"A Discussion on the need to improve Mesoscale Analyses for the NBM to support Field Operations"

Young-Joon (YJ) Kim
Chief, Analysis and Nowcast Branch

Mark Tew
Chief, Analysis and Mission Support Division

Andrew (Andy) Stern
Director

Analyze, Forecast, and Support Office
NWS/NOAA
Silver Spring, MD

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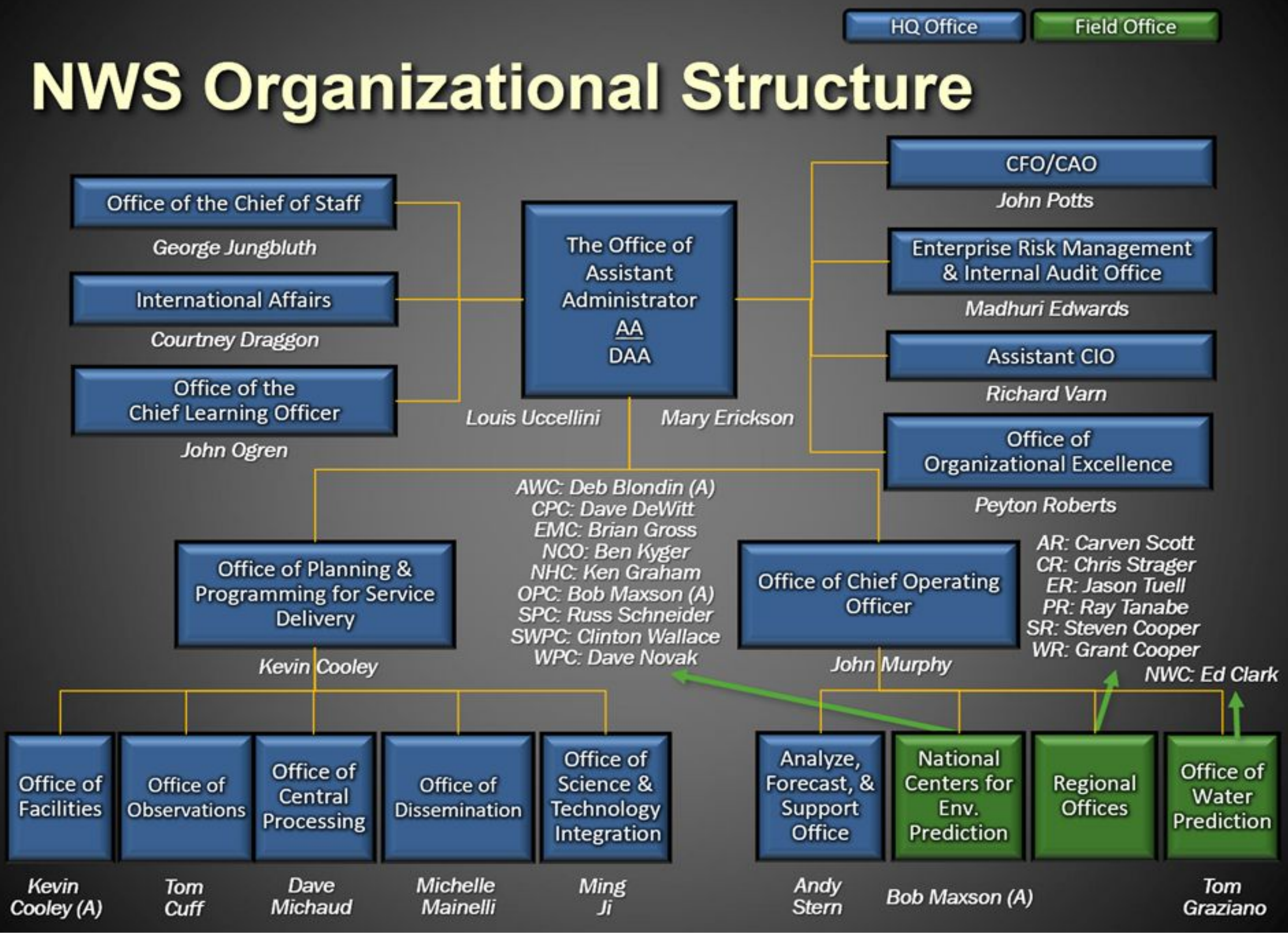
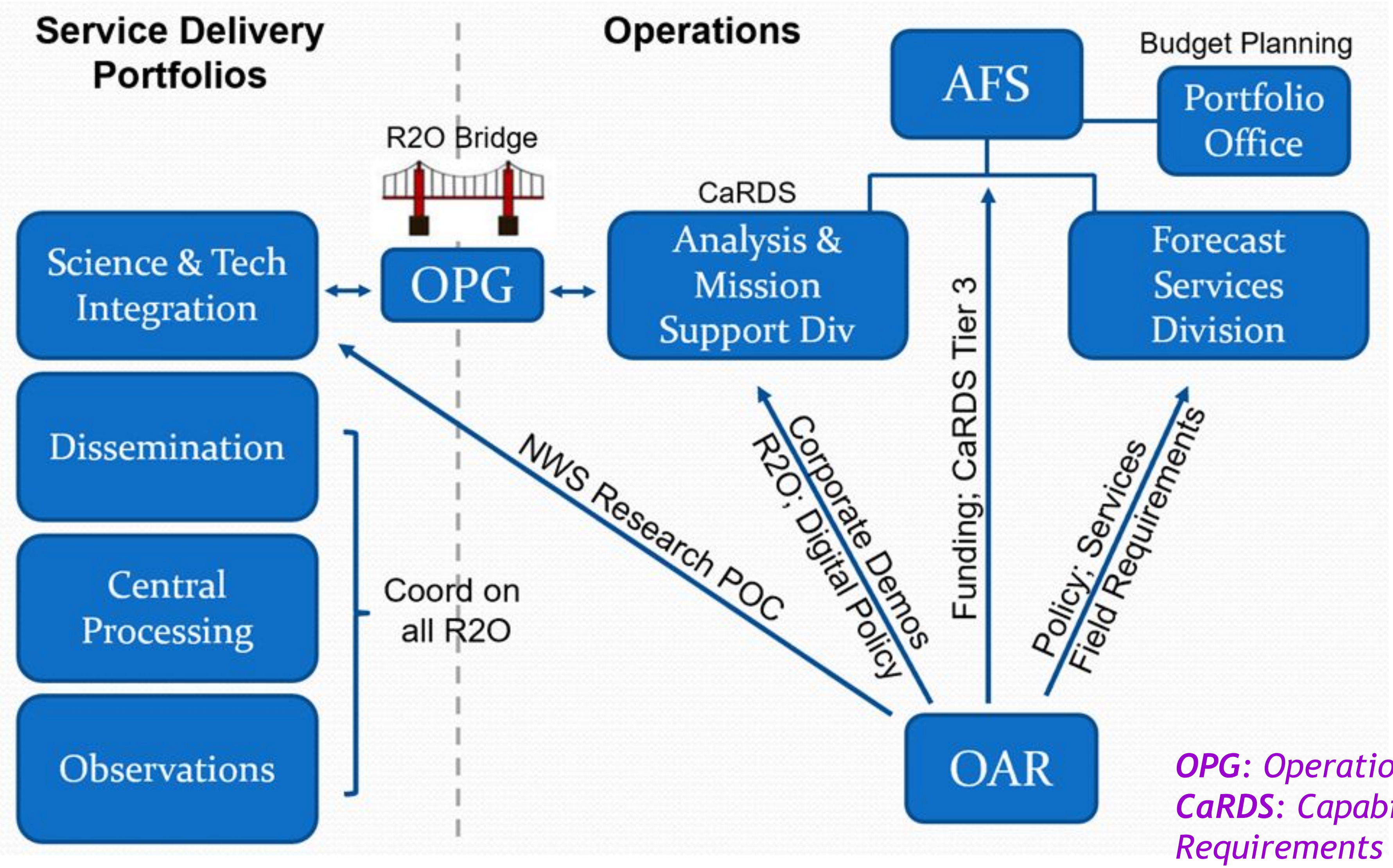
Goals Today

- Introduce ourselves
- NWS Governance - we are all in this together
- Review of field requirements vetting process
- Provide science challenges as identified by the field
- Start a discussion about linking field requirements to innovation

NWS Organizational Structure



Linking Operations to Innovation



***OPG**: Operations Proving Ground*
***CaRDS**: Capabilities and Requirements Decision Support*

Decision Making Councils

Executive Council
Chair: AA

- Provides NWS strategic direction
- Approves NWS planning and budgeting documents
- Serves as decision maker for high impact, high visibility issues including NWS transformational changes

Members: AA, DAA, CFO, COO, OPPSD

Mission Delivery Council
Chair: COO

- Transparently validates and prioritizes Field needs
- Discusses and recommends operational and service policies to ensure successful and consistent mission operations

Members: COO, AFS, NCEP, NWC, AR, ER, CR, SR, PR, WR

Portfolio Integration Council
Chair: OPPSD Director

- Ensures cross-Portfolio integration to support needs of mission execution
- Integrates the "Left side" under OPPSD with the "Right side" under COO

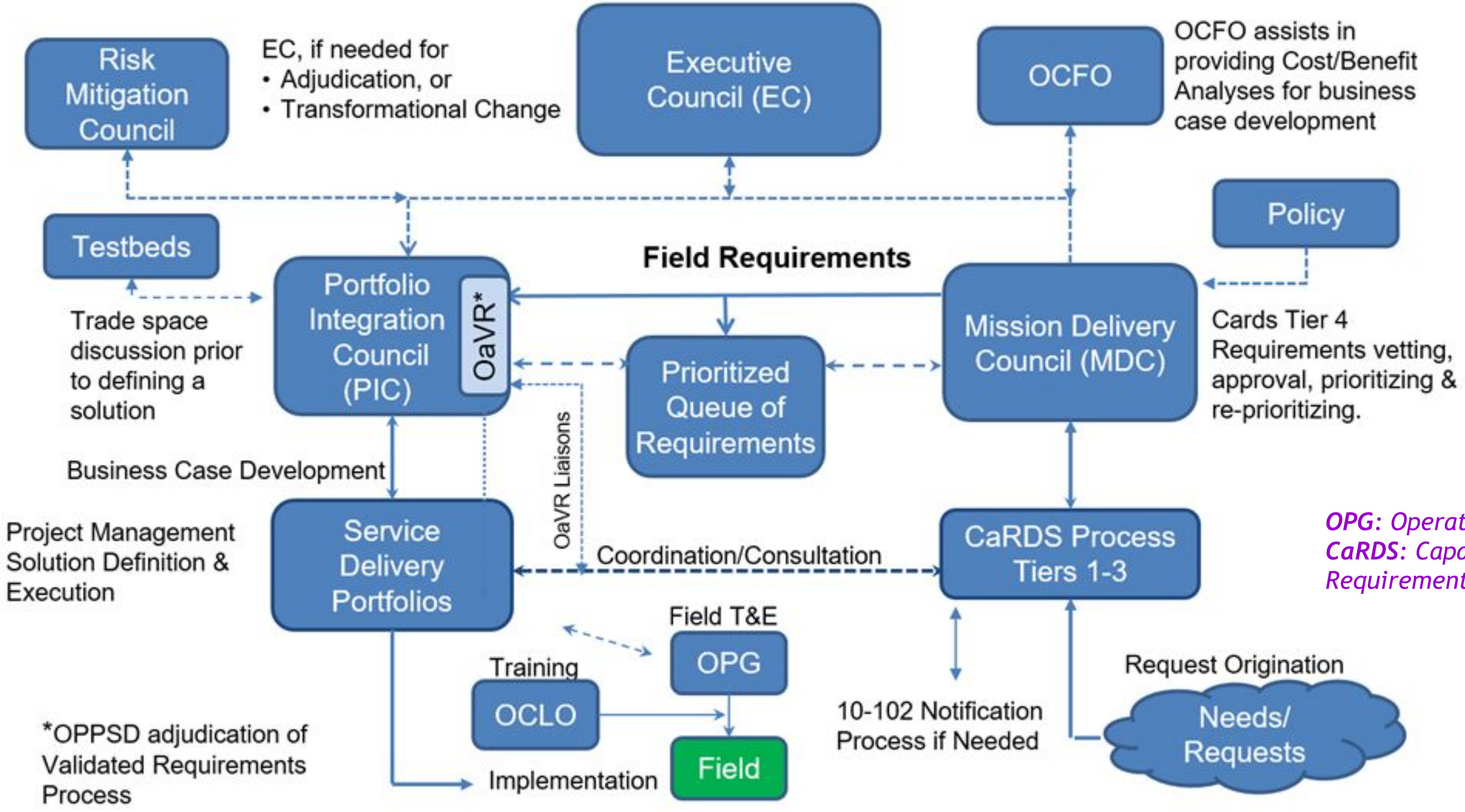
Members: OPPSD, COO, NCEP, NWC, Rotating RD, all five Service Delivery Portfolios, AFS

Enterprise Risk Council
Chair: DAA

- Identifies and monitors internal and external enterprise risks and issues
- Approves mitigation strategies for enterprise risks

Members: DAA, ACIO, CFO/CAO, COO, ERM, NCEP, NWC, OPPSD, Rotating CONUS RD, Rotating OCONUS RD

From Requirements to Innovation



OPG: Operations Proving Ground
CaRDS: Capabilities and Requirements Decision Support

Thank You

- ...for spending time with us today
- ...for getting to know us better
- ...for building relationships
- ...for responding to field needs
- as we together build a better Weather Service and Weather-Ready Nation!

AMBASSADOR™ WRN WEATHER-READY NATION

Addressing Field's Needs - Why URMA First?

- Analysis and Nowcast Branch of AFS concerns Analysis and Nowcast Tools.
- Among the Analysis and Nowcast tools used by NWS, RTMA/URMA (critical for NBM) was identified as one of the tools that needs to be urgently improved based on input from the field.
- We collected the field's needs on mesoscale analysis through surveys, opinions, testimonies, and forecast results, etc.
- We present some examples of the needs followed by a gap analysis.

RTMA: Real Time Mesoscale Analysis
URMA: UnRestricted Mesoscale Analysis
NBM: National Blend of Models

Field's Needs on Mesoscale Analysis & Gap Analysis

Slides based on Field's Input

+

Slides from RTMA/URMA Science Group

+

Slides of Gap Analysis

NWS Field Science Leaders Say, NBM and RTMA/URMA Need to be Improved.

