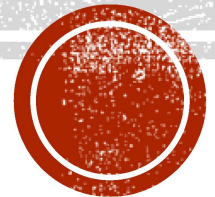# SESSION 12: SIMULATED DATA IN WRA
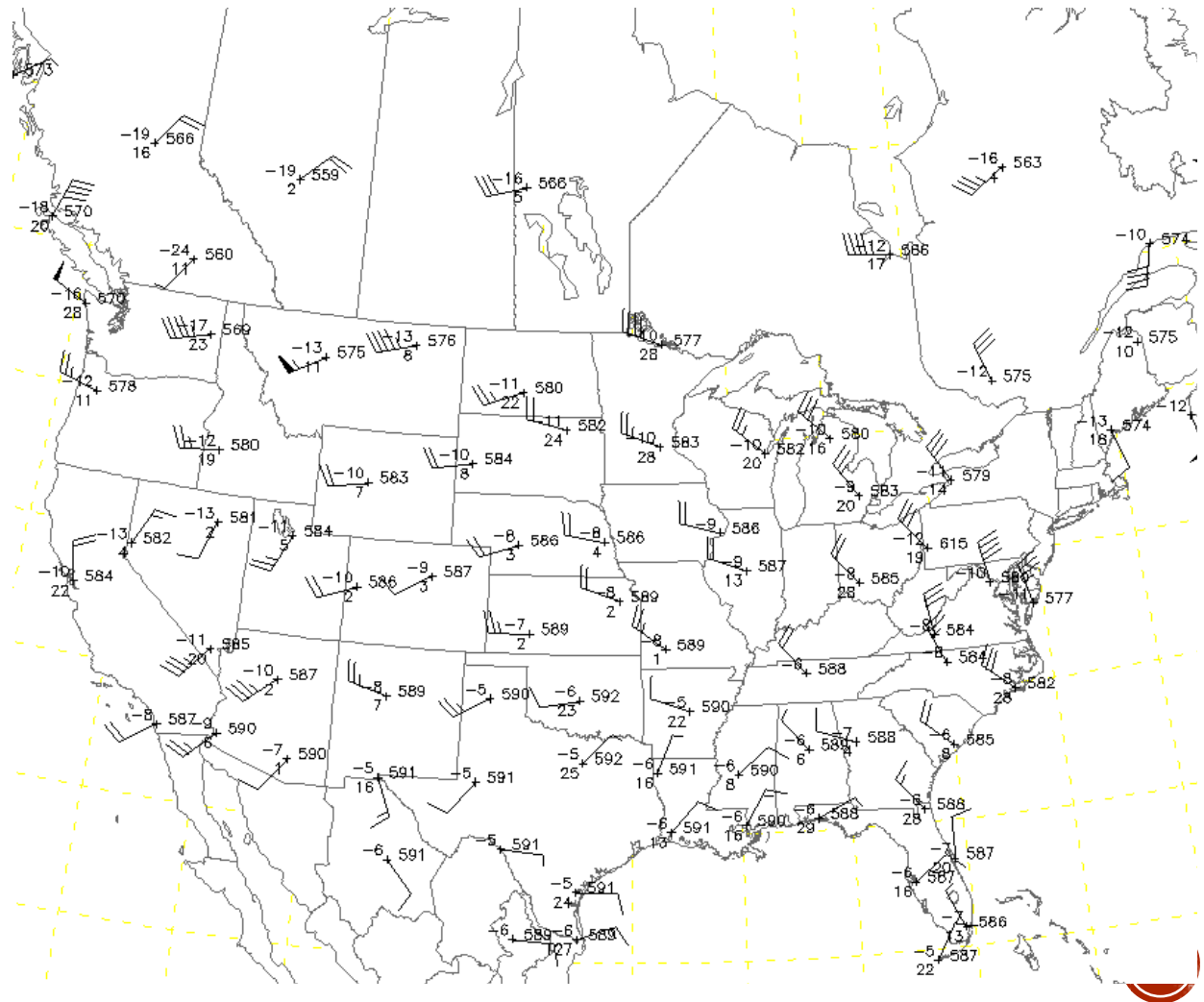
DATA TYPES

- Data can generally be considered "observed" or "modeled"

- We will consider observed data to be meteorological / geophysical data *collected* by an instrument at a certain place or time.

