What brings new MERRA2
Half-step forward towards new Reanalysis generation

Data and analysis: Pau Casso & Gil Lizcano
Speaking: Pep Moreno
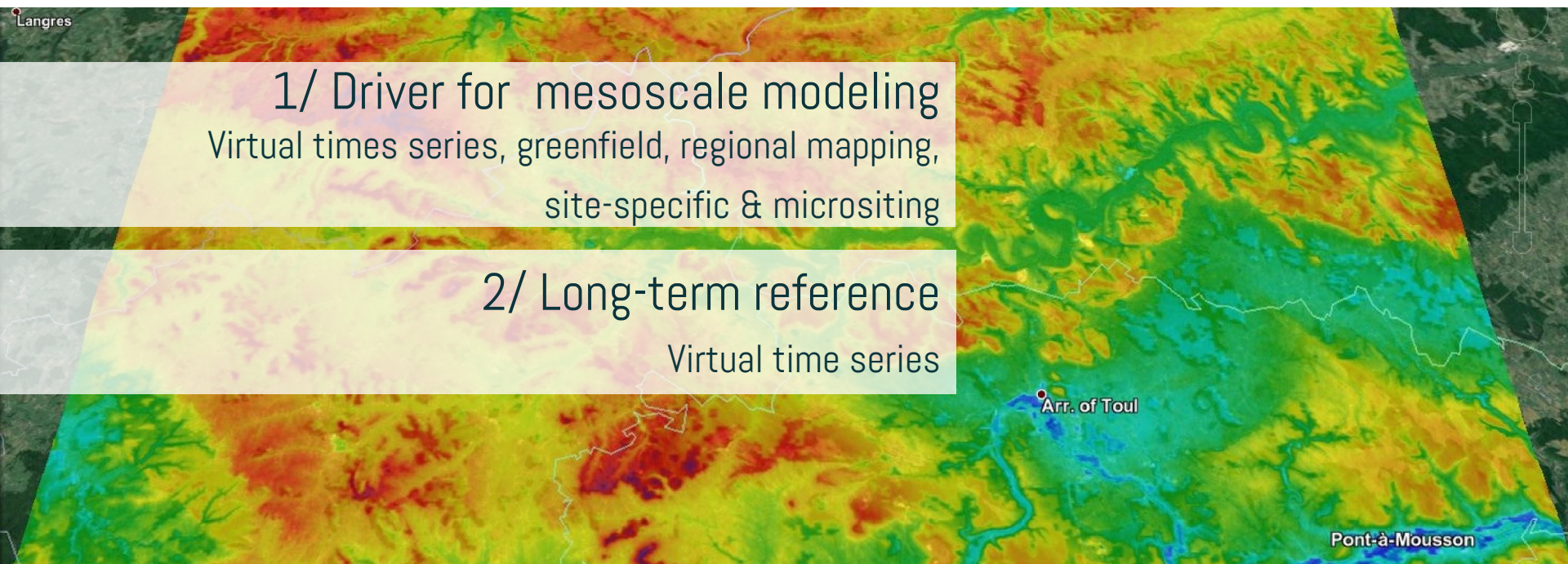
Get in touch:gil.lizcano@vortex.es

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Reanalysis and Wind Industry (Users)