- "*NBM* - please keep a top priority!
  - Primary Evolve goal - must demonstrate to the field that we are serious about supporting
    - To build trust, need to fix issues in a timely manner and keep enhancing
    - Quarterly bug fixes are critical
    - Try to keep to the yearly NBM version updates
  - V 3.2 and beyond -- enhancing/introducing probabilistic elements is critical"
- "*RTMA/URMA* and work on new *3D RTMA*
  - Updates are critical to NBM performance -- supports both bias correction and verification
    - Timely updates -- same as NBM -- should be sync'd as close as possible
  - Critical Obs decoding issues -- Need to implement fix for observation precision decoding error"

***NBM**: National Blend of Models*
***RTMA**: Real Time Mesoscale Analysis*
***URMA**: UnRestricted Mesoscale Analysis*

Taken from "Regional SSD Priorities – FY20 and beyond"
Presented on Dec. 5, 2018, at 2018 STI Annual Meeting by Bruce Smith, NWS CR SSD Chief

Strong Dependency of NBM on Verification Data
→ Need Reliable Verification (Analysis) for Reliable NBM

URMA	Max T	Min T	T	Td	Sky	Wind Speed	Wind Gust	PoP12	QPF06	Snow Amt	Wave Height
	MAE	MAE	MAE	MAE	Heidke	MAE	MAE	Brier	Heidke		
0-18 hours	47%	73%	100%	100%	98%	100%	94%	72%	90%	NA	NA
24-72 hours	52%	84%	100%	100%	91%	99%	91%	92%	75%	NA	NA
78-168 hours	100%	98%	100%	100%	75%	96%	NA	100%	NA	NA	NA

METAR	Max T	Min T	T	Td	Sky	Wind Speed	Wind Gust	PoP12	QPF06	Snow Amt	Wave Height
	MAE	MAE	MAE	MAE	Heidke	MAE	MAE	Brier	Heidke		
0-18 hours	29%	47%	94%	98%	97%	37%	87%	84%	NA	NA	NA
24-72 hours	29%	55%	95%	99%	94%	41%	85%	66%	NA	NA	NA
78-168 hours	97%	96%	99%	100%	60%	53%	NA	94%	NA	NA	NA

NBM IOC Dashboard (201802)
Percentage of 116 CONUS WFOs where NBM v3.1 is meeting IOC (-10% improvement over NDFD). [NDFD is compared with NBM available when forecast was prepared.]

Verification is % of CONUS WFOs where NBM meets IOC over past 3 months as measured by URMA / METAR using standard MDL verification site

IOC: Initial Operating Capability

Courtesy of J. Craven

"AFS11 Survey" Says, Field Forecasters Need More & Better Mesoscale Analysis, esp. over Complex Terrain.

2018 AFS11 0-18 Hr Forecast Survey (http://nws-afs11.org/survey_afs11/: Part I)

"Unmet Needs" with Most Counts	Count
Analysis - RTMA/URMA - Improved quality, hourly, surface, coverage & latency & QC, esp. over high/complex terrain, & Improved update/process time	31
Aviation - Ceiling/Visibility/Fog (esp. over complex terrain), Cloud/Sky Cover, VWP Analysis / Hodographs, LAMP, AMDAR, TAFS, EDR, etc.	32
Observation (Sounding) - High temporal/spatial resolution/real-time RAOBS/profiles, sampling, verification of more observation data	33
Precipitation (QPF/QPE/ptype) - Improved QPF guidance, prediction/analysis, bias-correction, latency	35

"Suggestions" on Analysis/Observation
Develop better verification than **RTMA/URMA**.
Continue to vest into **URMA** improvement.
Develop better **mesoanalysis** for hourly input to CAM ensembles.
Assimilate all surface **mesonets** using scientific-grade instrumentation in operational models.
Allow access to **mesoanalysis** in AWIPS.
Expand **mesonet** to outside government to improve obs. density
Develop a webcam **mesonet**, i.e., an internal website which aggregates publically-available webcams.

RTMA: Real Time Mesoscale Analysis

URMA: UnRestricted Mesoscale Analysis

URMA Wind Issues ~ Underestimated NBM Winds

Source: Feedback on MOS Products (Feb. 2019) - Source: Jeff Craven

- [Steve Keighton, SOO RNK (Roanoke, VA) WFO]
  - "NBM winds too low……"
  - "Largely a function of URMA wind issues having a low bias compared to station obs…."
  - "In relatively high gradient situations, GMOS is by far the best starting point for winds when compared to stations, especially in our mountain valleys where the model guidance does not do great job if mixing winds into the valleys"
  - "have a pretty good confidence that the ASOS/AWOS station data in these valleys is likely better than URMA winds"

- [Frank Alsheimer, SOO CAE (COLUMBIA, SC) WFO]
  - "We can't currently use the NBM winds because they are not sufficient for the wind grids, which we derive all our TAFs from, now."
  - "URMA/NBM does not work for DAS winds at the current time. The only option is … to blacklist EVERYTHING that is not ASOS/AWOS as long as we are using the wind grids for digital aviation."

NBM: National Blend of Models
URMA: UnRestricted Mesoscale Analysis
DAS: Digital Aviation Services

NWS Field Forecasters Say, RTMA/URMA Needs Improvement. (e.g., Cold pool over high mountain valley, 12/11/2018, Tabernash, CO)

- "Short range models including RAP and HRRR, and various other raw model output did not capture strength of inversions"
- "Higher retention of observations (versus background fields) desired in complex terrain, especially for T & Td"
- "RTMA/URMA could benefit from … additional high quality observations from other data sets. …. If we go through the automated QC and blacklist processes, we'll only improve analyses."
- "Better analyses and verification against actual observations versus model background fields (especially in complex terrain where even high resolution numerical modeling struggles)"

HRRR: High Resolution Rapid Refresh (model)
RAP: Rapid Refresh (mesoscale model)

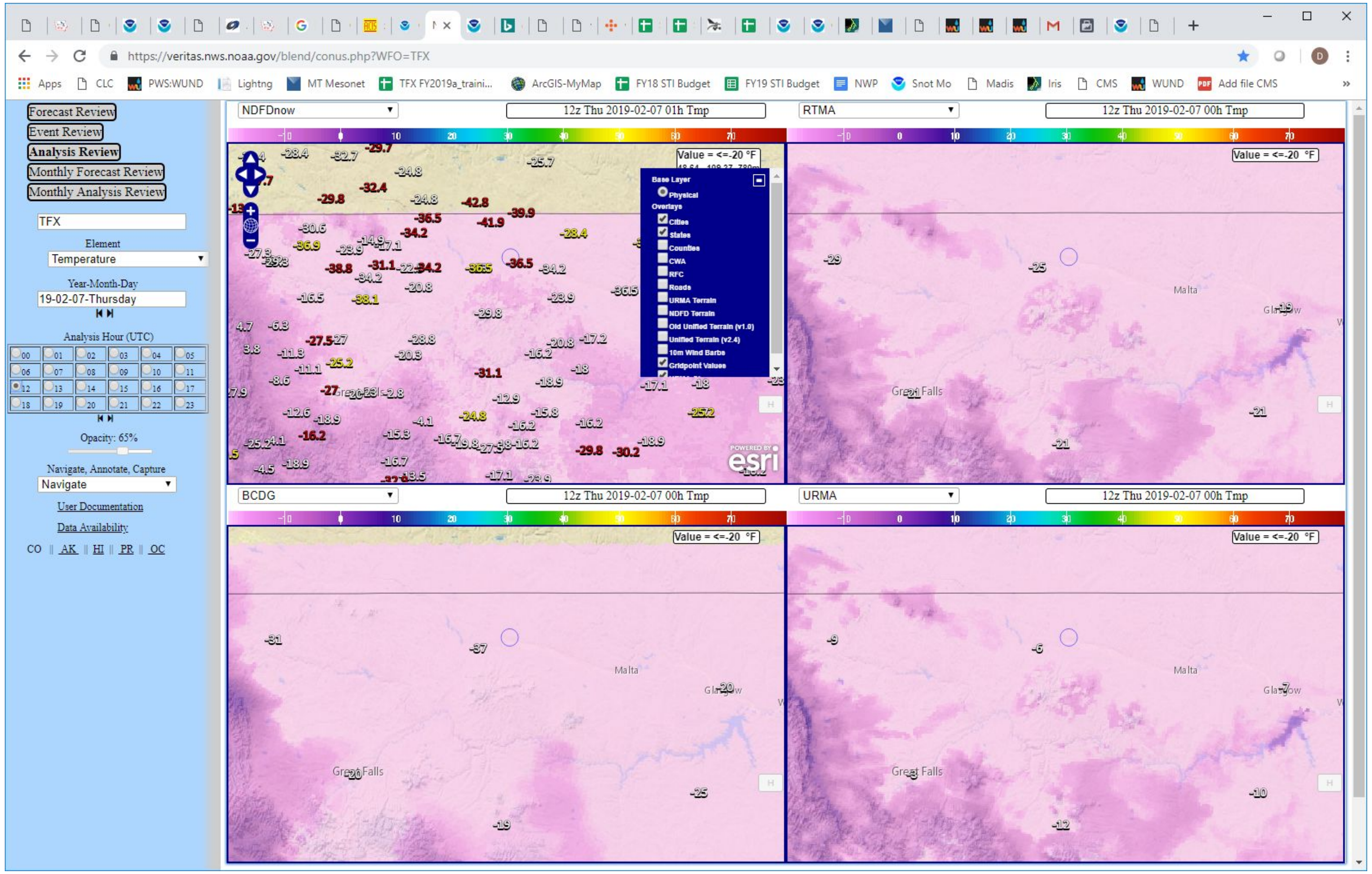
RTMA: Real Time Mesoscale Analysis
URMA: UnRestricted Mesoscale Analysis

Taken from "December 11, 2018 Inversion Event"
Posted on Dec. 14, 2018, on vLab RTMA/URMA Discussion Group by Dave Barjenbruch, NWS/CR/WFO/Boulder, CO

Cold Pool @TFX (Great Falls, MT) CWA

David Bernhardt (2/7/2019) - Source: vLab Forum

- [David Bernhardt] "RTMA/URMA appeared to have rejected most of the cold temperatures"
- "Its kind of hard to get the NBM to bias-correct to these cold temperatures when the analysis shows temperatures 15 to 20 degrees warmer than observations."
- "Again, it looks like the background field is in error and needs to be addressed."



RTMA: Real Time Mesoscale Analysis
URMA: UnRestricted Mesoscale Analysis

- [Jacob Carley] "nothing is done for the situation when temperatures are so cold they exceed the capabilities of the sensor (i.e. flat line reporting). Future ob qc upgrades could help with this, but I suspect they would be more apt to trigger a stuck-instrument flag and get tossed as a result. …… likely requires site-specific QC (e.g. time series considerations at each station), which is on our to-do list but will not be ready in time for v2.8."

The Cold Pool Dilemma in URMA

Paul Wolyn (2/5/2019) - Source: vLab Forum

- "Forecasters are faced with a dilemma:
  - Do we forecast closer to what the URMA would have or do we forecast closer to the observations?
  - If forecast is closer to observed values, argument can be made, based on the too warm URMA, that the forecasters are "degrading" the NBM forecast. The NBM uses the URMA for bias correction and verification.
  - If forecast is closer to URMA values, customers may think our forecasts are poor because they are too warm for the cold pools."
- "Can the weighting be locally changed based on elevation differences in complex terrain?"

NBM: National Blend of Models
URMA: UnRestricted Mesoscale Analysis

→ This is more of a science question, rather than a "philosophical question".

RTMA/URMA SOO Group Report

Dave Bernhardt (SOO-Great Falls) - Source: Andy Edman @2016 NPSR

From "a list of items that the RTMA "Good-Enough" Sub-group would like addressed with the RTMA and its assimilation process". "Until these items are addressed, it is difficult to determine what is a "good-enough" analysis."

2. **"Much expanded quality control of observations and mesonets."**
   - "It is important to reduce the number of observations that are rejected because they differ from the first-guess by a threshold amount."
   - "While these can be indicative of bad observations, they are often indications where the first-guess is not capturing reality and itself needs to be adjusted."
   - "These adjustments may include time continuity, neighbor agreement and other factors that should be accounted for in order for a station to be retained, even when it does not make the cut in the current scheme."

***RTMA**: Real Time Mesoscale Analysis*

RTMA/URMA SOO Group Report

Dave Bernhardt (SOO-Great Falls) – Source: Andy Edman @2016 NPSR

3. "Much expanded ability for different weighting for different observations in varied situations."

- "The current system weights observations very broadly, either METAR or other. This is particularly important when observations differ from the first-guess, yet agree with nearby observations that also differ from the first-guess.
- Such cases are indications that the first-guess may be missing critical local variations and needs to be more strongly adjusted toward the observations than in other circumstances ….."
- "Other variations in weighting are also warranted, such as weighting observations more strongly at grid points where sub-grid topographic variability is low - and less at grid points where the sub-grid topographic variability is high."
- "Expanded variation in weighting based on observation type is also necessary, where more weight is given to some types of mesonets (such as high quality sensors like permanent RAWS and possibly DoT), and less weight to other mesonets (such as public "backyard", CWOP and other such stations)."
- "This will help for mountain winter cold pools, marine layer inconsistencies, cold pools behind squall lines plus any other situation where the model background field is struggling with reality."

Wind Analysis Challenges

From RTMA/URMA Group

- Noted low wind speed bias in RTMA/URMA
  - Associated with assimilation of mesonet winds --- but...
- Representativeness
  - People live where these stations are, not at airports (but airports are important)
- Metadata gathering effort for CWOP, AWX, WxBug
  - Need for this has been presented to PMO, Nat'l Mesonet project
  - ***Proper metadata is crucial to using these valuable data correctly!***
- List of sensor heights for most providers from MesoWest
  - Stations accepted when sensor heights are known, even if <10 m.
  - 'default setting' assumes all wind obs are at 10 m
  - Any station can be flagged via if needed (stop-gap measure)
- Goal is to account for **ALL** mesonet stations in analysis.

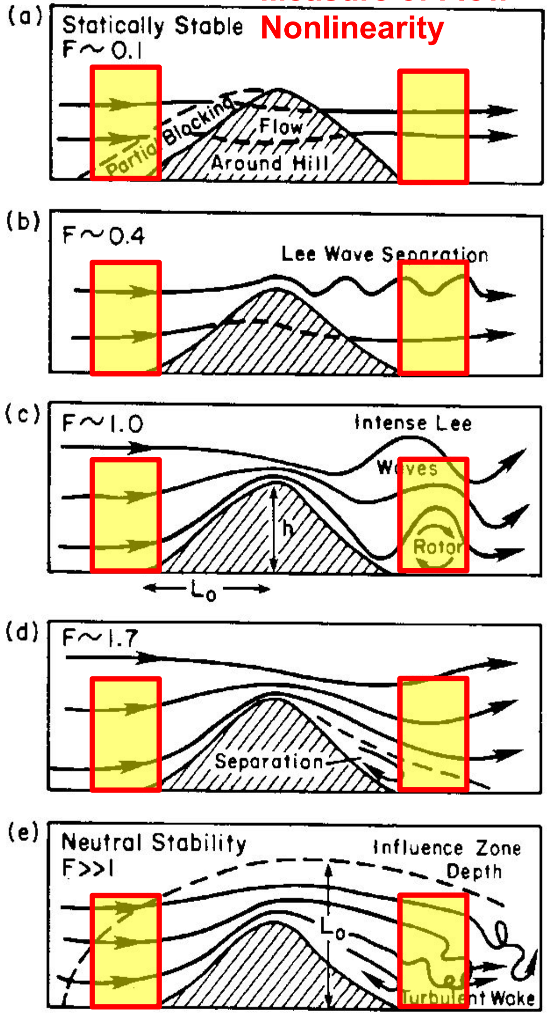
CWOP station photo from http://weather.gladstonefamily.net

may be okay if the chimney isn't used!