- We will define "modeled" data to be data *generated* by a set of computer code using dynamical equations, parameterizations, and the incorporation of observed data.
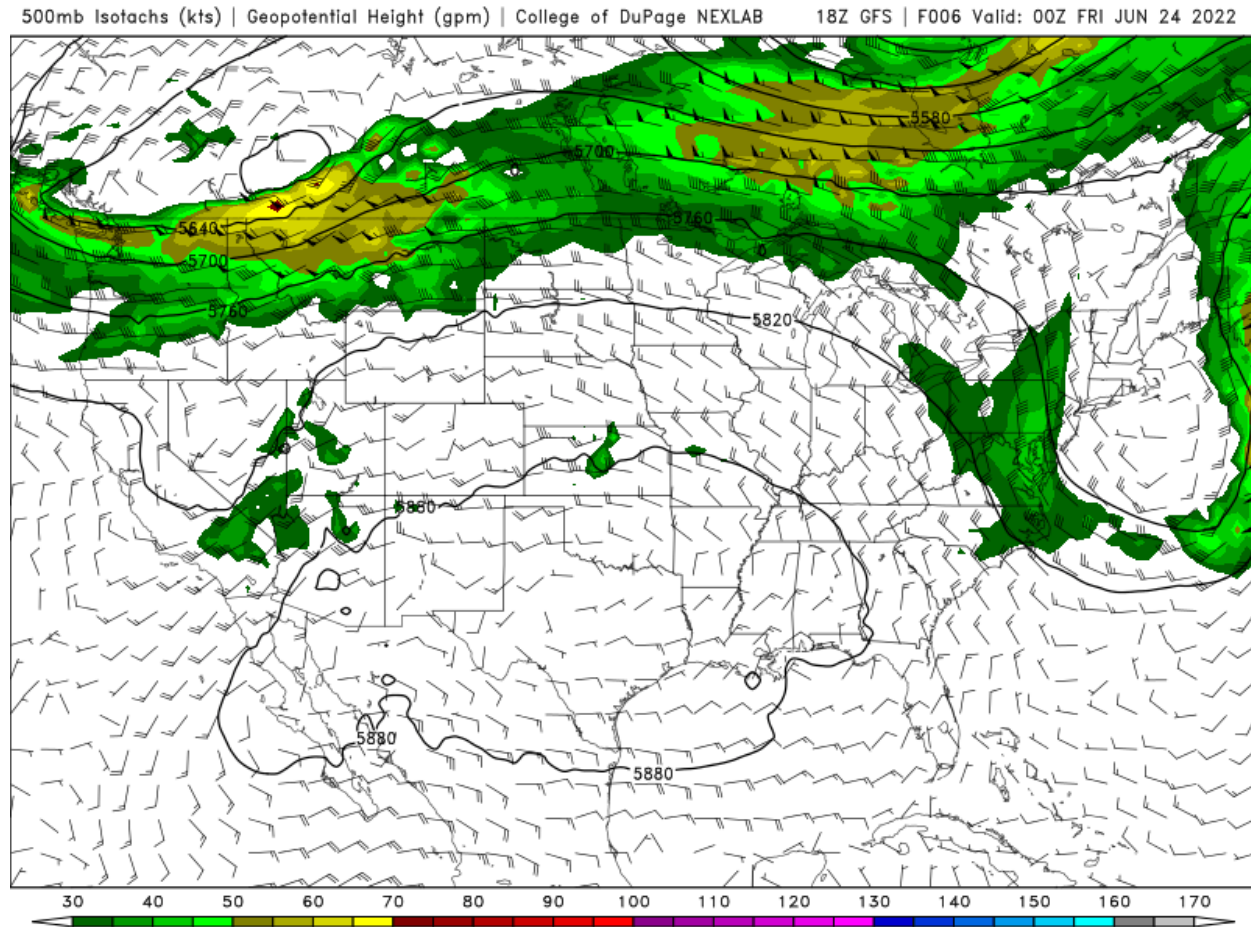
OBSERVED DATA EXAMPLE: 500 MB WINDS

- Radiosondes *measured* the 500 mb wind speeds at 00z today.

SIMULATED DATA EXAMPLE: 500 MB WINDS

- The GFS (that was initialized at 18z) simulated winds at 500 mb

500mb Isotachs (kts) | Geopotential Height (gpm) | College of DuPage NEXLAB   18Z GFS | F006 Valid: 00Z FRI JUN 24 2022

DATA TYPES

Observed Data

- Irregularly spaced
- Describe the current state of the atmosphere
- Include instrument error:
  - Bias
  - Random error
- Example include
  - Radar
  - Satellite
 - Surface measurements

Simulated Data

- Calculated on a grid
- Includes parameterizations for non-resolved things
- Incorporate observed for initial conditions
- Generally used for forecasting or hindcasting
- Examples include:
  - NWP Forecast models
  - Research models
  - Reanalysis Datasets

DATA TYPES

- Simulated data rely on the observed data for initial conditions.

- However, observations are typically irregularly spaced / shaped, and can be sparse.