MERRA2 & Changes

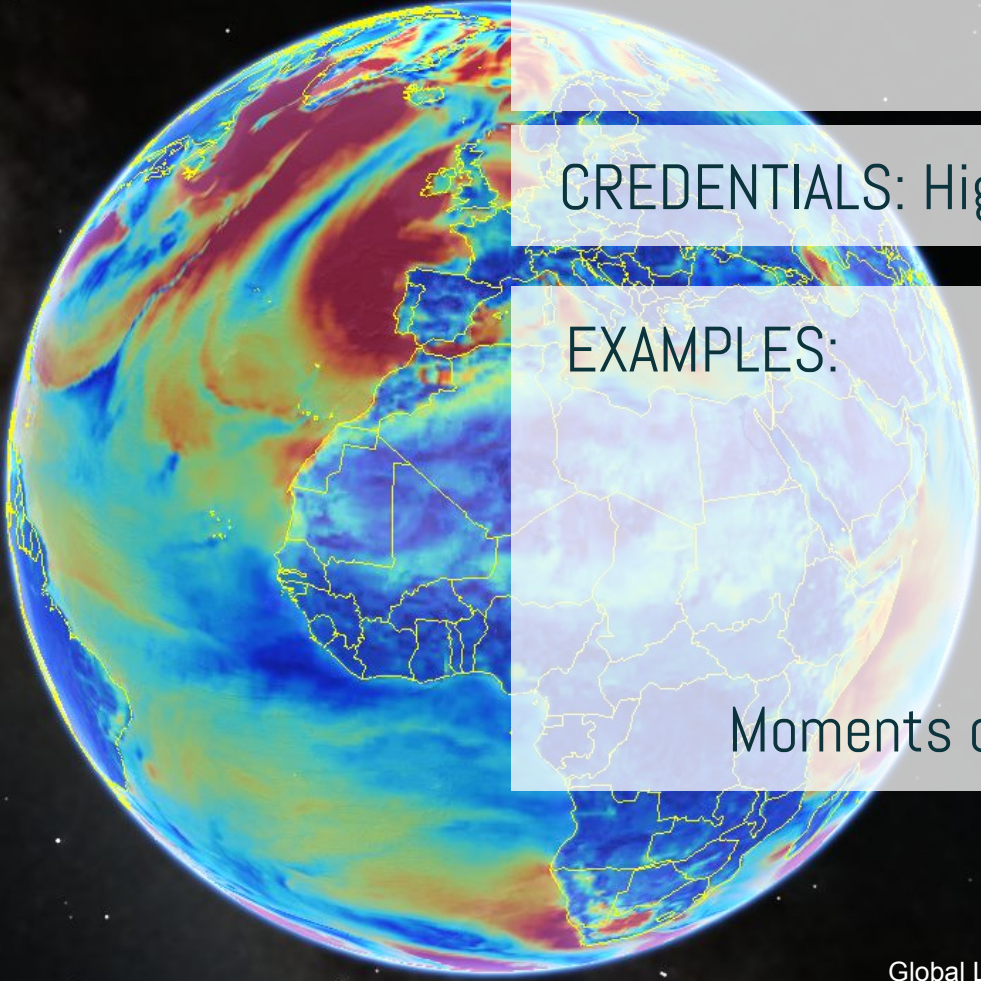MERRA2 & Quality

Working with Model data

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1/ Driver for mesoscale modeling
Virtual times series, greenfield, regional mapping,

site-specific & micrositing

2/ Long-term reference

Virtual time series

Long-term average 80m Wind Speed at 100m resolution
Source: WRF Downscaling driving by CFS/CFSR - VORTEX

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MOTIVATION: Global Market Needs

CREDENTIALS: High Correlation with Observations

EXAMPLES:

Downscaling Products
Bank acceptance
Tenders
Publications
Sessions on Specialized Fora
Moments of panic when MERRA went offline

Global Long-term average 80m Wind Speed Distribution at 9KM resolution
Source: WRF Downscaling driving by CFS/CFSR - VORTEX

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Background: Reanalysis viewed by the Wind Industry

REANALYSIS	MERRA	ERA-Interim	CFS-CFSR	MERRA2	ERA5
Generation	Third			3.5 *	Fourth
Long-term Reference Usage	+++	++	-	+++	
Mesoscale downscaling driver	+	++	+++	+	
Popular for	Easy access to data	Better correlation Offshore (EU)	Accurate downscaling results		
Resolution	Hourly / 0.5° x 0.667° 72 levels	4xday 0.75° x0.75° 72 levels	Hourly 0.5°x 0.5° 64 level	Hourly 0.5° x 0.667° 72 levels	Hourly 30Km (/2) 137 levels (X2)
Latency (weeks)	4	12	1	2	
User Notes	Overall good correlation	Arrived late *	Inconsistent SFC but Consistent 3D fields	Aerosol Assimilation	Deterministic & Ensemble (10 members)