CWOP: *Citizen Weather Observer Program*

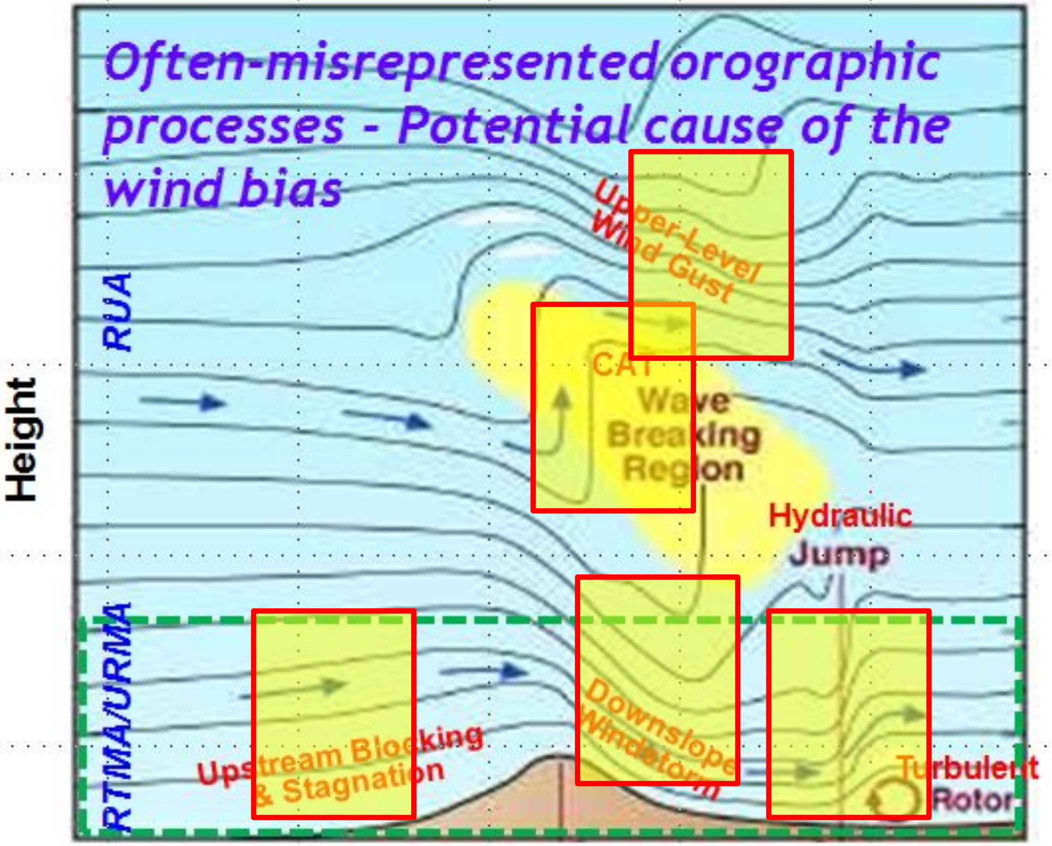
Gap Analysis: Complex Physical Mechanisms around Topography Affecting the Flow Physically and Dynamically

$F = Nh/U$ ~ Froude Number: Measure of Flow Nonlinearity



Barry (1992 Book)

***Flows over complex terrain** (mountains, coasts, lakes, & islands, etc.) are highly "**inhomogeneous**", "**transient**", "**anisotropic**" (in 3D).*



- ***Topographic flows** can be represented by different **flow regimes**".*
- ***Are the field's needs adequately met?***
  - ***Model biases over complex terrain including valleys, degrading mesoscale analysis!***
  - ***Metadata to include sensor heights!***
  - ***QC to retain "more" or "less" obs with the weighting depending on topographic variances in complex terrain?***
  - ***Different weighting for different observations in varied situations?***
  - ***Time continuity, neighboring agreement, and other factors?***
- *Our **gap analysis** suggests these flow regimes may not be systematically distinguished in **current QC algorithms & station flagging.***

Ongoing Wind QC Issues

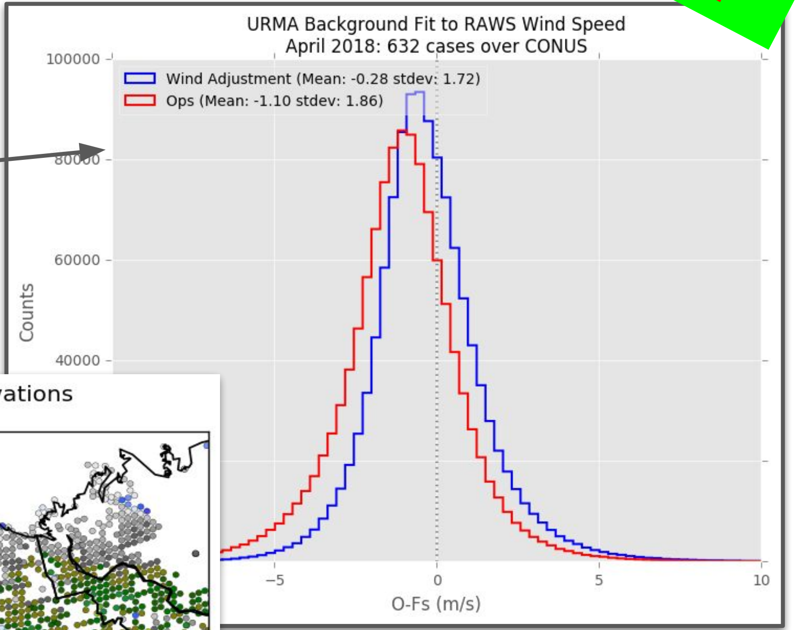
From RTMA/URMA Group

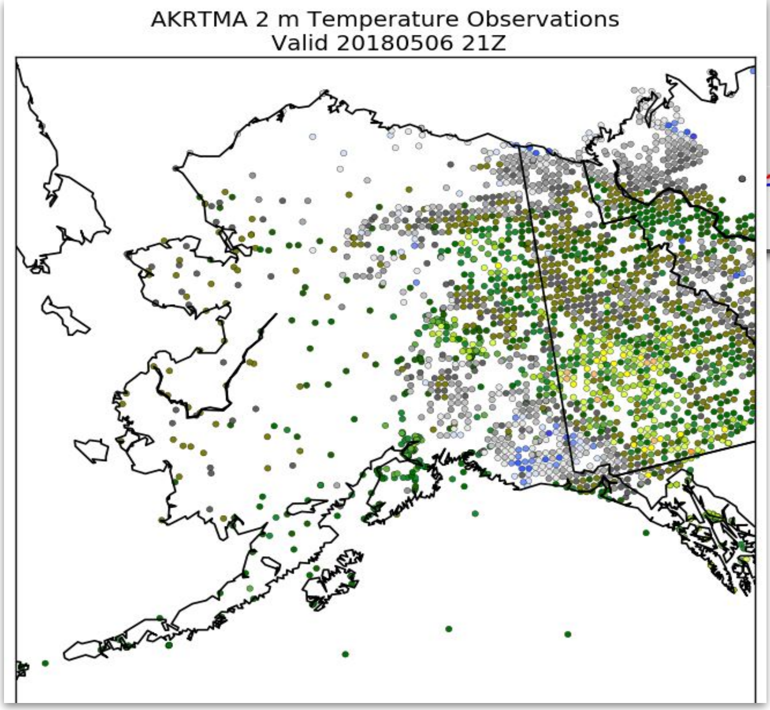
- Users continue to request stations be flagged via VLab form
  - If you have a long list of stations, just email me with a list (steven.levine@noaa.gov) instead of using the form
- Some improvement in wind QC will occur when v2.7 is implemented next week
- Ongoing experiment: Retrospective Nov. 4th testing with Great Falls, MT high wind event
  - Will use for wind operator work
  - Sensitivity tests to ob/network types and distributions
- Up-to-date KML files are no longer available on FTP server
  - Problem appears to be with FTP server, still being investigated
  - If you want up-to-date files, send us an email
- Want to trace a particular ob? Go here, then click “URMA Time Series”
  - Most METAR obs available

What's Next - Some highlights for v2.8

From RTMA/URMA Group

- Improve engagement with OCONUS partners
- Improve observation operators for wind
  - Incorporate similarity theory-based adjustment
  - Continue pursuit of enhanced station metadata with partners
- Continue improvement of QC
- Incorporate elevation adjustment in temperature assimilation
- Assimilation of VIIRS LSTs
  - Project with AK Region
- Update/enhance downscaling
- Snowfall analysis

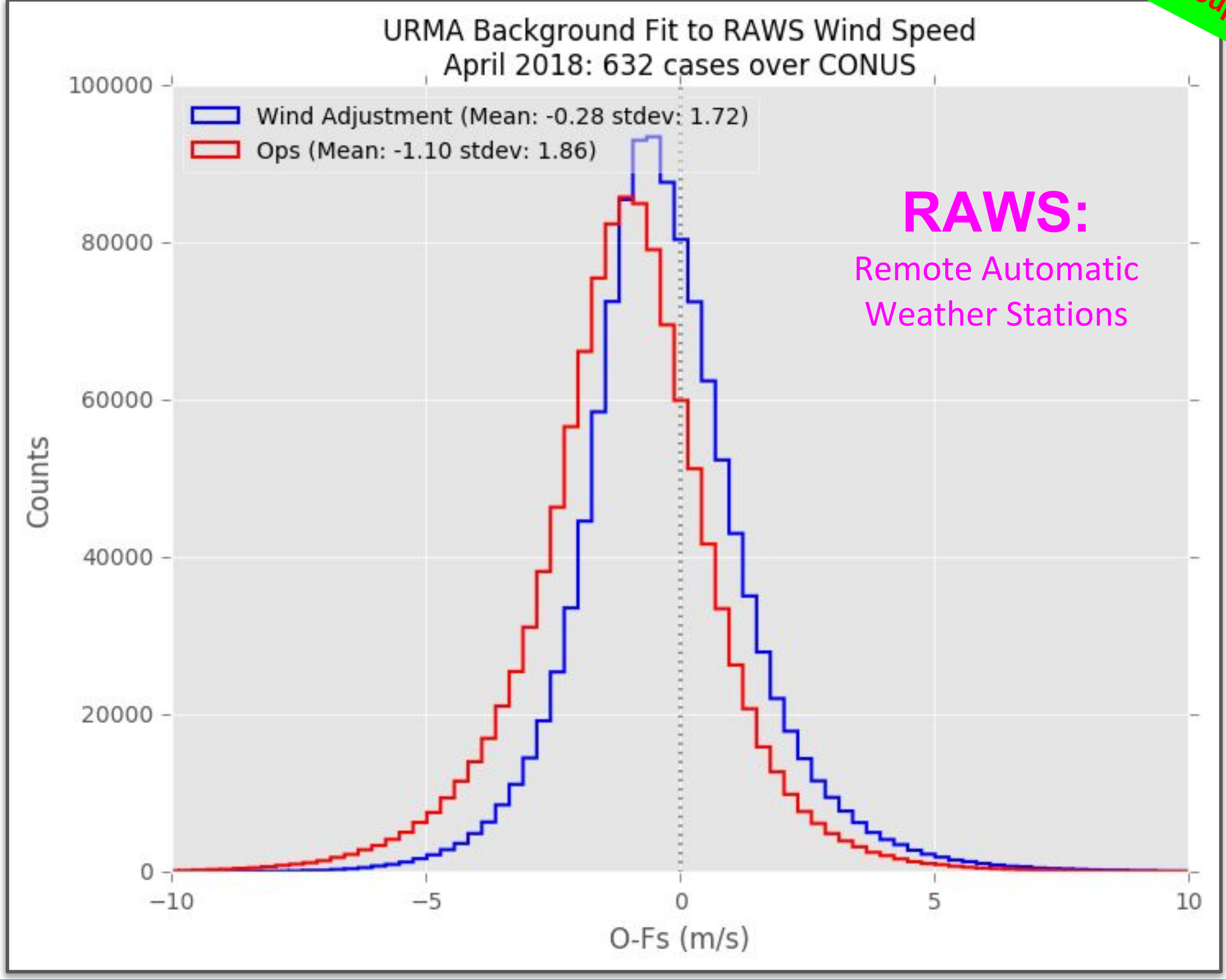




From RTMA/URMA Group

v2.8: Better Metadata, Better Wind Analysis

- Test very simple adjustment for 6m AGL winds from **RAWS**
  - Neutral stability, uniform roughness length for all sites
- Improved bias with fits to the background
- Challenge? Most mesonet networks have little to no metadata
- Those that have metadata are well-sited anyway
- More outreach is needed to gather and collect metadata before we can use