- Early on, hand analysis was used to provide simulations with initial conditions.

- Proved not to be good enough for longer-time forecasting, so interpolation via objective analysis was developed.

INTERPA-WHAT?

0.5° Lat

0.75° Long
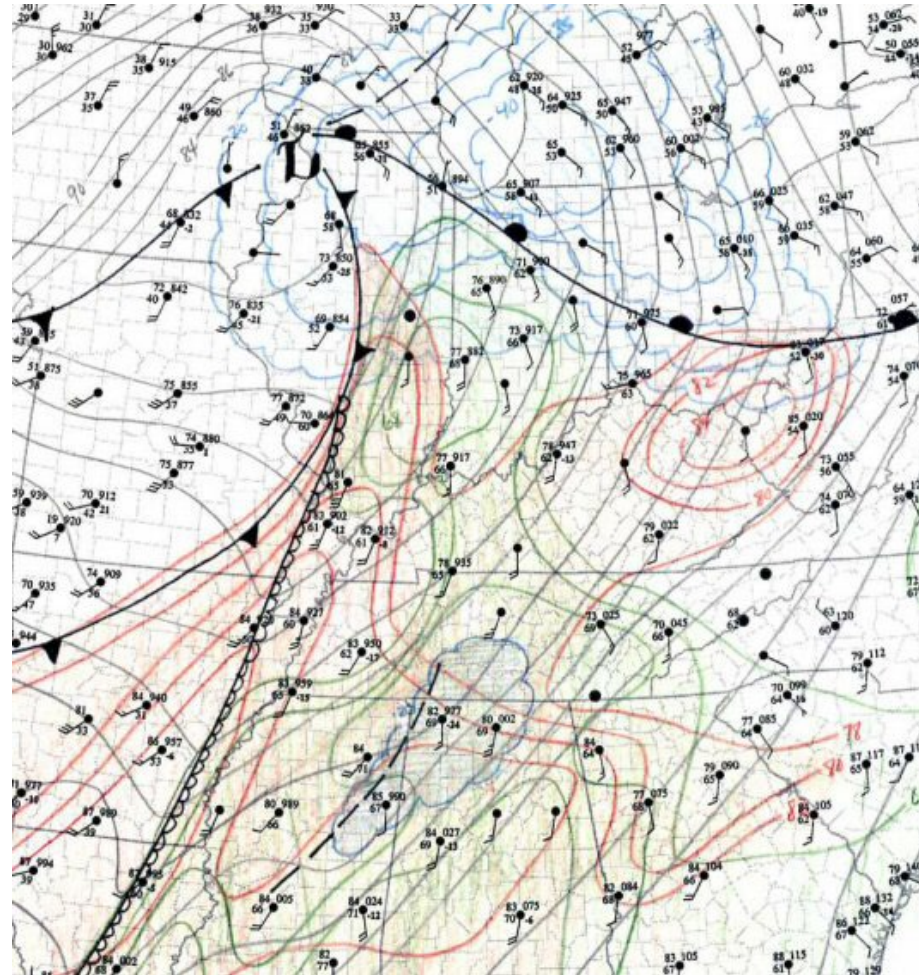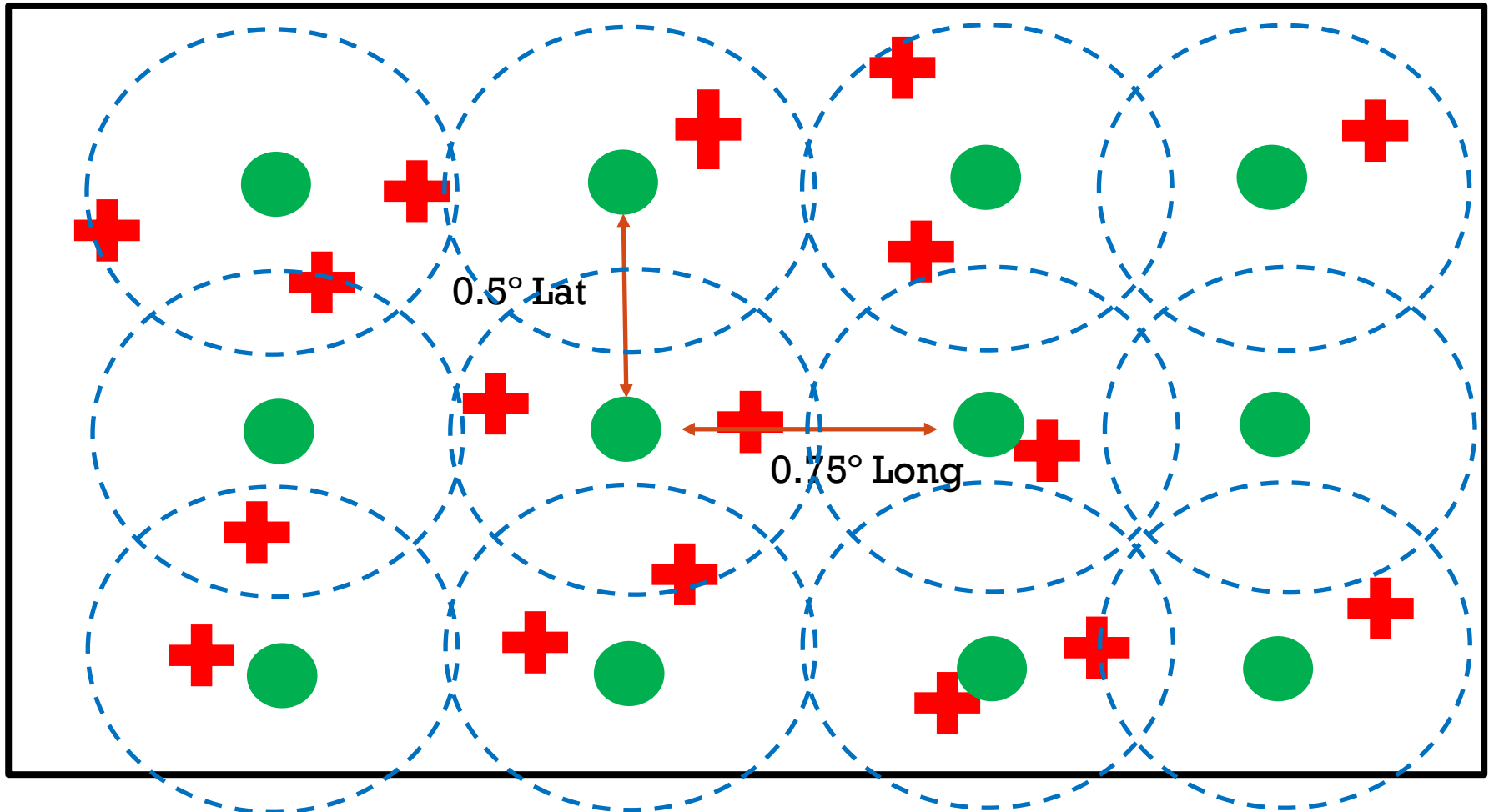
DATA TYPES

