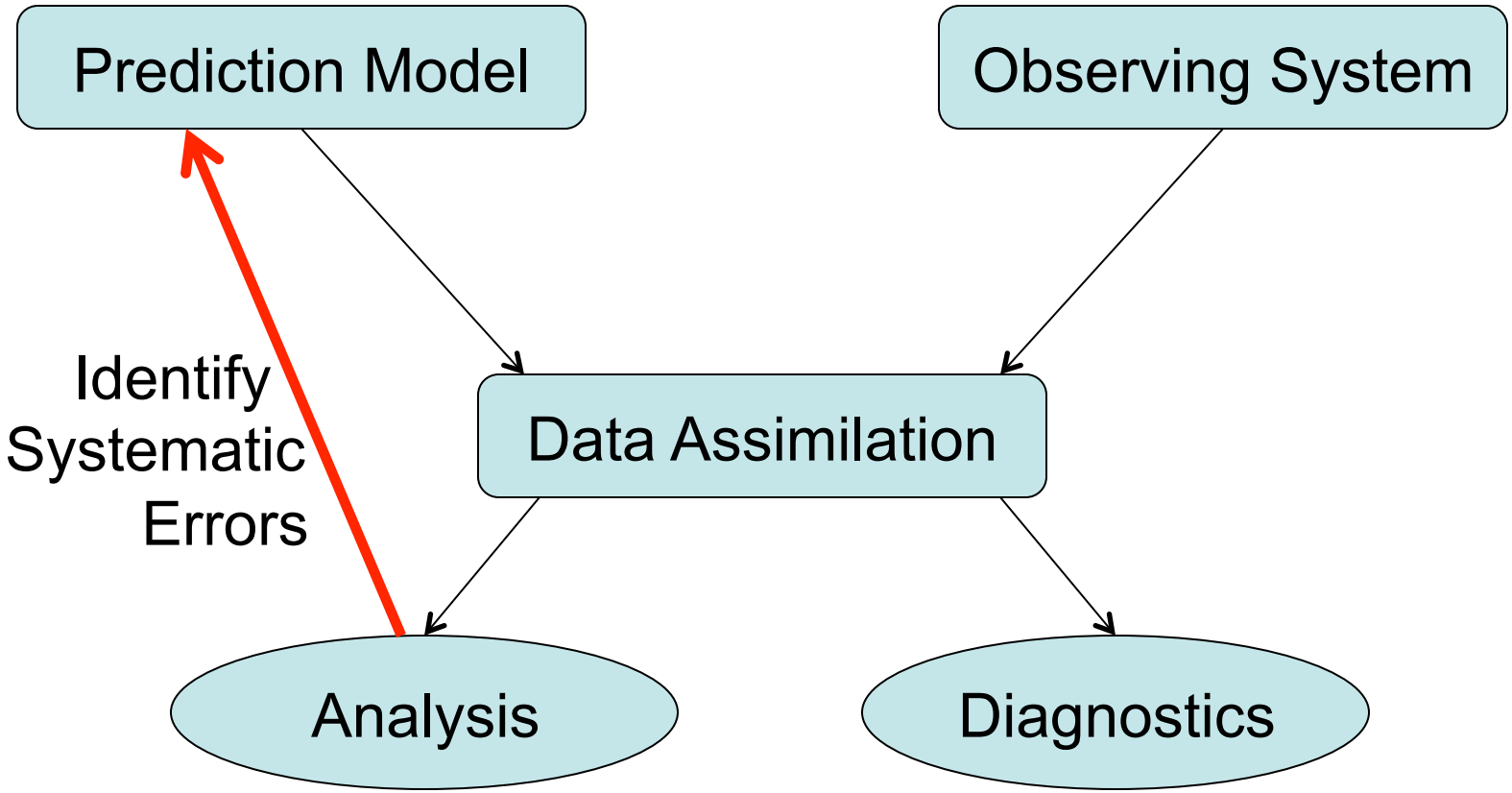

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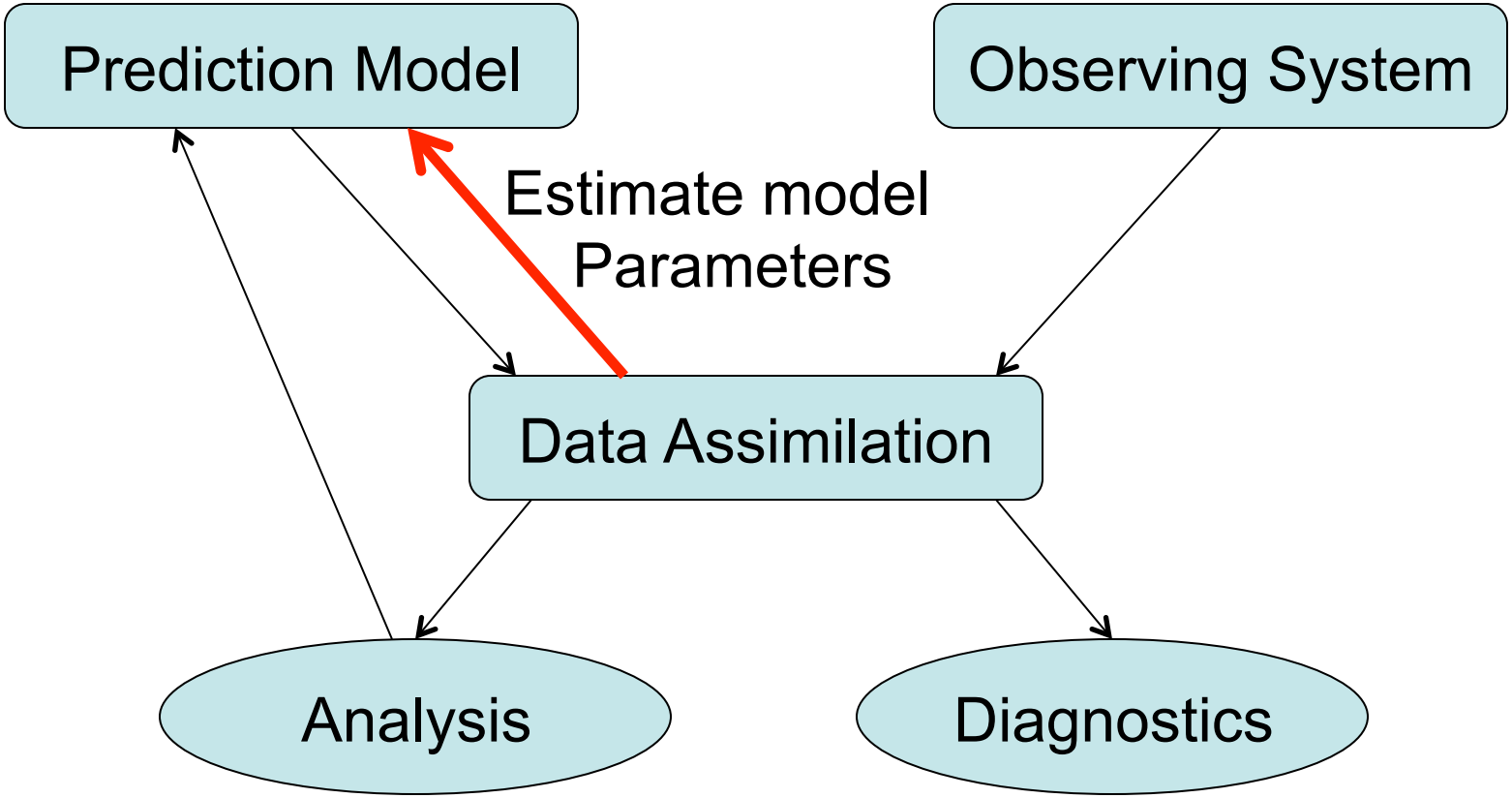