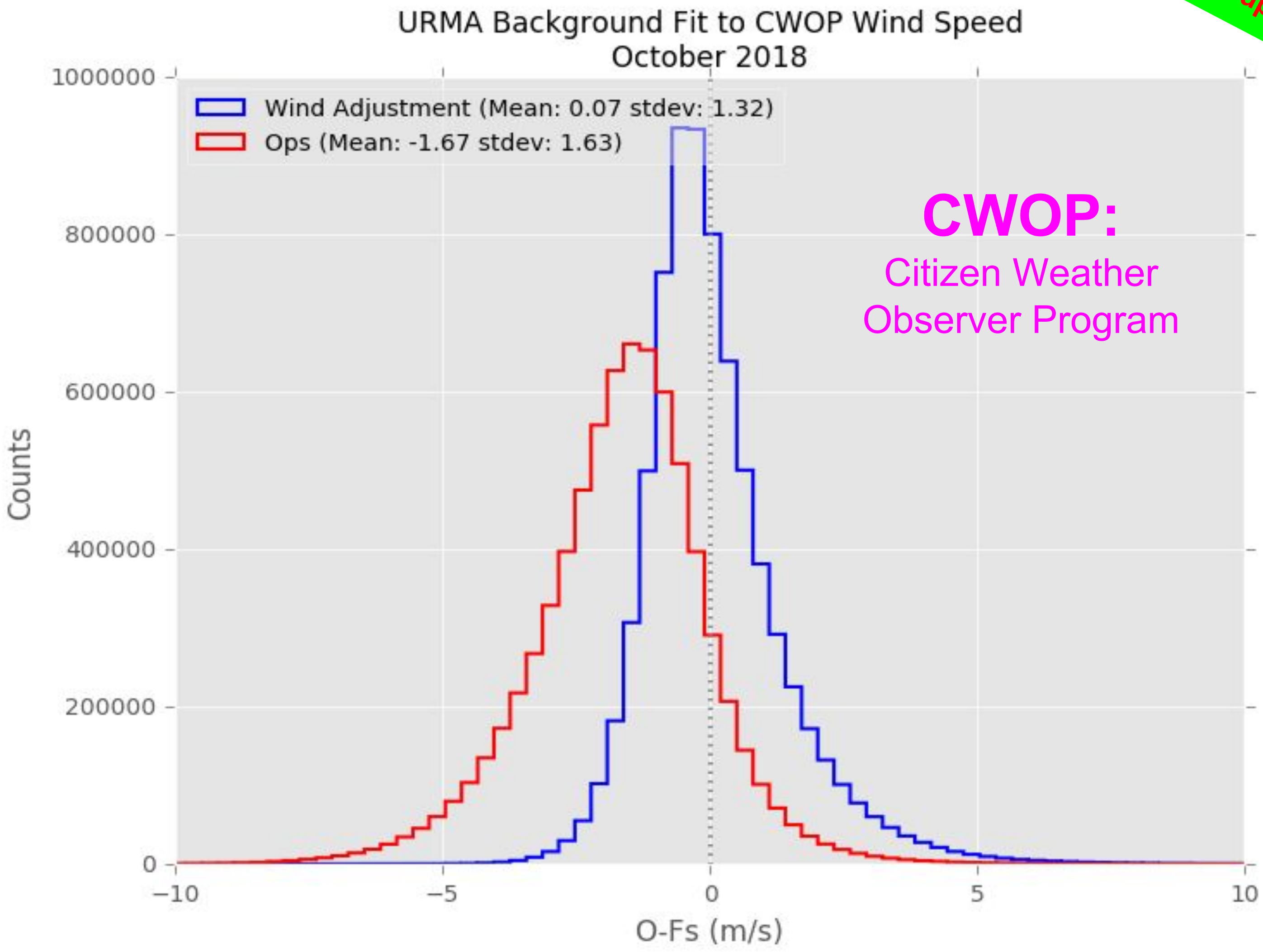


RAWS: Remote Automatic Weather Stations

CWOP Operator Improvements

From RTMA/URMA Group

- O-B difference histogram
- Background values are interpolated from HRRR background.
- Current RTMA
  - Assumed height 10 m
- **V2.8**
  - Log wind profile adjustment, assuming neutral stability
  - Assumed height 3 m
  - Roughness length assumed 1 m.
- **Lower O-B bias = less bias in the analysis.**



CWOP:
Citizen Weather Observer Program

RTMA/URMA SOO Group Report

Dave Bernhardt (SOO-Great Falls) - Source: Andy Edman @2018 NPSR

4. "Improve background co-variance "analysis uncertainty" grids so they are more representative of the current errors in the background, etc."

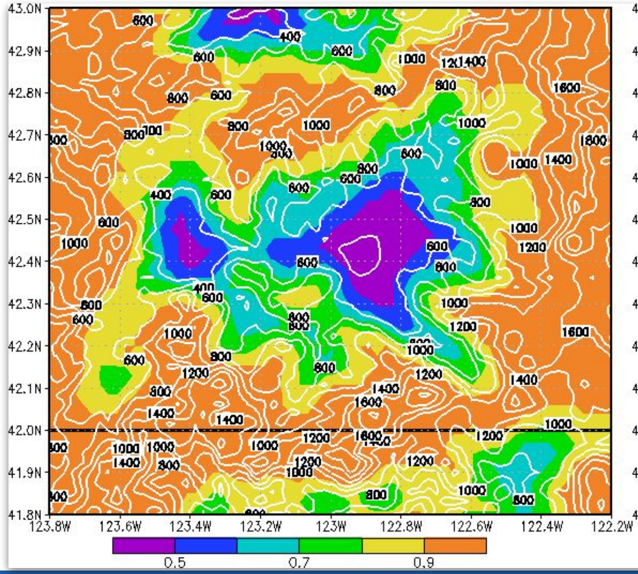
- "A threshold can be determined, but as a starting point, maybe we should consider something less than one-half of a standard deviation, difference from mean or variance."
- "These grids should be updated in real time with a running set of time periods - last hour, last day, last week, last month, last 3 months and last year.
- This would provide critical insight as to how the RTMA/URMA analysis is performing for both daily, seasonal and yearly basis.
- This information could … also be used to improve how the NDFD verifies, ie., is the gridded forecast within the RTMA analysis error."

Revised 2m T Background Error Covariance

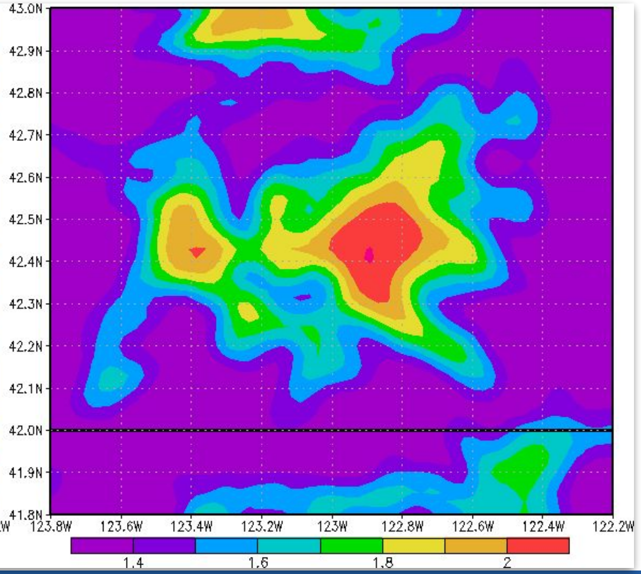
From RTMA/URMA Group

- Analysis is a statistical combination of the observations and background, weighted by their respective errors
- The background 2m T field can struggle in/around complex terrain (i.e. *an error in the background*)
- Incorporate a valley map into the background error to inflate the errors in complex terrain
    - Fit observations more closely where the RTMA/URMA background struggles - valley cold pools

Valley-map and Terrain (m)



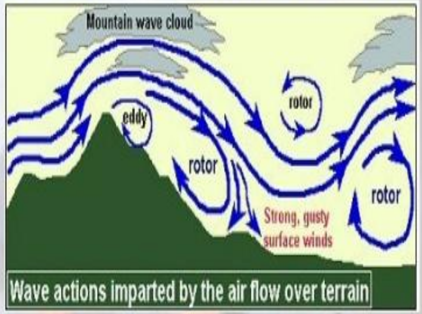
Temperature Background Error Stdev (K)



Gap Analysis: Complex Physical Mechanisms around Topography Affecting the Flow Physically and Dynamically

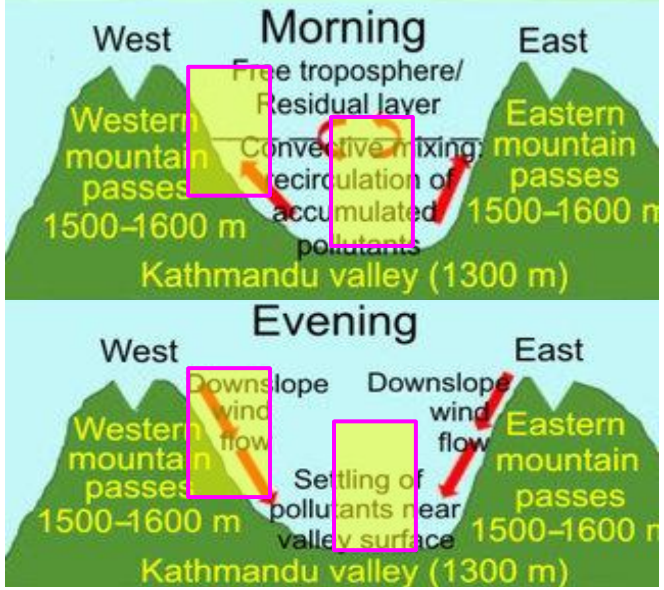
Ways Topography Alters Wind

Mechanical or Diverting Effects

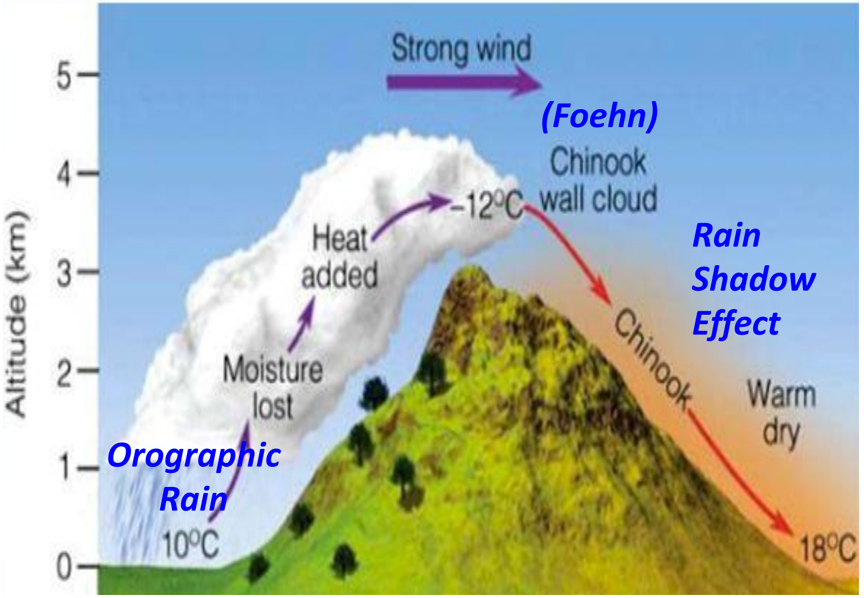


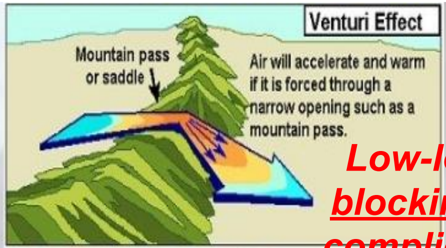
Mountain Waves

- Strong winds cross prominent terrain resulting in a wave
- Altocumulus lenticular cloud is a good indicator of mountain waves
- Air below ridge line can be turbulent
- Air over lee side basins can become warm, dry and unstable



Terrain of large variation (e.g., mountains) can have significant effect on __temperature__ and __humidity__ as well on __winds__.

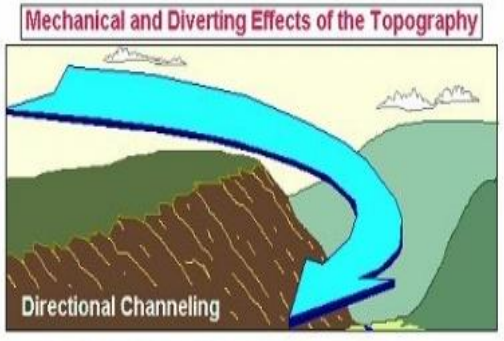




Low-level __flow blocking__ further complicates flow characteristics.

Venturi (Bernoulli) Effect

- Acceleration of air through a terrain constriction, such as a pass or gap
- Air accelerates through by the pressure gradient across the topographic constriction



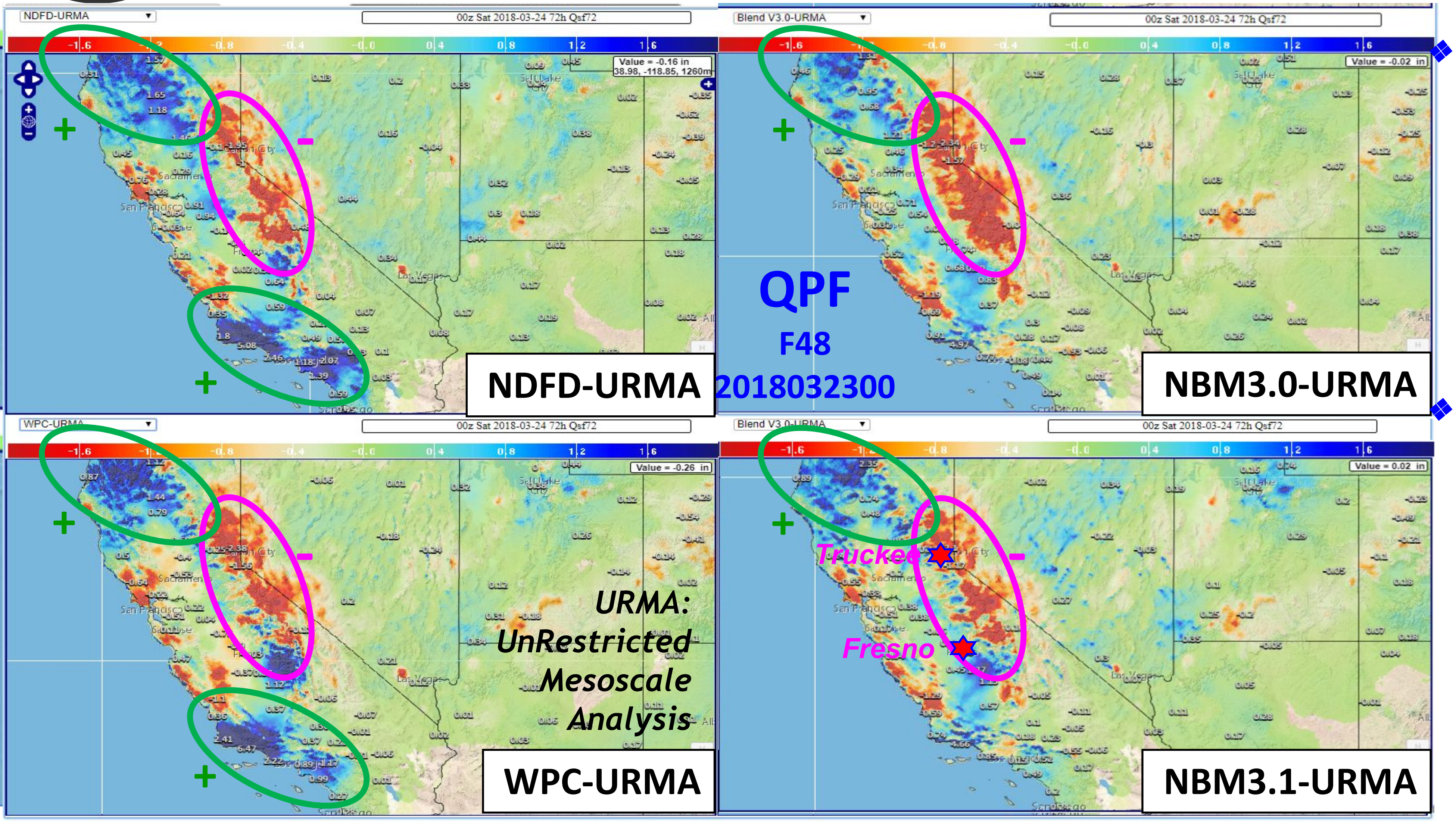
Directional Channeling

- Wind is channeled through valleys and drainages
- Airflow follows prominent terrain features