- Once the observations are interpolated to a grid, they can be used to either provide:
    - The initial conditions for a simulation
    - Corrections to simulations at regular intervals.

- This process of merging observed data with model data / model physics is called data assimilation (DA).
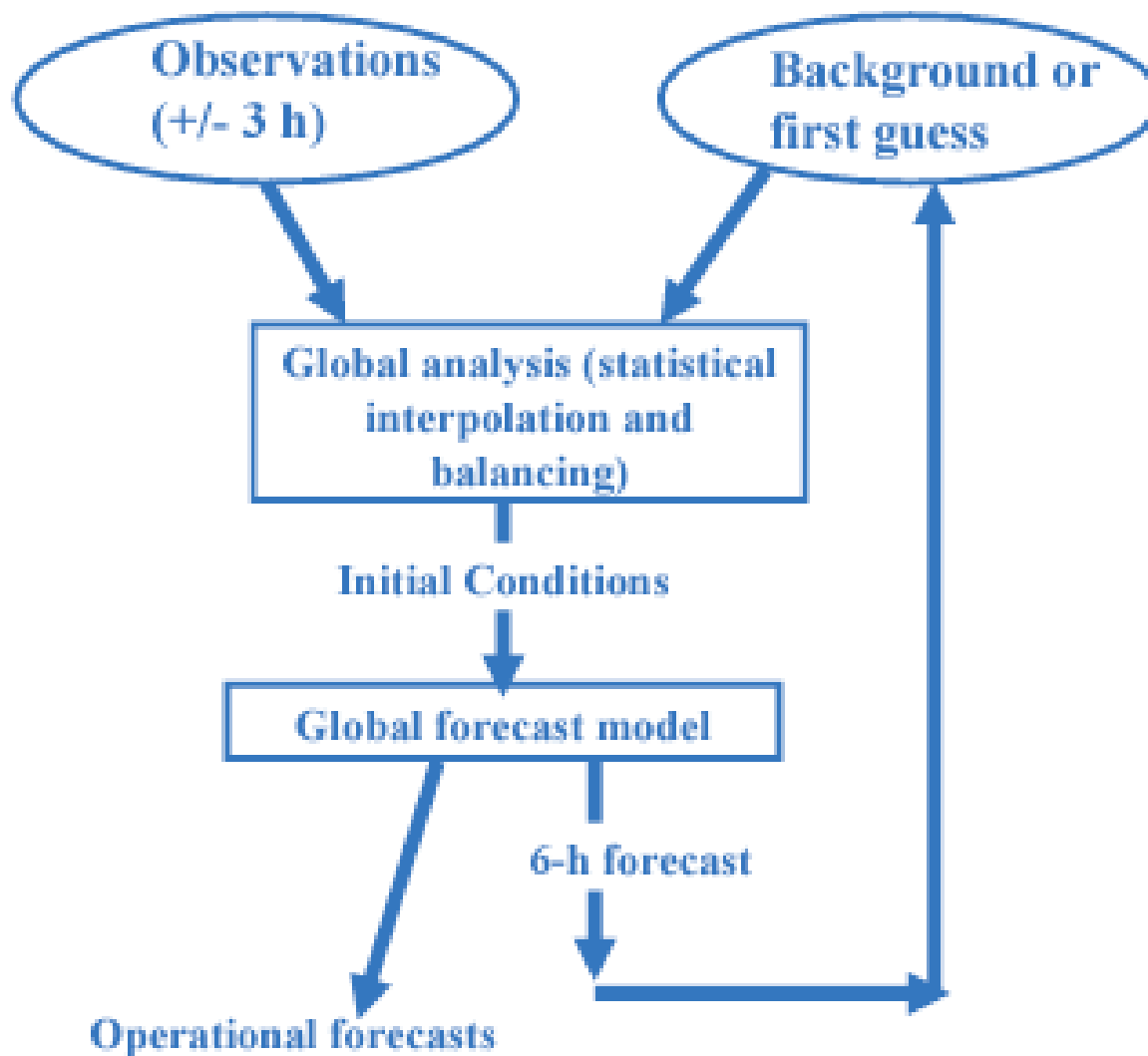
SIMPLE DA EXAMPLE