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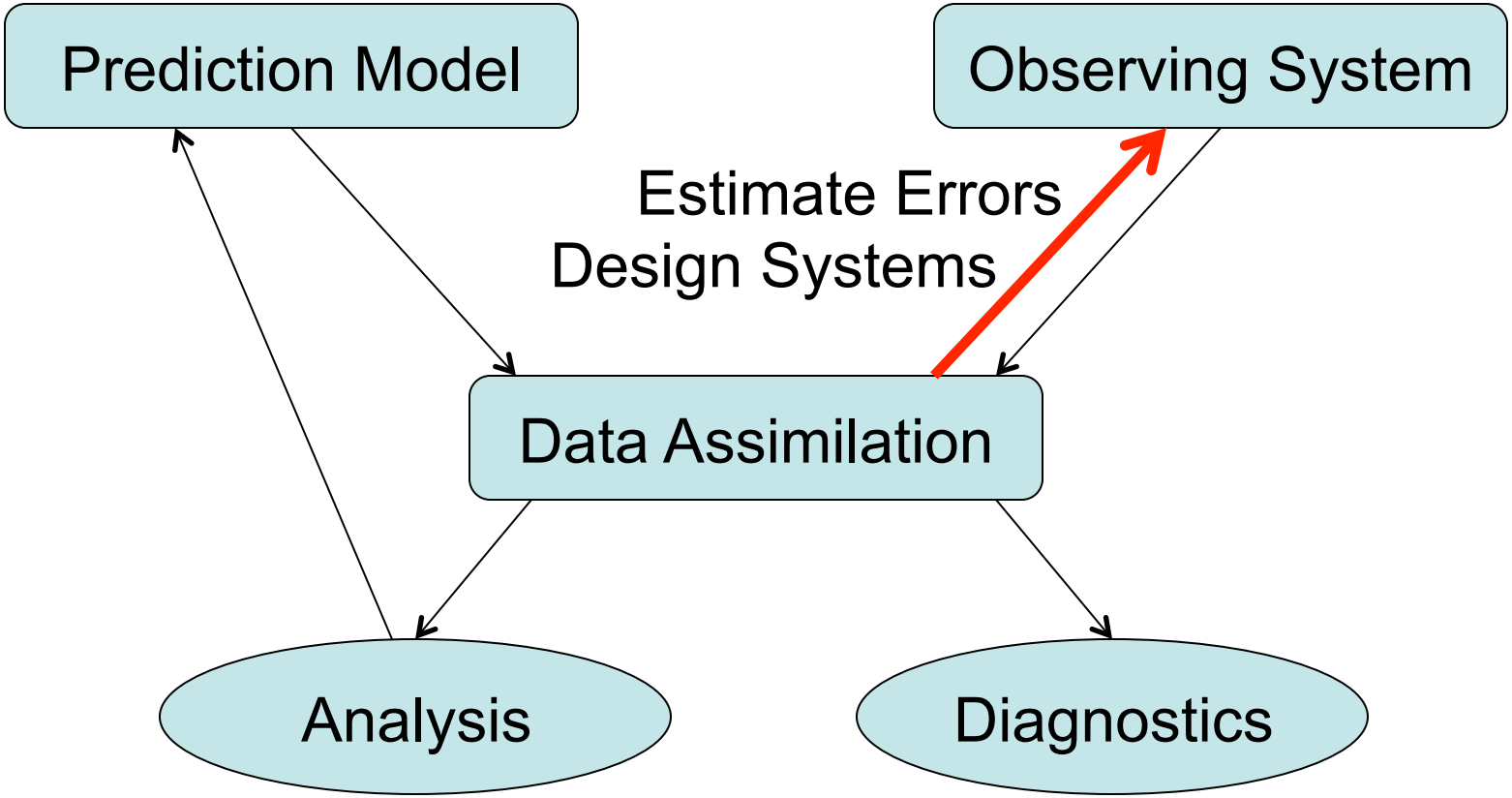
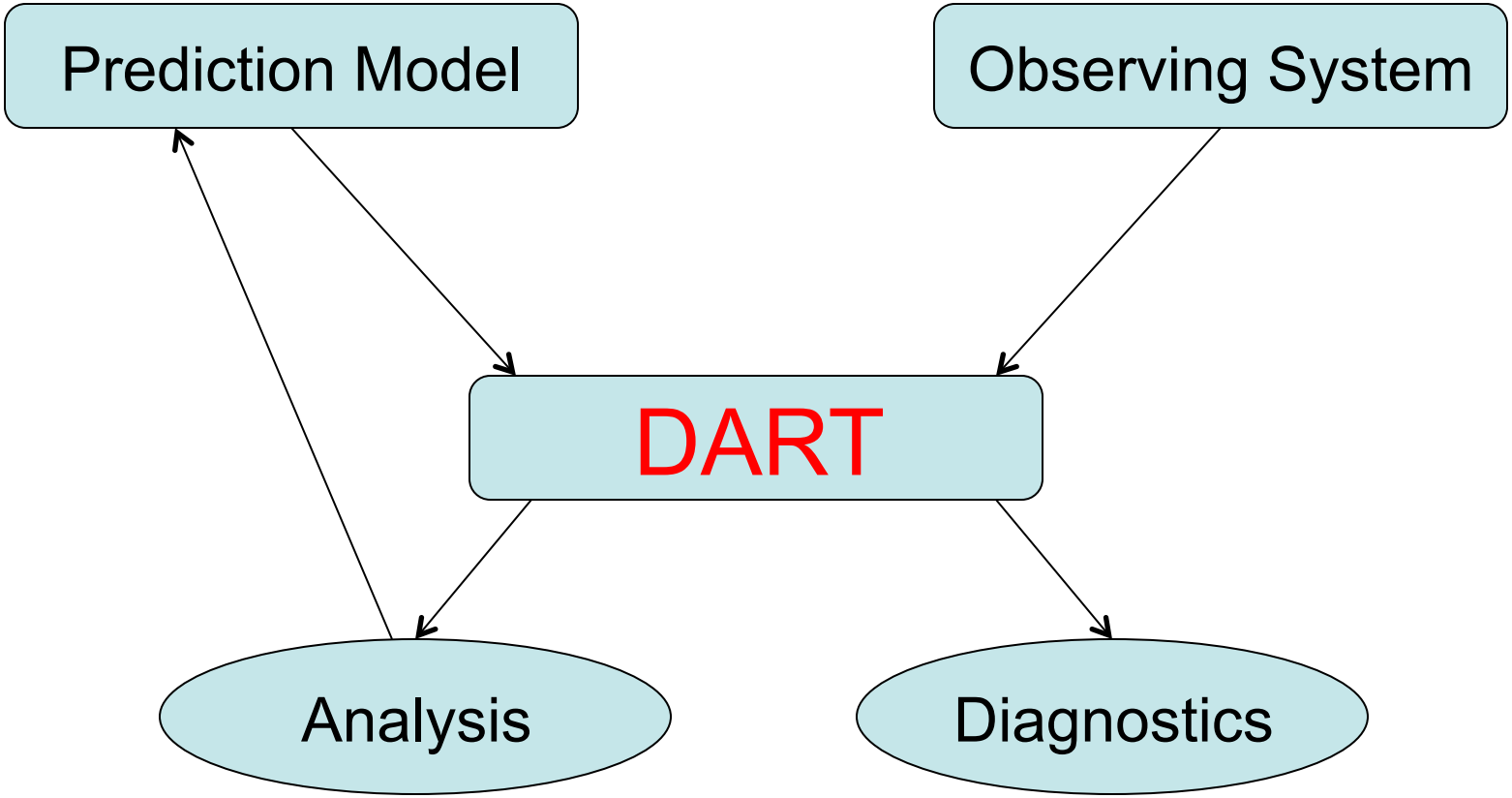