- *Are the effects due to __inhomogeneous, transient, and anisotropic nature of topographic flows__ fully represented in current __background error covariance__ and/or __downscaling__ algorithms, meeting the field's needs?*

NBM Case Study of CA-NV Atmospheric River (3/22~23/2018): 48 hour (Total) QPF/QPE Bias w.r.t. URMA [Kim & Tew, 8/30/2018 @NWA Meeting)

Significant QPF Biases over Sierra Nevada & along the CA Coasts



- *"All the guidance struggled on the __east slopes of the Sierra__ …., where Truckee, CA was much __wetter__ than any of the forecasts."*
- *"NDFD and WPC both outperformed NBM in the __valley__ and __mountains__ near Fresno, CA, as the NBM was __too wet__ __down low__ and __too dry__ __up high__."*

Matt Jeglum @WR
(from J. Craven 3/28/2018)

Comparisons of Rain Products with Gauges at "Relatively Wet Stations forming Good Orographic Ratio Pairs" (2018-03/20~23)

Station Name	NBM v3.0	NBM v3.1	NDFD	WPC	Obs (in)
Pocatello, ID	0.94	1.1	**0.7**	0.8	0.65
Craters of the Moon, ID	1.05	**1.15**	1.0	0.8	1.8
Sedgwick Peak, ID	1.3	2	1.35	**1.95**	1.9
Ely, NV	0.38	**0.65**	0.64	0.44	0.67
Wheeler Peak, NV	2.2	**3.5**	1.4	1.75	3.0
Salt Lake City, UT	**0.56**	0.76	0.59	0.73	0.43
Alta, UT	1.95	3.1	1.85	**2.25**	2.4
St George, UT	**0.25**	0.39	0.62	0.66	0.13
Midway Valley, UT	1.1	1.7	**2.0**	1.5	2.8
Las Vegas, NV	0.14	**0.08**	0.18	0.13	0.03
Rainbow Canyon, NV	2.25	**3.0**	1.0	0.6	4.6

Station Name	NBM v3.0	NBM v3.1	NDFD	WPC	Obs (in)
Reno, CA	0.6	**0.7**	0.54	0.44	1.1
Truckee, CA	1.79	2.03	**2.18**	1.75	3.4
Forni Ridge, CA	4.7	5.6	5.5	**6.0**	6.0
Fresno, CA	2.94	3.09	**2.25**	2.18	2.26
Dinkey Creek, CA	5.25	7.7	6.05	**8.5**	9.9
Santa Barbara, CA	5.33	**5.03**	5.44	6.83	2.95
La Granada Mtn, CA	**6.2**	6.9	9.1	9.7	5.8
Riverside, CA	**0.5**	0.68	1.59	1.17	0.16
Mount San Jacinto, CA	1.2	**1.95**	2.55	1.05	1.76
Mean Abs Error	1.0	0.7	1.2	1.1	n/a
Mean % Error	120	140	180	160	n/a
Overall Bias	-21%	-1%	-1%	-4%	n/a

Cities where NBM3.1 is closest to station obs.

Cities over steep topography or large terrain variation areas

NBM Performs Well Overall over terrain areas, but Shows Larger Biases over Steep Terrain &
→ Field's needs to improve URMA

Matt Jeglum @WR
(from J. Craven 3/28/2018)

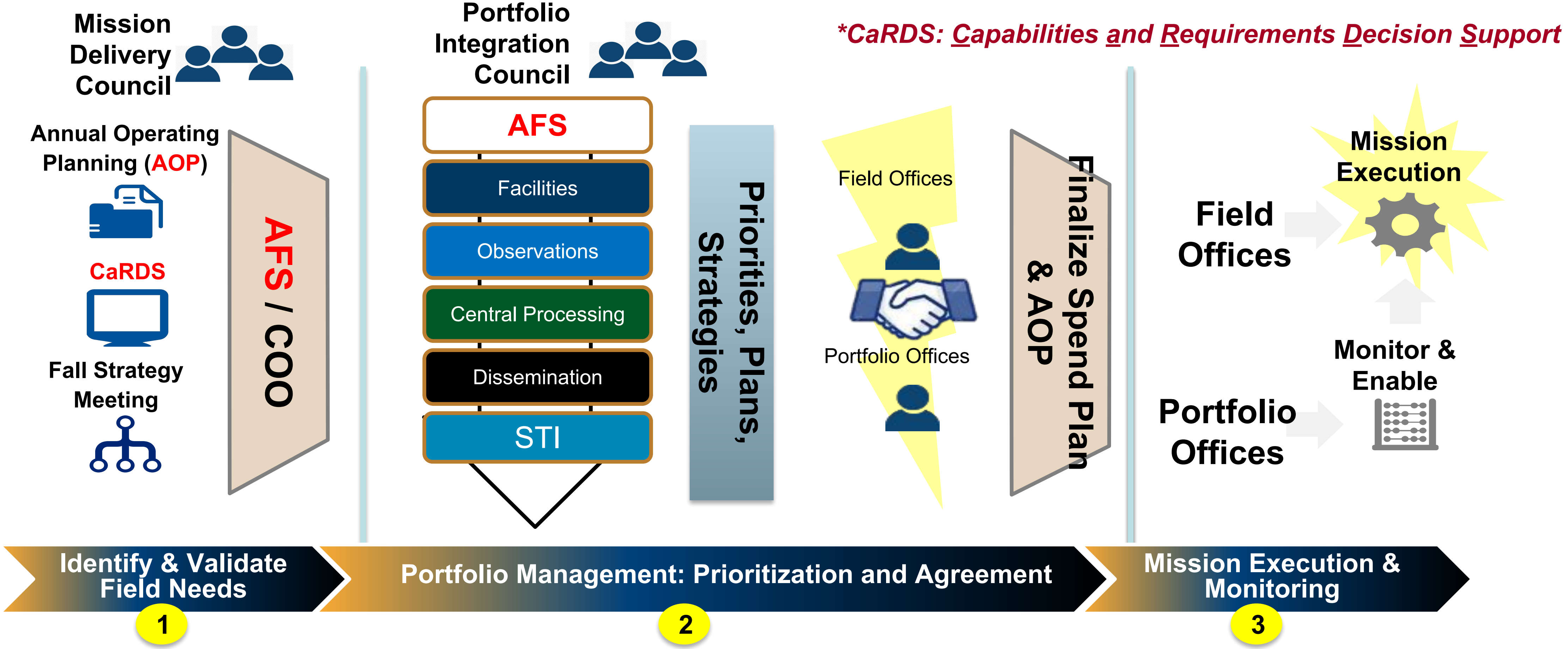
Summary & Open Discussion

- **The field requests to improve URMA/RTMA over complex terrain (more generally, areas of large terrain variation).**
  - By alleviating the reported biases in winds, temperature, and precipitation, etc.
  - Through improved quality control (QC), including station flagging, and analysis uncertainty specification (i.e., background error covariance), and metadata, etc.
- **A gap analysis - translating field's needs into modeling terms - strongly suggests the reasons behind the unmet needs on mesoscale analysis.**
  - To meet the unmet needs, i.e., alleviate the biases over complex terrain, the spatio-temporal variability of topographic flows should be systematically represented.
- **EMC and AFS work together.**
  - To better meet the field's needs via coordinated requirements (AFS) and solutions (EMC)
  - By finding agreed validation metrics (part of Analysis and Nowcast Framework for FY19)
  - By co-sponsoring milestones on mesoscale analysis for AOP process (starting from FY20).

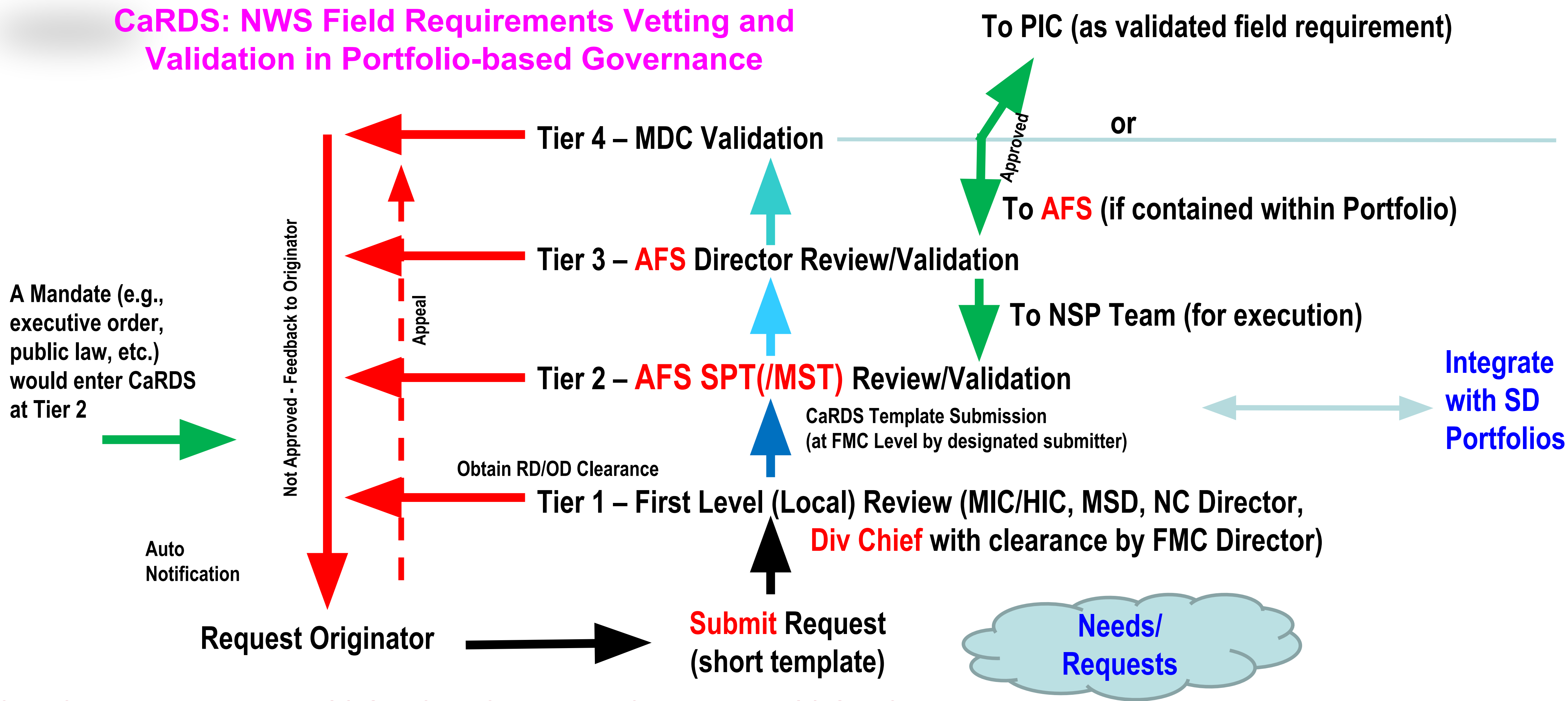
Extra Slides

CaRDS within NWS Governance (June 2017)

CaRDS is an important initial process to identify and validate field needs, which precedes other stages in the NWS Governance, followed by strategic planning and mission execution.



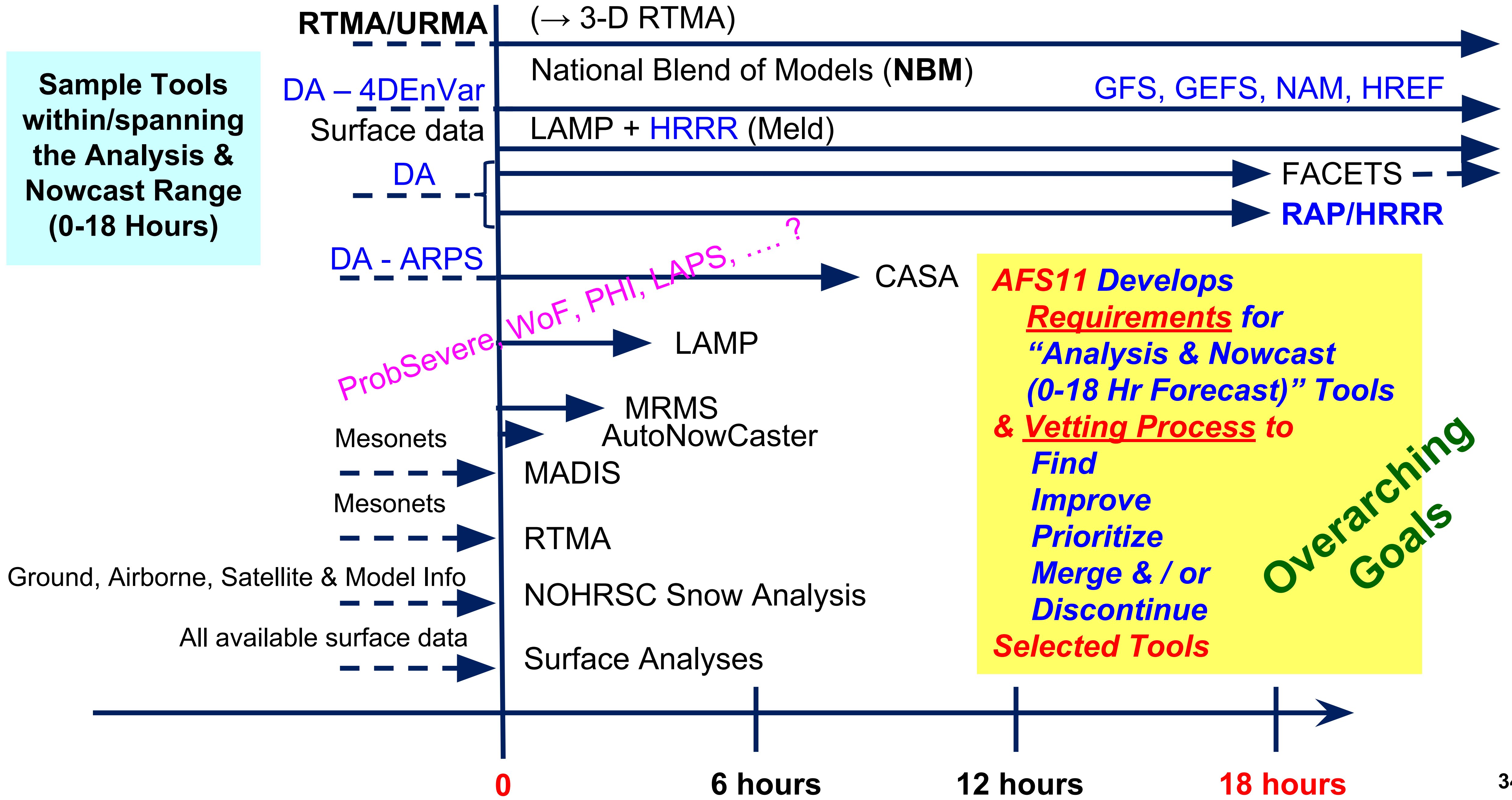
Validation Overview for CaRDS (Capabilities and Requirements Decision Support)