This example is for an operation forecast model (like the GFS)

Balancing refers to making sure the observations and the model agree

DATA ASSIMILATION

- Observed data can also be used to "correct" model data in regular intervals

Legend:
— Samples
— SampleMean
···· Correction
X Observation

State / Time
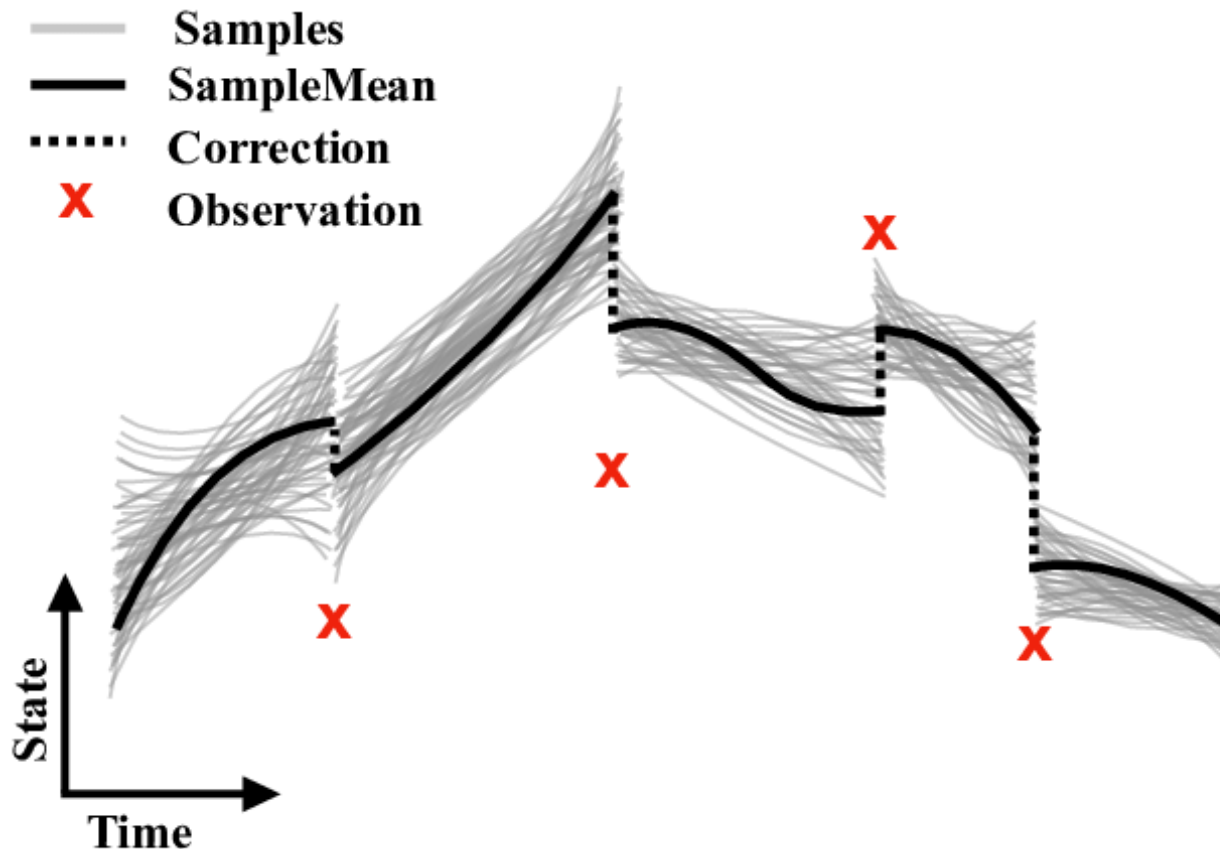
DATA ASSIMILATION

- Common DA techniques include:
  - Optimal Interpolation (OI) → older technique
  - Variational techniques
    - 3D VAR
    - 4D VAR
  - Ensemble techniques
    - EnKF

RE-ANALYSIS DATASETS

- MERRA - 2
  - Developed by NASA as an update to the original MERRA dataset. Considered to be greatly improved over the MERRA-1.
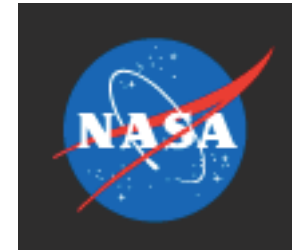
  - Specs:
    - $0.5°$ x $0.625°$ grid
    - Vertical grid: Single-level or 42 pressure levels
    - 1980 to present
    - 3D Var Assimilation technique
    - Variables are output as either time average or instantaneous

MERRA-2 VERTICAL GRID

Level	P(hPa)	Level	P(hPa)	Level	P(hPa)	Level	P(hPa)	Level	P(hPa)	Level	P(hPa)
1	1000	8	825	15	600	22	250	29	30	36	2
2	975	9	800	16	550	23	200	30	20	37	1
3	950	10	775	17	500	24	150	31	10	38	0.7
4	925	11	750	18	450	25	100	32	7	39	0.5
5	900	12	725	19	400	26	70	33	5	40	0.4
6	875	13	700	20	350	27	50	34	4	41	0.3
7	850	14	650	21	300	28	40	35	3	42	0.1

MERRA-2 ASSIMILATED DATA

Data type	MERRA-2 dates	Source
Conventional		
Raob, pibal, and dropsonde	1 Jan 1980–present	See Rienecker et al. (2011)
AIREP, PIREP, ASDAR, and MDCRS aircraft	1 Jan 1980–present	NCEP, ECMWF, and JMA
PAOB	1 Jan 1980–17 Aug 2010	BoM
Surface land	1 Jan 1980–present	NCEP
Surface ship and buoy	1 Jan 1980–present	ICOADS
Ground-based remotely sensed		
Wind profiler	14 May 1992–present	UCAR and NCEP
NEXRAD VAD wind	16 Jun 1997–present	NCEP
Satellite-derived wind		
GMS, MTSAT, and Himawari atmospheric motion vector	1 Jan 1980–present	NCEP and JMA