* Personal Opinion

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MISSION

- ❏ Operational since Feb/2016
- ❏ Development as a (fast) replacement to MERRA:
  - ❏ Observing data was becoming obsolete
  - ❏ MERRA Radiative Model was in danger
  - ❏ Migration to a new HPC
- ❏ Lifecycle ~ 5 years (at least)
- ❏ No plans for "MERRA3" *

- ❏ Important: REANALYSIS are CLIMATE products for a wide CLIMATE users Community

(*) An atmosphere chemistry oriented product should follow covering aerosol satellite period, 2000 onwards (TBC)

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CHANGES

- ❏ Newest Satellite missions (much more obs data)
- ❏ First to inject aerosol remote sensing data
- ❏ Latest NASA GEOS-5 GCM
- ❏ Cube sphere grid (same effective resolution)
- ❏ Changes in PBL/Turbulence schemes
- ❏ More wind over the Oceans (roughness vs stress)
- ❏ Stronger pressure gradients and winds around fronts and tropical cyclones
- ❏ Wetter atmosphere
- ❏ Changes to the background gravity wave drag
- ❏ …. (see reference)

[1] Development of the GEOS-5 atmospheric general circulation model: evolution from MERRA to MERRA2 A. Molod1 , L. Takacs2 , M. Suarez3 , and J. Bacmeister4
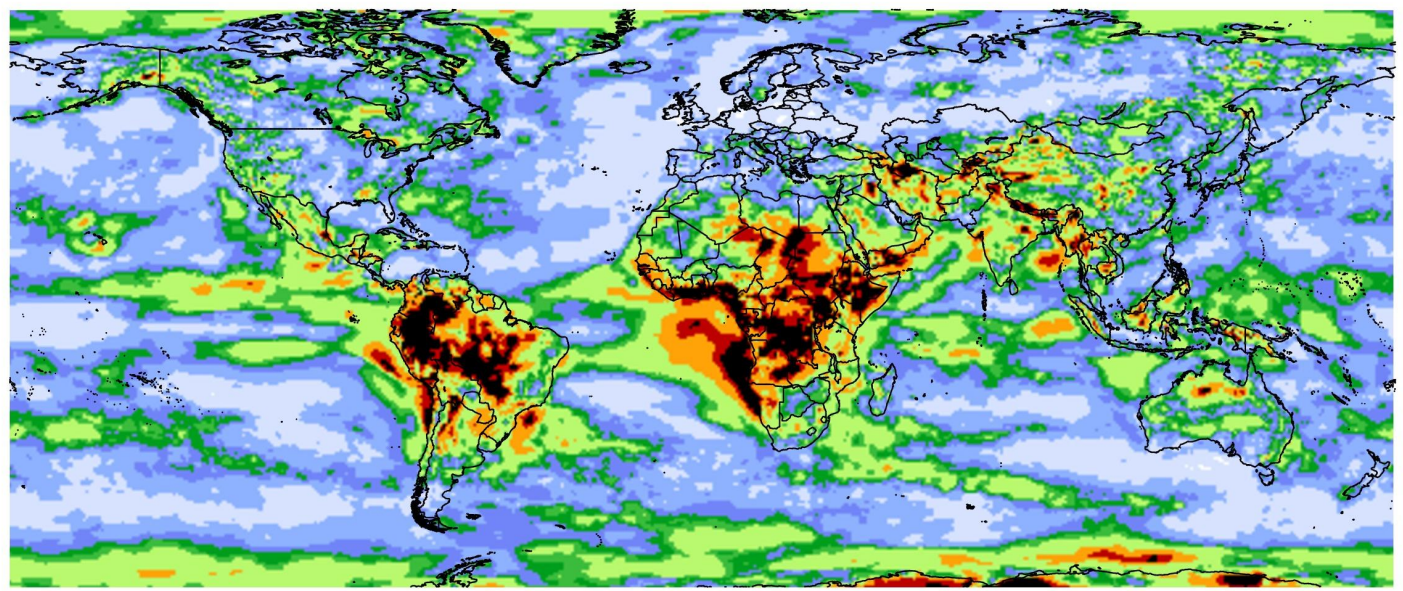http://www.geosci-model-dev.net/8/1339/2015/gmd-8-1339-2015.pdf