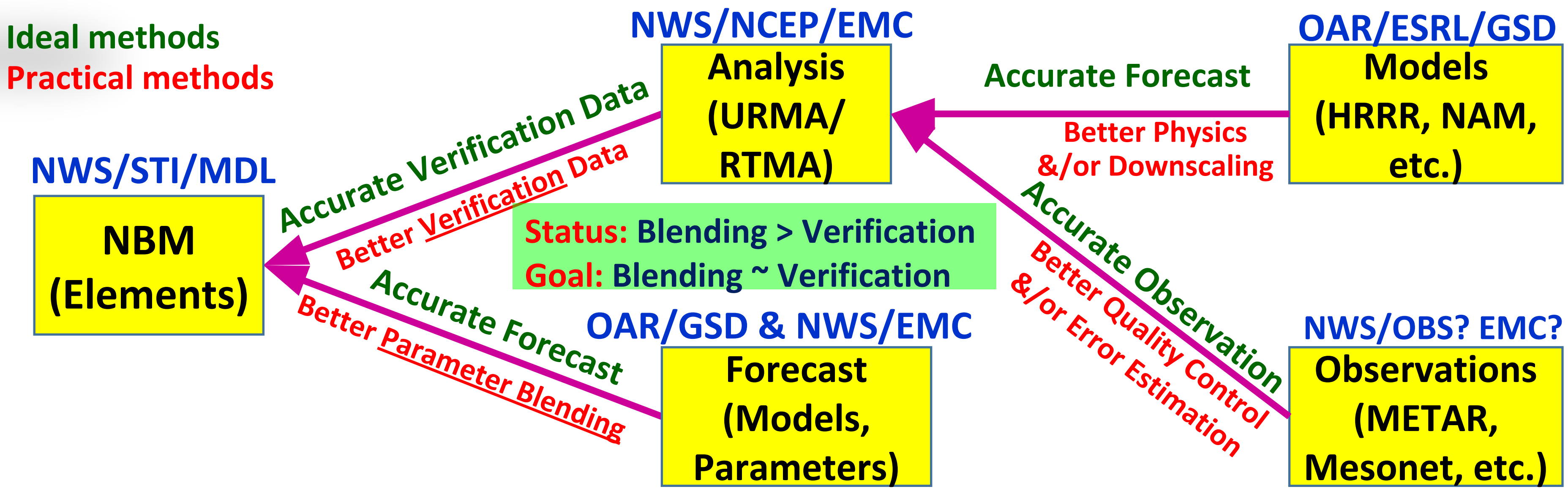
SPT: Service Program Team(s) @AFS2, MST: Mission Support Team(s) @AFS1

Source: Andy Stern

The Birth of Analysis and Nowcast Branch



Holistic Two-Tier Approach to Coherently Improve Mesoscale Analysis and Subsequently NBM



NWS/AFS11

***CaRDS 18-028*: Improved Mesoscale Analysis for NBM through Science-Based Enhancements to the Representation of Terrain Variation Effects**

→ Requires inter-office coordination and collaboration.

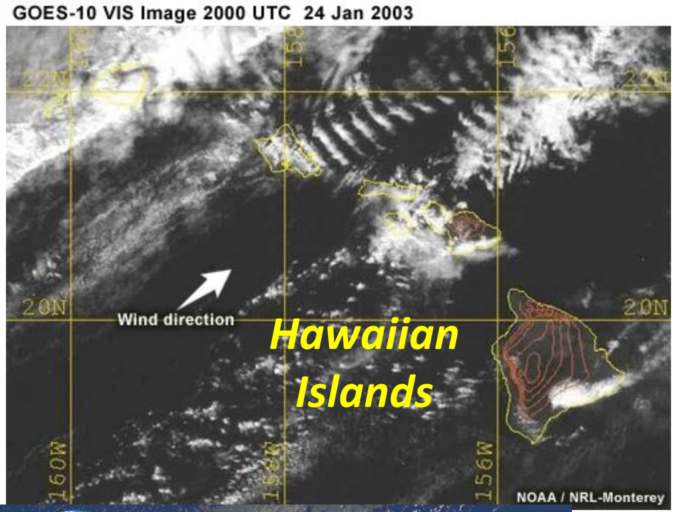
- To systematically improve the quality of NBM, the quality of URMA needs to be improved more urgently (as supported by the AFS11 field survey),
- By systematically and scientifically improving both the model physics and quality of observation data (thru improved quality control and/or error estimation),
- Especially over complex terrain where most significant errors are found.

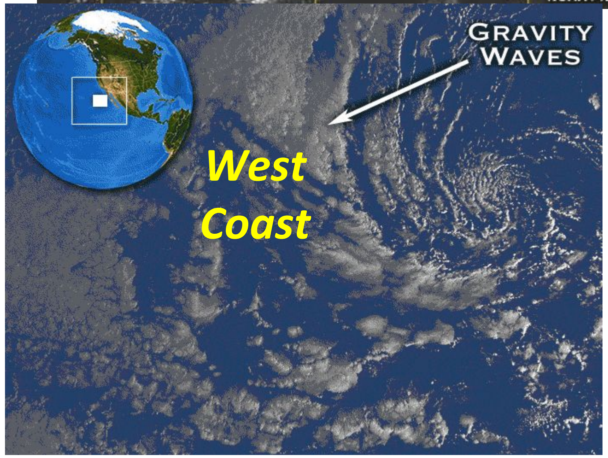
"RTMA/URMA Downscaling Meeting with focus on Biases over Complex Terrain" [YJ Kim, 12/16/2016 @EMC]

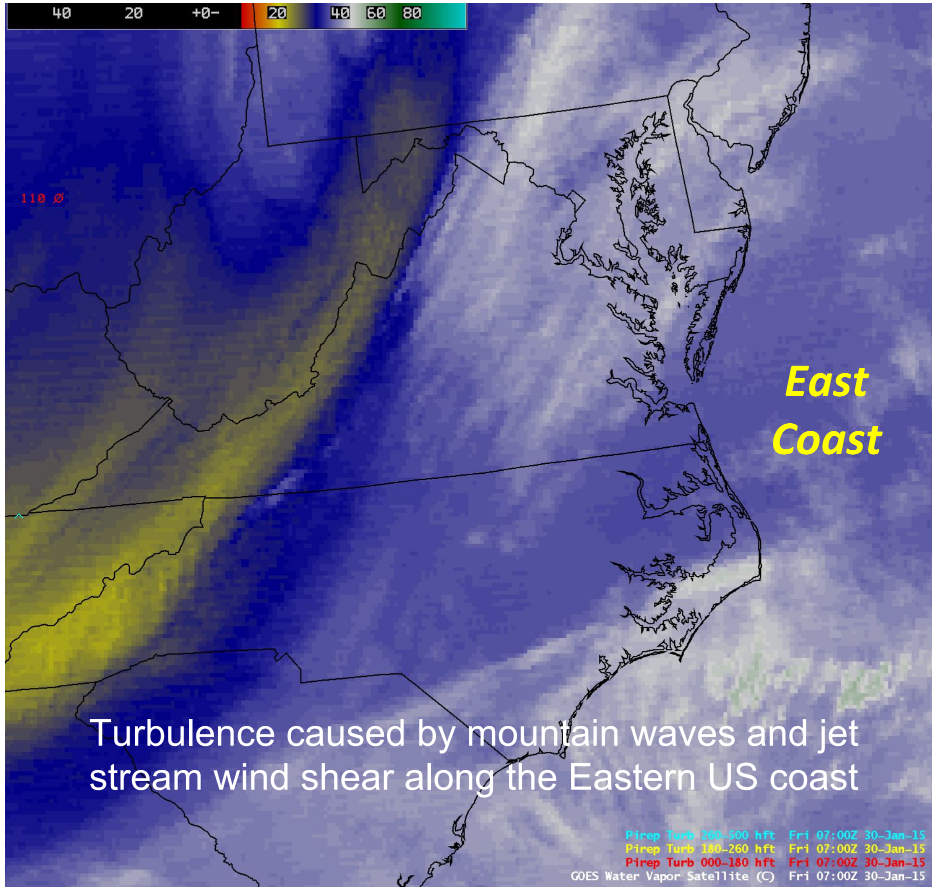
- **Andy Edman** @WR: Large Obs-URMA differences in humidity, temperature, etc.
- **Steve Levine** @EMC: Moisture increment adjustment, a function of the terrain-based anisotropy
- **David Barjenbruch** @CR: Downscaling difficulties over steep terrain
- **Geoff DiMego** @EMC:
  - We can't run the models with full resolution terrain so even when we run with 3 km grid-spacing we don't fully capture the terrain driven flows.
  - Downscaling (SmartInit) uses full resolution model fields and "puts" them on the NDFD grids with 2.5 km grid-spacing.
  - Temperature adjustments take elevation differences into account but much less adjustment of wind for terrain and that is mostly if we are near coastlines.
  - PBL height diagnosing method linked to wind gust bias.

Effects of Flows over Areas of Large Terrain Variation

Flow over complex terrain or areas of large terrain variation (mountains, coasts, islands, lakes, etc.), can generate various types and sizes of gravity waves, and associated turbulence, gust winds, warming, etc.







Field Needs Conveyed in RTMA/URMA SOO Group Report

Dave Bernhardt (SOO-Great Falls) - Source: Andy Edman @2016 NPSR

Quality Control (QC) [Report #2]	Quality Control (QC) [Report #3]	Data Assimilation [Report #4]	Model Physics [Not in the report]
"… reduce the number of observations that are rejected because they differ from the first-guess by a threshold amount"	"… the first-guess may be missing critical local variations and needs to be more strongly adjusted toward the observations"	"**background co-variance "analysis uncertainty**"	The model physics should be able to represent the full effects of terrain variations.
"While these can be indicative of bad observations, they are often indications where the first-guess is not capturing reality"	"… weighting observations more strongly at grid points where sub-grid topographic variability is low - and less at grid points where the sub-grid topographic variability is high"	"… consider something less than one-half of a standard deviation, difference from mean or variance."	The grid-scale effects can be better represented by higher-resolution terrain from increased model resolution.
"… adjustments may include time continuity, neighbor agreement and other factors that should be accounted for in order for a station to be retained, even when it does not make the cut in the current scheme"	"Expanded variation in weighting based on observation type …., where more (or less) weight is given to some types of mesonets"	"These grids should be updated in real time with a running set of time periods	The subgrid-scale effects can be better represented by improved orographic drag parameterization or downscaling.

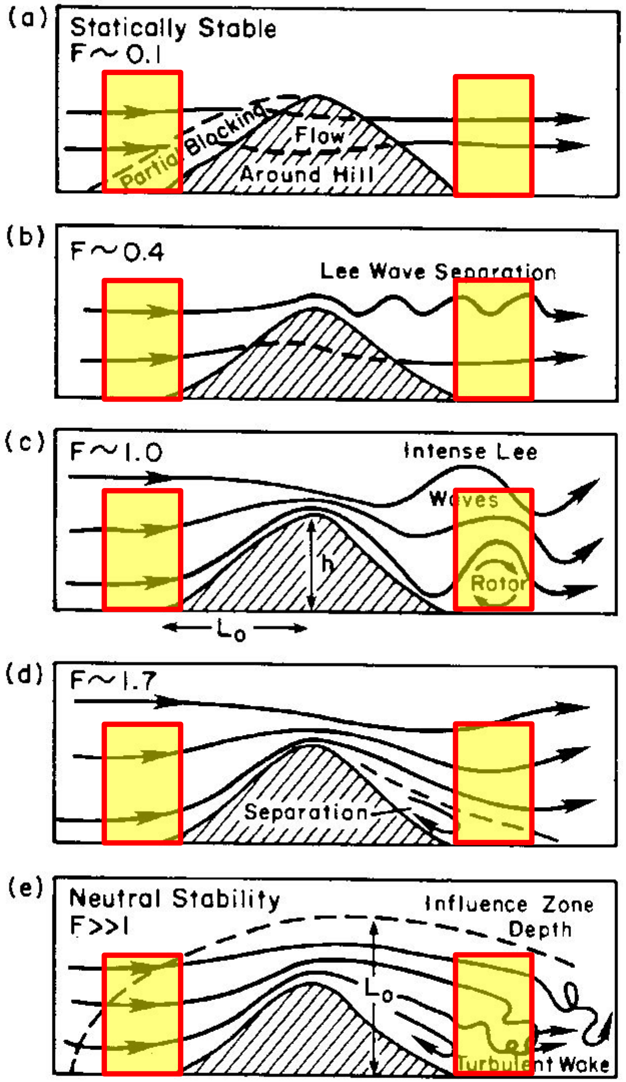
Science: Systematic Representation of Terrain Effects

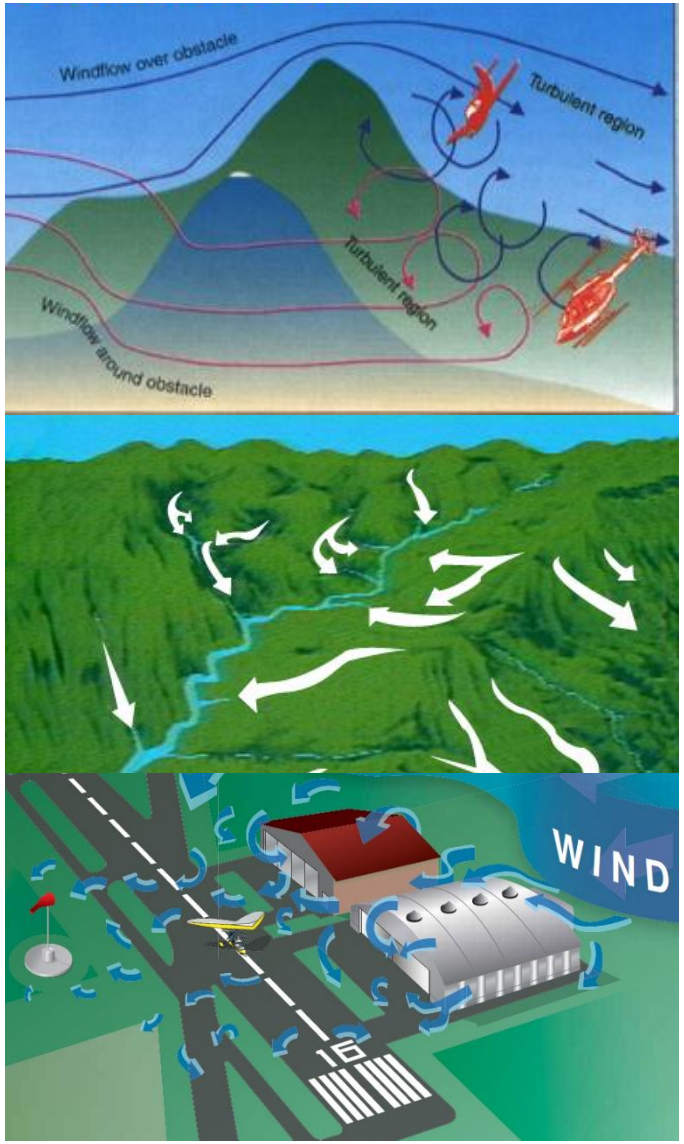
In order to systematically improve NWS' mesoscale analysis (e.g., URMA),