Meteosat atmospheric motion vector	1 Jan 1980–present	NCEP and EUMETSAT
GOES atmospheric motion vector	1 Jan 1980–present	NCEP
AVHRR atmospheric motion vector	**1 Oct 1982–present**	**CIMSS**
SSM/I surface wind speed	9 Jul 1987–4 Nov 2009	RSS
ERS-1 surface wind vector	5 Aug 1991–21 May 1996	ESA
ERS-2 surface wind vector	19 Mar 1996–29 Mar 2011	ESA
QuikSCAT surface wind vector	19 Jul 1999–22 Nov 2009	JPL
MODIS atmospheric motion vector	2 Jul 2002–present	CIMSS and NCEP
SSMIS surface wind speed	**23 Oct 2003–29 Oct 2013**	**RSS**
WindSat surface wind vector	**13 Aug 2007–4 Aug 2012**	**NCEP**
ASCAT surface wind vector	**15 Sep 2008–present**	**NCEP**
Satellite retrieved		
SBUV and SBUV/2 ozone	1 Jan 1980–31 Sep 2004	NASA GES DISC
SSM/I rain rate	9 Jul 1987–16 Sep 2009	NASA GES DISC
TMI rain rate	1 Jan 1998–8 Apr 2015	NASA GES DISC
MLS temperature	**13 Aug 2004–present**	**NASA GES DISC**
MLS ozone	**1 Oct 2004–present**	**NASA GES DISC**
OMI total column ozone	**1 Oct 2004–present**	**NASA GES DISC**
Radio occultation		
GPSRO bending angle	**14 July 2004–present**	**NCAR and NCEP**
Satellite radiance		
TOVS	1 Jan 1980–10 Oct 2006	NCAR and NESDIS
SSM/I	9 Jul 1987–4 Nov 2009	RSS
ATOVS (*NOAA-15, NOAA-16, NOAA-17,* and *NOAA-18*)	21 Jul 1998–present	NESDIS
GOES sounder (*GOES-8, GOES-10, GOES-11,* and *GOES-12* low resolution)	24 Apr 2001–31 Mar 2007	NCEP and NESDIS
AMSU-A (*Aqua*)	1 Sep 2002–present	NASA GES DISC
AIRS	1 Sep 2002–present	NASA GES DISC
GOES sounder (*GOES-11, GOES-12, GOES-13,* and *GOES-15* full resolution)	**1 Apr 2007–present**	**NESDIS**
ATOVS (*NOAA-19, MetOp-A,* and *MetOp-B*)	**21 May 2007–present**	**NESDIS**
IASI	**17 Sep 2008–present**	**NESDIS**
ATMS	**16 Nov 2011–present**	**NESDIS**
SEVIRI	**15 Feb 2012–present**	**NESDIS**
CrIS	**7 Apr 2012–present**	**NESDIS**