Data Assimilation Research Testbed (DART)

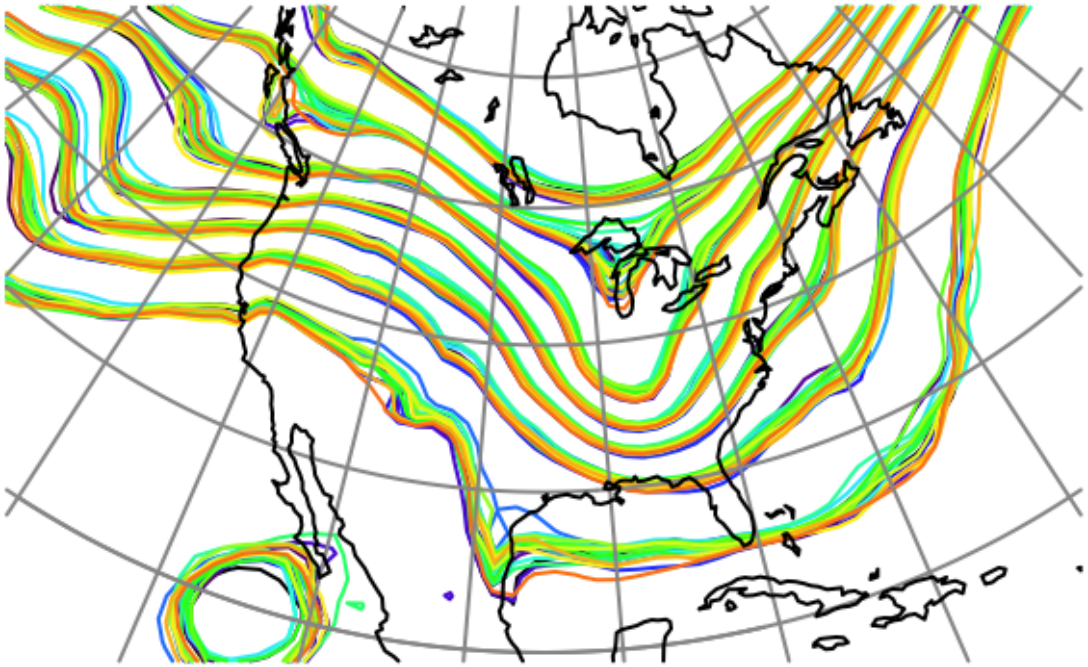


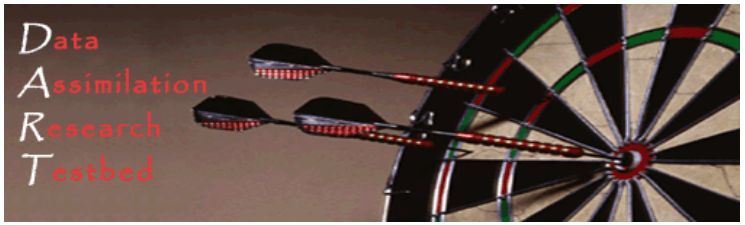
DART is a community ensemble assimilation facility.

What is Ensemble Data Assimilation?

Use an ensemble (set) of model forecasts.

Use sample statistics to get covariance between state and observations.





DART is used at:

48 UCAR member universities
More than 100 other sites

Public domain software for Data Assimilation

- Well-tested, portable, extensible, free!