- The **inhomogeneous, nonstationary, and anisotropic effects on the flow of the surface terrain variations (such as mountains, coastlines, lakes, islands, etc.)** should be and can be better represented through…

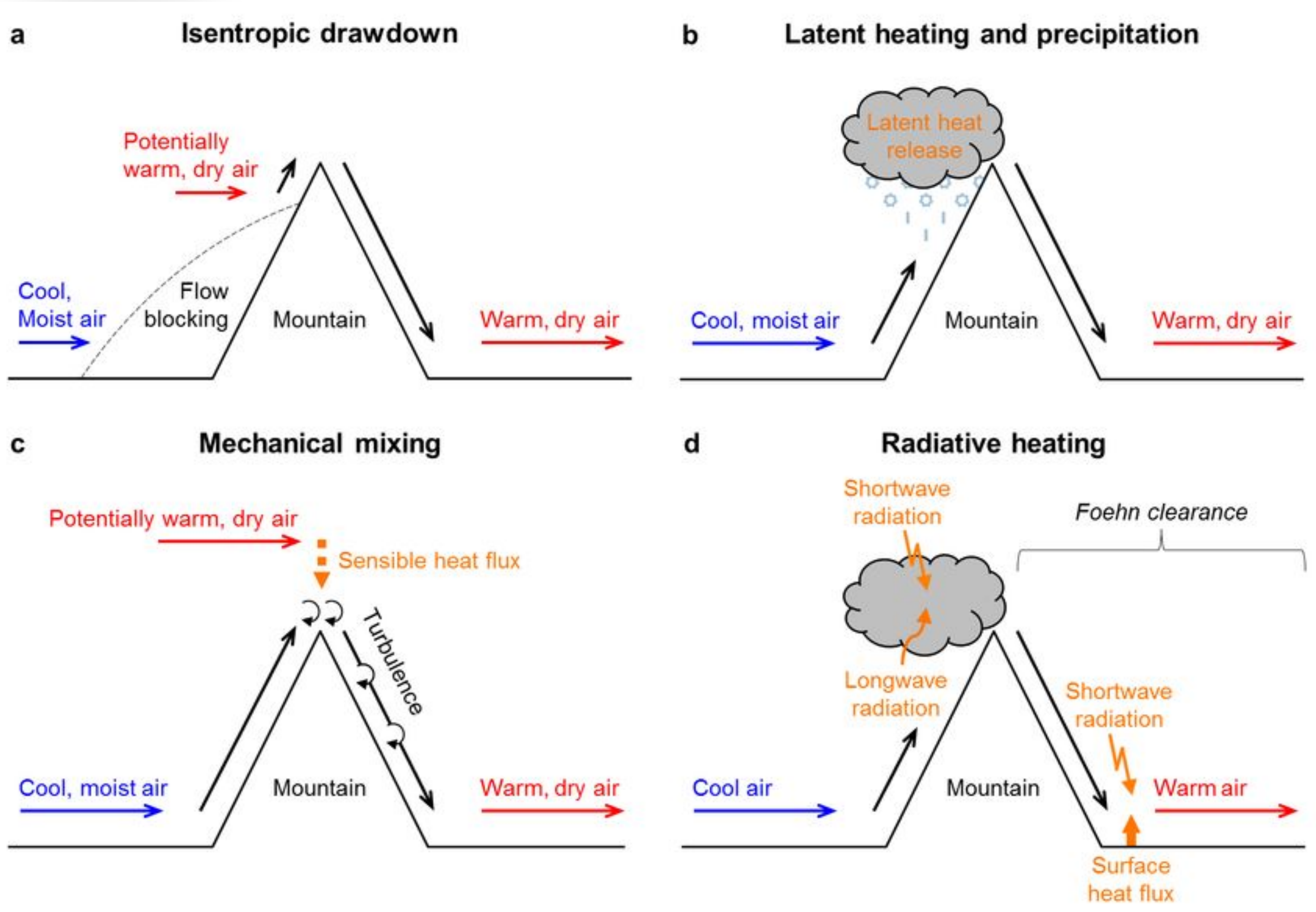
- More systematic and physical inclusion of **spatiotemporally-varying effects of terrain variation**, in…

  - **Models** (e.g., orographic drag parameterizations in "HRRR")
  - **Downscaling algorithms** (e.g., "SmartInit")
  - **Data Assimilation** (e.g., background error covariance)
  - **Bias Correction** (e.g., observational data QC)





Foehn Warming Mechanisms



a. Upwind of the mountain, cool, moist air can be **blocked** allowing potentially warmer, drier air to be advected isentropically down the lee slopes.

b. Without flow blocking there is ascent on the windward slopes so the air cools, leading to condensation and **latent heat release** which reduces the cooling; **precipitation** removes the condensed water, so that descent on the leeside is dry which increases the (pressure-related) warming leading to higher leeside temperatures.

c. As cool, moist air passes over the mountain it will **mix mechanically** with the overlying air mass; for a statically stable atmosphere this is potentially warmer (and usually drier) so corresponds to a **turbulent flux of sensible heat** into the foehn flow (and a turbulent flux of moisture out of it).

d. Associated with the mechanisms described in (a-c) there is often clear, dry air on the downwind slopes (the **'foehn clearance**') and cloud on the upwind slopes; this situation encourages **radiative flux convergence** and so warmer air on the leeside.

v2.7 RTMA/URMA Upgrade: Highlights

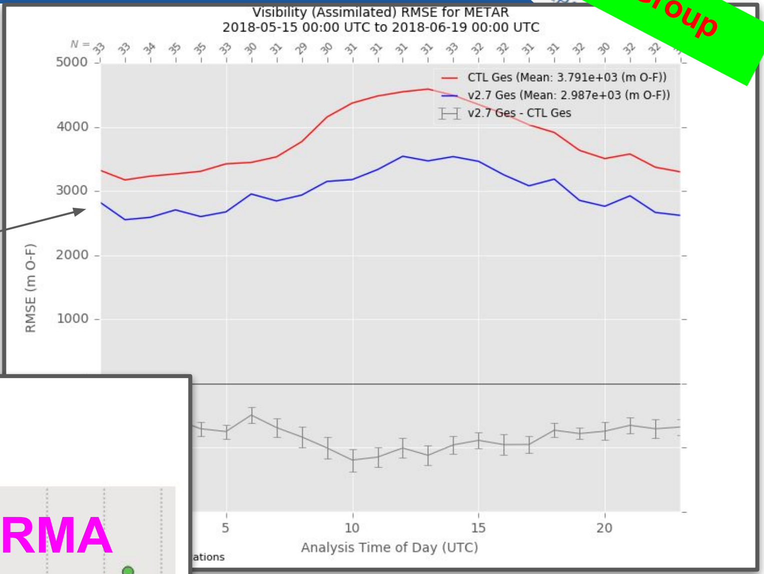
From RTMA/URMA Group

- Use of HRRR-AK in background ['Good enough' item 2, AK Region]
- Sky cover and ceiling analysis expanded for all domains [NBM, all regions]
- Improved C&V analysis via algorithm enhancement [FAA, AWC, NBM, all regions]
- Waves for OCONUS URMA [NBM, AK Region, Southern Region (PR), Pacific Region]
- Hourly system for Guam [NBM, Pacific Region]
- Better fit to observations ['Good Enough' item 3 and 4, all stakeholders]
- Winds QC → Ongoing process ['Good enough' item 2, all stakeholders]
- Fill in data coverage gaps in Precipitation URMA with MRMS/cmorph [NBM, Western Region, WPC, AWC]
- RTMA-RU → Improved latency (within 15min) and C&V [FAA, AWC]

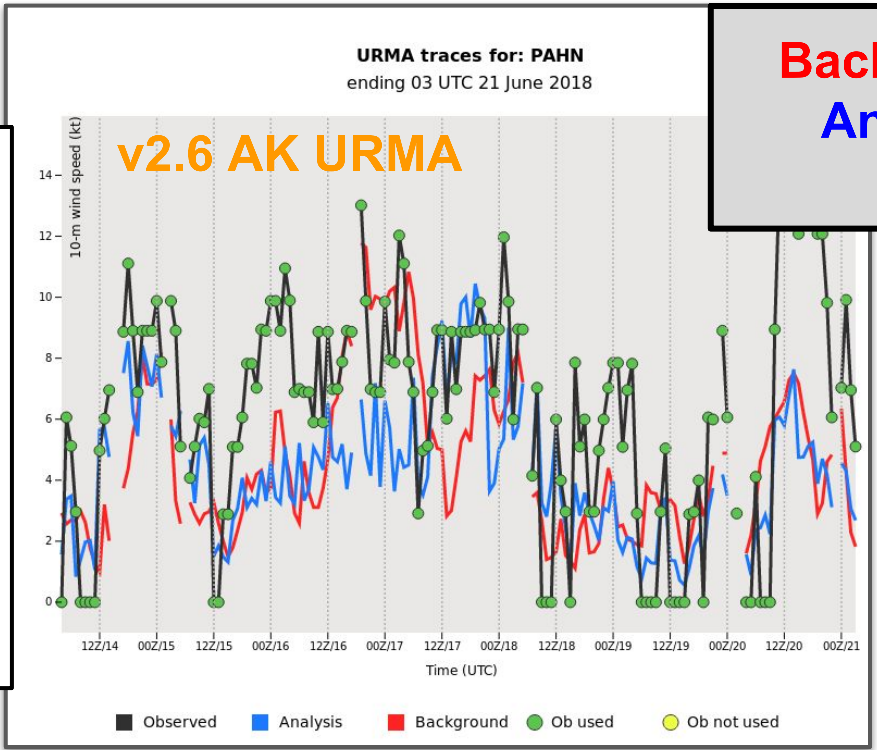
HRRR-Alaska for AKRTMA and AKURMA

From RTMA/URMA Group

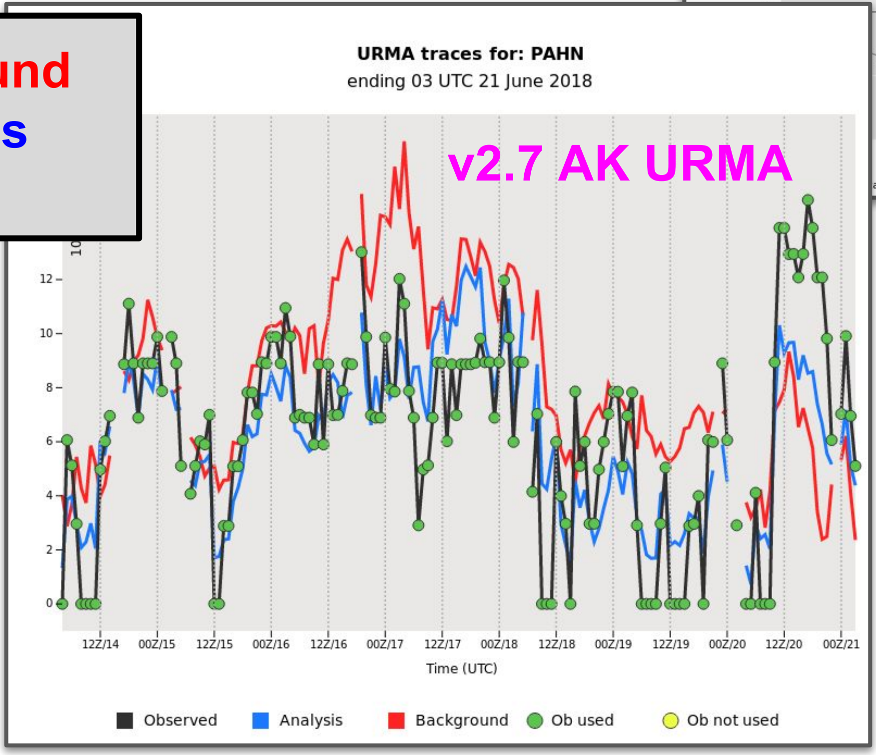
- 3 km HRRR-AK now used in background
- Finer grid spacing, better resolved terrain induced features
- Better background → better analysis [e.g. visibility]



10m Wind Speed (kts)