[2] MERRA-2: Initial Evaluation of the Climate Bosilovich et al http://gmao.gsfc.nasa.gov/pubs/tm/docs/Bosilovich803.pdf

[3] The GEOS-5 Atmospheric General Circulation Model: Mean Climate and Development from MERRA to Fortuna Andrea Molod, Lawrence Takacs, Max Suarez, Julio Bacmeister, In-Sun Song, and Andrew Eichmann http://gmao.gsfc.nasa.gov/pubs/docs/tm28.pdf
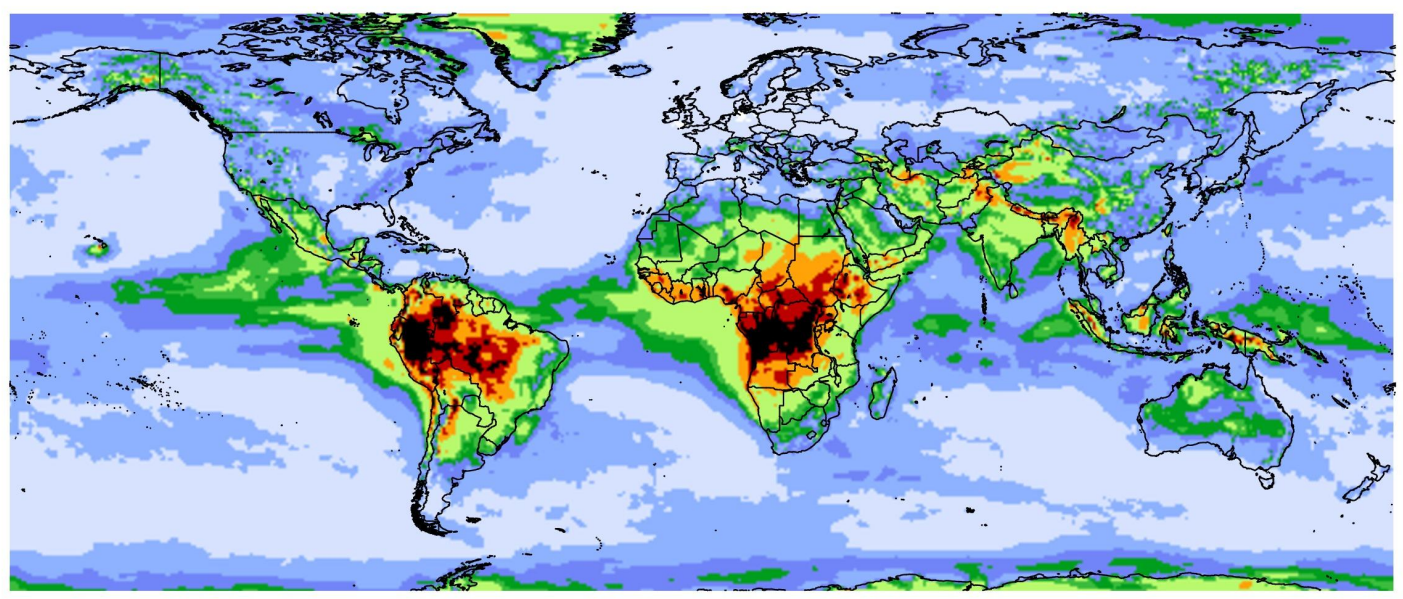
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MERRA2, differences