Models

- Toy to HUGE

Observations

- Real, synthetic, novel

An extensive Tutorial

- With examples, exercises, explanations

People: The DAReS Team

UNIVERSITY OF WASHINGTON

CIRES

THE UNIVERSITY OF UTAH

Central Weather Bureau

GFDL Geophysical Fluid Dynamics Laboratory Princeton, NJ

NOAA

PENNSTATE

CALIFORNIA INSTITUTE OF TECHNOLOGY 1891

JPL
Jet Propulsion Laboratory
California Institute of Technology

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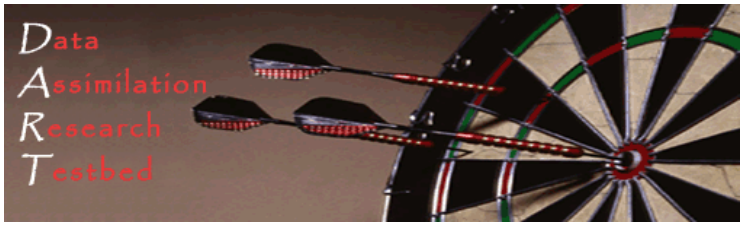


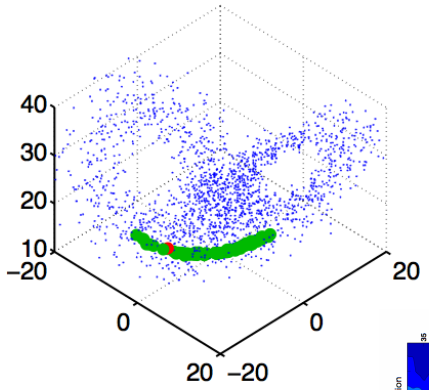
DART is:

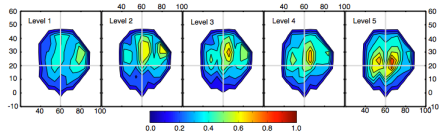
Education

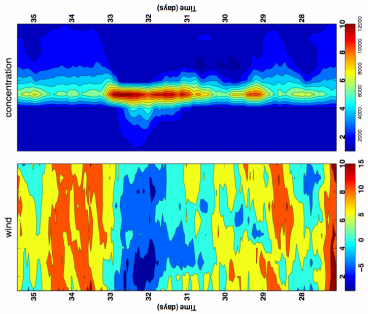
Exploration

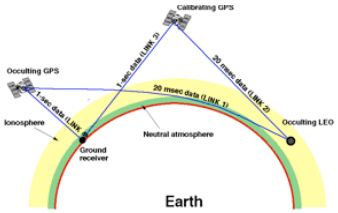
Research

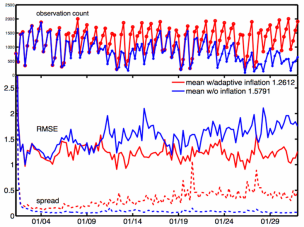
Operations

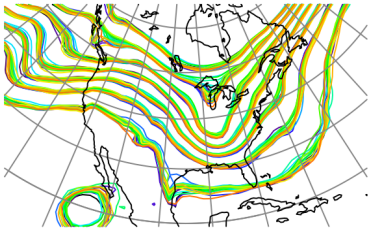


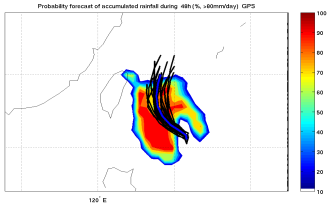












DART works with many geophysical models

Global Atmosphere models:

CAM	Community Atmosphere Model; (all 3 dynamical cores)	NCAR
CAM/CHEM	CAM with Chemistry	NCAR
WACCM	Whole Atmosphere Community Climate Model	NCAR
AM2	Atmosphere Model 2	NOAA/GFDL
NOGAPS	Navy Operational Global Atmospheric Prediction System	US Navy
ECHAM	European Centre Hamburg Model	Hamburg
Planet WRF	Global version of WRF	JPL
MPAS	Model for Prediction Across Scales	NCAR/DOE

DART works with many geophysical models

Regional Atmosphere models:

WRF/ARW	Weather Research and Forecast Model	NCAR
WRF/CHEM	WRF with Chemistry	NCAR
NCOMMAS	Collaborative Model for Multiscale Atmospheric Simulation	NOAA/NSSL
COAMPS	Coupled Ocean/Atmosphere Mesoscale Prediction System	US Navy
CMAQ	Community Multi-scale Air Quality	EPA
COSMO	Consortium for Small-Scale Modeling	DWD

DART works with many geophysical models

Ocean models:

POP	Parallel Ocean Program	DOE/NCAR
MIT OGCM	Ocean General Circulation Model	MIT
ROMS	Regional Ocean Modeling System (under development)	Rutgers
MPAS	Model for Prediction Across Scales (Under development)	DOE/LANL

DART works with many geophysical models

Upper Atmosphere/Space Weather models:

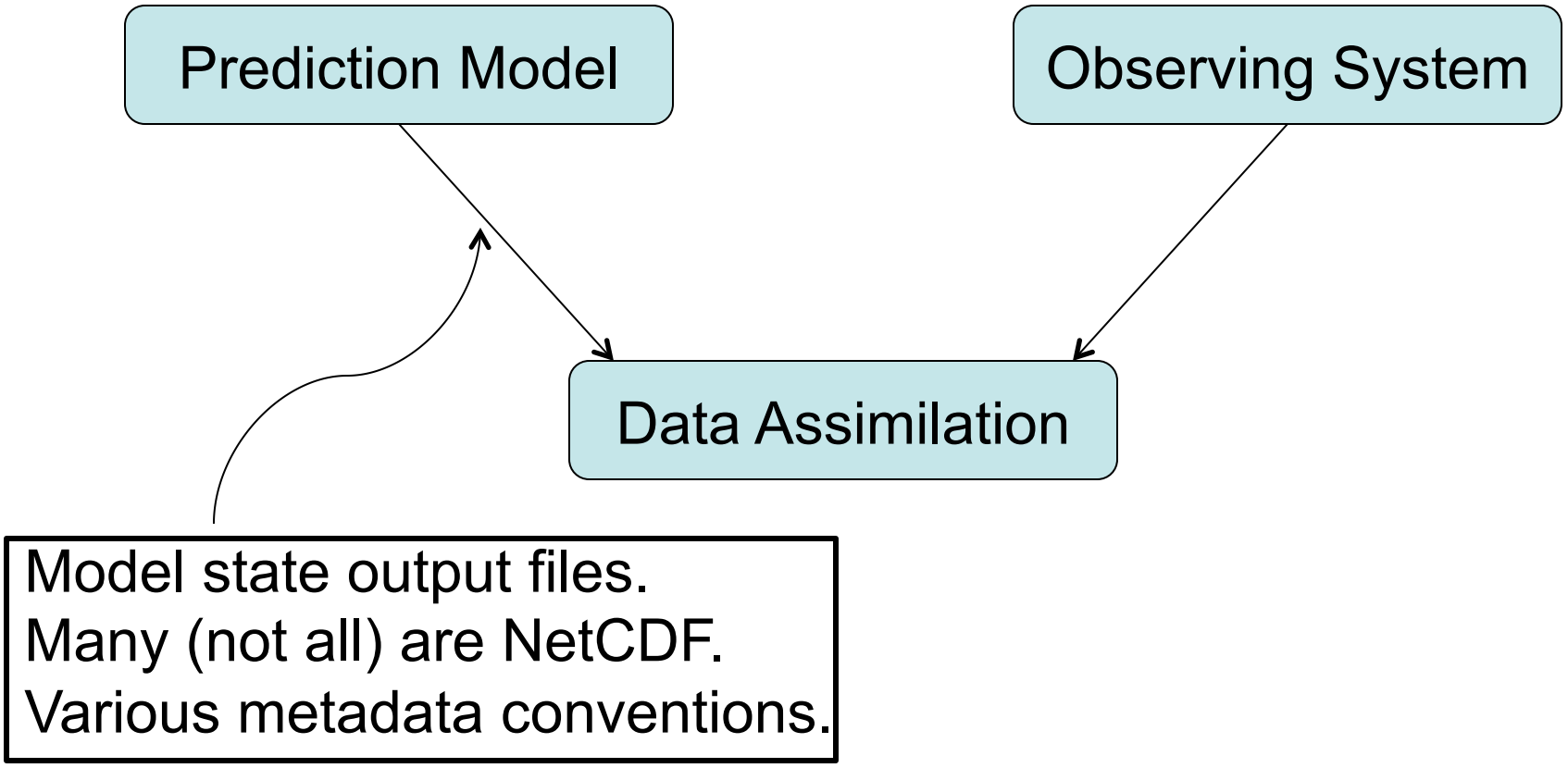
ROSE		NCAR
TieGCM	Thermosphere Ionosphere Electrodynamic GCM	NCAR/HAO
GITM	Global Ionosphere Thermosphere Model	Michigan
Solar Dynamo	Dynamo/sunspot model	NCAR/HAO

DART works with many geophysical models

Land Surface models:

CLM	Community Land Model	NCAR
NOAH	Relatively simple land model	Community

Model Forecast Data Formats in DART



Standardization would ease implementation.

DART users work with many observational datasets

Atmosphere Observations (1):

U,V,T,Q	NCEP: Radiosonde, AIRCRAFT (commercial), ACARS	BUFR
U,V	NCEP: Cloud Drift Winds from satellite	BUFR
U,V (ocean surface)	QUIKSCAT, including L2B (JPL)	HDF-4
T,Q,refractivity of the atmosphere	COSMIC Global Positioning Satellite radio occultation	NetCDF
T,Q,Tsurface	AIRS from Aqua/A-train satellite	HDF-4, HDF-EOS
U,V,T,Q,T, surface,pressure,altimeter	MADIS: ACARS, Marine and MESONET surface, METAR, radiosonde, satellite wind	NetCDF
Radar reflectivity, radial velocity	NCEP	Level2 (binary)

DART users work with many observational datasets

Atmosphere Observations (2):

U,V	MADIS; Wind Profilers, Atmospheric Motion Vectors (AMVs)	NetCDF, ASCII Text
U,V,T,Q,altimeter	OK mesonet (U. OK)	ASCII Text
Cloud Liquid Water Path, Cloud Top and Base Pressures	GOES satellite, CIMSS	NetCDF
U,V	SSEC (U Wisconsin): Cloud Drift Winds from satellite	ASCII Text
CO (carbon monoxide)	MOPITT	HDF
U,V	GOES CIMSS (U. WI); rapid-scan AMVs (Atmospheric Motion Vectors), satellite cloud winds	CIMSS ASCII

DART users work with many observational datasets

Atmosphere Observations (3):

T,Q,Total Precipitable Water	GOES CIMSS hyperspectral AIRS IR	CIMSS ASCII
Total Precipitable Water	AMSR, MODIS Microwave	ASCII Text
U,V	Operational typhoon bogus winds, Taiwan Central Weather Bureau	ASCII Text
U,V (at wind turbine hub height)	Seimens(?)	?
Electron density	COSMIC/FORMOSAT-3	LDM (UCAR/Unidata)
U,V,T	GTS	little-r
Chemical concentrations	IASI on EUMETSAT Polar System MetOp satellite	converted to ASCII intermediate format
Aerosol optical depth (AOD)	TERA and AQUA	HDF

DART users work with many observational datasets

Solar, Space Weather, Extraterrestrial Observations:

Radiances, Occultation on Mars	TES, limb sounder on Mars	?
Density, ion concentrations	CHAMP	NetCDF
Thermosphereic Mass Densities	CHAMP, GRACE	NetCDF
Electron densities	COSMIC	NetCDF
Total Electron Density	Garner GPS Archive	RINEX
Orbital element information	NORAD	ASCII
Solar Magnetic Fields	Wilcox, Mt Wilson, National Solar Observatories	?
Rotational, Meridional Circulation	Mt Wilson, SoHO, SDO, HMI	?