Background
Analysis
Obs

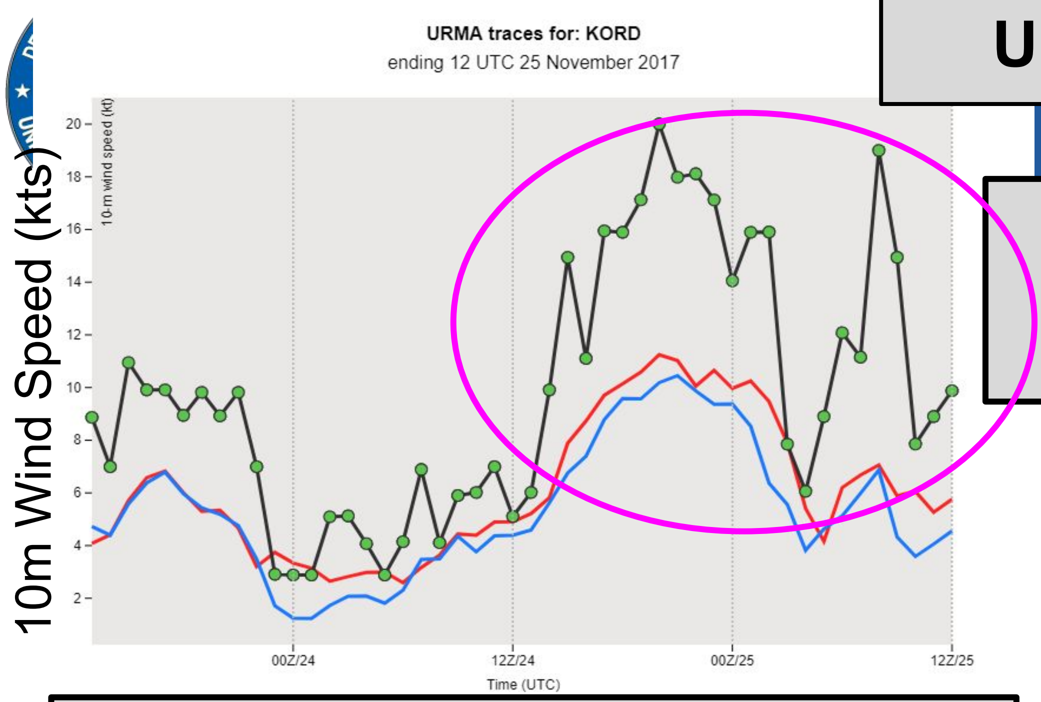


From RTMA/URMA Group

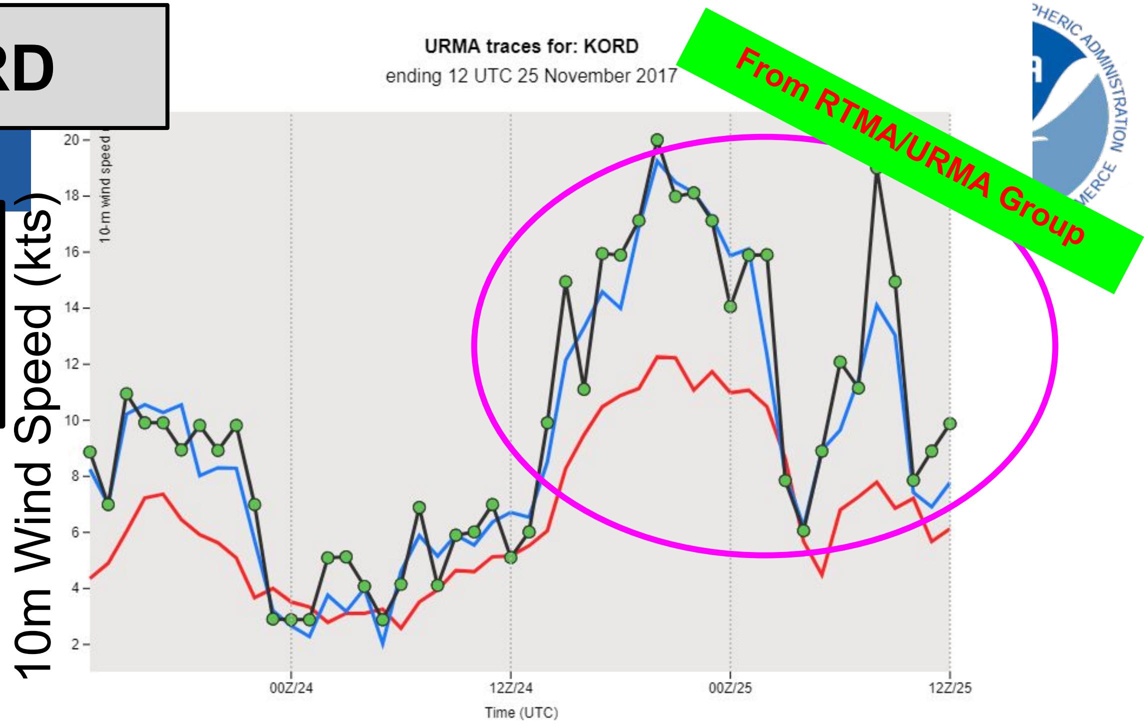
RTMA v2.7 (Nov. 28, 2018)

- IT evaluation is complete, NCO is ready to implement
  - Final approval given by NCEP director earlier this afternoon
- Implementation: Tuesday December 4, 12Z cycle
  - 12Z RTMA, 06Z URMA
- On December 4th, RTMA entry in COMET Model Encyclopedia will be updated with v2.7 documentation
  - Requested by SOO-DOH ‘Good Enough Group’
- **V2.7 Science Overview** here
  - Wind QC improvements
  - Background error improvements over complex terrain
  - Use of HRRR-Alaska
  - Much improved ceiling/visibility algorithm

URMA at KORD



Background
Analysis
Obs



Assimilate Winds as in Operations

No Assimilation of *any* Mesonet Winds

Next Steps for Winds?

- Develop comprehensive metadata database for mesonets → in progress w/ MesoWest, stakeholders, and collaborators
- Update provider use lists → in progress for **CONUS**
- Better metadata allows us to leverage DA algorithm to handle wind obs at heights other than 10 m
- Representativeness - METARs are often at airports. Fine for aviation but what about nearby urban areas where most mesonets reside?
  - Statistical analysis based on urban area mapping GIS data

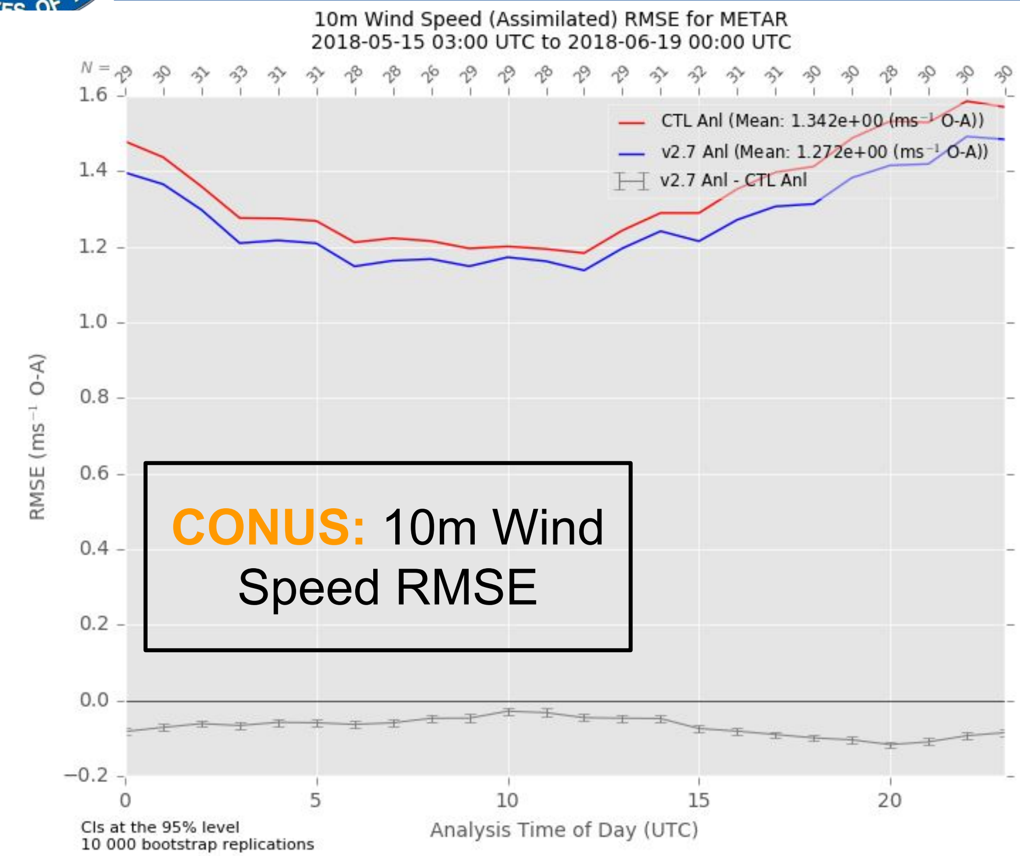
Metadata/Forward Operator Work

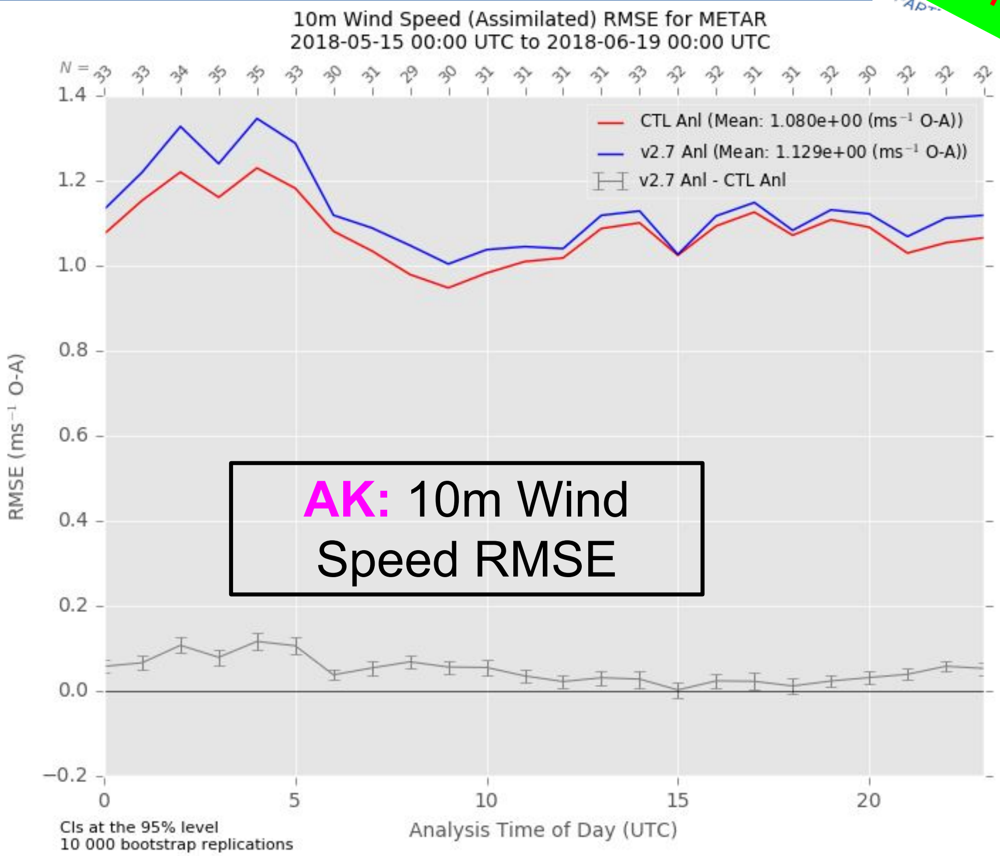
From RTMA/URMA Group

- Metadata (wind sensor height) gathering has continued over the past month
  - Incorporate sensor height into analysis via provider/subprovider
  - Up to now, all wind obs have been assumed at a height of 10 m AGL
  - Metadata provided by MesoWest, ESRL, and previous communications between EMC and providers
- Many ‘trusted’ providers have wind sensor heights < 10m
  - RAWS: 6 m
  - Some state mesonets (DE, NE, AZ, MI, MO): 3 m
  - Buoys: varies by system
  - Future ‘assumptions’: CWOP and AWS obs at 3 m, currently based on bulk stats/testing. More to come.
- Long term goal: Move away from rejecting stations with non-standard siting and towards using their metadata ***<u>when available</u>***
  - Some rejections for winds/gusts will still be necessary

From RTMA/URMA Group

10m Wind Stats





- **CONUS:** v2.7 URMA 10m wind RMSE is *slightly better* *(~0.07 m/s)*
- **OCONUS**: v2.7 URMA 10m wind RMSE is *slightly worse* *(~0.05 m/s for AK, ~0.1 to ~0.2 for HI and PR)*
  - Not a surprise! Removal of the wind use list in OCONUS will have this effect - engage stakeholders for real-time QCing of bad stations

"RTMA Good Enough" List

(Reported at 2016 NPSR)

1) Develop a more agile and responsive mechanism for updating observation station (METARs and mesonet) information, and improve the accuracy of station location information.
2) **Much expanded quality control of observations and mesonets.**
3) **Improve background co-variance "analysis uncertainty" grids so they are more representative of the current errors in the background, etc.**
4) Updated documentation of the RTMA/URMA system.

***METAR**: METeorological Aerodrome Report*
***RTMA**: Real Time Mesoscale Analysis*
***URMA**: UnRestricted Mesoscale Analysis*

“RTMA Good Enough” List

(2016 version probably with some updates or comments)

1) Develop a more agile and responsive mechanism for updating observation station (METARs and mesonet) information, and improve the accuracy of station location information.

- The stations should be located accurately within 0.001° (preferably 0.0001°). The station location updates should be implemented in operational systems within hours, or a few days, rather than months.
- The present system does not work well. There are varied means of determining station location (NWSLI, AirNav, etc.). NWS Instruction 30-1204 states that the station location (if on airport) is the FAA-assigned coordinates. These are often center-field coordinates that can vary markedly from the meteorological instrument’s coordinates.
- <u>The directive should be updated, noting the distinction between the airport and meteorological coordinates</u>.
- A formal and uniform means of establishing station location must be implemented.

“RTMA Good Enough” List

(2016 version probably with some updates or comments)

2) Much expanded quality control of observations and mesonets.

- It is important to reduce the number of observations that are rejected because they differ from the first-guess by a threshold amount.
- While these can be indicative of bad observations, they are often indications where the first-guess is not capturing reality and itself needs to be adjusted.
- These adjustments may include time continuity, neighbor agreement and other factors that should be accounted for in order for a station to be retained, even when it does not make the cut in the current scheme.

"RTMA Good Enough" List

(2016 version probably with some updates or comments)

3) Much expanded ability for different weighting for different observations in varied situations.

- The current system weights observations very broadly, either METAR or other. This is particularly important when observations differ from the first-guess, yet agree with nearby observations that also differ from the first-guess. Such cases are indications that the first-guess may be missing critical local variations and needs to be more strongly adjusted toward the observations than in other circumstances (detailed by research at the University of Utah).
  - Other variations in weighting are also warranted, such as weighting observations more strongly at grid points where sub-grid topographic variability is low - and less at grid points where the sub-grid topographic variability is high.
  - Expanded variation in weighting based on observation type is also necessary, where more weight is given to some types of mesonets (such as high quality sensors like permanent RAWS and possibly DoT), and less weight to other mesonets (such as public "backyard", CWOP and other such stations).
  - This will help for mountain winter cold pools, marine layer inconsistencies, cold pools behind squall lines plus any other situation where the model background field is struggling with reality.

"RTMA Good Enough" List

(2016 version probably with some updates or comments)

4) Improve background co-variance "analysis uncertainty" grids so they are more representative of the current errors in the background, etc.

- A threshold can be determined, but as a starting point, maybe we should consider something less than one-half of a standard deviation, difference from mean or variance.
- These grids should be updated in real time with a running set of time periods - last hour, last day, last week, last month, last 3 months and last year. This would provide critical insight as to how the RTMA/URMA analysis is performing for both daily, seasonal and yearly basis. This information could be also be used to improve how the NDFD verifies, ie., is the gridded forecast within the RTMA analysis error

"RTMA Good Enough" List

(2016 version probably with some updates or comments)

5) **Updated documentation of the RTMA/URMA.**

RTMA/URMA SOO Group Report

Dave Bernhardt (SOO-Great Falls) – Source: Andy Edman @2018 NPSR

Following is a list of items that the RTMA "Good-Enough" Sub-group would like addressed with the RTMA and its assimilation process.

- Until these items are addressed, it is difficult to determine what is a "good-enough" analysis.

1. Develop a more agile and responsive mechanism for updating observation station (METARs and mesonet) information, and improve the accuracy of station location information.
2. Much expanded quality control of observations and mesonets.
3. Much expanded ability for different weighting for different observations in varied situations.
4. Improve background co-variance "analysis uncertainty" grids so they are more representative of the current errors in the background, etc.
5. Updated documentation of the RTMA/URMA system.