Gelaro et al. (2017)

WIND PROFILES IN MERRA-2

- MERRA-2 offers 3 heights of wind data:
  - 2 m
  - 10 m
  - 50 m

- Data are available hourly as either instantaneous (0:00 time stamp) or time averaged (0:30 time stamp).

- Data are also available on pressure levels w/ 14 layers between 0 and 2 km.

WIND PROFILES IN MERRA-2

- Multiple studies have used MERRA-2 for *regional* WRA and / or wind power prediction.

  - Jourdier (2021) → use two levels to get alpha, then power law to adjust to hub height. This process is done at each time step to try to account for stability.

  - Ren et al. (2019) → Log Law using BL parameters available in MERRA-2
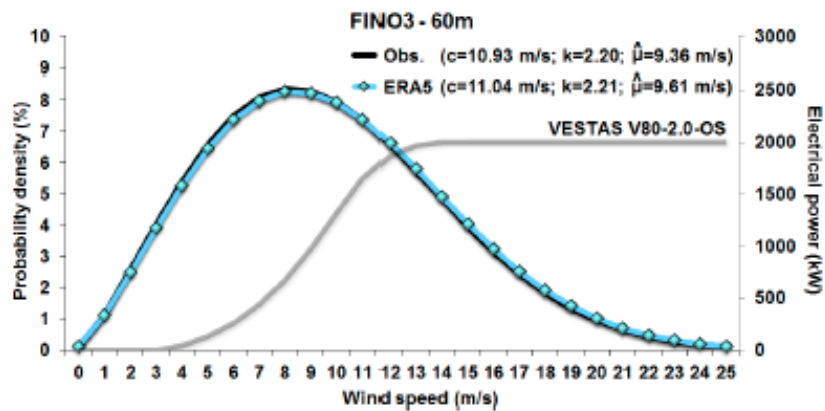
RE-ANALYSIS DATASETS

- ERA5
  - Developed by ECMWF (European Centre for Medium Range Weather Forecasting) and replaces ERA-Interim
  - Specs:
    - 0.25° x 0.25° grid
    - Vertical grid: Single-level or 37 pressure levels
    - 1959 to present
    - 4D Var Assimilation technique
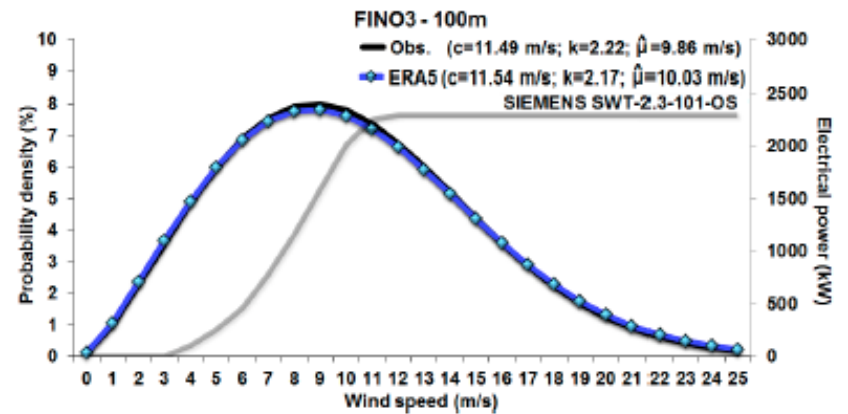   - Analysis (meteorological) variables are only output as instantaneous