DART users work with many observational datasets

Ocean Observations:

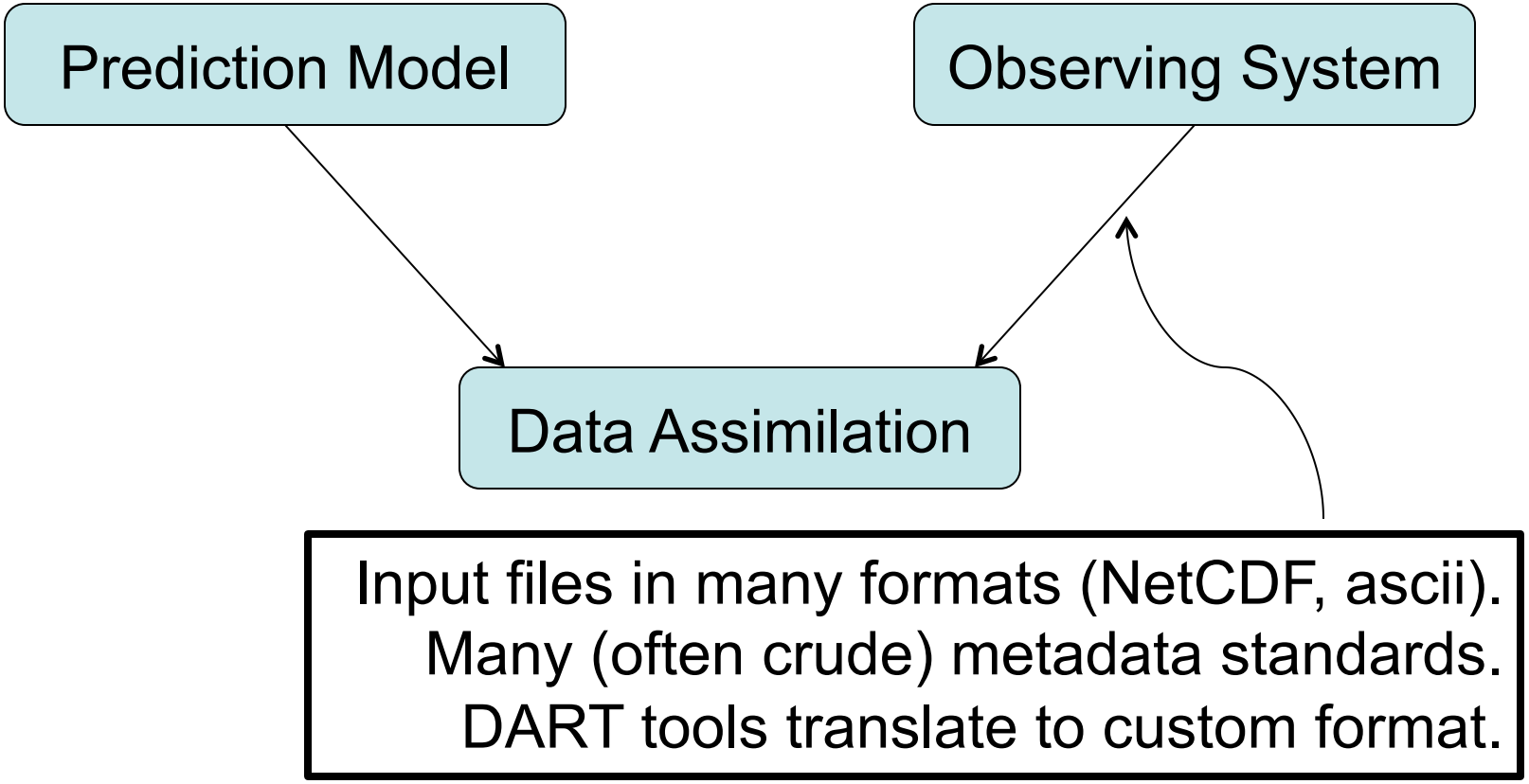
T,Salinity	World Ocean Database: Argo floats, CTD(ships), XBT,moored thermistors, drifting buoys(GT-SPP)	packed ASCII
Surface U,V currents	CODAR	ASCII Text

DART users work with many observational datasets

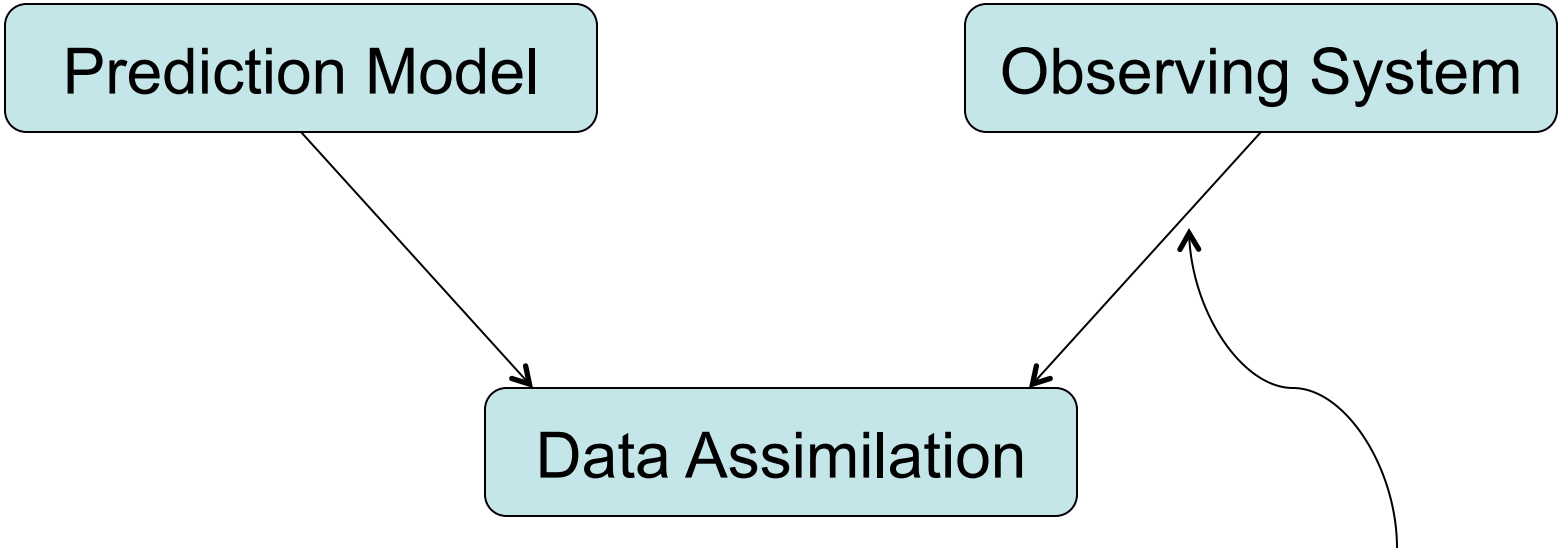
Land Observations:

Snow cover	MODIS	HDF
Heat Flux, Net Carbon	Ameriflux tower network	ASCII Text
Soil Moisture	COSMOS (neutron counter)	ASCII Text

Observation Data Formats in DART

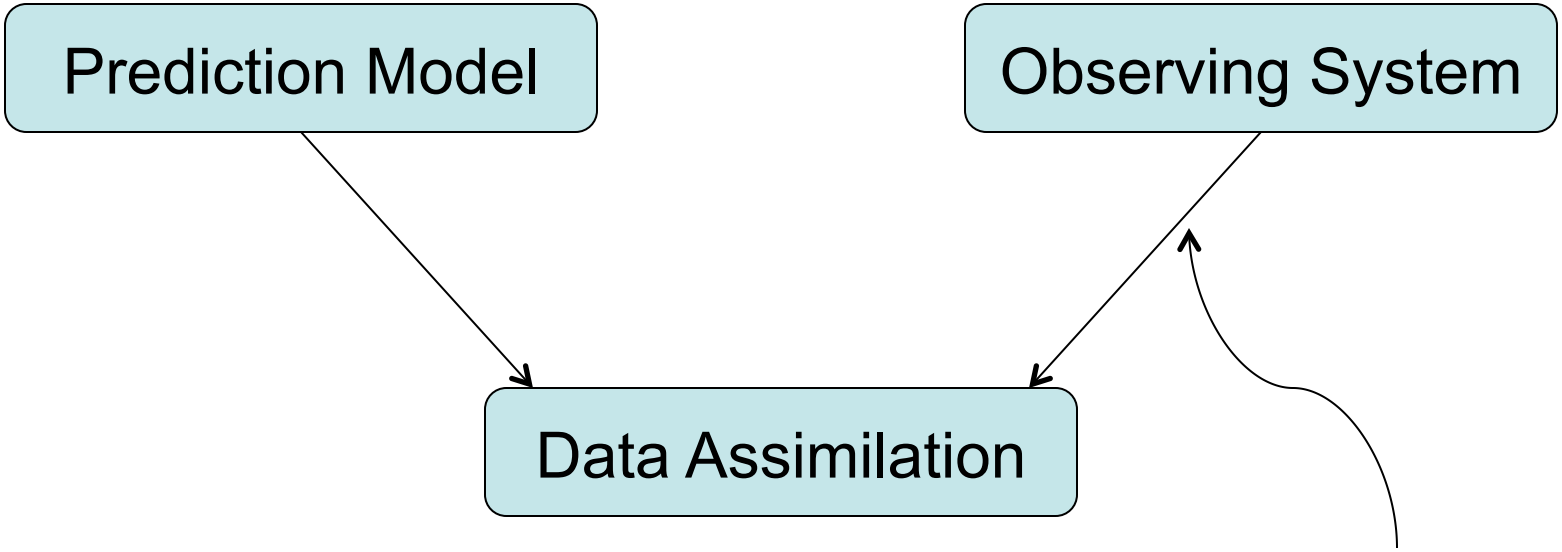


Observation Data Formats in DART



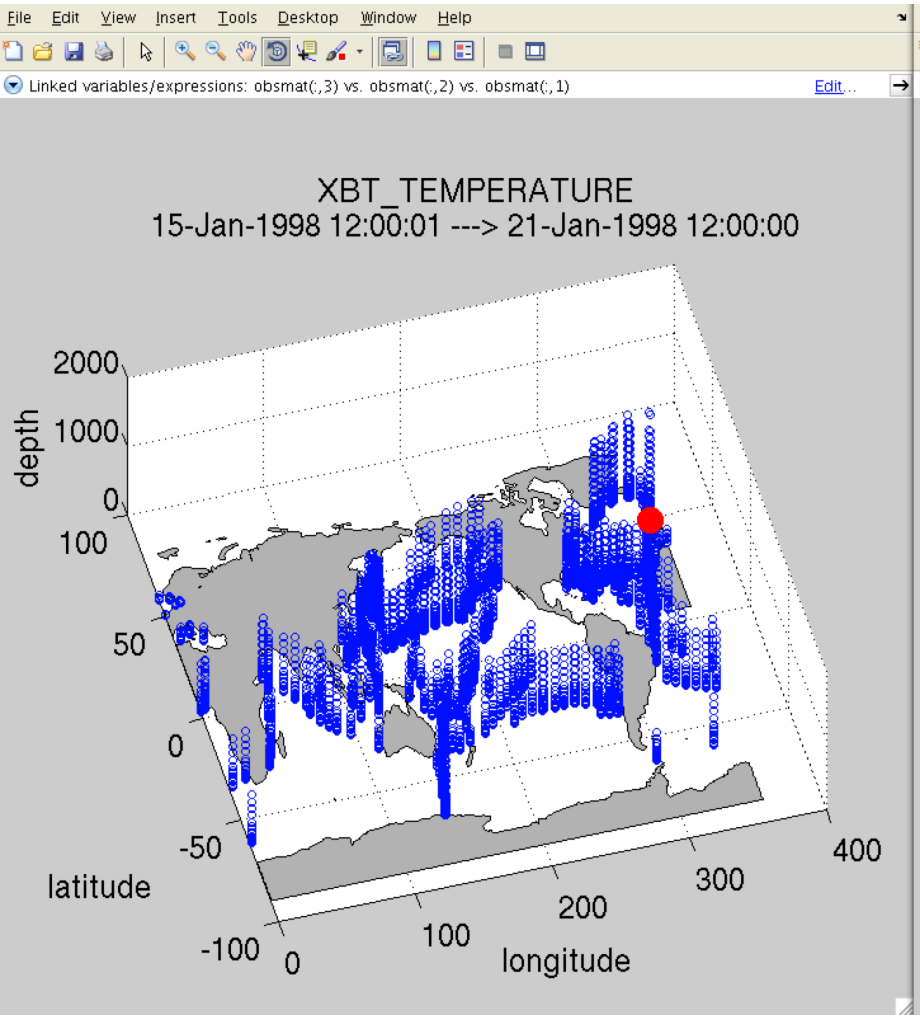
Often do additional ‘pre-processing’ to observation files.
Quality control, thinning, super-observations.
No mechanism to record these operations in metadata.