Interannual Variability

Monthly Variability

Near Surface Wind Speed — Annual Correlation

Near Surface Wind Speed — Monthly Anomaly Correlation
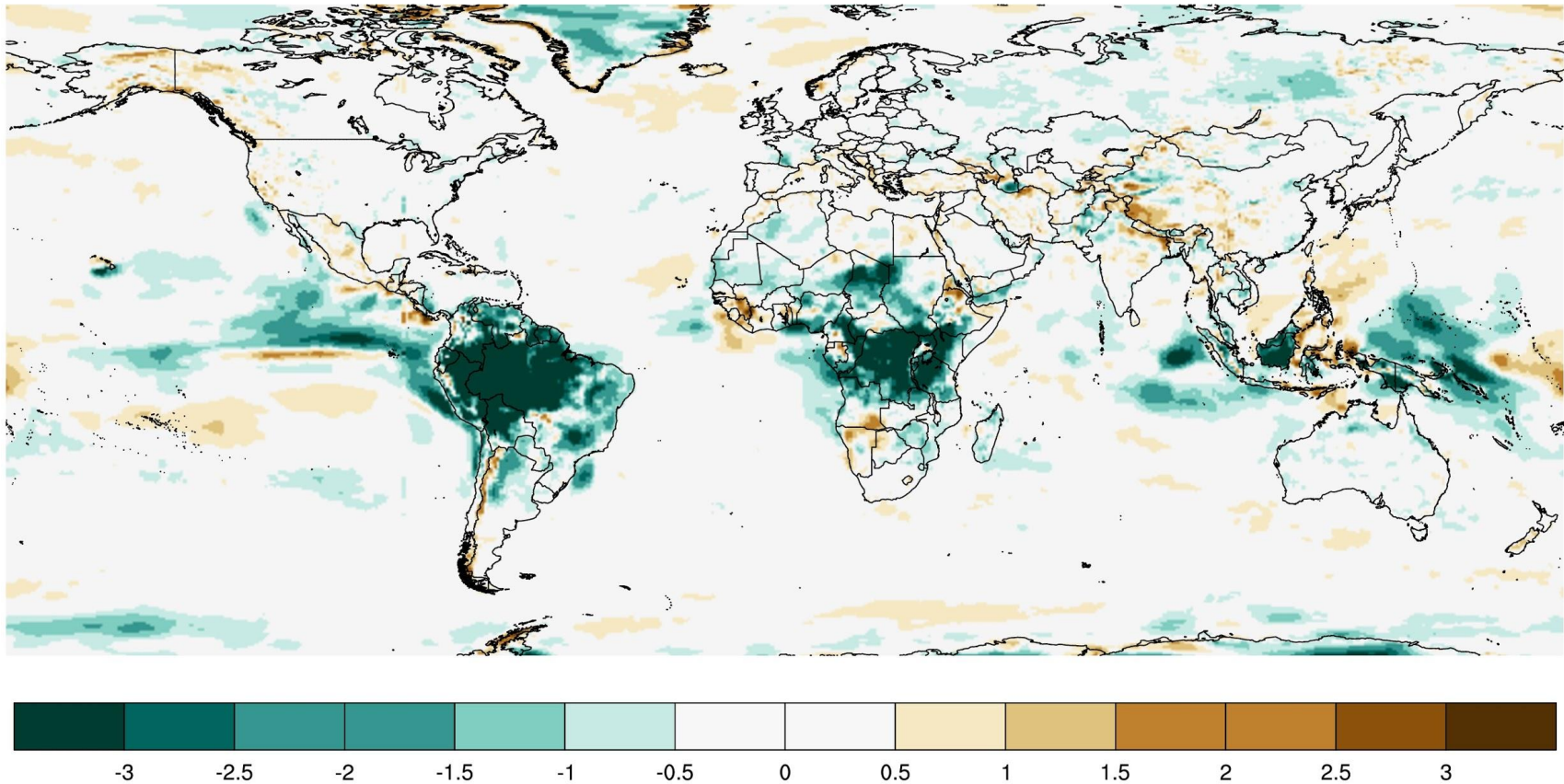
0.1   0.25   0.5   0.75   0.8   0.85   0.9   0.95   0.99
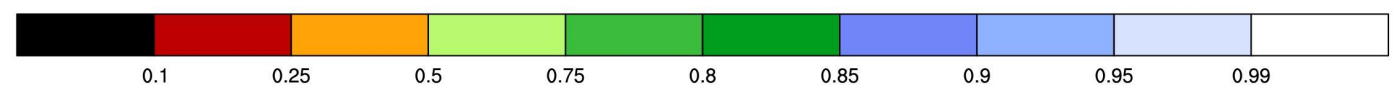
Change in Interannual Variability