WIND PROFILES IN ERA5

- ERA5 offers 2 heights of wind data:
  - 10 m
  - 100 m

- Data are only available hourly as instantaneous (0:00 time stamp)

- Data are also available on pressure levels w/ 28 levels between 0 and 2 km and approximately 14 levels below 500 m.
  - Wind is available on each pressure level, but the data have to be interpolated to a regular height grid.
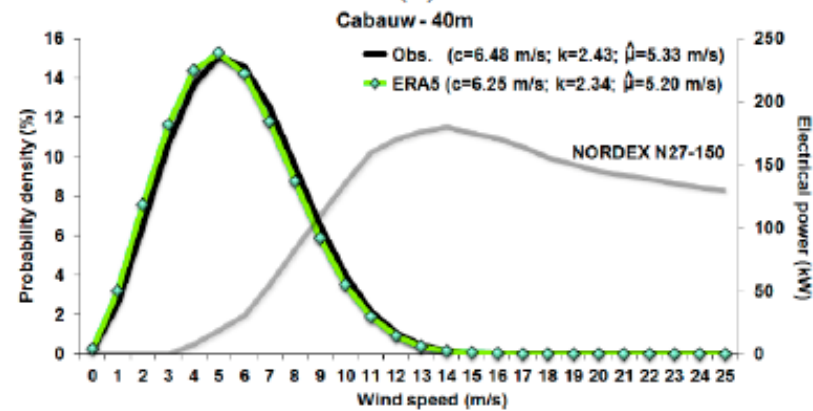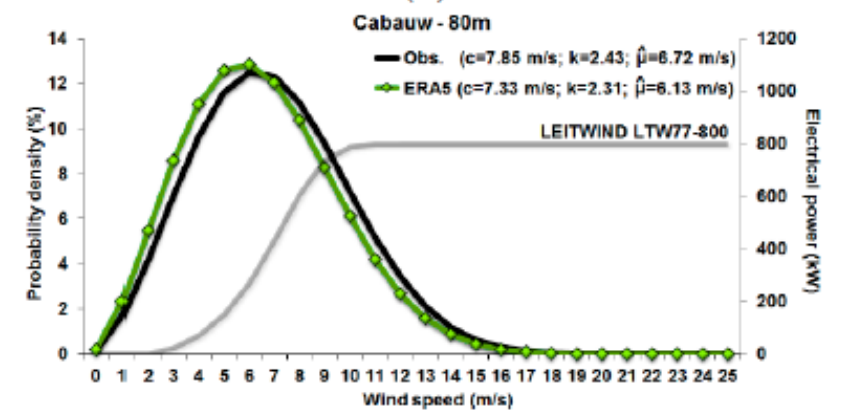
(a) FINO3 - 60m
Obs. (c=10.93 m/s; k=2.20; $\hat{\mu}$=9.36 m/s)
ERA5 (c=11.04 m/s; k=2.21; $\hat{\mu}$=9.61 m/s)
VESTAS V80-2.0-OS

(b) FINO3 - 100m
Obs. (c=11.49 m/s; k=2.22; $\hat{\mu}$=9.86 m/s)
ERA5 (c=11.54 m/s; k=2.17; $\hat{\mu}$=10.03 m/s)
SIEMENS SWT-2.3-101-OS

(c) Cabauw - 40m
Obs. (c=6.48 m/s; k=2.43; $\hat{\mu}$=5.33 m/s)
ERA5 (c=6.25 m/s; k=2.34; $\hat{\mu}$=5.20 m/s)
NORDEX N27-150

(d) Cabauw - 80m
Obs. (c=7.85 m/s; k=2.43; $\hat{\mu}$=6.72 m/s)
ERA5 (c=7.33 m/s; k=2.31; $\hat{\mu}$=6.13 m/s)
LEITWIND LTW77-800

Boulder - 50m
Obs. (c=4.86 m/s; k=1.81; $\hat{\mu}$=3.53 m/s)
ERA5 (c=3.07 m/s; k=1.97; $\hat{\mu}$=2.51 m/s)
NORDEX N27-150

Boulder - 80m
Obs. (c=5.10 m/s; k=1.78; $\hat{\mu}$=3.68 m/s)
ERA5 (c=3.29 m/s; k=1.91; $\hat{\mu}$=2.67 m/s)
LEITWIND LTW77-800

Gualtieri (2021)