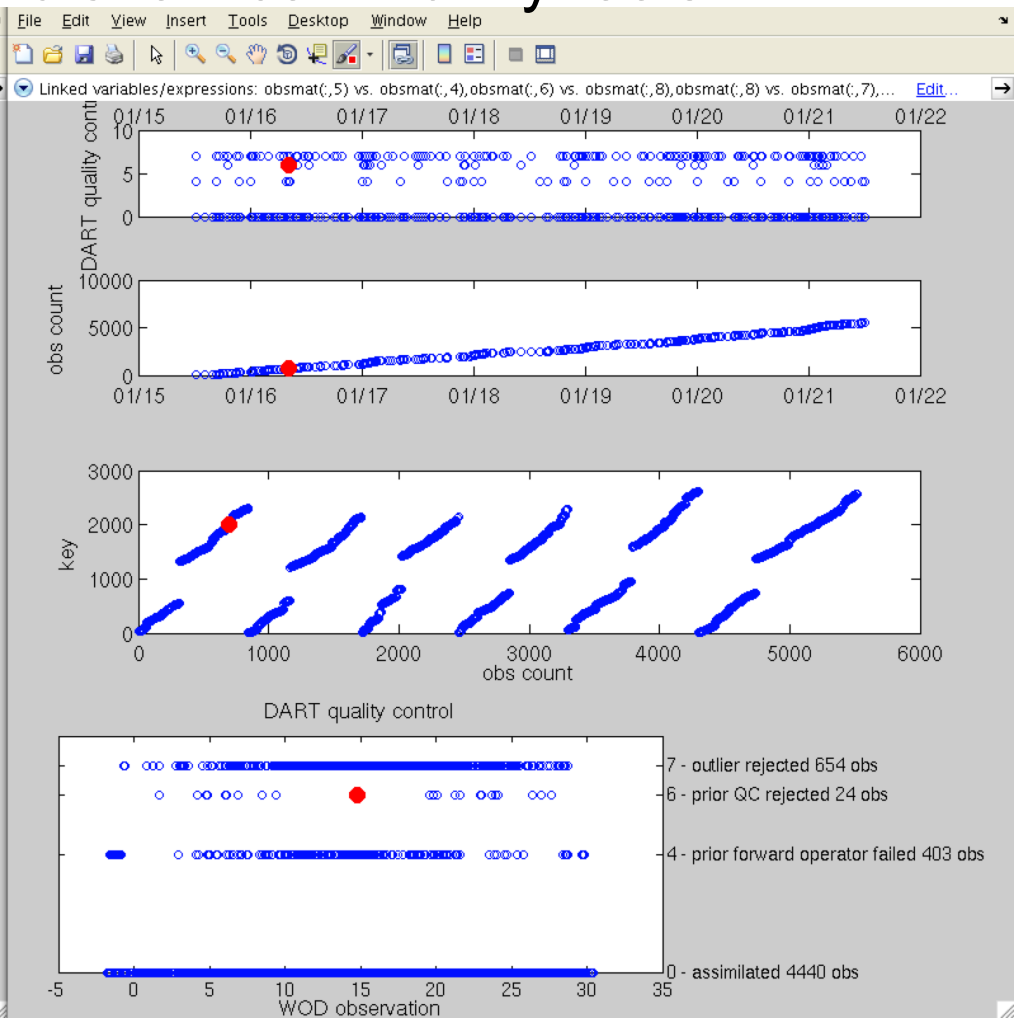
Observation Data Formats in DART



Great need for standardized file formats and metadata.
Need to record complete provenance of data.
Be able to recreate the data generation from file info.
DART observation space output just one more process.

DART Observation Visualization/Diagnostic Tools
Standard formats would allow community tools.





Summary

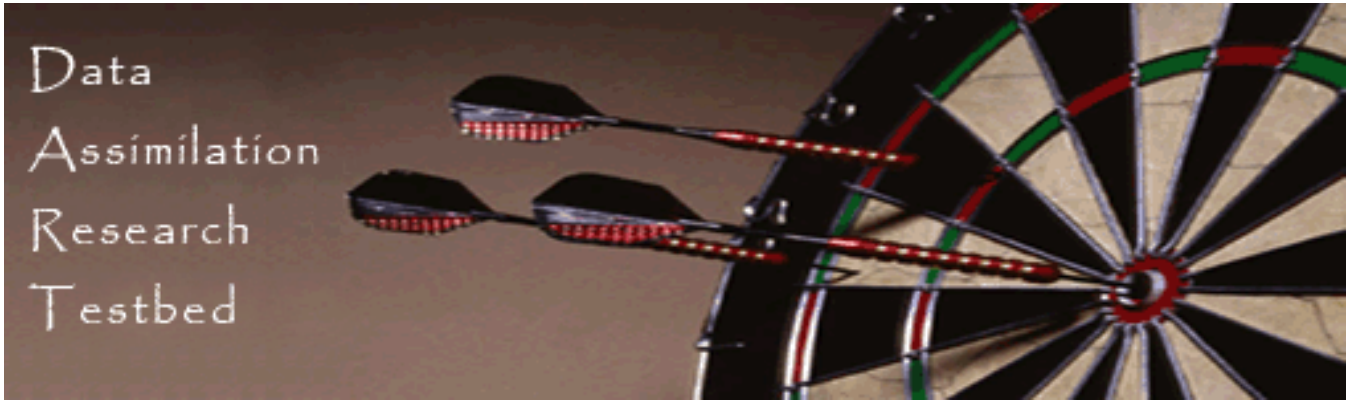
DART enables DA for diverse geophysical models:

- Most output is NetCDF,
- Need coordinated metadata standard.

DART users assimilate diverse observations:

- Data is in many formats,
- Standardized format would enable easier DA,
- Need coordinated metadata standard,
- Complete file provenance would facilitate science.

Learn more about DART at:



http://www.image.ucar.edu/DAReS/DART/

Anderson, J., Hoar, T., Raeder, K., Liu, H., Collins, N., Torn, R., Arellano, A., 2009: *The Data Assimilation Research Testbed: A community facility.* BAMS, **90**, 1283—1296, doi: 10.1175/2009BAMS2618.1