Interannual Variability Differences (STD of Annual Anomalies) **MERRA2 [%] - MERRA [%] 10m**.

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❏ Climate Quality
  - ❏ Daily cycles averages
  - ❏ Annual cycle
  - ❏ Inter-annual variability
  - ❏ Extreme events

❏ Passport / Credentials

	Factual
❏ Match the observed data -> Correlation (R^2)	+++
❏ Time consistent (Visual inspection / Test / Dig inside)	++
❏ Events Amplitude (OBS period = extreme anomaly)	+
❏ Usage context (Tuning / Bias correction /MCP / Recalibration)	+

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❏ Model data
  ❏ MERRA Wind Speeds, 50 m, hourly
  ❏ MERRA2 Wind Speeds, 50m, hourly
  ❏ DOWNSCALING STREAMS (WRF 3kM)

❏ Measurements:
  ❏ Wind mast data
  ❏ Industry standards
  ❏ hourly time series
  ❏ Quality check
  ❏ At least 12 consecutive months periods

Over 240 sites

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□ MERRA2, validation

No significant changes in correlation (as whole)

Hourly R2	Q10	Q25	Median	Q75	Q90
MERRA	0.42	0.56	0.62	0.72	0.76
MERRA2	0.47	0.56	0.62	0.73	0.72

Daily R2	Q10	Q25	Median	Q75	Q90
MERRA	0.63	0.69	0.76	0.84	0.92
MERRA2	0.67	0.73	0.79	0.86	0.93

Monthly R2	Q10	Q25	Median	Q75	Q90
MERRA	0.52	0.75	0.87	0.93	0.99
MERRA2	0.67	0.78	0.86	0.91	0.98

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Mean Bias [m/s]	Q10	Q25	Median	Q75	Q90
MERRA	**1.2**	**1.9**	**2.7**	**3.7**	**4.4**
MERRA2	1.0	1.9	2.5	3.7	4.5
Mean Bias[m/s]	**Q10**	**Q25**	**Median**	**Q75**	**Q90**
MERRA + WRF	0.3	0.5	0.8	1.1	1.6
MERRA2+ WRF	0.3	0.4	0.8	1.1	1.6

Selection Criteria (*): R2 Monthly >0.85 & R2 Daily > 0.75

|	MERRA	MERRA2	WRF-MERRA	WRF-MERRA2	WRF-CFS
Pass	45 %	47%	67%	68%	71%

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What brings new MERRA2

- ❏ Northern Hemisphere "speaking", no much change
- ❏ Lower variability and difference annual and monthly correlation patterns:
    - ❏ Africa (Ethiopia)
    - ❏ Mexico, North Chile & SE-NE Brazil
    - ❏ Ontario region
    - ❏ Western China
    - ❏ India (South)

- ❏ Verification against data:
    - ❏ Globally, similar R2 factors & bias ranges
    - ❏ Verification missed data for some critical regions
    - ❏ Downscaling keep adding value to 'save' model data for wind industry users

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Challenges are in our backend (end users)
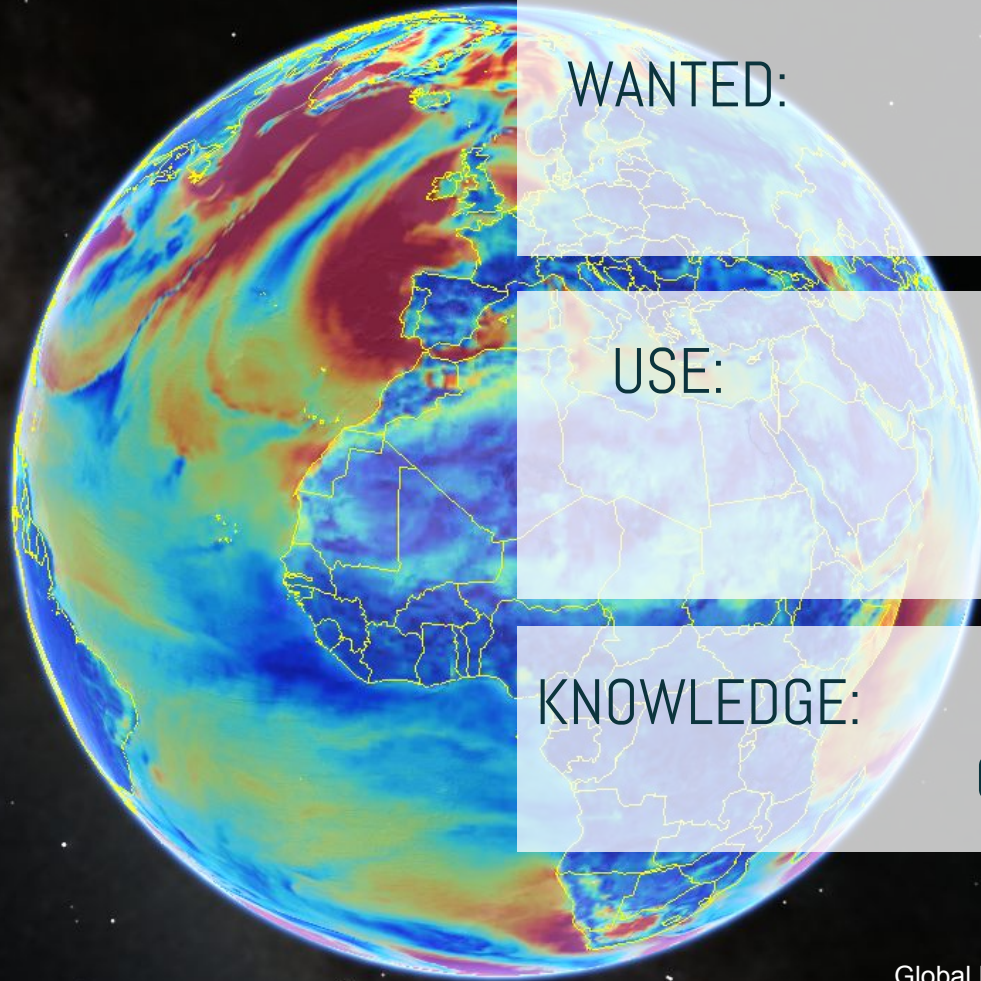
WANTED:

LT validation
Uncertainty and Error

USE:

Integrate model & observations
Dealing Multiple sources
Transitions between projects

KNOWLEDGE:

Consistency over time
Climate Knowledge & Perceptions

Global Long-term average 80m Wind Speed Distribution at 9KM resolution
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